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PERFORMANCE OF CELLULAR IoT CONNECTIVITY FOR SMART CITY APPLICATIONS



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CONNECTED DEVICES IN 2022

29 BILLION

Source: Ericsson Mobility Report, June 2017

11.6 BILLION
MOBILE PHONES, PC'S, LAPTOPS, TABLETS



17.6 BILLION
IoT DEVICES

CELLULAR IoT

From 3GPP Release 13



EC-GSM-IoT

Global cellular IoT for all GSM markets

LTE-M

Wide range of Massive IoT applications

NB-IoT

Ultra low-end Massive IoT applications

- **Extending existing cellular networks for IoT**
 - Co-existence with high performance mobile broadband services / devices
- **Optimized for IoT services**
 - Infrequent small messages
 - Low device complexity & cost
 - Long battery lifetimes
 - Extended coverage
 - Scales to massive number of connected devices

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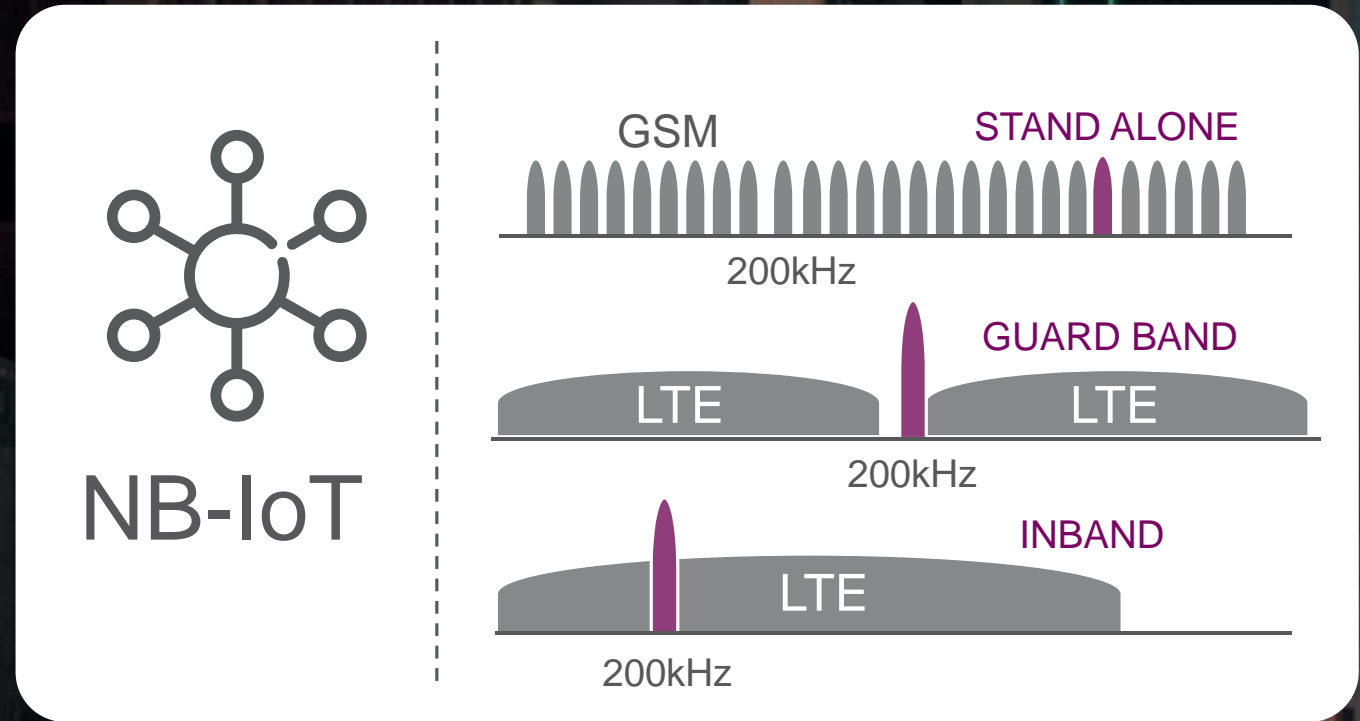
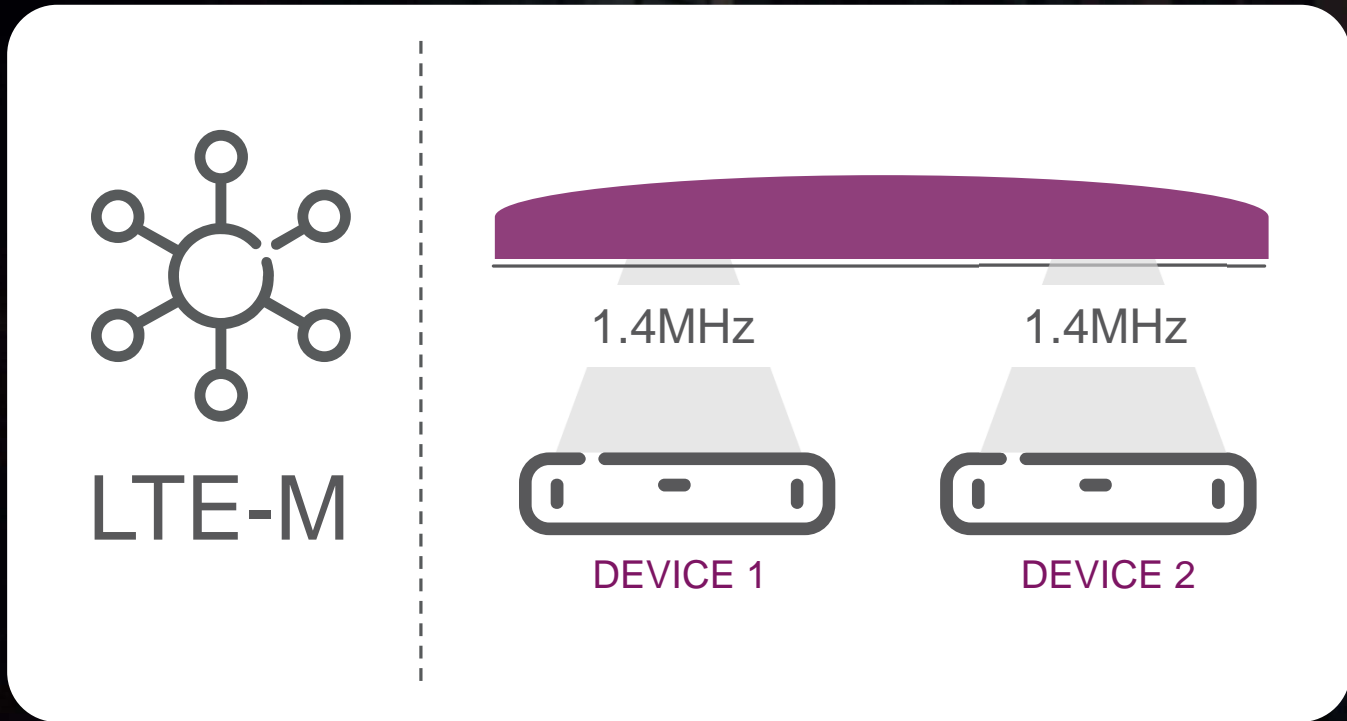
NB-IoT

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FLEXIBLE DEPLOYMENT

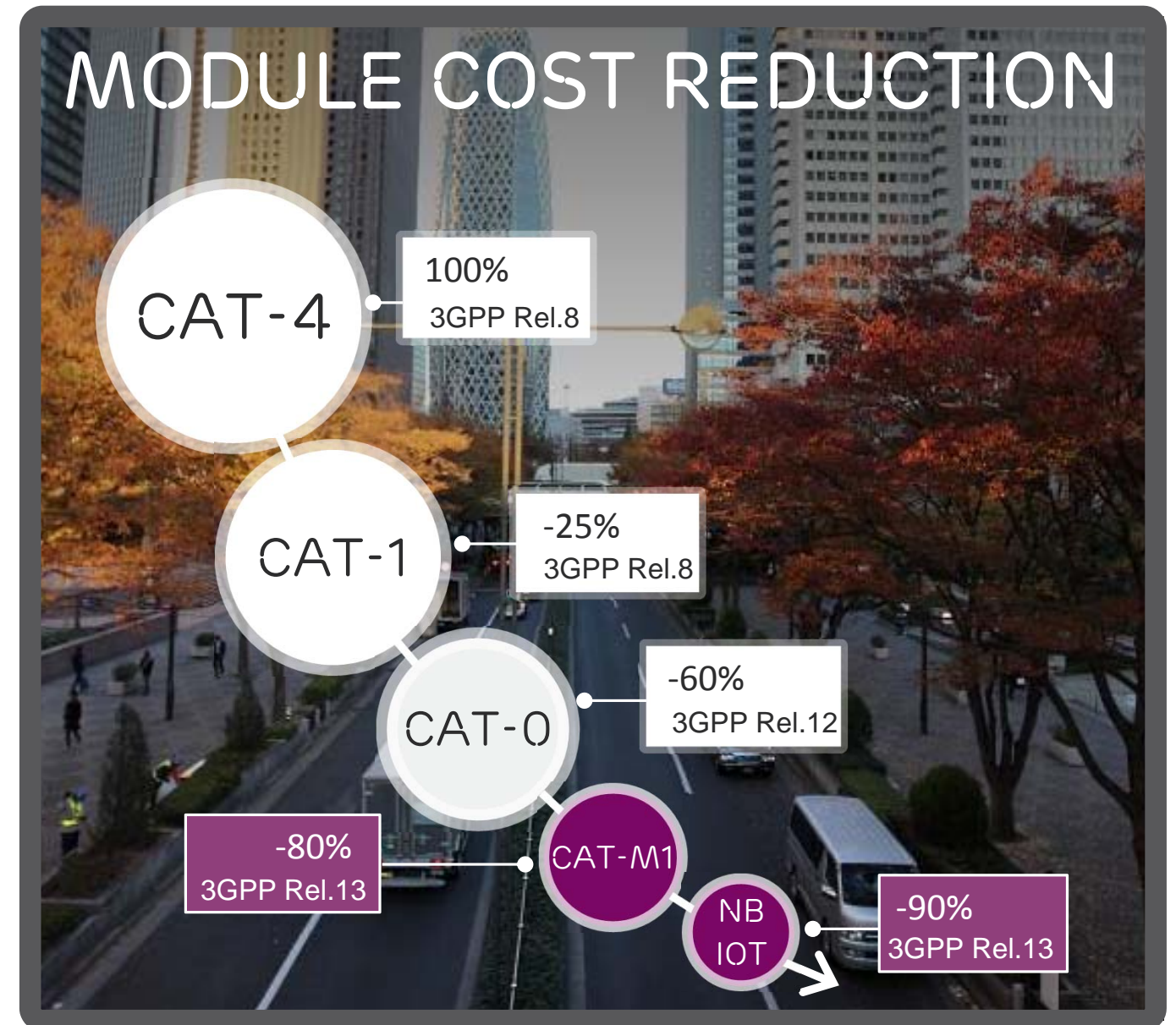
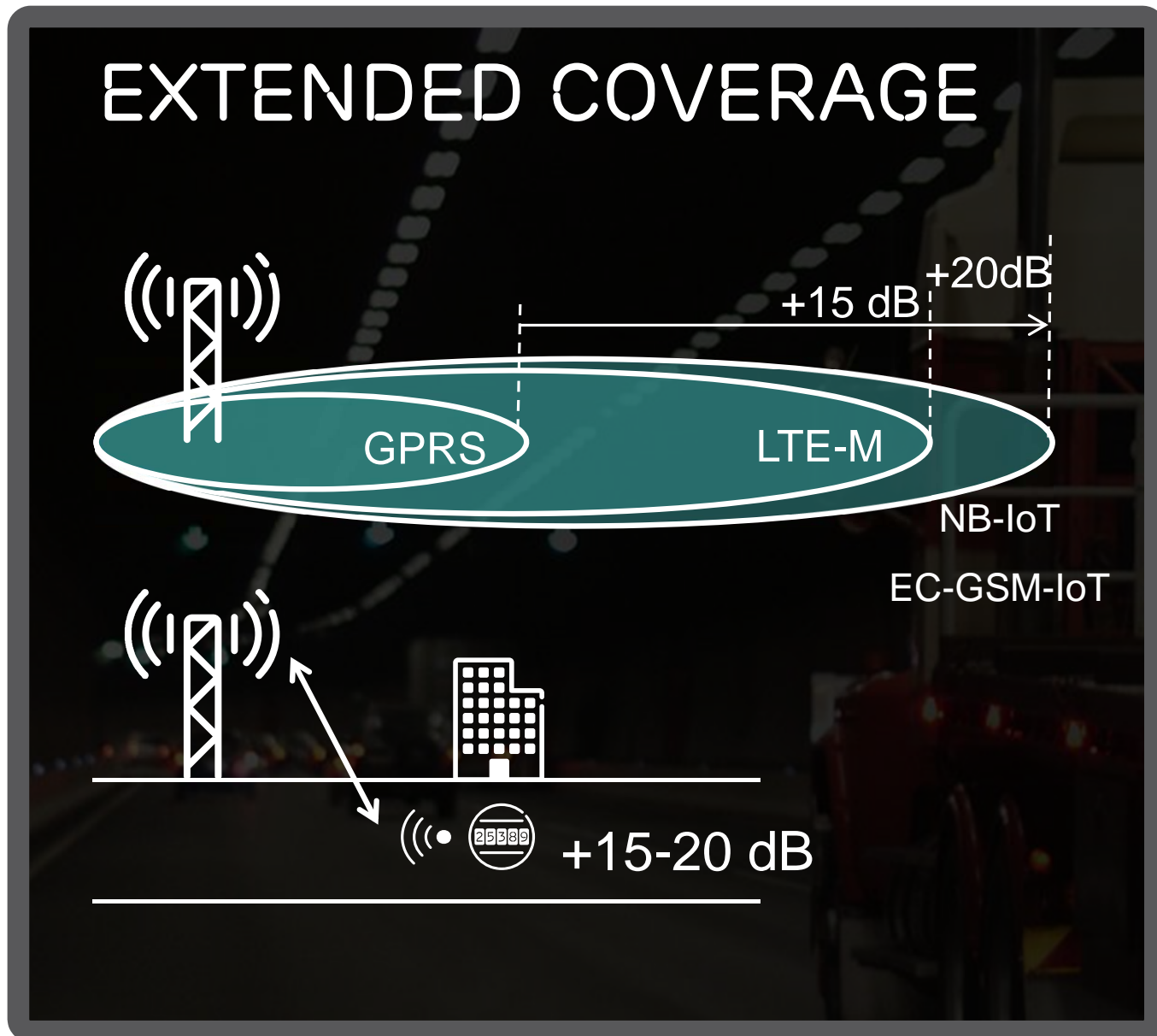
BASED ON LTE NETWORK INFRASTRUCTURE



Device receives part of LTE carrier
Devices Multiplexed across LTE carrier
Leverage full capacity of wideband LTE carrier

Device receives NB-IoT carrier
The capacity of NB-IoT carrier is shared by all devices
Capacity is scalable by adding additional NB-IoT carriers

CELLULAR IoT FEATURES (1)

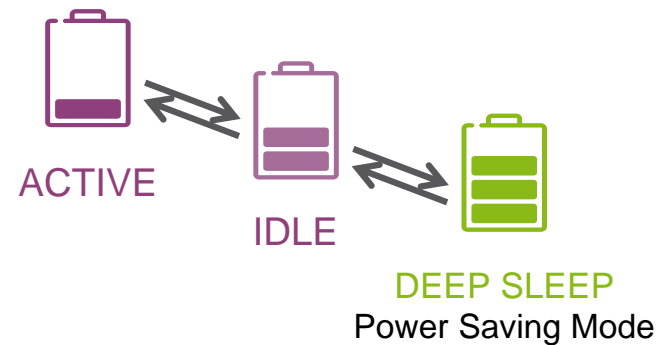


CELLULAR IoT FEATURES (2)

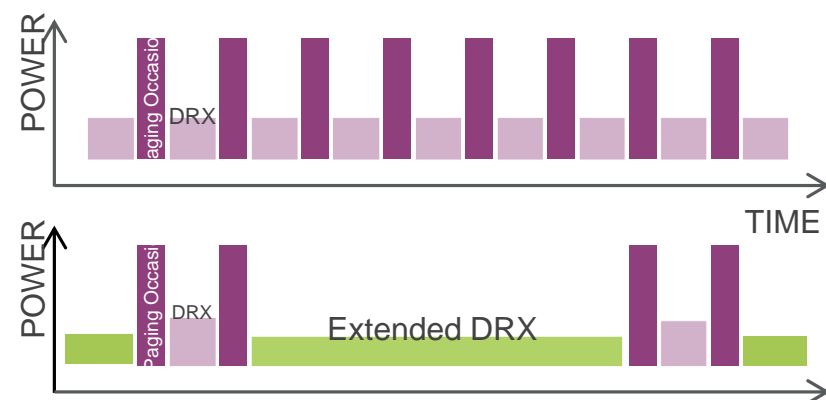


10+ YEARS BATTERY LIFE

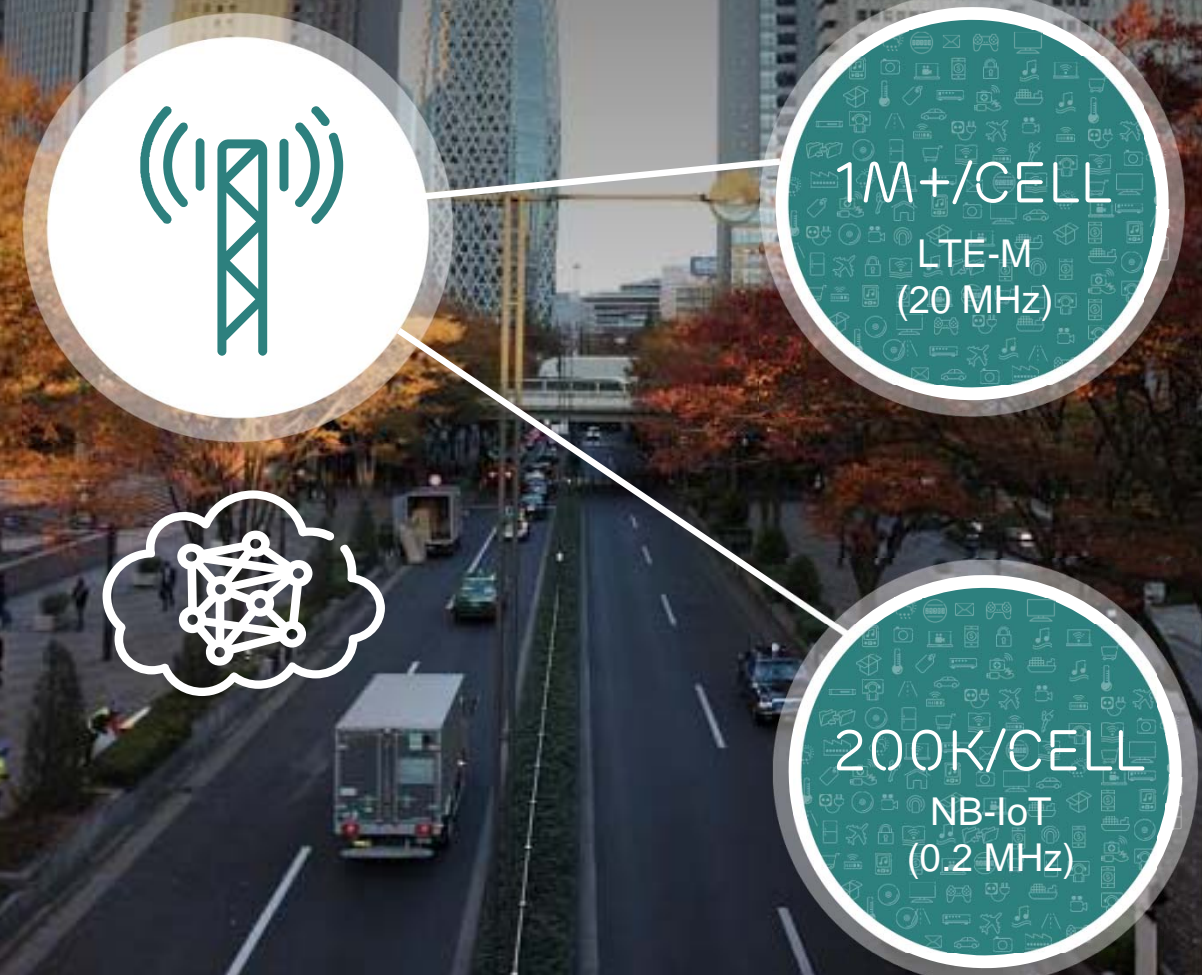
POWER SAVING MODE



EXTENDED DRX



EXTREME SCALABILITY



SMART CITY - IoT COVERAGE



Massive IoT connected devices in a city scenario

- Outdoors – only signal attenuation (no indoors path loss)
- Indoors – apartment (indoors path loss of 10–30 dB)
- Indoors – basement partly underground (additional indoors path loss of 5 dB)
- Deep indoors – basement fully underground (additional indoors path loss of 20 dB)



RADIO MODEL FOR SMART CITY IoT

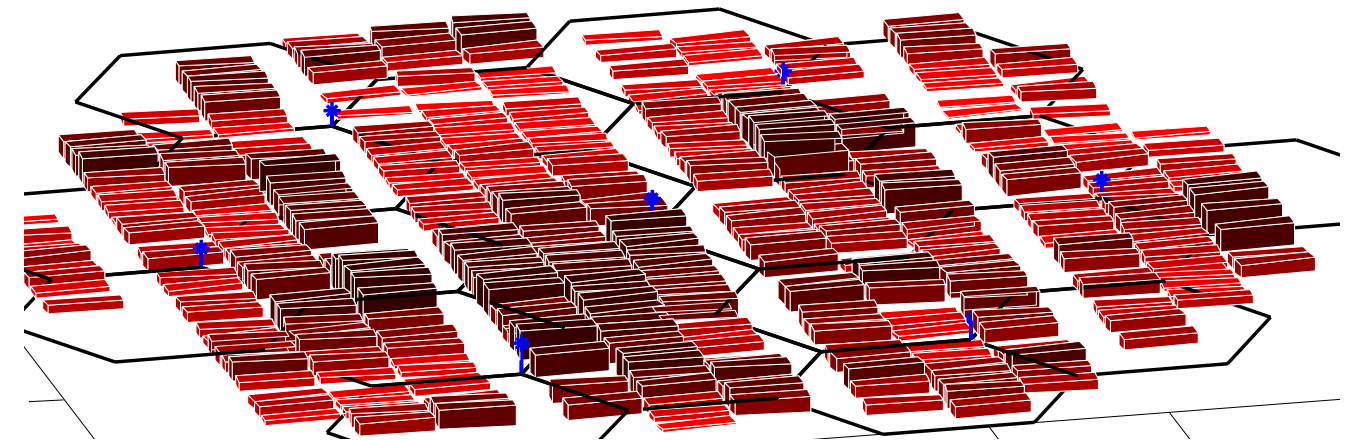


› Simulation model for broadband LTE, LTE-M and NB-IoT in a city

- 3-dimensional city model
- Close to 1,000 buildings / km²
- An average of 5 floors per building
- Typical radio base station site characteristics – inter-site distances of around 500 meters
- Line-of-sight and non-line-of-sight characteristics, including outdoor-to-indoor and indoor radio propagation models
- Commercial LTE network used for calibration

› IoT devices uniformly distributed outdoors and indoors across the city

- Density of around 20,000 devices / km²
- Signal strength attributed to the different environments



RADIO MODEL FOR SMART CITY IoT

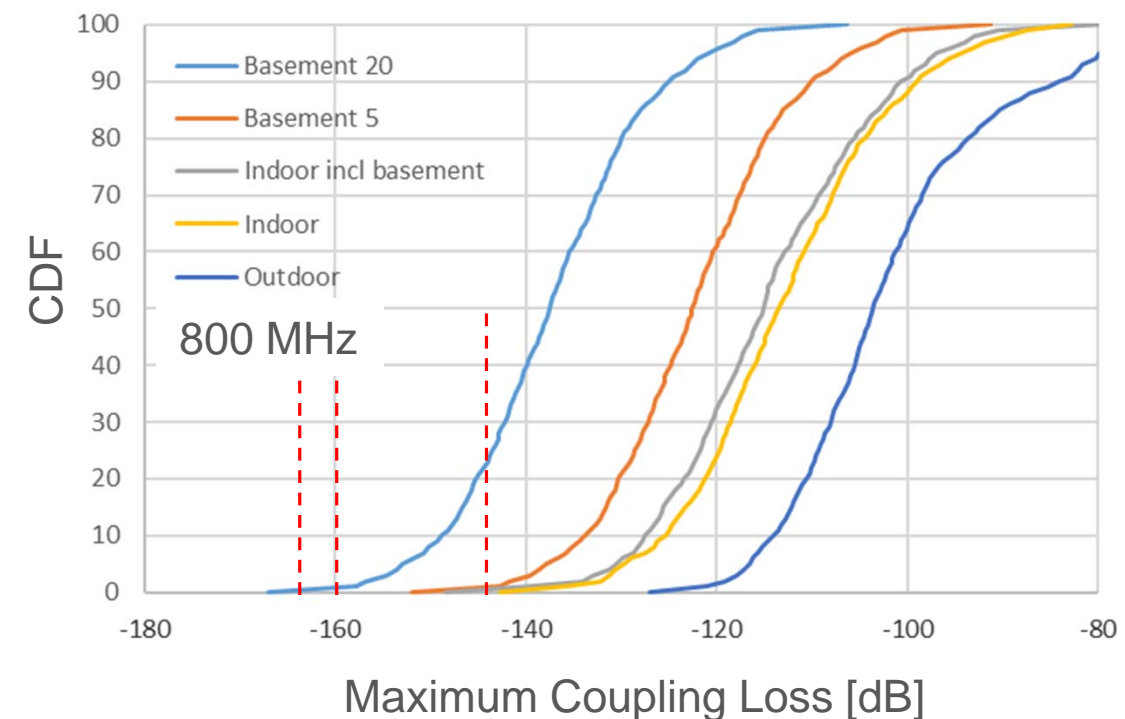


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RADIO PROPAGATION MODEL



Model

- › 3D city model created based on city construction statistics (roads, houses)
- › Simplified raytracing from base station sites
 - Explicit line-of site (LoS) determination to outdoor user or building (for indoor user)
- › Combination of statistical propagations models per user
 - Outdoor LoS / non-LoS
 - Outdoor-to-indoor penetration loss
 - Indoor propagation

City cellular network

- › Configuration of the model for a metropolitan city with characteristic building statistics
- › Real site data of a commercial LTE network
- › Calibration of propagation model with real-life LTE network measurements

J.-P. Charles, et al. "Refined Statistical Analysis of Evolution Approaches for Wireless Networks," IEEE Trans. on Wireless Communications, vol. 14, no. 5, May 2015

EXTENDING LTE COVERAGE FOR IoT



Percentage of devices reached in the massive IoT city scenario

	800 MHz band			2.6 GHz band		
	LTE MBB (144 dB)	LTE-M (160 dB)	NB-IoT (164 dB)	LTE MBB (144 dB)	LTE-M (160 dB)	NB-IoT (164 dB) ¹
Outdoors	100	100	100	100	100	100
Indoors – apartment	100	100	100	97	100	100
Indoors – basement partly underground	99	100	100	83	99	99
Deep indoors – basement fully underground	77	99	99	32	86	92

¹ Radio Frequency (RF) requirements for NB-IoT have not yet been formally defined for the 2.6 GHz band

Coverage is enhanced for low data rate IoT devices by reducing the data rate

CONCLUSION

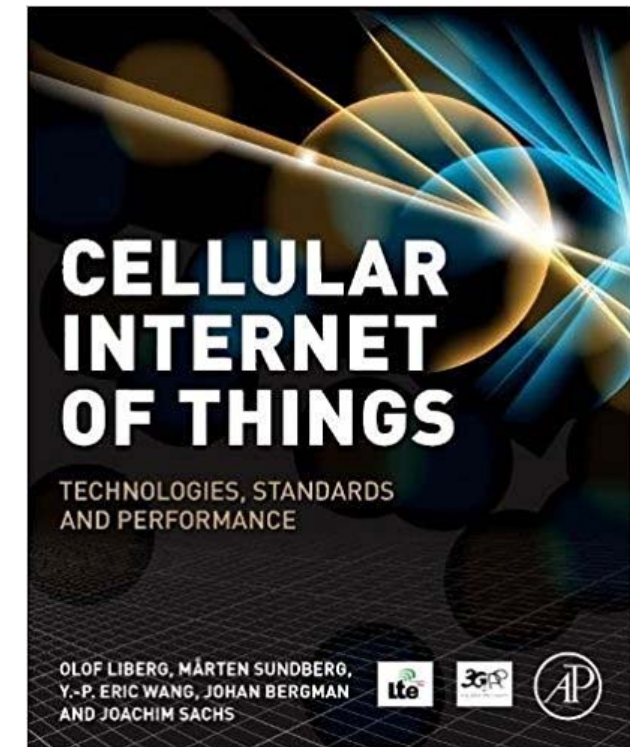


- › Cellular networks have been extended for IoT connectivity
 - LTE Machine Type Communication (LTE-M)
 - Narrowband IoT (NB-IoT)
 - Extended Coverage GSM IoT (EC-GSM-IoT)
- › Cellular IoT: optimized for IoT device and service needs
 - Long battery lifetimes
 - Low device complexity & cost
 - **Extended coverage**
 - Scalability for massive number of devices
- › **Typical cellular network deployments with Cellular IoT capabilities can provide connectivity for Smart City IoT applications**

MORE INFORMATION



- › O. Liberg, M. Sundberg, Y.-P. E. Wang, J. Bergman, J. Sachs, *Cellular Internet of Things – Technologies, Standards and Performance*, Academic Press, September 2017, ISBN: 9780128124581
<https://www.elsevier.com/books/cellular-internet-of-things/liberg/978-0-12-812458-1>
- › White Paper, “Coverage Analysis of LTE-M Category-M1,” January 2017,
<https://www.ericsson.com/assets/local/narratives/networks/documents/coverage-analysis-of-lte-cat-m1-white-paper.pdf>
- › Ericsson Mobility Report, June 2017
<https://www.ericsson.com/en/mobility-report>



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