Charging Forward
- AI in Wireless

IEEE ICC 2019

May 23, 2019 Shanghai

AI: 60 Year Ups and Downs, Overturn is coming

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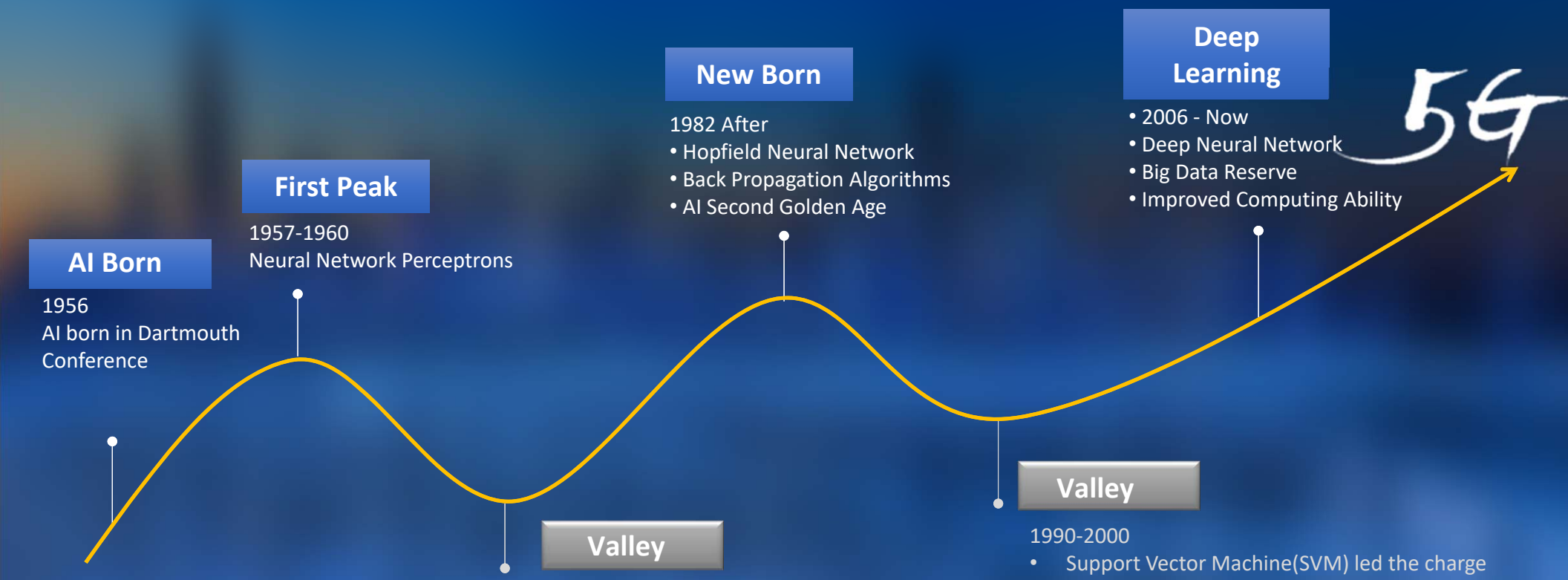

Why AI/ML in Wireless Network

Complicated Wireless Networking Environment

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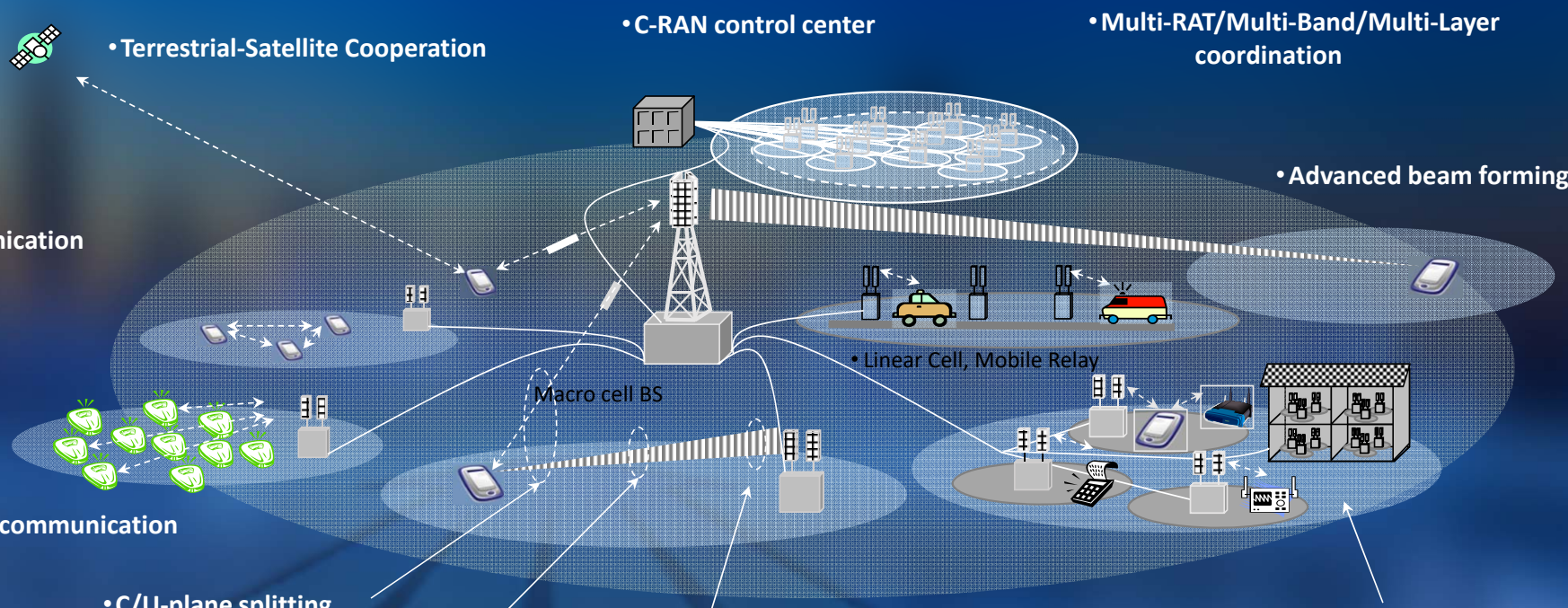

As Wireless Technology evolves, the complicated network demands AI/ML become part of the solution!

Customer Demands

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Smart Network Location and Solution

- Problem：Hardware Failure、Software Malfunction、System Performance、Coverage、End User Isolation
- Value：With assistance from AI，solving network location solution，improve network quality, End User satisfaction.

Smart RRM

- Issue：Mobility management, Load balancing, Carrier aggregation, Interference management、QoS management
- Value：With assistance from AI, Increasing Radio Resource Efficiency, Increase Sys. Functions，High ROI

Smart Self-Adjusting Parameters

- Parameters：VOLTE, Antenna, mMIMO, eNB/eNB
- Value：With assistance from AI, reduce human involvement, reduce parameter and optimization cost

Predicable Networking

- Content：Voice Service Capacity, eNB/gNB, RAN Resource/Capacity forecasting, User behavior forecasting, RF finger print, outage forecasting
- Value：With assistance from AI, forecasting futures, guiding operations

Enhanced Feature

Quality Network

Increased Efficiency

Reduced Cost

Wireless Network AI Feature Requirements

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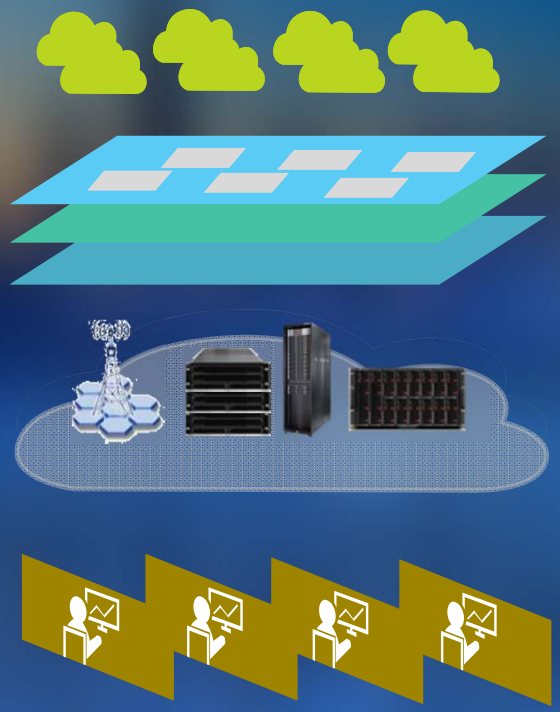

Human-Managed Network

Self Learning

Request Respond

Self Healing

Predicable

Self Progression

Humanless

AI/Big Data Based Self-Managed Network


Industry Developing
Smart Network

AI Assisted Network Evolution Path

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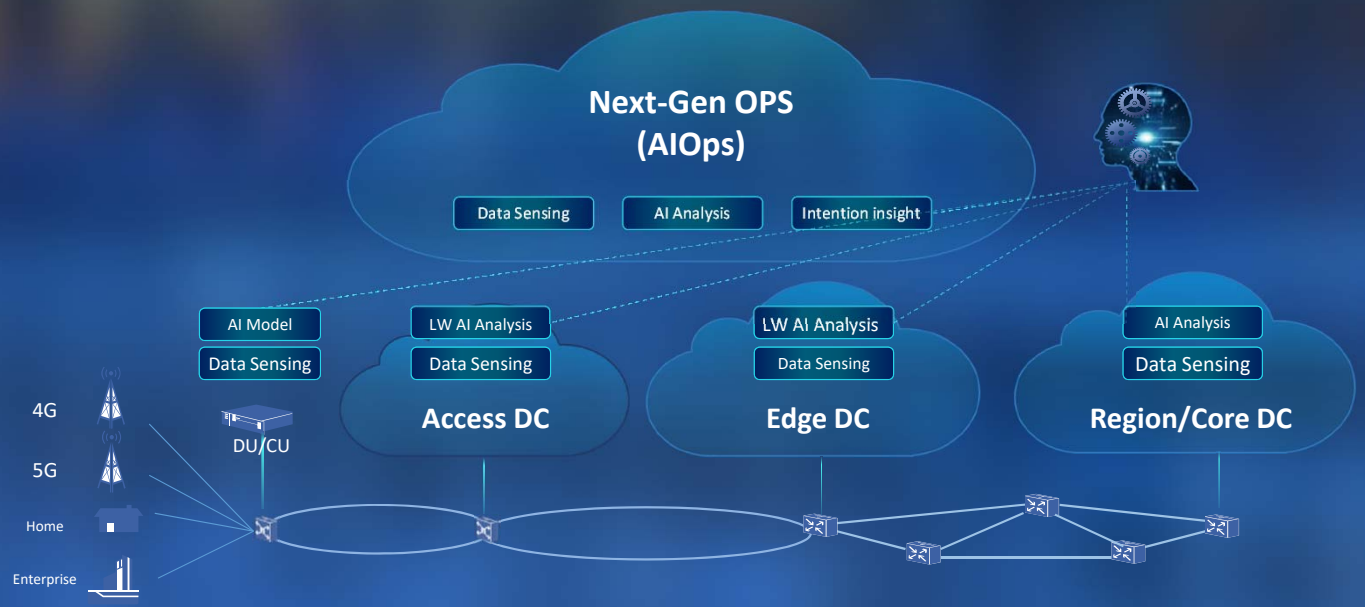
Networking Cloud Transformation and NFV Commercialization NOT taking place as fast as people expected



Ubiquitous AI Assisted Network Evolution Path

AI Assisted Network Capabilities

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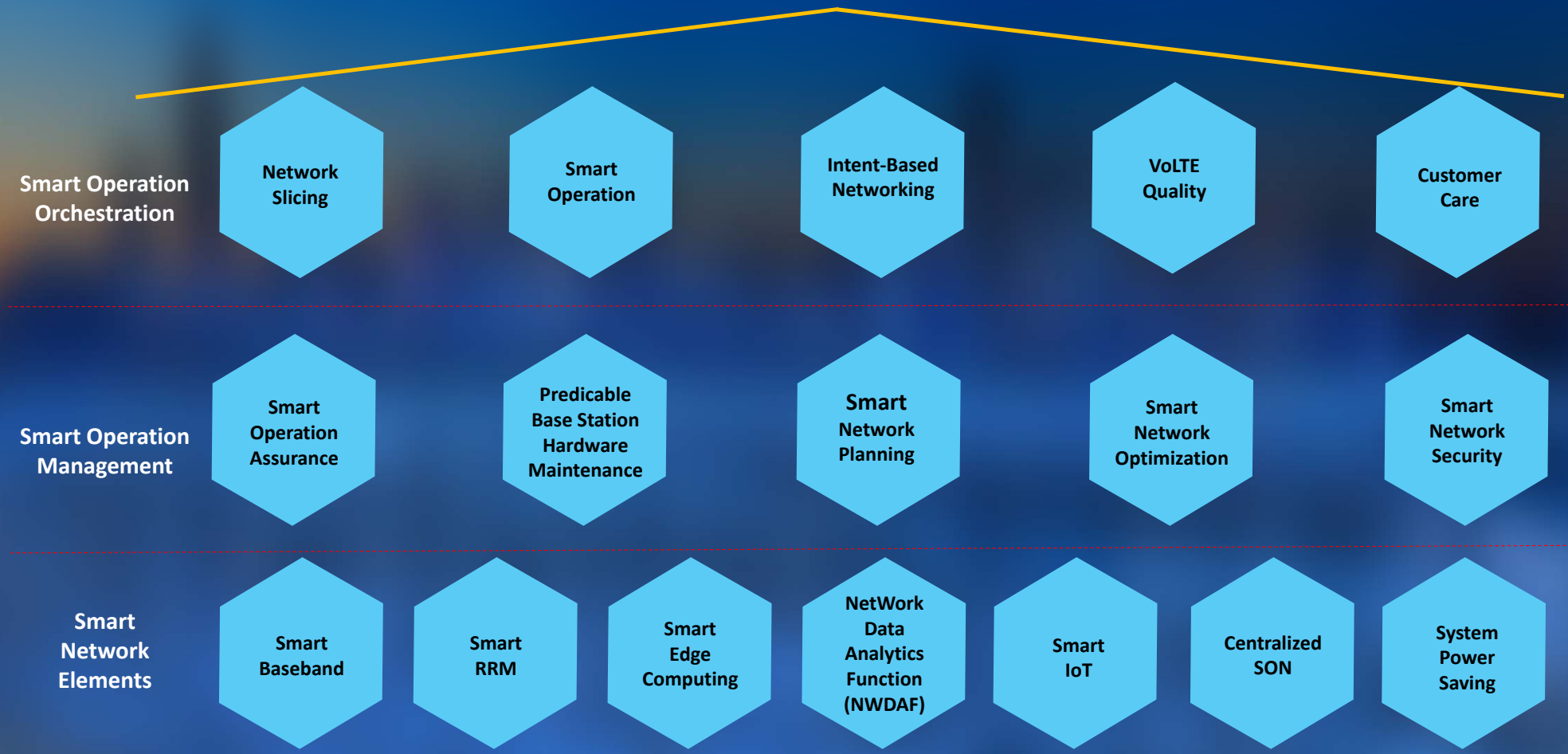


AI/ML Enabled Smart
Wireless Network

AI/ML Smart Network Architecture

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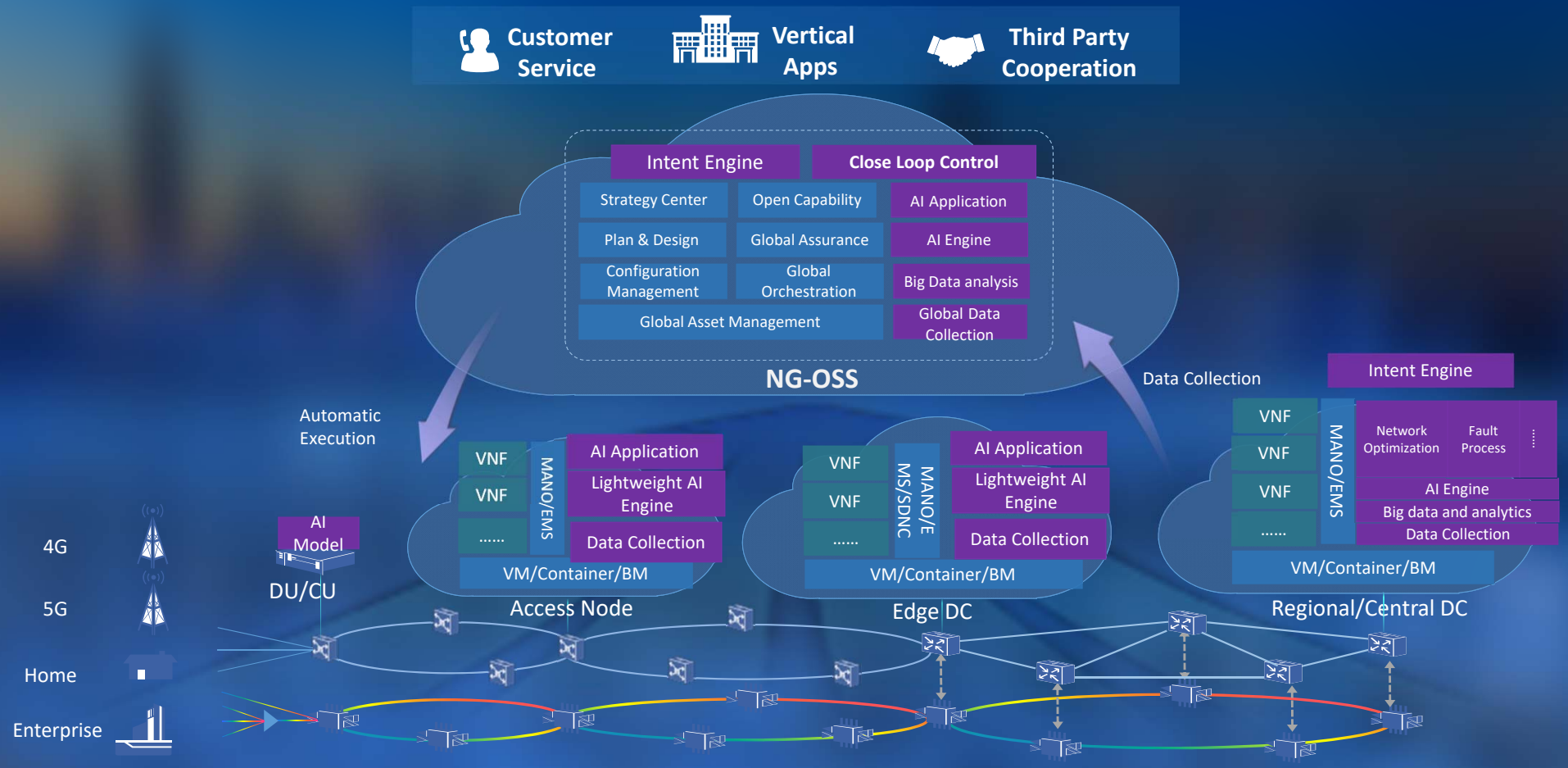

Intelligent Network Evolution Grading Method

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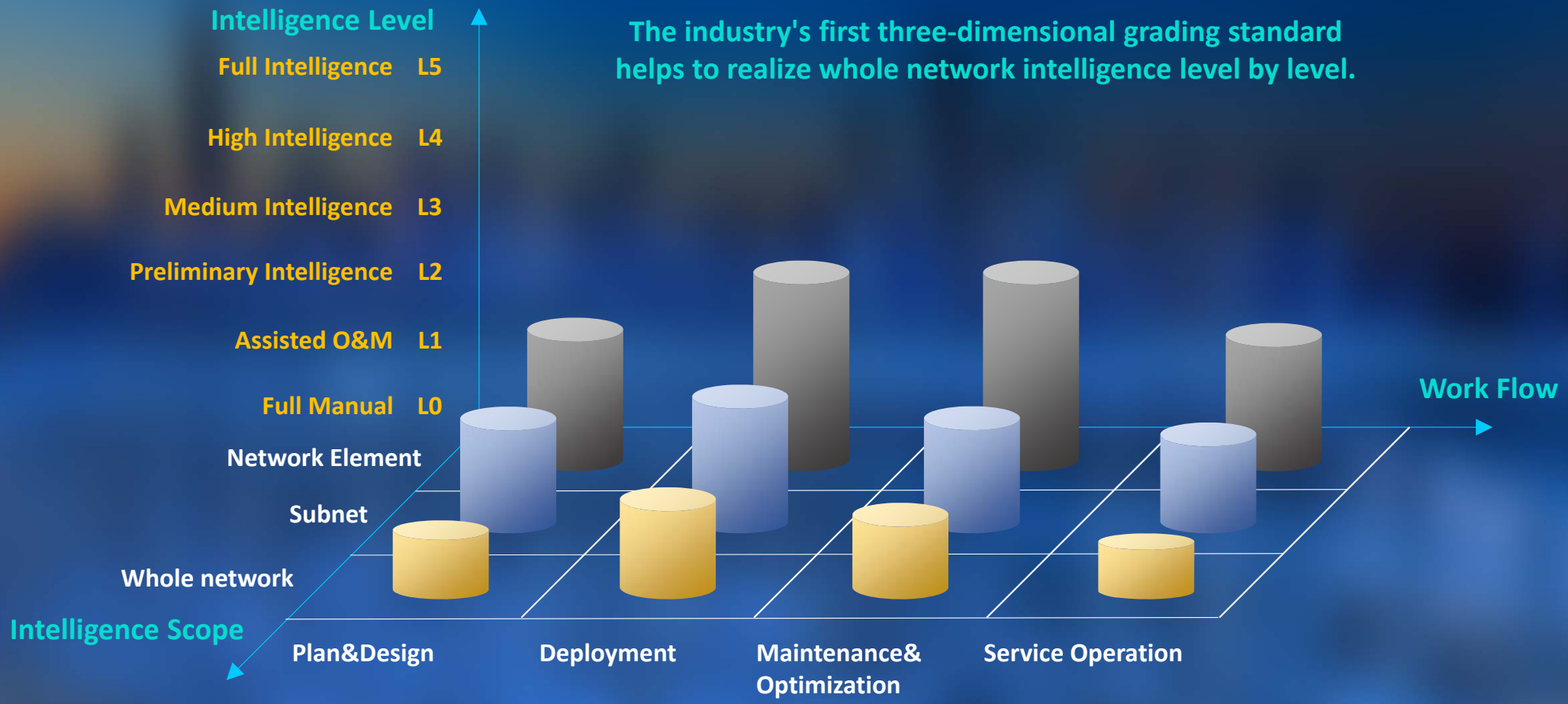
The industry's first three-dimensional grading standard helps to realize whole network intelligence level by level.




Use Cases

AI, Ushering in the Intelligent Wireless Network

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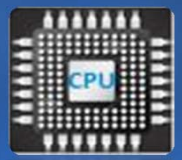
Intelligent BS	Edge intelligence	Intelligent network planning &optimization	Intelligent operation and maintenance
• beam forming • Intelligent power saving • RF fingerprint • Voice drop optimization • Load balancing •	• Video optimization • Message feature recognition • ML based service optimization •	• Cell Coverage Optimization (CCO) • Capacity assessment prediction •	• Network security detection • KPI intelligent detection • Performance RCA • Intelligent slice • Network self-optimization • .....









Energy Saving with Intelligence

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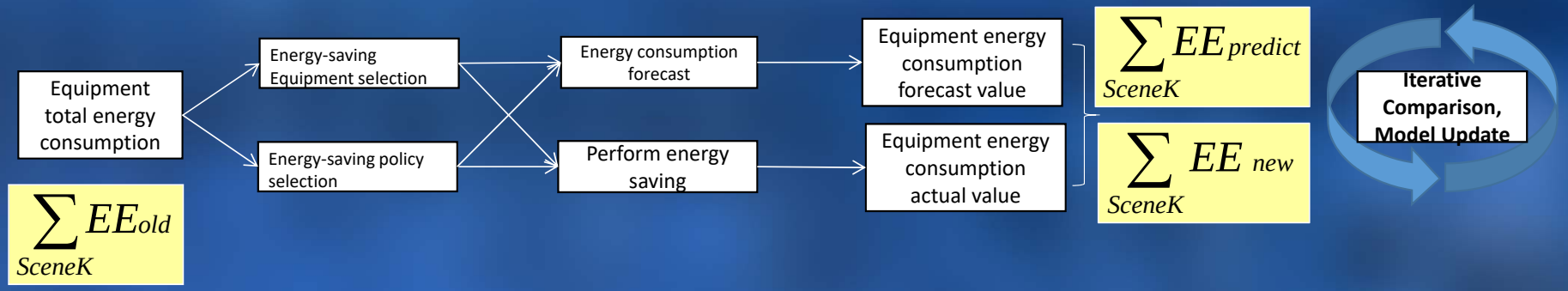
Supporting multi-band, multi-mode, multi-vendor heterogeneous network energy-saving scenarios

- Prediction
  - *Telephone traffic tide forecast (time period);*
  - *Energy saving effect prediction (energy consumption, performance, coverage, etc.);*
- Intelligent control
  - *Intelligent energy-saving control (devise intelligence, algorithm intelligence, etc.);*
  - *Intelligent parameter configuration (dynamic threshold, etc., black and white list, etc.);*
  - *Multi-network collaborative energy saving;*
- Evaluation
  - *Energy-saving assessment (energy consumption, performance, coverage, etc.);*
- Optimization
  - *Energy consumption/performance/load model dynamic optimization*



RF Fingerprint

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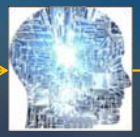
1 Collect data 2 Data preprocessing 3 Machine learning

MR data
HO data

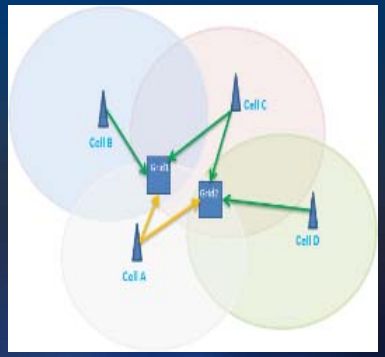
Data cleaning
Data aggregation
.....
Algorithm related data conversion



RF fingerprint database

Grid No.	Grid Index		
	Cell	Strongest same fre. adjacent cell1	Strongest same fre. adjacent cell2
Grid1	Cell A -85dBm	Cell B -90dBm	Cell C -95dBm
Grid2	Cell A -90dBm	Cell C -90dBm	Cell D -100dBm

Established by RSRP and more



4 RF fingerprint database update

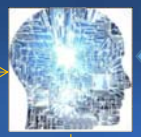
UE real-time info

RF fingerprint database
grid1 onlineUEinfo
neighborCellInfo
grid2 onlineUEinfo
neighborCellInfo
.....

App. Accomplishes :
- ✓ Load balancing
- ✓ Secondary node selection
- ✓ Cross frequency free measurement blind cutting
- ✓ 5G voice fall back

Intelligent RF fingerprint based on historical and real-time info

RRM



Networks

1 Function trigger

2 Inference

3 Execution advice

Smart Operation Management

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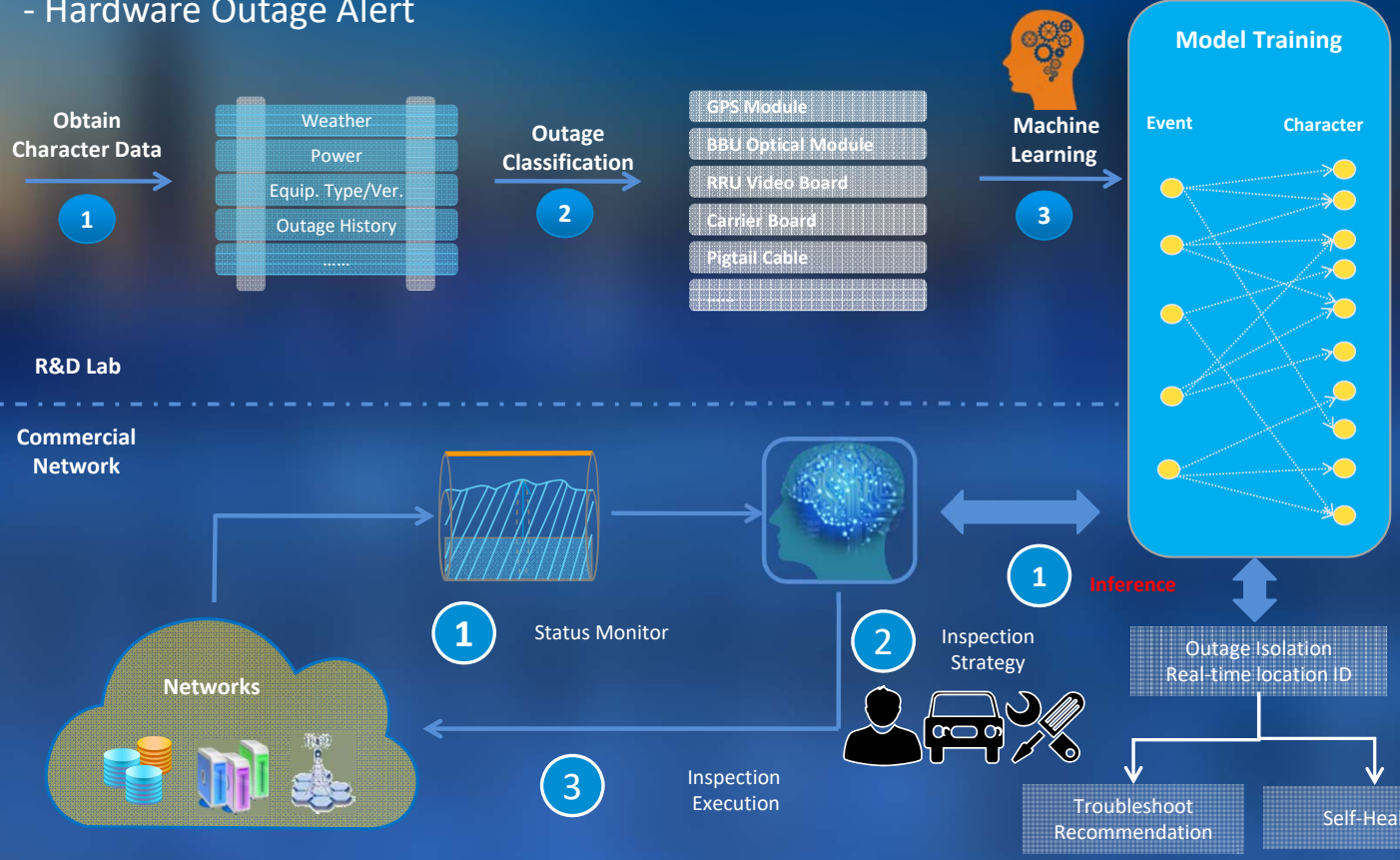
Base Station HW maintenance predictability
- Hardware Outage Alert



Pain Points

- The lack of efficient inspection methods for hardware health, high cost of network inspection, and hope to reduce costs
- Potential hardware problems are difficult to detect and discover in advance

Value

- Save network inspection costs
- AI predicts the occurrence time and probability of each failure of each station
- Reorganize the annual inspection plan based on the forecast results
- Through prediction, discover potential hardware problems and provide timely warnings, provide best troubleshooting suggestions, and some problems quickly self-heal

Intelligent Root Cause Analysis (RCA)

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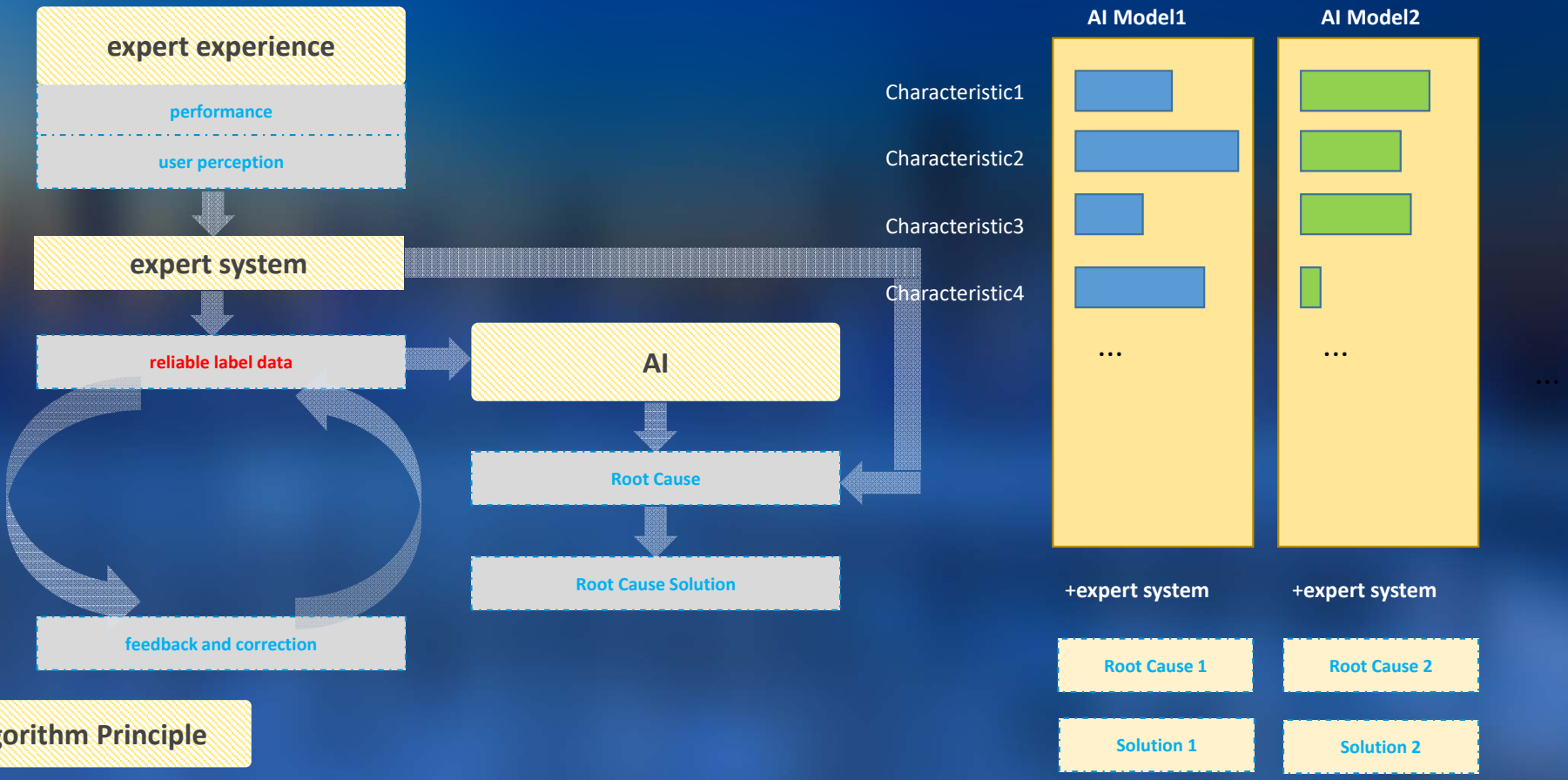

Algorithm Principle

- Use expert experience to construct reliable label data, and need feedback and correction
- Use reliable data to build AI Model for one root cause;
- Adopt AI model and expert experience to determine root cause

AI Assisted KPI Deterioration Detection

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Intelligent KPI Deterioration Detection off_line Analysis system

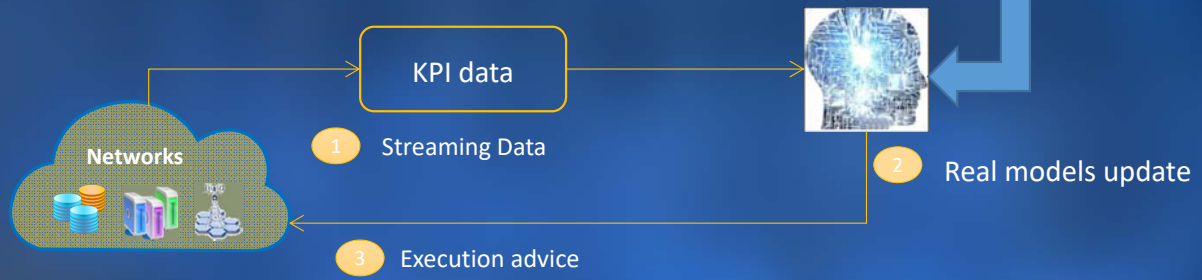
1 Collect data 2 Data preprocessing 3 Machine Learning

KPI data → Imputations of missing values; Removing high pulses; ..... ; Periodic pulse detection → Data Categorization → Competition : SARIMA/ETS/BATS/ HoltWinters/Olympic/ KDE/RNN/SST/ DBSCAN/Pearson

4 training → Models

- ✓ E-RAB Setup Success Rate
- ✓ RRC Establishment Success Rate
- ✓ E-RAB Drop Rate

Intelligent KPI Deterioration Detection real-time Analysis system

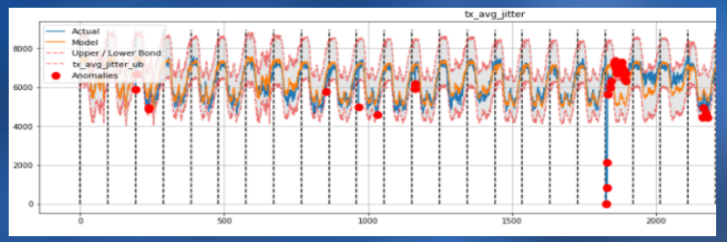


Key Point

- **Intelligent KPI Deterioration Detection off_line Analysis system**
  1. **runs nightly for each KPI**
  2. **Data categorization:tries to identify stat as near, multinomial, step function, etc,If one of those matches, that different Machine Learning algorithm is used**
  3. **Competition: different Machine Learning algorithm include SARIMA/ KDE/RNN/SST etc.**
- **Intelligent KPI Deterioration Detection real-time Analysis system**
  2. **Real models update based on steaming data**

Apply & Value

- **It is dynamic and personalized down to individual KPI**
  1. **Varies from object to object.**
  2. Varies from time to time.
  3. **Varies from metric to metric.**



Smart Massive MIMO

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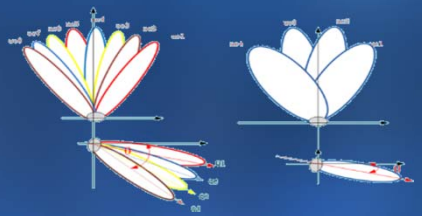
Large-scale antenna

Antenna Oscillator 128~256

3D MIMO UE Flexible Tracking
Reduce Interference

3D MIMO **2D MIMO**



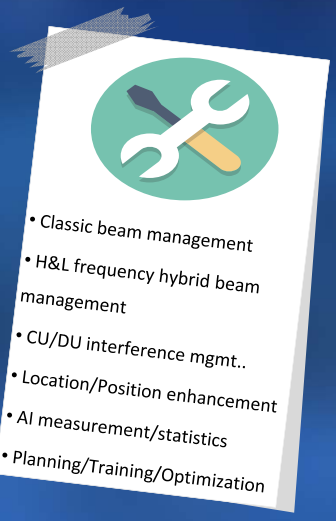
Horizontal & vertical Beamforming

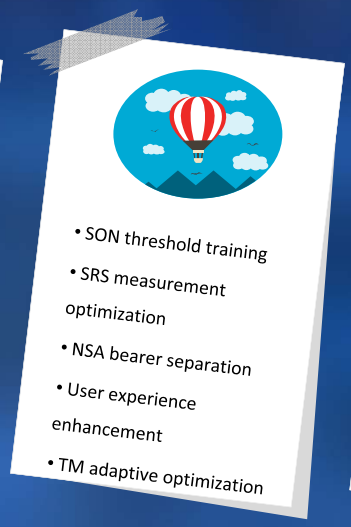
Horizontal Beamforming

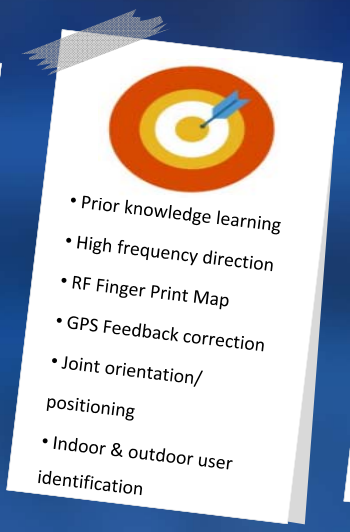
Digital Map

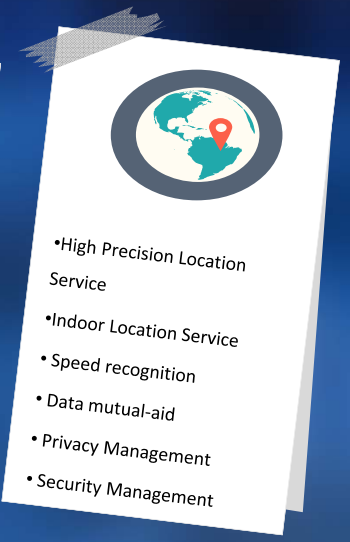
RF Finger Print

Rules Training









Coverage Analysis RSRP Prediction

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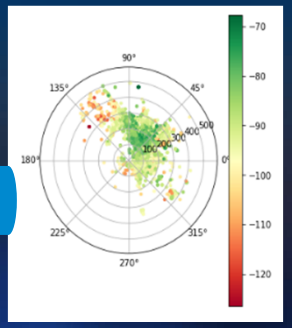
Existing Multi-Cell
3D Geographical Features

Reference

AI

RSRP Sample



Model Training

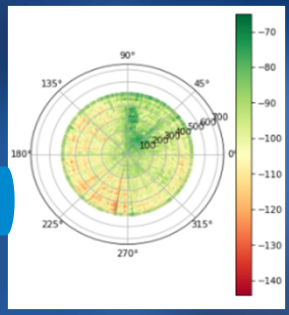
RSRP Prediction

New Multi-Cell
3D Geographical Features

Adjustable Reference

AI
(Trained)

RSRP Distribution




Real World Practice

AI Helps Increasing Operation Efficiency in Europe

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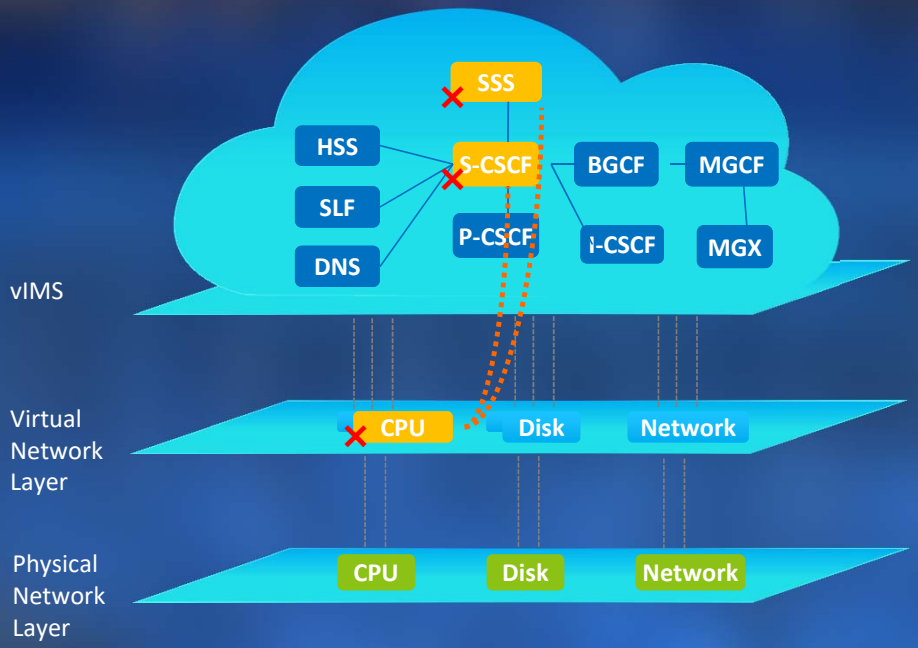
- **Challenge:** the number of traditional RCA(Root Cause Analysis) rules falls far short of the actual alarm requirements under the new network architecture
- **Training:** millions of historical warning data, 41 effective rules were extracted efficiently and accurately
- **Multi-data source:** **including alarms from physical network layer, virtual network layer, business layer and orchestrators. Cross layer comprehensive analysis are conducted**



		W/O AI	W AI
43% ↓	# of Alarm	70/Day	40/Day
76% ↓	Rule Extraction Time	30 P. Day	7 P. Day
96% ↓	Rule Deployment Time	5 Day	0.2 Day
58% ↑	Rule Extraction Quantity	26 Rules	41 Rules

AI Assists Coverage & Capacity Optimization in China

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AI Training improves Weak/Over/Overlap Coverage, Increasing Network Quality

Data Source

Config/Perf. Data	MR Report Call Details	Min. Path Measurement
3D Map	Engineering Parameters	DPI

Training :

- ✓ AI Based power self-optimization prediction
- ✓ AI based antenna self-optimization prediction
- ✓ AI based antenna self-optimization in heuristic style

AI reasoning output :

- ✓ Antenna tilt down adjustment advice
- ✓ Power supply parameter advice
- ✓ Adjacent cells suggestion
- ✓ Project implementation proposal

Results:

Antenna Optimization :

- ✓ DL SINR increase 1.33dB
- ✓ RSRQ average increase 0.77db
- ✓ CQI increase 0.41
- ✓ UL SINR increase 1.24dB

Power Optimization :

- ✓ DL SINR increase 0.66db
- ✓ RSRQ均 increase 0.23db
- ✓ CQI increase 0.12
- ✓ ULSINR increase 0.03dB

AI Assuring H. Dense Capacity and Auto-RCA in Asia

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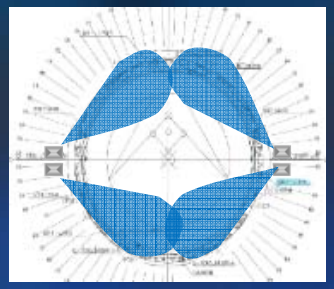
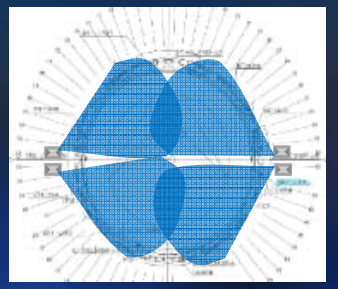
AAPC

Baseball scenario



Automatically adjust the weight to suit the needs of scene

Concert scenario



Load Balance

Traditional LB		AI-based LB
Low PRB Utilization		High PRB Utili. Auto switch
4UE HO 30 seconds	Before → After	20UE HO 10 seconds
Idle User		CN/Idle User LB

RCA

Top N alarm

Freq. occurring alarm	Upload reports or delay reports in a consolidated form
RCA alarm	Provide accurate fault location, problem solution
Uncertain alarm	Do not report, send only reminder


Thanks!
ZTE Leading 5G Innovations