An Integrated Load-based Power Saving Scheme in IEEE 802.16e

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Abstract

There are three types of power saving in the specification of IEEE 802.16e, Type I, II, and III. Most of the research works focused on Type I or Type II, which means these previous works inherited the limitation of Type I or Type II in selection of the sleeping pattern: either adopting the exponential pattern of Type I or the constant pattern of Type II for the sleep window size. In our previous work [1-2], the limitation of adopting Type I or Type II was discussed, and the idea of applying traffic modeling and measurement called Load-Based Power Saving (LBPS) was proposed. Poisson process is adopted in LBPS for traffic modeling for simplicity. The objective of LBPS is to adaptively adjust sleep window size of each MSS to better fit in current traffic (load) condition by traffic measurement. To consider both real time and non-real time traffic characteristic, LBPS-Real Time (LBPS-RT) is proposed to effectively schedule traffic and support the traffic delay requirement in the paper. Simulation results demonstrate that better power saving efficiency can be achieved by LBPS-RT than Type I and II. In addition, the delay bound requirement can be achieved in our proposed LBPS-RT scheme.

Keywords: LBPS, Power Saving, 802.16e, Sleep

1 Introduction and Method

A basic version of LBPS, *LBPS-Aggr*, in which all of the traffic in the network is treated as a single aggregate flow in estimation of the sleep window size, was proposed in our previous work. Two enhanced versions namely *LBPS-Split* and *LBPS-Merge* were also proposed [2]. The two enhanced schemes adopt the idea of group splitting or merging in sleep schedule to make the best of power saving. These previously proposed schemes mainly focused on non-real-time traffic. In this paper, a new scheme called *LBPS-RT* is proposed to integrate real-time and non-real-time traffic in power saving.

Both *LBPS-Split* and *LBPS-Merge* can achieve good power saving efficiency, but they present different features in determining the sleep window size. All groups of MSS in *LBPS-Split* share the same size of sleep window, while *LBPS-Merge* allows different window sizes. Since real-time supporting involves delay bound supporting, which requires the ability to allow different sleep window sizes in power saving, the proposed *LBPS-RT* is thus based on *LBPS-Merge*. There are two aspects to be addressed in *LBPS-RT*:

(1) The threshold of data accumulation in *LBPS-Merge* is set as the amount of a whole time frame data so that the MSS (or a merged group of MSSs) can make the best of its awake time frame. However, in the case of real-time MSS, the sleep window size calculated according to the threshold could lead to the violation of the delay bound. Therefore, the delay bound of the real-time MSS must be taken into consideration in determining the sleep window size in *LBPS-RT*. The revised formula for the sleep window size of a real-time MSS is as follows: (More specifically, K^{rt} is the length of an awake-and-sleep cycle, and the sleep window size is thus K^{rt}*-1*)
$K^{rt}=Min\{K^*, \textit{Delay Bound of MSS}\}$, where K^* is calculated according to data accumulation method. Once the length of an awake-and-sleep cycle for a real-time MSS is determined, data accumulation (denoted by *W**) for the MSS is re-calculated as follows:
$W^* \equiv Min\{W \mid P_{LBPS-RT}(K^{rt},W) \geq Prob\_TH\}$
(Note that *Prob_TH = 0.8* in the simulation)
$P_{LBPS-RT}(K^{rt},W) \equiv Prob[\textit{ \# of packet arrival in } K^{rt} \textit{ Time Frames} < W] = \sum_{i=0}^{W} \frac{e^{-\lambda K^{rt}T}(\lambda K^{rt}T)^i}{i!}$, where T is the length of a time frame, λ is the estimated load of the real-time MSS.

(2) Instead of a whole awake time frame for an MSS (or a merged group of MSSs) in sleep scheduling, the MSS only requires part of the awake time frame, i.e. the expected amount of data is *W** which is only a fraction of a time frame data. The equation for schedubility test in *LBPS-Merge* is also required to be revised in the following.
Since it's difficult to check the schedubility of groups with any possible value of K^*, the value of K^* is converted to the closest and smaller power of 2, denoted by $K^{\#}$ (i.e. $K^{\#} = 2^{\lfloor Log_2 K^* \rfloor}$) in *LBPS-Merge*. With the property of powers of 2, a quick check for schedubility can be obtained. Schedubility of a number of groups with different $K^{\#}$ values is defined by the following equation: $Schedubility = \sum_i \frac{1}{K_i^{\#}}$. The value of *Schedubility* equals or smaller than 1 ($Schedubility \leq 1$)

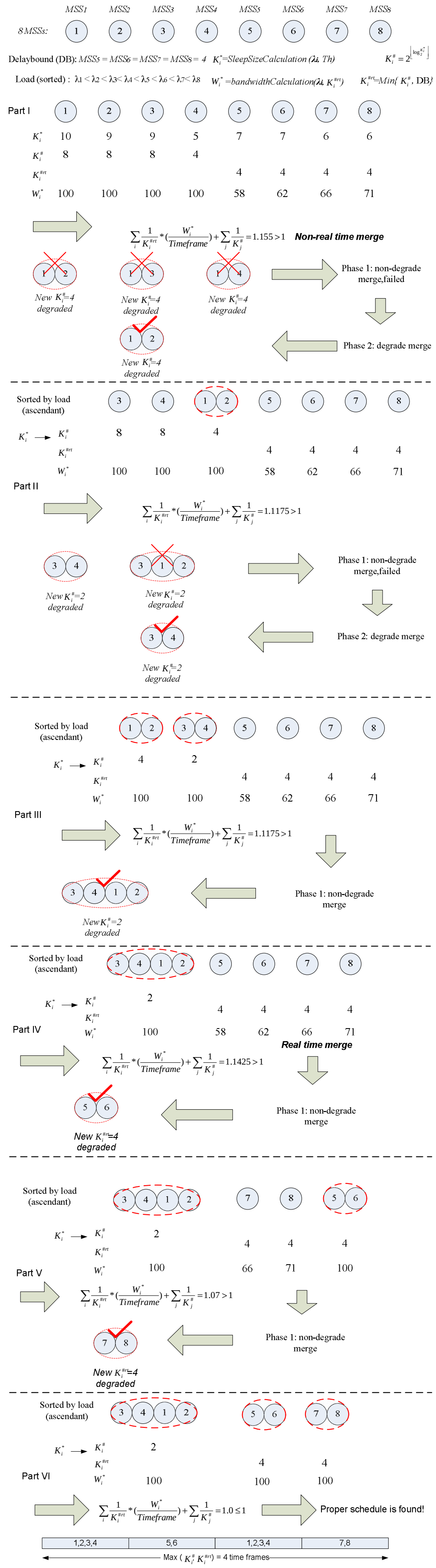

Figure 1. An example of LBPS-RT

indicates that a feasible schedule can be found. *Schedubility* > 1 indicates the necessity of merging some groups.

Revised equation of *Schedubility* in *LBPS-RT* is as follows: $Schedubility = \sum_i [\frac{1}{K_i^{\#rt}} \times (\frac{W_i^*}{TFdata})] + \sum_j \frac{1}{K_j^{\#}}$, where

i indicates the real-time MSS (or group), *j* non-real-time MSS (or group), and *TFdata* the total capacity of data in a time frame. Once the test of *Schedubility* is approved, *LBPS-RT* generates a feasible schedule for power saving.

2 Performance Analysis and Conclusion

Figure 1 illustrates an example of *LBPS-RT*. Some simulation results are shown in Figure 2 and Figure 3, which demonstrate the benefit of *LBPS-RT* to integrate both real-time MSS (rtPS) and non-real-time MSS (nrtPS) in power saving. Our proposed *LBPS-RT* can achieve higher power saving efficiency and obey delay requirement of real-time traffic. Our proposed *LBPS-RT* scheme outperforms than Type I & II.

References

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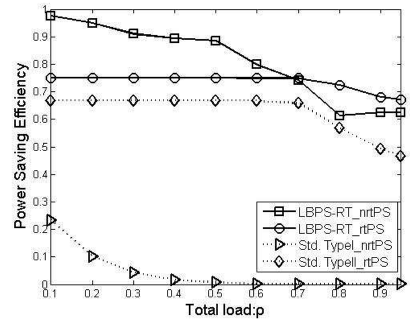

Figure 2. Power saving efficiency (rtPS ratio=0.3)

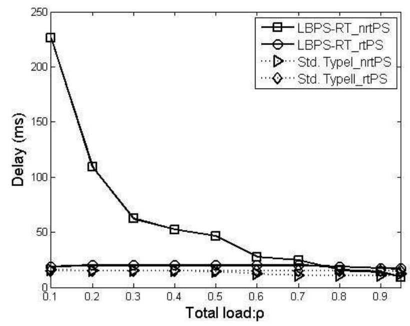

Figure 3. Avg. access delay time (rtPS ratio=0.3)