Things Coverage
Network Planning
White Paper
– Bring Everything Connected

A Things-Oriented
Network Planning Methodology

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Executive Summary

After a long process of nurturing emerges the rapid development of the Internet of Things (IoT) market. Operators enjoy exceptional advantages regarding networks, professionals, technologies, capitals, and services to expand the IoT market. The collaboration between operators and vertical industries empowers new capabilities. Operators are playing a key role in the prevailing IoT trend. Before the advent of 5G by 2020, operators can utilize existing networks to explore new network capabilities, provide new experience, and promote the emergence of new markets and IoT applications.

However, diverse IoT services and divergent business requirements lead to new challenges for network construction. IoT network planning and deployment must shift from network-centric to use case-centric to provide excellent things experience and maximize IoT value.

Huawei has conducted in-depth research on IoT network construction to facilitate the experience evaluation of things. As a result, Huawei proposes an innovative 5-dimensional experience definition (based on Availability, Bandwidth, Coverage, Delay sensitivity, and Energy efficiency), and the world’s first requirement baseline to evaluate typical services (such as smart meters, connected cars, and industry control and so on). According to the 5-dimension experience of things, Huawei has also proposed the first things-oriented network planning methodology (Things Coverage) to help operators accelerate network construction and comprehensively ensure robust development of IoT services in locations situated throughout deployed operators’ networks.
1. IoT Industry Insight

The era of IoT has arrived.

After many years of development and exploration, IoT has entered a phase featuring standard and systematic construction based on fragmented deployment during the initial phases. IoT applications are released for a wide range of industries (smart cities and logistics). It is expected that IoT will quickly penetrate into all aspects of life and flourish in a growing market space.

1.1 IoT Stimulates New Connection Value

With the rapid popularity of mobile devices in recent years and continuous expansion of peripheral platforms and services, the IoT market space is quickly expanding. According to a forecast released by Internet Data Center, the market presence of global IoT reached USD$700 billion by 2015 and is expected to achieve USD$1700 billion by 2020, with a compound annual growth rate (CAGR) of 20%. According to a forecast released by Gartner, the quantity of IoT devices has reached 4.9 billion by 2015 and is expected to reach 20.8 billion by 2020, with a CAGR of 34%. IoT is extensively entering diverse industries, and is gaining wide acceptance from applied scenarios such as smart home, education, healthcare, wearable devices, and connected cars.

![IoT market presence prediction (unit: USD$100 million)](image)

1.2 Divergent IoT Scenarios and Requirements

Different from traditional user-centric services, IoT services have divergent requirements for network functions. In this document, IoT services are classified into three categories based on scenarios: individual, public, and industrial.

![IoT connections](image)
Diverse services in different scenarios have divergent requirements. In the industry control, Functional Data or Process Data used for real-time control and surveillance status feedback requires low latency and high data rates. In comparison, Informational Data used for non-real-time status data report has low requirements for delay and bandwidth. For details, see the following table.

<table>
<thead>
<tr>
<th>Type</th>
<th>Use case</th>
<th>attribute</th>
<th>throughput</th>
<th>latency</th>
<th>reliability</th>
<th>mobility</th>
<th>security</th>
<th>Tech</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Data</td>
<td>Real-time control for factory automation</td>
<td>Real time</td>
<td>~1 Mb/s</td>
<td>~1ms E2E</td>
<td>critical 10^-9</td>
<td>Yes (mobile robot)</td>
<td>high</td>
<td>5G</td>
</tr>
<tr>
<td></td>
<td>Laser sensor, vision sensor, camera</td>
<td>High data rate; Real time</td>
<td>4K: 30-40Mbps 2D laser sensor; 14Mbps</td>
<td>100ms; 1ms E2E (combination with real-time control)</td>
<td>critical 10^-5</td>
<td>Yes (mobile robot)</td>
<td>high</td>
<td>5G</td>
</tr>
<tr>
<td>Informational Data</td>
<td>Track, Monitor</td>
<td>Massive</td>
<td>Low, ~100kbps in burst</td>
<td>1s level:</td>
<td>critical</td>
<td>yes</td>
<td>high</td>
<td>NB-IoT</td>
</tr>
<tr>
<td></td>
<td>Reporting for process automation</td>
<td>Massive</td>
<td>~1 Mb/s</td>
<td>10ms-1s</td>
<td>critical</td>
<td>yes</td>
<td>high</td>
<td>4G, 4.5G</td>
</tr>
</tbody>
</table>

1.3 Operators’ Opportunities

IoT has manifested as an inescapable reality. The rapid growth of IoT has gained significant popularity as a global trend. However, networks are far from adequately functional and capable of supporting these applications.

Operators enjoy exceptional advantages regarding networks, professionals, technologies, capitals, and services to expand the IoT market. The collaboration between operators and vertical industries empowers new capabilities. Operators are playing a key role in the prevailing IoT trend even before the advent of 5G by 2020. These operators can utilize existing networks to explore new network capabilities, provide new experience, and promote the emergence of new markets and IoT applications.

With a lack of experience in IoT evaluation and construction, how to help operators address new challenges, precisely evaluate IoT potential values, and perform rational investment in rapid service delivery? This document presents new solutions to handle these issues.
2. IoT Benefits for Operators

2.1 IoT Is a Future Strategy

IoT services feature the long tail effect. Limitless connection dividends and the existence of high-value connections in the blue ocean market help operators obtain new users and expand into a new market space to seek additional profit.

IoT services allow operators to profit from vertical industries beyond pipeline value and expand the business boundary using existing networks. IoT proves to be operators’ optimal choice to help stimulate the development of the industry and realize untapped network potential, and will become operators’ network infrastructure.

2.2 Operators Enjoy Exceptional Advantages in Expanding the IoT Market

Operators enjoy exceptional advantages in expanding the IoT market. According to the latest survey report released by MachNation, SMEs comprise 90% of the entire vertical industry chain, but remain incapable of collaborating with all players and lack R&D capabilities. However, operators can provide pipeline R&D capabilities and accumulate industry knowledge to allow SMEs to provide diverse services.

The MachNation report also shows that local partners comprise 70% of the vertical market. Operators are advantageous in local services and sales networks, as well as excellent credits. Mature localization capabilities are beneficial for the quick establishment of a fully comprehensive local vertical market ecosystem.

According to IoT Deployment and a Usage Trend Survey released by Strategy Analytics in 2016, operators ranking position rose from No.5 in 2015 to No.2 in 2016 as a listed record of influential IoT industry partners. This demonstrates operators’ profound influence on IoT selection and decisions.

![Operators' Influence](image)

Operators possess strengths to obtain a key role as an enabler of IoT applications to vastly explore the huge underlying potential of the vertical industry market space.

In fact, a majority of operators began to proactively explore IoT opportunities since last year, and over 70 operators have deployed Low Power Wide Area (LPWA) for trial experimentation. Top operators regard IoT as a long-term strategy and build dedicated IoT/M2M business departments to extensively develop solutions, services, platforms, and pipelines for vertical industries. Vodafone has claimed the implementation of 90% service coverage, which pertains to smart meter reading, connected cars, asset tracing, and consumer electronics to be released by 2023. Telefonica has incorporated digital home applications as part of a “6G Play” strategy, with a specific focus towards fleet management, connected cars, smart home and city. China Mobile proposed a connection-centric strategy, promising “larger scale of connection, better connection services, and powerful connection applications”, and an attractive prospect to achieve five billion connections by 2020.

2.3 IoT’s New Requirements for Operators’ Network Planning

Current network planning cannot enable IoT to manifest as a future development strategy or allow for the full leverage of operators’ competitive advantages. Future IoT-oriented network planning must meet the following requirements:

- Implements precise coordination between MBB and IoT networks to provide IoT experience and achieve network construction targets with lower total cost of operation (TCO) and a maximized utilization of legacy networks.
- Satisfies various service requirements based on different service experience models and supports differentiated network planning solutions for multiple scenarios.
- Provides visual displays and an accurate prediction of IoT performance and capacity through experience-based service provision maps to reduce time to market (TTM) and accelerate service release.
- Predicts and protects operators’ return on investment (ROI) in the next several years according to the development trend and average revenue per user (ARPU) of connected users, CAPEX, and OPEX.

3. Things Coverage Network Planning Methodology

Huawei proposes the first IoT-oriented Things Coverage network planning theory to help operators implement rapid network construction and maximize IoT value.

3.1 IoT Experience Evaluation Standard

Different from traditional user-centric services, IoT services have divergent requirements for network functions. Due to a lack of subjective and comprehensive feedback, IoT experience evaluation and management are facing new challenges.

No standard IoT experience definition currently exists within the industry. Huawei conducts research on multiple networks of things, and proposes innovative for a 5-dimensional experience definition based on Availability, Bandwidth, Coverage, Delay sensitivity, and Energy efficiency. This evaluation standard can then be used to define typical IoT experience, such as smart meters, connected cars, and industry control.
For example, smart meters require a score of 5 in both coverage (due to intensive coverage underwater) and energy efficiency (due to ten-year-long battery life), but have a low requirement for delay. Connected cars require a delay sensitivity score of 5 for real-time vehicle data acquisition, but only require an energy efficiency score of 3. Industry control has a low requirement for energy efficiency, but requires both high reliability and delay sensitivity scores of 5.

### 5-dimensional experience of things

![Diagram](image)

### 5-dimensional experience of typical IoT use cases

<table>
<thead>
<tr>
<th></th>
<th>LTE Capability</th>
<th>Smart Water Meter</th>
<th>Drive Assistant</th>
<th>Industry Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Bandwidth</td>
<td>4 5Mbps</td>
<td>2 50kbps</td>
<td>4 10Mbps</td>
<td>5 50Mbps</td>
</tr>
<tr>
<td>Coverage</td>
<td>3 Normal</td>
<td>5 Deep</td>
<td>4 Normal</td>
<td>5 Deep</td>
</tr>
<tr>
<td>Delay Sensitivity</td>
<td>3 60-80ms</td>
<td>1 5sec</td>
<td>5 1ms</td>
<td>5 1ms</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>3 14hours@4000mAh</td>
<td>5 10years@4800mAh</td>
<td>3 Normal</td>
<td>3 Normal</td>
</tr>
</tbody>
</table>

### 3.2 New Characteristics of IoT Network Planning Method

IoT Network planning and deployment are significantly different from user-centric MBB networks. Things Coverage implements a shift from network-centric toward application-centric network planning to provide excellent application experience and maximize IoT value.

#### 3.2.1 Application-centric Network Planning

In the MBB era, networks mainly provide voice and data services specifically targeted at users. The considerable quantity and diversified things in vertical industries must utilize business-to-business to consumer (B2B2C) or business to business to business (B2B2B). Things Coverage supports the service provision map used for vertical industries to enhance service provision capabilities of business halls.

IoT-oriented application deployment and monitoring are of immense value. IoT applications may be deployed in locations exceeding that range of users' activity, such as water meters inside building pipes and water quality surveillance sensors. These applications cannot proactively provide feedback acting as users. Upon network interruption, applications are easily disconnected and data loss may lead to reduced revenue and increased O&M costs. Information obtained from networks and other nodes may not be promptly received, resulting in major accidents and have large implication in relation to in road safety and industry control. Network planning must consider characteristics of different IoT applications deployed in locations beyond the scope of users to formulate customized solutions based on thorough evaluation and positioning.

#### 3.2.2 IoT Experience Assurance

Superior IoT experience is a core competitive edge of differentiated networks. Different IoT services have 5-dimensional divergent requirements. Things Coverage selects highly sensitive dimensions for experience-
centric network planning.

In terms of energy efficiency with regards to NB-IoT smart water metering, network planning is performed based on an analysis. This analysis involves communication chip and battery through a theoretical modeling estimation method to meet battery lifecycle requirements and provide an excellent service experience.

Power consumption of terminal chips is calculated from the sum of RX, TX, idle, and deep sleep states. The power consumption in each status is current power multiplied by status duration, and is provided in the following formula:

Battery Power Consumption Per Day

Battery Life = \((\text{BatteryVolume} \times \text{BatteryNum} \times \text{PowerEfficiency}) / (\text{Battery Power Consumption Per Day})\)

Battery life is determined by traffic model and coverage quality. Different coverage quality may lead to a significant difference in RX, TX, and idle state duration.

3.2.3 IoT Value Maximization

Valued IoT areas are identified through a diverse range of information (distribution of connected devices, MBB network hotspots, and electronic maps). Furthermore, the wireless solution cloud platform WNS Space implements grid-level analysis, scoring, and sequence to identify high-, medium-, and low-value IoT areas. Things Coverage provides different network planning targets for high-, medium-, and low-value IoT areas for precise site planning and conducts predicted analysis to help operators maximize ROI.

3.3 Things Coverage Network Planning Process and Key Technologies

Things Coverage must meet each type of service models and SLA requirements while ensuring high network resource capacity utilization and favorable service experience to maximize operators’ ROI. In addition, effective feedback must be provided based on the actual operating status of diverse services to improve the next iteration of planning to achieve a virtuous cycle between planning and evaluation.
3.3.1 Things Requirement Definition

The requirements of things are defined based on 5-dimension experience requirements and specific service models. Different IoT services use divergent IoT service models.

- Smart metering produces a small amount, but major proportion of uplink data transmission. The interval of uplink data transmission may occur once every several hours or at least one per day. Downlink data mainly contains a small amount of network query and software upgrade data received at a relatively low frequency.

- Logistics tracing produces a small amount, but major proportion of uplink data transmitted at a distinct high frequency.

- Connected cars (vehicle-mounted entertainment) produce a significant source of downlink data transmissions (map and video reception), and a minimal amount of uplink data transmissions (vehicle status information).

<table>
<thead>
<tr>
<th>UL traffic model</th>
<th>Value</th>
<th>DL traffic model</th>
<th>Value</th>
<th>Software Upgrade</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL Report Size(Byte)</td>
<td>200</td>
<td>DL Request Packet Size(Byte)</td>
<td>100</td>
<td>Software Package Size(KB)</td>
<td>100</td>
</tr>
<tr>
<td>UL Report Number per traffic</td>
<td>1</td>
<td>UL Response Report Size(Byte)</td>
<td>100</td>
<td>DL Packet Size(Byte)</td>
<td>1000</td>
</tr>
<tr>
<td>Traffic times per day</td>
<td>12</td>
<td>DL Packet Number per traffic</td>
<td>1</td>
<td>Upgrade times per year</td>
<td>0.5</td>
</tr>
<tr>
<td>Traffic times per year</td>
<td>24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.3.2 Air Interface and Frequency Band Selection

Air interface is selected based on different SLA targets. For example, massive machine type communication (MMTC) services featuring low rate, low power consumption, and a massive quantity of connections can choose from NB-IoT and enhanced Machine Type Communication (eMTC) based on a specific rate range. Connected cars can select from LTE, LTE-V, and 5G based on different rate and delay requirements.

Frequency bands are selected based on different application requirements. For example, NB-IoT preferentially uses low frequency bands.

3.3.3 Multi-dimensional Collaborative Planning

Things Coverage supports network planning according to multiple dimensions (coverage, capacity, and multi-layer coordination).

Single service layer

- Compared with the traditional MBB network coverage planning, networks for things are far more complex. Various key technologies are applied to improve network planning precision. For details, see section 3.2.4.

- Capacity planning supports a predictive forecast based on a massive amount of connections in a specific cell. This is derived from IoT terminal traffic models and geographical distribution before service provisioning, and uses actual IoT traffic model statistics and network capacity satisfaction levels to identify areas with connection bottleneck after service provisioning. As a result, connection-based planning can effectively satisfy actual service requirements.

- According to multiple service experience targets, key factors affecting superior service experience are identified for modeling.

Multiple services using a single air interface or frequency band

- The combination of services provided for things and MBB networks meets diversified service requirements through collaborative planning of site, antenna, spectrum, admission control, congestion control, and QoS parameters.
3.3.4 Precise Network Planning Using Key Technologies

Things Coverage enhances network planning precision using key technologies, such as propagation models, measurement reports (MRs), and digital maps.

- Propagation Models

Thing-centric and MBB user-centric networks are deployed in different locations and use different propagation models. Based on a substantial quantity of theoretical research, Things Coverage presents models and parameters in typical application scenarios to better support network planning simulation.

- MBB MRs

Things Coverage utilizes existing MRs from mobile phones in an MBB network to enhance accuracy of NB-IoT coverage prediction. MBB MRs are then used for the calculation of outdoor coverage, with a careful consideration afforded to penetration loss produced from the rapid implementation of IoT network planning.

- Digital Maps

Digital maps offer geographic information of a rich variety of industries, including smart parking, transportation, metering, and agriculture and environment monitoring.
4. Network Construction Cases

An operator uses Things Coverage to implement network planning for smart metering. The following figure shows a service provision allocation map based on Things Coverage in suburban, urban, and densely-populated urban areas.

In simulation planning, indoor intensive coverage ratio increases by 20% according to the service provision map (including penetration loss). As a result of this meticulous testing the extended battery life for smart water meters is increased by over 10 years.

Case of Network Planning for Smart Water Meters

Conventional Planning

Coverage Based Planning

Energy Efficiency Based Planning

Input: Propagation Model for deep indoor, underground, height.

Input: Water meter traffic model and battery information.
5. Prospects

In 2017, the Things Coverage solution will help Deutsche Telekom, Vodafone, China Unicom, and China Telecom to implement nation-wide IoT network planning and transform 1/5 of global base stations to support IoT.

With the rapid emergence and large-scale deployment of diverse IoT applications, Huawei will continuously conduct in-depth research in the following technologies for improved network construction in the following aspects:

- IoT network planning based on new air interface and frequency bands
- Key experience modeling (ultra-low latency)
- Dynamic resource sharing of multiple services
- Enhanced positioning precision of IoT applications
- Big data mining of IoT and MBB network coordination

IoT planning and evaluation capabilities of the WINS Space platform will continue to increase and develop to support rapid IoT deployment and help operators to implement large-scale network construction.

Huawei is dedicated to gaining further cooperation with more operators and vertical industry partners to formulate a recognized IoT evaluation system and planning standard. Innovative solutions and open IoT planning ideas can facilitate operators in arriving at rational investment decisions and perform efficient deployment to boost the prosperity and development of IoT.

Glossary

NB-IoT: Narrow Band Internet of Things
LPWA: Low Power Wide Area
CAGR: Compound Annual Growth Rate
3GPP: Third Generation Partnership Project
TTM: Time to Market
dB: Decibel
SLA: Service Level Agreement
MR: Measurement report
M2M: Machine to Machine communication
eMTC: Enhanced Machine Type Communication