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MASSIVE IOT COVERAGE IN THE CITY

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A wide range of Internet of Things (IoT) services are being embraced in cities. Deep indoor connectivity is a requirement for many of these services. Simulation of a realistic large-scale IoT service scenario in a city showed that up to 99 percent of devices located deep indoors could be reached with new cellular technologies for the IoT

Cellular networks are well-suited to providing connectivity for emerging IoT applications due to their ubiquitous deployments, as well as their inherent characteristics, which include security and reliability. Currently, the main role of cellular networks is to provide mobile broadband coverage. Connectivity for IoT devices poses new coverage challenges for a variety of use cases. The newly standardized 3GPP Low-Power Wide-Area (LPWA) cellular technologies, Cat-M1 and NB-IoT, can be deployed on existing LTE networks, and are helping to overcome these challenges. The technologies meet massive IoT coverage requirements and support a wide range of low-cost devices.

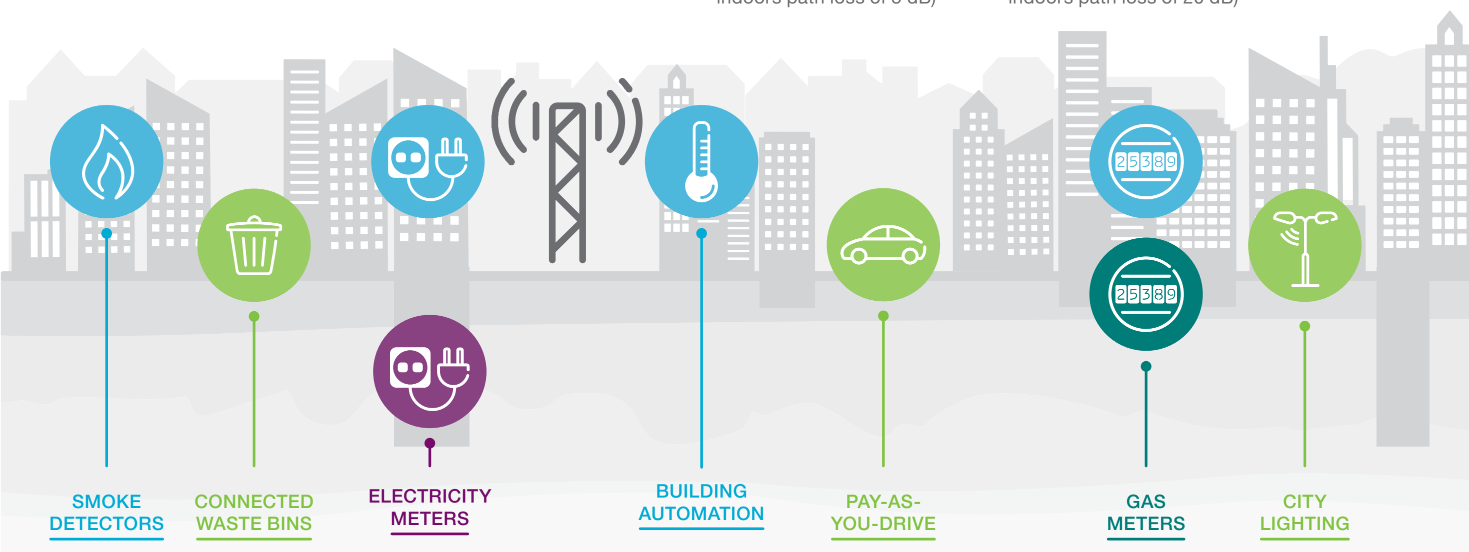
Supporting diverse use cases

Cat-M1 is a solution designed to support a wide range of IoT applications, from simple to rich content. This includes such applications as connected waste bins through to alarms incorporating emergency voice assistance and fleet management. Cat-M1 provides theoretical peak uplink data throughput of around 1 Mbps. However, there is a compromise between the data throughput and coverage: the lower bitrate the application requires, the further the coverage is extended for the application. The minimum connectivity target has been set to a maximum coupling loss (MCL)[1] of 160 dB where the achievable uplink data rate is around 1 kbps.[2] This can be compared to an MCL of 144 dB for broadband LTE with up to 1 Mbps in downlink and a few 10s of kbps in uplink.

NB-IoT is a narrowband solution, which is designed to provide even better coverage and enables deployment of devices with an even lower cost than Cat-M1. It targets ultra-low-throughput IoT applications, such as smoke detectors and utility meters. The minimum connectivity target has been set to an MCL of 164 dB where the achievable uplink data rate is around 300–400 bps.[3] Both technologies support the massive IoT use cases exemplified in the figure below.

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)



[1] Maximum coupling loss (MCL): Coupling loss is a measure of the attenuation of the radio signal between the transmitter and receiver. MCL is the largest attenuation the system can support with a defined level of service. This can also be used to define the coverage of the service

[2] An MCL of 159.7 dB is a 3GPP target that has been evaluated and exceeded by the industry. See also industry white paper "Coverage Analysis of LTE-M Category-M1, Version 1.0, January 2017"

[3] An MCL of 164 dB is a 3GPP target that has been evaluated and exceeded by the industry

Percentage of devices reached in the massive IoT city scenario

	800 MHz band			2.6 GHz band		
	LTE MBB (144 dB)	Cat-M1 (160 dB)	NB-IoT (164 dB)	LTE MBB (144 dB)	Cat-M1 (160 dB)	NB-IoT (164 dB)[4]
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

Massive IoT city model

Network coverage for massive IoT applications in a metropolitan area was analyzed. Measurements from a commercially deployed LTE network[5] for broadband services were used to calibrate a model for simulating broadband LTE, Cat-M1 and NB-IoT coverage. A three-dimensional model of a city was used, with close to 1,000 buildings per square kilometer with an average of 5 floors per building. Both line-of-sight and non-line-of-sight characteristics, including outdoor-to-indoor and indoor radio propagation models, were considered. Typical radio base station site characteristics were assumed, with inter-site distances of approximately 500 meters.

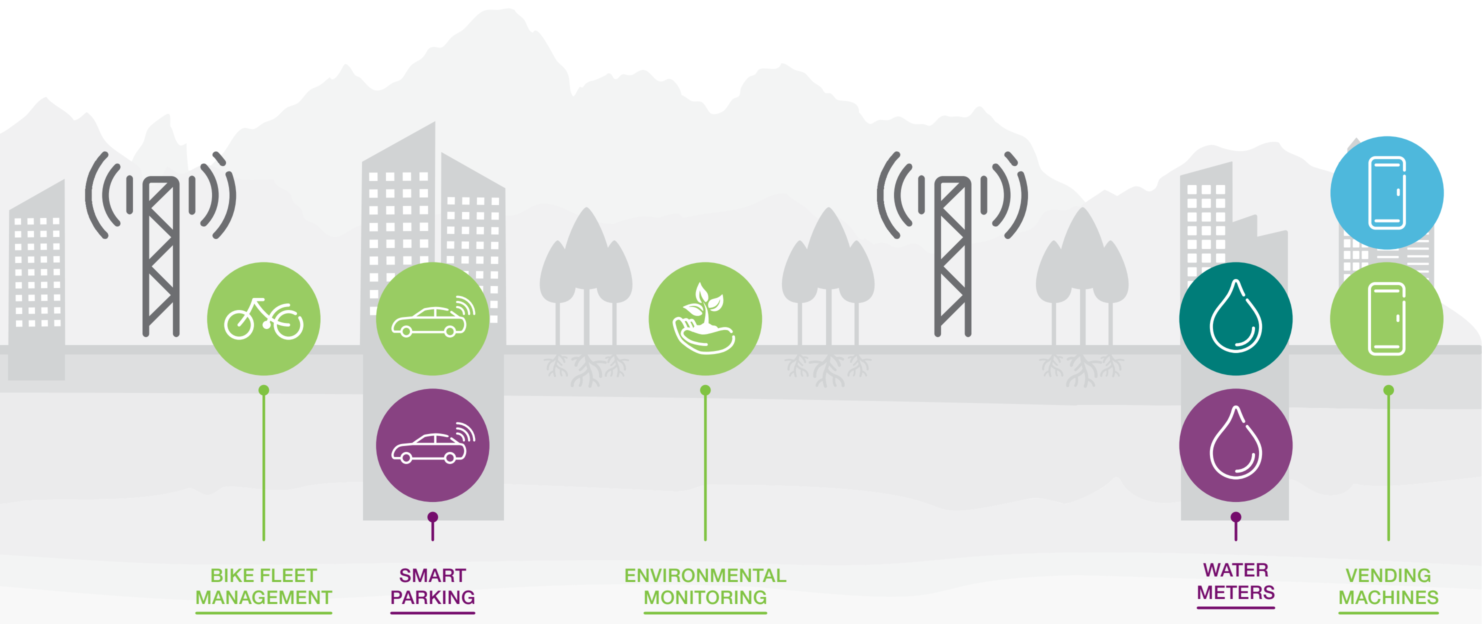
IoT devices, with a density of around 20,000 per square kilometer, were uniformly distributed across the city, both outdoors and indoors, and corresponding signal strength attributed to the different environments. For example, basements located partly underground were modelled with an additional path loss[6] of 5 dB in addition to the signal attenuation indoors (10–30 dB), and those fully underground (deep indoors) with 20 dB.

The coverage was simulated for an IoT application on broadband LTE, Cat-M1 and NB-IoT. The same cell layout was used to calculate coverage for each technology. Network coverage was analyzed in two frequency bands: one lower band (800 MHz) that has the advantage of stronger signal propagation for further coverage, and one higher band (2.6 GHz) offering greater capacity. The table above shows the percentage of devices reached for each technology.

Extending the LTE coverage for IoT

The 800 MHz band modelling showed that in challenging radio signal propagation environments, such as deep indoors, both Cat-M1 and NB-IoT can reach up to 99 percent of the devices. This can be compared to broadband LTE that would reach 77 percent of mobile broadband devices. In the 2.6 GHz capacity band, the coverage of both Cat-M1 and NB-IoT is also substantially better than the broadband LTE coverage of only 32 percent.

Coverage is enhanced for low-data-rate IoT devices by reducing the data rate to provide additional coverage. With 3GPP targets already exceeded in evaluations, the enhancements will enable massive IoT city deployments with up to 99 percent coverage of devices using cellular networks for connectivity.



[4] Radio Frequency (RF) requirements for NB-IoT have not yet been formally defined for the 2.6 GHz band
[5] Mobile network of a major European operator in a metropolitan area
[6] Path loss is the signal decrease that occurs as the radio waves travel through the air or through obstacles

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Ericsson
SE-164 80 Stockholm, Sweden
Telephone +46 10 719 0000
www.ericsson.com

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