WRife: A Wireless Epidemic Data Collection Protocol Suitable for Medical Monitoring

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Abstract

In modern hospitals, collection of patients' health related data is one of the major time consuming activities for health-care personnel. Manual process of doing this is monotonous, error-prone, time consuming and well suited for electronic support. In this scenario, wired links provide high reliability and bandwidth but at high cost of installation, and maintenance. In addition to that it is problematic if wired devices are connected to people or equipment when they are mobile. Radio communication channels can potentially reduce cost of installation and enable mobile data collection. However, the selection of transmission power and communication protocol exposes a range of scalability, privacy, integrity, and safety concerns. We propose the integration of a novel composition of cryptographic and epidemic data collection techniques with suitable properties for this problem.

While Wi-Fi and other similar wireless networking standards provide significant bandwidth and range, they require provisioning of substantial mobile power sources and they emit sufficient RF radiation to interfere with closely coupled medical devices, and may even create health hazards. Low power devices provide complementary benefits and pose complementary challenges. While low power radios reduce interference and safety concerns, their range is limited and therefore an extensive infrastructure is required to relay data.

Furthermore, medical telemetry demands a variety of security properties. A system must guard confidentiality through protection against attackers compromising confidentiality by eaves-dropping the communication among wireless devices. Furthermore a system should be resilient against attackers who attempt inject erroneous data in to the system. Finally, medical data can be time–sensitive, and a mechanism must be provided to guarantee that critical samples are transmitted to upload points in a timely fashion.

We propose the use of an epidemic communication protocol for low-bandwidth data collection from medical sensors in non-critical-care contexts. Fixed and mobile radio devices are responsible for disseminating information from medical sensors to server. The incorporation of mobile devices permits their opportunistic use as "data-mules" to transport samples beyond the limited communication radius of short-range devices. Due to epidemic communication, copies of same samples are likely to be present simultaneously on multiple devices and result into waste of bandwidth as well as power. An anti-entropy mechanism is used to erase copies of samples after they are uploaded to the servers. The samples are disseminated in an ascending monotonic sequence. Servers maintain the database in the form of monotonic sequences of health related data. Deletion of unnecessary samples is simplified by maintaining the monotonic order of samples during exchange of data within devices.

Like other peer-to-peer approaches, epidemic protocols are susceptible to information poisoning where attackers inject corrupted control or sample data. Without suitable access-control or cryptographic guarantees, corrupted samples can easily get uploaded to the server without being noticed and valid samples might be lost or replaced with bogus data. Thus integrity of the system can be violated. To guard against this, we employ distinct cryptographic ciphers protect the integrity of protocol and sensor data. The incorporation of time stamps and expiration dates permits sensors, mules, and data collection infrastructure to detect when data is not delivered in a timely fashion. We propose that alarms be used to trigger manual intervention such situations, and thus critical samples can be reliably uploaded in a timely fashion. Thus a patient in critical condition may never stay unnoticed till his/her status becomes fatal. A timely generated alarm helps the system to become aware of a patients' critical condition.