Research on energy saving algorithm based on IEEE802.16m

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ABSTRACT. IEEE 802.16m is one of the 4G standards, in order to save the terminal energy consumption, the protocol introduces a sleep mode. With the rapid development of network, network traffic distribution is no longer Poisson distribution but self-similar distribution. Based on similar traffic distribution, This paper use a demonstration and test method of mathematics to analyze exponential increase algorithm. Theoretical and experimental results show that the algorithm has some limitations, more effective way should be provided so as to improve the network performance.

1. INTRODUCTION

Wireless MAN-Advanced is also known as 802.16m,which defined one of the 4G standards. It was widely used in the military field. IEEE 802.16m standard is also called WirelessMAN –Advanced or WiMax2, it is the second generation of WiMAX international standard after 802,16e. In order to save energy in terminal energy, IEEE802.16e and IEEE802.16m provided the power-management function. Power-management was mainly used the sleep mode and idle mode to save power consumption of [1-3] terminal.

The idle mode will be started in a long time, it will save more energy than sleep mode. But in order to meet the requirements of 4G quality of service(QoS),such as response time.

Sleep mode is better than the idle mode. The sleep mode has a connection state .In sleep mode, The MS will stop work so as to save the energy in accordance with the period of prenegotiation. Sleep mode is shown in Figure.1 in IEEE802.16m. The power consumption of the sleep cycle is less than listening window. The length of windows can be dynamically extended. When packets arrive at the dormant adjustment. When data arrive at the sleep time, it will wait for staying awake. This delay affects the quality of service.

IEEE 802.16m has not been researched long time ago. Bong Dae Choi [4] considered the relationship between the size of the sleep period and use Markov chain method to analyze the performance of the dormancy mechanism. IEEE 802.16m. S.Baek, J.Son[5,6] used queuing model to analyze the dormancy. But the model is discussed in the business based on the passion distribution. This paper will combine the reality, using the heavy tailed distribution of flow distribution to analyze the energy performance.

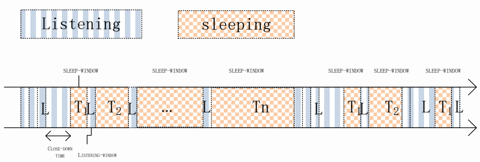

Figure 1:： sleep mode

2. DESCRIPTION and ALGORITHM ANALYSIS

According to the sleep mechanism, IEEE802.16m sleep schematic diagram shown in figure 2. In a dormant period, sleeping window and listening window appear alternately. The length of window can be dynamically adjusted. When the MS did not receive date, the sleeping window will be changed as formula.1

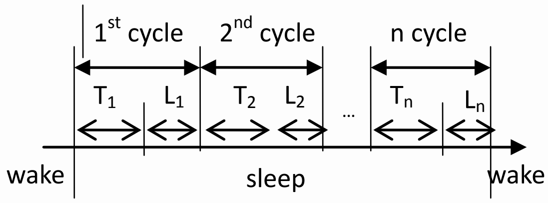

Figure 2: IEEE 802.16m sleep mode

According to this formula, if T_{min} and T_{max} are fixed, in a dormant period, the next sleep window is 2 times than the front, until it reached the maximum value .

$$E(t)=\int_{t-1}^{t} 1/(1+\mathrm{x})\ 1^{1-a}dx \Big/ x$$

$$=\left[(1+2^{t-1}T_{min})^{1-a}-(1+2^{t}T_{min})^{1-a}\right]\Big/ 2^{t}T_{min}-2^{t-1}T_{min} \qquad (1)$$

At present, the audio and video business has gradually become popular. The network traffic is not a simple Poisson distribution and more self similarity [7]. In this paper,we will use the Patero distribution to discuss the performance of the sleep mode. At the same time, the average energy consumption and average delay will as import performance indicators [8].

Patero Density function, such as formula.2

$$p(x)=\frac{1}{(1+x)^{a}} \qquad (2)$$

Patero distribution function,such as formula .3

$$F(x)=1-(1+x)^{1-a} \qquad (3)$$

The data packet arrived at the jth sleep it's probability as formula.4

$$F(x)=\int_{t-1}^{t} 1/(1+\mathrm{x})\ 1^{1-a}dx$$

$$=-(1+x)^{1-a}\Big|_{t-1}^{t}$$

$$=(1+2^{t-1}T_{min})^{1-a}-(1+2^{t}T_{min})^{1-a} \qquad (4)$$

After reaching the maximum value it's probability as formula.5

$$F(x)=\int_{t}^{t+T_{max}} 1/(1+\mathrm{x})\ 1^{1-a}dx$$

$$=-(1+x)^{1-a}\Big|_{t}^{t+T_{max}} \qquad (5)$$

$$T_j=\begin{cases} T_{min}, & (j=1) \\ \min\left(2^{j-1}T_{min}, T_{max}\right), & (j>1) \end{cases}$$

The average response time at the tths the formula .6

(6)

After reaching the maximum The average response time.as the formula .7

$$E(t)=\int_{x}^{x+T_{max}} 1/(1+\mathrm{x})\ 1^{1-a}dx \Big/ x$$

$$=\left[(1+x)^{1-a}-(1+x+T_{max})^{1-a}\right]\Big/ T_{max} \qquad (7)$$

The average response time as formula .8

$$\begin{aligned}E(D) &= \sum_{n=1}^{\infty} E(t)F(t) \\ &= \sum_{t=1}^{t=k} E(t)F(t) + \sum_{t=k+1}^{\infty} E(t)F(t) \\ &= \sum_{t=1}^{t=k} \left[(1+2^{t-1}T_{\min})^{1-a} - (1+2^{t}T_{\min})^{1-a}\right]^2 \Big/ 2^t T_{\min} - 2^{t-1}T_{\min} + \\ &\sum_{t=k+1}^{\infty} \left[(1+x)^{1-a} - (1+x+T_{\max})^{1-a}\right]^2 \Big/ T_{\max}\end{aligned} \tag{8}$$

average energy consumption as formula .9

$$\begin{aligned}&E(en) \\ &= \sum_{j=1}^{\infty} F(n=j) \sum_{k=1}^{j} (T_k E_s + LE_L) \\ &= \sum_{j=1}^{I} ((1+2^{t-1}T_{\min})^{1-a} - (1+2^{t}T_{\min})^{1-a}) * \sum_{k=1}^{j} (T_k E_s + LE_L) \\ &+ \sum_{j=I+1}^{\infty} \left[(1+x)^{1-a} - (1+x+T_{\max})^{1-a}\right] * \sum_{k=1}^{j} (T_k E_s + LE_L)\end{aligned} \tag{9}$$

ES:the Power of sleeping

EL:the power of listening

According to the formula.8,formula.9 concluse that: with the parameter a increases, the average energy consumption and delay increases; with the increase of T_{min}, the average energy consumption and delay increases; with the increase of T_{max}, the average energy consumption and delay are increased.

3 PARAMETERS of PERFORMACE EVALUATION

In order to analyze sleep parameters (T_{min}, T_{max}, and a) on the performance of average waiting time and average energy consumption, we use MATLAB to do the experiment.

Parameters settings are as follows: a = 2, L = 5ms, T_{min}= 1ms, T_{max} =1024ms, ES =1, EL =5, it will be adjusted in different evaluation.

3.1 EFFECTS of a

The parameter a is the index of flow distribution. The value of e a should be greater than 1, the greater of a the more obvious of flow distribution. Through experiments, it shows that the average delay increase as the increase of a and the average energy consumption also increased with the increase of a, consumption of the results were shown in Figure 3 and 4).

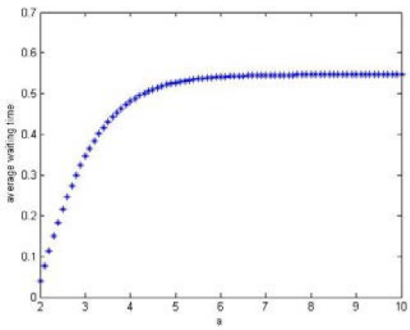

Figure 3:the influence of average waiting time base on a

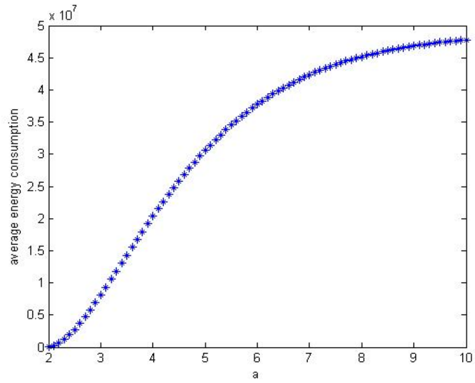

Figure 4:the influence of average energy consumption base on a

3.2 EFFECTS of T_{min}

The minimum sleep interval Tmin increased from 1 to 100, and a=2 simulation experiments, the maximum is 1024. The algorithm in the simulation of the average waiting time and average energy consumption of the results were shown in Figure 5, figure 6. consumption will increase. Experiments showed that, with the increase of Tmin, the average delay and average energy

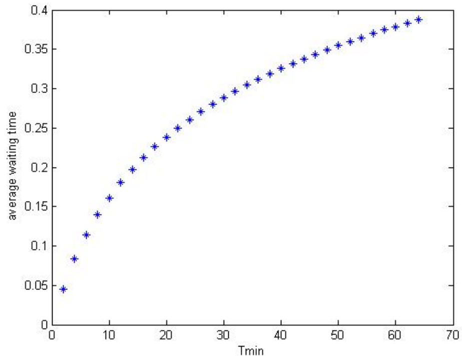

Figure 5:theinfluence of average waiting time base on Tmin

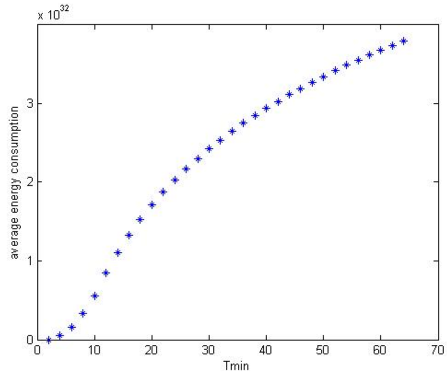

Figure 6:the influence of average energy consumption base on Tmin

3.3 EFFECTS OF T_{max}

The maximum sleep interval Tmax increased from 32 to 1024. The influence of the average waiting time and average energy consumption were shown in Figure 7, figure 8

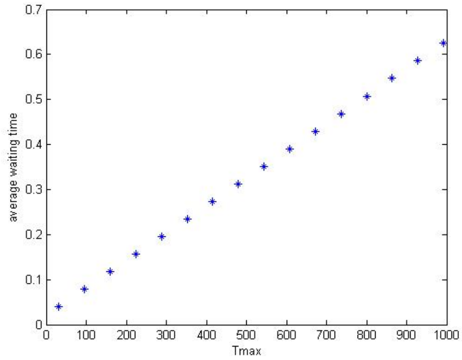

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Figure 7:theinfluence of base on Tmax

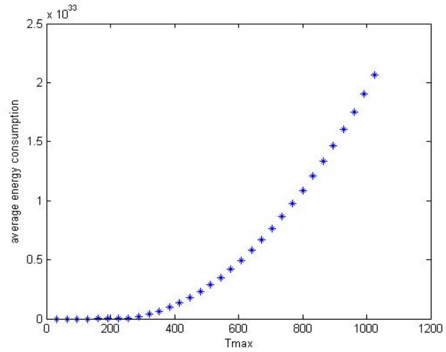

Figure 8:the influence of average energy consumption base on Tmax

From the simulation, it shows that: with the increase of T_{max}, the average waiting time and the energy consumption is increasing.

Through the experiments, In the case of self -similar distribution, we find that in the case of exponential increase algorithm of sleep mode, the average waiting time and average energy consumption will increase with the parameters.

With the advent of 4G, voice and video be more popular, the flow distribution is also more complex. In order to improve the QoS and save more energy, the exponential increase algorithm of sleep mode doesn't fit for IEEE802.16m

4. CONCLUSION

This paper researched the sleep mode of IEEE802.16m based on the self similar distribution. After theoretical analyses and simulation experiments, the authors concluded that the exponential increase algorithm of sleep mode don't fit for IEEE802.16m at the environment of High speed network.

We Should put forward a more practical sleep algorithm, not only can save energy at the same time but also improve the response time delay, in order to improve the network quality of service requirements. The study has a certain significance of the analysis and help for following sleep algorithm analysis of IEEE802.16m.

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