Healthcare IoT Consortium

東京大学 THE UNIVERSITY OF TOKYO

Future of Healthcare IoT: Challenge of HIT

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Future of Internet and Health

PewResearchCenter

NUMBERS, FACTS AND TRENDS SHAPING THE WORLD

MARCH 11, 2014

The Web at 25 in the US

Digital Life in 2025

Experts predict the Internet will become 'like electricity' — less visible, yet more deeply embedded in people's lives for good and ill

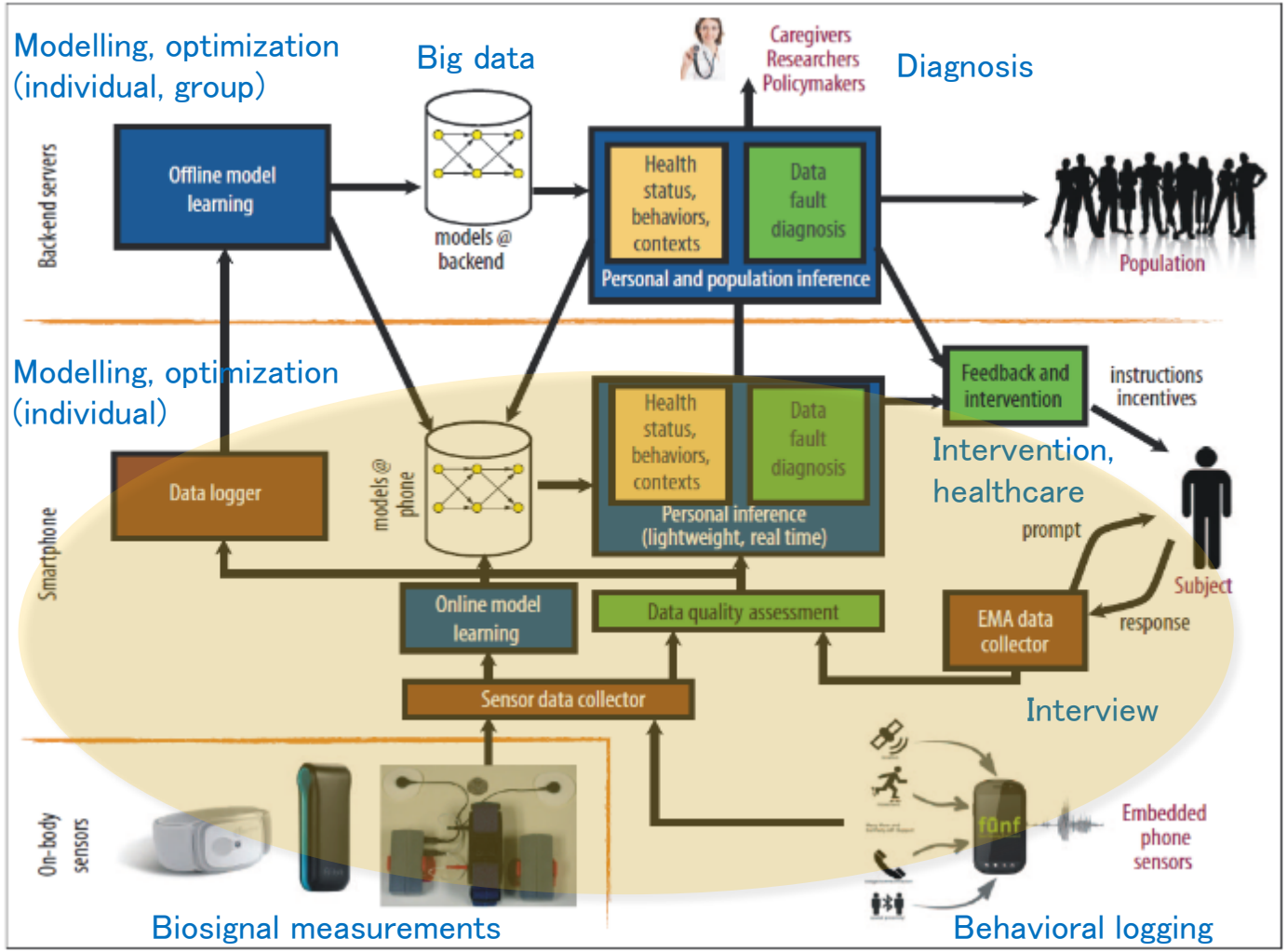
LG: Lifeband Touch & Heart Rate Earphone

OS for Smartwatch Android Wear

Aron Roberts, software developer at the University of California-Berkeley, said, "We may well see **wearable devices and/or home and workplace sensors** that can **help us make ongoing lifestyle changes and provide early detection for disease risks, not just disease**. We may literally be able to adjust both medications and lifestyle changes on a day-by-day basis or even an hour-by-hour basis, …

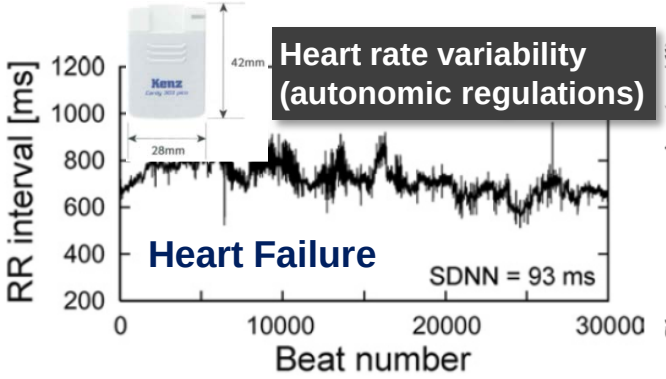
(http://www.pewinternet.org/2014/03/11/digital-life-in-2025/)

Mobile Health （m-Health） by National Institute of Health



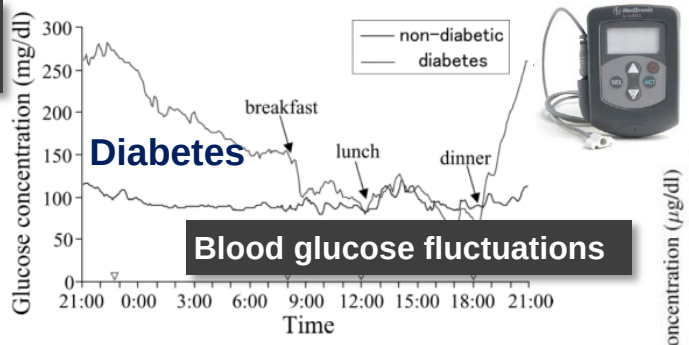
(Kumar, S et al., IEEE Computer, 46(1): 28, 2013)

Bio-behavioral ILD： Large-scale, Multi-dimensional, Multi-scale & Complex Data



Heart rate variability (autonomic regulations)

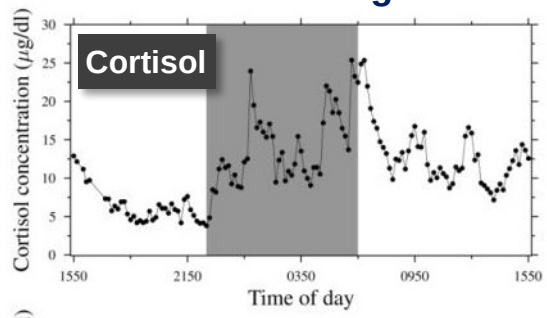
Heart Failure



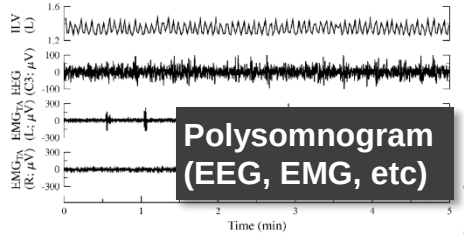
Diabetes

Blood glucose fluctuations

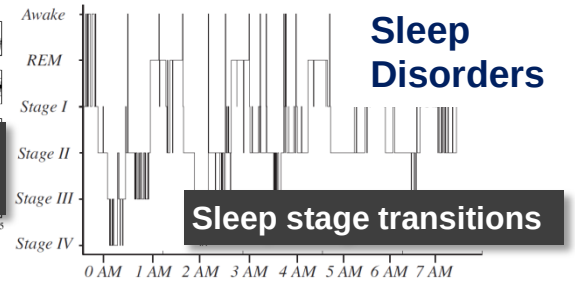
Chronic Fatigue/Pain



Cortisol

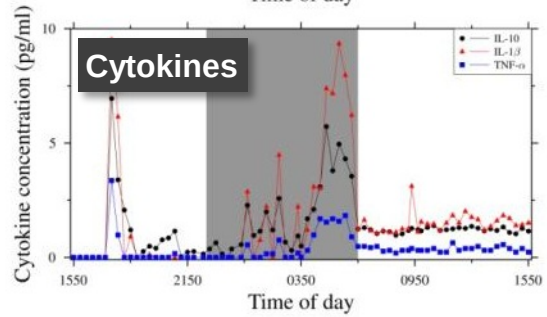


Polysomnogram (EEG, EMG, etc)



Sleep Disorders

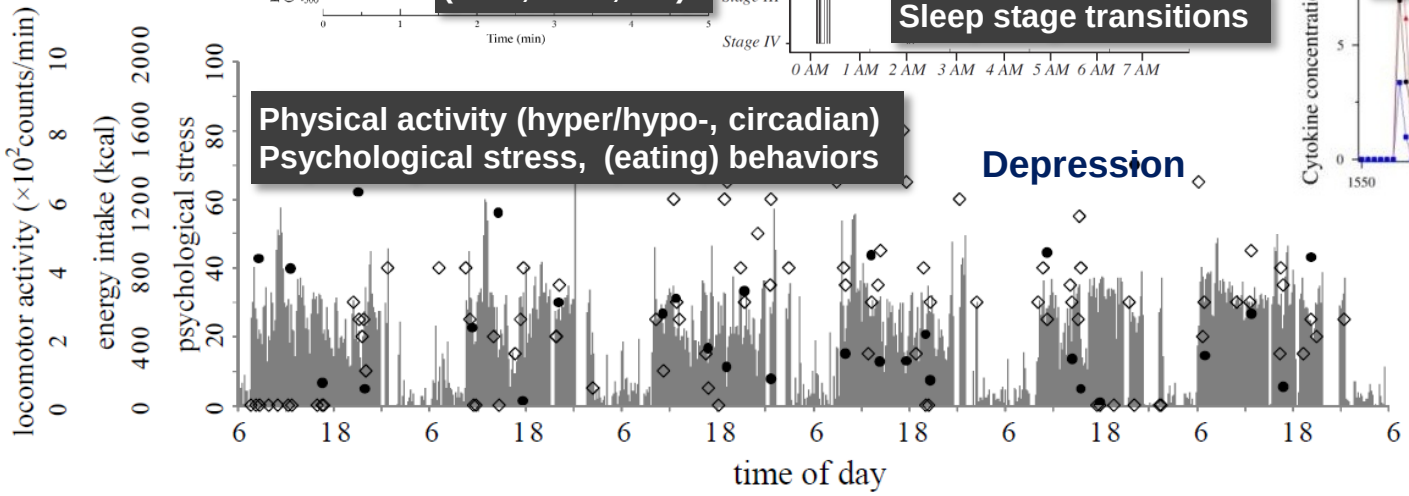
Sleep stage transitions



Cytokines

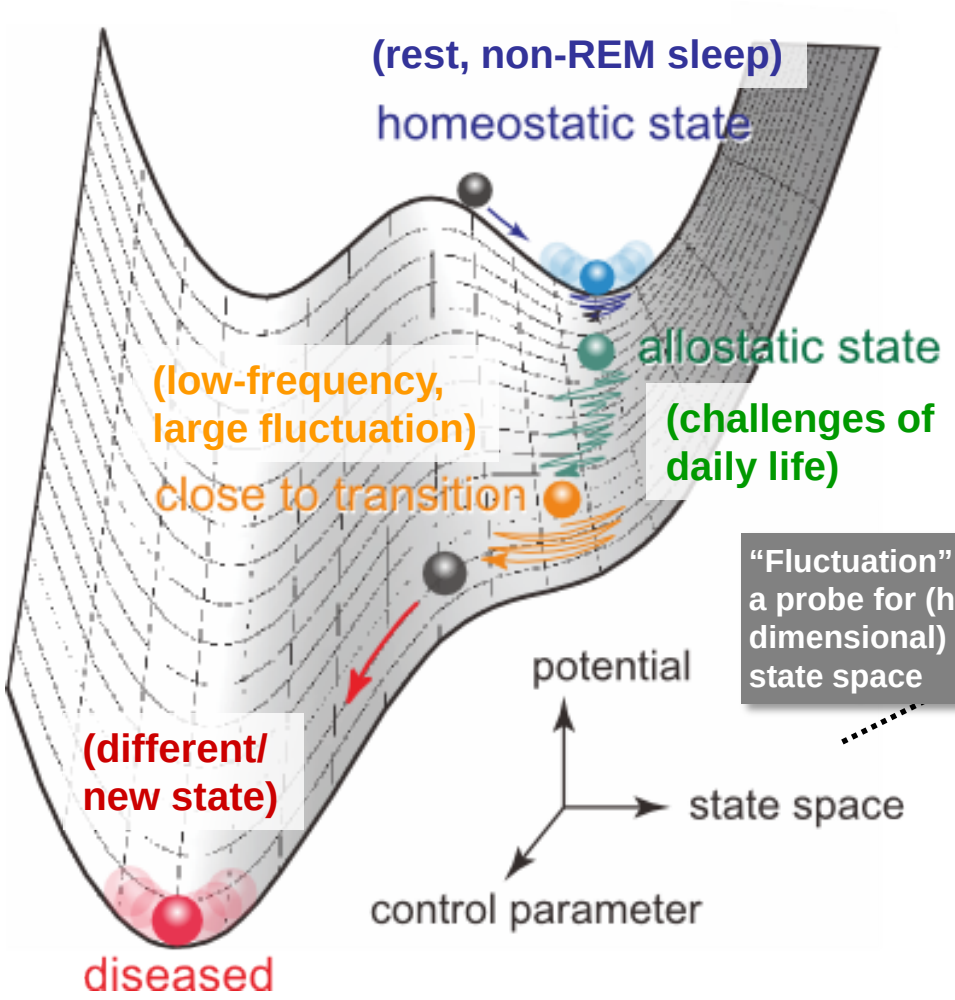
Physical activity (hyper/hypo-, circadian)
Psychological stress, (eating) behaviors

Depression



(ILD ＝Intensive Longitudinal Data)

Perspective of Study of Dynamical Disease through ILD

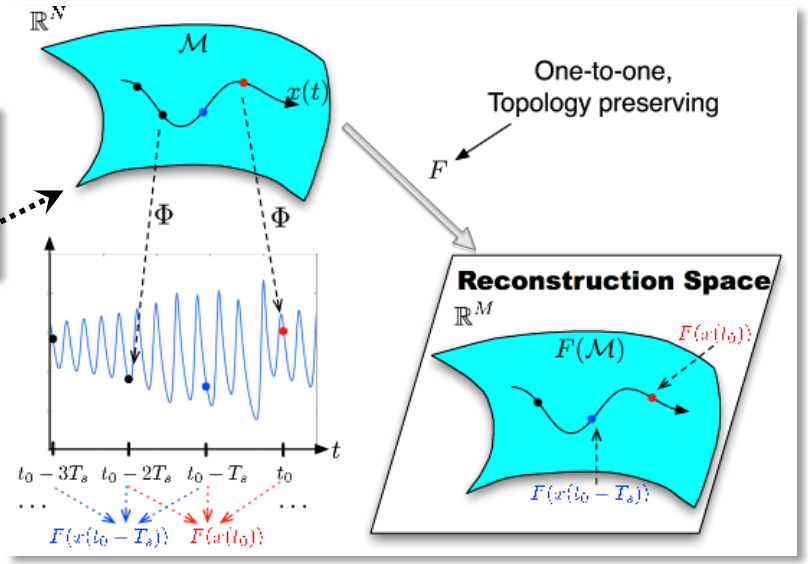


"Fluctuation" as a probe for (high dimensional) state space

Basic Strategies

- Dynamical state changes from fluctuation properties
- Use characteristics near transition point for prediction
- From ILD to dynamics (difficult)

("Taken's embedding theorem" from http://cnx.org)



(Nakamura, Kiyono, et al., Proc. IEEE, 104: 242, 2016)

ILD of Physical Activity: Toward Objective Measures in Psychiatry

Measurement of spontaneous physical activity (SPA) by a wearable device

- Long-term continuous monitoring in daily life
- Rich dynamical characteristics of physical activity

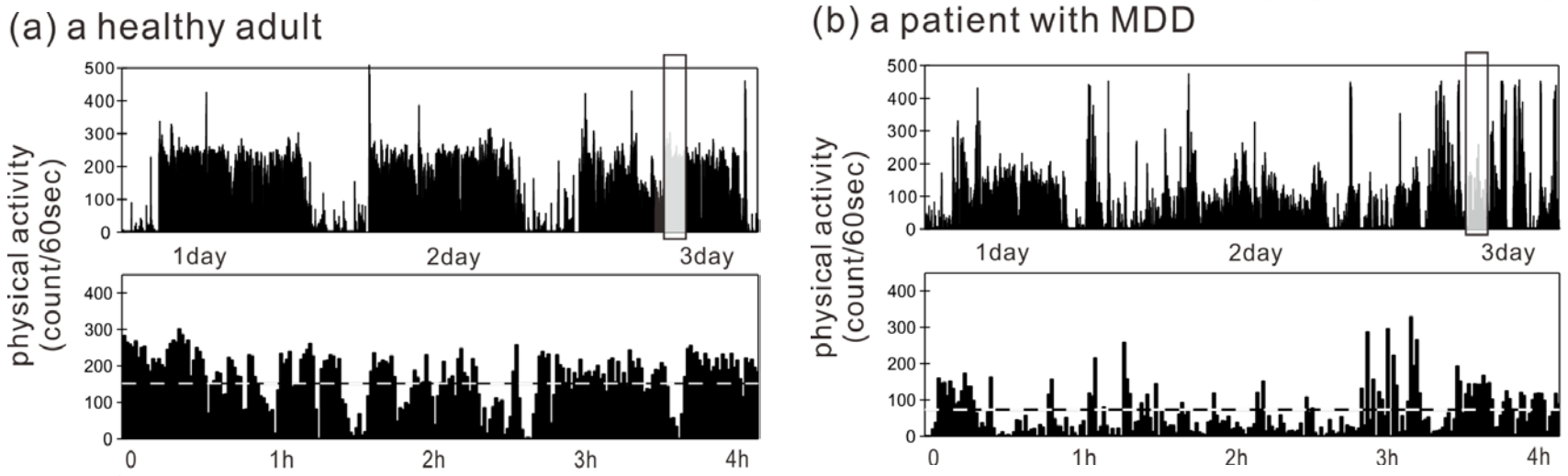
Actigraph Mini-Motionlogger
Ambulatory Monitors Inc.

ILD of Physical Activity: Major Depressive Disorder (MDD)

Measurement of spontaneous physical activity (SPA) by a wearable device

- Long-term continuous monitoring in daily life
- Rich dynamical characteristics of physical activity

Actigraph Mini-Motionlogger
Ambulatory Monitors Inc.

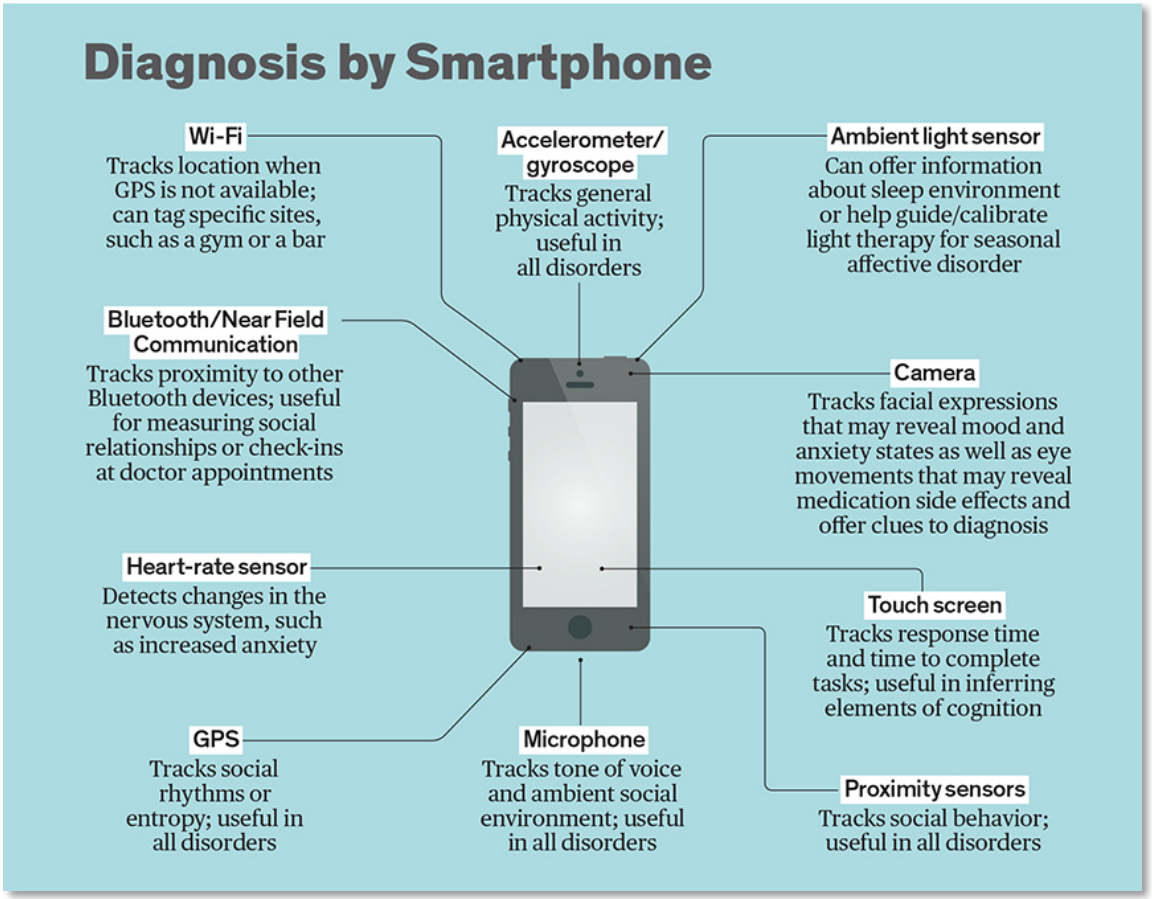


Healthy subjects
- clear circadian rhythm
- sustained activity

Depressive patients
- disruption of circadian rhythm
- **intermittent bursts**

(Nakamura, et al. Phys. Rev. Lett. 99: 138103, 2007)

Digital Psychiatry App



(Torous, J. IEEE Spectrum, July, 2017, pp. 44-50)

Co-variation of Self-Reported Depressive Mood and Physical Activity in MDD

■ selected model:

$$(\text{depression})_{ij} = \pi_{0i} + \pi_{1i}\,(\text{mean})_{ij} + \pi_{2i}\,(\text{skewness})_{ij} + \pi_{3i}\,(\text{mean} \times \text{skewness})_{ij} + \varepsilon_{ij}$$

$$\pi_{0i} = \gamma_{00} + \zeta_{0i}$$
$$\pi_{1i} = \gamma_{10} + \zeta_{1i}$$

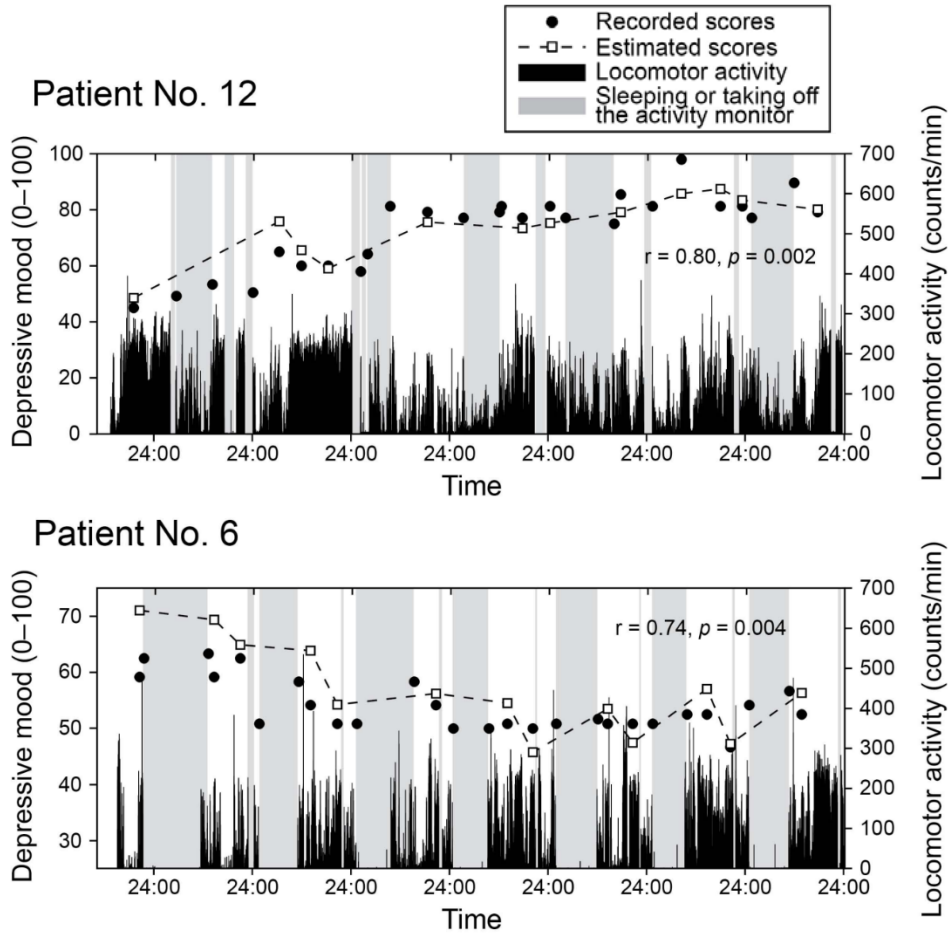
} Random effect

$$\pi_{2i} = \gamma_{20}$$
$$\pi_{3i} = \gamma_{30}$$

} Fixed effect

The association between momentary self-reported depressive mood and locomotor activity exists in MDD patients

Continuous objective evaluation of depressive mood



(Kim, Nakamura, et al., IEEE J. Biomed. Health Informatics 19: 1347, 2015)

Covered as Featured Article

(Kim, Nakamura, et al., IEEE J. Biomed. Health Informatics 19: 1347, 2015)

Summary: Future of Healthcare IoT – Introduction to HIT Follows

- Data-driven approaches (big data and/or ILD)
- Systems approaches for risk control using ILD
- Predictive and personal healthcare

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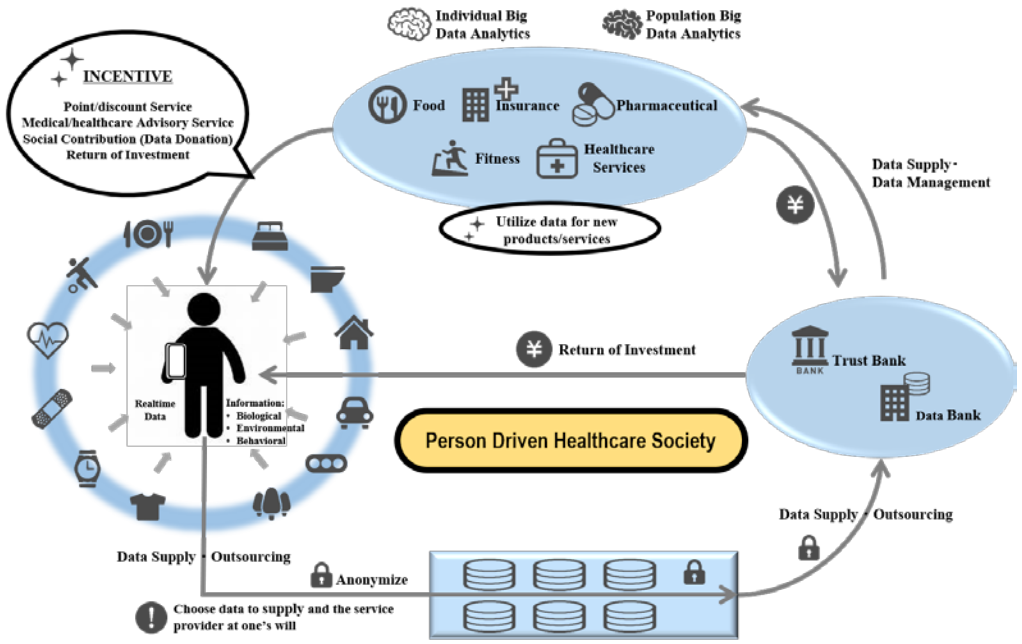
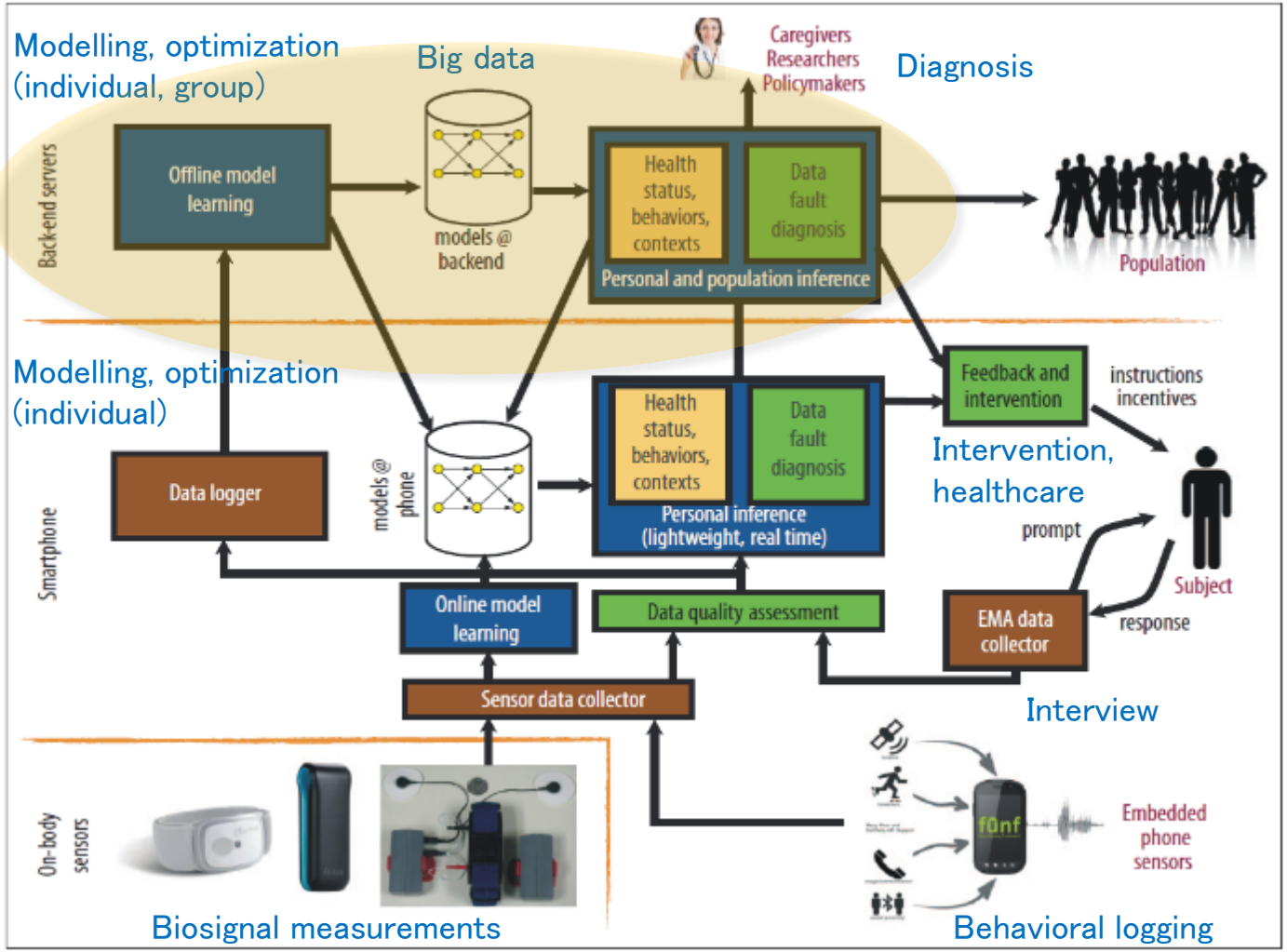


(https://healthcareiotcons.com/)

Open Issues in m-Health: Lack of Big Data



(Kumar, S et al., IEEE Computer, 46(1): 28, 2013)

Current Status and Issues of Healthcare Cloud

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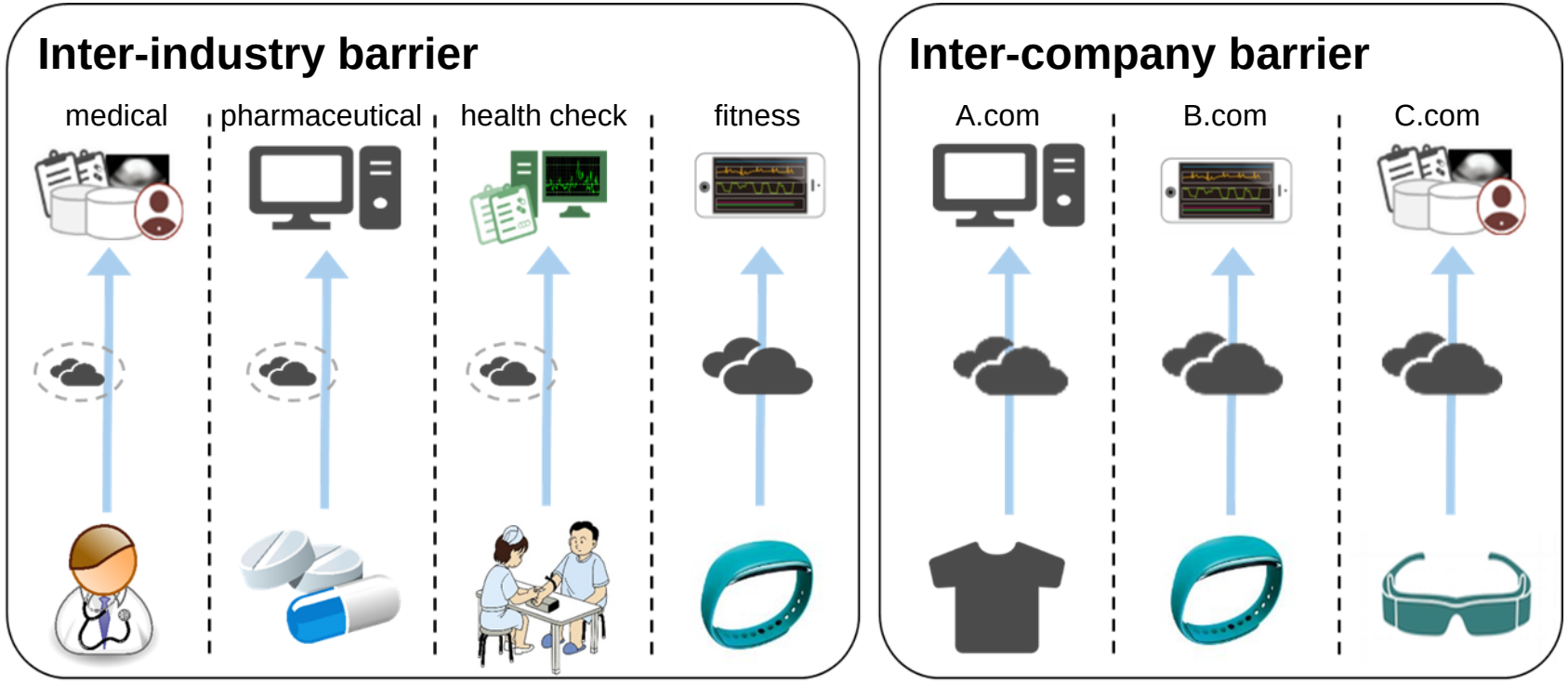
- Services are divided into **vertical integration** within industry or company and each company manages data independently, making mutual utilization for healthcare big data construction difficult.
- Data belongs to a service providing company and **individuals can not enjoy the value**.
- Continuous use is not done due to **insufficient incentive**.



Healthcare IoT Consortium
(HIT)

Person Driven Healthcare

October 4, 2017

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HIT Secretariat

Our Missions

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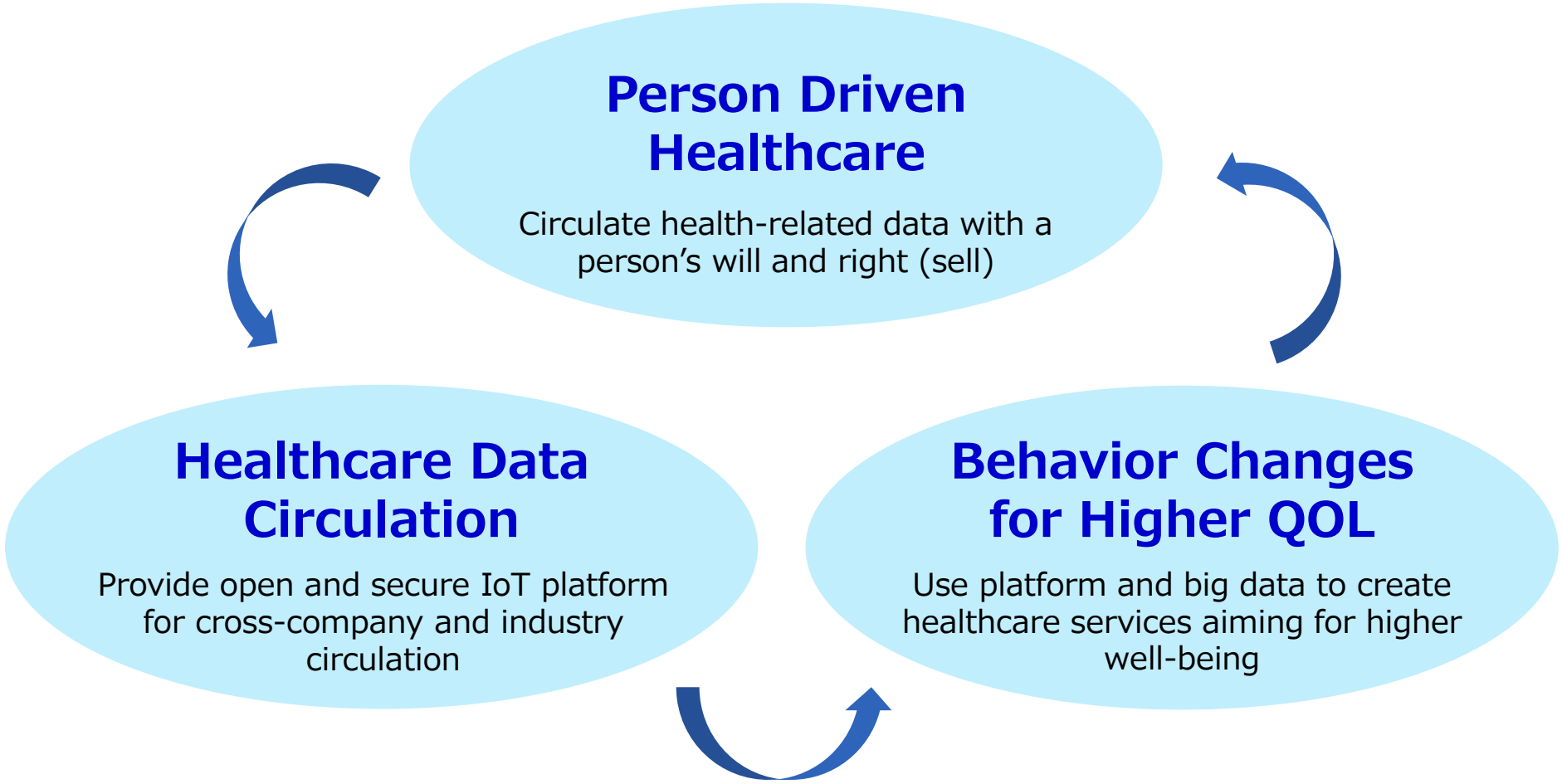
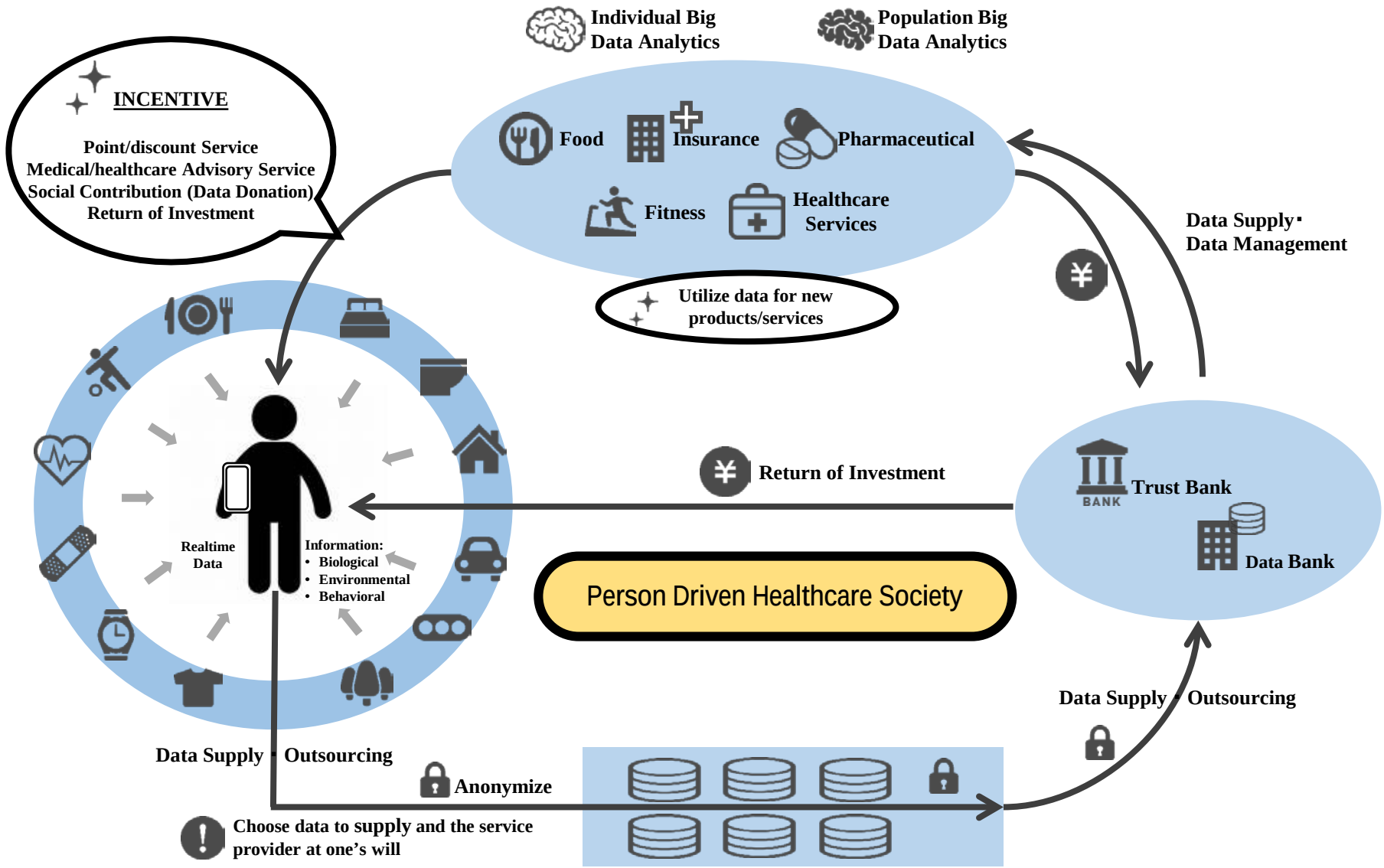


Image of Society to Realize



Membership Organizations

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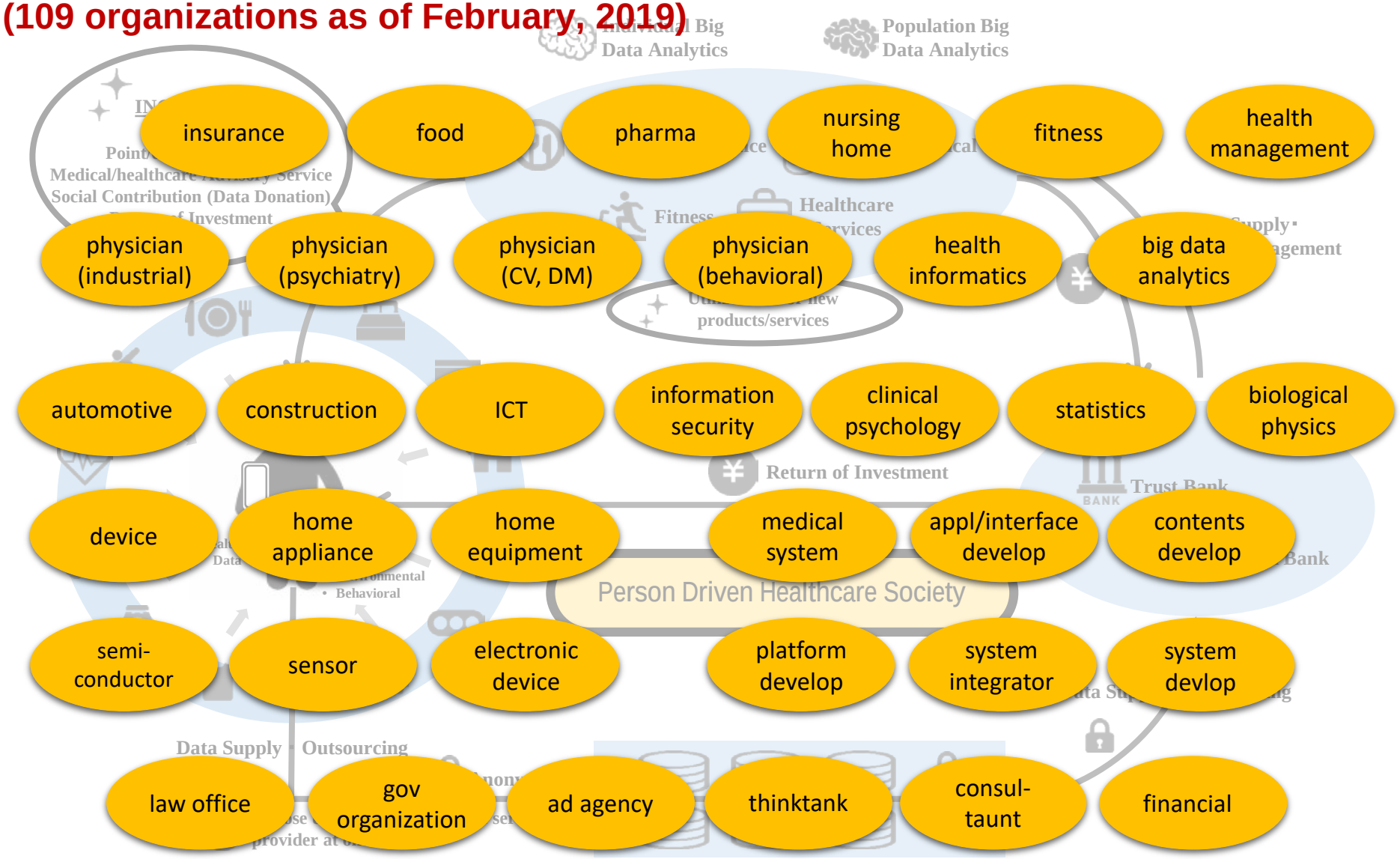
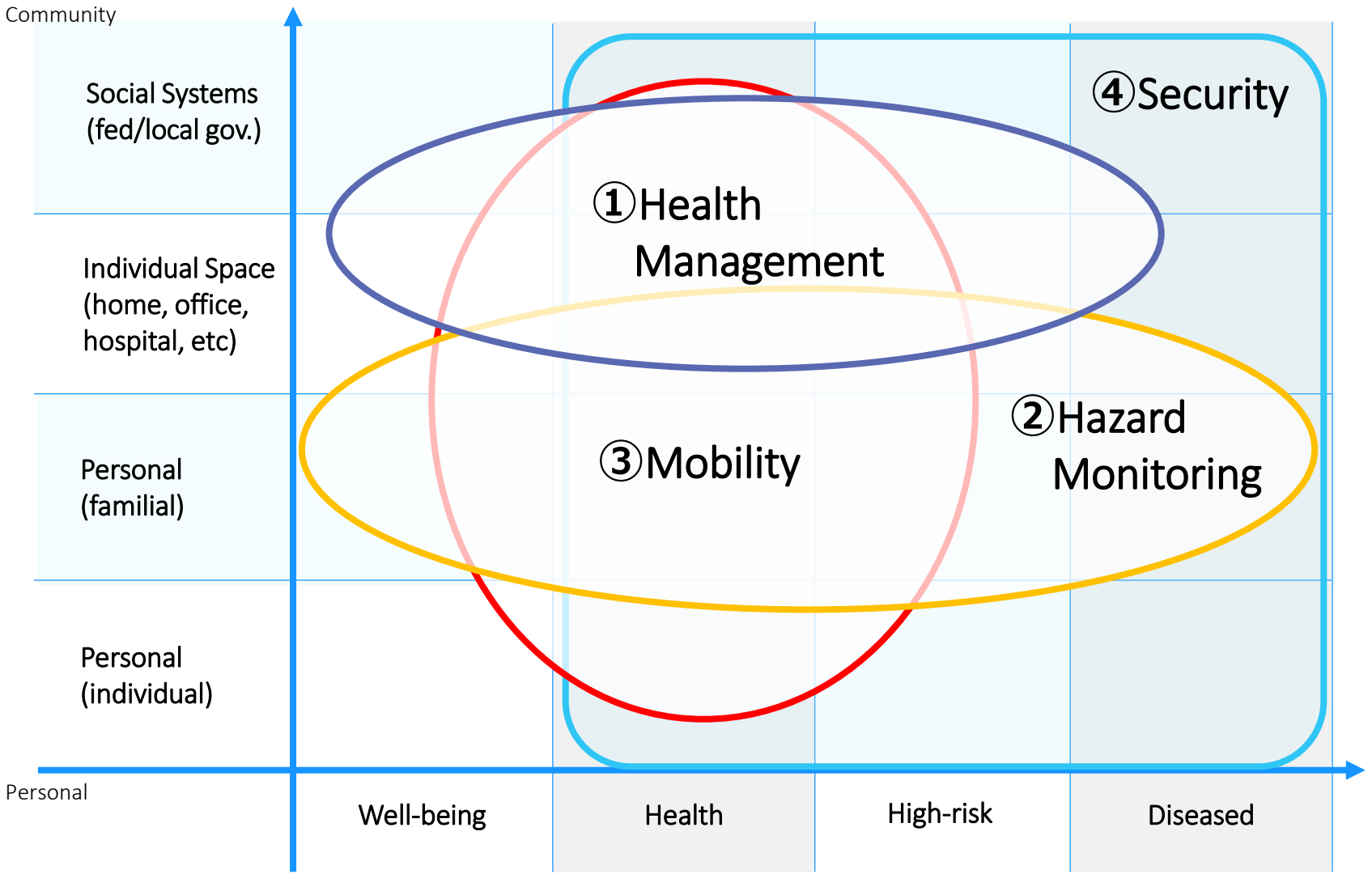
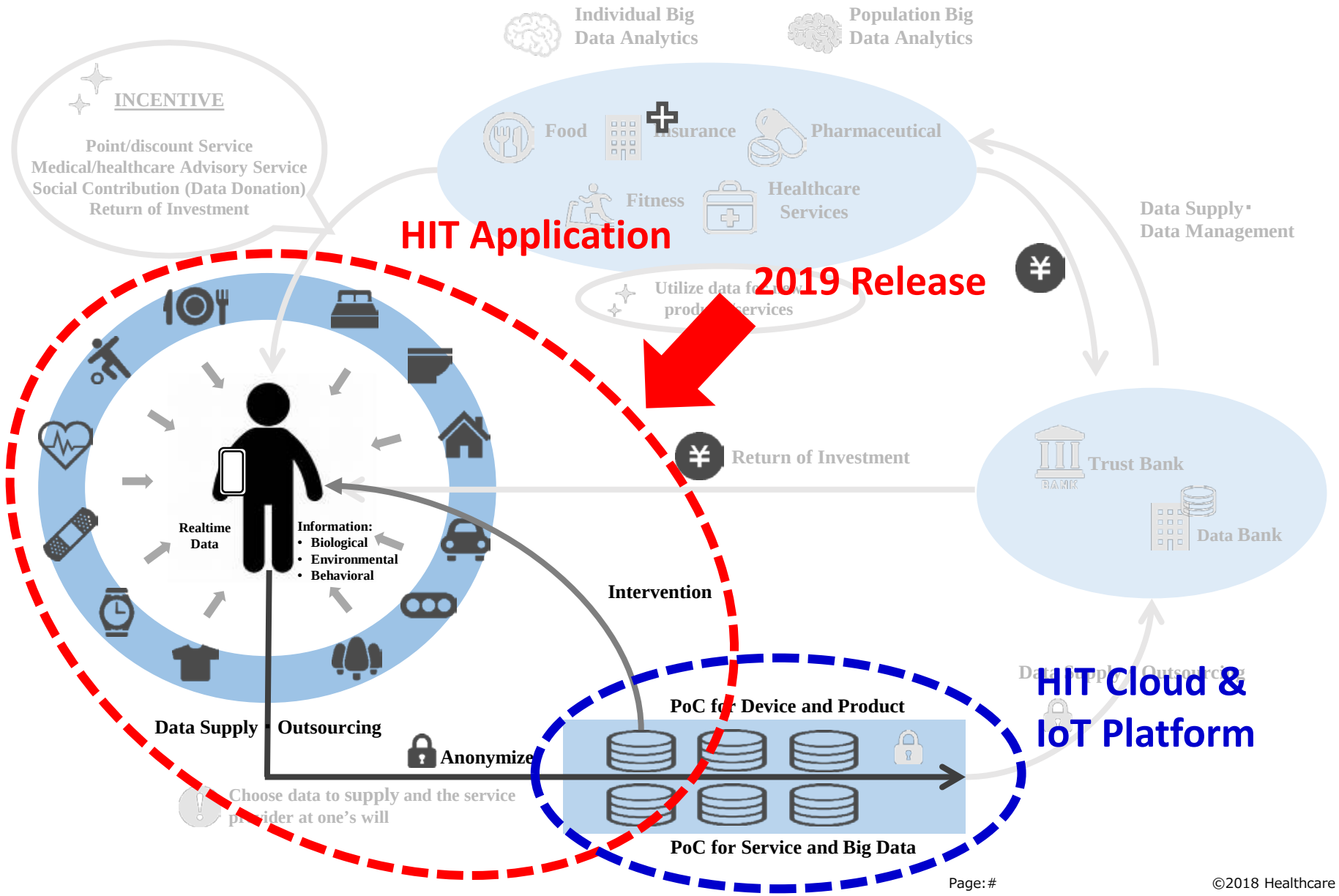
(109 organizations as of February, 2019)



Scopes



HIT Open Innovation Platform (2019)



HIT Platform - Details

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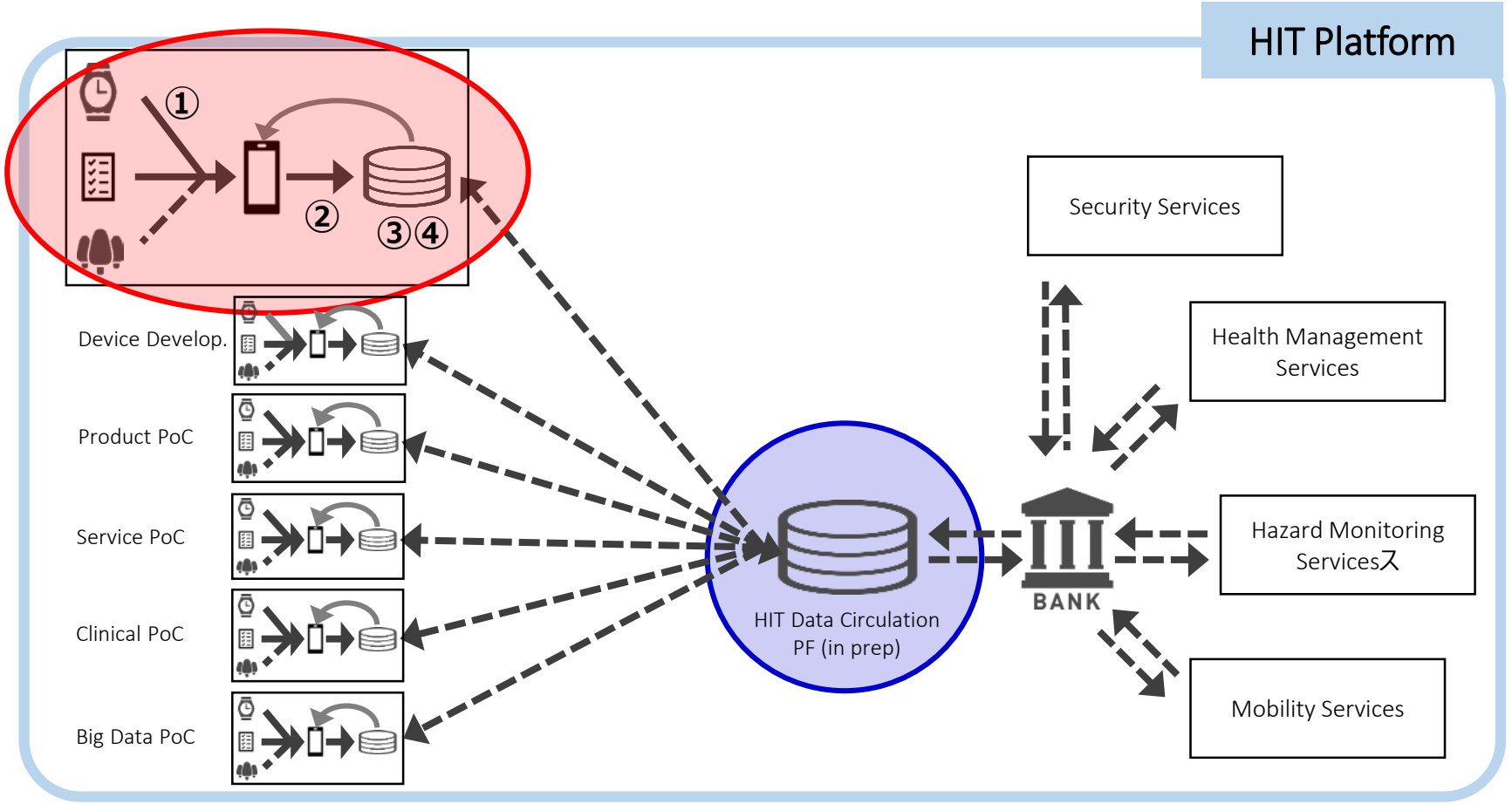
Open Innovation (free) Platform

1. Data transfer from recommended IoT devices to HIT application.
2. And to HIT cloud server
3. Linux server package and the manual.
4. Server (e.g., AWS) setup service for a fee

What may be required further

- Data analytics and intervention protocols (with possible collaboration)
- Cost for additional devices and custom apps
- Cost for a proprietary server
- Collaborative research cost



Overview of HIT App/Platform

Ecological Momentary Assessment (EMA)

・Data visualization
・Intervention message

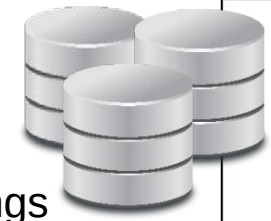
for Android/iOS

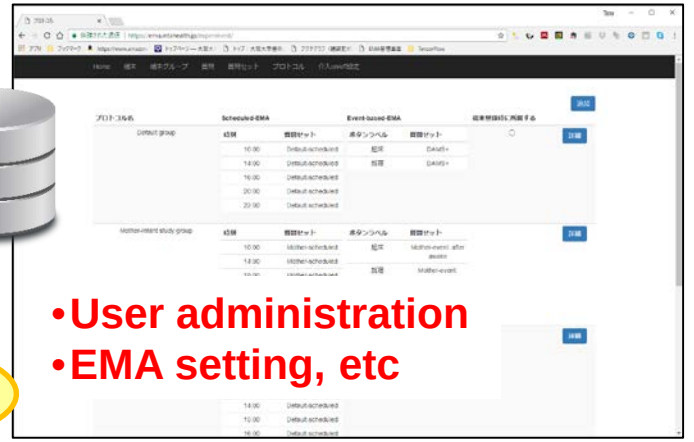
Real-time data transmission

Update settings
Intervention

Bluetooth connection

Cloud database server





・User administration
・EMA setting, etc

Real-time analysis

JITAI

Results

Analysis server

IoT devices
（activity tracker, HR monitor, etc.）

Fitbit, Rennesas real time sleep tracker, Omron environ. sensor, etc

Data visualization

EMA: Ecological Momentary Assessment; JITAI: Just-in-Time Adaptive Intervention

Summary: Future of Healthcare IoT

- Data-driven approaches (big data and/or ILD)
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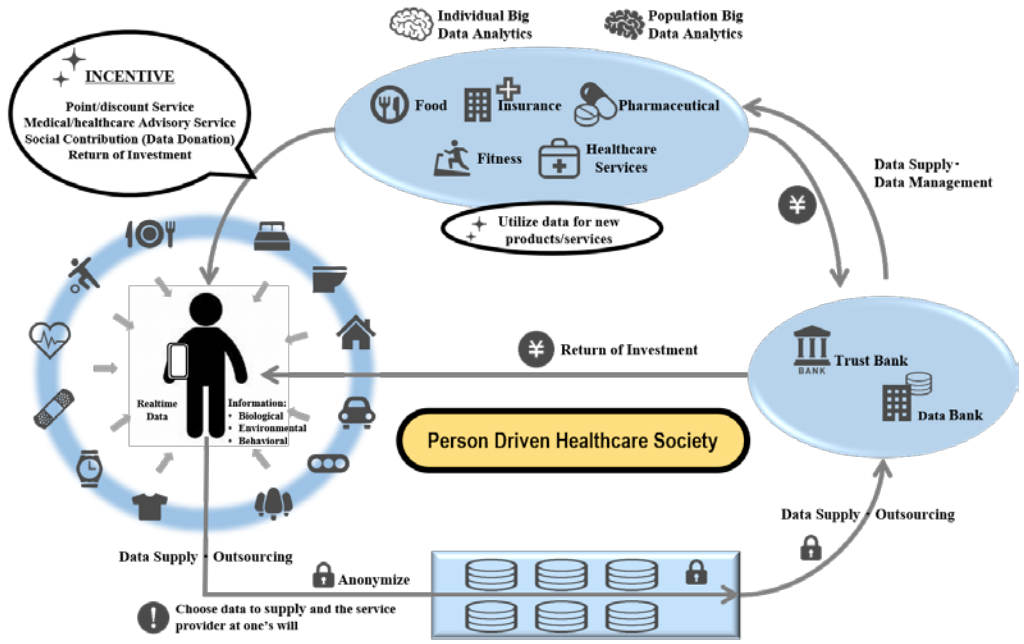
Free for academic/governmental members
(100,000 yen/year for industry members)



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