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

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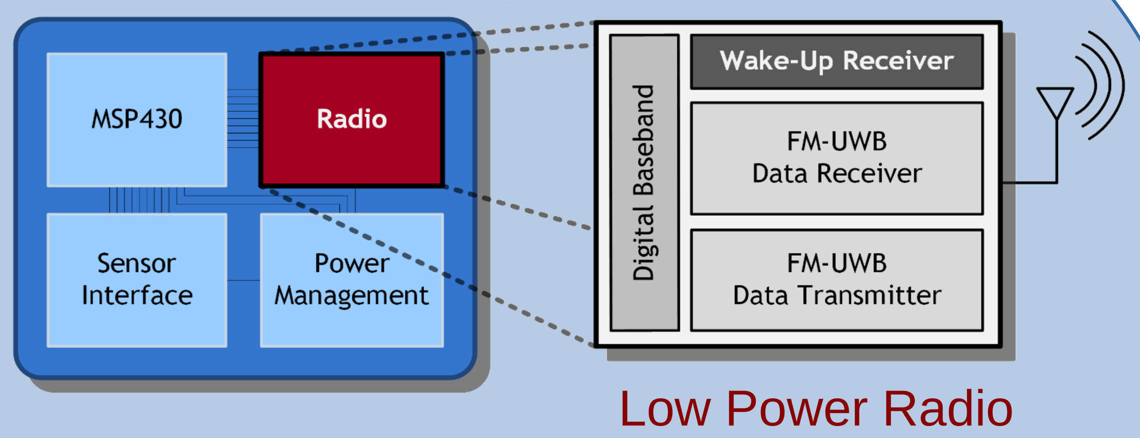
WiseSkin RTD 2013

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". In order to achieve flexibility, freedom of movement and comfort, the sensing capabilities built into the artificial skin must be unobtrusive, highly miniaturized and ultra-low power (ULP). Advances in the fields of micro and nanotechnology as well as biological systems enable ever more powerful miniaturized sensor devices, opening the door to new solutions. 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.

Wireless Transceiver

Objective: Design of a very low-power, miniature transceiver capable of satisfying the throughput and latency needs of the high-density wireless sensor network

Miniature Sensor Node

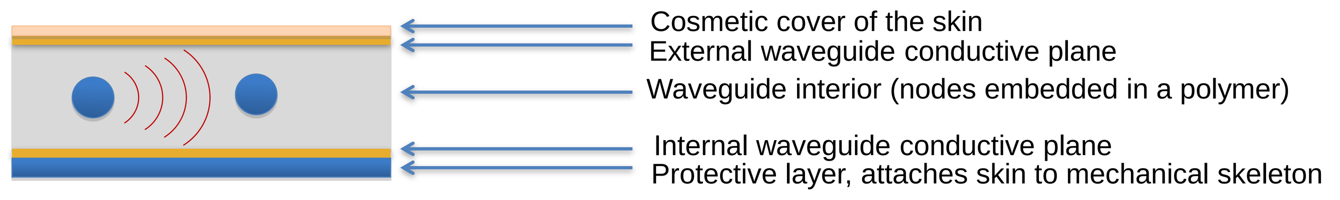


Low Power Radio

- Low Power
- Small Size
- Low/Medium Data-Rate
- Low cost

FM-UWB – solution for HD-WSN

- Spread signal energy over a very wide band
- Robust against interference and frequency selective channels
- Low overhead in terms of synchronization and start-up time (suitable for small packets)
- Does not require high-precision off-chip components such as crystals or BAW resonators
- Simple architecture – easy to miniaturize and integrate into a small sensor node
- Current lowest power implemented receiver consumes only 590 μW
- Demonstrated data-rates up to 1 Mb/s (sufficient for this application)



Preliminary channel measurements conducted at EPFL

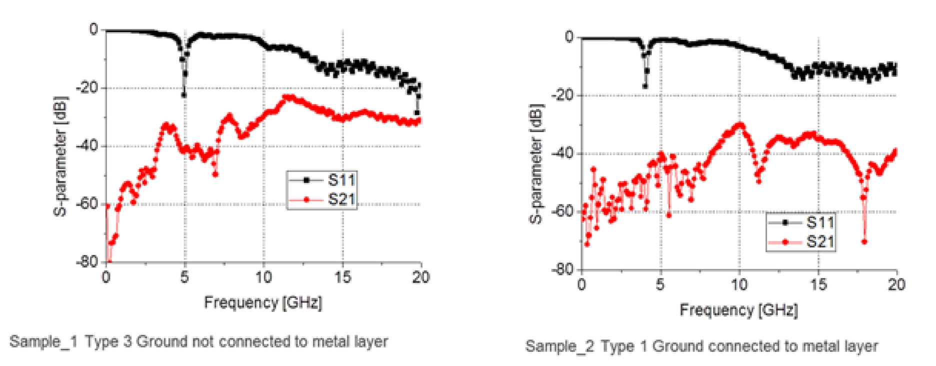


Figure 2. Frequency response characterization of the waveguide (CSEM).

- Preliminary measurements used to estimate channel characteristics (Fig. 2) (geometry and materials might change in the final prototype)
- Miniature antenna dictates the use of higher frequencies for wireless communication to avoid high losses

Next Steps

- Design of dedicated hardware optimized for the application
- Transceiver capable of adapting to existing conditions (ex. dynamically adjust power consumption)
- Implement communication on different channels to ease routing

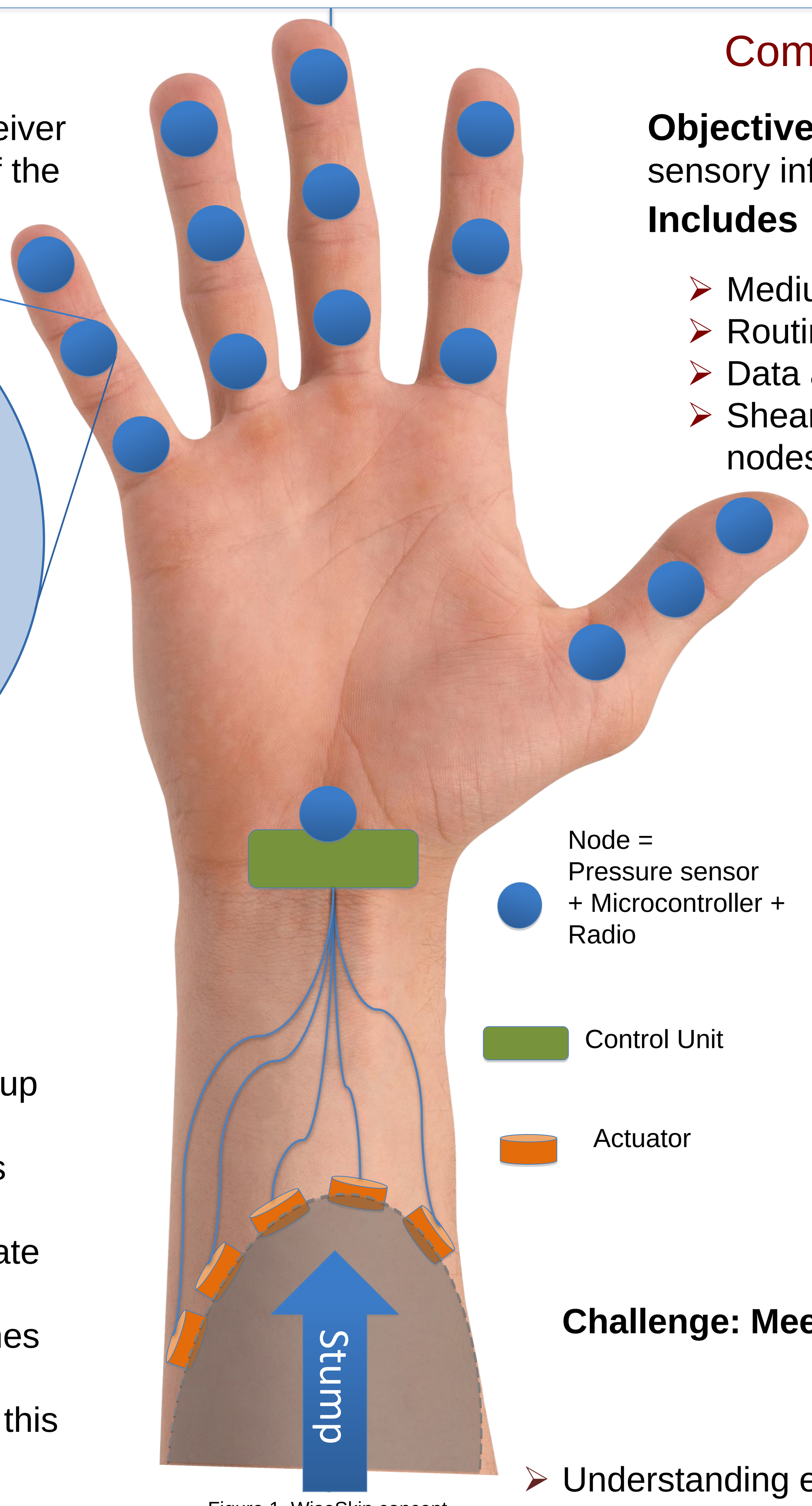


Figure 1. WiseSkin concept for prosthetics

Communication Protocol

Objective: Provide the end-to-end communication of the sensory information to the actuation part

Includes

- Medium access control
- Routing
- Data aggregation/concatenation
- Shear detection through multiple nodes

Problem Statement

- Functional constraints
  - Local communication to detect shear
  - Global communication to transport touch and shear
- Latency constraints
  - To ensure natural response of the prosthesis
- Minimize energy consumption
  - To reduce prosthesis charging frequency and weight
- Scalability
  - Number of sensors will increase
  - Data per sensor will increase (temperature, position, ...)
  - Coexistence with other hands
  - Minimal configuration effort

Challenge: Meet all the previous constraints simultaneously

Status

- Understanding end-to-end unreliability
  - Exploitation of in-house results disappointing
  - Deployments with deficient packet error rates are common in the literature for different platforms
  - New test set up ready (Fig. 3)
    - 1st version: ~6 WiseNodes, multi-hop linear topology
- Identification of bio-inspired features that can be implemented in the comm. protocol
  - Currently analyzing feasibility of identified factors
- Definition and estimation of figures of merit and constraints in the communication system
  - On going

Figure 3. Test bed for understanding the end-to-end reliability

Next Steps

- Experiments with the test bed:
  - Investigate the reasons for high unreliability
  - Simulate in OMNET++
  - Measure the impact of several communication parameters in the Packet Error Rate
- Implement the bio-inspired features in a communication protocol and evaluate its effectiveness
- Extend the definition of figures of merit done in the publication "WiseSkin for Tactile Prosthetics" [2] for different communication scenarios.

References: [1] PNGIMG. hands_PNG929.png [Image]. Retrieved from http://pngimg.com/upload/hands_PNG929.png
[2] C. Antfolk *et al* (2014, April). *WiseSkin for Tactile Prosthetics.* Paper presented at the International Symposium of Medical Information and Communication Technology, Florence, IT.