# Demo Abstract: MEDiSN: Medical Emergency Detection in Sensor Networks


JeongGil Ko, Răzvan Musăloiu-E.
Jong Hyun Lim, Yin Chen, Andreas Terzis
Johns Hopkins University

Tia Gao
Walt Destler
AID-Networks

Leo Selavo
University of Latvia



## ABSTRACT

Staff shortages and an increasingly aging population are straining the ability of emergency departments to provide high-quality care. Moreover, there is a growing concern about the ability of hospitals to provide effective care during disaster events. Tools that automate patient monitoring would greatly improve efficiency, quality of care, and the volume of patients treated. Towards this goal, we have developed *MEDiSN*, a wireless sensor network for monitoring patients' vital signs in hospitals and disaster events. MEDiSN consists of *Patient Monitors* which are custom-built, patient-worn motes that sample, compress and secure medical data, and *Relay Points* that form a static multi-hop wireless backbone for carrying patient data. Moreover, MEDiSN includes a back-end server that persistently stores medical data and presents them to multiple GUI clients. MEDiSN's heterogeneous architecture enables it to address the compound challenge of reliably delivering large volumes of data while meeting the application's QoS requirements.



## Categories and Subject Descriptors

C.2.1 [**Network Architecture and Design**]: Wireless communication

## General Terms

Design, Experimentation, Performance

## Keywords

Sensor Networks, Physiological Monitoring, Collection Tree Protocol, CC2420 Security


## 1. SUMMARY OF MEDISN

The increasing size of the aging population [1], nursing staff shortages [2], and decreasing hospital capacities [3] suggest that the current level of patient care may decrease in the future. Furthermore, lack of resources and communication infrastructure can also prevent care givers from saving lives in disaster response scenarios in which hospitals' emergency departments are overloaded with critical patients. Additionally, when mass casualties occur there should be more efficient ways to monitor the health status of both first responders and the wounded victims.

In response to these challenges, we have assembled an interdisciplinary team of researchers and practitioners to develop a Wireless Sensor Network (WSN) system with the goal of automating the health monitoring process both in hospitals and for mass casualties. Figure 1 provides an overview of MEDiSN comprising a set of *Patient Monitors* (PMs), *Relay Points* (RPs) and a *Gateway*. PMs are motes equipped with medical sensors (e.g., PulseOx, ECG, etc.) which record the patients' vital signs. The PM's processing core is the Sentilla Tmote Mini which combines a Texas Instruments MSP430 microcontroller with a TI/Chipcon CC2420 low-power radio in a mini-SDIO form factor. Unlike previous proposals, our system includes a dedicated wireless mesh infrastructure of RPs that relay the PMs' measurements. This makes MEDiSN capable of scaling up to monitor a high number of PMs and be used in mass casualty scenarios where many individuals should constantly be monitored.

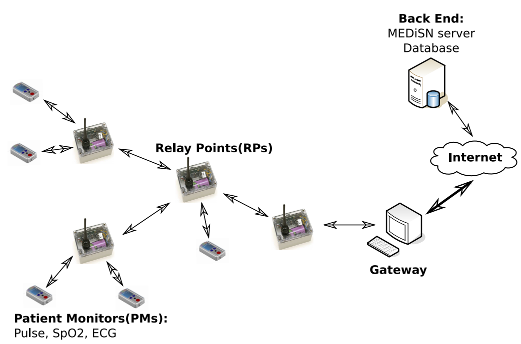


**Figure 1: The MEDiSN Architecture, including multiple Patient Monitors (PMs) that collect patients' vital signs, Relay Points to forward the data and a gateway to collect individual measurements from PMs and send management commands.**

To design a system for use in medical care several things should be considered. First, the privacy of patients' data must be protected. We achieve this by performing end-to-end encryption and authentication of PM data. Second, due to the large volume of data that medical sensors may generate (for example, ECG is sampled at 250Hz), the measure-

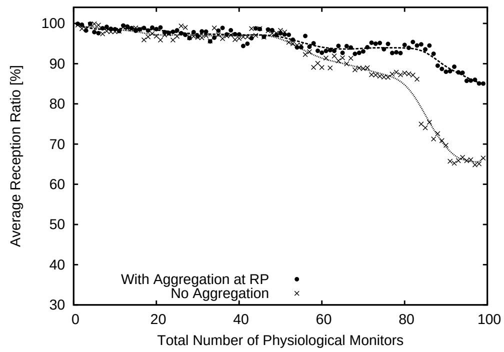


**Figure 2: Tossim experiment showing the average reception ratio of packets with and without aggregation at the RPs.**

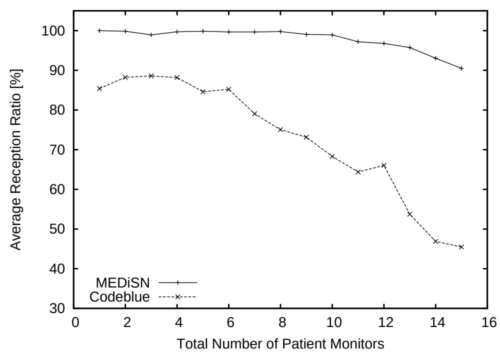


**Figure 3: Performance comparison with CodeBlue.**

ments must be compressed to conserve network bandwidth. For this, we have compared several lossless compression algorithms and found that the delta compression algorithm offers the best combination of high compression ratio and low implementation complexity. Therefore, we introduce a new delta compression scheme that is suited to compress ECG signals by detecting the waveform of ECG signals.

We use the Collection Tree Protocol (CTP) [4] as the main routing infrastructure for delivering PM measurements to the gateway. We enhance CTP with a mechanism to deliver commands from the gateway to individual PMs. Data flowing in both directions are protected by hop-by-hop retransmissions. Furthermore, we improve the system's capacity by optimizing the MAC back-off timers that RPs use, considering that they consistently forward large amounts of data. Finally, we have implemented an RP selection mechanism which ensures that PMs stay connected to the wireless backbone even when they are mobile.

## 2. PRELIMINARY RESULTS

Figure 2 shows the scalability of MEDiSN when transmitting only the essential information needed to monitor health of individuals. Tossim results show that when sending data every second from each of 80PMs, over 90% of the data sent from PMs reach the gateway with the help of aggregation techniques implemented on top of CTP.

Figure 3 compares MEDiSN with CodeBlue [5] in an indoor environment with variable number of PMs. In this test each PM generates 115 byte packets at a rate of 3Hz. Additional results of MEDiSN from a prototype implementation and simulations indicate that MEDiSN can achieve high levels of network utilization and that hop-by-hop retransmissions can effectively mask the effects of collisions and interference. Furthermore, we see that the proposed system can sustain high data delivery ratios even when the PMs are mobile.

## 3. DEMO DESCRIPTION OF MEDISN

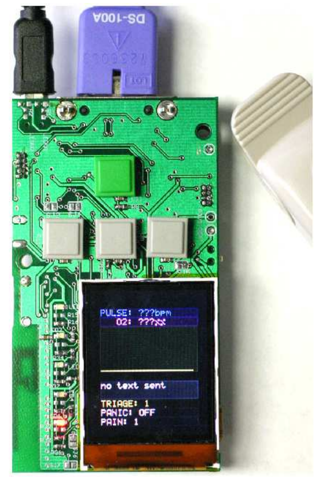

**Figure 4: Custom vital sign collecting hardware developed for MEDiSN.**

Through the demo the authors will show the effectiveness and applicability of MEDiSN in real life. The demo will consist of one laptop as the gateway, several RPs and multiple PMs. The gateway mote and RPs will be Tmote Skys and the PMs will be custom made physiological monitors such as the device shown in Figure 4. The PMs will be mobile and will establish a twoway communication with the gateway using the RP's infrastructure. The demo will also show that the procedures of placing RPs can be done in a simple yet efficient way.

## 4. REFERENCES


[1] W. C. Mann, "The Aging Population and Its Needs," *IEEE Pervasive Computing*, 2004

[2] American Association of Colleges of Nursing. Nursing Shortage Fact Sheet. Available at: `http://www.aacn.nche.edu/Media/Backgrounders/shortagefacts.htm`, March 2004.

[3] The Center for Disease Control. Press Release: Visits to U.S. Emergency Departments at All-Time High; Number of Departments Shrinking. Available at:`http://www.cdc.gov/od/oc/media/pressrel/r050526.htm`, May 2005.

[4] R. Fonseca, O. Gnawali, K. Jamieson, S. Kim, P. Levis, A. Woo, "The Collection Tree Protocol (CTP)," *TEP 123 Draft,* 2006

[5] D. Malan, T. Fulford-Jones, M. Welsh, S. Moulton, "CodeBlue: An Ad Hoc Sensor Network Infrastructure for Emergency Medical Care," *in proc. International Workshop on Wearable and Implantable Body Sensor Networks,* 2004.