Microservice Ecosystem for Digital Health in Integrated Care Settings

Keynote
IEEE Congress on Services
Aula Magna, Universita' degli Studi di Milano, Milano, Italy

Sumi Helal, PhD, FIEEE, FIET
Professor & Chair in Digital Health
Director of the Centre on Digital Health & QoL Technologies
Faculty of Science & Technology
Faculty of Health and Medicine
Lancaster University

12 July 2019
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

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.
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**
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.
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 expectancy 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 25,000 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% reduction in paperwork time
  - 29% increase in patient face time
  - 2 extra patients seen daily
- A telehealth hub across 210 care homes
  - 35% reduction in hospital admissions
  - 53% reduction in A&E use
  - 59% reduction in hospital bed days

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
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
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

STEP 1:
3 IoT Things placed in a smart house and powered up.

STEP 2:
IDE (now also an RTE) tune to the Smart House to browse the microservices and program them into apps.
The Microservice Value for IoT: Integrate Once, Program Everywhere

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

Atlas Communication Layer
- ZigBee
- Ethernet
- Wi-Fi
- Antenna

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

Independent Living and Successful Aging
Floor Plan of the Gator Tech Smart House

Gator-Tech SMART HOUSE

UNIVERSITY of FLORIDA
The Foundation for The Gator Nation

DIGITAL HEALTH
A Multidisciplinary Team
Computer Science, Electrical Eng., Clinical Psychology, Rehab Science, end users
Community – Part of the Team
Technology Validation through Live-in-Trials
Example SODA Services:
SmartWave & SmartFloor
From “Smart Home in a Box” to Digital Plumbing
Whyndyke Garden Village, UK
An NHS Healthy New Town

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.
Whyndyke Garden Village, UK
An NHS Healthy New Town

<table>
<thead>
<tr>
<th>Land use (Use Class)</th>
<th>Maximum amount (GEA where applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (C3)</td>
<td>1400 units</td>
</tr>
<tr>
<td></td>
<td>Of which up to:</td>
</tr>
<tr>
<td></td>
<td>350 x 2 bed (25%)</td>
</tr>
<tr>
<td></td>
<td>700 x 3 bed (50%)</td>
</tr>
<tr>
<td></td>
<td>280 x 4 (20%)</td>
</tr>
<tr>
<td></td>
<td>70 x 5 bed (5%)</td>
</tr>
<tr>
<td>Primary School 1.5 form entry (D1)</td>
<td>1.5ha</td>
</tr>
<tr>
<td>Neighbourhood Centre 1 containing:</td>
<td>0.7 ha</td>
</tr>
<tr>
<td>Public House/ Restaurant (A4, A3)</td>
<td>550 sqm</td>
</tr>
<tr>
<td>Foodstore (A1)</td>
<td>400 sqm</td>
</tr>
<tr>
<td>Health Centre (D1)</td>
<td>600 sqm</td>
</tr>
<tr>
<td>Residential (C3)</td>
<td>56 no. units</td>
</tr>
<tr>
<td>Neighbourhood Centre 2 containing:</td>
<td>0.4 ha</td>
</tr>
<tr>
<td>Retail Units (A1)</td>
<td>350 sqm</td>
</tr>
<tr>
<td>Cafe (A3)</td>
<td>100 sqm</td>
</tr>
<tr>
<td>Financial and Professional Services (A2)</td>
<td>100 sqm</td>
</tr>
<tr>
<td>Hot Food Take-away (A5)</td>
<td>100 sqm</td>
</tr>
<tr>
<td>Residential (C3)</td>
<td>32 no. units</td>
</tr>
<tr>
<td>Employment</td>
<td>20 ha</td>
</tr>
<tr>
<td>B2</td>
<td>40,000 sqm</td>
</tr>
<tr>
<td>BB</td>
<td>80,000 sqm</td>
</tr>
<tr>
<td>Community Centre</td>
<td>500 sqm</td>
</tr>
</tbody>
</table>
1 IN 3
CHILDREN IN YEAR 6 IS OVERWEIGHT OR OBESE

36,815
DEATHS PER YEAR COULD BE AVOIDED THROUGH INCREASED PHYSICAL ACTIVITY

MORE THAN IS SPENT ON POLICE AND FIRE SERVICES AND THE JUDICIAL SYSTEM
IS SPENT EACH YEAR TREATING OBESITY AND DIABETES

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

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

Lancaster University
DIGITAL HEALTH
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
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?
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
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
The Emergence of Crowdsourcing as a Serious Business

UBER Health
Uber of Digital Health

- 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 Health Kiosks (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

Cloud Server

Collect and report data

Data integration

Human intelligence or sensors

Air quality
Noise level
Flow of citizens
Traffic congestion status

Micro-Task
Crowdsensing/Crowdsourcing: Preliminaries

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

**Three-stage Lifecycle**

- **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

Basic process:

- 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.

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
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.