

An Efficient Transmission Scheme for Short Message Service in IEEE 802.16 Systems

Sung-Min Oh* and Jae-Hyun Kim*

**Ajou University, School of Electrical and Computer Engineering*

smallb01@ajou.ac.kr and jkim@ajou.ac.kr

Abstract— Short message service (SMS) has two main features, namely small-sized SMS packet and high acceptable-delivery delay. For these features, this paper proposes an efficient transmission scheme for SMS in IEEE 802.16 systems. In order to reduce a message overhead, the proposed scheme exploits the existing connection instead of generating a new connection. In addition, it adopts the piggyback scheme with a periodic control message for the bandwidth request to reduce the message overhead and probability of collisions. From the simulation results, the proposed scheme has been shown to reduce the message overhead of the conventional scheme by about 99 %.

Keywords— Communication system signalling, data transmission, mobile communication, and resource management

I. INTRODUCTION

MS has been considered as one of the most significant applications in the next generation wireless communication systems. SMS has two features, namely small-sized SMS packets (up to 100 bytes) and a high acceptable-delivery delay (up to 30 seconds) [1], [2]. In IEEE 802.16 systems, a connection should be initiated between a base station (BS) and a subscriber station (SS) in order to transmit a SMS packet. In addition, a SS has to experience a bandwidth request procedure in order to obtain the required bandwidth for the SMS packet [3]. Unfortunately, these processes are inefficient for sending small-sized SMS packets. The reason for this is that the size of the connection generation messages is larger than the SMS packet size. In addition, a SS has to contend to obtain some bandwidth whenever the SS has a transmitting packet. If a bandwidth request message collides with other messages, the SS retransmits a bandwidth request message after some delay [3], [4]. For this reason, it is possible that a SS has to transmit several additional messages in order to send a small-sized SMS packet. This appears to be rather an inefficient procedure and hence this paper defines these additional messages as message overhead. In this way a more efficient transmission scheme for SMS may be realized that reduces the message overhead in IEEE 802.16 systems.

Unfortunately, SMS related works have focused on the

transmission of a SMS packet on the networks. Thus, Zheng et al. [5] and Haung [6] have studied on the optimal buffer size in the GPRS/UMTS networks. Unlike these related works, this paper investigates the efficient transmission of a SMS packet on the wireless networks, because it is very important issue to efficiently use the wireless resource in the wireless networks.

In cellular networks, SMS packets are transmitted through the signaling channel in order to avoid the message overhead [7]. IEEE 802.16 systems do not have the signaling channel, however IEEE 802.16 defines a ranging subchannel which is similar to the signaling channel in cellular networks. Unfortunately, the ranging subchannel can transmit only 288 bits or 864 bits when a modulation and coding scheme (MCS) level is QPSK 1/2 or 64 QAM 1/2, respectively. Thus, a SMS packet can be fragmented to be transmitted through a ranging subchannel. Since the fragmentation of a SMS packet can cause overheads in the transmission of the packet, this transmission scheme, defined in cellular networks, is unsuitable for IEEE 802.16 systems. Consequently, a novel transmission scheme is required for SMS in IEEE 802.16 systems.

This paper proposes such an efficient transmission scheme for SMS in IEEE 802.16 systems. The key ideas of the proposed scheme are twofold, namely, i) It omits the connection generation procedure by using management connection identifier (CID) in order to reduce the connection generation overhead, and ii) It exploits the piggyback scheme using a periodic control message in order to reduce the bandwidth request overhead. Since this scheme can eliminate a contending rate, which is caused by the bandwidth request message for SMS, the proposed scheme can decrease the collision probability of the bandwidth request message from SSs. The detailed description will be presented in section III.

II. THE CONVENTIONAL TRANSMISSION SCHEME FOR SMS

IEEE 802.16 does not define the transmission scheme for SMS, it merely defines five scheduling types as unsolicited grant service (UGS), extended real-time polling service (ertPS), real-time polling service (rtPS), non real-time polling service (nrtPS), and best effort (BE) service. This paper defines SMS as a BE service in IEEE 802.16 systems, because SMS can randomly generate packets and is insensitive to the delay.

Fig. 1 represents the operation procedure of the conventional

transmission scheme, and Fig. 2 indicates the flow chart of a SS. As shown in Fig. 1, the IEEE 802.16 systems perform two operations, namely connection generation and bandwidth request, when it receives a SMS packet from the upper layer. The connection generation operation generates a service flow between a BS and a SS. The IEEE 802.16 system defines a service flow to guarantee some quality of service (QoS), and it exploits a transport CID to manage the service flow [3]. Thus, the IEEE 802.16 system creates a transport CID whenever it receives a new packet. In the connection generation operation, the SS transmits a dynamic service addition-request (DSA-REQ) message to generate a new transport CID. At this time, the DSA-REQ message includes a type length value (TLV)-encoded-information parameter to deliver a QoS information of the service flow. The size of the TLV-encoded-information parameter is variable within a range of 104 ~ 230 bytes. If a BS can support the service flow, the BS transmits the DSA-response (RSP) message with a transport CID as shown in Fig. 2. Therefore, wireless resources are spent to generate a communication connection between the BS and a SS.

After the connection generation operation, the SS transmits a bandwidth-request (BW-REQ) header to obtain the radio bandwidth for a packet by using the random access scheme. In this random access scheme, the SS transmits a BW-REQ ranging-request (RNG-REQ) message, through a ranging subchannel, to obtain the radio bandwidth for transmitting the BW-REQ header as shown in Fig. 2. The BW-REQ RNG-REQ message includes an orthogonal ranging code randomly selected by the SS. When several SSs simultaneously choose the same orthogonal ranging code in a ranging subchannel, the SSs will experience collisions. The SSs retransmit a BW-REQ RNG-REQ message after some delay until they successfully transmit their BW-REQ RNG-REQ messages. When a BS successfully receives a BW-REQ RNG-REQ message from a SS, the BS transmits a CDMA-allocation-information-element (IEs) to the SS in order to indicate that the SS has successfully transmitted a BW-REQ RNG-REQ message as shown in Fig. 2. Then the SS sends a BW-REQ header with the required bandwidth to the BS. The BS allocates some bandwidth using UL-MAP IEs, and the SS transmits a packet through the allocated bandwidth to the BS.

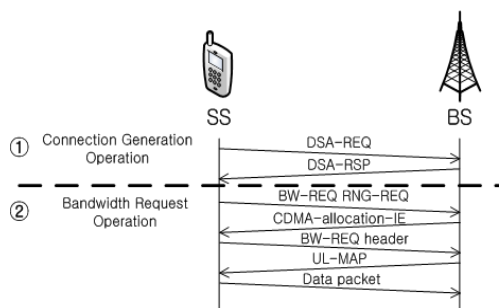


Figure 1. Operation procedure of the conventional transmission scheme for SMS

As mentioned above, several messages have to be transmitted to send a rather small-sized SMS packet, e.g. DSA-REQ (230 bytes) + BW-REQ RNG-REQ (18bytes) + BW-REQ header (6bytes) for uplink transmission. In order to reduce this message overhead, this paper proposes a more efficient transmission scheme for SMS.

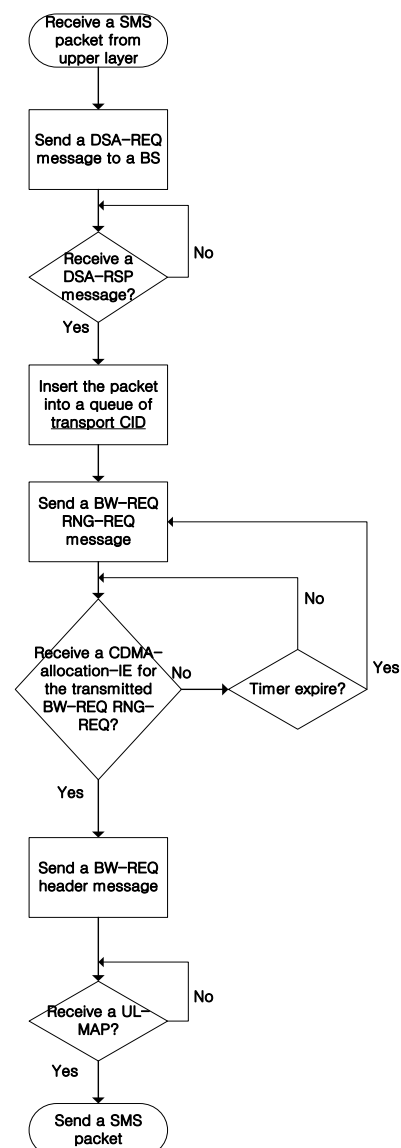


Figure 2. A flow chart of a SS for the conventional transmission scheme for SMS

III. THE PROPOSED TRANSMISSION SCHEME FOR SMS

The proposed scheme for SMS has three main features in IEEE 802.16 systems. Firstly, the proposed scheme omits the connection generation operation in order to avoid the message overhead. To send a small-sized packet, it unfortunately needs the exchange of several messages which are used to generate a transport CID in the conventional transmission scheme. For this reason, the proposed scheme uses a management CID, which is previously assigned to manage a SS by a BS, instead

of a transport CID. Secondly, the proposed scheme exploits the piggyback scheme using a periodic control message instead of the bandwidth request operation in order to reduce the message overhead and probability of collisions. Thirdly, the proposed scheme can aggregate multiple SMS packets continuously transmitted. This feature can also reduce the message overhead for each SMS packet. In the proposed scheme, a SS can request some bandwidth for all SMS packets, which are waiting in a queue, by using the periodic control message. Consequently, the proposed scheme can reduce the message overhead as well as the collision probability of the BW-REQ RNG-REQ message. The detailed description of this is as follows.

Fig. 3 indicates the operation procedure of the proposed transmission scheme, and Fig. 4 represents the flow chart of a SS for the proposed scheme. This paper assumes that the system can identify a SMS packet using a TCP/UDP source or destination port number, or IP header information when a SMS packet is received from the upper layer. For this reason, the proposed scheme cannot affect to the other service classes. As shown in Fig. 3, the proposed scheme omits the connection generation operation unlike the conventional scheme. In order to omit the connection generation operation, the proposed scheme stores the SMS packet into a queue related to the management CID when it receives a SMS packet from upper layer as shown in Fig. 4. In the bandwidth request operation, the SS waits for the time when the periodic RNG-REQ message is transmitted. This paper exploits a periodic RNG-REQ message in order to request some bandwidth required for a SMS packet and it proposes to define a new bandwidth-request field, whose size is 2 bytes, in the TLV-encoded-information of the periodic RNG-REQ message. In addition, this paper defines a reserved bit in the UL-MAP IEs as a SMS-flag bit in order to indicate that the grant allocated by a BS is for a SMS packet. When a BS receives a periodic RNG-REQ message which includes a bandwidth-request field, it allocates some bandwidth using UL-MAP IEs with the SMS-flag bit '1' to the SS. When a SS sends a periodic RNG-REQ message to a BS, it waits for a UL-MAP. If the SS does not receive a UL-MAP message with SMS-flag bit '1' until the time to transmit the next periodic RNG-REQ, the SS retransmits a periodic RNG-REQ message to the BS as shown in Fig. 4. This process is to resolve a collision among the periodic RNG-REQ message. If the SS receives a UL-MAP message with a SMS-flag bit '1', the SS transmits a SMS packet which is in the queue related to the management CID. Therefore, a SS can transmit a SMS packet with a few message overheads by using the proposed scheme. In addition, the proposed scheme can decrease the collision probability of the BW-REQ RNG-REQ message because the BW-REQ RNG-REQ message for a SMS packet can be omitted during bandwidth request operation.

In spite of these merits of the proposed scheme, implementation possibility of the proposed scheme has to be

considered because it needs to change the IEEE 802.16 system for a SMS. In addition, it can have an impact on the conventional management scheme, because it uses the management CID in order to reduce the message overhead. However, it just needs to be added the TLV field in periodic RNG-REQ message and the SMS-flag bit in UL-MAP message. Also, it merely uses the management message without an addition of a new algorithm. For this reason, the implementation possibility and the impact on the conventional system cannot be a problem.

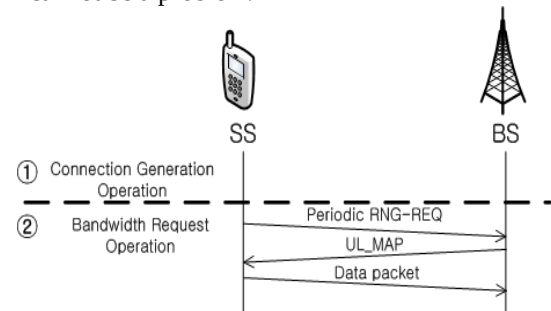


Figure 3. Operation procedure of the proposed transmission scheme for SMS

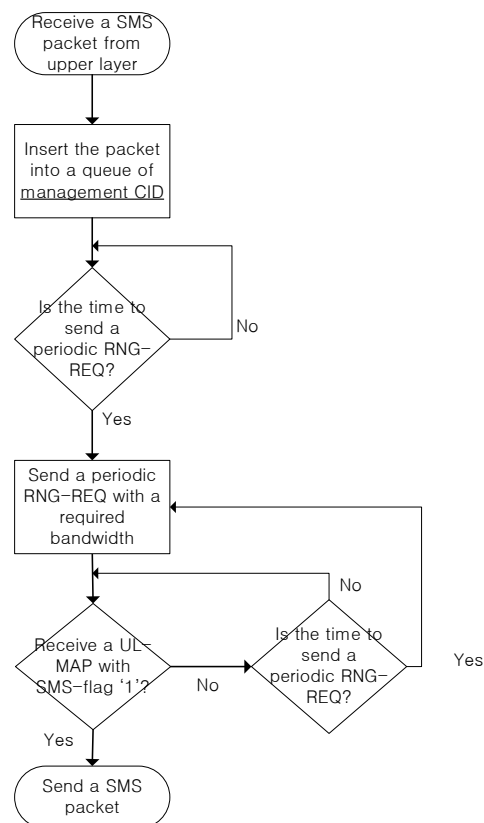


Figure 4. A flow chart of a SS for the proposed transmission scheme for SMS

IV. SIMULATION ENVIRONMENT

This paper has simulated the system performance using the OPNET tool. This paper assumes that a channel error is not generated. SMS packets are assumed to be generated with

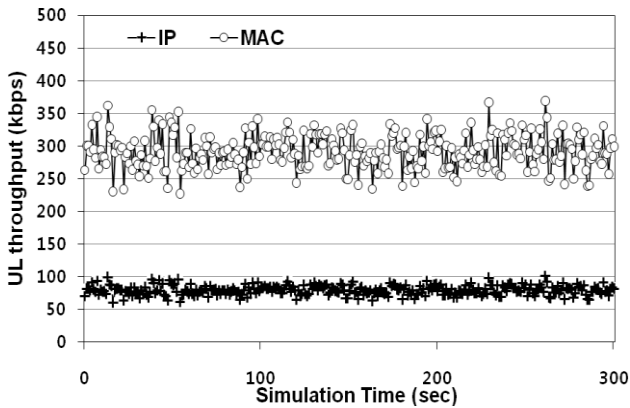
Poisson distribution in a SS and the system parameters are shown in Table I. The number of ranging codes represents the number of resources required for the random access scheme. Since IEEE 802.16 does not define the exact number of ranging codes, this paper assumes that the number of ranging codes in a frame is 10 and 50 for the BW-REQ RNG-REQ and 10 for the periodic RNG-REQ as shown in Table I. The IEEE 802.16 standard defines the initial backoff window size as the power of 2 with a range of $0 \sim 15$ [3]. The initial backoff window size can also affect the system performance. However, we focus on the efficiency of transmission scheme for SMS and for this reason this paper does not include the simulation results according to the initial backoff window size. The period of the periodic RNG-REQ can also be variable, because the default value is not defined in the IEEE 802.16 standard. Thus, this paper evaluates the system performance for the proposed scheme when the period of the periodic RNG-REQ is 200 and 500 msec.

Table 1. Simulation Parameters

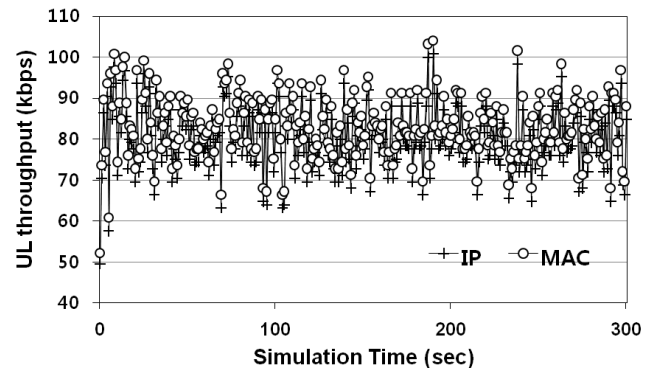
Simulation Parameters	Value
Arrival rate in a SS	Poisson distribution with mean 0.01, 0.1, 1, and 10 packets per second
The number of ranging codes in a frame for BW-REQ RNG-REQ (N_B)	10 and 50
The number of ranging codes in a frame for periodic RNG-REQ	10
Initial backoff window size	4
Period of periodic RNG-REQ (T_p)	200 and 500 msec
Frame size	5 msec [3]

V. SIMULATION ENVIRONMENT

This paper evaluates the system performance in terms of uplink (UL) throughput, message overhead, and average access delay for SMS messages. The UL throughput means the number of bits received per second and for this reason, the MAC UL throughput includes the message overhead whereas the IP UL throughput includes only the size of the SMS packet. Thus, the message overhead of the conventional and proposed scheme can be inferred from comparing the MAC and IP UL throughput. The access delay means the time to transmit a SMS packet from a SS to a BS.

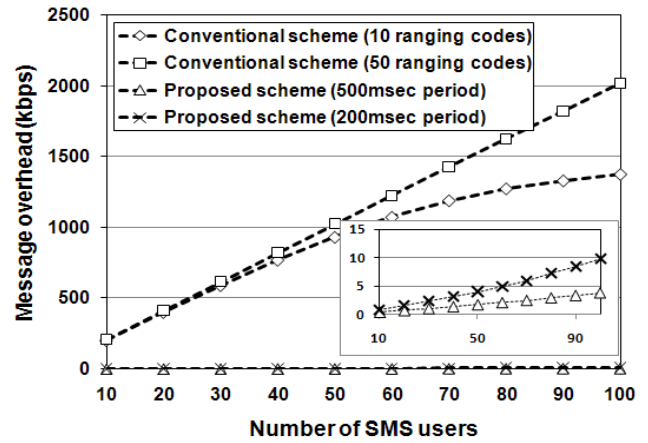


(a) Conventional scheme (10 ranging codes)

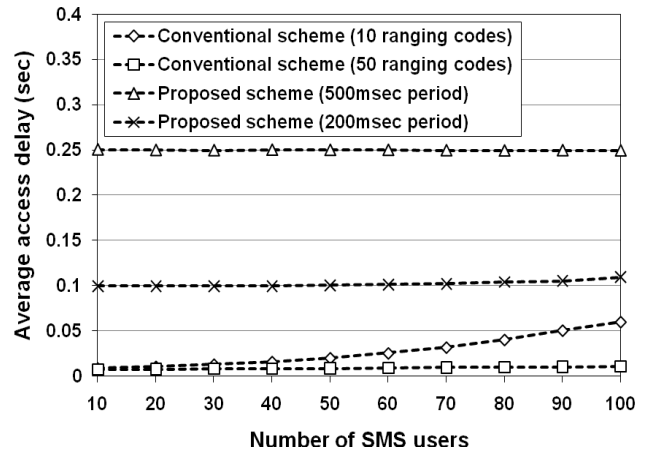


(b) Proposed scheme (200 msec)

Figure 5. IP and MAC UL throughput (10 SSs and 10 SMS packets per second for a SS)



(a) Message overhead



(b) Average access delay

Figure 6. System performance according to the number of SMS users (10 packets per second for a SS)

Fig. 5 represents the MAC and IP UL throughput according to the simulation time. Fig. 5 (a) indicates the MAC and IP UL throughput for the conventional scheme. As shown in Fig. 5 (a), the difference between the MAC and IP UL throughput is about 200 kbps. This means that the conventional scheme causes the message overhead by 200 kbps. Fig. 5 (b) represents the MAC

and IP UL throughput for the proposed scheme. In contrast with the conventional scheme, the proposed scheme causes almost no message overhead as shown in Fig. 5 (b). From this simulation result, we can infer that the proposed scheme can reduce the message overhead compared to the conventional scheme. In order to confirm this result, this paper evaluates the system performance according to the number of SMS users.

Fig. 6 represents the message overhead and average access delay according to the number of SMS users. Fig. 6 (a) indicates the message overhead. As shown in Fig. 6 (a), the proposed scheme can reduce the message overhead by 0.2 ~ 2 Mbps. For this reason, the proposed scheme can reduce the message overhead by the omission of the connection generation operation, and the multiple SMS packets aggregation using a periodic control message. In addition, the proposed scheme can avoid collisions generated during the bandwidth request operation by using the piggyback scheme. For the conventional scheme, the increase rate of the message overhead degrades as the number of SMS users increases when the number of ranging codes is 10, because the MAC throughput decreases by the increase of the collision rate of BW-REQ RNG-REQ messages. On the other hand, the message overhead of the proposed scheme linearly increases because of the low collision rate of periodic RNG-REQ messages. Here, the conventional scheme can also reduce the collision rate by increasing the number of ranging codes. However, this case can also cause the increase of the message overhead as shown in Fig. 6 (a). Consequently, simulation results show that the proposed scheme can transmit a SMS packet in a much more efficient way. It is expected that the reduction of the message overhead can lead to the increase of the SMS capacity or the improvement of the system performance for other service classes.

Fig. 6 (b) indicates the average access delay according to the number of SMS users. The proposed scheme has to experience some delay to transmit a SMS packet because it has to wait for the next available transmission time of the periodic RNG-REQ message. As shown in Fig. 6 (b), the average access delay of the proposed scheme is 100 and 250 msec when the period of periodic RNG-REQ message is 200 and 500 msec, respectively, whereas that of the conventional scheme is 8 ~ 60 msec. However, [2] defines that the acceptable-delivery delay for SMS messages is about 30 seconds. For this reason, this access delay of the proposed scheme can be negligible.

In order to confirm the efficiency of the proposed scheme when the SMS packet arrival rate is low, this paper evaluates the reduced overhead ratio according to the SMS packet arrival rate. The reduced overhead ratio indicates the ratio of the message overhead reduced by the proposed scheme to the message overhead of the conventional scheme. Fig. 7 represents the reduced overhead ratio according to the SMS packet arrival rate. As shown in Fig. 7, the reduced overhead ratio is almost same as 99%. The reduced overhead ratio

rapidly increases when the arrival rate is 10 packets per second, because SMS packets are aggregated by the piggyback scheme using a periodic control message. Therefore, we can conclude that the proposed scheme can efficiently support the SMS compared to the conventional scheme.

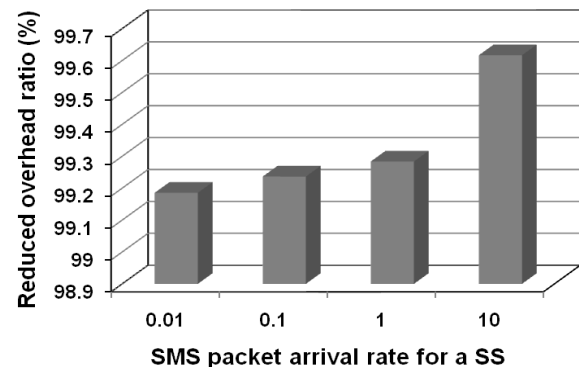


Figure 7. Reduced overhead ratio according to SMS packet arrival rate for a SS (50 SMS users, conventional scheme with 50 ranging codes, proposed scheme with 200 msec period)

VI. CONCLUSION

This paper proposed an efficient transmission scheme for SMS considering two main features of SMS such as a small-sized packet and a high acceptable-delivery delay. By the simulation results, the proposed scheme can reduce the message overhead of the conventional scheme with guaranteeing QoS.

The key idea of this paper has been derived from considering the main features of SMS. This means that it is still necessary to consider the traffic features in application layer in order to improve the system efficiency.

ACKNOWLEDGMENT

This research was supported by the MKE, Korea, under the ITRC support program supervised by the IITA (IITA-2009-C1090-0902-0003) and by the IT R&D program of MKE/IITA (2008-F-951-01, Research on Ubiquitous Mobility Management Methods for Higher Service Availability).

REFERENCES

- [1] C. Peersman, S. Cvetkovic, P. Griffiths, and H. Spear, "The global system for mobile communications short message service," *IEEE Personal Communications*, vol. 7, no. 3, pp. 15-23, 2000.
- [2] ITU-T G.1010, "End-User Multimedia QoS Categories," Nov. 2001.
- [3] IEEE 802.16eTM -2005, "IEEE Standard for Local and Metropolitan Area Networks – Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems Amendment2," Feb. 28, 2006.
- [4] L. W. Chen and Y. C. Tseng, "Design and Analysis of Contention-Based Request Schemes for Best-Effort Traffic in IEEE 802.16 Networks," *IEEE Commun. Lett.*, vol. 12, no. 8, pp. 602 – 604, Aug. 2005.
- [5] J. Zheng and E. Regentova, "QoS-based Optimal Buffering for Short Message Transfer in GPRS/UMTS Networks," in *Proc. IEE VTC 2005-spring*, vol. 5, Jun. 2005, pp. 2721 – 2725.
- [6] Yieh-Ran Haung, "Determining the Optimal Buffer Size for Short Message Transfer in a Heterogeneous GPRS/UMTS Network," *IEEE Trans. Veh. Technol.* vol. 52, pp. 216 – 225, Jan. 2003.
- [7] Z. Naor, "An Efficient Short Message Transmission in Cellular Networks," in *Proc. IEEE INFOCOM 2004*, vol. 1, Mar. 2004, pp. 7 – 11.