PERFORMANCE ANALYSIS OF PUSH TO TALK OVER IEEE 802.16E WITH SLEEP/IDLE MODE

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ABSTRACT

We investigate how much power saving can be achieved for a PTT service by employing IEEE 802.16e with sleep mode and idle mode. Sleep mode and idle mode operations in the IEEE 802.16e standard provide with power saving mechanisms for mobile stations. A mobile station with PTT functionalities employs sleep mode during a session and idle mode during off-session is modelled as a semi-Markov chain. We obtain power consumption ratio, session power consumption ratio, sleep mode power consumption ratio, call setup delay and talker arbitration delay. Using our mathematical model, we can find the optimal system parameters such as the sleep window which minimize the power consumption of the mobile station while satisfying the required QoS on call setup delay and talker arbitration delay. The numerical examples show that the sleep mode and idle mode provide a considerable reduction on energy of mobile station.

INTRODUCTION

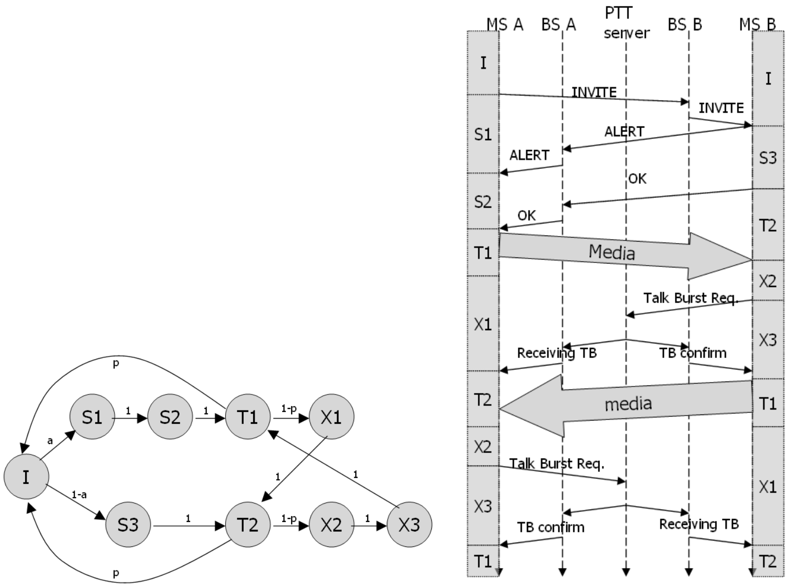
Walkie-talkie is a half-duplex communication service, in which communication can only travel to one direction at a moment. A user has to press a button in order to speak and releases it in order to listen. Push to talk(PTT) service works like a walkie-talkie in wireless networks. A key merit of PTT service is one-to-many group conversations where the calling party can simultaneously communicate with all the members in a group. PTT is intended to provide rapid communications for business and consumer customers of mobile networks. In PTT communication, only uplink resource is allocated to the user to speak and only downlink resource is allocated to the users to listen. Thus, we can save the resource(bandwidth), in contrast with both uplink and downlink resources are allocated to all users for voice service. Open Mobile Alliance(OMA) provides a Push to Talk over cellular(PoC) standard[3] on the application layer.

The IEEE 802.16 standard is for the air interface between subscriber stations and a base station. An amendment to the standard, IEEE 802.16e-2005[1] expanded IEEE 802.16 standard to allow for mobile subscriber stations. Due to the mobility of subscriber station, the power saving is one of the significant issues for the battery-powered mobile station. The IEEE 802.16e standard defines sleep mode and idle mode operations to save the energy of the mobile station.

Let us consider a PTT service employs at IEEE 802.16e network, i.e. PHY/MAC protocol of a PTT device follows the IEEE 802.16e standard. Hence the sleep mode and idle mode operations are used for the PTT service in the mobile device. Since there is no standard about PTT over IEEE 802.16e, we assume that the application layer protocol of the PTT device follows the PoC standard[3]. We model a stochastic behavior of the PTT device as a semi-Markov chain. Using our mathematical model, we can find the optimal system parameters such as the sleep window and the close-down time which minimize the power consumption of the mobile station providing PTT service while satisfying the required QoS on call setup delay and talker arbitration delay. The numerical examples show that the sleep mode and idle mode provide with a considerable reduction on energy of mobile station.

SYSTEM MODELING

The stochastic behavior of the PTT device over IEEE 802.16e with sleep mode and idle mode



(a) Transition diagram

(b) PTT flow chart with states of semi-Markov chain

Figure 1. Semi-Markov chain

is modelled as a semi-Markov chain as shown in Figure 1.

Power consumption ratio, the ratio of power consumption per frame as MS is applied to both sleep mode and idle mode to that as MS is awake at all times, is obtained by

$$PowerConsumptionRatio = \sum_{i \in A} \pi_i^* E_i \tag{1}$$

where π_i^* is the steady-state probability of the semi-Markov chain and E_i is the ratio of power consumption per frame as MS is applied to the sleep mode and idle mode to that as MS is awake at all times in state i.

Sleep mode power consumption ratio, the ratio of power consumption per frame as MS is applied to both the sleep mode and idle mode to that as MS is applied to only idle mode, is obtained by

$$SleepModePowerConsumptionRatio = \frac{PowerConsumptionRatio}{\pi_I^* E_I + (1 - \pi_I^*)} \tag{2}$$

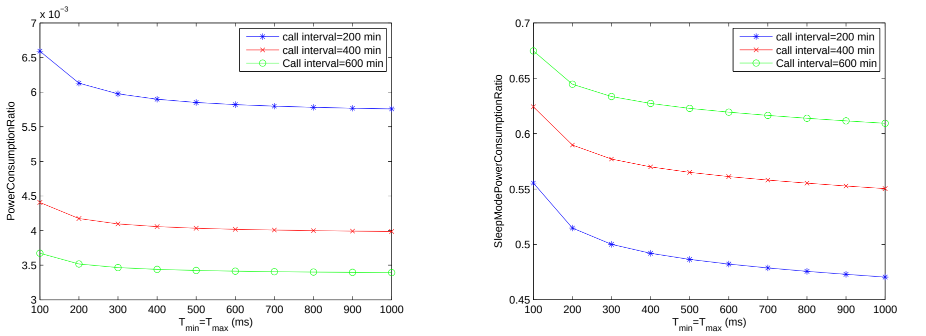
The mean increased call setup delay and talker arbitration delay due to the sleep mode are obtained by

$$\begin{aligned} D_{S1} &= \eta_{S1} - \int_0^\infty x\, dF_{S1}(x) \\ D_{X1} &= \eta_{X1} - \int_0^\infty x\, dF_{X1}(x) \\ D_{X3} &= \eta_{X3} - \int_0^\infty x\, dF_{X3}(x) \end{aligned} \tag{3}$$

where η_i is the residence time in state i.

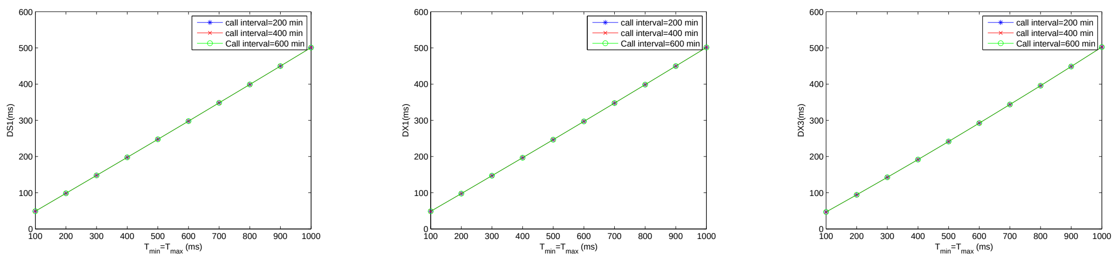
NUMERICAL RESULTS

Since a PTT device is mostly in idle mode, it is intuitively obvious that the power consumption ratio in Figure 2(a) is almost 0. Figure 2(b) implies that sleep mode provide with a considerable reduction on energy of mobile station. Figure 3 shows the increased call setup delay and increased talker arbitration delay due to the sleep mode operation. We see that these delays increase, as the sleep window increases.



(a) Power Consumption Ratio (b) Sleep Mode Power Consumption Ratio

Figure 2. Power Consumption Ratio and Sleep Mode Power Consumption Ratio



(a) Increased call setup delay(DS1) (b) Increased talker arbitration delays(DX1) (c) Increased talker arbitration delay(DX3)

Figure 3. Increased call setup delay and increased talker arbitration delay

ACKNOWLEDGMENT

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