IoT @ Aarhus University Hospital

Creating a transparent hospital and optimising patient flow

Mikkel Harbo, Director, mha@systematic.com
Contents

1. Background - in hospital logistics & research

2. Digitalisation - of the hospital service functions

3. Scaling up – the IoT capabilities
1. Background – in hospital logistics & research
Systematic in Healthcare

Columna CIS
Clinical Information System

Patient record
Medication
Patient administration
Booking

Columna Flow
Patient Flow Management

Patient Flow
Clinical Logistics
Service Logistics
Wayfinding

Columna Cura
Social & elderly care

Citizen record
Social services
Housing
Aids & equipment

Columna Citizen
Telemedicine

Personal medical record
Telemedicine

Medical Device Integration

Wireless data capture
Vendor neutral archive
Activities in hospitals generate Big Data

PosLogistics – the first research project (2011-2014)

Analysis of data set with collection of 10 days of data:
- 12,000 smartphones detected
- 1 billion Wi-Fi hotspot connections
Logistics from data analysis

PosLogistics – the first research project (2011-2014)

1. Motion trajectories are calculated
   - Machine Learning classifies common routes

2. Transportation mode detection
   - Machine Learning classifies the modes

3. Combined to estimates of travel times for transport tasks
   - Optimal task start times are calculated
A world of possibilities with localisation

How do we ensure...
- **synergy** between projects?
- **flexibility** to change solutions and prioritization?
- **independence** and ability to focus on the end goal?
Solve the Integration challenge

End user systems

- Way Finding
- Bed flow
- Trolley flow
- Patient flow

Tracking Technologies

- Wireless
- Sound
- Barcode
- NFC

Search

XX

XX

XX
Solve the Integration challenge

End user systems
- Way Finding
- Bed flow
- Trolley flow
- Patient flow

Tracking Technologies
- Wi-Fi
- Radar
- Barcode
- NFC

Search
Solve the Integration challenge

End user systems
- Way Finding
- Bed flow
- Trolley flow
- Patient flow

Integration of identification, location and tracking

Tracking Technologies
- WiFi
- Sound
- Barcode
- Chip

Search
Patient Hansen with electronic tag (A)
Orderly Jens with smartphone (B)
Bed with Wi-Fi-tag (C)

Integration System for Tracking and Identification

Staff with Patient Record
Person with smartphone
Integration System for Tracking and Identification

A is at position 34,56,3
Patient Hansen with electronic tag (A)

B is at position 26,67,2
Orderly Jens with smartphone (B)

C is at position 34,56,3
Bed with Wi-Fi-tag (C)
Patient Hansen is in bed B722 in wake-up room R115

Integration System for Tracking and Identification

A is at position 34,56,3
Patient Hansen with electronic tag (A)

B is at position 26,67,2
Orderly Jens with smartphone (B)

C is at position 34,56,3
Bed with Wi-Fi-tag (C)
Patient Hansen is waking up

Integration System for Tracking and Identification

- Staff with Patient Record
- Person with smartphone
- Patient Hansen with electronic tag (A)
- Orderly Jens with smartphone (B)
- Bed with Wi-Fi-tag (C)
Integration System for Tracking and Identification

Where is the closest Orderly?

Staff with Patient Record

Person with smartphone

Integration System for Tracking and Identification

Patient Hansen with electronic tag (A)

Orderly Jens with smartphone (B)

Bed with Wi-Fi-tag (C)
Integration System for Tracking and Identification

Where is the closest Orderly?

Orderly Jens is in room R17

Patient Hansen with electronic tag (A)
Orderly Jens with smartphone (B)
Bed with Wi-Fi-tag (C)

Pull

Simplifying critical decision making
Integration System for Tracking and Identification

Standardized interface

- Patient Hansen with electronic tag (A)
- Orderly Jens with smartphone (B)
- Bed with Wi-Fi-tag (C)

Staff with Patient Record

Person with smartphone
Reference architecture for object location and identification

Layer 5: User Systems
Using tracking data

Layer 4: Integration System for Tracking and Identification
Collecting, enriching, and exposing relevant tracking data

Layer 3: Tracking Systems
Filtering and exposing tracking data

Layer 2: Readers
Physical recording of movement and events

Layer 1: Mobile objects
Physical objects carrying id-tags or sensors

Layer 4 = Columna IoT Platform
Decouples tracking technologies and user systems
Standardised (GS1 / EPCIS 1.0)
Efficient and reliable access tracking data

National reference architecture
2. Digitalisation of the hospital service functions
Columna Service Logistics

Tasking  Searching  Beds  Trolleys  Transporing  Cleaning

INTERNET OF THINGS PLATFORM
Columna Service Logistics

Tasking | Searching | Beds | Trolleys | Wayfinding | Domestics

Columna Cleaning

Columna Task

INTERNET OF THINGS PLATFORM
Service Logistics – where does it fit in?

**Patient flow**

- In-patient
- Examination
- Operation
- Aftercare
- Discharge

**Service Logistics**

- Transport – the last 50m (Goods, Samples, Medicine, Food, Blood)
- Waste handling
- Cleaning
- Linen handling
- Maintenance

**Tasks**

- Patient transport
- Patient assist
- Equipment handling

**Clinical logistics**

- Bed handling

**Supply logistics**

- Goods
- Waste
- Medicine
- Equipment
- Sterile goods
- Food
- Clothing, linen

**Supply chain**
The challenge

1 to 1 communication

No transparency!
The solution

Simplicity

Tasks

Transparency & Empowerment

Simplicity
Columna Task

- Order tasks
- Monitor tasks
- Edit / cancel tasks

Orderly
- Book | Start | Complete tasks
- Reject tasks
- Register tasks

Requestor

Manager

Supervisor

Orderly staff room

Overview of task execution

Simplifying critical decision making
Many users... Many tasks ... help is needed!

Unique requesters

Tasks completed per month (January 2019)
Many users... Many tasks ... help is needed!

Unique requesters

Tasks completed per month (January 2019)
Workload Forecast

- **Situation**
  - Organized in “silos”
  - Activity levels / productivity varies

- **Problem**
  - Periods of high/low workload are hard to discover
  - Redistributing the workforce is difficult

- **Solution**
  - Real time prediction of workload
  - Foresight of “surplus” and “shortage”
Machine learning - What is that?

Labelled historic data

New data

Algorithm

Stores and uses relations

Finds (automatically) patterns / relations in data

Prognose
Can we predict the ad-hoc tasks?

# Daily ad-hoc tasks
Can we predict the ad-hoc task? Yes!

Average forecast error: 1.3 tasks
Build-in forecasting capabilities in Hospital Logistics

DABAI – the second research project (2016-2020)

- Patient flow (Beta)
- Service Logistics
- Clinical Logistics
- EHR

Forecast platform

1. Patient flow in hospitals
2. Workload & tasks in Service Logistics
3. Inpatient Length Of Stay
4. Acute overcrowding of hospital departments
5. Likely hood of re-admission
6. DIY Machine Learning support

Simplifying critical decision making
3. Scaling up – the IoT capabilities
Systematic in Healthcare

Columna CIS
Clinical Information System

Patient record
Medication
Patient administration
Booking

Columna Flow
Patient Flow Management

Patient Flow
Clinical Logistics
Service Logistics
Wayfinding

Columna Cura
Social & elderly care

Citizen record
Social services
Housing
Aids & equipment

Columna Citizen
Telemedicine

Personal medical record
Telemedicine

Medical Device Integration

Wireless data capture
Vendor neutral archive
Columna Flow
A Future Patient Flow Management Solution

End User Systems

Citizens
- Self service
  - Columna Wayfinding (Web app, smart phone app, Self-service terminal)
  - Columna Signage (Digital signage)
- Self registration & Queing

Clinicians
- Clinical Logistics
  - Columna Clinical Logistics (nurse-patient-bed)
  - Columna Patient Flow (Ward & Hospital conference)
  - Columna Forecasting (AI) (Pt. flow Regional-Hospital-ward level; Patient stay: length, readmission risk)
- Tasking, Messaging and Locating
  - Columna Now (RTLS) (locationing)
  - Columna Alarm (RTLS) (Par level; Geofencing)
  - Results (lab results)

Assistants
- Service Logistics
  - Columna Bed (stock, location, task, status)
  - Columna Trolley (location, task, timing)
  - Columna Cleaning (plan digitalisation, execution)
  - Patient home transport (3rd party transporting)

Master Data Systems & Services

- IoT Platform
  - Location
  - Track
  - Routing

- Machine Learning Forecasting Platform
  - Flow
  - Stay
  - Work load

- Communication
  - Tasking
  - Messaging
  - Organisation
Columna Flow
A Future Patient Flow Management Solution

End User Systems

Citizens
- Self service
  - Columna Wayfinding (Web app, smart phone app, Self-service terminal)
  - Columna Signage (Digital signage)
- Self registration & Queing

Clinicians
- Clinical Logistics
  - Columna Clinical Logistics (nurse-patient-bed)
  - Columna Patient Flow (Ward & Hospital conference)
  - Columna Forecasting (AI) (Pt. flow Regional-Hospital ward level; Patient stay: length, readmission risk)

Assistants
- Service Logistics
  - Columna Bed (stock, location, task, status)
  - Columna Trolley (location, task, timing)
  - Columna Cleaning (plan digitalisation, execution)

Master Data Systems & Services
- IoT Platform
  - Location
  - Track
  - Routing

Machine Learning Forecasting Platform
- Flow
- Stay
- Work load

Communication
- Tasking
- Messaging
- Organisation
Status on the IoT implementation
Aarhus University Hospital - in numbers

Hospital size
- 10,000 employees
- 500,000 m2
- 980 beds
- ~ 800,000 ambulant visits
- ~ 90,000 admissions
- ~ 80,000 operations

IoT penetration
- + 3,000 Passiv RFID antennas and a Cisco network
- +4,500 tagged trolleys
- +1,250 tagged medical equipment (potential + 40,000)
- 1,000 + tagged beds
- 500 + tagged employees (next step 2,000 more)
- 100,000 tagged clothes items
Thank you

... hear more at Stand 25

Contact information
Mikkel Harbo, +45 2544 2803, mha@systematic.com