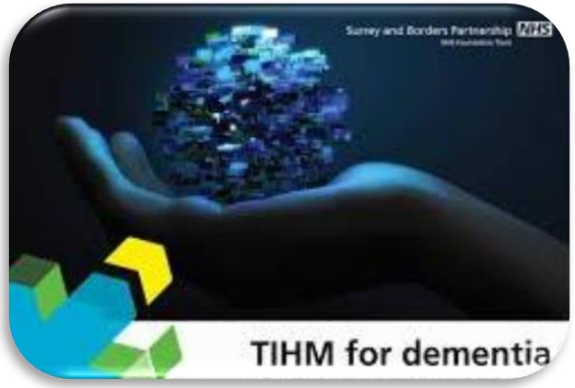
The Internet of Things for Dementia Care



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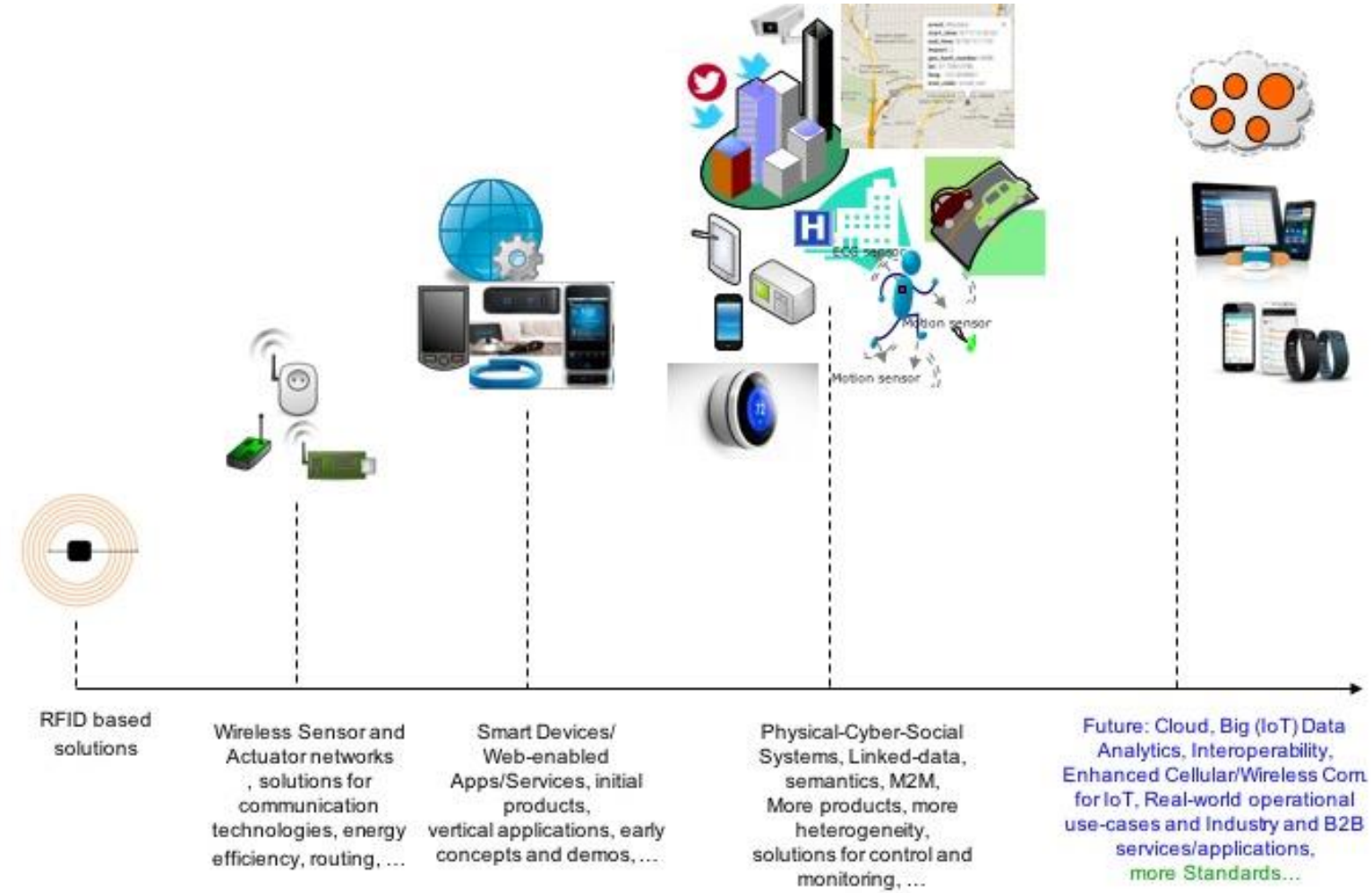
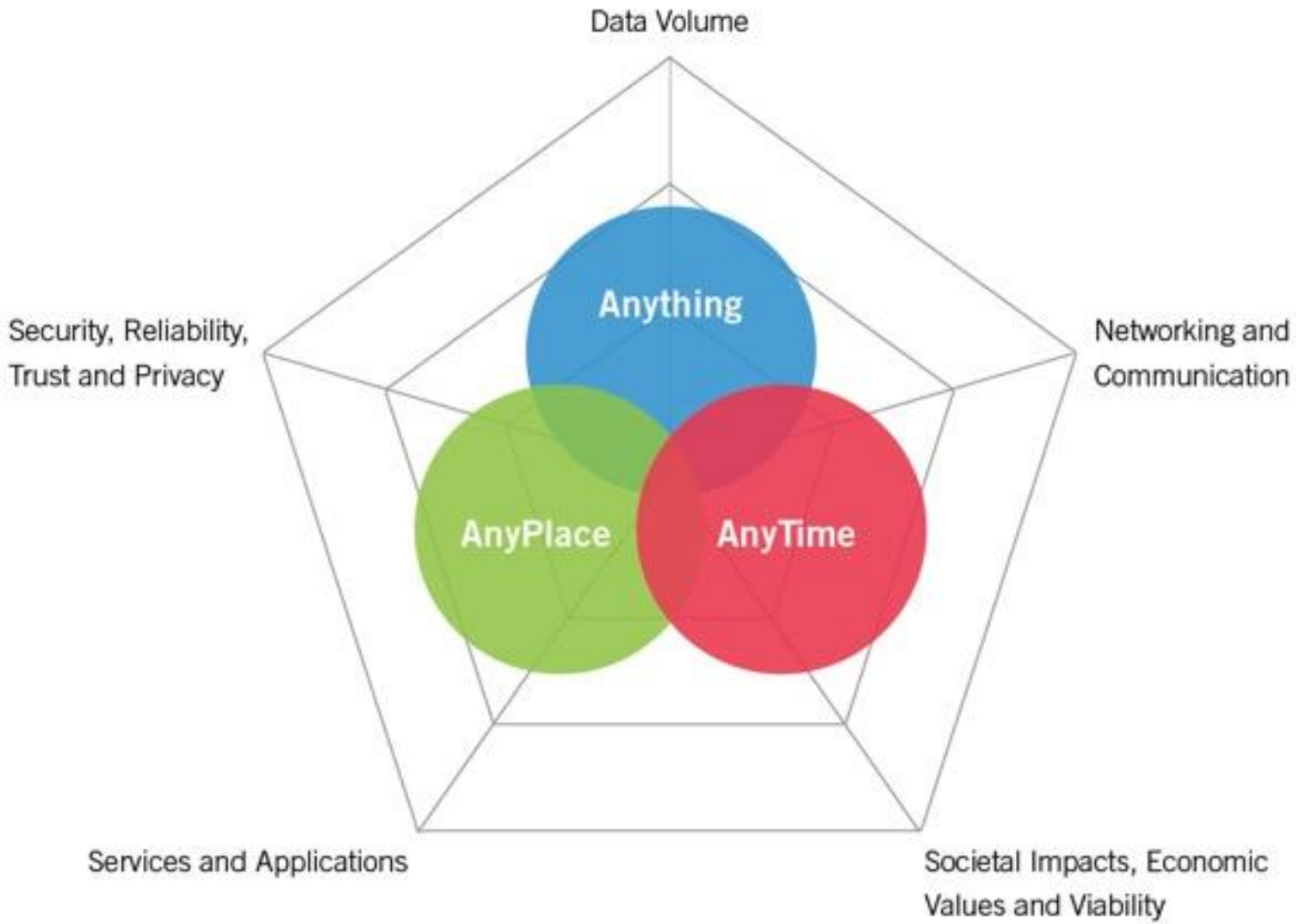
Internet of Things: the story so far



P. Barnaghi, A. Sheth, "Internet of Things: the story so far", IEEE IoT Newsletter, September 2014.

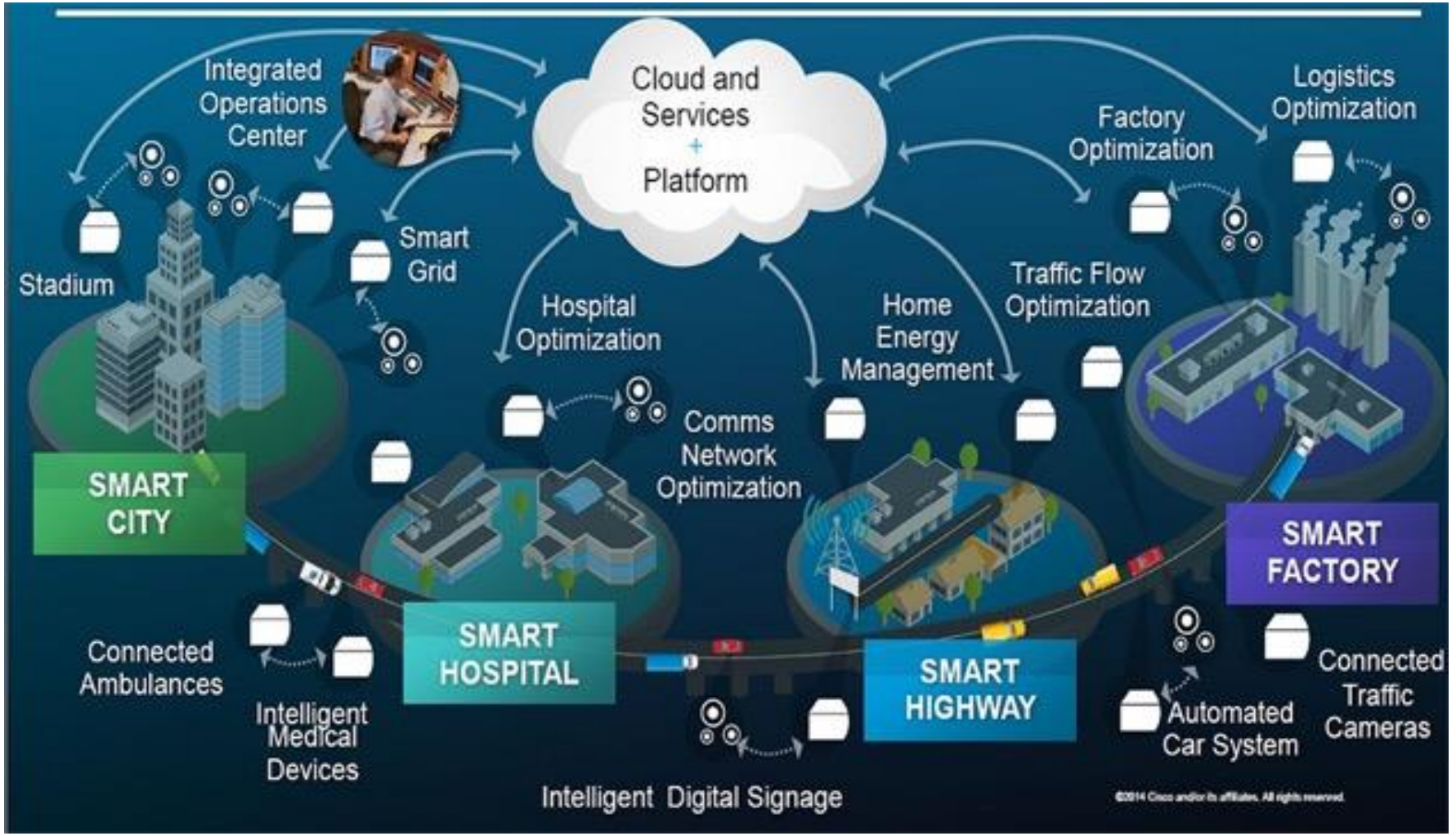


P. Barnaghi *et al.*, "Digital Technology Adoption in the Smart Built Environment", IET Sector Technical Briefing, March 2015.

IoT data challenges

- Multi-modality and interoperability
- Noise and incompleteness
- Time and location dependency
- Dynamicity and quality
- Requires (near-) real-time analysis
- Data alone may not give a clear picture → we need contextual information, background knowledge, multi-source information and data analytics solutions

IoT applications and services



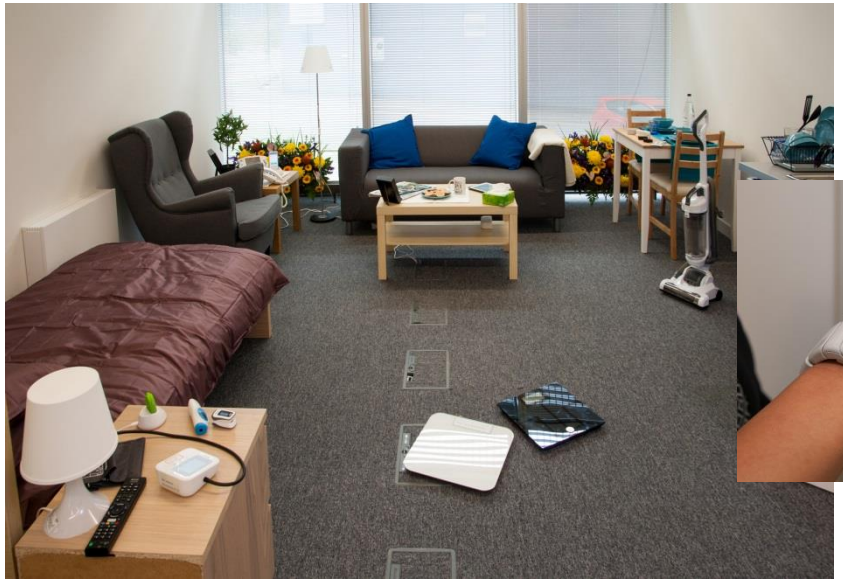
Source: https://datafloq.com/read/internet-of-things-more-than-smart-things/1060

Healthcare challenge: dementia

- More than 46 million people with dementia around the world
- Around 850,000 dementia patients in the UK (estimated to grow to 1 million by 2025)
- Estimated to cost £26bn p/a in the UK (Alzheimer's Society): health and social care (NHS and private) + unpaid care
- Develop innovative living environments which helps dementia patients and their carers to enjoy better health and quality of life, with reduced dependence on institutional care.

TIHM: An IoT testbed for dementia

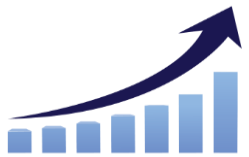
- Technology Integrated Health Management (TIHM)
- Monitoring elderly homes to provide personal healthcare applications for predictive solutions.



Technical challenge

- Security (hardware and software)
- Interoperability, integration
- Data governance
- Scalability





Semantic modelling: FIHR4TIHM

FHIR4THIM - Data Model

Working Draft

Latest version:
http://iot.ee.surrey.ac.uk/tihm/models/fhir4tihm/ (FHIR-JSON samples, HyperCat-JSON samples, Terminologies)
Last Update:
Date: 17:00:00 19/08/2016 BST

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See Acknowledgements

Abstract

Health Level-7or HL7 refers to a set of international standards for transfer of clinical and administrative data between software applicatio
providers.HL7 specifies a number of flexible standards, guidelines, and methodologies by which various healthcare systems can commu
guidelines or data standards are a set of rules that allow information to be shared and processed in a uniform and consistent manner.

In particular, the Fast Healthcare Interoperability Resources (FHIR) is a new standard from HL7 International designed to be easier to im
extensible than other versions of HL7. The FHIR leverages a modern web-based suite of API technology, including a HTTP-based REST
Style Sheets for user interface integration, and a choice of JSON or XML for data representation.

Status of this Document

This is a work in progress and as such is subject to change. Comments are very welcome, please send them to First Author.

1. Introduction
    1.1 Types of elements
    1.2 Cardinality
2. FHIR UML Diagrams
    2.1 Patient

- **Observation - value[x] / valueQuantity:** Data which are represented as a single value, such as body/room temperature,

▾Example (Room temperate)


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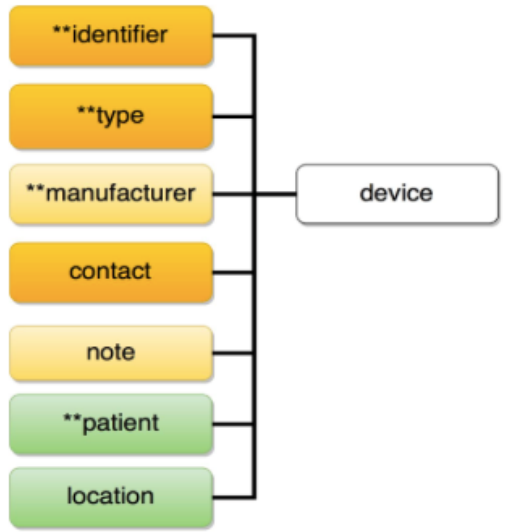
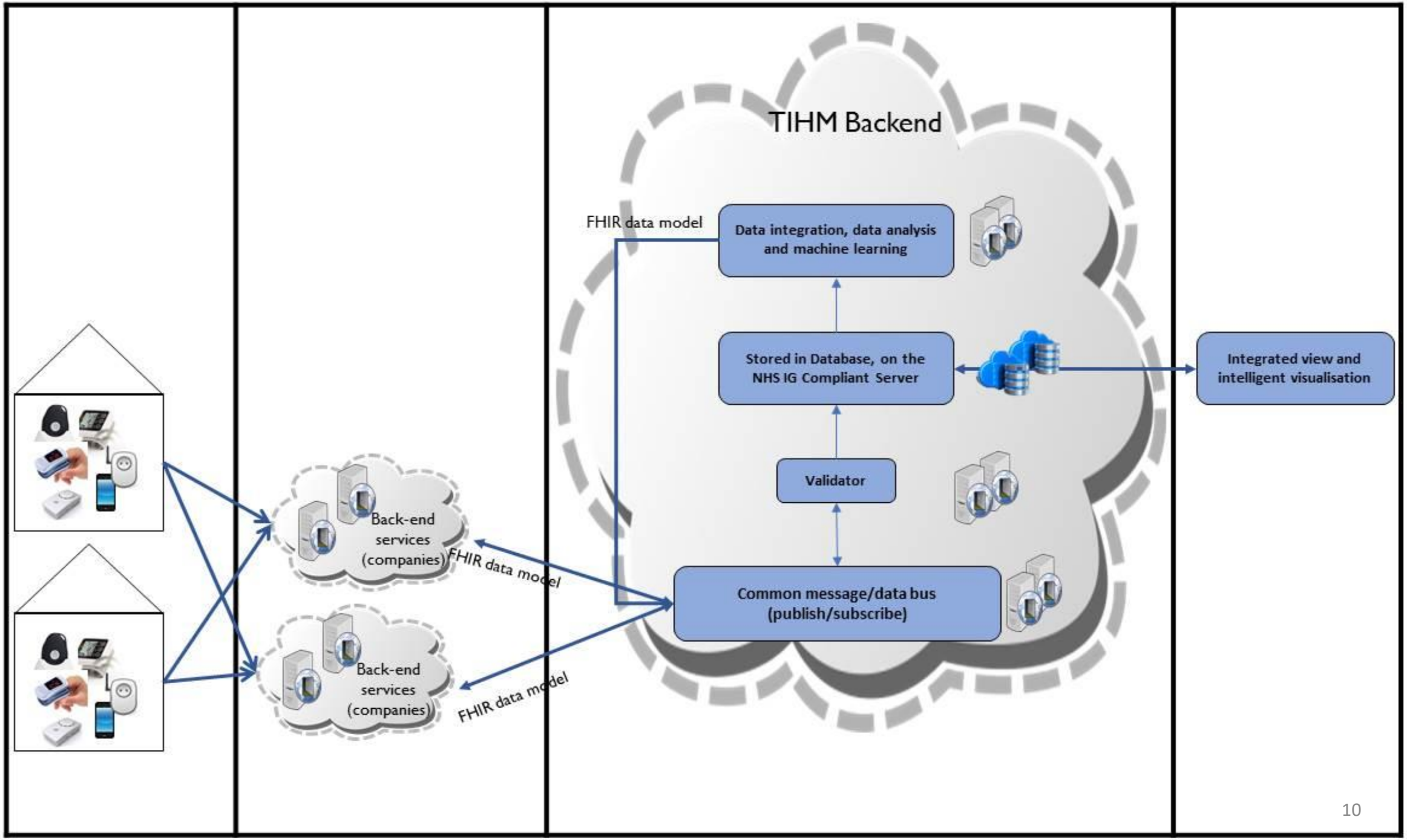
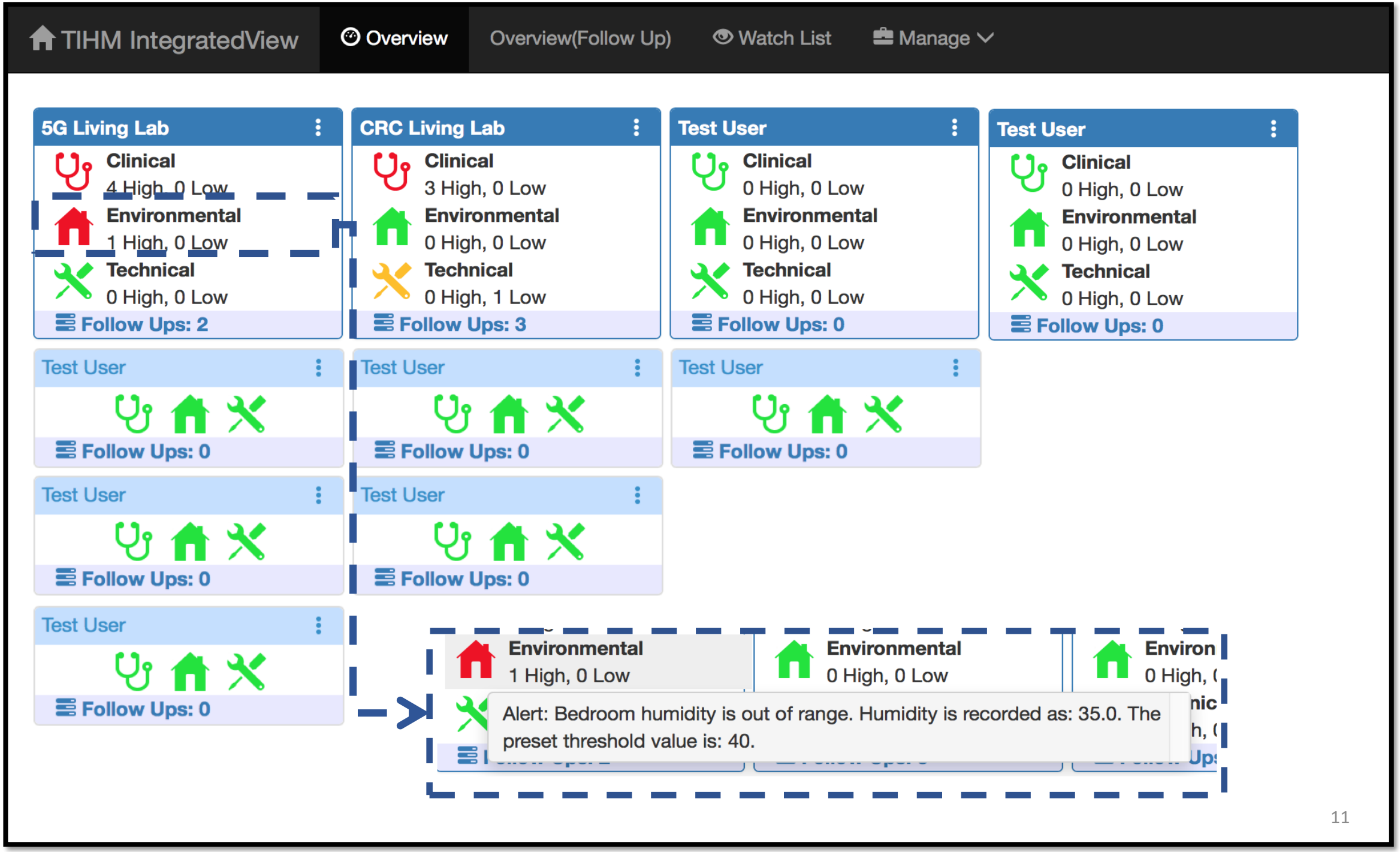
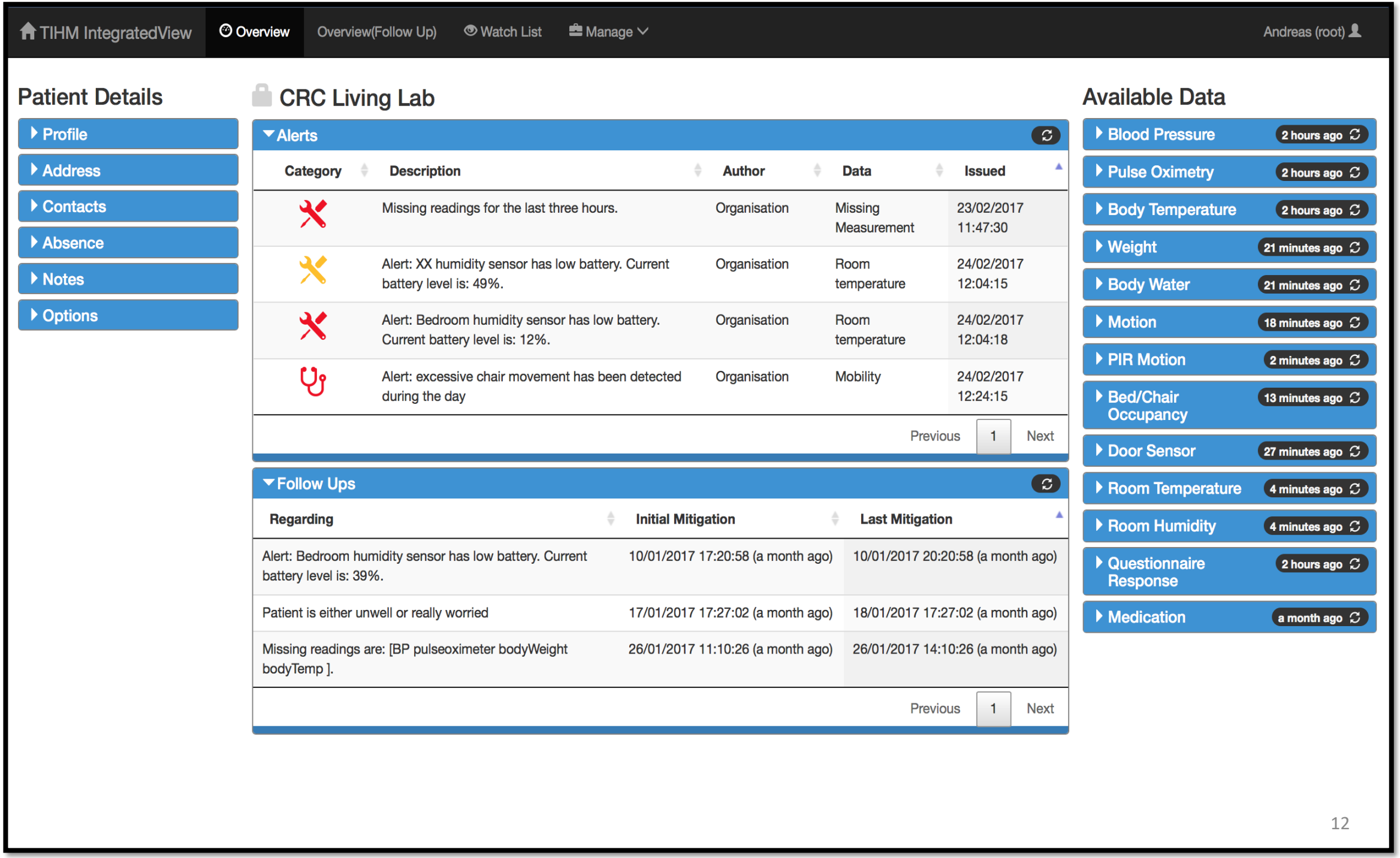
{
  "resourceType": "Bundle",
  "type": "transaction",
  "entry": [{
    "resource": {
      "resourceType": "Observation",
      "identifier": [{
          "value":"dfeeeef0-5d7a-11e6-a5a8-180373bf7644"
      }],
      "subject": {
        "reference": "Patient:TIHM-P1"
      },
       "device": {
        "display":
        "reference
      },
      "code": {
        "coding": [
          "system
          "code":
          "display
        }]
      },
      "valueQuant
        "value": 1
        "unit": "Ce
        "system":
      },
      "status": "fin
      "issued":"20
      "comments":
    }
  }]
}
```


TIHM Backend
FHIR data model
Data integration, data analysis and machine learning
Stored in Database, on the NHS IG Compliant Server
Validator
Common message/data bus (publish/subscribe)
Integrated view and intelligent visualisation
Back-end services (companies)
FHIR data model
Back-end services (companies)
FHIR data model


TIHM IntegratedView
Overview
Overview(Follow Up)
Watch List
Manage
5G Living Lab
Clinical
4 High, 0 Low
Environmental
1 High, 0 Low
Technical
0 High, 0 Low
Follow Ups: 2
CRC Living Lab
Clinical
3 High, 0 Low
Environmental
0 High, 0 Low
Technical
0 High, 1 Low
Follow Ups: 3
Test User
Clinical
0 High, 0 Low
Environmental
0 High, 0 Low
Technical
0 High, 0 Low
Follow Ups: 0
Test User
Clinical
0 High, 0 Low
Environmental
0 High, 0 Low
Technical
0 High, 0 Low
Follow Ups: 0
Test User
Follow Ups: 0
Test User
Follow Ups: 0
Test User
Follow Ups: 0
Test User
Follow Ups: 0
Test User
Follow Ups: 0
Test User
Follow Ups: 0
Environmental
1 High, 0 Low
Environmental
0 High, 0 Low
Environ
0 High,
Alert: Bedroom humidity is out of range. Humidity is recorded as: 35.0. The preset threshold value is: 40.


TIHM IntegratedView
Overview
Overview(Follow Up)
Watch List
Manage
Andreas (root)
Patient Details
Profile
Address
Contacts
Absence
Notes
Options
CRC Living Lab
Alerts
Category
Description
Author
Data
Issued
Missing readings for the last three hours.
Organisation
Missing Measurement
23/02/2017 11:47:30
Alert: XX humidity sensor has low battery. Current battery level is: 49%.
Organisation
Room temperature
24/02/2017 12:04:15
Alert: Bedroom humidity sensor has low battery. Current battery level is: 12%.
Organisation
Room temperature
24/02/2017 12:04:18
Alert: excessive chair movement has been detected during the day
Organisation
Mobility
24/02/2017 12:24:15
Previous
1
Next
Follow Ups
Regarding
Initial Mitigation
Last Mitigation
Alert: Bedroom humidity sensor has low battery. Current battery level is: 39%.
10/01/2017 17:20:58 (a month ago)
10/01/2017 20:20:58 (a month ago)
Patient is either unwell or really worried
17/01/2017 17:27:02 (a month ago)
18/01/2017 17:27:02 (a month ago)
Missing readings are: [BP pulseoximeter bodyWeight bodyTemp].
26/01/2017 11:10:26 (a month ago)
26/01/2017 14:10:26 (a month ago)
Previous
1
Next
Available Data
Blood Pressure
2 hours ago
Pulse Oximetry
2 hours ago
Body Temperature
2 hours ago
Weight
21 minutes ago
Body Water
21 minutes ago
Motion
18 minutes ago
PIR Motion
2 minutes ago
Bed/Chair Occupancy
13 minutes ago
Door Sensor
27 minutes ago
Room Temperature
4 minutes ago
Room Humidity
4 minutes ago
Questionnaire Response
2 hours ago
Medication
a month ago

Combinatory insights and predictive models

- Extracting meaningful information from a combination of clinical and environmental measurements
  - Machine learning for detecting Urinary Tract Infection (UTI)
  - Machine learning for detecting Agitation/Irritation/Aggression (AIA)

- Pattern identification for state prediction in dynamic data streams
  - Used for pattern analysis of home appliances use and daily activity data

In conclusion

- Great opportunities and many applications
- Enhanced and (near-) real-time algorithms to extract actionable information.
- Supporting more automated decision making and in-depth analysis of events and occurrences by combining various sources of data.
- Providing more and better information to clinicians/citizens.
- Data management issues (privacy, security, trust,…);
- Reliability and dependability of the systems

Thank you

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