Implanted User Devices

Gabe Grimley

Division of Science and Mathematics
University of MN, Morris

April 28th, 2014
What are user devices?

Music players, cellular telephones, and other computing devices.
Implanted?

- Theoretically always-available interaction.
- Not visible.
- Never lost.

**IMAGE:** Artificial skin covering prototype device

(Credit: Holtz, et al.)
Early Implanted Devices

Pacemakers
Cochlear Implants
Implantable Cardioverter Defibrillators
Artificial Joints
Early Pacemaker

(Credit: Medtronic)

**IMAGE:** 1958 External Pacemaker
Essential Components:

What are they and how have they affected us?
Printed Circuit Board

Development started in 1903
Patent filed in 1927

(Credit: Wisegeek.com)

IMAGE: Example of a printed circuit board
Hybrid Circuitry

Developed in late 1950s.

Consists of one or more transistor chips and passive components mounted together.

**IMAGE:** Hybrid Circuit covered in orange epoxy
Developed in 1958 by Jack Kilby of Texas Instruments.

Components and chip made out of same block of semiconductor material.

(Credit: JGScraft.com)

IMAGE: Example of a microchip
Communication and Security:

Why is it important?
Heart-to-Heart

*Programmer* - the device to interact with implanted device.  
*IMD* - Implanted Medical Device

**Secure-channel setup phase**

*Secure but unauthenticated communication channel*

*Achieved through contact between Programmer and IMD patient.*

**Authentication phase**

1st: *Physiological Value* (PV) reading taken by both  
2nd: PV readings used as "passwords"  
3rd: If Programmer’s PV = IMD’s PV, access granted  
4th: Authentication achieved
Heart-to-Heart

**Programmer** - the device to interact with implanted device.

**IMD** - Implanted Medical Device

**Secure-channel setup phase**

*Secure but unauthenticated communication channel*

*Achieved through contact between Programmer and IMD patient.*

**Authentication phase**

1st: **Physiological Value** (PV) reading taken by both

2nd: PV readings used as "passwords"

3rd: If Programmer’s PV = IMD’s PV, access granted

4th: Authentication achieved
Near-Field Communication (NFC)

Form of wireless communication
Smartphones have NFC capability

Differences between NFC and WiFi:
- Utilizes electromagnetic radio fields – WiFi uses radio transmissions.
- Operates in 13.56MHz frequency band
- Average range $\approx$ 1 meter – WiFi average range $\approx$ 13 meters
Near-Field Communication (NFC)

Form of wireless communication
Smartphones have NFC capability

Differences between NFC and WiFi:
- Utilizes electromagnetic radio fields – WiFi uses radio transmissions.
- Operates in 13.56MHz frequency band
- Average range $\approx 1$ meter – WiFi average range $\approx 13$ meters

Near-Field Communication (NFC)

Form of wireless communication
Smartphones have NFC capability

Differences between NFC and WiFi:

Utilizes electromagnetic radio fields – WiFi uses radio transmissions.
Operates in 13.56MHz frequency band
Average range $\approx 1$ meter – WiFi average range $\approx 13$ meters

Implanted User Devices

Current State

Two main challenges: Interface & Power
Interfaces

*Definition:* The point of interaction with computer software or hardware

*Examples:*
- Touchscreen, mouse, microphone, GUI (graphical user interface)
Some solutions:

EarPut

Magic Finger

Voice Interaction
EarPut

**IMAGE:** 2013 prototype device

**Touch-based interaction**

**12 touch areas**

**Registers touches and swipes**

(Credit: Lisserman, et al.)
EarPut

(Credit: Lisserman, et al.)
Magic Finger

IMAGE: 2012 prototype MagicFinger device.

Uses optical mouse sensor and micro RGB camera. Tap input (sensing contact) or gesture input (positional movement).
Voice Interaction

Technology exists:
Dragon Dictate, Siri, Cortana...

Limitations:
Languages, accents, privacy.

IMAGE: Apple’s Siri
Constraints:
No screen

Possible Alternatives:
LED-indicators
Vibration
Audio
Output

**Constraints:**
No screen

**Possible Alternatives:**
LED-indicators
Vibration
Audio
Devices

**IMAGE:** Devices used by Holtz, et al. 2012.
Inductive Charging:

1st Magnetic field induced in transmitter coil by alternating current (AC)

2nd Sends energy from transmitter to receiver coil via magnetic coupling

3rd Receiver converts energy received into a direct current (DC)

4th DC used to charge battery
Holtz, et al. using inductive charging on test subject. Minimal loss of power through skin.
Considerations

**Physical Concerns:**
- Repercussions of radio waves
- Repercussions of inductive charging
- Allergic reactions
- Infections

**Ethical Concerns:**
- Affordable to all?
- Devices for entertainment vs. for improvement of life
Implanted user devices are becoming a reality.
They may not replace hand held devices
Decisions need to be made in ethical concerns

Questions?