

SISTEM KOMUNIKASI NIRKABEL

MODUL 8

TEKNOLOGI NARROWBAND – IOT (NB-IOT)

Mochammad Zen Samsono Hadi, ST. MSc. Ph.D

Topik Bahasan

- **Pengantar LPWA**
- Evolusi Standar NB-IoT dan Perkembangan Industri
- Teknologi Utama NB-IoT
- Solusi NB-IoT

Pengantar nb-IoT

- Berbeda dengan Internet tradisional, **Internet of Things (IoT)** bekerja dalam skenario komunikasi yang beragam dan kompleks.
- Skenario komunikasi nirkabel yang berbeda memiliki kebutuhan yang berbeda-beda. Terdapat skenario komunikasi di mana paket kecil kadang-kadang ditransmisikan melalui perangkat pasif sebagai skenario **low-power wide-area (LPWA)**.
- Dalam skenario LPWA, **NB-IoT** adalah salah satu teknologi yang paling banyak digunakan. Teknologi ini mematuhi spesifikasi 3GPP, diterapkan pada pita frekuensi resmi operator, dan menyediakan jaringan publik untuk perangkat IoT, sehingga mendorong pengembangan utilitas publik IoT.

LPWA - SigFox

- **Jaringan SigFox** menggunakan teknologi Ultra Narrow Band (UNB). Konsumsi daya transmisiya rendah dan koneksi datanya stabil. Tautan radionya menggunakan pita frekuensi unlicensed radio ISM. Penggunaan frekuensi bervariasi menurut undang-undang dan peraturan nasional. Pita frekuensi 868 MHz banyak digunakan di Eropa, dan pita frekuensi 915 MHz digunakan di Amerika Serikat.
- Jaringan ini mengadopsi teknologi **modulasi ultra narrow-band**. Sebuah base station dapat mengirimkan pesan jaringan pada jarak lebih dari 1000 km. Setiap base station mendukung maksimal satu juta perangkat IoT.
- SigFox lebih banyak digunakan untuk koneksi IoT karena menggunakan pita frekuensi yang tidak berbayar, perangkat yang mengonsumsi sedikit daya, dan arsitektur jaringan yang disederhanakan.



LPWA - LoRa

- **Long Range (LoRa)** adalah teknologi berbasis lapisan fisik yang mengimplementasikan komunikasi data melalui jaringan.
- Dikelola oleh LoRa Alliance.
- Teknologi ini mendukung **transmisi data dua arah** dan mematuhi serangkaian standar open source.
- Solusi spesifik untuk implementasi jaringan disebut LoRaWAN, yang dikembangkan oleh Semtech dan didukung oleh IBM.
- Penerapan LoRa mencakup pembacaan meter otomatis, peralatan rumah pintar, otomatisasi gedung, sistem peringatan dan keamanan nirkabel, pemantauan dan pengendalian industri, dan sistem irigasi jarak jauh.
- LoRa menggunakan **unlicensed spektrum**.



LPWA - NB-IoT

- **NB-IoT** adalah narrow-band IoT berbasis seluler. Dibangun di jaringan seluler dan membutuhkan bandwidth hanya 180 kHz. Dapat langsung diterapkan pada jaringan GSM, UMTS, dan LTE eksisting untuk mengurangi biaya penerapan dan menerapkan peningkatan yang lancar.
- **NB-IoT** adalah teknologi baru yang banyak digunakan untuk pasar IoT LPWA. Memperluas cakupan dan koneksi luas dengan tarif rendah, biaya, konsumsi daya, dan arsitektur optimal.
- Menurut 3GPP Release 14, **NB-IoT** mendukung skenario penentuan posisi dan mobilitas base station dengan kecepatan kurang dari 80 km/jam.



LPWA – eMTC

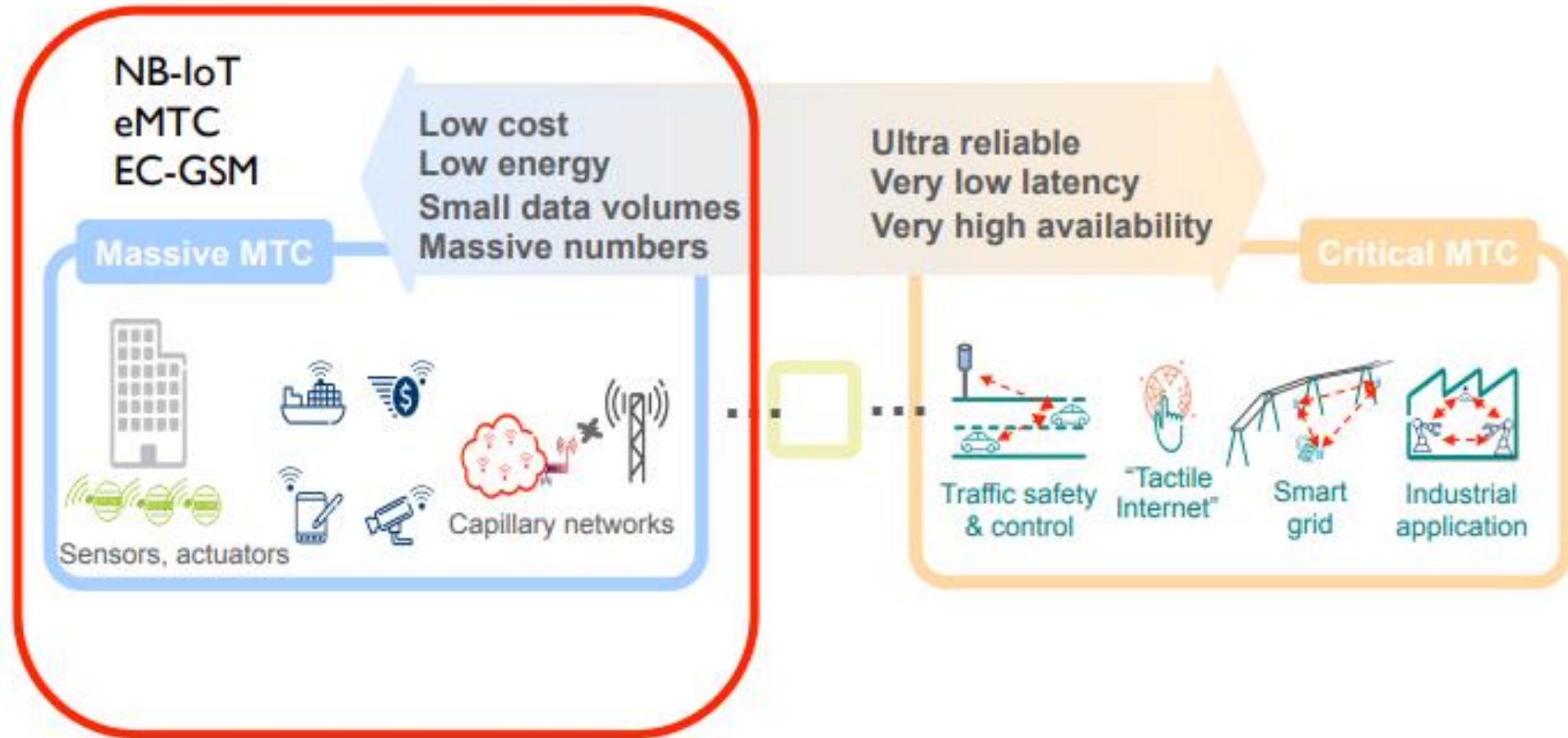
- **eMTC:** enhanced machine-type communication => sub-type dari LTE
- **eMTC** adalah solusi IoT nirkabel yang diusulkan oleh Ericsson. Solusinya dengan merancang fitur-fitur jaringan IoT nirkabel berdasarkan teknologi akses LTE. Terutama digunakan dalam skenario IoT yang memerlukan tarif rendah, jangkauan luas, konsumsi daya rendah, dan jumlah koneksi yang banyak.
- eMTC memiliki kecepatan yang lebih tinggi (hingga 1 Mbit/s) dan konsumsi daya serta cakupan dan kapasitas yang lebih kecil dibandingkan NB-IoT.
- eMTC juga mendukung komunikasi suara.



Perbandingan Teknologi LPWA

	SigFox	LoRa	NB-IoT	eMTC
Frequency band	Sub-GHz unlicensed frequency band	Sub-GHz unlicensed frequency band	Mainly sub-GHz licensed frequency band	Sub-GHz licensed frequency band
Transmission rate	100 bit/s	0.3–5 kbit/s	< 250 kbit/s	< 1 Mbit/s
Typical distance	1–50 km	1–20 km	1–20 km	2 km
Typical application	Smart home appliances, smart electricity meter, mobile healthcare, remote monitoring, and retail	Smart agriculture, intelligent building, and logistics tracking	Water meter, parking, pet tracking, garbage disposal, smoke alarm, and retail devices	Shared bicycle, pet collar, POS, and smart elevator

Target Use-case LPWA / NB-IoT



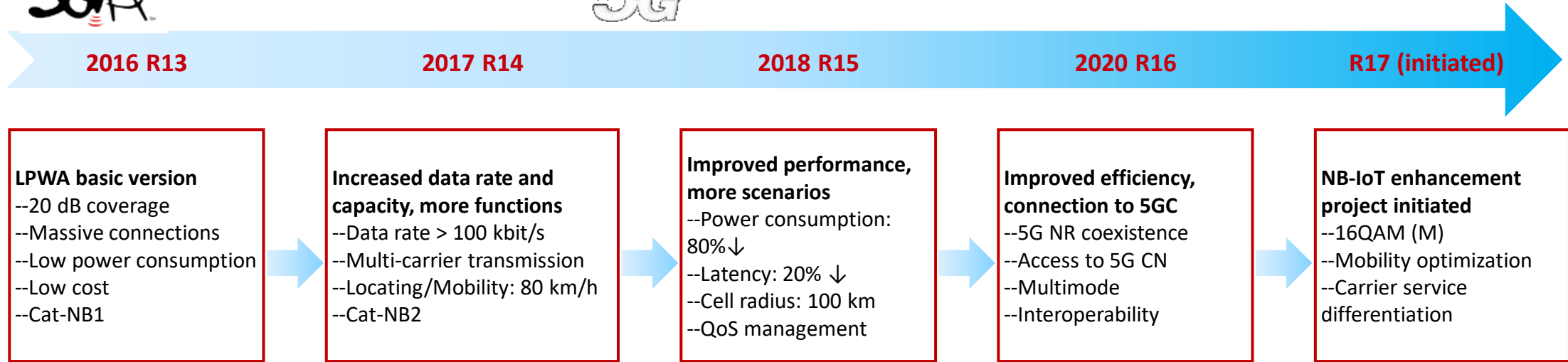
Topik Bahasan

- Pengantar LPWA
- **Evolusi Standar NB-IoT dan Perkembangan Industri**
- Teknologi Utama NB-IoT
- Solusi NB-IoT

Elemen NB-IoT



Evolusi Standar NB-IoT



Teknologi yang Ditentukan oleh 3GPP Akan Berkembang menjadi 5G

- On July 7, 2019, 3GPP and the 5G Promotion Group of MIIT put forward the NR and NB-IoT proposals to the ITU.
- 3GPP Release 15: **NB-IoT and NR can coexist**. Existing UEs are not affected.
- 3GPP Release 16: Technical standards meeting 5G requirements are officially accepted as a 5G technical standards.

Industri mengakui evolusi NB-IoT dan setuju untuk memasukkan NB-IoT secara keseluruhan ke dalam rencana 5G.

Company	Proposal
China Mobile	✓ Jointly promot NB-IoT access to 5G devices and the core network based on R16.
DT	✓ No requirement on developing NR-based LPWA solutions. NB-IoT can meet IMT-2020 requirements.
E	✓ In the 5G era, continue using NB-IoT and LTE-M to meet LPWA service requirements.
Q	✓ NB-IoT/eMTC is 5G mMTC.

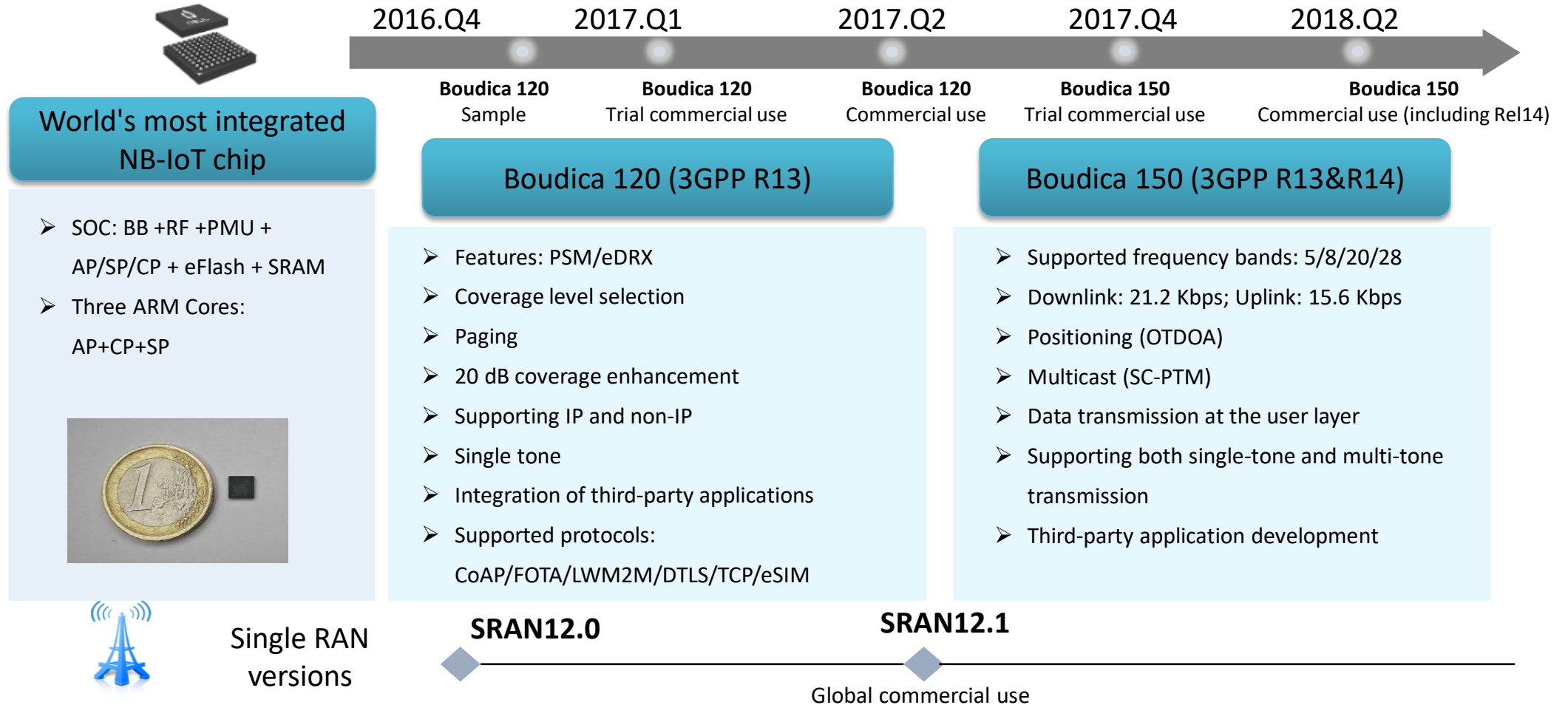
Teknologi LPWA Diadopsi oleh Operator Global

NB-IoT dulu + eMTC	
eMTC dulu + NB-IoT	
LoRA dulu + eMTC	

Pilihan Spektrum NB-IoT dari Operator Global

<p>APT 700 MHz</p>	  Latin America
<p>800 MHz</p>	   Germany Hungary
<p>850 MHz</p>	    
<p>900 MHz</p>	         Germany, Holland, Poland, Austria Germany
<p>1800 MHz</p>	   

Huawei Merilis Versi Chip dan Network NB-IoT Komersial Pertama di Dunia



Daftar Mitra Ekosistem NB-IoT



1000+ Industry Partners and 40+ Industries

Smart water



Smart gas



Smart streetlight



Smart parking



Asset tracking



Smart agriculture



Smart meters



Smoke detection



Air quality monitoring



Children/Pet tracking



Bicycle sharing



White goods



Healthcare



Solution integration



Seven NB-IoT Open Labs

Mature development environment and test tools

Topik Bahasan

- Pengantar LPWA
- Evolusi Standar NB-IoT dan Perkembangan Industri
- **Teknologi Utama NB-IoT**
- Solusi NB-IoT

NB-IoT Physical Layer

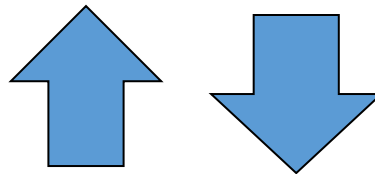
Physical layer design

- System bandwidth: 180 kHz
- Downlink technology: OFDMA; SCS 15 kHz; 12 subcarriers
- Uplink technology: SC-FDMA

Physical channels dan physical signal

- Untuk menyederhanakan implementasi, NB-IoT menghilangkan saluran fisik yang tidak perlu, hanya menyisakan tiga jenis saluran fisik dan dua jenis sinyal referensi di downlink dan dua jenis saluran fisik dan satu jenis sinyal referensi di uplink.

- Dua jenis uplink physical channels:
 - NPUSCH
 - NPRACH
- Satu jenis uplink physical signal:
 - NDMRS



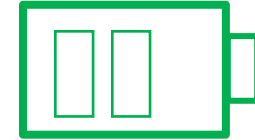
- Tiga jenis downlink physical channels:
 - NPBCH
 - NPDCCH
 - NPDSCH
- Dua jenis downlink physical signals:
 - NRS
 - NSS

- Melalui target rate yang lebih kecil, repeated transmission, dan lower-order modulation, **NB-IoT** physical channels mencapai **wider coverage, lower costs, dan lower power consumption**.

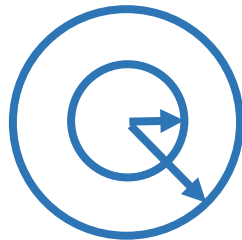
Fitur Utama NB-IoT



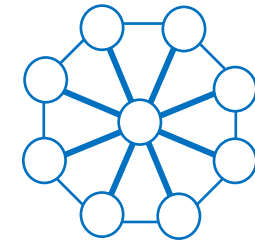
Ultra-low cost



**Ultra-low power
consumption**



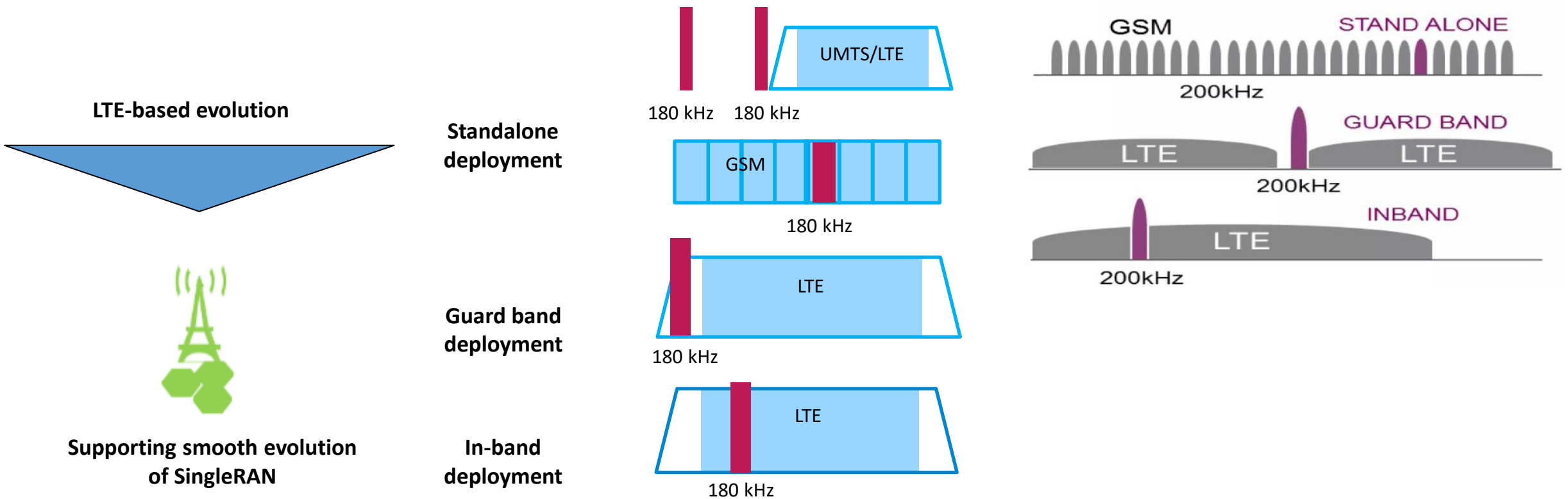
Ultra-wide coverage



Massive connections

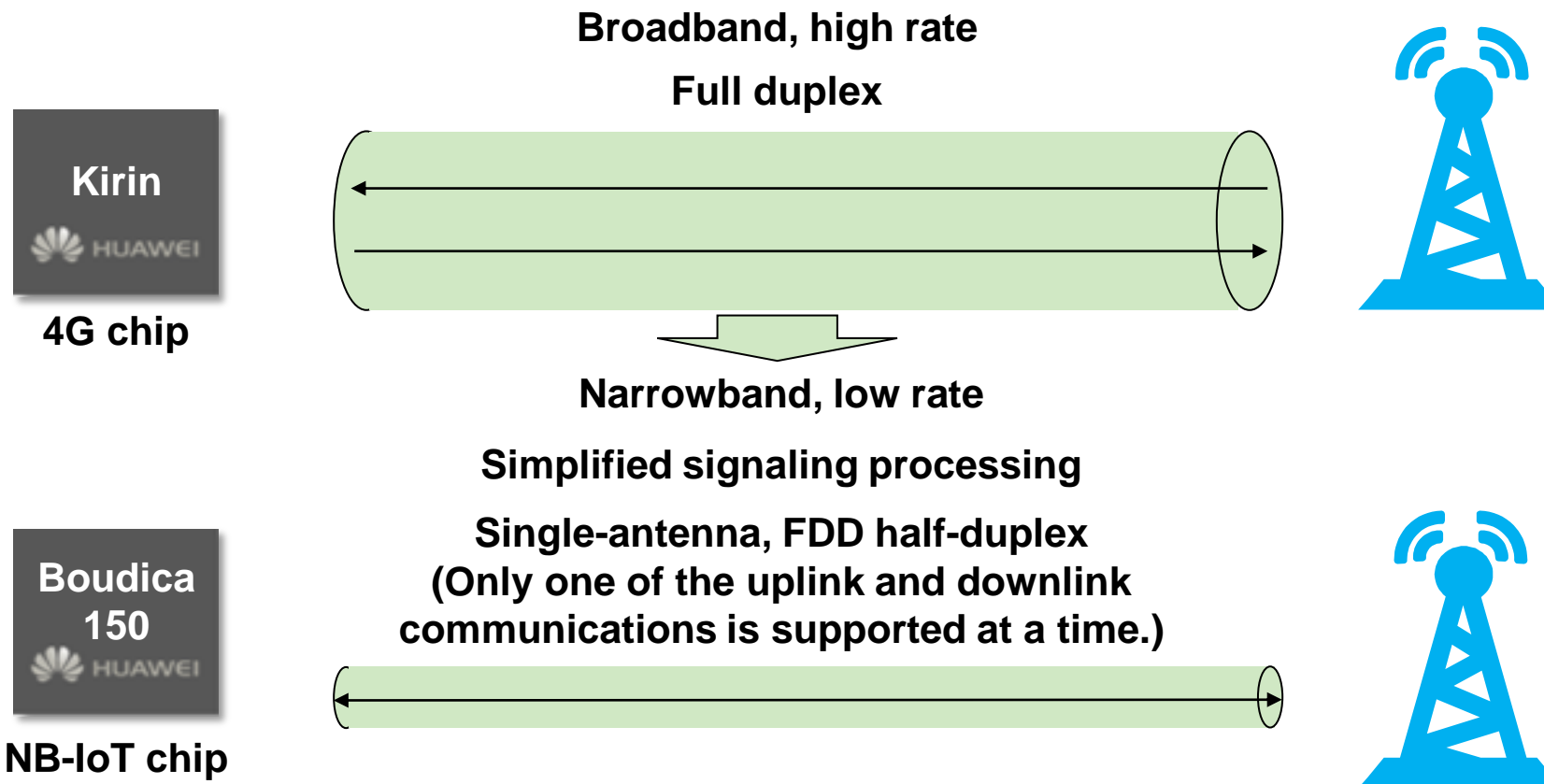
Mode Penerapan NB-IoT

- NB-IoT mendukung evolusi berbasis LTE dan penerapan pita frekuensi yang fleksibel untuk memenuhi berbagai kebutuhan operator, sehingga mengurangi biaya penerapan dan pemeliharaan jaringan.

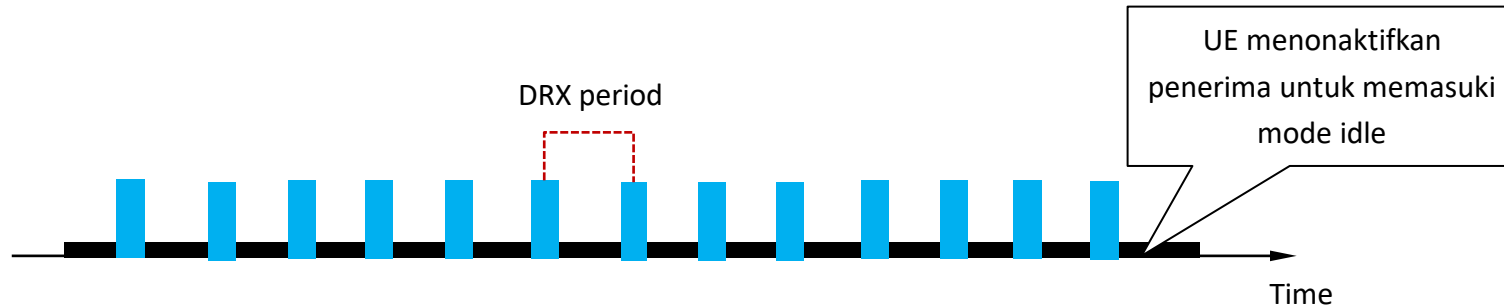


Ultra-low Cost: Chip Komunikasi yang Dirancang Khusus untuk IoT

- Modul perangkat keras fisik yang tidak begitu penting disesuaikan dengan fungsi dan algoritma yang disederhanakan, sehingga mengurangi biaya chip.



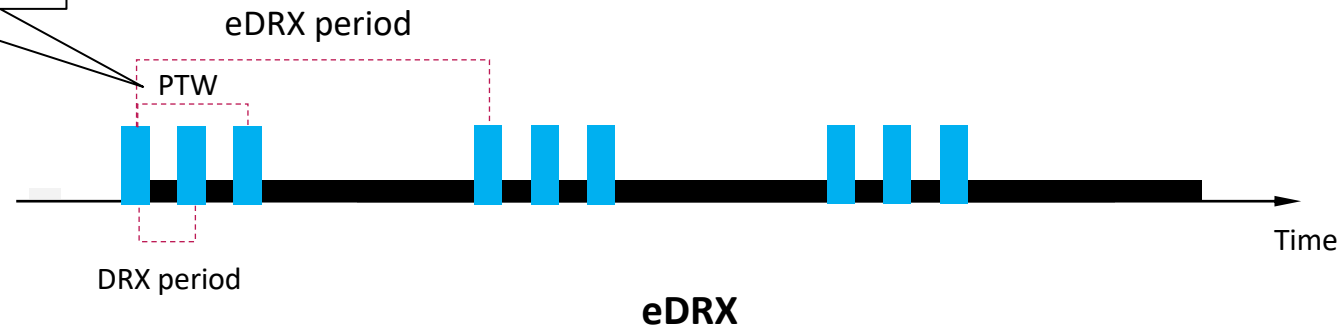
Konsumsi Daya Ultra-Low: DRX dan eDRX



DRX

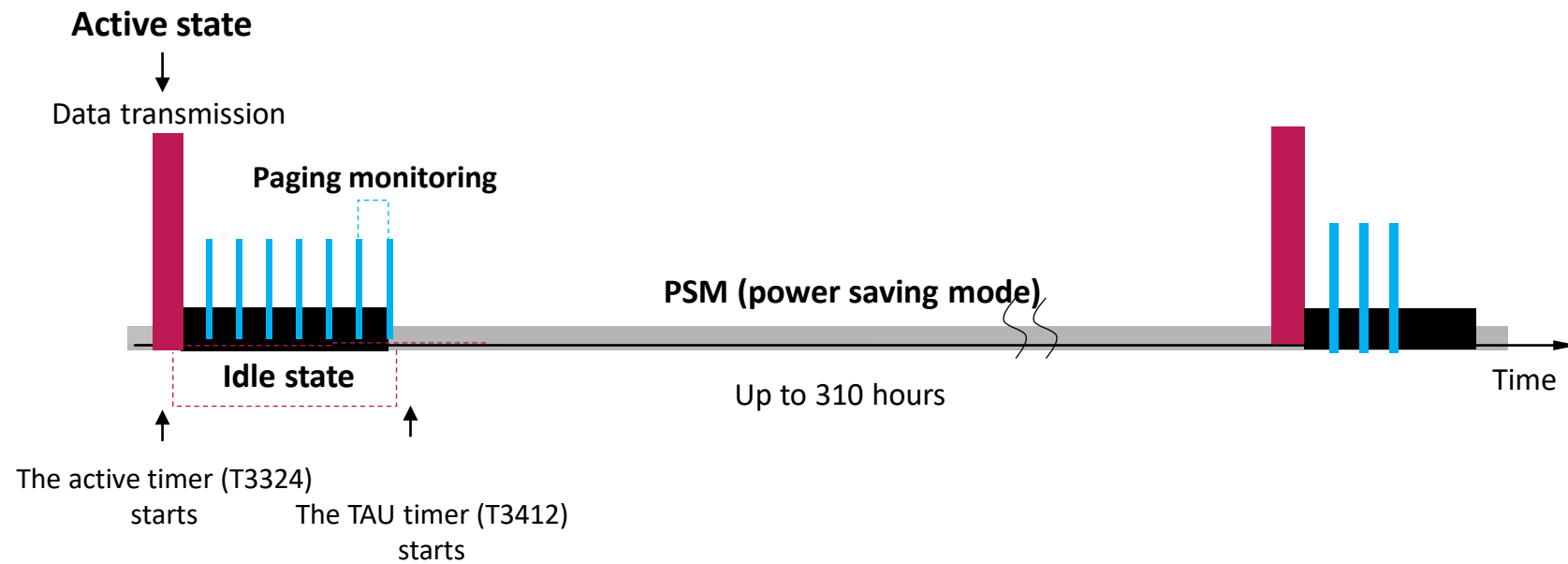
UE secara berkala memonitor saluran paging di PTW untuk memeriksa apakah ada layanan downlink.

MME menentukan periode DRX dan eDRX berdasarkan jenis layanan dan kemampuan perangkat.



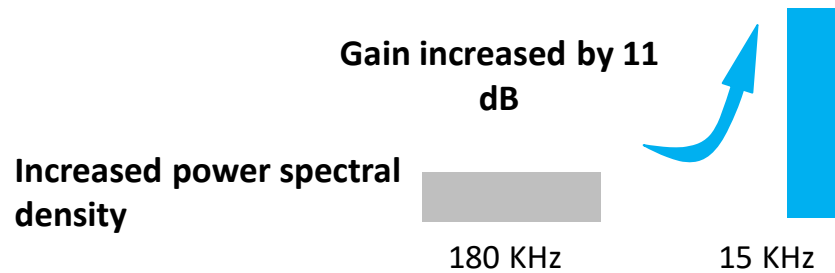
MME: Mobility Management Entity
PTW: Paging Time Window
DRX: Discontinuous Reception
eDRX: extended DRX

Konsumsi Daya Ultra-Low : PSM

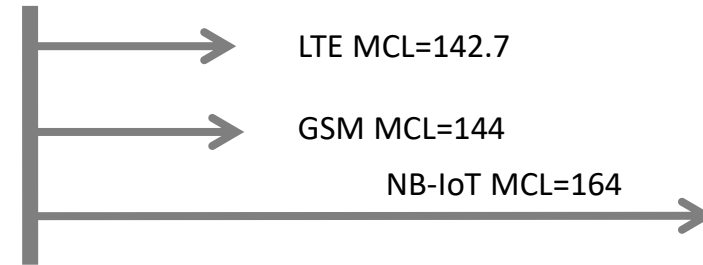


Cakupan Ultra-Wide: Meningkatkan Power Spectral Density, Time-Domain Retransmission

Deep coverage solution

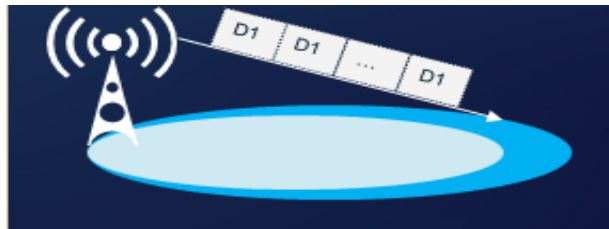


20 dB more maximum coupling loss (MCL) than GPRS



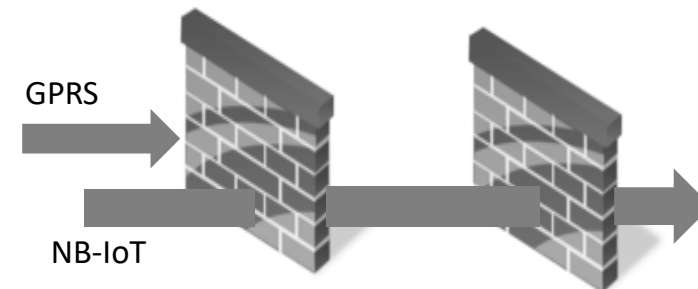
Downlink gain increased by 9 dB
Uplink gain increased by 12 dB

Repeated transmission



Coverage comparison

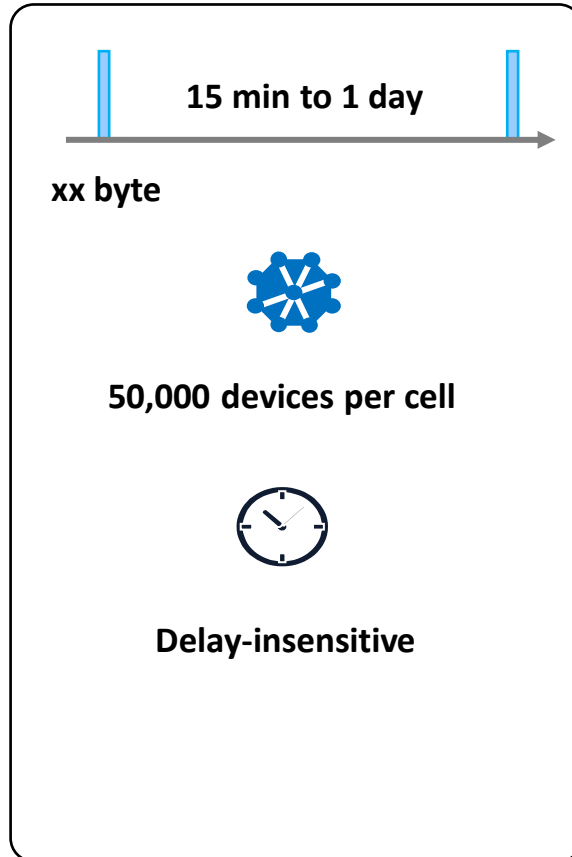
The coverage distance of NB-IoT is three times that of GPRS.



NB-IoT signals can penetrate through two more walls than GPRS signals.

Massive Connections: Mengurangi Konsumsi Sinyal Air-Interface dan Penggunaan Resource

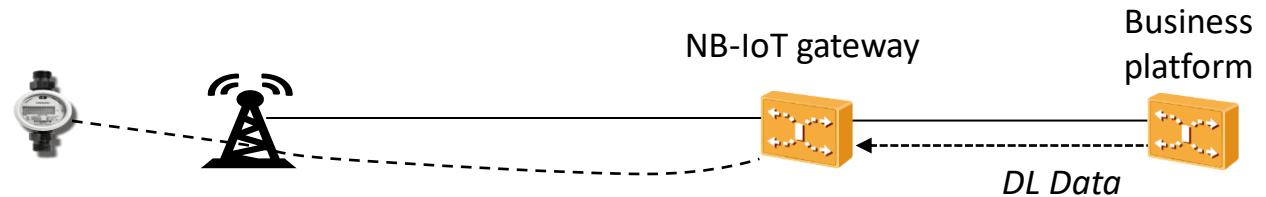
Kapasitas lebih dari 50.000 pengguna



Traffic model

Key technology 1:

Small uplink service scheduling unit: 15 kHz in NB-IoT VS.180 kHz in LTE



Key technology 2: air interface signaling overhead reduction

Key technology 3:

PSM and eDRX reduce the resource usage of each device.

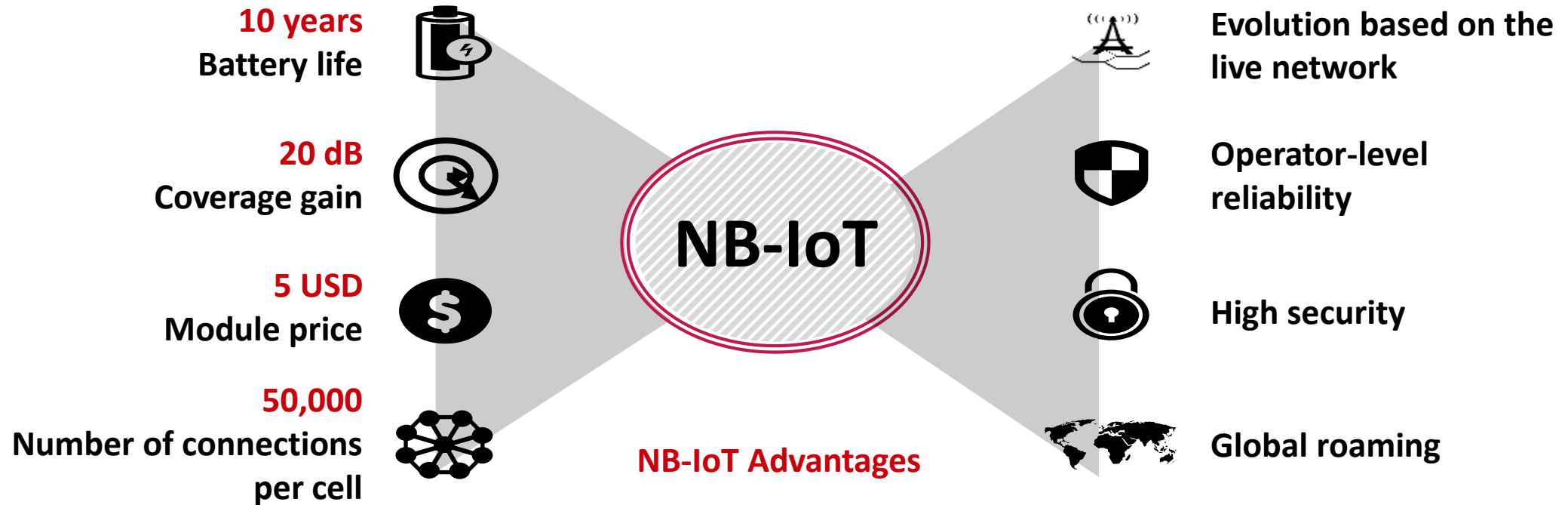
Key technology 4: base station optimization

- Independent admission and congestion control
- UE context storage

Key technology 5: core network optimization

- UE context storage
- Downlink data cache

Ringkasan Fitur Utama NB-IoT



Low Cost

\$5 module cost

- Simplified RF hardware
- Simplified protocols to reduce costs
- Reduced baseband complexity

Low Power Consumption

10-year battery life

- Simplified protocols and lower chip power consumption
- High PA efficiency
- Short TX/RX duration

Wide Coverage

20 dB gain

- Increased narrowband PSD
- Retransmission times: 16
- Coding gains
- Improved indoor coverage

Massive Connections

50,000 connections per cell

- High spectral efficiency
- Small-packet data transmission
- Low device activation ratio

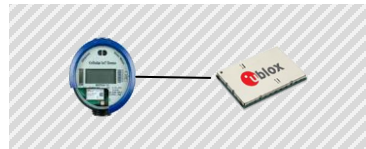
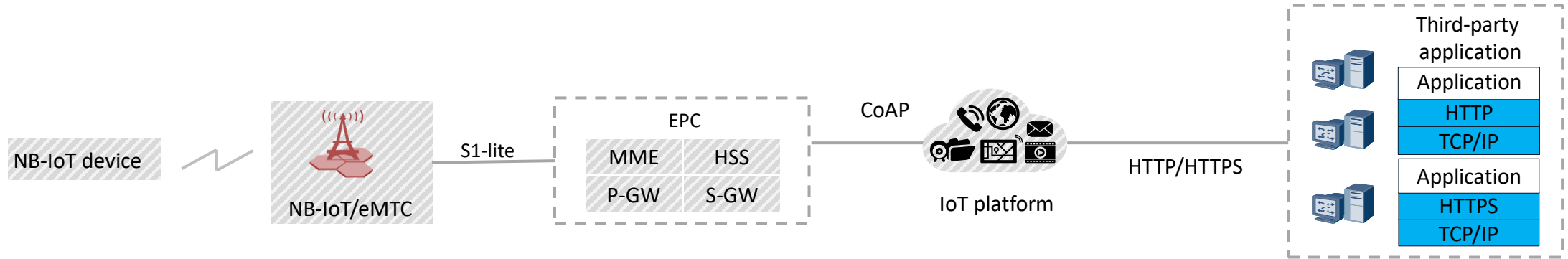
Ringkasan NB-IoT

	NB-IoT
Deployment	In-band & Guard-band LTE, standalone
Coverage (MCL)	164 dB
Downlink	OFDMA, 15 KHz tone spacing, TBCC, 1 Rx
Uplink	Single tone: 15 KHz and 3.75 KHz spacing, SC-FDMA: 15 KHz tone spacing, Turbo code
Bandwidth	200 KHz
Highest modulation	QPSK
Link peak rate (DL/UL)	DL: ~30 kbps UL: ~60 kbps
Duplexing	HD FDD
Duty cycle	Up to 100%, no channel access restrictions
MTU	Max. PDCP SDU size 1600 B
Power saving	PSM, extended Idle mode DRX with up to 3 h cycle, Connected mode DRX with up to 10.24 s cycle
UE Power class	23 dBm or 20 dBm

Topik Bahasan

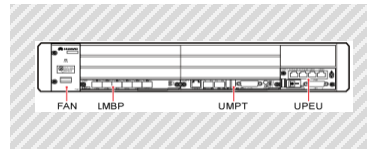
- Pengantar LPWA
- Evolusi Standar NB-IoT dan Perkembangan Industri
- Teknologi Utama NB-IoT
- **Solusi NB-IoT**

Arsitektur Solusi NB-IoT



NB-IoT device

- Wireless connection
- Virtual SIM card
- Sensor port
- Application residence
- Support for NAS data



NB-IoT eNodeB

- Low-cost site solution
- Supporting large-capacity connections with new air interface



IoT core network

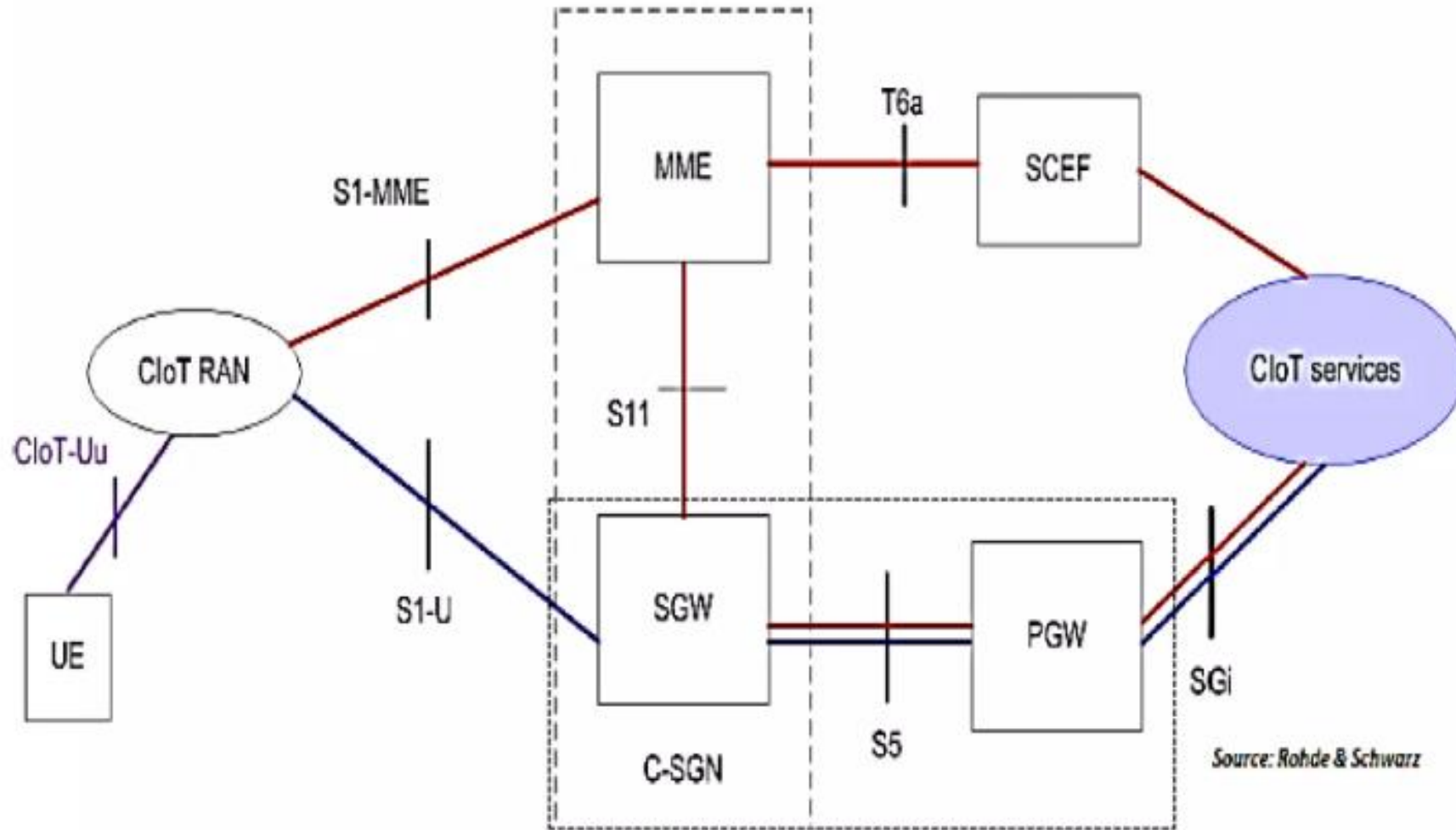
- Mobility, security, and connection management
- Secure access for devices without SIM cards
- UE energy saving
- Congestion control and traffic scheduling
- Billing
- Support for NAS data



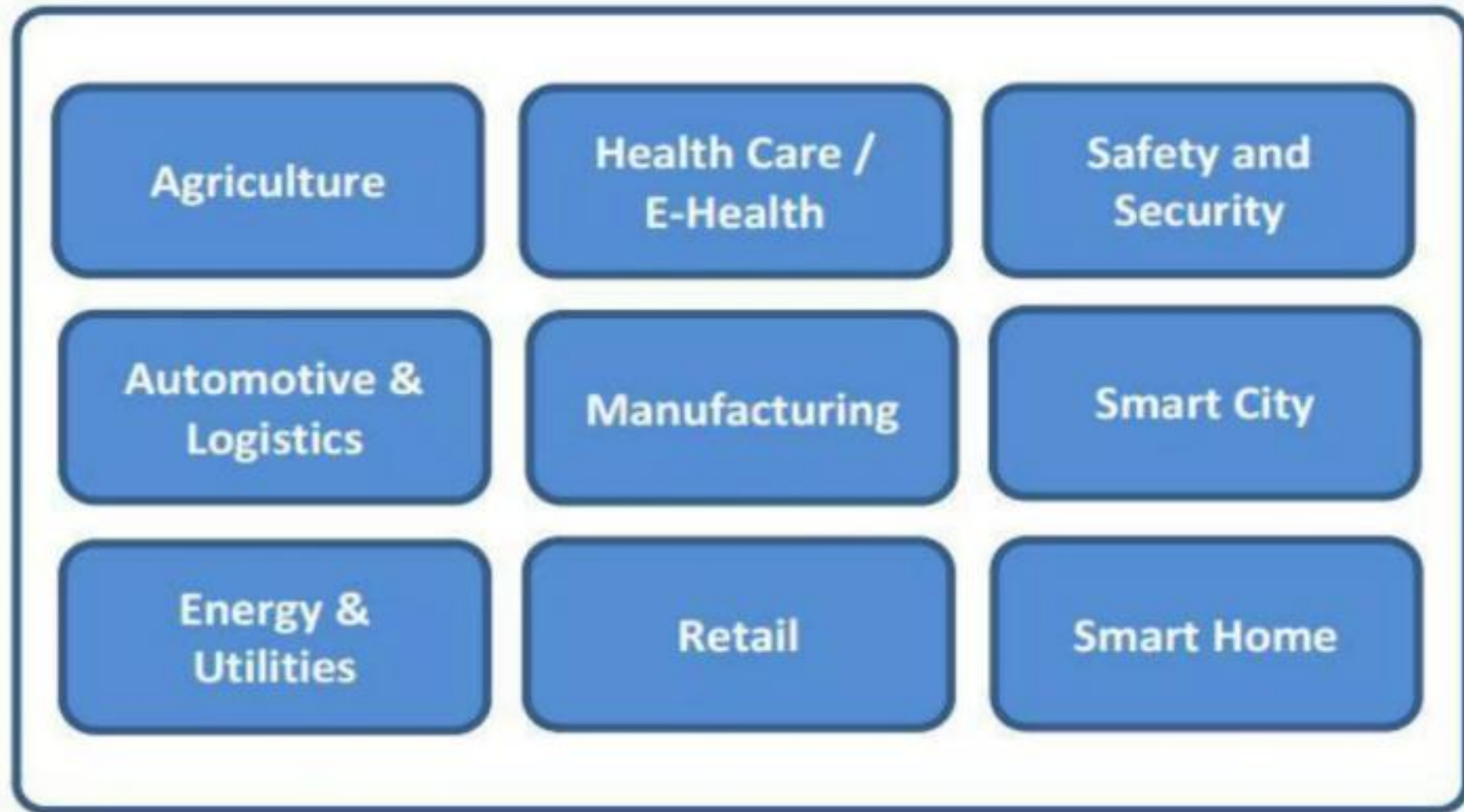
IoT platform

- Compatible with application-layer protocol stacks
- Device/SIM OTA
- Device and event subscription management
- Open APIs (to the industry and developers)
- OSS/BSS (for self-help subscriber creation and billing)
- Big data analysis

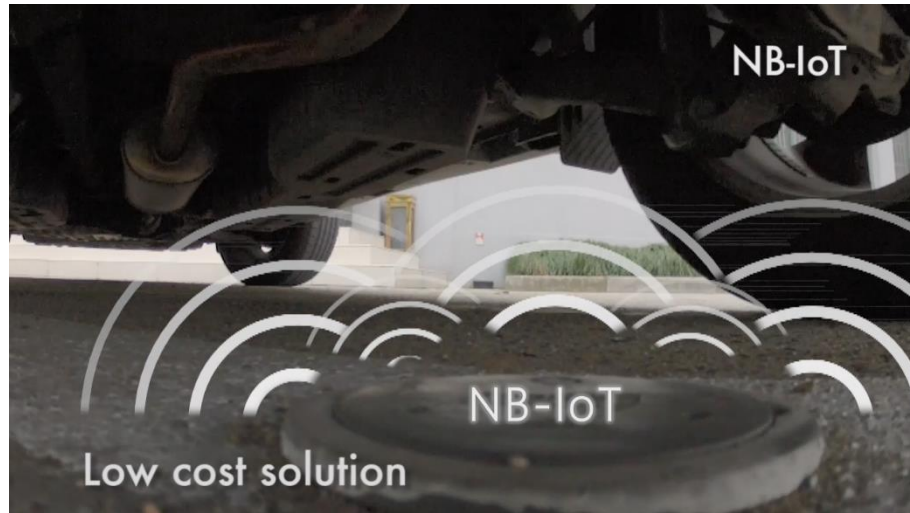
Arsitektur NB-IoT



Pasar Potensial Utama untuk layanan NB-IoT



Aplikasi berbasis NB-IoT

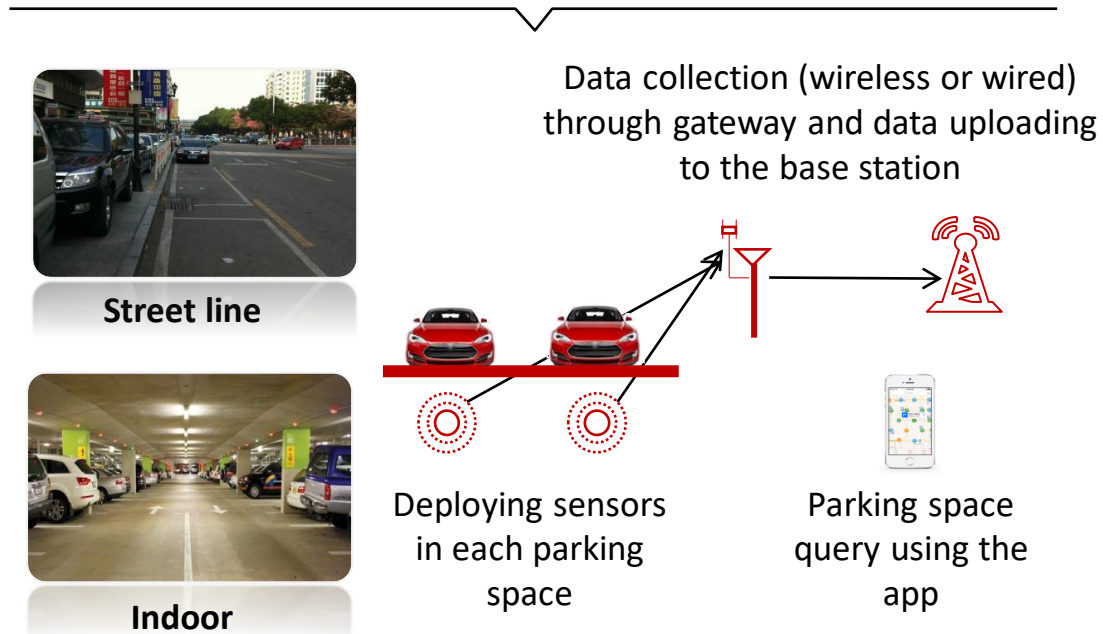


Shared bikes



NB-IoT Solution: Smart Parking

Challenges to Current Smart Parking



Difficult fault locating



High cost (extra devices and space)

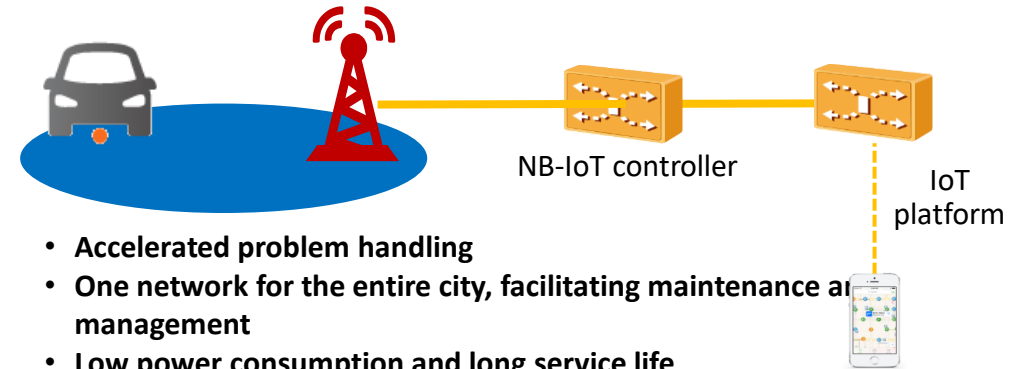


High power consumption



Multi-level network

NB-IoT Provides More Efficient Smart Parking Services



- Accelerated problem handling
- One network for the entire city, facilitating maintenance and management
- Low power consumption and long service life
- Separated from the real estates, facilitating site selection and installation
- Enterprises do not need to maintain networks, reducing operation costs.

Smart parking-based vehicle detector

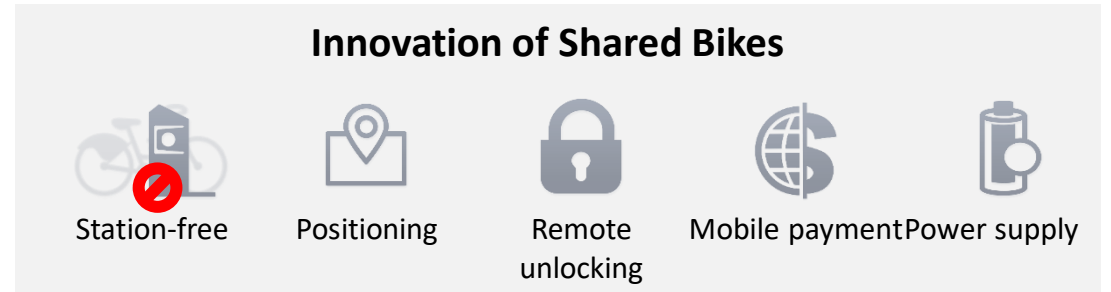
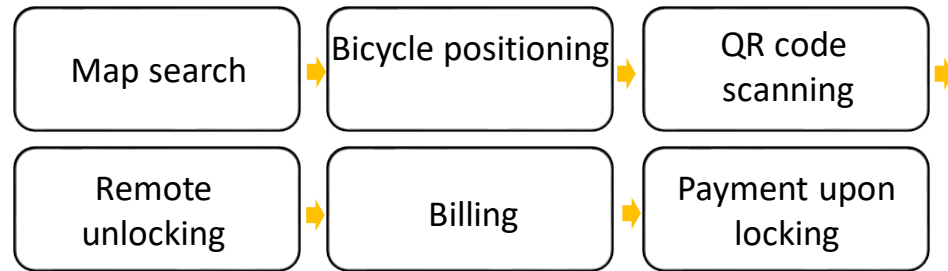





Operating temperature:
-40°C to +70°C

Diameter: 90 mm; Height: 80 mm

Material: aluminum

NB-IoT Solution: Shared Bikes



Mechanical Lock	GPRS Electronic Lock	NB-IoT Lock
		
<ul style="list-style-type: none"> • Static passwords: A bicycle can be used by any one who knows the password, eliminating bicycle usage fees. • Lack of positioning, raising risks of bicycle theft 	<ul style="list-style-type: none"> • High-cost • The first-generation bicycle uses a motor. The first 30 minutes or 5 km of cycling is not smooth, resulting in poor user experience. • The second-generation (Lite) uses a solar panel, which is easily affected by external factors (weather and blockage). 	<ul style="list-style-type: none"> • Built-in 13000 mAh battery providing two years of power supply • The 20 dB coverage gain ensures the communication of services such as remote unlocking and positioning.

Operators' Business Models

- Service**: Capability openness: For example, identity authentication and deposit are not required for postpaid users.
- Cloud services**: industry cloud application deployment and data storage
- IoT platform**: tens of millions of concurrent services; lock management
- Connectivity**: Guarantee for unlocking success rate and battery life
- Lock**: NB-IoT modules
- Bicycle**

NB-IoT Solution: Smart Street Lamp



High energy bill

30-50% of the public mains is used for power street lamps.



Large manpower

Time required to install 50 street lamps: 20 persons, 2 days

Legal litigation and public safety joint liability

NORTHJERSEY.COM : NEWS

Broken streetlight to be cited in suit in Ridgewood pedestrian's death

JANUARY 6, 2014
BY CHRIS HARRIS



Remote power on/off



Remote switch timer configuration



Real-time status obtainment

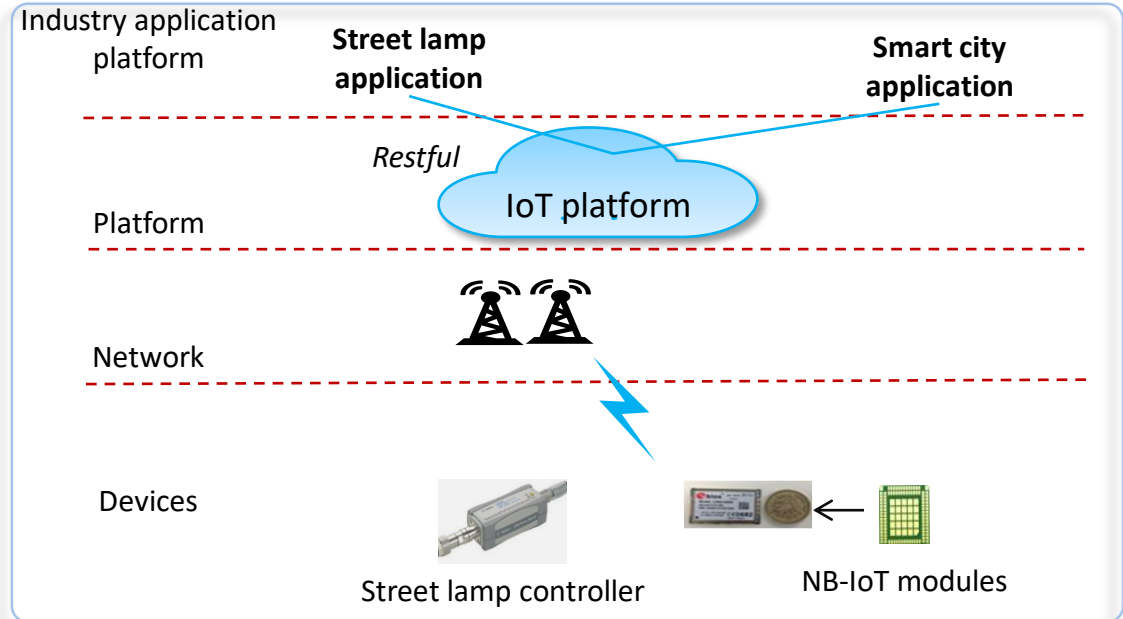


Remote troubleshooting

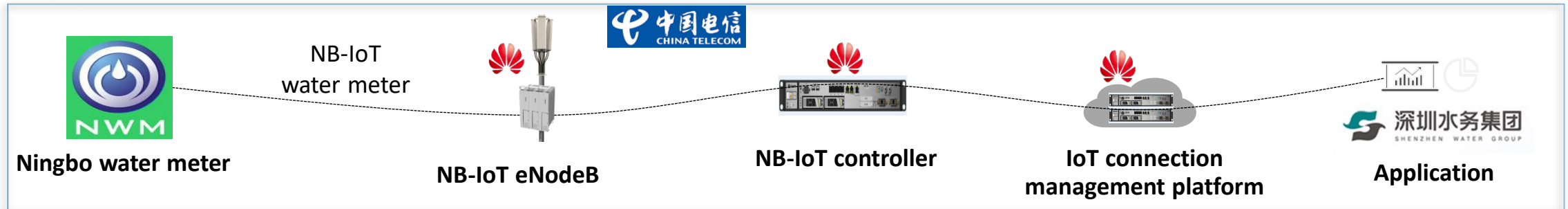


Remote upgrade

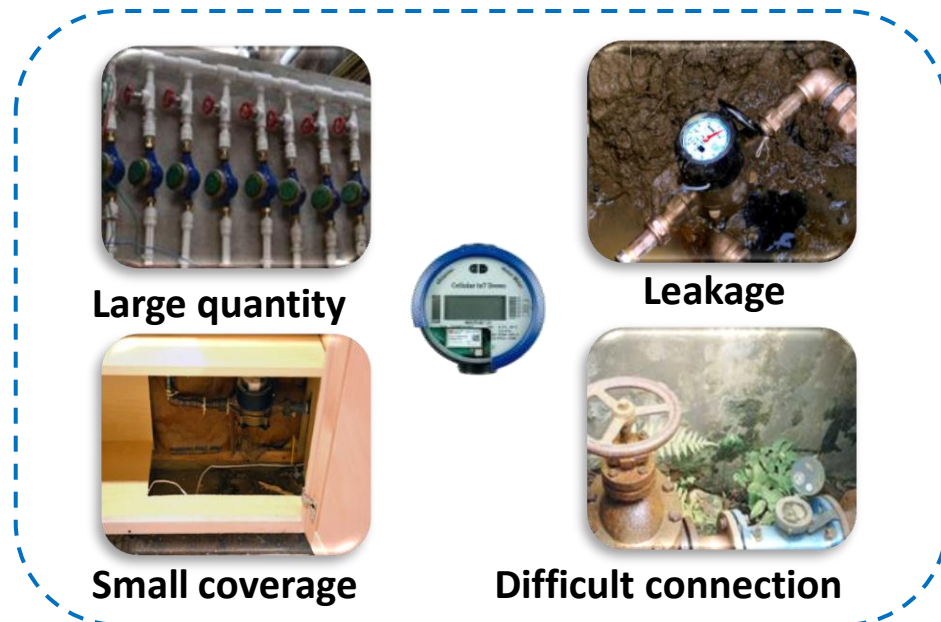
Each street lamp saves 2 USD per month.
Real-time fault reporting, zero-wait maintenance



NB-IoT Solution: Smart Meter Reading



Internet+ smart water meter



IoT Platform Values

- Device management (LwM2M/PSM message caching)
- Asset management
- SIM card management
- Device status monitoring
- Alarm management

Quiz

1. Manakah dari berikut ini yang bukan merupakan fitur utama NB-IoT?
 - A. Wide coverage
 - B. Low power consumption
 - C. Massive connections
 - D. High bandwidth
2. Mode manakah yang dapat membantu NB-IoT menghemat daya paling besar?
 - A. DRX
 - B. eDRX
 - C. PSM
 - D. Idle
3. (True or False) Semua jaringan NB-IoT diimplementasikan pada pita frekuensi sub-GHz berlisensi.