LogDynamics
International Graduate School

Radio Resource Management for Machine-to-Machine Communications in Future Mobile Networks

Machine-to-Machine (M2M) communication aims at enabling machines to communicate with each other without human intervention. Its implementation areas include transportation, smart metering and monitoring, production, traffic systems, healthcare etc. In logistic processes, goods require monitoring of environmental factors during transportation. M2M communications can help in taking prompt restorative measures and counteracting unwanted situations. It can improve the process of delivering goods with assurance of time, place, quantity and quality. The hurdles in fulfilling these guarantees are caused by the increasing requirements of the consumers from the limited available resources. Such changes in the environment are the causes of “dynamics in logistics”.

M2M communications are currently based on contemporary wireless communication technologies (like GSM/ GPRS), which are fulfilling the data requirements of M2M applications sufficiently. However, the number of M2M devices might undergo an exponential growth in coming years. The current wireless systems might run out-of-capacity. Long Term Evolution (LTE) is the recent wireless communication standard. The radio access network of LTE consists of only two nodes, i.e., the eNodeB and User Equipment (UE). In the access network, the radio resources are allocated by the Medium Access Control (MAC) layer scheduler of the eNodeB to the UEs for downlink and uplink. LTE is expected to be the future technology for providing M2M services and it is primarily developed for broadband data services. With narrowband M2M applications, it might not achieve spectrum and cost efficiency. Therefore, redesigning the resource allocation techniques could provide efficient service to regular and M2M users of various Quality of Service (QoS) classes.

Research Questions

M2M communications over LTE networks pose several challenges. A major issue is the expectedly large number of M2M messages and their varying sizes in future. An M2M message size can be just a few bits up to even several mega bytes. In cases of emergencies, such as fire, flood etc. the simultaneous resource request by several devices can severely degrade the networks performance and block resources for other users. Another issue is the fulfillment of varying QoS requirements of different types of M2M devices. Due to the diversity of size and QoS requirements, the scheduling algorithms could be very complex. Addressing these challenges should cause hindrances to regular LTE services.

Future Solutions

A commonly perceptible approach is to extend the network and deploy supplementary hardware. However, purchasing hardware to increase network capacity is costly and resolves the issues only temporarily. Efficient methods are required to overcome the research problems.

The prevailing conventional QoS classes of regular LTE services are not sufficient to represent the regular and M2M traffic collectively. The resource scheduling can be made simpler if the QoS classes of regular and M2M communications are combined and categorized within a common framework. A new categorization of regular and M2M classes is illustrated in Table 1.

Service Class	Requirements		Regular class	M2M class
	Delay	Accuracy		
1	strict	strict		emergency alerting
2	strict	flexible	voice	
3	strict	flexible	video	mobile streaming
4	strict	strict	web browsing	mobile point-of-sale
5	flexible	strict	file transfer	smart metering
6	flexible	flexible		regular monitoring

Table1: Regular and M2M QoS class categorization

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To reduce the complexity of the downlink scheduling algorithms, scheduling can be performed for each QoS class separately with low complexity algorithms. A resource estimator can be designed (Figure 1) to allocate resources to different QoS classes based on current and previous cell traffic information

In uplink scheduling, the resources should be allocated in such a manner that the Physical Resource Blocks (PRBs) allocated to a single device are contiguous to each other. Therefore, instead of QoS class grouping, device based grouping can be utilized. The resource estimator can allocate resources to user groups instead of QoS classes and facilitate devices transmitting multiple traffic types. Each group of devices would be striving to acquire network resources.

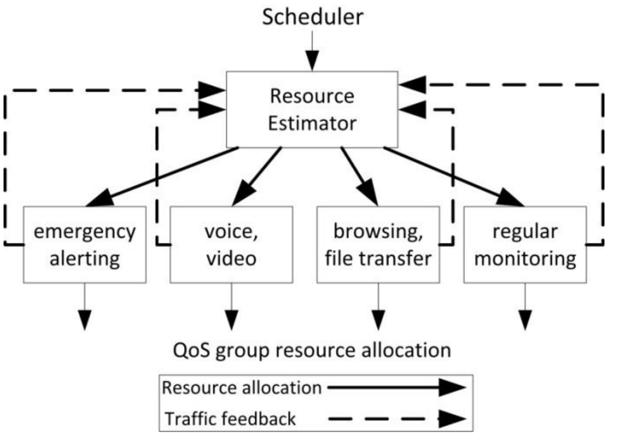

Figure 1: Resource estimator block diagram

A practical approach to enhance spectral efficiency is to reduce the size of the smallest resource allocation unit from PRB to subcarrier and allocate subcarriers to devices. The resources can be efficiently utilized if several devices can share a single PRB and avoid bandwidth wastage.

Methodology

The starting step to realize the probable solutions to the research problems is the mathematical modeling of novel scheduling algorithms. The algorithms should consider user QoS requirements, user channel conditions and fairness. The uplink scheduling constraints should be taken into account by the scheduler and the computational complexity should be kept to minimum.

The evaluation of scheduling algorithms would be performed by implementing the simulation model of M2M devices over LTE network using OPNET simulator (Figure 2). The simulation model can be utilized to analyze and compare the proposed scheduling algorithms with other well-known algorithms by obtaining results for various user performance parameters. Several traffic and channel scenarios can be configured and compared in terms of performance by simple configuration changes.

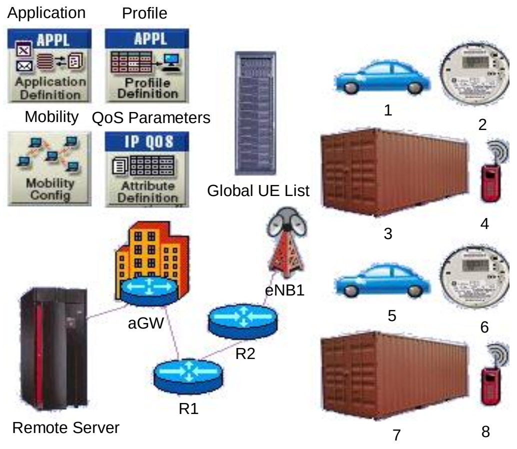

Figure 2: LTE OPNET system simulator

The simulation model would be validated by developing an analytical model. The analytical model can be used to evaluate the system performance. Results comparison can be achieved in less time with less effort using analytical model as compared to simulation model.

Expected Results

Logistic processes could be facilitated by transmitting a huge number of M2M messages of varying sizes over LTE network with 1) fulfillment of quality of service and security requirements, e.g. delay and throughput 2) reduced computational complexity of LTE scheduling algorithms and 3) minimum hindrance to regular LTE services.

Efficiently assisting the re-routing of vehicles and handling alterations in production strategies resulting from dynamics in logistics are greatly beneficial for wielding logistic processes successfully. Furthermore, the suggested ideas can help in significantly improving emergency and disaster management with M2M devices.

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