(How) Will RTLS transform healthcare delivery (research) ?

Strengths & Limitations

Avishai Mandelbaum
August 2019

Search **SEELab Technion**

*Long version will be uploaded

Outline

- “Introduction”

- Helpful history

- Strengths, via data

- Limitations, relative to needs

- Examples, that hint at future apps: Research, Practice

- Concluding speculations

Caveats:

- RTLS = Location+ID tracking of human operations, which is automatic, continuous, online
- Technology transparent (RF or IR, US, WIFI, BLT, UWB, Smartphone; passive/active,…)
- General healthcare delivery

(How) Will RTLS transform healthcare delivery (research) ?

- Widely acknowledged that healthcare delivery, its models and practice and research, must and is due to undergo transformational changes.

- My view is that "RTLS+**DFCI**", by enabling evidence-based modelling / practice / research / partnerships (e.g. **Sarah, Ryan, Craig**), is a prerequisite for such a transformation (e.g. research relevance).

Consider Cost of Care, as one central example:

Cost of Care

- "There is little doubt that the most generally troublesome feature of recent experience with all aspects of medical care in the United States today is the increase in **cost**, however defined, of the hospital component of that care."

Cost of Care

- "There is little doubt that the most generally troublesome feature of recent experience with all aspects of medical care in the United States today is the increase in **cost**, however defined, of the hospital component of that care."

From "A System for Cost and Reimbursement Control in Hospitals," Yale U.

1975, Fetter et al = inventors of DRG (see Interfaces 1991).

Cost of Care

- "There is little doubt that the most generally troublesome feature of recent experience with all aspects of medical care in the United States today is the increase in **cost**, however defined, of the hospital component of that care."

From "A System for Cost and Reimbursement Control in Hospitals," Yale U.

1975, Fetter et al = inventors of DRG (see Interfaces 1991).

- Cost?
  - Patients (if uninsured, can negotiate down significantly)?
  - Providers (isolated from costs to optimize care)?
  - Hospitals = billing charges?
  - Insurance = reimbursements (?30% of charges, after negotiations)?

True cost?

Cost of Care: by **ICD?**

- **ICD-10** is the 10th revision of **ICD = International Classification** of **Diseases**: medical classification list that contains codes for diseases, signs and symptoms, abnormal findings, complaints, social circumstances, and external causes of injury or diseases.

- There are presently about **140,000** ICD codes (over 70,000 ICD-10-PCS procedure codes and over 69,000 ICD-10-CM diagnosis codes; compared to about 3,800 procedure codes and roughly 14,000 diagnosis codes found in the previous ICD-9-CM).

Cost of Care: by **ICD?**

- **ICD-10** is the 10th revision of **ICD = International Classification** of **Diseases**: medical classification list that contains codes for diseases, signs and symptoms, abnormal findings, complaints, social circumstances, and external causes of injury or diseases.

- There are presently about **140,000** ICD codes (over 70,000 ICD-10-PCS procedure codes and over 69,000 ICD-10-CM diagnosis codes; compared to about 3,800 procedure codes and roughly 14,000 diagnosis codes found in the previous ICD-9-CM).

- ICD is the basis for **DRG = Diagnosis Related Groups**, which are assigned by a **"grouper" program: 140K → 750 groups**.

- (The World Health Organization (WHO) owns, develops and publishes ICD codes, and national governments and other regulating bodies adopt the system.)

Cost of Care: by **DRG**

"Diagnosis Related Groups (DRGs) originally developed to provide product-definitions for the output of hospitals. …, accounts for diagnoses, procedures, age, sex, discharge status, and the presence of complications or comorbidities …, basis for budgeting, cost control, and quality control in hospitals." Fetter, Interfaces, 1991.

DRGs (originally 467 categories, now over **750** & AllPatients or APRefined) used in the US since 1982 to determine how much Medicare pays the hospital for each "product", since patients within each category are clinically similar and are thus expected to use the same level of hospital resources (providers, equipment, medication, bed, …):

DRG Cost = Standardized amount per discharge x DRG "Resource Intensity" (Relative Weight)

Cost of Care: via **RTLS = Personalized Evidence-based**

"Diagnosis Related Groups (DRGs) originally developed to provide product-definitions for the output of hospitals. …, accounts for diagnoses, procedures, age, sex, discharge status, and the presence of complications or comorbidities …, basis for budgeting, cost control, and quality control in hospitals." Fetter, Interfaces, 1991.

DRGs (originally 467 categories, now over 750 & AllPatients or APRefined) used in the US since 1982 to determine how much Medicare pays the hospital for each "product", since patients within each category are clinically similar and are thus expected to use the same level of hospital resources (providers, equipment, medication, bed, …):

DRG Cost = Standardized amount per discharge x DRG "Resource Intensity" (Relative Weight)

But patients' resource utilization varies significantly by the individual, and here

RTLS can come to the rescue by measuring personalized true costs of care.

This could/would change healthcare (e.g. enabling evidence-based management, market-based models of care, …).

(How) Will RTLS transform healthcare delivery (research) ?

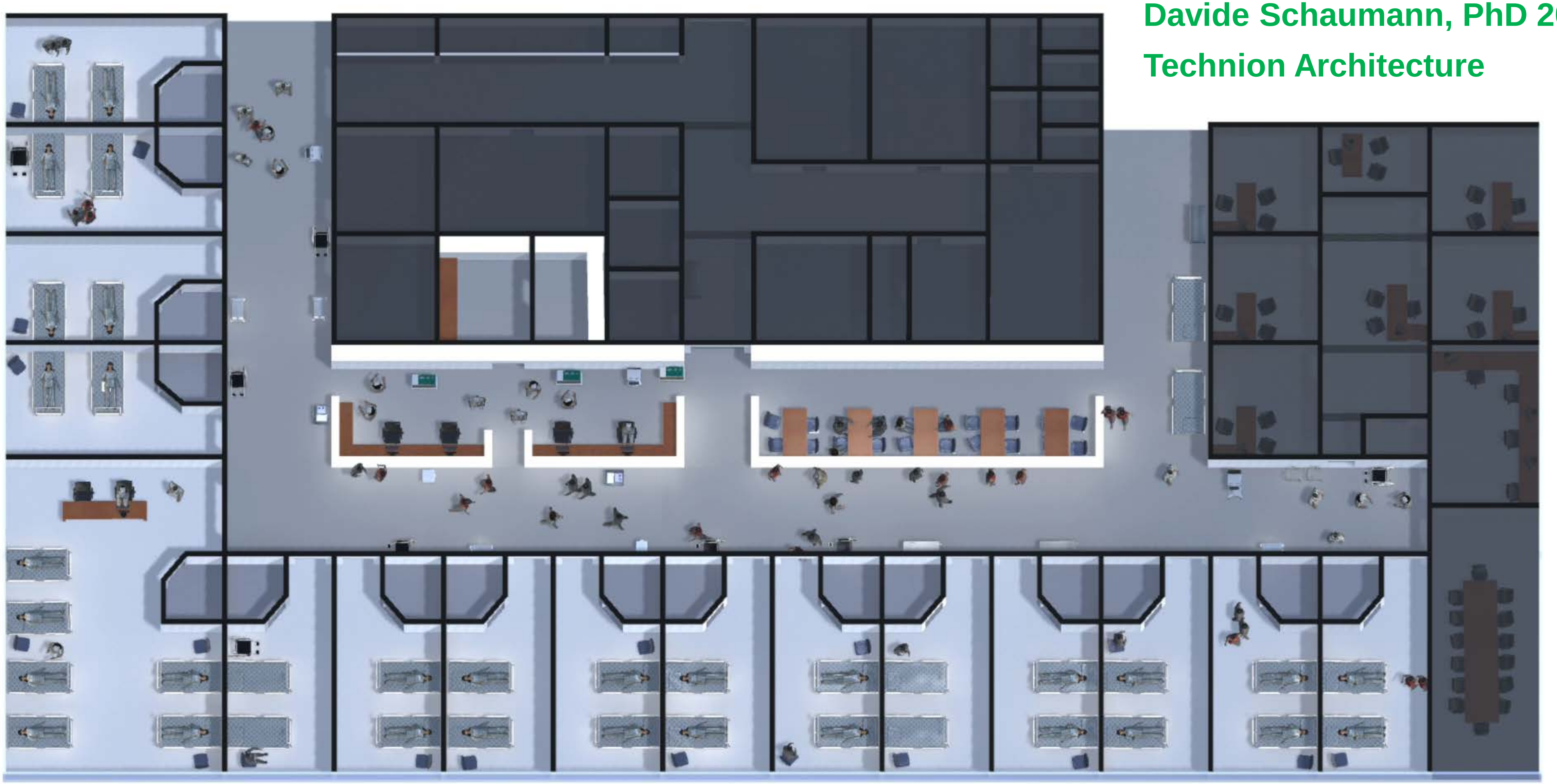
- Widely acknowledged that healthcare delivery, its models and practice and research, must and is due to undergo transformational changes.

- My view is that "RTLS+**DFCI**", by enabling evidence-based modelling / practice / research / partnerships (e.g. **Sarah, Ryan, Craig**), is a prerequisite for such a transformation (e.g. research relevance).

… and consider Process and Spacial Design, as a 2nd central example:

(Physical) Simulation of an Internal Medicine Ward

Davide Schaumann, PhD 2018
Technion Architecture



(Physical) Simulation of an Internal Medicine Ward

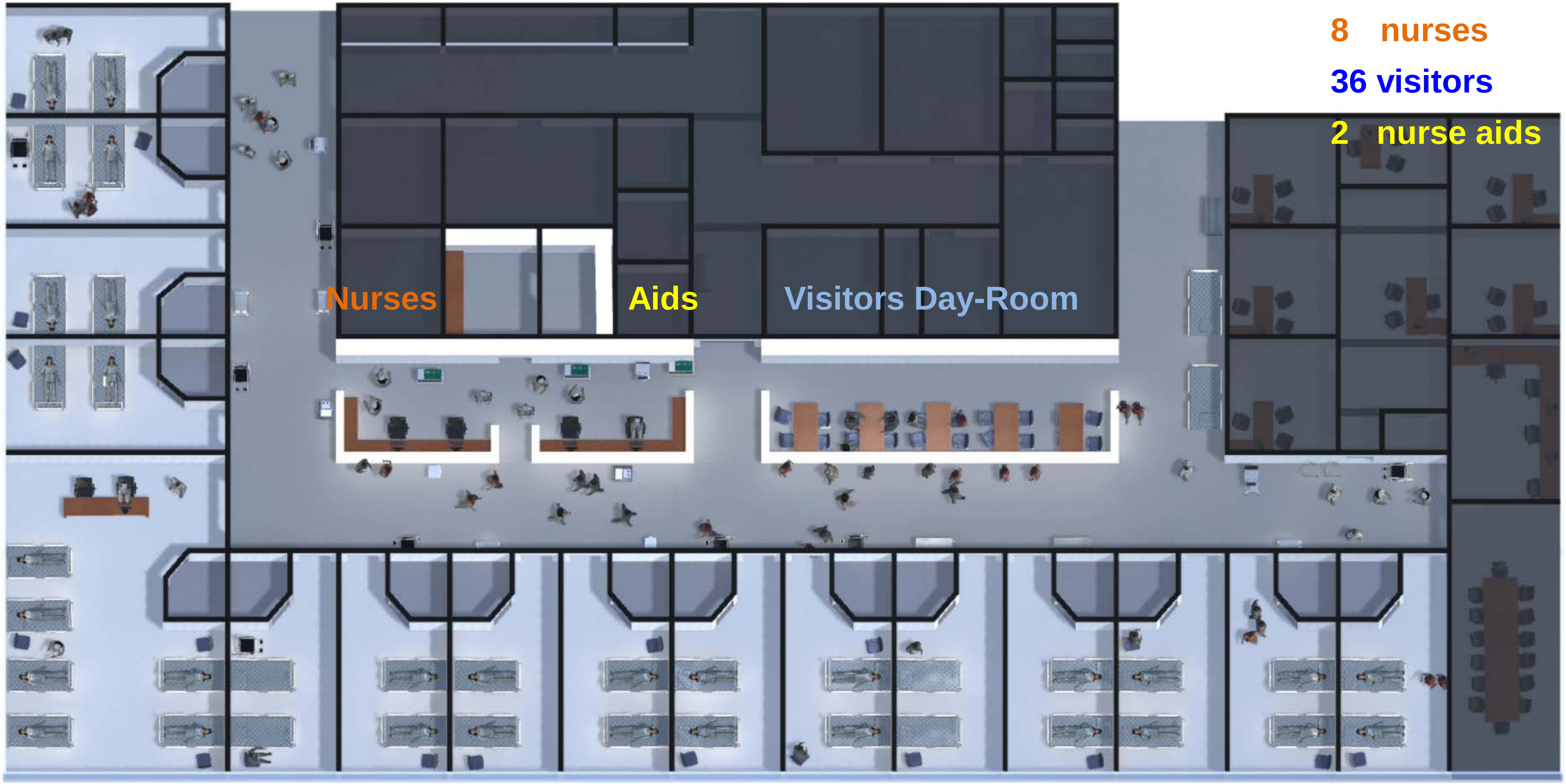
36 patients

6 doctors

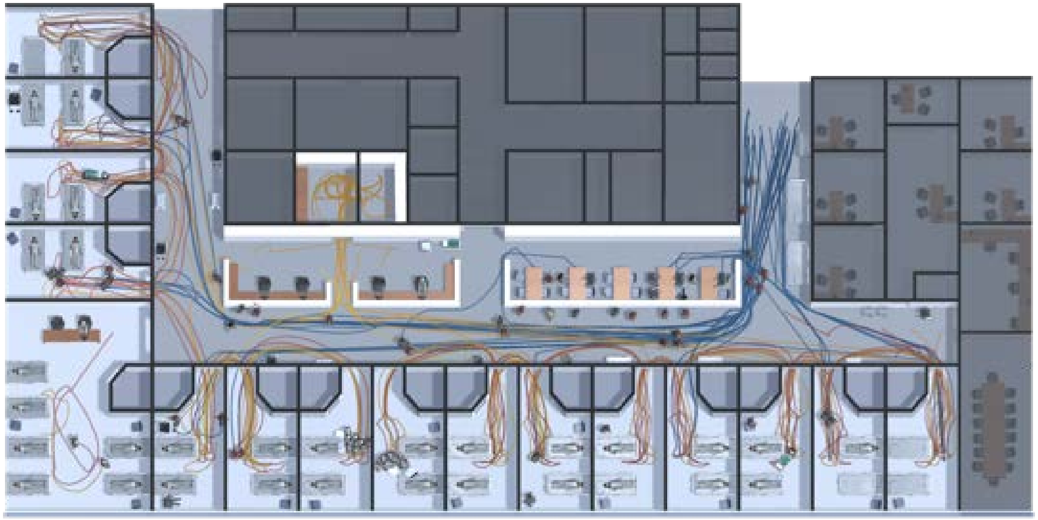
8 nurses

36 visitors

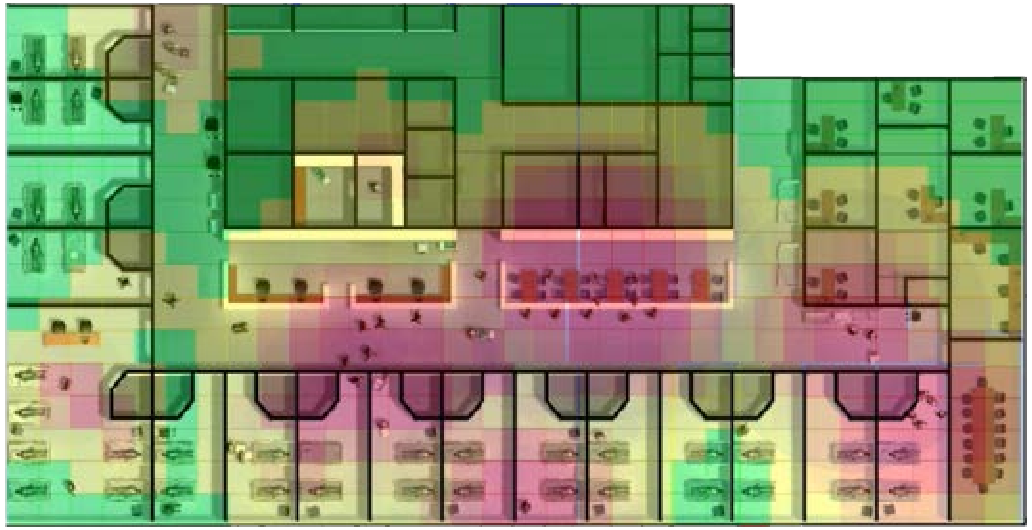
2 nurse aids



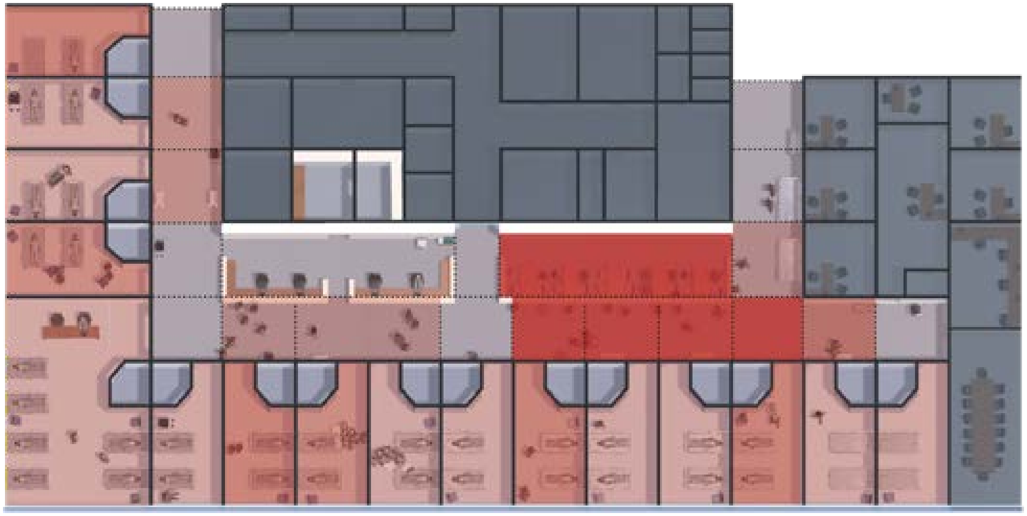
Human-Centric Analysis of Spatial Utilization



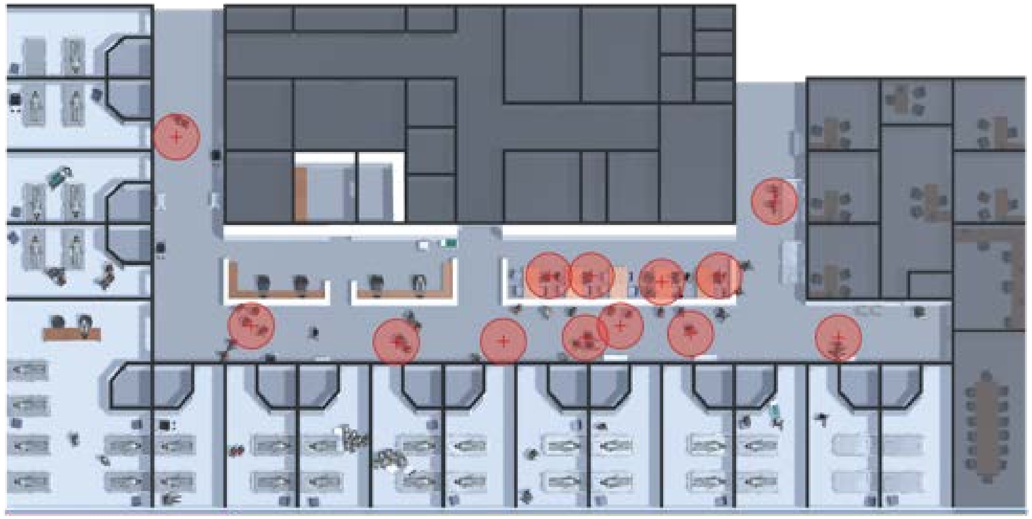
Travelled Paths



Noise (**Talking,** can AC, **…**)



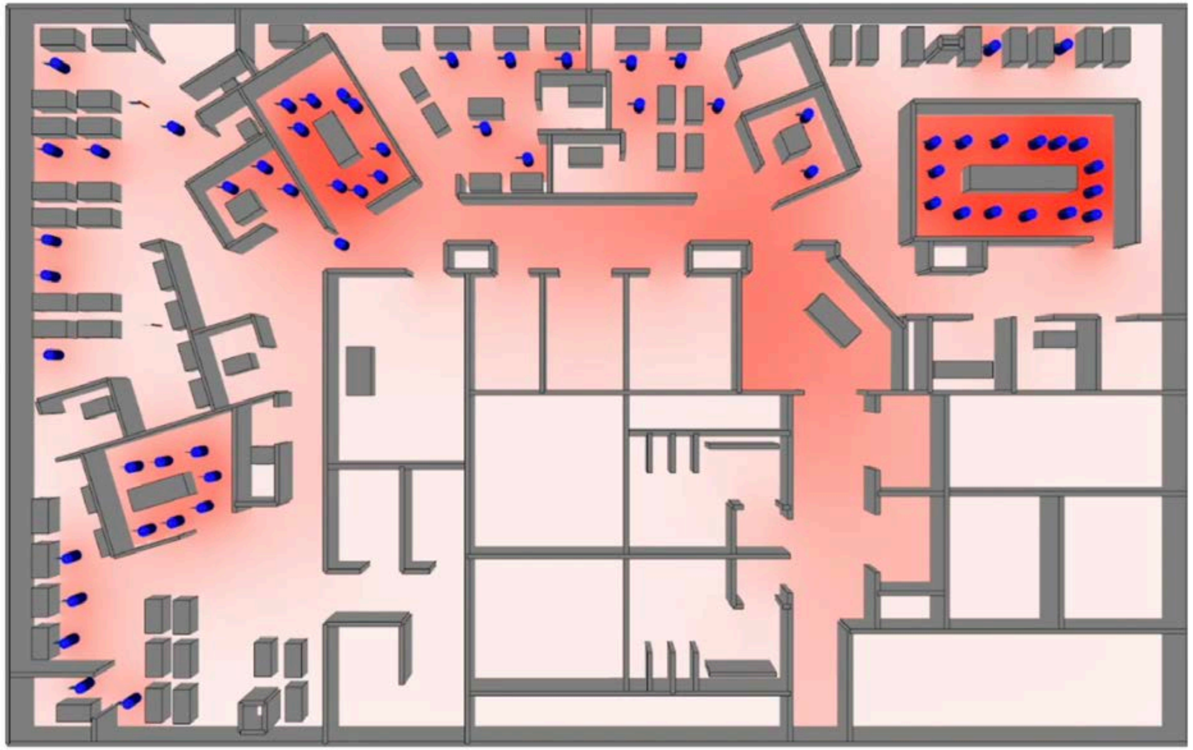
Density of People in Space



Social Interactions (**Staff-Visitor,** can Staff-Staff)

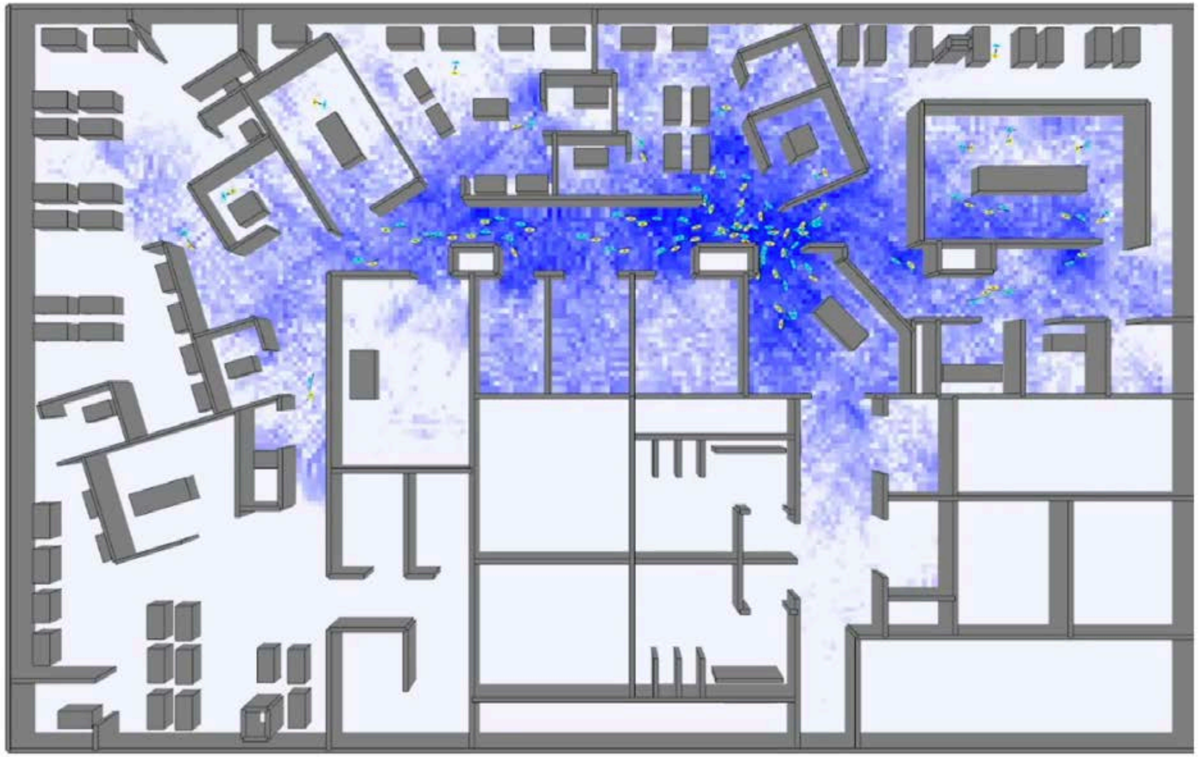
Schaumann et al. “Simulating the impact of facility design on operations: A study in an internal medicine ward.” 2019, *In Press*

Environmental Conditions: Heat, Noise (Refined)



Thermal simulation of occupants' **body heat**

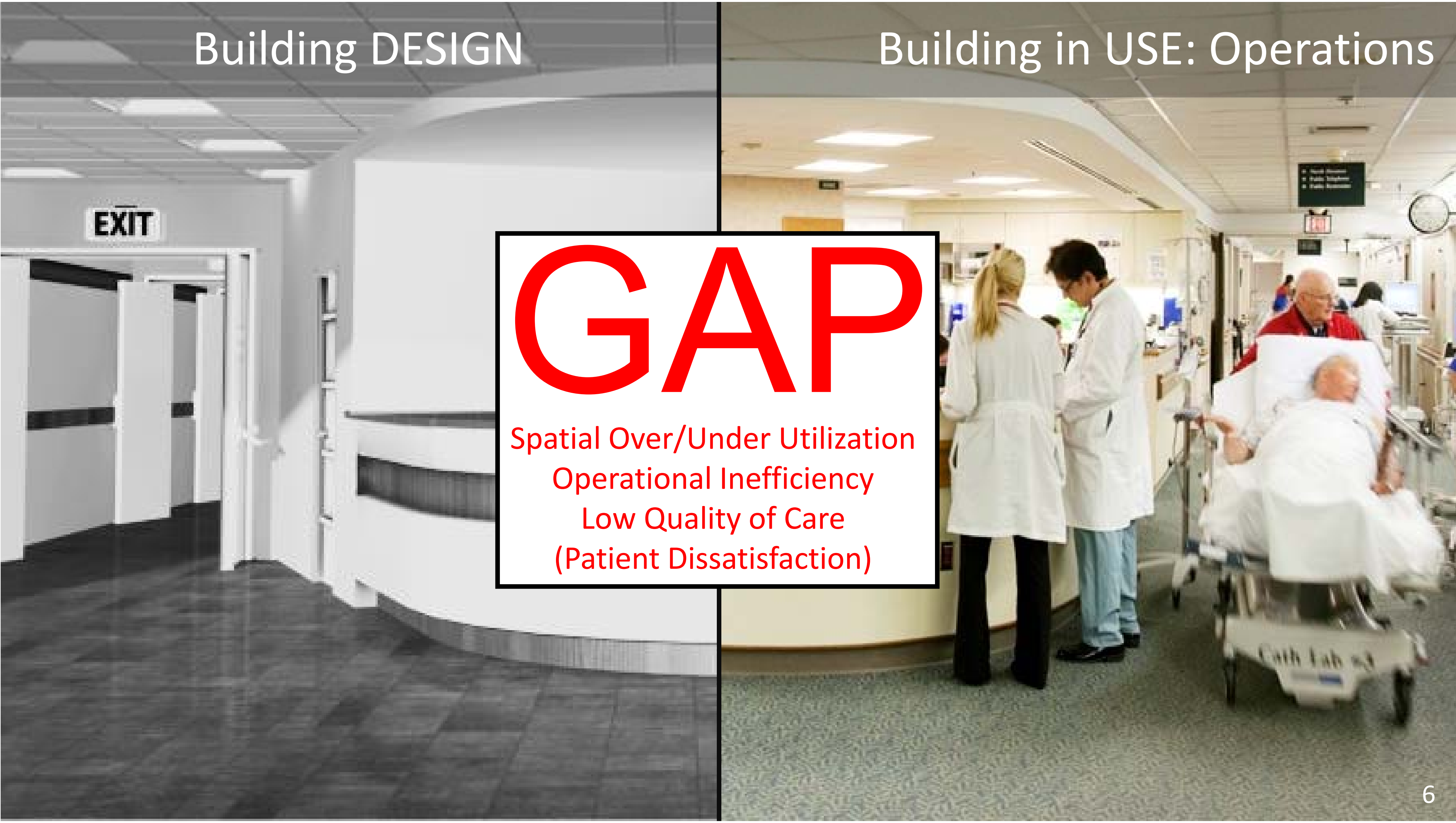
(differential equations)



Acoustics simulation of occupant's **footstep**

sound = f(floor material, wall absorption,…)

Schaumann et al. "JOIN: An Integrated Platform for Joint Simulation of Occupant-Building Interactions. Architectural Science Review." 2019, in Review


Building DESIGN
Building in USE: Operations
EXIT
GAP
Spatial Over/Under Utilization
Operational Inefficiency
Low Quality of Care
(Patient Dissatisfaction)

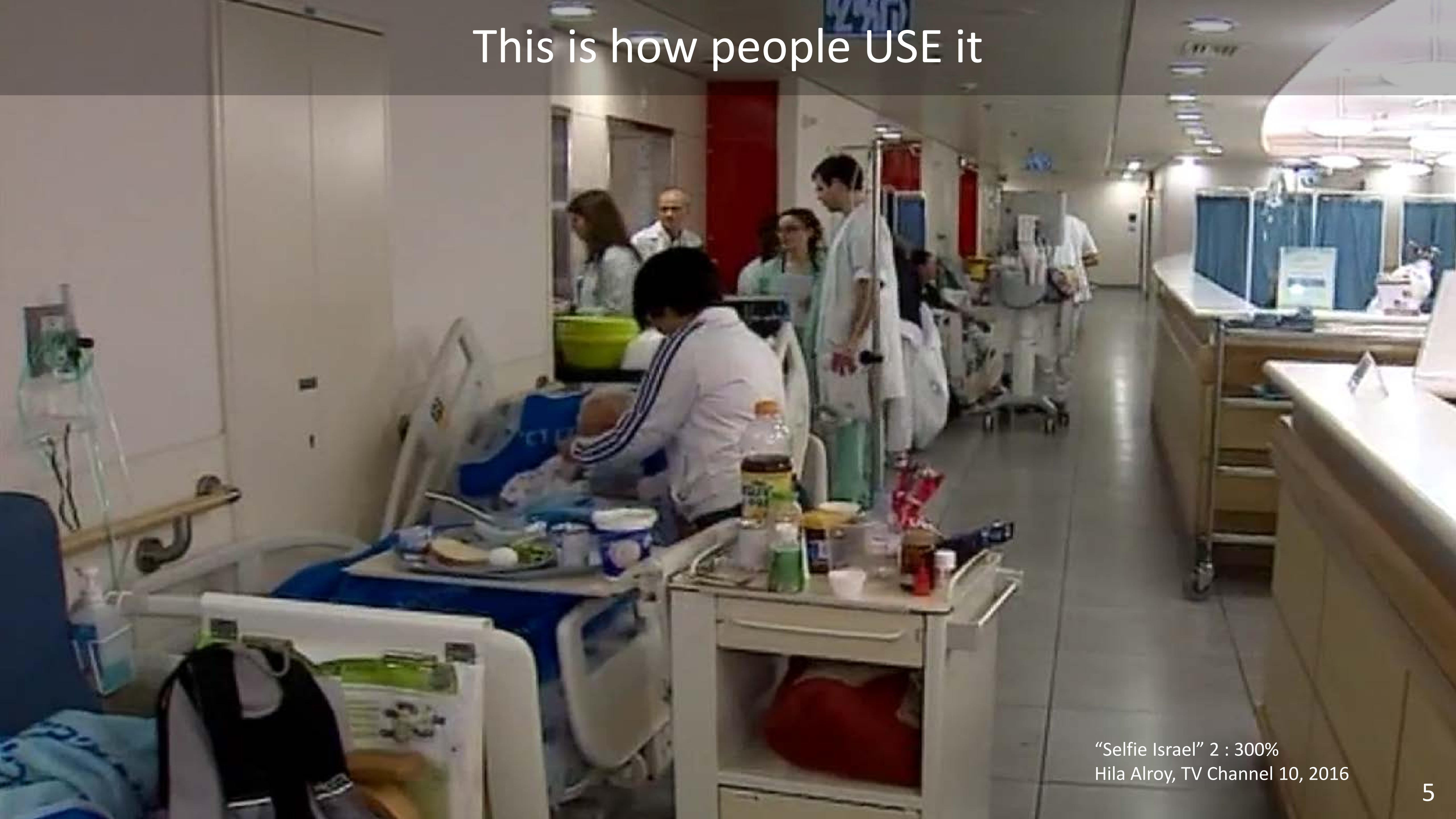
This is how architects DESIGN a hospital

This is how people USE it

This is how architects DESIGN a hospital

Sharon Architects & Ranni Ziss Architects, 2007

This is how people USE it



“Selfie Israel” 2 : 300%
Hila Alroy, TV Channel 10, 2016

Main Takeaways – Practice (Hospital-Centered)

- Operational & within hospital:
  - Personalized evidence-based: resource utilization/cost, patient/infection paths
  - Adherence to “clinical” constraints (e.g. 1-hour door-to-stent time, …)
  - EMR (Epic) integration
- Operational & beyond hospital:
  - Complete (operational) cycle of care (e.g. readmissions, ED blocking, IW boarding), and reduce hospital disconnect from community
  - Outdoor tracking: integrate RTLS with wearables/smartphones (community, home)

Main Takeaways – Practice (Hospital-Centered)

- Operational & within hospital:
  - Personalized evidence-based: resource utilization/cost, patient/infection paths
  - Adherence to “clinical” constraints (e.g. 1-hour door-to-stent time, …)
  - EMR (Epic) integration
- Operational & beyond hospital:
  - Complete (operational) cycle of care (e.g. readmissions, ED blocking, IW boarding), and reduce hospital disconnect from community
  - Outdoor tracking: integrate RTLS with wearables/smartphones (community, home)

- Beyond operational & within hospital:
  - Smart Hospital: social-networks (multi-directional connection); noise, energy (heat), crowdedness; operational + clinical + psychological + financial dimensions
- Beyond both: technology around the corner
  - Complete cycle of care (community, home), that integrates the physical + above dimensions, …
  - Comparing performance (hospitals, states, city vs. periphery, …)

Main Takeaways – Research + Practice: OR/DS/OM/IE, (Social) Networks, <>Mining, ML, Ethics, Incentives, …

1. RTLS data affects both
   - Empirical and
   - Theoretical research.
2. RTLS-based Empirical Research is to affect both
   - the Practice in Hospitals and
   - the Practice of Research.
     - e.g. Practice in Hospital: our empirical analysis revealed gaps between the scheduled and the actual, which will help reduce this gap
     - e.g. Practice of Research: ample data will help identify novel research opportunities and validate existing research.
3. RTLS-based Theoretical Research is to affect both
   - The Practice in Hospitals and
   - the Practice of Research.
     - e.g. Practice in Hospital: novel technologies & tools – smartphone; planning, scheduling, control
     - e.g. Practice of Research: this is clear as novel research stimulates further research

(Operations) Research Goal (within reach)

e.g. Specific Emergency-Department, with ample reliable data (or Call Center, or …)

Goal: Create in Real-time, via (semi- or fully-automatic) mining of ED **processes, models** (empirical, statistical, simulation, mathematical,…) and **algorithms** for their analysis.

(Operations) Research Goal (within reach)

e.g. Specific Emergency-Department, with ample reliable data (or Call Center, or …)

Goal: Create in Real-time, via (semi- or fully-automatic) mining of ED **processes, models** (empirical, statistical, simulation, mathematical,…) and **algorithms** for their analysis.

This will support, for example:

- Real-time: control of patient-flow (bottlenecks); status-info + prediction ("waze")
- Short-term: on Monday, set Tuesday's staffing levels (or next week's); real cost of care for the individual patient (vs. mean/negotiated costs)
- Long-term: capacity allocation, facility/triage design; social network (e.g. correlated w/ outcomes); change-management (Epic); congestion laws

Outline

- “Introduction”

- **Helpful history**

- **Strengths, via data**

- **Limitations, relative to needs**

- **Examples, that hint at future apps: Research, Practice**

- **Concluding speculations**

Technion SEELab

SEE = Service Enterprise Engineering
Collecting Data for Research and Teaching

Home for all the data in this lecture, and much more

Founded in **2007**
by **Paul Feigin and AM**

$1M seed: **Hal & Inge Marcus**

3 Researches (professionals)
Students, PostDocs, Visitors

Technion SEELab

SEE = Service Enterprise Engineering
Collecting Data for Research and Teaching

Home for all the data in this lecture, and much more

In the making or planning:

SEENYC @ Jacobs Technion-Cornell Inst.
w/ **Itai Gurvich** (PI), …

SEEZHEN @ CUHK-Shenzhen /SRIBD
w/ **Jim Dai, …**

SEELab = Environment for Graphical EDA

Operational histories (customers, servers) at the **individual-transaction level**, e.g.

1. Bank Anonymous Call-Center: **1 year, 350K calls by 15 agents** (during 2000) – started all
2. U.S. Bank Call-Center : **2.5 years, 220M calls, 40M by 1000 agents**
3. Israeli Cellular Company: **2.5 years, 110M calls, 25M calls by 750 agents;**
4. ILBank (2 years)
5. Back to Bank Anonymous: **from January 2010,** daily-deposit at a SEESafe

6. Click-stream data: Service Engineering **internet website** (2 years)

7. *Hospital: Rambam (Home) Hospital : **4 years, 1000 beds**, inter-ward patient flow

8. Hospital: **Emergency Departments** (ED) patient flow
- 5 EDs in Israel: 1-2 years, **late David Sinreich**, ED arrivals & LOS
- ED in Seoul: 2 months, **K. Song-Hee & W. Cha**, pilot
- ED in Singapore: 2 years, pilot

9. RTLS (Real-Time Location System) **U.S. Ambulatory Hospital: Since November 2013**
- **250K events/day (1GB/week): 1000 patients, 300-400 staff (1500 tagged entities), every 3 sec's**
- Infrastructure: **900 readers (sensors) over ceilings of 7 (now 8) clinical floors**
- Both actual and planned (appointment book of resources: staff, patients, rooms)

10-13: Chat Services (Europe); ILBank Warehouse; Smart-City Simulator (Haifa, …); Courts (Israel)

***Open & Free for (reproducible) research and teaching**

Data-Collection Technologies (leaving aside Interfaces)

Operational histories (customers, servers) at the **individual-transaction level**, e.g.

1. **ACD: Bank Anonymous Call-Center: 1 year, 350K calls by 15 agents** (during 2000) – started all
2. **ACD + IVR: U.S. Bank Call-Center** : **2.5 years, 220M calls, 40M by 1000 agents**
3. **ACD:** Israeli Cellular Company: **2.5 years, 110M calls, 25M calls by 750 agents;**
4. **IVR + CRM** (SBR): ILBank (2 years)
5. **ACD:** Back to Bank Anonymous: **from January 2010,** daily-deposit at a SEESafe

6. Click-stream data: Service Engineering **internet website** (2 years)

7. **Hospital IS: Home (Rambam) Hospital : 4 years, 1000 beds, inter-ward patient flow**

8. **Hospital IS**: **Emergency Departments** (ED) patient flow
   - 5 EDs in Israel: 1-2 years, **late David Sinreich**, ED arrivals & LOS
   - ED in Seoul: 2 months, **K. Song-Hee & W. Cha**, pilot
   - ED in Singapore: 2 years, pilot

9. **RTLS (Real-Time Location System) U.S. Ambulatory Hospital: Since November 2013**
   - **250K events/day (1GB/week): 1000 patients, 300-400 staff (1500 tagged entities), every 3 sec's**
   - Infrastructure: **900 readers (sensors) over ceilings of 7 (now 8) clinical floors**
   - Both actual and planned (appointment book of resources: staff, patients, rooms)

10-13: Chat Services (Europe); ILBank Warehouse; Smart-City Simulator (Haifa, …); Courts (Israel)

SEELab History:

Shapes the Present and Informs (Enhances & Constrains) the Future

Started with Call Centers, then Hospitals, …

Data originates in Service Event-Log files:

Operational histories (event time stamps), of both customers & service providers, at the level of the individual transaction

What defines a call center, back office ...

global AI industry Financial Times ...

Pinterest

Admission Essays Service - Smart ...

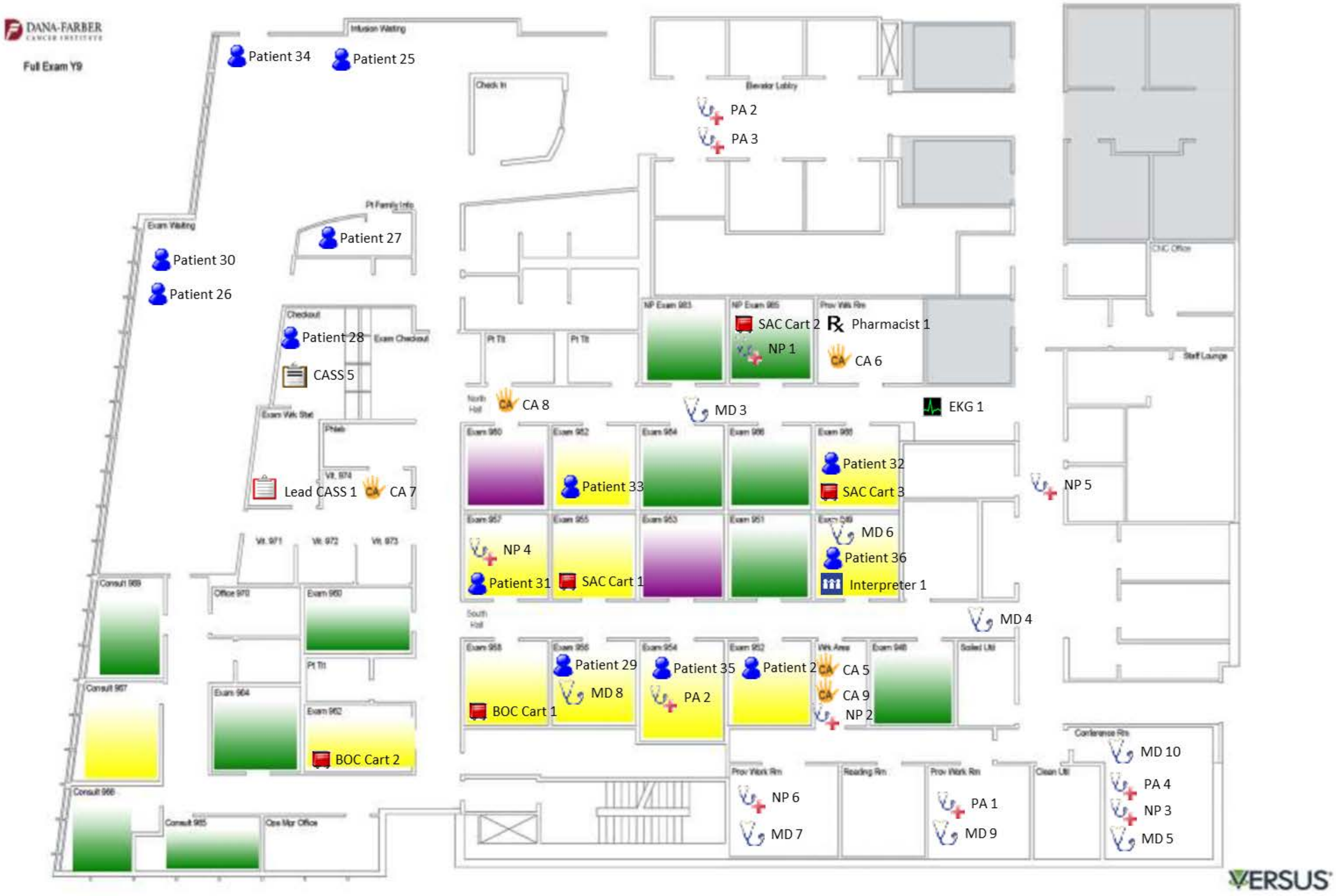
“Courage & Strength” from Call-Centers = Fruit-Flies of Hospitals

Call Center: Call Center Environment

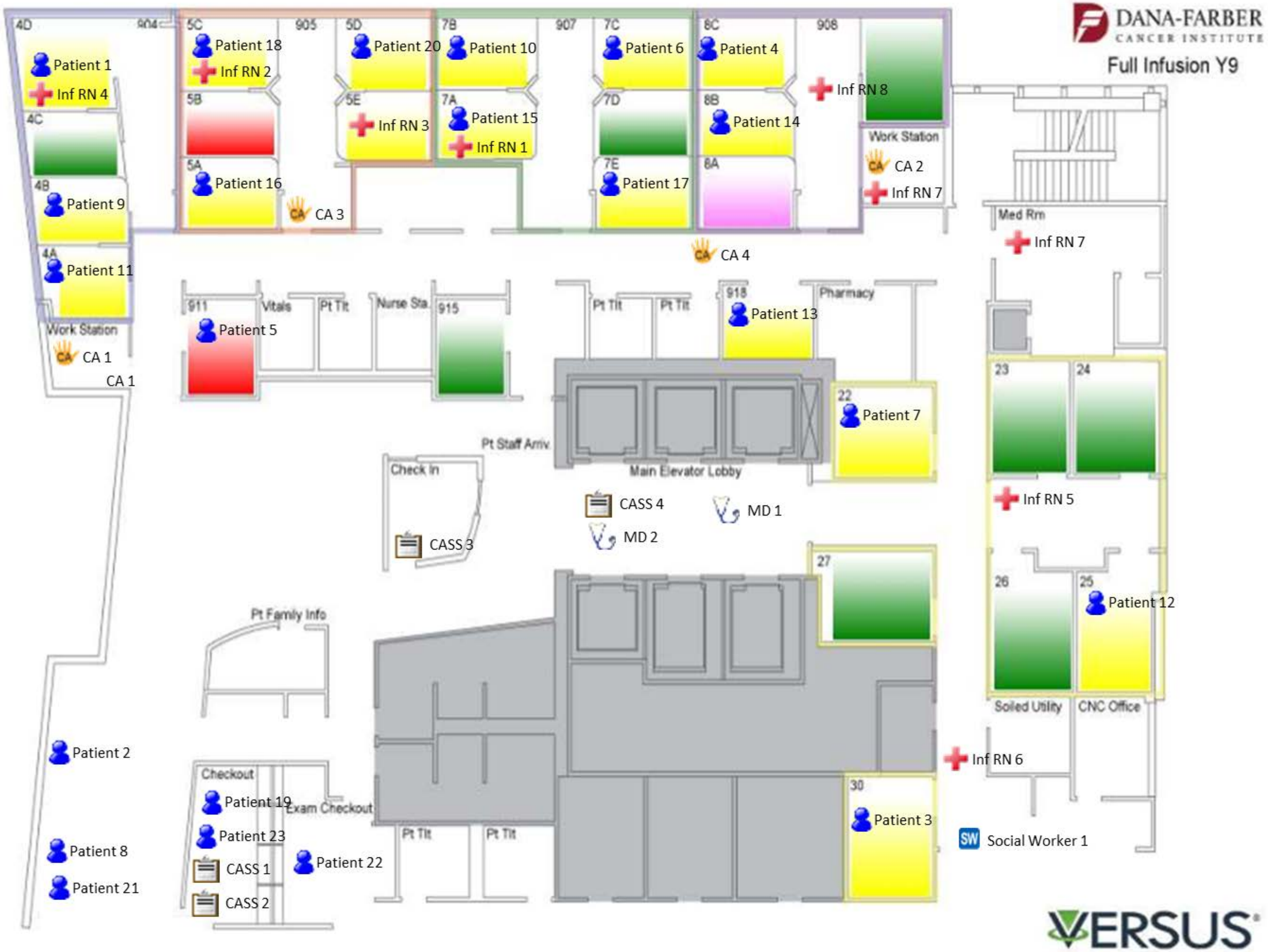
Tech 911 Headquarters - Event Sponsor ...

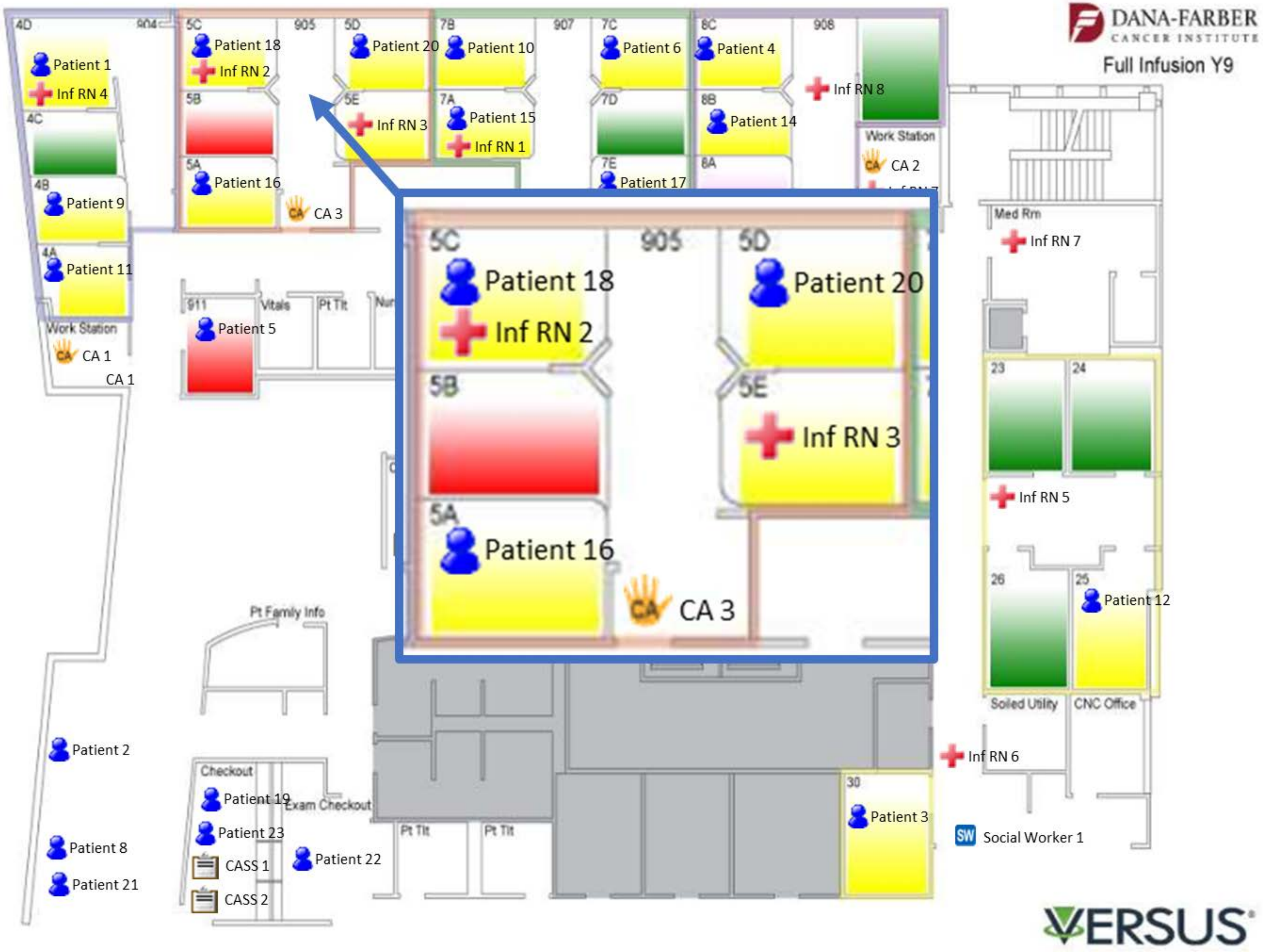
Isometric Call Center Office Royalty ...

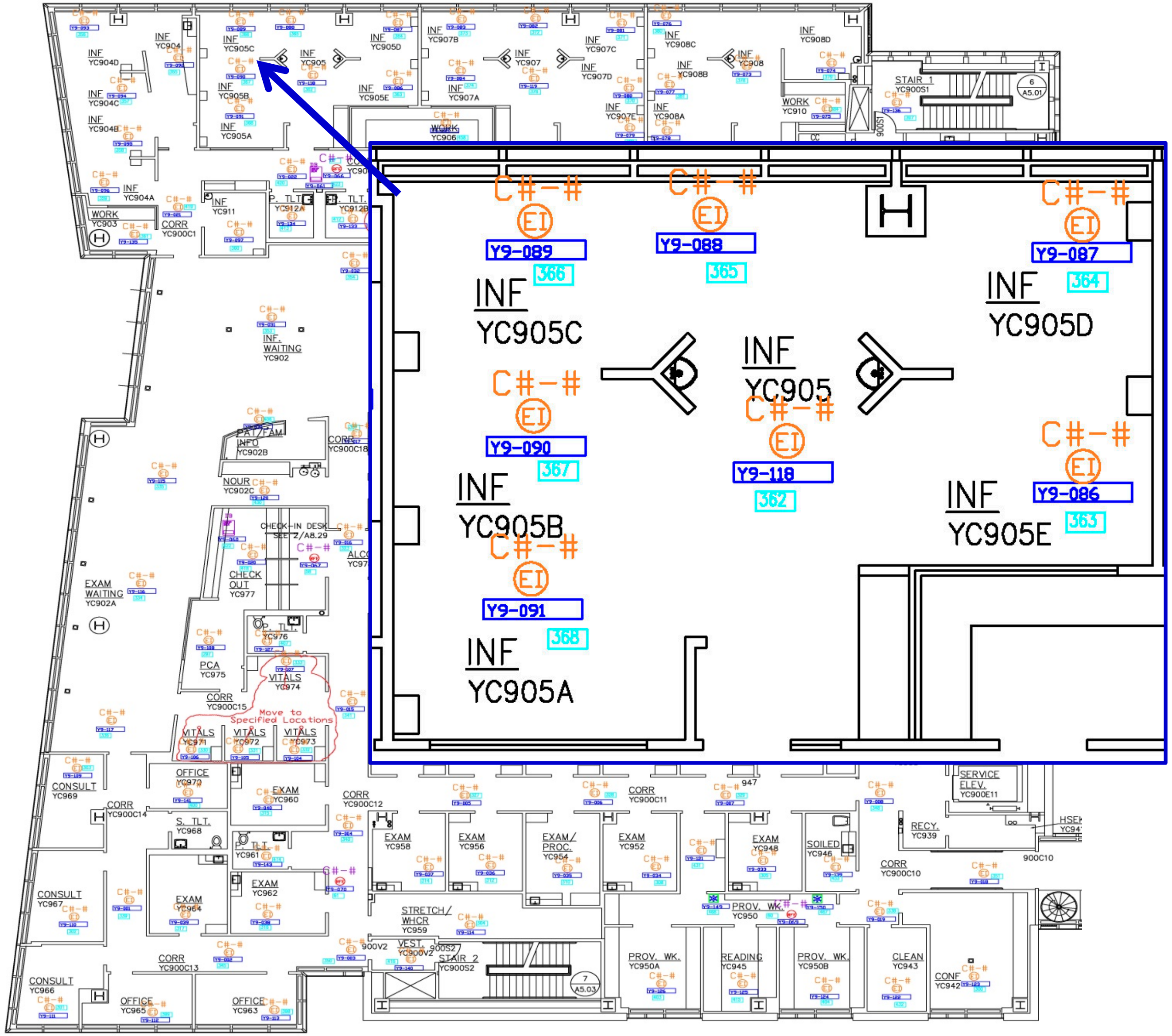
Company Business News Latest Indian ...



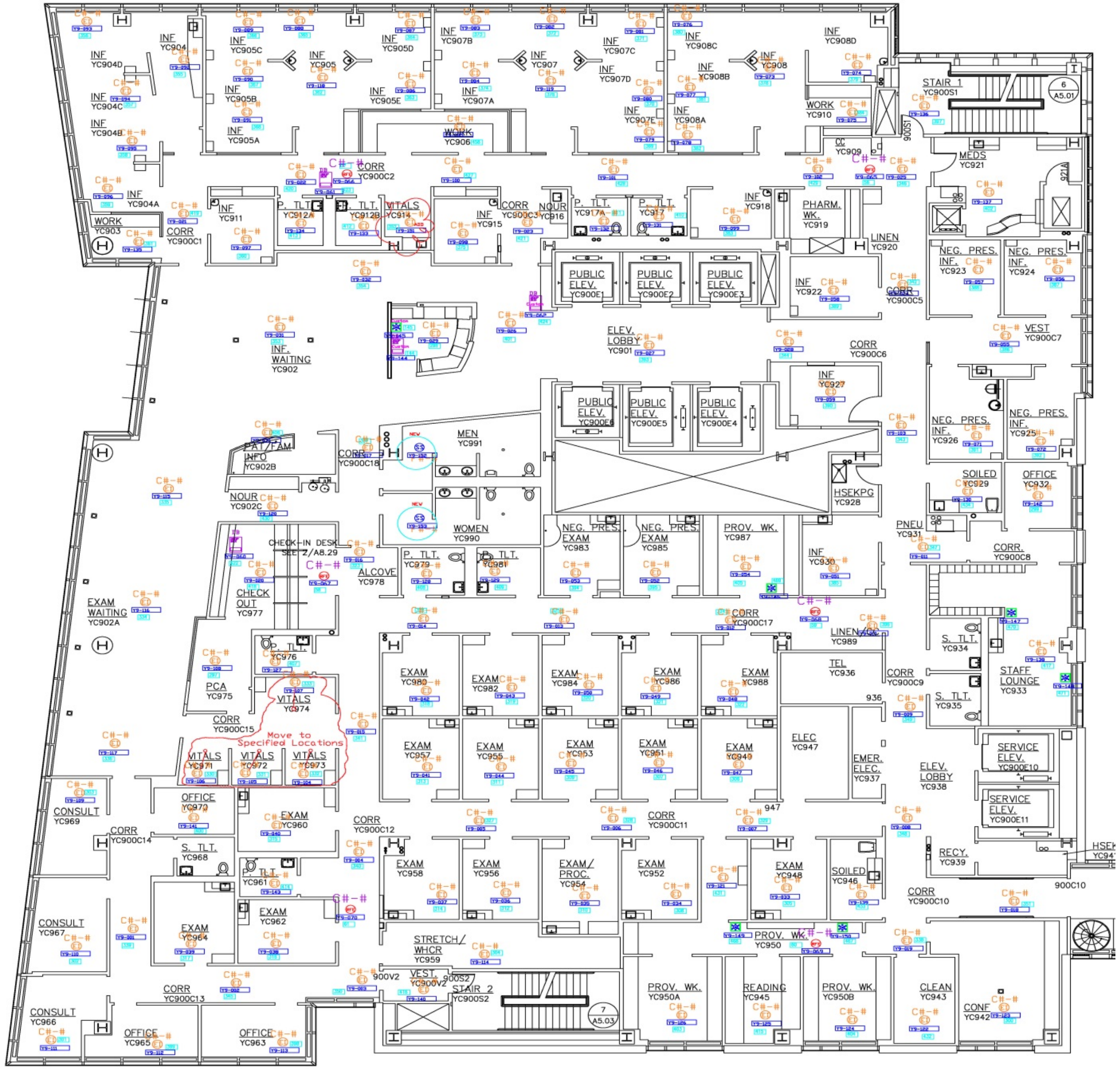
DANA-FARBER CANCER INSTITUTE
Full Exam Y9
Patient 34
Patient 25
Patient 30
Patient 26
Patient 27
Patient 28
CASS 5
Lead CASS 1
CA 7
CA 8
PA 2
PA 3
SAC Cart 2
NP 1
Pharmacist 1
CA 6
MD 3
EKG 1
Patient 33
Patient 32
SAC Cart 3
NP 5
NP 4
Patient 31
SAC Cart 1
MD 6
Patient 36
Interpreter 1
MD 4
BOC Cart 1
Patient 29
MD 8
Patient 35
PA 2
Patient 2
CA 5
CA 9
NP 2
BOC Cart 2
MD 10
PA 4
NP 3
MD 5
NP 6
MD 7
PA 1
MD 9
VERSUS


DANA-FARBER CANCER INSTITUTE
Full Infusion Y9
4D
904
5C
905
5D
7B
907
7C
8C
908
Patient 1
Inf RN 4
Patient 18
Inf RN 2
Patient 20
Patient 10
Patient 6
Patient 4
Inf RN 8
4C
5B
5E
Inf RN 3
7A
Patient 15
Inf RN 1
7D
8B
Patient 14
Work Station
CA 2
Inf RN 7
4B
Patient 9
5A
Patient 16
CA 3
7E
Patient 17
8A
Med Rm
Inf RN 7
4A
Patient 11
CA 4
Work Station
CA 1
CA 1
911
Vitals
Pt Tlt
Nurse Sta.
915
Patient 5
Pt Tlt
Pt Tlt
918
Patient 13
Pharmacy
23
24
22
Patient 7
Pt Staff Arriv.
Check In
Main Elevator Lobby
CASS 4
MD 1
MD 2
CASS 3
Inf RN 5
27
26
25
Patient 12
Pt Family Info
Soiled Utility
CNC Office
Patient 2
Inf RN 6
Checkout
Patient 19
Exam Checkout
Pt Tlt
Pt Tlt
30
Patient 3
Patient 23
Social Worker 1
Patient 8
CASS 1
Patient 22
Patient 21
CASS 2
VERSUS


DANA-FARBER CANCER INSTITUTE
Full Infusion Y9
4D
904
Patient 1
Inf RN 4
4C
4B
Patient 9
4A
Patient 11
Work Station
CA 1
CA 1
5C
Patient 18
Inf RN 2
5B
5A
Patient 16
CA 3
905
5D
Patient 20
5E
Inf RN 3
7B
Patient 10
7A
Patient 15
Inf RN 1
907
7C
Patient 6
7D
7E
Patient 17
8C
Patient 4
8B
Patient 14
8A
908
Inf RN 8
Work Station
CA 2
Med Rm
Inf RN 7
911
Vitals
Pt Tlt
Patient 5
23
24
Inf RN 5
26
25
Patient 12
Soiled Utility
CNC Office
Pt Family Info
Patient 2
Checkout
Patient 19
Exam Checkout
Patient 23
CASS 1
CASS 2
Patient 22
Patient 8
Patient 21
Pt Tlt
Pt Tlt
30
Patient 3
Inf RN 6
Social Worker 1
VERSUS

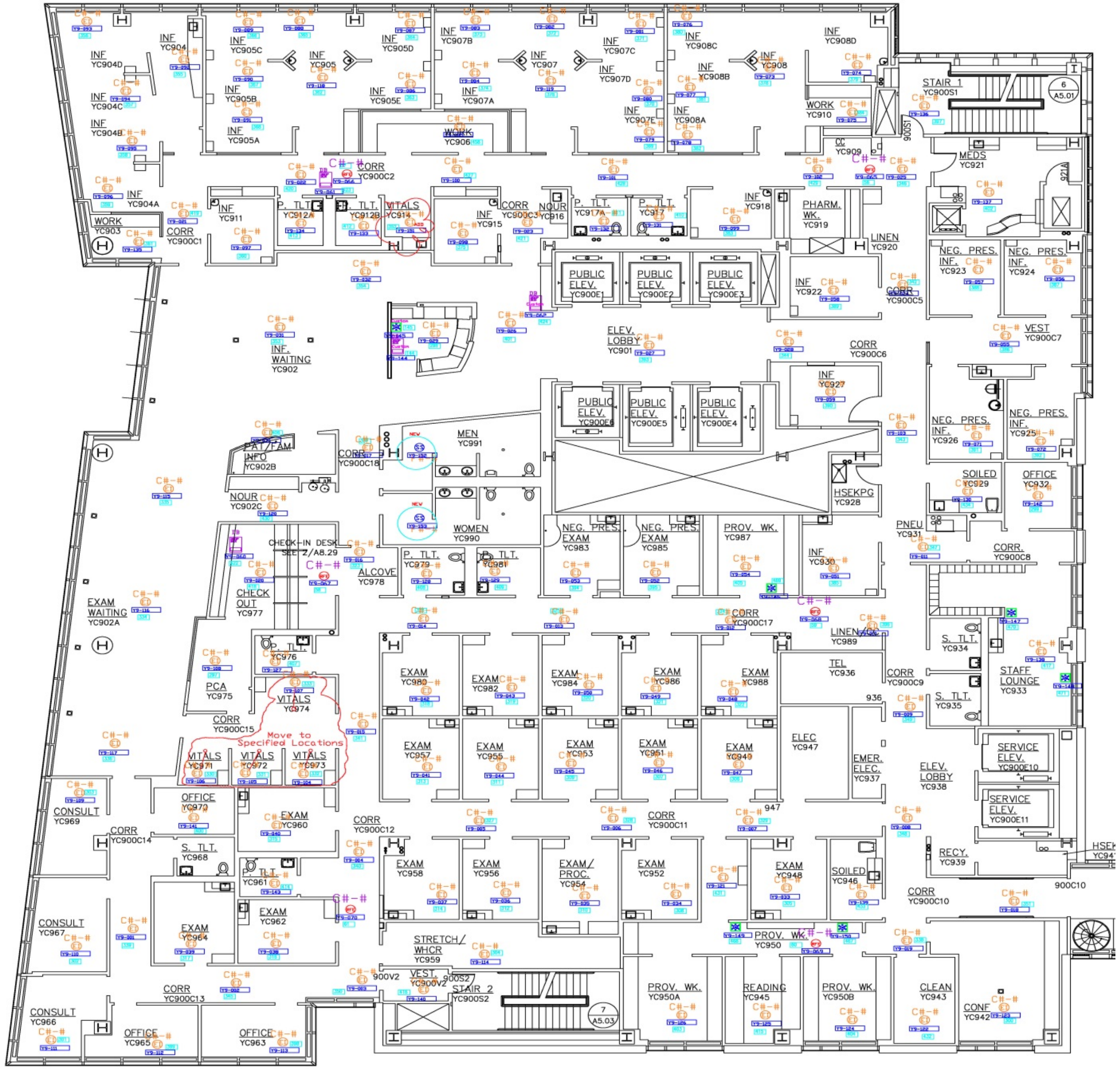

C#-#
EI
Y9-089
366
Y9-088
365
Y9-087
364
INF
YC905C
INF
YC905D
INF
YC905
Y9-090
367
Y9-118
362
Y9-086
363
INF
YC905B
INF
YC905E
Y9-091
368
INF
YC905A
Move to Specified Locations

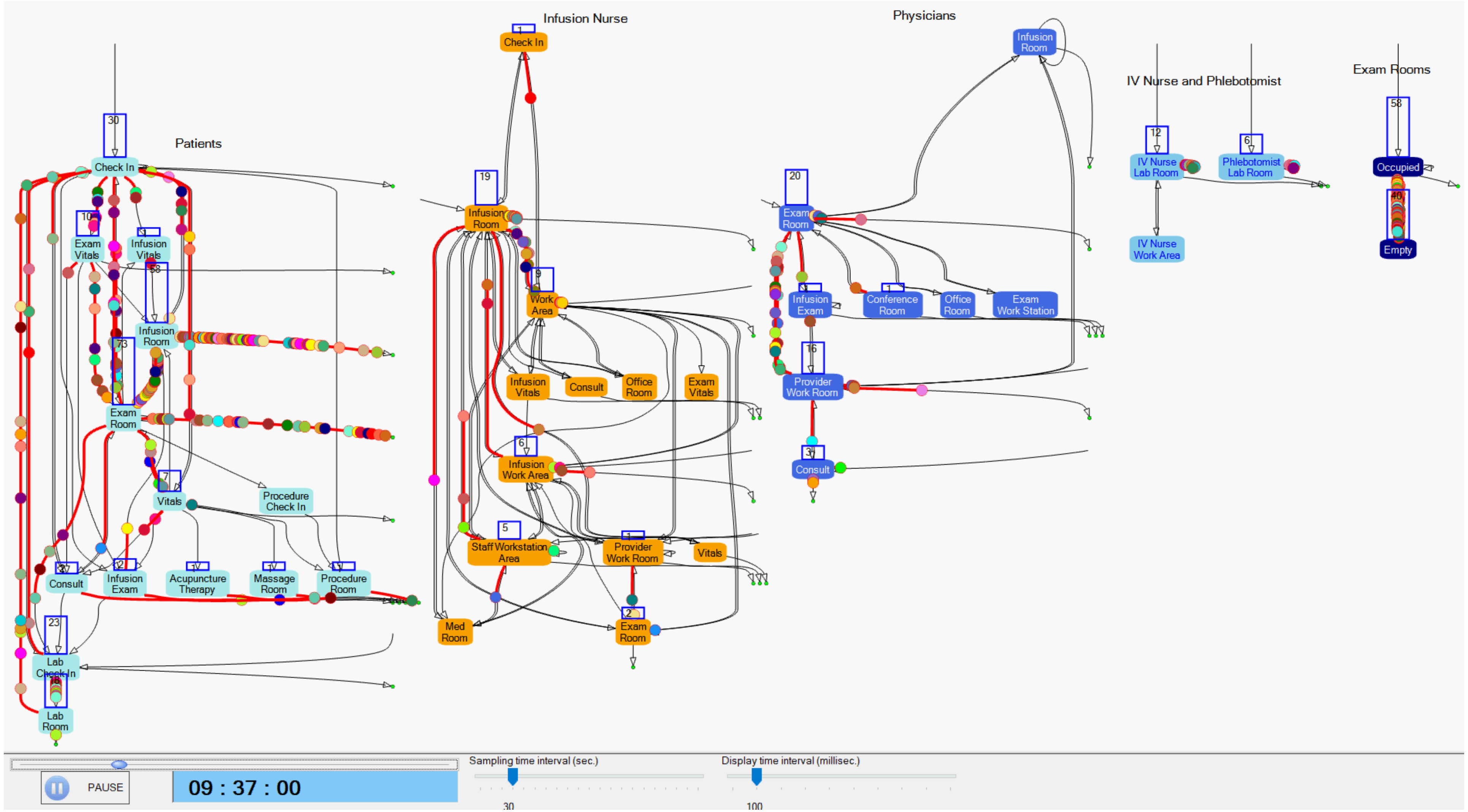
900 RTLS sensors
Location every 3 seconds
1GB per week
Since November 2013

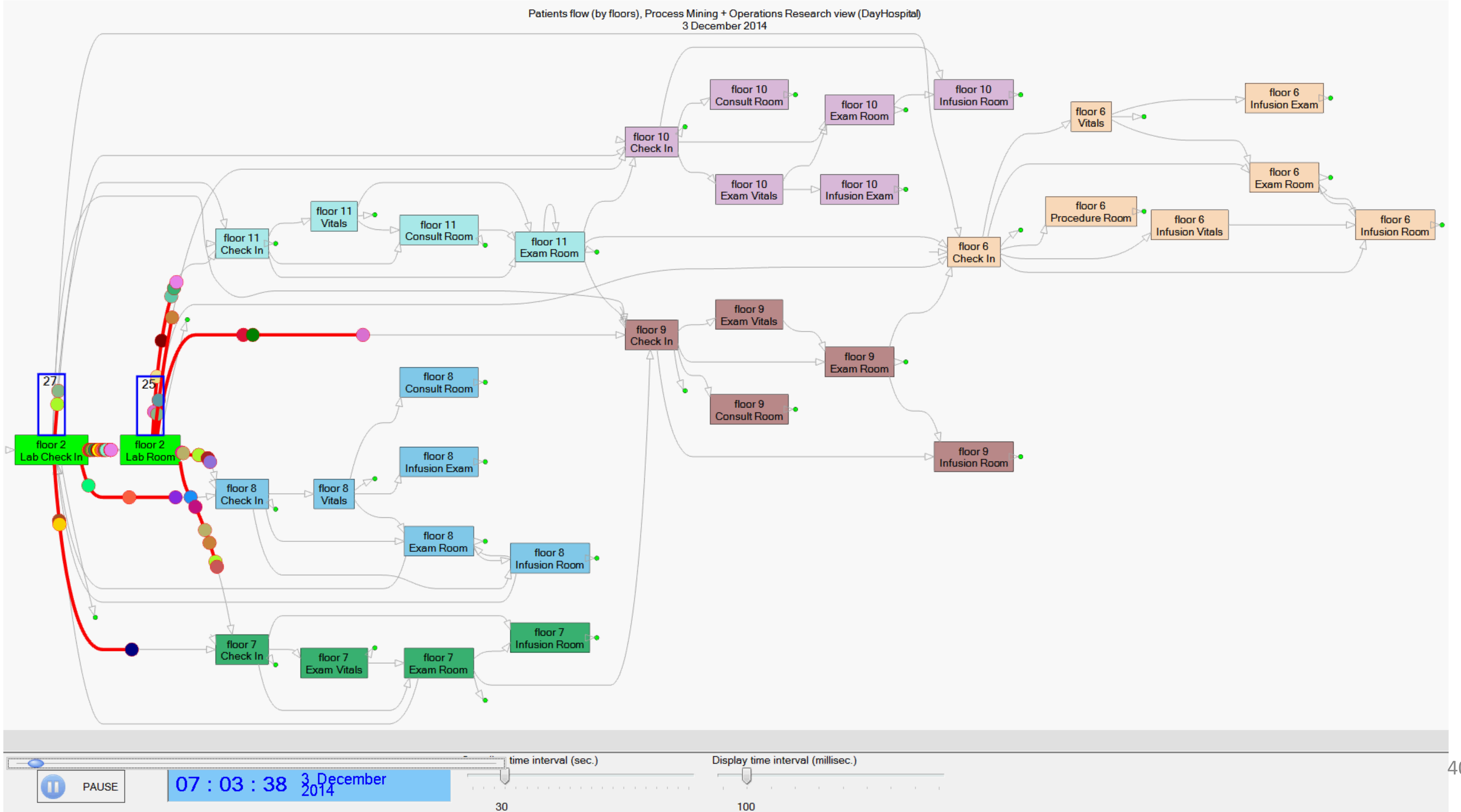


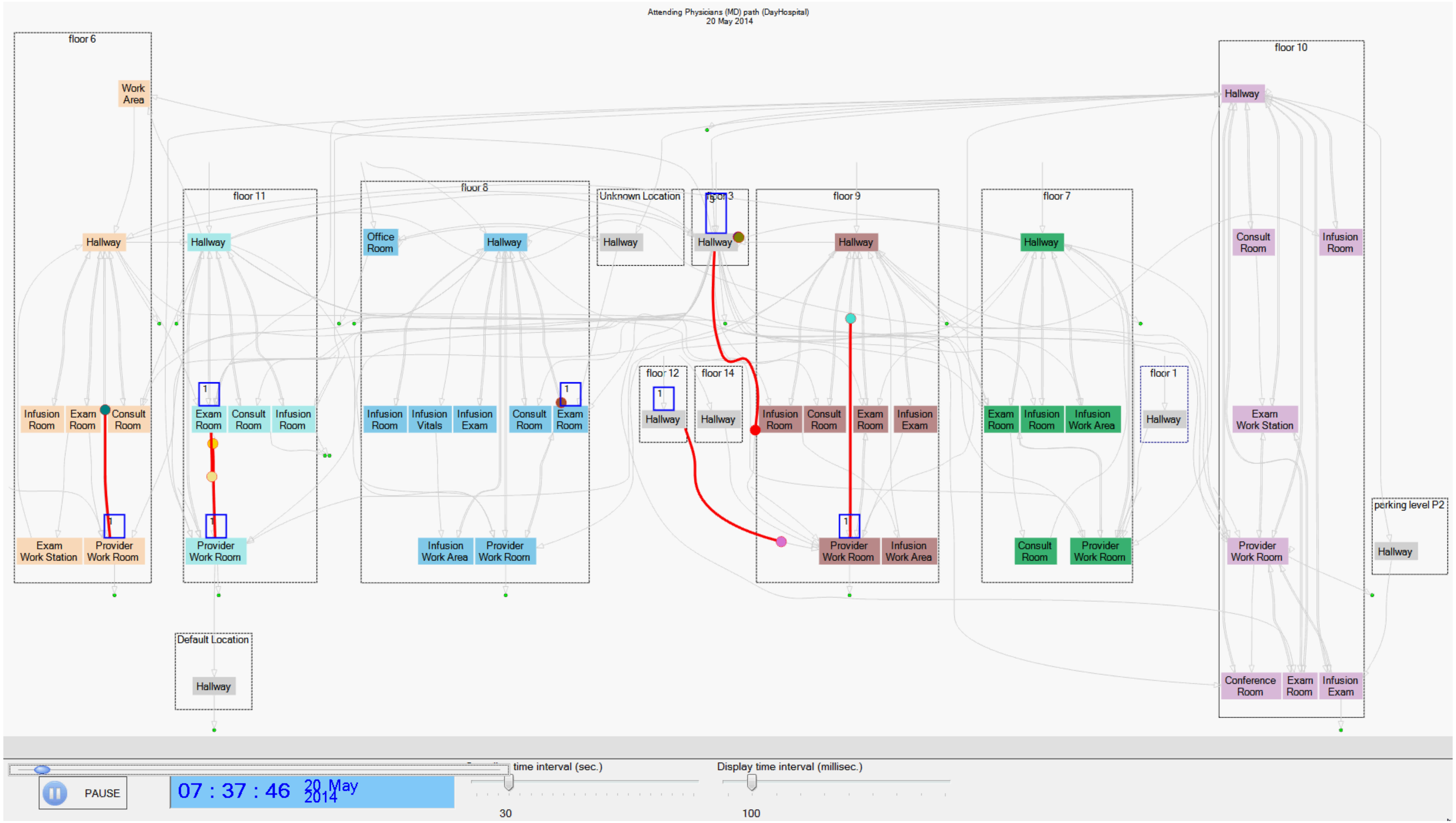
900 RTLS sensors
Location every 3 seconds
1GB per week
Since November 2013

900-1000 patients per day
300-400 doctors & nurses
8 clinical floors

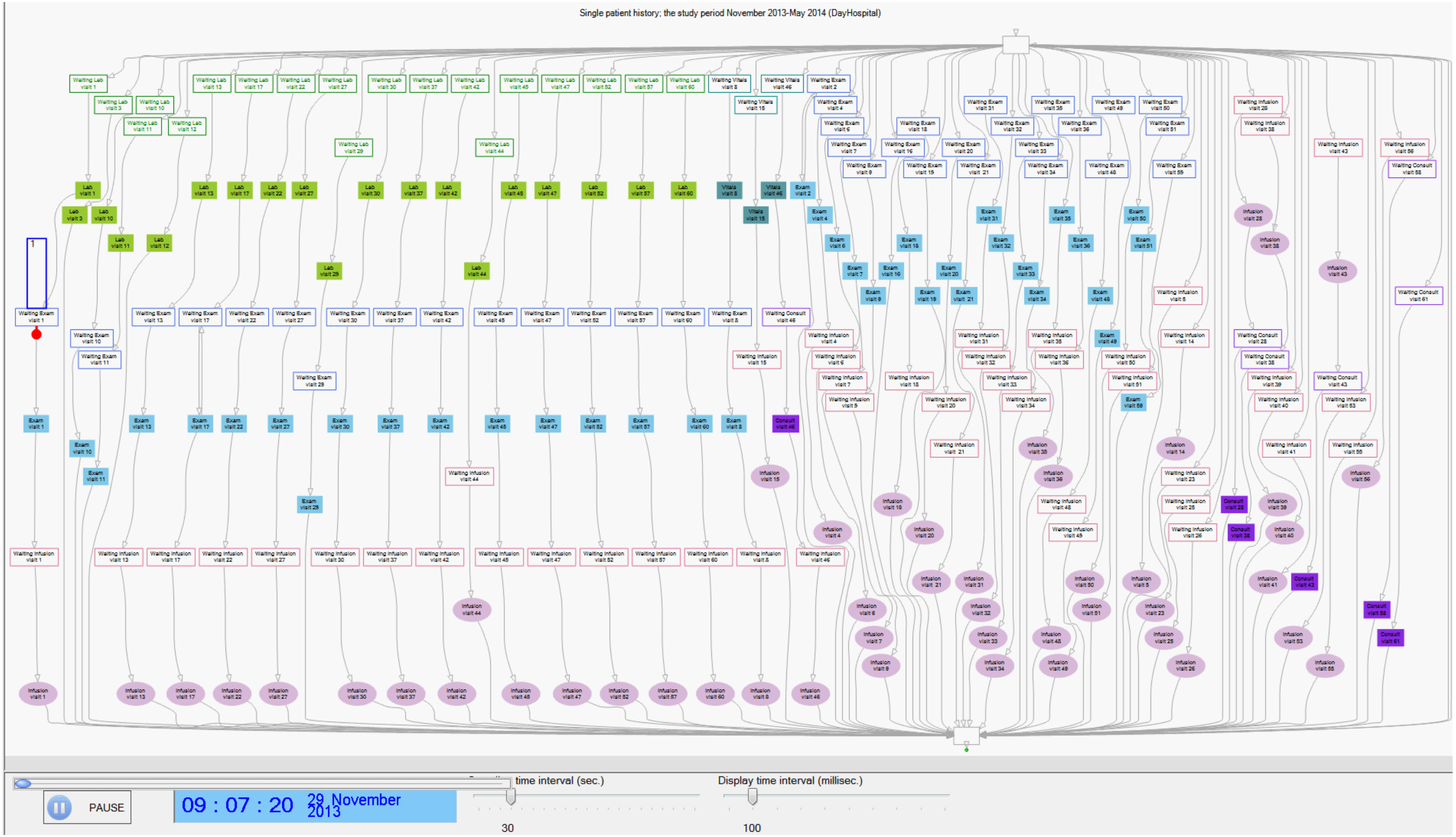



Patients
Check In
Exam Vitals
Infusion Vitals
Infusion Room
Exam Room
Vitals
Procedure Check In
Consult
Infusion Exam
Acupuncture Therapy
Massage Room
Procedure Room
Lab Check In
Lab Room
Infusion Nurse
Check In
Infusion Room
Work Area
Infusion Vitals
Consult
Office Room
Exam Vitals
Infusion Work Area
Staff Workstation Area
Provider Work Room
Vitals
Med Room
Exam Room
Physicians
Infusion Room
Exam Room
Infusion Exam
Conference Room
Office Room
Exam Work Station
Provider Work Room
Consult
IV Nurse and Phlebotomist
IV Nurse Lab Room
Phlebotomist Lab Room
IV Nurse Work Area
Exam Rooms
Occupied
Empty
PAUSE
09 : 37 : 00
Sampling time interval (sec.)
30
Display time interval (millisec.)
100


Patients flow (by floors), Process Mining + Operations Research view (DayHospital)
3 December 2014
floor 2 Lab Check In
floor 2 Lab Room
27
25
floor 11 Check In
floor 11 Vitals
floor 11 Consult Room
floor 11 Exam Room
floor 10 Check In
floor 10 Consult Room
floor 10 Exam Room
floor 10 Infusion Room
floor 10 Exam Vitals
floor 10 Infusion Exam
floor 9 Check In
floor 9 Exam Vitals
floor 9 Exam Room
floor 9 Consult Room
floor 9 Infusion Room
floor 8 Check In
floor 8 Vitals
floor 8 Consult Room
floor 8 Infusion Exam
floor 8 Exam Room
floor 8 Infusion Room
floor 7 Check In
floor 7 Exam Vitals
floor 7 Exam Room
floor 7 Infusion Room
floor 6 Check In
floor 6 Vitals
floor 6 Infusion Exam
floor 6 Exam Room
floor 6 Procedure Room
floor 6 Infusion Vitals
floor 6 Infusion Room
PAUSE
07 : 03 : 38
3 December 2014
time interval (sec.)
30
Display time interval (millisec.)
100

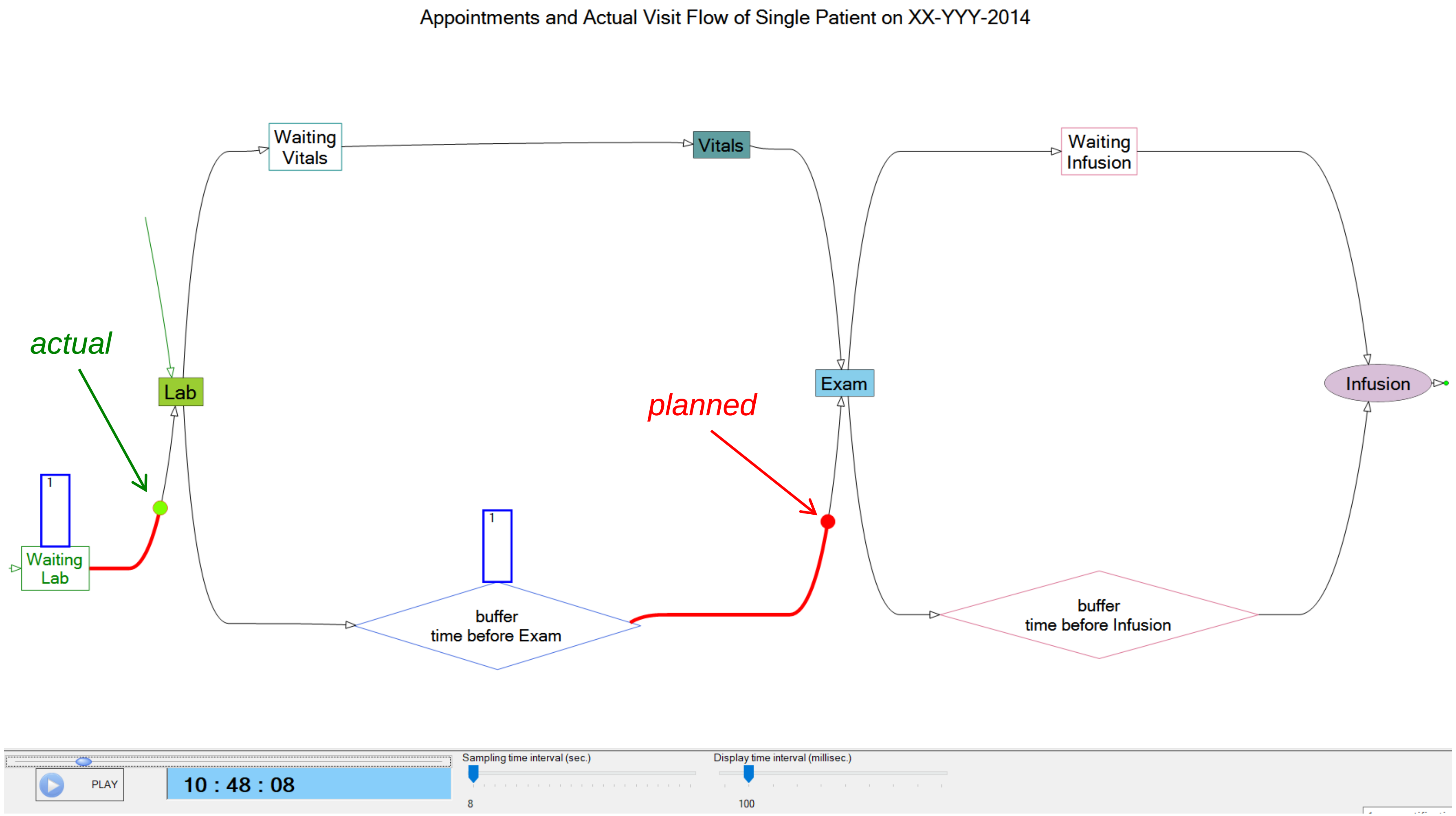


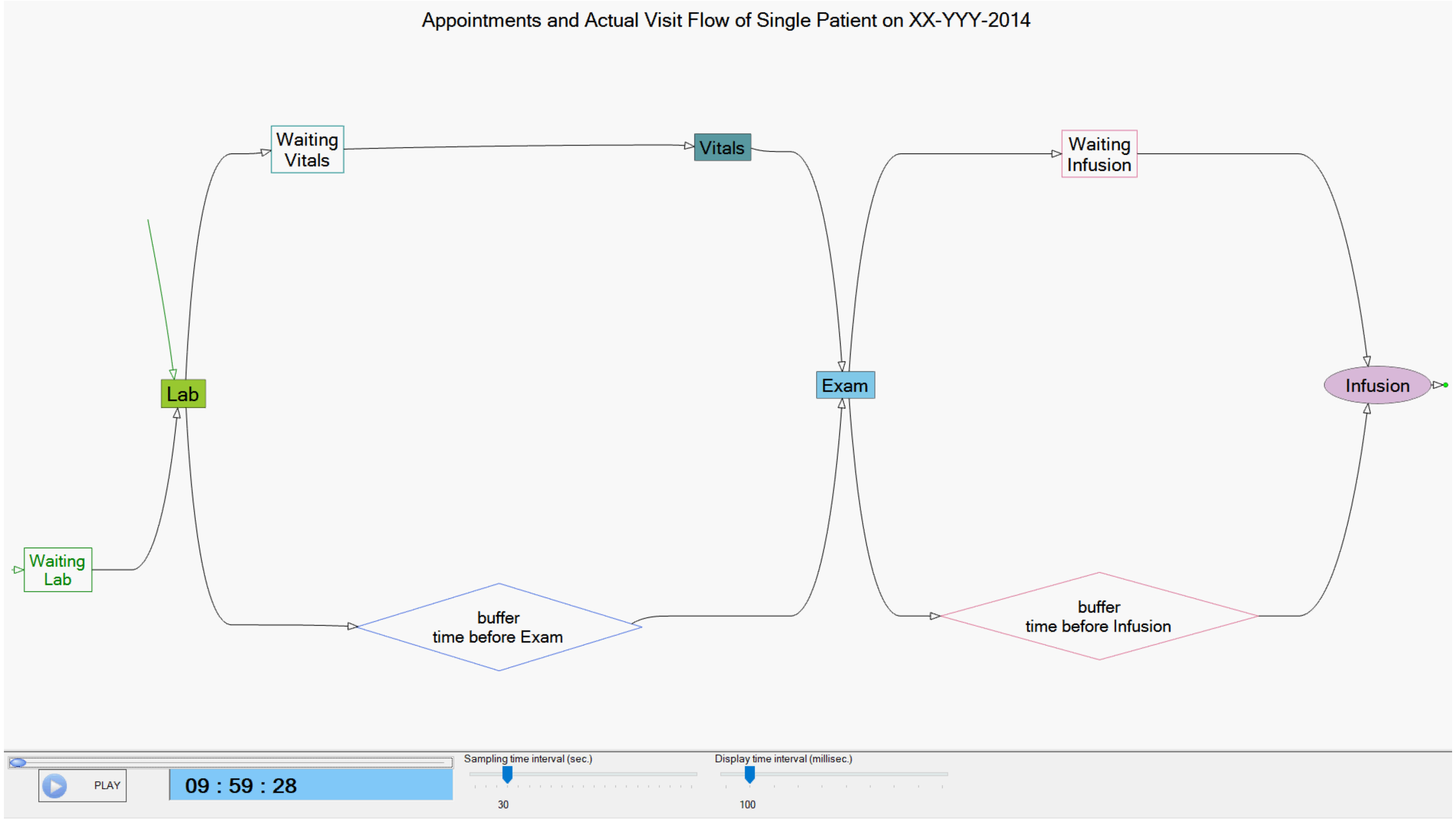
Attending Physicians (MD) path (DayHospital)
20 May 2014
floor 6
Work Area
Hallway
Infusion Room
Exam Room
Consult Room
Exam Work Station
Provider Work Room
floor 11
Hallway
Exam Room
Consult Room
Infusion Room
Provider Work Room
floor 8
Office Room
Hallway
Infusion Room
Infusion Vitals
Infusion Exam
Consult Room
Exam Room
Infusion Work Area
Provider Work Room
Unknown Location
Hallway
floor 3
Hallway
floor 12
Hallway
floor 14
Hallway
floor 9
Hallway
Infusion Room
Consult Room
Exam Room
Infusion Exam
Provider Work Room
Infusion Work Area
floor 7
Hallway
Exam Room
Infusion Room
Infusion Work Area
Consult Room
Provider Work Room
floor 1
Hallway
floor 10
Hallway
Consult Room
Infusion Room
Exam Work Station
Provider Work Room
Conference Room
Exam Room
Infusion Exam
parking level P2
Hallway
Default Location
Hallway
PAUSE
07 : 37 : 46
20 May 2014
time interval (sec.)
30
Display time interval (millisec.)
100

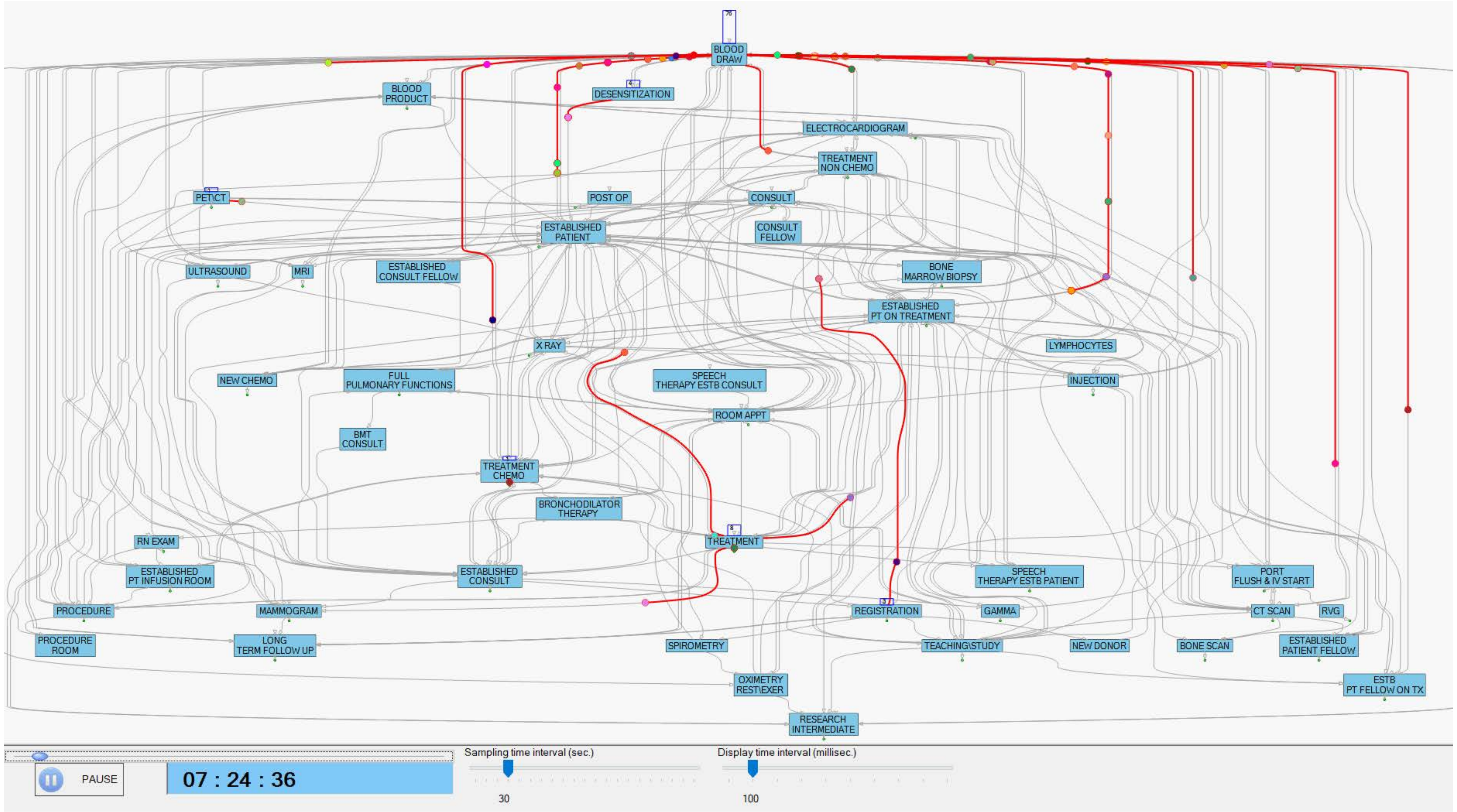

Single patient history; the study period November 2013-May 2014 (DayHospital)
PAUSE
09 : 07 : 20
29 November
2013
time interval (sec.)
30
Display time interval (millisec.)
100

Appointment-Net vs. Actual-Net

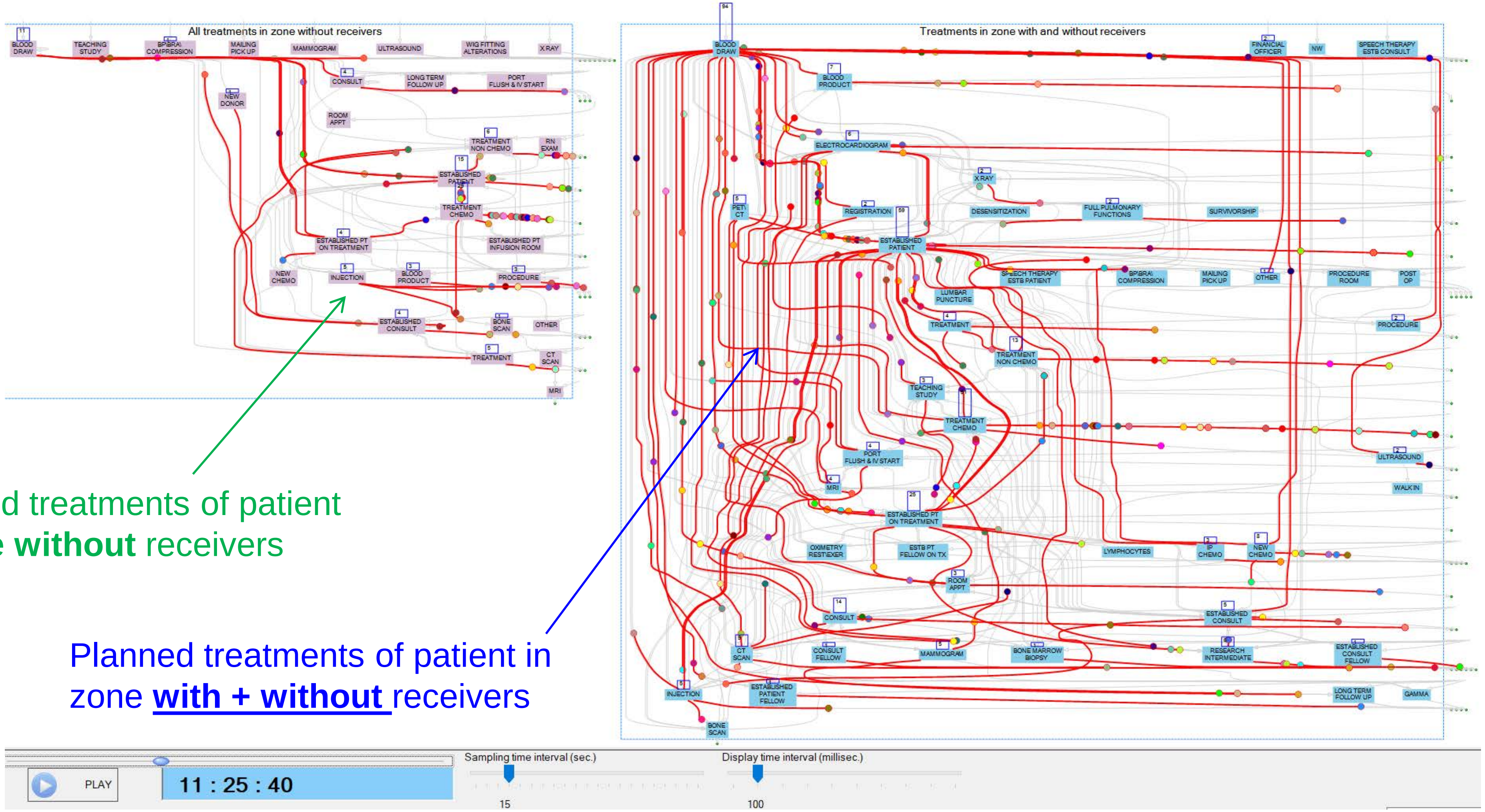
Single Patient




Appointments and Actual Visit Flow of Single Patient on XX-YYY-2014
Waiting Vitals
Vitals
Waiting Infusion
Lab
Exam
Infusion
Waiting Lab
buffer
time before Exam
buffer
time before Infusion
Sampling time interval (sec.)
Display time interval (millisec.)
PLAY
09 : 59 : 28
30
100

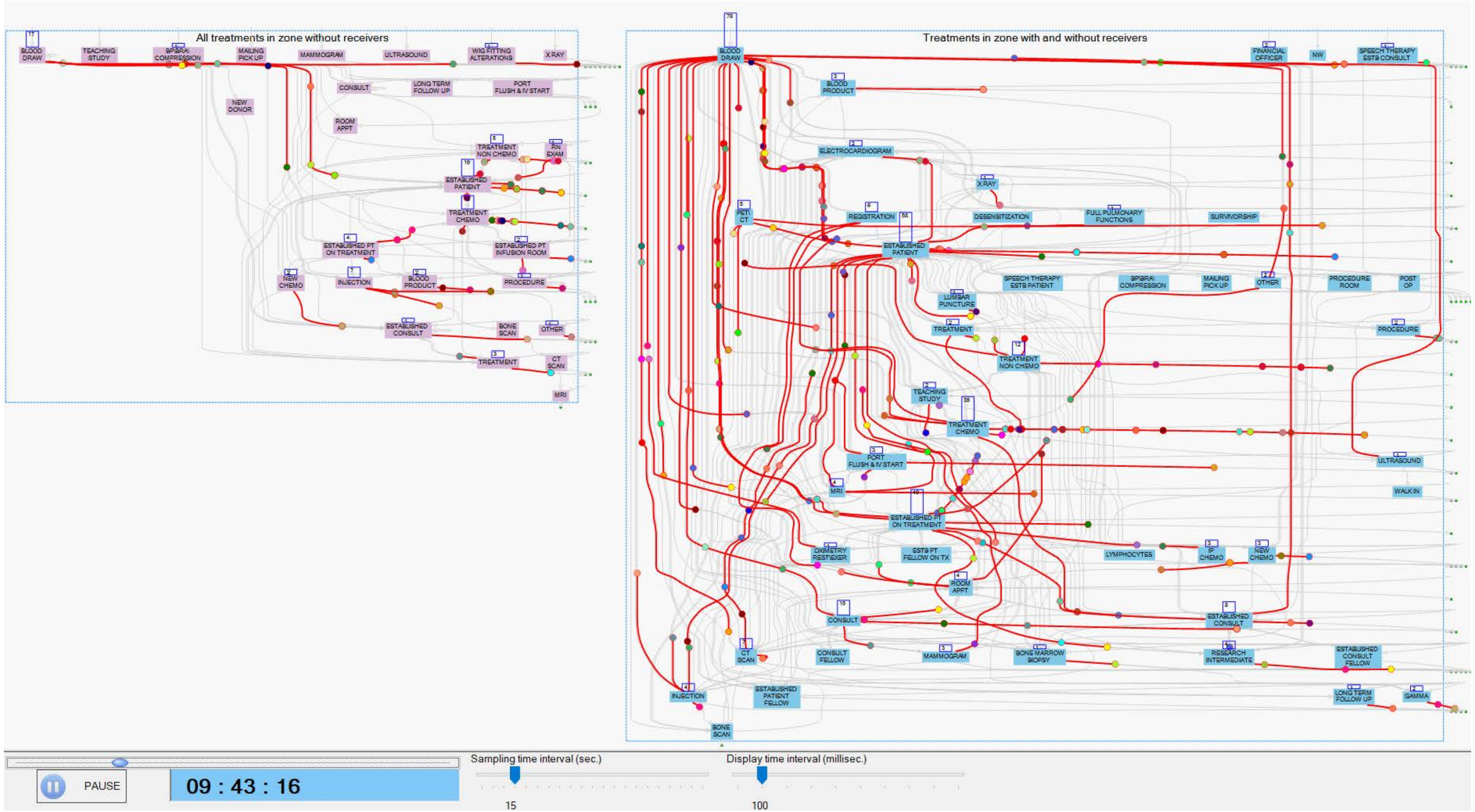

BLOOD DRAW
BLOOD PRODUCT
DESENSITIZATION
ELECTROCARDIOGRAM
TREATMENT NON CHEMO
PET\CT
POST OP
CONSULT
ESTABLISHED PATIENT
CONSULT FELLOW
ULTRASOUND
MRI
ESTABLISHED CONSULT FELLOW
BONE MARROW BIOPSY
ESTABLISHED PT ON TREATMENT
X RAY
LYMPHOCYTES
NEW CHEMO
FULL PULMONARY FUNCTIONS
SPEECH THERAPY ESTB CONSULT
INJECTION
ROOM APPT
BMT CONSULT
TREATMENT CHEMO
BRONCHODILATOR THERAPY
RN EXAM
TREATMENT
ESTABLISHED PT INFUSION ROOM
ESTABLISHED CONSULT
SPEECH THERAPY ESTB PATIENT
PORT FLUSH & IV START
PROCEDURE
MAMMOGRAM
REGISTRATION
GAMMA
CT SCAN
RVG
PROCEDURE ROOM
LONG TERM FOLLOW UP
SPIROMETRY
TEACHING\STUDY
NEW DONOR
BONE SCAN
ESTABLISHED PATIENT FELLOW
OXIMETRY REST\EXER
ESTB PT FELLOW ON TX
RESEARCH INTERMEDIATE
PAUSE
07 : 24 : 36
Sampling time interval (sec.)
30
Display time interval (millisec.)
100

Processes in zones with and without receivers (Appointments)



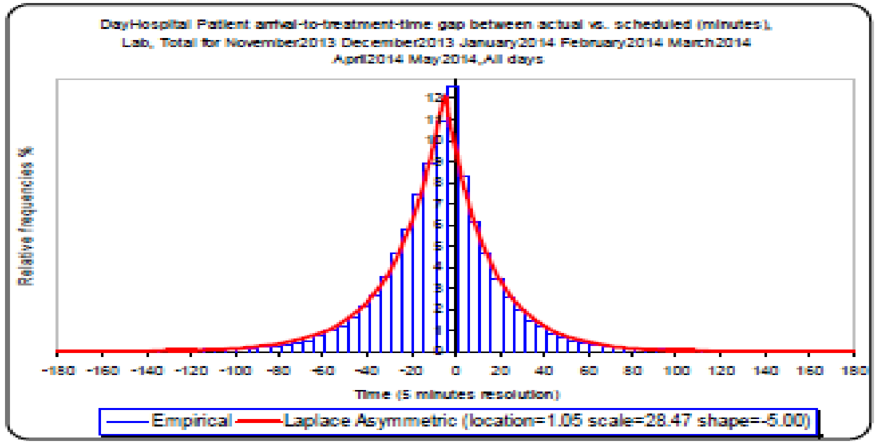
Planned treatments of patient
in zone **without** receivers

Planned treatments of patient in
zone **with + without** receivers

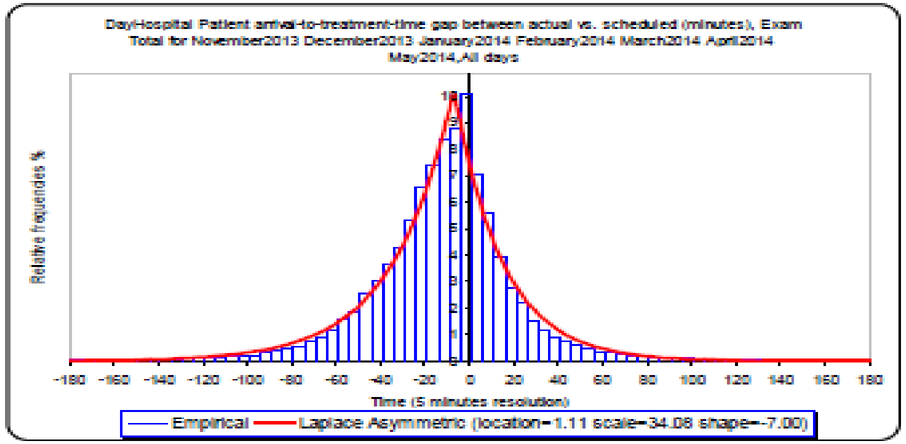

All treatments in zone without receivers
Treatments in zone with and without receivers
PAUSE
09 : 43 : 16
Sampling time interval (sec.)
15
Display time interval (millisec.)
100

Primitives: Punctuality
Planned vs. Actual Arrival to Service
@ Stations 1, 2, 3 in a Hospital

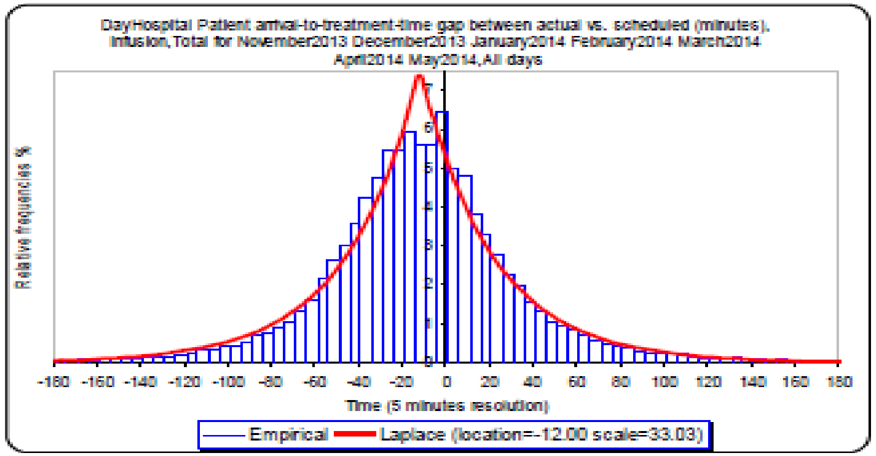
Lab (mean = -7 min)



Exam (mean = -12 min)



Infusion (mean = -12 min)



Technion SEE Center Service Enterprise Engineering

Applications in DFCI, ...

Control: rooms status, physicians location, long wait times

Planning: number infusion chairs, load-balancing among floors

Management: evidence-based (e.g. room for physician vs. for patient)

Applications in DFCI, **...**

Control: rooms status, physicians location, long wait times

Planning: number infusion chairs, load-balancing among floors

Management: evidence-based (e.g. room for physician vs. for patient)

and

- **Appointment Systems**: 30% cost reduction ⇨ planned pilot
- **Time & Motion Studies** (IE of the 21st century): cost of care
- **Mining Social Networks**: relate to outcomes (treatment, learning)
- **Prediction**: “waze” (times on a given care-path, predict path)
- …

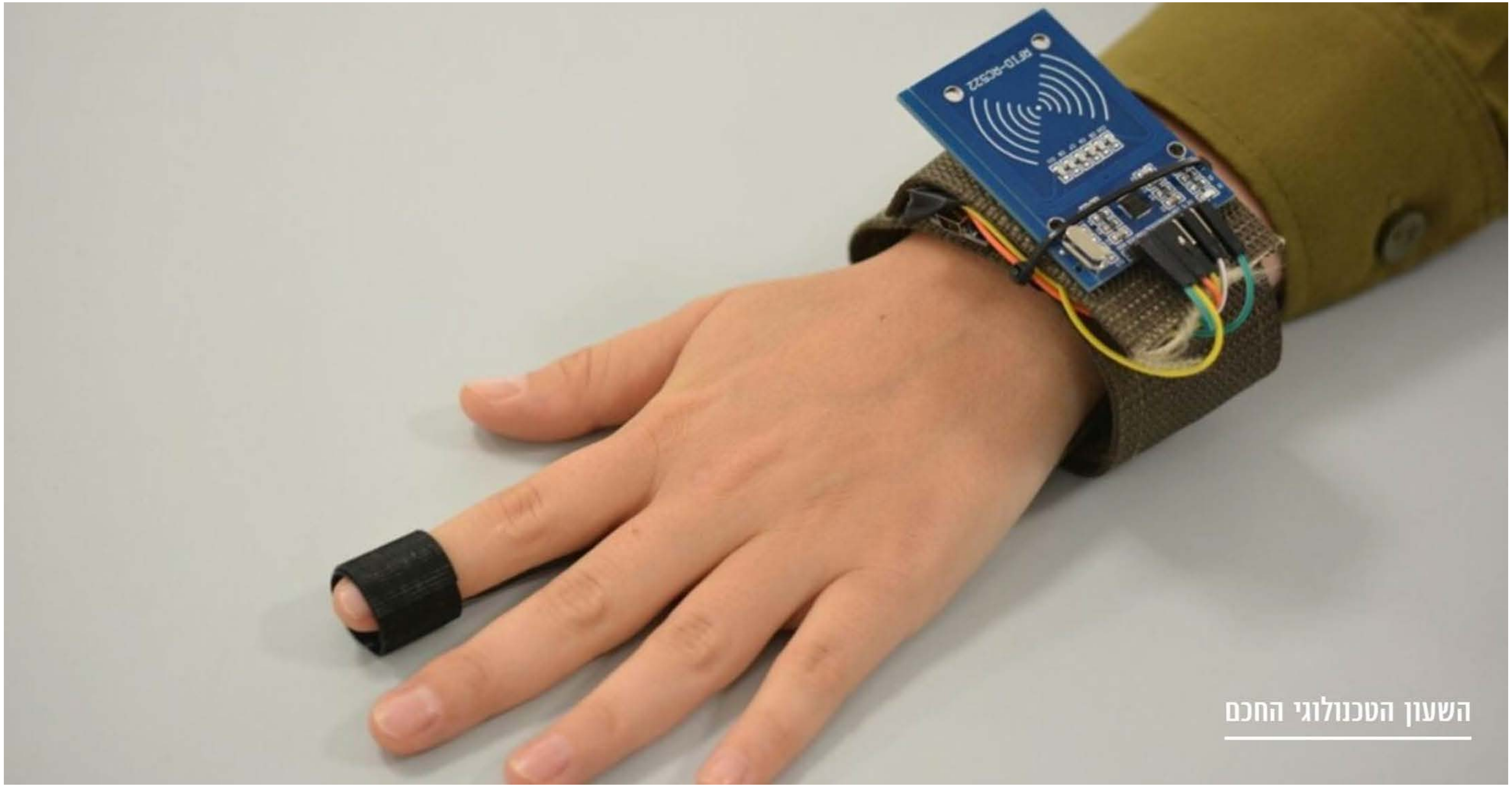
(How) Will RTLS transform healthcare delivery (research) ?

- Healthcare delivery must and is due to undergo transformational changes
- “RTLS+**DFCI**” is a prerequisite for such a transformation

Around the corner:

- RTLS**+**, via wearable personalized sensors (active smartphones): Operational, physical and physiologic tracking.
- This will empower people, both healthy or not (e.g. chronic), to routinely conduct self-monitoring and self-care (e.g. full cycle of care).
- Data-based research-partnerships require Infrastructure (funding).
- Will empower researchers and organizations to develop and adopt novel models of delivery, world-wide (e.g. China).

Physiological Dimension: BioMarkers
MCE Smart Watch (Israeli Army)



Research: Infrastructure for Data Science (NSF Proposal 5/7/29, Itai Gurvich PI)

Hospitals, courts, public transportation generate … **vast amounts of operational data, at unprecedented resolution and quality**. Yet harnessing this data **for publishable, reproducible and scalable research** is an acknowledged and yet-to-be overcome **challenge**.

… develop **infrastructure – physical (a data lab), human (a research team) and scientific (scholarly knowledge)** – to advance **data-science for processing networks in general, and healthcare systems in particular.**

Research: Infrastructure for Data Science (NSF Proposal 5/7/29, Itai Gurvich PI)

Hospitals, courts, public transportation generate … **vast amounts of operational data, at unprecedented resolution and quality**. Yet harnessing this data **for publishable, reproducible and scalable research** is an acknowledged and yet-to-be overcome **challenge**.

… develop **infrastructure – physical (a data lab), human (a research team) and scientific (scholarly knowledge)** – to advance **data-science for processing networks in general, and healthcare systems in particular.**

… propose **blueprint for data-science labs**, …

Following the model of Technion SEELab and it partnership with DFCI

Research: Infrastructure for Data Science (NSF Proposal 5/7/29, Itai Gurvich PI)

Hospitals, courts, public transportation generate … **vast amounts of operational data, at unprecedented resolution and quality**. Yet harnessing this data **for publishable, reproducible and scalable research** is an acknowledged and yet-to-be overcome **challenge**.

… develop **infrastructure – physical (a data lab), human (a research team) and scientific (scholarly knowledge)** – to advance **data-science for processing networks in general, and healthcare systems in particular**

… propose **blueprint for data-science labs**, …

Following the model of Technion SEELab and it partnership with DFCI

Research challenge: Why has the DFCI+Technion partnership model been successful (personal, organizational & both)

The Technion SEE Center / Laboratory

Data-Based Service Science / Engineering

Technion
S.E.E
Center
Service Enterprise Engineering