Medicare system

Chelsea Chen
Sam Kim

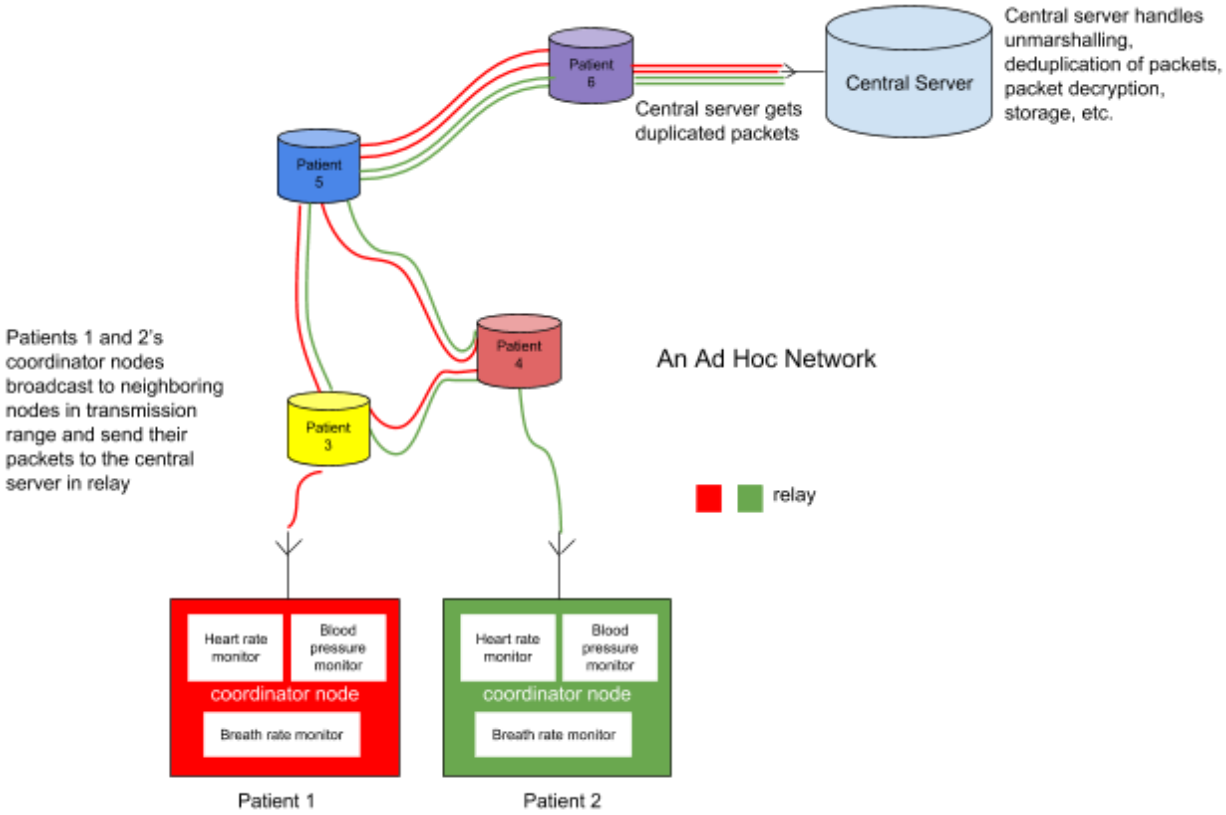
Project Description

In a hospital or patient care system, responding quickly to changes in patient's health and taking appropriate actions is very important. Although high precision medical devices that measure the state of the patients, such as vital monitors, are very useful in identifying patients' state of health and are heavily used in hospitals, they wouldn't be of much help if doctors or nurses don't get notified of sudden needs of critical care.

Therefore, the motivation of our project is to build a medicare communication system with these medical devices using wifi communication. Data gathered from the medical devices would get transmitted to other nodes, such as a central hospital tablet or a mobile device (eg. a phone). Doctors and nurses can get alerted to critical changes in patients' state of health by simply monitoring nodes within this communication system.

The system would have to be secure and reliable. Since medical data is private information, we will explore CDMA to add security in transmitting packets. Reliability and fast transmission is also a requirement in the system, and thus we'll explore TDMA in that regards. There will be tradeoff between using CDMA and TDMA, ie. security and fast transmission.

System Diagram



Project Motivation

- Real world problem: **Continuous monitoring** and **secure transmission** of patient vitals while allowing patients to **move freely** in the absence of reliable wireless infrastructure.
- Project implications
    - data resiliency, fault tolerance for **"*continuous monitoring*"**
    - CDMA, end-to-end encryption for **"*secure transmission*"**
    - ad-hoc network for **"*mov[ing] freely*"**
        - TDMA (burst transmission) for energy efficiency

Project details

- To simulate a hospital environment, we'll use 3 to 4 packet sending nodes, where each node has its set of medical data (ECG, EMG, etc) and the nodes themselves can simply be laptops.
- In our attempt to simulate the hospital environment, we will treat each raspberry pi as a node in the ad-hoc system. Each node represents a potential patient that has vital information (hard-coded, fake data) to send out.
- Hardware for data transmission:
    - Raspberry Pi
    - Laptops

Main Learning Opportunities

- **Ad-hoc networking**
    - Setting up a mesh network using B.A.T.M.A.N. with Raspberry Pis
    - Stretch goal: Algorithm to find and use the minimum path
- **TDMA vs CDMA**
    - Emulate TDMA and CDMA as a way to send patient sensor data and compare based on a few metrics:
        - Bit rate (Important to be alerted of a patient's critical conditions ASAP)
        - Security (Very important to keep patient data secure over the air)
        - Energy efficiency (So patients can roam freely longer without having to recharge)
    - Pros for TDMA
        - In the paper we looked at, TDMA makes the most sense because there are a fixed number of sensor nodes trying to send data
        - TDMA can have very high bit rate
        - TDMA is inherently energy efficient
    - Pros for CDMA
        - CDMA is more secure (less susceptible to packet sniffing)
        - CDMA can be better for a flexible number of sensor nodes (the paper assumed each patient has 4 vitals; but in the real world, different patients will need different vital measurements)
- **Error encoding**
    - Experiment with different data resiliency techniques to improve wireless range
- **Stretch goal #1: Smarter path routing**

    - Minimum path loss algorithm
    - Packet prioritization
- **Stretch goal #2: Localization**
    - Determine location of patients

Milestones

Checkpoint 2 - Already completed

1. Create a wifi “wrapper” around the medical devices. These are laptops with sample medical data sent through raspberry pi’s using wifi.

2. Update proposal to include more features - from stationary nodes to mobile nodes.

Milestone 1 - Setup relay hopping

Deadline: Wed 11/28

1. Use 4 Raspberry Pi’s and set up an ad-hoc mesh network using B.A.T.M.A.N. open mesh network setup for Pi’s.

2. Successfully transmit a packet from source to destination node.
    a. [Source] → [Relay Node A] → [Relay Node B] → [Destination]

3. Measure packet loss, reliability with/without the ad-hoc network.
    a. Expected results are that the ad-hoc network allows greater range without packet loss so patients have greater mobility/freedom.
    b. We intend to include these results in our poster session.

Milestone 2 - Comparison between CDMA and TDMA

Deadline: Sun 12/2

1. Set up CDMA on source/destination nodes and perform measurements.
    a. Encryption/decryption on source/destination nodes.

2. Set up TDMA on source/destination nodes and perform measurements.
    a. First specify a fixed number of nodes.

3. Compare CDMA/TDMA on 3 metrics: Bit rate, security, and energy efficiency

Milestone 3 - Extending wireless range with data resiliency and fault tolerance

Deadline: Wed 12/5

1. Add more metadata (data length, data, location, resiliency overhead, etc) to each packet to reduce data loss in relay.

2. Add data encoding (parity bit) to the packets and perform error checking at the destination.

3. Record any noticeable range improvements from any strategy used for marshalling/unmarshalling packets.

Stretch goals - Optimizing and extending the system.

- Smarter path routing
    - Save bandwidth by finding minimum path from source to destination, instead of wastefully broadcasting to everyone
    - Prioritize critical, urgent patient data by including some kind of priority levels in the packets and implementing a prioritization algorithm in relay nodes

- Tracking the patient's location
    - Might be useful in large hospital settings where patients can get lost
    - Use localization techniques used in class
    - Either use triangulation or work backwards from FSPL

- Improved encryption techniques
    - Beyond CDMA, additional encryption techniques

- Set up thresholds and SMS alert services on the server backend
    - Just for completeness
    - Not too important and not very related to 18-452/750 topics

References

- A Hospital Healthcare Monitoring System Using Wireless Sensor Networks
- Security Issues in Healthcare Applications Using Wireless Medical Sensor Networks: A Survey
- B.A.T.M.A.N. Mesh Network