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A-TLSA: An Adaptation of the Two-Level Scheduling Algorithm from WiMAX to LTE Networks

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Abstract—Scheduling in LTE (Long-Term Evolution) is a challenging functionality to design, especially in the uplink. We propose in this paper an adaptation of TLSA (Two-Level Scheduling Algorithm) which have been proposed in Worldwide Interoperability for Microwave Access (WiMAX) in LTE context. We first propose a mapping service classes between WiMax and LTE and then propose the bandwidth allocation strategy inter-classes and intra-classes. It's insure first QoS for all service classes avoiding starvation of lower priority classes (i.e. Best Effort). In the second time, it ensures fair bandwidth allocation in each class.

I. INTRODUCTION

In recent years, LTE Long Term Evolution, also known as 3G has become the main technology to allow mobile internet access on smartphones. The 3GPP (3rd Generation Partnership Project) has introduced the LTE (Long-Term Evolution) specifications as the next step for the 4G/5G cellular networks. The main objectives of LTE is to support several hundreds of active users per cell, to reduce user plane latency, to support connection with several antennas simultaneously and to be able to adjust the width of the spectrum used. Thus, scheduling LTE's uplink requires particular attention. It's plays a crucial role as it manages the limited radio resources at LTE's access level.

Scheduling in LTE is managed on the level of the base station called eNB (evolved NodeB) and operates within LTE's MAC layer. It's responsible for allocating shared radio resources among mobile User Equipments (UEs). The intelligence of the eNB is associated with awareness of network conditions such as wireless channel quality and the

QoS experienced by the diverse Internet services running over the LTE interface.

II. TLSA

TLSA Two-Level Scheduling Algorithm is an uplink scheduling algorithm originally designed for WiMAX [1]. In this work, we have attempt to adapt it to LTE. The algorithm works as follow : at the first level, the bandwidth is distributed among the classes of traffic. It guarantees QoS requirements, and prevents starvation from lower priority classes. At the second level, class-specific algorithms are used to distribute the class allocated bandwidth among the active connections of the same, with the aim to ensure fair resources allocations among flows of the same class.

The First Level Scheduling (FLS) must ensure the following conditions : QoS is ensured for all classes of traffic ; lower priority flows could not affect higher priority flows ; lower priority traffic is not starved ; (iv) high bandwidth utilisation.

III. ADAPTATION

Adapting this algorithm from WiMAX to LTE is an harsh task, as there are huge differences between these two technologies:

- Classes of traffic are not the same.
- The buffer status reports work in a different way : for WiMAX, each flow reports its own buffer status, whereas in LTE, flows are packed into a group, and only the buffer status of the groups are reported. Moreover, in WiMAX

the value reported is a new bandwidth request, whereas in LTE it's a raw value of the buffer (ie. a previous request can be overlapped in a new buffer status value). LTE defines only 4 groups of flows, numbered from 0 to 3 (the lower is the number, the higher is the priority)'

- LTE's transmission time interval (TTI) lasts 1 millisecond, whereas WiMAX's one is 20 milliseconds.

The first point seen above is probably the more important. As the classes of traffic are slightly different, we have to find an equivalence between WiMAX's classes and LTE's ones. WiMAX uses 5 different classes :

- UGS Unsolicited Grant Services which is a constant bit-rate and delay constraint class.
- eRTPS Extended Real Time Polling Service which have a definition really close to UGS.
- RTPS Real Time Polling Service which is a delay constraint class.
- NRTPS Non-Real Time Polling Service which has a minimum throughput guaranteed.
- BE Best Effort a class without any specific requirement.

LTE uses 9 different classes [2] (further definition defines 4 additional classes) :

- Classes 1 and 2 are for conversational voice and video (delay constraint, guaranteed bitrate).
- Class 3 is for real time gaming (high delay constraint).
- Class 4 is for non-conversational video (buffered streaming) (guaranteed bitrate).
- Class 5 is IMS signalling (delay constraint, non-guaranteed bitrate)
- Class 7 is for voice, video, live-streaming, interactive gaming (but non-guaranteed bitrate)
- Classes 6, 8 and 9 are for all other usages, TCP-based connections (no delay constraint, non-guaranteed bitrate). The only difference between these classes is that users of class 6 have a higher priority on users of class 8, whose have a higher priority on users of class 9.

For A-TLSA, we propose the following matching:

- UGS and eRTPS are mapped to classes 1, 2, and 5 in group 0. We have added the class 5 in this group, despite it's not a GBR Guaranteed BitRate because the delay constraint on class 5 is high and it's a low throughput class.
- RTPS is mapped to class 3 in group 1, as there are delay constraint classes.
- NRTPS is mapped to class 4 in group 2, because only GBR classes in LTE report their bitrate at the connection setup event, and we need to know that value to ensure a minimum guaranteed.
- BE is mapped to classes 6, 7, 8, 9 in group 3, as they are all the remaining classes.

We have also changed the way RTPS (group 1 for LTE) does its intra-class distribution. In WiMAX, the TLSA algorithm uses a service ratio for each flow, and allocates a flow only if this service ratio is below the global service ratio. This ensures the fairness inside the rtPS class. The algorithm also keeps track of packet deadlines and makes sure they does

not miss it. The service ratio can be roughly defined as the bytes requested over the bytes allocated. First, because buffer status reports raw value in LTE, we have redefined it to bytes requested over bytes requested plus bytes allocated. With this new equation, we have the equivalence for the intra-class distribution. But moreover, we have redefined it in terms of PRB Physical Resource Blocs , because the algorithm finally allocates PRB and not raw bytes. This give us a more precise allocation scheme, bringing an higher global throughput.

IV. SIMULATION

The algorithm has been implemented under NS-3 [3], an open source discrete event network simulator written in C++. Simulations show that the awaited mechanism works correctly. However, no comparison with other algorithms have been done for the moment, this will be a future work.

V. CONCLUSION

Adapting the TLSA algorithm to the LTE is not an easy task, as the differences between WiMax and LTE are really important, especially the mechanism of buffer reporting. The solution proposed here keeps the internal logic of the algorithm, while innovating on the allocation using directly PRB units. The resulting algorithm is working, there are some features we will develop in a near future :

- WiMAX algorithm originally does not take into account link quality status. Modern schedulers have absolutely to take it into account, as it's an essential feature reflecting the real conditions.
- WiMAX has a frame duration of 20 milliseconds, but LTE's one is really shorter (1ms for each subframe), so we will review the minimum guaranteed for group 3 to allocate it over several subframes, saving a lot of headers and increasing the global throughput (when you allocate consecutive blocs of resources the average byte count by bloc increases).
- Compare our algorithm with other ones.

The rapid development of Internet of Things - IoT - brings also new problematics. LTE-M is an emerging technology to include IoT communications over the 3G/4G technologies. IoT has many types of connections : the delay constraint, the throughput vary in accordance with the kind of objects. For small objects, communications have an ultra-low intermittent throughput, but aspects such as power management become predominant. Thus, integrating this kind of communications to our scheduling algorithm is a new challenge to be achieved in the future...

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