Internet of Things Device for a Safer, More Efficient Medical Asset Management System

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Objectives

- Enhance patient safety by reducing medical equipment malfunctions
- Enable hospital staff to perform predictive maintenance
- Eliminate time wasted searching for equipment
- Collect valuable equipment operation statistics for asset managers

Background

- Healthcare providers face a number of asset management challenges, including the need to reduce operating costs and eliminate the risks posed to patients by medical equipment failure
- At least 50,000 serious adverse events are caused by medical devices annually in the US, with over 3,000 of such events being patient deaths [1]
- The FDA has called for improvement in medical device surveillance across the country [2]
- Nurses spend between one and six hours per shift searching for equipment [3]
- Advancements in industrial asset management may hold the solutions to these healthcare challenges. Such advancements include:
  - *Predictive maintenance*, whereby the behavior and environmental exposure of equipment are monitored so that failure can be addressed before it materializes
  - *Real-time location systems*, which use Internet of Things technology to keep track of asset location within a facility

PatSTARS Module

With support from the LMI Research Institute, this project led to the development of the Patient Safety Tracking and Reporting System (PatSTARS). The core of this system is the PatSTARS module, a small, light-weight device which, once affixed to a medical asset, tracks the operating conditions of that asset. The major design features are described below:

Environmental Monitoring

- PatSTARS module measures *temperature*, *humidity*, and *atmospheric pressure*, as extremes in these conditions can cause immediate damage to equipment, and suboptimal conditions can degrade assets over time.
- PatSTARS module also detects *vibration* along three axes which is vital for detecting impending malfunctions in equipment with moving parts. This can also help alert staff to equipment mishandling.

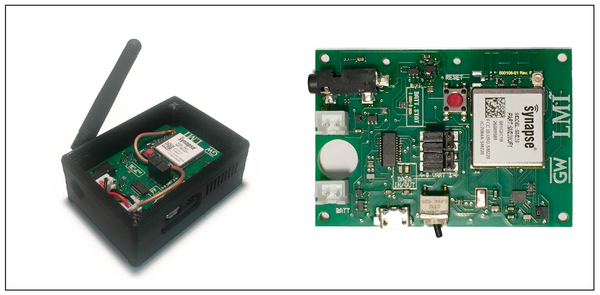

Figure 1: PatSTARS module *(left)*; internal circuitry *(right)*

Location Sensing

- Room-level location reporting is achieved by polling strategically placed stationary nodes.
- PatSTARS module uses an altimeter to determine facility level/floor, reducing system infrastructure by up to 67%.

Current Monitoring

- PatSTARS module is compatible with an external, non-invasive current sensor, enabling it to detect power spikes and fluctuations that may damage equipment.
- This enables the tracking of equipment *usage and operating hours*, two sets of information crucial to improving asset management strategy.

Additional Features & Functionality

- Qi wireless charging
- Sleep cycles to extend battery life
- AES-128 encrypted communication
- U.FL antenna for improved range
- SNAP operating system enables Python programming
- 3D printed case made of ABS plastic

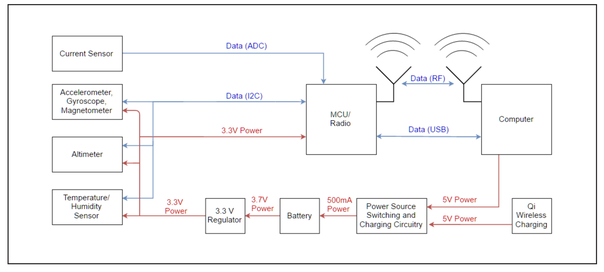

Figure 2: PatSTARS module block diagram

Network

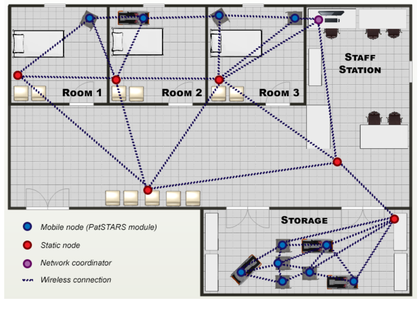

Figure 3: Example PatSTARS network configuration

- Ad hoc, mesh topology for maximum flexibility
- Network coordinator transmits instructions to modules and stores collected data
- Independent from existing wireless infrastructure
- 2.4GHz communication enables functionality internationally
- Stationary nodes are used both for location sensing and to bolster network reliability

Ongoing Work

- Definitive predictive maintenance algorithms for different types of equipment
- Additional memory for *store-and-forward* capability
- Multi-mesh communication across healthcare networks
- Passive RFID capability for straightforward module substitution without interruption to data collection
- Longer battery life or battery-free

Case Study

- A limited version of the PatSTARS system is currently deployed in the field in order to generate the data required for the development of a robust predictive maintenance algorithm
- Included below are samples of data collected so far. More data collection and analysis remains to be done before results may be considered definitive.

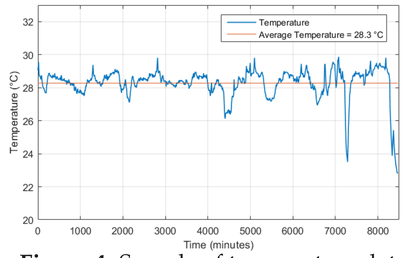

Figure 4: Sample of temperature data

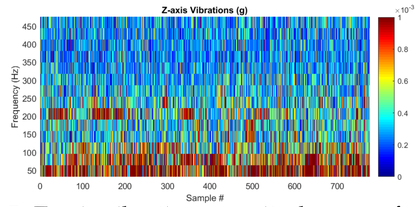

Figure 5: Z-axis vibration magnitude across frequencies

Conclusions

- This project demonstrates a proof of concept for the adoption of predictive, condition-based maintenance in healthcare facilities.
- PatSTARS will reduce operating expenditures by reducing unnecessary maintenance and time-wasting searches for equipment
- PatSTARS will save patient lives by detecting damaging conditions before equipment malfunctions occur
- Impact extends beyond domestic hospitals, as the system is especially suitable for rugged settings, such as military combat bases and medical facilities in developing countries

References

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