



Health Education Technology Research Unit

Autonomous technology for health care

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Presentation Outline

- Motivation
- Impact of technology
- Aging and ICT
- An example
- Conclusions



Rising Cost of Health Care

- *According to the National Coalition on Health Care:*
 - Total US health expenditures increased by 6.9 percent in 2005 (the latest year that data is available) – two times the rate of inflation.
 - In 2005, health care spending in the United States reached \$2.0 trillion, and was projected to reach \$2.9 trillion by 2015.
 - In 2003, the United States spent 15.3 percent of its Gross Domestic Product (GDP) on health care. It is projected that the percentage will reach 20 percent by 2015.



Rising Cost of Health Care

- *According to the Canadian Institute for Health Information the numbers here are similar, in 2005:*
 - 7.7% increase over the last year
 - three times the rate of inflation of 2.7%.
 - \$142.0 billion in 2005
 - 10.4% of GDP in 2005



Solutions: Electronic Patient Records (EPRs, EMRs, EHRs...)

- In the US and EU there are a major efforts to digitize patient records
 - "We will make wider use of electronic records and other health information technology to help control costs and reduce dangerous medical errors."
-- President George W. Bush, January 31, 2006
- (I am still unsure what is happening in Canada)



Will Electronic Records do it?

- “As implemented, EHRs were not associated with better quality ambulatory care.” (Electronic Health Record Use and the Quality of Ambulatory Care in the United States, Jeffrey A. Linder, et al., Arch Intern Med. 2007;167:1400-1405.)
- “...effective EMR implementation and networking could eventually save more than \$81 billion annually.” (“Can Electronic Medical Record Systems Transform Health Care? Potential Health Benefits, Savings, And Costs” Richard Hillestad *et al*, Health Affairs, 24, no. 5 (2005): 1103-1117
 - That is a one time reduction of about 4% of costs



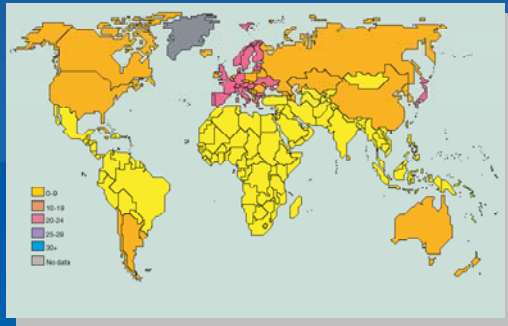
How else can HIT make an impact?

- David Brailer, (former) National Coordinator for Health IT (US):
 - [...] from a technology perspective – that’s when it gets really interesting, because it is not about a doctor using a keyboard – it is about [...] a streaming set of information that is flowing from a patients home, body, etc to allow people to be empowered and autonomous at home and not in a nursing home.”



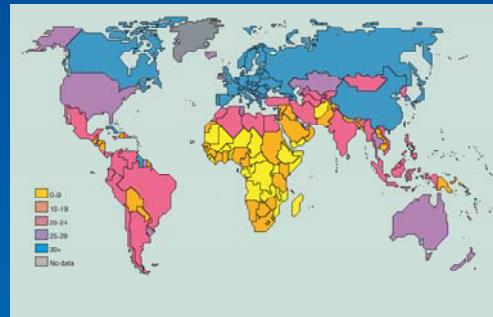
Worldwide age wave is coming

2002

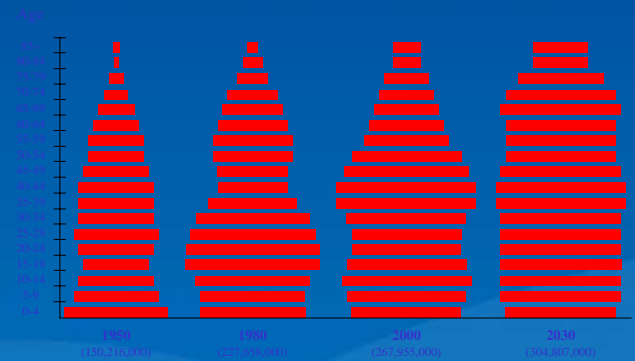


Percentage of Population over 60 years old
Global Average = 10%

2050



Percentage of Population over 60 years old
Global Average = 21%



Source: U.S. Census

SOURCE: United Nations • "Population Aging • 2002"

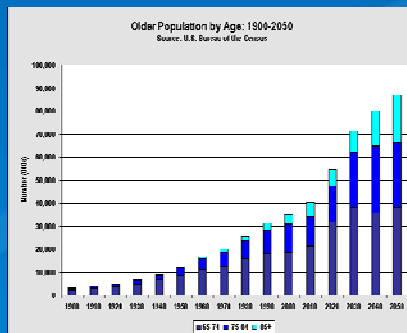


Table compiled by the U.S. Administration on Aging based on data from the U.S. Census Bureau.

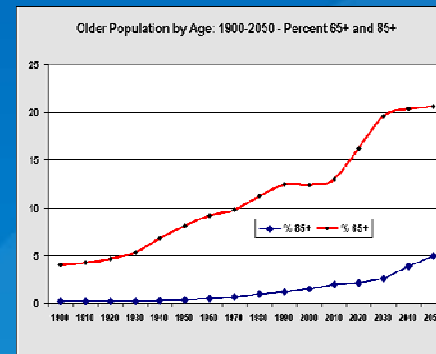


Table compiled by the U.S. Administration on Aging based on data from the U.S. Census Bureau.



How will we handle this?

- Group care facilities are very expensive
 - Monetary cost to
 - The individual and their family or
 - Or the social welfare system
 - Health/happiness cost
 - Leaving ones home is often difficult or even traumatic.
- Current efforts to alleviate this focus on EHRs or telemedicine:
 - Connect patient to doctors and nurses remotely
 - Still requires one-on-one care, however much more convenient



What is Telemedicine?

- Telemedicine is a technology-rich alternative to a traditional face-to-face physician consultation.

Physician Station



Patient Station



Courtesy Dr. Richard Re,
Ochsner Clinic

- Telemedicine remains a one-to-one activity, more convenient of course



Current Devices and Systems

- E.g., Honeywell HomMed Products
 - <http://www.hommed.com>
 - Telemedicine applications



Blood Glucose



Peak Flow/FEV₁



Spirometer



PT/INR



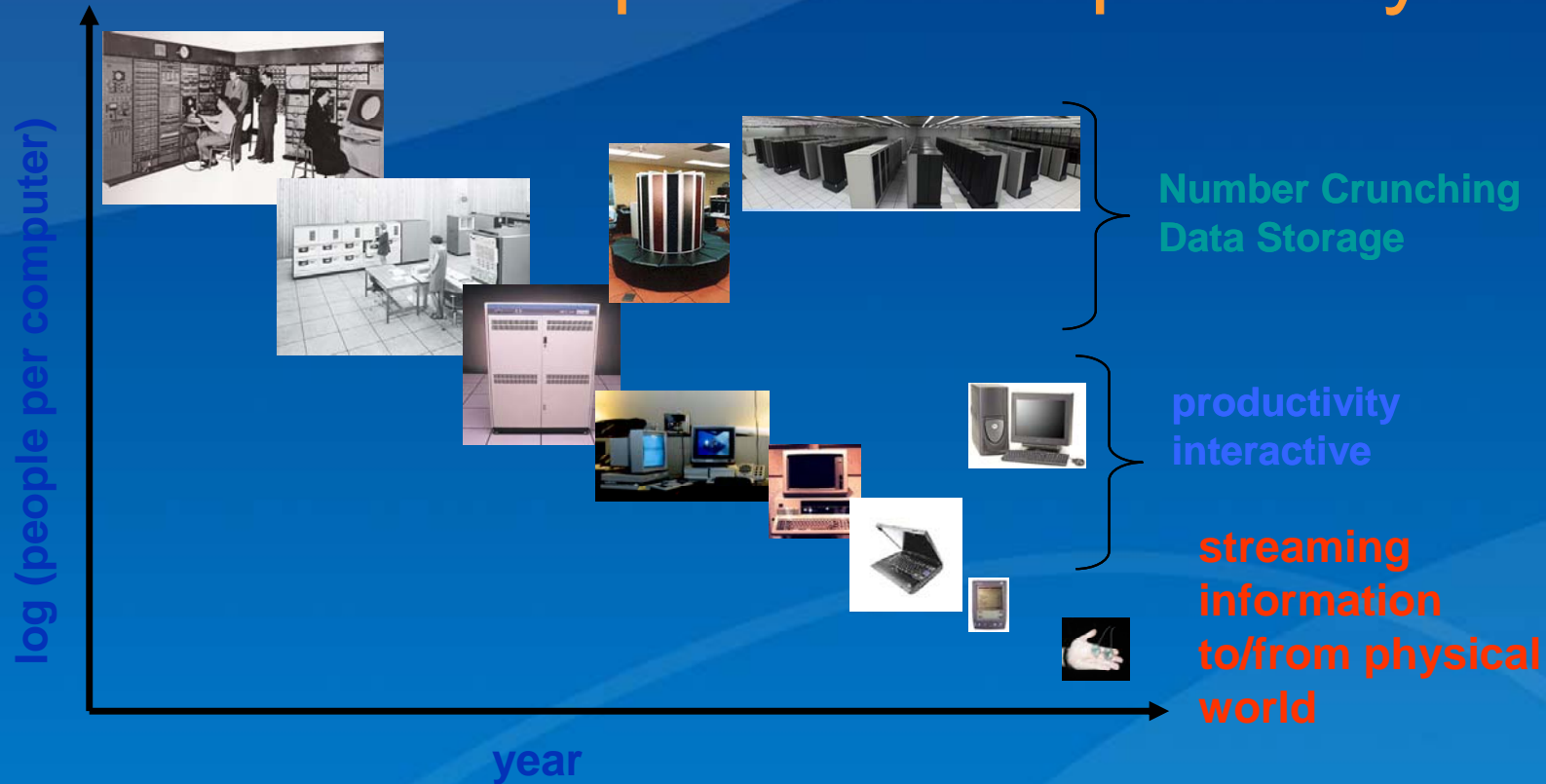
ECG



Oximeter



Technology Trends: Bell's Law – new computer class per 10 years



- Enabled by technological opportunities
- Smaller, more numerous and more intimately connected
- Ushers in a new kind of application
- Ultimately used in many ways not previously imagined



What can we do with these advances in technology?

- The low cost and high processing power can help by:
 - Providing preventive tools
 - Improving safety, security, monitoring, at home
 - Empowering and educating people to monitor their own health and care
 - Enabling technology cooperation, delivery of services
- Indeed if we think of **automating** much of the monitoring and alerting:
 - This could drastically reduce the amount of care required to provide the same (or better) level of care

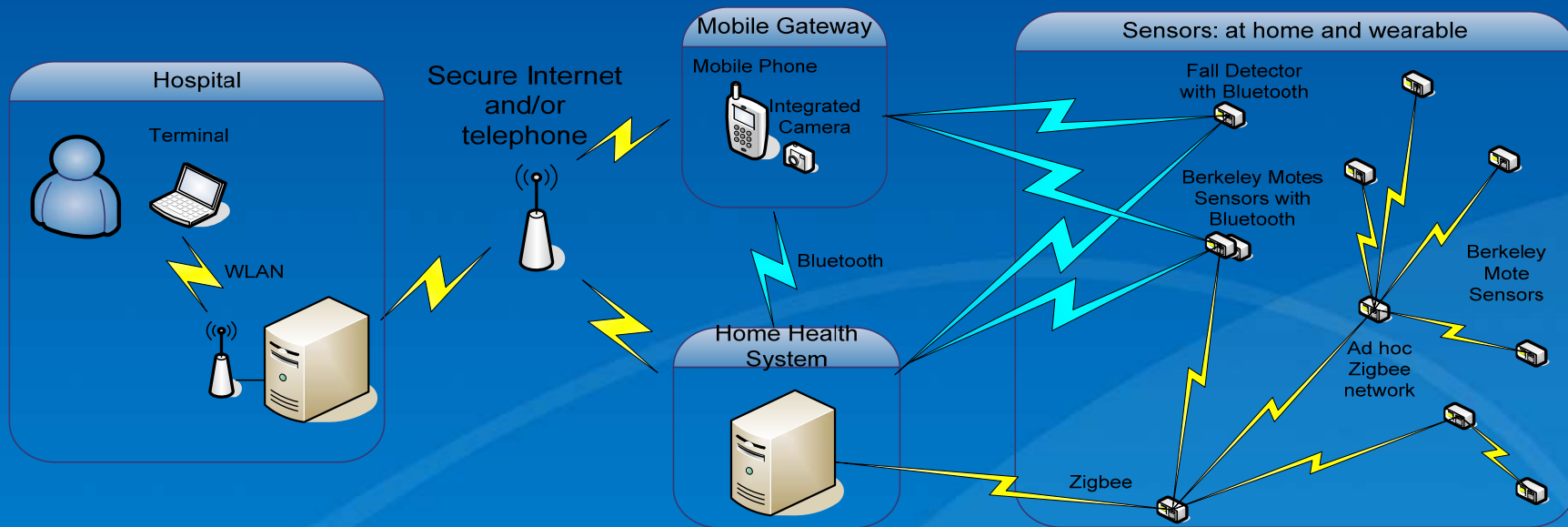


ICT for Assisted Living

- Telemedicine is part of it
- But it also includes **smart monitors and sensors**
 - **Autonomously** detect and alert the user and/or care providers of
 - Accidents
 - Acute illness
 - Deterioration of condition
 - This will allow the user to remain at home in a safe and secure environment and delay the transition to group care facilities longer than otherwise



A System (ITALH)



Components: Privacy

- Privacy and security are critical components of this system, which is enabled through
 - Embedded processors and software so that raw data is not broadcast
 - (unless specifically requested by an authenticated user)
 - This also vastly reduces the bandwidth requirements
 - Data encryption and wireless security
- The system is by default a closed, home/personal system
 - Care givers can have access from the outside with proper authorization



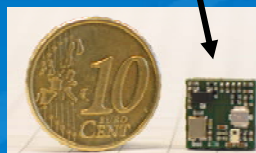
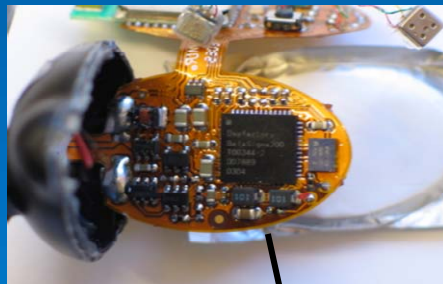
Components: Smart Sensors

- The monitors and sensors include embedded software systems which can autonomously detect events of concern, e.g.:
 - Wearable sensors
 - Fall sensors
 - Heart rate, pulse monitors, etc.
 - Stationary sensors
 - Motion detectors
 - Camera systems
- On their own, we can not expect to have sufficient accuracy, however in combination they will



Components: Sensors

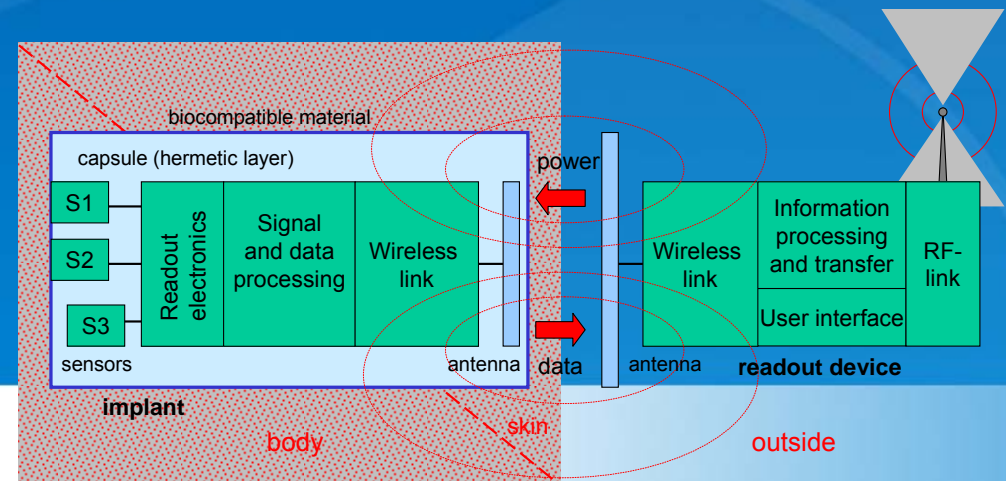
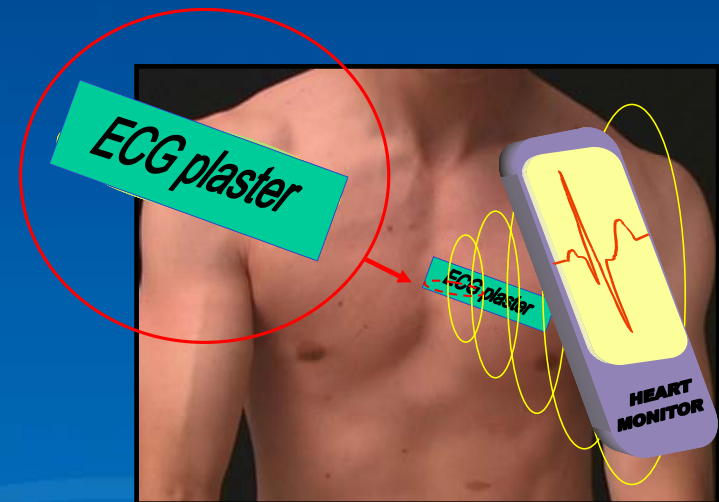
- Biometric sensors
 - Wearable
 - Implantable(Tampere University of Technology)



System Miniaturization and Integration for 3D Stacked SiP by

HETRU
TUT/ELE

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Components: Gateways

- Home gateway
 - The fixed home devices and wearable devices connect to the home gateway
 - Currently Laptop PC (Windows) based
 - Investigating smaller, less expensive systems, e.g. PXA255 systems (very small Intel processor, Linux OS)
 - Allow connections from caregivers via internet and/or telephone



Components: Wireless Connectivity

- Wearable sensors can connect to the mobile phones using Bluetooth radios
- Also using Berkeley Telos Mote (802.15.4) devices

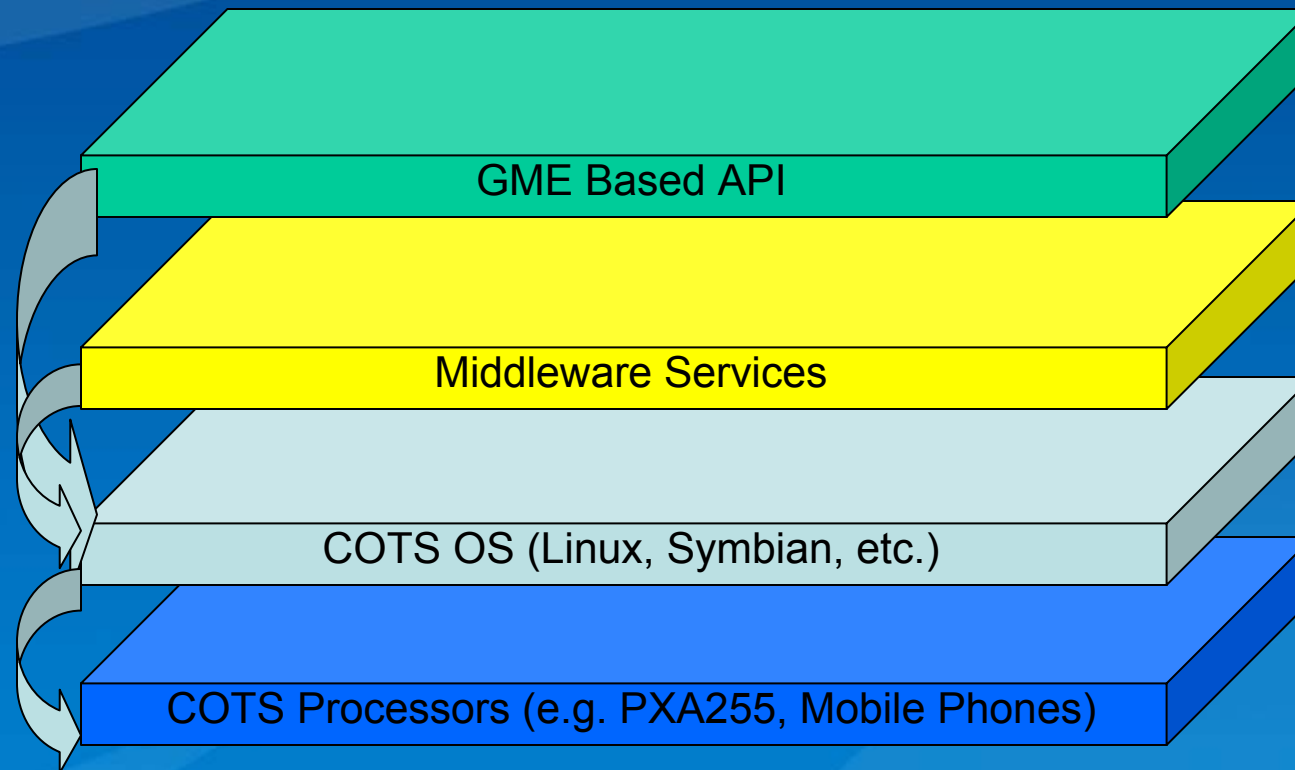


Components: Setup and User Interfaces

- To be effective, the system must be designed to be:
 - Easy to set up and maintain
 - Have a variable level of interaction possible by the user to accommodate a large range of skill and interest in using the device
 - ***The primary concern is to ensure that it is used***



Components: Integrated Tool Chain

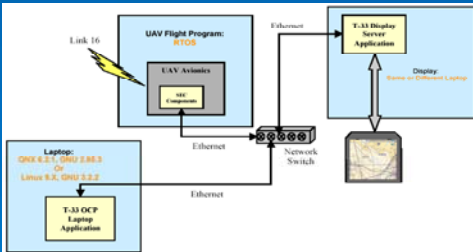
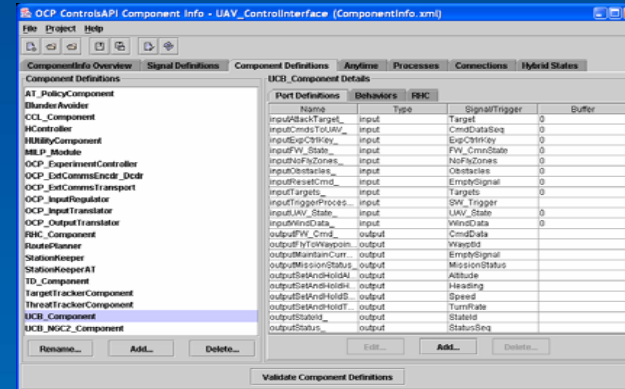


Toolchain background

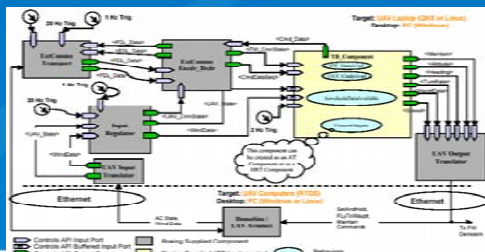
High Confidence Medical Device Software and Systems (HCMDSS) Workshop

Insup Lee
 Department of Computer and Information Science
 University of Pennsylvania

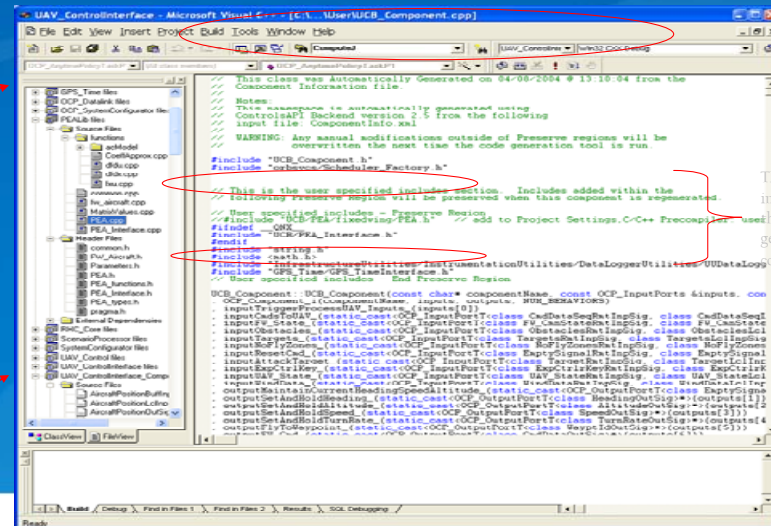
June 2-3, 2005
 Philadelphia, PA



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UCB Pursuit/
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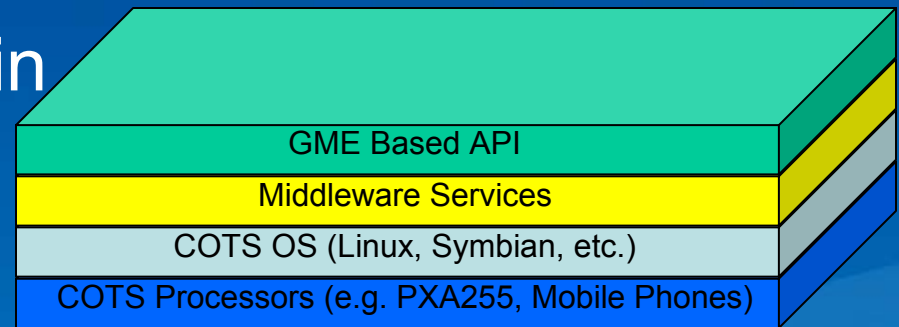


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Toolchain Goal

- The goal of this tool chain is to allow:
 - Individual and separate approval for tools within the chain
 - Simplify the approval for the output of these tools
 - Allow the approval of incremental changes in components of the system



First Smart Sensor: Fall Detector

- In Canada falls are the leading cause of fatal and nonfatal injuries to older people (Source: NTR/CIHI 2001):
 - 58% of major injuries in people 65 and over are caused by unintentional falls
 - Compared to 26% for 35-64 year olds
 - And 12% for 20-34 year olds
 - In fact it is even more serious than that:
 - 86% for 75-84
 - 94% for 85+
 - (Source: Ontario Trauma Registry, Canadian Institute for Health Information, 2002)



Fall Detector (Version 3)

- Features:
 - TelosB/Tmote Sky based
 - 3-axis, ± 10 g accelerometers
 - 2-axis gyroscope
 - Battery powered
 - USB and wireless Zigbee connection
 - NesC programmable
 - 80 Hz sampling

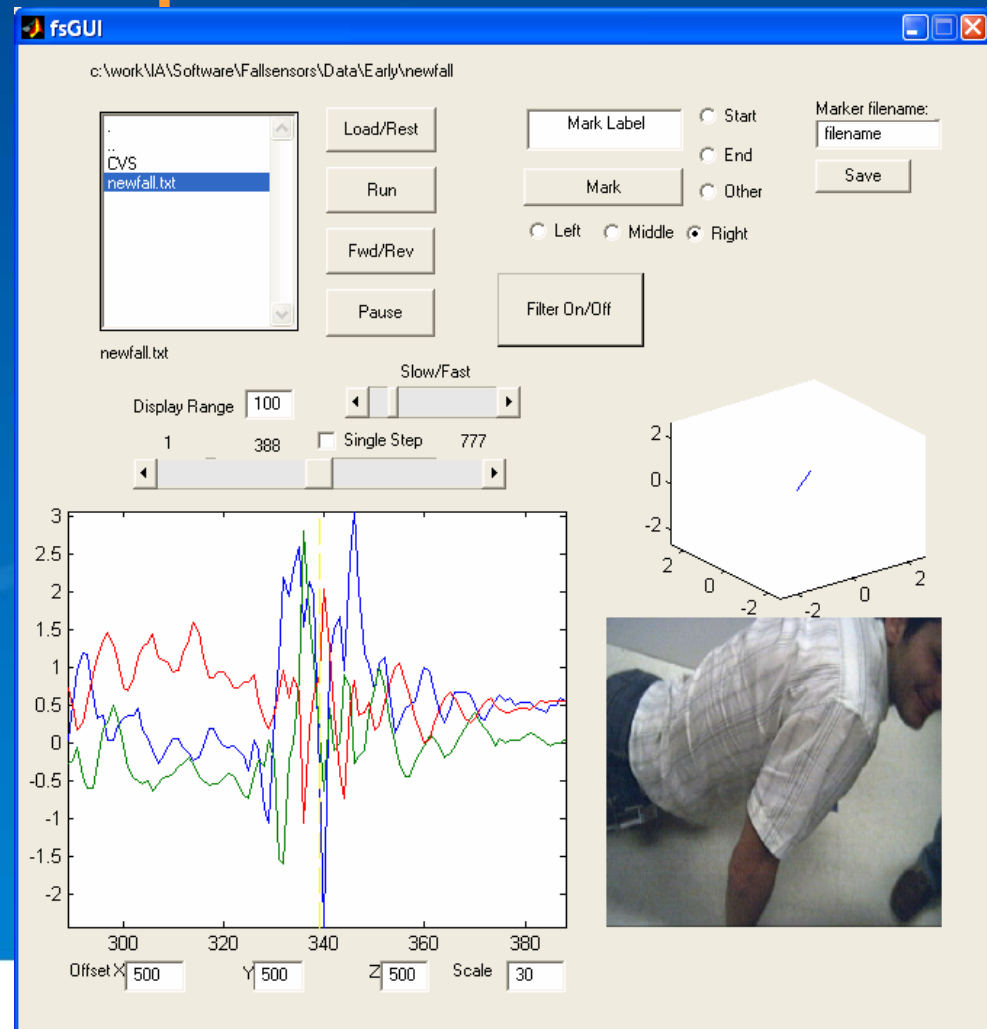


(Designed By Roozbeh Jafari)

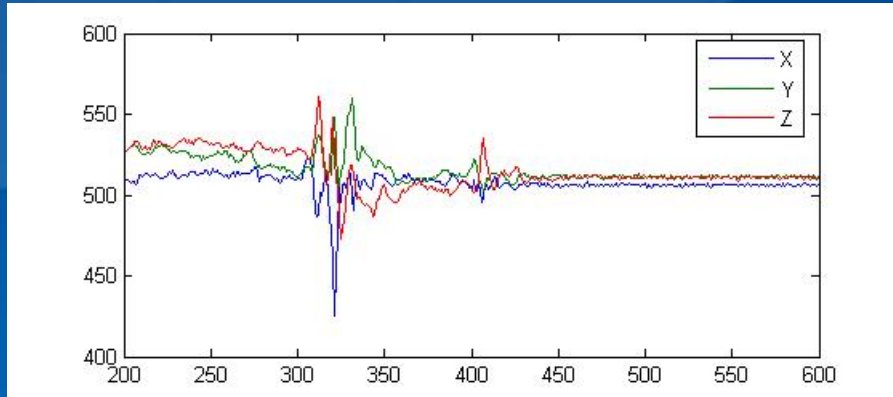


Experimental work and development

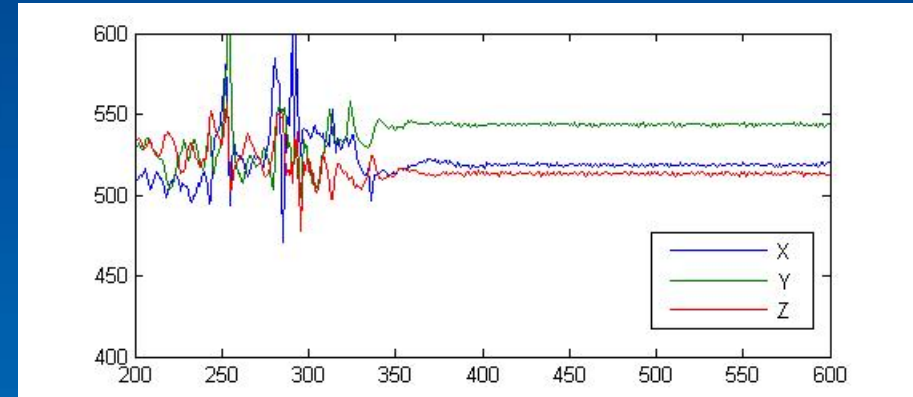
- Regular field testing provides
 - data,
 - evaluation
 - feedback from target users



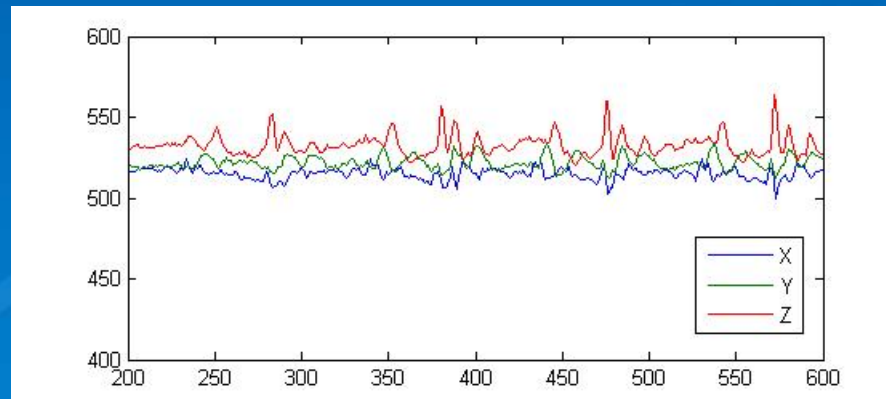
Acceleration Analysis



Fall backwards from sitting to standing transition



Fall forward after bouncing off a small object

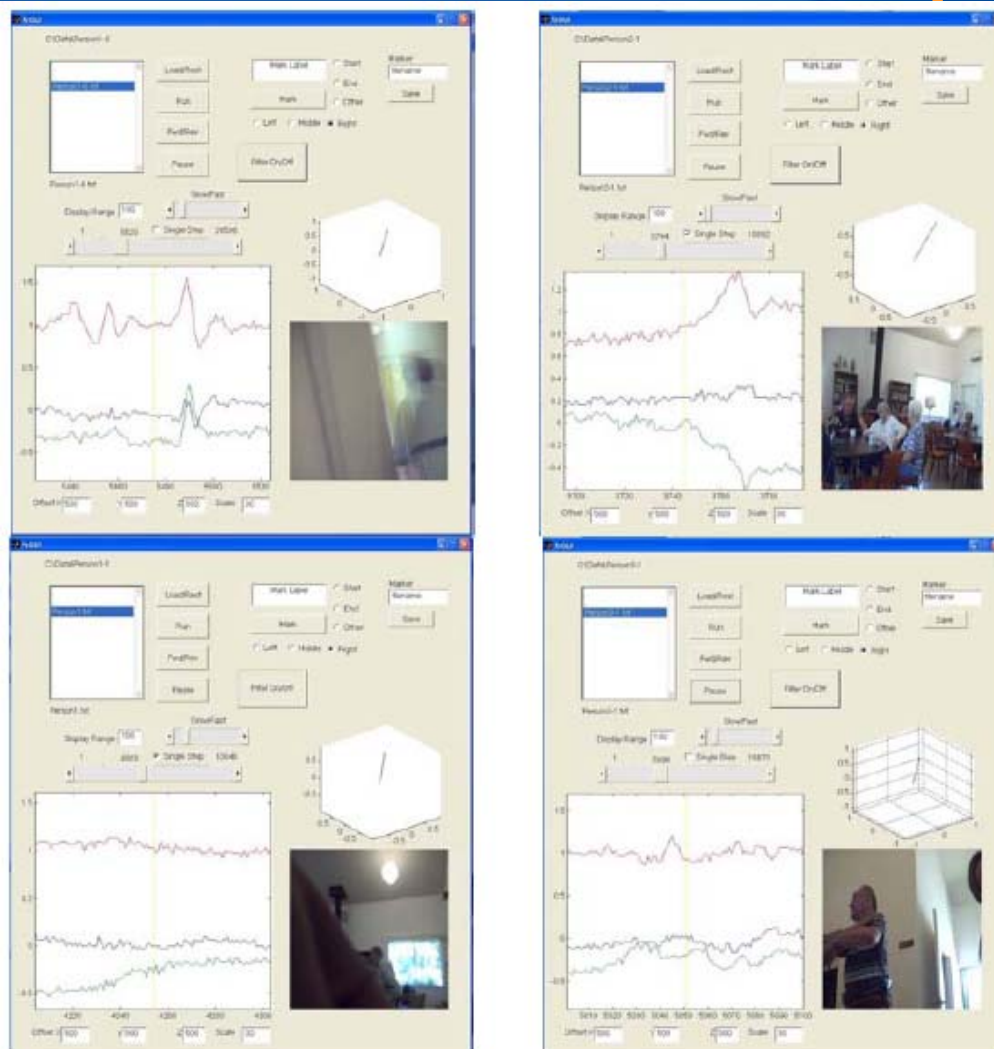


Walking regularly

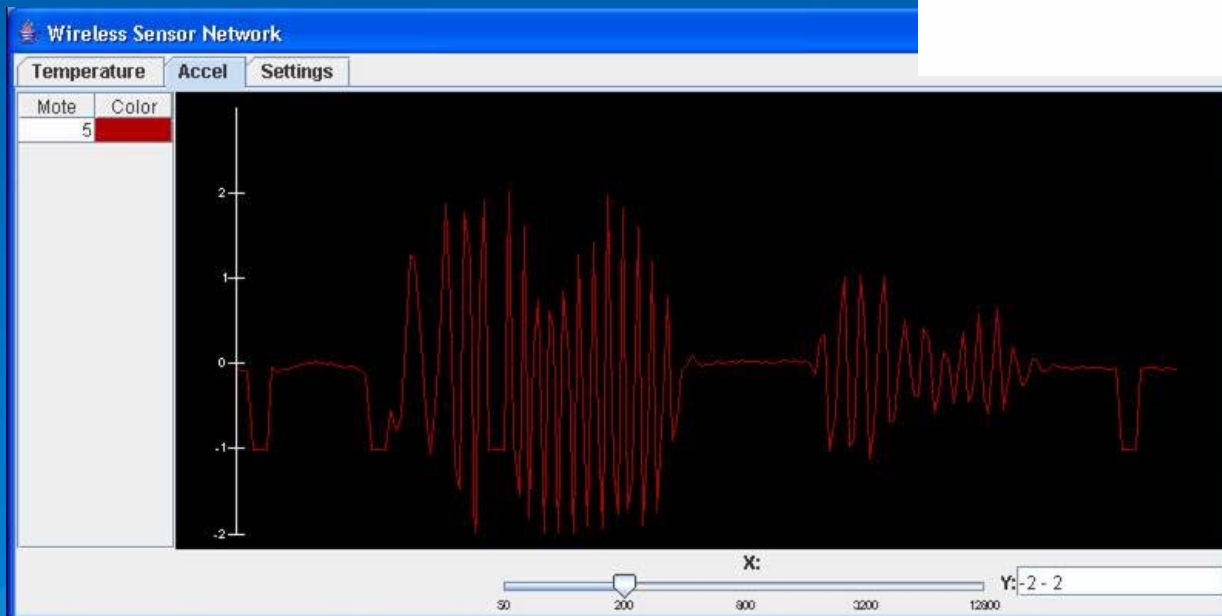
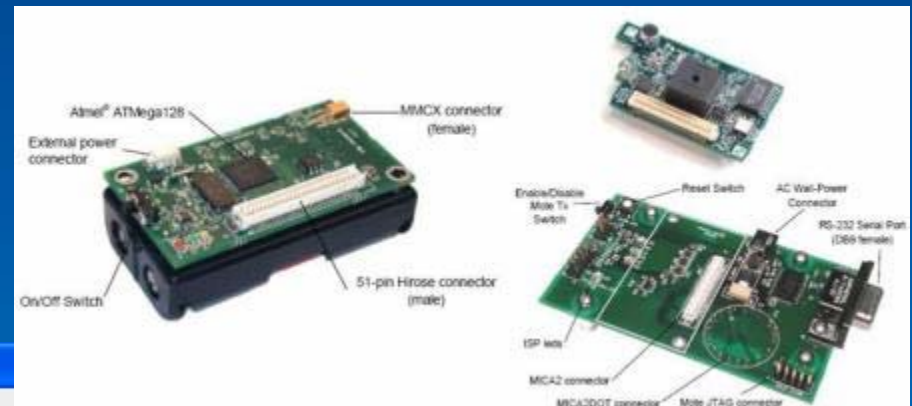


Data and Opportunities

- The recorded data from accelerometer based fall sensor is analyzed and replayed with this Matlab program.
- Examples
 - an elderly woman walking with a walker (top right),
 - a woman sitting down (top left),
 - a woman standing up (bottom right)
 - a man stretching his arm (bottom left)



Currently: Building a local testbed



Future Work and Possibilities

- Continue building up activity sensor system
- Add biometric sensors
- Home and mobile system to be connected to the outside
- Integrate such technology
 - Into a full home care system (Tashiro, Stanyon, Hung)
 - Into NICU systems (McGregor)
 - With plug and play capabilities (Liscano)



Conclusions

- New ICT has the potential to dramatically affect health care delivery
- Patient education is one area that will be affected
- Challenges remain in the technology to make it cost effective and reliable





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Questions?

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