

Using Mobile Devices to Communicate, Control, and Compute in the Ubiquitous Computing Society

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Outline

- Trends in Computing
- Why Microsoft is Interested
- Select Examples of Ubiquitous Computing at Microsoft Research

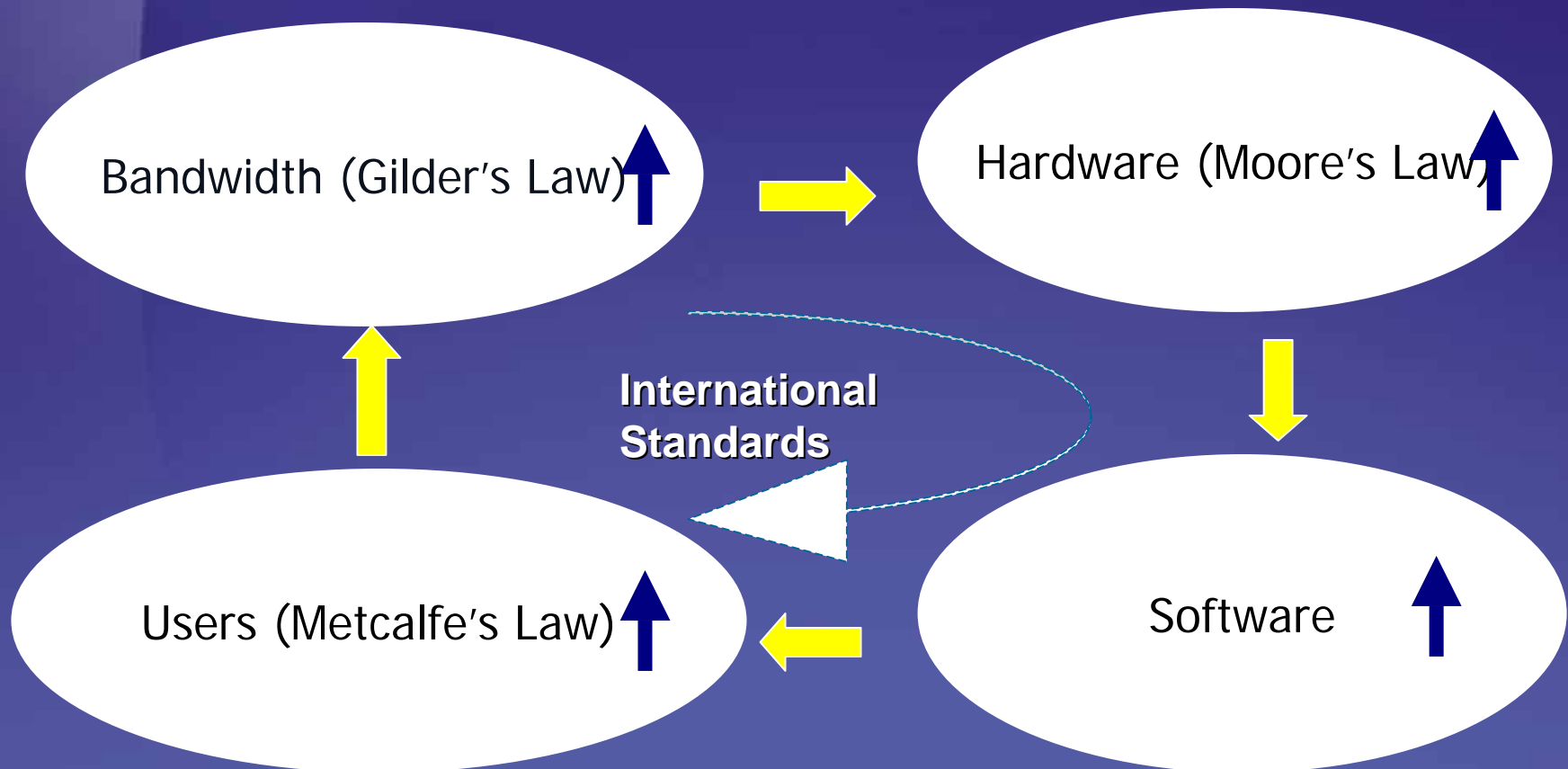
Advances in Computing (1)

- ▶ Moore's Law still going strong
 - ▶ CPU 1.5x, GPU 5x, storage 2x, bandwidth 4x
 - ▶ Miniaturization continues
- ▶ Internet continuing its exponential growth
 - ▶ Internet => X-Internet (600M cars, 1.5B phones, 30B chips)
 - ▶ XML revolution leading to web service
 - ▶ IPv6 embracing strong support
 - ▶ New \$ apps: on-line games, messaging, chatting/dating
- ▶ Wireless deployment continuing
 - ▶ Data traffic > voice traffic
 - ▶ WiFi 802.11 accelerating
 - ▶ New standards in WiMAX and UWB
 - ▶ 3G roll-out in Asia

Advances in Computing (2)

- ▶ Smart devices and gadgets increasingly popular
 - ▶ Low power CPU and ASICs
 - ▶ Fuel cell battery with 1 month cell phone usage on the horizon
- ▶ New digital media applications becoming mainstream
 - ▶ DTV, DVD, streaming media, videophone, video games, entertainment
- ▶ Security and reliability rising to spotlight
 - ▶ Trustworthy computing

Laws in Computing





New Wave of Computing

Technology:	Networking + Computing + Storage
Scope:	PC => PC+
Architecture:	Distributed, loosely-coupled and connected grid
Environment:	Trustworthy Computing
Capability:	PC => PC ³

Personal Computer => Personal Computing + Communications
+ Control + Entertainment

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Microsoft Global Impact

Windows Mobile

- #1 worldwide volume share of PDA market
- 40 device makers, 68 mobile operators in 48 countries
- 640,000+ developers worldwide
- 18,000+ Windows Mobile applications
- **Fastest** growing business in Microsoft



Windows Embedded

- ▶ #1 commercial OS for embedded devices worldwide with 8,000 OEMs shipping
- ▶ #1 RTOS vendor worldwide
- ▶ 2,500+ Windows Embedded Partners
- ▶ Over 250,000 downloads of shared source



Moto Q



Fast Growing Market



- ▶ Fastest growing market in the world
- ▶ Incredible rate of innovation
- ▶ China is already the #1 market for Windows Mobile phones

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Ubiquitous Computing in the Computer-Mediated Living Group

MSR Cambridge



Microsoft Research Asia Advanced Technology Center

computer-mediated living

- ▶ The group's vision is fundamentally interdisciplinary
 - ▶ brings together:
 - hardware engineering
 - computer science
 - psychology, and
 - sociology
- ▶ addresses the problem of *designing* technology to support people in their everyday life

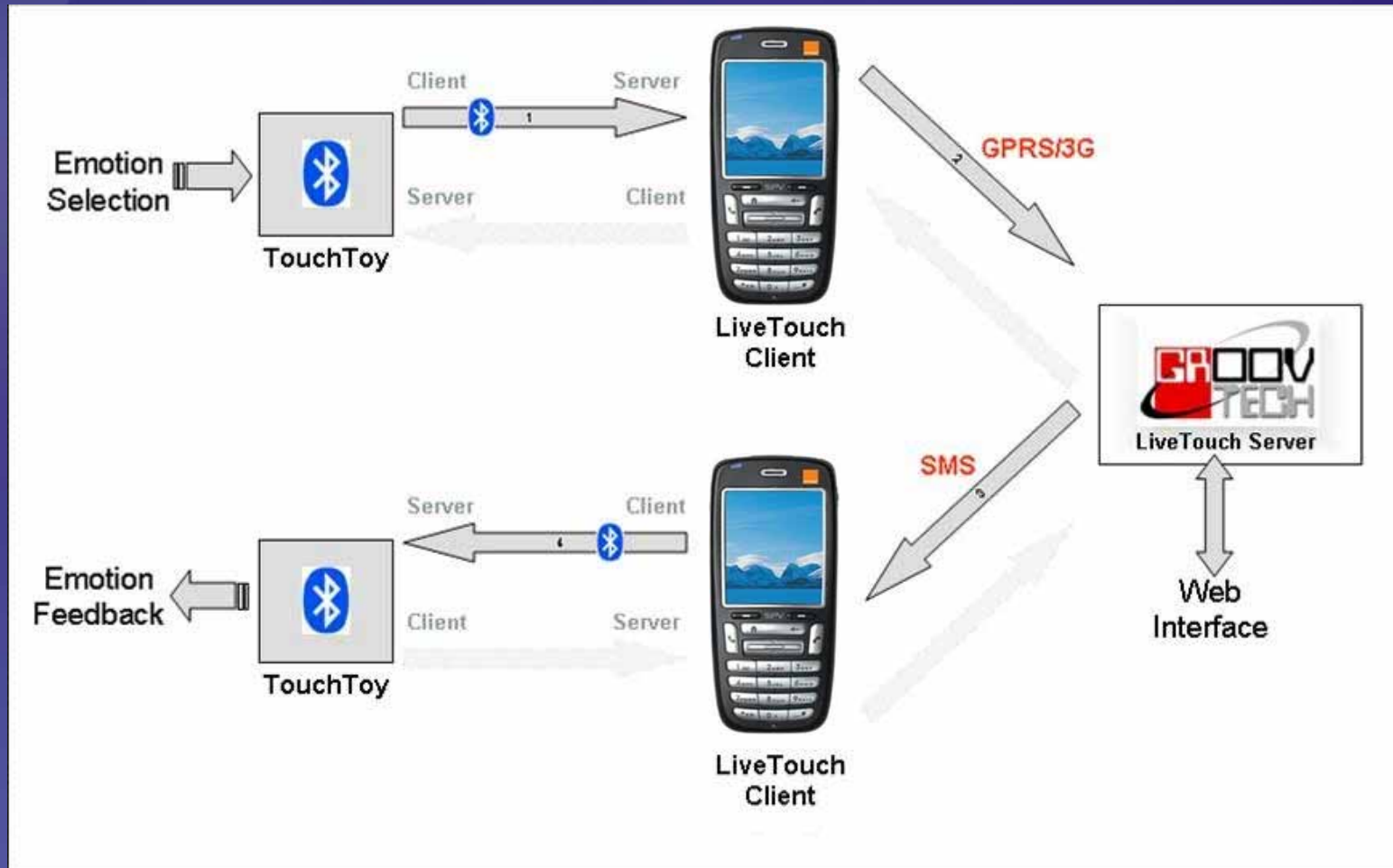
building socio-digital systems

- ▶ ubiquitous computing
 - ▶ for us, the interplay between physical and digital artefacts in everyday life
- ▶ three approaches to our work in this area
 - ▶ ethnographic field work
 - ▶ family practices, surfaces in the home
 - ▶ car travel as an extension of home life
 - ▶ mobile communication behaviour (TouchTalk)
 - ▶ technology probe studies
 - ▶ HomeNote: messaging to place
 - ▶ Whereabouts Clock: coarse-grained location
 - ▶ prototype technologies
 - ▶ WASP: wireless actuator and sensor platform
 - ▶ zCast: data broadcasting over TV and radio



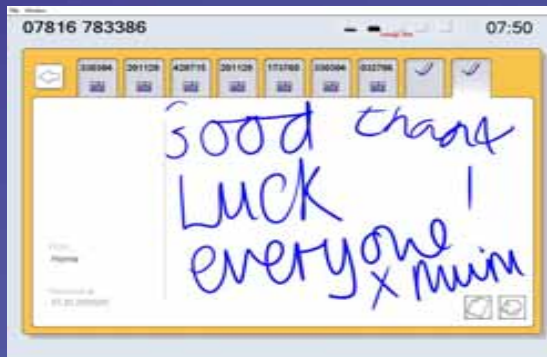
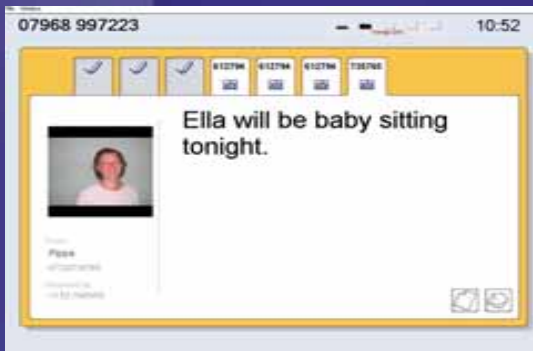
touchtalk

Exploring communication: subtle emotional messaging



homenote

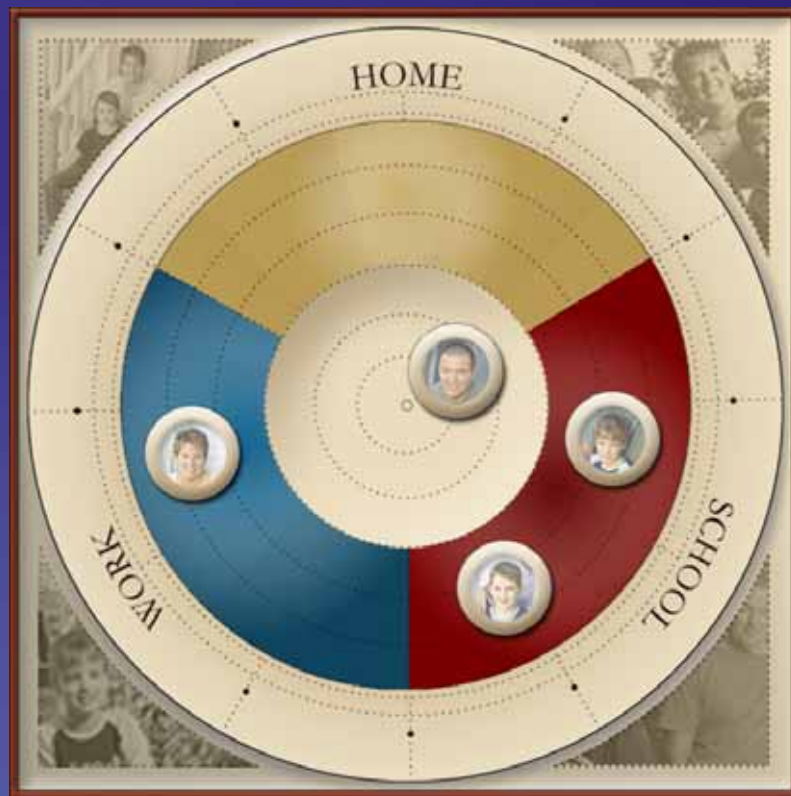
- ▶ A situated message board for the home
- ▶ Supports remote SMS “broadcasting” to the home and local scribble



- ▶ Testing in real homes shows its value in:
 - ▶ Broadcasting calls for action
Can you pick me up?
 - ▶ Social touch
Good luck on your exams!
 - ▶ Reminders
Buy tickets. Call Jenny
 - ▶ Micromanagement
Just leaving. Home in 10 mins.

whereabouts clock

- ▶ Display for multiple household members
- ▶ Situated, always on, public broadcasting
- ▶ Coarse-grained location data based on mobile phone
- ▶ Automatic rather than deliberate communication
- ▶ Ability to text more detail
- ▶ Office version first



wasp

- ▶ A wireless actuator and sensor platform
 - ▶ a development platform for embedded devices
- ▶ integrates wireless with sensing and actuation
 - ▶ GPRS/GSM/SMS and Bluetooth in 1st instance
 - ▶ sensors include physical location & environment
 - ▶ actuators largely visual feedback
- ▶ enabler for understanding
 - ▶ new application areas
 - ▶ underlying technology
- ▶ building working prototypes
 - ▶ stimulate innovative application development
 - ▶ highlight the real technical and design issues
 - ▶ allow trials and feedback from real users



zcast

- ▶ datacasting to fixed and mobile devices
- ▶ digital radio and digital television transmission (DAB and DVB) covering Cambridge
 - ▶ 12 MS households taking part
 - ▶ bringing movies, extra programming, Windows Update, etc. to Media Center PCs over the airwaves
 - ▶ DAB-enabled SmartPhones for mobile experiments with BT
- ▶ research goals
 - ▶ characterize and improve datacasting networks
 - ▶ explore HCI issues in home/mobile media consumption

zcast schematic



HealthGear: A Real-time Wearable System for Monitoring and Detecting Sleep Apnea

Nuria Oliver
Microsoft Research



Microsoft Research Asia Advanced Technology Center

Introduction

- ▶ Need for wearable health monitoring devices:
 - ▶ Aging population in developed countries
 - ▶ Rural areas in developing countries
- ▶ They would:
 - ▶ Enable the detection of early signs of health deterioration
 - ▶ Notify health care providers in critical situations
 - ▶ Enhance sense of connectedness with loved ones
 - ▶ Find correlations between lifestyle and health
 - ▶ New dimension in sports conditioning
 - ▶ Transform health care

However...

- ▶ To make these devices practical a series of technical, legal and sociological obstacles need to be overcome:
 - ▶ Non-intrusive
 - ▶ Comfortable to wear
 - ▶ Efficient in power consumption
 - ▶ Preserve privacy
 - ▶ User-friendly
 - ▶ Low failure rate
 - ▶ Minimal false alarms

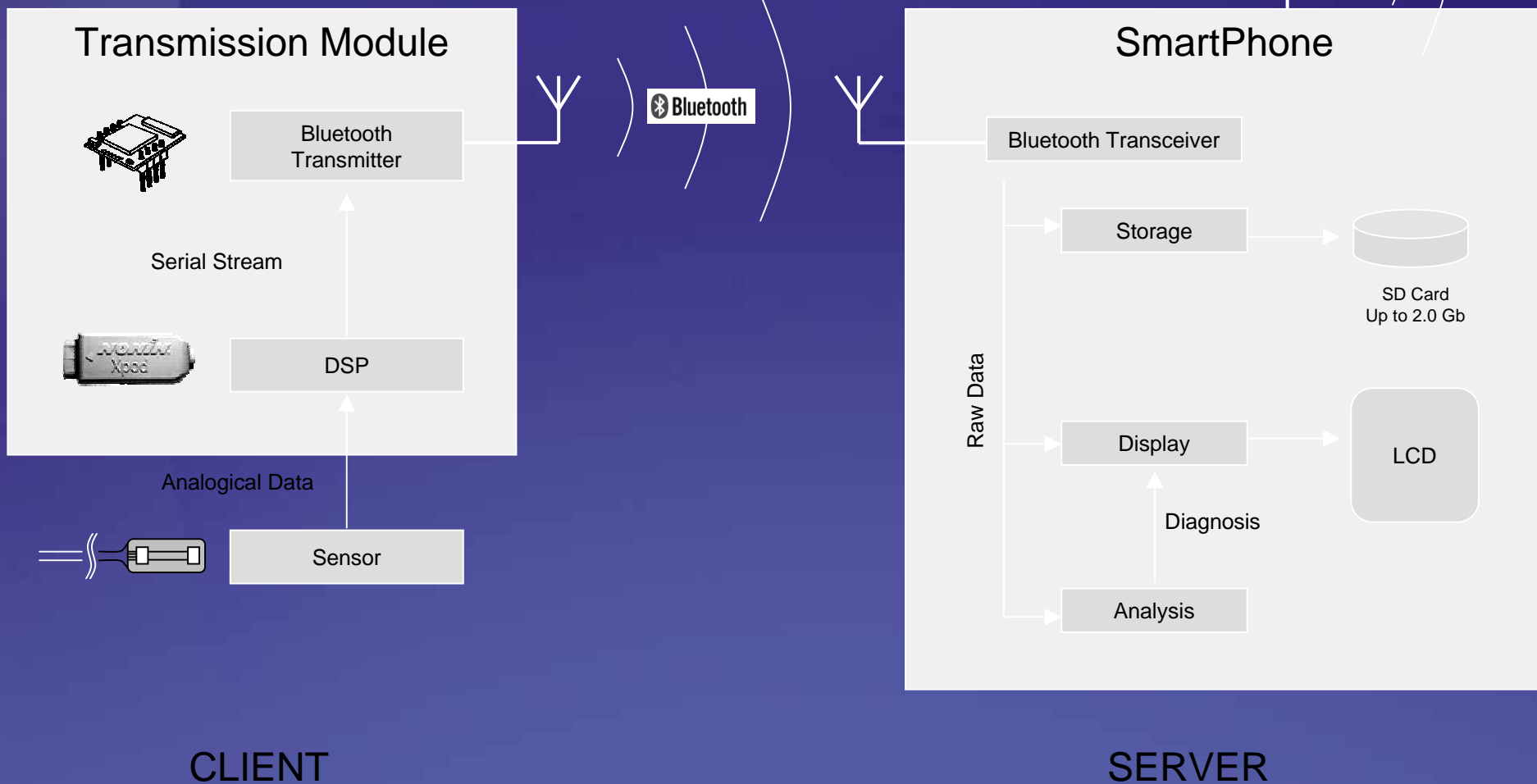
HealthGear

- ▶ Real-time, wearable health monitoring system
- ▶ Cell phone as central processing unit (Audiovox SMT5600)
 - ▶ Personal Computer for millions of people
 - ▶ Communication capabilities (GPRS, etc)
 - ▶ Multimodal: camera, microphone, etc
- ▶ Continuous recording of blood oximetry, heart-rate and plethysmographic signal
- ▶ Real-time analysis and presentation of physiological data to the user

HealthGear



Architecture



Sleep Apnea

- ▶ Underdiagnosed but common condition
 - ▶ Affects children and adults
 - ▶ 4% in men and 2% in women (higher for elderly)
 - ▶ Untreated causes \$3.4 billion of medical costs
 - ▶ 40 million undiagnosed Americans
- ▶ Periods of interrupted breathing (apnea) and periods of reduced breathing (hypoapnea)
- ▶ Leads to:
 - ▶ Hypoxia, asphyxia and awakenings
 - ▶ Increased heart-rate, high blood pressure
 - ▶ Extreme fatigue, poor concentration
 - ▶ Compromised immune system
 - ▶ Cardio/cerebrovascular problems

Sleep Apnea: Diagnosis

- ▶ Nocturnal Polysomnography (PSG):
 - ▶ In sleep center for 1-2 nights
 - ▶ Continuous, simultaneous multi-channel measurements of 8 physiological signals 😊
 - ▶ Very expensive, cumbersome, time consuming, just one sample and subject to manual scoring and human error ☹
- ▶ Pulse oximetry:
 - ▶ Useful as screening and diagnostic tool
 - ▶ One simple, light-weight sensor on finger, toe or earlobe



Automatic Detection of Sleep Apnea

- ▶ **Multithreshold Time Analysis:**
 - ▶ Defines multiple levels of desaturation (drop gap) and resaturation (return gap)
 - ▶ Desaturation starts as soon as the oxygen level falls below a baseline by a certain amount and continues until the signal recovers to a level, which is lower than the baseline by 25% of the specified amount
 - ▶ Our algorithm defines 11 threshold for all possible values of desaturation from 5% to 15% in increments of 1%



Automatic Detection of Sleep Apnea

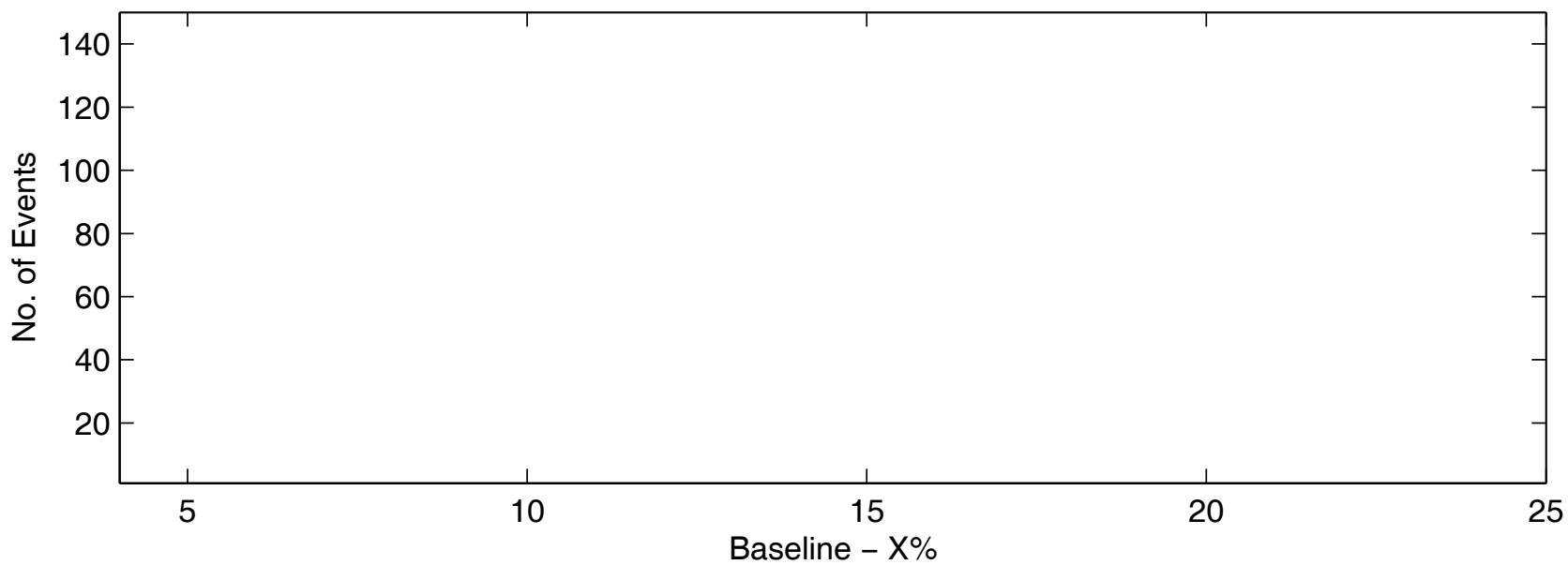
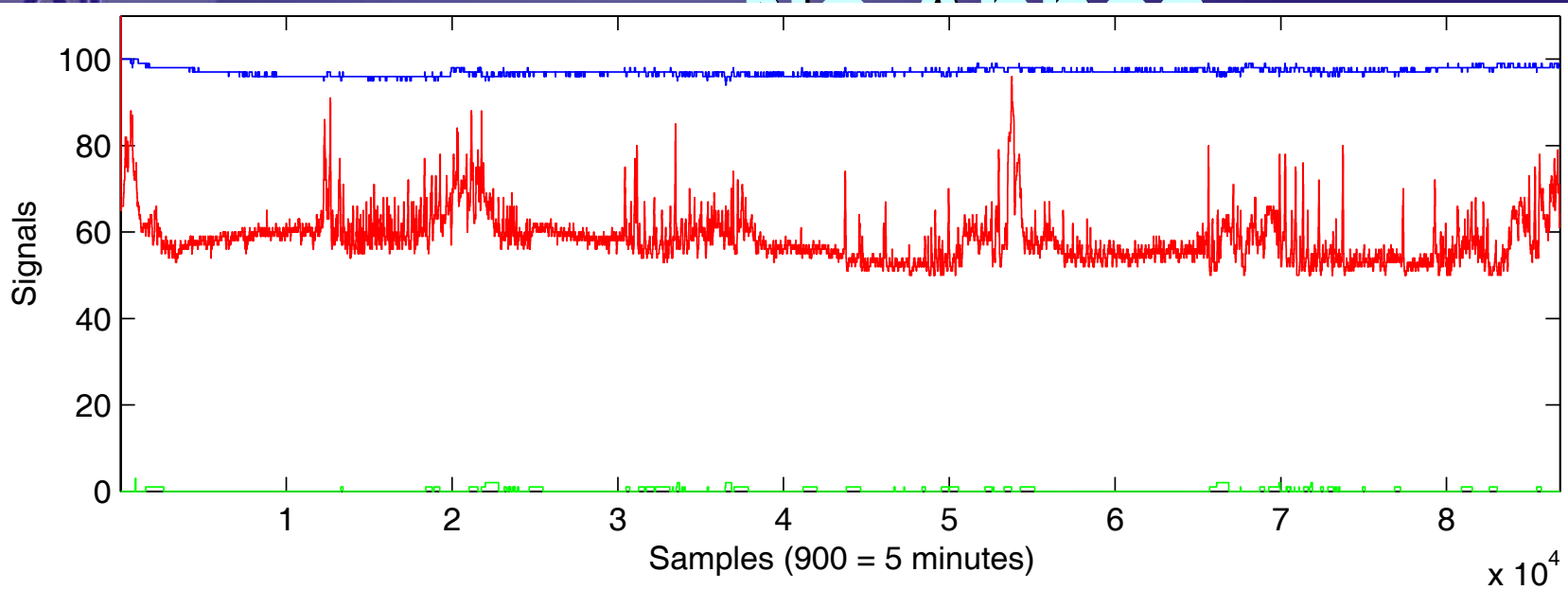
▶ Spectral Analysis:

- ▶ Periodogram of the mean-subtracted oximetry signal
- ▶ Sleep apnea events are detected as a peak in the range 0.015-0.04Hz
- ▶ This frequency has a physiological explanation corresponding to the typical lengths of apnea events

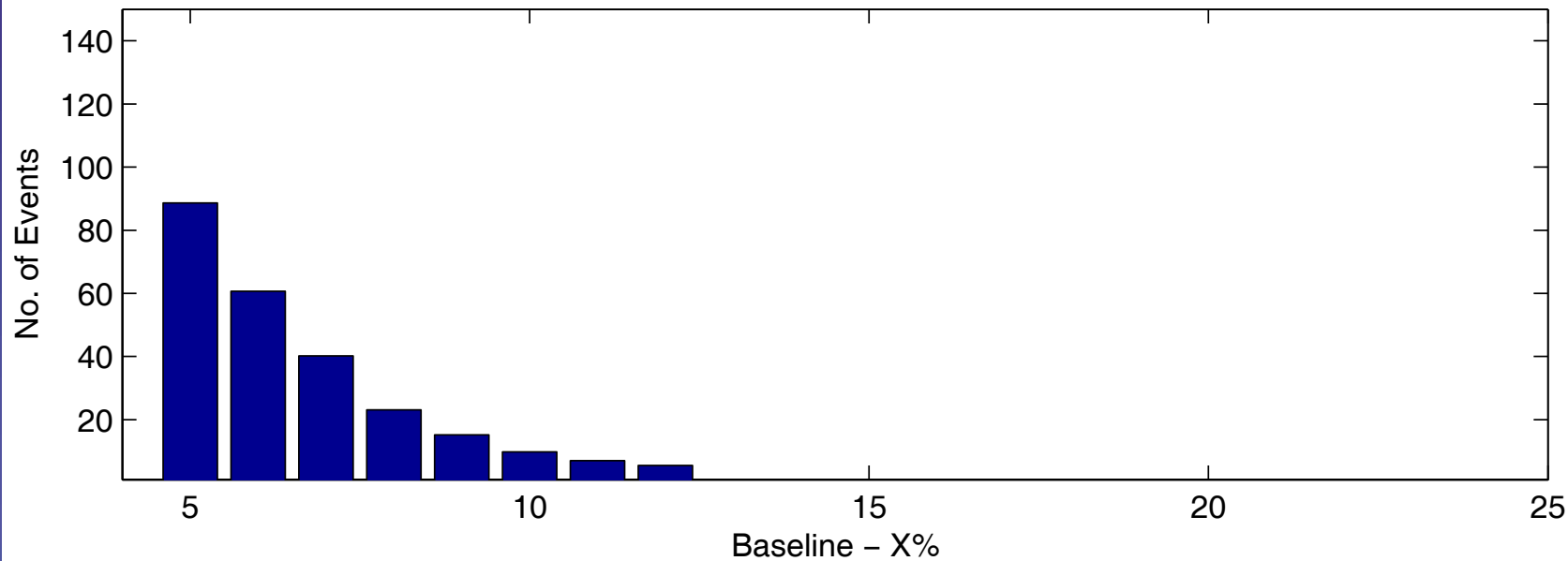
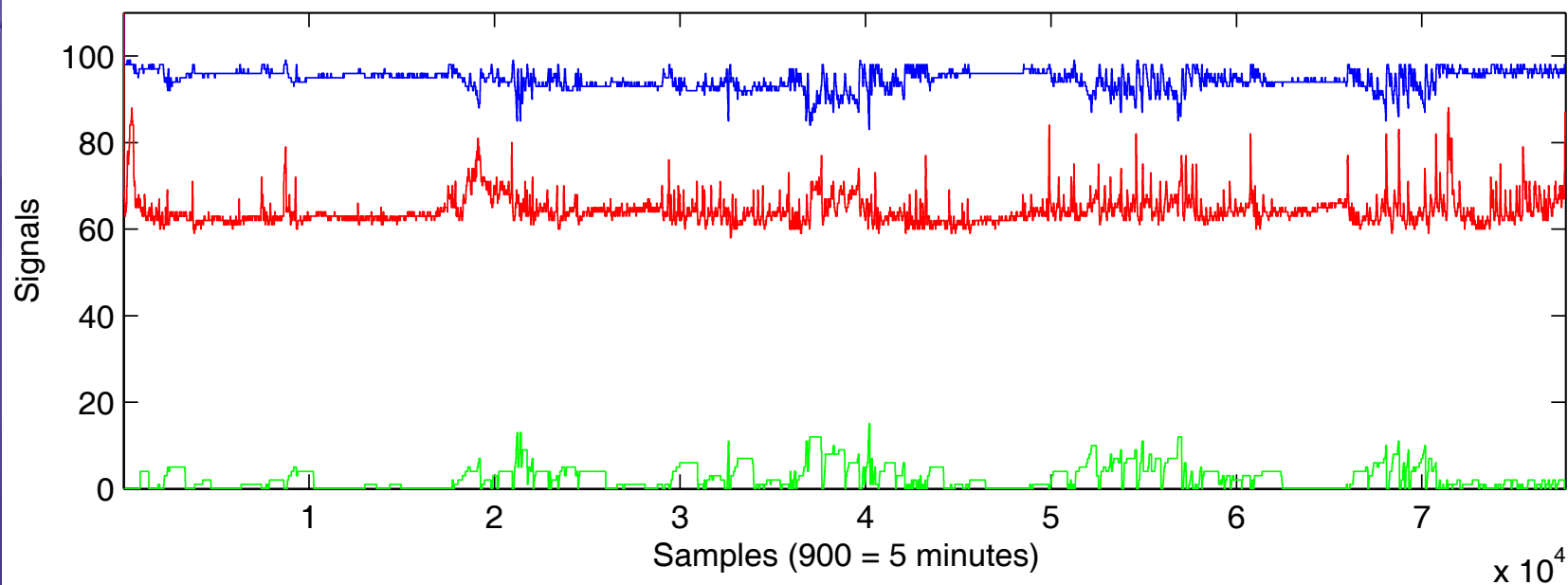


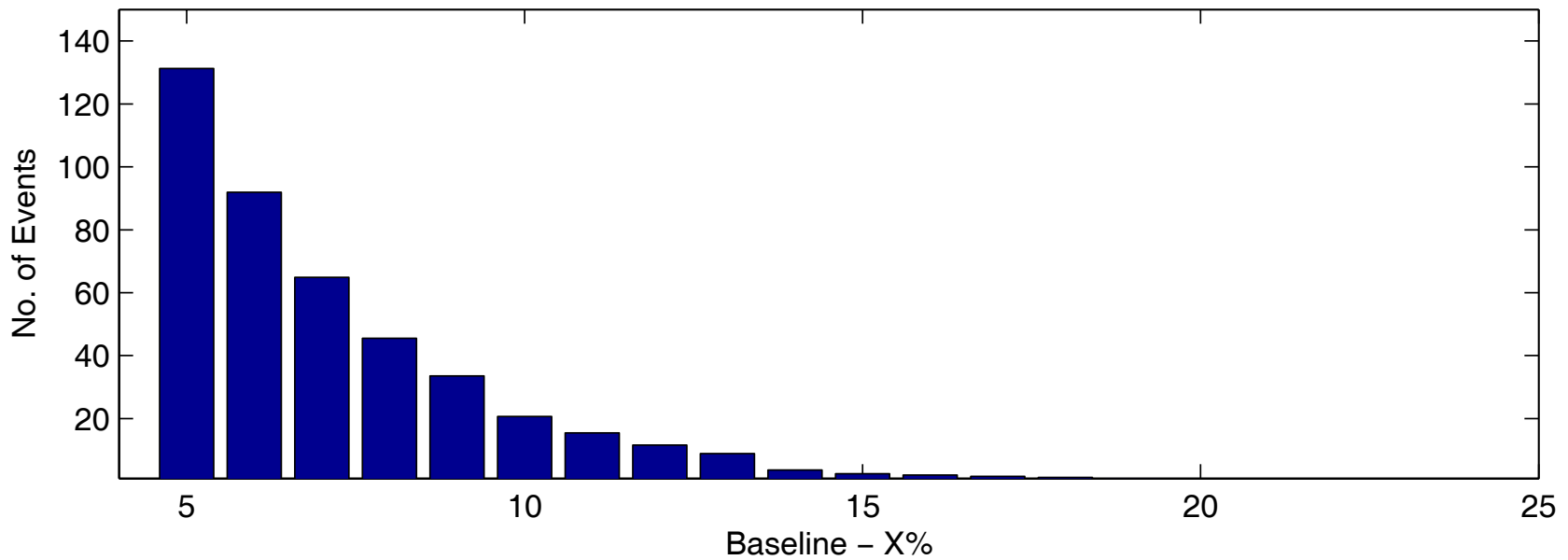
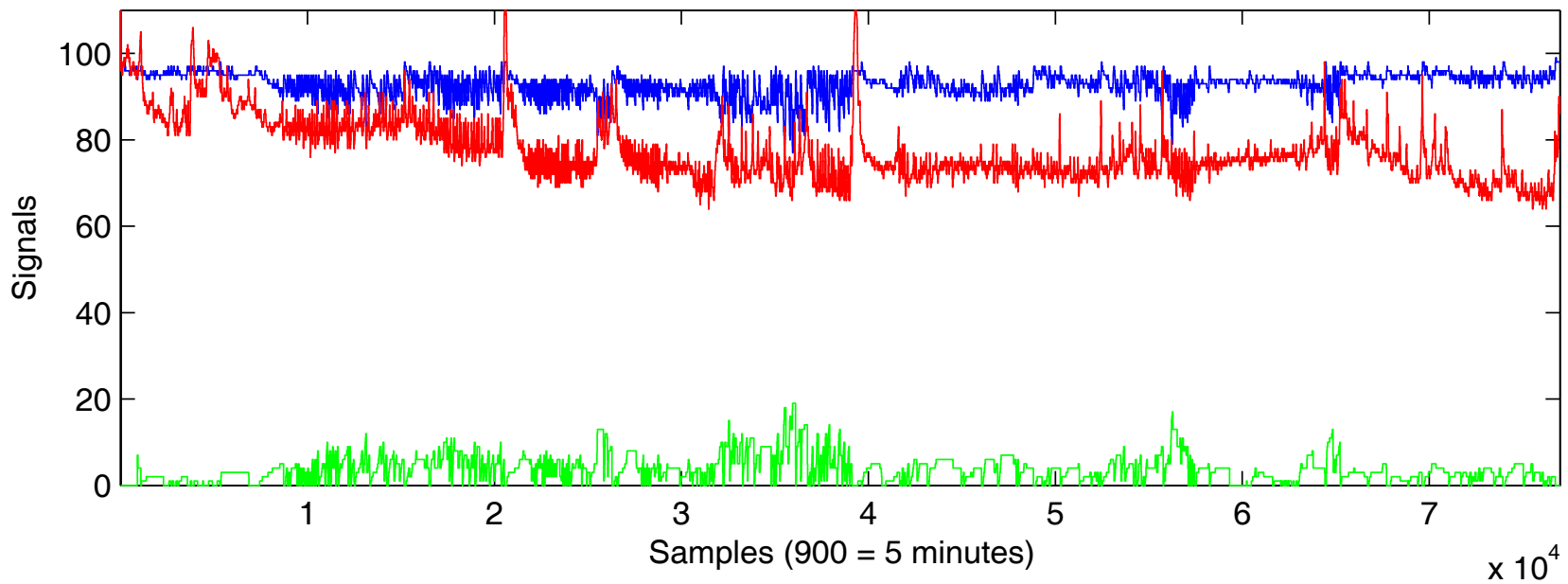
Sleep Study

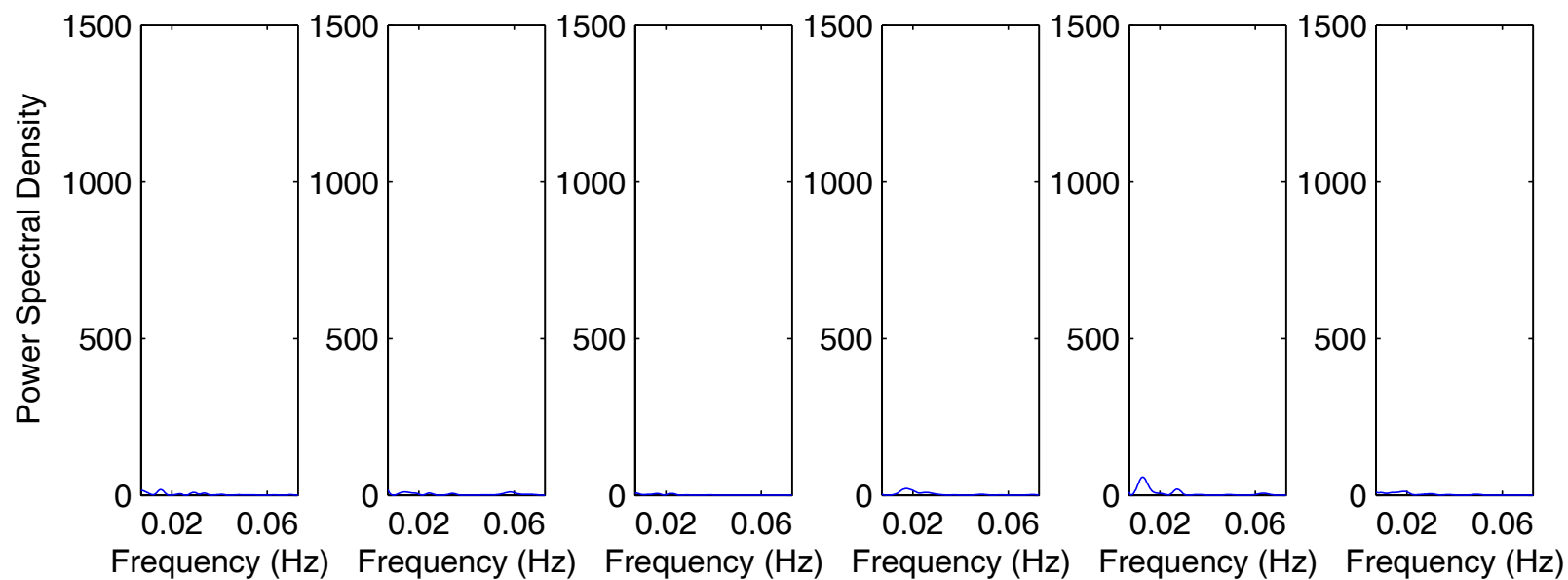
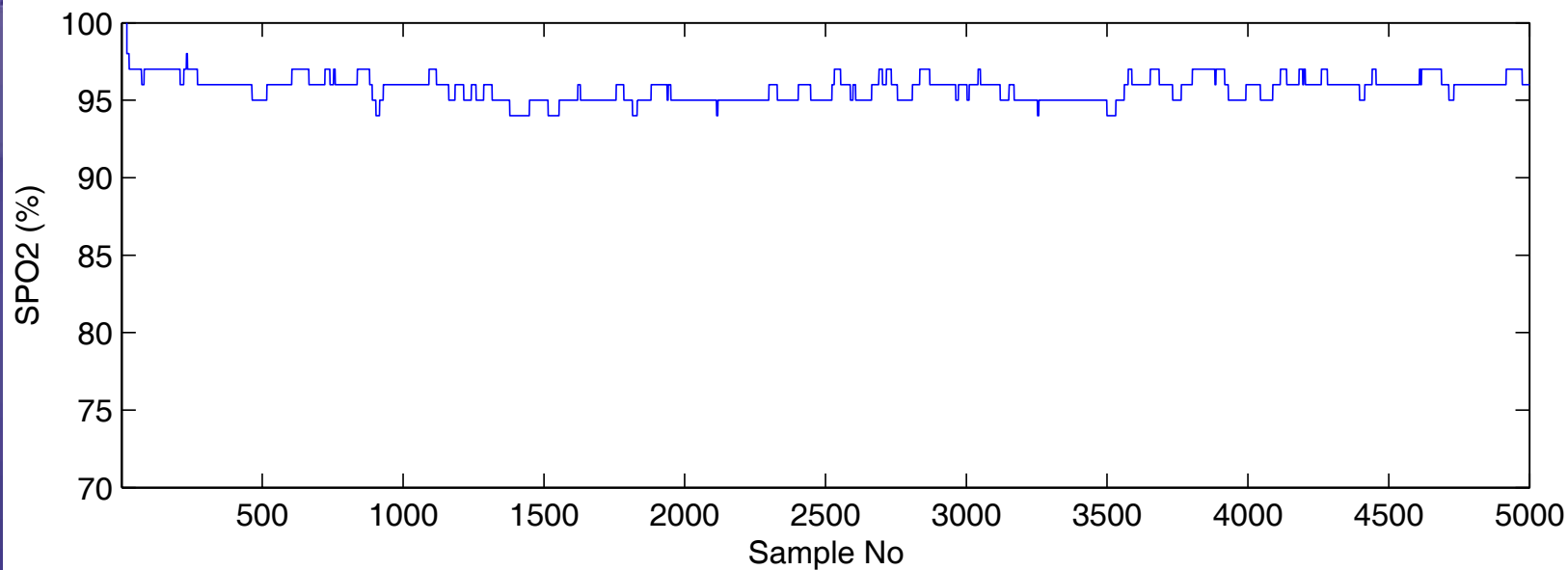
- ▶ 21 volunteers:
 - ▶ 80% male, ages 25-65
 - ▶ 30% healthy, 70% with sleep apnea or suspected
- ▶ Wore HealthGear for one full night in their own homes



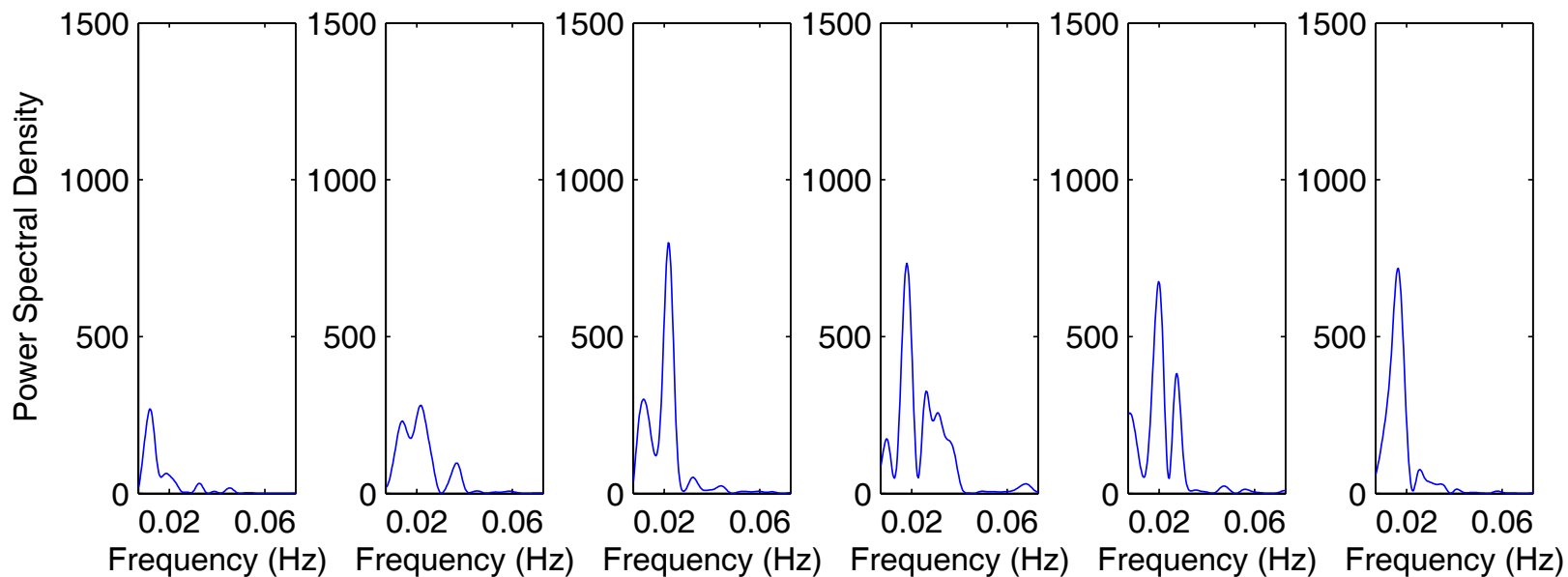
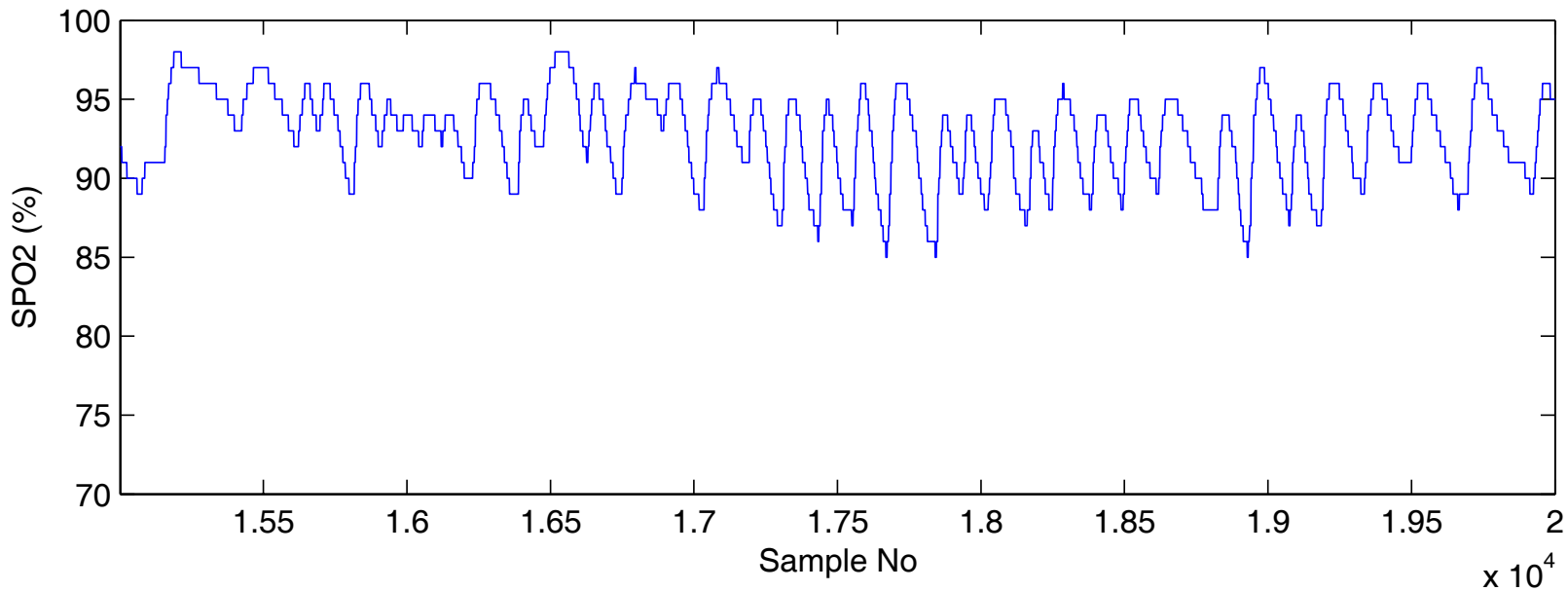
MIL Core Analysis



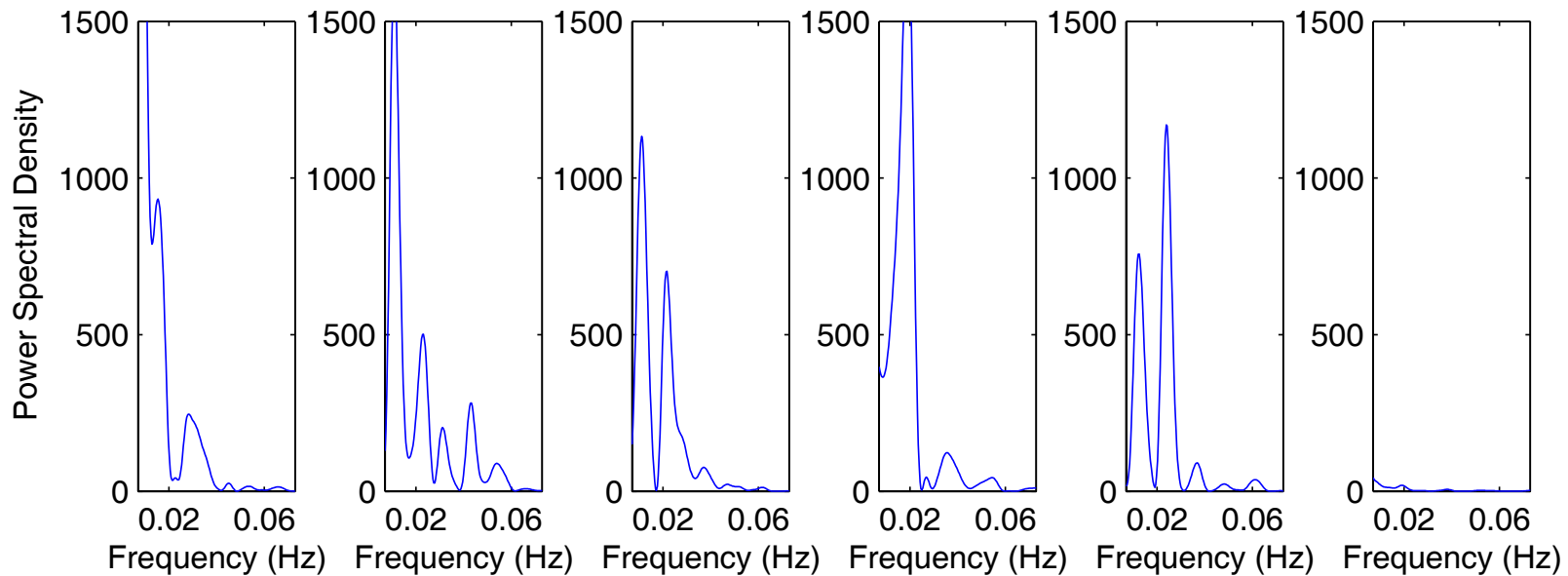
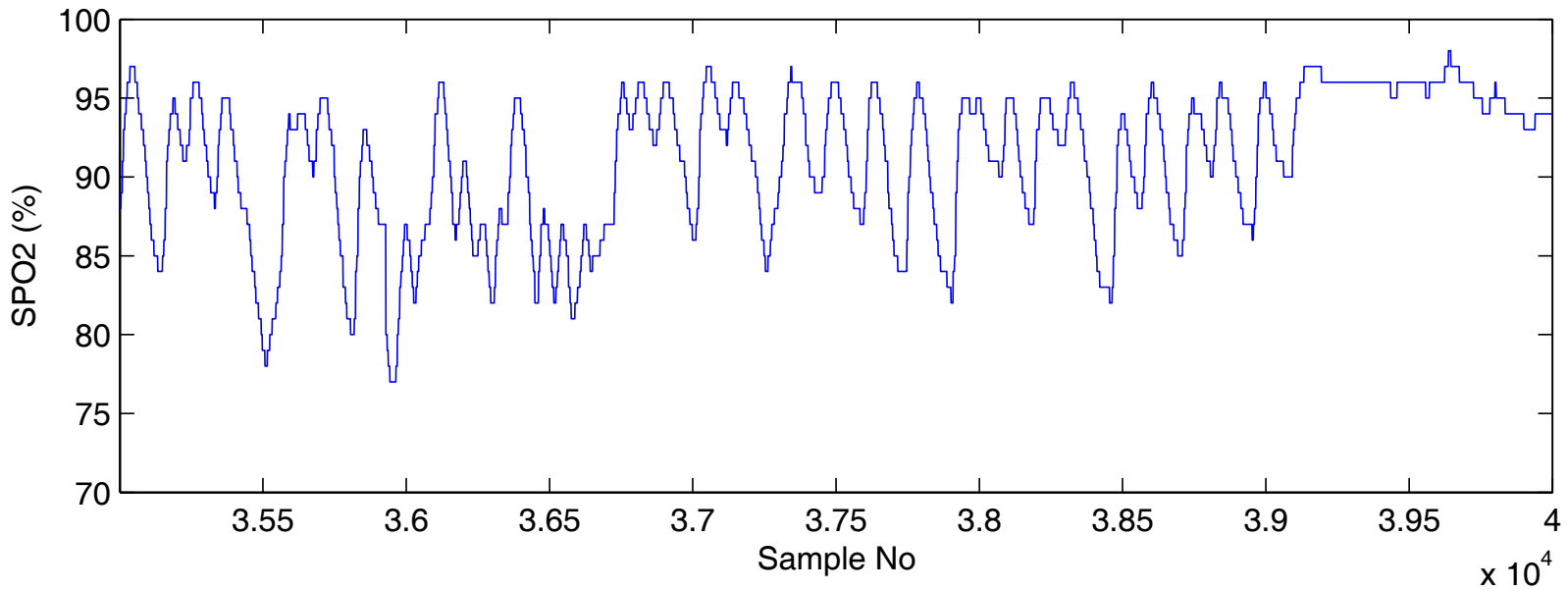




M-HL Coherence Analysis



Severe Apnea



Summary

- ▶ Accurate sleep apnea detection
- ▶ Light-weight sleep monitoring system
- ▶ High acceptance rates

- ▶ Long-term sleep studies
- ▶ Collaboration with doctors
- ▶ Additional sensors
- ▶ Identifying correlations between lifestyle, environmental factors and physiology

Conclusion

- Computing will be seamlessly embedded into the fabrics of daily lives
- Continuing hardware evolution trends will make devices ubiquitous
- Software innovation is key to delivering these additional services

Thanks!

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<http://research.microsoft.com/users/echang>