C. Channel Aware Scheduling Algorithm

It has been proved that the scheduling algorithm that considered the channel state information (CSI) performs better than the algorithm that does not consider the CSI [19].

i. TRS: Temporary Removal Scheduler

The TRS scheduler makes the scheduling list in accordance with the SSs that have Signal Interference Ratio (SIR) greater than a preset threshold [20]. When the radio conditions are poor then the scheduler suspends the packet call from the scheduling list for an adjustable time period. The scheduling list contains all the SSs that can be served at the next frame. When the expires, the suspended packet is checked again and if the radio conditions are still poor the packet is suspended for another time period. This process is repeated times, where is equal to consecutive suspend procedure. The TRS scheduler can be combined with Round Robin (RR) and maximum Signal to Interference Ratio schedulers. When TRS is combined with RR the whole radio resources are divided by the numbers of subscribers in the list and the entire subscriber will get resources equitably.

ii. A Queue and channel Aware Downlink Scheduler

[21] designs a queue and channel aware downlink scheduler (priority based) algorithm for WiMAX, where all of the QOS metrics, such as channel, queue, non-urgent and urgent data status are translated to priority metric by a black-box formula in the study, but is not fair to all users, as there is no channel quality information (CQI) reporting metrics.

iii. Cross layer downlink scheduler

[22] works on a cross layer scheduler that assigns priority for each flow based on its service and channel status, then the flow with highest priority is scheduled, it only give precedence to good channel flow and thus bad channel flow suffers. In [22], the author proposed cross layer downlink scheduler at the MAC layer with the physical (PHY) layer, by which each downlink connection utilize Adaptive Modulation and Coding scheme at the PHY layer based on the estimated channel condition of a SS. A connection is assigned priority based on its channel quality and service priority where the scheduler schedules the connection with the highest priority each time.

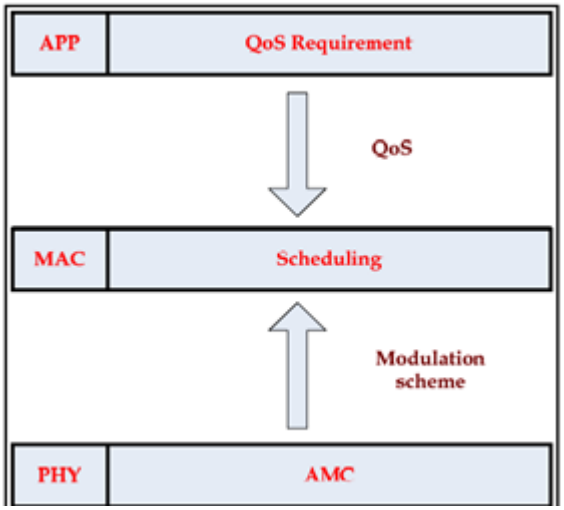

Figure 7: Cross Layer

iv. Modified Largest Weighted Delay First (MLWDF)

[23] Has been proposed to support specific QOS parameters such as provide packet delay and minimum throughput guarantee for various users sharing a wireless channel. This has been achieved by maintaining the data packet delays below a specific threshold. MLWDF scheduler has utilized both current channel state conditions and the state of the queue (queue length) in making the scheduling decision.

D. Weight and priority Calculations

As discussed in above section of algorithms, the main aim of scheduler is to decide the priority of users to decide the order of servicing them. This order is commonly calculated by weight and priority procedures. Following are some of the factors that can be used in the weight and priority based schemes.

Weight factors: (1) queue length and packet delay, (2) the number of slots, (3) size of bandwidth request, (4) average data rate, or (5) minimum reserved rate.

Priority factors: (1) priority service order (UGS > ertPS > rtPS > nrtPS > BE) from higher priority to lower priority service order respectively, (2) packets delay (highest priority assigned to packets with largest delay), (3) the queue length (more bandwidth to connections with longer queue length), (4) based on SS channel quality.

5. State-of-Art-of Schedulers

Table 3: State-of-Art-of Schedulers

Scheduling Algorithm	Properties	Limitations
WRR	Suitable for non -real time applications	Does not perform well in variable packet size
EDF	Focusing on efficiency	Unfit for non-real time applications
WFQ	More fairness added	Does not consider the start time of a packet
DFPQ	Provide more fairness to system	Complex implementation
TRS	Good throughput	SS with lower SIR than preset threshold suffers
Cross layer	Good throughput, high frame utilization	Can be implemented only at BS
MLWDF	Minimum delay, good throughput	Complex implemented

6. Conclusion

In this paper we presented the downlink scheduling. Starting from its basic concepts to the scheduling mechanism and the existing downlink algorithms, their aspects methodology, advantages and limitations are discussed. In order to give comparative study between the discussed algorithms, we draw one summary table showing the strength and limitations of the algorithms, discussed in the paper. All the proposed WiMAX algorithms could not be studied in the paper, but we presented the algorithms belonging to present scheduling mechanisms.

Scheduling is a main component of the WiMAX that assures QOS to various service classes. None of the previously proposed schemes have considered all the connection QOS requirements in their algorithms. Thus, research of optimal and robust schedulers for WiMAX systems is still an open research problem.

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