Microservice Ecosystem for Digital Health in Integrated Care Settings

Keynote

IEEE Congress on Services

Aula Magna, Universita' degli Studi di Milano, Milano, Italy

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Keynote Agenda

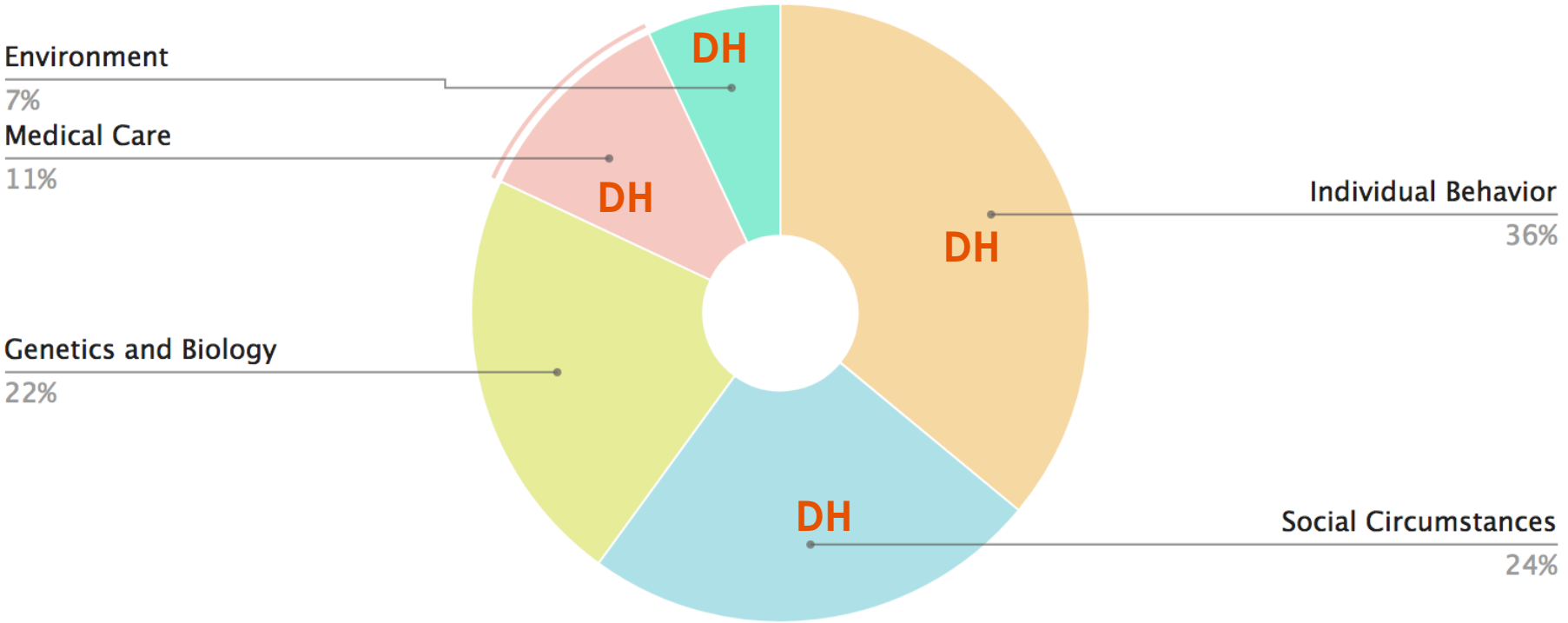
- The Evolving Landscape of Digital Health
- Evidence Digital Health Works
- The Promise of Microservices for Digital Health
- Microservices Enabling Health IoT
- Microservices Enabling New Delivery Models in Integrated Care Settings
- Challenges and Impediments
- Conclusions

Digital Health

- The use of digital technology to implement or support:
  - Personal health
  - Active and healthy Living
  - Active and Healthy Aging
  - Delivery of health and social care services
  - Learning Health Systems
    - Disease understanding
    - Behavior understanding
    - Others

Determinants of Health

Surprising Statistics



How much of an effect different factors have on an individual's health outcome

Changing Individuals and Populations Lifestyle through Digital Health

Transforming the Care Delivery System

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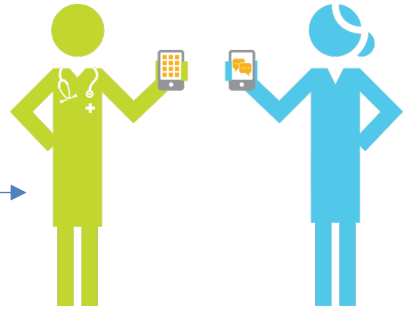
Treat patients through their "digital cases (Data)", asynchronously. 187 patients from 2:00-4:30pm by 5 Physicians.

Patient engagement and self-care (Navigation)



Community resilience is the sustained ability of a community to utilize available resources to respond to, withstand, and recover from adverse situations

DIGITAL HEALTH

A Practical View of the Evolving Digital Health Landscape

- **Health Navigation**
  - Personal Health and Wellness
  - Patient Engagement
  - Empowerment, e-coaching & behavioral change
  - Democratized Healthcare

- **Digital Plumbing**
  - Healthy Places: Smart Homes, Healthy Communities, Healthy New Towns
  - Promoting Active and Health Living and Aging
- **Digital Health as a Service**

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Key Digital Health Priority

Transform the current reactive primary care system (a **point-of-care paradigm**) into a proactive **Health Navigator** – a **continuum-of-care paradigm** capable of providing **personalized** and **timely guidance** and **just-in-time interventions**, while availing real-time, individual- and **population-level health information** to individuals, healthcare *organizations, governments, and* policy makers.

DIGITAL HEALTH

Successful Examples of Digital Health Technology in the Market Today

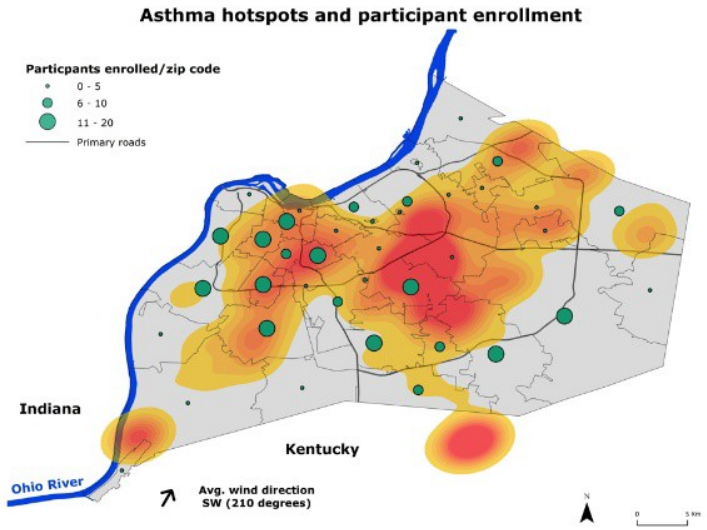
Karda

ECG, Atrial Fibrillation Screening, more.

Successful Examples of Digital Health Technology in the Market Today

Propeller Health

Allergy, Pediatric Asthma



Successful Examples of Digital Health Technology in the Market Today

OpenNotes

OpenNotes is the international movement that's making health care more transparent.

It urges doctors, nurses, therapists, and others to invite patients to read the notes they write to describe a visit.

Evidence Digital Health Works?

The Liverpool Connected Health Study

Long term, large scale in the city of Liverpool in the UK.

Philips Healthcare

30% of people in Liverpool live with one or more long term conditions

The difference in life expecatncy between areas of the city can vary by more than 10 years

The number of patients with Chronic Obstructive Pulmonary Disease offered rehabilitation varies between 24% and 79% in the city

Almost 26,000 older people have a long term illness that limits their day-to-day activities a lot

Over half of adults in Liverpool are overweight or obese

86% of people in Liverpool are not active enough to maintain good health

Figure 1: Healthy Liverpool challenges

The Liverpool, UK, Study

Simple Connected Health Technology

Evidence of health technology benefit for providers

A mobile working solution for community nurses

-60% Paperwork time

Patient face time +29%

2 extra patients seen daily

A telehealth hub across 210 care homes

-35% Hospital admissions

-53% A&E use

-59% Hospital bed days

0

Evidence of health technology benefit for patients

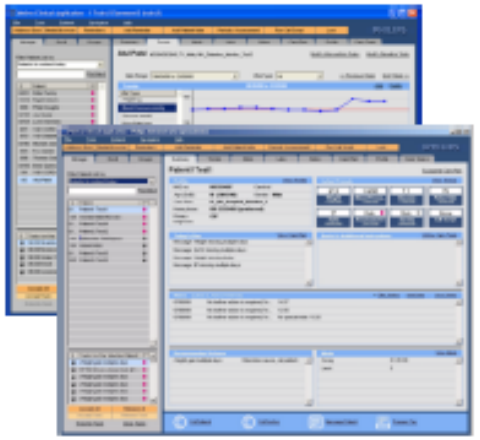
75% of the UK population goes online for health information

Patients using technology to manage their COPD:

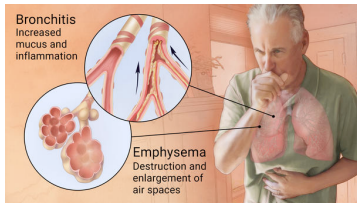
97% High satisfaction

62% Increased confidence

94% Better treatment compliance

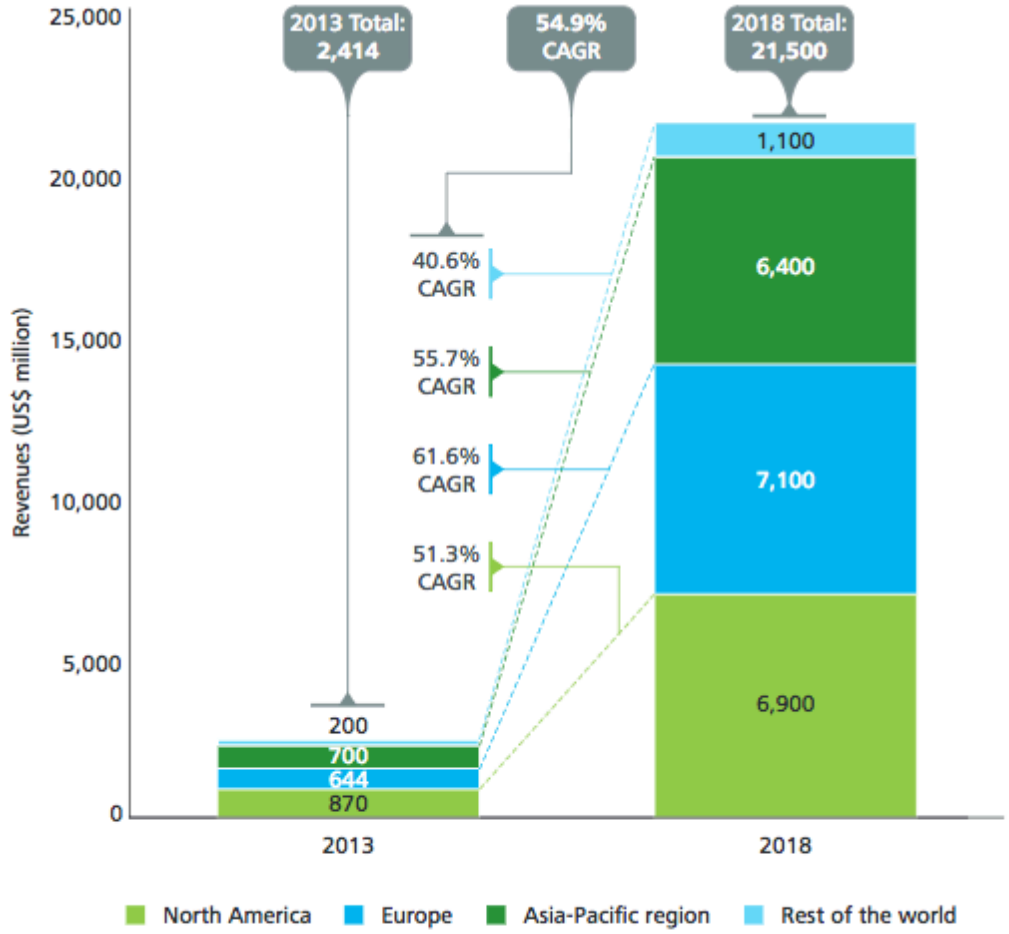


Chronic Obstructive Pulmonary disease



Market Indicators:

Global Digital Health Market Revenues Growth Rates: 2013-2018



Source: Mobile health technologies and global markets, BCC Research, 2014

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Digital Health as a Service

- Use of services, and microservices to enable many needed integrations, **most notably integrating health and social care**.
- **What is sought** is flexibility in the implementation of care pathways, many of which are overlapping and intertwined.
- **First**: The simplest service is a health device. Enabling a healthy ecosystem for Health IoT
- **Second**: Enabling new and direly-needed care delivery models in integrated health/social care settings

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The Various Integrations Enabled by Digital Health

- Primary and specialist health care services
- Health and social care services to better coordinate the care pathways, removing inefficiencies, and minimizing potential patient frustrations and quality of service issues
- Physical and mental health services to expand the definition of frailty into a holistic body and mind approach which leads to better personalized assessments and intervention plans for frail elderly
- Service care with patient self-care (patient engagement) through personalized and empowering interactive tools for increasing user awareness and levels of engagements
- Human expertise with machine expertise in the delivery of care by utilizing Artificial Intelligence as appropriate and effective.
- Merging notion of microservices (machine- or human-delivered microservices) with traditional care delivery

Microservices Ecosystem Key Goal
in Integrated Health and Social Care

Ensure measurably better outcome, lower cost, high quality, personalized and seamless delivery of integrated health and social care, inclusive of patients and community engagement.

Microservices for Integrating Health and Social Care Services:

- Better coordination of the care pathways, improving outcomes
- Removing inefficiencies, and reducing unit and total cost
- Minimizing potential patient frustrations and quality of service issues.

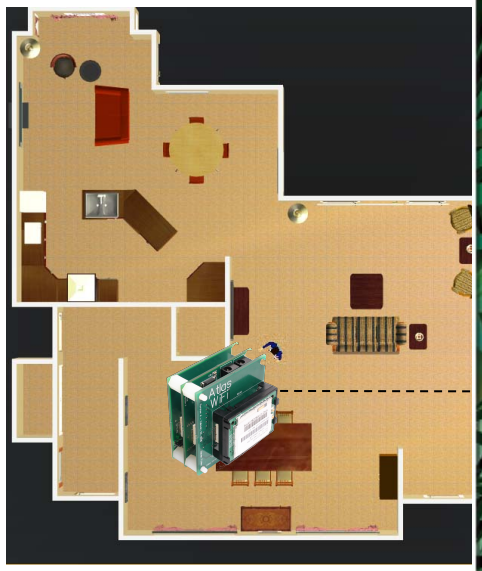
An Ecosystem for Health IoT

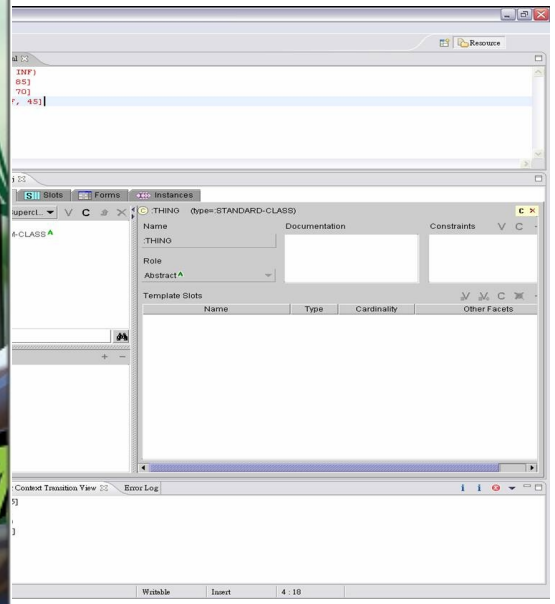
Service Oriented Device Architecture (SODA)

- At the simplest level, SODA lets programmers deal with devices such as sensors and actuators just as business services are used in today's enterprise SOAs.
- SODA converts hardware devices to software services with well-defined interfaces, independent of the programming language and the computing platforms to which they are connected.
- SODA is not just API'ing a device
- SODA standard was proposed by University of Florida and attempted by IBM.

Microservices for Health IoT

SODA – Service-Oriented Device Architecture





Service Bundles appear in the IDE

STEP 1:

3 IoT Things placed

house and powere

n RTE) tune to the Smart

e the microservices and

n into apps.

SODA

Atlas Thing Architecture & Device Description Lang.

The Microservice Value for IoT: Integrate Once, Program Everywhere

```
<Sensor>
<Description>…</Description>
 <Interface>
  <Signal id="ADC1">…</Signal>
  <Reading id="Temp1">
   <Type>Physical</Type>
   <Measurement>Temperature
</Measurement>
   <Unit>Centigrade</Unit>
   <Computation>
  <Type>Formula</Type>
  <Expression> Temp1 = (((ADC1/1023)
* 3.3)-0.5)* (1000/10)</Expression>
   </Computation>
  </Reading>
 </Interface>
</Sensor>
```

Example DDL for TMP36 ANALOG TEMPERATURE SENSOR

Example personal health device(blood pressure monitoring device), integrated once via Atlas adaptor, into a SODA microservice.

Atlas Thing Architecture

The ATLAS Platform

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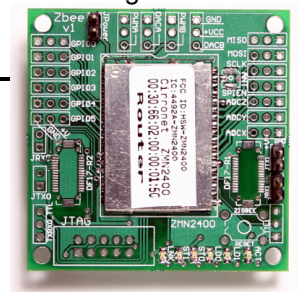
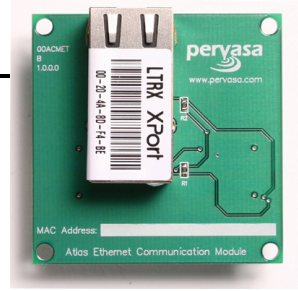
Atlas Communication Layer

ZigBee

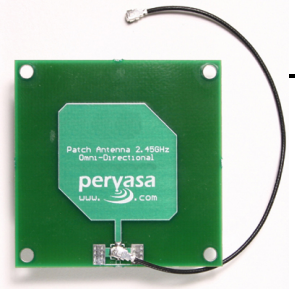


Ethernet



Wi-Fi

Antenna



peryasa

best of sensors expo 2007

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DEPARTMENT OF EDUCATION UNITED STATES OF AMERICA

NOKIA

service oriented device architecture SODA

NIDRR

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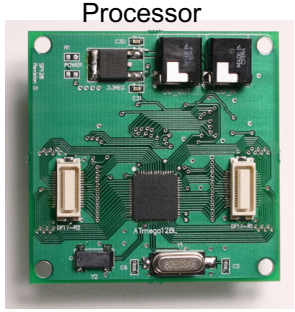
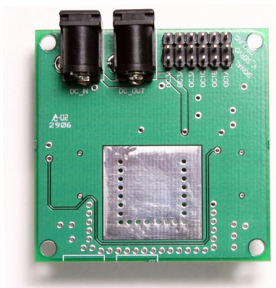
Atlas Processing Layer

Processor



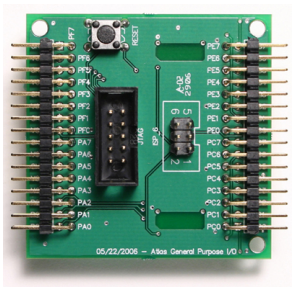
Atlas Device Interface Layer

Servo

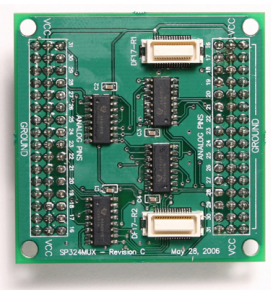


8 Analog

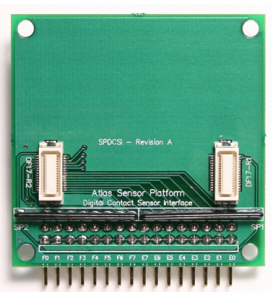
GPIO



32 Analog

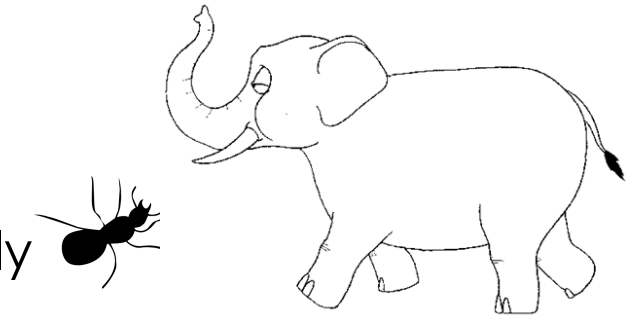


16 Digital



SODA Microservices:
Blessings or Curse?

- The Ant, the Elephant, the Monkey & the Giraffe, or:
  - **Bless** because
    1. we can program and reprogram any logic and any application (very expressive).
    2. Utility of any *thing* in the IoT is maximized.
  - **Curse** because:
    1. SODA over-promises (an elephant for an ant), artificially masking failures, leading to complex uncertainties.
    2. SODA is too powerful (too expressive) to be safe.
- Make it Work: IoT Tranx, Virtual Sensors, others.



The Gator Tech Smart House

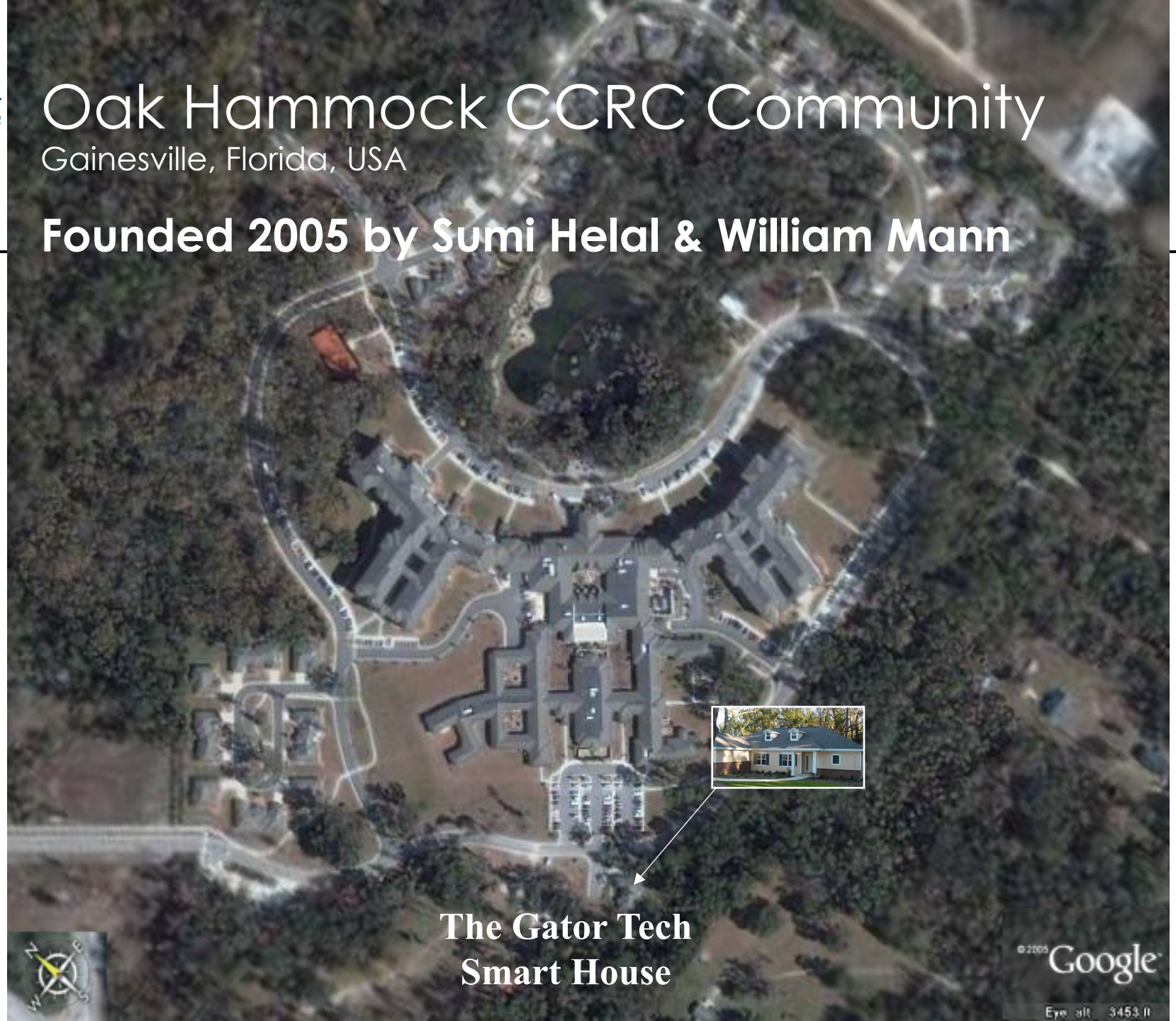
Provide ambient assisted Living for older adults with cognitive and physical impairments

Uses SODA microservices through a Cloud-Edge-Beneath (CEB) architecture

Oak Hammock CCRC Community

Gainesville, Florida, USA

Founded 2005 by Sumi Helal & William Mann



The Gator Tech Smart House

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Independent Living and Successful Aging

Floor Plan of the Gator Tech Smart House

Gator-Tech SMART HOUSE

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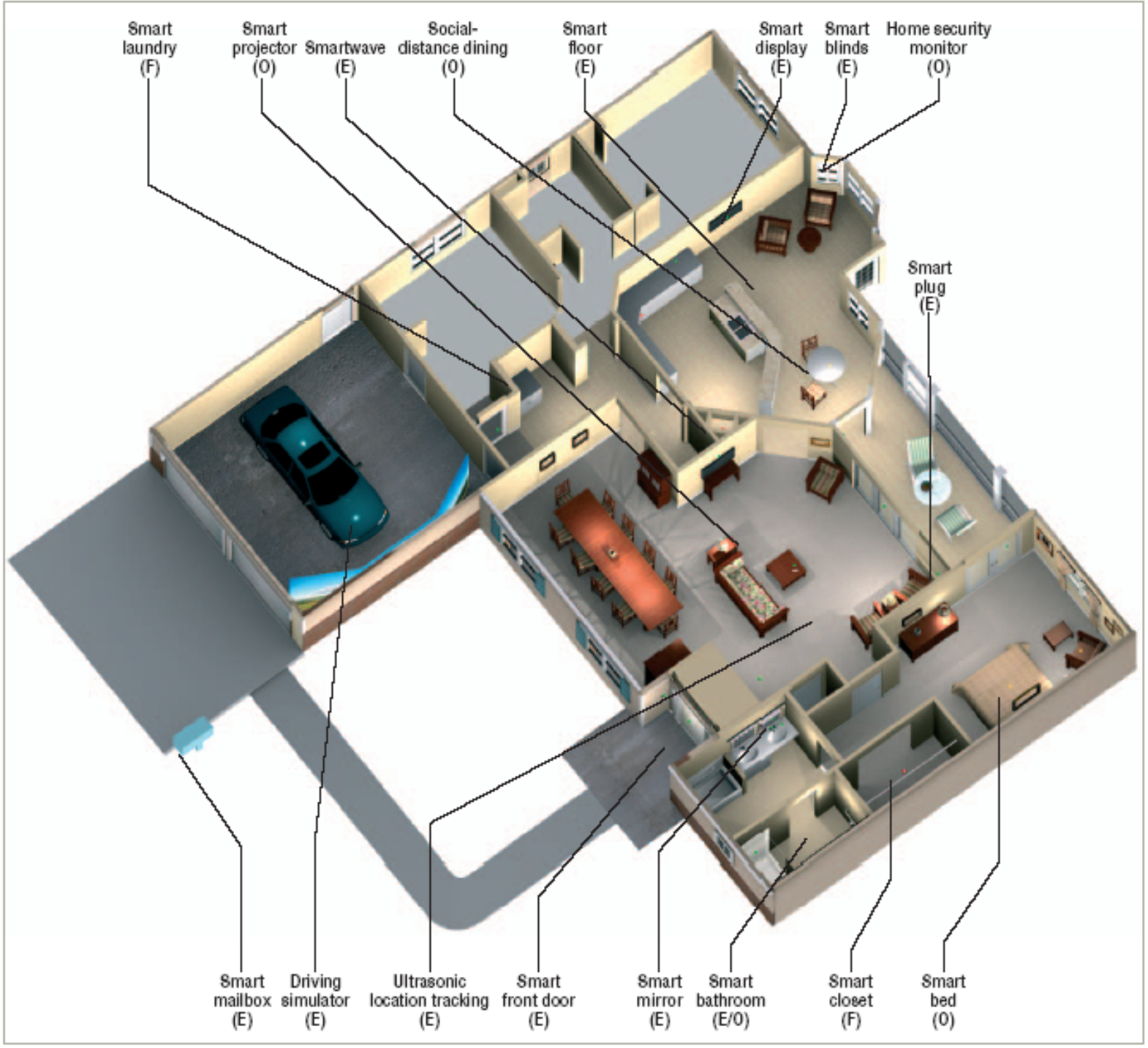
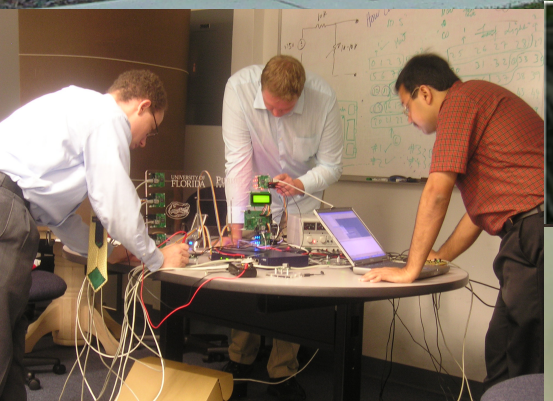


A Multidisciplinary Team

Computer Science, Electrical Eng.,
Clinical Psychology, Rehab Science, end users



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Community – Part of the Team

Technology Validation through Live-in-Trials

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Example SODA Services:

SmartWave & SmartFloor

From “Smart Home in a Box” to Digital Plumbing

Whyndyke Garden Village, UK

An NHS Healthy New Town

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WGV
Creating communities for a better tomorrow

Cassidy+Ashton

A vision to be a community where the healthy option is the default lifestyle option, and health and wellbeing are second nature, not after thoughts

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Whyndyke Garden Village, UK

An NHS Healthy New Town

Land use (Use Class)	Maximum amount (GEA where applicable*)
Residential (C3)	1400 units Of which up to: 350 x 2 bed (25%) 700 x 3 bed (50%) 280 x 4 (20%) 70 x 5 bed (5%)
Primary School 1.5 form entry (D1)	1.5ha
Neighbourhood Centre 1 containing:	0.7 ha
• Public House/ Restaurant (A4, A3)	550 sqm
• Foodstore (A1)	400 sqm
• Health Centre (D1)	600 sqm
• Residential (C3)	56 no. units
Neighbourhood Centre 2 containing:	0.4 ha
• Retail Units (A1)	350 sqm
• Café (A3)	100 sqm
• Financial and Professional Services (A2)	100 sqm
• Hot Food Take-away (A5)	100 sqm
• Residential (C3)	32 no. units
Employment	20 ha
• B2	40,000 sqm
• B8	80,000 sqm
Community Centre	500 sqm

Figure 31 – Illustrative Layout Plan

Putting Health into Place
Introducing NHS England's Healthy New Towns programme

1 IN 3

CHILDREN IN YEAR 6 IS OVERWEIGHT OR OBESE

WGV

Creating communities for a better tomorrow

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36,815

DEATHS PER YEAR COULD BE AVOIDED THROUGH INCREASED PHYSICAL ACTIVITY

MORE IS SPENT EACH YEAR TREATING **OBESITY AND DIABETES**

THAN IS SPENT ON **POLICE AND FIRE** SERVICES AND THE **JUDICIAL SYSTEM**

1. PLAN AHEAD COLLECTIVELY
2. PLAN INTEGRATED HEALTH SERVICES THAT MEET LOCAL NEEDS
3. CONNECT, INVOLVE AND EMPOWER PEOPLE AND COMMUNITIES
4. CREATE COMPACT NEIGHBOURHOODS
5. MAXIMISE ACTIVE TRAVEL
6. INSPIRE AND ENABLE HEALTHY EATING
7. FOSTER HEALTH IN HOMES AND BUILDINGS
8. ENABLE HEALTHY PLAY AND LEISURE
9. PROVIDE HEALTH SERVICES THAT HELP PEOPLE STAY WELL
10. CREATE INTEGRATED HEALTH CENTRES

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Cassidy+Ashton

WGH Metrics of Success

- **Healthier Community** as measured by many outcomes over time
- New, proven, and **better health and social care delivery** model
  - Unit and Total Cost
  - Patient Satisfaction
  - Scalability & Sustainability (Ratio of patients/physician)
  - Reduced errors and improved quality of care

Digital Plumbing Requirement

From Smart Homes to Smart-Ready Homes

- Scaling exercise points out that Smart Home was a great experiment but it was just this.
- **It is a bad idea to build any smart homes for other then experimentation**
- We should move into creating smart-ready homes, instead of smart homes. **Why?**
- **Challenges:**
  - Major disruption to the housing associations (builders). How can they be brought on board?
  - And if they come on board, they will ask what is smart-ready homes? Do we know what they are exactly?

WGV Community Resiliency and Engagement Model

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Community resilience is the sustained ability of a community to utilize available resources to respond to, withstand, and recover from adverse situations.

- **WGV Uber of Digital Health**
  - Transportation
  - Part of microservice implementations by the health and social care system
- **Technologies:**
  - Mobile Apps
  - The Tech shop
  - Mediation Technology: Crowdsourcing Platform
  - Integration into the near by Integrated Care Systems

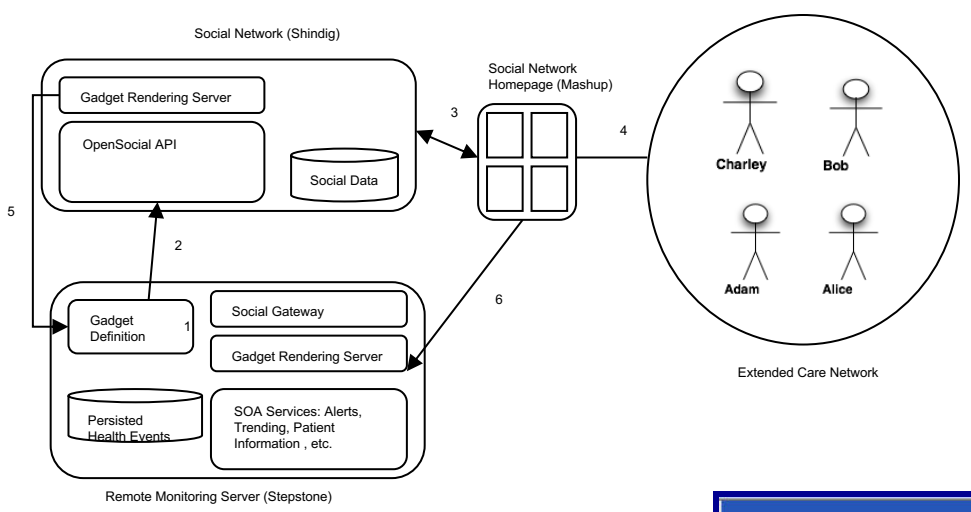
DIGITAL HEALTH

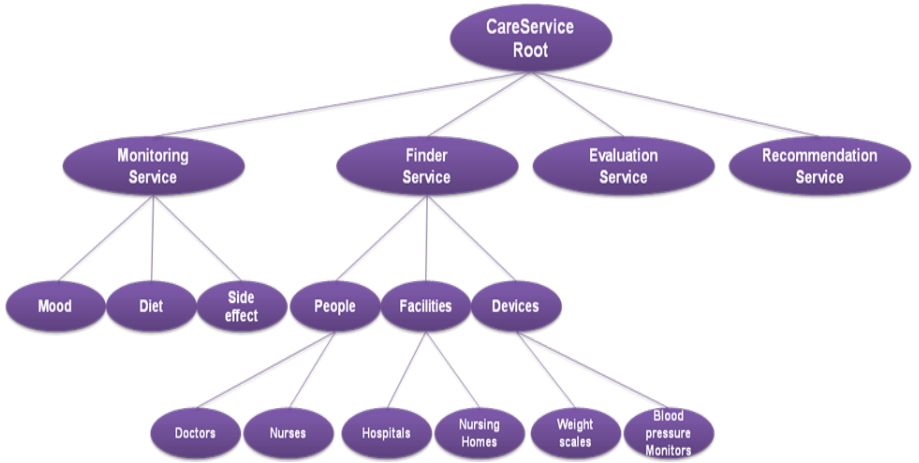
A Brief **Local** History of Community Resiliency - **Ven. Arc. della Misericordia di Firenze**

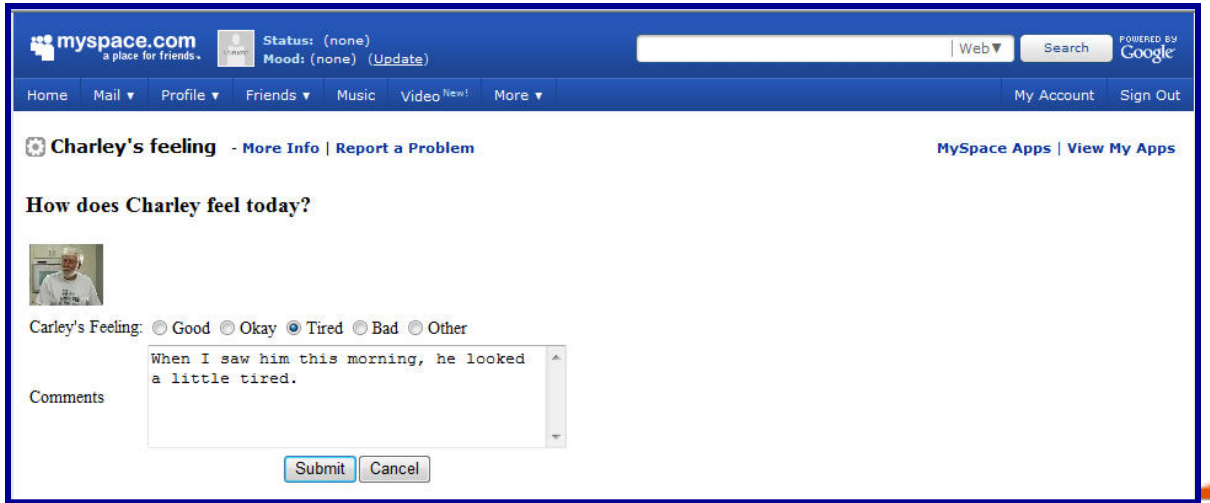
- **Della Misericordia di Firenze** is the oldest Brotherhood for the care of the sick and the oldest private voluntary institution in the world still active since its foundation, dated in 1244.
- Its lay members, called **brothers**, still continue to provide part of the **infirm transport service** in the city, and until April 2006 still wore the traditional black dress (dating back to the seventeenth century), today reduced to use in representation ceremonies due to national regulations inspired by road safety. **[Wikipedia]**

Ven. Arc. della Misericordia di Firenze

Participatory Health
Leveraging Social Network Effect







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IBM

The Emergence of Crowdsourcing as a Serious Business

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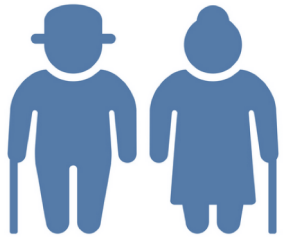
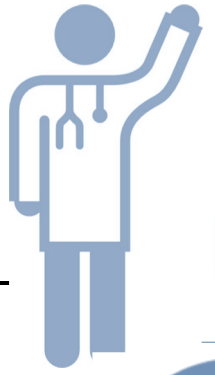
UBER Health

DIGITAL HEALTH

Uber of Digital Health





Care Provision

Care Demands

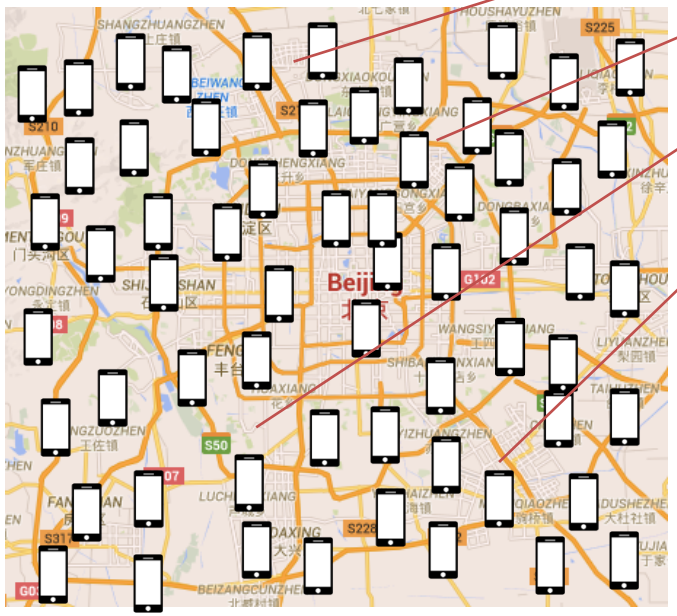
- Nurse at Home
- Remote Doc/Nurse at Home
- Virtual Doc/Nurse at Home
- Primary Care: Patient Visit
- Community Bus Service
- Disability Services
- User Needs Crowdsourced Microservices
- Persuasion and empowerment using emotional interfaces

- F2F Appointments
- Remote Doc Appointments
- Home HealthKiosks (Alexa, Orbita, etc.)
- User Needs Crowdsourced Microservices
- Smart Home Continuous monitoring and assessment
- Emergency Help
- Help in any of several activities of daily living

A Brief Word on Crowdsensing/Crowdsourcing

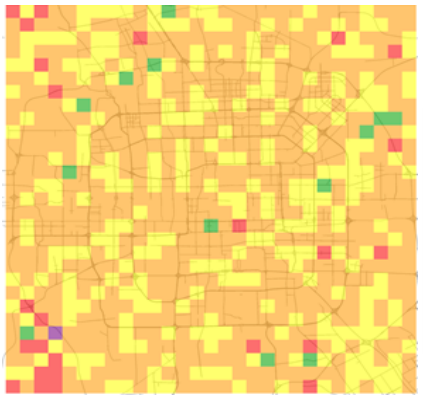
Human intelligence or sensors

Collect and report data

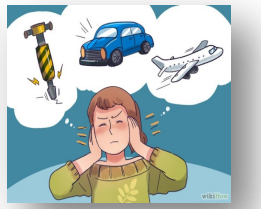


Cloud Server

Data integration



Air quality



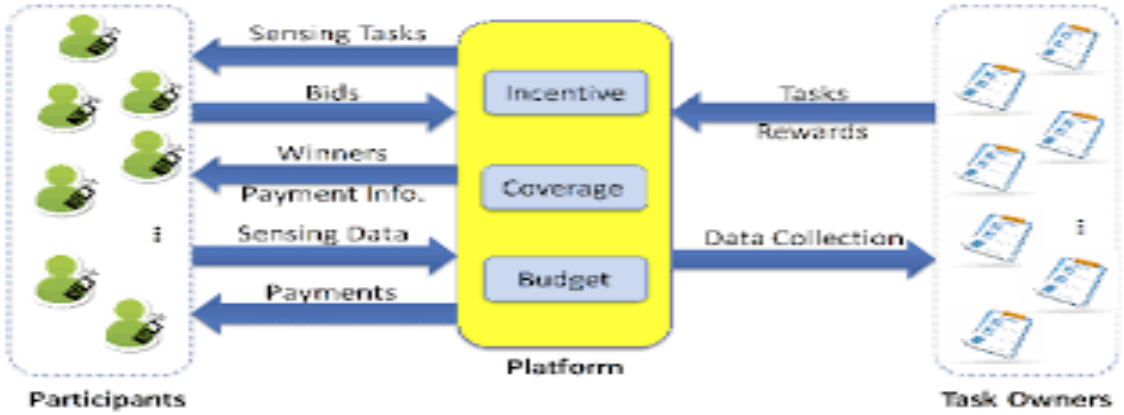
Noise level

Flow of citizens

Traffic congestion status

Crowdsensing/Crowdsourcing: Preliminaries

- Stakeholders
  - Organizers (requesters)
  - Participants (workers)
  - CSC platform



Three-stage Lifecyle

Task/App Creation

programming Model/Toolkits
Micro-Task design

Worker Selection & Task Assignment

Cost/Quality/Latency control

Task Execution and Data Integration

Energy saving, Privacy preserving
Data visualization

Crowdsourced Food Delivery and Crowd Logistics

Order is placed on retailer's website. Order is routed to a community of drivers

Crowdsourced driver accepts order

Customer receives tracking, driver profile, and driver contact information

Driver delivers the order

Basic process

Major Service Platforms in China
-- Ele.me
-- Baidu Waimai

Leverages the power of crowdsourcing to provide on-demand deliveries from food restaurants to the consumers

Crowd-based Bike Sharing Rebalancing

Bike sharing systems

Crowd-based bike rebalancing

participants are given incentive rewards to rent or return bikes from alternative stations instead of the nearest station

DH Challenges Beyond General Crowdsourcing

- **Multi-expertise Collaborations**
  - General crowdsourcing usually requires simple skills or sensors
  - "DH + Crowd" are more complex: require multiple expertise
    - Example: Uber car is not an ambulance (driving + nursing + …)
- **Reputation Management and Skill Training**
  - Professional qualifications & confidentiality adherence, and service reputation need to be highly and carefully managed
  - Training and certifications may be needed, but can be outsourced as other crowdsourced tasks.
- **Privacy and Ethics Concerns**
  - Personal health information/profile is much more sensitive
  - Tradeoff between health data sharing requirement and privacy preserving

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Conclusions

- **Let us exploit SERVICES to a great Societal Benefit** and Impact - Healthy people, Healthy Communities, Healthy Nations.
- **Microservices could enable and shape the Health IoT** technology
- **Microservices could enable the Uber of digital** Health for community engagement and to potentially start up a microservice economy.
- **Let us work on Digital Health advancement** together through the IEEE Congress on Services.

DIGITAL HEALTH