Battery Lifetime Extension Method by using Background Traffic Synchronization

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***Abstract*— We proposes a battery lifetime extension method through the background traffic synchronization on smartphones. Battery lifetime is very important factor due to the restrictive battery lifetime on smartphone. In proposed method, smartphone stacks the received background traffic in the buffer during the threshold time. The stored background traffic processes at data packet processing time. If there is no data packet to process for the threshold time, the stored background traffic is dropped. By applying this method to DRX, the idle mode cycle of smartphone can be extended. Therefore, the battery sleep time is increased through reducing the number of background packet transmission over wireless. For performance analysis, we use M/M/1 queueing model and compare the sleep time between existing and proposed method. As a result, we can prove that the power consumption of the proposed method is lower than the existing method. That is, the battery lifetime of the proposed method is more extended than existing method.**

***Keywords*—LTE, DRX, Background traffic, Battery lifetime**

I. INTRODUCTION

In recent years, the various wireless access technologies were diffused along with the advancement of wireless network technique. In addition, the miniaturization of the high specification terminal became possible with the advancement of hardware and software. Accordingly, the supply of the smartphone is on the increase and a kind of smartphone based application service is increased due to the exponential. Presently, the various service including SNS(Social Network Service), media streaming service, network game, and etc. is provided to the user through the smartphone based application[1]. However, the use of application service causes the problem called battery lifetime reduction in the smartphone using battery of restricted capacity. Particularly, in the case of SNS, even when the user doesn't use smartphone, the background traffic is produced and battery is consumed. The background traffic is drastically increased if the user uses several SNS applications.

In SNS, the background traffic is generated for session maintenance, synchronization and etc. between smartphone and application server. In addition, the background traffic for ping test and error control is additionally generated between smartphone and the equipment of telecommunication provider. The background traffic refers to TCP(Transmission Control Protocol), HTTP(Hypertext Transfer Protocol), ICMP(Internet Control Message Protocol), NBNS(NetBIOS Name Server) Protocol, and etc. In the smartphone, the background traffic is important factor for the maintaining service. However, it has the problem that it induces the battery consumption which the user doesn't desire. Therefore, research for reducing the power consumption generated by background traffic production is needed.

The existing research that reduces power consumption of smartphone and extension the battery lifetime is classified into the device level, equipment level, and network level. The representative research in device level is the research of technology for reducing power consumption of hardware chip. The representative research has DVS(Dynamic voltage Scaling)[2]. The research in equipment level is the thing about technology using the mutual cooperation of hardware module of smartphone and software. Representatively, there is the research on communication module selection algorithm and sleep mode control mechanism[3]. The research in the network level is technology using the network infrastructure. There is representatively DRX(Discontinuous Reception) and DTX(Discontinuous Transmission)[4].

In this paper, we propose the power consumption reduction and battery lifetime extension method in network level. The background traffic is received even while smartphone is idle mode state, and the smartphone is answered to this traffic. At this time, the battery of smartphone is consumed. In the proposed method, the background packet received for the idle mode state of smartphone is stored to the buffer. If the background packet remains in buffer when the smartphone is converted for data packet processing to the active mode, the smartphone processes all packets including the background packet. That is, the background packet processes with data packet, and the smartphone doesn't convert to active mode in order to process the background packet only. The times in which the smartphone is converted for packet transmission to active mode can be decreased through the proposed method. Therefore, the battery lifetime of smartphone can be extended. M/M/1 queueing model was used for performance analysis of the proposed method. Consequently, the power consumption according to idle mode time of existing method and proposed method were compared based on power which smartphone consumes in average.

The rest of this paper is organized as follows. Section II describes a traffic analysis of SNS application and the various method of battery lifetime extension in mobile node. Next,

Section III presents the proposed battery lifetime extension method. Also, Section IV shows the performance evaluation and results. Finally, Section V concludes this paper.

II. Related Work

In this section describes the related works regarding traffic analysis result of SNS application. In addition, we introduce battery lifetime extension method of mobile node.

A. Traffic Analysis of SNS Application

SNS is one among the most popular service to the smartphone user. In globally popular SNS application, there are the Facebook, Tweeter, Kakao talk, Skype, and etc. The most of smartphone users sets up and uses one kind or greater above application. However, even while the smartphone is the idle mode state, SNS application produces and transmits the background packet including the Keep-alive, and etc. for the maintaining service.

Baghel, S.K. analyze background traffic which is generated in Facebook and Skype application during idle mode of smartphone by using the wireshark[5]. According to the analyzed result, the Facebook application produced several HTTPS, ICMP, and NBNS packet. In the case of Skype application, because the packet was encrypted, a kind of packet could not be analyzed. However, it confirmed that Skype produces the background traffic which is more than Facebook. In addition, this paper mentions about method of solving the power consumption incremental problem because of background traffic generation through the mutual cooperation with base station. Baghel, S.K. proposed the method that extends the idle mode time by applying DRX to the smartphone.

Min Woo Kim and Hyun Yang analyze various SNS applications including the Kakao talk, Yahoo Messenger, and etc.[6][7]. By using the wireshark like [5], the background traffic was analyzed during idle mode time and though this, the several features were discovered. The first feature is that the several SNS applications produce periodically the traffic called Keep-alive. Keep-alive is the traffic used for session maintenance, synchronization, and etc. between smartphone and server. The second feature is that the background traffic generation period of SNS application is irregular. It is one among the cause in which this increases the mobile network usage frequency of smartphone.

B. Battery Lifetime Extension Method

The existing battery lifetime extension method can be classified as the device level, equipment level, and network level. There is the research that it relates to hardware chip for comprising the smartphone among the battery lifetime extension method in device level. DVS is technology which operates the workload of processor by using low power. Therefore, it is possible that the smartphone is operated by using the relatively lower power. However, this method has defect that the service quality can be degraded.

The battery lifetime extension method in equipment level is the method through function binding of hardware module and software. For example, there is the communication module selection algorithm, sleep mode control method[3], and etc. The communication module selection algorithm is the technique controlling communication module automatically for the power saving of mobile node considering energy consumption and transfer time. The sleep mode control method is the technique for reducing power consumption of mobile node through the sleep mode time control.

The battery lifetime extension method in network level is the technology using network infrastructure mainly. In 3GPP standardization group, DRX/DTX was proposed for battery lifetime extension of mobile node[4]. DRX has the sleep mode that called DRX cycle. In DTX, the base station is transmit to mobile node after aggregating the traffic. Therefore, the terminal can extend sleep mode time through the cooperation with base station. In this paper, the approach to battery lifetime extension method of mobile node is considered in the network level.

III. Proposed Method

This section describes the background traffic synchronization algorithm for battery lifetime extension of the smartphone. Firstly the smartphone structure to be proposed is described and next the background traffic synchronization algorithm is introduced.

A. Smartphone Architecture of The Proposed Model

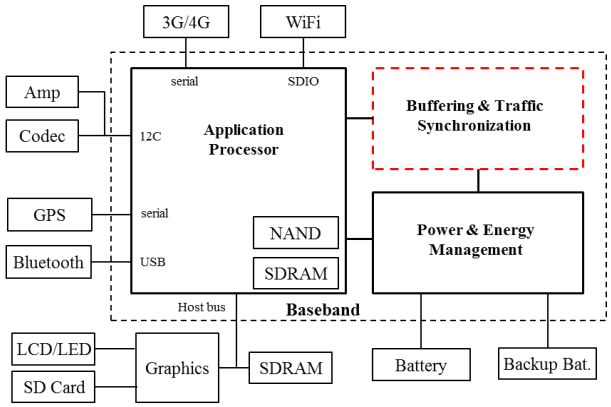

Figure 1. Smartphone Hardware Architecture for the Proposed Model

Fig. 1 shows hardware architecture of smartphone for the proposed method. Generally, smartphone is consists of application processor and power management module[8]. The application processor is consists of RF communication module, GPS, codec module, graphics processor, and memory. The RF communication module manages data communication of smartphone. The codec module manages encoding/decoding of video and audio frame. The power and energy management module manages the active/idle mode control of battery and backup battery, correct voltage control, and etc.

In this proposed method, the buffering and traffic synchronization module is added. This module does the manager role determining the buffering or drop of received background traffic. In addition, in this module, the transmitting timing of data traffic and background traffic is synchronized.

B. Background Traffic Synchronization Algorithm

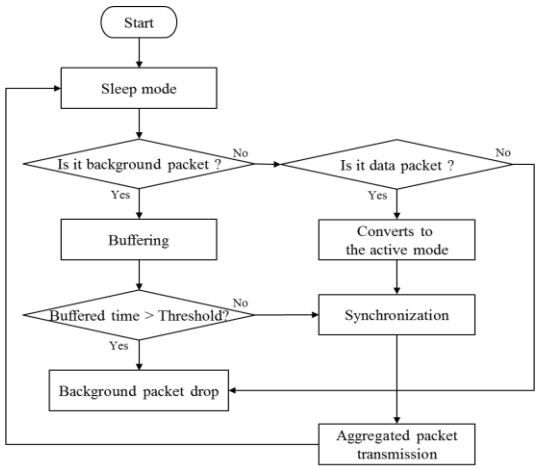

Figure 2. Background Traffic Synchronization Algorithm in Smartphone

Fig. 2 shows the background traffic synchronization algorithm for power efficiency of smartphone. The background packet includes a variety of packets such as ICMP, NBNS, Keep-alive packet, and etc. The ICMP is one of the core protocols of the internet protocol suite. It is used by network devices to send error messages indicating. ICMP can also be used to relay query messages. The NBNS is one of the session layer protocol. It is performed name registration, search, release, and etc. about network resources. In application service, the Keep-alive is the packet for service state notification between server and terminal. Whenever data packet is received, the smartphone has to send the ACK. The synchronization means that it is matched the transmitting timing of data packet and background packet. That is, the proposed algorithm transmits background packet when transmitting the ACK about data packet. The threshold plays the role like timer. It is decides the time that that background packet will queue in the buffer.

In the Fig. 2, it assumes that smartphone operates with idle mode in the beginning. If the packet is received while the smartphone is in idle mode state, the smartphone classifies this packet. If the received packet is background packet, the packet is stored as the buffer. The buffered packet stays in buffer during the threshold time and waits for the processing. If data packet arrives at the smartphone, the smartphone is converted to active mode. In active mode, the background packet is processed with data packet. If the data packet is not received for the threshold time, the background packet in the buffer is dropped. The purpose of background packet is service maintaining and administration, and it doesn't include actual data. Therefore, the problem is not generated due to the packet drop or delay. Consequently, since reducing the response number about the background packet, the mobile network usage time of the smartphone can be reduced. The idle mode time of smartphone can be extended through the network usage time reduction. That is, smartphone battery lifetime can be extended by using the proposed algorithm.

C. Proposed Algorithm is Applied to the DRX

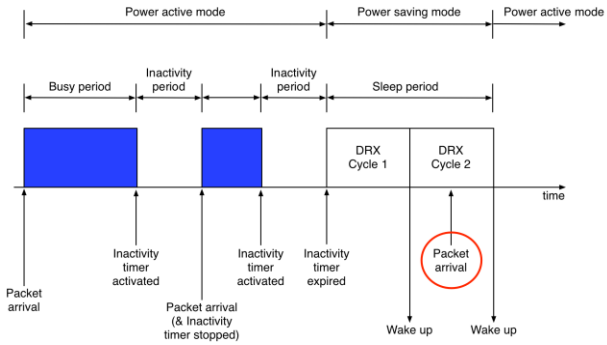

Figure 3. DRX Timing Diagram

Fig. 3 is DRX timing diagram that proposed in 3GPP. DRX was proposed for battery lifetime extension of the mobile terminal using LTE. The operation of DRX is classified into the power active mode and power saving mode. The power active mode operates the busy period when the packet arrived, and it converts to the inactivity period if the packet processing was completed. DRX sets the timer when converting to the inactivity period. It enters into the power saving mode if the timer is expired. The power saving mode has sleep period called DRX cycle. If the packet arrives at DRX cycle, this is sensed in wake up time and the terminal converts to the power active mode. If there is no received packet, the terminal has the next DRX cycle[9]. That is, DRX is the sleep time extension method through the time that terminal doesn't process the packet. Base station performs DTX in order to support DRX of the terminal. DTX sends packet from the base station to the smartphone after aggregation during certain time.

There is no classification of the background packet and data packet, the method of 3GPP converts to the power active mode about all packets from the power saving mode. If the proposed method is applied to the method of 3GPP, the mode switching by the background packet can be removed. Thereby, the additional power saving effect of the terminal can be caused.

IV. PERFORMANCE ANALYSIS

This section presents the performance analysis for the proposed method by using M/M/1 queueing model. We compares the idle mode time and power consumption of the proposed method with the existing method.

In M/M/1 model, the packet arrival rate follows the Poisson distribution. The service probability of packet follows the exponential distribution. Accordingly, the arrival rate of the background traffic follows the Poisson distribution and the service rate follows the exponential distribution.

Fig. 4 present the number of average packet queued in smartphone according to the arrival rate (λ). We used equation (1) in order to calculate the average packet quantity. Drop(10/5/2) means percentage of the dropped packet by proposed algorithm. Fig. 4 shows that number of average background packet at the proposed method is less than the existing method.

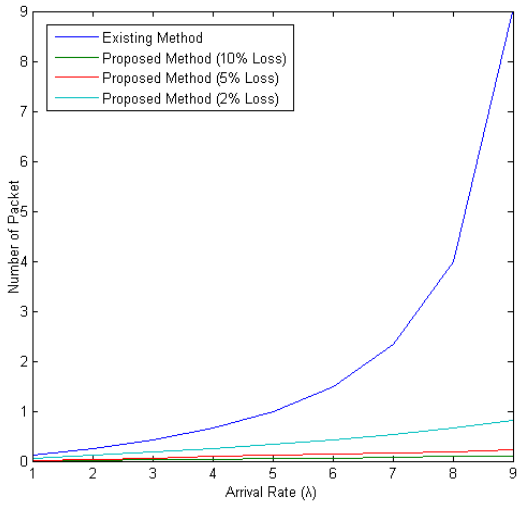

Figure 4. The Average Number of Background Packet in Smartphone

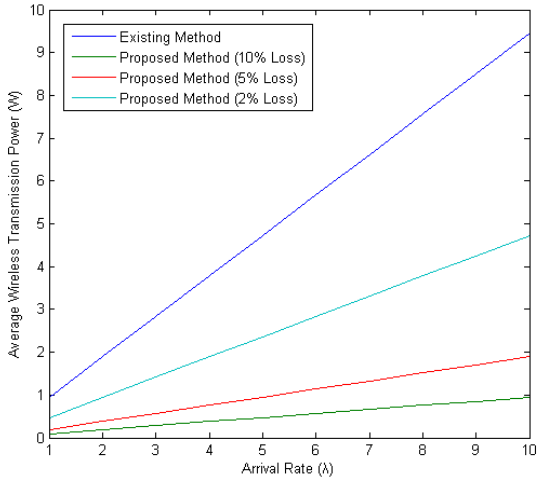

Figure 5. The Average Wireless Transmission Power in Smartphone

$$N = \frac{\rho}{1-\rho}, (\rho = \frac{\mu}{\lambda}) \quad (1)$$

$$P(Watt) = 1.408 \times 10^{-7} (W/bit) \times \lambda (Mbytes) \quad (2)$$

Fig. 5 shows the average wireless transmission power consumption of the smartphone according to arrival rate of the background traffic. We used equation (2) in order to calculate the consumed power for packet transmission.

Next, we compare the power consumption according to the idle mode of the proposed method with the existing method. The power which the smartphone consumes in idle mode state for the wireless(IEEE802.22) transmission is 58mW and it consumes 868mW when being active mode[10]. The equation (2) was used in order to calculate the transmission power of the smartphone[11]. In the smartphone environment, the arrival rate of background traffic and data traffic is various depending on the user usage pattern. Therefore, in this paper, the arrival rate of background traffic and data traffic is assumed as 1:1 for the expedience of analysis.

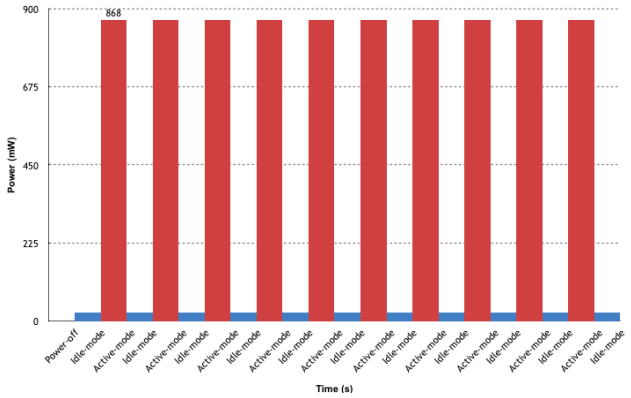

Figure 6. Idle and Active Mode Cycle in Existing Method

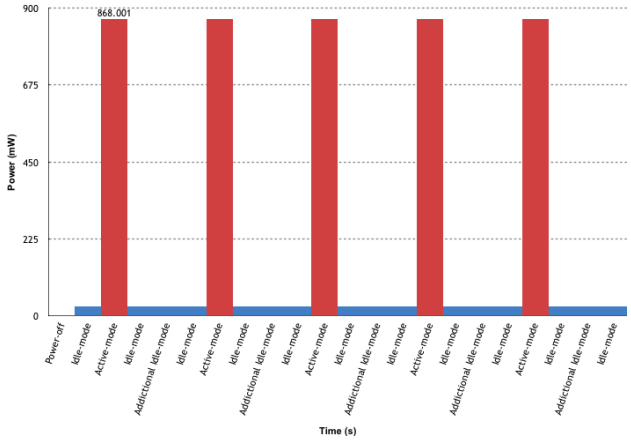

Figure 7. Idle and Active Mode Cycle in Proposed Method

Fig. 6 shows the idle-active mode cycle of existing method. The existing method converts to the active mode regardless of a kind of traffic. Fig. 7 shows the idle-active mode cycle of the proposed method. The proposed method doesn't convert to the active mode even if the background packet is received. It converts to the active mode in the reception of data packets. Therefore, the idle mode time can be extended like fig. 7. The added idle time extends the battery life of the smartphone. If this proposed method is applied to DRX, it is expected to extend the DRX cycle length.

V. CONCLUSIONS

This paper proposed the battery lifetime extension method through the background traffic synchronization. According to the proposed method, the idle mode time could be extended since the smartphone transmitted the background packet in data packet transmission time. This is the method for reducing the power consumption generated by the frequent wireless network access. M/M/1 queueing model was used for the performance analysis. The power consumption according to the idle mode cycle was compared with the existing method.

Consequently, the power consumption of the proposed method could prove the decrease through the comparison with the existing method. It proved to could extension the battery lifetime of the smartphone by using this method.

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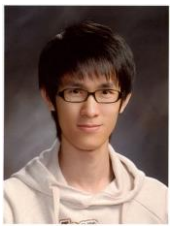

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