The IoT Runs Through You

Energy Transfer and Communication Through the Body

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Implantable Medical Devices

- As of 2000, over 20 million individuals with implantable medical devices in the U.S.
  - $300 billion in associated costs
- Each year in the U.S.:
  - 250,000 new cardiac pacemakers
  - 100,000 new implantable cardioverter defibrillators
- 120,000 patients with cochlear implants in the U.S.
Implantable Medical Devices

- Long-term monitoring and treatment
  - Continuous therapy
  - Prostheses
  - Monitoring (biosensors)
- Challenges: Diversity in size, function, power requirements
Wireless Implantable Medical Devices

- Wireless power
  - Miniaturization, longer implant lifetime
  - Replace or supplement battery power
  - Electromagnetic
  - Wireless communication
- Complicated by dynamic and unpredictable tissue
  - Differences among patients, across areas of the body, and over time
  - Safety, efficiency
Tissue Environment

- Unpredictable
  - Estimate based on measured values
- Variable
  - Differences among patients
- Dynamic
  - Changes over time

Typical Values

Range of Variation

Gabriel et al. 1996

Kim et al. 2007
Tissue Variability

- Device Location
  - Pacemaker vs. cortical implant
- Tissue Structure
  - Tissue “layers”, thicknesses
- Tissue Components
  - Cells, water, ions, proteins

- Maintain safety, efficiency
Strategies and Current Research

- **Expected Values and Variation**
  - Measurements, models of tissue properties
  - Effects of variations on powering/communicating with implantable devices
- **Adaptive Devices**
  - Tunable device components, sensing for feedback control
  - Tune to individual patients, adapt over time
Questions?

References

