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Coverage Enhancement Using CAT-M

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Abstract - *Internet of things (IoT) is a word we hear quite a lot in recent days, and it's said to be future of the communication. Humans have developed many devices to interact and so as communication medium needs to be developed in order to communicate between machines which is known as Machine Type Communication (MTC). The backbone for this MTC is Internet of things (IoT) framework. As much more inventions and enhancements are taking in order to enrich experience, CAT-M Technology was introduced. It aims in optimizing legacy LTE network for the IOT devices. In this paper a testbed is created for UE to latch and logs were collected to analyze coverage of the Network.*

Key Words: **CAT-M, Coverage Enhancement level, MTC, IoT, RACH.**

1.INTRODUCTION

The future of Mobile ecosystem is expected to be 'Internet of Things' (IoT). As shown in Fig 1, the Growth of Cellular lies in IoT services [1]. Currently the Cellular IOT are used in many fields such as vending machines, utility meters, automotive (smart traffic, fleet management, security monitoring, real time traffic information to the vehicle, and reporting), medical metering and alerting as shown in Fig 2 [2].

Machine to Machine (M2M) communication device requires Low Cost, Low Power and High Coverage.
M2M devices need to be of low complexity which are used for low data rate communication.

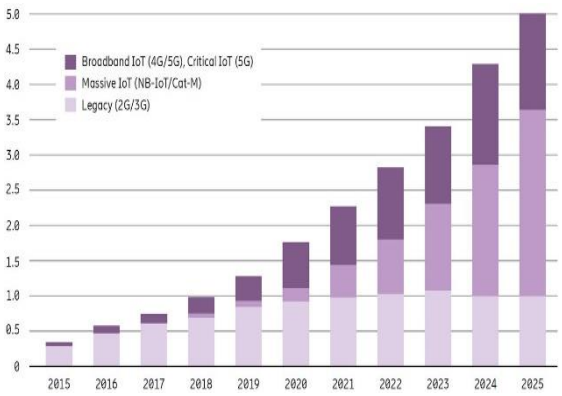

Fig. 1. Growth of Cat-M [1]

The New technology has developed which are deployed over the existing one, which refers to low deployment cost. The devices should act as 'Set and forget type' where there is less maintenance. Such devices should run in ultralow power mode for longer battery life. Alongside the coverage is a main strand. Several methods are implemented to extend the Coverage area to reach remote areas.

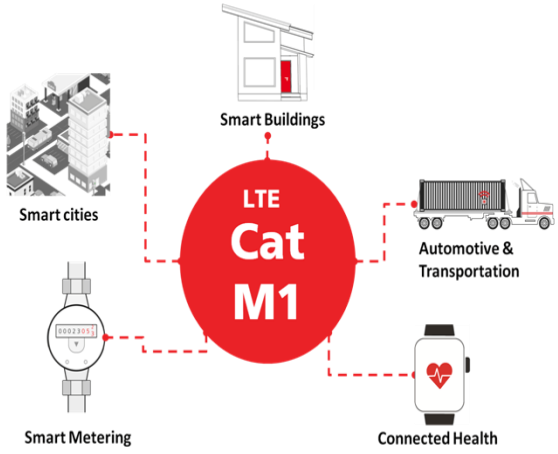

Fig. 2. CAT-M Applications

The New category device namely 'LTE CAT-M' is developed which was incorporated by 3GPP to support M2M and IoT features. Since Legacy LTE devices were optimised differently, the MTC terminals behavior is different than legacy LTE Device. The new User Equipment (Referred as UE Device) for MTC operation is been optimized for low power consumption and better coverage than the existing network.

Here, various methods to increase the Coverage area has been discussed. It explains the architecture and how the test setup for experiment was created. The test was performed on 'BG 96 Quetal' module which has 'Qualcomm 9206' module. The software such as Wireshark, QXDM were used for log collection. In this paper, Section 2 discusses about methodology adopted and Cell configuration details. Section 3 discusses about hardware components and architecture of proposed work. Section 4 explains the types of methods which can be implemented to achieve the Results. Finally, the Results are discussed in the Section 5.

2. METHODOLOGY:

This paper focuses on the configuration of LTE CAT-M cell and analysis of Coverage Enhancements. An overview of CAT-M cell configuration steps as shown in Fig 3.

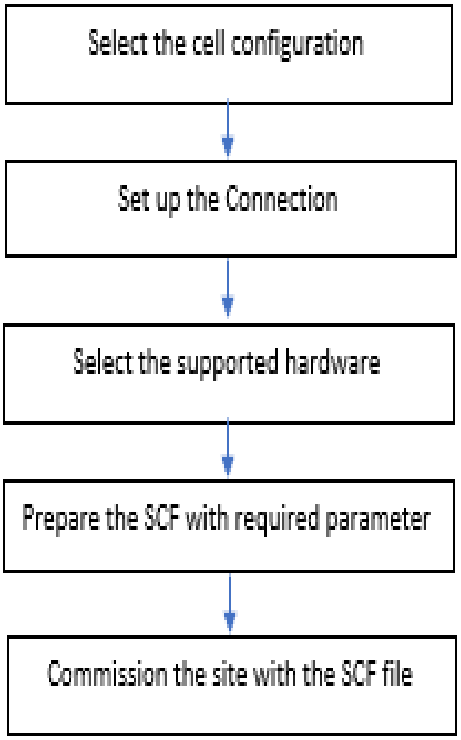

Fig. 3. Cell Configuration Steps

1. The Cell support technologies like WCDMA, LTE and GSM. So, the cell configuration needs to be selected.
2. Once the configuration is done, supporting hardware such as system module and radio frequency module are to be selected.
3. The integration of all hardware is to be made.
4. The CAT-M Technology can be deployed on legacy LTE network, some modification is to be made such as enabling the CAT-M in the site. These are modified in the Site Configuration File.
5. The Site configuration file is then uploaded to the eNB, once done successfully, the site will be on air and ready to be connect for CAT-M capable devices.
6. The CAT-M device will search the network and connects to supported network.
7. The Wireshark, EMIL and QXDM software are used to collect the logs while Devices are attached to the network.

3. HARDWARE DETAILS AND ARCHITECTURE:

The CATM supports 5, 10, 15 & 20MHz frequency. The Hardware components include Airscale, FSMF or FZM. It can support various combinations such as 1Tx/1Rx, 1Tx/2Rx, 2Tx/2Rx, 2Tx/4Rx and 4Tx/4Rx eNB configurations.

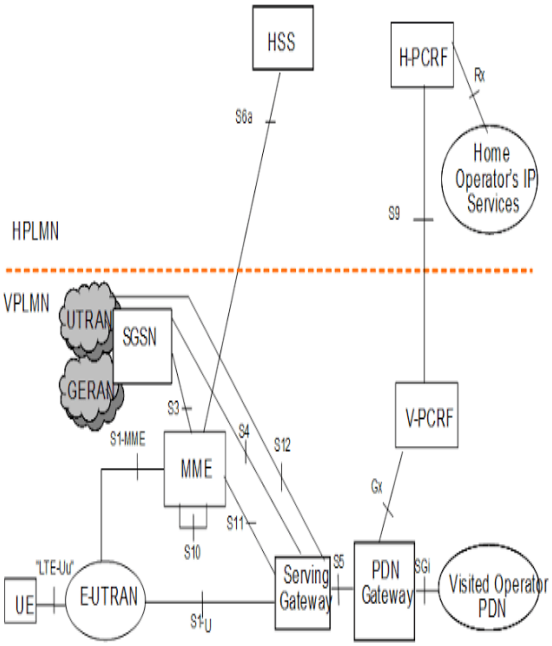

Fig. 4. Architecture of LTE

The LTE architecture is as shown in Fig 4. UE latching to the Network procedure are as follows:

1. The Device will search for available network and will choose the network with more power.
2. When Device attempts for network connection establishment, the RACH process is initialised and after successful RACH process, the device connects to network.
3. The network provides a specific IP to the connected device for communication. The IP is dynamic and changes accordingly with new device attached.
4. The CAT-M supports CE Mode A and Mode B, where Mode suggests the type of coverage for device. Mode A is normal coverage and Mode B is for Extreme coverage. These parameters are set in the Site Configuration File. The CE Mode A works as default mode where moderate coverage enhancement is needed.

4. METHODS TO IMPROVE COVERAGE:

Many methods are implemented in order to increase the coverage, some commonly used techniques are as explained.

1. TX power: When power in transmission is increased, it proportionally increases the coverage, but it cannot be increased above the limit which results in increased cost, increased intercell interference and peak current drawn.
2. Repetition: It is the most common method implemented in various communication and not only restricted in CAT-M, because it's simple and cost effective. But the issue with Repetition is it might increase the transmission delay.
3. Frequency hopping: The CAT-M maximum bandwidth is only 1.08Mhz compared to the LTE which is 10 Mhz. So, in LTE-M it allows UE and eNB to use cross subframe channel estimation since hopping occurs in various sub frames.
4. Redundancy version cycling: When small transport blocks are used, it contains overhead such as CRC, MAC and RLC which results in less spectral efficiency. So larger transport block is used to achieve more spectral efficiency.
5. Power spectral density boosting: It used to increase Downlink (DL) coverage. The power is varied across the Physical Resources Block (PRB) where more power is applied to certain PRB.

5. CONCLUSION:

The Reference Signal Receive Power (RSRP) is determined by UE while measuring power in the downlink channel. Depending on coverage level, the Modes is selected. The CAT-M consists of 4 levels in which two levels are for MODE A and other two for MODE B.

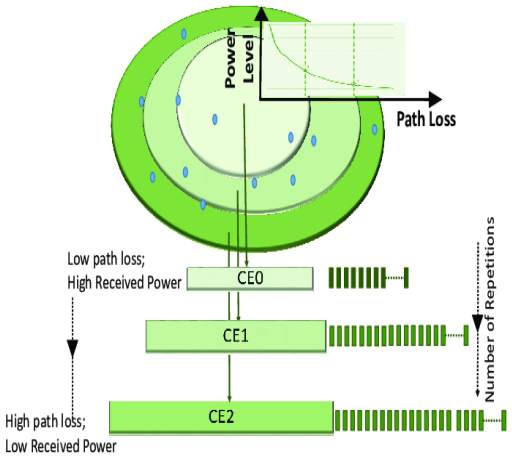

Fig. 5. CE Levels for Coverage Enhancement

The number of PRACH repetition depending on the coverage as shown in Fig 5 is determined By UE after reading system information in PRACH configuration. And eNB would also know the coverage level of UE by transmitted preambles. eNB by knowing coverage level will decide the number of repetitions on data and control channels.

Whenever a greater number of repetitions occurs, it results in less throughput. And device battery life would also be reduced along with huge loss in the network resource.

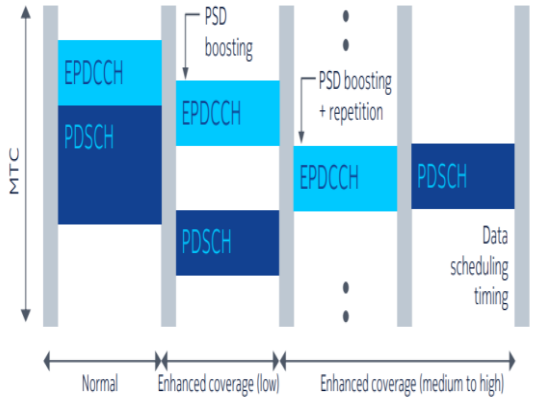

Fig. 6. Enhanced coverage using Power Boosting and Repetition [10]

The coverage enhancement can be further achieved by using combination of techniques such as repetition along with Power boosting. Some of the Downlink channels PCFICH and PHICH are eliminated. For the Normal coverage, available bandwidth can be utilized and in Extended coverage, PSD Boosting and Repetition are used together to reach remote areas with poor coverage.

Coverage In LTE-M is increased by operating in 1.4 MHz compared to 20 MHz which yields 11.5 dB improvement. Further, LTE-M allows to reduce output power by 3 dB which lowers implementation cost. Control and data signals can be repeated to reach the required coverage enhancements.

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