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White Paper

Advancing IoT Connectivity with LTE Cat 1.bis technology

This paper delves into IoT applications, shedding light on the diverse data rate requirements they entail. By dissecting LTE-M, NB-IoT, and LTE Cat 1.bis, the paper elucidates how these advancements address data rate challenges. Focussing on LTE Cat-1bis, a game-changer introduced in 3GPP Release 13.

With a spotlight on power conservation techniques, cost structure, and coverage capabilities, this paper presents a holistic understanding of LTE Cat 1.bis's superiority and brings insights into the intricate IoT data rate landscape. Discover the transformative potential of LTE Cat 1.bis, and grasp its pivotal role in shaping the IoT future.

Executive Summary

Discover the evolving landscape of IoT applications with diverse data rate needs, ranging from modest kilobits to high-megabit demands. This paper presents a comprehensive exploration of IoT data rate requirements, technological solutions, and the pivotal role of LTE Cat 1.bis.

What you'll learn:

- The spectrum of IoT data rate requirements and the importance of efficient connectivity solutions.
- The technological advancements in IoT connectivity, including LTE-M, NB-IoT, and the transformative LTE Cat 1.bis.
- The benefits of LTE Cat 1.bis in terms of data rates, power consumption, coverage, and cost.
- The implications of LTE Cat-1bis for IoT developers, designers, and manufacturers, and its role in accelerating global IoT adoption.
- LTE Cat 1.bis emerges as a powerful solution to bridge the gap between diverse IoT needs, offering reliable connectivity, enhanced power efficiency, and improved cost-effectiveness.

Key takeaways

- **Power conservation:** Power-saving techniques such as extended discontinuous reception (eDRX) and power-saving mode (PSM) enhance battery life.
- **Coverage and cost advantages:** LTE Cat 1.bis excels in coverage capabilities and challenging RF environments, with a competitive cost structure due to its simplified design.
- **Global adoption trend:** The adoption and certification of Cat 1.bis devices are growing globally for diverse IoT applications.
- **Diverse data rate demands:** IoT applications span a wide spectrum of data rate needs, from kilobits for temperature sensors to high-megabit requirements for real-time video streaming.
- **Technological solutions:** Non-3GPP and 3GPP IoT air interface technologies, including LTE-M, NB-IoT, and LTE Cat 1.bis, cater to varied demands.
- **LTE Cat 1.bis innovation:** Introduced in 3GPP Release 13, effectively reduces device size and cost.

Understanding the benefits of Cat 1.bis technology

In the ever-evolving domain of IoT applications, we observe a diverse array of data rate necessities. On one extreme, we have applications like temperature monitoring sensors, requiring only a handful of kilobits per second to function effectively. These applications, despite their modest data needs, play an integral role in maintaining optimal conditions in environments ranging from homes to industrial facilities. Progressing upwards in the data rate spectrum, we encounter a multitude of applications operating within a range of tens to hundreds of kilobits per second. These include a variety of devices serving various purposes, each with its own unique data requirements.

Moving into the **middle tier**, we see applications such as telematics systems used in fleet management, which require a throughput in the **1 to 10 Mbps range**. These systems need the capability to transmit large quantities of data for tracking and monitoring fleet operations, fuel consumption, vehicle health, and so forth.

At the **top end of the spectrum**, we have real-time video streaming for security surveillance, marking the high-demand applications. These require significant data rates of **100 to 150 Mbps** to provide smooth, real-time footage, critical for maintaining security and vigilance.

Meeting requirements

Given the diverse nature of these requirements, a range of technological solutions have been utilised. Both non-3GPP and 3GPP IoT air interface technologies have been deployed to meet these needs. Particularly, in the 3GPP domain, LTE-M and NB-IoT, two IoT-specific standards introduced in 3GPP Release 13, have been paramount. Also introduced in 3GPP Release 13 was LTE Cat1.bis, a solution purposefully designed for IoT applications. Unlike its precursor LTE Cat 1, LTE Cat1.bis can operate using a single antenna, thereby offering the same level of data rate, reliability, and latency, but in a smaller and more cost-effective package.

Before the advent of LTE Cat1.bis, the only standards supporting single antenna designs, such as LTE Cat 0, LTE Cat M1, and LTE Cat NB1 (NB-IoT), provided a maximum throughput of 1 Mbps. This proved insufficient for many real-time data acquisition applications.

With LTE Cat1.bis, IoT devices can maintain the same data rate of 10 Mbps for downlink and 5 Mbps for uplink as with LTE Cat1, all the while operating with a single antenna design. This innovation reduces not only the number of antennas but also matches LTE Cat1 in terms of network capabilities - data rates, signal bandwidth, and latency. As a result, it reduces the overall size and cost of manufacturing IoT devices, improving overall time-to-market.

Application Demands

For applications demanding strict size requirements and reliable network quality, such as wearables, health monitoring, asset tracking, and smart metering, LTE Cat1.bis modules and devices present a fitting alternative. The hardware costs of LTE-Cat1.bis are comparable to those of LTE-M and NB-IoT devices. However, with its provision of a higher data rate, LTE Cat1.bis can offset the cost, balancing cost and performance for a wide array of applications.

The emergence of LTE Cat1.bis stands as a considerable advancement in IoT communications, enabling network operators, device manufacturers, and vendors to connect compact IoT devices reliably while offering high data rates. It signifies a promising progression in the field of IoT, where efficiency and performance harmoniously coexist.

Network Conditions

Not all operators deploy LTE-M or NB-IoT, and the deployment of these technologies remains segmented. About 110 operators across roughly 60 countries have deployed NB-IoT. Conversely, LTE-M has been commercialized by about 60 operators in 34 countries. These technologies are available in most regions of Europe, North America, Australia, and parts of Asia.

Cat 1bis devices operate on the standard LTE network, the same network that our mobile phones use. Unlike LTE-M and NB-IoT, operators don't need to upgrade their RAN or core network for Cat 1bis. In the LTE network, a Cat 1bis device is treated like a Cat 1 device with one key difference: Cat 1bis requires a single receive (Rx) antenna instead of the two antennas used in Cat 1.

There is no dedicated bandwidth allocated for Cat 1bis devices; they coexist with regular LTE Cat 1, Cat 4, and smartphones on the same network and spectrum.

Power Consumption

Power conservation is a critical aspect in the design and operation of IoT devices, especially in situations where the battery life can greatly impact the overall effectiveness of a device. In response to this, 3GPP has innovated power-saving techniques such as extended discontinuous reception (eDRX) and power-saving mode (PSM).

A vast array of applications, including smart energy meters and tracking devices, exhibit predictable data transmission patterns. This regularity allows these devices to benefit from eDRX and PSM, resulting in extended DRX sleep cycles. While these features are typically utilised in NB-IoT and LTE-M networks, they are equally applicable to Cat 1.bis devices.

According to surveys, many major operators across regions such as the United States, Europe, and Asia have incorporated both PSM and eDRX for their Cat 1 and Cat 1.bis devices. As a result, devices like energy meters and trackers employing Cat 1.bis can now experience extended sleep cycles on par with those of LTE-M-based devices.

Investigating further into power consumption, we note that some asset tracking applications allow for the device to operate in a power-down mode. Here, the device periodically wakes up to transmit data but remains otherwise powered down and inaccessible.

Significantly, Cat 1.bis devices, similar to NB-IoT and LTE-M devices, feature only one receive RF chain. This design offers an architectural advantage over conventional Cat 1 devices, leading to lower costs, increased power efficiency, and more flexibility in the design of devices with form factor constraints.
An important metric tied to the battery life of a device is the "ON" time: the duration a device must be active to complete a data transaction. While examining device "ON" time, it is crucial to consider the data rates.

Although NB-IoT NB2 and LTE Cat-M1 offer peak uplink data rates of 160 Kbps and 375 Kbps in half-duplex mode respectively, the typical data rates achieved in practical situations can be considerably lower. When a device needs to upload or receive 500 bytes of data on NB-IoT and LTE-M, the device ON time is around 400 milliseconds and 40 ms respectively. However, a Cat 1.bis device can complete the same data transaction in a mere 8 ms at a throughput of 500 Kbps.

Moreover, tasks unrelated to the cellular modem, such as sensor data processing and location tracking, increasingly dominate device power consumption. Despite this, the power usage of LTE Cat 1.bis modems now matches or even surpasses that of LTE-M modems.

Cost Structure

Analysing the cost structure, it becomes clear that LTE Cat 1.bis modules and devices demonstrate a competitive edge over Cat 1 devices. This advantage stems from their simplified design, requiring only a single antenna and a single receive RF chain, compared to the dual antennas needed for Cat 1 devices. Furthermore, while LTE-M and NB-IoT technologies offer minor cost benefits, mostly due to their SAWless RF front end, the costs associated with Cat 1.bis align closely with those of low-power wide-area network (LPWAN) modules.

The superior coverage capabilities of LTE Cat 1.bis devices further enhance their appeal. Although these devices operate with fewer antennas, they still excel in challenging RF environments. For applications like asset tracking or data aggregation for parking and energy meters that operate in difficult RF conditions such as basements, elevators, and deep indoor locations, the coverage benefits of LTE Cat 1.bis cannot be overstated. Therefore, when the balance between cost, performance, and coverage is considered, LTE Cat 1.bis emerges as an extremely effective and efficient solution for a wide array of IoT applications.

Conclusion

If you're in the business of designing and developing for the Internet of Things, you operate in a low-throughput, low-power environment. You're always looking for wireless standards that can efficiently connect devices like parking meters, asset trackers, and energy meters while operating on a tight power budget.

1. We at Acal BFi believe that LTE Cat 1bis holds significant potential and meets the most crucial needs for IoT developers, designers, and manufacturers. Furthermore, it includes features that will speed up IoT adoption globally. Cat 1bis offers benefits that ease IoT adoption challenges.

2. It supports power-saving features, has a broader global roaming footprint, and lower power consumption, enabling manufacturers to build devices that are easy to deploy and offer extended battery life. LTE-M provides coverage benefits, but these may not be applicable in non-stationary use cases like globally deployed asset trackers.

3. Compared to LPWAN modules, Cat 1.bis modems are competitively priced with a clearly defined evolution path in 3GPP standards through future eRedCap-based products. The adoption and certification of Cat 1bis-based devices have increased significantly, with the trend set to accelerate following the lead of AT&T, Verizon, and Deutsche Telekom among others, embracing Cat 1bis.

About Acal BFi

Acal BFi is a leader in advanced solutions for tomorrows technologies, providing engineering, design, manufacturing and tailored services as well as delivering a broad range of specialist products and solutions across Europe. Specialising in a range of technologies, namely Power & Magnetics; Communications & Sensors; Electromechanical; Imaging & Photonics; and Embedded Computers & Displays, Acal BFI have a focus on a consultative, design-led approach that aims to develop, in collaboration with customers and their own expert field engineers and Technology Centre capabilities, designs and custom solutions that meet a project’s specific requirements.

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