

写在《科技之魅》的前面

Preface to the Charm of Science and Technology

科技的魅力在于创新，从“万物互联”到“万物智联”，科技发展赋能经济社会生产生活，引领人类迈向数字世界，不断触摸前沿科技发展脉动，创造美好的数字未来。

The charm of technology lies in innovation. From the "Internet of Everything" to the "Artificial Intelligence of Everything", technological advances empower the economic and social aspects of production and life, leading human society into the digital world. It touches the pulse of cutting-edge technological development, creating a promising digital future.

当前，以互联网为代表的新一轮科技革命和产业变革深入演进，6G、人工智能、量子计算等新兴技术进入发展快车道，数字化、网络化、智能化进程全面提速。在此时代背景下，“世界互联网领先科技成果发布活动”升级为“世界互联网大会领先科技奖”，在展现全球互联网领域最新科技成果、彰显互联网从业者的创造性贡献、搭建全方位的创新交流平台等方面将发挥更加重要的作用。

A new wave of technological revolution and industrial transformation is unfolding, with the Internet serving as a key driver. Emerging technologies such as 6G, artificial intelligence, and quantum computing are advancing rapidly. The processes of digitization, networking, and intelligence is accelerating at an unprecedented pace. In this context, "the Release Ceremony for World Leading Internet Scientific and Technological Achievements" has been upgraded to "the World Internet Conference Awards for Pioneering Science and Technology". This upgrade aims to play a more significant role in showcasing the latest technological accomplishments in the global Internet field, highlighting the creative contributions of Internet practitioners, and fostering a comprehensive platform for innovation exchanges.

作为世界互联网大会领先科技奖评审委员会主席，我欣喜看到本年度成果征集持续得到全球范围的广泛关注和积极响应。今年成果首次区分基础研究、关键技术与工程研发三种类型。在基础研究组主任委员美国互联网先驱戴夫·法伯先生，关键技术组主任委员中国工程院院士吴建平先生，工程研发组主任委员韩国互联网之父全吉男教授等40位中外专家的支持下，我们共征集到来自中国、美国、俄罗斯、英国、意大利、日本、韩国、阿联酋等多个国家及地区的领先科技成果246项，涵盖人工智能、5G、6G、大数据、网络安全、高性能芯片、工业互联网等众多前沿科技领域。经过专家推荐，57项优秀成果，收录于本年度《科技之魅》成果手册。我们相信，这些成果的不断转化落地，将更好地推动经济社会韧性发展，为构建网络空间命运共同体、推动人类文明进步提供更多可能。

As the chairman of the World Internet Conference Awards for Pioneering Science and Technology Review Committee, I am thrilled to see the global attention and positive responses this year's collection of achievements has received. This year, for the first time, the achievements

世界互联网大会领先科技奖评审委员会

World Internet Conference Awards for Pioneering Science and Technology Review Committee

have been categorized into three types: Basic Research, Key Technology, and Engineering Research and Development. With the support of 40 experts from all over the world, including Mr. David Farber, an American Internet pioneer and the Director of the Basic Research; Mr. Wu Jianping, an Academician of the Chinese Academy of Engineering and the Director of the Key Technology; and Professor Chon Kilnam, the Father of the Korean Internet and the Director of the Engineering Research and Development, we have collected a total of 246 achievements from countries and regions, such as China, the United States, Russia, the United Kingdom, Germany, Italy, Japan, Korea, and the United Arab Emirates. These achievements cover a wide range of cutting-edge technological fields, including artificial intelligence, 5G, 6G, big data, cybersecurity, high-performance chips, and the industrial Internet. After thorough review by the experts, 57 leading achievements have been selected and compiled into a publication called "The Charm of Science and Technology". We firmly believe that the continued implementation of these achievements will better promote resilient economic and social development, offer more possibilities for building community with a shared future in cyberspace and advance human civilization.

星燧贸迁，晷刻渐移。伴随着世界互联网大会国际组织的发展，《科技之魅》将持续记录互联网科技创新的非凡成就。希望《科技之魅》持续传递互联网创新发展的智慧与力量，引领未来互联网技术发展方向，为国际交流互鉴和科技成果转化拓展更为广阔的空间。

With the passage of time and the evolution of the World Internet Conference, the Charm of Science and Technology will continue to document the extraordinary achievements of Internet technological innovation. We aspire for this publication to consistently transmit the wisdom and power of Internet innovative development, guide the future direction of Internet technology and provide a broader space for international exchange, mutual learning, and the transformation of technological achievements.

科技之魅



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01

世界互联网大会领先科技奖获奖成果

Leading Achievements of World Internet
Conference Awards for Pioneering Science and Technology

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《科技之魅》收录成果
Charm of Science and Technology Collection

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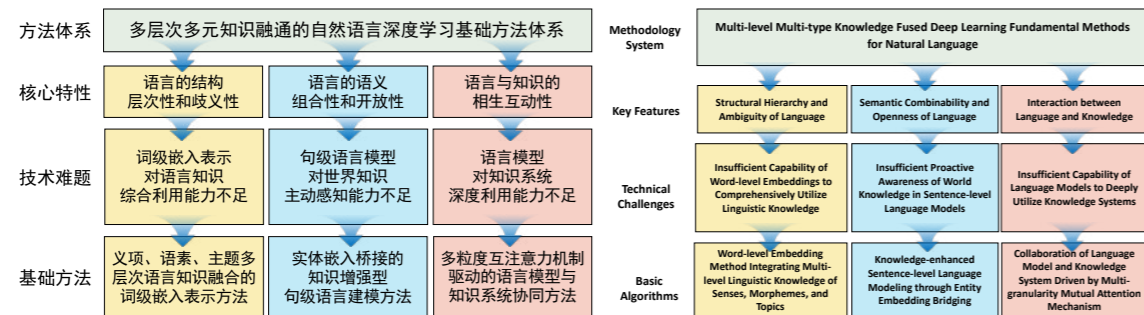
01 世界互联网大会 领先科技奖获奖成果

Leading Achievements of World Internet Conference
Awards for Pioneering Science and Technology

基础研究组 Basic Research

多层次多元知识融通的自然语言深度学习基础方法

Multi-Level Multi-Type Knowledge Fused Deep Learning Fundamental Methods for Natural Languages



● 多层次多元知识融通的自然语言深度学习基础方法体系架构

● The Systematized Framework of Multi-Level Multi-Type Knowledge Fused Deep Learning Fundamental Methods for Natural Languages

多层次多元知识融通的自然语言深度学习基础方法体系框架

The Systematized Framework of Multi-Level Multi-Type Knowledge Fused Deep Learning Fundamental Methods for Natural Languages

清华大学
Tsinghua University



华为技术有限公司
Huawei Technologies Co., Ltd.



引言

自然语言处理是人工智能重大前沿领域。清华大学与华为技术有限公司多年来研究并建立了一套多层次多元知识融通的自然语言深度学习基础方法体系，在该方向学术创新和开源共享方面取得了具有国际领先性和影响力的成果。

Introduction

Natural Language Processing (NLP) is a cutting-edge research field in artificial intelligence. Tsinghua University and Huawei Technologies Co Ltd. have devoted a significant attention to research and establishment of the multi-level multi-type knowledge fused deep learning fundamental methods for natural languages in the past years, achieving internationally advanced and influential outcomes in academic innovation and open-source sharing.

具有国际一流水平的多层次多元知识融通的自然语言深度学习基础方法

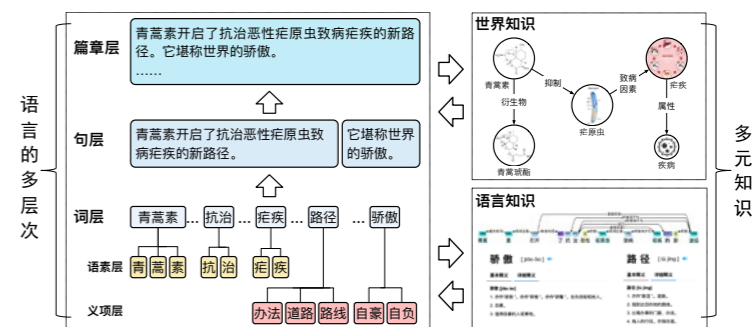
A world-class multi-level multi-type knowledge fused deep learning fundamental method for natural language

本项目针对词级嵌入表示对语言知识综合利用能力不足、句级语言模型对世界知识主动感知能力不足以及语言模型对知识系统深度利用能力不足这三个深刻挑战，建立了较为完整的多层次多元知识融通的自然语言深度学习基础方法体系，包括义项、语素、主题多层次语言知识融合的词级嵌入表示方

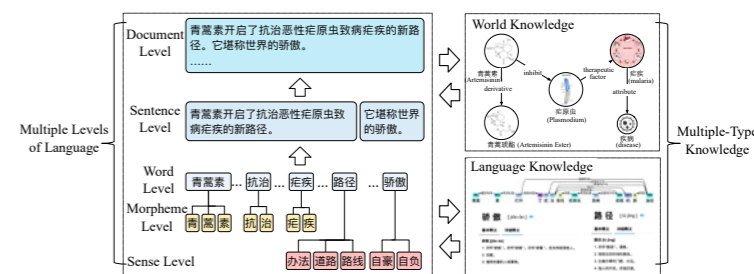
法、实体嵌入桥接的知识增强型句级语言建模方法以及多粒度注意力机制驱动的语言模型与知识系统协同方法，突破了自然语言深度学习的若干重要瓶颈制约，显著提升了自然语言处理模型的基本能力。

This project addresses three profound challenges: the insufficient ability of word-level embedding representations to utilize linguistic knowledge comprehensively, the inadequate proactive awareness of world knowledge by sentence-level language models, and the insufficient ability of language models to deeply utilize knowledge systems. A relatively complete multi-level multi-type knowledge fused deep learning fundamental methods for natural languages has been established. This includes the word-level embedding method integrating multi-level linguistic knowledge of senses, morphemes, and topics; the knowledge-enhanced sentence-level language modeling through entity embedding bridging; and the collaboration of language model and knowledge system driven by multi-granularity mutual attention mechanism, significant bottlenecks restricting the advancement

of deep learning in NLP, significantly enhancing the fundamental capabilities of NLP models.

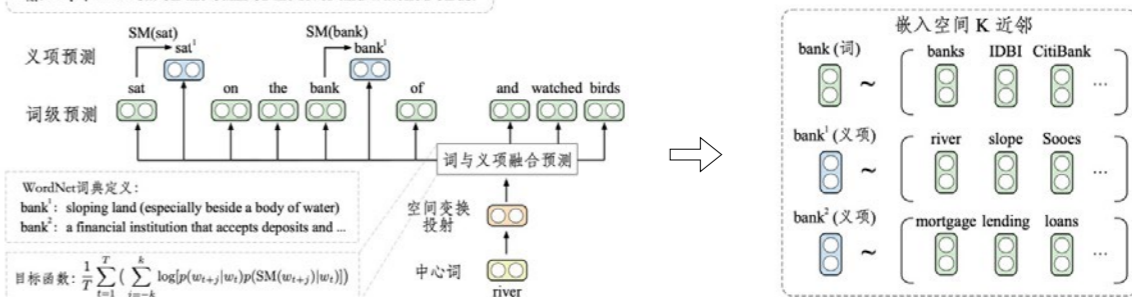


● 自然语言的多层次及多元知识



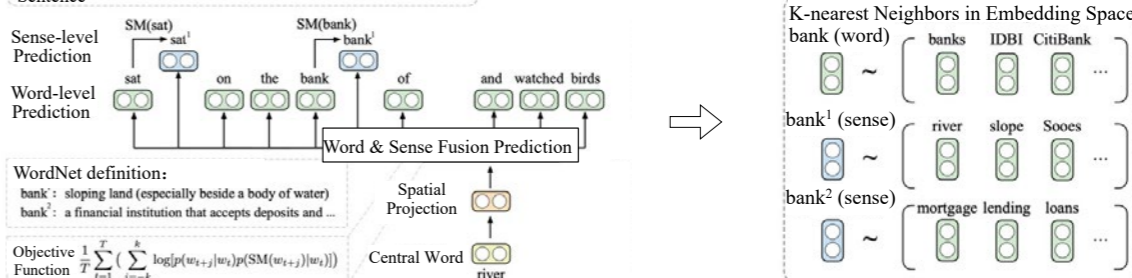
● Multiple Levels of Natural Language and Multi-type Knowledge

输入句子: ... sat on the bank of the river and watched birds.

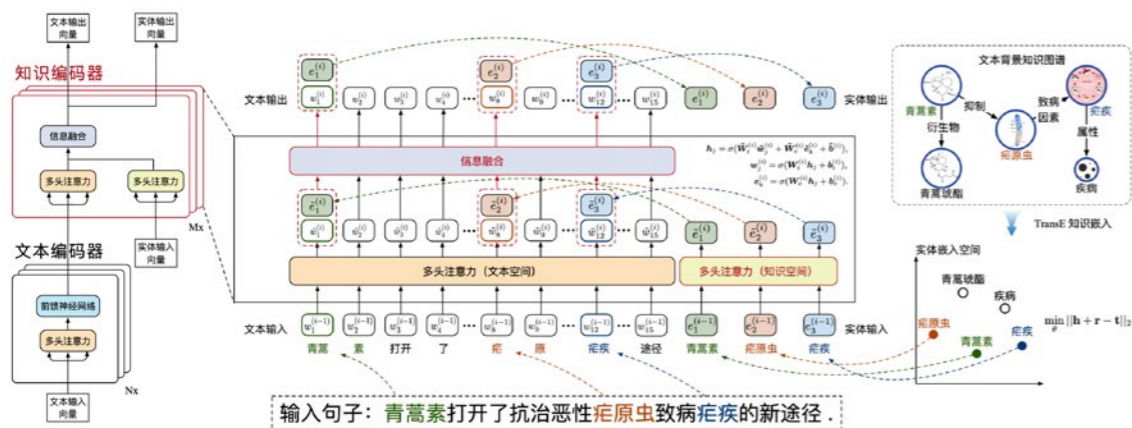


● 词典定义使能的词义表示与排歧一体化义项嵌入方法

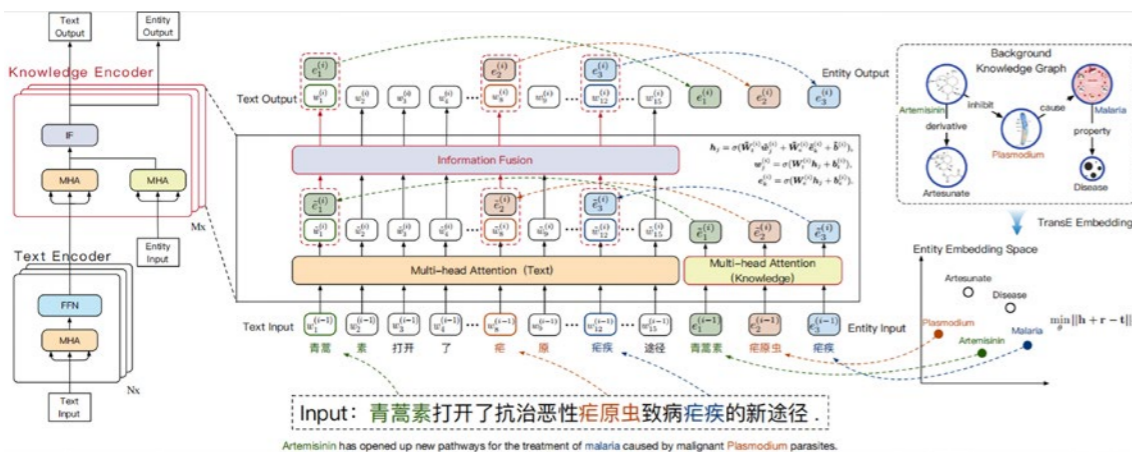
Input Sentence: ... sat on the bank of the river and watched birds.



● Dictionary-enabled Sense Representation and Disambiguation Integrated Sense Embedding Method



知识增强的句级语言建模方法 ERNIE



Knowledge-enhanced Sentence-level Language Modeling Method ERNIE

具有国际影响力的语言与知识融通开源系统

An internationally influential open-source system for the fusion of language and knowledge

基于该方法体系，我们在最具影响的国际开源平台 GitHub 上发布了 4 个开源代码，形成了一套语言与知识融通的深度学习开源系统。共获 2000 多个星标，500 余次复刻，在语言与知识融通的自然语言深度学习方向上的开源影响居世界领先之列，复刻者包括谷歌、微软、阿里巴巴、腾讯、京东、百度等科技公司。本成果已成功应用于华为云，服务 150 余个国家和地区，取得良好效果（华为云目前市场份额中国排第二、世界排第五，服务 150 多个国家和地区，全球有超过 3 万家合作伙伴，260 万开发者，云市场上架应用超过 6100 个，在全球范围具有较大影响力）。

Based on this algorithmic framework, we have released 4 open-source software on GitHub, the most influential international open-source platform, constituting a deep learning open-source system for the integration of language and knowledge. This system has garnered over 2,000 stars and has been forked more than 500 times, ranking it among

the world's leading influences in the field of deep learning for natural language integration with knowledge. Notably, the forkers include tech giants like Google, Microsoft, Alibaba, Tencent, JD.com, and Baidu. Our achievement has been successfully implemented in Huawei Cloud, serving over 150 countries and regions with significant results (Currently, Huawei Cloud holds the second-largest market share in China and ranks fifth globally. It serves more than 150 countries and regions, boasts over 30,000 partners worldwide, accommodates 2.6 million developers, and has listed more than 6,100 applications in its cloud marketplace, making it highly influential on the global stage).

ERNIE与同类开源模型对比

清华大学与华为联合发布的 ERNIE	★ 1382 复刻267
北京大学与腾讯公司联合发布的 K-BERT	★ 899 复刻202
RIKEN 发布的 LUKE	★ 655 复刻94
RIKEN 发布的 LUKE	★ 352 复刻53
美国前沿人工智能研究机构 AI2 发布的 KnowBERT	★ 62 复刻12
微软发布的 HittER	★ 62 复刻12

“复刻”ERNIE的代表性单位



本成果之一 ERNIE 的开源影响

Comparison of ERNIE with Similar Open-Source Models

ERNIE, jointly released by Tsinghua University and Huawei	1382 stars 267 forks
K-BERT, co-released by Peking University and Tencent	899 stars 202 forks
LUKE, released by RIKEN, Japan's applied science research institute	655 stars 94 forks
KnowBERT, released by Allen Institute for AI (AI2)	352 stars 53 forks
HittER, released by Microsoft Research	62 stars 12 forks

Representative Organizations "forking" ERNIE



The Open-source Impact of One of This Achievements, ERNIE

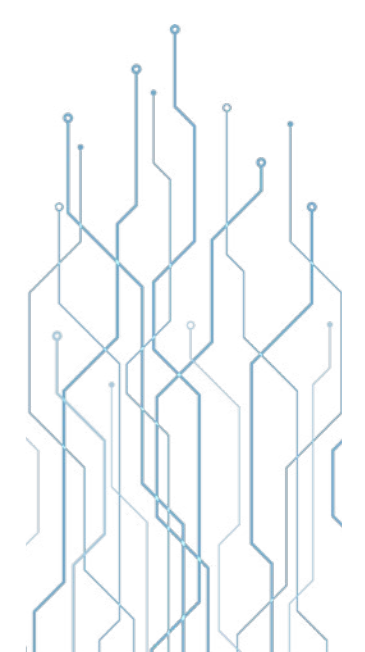
具有国际认可度的语言与知识融通系列学术论文

A series of internationally recognized academic papers on the fusion of language and knowledge

本成果 5 篇代表性论文得到了国际学术界较为广泛的关注，Google Scholar 引用共 2697 次（最高单篇引用 1250 次）。如：本成果的代表性论文之一在国际顶会 ACL 2019 发表的 660 余篇论文中学术影响力名列前茅；美国三院院士 Li Fei-Fei 在其重要论文中指出本成果取得了当时语义评测的最好性能；著名 Word2Vec 模型的提出者 Tomas Mikolov 也在其重要论文中提及本成果；美国国家医学院院士、MIT 教授 Peter Szolovits 团队将本成果之一——ERNIE 作为其相关研究的基础架构，并与医学知识库全面对接，发展出 c-ERNIE 医学模型和医学领域智能问答系统 M-cERNIE。引用者还包括美国文学与科学院院士、斯坦福大学教授 Dan Jurafsky, ACL2020 主席、慕尼黑大学讲席教授 Hinrich Schütze, ACM/AAAI 会士、斯坦福 SAIL 实验室主任 Christopher Manning, ACL 会士、日本著名 NLP 学者 Yuji Matsumoto 等。

The five representative papers of this achievement have garnered considerable attention from the international academic community, with a total of 2,697 citations on Google

Scholar, the highest single paper being cited 1,250 times. For example, one of the representative papers from this achievements stood out prominently in terms of academic influence among over 660 papers published in the top conference ACL 2019. Li Fei-Fei, a fellow of the American academies, pointed out in her significant paper that our achievement had the best performance in semantic evaluation at the time. Tomas Mikolov, the proponent of the renowned Word2Vec model, also mentioned our achievement in his seminal work. The team of Peter Szolovits, Fellow of the National Academy of Medicine and a professor at Massachusetts Institute of Technology (MIT), adopted one of our achievements, ERNIE, as the foundational framework for their research. They fully integrated it with medical knowledge bases, resulting in the development of the c-ERNIE medical model and the medical domain intelligent question-answering system M-cERNIE. Other notable citers include Dan Jurafsky, a fellow of the American Academy of Arts and Sciences and a professor at Stanford University; Hinrich Schütze, the chair of ACL2020 and a chaired professor at the University of Munich; Christopher Manning, an ACM/AAAI fellow and director of the Stanford Artificial Intelligence Laboratory (SAIL); and Yuji Matsumoto, an ACL fellow and a renowned NLP scholar in Japan.





Peter Szolovits

美国国家医学院院士

AAAI会士

美国医学信息学院“莫里斯-科伦卓越奖”获得者



麻省理工大学与IBM联合推出的BioNLP2020论文中高度肯定了ERNIE的学术思想，并以ERNIE作为他们研究的基础架构，与医学知识库全面对接，发展出医学c-ERNIE和M-cERNIE，取得超越BERT的实验结果。该论文用整整一章详细阐释ERNIE，17次提及ERNIE，加上cERNIE、M-cERNIE共提及43次。

Abstract

serve as a rationale for the answer. Further, we also incorporate medical entity information in these models via the ERNIE (Zhang et al., 2019a) architecture. We train our models on

We incorporate medical entity information by including entity embeddings via the ERNIE (Zhang et al., 2019a) architecture (Zhang et al., 2019a) and observe that the model accuracy and ability to generalize goes up by ~.3% over BERT_{base} (Devlin et al., 2019).

3.2 Enhanced Language Representation with Informative Entities (ERNIE)

We adopt the ERNIE framework (Zhang et al., 2019a) to integrate the entity-level clinical concept information into the BERT architecture, which has not yet been explored in the previous works.

ERNIE has shown significant improvement in different entity typing and relation classification tasks, as it utilizes the extra entity information which is provided from knowledge graphs. ERNIE uses BERT for extracting contextualized token embeddings and a multi-head attention model to generate entity embeddings. These two set of embeddings are aligned and provided as an input to an information fusion layer which provides entity-enriched token embeddings. For a token (w_j) and its aligned entity (e_k = f(w_j)), the information fusion process is as follows:

h_j = sigma(W_t^{(j)} w_j^{(j)} + W_e^{(j)} e_k^{(j)} + b^{(j)}) (1)

Here h_j represents the entity enriched token embedding, sigma is the non-linear activation function, W_t refers to an affine layer for token embeddings and W_e refers to an affine layer for entity embeddings. For the tokens without corresponding entities, the information fusion process becomes:

h_j = sigma(W_t^{(j)} w_j^{(j)} + b^{(j)}) (2)

Initially, each entity embedding is assigned randomly and is fine-tuned along with token embeddings throughout the training procedure. The

ERNIE architecture would be applicable to the model even if the logical forms are not available.

context. We fine-tuned these entity embeddings along with the token embeddings, as opposed to using learned entities and not fine-tuning during downstream tasks (Zhang et al., 2019a). The architecture is illustrated in Fig 2.

Table with 4 columns: Dataset, Model, F1-score, Exact Match. Rows include BERT, cBERT, ERNIE, and M-cERNIE.

icalBERT (cBERT) (Alsentzer et al., 2019). We use cBERT as the multi-head attention model for getting the token representations in ERNIE. We refer to this version of ERNIE, with entities from Met.aMap, as cERNIE for clinical ERNIE. Our final multi-task learning model, incorporated with an auxiliary task of predicting logical forms, is referred to as M-cERNIE for multi-task clinical ERNIE. The code for all the models is provided at

cERNIE的开源项目仓库中专门对如何使用ERNIE进行了说明

Code snippets for ERNIE architecture and training instructions.

● 本成果典型引用



Peter Szolovits

Fellow of the National Academy of Medicine,

AAAI Fellow,

The American Medical Informatics Association's

"Morris F. Collen Award of Excellence"



In the BioNLP2020 paper jointly released by MIT and IBM, they highly praised ERNIE. They adopted ERNIE as the foundational framework for their research, fully integrated it with medical knowledge bases, resulting in the development of the medical c-ERNIE and M-cERNIE, achieving experimental results surpassing BERT. The paper dedicated an entire chapter to detailing ERNIE, mentioning it 17 times, and with the inclusion of cERNIE and M-cERNIE, ERNIE was referenced a total of 43 times.

Abstract

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The open-source repository for cERNIE provides specific instructions on how to use ERNIE.

Code snippets for ERNIE architecture and training instructions.

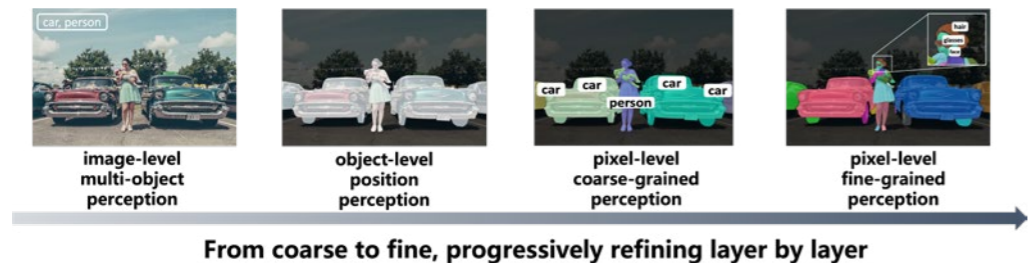
● A Typical Citation of This Achievement

视觉媒体的层次化内容感知

Hierarchical Content Perception of Visual Media



◎ 图像级、物体级到像素级的递进层次化视觉内容感知理论和解决方案



◎ Theoretical and Practical Approaches to Progressive Hierarchical Visual Content Perception: From Image-Level to Object-Level to Pixel-Level

北京交通大学
Beijing Jiaotong University



南开大学
Nankai University



引言

如何模拟大脑的认知机制，实现高效且层次化的视觉内容感知一直是计算机视觉领域的重大挑战。项目研究了如何赋予计算机层次化感知的能力，系列研究成果被引超 6000 多次，并在相关领域的后续发展中扮演了重要的引领角色。

Introduction

Simulating the cognitive mechanisms of the brain to achieve efficient and hierarchical perception of visual content remains a formidable challenge in the field of computer vision. This project explores how to endow computers with the capability for hierarchical perception. The series of research outputs have amassed over 6,000 citations, playing a crucial guiding role in the subsequent evolution of related domains.

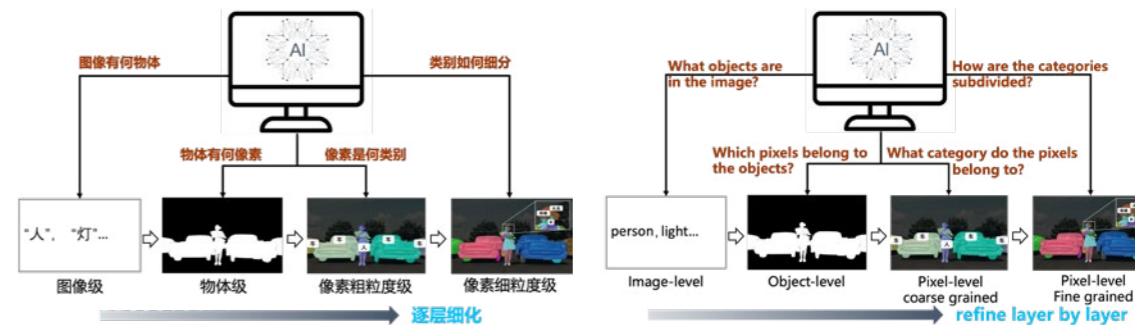
本项目形成了由粗到细的递进视觉感知理论和解决方案

The project has developed a progressive theory and solutions for visual perception, ranging from coarse to fine-grained levels

北京交通大学数字媒体信息处理团队和南开大学媒体计算实验室围绕视觉媒体的层次化内容感知项目，以视觉媒体为主要研究对象，系统深入地研究了视觉内容层次化感知的相关理论和方法，形成了从图像级、物体级到像素级粗粒度及细粒度的递进感知理论和解决方案，回答了“图像有何物体，物体有何像素，像素是何类别，类别如何细分”的系列问题。所涉及的研究内容包括图像级多物体感知、物体级位置感知、像素级粗粒度感知、像素级细粒度感知等。8 篇代表性论文成果均发表在国际顶级期刊 / 会议上，Google 引用超 6000 多次，部分论文为各自研究方向的早期开拓性研究成果，并对相关方向的后续发展具有重要引领作用。成果得到了图灵奖获得者及 100 多位国际电气与电子工程师协会会士 (IEEE Fellow) 的关注，部分技术作为标配功能运行于上亿部华为旗舰手机上。

The Digital Media Information Processing Team at Beijing Jiaotong University, in partnership with the Media Computing Laboratory at Nankai University, centered their research on hierarchical content perception in visual media. The initiative delves systematically into the theories and methodologies related to hierarchical perception of visual content, establishing a progressive framework that spans from image-level and object-level to pixel-level perception, both in coarse and fine-grained resolutions. This research addresses a series of questions such as "What objects are in the image? What pixels constitute the

object? What categories do these pixels belong to? How can these categories be further subdivided?" The scope of the research encompasses image-level multi-object perception, object-level spatial perception, pixel-level coarse-grained perception, and pixel-level fine-grained perception. Eight seminal papers have been published in international journals and conferences, amassing over 6,000 citations on Google Scholar. Some of these papers represent pioneering contributions in their respective research directions and have significantly influenced subsequent developments in related fields. The work has garnered attention from Turing Award winners and over 100 IEEE Fellows. Additionally, some of the technologies have been integrated as standard The capabilities in hundreds of millions of Huawei smartphones.



◎ 课题组研究成果系统地回答了“图像有何物体，物体有何像素，像素是何类别，类别如何细分”这一系列计算机视觉研究的基础问题

◎ The research outcomes from the project systematically address fundamental questions in computer vision research, such as "What objects are present in the image? What pixels make up these objects? To which categories do these pixels belong? How can these categories be further subdivided?"

本研究揭示了不同层次化视觉内容理解任务的内在关联，促进了视觉感知研究的发展

The research clarifies the intrinsic connections among various hierarchical tasks in visual content comprehension, thereby fostering the advancement of studies in visual perception

首先，在图像级感知层面，项目研究成果揭示了图像全局与局部感知之间的内在关联，并构建了一个名为“图像分解 - 局部感知 - 全局融合”的内容理解框架。将多类别感知任务转化为多个单类别感知任务，成功突破了多类别感知任务中训练样本匮乏的瓶颈；

其次，在物体级感知层面，发现了不同层次特征对图像中物体像素位置检测的影响机理，构建了多尺度短连接的特征融合框架，挖掘了不同层次特征的互补信息，形成了结构完整、细节饱满的物体位置感知图；

进一步地，在像素级粗粒度感知层面，揭示了图像级语义信息同物体位置的内在关联，提出了“识别 - 擦除相对抗”的计算模式，构建了将类别语义从图像级迁移到像素级的推理框架，形成了一系列非完美标注下粗粒度语义分割理论；

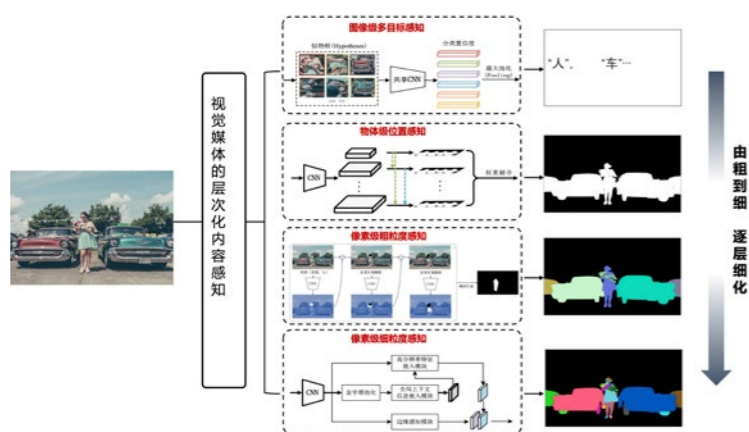
最后，更进一步地，在像素级细粒度感知层面，揭示了图像上下文信息、高分辨率特征及边缘细节信息对细粒度像素类别感知的影响机理，构建了融合互补感知信息的

像素类别细分框架，解决了相邻像素细粒度语义类别易混淆的新挑战。

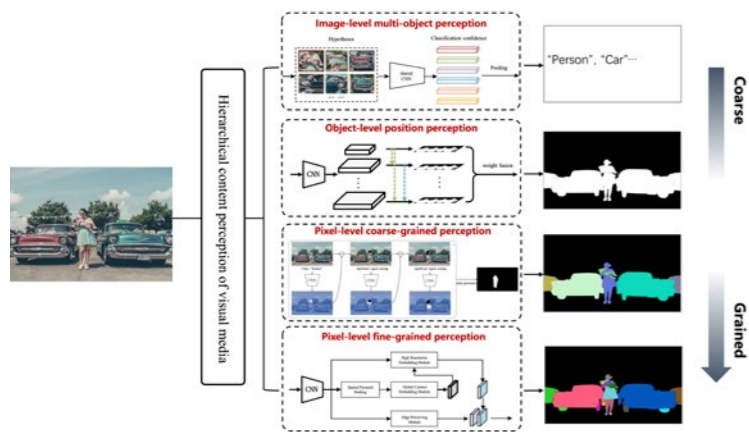
Firstly, at the level of image-based perceptual understanding, the research outcomes elucidate the intrinsic correlation between global and local image perception. A conceptual framework, termed "Image Decomposition-Local Perception-Global Fusion", was introduced. This framework transforms multi-class perception tasks into multiple single-class perception tasks, thereby successfully overcoming the bottleneck of insufficient training samples in multi-class perception endeavors.

Secondly, at the object-level perception layer, the study uncovers the mechanisms by which hierarchical features influence the detection of object pixel locations within images. A multi-scale feature fusion architecture with short connections was developed, mining the complementary information from different hierarchical features to form a structurally coherent and detail-rich object localization map.

Moreover, at the pixel-level coarse-grained perception layer, the research reveals the intrinsic relationship between image-level semantic information and object localization. A computational paradigm, dubbed "Recognition-Erase Adversarial," has been proposed.



针对层次化感知的几个关键问题，课题组着重研究了图像级多物体感知、物体级位置感知、像素级粗粒度感知和像素级细粒度感知，有效促进了视觉感知研究技术的发展



Addressing several pivotal issues in hierarchical perception, the research team has intensively investigated image-level multi-object perception, object-level spatial awareness, pixel-level coarse-grained perception, and pixel-level fine-grained perception, thereby substantially advancing the state-of-the-art in visual perception research methodologies

This paradigm constructs an inferential framework for transferring class semantics from the image level to the pixel level, leading to a suite of theories on coarse-grained semantic segmentation, even with imperfect annotations.

Furthermore, delving even further into pixel-level fine-grained perception, the study unveils the impact mechanisms of image contextual information, high-resolution features, and edge detail on fine-grained pixel class perception. A framework for the fusion of complementary perceptual information at the pixel class granularity has been established, resolving the novel challenge of semantic class confusion among adjacent pixels at a fine-grained level.

Lastly, at the pixel-level fine-grained perception layer, the research uncovers the mechanisms by which image context, high-resolution features, and edge details influence fine-grained pixel category perception. A framework is developed that integrates complementary perception information for pixel category refinement, addressing the new challenge of easily confused adjacent pixel fine-grained semantic categories.

研究成果获 6000+ 谷歌引用，包括图灵奖获得者及 100 多位国际电气与电子工程师协会会员 (IEEE Fellow)

The work has garnered over 6,000 citations on Google Scholar and has been recognized by Turing Award winners and over 100 IEEE Fellows

项目成果所对应的 8 篇代表性论文得到了 CMU 等美国顶尖高校及谷歌、腾讯等一流研究机构的广泛关注，并得到了图灵奖获得者 Yoshua Bengio 和 100 多位 IEEE Fellows 的引用，论文 Google 总引 6054 次。计算机视觉最高奖 Marr 奖得主、瑞士苏黎世联邦理工学院 Luc Van Gool 教授及其合作者在其 IEEE CVPR 会议工作中将本项目成果用于解决弱监督语义分割任务，并取得了当年 CVPR LID 竞赛的冠军；IEEE Fellow Bernt

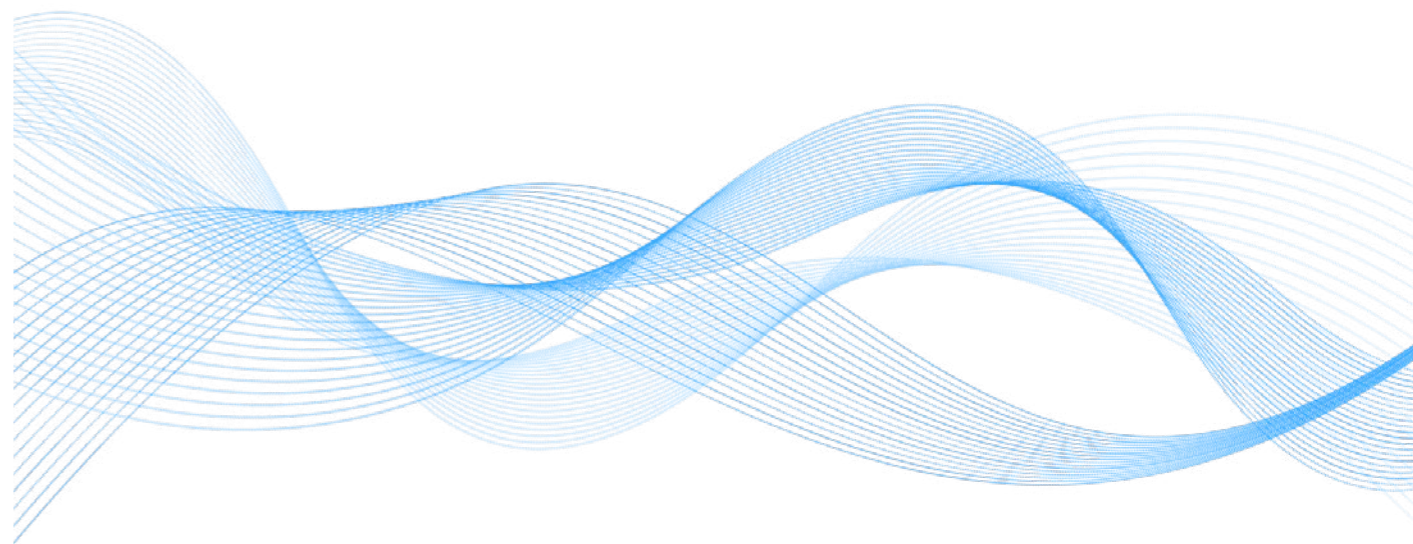
Schiele 教授及其合作者在其 IEEE CVPR 会议著名的 Cityscapes 文章中评价本项目的成果“探索了不同形式弱标注下的语义分割研究”；本项目在图像级类别感知方面的成果在国际知名 PASCAL 数据集上首次将性能提升到 90%+；在像素细粒度感知方面的成果斩获 2018 IEEE CVPR LIP 竞赛所有人体精化解析赛道的冠军。

The project's achievements, encapsulated in eight seminal papers, have garnered widespread attention from premier American institutions such as Carnegie Mellon University, as well as leading research organizations like Google and Tencent. These works have been cited by Turing Award laureate Yoshua Bengio and over one hundred IEEE Fellows, accumulating a total of 6,054 Google Scholar citations. Luc Van Gool, a Marr Prize recipient and professor at ETH Zurich, along with his collaborators, employed the project's findings to address weakly-supervised semantic segmentation tasks in their work presented at the IEEE CVPR conference, subsequently clinching the championship



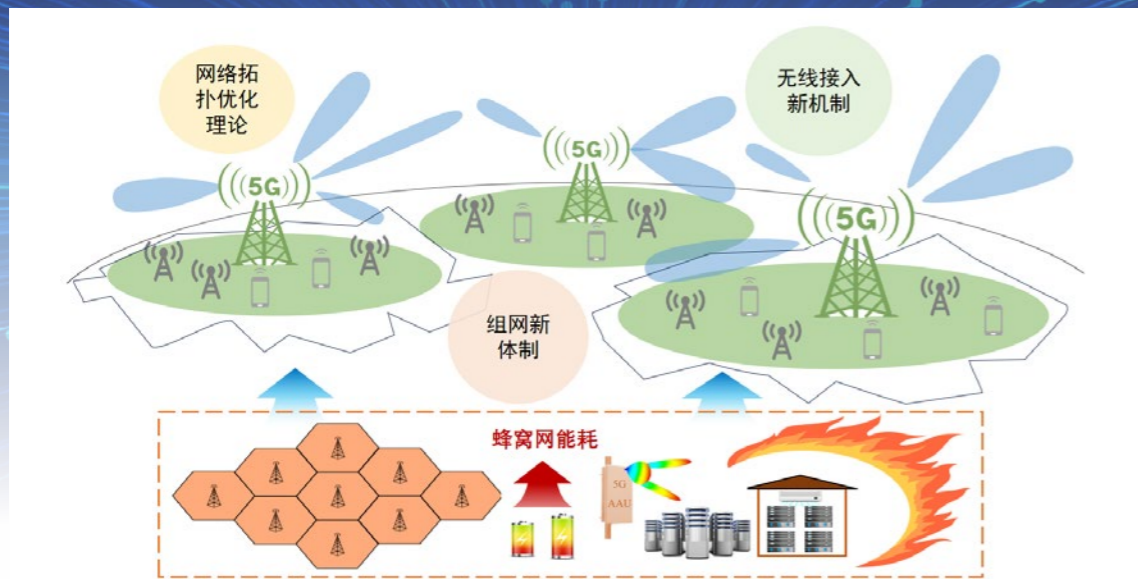
本项目相关技术在 2018 IEEE CVPR LIP 国际竞赛中斩获所有人体部件解析赛道（共 3 个）的冠军，极大引领了后续的单人图像、多人图像人体部件解析及多人视频人体部件解析等研究
The technologies developed within this project triumphed in all human body part parsing tracks (a total of three) at the 2018 IEEE CVPR LIP international competition, thereby significantly pioneering subsequent research in single-person image, multi-person image, and multi-person video human body part parsing

in that year's CVPR LID competition. IEEE Fellow Bernt Schiele and his co-authors, in their renowned Cityscapes paper at the IEEE CVPR conference, lauded the project for "exploring semantic segmentation research under various forms of weak annotation." The project's contributions to image-level class perception have for the first time elevated performance metrics to above 90% on the internationally acclaimed PASCAL dataset. Moreover, its advancements in pixel-level fine-grained perception secured the championship in all fine-grained human parsing tracks at the 2018 IEEE CVPR LIP competition.



5G 移动通信系统高效机理研究

Research on High-Efficiency Mechanisms in 5G Mobile Communication System



● 5G 移动通信系统高效机理研究
● Research on High-efficiency Mechanisms in 5G Mobile Communication System

华中科技大学
Huazhong University of Science and Technology

新加坡科技设计大学
Singapore University of Technology and Design



引言

针对目前的 5G 能效难题，项目组面向 5G 超密集蜂窝组网架构、基站拓扑理论以及高效低延时接入等极具挑战课题，解决了 5G 网络能效解耦优化难题，提出了 5G 移动通信系统高效理论体系。

Introduction

In response to the current challenges in 5G energy efficiency, the project team tackled highly challenging issues related to 5G ultra-dense cellular network architecture, base station topology theory, and high-efficiency low-latency access. The team successfully addressed the optimization challenges of decoupling energy efficiency in 5G networks and proposed a theoretical framework for high-efficiency 5G mobile communication systems.

5G 高效网络架构

High-efficiency Mechanisms in 5G Mobile Communication System

成果首次揭示了 5G 超密集蜂窝组网新体制下的能效与吞吐量饱和效应，并提出了创新的分布式超密集组网架构解决方案，使 5G 基站超密集组网时的能效提高了 2 个数量级；同时，通过引入马尔科夫链模型和泛效用函数，成功攻克了多维非线性解耦问题，实现了移动通信网络能效从局部信道优化到全局时空维度的协调优化；该成果获得了 2022 年英国工程技术学会

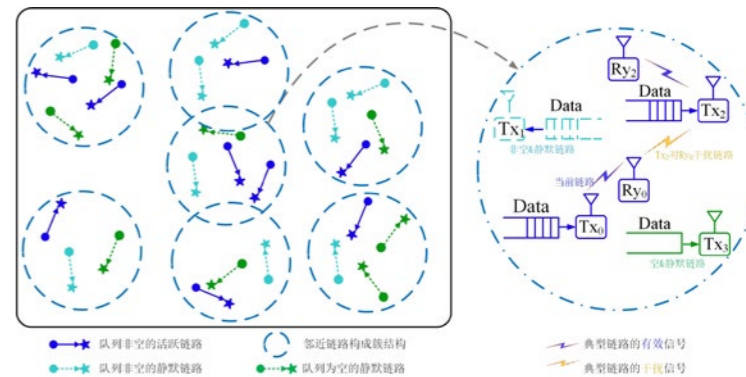
(IET) 全球工程与技术创新成果奖。

For the first time, the achievement unveiled the interplay between energy efficiency and throughput saturation within 5G's new ultra-dense cellular network architecture of 5G. It introduced an innovative distributed ultra-dense network architecture solution, resulting in a two-order-of-magnitude improvement in energy efficiency when deploying 5G base stations in an ultra-dense network. Additionally, by incorporating Markov chain models and functional utility functions, the project successfully addressed the multi-dimensional nonlinear decoupling problem, enabling the coordinated optimization of energy efficiency in mobile communication networks from local channel optimization to a global spatiotemporal dimension. This accomplishment was honored with the 2022 IET (Institution of Engineering and Technology) Global Engineering and Technology Innovation Achievement Award.

以泛函理论统一网络随机拓扑性和业务流马尔科夫链特性构建网络全局能效优化机理

Utilizing functional theory to unify the random topological characteristics of networks and the Markov chain properties of traffic flows for the construction of a global network efficiency optimization mechanism

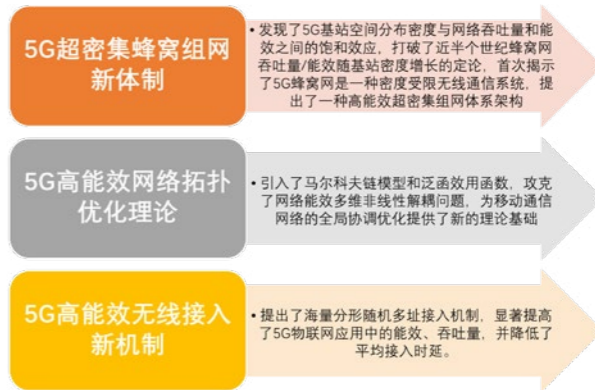
首先，成果发现了 5G 基站空间分布密度与网络吞吐量和能效之间的饱和效应，打破了近半个世纪蜂窝网吞吐量/能效随基站密度增长的定论，首次揭示了 5G 蜂窝网是一种密度受限无线通信系统，系统阐明了网络体系架构对能效和吞吐量的作用机制，提出了分布式超密集组网体系架构，获得了国际电信行业组织的推荐，对 5G 网络部署和性能优化产生重要影响；其次引入了马尔科夫链模型和泛效用函数，攻克了网络能效多维非线性解耦问题，为移动通信网络的全局协调优化提供了新的理论基础。这一理论体系不仅对学术界有重要贡献，还应用于实际产品，推动了移动通信产业



● 宏观随机拓扑分布尺度和微观业务动态服务尺度时空网络示意图
● Spatiotemporal Network Schematic Illustrating Macroscopic Random Topology Distribution Scale and Microscopic Dynamic Business Service Scale

的发展，创造了数十亿元的销售收入和利润；最后提出了海量分形多址接入机制，显著提高了 5G 物联网应用中的能效、吞吐量，并降低了平均接入时延。该创新为 5G 物联网在智慧城市等领域的应用提供了重要的理论依据。

Firstly, the achievement uncovered the saturation effects between the spatial density of 5G base stations and network throughput and energy efficiency. It shattered the long-held belief that cellular network throughput/efficiency increases with base station density, which had been established for nearly half a century. For the first time, it revealed that 5G cellular networks operate as density-constrained wireless communication systems. The system elucidated the architectural mechanisms affecting energy efficiency and throughput, introducing a distributed ultra-dense network architecture that received recommendations from international telecommunications industry organizations. This has had a significant impact on 5G network deployment and performance optimization. Secondly, the introduction of Markov chain models and functional utility functions successfully tackled the multi-dimensional nonlinear decoupling problem in network energy efficiency. It provided a new theoretical foundation for the global coordinated optimization of mobile communication networks. This theoretical framework has not only made important contributions to the academic community but has also been applied in practical products, driving the growth of the mobile communication industry, and generating billions in sales revenue and profits. Lastly, the proposal of the massive fractal multiple access mechanism significantly improved energy efficiency, throughput, and reduced average access latency in 5G Internet of Things applications. This innovation provided a crucial theoretical basis for the application of 5G IoT in smart cities and other fields.



● 成果的科学价值 ● The Scientific Value of the Achievement

理论成果获评国际通信领域权威机构最佳论文和 2022 年 IET 全球工程与技术创新成果奖

The theoretical achievement has been awarded the Best Paper by a prestigious international communication authority and the 2022 E&T Innovation Award presented by IET

研究成果的代表性论文在国际通信和网络领域权威期刊中发表，其中一篇论文被评选为 IEEE 通信学会月度最佳论文，另一篇获得回传 / 前传网络领域最佳论文奖。这些论文在谷歌学术引用中积累了高达数千次的引用次数，进一步印证了其在学术界的重要地位。国际电信行业组织（5G Americas）推荐该研究成果为新一代蜂窝网解决方案，表明其在 5G 通信领域的前瞻性和实际应用潜力。此外，研究团队提交了全球首个面向 5G 智慧城市的联邦学习参考架构国际电信联盟标准提案，该提案已获得国际电信联盟 (ITU) SG20 全会的批准立项。这一标准提案进一步证明了该研究成果在国际学术界的积极影响和前瞻性，为未来通信系统的发展提供了有力支持，并将对全球通信技术和智慧城市建设产生深远影响。

The representative papers of the research achievement have been published in prestigious journals in the field of international communications and networking. One of these papers was selected as the IEEE Communications Society's Monthly Best Paper, while another received the Best Paper Award in the field of backhaul/front-haul networks.

These papers have accumulated thousands of citations in Google Scholar, further affirming their significant standing within the academic community. The International Telecommunication Industry Association (5G Americas) has recommended this research achievement as a next-generation cellular network solution, highlighting its forward-looking nature and practical application potential in the field of 5G communications. Additionally, the research team submitted the world's first federated learning reference architecture proposal for 5G smart cities to the International Telecommunication Union (ITU) standardization process. This proposal has received approval and initiation at the ITU SG20 plenary meeting. This standardization proposal further demonstrates the positive impact and forward-looking nature of this research achievement within the international academic community, providing strong support for the development of future communication systems and having profound implications for global communication technology and smart city construction.



● 论文获奖证书
● Award Certificate



● 国际电信联盟标准提案
● ITU Standard Proposal



● 获得 IET 全球工程与技术创新成果奖
● Received the E&T Innovation Award presented by IET

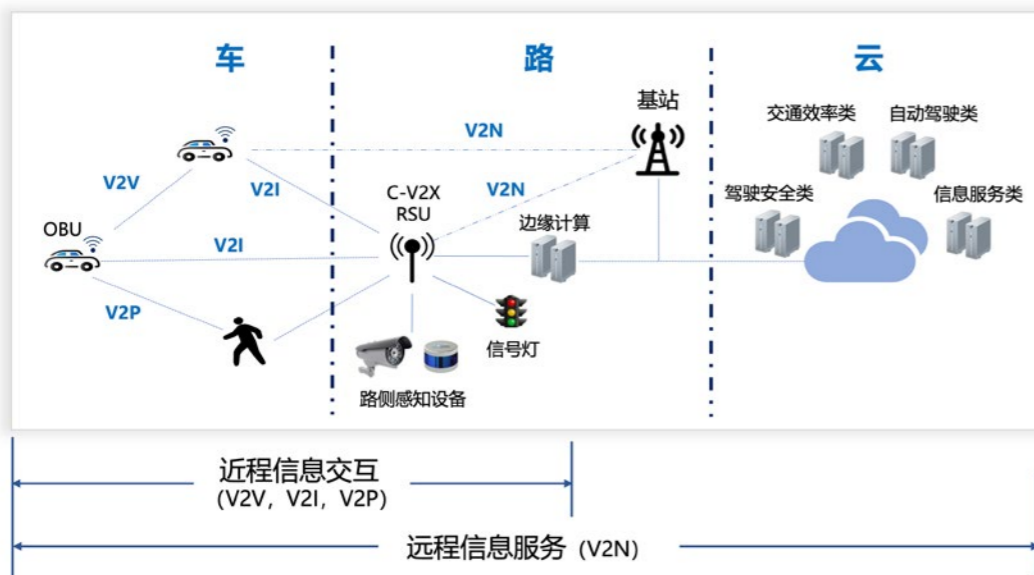
世界互联网大会 领先科技奖获奖成果

Leading Achievements of World Internet Conference
Awards for Pioneering Science and Technology

关键技术组 Key Technology

C-V2X 车联网通信关键技术研究与应用

Research and Application of Key Cellular Vehicle-to-Everything (C-V2X) Technologies



● C-V2X 车联网及车路云协同应用
● C-V2X and Vehicle-Infrastructure-Cloud Cooperative Applications

中国信息通信科技集团有限公司 (简称: 中国信科)
China Information and Communication Technology Group Co., Ltd. (CICT)



移动通信及车联网国家工程研究中心
National Engineering Research Center of Mobile Communications and Vehicular Networks



中信科智联科技有限公司
CICT Connected and Intelligent Technologies Co., Ltd.



宸芯科技股份有限公司
Morningcore Holding Co., Ltd.



大唐联仪科技有限公司
DT LinkTester Technology Co., Ltd.



引言

中国信科 / 大唐陈山枝团队于 2013 年最早提出 LTE-V2X 车联网技术, 创新提出蜂窝与直通融合的车联网系统架构, 开创了蜂窝车联网 (C-V2X) 技术路线, 率先研发出 C-V2X 芯片、模组、终端设备、测试仪表等产品并落地应用, 推动形成产业生态。

Introduction

The team of Dr. Shanzhi CHEN from CICT/Datang proposed LTE-V2X technology in 2013 for the first time in the world. The first V2X

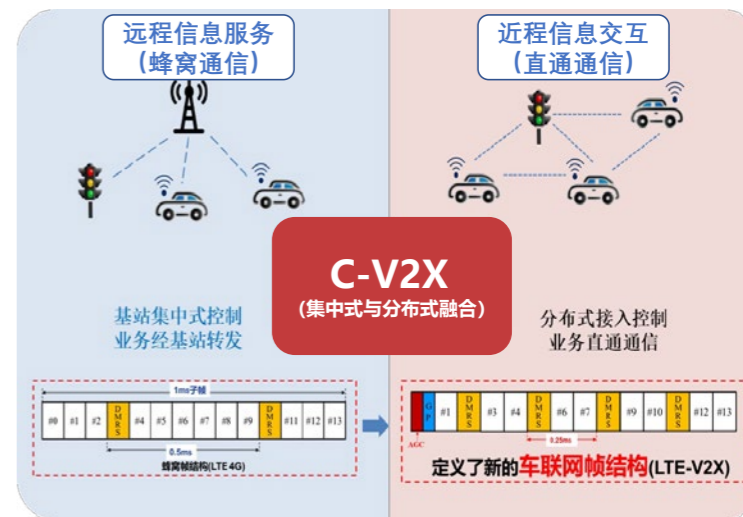
communication technology integrating cellular communication and direct communication was innovatively introduced, which establishes the technical routes of C-V2X (Cellular-V2X). The team has developed the world's first commercial C-V2X chipset, automotive-grade C-V2X module, OBU (On-Board Unit), RSU (Roadside Unit), and test instruments. These devices have been widely deployed and applied in industrial practice. All these efforts have promoted to form the relatively complete C-V2X industrial ecosystem.

突破多项 C-V2X 车联网通信关键技术, 实现低时延高可靠及大范围大带宽通信, C-V2X 成为主流国际标准

Breakthroughs of the key C-V2X technologies have been achieved by the project team to realize low-latency and high-reliability, large-range and high-bandwidth communications. C-V2X standards have become the mainstream international V2X communication standards

针对车联网通信高频度群发群收、通信对象随机突发、无线传播环境复杂快时变等难题, 提出高速移动下分布式无线信道接入控制方法、复杂车载环境下干扰控制及频偏处理方法、蜂窝车联网系统架构与协同控制方法等创新性技术, 使 C-V2X 车联网通信既可实现低时延、高可靠近程信息交互, 又可实现大范围、大带宽远程信息服务。

V2X communication faces the technical challenges such as high-frequency multiple transmissions and receptions, random and burst communication peers, and complex and fast time-varying wireless propagation environments. The innovative technical mechanisms were proposed, including the distributed wireless channel access control mechanism, the interference control and frequency shift processing mechanism, and C-V2X system architecture and cooperative control mechanism. Both the short-range information exchange among vehicle-to-vehicle, vehicle-to-infrastructure and vehicle-to-pedestrian, and the remote information services between vehicle-to-cloud can be achieved.



● 蜂窝与直通融合的系统架构及接入控制方法
● C-V2X System Architecture and Access Control Mechanism

2015 年开始, 项目团队联合友商在 3GPP 制定 C-V2X 国际标准, 担任项目联合报告人, 完成 29 项标准制定。

Since 2015, the team of Dr. Shanzhi CHEN from CICT/Datang, worked as the rapporteur, has been collaborating with relevant companies to complete the development of 29 standards in 3GPP.

NGMN 和 5GAA 等国际权威组织通过性能仿真和实际道路测试表明, C-V2X 在时延、可靠性、传输距离等性能指标方面优于 DSRC (IEEE 802.11p) 同类技术。目前, C-V2X 已得到中国、美国等国家采用, 成为主流国际标准。

International organizations such as NGMN and 5GAA have conducted performance evaluation using simulation and real road testing. The results show that C-V2X outperforms DSRC (IEEE 802.11p) in latency, reliability, and transmission distance. Currently, C-V2X has been adopted in many countries such as China and U.S., and has become the mainstream international standards.



● C-V2X 成为全球车联网主流国际标准
● C-V2X Has Become the Mainstream International Standards

项目单位研制首台套 C-V2X 芯片和设备,在车端、路侧得到规模应用,实现车路云协同,推动 C-V2X 产业生态形成

CICT/Datang has developed the world's first commercial C-V2X chipset and devices with large-scale applications in vehicles and roadside infrastructures to realize Vehicle-Infrastructure-Cloud Cooperation and promote the C-V2X ecosystem

依托科技成果,项目单位在业内率先研制出 C-V2X 芯片、车规级模组、终端设备 (OBU)、路侧设备 (RSU)、测试仪表等关键产品。

Based on the research results, CICT/Datang has developed the core C-V2X devices and released the world's first C-V2X chipset, automotive-grade C-V2X module, On-Board Unit (OBU), Roadside Unit (RSU), and first domestic testing instrument.

研制首台套C-V2X芯片和设备,推动产业应用



● 中国信科 C-V2X 系列产品
● Series of C-V2X Devices of CICT/Datang

项目单位与产业界合作, 支撑 C-V2X 大型互联互通测试及安全验证测试, 在国家级车联网先导区、智能网联汽车测试示范区及“双智”试点城市广泛部署, 在智慧高速、智能交通、智慧园区等场景落地应用, 取得了规模经济效益。

Collaborating with C-V2X industry, CICT/Datang supports large-scale C-V2X interoperability testing and security verification activities. The C-V2X devices of CICT/Datang have been widely deployed in National Pilot Areas, National Intelligent and Connected Vehicles (ICV) Demonstration Areas, and Pilot Cities of ICV and Smart Cities in China. And they have been applied in the typical scenarios such as smart expressways, intelligent transpor-

tations, and smart parks. The significant economic benefits have been achieved through the above deployments and applications.



● 中国信科 C-V2X 产业应用
● The C-V2X Industrial Applications of CICT/Datang

项目科技成果获得中美日韩等授权发明专利 548 件, 436 件被 ETSI (欧洲电信标准化协会) 披露为国际标准必要专利。

CICT/Datang has achieved 548 C-V2X related patents granted respectively by China, the U.S., European countries, Japan, and the Republic of Korea, and 436 of them were declared as standard essential patents by ETSI (European Telecommunications Standards Institute).

中国信科积极推动形成较为完整的 C-V2X 产业生态。C-V2X 技术在福特、奥迪、上汽、蔚来等全球车企实现前装量产。

CICT/Datang plays an active role in promoting to form a relatively complete ecosystem of industrial chain. The factory-installed C-V2X devices for mass production have been available among global OEMs (Original Equipment Manufacturers) such as Ford, Audi, SAIC, NIO, etc.

截至目前, 已经有十几家主流车企发布了C-V2X前装量产车型
跨国车企在中国计划C-V2X阶梯量产: 2025年50%, 2027年标配



● C-V2X 前装量产车型
● Mass-produced Vehicle Models with Factory-installed C-V2X Devices

依托 C-V2X 技术, 跨界合作形成并推进车路云融合发展方案, 赋能汽车与交通产业转型升级

Relying on C-V2X technology, cross-industry collaboration forms and promotes the vehicle-infrastructure-cloud cooperative system, empowering the transformation and upgrading of the automotive and transportation industries

在汽车电动化、智能化、网联化转型以及道路数字化、信息化转型过程中, C-V2X 车联网发挥低时延、高可靠等通信性能优势, 有效赋能智能网联汽车和智慧交通产业变革, 历史性跨界融合了汽车、交通、通信等行业。

Due to the performance advantages in low latency and high reliability, C-V2X enables the electrification, intellectualization, and connectivity of vehicles, as well as the digitalization and informatization of transportation infrastructure, thereby effectively empowering ICV and Intelligent Transportation System, and historically integrating automotive, transportation, communication and other industries.

C-V2X 将构建人-车-路-云间基础连接能力, 提升道路安全、改善交通效率、降低能源消耗, 催生新的车联网平台经济发展模式; 同时, C-V2X

与单车智能深度融合, 增强协同感知、决策、控制能力, 促进智能网联汽车、智慧交通、智慧城市发展, 带动未来出行服务变革, 加速新的万亿级市场构建。

C-V2X will provide the basic connectivity capabilities among vehicle-infrastructure-pedestrian-cloud, improve road safety and traffic efficiency, reduce energy consumption, and leverage V2X platform economy. At the same time, the deep integration of C-V2X and the on-board intelligence will enhance the capabilities of cooperative perception, decision-making and control, promote the development of ICV, ITS, and smart cities, drive the transformation of future mobility services, and foster a new trillion-level market.



● C-V2X 车联网赋能车路云协同融合创新
 ● C-V2X Empowering Vehicle-Infrastructure-Cloud Collaboration

目前，中国在京津冀、大湾区、长三角、成渝地区形成了多个车联网产业集群，加速推进车路云一体化发展。美国智能交通协会（ITS America）发布 V2X 部署计划，加速全国范围规模化部署。C-V2X 在全球成为主流车联网通信技术，得到广泛应用。

At present, China has formed a number of V2X industrial clusters in the Beijing-Tianjin-Hebei region, the Greater Bay Area, the Yangtze River Delta, and the Chengdu-Chongqing region, accelerating the development of vehicle-infrastructure-cloud cooperative system. Moreover, the ITS America released a V2X deployment plan to accelerate large-scale nationwide deployment in the U.S. C-V2X has become a mainstream V2X communication technology around the world and has been widely deployed.

项目团队引领 C-V2X 技术创新，发表 C-V2X 经典论文多篇，出版业界首部 C-V2X 中英文专著，在国际产生深远影响

The team of Dr. Shanzhi CHEN from CICT/Datang has led the innovation of C-V2X technology, published several C-V2X classic papers, and published the first C-V2X monograph in Chinese and English, which has far-reaching influence in the world

发表 SCI 检索学术论文 7 篇，其中 3 篇 C-V2X 经典论文成为期刊的 Popular Article (Top 50)，2 篇成为 ESI 高被引论文。

The team of Dr. Shanzhi CHEN from CICT/Datang has published a series of C-V2X related SCI-indexed papers, and the most classic three ones have become popular articles (the 50 most frequently accessed documents) of journals and two of them have been included as ESI highly cited papers.

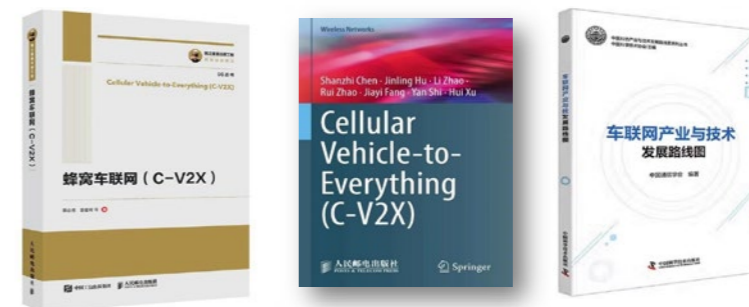
出版国际首部蜂窝车联网 (C-V2X) 专著，系统介绍 C-V2X 技术原理、产业实践。IEEE VTS (Vehicular Technology Society) 对其评价：“这是国际上第一本 C-V2X 学术专著，C-V2X 是最具潜力的车联网无线通信技术”。

The world's first monographs dedicated to C-V2X were published in both Chinese and English, in which the technical principles and industrial practices of C-V2X technology was systematically introduced. The English version of C-V2X monograph was recommended by IEEE VTS (Vehicular Technology Society) as "This is the first book dedicated to C-V2X, which is the most promising wireless communication technology for V2X com-

munications and has become an essential enabling technology for Intelligent Transportation System (ITS) and Automated Driving".

联合产业界、高校和科研机构，连续多年编写车联网白皮书、产业与技术发展路线图，得到产学研用各界广泛认可。

Collaborating with industry, universities and research institutions, the team of Dr. Shanzhi CHEN from CICT/Datang has formulated a series of C-V2X related whitepapers, roadmaps for industrial and technological development, which have been widely recognized by both industry and academia.

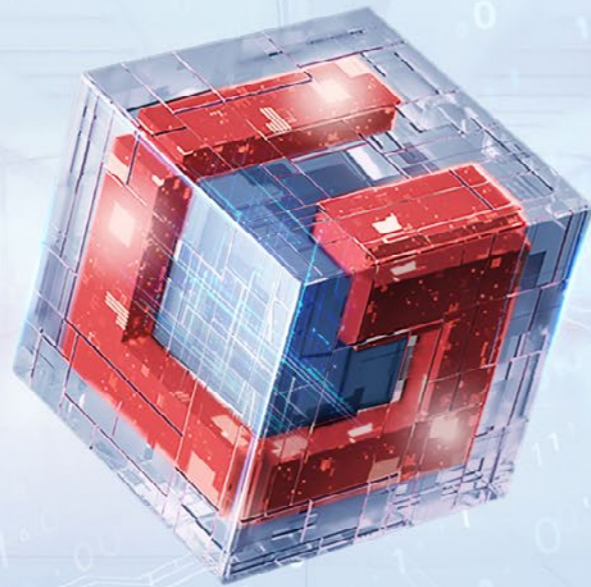


● C-V2X 专著及产业白皮书
 ● C-V2X Monographs and Industrial Whitepapers

GaussDB: 分布式数据库

GaussDB: Distributed Database

高可用、高安全、高性能、高弹性、高智能
Availability, Security, Performance, Scalability, Intelligence



20+年技术积累 | 2000+人才持续投入 | 700+授权专利 | 80+篇数据库顶会论文

◎ 企业级分布式数据库 GaussDB，具备高性能，高可用，高扩展，高智能，高安全技术优势，支撑企业数字化转型，广泛覆盖国家十四个关键基础行业

◎ The enterprise-level distributed database GaussDB features high performance, high availability, high scalability, high intelligence, and high security, supports digital transformation of enterprises, and covers 14 fundamental industries in China

清华大学
Tsinghua University

华为技术有限公司
Huawei Technologies Co., Ltd.

华为云计算技术有限公司
Huawei Cloud Computing Technologies Co., Ltd.



引言

GaussDB 是面向数字基础设施的企业级分布式数据库，作为新一代分布式数据库，GaussDB 通过多维度创新，构筑了高性能、高可用、高弹性、高智能、高安全等关键技术优势，满足金融、政企等行业全场景、智能化的数据库管理需求，支撑千行百业数字化转型，广泛覆盖包含金融、政府、制造等十四个国家关键基础行业。

Introduction

GaussDB is an enterprise-level distributed database oriented to digital infrastructure. As a next-generation distributed database, GaussDB builds key technical advantages such as high performance, high availability, high elasticity, high intelligence, and high security through multi-dimensional innovation. It meets all-scenario and intelligent database management requirements of industries such as finance, government, and enterprise. It supports digital transformation of diverse industries, covering 14 fundamental industries in China, such as finance, government, and manufacturing.

“五高”关键技术竞争力加速数智融合创新，给世界一个更优选择

"Five Highs" Accelerate Data-AI Convergence and Innovation, Providing a Better Choice for You

成果创新点主要集中在如下五大方面：

The main innovations of this project are mainly concentrated in the following five aspects:

一是突破了分布式查询优化和事务处理技术，提出了支持近数据计算的分布式查询优化技术、全链路并行编译执行方法、大规模分布式事务处理机制，大幅度提升了分布式查询性能，达到业界领先水平。

Firstly, breakthroughs in distributed query optimization and transaction processing technologies, and proposal of near data query processing, full-link parallel compilation and execution methods, and large-scale distributed transaction processing mechanisms, greatly improving parallel query performance and reaching the industry-leading level.

二是突破多层级高可用容灾技术，提出故障自感知的副本间高可用、中国首个基于共享存储的同城双集群“RPO=0”容灾、基于并行流式复制的异地多活容灾，满足金融、电信等领域严苛要求。

Secondly, breakthroughs in the multi-level HA (High Availability, HA) DR (Disaster Recovery, DR) technology and proposal of the multi-copy HA that supports automatic detection of faults, China's first intra-city dual-cluster "RPO=0" DR based on shared storage, and remote multi-active DR based on parallel stream replication, meeting strict requirements in finance and telecom fields.

三是突破云原生计算存储分离与弹性伸缩技术，实现资源的精细化、共享化管理，秒级的存储节点扩容和业务无感的计算节点弹性伸缩。

Thirdly, breakthroughs in cloud-native computing-storage separation and elastic scaling technologies to implement refined and shared resource management, second-level storage node scaling, and elastic computing node scaling without affecting services.

四是突破数据库的智能优化技术，提出 ABO 优化器，实现基数估计与计划选择准确倍数提升；提出库内 AI 模型训练与推理，性能提升 10 倍；构建数据库自治运维平台，运维调优效率百倍提升。

Fourthly, breakthroughs in the intelligent optimization technology of databases and proposal of the ABO to improve the accuracy of cardinality estimation and plan selection; proposal of in-database AI model training and inference to improve the performance by 10 times; building of an autonomous database O&M platform to improve the O&M and tuning efficiency by 100 times.

五是突破分布式数据库多方位安全技术，创新性提出全密态数据处理、防篡改数据处理和自治安全管控，构筑了全栈国密算法体系，多方位、全生命周期保护用户数据安全。

Fifthly, breakthroughs in multi-dimensional security technologies of distributed databases, innovative proposal of fully-encrypted data processing, anti-tamper data processing, and autonomous security control, and building of a full-stack Chinese national cryptographic algorithm system to protect user data security in all aspects and throughout the lifecycle.



© 分布式数据库 GaussDB, 给世界一个更优选择



© Distributed database GaussDB, a better choice for you

20 余年数据库领域技术积累，2000+ 数据库专项人才持续投入，研发团队获得授权专利 700+，发表国际顶会论文 80 余篇，主导或参与全球数据库行业标准 10 余项，获得荣誉或奖项 20 余项。

With more than 20 years of technical accumulation in the database field and more than 2,000 talented database developers continuously working in this field, the R&D team has obtained more than 700 authorized patents, published more than 80 papers at international summits, led or participated in more than 10 global database industry standards, and won more than 20 honors or awards.

DISTRIBUTED DATABASE

历经企业自身实践和金融场景严苛考验，GaussDB 稳定运行并持续高速增长，广泛覆盖重点行业领域

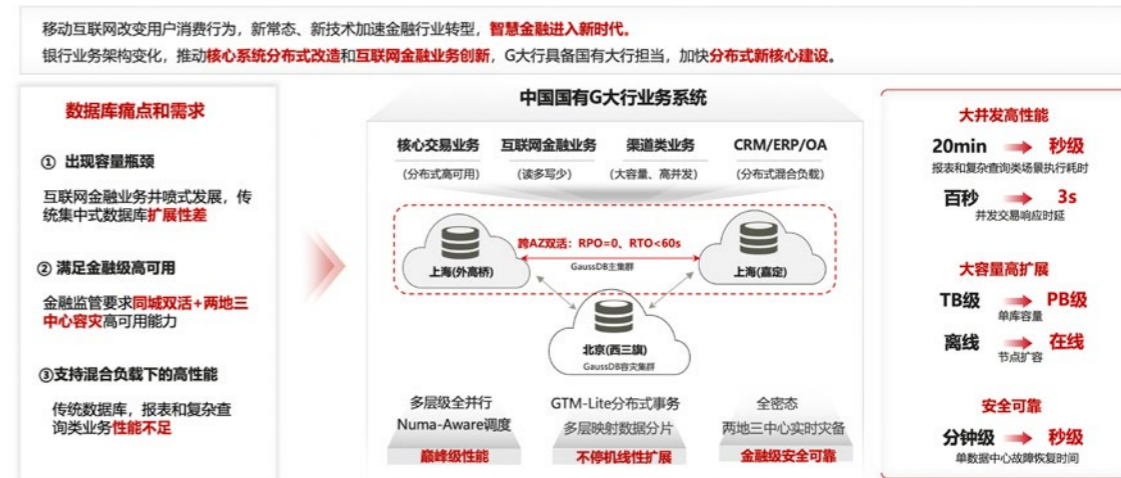
GaussDB Runs Stably and Continues to Grow Rapidly After Rigorous Tests in Enterprise Practices and Finance Scenarios, Covering a Wide Range of Key Industries

凭借高性能、高可用、高弹性、高智能、高安全等技术优势及易部署、易迁移等特点，GaussDB 已广泛覆盖金融、政企等十大关键基础行业，并规模化应用，产生直接或间接经济效益超数百亿元，连续六次获得 IDC 本地部署中国数据库市场份额第一，全球唯一获得云数据库管理系统“客户之选”的云厂商，客户满意和推荐度高达 98%。其中，华为集团已经全面上线 GaussDB，在终端云业务中上线 6000+ 套，数据管理规模超 6PB，服务 4 亿+ 终端用户，在流程 IT 企业 ERP 业务中上线 600 套，经受住企业最复杂业务的挑战，业务处理效率相比旧系统提升 10X 以上，在运营商领域，全球部署 30 万套，覆盖全球 100+ 国家。中国国有 7 家大型银行有 5 家选择 GaussDB 作为主要数据库路线，中国国有 G 大银行依托 GaussDB 卓越的性能以及同城双集群 RPO=0 技术上线全球信贷系统并在全行 70+ 业务中推广应用，覆盖银行 A、B、C、D 各类业务；中国邮政储蓄银行基于 GaussDB 数据库，全新打造了新一代个人业务核心系统，轻松支撑海量交易，拥有弹性伸缩、金融核心级高可用等能力，为全行 6.5 亿个人客户，4 万个网点提供日均 20 亿笔、峰值 6.7 万笔 / 秒的交易处理能力。

With technical advantages such as high performance, high availability, high flexibility, high intelligence, and high security, as well as easy deployment and migration, GaussDB has been widely used in 14 fundamental industries such as finance, government, and enterprise. The large-scale application of GaussDB generates direct or indirect economic benefits amounting to tens of billions of CNY. GaussDB has ranked No.1 in China's IDC local database market share six times in a row, and is the world's only cloud vendor

to be named "Voice of the Customer" Voice of the Customer for Cloud Database Management Systems, with a customer satisfaction and recommendation rate of 98%. Huawei has launched and deployed more than 6,000 instances of GaussDB in device cloud services, managing more than 6 PB data and serving more than 400 million end users. In addition, 600 instances of GaussDB have been deployed in business process & IT enterprise ERP services, overcoming the challenges of the most complex enterprise services. Compared with old systems, the service processing efficiency is improved more than 10-fold. In telecommunications, 300,000 instances of GaussDB are deployed globally, covering more than 100 countries. Five of the seven largest state-owned banks in China have chosen GaussDB as the main database. Based on the excellent performance of GaussDB and the intra-city dual-cluster "RPO=0" technology, China's state-owned Bank G has launched the global credit system and applied it in more than 70 services, covering four service classes: A, B, C, and D. Based on GaussDB, Postal Savings Bank of China (PSBC) has built a next-generation core system for personal banking services to easily support massive transactions. The system provides capabilities such as elastic scaling and financial-grade availability, serving 650 million individual customers and enabling 40,000 branches to process 2 billion transactions per day and 67,000 transactions per second in peak hours.

GaussDB 分布式数据库，加速中国国有 G 大行核心交易系统分布式改造



© GaussDB 分布式数据库，加速中国国有 G 大行核心交易系统分布式改造

GaussDB Distributed Database Accelerates Distributed Reconstruction of Core Transaction Systems of State-owned Bank G

Mobile Internet has changed transaction patterns. New technologies and the new normal have been accelerating financial transformation. Intelligent finance is ushering in a new era. State-owned bank G has been stepping up efforts to establish new distributed core systems and spearhead innovation for Internet-based financial services.

Pain points and requirements

(1) Large capacity
Traditional centralized databases have struggled to scale fast enough to meet the mushrooming demands of Internet finance.

(2) Financial-grade HA
Financial supervision calls for intra-city active-active DR and geo-redundant DR.

(3) HTAP
Traditional databases are too slow to respond to reporting and complex queries.

Systems of state-owned bank G

Superior performance, even for high concurrency
20 minutes → Seconds
Reporting and complex queries

100+ seconds → 3s
Response latency for concurrent transactions

Large capacity and high scalability
TB → PB
Capacity of a single database

Offline → Online
Node expansion

Security and reliability
Minutes → Seconds
Fault recovery time for a single data center

© GaussDB assisting China's state-owned Bank G with distributed transformation of their core transaction systems

GaussDB 数据库支撑中国邮政储蓄银行新一代核心云原生分布式创新实践

6大行之一

4万 线下网点

18亿 账户

6.5亿 用户

20亿笔 日均交易

核心系统分布式改造挑战

挑战1: 解决容量瓶颈
拥有百TB级的海量历史数据、千亿级单表数据量

挑战2: 业务高并发低时延要求
高峰期上百万的用户并发量, 查询请求毫秒级响应

挑战3: 金融最高级可用性要求
极端环境下继续对外提供服务, RTO、RPO要求极高

新一代个人业务核心统一查询系统

业务应用极致体验

季度结息

原核心: 140分钟
新核心: 35分钟

联机交易: 30% ↑
批处理效率: 33% ↑

500T 超大 存储容量
10年 超长 查询范围

© GaussDB 数据库支撑中国邮政储蓄银行新一代核心云原生分布式创新实践

PSBC launches a Distributed, Cloud-Native Core Transaction System with GaussDB

One of the six state-owned banks in China

40,000 traditional bank branches

1.8 billion accounts

650 million users

2 billion transactions per day

Challenges of transforming core banking systems into a distributed architecture

Challenge 1: Capacity bottlenecks
Hundreds of terabytes of historical data and hundreds of billions of records per table

Challenge 2: High concurrency and low latency
Tens of thousands of concurrent requests in peak hours, response to query requests in milliseconds

Challenge 3: Financial-grade HA
Near-zero downtime in extreme environments; high requirements on RTO and RPO

New-generation core unified query system for personal banking services

Amazing user experience

Quarterly interest settlement

Original core: 140 minutes
New core: 35 minutes

Online transactions: 30% ↑
Batch processing: 33% ↑

Ultra-large storage: 500 TB
Long query range: 10 years

© PSBC launching a distributed, cloud-native core transaction system with GaussDB

汇聚产业力量, 引领数据库领域技术创新, 共建数据库繁荣新生态

Aggregating Industry Forces, Leading Technological Innovation in the Database Field, and Building a New Prosperous Database Ecosystem

GaussDB 在技术进步方面, 充分发挥了软硬件全栈协同以及云基础设施弹性等优势, 给企业提供更高性能、更高可靠、更低成本的数据库服务体验。新技术如智能化、安全防护等关键技术引领产业创新发展, 给企业提供更优、更安全的数据服务。产业生态方面, GaussDB 聚焦数据库关键技术突破, 并将统一单机主备内核 openGauss 源代码开放, 构建数据库开源根社区, 繁荣数据库生态。开源三周年里, 坚持技术创新, 如期发布 7 个版本, 吸引 390+ 单位加入社区, 近 5500+ 数据库开发者参与社区贡献, 总代码量已超过 1500 万行, 全球下载量超过 220 万, 覆盖 110+ 国家或地区, 十二家社区单位基于 openGauss 推出数据库商业发行版本, 广泛应用于政府、金融、电力等重点行业核心场景。

In terms of technological change, GaussDB fully utilizes advantages such as full-stack collaboration between software and hardware, as well as elastic cloud infrastructure, to provide enterprises with database service experience with higher performance, higher reliability, and lower costs. New technologies, such as AI and security protection, lead industry innovation and development, in addition to providing enterprises with better and

more secure database services. In terms of the industry ecosystem, GaussDB focuses on making breakthroughs in key database technologies, opens the openGauss source code that provides the unified single-node or primary/standby kernel to build an open-source root community, and allows the database ecosystem to prosper. On its third anniversary of being open-source, openGauss adhered to technological innovation by releasing seven versions as scheduled, attracted over 390 organizations to join the community, and contributed nearly 5500 database developers to the community. With over 15 million lines of code, GaussDB has been downloaded more than 2.2 million times worldwide in over 110 countries and regions. Twelve organizations have launched commercial database releases based on openGauss, which are widely used in core scenarios of key sectors such as government, finance, and electric power.

openGauss迈向生态发展期, 规模进入关键基础设施行业

2019.09 宣布开源
2020.06 社区上线 代码开源
2020.07 TC委员会成立
2021.03 Release 2.0.0 首个 LTS 版本发布
2021.09 社区理事会成立
2022.03 Release 3.0.0 多场景支持
2022.09 分布式解决方案
2023.03 Release 5.0.0 资源池化 数据全生命周期管理

2200,000+次 390+企业 5500+开发者 110+国家 4.9W套累计装机 1500万+行代码量

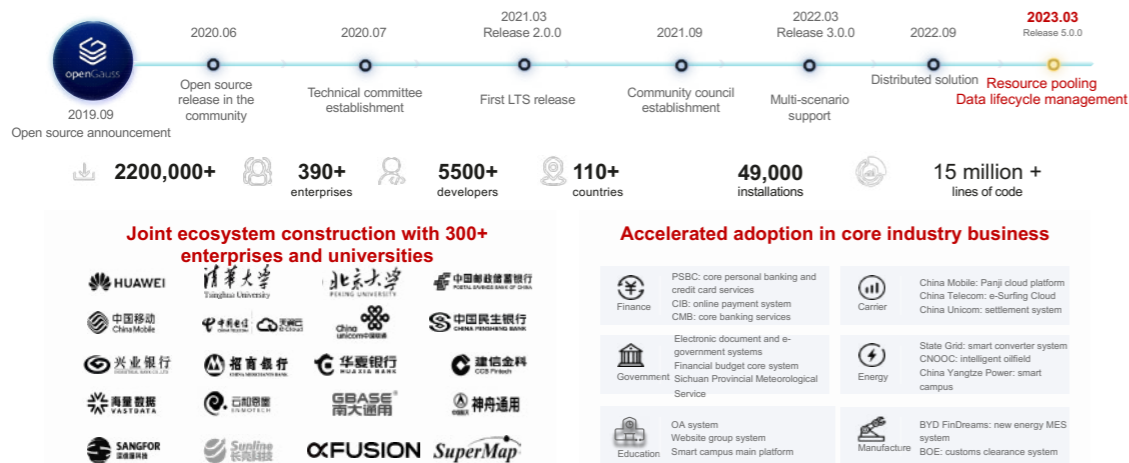
300+ 企业、高校共建生态

加速规模进行业核心

© 汇聚产业力量, 构建数据库开源根社区

DISTRIBUTED DATABASE

The openGauss Ecosystem Is Entering Critical Infrastructure Industries



Aggregating industry forces and building a database open-source root community

共建数据库健康繁荣生态，共赢未来



共建数据库繁荣新生态，给世界一个更优选择

Building a Healthy, Robust Database Ecosystem for a Win-Win Future



Building a new prosperous database ecosystem to provide a better choice for you

产、学、研、用高效融合，激发创新，引领未来，加速数据库产业发展

Efficient Integration of Industry, University, Research, and Use, Stimulating Innovation, Leading the Future, and Accelerating Database Industry Development

人才是数据库产业发展的源泉和动力。在中国教育部的支持下，GaussDB 作为数据库产教融合重点方向，目前已经出版了 6 本 GaussDB 相关教材，在超过 110 所高校开展相关教学，累积培养了 3.9 万名 GaussDB 数据库人才，GaussDB 人才认证体系，累积认证了 8000+ 数据库专家。在产学研融合方面，GaussDB 研发团队与高校一起持续投入下一代数据库关键技术难题研究，通过“黄大年茶思屋”等合作以及思想交流平台，与全球知名高校、专家学者一起探索数据库的未来发展方向。

Talent is the source and driving force for developing the database industry. With the support of the Ministry of Education of the PRC, GaussDB is regarded as the key direction of

industry-education integration. Currently, six GaussDB-related textbooks have been published, and are used in more than 110 universities. 39,000 talented GaussDB database developers have been cultivated. The GaussDB talent certification system has been developed, with more than 8,000 database experts certified. In terms of industry-university integration, the GaussDB R&D team worked with universities to continuously research key technical problems of next-generation databases. Through cooperation and thought exchange platforms such as Huang Danian Chaspark, the GaussDB R&D team worked with world-renowned universities, experts, and scholars to explore the future development direction of databases.

产教融合，加速 GaussDB 技术路线人才培养



产教融合，加速 GaussDB 技术路线人才培养

Developing GaussDB Technical Experts Through Industry-Education Integration



Developing GaussDB technical experts through industry-education integration

产学融合，共同研究下一代数据库关键技术

<p>更智能</p> <p>DBA调优→AI辅助智能调优</p> <p>AI解决数据库长期运行的“慢、满、错、夯、宕”问题</p>	<p>更快速</p> <p>存算分离→分层池化→融合执行</p> <p>存算分离实现高性能上云，分层池化解决弹性伸缩，融合执行支撑重载计算</p>	<p>更安全</p> <p>权限控制→密态计算→数据胶囊</p> <p>密态计算解决安全上云，下一跳数据胶囊实现数据安全流转</p>
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<p>与海内外知名高校和学会保持长期合作</p>  <p>数据库专业委员会</p>	<p>新华茶思屋</p> <p>CHASPARK</p> <p>聚焦学术领域的探索、牵引、开放、思辨 收获智慧火花，结识青年才俊，产学研相互促进</p>	<p>与全球高校基于项目广泛合作</p> 
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● 产学融合，共推 GaussDB 技术路线，研究下一代数据库关键技术

Jointly Exploring Key Technologies of Next-Generation Databases Through Industry-Education Integration

<p>More intelligent</p> <p>DBA optimization → AI-assisted intelligent optimization</p> <p>AI solves the long-running database problems such as slow response, insufficient resources, errors, suspension, and breakdown.</p>	<p>Faster</p> <p>Separation of storage and computing → Layered pooling → Converged execution</p> <p>Separation of storage and computing enables high-performance cloudification, hierarchical pooling enables elastic scaling, and converged execution enables heavy-load computing.</p>	<p>More secure</p> <p>Permission control → Encrypted computing → Data capsule</p> <p>Encrypted computing secures cloud migration and next-hop data capsules implement secure data transfer.</p>
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<p>Long-term cooperation with well-known universities and institutes in and outside China</p>  <p>Database Profession Committee</p>	<p>新华茶思屋</p> <p>CHASPARK</p> <p>Building an exploratory, leading, open, and creative academic climate Acquainted with young talent to promote prosperity in the industry, academic, and research circles</p>	<p>Extensive project cooperation with global universities</p> 
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● Promoting GaussDB technology roadmap and researching key technologies of next-generation databases through industry-university integration

知识增强大语言模型关键技术

The Key Technologies of Knowledge-enhanced Large Language Model

知识增强大语言模型			ERNIE Bot		
知识增强	检索增强	对话增强	Knowledge-Enhancement	Retrieval-Enhancement	Dialogue-Enhancement
有监督精调	人类反馈的强化学习	提示	SFT	RLHF	Prompt
预训练大模型			Pre-training Large Model		

● 知识增强大语言模型

● Knowledge-enhanced Large Language Model

百度
BAIDU



引言

知识增强大语言模型关键技术，从数万亿数据和数千亿知识中融合学习，突破知识内化和外用技术，模型效果更好，效率更高，具备知识增强、检索增强、对话增强等独有技术优势。和飞桨平台联合优化，大幅提升性能。

Introduction

The Key Technologies of Knowledge-enhanced Large Language Model enable integrated learning from trillions of data and hundreds of billions of knowledge. The breakthroughs in knowledge internalization and externalization bring better model performance and efficiency, thanks to unique advantages of knowledge enhancement, retrieval enhancement and dialogue enhancement, as well as the joint optimization with the PaddlePaddle platform.

知识增强大语言模型创新技术

Innovative Technologies of Knowledge-enhanced Large Language Models

知识增强：突破知识内化和外用技术，解决多源异构数据和知识难以统一表示和利用难题，以超越人类水平 0.8 个百分点的成绩登顶国际权威评测。

知识增强：Knowledge enhancement: a breakthrough in knowledge internalization and externalization that solves the difficulties of representing and utilizing data and knowledge in a unified manner, and helps the model winning the first place at SuperGLUE with 0.8 percentage points beyond human level.

检索增强：实现搜索引擎和大语言模型联合优化，生成内容准确率高、时效性强。

检索增强：Retrieval enhancement: the joint optimization of the search engine and the large language model has increased the accuracy and timeliness of the generated content.

对话增强：全球首个百亿参数对话大模型，国际权威评测获 11 项冠军，

使得大语言模型具备记忆机制、上下文理解和对话规划能力，增强对话连贯性和合理性。

对话增强：Dialogue enhancement: with the help of the world's first hundred-billion-parameter dialogue large model which has won 11 champions at the Dialogue System Technology Challenge, the large language model has obtained the capabilities of dialogue memory, in-context understanding and dialogue planning, and is able to produce more coherent and reasonable dialogues.

知识点增强：通过对输入和输出阶段进行知识点增强，提升模型效率和效果。

知识点增强：Knowledge point enhancement: the knowledge point enhancement in both input and output stages has greatly increased the model's efficiency and performance.

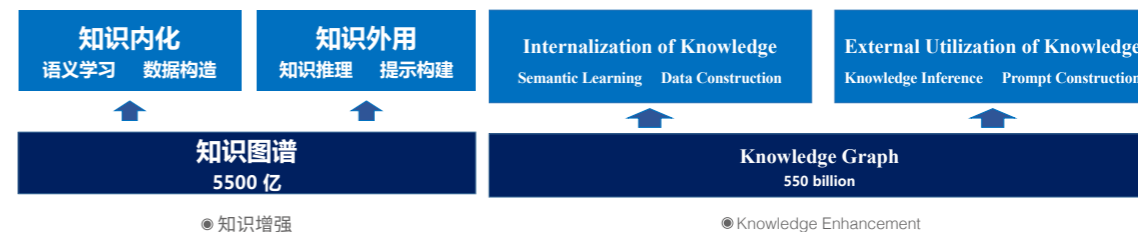
智能体机制：提出包括理解、规划、反思和进化能力的智能体机制，实现可靠执行、自我进化及思考过程白盒化。

智能体机制：Agent Mechanism: The proposed agent mechanism includes the abilities of un-

derstanding, planning, reflecting and evolving, resulting in an intelligent agent that is capable of reliable execution, self-evolution and shows an interpretable thinking process.

模型框架联合优化：大语言模型和飞桨深度学习平台联合优化，快速迭代升级，推理性能提升 50 多倍。

Joint Optimization of Model and Deep Learning Framework: The joint optimization of the large language model ERNIE and the deep learning platform PaddlePaddle makes it possible to iterate rapidly. As a result, the inference efficiency of the model has increased over 50 times.



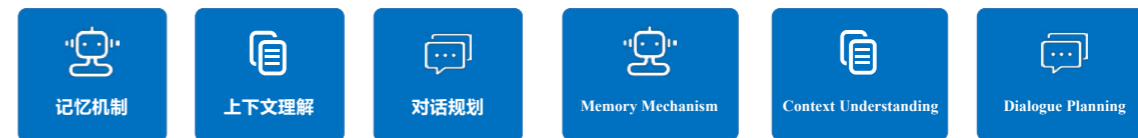
● 知识增强

● Knowledge Enhancement



● 检索增强

● Retrieval Enhancement



● 对话增强

● Dialogue Enhancement



● 知识点增强

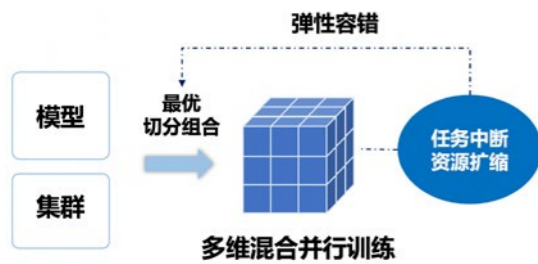
● Knowledge Point Enhancement



● 智能体机制

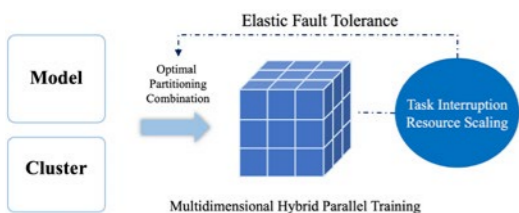
● Agent Mechanism

端到端自适应混合并行训练



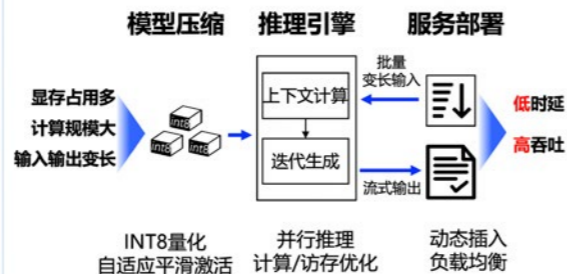
◎ 模型框架联合优化

End-to-End Adaptive Hybrid Parallel Training

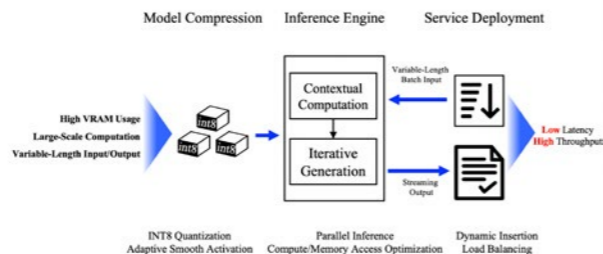


◎ Joint Optimization of Model and Deep Learning Framework

压缩、推理、服务部署协同优化



Compression, Inference, and Service Deployment Collaborative Optimization



集约化生产，平台化赋能千行百业

Intensive Production for Large Models and Platform Based Empowerment for Industries

知识增强大语言模型关键技术应用于智能搜索、通用对话、文心产业级知识增强大模型等，并通过飞桨深度学习开源开放平台赋能千行百业，降低人工智能技术创新和应用门槛，加速产业转型升级。

The key technologies have been applied in Intelligent Search, General-purpose Dialogue and ERNIE large models, etc., and have empowered a large number of industries through PaddlePaddle, the open-source deep learning platform by lowering the threshold for artificial intelligence technology innovation and application, and accelerating industrial transformation and upgrading.

智能搜索结果更精准，搜索研发效率更高、创新更快，每天满足数十亿搜索请求，大幅提升搜索效果和体验。

Intelligent Search powered by technologies of knowledge-enhanced large language model delivers more accurate results and better search experience to satisfy billions of users' demands. The technologies also make the development more efficient and the innovation process faster.

通用对话成果应用于通信、能源、金融、媒体等 20 多个行业，服务超过 10 亿用户，部署 5 亿台智能设备，经济效益近 80 亿。

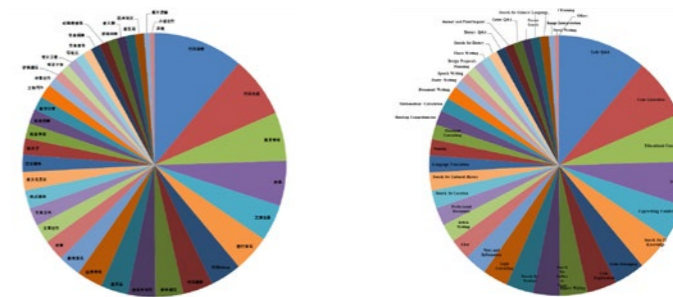
General Dialogue system powered by these technologies has applied in more than 20

industries such as telecommunication, energy, finance and media, etc. and served over a billion users on over 500 million smart devices, bringing economic benefit of nearly 8 billion Yuan.

文心产业级知识增强大模型，包括基础和行业大模型等，通过工具与平台赋能客户及用户从开发到落地部署全流程。已有超过 15 万客户及伙伴申请接入大语言模型平台，成功实践了“集约化生产，平台化应用”的大模型产业模式，赋能产业智能化升级。

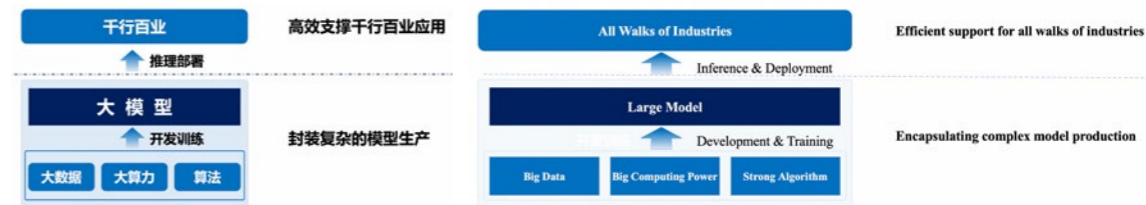
ERNIE knowledge-enhanced large models, including foundation model and industrial model, enable customers and users to easily develop and deploy the entire process of AI applications through

toolkit and platform. More than 150,000 customers and partners have applied to access the big language model platform, successfully practicing the large model industrial model of "intensive production and platform application", and empowering industrial intelligent upgrading.



◎ 丰富应用场景

◎ Various Application Scenarios



◎ 产业模式

◎ Industrial Model of Large Language Model

重塑产业，变革科研范式，助力探索通用人工智能
Reshape the Industry, Transform Research Paradigm and Support the exploration of AGI

知识增强大语言模型关键技术的突破，对人工智能领域而言，将有助于探索通用人工智能发展；对前沿科技领域而言，正在变革科研范式，加速重大发现、重大发明的进程；对产业而言，大模型技术将助力重塑产业，掀起智能化浪潮。

The breakthrough of key technologies of knowledge-enhanced large language model would help explore the way to AGI, transform research paradigm to speed up big inventions and discoveries, and reshape the industry to boost the wave of industrial upgrading and transformation.

1. 知识增强大语言模型具备了理解、生成、逻辑和记忆人工智能四项基础能力，为发展通用人工智能提供了技术基础。

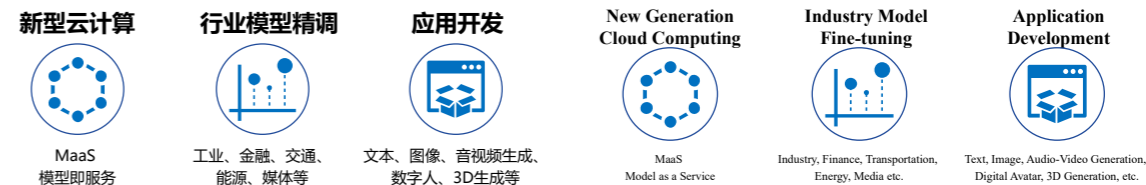
The knowledge-enhanced large language model is capable of understanding, generating, logic and memorizing known as AI's fundamental abilities, which provides a technical foundation for the development of AGI.

2. 知识增强大语言模型在跨学科、跨领域任务中表现出色，有助于科学家整合学术资源，试验新思路、新想法，以更快的速度产生新的突破和发现。

The knowledge-enhanced large language model performs well in interdisciplinary or cross-disciplinary tasks, which helps scientists to integrate academic resources, experiment with new ideas and ideas, and produce new breakthroughs and discoveries faster.

3. 带来新的产业机会，如云智一体的模型即服务、行业大模型催生的产业发展空间、新的现象级应用等。据预测，到 2030 年，以大语言模型为代表的人工智能技术有望创造 15.7 万亿美元的增长。

The knowledge-enhanced large language model would foster new industries or new business opportunities such as cloud-AI integrated model as a service, new market boosted by industrial large models and new phenomenal applications. Reportedly, AI technologies, mainly large language models and generative AI, could contribute up to \$ 15.7 trillion to global economy in 2030.

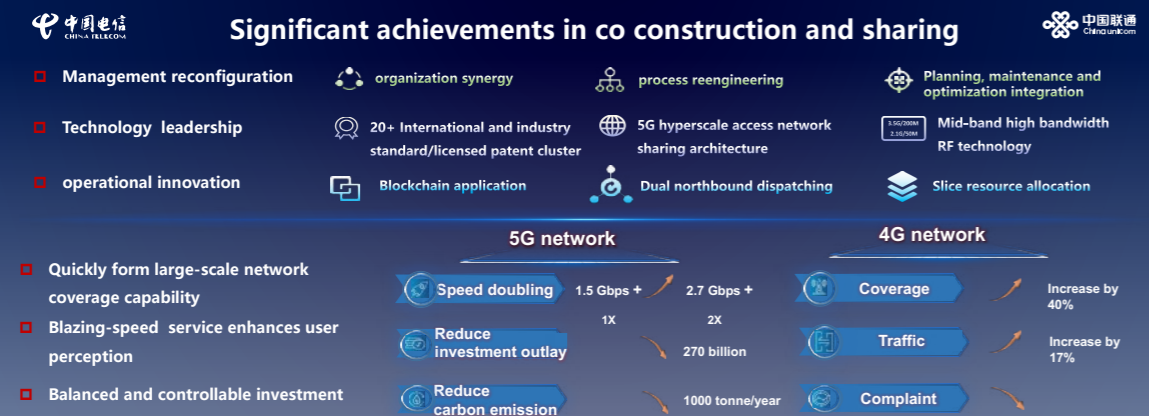


◎ 大模型产业机会

◎ Business Opportunities of Large Language Model

4G/5G 移动通信共建共享关键技术创新与产业化

Technological Innovation and Industrial Applications of 4G-5G Co-construction and Sharing



中国电信集团有限公司
China Telecom Corporation Limited

中国联合网络通信集团有限公司
China United Network Communications Group Corporation Limited



引言

自 2019 年以来，中国电信与中国联通深耕 5G 共建共享新赛道，用最短时间、花较少投资快速建成了全球首张、规模最大、网速最快的 5G 独立组网（SA）共建共享网络，实现了大规模产业化应用，引领全球 5G 发展。

Introduction

Since 2019, China Telecom and China Unicom have deeply cultivated a new track for 5G co-construction, becoming the industry's first pairs to jointly build and share mobile networks. They have now engineered the world's largest, fastest shared 5G standalone (SA) network and put it into scaled commercial operations in a short period of time and with the least possible investment, blazing a new path leading global 5G development.

中国电信与中国联通在 5G 网络共建共享关键技术、标准演进、运营机制、管理模式、产业协作等方面实现创新与突破，多项 5G 关键技术全球领先

China Telecom and China Unicom have achieved breakthroughs in key technologies, standard evolution, operation mechanisms, management models, and industry collaboration for 5G network co-construction and sharing through joint innovation

全球首个 5G 共建共享 SA 规模组网工程，无成熟经验可循、无标准技术方案、无成功案例可鉴。中国电信与中国联通先后解决了共享网络“带宽翻倍，多频共存”、“两网合一网，4G/5G 协同”等一系列组网运营难题，确保了共建共享网络下的良好用户体验。

To build the world's first large-scale 5G shared SA network, it means there would be no experience, standards, or successful cases to learn from. China Telecom and China Unicom overcame a number of networking and operation issues, including "doubled bandwidth and multi-band coexistence" and "4G-5G synergy in shared networks", to ensure user experience.

全球首创“一张物理网，两张逻辑网，多张定制网”5G 超大规模接入网共享网络架构，开创了接入网资源共建共享、核心网各自建设独立运营、业务差异化经营发展的新模式。

As the world's first "one physical network, two logical networks, multiple customized networks" 5G ultra-large-scale access network sharing network architecture, it creates a new model of joint construction and sharing of access network resources, independent operation of core networks, and differentiated business development.

创新性提出 4G/5G 动态频谱共享技术，实现了一网多用。提出基于上下行解耦的大带宽超级上行增强技术，大幅延伸了 3.5GHz 大带宽的覆盖。牵头定义了 FDD 大带宽、多载波聚合、高功率传输等 5 项无线技术国际标准。

They also innovated dynamic 4G-5G spectrum sharing that helps them provide services to their respective users in one network, and high-bandwidth Super Uplink with downlink

and uplink decoupling that noticeably extends the coverage of the 3.5 GHz band. Furthermore, they initiated to develop the industry specifications for five major technologies, including FDD high bandwidth, multi-carrier aggregation, and high-power transmission.

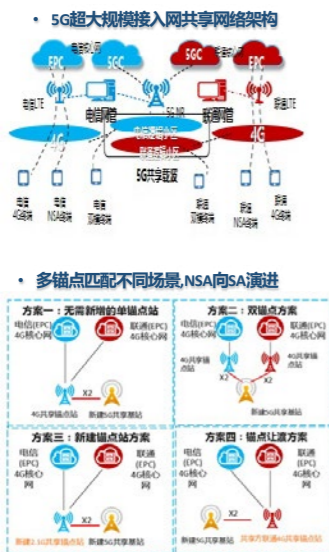
面对复杂的网络协同管理问题，电联双方求同存异、重塑流程，成立了跨运营商项目团队，共同推动“规建维优”端到端协同。为解决两张逻辑网间资源公平使用和高效调度难题，电联自研了 5G 共建共享区块链调度平台，全面提升了共享网络共建共维共治效率。

Faced with the complex problem of network collaborative management, China Telecom and China Unicom reconstructed their processes and set up a joint team to promote end-to-end collaborated planning, construction, maintenance, and optimization. In order to solve the problem of fair use of resources and efficient scheduling between the two logical networks, they have developed a 5G co-construction and shared blockchain scheduling platform, which comprehensively improves the efficiency of co-construction and co-governance of shared networks.

2023 年，电联作为全球移动通信系统协会（GSMA）官方指定运营商牵头制定《5G 网络共建共享指南》，为全球 5G 网络实现合作共享共赢提供了系列技术规范参考。

In 2023, China Telecom and China Unicom were officially designated by the Global Systems for Mobile Communications Association (GSMA) to formulate the guide on 5G network co-construction and sharing, providing technological specifications for global 5G network sharing.

网络架构创新



◎ 5G 超大规模接入网共享网络架构及各项重大突破, 助力 4G/5G 共享网络协同组网控制, 保障现网用户体验

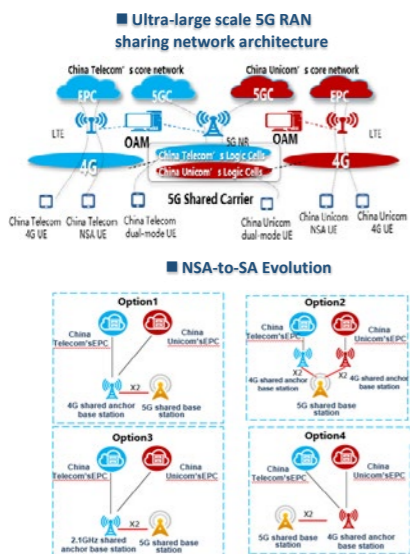
关键技术创新



管理与运营调度创新

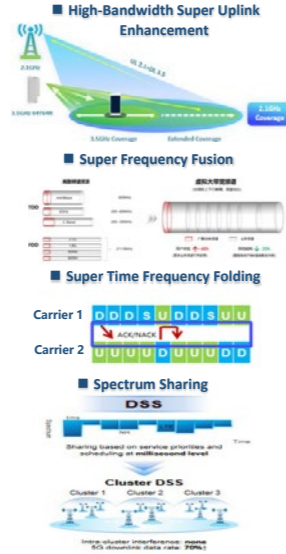


Network Architecture Innovation

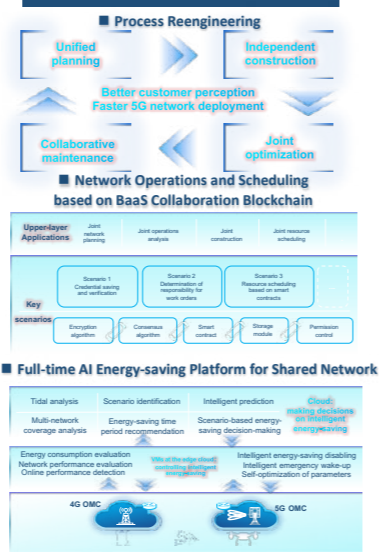


◎ Ultra-large scale 5G RAN sharing network architecture and major breakthroughs, assisting in 4/5G collaborative networking and guarantee for user perception

Key Technological Innovation



Management and Operation Scheduling Innovation



◎ GSMA 官方发布《5G 网络共建共享指南》, 中国电信与中国联通为全球运营商提供 5G 高质量发展新思路

◎ The GSMA officially released the "5G Network Co-construction and Sharing Guide", introducing new networking pattern of China Telecom and China Unicom to global operators looking for high-quality 5G growth

电联共建共享网络的打造, 实现了 5G 移动通信共建共享关键技术创新与产业化, 填补了全球产业空白, 取得了重大的社会效益和经济效益

In addition to key technological innovations and industrial applications, 5G network sharing between China Telecom and China Unicom has produced significant social and economic benefits

通过 5G 共建共享这种全新的建设运营模式, 电联在快速建成覆盖广、技术优、投资省、体验佳的全球最大规模 5G SA 共享网络的基础上, 实现了良好的社会和经济效益, 输出了丰硕的技术管理创新成果, 打造了行业标杆和全球榜样。

Through 5G co-construction and sharing, China Telecom and China Unicom built the largest 5G SA shared network in the world has ever seen based on advanced technologies to guarantee wide coverage and premium experience with high investment effectiveness. Their joint practice created a bunch of technological and management achievements and produced significant social and economic results, providing a new industry benchmark for the world.

社会效益方面, 双方通过共建共享, 在短时间内高效实现了 5G 网络高质量规模化覆盖, 为加快 5G 业务发展, 服务千家万户、赋能千行百业、助力抗险救灾、做好重大活动保障奠定了坚实的网络基础。双方 5G 业务快速发展, 5G 用户累计已超过 3.3 亿户。

In terms of social benefits, the two parties have efficiently built high-quality 5G networks to provide scaled coverage in a short period of time, enabling a solid foundation for 5G to expand among public consumers and various industries. This contributes to disaster relief efforts and supporting smooth operations in key events. The 5G services of the two parties have developed rapidly, and the cumulative number of 5G users has exceeded

330 million.

经济效益方面, 双方充分整合发挥各自资源禀赋, 实现频率、机房、站址、等优势互补, 极大缓解了运营商在 5G 建设和运营上的资金压力。通过 4G/5G 网络共建共享, 双方已累计为国家节省资本支出 (CAPEX) 超 2700 亿元, 每年节省运营支出 (OPEX) 超 300 亿元, 年减少碳排放超 1000 万吨, 推动了新型信息基础设施建设沿着绿色低碳高效的方向加快发展。

In terms of economic benefits, China Telecom and China Unicom maximized their respective advantages in spectrum, equipment rooms, and site resources to substantially relieve the capital pressure arising from 5G construction and operations. Through 4G-5G network co-construction and sharing, they have saved more than CNY270 billion of CAPEX, in addition to CNY30 billion of OPEX annually, while cutting carbon emissions by over 10 million tons per year. This helps accelerate the development of new green information infrastructure.



◎ 第 31 届世界大学生运动会，中国电信以“智慧赛事”建设为着力点，以“智能弹性算网”为底座，全力打造“智慧大运”

◎China Telecom brought intelligent scalable computing network foundation based on high-quality 5G connectivity to the 31st FISU Summer World University Games

加快 5G 建设速度、减轻 5G 投资压力，共建共享是高质量发展的最佳选择

To accelerate the speed of 5G construction, and reduce the pressure of 5G investment, co-construction and sharing is the best choice for high-quality development.

电联通过共建共享，在科技创新、资源互补、频率共用等方面形成合力，用最短时间、花较少投资快速建成了全球首张、规模最大、网速最快的 5G 共享网络，实现了 C-Band 200M 带宽下 2.7Gbps 全球最高商用速率，达到了“1+1>2”的良好效果，为大型企业协同发展提供了新路径。

Based on network co-construction and sharing, China Telecom and China Unicom pulled together their separate strength in innovation to supplement each other on spectrum and other resources. This enabled them to build the industry's largest shared 5G SA network in a very short period of time with the least possible investment. This is the first time that two major operators have teamed up to build and share networks. With a C-Band 200 MHz bandwidth, the network can provide a 2.7 Gbps of downlink speed, which stands at the highest peak in commercial networks. This level of performance would not be achievable had they chosen to build networks separately. Therefore, this network model provides enterprises a new distinctive path towards collaborated business growth.

5G 共建共享的新模式也得到了国际同行的高度认可和借鉴学习。共享网络架构获得 2021 年“德国 IF（汉诺威）工业设计奖”，双方集团公司被 GSMA（全球移动通信系统协会）授予 2021 年度亚洲移动大奖，日本 KDDI、韩国 LG U+、马来西亚 U mobile 等海外多家通信运营商上门学习 5G 共建共享有关的技术、管理、运营等经验做法。

The new model of 5G co-construction and sharing is highly recognized globally and provided a good example to industry peers. The network sharing architecture won the "IF Industrial Product Design Award in 2021", and China Telecom and China Unicom won the 2021 winners of "Outstanding Contribution to the Asia Mobile Industry" from GSMA. Leading operators, including KDDI Japan, LG U+ South Korea, U Mobile Malaysia, consulted China Telecom and China Unicom on the technologies, management, and oper-

ations related to 5G co-construction and sharing.

中国联通与中国电信将继续秉承开放、合作、共赢心态，与全球合作伙伴携手，共同开展网络共享新技术研究、新模式探索、新业务突破，推动行业生态发展，促进全球数字经济蓬勃发展。

Upholding the spirit of openness, collaboration, and shared success, China Telecom and China Unicom will continue to work with all partners on the technological research, model exploration, new business breakthrough, and ecosystem development of network co-construction and sharing, contributing to the thriving of the global digital economy.

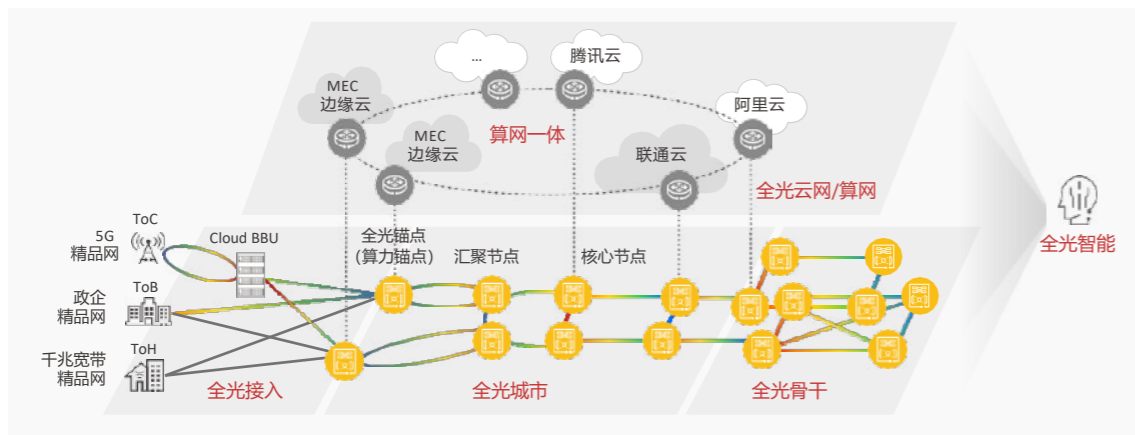


◎电联 5G 共建共享工程荣获 2021 年 GSMA 亚洲移动产业最佳突出贡献奖

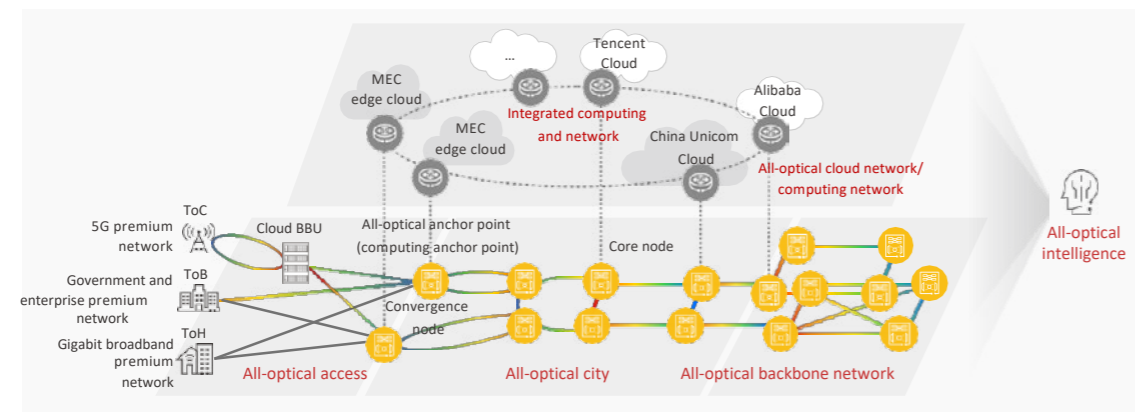
◎China Telecom and China Unicom were awarded "2021 Outstanding Contribution to the Asia Mobile Industry" by the GSMA for their 5G co-construction and sharing practice

中国联通全光底座关键技术创新与应用

All-Optical Infrastructure Innovation and Application of China Unicom



● 全光底座，从全光骨干网、全光城域网和全光接入网，为新型数字基础设施提供基础底座



● All-optical infrastructure provides the foundation for new digital infrastructure from all-optical backbone network, all-optical metropolitan area network and all-optical access network

中国联合网络通信有限公司
China Unicom



华为技术有限公司
Huawei Technologies Co., Ltd.



引言

中国联通提出全光底座体系架构，联合华为公司开展了全光底座关键技术、设备研制和规模组网应用，构建了覆盖中国（186个ROADM+1279个OA）的单域WSON智能全光骨干网络，一体化实现联家、联企、联算的多业务综合承载，经济与社会效益十分显著，有力提升了北京冬奥会等国际重大赛事的网络服务品质。

Introduction

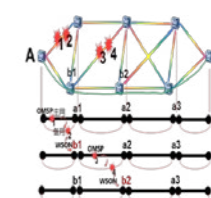
China Unicom proposed the all-optical infrastructure system architecture, cooperated with Huawei to carry out all-optical infrastructure key technology, equipment development and networking application, and constructed a single-domain WSON intelligent all-optical backbone network covering China (186 ROADM+1279 OA). This network integrally realized multi-service comprehensive bearing of homes, enterprises, and computing power, which gains significant economic and social benefits and effectively improves the quality of network services for major international events such as the Beijing Winter Olympics.

建成全球最大规模单域 WSON 智能全光网络 Building the Largest Single-Domain WSON Network in the World

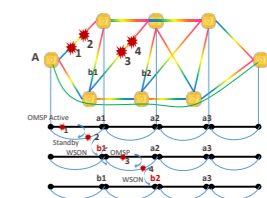
中国联通全光底座架构体系从网络架构、全光交换、全光接入等挑战出发，实现多项技术创新：首次提出 OMSP 和 WSON 的保护与协同机制，以及“集中+分布式”控制架构，实现了骨干 ROADM 网络 50ms 保护倒换，且可抗连续 13 次断纤，建成覆盖全国的单域 WSON 网络。首次提出接入环共享汇聚点波道的城域池化波分技术，实现空间及功耗节省 50%，以及基于数字标签的自动化运维，方案国际领先。首次定义应用于城域综合业务接入的全光锚点，提出了基于数字标签调谐和波长可调谐的全光接入技术，主导制定了 ITU-T G.698.4 国际标准，实现全业务运营商的全光综合接入。提出了支持业务感知、灵活业务映射、带宽调整的光业务网 (OSU) 技术及其控制协议 (OSP)，支持 2M~100G 的全业务高效联接。

China Unicom's all-optical infrastructure system architecture starts from the challenges of network architecture, all-optical switching and all optical access, and realizes a number of technical innovations: The protection and coordination mechanism of OMSP and WSON, as well as the "centralized + distributed" control architecture are proposed for the first time. The 50 ms protection switching of the backbone ROADM network is realized, protection against 13 fiber cuts is implemented, and a single-domain WSON network covering the whole country is constructed. Then it is the first time to propose the metro pooling wavelength division technology in which access rings share aggregation nodes. This technology reduces space and power consumption by 50%, and implements automatic operation and maintenance based on digital labels, which makes the all-optical in-

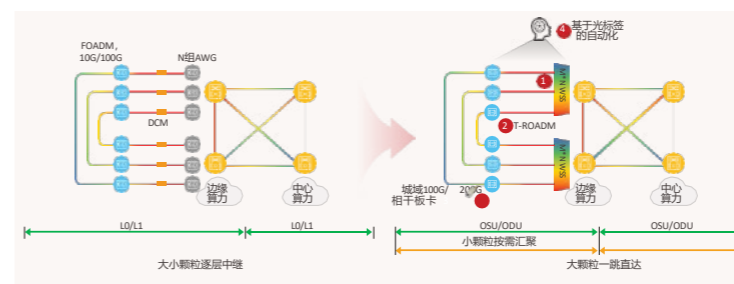
frastructure solution the leading solution in the world. Next, the all-optical anchor for metro integrated service access was defined for the first time, and the all-optical access technology based on digital label pilot tone modulation and wavelength tuning was proposed, and the ITU-T G.698.4 standard was established with realizing integrated all-optical access for all-service operators. Besides, it also proposes the Optical Service Network (OSU) technology that supports service awareness, flexible service mapping, and bandwidth adjustment as well as its control protocol (OSP), and supports efficient access of any service from 2M to 100G.



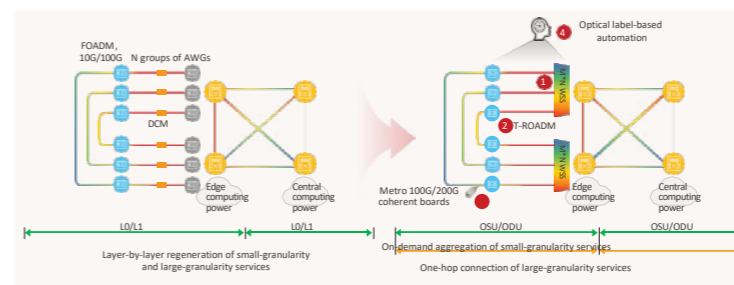
* 京津冀ROADM现网测试连续13次断纤依旧可以成功恢复业务。



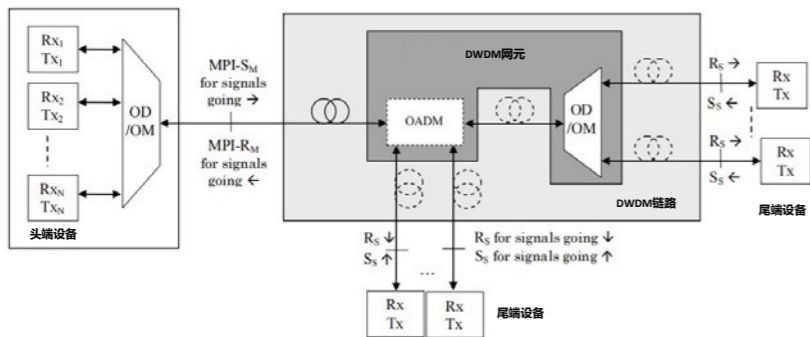
Services can still be restored after 13 consecutive fiber cuts on the ROADM network in Beijing, Tianjin and Hebei.



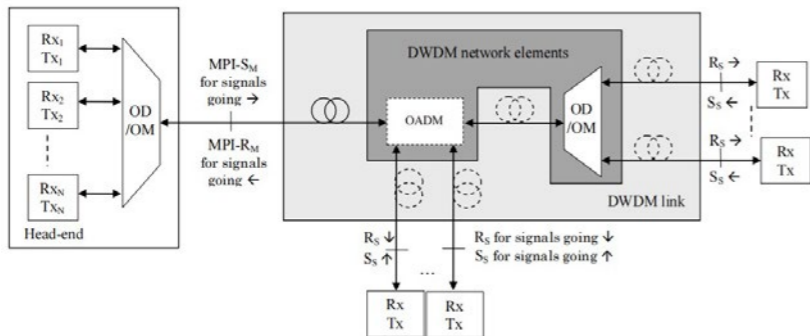
● 传统波分与城域池化波分对比图



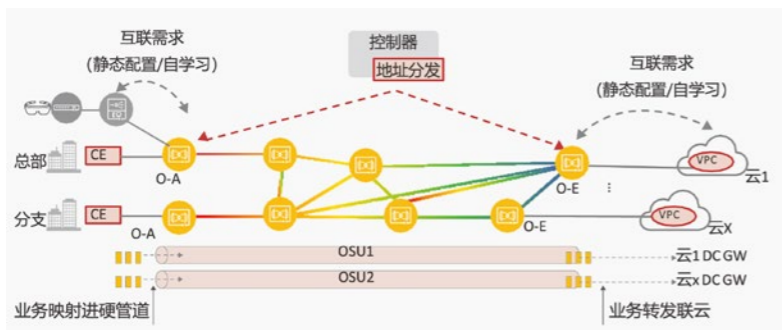
● Comparison between traditional DWDM and the metro pooling WDM



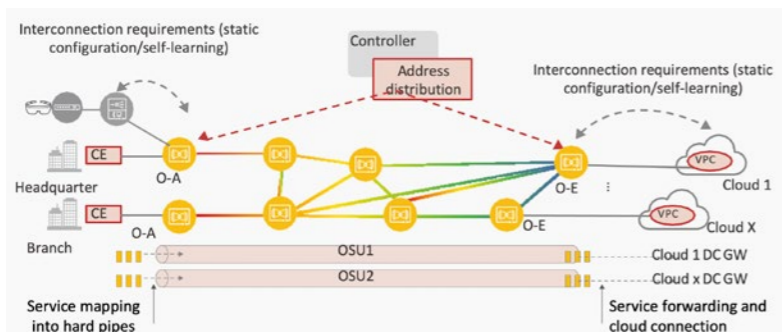
城域全光接入技术原理图



The schematic diagram of the all-optical access technology



光业务网技术及 OSP



Optical Service Unit and OSP technology

全光底座成果规模应用，经济和社会效益显著

All-optical Infrastructure has been Applied on a Large Scale and Gained Significant Economic and Social Benefits

中国联通的全光底座体系架构及网络建设运营以来，经济和社会效益显著。本项目直接经济效益约 200 亿元；本项目自投入运营以来，已累计服务超过 2.13 亿 5G 用户，超过 8900 万宽带用户，超过 100 万条政企专线。骨干 ROADM 网络带来功耗每年降低 12.8 亿瓦，相当于减少 CO2 排放 746.73 吨，减少 SO2 排放 38.56 吨。本项目成果很好地服务了北京 2022 年冬奥会和冬残奥会，打造的大带宽、高可靠、零丢包、低时延 8K 超高清承载网，保障全球观众可通过 8K 超高清欣赏奥运盛宴。全光底座实现“联企、联家、联算”，在推动数字经济发展和数字化转型等方面取得了显著的社会效益。

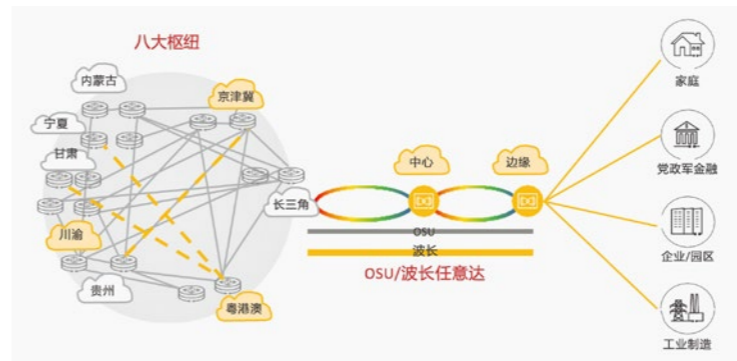
China Unicom's all-optical infrastructure system architecture and network construction have achieved significant economic and social benefits. The direct economic benefits of this project are approximately CNY20 billion. Since this project was put into operation, it has served more than 213 million 5G users, more than 89 million broadband users, and more than 1 million government and enterprise private lines. The backbone ROADM network reduces power consumption by 1.28 billion watts per year, which is equivalent to reducing CO2 emissions by 746.73 tons and SO2 emissions by 38.56 tons. This project also benefited the Beijing 2022 Winter Olympics and Paralympics, creating a high-bandwidth, high-reliability, zero-packet-loss, and low-latency 8K UHD transport network to ensure that global audiences can enjoy 8K UHD Olympic feast. The all-optical infrastructure realizes "connected homes, connected enterprises, and joint computing", and has achieved significant social benefits in promoting the development of digital economy and digital transformation.

项目成果全球应用，助力推动全球互联网发展演进，构建世界网络空间命运共同体

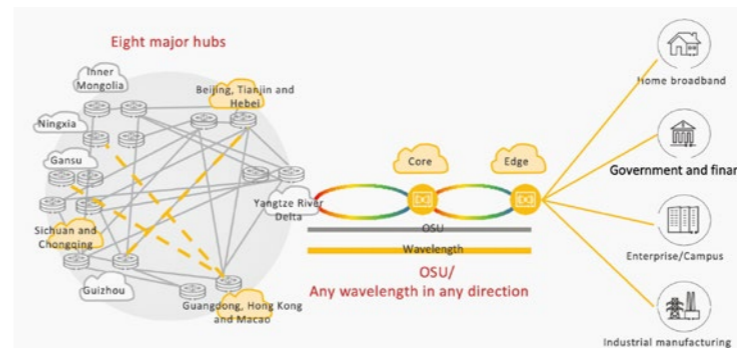
The Project Achievements Contribute to the Development and Evolution of the Global Internet, Fostering the Creation of a Global Cyberspace Community with a Shared Future

在下一代光网络的技术推广和应用创新中，中国联通和苹果公司结合全光底座架构和技术体系开展了大量的研究和测试工作，为下一代光网络技术的发展成熟和应用示范起到了先行先试的作用。在中国产业推动下，目前全球已有超过 100 张网络部署 ROADM、池化波分 and 全光接入技术光业务网，全球 32 个国家 40+ 商用网络部署 400G 技术，成为全球互联网发展的基石，助力各国实现信息时代数字化、网络化、智能化。

In the technology promotion and application innovation of next-generation optical networks, China Unicom and Huawei have carried out a large amount of research and testing work based on the all-optical infrastructure architecture and technical system, playing a leading role in the development and application of next-generation optical network technology. Driven by China's industry, more than 100 networks around the world have adopted the ROADM, pooling wavelength division, and all-optical access technologies, and more than 40 networks in 32 countries have adopted 400G technologies. The all-optical infrastructure has become the cornerstone of the development of the global Internet, helping countries achieve digitalization, networking, and intelligence in the information age.



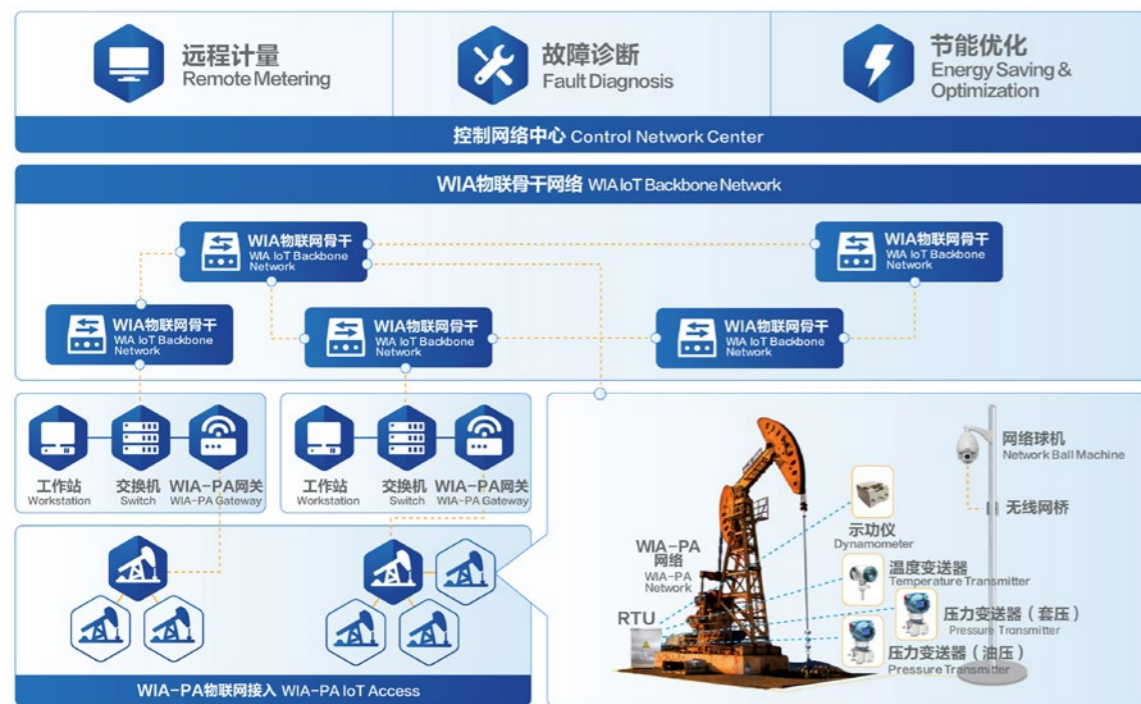
向上联云联算，向下联企联家



Connecting homes, enterprises, and joint computing

智慧油田工业物联网 WIA-PA 技术与系统

IIOT WIA-PA Technology and System of Intelligent Oilfield



● 工业物联网 WIA-PA 技术与系统形成智慧油田生产新模式
● IIoT WIA-PA technology and system forms a new production model of intelligent oilfield

中国科学院沈阳自动化研究所
Shenyang Institute of Automation, Chinese Academy of Sciences

中国石油大庆油田
Daqing Oilfield of CNPC

中国石油辽河油田
Liaohe Oilfield of CNPC

沈阳中科奥维科技股份有限公司
Chinese Academy of Sciences-ALLWIN Technology Co. LTD.



引言

智慧油田工业物联网 WIA-PA 技术与系统，突破极端环境下的广域超大规模、高可靠物联网技术，形成了系列国际和中国标准，研发核心芯片和超低功耗仪表终端，构建油田生产全覆盖的工业物联网系统，形成智慧油田生产新模式。

Introduction

IIoT WIA-PA technology and system of intelligent oilfield breaks through the ultra-large-scale, high-reliability IoT networking technology in extreme environments, publishes a series of international and Chinese standards, develops core chips and ultra-low power consumption instrument terminals, builds an industrial IoT system with full coverage of oilfield production, and forms a new intelligent oilfield production model.

研发出 WIA-PA 协议标准和系列仪表设备，构建了油田生产全覆盖的物联网系统

We develop the industrial Internet of Things WIA-PA technical standards and a series of instruments and equipment, and build the IoT system covering all oilfield production processes

广域超大规模、高可靠、高实时无线组网技术：实现了单网关千点级工业无线网络秒级确定性时延和 99% 以上传输可靠性的领先指标，形成了系列国际标准和国家标准。

Wide-area ultra-large-scale, high-reliability, and high-real-time wireless networking technology: It has achieved international leading indicators of second-level deterministic delay and transmission reliability above 99% for single-gateway thousand-point industrial wireless networks, forming China's only international standard in this field.

适应野外极端环境的仪表终端超低功耗运行技术：同步精度达到微秒级，达到国际同类产品的最好水平。

Ultra-low power consumption operation technology for instrument terminals adapted to the extreme environment in the wild: Synchronization accuracy reaches the level of micro-seconds, reaching the best level of similar international products.

产量计量模式创新：提出了基于工业物联网技术的油井产量计量方法，由原来硬件计量模式转变为动态、实时、精准软计量创新模式，大幅降低生产运行成本。

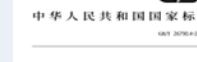
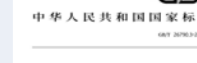
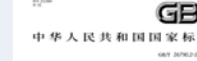
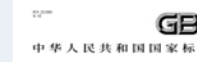
Innovation in production measurement mode: The oil well production measurement method based on industrial IoT technology is proposed, which profoundly changes the production measurement mode of a single well in the oilfield, from the original hardware measurement mode to the dynamic, real-time, and accurate soft measurement innovation mode, and greatly reduces the production and operation cost.

装备运维模式创新：利用功图实现油井工况的自动识别，由原来事后运维转变为在线诊断、预测性运维的创新模式，实现油井故障的精准识别和快速响应。

Innovation in equipment operation and maintenance mode: The diagram card is used to realize real-time and automatic identification of oil well conditions, and the innovative mode of online diagnosis and predictive operation and maintenance, so as to realize the accurate identification and rapid response of oil well faults.

采油工艺创新：通过油水井采注协同优化和智能变频控制技术，建立“采注协同、智能决策、自动调参”的创新采油工艺模式，大幅提高油井生产效率，有效降低系统能耗。

Innovation in oil production process: Through the collaborative production-injection optimization of oil and water wells, and the intelligent frequency conversion control technology, the innovative oil production process mode of "production and injection coordination, intelligent decision-making and automatic parameter adjustment" is established, which greatly improves the production efficiency of oil wells and effectively reduces the energy consumption of the production system.



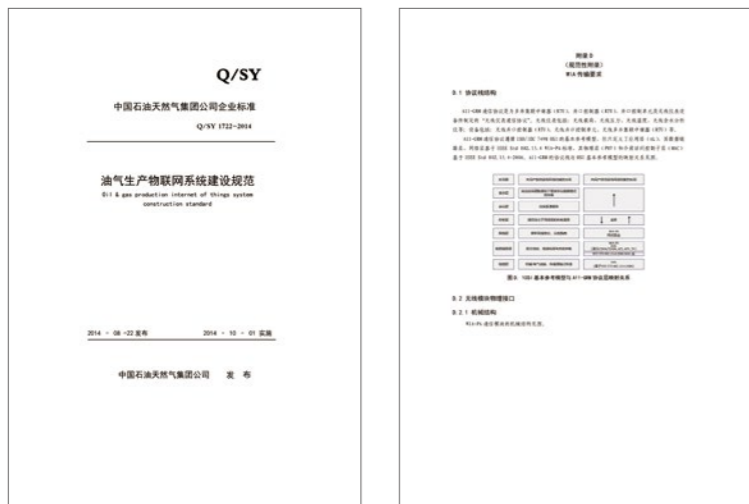
● WIA 规范国际标准和国家标准
● WIA International and Chinese Standards

WIA-PA 协议标准被中石油采标成为行业标准，并实现规模化应用

The WIA-PA protocol standard has been adopted by CNPC as an industry standard and has been applied on a large scale in CNPC oilfields

2019 年同中国石化的大庆油田、辽河油田签署全面推广使用 WIA-PA 技术的战略合作协议，开展工业物联网 WIA-PA 技术与系统数字化工程建设，在 3-5 年实现油田的油水井全面数字化覆盖。

In 2019, we signed a strategic cooperation agreement with Daqing Oilfield and Liaohe Oilfield of CNPC to promote the use of WIA-PA technology, carried out the construction of IIoT WIA-PA technology and system digitization project, and achieved digital cover-



◎ WIA-PA 协议标准被中石油采标成为行业标准

◎ The WIA-PA protocol standard was adopted by CNPC as an industry standard

age of oil and water wells in 3-5 years.

目前，WIA-PA 协议标准被中石油采标成为行业标准，并实现规模化应用，覆盖油水井 2 万余口，应用 WIA-PA 终端设备 10 万余台套。

At present, WIA-PA has been adopted as an industry standard by CNPC and has been applied on a large scale, covering more than 60,000 oil and water wells and applying more than 200,000 sets of WIA-PA terminal equipment.

基于 WIA-PA 网络技术的生产监测与优化控制系统集“生产监测、生产优化、生产管理”于一体，有效解决了油田大规模广域分布采油井的实时监控难题，为油田稳产增产发挥重要作用，创造了显著的社会与经济效益。

The WIA-PA-based production monitoring and optimization control system integrates production monitoring, production optimization, and production management, effectively solves the problem of real-time monitoring of large-scale wide-area distributed production wells in oilfields, plays an important role in the stable production and increase of oilfields, and creates significant social and economic benefits.

实现了生产计量、装备运维和采油工艺的全面创新，形成智慧油田生产新模式

It has realized the comprehensive innovation of production measurement, equipment transportation, and oil recovery technology, and formed a new production model of intelligent oilfields.

中国科学院沈阳自动化研究所联合中国石油和沈阳中科奥维有限公司，在大庆油田和辽河油田部署 WIA-PA 技术与系统，实现了生产计量模式、装备运维模式和采油工艺的全面创新，大幅提高油田生产智能化水平，平均泵效提高了 1.8%，能耗降低了 8.5%，减少无效低效注水 19%，为破解油气生产过程提效难、生产操作成本高、油气综合含水高的“一难两高”问题提供了有效解决方案。

Shenyang Institute of Automation, PetroChina, and ALLWIN deployed WIA-PA technology and system in Daqing Oilfield and Liaohe oilfield, and realized the comprehensive innovation of production measurement mode, equipment operation and maintenance mode and oil recovery process, greatly improved the intelligent level of oilfield production, increased the average pump efficiency by 1.8%, reduced energy consumption by 8.5%, reduced ineffective and inefficient water injection by 19%. It provides an effective solution to solve the "one difficulty and two high" problems.

通过构建油田生产全覆盖的工业物联网系统，实现对偏远分散油井生产过程的实时在线监测和优化控制，已初步形成集无人干预的远程计量、故障诊断、节能优化于一体的智慧油田生产新模式，以数字化转型驱动油气产业高质量发展。

By constructing the IIoT system with full coverage of oilfield production, real-time online monitoring and optimization control of remote and dispersed oil well production processes have been achieved, and a new intelligent oilfield production model integrating remote measurement, fault diagnosis and energy-saving optimization with unmanned intervention has been initially formed, so as to drive the high-quality development of the oil and gas industry through digital transformation.



◎ WIA 技术成果荣获国家技术发明奖二等奖

◎ WIA-related technological achievements won the second prize of the State Technological Invention Award



◎ WIA-PA 终端设备实现油井生产状态的实时在线感知

◎ The WIA-PA terminal devices enable real-time and online perception of the production status of the oil wells

全球首个 5G Advanced-ready 调制解调器及射频系统

The World's First 5G Advanced-ready Modem-RF System

高通无线通信技术（中国）有限公司
Qualcomm Wireless Communication Technologies (China)



引言

高通公司于 2023 年 2 月推出全球首个 5G Advanced-ready 调制解调器及射频系统——骁龙 X75，凭借对未来 5G Advanced 功能的支持、AI 硬件加速两大首创性特性，以及突破性的 5G 性能和无与伦比的频谱灵活性，助力开启蜂窝通信的新阶段。

Introduction

Qualcomm introduced the world's first 5G Advanced-ready modem-RF system, Snapdragon X75, in February 2023. Snapdragon X75 is unlocking a new phase in cellular communications, with the first-to-launch features including the support for upcoming 5G Advanced capabilities and AI hardware acceleration, and also breakthrough 5G performance and unmatched spectrum flexibility.

骁龙 X75 率先引入 5G Advanced-ready 等先进特性，突破连接边界

Snapdragon X75 first introduces the advanced features such as 5G Advanced-ready to push the boundaries of connectivity

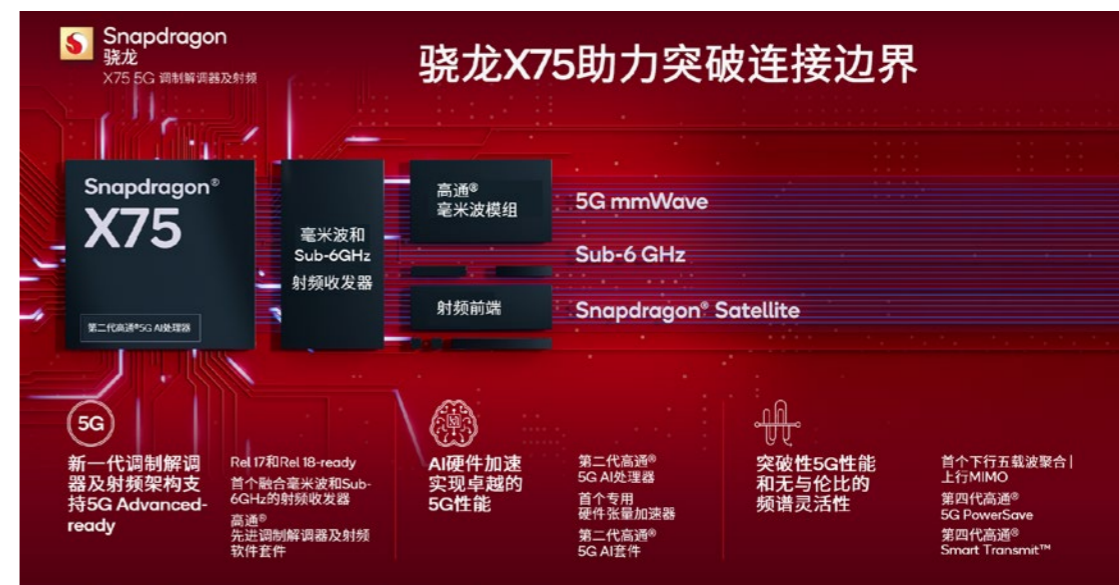
骁龙 X75 作为全球首个 5G Advanced-ready 调制解调器及射频系统，引入了全新架构、全新软件套件和多项全球首创特性，助力突破蜂窝连接边界，包括网络覆盖、时延、能效和移动性。骁龙 X75 是首个采用专用硬件张量加速器的调制解调器及射频系统，其 AI 性能提升至前一代产品的 2.5 倍以上，支持更高阶的矩阵处理和更复杂的 AI 模型。

As the world's first 5G Advanced-ready modem-RF system, Snapdragon X75

introduces a new architecture, a new software suite and includes numerous world's first features to push the boundaries of connectivity including coverage, latency, power efficiency and mobility. Snapdragon X75 is the first modem-RF system with a dedicated hardware tensor accelerator, enabling over 2.5 times better AI performance compared to the previous generation product, and supporting higher-order matrix processing and more complex AI models.

骁龙 X75 还支持多项先进特性，包括：全球首个面向毫米波频段的十载波聚合，全球首个 Sub-6GHz 频段下行五载波聚合和 FDD 上行 MIMO；面向毫米波和 Sub-6GHz 频段的融合射频收发器；先进调制解调器及射频软件套件进一步提升用户场景的持续性能表现；支持在两张 SIM 卡上同时使用 5G/4G 双数据连接等。

Besides, Snapdragon X75 enables many advanced features, including the world's first 10-carrier aggregation for mmWave, 5x downlink carrier aggregation and FDD uplink MIMO for Sub-6 GHz bands, converged transceiver for mmWave and Sub-6 GHz, advanced modem-RF software suite further improving sustained performance across user scenarios, 5G/4G Dual Data on two SIM cards simultaneously.



骁龙 X75 将先进 5G 技术扩展至各类终端和众多行业

Snapdragon X75 expands the advanced 5G technologies to all kinds of devices and many industries

当前，全球数字经济发展以数字化为关键生产要素，5G 是实现数字社会的重要基础设施。5G Advanced 作为 5G 演进的第二个阶段，将支持数据通信以外的功能，从而进一步增强用户体验。

Today, digitization is a key factor of production in the global digital economy, and 5G is an important infrastructure for digital society. 5G Advanced, the second phase of 5G evolution, will support capabilities beyond data communications that can further enhance user experiences.

2023 年 2 月，高通基于骁龙 X75 推出全球认证的模组参考设计。仅在骁龙 X75 发布两周内，移远通信、美格智能、广和通等多家中国厂商就推出了搭载骁龙 X75 的 5G 模组。

In February 2023, Qualcomm announced the Snapdragon X75-based globally certified reference design. Just in two weeks after the launch of Snapdragon X75, many Chinese companies including Quectel, MeiG, and Fibocom have unveiled 5G modules powered by Snapdragon X75.

基于高通与中国生态伙伴的紧密协作，骁龙 X75 正将先进的 5G 技术和特性扩展至各类终端和众多行业。智能手机、移动宽带、汽车、计算、工业物联网、固定无线接入和 5G 企业专网等广泛用例将在骁龙 X75 的助力下，快速迈入 5G Advanced。

Building on close collaboration between Qualcomm and its Chinese ecosystem partners, Snapdragon X75 is expanding the advanced 5G technologies and features to all kinds of devices and many industries. Snapdragon X75 empowers a wide spectrum of use cases including smartphones, mobile broadband, automotive, compute, industrial IoT, FWA, and 5G private networks to rapidly move towards 5G Advanced.



骁龙 X75 打造“基础赋能型连接平台”典范，赋能产业数字化升级

Snapdragon X75 sets the example of "basic enabling connectivity platform" to empower industrial digitalization and upgrading

5G 是加速产业结构优化升级、助力经济高质量发展的关键动力。作为基础赋能型连接平台，骁龙 X75 将助力开启 5G 下一阶段发展。

5G is a key driver for accelerating industrial structure optimization and upgrading as well as spurring high-quality economic development. As a basic enabling connectivity platform, Snapdragon X75 will spark the next phase of 5G.

在技术侧，5G-Advanced 使 5G 的带宽速度和连接密度分别提升 10 倍，将时延进一步降低 10 倍。骁龙 X75 率先引入 5G-Advanced 等面向未来的 5G 特性，并且能够通过软件升级快速采用 5G Advanced 新特性。骁龙 X75 首次采用专用硬件张量加速器，并引入 5G AI 套件，进一步释放“利用 AI 技术提升 5G 性能”的创新潜力和应用价值。

From the perspective of technology improvement, 5G Advanced will increase bandwidth speed and connection density of 5G by 10 times respectively, and further reduce latency by 10 times. Snapdragon X75 first introduces future-proof 5G features such as 5G Advanced and enables rapid adoption of new 5G Advanced features with a software-upgradeable architecture. Snapdragon X75 is the first modem-RF system with a dedicated hardware tensor accelerator, and it introduces 5G AI suite, further unleashing the innovation potential and application value of "improving 5G performance with AI technologies".

在产业侧，正值 5G 商用四周年，5G 迈入应用规模化发展新阶段，成为赋能千行百业、带动经济社会高质量发展的驱动力量。高通公司通过骁龙 X75 提供强大的连接平台支持，携手广泛产业的生态伙伴，共同推动产业结构升级和数字化转型。

From the perspective of industrial upgrading, 5G has developed into a new phase of application development at scale four years after its commercialization in China, and has become a driving force to empower industries and promote high-quality economic and social development. With Snapdragon X75, Qualcomm provides a powerful connectivity platform and works with ecosystem partners from a wide range of industries to jointly facilitate industrial structure upgrading and digital transformation.



骁龙 X75 实现全球最快 5G Sub-6GHz 传输速度，创造载波聚合连接纪录

Snapdragon X75 achieves the world's fastest 5G speed with Sub-6 GHz bands, and sets a record for carrier aggregation

骁龙 X75 支持包括基于 TDD 频段的四载波聚合以及 1024QAM 在内的先进 5G 特性，在 5G 独立组网网络配置下实现了高达 7.5Gbps 的下行传输速度，该成果创造了 Sub-6GHz 频段全球最快的 5G 传输速度纪录。

Snapdragon X75's advanced 5G capabilities of 4x carrier aggregation (CA) on TDD bands and 1024 quadrature amplitude modulation (QAM) enable a 7.5 Gbps downlink speed with a 5G standalone network configuration, setting the world's fastest 5G speed record with Sub-6 GHz spectrum.

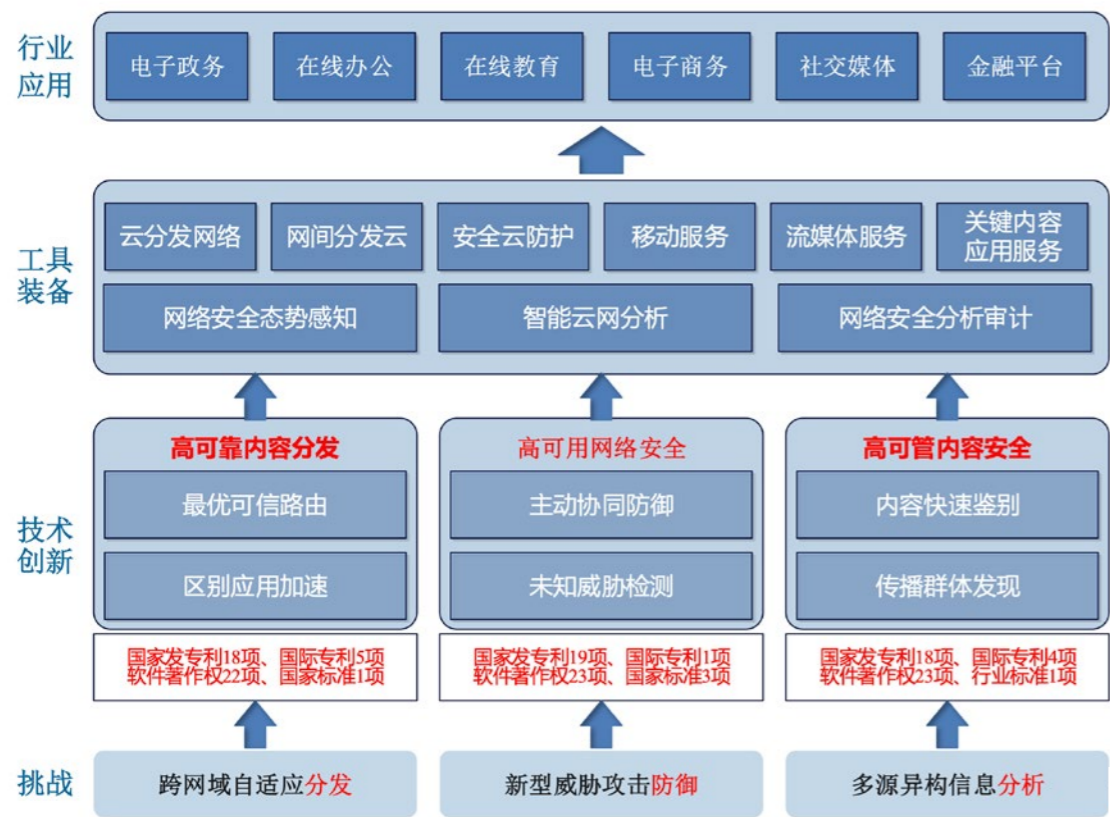
此外，骁龙 X75 实现了全球首个在 FDD 频段运行两路上行载波和四路下行载波并发的 5G 载波聚合连接，为未来提升 5G 性能和灵活性铺平道路。

Besides, Snapdragon X75 achieves the world's first simultaneous 5G 2x uplink and 4x downlink carrier aggregation for FDD spectrum, paving the way for the future of 5G performance and flexibility.

5G ADVANCED-READY

大规模云网融合系统内容高效可靠分发与主动防御技术研发及产业化

Research and Development and Industrialization of Efficient, Reliable Distributed Content and Proactive Defense Technologies for Large-scale Cloud-network Convergence Systems



● 项目总体方案架构
● Overall Architecture of the Project

上海交通大学
Shanghai Jiaotong University

网宿科技股份有限公司
Wangsu Science and Technology Co., Ltd.

奇安信科技集团股份有限公司
Qi'anxin Group Co., Ltd.

科来网络技术股份有限公司
Kelai Network Technology Co., Ltd.

上海鹏越惊虹信息技术发展有限公司
Shanghai Pengyuejinghong Information Technology Development Co., Ltd.



引言

项目突破了大规模云网融合系统高可靠内容分发、网络攻击协同防御和信息内容快速精准鉴别等三方面关键技术，研制了9大类云网内容分发与主动防御工具装备、构建了全球智能分发平台、形成了19个行业一体化解决方案。

Introduction

The project has made breakthroughs in three key technologies for large-scale cloud-network convergence systems: highly reliable content distribution, coordinated cyber-attack defense, and rapid and accurate identification of information content. It has developed 9 categories of tools and equipment for cloud-network content distribution and proactive defense, built a global intelligent distribution platform, and formed 19 industry-integrated solutions.

超大规模云网融合系统的内容自适应分发、多元网络攻击协同防御以及全流程多方位内容安全分析监管

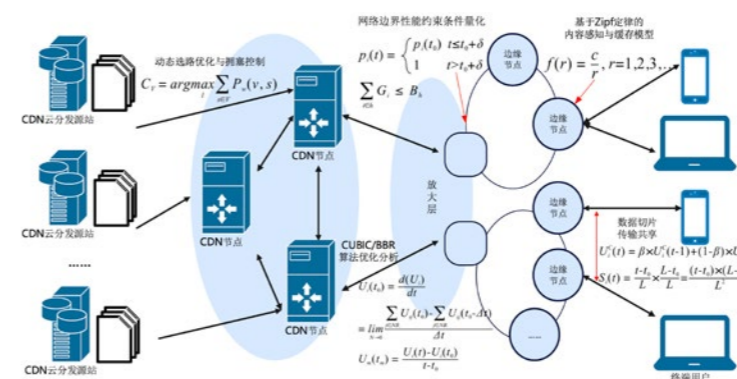
Adaptive Content Distribution, Collaborative Multi-Vector Cyber Attack Defense, and Omnidirectional Content Security Analysis and Regulation Throughout the Process for Ultra-Large-Scale Cloud-Network Convergence Systems

成果有三方面的技术创新：

在超大规模云网融合系统内容自适应分发方面，项目提出了内容自适应分发技术，设计了随机网络边界性能约束条件的量化方法，引入了动态可信路由优化技术，在CDN网络层线路状态探测与动态选路优化领域取得显著提升，同时还提出了多元异构应用通用时延反馈评估方法。

The results have three aspects of technical innovation:

In adaptive content distribution for ultra-large-scale cloud-network convergence systems, the project proposed adaptive content distribution technology, designed a quantification



● 长期对标 CDN 发明人创办的 CDN 行业国际龙头 Akamai (阿卡迈)，提出了全网节点实时状态加权制导的动态选路优化技术，以及分级分类配置驱动的区别应用加速策略，突破了多媒体信息跨网跨域高效可信加速传输难点

● With long-term benchmarking against Akamai, founded by the inventor of CDN and the international leader in the CDN industry, the project proposed dynamic route optimization technology guided by real-time weighted node status across the network, as well as differentiated application acceleration policies driven by hierarchical classification and configuration, breaking through the difficulties in efficient and reliable cross-network cross-domain acceleration of multimedia information transmission

method for random network boundary performance constraints, and introduced dynamic trustworthy routing optimization technology, achieving significant improvements in network layer circuit state detection and dynamic route optimization for CDN networks. It also proposed a universal latency feedback evaluation method for diverse heterogeneous applications.

在云边一体化多元网络攻击协同防御方面，项目引入了跨层次多协议流量监测与协同防御技术，解决了DDoS攻击防御的跨网资源调度问题。项目首次提出了基于动态图计算的多源异构网络安全大数据聚合分析方法，解决了高级持续性威胁防御的跨域协作共享问题。

In integrated multi-vector cyber attack collaborative defense for cloud-edge integration, the project introduced cross-layer multi-protocol traffic monitoring and collaborative defense technology, resolving cross-network resource scheduling issues in DDoS attack defense. The project first proposed a security big data aggregation and analysis method based on dynamic graph computing for multi-source heterogeneous networks, resolving cross-domain collaboration and sharing issues in advanced persistent threat defense.

在超大规模云网融合系统的全流程多方位内容安全分析监管方面，项目发明了融合轻量级深度学习算法与智能运算集群架构的多模态内容分析理解与快速检测技术，并提出了以广域内容分发为中心的信息传播群体行为分析技术。

In omnidirectional content security analysis and regulation throughout the process for ultra-large-scale cloud-network convergence systems, the project invented a multi-modal content analysis, understanding and rapid detection technology integrating lightweight deep learning algorithms and intelligent computing cluster architectures. It also proposed a crowd behavior analysis technology centered on wide-area content distribution for information dissemination.

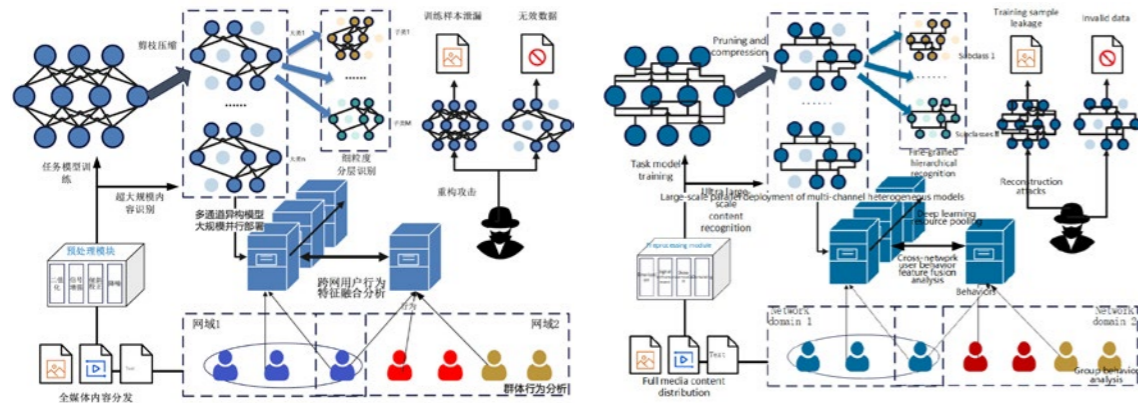
高效内容分发、国家基础设施安全、民生工程支持、犯罪案件侦破、会议活动网络安全保障和人才培养

Efficient Content Distribution, National Infrastructure Security, Public Service Project Support, Crime Investigation and Solving, Conference and Event Cybersecurity, and Personnel Training

项目成果在近三年内实现了巨大的经济和社会效益，其中包括新增销售额 116.51 亿元、利润 15.25 亿元，以及创收外汇 159 万美元。主要反映在以下六个方面：通过高效内容分发服务支撑了央视网、字节跳动、腾讯视频、爱奇艺、芒果 TV 等平台，实现了海量内容高速分发；为交通、金融、电商等国家重要基础设施提供网络安全保障，为 12306、腾讯视频、字节跳动等应用提供安全服务；保障民生工程内容安全，为央视春晚、北京冬奥会、俄罗斯世界杯等重要网络直播提供内容安全保障；协助公安机关成功破获多起新型涉网黑灰产犯罪案件，涉案金额超过 2.32 亿元；参与国家及社会重要会议活动期间的网络空间安全保障工作；培养了超过 2500 名本科生和近 1900 名研究生，开展了近万人次的培训，推动网络空间安全青少年科普教育。

The project results have achieved huge economic and social benefits in the past three years, including 11.651 billion RMB in new sales, 1.525 billion RMB in profits, and 1.59 million USD in foreign exchange revenue. This is mainly reflected in six aspects: supporting platforms like CCTV.com, ByteDance, Tencent Video, iQiyi, and Mango TV to achieve

high-speed distribution of massive content through efficient content delivery services; providing network security guarantees for important national infrastructure like transportation, finance, and e-commerce, and providing security services for applications like 12306, Tencent Video, and ByteDance; securing public service project content safety, providing content security guarantees for important live streams like the CCTV Spring Festival Gala, Beijing Winter Olympics, and FIFA World Cup in Russia; assisting public security agencies in successfully cracking down on new types of internet-related black and gray production crimes, with cases involving over 232 million RMB; participating in network security protection during major national and social events and conferences; training over 2,500 undergraduates and nearly 1,900 postgraduates, carrying out nearly 10,000 training sessions, and promoting popular science education on cybersecurity among teenagers and youth.



● 形成了以广域内容分发为中心的信息传播群体行为分析方法，推动我国网络信息安全分析能力实现“被动过滤监测—主动分析发现—快速精准鉴别”的跨越式发展，协助公安机关成功破获多起新型涉网黑灰产犯罪案件

● An information dissemination crowd behavior analysis method centered around wide-area content distribution has been formed, promoting China's online information content security analysis capabilities to achieve a leapfrog development from "passive filtering and monitoring" to "proactive analysis and discovery" to "rapid and accurate identification", assisting public security agencies in successfully cracking down on new types of internet-related black and gray production crimes

在内容分发、网络安全和社会稳定领域取得显著影响，为全球内容分发和网络安全提供了关键支持

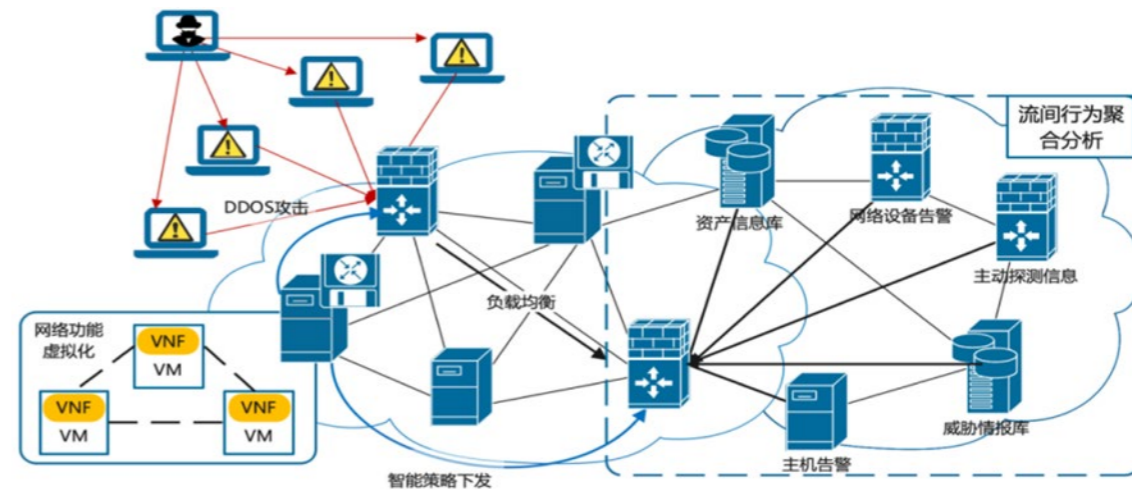
Achieving Significant Influence in Content Distribution, Cybersecurity and Social Stability, Providing Critical Support for Global Content Delivery and Cybersecurity

该项目成功研制了 9 大类云网内容分发与主动防御工具装备，搭建了全球庞大的服务平台，日均分发超过 123 亿个流媒体文件、处理万亿级内容服务请求，服务规模中国第一、全球第二，为中国互联网百强企业和

15000+ 政企、教育、金融、交通等行业用户提供高效可靠的全球内容分发、网络攻击防御和海量信息鉴别服务，有效支撑了全球重大会议活动期间的大规模云网融合系统网络空间安全。项目成果应用于中国领先的内容分发公司网宿科技，成功抵御最高强度 DDoS 攻击（峰值流量达 2.09Tbps），保障了视频内容提供商的高效可靠运行和非法内容阻断，营造了清朗网络空间。此外，项目成果还应用于中国政府部门和大型企事业单位，提供了网络高级持续性威胁检测与处置保障，助力成功破获多起新型涉网诈骗和黑灰产重大案件，涉案金额过亿。项目的影响力跨足了内容分发、网络安全、社会稳定和刑事侦破等多个领域，为全球内容分发和网络安全提供了关键支持。

This project has successfully developed 9 categories of cloud-network content distribution and proactive defense tools and equipment, building a huge global service platform that distributes over 12.3 billion streaming media files per day and handles trillions of content service requests. With the largest service scale in China and second largest globally, it provides efficient and reliable global content distribution, cyber attack defense and massive information identification services to China's top 100 internet companies and over 15,000 government, corporate, education, finance, transportation and other industry users, effectively supporting the network security of ultra-large-scale cloud-network convergence systems during major global conferences and events. The project

results have been applied to China's leading content delivery company Wangsu Science and Technology, successfully defending against the highest intensity DDoS attacks (with peak traffic reaching 2.09Tbps), ensuring efficient and reliable operations for video content providers and blocking illegal content, fostering a clear online space. In addition, the project results have also been applied in Chinese government departments and large enterprises, providing advanced persistent threat detection and response security, assisting in the successful cracking down of several new types of internet fraud and black/gray industry major cases, with case values exceeding 100 million RMB. The project's influence spans content distribution, cybersecurity, social stability and criminal investigation fields, providing critical support for global content delivery and cybersecurity.



● 充分利用大规模云网融合系统的资源弹性灵活、信息多源异构优势，实现了超大规模云网融合环境 DDoS 攻击防御跨网资源调度和高级持续性威胁跨域协同防御，有效支撑了国内外重大会议活动期间的大规模云网融合系统网络空间安全

● By fully leveraging the resource elasticity and flexibility as well as the multi-source heterogeneous information advantages of large-scale cloud-network convergence systems, cross-network resource scheduling for DDoS attack defense and cross-domain collaborative advanced persistent threat defense have been achieved in an ultra-large-scale cloud-network convergence environment, effectively supporting network security of large-scale cloud-network convergence systems during major domestic and international conferences and events

IBM 生成式人工智能 watsonx: 企业级 AI 的未来

IBM watsonx: The Generative AI for Business



- IBM watsonx 数据及人工智能平台
- IBM watsonx Data and AI Platform

国际商业机器（中国）有限公司
International Business Machines Corporation



引言

为了满足企业级 AI 的需求，IBM 基于在 AI 领域数十年的积累，在今年五月率先发布了企业级 AI 与数据平台 watsonx。watsonx 不仅能帮助企业运用大模型和生成式 AI，同时，也能解决企业级 AI 应用的三大挑战：找到需要的数据、建立合适的模型、监管系统的运营。

Introduction

IBM announced its new enterprise-grade AI and data platform watsonx at its Think conference in May this year, to fulfill the demands of enterprise AI and put its decades-long AI expertise to work. Watsonx aims to address the three major challenges in enterprise AI, namely finding the right data, building the right models, and ensuring the right guardrails are in place.

助力企业将 AI 转化为核心生产力，降本增效、提高生产力、提升客户体验

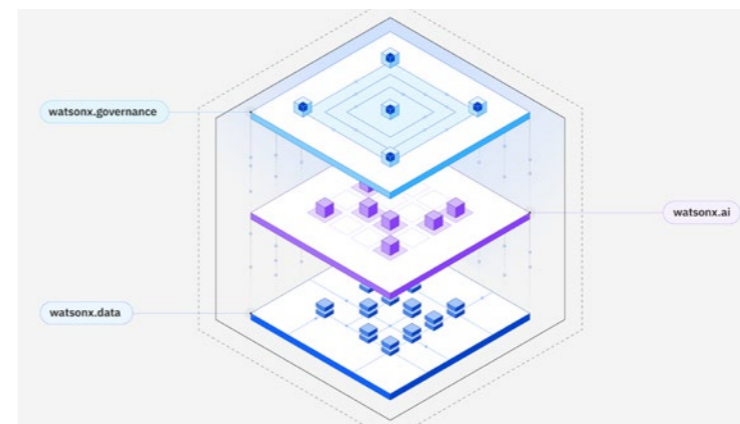
Help enterprises transform AI into core productivity, reduce costs and increase efficiency, improve productivity, and enhance customer experience

今天，“让 AI 成为核心生产力”已经成为企业的迫切需求。要实现这一目标，企业需要的是根据其业务需求和自身数据量身定制的生成式 AI 和模型。因此，企业应该更关注企业级基础模型（如针对特定业务领域训练的基础模型），降低 AI 应用成本，并通过微调模型实现更快部署，确保性能的同时保障合规与安全。

It is becoming clear today that companies need generative AI that can be translated into productivity. That means generative AI models tailored for specific business demands and deployed using proprietary data of enterprise users. Companies need to focus on foundation models built for industry-specific scenarios and easy to finetune, to accelerate and simplify AI deployment while ensuring the right governance is in place.

为了满足企业级 AI 的需求，IBM watsonx 提供了一个包括 AI 开发平台、湖仓一体方案和 AI 治理在内的工具包，帮助企业从数据的准备、模型及应用的构建，到 AI 全生命周期的治理，在跨业务场景中快速训练并部署 AI 能力。IBM 已经确定的早期用例包括数字劳动力、IT 自动化、应用程序现代化、安全性和可持续性，并持续打造上述业务领域的基础模型集合。

Watsonx, with its AI studio (watsonx.ai), lakehouse solution (watsonx.data), and AI governance platform (watsonx.governance), is uniquely positioned to facilitate the entire data and AI lifecycle, from data preparation to model development, deployment, and monitoring. The early AI use cases that IBM has identified range from digital labor, IT automation, application modernization, and security to sustainability.



- watsonx 及其核心组件
- watsonx and its core components

企业级 AI 应用的主要场景及 IBM 解决方案

Key scenarios of enterprise AI application and IBM's solutions

IBM watsonx 已在全球陆续上市，其中 AI 开发平台 watsonx.ai 和湖仓一体方案 watsonx.data 已上市，AI 治理平台 watsonx.governance 计划于 2023 年第四季度上市。

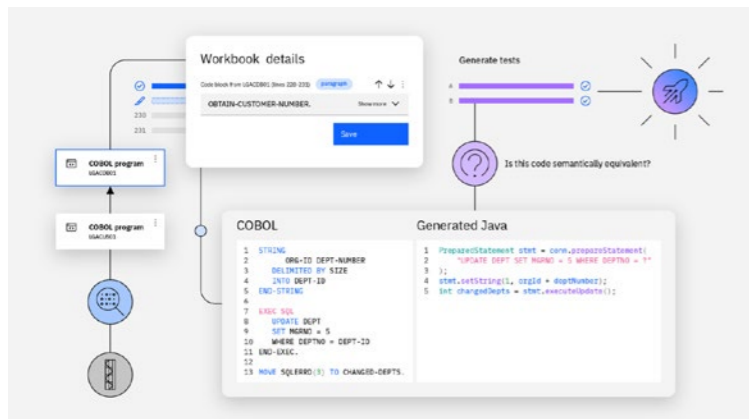
IBM watsonx is on the course of general availability worldwide: watsonx.ai and watsonx.data have been rolled out and watsonx.governance will be available in the fourth quarter of 2023.

在上市以前，已有来自各行各业的 150 多个用户参与了 watsonx 平台的测试和技术预览，其中 40 多个企业客户基于早期体验做了分享和推荐。IBM 看到，人工智能在不同行业的应用场景，无论是金融、制造、零售还是健康、教育、可持续发展，其最直接的价值就是优化业务流程，从而降本增效、提高生产力、提升客户体验。

Before its official launch in May, watsonx platform had been open to over 150 users from across industries for tech preview and test, with some 40 users giving their feedback and recommendations based on their initial experience. AI's immediate value that IBM sees in these use cases, from finance and manufacturing to retail and healthcare, is process optimization, which leads to lower cost, higher productivity, and better customer experience.

为此，IBM 致力为需要大语言模型（LLMs）、IT 自动化模型、数字劳动力模型、网络安全模型等专用模型的业务场景开发基础模型。此外，IBM 正将 watsonx.ai 基础模型注入其核心 AI 和自动化产品，以及咨询服务。在 IBM 将基础模型应用于客户的早期工作中，价值实现时间比传统的 AI 方法快 70%。

To this end, IBM is devoted to developing foundation models for businesses with large language models (LLMs), IT automation models, digital labor models, cybersecurity models, and many more to come. In addition, IBM is actively infusing watsonx.ai foundation models in its major AI and automation software solutions as well as its consulting services. In IBM's early work applying basic models with clients, IBM has watched clients time to value go up to 70% faster than with a traditional AI approach.



● watsonx Code Assistant 帮助主机开发人员提高编程效率
● watsonx Code Assistant boosts IBM Z developers' productivity

拥抱开源、开放，与合作伙伴生态携手共创

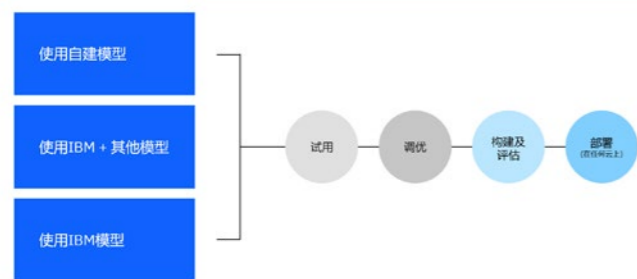
Embrace an open-source approach and co-create with ecosystem partners

遵循 IBM 的开源、开放和混合云与人工智能发展战略，watsonx 采用了开源、开放和云原生技术。IBM 积极参与并捐赠 AI 开源项目，例如在 Hugging Face AI 开源社区中贡献基础模型和数据集。IBM 基于开源和开放的理念设计了全栈企业级 AI 技术平台，使用户能够透明地训练、优化、推理和管理 AI 模型，并同时屏蔽了模型的异构性。

Following IBM's strategy of open source, openness, and hybrid cloud in the development of artificial intelligence, watsonx adopts open source, openness, and cloud-native technologies. IBM actively participates in and contributes to AI open-source projects, such as providing foundational models and datasets in the Hugging Face AI open-source community. IBM has designed a full-stack enterprise-grade AI technology platform based on open source and openness principles, allowing users to transparently train, optimize, reason, and manage AI models while abstracting away model heterogeneity.

IBM 拥有全面的基于机器学习和基础模型的企业级 AI 产品组合，并借助广泛的合作伙伴生态，已经部署到 20 多个行业的众多用户当中。例如，SAP 和 IBM 咨询合作打造的 25 个联合智能行业解决方案为全球客户提供

未来，企业将在多个云上使用多个模型，IBM watsonx 可以让 AI 成为企业的核心生产力



● watsonx 全面拥抱开源开放
● watsonx fully embraces open source



AI 驱动的洞察和自动化能力，从而提升客户体验。

IBM is actively bringing its enterprise-grade AI solutions to more than 20 industries with the "power of ecosystem", such as the 25 intelligent solutions co-developed by IBM Consulting and SAP that provide clients with AI-powered insights and automated capabilities.

将信任置于 AI 战略的核心

Putting trust at the core of AI strategy

IBM 认为，值得信赖的 AI 有赖于五大支柱：可解释性、公平性、稳健性、透明度和隐私性。IBM 设计 watsonx 时遵循这些信任的核心原则，同时尽可能使其易于访问。

IBM believes that there are five pillars to trustworthy AI: explainability, fairness, robustness, transparency, and privacy. IBM has designed watsonx to adhere to these core principles of trust while being as accessible as possible.

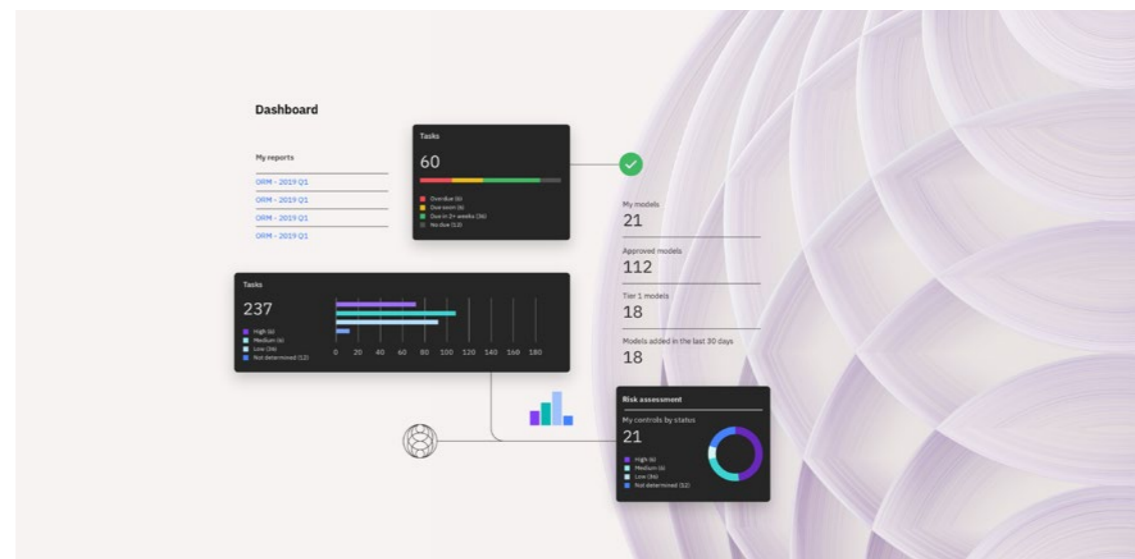
watsonx.governance 组件是一个自动化的数据和模型生命周期解决方案，用于制定策略、分配决策权并确保组织对风险和投资决策负责。watsonx.governance 采用软件自动化来帮助增强客户降低风险、帮助满足监管要求和解决道德问题的能力，使得客户无需切换数据科学平台而产生过高的成本，哪怕是使用第三方工具开发的模型。它使企业能够自动化和整合多个工具、应用程序和平台，同时可以记录数据集、模型、相关元数据和管道的来源。

The watsonx.governance component is an automated data and model lifecycle solution for developing strategy, assigning decision-making authority, and ensuring that organizations are accountable for risk and investment decisions. watsonx.governance uses software automation to help enhance customers' ability to reduce risk, help meet regulatory requirements, and address ethical issues, eliminating the prohibitive cost of switching data science platforms, even for models developed using

third-party tools. It enables enterprises to automate and integrate multiple tools, applications, and platforms, while documenting the origin of datasets, models, associated metadata, and pipelines.

通过提供有助于安全和保护客户隐私的机制，并主动检测模型偏差和漂移，watsonx.governance 可帮助组织满足道德标准并主动管理风险和声誉。法规可以被转化为规则和业务流程，以帮助确保合规性，而可定制的报告和仪表板则有助于保持利益相关者的可见性和协作。

By providing the mechanisms to help secure and protect customer privacy, and proactively detect model bias and drift, watsonx.governance helps organizations meet ethics standards and proactively manage risk and reputation. Regulations can be translated into policies and business processes to help ensure compliance, while customizable reports and dashboards help maintain stakeholder visibility and collaboration.



● watsonx.governance 工作界面预览
● Preview of the watsonx.governance working interface

世界互联网大会
领先科技奖收录成果集

Collection of Shortlisted Achievements of
World Internet Conference Awards for
Pioneering Science and Technology

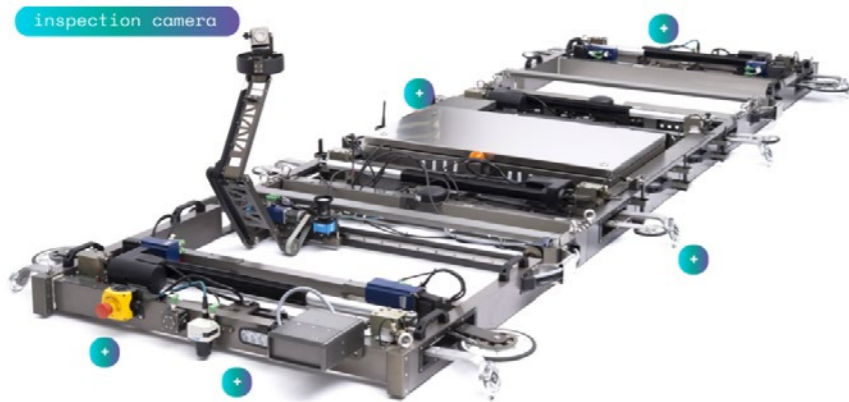
世界互联网大会 领先科技奖获奖成果

Leading Achievements of World Internet Conference
Awards for Pioneering Science and Technology

工程研发组 Engineering Research and Development

ARGO：机车车辆的自主检查机器人

ARGO：Autonomous Inspection of Rolling Stocks



下一代机器人智能制造有限责任公司
Next Generation Robotics Company



引言

ARGO 是下一代机器人公司（Next Generation Robotics）制造的新型轨道车辆检查机器人，用于普通轨道车辆的自主安全检查。通过人工智能算法进行预测性维修和高精度重复操作，进而取代当前目视检查程序，以提高列车安全性。

Introduction

ARGO is a new railcar inspection robot manufactured by Next Generation Robotics for autonomous safety inspections of general railcars. Predictive maintenance and high-precision repetitive operations are performed through artificial intelligence algorithms, which in turn replace current visual inspection procedures to improve train safety.

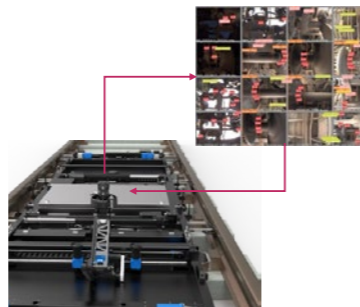
通过人工智能辅助预测性维护，适用于标准轨道

Predictive maintenance assisted by artificial intelligence for standard track

ARGO 是一种可对列车进行自主安全检查的新型机器人。它可以取代目前由操作员在维修现场对坑轨、检查坑进行的目视检查程序，以提高列车的安全性，并通过自动化和相关数据数字化的方式实现更高频次、更高精度操作。该机器人可在轨道内运行，能够从底部对列车进行安全检查，通过人工智能算法检查制动片、螺栓、制动盘、列车接头等关键部件，从而实现与铁路基础设施的无缝集成。得益于机器人技术与人工智能的结合，ARGO 可以实现预测性维护过程。

ARGO is a new robot that performs autonomous safety inspections of trains. ARGO can replace the current visual inspection procedures of pit rails and inspection pits carried out by operators at the maintenance site in order to improve train safety and enable higher-frequency and higher-precision operations through automation and digitization of

relevant data. The robot has been devised to be seamlessly integrated in the railway infrastructure, since it can run inside the tracks and is therefore able to perform safety inspections of the train from the bottom, checking critical parts like brake pads, bolts, brake disks, train joints, etc. by means of artificial intelligence algorithms. Benefiting from the combination of robotics and artificial intelligence, ARGO enables predictive maintenance processes.



● 通过人工智能辅助预测性维护
● Predictive Maintenance assisted by Artificial Intelligence

拥有超过 5 项国际专利，当前已在欧洲市场成功实现商业化

Covered by more than 5 international patents, currently successfully commercialized in the European market

ARGO 配备了复杂的计算机视觉算法，可以自动识别大量重要部件和故障部位，并进行自动检查，以确保列车安全。并且，ARGO 可适用于任何标准铁路，甚至无需将列车驶入专门的检查坑，可以在每个车站、每个检查坑进行安全检查，不再受空间的限制。而且，由于 ARGO 配备了激光雷达传感器，它可以安全地与人类互动。目前，下一代机器人公司已在欧洲市场申请专利并实现商业化。未来，这项技术将正式进入国际市场，为世界铁路行业的发展尽一份力。

The robot is equipped with sophisticated computer vision algorithms that can automatically recognize a large number of important parts and faults, and perform automatic inspections to ensure the safety of the train. The robot can be adapted to any standard railroad and does not even require trains to be driven onto specialized inspection pits. This allows safety inspections to be carried out at every station, at every pit, no longer limited by space. And, because the robot is equipped with LIDAR sensors, it can interact safely with humans. At present, the robot has been patented and commercialized by the Next Generation Robotics in the European market. In the future, this technology will formally enter the international market, and do its best for the development of world's railroad industry.



● 从传统的推车式机器人到集成传统商用机器人组件
● From traditional cart-based robot to the integration of traditional commercial robot components



● 将高度专业化的机器人无缝集成到铁路基础设施中
● Highly specialized robot seamlessly integrated into railway infrastructure

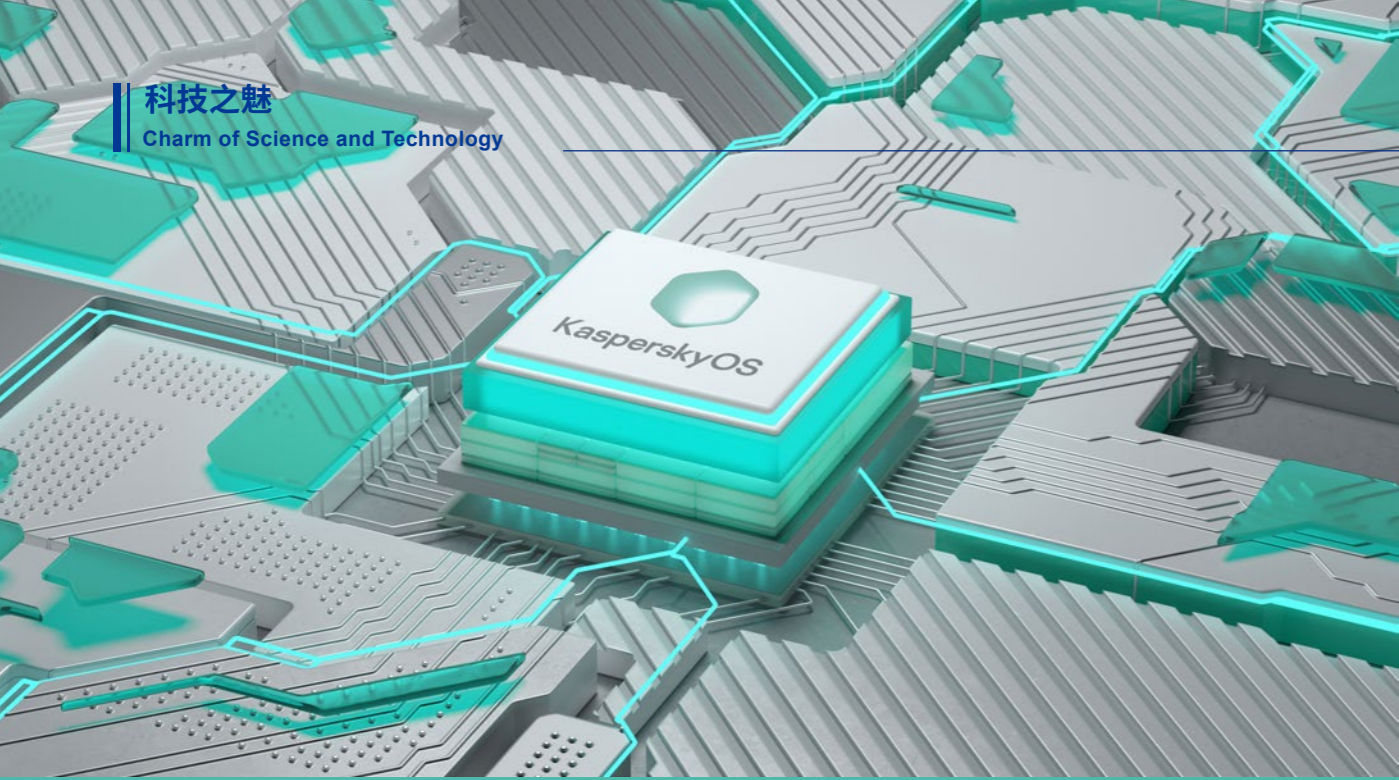
未来该技术将正式进入国际市场，加入铁路行业的发展进程

In the future, this technology will officially enter the international market and join the development process of the railway industry

在工业 4.0 与数字化的大背景下，ARGO 机器人致力于从数字化数据收集、人工智能数据分析和重复性操作三个方面完善工业 4.0 要求的预测性维护能力。首先，数字化数据收集。通过用于视觉检测的高清摄像机对列车底部进行全方位多角度的观测与数据收集。之后，通过智能导航和人工视觉算法对观测结果进行人工智能数据分析。最后，通过多次重复操作最终得到用于传感器精确定位的机器人解决方案。该解决方案未来将节省人力成本及资源，提高列车检查工作效率，同时将在包括中国在内的多个国家商业化，加入世界工业 4.0 与数字化发展进程。

In the context of Industry 4.0 and digitalization, ARGO Robotics is committed to perfecting the predictive maintenance capabilities required by Industry 4.0 in three areas: digital data collection, artificial intelligence data analysis and repetitive operations. Firstly, digital data collection. The HQ camera for visual inspection is used to observe and collect data from all directions and angles on the bottom of the train. Afterwards, the results are analyzed by artificial intelligence through intelligent navigation and artificial vision algorithms. Finally, a robotic solution for precise positioning of the sensors is created by repeating the process several times. This solution will save manpower costs and resources, improve the efficiency of train inspections, and will be commercialized locally in China, joining World's Industry 4.0 and digital development process.





卡斯基汽车安全网关 (基于卡斯基操作系统) Kaspersky Automotive Secure Gateway (based on KasperskyOS operating system)

卡斯基
Kaspersky

Airbiquity (OTAmatic 升级系统)
Airbiquity (OTAmatic update system)

AUTOSAR 联盟
AUTOSAR Consortium



引言

卡斯基汽车安全网关是下一代汽车的安全网关解决方案，可满足汽车架构内安全通信的关键需求。其 OEM 可在汽车的电子控制器单元中嵌入卡斯基汽车安全网关，从而能够打造稳健的网络免疫系统，确保使用 ISO/SAE 21434 标准时遵守联合国 R155 和 R156 汽车法规。

Introduction

Kaspersky Automotive Secure Gateway (KASG) is a secure gateway solution for next-generation vehicles that addresses the critical need for secure communication within the architecture of cars. By embedding KASG in the ECUs of the car, its OEM can establish a robust cyber-immune system that ensures compliance with UN R155 and R156 automotive regulations using ISO/SAE 21434.

“设计即安全”的操作系统提供安全保障
Secure-by-design KasperskyOS provides security guarantees

由于 OEM 的新技术和商业模式，汽车行业在 E/E 架构设计方面面临着挑战。汽车行业还因联合国 R155 和 R156 等法规而受到一定影响，此类法规要求采用设计即安全

系统。此外，对大量分级供应商进行管理，也提高了供应链安全方面的复杂性。而主动将安全措施直接集成至架构内，对于确保遵守法规并打造安全的联网车辆生态系统有着至关重要的意义。

The automotive industry faces challenges in E/E architecture design due to new technologies and business models of OEMs. It is also impacted by regulations like UN R155 and R156 which has the requirements for secure-by-design systems. Additionally, managing a large number of Tier suppliers adds complexity to supply chain security. Proactive integration of security measures directly into the architecture is crucial to ensure compliance with regulations and establish a secure ecosystem for connected vehicles.

卡斯基长期致力于解决如何使用不可信的组件创建可信赖的信息系统这一问题。卡斯基操作系统是一个构建网络免疫解决方案的平台，旨在为具有高信息安全要求的 IT 系统奠定基础，包括设计即安全系统的开发，可抵御各种已知的和新型网络攻击。

Kaspersky has long been working on the problem of how to create a trusted information system from untrustworthy components. KasperskyOS a platform for building Cyber Immune solutions, which is designed to serve as the basis for IT systems with high information security requirements, including the development of secure-by-design systems, rendering both known and new types of cyberattacks ineffective.

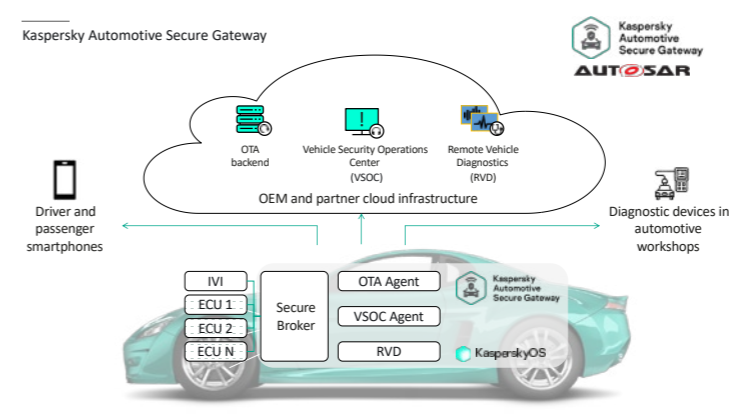
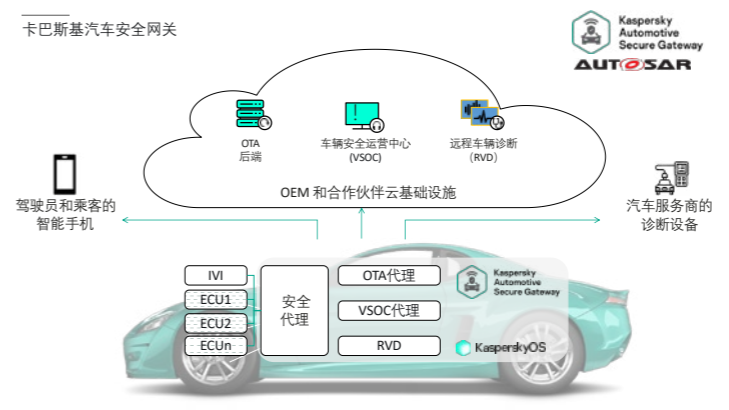
卡斯基操作系统的独特架构使 IT 产品具备网络免疫功能成为可能。这些产品几乎不可能被入侵或影响其关键功能的使用，即使在恶劣的环境里也能持续可靠的运行。以卡斯基操作系统为基础创建的网络免疫解决方案无需额外配置（应用型）安全功能。

The distinctive architecture of KasperskyOS makes it possible to create IT products that are Cyber Immune. It is virtually impossible to hack these products or affect their critical functions, and they continue to function reliably even in hostile environments. Cyber Immune solutions built on KasperskyOS do not need additional (applied) security features.

执行自适应标准，推动行业创新 KASG implementing adaptive standards and fostering innovation of the industry

卡斯基汽车安全网关目前已广泛参与到各类车联网项目中。卡斯基汽车安全网关执行 AUTOSAR 自适应标准，提供了一个具备公共应用程序接口 (API) 的开放平台，让合作伙伴能够轻松将其车辆的 AUTOSAR 应用程序（包括开源应用程序）移植到卡斯基汽车安全网关。汽车行业可利用卡斯基汽车安全网关强化安全措施，确保联网车辆安全运行。卡斯基持续支持技术合作伙伴和开发者群体发展，不断推动汽车网络安全领域的创新。

Kaspersky Automotive Secure Gateway is actively involved in various automotive projects. Implementing the AUTOSAR Adaptive standard, KASG provides an open platform with publicly available APIs. This allows partners to easily port their automotive AUTOSAR applications, including open-source ones, to KASG. By leveraging KASG, the automotive industry can bolster security measures, ensuring the safe and secure operation of connected vehicles. Kaspersky continues to support the growth of technology partners and the developer community, fostering innovation in automotive cybersecurity.



卡斯基操作系统“天然的”安全性，已植根于该系统的架构和理念内。网络免疫是通过将系统划分为孤立的组件，并控制组件之间的相互作用来保证的。在设计阶段便指明了每个可允许操作的安全策略。仅系统管理员和应用程序开发人员许可的操作才能运行和工作。卡斯基操作系统与开发 IT 产品的方法相结合，为创建对网络威胁免疫的可信赖信息系统奠定了有效且坚实的基础。

The "innate" security of KasperskyOS is embedded in its architecture and philosophy. Cyber Immunity is ensured by dividing the system into isolated components and con-

trolling the interaction between them. At the design stage, security policies are defined that specify each permissible action. Only what is allowed by the system administrators and application developers can run and work. KasperskyOS, together with the methodology for developing IT products, serves as an effective and reliable basis for creating trusted information systems that are immune to cyber threats.



支持开放平台，促进行业发展

KASG supports open platforms and promotes the development of the industry

卡斯基汽车安全网关是一款尖端产品，旨在增强汽车电子控制单元的安全性及连通性。它促进了车载信息娱乐系统、云基础架构、移动应用和 4G、蓝牙、USB 和 WiFi 等外部接口之间实现的无缝通信。这款产品实现了网络免疫，且遵守联合国 R155 与 R156 法规，有效降低了网络安全风险，确保了汽车行业的合规性。

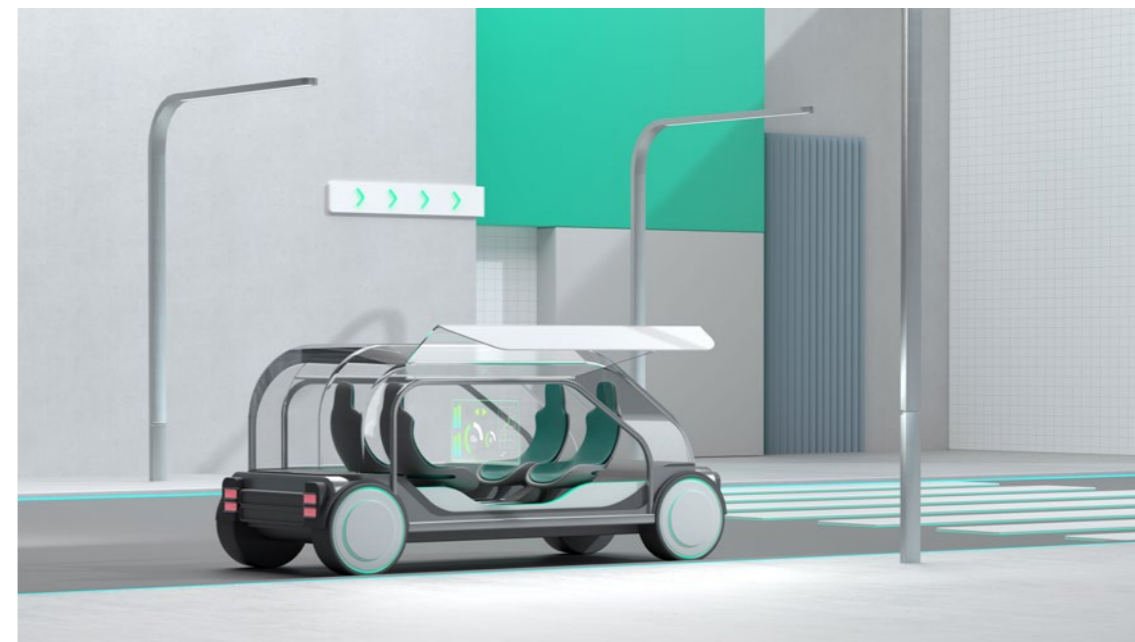
Kaspersky Automotive Secure Gateway, is a cutting-edge product designed to enhance the security and connectivity of electronic control units (ECUs) in automobiles. It facilitates seamless communication between the in-vehicle infotainment system, cloud infrastructure, mobile applications, and external interfaces such as 4G, Bluetooth, USB, and WiFi. By implementing cyber immunity and adhering to UN R155 and R156 regulations, KASG effectively reduces cybersecurity risks and ensures compliance within the automotive industry.

卡斯基汽车安全网关的影响力已经惠及到车辆功能和安全的各个

方面。它可以实现关键数据和消息的安全传输，包括电子控制单元配置数据、软件更新以及诊断功能的访问权限。其利用 AUTOSAR 自适应标准，且支持配备公开 API 的开放平台，促进了汽车应用程序（包括开源应用程序）之间的协作与兼容，促进了创新，并激励开发强大、安全且标准化的汽车解决方案。

The impact of Kaspersky Automotive Secure Gateway extends to various aspects of vehicle functionality and safety. It enables the secure transmission of critical data and messages, including ECU configuration data, software updates, and

access to diagnostic functions. By leveraging the AUTOSAR Adaptive standard and supporting an open platform with publicly available APIs, KASG promotes collaboration and compatibility among automotive applications, including open-source ones. This facilitates innovation and encourages the development of robust, secure, and standardized automotive solutions.



专利奖项鉴证网络免疫未来

Patents and awards authenticate the future of Cyber Immunity

卡斯基汽车安全网关已经获得了包括中国、美国及欧洲在内的 10 余项国际专利，并荣获 2022 年由俄罗斯国家技术倡议组织 (NTI) Autonet 颁发的“网联汽车的最佳解决方案”奖项。

Kaspersky Automotive Security Gateway has obtained more than 10 international patents, including in China, the United States and Europe, and has been awarded the "Best Solution for the Connected Vehicles" by NTI Autonet in 2022.

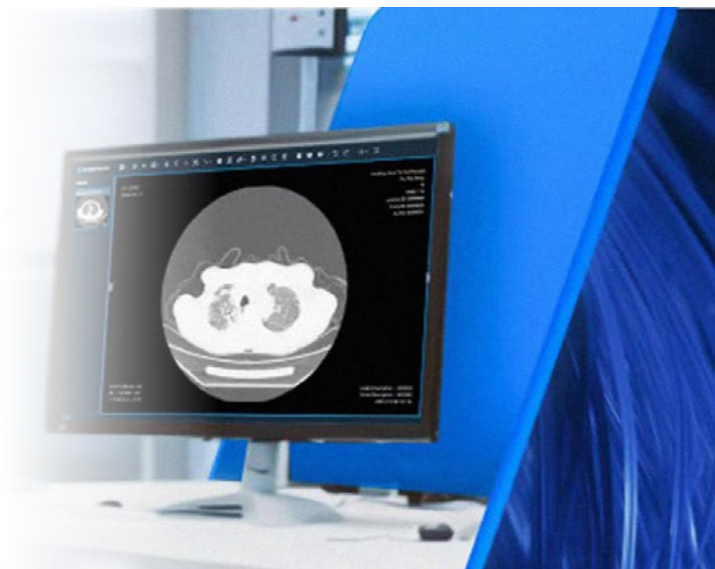
我们相信，未来的 IT 和信息安全的发展方向是网络免疫。网络免疫 IT 系统引领我们向更安全、更具韧性的数字世界又迈进了一步。卡斯基将继续以网络免疫方法为基础，不断打造战略技术合作伙伴关系。

We believe that Cyber Immunity is the future of IT and information security. Cyber Immune IT systems are bringing a more secure and resilient digital world closer. Kaspersky will continue to build strategic technological partnerships based on the Cyber Immune approach.



腾讯觅影数智医疗影像平台

Tencent AIMIS Medical Imaging Platform of Digital Intelligence



腾讯医疗健康(深圳)有限公司
Tencent Healthcare (Shenzhen) Co., Ltd.



引言

腾讯觅影数智医疗影像平台，专注数字医疗影像云端应用、科研及管理，搭载人工智能分析引擎，通过影像数据和业务流程的互联互通，为医疗机构提供产、学、研、管一体化医疗影像解决方案，助力医疗 AI 产学研协同创新。

Introduction

Equipped with an artificial intelligence analysis engine, Tencent AIMIS Medical Imaging Platform of Digital Intelligence focuses on cloud-based application, scientific research and management of digital medical images. Through the connectivity of image data and business processes, it provides medical institutions with a medical imaging solution that integrates industry, university, research and management, assisting industry-university-research collaborative innovation of medical AI.

推动中国医疗影像 AI 全链条创新

Promoting the Innovation on the Whole Chain of Medical Imaging AI in China

作为医疗数据最密集领域之一，医学影像与 AI 的结合有着广阔想象空间，但实际发展过程中，医疗影像 AI 面临数据来源分散、标注耗时、适用算法缺乏、产学研管结合难等诸多瓶颈。

As one of the most intensive fields of medical data, the combination of medical imaging and AI has a broad imagination. However, in the actual development process, medical imaging AI faces many bottlenecks such as dispersed data sources, time-consuming annotation, lack of applicable algorithms, and difficulty in industry-university-research-management cooperation.

“腾讯觅影数智医疗影像平台”，通过数字化及智能化升级，深耕医疗影像“产学研管”全链条创新，实现医疗影像 AI 的多场景、规模化应

用以及可持续发展。

Tencent AIMIS Medical Imaging Platform of Digital Intelligence, through digitalization and intelligent upgrading, is deeply engaged in the innovation on the whole chain of medical imaging in forms of industry-university-research-management cooperation, and realizes multi-scenario, large-scale application and sustainable development of medical imaging AI.

在业务应用层面，平台通过“影像云+影像 AI”的方式，激活远程诊断、远程会诊、远程示教查房、辅助诊断等数字影像应用。

At the business application level, the platform activates digital imaging applications such as remote diagnosis, teleconsultation, remote demonstration and ward round, and assisted diagnosis through the “Medical Imaging Cloud + Medical Imaging AI” approach.

在科研层面，依托“国家新一代人工智能医疗影像开放创新平台”，提供从数据脱敏、接入、标注，

到 AI 模型设计、训练、部署、应用的多模态医学影像及病理数据一站式平台。

At the scientific research level, relying on the National New Generation of Artificial Intelligence Open Innovation Platform for Medical Imaging, the platform provides a one-stop solution for multimodal medical imaging and pathology data, from data desensitization, access and labeling to AI model design, training, deployment and application.

此外，平台还形成了一套整体化的人工智能示教实训体系，并具备影像质控的统一标准，使信息安全有保障。

In addition, the platform has formed a set of holistic artificial intelligence demonstration and training system, and has a unified standard for image quality control, so that information security is guaranteed.



● 腾讯觅影数智医疗影像平台提供产、学、研、管一体化医疗影像解决方案

● Tencent AIMIS Medical Imaging Platform of Digital Intelligence provides a medical imaging solutions integrating industry, university, research and management

孵化三个 AI 临床器械、20 多个科研 AI

Incubating Three AI Clinical Devices and More than 20 Research AIs

依托“腾讯觅影数智医疗影像平台”，腾讯健康已成功打造了肺炎、青光眼、结肠三项临床级 AI 辅助诊断产品，并获批三类医疗器械注册证。

Relying on the Tencent AIMIS Medical Imaging Platform of Digital Intelligence, Tencent HealthCare has successfully built three clinical-grade AI-assisted diagnostic products for pneumonia, glaucoma, and colon, and has been approved for the registration of Class III medical devices.

其中，“肺炎 CT 影像辅助分诊及评估软件”在 2020 年新冠疫情最严峻的时刻，助力武汉大学附属中南医院影像科团队，为雷神山医院的 24000 多名患者进行肺部 CT 辅助诊断。

The Pneumonia CT Imaging Assisted Diagnosis and Evaluation Software helped the imaging team at Zhongnan Hospital of Wuhan University to perform CT lung diagnosis for more than 24,000 patients at Lei Shen Shan Hospital during the worst period of the COVID-19 pandemic in 2020.

“慢性青光眼样视神经病变眼底图像辅助诊断软件”及“结肠息肉电

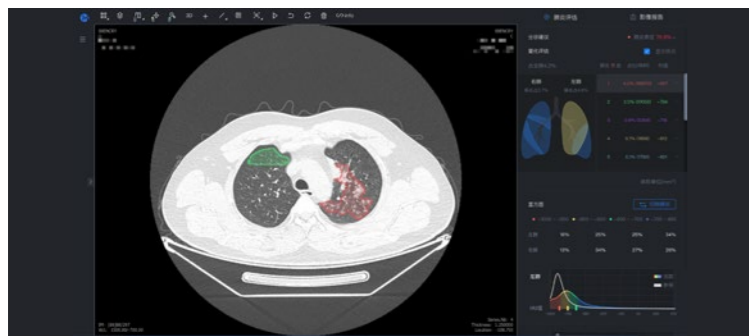
子内窥镜图像辅助检测软件”，分别通过了创新医疗器械产品注册，采用人工智能算法，为医生提供临床辅助分诊建议，助力提升大规模疾病筛查的检出率。根据临床试验，青光眼 AI 引擎能够降低漏诊率 20%，降低误诊率 2%；结肠 AI 引擎能够帮助医生提升息肉检出率 20% 以上。

The Glaucoma Artificial Intelligence Software and the Colon Polyp Electronic Endoscopy Image Assisted Detection Software have been registered as innovative medical device products. The software utilizes artificial intelligence algorithms to provide doctors with clinically-assisted triage recommendations, helping to im-

prove the detection rate of large-scale disease screening. According to clinical trials, the glaucoma AI engine was able to reduce the rate of missed diagnosis by 20% and the misdiagnosis rate by 2%; and the colon AI engine was able to help doctors improve the detection rate of polyp by more than 20%.

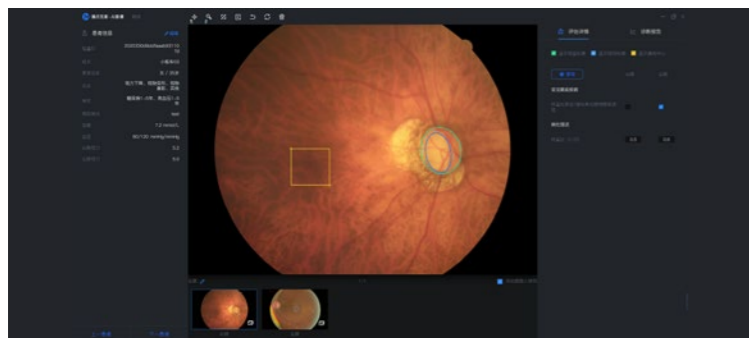
此外，“腾讯觅影数智医疗影像平台”还集成和开放了腾讯团队自研的20多种科研级别的AI引擎，涵盖糖尿病视网膜病变、脑胶质瘤、肝癌、乳腺钼靶、肺结节等疾病，供用户进行医学影像人工智能科研。

In addition, the Tencent AIMIS Medical Imaging Platform of Digital Intelligence also integrates and opens up more than 20 types of research-level AI engines developed by Tencent's team, covering diseases such as diabetic retinopathy, glioma, liver cancer, mammary gland molybdenum target, and lung nodules, for users to conduct AI research on medical imaging.



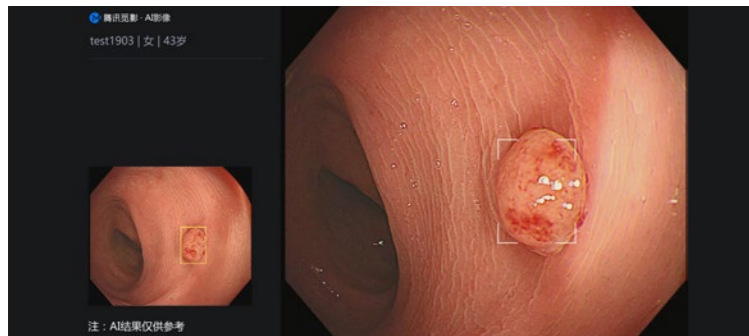
● 腾讯觅影肺炎 AI 曾在新冠疫情中支持抗疫前线

● Tencent AIMIS Pneumonia AI was used on the front lines during the COVID-19 pandemic



● 腾讯觅影青光眼 AI 能够降低漏诊率

● Tencent AIMIS Glaucoma AI can reduce missed diagnosis rate



● 腾讯觅影结肠 AI 帮助医生提升息肉检出率

● Tencent AIMIS Colon AI helps doctors improve the detection rate of polyp

AI 抗击新冠肺炎疫情获肯定

AI is Well-recognized for Fighting COVID-19

全面激活医疗 AI 科研与应用

Full Activation of Medical AI Scientific Research and Application

在科研合作上，腾讯觅影数智医疗影像平台已全面开放了20多种自研AI引擎，为17所高校与科研院所、23家公立医院以及33家科技企业提供医疗AI科研服务。助力国内病理诊断领域首家上市公司“安必平”建设宫颈液基细胞学AI数据库，发展宫颈细胞病理AI；携手全球领先的医疗器械及解决方案供应商迈瑞医疗开发“全自动外周血细胞形态学分析仪”，填补了国产空白，在包括意大利、西班牙的全球400多家医院完成装机。

In terms of scientific research cooperation, Tencent AIMIS Medical Imaging Platform of Digital Intelligence has fully opened up more than 20 types of self-developed AI engines, providing medical AI scientific research services for 17 universities and research institutes, 23 public hospitals, and 33 technology enterprises. Assisted Guangzhou LBP Medicine Science & Technology Co., Ltd, the first listed company in the field of pathology diagnosis in China, to build an AI database for cervical liquid-based cytology and develop cervical cytopathology AI; cooperated with the world's leading medical device and solution provider Shenzhen Mindray Medical to develop the "Fully Automated Peripheral Blood Morphology Analyzer", filling a gap in the domestic market, and completed the installation in more than 400 hospitals around the world, including Italy and Spain.

目前，腾讯觅影数智医疗影像平台已聚合形成了医疗影像AI的全场景应用，为医疗AI应用普及提供支撑，推动医疗影像服务的全面升级：在医生端，通过医疗影像浏览、多边影像协同、远程会诊、移动诊断等工具，为医生打造了智能工作台；在患者端，影像档案实

现长久存储，家庭成员档案共同管理，衔接线上问诊与转诊。

At present, the Tencent AIMIS Medical Imaging Platform of Digital Intelligence has aggregated and formed a full-scene application of Medical Imaging AI, providing support for the popularization of medical AI applications and promoting the comprehensive upgrade of medical imaging services. On the doctor's side, an intelligent workbench has been created for doctors through tools such as medical image browsing, multilateral image collaboration, remote consultation, and mobile diagnosis; on the patient's side, long-lasting storage of image files has been realized, and family members' files are co-managed to connect online consultation and referral.

此外，腾讯还一直致力于推动医疗AI的应用下沉，青光眼AI落地江西省赣州市于都县，为农村居民提供健康筛查，大幅提升眼底疾病筛查效率和检出率。

In addition, Tencent has also been committed to promoting the application of medical AI, such as landing the glaucoma AI in Yudu County, Ganzhou City, Jiangxi Province, which has dramatically improved the efficiency and detection rate of fundus disease screening by providing health screening for rural residents.



● 迈瑞医疗血细胞形态学分析仪搭载腾讯 AI，填补国产空白

● Mindray Blood Cell Morphology Analyzer with Tencent AI Fills Domestic Gap



● 江西省赣州市于都县村民接受青光眼 AI 筛查

● Villagers in Yudu County, Ganzhou City, Jiangxi Province, Received AI Screening for Glaucoma

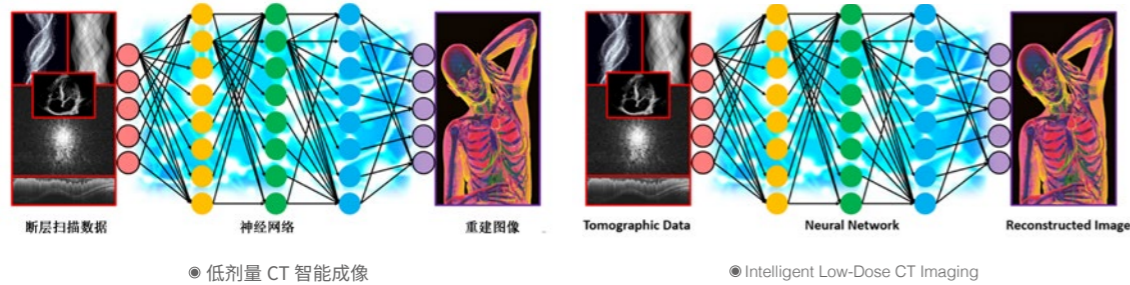
02 《科技之魅》 收录成果

Charm of Science
and Technology Collection

基础研究组 Basic Research

低剂量 CT 智能成像理论与方法

Theory and Methods of Intelligent Low-Dose CT Imaging



四川大学
Sichuan University

东南大学
Southeast University

成都市第六人民医院
Chengdu Sixth People's Hospital



引言

将低剂量 CT 成像与人工智能技术相结合，解决了低剂量 CT 图像非线性表示、先验表示和图像噪声分离等基础问题，建立了新的低剂量 CT 智能成像理论、方法和技术体系，提高了成像安全性、精准性和实时性。

Introduction

The combination of low-dose CT (LDCT) imaging with artificial intelligence technology can address fundamental issues in LDCT imaging, such as non-linear representation, prior representation, and image noise separation. This has led to the development of a new theory, methodology, and technical framework for intelligent LDCT imaging, thereby enhancing imaging safety, precision, and real-time performance.

国际领先的低剂量 CT 智能去噪与成像算法

World-Leading Low-Dose CT Intelligent Denoising and Imaging Algorithm

国际上首次将深度学习技术引入到低剂量 CT 成像领域，率先将深度学习模型与 CT 成像相结合，创新提出了系列以特征学习的低剂量 CT 图像处理方法；部分成果已成为国际低剂量 CT 图像后处理领域广泛使用的基准算法。

Internationally, it was the first time introducing deep learning techniques into the field of LDCT imaging. Leading the way to combine deep learning models with CT imaging, innovative series of feature learning-based LDCT imaging methods were proposed. Some of the achievements have become widely adopted benchmark algorithms in the field of LDCT post-processing.

国际上首次将传统低剂量 CT 迭代重建方法纳入到深度学习体系中，

有效保证了低剂量 CT 图像重建不引入新的伪影，同时使得深度迭代重建网络具备可解释性，速度、性能得到较大提升。

It was the first attempt internationally to incorporate traditional LDCT iterative reconstruction methods into the deep learning framework, effectively avoiding the introduction of new artifacts in the reconstruction process. Simultaneously, this achievement provides interpretability to deep iterative reconstruction networks, leading to significant improvements in speed and performance.

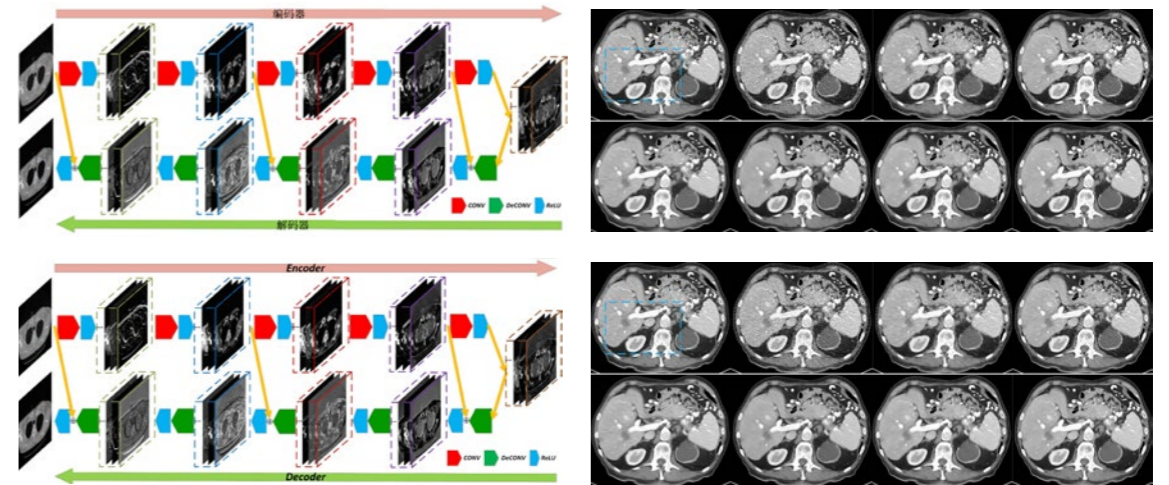
将稀疏表示以及低秩分解与高维能谱 CT 重建相结合，提出了多维联合稀疏表示的高维能谱 CT 图像重建方法，有效抑制噪声和伪影，提高算法精准性，加速成像过程。

Combining sparse representation and low-rank decomposition with high-dimensional spectral CT reconstruction. A novel multi-dimensional joint sparse representation-based high-dimensional spectral CT image reconstruction method was proposed. This effectively suppresses noise and artifacts, enhances algorithm precision, and accelerates the imaging process.

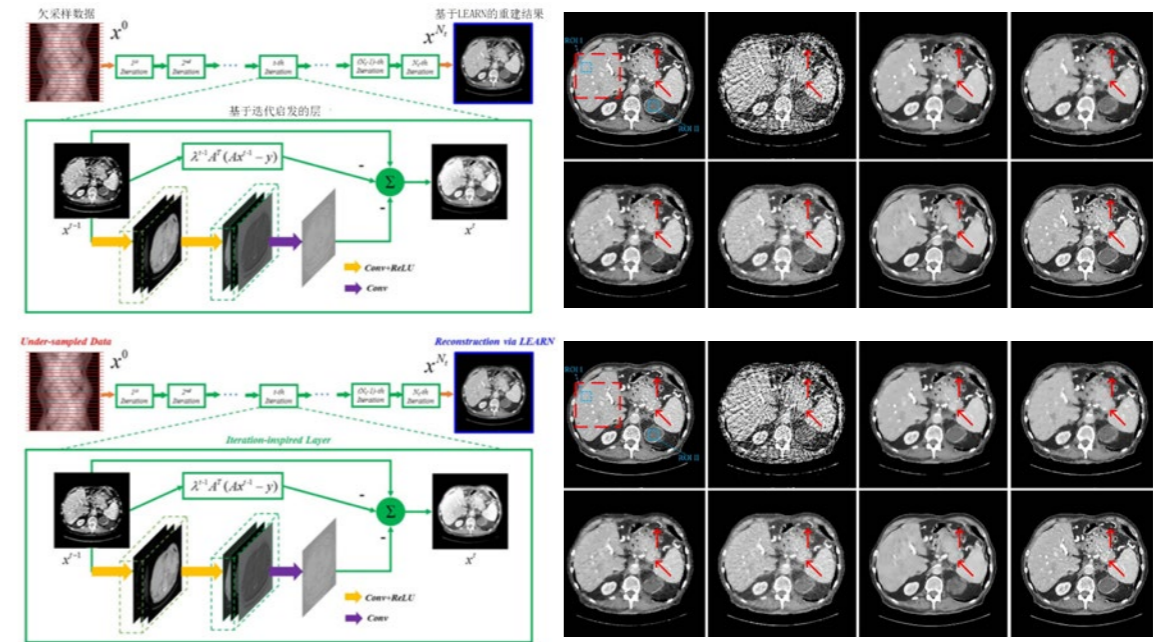
tation-based high-dimensional spectral CT image reconstruction method was proposed. This effectively suppresses noise and artifacts, enhances algorithm precision, and accelerates the imaging process.

在国际顶级期刊或会议上发表论文 60 余篇，其中 Google Scholar 总被引超过 7000 余次，ESI 高被引论文 6 篇。

Published over 60 papers in top-tier international journals and conferences, with a total of over 7,000 citations on Google Scholar, including 6 Essential Science Indicators (ESI) highly cited papers.



◎ RED-CNN 神经网络框架及成像结果比较
◎ Overall of the proposed RED-CNN and comparison of different imaging results



◎ LEARN 迭代重建网络框架及成像结果比较
◎ Overall of the proposed iterative reconstruction network LEARN and comparison of different imaging results

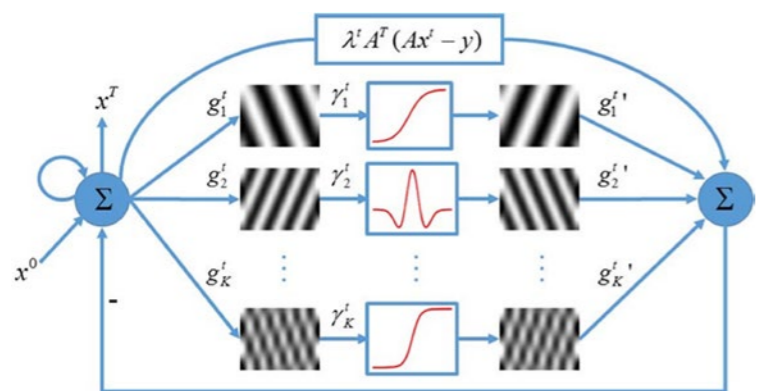
解决低剂量 CT 图像表示和图像噪声分离等基础问题

Addressing Fundamental Problems of Representation and Image Noise Separation in LDCT Image

非线性子空间表示的低剂量 CT 图像噪声分离机理发现及其意义：发现了基于非线性子空间表示的低剂量 CT 图像噪声分离机理，奠定了基于特征表示学习和图像噪声分离的低剂量 CT 图像后处理理论研究和方法基础，开辟了低剂量 CT 图像后处理研究新方向。

Discovery and Significance of Nonlinear Subspace-Based LDCT Image Noise Separation Mechanism: The discovery of the noise separation mechanism based on nonlinear subspace representation in LDCT images has laid the foundation for theoretical research and methods in the field of post-processing based on feature representation learning and noise separation. It has built a new research interest in the study of LDCT image post-processing.

可学习的 CT 图像先验表示体系及其重建方法创新：发现了 CT 图像内在先验表示原理，提出了可学习的先验表示体系，首次提出并建立了数据驱动下的可解释低剂量 CT 图像迭代重建理论与方法，开创发展了低剂



可解释低剂量 CT 图像迭代重建理论

Interpretable LDCT Image Iterative Reconstruction Theory

数字化 (SiPM) PET/CT
ScintCare PET/CT 720L



算法应用于明峰医疗 CT 设备

Algorithms were applied to MinFound CT equipment

量 CT 成像新方向。

Innovations in Learnable CT Image Prior Representation System and Reconstruction Methods: Discovered the intrinsic prior representation principles of CT images and proposed a learnable prior representation system. Pioneered the development of interpretable LDCT image iterative reconstruction theory and methods under data-driven frameworks, introducing a new research interest in LDCT imaging.

能谱 CT 图像重建的创新理论与方法：提出发展了能谱 CT 谱域线性校正匹配理论和结构性集群分析理论，提出了基于图像-能谱相似性先验表示的能谱 CT 图像重建理论和方法，有效推进了能谱 CT 设备的临床使用。

Innovative Theories and Methods for Spectral CT Image Reconstruction: The development of spectral domain linear correction theory and structural clustering analysis theory has been proposed. The theory and methods for spectral CT image reconstruction based on image-spectrum similarity prior representation have been introduced. These advancements have effectively promoted the clinical use of spectral CT equipment.

成果应用于国内 4 家医疗企业和 2 所三甲医院，新增产值约 1.92 亿元，利润 3050 万元，全程参与了抗击新冠疫情，完成肺部低剂量筛查约 5000 例。

The achievements have been applied in four domestic medical enterprises and two 3A hospitals, contributing to an additional revenue of approximately 192 million RMB and a profit of 30.5 million yuan. We were actively involved throughout the fight against the COVID-19 pandemic and successfully conducted low-dose lung screenings for approximately 5,000 cases.

国际一流专家和权威学术媒体的高度评价

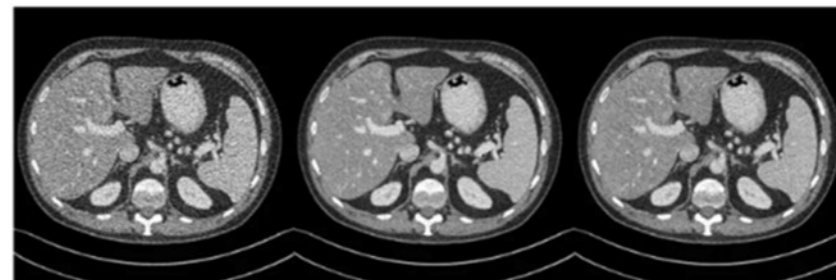
Highly Commented by World's Leading Experts and Authoritative Academic Medias

与国际同行密切交流，研究成果得到了中国科学院院士徐宗

本教授，中国工程院院士高文，美国国家科学院及工程院院士 James A. Sethian 教授，美国国家工程院院士 Maryellen L. Giger 教授、Jason Cong 教授、瑞士工程科学院院士 Michael Unser 教授、加拿大工程院院士 Rabab K. Ward 教授等中外院士及 JongChul Ye 教授、Ge Wang 教授、Mannudeep K. Kalra 教授、Zhengrong Liang 教授、Eric Miller 教授、Cynthia H. McCollough 教授、林宙辰教授、任秋实教授等 IEEE/SPIE/AIBME/AAPM Fellow 的肯定和正面评价，在 Nature Machine Intelligence 等期刊进行了多次正面引用和评述，如：“provides a baseline”、“pioneering”、“state-of-the-art”、“impressive”，被国际学术媒体 Physics World、林岛诺贝尔奖得主大会等选为亮点工作进行专题报道。应邀在国际会议做专题报告 30 余次，受邀在 CT 成像旗舰会议 The Fully3D 2017、SPIE Optical Engineering + Applications 2017 及 SIAM Conference on Imaging Science 2018 上做大会特邀报告。

We have maintained close communication with international peers, and our research findings have received positive evaluations and endorsements from academicians both in China and abroad, including Professor Zongben Xu, Academician of the Chinese Academy of Sciences, Professor Wen Gao, Academician of the Chinese Academy of Engineering, Professor James A. Sethian, Member of the National Academy of Sciences and the National Academy of Engineering in the United States, Professor Maryellen L. Giger, Professor Jason Cong, Professor Michael Unser, Fellow of the Swiss Academy of

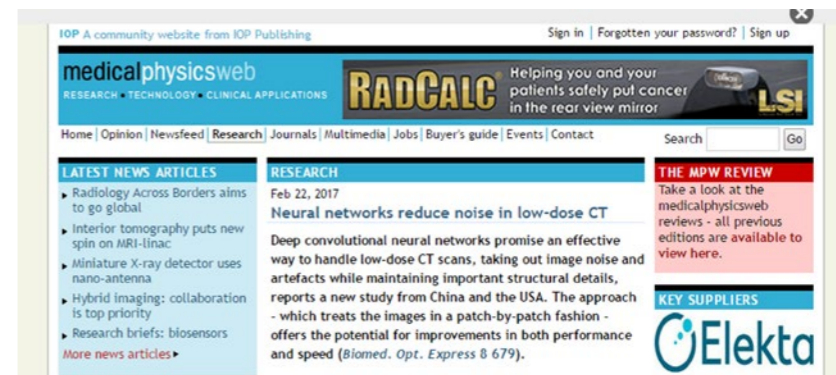
Engineering Sciences, Professor Rabab K. Ward, Fellow of the Canadian Academy of Engineering, and others. Furthermore, our works have garnered affirmative citations and reviews in publications published in top-tier journals such as Nature Machine Intelligence, and have been positively acknowledged by numerous IEEE/SPIE/AIBME/AAPM Fellows, including Professors Jong Chul Ye, Ge Wang, Mannudeep K. Kalra, Zhengrong Liang, Eric Miller, Cynthia H. McCollough, Zhouchen Lin, and Qiushi Ren, etc, such as "provides a baseline", "pioneering", "state-of-the-art", "impressive". Besides, our works were selected as featured work for special coverage by international academic media such as Physics World and the Lindau Nobel Laureate Meetings. We have been invited to give keynote presentations at more than 30 international conferences and have been specially invited to speak at leading CT imaging conferences like The Fully3D 2017, SPIE Optical Engineering + Applications 2017, and the SIAM Conference on Imaging Science 2018.



A low-quality, low-dose CT scan (L) is improved using machine learning into a version (R) comparable to a standard-dose CT image (M). Machine learning could enable simpler, cheaper, safer scanners. Credit: Ge Wang, in a collaboration between RPI, Sichuan Univ. & MGH/Harvard

林岛诺贝尔奖得主大会报道

Lindau Nobel Laureate Meetings coverage



Physics World 报道

Physics World coverage

跨空间大数据关联表征学习理论与方法

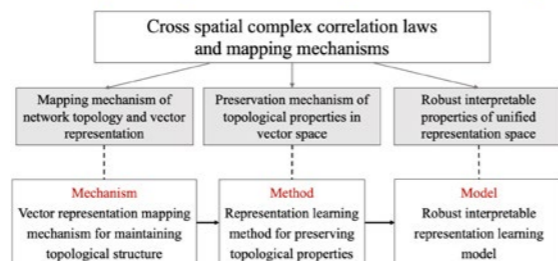
Theory and Method of Cross-space Big Data Correlational Representational Learning

跨空间大数据关联表征学习科学问题



在跨空间大数据关联统一表征研究上取得重要进展，提出鲁棒可解释的跨空间统一关联表征理论方法

Cross spatial big data association representation learning



Important progress has been made in the research on the unified representation of cross-space big data association, and a robust and interpretable cross-space unified association representation theory method has been proposed

清华大学
Tsinghua University



引言

跨空间大数据分析是从大规模多源异构数据中发现并利用深层次、多尺度、全周期关联规律的核心，已成为社会治理、公共安全等国家重大战略需求的共性基础。

Introduction

Cross-space big data analysis is at the core of discovering and utilizing deep-level, multi-scale, and full-cycle association rules from large-scale multi-source heterogeneous data. It has become a common foundation for national major strategic demands such as social governance and public security.

建立了跨空间大规模网络表征学习理论体系

Establish cross-space large-scale graph representation learning theoretical system

传统理论与方法一直受限于文本、图像等固有表征空间的局限，难以刻画跨空间异构数据实体的复杂关联关系与本质关联规律，导致跨空间大数据关联不能识别、规律无法发现、态势难以预测的困境。如何突破固有表征空间局限，构造跨空间异构实体关联的统一表达，揭示跨空间复杂关联关系的驱动要素和演化机理，建立跨空间大数据关联表征学习理论与方法，是长期困扰国际学术界的一个基本难题。

Traditional theories and methods have been limited by the inherent representation spaces of text and images, making it difficult to depict the complex association relationships and essential correlation patterns of cross-space heterogeneous data entities, leading to the predicament of not being able to identify cross-space big data associations, discover

correlation patterns, and predict trends. How to break through the limitations of inherent representation spaces and construct a unified expression of cross-space heterogeneous entity associations, reveal the driving factors and evolutionary mechanisms of complex cross-space correlation relationships, and establish cross-space big data association representation learning theories and methods, has long been a basic puzzle troubling the international academic community.

针对上述难题，本成果从跨空间大数据关联的拓扑结构和演化性质入手，建立基于大规模异构网络的跨空间大数据关联统一表达，揭示网络拓扑空间和向量表征空间的映射机理，构建外在拓扑结构保持、内在演化性质对等、总体可靠性能保障的大规模网络表征学习理论体系，为发展跨空间大数据关联表征学习理论做出创造性贡献。

We address the cross-space big data association representation learning problem by breaking through the limitations of the inherent representation space. It approaches the problem by studying the topological structure and evolutionary properties of cross-space big data associations from the perspective of large-scale heterogeneous networks. The project aims to establish a unified representation of cross-space big data associations based on large-scale heterogeneous networks, reveal the mapping mechanism between network topological space and vector representation space, and construct an external

topological structure preservation, internal evolutionary property equivalence, and overall reliability-ensured large-scale network representation learning theoretical system.

传统方法：信息、社会 and 物理空间独立表征



传统方法难以刻画跨空间复杂关联与本质规律

Traditional methods: independent representation of information, society, and physical space



Traditional methods are difficult to capture the cross-space complex correlations and essential laws

为发展跨空间大数据关联表征学习理论做出创造性贡献

Make a creative contribution to the development of cross-space big data association representation learning theory

1. 揭示网络拓扑空间和向量表征空间的映射机理，阐明拓扑结构对网络表征学习的基础性作用，提出首个高阶相近性结构保持的深度网络表征学习方法，实现关联分析从拓扑结构分析到深层表征学习的突破，为跨空间大数据关联表征学习奠定了重要理论基础。

1. This project revealed the mapping mechanism between the network topology space and the vector representation space, explaining the fundamental role of topological structure in network representation learning. They proposed the first deep network representation learning method with high-order similarity structure preservation, and achieving a breakthrough from topological structure analysis to deep representation learning for association analysis. This foundation laid important theoretical groundwork for

cross-space big data association representation learning.

2. 阐明网络拓扑性质是跨空间大数据关联分析的重要保证，揭示在向量表征空间保持网络非对称传递性的可行路径，建立拓扑性质保持的有向图与动态图高效表征学习模型，实现拓扑性质约束下大规模网络表征学习计算复杂度从立方级到线性级的跨越。

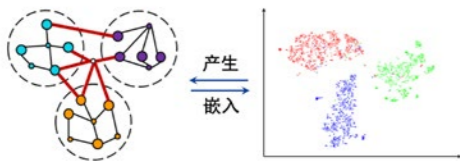
2. This project demonstrated that network topological properties are an essential guarantee for cross-space big data association analysis. They revealed the feasible path for maintaining the network's asymmetric transmission property in the vector representation space. An efficient representation learning model for directed and dynamic graphs with preserved topological properties was established, achieving a cross-scale network representation learning computational complexity from cubic to linear level under topological property constraints.

3. 针对跨空间复杂关联导致的表征鲁棒可解释难题，发现

Wasserstein 空间不确定性、结构相近性、拓扑传递性的一致性度量，揭示弱先验条件下网络表征维度的解耦路径及其理论收敛上界，实现跨空间关联表征鲁棒可解释的可靠性突破。

3. Addressing the challenge of cross-space representation robustness and interpretability due to complex associations, this project discovered Wasserstein space uncertainty, structural similarity, and topological transferability as a consistent measure for measuring the associations between different spaces. This model can achieve disentanglement of network representation dimensions under weak prior conditions, thus improving representation robustness and interpretability.

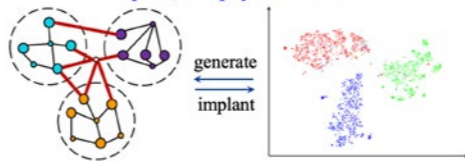
跨空间大数据本质上是信息空间、社会空间与物理世界耦合所构成的复杂系统



突破固有表征空间局限，构建跨空间大数据关联统一表征是实现跨空间大数据关联理解和预测的根本途径

构建大规模异构网络的跨空间大数据关联统一表达，建立跨空间大数据关联表征学习理论与方法，是实现跨空间大数据分析的核心问题

Cross spatial big data is essentially a complex system composed of the entangling of information space, social space, and physical world



Breaking through the inherent limitations of representation space and constructing a unified representation for cross spatial big data association is the fundamental way to achieve understanding and prediction of cross spatial big data association

Constructing a unified representation of cross-space big data association for large-scale heterogeneous networks, and establishing the theory and method of cross-space big data association representation learning, are core issues in achieving cross-space big data analysis

相关成果受到百余位院士和 ACM/IEEE Fellow 等的正面评价

The representative papers related to this project have been positively evaluated by more than 100 academicians and ACM/IEEE Fellows

图灵奖获得者 Yoshua Bengio 教授评价所提出的高阶相近性结构保持的深度网络表征学习方法是表征学习中聚焦局部和全局表征的唯一工作；评价所提出的解耦图神经网络模型取得解耦关联表征的最先进结果之一。Nature 子刊发文评价所提出有向图模型是图嵌入表征方向最先进的。

Turing Award winner Yoshua Bengio professor evaluated the proposed model as the only work in representation learning that focuses on local and global representations. He also

evaluated the proposed method as one of the most advanced results for disentangling associated representations. A paper published in Nature Communications commented that the proposed model is the most advanced in the field of graph embedding representation.

代表作	国际著名会议	Web of Science他引次数	谷歌总他引	论文影响
[1]	ACM SIGKDD	1119	2192	KDD 2016引用影响力第3
[2]	ACM SIGKDD	482	1031	KDD 2016引用影响力第4
[3]	AAAI	389	726	AAAI 2017引用影响力前10
[4]	ACM SIGKDD	59	196	KDD 2019引用影响力前10
[5]	ICML	41	159	

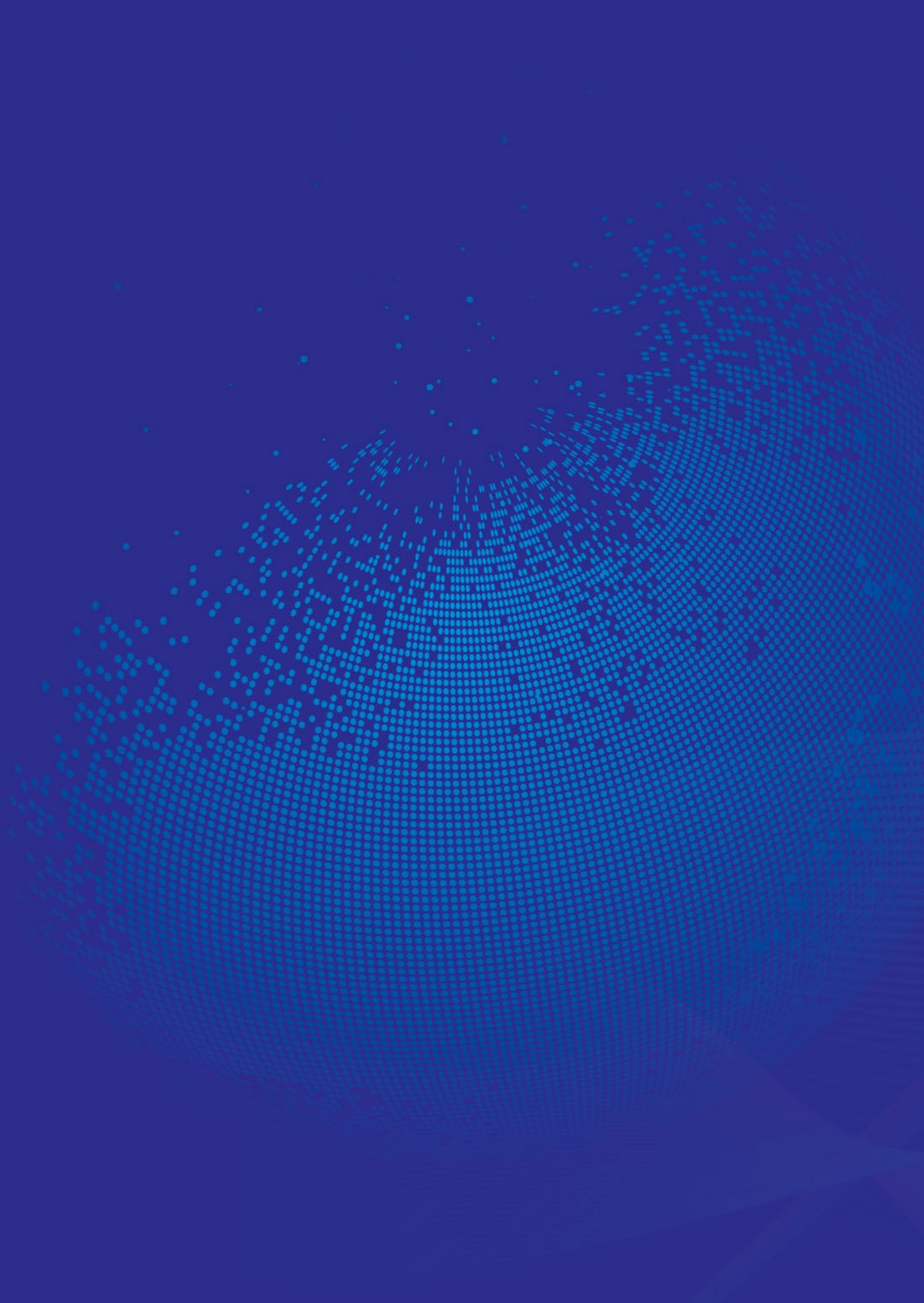
WOS他引		谷歌总他引	
5篇	单篇最高	5篇	单篇最高
2090	1119	4304	2192

代表性论文被引用情况

Representative work	International conference	Web of Science Total citation by others	Google Total citation	Paper Impact
[1]	ACM SIGKDD	1119	2192	KDD 2016 Citation Impact 3rd
[2]	ACM SIGKDD	482	1031	KDD 2016 Citation Impact 4th
[3]	AAAI	389	726	AAAI 2017 Citation Impact Top 10
[4]	ACM SIGKDD	59	196	KDD 2019 Citation Top 10 Influencers
[5]	ICML	41	159	

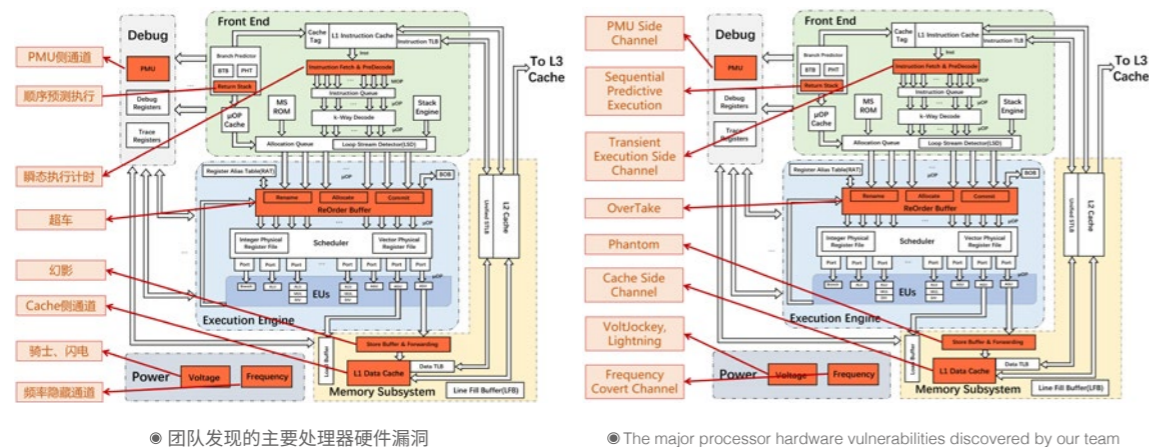
WOS citation		Google citation	
All	Highest	All	Highest
2090	1119	4304	2192

Citations of representative papers



现代处理器重大漏洞发现

Exposing the Major Vulnerabilities in Modern Processors



● 团队发现的主要处理器硬件漏洞

● The major processor hardware vulnerabilities discovered by our team

清华大学
Tsinghua University

中关村实验室
Zhongguancun Laboratory (ZGC LAB)

北京邮电大学
Beijing University of Posts and Telecommunications (BUPT)

哈尔滨工业大学
Harbin Institute of Technology (HIT)

国家计算机网络与信息安全管理中心
CNCERT



引言

发现处理器重大安全漏洞——“骑士”，这是被国际认可的新一类硬件漏洞。提出一系列处理器漏洞自动化检测与挖掘方法，设计并实现大规模分布式处理器漏洞智能挖掘平台，推广应用于多个行业中，并发现多个处理器硬件漏洞。

Introduction

We discover a major processor vulnerability ("VoltJockey"), which is a new type of hardware vulnerability recognized internationally. Besides, we propose a series of automatic detection and mining methods for processor vulnerabilities. Moreover, we design and implement a large-scale, distributed, and intelligent processor vulnerability mining platform, which is applied in multiple industries with several processor hardware

vulnerabilities are discovered.

自动化、批量化、智能化漏洞挖掘

Achieving Automated, Batch, and Intelligent Vulnerability Mining

发现主流处理器重大安全漏洞——“骑士”，是被国际认可的新一类（低功耗类）硬件漏洞（CVE-2019-11157），能同时攻破 Intel

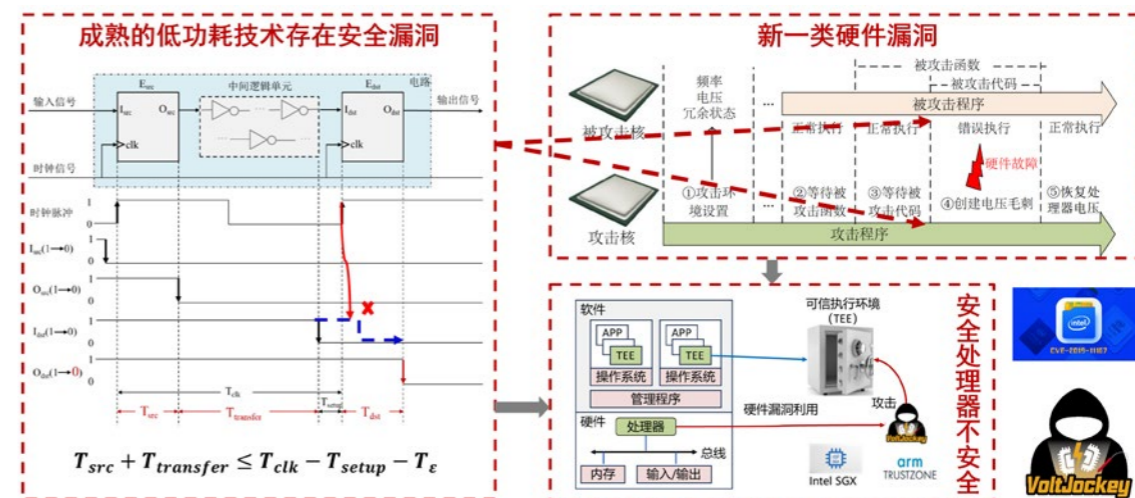
SGX 和 ARM TrustZone 等可信执行环境。

We discover a major hardware vulnerability in mainstream processors, which is named "VoltJockey". It is a new type (low-power-consumption-type) of hardware vulnerability recognized internationally and is assigned a CVE number of CVE-2019-11157. We successfully utilize the "VoltJockey" vulnerability to break main trusted execution environments such as Intel SGX and ARM TrustZone.

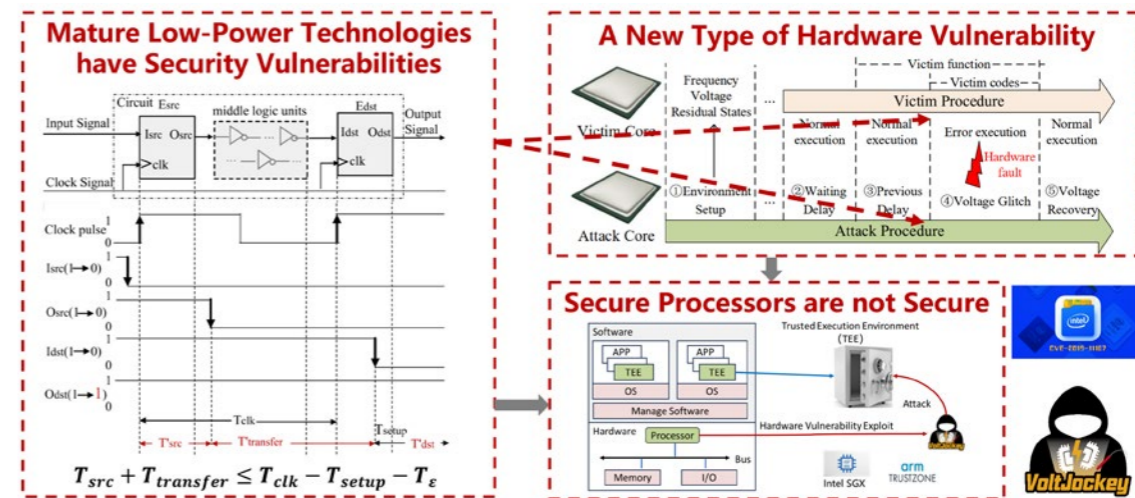
在理论层面，提出基于熵变、基于模型检验的形式化验证和基于多层次覆盖率模型的处理器漏洞检测与挖掘方法。在架构层面，设计并实现大规模分布式处理器漏洞挖掘与安全检测平台，一定程度上克服处理器的状态空间和执行路径爆炸问题，支持对处理器进行批量化、自动化和智能化漏洞挖掘与安全检测。该平台已推广应用于多个行业中，并进一步发现 7 个硬件漏洞以及 5 种 Cache 侧信道攻击。

At the theoretical level, we propose a series of processor vulnerability detection and

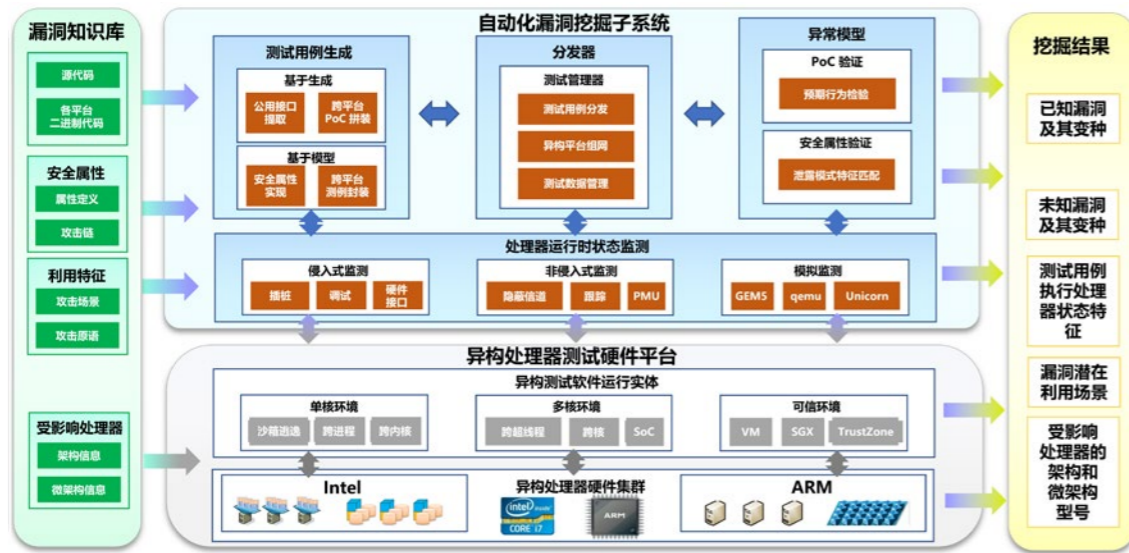
mining methods based on the entropy change, formal verification, and multi-level coverage model. At the architectural level, we design and implement a large-scale, distributed, and intelligent processor vulnerability mining and security detection platform, which overcomes the explosion problems of processors' state space and execution path to a certain extent. The platform can achieve automated, batch, and intelligent vulnerability mining and security detection for processors. We have applied the platform in many industries and discover seven hardware vulnerabilities as well as five cache side channel attacks.



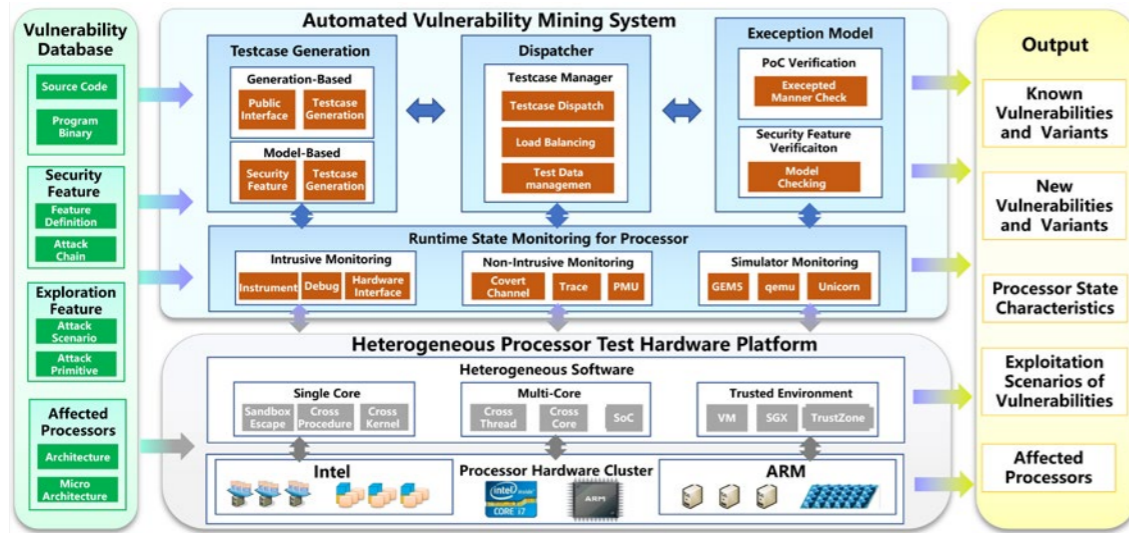
● “骑士”漏洞是被国际认可的新一类硬件漏洞



● The "VoltJockey" vulnerability is a new type of internationally recognized hardware vulnerability



© 大规模分布式处理器漏洞挖掘与安全检测平台



© Large-scale, distributed, and intelligent processor vulnerability mining and security detection platform

解决空间爆炸科学问题

Solving the Scientific Problem of State-Space Explosion

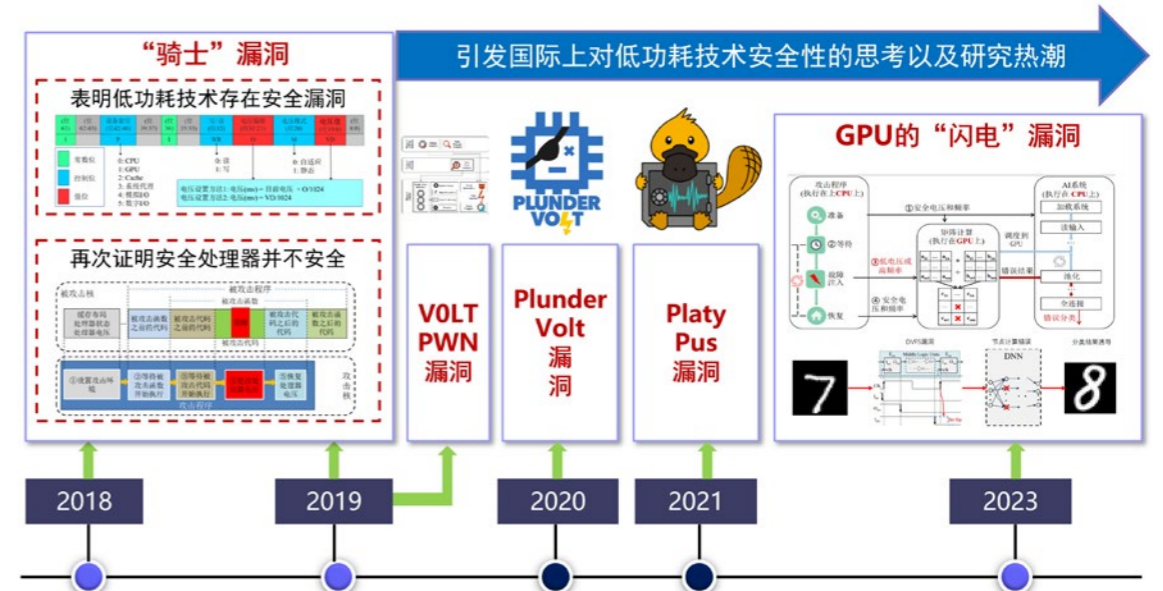
团队发现的“骑士”漏洞表明成熟的低功耗技术依然存在安全漏洞，该漏洞可有效突破处理器的安全区，再次证明所谓的“安全处理器”并不安全，引发国际上对处理器低功耗技术安全性的思考以及研究热潮，并促进了安全低功耗技术设计的发展。

The "VoltJockey" vulnerability discovered by our team shows that the mature low-power technologies still have security issues. Besides, we have demonstrated that the "VoltJockey" vulnerability can be uti-

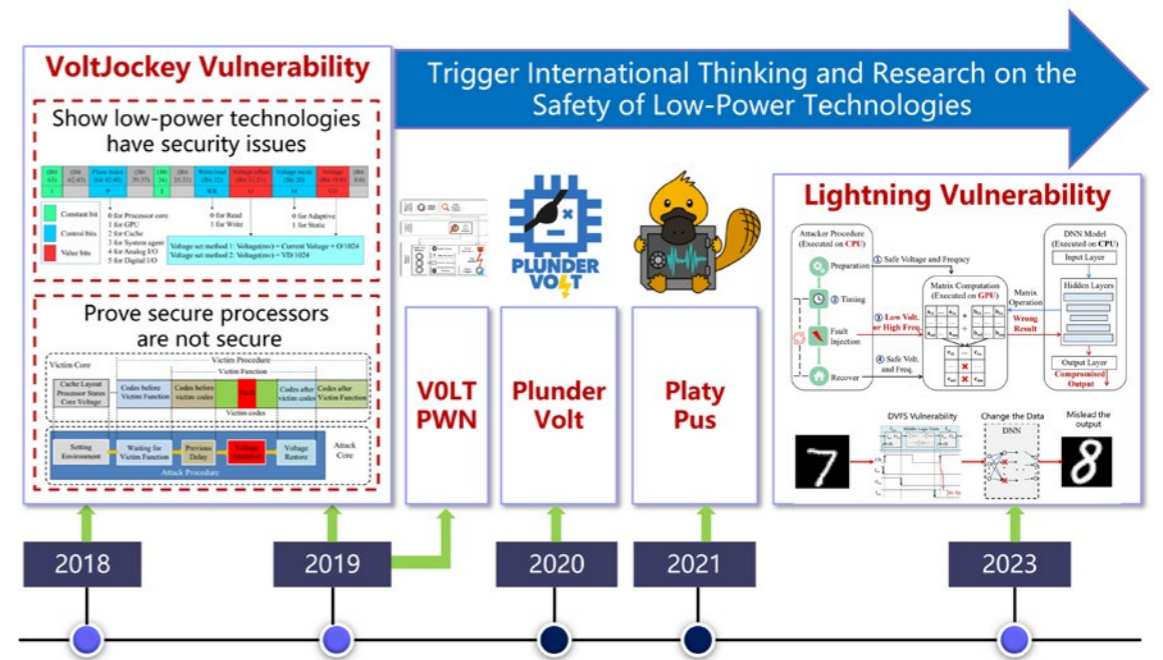
lized to break the processor's trusted execution environment, which proves that the so-called "secure" processors are "not secure". The "VoltJockey" vulnerability actually triggers an international trend of researching about the security of processor's low-power technologies and helps to design secure low-power technologies.

团队总结出“共享是处理器漏洞本质原因”的漏洞机理论点，该论点为学者开展处理器安全研究和处理器厂商设计安全策略提供指引。此外，团队提出的方法以及设计的平台可在一定程度上解决处理器空间爆炸的领域关键科学问题。

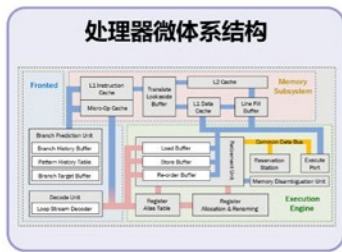
We propose a judgment that "sharing is the root cause of processor hardware vulnerabilities", which provides guidance for scholars to carry out research on processor's security and helps processor vendors to design security policies. In addition, our proposed methodologies and designed platform can address the key scientific problems of processor space explosion to a certain extent.



© “骑士”漏洞引领国际上对处理器低功耗技术安全性的研究



© The "VoltJockey" vulnerability leads the international research on the security of processor's low-power technologies



商用处理器芯片



状态空间爆炸 ①

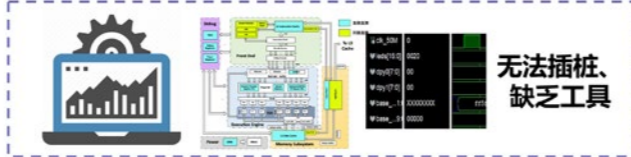
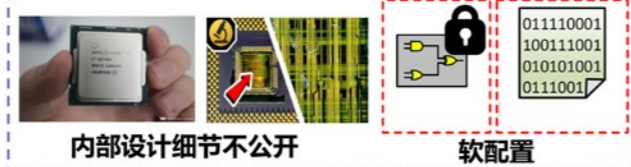
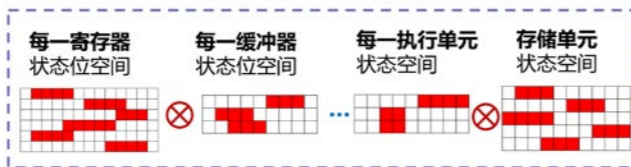
难检测

复杂封闭的设计 ②

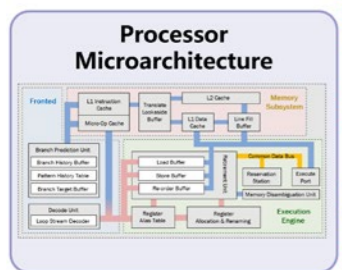
难分析

运行时覆盖率 ③

难度量



处理器漏洞自动挖掘突出问题



Commercial Processor Chips



State-Space Explosion ①

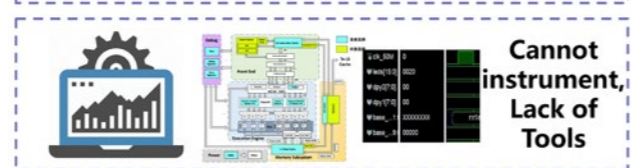
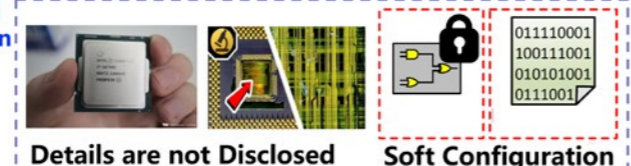
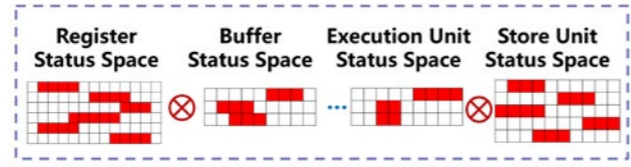
Hard to Detect

Complex and Closed Design ②

Hard to Analyze

Runtime coverage ③

Hard to Measure



The outstanding issues in automatically mining the processor vulnerabilities

发现新一类处理器安全漏洞

Discovering a New Type of Processor Hardware Vulnerability

团队发现的“骑士”漏洞及“闪电”漏洞得到 Intel、Qualcomm、Nvidia 等芯片厂商的确认，并在官网上对漏洞进行专门的披露。Intel 为“骑士”漏洞申请了一个国际统一漏洞库编号，“闪电”漏洞也被中国国家信息安全漏洞共享平台收录，这是被国际认可的新一类（低功耗类）漏洞。

The "VoltJockey" and "Lightning" vulnerabilities discovered by our team have been confirmed by the chip manufacturers such as Intel, Qualcomm, and Nvidia. Specifically, the

"VoltJockey" vulnerability has been disclosed on the Intel's official websites. Intel also integrates the "VoltJockey" vulnerability into the Common Vulnerabilities & Exposures (CVE). In addition, the "Lightning" vulnerability has been included in the China National Vulnerability Base. In fact, the two vulnerabilities are a new type of internationally recognized vulnerabilities (low-power-consumption-type).

团队的处理安全研究成果发表在多个领域高水平学术会议和期刊上，获得 ICCD 和 AsianHost 会议的最佳论文奖，被国际同行学者广泛引用，同时得到了媒体的广泛宣传、同行学者的高度评价以及主流处理器厂商的极大关注。目前已经与主流处理器厂商开展了深度合作。

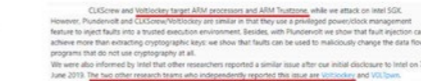
Our research results on the processor security have been published in a number of high-level academic conferences and journals, and win the best paper awards in ICCD

and AsianHost conferences. They have been widely cited by international well-known scholars and reported by the worldwide media. Besides, they have attracted great attention from the mainstream processor manufacturers. At present, we have carried out in-depth cooperation with mainstream processor manufacturers.

论文发表

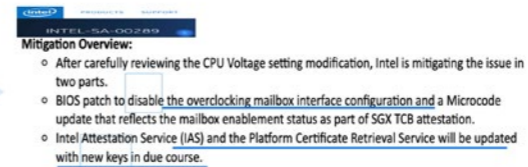
- CCS、DAC、FAST、ICCD、ICCAD、IEEE TCAD、TCAS-I、ACM TODAES
- 获得ICCD和AsianHost最佳论文奖

国际同行评价



可有效攻击ARM和Intel主流处理器的安全执行环境

公司响应



促进了新一代安全低功耗技术的设计工作

漏洞发现促进了新一代安全低功耗技术的研发

Paper

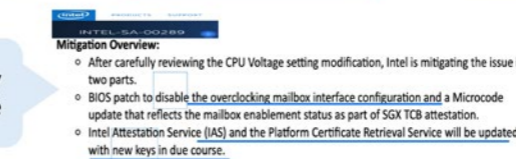
- CCS、DAC、FAST、ICCD、ICCAD、IEEE TCAD、TCAS-I、ACM TODAES
- Win the best paper awards in ICCD and AsianHost conferences

Scholar Evaluation



Can Effectively Attack the Trusted Execution Environment of ARM and Intel Processors

Company Response

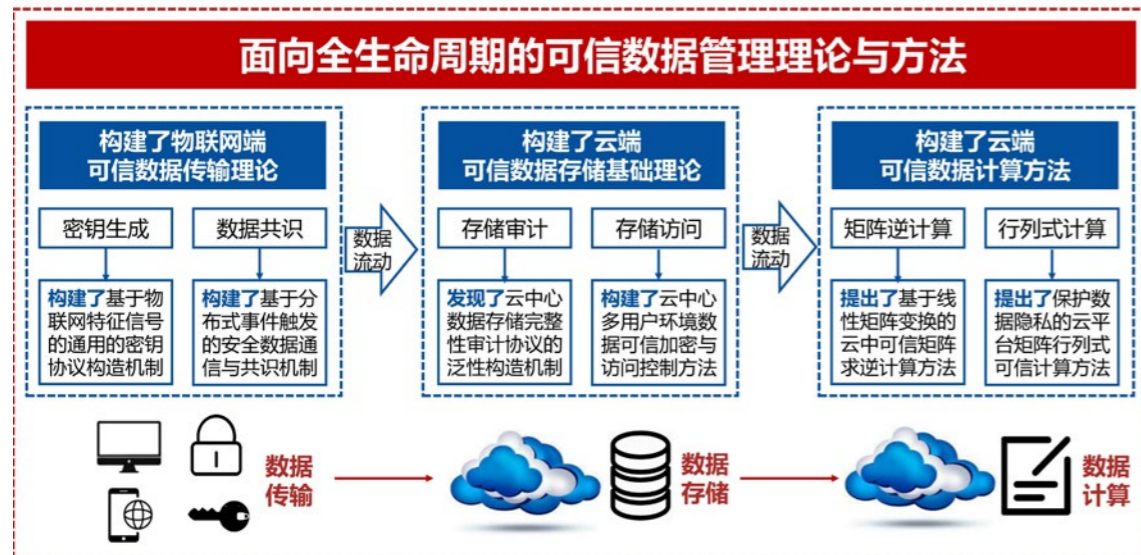


Help to Design Secure Low-Power Technologies

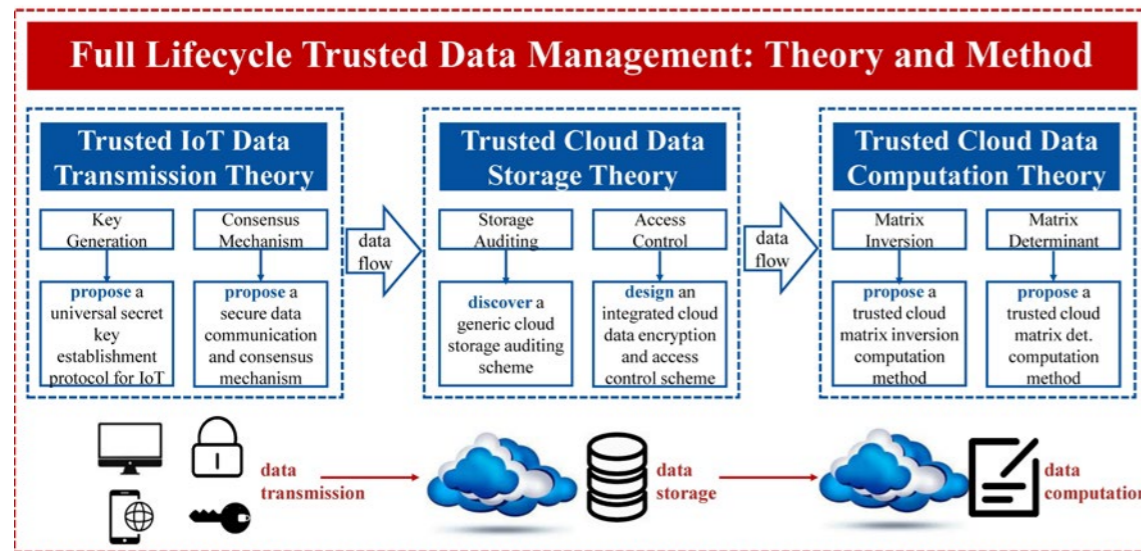
The exposed vulnerabilities foster the development of next-generation secure low-power technologies

面向全生命周期的可信数据管理理论与方法

Full Lifecycle Trusted Data Management: Theory and Method



◎ “面向全生命周期的可信数据管理理论与方法” 概览



◎ An Overview of the Proposed Trusted Data Management Theory and Method

引言

随着网络空间安全重要性的逐步提升，可信数据处理研究引起了全球的重视。当前可信数据处理面临数据来源广泛、数据体量大、数据控制权转移等新型挑战，传统可信数据处理方法难以适用当代的新型计算范式。

Introduction

As the significance of cybersecurity in the cyberspace continues to grow, research on trusted data processing has garnered global attention. Presently, trusted data processing faces novel challenges such as diverse data sources, large data volumes, and data control transfers. Traditional methods for trusted data processing are inadequate to address the demands of contemporary computing paradigms.

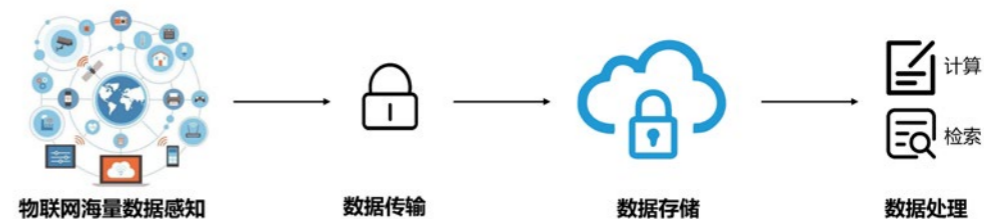
建立了新型计算范式下全生命周期可信数据管理基础理论与方法

We have established foundational theory and methodology for trusted data processing throughout the entire lifecycle under the new computing paradigm

针对物联网、云计算这一新型计算基础设施下的可信数据管理问题，从数据传输、数据存储和数据计算的全生命周期角度，展开了基础性探索研究，取得了系统性和原创性成果。构建了基于动力系统的密码算法分析与设计基础理论，解决了底层核心密码算法的安全性设计问题。构建了以物联网为端的可信数据传输基础理论，实现了可信数据安全传输。构建了以云为中心的可信数据存储基础理论，保障了云中数据存储的可信性。提出了以云为中心的数据可信计算方法，解决了云平台科学计算的数据隐私保护与结果验证问题。以上成果发表于网络空间安全领域的国际顶级会议和期刊，出版学术专著1部。相关工作得到了包括中国工程院院士、欧洲科学院院士、IEEE Fellow、ACM Fellow等诸多国际知名学者的高度评价。

Aiming at the trusted data processing challenges in the new computing infrastructure

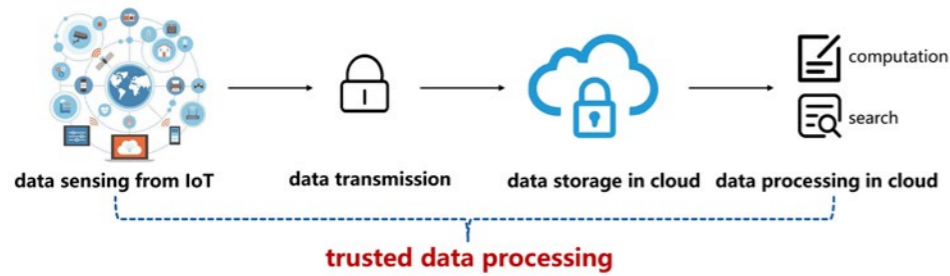
such as the Internet of Things (IoT) and cloud computing, we conducted fundamental exploratory research. From the perspective of the entire lifecycle of data transmission, storage, and computation, we achieved systematic and original results. We developed a foundational theory for the analysis and design of cryptographic algorithms based on dynamical systems, effectively resolving security design issues of core cryptographic algorithms. We established a foundational theory for trusted data transmission with a focus on the IoT, enabling the secure transmission of trusted data. Additionally, we constructed a foundational theory for trusted data storage centered around the cloud, ensuring the trustworthiness of data storage in the cloud. We proposed a cloud-centric approach to trusted data computation, effectively addressing data privacy protection and result verification challenges in scientific computing on cloud platforms. These results have been presented at premier international conferences and published in top-tier journals in the field of cybersecurity. Additionally, one academic monograph has been published. Our work has received high acclaim from distinguished international scholars, including members of the Chinese Academy of Engineering, the European Academy of Sciences, IEEE Fellows, and ACM Fellows.



建立了面向全生命周期的可信数据管理理论与方法

◎ 建立了面向全生命周期的可信数据管理理论与方法





● Establishing foundational theory and methodology for trusted data processing

解决了底层密码算法安全设计问题，物联网端数据高效安全传输问题，以及云端数据安全存储与可信计算问题

These achievements have successfully addressed the security design issues of underlying cryptographic algorithms, efficient and secure data transmission at the IoT edge, and secure data storage and trusted computation in the cloud

构建了基于动力系统的新型密码算法设计与分析基础理论。提出了基于代数结构的周期分析方法，发现了当前算法存在的安全问题，得到了保障算法安全性的充分条件。

We developed a foundational theory for the design and analysis of novel cryptographic algorithms based on dynamical systems. By introducing algebraic structure-based periodic analysis methods, we identified security vulnerabilities in existing cryptographic algorithms and derived sufficient conditions to ensure cryptographic primitive security.

构建了以物联网为端的可信数据传输基础理论。提出了基于物联网特征信号的通用密钥协议构造方法，设计了基于分布式事件触发机制的安全通信协议，保障了数据实时安全通信。

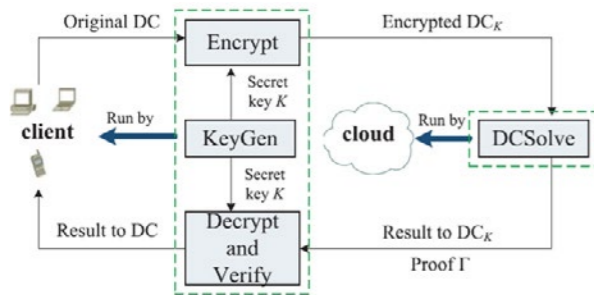
We established a foundational theory for trusted data transmission with a focus on the Internet of Things (IoT). We proposed a general key establishment protocol based on IoT characteristic signals and designed a secure communication protocol based on distributed event-triggered mechanisms, ensuring real-time secure communication of IoT data.

构建了以云为中心的可信数据存储基础理论。发现了云存储审计问题与字符串匹配问题的科学关联，提出了云存储审计协议的泛性构造方法，保障了云中数据存储的可信性。

We constructed a foundational theory for trusted data storage centered around the cloud. We discovered a scientific correlation between cloud storage auditing and string matching problems and proposed a generic construction method for cloud storage auditing protocols, ensuring the trustworthiness of data storage in the cloud.

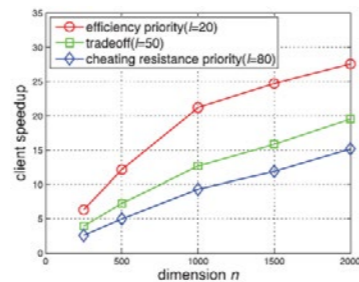
提出了以云为中心的数据可信计算方法。提出了云中矩阵求逆可信计算方法，构造了云平台矩阵行列式可信计算机制，解决了云平台矩阵计算的数据隐私保护与结果验证问题。

We proposed a cloud-centric approach to trusted data computation. We introduced a trusted computation method for matrix computation in the cloud and developed a trusted computation mechanism for cloud platform matrix computations. These work address data privacy protection and result verification challenges in privacy-preserving and verifiable matrix computation on cloud platforms.



● 提出的云端数据可信处理方法提升效率 5 倍以上

● The proposed cloud-based trusted data processing methods have achieved an efficiency improvement of more than 5 times



担任云计算领域顶级期刊副主编，入选 IEEE Fellow、爱思唯尔高被引学者，获得学术会议最佳论文奖

Team members have served as Associate Editors of top-tier journals in the field of cybersecurity and cloud computing, have been recognized as IEEE Fellow and highly cited researcher by Elsevier, and have received Best Paper Awards at academic conferences

在国际上较早地研究了全生命周期可信数据管理问题，取得了原创性研究成果，获得了同行的高度认可。在国际顶级会议及期刊上发表可信数据处理相关论文 100 余篇，其中在 JCR 一区期刊、CCF A 类推荐会议/期刊上发表论文 52 篇，谷歌学术引用超万次，出版学术专著 1 部。

Our team has conducted pioneering research on trusted data processing throughout the entire lifecycle, resulting in original research achievements that have gained high recognition from the community. The team has published over 100 papers on trusted data processing in top international conferences and journals. Among them, 52 papers have been published in JCR Q1 journals and CCF A-level recommended conferences/journals. Our work has garnered over 10,000 citations on Google Scholar. We have also published one academic monograph.

成果完成人廖晓峰教授入选 IEEE Fellow、教育部长江学者特聘教

授，并连续 9 年入选爱思唯尔中国计算机学科高被引学者，成果完成人向涛教授担任云计算顶级期刊《IEEE Transactions on Cloud Computing》副主编，相关论文获得 WASA 2018、MASS 2018、PAMCO 2016 等多个国际知名学术会议最佳论文奖。

Professor Xiaofeng Liao, one of the key contributors, has been recognized as an IEEE Fellow, a Changjiang Scholar Distinguished Professor by the Ministry of Education, and has been listed as a highly cited researcher in the field of computer science by Elsevier for nine consecutive years. Professor Tao Xiang serves as an Associate Editor for the top-tier journal "IEEE Transactions on Cloud Computing". The team's research papers have received Best Paper Awards at renowned international conferences such as WASA 2018, MASS 2018, and PAMCO 2016.

完成人团队的工作得到包括中国工程院院士、中国工程院外籍院士、欧洲科学院院士、加拿大工程院院士、加拿大皇家科学院院士等国内外知名专家的广泛引用和高度评价。

The work of the team and its members have been widely cited and highly praised by renowned experts, including members of the Chinese Academy of Engineering, foreign members of the Chinese Academy of Engineering, members of the European Academy of Sciences, members of the Canadian Academy of Engineering, and members of the Royal Society of Canada.

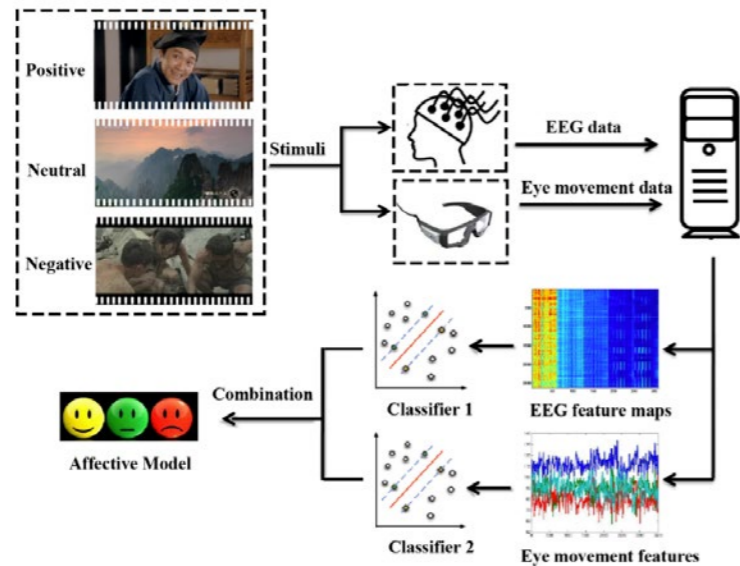


● 廖晓峰教授担任顶级期刊 IEEE TCC 副主编、入选国际电气与电子工程师协会会员 (IEEE Fellow)

● Prof. Xiaofeng Liao, serving as an Associate Editor for the prestigious journal IEEE Transactions on Cloud Computing (IEEE TCC) and being elected as a Fellow of the Institute of Electrical and Electronics Engineers (IEEE)

多模态情感脑机接口的情绪表征机理研究

Research on Emotion Representation Mechanisms for Multi-Modal Affective Brain-Computer Interfaces



- 基于脑电信号与眼动信号融合的多模态情感脑机接口架构，可有效融合被试情绪状态变化的内部生理特征与外部行为模式，显著提升情绪识别的准确率
- A multimodal affective brain-computer interface architecture based on the fusion of EEG (Electroencephalogram) and eye movement signals. The architecture can effectively fuse internal physiological features and external behavioral patterns of emotional state changes in subjects, significantly improving the performance of emotion recognition

上海交通大学
Shanghai Jiao Tong University



上海零唯一思科技有限公司
Emotion Helper



引言

多模态情感脑机接口的研究目标是实现对人的情绪进行识别和调控。我们针对情绪脑电表征、多模态信号融合、情感实验范式和开放数据集等问题和挑战，开展了理论分析、模型构建和实验设计，取得了具有原创性的研究成果。

Introduction

The research goal of multimodal affective brain-computer interfaces is to develop intelligent machines to recognize and regulate human emotions. We have carried out theoretical analysis, model construction, and experimental design to address the problems and challenges of emotional EEG characteristics, multimodal signal fusion, emotional experimental paradigms, and public datasets, and have achieved original research results.

情绪表征的跨时间和跨个体稳定特性

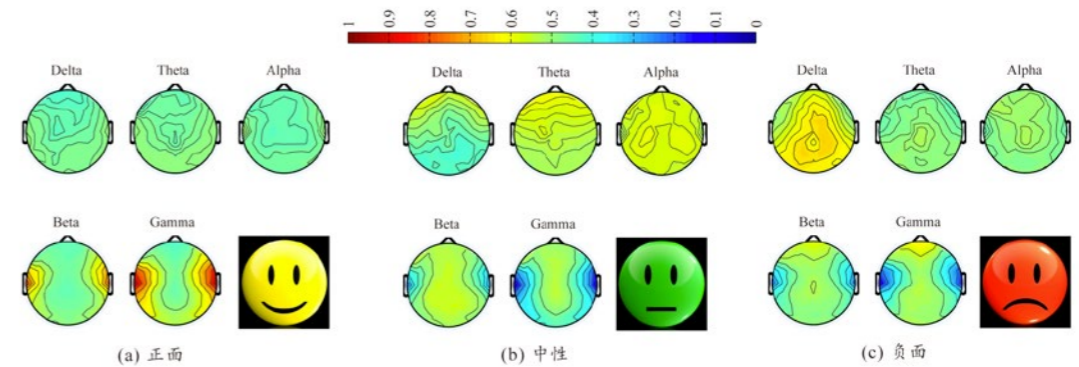
Stability Characteristics of Emotion Representations Across Time and Across Individuals

在情绪脑电表征方面，我们首次发现了情绪脑电信号的关键频段与关键脑区。在情绪识别任务中，脑电信号的高频段在情绪识别任务中发挥着更重要的作用。同时，我

们所提出的微分熵特征已成为情感脑机接口研究中最广泛使用的特征之一。我们在国际上首次证明了情绪脑电模式随时间变化保持稳定重要特性，证明了对于某种特定情绪，大脑活动的神经模式在个体间普遍稳定存在。在多模态架构方面，我们首次提出了脑电与眼动信号融合的全新多模态情感脑机接口架构，揭示了脑电和眼动信号在情绪表征上的互补特性。我们构建的 SEED 数据集为情感脑机接口领域的计算方法研究提供了统一的测试标准，现已成为情感脑机接口领域最具有代表性的数据集。

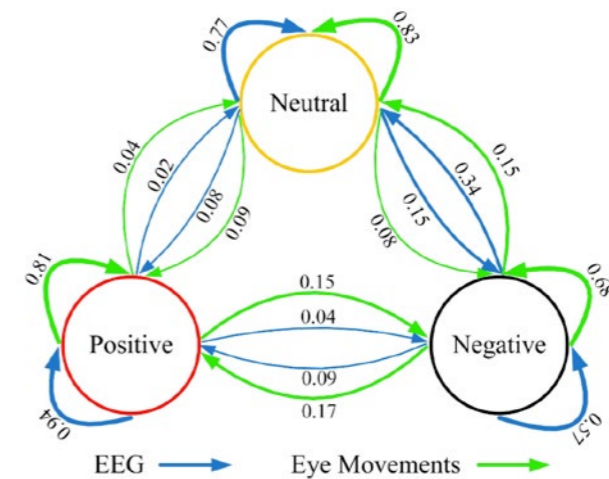
In terms of emotional EEG characteristics, we have identified for the first time the key frequency bands and key brain regions of emotional EEG signals. The high-frequency bands of EEG signals play a more important role in emotion recognition tasks. Meanwhile, the differential entropy feature proposed by our research team has become one of the most widely used features in affective brain-computer interface research. For the first time in the international arena, we have demonstrated the important property that emo-

tional EEG patterns remain stable over time, proving that for a particular emotion, the neural pattern of brain activity is universally stable across individuals. In terms of multimodal architectures, we proposed in the first place a new multimodal affective brain-computer interface architecture that fuses EEG and eye-movement signals, revealing the complementary properties of EEG and eye-movement signals in emotion recognition. The SEED dataset we constructed provides a unified test standard for computational models in the field of affective brain-computer interfaces and is now the most representative dataset in the field of affective brain-computer interfaces.



● 三类情绪识别任务中脑电信号的表征特性

● Representation properties of EEG signals in three-class emotion recognition tasks



● 脑电与眼动信号在情绪识别表征上具有互补特性

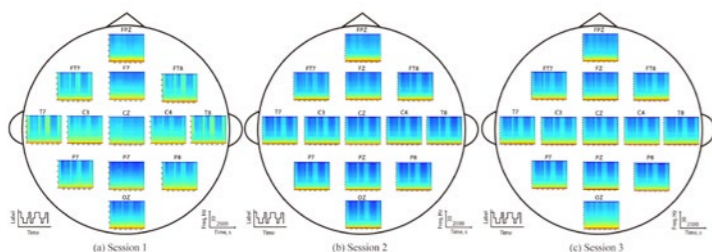
● The complementary characteristics of EEG and eye movement signals in emotion recognition

多模态情感脑机接口架构及脑电与眼动的互补特性

Multimodal Affective Brain-Computer Interface Architecture and Complementary Characteristics of EEG and Eye Movements

多模态情感脑机接口中不同信号的情绪表征模式是情感脑机接口研究的重要科学问题，也是情感脑机接口需要揭示的基本特性。我们发现的情绪脑电关键频段与关键脑区为情感脑机接口的情绪客观表征提供了信号层面的理论支撑。我们设计了跨时间的情绪诱发实验，构建不同时间段的情绪识别模型，分析了不同导联脑电信号的频谱特征随时间变化的特性，并利用脑地形图分析了不同情绪的神经模式。同时，我们从情绪识别准确率的角度定量地分析了情绪随时间变化的稳定特性。我们在国际上提出了脑电与眼动信号融合的多模态情感脑机接口架构，为开发高精度的新型多模态情感脑机接口提供了一项崭新的技术解决方案，并开拓了多模态情感脑机接口研究的新领域。

The representation patterns of different signals in multimodal affective brain-computer interfaces are important scientific questions and fundamental characteristics that need to be explored in affective brain-computer interface research. The identified key frequency bands and brain regions associated with emotions in electroencephalography (EEG) provide theoretical support for the objective representations of emotions in brain-computer interfaces at a signal level. We conducted emotion induction experiments across time, constructed emotion recognition models for different time periods, analyzed the temporal characteristics of spectral features in EEG signals of different electrodes, and used brain topography to analyze the neural patterns of different emotions. Additionally, we quantitatively analyzed the stability of emotions over time from the perspective of emotion recognition accuracy. Internationally, we proposed a multimodal emotion brain-computer interface architecture that combines EEG and eye movement signals, providing a novel technical solution for developing high-performance multimodal affective brain-computer interfaces and pioneering a new field in multimodal affective brain-computer interface research.



不同时间情绪实验下的不同脑区的脑电频谱特征分布

The distributions of EEG spectral features in different brain regions under emotion experiments on different days

SEED 数据集是国际上最大的、最常用的情感脑电数据集

The SEED Dataset is the Largest and Most Commonly Used International Emotion EEG Dataset

在多模态情感脑机接口领域，由于相关数据采集代价高，采集设备昂贵，缺乏可靠的公共数据集。我们在开展脑电表征机理基础研究的同时，建立了具有国际影响力的公开情绪脑电数据集：上海交通大学情绪脑电数

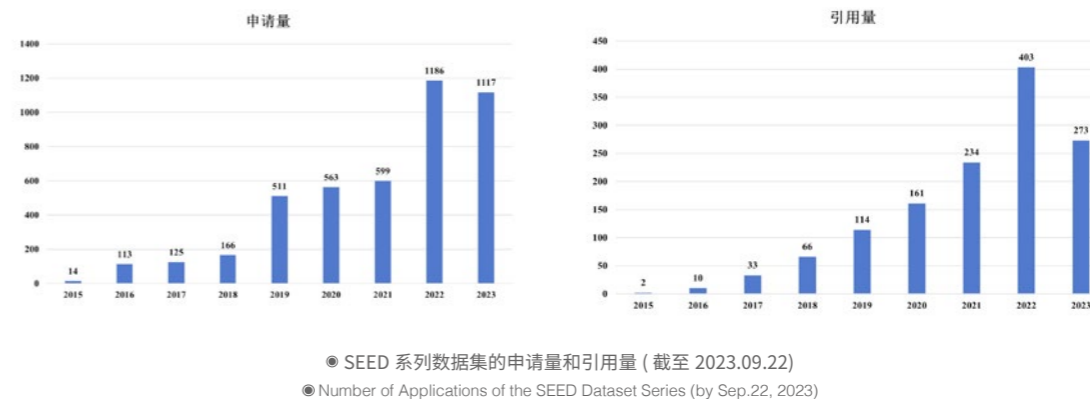
据集 SEED (SJTU Emotion EEG Dataset)。该数据集包括三类情绪脑电数据集 SEED、四类多模态情绪脑电数据集 SEED-IV、五类多模态情绪脑电数据集 SEED-V、多模态疲劳驾驶检测数据集 SEED-VIG、跨文化中德情绪脑电数据集 SEED-GER 和跨文化中法情绪脑电数据集 SEED-FRA。

In the field of multimodal affective brain-computer interfaces, due to the high cost of data collection and the expense of acquisition equipments, there is a lack of reliable public datasets. While conducting fundamental research on the emotion mechanisms of electroencephalography (EEG), we have established an internationally influential open emotion EEG dataset, the Shanghai Jiao Tong University Emotion EEG Dataset (SEED). This dataset comprises three categories of emotion EEG datasets, SEED, four categories of multimodal emotion EEG datasets, SEED-IV, five categories of multimodal emotion EEG datasets, SEED-V, a multimodal fatigue driving detection dataset, SEED-VIG, cross-cultural Chinese-German emotion EEG datasets, SEED-GER, and cross-cultural Chinese-French emotion EEG datasets, SEED-FRA.

目前，已有来自全球 81 个国家和地区的超过 1500 家高校和研究机构的超过 4000 个实验室申请使用 SEED 数据集，其中包括哈佛大学、麻省理工、斯坦福、清华大学和北京大学等国内外高校和研究机构。使用 SEED 系列数据集发表的杂志和会议论文达 1296 篇，其中 IEEE 汇刊超 100 篇。SEED 系列数据集是目前国际上开展情感脑机接口研究所使用的最大的、最常用的标准脑电数据集。

Currently, SEED datasets have been applied for use by over 1,500 universities and research institutions from 81 countries and regions around the world, including prominent institutions such as Harvard University, Massachusetts Institute of Technology, Stanford University, California Institute of Technology, Johns Hopkins University, Tsinghua University, Peking

University, and the Institute of Automation of the Chinese Academy of Sciences. The publications utilizing the SEED dataset series include 1,296 journal and conference papers, with over 100 papers published in IEEE transactions. The SEED dataset series is one of the most commonly used standard EEG datasets for conducting research on affective brain-computer interfaces internationally.



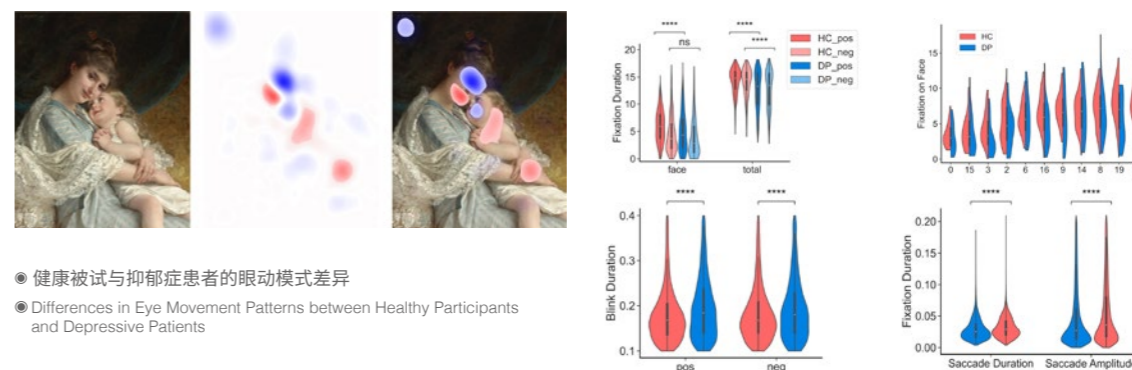
SEED 系列数据集的申请量和引用量 (截至 2023.09.22)
Number of Applications of the SEED Dataset Series (by Sep.22, 2023)

多模态情绪表征机制的研究为实现抑郁症的客观诊断提供了理论支撑

Emotion Representation Mechanisms Provide Theoretical Support for Objective Diagnosis of Depression

据 WHO 数据，全球有超过 3.5 亿人罹患抑郁症，我国抑郁症患者人数超过 1 亿。尽管抑郁症患者人群庞大，但目前针对抑郁症的诊断仍主要依赖量表和医患之间的交流，尚没有一种客观的生理指标能够辅助精神科医生进行辅助诊断。本成果中多模态融合的深度学习架构为抑郁症辅助客观诊断提供了算法支撑，多模态脑电和眼动之间的互补性的发现为抑郁症辅助客观诊断提供了关键技术，同时成果中展示的脑电关键频段、关键脑区以及情感脑机接口中的稳定脑电表征模式为抑郁症辅助客观诊断提供了理论依据。

According to the World Health Organization (WHO), more than 350 million individuals worldwide are afflicted by depression, with over 100 million sufferers in China alone. Despite the substantial population affected by depression, the current diagnostic methods predominantly rely on questionnaires and communication between healthcare profes-



健康被试与抑郁症患者的眼动模式差异

Differences in Eye Movement Patterns between Healthy Participants and Depressive Patients

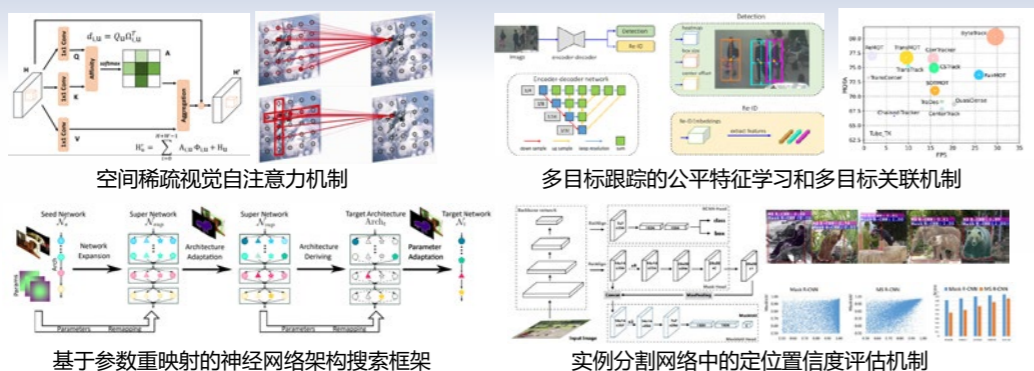
面向复杂场景视觉理解的高效率神经网络方法

Efficient Neural Network Approaches for Visual Understanding in Complex Scenes

应用场景

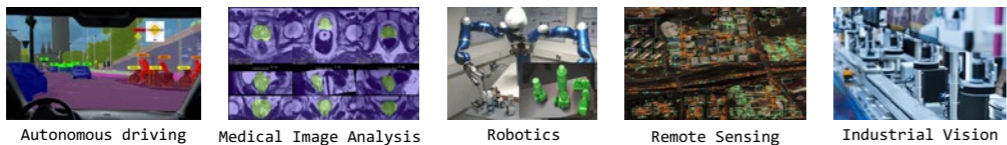


创新机制

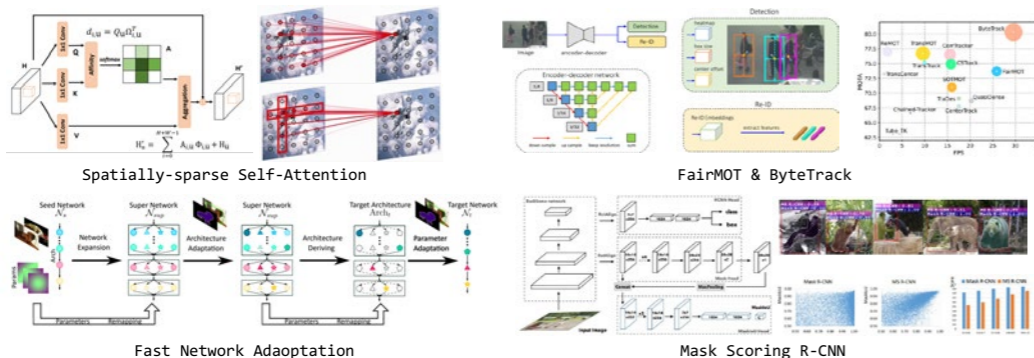


从神经网络的基本操作、任务框架设计、硬件感知推理等角度提出了四大创新机制，显著提升了自动驾驶等应用场景中视觉理解任务的计算效率和数据利用效率

Application scenarios



Innovation mechanism



We propose four innovative mechanisms from the perspectives of neural network fundamental operations, task framework design, and hardware-aware inference, significantly enhancing the computational and data utilization efficiency of visual understanding tasks in applications like autonomous driving

引言

视觉理解是人工智能领域的重要问题，而复杂场景中的高效精准的视觉理解技术是提升自动驾驶、移动机器人、医学影像分析等重要应用的关键。成果围绕视频图像中的目标检测、分割和跟踪等计算机视觉中的基础问题，在深度神经网络的表达机制、结构设计、管线设计等层面取得了突破，并在学术界受到了广泛的关注。

Introduction

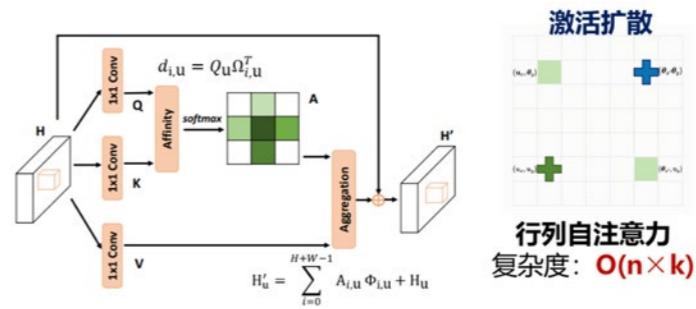
Visual understanding is an important problem in the field of artificial intelligence. Efficient and precise visual understanding techniques in complex scenes are key to improving important applications such as autonomous driving, mobile robotics, and medical image analysis. These achievements revolving around fundamental computer vision problems such as object detection, segmentation, and tracking in video images have made breakthroughs in the representation mechanisms, architecture design, and pipeline design of deep neural networks, which have received widespread attention in the academic community.

首创空间稀疏视觉注意力、实现目标精准刻画和关联

Pioneering Spatial Sparse Visual Attention and Achieving Precise Characterization and Correlation of Targets

在计算机视觉领域首创了空间稀疏的自注意力机制。自注意力机制是 Transformer 的核心，也是当前大语言模型等先进技术的核心。申报成果中 CCNet 论文提出将稠密自注意力分解为行自注意力和列自注意力，采用连续两次稀疏的行列自注意力来逼近一次稠密的自注意力，将自注意力建模的时空复杂度从 $O(N^2)$ 降低到 $O(N)$ 。首创了目标检测特征和重识别特征之间的公平学习机制，提出了统一的 FairMOT 多目标跟踪框架，开创了多目标跟踪中的多任务公平性研究的先河。首创了多目标跟踪中的低置信度检测关联机制，提出了一套速度快、准确度高、普适性强的多目标检测框架，打破了传统 MOT 框架中舍弃低置信度检测结果的思路。

We pioneer a spatial sparse self-attention mechanism in the field of computer vision. Self-attention is the core of Transformer and other advanced technologies such as Large Language Models (LLM). The paper of CCNet in the reported achievements proposes to decompose dense self-attention into row-wise self-attention and column-wise self-attention, using two consecutive sparse row-column self-attentions to approximate one



提出将稠密自注意力结构分解为行自注意力和列自注意力，相比于稠密自注意力快 6.5 倍，内存消耗降低了 91.4%

We propose to decompose the dense self-attention structure into row-wise self-attention and column-wise self-attention. Comparing to dense self-attention, our approach is 6.5 times faster and reduces memory consumption by 91.4%

dense self-attention, which reduces the spatiotemporal complexity of self-attention modeling from $O(N^2)$ to $O(N)$. We propose the first fair learning mechanism between object detection features and re-identification features, proposing the unified FairMOT multi-object tracking framework, which breaks new ground in the research of fairness in multiple tasks. We also pioneer a low-confidence detection association mechanism in multi-object tracking, presenting a fast, highly accurate, and universal multi-object detection framework that disrupts the traditional MOT framework's approach of discarding low-confidence detection results.

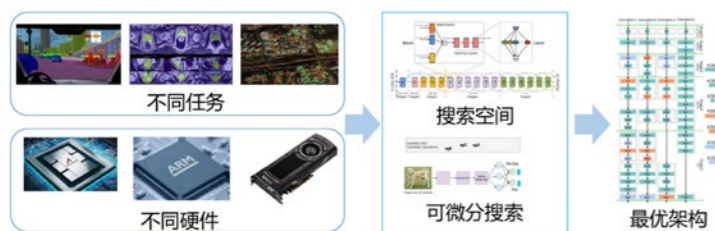
复杂场景高效率视觉理解神经网络方法从底层原理、任务网络设计、特定硬件上的实现三个层面上实现了对于视觉理解三大基础任务检测、分割、多目标跟踪的全面提升

Efficient visual understanding neural network methods for complex scenes achieve comprehensive improvements in the three fundamental tasks of visual understanding, detection, segmentation, and multi-object tracking, from the perspectives of fundamental principles, task network design, and implementation on specific hardware

CCNet 中“行自注意力 + 列自注意力”的新机制对于 Transformer 中核心的自注意力模块的时空复杂度的显著减低，通过构建自适应的全图感受野，显著提升深度卷积神经网络对于多尺度、形状各异物体的刻画和表达能力，极大的推动了视觉 Transformer 技术的发展。Mask Scoring R-CNN 揭示了 Mask R-CNN 中物体蒙版质量和物体分类概率不存在相关性，构建了一个与物体分割平行的蒙版质量估计网络，在几乎不增加计算量的情况下，显著提升物体分割的精度 (2-3% AP)。FairMOT 和 ByteTrack 在多个主流多目标跟踪

评测集上均达到业内领先的水平，速度首次在单块 Nvidia V100 显卡上达到每秒 30 帧，在复杂场景下可以得到鲁棒的结果。FNA++ 通过引入网络架构迁移学习的理念，突破了传统深度模型迁移学习中要求源模型和目标模型结构一致的限制，针对特定硬件、特定任务、特定场景，自动优化检测分割网络的架构，降低深度网络计算复杂度，提升检测分割模型的推理速度，实现低计算能力芯片上的高精度物体检测分割。

The new mechanism of "row-wise self-attention + column-wise self-attention" in CCNet significantly reduces the spatiotemporal complexity of the core module self-attention in Transformers. By constructing an adaptive global receptive field, it notably enhances the ability of deep convolutional neural networks to characterize and represent objects of varying scales and shapes, which greatly propels the development of visual Transformer technology. Mask Scoring R-CNN reveals that there is no correlation between object mask quality and object classification probability in Mask R-CNN and introduces a mask quality estimation network parallel to object segmentation, which significantly improves the accuracy of object segmentation (2-3% AP) with almost no increase in computational cost. FairMOT and ByteTrack achieve industry-leading performance on multiple mainstream multi-object tracking benchmarks and a speed of 30 FPS on a single Nvidia V100 GPU, producing robust results in complex scenes. By introducing the concept of network architecture migration learning, FNA++ breaks through the limitation of traditional deep model migration learning that requires the same structure of source and target models, automatically optimize the architecture of detection and segmentation network for specific hardware, tasks, and scenarios, reduces the computational complexity of the deep network, and improves the inference speed of detection and segmentation model, achieving high-precision object detection and segmentation on a low-computing-capacity chip.



● FNA++ 方法利用异构神经网络之间的参数共享，能够快速地为不同任务、不同硬件搜索可以快速推理的检测分割网络模型

● The FNA++ method leverages parameter sharing between heterogeneous neural networks, rapidly searching for detection and segmentation network models which can perform efficient inference across different tasks and hardware

Ccnet: Criss-cross attention for semantic segmentation Z Huang, X Wang, L Huang, C Huang, Y Wei, W Liu IEEE Transactions on Pattern Analysis and Machine Intelligence	2347	2020
Fairmot: On the fairness of detection and re-identification in multiple object tracking Y Zhang, C Wang, X Wang, W Zeng, W Liu International Journal of Computer Vision 129 (11), 3069-3087	933	2021
Mask scoring r-cnn Z Huang, L Huang, Y Gong, C Huang, X Wang Proceedings of the IEEE/CVF conference on computer vision and pattern ...	931	2019
ByteTrack: Multi-object tracking by associating every detection box Y Zhang, P Sun, Y Jiang, D Yu, F Weng, Z Yuan, P Luo, W Liu, X Wang European Conference on Computer Vision, 1-21	541	2022
Fna++: Fast network adaptation via parameter remapping and architecture search J Fang, Y Sun, Q Zhang, K Peng, Y Li, W Liu, X Wang IEEE Transactions on Pattern Analysis and Machine Intelligence	28	2020

● 五篇代表作的谷歌学术引用情况

● Google Scholar Citations of the Five Representative Work

五篇代表作均发表于人工智能领域顶级期刊和会议，总引用超过 4780 次，被应用于蛋白质结构预测 AI AlphaFold 中

The five representative works have been published in top-tier journals and conferences in the field of artificial intelligence, with a total of over 4780 citations, which have been applied in the AI AlphaFold for protein structure prediction

DeepMind 等机构发表的《Nature》文章《高精度蛋白质结构预测与 AlphaFold》中将被提名人工作 CCNet 作为基础的特征提取模块，并称 CCNet 和 Axial-deeplab 启发了采用注意力方法来解译蛋白质序列的探索。

谷歌大脑团队发表在 ICLR 2021 上的文章《一张图片可类比为 16*16 的单词 :transformer 用于大规模的图像识别》(ViT 的开山之作) 中采用 CCNet 的做法构建了 AxialViT 网络，并指出 CCNet 中的行列轴向注意力是一种简洁高效的用以处理具有大量输入的注意力网络的方法。

YOLOv7 团队论文《YOLOv7: 训练可调整的免费模型集，在实时物体检测领域取得新的最先进成果》开篇就以 FairMOT 和 ByteTrack 为多目标跟踪的典型工作，指出实时目标检测是计算机视觉中重要且必须的组件。

The paper "Highly accurate protein structure prediction with AlphaFold" published in "Nature" by DeepMind and others uses the nominee's work CCNet as the foundational feature extraction module and states that CCNet and Axial-deeplab have inspired the exploration of using attention methods to interpret protein sequences.

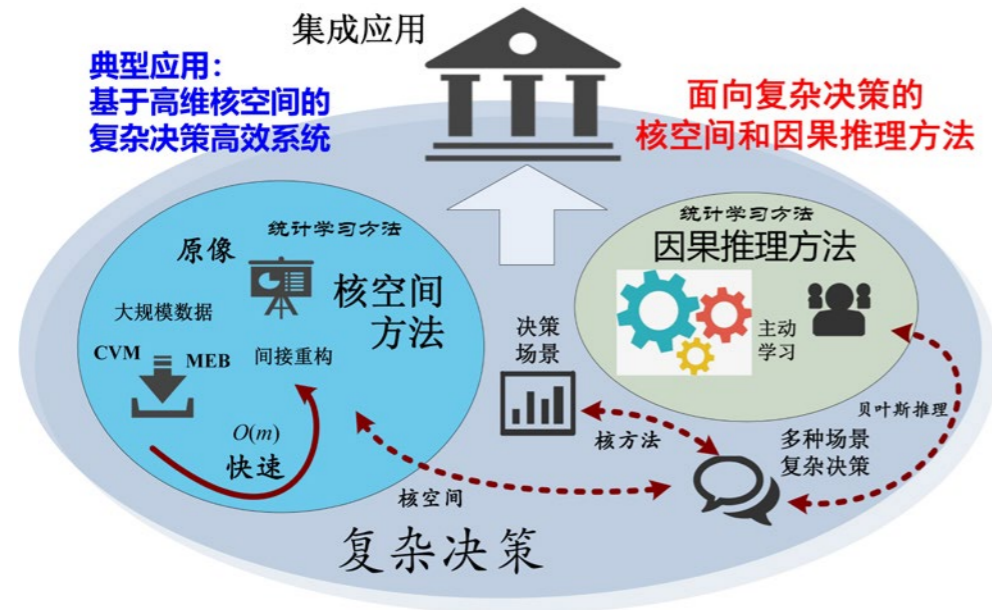
In the Google Brain's paper "An Image is Worth 16x16 Words: Transformers for Image Recognition at Scale" (the pioneering work of ViT) published in ICLR 2021, they apply CCNet's approach to build the

AxialViT network and point out that the row-column axial attention in CCNet is a concise and efficient method for handling attention networks with a large number of inputs.

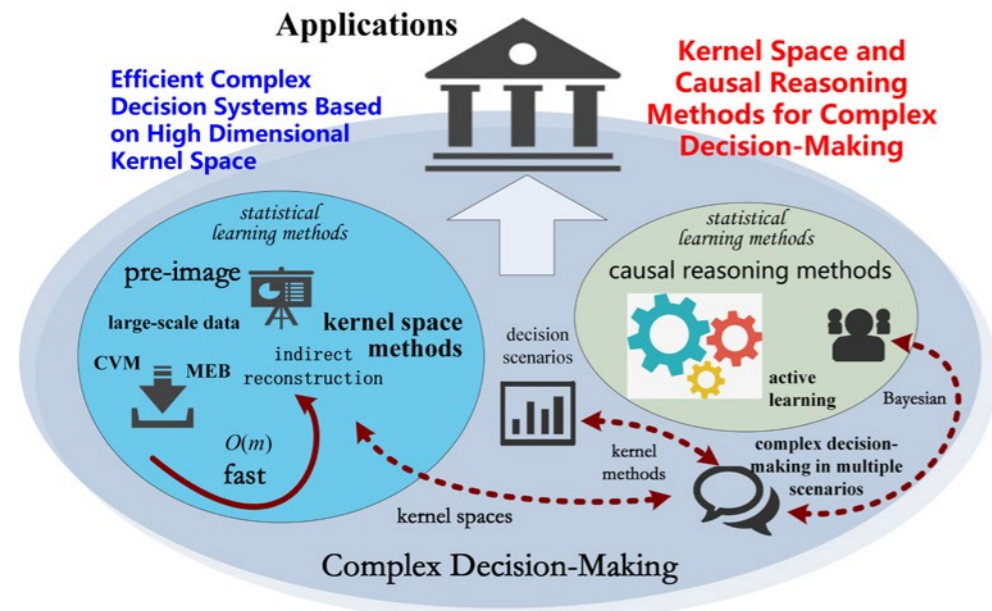
In the YOLOv7 team's paper "YOLOv7: Trainable bag-of-freebies sets new state-of-the-art for real-time object detectors", the introduction begins by citing FairMOT and ByteTrack as typical works in multi-object tracking and emphasizes that real-time object detection is an important and essential component in computer vision.

面向复杂决策的核空间和因果推理方法

Kernel Space and Causal Reasoning Methods for Complex Decision-Making



● 面向复杂决策的核空间和因果推理方法及高效系统



● The Kernel Space and Causal Reasoning Methods and Efficient Systems for Complex Decision-Making

中国人民大学
Renmin University of China

香港科技大学
Hong Kong University of Science Technology

北京大学
Peking University



引言

现实世界的数据体现出日益增长的复杂性，如何更好地利用复杂数据资源提高决策水平，是人工智能的重要前沿研究课题。本成果针对面向复杂决策环境下人工智能中的核空间及因果推理方法，开展了较为系统深入的研究。

Introduction

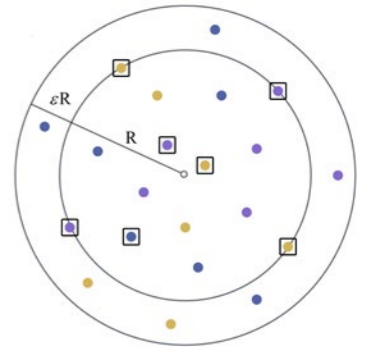
Nowadays, the data in the real world are featured with increasing complexity. How to better utilize complex data resources to improve decision-making level is an important cutting-edge research topic in artificial intelligence. This work conducts a systematic and in-depth study on kernel space and causal reasoning methods for complex decision-making environments.

提出了核心向量机算法及间接原像重构方法

We proposed a core vector machine and an indirect pre-image reconstruction method

提出了一种基于最小闭包球的核心向量机算法，通过迭代寻找高维特征空间的核心集，给出了原始最小闭包问题的最优近似解，避免了训练向量反复进出工作向量集合，其计算复杂度与数据量大小呈近似线性关系，空间复杂度与训练样本数无关，可用于海量数据场景。进一步提出了一种基于多维尺度分析的间接原像重构方法，建立了从核空间到输入空间的维持局部线性的逆映射模型，通过距离约束非迭代的直接找到原像的位置，该方法没有陷入局部极小问题，适用于大多数常用的核函数等。此外，还发展了一种基于因果图模型的主动学习方法，在序贯干预架构中提出了极大极小和最大熵准则判断最优的实验方案，使因果结构的主动学习可以高效地在因果系统的子集中局部进行。

We presented a core vector machine algorithm based on the minimum enclosing ball, which iteratively searches for the core set of high-dimensional feature space and provides the optimal approximate solution of the original minimum enclosing problem. The method avoids the repeated entry and exit of training vectors of the working vector set. Its computational complexity is approximately linear with the size of the data, and its spatial complexity is independent of the number of training data, making it suitable for massive data scenarios. Further, we proposed an indirect pre-image reconstruction method based on multidimensional scale analysis, established an inverse mapping model that maintains local linearity from the kernel space to the input space, and found the position of the pre-image noniteratively through distance constraints. This method does not have the problem of local minima and is suitable for most commonly used kernel functions. In addition, we developed an active learning method based on the causal network model and an experimental scheme using the minimax and maximum entropy criteria to determine the optimal outcome in the sequential intervention architecture. This method enables active learning of causal structures to be efficiently carried out locally in subsets of causal systems.



● 基于最小闭包球的核心向量机算法

● The core vector machine algorithm based on the minimum enclosing ball

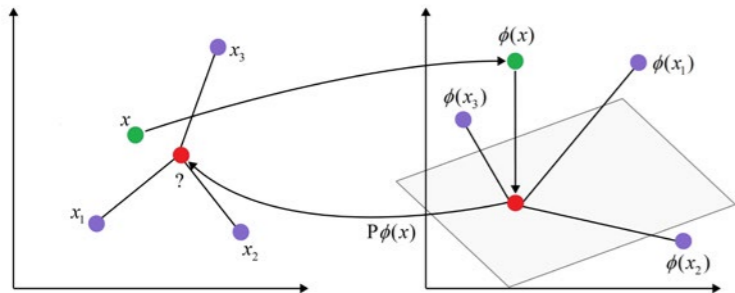
实现了一类支持向量机快速训练，减小了算法复杂度

We implemented a fast support vector machine with reduced computational complexity

提出了面向复杂优化问题的核空间高效算法创新设计，从理论上证明了支持向量机中求解支持向量的凸二次规划问题与求解核心集的最小闭包球问题的等价关系，在处理大规模数据时性能优越。利用多维尺度分析法确定原像的位置，实现了一种基于多维尺度分析的间接原像重构方法，该方法不需要迭代计算、不会陷入局部极小。提出了概率图模型主动学习中的学习结构等价类，实现以最小的实验代价获取最多的因果信息，在理论上给出了干预信息的因果图表示，基于因果学习和推断选择最优实验方案，降低了干预实验成本。研究了核空

间方法面对不同领域环境下的广泛适应性，讨论了面向多种复杂环境的核空间和因果推理的方法体系，提出了若干新模型、新理论和新方法。

We presented an innovative design of efficient kernel space algorithms for complex optimization problems and theoretically proved the equivalence between solving convex quadratic programming problems for support vectors in support vector machines and solving the minimum enclosing ball problem of the core set. It has superior performance in processing large-scale data. A multi-dimensional scale analysis method was used to determine the position of the pre-image, and an indirect original image reconstruction method based on multi-dimensional scale analysis was implemented. This method does not require iterative calculations and does not fall into local minima. A learning structure equivalence class in probability graph model active learning was proposed to obtain the most causal information with the minimum experimental cost. A causal graph representation of intervention information was theoretically provided, and the optimal experimental scheme was selected based on causal learning and inference, reducing the cost of intervention experiments. We also studied the widespread adaptability of kernel space methods in different domain environments, discussed the methodology system of kernel space and causal reasoning for multiple complex environments, and developed a series of new models, theories, and methods.



●基于多维尺度分析的间接原像重构方法

● Indirect pre-image reconstruction method based on multidimensional scale analysis

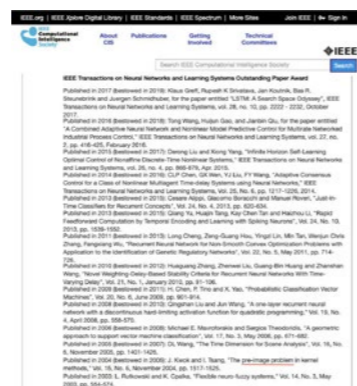
多项国际同行的研究在本成果的基础上进行了延伸

Many international peers have extended their research based on this work

本成果引起了国际同行的广泛兴趣，WoS 上有 1076 项研究，Google 学术上有 2063 项研究，在本成果的基础上进行了进一步延伸和验证，其中包括多位著名国际学术权威发表在 IEEE-TPAMI 及 JMLR 上的拓展工作，关于核空间原像本真表达的研究获得 IEEE-TNNLS 期刊年度论文杰出奖。在发展本成果的研究中，13 篇发表在 IEEE-TPAMI，20 篇发表在 JMLR，131 篇发表在其它 IEEE Transactions。典型的包括：(1) IEEE Fellow、Stony Brook University 的 Allen Tannenbaum 教授用 2 篇 IEEE-TPAMI 论文对本成果进行了连续改进和提升。(2) IEEE-TPAMI 编委 Stefanos Zafeiriou 教授在 IEEE-TIP 论文中采用了本成果构造基的方法实现原像的思路。(3) 核方法领域泰斗之一 Bernhard Scholkopf 教授的 IEEE-TPAMI 论文采用了本成果作对比成果。(4) 统计学著名期刊 Annals of Statistics 主编 Buhlmann 教授，对本成果连续用 4 篇论文进行了扩展研究，进一步发展了几乎相同的干预因果等价类。

This work has attracted widespread interest from international scholars, with 1076 studies cited on WoS and 2063 on Google Scholar. The work has been further extended and validated, including the expansion work of several international academic authorities

published on IEEE-TPAMI and JMLR. The research on the pre-image of a feature vector in the feature space induced by a kernel has won the IEEE-TNNLS Outstanding Paper Award. Among the studies based on this work, 13 were published in IEEE-TPAMI, 20 were published in JMLR, and 131 were published in other IEEE Transactions. Typical examples include: (1) Allen Tannenbaum, IEEE Fellow, Professor at Stony Brook University, consecutively improved and enhanced this work with two IEEE-TPAMI papers. (2) Professor Stefanos Zafeiriou, an associated editor of IEEE-TPAMI, adopted the method of constructing the basis of this work to implement the pre-image in his IEEE-TIP paper. (3) Professor Bernhard Scholkopf, one of the leading authorities in the field of kernel methods, used this work as a comparative result in his IEEE-TPAMI paper. (4) Professor Buhlmann, editor-in-chief of Annals of Statistics, extended this research work with four consecutive papers, and developed almost identical intervention causal equivalence classes.



●IEEE-TNNLS 期刊年度杰出论文奖

●IEEE-TNNLS Outstanding Paper Award

(<https://cis.ieee.org/awards/past-recipients#TNNOutstandingPaperAward>)

《科技之魅》收录成果

Charm of Science and Technology Collection

关键技术组 Key Technology

华为云盘古大模型 Huawei Cloud Pangu Models

●华为云盘古大模型重塑千行百业
●Reshaping Industries with Huawei Cloud Pangu Models

华为云计算技术有限公司
Huawei Cloud Computing Technologies Co., Ltd.



引言

华为云盘古大模型扎根行业，将一套通用的流水线复用到不同的场景，减少专家的干预和人为调优，降低人工智能开发的门槛和成本。盘古大模型包含计算机视觉、自然语言处理、科学计算等多个分支，并支持跨模态语义理解。

Introduction

Expanding on the concept of "AI for Industries", Huawei Cloud Pangu Models offer a set of AI development pipeline and workflows to develop and deploy AI models and applications for a wide range of different tasks across different industries, with minimum human intervention and manual parameter tuning. This helps to simplify AI development and lower its costs. Pangu foundation models include compute vision (CV) model, natural language processing (NLP) model, scientific computing model, and more, and support multimodal semantic understanding.



●盘古大模型架构图



●Architecture of Pangu Models

四大关键举措，实现大模型与行业结合，打造行业大模型

Four Keys to Operationalizing Industry Models

基于基础大模型打造行业大模型，从“知”到“行”，有四大关键举措：

There are four key measures to build industry models based on foundation models.

1. 沉淀行业知识

盘古学习了 10 多个行业的公开数据，涵盖金融、政务、气象、医疗、健康、互联网、教育、汽车、零售等，深入了解 400 多个业务场景，帮助大模型具备行业知识，熟悉行业机理。

1. Accumulating industry knowledge

Pangu Models have been pre-trained with open datasets from more than 10 industries, including finance, government, meteorology, healthcare, health, Internet, education, automotive, and retail. Pangu Models dive deep into over 400 industry scenarios and are combined with industry knowledge and know-how.

2. 淬炼行业技能

盘古结合专家和行业数字环境的反馈进行强化学习，以达到符合

行业应用的最佳结果。

2. Embedding industry skills

Reinforcement learning based on feedback from both experts and digital environments ensures that our industry models can achieve state-of-the-art performance over time.

3. 对话专业工具

盘古打通了 10 多种行业插件和工具，包括数学计算、知识图谱、求解器、企业搜索、SQL、时空数据库等，同时大模型与业务系统融合，产生“对话与交流”，让大模型能调用大量行业资产和工具。

3. Connecting professional tools

Pangu Models have integrated more than 10 industry plugins and tools, including math calculation, knowledge graph, solver, enterprise search, SQL, and spatiotemporal databases. Pangu combines pre-trained AI models with business systems to invoke a wealth of industry assets and tools through human-AI communication.

4. 保障安全合规

盘古提供公有云、混合云、大模型专区三种模式，保障安全部署；同时，建立长效机制，确保大模型安全合规，确保大模型使用边界。

4. Security & compliance

Customers can deploy Pangu Models on a public cloud, hybrid cloud, or dedicated zone the way that best fits. Long-term mechanisms ensure security and compliance for industry models and clarify boundaries concerning model use.



●4 大关键举措打造行业大模型



●Four keys to operationalizing industry models

盘古大模型，重塑千行万业

Pangu Models: Reshaping Industries with AI

盘古大模型扎根行业，将 AI 带入行业核心生产系统，实现对千行万业的重塑。

Pangu Models are reshaping industries by extending AI to customers' core production systems.

1. 盘古气象大模型：首个精度超过传统数值预报方法的 AI 模型，速度相比传统数值预报提速 10000 倍以上。盘古气象大模型的研究结果被发表在国际顶级学术期刊《自然》正刊上。

1. Pangu Meteorology Model (Pangu-Weather) is the first AI model that can predict weather more accurately than conventional numerical weather prediction (NWP) methods, and 10,000 times faster. Research results about Pangu-Weather have been published on Nature, a renowned scientific journal.

2. 盘古药物分子大模型：实现先导药的研发周期从数年缩短至一个月，研发成本降低 70%。助力西交大一附院刘冰教授团队发现世界 40 年来首个新类别、新靶点的抗生素，目前已进入临床阶段。

2. With Pangu Drug Molecule Model, the cycle of lead compound discovery was reduced from several years to just one month, and R&D costs were slashed by 70%. Using this model, a team led by Professor Liu Bing of the First Affiliated Hospital of Xi'an Jiaotong University discovered the world's first new superantibiotic in the last 40 years, with a new target and in a category of its own. This drug is now in clinical trial stage.

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Accurate medium-range global weather forecasting with 3D neural networks

Kaifeng Bi, Lingxi Xie, Hengheng Zhang, Xin Chen, Xiaotao Gu & Qi Tian

Nature 619, 533–538 (2023) | [Cite this article](#)

126k Accesses | 7 Citations | 1567 Altmetric | [Metrics](#)

An [Author Correction](#) to this article was published on 14 September 2023

This article has been [updated](#)

Abstract

Weather forecasting is important for science and society. At present, the most accurate forecast system is the numerical weather prediction (NWP) method, which represents atmospheric states as discretized grids and numerically solves partial differential equations that describe the transition between those states¹. However, this procedure is computationally expensive. Recently, artificial-intelligence-based methods² have shown potential in accelerating weather forecasting by orders of magnitude, but the forecast accuracy is still significantly lower than that of NWP methods. Here we introduce an artificial-

●华为云盘古气象大模型研究成果在《Nature》正刊发表

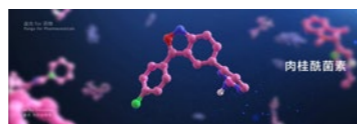
●Paper about Huawei Cloud Pangu-Weather Model published on Nature

3. 盘古矿山大模型：实现矿下无人少人安全作业，井下异常监测识别准确率超过 95%。智能洗选煤提升精煤回收率 0.1% ~ 0.2%，焦化配煤优化有效降低成本 3 元 / 吨。

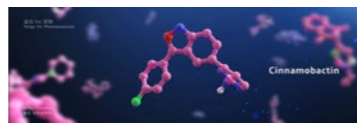
3. Pangu Mining Model delivers an underground anomaly detection accuracy of over 95%, so that coal mines only need a small, or even no crew underground. The yield of refined coal can be increased by 0.1% to 0.2%. The cost of coal blending can be reduced by CNY3 per ton.

盘古大模型已经在金融、政务、矿山、铁路、气象、药物研发、制造、汽车等行业打造 L1 层行业大模型。

We have operationalized L1 industry models in various industries such as finance, government, mining, railway, meteorology, drug R&D, manufacturing, and automotive.



●基于华为云盘古药物分子大模型筛选得到的药物分子



●Drug molecules obtained by Huawei Cloud Pangu Drug Molecule Model

技术扎根，极致效能，打造世界 AI 另一极

Honing Technology and Efficiency: Giving the World Another Option to Build AI

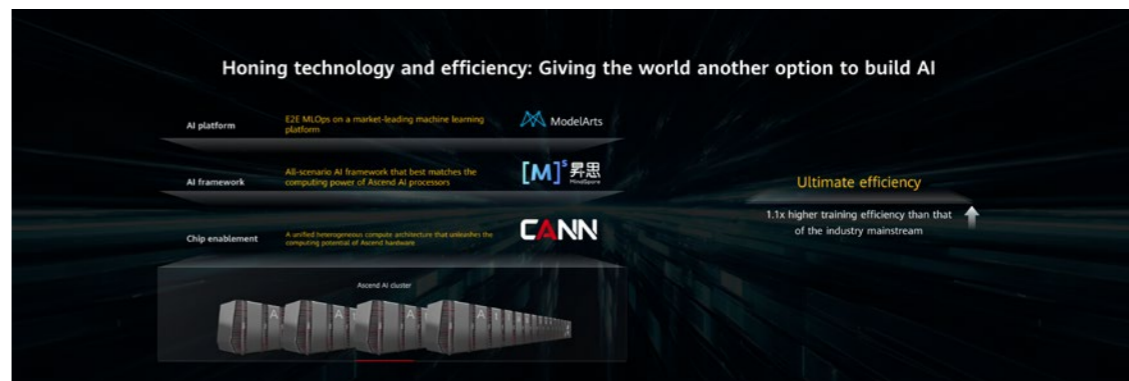
盘古大模型的创新，是各项 AI 根技术创新，包括最底层以鲲鹏和昇腾为基础的 AI 算力云平台，昇腾的计算引擎 CANN、AI 的开发框架 MindSpore，以及 AI 开发平台 ModelArts，为大模型开发和运行，提供分布式并行加速、算子和编译优化、集群级通信优化等关键能力。

Pangu Models are all about the innovation of core technologies of AI, including an AI compute cloud platform built on Kunpeng and Ascend, CANN (compute engine), MindSpore (AI development framework), and ModelArts (AI development platform). Key capabilities include distributed parallel acceleration, operator and compilation optimization, and cluster communications optimization for AI model development and running.

盘古大模型是基于全中国自主技术训练出来的大模型，其训练效能，当前已经达到业界主流 GPU 的 1.1 倍。盘古大模型实现了在非主流 GPU 上的训练和开发，并开发了全套开发工具，为全球客户打造世界 AI 另一极，为所有 AI 开发者提供新的选择。



●技术扎根，极致效能，打造世界 AI 另一极



●Honing technology and efficiency: Giving the world another option to build AI

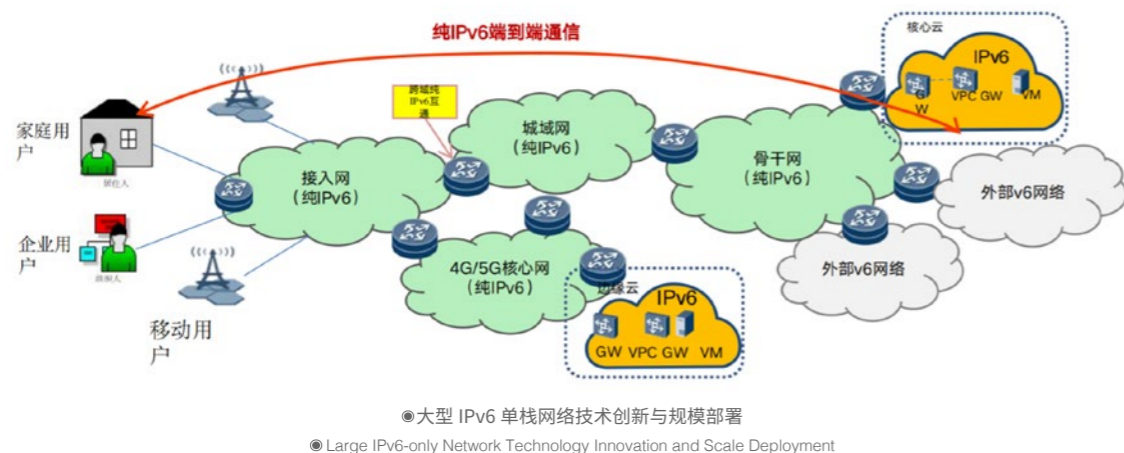
盘古大模型致力于深耕行业，打造金融、政务、制造、矿山、气象、铁路等领域行业大模型和能力集，将行业知识 know-how 与大模型能力相结合，重塑千行百业，让每个行业、每个企业、每个人都拥有自己的专家助手，让工作更高效更轻松。

Based on Pangu Models, we have been building tailored models and capability sets for a wide range of industries, such as finance, government, manufacturing, mining, meteorology, and railway. These industry models combine industry knowledge and know-how with pre-trained deep neural networks to reshape respective industries with AI, and offer expert-level assistants for every enterprise and individual to help them improve productivity and efficiency.

Huawei's AI core technologies can train Pangu Models 1.1 times faster than mainstream GPUs in the industry. Pangu Models are trained and developed based on Huawei Ascend AI cloud services. Huawei also provides a full set of AI development tools. We now offer another option for global customers, partners, and developers to build, train, and use AI models.

大型 IPv6 单栈网络技术创新与规模部署

Large IPv6-only Network Technology Innovation and Scale Deployment



中国电信集团有限公司
China Telecom Corporation Limited



清华大学
Tsinghua University



下一代互联网国家工程中心
China Future Internet Engineering Center(CFIEC)



北京天创赛斯科技有限公司
Beijing Tianchuang Saisi Technology Corporation Limited



引言

针对网络向 IPv6 单栈演进的难题，团队自主提出了多域 IPv6 单栈组网架构及核心技术，实现由多个自治域组成的网络内部设备只配置 IPv6 协议，支持基于 IPv6 跨自治域统一承载云网业务，实现多场景纯 IPv6 能力协同，满足大规模商用网络向 IPv6 单栈演进需求。

Introduction

In response to the challenge of the evolution towards IPv6-only network, the team independently proposed a multi-domain IPv6-only networking architecture and core technologies, which enables the internal devices of a network composed of multiple autonomous domains to be configured only with IPv6 protocol. It supports unified cloud network services delivery across autonomous domains based on IPv6, achieves multi-scenario IPv6-only capability collaboration, and meets the needs of large-scale networks evolving towards IPv6-only.

在国际上牵头多域 IPv6 单栈总体技术标准制定，解决大型网

络向 IPv6 单栈演进难题

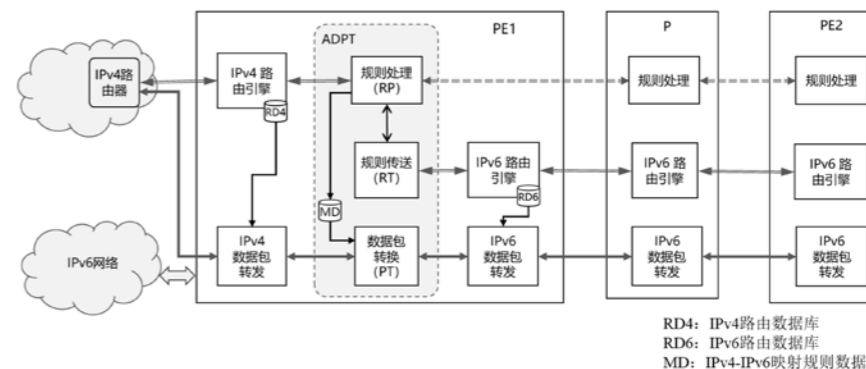
Leading the development of overall technical standards for multi-domain IPv6-only internationally, solving the problem of large-scale networks evolving towards IPv6-only

自主提出了新型的 IPv6 单栈网络架构及技术，并在国际 IETF 牵头相关标准制定。针对“IPv4 即服务 (IPv4-as-a-Service)”、单栈高效转发和多域协同问题，本方案将整个 IPv4 地址映射到 IPv6 地址空间中，实现地址空间一体化；

控制面支持地址映射规则的跨域自动交换，提供了路径可达性信息；数据面灵活支持原生 IPv6、隧道、翻译和 SRv6 等多种格式，满足多业务承载要求。本项目已完成多项 IETF RFC，目前正在 IETF 牵头多域 IPv6 单栈组网标准的制定，在国际上得到了包括 Verizon、瑞士电信和 Orange 等多家运营商的支持。另外，在欧洲 ETSI 立项了 5G 网络的 IPv6 单栈测试标准的制定。

The team has independently proposed a new IPv6-only network architecture and technologies and has led the development of relevant international standards in IETF. To address the issues of "IPv4 as a Service", IPv6-only efficient forwarding, and multi-domain collaboration, this solution maps the entire IPv4 address space to the IPv6 address space, achieving address space unification; The control plane supports the automatic exchange of address mapping rules cross domain, so as to provide path reachability

information; The data plane flexibly supports multiple formats, such as native IPv6, tunnel, translation, and SRv6 to meet the requirements of multi-service bearers. This team has completed multiple IETF RFCs and is currently leading the development of multi-domain IPv6-only networking standards. It has received support from multiple operators, including Verizon, Swiss Telecom, and Orange. In addition, ETSI in Europe has initiated the development of IPv6-only testing standards for 5G networks.

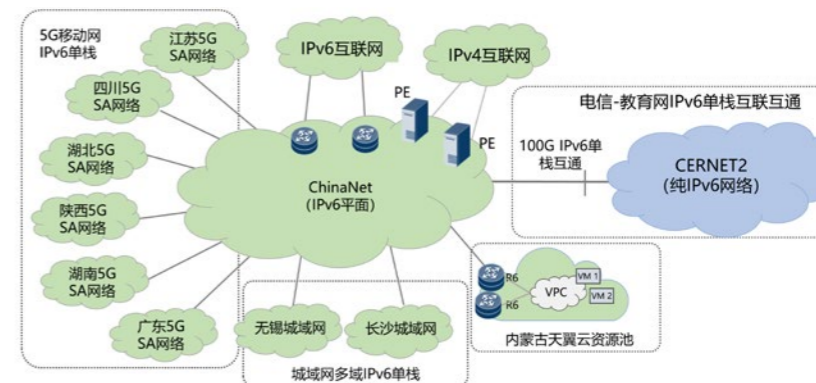


建立了全球首个多场景一体化 IPv6 单栈示范网络

Established the world's first multi-scenario integrated IPv6-only demonstration network

该示范网络涵盖 5G、城域网、骨干网和云资源池在内的多场景一体化，实现了首个 5G SA 网络的 IPv6 单栈落地部署，同时开创了国内运营商间 IPv6 单栈直接互通的先河。

This demonstration network covers the integration of multiple scenarios including 5G, metropolitan area network, backbone network, and cloud resource pool, achieving the first case of IPv6-only deployment in 5G SA network, and pioneering the direct IPv6-only inter-connection among Chinese operators.



本项目产生了重要的社会效益。首先，本项目践行和推动了中国关于 IPv6 发展得重要政策的落实，通过自主创新和部署 IPv6 单栈树立新的发展标杆，带动产业按照中国的 IPv6 规划向单栈方向发展。其次，国际 IETF 牵头多域 IPv6 单栈标准的制定，为国际互联网演进贡献中国方案，为构建网络空间命运共同体贡献力量。大大提升了中国在国际互联网界的技术地位和实质影响力。在研究期间，项目负责人解冲锋在 2021.1~2023.1 期间，担任欧洲通信标准化协会（ETSI）IPv6 创新工作组（IPE ISG）副主席，于 2017 年获世界 IPv6 论坛颁发的“全球 IPv6 领袖奖”。

This project has generated significant social benefits. Firstly, It has implemented and promoted the implementation of the policies related to the development of IPv6 in China, setting a new development benchmark for IPv6-only through independent innovation and deployment, and driving the industry to develop towards single stack direction according to China's IPv6 plan. Secondly, it is leading the development of multi domain IPv6-only standards in IETF, contributing China's solution to the evolution of the global internet and contributing to the construction of a community with a shared future in cyberspace. It has greatly enhanced China's technological status and substantial influence in the international internet community. During the research period, project leader Xie Chongfeng served as Vice Chairman of the IPv6 Innovation Working Group (IPE ISG) of the European Telecommunications Standardization Institute (ETSI) from November 2021 to January 2023. He was awarded the "Global IPv6 Leader Award" by the World IPv6 Forum in 2017.

在经济效益方面，本项目实现了首个包括 5G SA 网络在内的跨域一体化 IPv6 单栈示范，网络能力覆盖 3000 万以上的用户。本网络示范涉及 10 亿以上的相关产业规模。另外，实现了首个运营商间 IPv6 单栈互通，在中国电信和中国教育网之间建立了首条 100G 的纯 IPv6 直连电路，带宽利用率达到 60%。在物联网应用方面，中国电信物联网 AIOT 平台南向支持百万级 IPv6 单栈用户接入，IPv6 单栈能力覆盖全国 31 省。预计到 2024 年底，中国电信将新增 NB 连接数 2 亿，按 30% 的 IPv6 连接数预估，估计将带动设备厂商产业链增长约 15 亿元。

In terms of economic benefits, this project has achieved the first cross domain integrated IPv6-only demonstration, including 5G SA network, with network capacity covering over 30 million users. This network demonstration involves a scale of over 1 billion RMB Yuan related industries. In addition, the first IPv6-only interoperability between operators has been achieved, and the first 100Gbps IPv6-only direct connection circuit has been established between China Telecom and China Education and Research Network (i.e. CERNET), achieving a bandwidth utilization rate of 60%. In terms of IoT applications, China Telecom's IoT platform, i.e. AIOT, supports access to millions of IPv6-only users southward, with IPv6-only capabilities covering 31 provinces across the country. It is expected that by the end of 2024, China Telecom will add 200 million new NB connections. Assuming 30% of users are IPv6-only users, it is estimated that it will drive the growth of equipment manufacturers' industry chain by about 1.5 billion RMB Yuan.

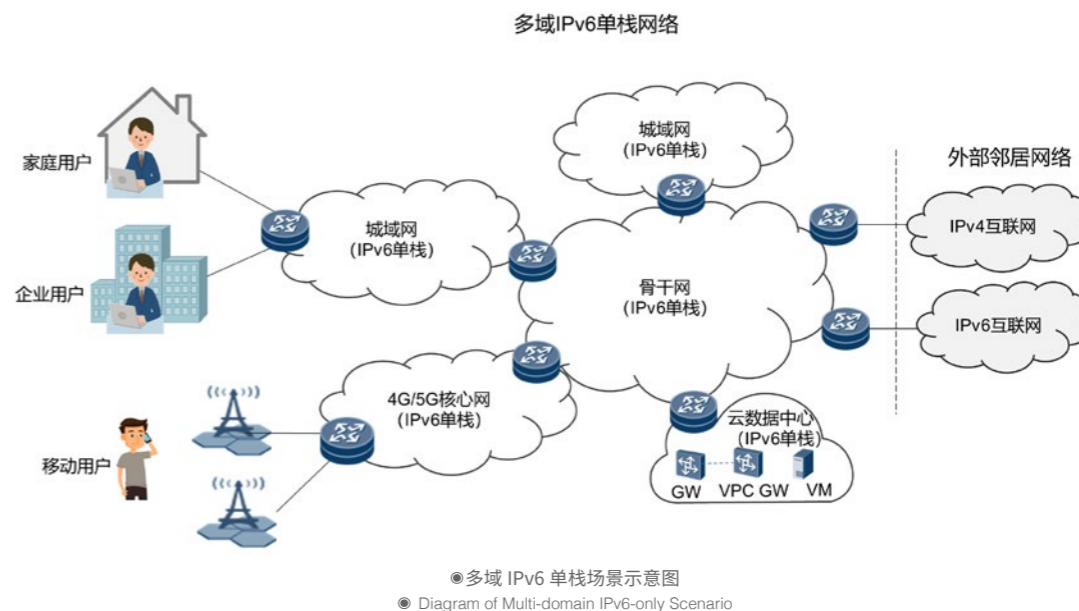
以体系化的方案设计推动基础网络、业务和终端产业向 IPv6 单栈全面演进

Promote the comprehensive evolution of base network, service, and terminal industries towards IPv6-only through systematic solution design

本成果对于 IPv6 产业结构调整、优化和升级产生了重要影响。对于网络设备产业，项目方案的需要位于网络边缘的 PE 类设备支持相关的技术要求，推动网络设备的功能升级。网络内部的核心设备仅需要保持 IPv6 协议，不再需要保持 IPv4 协议，该特性将促使相关产业链淘汰落后的技

术特性，释放设备的相关资源，留有更多的资源空间发展新功能特性。同时，本成果需要终端支持符合国际标准定义的 IPv6 单栈客户端功能，主流的操作系统如：安卓、IOS、windows、Linux 等系统上该功能已实现。对于不支持该功能的系统，需要开发和适配。对于新型的终端，如物联网终端，需要从其芯片和模组层面实现对于 IPv6 单栈的完整支持。在者，向产业界传递出 IPv6 单栈演进的明确信号，促进我国互联网应用产业向 IPv6 单栈的演进，提升全网的 IPv6 流量的占比，逐步减少和弱化对于 IPv4 协议的使用。

This achievement has had a significant impact on the adjustment, optimization, and upgrading of the IPv6 industry structure. For the network equipment industry, the project requires PE devices located at the edge of the network to support relevant technical requirements and promote the functional upgrading of network devices. The core devices within the network only need to maintain the IPv6 protocol, no longer the IPv4 protocol. This feature will promote the elimination of outdated technological features in the relevant industry chain, release the relevant resources of the devices, and leave more resource to develop new functional features. At the same time, this achievement requires the terminal to support IPv6-only client function that meets the international standard definition. This function has been implemented in mainstream operating systems such as Android, IOS, Windows, Linux, etc. For systems that do not support this feature, development and adaptation are required. For new types of terminals, such as IoT terminals, complete support for IPv6-only needs to be achieved at the chip and module level. At the same time, it sends a strong signal to the industry about the evolution of IPv6-only, promotes the evolution of China's internet application industry towards IPv6-only, increases the proportion of IPv6 traffic in the whole network, and gradually reduces the usage of IPv4 protocol.



多域 IPv6 单栈网络指的是由多个自治系统组成、由统一的机构管理运营的 IPv6 单栈网络系统，每个自治系统均采用 IPv6 单栈方式组网和运营，并且相互之间通过 IPv6 单栈互联互通。为了支持业务的平滑过渡，多域 IPv6 单栈网络仅在网络边缘的 PE 设备上保留 IPv4 特性，支持存量 IPv4 业务数据的接入，确保用户体验不降低。

Multi-domain IPv6-only network refers to an IPv6-only network system composed of multiple autonomous systems and managed and operated by an organization. Each autonomous system adopts IPv6-only networking and operation and is interconnected with each other through IPv6-only. To support smooth service transition, multi-domain IPv6-only networks retain IPv4 characteristics only on PE devices at the network edge, support access to existing IPv4 service data, and ensure that user experience is not reduced.

Large IPv6-only Network
Technology Innovation and
Scale Deployment

讯飞星火认知大模型

IFLYTEK SPARK Cognitive Large Language Model



讯飞星火认知大模型具有跨领域的知识和语言理解能力，可实现从提出问题、规划问题到解决问题的全流程闭环



IFLYTEK SPARK, a cognitive large language model, possesses cross-domain knowledge and language comprehension abilities, enabling end-to-end closed-loop from problem formulation and planning to final solution

科大讯飞股份有限公司
IFLYTEK Co., Ltd.



引言

讯飞星火认知大模型是科大讯飞基于“1+3+1”创新体系自主研发的新一代认知智能大模型，具有文本生成、知识问答、逻辑推理、语言理解、数学、代码、多模交互和文图生成等七大核心能力，构筑起通用人工智能的新生态。

Introduction

IFLYTEK SPARK is a next-generation model of cognitive intelligence developed independently by iFLYTEK, based on a "1+3+1" innovation system. It possesses seven core capabilities: text generation, knowledge question-answering, logical reasoning, language comprehension, mathematics, coding, multi-modal interaction, and text and image generation, offering a new ecosystem for general artificial intelligence.

创新提出“1+3+1”大模型全链条关键技术体系

Innovative "1+3+1" comprehensive key technology system for large language models

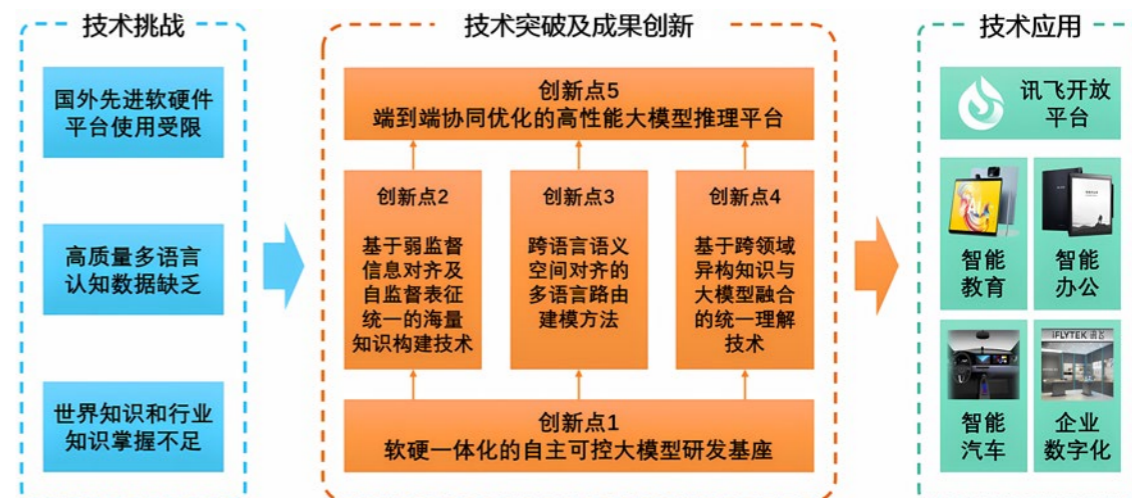
针对认知智能大模型研发中的大规模算力集群构建难、高质量多语言认知数据缺乏、世界知识和行业知识掌握不足等技术难题，科大讯飞创新提出了“1+3+1”大模型全链条关键技术体系：训练平台方面，基于主流国产化软硬件平台打造了软硬一体化的大模型研发基座；关键技术方面，提出了基于弱监督信息对齐及自监督表征统一的海量知识构建技术、跨语言语义空间对齐的多语言路由建模方法和基于跨领域异构知识与大模型融合的统一理解技术；推理平台方面，设计了大模型端到端协同推理优化框架。基于相关技术已主导制定国际标准4项，获得世界顶级人工智能挑战赛 Open Graph Benchmark 知识图谱榜单、生成式文本摘要国际比赛 GENIE - Summarization XSUM、国际对话系统技术挑战赛 DSTC、常识推理挑战赛 OpenBookQA、逻辑推理机器阅读理解挑战赛 ReClor、国际语义评测 SemEval、多模态阅读理解评测 VCR、多语言理解评测 XTREME 等国际冠军 30 余项；被《麻省理工科技评论》中国评为“最聪明”的国产大模型。

In response to the technological challenges in the development of large language models of cognitive intelligence, such as the difficulty in constructing massive computing clusters, the lack of high-quality multi-lingual cognitive data, and insufficient global and industry knowledge, iFLYTEK has offered an innovative "1+3+1" comprehensive key technology system for building large language models.

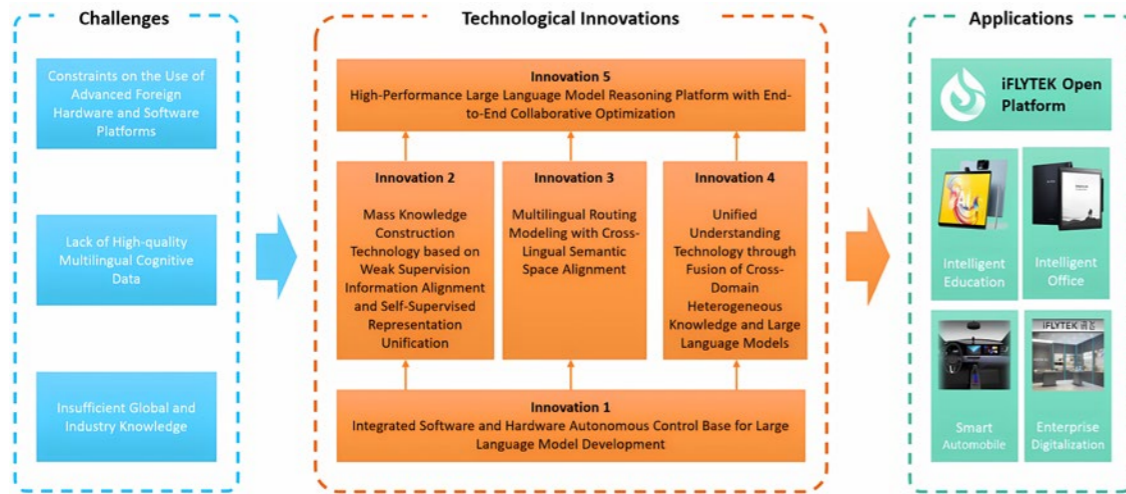
In terms of machine training, we have built an integrated software and hardware research

base for large language model development embracing mainstream domestic software and hardware platforms. So far as key technologies are concerned, we have introduced massive knowledge construction techniques based on weakly supervised information alignment and self-supervised representation unification, multilingual routing modeling based on cross-lingual semantic space alignment, and unified understanding techniques based on the fusion of cross-domain heterogeneous knowledge and large language models. On the side of logical reasoning, we have designed an end-to-end collaborative reasoning optimization framework for large language models.

We have led the development of four international standards in relevant technologies and scored over 30 international championships in top-notch artificial intelligence challenges, including Open Graph Benchmark in knowledge graph, GENIE - Summarization XSUM in generative text summarization, DSTC in dialogue systems, OpenBookQA in common-sense reasoning, ReClor in logic-based machine reading comprehension, SemEval in semantic evaluation, VCR in multi-modal reading comprehension, and XTREME in multilingual understanding. Additionally, iFLYTEK SPARK is recognized as the "Smartest" domestically produced large language model by MIT Technology Review China.



总体技术框架



© Overall Technical Framework

率先发布多个行业应用产品并实现规模化落地

The first to release multiple industry products and achieve large-scale applications

基于显著领先的“智能涌现”能力，讯飞星火认知大模型已从五大路径开展成果落地：一是结合现有业务进行应用示范，率先实现在教育、医疗、办公、汽车等多个行业深度应用。二是依托开放平台打造行业生态，首批获批面向全民开放，首日14小时用户数突破100万，登上AppStore免费总排行榜第一。三是面向行业痛点解决实际问题，已与超10000家企业合作对接，共同探索千行百业的智能化跃迁，打造自主创新的国产算力底座。四是助力企业内部运营提质增效，在新华社研究院中国企业发展研究中心发布的《人工智能大模型体验报告2.0》中，讯飞星火的工具提效能力位列榜首。五是打造个人AI助手，实现三方插件首发上线，已开放超过12000款智能助手，覆盖职场、生活、营销等五大板块的24个典型场景。讯飞星火将持续提升七大核心能力，推出更多元的应用产品，用人工智能建设美好世界。

Based on its advanced “emergent intelligence” capabilities, our IFLYTEK SPARK has entered into application through five major paths.

First, we have developed demonstrational applications in combination with our existing businesses, taking the lead in realizing in-depth applications in education, medicine, office, automobile, and other industries.

Second, we have constructed an industry ecosystem relying on our open platform. As one of the first approved to be open to the public, our mobile app got more than 1 million

users in the first 14 hours and ranked first among Appstore free apps.

Third, we have solved practical industry problems. We have collaborated with over 10,000 enterprises to explore the intelligent leap for thousands of industries and create a domestic computing base with independent innovation.

Fourth, we have helped enterprises improve their internal operation quality and efficiency. In the “Artificial Intelligence Large Language Model Experience Report 2.0” released by the China Enterprise Development Research Center of the Xinhua News Agency Research Institute, IFLYTEK SPARK ranked first in terms of tool efficiency improvement.

Fifth, we have created AI assistants. As the first to release third-party plugins, we have offered over 12,000 intelligent assistants, covering 24 typical scenarios in five major sectors such as work, life, and marketing.

IFLYTEK SPARK will continue to enhance its seven core capabilities, unveil more application products, and use artificial intelligence to build a better world.

IFLYTEK SPARK COGNITIVE LARGE LANGUAGE MODEL

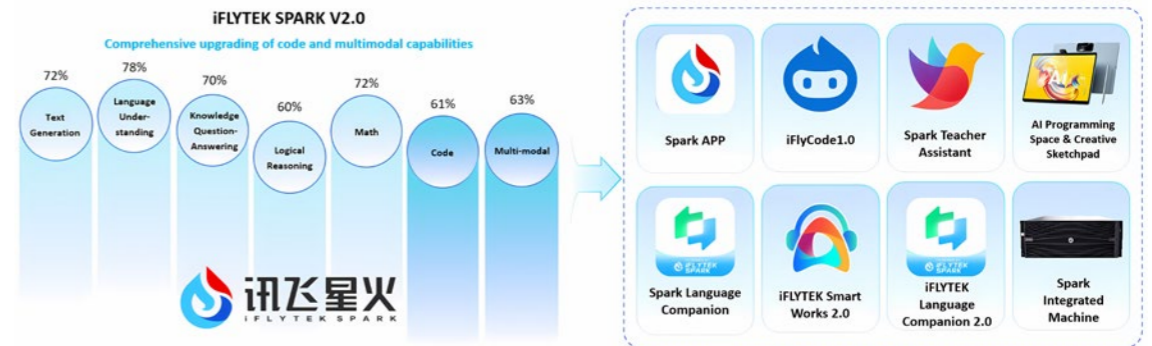
星火能力持续升级，应用产品不断丰富



*测试数据来源：按照认知智能国家重点实验室联合中科院人工智能产学研创新联盟、长三角人工智能产业联盟设计的《通用认知智能大模型评测体系》，基于真实用户数据，构建的全新测试集。

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Continuously upgrading capabilities and enriching application products

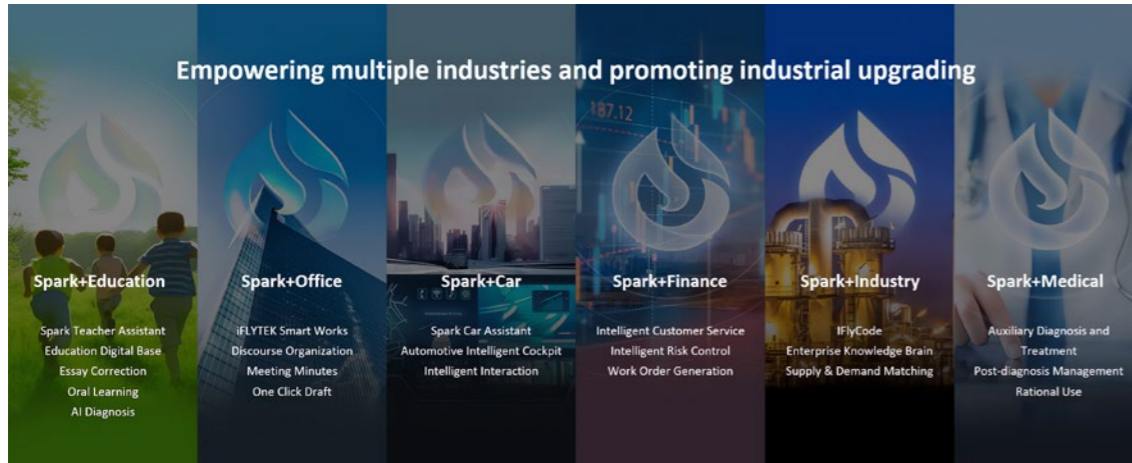


*Source: Based on the “Large Language Models of General Cognitive Intelligence Evaluation System” designed by the National Key Laboratory of Cognitive Intelligence in collaboration with the Chinese Academy of Sciences Artificial Intelligence Industry University Research Innovation Alliance and the Yangtze River Delta Artificial Intelligence Industry Chain Alliance, a new test set is constructed based on real user data.

© Innovative Products



© 行业深度应用



● In-depth Applications in Industries

推动认知大模型技术加速进入生态赋能新阶段

Accelerating the entry of cognitive large language models into a new stage of ecosystem empowerment

讯飞星火认知大模型是科大讯飞数十年磨一剑的重要成果，实现从技术探索到场景落地再到生态赋能的连续进阶，成为中国大模型快速发展的缩影。讯飞星火仅半年攻关成功发布，多维能力达到国际前沿水平，展现了科大讯飞在人工智能领域的技术积累和创新能力。从 B 端到 C 端的应用场景不断拓展，催生出新的商业模式和服务模式，如智能 RPA、智能编程、智能创作等，推动了各行业加速数字化、智能化转型。带动产业链创新链整体提升，与华为联合发布“星火一体机”，高算力 AI 芯片、高性能的算子库、多卡高速互联、分布式存储协同优化，实现私有化大模型的训练和推理一体化部署。以生态力量拓展大模型能力边界，星火 API、星火助手、星火插件全面开放，携手全球开发者和合作伙伴，共建人工智能“星火”生态，拥抱大模型时代的创新机遇。

IFLYTEK SPARK is a milestone that iFLYTEK has built through decade-long efforts, standing for a leap from technological exploration to scenario applications and then to ecological empowerment, and a microcosm of the rapid development of large language models in China.

We released the IFLYTEK SPARK after only 6 months of dedicated research and development, and its multi-dimensional capabilities have reached the global cutting edge, which proves our technological and innovation capabilities in the field of artificial intelligence.

The expansion of its application scenarios from the business side to the consumer side

has spawned new business and service models, such as intelligent RPA, intelligent programming, and intelligent creation, accelerating digital and intelligent transformation in various industries.

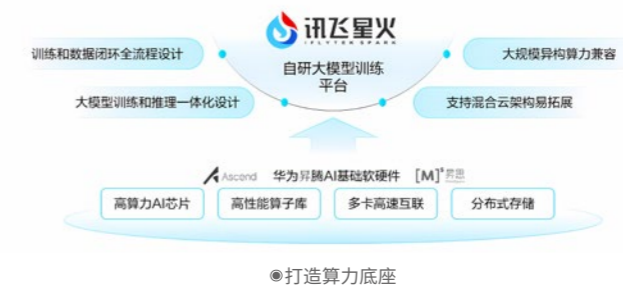
It can drive the overall improvement of the industrial chain and innovation chain. Together with Huawei, we have jointly released a "Spark Integrated Machine", featuring high computing power AI chips, high-performance operator libraries, multi-card high-speed interconnection, and distributed collaborative storage optimization, to achieve the integrated deployment of training and reasoning for private large language models.

To push back the boundaries of large language model capabilities by virtue of ecological power, the Spark APIs, Spark Assistants, and Spark plugins are fully open. We're working together with global developers and partners to build an artificial intelligence "Spark" ecosystem and embrace the innovation opportunities of the era of large language models.

IFLYTEK SPARK COGNITIVE LARGE LANGUAGE MODEL

联合攻关，打造全国产化算力底座

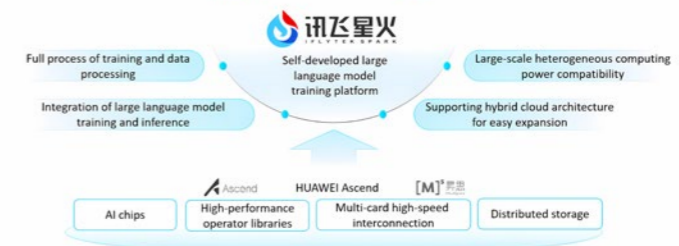
实现单卡性能对标英伟达A100，形成面向超大模型训练的国产算力集群优势



● 打造算力底座

Joint research to create a fully domestic computing power base

Single-card performance benchmarking against NVIDIA A100, forming the advantage of domestic computing power clusters for training big models



● The Computing Base

开放合作，共建通用人工智能新生态



● 共建行业生态

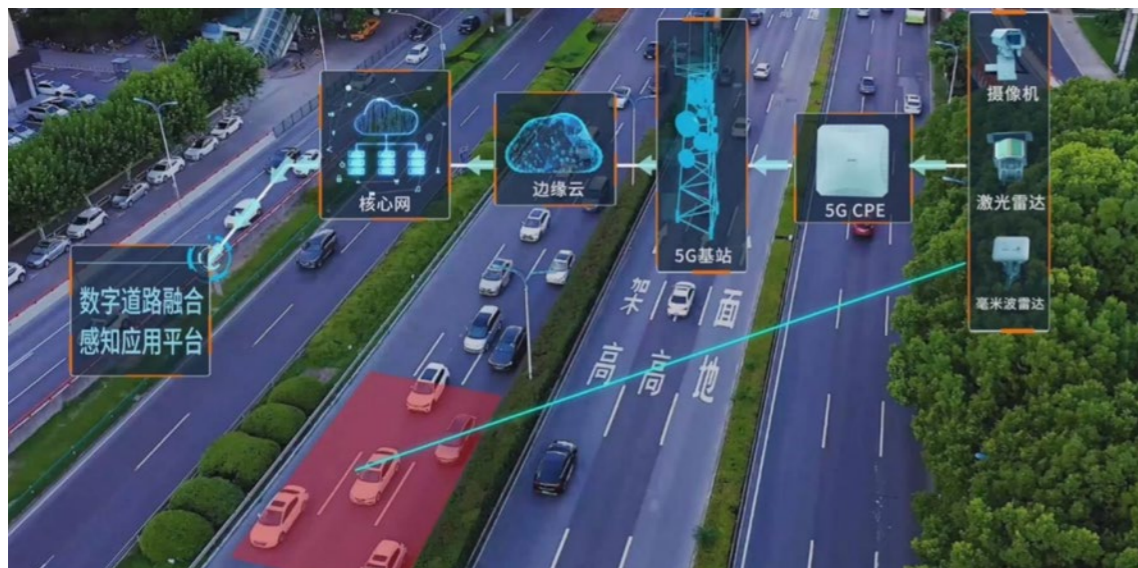
Open collaboration to jointly build a new ecology of general artificial intelligence



● Joint Construction of Industry Ecosystems

基于 B5G 融合感知的城市数字道路关键技术 研究及示范应用

Key Technology Research and Applications of Urban Digital Road Based on B5G Fusion Perception



● 基于 B5G 融合感知的城市数字道路业务系统示意图
● Diagram of Urban Digital Road Application System Based on B5G Fusion Perception

中国联合网络通信有限公司
China United Network Communications Corporation Limited



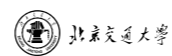
中信科智联科技有限公司
CICT Connected and Intelligent Technologies Co., Ltd.



北京首钢建设投资有限公司
Beijing Shougang Construction Investment Co., Ltd.



北京交通大学
Beijing Jiaotong University



引言

该成果针对未来城市交通精细化管理的需求和挑战，开展基于 B5G 融合感知数字道路的关键技术研究，构建创新业务体系并打造标杆应用案例，加快推动国内数字交通产业发展。

Introduction

In response to the requirement and challenges of refined management of urban transportation in the future, the project conducted research on key technologies of digital roads based on B5G fusion perception and developed an innovative application system and accomplished benchmark demonstration cases, promoting the rapid development of the domestic digital transportation industry.

关键技术突破，打造“精准定位 + 可靠通信 + 融合感知”的数字道路创新业务体系

Breakthroughs in key technologies, creating a digital road innovation application system with a combination of precise positioning, reliable communication, and integrated perception

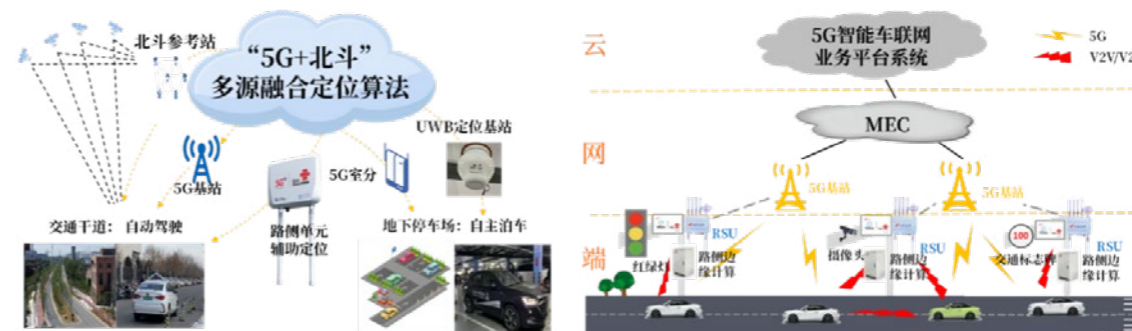
数字道路发展主要面临三大挑战：遮挡环境下车辆连续精准定位难，复杂交通环境下的路网协同难以及多样化交通场景的统一管理难。

Three major challenges exist in the development of digital roads: continuous and precise positioning of vehicles in obstructed environments, coordination of traffic networks in complex traffic environments and unified management of diverse traffic scenarios.

针对上述难题，项目团队完成了如下关键技术突破：首先，突破“5G+北斗”多源融合高精定位关键技术，提出基于 5G 大规模天线波束结合 RSU 信号校正的定位方法，实现了室内外无缝覆盖的厘米级定位能力；其次，构建 5G 蜂窝车联网融合组网机制，通过全局与区域通信的互补以及优化的资源配置及业务接入方法，实现时延小于 10ms 的车路云协同数据交互，达到业界先进水平；最后，研究全域交通融合感知算法，通过车端 + 路端的全方位协同感知能力，实现交通参与目标轨迹识别准确率不低于 95%，助力数字道路精细化管控。在技术突破的基础上研发数字道路业务系统平台，实现交通态势智能分析及高效管控。

Key technological breakthroughs have been accomplished for the above challenges. Firstly, the project achieved a breakthrough in the key technology of "5G+Beidou" multi-

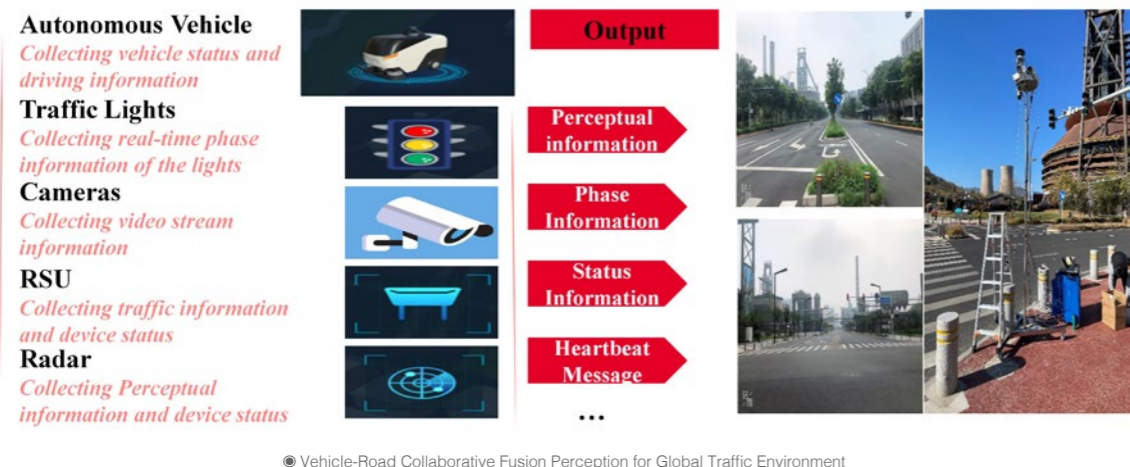
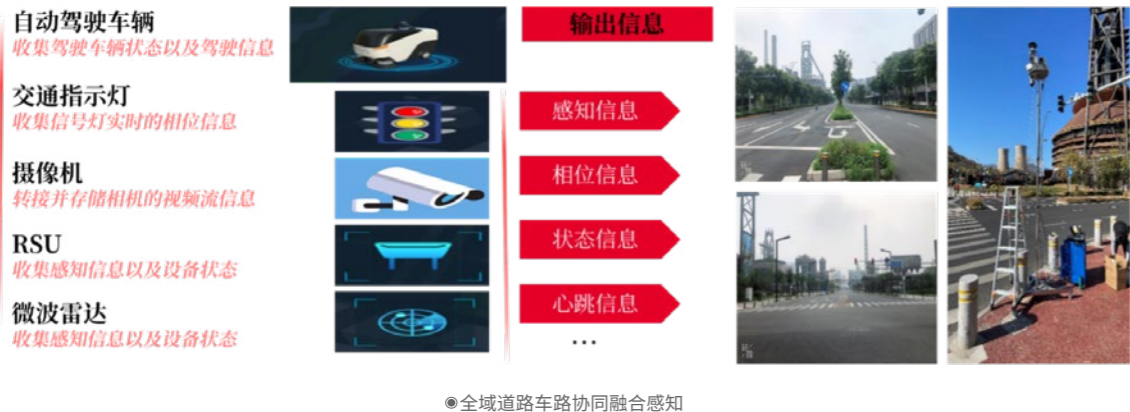
source fusion high-precision positioning, proposing a positioning method based on 5G large-scale antenna beam combined with RSU signal to achieve centimeter-level positioning capability for seamlessly indoor and outdoor coverage. Secondly, the 5G+C-V2X integrated networking was proposed, which enables the vehicle-road-cloud collaborative data interaction with a latency of less than 10ms on the basis of the complementarity of wide area and regional communication, as well as optimized resource configuration and business access mechanism, reaching an advanced level in the industry. Finally, research on the traffic fusion perception algorithm has been conducted, which achieves an accuracy rate of over 95% in identifying trajectories for traffic participants through the comprehensive collaborative perception of vehicle side and road side, helping the refined management of digital roads. Then, A digital road application system platform has been developed based on technological breakthroughs to achieve intelligent analysis and efficient control of traffic situation.



● “5G+北斗”多源融合高精定位 & 5G 蜂窝车联网融合组网



● “5G+Beidou” Multi-source Fusion High-precision Positioning & 5G+C-V2X integrated networking



标杆示范应用，奥运史上首次 5G 无人车火炬接力

Benchmark demonstrations - the first torch relay with 5G unmanned vehicle in Olympic history

在 2022 年北京冬奥会期间实现了奥运史上首次 5G 无人车火炬接力；在北京冬奥村落地 5G 无人清扫创新业务，助力冬奥期间的疫情防控；在首钢园区实现无人接驳巴士、无人零售车等平稳运营，满足全天候便捷出行需求。

The project completed the first torch relay with 5G unmanned vehicle in Olympic history during the 2022 Beijing Winter Olympics Games and launched 5G unmanned cleaning innovative services in the Beijing Winter Olympics Village to assist in epidemic prevention and control. In addition, unmanned shuttle buses, unmanned retail vehicles, etc. have officially operated in Shougang Park, meeting the requirement of 24-hour convenient transportation.

此外，面向“后冬奥遗产再利用”，在北京首钢园区实现了 5G 智慧园区关键场景全息业务的精细化管理；在河北荣乌高速、雄安新区数字道路等试点道路，实现交通态势全方位监管业务，赋能中国城市数字道路建设发展。

Moreover, focusing on "Reuse of Winter Olympics Heritage", we have implemented refined management of key holographic application scenarios of 5G smart park in Shougang Park. Comprehensive traffic situation supervision services have been applied on pilot roads such as Rong Wu Expressway in Hebei and digital roads in Xiong'an New Area, empowering the construction and development of digital roads in China.

成果得到 CGTN、CCTV、人民网等多家主流媒体的报道，取得学术界和媒体的广泛关注。通过推动核心技术及自研产品的落地应用，实现经济效益数千万元。

The project has been reported by multiple mainstream media outlets, such as CGTN, CCTV, People's Daily, etc., attracting widespread attention from academic and media

circles. By promoting the implementation of core technologies and self-developed products, a revenue of tens of millions has been achieved.



●2022 北京冬奥会 5G 无人车火炬接力
● Torch Relay with 5G Unmanned Vehicle in 2022 Beijing Winter Olympic Games

发挥科研牵引作用，推动数字交通产业发展

Leveraging scientific research leadership and promoting the development of digital transportation industry

成果基于研究成果牵头 / 参与 3GPP、5GAA、CCSA 等国内外标准立项 30 余项，例如牵头 5GAA 首个高精定位课题“High-Accuracy Positioning for C-V2X”，形成前沿技术前瞻影响力。申请发明专利 20 余项，并将专利标准联动，推动创新成果转化。发表学术论文 20 余篇（多篇 SCI、EI 检索），专著 3 本。相关成果获得“第二十三届中国专利优秀奖”、“中国通信学会科学技术二等奖”等重要奖项 30 余项，参加国家“十三五”



●第二十三届中国专利优秀奖 & 中国通信学会科学技术二等奖
● The 23rd China Patent Excellence Award & The Second Prize in Science and Technology of China Institute of Communications



●产业生态合作
● Industrial Ecological Cooperation

科技成就展、数字中国峰会等重大展会，并发布 10 余本行业白皮书。与中科院、北京市科协等密切合作，成功申报 4 项科协基地与人才计划项目，打造优质科研人才梯队。在生态合作方面，整合各领域合作伙伴资源，构建国内的芯片、终端、平台、应用等车联网产业链关键要素的闭环，打通“核心技术攻关 -> 创新产品孵化 -> 业务示范应用”的科研脉络，在提升自身影响力的同时助力产业布局。

On the basis of the above research, we have led & participated in over 30 standards in domestic and foreign organizations, such as 3GPP, 5GAA, and CCSA, e.g., the first high-precision positioning project in 5GAA "High Accuracy Positioning for C-V2X", forming a forward-looking influence on standard techniques. We have applied for more than 20 invention patents and associated standard content with patents to promote the transformation of innovative technologies, published more than 20 academic papers (multiple SCI and EI indexed), 3 monographs, and won more than 30 important awards such as "The 23rd China Patent Excellence Award" and "The Second Prize in Science and Technology of China Institute of Communications". Relevant achievements have participated in many major exhibitions, such as the National 13th Five Year Plan Science and Technology Innovation Achievement Exhibition and the Digital China Summit, and more than 10 white papers have been released. We have close cooperation with the China Association for Science and Technology and the Beijing Association for Science and Technology and have successfully applied for 4 projects involving science and technology innovation bases and talent plans, building a high-quality scientific research team. In terms of ecological cooperation, we have integrated partner resources in various fields to build a closed loop of domestic Internet of the vehicle industry chain, covering chips, terminals, platforms, applications and so on, establishing a scientific research framework of "core technology research, innovative product development and demonstration application" to enhance the enterprise's self-influence and assist in the industrial layout.



©本团队开发的太赫兹高速通信系统应用于2023年世界大学生运动会赛事视频转播，支持8K无压缩超高清视频的无线传输
© The developed THz communication system has been applied for the international broadcasting center's new technology demonstration project at the 31st Summer Universiade in Chengdu, carrying out experimental verification of 8K HD video broadcasting for the universiade events

面向体育赛事 8K 高清视频转播应用的太赫兹高速无线通信系统

Terahertz High-speed Wireless Communication Systems for 8K High-definition Video Broadcasting and Sports Events

电子科技大学
University of Electronic Science and Technology of China



引言

太赫兹通信作为 6G 通信的重要候选技术之一，在全球范围内掀起了研究热潮。本团队开发的太赫兹高速通信系统，应用于 2023 年世界大学生运动会 8K 无压缩超高清赛事视频转播，解决了体育赛事超高清视频传输最前一公里无线传输的难题。

Introduction

Terahertz (THz) communication technology, as one of the important options for 6G

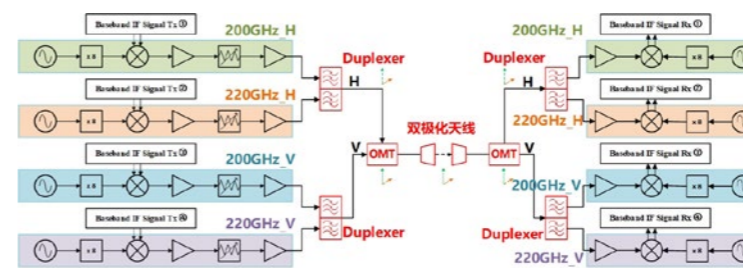
communications, has set off a research boom in the world. The terahertz high-speed communication system developed by our team, has been applied to the 8K uncompressed ultra high definition video broadcasting of the 2023 Summer Universiade in Chengdu, solving the problem of wireless transmission in the first mile of ultra high definition broadcasting of sports events.

基于多维复用的太赫兹固态实时通信新架构及超高速无线实时传输系统

A new architecture for Terahertz solid state real time communication based on multidimensional multiplexing and an ultra high speed wireless real time transmission system

结合极化复用与频分复用技术，突破高速数模 / 模数转换的带宽、采样速率等方面的技术瓶颈，提升信号带宽与频率利用率，实现超高速信号实时传输。

Combining polarization multiplexing and frequency division multiplexing technologies, we have proposed an initiative communication system architecture which breaks through the bottlenecks of high-speed analog-to-digital/digital-to-analog converters, thus improving the spectrum efficiency and realizing ultra-fast real-time signal transmissions.



◎系统架构图
◎ System architecture diagram

提出低复杂度的超高速信号处理方法和太赫兹宽带射频非线性基带补偿方法，提出基于混合计算的超高速 LDPC 编译码和低比特 QAM 解调电路实现方法，解决了太赫兹超高速实时信号处理复杂度高和功耗大的难题，研制出实时传输速率超过 100Gbps 的太赫兹基带信号处理单元。

We have proposed low-complexity ultra-high-speed signal processing methods to accommodate to terahertz broadband RF imperfections and proposed a hybrid computing based ultra-high-speed LDPC encoding/ decoding method and a low bit QAM demodulation circuit implementation method, supporting the development of the terahertz base-band signal processing unit with a real-time transmission rate exceeding 100Gbps, with low complexity and power consumption.

提出基于单片集成技术的太赫兹器件三维电磁模型建立方法，解决 I、Q 两路一致性问题，实现宽带信号的正交调制解调，大幅降低系统前端复杂度。

We have proposed a three-dimensional electromagnetic modeling method tailored for terahertz devices, based on which we developed a terahertz wideband quadrature modulator that can improve the coherence of in-phase and quadrature inputs, thus significantly reducing the complexity of the system front-end.

提出片上双层近场耦合谐振的太赫兹超构调制芯片技术。解决了太赫兹片上调制速率慢、损耗大的问题，研制出速率超过 100Gbps 的太赫兹超构调制芯片。

We have developed an on-chip double-layer near-field coupling resonant hyper-structured THz modulation chip that achieves over 100Gbps data rate, solving the problem of

low modulation rate and high loss challenges of the THz on-chip modulations.

本成果的推广应用主要体现在创新研究、标准输出、应用示范、经济效益四个方面：

The promotion and application of this achievement are mainly reflected in four aspects: innovative research, wireless communication standards output, application demonstrations, and economic benefits:

在创新研究方面，自 2019 年以来，基于本成果的相关创新研究发表 SCI 论文 100 余篇，授权专利 50 余项，获得太赫兹技术方向国家技术发明二等奖 1 项，其他省部级一等奖 3 项。

In terms of innovative research, since 2019 and based on this achievement, we have published more than 101 papers and 55 invention patents, and won the Second Prize of the National Technical Invention Award.

在标准研究方面，基于本成果的太赫兹通信技术，已输出到 IMT-2030 (6G) 推进组白皮书《太赫兹通信技术研究报告》，参与的《太赫兹通信应用场景研究》获得中国通信标准化协会的优秀研究成果奖。

In terms of wireless communication standards output, based on this achievement we have output 6G white papers, named as "Terahertz Communication Technology Research Report", to China IMT-2030 (6G) Promotion Group.

在应用示范方面，基于本成果研制的 80Gbps 太赫兹高速通信系统，电子科技大学联合成都广播电视台开展了面向体育赛事转播的应用验证。

In terms of application demonstrations, based on this achievement, we have developed an 80Gbps terahertz high-speed communication system, and has collaborated with Chengdu Radio and Television Station to carry out application verification for sports event broadcasting.



◎支持高速实时业务的太赫兹高速通信设备与系统

◎ Terahertz high-speed communication equipment and systems that support high-speed real-time services

在经济效益方面，“信息视频化、视频超高清化”已经成为全球信息产业的大趋势。到 2022 年底，超高清占视频点播 IP 流量的百分比将高达 35%，我国超高清视频产业规模超 4 万亿元。在世界大学生运动会上应用太赫兹通信实现 8K 超高清视频无线传输，有望助推打造超高清视频产业新型生态体系，为下一代信息技术产业的发展产生积极作用。

In terms of economic benefits, "information video and video ultra high definition" has become a major trend in the development of the global information industry. By the end of 2022, the proportion of ultra high definition in video on demand IP traffic will reach as high as 35%, and the scale of China's ultra high definition video industry will exceed 4 trillion yuan. The application of terahertz communication to achieve wireless transmission of 8K ultra high-definition video at the World University Games is expected to promote the creation of a new ecological system for the ultra high-definition video industry and play a positive role in the development of the next generation information technology industry.

本成果在太赫兹固态实时通信架构、超高速基带信号处理、太赫兹器件三维电磁模型、太赫兹超构调制芯片等方面实现了突破：

This achievement has achieved breakthroughs in terahertz solid-state real-time communication architecture, ultra high speed baseband signal processing, three-dimensional electromagnetic model of terahertz devices, and terahertz superstructure modulation chips:

在学术成果方面，太赫兹技术相关成果获得国家技术发明二等奖 1 项、国防技术发明一等奖 1 项、四川省技术发明一等奖 2 项。

In terms of academic achievements, our developed terahertz technologies have won the Second Prize in National Technical Invention Award and the First Prize in the Sichuan Natural Science Award.

在技术扩展能力方面，本成果提出了多维复用的太赫兹固态实时通信新架构，支持多路并行高速太赫兹通信链路，所提架构具备扩展至 Tbps 速率的能力。

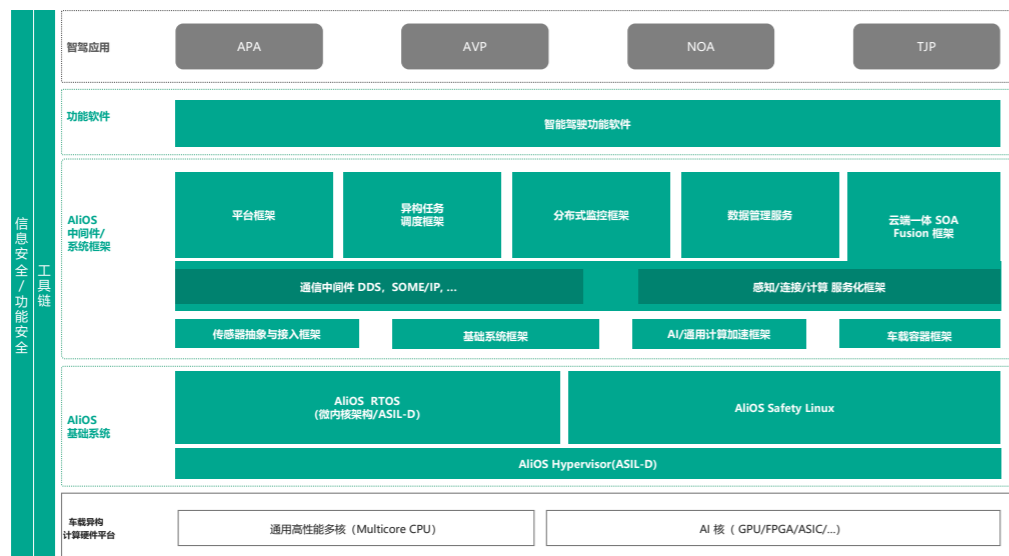
In terms of technical scalability, the proposed multi-dimensional multiplexed terahertz solid-state real-time communication architecture is capable of scaling up to a terabit per second (Tbps) rate.

美国阿拉莫斯国家实验室副主任 Antoinette J Taylor (OSA Fellow/IEEE Fellow) 在综述论文 (Rep. Prog. Phys. 2016, 79, 076401) 评述“这项成就开创了发展高性能太赫兹无线通信系统的新方向”。

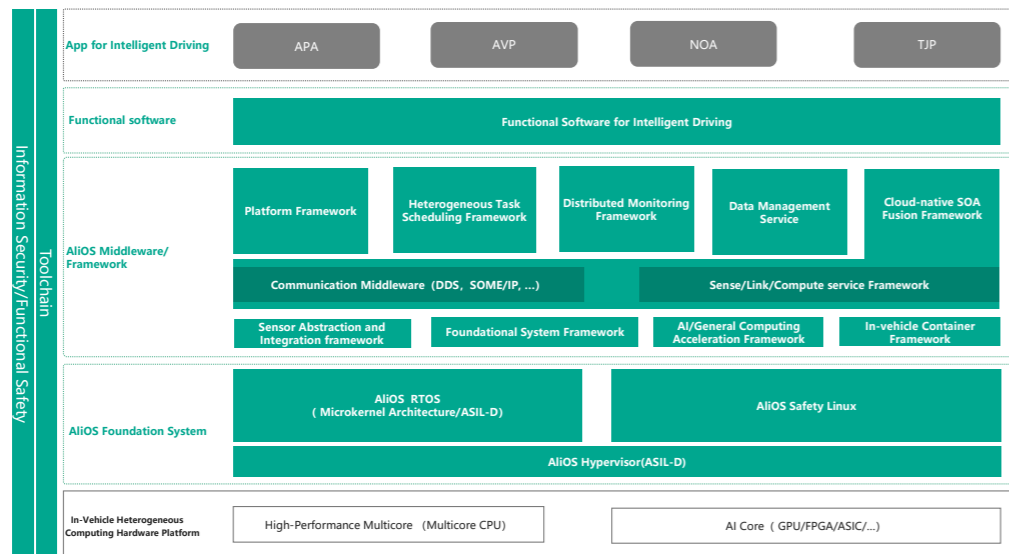
Antoinette J Taylor (OSA Fellow/IEEE Fellow), Associate Director of Alamos National Laboratory, commented in a review paper (Rep. Prog. Phys. 2016, 79, 076401) that "this achievement opens up a new direction for the development of high-performance terahertz wireless communication systems".

AliOS Drive 智能驾驶操作系统

AliOS Drive Operating Systems for Autonomous Vehicles



©AliOS Drive 智能驾驶操作系统架构图



© The architecture diagram of the AliOS Drive

引言

AliOS Drive 智能驾驶操作系统是为高速发展的智能驾驶行业提供的高安全、高可靠、高性能的车用操作系统，在技术上拥有异构双核驱动、分层解耦、跨域融合、兼顾功能安全与性能等核心特色。

Introduction

AliOS Drive Operating System for Autonomous Vehicles is a high-security, high-safety, highly reliable, and high-performance operating system for the rapidly developing intelligent driving industry. It is heterogeneous dual-kernel based, with secure and safe cross-system fusion, and designed using layered and decoupling architecture.

AliOS Drive 智能驾驶操作系统双核驱动，兼具安全与性能优势

AliOS Drive Operating System for Autonomous Vehicles is heterogeneous dual-kernel based, with both safety and high-performance advantages

AliOS Drive 智能驾驶操作系统既能规避目前智驾系统单纯使用 Linux 带来的功能安全风险，又能提供单纯微内核所不具备的高性能。

AliOS Drive Operating System for Autonomous Vehicles mitigates the Functional Safety (FuSA) risks brought by using Linux alone, while also enables high-performance computing that traditional microkernels are not good at.

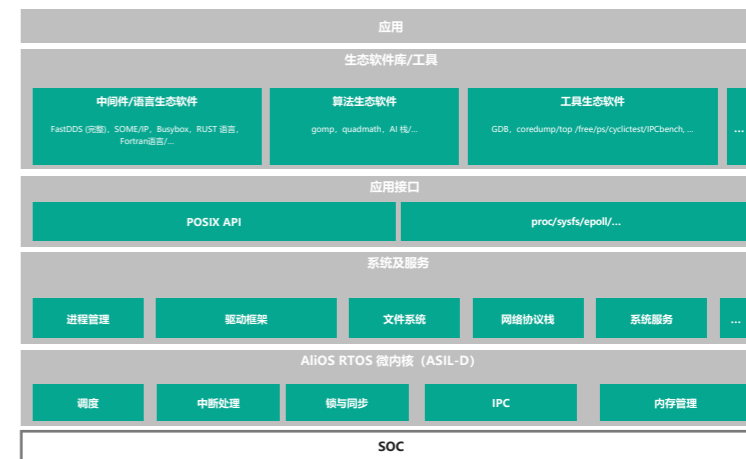
AliOS Drive 分为安全域和性能域，其中安全域为 AliOS RTOS，是自研微内核架构实时操作系统，已通过 ISO26262 汽车功能安全最高等级“ASIL-D”的产品认证，最大调度延迟和最大中断延迟均小于 10 微秒，支持 POSIX PSE-54 标准，能兼容已有的智驾软件生态；性能域为 AliOS Safety Linux，基于 Linux 进行实时性安全性增强，

平均调度延迟和中断延迟小于 10 微秒（最大小于 200 微秒），可支撑自动驾驶高性能计算需求，提供资源隔离和安全监测机制；自研的 AliOS Hypervisor 通过了 ISO26262 汽车功能安全最高等级“ASIL-D”产品认证，CPU 虚拟化性能损失小于 5%，为双内核提供了安全高性能融合机制，使得整个 AliOS Drive 兼具安全与性能优势。

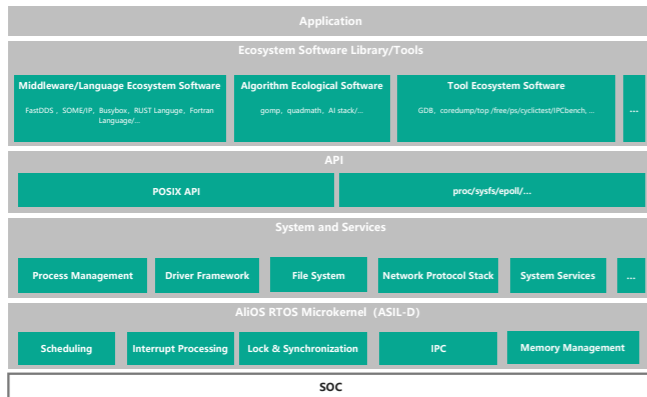
AliOS Drive has a safety domain subsystem and a performance domain subsystem. The safety domain subsystem is founded by AliOS RTOS, which is based on a self-developed safety real-time microkernel. It has been awarded the Functional Safety product (ISO26262 ASIL-D) certificate, of the highest level of automobile FuSA, by TÜV Rheinland. The maximum scheduling delay and the maximum interrupt delay of it are both less than 10 microseconds and it supports the POSIX PSE-54 standard. It is compatible with the existing intelligent driving software ecosystem. The performance domain subsystem is founded by AliOS Safety Linux, which is based on the open-source Linux with deterministic and safety enhancement. The average scheduling and interrupt delay are less than 10 microseconds with the maximums less than 200 microseconds, while there's no performance degradation as usually observed on real-time patched (PREEMPT_RT) community Linux. It's capable of supporting the high-performance computing required by autonomous driving tasks. Meanwhile it provides a systematic safety enhancement by kernel space/user space resource isolation and safety monitoring. The self-developed AliOS Hypervisor provides a secure, safety and fast fusion mechanism for dual-kernel through virtualization techniques, and has been awarded the Functional Safety product (ISO26262 ASIL-D and IEC61508 SIL3) certificate, and the loss of CPU performance caused by virtualization is less than 5%. The fusion mechanism makes the AliOS Drive have both safety and high-performance advantages.

AliOS Drive 还包含 AI/通用算力加速框架、确定性调度框架等。其中，AI/通用算力加速框架横向提供多硬件平台接入能力，纵向提供业界有竞争力的性能解决方案；确定性调度框架解决复杂智驾场景下任务执行确定性问题，支持异构计算环境下的全局化编排。

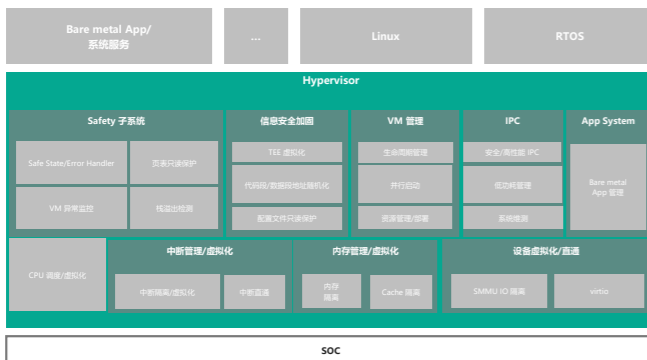
In addition to the underlying OS, AliOS Drive also provides AI/General computing optimization framework, deterministic scheduling framework, etc. The AI/General computing optimization framework provides multiple hardware platforms support capability and the competitive performance solutions in the industry. The deterministic scheduling framework solves the challenges of non-deterministic task execution time in complex autonomous/ADAS driving scenarios, supporting global orchestration of tasks under heterogeneous computing environments.



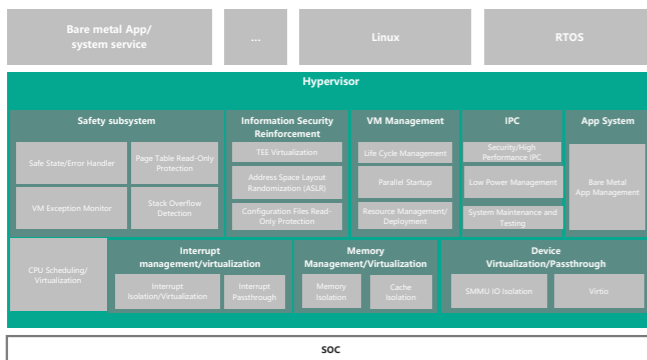
©AliOS RTOS 架构图



◎ The architecture diagram of AliOS RTOS



◎AliOS Hypervisor 架构图



◎ The architecture diagram of AliOS Hypervisor

AliOS Drive 智能驾驶操作系与智驾芯片深度融合，已获车企商业定点

The AliOS Drive Operating System for Autonomous Vehicles and the SoC for intelligent driving deeply integrate, which has got commercial contracts for mass production

斑马智行已经与中国国内主流智驾芯片公司如地平线、芯驰等达成战略合作协议，基于地平线、芯驰智驾 SoC + AliOS Drive 共同打造高级别的智能驾驶解决方案，AliOS Drive 也已获得上车量产的商业合同。

Banma Network Technology Co.,Ltd has reached a strategic cooperation agreement with China's domestic mainstream intelligent driving chip companies such as Horizon Robotics and SemiDrive, jointly developing advanced intelligent driving solutions. AliOS Drive has also got commercial contracts for mass production.

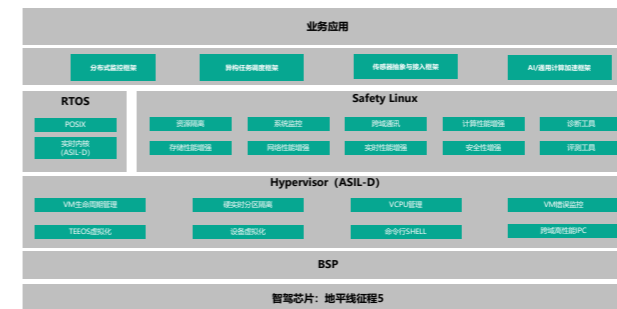
斑马提出“AI+OS+ 芯片”的开放式生态协同新范式，推动 OS 与芯片联合定义，形成技术底座，共同支持自动驾驶算法创新。作为底层操作系统，AliOS Drive 智能驾驶操作系统一方面与芯片协同，让算力发挥出更大作用，另一方面更好地支撑功能软件与应用软件开发，带来安全、智能的 APA、AVP、NOA、TJP 等辅助驾驶及自动驾驶体验。

Banma has proposed a new paradigm of open ecological collaboration of "AI+OS+Chip" which promotes the joint definition of OS and chip, and forms a technical foundation, and also supports the innovation of autonomous driving algorithms. As the underlying operating system, on the one hand, the AliOS Drive cooperates with the chip to make computing power play a more important role; on the other hand, it provides more excellent supporting of the development of functional software and application software which brings more safe and more intelligent APA, AVP, NOA, TJP driving experience.

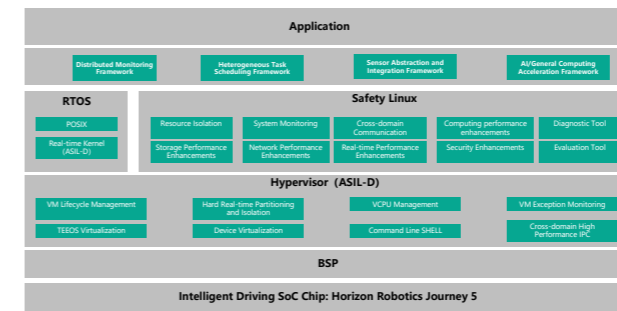
AliOS Drive 解决来自自动驾驶的四大挑战，一是符合功能安全要求，支撑实时与高性能计算；二是实现对传感器带来的 AI 大数据的流转与处理；三是满足自动驾驶应用的复杂性要求，兼容、拓展支撑生态，软硬解耦；四是应对自动驾驶应用的社会性、敏感性，实现对系统信息与数据安全的强化支撑。

AliOS Drive solves the four major challenges of autonomous driving. Firstly, it meets functional safety requirements and supports real-time and high-performance computing. Secondly, it realizes the transfer and processing of AI big data brought by sensors. Thirdly, it meets the complexi-

ty requirements of autonomous driving applications and expand the support ecology and decoupling software and hardware. Fourthly, it responds to the social nature and sensitivity of autonomous driving applications, providing strongly protection for data security.



◎基于 AliOS Drive + 智驾芯片地平线征程 5 的量产方案



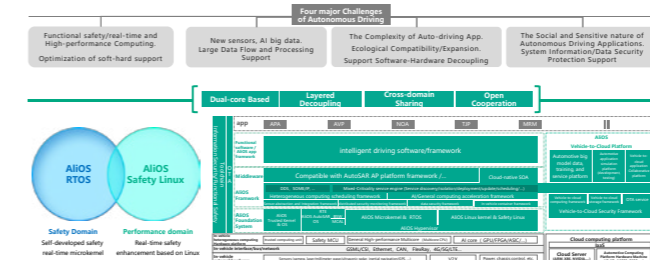
◎ The architecture diagram of mass production solution based on the AliOS Drive and the Journey 5 SoC of Horizon Robotics for intelligent driving

AliOS Drive 双核驱动解决四大挑战



◎AliOS Drive 双核驱动解决四大挑战

AliOS Drive Dual-core Based Solves Four Major Challenges



◎ AliOS Drive is heterogeneous dual-kernel based, solving the four major challenges

AliOS Drive 智能驾驶操作系统双核驱动，解决智驾行业的四大挑战

AliOS Drive Operating System for Autonomous Vehicles is heterogeneous dual-kernel based, solves the four major challenges of autonomous driving

AliOS Drive 智能驾驶操作系统可以为行业带来技术与产业价值：

1. 为汽车智驾场景提供满足功能安全要求及性能需求的安全技术底座。2. 秉持开放、分层解耦与标准化思想，提供高效的基础技术底座、工具链及 SOA 架构能力，助力车企构建开放可控的技术和供应链体系，同步联合生态伙伴与车企共创差异化产品和服务。3. 提供高标准的信息安全能力，助力车企满足数据安全与网络安全监管要求。4. 探索车云一体技术，尝试推进云原生技术应用在汽车领域，帮助车企提高跨硬件平台的代码复用率，降低软件定义汽车时代的软件投入成本。

AliOS Drive Operating Systems for Autonomous Vehicles can bring technology and industrial value to the industry:

1. It provides a safety technology infrastructure that meets both functional safety requirements and performance requirements for smart car driving scenarios.2. Adhere to the idea of openness, layered decoupling and standardization, it provides efficient technology base, tool chain and SOA architecture capabilities, so that the car OEMs can build open and controllable technology and supply chain systems, and jointly create differentiated products and services with ecological partners and car manufacturers.3. It provides high level information security capabilities to help car OEMs meet the regulatory requirements of data and network security.4. It explores car and cloud integration technology, tries to apply cloud-native technology in the automobile field, helps automobile OEMs improve the code reuse rate across hardware platforms, and reduces software investment costs in the era of software-defined vehicles.

ZDNS 下一代互联网基础资源寻址关键技术、国际标准及应用

ZDNS Key Technologies, International Standards and Applications of Next-Generation Addressing System for Internet



●ZDNS 下一代互联网基础资源寻址关键技术筑牢数字经济重要网络根基

●ZDNS key technologies of the next-generation addressing system for Internet lay solid network foundations for the digital economy

互联网域名系统国家工程研究中心
Internet Domain Name System National Engineering Research Center



引言

ZDNS 下一代互联网基础资源寻址关键技术、国际标准及应用实现互联网基础资源寻址关键技术创新突破，全面支持 IPv6，已在全球 30 多个国家和地区规模部署，为 IPv6 流量提升提供了有力支撑。有力推动了中国乃至全球互联网基础资源领域的技术进步。

Introduction

ZDNS key technologies, international standards and applications of the next-generation addressing system for Internet represent breakthroughs in the key technological

innovations in Internet basic resource addressing. ZDNS has been deployed on a large scale in more than 30 countries and regions around the world, providing strong support for the improvement of IPv6 traffic. It has effectively promoted the technological progress in Internet basic resources in China and the world.

通过系统性、原创性技术创新，解决域名基础软件多项问题 Solve multiple problems in domain name infrastructure software through systematic and original technological innovations

ZDNS 以下一代互联网基础资源寻址关键技术、国际标准及应用通过技术创新，解决了域名基础软件长期存在的解析性能及数据更新性能低，智能线路少，安全漏洞多，对 IPv6 技术标准的支持度差等难题；创建 RPKI 数据安全威胁模型和 RPKI 本地化控制机制。

Through technological innovations, ZDNS key technologies, international standards and applications of the next-generation Internet addressing system for Internet has solved the long-standing issues in domain name infrastructure software-low performance in resolution and data update, lack of intelligent routes, multiple security vulnerabilities, and poor support for IPv6 technology standards. ZDNS has also pioneered the RPKI data security threat model and RPKI local control mechanism.

1. IPv6 及双栈域名高性能智能解析系列关键技术

Key Technologies of IPv6 and Dual-Stack Domain-Name High-Performance Intelligent Resolution

缓冲加速高性能解析处理方法，高并发 DNS 服务方法，基于 AA、AAPF 记录的 IPv6 业务访问方法，基于域名热度的缓存 TTL 动态变更方法，多智能线路下的 DNS 数据更新通知方法，嵌套视图的 DNS 解析方法等。实现从配置接收、报文处置、缓存映射等性能及容量提升，实现 IPv4/IPv6 双栈解析性能超过 2000 万 QPS（每秒查询次数），数据更新性能超过 2600 UPS（每秒更新条数），智能线路数量超过 100 万条。

Technical innovations of ZDNS include methods of cache acceleration high-performance resolution, high-concurrency DNS service, IPv6 business access based on AA and AAPF records, TTL cache dynamic modification based on domain name popularity, DNS data update notification under multi-intelligent routes, and DNS resolution for nested views. Through these innovation, ZDNS has strongly improved performance and capacity in configuration reception, message handling, cache mapping, and more. It can achieve 20 million QPS (queries per second), 2,600 UPS (updates per second), and serve 1 million intelligent routes.

2. 下一代域名系统安全可靠系列关键技术

A series of Key Technologies for the Security and Reliability of the Next-Generation Domain Name System

创新性提出针对随机域名攻击的主动防护方法，路由起源授权的自动签发方法，源地址域名安全查询方法，分布式数据一致性同步方法，过滤 DNS 隧道通信数据方法，DNSSEC 签名服务热备方法，基于 DHCP 服务器集群负载分配地址的方法等。“红枫”系统面向域名数据同步、数据分发、根区文件数据存储全流程，实现 5 类 13 种威胁的全面防护和超百万级的域名保全。

ZDNS innovatively proposed an active protection method against random domain name attacks, an automatic issuance method for routing origin authorization, and a security query method for source address domain names. It also put forward distributed data consistency synchronization, DNS tunnel communication data filtering, DNSSEC signature service hot backup, and address allocation method based on DHCP server cluster load balance, etc. For the entire process of domain name data synchronization, data distribution, and root zone file data storage, the Maple System provides a comprehensive protection against 5 categories, 13 types of threats, and preserves over one million domain names.



●下一代互联网基础资源寻址关键技术承载网络升级，服务数字化转型

●Key technologies of the next-generation addressing system for Internet facilitate network upgrading and serve digital transformation

1. 赋能千行百业数字化转型：在互联网基础资源领域，按照“软件+硬件+云服务”的商业模式，面向金融、能源、电力、政府、教育、医疗等行业广泛应用。

Empower digital transformation of various industries: In the field of Internet basic resources, according to the business model of "software+hardware+cloud services", ZDNS is widely utilized in finance, energy, electricity, government, education, medical care and other industries.

2. 支撑全球网络生态链创新：本项目成果成为作为支撑 5G 网络建设的基础网元，成果广泛应用于全球 5G 核心网建设。形成以互联网基础资源域名系统软件“红枫”为核心，与全球主流芯片、操作系统、容器和云化环境融合的创新生态链。

Supporting innovation in global network ecosystem: The outcomes of ZDNS have served as the foundational network elements to support the construction of 5G networks and have been extensively applied in the global construction of 5G core networks. It has formed an innovative ecosystem that integrates the core Internet basic resource domain name system software Maple with mainstream chips, operating systems, containers, and cloud environments worldwide.

3. 推动互联网国际标准建设：ZDNS 牵头起草的 RPKI 依赖方系统技术要求 (RFC8897)，进一步将 RFC8416 规范列为 RPKI 技术体系的核心基础功能。互联网路由安全核心标准 BGPsec(IETF RFC 8205) 推荐使用 RFC 8416 作为 RPKI 时代路由本地化控制的技术手段。在 RFC 8416 发布后，欧洲互联网信息中心和全球知名互联网基础软件开源机构 NLnet Labs 等主流机构均宣布其 RPKI 验证软件支持 RFC 8416 技术标准，成为全球应用最为广泛的 RPKI 核心技术标准之一。

Promote the construction of Internet international standards: RPKI Relying Party System's Technical Requirements (RFC8897) drafted by ZDNS further listed RFC8416 specifications

ZDNS 下一代互联网基础资源寻址关键技术服务我国各行业数字化转型，全面助力我国数字经济高质量发展。

ZDNS key technologies of the next-generation addressing system for Internet can serve the digital transformation of various industries in China and comprehensively contribute to the high-quality development of the China's digital economy.

在智慧金融领域，本项目成果已应用到全国主要大型金融机构，推动我国金融行业在业务流程、客户服务得到全面提升，实现金融产品、风控、获客、服务的智慧化；

In the field of smart finance, the results have been applied in major financial institutions

nationwide, bringing about overall improvement in business processes and customer service in the financial industry, as well as the smartization of finance products, risk management, and customer acquisition and services.

在数字政府领域，本项目成果已广泛应用到国家和各省市县电子政务网，推动了我国电子政务服务水平进一步提升，以及网络化、数字化、智慧化的利企便民服务体系的不完善；

In the field of digital government, the results have been widely applied to the national as well as provincial, municipal and county-level e-government networks, further enhancing the country's e-government services and continuously improving the networking, digitalization, and smartization of the government service systems

tion as the core basic function of RPKI technical system. Internet routing security core standard BGPsec (IETF RFC 8205) recommends using RFC 8416 as the technical means of routing local control with the RPKI. After the release of RFC 8416, NLnet Labs (the Netherlands), a world-renowned Internet open-source institute, announced that their RPKI verification software supports RFC 8416 technical standard, making RFC8416 one of the most widely used RPKI core technical standards in the world.



●下一代互联网基础资源寻址关键技术创新生态链产品

●Next-generation Internet basic resources address key technological innovation ecological chain products

for enterprises and the public.

在智慧能源领域，本项目成果有力推动了智慧能源建设应用，促进能源生产、运输、消费各环节智能化升级。此外，本项目成果也支撑了我国工业数字化、农业数字化、智慧城市、智慧教育的发展。

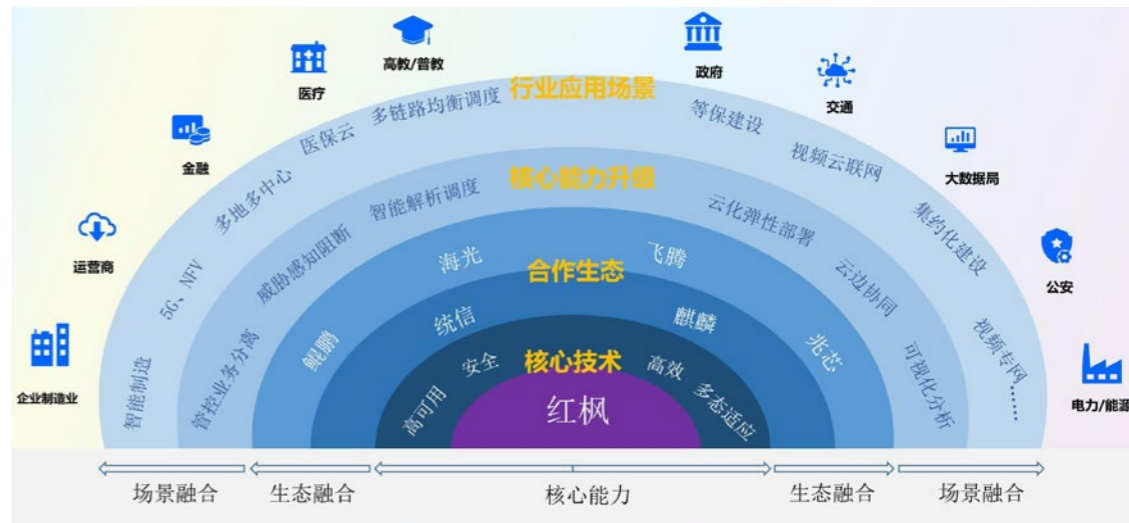
In the field of smart energy, the results have effectively promoted the construction and application of smart energy, and have accelerated the intelligent upgrading of links like energy production, transportation, and consumption. In addition, the results have also strongly facilitated the development of industrial digitalization, agricultural digitalization, smart cities, and smart education in China.

RPKI 技术将催生新一代的网络路由器、新一代的 IP 地址管理

系统以及全新的 RPKI 路由数据认证系统，牵引相关的电信运营商、云服务商、互联网交换中心以及规模网络企业的网络运维管理技术进行相应的升级并改造其 IP 地址管理系统和路由控制系统，带动全球 IP 地址（特别是作为资源增量的 IPv6 地址）管理系统、路由器完成技术升级。

The RPKI technology will drive the development of new-generation network routers, IP address management systems, and all-new RPKI routing data authentication systems. This will lead to upgrades of network operation and maintenance management technology by telecom operators, cloud service providers, Internet exchange centers, and

large-scale network enterprises as well as the transformations of their IP address management systems and routing control systems. It will also accelerate the upgrading of global IP address management systems and routers, particularly for IPv6 addresses as incremental resources.



●ZDNS 下一代互联网基础资源寻址关键技术服务我国各行业数字化转型，全面助力我国数字经济高质量发展

●ZDNS next-generation Internet basic resource addressing key technology serves the digital transformation of various industries in China and comprehensively contributes to the high-quality development of the China's digital economy

截至 2023 年 5 月，ZDNS 获得授权发明专利 54 项，牵头 IETF 国际标准 3 项，行业标准 17 项。自主“红枫”系统是我国唯一全功能支持 DNS 领域标准的域名基础软件，处于国际领先水平，已在全球 30 多个国家和地区规模部署，服务全球 60 个新通用顶级域，为全球下一代互联网规模部署做出了突出贡献。

As of May 2023, ZDNS has been authorized with 54 invention patents, led 3 IETF international standards and 17 industry standards. The world-leading independent Maple system is the only domain name basic software in China that fully supports DNS standards. It has been deployed in more than 30 countries and

regions worldwide, serving more than 60 new generic top-level domains, contributing to the mass deployment of the next-generation Internet across the globe.



●红枫系统全面支持下一代互联网

●The Maple system supports the next-generation Internet

超高清国产技术标准及低延迟视频云化直播制播技术创新及应用

Innovation and Application of UHD Technology Standards and Low-Latency Video Cloud-based Live Broadcasting Technology



●基于 AVS3 编解码的超高清直播效果
● AVS3 codec-based ultra-high-definition live broadcast results

咪咕文化科技有限公司
China Mobile MIGU Company



引言

为满足沉浸式音视频技术发展与服务体验提升需求，面向超高清体育直播应用场景针对下一代编解码标准进行规模化应用。中国移动咪咕公司在 AVS3.HDR vivid、Audio Vivid 等超高清音视频标准上持续投入，拓展并发展应用范围与服务质量。

Introduction

For the further development of immersive audio and video technology, China Mobile MIGU has continuously invested in next-generation codec standards for ultra-high-definition audio and video, such as AVS3, HDR vivid, Audio Vivid, and so on. The next-generation codec standards have been applied on a large scale in UHD sports broadcasting application scenarios.

体育赛事“视觉+听觉”的全方位超高清沉浸体验

An all-encompassing UHD immersion experience for sporting events

为了能让咪咕视频的用户在不同终端获得更趋真实的沉浸式视觉和听觉体验，咪咕公司分别从音视频的编码、终端解码渲染以及传输架构升级上开展了技术创新。

In order to provide users with a more realistic and immersive visual and acoustic experience on different terminals, Migu has carried out technological innovations

in audio and video coding, terminal decoding and rendering, and upgrading the transmission architecture.

重点针对赛事直播场景特性，优化了视频编码核心算法、参数，实现赛事直播场景化转码生产，提升了赛事直播内容质量。基于赛事直播，积累了咪咕视频质量数据集，形成了检测主/客观评测参考方法及指标的主客观标准，构建了场景、评价、规范、生产质量迭代优化体系。

Focusing on the characteristics of the live match scene, MIGU realizes the live match scene-based transcoding production by enhancing the core video coding algorithms and parameters, which in turn enhances the quality of the live content. A large number of quality datasets have been accumulated in the process, allowing MIGU to also gain a set of methods and standards for detecting subjective and objective live content quality evaluation, and constructing an iterative system for scenario, evaluation, specification and production quality.

通过低时延专属制播链路、低时延转码算法、低时延传输分发、播放器追帧技术、全链路智能缓冲、边缘缓冲时移、多平面智能容灾调度等技术，实现低时延链路生产、多平面低时延分发、多平面智能调度，满足覆盖 WWW/ 移动端 APP 的 4K HDR 50FPS 原画质低时延播出要求，提供可支持千万级高并发、高码率、高帧率、低卡顿的赛事直播低时延传输分发服务能力。

MIGU realizes low-latency link production, multi-plane low-latency distribution, and multi-plane intelligent disaster-tolerant scheduling by means of low-latency exclusive production and broadcasting links, low-latency transcoding algorithms, low-latency transmission and distribution, player frame chasing technology, full-link intelligent buffering, edge buffering time shifting, and multi-plane intelligent disaster-tolerant scheduling, and other technologies. It achieves 4K HDR 50FPS original picture-level low-latency broadcasting requirements covering WWW/Mobile APP, which provides low-latency transmission and distribution service capability for live event broadcasting that can support ten million levels of high concurrency, high bit rate, high frame rate and low lag.



●AVS 与 HDR vivid 在卡塔尔世界杯的应用情况
● AVS and HDR vivid in Qatar World Cup Live Streaming Application

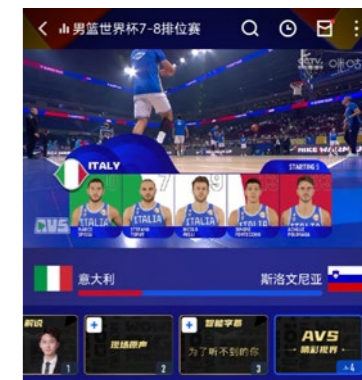
超高清沉浸式音视频技术能力创新、标准引领与规模应用 UHD Immersive Audio and Video Technology Innovation and Scale Application

通过咪咕视频“睛彩视界”独家直播视角和“Vivid 菁彩视听”视角，为客户提供“视觉+听觉”的全方位超高清沉浸体验，为后续音视频标准的使用奠定坚实的基础。

MIGU Video APP provides users with "visual&auditory" UHD immersion experience by adding the exclusive "Eye color vision" live view and "Vivid audio vision" live view, which lays a solid foundation for the subsequent use of audio-video standards.

2020 欧洲杯实现业内 HDR Vivid 首次在移动端试点应用。2022 年北京冬奥会实现业内 AVS3 首次在移动端试点应用以及 HDR Vivid 软渲染方案首次在移动端试用。2022 年卡塔尔世界杯实现了业内 AVS3 和 HDR Vivid 的首次移动端规模化商用，以及 Audio & HDR Vivid 双 Vivid 同时在重大型体育赛事应用。

At Euro 2020, MIGU piloted HDR Vivid on mobile for the first time in the industry. For the 2022 Beijing Winter Olympics, MIGU piloted AVS3 and HDR Vivid soft rendering solution on mobile for the first time in the industry. For the 2022 FIFA World Cup Qatar, MIGU commercialized AVS3 and HDR Vivid on mobile for the first time in the industry, and also applied Audio & HDR Vivid to major sports events.



●AVS 在男篮世界杯的应用情况
● AVS in the Men's Basketball World Cup Live Streaming Application

积极打造产业生态，打造国际领先的内容生产体系

Promoting industrial development and building an internationally leading content production system

该成果是中国移动咪咕公司积极打造产业生态建设的结晶，在大视频领域聚合产业链、构筑生态链、提升价值链，促进上下游企业协同联动不断做大做强产业链。此外，牵头或参与建设 5G 多媒体创新、中国超高清视频等 6 大行业生态联盟，联合头部企业、科研院所、高校力量，不断健全 5G+ 大视频的差异化能力体系。咪咕公司全球重大重点赛事直播技术创新团队积极发挥咪咕公司“内容 + 科技 + 融合创新”优势，用团队的坚持为每一场重大赛事保驾护航，用技术的创新打造中国移动内容运营高频正弦波。

China Mobile MIGU Company actively builds industrial ecosystems, promotes collaboration between upstream and downstream enterprises in the field of UHD audio and video, and continuously enlarges and strengthens the industrial chain. In addition, MIGU leads

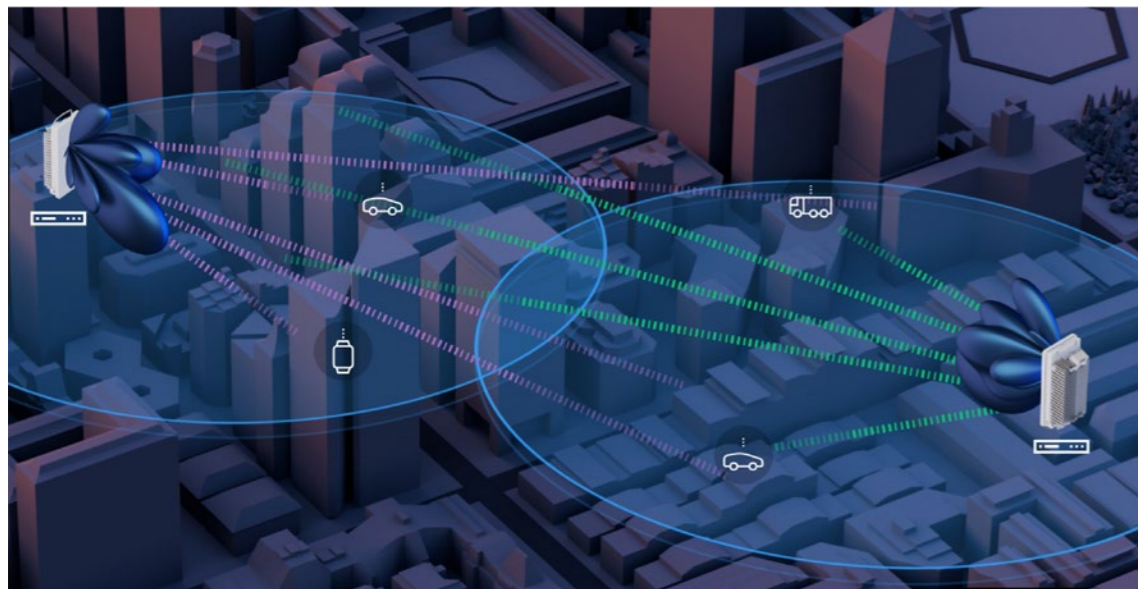
or participates in the construction of six industry ecological alliances, including 5G multimedia innovation alliance and China's UHD video alliance, and unites the strengths of head enterprises, research institutes and colleges and universities to continuously improve the differentiation capability of 5G UHD video. The technology innovation team of Migu Company for live broadcast of major and key events around the world actively leverages the advantages of "content and technology and integration and innovation" of Migu Company, and uses the team's persistence to escort every major event, and uses technological innovation to create a high-frequency sine wave of content operation for China Mobile.



●科技看亚运，上中国移动咪咕

● Watch the Asian Games with the latest technology on China Mobile's MIGU Video App

智感波束技术 Interference Sensing



●智感波束技术能够有效减轻小区间干扰，持续提升 5G 网络容量和用户体验（上下图分别是智感波束技术使用前、后的对比）

● Interference sensing technique can mitigate the inter-cell interference and improve operator network capacity and performance. (A contrast between scenarios "Without Interference Sensing" and "With Interference Sensing")

爱立信（中国）通信有限公司
Ericsson (China) Communications Co., Ltd.



引言

为了更好地应对 5G 移动网络小区间的干扰问题，爱立信利用智感波束技术，实时收集小区用户信息和相邻小区干扰信息，同时通过大规模天线技术（Massive MIMO）波束赋形能力和大计算量的智能感知算法来减轻干扰，持续提升 5G 网络容量和用户体验。

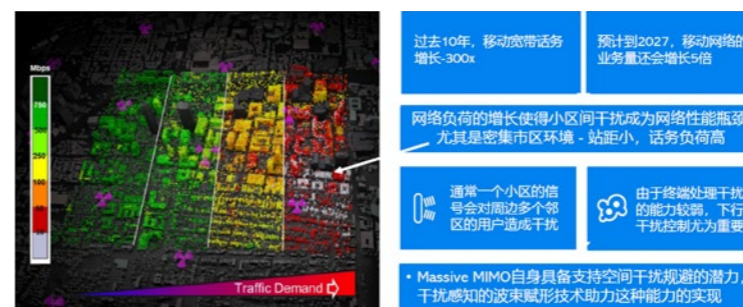
Introduction

To cope with the problems arising from the inter-cell interference in 5G mobile networks, Ericsson interference sensing technique, real-time collecting cell user information and neighbor cells interference information, uses Massive MIMO beamforming capabilities together with the algorithm of a smart sense to mitigate the inter-cell interference, and constantly improve operator network capacity and performance.

应用创新的波束赋形算法，搭载领先的硬件和信号处理技术，有效降低小区间的干扰

Innovative beamforming algorithm together with powerful hardware and signal processing techniques contributing to the mitigation of interference

小区间干扰是 5G 移动网络性能和容量提升的瓶颈之一。在城市地区，业务流量负荷重、站点间距近，更易导致严重的小区间干扰，给高业



●干扰逐渐成为 5G 网络业务发展的瓶颈，智感波束技术助力规避干扰



● Interference sensing technique helps to mitigate the interference which has become a bottleneck for NR network development

务负荷保障带来较大挑战。5G 网络基于中频段广泛部署的 Massive MIMO 可以提供卓越的覆盖效果，但并不能解决小区间干扰问题。

The network performance and network capacity are limited by inter-cell interference, which is a bottleneck for NR network performance evolution, particularly in urban area where often encounter the challenge of both heavy traffic load and small inter site distance. Massive MIMO on mid band could provide a superior experience, but it cannot solve the impact of inter-cell interference.

爱立信智感波束技术基于基站强大的硅芯计算平台和最先进的信号处理技术，通过对相邻小区的干扰信息进行采集并实时计算，相应生成赋形权值，在进行波束赋形传输时，即能确保本小区用户体验，同时能避免对相邻小区的干扰。小区间干扰的消除，会带来小区容量和用户体验的明显提升，不仅对部分小区有增益，对所有爱立信 Massive MIMO 覆盖小区都有增益，将显著提升 5G 网络容量和用户体验。

The innovation of Ericsson Interference Sensing, based on the powerful Ericsson Silicon compute platform and the state-of-the-art signal processing techniques in the base station, lies in that the interference information of neighbor cells is real-time collected and computing calculated, and then beamforming weights are generated, which will not only ensure the user experience of serving cells, but also avoid the interference to neighbor cells. The mitigation of inter-cell interference will lead to a significant improvement in cell capacity and user experience, which not only benefits some cells but also all Ericsson Massive MIMO covered cells. Therefore, 5G network performance and user experience can be lifted to a new height.



●智感波束技术通过波束动态即时控制达到小区间干扰最低,网络性能最优

● Interference sensing technique adopts real-time adjustment algorithm on beamforming to achieve interference mitigation and network performance improvement

该方案易部署、低投入、兼容性强,能够大幅提升 5G 网络传输能力

This technique features easy deployment, cost-effectiveness and highly compatibility, which could greatly improve NR network performance and frequency efficiency

智感波束技术是单纯的软件功能,不需新的硬件投入,且对于现网存量用户终端完美兼容,不需要终端升级即可享受到升级的网络体验。相较于 3GPP 标准演进中的部分网络性能提升新技术需要终端升级,智感波束技术具有部署更便捷、终端兼容性更普遍、受益用户更广泛的优势。

Interference sensing feature can be supported by software upgrade based on the gNBs already deployed, and there is no need for new hardware investment. It is perfectly compatible with legacy UEs in live network, allowing users to enjoy the upgraded experience without the need for UE upgrade. Compared to some new techniques in the evolution of the 3GPP standard that require UE upgrade to improve performance, Interference Sensing has the advantages of more convenient deployment, more universal UE compatibility, and a wider range of beneficial users.

更重要的是,智感波束对于干扰的感知和探测完全基于无线链路,而不依赖于基站之间的有线传输链路。运营商在网络中部署这项技术不需要在基站间通过接口传递信息,不会增加额外的接口传输负担。该技术在广泛应用于爱立信 Massive MIMO 基站覆盖区域后,将会给所有覆盖小区都带来下行 20%-40% 的容量提升。



●智感波束技术经模拟高负荷网络的外场测试验证,实现 40%+ 的吞吐量性能增益

● It has been verified that a gain of 40% can be achieved during the field trial of interference sensing technique in simulated high traffic load network

Moreover, the sensing and detection of interference methods of this technique is completely based on the wireless link instead of the wired transmission link between the base stations. The operators can deploy this interference sensing feature in network without any additional load on interface between different sites since it doesn't rely on interface for information exchanges. Once this technique is widely enabled in the coverage area of Ericsson's Massive MIMO base station, it will bring a downlink capacity increase of 20%-40% for all coverage cells.

在 2023 年的世界移动通信大会 (Mobile World Congress, 简称 MWC) 期间,这一方案一举荣获两项 GTI 年度大奖,标志着该方案独特的技术创新性、对 5G 网络整体性能与终端用户体验的提升,以及对通信产业的重要贡献获得了业界认可。该技术已完成技术验证,待下一步推广应用。

During the 2023 Mobile World Congress, the interference sensing technique has been granted two outstanding awards of GTI, which has demonstrated the technique's unique innovation and its contribution to the improvement of 5G network performance and user experience as well as the recognition from the ICT industry. This technical verification has been completed and awaits for release.

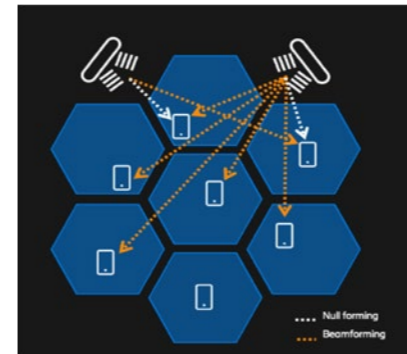
智感波束技术将服务于更多高业务负荷密集区域,助力通信运营商捕捉连接的全方位价值
Widely deployed in high loaded dense areas to help operators deliver greater value of 5G connection

智感波束技术利用现有设备能力,兼容现网存量终端,显著提升 5G 网络容量和用户体验,不仅是对现有已建设 5G 网络能力的充分利用和深度挖潜,而且是对现有 5G 网络投资的尊重和保护,同时也引领了 5G 网络技术发展的新方向。

Interference Sensing can utilize legacy gNB capabilities and compatible with legacy UEs, significantly improving 5G network capacity and user experience. It fully utilizes and deeply explores the existing 5G network capabilities, respects and protects investment in existing 5G networks, and also leads a new direction in the development of 5G network technology.

在短期内,智感波束技术可以用于 5G 高业务负荷密集城区、高业务负荷事件等场景,提供更多的网络容量缓解业务负荷压力(例如市区、无线业务集中的体育馆或有 Massive MIMO 覆盖的广场等地区)。从长期来看,大多数城市 5G 区域都会在业务负荷增长的过程中面对干扰问题,这一技术则能成为降低干扰的利器。

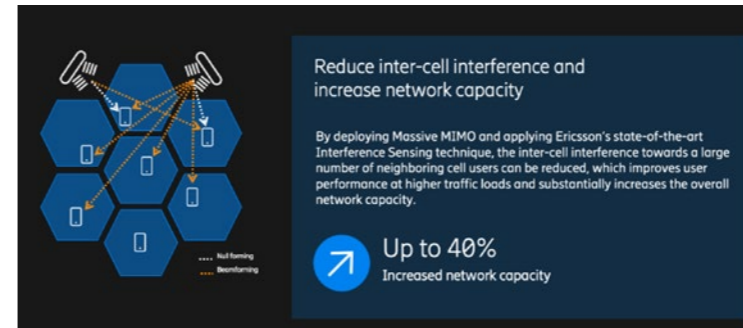
In short term, the interference sensing solution could help high loaded dense urban area, high traffic event case (e.g. urban area, high traffic load event in stadium, or square with Massive MIMO coverage, among other areas) to offer more network capacity. For long term most of major cities will require it to address serious interference issue as traffic growth.



- ✓ 降低小区间干扰
- ✓ 提升网络容量

通过部署 Massive MIMO 和爱立信领先的干扰感知技术,小区间的干扰和对邻区用户的干扰能够显著降低,这也提升高业务负荷场景的用户体验,最终提升整体网络容量。

网络容量提升达 40%



●智感波束技术的使用能够显著提升网络容量和传输效率

● Interference Sensing technique greatly improve network capacity and performance

在 5G 网络部署的新阶段,为不断提升的网络容量和用户体验,在引入新的频谱、进行更小的站间距建设之外,干扰抑制解决方案是提高网络容量和性能的重要路径。爱立信智感波束解决方案将助力运营商以高性能的网络部署方式充分释放 Massive MIMO 技术的潜力,提升 5G 网络的能源效率,最大化频谱投资的价值。

For the new phase of 5G network deployment, interference mitigation solution is an important approach to improve network capacity and performance in addition to leveraging new spectrum and building new base stations with shorter site distance for ever-increasing network capacity and user experience. Ericsson's Interference Sensing solution will enable operators to unlock the full potential of Massive MIMO technology in high-performance network deployments, improve the energy efficiency of 5G network, and maximize the value of spectrum investments.



●智感波束技术可以用于大型赛事活动场馆等 5G 高业务负荷密集区域,提供更多的网络容量

● The interference sensing solution could be deployed at stadium for large events and other 5G high loaded dense urban area to offer more network capacity

趣链区块链平台

Technological Achievement: Hyperchain



杭州趣链科技有限公司
Hyperchain Technology Co., Ltd



引言

趣链区块链平台是趣链科技自主研发的企业级联盟区块链平台，是实现多方可信协作、价值互联互通的分布式商业基础设施。

Introduction

Hyperchain is an enterprise-level consortium blockchain platform independently developed by HYPERCHAIN TECHNOLOGY. It is a distributed commercial infrastructure that enables multi-party trusted collaboration and value interconnection features.

趣链区块链平台是趣链科技自主研发的企业级联盟区块链平台，具有广泛的国际影响力

An Internationally Influential Consortium Blockchain Platform by HYPERCHAIN TECHNOLOGY

趣链区块链平台是趣链科技自主研发的企业级联盟区块链平台，是实现多方可信协作、价值互联互通的分布式商业基础设施。平台提供自适应共识算法、多语言智能合约引擎、全国密支持、多维隐私保护、软硬协同一体化等多项核心技术功能，具有万级 TPS 吞吐量和毫秒级系统延迟，

支持交易级别的隐私数据保护、混合型数据存储、可信执行环境、联盟自治、预言机以及可视化运维等特性，满足企业级应用在高安全、高性能、可扩展、易运维、规范监管等方面的需求。

Hyperchain is an enterprise-level consortium blockchain platform independently developed by HYPERCHAIN TECHNOLOGY, which is a distributed commercial infrastructure enables multi-party trusted collaboration and value interconnection features. The platform's core protocol comprises a large-scale hierarchical networking model, a highly robust consensus mechanism, secure and user-friendly smart contracts, and hybrid storage model.

It boasts a throughput of 10,000 transactions per second (TPS) and millisecond-level system latency. Additionally, it supports transaction-level privacy data protection, hybrid data storage, trusted execution environments, alliance autonomy, oracles, and visual operation and maintenance, among other features. These capabilities meet the demands of enterprise-level applications, including high security, high performance, scalability, ease of operation and maintenance, and standardized supervision.

基于该平台，趣链科技牵头和参与制定区块链领域国际标准 80 余项。例如，2023 年 7 月 10 日 -21 日，在国际电信联盟第十六研究组（简称：ITU-T SG16）日内瓦全体会议期间，由公司牵头研制的国际标准：ITU-T F.751.13 (ex F.DLT-DPT): Framework and requirements for distributed ledger technology-based distributed power trading system（基于区块链的分布式电力交易系统框架和要求）获批结项。该标准是我国首项基于区块链技术在分布式电力交易方面的国际标准，规定了基于区块链的分布式电力交易系统的参考架构、参与主体和技术要求，可以为区块链技术提供方、分布式电力交易系统使用方等在系统的开发、设计和使用过程中提供参考和指南。

Based on Hyperchain, the company has taken the lead and participated in the formulation of more than 80 international standards in the blockchain field. For example, during the ITU-T SG16 Geneva plenary meeting from July 10 to 21, 2023, the international standard——ITU-T F.751.13 (ex F.DLT-DPT): Framework and requirements for distributed ledger technology-based distributed power trading system developed by the company was approved for completion. This standard is China's first international standard for



●ITU-T SG16 在日内瓦召开全体会议
●ITU-T SG16 Geneva Plenary Meeting

distributed power trading based on blockchain technology. It stipulates the reference architecture, participating entities and technical requirements of a distributed power trading system based on blockchain and can provide blockchain technology with provide reference and guidance to parties and distributed power trading system users during the development, design and use of the system.

支撑 200 余项落地应用，实现多场景多领域深度赋能

Hyperchain Delivers More Than 200 Tangible Business Outcomes for Clients in Multiple Scenarios and Fields

趣链区块链平台已支撑 200 余项落地应用，在智慧城市、金融科技、能源双碳等多个领域为企业数字化转型提供助力。一是助力数字城市建设，如为舟山市普陀区搭建“健康共富方舟”，链上健康管理数据近 30 万人次，帮扶海岛老人近 3 万人。二是助力金融服务升级，如搭建江西省安全可信金融大数据共享平台，实现金融大数据的安全采集、高效治理、综合利用和可信共享。三是助力提高执法办事效率，如联合重庆市渝中区检察院打造“非羁押数字管控平台”项目。四是助力推进“双碳”减排进程，如为浙江省搭建减污降碳协同增效平台，已为浙江省 1600 余家企业提供碳与排污权的综合管理服务。五是助力实现知识产权确权，如打造浙江省知识产权区块链公共存证平台，实现知识产权一站式服务。目前，趣链科技基于趣链区块链平台已服务超过 300 家中国国家机构及头部企业，同时在中国香港、日本等国际市场积极探索区块链的创新应用，已支撑业务规模达数万亿人民币。

The platform delivers more than 200 tangible business outcomes for clients, providing assistance for the digital transformation of enterprises in Smart City,

Banking and Financial Services, Smart Energy Management, Carbon Management and Calculation, and other fields.

Firstly, Hyperchain supports the construction of smart city, such as building a Health Management Application for Putuo District, Zhoushan City. This blockchain-based app accumulated health management data for nearly 300,000 people and helps nearly 30,000 elderly people on islands.

Secondly, it facilitates digital transformation in traditional banking and financial services, for example, building a Safe and Trustworthy Financial Big Data Sharing Platform in Jiangxi Province to achieve safe collection, efficient management, comprehensive utilization and trustworthy sharing of financial big data.

The third point is to assist the digital judicial field in improving law enforcement efficiency, such as cooperating with the Chongqing Yuzhong District Procuratorate to build a Non-Detained Individuals Management Platform. Meanwhile, Hyperchain promotes the low-carbon emission reduction process. For example, it has built a government carbon governance platform for Zhejiang Province for pollution reduction and carbon emissions. The platform has already provided comprehensive management services for carbon and pollutant emissions rights to over 1,600 companies in Zhejiang Province. Finally, it

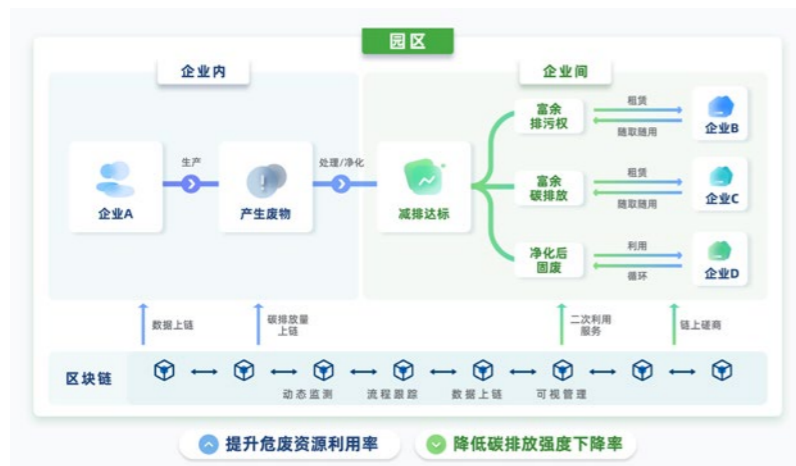
promotes the confirmation of intellectual property rights. In Zhejiang Province, the company has established the Zhejiang Provincial Intellectual Property Blockchain Public Notarization Platform to realize one-stop service for intellectual property rights.

At present, HYPERCHIAN TECHNOLOGY has served more than 300 Chinese state institutions and leading enterprises based on the consortium blockchain platform. At the same time, it is actively exploring innovative applications of blockchain in international markets such as Hong Kong, China, and Japan, and has supported a business scale of tens of thousands billion yuan.



趣链区块链平台应用生态图

Hyperchain Application Ecological Map



趣链区块链平台在园区碳管理中的应用示意图

Application diagram of Hyperchain for carbon management in campus

在中国多项权威测评中名列前茅 A Top Performer in Numerous Authoritative Chinese Evaluations

趣链区块链平台是中国第一批通过工信部标准院与信通院区块链标准测试的区块链平台，并在2017-2022年中国信通院可信区块链测评中连续荣获第一，符合中国人民银行《金融分布式账本技术安全规范》。平台相继荣获2019中国区块链十佳底层技术平台、2020区块链技术与应用创新成果（中国通信学会）、福布斯区块链50强——中国建设银行区块链底层平台等奖项。

Hyperchain is one of the first batch of blockchain platforms in China to pass the blockchain standard test of the Ministry of Industry and Information Technology's Standards Institute and the China Academy of Information and Communications Technology. It has continuously secured the top position in the trusted blockchain evaluation conducted by the China Academy of Information and Communications Technology from 2017 to 2022, as well as the Security Specifications for Financial Distributed Ledger Technology by the People's Bank of China. The platform has successively received awards such as China's Top Ten Blockchain Underlying

Technology Platforms in 2019, 2020 Blockchain Technology and Application Innovation Achievements (China Communications Society), and Forbes Top 50 Blockchain-China Construction Bank Blockchain Underlying Platform.



在第八批可信区块链评测中，趣链区块链平台 (Hyperchain) 通过功能分级专项测试并取得了最高评级3级 (先进级)

In the 8th batch of trusted blockchain evaluation, Hyperchain passed the special test of functional classification and achieved the highest rating of level 3 (advanced level)



移动视联算力系统



●面向通感算传泛在融合视联算力系统为 8000 万用户，36 万个行政村、13 万个社区、129 万个商铺和 190 万路天网雪亮工程提供技术支撑和服务

●IoVTC System has provided technical support and reliable services for 80 million customers, 360 thousand administrative villages, 130 thousand communities, 1.29 million shops and 1.9 million video streams of national SkyNet Project

面向通感算传泛在融合的视联算力系统创新与应用

Innovation and Application of Internet of Video Things Computing (IoVTC) System for Ubiquitous Integration of Communication, Sensing, Computation, and Transmission

中移（杭州）信息技术有限公司（中国移动智家中心）
China Mobile (Hangzhou) Information Technology Co., Ltd.



引言

人类社会迈入数智时代，信息化网络要实现从服务人与物到支撑智能体高效联接的跃迁。移动视联算力系统依托通信、感知、算力、传输等技术融合创新，成为支撑未来社会高效可持续发展的网络信息服务底座，赋能多彩的新业务。

Introduction

As human society is now entering the era of intelligence, future communication networks need to undergo a leap from serving people and connecting people with things to support the efficient connection

of intelligent entities. The IoVTC system of China Mobile has overcome several key challenges in communication, sensing, computation and transmission technologies, and innovatively achieved convergence. It has served as the fundamental network information service infrastructure that supports an efficient and sustainable social development in the future, empowering a diverse range of new creative business.

三大技术创新构筑新型网络信息服务底座

Three key technology innovations built a new fundamental network information service infrastructure

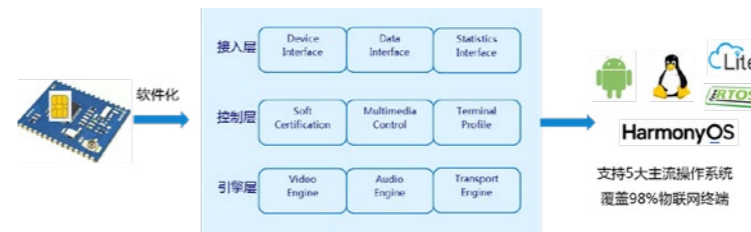
中国移动从物联通信、感知编码、并网计算等方面的关键技术难点出发，实现了三项技术创新。

China Mobile has achieved three technological innovations by addressing key technical challenges in areas of IoT communication, user perception based video coding, and grid computing.

首次提出了软件定义物联多媒体通信架构，全软件化实现信媒协议和多媒体编解码算法，结合微内核、插件化分层技术，实现无通信模组的电信级通信，并构建一套快速适配物联网终端的架构，赋能 120 家生态合作伙伴，超 600 款终端。

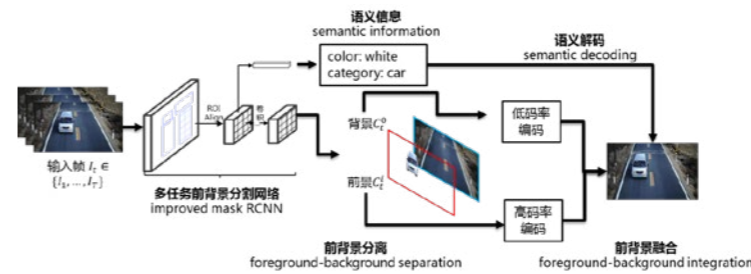
China Mobile has introduced software-defined IoT multimedia communication architecture for the first time, which utilizes software to implement signaling protocol modules and video/audio codec algorithms. By leveraging microkernel and plugin-based layering technologies, it constructs an architecture that enables rapid adaptation for ubiquitous IoT devices. This architecture empowers IoT devices with multimedia communication capabilities without any communication chips or modules, which has served over 120 cooperative partners and over 600 IoT devices.

首次大规模应用了面向用户感知的增强型视频编码。搭建基于 QoE



●软件定义物联多媒体通信架构

● Software-defined IoT multimedia communication architecture



●基于语义分割和场景识别的增强型视频编解码

● Enhanced video encoding and decoding technologies based on semantic segmentation and scene recognition

感知与认知模型的视频感知通信平台，研发基于语义分割、目标跟踪及场景识别的编解码技术，优化配置网络传输和编码资源，平均码率较 H.264 降低 47%。

China Mobile has firstly implemented and deployed user perceptual enhanced video coding on a large scale. We have developed a video perceived communication platform based on Quality of Experience (QoE) perception and cognition models. A mount of research and development on encoding and decoding technologies has been conducted based on semantic segmentation, object tracking and scene recognition. The integration of these advanced technologies enhances the overall multimedia communication experience and efficient utilization of network resources. It achieves an average bitrate saving of approximately 47% compared to H.264 without compromising the subjective quality of the video.

创新研发全域算力并网调度技术，构建跨域多层的云网一体化平台和边缘算仓，支撑 EB 级大规模云存储集群，为超 8000 万用户提供视联算力服务。

China Mobile has developed a global-scale integrated video computing power and network scheduling techniques. By combining hierarchical layering with cloud-based and edge-based computing power resources, as well as deployment of edge algorithm warehousing, it can support EB-level super-large scale cloud storage cluster, and serve 80 million users with the service of Internet of Video Things computing.

网络信息服务底座支撑社会数智化转型发展

The new fundamental network information service infrastructure supporting the digital and intelligent transformation and development of the society

视联算力系统已广泛应用于智慧家庭、数字乡村、公共安全等重大工程，产生了显著的经济和社会效益，近三年的收入贡献超 150 亿元。

The loVTC system has been widely applied into several major national projects such as smart home, digital village, and public security. It has brought significant social and economic benefits, with an overall revenue of over 15 billion yuan in the past three years.

助力社会公共安全保障，对接 140 个地市的 170 万路天网雪亮系统，为国家安全保障体系提供最大的社会面资源支持。

The loVTC system assists the guarantee of public safety in the society. By interconnecting with more than 1.7 million video surveillance connections over 140 cities from national Skynet Project, the system provides the greatest support from social resources.

助力数字乡村振兴建设，聚焦三农需求，打造“平安三助”服务，覆盖 36 万个行政村，惠及 2 亿村民。

The loVTC system assists the construction of digital rural revitalization. The system targets at agricultural, rural and farmers' demands and provides services for 360 thousand administrative villages and 200 million farmers.

助力智慧家庭安全看护，基于用户自分享模式，守护 4500 万个家庭，



●基于中国移动视联网算力系统打造数字乡村智慧大屏助力数字乡村振兴建设

●The digital village smart screen aims to support the construction of digital rural revitalization based on China Mobile's loVTC system



●基于中国移动视联网算力系统助力数字乡村高效治理

●The highly efficient governance of digital village based on China Mobile's loVTC system

为 900 万外出务工人员提供远程看家护院服务。

The loVTC system assists the safety protection of smart home. Based on innovative mode of self-sharing, the system takes care of 45 million families and provides remote care services for 9 million expatriate workers.

助力银发健康养老服务，为银发人群打造适老关爱产品，入选《生活黑科技》电视栏目，成为“跨越数字鸿沟，让老人“触网”不落单”的典型案列。

The loVTC system assists the healthcare service for the elderly. Products provided by the system was broadcasted by a TV program of "Science and Education" and became a typical case of allowing the elderly to surf over the Internet without any fears behind.

助力人民食品安全保障，推进网络餐饮治理的制度改革和食品溯源创新。

The loVTC system assists the guarantees of people's food safety. It accelerates the regulation revolution and innovation for the management of online catering services.

泛在融合支撑重大战略需求，推动技术和产业体系跃升

Ubiquitous integration of advanced technologies meeting the national major strategic needs, as well as promoting the development of technological and industrial systems

中国移动智家中心牵头制定和发布了移动视联 3 项国际标准、3 项行业标准，填补了家庭安防领域和物联网智能通信领域的国际标准空白，有效解决了业界厂商终端接入、媒体传输和视频存储等技术方面存在的规范、不统一、无法互通的问题，实现了视联网算力系统海量终端接入、安全网络传输、合规业务运营、规模应用发展。

The smart home operational center of China Mobile has led the development and release of three international standards

in International Telecommunication Union (ITU) and three industrial standards for loVTC technologies, which has filled the gap of international standards in the home surveillance and IoT based intelligent communication fields. These standards can solve the issues of lacking of standardization, uniformity and abilities of interconnection in video access, transportation and storage stages. Thus, the loVTC system can afford massive terminal access, secure network transmission, compliant business operations, and scalable application development.

视联网算力系统服务超 8000 万用户，承载 120 家合作伙伴的超 600 款终端，研发通、感、算、传四大专业技术能力赋能芯片、终端、应用等产业链上下游合作伙伴：1) 面向用户感知的视频编解码能力；2) 轻量级、适配广的新型视联接入能力；3) 面向千类场景、EB 级数据的秒级视频检索能力；4) 支撑亿级用户接入、千万级并发的视频传输能力。



●中国移动智家中心牵头制定和发布视联网算力多项国际和行业标准

●Smart home operational center of China Mobile led developing and releasing several international and industrial standards for loVTC key technologies

拥有多项知识产权，荣获多项国际权威认证

Possessing multiple intellectual property rights and receiving numerous international authoritative certifications

移动视联网算力系统构筑新型网络信息服务底座，实现通信与感知、计算、传输等深度融合，在中国及港澳地区规模化应用推广。在网络通信、视频编码、安全传输、算力分发等关键技术方面沉淀核心知识产权 10 项，完成平台、终端、传输服务等相关软著 8 篇，获得 ISO/IEC 等 5 项认证，包括信息技术服务管理体系、信息安全管理、云安全管理体系、公有云个人信息保护管理体系，有效保障业务的安全可持续发展。

The loVTC system has formed as the new fundamental network information service infrastructure, realizing the deep integration of technologies in video communication, perception, computing, and transmission areas, which has been widely applied in mainland China, Hong Kong and Macau regions. In the areas of network communication, video encoding, secure transmission, and computing power distribution, China Mobile has secured 10 core intellectual property rights. They have also completed 8 software copyrights related to platforms, terminals, and transmission services. They have been awarded 5 certifications from organizations such as ISO/IEC, which include Information Technology Service Management System, Information Security Management System, Cloud Security Management System, and Public Cloud Personal Information Protection Management System, ensuring the secure and sustainable development of their business.

The loVTC system is now serving over 80 million subscribers, 600 types of terminals from 120 companies. It has researched and developed four major technical capabilities in communication, perception, computation, and transmission. These capabilities empower partners throughout the industry chain, from chipsets to terminals to applications: 1) Video encoding and decoding capability oriented towards user perception; 2) Lightweight and broadly adaptable new loVTC access capabilities; 3) Real-time video retrieval capabilities for exabytes of data across thousands of scenarios; 4) Video transmission capabilities supporting billions of user accesses and tens of millions of concurrent connections.



●视联网算力系统赋能上下游产业链

●The loVTC system empowering the entire industry chain



●移动视联网算力系统获得多项 ISO/IEC 国际权威认证

●The loVTC system obtained several international authoritative certificates from ISO and IEC



面向知识工作者的个性化轻量语言模型大象 GPT

EverGPT: A Personalized Lightweight Large Language Model for Knowledge Workers

印象（上海）数字科技有限公司
Yinxiang (Shanghai) Digital Technology Co.,Ltd.



引言

「大象 GPT」的诞生得益于印象科技在信息处理与知识管理领域的丰富积累。专门的训练指令数据集及数据增强算法和流程，保证「大象 GPT」能够更好地为知识工作者的学习与工作场景服务，提高信息处理能力，提升知识管理效率。

Introduction

The birth of EverGPT benefits from the rich accumulation of Ever Inc. in the field of information processing and knowledge management. Specialized instruction datasets, along with data augmentation algorithms and related filtering processes ensure that EverGPT can better serve the learning and working scenarios for knowledge workers, improve information processing capabilities, and enhance knowledge management efficiency.

专属数据训练、专业领域调优的轻量化模型 Lightweight model fine-tuned with specialized data

基于印象科技对个人知识管理领域深入的理解和对用户长期反馈的精准捕捉，通过采用独创的数据过滤和增强算法，利用多语言混合指令构造方法与数据质量优化，确保了训练数据的质量和针对性，为模型的高效训练和准确性提供了坚实的基础。

开源预训练大语言模型基础上进行有监督的大量训练和调优，进一步加入在知识管理领域的专业知

识和用户反馈，以实现更为精准和高效的模型输出。大象 GPT 的训练和应用专注于知识管理和生产力提升领域，它在这些领域的应用效果优于通用模型。在模型规模可控的前提下，在专业场景下百亿级参数的轻量化模型推理能力接近千亿级模型。在处理事实性问题时大象 GPT 结合了知识图谱的方法，提高了处理事实性问题的准确性和效率，能够更好地理解、协助和增强用户的思考，帮助知识工作者更高效地管理和利用他们的知识。

Based on Ever Inc.'s in-depth understanding in the field of personal knowledge management and accurate capture of long-term user feedback, several unique data filtering and augmentation algorithms are used, along with advanced multi-language instruction mixture strategy and data quality evaluation process, to ensure the quality and relevance of training data, providing a solid foundation for efficient model training.

Based on the open-source pre-trained large language model, a large amount of supervised training and tuning is conducted, and professional knowledge and user feedback in the field of knowledge management are further incorporated to achieve more accurate and efficient model output. The training and application of EverGPT focus on the fields of

knowledge management and productivity improvement, and its application effect in these fields is better than that of general models. Under the premise of controllable model size, the lightweight model inference capability of the billion-level parameter model in professional scenarios is close to that of the hundred-billion-level model. When dealing with factual problems, EverGPT combines the method of knowledge graph to improve the accuracy and efficiency of dealing with factual problems, and can better understand, support, and augment users' thought processes, helping knowledge workers to manage and utilize their knowledge more efficiently.



率先部署应用、持续迭代优化

Lead the deployment of applications and continuously iterating for optimization

大象 GPT 这一突破性的技术成果，使得印象科技成为中国率先全面上线 AIGC 服务的工具产品提供商。大象 GPT 驱动的印象 AI 服务已经全面赋能印象科技旗下的印象笔记、Verse 等系列效率工具产品，覆盖信息收集、内容创作、归纳总结、文档分析、时间管理等智能化知识管理全场景服务。

The breakthrough technology of EverGPT has enabled Ever Inc. to become the first comprehensive AIGC service provider in China. EverAI driven by EverGPT has fully empowered Ever Inc.'s efficiency tool products such as Yinxiang Biji, Verse, covering intelligent knowledge management services in all scenarios such as information collection, content creation, summarization, document analysis, and time management.



● 「大象 GPT」 赋能印象科技旗下的全系列产品
● EverGPT empowers the full product line under Ever Inc

印象 AI 服务上线后，从交互体验、模型调优、私有化模型等方面获得了来自首批知识工作用户的实操反馈。这些来自第一线的深刻洞察协助印象科技沿着“个人/企业私人 AI 知识助理”的方向持续探索大象 GPT 的发展，同时将在信息处理与知识管理垂直大模型领域独到的思考和实践经验转化为系列落地产品方案。

After the launch of EverAI, the first group of knowledge workers has provided practical feedback on its interaction experience, model tuning, and private model usage. These

frontline insights have assisted Ever Inc. in continuing to explore the development of the EverGPT towards the direction of "personal/corporate private AI knowledge assistants". At the same time, the unique thinking and practical experience in information processing and knowledge management fields as to vertical large models will be consistently transformed into a series of landing product solutions.

大象 GPT 在印象笔记等系列产品中的应用已成功赋能数百万知识工作者。用户借助大象 GPT 提供的 AI 帮我写等一系列智能写作助理功能，数据创建量提升 3-5 倍，周活频次提升 2-3 倍，单篇内容书写字数提升 4-5 倍；制作方案、构思大纲的速度更是倍数提升。

The application of EverGPT in products such as Yinxiang Biji has successfully empowered millions of knowledge workers. With EverGPT's help in intelligent writing assistant functions such as "AI Help Me Write", users have increased their data creation by 3-5 times, weekly activity frequency by 2-3 times, and single content writing word count by 4-5 times. The speed of creating plans and outlines has also increased significantly.

行业赋能、助力新质生产力提升 Empowering the industry and enhancement of new-quality productivity

大象 GPT 在印象笔记等系列产品中的成功应用，证明了 AI 技术在知识管理与生产力提升领域的巨大潜力，也为行业内其他企业提供了宝贵的参考。

The successful application of EverGPT in series products such as Yinxiang Biji proves the enormous potential of AI technology in the field of knowledge management and productivity improvement, and also provides valuable reference for other enterprises in the industry.

大象 GPT 在全球开源峰会等一系列公开论坛中亮相，得到了业内同行的充分认可。印象科技在大语言模型训练上积累的经验、模型与应用相结合实现闭环反馈的模式，帮助专注垂直领域模型研究的同行加快大模型的研究与迭代进程，推动 AI 技术尽快落地赋能。

EverGPT has appeared in a series of public forums such as the Global Open Source Summit and has been fully recognized by industry peers. Ever Inc.'s experience in large

language model training, combined with models and applications, has helped colleagues who focus on vertical domain model research to accelerate the research and iteration process of large models through a closed-loop feedback mode, promoting the rapid landing of AI technology.

而大象 GPT 本身的应用落地，提高了知识工作者的信息处理和知识管理的效率，为知识驱动型企业和团队节省大量的人力和时间成本，提升全民信息素养，促进社会信息化进程，以最终实现社会新质生产力的提升。

The application of EverGPT itself improves the efficiency of information processing and knowledge management for knowledge workers, saves a lot of manpower and time costs for knowledge-driven enterprises and teams, enhances the information literacy of the general public, promotes the process of social informatization, and ultimately realizes the improvement of new social productive forces.

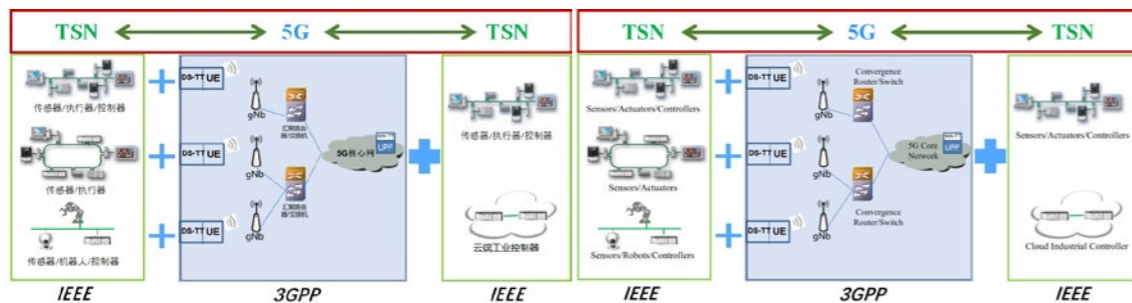


● 「大象 GPT」 在不同场景下提供的 AI 服务
● AI services powered by EverGPT in different scenarios



5G-TSN 协同组网及关键技术

Key Technologies for 5G-TSN Cooperation Network



◎ 5G-TSN: 面向工业场景的有线与无线融合确定性网络
◎ 5G-TSN: Deterministic Network integrated with wired and wireless techniques for Industrial Scenarios

北京科技大学
University of Science and Technology Beijing

中兴通讯股份有限公司
ZTE Cooperation

中国联合网络通信有限公司
China Unicom

北京邮电大学
Beijing University of Posts and Telecommunications

北京东土科技股份有限公司
Beijing Kyland LMT. Company

重庆邮电大学
Chongqing University of Posts and Telecommunications



引言

面向“5G+ 工业互联网”新基建战略，针对 5G 深度赋能工业面临的技术能力不足、确定性保障欠缺的难题，引入时间敏感网络机制，构建有线与无线融合的确定性网络，为智能工厂提供低时延、高可靠、确定性的数据传输保障。

Introduction

In order to fulfill new infrastructure strategy of "5G+Industrial Internet", Time-Sensitive Networking mechanisms are introduced into 5G system to construct the deterministic network integrated with wired and wireless techniques, addressing the challenges faced when 5G are used for vertical fields, including insufficient technical capability and lack of deterministic guarantees. Integration of 5G and TSN can provide low latency, ultra reliability and deterministic communications for future smart factory.

实现跨 5G 与 TSN 的确定性传输保障

Fulfill the deterministic communications across 5G and TSN

针对多样化工业业务承载及实时工控业务可靠传输需求，围绕适配 TSN 的 5G 增强技术及 5G-TSN 跨域协同优化难题，构建 5G-TSN 协同理论技术体系，打造 5G-TSN

端到端网络试验床，实现跨 5G 与 TSN 端到端传输时延小于 1 毫秒，时间同步精度小于 100 纳秒，传输可靠度达 99.99%，并保证多业务传输条件下微秒级时延抖动。

In order to fulfill new infrastructure strategy of "5G+Industrial Internet", Time-Sensitive In order to meet the transmission requirements of multiple industrial services and real-time automation control traffics, the project propose the 5G-TSN cooperation theories and mechanisms, furthermore, the project establishes an end-to-end 5G-TSN network test-bed, which can achieve low end-to-end transmission latency less than 1ms, time synchronization accuracy less than 100ns and transmission reliability higher than 99.99%, which demonstrates that the proposed 5G-TSN schemes and new developed 5G devices can provide bounded latency for high priority traffic in multiple traffics scenario.

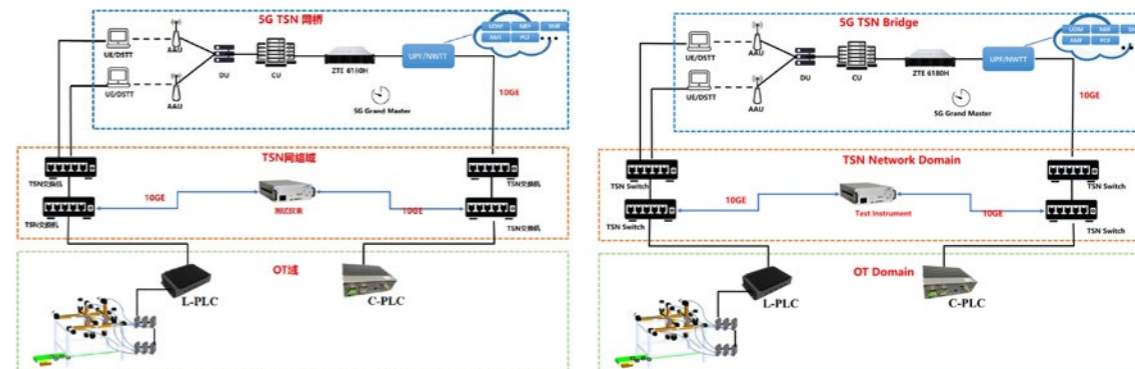
突破 5G 空口超低时延保障技术及 5G-TSN 协同优化方法，实现毫秒级跨网确定性传输，为 5G 深度赋能千行百业奠定坚实技术基础。

The project breaks through the 5G radio ultra-low latency guarantee technology and the 5G-TSN cooperation optimization mechanisms, achieving millisecond level deterministic transmission across 5G and TSN, which enables 5G as a solid technical foundation for

vertical industries.

面向工业典型场景，结合自主研发的云化 PLC，研发了 5G-TSN 端到端实验床，实现跨网传输时延小于 1ms，达到国际领先水平。

As to typical industrial scenario, the project build establishes an end-to-end 5G-TSN network testbed combining with self-developed cloud-based PLC, which achieves transmission latency across 5G and TSN less than 1ms. The test results demonstrates that the performance of developed 5G-TSN testbed reaches international leading level.



◎ 跨 5G 与 TSN 的端到端组网示意图
◎ Illustration of 5G-TSN networking

核心设备及试验床突破

- 自研支持超低时延的 5G 原型终端、TSN 测试仪器
- 支持 5G-TSN 协同优化的网关及试验床

跨网时间同步精度 小于 100 纳秒

平均时延: 604.36 微秒

Breakthrough in Core Equipment and Testbeds

- Self-developed 5G prototype terminals and TSN testing instruments

Cross-network time synchronization accuracy is for below 100 ns

Average latency: 604.36us

◎ 核心设备突破与测试结果
◎ Breakthroughs of core devices and test results

构建未来智能工厂统一承载网络

Building a unified carrier network for future smart factories

项目提出了适配工业自动化的 5G-TSN 协同实时传输理论及关键技术体系，出版专著 1 部，发表论文超过 20 篇，形成包括三项 PCT 专利在内的发明专利超过 25 项，在确定性网络方面牵头编制 ITU-T 国际标准 4 项；研制了 5G-TSN 新型网关，并面向工业场景搭建了端到端试验床，时延、跨网时间同步、数据传输可靠性等性能指标达到国际领先。项目相关研究填补国内外相关领域的空白，对于 5G 与 TSN 在工业领域及未来智能工厂的应用具有重要意义。

The project presents a theoretical and key technical system of 5G-TSN cooperation transmission for industrial automation applications, one publication and more than 20 academic papers have been published with over 25 patents, including three PCT patents. Meanwhile, leading the drafting of 4 ITU-T international standards in deterministic networking. Furthermore, this project has also successfully designed a novel 5G-TSN gateway and established an end-to-end testbed for industrial scenarios, thereby attaining international prominence in performance metrics like latency, cross-network time synchronization, and data transmission reliability. The research from this project has filled gaps in the relevant fields both domestically and internationally. It is of significant importance for the application of 5G and TSN in the industrial sector and future smart factories.

5G-TSN 将成为 5G 深度赋能垂直行业的关键基础技术，是 6G 演进的重要方向之一

5G-TSN will become a key foundational technology for 5G to deeply empower vertical industries and is one of the important directions for 6G evolution

5G 工业应用是工业互联网的重要组成部分，5G 与 TSN 进行融合，将弥补 5G 在低时延及确定性保障方面的短板，为工业控制的云化提供网络保障，促进工业控制与网络信息技术的真正融合。项目构建了基于 5G-TSN 的网络化协同控制，助力无线自动化控制、工业机器人、预测性维护、柔性生产、车联网等行业突破，赋能新型工业化中工业化和信息化深度融合关键技术的实现，为工业互联网发展开创新空间。

5G industrial application is an important part of the industrial internet. By integrating 5G with TSN, it addresses the challenges of 5G in terms of low latency and deterministic assurance. This combination provides robust network support for the cloud-based transformation of industrial controls, fostering a seamless integration between industrial control and network information technologies. The project builds networked collaborative control based on 5G-TSN, facilitating advancements in sectors such as wireless automation control, industrial robots, predictive maintenance, flexible production, and vehicular networking. The project also promotes the realization of key technologies for the deep integration of industrialization and informatization in new industrialization, carving out new horizons for the growth of the industrial internet.



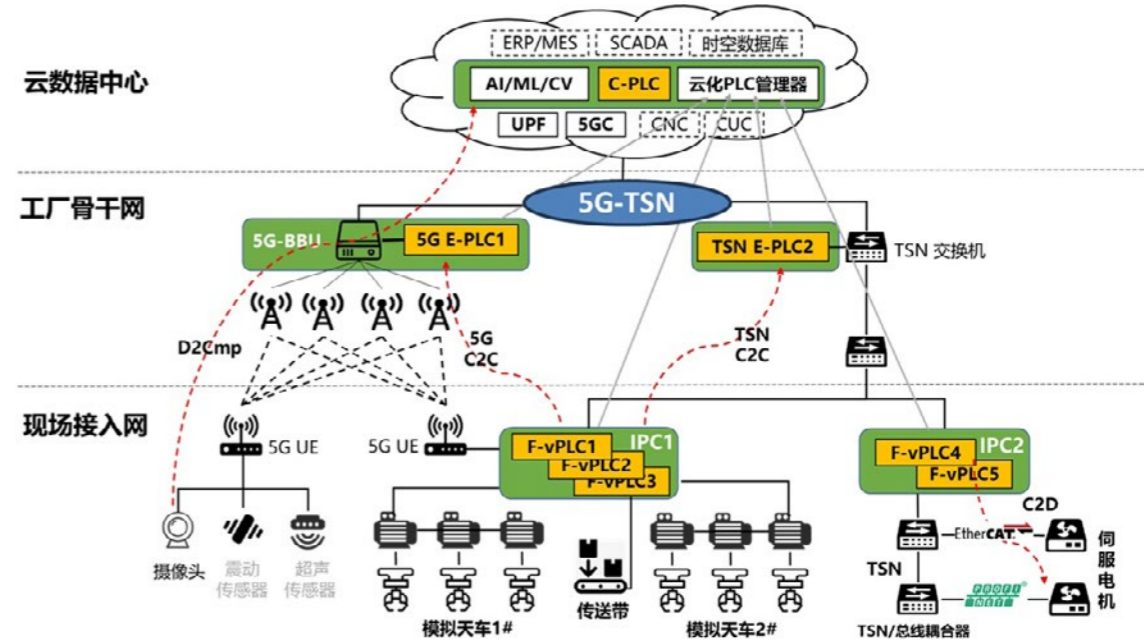
项目部分成果展示
Partial achievements of the project



云数据中心

工厂骨干网

现场接入网



基于 5G-TSN 的云化控制应用示意图

Cloud Center

Backbone Network

Access Network

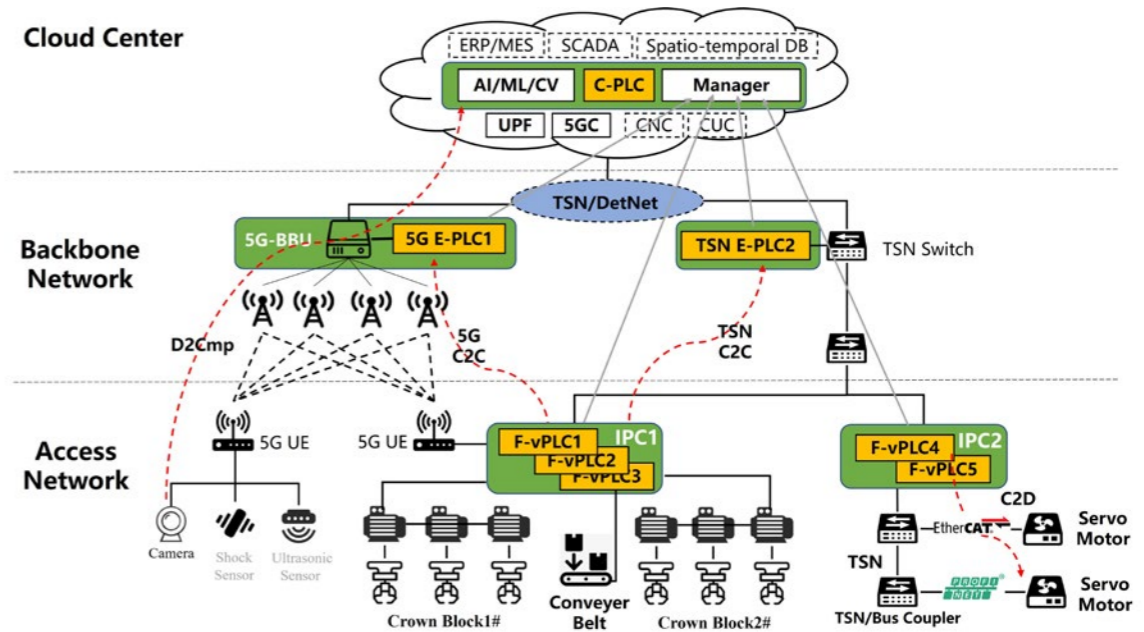
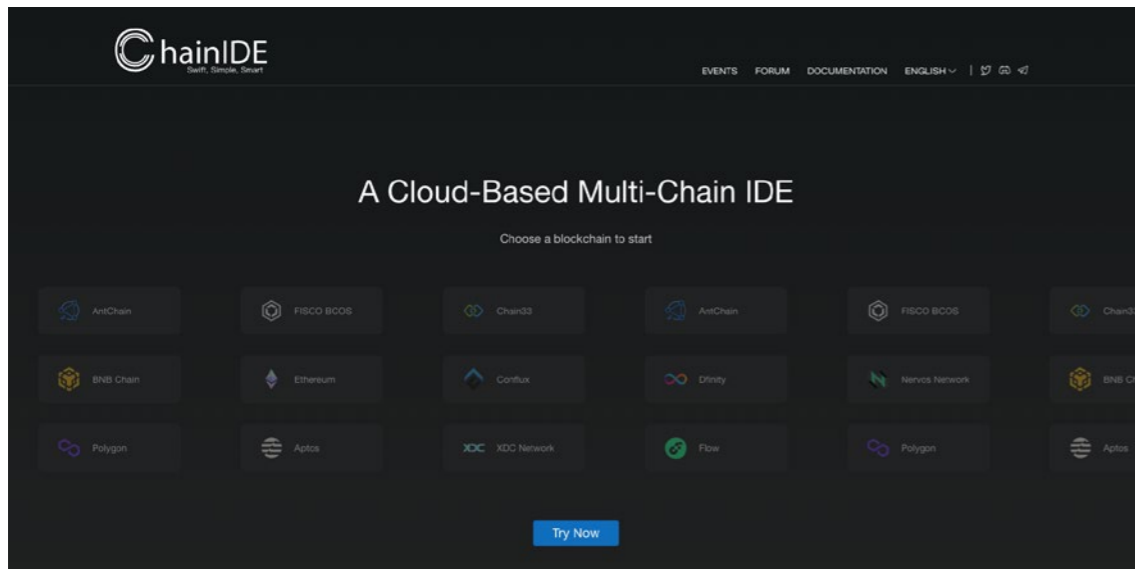


Illustration of cloud-based control applications leveraging 5G-TSN

多链云端集成 IDE

Cloud-based Multi-chain IDE



● 多链云端集成 IDE- ChainIDE 官网
● Cloud-based Multi-chain IDE - ChainIDE Homepage

南京纯白矩阵科技有限公司
Nanjing WhiteMatrix Technology Company



引言

ChainIDE 是一款全球领先的云端多链区块链开发环境，它内置丰富的插件系统和沙盒环境，覆盖了智能合约开发全生命周期，目前已经帮助 160 余个国家的开发者，提供了 800 万次的智能合约编译服务，是目前全球区块链开发者流量的主流入口。

Introduction

ChainIDE is the world's leading cloud-based multi-chain blockchain development environment. It features a rich plugin system and a sandbox environment, covering the entire lifecycle of smart contract development. Currently, it has assisted developers from over 160 countries, providing over 8 million smart contract compilation, making it the primary entry point for blockchain developers worldwide.

基于多链的云端集成智能合约开发环境 IDE

Cloud-based integrated smart contract development environment IDE supporting multi-chains

本项目的核心理念是利用云计算的能力来提高开发效率。通过这个环境，开发者可以省去大量繁琐的本地配置工作，将多条区块链的节点客户端、运行环境、SDK 和智能合约编辑器集成到一个平台。这一创新方法不仅大大节省了开发者的时间，利用云端存储还可以不分平台和终端，开发

的边际成本得以极大降低。具体技术创新包括：

1. 前端多链支持插件化，降低了多链开发的复杂度、提高系统的扩展性。
2. 虚拟机沙盒环境可伸缩化，利用云计算算力在浏览器获得桌面级别的开发体验。
3. 基于微服务的智能合约 DevOps 化，采用了持续部署策略，使智能合约的开发和部署更加高效。
4. 多链运维可视化：强调共识交易的过程跟踪，提供了可视化解决方案，以便更好地管理和监控多链环境。

The core concept of this project is to leverage the capabilities of cloud computing to enhance development efficiency. Through ChainIDE, developers can eliminate extensive local configuration work by integrating multiple blockchain node clients, runtime environments, SDKs, and smart contract editors into one platform. This innovative approach not only significantly saves developers' time but also using cloud storage greatly reduces the marginal cost of development, regardless of platform and terminal constraints.

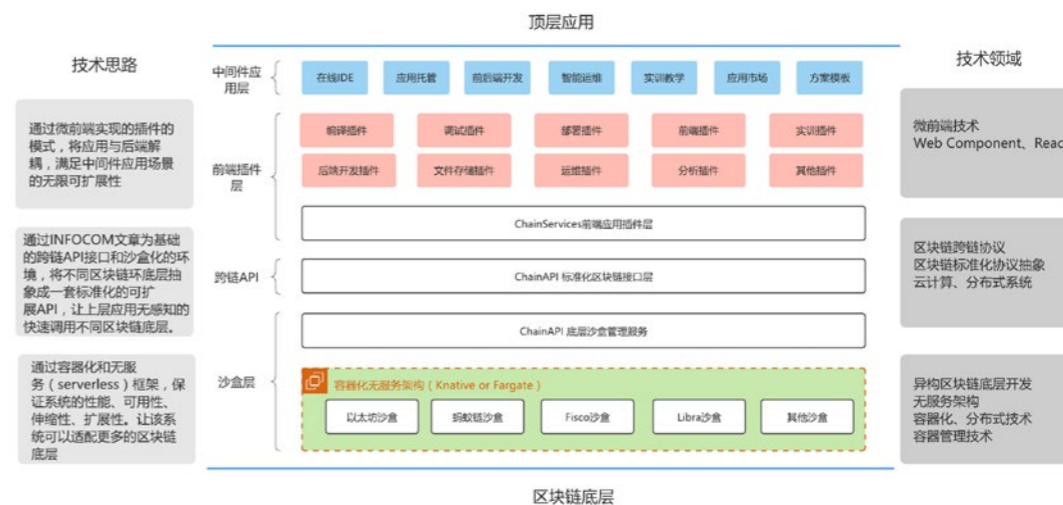
Specific technological innovations include:

1. Frontend support for multi-chain through plugin system, reducing the complexity of multi-chain development and enhancing system scalability.
2. Scalable virtual machine sandbox environment, utilizing cloud computing power

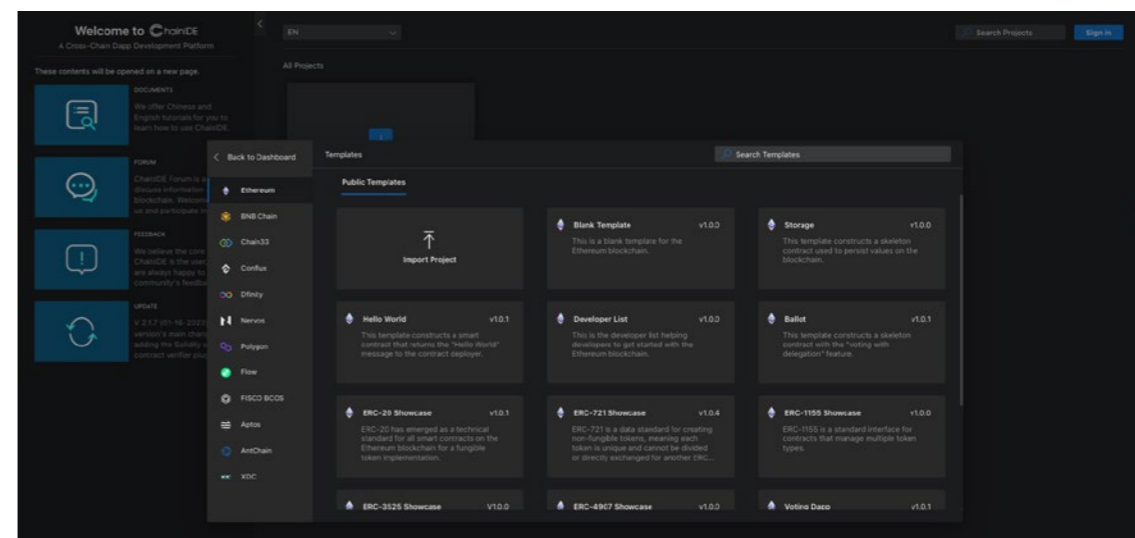
to achieve a desktop-level development experience in just one browser.

3. Smart contract DevOps based on microservices, adopting a continuous deployment strategy to make smart contract development and deployment more efficient.

4. Visualization of multi-chain operations, emphasizing the tracking of consensus transactions and providing a visual solution for better managing and monitoring multi-chain environments.



● ChainIDE 项目技术路线
● ChainIDE's Technology Roadmap



● ChainIDE 云端操作界面
● ChainIDE's Web UI

服务全球区块链开发者，获得多个国际区块链官方认可

Serving blockchain developers worldwide and obtaining recognition from multiple international blockchain authorities

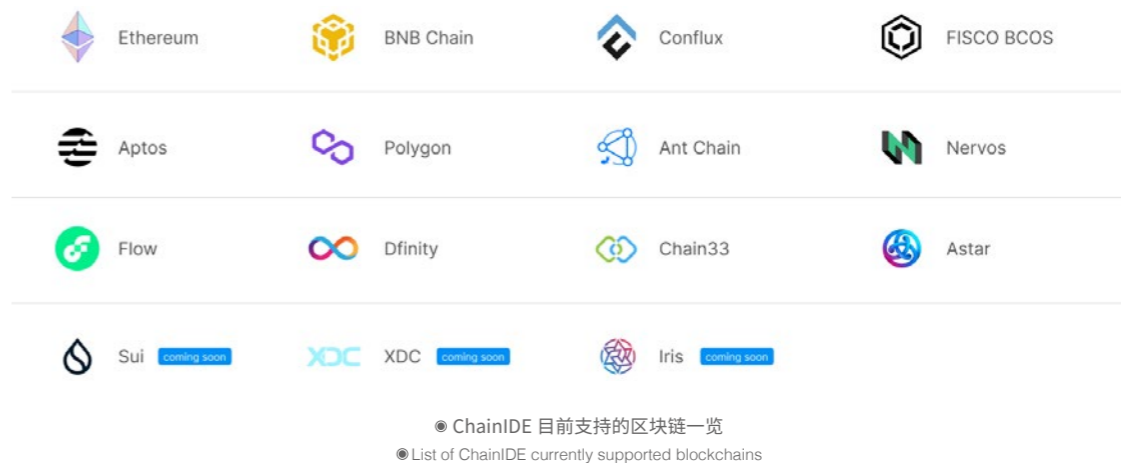
本项目目前已支持 ETH, BSC, Conflux, Dfinity, Nervos, Polygon, Flow, Aptos, Chain33, Fisco Bcos, Ant, XDC 等 12 条区块链，并与 Astar, Sui, Iris 达成合作，将在未来支持更多主流区块链。为目前市场上已知的支持链数量最多的智能合约开发 IDE，且被 ETH、BSC 等超过 7 家区块链开发者官方网站收录和推荐。广泛应用于全球超过 160 个国家，超 800 万次的智能合约编译，是目前全球区块链开发者流量的主流入口。

同时，本项目已发布软件著作权 30+ 项，发明专利申请 10+ 项，发表高水平国内外期刊 / 会议论文 6 篇以上。获得包括第四届中国区块链开发大赛一等奖、全球区块链企业创新 50 强、2021 年度区块链全国区块链技术应用精选案例等荣誉奖项，被加拿大不列颠哥伦比亚大学、加拿大阿尔伯塔大学、香港中文大学等多所 Top 100 大学纳入课程相关，并被包括蚂蚁金服，腾讯，趣链在内的诸多用户使用，因此拿到蚂蚁金服战略投资。

The project currently supports 12 blockchains, including ETH, BSC, Conflux, Dfinity, Nervos, Polygon, Flow, Aptos, Chain33, Fisco Bcos, Ant, XDC, and has partnered with Astar, Sui, and Iris for future support of more popular blockchains. It is the most widely known smart contract development IDE that supports the largest number of chains in the market and has been featured and recommended on official websites by over 7 blockchain authorities, including ETH and BSC. It has been widely served

in over 160 countries, with over 8 million smart contract compilations, making it the primary choice for global blockchain developers.

Furthermore, the project has obtained more than 30 software copyrights, applied for more than 10 invention patents, and published over 6 high-level domestic and international journal/conference papers. It has received prestigious awards, including the first prize in the 4th China Blockchain Development Contest, recognition among the Top 50 Global Blockchain Innovators and selection as a featured blockchain technology application case in 2021. It has been incorporated into the curriculum of several top 100 universities, including the University of British Columbia, the University of Alberta, and the Chinese University of Hong Kong. Moreover, it has been used by various users, including Ant Financial, Tencent and Hyperchain, and received strategic investment from Ant.



● ChainIDE 目前支持的区块链一览
● List of ChainIDE currently supported blockchains

弥补市场同类产品的短板，显著降低了开发门槛，推动区块链产业和市场的稳健增长

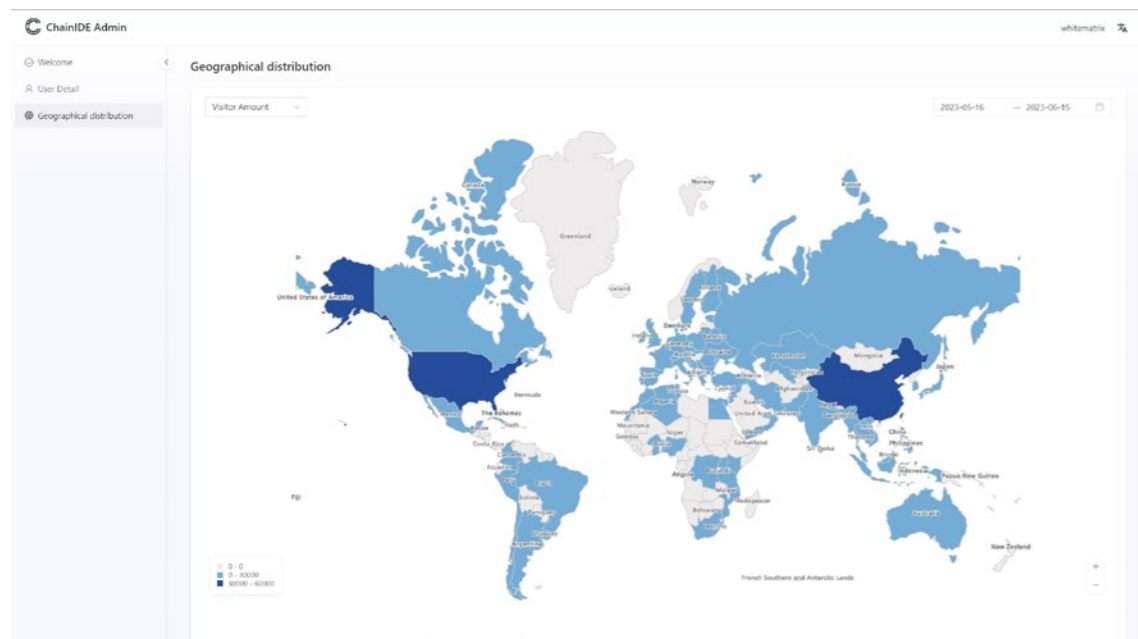
Addressing the shortcomings of similar products in the market, significantly lowering the barriers to entry for developers, and driving the steady growth of the blockchain industry and market

近些年来，在国际范围内，全球区块链相关行业正迅速蓬勃发展。区块链技术被广泛的应用于政府安全、金融、知识产权、衣食住行、社交等各个领域。区块链的发展需要依托于智能合约的稳固基础，智能合约的开发效率很大程度上制约了全球区块链行业的发展速度。目前市场上针对智能合约开发的各类应用层出不穷。而本项目作为一款跨平台跨终端、支持 10 条以上区块链的云集成智能合约开发环境 IDE，弥补了同类型产品学习成本高、跨链开发复杂、无法覆盖智能合约开发生命全周期等缺陷，

极大提高了开发者的开发和交付效率，对于中国乃至全球区块链产业的发展，都有着重要意义。

In recent years, on an international scale, the global blockchain-related industry has been rapidly flourishing. Blockchain technology has found widespread applications in various sectors, including government security, finance, intellectual property, daily life, and social interactions. The development of blockchain relies on a robust foundation of smart contracts, and the efficiency of smart contract development significantly influences the pace of growth in the global blockchain industry. Currently, the market is flooded with various application layers dedicated to smart contract development.

However, this project, serving as a cross-platform, cross-device, cloud-based integrated smart contract development environment IDE supporting over 10 blockchains, addresses the shortcomings seen in similar products, such as high learning curves, complexity in cross-chain development, and the inability to cover the entire smart contract development lifecycle. It greatly enhances developers' efficiency in development and delivery. This holds significant importance for the development of the blockchain industry in China and globally.



● ChainIDE 目前的用户分布图
● ChainIDE's User Distribution



● ChainIDE 赋能产业链
● How ChainIDE empowers Industries

生物数据隐私计算平台

Biodata Privacy Computation Platform

GCM Global Catalogue of Microorganisms | WDCM NMDC

[首页](#)
[病原物种](#)
[工具](#)
[隐私计算](#)
[统计](#)
[帮助](#)

国家病原微生物数据库

服务于公共卫生和传染病防控的国家病原微生物大数据平台

“单向隐私计算”

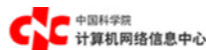
单向隐私计算服务面向具有数据安全保护需求的重要高致病性病原菌及病毒的基因序列数据分析对比需求，使用了基于国产可信硬件的隐私计算方案，保障经加密后的基因序列在加密态的内中进行序列分析；当分析完成后，相关加密数据会被立刻彻底销毁。在此过程中，通过前沿密码学、隐私计算、区块链等数据安全技术，保障包括计算分析服务提供方在内的各方，对数据不可见。

- 国家微生物科学数据隐私计算平台网页界面
- Biodata Privacy Computation Platform Web

中国科学院微生物研究所
Institute of Microbiology, Chinese Academy of Sciences



中国科学院计算机网络信息中心
Computer Network Information Center, Chinese Academy of Sciences



绿盟科技集团股份有限公司
NSFOCUS



国家科技基础条件平台中心
National Science and Technology Infrastructure Center, Ministry of Science and Technology



引言

国家微生物科学数据隐私计算平台采用了基于可信硬件的隐私计算方案，可实现高致病性病原菌及新冠、流感等病毒数据在安全保护条件下进行分析和共享。

Introduction

Biodata Privacy Computation Platform adopts a privacy computing scheme based on trusted hardware, which can realize the analysis and sharing of highly pathogenic bacteria and virus data such as COVID-19 and influenza under the condition of security protection.

隐私计算助力便捷高效实现数据安全共享，服务生物数据应用

Privacy Computing Helps Achieve Convenient and Efficient Data Security Sharing and Serve Biological Data Applications



- “掘金数据时代”2022年度隐私计算优秀应用案例
- The platform won the annual excellent application case of privacy computing in the era of gold digging data in 2022

目前全球生物安全局势严峻，生物安全也面临着巨大的威胁。重大传染病防控是生物安全管理中的重中之重，生物数据隐私计算平台利用区块链和隐私计算的技术保障了数据的安全可信流转，助力了科学数据更好地支撑国家重大传染病防控，也是国家生物安全大数据体系建设的重要环节。由中国科学院微生物研究所牵头的国家微生物科学数据中心及中国科学院微生物科学数据中心，与中国科学院计算机网络信息中心、绿盟科技集团合作，国家微生物科学数据隐私计算平台于23年4月23日正式上线。平台

除了申请相关专利软著之外，2022年荣获掘金数据时代年度隐私计算优秀应用案例。以微生物数据中心建设案例为蓝本，隐私计算技术支撑的科学数据计算平台模式有望在更多科研和产业领域促进数据安全流通增值。

At present, the global biosafety situation is grim, and biosafety is also facing a huge threat. The prevention and control of major infectious diseases is the top priority in biosafety management. The biodata privacy computation platform uses the technology of block chain and privacy computing to ensure the safe and credible flow of data and helps scientific data to better support the prevention and control of major infectious diseases in the country. It is also an important part of the construction of the national biosafety big data system. The National Microbiology Data Center and the Microbiology Data Center of Chinese Academy of Sciences, led by the Institute of Microbiology, Chinese Academy of Sciences, cooperated with the Computer Network Information Center, Chinese Academy of Sciences, and NSFOCUS, the biodata privacy computation platform was officially launched on April 23, 2023. In addition to applying for related patents and soft works, the platform won the annual excellent application case of privacy computing in the era of gold-digging data in 2022. Based on the case of microbial data center construction, the biodata privacy computation platform model supported by privacy computing technology is expected to promote value-added of data security circulation in more scientific research and industrial fields.

隐私计算赋能科学数据计算平台建设，推动数据安全流通增值

Privacy computing enables the construction of scientific data computing platforms to promote value-added of data security circulation

平台面向重要高致病性病原菌及新冠、流感等病毒数据，针对其在安全保护条件下进行分析和共享的需求，使用了基于可信硬件的隐私计算方案，保障经加密后的基因序列在加密态的内中进行序列分析。在此过程中，通过前沿密码学、隐私计算、区块链等数据安全技术，保障包括计算分析服务提供方在内的各方，对数据可用不可见。平台中进行互联互通的相关数据受到符合国家密码标准的数字签名技术保护；平台使用区块链技术完成全流程监控，通过哈希、签名等密码学技术对关键流程进行了各方不可否认的存证，并提供科学数据链颁发的全网唯一的区块链证书以确保数据权益。该平台是目前我国科学数据领域，利用区块链和隐私计算技术，实现对具有数据风险保护要求的科学数据实现“可用不可见”的应用实践，为解决数据安全、数据确权等长期困扰数据流通利用的难题提供了解决方案，具有重要的示范意义。

The platform is oriented to important highly pathogenic bacteria and virus data such as COVID-19 and influenza and uses a privacy computing scheme based on trusted hardware to ensure that the encrypted gene sequence is analyzed in the encrypted memory in order to meet the needs of analysis and sharing under the condition of security protection. This process, through cutting-edge cryptography, privacy computing, blockchains, and other data security technologies, to ensure that all parties, including computing and analysis service providers, cannot see the data. The relevant data for interconnection and intercommunication in the platform are protected by digital signature technology conforming to the national password standard; The platform uses block chain technology to complete the whole process of monitoring, through hash, signature, and other cryptographic technologies, the key process is undeniably certified by all parties and provides the only block chain certificate issued by the scientific data chain to ensure the rights and interests of data. The platform is the application practice of "available and invisible" for scientific data with data risk protection requirements in the field of scientific data in China by using block chain and privacy computing technology, which provides a solution to the problems that have plagued data circulation and utilization for a long time, such as data security and data right confirmation, and has important demonstration significance.



● 国家微生物科学数据隐私计算平台架构示意图
● Biodata Privacy Computation Platform Architecture Schematic

隐私计算打破数据孤岛困境，盘活数据要素实现产业升级

Privacy Computing Breaks the Dilemma of Data Isolated Island, Activates Data Elements and Realizes Industrial Upgrading

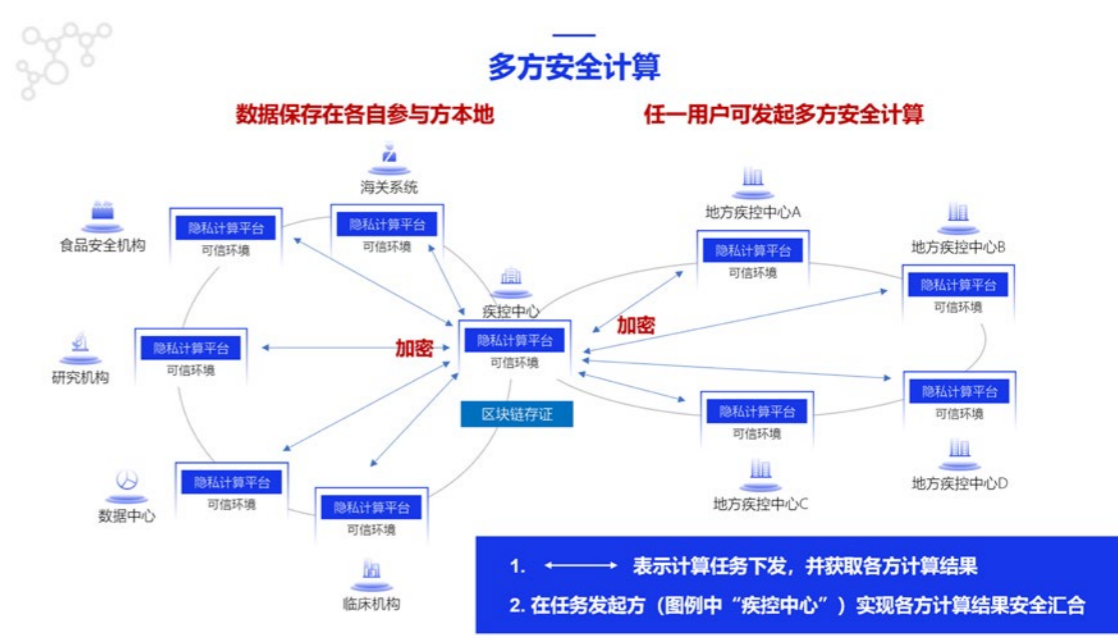
该平台为生物医药领域研发人员提供安全、高效、可信的数据共享平台。通过应用隐私计算技术，平台可以在保障数据隐私的前提下，提供高效、安全的生信数据分析服务，这将有助于打破生物医药领域当前存在的数据孤岛困境，赋能跨机构、跨平台、跨领域生信数据交流合作，加速科研成果转化应用落地，推动生物医药产学研联合、激活数据要素流通发挥倍增作用、实现产业升级创新发展。同时，平台采用可信硬件与国密 SM 系列密码算法，可以有效保障平台中生信数据与计算程序的数字权利的完整性，助力产业自主知识产权进步。

The platform provides a safe, efficient and credible data sharing platform for R&D personnel in the field of biomedicine. Through the application of privacy computing technology, the platform can provide efficient and secure data analysis services under the premise of data privacy protection, which will help to break the current data island dilemma in the field of biomedicine, enable cross-institutional, cross-platform and cross-domain data exchange and cooperation, and accelerate the transformation of scientific research achievements, promote the combination of biomedical industry, University and research, activate the circulation of data elements to play a multiplier role, and achieve industrial upgrading, innovation and development. At the same time, the platform uses trusted hardware and state secret SM series cryptographic algorithms, which can effectively guarantee the integrity of the digital rights of the data and computing programs in the platform, and promote the progress of independent intellectual property rights in the industry.

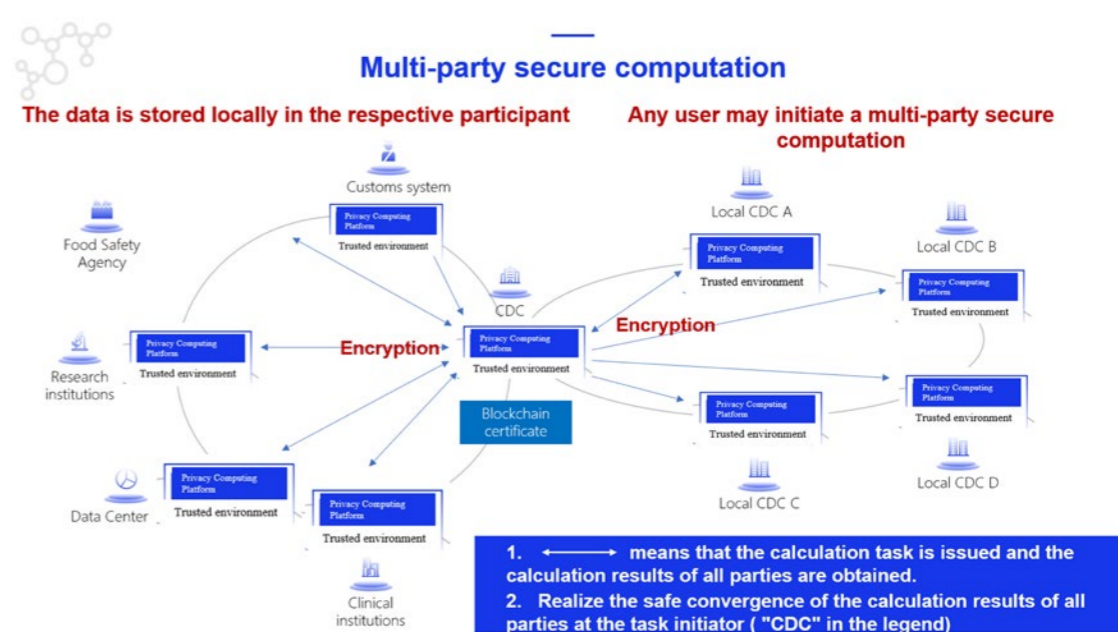
该平台实现隐私保护下与疾控中心网络互联互通，助力各地疾控预警；

实现隐私保护下与国家致病菌识别网互联互通，助力暴发疫情病原菌的基因组特征分析和溯源调查；实现隐私保护下与食品安全风险评估中心互联互通，助力食源性致病菌监测和风险评估；实现隐私保护下与中国检验检疫科学院互联互通，助力商用新冠引物的评估。

The platform can realize the network interconnection with the CDC under the protection of privacy and help the disease control and early warning of various regions. It realizes the interconnection with the national pathogen identification network under the protection of privacy, and facilitate the genomic characteristics analysis and traceability investigation of pathogenic bacteria in outbreaks; It achieves privacy protection and food safety risk assessment center connectivity to help foodborne pathogen surveillance and risk assessment; It enables interconnectivity with the Chinese Academy of Inspection and Quarantine Sciences under privacy protection, facilitating the evaluation of commercial COVID-19 primers.



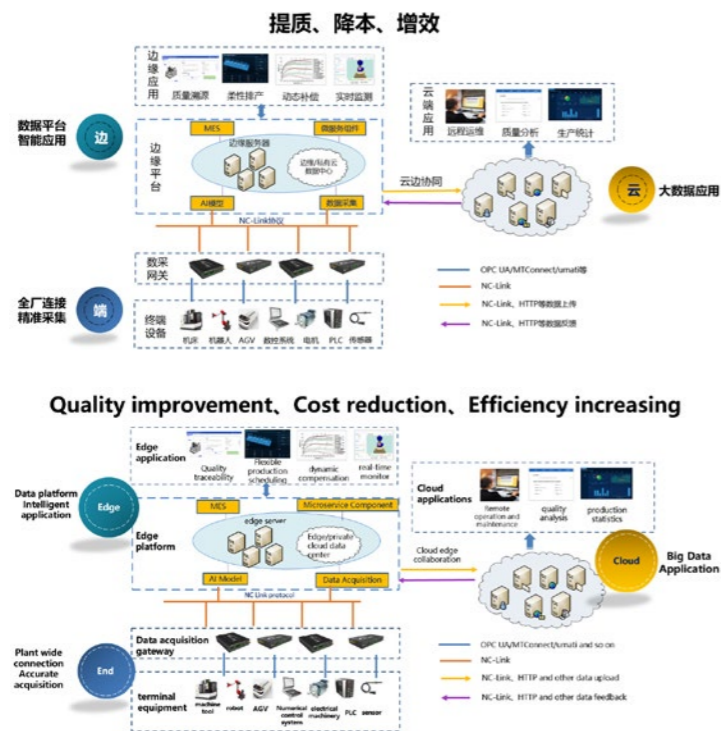
● 疾控体系下平台互联互通应用场景示意图



● Schematic diagram of platform interconnection and interoperability application scenarios

面向数控装备的工业互联网一体化解决方案 iNC-Cloud

Industrial Internet Integration Solution for CNC Equipment - iNC-Cloud



● iNC-Cloud 平台“端-边-云”协同数据融合
● iNC-Cloud platform "End-Edge-Cloud" collaborative data fusion

华中科技大学
Huazhong University of Science and Technology



国家智能设计与数控技术创新中心
National Center of Technology Innovation for Intelligent Design and Numerical Control

NCDC 国家智能设计与数控技术创新中心
National Center of Technology Innovation for Intelligent Design and Numerical Control

武汉华中数控股份有限公司
Wuhan Huazhong Numerical Control Co., Ltd.



引言

面向数控装备的工业互联网一体化解决方案 iNC-Cloud，建立统一的数控机床互联互通协议标准 NC-Link，实现多源异构设备、系统的连接与多源异构数据集成，为智能产线、智能车间、智能工厂提供解决方案。

Introduction

iNC-Cloud, an industrial internet unified solution for CNC equipment, establishes a uni-

fied CNC machine tool interconnection protocol standard NC-Link. And it also realizes the connection of multi-source heterogeneous devices and systems, and multi-source heterogeneous data integration. Based on this standard, it can provide solutions for intelligent production

lines, intelligent workshops, and intelligent factories.

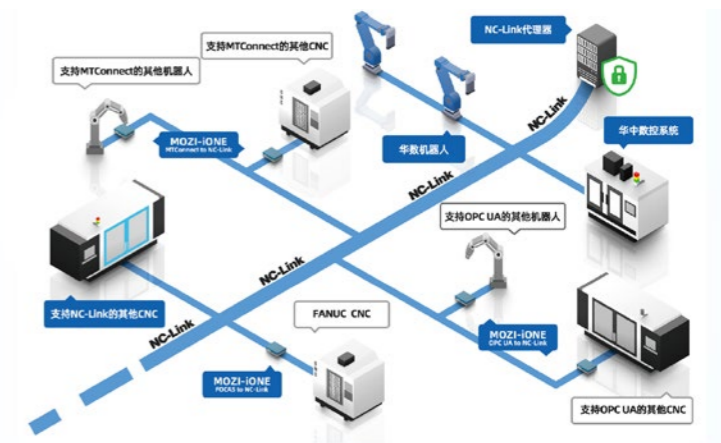
基于 NC-Link 标准协议及标识解析的数控装备工业互联网平台 iNC-Cloud

iNC-Cloud, a CNC Equipment Industrial Internet Platform Based on NC-Link Standard Protocol and Identification Resolution

本项目形成了中国智能工厂数控机床互联接口规范 NC-Link (GB/T 41970-2022)，打破因工业设备通讯接口相异造成的“信息孤岛”，实现装备数据纵向集成；集成商用密码技术，覆盖事前、事中、事后的全视角数控装备安全防护，提升工业母机的安全性能；构建面向智能产线、智能车间、智能工厂的工业互联网一体化解决方案 iNC-Cloud，提供开放式 APP 开放平台、微服务组件、低代码开发、二次开发接口等；建立标识解析二级节点（机床行业）及“关键功能部件厂-数控机床厂-用户厂”三级数据中心，融合数据治理共享机制，实现跨企业上下游数据横向集成。围绕机床全生命周期数据管理，为车间生产管理、设备远程运维、预测性维护、工业产品溯源等智能应用提供稳定、可靠、可持续的解决方案，为数控装备领域赋能。

The project has developed the NC-Link (GB/T 41970-2022) specification for the interconnection interface of intelligent industrial CNC machine tools in China, effectively eliminating the "information silos" caused by disparate communication interfaces of industrial equipment and achieving vertical integration of equipment data. It incorporates advanced commercial encryption technology to ensure comprehensive security protection for CNC equipment throughout all stages, from pre-operation to operation and post-operation, thereby enhancing the safety performance of machine tools. Additionally, the project establishes iNC-Cloud, an integrated solution tailored for the

industrial internet, specifically targeting smart production lines, workshops, and factories. iNC-Cloud provides an open APP platform, microservice components, low-code development capabilities, and secondary development interfaces. Furthermore, it constructs a two-level node identification resolution system within the machine tool industry and a three-level data center comprising "key component factory - CNC machine tool factory - user factory" integrating data governance and sharing mechanisms to achieve horizontal integration of upstream and downstream data across enterprises. With a primary focus on the effective management of machine tool lifecycle data, this project offers stable, reliable, and sustainable solutions for intelligent applications such as workshop production management, equipment remote operation and maintenance, predictive maintenance, and industrial product traceability, empowering the field of numerical control equipment.



● 基于 NC-Link 标准的装备数据集成和互联互通
● Equipment Data Integration and Interconnection Based on NC-Link Standard



● 面向数控装备的工业互联网一体化解决方案 iNC-Cloud
● Industrial Internet Integration Solution iNC-Cloud for CNC Equipment

iNC-Cloud 建立数控装备互联互通标准，推动智能制造发展
iNC-Cloud establishes a communication standard for CNC equipment interconnection, promoting the development of intelligent manufacturing

iNC-Cloud 立足机床装备制造领域行业和企业的特点、痛点和需求，充分发挥平台在设备互联、数据采集、远程运维等典型应用场景上的优势，已在航空航天、高端装备、汽车制造、电子加工等领域近 700 家工业企业应用。形成了中国数控装备互联互通的协议标准 NC-Link，在数控装备行业得到广泛推广和应用。通过中国机床工具工业协会推广应用，共建 NC-Link 开源社区，建立数控机床互联互通协议标准联盟，指导国内的机床制造厂商建立机床互联机制，提高中国数控机床的国际竞争力。核心技术已形成 14 项相关专利、33 项软著。iNC-Cloud 面向工业母机的应用场景具体鲜明，为装备制造行业提供生产管控、远程运维、预测性维护等智能应用，实现机床全生命周期数据管理应用生态，推动企业数字化转型和智能制造发展。



◎ iNC-Cloud 整体应用成效
◎ Overall Application Effectiveness of iNC-Cloud



◎ iNC-Cloud 标准、专利成果及奖项
◎ iNC-Cloud Standards, Patent Achievements, and Awards

iNC-Cloud is tailored to the unique characteristics, pain points, and needs of the machine tool equipment manufacturing industry and enterprises. It fully leverages the platform's advantages in typical application scenarios such as equipment interconnection, data collection, and remote operation and maintenance. It has been applied in nearly 700 industrial enterprises in fields such as aerospace, high-end equipment manufacturing, automotive manufacturing, and electronic processing. NC-Link is a standard for the interconnection and communication of CNC equipment in China that has been widely promoted and applied in the CNC equipment industry. Through promotion by the China Machine Tool Industry Association, we jointly built an NC-Link open-source community to establish a CNC machine tool interconnection communication protocol standard alliance. This initiative aims to guide domestic machine tool manufacturers in establishing machine tool interconnection mechanisms to improve China's international competitiveness in CNC machine tools. The core technology has resulted in 14 related patents and 33 software copyrights. iNC-Cloud has specific application scenarios for industrial mother machines by providing intelligent applications such as production control, remote operation and maintenance, and predictive maintenance for the equipment manufacturing industry. It achieves the full lifecycle data management application ecology of machine tools while promoting enterprise digital transformation and intelligent manufacturing development.

iNC-Cloud 促进数控装备全生命周期数据管理的应用生态协同

iNC-Cloud fosters collaboration in the application ecosystem for full lifecycle data management of CNC equipment

iNC-Cloud 建立了中国数控装备互联互通标准，为数控机床互联互通建立了一套统一的指导性规范。主导建立 NC-Link 技术开源社区，共建开放共享、创新活跃的工业智能应用新生态。iNC-Cloud 联合地方政府，共同建设了开放赋能、

生态创新、持续迭代的“数控机床产业大脑”，为行业企业提供智能生产、管理运维、安全生产等应用，促进传统产业生产力再升级。iNC-Cloud 依托机床行业标识解析二级节点影响力，全面整合上下游企业数据及服务能力，极大地提升了行业数据传输、共享、应用的数控装备全生命周期数据管理的生态协同圈。iNC-Cloud 面向工业母机与新一代信息技术的深度融合，以数字化、网络化、智能化生产建设推进高端制造领域的转型升级，加快推动全球新型工业化发展。

iNC-Cloud has established the China CNC equipment interconnection communication standard and developed a unified set of guiding specifications for the interconnection of CNC machine tools. It spearheads the establishment of the NC-Link technology open-source community, fostering an open, collaborative, innovative, and dynamic industrial intelligent application ecosystem. In collaboration with local governments, iNC-Cloud has developed a "CNC machine tool industry brain" characterized by open empowerment, ecological innovation, and continuous advancement. This initiative provides enterprises in the sector with applications geared towards intelligent production, management, maintenance, and safety, thereby fostering an upgrade in traditional industrial productivity. By relying on the influence of secondary nodes in the machine tool industry, iNC-Cloud comprehensively integrates data and service capabilities from upstream and downstream enterprises to significantly enhance ecological collaboration throughout the full lifecycle data management process of CNC equipment in this industry including data transmission, sharing, and application. Through deep integration between industrial mother machines and new generation information technology, iNC-Cloud promotes the transformation and upgrading of high-end manufacturing with digital, networked and intelligent production construction, and accelerates the development of new global industrialization.



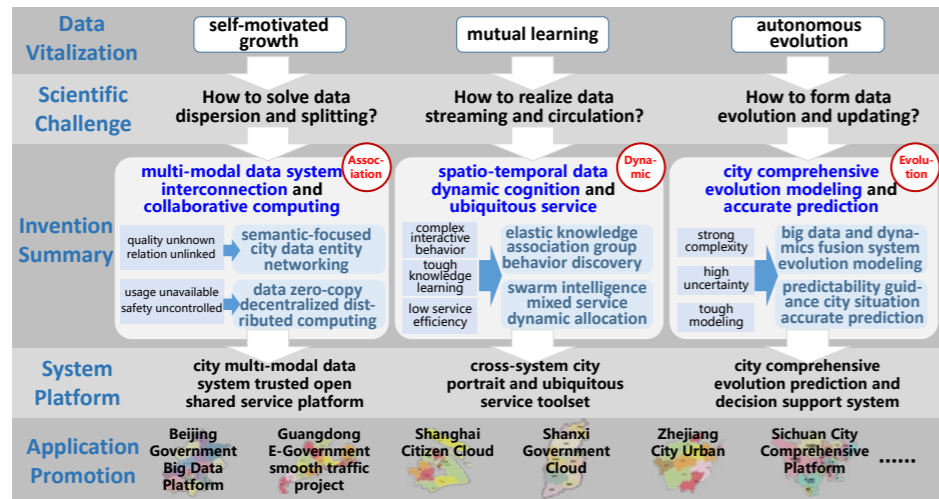
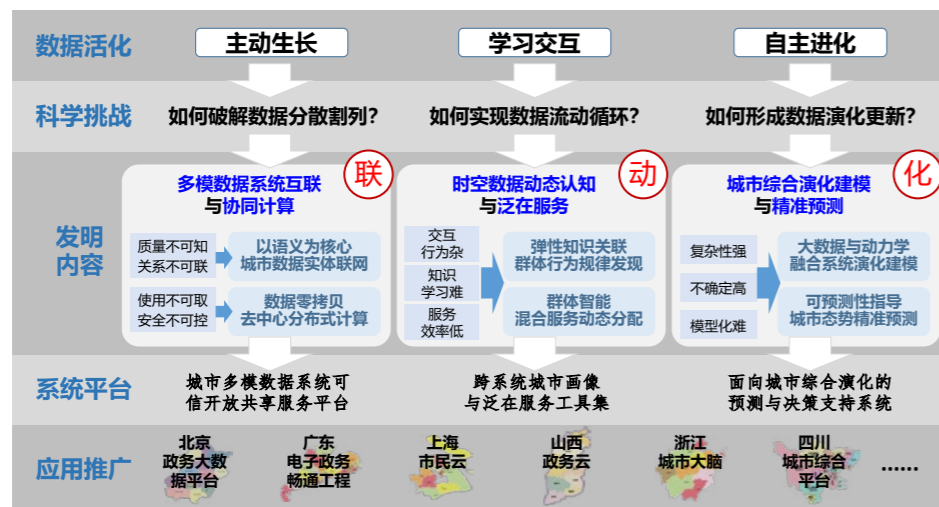
◎ NC-Link 开源社区
◎ NC-Link Open Source Community



◎ iNC-Cloud 为数控机床产业大脑赋能
◎ iNC-Cloud empowers the brain of the CNC machine tool industry

数据活化的关键技术及其智慧城市应用

Key Technologies of Data Vitalization and Their Applications in Smart City



● 数据活化的关键技术及其智慧城市应用发明体系
● Key Technologies of Data Vitalization and Related Smart City Application and Invention System

发明并突破了城市数据系统互联、时空动态认知服务、综合演化建模预测等数据活化的关键技术，成果在中国3个直辖市和12个省份的重要城市进行应用。

Innovations and breakthroughs have been made in key technologies of Data Vitalization, such as urban data system interconnection, spatio-temporal dynamic cognitive service, and comprehensive evolution modeling prediction. Relevant achievements have been applied in 3 municipalities and 12 important cities in China.

引言

为了解决数据分散割裂、实现数据流动循环、形成数据系统演化更新。项目组开展了数据活化的关键技术创新，形成了以数据活化思想为核心的智慧城市中国标准体系，为在中国智慧城市中实现“三融五跨”提供有效解决方案。

Introduction

In order to solve the problem of data fragmentation, achieve data flow circulation, and form data system evolution and update. The project team carries out key technological innovation of Data Vitalization, forms a Chinese standard smart city system centered on Data Vitalization, and provides effective solutions for realizing "three integrations and five expansions" in Chinese smart city.

突破数据活化关键技术，支撑智慧城市应用发明

Pioneering breakthroughs in key Data Vitalization technologies to support Smart City application and invention

为解决数据分散割裂问题，发明了多模数据系统互联与协同计算方法。首次提出了以语义为核心的城市数据实体联网技术，突破了数据零拷贝的去中心化分布式计算方法，研制了城市多模式数据系统互联支撑环境，实现了数据实体与关系的主动生长。

To address data fragmentation, we introduced a multi-mode data system interconnection and collaborative computing method. It proposes urban data entity networking technology based on semantics for the first time, breaks through the decentralized distributed computing method of data zero-copy, develops a multi-mode urban data system interconnection support environment, and finally realizes the active growth between data entity and data relationship.

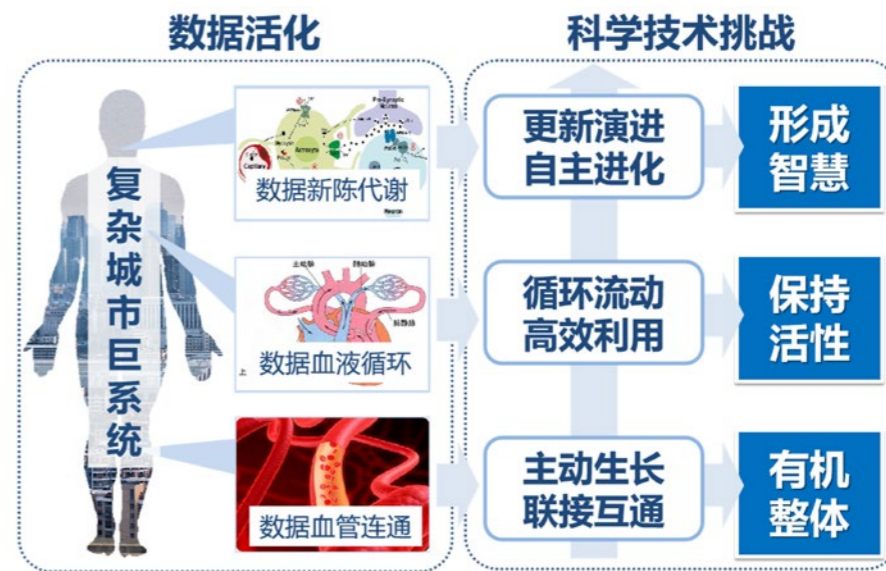
为实现数据的高效流动循环，发明了时空数据动态认知与泛在服务技术，发明了基于群体智能的混合式高效服务动态分配方法，支撑了“数据-

知识-服务”的高效循环，实现了城市服务的优化配置和高效利用。

To facilitate efficient data circulation, we developed spatio-temporal data dynamic cognition and ubiquitous service technology as well as a hybrid efficient service dynamic allocation method based on swarm intelligence, which supports the efficient cycle of "data-knowledge-service" and realize optimal allocation and efficient utilization of urban service.

为形成数据系统的演化更新，发明了城市综合演化建模与精准预测技术。突破了大数据与动力学模型融合的演化建模技术，首创了可预测性指导的城市态势精准预测方法，实现了城市物理空间和数据空间的同步演化更新。

To foster the evolution and updating of data systems, we pioneered comprehensive urban evolution modeling and accurate prediction technology, which breaks through the integration of big data and dynamic model, creates the first prediction method to guide urban situations, and realizes the simultaneous evolution and update between urban physical domain and data domain.



● 数据活化关键技术的创新思路与技术挑战
● Innovative ideas and challenges of key technologies for Data Vitalization

支撑头部企业产品研发，产生经济效益超 21 亿元

Support the product development of top-tier enterprises, yielding an economic benefit of over 2.1 billion yuan

项目组与神州数码、太极股份等公司合作，应用于广东省电子政务畅通工程、山西省政务云大数据平台等。与万达信息、数字政通等公司合作，应用于杭州城市大数据的基于数据活化的数字资源超市平台、成都市天府市民云、西安市城市综合管理服务平台等。与阿里云、京东城市等公司合作，应用于四川省级城市综合管理服务平台、青岛市城市运行管理服务平台、京东域治理现代化指挥中心平台等。

The project team collaborates with companies such as Digital China and Taiji Corporation, applying their work to projects like the Guangdong Province's E-Government Streamlining Project and the Shanxi Province's Government Cloud and Big Data Platform. In partnership with Wanda Information and Digital Government Communication, their contributions are implemented in platforms such as Hangzhou's Digital Resource Supermarket Platform based on Data Activation, Chengdu's Tianfu Citizen Cloud, and Xi'an's Urban Comprehensive Management Service Platform. Additionally, in cooperation with Alibaba Cloud and JD iCity, their expertise is utilized in platforms like the Sichuan Provincial Urban Comprehensive Management Service, Qingdao's Urban Operation Management Service Platform, and JD's Regional Governance Modernization Command Center.

本项目成果在上述企业进行了实际应用，近三年产生经济效益共计 21.27 亿元。

The outcomes of this project have been practically implemented in the aforementioned enterprises, yielding an economic benefit of 2.127 billion yuan over the past three years.



广泛应用于北京、上海、重庆、广东、江苏、浙江等 60 余座城市智慧城市建设，显著提升城市运营管理效率和城市综合服务水平

与头部企业合作，技术应用显著提升城市运行效率

Collaborating with top-tier enterprises, the application of technology has significantly improved urban operational efficiency

服务中国国家科技创新，推进标准评估评价，支撑产业创新发展

Serve China's national scientific and technological innovation, promote standard assessment and evaluation, and support the industrial innovation ecosystem

本发明成果支撑了“感-联-知-用-融”五层智慧城市技术框架和国家标准体系的建立，推动中国智慧城市总体技术和应用达到国际世界领先行列。数据活化关键技术广泛应用于城市大脑、城市操作系统、智慧城市大数据服务平台、智慧城市市民服务平台等，支撑了中国智慧产业技术创新，促进了产业升级和培育新兴业态。

The invention achievement supports the establishment of a "sense-connection-knowledge-use-integration" five-layer smart city technology framework and national standard system, promoting China's smart city overall technology and application to reach international leading ranks. Key technologies of Data Vitalization are widely used in city brains, city operating systems, smart city big data service platforms, and smart city citizen service platforms, etc., bolstering China's technological innovation in the smart industry, promoting industrial upgrades, and fostering emerging business models.

本项目团队牵头和参与制定了 10 项国家标准，推动 29 项国家标准的应用实施等工作，其中牵头研制的国家标准《新型智慧城市评价指标》支撑了 2016 年全国范围 220 个城市的新型智慧城市评价工作。

The project team leads and participates in the formulation of 10 national standards and promotes the application and implementation of 29 national standards. Among them, the national standard "Evaluation Indicators for New-type Smart Cities" led by the group supports the evaluation work of 220 new smart cities across the country in 2016.

本项目团队牵头成立了中国（中关村）智慧城市产业技术创新战略联盟，汇聚了 200 多家国内智慧城市领军高校、企业和科研院所，推进关键技术与集成创新的深度融合。

The project team spearheaded the establishment of the Z-Park Strategic Alliance

of Smart City Industry Technology Innovation, which brings together more than 200 domestic leading universities, enterprises and scientific research institutes in smart city to promote an in-depth fusion of key technology and integrated innovation.



- 建立具有数据活化特色的国家智慧城市标准体系，打造创新生态，并向国际输出我国先进经验
- Establish a national smart city standard system with Data Vitalization characteristics, create an innovation ecosystem, and export advanced experience to the world

推动国际合作与服务疫情防控

Promote international cooperation and support epidemic prevention and control

与美国麻省理工学院共同主办了 IEEE International Conference on Universal Village；与澳大利亚墨尔本大学共同推动城市基础设施的相关技术发展；推进了《ISO/IEC 30145-3: SmartCity Engineering Framework》和《ISO/IEC 30146: Information technology - Smart city ICT indicators》等国际标准制定。



打造创新生态向国际输出我国先进经验

Cultivate an innovative ecosystem and export China's advanced experiences to the international community

In collaboration with the Massachusetts Institute of Technology (MIT), we co-hosted the IEEE International Conference on Universal Village. Together with the University of Melbourne in Australia, we jointly advanced the development of technologies related to urban infrastructure. We also contributed to the establishment of international standards such as "ISO/IEC 30145-3: Smart City Engineering Framework" and "ISO/IEC 30146: Information technology - Smart city ICT indicators".

新冠疫情暴发后，本项目团队受国务院联防联控机制科研攻关工作组委托，组建“北航新冠疫情大数据分析团队”，将本发明成果应用于新冠疫情防控工作，获全国科技系统抗击新冠肺炎疫情先进集体、北京市抗击新冠肺炎疫情先进个人等荣誉。

Following the outbreak of COVID-19, our project team was commissioned by the State Council's Joint Prevention and Control Mechanism Scientific Research Working Group. We formed the "Beihang COVID-19 Big Data Analysis Team" and applied the achievements of our invention to COVID-19 prevention and control efforts. For our contributions, we received accolades like the "Advanced Collective of the National Science and Technology System in Combating COVID-19" and the "Exemplary Individual in Beijing's Fight Against COVID-19".



- 服务全国“新冠肺炎疫情防控”重大需求
- Address the nation's critical requirements for "COVID-19 prevention and control"

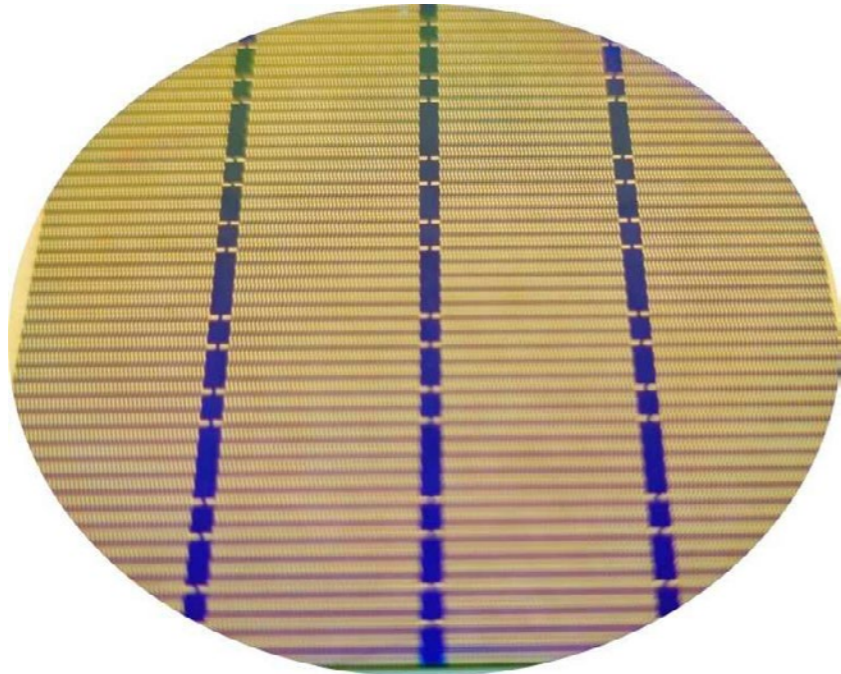
《科技之魅》收录成果

Charm of Science and Technology Collection

工程研发组 Engineering Research and Development

5G 光芯片

5G Optical Chip



● 5G 光芯片晶圆
● 5G optical chip wafer

武汉光迅科技股份有限公司
ACCELINK TECHNOLOGIES CO.,LTD.



引言

围绕 5G 高速率、高带宽、高可靠性等要求，在国内率先研制出工温、商用 5G 光芯片，包括 25Gb/s DFB 激光器芯片、C 波段 25Gb/s EML 和可调谐激光器芯片，性能与国际市场主流立品水平相当，具有高性能、低成本等特点。

Introduction

Focusing on the requirements of high speed, wide bandwidth and long reliability for 5G, first to develop industrial temperature 5G optical chip for commercial application in China, including 25Gb/s DFB laser chip, C-band 25Gb/s EML chip and ITLA chip. The performance of these chips is comparable to the mainstream products in the international market. Much more, these chips are also with characteristics such as high quality and low cost.

5G 网络光芯片的重要突破

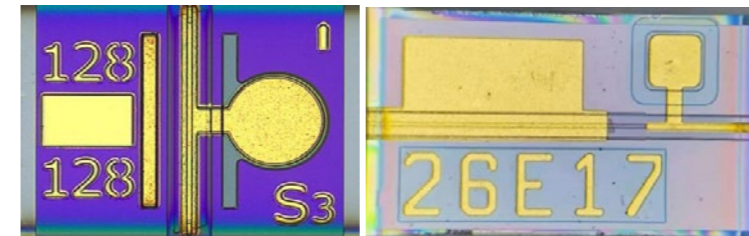
Important Breakthroughs in 5G Optical Chip Network

5G 光电子芯片是 5G 的核心组成部分，是 5G 网络的“心脏”，对 5G 的发展与应用起着决定性的作用。

5G optical chip is the core component of 5G industry, the heart of 5G network, which plays a decisive role in the development and application of 5G.

公司突破了光芯片设计、外延生长、端面镀膜技术和可靠性技术难题，研制出了 5G 用高可靠、低成本 25Gb/s DFB 激光器芯片、C 波段 25Gb/s EML 和可调谐激光器芯片，相关技术标达到国际先进水平。代表着中国高端光芯片首次应用于光通信网络，支撑 5G 光网络的发展与应用。

Accelink has overcome the challenges of optical chip design, epitaxial growth, end face coating technology, and reliability technology. Accelink has developed a high-reliability and low-cost 25Gb/s DFB laser chip, C-band 25Gb/s EML and ITLA of 5G, and the relevant technical specifications have reached the international advanced level. Representing the first application of Chinese high-end optical chip in optical communication networks, supporting the development and application of 5G optical networks in the world.



● 25Gb/sDFB 芯片 (250μm*160μm)
● 25Gb/s DFB Chip (250μm*160μm)
● 25Gb/s EML 芯片 (520μm*250μm)
● 25Gb/s EML Chip (520μm*250μm)

5G 之光赋能千行百业

The Light of 5G Empowers Thousands of Industries

5G 光芯片已经实现了大批量生产应用，并成功应用于全球的智慧交通、智慧旅游、先进制造、远程医疗、智慧矿山等领域，改变了传统产业的运营模式，提高了效率，并加强了安全保障。代表性的应用如武汉第七届世界军人运动会赛事直播，2022 年北京冬奥会视频直播、智慧防疫、智慧医疗，栾川 5G 智慧矿山等。创造了 40 多亿元的经济效益，促进了全球 5G 的建设与发展。

The 5G optical chip has achieved large-scale production and application, and has been successfully applied in fields such as smart transportation, smart tourism, advanced manufacturing, remote medicine, and intelligent mine and so on. It has changed the operation mode of traditional industries, improved efficiency, and strengthened security. Representative applications include the live broadcast of the 7th CISM Military World Games in Wuhan, the live broadcast of the 2022 Beijing Winter Olympics video, smart epidemic prevention, and smart healthcare, and the 5G smart in Luanchuan Mines, etc. It has created over 4 billion yuan in economic benefits and promoted the construction and development of 5G globally.



● 5G 用于第七届世界军人运动会赛事直播
● 5G for live broadcasting of the 7th CISM Military World Games



● 河南栾川 5G “智慧矿山”
● Henan Luanchuan Mine: 5G “Intelligent Mine”



● 北京冬奥会高铁 5G 超高清演播室
● 2022 Beijing Winter Olympics high-speed rail 5G ultra HD studio

“中国智造”服务全球信息产业

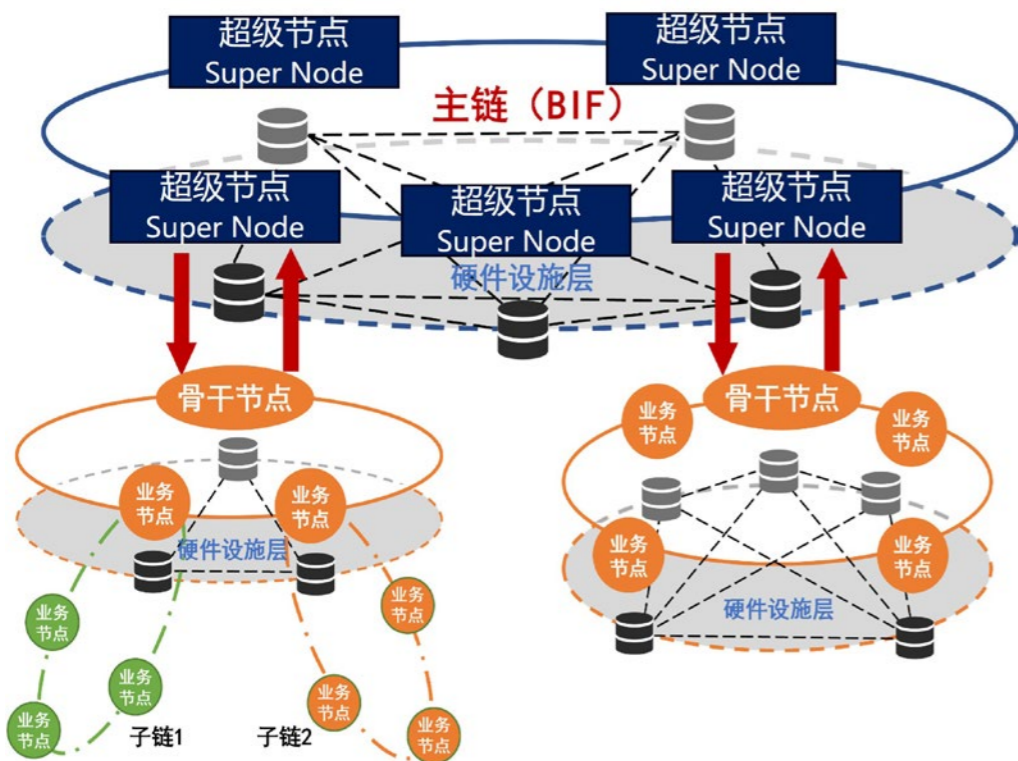
“Made in China” Serves the Global Information Industry

5G 光芯片已销售一百多万只，应用于全球主流通信设备制造公司光网络设备，服务于全球的电信运营商、互联网公司、广电运营商等，方便了人们的生产与生活，促进了信息产业技术进步和经济发展，为全球经济、社会发展做出了重要贡献。

More than one million 5G optical chips have been sold, which are used in optical network equipment of mainstream global communication equipment manufacturing companies, serving global telecom operators, internet companies, Broadcast Television network operators, etc., facilitating people's work and life, promoting technological progress and economic development of the information industry, and making important contributions to global economic and social development.

“星火·链网”数据服务网络

Xinghuo BIF Data Service Network



◎“星火·链网”数据服务网络架构
◎ Xinghuo BIF Data Service Network

中国信息通信研究院
China Academy of Information and Communications Technology

CAICT 中国信通院

引言

“星火·链网”是在工业和信息化部指导和支持下，由中国信息通信研究院牵头建设的新型基础设施，以代表产业数字化转型的工业互联网为主要应用场景，以网络标识这一数字化关键资源为突破口，推动区块链的应用发展，实现新基建的引擎作用。

Introduction

"Xinghuo Blockchain Infrastructure & Facility" (Xinghuo BIF) is a "new infrastructure" for the digital economy, which is planned and deployed by China Academy of Information and Communications Technology, under the guidance of the Ministry of Industry and Information Technology. It aims to promote the application of blockchain, as the engine role of new infrastructure. The main application scenario of Xinghuo BIF is the industrial Internet, which includes the network identification, a key digital resource for breakthroughs.

创新性的提出基于许可公有链技术的“1+N”链群架构，内嵌分布式标识体系

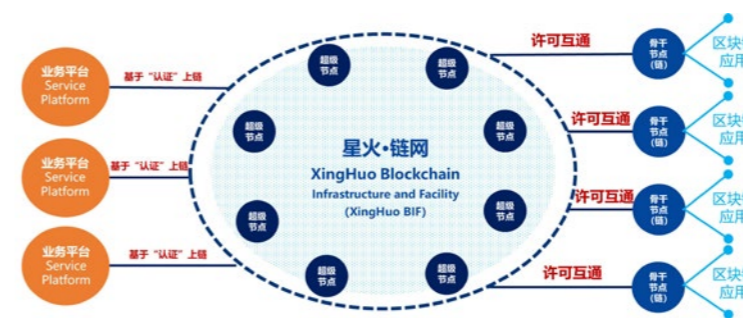
The 1+N chain group architecture based on permissioned public chain technology, embedded distributed identity system

针对现有区块链之间相互独立、互通困难，公有链执行效率低、监管难，联盟链去中心化程度低等问题，创新性提出了“星火·链网”，具备公有链开放接入、灵活、可扩展以及联盟链易于管理、高性能、安全可控等特点。

Existing blockchains have specific disadvantages including independent of each other, difficult to communicate with each other, low execution efficiency and low degree of decentralization. To address those issues, Xinghuo BIF takes advantage of the characteristics of public chain, such as flexibility, and scalability, and the characteristics of the consortium blockchain including easy management, high performance, security and controllability.

同时，“星火·链网”内嵌星火智能标识 (Blockchain-based identifier, BID)，以区块链作为标识对象交互的信任基础设施，建立了安全可信、异构兼容的标识服务体系，助力数据要素生命周期的互联互通，赋能全链条、各环节的可信协同。“星火·链网”上标识注册量超1500万，标识查询服务能力单机QPS达到150万+，TPS达到25000+，解析成功率达到99.9%。依托此项目形成75项专利、56个软著、26项标准和29篇论文。

Meanwhile, Xinghuo BIF embeds Blockchain-based identifier (BID), which adopts blockchain as a trust infrastructure for identifying object interactions. It builds a secure, trustworthy, heterogeneous and compatible identification service system, facilitating the interconnection of the life cycle of data elements and enable trusted collaboration across the entire chain and in all links. Xinghuo BIF has been constructed domestically, with more than 15 million registered distributed identities, a single-machine QPS query service capacity of 1.5 million+, a TPS of 25,000+, and a resolution success rate of 99.9%. Relying on this project, 75 patents, 56 soft works, 26 standards and 29 papers have been formed.



◎“星火·链网”许可公有链体系架构
◎ Xinghuo BIF licensed public chain Infrastructure

节点建设规模持续扩大，公共服务能力走深向实

The scale of node construction continues to expand, and the public service capabilities are improved profoundly

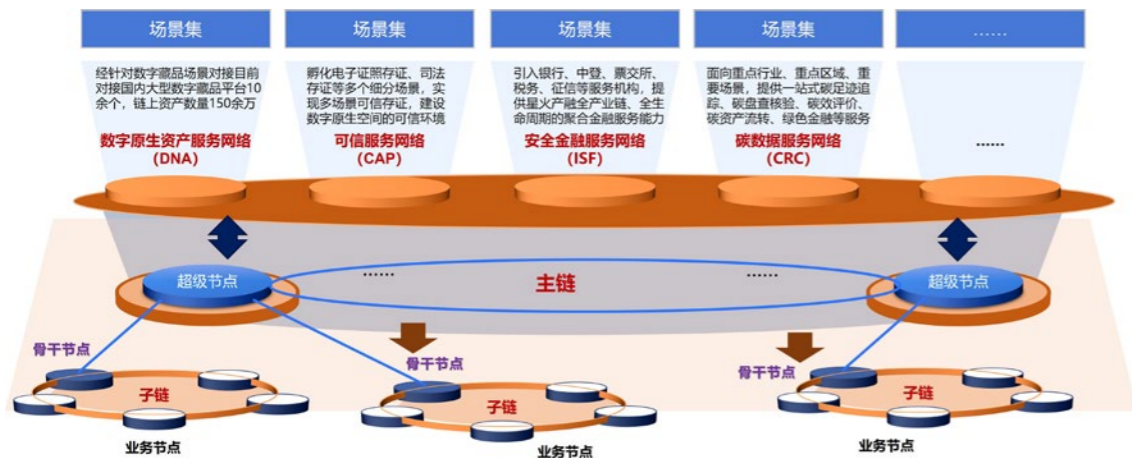
通过“星火·链网”超级节点、骨干节点等的建设运营，可推动建立

全国领先数据流通基础设施打通信息孤岛的壁垒，实现数据安全共享，为数字经济发展提供安全保障，具有巨大的潜在间接经济效益。

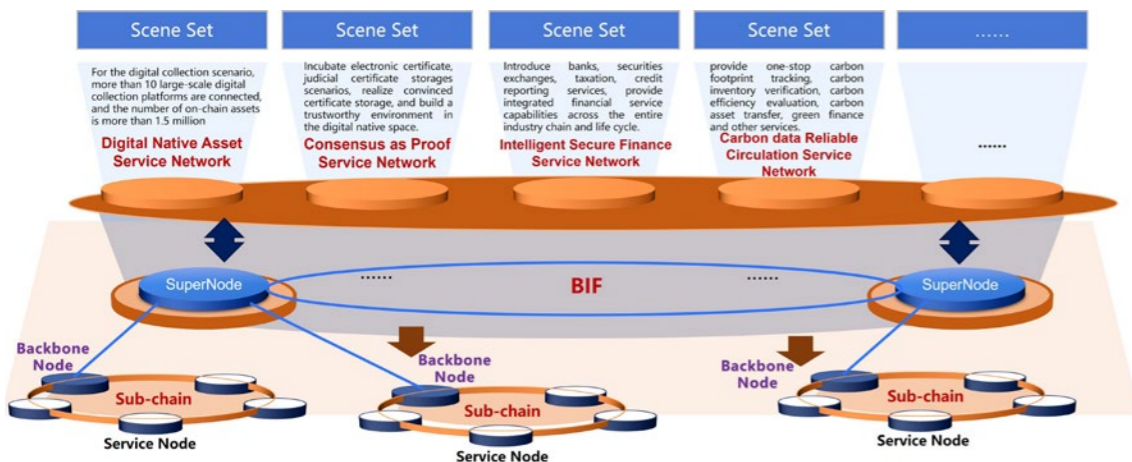
By constructing and operating the super/backbone nodes of Xinghuo BIF, this project can promote the establishment of a leading national data circulation infrastructure that breaks down barriers to information islands, realizes safe data sharing between industries, and provides security guarantees for the development of digital economy.

目前已完成武汉、重庆、北京、沈阳、柳州等超级节点，以及江苏昆山、山东胶州、武汉汉阳等骨干节点的建设部署。“星火·链网”已形成包括数字原生资产服务网络 (DNA)、智能安全金融服务网络 (ISF)、可信存证网络 (CAP) 和数字化追溯网络 (DDR) 等公共服务网络，面向工业、金融、智慧城市等领域开展规模化应用。同时，“星火·链网”高度重视海外市场，发展并构建“星火·链网”国际 (ASTRON)，依托 G20、金砖、上合、中国—东盟、一带一路等国际合作，香港、澳门和东南亚多国推动许可公有链节点落地，赋能跨境数字贸易和跨境数据流通。

Currently, a series of super nodes such as Wuhan, Chongqing, Beijing, Shenyang, Liuzhou, and backbone nodes such as Kunshan, Jiaozhou and Hanyang have been deployed. Many public service networks, such as the Digital Native Asset (DNA), Intelligent Secure Financial (ISF), Consensus as Proof (CAP) and Digital Data Registry (DDR), have been formed, and carry out large-scale applications in industry, finance, smart cities and other fields. Meanwhile, Xinghuo BIF attaches great importance to overseas markets. It develops international Xinghuo Blockchain Infrastructure & Facility based on the international cooperation with G20, BRICS, SCO, China-ASEAN, and the Belt and Road. With the implementation of licensed public chain nodes in Hong Kong, Macau and many Southeast Asian countries, cross-border digital trade and cross-border data flows are just around the corner.



“星火·链网”公共服务体系



Xinghuo BIF public service system

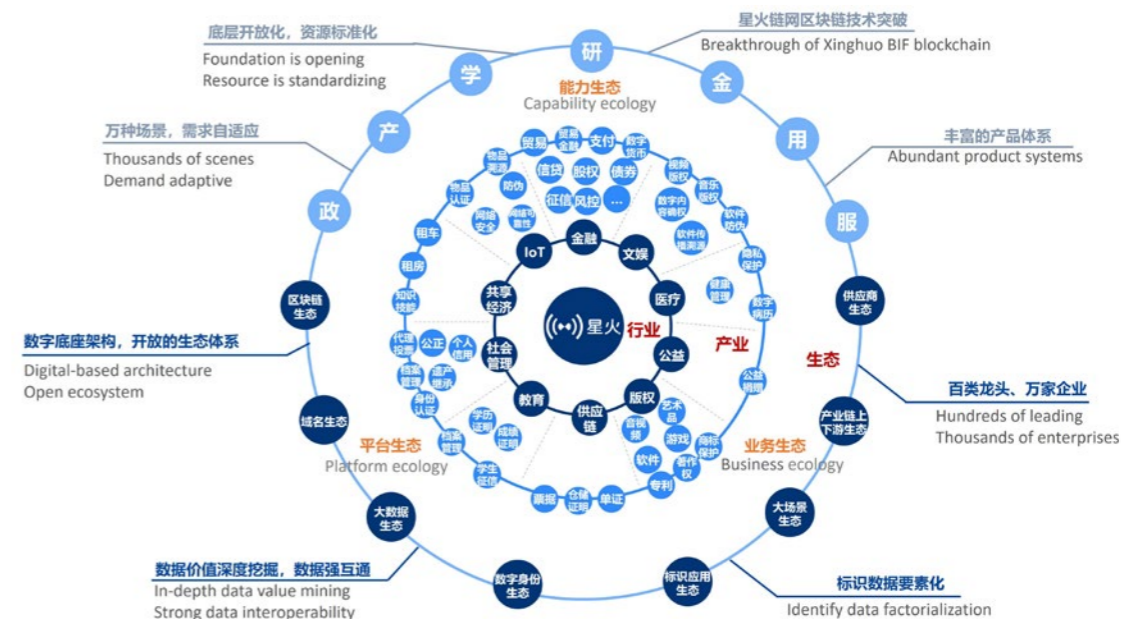
产业生态不断繁荣，赋能数字经济规模化发展

The industrial ecology continues to prosper, empowering the large-scale development of the digital economy

“星火·链网”以区块链技术为核心，面向多元复杂的产业经济形态和不断提升的数字化转型需求，提供基础设施能力，通过向全国布局区块链基础设施，聚合产业、区域优势资源，形成产业创新发展动能，将助推信息产业的跨越式发展。同时，“星火·链网”面向不同的区域和行业提供区块链服务，可以带动区域发展，推动行业协作，促进数据的可信融通，进而助力产业数字化变革。此外，依托中关村区块链产业联盟（ABI）共吸纳 350 余家成员单位入驻，核心单位超过 70 家（截至 2023 年 8 月）。形成了地域覆盖广，产业覆盖广，主体类型覆盖广，供给需求侧全覆盖的国际化会员网络。

Xinghuo BIF relies on blockchain technology, and provides infrastructure capabilities for diverse and complex industrial economic forms and rising digital transformation needs. It will promote the leap-forward development of the information industry via deploying blockchain infrastructure across the country, aggregating industrial and regional advantageous resources, and forming momentum for industrial innovation and development. At the same time, Xinghuo BIF provides

blockchain services to different regions and industries, which can drive regional development, deepen the collaboration of industries, facilitates the trusted access of data. Such initiatives assist the digital revolution of the industry. In addition, relying on the Alliance of Blockchain Industry, Z-park (ABI), more than 350 member units have been attracted to settle in, with more than 70 core units (as of August 2023). An international membership network has been formed with wide geographical coverage, wide industrial coverage, wide coverage of subject types, and full coverage of the supply and demand sides.



“星火·链网”产业生态体系
Xinghuo BIF Industrial ecosystem

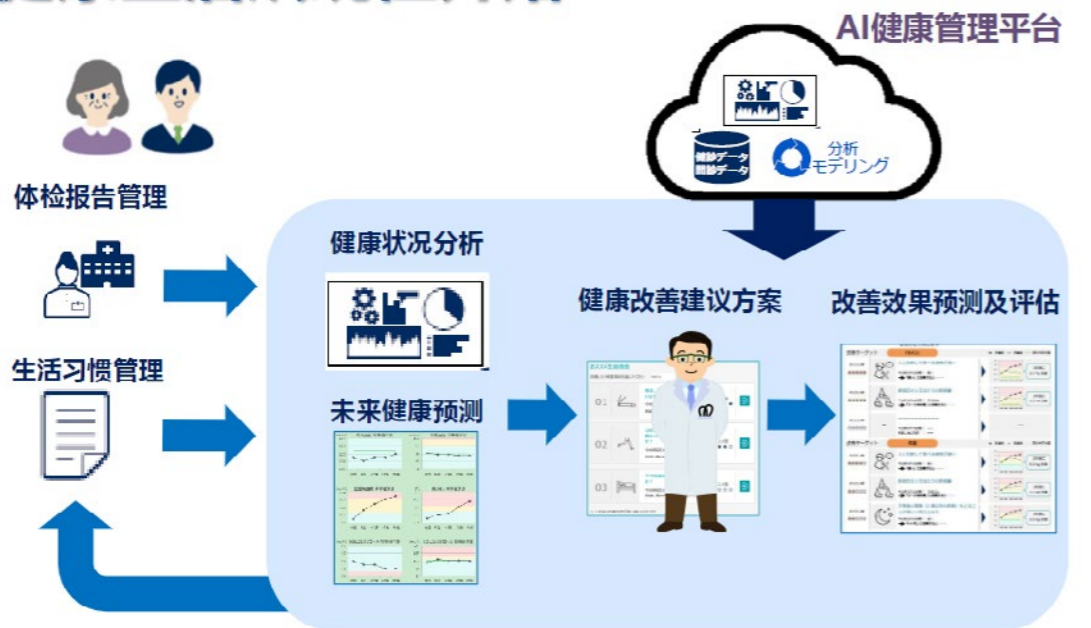
Xinghuo BIF Data Service Network

NEC: 基于先进的“因果数据分析”引擎技术的AI健康管理系统

NEC: AI Health Management System Based on Advanced Causality Analysis Engine Technology

AI健康管理系统

健康生活从现在开始!



日电卓越软件科技(北京)有限公司
NEC Corporation



引言

该成果基于先进的“因果数据分析”引擎技术，可对个人健康状况进行分析和预测。通过收集个人近两年的健康数据（如体检指标及生活习惯等），作出未来三年健康变化趋势的预测，并对慢性生活习惯病相关指标的劣化风险进行提示，以提供最佳的改善建议。

Introduction

This achievement is based on the advanced "causal data analysis" engine technology,

which can analyze and predict personal health status. By collecting personal health data in the past two years (such as physical examination indicators and living habits, etc.), we can predict the health change trend in the next three years, and prompt the deterioration risk of related indicators of chronic lifestyle diseases, so

as to provide the best improvement suggestions.

利用因果分析技术预测未来体检指标变化

Predicting future changes in physical examination indicators using causal analysis techniques

① 支持多变量的探索型因果分析：无需具备相关经验知识，自动观测数据变量的因果关系。通过独特的快速搜索算法，大幅提高计算速度，支持多达 100 变量级别的数据分析并将分析时间缩短到原有方法的 1/50 以下。

Support multivariate exploratory causal analysis: automatically observe the causal relationship of data variables without relevant experience and knowledge. Through the unique fast search algorithm, the calculation speed is greatly improved, the data analysis of up to 100 variables is supported, and the analysis time is shortened to less than 1/50 of the original method.

② 支持多种混合类型数据的因果分析：在健康预测分析等应用中，数据种类繁多，包含有连续数据、离散数据、定序数据、类别数据等，该成果提出混合数据因果推理方法，与现有方法相比获得了更高的精度。

It supports causal analysis of mixed data: in applications such as health prediction and analysis, the types of data are complicated, including continuous data, discrete data, ordered data, category data, etc. This achievement puts forward a causal reasoning method of mixed data, which has obtained higher accuracy compared with existing methods.

③ 支持专家知识的交互式嵌入：利用行业专家的经验常识，对自动获得因果关系进行纠错，提高准确度。实现日本预防性医疗专业医师意见交互式嵌入，集成已验证的因果关系，通过模型的自动更新提高模型的预测精度。

Support the interactive embedding of expert knowledge: use the experience and com-

个人健康预测

用预测模型分析过去的体检数据，预测现有生活习惯下将来的健康状况。针对可能风险，提供合理的生活习惯改善的建议。
通过模拟习惯改变对健康指标的影响，可以激励个人改变自己的生活习惯，有效减少高危慢性病的产生。



● 模拟个体生活习惯改变有效减少高危慢性病的产生
● Simulating the change of individual living habits effectively reduces the occurrence of high-risk chronic diseases

mon sense of industry experts to correct the causal relationship automatically and improve the accuracy. Realize the interactive embedding of Japanese preventive medical doctors' opinions, integrate the verified causal relationship, and improve the prediction accuracy of the model through automatic updating of the model.

④ 集成化的健康因果分析：研发集成关键因素分析、因果图的复杂度控制、干预效果仿真、因果关系可视化等多种必要的功能，降低健康预测技术难度，快速地获取健康专家的反馈意见，用于加快技术的迭代改进。

Integrated health causal analysis: R&D integrates key factor analysis, complexity control of causality diagram, simulation of intervention effect, causality visualization and other necessary functions to reduce the technical difficulty of health prediction and quickly obtain feedback from health experts for accelerating iterative improvement of technology.

合理制定个人健康管理方案

Rational formulation of personal health management plan

① 已经完成 AI 健康检测模型的原型开发（基于日本人群脱敏后健康数据）、完成平台服务及安卓应用基础功能开发。

The prototype development of AI health detection model (based on desensitized health data of Japanese population), platform service and basic function development of Android application have been completed.

② 产品雏形已经可以实现个人健康的基本分析，未来 3 年的发展趋势预测。可以根据个人情况，给出生活习惯的改善建议。并对改善效果进行模拟预测，激励个人明确预期效果，积极进行个人健康改善实践。

The prototype of the product can realize the basic analysis of personal health and predict the development trend in the next three years. Suggestions for improving

living habits can be given according to personal circumstances. And the improvement effect is simulated and predicted, which encourages individuals to make clear the expected effect and actively carry out personal health improvement practice.

③ 产品研发阶段，需要大规模人群5年的健康数据。产品研发成功后，无需额外过多资源，通过持续的检测数据输入，即可完成模型的迭代升级。

In the product development stage, 5 years' health data of large-scale population is needed. After the product is successfully developed, the iterative upgrade of the model can be completed through continuous detection data input without excessive additional resources.

④ 产品作为健康检测引擎，可以作为子功能嵌入第三方系统，或者同第三方的健康管理平台联动，并支持多种应用模式。

As a health detection engine, the product can be embedded into a third-party system as a sub-function, or linked with a third-party health management platform, and supports multiple application modes.

基本功能（示意图）

支持多种使用方式

- 手机APP：便于老人或护理人员随时查看
- Web页面：养老机构统一管理



● 可查看健康预测及改善建议
● Check the health forecast and suggestions for improvement.

集健康数据收集、分析和预测为一体的智能化服务平台 Intelligent service platform integrating health data collection, analysis and prediction

该项目基于因果数据分析的引擎技术进行数据挖掘和精准分析，进行准确的预测和诊断，提出更有效的干预措施和治疗方案；项目采用先进的

机器学习和深度学习等人工智能技术，通过学习大量真实数据，优化和提升系统自身的预测精度和准确性。为企业和政府提供有效的健康管理方案，降低人群的健康风险，

提升生产力和社会稳定性。解决一系列健康管理领域的难点问题，如传统医疗数据的不完整和不一致、数据分析和预测的不精准等问题。该项目的推广和应用也将会带来广泛的市场价值和社会效益，如提升健康管理行业的效率和水平、推动医疗信息化建设、促进人们的健康意识和行为转变等。

Based on the engine technology of causal data analysis, the project carries out data mining and accurate analysis, makes accurate prediction and diagnosis, and puts forward more effective intervention measures and treatment schemes; The project adopts advanced artificial intelligence technologies such as machine learning and deep learning, and optimizes and improves the prediction accuracy and accuracy of the system itself by learning a large number of real data. It provides effective health management programs for enterprises and governments, reduce the health risks of people, and improve productivity and social stability. It solves a series of difficult problems in the field of health management, such as incomplete and inconsistent traditional medical data, inaccurate data analysis and prediction. The popularization and application of this project will also bring a wide range of market value and social benefits, such as improving the efficiency and level of health management industry, promoting the construction of medical information, and promoting people's health awareness and behavior changes.

3) 个人随身的健康指导师，提高满意度，形成稳定长久的客户关系

现状：

- 生活习惯和健康之间影响关系模糊，缺乏持续动力改善现有习惯。
- 专业指导费时费力，沟通等各种因素，影响实际效果。

健康管理系统：

- 简单易用的界面，个人可以随时查阅，根据个人时间来进行自我生活改善。
- 每人量身定制的“体检结果解说动画”、“今后的预测值”、“生活习惯改善的建议”等功能。



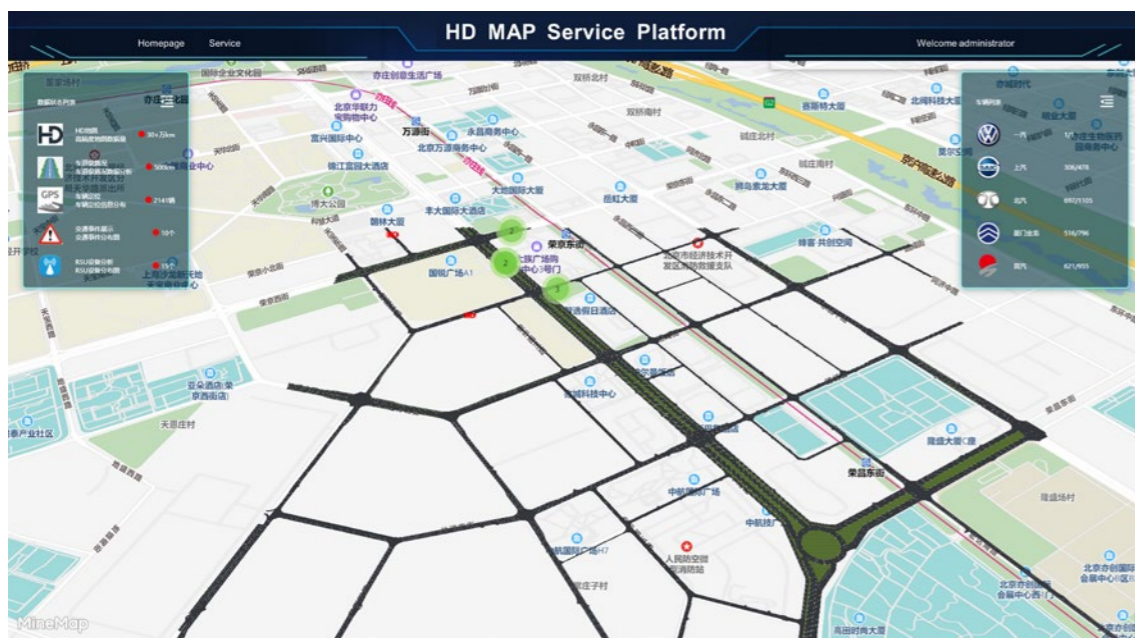
● 简单易用的界面为个人量身定制预测功能
● Easy-to-use interface, Customize forecasting features for individuals

高精度动态地图基础平台

HD Dynamic Map Basic Platform



● 高精度地图服务平台



● High definition map service platform

北京四维图新科技股份有限公司
NavInfo Co.,Ltd.



引言

面向智能网联汽车发展需求，整合场景数据、基础地图数据、实时动态数据等，构建高精度动态地图基础平台，打造高精地图采集、生产、发布、更新闭环，实现数据资源汇聚共享，支撑高级别自动驾驶对地图数据的应用需求。

Introduction

For the development of intelligent connected vehicles, we built a high definition dynamic map basic platform based on the scene data, basic map data and real-time dynamic data, created a closed loop of HD map survey, production, release and update. It has realized the convergence and sharing of data resources, and supported the application requirements of HD map for high-level autonomous driving.

打造高精地图采集 - 生产 - 发布 - 更新闭环

Create a closed loop of HD map survey, production, release and update

面向城市复杂场景，研发了多传感器融合的高精度专业移动测量系统，解决了多传感器时间同步、高效存储难题，系统绝对精度达到厘米级；研发了高精度地图自动采集软件，实时在线监测地图质量，并优化采集路线，满足高效率、高质量采集要求；提出了高精地图全要素自动提取技术，研发了支持 120 余种高精度地图元素的自动化矢量提取算法，其中，超过 30 类要素自动化提取率达到 100%，其余要素自动化率提取超过 93%。

For the complex urban scenes, we have developed the high-precision professional mobile Mapping System Vehicle with multi-sensor fusion, which solves the problems of multi-sensor time synchronization and efficient storage. The absolute accuracy of the system has reached the centimeter level. At the same time, in order to monitor the map quality online, optimize the collection route, and meet the requirements of high efficiency

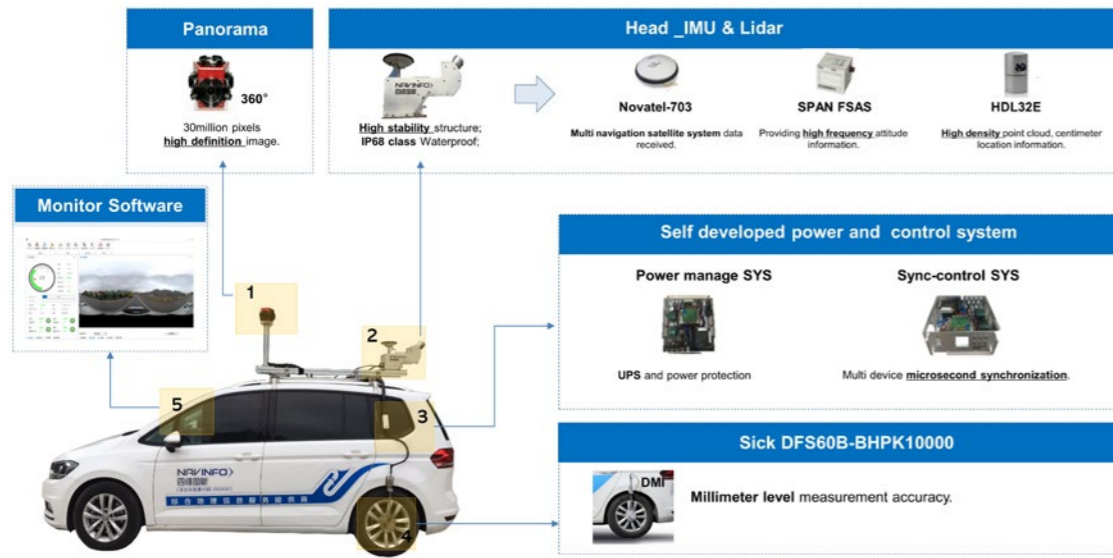
and high quality, HD map automatic acquisition software is developed. We have proposed automatic extraction technology of all elements of HD map, and developed automatic vector extraction algorithm supporting more than 120 high-precision map elements. Among them, the automatic extraction rate of more than 30 elements reached 100%, and the other more than 93%.

针对自动驾驶地图更新工作量、时效性差的难题，以高精度地图为底图，构建融合众源数据的高精度地图动态更新机制。建立了高精度动态地图基础平台，实现高精地图动态信息实时更新及 7*24 小时的发布服务。

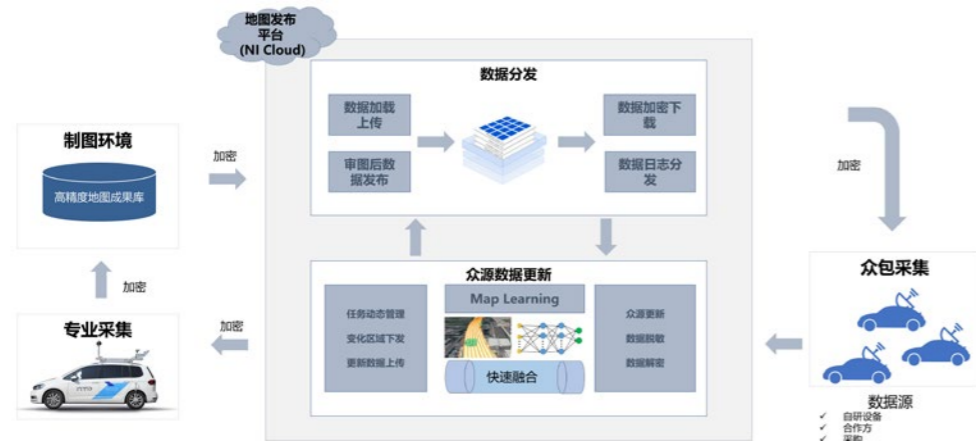
To solve the problem of heavy workload and poor timeliness of HD map update, the dynamic update mechanism of high-precision map is constructed by integrating multi-source data. We have developed a HD dynamic map basic platform, which not only realizes real-time update of HD map dynamic information, but also supports 7*24 hours release service.



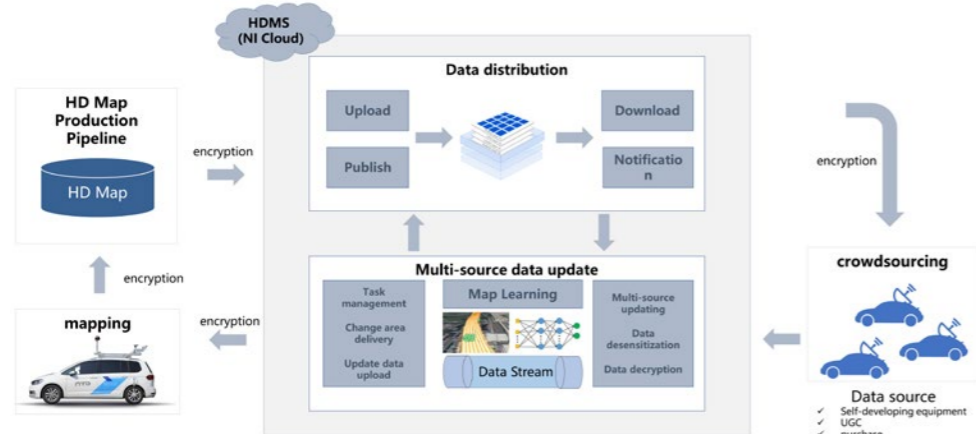
● 移动采集测量车



Mobile Mapping System Vehicle



高精地图在线更新架构



HD Map Online Update Architecture

高精地图覆盖中国高速 38 万多公里，服务于国内外车厂

The HD map covers more than 380,000 kilometers of high-speed roads in China, and serves domestic and foreign automakers

基于高精度制图系统与更新技术，使地图生产周期缩短 40%，成本降低 30%。建立了覆盖中国高速公路 38 万多公里的高精度自动驾驶地图数据，高精地图里程行业领先。高精地图里程行业领先。依托高精度地图动态平台，为宝马、奔驰、长城、小马智行、毫末智行等近百家整车企业、系统商和政企提供服务，近三年经济效益达 5.27 亿元。此外，四维图新参与了首个国际 NDS.Live 应用的开发，形成了国际影响力。

Based on high-precision mapping systems and update technology, the map production cycle is shortened by 40% and the cost is reduced by 30%. It has established high-precision automatic driving map data covering more than 380,000 kilometers of high-speed roads in China, and the high-precision map mileage is leading the industry. Relying on the HD dynamic map platform, we provide services to nearly a hundred automotive companies, system integrators, and government enterprises, including BMW, Mercedes-Benz, Great Wall Motors, Pony.ai, and HAOMO.AI. In the past three years, the economic benefit reached 527 million yuan. In addition, we participated in the development of the first international NDS.Live application, and formed an international influence.

高精度动态地图基础平台为智能网联汽车产业链上下游企业提供基础数据服务和基础地图服务，推动产业协同发展。构建智能交通数字孪生底座，将高精度地图融入智慧交通场景，大大提高道路的通行效率，并降低

事故发生率。

Based on the platform, we provide basic data services and map services for upstream and downstream enterprises of the intelligent connected vehicle industry chain, and promote the coordinated development of the industry. It can build a digital twin base for intelligent transportation, integrating high-precision maps into intelligent transportation scenarios, greatly improving road traffic efficiency and reducing accident rates.

同时，为自动驾驶领域降本增效、节能减排、技术迭代升级等提供了更优质的解决方案，提高能源利用率，减少环境污染。

At the same time, it can provide better solutions for automatic driving to reduce cost and increase efficiency, energy conservation and emission reduction, technology iteration and upgrading, improve energy efficiency and reduce environmental pollution.



智能网联运营监管应用

Application of Intelligent Connected Operation Supervision

地图产业优化升级，促进汽车产业深度融合

The map industry is optimized and upgraded to promote the deep integration of the automobile industry

高精度动态地图基础平台为智能网联汽车发展与运营提供了先进技术、信息支撑和融合服务，有效提升我国智能网联汽车产业的研发水平和自主创新能力。基于高精地图数据采集、制作、发布、更新一体化能力，为智能驾驶、智能网联汽车行业打造完整的解决方案，在交警、公安、交通、规划等领域，解决了能源节约、交通安全、智慧城市建设等方案的技术和产业难题。获得了全球首个 L3 级高精度动态地图量产订单，为宝马在华生产的 L3 级及以上的自动驾驶汽车提供高精度动态地图及数据服务；同时与国内外车厂、系统集成商、通信与电子厂商缔结合作关系；此外还分别与清华大学、上海交通大学等院校建立了战略合作关系，在高精度动态地图技术体系研究、人才培养等方面建立了深度合作，实现整车厂、运营商、市政企业等产业链上下游企业的共同发展，对构筑共建、共治、共享的数字化城市产生了积极影响。

The HD dynamic map basic platform provides advanced technology, information support, and integrated services for the development and operation of intelligent connected vehicles, effectively improving the research and development level and independent innovation ability of China's intelligent connected vehicle industry. Based on the integrated ability of high-precision map data collection, production, release, and update, we have created a complete solution for the intelligent driving and intelligent connected vehicle industry. In the fields of traffic police, public security, transportation, city planning, etc.,

we have solved the technical and industrial challenges of energy conservation, traffic safety, and smart city construction. We obtained the world's first L3 high-precision dynamic map mass production order, providing high-precision dynamic map and data services for the L3+ vehicle produced by BMW in China. At the same time, we established cooperative relationships with domestic and foreign car manufacturers, system integrators, communication and electronics manufacturers. In addition, strategic cooperation has been established with universities such as Tsinghua University and Shanghai Jiao Tong University, and deep cooperation has been established in the research of high-precision dynamic map technology system and talent cultivation. We have achieved the joint development of upstream and downstream enterprises in the industrial chain, including vehicle manufacturers, operators, and municipal enterprises, which has had a positive impact on building a digital city that is jointly built, governed, and shared.



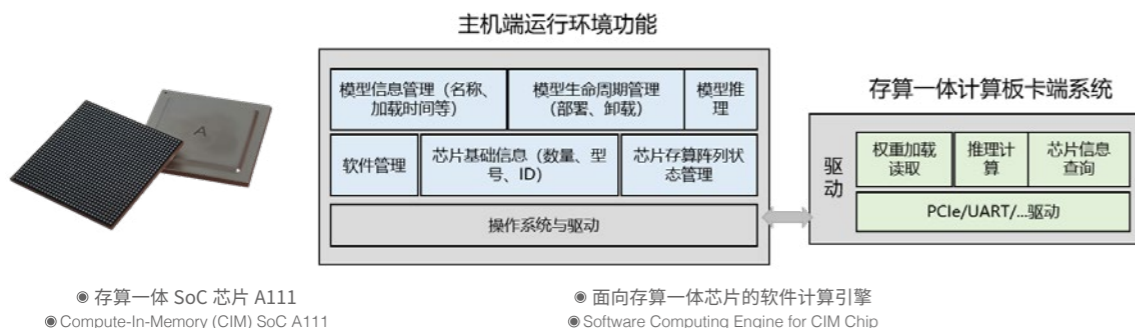
◎ The Industrial Partners



◎ 产业合作伙伴

基于忆阻器的存算一体 SoC 芯片及计算引擎

The ReRAM-Based Compute-In-Memory SoC and Software Engine



中国移动通信有限公司研究院
China Mobile Research Institute



清华大学
Tsinghua University



引言

中国移动联合清华大学打造忆阻器存算一体 SoC 芯片及软件计算引擎，软硬协同突破冯·诺依曼架构“存储墙”与“功耗墙”，大幅提升 AI 算力与能效，本成果标志着基于新型存储器的存算一体技术迈出关键性一步。

Introduction

China Mobile and Tsinghua University have developed a ReRAM-Based Compute-In-Memory (CIM) SoC and software engine, achieving a significant breakthrough in overcoming the "memory wall" and "power wall" of von Neumann architecture, while greatly enhancing Artificial Intelligence (AI) computing power and energy efficiency. This achievement marks a critical milestone in CIM based on emerging nonvolatile memory (eNVM) devices.

突破冯·诺依曼架构瓶颈，有效提升 AI 算力和能效

Breaking the von Neumann bottleneck and enhancing AI computing power and energy efficiency

近年来人工智能尤其是大模型对算力的需求呈爆炸式增长，而经典的冯·诺依曼架构因存储与计算分离带来的数据搬运时延及能耗成为算力增长的主要瓶颈。存算一体技术通过模拟人脑“存算一体化”工作机制，在存储器内部实现高效的数据计算，突破冯·诺依曼架构瓶颈，解决存算分离带来的“存储墙”、“功耗墙”问题，大幅提升算力和能效水平。

In recent years, AI especially Large Language Models (LLMs), calls for rapidly increasing computing power. However, the intrinsic inefficiency of data-shuttling in the von Neumann architecture is the major bottleneck. CIM, a brain-inspired technology, could efficiently compute within memory devices, offering a promising solution for improving

computing power and energy efficiency that can break through the limits of the von Neumann bottleneck.

中国移动联合清华大学设计研发异构、多核、通用的忆阻器存算一体 SoC 智能芯片 A111，片上集成近四百万忆阻器单元，峰值算力可达 15TOPS，推理能效达 2.68TOPS/W，相比传统智能芯片提升 3 倍以上。研发基于 PCIe 协议的存算一体计算板卡，可实现存算一体芯片同 ARM、X86 架构设备的集成。

China Mobile and Tsinghua University have designed and developed the heterogeneous, multi-core, and general-purpose CIM intelligent SoC A111 based on ReRAM. This chip integrates nearly four million ReRAM units, boasting the compute performance up to 15 TOPS and the inference efficiency of 2.68 TOPS/W. Compared to traditional intelligent chips, it offers over a threefold improvement. Additionally, a PCIe card has been developed for integrating the CIM chip with ARM or X86 devices.

研发适配存算一体芯片的软件计算引擎，兼容主流 AI 框架，提供 AI 模型编排、部署、推理、管理、验证、优化等服务，软硬协同提升 AI 计算性能，降低用户开发门槛。

We have developed a software engine tailored for the CIM chip, which is compatible with mainstream AI frameworks. The software engine contains the following functions, such as compilation, deployment, inference, management, validation, and optimization. The collaboration of hardware and software enhances AI computing performance and lowers the development difficulty.

存算一体芯片及软件为端、边、云提供强算力、高能效的新型计算方案

The chip and software provide a brand-new solution with high computing power and energy efficiency for cloud, edge and device scenarios

该成果在智慧工厂 PCB 质检场景实现了存算一体“芯片、板卡、终端、软件、算法、应用”端到端技术验证，图片检测效率 540 张/小时，满足行业应用需求，可节约复检人工成本 90% 以上。

Tailored to the industry-oriented detection of PCB defects, we have finished an end-to-end validation for the CIM technology, integrating the chip, card, device, software, algorithm and application. As a result, the throughput of the PCB production line has been promoted to 540 h⁻¹, meeting industry application requirements, and it can eliminate at least 90% of manual work spent on reinspection.

未来，基于忆阻器的存算一体 SoC 芯片可广泛应用于物联网、自动驾驶、数据中心等小、中、大算力场景，为端-边-云提供更高算力、更高能效的新型算力解决方案。在端侧，在相同功耗下可以为设备提供更高算力，支持 AI 模型的本地化部署，有效保护终端隐私；在边侧，可助力提升边缘系统的智能化程度，解决复杂边缘计算场景对高算力及低功耗的要求；在云端，存算一体技术可以支持大规模 AI 推理和训练，满足多任务复杂算力需求，助力实现数据中心 AI 运算能效提高。

In the future, the CIM based on ReRAM can find widespread applications across various scenarios such as the Internet of Things, autonomous driving, and data centers, offering novel solutions with higher computing power and efficiency.

For the device, CIM can provide higher computing power with the same power consumption, enabling the AI localization and guaranteeing the endpoint security.

For the edge, CIM can contribute to enhancing the intelligence of edge systems, balancing the performance and energy consumption in the complex edge computing scenarios.

For the cloud, CIM can be utilized for large-scale AI inference and training, meeting the computing power requirements of multitasking scenarios, thereby improving the computing efficiency of data centers.

构建算力技术新生态，助力产业数智化升级

Building a new ecology of computing power to accelerate the upgrade of the industrial digital transformation

基于忆阻器的存算一体 SoC 芯片创新使用 2T2R (双晶体管双忆阻器) 单元结构存储权重参数，实现大规模、高可靠的忆阻器阵列，更好支持人工智能应用。成果涉及的相关技术创新点，以论文形式发表在集成电路领域顶级会议 IEDM 和《Advanced Materials》等国际顶级学术期刊。同时

设计存算一体通用软件计算引擎架构，向上提供统一 API 接口，向下兼容不同存算一体芯片硬件，联合业界主流存算一体芯片厂家在先进计算产业发展联盟立项研究存算一体软件计算引擎标准，共同推进存算一体产业生态发展。

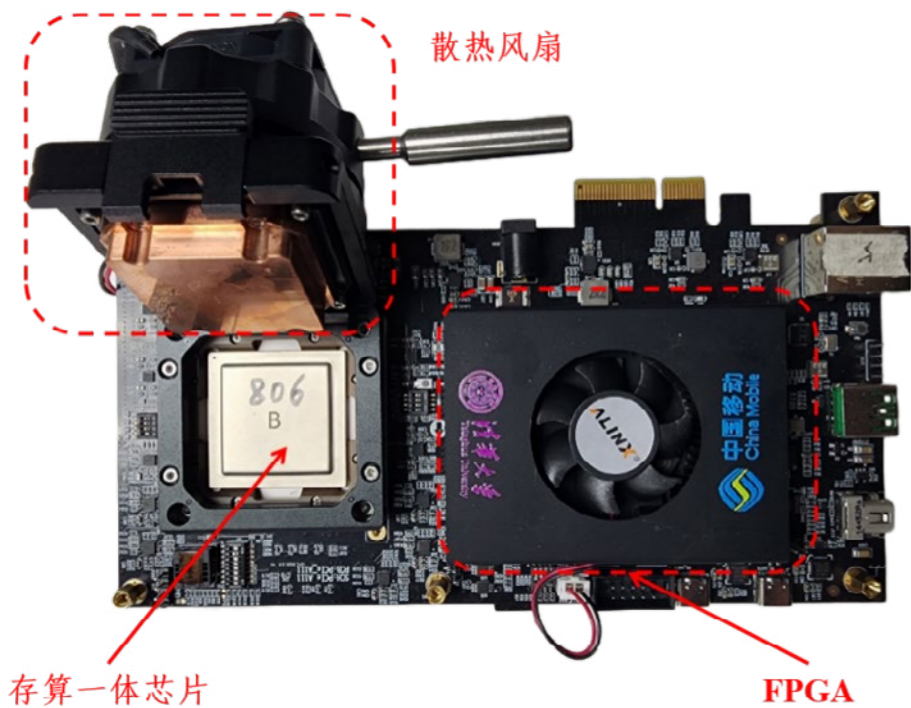
The CIM chip based on ReRAM employs an innovative 2T2R (two-transistor-two-resistor) unit structure for storing parameters, achieving the large-scale and highly reliable ReRAM array, which is more suitable for AI applications. These key technological innovations associated with this achievement have been published in top-tier conferences such as IEDM (International Electron Devices Meeting) and international academic journals like "Advanced Materials".

Simultaneously, a universal software engine architecture for CIM has been designed, offering a unified APIs to ensure the compatibility, while supporting various CIM chips. Collaborating with the leading CIM companies, we establish a project to study the standard of CIM software engine in Advanced Computing Industry Alliance (ACIA), in order to promote the development of the ecology of CIM.

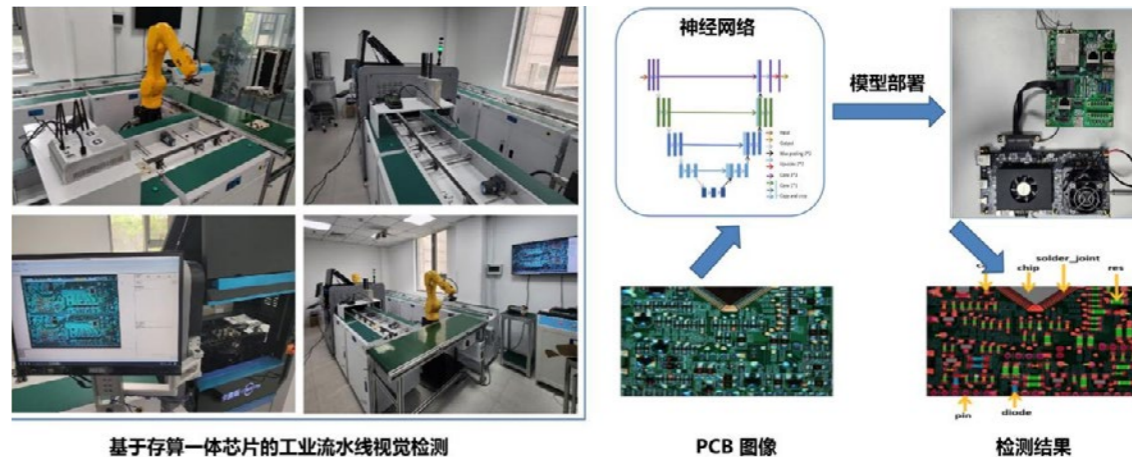
基于忆阻器的存算一体芯片从材料、器件、计算范式、架构等方面进行革新，兼具算力、功耗、成本优势，大幅提升算力和能效水平，推动算力绿色化发展。配合软件计算引擎，可实现典型人工智能算法在芯片的灵活部署与优化，助力产业数智化升级。

The CIM chip based on ReRAM represents a groundbreaking innovation in materials, devices, computational paradigms and architecture. It offers a unique combination of computing power, energy efficiency and price, significantly elevating the computing performance and energy efficiency, which contributes to the development of green computing.

When coupled with software engine, it enables flexible deployment and optimization of typical AI models on the CIM chips, thereby facilitating the upgrade of the industrial digital transformation.



● 忆阻器存算一体 SoC 芯片及计算板卡
● ReRAM-Based CIM SoC and PCIe Card



基于存算一体芯片的工业流水线视觉检测

PCB 图像

检测结果

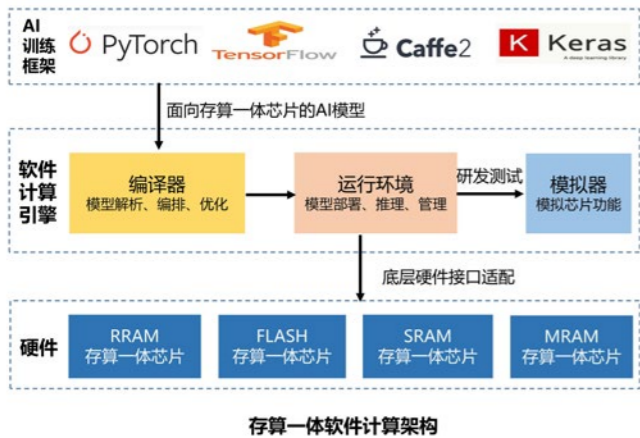
● 基于存算一体芯片的边缘智能示范演示平台
● Edge Intelligence Demonstration Platform Based on CIM Chip



● 存算一体芯片为端、边、云提供立体泛在的高效算力

● The CIM Chip Offers a Comprehensive Cloud-Edge-Device Ubiquitous Computing Power Deployment

兼容多种AI框架 降低开发门槛 屏蔽硬件差异 发挥芯片性能

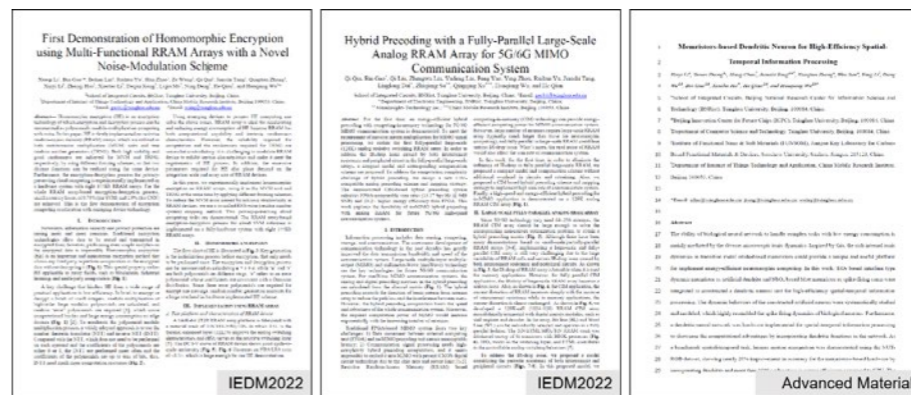


存算一体软件计算架构

● 存算一体软件计算引擎
● CIM Software Engine



存算一体模拟器视图



● 本成果已发表多篇高水平论文
● Related Published Papers

Theranica: 数字疼痛治疗管理设备 Nerivio

Theranica: Digital Pain Treatment Management Equipment Nerivio

基于神经科学的创新技术



● 可穿戴设备支持连接智能手机，用于治疗急性偏头痛
 ● Wearable equipment to treat acute migraine. Support the connection of smart phones

Theranica Bioelectronics

引言

Nerivio® 是以色列数字治疗公司 Theranica Bioelectronics 开发的可穿戴神经调节装置，基于触发脑干内源性疼痛抑制机制，能有效地缓解并治疗青少年的急性偶发或慢性偏头痛，且没有通常治疗性药物的副作用，还可通过智能手机收集治疗数据与医生共享。

Introduction

Nerivio® is a wearable neuromodulation device developed by Theranica Bioelectronics, an Israeli digital therapy company. Based on triggering endogenous pain suppression mechanisms in the brainstem, it effectively relieves and treats acute episodic or chronic migraines in adolescents without the side effects usually associated with therapeutic medications and allows for the collection of therapeutic data that can be shared with physicians via smartphone.

一种安全有效的偏头痛预防治疗方法

A safe and effective preventive treatment for migraine headaches

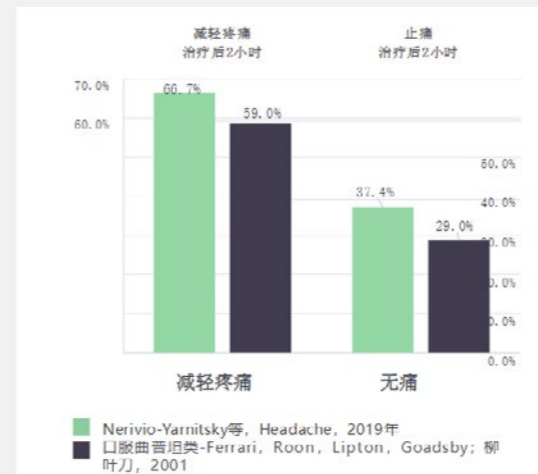
Nerivio 集成了最先进的神经调控和神经科学技术，其设备可监测偏头痛发作并记录在手机应用中，生成具有密码保护、HIPAA 兼容的私人日记；进而为用户提供偏头痛的个人统计分析，用户可以一键点击与医生或医疗机构分享应用中的数据，为用户提供更好的疗程依从性和个性化的疗效提示。该设备的创新设计产生的专利波形输送到 C 型纤维神经，触发了脑干中镇痛剂的减痛机制。通过使用专有的

神经肌肉电刺激 (ENS/NMES) 和蓝牙低能量技术，用最大功效机制来收集和确认来自治疗肌肉的肌电图信号。在整合 Nerivio 技术后，用户可以根据需求和便利性定制偏头痛治疗方案，并接收预防性治疗的提醒，跟踪其偏头痛模式，通过使用横膈膜呼吸、肌肉放松和引导想象等技术的教育和放松指导干预帮助用户。

Nerivio integrates state-of-the-art neuromodulation and neuroscience technologies with a device that monitors migraine episodes and records them in a mobile app, generating a private diary which is password-protected and HIPPA-compliant. It presents users with personal statistical analysis of migraine headaches, allowing users to share data from the app with their doctor or healthcare provider with a single click, providing users with better adherence to their regimen and personalized efficacy tips. The innovative design of the device produces a patented waveform delivered to the C-fiber nerves that triggers the pain-reducing mechanism of analgesics in the brainstem. By using proprietary neu-

romuscular electrical stimulation (ENS/NMES) and Bluetooth low energy technology with maximum efficacy mechanisms to collect and confirm EMG signals from the treated muscles. With the integration of Nerivio technology, users can customize their migraine treatment plan based on need and convenience, receive reminders of preventive treatments, track their migraine patterns, and help users with guided educational and relaxation interventions using techniques such as diaphragmatic breathing, muscle relaxation, and guided imagery.

有效|安全|易于使用|数字



临床疗效等于最佳处方药，但具有更高的安全性：

- 无全身副作用
- 不用担心药物与药物的相互作用
- 不存在滥用药物风险
- 无过度用药的风险

● 该成果有多篇可靠的、经过同行评审的临床数据支持
 ● The results are supported by multiple reliable, peer-reviewed clinical data

一个非侵入性的、不含药物的、易于使用的电子装置

The invention discloses a non-invasive, drug-free and easy-to-use electronic device

Nerivio 在皮肤上发射微弱的电脉冲进行电刺激，产生 CPM 关键路径法以抑制偏头痛，在偏头痛发作时患者可自行进行治疗。该产品市场已经扩展到欧洲和亚洲，利用远程医疗平台扩展到产科和初级保健处方，并受美国大部分医疗保险公司覆盖。美国食品和药物管理局批准 Nerivio 神经刺激设备是基于一项前瞻性的随机、双盲、假对照、多中心的临床试验，共有 296 名急性偏头痛患者参加。该试验在美国的七个地点和以色列的五个地点进行，主要目的是研究治疗两小时后偏头痛减少的患者百分比。研

究发现，使用主动设备的刺激比使用对照设备的刺激更有效，66.7% 的 Nerivio 患者报告偏头痛减少，而通过对照设备接受刺激的患者只有 38.8%。主动装置对 27.9% 的病人有治疗作用，而大约 37.4% 的病人在治疗两小时后没有疼痛。此外，与 Nerivio 设备有关的不良事件也很低。

Nerivio electrically stimulates the skin by

emitting weak electrical impulses, generating the CPM for migraine suppression, which the patient can self-administer during a migraine attack. The product market has expanded into Europe and Asia, utilizing telemedicine platforms to expand into obstetrics and primary care prescribing, and is covered by the majority of health insurers in the United States. FDA approval of the Nerivio neurostimulation device was based on a prospective, randomized, double-blind, sham-controlled, multicenter clinical trial of 296 patients with acute migraine. Conducted at seven sites in the U.S. and five sites in Israel, the primary objective of the trial was to study the percentage of patients who experienced a reduction in migraine headaches after two hours of treatment. The study found that stimulation with the active device was more effective than stimulation with the control device, with 66.7% percent of Nerivio patients reporting a reduction in migraines, compared to 38.8% percent of patients receiving stimulation via the control device. The active device had a therapeutic effect on 27.9% of patients, while approximately 37.4% of patients were pain-free after two hours of treatment. Additionally, adverse events associated with the Nerivio device were low.

真正的数字治疗



● 通过 APP 收集治疗数据并与医生进行分享

● Collecting treatment data and sharing it with doctors through an app

针对青少年群体提供预防和缓解偏头痛的途径

Providing access to migraine prevention and relief for the adolescent population

2019年5月，以色列初创公司 Theranica 获得美国食品和药物管理局的初步批准，用于治疗青少年急性偶发或慢性偏头痛。此项批准基于该公司资助的一项研究结果，来自12家诊所的252名患者使用非侵入性可穿戴设备来治疗他们的偏头痛发作。2021年初，Nerivio 被批准用于12至18岁的患者，该批准是基于248名参与者的随机安慰剂对照试验的结果。该研究发现，那些每隔一天使用该设备的慢性或发作性偏头痛患者每月的偏头痛天数减少了四天。接受安慰剂的人，偏头痛天数减少了1.3天。“Nerivio 在急性偏头痛治疗方面已经具有良好的疗效和安全性，”南加州头痛中心主任、论文共同作者 Andrew Blumenfeld 博士说。

州头痛中心主任、论文共同作者 Andrew Blumenfeld 博士说。

In May 2019, Israeli startup Theranica received preliminary approval from the U.S. Food and Drug Administration for the treatment of acute episodic or chronic migraine headaches in adolescents. The approval is based on the results of a company-funded study in which 252 patients from 12 clinics used a non-invasive wearable device to treat their migraine attacks. In early 2021, Nerivio was approved for use in patients between the ages of 12 and 18, and that approval was based on

the results of a randomized, placebo-controlled trial with 248 participants. The study found that those with chronic or episodic migraine who used the device every other day had four fewer migraine days per month. Those who received a placebo had 1.3 fewer migraine days." Nerivio already has good efficacy and safety in acute migraine treatment," said Andrew Blumenfeld, PhD, Director of the Southern California Headache Center and co-author of the paper.

荣获《时代》评选的2019年最佳50项发明

2019年10月，在美国面市

Outstanding Launch in USA

Started Oct 2019
Cash Model

7 Sales reps 7个销售代表	2 Telemedicine platforms 2个电商平台	800 Clinics 800家诊所	1,300 Prescribing HCPs 经过1300个医务工作者开处方	14,000 Patients 已为14,000名患者服务	70,000 Treatments 70,000次治疗
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theranica

● 有效的预防性治疗，缓解偏头痛
● Effective Preventive Treatment for Migraine Relief

“源图” 开源软件供应链重大基础设施

Open Source Map: A Major Infrastructure for Open Source Software Supply Chain



“源图” 开源软件供应链重大基础设施
Open Source Map: A Major Infrastructure for Open Source Software Supply Chain

中国科学院软件研究所
Institute of Software, Chinese Academy of Sciences (ISCAS)



中科南京软件技术研究院
Nanjing Institute of Software Technology



北京中科微澜科技有限公司
Beijing Zhongke Weilan Technology Co., Ltd.



引言

“源图”基于源代码大数据的前瞻科学研究，构建开源软件采集存储、开发构建、测试集成、发布运维、知识化与智能推荐于一体的基础设施，旨在实现开源软件安全治理和可靠供应，服务产业高质量发展。

Introduction

Open Source Map, based on cutting-edge scientific research using big data from open-source code, is an integrated infrastructure for collecting, storing, developing, testing,

integrating, releasing, and providing knowledge-based and intelligent recommendations for open-source software. Its goal is to achieve secure governance and reliable supply of open-source software, serving the high-quality development of the industry.

“源图” 打造集开源软件采集存储、开发测试、集成发布、运维升级等一体化设施

Open Source Map has created an integrated infrastructure for open-source software collection, storage, development, testing, integration, release, operation and upgrades

“源图”实现对代码托管平台、包管理器、开源社区等多源数据的知识融合，构建包含软件、漏洞、组织、开发者等实体类型的大型开源软件知识图谱。该图谱共整合了逾 1.6 亿个软件、1.9 亿个实体、28 亿条关系，累计获取代码仓库超 1900 万款、代码总行数超 2200 亿行，开源许可证超 3200 个，SBOM+ 软件分析达到 350 万款。此外，“源图”构建了中国最大的开源软件供应链漏洞库及漏洞感知平台，包含超过 30 万个漏洞，7 万个漏洞 PoC，10 万条威胁情报，实现潜在安全风险推理及攻击预测。该平台已为超过 60 家重要单位进行软件供应链安全检测，发现漏洞、病毒等安全威胁 1500 余个，并获得相关部门的感谢信。“源图”成功入选 2022 年度中国科学院网信工作十大进展，相关技术获得 2021 年北京市科技进步一等奖、2022 年电子学会科技进步二等奖。中国科学院软件研究所目前已获得 ISO 5230 国际标准的 OpenChain 测评资质，保障国产开源软件合规“出海”。

Open Source Map achieves knowledge integration from multiple sources, including code hosting platforms, package managers, and open-source communities. It constructs a large-scale knowledge graph of open-source software, encompassing entities such as software, vulnerabilities, organizations, and developers. This knowledge graph consists of over 160 million software packages, 190 million entities, 2.8 billion relationships, 19 million code repositories, 220 billion lines of code and 3,200 open-source licenses. Additionally, it enables SBOM+ analysis for 3.5 million software packages. Open Source Map

has also achieved the construction of China's largest open-source software supply chain vulnerability database and vulnerability perception platform. It encompasses over 300,000 vulnerabilities, 70,000 vulnerability Proof of Concepts (PoCs), and 100,000 threat intelligence records, enabling inference of potential security risks and attack predictions. The platform has conducted software supply chain security assessments for over 60 prominent organizations, identifying more than 1,500 security threats such as vulnerabilities and viruses. This achievement has been acknowledged with appreciation letters from relevant departments. Open Source Map has also been selected as one of the top ten advancements in the Internet and Information Work by the Chinese Academy of Sciences for the year 2022. Furthermore, the related technologies received the first prize for scientific and technological progress from the Beijing Municipal Government in 2021 and the second prize for scientific and technological progress from the Chinese Institute of Electronics in 2022. The Institute of Software of the Chinese Academy of Sciences has currently obtained OpenChain ISO/IEC 5230 standard evaluation qualification, ensuring compliance of domestic open-source software for global markets.



中国科学院软件研究所成为 OpenChain ISO/IEC 5230 标准第三方测评机构
ISCAS has become the third-party certifier for the OpenChain ISO/IEC 5230 standard

“源图”开源软件供应链平台做到“用得上、有影响”，实现对千行百业的支撑实践

Open Source Map achieves practical and impactful utilization, providing support to various industries

“源图”在供应链安全、开源项目应用上为开放原子开源基金会提供了有效支撑，保障了基金会的软件依赖快速移植适配、工具链分析构建、项目风险管控等关键工作顺利进行。基于“源图”持续开展了四届开源之夏活动，推动高校学生在 openEuler 开源操作系统社区实习实践，并成为近三年高等学校开源的 No.1 品牌，相关成果已纳入社区主线并在华为、阿里、字节、京东、腾讯等企业落地应用。“源图”服务中国科学院，对全院的科研软件、ARP 系统和人工智能平台进行实时检测；同时服务电力电网、工业机器人、医疗、能源等国家关键基础设施领域，发现漏洞、病毒等安全威胁 1500 余个，收到多封关键单位的感谢信，并入选“2022 年南京市标杆应用场景”。

Open Source Map has provided effective support to the OpenAtom Foundation in terms of supply chain security and open-source project applications, ensuring the swift porting and adaptation of open-source software dependencies, the construction of toolchains, and the management of project risks for various projects under the foundation. Based on the Open Source Map, the Open Source Promotion Plan has been held for four consecutive years, promoting internships and practical experience for college students in the openEuler open-source operating system community. It has become the No.1 brand in open source among higher education institutions in the past three years. The relevant achievements have been gradually incorporated into the community's mainline, and applied in companies such as Huawei, Alibaba, ByteDance, JD.com, and Tencent. Open Source Map provides services to the Chinese Academy of Sciences, conducting real-time monitoring of research software, ARP systems, and artificial intelligence platforms across the entire institution. Meanwhile, it supports critical national infrastructure sectors such as power grids, industrial robots, healthcare, and energy. It has discovered over



● “源图”入选“2022 年南京市标杆应用场景”

● Open Source Map has been selected as the "Benchmark Application Scenario in Nanjing in 2022"

1,500 security threats, including vulnerabilities, viruses, etc., and has received appreciation letters from multiple critical units. It has also been selected as the "Benchmark Application Scenario in Nanjing in 2022".

“源图”提供开源软件安全保障，推动开源生态发展

Open Source Map offers open-source software security and compliance assurance and promotes the development of the open-source ecosystem

“源图”开源软件供应链重大基础设施为社会各界提供基础设施支撑。“源图”集成合规性分析、安全性分析、可维护性分析、供应链推荐四大核心功能，支撑了 openEuler、openAnolis 等操作系统“根”社区的发展。基于“源图”研发的 SBOM+ 软件成分分析系统、许可证合规性分析系统等，已在中国科学院计算机网络信息中心等单位应用。此外，针对开源软件供应存在的风险，“源图”启动开源软件供应链点亮计划，发动全球力量参与开源软件的建设，进一步打造良好的开源生态。

Open Source Map provides foundational support for various sectors of society. It integrates four core functionalities: compliance analysis, security analysis, maintainability analysis, and supply chain recommendations, supporting the development of the "root" communities of operating systems such as openEuler and openAnolis. The SBOM+ software component analysis system and license compliance analysis system, developed based on Open Source Map, have been applied in enterprises such as the Computer Network Information Center of the Chinese Academy of Sciences. Furthermore, in response to the risks associated with the open-source software supply chain, Open Source Map has launched the Open Source Software Supply Chain Promotion Plan to mobilize global forces to participate in the construction of open source software, ultimately creating a thriving open-source ecosystem.



● 中国科学院软件研究所加入 openEuler 社区助力开源生态发展

● ISCAS has joined the openEuler community to contribute to the development of the open-source ecosystem



● 中国科学院软件研究所成为首批加入 OpenHarmony 项目群工作委员会成员

● ISCAS has become one of the first members to join the OpenHarmony project group working committee

“源图”厚积薄发，引领开源新生态

Open Source Map accumulates steadily and leads the emergence of a new open-source ecosystem

“源图”开源软件供应链平台关键技术研究于 2019 年 10 月在中国科学院先导专项支持下启动。2021 年 3 月在南京市启动了“源图”基础设施平台建设，之后在世界互联网大会分论坛上陆续发布“源图”1.0 版本和 2.0 版本。目前，“源图”平台已累计获取、分析开源软件超过 1.6 亿款，服务于数十家互联网、金融、医疗、装备制造等行业头部企业，可完全替代价格昂贵的国外同类软件。目前已申请的相关知识产权共计 100 余项，其中相关论文 20 余篇，出版书籍 3 本，相关专利 30 余项，软著 50 余项。

The research on key technologies of Open Source Map was initiated in October 2019 with the support of the Chinese Academy of Sciences pilot project. In March 2021, the construction of the Open Source Map was launched with the support of the Nanjing Municipal Government. Subsequently, the Open Source Map version 1.0 and version 2.0 were released successively during the sub-forum at the World Internet Conference. Currently, Open Source Map has accumulated and analyzed more than 160 million open source software, and has served dozens of leading companies in industries such as internet, finance, medical, and equipment manufacturing, fully replacing expensive foreign software. Currently, more than 100 intellectual property rights have been applied for, including over 20 related research papers, 3 published books, more than 30 related patents, and over 50 software copyrights.



● 开源软件供应链重大基础设施建设启动会

● The launching ceremony of major infrastructure construction for open source software supply chain

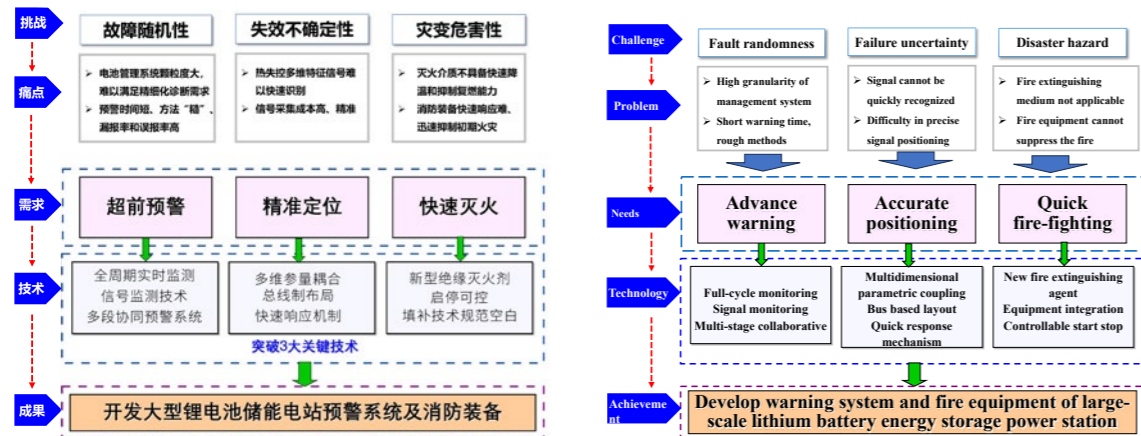


● “源图”亮相世界互联网峰会

● Open Source Map makes an appearance at the World Internet Conference

锂电池储能系统安全防控成套装备研制及其工程化

Development and Engineering of Safety and Control Complete Equipment for Lithium Battery Energy Storage System



● 锂电池储能系统安全防控成套装备研制及其工程化技术思路

● Technical Ideas of Development and Engineering of Safety and Control Complete Equipment for Lithium Battery Energy Storage System

华中科技大学
Huazhong University of Science and Technology



湖北工业大学
Hubei University of Technology



深圳供电局有限公司
Shenzhen Power Supply Bureau Co., Ltd.



引言

项目以保障锂电池储能系统安全运行为目标，设计了全周期储能电站电池状态实时监测与高精度预警系统，开发了热失控电池精准定位及快速响应技术，首创了带电场景下高效电池火灾灭火方式及成套装备。

Introduction

The project aims to ensure the safe operation of lithium battery energy storage systems, designs real-time monitoring of battery status for full cycle energy storage power plants and high-precision early warning systems, and develops precise positioning and rapid response technology for thermal runaway batteries, pioneered an efficient battery fire extinguishing method and complete equipment in live scenarios.

锂电池储能系统消防安全防护专家

Expert in Fire Safety Protection of Lithium Battery Energy Storage Systems

攻克大型锂电池储能电站爆燃预警不可测的技术难题，提出了大数据驱动全周期故障诊断与实时监测方法，开创了基于一致性离群识别异构信息特征的锂电池热失控信号检测技术，综合故障预警准确率达99%；创建了“机-电-热-声-气”高可靠性多场耦合模型，提出了BMS联动多级实时防控的快速响应策略，系统响应时间 $< 1s$ ；开发了准确性极高的灭火剂分子结构设计算法模型，合成了系列新型氟化物材料“氟四方TM”研制了成套消防集成装备，引领了锂电池储能消防技术的历史跨越发展。

The project have overcome the technical challenge of unmeasurable detonation warning for large-scale lithium battery energy storage power stations, proposed a big data-driven full cycle fault diagnosis and real-time monitoring method, and pioneered a lithium battery thermal runaway signal detection technology based on consistent outlier recognition of heterogeneous information features, with a comprehensive fault warning accuracy of 99%; it also have created a highly reliable multi-field coupling model of "mechanical-electrical-thermal-acoustic-gas" and proposed a fast response strategy for BMS linkage multi-level real-time prevention and control, with a system response time of less than 1 second, and developed a highly accurate molecular structure design algorithm model for fire extinguishing agents, synthesized a series of new fluoride materials "Fluorine TetragonalTM", and developed a complete set of fire protection integrated equipment, leading the historical leap development of lithium battery energy storage fire protection technology.

面向双碳目标解决规模化储能技术应用的重大技术需求

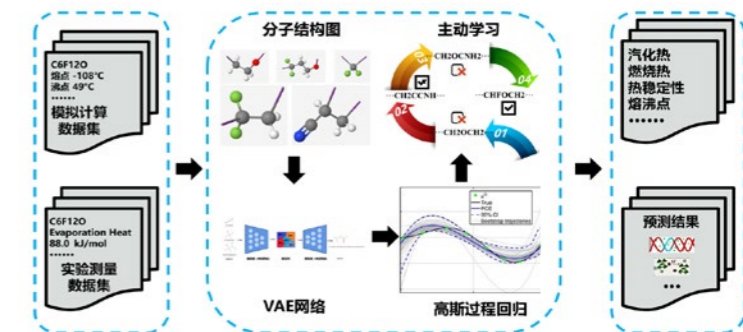
Major technical requirements for addressing the application of large-scale energy storage technology towards the dual-carbon goal

技术产品融合了具有消防一体，精准定位、多次启停等系列核心技术，采用专利产品新型高效绿色“氟四方TM”锂电池灭火剂，形成了成套消防集成装备，实现“电芯不起火、模组不蔓延、系统不爆炸”的三级火灾安

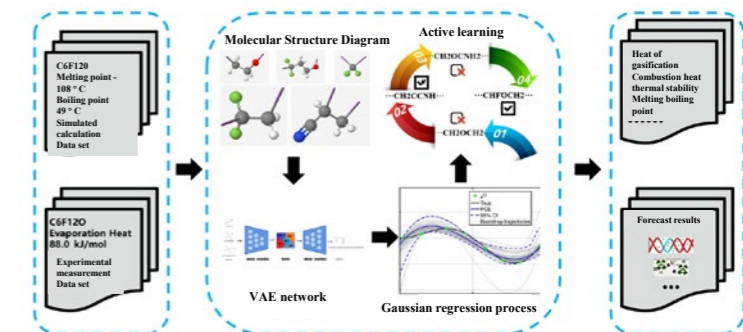


● 基于深度学习的大数据驱动全周期故障诊断与实时监测方法

● A Method for Big Data Driven Full Cycle Fault Diagnosis and Real Time Monitoring Based on Deep Learning



● 基于机器学习技术的新型材料分子结构设计技术

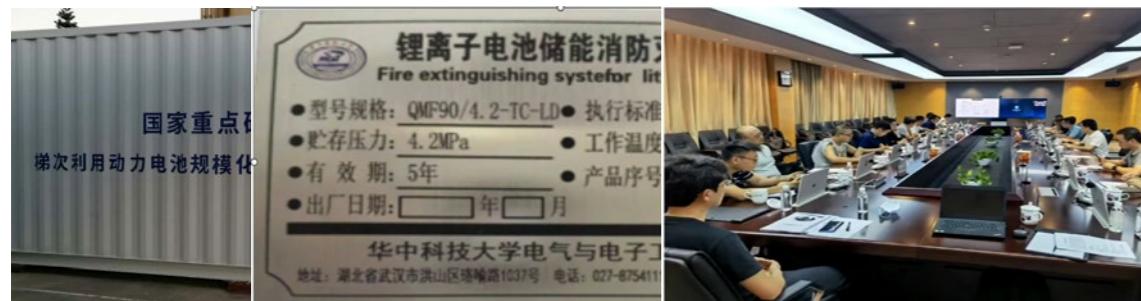


● New Material Molecular Structure Design Technology Based on Machine Learning Technology

锂能等锂电池储能头部企业，推广到广东、江苏、浙江、湖北等地大型储能电站，其中部分产品出口国际市场，直接经济效益超 10 亿元，产生了重大的经济和社会效益。

The technical products integrate a series of core technologies with integrated fire prevention and control, precise positioning, and multiple starts and stops. The patented product new high-efficiency green "Fluorine Tetragonal™" lithium battery fire extinguishing agent is used to form a complete set of fire protection integrated equipment, achieving three-level fire safety prevention and control of "no fire in the battery cell, no spread of the module, and no explosion in the system", and the relevant technologies and equipment are industrialized and put into operation and installation. The project team led the development of technical specifications for evaluating lithium battery fire extinguishing agents and testing specifications for early warning system, relevant technologies incubated Wuhan 3F New Material Technology Co., Ltd. The achievements were applied to leading

lithium battery energy storage enterprises such as national defense major equipment. China Energy Construction Energy Storage Technology, China Electronics Technology Group Corporation, and Yiwei Lithium Energy, they also promoted to large energy storage power stations in Guangdong, Jiangsu, Zhejiang, Hubei, and other places. Some of the products were exported to the international market, with direct economic benefits exceeding 1 billion yuan, Significant economic and social benefits have been generated.



● 锂电池储能系统安全防控成套装备工程应用

● Engineering Application of Safety Prevention and Control Complete Equipment for Lithium Battery Energy Storage System

储能安全关键技术与装备的国际引领

International leadership in key technologies and equipment for energy storage safety

国内外同行在重要学术刊物、学术专著、重要国际学术会议上公开发表多个学术性评价意见。《科技日报》报道指出：“团队针对锂电池储能系统火灾特点，利用人工智能算法，在国际上首次筛选出高吸热阻燃灭火材料，开发出含有 3 种成分以上的复配型灭火剂。”《湖北日报》头版报道了项目组所开发的新型氟化灭火剂产业化进展，华中科技大学科研成果电子氟化液的投产，对于保护我国能源安全具有重大战略意义。中国电力企业联合会鉴定认为：储能电池及系统安全预警技术达到国际领先水平；中国科促会鉴定认为：新型灭火剂的算法模型、复配方法和抑制复燃技术达到国际领先水平。

Domestic and foreign peers have publicly expressed multiple academic evaluations in important academic journals, academic monographs, and important international academic conferences. According to a report by Science and Technology Daily, "The team has used artificial intelligence algorithms to screen high heat absorbing and flame-retardant fire extinguishing materials for the first time internationally, and developed a composite fire extinguishing agent containing more than three components, based on the characteristics of battery energy storage system fires." The front page of Hubei Daily reported on the industrialization progress of the new

fluorinated fire extinguishing agent developed by the project team, and the production of electronic fluorinated liquid, a scientific research achievement of Huazhong University of Science and Technology, has significant strategic significance for protecting China's energy security. The China Electric Power Enterprise Federation has identified that the safety warning technology for energy storage batteries and systems has reached an international leading level; The China Association for the Promotion of Science and Technology has identified that the algorithm model, compounding method, and suppression technology of new fire extinguishing agents have reached international leading levels.



● 成果相关技术被众多媒体深度报道和转载

● The reported and reprinted by multiple media outlets of achievements related technologies

“锂离子电池储能安全设计、预警及消防技术研究与应用”通过了中国电力企业联合会科技成果鉴定：该项目成果总体达到国际先进水平，其中储能电池及系统安全预警技术达到国际领先水平。

“新型锂电池储能系统消防灭火剂关键技术与应用”通过了中国国际科技促进会科技成果鉴定：新型灭火剂的算法模型、复配方法和抑制复燃技术达到国际领先水平，取得了显著的经济和社会效益，具有广阔的推广价值及应用前景。



The research and engineering application olithium-ion battery energy storage safety design, early warning, and fire protection technology has passed the scientific and technological achievements appraisal of the China Electric Power Enterprise Federation. The overall achievements of this project have reached the international advanced level, with the energy storage battery and system safety early warning technology reaching the international leading level.

The key technologies and applications of the new lithium battery energy storage system fire extinguishing agent have passed the scientific and technological achievements appraisal of the China Association for the Promotion of International Science and Technology. The algorithm model, compounding method, and suppression of reignition technology of the new fire extinguishing agent have reached the international leading level, achieved significant economic and social benefits, and have broad promotion value and application prospects.

● 成果相关技术的鉴定意见

● Appraisal opinions on achievements related technologies

实现全周期预警监测、精准快速识别与高效灭火集成

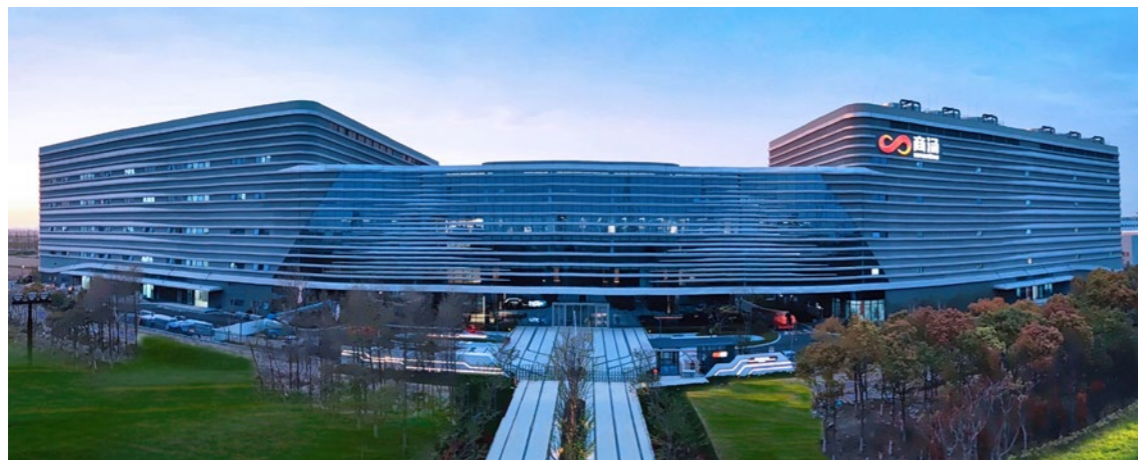
Realized full cycle early warning and monitoring, precise and rapid identification, and efficient fire extinguishing integration

经长达十余年刻苦攻关，在国家重点研发计划、国防科工局军用技术推广、国网/南网科技项目等支持下，率先锂电池储能系统安全运行关键技术与装备工程化的攻关，在爆燃预警高精度监测、故障快速识别定位、高效灭火技术等共性核心技术上取得突破，已授权发明专利 42 项，国际专利 8 项，实用新型专利 39 项，获软件著作权 7 项，发表 SCI 论文 100 余篇（封面论文 5 篇，高被引 3 篇），牵头发布实施省/团标准 4 项，出版中文专著 1 部。

We have taken the lead in tackling key technologies and equipment engineering for the safe operation of lithium battery energy storage systems with the support of national key research and development plans, military technology promotion by the National Defense Science and Industry Bureau, and national/southern power grid technology projects. After more than ten years of hard research and development, the project have made breakthroughs in common core technologies such as high-precision monitoring of detonation warning, rapid fault identification and positioning, and efficient fire extinguishing technology, and have authorized 42 invention patents, 8 international patents, 39 utility model patents, 7 software copyrights obtained, over 100 SCI papers published (5 cover papers, 3 highly cited), led the publication and implementation of 4 provincial/group standards, and published 1 Chinese monograph.

新一代 AGI 基础设施：商汤大装置 SenseCore 与商汤日日新 SenseNova 大模型体系

Next-generation AGI Infrastructure: SenseCore AI Infrastructure and SenseNova Foundation Model Set



商汤科技
SenseTime



引言

人工智能进入 2.0 时代，其核心是支撑大模型生产的 AI 原生基础设施。随着大模型的进一步发展，当前业界对大算力的需求非常旺盛。为此商汤前瞻性地打造了高效率、低成本、规模化的新型人工智能基础设施。

Introduction

Artificial intelligence has entered the 2.0 era, the core of which is the AI native infrastructure that supports the production of big models. With the further development of big models, the current demand for big computing power in the industry is very strong. To meet the demands, SenseTime has proactively built an efficient, cost-effective, and scalable new infrastructure for artificial intelligence.

从 AI 原生基础设施到行业解决方案的商汤智慧

Leading Business Practices of Industry Solutions powered by AI Native Infrastructure of SenseTime

商汤 SenseCore 融合了 AI、超算与大数据的核心能力，通过为 AI 优化的高性能计算、高性能存储及缓存、高性能网络，以存算分离，大规模弹性、容错调度等特征，支撑大模型在数千张卡、PB 级存储上，完成万亿级参数大模型训练。基于 SenseCore 大装置，商汤推出‘日日新 SenseNova’大模型体系，为政企客户提供了多种灵活的 API 接口和服务，

包括图片生成，自然语言生成，视觉感知通用任务与标注服务。

SenseCore integrates the core capabilities of AI, supercomputing and big data, and supports the training of big models with trillions of parameters on thousands of cards and petabytes of storage through high-performance computing, high-performance storage and cache, and high-performance network optimized for AI, with features such as storage and computation separation, large-scale elasticity, and fault-tolerant scheduling. Based on the SenseCore large device, SenseTime launched the "SenseNova" large model system, which provides a variety of flexible API interfaces and services for government and enterprise customers, including image generation, natural language generation, visual perception common tasks, and annotation services.

商汤 SenseCore 大模型平台以人工智能大模型训练、推理、微调为核心驱动垂直优化的 AI 云，为企业提供高性能、安全、可靠的大模型训练、微调、推理云服务方案，全面提升企业 AI 应用的效果和价值，加速业务创新和发展。

SenseCore uses artificial intelligence large model training, reasoning, and fine-tuning as the core to drive the vertically optimized AI cloud, providing enterprises with high-performance, safe, and reliable cloud service solutions for large-scale model training, fine-tuning, and reasoning, and comprehensively improving enterprise AI. The effect and value of applications can accelerate business innovation and development.

基于 SenseCore AI 原生云基础设施，SenseCore AI 平台服务打造了开箱即用的大模型服务。其中，模型即服务（Model-As-A-Service）基于

商汤“日日新”大模型体系，及开源模型体系，为行业应用提供大模型推理、微调 API。

Based on the native cloud infrastructure of SenseCore AI, the SenseCore AI platform services have created a plug-and-play solution for large-scale models. Among them, the Model-As-A-Service leverages the SenseNova large model system and open-source model system to provide industry applications with large-scale model inference and fine-tuning APIs.



● SenseCore 商汤 AI 大装置架构图
● Architecture of SenseCore

“普惠 弹性 开放”的 AI 原生基础设施

SenseCore provides a set of "inclusive, flexible and open" AI-native infrastructure

商汤 SenseCore 大装置提供了高效的计算资源和基础设施支持，可以支持 20 个千亿超大模型同时训练，4000 卡并行超级节点，训练速度最多提升 70%。基于 AI 原生云基础设施，SenseCore 大模型平台为行业提供了开箱即用、高性能、低成本的大模型服务，将模型部署时间从传统 2 周减少至最少 2 小时；可蒸馏、微调应用于 20+ 个行业场景，用于数据自动标注时提升 4 倍以上效率。商汤 SenseCore 大模型平台将大大加速行业大模型应用研发，加速人工智能技术的进步和应用场景的扩展。

At the same time, it provides efficient computing resources and infrastructure support,

which can support the simultaneous training of twenty 100 billion super-large models, 4,000 card parallel super nodes, and the training speed can be increased by up to 70%. Based on the AI-native cloud infrastructure, the SenseCore large model platform provides the industry with out-of-the-box, high-performance, and low-cost large model services, reducing the model deployment time from the traditional 2 weeks to at least 2 hours; it can be distilled and fine-tuned for applications 20+ industry scenarios, which can increase the efficiency by more than 4 times when used for automatic data labeling. SenseC-

ore large-scale model platform will greatly accelerate the research and development of large-scale model applications in the industry, accelerate the progress of artificial intelligence technology and the expansion of application scenarios.



◎SenseCore 商汤 AI 大装置支持大模型产业发展蓝图

◎Development Blueprint of SenseCore Supporting Foundation Model Industry

商汤大装置 SenseCore 与商汤日日新 SenseNova 大模型体系 SenseCore AI infrastructure and SenseNova foundation model set

大模型时代的软件开发，由分布式的小模型迭代训练，进化到了中心化的大模型 2.0 时代。商汤 AI 大装置融合了 AI、超算与大数据的核心能力，通过为 AI 优化的高性能计算、高性能存储及缓存、高性能网络，以存算分离，大规模弹性、容错调度等特征，支撑大模型在数千张卡、PB 级存储上，完成万亿级参数大模型训练。

Software development in the era of large models has evolved from iterative training of distributed small models to the era of centralized large models 2.0. SenseTime's large AI device integrates the core capabilities of AI, supercomputing and big data. Through high-performance computing, high-performance storage and caching, and high-performance networks optimized for AI, it features storage and computing separation, large-scale elasticity, fault-tolerant scheduling and other features, supporting large models on thousands of cards and PB-level storage, and completing training of large models with trillions of parameters.

此外 SenseCore AI 平台产品，提供了模块化、全链条的数据、训练

及推理能力。可实现百亿级数据管理及检索，人工标注服务，加速 AI 大模型研发效率。一键量化、一键部署、一键应用，提供了大模型快速上线验证的工具，加速创新。

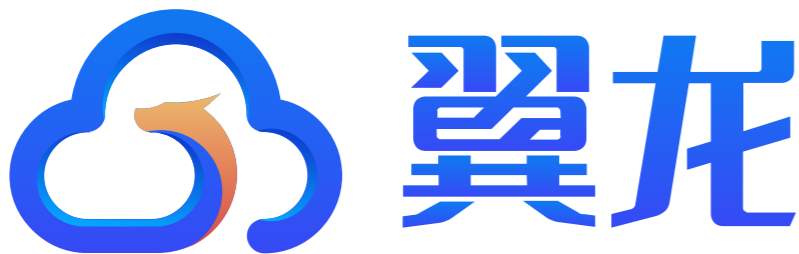
In addition, SenseCore AI platform products provide modular, full-chain data, training and reasoning capabilities. It can realize tens of billions of data management and retrieval, manual annotation services, and accelerate the efficiency of AI large model development. One-click quantification, one-click deployment, and one-click application provide tools for rapid online verification of large models and accelerate innovation.



◎商汤日日新大模型

◎SenseNova foundation model set

翼龙平台 Yilong



- 中国电信数字化技术底座翼龙平台，以远古时代的天空霸主命名，寓意着卓越和强大，平台能够引领各行各业腾云而上，在数字时代中翱翔
- Yilong, a digital technology platform developed by China Telecom, is named after a sky lord (Pterosaur) in ancient times, signifying excellence and power and hoping that the platform can lead all industries to soar in clouds in the digital age

中国电信集团有限公司
China Telecom Corporation Limited



引言

中国电信为服务好超大规模、超级复杂的 IT 系统上云，自主研发了高性能数据库、多云管理、跨三层监控等关键技术，结合中国电信遍布中国的天翼分布式云，最终打造了大规模多云数字化技术底座翼龙平台，实现了“上云、用云、管云”一站式全栈云服务。

Introduction

To serve super-large-scale and super-complex IT systems in clouds, China Telecom has independently developed many key technologies, including a high-performance database, multi-cloud management, and three-tier monitoring, all of which are compatible with China Telecom's CTyun across China. As a result, China Telecom can forge a large-scale multi-cloud digital technology platform - the Yilong platform, which empowers organizations to "transform to clouds, use clouds, manage clouds" with a one-stop full-stack cloud service.

翼龙平台攻克了多云管理、组件自动开通、全链路监控、持续集成交付等难题，通过丰富的 API 能力提供全方位上云服务
Overcoming such challenges as multi-cloud management, automatic component activation, full-stack monitoring, and continuous integration and delivery, the Yilong platform provides a full range of cloud services through rich APIs

针对传统数据库性能瓶颈难题，研制了事务型与分析型融合的分布式数据库（TeleDB），支持千万级并发用户访问，可对 PB 级数据进行处理，整体性能提升 10 倍，其中可靠性达 99.999%。

To address the performance limitations of traditional databases, we have developed a distributed database TeleDB which integrates transactional and analytical operations, supports 10 million concurrent accesses and petabytes of data processing, and improves overall performance by 10 times, providing a reliability of 99.999%.

针对多云使用难的问题，研制了贯穿 SaaS/PaaS/IaaS 三层云服务的技术底座，实现了多种 IaaS/PaaS 资源一体化自助订购，由原来 3-5 天人工安装配置开通缩短到分钟级自动开通。

To deal with the difficulties in using multiple clouds, we have developed a SaaS/PaaS/IaaS three-layer cloud service platform, Yilong. By enabling integrated self-service ordering of multiple IaaS/PaaS resources, we have shortened the original 3-5 days required for manual installation, configuration and deployment to just a few minutes for automated provisioning.

针对业务交付慢的问题，发明

了分层分级多分支流水线、三级任务调度算法、异构环境混合部署等技术，实现了云上应用的敏捷交付，应用开发交付效率提升 3 倍。

To solve the problem of slow applications go-live, we have invented such technologies as a layered hierarchical multi-branch pipeline, a three-tier task-scheduling algorithm, and hybrid deployments in heterogeneous environments, enabling agile delivery of applications on the cloud and improving application development and delivery efficiency by 3 times.

针对多系统难监控、故障难恢复的难题，创新构建混合链监控技术，实现云上应用的智能运维，支持日均千万级订单的实时监控能力，支持分钟级的端到端实时监控。

To tackle the challenge of monitoring and fault recovery across multiple systems, we have innovated hybrid chain monitoring technology that enables intelligent operation and maintenance of applications on the cloud and supports the capability of real-time monitoring of ten million orders per day and end-to-end real-time monitoring at the minute level.



- 翼龙主要创新技术包含融合型分布式数据库技术、集成一体化 PaaS 服务技术、大规模复杂应用敏捷开发交付等技术



- Major innovations of the Yilong platform include the integrated distributed database technology, the integrated PaaS service technology, and agile development and delivery of large-scale complex applications

翼龙平台支撑中国电信成功实现 2 年内 3000 多套 IT 系统上云的目标，助力 18 个行业的百余客户实现数字化转型

The Yilong platform has supported China Telecom in achieving its goal of transforming over 3,000 IT systems to the cloud within 2 years and has helped over 100 customers in 18 industries achieve their digital transformation

翼龙平台广泛的应用于中国电信及其客户上云工作中，已形成一个成熟的上云生态，为社会带来的效益如下：

Widely adopted by both China Telecom and its customers in cloud-based operations, the Yilong platform has established a mature cloud transformation ecosystem that delivers massive benefits to society:

经济效益方面，中国电信应用该成果极大地节约了成本。截至 2021 年底，中国电信全网盘活利旧、共享复用资源节资 5.5 亿元；下线商用软件 1120 套节资 7000 万元；关停低效系统节约投资 1.4 亿元。翼龙平台已全面支撑中国电信 3000 余套系统上云，支持客户 IT 上云拉动收入超 4.7 亿元。从外部看，翼龙数字化云平台底座已产生经济效益 14.58 亿。截至 2022 年底，支撑客户 IT 上云案例 686 个，打造了中国重型汽车集团有限公司、安徽省财政厅、哈尔滨统计局、重庆燃气集团等标杆项目。

In terms of economic benefits, China Telecom has achieved significant cost savings by employing Yilong. By the end of 2021, China Telecom had saved 550 million yuan by revitalizing old resources and sharing reusable resources across the entire network, saved 70 million yuan by shutting down 1,120 sets of commercial software, and saved 140 million yuan in investment by shutting down inefficient systems. The Yilong platform fully supports China Telecom's over 3,000 systems to operate in the cloud, while helping customers transform their IT systems to the cloud, driving over 470 million yuan in revenues. In addition, Yilong, the digital cloud platform, has generated economic benefits of 1.458 billion yuan for external customers. By the end of 2022, it had supported 686 customer projects in transforming their systems to the cloud. Our customers include China National Heavy Duty Truck Group Co., Ltd., Anhui Provincial Department of Finance, Harbin Bureau of Statistics and Chongqing Gas Group Corporation Ltd.

社会效益方面，翼龙平台赋能千行百业快速上云、便捷用云、高效管云，其中四个主要客户包括中国重型汽车集团有限公司、安徽省财政厅、哈尔滨统计局、重庆燃气集团。

In terms of social benefits, the Yilong platform has empowered cloud transformation across various industries, and assisted all customers in conveniently using and efficiently managing the cloud, including four major customers mentioned above.

环境效益方面，中国电信全网盘活利旧复用资源，间接减少因 PCB 生产带来的环境问题；提升 CPU、内存峰值利用率，节省电力，减少碳排放。

In terms of environmental benefits, China Telecom's revitalization and reuse of idle resources across its network have indirectly alleviated the environmental issues associated with PCB production. Additionally, by improving the peak utilization rate of CPUs and memories, it has saved a significant amount of electricity and reduced carbon emissions.

1.云基础架构带来的成本节约比：
不低于40%

- 1. 盘活主机1.58万台，节约5.5亿
- 2. 关停低效系统267套，节约1.4亿
- 3. 数字化办公成本降低40%-50%，节约约1.4亿

2.模块化、平台化带来的成本节约比：不低于30%

- 1. 关停1586台主机，复用347台，节约2339万
- 2. 近110+合作伙伴260+套业务平台，统一翼龙技术底座，开发成本降低30%

当前翼龙平台在中国电信内部支撑系统超3000个，实现IT系统100%云化，客户覆盖18个行业、服务100余客户

1. Cost saving ratio from cloud infrastructure: no less than 40%

- 1. Revitalized 15,800 mainframes, saving ¥550 million
- 2. Shut down 267 inefficient systems, saving ¥140 million
- 3. Reduced digital office costs by 40-50%, saving approximately ¥140 million

2. Cost saving ratio from modularization and platformization: no less than 30%

- 1. Shut down 1586 mainframes, reused 347 ones, saving 23.39 million
- 2. Nearly 110+ partners' 260+ business platforms were unified in the Yilong technology base, reducing development costs by 30%.

Currently, the Yilong platform is supporting over 3,000 systems in China Telecom, achieving 100% cloud transformation of IT systems. And it serves over 100 customers across 18 industries

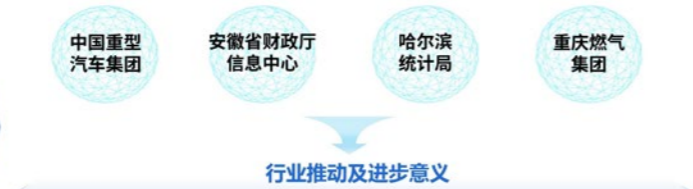
中国电信开展科技创新攻关，结合研究成果与成熟能力打造翼龙平台，赋能企业上云用云与数字化转型，以技术推动社会进步

China Telecom has made great efforts in technological research and development and built the Yilong platform based on research results and mature capabilities. The platform enables enterprises to undergo cloud and digital transformation, thereby promoting social progress via technology

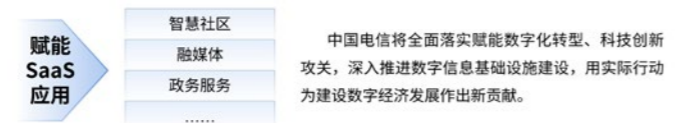
通过使用翼龙 PaaS 组件彻底解决了性能瓶颈。中国电信集团 3000 余套系统使用翼龙平台自研 PaaS 组件，支撑全国千万级并发用户访问。在翼龙数字化底座的内外应用，产生了众多迁移上云的成功案例，为行业树立了企业数字化转型标杆。中国电信助力数字经济建设。发挥云网融合优势，积极输出翼龙技术底座、上云方法路径，赋能各行各业数字化

翼龙多云大规模数字底座，平台赋能千行百业

翼龙平台基于“2+4+31+X”的天翼分布式云布局，针对业务上线慢、多云使用难等问题，攻克了数据库、敏捷交付、智能运维等技术难题，提供了企业“上云、用云、管云”通用的一站式全栈云服务。



自研PaaS组件，全面引领企业上云，赋能千行百业数字化转型



Yilong Multi-Cloud Massive Digital Base Empowered Cloud Transformation Across Various Industries

Based on the "2+4+31+X" distributed CTyun, Yilong Platform has overcome technical problems with databases, agile delivery, and intelligent operation and maintenance, while empowering organizations to "transform to clouds, use clouds, manage clouds" with a one-stop full-stack cloud service, so as to address such problems as slow business deployments and difficult usage of multiple clouds.



Industrial Promotion and Progressive Significance Self-developed PaaS components lead enterprises to clouds, empowering the digital transformation across industries.



转型。翼龙平台使中国电信在云计算领域从追随者转变为开发者、倡导者。

Employing of the Yilong PaaS components can greatly resolved performance bottlenecks. Yilong's self-developed Paas components support over 3,000 systems for China Telecom, processing ten million concurrent user visits nationwide. Numerous successful cloud migration cases of deploying Yilong within and outside China Telecom set a good example of digital transformation for industries. China Tele-

com assists the construction of digital economy by taking advantage of cloud network integration. It has actively exported the Yilong platform and its cloud-based transformation methodology to various industries. In this process, the Yilong platform also transformed China Telecom from a follower to a developer and advocate in the field of cloud computing.

翼龙平台带来的经济价值包括：基础架构带来的成本节约不低于40%。全网利旧盘活、关停系统，节约1.4亿。统一技术底座，在业务上云方面降低30%开发成本。

The economic value brought by the Yilong platform includes: cost savings of no less than 40% resulting from changes in the infrastructure, savings of 140 million yuan from revitalizing and shutting down old systems, and a decrease of development cost by 30% in terms of cloud-based operation due to utilization of the unified technology platform.



通过翼龙平台一体化能力，结合标准化上云实施路径方法，使得在承载中国电信全网3000余套IT系统安全稳定运行的同时，也助力各行各业实现规模化上云转型

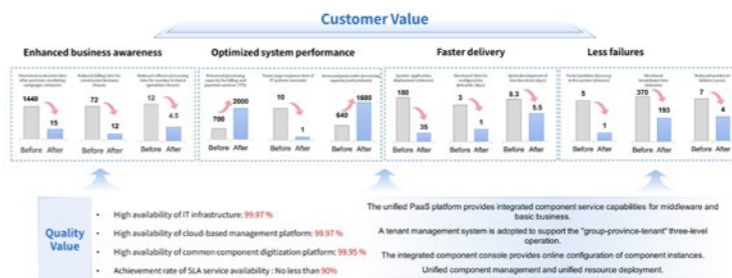


By giving play to the integrated capability of the Yilong platform, combined with the standardized cloud transformation methodology, over 3,000 IT systems across China Telecom's entire network can operate safely and stably, while facilitating various industries to undergo large-scale cloud transformation



- IT基础架构可用性: 99.97%
- 云化管理平台可用性: 99.97%
- 共性组件数字化平台可用性: 99.95%
- SLA的服务可用性达成率: 不低于90%

翼龙平台帮助客户高效、便捷、高质量地研发部署自身SaaS化应用，提升用户感知



- High availability of IT infrastructure: 99.97%
- High availability of cloud-based management platform: 99.97%
- High availability of common component digitization platform: 99.95%
- Achievement rate of SLA service availability: No less than 90%

The Yilong platform helps customers develop and deploy their own SaaS-based applications efficiently and conveniently in a high-quality manner, while enhancing user experience

翼龙平台帮助客户优化系统性能、提升研发运维效率、改善业务感知，助力客户提质增效，实现高质量上云用云

The Yilong platform has enabled customers to optimize their system performance, enhance R&D and O&M efficiently, and improve customer experience. Furthermore, it has helped customers achieve greater quality and efficiency, as well as high-quality cloud usage

随着企业规模越大，内部流程越复杂，数据资产越丰富，越需要强大的PaaS层进行资源管理和调配。翼龙平台通过支撑IT上云，实现业务快速交付和运营效率提升，改善了用户感知，优化了系统性能，加快了交付速度，降低了故障频率，解决了业务痛点和难点。

Large enterprises typically have complex internal processes and rich data assets, which often require a powerful PaaS layer for resource management and provisioning. By supporting cloud-based IT operations, the Yilong platform can rapidly deliver services, enhance operational efficiency, improve user experience, optimize system performance, and reduce fault frequency. Therefore, it can solve many business pain points and difficulties.

翼龙平台还实现了IT质量提升，使IT基础架构高可用性达99.97%，云化管理平台高可用性达99.97%，共性组件数字化平台高可用性达99.95%，SLA的服务可用性达成率不低于90%。

The Yilong platform can also improve IT quality, with high availability of infrastructure (99.97%), cloud-based management platform (99.97%), common component digitization platform (99.95%), and service availability of no less than 90% for SLAs.

安全可靠溯源的 VoWiFi 技术创新及应用示范

Secure and Traceable VoWiFi Technology Innovation and Application Demonstration

用电信宽带打电话 VoWiFi让远方的爱更近了



● 安全可靠溯源的 VoWiFi 技术
● Secure and traceable VoWiFi technology

中国电信集团有限公司
China Telecom Corporation Limited



引言

安全可靠溯源的 VoWiFi 技术通过 WiFi 信号承载移动语音业务，实现了一种快速、安全、经济的方案，解决移动网络弱覆盖场景带来的语音、短信等业务质量问题。提升用户通信体验，满足人民对美好信息生活的向往。

Introduction

Secure and traceable VoWiFi (Voice over WiFi) technology carries mobile voice services through Wi-Fi signals, realizing a fast, secure and economical solution to solve the voice, SMS and other service quality problems caused by weak mobile network coverage. Thus enhancing users' communication experience to better fulfil people's aspiration for an information-oriented lifestyle.

攻克 WiFi 与 5G 融合组网、用户精准溯源等核心难题，实现安全可靠溯源的 VoWiFi 业务

Overcoming core challenges such as the integration of WiFi and 5G networks, the user accurate traceability, and realizing secure and traceable VoWiFi services

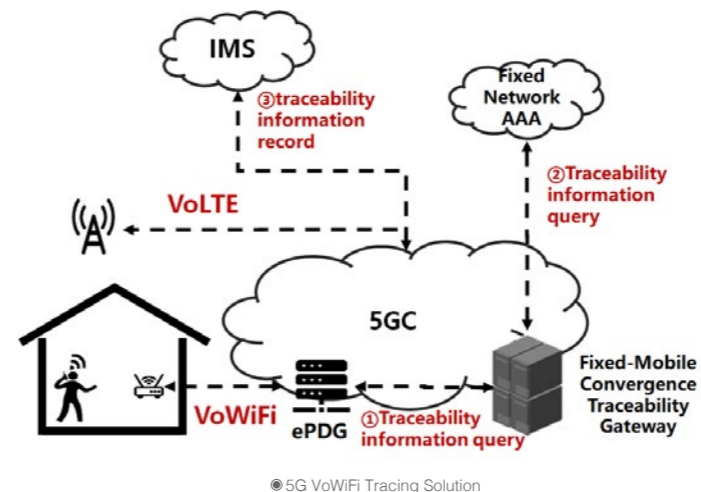
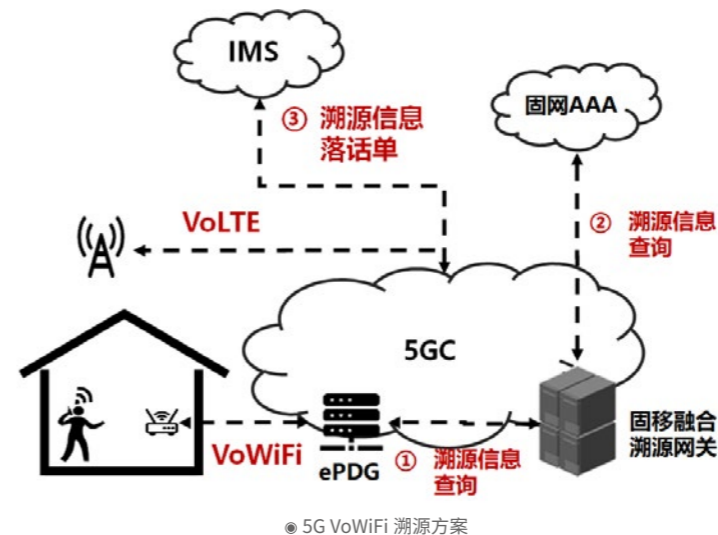
为有效解决居民住宅、乡村区域移动网络弱覆盖带来的语音、短信等业务质量问题，中国电信深入实践三千兆融合，攻克了 WiFi 与 5G 融合组网、用户精准溯源等多个关键技术难题，打造安全可靠溯源的 VoWiFi 技术，实现了多项技术

创新：

To effectively improve the voice, SMS and other service quality problems caused by weak mobile network coverage in residential and rural areas, China Telecom has deeply implemented the "Triple Gigabit" convergence, successfully overcoming key technological challenges such as the integration of Wi-Fi and 5G networks, the user accurate traceability, thus developing secure and traceable VoWiFi technology, resulting in a number of technological innovations:

1. 国际上首个基于 5G SA 的 VoWiFi 组网方案，解决 5G 用户使用 VoWiFi 业务问题，并完成商用部署和用户放号。
2. 业内首创基于固移融合网络和用户的鉴权、溯源方案，通过移动用户和固网“双因子”鉴权方式，实现精准到户的溯源能力，精度高于移动网。2022 年 5 月在上海打通了全球首个端到端带溯源的 VoWiFi First Call。
3. 研发业界首台固移融合溯源网关，保障用户通信安全，助力电信反诈。

1.The first VoWiFi networking solution based on 5G SA in the world, resolving the issue



of 5G users using VoWiFi services, and completing commercial deployment and user number release.

2. The industry's pioneering authentication and traceability scheme based on fixed mobile converged network and users, through the "dual factor" authentication method of mobile users and fixed network, realizes the traceability of accurate to household, which is higher than that of mobile network. In May 2022, the world's first VoWiFi First Call with end-to-end traceability was opened in Shanghai.

3. The industry's first fixed mobile convergence traceability gateway was developed to ensure user communication security and help telecom anti-fraud.

VoWiFi 在中国电信实现了商用部署，全面提升了移动网用户的通信感知

VoWiFi achieved commercial deployment in China Telecom and comprehensively improved the communication perception of mobile network users

安全可靠溯源的 VoWiFi 技术目前已进入商用推广阶段，今年 5.17 电信日，上海等三省已正式推出试商用，试商用用户感知整体体验良好，投诉问题有效解决。

The secure and traceable VoWiFi technology has now entered the commercial promotion stage. On Telecom Day, May 17th this year, three provinces including Shanghai have officially launched the trial commercial deployments. The overall experience of the trial commercial users is good, while the complaints are effectively solved.

经济效益方面，VoWiFi 可解决城市居民区或边远乡村等区域因弱覆盖导致的语音、短信问题，大幅压降居民区弱覆盖投诉，年降本超 5 亿元。

In terms of economic benefits, VoWiFi can solve the voice and SMS problems caused by weak coverage in urban residential areas or rural areas, greatly reducing the complaints of weak coverage in residential areas, resulting in an annual cost reduction of over 500 million yuan.

社会效益方面，VoWiFi 可以通过 WiFi 网络提供更稳定、更快速、更安全的无线通信服务，满足用户对于通信质量的要求，提升用户通信体验，满足人民对美好生活的向往。

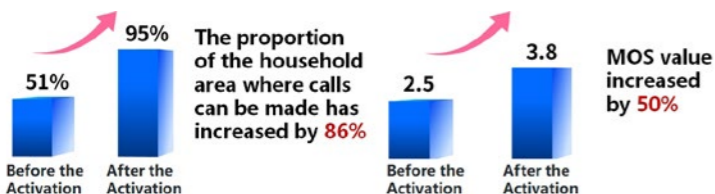
In terms of social benefits, VoWiFi can provide more stable, faster and safer wireless communication services through WiFi networks, meet users' requirements for communication quality, improve users' communication experience, thus better fulfilling people's aspirations for a better life.

生态环境效益方面，VoWiFi 可等效减少居民区内基站建设，降低能源消耗，减少碳排放，推动网络绿色发展。每年可等效减少碳排放 43.2 万吨。

In terms of ecological and environmental benefits, VoWiFi can effectively reduce the need for base station construction in residential areas, thereby reducing energy consumption and carbon emissions, and promoting the green development of the network. It can lead to an annual equivalent reduction in carbon emissions of 432,000 tons.



VoWiFi 用户体验测试结果



VoWiFi User Experience Test Results

通过标准牵引产业成熟，拉动上下游发展，成果获得多方报道

Through standards to promote the maturity of the industry and drive the development of upstream and downstream, the achievements have received extensive media coverage

在研发道路上，中国电信充分发挥标准引领作用，在 GSMA 牵头形成 VoWiFi 终端需求白皮书；在 3GPP 完成 VoWiFi 与蜂窝互操作协议测试标准；在 GCF 牵头 VoWiFi 终端互操作协议一致性认证项目。从需求、创新技术方案、测试到认证全链条推动 VoWiFi 终端产业成熟。

On the road of research and development, China Telecom gives full play to the leading role of standards, leading the formation of the VoWiFi terminal demand white paper in GSMA, completing the VoWiFi and cellular interoperability protocol test standards in 3GPP, leading VoWiFi terminal interoperability protocol consistency certification project in GCF. From demand, innovative technical solutions, testing to certification, the whole chain promoted the maturity of VoWiFi terminal industry.

同时，由中国电信牵头各方成立 5G VoWiFi 创新联盟，不仅推动 5G 网络设备商完成了现网升级；还获得了包括华为、苹果等头部厂商 10 余款终端产品的支持。

Meanwhile, China Telecom led the establishment of the 5G VoWiFi Innovation Alliance, which not only promoted 5G network equipment manufacturers to complete the network upgrades, but also won the support of more than 10 leading device manufacturers including Huawei and Apple.

今年 MWC 世界移动通信大会期间，5G VoWiFi 技术作为中国电信十大科创成果正式发布。目前，VoWiFi 相关成果的发布已得到新华社、人民网、人民邮电报等数百家媒体的转载报道。

During this year's MWC, 5G VoWiFi technology was officially released as one of China Telecom's top ten scientific and technological achievements. Currently, the release of VoWiFi-related achievements has been reprinted and reported on by hundreds of media outlets including Xinhua News Agency, People's Daily Online, and People's Posts and Telecommunications News.



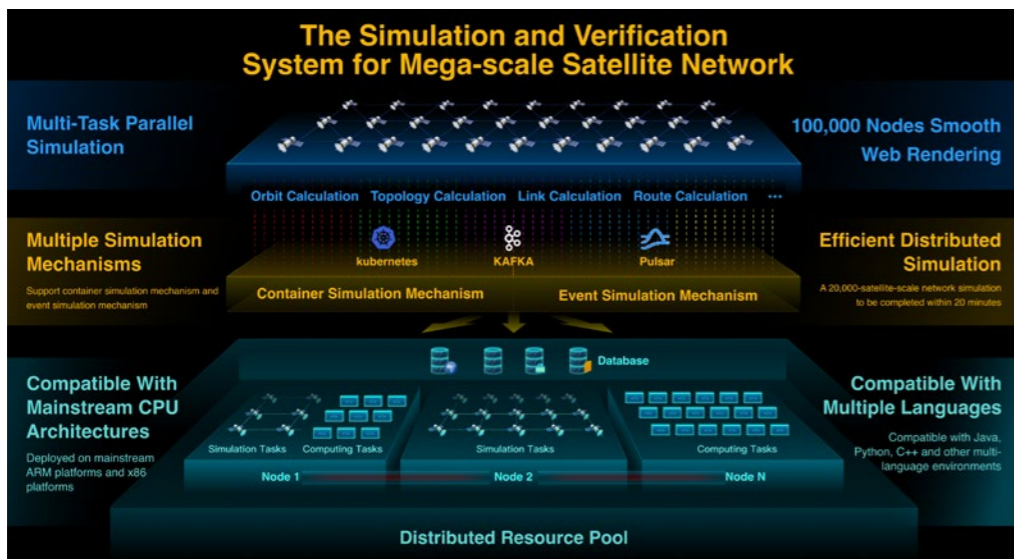
5G VoWiFi 创新联盟成立
5G VoWiFi Innovation Alliance Established

空间超大规模卫星网络仿真验证系统

The Simulation and Verification System for Mega-scale Satellite Network



空间超大规模卫星网络仿真验证系统架构示意图



The Architecture of the Simulation and Verification System for Mega-scale Satellite Network

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引言

鹏城实验室联合哈尔滨工业大学面向卫星网络技术和商用需求，构建了空间超大规模卫星网络仿真验证系统，支持不小于2万节点卫星网络的组网规划、性能分析、关键技术仿真等，助力卫星互联网和6G NTN技术标准化。

Introduction

PengCheng Laboratory, in collaboration with Harbin Institute of Technology, has developed the Simulation and Verification System for Mega-scale Satellite Network (hereinafter referred to as "the simulation system"), targeting researches on satellite network technologies and business demands. The simulation system supports satellite network planning, network performance prediction, and key technology simulation of a satellite network with no less than 20,000 nodes, and helps standardize satellite Internet and 6G NTN technology.

分布式高并发仿真引擎使能万级卫星网络高效仿真

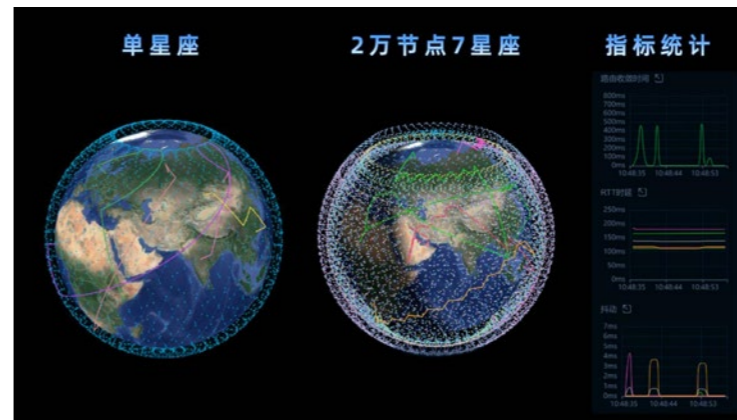
Distributed High-concurrency Simulation Engine Enables Efficient Simulation of 20,000-satellite-scale Network

研发了计算和仿真分离的分布式云原生仿真系统，实现了超大规模动态卫星网络亿级计算任务的秒级处理，以及仿真效率随算力资源的线性增长，万级规模卫星网络仿真可在20分钟内完成。

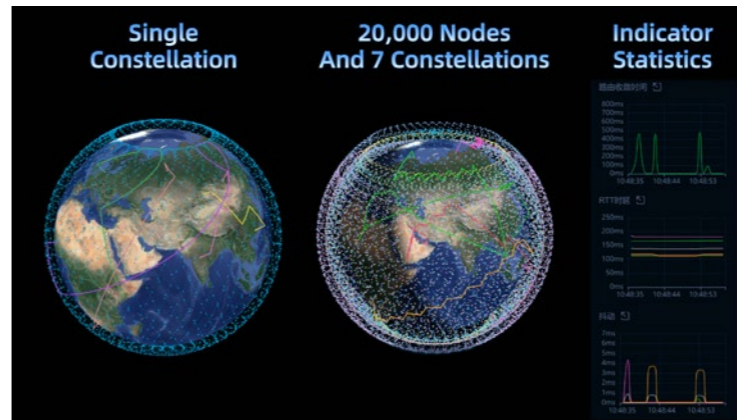
By separating the computation and simulation, the distributed cloud native simulation system was developed. The simulation system is able to handle a billion of computing tasks of a mega-scale dynamic satellite network in seconds and improve simulation efficiency linearly as the computing resources increase, which allows a 20,000-satellite-scale network simulation to be completed within 20 minutes.

突破了分布式高效事件仿真机制，解决了容器仿真机制下网络仿真规模小、效率低等问题，实现了万级卫星网络场景下星地通信协议仿真、星间路由仿真、频率规划和干扰规避等复杂功能。

By accomplishing a distributed event-based simulation framework, the simulation system solves the small scale and low efficiency problems of container-based network simulation. The simulation system realizes complex simulation functions for 20,000-satellite-scale networks, such as the simulation of satellite-ground communication protocol, the satellite network routing scheme, frequency planning, interference avoidance, etc.



多星座卫星网络路由协议仿真



Routing Protocol Simulation of Multi-constellation Satellite Network

支持超大规模卫星网络仿真的前端流畅渲染，通过CesiumJS下的拆分重组数据集、聚合渲染实体、剔除遮挡实体、计算渲染分离等技术优化，实现了10万级卫星网络的前端三维流畅渲染。

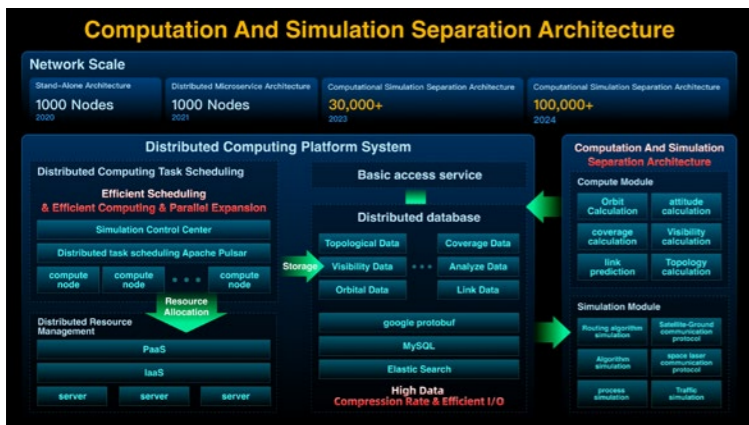
Depending on the high performance of CesiumJS, smooth 3D rendering of a satellite network with 100,000 nodes has been achieved on the graphical user interface of the simulation system by implementing a set of optimizations, such as splitting and rebuilding data set, aggregating rendered entities, removing blocked entities, separating computing and rendering, etc.

兼容主流ARM架构和X86架构处理器的分布式部署，满足不同用户对云平台底层架构的灵活选择。

The processor compatibility of the simulation system has been tested, allowing the simulation system to be deployed on mainstream ARM platforms and X86 platforms, which provides multiple choices of underlying architecture of cloud platform for users.



空间超大规模卫星网络仿真验证系统计算和仿真分离架构

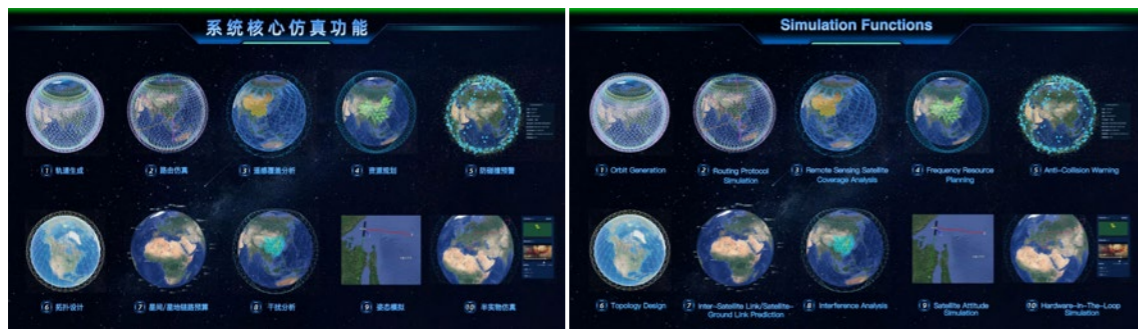


The Architecture of Separating Computation and Simulation

支持卫星网络关键技术仿真验证，驱动产业技术创新

The Simulation System Supports Key Technology Simulation and Verification of Satellite Networks and Powers the Satellite Industrial Technology Innovation

卫星互联网技术研究过程中通常需要轨道类仿真软件、网络协议类仿真软件等多软件配合使用才能开展仿真，针对这一痛点，鹏城实验室研发了空间超大规模卫星网络仿真验证系统，具备复杂卫星网络场景构建、轨道计算、网络通信协议库、业务模拟等基础能力，支持卫星网络拓扑设计、



空间超大规模卫星网络仿真验证系统核心功能

Key Features of the Simulation System

空间 / 星地链路预算、星地 DVB 协议仿真、路由仿真、防碰撞预警、频率规划与干扰仿真、半实物仿真等 10 大核心功能。

In order to carry out a complete simulation, the research on satellite-based Internet technology typically requires fused use of multiple softwares, such as the orbit simulation software and the network protocol simulation software. To address this issue, Pengcheng Laboratory developed the simulation system, which offers basic functions like complex satellite network scenario construction, satellite position computation, communication protocol libraries and transaction simulation. Further more, the simulation system provides 10 key features, such as satellite network topology design, inter-satellite link/satellite-ground link prediction, satellite-ground DVB protocol simulation, network routing scheme simulation, collision warning, frequency planning, interference simulation and hardware-in-the-loop simulation, etc.

仿真系统已应用于银河航天、航天恒星、中国星网等多家卫星通信核心企业的技术验证，并获得了应用单位的认可，有力支撑卫星通信产业技术研究。

The simulation system has been applied for technical verification by several enterprises in satellite industry, including Yinhe Hangtian (Beijing) Technology Co. Ltd., Space Star Technology Co. Ltd. and China Satellite Network Group Co. Ltd. It has gained endorsements from these enterprises, whose technical researchs have been guaranteed by the simulation system.

(三) 成果展示



航天恒星科技有限公司基于鹏城分布式仿真引擎的应用
The Application of the Simulation System by Space Star Technology Co. Ltd.



基于鹏城实验室仿真平台，503所将构建起支撑万级规模星座网络仿真系统。系统按照基础层、资源层、引擎层、业务层和应用层五层体系结构进行搭建。通过引擎层将基础层、资源层、业务层、应用层有效贯穿起来，实现业务与功能分离、模型与数据分离、模型与平台分离。

鹏城实验室

打造卫星通信行业专用仿真系统，开启卫星互联网技术研究新征程

The Dedicated Simulation System for Satellite Communication Industry Launches a New Journey of Satellite Internet Technology Research

空间超大规模卫星网络仿真验证系统针对中国卫星互联网建设和技术研究的迫切需求而设计，旨在为卫星互联网行业技术研究提供专用仿真平台，提升技术成熟度、加快卫星网络部署。目前，鹏城实验室围绕卫星网络规划、关键仿真、网络运维等深度需求，已经与多家卫星通信网络研究和产业核心单位联合，进行了三年研发规划，不断丰富仿真系统功能，持续提高仿真性能，打造多语言兼容的卫星仿真类开放平台，为卫星行业的研究和应用提供更多的支撑。

The simulation system is designed to meet

the urgent needs of China's satellite Internet construction and technical research, with the purposes of providing a dedicated satellite Internet researching platform and enhancing technological maturity. Regarding to the these demands, Pengcheng Laboratory, along with several companies in satellite Internet industry, have worked out another three-year development plan. The united entity will continuously enrich the features, optimizing the efficiency of the simulation system and eventually build an open multilingual satellite simulation platform, so as to further support the researches and applications of satellite industry.



航天主要企业试用证明

Trial Certificates from Major Aerospace Companies

曙光 ParaStor 液冷存储系统

Sugon ParaStor Liquid-Cooled Storage System



曙光信息产业股份有限公司
Sugon

中科曙光
Sugon

引言

数据中心作为支撑数字经济的“基座”，建设和发展都面临着巨大的能耗挑战。为了落实“双碳”发展战略，实现数据中心绿色目标，凭借多年在液冷和存储领域的技术积累，曙光推出业内首款高密度液冷存储方案——曙光 ParaStor 液冷存储系统。

Introduction

As the base supporting the digital economy, the data center faces a huge challenge of energy consumption in terms of its construction and development. To implement the strategy of Carbon Peaking and Carbon Neutrality and realize the green and energy-saving target of the data center, Sugon, by virtue of its technology accumulation of years in the fields of liquid cooling and storage, launches the first high-density liquid-cooled storage solution in the industry—Sugon ParaStor Liquid-Cooled Storage System.

打造行业先驱 业内先进液冷存储系统

A pioneer in the industry and Advanced liquid-cooled storage system

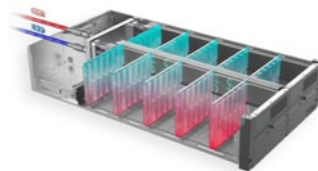
曙光 ParaStor 液冷存储系统，开创性地将液冷技术与存储技术深度结合，为存储领域液冷产品打造行业先驱。

Sugon ParaStor Liquid-Cooled Storage System deeply integrates the technologies of liquid cooling and storage in a groundbreaking way, becoming a pioneer in the industry for liquid cooling products in the sector of storage.

曙光 ParaStor 液冷存储系统，继承了曙光 20 余年的技术优势，巧妙地将换热效率更高的冷板式液冷方案与存储技术结合，显著降低内存、HDD 存储关键部件的工作温度，大幅降低散热功率。相比于风冷，液冷存储系统性能提升超过 20%。为了将“绿色”发挥到极致，曙光还对系统软件进行了深度优化，通过采用大比例纠删码、数据重删压缩、硬盘分区休眠、电源功耗精细化控制等技术，在保证容量和性能的基础上，充分提高存储资源利用率，最大限度降低存储系统功耗。

Sugon ParaStor Liquid-Cooled Storage System inherits Sugon's technological advantage

of over 20 years and neatly combines the cold plate liquid cooling scheme featured by higher heat exchange efficiency with the storage technology, significantly reducing the operating temperature of the critical components of memory and HDD storage, and the heat dissipation power is greatly reduced. Compared with air cooling systems, the performance of liquid cooling storage systems improves by more than 20%. In order to give full play to the green feature, Sugon also makes an in-depth optimization of the system software by adopting technologies such as large-scale erasure codes, data de-duplication and compression, disk partition hibernation, and fine control over power consumption to fully improve the utilization rate of storage resources and minimize the power consumption of the storage system on the basis of ensuring capacity and performance.



● 软硬一体液冷存储方案
● A liquid-cooled storage solution integrating software and hardware

绿色存力 打通绿色数据中心最后一站

Green storage, accessing the last stop of the green data center

在应用层面，曙光 ParaStor 液冷存储系统灵活配置多种场景。

From the perspective of applications, Sugon ParaStor Liquid-Cooled Storage System can be configured flexibly to adapt to a variety of scenarios.

与曙光液冷服务器技术同源，为便于数据中心基础设施的统一规划、设计和共用，曙光 ParaStor 液冷存储系统可便捷、高效地与液冷服务器形成“存算一栈式”液冷方案，可将数据中心 PUE 值降至 1.1 以下。

For the purpose of facilitating the unified planning, design, and sharing of data center infrastructure, Sugon ParaStor Liquid-Cooled Storage System, with the same technical origin as Sugon liquid cooling server, can conveniently and efficiently constitute a liquid cooling solution of "Storage and Computing in One Stack" with the liquid cooling server, which can reduce the data center PUE to less than 1.1.



● 存算一栈式液冷方案
● Liquid cooling solution of "Storage and Computing in One Stack"

节能减排 年度节约 450 万度电量

Achieving energy conservation and emission reduction and saving electricity of about 4.5 million kWh annually

数据显示，存储系统的功耗约占数据中心 IT 设备系统总功耗的 35%，仅次于服务器能耗，液冷存储是实现数据中心“深度绿色化”的关键一环，以 EB 级数据中心耗电量为例，采用液冷存储相比风冷存储，一年可节约 450 万度电量，减少 1493 吨 CO₂ 排放，支持 2812 个家庭的年度电量，相当于种植 82957 棵树。

Data reveals that the power consumption of the storage system approximately accounts for 35% of the total power consumption of the IT equipment system in the data center,

second only to the server power consumption. Liquid cooling storage is a key part of achieving the deep greening of data centers. Take the power consumption of an EB-level data center for example: in comparison with the air cooling storage, the liquid cooling storage can save electricity of 4.5 million kWh per year, reduce CO₂ emissions of 1,493 tons, and provide annual power consumption for 2,812 households, equivalent to planting 82,957 trees.

崖山数据库系统

YashanDB



崖山数据库系统 YashanDB

企业级融合数据管理解决方案

自研|高端|根技术



●崖山数据库系统：企业级融合数据管理解决方案

●YashanDB: Enterprise-Grade Hybrid Data Management Solutions

深圳计算科学研究院
Shenzhen Institute of Computing Sciences



引言

该成果是深圳计算科学研究院自主研发的新型数据库系统，融入原创理论，支持单机 / 主备、共享集群、分布式等多种部署方式，覆盖 OLTP/HTAP/OLAP 场景，当前已规模化复制应用在金融、政府、央国企、能源等重点行业数十个核心系统。

Introduction

YashanDB, a new database system completely independently designed and developed by Shenzhen Institute of Computing Sciences (referred to as SICS), incorporates original theories, supports multiple deployment methods such as stand-alone/primary-standby, shared-disk, and distributed, covers OLTP/HTAP/OLAP transactions and analyzes mixed load scenarios, and is fully compatible with privatization and cloud infrastructure, providing clients with one-stop enterprise-level hybrid data management solutions to meet the needs of key industries such as finance, government, state owned enterprise and energy for high performance, concurrency and security.

打破传统数据库理论，让数据库性能、成本、可用性达到新高度

YashanDB: Breaking through traditional database theories, allowing DBMS performance, cost and availability to reach new heights

该成果基于原创内核架构，全面支持众核、RDMA、智能计算、云基础设施等面向未来的软硬件技术。融入深算院原创的有界计算、近似计算、并行可扩展、并行事务和跨模融合计算理论，相关成果荣获“皇家学会沃尔夫森研究优秀奖 (Royal Society Wolfson Research Merit Award)”、ACM PODS/SIGMOD/ICDE/VLDB 四大数据库国际顶级会议奖项。主要创新性如下：

YashanDB, based on its original kernel architecture, fully supports future-oriented software and hardware technologies such as manycore processors, RDMA, AI computing and cloud infrastructure. It incorporates our original Bounded Evaluation theory, Data-driven Approximation theory, Parallel Scalability theory, Transaction parallelism theory and Cross-Modal Fusion Computation theory. These theories have won the Royal Society Wolfson Research Merit Award, and top international conference awards including ACM PODS, SIGMOD, ICDE, and VLDB. The main innovations are as follows:

该成果融入了有界计算方法，将大数据变小，实现受限资源下的大数据查询。经实测数据量从 10GB 增长到 1TB，崖山数据库系统响应时延维持亚秒级，性能提升千倍以上且未衰减。

It creatively proposes and validates the bounded evaluation computation method, which explores intrinsic correlations and constraints within the data, enabling queries on big data under constrained resources. Through benchmarking, the response latency of YashanDB maintains at the sub-millisecond range even when the data volume increases from 10GB to 1TB.

该成果通过细粒度并发控制、免锁事务优化和自适应并发调度算法等技术，最大程度提升单机的事务处理性能，提供可用于生产的 Benchmark 性能测试配置和测试数据，性能超出主流商业数据库 30% 以上。

YashanDB has achieved excellent single-machine transaction processing performance through fine-grained concurrency control, lock-free transaction optimization, and adaptive concurrency scheduling algorithms. According to the well-known benchmarking system TPC-C, YashanDB outperforms mainstream commercial databases by more than 30%.

该成果面向企业核心业务场景推出了可完全自主演进的共享集群技术，具备天然高可用优势，做到大负载下 RTO < 10s, RPO=0。

For mission critical business system, YashanDB has launched a shared-disk technology that can be fully autonomously evolved, providing high availability with Recovery Time Objective (RTO) <10s and Recovery Point Objective (RPO)=0 under heavy loads.



●凭借技术创新，崖山数据库系统荣获第五届数字中国建设峰会“十大硬核科技”

●With technological innovation, the YashanDB was honored as one of the "Top Ten Hardcore Technologies" at the 5th Digital China Summit

赋能千行百业，推动行业提质降本增效

Empowering thousands of industries, YashanDB promotes industry quality improvement, cost reduction, and efficiency enhancement

崖山数据库系统作为通用基础软件，可面向高端核心、HTAP 混合负载、实时数仓、实时多模数据管理与分析、办公 OA 等多种场景，具备可复制性商用能力。

As a general basic software, YashanDB can be used in various scenarios such as mission critical systems, HTAP hybrid load, real-time data warehouse, real-time Cross-Modal data management and analysis, Office Automation, etc., and has replicable commercial capabilities.

截止目前，该成果已规模化复制应用在金融、政府、央国企、能源等重点行业数十个重要核心业务系统上线应用，满足用户对高性能、高可用、高安全性的要求。

YashanDB has been mass adapted in dozens of mission critical systems in key industries such as finance, government, state-owned enterprises, and energy, meeting the requirements for high performance, high availability, and high security.

经行业实际应用场景验证，部署崖山数据库系统后整体使用成本仅为国际主流产品的 1/6，在应用改造成本、license 费用与维护成本以及相同硬件条件下性能表现方面均具备显著优势。同时该成果充分考虑对国际主流生态的兼容能力，在某银行 CRM 系统迁移过程中，实现了百万行存储过程的平滑迁移，大幅降低了企业替换改造的成本。

Through practical scenarios, it has been verified that deploying YashanDB significantly reduces overall costs compared to mainstream commercial databases, with a cost advantage of only 1/6 in terms of application migration costs, license fees,

maintenance costs, while achieving comparable performance under the same hardware conditions. Meanwhile, YashanDB is compatible with the international mainstream ecology. In one bank's CRM system, YashanDB enabled a smooth migration of millions of lines of stored procedures, greatly reducing the costs of enterprises for database replacement and transformation.



● 不同行业上线崖山数据库系统应用效果图

● The application effect diagrams of the YashanDB in various industries going live

繁荣数字化人才生态，助推行业数字化转型

Promoting the digital talent ecosystem and boosting industry digital transformation

崖山数据库团队注重产学研融合，打造了一套完整的数据库培训认证体系（YCA、YCP、YCE），开展走进高校系列人才培养，培养了一批高端

的数据库内核人才，为国产数据库长远发展厚植一方沃土。

The YashanDB team values industry integration, academia, as well as research, and has developed a comprehensive DBMS training and certification system, including YCA (YashanDB Certified Associate), YCP (YashanDB Certified Professional), and YCE (YashanDB Certified Expert). We carried out a series of talent

training programs in universities, and cultivated a group of high-end DBMS talents, providing a fertile ground for the long-term development of domestic DBMS.

同时，崖山数据库团队携手了中国 30 多家主流硬件伙伴，联合打造解决方案，构建了良好的上下游产业链生态，一站式满足用户数字化转型需求，夯实数字化技术底座。

The YashanDB team has collaborated with over 30 mainstream hardware and software partners in China to jointly create solutions and build an upstream and downstream industrial ecosystem to meet users' needs of digital transformation in one stop.



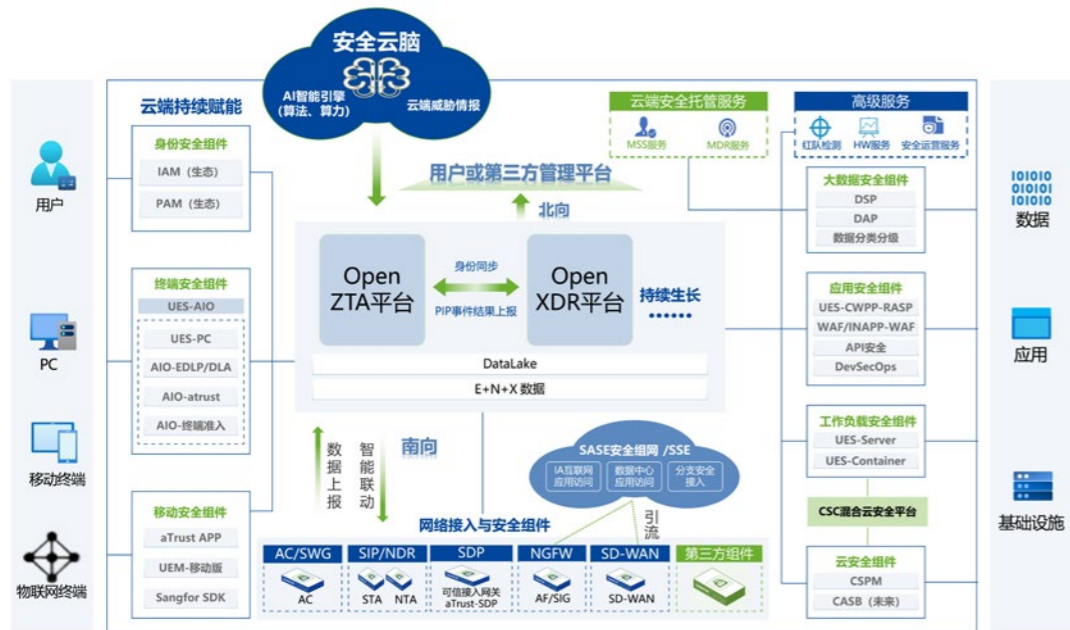
● 崖山数据库系统团队携手上下游伙伴共促行业数字化转型

● YashanDB team collaborates with upstream and downstream partners to jointly promote the digital transformation of the industry

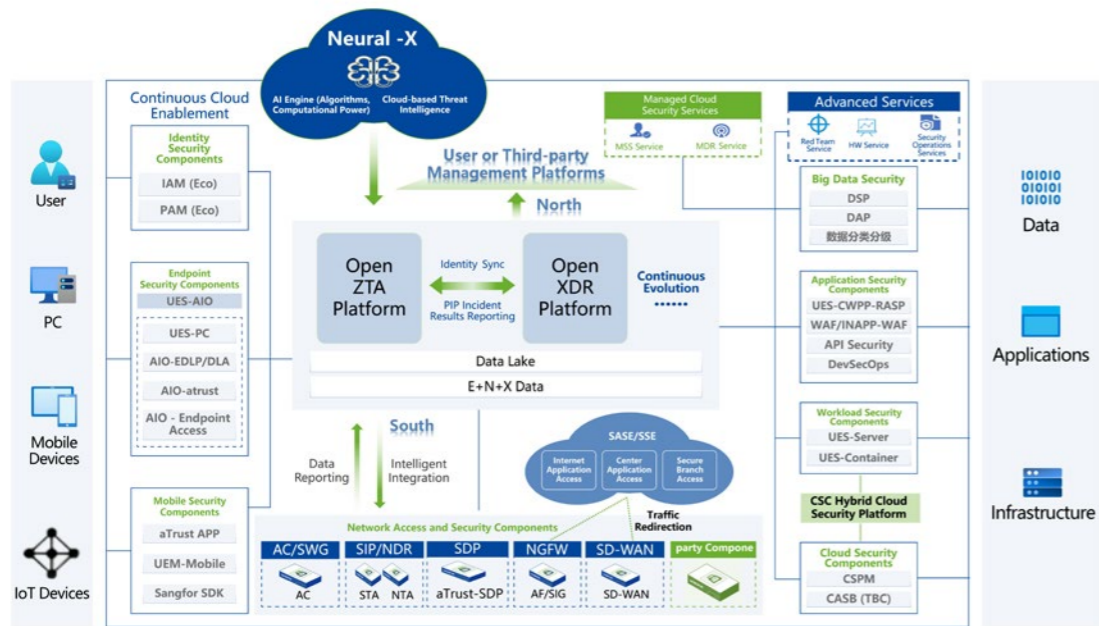
云地协同的新一代人工智能安全引擎

Next-generation Cloud-local Collaborative AI Security Engine

深信服科技股份有限公司
Sangfor Technologies Inc.



© 云地协同的新一代人工智能安全引擎架构



© Architecture of Next-generation Cloud-local Collaborative AI Security Engine

引言

信息技术就像新时代的火种，既为人们带来便利和机会，也会引入风险和隐患。面对层出不穷的技术创新，安全威胁也层层加码，“云地协同的新一代人工智能安全引擎”应运而生。该成果由深信服科技股份有限公司研发，是代码自主率超过90%的安全能力引擎，成功实现了人工智能大模型在国内安全领域首个垂直应用，用人工智能铸造新时代的盾牌。

Introduction

Information technology is akin to the spark that lights up the new era. While it provides unparalleled convenience and opportunities, it also presents challenges and risks. In an era of relentless technological innovations and escalating security threats, the next-generation cloud-local collaborative AI security engine emerged. The Engine is independently developed by Sangfor, with over 90% of the code written by in-house programmers. It marks the first vertical application of large-scale AI models in China's security field, harnessing AI to forge a security shield for the new era.

云地协同人工智能：中国安全领域首个大模型垂直应用

Cloud-local Collaborative AI: First Vertical Application of Large-scale AI Models in China's Security Field

基于大模型的人工智能新一代网络攻击识别技术，该成果将自然语言大模型运用于网络攻击识别，构建智能化引擎，实现了面向5千万级高度混淆恶意样本检测中，平均检出率从45.6%提升至95.7%，误报率从21.4%降低至4.3%。首创将随机森林、长短期记忆（LSTM）神经网络等小模型，与生成式预训练变换器大模型进行强化学习结对。

Based on next-generation cyber attack recognition technology, the Engine utilizes large-scale natural language models for cyberattack detection. This significantly improved the average detection rate of malicious code in approximately 50 million highly obfuscated samples from 45.6% to 95.7%, while reducing the false positive rate from 21.4% to 4.3%. The Engine combines small models, such as random forests and Long Short-Term Mem-

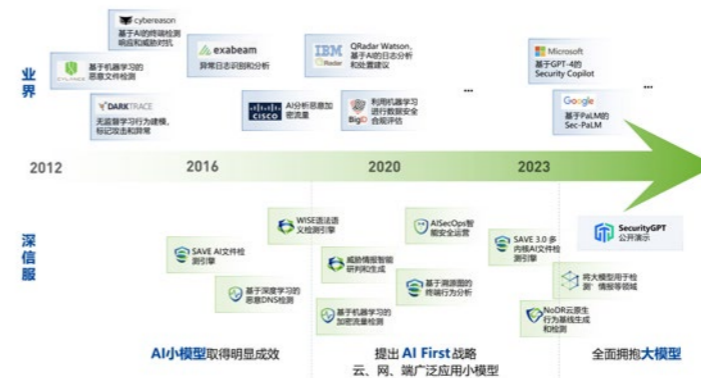
ory (LSTM) neural networks, with generative pre-trained transformer models to bolster learning.

云地协同的网络安全智能化运维和处置技术，该成果利用人工智能云端大小模型迁移和级联研判架构，以及本地分布式联邦学习算法，实现客户本地网络安全和系统运行风险的研判、定位和辅助处置。提升安全风险处置效率98%，降低设备平均故障时长85%。

Cloud-local collaborative intelligent O&M and management for network security: The Engine uses cloud-based model migration, cascaded decision-making architecture, and distributed federated learning algorithms to assess, locate, and manage network risks in the local systems of customers. The Engine improved the risk handling efficiency by 98% and reduced the mean time to repair (MTTR) by 85%.

面向人工智能训练和推理过程的数据安全保障技术，该成果利用外源数据加密和安全增强所有权证明算法，在人工智能云端和本地虚拟化环境中实现了训练和推理数据的安全有效存储和使用，采用双级PoW算法保障数据所有权检查准确率，实现千亿级训练数据和55万设备实时推理数据的安全可靠使用。

Data security assurance technology based on AI training and inference: The Engine uses external data encryption and proof-of-ownership algorithms to ensure the secure storage and application of training and inference data in cloud and local virtual environments. It adopts a twin-stage PoW algorithm to ensure precise verification of data ownership. This facilitates the safe and reliable use of 100 billion training data and real-time inference data from 550,000 devices.



© 从小模型到大模型，人工智能安全技术之路

云边端协同的视联网技术创新与 超大规模应用实践

Innovation in IoVT (Internet of Video Things) Technology and Ultra-Large-Scale Application Enabled by Cloud-Edge-Device Collaboration

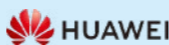


◎云边端协同的视联网体系架构
◎IoVT system architecture enabled by cloud-edge-device collaboration

中国电信集团有限公司
China Telecom Corporation Limited



华为技术有限公司
Huawei Technologies Co., Ltd.



瑞芯微电子股份有限公司
Rockchips Electronics Co., Ltd.



引言

为有效推进数字社会治理精准化、普及数字生活智能化，实现数字基础设施的高效联通，中国电信率先提出并构建了新一代信息基础设施：天翼视联网。视联网是中国电信基于云网融合打造的超大规模云化视频综合服务网络，是中国电信的“第五张基础网”，全面服务个人、家庭、行业、社会治理等应用场景。

Introduction

In order to promote precise digital social governance and intelligent digital living, thereby efficiently connect digital infrastructure, China Telecom took the lead in proposing and building the next-generation information infrastructure — e-Surfing IoVT. The e-Surfing IoVT

is an ultra-large cloud-based integrated video service network developed by China Telecom based on cloud-network convergence. It is the carrier's "fifth basic network" serving various application scenarios in China, such as individuals, homes, industries, and social governance.

五大技术创新打造超大规模视频服务网络

Ultra-large Video Service Network Based on Five Technological Innovations

本成果通过云资源池智能调度、批量处理及快速切换技术的突破，提高传输效率 50% 以上。通过分布式非关系数据库关键技术突破，满足千亿级文件数据存储需求。构建了 AI 算法一点接入，全网下发能力；创新实现视联网数据融通，跨部门共享；创新应用 SRv6 的协议升级和云网控制器的全局路径编排；创新应用基于新型城域网的端到端 IPv6 能力；应用 Flex-E 切片技术实现差异化网络保障；创新实现视联网的混合组网灵活调度，实现全网状互联。

China Telecom innovated key technologies of dynamic resource pool scheduling, batch processing, and rapid switch-over, increasing transmission efficiency by over 50%. The carrier also made breakthroughs in key technologies of distributed non-relational databases, supporting EB-level media file data storage. China Telecom developed network-wide delivery of AI algorithms based on one-point access. Based on the IoVT, it innovatively implemented data integration and cross-department sharing. The carrier adopted SRv6 protocol upgrade, global path orchestration of the cloud network controller, and E2E IPv6 based on new metro networks. It achieved differentiated quality assurance through Flex-E slicing technology, and fully-meshed interconnection through the flexible scheduling of the hybrid networking of IoVT.

在 AI 平台方面，视联网搭载了“全网、区域、边、端”四级算力的 AI 产品和能力，研发了业内

首个面向城市治理的“星河”通用视觉模型。

The IoVT is based on the AI product and capability platform that provides four-level computing power (network, region, edge, and device). The carrier has also developed the Milky Way general visual model for city governance, which is the first of its kind in the industry.

在视频编码方面，项目研发的机器视觉视频编码方法对比 H.266/VVC 取得了 30% 的性能增益，自研的 HPV-RCNN 算法在单类别精度上提升了 5.85%。

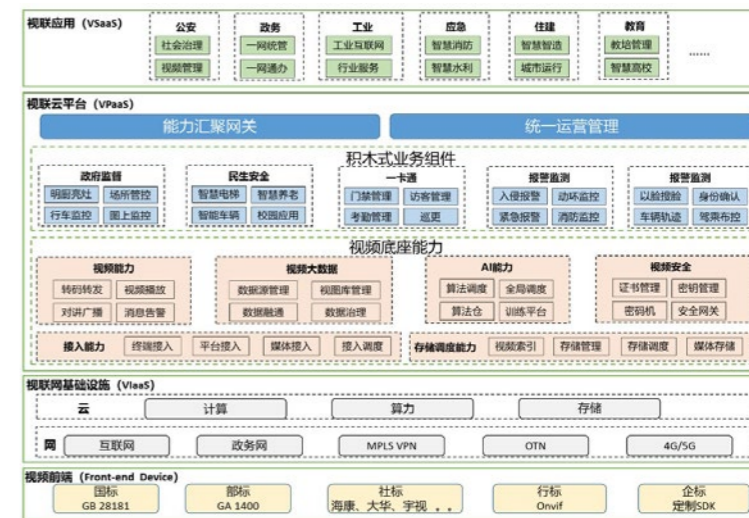
The e-Surfing IoVT has seen technical breakthroughs in visual encoding. Compared with H.266/VVC, its intelligent video encoding method increases performance by 30%. The performance of the self-developed HPV-RCNN algorithm increases the single-category precision by 5.85%.

在视频安全方面，项目提出了“基于内生安全和芯片的全方位多层次家庭个人信息保护创新应用”，解决家庭用户对隐私安全的担忧。

In terms of security, China Telecom has developed the innovative application of all-round multi-layer home personal information protection based on endogenous security and chips. This application ensures the privacy security of home users.

在硬件方面，项目研发的新型光圈镜头，成像稳定性提升 50%，感光度提升了 75%。

When it comes to hardware, China Telecom has innovatively developed the new lens that improves the imaging stability by 50% and the photographic sensitivity by 75%.



◎视联网系统架构
◎System architecture of IoVT

视联网正成为数字化转型时代必不可少的新型基础设施 e-Surfing IoVT: An Indispensable New Infrastructure for Digital Transformation

在基于云边端协同打造的超大规模云化视频综合服务网络——视联网目前正逐步成为中国电信的“第五张基础网”，服务于家庭、乡村、社区、行业治理等多场景领域，覆盖全国数十万行政村。星河 AI 平台依托四级算力和各类算法，协同 100 多个行业合作伙伴，汇集了智慧城市、社会治

理、工业质检、明厨亮灶、智能客服等众多场景化综合信息解决方案，已支撑 500 多个产业数字化项目落地。明厨亮灶、智慧社区等行业应用本地网覆盖率超过 80%；数字乡村应用以场景化 AI 为抓手，推进空白村拓新和存量村深耕，月均净增超过 15 万户；面向个人用户家庭，使用视联网天翼看家平台和天翼云存储能力，为客户提供的家庭安防与智能看护类产品服务绑定终端超 3000 万，用户价值凸显；基于天翼云眼标准产品推出的智慧商圈、智慧厅店等中小企业应用接入设备超 200 万路。视联网正成为数字化转型时代必不可少的新型基础设施。

The e-Surfing IoT is now becoming the "fifth basic network" of China Telecom. It serves multiple scenarios such as homes, rural areas, communities, and industry governance, covering hundreds of thousands of administrative villages in China. Based on four-level computing power and various algorithms, the Milky Way AI platform coordinates over 100 industry partners and integrates many scenario-based comprehensive information solutions, such as smart city, social governance, industrial quality inspection, food safety monitoring, and intelligent service chatbot. The platform has supported the implementation of more than 500 industry digitalization projects. Food safety monitoring and smart community applications have been deployed on local networks with a coverage of over 80%. Digital village application draws on scenario-based AI to develop new villages and dive deeper in existing villages, with an average monthly net increase of 150,000 users. The e-Surfing Webcam platform and e-Surfing cloud storage capabilities are used to provide home security protection and intelligent care services for individual home users. Over 30 million terminals have been bound to the e-Surfing IoT, bringing out significant user benefits. The e-Surfing IoT capitalizes on the e-Surfing Cloud eye in standard products and serves SME users with applications like smart business districts and smart halls/stores. More than 2 million channels of industry application access devices have been connected to the system. The e-Surfing IoT is becoming an indispensable new infrastructure for digital transformation.



● 视联网应用案例
● IoT application cases

发挥央企责任担当，引领产业链良性发展 Fulfilling Responsibilities as a State-Owned Enterprise, and Driving Shared Development of the Industry Chain Ecosystem

截至 2022 年 12 月，中国电信视联网直接收入超 35 亿，终端接入数已超 4000 万，覆盖全国 30 余万行政村（覆盖率 73%）。平台为超 30 个行业平台、超 500 个政府平台提供服务对接。形成了 10 大类 39 项开放能力，在 17 省落地了 20 个 SaaS 应用；以视联网为底座打造的平安慧眼、天翼应急、平安校园、智慧工地、看家护院等产品广泛应用于联防联控、疫情防控、防洪监测等民生工程，成为全国“雪亮工程”、平安城市等工

作的重要信息化平台。并且协同央视网打造“直播中国”报道平台，在疫情报道、云游中国、美丽乡村等工作上取得显著成效与较高社会反响。

By December 2022, the direct revenue of China Telecom's IoT exceeded 3.5 billion yuan, and the number of terminals accessed exceeded 40 million, covering more than 300,000 administrative villages across the country (with a coverage rate of 73%). The system has been interconnected with more than 30 industry platforms and more than 500 government platforms. It provides 39 open capabilities of 10 categories, as well as over 20 SaaS applications, which have been deployed in 17 provinces. Based on the e-Surfing IoT, SaaS applications such as Ping An smart eye, e-Surfing emergency response, safe campus, smart construction site, and home security protection are widely used in people's wellbeing projects such as social governance, pandemic prevention and control, and flood defense supervision, providing an important information platform for Sharp Eyes project and Safe City in China. China Telecom collaborated with CCTV (China Central Television) to build the Live China platform. Its series special coverages such as pandemic briefings, Visiting China Online, and Beautiful Countryside programs were well received.

作为产业链的引领者，依托云网优势，带动芯片、终端、人工智能、算力等云网设备产业链伙伴共同发展，打造了基于视频的全国性新型数字化基础设施。与 50 余家合作伙伴累计对接近 300 款摄像头，拉动产值超过 200 亿元，已初具规模和引领优势。

As a leader in the industry chain, China Telecom has promoted the development of partners of the cloud and network device industry chain involving chips, terminals, AI, and computing power based on its advantages in cloud and network. It has built a new national digital infrastructure based on video. China Telecom has worked with over 50 partners to introduce nearly 300 types of cameras to the e-Surfing IoT that has driven output value of over 20 billion yuan and initially demonstrated scale and leading advantages.



● 视联网行业应用生态体系
● Application ecosystem of IoT

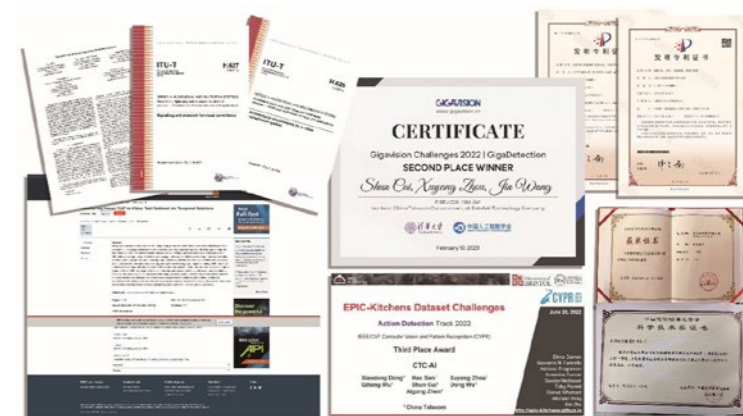
构建产学研生态合作，助力天翼视联业务发展 Building Academic-Industry-Research Ecosystem Cooperation to Support the Development of e-Surfing IoT Services

Carrying out Ecosystem Cooperation and Promoting the Development of e-Surfing IoT Services

视联网不断推出智慧医保、水域监控、平安校园、天翼看机房、智慧电梯等标准行业应用产品，在公共安全监管方面发挥巨大作用。同时，联合政府、高校、国家实验室开展产学研生态合作，输出数字生活优势场景案例；与浦江实验室、头部高校等科研单位开展基于视频/图像数据的典型模型标签集定义与规范制定等研究工作。牵头推动 ITU-T SG16 成立“视频监控业务与系统”，负责组织推进视频监控系列标准研究，维护标准化路线图，组织认证测试；主导成立 ISO/IEC JTC1 SC29 VCM 专家组，SAC TC28 SC29 DCM 组，主导相关标准工作。

Based on the e-Surfing IoT, China Telecom has continuously launched standard industry application products, such as smart medical insurance, water supervision, safe campus, equipment room

supervision, and smart elevator. These products play an important role in public security supervision. Additionally, China Telecom cooperates with government departments, colleges and universities, and national laboratories to carry out ecosystem cooperation and produce cases of digital living. China Telecom also worked with Pujiang Lab and top colleges and universities to research key common technologies of AI-visual foundation models. Together, they defined and formulated typical model tag sets and specifications based on video/image data. China Telecom took the lead in driving ITU-T SG16 to propose Visual Surveillance Systems and Services. It is responsible for organizing and promoting the research on visual surveillance standards, maintaining the standardization roadmap, and organizing certification tests. China Telecom also took the lead in establishing the ISO/IEC JTC1 SC29 Video Coding for Machine (VCM) expert group and SAC TC28 SC29 Data Coding for Machine (DCM) group to preside over related standards work.



● 部分标准、获奖、论文集专利情况
● Standards, awards, essays, and patents



● 福瑞泰克 ODIN 智能驾驶数智底座
● Freetech ODIN Intelligent Driving Platform

福瑞泰克 ODIN 智能驾驶数智底座 Freetech ODIN Intelligent Driving Platform

福瑞泰克智能系统有限公司
Freetech Intelligent Systems Co.,Ltd.



引言

随着汽车智能化的快速发展，自动驾驶向着从低速到高速，从封闭到开放的方向持续演进。汽车电子电器架构迈向中央计算、集中式架构，可实现感知共享、算力共享、电源共享等；汽车软件迈向统一架构，支持功能不断迭代，使得智能汽车自学习、自成长。

Introduction

With the rapid development of automotive intelligence, the evolution of autonomous driving continues from low speed to high speed, from closed to open systems. Automotive electronic architecture is moving towards centralized computing and centralized architecture, enabling perception sharing, computational power sharing, and power sharing. Automotive software is transitioning towards unified architecture, supporting continuous iteration of functionalities, enabling intelligent vehicles to self-learn and self-grow.

智能驾驶“成长进化”的“智擎”

Intelligent Driving's "Growth Evolution" Engine

作为软硬全栈、全周期的可持续智能进化平台，福瑞泰克 ODIN 智能驾驶数智底座包括传感器、中央计算平台、自动驾驶算法和数据闭环四大支柱模块，通过部署在每个模块的产品和解决方案，以积木式模块化适配需求，联合客户及合作伙伴持续进行系统集成与智能驾驶技术迭代和优化，

实现真正平台化、客制化、高性价比、快速交付的量产解决方案。福瑞泰克通过多颗 SoC 芯片和 MCU 芯片部署的系统架构、硬件架构和软件架构的设计，把高阶智能驾驶的功能模块部署在多个异构芯片和多个核中，创新性地实现国际领先的算力水平，达到高性能和高安全性，提供 CNP 城区点到点领航辅助驾驶，HPA 记忆泊车，AVP 远程自动泊车等先进功能。福瑞泰克 ODIN 智能驾驶数智底座优势包括算力按需灵活分配、感知硬件可插拔，算力可拓展，软件、硬件均可 OTA，使得汽车智驾功能的边界可以不断拓展。高性价比 + 极致性能，

不断提升智能驾驶产品的安全性和用户体验，打造助力智能驾驶技术发展的“智擎”。

As a sustainable intelligent evolution platform with full-stack software and hardware capabilities throughout the entire lifecycle, Freetech ODIN Intelligent Driving Platform comprises four core modules: AD Sensors, AD Computation Center, AD Algorithms, AD Data Platform. By deploying products and solutions in each module, it adapts to diverse requirements through modular and adaptable configurations, collaborating continuously with customers and partners for ongoing system integration and the evolution and optimization of intelligent driving technology. This approach achieves genuine platformization, customization, cost-effectiveness, and rapid delivery of mass-produced solutions. Freetech ODIN achieves international leadership in computational power by deploying advanced modules and cores across multiple heterogeneous chips and microcontroller units (MCUs), innovatively realizing high-performance and high-security levels. It provides advanced features such as CNP urban point-to-point navigation assistance, HPA memory parking, and AVP remote automated parking. Freetech ODIN Intelligent Driving Platform advantages include on-demand flexible allocation of computational power, plug-and-play sensor hardware, expandable computational capabilities, and over-the-air updates for both software and hardware. This flexibility allows the continuous expansion of the boundaries of automotive intelligent driving functions. With a focus on cost-effectiveness and ultimate performance, it continuously enhances the safety and user experience of intelligent driving products, serving as the "Smart Engine" driving the development of intelligent driving technology.

制，可插拔的激光雷达的算法及先进的 BEV 以及 Transformer 融合算法，大幅提高功能安全以及预期功能安全的鲁棒性。

· 数据闭环系统：通过数据上传、清洗、标注以及对数据进行训练来形成感知、规控算法的不断优化和迭代。采用迁移学习、联邦学习等先进 AI 手段来应对数据安全的挑战。已联合主机厂及国家级超算中心开展众包数据共享及数据安全应用。

The Full-Stack ODIN Intelligent Driving Platform, with Four Core Modules:

· AD Computation Center: Serving as the 'superbrain' of intelligent driving, it has mass-produced the industry-leading NOA integrated parking and driving solution. It supports up to 12V5R complete sensor configurations, allowing flexible addition of LiDAR, and supports Level 3 intelligent driving capabilities.

· AD Sensors: In-house developed and manufactured high-resolution camera modules, including 8 million pixels for front view, 5 million pixels for side view, and 3 million pixels for panoramic view. Industry-leading mass-produced 4D imaging millimeter-wave radar FVR40, capable of reaching a peak of 50,000 points per second.

· AD Algorithms: Based on multi-level hyper-converged perception, scene-based planning and control, plug-and-play LiDAR algorithms, and advanced BEV Transformer fusion algorithms, significantly enhancing functional safety and the robustness of expected functional safety.

· AD Data Platform: Continuously optimizing and iterating perception, planning, and control algorithms through data upload, cleaning, labeling, and training processes. Utilizing advanced AI techniques such as transfer learning and federated learning to address data security challenges. Collaborating with OEMs and national-level supercomputing centers to conduct crowdsourced data sharing and implement data security applications.



● ODIN- 开创领先的智能驾驶平台
● ODIN: Pioneering the Leading Intelligent Driving Platform

“即插即用”的智能驾驶模块化平台 "Plug-and-play" intelligent driving modular platform

全栈式 ODIN 数智底座四大核心模块：

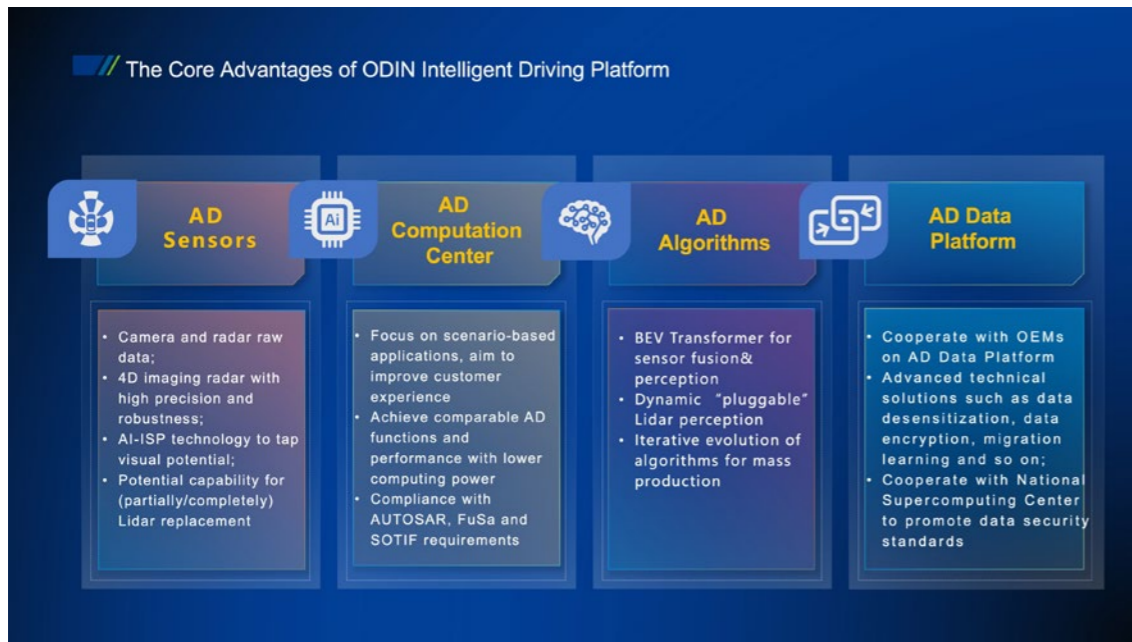
· 中央计算平台：作为智驾“超级大脑”，已量产业界领先的 NOA 行泊一体方案。支持最高到 12V5R 全套传感器配置，可灵活加装激光雷达，支持 L3 级智能驾驶功能。

· 核心传感器：自研自产全系高像素摄像头模组，包括 800 万像素前视、500 万像素侧视、300 万像素环视。业内领先量产的 4D 成像毫米波雷 FVR40，峰值可以达到每秒 5 万个点。

· 自动驾驶算法：基于多层次的超融合感知以及基于场景的规划和控



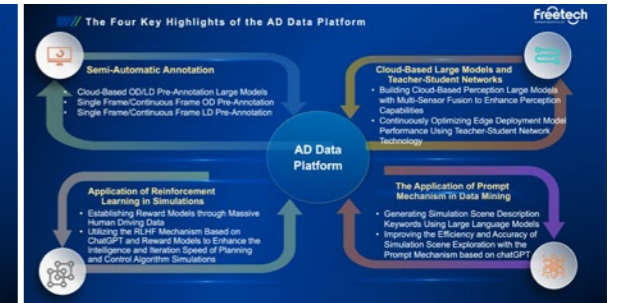
● ODIN 数智底座核心优势



● The Core Advantages of ODIN Intelligent Driving Platform



● 数据闭环系统四大亮点



● The Four Highlights of the AD Data Platform

数据驱动下的“智驾平台即服务”

Data-Driven "Intelligent Driving Platform as a Service"

在软件定义汽车的时代，厂商和用户将转化为全生命周期的合作关系，形成“用户不断提供数据、厂商不断扩展服务”的良性循环。福瑞泰克提出的“智驾平台即服务”理念，基于 ODIN 数字底座为客户提供更灵活、更多选项的平台可移植的开发服务价值，快节奏、标准化的开发可以提升客户的开发能力，同时全生命周期地对产品进行跟踪、评估及更新。福瑞泰克并不盲目追求芯片大算力，而是更关注基于场景与用户体验强相关的功能和性能，再用比较小的算力来实现市场所需要的自动驾驶的功能和性能，让 C 端消费者用得起用得好。搭载福瑞泰克 ODIN 数智底座的高阶智能驾驶产品已在国内头部汽车品牌普及车型上实现大规模的量产，2023 年产值预计将达到 10 亿。

In the era of software-defined cars, manufacturers and users will transform into a lifelong cooperative relationship, forming a virtuous cycle of "users continuously providing data, manufacturers continuously expanding services". FreeTech proposes the concept of "Intelligent Driving Platform as a Services", based on the ODIN Intelligent Driving Platform, to offer customers more flexible, customizable, and portable platform development services. Fast-paced, standardized development can

enhance customers' development capabilities, while enabling the tracking, assessment, and updates of products throughout their lifecycle. FreeTech does not blindly pursue high computational power in chips but focuses more on functionalities and performance strongly related to scenarios and user experiences. It utilizes relatively smaller computational power to achieve the functionalities and performance required by the market for autonomous driving, making it affordable and efficient for end consumers. High-end intelligent driving products equipped with FreeTech ODIN Intelligent Driving Platform have achieved large-scale production on popular car models of top domestic automobile brands. The estimated output value for 2023 is expected to reach 1 billion RMB.



● 智驾平台即服务



● Intelligent Driving Platform as a Service

查看扫描结果

扫描任务信息

任务编号: SCAN438049

业务系统: system_test1017 数据库: POHTest 数据库类型: Sql Server

扫描频次: 单次 部门: dps 负责人: Zhixiang Z Zhang

该数据库扫描耗时 0小时0分钟1秒, 共扫描字段 31 个, 其中涉及敏感信息的有 31 个

扫描开始时间: 2023-07-10 11:08 扫描结束时间: 2023-07-10 11:08

POHTest

只看待确认识别结果 人工判断优先: 否

字段名称	扫描样例数据	敏感信息标签(系统)	敏感信息标签(手动)	primary identifier	数据安全管理办法
person_basicInfo					
person_identifyInfo					
person_netInfo	IMEI 14345643478901234	银行账户	银行账户	银行账户	请选择
person_physicInfo	MAC 00-16-EA-AE-3C-40	设备MAC地址	设备MAC地址	设备MAC地址	请选择
person_educationInfo					
person_otherInfo	ip 199.255.255.255	IP地址	IP地址	IP地址	请选择

个人数据扫描、标签管理

Check scan results

Scanning task information

Task number: SCAN438049

Business system: system_test1017 Database: POHTest Database type: Sql Server

Scan frequency: Single time Department: dps Owner: Zhixiang Z Zhang

The database scan duration 0hour(s)0minute(s)1second(s). Total scan field(s) 31 Involved sensitive information includes 31

Start time of scan: 2023-07-10 11:08 End time of scan: 2023-07-10 11:08

POHTest

View to be confirmed result only Manual judgments first: No

Field name	Scan Sample Data	Sensitive information tag (system)	Sensitive information tag (manual)	primary identifier	Data security management measures
person_basicInfo					
person_identifyInfo					
person_netInfo	IMEI 14345643478901234	Bank account	Bank account	Bank account	Please select
person_physicInfo	MAC 00-16-EA-AE-3C-40	Device MAC address	Device MAC ad	Device MAC address	Please select
person_educationInfo					
person_otherInfo	ip 199.255.255.255	IP address	IP address	IP address	Please select

Personal data scanning and tag management

低成本打造企业合规智脑，赋能社会责任履行和公众权益保护
Building a compliance smart brain with low cost, empowering social responsibility fulfillment and protection of public rights and interests

归一式智能化的隐私运营及管理的中心，适用于所有行业领域下的不同类型企业。具有良好的市场价值，借助强大的智脑中台可在降低企业合规成本的情况下，助力企业合规，赋能其社会责任履行，保障市场消费者的权益，经济社会价值意义显著。

POH is applicable to different types of enterprises in all industries, and can significantly reduce compliance costs for enterprises while helping them achieve compliance, fulfill social responsibilities, and protect consumer rights, thus providing significant economic and social value.

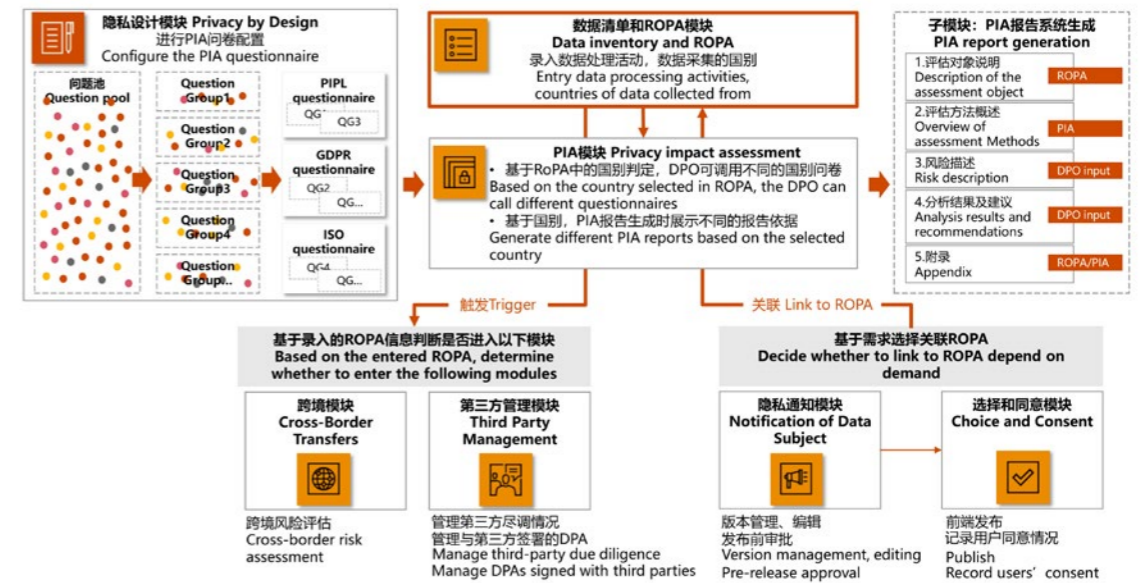
中台通过引擎聚合分析全球 50+ 国家地区的隐私法规的异同，淬炼寻定“最大公约数”，统筹设计隐私合规义务事项框架，确保了归一式的全局合规功能设计的权威性及可用性。此外，辅以专业的法律+技术的咨询/托管服务，保障了智能化的功能应用和企业使用体验。

We analyze the similarities and differences

es in privacy regulations in over 50 countries worldwide, identify the "highest common denominator", and design a framework for privacy compliance obligations to ensure the authority and usability of the all-in-one global compliance function design. In addition, we provide professional legal and technical consulting/hosting services to make sure the intelligent application of functionalities and the user experience for enterprises.

目前采用此中台应用的企业类型已经涵盖了智能制造、汽车、金融及快销等行业。系统的技术应用成熟，市场认可度高，一朝投入，朝朝受益。

Currently, the application of POH has covered industries such as intelligent manufacturing, automotive, finance, and FMCG. The system's technical application is mature, and it has high market recognition. Once invested, enterprises can benefit from it continuously.



合规证据链界面：清晰展示触发的合规工作项和对应的证据附件，并盖以时间戳，有力证明合规工作开展时间

Compliance evidence chain interface: clearly displays triggered compliance tasks and corresponding evidence attachments, strongly proves the timing of compliance work being conducted

普华永道全球网络通力合作服务当地，百强企业的选择

PwC's Global Network Institution collaborate to provide local services, making it the preferred choice for leading enterprises

归一式智能化的隐私运营及管理的中台，瞄准隐私全局合规的目标，以数据处理活动清点识别为“线”，穿透隐私风险评估、第三方、跨境、隐私声明、用户同意等管理的“关键针眼”；紧扣企业合规多角色管理的锚点，融合多样化内控机制，配置自定义的评估和审批流程。确保了隐私合规工作的完整性、可实施性。

POH aims to achieve comprehensive privacy compliance, with record of data processing activities as the "line" that penetrates through key areas such as privacy impact assessment, third-party management, cross-border management, privacy statements, and user consent. It anchors on the multiple roles of enterprise management, integrates diverse internal control mechanisms, and customisable assessment and approval process. This ensures the integrity and feasibility of privacy compliance work.

有效保障了企业在深耕厚植业务活动的过程中，把隐私合规工作举重若轻地渗透到产品业务中，筑牢隐私合规管理基本功，打造隐私合规形象典范，避免展业中侵犯个人隐私和监管处罚，获取市场公众及当局监管信任，保障业务合规运行。

POH effectively ensures that enterprises integrate privacy compliance work into their business activities, strengthen the basic skills of privacy compliance management, avoid violating personal data and being subject to regulatory penalties during business

operations, gain trust from the public and supervisory authorities.

结合普华全球各地资深咨询顾问行业经验，延续咨询项目的成果，融合个性化的企业需求，做到每次部署都契合当地法律与企业现状，将合规融入企业工作习惯，夯实了企业隐私合规的基本功，切实提升了企业隐私合规管理的能力和效率。

Combining the industry experience of senior consultants from PwC Global Network Institution, POH builds on the achievements of consulting projects and integrates customised corporate requirements, ensuring that each deployment is in line with local laws and the current situation of the enterprise. It incorporates compliance into the work habits of the enterprise, effectively enhancing the capabilities and efficiency of enterprise privacy compliance management.



◎ 解决通用型软件无法满足个性化需求的难点

◎ Addressing the challenges of generic software's inability to meet unique needs