Intrabody Communication: Applications and Practical Issues

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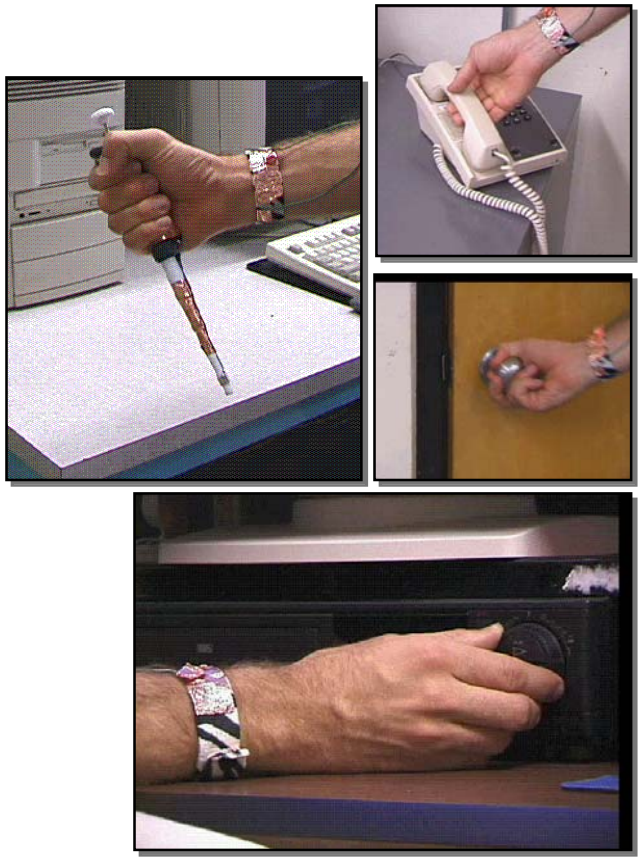
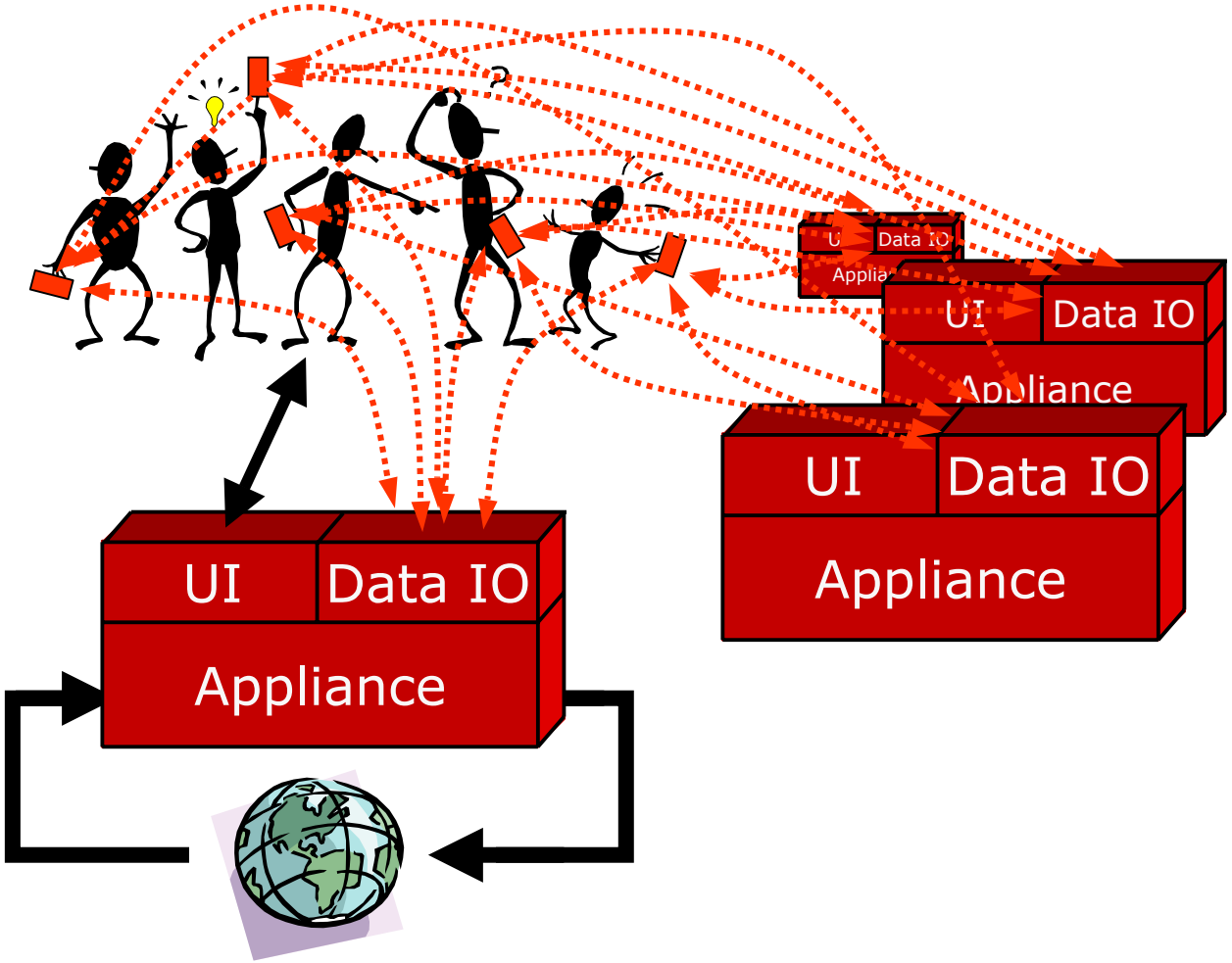
What is Intrabody Communication?

- Low power electrical signals sent through the human body
- Allows ubiquitous and wearable devices to communicate
- The big benefit: signal stays very close to the body



Motivating Ubicomp Scenario: User Association



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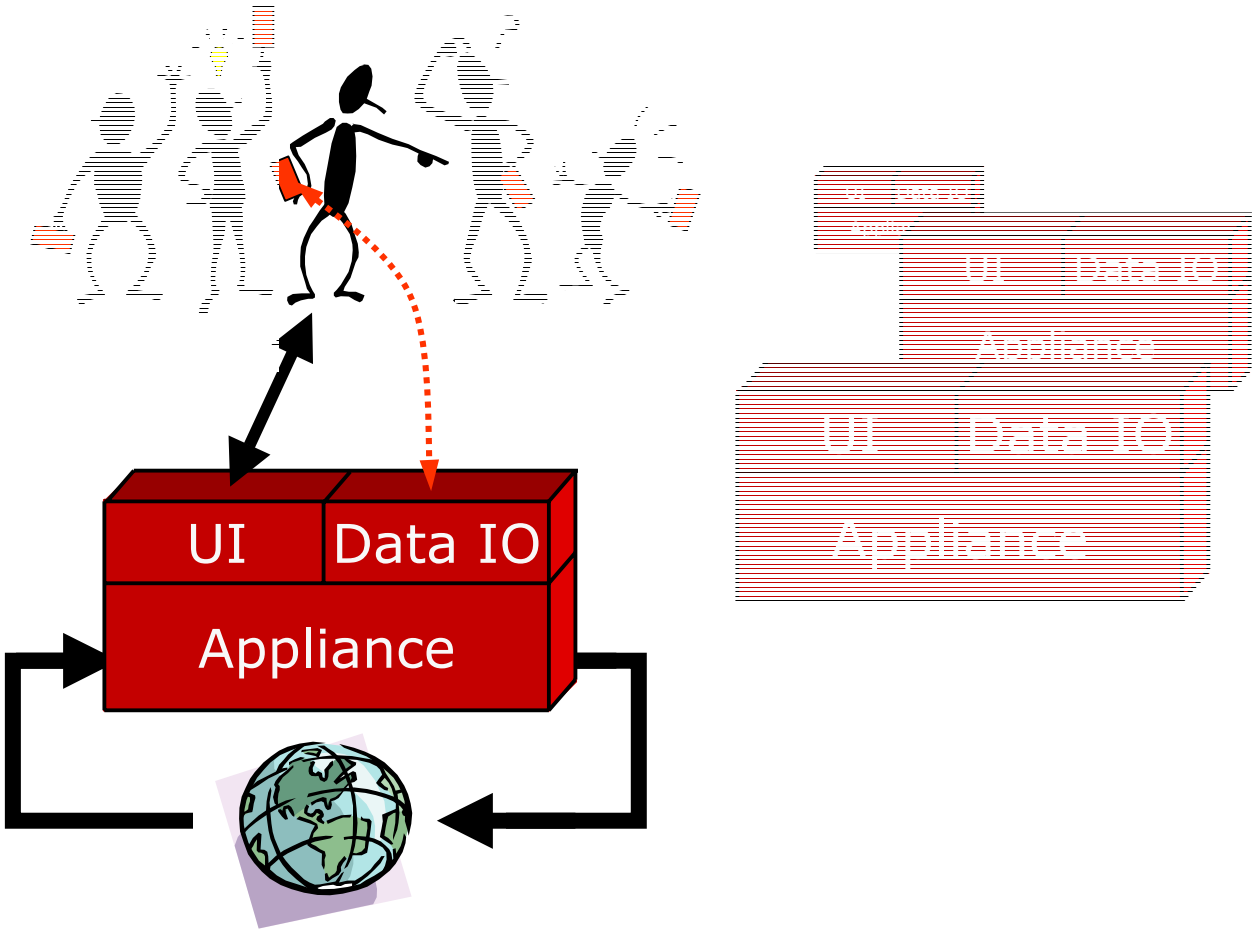
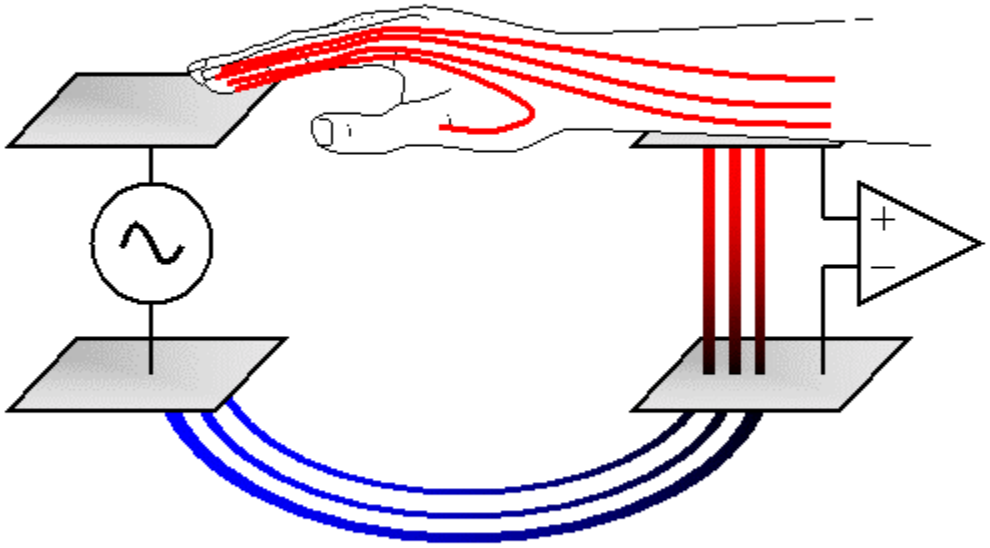
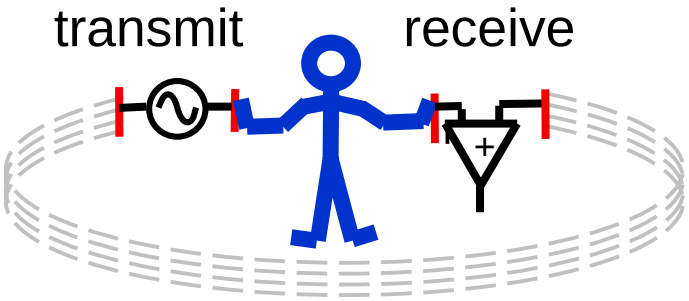
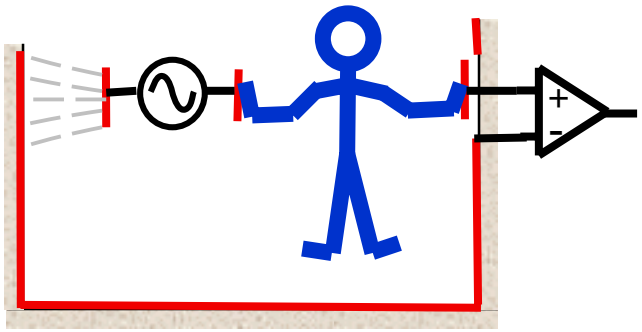


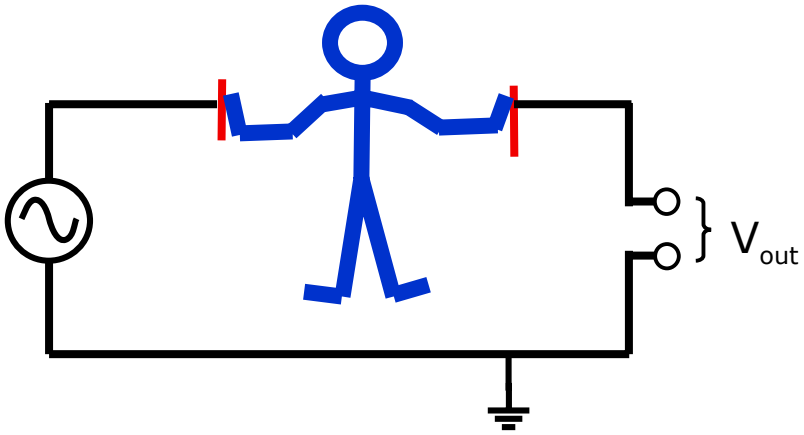
Basic Principles

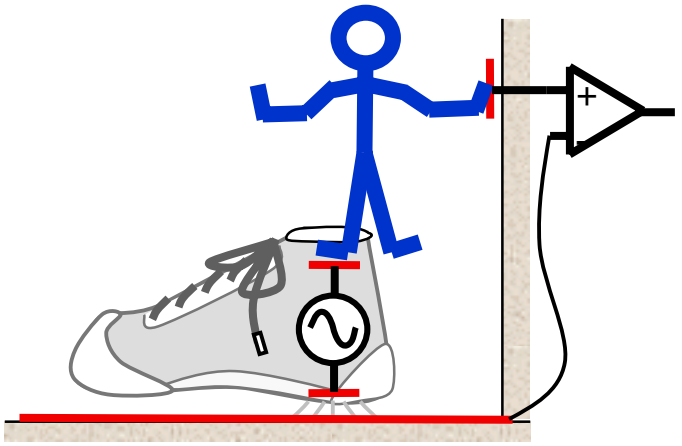


Principles Applied

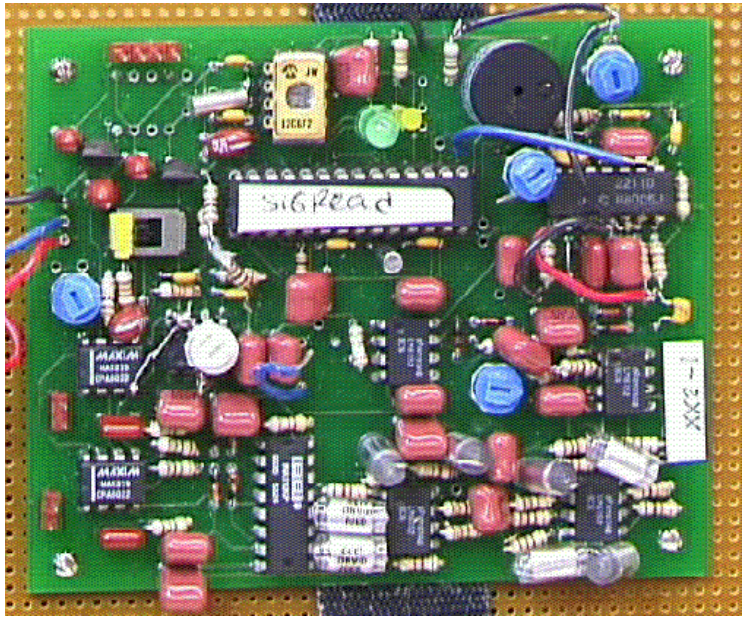








Our Implementation

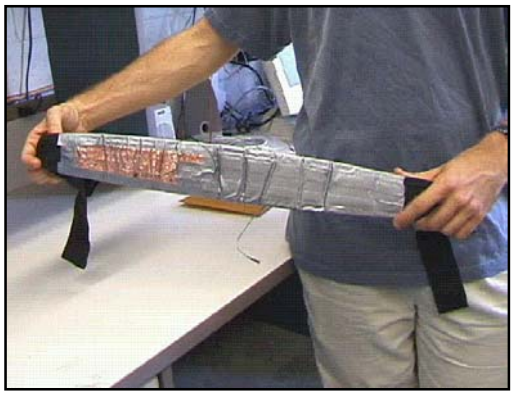


- Size: 8cm x 13cm
- Power: 4 9V batteries
- Data rate: 56 kbps
- Data encoding: FSK
- Frequencies: 140 kHz and 180 kHz
- TX voltage swing: 20V peak-to-peak

Basic Experiment Setup

Coupling to the Body

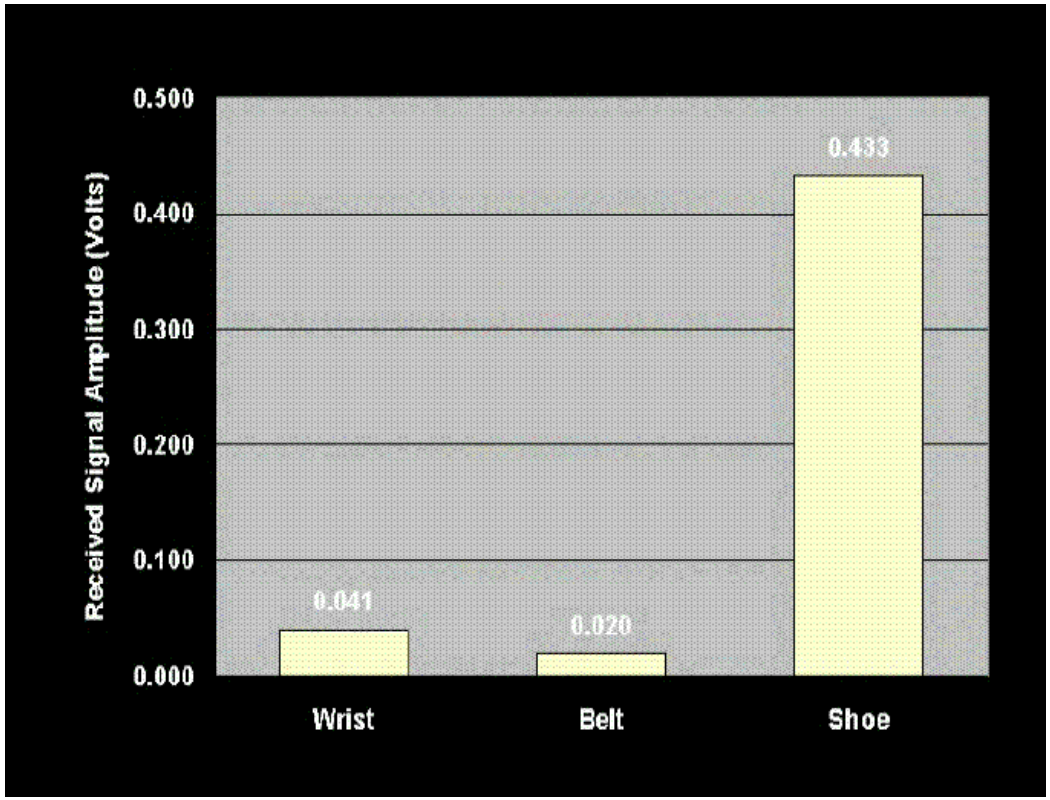
Wrist Strap



Belt

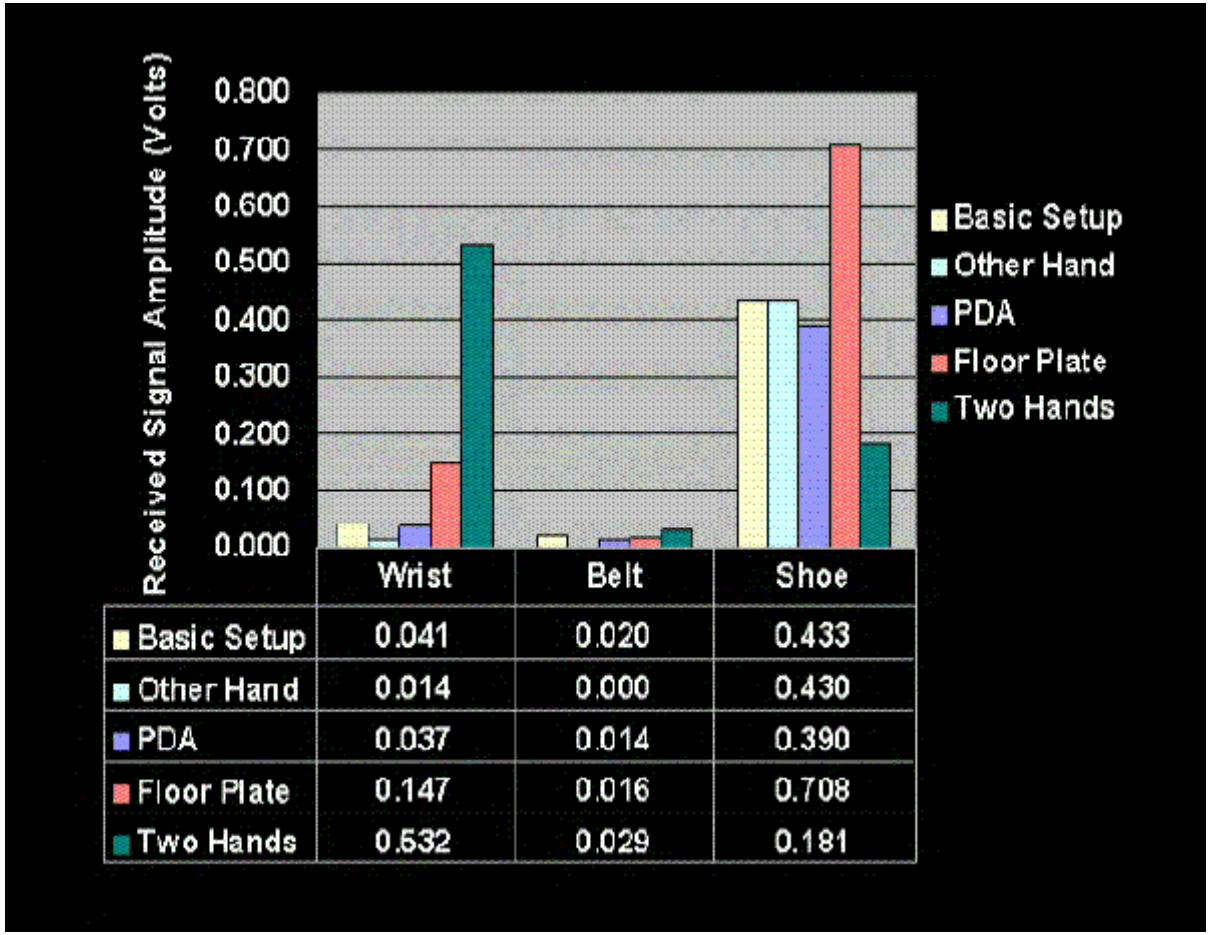
Shoe

Findings



- Minimum signal amplitude for communication: 20 mV

Other Situations



	Wrist	Belt	Shoe
Basic Setup	0.041	0.020	0.433
Other Hand	0.014	0.000	0.430
PDA	0.037	0.014	0.390
Floor Plate	0.147	0.016	0.708
Two Hands	0.532	0.029	0.181

Communication without Touch

- Non-touch communication is undesirable, but it happens
- One trick: reducing transmit voltage
  - Works with the shoe
  - Doesn’t work with wrist and belt because of ground plate impedance variations

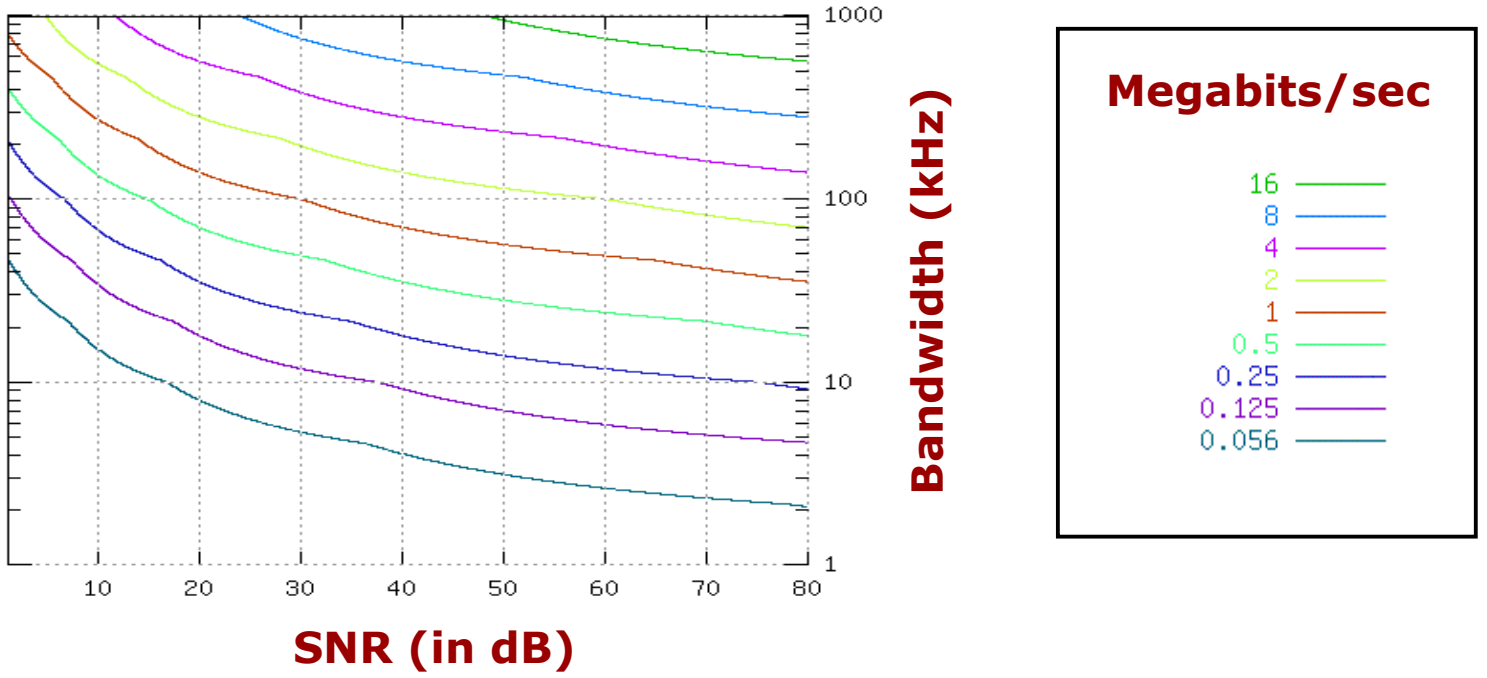
Other Experiments

Experiment	Result
■ Raising shoe	2-5 times weaker signal
■ Changing grounding plate size	large plates roughly similar
■ Gloves	1-2 times weaker
■ Barefoot	little difference
■ Multiple transmitters	distinguished well

Theoretical Maximum BW

- Hartley-Shannon Law: max. error-free capacity:

$$\text{capacity} = \text{bandwidth} * \log_2(1 + \text{SNR})$$



Application Taxonomy

1. Personal Area Networks
2. Collect Data from Environment
3. Customize Environment on per user basis
4. Customize Environment on per user task basis

Competing Technologies

Method	Examples	Features
short-range RF	Bluetooth, RF Monolithics	Ok for PAN, prob w/multiple people, eavesdropping
infrared	IR badges, Eye-R	Problems outdoors, greater power, less intentional
ID at physical user-interface	password, iButtons, RFID, fingerprint, barcode	Passive, customization stored with device, privacy issues, administrative and operational overhead, less inconspicuous

Health Concerns

- Short term:
  - Shock – unlikely
  - Pacemakers – may be affected
- Long term:
  - Cancer – difficult to predict, similar to power-line studies
  - Other effects -- unknown

Future Goals

- Achieve touch-only communication
- Increase speed
- Build a deployable board
- Evaluate in practical environment

Conclusions

- Intrabody communication may provide ubicomp with touch-selective communication
- Watch for new results over the next several months

- Visit us on the web at:
  http://portolano.cs.washington.edu/projects/contact

Other Findings

- Using the other hand with the wrist coupler reduced signal strength by 0.5
- A portable PDA has a weaker signal, but was position-dependent
- Grounding or putting a conductive plate down helps a lot
- Touching both xmit plates generates a strong signal w/wrist and belt only

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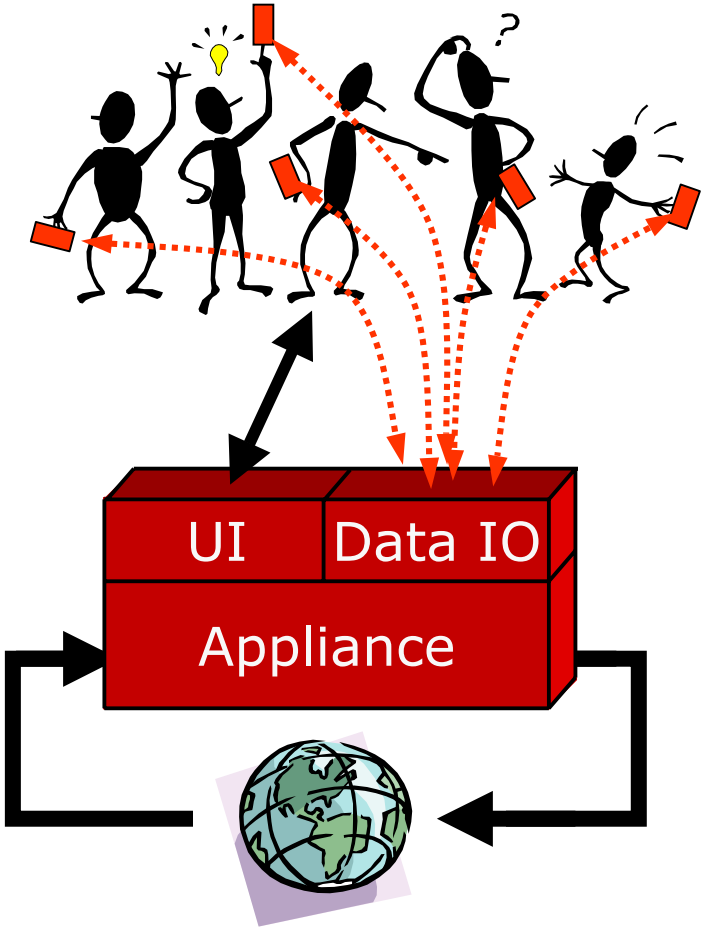

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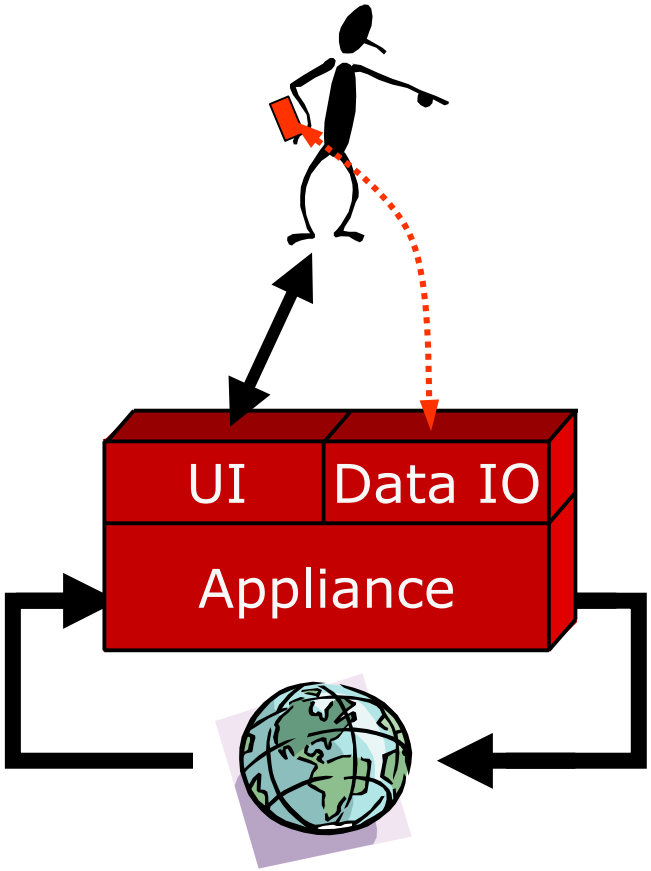

Basic Principles