Admission control in medical-grade WLAN

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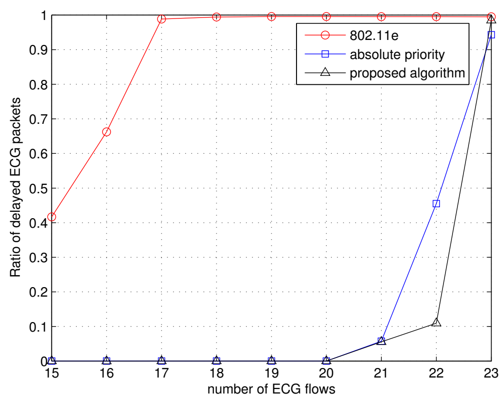

Fig. 1. Ratio of delayed ECG packets over total received ECG packets.

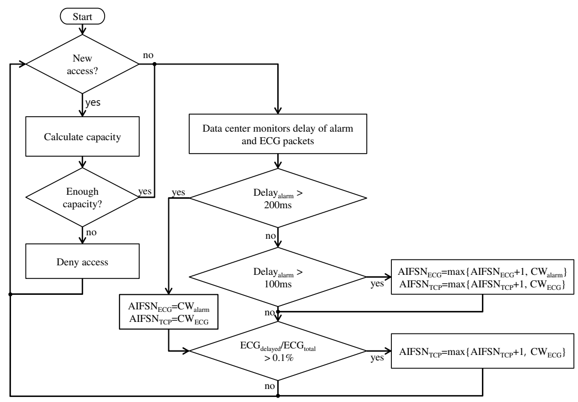

Fig. 2. Flowchart of proposed algorithm with admission control.

***Abstract*—In this paper, we design an admission control mechanism on top of our previous study on medical-grade wireless LAN. The proposed admission control scheme controls the total number of real-time electrocardiogram (ECG) monitoring connections in order to guarantee the medical-grade quality of service. We verify the performance of the proposed scheme with ns-2 simulation.**

I. Introduction

Currently, we are living in the wireless communication age. Healthcare community is also adopting various wireless technologies in medical environments [1]–[4]. However, unlike conventional wireless applications, medical wireless connectivity has to strictly guarantee the required quality of service (QoS) level, which is so-called medical-grade QoS.

As shown in Fig. 1, previous study in [5] shows that the conventional WLAN is insufficient to guarantee the medical-grade QoS. In order to overcome this shortcoming, an absolute priority scheme is proposed in [6] in order to enhance the performance of WLAN in the unsaturated regime.

In this paper, we propose an admission control scheme based on the absolute priority algorithm to avoid performance degradation in the saturated regime. The proposed scheme first calculates the capacity of real-time ECG monitoring connections and decides the admission of a newly arrived connection based on this information.

II. Admission Control Algorithm

The overall flowchart of the proposed admission control scheme is depicted in Fig. 2. The data center first calculates the capacity of real-time ECG connections. Based on the capacity, it decides whether or not to accept a newly requested connection. For an admitted connection, the data center monitors the delay of alarm and ECG packets which have relatively high priority. To meet the required QoS, we set two threshold values, 100 ms for the delay of alarm and 0.1% for the delayed ECG packet ratio. If the measured value exceeds each threshold, the algorithm increases the AIFSN of relatively low priority traffic.

In order to calculate the capacity of ECG connections, we adopt the results on VoIP capacity of IEEE 802.11 WLAN in [7], which analyzes the capacity of constant bit rate (CBR) VoIP trafffic theoretically. Since ECG connections generate CBR traffic, we can calculate the ECG connection capacity of 802.11 WLAN in a similar manner as in [7] as follows:

$$N_{ECG} = P_{int}/T_{total}, \tag{1}$$

where N_{ECG} is the maximum number of ECG connections, P_{int} is the interval of packetization, and T_{total} is the total transmission time of ECG connections.

Here, the total transmission time T_{total} includes arbitration inter-frame spacing (AIFS), backoff time, and headers. Consequently, we can represent T_{total} as follows:

$$T_{total} = T_{AIFS(ECG)} + T_{data} + T_{bo}.$$

The backoff time, T_{bo}, is calculated as $BO * T_{slot}$, where T_{slot} is a slot time that depends on the physical layer and BO is the backoff slot size. Since the backoff slot size is randomly selected in $(0, CW_{ECG})$, its average is $CW_{ECG}/2$. Thus, the capacity of ECG connections in (1) can be expressed as

$$N_{ECG} = \frac{P_{int}}{T_{AIFS(ECG)} + T_{data} + T_{slot} \cdot CW_{ECG}/2}, \quad (2)$$

and we can calculate an analytical value of 25.69 for N_{ECG} under typical parameter setting.

III. Performance Evaluation

In order to verify the analytical capacity of ECG connections and validate the proposed admission control scheme in Fig. 2, we carry out simulation with ns-2 network simulator [8].

First, we validate admission control in Fig. 3. If we do not apply admission control, the simulation result shows that the actual capacity is 22, which does not match with the analytical value of 25.69. The reason is that the capacity in (2) is the maximum value under the assumption of no collision. Hence, we further generate ECG connections in a scheduled manner that does not initially collide each others.[1] The result of scheduled ECG connections is given as a blue curve marked with squares, which agrees with the analytical capacity. Furthermore, we can verify that the proposed admission control scheme successfully prevents the network from saturation.

In Fig. 4, we measure the delay of ECG connections in the time domain. We divide ECG connections into three groups and start each group at $t = 5$ second, $t = 300$ second, and $t = 500$ second, respectively. When the third group starts its transmission, the network becomes saturated until the first group stops transmission at $t = 550$ second. As a result, the delay of ECG increases until $t = 550$ second, and then decreases afterwards once the network is unsaturated. In the meantime, if we apply the proposed admission control algorithm, ECG connections experiences little delay as the black curve that remains very close to zero.

IV. Conclusion

The wireless technologies are generalized these days. With wireless medical devices, medical-grade QoS is a critical issue. We have proposed an efficient admission control mechanism that can guarantee the required medical-grade QoS. By adopting the capacity result in VoIP connections, we have accurately calculated the ECG capacity. Our simulation results show that the proposed admission control scheme can properly deal with newly requested ECG connection.

Acknowledgements

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[1]Since ECG traffic is CBR, there will be no collision among them as long as they do not initially collide.

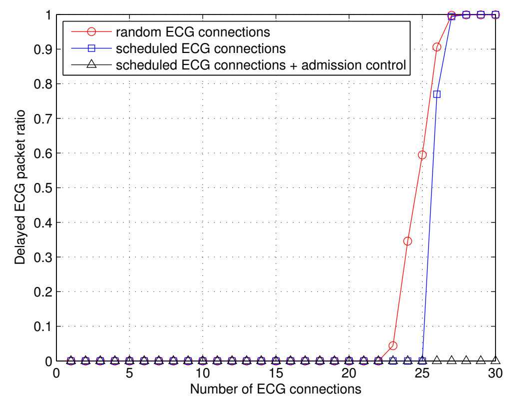

Fig. 3. Performance comparison with and without admission control.

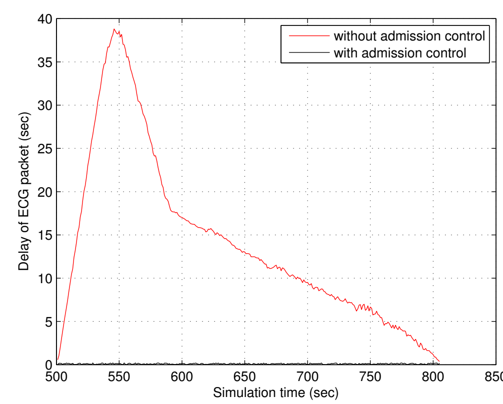

Fig. 4. Delay of ECG monitoring packets in the time domain.

References

[1] GE Healthcare. Product features–wireless technologies. [Online]. Available: http://www.gehealthcare.com
[2] Philips. Patient monitoring–intellivue telemetry system. [Online]. Available: http://www.medical.philips.com
[3] Welch Allyn. Micropaq wearable monitor. [Online]. Available: http://www.welchallyn.com
[4] K. Kang, K.-J. Park, J.-J. Song, C.-H. Yoon, and L. Sha, "A medical-grade wireless architecture for remote electrocardiography," *IEEE Transactions on Information Technology in Biomedicine*, vol. 15, no. 2, pp. 260–267, 2011.
[5] S. Son, K.-J Park, and E.-C Park, "Adaptive tuning of IEEE 802.11e EDCA for medical-grade QoS," in *Proc. IEEE Fifth International Conference on Ubiquitos and Future Networks (ICUFN 2013)*, 2013, pp. 650–651.
[6] H. Lee, K.-J. Park, Y.-B. Ko, and C.-H. Choi, "Wireless LAN with medical-grade QoS for e-healthcare," *Journal of Communications and Networks*, vol. 13, no. 2, pp. 149–159, 2011.
[7] S. Shin and H. Schulzrinne, "Measurement and analysis of the VoIP capacity in IEEE 802.11 WLAN," *IEEE Transactions on Mobile Computing*, vol. 8, no. 9, pp. 1265–1279, 2009.
[8] The network simulator (ns-2). [Online]. Available: http://www.isi.edu/nsnam/ns/