



# Smart America Challenge Team: Closed Loop Healthcare: from home to hospital to home

Presented at  
Smart America Expo  
June 11, 2014  
Washington DC



SmartAmerica Closed Loop Healthcare Team  
Development & Demo at the MGH/MD PnP Lab, Cambridge, MA March 18-20 2014

# Closed Loop HealthCare Team: Home to Hospital to Home

## Expo Participants



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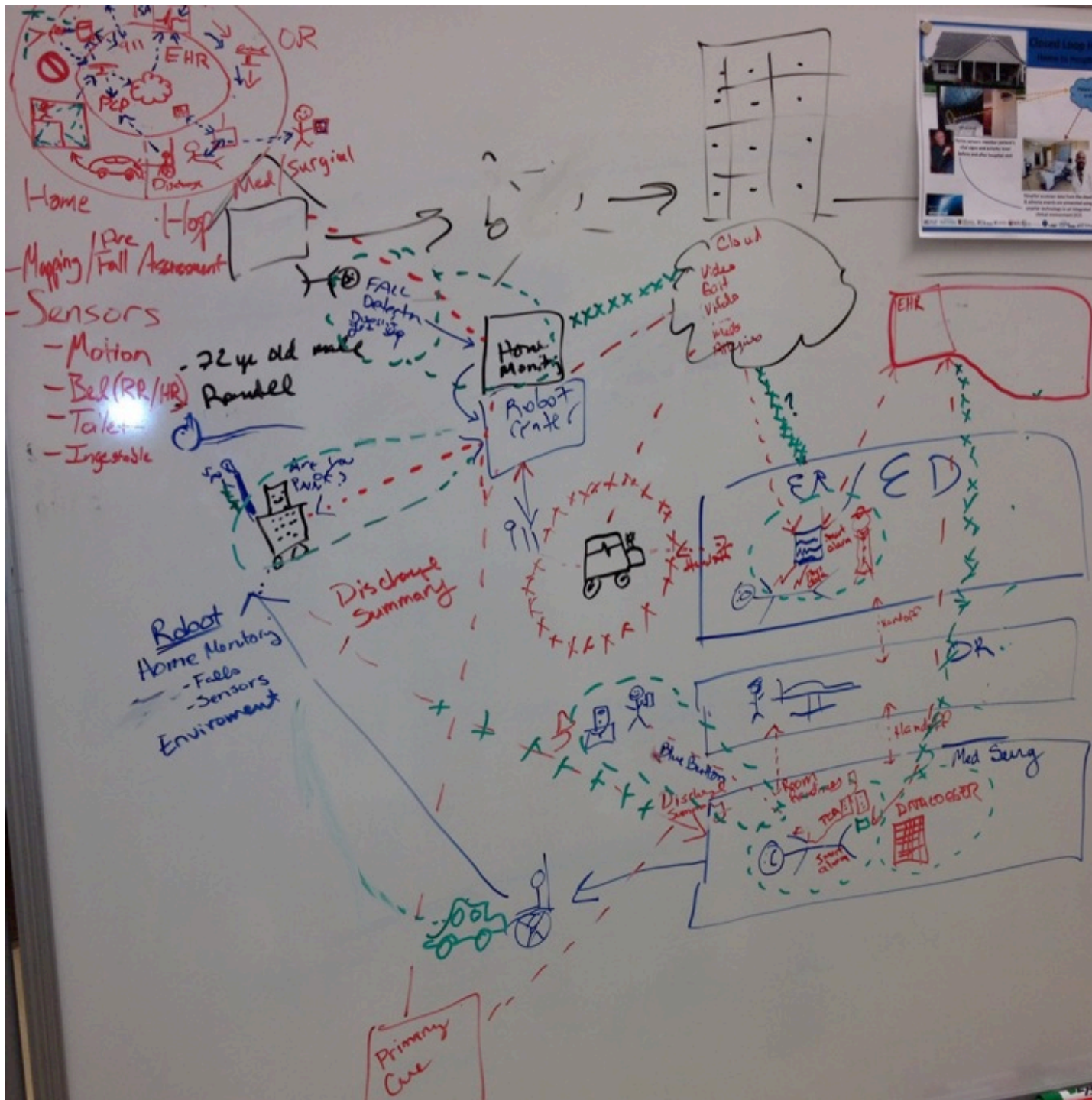




## Closed Loop HealthCare Team Geographic Distribution



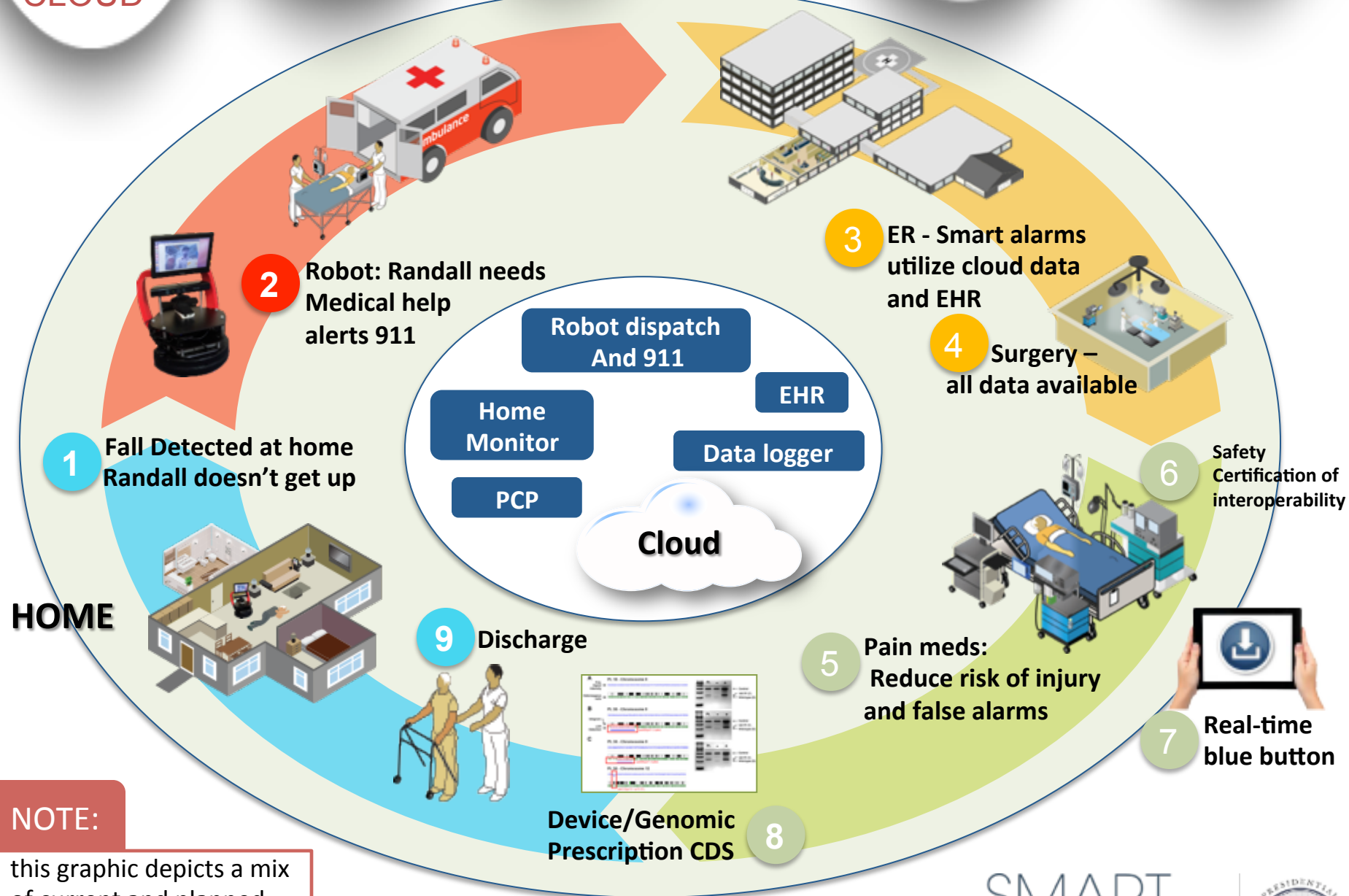




Smart America  
CLHC

March 2014

# CLOUD Closed Loop HealthCare Team: Home to Hospital to Home

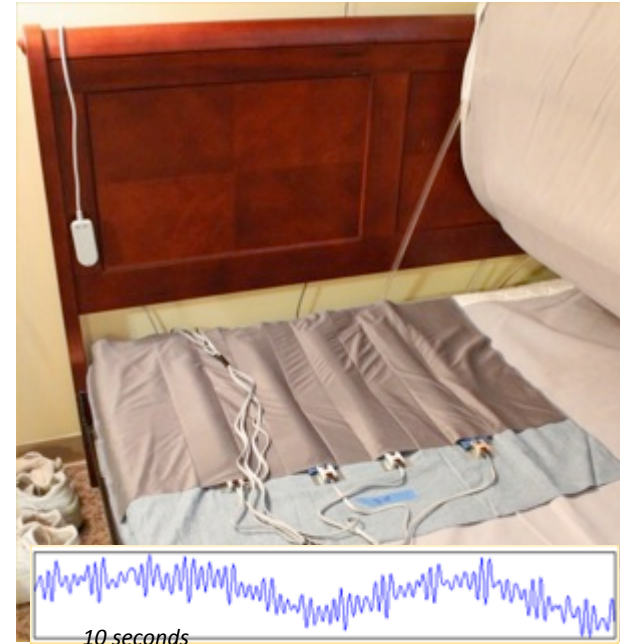
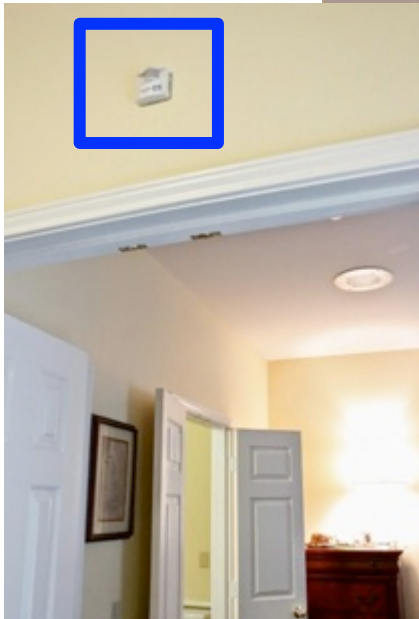
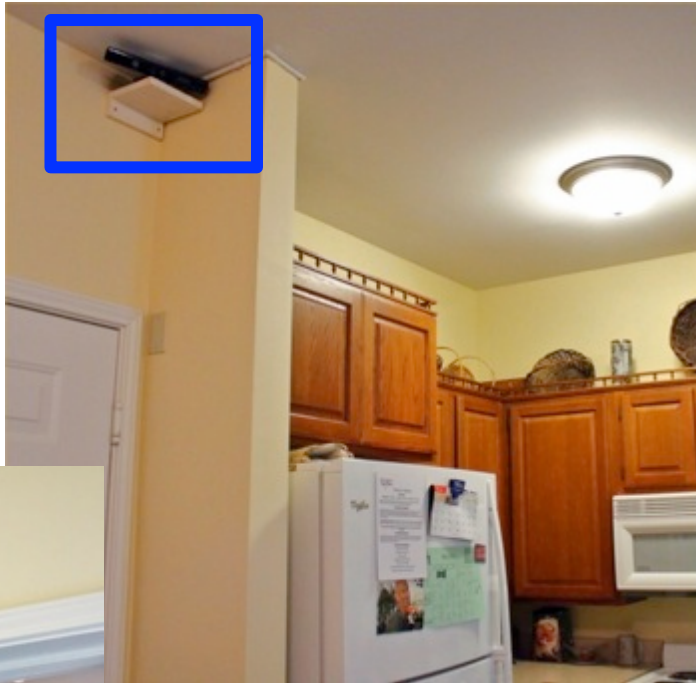


## NOTE:

this graphic depicts a mix  
of current and planned  
capabilities.

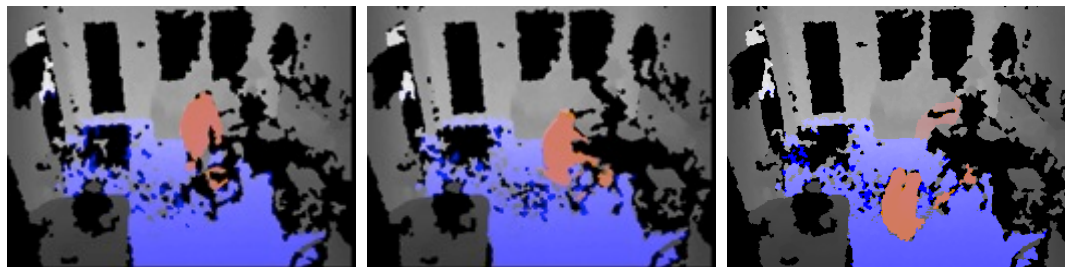
# Randall at Home

Depth camera for in-home fall detection  
so Randall gets help fast



Bed sensor logs sleep patterns.

Motion sensors log activity.





# Real-Time Fall Detection

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- Alert sent to caregivers with embedded link to depth video clip

Possible fall detected!

Fall confidence: 0.86

ID: 3012

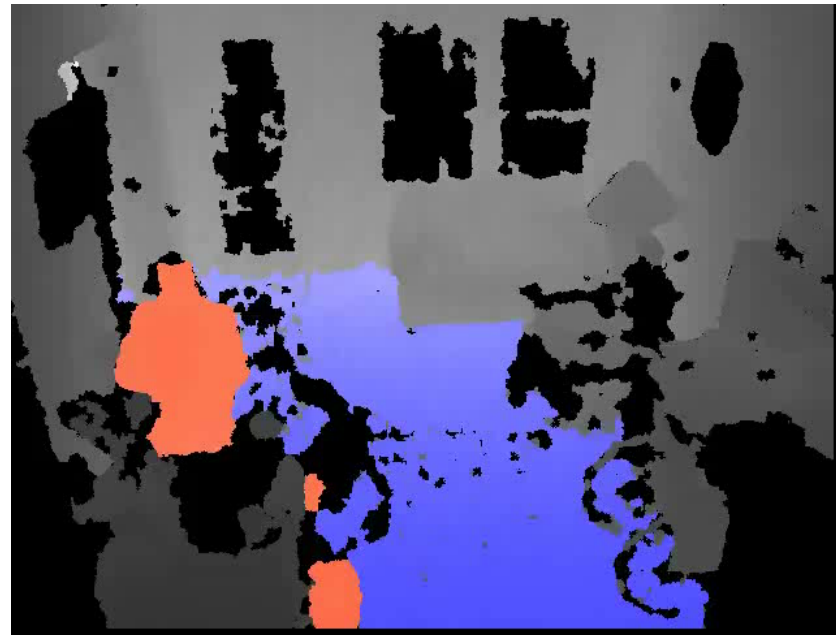
IP: 10.0.1.200

Date: 12\_04\_2013

Time: 16\_08\_45\_531

Another person was not detected walking in the room.

Video: 





# Fall Detection and analysis ...

Can change the course and outcome of the event

More information about the fall can influence medical intervention

Randall's data from home helps avoid un-necessary head CT scan. Fall > 3 feet, may require CT

Nationally - \$30B in wasted MRI/CT imaging

\$2,000 each head scan. Radiation = 30 chest x-rays

What if we know his head did not sustain impact?

CLOUD

Motion  
Sensors

Bed  
Sensor

Fall  
Detection

1

Fall Detected at home Randall doesn't get up

2

Robot dispatch performs triage alerts 911

3

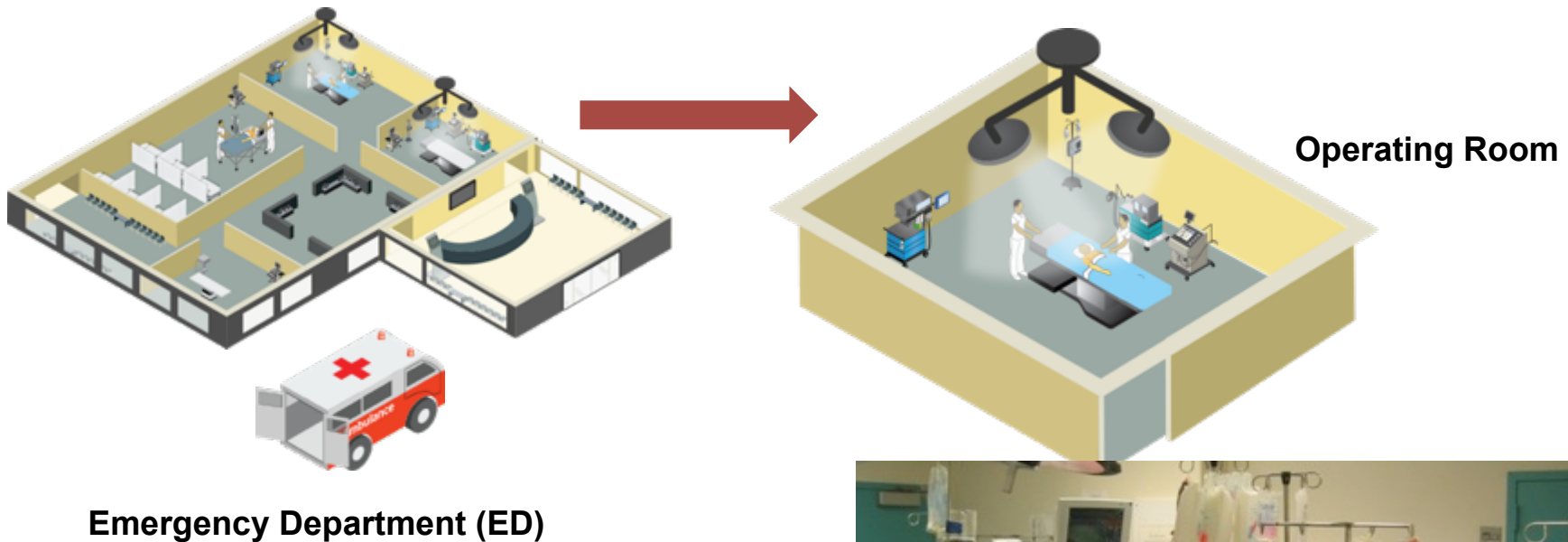
911 dispatch



SMART  
AMERICA



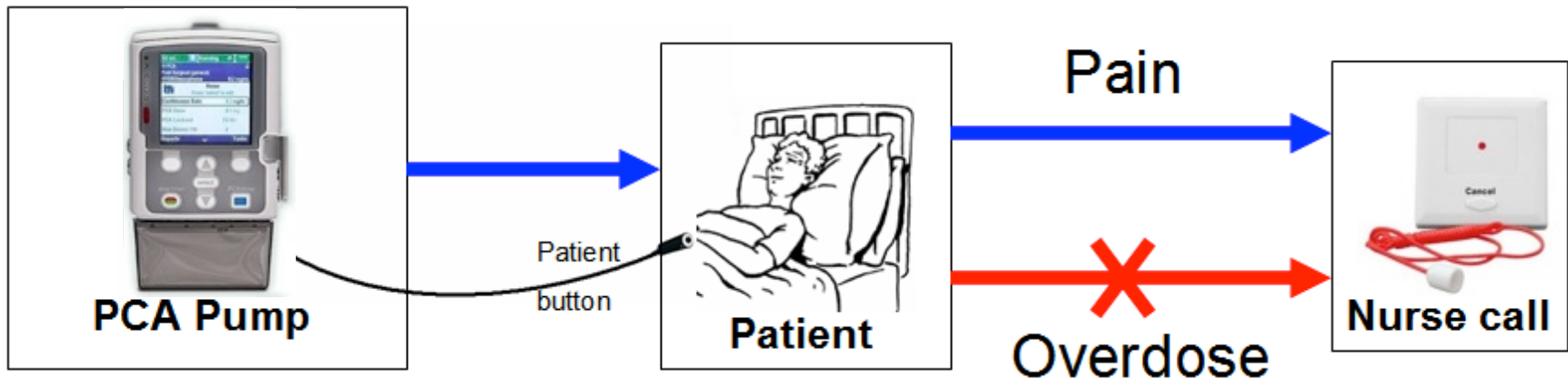
Hospital will have standards-based “Integrated Clinical Environments”, for full data interchange, device coordination, closed-loop control, “black box recorder”, “IoT for Health Care”  
Not available today, but we prototyped parts of this vision ...



In ED: Retrieving data from remote EHR  
Then: Transfer all data and device settings  
from ED->Operating Room



# Patient-Controlled Analgesia (PCA) system *safety concerns*



- *Patients can call to request more pain medication, but, cannot call for help when over-medicated.*
- *Over-medication can cause respiratory and cardiac arrest*
- *Comprehensive monitoring is not typically used due to high false and nuisance alarm rate*
- *“Safe PCA System” prototype uses information from medical monitors, EMR, and IV pump to prevent overdose*



# Reducing false alarms will reduce alarm fatigue

## Safer, more effective pain control

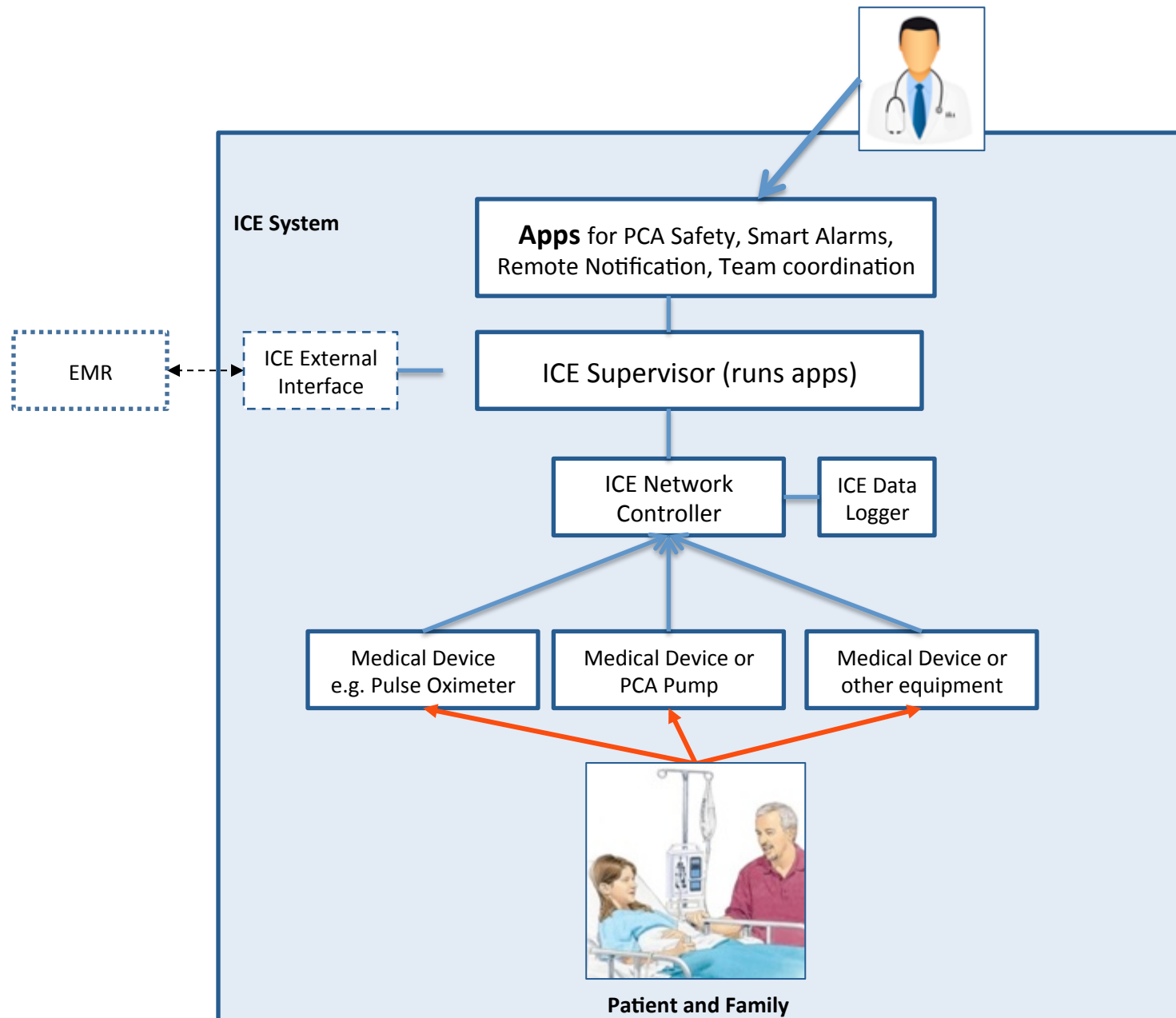


Pain Medication-related Injuries could be prevented with Medical CPS:

- Over 6000 patients severely injured/killed each year
- Up to \$145M impact
- Untreated pain
- PREVENTABLE events!

Real-time blue button data available to family and staff

# Integrated Clinical Environment Architecture



Standard ASTM F2761 recognized by FDA in August 2013

# Smart Alarm Intensive Care Unit

New System

Old System

Time:

3:03:23 PM

Demo:

Threshold

Smart Alarms

0

2

**Clinical Decision  
Support**

**Mr. John Nava**

*Last 10 minutes*

Total Alarms

Total Alarms

Complications

Risk Factors

**Blood  
Pressure**  
Normal

**65.9**  
mm Hg

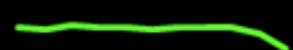
68  
66  
64



**Heart Rate**  
Slightly Low

**57.3**  
bpm

70  
60  
50



HR Low  
Alarm

**Oxygen  
Saturation**  
Normal

**100**  
%

100  
0



**Respiratory  
Rate**  
Slightly High

**22.1**  
rpm

22.2  
22  
21.8



RR High  
Alarm

Quiet Time:

4

0

Intro

Run

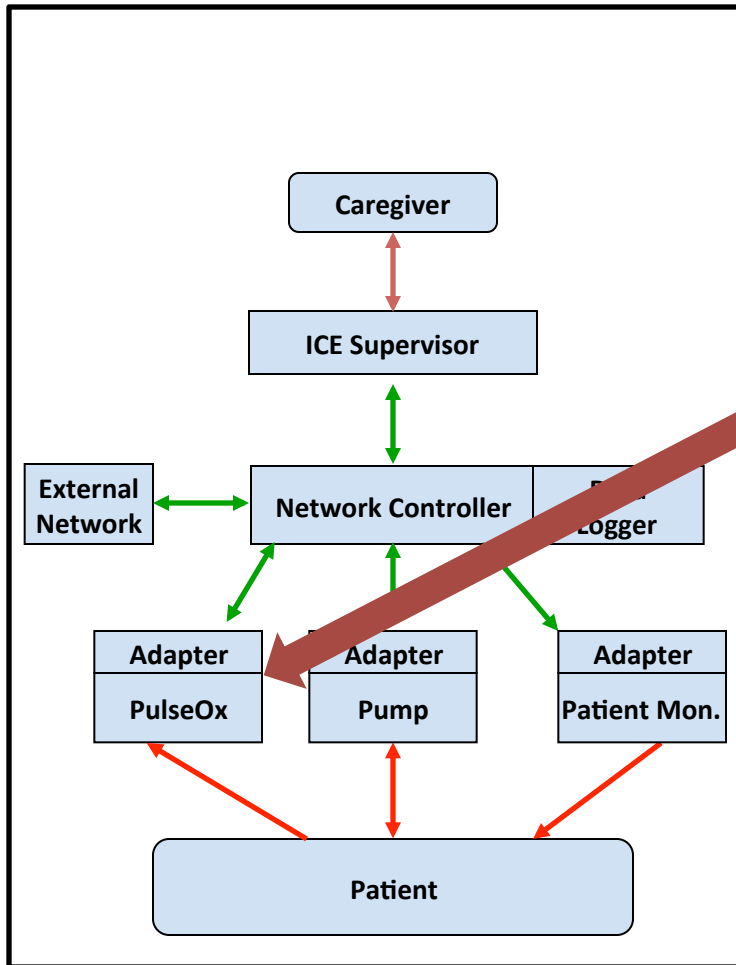
ICU: 21,000  
Alarms/day





# ASTM F2761 “ICE” standard for the Integrated Clinical Environment

Safe Interoperability can be enabled by Medical CPS



MD PnP™  
Getting Connected for Patient Safety™

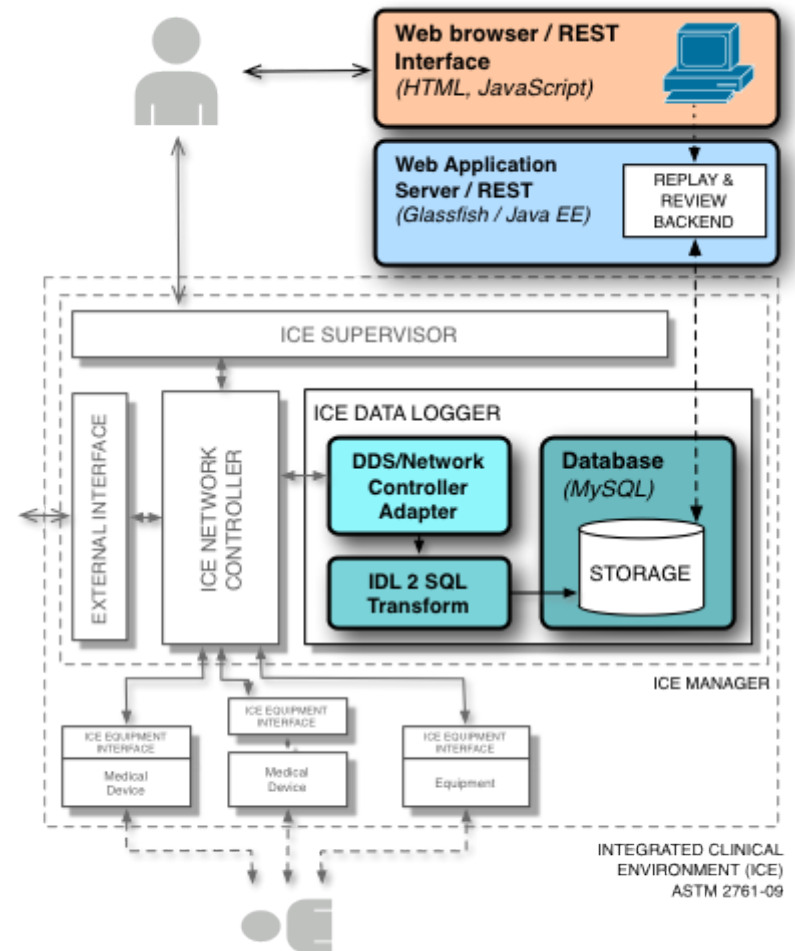


SmartAmerica Medical device interface  
performance certification pilot.  
Identified data persistence from Pulse  
Oximeter that could results in erroneous  
diagnosis from Clinical Decision Support app

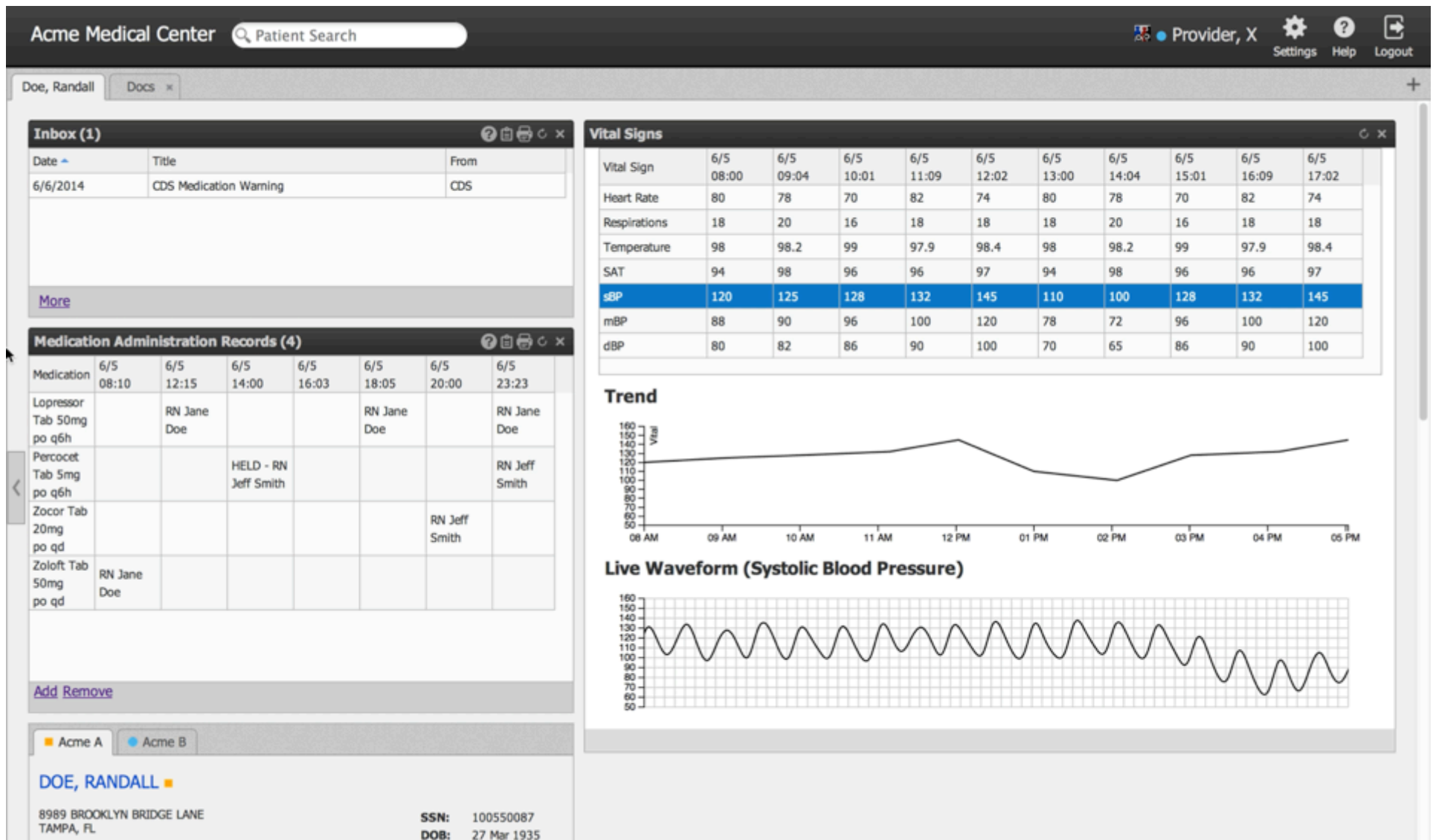
# Data Logger “Black Box Recorder” for the Integrated Clinical Environment (ICE)



- A Data Logger is a foundational component of MCPS clinical network. Required to improve forensic analysis of clinical adverse events and near misses
- Required to address safety (Regulatory Science) and liability concerns of network medical systems
- NIST Prototype Features:
  - Platform Independent, Plug-n-play & DDS compliant VM based Data Logger
  - Browser based Playback: Intuitive Data Visualization with Annotation and Search capabilities (Mobile Compatible)
  - Modular Architecture (Loose Coupling)

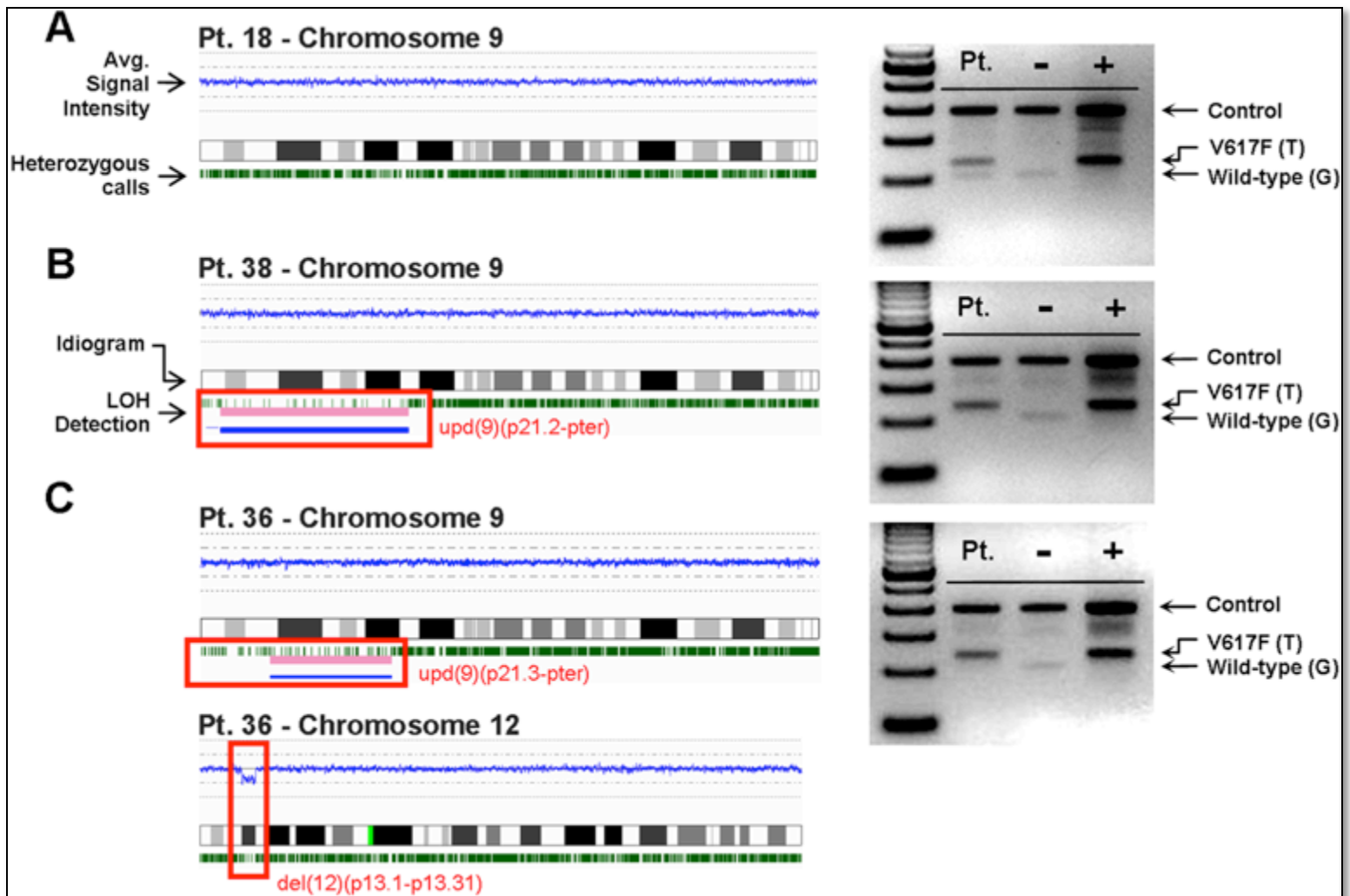


# Personalized Medicine: EMR data & Blood Pressure after Metoprolol Administered





# Randall's Genomic Profile



## EMR Alert: Don't use beta blocker class of blood pressure medications

Acme Medical Center

Patient Search

Provider, X

Settings

Help

Logout

Doe, Randall

Docs

Inbox (1)

Date	Title	From
6/6/2014	CDS Medication Warning	CDS

More

Medication Administration Records (4)

Medication	6/5 08:10	6/5 12:15	6/5 14:00	6/5 16:03	6/5 18:05
Lopressor Tab 50mg po q6h		RN Jane Doe			RN Jane Doe
Percocet Tab 5mg po q6h			HELD - RN Jeff Smith		
Zocor Tab 20mg po qd					
Zoloft Tab 50mg po qd	RN Jane Doe				

Add Remove

Acme A

Acme B

DOE, RANDALL

8989 BROOKLYN BRIDGE LANE  
TAMPA, FL

SSN: 100550087  
DOB: 27 Mar 1935

Vital Signs

Vital Sign	6/5 08:00	6/5 09:04	6/5 10:01	6/5 11:09	6/5 12:02	6/5 13:00	6/5 14:04	6/5 15:01	6/5 16:09	6/5 17:02
	80	78	70	82	74	18	20	16	18	18
	98	98.2	99	97.9	98.4	94	98	96	96	97
	110	100	128	132	145	78	72	96	100	120
	70	65	86	90	100					

01 PM

02 PM

03 PM

04 PM

05 PM

160

150

140

130

120

110

100

90

80

70

60

50

Inbox Details ~ CDS Medication Warning

Date: 6/6/2014

Type: Alert

Priority: HIGH

From: CDS

Description: CDS Medication Warning

Detail: The Pharmacogenomics Clinical Decision Support System has detected a transient, but significant blood pressure reduction associated with this patient's Lopressor administration. This patient also has Single Nucleotide Polymorphisms (Ser49Gly, Arg389Gly) in the ADRB1 gene that have been associated with variable Lopressor efficacy. An alternative class of medication may be indicated if more predictable blood pressure control is desired.

# Open Healthcare



Healthcare Technology



Reference  
Implementation



Devices

Information Technology



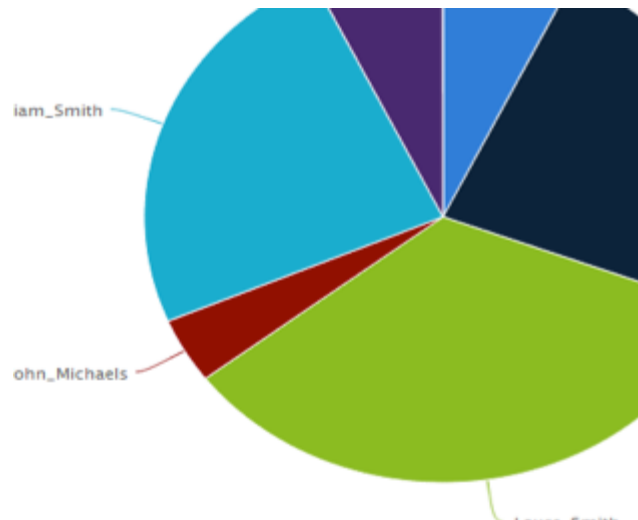
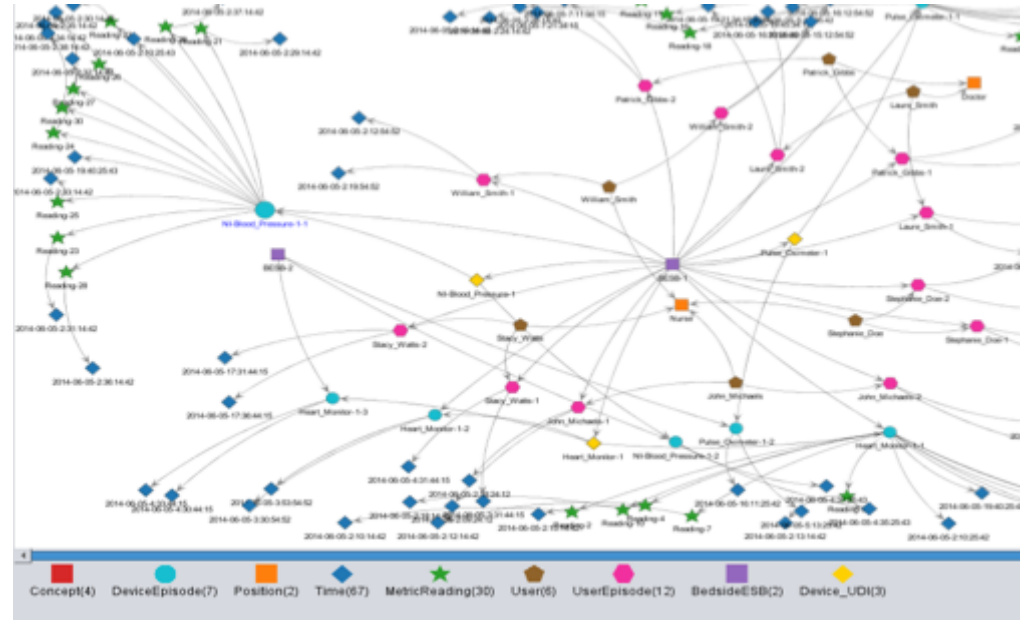
# OpenICE + Analytics

IoT for Health Care can provide greater data granularity

SEMOSS is an open analytics technology - can find connections between data stored in multiple repositories.

Data from DOCBOX's ICE Manager and open source middleware + tools. Questions that could be answered:

- How many times did this patient utilize this device ?
- Who are the various users working with this device?
- How much time Nurse ABC spend providing direct patient care across the continuum of care (all patients all units)



# Patient is discharged ... to a smarter home

CLOUD

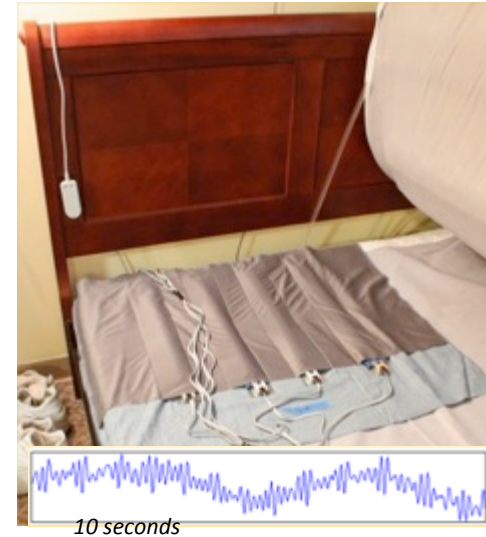
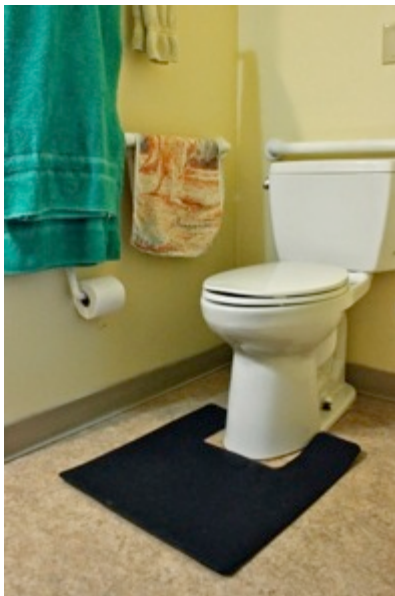




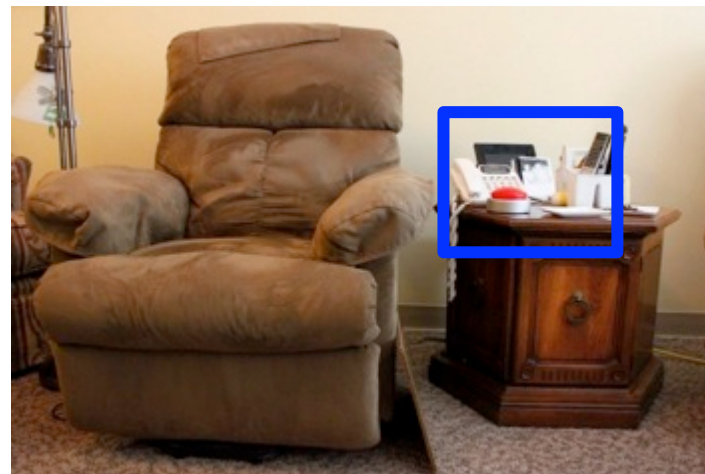
# Home Again

## Sensors & Health Alerts Prevent Re-Hospitalization

in-home fall detection  
and gait analysis



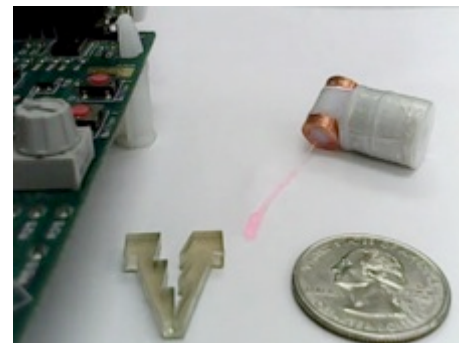
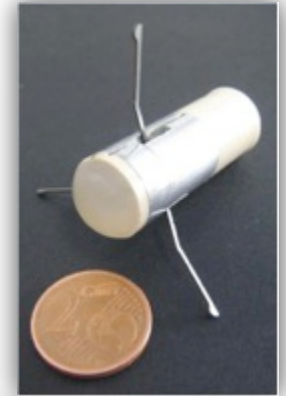
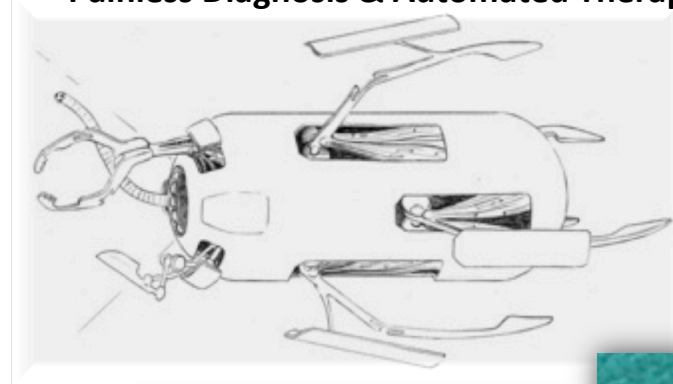
Bed sensor under the mattress logs  
pulse, respiration & restlessness



# Capsule Robots for Non Invasive Healthcare Monitoring and Localized Drug Delivery



Painless Diagnosis & Automated Therapy



Controllable Capsule for Localized Drug Delivery  
On Display at the *Closed Loop Healthcare* Booth

