Charging Forward
-AI in Wireless

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AI: 60 Year Ups and Downs, Overturn is coming

- 1956: AI born in Dartmouth Conference
- 1957-1960: Neural Network Perceptrons
- 1982: Hopfield Neural Network, Back Propagation Algorithms, AI Second Golden Age
- 2006-Now: Deep Neural Network, Big Data Reserve, Improved Computing Ability
- 1990-2000: Support Vector Machine (SVM) led the charge, Limitations in expert system
Why AI/ML in Wireless Network
As Wireless Technology evolves, the complicated network demands AI/ML become part of the solution!
Customer Demands

**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
Wireless Network AI Feature Requirements

AI/Big Data Based Self-Managed Network

Self Learning

Self Healing

Self Progression

Request Respond

Predicable

Humanless

Human-Managed Network
Industry Developing Smart Network
Networking Cloud Transformation and NFV Commercialization NOT taking place as fast as people expected

Ubiquitous AI Assisted Network Evolution Path
AI Assisted Network Capabilities

Smart Operation Orchestration
- Network Slicing
- Smart Operation
- Intent-Based Networking
- VoLTE Quality
- Customer Care

Smart Operation Management
- Smart Operation Assurance
- Predicable Base Station Hardware Maintenance
- Smart Network Planning
- Smart Network Optimization
- Smart Network Security

Smart Network Elements
- Smart Baseband
- Smart RRM
- Smart Edge Computing
- NetWork Data Analytics Function (NWDAF)
- Smart IoT
- Centralized SON
- System Power Saving
AI/ML Enabled Smart Wireless Network
Intelligent Network Evolution Grading Method

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

## Intelligent BS
- Beam forming
- Intelligent power saving
- RF fingerprint
- Voice drop optimization
- Load balancing
- ......

## Edge intelligence
- Video optimization
- Message feature recognition
- ML based service optimization
- ......

## Intelligent network planning & optimization
- Cell Coverage Optimization (CCO)
- Capacity assessment prediction
- ......

## Intelligent operation and maintenance
- Network security detection
- KPI intelligent detection
- Performance RCA
- Intelligent slice
- Network self-optimization
- ......

## Intelligent network planning & optimization
- Cell Coverage Optimization (CCO)
- Capacity assessment prediction
- ......
Energy Saving with Intelligence

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

- **Equipment**
  - Equipment total energy consumption
  - Equipment energy consumption forecast
  - Equipment energy consumption forecast value
  - Equipment energy consumption actual value

\[ \sum_{SceneK} EE_{old} \]
\[ \sum_{SceneK} EE_{predict} \]
\[ \sum_{SceneK} EE_{new} \]

Iterative Comparison, Model Update
RF Fingerprint

1. Collect data
2. Data preprocessing
3. Machine learning

- MR data
- HO data
- Data cleaning
- Data aggregation
- Algorithm related data conversion

4. RF fingerprint database update

Intelligent RF fingerprint based on historical and real-time info

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Established by RSRP and more

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

1. Function trigger
2. Inference
3. Execution advice
Smart Operation Management

Base Station HW maintenance predictability - Hardware Outage Alert

- Obtain Character Data
- Outage Classification
- Machine Learning

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)

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

Key Point
- Intelligent KPI Deterioration Detection off-line Analysis system
  1. Collect data
  2. Data preprocessing
  3. Machine Learning
    - Competition: SARIMA/ETS/BATS/HoltWinters/Olympic/KDE/RNN/SST/DBSCAN/Pearson
  4. Training

- Intelligent KPI Deterioration Detection real-time Analysis system
  1. Streaming Data
  2. Real models update
  3. Execution advice

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.

Intelligent KPI Deterioration Detection off-line Analysis system

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Smart Massive MIMO

Large-scale antenna

Antenna Oscillator 128~256

3D MIMO UE Flexible Tracking
Reduce Interference

3D MIMO
2D MIMO

Horizontal & vertical Beamforming
Horizontal Beamforming

Joint beam management
Beam tracking
High frequency direction
H. frequency or L. speed decision orientation
Indoor or outdoor determination

AI Assistance

LBS Enhancement
eNB/gNB position

Digital Map
RF Finger Print
Rules Training

- Classic beam management
- H&B frequency hybrid beam management
- CU/DU interference mgmt..
- Location/Position enhancement
- AI measurement/statistics
- Planning/Training/Optimization

- SON threshold training
- SRS measurement optimization
- NSA bearer separation
- User experience enhancement
- TM adaptive optimization

- High precision location
  service
- Indoor location service
- High frequency direction
- RF Finger Print Map
- GPS Feedback correction
- Joint orientation/positioning
- Indoor & outdoor user identification

- Prior knowledge learning
- High speed recognition
- Data mutual aid
- Privacy Management
- Security Management
Coverage Analysis RSRP Prediction

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

- **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.

### Performance Improvement:

- **% of Alarm:**
  - Without AI: 70/Day
  - With AI: 40/Day
  - Improvement: 43%

- **Rule Extraction Time:**
  - Without AI: 30 P. Day
  - With AI: 7 P. Day
  - Improvement: 76%

- **Rule Deployment Time:**
  - Without AI: 5 Day
  - With AI: 0.2 Day
  - Improvement: 96%

- **Rule Extraction Quantity:**
  - Without AI: 26 Rules
  - With AI: 41 Rules
  - Improvement: 58%
AI Assists Coverage & Capacity Optimization in China

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

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

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 average increase 0.23dB
- CQI increase 0.12
- ULSINR increase 0.03dB

AI reasoning output:
- Antenna tilt down adjustment advice
- Power supply parameter advice
- Adjacent cells suggestion
- Project implementation proposal

Data Source:
- Config/Perf. Data
- MR Report
- Call Details
- Min. Path Measurement
- 3D Map
- Engineering Parameters
- DPI
AI Assuring H. Dense Capacity and Auto-RCA in Asia

**Load Balance**

- Traditional LB
- Low PRB Utilization
- 4UE HO 30 seconds
- Idle User

Before → After

- AI-based LB
- High PRB Util. Auto switch
- 20UE HO 10 seconds
- CN/Idle User LB

**RCA**

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

**AAPC**

Baseball scenario

Concert scenario

Automatically adjust the weight to suit the needs of scene

-AAPC

-Concert scenario