THE KNOWN UNKNOWNS OF MOBILE HEALTH

A Research Agenda

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RESEARCH IN HEALTH AND WELFARE TECHNOLOGIES AT HUT

**PRODUCTION**
- processes, quality, logistics, accounting

**SERVICE ENGINEERING / SERVICE OPERATIONS MANAGEMENT**
- Sensors and monitoring systems

**TECHNOLOGY**
- ICT, electronic devices

**FACILITIES**
- Hospital architecture

**PROCESS-BASED LAYOUTS**

**HEMA**
Institute of Healthcare Engineering, Management and Architecture
THE KNOWN UNKNOWN

Technology

What mobile technology can do for you

Clinical medicine
What the doc can do for you

The Known Unknown

What you can do for you

Patient empowerment

What is good for you.

Behavioral medicine
PRINCIPLES OF SCIENTIFIC EXPLANATION

A • causes, • strengthens, • enables B

1. A comes before B
1. A co-varies with B
1. There is no C to impact both A and B
1. There is a mechanism to connect A and B

This is Operations Management!
TOWARDS AT THEORY OF HOW / WHY IT WORKS

INDEPENDENT VARIABLE

Mobile health solutions
Asyncronous patient-provider interaction, monitoring, etc.

DEPENDENT VARIABLE

Health outcomes
Cost-benefit

Service Production and Consumption System

Output-outcome relationship
Time-location constraints
Control information

Service marketing,
Service –dominant Logic (SDL)
Behavioral medicine

Service Engineering
Supply chain logistics
Theory of Constraints (TOC)
Work-flow modeling
Management accounting
WHERE DO WE EXPECT THE IMPACT TO SHOW?

1. Macro: healthcare productivity
2. Meso: healthcare operating modes
3. Micro: processes, episodes, events
THE ASSUMED IMPACT OF MOBILE SERVICES

1. Improved allocative efficiency
   • Time/location constraints to access
   • Less travel
   • Appropriate asset specificity

1. Improved economic (output) efficiency
   • Unit, episode, and life-cycle cost
   • Staffing

1. Improved technical (output) efficiency
   • Capacity utilization rate: less no-show
   • Service event duration
   • Scheduling

1. Improved outcome efficiency
   • Disease management: monitoring, early warning & intervention
   • Time-series data
   • Compliance, co-production, stay on routine
   • Extended reach
ACCESS IN A TIME-LOCATION CONSTRAINED SERVICE PRODUCTION SYSTEM

NEED ARISES

TIME/LOCATION ACCESS

- communication
- distance
- transport
- opening hours
- waiting time

SERVICE Provision Point (SPP)
- Service Provision Time (SPT)
- Service Provision Location (STL)

NEED ANSWERED
ACCESS MAXIMIZATION IS RESTRICTED BY ASSET SPECIFICITY AND CAPACITY UTILIZATION

- SPP: Highly specialized care
- SPP: Specialist care
- SPP: Health centre
- SPP: Health station
- SPP: Drop-in

1. Macro

Asset specificity

Capacity utilization constraint

Catchment area of served population

Access
MOBILE SERVICES MAY BREAK, AMEND OR TWIST TIME-LOCATION CONSTRAINTS

<table>
<thead>
<tr>
<th>Time constraint</th>
<th>Mobility</th>
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<tbody>
<tr>
<td>Real-time telemedicine phone counseling videoconferences</td>
<td>Asynchronous services (SMS, e-mail, continuous biometric monitoring, etc.)</td>
</tr>
<tr>
<td>Time-location – constrained service</td>
<td>Unscheduled, Contact-to-care waiting time</td>
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<tr>
<td>On-demand &amp; on demand appointments at SPP</td>
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</tbody>
</table>

1. Macro

SERVICE PROVISION LOCATION (SPL)

SERVICE PROVISION TIME (SPT)

MoBILITY Location constraint

different

same

synchronous

asynchronous
HEALTHCARE OPERATING MODES

VISIT
- On demand
- Access
- Event
- Done
- Go to

CURE
- Before
- 1 2 3 4
- After

CARE
- Preparations
- Mobilization
- Rehab

ELECTIVE
- Resembles:
  - custom manufacturing

EMERGENCY
- Resembles:
  - rescue services
  - security

PROJECT
- Resembles:
  - shipbuilding
  - software development

PREVENTIVE
- Resembles:
  - financial services

2. Meso
HEALTHCARE OPERATING MODES

VISIT

CURE

CARE

ELECTIVE

EMERGENCY

PROJECT

PREVENTIVE

Performance issues:

- access
- event mg.
- sequence
- flow
- inventory
- cycle time
- output
- status
- SLA
- deadline
- preparations
- mobilization
- urgency
- prioritization
- outcome
- coordination
- expected value
- health behavior

MOBILE SERVICE
THE KNOWN UNKNOWN

Technology

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What is good for you.

Behavioral medicine
Cleveland Clinic Home Monitoring Pilot
Overview

• Microsoft’s Vision in Health
• Cleveland Clinic Pilot
Vision
Healthcare is undergoing a “Copernican Shift” with the consumer now placed at the center of various healthcare programs.

- Consumer Services
  - Diet and Fitness
  - Wellness

- Provider
  - Education
  - Encounter Management

- Supplier
  - Consumer Safety
  - Lifestyle Management

- Payer
  - Disease Management
  - Cost Containment

- Employer
  - Benefits Management
  - Corporate Wellness

In 1543, Copernicus was the first to propose that the Earth rotated around the sun, while accepted scientific thought at the time believed the Earth was the center of the universe. Copernicus effectively “changed the center of the universe”.
Our vision is to **improve health around the world through software innovation**

Health Solutions Group: Bringing together information from across the healthcare ecosystem

---

**Unified Intelligence System**

Allows hospital enterprises to unlock the power of data sitting in clinical, financial, and administrative silos. Without replacing current systems, Amalga offers the ability to capture, consolidate, store, access, and quickly present data in meaningful ways.

---

**Health Information Platform**

Designed to put consumers in control of their health information. A free HealthVault account helps you collect, store and share information with family members and gives you a choice of applications and devices to help manage your fitness, diet and health.

---

**Partner Applications**

- **Enterprise**
- **Consumer**

---

**Hospital Legacy Systems**
Health Life Stages: Shifting Needs and Interests

- **Early Childhood**
  - Puberty

- **First Job**
  - Job Change

- **First Child**
  - **Fitness Concern Function**

- **First Grandchild**
  - Job Change
  - Retirement

- **YOUTH**
- **ADULTHOOD**
- **SENIOR**

“Family Health Manager”

---

[Microsoft HealthVault logo]
Technology Has Changed Expectations
HealthVault - Empowering Consumers

Collect
Validate
Store
Analyze
Share
Health, Devices and Microsoft Software

Health Measurement Devices

Portable Devices

Wearable Devices

Wearable Devices

Desktop Devices

Floor Devices

Ambient Sensors

Room Devices

Desktop Devices

Health Interface Devices

Microsoft Software

Windows Live

Windows Vista

XBOX 360

XBOX Live

HealthVault Connection Center

MSN Direct

MSN Mobile

Windows Media Center

Microsoft TV

Sync

Windows Automotive

HealthVault

Surface

Mediaroom
Cleveland Clinic Pilot
Pilot Objectives

• Can we empower consumers/patients to take an important role in managing their chronic disease?

• Will patient outcomes improve with better data integrity and compliance?

• Can clinician efficiency improve by having a more reliable and up-to-date data?

• Can we improve the quality of a patient visit and reduce length of appointment time with more integrated physician and patient involvement in disease treatment?

• Can we reduce costs by using “off the shelf” home medical devices and leveraging patient’s existing home computer and internet connection?
Cleveland Clinic Pilot

• Collaboration between Microsoft and Cleveland Clinic

• At-home digital medical devices upload medical information to patient’s HealthVault account

• HealthVault sends patient information to secure Cleveland Clinic MyChart account

• Online log of readings available to patient’s physician
Cleveland Clinic Pilot

- 460 Cleveland Clinic patients representing three disease categories
  - 400 Hypertension – 1 Device
  - 30 Heart Failure – 4 Devices
  - 30 Diabetes – 5 Devices
- Devices include
  - Blood Pressure
  - Blood Glucose Meter
  - Peak Flow Meter
  - Digital Weight Scale
  - Pedometer
- Rollout across Cleveland Clinic Integrated Delivery Network
Cleveland Clinic Home Monitoring

Microlife

A&D Medical
Lifescan
Omron

HealthVault Connection Center

HealthVault

Microsoft

Diabetes Patient

Cleveland Clinic
MyChart

Physician

Cleveland Clinic
MyPractice

Podfitness.com
MyVitalData
MinuteClinic
NoMoreClipboard.com
HealthVault Account

Sound Health Solutions
Pilot Observations

- Patient age factors into success of setup
  - Heart Failure patients are 65+

- Installing software and devices varies across configurations

- Device Industrial design still greatly lacking
  - Setting clock on device requires special key combinations
  - Too many buttons, buttons too small, not intuitive
  - Connectivity solutions are “not good enough”
    - USB port hard to plug-in for elderly
    - Bluetooth pairing is complicated and limited range in home environment
    - Cell Phone networks don’t have 100% coverage in North America

- Data integrity even when controlled by patient
  - Digital Signatures
  - Audit Log history
Interesting Developments

- Low-cost solutions
  - Fugoo $99 Windows PC
  - Netbooks ~$250

- Blood Pressure Monitor Integrated into Mouse
  - MDMouse – CalHealth

- Devices with built-in cell connectivity
  - Amazon Kindle interesting model with integrated cell phone without required cell phone plan
Summary

• Mobile Health and Mobile technology is still in its infancy
  – Lots of challenges to overcome
  – Very high potential

• Business models are still insufficient
  – Limited/no incentive model for physician to connect with patient outside the clinical environment

• Lots of information systems
  – Lots of data “islands”

• Increasing desire for patient involvement in their own care

• No substitute for human interaction
  – But it can be enhanced with increased communication over a variety of mediums
Telehealth: Innovations in the Delivery of Health Care

Naomi Fried, Ph.D.
Vice President
Innovation & Advanced Technology
Chair, KP Telehealth Working Group
About Kaiser Permanente

- Nation’s largest nonprofit health plan
  - Integrated health care delivery system
    - 8.7 million members
    - 13,000+ physicians
    - 156,000+ employees
  - Serving 9 states and the District of Columbia
    - 32 hospitals and medical centers
      - 416 medical offices
    - $35 billion annual revenues
To provide affordable, quality health care services and to improve the health of our members and the communities we serve.
Our Structure

- **Kaiser Foundation Health Plans**
  Nonprofit, public-benefit corporations that contract with individuals and groups to arrange comprehensive medical and hospital services. Kaiser Foundation Health Plans contract with Kaiser Foundation Hospitals and medical groups to provide services.

- **Kaiser Foundation Hospitals**
  A nonprofit, public-benefit corporation that owns and operates community hospitals in California, Oregon, and Hawaii; owns outpatient facilities in several states; provides or arranges hospital services; and sponsors charitable, educational, and research activities.

- **Permanente Medical Groups**
  Partnerships or professional corporations of physicians. Each region has its own Permanente Medical Group. The Permanente Medical Groups assume full responsibility for providing and arranging necessary medical care in each region.
Telehealth: Our Definition

What is Telehealth?

A process and system for care delivery that extends beyond traditional walls, bringing health care and wellness into the everyday experience of members and their families

How does it work?

Communication, information, and bio-metric technologies are leveraged to extend and enhance the clinician, caregiver, and patient relationships
KP’s Vision for the Future: “Blue Sky”

Integration & Leveraging
- Medical services are integrated with wellness activities; care delivery processes are integrated with health plan operations.
- IT functionality enables us to leverage scarce or specialized clinical resources - MDs, RNs and other clinical staff.

Home as the Hub
- The home, and other settings, will grow significantly as a locale of choice for some care delivery (diagnostics).
- An individual’s care delivery support system has expanded to explicitly include other community and family resources.

Customization
- Occurs at any level of the members’ journey with KP (choosing health plans, cost sharing, individual care pathways, and communication modalities.)
- The member drives customization and KP responds.

Secure and seamless transitions
- ‘Warm Handoffs’ - The human skill sets and operational processes to deliver care and service effectively, efficiently, and compassionately.

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Secure and seamless transitions
- ‘Warm Handoffs’ - The human skill sets and operational processes to deliver care and service effectively, efficiently, and compassionately.
Kaiser Permanente’s Telehealth programs span the Member experience and touch all aspects of their care.
Value of Telehealth Programs

For the member: improvement in health, wellness, access, quality of care and quality of life, convenience, and safety

For the provider: professional sustainability and satisfaction, alternate methods for managing patients, time savings, ability to leverage providers who are in short supply

For the organization: cost reduction in providers and facilities, increased patient satisfaction
Summary

- KP is innovating in the delivery of care
- Telehealth is a paradigm shift in delivery of care
- Telehealth programs work across the continuum of care
- Members benefit directly from telehealth programs
- Implementation of telehealth strategy requires many parts of our organization
Questions & Contact Information

For more information about the Telehealth strategy at Kaiser Permanente, please contact Naomi Fried at:

- 510-271-6380
- naomi.fried@kp.org
Collapsing Time and Space in Healthcare
Mobile Services Are Becoming the Center of Life
Amazon Kindle - Wireless Reading Device

"This isn't a device, it's a service." - Jeff Bezos, Amazon

The Kindle's real breakthrough springs from a feature that its predecessors never offered: wireless connectivity, via a system called Whispernet. (It's based on the EVDO broadband service offered by cell-phone carriers, allowing it to work anywhere, not just Wi-Fi hotspots.)

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World’s First Integrated Low Power Chipset with 3G and Enables GHz Performance
Phone Is the Most Personal Device

4.0 Billion Cell Phones
Over 3 Billion More Than Any Other Computing or Consumer Electronics Device

• Connection to network
• Significant local processing
# Wireless Health Market Development

**Accelerating the Convergence of Wireless and Medicine**

<table>
<thead>
<tr>
<th>Founder</th>
<th>Catalyst</th>
<th>Partner</th>
<th>Partner</th>
<th>Innovator</th>
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<tbody>
<tr>
<td>Wireless Health Institute</td>
<td>Contiua Health Alliance</td>
<td>mHealth Alliance</td>
<td>Sensor Lab</td>
<td>Wireless Prototyping &amp; Trials</td>
</tr>
</tbody>
</table>

## Corporate R&D
- **Ultra Low Power Radios**
- **BAN/PAN’s Collaboration Platforms**

## Ventures
- **Triage Wireless**
- **Chealcomm**

## Wireless Reach
- Miami, China, Egypt, Peru, Spain, Thailand, Portugal, Kenya & Indonesia

## Consumer Health
- **Lifecomm**

## Global Smart Services
- **Cardionet**
- **Cardiomems**
- **Triage Wireless**

## Diagnostics ‘as a Service’
- **Diagnostics**
- **Therapeutics**
- **Monitoring**
- **Remote Presence**

## Personal Supply Chain Management™
- **3G Medical Gateways**
- **Better Consumer Experiences**

## Services & Handsets
- **Corporate R&D**
- **Ultra Low Power Radios**
- **BAN/PAN’s Collaboration Platforms**

## Collaborations Platforms
- **Ventures**
- **Triage Wireless**
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## Better Consumer Experiences
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## Diagnostics ‘as a Service’
- **Diagnostics**
- **Therapeutics**
- **Monitoring**
- **Remote Presence**

## Personal Supply Chain Management™
- **3G Medical Gateways**
- **Better Consumer Experiences**
Wireless Mobile Devices and Biosensors Will Transform Healthcare

- ECG
- Smart Bandages
- Blood Pressure, Pulse
- Glucometer
- Smart Pills or Internal Sensors
- Weight/Body Composition
- Environmental Sensors
- Pedometer
Wireless Health Connectivity Collapses Time and Space

In-Body
Drug Delivery Systems & Sensors

Neurological & Diabetes
“Courtesy of Medtronic”

COMMERCIAL
- Tremor
- Peripheral Vascular Disease
- Chronic Pain
- Malignant Pain
- Spinal & Cerebral Spasticity
- Liver Cancer
- Gastroparesis
- Diabetes
- Urinary Incontinence

IN DEVELOPMENT
- Parkinson’s Disease
- Dystonia
- Obsessive-Compulsive Disorder
- Depression
- Epilepsy
- Occipital Neuralgia
- Angina Pain
- Nonopioid Pain
- Obesity
- Diabetes
- Interstitial Cystitis
- Bowel Disorders

On-Body
SMART Band-Aids ™ in Development

Urgent Care
- Identity
- Heart rate
- Respiratory rate
- ECG
- SPO2
- Temperature
- Blood Pressure
- Motion

Fitness
- Heart rate
- Respiratory rate
- Distance/Steps
- Speed
- Elevation
- Motion
- Caloric Intake

Occupational
- Heart rate
- Respiratory rate
- Motion
- Temperature
- Hydration
- Electrolytes
- Identity

Chronic Care
- Compliance
- Heart Rate
- Blood pressure
- Hydration
- Pressure
- Weight
- Ischemia
- Motion
- Identity

Diagnostic
- Compliance
- Heart Rate
- Respiratory rate
- Motion
- Temperature
- Blood pressure
- Hydration
- Pressure
- Weight
- Ischemia
- Gait
- Identity

Therapeutic
- Compliance
- Heart Rate
- Blood pressure
- Hydration
- Pressure
- Weight
- Ischemia
- Drug Delivery
- Identity

Band-Aid ® is a Registered Trademark of Johnson & Johnson Consumer Companies, Inc. 2007.
CardioMEMS miniature implantable sensors use radiofrequency energy to transmit real-time data and communicate this information to the patient’s physician for the management of patients with congestive heart failure.

- Cardiac Output
- Blood Pressure
- Heart Rate

CardioNet’s Diagnostic Devices wirelessly and remotely detect cardiac arrhythmias.

- ECG
- Heart Rate
- Respiratory Rate
Fitness

Smart Band-Aids © will enable people to measure and wirelessly transmit information while exercising.

Health maintenance
- Heart Rate
- Respiratory Rate
- Distance/Steps taken/Relative motion
- Speed
- Elevation
- Calories Burned

Home Health Hubs

Home Health Hubs enable people to capture and wirelessly transmit vital signs, improving health, and fitness maintenance.

Remote Care
- Caregiver Connections
- Diagnostics
- Monitoring

Health Maintenance
- Coaching
- Diary Functions

Healthcare Devices

- Omron Body Composition Meter
- Omron Pedometer
- Omron Blood Pressure Monitor
- Johnson & Johnson Glucose Meter

Cellular Network
SMART Band-Aids ©

Smart Band-Aids © are merging wireless body-area network communications (WBAN) with improved biosensors and continuous blood pressure.

- Continuous Blood Pressure
- Heart Rate
- SP02
- Other Vital Signs

Patch Drug Delivery

A Wireless Patch Drug Delivery system, or wireless transdermal patch, is an adhesive patch with a drug reservoir that is placed on the skin to deliver a specific dose of medication. Sensors transmit data for monitoring and control purposes.

- Control Patch Activation
- Monitor Use
- Monitor Therapy
- Adjust Drug Delivery
Targeted Drug Therapy

MicroCHIPS' drug therapy solution provides patients with implantable chips that monitor the amount of medication the body needs. This information is wirelessly sent, collected, and available for analysis by physicians, caregivers, and patients.

- Osteoporosis
- Diabetes
- Cardiology
- Ophthalmology

Remote, Mobile Clinics

Mobile diagnostic kits in development bring safe, effective treatment to those living in remote areas of India. This idea will provide a proof of concept that can be expanded globally.
Medication Compliance

Proteus develops products that integrate in-body electronics and sensor technologies into existing pharmaceuticals to improve therapeutic outcomes. Embedded transmitters in pills are activated when patients digest them. Once activated, it sends a message to a band aid receiving signals that the medication has been taken, and at what time.

- Measures Compliance
- Improves Therapeutics
Personal Supply Chain Management™ easily replenishes your medication before you run out, saving you time and money.

Example: COPD Patients are reminded to order more inhalers or oral medications before they run out.

Personal Supply Chain Management™ Flow Diagram
Transforming Healthcare

LifeCOMM Diabetes Management Solution
Phone Reminds Patients to Take Their Meds
Improving health and heart fitness with NOKIA’s N79 Active & wireless Polar Bluetooth WearLink heart rate belt

- Heart Rate Monitor
- Fitness Diary
- GPS tracking to record and publish your favorite routes
- Fitness social network
The intelligent connection to health

Connect patients with their physician using mobile phone video chat, instant messaging, email and text messaging.

Health Consultation - Any network, any device, anywhere.
Challenge: Building a Platform for Sensors

- **Ultra Low Power**
  - Extended battery life
- **Security**
  - Data must remain private
- **Integration with sensors**
  - Sensor-specific processing on platform
  - Easy configuration
- **Smart nodes**
  - IP transport and protocols from sensor to servers
- **Flexible deployment topologies**
  - Star or mesh
  - Scalability
Challenge: Personal Health View

- Decentralized

- Standards for Interoperability
  - Security/access control
  - Aggregation
Consumers are not afraid of Telehealth
Thank You
Optimizing Patient Care In Clinical Units Using Wireless Patient Identification and Tracking

CMU Workshop on Mobile Healthcare

Yacine Belala, SAP Research Canada
Keith Klemba, SAP Research Palo Alto
February 2009
1. Problem Background
2. Issues
3. Research Opportunities
4. Open Questions and Discussion
Steps:

1. Patient A arrives in Exam Room. Patient A is equipped with a wireless device that allows proper ID (e.g. RFID wristband)

2. System identifies patient and records time. Reader Location is associated with patient location

3. System identifies medical devices to be used for care episode.

4. Exam data collected and correlated with patient ID. Patient data is accessed if available

5. Data is archived for the care episode

6. Patient B enters room while Patient A is still in (Med devices could be reused at different times)

7. System detects to which patient collected data belongs

8. Data collection for Patient A is stopped when patient leaves room. Session is kept active for next step
Current Automation Not Adequate for Healthcare Workflows

- Healthcare workflows are dynamic:
  - Regular updates in treatment protocols
  - Unexpected changes in patient status
  - Mismatch between clinical decision systems (linear) and the way care is performed (collaborative, multitasking and reactive) leading to underutilization

Human Aspects

- Tagging Patients and Staff
  - Privacy Constraints
  - Finding an appropriate place on the body (injuries to the skin, interference with care delivery....)

From a technology perspective

- Massive disparate non-standard data (Which data to collect on top of time and location)
- Potential for Electromagnetic Interference (EMI)
- Accuracy/Readability of location information due to short ranges
- Mobility not addressed by standard solutions (RFID assumes static readers)
Research opportunities

- Patient flow monitoring processes that make use of medical protocols
  - Define processes to support specific care protocols for patients, KPI
  - How to react in real-time to deviations from protocols (context-awareness?)
- Combination of multiple wireless technologies to support the processes defined, such as:
  - RFID for “Point-of-care”
  - Wireless LAN/Active RFID….
    - To account for patient mobile patients
    - Data transfer during patient handoff (higher rates)
- Usability for staff (key for acceptance)
  - Staff requirements
    - Nurses cannot wear PDA. No Belt. Too heavy for pockets. Alternatives displays?
  - How to switch between several patients handled simultaneously

Source: http://model.pih.org/HIVmanual/protocol3_3
Open Questions & Discussion

- Is it possible to use wireless patient flow monitoring to provide “true” patient-centric care? (Not simply automate paper flow)
  - Getting the right data without overwhelming staff
  - Tradeoffs between access and security…

- What current barriers/challenges could be removed/addressed
  - What key process steps, cycle times, backlogs, rework errors could be improved using wireless technologies?
  - What measures of quality, productivity, patient satisfaction… need to be accounted for?
  - What would be key to get medical practitioners and institutional buy-in?
Thank you!
Improving health outcomes through collaborative gerontechnology

Benay Dara-Abrams & Wayne Pan
Kinnexxus, Inc.

Mobile Health Workshop @ CMU-Silicon Valley
February 11, 2009
What is gerontechnology?
What is collaborative gerontechnology?
FOR
TO
WITH
promote respect, dignity
enable independence
Responsibility for ALL levels

Aging Individual

Family

Social Services

Medical

Limited responsibility

Physiological

Physical

Cognitive

Social

Spiritual
Person-environment fit

- Keep the senior actively engaged by making it challenging enough
- Not too challenging - frustration
- Not too easy - boredom
- Just the right amount
Current senior environment

• Chaotic
• Fragmented
• Difficult to navigate
• Isolating
• Dysfunctional
• Inefficient
• Costly
Current senior environment

- Lack of predictability
- Disconnected, unreliable
- Lack of coordination
- Depression
- Ineffective
- Time-consuming
- Not sustainable
Community
- Home Community
- Membership Organizations
- Senior Living Facility
- Individuals in Transition

Senior

Family & Friends
- Primary Caregiver
- Secondary Caregivers
- Supporters
- Local vs. Remote Co-location ("rovers")

Professional Care Providers
- Remote vs. In-Home
- Primary vs. Secondary Direct vs. Indirect
Introducing the Senior Ecosystem™
How can the Senior Ecosystem™
improve health outcomes?
Physical health embedded in a social context

- Reminders
- Status checks
- Vital signs
- Clinical metrics
- Ubiquitous monitoring
- Social interaction
- Routinize
personal health

outpatient

inpatient
health 2.0
participatory healthcare
enabled by information
software and community
patients can be
effective partners
in our own healthcare
personal health

- outpatient
- inpatient
personal health

- outpatient
- inpatient
personal health

outpatient

inpatient
health 2.0
DO I HAVE HIGH BLOOD PRESSURE?

WELL, I REVIEWED THE READINGS YOU UPLOADED THROUGH THE WEB

AND YOUR AVERAGE READING IS BELOW 135/85

from: www.tedeytan.com/2008/06/23/1139
The Senior Ecosystem™
We’re all connected. Are YOU?
Thank you
Quality of Life Technology: Mobile Healthcare

Dan Siewiorek

Mobile Computing
February 11, 2009
Quality of Life Technology Engineering Research Center

Takeo Kanade
Director
U. A. and Helen Whitaker University Professor
Robotics Institute
Carnegie Mellon University

Rory Cooper
Co-Director
FISA/PVA Chair and Distinguished Professor
Dept of Rehabilitation Science and Technology
University of Pittsburgh

Intelligent systems that augment body and mind
... Technology to Enable Self-determination for Older Adults and People with Disabilities
QoLT Vision: Outcome

Intelligent systems that augment body and mind

Increase **employability** and **productivity** across the life span

Expand the range of environments in which people will be independently and safely mobile, increasing **community participation**

Expand the number of people and number of years that they can **live independently** at home

Enhance **QoL** and **capacity** of caregivers

*Relate human physiological, physical, and cognitive function to the design of intelligent systems*

*Create technologies & systems that make measurable positive impact on quality of life*

*Work closely with user groups throughout design, development, test, and deployment phases for adoption, evaluation, and privacy concerns*

*Develop the QoLT curriculum, motivate students and inspire under-represented groups to pursue QoLT careers*
QoLT ERC Research Model

- Human-System Interaction
- Perception and Awareness
- Mobility and Manipulation
- Person and Society

people & their environments

intentions & information

assistance & effect

users, providers, payers
QoLT Systems

Personal Mobility & Manipulation Device
• Combine manipulation and mobility assistance with perception and decision making wherever a person goes.

Virtual Coach
• Provide cognitive and reasoning assistance wherever a person goes and whatever he or she does.

Active Home
• Combine manipulation assistance with a perceptive environment. Our initial focus is providing this service in the home.

Safe Driving
• Providing ways to make driving safer for older adults and people with disabilities.
Integration Testbed
Turning Vision into Reality

McKIZ:
McKeesport Independence Zone
(Blueroof)

10-acre 12-block area with
12~15 single family houses with:
church, convenience store, community center and other
infrastructures

End user participation daily living situation: application of PASIM
(Person and Society Infusion Model)

Residential agreement on data collection

Pedestrian and vehicular traffic

Sensor saturation in home

Complete monitoring and wireless coverage in environment

Enthusiastic industry, local government and other stakeholder’s
support
Virtual Coach

Seated Activity

Anaerobic Exercise

Mobile Sensors

Aerobic Exercise

Wheel Chair Propulsion
Virtual Coach Architecture

User Interaction
Input

Personal Agency
Adjust capability of Interaction

Coaching Domain
Model

Labeled Data Base

P&A Sensing

Prescription

Authoring

Reminding

User Engagement
Output

User Interaction
Input

Prescription

Authoring

Coaching Domain
Model

Labeled Data Base

P&A Sensing

Reminding

User Engagement
Output
Feature Space After Linear Discriminant Analysis (LDA) Transformation
Audio and Light Sensor Clustering
Manual Wheelchair
Propulsion Patterns

Fig 2. Propulsion patterns. Four classic propulsive strokes are shown: (A) semicircular (SC); (B) SLOP; (C) DLOP; and (D) arcing (ARC). The dark bars to the right of each pattern represent the beginning of the propulsive stroke. The dark bars to the left of each pattern represent the end of the propulsive stroke and the beginning of recovery.
Assessment of Psychosocial Stress
Expected capabilities

3 years
• Primary measures: physical activity, location, biological signs
• Example coaches: balance, seated activity recognizer, exercise motivation to encourage user to adhere to clinicians plan

5 years
• Determination of user activity and intent from primary sensors of physical activity, location, biological signs
• Example coaches: cognitive, social

10 years - Autonomic Virtual Coach
• System is responsible for it’s own management and evolution
• Assess changes in user abilities
• Request synthesis of new functionality for coach to adapt to changes
• Automatic download of new capability
Thank you.