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(Electrical Engineering, courtesy)

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Health Institute (WHI)

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UCLA

**You're As Sick (or Well) As A  
Hacker Wants You To Be**

# Problem Statement

How often do you put  
gas in your car?



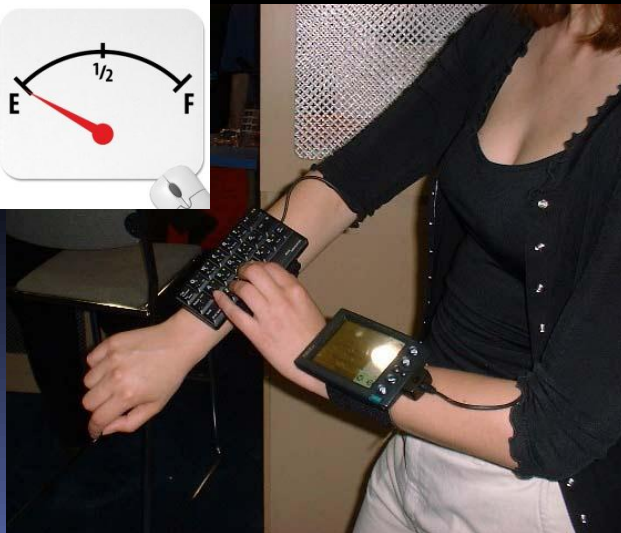
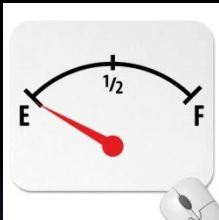
Method 1: Take your car in once a month for them to check its gas level.



Brilliant invention  
Answer: when it is about to run out of gas!



Method 1  
Do CBC once a year



Brilliant invention  
Be monitored continuously



**WIRELESS HEALTH**  
**UCLA**

Wireless Health Institute (WHI)



# Wireless Health

- The convergence of wireless, microsensor technologies with medical sciences
  - Fundamental advance in healthcare quality and accessibility
- Deliver healthcare:
  - Adapted to each individual
  - Continuous and global
- Wireless Health Institute
  - Campus-wide collaboration
  - Industry and community partners



# Wireless Health Institute (WHI)

- Campus Community
  - School of Medicine
  - Medical Center
  - School of Engineering
  - School of Nursing
  - School of Public Health
  - College of Letters & Science
  - Anderson School of Management
  - Tech Transfer Office \$
- Unique approach
  - End-to-end integration from sensing to medical informatics to call center
  - Develop and verify new healthcare methods and services
  - Establish standards for efficacy, reliability, interoperability, and security

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**WIRELESS HEALTH UCLA**

**UCLA Wireless Health Community**

The current proliferation of broadband wireless services, along with more powerful and convenient handheld devices, will enable a transformational change in health management and healthcare with the introduction of real-time monitoring and guidance for a wide array of patient needs. Low-cost sensors and wireless systems can now create a constantly vigilant and pervasive monitoring capability at home, at work, and in conventional point-of-care environments. A large research community and a fast-growing industry is beginning to connect medical care with technology developers, vendors of wireless and sensing hardware systems, network service providers, and enterprise data management communities. Wearable devices focusing on personal health, rehabilitation, and early disease detection are now being developed and some early products have appeared. New Wireless Health services will support large communities. For example, ubiquitous personal wireless devices also enable participation and development of collective results from large populations. Concepts and new programs under development now are focused on "healthy cities" where many decisions and design objectives may appear that guide development of urban environments to promote health and wellness.

The UCLA Wireless Health community includes an interdisciplinary group of experts and innovators from many UCLA Schools including Engineering, Law, Management, Medicine, Nursing, Public Health, and Theater, Film, and Television.

This web site resource is created by the UCLA Wireless Health community and will describe advances, new technologies and data sources available, and community events. We look forward to learning about your interests, needs, and opportunities for collaborations.

**News Headlines**

**October 31, 2008**  
The SmartCane is featured on the Discovery Channel Website. Read about it [here!](#)

**September 27, 2008**  
Welcome to the UCLA Wireless Health website!

**June 1, 2008**  
Foad Jabri, Alreza Vahdatpour, Hyukje Nohedi, Hagop Hagopian, and Majid Sarrafzadeh received a best-paper award for their paper "Ubiquitous Personal Assistive System for Neuropathy." The paper was presented at the Second ACM International Workshop on Systems and Networking Support for Healthcare and Assisted Living Environments (HealthNet 2008).

[More News Headlines](#)

**Focus Areas**

- Overall System
- Wireless Health Disease Management
- Wireless Health for Public Health and Wellness
- Security, Privacy and Compliance in Wireless Health

UCLA Healthcare DAVID GEFFEN SCHOOL OF MEDICINE AT UCLA

UCLA Engineering Henry Samueli School of Engineering and Applied Science

UCLA Anderson School of Management

UCLA SCHOOL OF NURSING

SCHOOL OF CALIFORNIA, LOS ANGELES SCHOOL OF PUBLIC HEALTH Building Healthy Futures...

FILM AND TELEVISION

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**UCLA SCHOOL OF ENGINEERING**

**UCLA Wireless Health Community**

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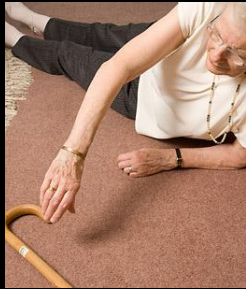
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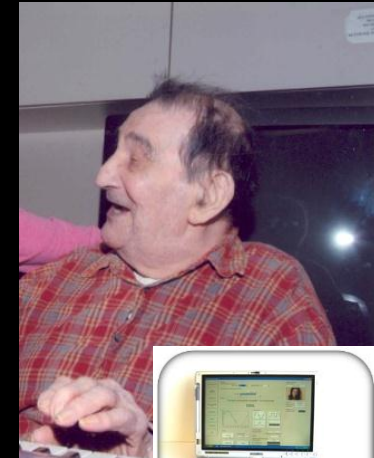
FILM AND TELEVISION



SmartCane

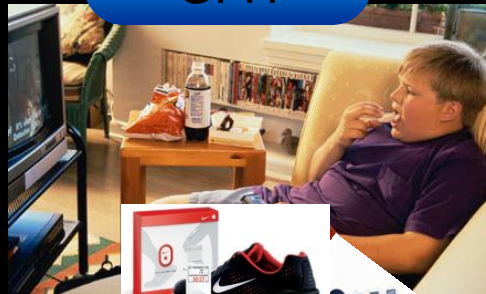


SRA



CMAS

GFH



SmartShoe



MHG



PAM

HPC





# Gaming For Health

# Facts about Child Obesity



- Children aging 8-18 spend more time (44.5 hr/week) in front of computer game screens than any other activity except sleeping
- 30.3% of children (age 6-11) are overweight and 15.3% are obese
- Another country that I just visited: around 200 million people are thought to be overweight, and 60 million (7.1%) obese.

# No Pain No Game

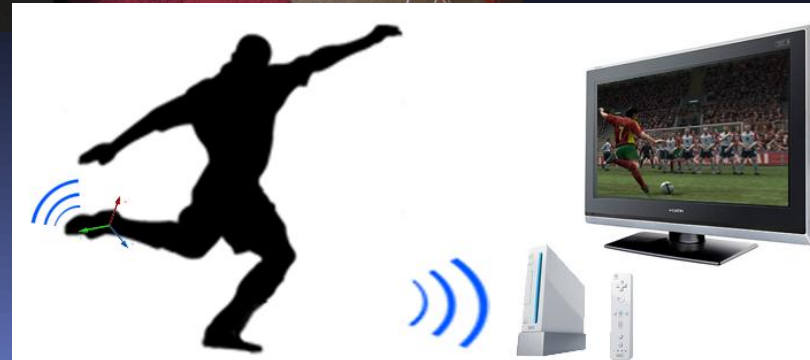
- Encourage children to engage in exercise in exchange for home entertainment.
- Solution: PAM + automatic TV /PC controller





# Gaming for Health

- Eight prototypes, 4 patents
- (Soccer) Ball of Fire, I am Mario , Penguin, Stage Presence: Guitar Hero, DDR, FPS



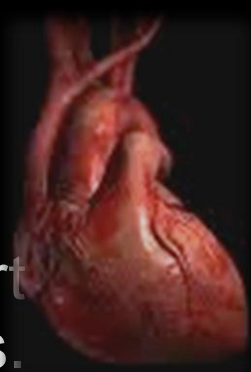




Project: WANDA

- Congestive Heart Failure (CHF)

- A leading cause of hospitalization
  - Causes: damage to the heart as a result of a heart attack, chronic hypertension, or exposure to toxins.
  - Symptoms : shortness of breath, lower extremity swelling, chest pain, and limitations on exercise tolerance.
  - About 500,000 new cases of HF diagnosed each year in the US
  - About 5 million Americans suffer from HF
  - Effective monitoring methods
    - Check his/her weight on a daily basis
    - Monitor diastolic and systolic heart rate readings
    - Monitor patients' daily activity
    - Check the Heart Failure Somatic Awareness Scale (HFSAS)



# INTRODUCTION

- **WANDA**
  - Provide an avenue to record and track patients' health information on a daily basis
  - Give a real-time computer-based analysis without visiting specialists
  - Applied to a study for Congestive Heart Failure (CHF) patients



# Test Bed and Result

- Approved by the UCLA Institutional Review Board (IRB)
- Pilot data has been collected to test the system, since November, 31, 2009.
- 16 Congestive Heart Failure patients are currently using WANDA.
  - Prof. Lorraine's group in School of Nursing, UCLA recruited patients
  - Subjects are older than 60 years old
  - Received a large grant to do clinical trial on 750 subjects





# Smart InSoles: Diabetes, Fall Prevention

# Smart Insole (MediSens)



Smart Insole



SmartShoe



# Epidural Stimulation (ES)

# Spinal Bridge

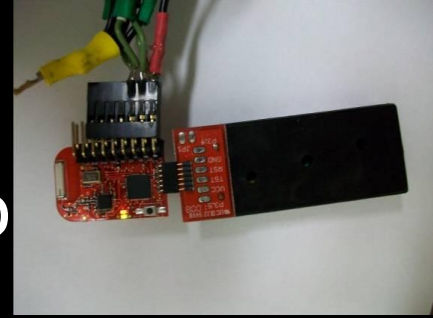
- Simple epidural stimulation (ES) along with the proper sensory input can invoke stepping patterns in paralyzed animals
- Currently, such invocation is controlled by the experimenters
- The next step is to allow subjects to control their own stimulation





## Spinal Bridge

- We've created an implantable device to produce proper ES
- Subjects trigger ES by attempting to walk with their forelimbs
- The device detects walking patterns through EMG



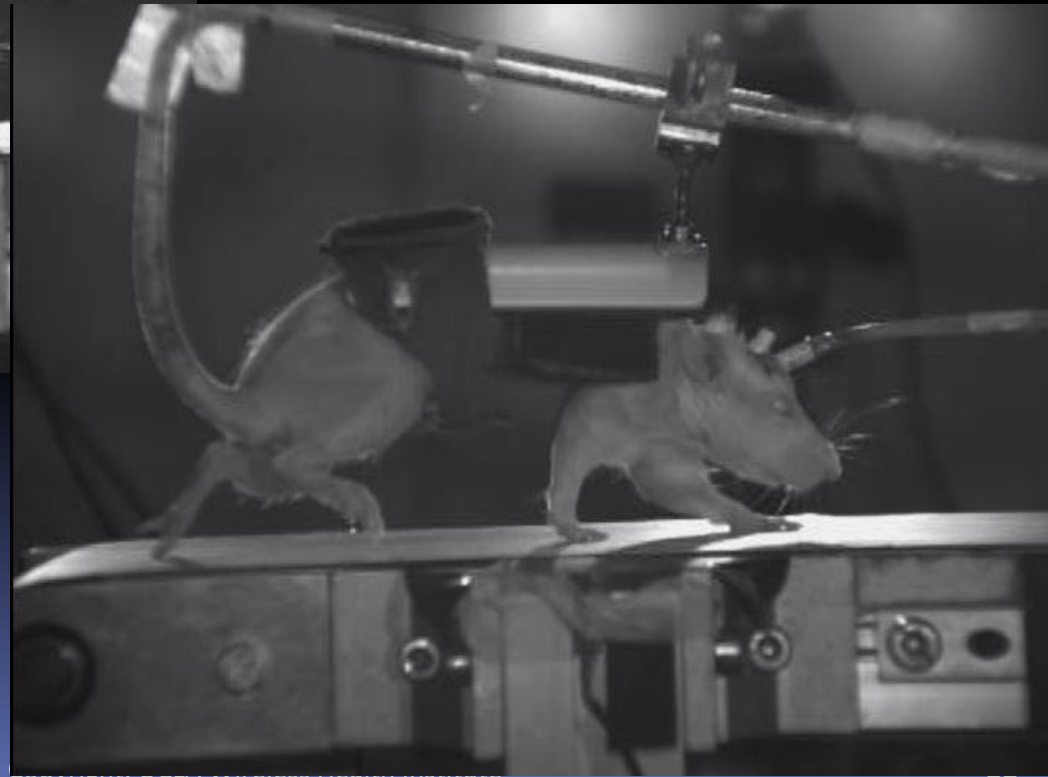
For the first time, rats with completely severed spinal cords were able to walk bipedally on a treadmill with a near normal gait while bearing their full weight.

# Spinal Bridge



Without ES, subjects are unable to induce stepping in their hind limbs

ES triggered by EMG from the forelimbs induce stepping in the hind limbs





**Hackers  
Can  
Kill You!**

- Researchers had been able to gain wireless access to a combination heart defibrillator and pacemaker. They were able to **reprogram it to shut down and to deliver jolts of electricity that would potentially be fatal** -- if the device had been in a person
- Also been able to glean personal patient data by eavesdropping on signals.



researchers from Beth Israel Deaconess Medical Center, Harvard Medical School, the University of Massachusetts Amherst, and the University of Washington. "[Security and Privacy of Implantable Medical Devices](#)," Daniel Halperin, Thomas S. Heydt-Benjamin, Kevin Fu, Tadayoshi Kohno, and William H. Maisel, IEEE Pervasive Computing, January 2008.

"[Pacemakers and Implantable Cardiac Defibrillators: Software Radio Attacks and Zero-Power Defenses](#)," Daniel Halperin, Thomas S. Heydt-Benjamin, Benjamin Ransford, Shane S. Clark, Benessa Defend, Will Morgan, Kevin Fu, Tadayoshi Kohno, and William H. Maisel, IEEE Symposium on Security and Privacy, May 2008.

# Pacemaker

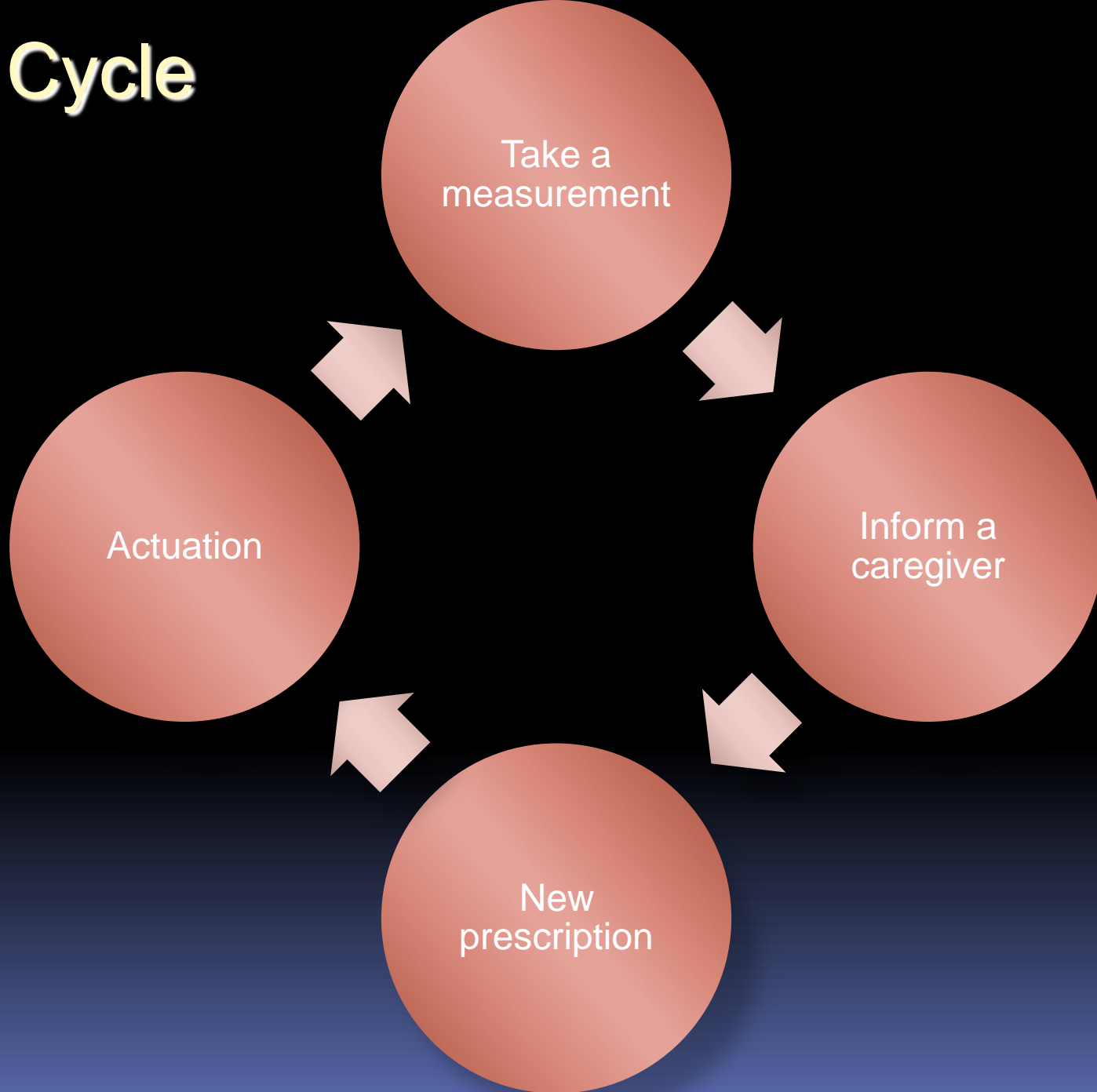
- As part of our research we evaluated the security and privacy properties of a common ICD. We investigate whether a malicious party could create his or her own equipment capable of wirelessly communicating with this ICD. Using our own equipment (an antenna, radio hardware, and a PC), we found that someone could violate the privacy of patient information and medical telemetry. The ICD wirelessly transmits patient information and telemetry without observable encryption. **The adversary's computer could intercept wireless signals from the ICD and learn information including: the patient's name, the patient's medical history, the patient's date of birth, and so on.**
- Using our own equipment (an antenna, radio hardware, and a PC), we found **that someone could also turn off or modify therapy settings stored on the ICD. Such a person could render the ICD incapable of responding to dangerous cardiac events.** A malicious person could also make the ICD **deliver a shock that could induce ventricular fibrillation, a potentially lethal arrhythmia.**



# Examples of Home “Medical” Devices

- Weight Scale
- Blood Pressure Monitors
- Glucose Monitor
- Pulse OX
  
- Hospitals / ER (HER)
  
- Sports (Polar, ...)
  
- More than 70,000 children and teens go to the emergency room each year for injuries and complications from medical devices [CBS News]

# The Cycle



Measure  
your  
weight



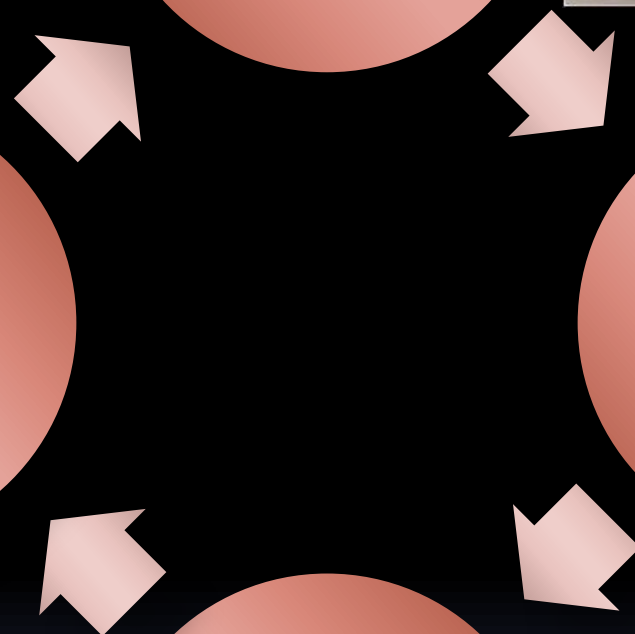
Think  
about it



Indulge



...



# Device Hacking General Approach

- Device-side manipulations
- Snoop at pairing time allows for multiple possible manipulations.
  - Can pair into device
  - steal readings
  - alter configurations to make device useless
  - mimic devices to patient to alter information

# BP monitors

How it is used in practice:

- A patient takes reading
- If the number is too high or too low, an action is prescribed
- **Most patients are admitted to the hospital. Death may follow.**
- *A leading manufacturer and distributor of blood pressure monitors for home use. With more than 100 million monitors sold worldwide to date.*





# Company X Medical Bluetooth Blood Pressure Monitor

- Device's security is simply by hiding
- Pairing with device allows for snooping
- Protocol can be replicated to forward fake data to patient
- Can steal data so it doesn't arrive at patient's computer
- Can change communication standards so device becomes useless to the user



Demonstration

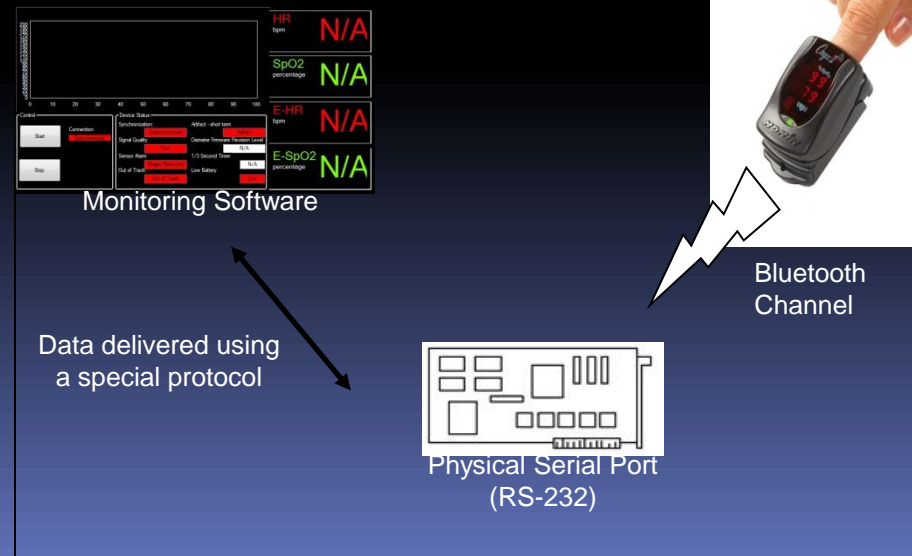
# Pulse Ox

- Measures oxygen level
- Because of their simplicity and speed, pulse oximeters are of critical importance in emergency medicine
- and are also very useful for patients with respiratory or cardiac problems, especially COPD, or for diagnosis of some sleep disorders such as apnea and hypopnea.
- Portable, battery operated pulse oximeters are useful for pilots operating in a non-pressurized aircraft above 10,000 feet

# Pulse Oximetry

- An off-the-shelf (OTS) oximetry monitoring system.
- It remotely provides vital information (heart beat and SPO2 %) using Bluetooth® wireless technology
- It is a recipient of the Bluetooth® SIG Best of CES 2009 award

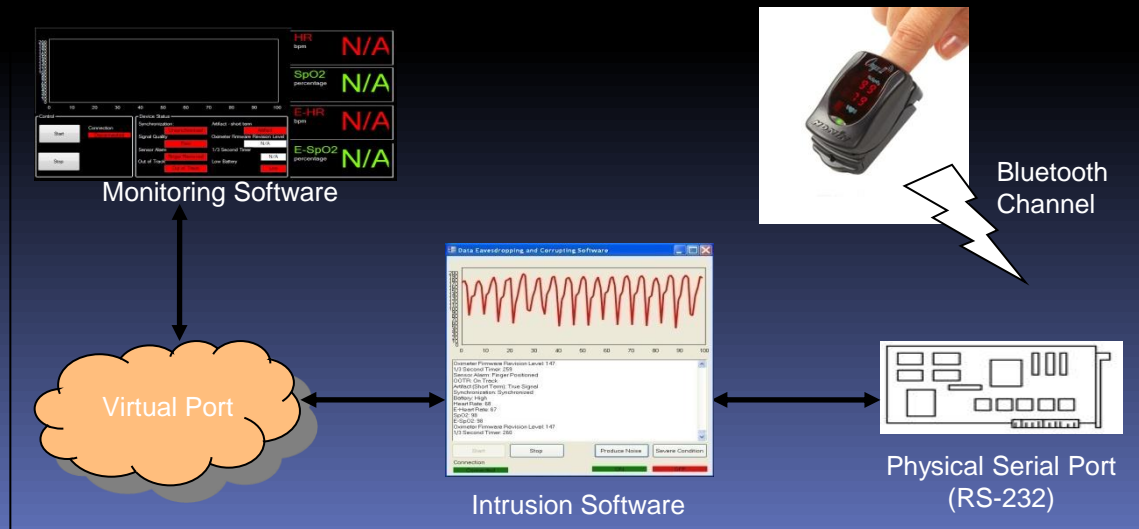
- The system Architecture



- **Intrusion Technique**

- The intrusion software intercepts the signal that is transmitted from the monitoring device to the computer
- The interception of the signal is achieved by employing “**Virtual Serial Port**”
- As a result, we can (i) **eavesdrop** and (ii) **corrupt** the vital signals without letting the Monitoring Software aware of such events.

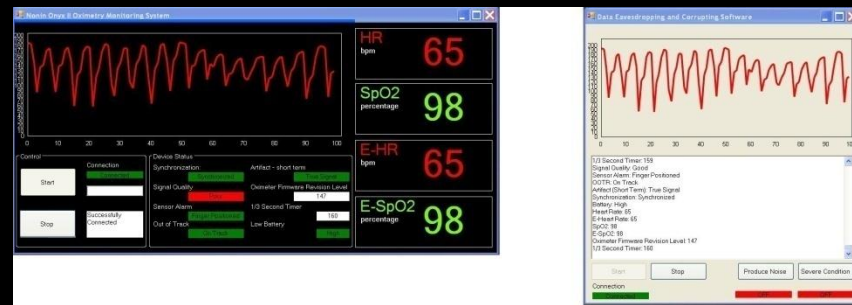
Security Intrusion  
Technique



# Possible Events of Security Intrusion

- Eavesdropping

The intrusion software can eavesdrop the vital signal generated from the device without the monitoring software being aware of this event.



- Corruption

The intrusion software can corrupt the vital signal generated from the device. For instance, the intrusion software may generate a false abnormal event and deliver it to the monitoring software, which result in severe health condition of the patient subject.



## Demonstration



# Conclusion

- With the cost of healthcare growing rapidly, innovation in Wireless health is a necessity.
- Many devices exist in the market, many more to come in the next few years – and this is all good.
- Close attention to security and privacy is needed: by researchers, manufacturers, government, third part certification labs