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WiseSkin RTD 2013

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WiseSkin Communication Protocol: A Novel Approach for High Density Wireless Sensor Networks

C. Rojas[1,2], J. Decotignie[1,2] and J. Farserotu[1,2]

[1]Centre Suisse d'Electronique et de Microtechnique (CSEM), [2]École Polytechnique Fédérale de Lausanne (EPFL)

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EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

The WiseSkin concept for tactile prosthetics targets the restoration of a natural sense of touch to persons using prosthetics. A sense of tactility is needed for providing feedback for the control of prosthetic limbs and to perceive the prosthesis as a real part of the body, this creates a sense of "body ownership". Our aim is to develop a high density wireless sensor network embedded in an artificial skin that offers scalability, robustness, ease of use and manufacturability. In order to enable a realistic sense of tactility, the communication protocols (MAC and routing) must meet challenging targets in the latency, data rate, scalability, power and flexibility. We present the comparison of our proposed routing protocol (via OMNET++ simulations) with an ideal protocol and the previous solution for our platform.

Objective

Design the routing and MAC protocols to enable the wireless communication of tactile events in WiseSkin [1].

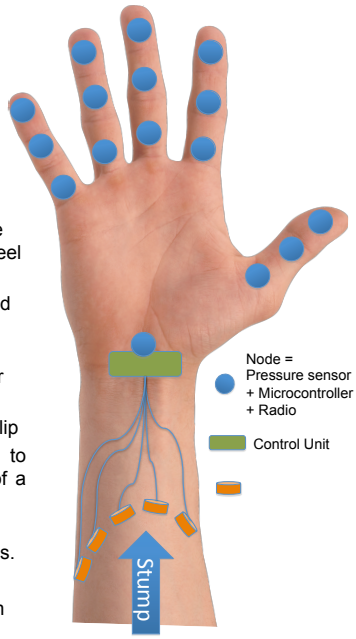

Figure 1. WiseSkin concept for prosthetics.

Challenges

The system must react to tactile stimulus and allow the user to feel it realistically, which requires:

- A sensor-to-sink latency bound smaller than 20 to 50 ms.
- Supporting a sampling and update rate up to 1000 Hz per sensor in case of slip.
- Distributed measurement of slip
- Support for networks of 10s to 100s of nodes in the palm of a hand.
- Capacity to handle total data volumes of 24 kbps - 2.4 Mbps.
- Low power consumption.
- Handle the fast transition from low traffic, when the skin is inactive, to traffic surges, that can generate congestion, upon stimuli.

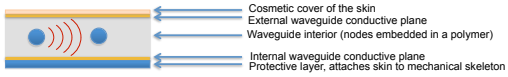

Figure 2. Transversal view of the WiseSkin system

Strategy

- Adapt to changes in the traffic.
  - Under high traffic, communicate only the important tactile events with high reliability.
- Design a MAC and routing protocols to cope with the variability of the traffic.
- Reduce the latency and support the distributed measurement of slip.

Status

- Developing a proactive (Node Initiated) routing protocol with high reliability.
- Testing the embedded code with simulations (OMNET++ [2]) and a real deployment.

Results

Our routing protocol was compared with an Ideal protocol and the previous solution for our platform:

- Node Initiated: Each node proactively searches and optimizes the route to the sink by exploring its neighborhood. **This is our proposed protocol**. It is also fully distributed.
- Centralized Processing: A server with error-free and instant access to the neighborhood information of each node finds the optimal routes to the sink (ideal protocol).
- Sink Initiated: The sink uses a flood transmission that propagates through the network to allow each node to obtain a route. This is the previous solution for our platform.

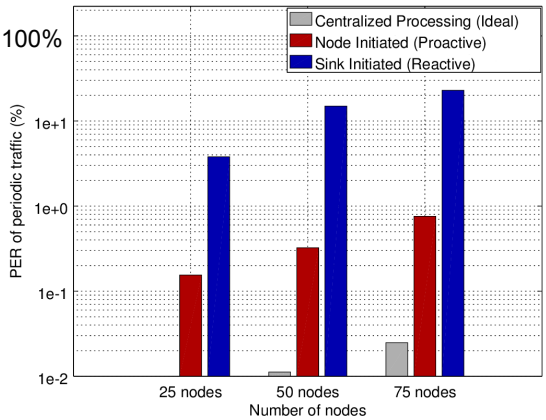

Figure 3. Packet Error Rate as a function of the number of nodes. Conditions: grid topology (OMNET++ simulation)

The results suggests that our proposal (red bar) can achieve a Packet Error Rate that is one order of magnitude smaller than the current solution (blue bar) for all the tested network sizes, while being proactive (mitigates the problems of having a disconnected node). This reduction was achieved by improving the routing metric.

Next Steps

- Test the routing protocol with a hardware deployment.
- Optimize the latency.
- Study traffic reduction techniques.
- Explore MAC schemes that can adapt to traffic variations.

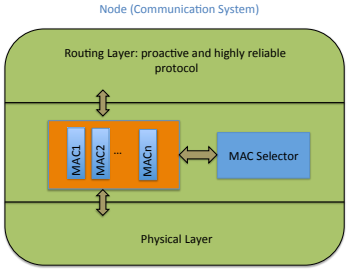

Figure 4. Simplified schematic of the protocol stack of a wireless sensor node with a MAC that can be adapted according to the traffic. This architecture will be tested as a next step.

References: [1] C. Antfolk, V. Kopta, J. Farserotu, J.-D. Decotignie, and C. Enz, "The WiseSkin artificial skin for tactile prosthetics: A power budget investi- gation," in *2014 8th International Symposium on Medical Information and Communication Technology (ISMICT)*, pp. 1–4.
[2] A. Varga *et al.*, "The omnet++ discrete event simulation system," in *Proceedings of the European Simulation Multiconference (ESM2001)*, vol. 9. sn, 2001, p. 185.
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