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Nokia Networks

The Evolution of Wireless Networks for the Internet of Things

NSF Wireless Cities Workshop
Presenter: Phil Fleming
Mobile Networks Senior Technology Advisor
Nokia Networks
Arlington Hts., IL

Slim Radio | Low cost & power for massive machine type communication

Mobile IoT for small, infrequent & low cost data transfer

Power saving

Longer sleeping cycles*

Less signaling for wakeup

Power Save Mode

eDRX

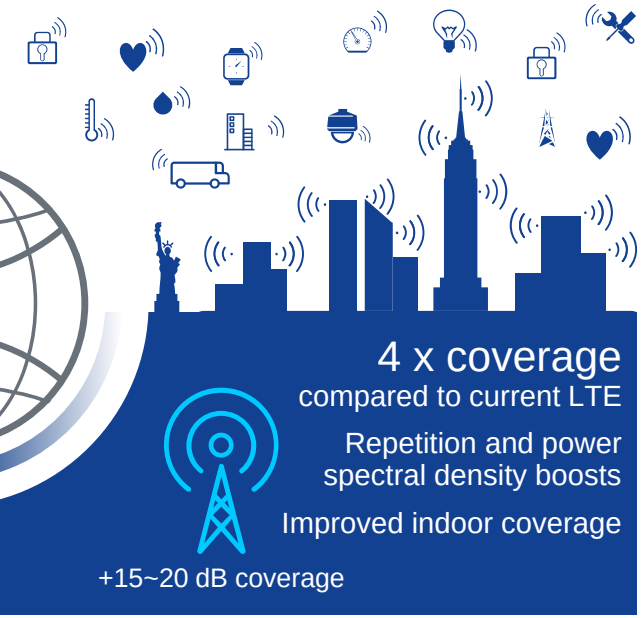
Simplified modems

Narrowband transmission

Reduced transmit power

Limited downlink transmission modes

UE processing relaxations



4 x coverage

compared to current LTE

Repetition and power spectral density boosts

Improved indoor coverage

+15~20 dB coverage

>10 years

Battery life with two AA batteries

Very low device cost

Standard availability

3GPP Rel-13

10,000 x	>10 Gbps	100 Mbps	<1 ms	10-100 x	ultra low	10 years

*) Extended Discontinuous Reception (DRX)

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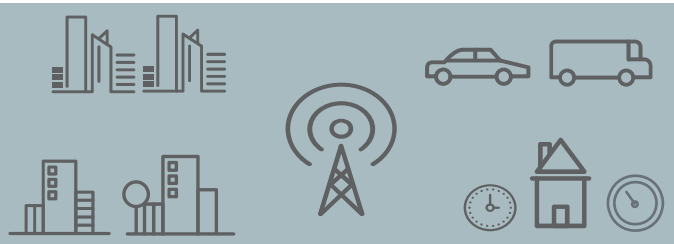
IoT Wireless Connectivity
Technology Choices



- Simple cheap devices
- Low energy consumption
- Massive number of devices
- Full coverage

Internet of Things

- 3GPP RAN (Rel-12/13)
  - LTE evolution for MTC (LTE-M 1.4MHz)
  - LTE evolution for NB-IoT (200kHz)
- 3GPP GERAN (Rel-13)
  - Enhanced Coverage GPRS (EC-GPRS)

licensed spectrum

- Short range
  - Bluetooth Low Energy
  - Wi-Fi, IEEE802.11ah
  - ZigBee
  - Z-wave
  - …
- Long range
  - Sigfox
  - LoRa
  - Weightless
  - Ingenu
  - …

unlicensed spectrum

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IoT Technology Space

	SIGFOX	LoRa	Short-range	NB-IoT Rel. 13	LTE-M Rel. 13	EC-GSM Rel. 13	5G (targets)
Range MCL	<12km 160 dB	< 10km 157 dB	10cm to 200m	<15km 164 dB	< 10km 156 dB	< 15km 164 dB	<12km 160 dB
Spectrum Bandwidth	Unlicensed 900MHz 100Hz	Unlicensed 900MHz <500kHz	Unlicensed 2.4 GHz	Licensed IMT 200 kHz shared	Licensed IMT 1.4 MHz shared	Licensed 8-900MHz shared	Licensed IMT shared
Data rate	<100 bps	<10 kbps	<100s Mbps	<200 kbps	<1 Mbps	<70 kbps	<1 Mbps
Use case	Smart Grid/City/ Monitoring	Smart Grid / City/ Monitoring	Smart home/factory	Smart Grid/City/ Monitoring	Smart Grid / City / Monitor./ vehic.	Smart Grid / City / Monitor./ vehic.	Smart Grid / City / Monitor./ vehic.
Module cost	4.00$ (2015) 2.64$ (2020)	4.00$ (2015) 2.64$ (2020)	Not available	4$ (2016) 2-3$ (2020)	5.00$ (2016) 3.30$ (2020)	4.5$ (2016) 2.97$ (2020)	<$2
Network cost, US example* (cost drivers)	$10/year/km^2 >$80M/year (HW+SW+Service)	$10/year/km^2 >$80M/year (HW+SW+Service)	Not available	$1/year/km^2 <$7M/year (SW upgrade)	$1/year/km^2 <$7M/year (SW upgrade)	$1/year/km^2 <$7M/year (SW upgrade)	Included in 5G deployment

LTE for IoT

Wide area network coverage

Worldwide deployment, ubiquitous coverage, cell coverage comparable to GSM low data rates

Mature worldwide standards with large number vendors and operators, robust inter-operability

High network reliability

High performance

Robust features

Security, policy and charging, managed QoS, etc

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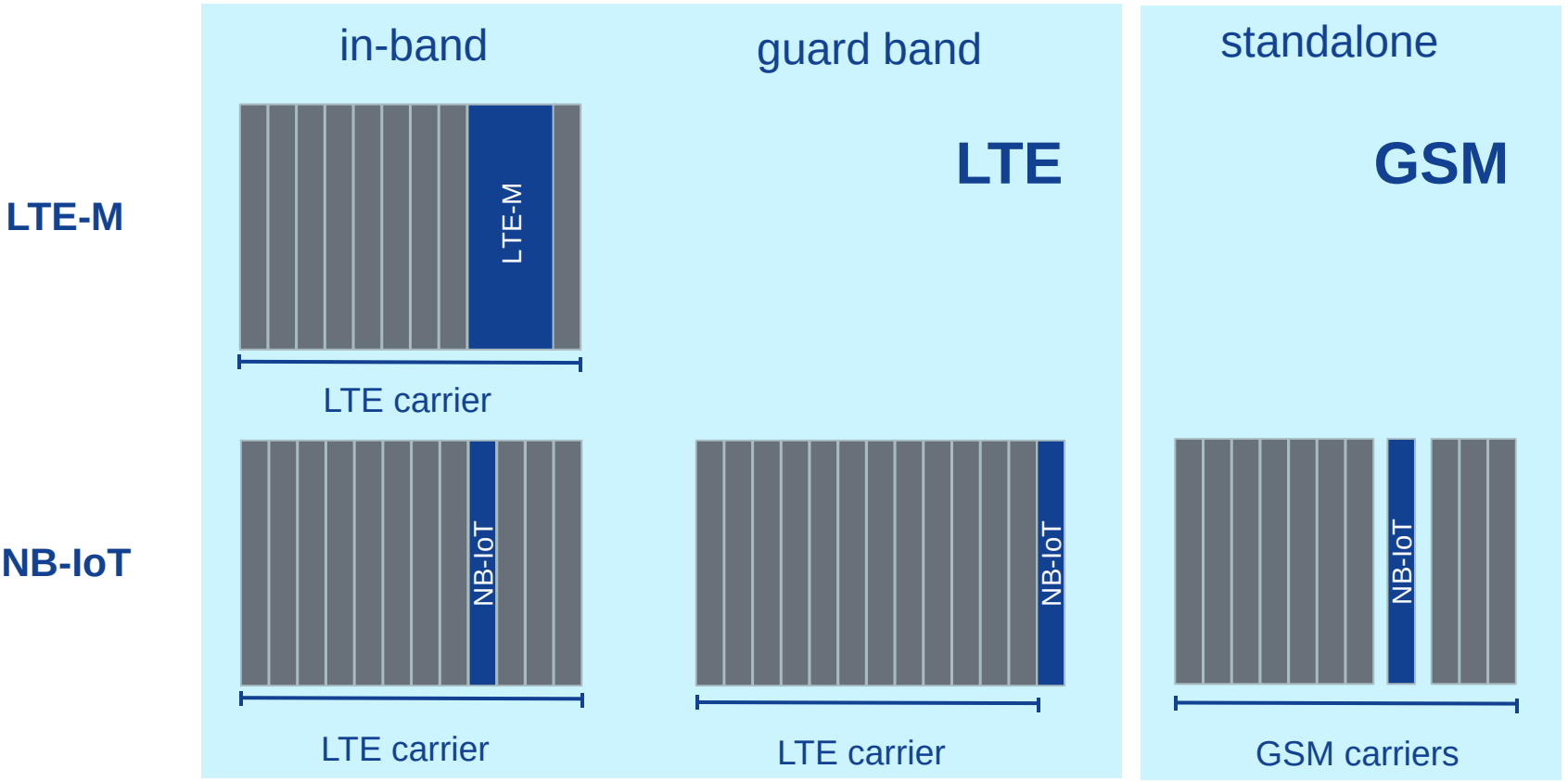
Cellular IoT Solution Space

3GPP Radio Solution

Targets	LTE-M (1.4 MHz)	NB-IoT (200 kHz)	EC-GSM (200 kHz)
Improved coverage including indoor	156 dB MCL (+15 dB improvement)	164 dB MCL (+20 dB improvement)	164 dB MCL (+20 dB improvement)
Massive MTC capacity	>52K UEs/cell/180 kHz	>52K UEs/cell/180 kHz	>52K UEs/cell/180 kHz
Data rate	< 1 Mbps	< 200 kbps	< 70 kbps
Improved power efficiency - battery life	>10 years	>10 years	>10 years
Latency	<10 secs	<10 secs	<10 secs
Low cost module	5.00$ (2016), 3.30$ (2020)	4$ (2016), 2-3$ (2020)	4.5$ (2016), 2.97$ (2020)
Deployment scenarios	In-band	Stand-alone, in-band, guard-band	Stand-alone

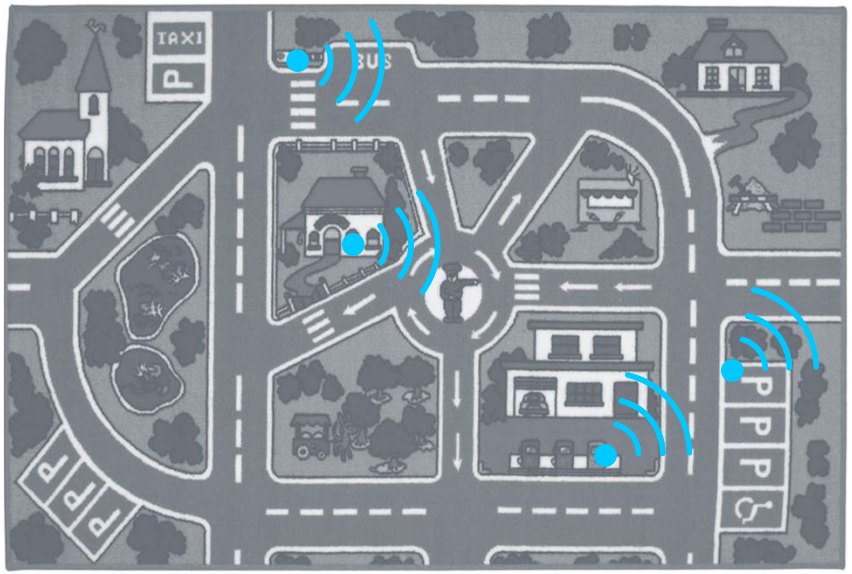
*MCL - minimal coupling loss

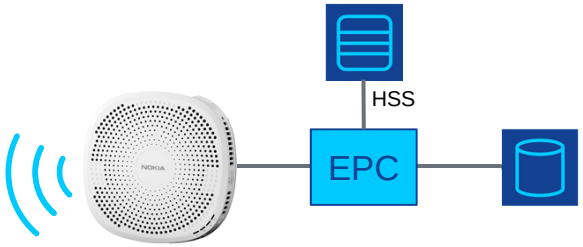
IoT Deployment Options



LTE-M Demonstration Setup

Overview





Nokia Flexi Zone
FDD/1.4MHz

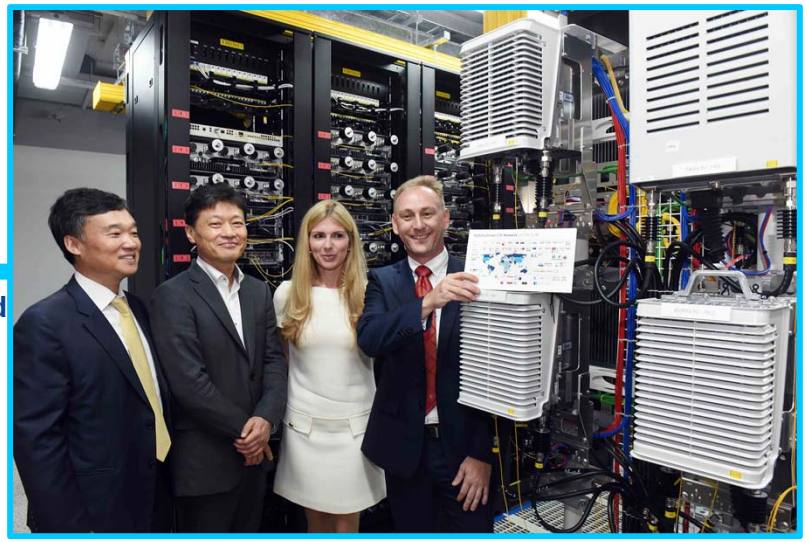
- Nokia TECH Sensor/IoT technology
- Advanced SW Cloud Platform for driving the use cases

At MWC, we demonstrated several type of sensors using mock up models placed on a small scale city. City model was modeled with the flat rug approx. 1 x 2 m in size displaying street, parking area and associated building on top of which we placed our sensors and street lamps.

N-way-partnering: Nokia and KT opened IoT^2 lab in Korea in June 2015

Dedicated space for customers/partners for testing their IoT equipment / systems

Connected



Nokia lab including LTE RAN (both FDD & TDD), EPC, IMS, etc for any kind of network infrastructure related testing. Plan to expand to have Radio Cloud, 5G as well.

- This is a lab to do **Inter-operability Test (IoT)** on **Internet of Things (IoT)** ➔ IoT^2
- 3GPP Rel-8 **Cat-1**, Rel-12 **Cat-0**, Rel-13 **Cat-M1** have been tested
- One of next steps can be **NB-IoT** test/demo/PoC with Korean industry (3GPP progress dependent)

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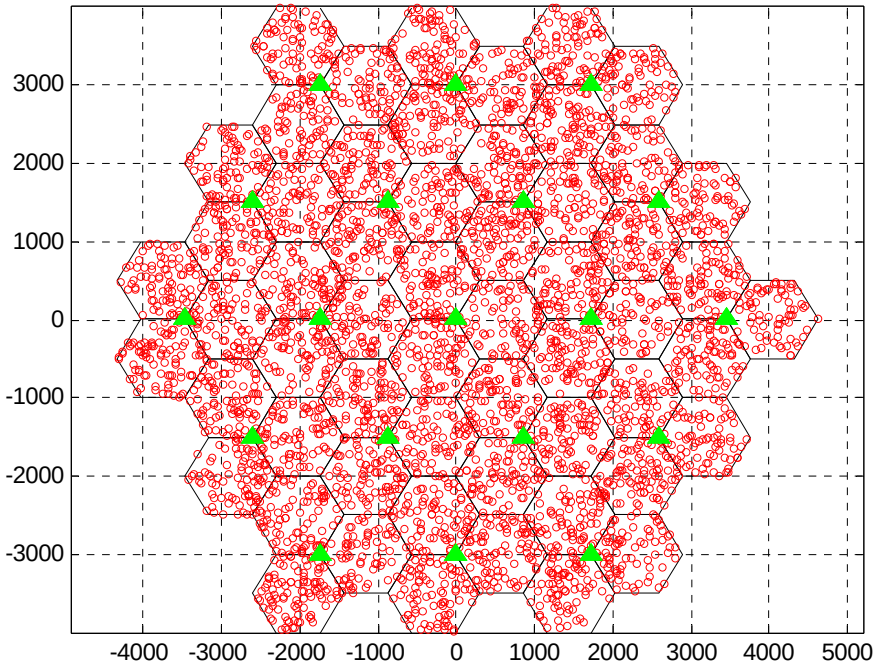
Capacity Analysis

Case	Household Density per Sq km	Inter-site Distance (ISD) (m)	Number of devices within a household
Urban	1517	1732 m	40

- Traffic model is machine reporting (80%) and network command (20%)
- In stand-alone deployment, at least 71k devices/cell/200 kHz can be supported



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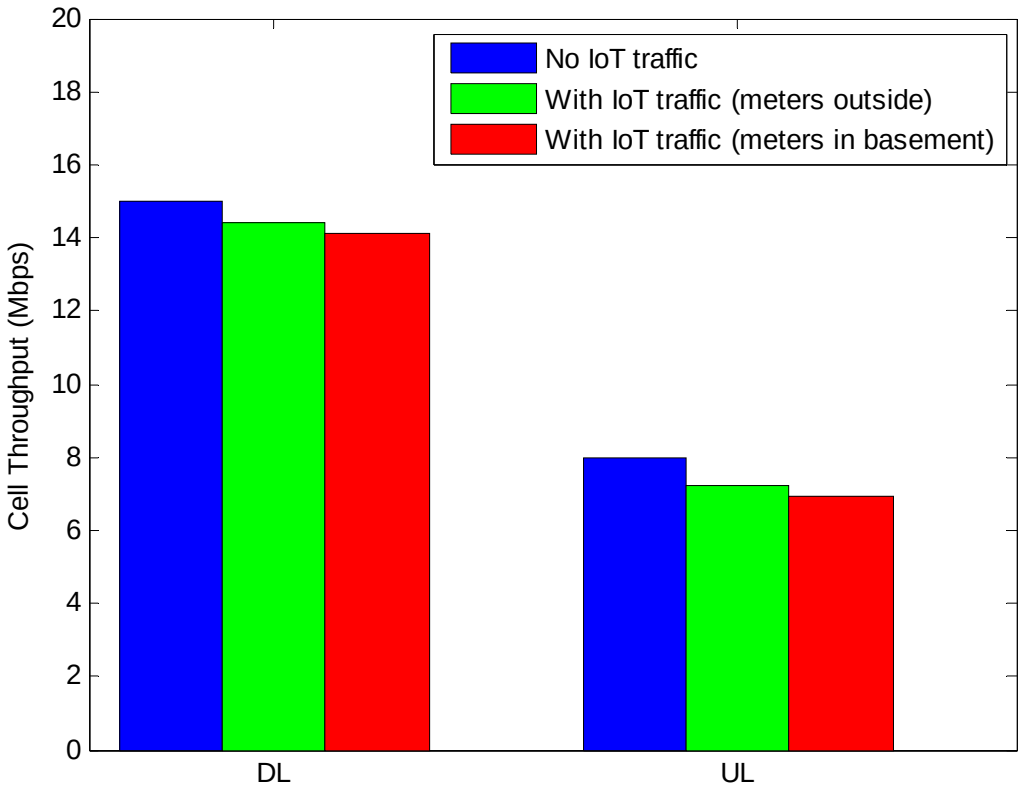
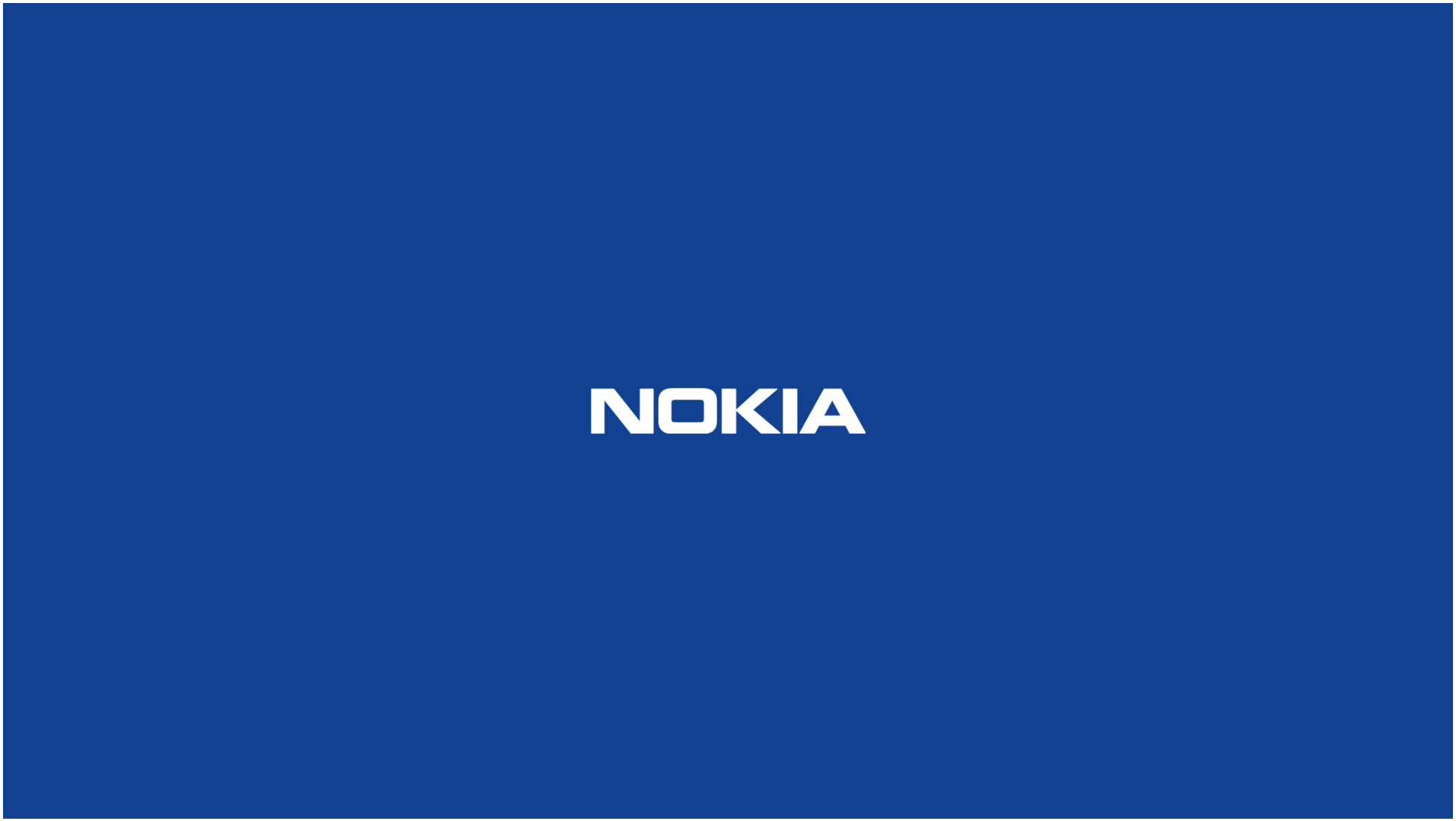
Impact to Data Traffic



- Suburban macrocell (1732m ISD)
- IoT traffic is a mixture of smart meters, home security systems, and sensors
- Small impact from IoT traffic to data traffic.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