Poster: Towards a Flexbile Network API for Fat In-body Communication

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Abstract

The human body's fat tissue can be used as a communication channel for radio frequency-based communication. As this channel supports high data rates, it enables many applications. Since these applications have very different requirements, there is a need for a flexible network API. We present some basic ideas for such an API.

1 Introduction

Already in 2005, 25 million US citizens were relying on implanted medical devices such as pacemakers for life-critical functions [5]. This number es expected to increase as new application areas for implanted medical devices such as drug delivery systems, intracranial pressure monitoring devices and artificial kidneys are emerging. These implanted devices will also be networked, as more and more (elderly) people have multiple diseases that can benefit from implanted devices.

We have recently shown that the human body's adipose (fat) tissue can be used as a communication channel for radio frequency (RF)-based communication [1, 2]. We call this communication channel Fat-IBC. As adipose tissues retain less water than muscle and skin, they have a lower dielectric constant which means that radio waves travel better through adipose tissues than muscle and skin. As shown in Figure 1, muscle and skin also act as a waveguide for fat communication.

One major advantage of this approach is that it can support higher data rates [2] than other in-body communication methods such as capacitive and galvanic coupling. This capability enables the support of multiple sensors and, in the long run, facilitates more data-intensive applications like electronic arms and brain-to-machine interfaces. Furthermore, coupling out signals at low power from inside the human body is impossible from many locations. Therefore, a communication channel within the human body will allow to transfer in-body data to a location from where it is easy to couple out the signal.

In the newly started BOS (Body Operating System) project, we aim to create a cross-platform, modular, and energy-efficient software toolkit for developing body computing ap-

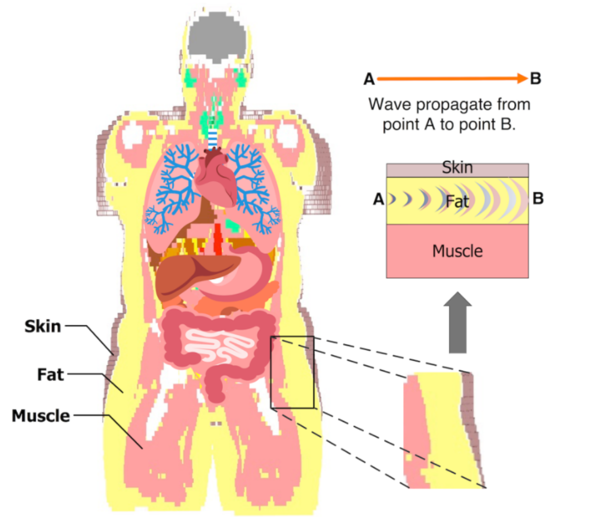

Figure 1: The fat tissue can be used for communication within the human body. Fat is typically situated between skin and muscle that act as a waveguide.

plications that employ sensors and actuators in and on humans, as well as computing platforms outside of human bodies. We assume that many of these sensors and actuators are implanted and communicate via Fat-IBC. While these devices are severely resource-constrained, other on-body devices may possess more resources.

2 Need for a flexible API

Fat-IBC requires an API that is flexible for several reasons. Applications and devices that use Fat-IBC have very different requirements. For example, a deeply implanted device such as an artificial organ may provide some status data. As such a device is severely energy constrained, data must be transferred at an energy cost as low as possible. Other devices may not be as deeply implanted and are hence less energy-constrained. In applications such as bionic arms where a hand prosthesis receives data from a brain-to-machine interface, low latency and high data rates are required.

Another interesting application is to use Fat-IBC for sensing. Figure 2 (from [6]) shows the simulation results from a scenario where a tumour or another perturbant is growing. The results demonstrate that as the tumour grows, the RSSI at the receiver decreases. Monitoring such a decrease over time enables the detection of, for example, a tumour relapse [7]. We

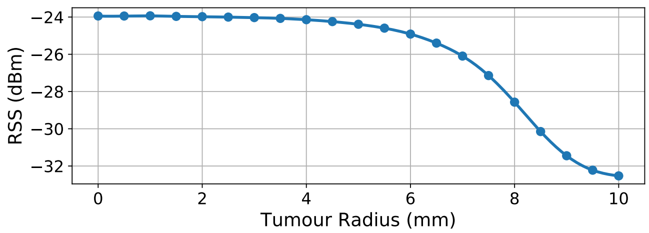

Figure 2: Simulation Result. As the tumour grows, the RSSI decreases. Monitoring this decrease over a period of time reveals the presence of the tumour/perturbant in the channel.

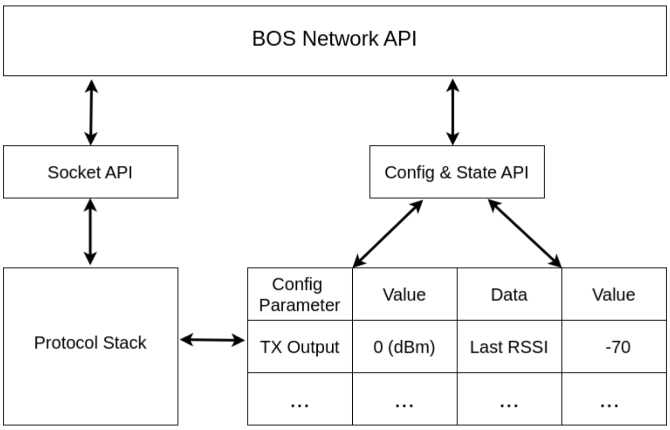

Figure 3: BOW'S Network API. We aim at supporting a traditional Socket API as well as flexibility by separating protocol logic and configuration. The latter also allows for optimization based on collected data.

have earlier devised mechanisms to perform such tumour detection in a privacy-preserving manner [6]. This requires frequent changes of the transmission power. Moreover, the fat tissue that is used for communication may deteriorate over time, for example, when a person ages. Therefore, it is necessary to record and store information about the performance of the channel, for example, in terms of received signal strength.

3 Towards a Flexible Network API

POSIX-based APIs offer benefits in terms of portability, compatibility, reusability, familiarity, and interoperability. Therefore, we believe that it is beneficial to provide a Socket API through which networked applications send and receive data. In addition, we need the flexibility described in the previous section. Hence, our overall API supports both a Socket API and provides support for configuration and optimization. Our ideas for a flexible architecture are depicted in Figure 3. It is inspired by Finne et al.'s [4] Chi and the APIs for SDNs [3]. The latter offers APIs that allows applications to retrieve data collected by the network through SDN's northbound APIs. After performing optimizations on this data, for example, traffic engineering applications in data centers may optimize the traffic engineering policies in order to minimize power consumption and link congestion [3].

Chi has been designed to enable cross-layer optimizations in wireless sensor networks while avoiding an unmodular cross-layer design. The key idea and insight behind Chi is that protocol logic is separated from protocol configuration data in order to make it possible to alter the configuration without having to change the logic. Configuration data is stored in a central component called a blackboard that is accessible to all protocol layers. Applications or protocol layers can subscribe to certain parameters and get notified when these parameter change.

Figure 3 outlines our basic architecture. As in Chi, this architecture features a central store, a blackboard, to store configuration parameters and data. We separate between configuration parameters such as the transmit power of the radio as well as data or state, for example, measured RSSI values. The data can be stored in the blackboard itself but the blackboard can also hold a handle to a data store. The latter could also be placed in a less resource-constrained device that has the power and computing capabilities to perform optimizations. The data as well as the optimization parameters can be retrieved through the BOS Network API. This is important as a BOS system may comprise of both very resource-constrained implants but also less resource-constrained devices that are on the body.

4 Conclusions

We have presented the outline of a network API for BOS. A BOS system may contain very resource-constrained implants and more powerful devices. Implants communicate via Fat-IBC, and may have very different requirements in terms of bandwidth and data rate. To support such a variety of demands we combine a traditional Socket API with a flexible blackboard inspired by architectures that enable configuration and optimization across various protocol layers and on collected communication state.

Acknowledgements

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