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A method for enhancing speed of bluetooth based telemedicine services

Dear Editor,

Telemedicine is a rapidly developing tool of clinical medicine where medical information is transferred via telephone, the Internet or other networks for the purpose of consulting as a remote medical procedure. However, the Internet of Things vision and emerging 4G services, fuelled with the flexibility of mobility, is expected to transform the structure of telemedicine services from its current static networks to highly mobile wireless networks.

Bluetooth, which is a low-power radio technology, is broadly used by the components of wireless personal area networks (WPANs) such as pulse oximeters, blood pressure and blood glucose devices, mobile phones, computers, handsets, printers etc. for various medical studies. The major drawback of Bluetooth is its rather long connection establishment delay, which is the time required for two devices to setup a connection in order to exchange information.[1] Hence, Bluetooth is currently used for static or low mobility telemedicine services. However, there is a demand for more flexible and more mobile wireless telemedicine user-end networks. In this article, our aim is to introduce a new method that improves connection time.

Studies in the literature point out two serious problems about the Bluetooth inquiry procedure: the high connection delay and the low probability of connecting a specific node. The problem of high connection delay of Bluetooth devices is handled by several studies in the literature.[1-4] Proposed methods enhance the connection establishment delay by splitting the connection types into two groups according to frequency of connection,[1] using different random backoff (RB) delays and a single train,[2] using IrDA for device discovery,[3] and using RFID for the Bluetooth connection establishment procedure.[4] These methods shorten the connection establishment delay down to 1.28s, 2.27s, 1.62s and 4s, respectively.

In this article, we propose a new method that introduces a frequency freezing function, which freezes the frequency upon reception of the first inquiry access (IAC) packet until beginning of paging procedure. Figure 1 shows the comparison of the specifications (A) and frequency freezing method (B). The inquirer chooses a train (T_a) and the inquiry scanner switches its listening frequency (F_1, F_2, F_3…) in every 18 timeslots. Assuming that the frequencies of inquirer and inquiry scanner coincide at the frequency F_5, inquiry scanner returns to the inquiry scan state with different frequencies, F_{12} and F_5, after RB delay expires. In the current system, it is not certain that the train T_a includes the frequency F_{12}. In this case, the inquiry scanner cannot receive the second IAC packet because of not coinciding at the same frequency band, so the inquiry scanner returns to the standby state then listens for the first IAC packet again. Thus, the connection establishment delay becomes higher. If the two devices do not manage to coincide for the second IAC during frequency synchronization (FS) delay in the inquiry

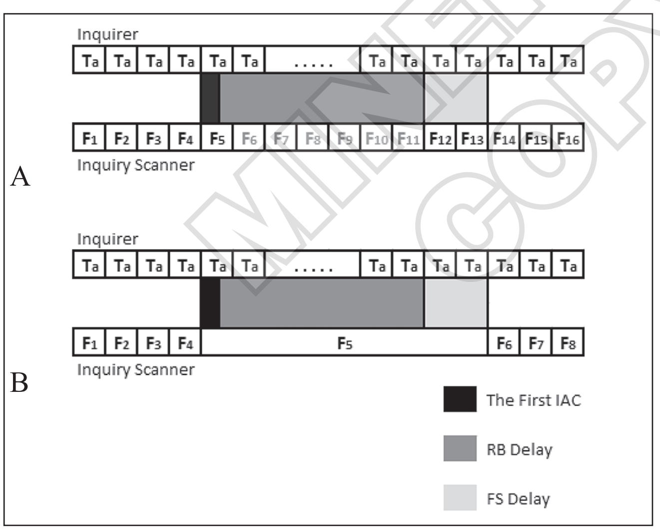

Figure 1.—The diagram of comparison of frequency switching of two methods. A) Specifications; B) frequency freezing method.

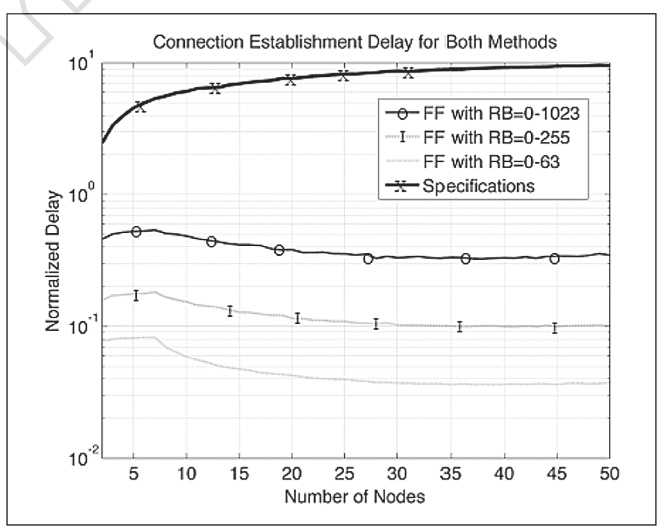

Figure 2.—The connection establishment delays of both methods for piconet.

procedure for 10.24s, the connection among them cannot be established. On the other hand, in the frequency freezing method, the inquiry scanner listens for the second IAC packet at frequency F_5 that the inquiry scanner receives the first IAC. The train T_a definitely contains frequency F_5, since the first IAC packet is received at that frequency.

We examined the connection establishment delay of a piconet for different number of devices ranging from 2 to 50 for various RB delays (0-63, 0-255, 0-1023) with our self-developed C/C++ Bluetooth simulator (Figure 2). The average connection establishment delay is shown to reduce to 40-350ms in frequency freezing method, while it reaches over 10s in the specifications.

The present and future developments in wireless technologies are expected to transform the structure of telemedicine services from its current static networks to highly mobile wireless networks. Mobility requires fast enough connection setup times and data transfer speeds compared to mobility speed and there are technical drawbacks to fast direct connection setup between monitoring devices and the healthcare providers in wireless networks, especially for Bluetooth enabled wireless devices. However, the high connection establishment delay of the Bluetooth technology currently limits its usage to static or low mobility telemedicine services.

The proposed method enhances the discovery time, shortening the waiting time of a patient from about 2s to 0.05-0.5s for any Bluetooth enabled medical device to connect and be ready for communicating patient health information. The proposed method solves the demand for more flexible and more mobile Bluetooth-based wireless telemedicine user-end networks and transforms Bluetooth into a candidate technology for mobile telemedicine applications.

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Conflicts of interest.—The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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