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IEEE 4th World Forum on Internet of Things

中国科学院自动化研究所
复杂系统管理与控制国家重点实验室

Parallel Logistics in the Social IoT Era

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The State Key Laboratory for Management and Control of Complex Systems
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Singapore

Contents

AI and Logistics

What is the Impact of AlphaGo on Logistics Science?

Fei-Yue Wang, J. J. Zhang, et al. Where Does AlphaGo Go: From Church-Turing Thesis to AlphaGo Thesis and Beyond.

IEEE/CAA Journal of Automatica Sinica, 2016, 3(2):113-120.

Where Does AlphaGo Go: From Church-Turing Thesis to AlphaGo Thesis and Beyond

Fei-Yue Wang, *Fellow, IEEE,* Jun Jason Zhang, *Senior Member, IEEE,* Xinhu Zheng, *Student Member, IEEE,* Xiao Wang, Yong Yuan, Xiaoxiao Dai, *Student Member, IEEE,* Jie Zhang, Liuqing Yang, *Fellow, IEEE*

***Abstract*—An investigation on the impact and significance of the AlphaGo vs. Lee Sedol Go match is conducted, and concludes with a conjecture of the AlphaGo Thesis and its extension in accordance with the Church-Turing Thesis in the history of computing. It is postulated that the architecture and method utilized by the AlphaGo program provide an engineering solution for tackling issues in complexity and intelligence. Specifically, the AlphaGo Thesis implies that any effective procedure for hard decision problems such as NP-hard can be implemented with AlphaGo-like approach. Deep rule-based networks are proposed in attempt to establish an understandable structure for deep neural networks in deep learning. The success of AlphaGo and corresponding thesis ensure the technical soundness of the parallel intelligence approach for intelligent control and management of complex systems and knowledge automation.**

***Index Terms*—ACP, AlphaGo, AlphaGo Thesis, Church-Turing Thesis, deep learning, deep neural networks, deep rule-based networks, knowledge automation, parallel intelligence, parallel control, parallel management.**

I. Introduction

THE match of AlphaGo vs. Lee Sedol is a history making event and a milestone in the quest of artificial intelligence (AI). The computer Go program AlphaGo by DeepMind has won 4:1 in a five game match against one of the world's best players, Lee Sedol, from Korea. The victory has come considerably sooner than anyone has expected and has astonished many in the AI field. Nolan Bushnell, the founder of Atari and a Go Guru himself, was so impressed by AlphaGo's feat: "Go is the most important game in my life", he said, "It is the only game that truly balances the left and right sides of the brain. The fact that it has now yielded to computer technology is massively important"[1]. The defeat over humanity by a machine has also generated huge public interests in AI technology around the world, especially in China, Korea, U.S., and U.K. To many people, IT has a new meaning from this moment: it stands not just for Information Technology or Industrial Technology, it is Intelligent Technology now, and the age of new IT is coming[2].

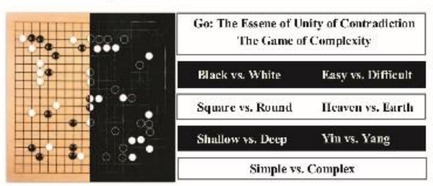


Fig. 1. Go: A game of complexity and a symbol for unity of contradiction.

Manuscript received March 30, 2016; accepted April 6, 2016. This work

The AlphaGo Thesis: New Definition of IT

From Past IT to New IT

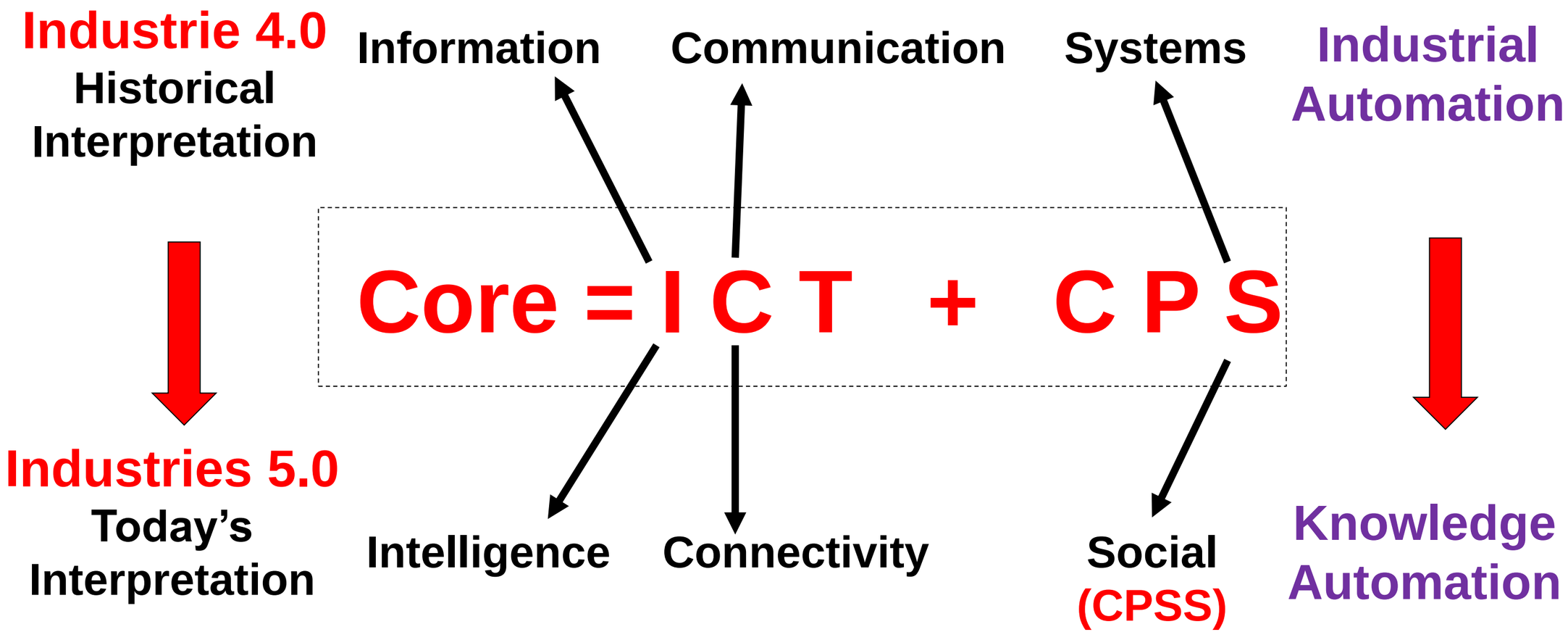
IT = Old "IT" + Past "IT" + New "IT"

Old "IT" = Industrial Technology

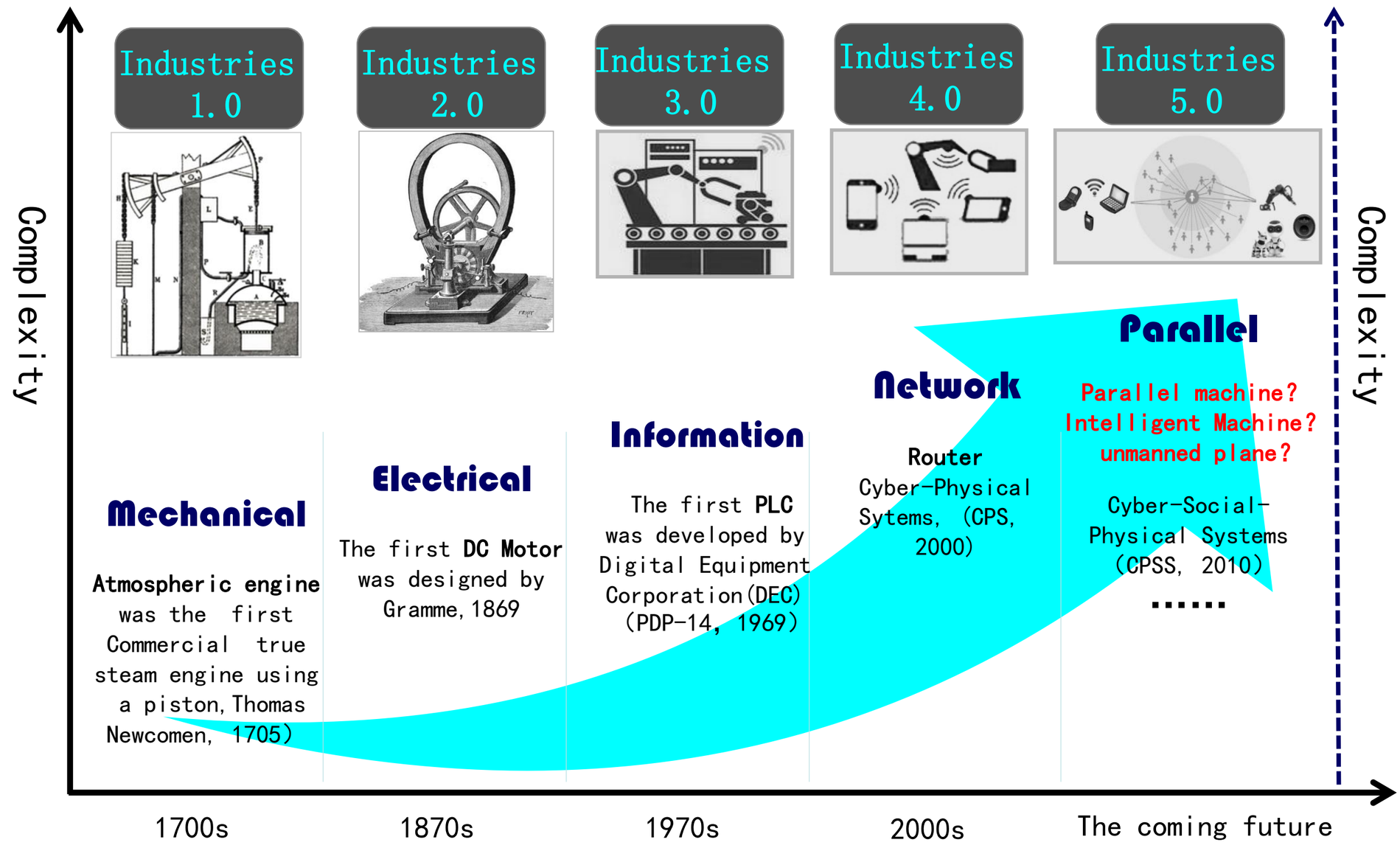
Past "IT" = Information Technology

New "IT" = Intelligent Technology

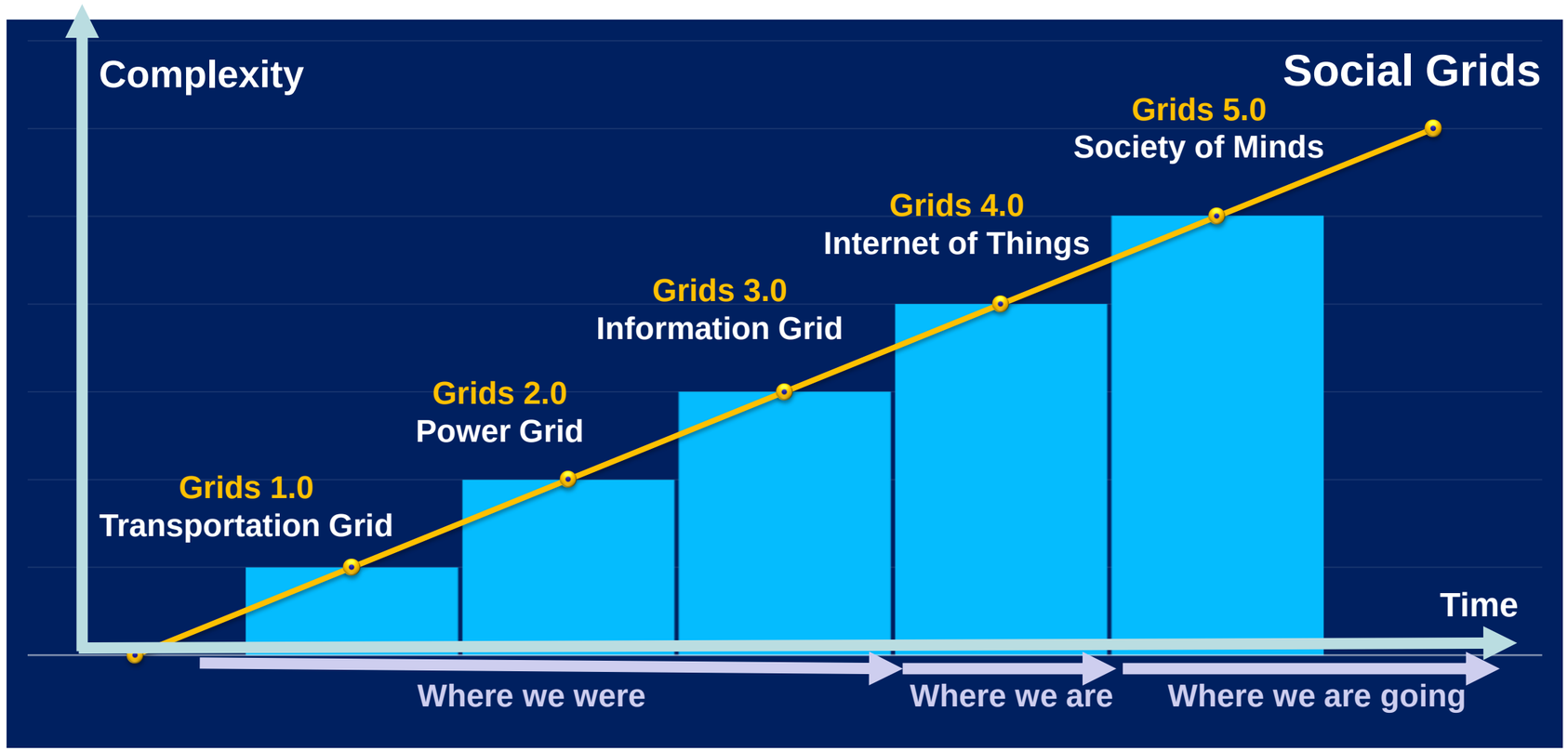
Different Interpretations, Different Ages



Industries 5.0



Progress of Technology
Social Infrastructures



Social Transportation	**Social** Energy	**Social** Computing	**Social** Manufacturing	**Social** Intelligence

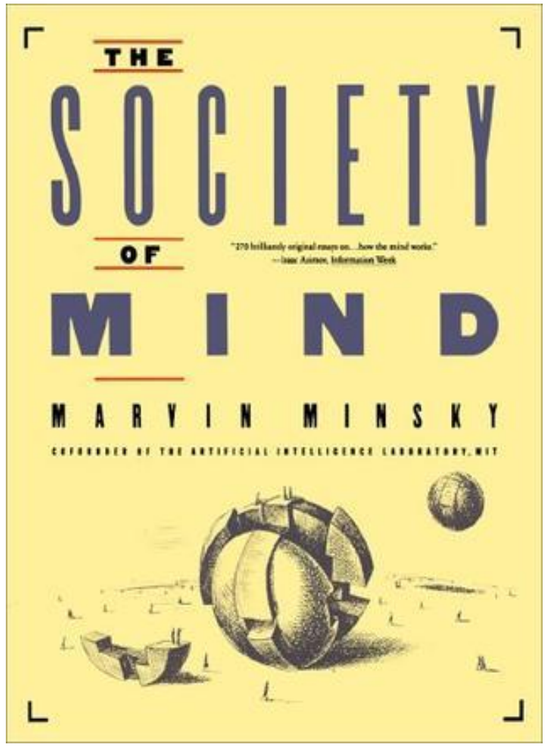
Social Infrastructure + Shared Economy = Smart Societies

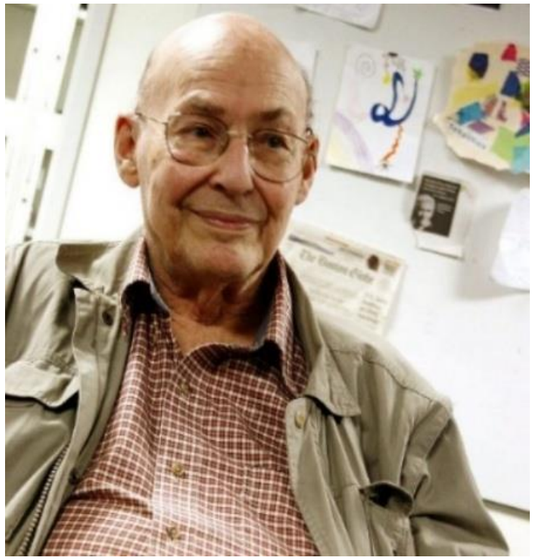
From the Society of Mind to the Internet of Minds

"What magical trick makes us intelligent? The trick is that there is no trick. The power of intelligence stems from our vast diversity, not from any single, perfect principle."

——Marvin Minsky
Source/Notes

The Society of Mind (1987) , p.308





Marvin Lee Minsky
(Aug 9, 1927 – Jan 24, 2016) was an American cognitive scientist in the field of artificial intelligence (AI), co-founder of the Massachusetts Institute of Technology's AI laboratory, and author of several texts on AI and philosophy.

Social Grids and Karl Popper's Three-World Model of Reality

Grids 1.0

World I :
Physical World

Energy
Old IT

Grids 2.0

Grids 3.0

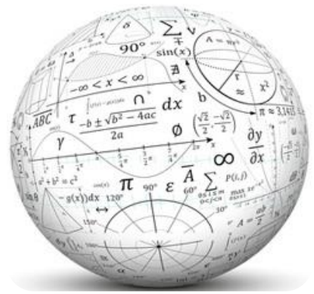
World II :
Mental World

Entropy
Past IT

Grids 4.0

Grids 5.0

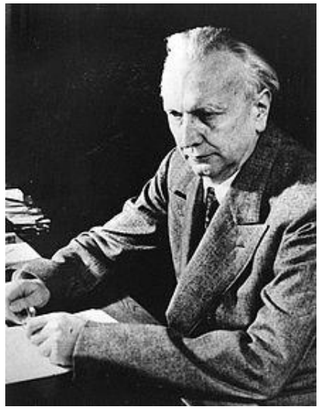
World III :
Artificial World

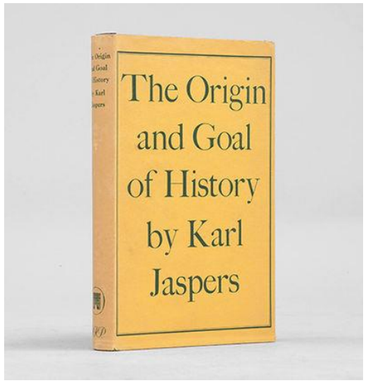


Entanglement
New IT

The Coming Third Axial Age

The First Axial Age	The Second Axial Age	The Third Axial Age
人性 **Humanity**	理性 **Rationality**	智性 **Intelligence**
物理世界 	心理世界 	虚理世界 
春秋战国 **Spring and Autumn** **(800S – 200S BC)**	**文艺复兴** **Renaissance** **(1300S – 1900S)**	**哥德尔定理** **Godel Theorem** **(1900s –)**





The Axial Age: Karl Jaspers , *The Origin and Goal of History*, 1949

New Frontier in the New Age
Mining Karl Popper's Artificial World

Grids 1.0

World I:
Physical World

Old IT

Grids 2.0

Grids 3.0

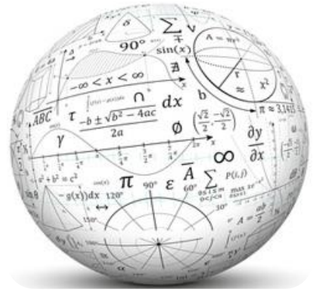
World II:
Mental World

Past IT

Grids 4.0

Grids 5.0

World III:
Artificial World

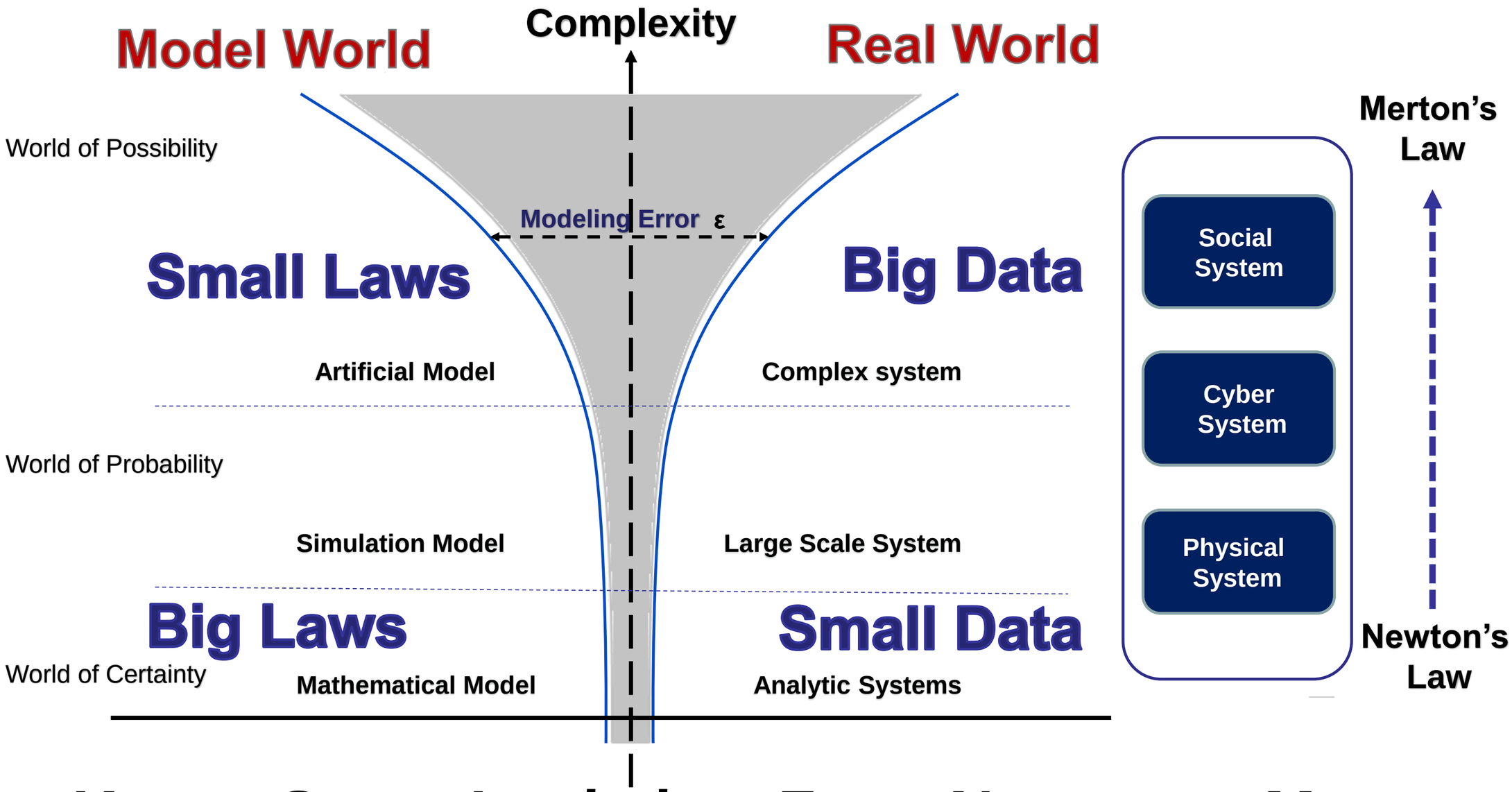


New IT

IT = old IT + past IT + new IT

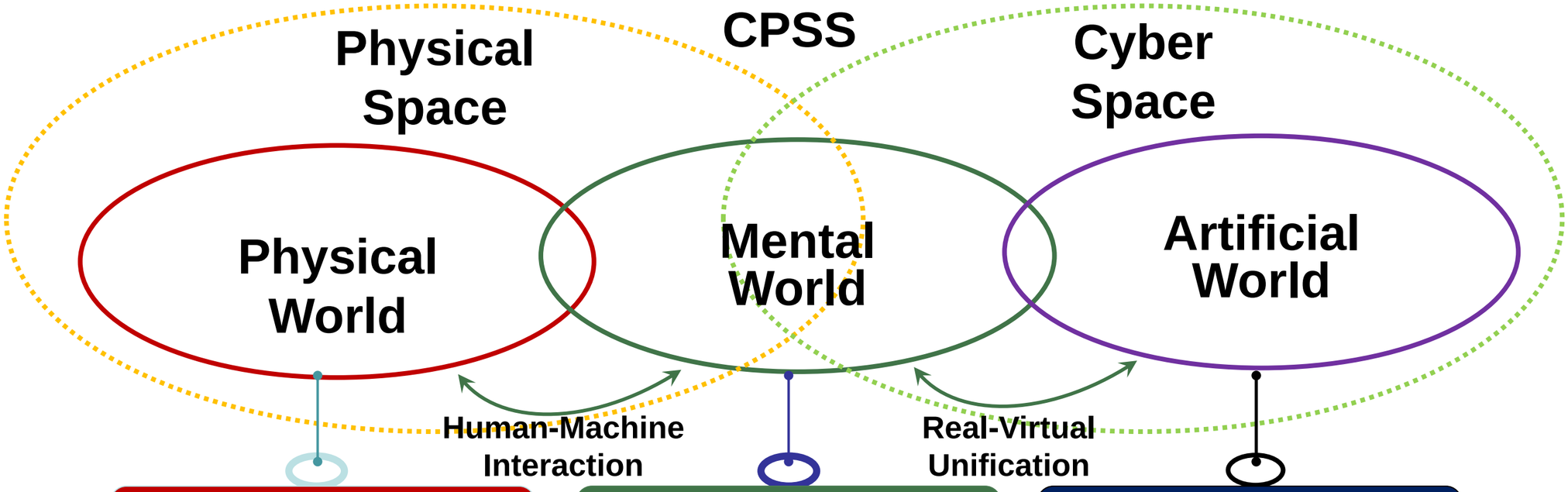
Industrial Technology	Information Technology	Intelligent Technology

Complexity Challenge: The Gap between Models and Reality



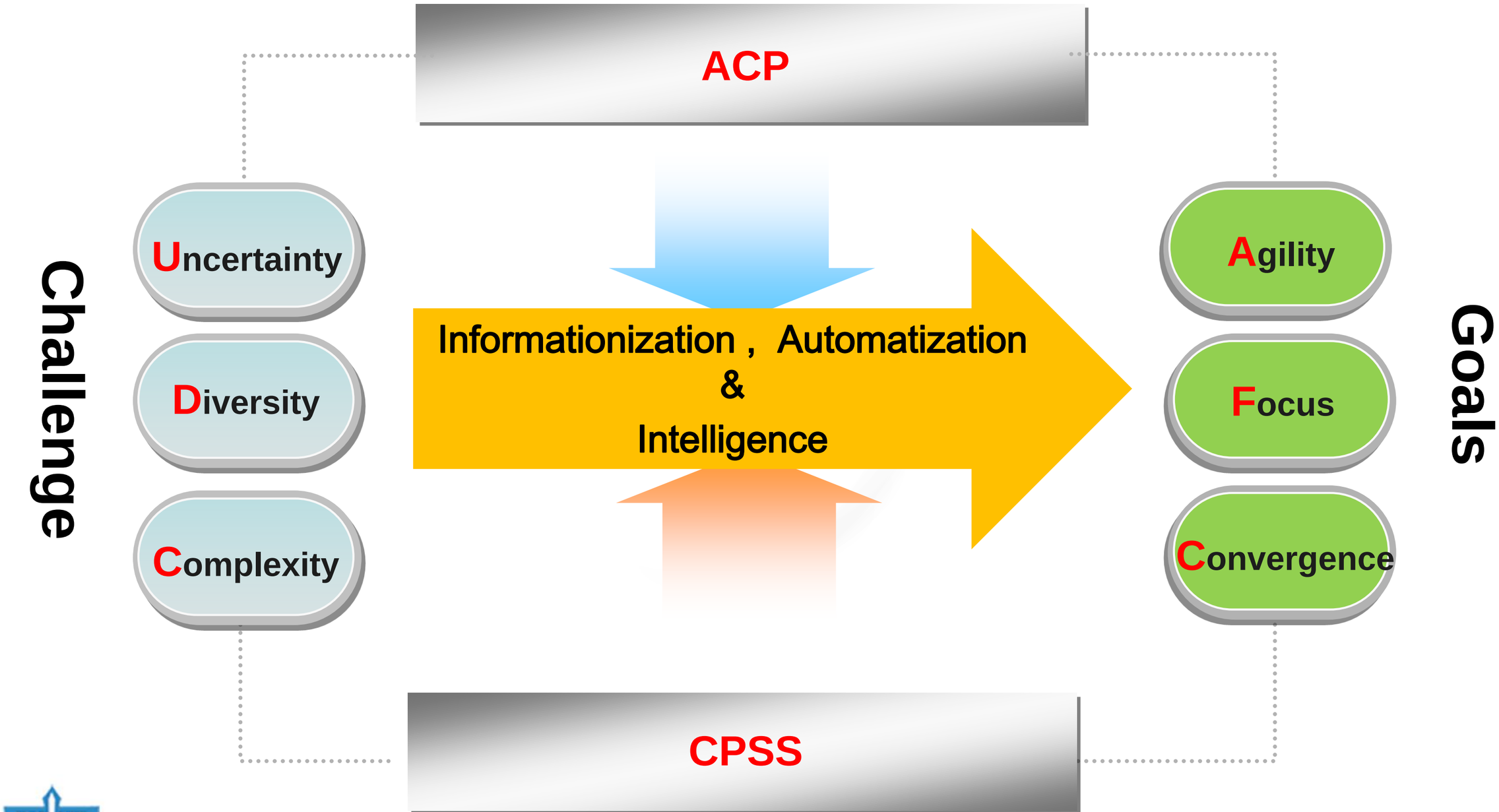
Key to Smart Logistics: From Newton to Merton

Smart Logistics Needs Smart Infrastructure: CPSS

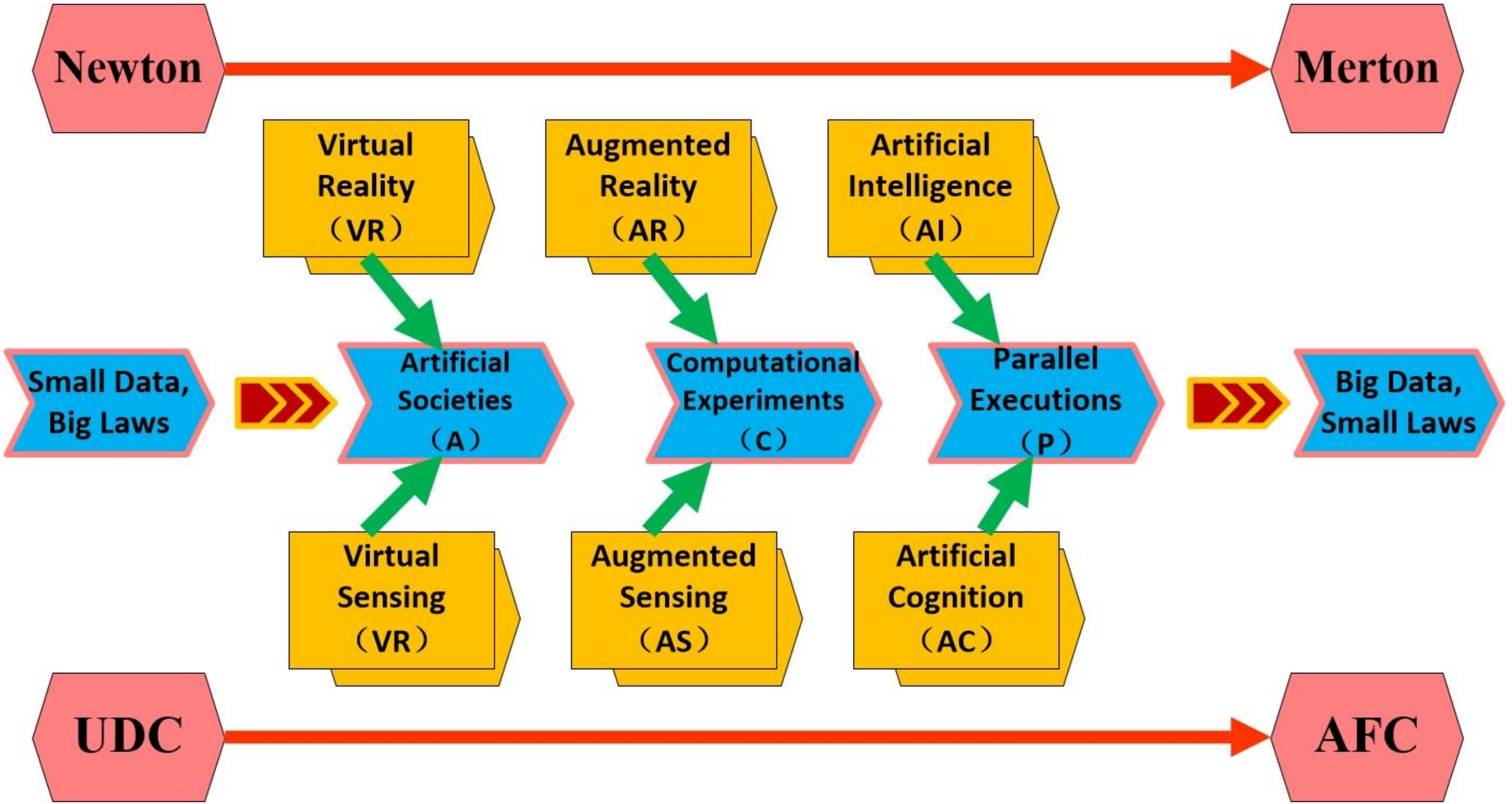


Tasks and Motivation	Resource Disparity	Information Disparity	Intelligence Disparity
Technological Development	Old IT Industrial Technology	→ Past IT Information Technlogy	→ New IT Intelligent Technology
Goal and Future	Human-Machine Integrated	Knowledge-Action Converged	Real-Virtual Merged

The Mission of Smart Logistics: From UDC to AFC

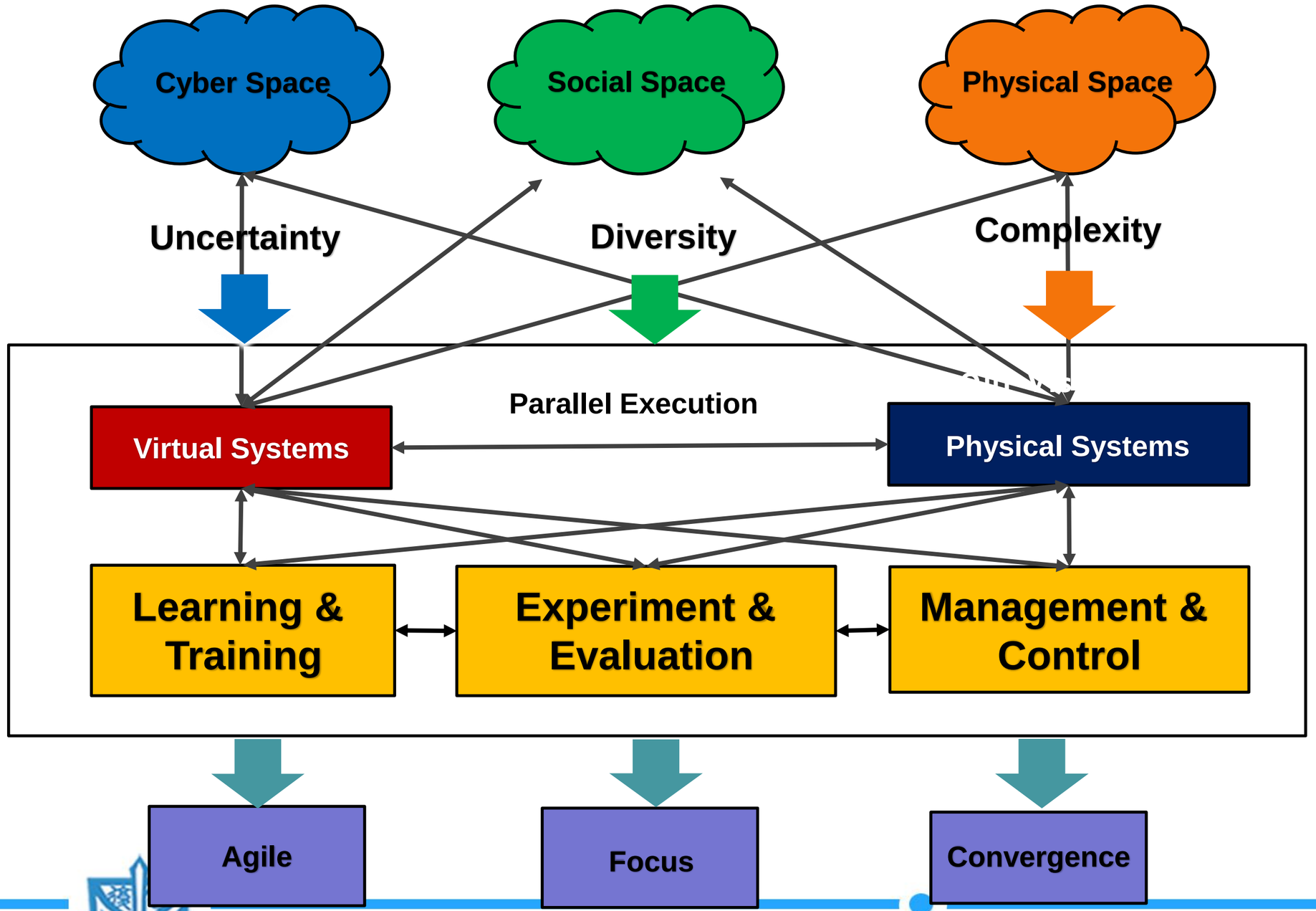


Smart Logistics Requires New Intelligence: Parallel Intelligence



ACP for Parallel Intelligence: A CPSS-based Approach

ACP = Artificial System + Computational Experiments + Parallel Execution



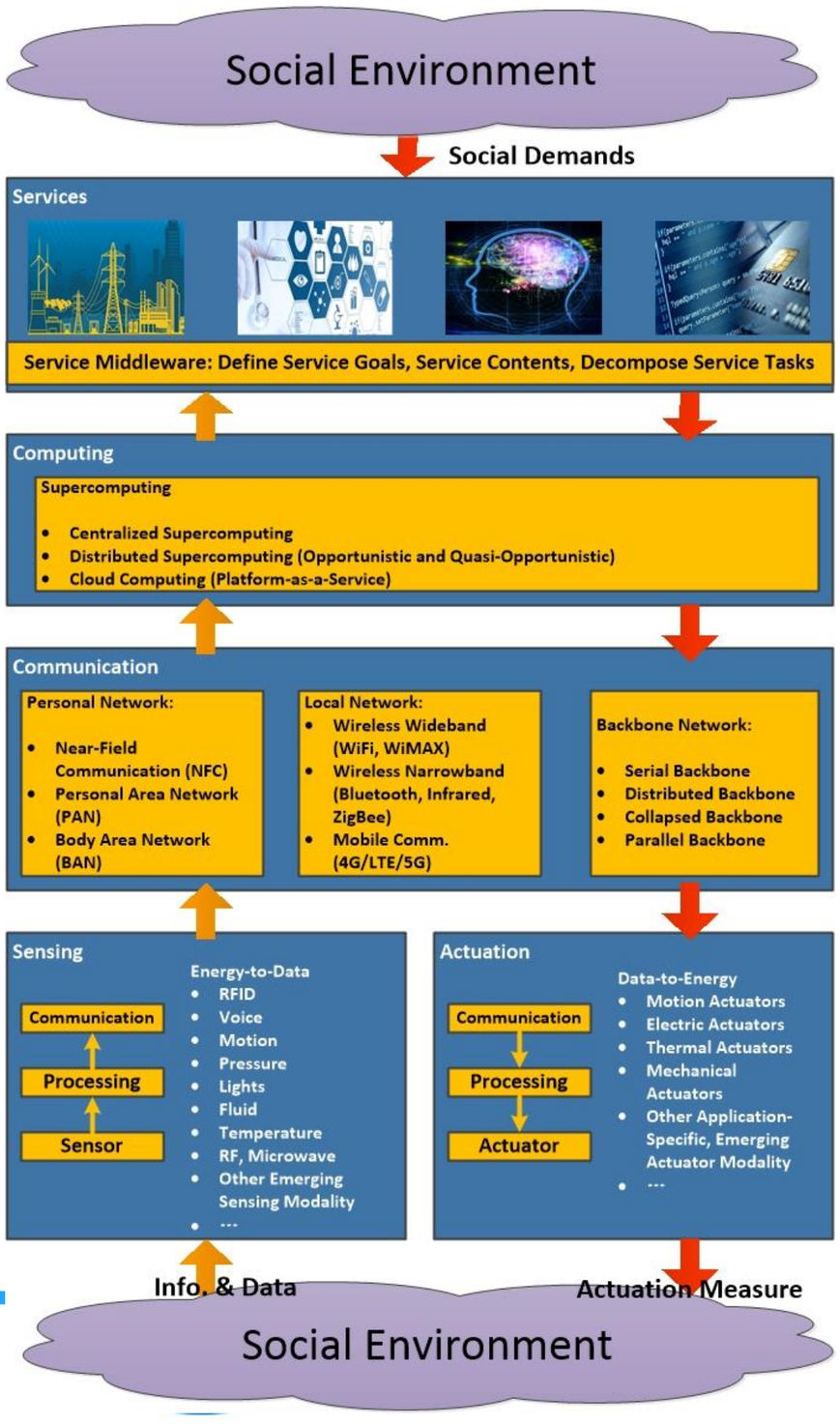
Essentials of ACP Approach

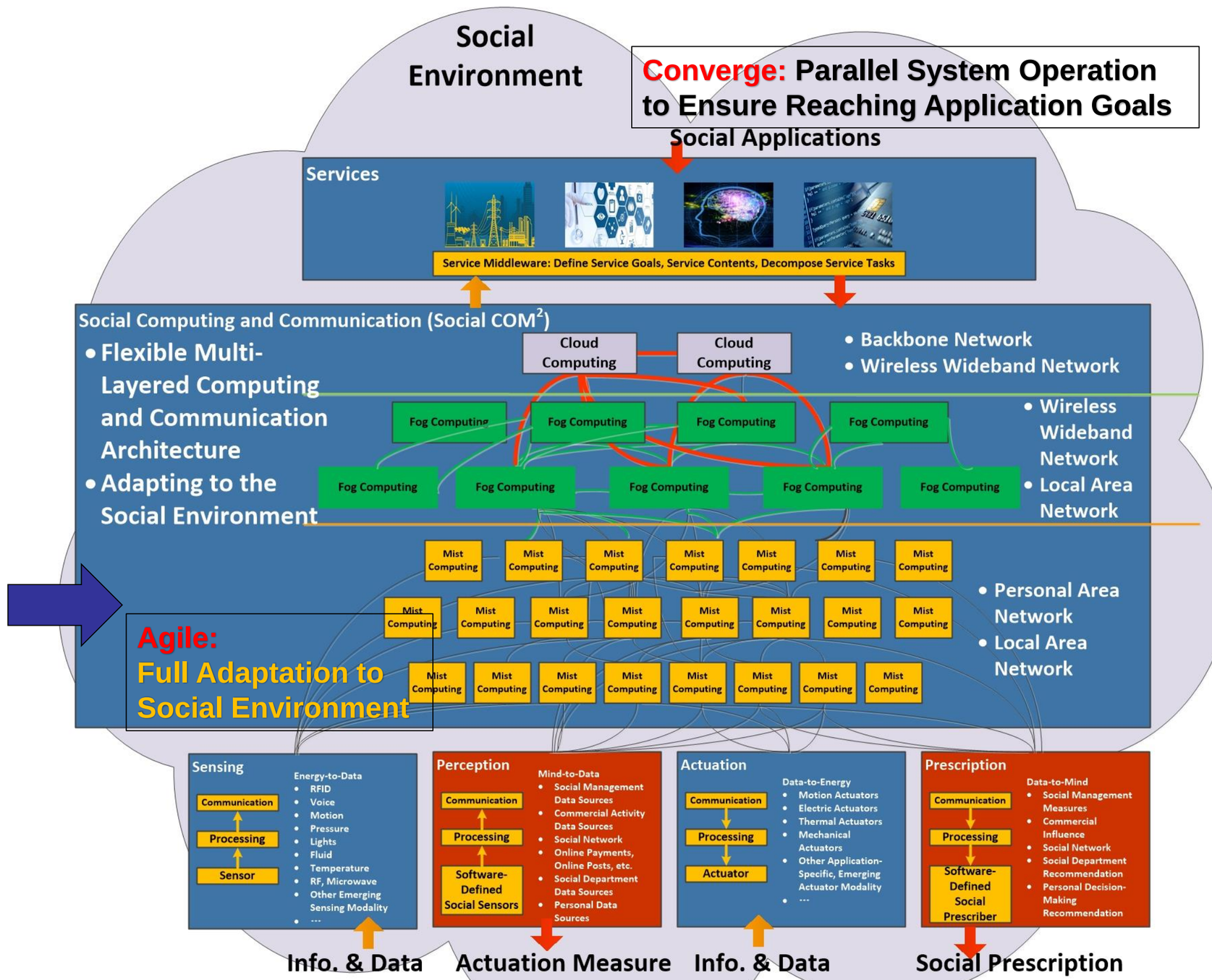
- **Artificial Complex System Modeling**
- **Computational Experiments for Analysis and Evaluation of Complex Systems**
- **Parallel Execution for Control and Management of Complex Systems**
- **Utilization of Modern High Performance Computing Technology**

Contents

Vision of Parallel Logistics Infrastructure Interconnecting Things, People and Society

Parallel Logistics: Logistics in 5G and IoT Era
A Paradigm Shift for Society-Oriented Architecture





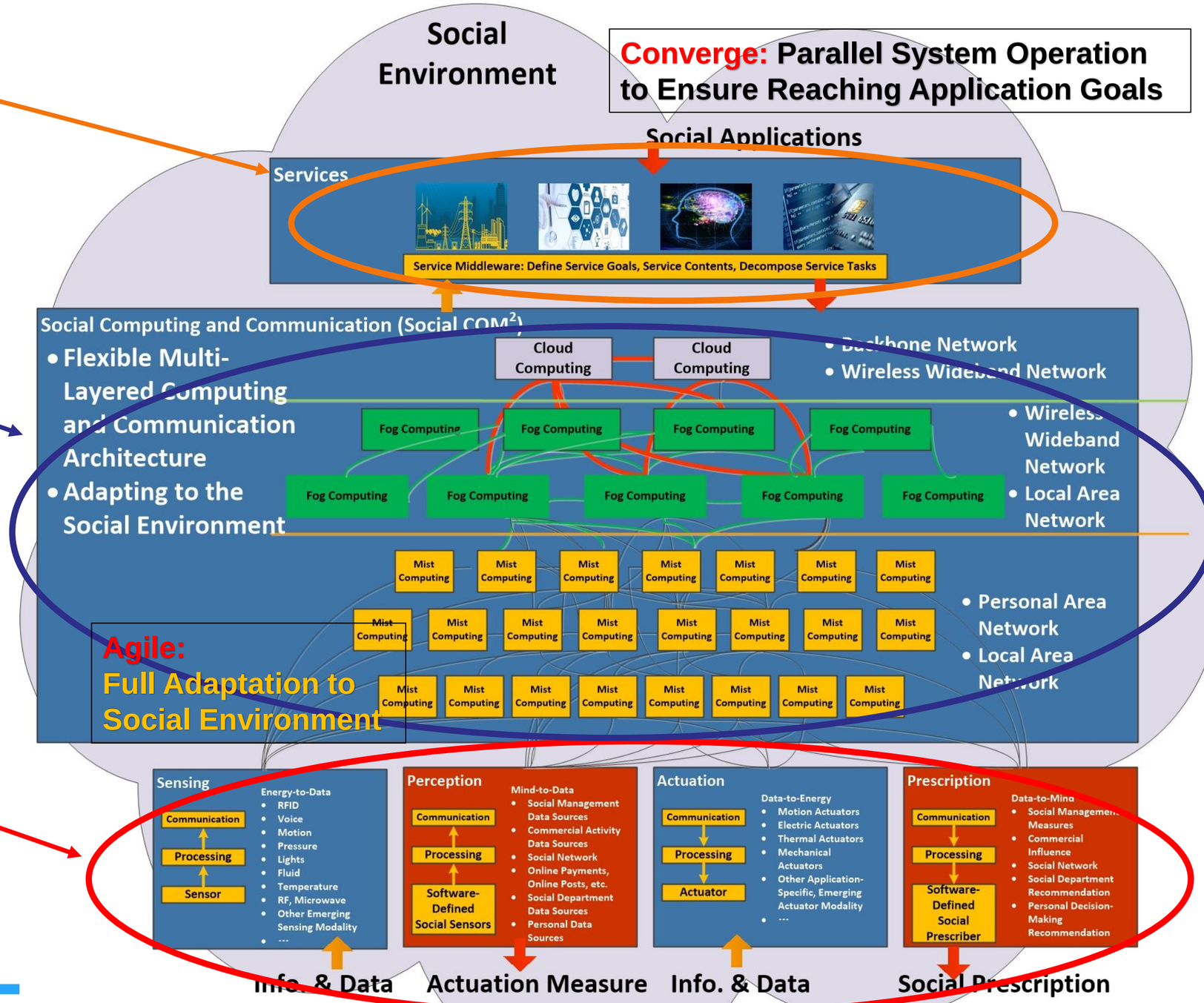
Focus: Feed Back Mechanism in Sensing, Perception, Actuation and Prescription for the Precision Operation

Challenges and New Opportunities in The New Society-Oriented Architecture

- Renewed Middleware that Sets Goals, Develops Strategy, Specify Procedure & Process, Perform Tasks

- Coordination of Multi-Layered, Interconnected Computing and Communication Systems
- Adaptation Mechanism
- Parasitic Communication and Computing Capability of the Society

- Enabling and Joint Design of Precision Operation
- Social Perception & Prescription
- Together with Sensing & Actuation of Things



Focus: Feed Back Mechanism in Sensing, Perception, Actuation and Prescription for the Precision Operation

Issues in Modern Logistics

Complexity

Massive, Heterogenous Logistics Data Analysis

Complexity in

- Railway Network Data
- Highway Network Data
- Commodity Supply Data
- Vehicle Supply Data
- Logistics Park Data

Diversity

Diverse Demands in Social Logistics and Transportation Process

Diversity in

- Commodity Supply
- Spatial-Temporal Requests and Needs
- Service Goals
- Diverse Organizational Process

Uncertainty

Uncertain Demands in Social Logistics Uncertain Distribution of Transportation Resources

Uncertainty in

- Customer Needs and Commodity Supply
- Transportation Capacity and Distribution

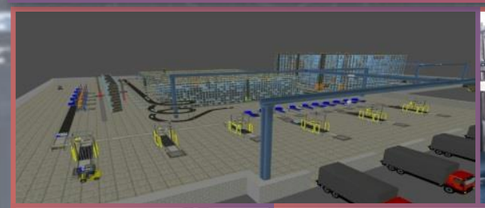
Steps towards Parallel Intelligent Logistics Systems

Traditional Logistics Process



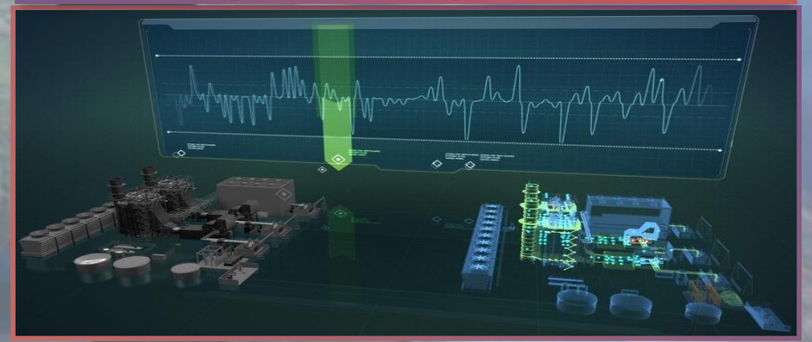


Informationized and Automated Logistics Process





Parallel Intelligent Logistics Systems



Parallel Intelligent Logistics Systems

03
Parallelized

02
Digitized

01
Informationized

01

Enterprise Information System

Management & Control

Analysis & Optimization

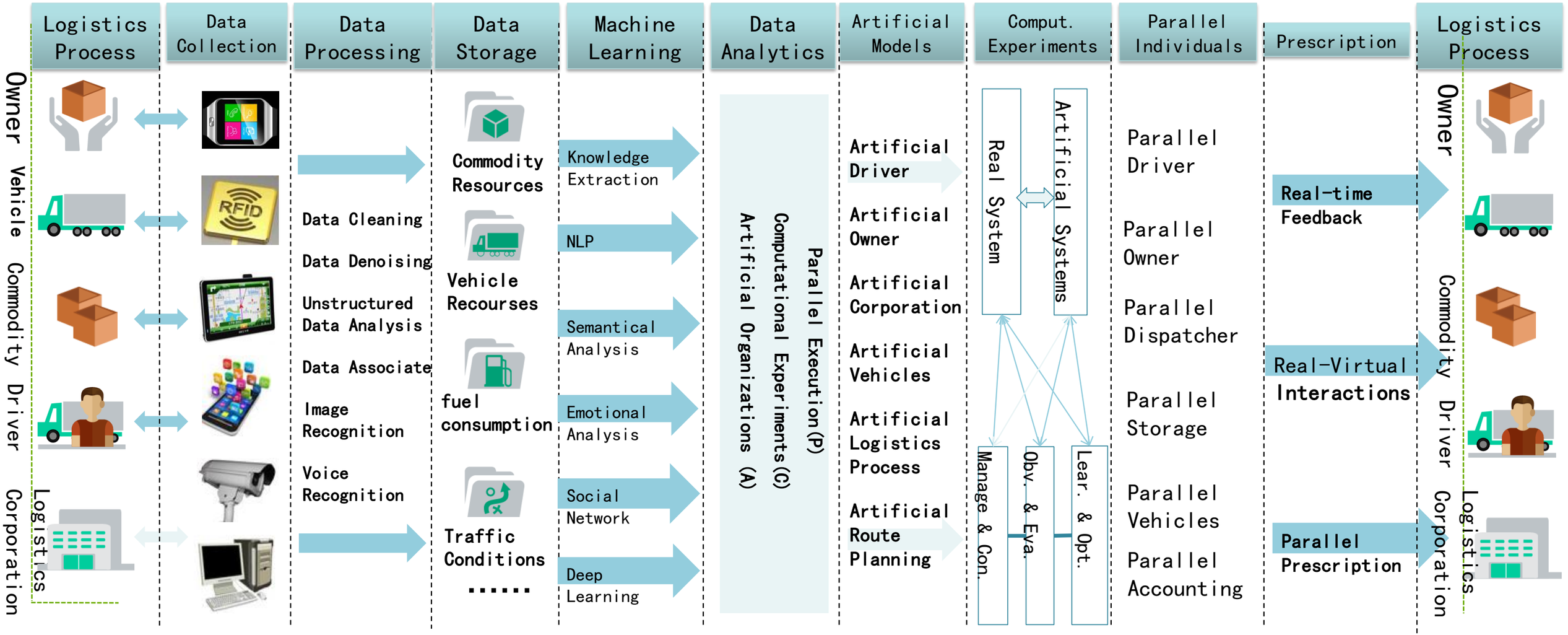
02

Digitized Enterprise Platform

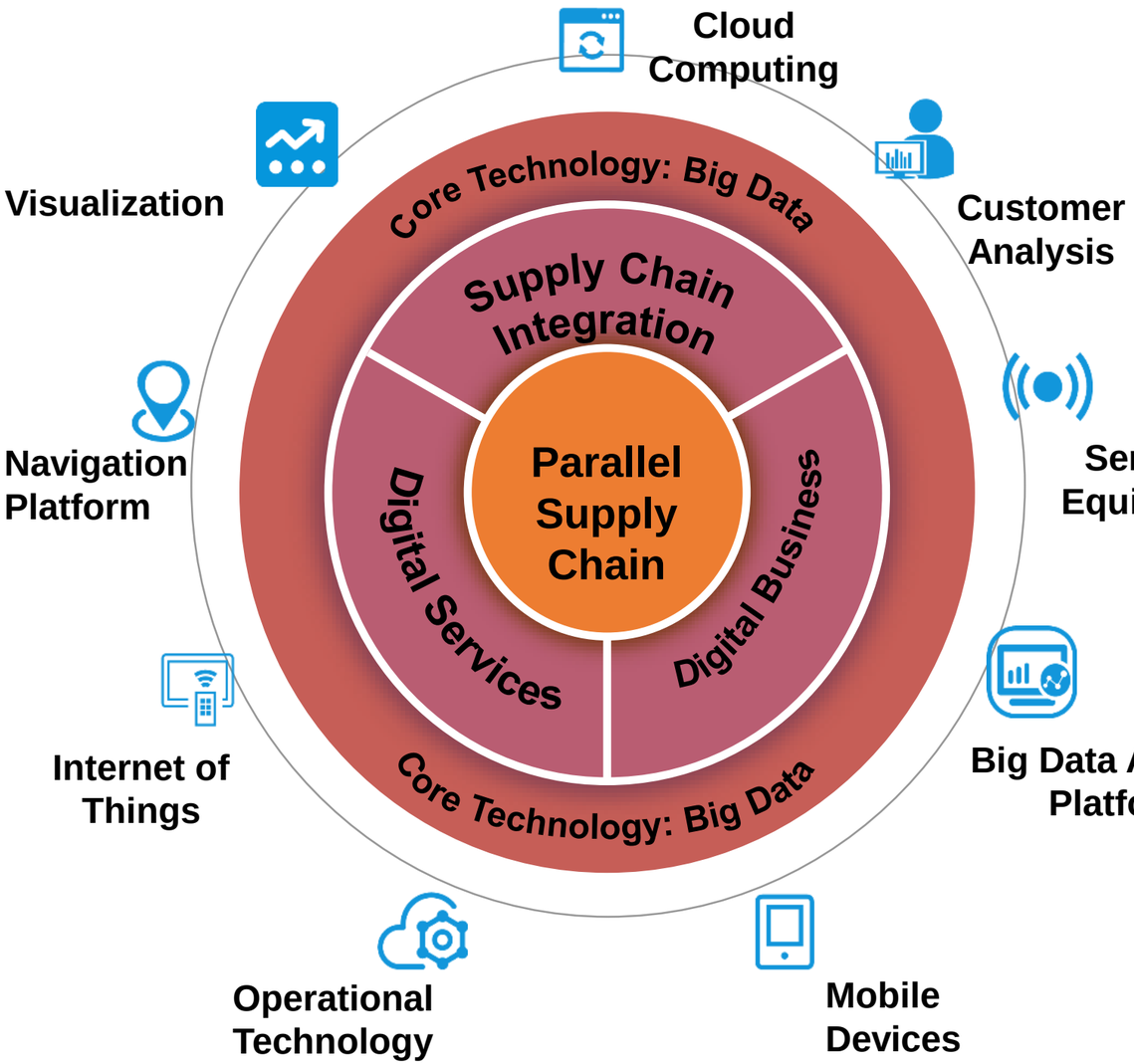
03

Physical Logistics Systems ⟷ Computational Experiments ⟷ Artificial Logistics Systems

Solutions: The Overall Architecture



Applications of Parallel Intelligence in Logistics



Applications:

- Top-level supply chain system design
- Marketing
- Consumer behavior analysis; market activity experiments; sale prediction
- Supply chain management
- Supply chain visualization and early alarm; demand predication and pull-supply-chain coordination
- Optimization of storage and distribution's locating and pathing; equipment demand and maintenance prediction
- Operation and management
- Personnel training
- Management and control based on data intelligence
- Real-time computation assisted decisions

Optimization and Parallel Execution in Logistics

Parallel Execution
and
Management & Control

Real-time Marketing Data Collection and Analysis	Demand-driven Material Preparation & Purchase	Precision Production and Process Coordination	End-user Oriented National Storage Deployment and Managment	Joint Highway, Railway, Waterway Intelligent Planning and Analysis	Market Demand, Material, Production, Sales Big Data Analysis
Demand	Purchase	Production	Storage	Transportation	Data






Logistics Revolution Brought by Parallel Systems

In the future, logistics will heavily depend on the intelligence and functionalities of its dual software-defined artificial systems, rather than only on its physical logistics system

Traditional form of organization is no match for parallel system based logistics

Enterprise supply chain and logistics processes will be overturned by parallel system technology

For enterprises in logistics industry, this is a matter of life or death, not just about performance enhancement

Contents

City Joint Distribution Center in Wen-Guan-Tun, Shenyang

Before Reconstruction

特色：铁路资源
技术：资源整合、信息技术
业务：城市共同配送、公铁联运、金融物流、流通加工
目标：大交通、大物流、大辐射

Reconstruction

Features：Railway Resource
Technology: Resource Integration & Information Technology
Business: City Joint Distribution Center , highway-railway combined transportation, Logistics Finance
Goals: Great Traffic, Large Logistics, Large Radiation

After Reconstruction

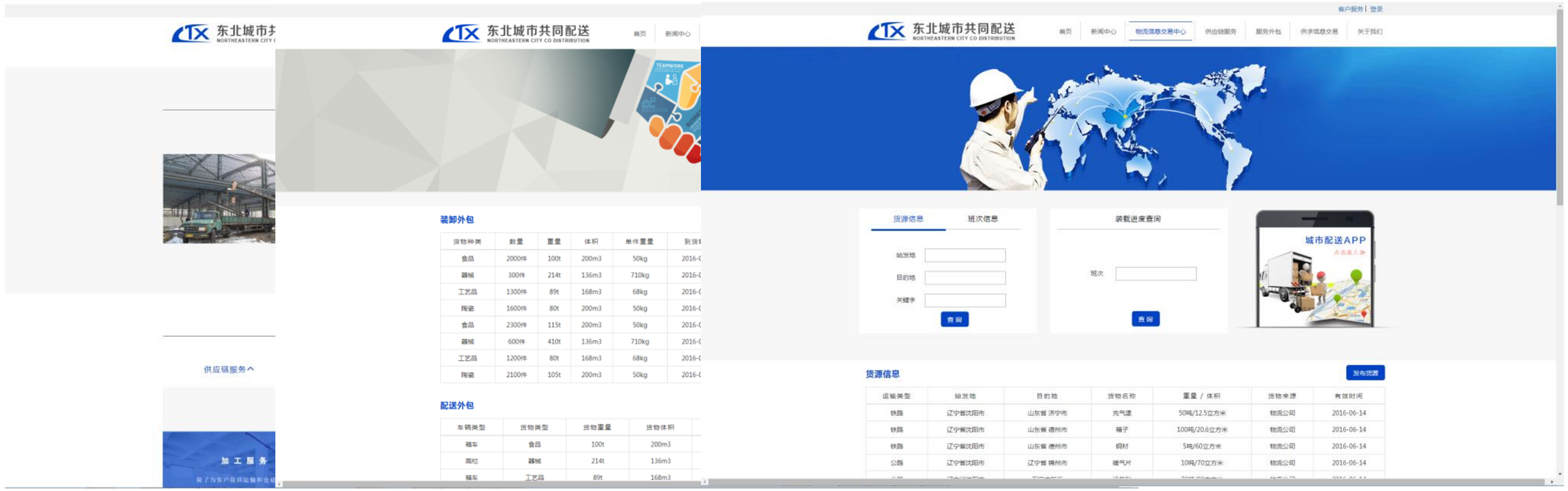
Intelligent Management Center In Wen-guan-tun

Intelligent Management Center In Wen-guan-tun

以发展城市物流共同配送功能为主线，开展民用快销品仓储、分拣、加工、包装及配送业务，提供线上线下交易平台等一体化服务及“海铁联运”、“公铁联运”等全程物流解决方案。

- Focus on city joint distribution center with warehouse, sorting, processing, package and distribution, etc.
- Develop integrated platform like online-offline traction
- Provide logistics solutions like rail-road transport

External Service Interface System



系统主要由门户网站和手机APP组成，是系统平台的综合服务窗口，设有新闻动态、供求信息、行业标准等展示功能，订单查询、城市配送、仓储服务、货物运输、末端网点查询等服务功能

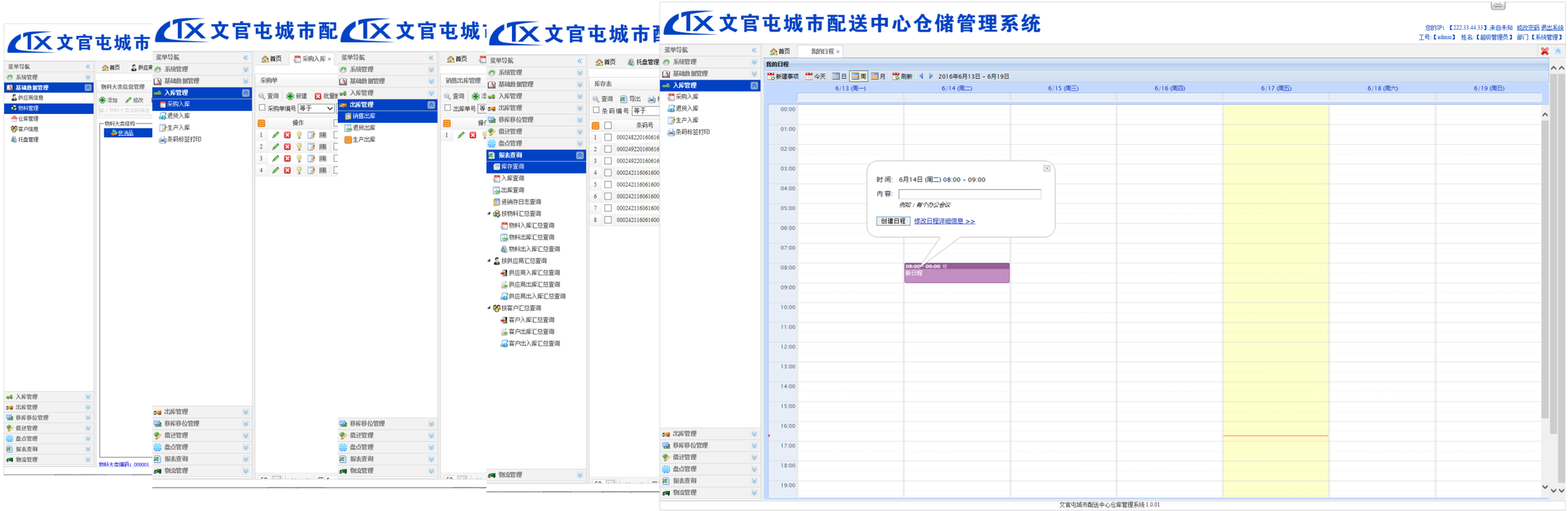
- ✓ The system contains website and APP
- ✓ Displaying functions: News, supply information, industry standard, etc.
- ✓ Service functions: order search, distribution, warehouse, transport, etc.

Order Management System

订单管理系统包括订单接收、订单归集、订单执行等功能。通过制定仓储计划和运输计划，对订单进行汇总、调度、改派等操作，帮助管理人员和客户动态掌握订单最新状态，实现订单全程跟踪管理

- ✓ Functionalities like order reception, collection, transport
- ✓ Make warehouse and transport plan
- ✓ Help the workers learn orders' situation and tracking

Warehouse Management System



该系统包括出入库管理、仓储作业计划、库存状态以及托盘货架管理等功能。利用条码和无线射频识别技术，对仓库流程和空间进行有效管控

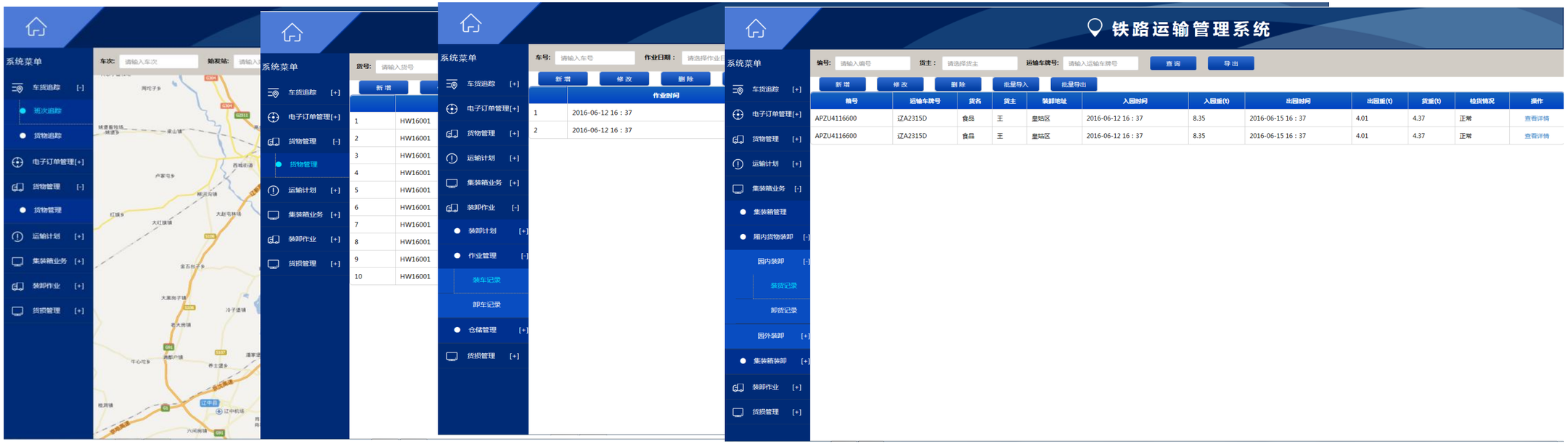
- ✓ Functionalities like storage management, Warehouse operation plan, inventory status, etc.
- ✓ Control warehouse process with barcode technology and RFID

City Joint Distribution Management System

车辆管理系统会对车辆空置、在途配送或等待装车等具体情况进行识别，优化车辆配置及配送线路。

- ✓ Orders and vehicles distribute according to the orders
- ✓ Optimization vehicle’s transport routes

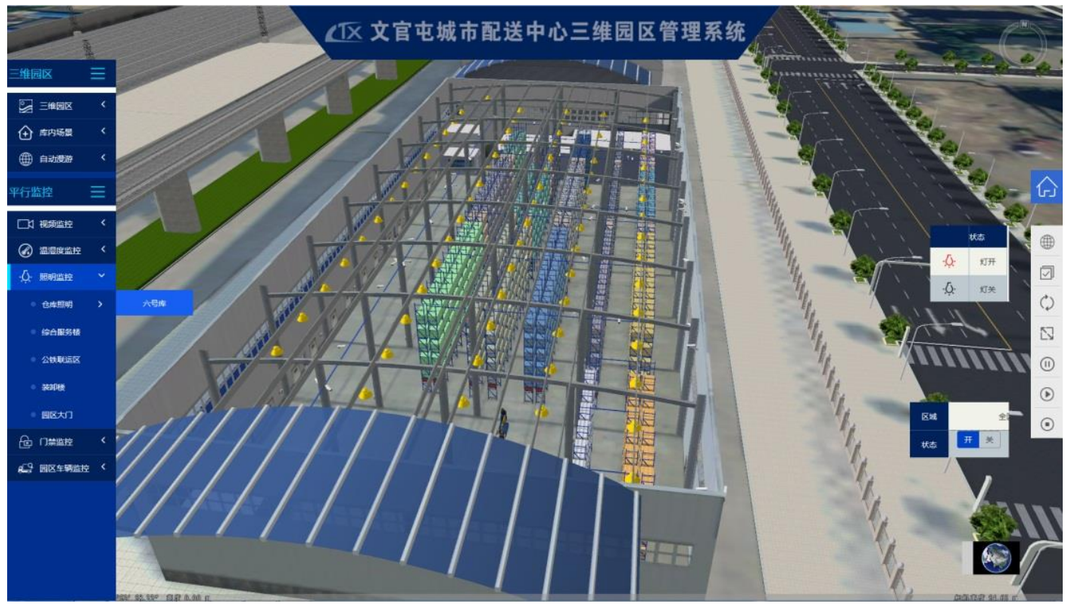
Railway Transportation Management System

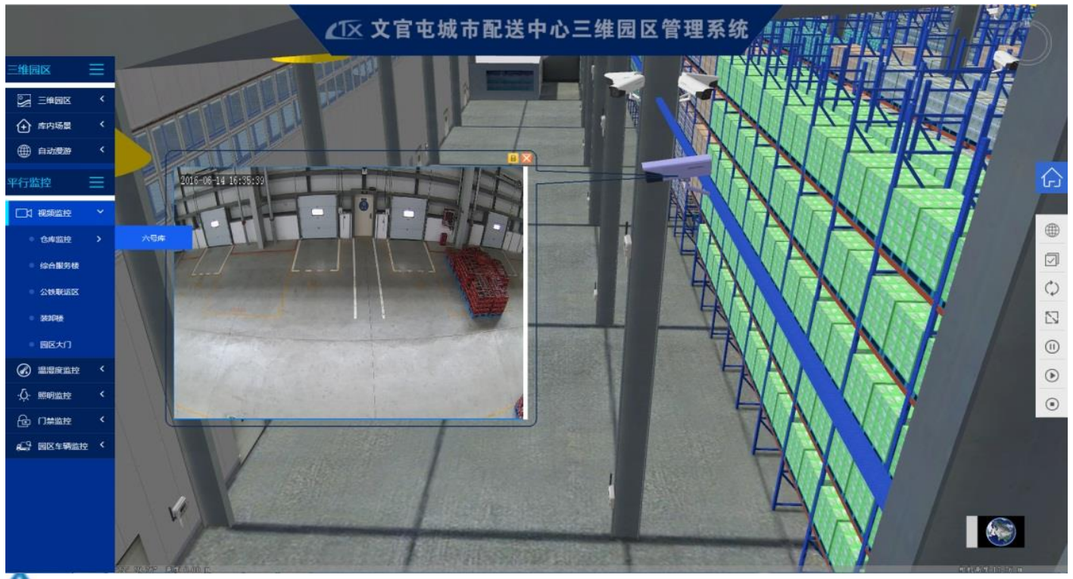


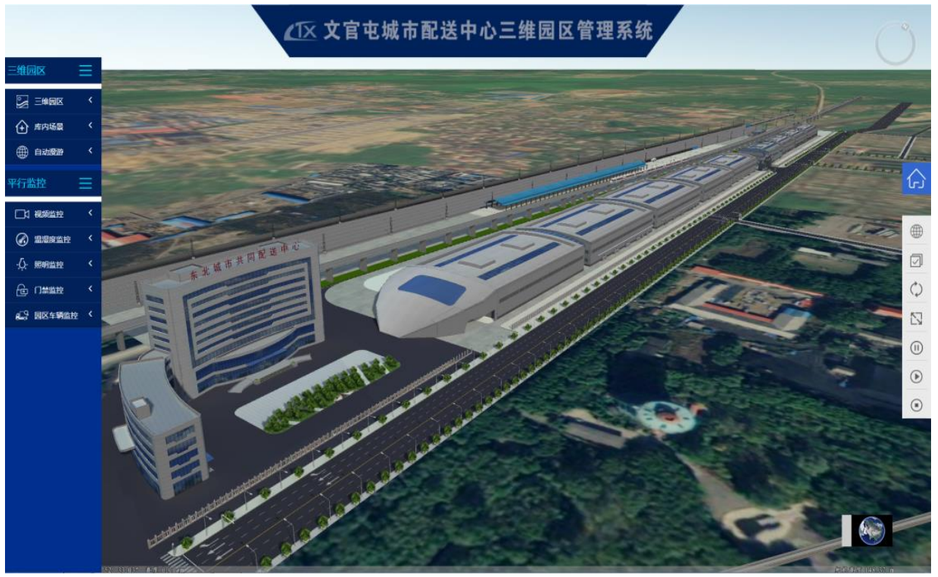
铁路运输管理系统包括单据管理、货物管理、运输计划、装卸作业管理、货损管理、集装箱业务、班列信息查询等功能，

- ✓ Functionality: order management, cargo management, transport plan, container operator, train status information research

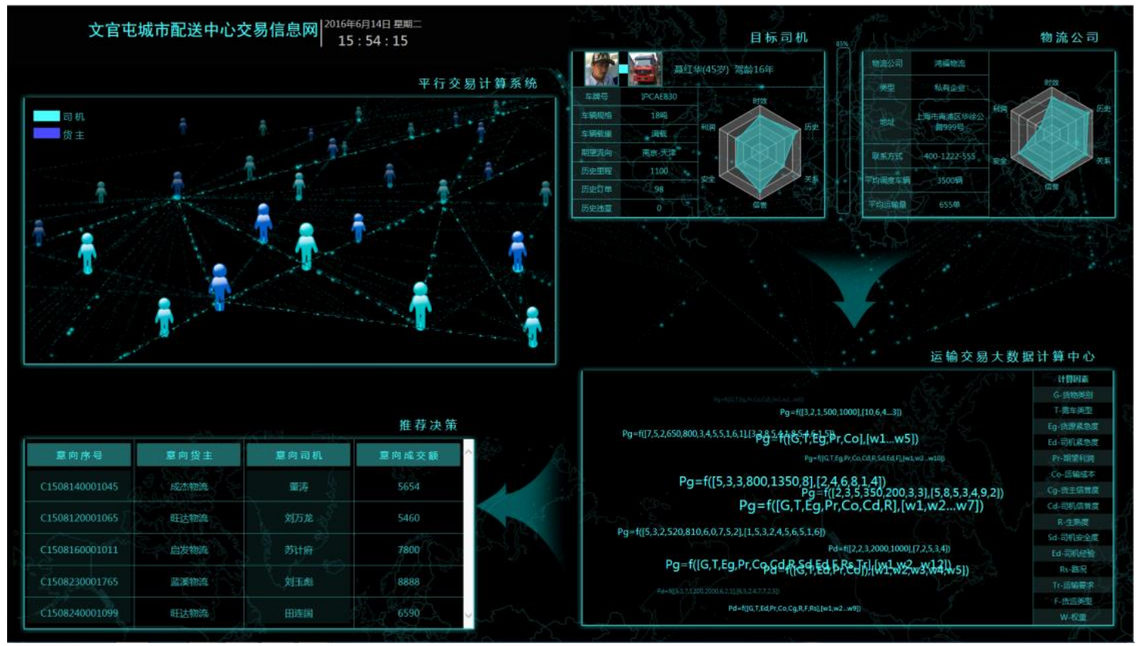
Management & Control System of 3D Logistics Park







Intelligence Decision Supporting System

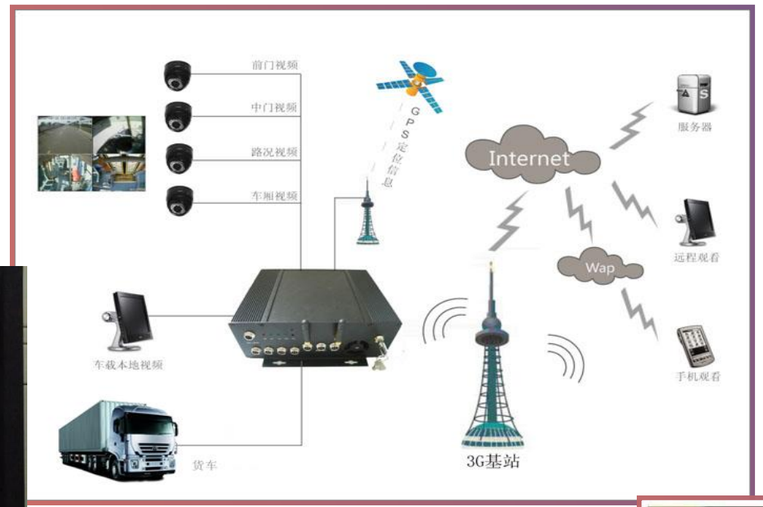


文官屯智能管理平台通过对积累的物流大数据进行分析、建模，可以为每家客户量身定制个性化、差异化仓储配送服务，快速制定出高效合理的物流配送方案，并实时进行监控；通过对物流园区人员作业数据的分析，可以进行人员合理配置和利用。

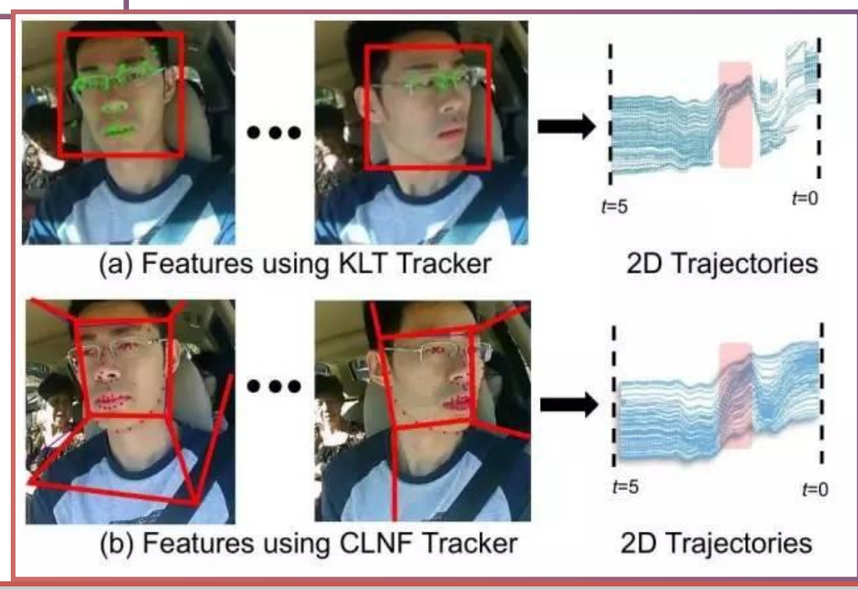
- ✓ Analysis and modeling on logistics big data
- ✓ Provide custom service in personalized, differentiation distribution
- ✓ Make a reasonable and efficient logistics distribution plan quickly
- ✓ Real-time monitor
- ✓ Rationally allocate and effectively utilize human resources

Vehicular Safety Big Data Monitoring

Traditional Vehicle and Driver Monitoring



AI based Infrastructure and Monitoring



Parallel Monitoring=Driving Behavior Recognition + Facial Recognition

Contents

Immanuel Kant' "Critique of Pure Reason" and Parallel System Methodology

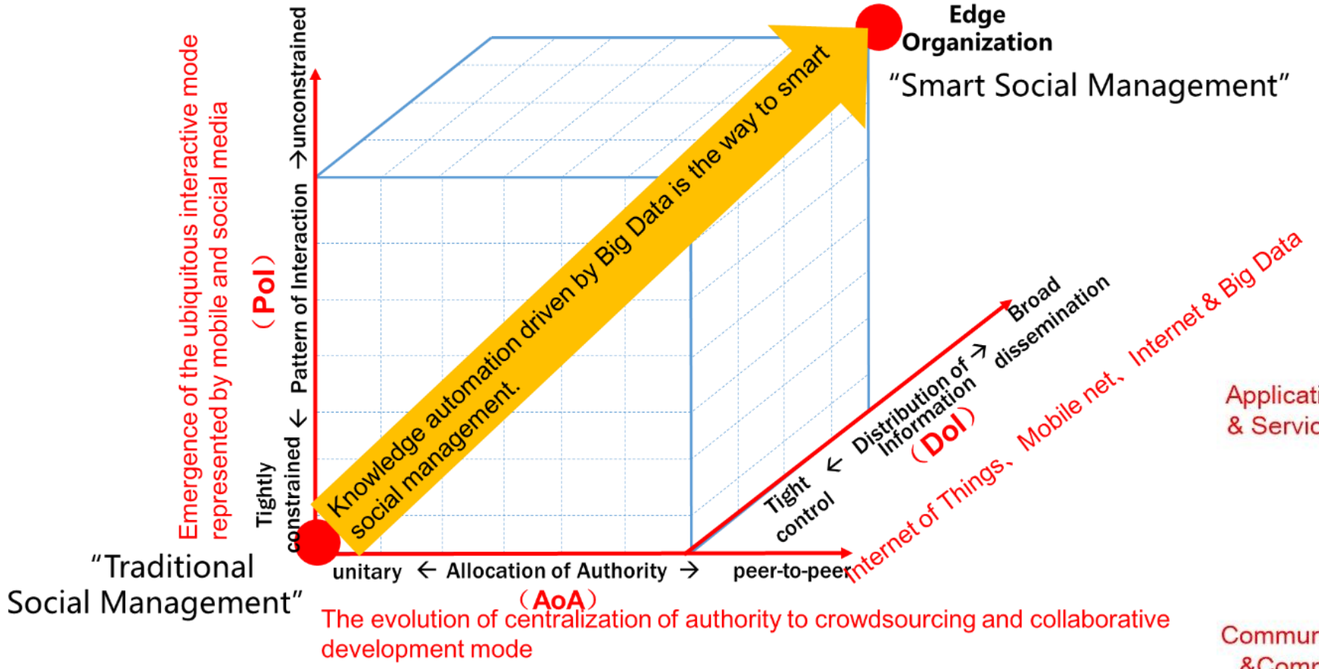
Kant's Motivation in *Critique of Pure Reason:*

- Copernican Revolution: Not knowledge according to objects, but objects according to knowledge.

Motivation for Parallel System

- Parallel Revolution: Not Intelligence according to objects, but objects according to Intelligence.

Eventually, Smart Logistics for Smart Society



The evolution of centralization of authority to crowdsourcing and collaborative development mode

Modem logistics will become complex systems in the incoming technological revolution, and thus needs a new paradigm for its management and control

We expect smart logistics will play a vital role in many IoT areas, not only smart business, eventually, an important step toward the smart society

Thanks

Q&A