Use of Mobile M2M Communication in E-Logistics

LogDynamics
International Graduate School

Logistic processes such as fleet management and tracking of assets deeply rely on Machine-to-Machine (M2M) communication services. In recent years, M2M communication is being considered as one of the most technologies that will be dominating future intelligent pervasive applications. The wide application area of mobile M2M communications includes logistics, smart metering, e-healthcare, surveillance and security, intelligent transportation, city automation, smart monitoring and many more.

Existing mobile standards are defined in terms of generations. These standards were designed and optimized to support broadband traffic with a relatively small number of users per cell. Current mobile standards such as GSM (Global System for Mobile Communications), UMTS (Universal Mobile Telecommunication System), and LTE etc. are providing services to distinct M2M applications. However, it is expected that the number of M2M devices and their traffic will grow exponentially. The worldwide number of devices will reach 50 billion by the end of 2020. Current mobile standards are expected to run out of capacity and will not be able to support the traffic with such a large number of devices.

M2M in E-Logistics

The use of M2M communication for logistic processes and transport operations is fast becoming a necessary part for companies to stay ahead through real-time control over resources and freight movements. For instance, in logistics the movements of the vehicles, containers, etc. are being tracked regularly through sensors which collect data of the location, vehicle speed, temperature, distribution progress, fuel consumption etc. and then this information is sent to the concerned application servers. Moreover, the goods which are transported are monitored regularly with sensors in order to accomplish in time delivery and to handle any un-desirable situations during the transport process.

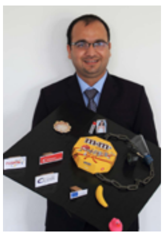
Problem Definition

The distinctive characteristics of M2M traffic pose serious challenges for cellular service providers as well as for mobile network research. The most challenging problem is the expected large number of small sized M2M messages. Moreover, several M2M applications also demand mobility support. Existing mobile standards are neither designed to handle small-sized payloads efficiently nor to support simultaneous access of thousands of devices. Consequently, this will lead to network congestion. According to present standardizations, the smallest unit of radio spectrum allocable to a single device is 1 PRB (Physical Resource Block) which is capable to transmit more than a thousand bits under favorable channel conditions. However, allocating 1 PRB to a single M2M device will significantly degrade radio spectrum utilization due to the fact that M2M sensors mainly transmit and receive small data packets.

Proposed Methodology – QoS-Aware M2M Data Aggregation

Quality-of-Service (QoS) provisioning is one of the major requirements of various M2M applications. Currently, in our proposal these small data packets are aggregated at the Packet Data Convergence Protocol (PDCP) layer of the RN. The PDCP layer is selected to perform packet aggregation in order to maximize the multiplexing gain, i.e. without ag-gregating the additional headers such as those from the PDCP, Radio Link Control (RLC) and Medium Access Control (MAC). An aggregation buffer is created at the PDCP layer which aggregates the incoming packets either according to the capacity of the available Transport Block (TB) or with an expiry timer.

The former technique significantly improves the PRB utilization due to the fact that traffic from a large number of devices is aggregated before being served.



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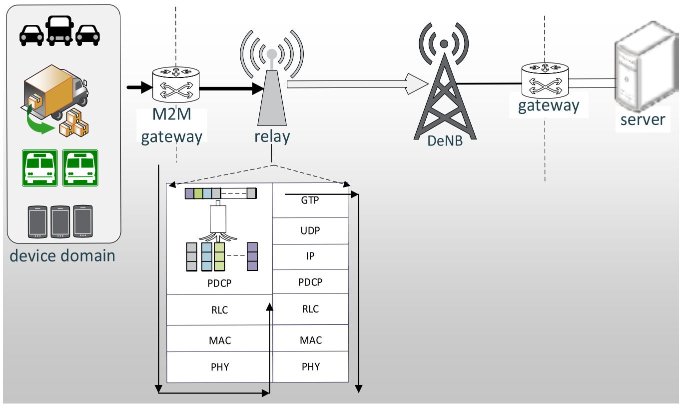
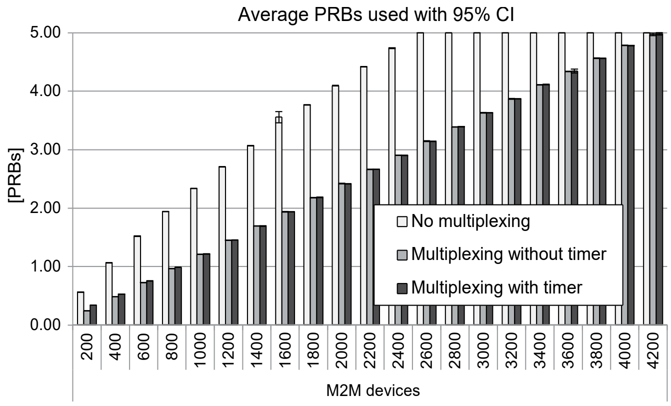


QoS aware-traffic in uplink



Average number of PRBs used at the Un air interface away from the RN in the uplink

However, this approach of aggregation degrades the QoS performance of delay-intolerant M2M traffic. Therefore, an expiry timer is introduced to minimize the multiplexing delay at the RN.

The scheme described above does not take into ac-count the QoS of incoming M2M packets. Therefore, in the future the proposed scheme can be updated to a QoS-aware traffic aggregation scheme. The data pa-ckets can be aggregated according to their QoS metric. For instance, data packets from a high prioritized M2M traffic such as emergency information can be aggregated and served before the packets which belong to a low prioritized traffic such as regular temperature measurement information. Moreover, in case of delay-intolerant information, packets can be either multiplexed without introducing the delay, or can be sent directly to the donor eNodeB without multiplexing.

The proposed QoS-aware traffic aggregation tech-nique can be implemented using LTE-A traffic categorization. For this reason, separate buffers can be created at the RN. Each buffer aggregates traffic of a particular QoS class. Upon the availability of radio resources by the donor eNodeB, the RN will serve the data in separate buffers according to their priority. For instance, the buffer with the highest priority traffic will be served first.

Moreover, in the case of strict delay-intolerant applications like e-health emergency information, the data packets can be sent without waiting for multiplexing. This decision can be made depending on the delay budget of a packet. Furthermore, for fairness, it is also possible to serve packets from all the separate buffers simultaneously provided the served aggregated packet will have the highest percentage of packets from a high prioritized traffic.

Outlook

Later, the data aggregation concept can also be implemented for the downlink M2M traffic. In downlink, the individual data packets can be aggregated at the donor eNodeB in order to save radio resources. The aggregated data can be de-multiplexed at the RN in case of relayed M2M communication. This will significantly improve the PRB utilization as well as enhance the coverage and energy consumption of low-powered M2M devices and at the same time will reduce sufficient propagation losses as M2M devices are mainly dedicated for a specific data class.