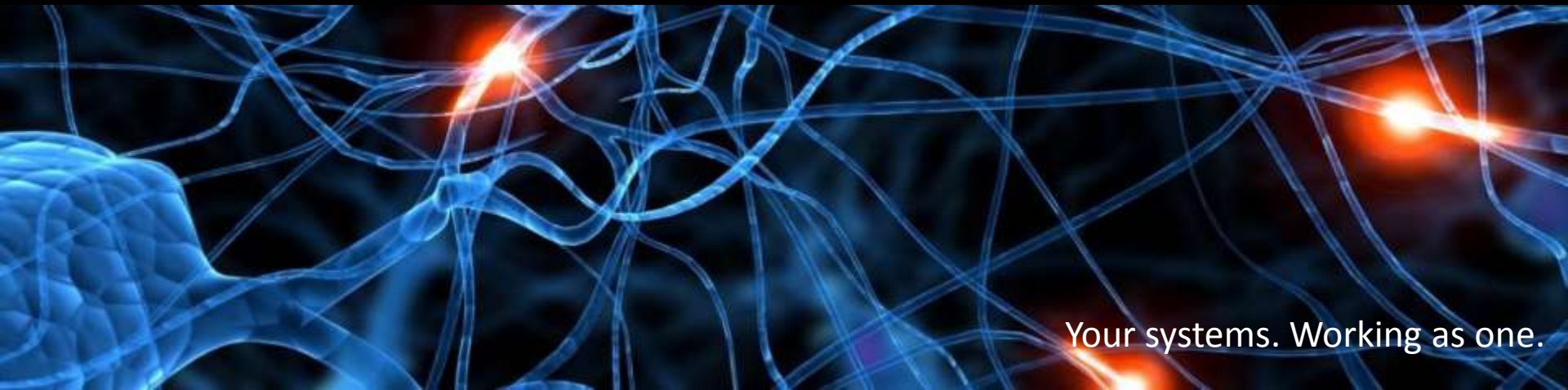
Real-World Applications of OMG Technology in Medicine

Stan Schneider, PhD



“Last Mile problems”

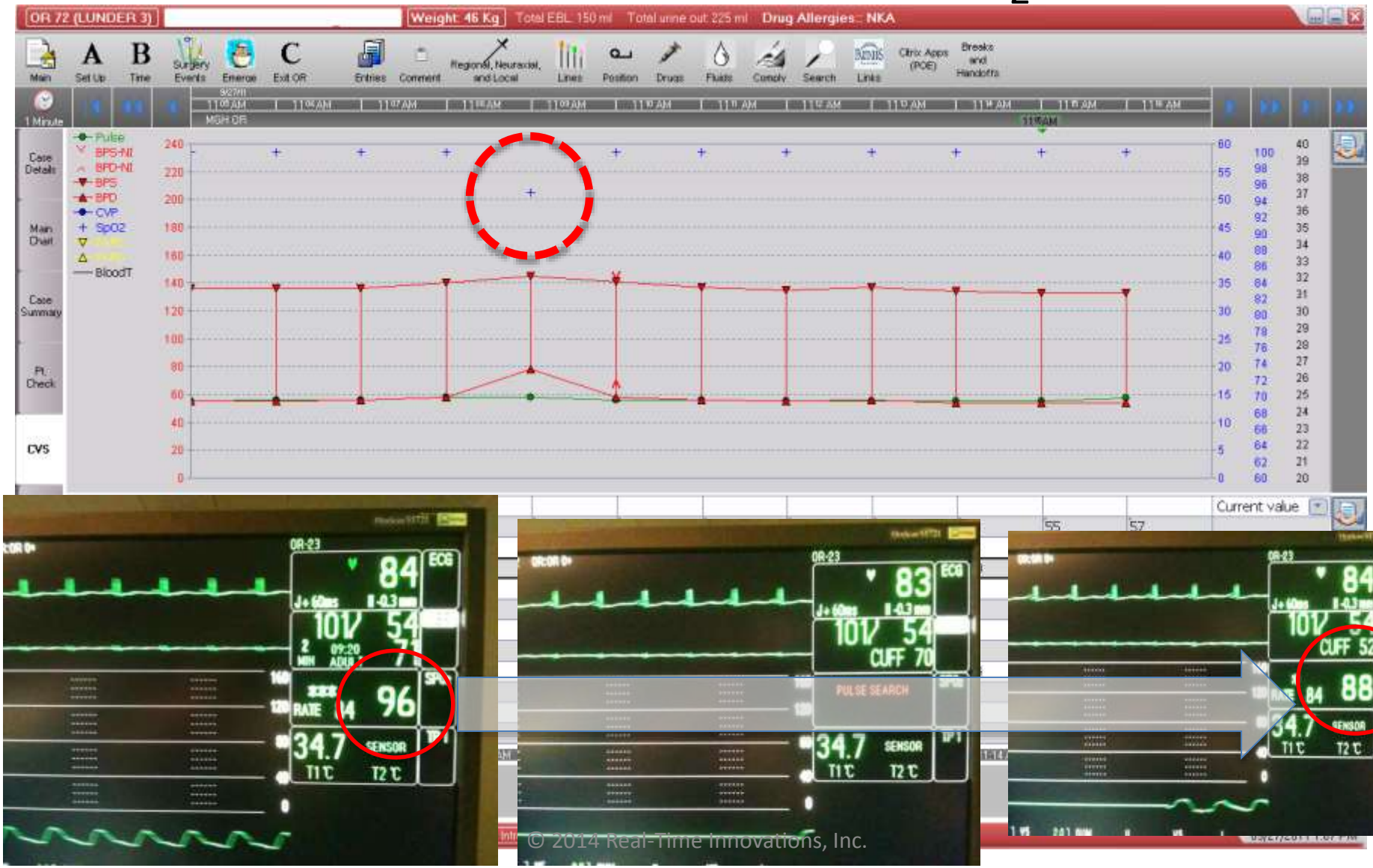
Example - Infusion technology:

1. Decision support?
2. Prevent contra-indicated infusion?
3. “Artificial pancreas” Capabilities? (closed loop)
4. Consolidate all data for adverse event analysis?
5. Check device status, software version? Recall?
6. Support Meaningful Use #3?

SpO_2 must be interpreted appropriately. Erroneous data points could be flagged/rejected

1. BP cuff inflation status is not recorded in EHR
2. Waveforms not recorded

NIBP-SpO_2 Interaction

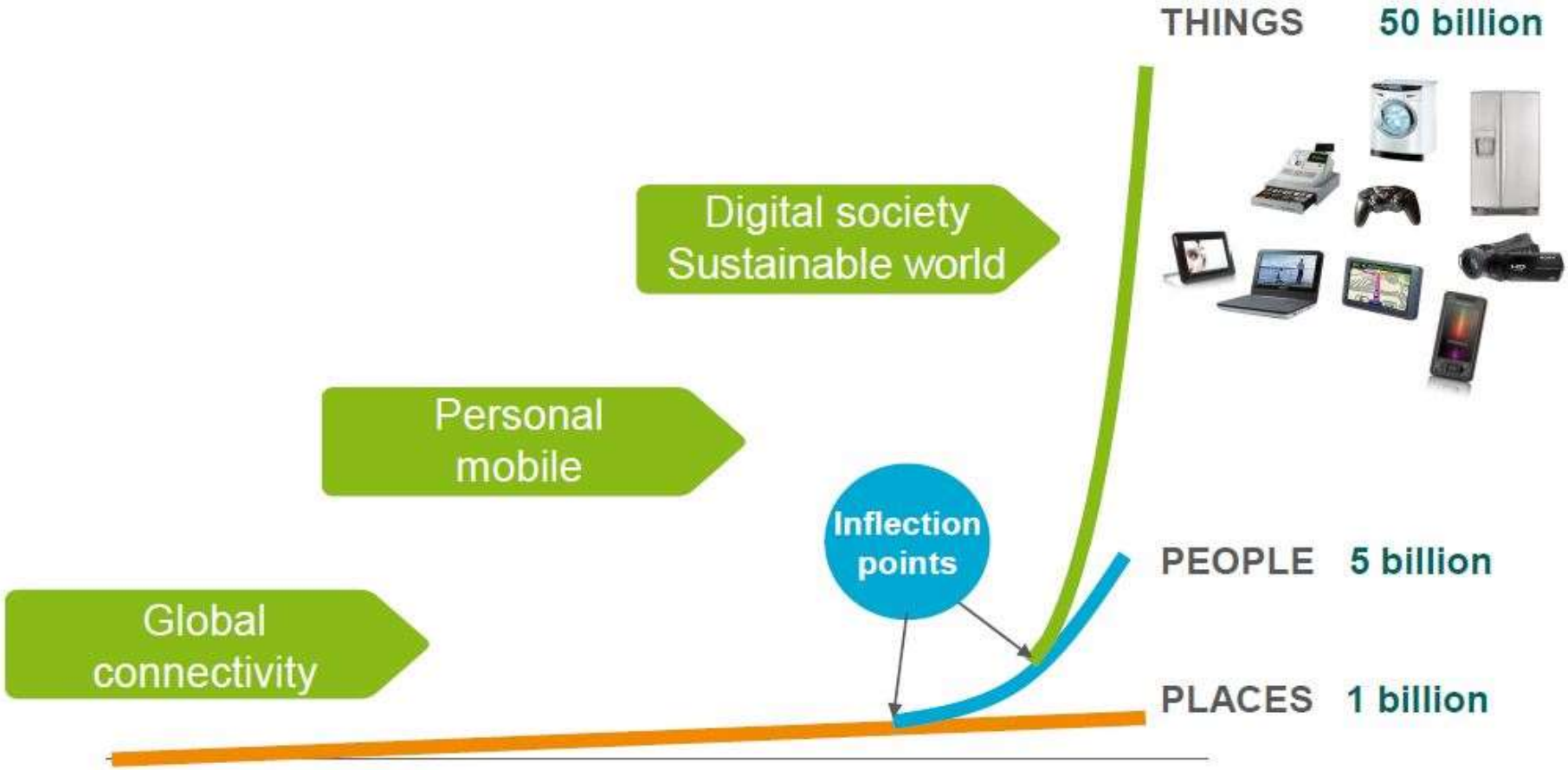


Problem – Pulse-rate counting error due to atypical plethysmogram.
Other monitor data could be used to detect and reject this error.
Waveforms could be recorded to enable manufacturers to improve device algorithms.

Result: False alarms, incorrect data in permanent record.

What Can Change That?

The Internet of Things



DDS: Distribute Device Data

Real-Time Analytics & Control

Operator HMI

Cloud Integration

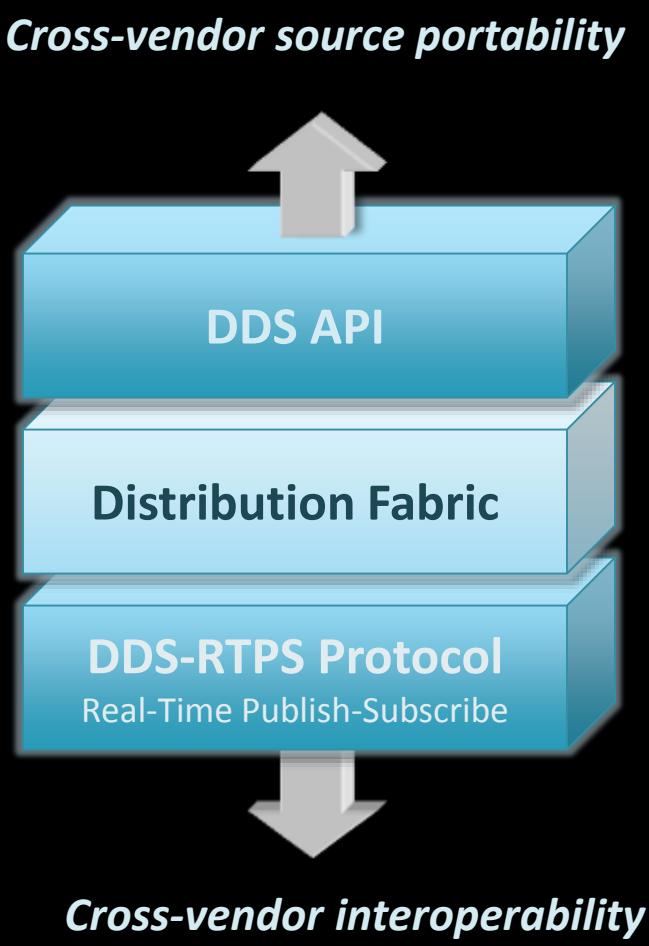
Sensors

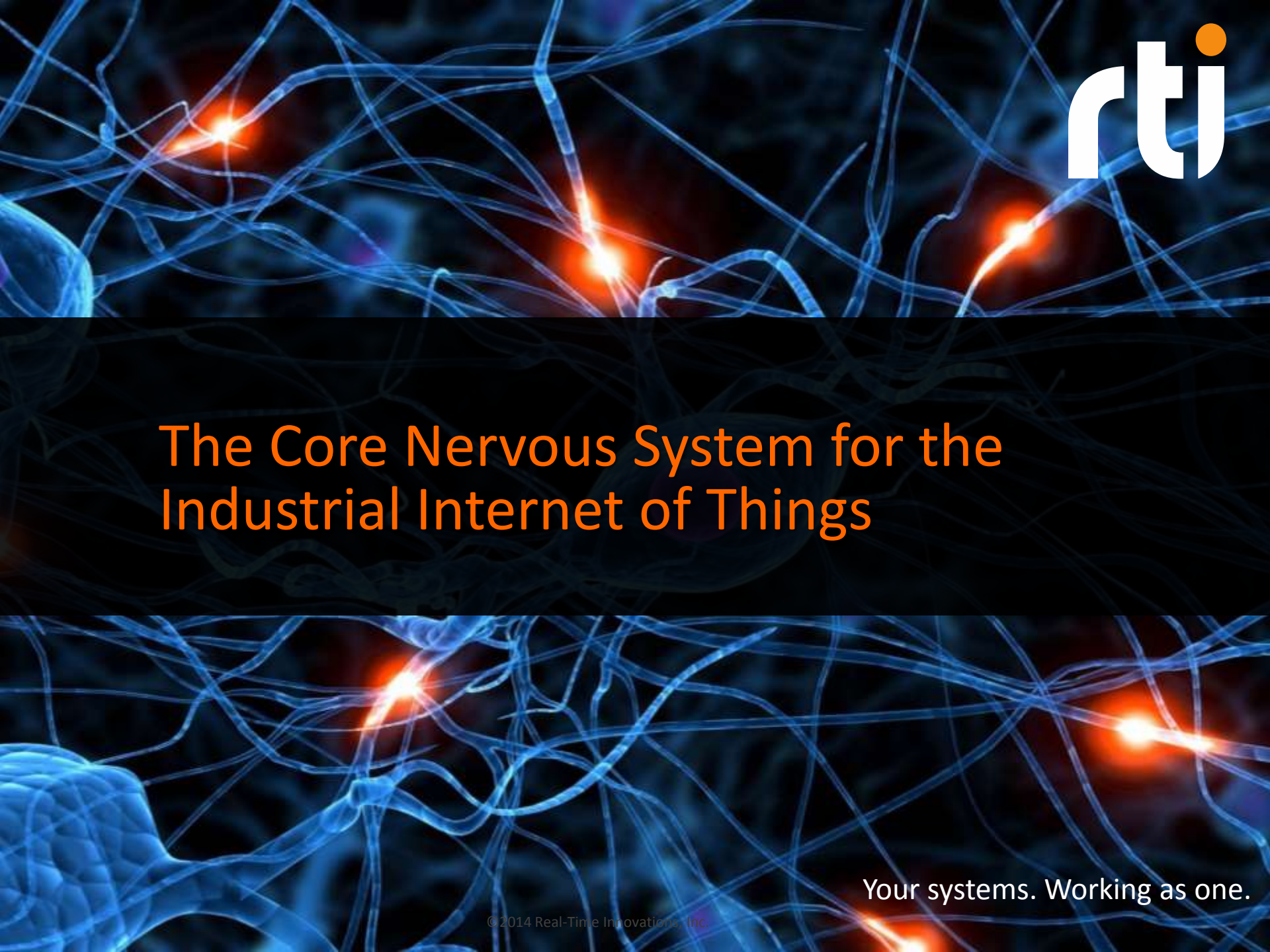
Actuators

Data Distribution Service (DDS)

The DDS Standard

- Data Distribution Service from OMG
- OMG: world's largest systems software standards org
  - 470+ members
  - UML, DDS, Industrial Internet Consortium
- DDS: open & cross-vendor
  - Standard API enables choice of middleware
  - Standard wire spec enables subsystem physical interoperability
  - 12 implementations

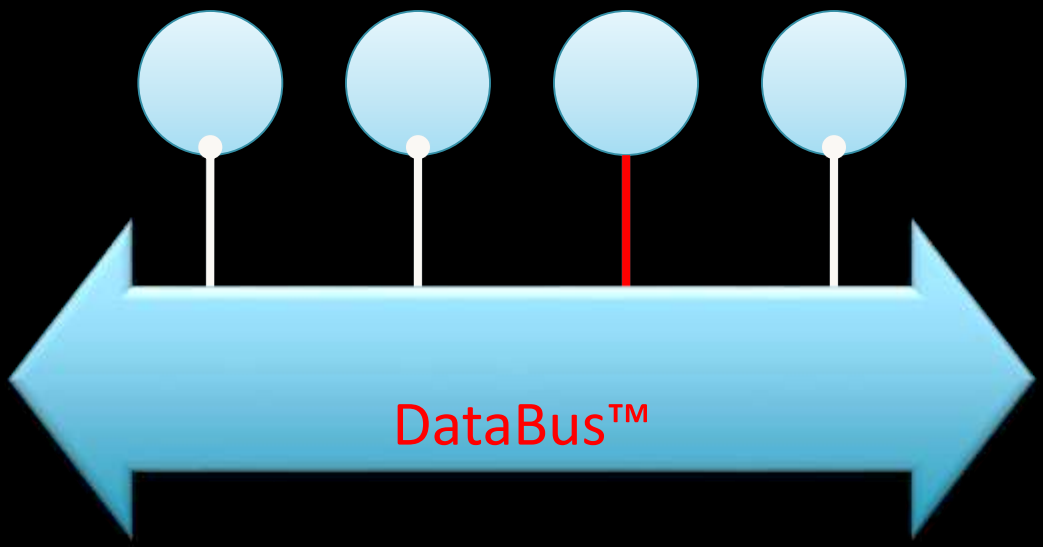




The Core Nervous System for the Industrial Internet of Things

Your systems. Working as one.

DDS: The Software DataBus



- Data centric
  - Like a database for moving data
- Decouples modules
  - Like SOA
- Plug and play flexibility
  - Like a hardware bus
- Peer-to-peer performance
  - Like streaming protocols
- Standards-based interoperability
  - Like TCP/IP

Scalable, high performance, reliable infrastructure

Smart Machines in the IIoT

- Defense
- Transportation
- Industrial
- Energy
- Communications
- Healthcare

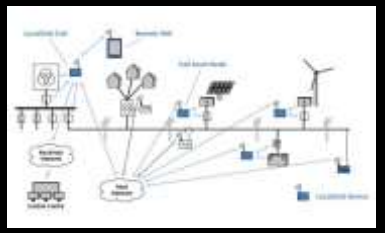










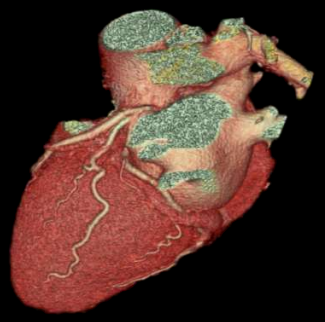


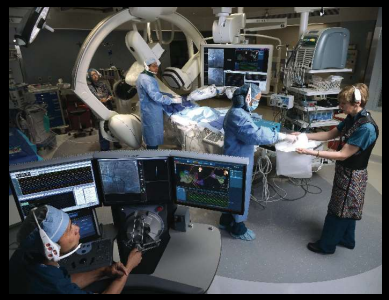

How Networked Things Are Changing Medicine

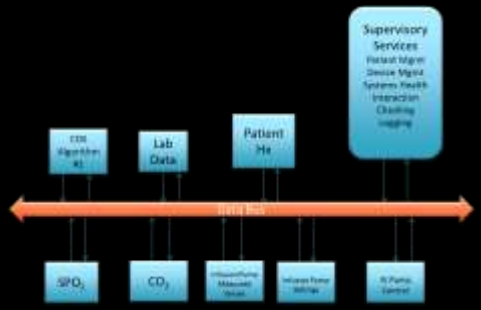
Real applications in connected medical devices

DDS in Medical

- Imaging & Treatment Systems
  - Compelling problem: fast device integration
- Surgical Systems
  - Compelling problem: feedback, video, patient monitoring
- Connected Medical Devices
  - Compelling problem: Patient safety, multi-device platform, hospital integration







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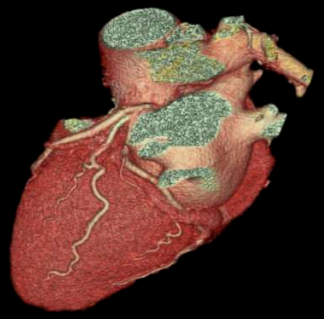
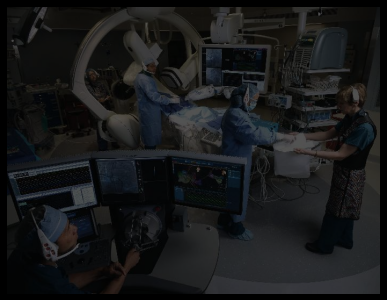
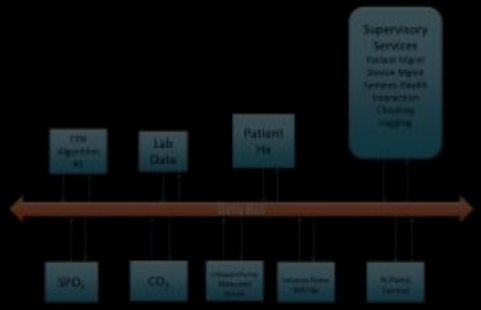
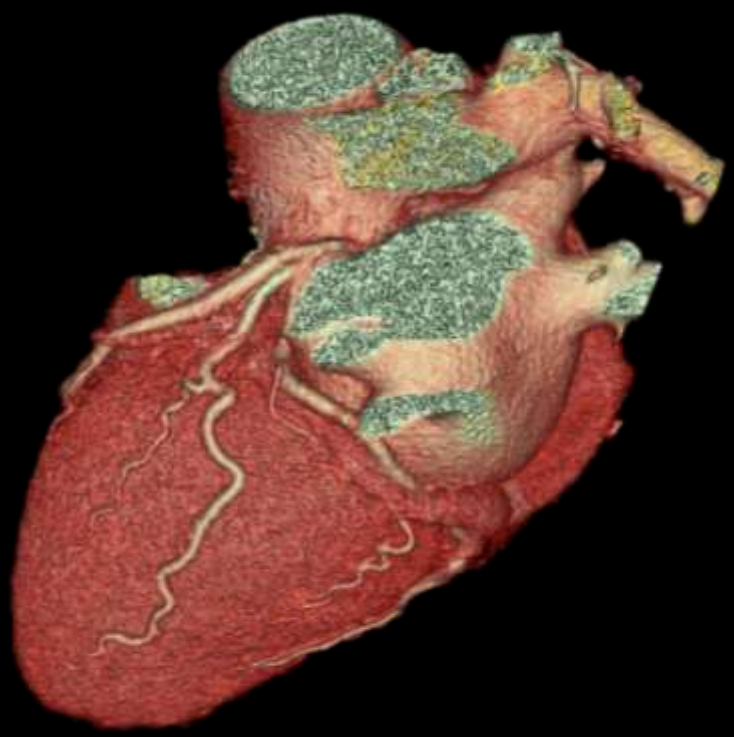




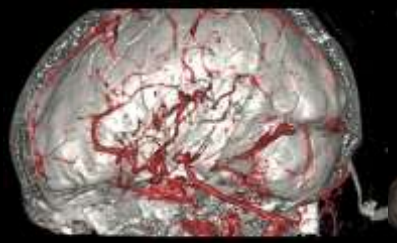


Medical Imaging & Treatment Systems



- Imaging systems require massive data flows and fast performance
  - CT machines require precise distributed control
  - Any one of many MRI receivers can saturate a 1Gbit network
- Treatment systems require precise distributed control and safe operation

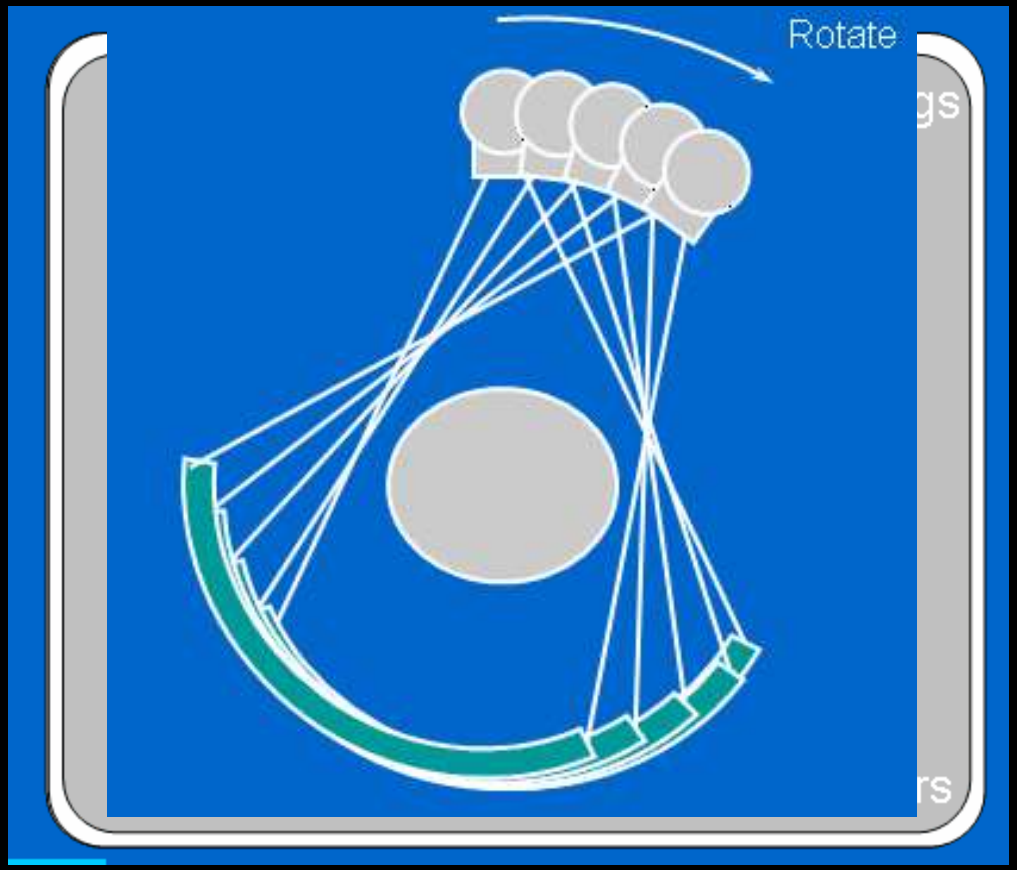
Computed Tomography (CT)



Revolution®

CT Basics

- Spin an xray source around an object
- Time exposure carefully to get the right image or freeze motion
- Collect the projection data during spin
- Do the math

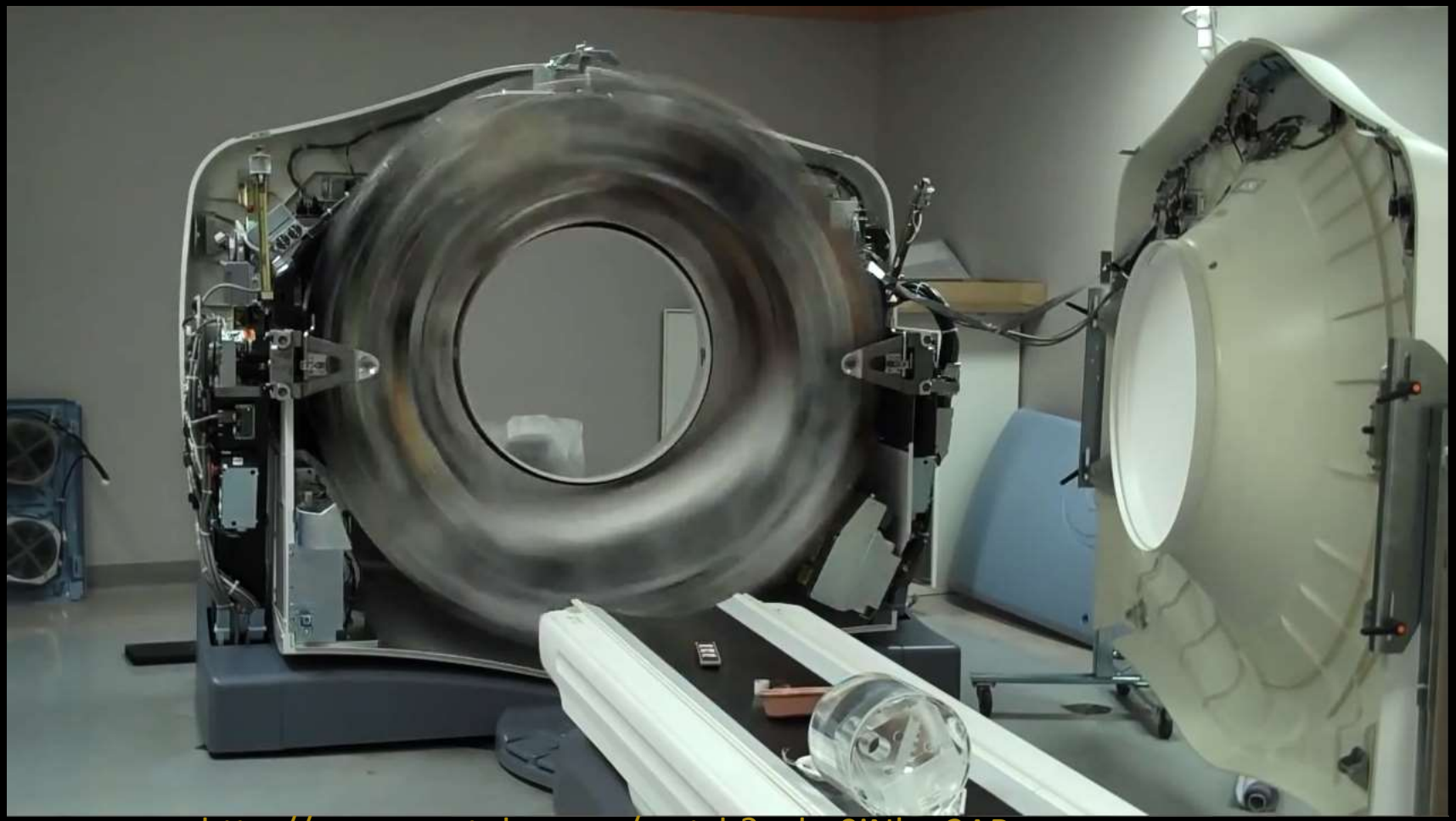


CT Scanner: Coordinated Control

- Coordination
  - Generator
  - Scanner
  - Power
  - Servo
- Burst image data acquisition
- Control & monitoring
  - Systems ready for scan
  - Status during scan
- Operator interface
- Integration
  - Multiple programming languages, OS, data models
  - Data archiving

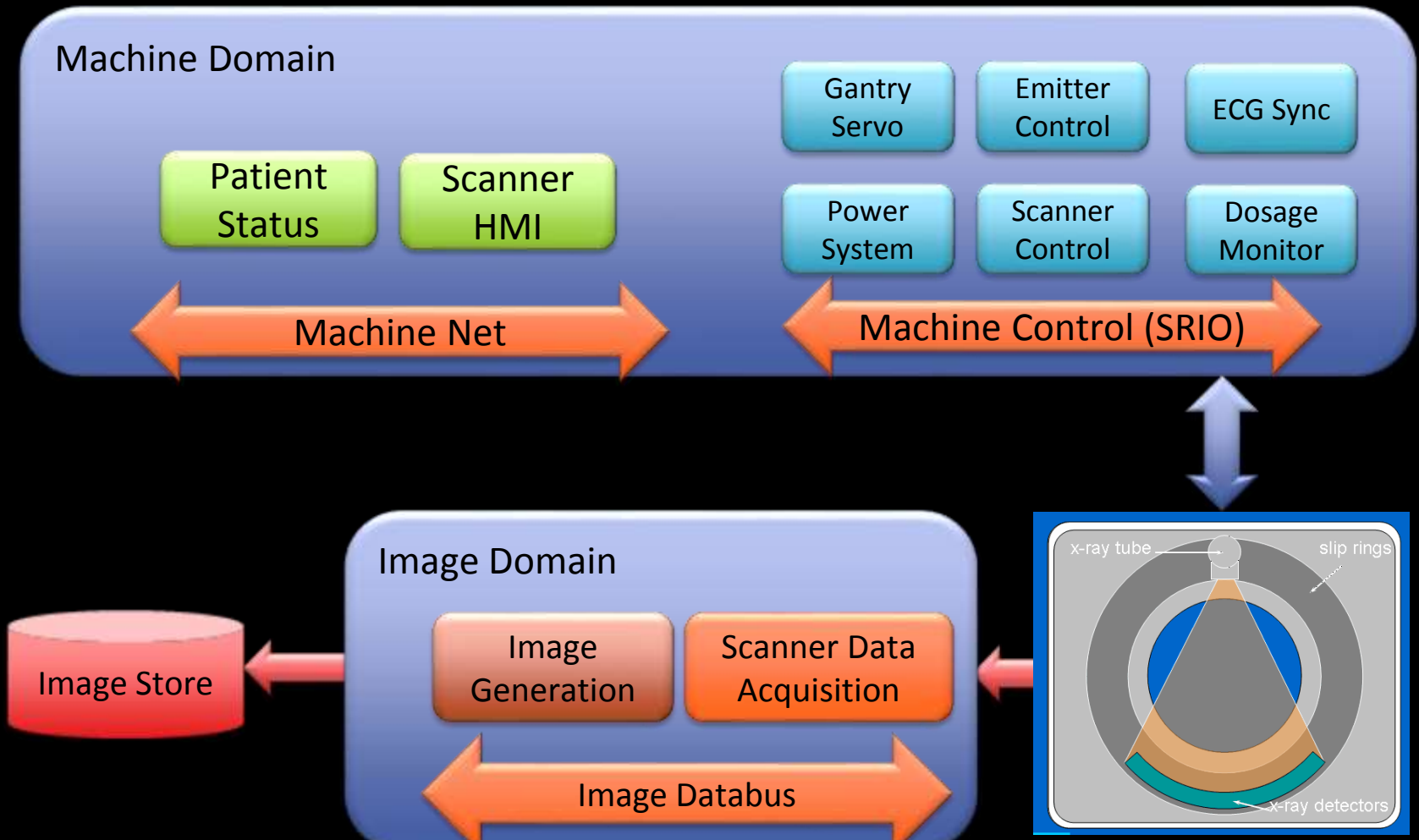
Image is for conceptual understanding only.
This is a previous generation device.

CT Scanner in Operation



http://www.youtube.com/watch?v=bg0iNhw2ARw

CT Scanner Control



Ultrasound Imaging

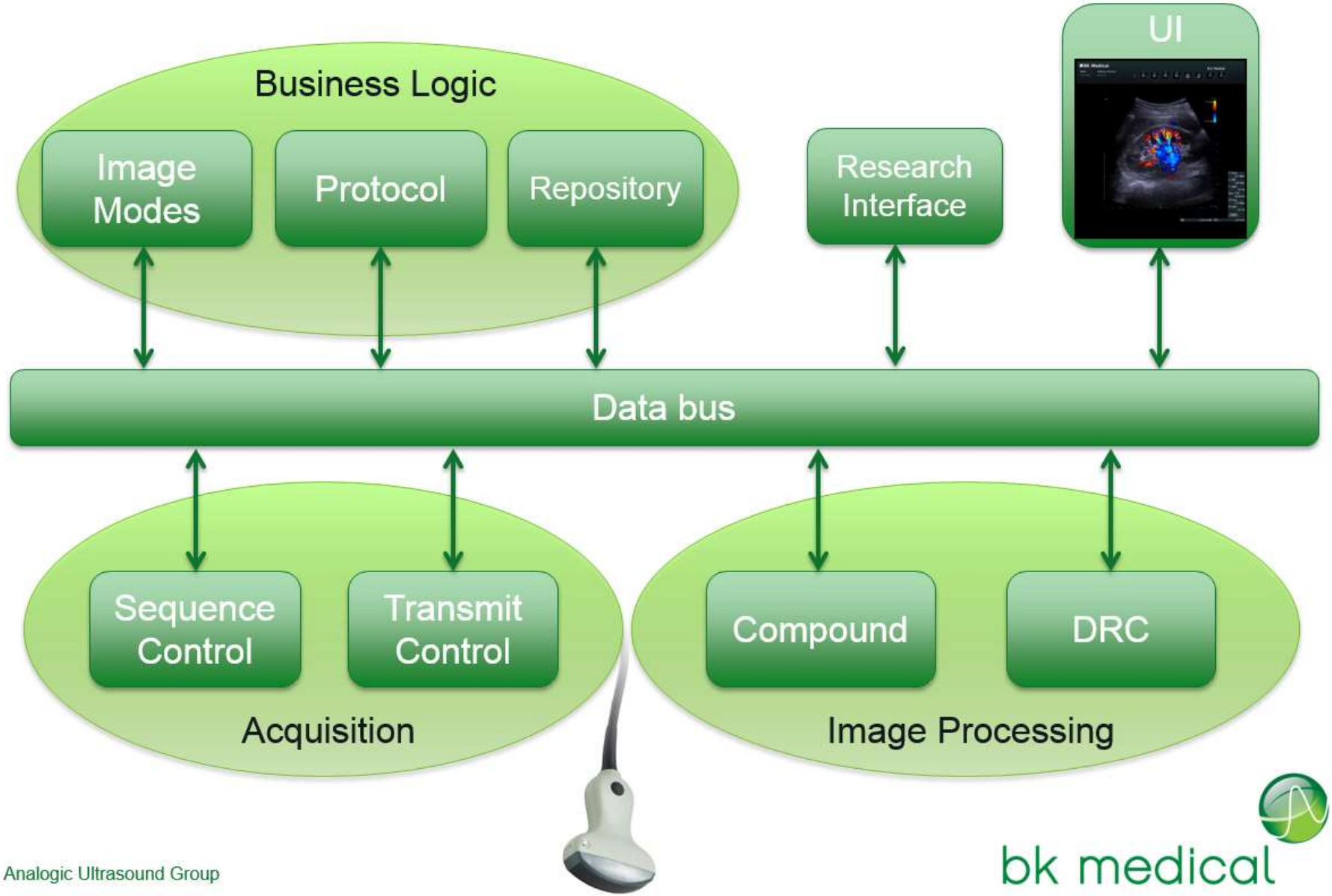
bk medical

”BK Medical is truly redefining Medical Ultrasound Imaging where the traditional single user / single system approach is being replaced with fully scalable and distributed multi-user systems

This required a completely new way of gluing the individual components together. For this reason we selected the RTI DDS middleware as this gives us all the flexibility and the abstraction layer needed for the future of Analogic Ultrasound”

-- Jesper Lomborg Manigoff, VP of Engineering, Analogic Global Ultrasound

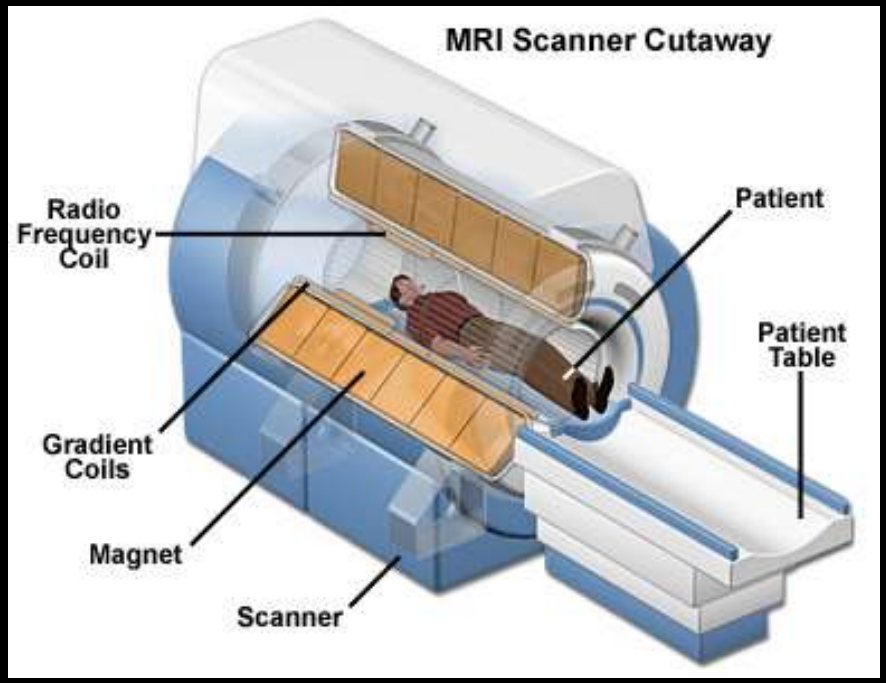
Ultrasound Scanner



bk medical

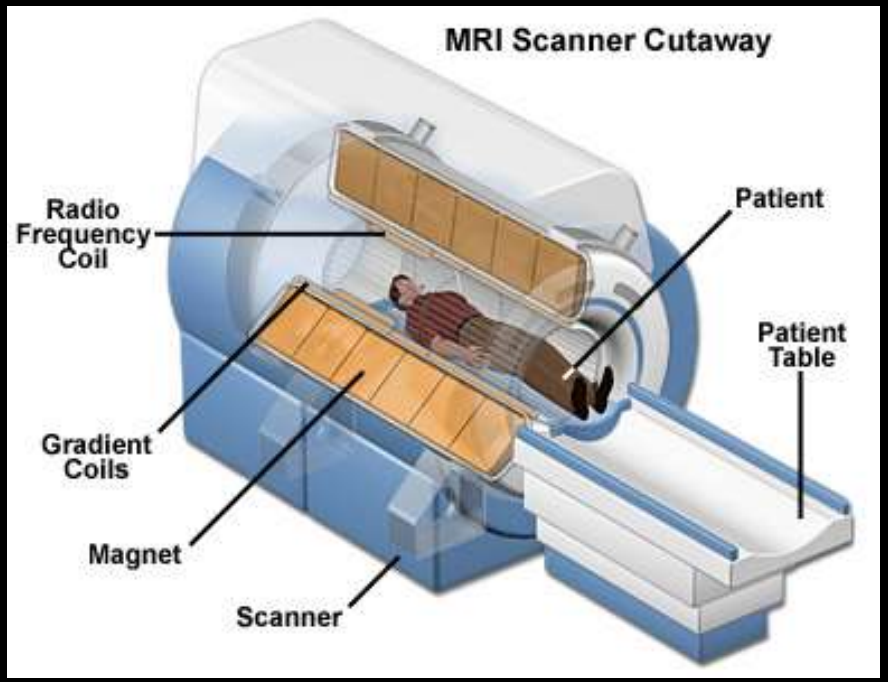
MRI Basics

- Start with a strong (2T) magnetic field
- Excite H nuclei in a plane
- Control gradient magnets to get different (phase, frequency) resonance from every point in that plane
- Collect the data
- Do the math



MRI Data Challenges

- Gradient coil coordination
- Excitation control
- Handle burst imaging data
  - Receiver data throttling
  - Coordinating multiple networks
- Patient positioning
- Image transfer



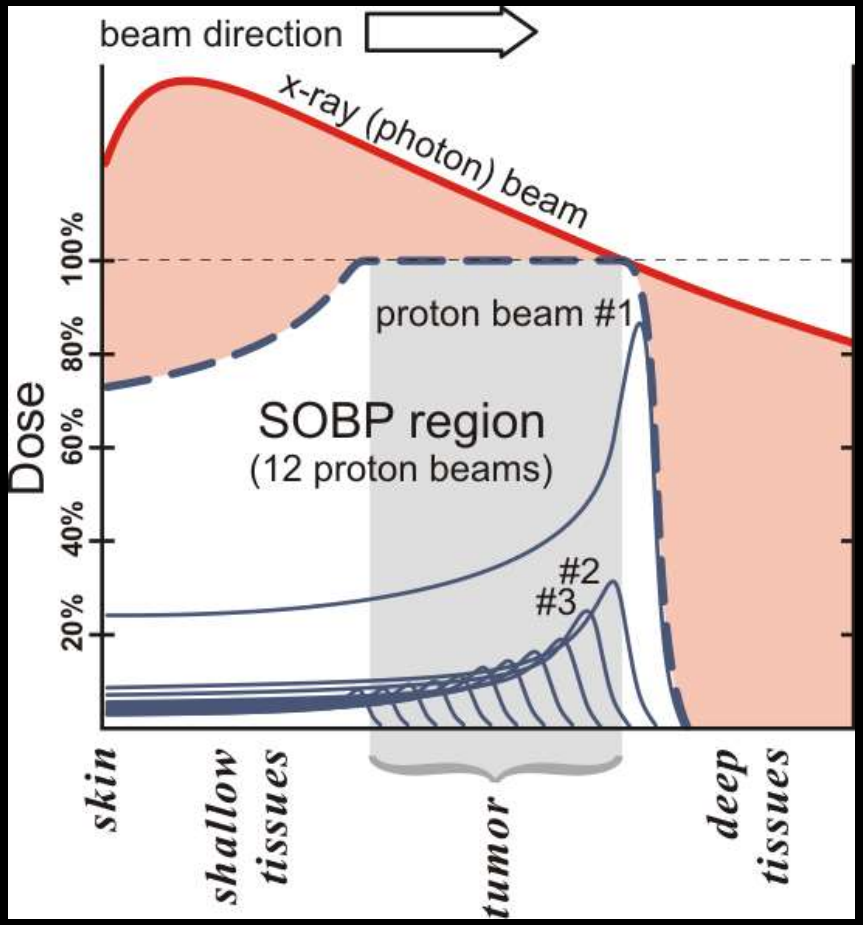
Advanced Proton Therapy

First patient treated Dec 2013,
Siteman Cancer Center, St. Louis

- Mevion's Proton-Beam Radiation Therapy system zaps tumors with accelerated protons
- The treatment must be continuous for 30-40 days; downtime endangers treatment success
- With DDS, Mevion's PBRT delivers dependable treatment at low cost

Proton Beam Therapy

- Unlike Xrays, PBRT precisely delivers energy with little tissue exposure
- Controlling exposure requires positioning patient in 3D



PBRT Data Challenges

- Supercon-ducting synchro-cyclotron control
- Coordinate
  - Imaging
  - Patient positioning
  - Treatment
  - Machine control
  - Hazard mitigation

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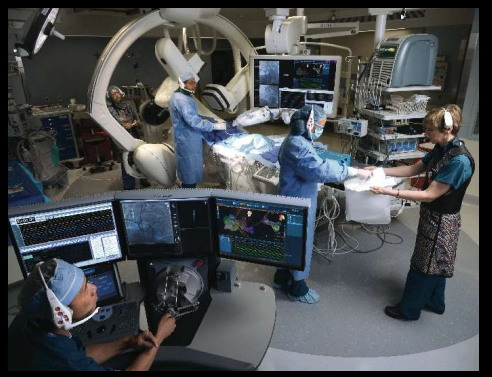
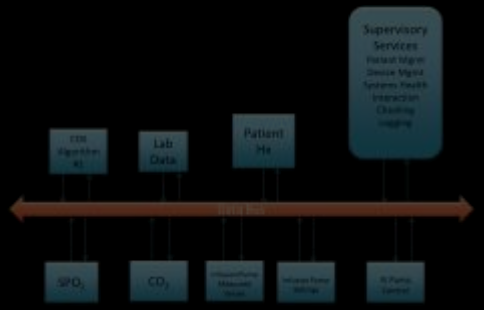




Surgical Operating Room Integration

- Patient status
  - Waveforms
  - Data recording
- Multi-channel video
- Many recipients
  - Surgeon
  - Operating theater
  - Students & observers
  - Offsite

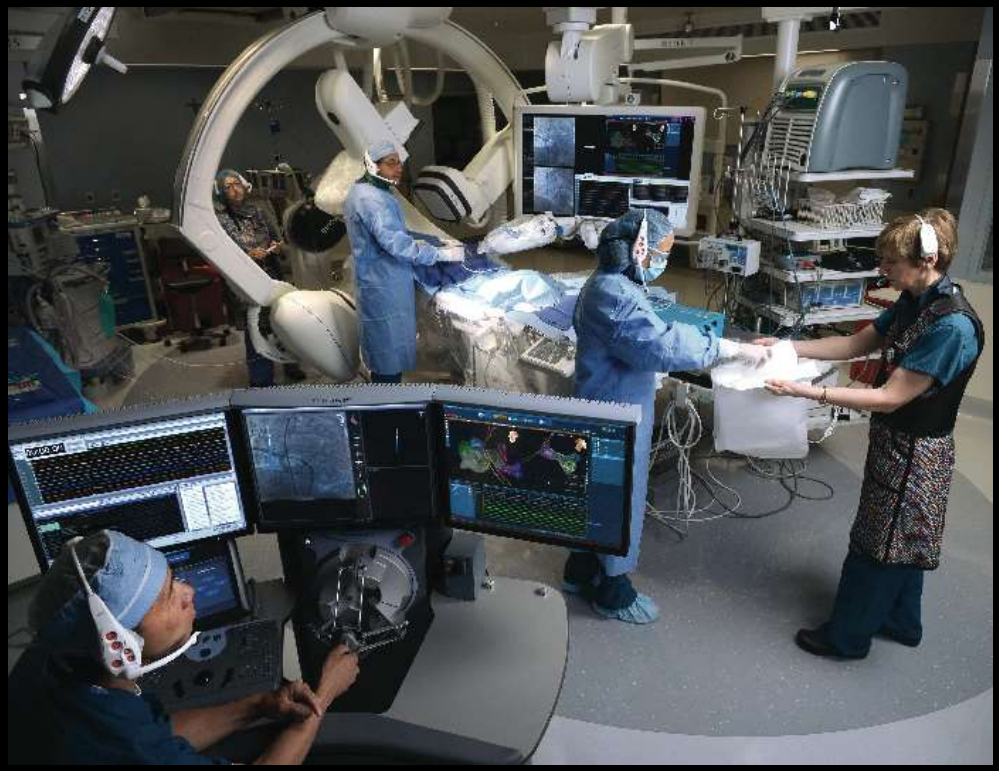
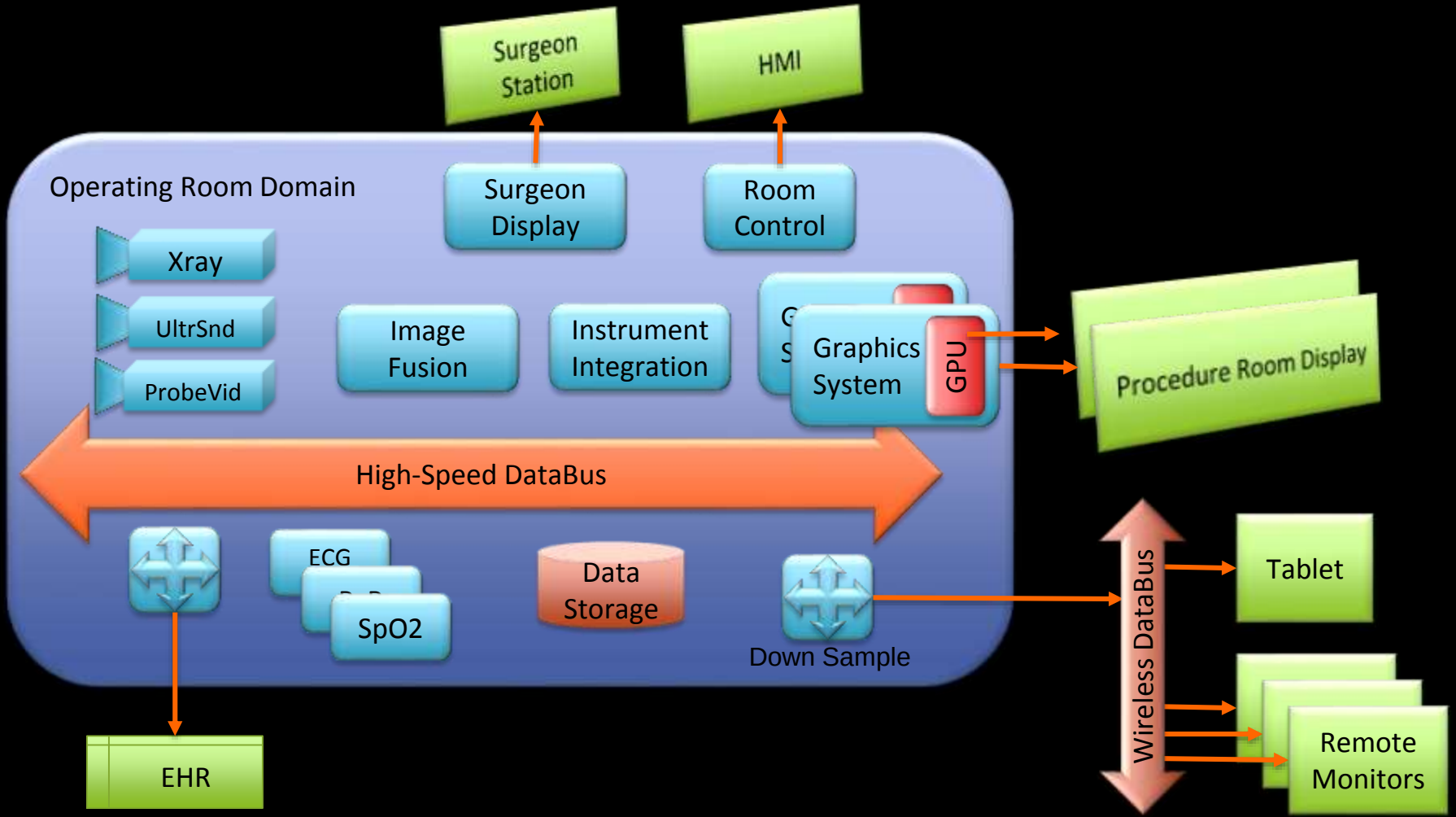


Image is for conceptual understanding only. This is not a current RTI application

Surgical Robotics

- The Minimally Invasive Robotic Surgery (MIRS) system at DLR coordinates three robots to perform delicate heart surgery.
- The system closes a distributed loop between the robots and the remote surgeon's control at 3kHz.
- RTI enables new medical techniques

Interventional Surgical Theatre



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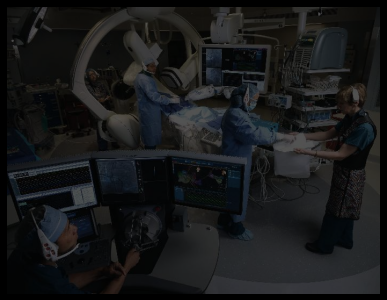
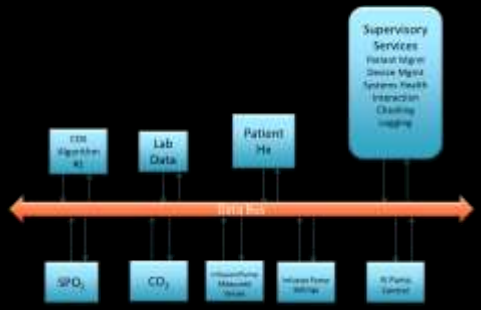




Device Connection for Patient Safety

- Hospital error is the 6th leading cause of preventable death
- DocBox integrates devices to improve patient safety
- RTI Connext ties together devices, services, and displays in real time

"RTI Connext DDS met all our needs – whether we're handling 12 patients, or 200."

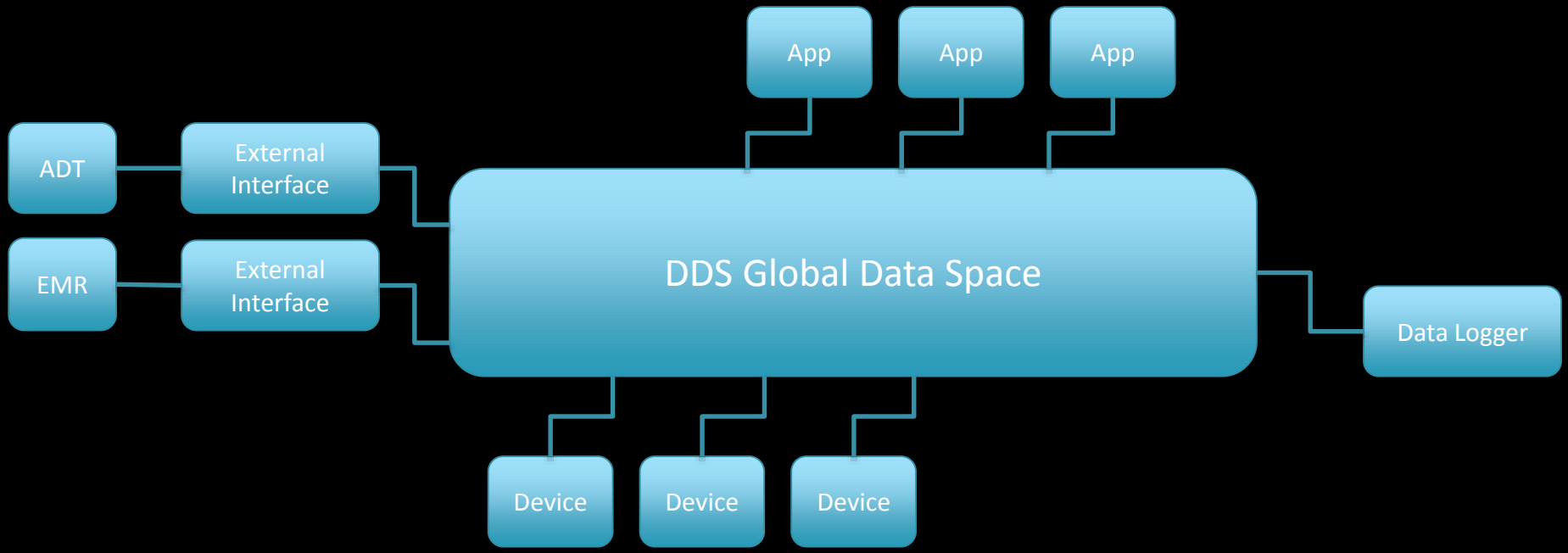
-- DocBox Founder, Tracy Rausch

Industry Interoperation

- The Integrated Clinical Environment (ICE) standard specifies interoperability for medical devices
- All ICU & operating room devices — from blood pressure cuffs to intravenous pumps to ventilators — could be interconnected according to the ICE standard
  - Complete logging
  - Automatic error detection
  - Better care
- The DDS standard and RTI middleware enables plug & play interoperability across manufacturers

ASTM F2761

Data Distribution Service for ICE

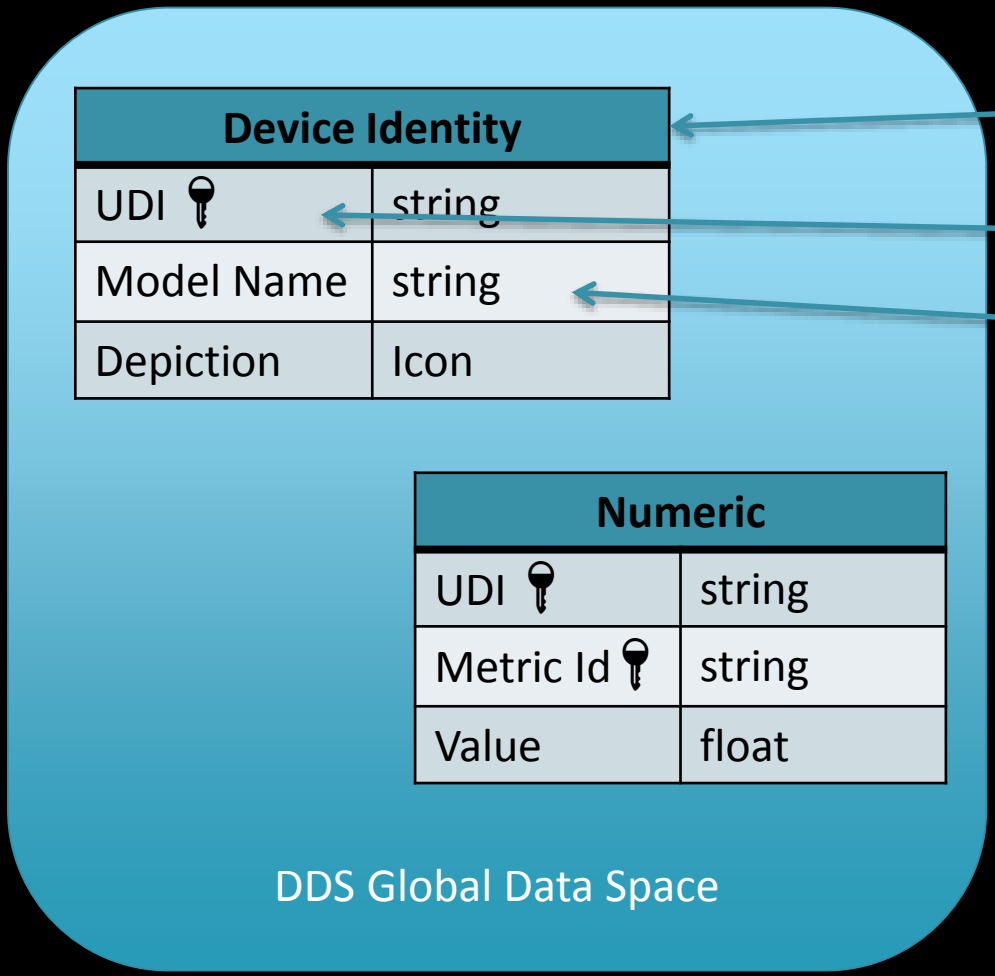


Benefits offered by DDS

- Discovery / Presence
- Data-Centric Information Model / Type Safety (agree to data structure in advance)
  (Distinct from underlying messaging)
- QoS Policy Compatibility Checking / Runtime Enforcement

MD PnP™
Getting connected for patient safety™

DDS Global Data Space



Shared Information Model

Topic – What data is exchanged?

Key – How are unique instances identified?

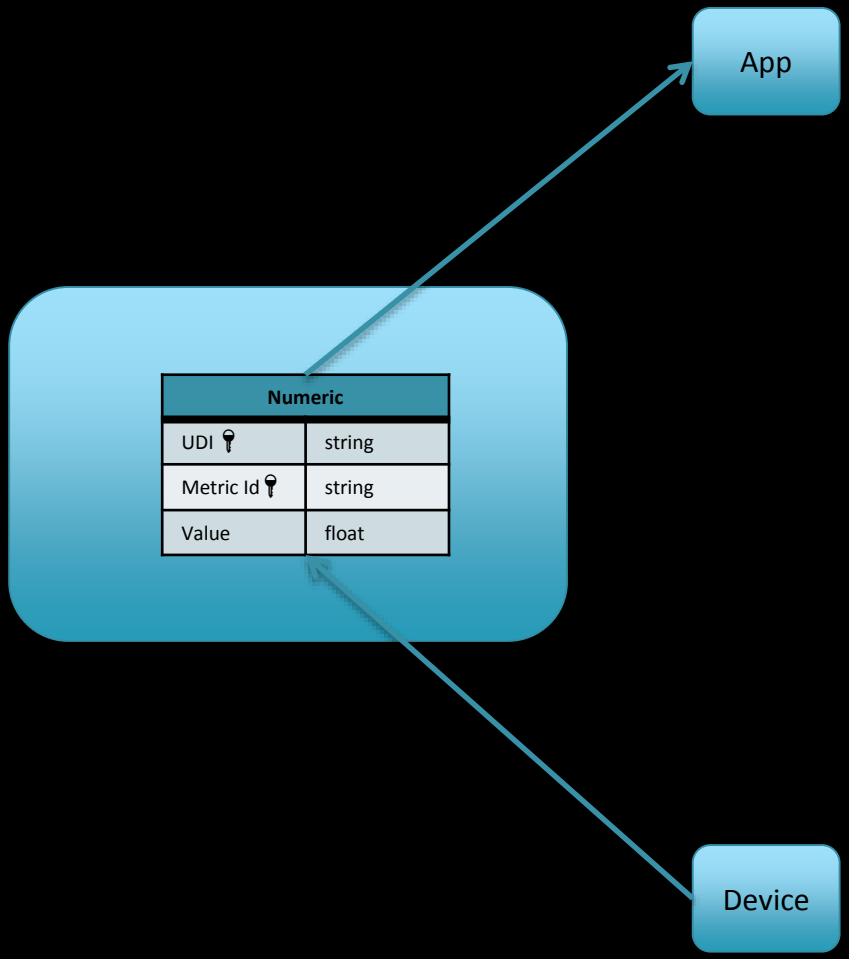
Type – What is the data structure?

QoS – Non-functional policies for data propagation (next slide)

Data-Centric

- DDS standard for *sharing data*
- Supports any OS, languages, transports
- Enforces QoS policies

Quality of Service



- "Match" only when requested and offered policies are compatible
- Mis-matches reported at runtime
- Policy violations reported at runtime

Example

Deadline Policy – Defines the maximum interval between samples

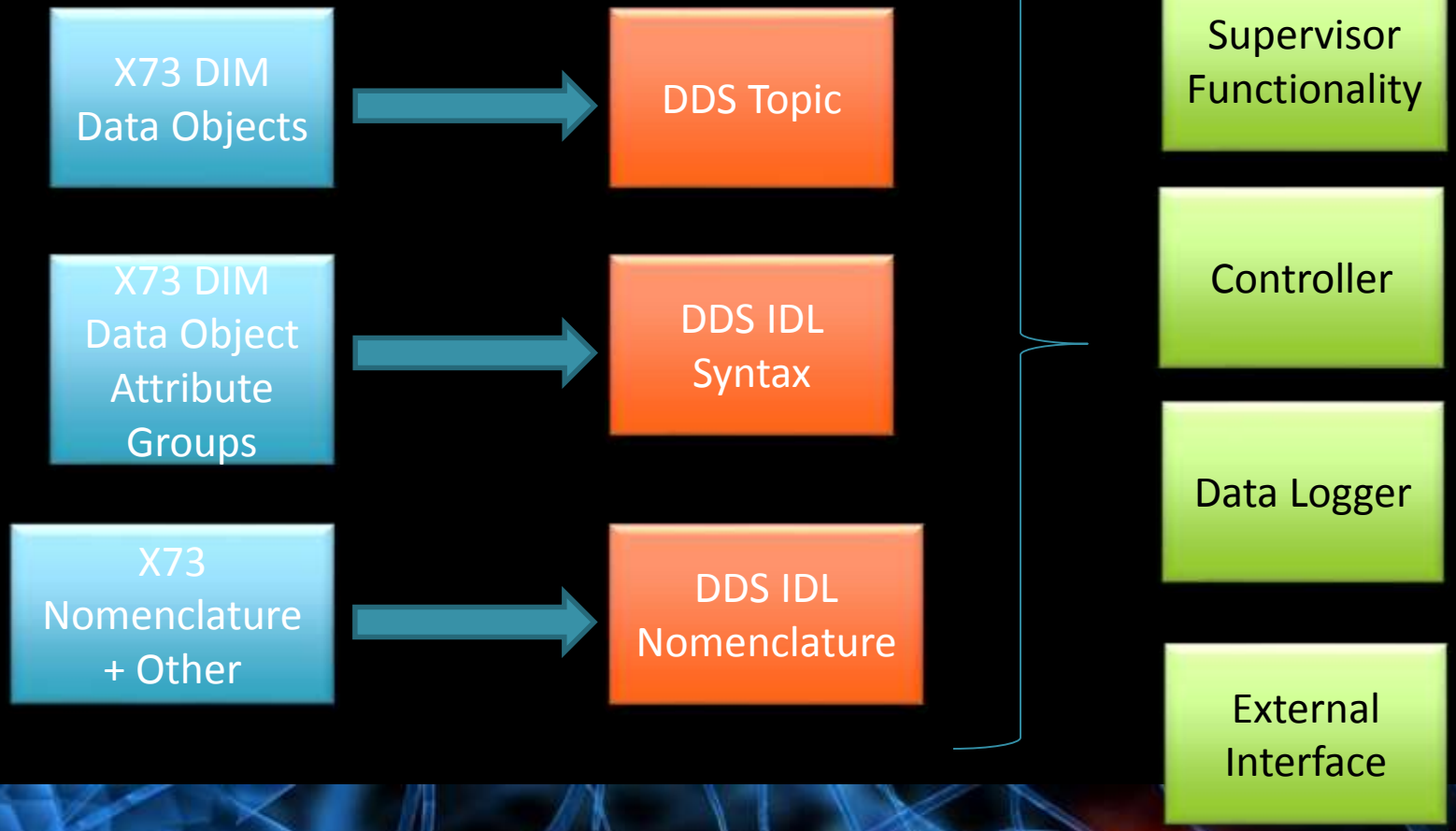
5 seconds Requested, 10 seconds Offered

→ NO Match [data is too old]

5 seconds Requested, 2 seconds Offered

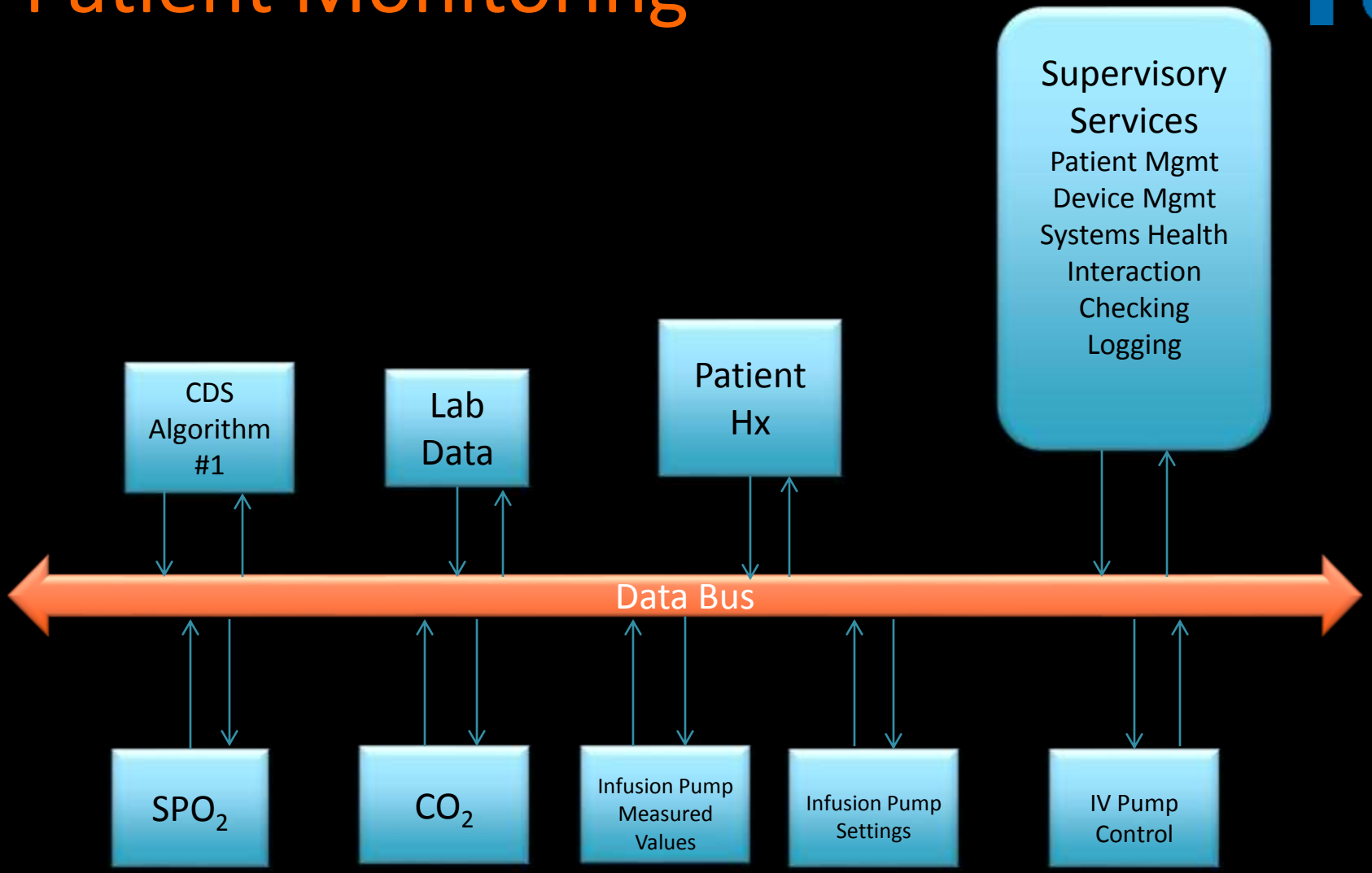
→ Match [data is current]

OMG DDS + IEEE 11073 + ASTM F2761

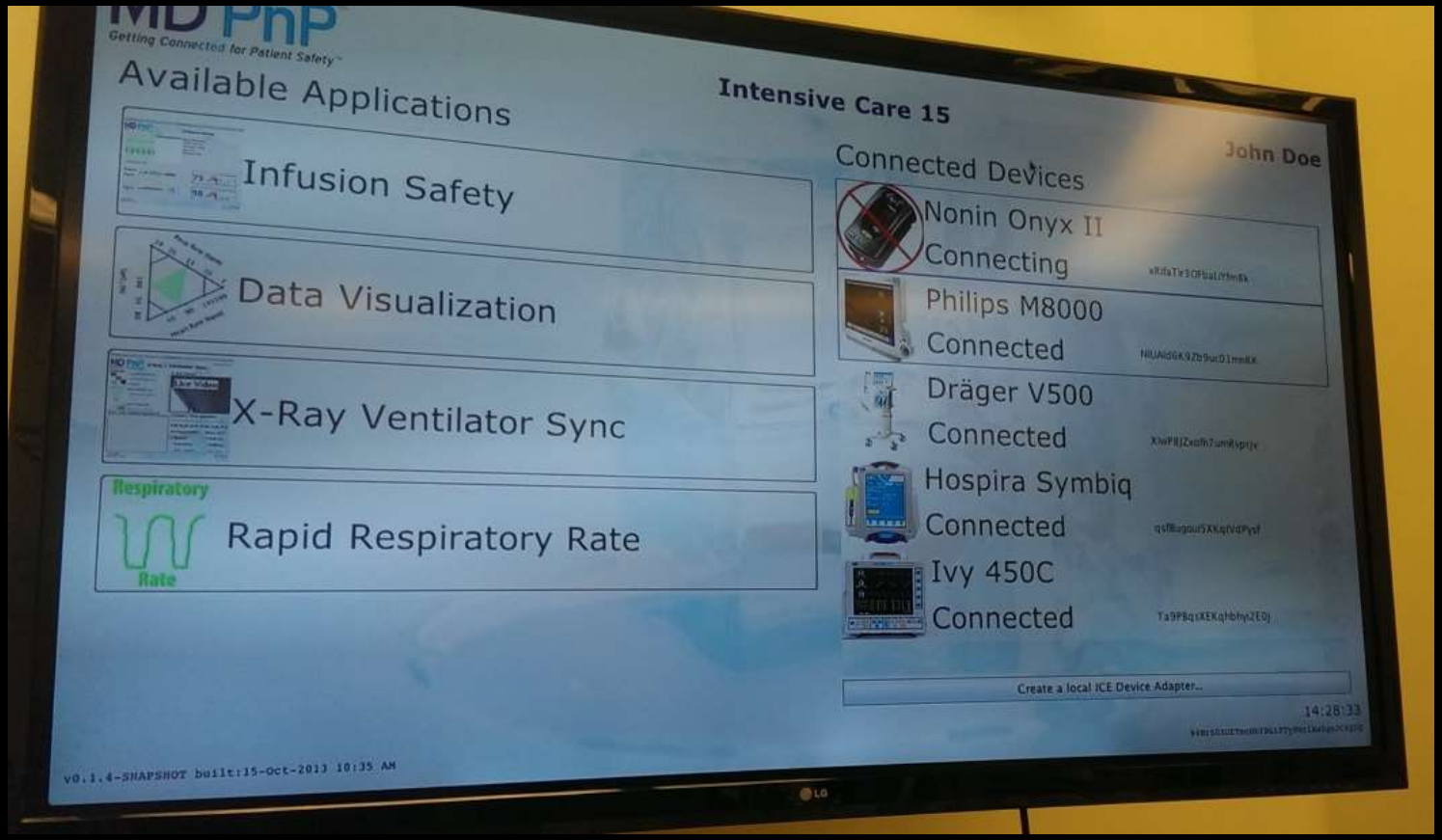


(a lot of work remai

Patient Monitoring

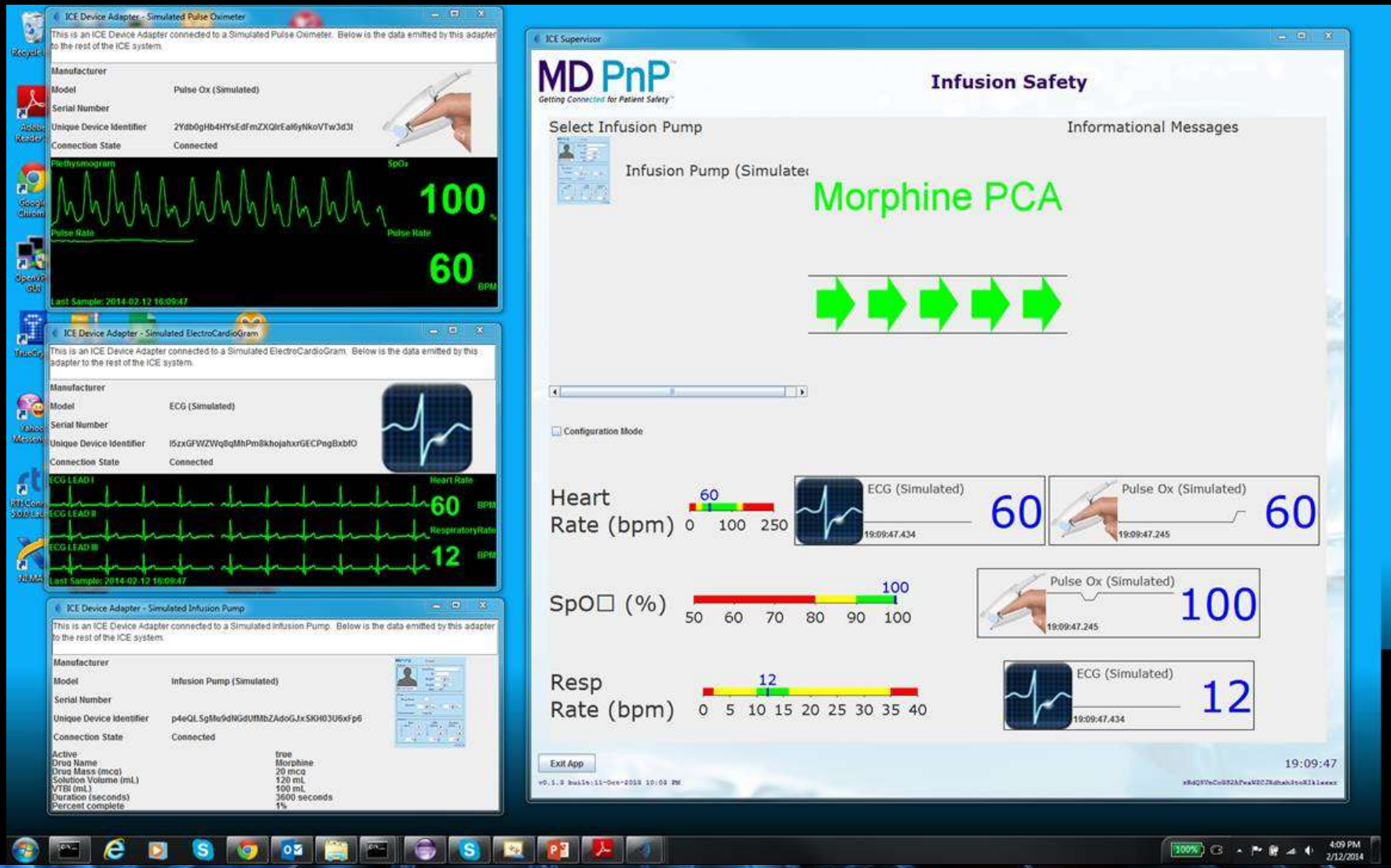


CIMIT ICE Interface

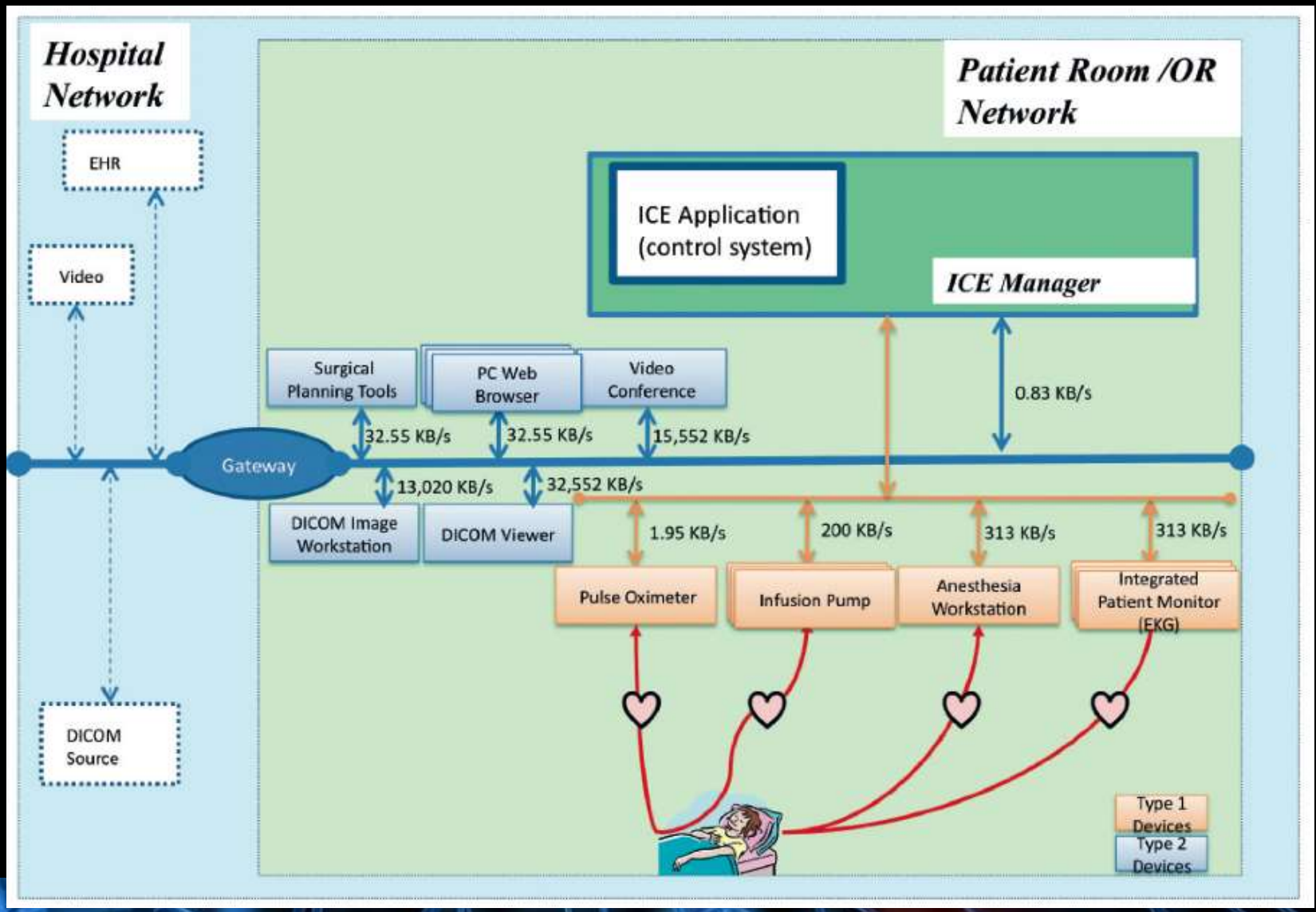


Center for Integration of Medicine and Innovative Technology (CIMIT)
See MDPnP.org & docboxinc.com

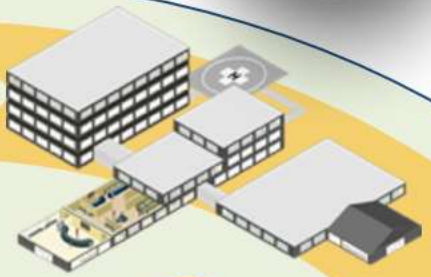
Infusion Safety (PCA) App



Patient Monitoring: ICE



CLOUD



2 Robot: Randall needs Medical help alerts 911

3 ER - Smart alarms utilize cloud data and EHR

4 Surgery – all data available

Robot dispatch And 911

EHR

Home Monitor

Data logger

PCP

Cloud

1 Fall Detected at home Randall doesn't get up

HOME

6 Safety Certification of interoperability

5 Pain meds: Reduce risk of injury and false alarms

7 Real-time blue button

9 Discharge

Device/Genomic Prescription CDS 8

NOTE:

this graphic depicts a mix of current and planned capabilities.

SMART AMERICA

PRESIDENTIAL INNOVATION FELLOWS

Inter-Vehicle Communications

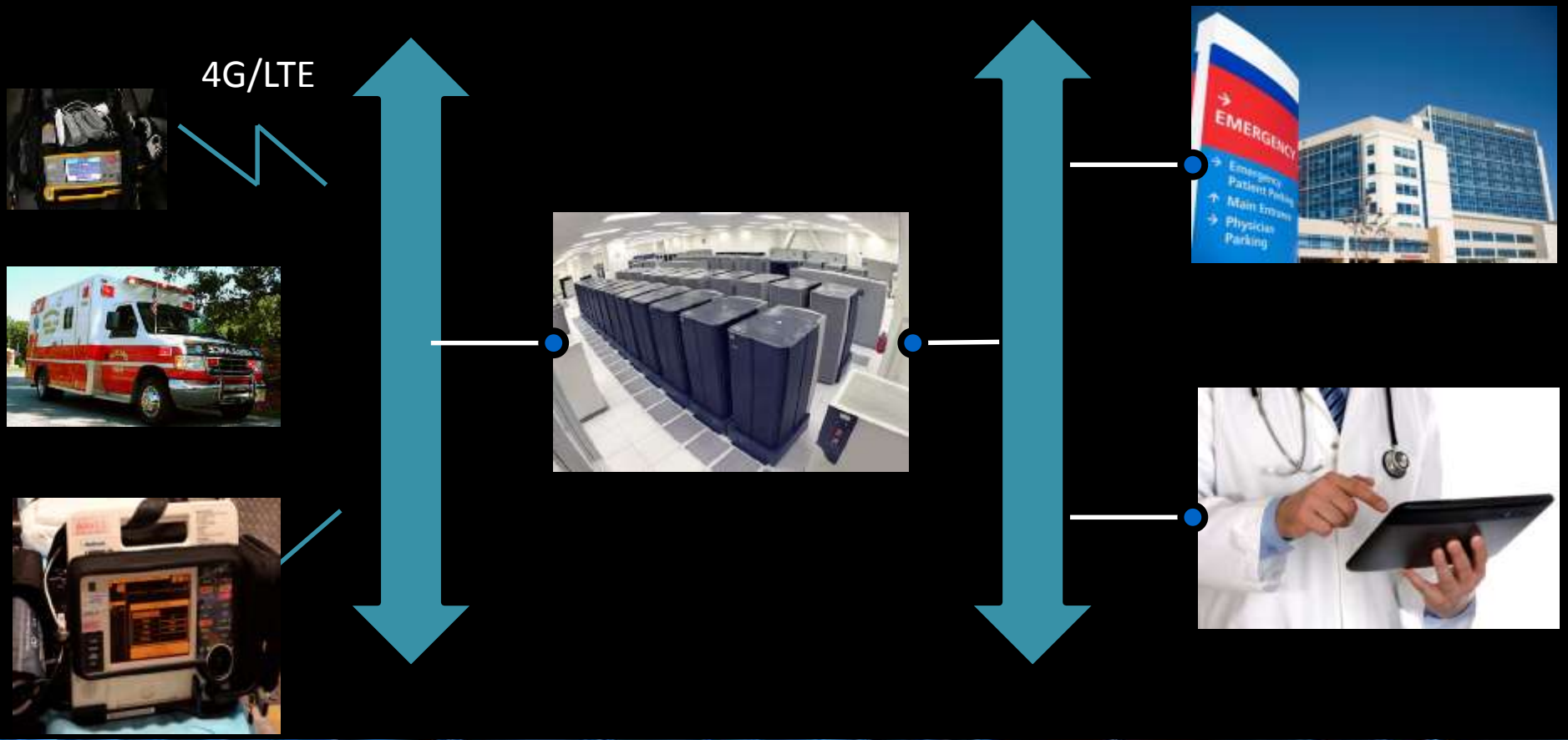
- Exelis (ITT) C4i provides command and control systems for military and civilian agencies (fire/police/emergency response)
- RTI Connext DDS connects GUIs to servers that route voice and video
- RTI met the critical needs: scalability, routing, recording

EMS Device Integration Platform

- The largest EMS equipment provider supplies emergency response equipment to 60% of the world's emergency vehicles
- Uses RTI middleware for mobile device bus, in-vehicle platform, cloud connectivity

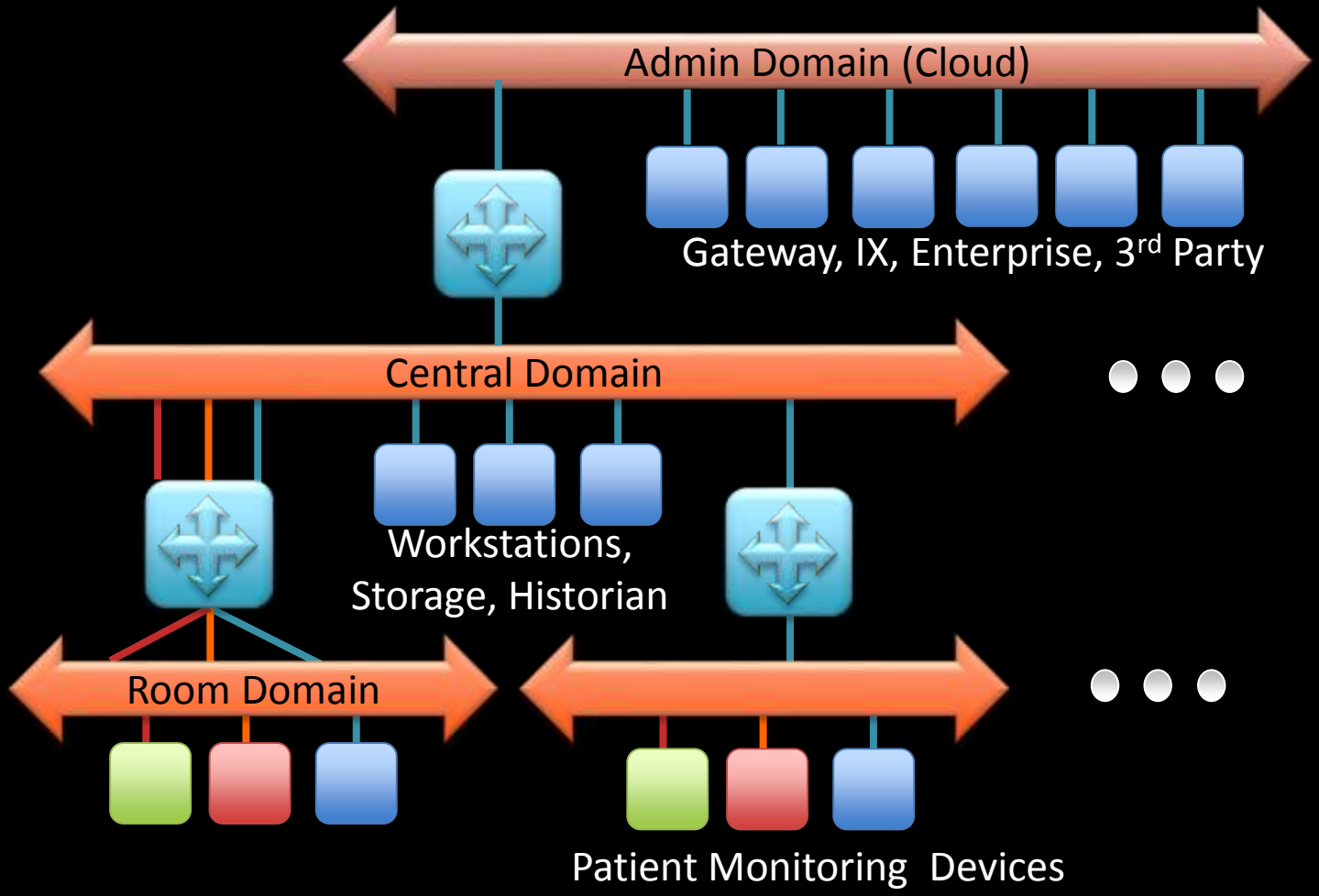
EMS Cloud Integration

Connecting devices with hospitals to provide better treatment while en-route

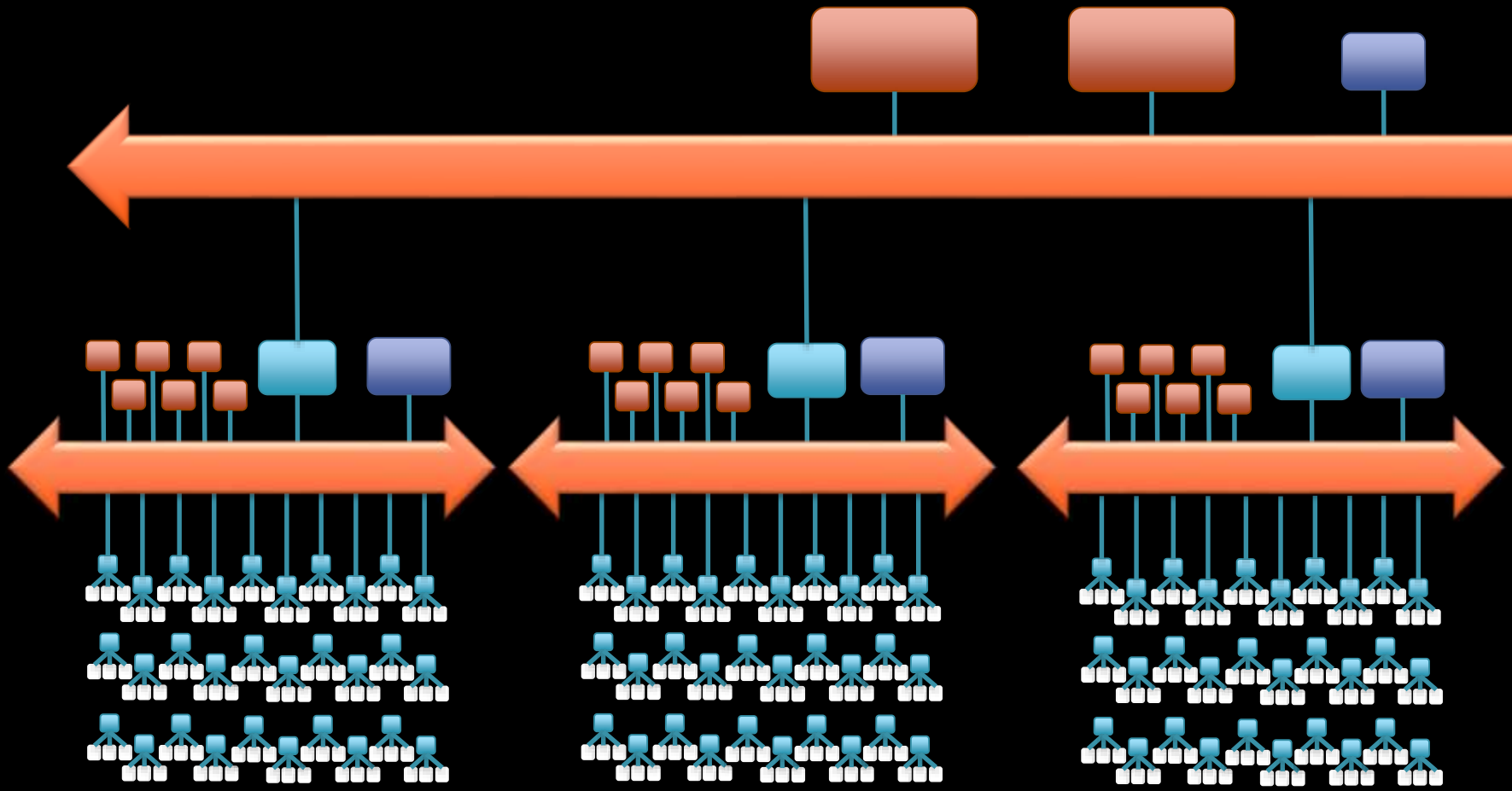


Hospital Integration

CDS Data Architecture

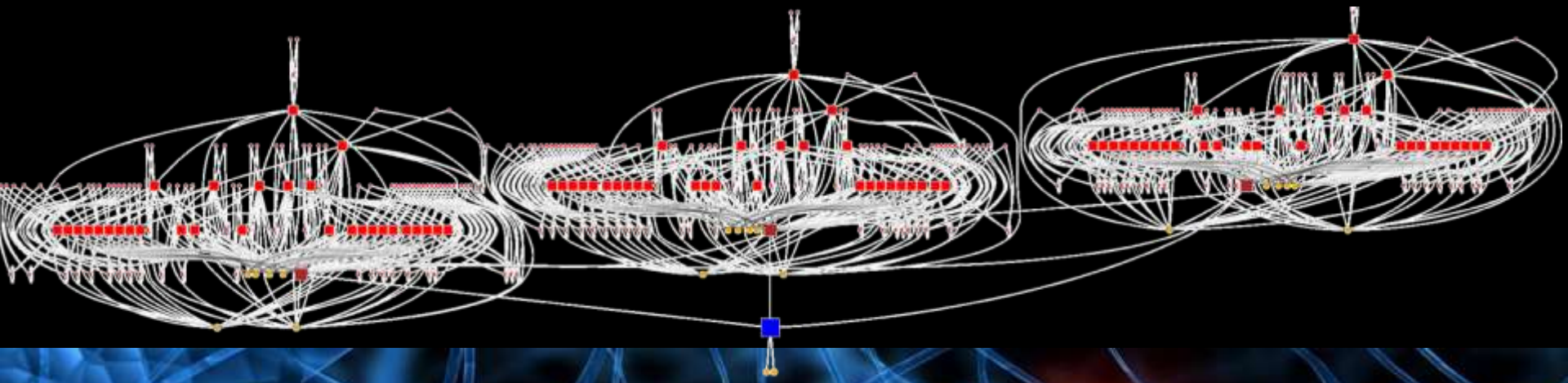


CDS System of Systems



Hospital Integration Data Challenges

- Hospital net challenge
  - 1000s of patients, >100k devices
  - Wired/wireless/ISM
  - Moving patients
  - 100% uptime, security
  - Real-time waveforms
- RTI DDS technology
  - Data centric addressing
  - Smart data filtering
  - Routed deployment
  - Optimized updates
  - Automated test harness

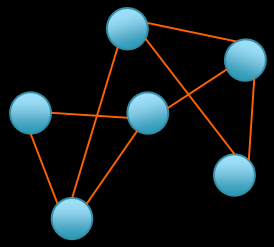


How Can Things Do Those Things?

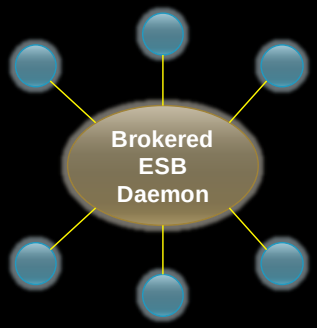
Technology

Types of Middleware

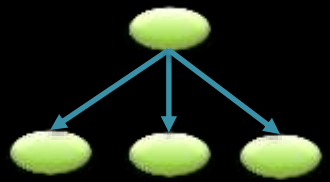
Point-to-Point



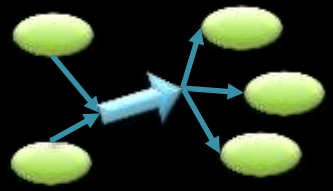
Client/Server



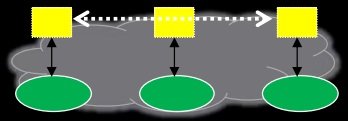
Publish/Subscribe



Queuing



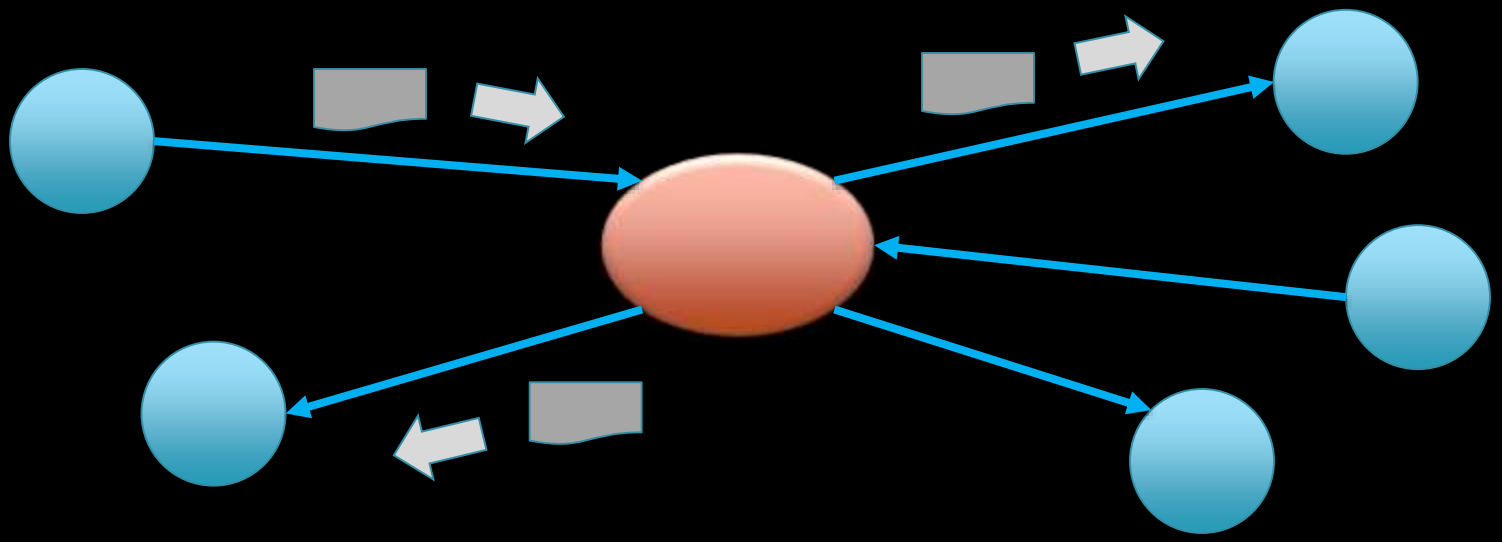
Data-Centric



Data-Centric
Publish/Subscribe (DCPS)
DataBus

Message Centric Approach

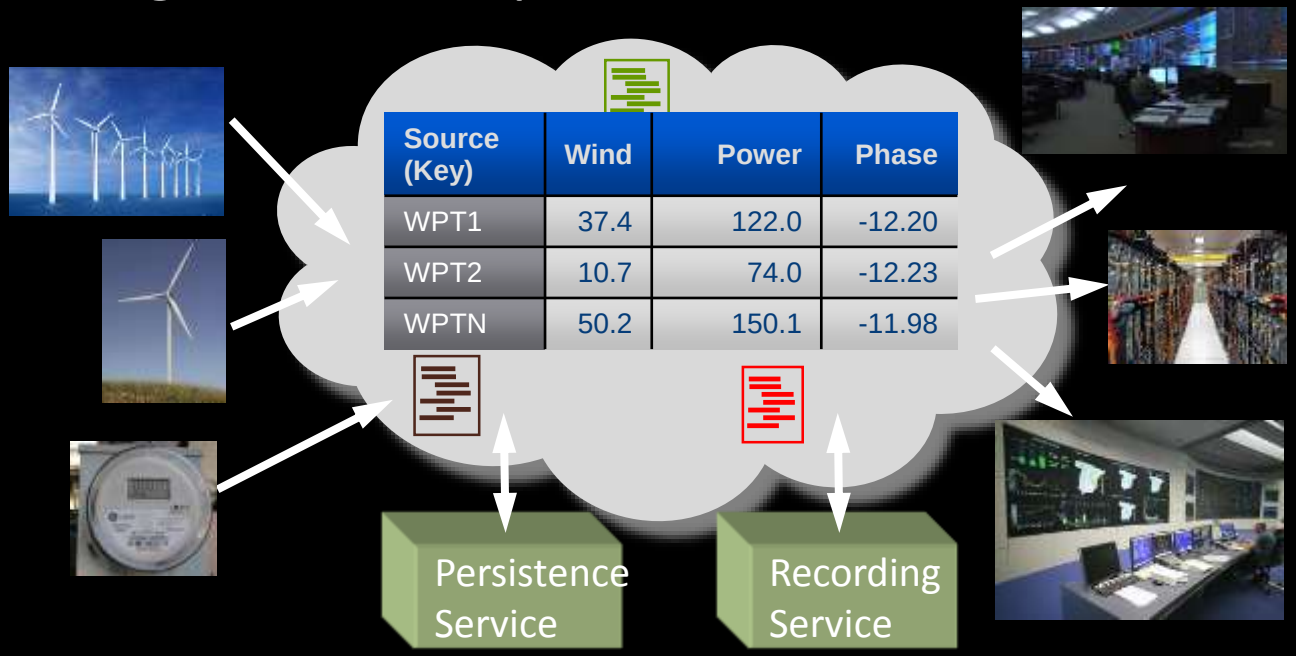
- Traditional middleware exchanges messages
- Infrastructure is unaware of the content
- Developers write applications that send messages between participants



Popular standards: JMS API; AMQP wire spec

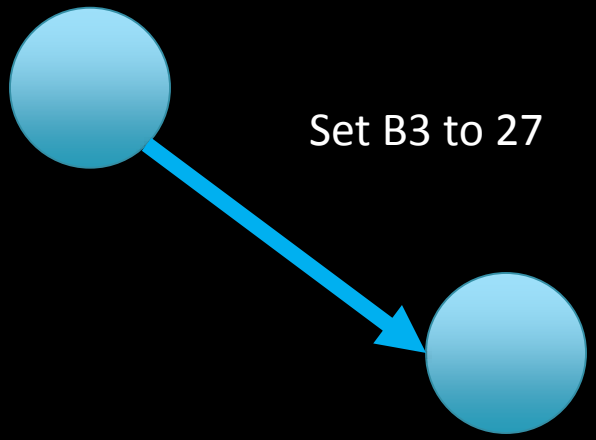
Data Centric Approach

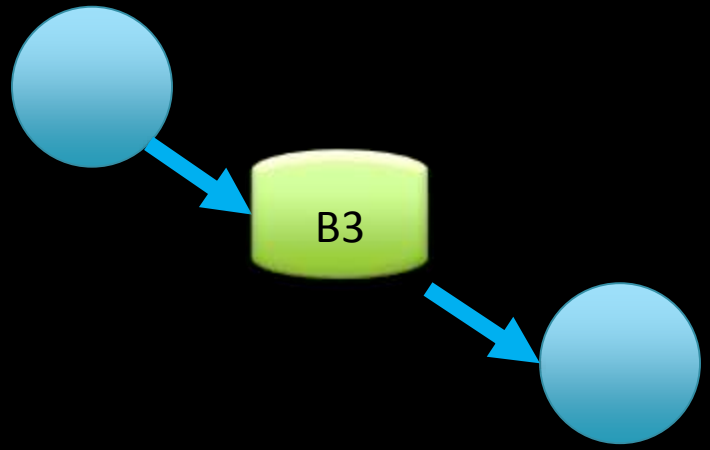
- Data-centric middleware maintains state
- Infrastructure manages the content
- Developers write applications that read and update a virtual global data space



Popular standards: DDS API, wire spec

Coupling





- Verb-based: applications interact with each other
- Noun-based: applications interact with data model

Managing State

- Data centric
  - Single version of truth enables interoperation
  - Content-aware infrastructure eases integration
  - Clear rules for access, changes, updates tame complexity
- Technologies
  - Database
  - Data-centric middleware

QoS: Quality of Service

QoS Policy	QoS Policy
DURABILITY	USER DATA
HISTORY	TOPIC DATA
READER DATA LIFECYCLE	GROUP DATA
WRITER DATA LIFECYCLE	PARTITION
LIFESPAN	PRESENTATION
ENTITY FACTORY	DESTINATION ORDER
RESOURCE LIMITS	OWNERSHIP
RELIABILITY	OWNERSHIP STRENGTH
TIME BASED FILTER	LIVELINESS
DEADLINE	LATENCY BUDGET
CONTENT FILTERS	TRANSPORT PRIORITY

Volatility

Infrastructure

Delivery

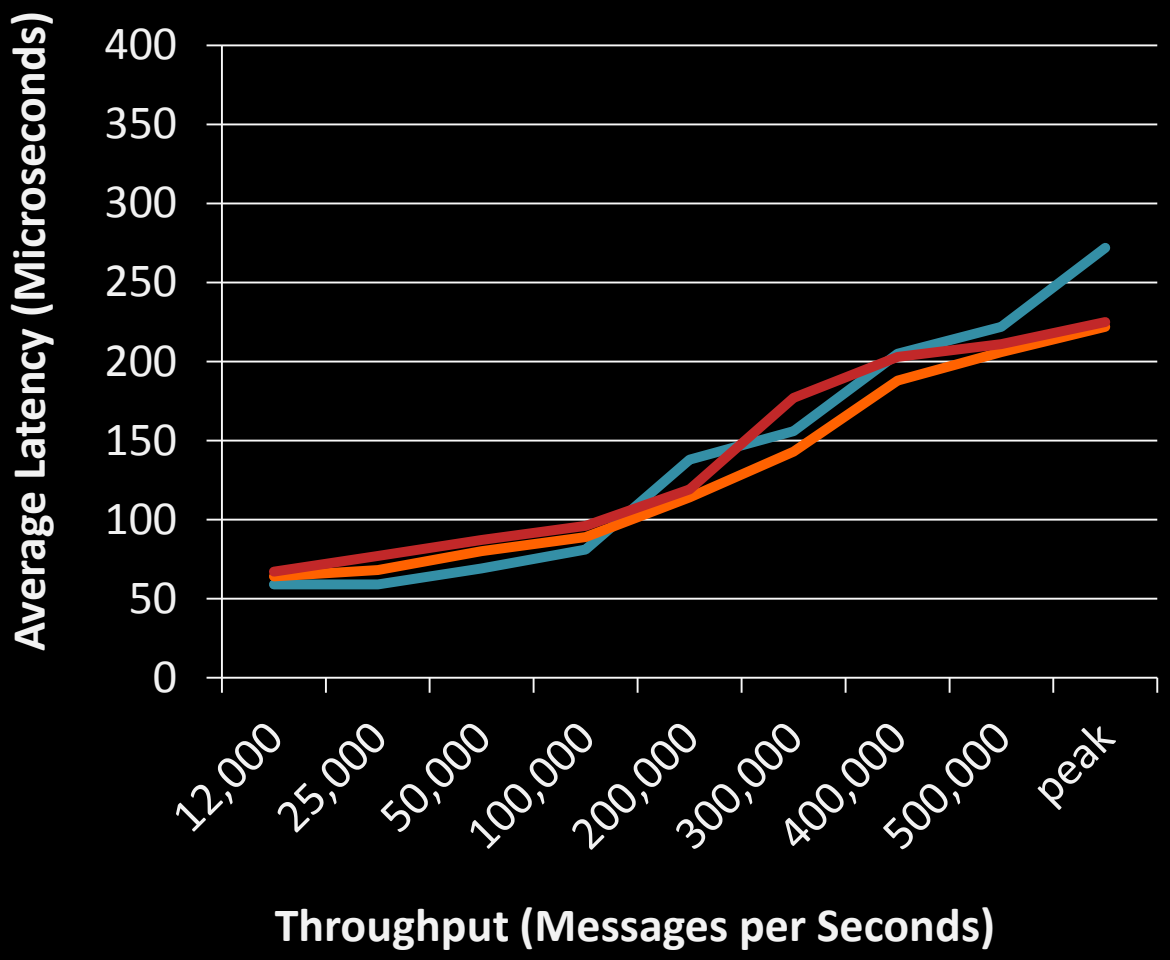
User QoS

Presentation

Redundancy

Transport

Performance Under Load

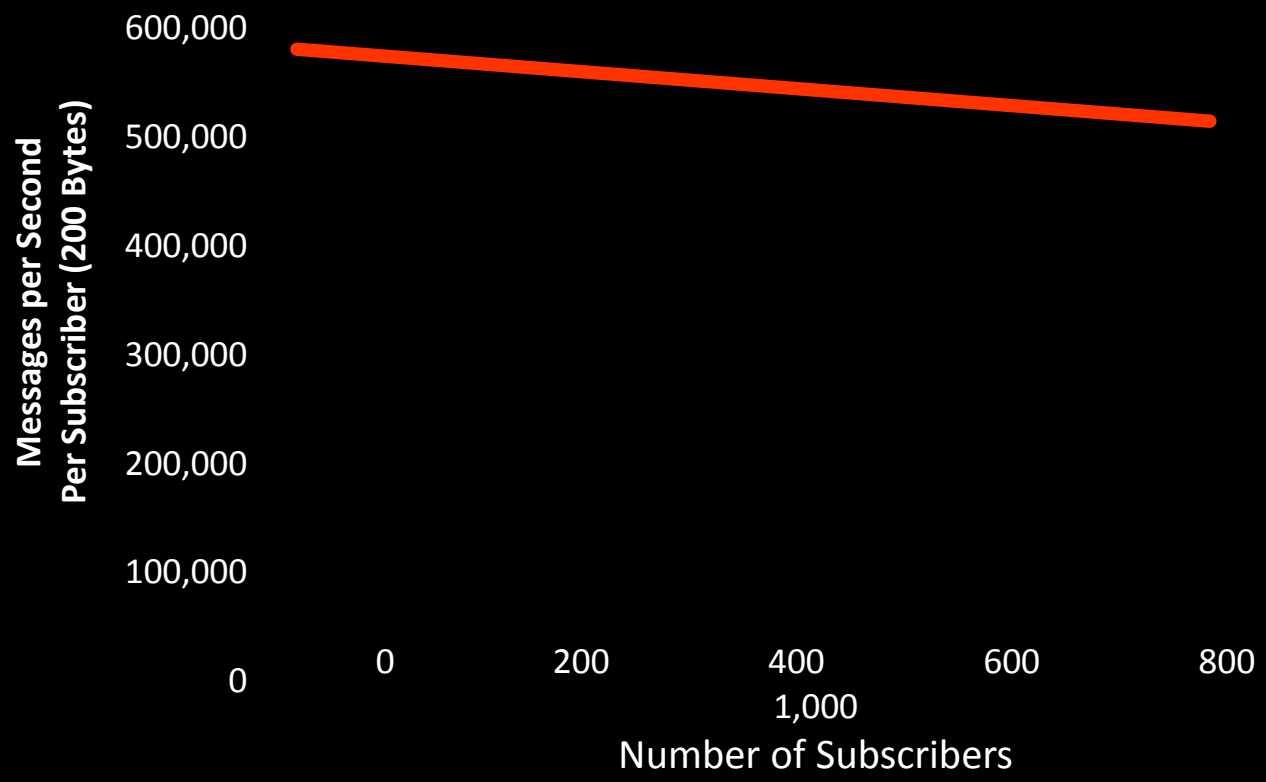


- Reliable multicast
- Fully meshed, reliable

Orders of magnitude faster than IT solutions
Fastest DDS solution

Comprehensive results online at www.rti.com

Reliable Multicast



- *Millions of data elements*
- *.5m updates/sec (batched)*
- *10s µs latency*
- *1000s of consumers*

1 → ~1000 subscribers, < 15% throughput decrease

End-to-End DataBus

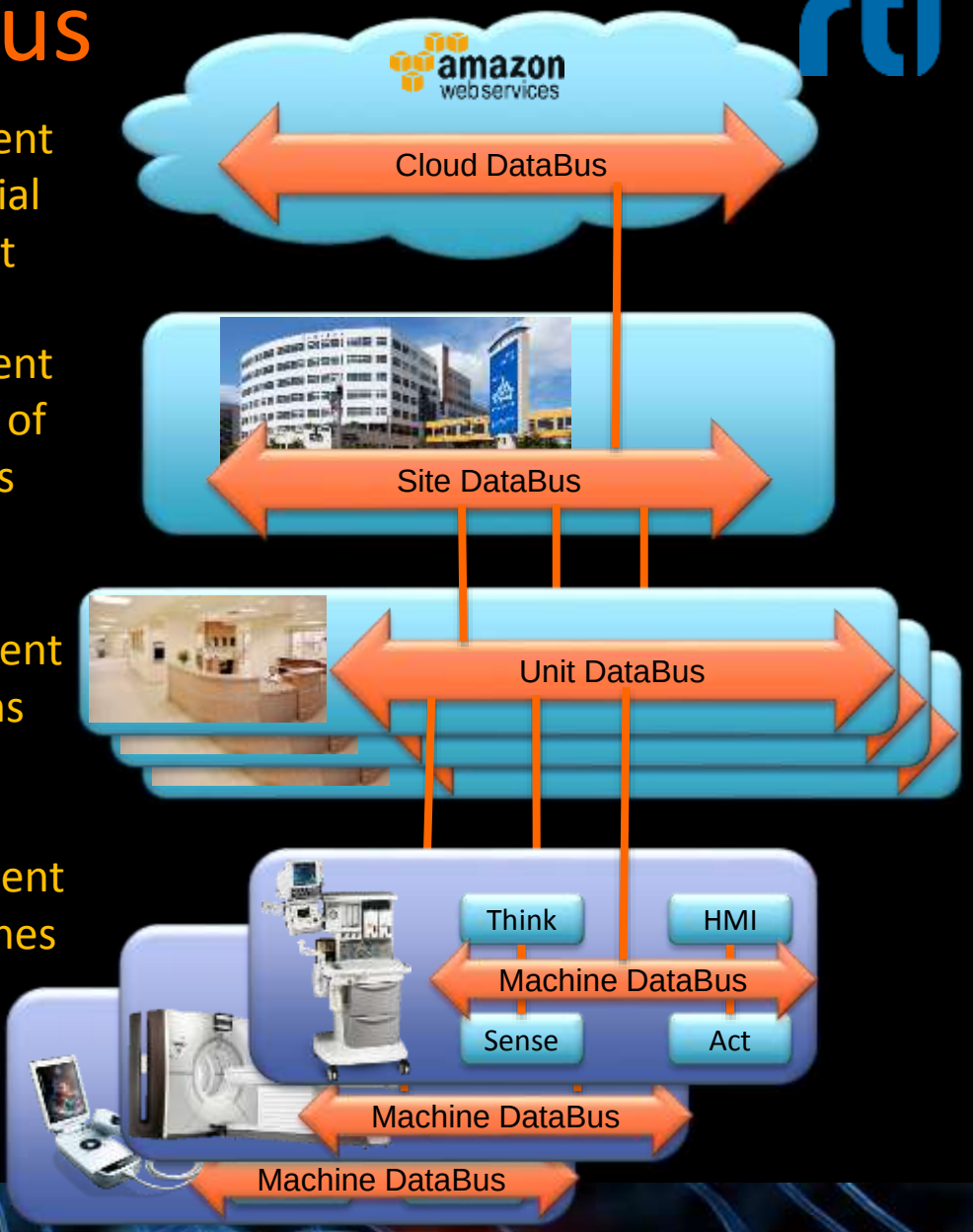
- Connect…
  - Fast
  - Seamless
  - QoS controlled
  - Secure
  - Data centric
- …80 Platforms…
  - Micro controllers
  - Certified systems
  - Embedded
  - Mobile
  - Desktop
  - Cloud
- …over 12 Transports
  - UDP or TCP
  - D/TLS (secure)
  - Wireless or wired
  - Shared memory
  - Backplane
  - Cloud virtual connect

Intelligent Industrial Internet

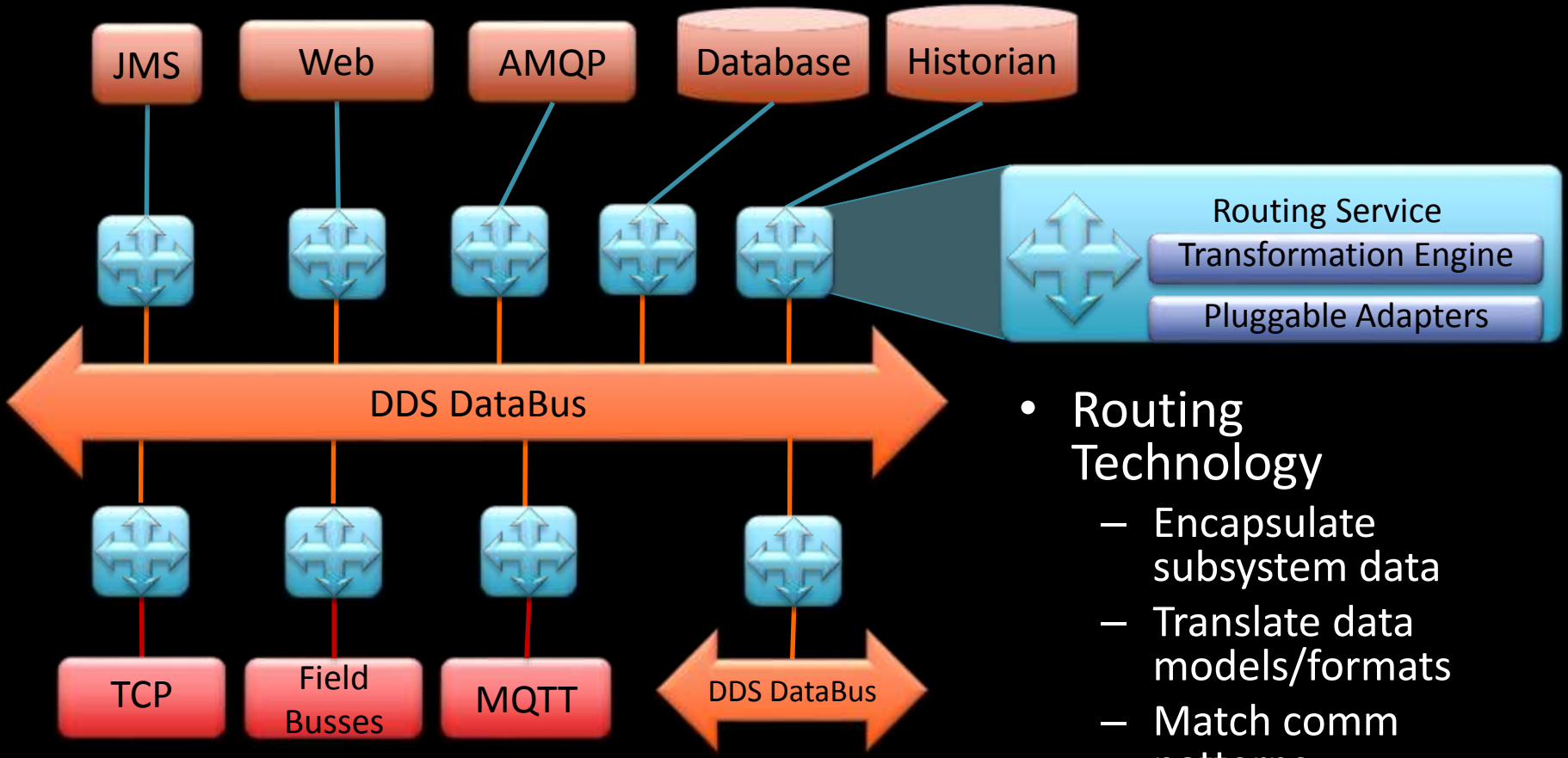
Intelligent System of Systems

Intelligent Systems

Intelligent Machines

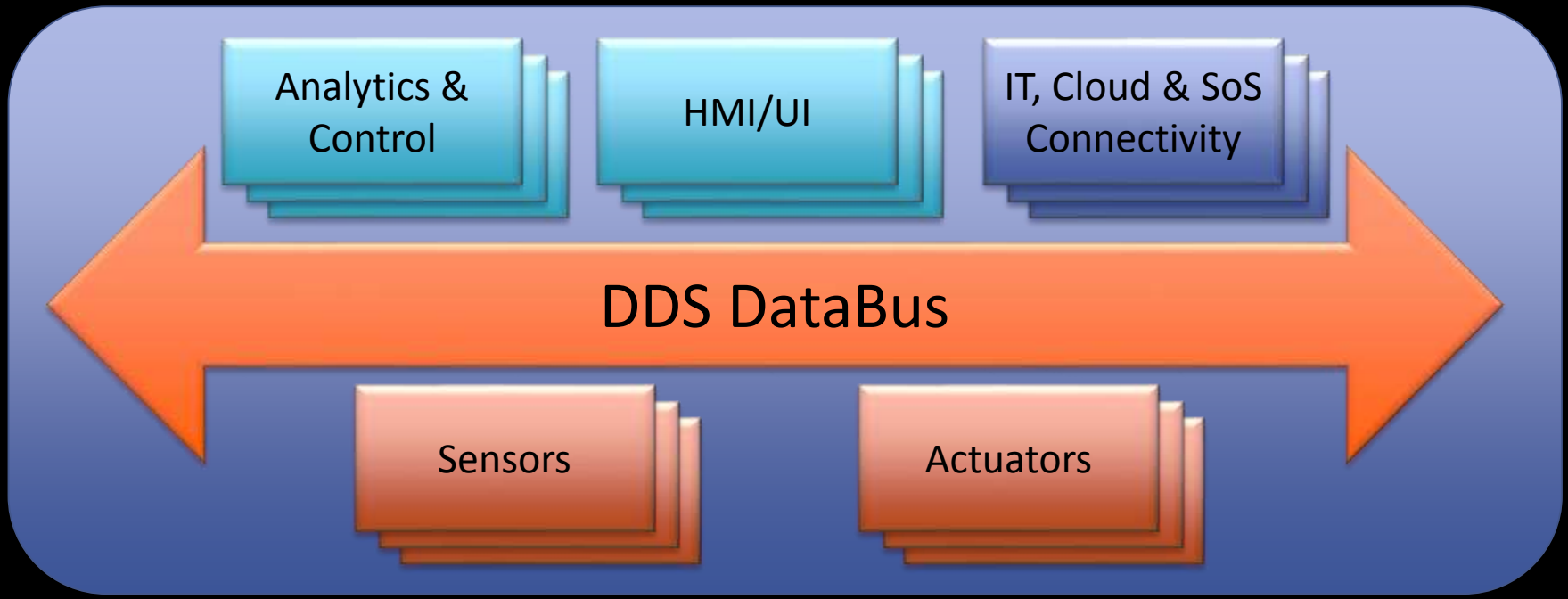


Route to Build Complete Hierarchy

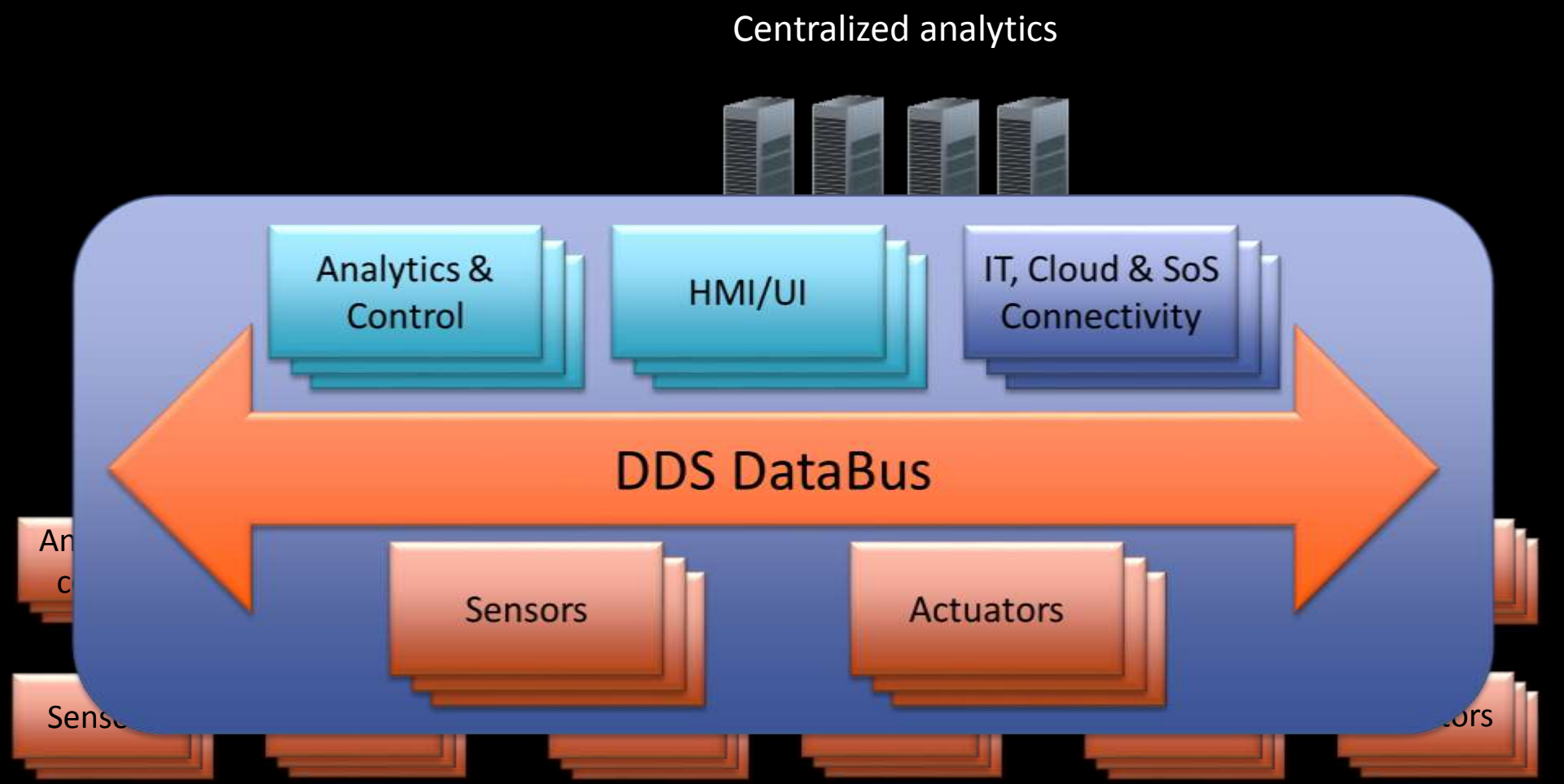


- Routing Technology
  - Encapsulate subsystem data
  - Translate data models/formats
  - Match comm patterns

Strive For: One Logical Dataspace…



…Hiding Complex Network Topologies



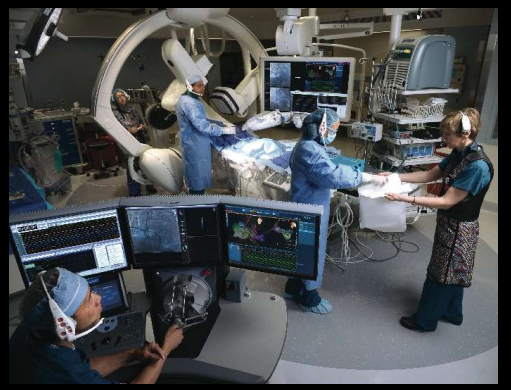
Choose DDS If…

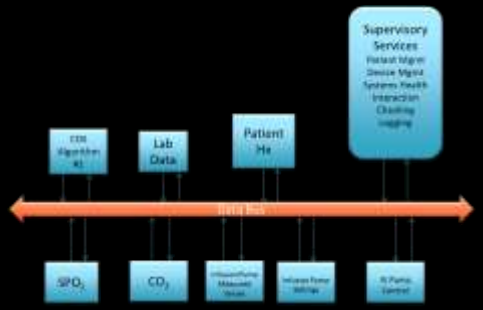
- Disaster if offline for 5 minutes?
- Measure performance in ms or us? Or scale >100+ applications? Or 10k+ data values?
- Code active lifetime >3 yrs?

- 2 or 3 => DDS

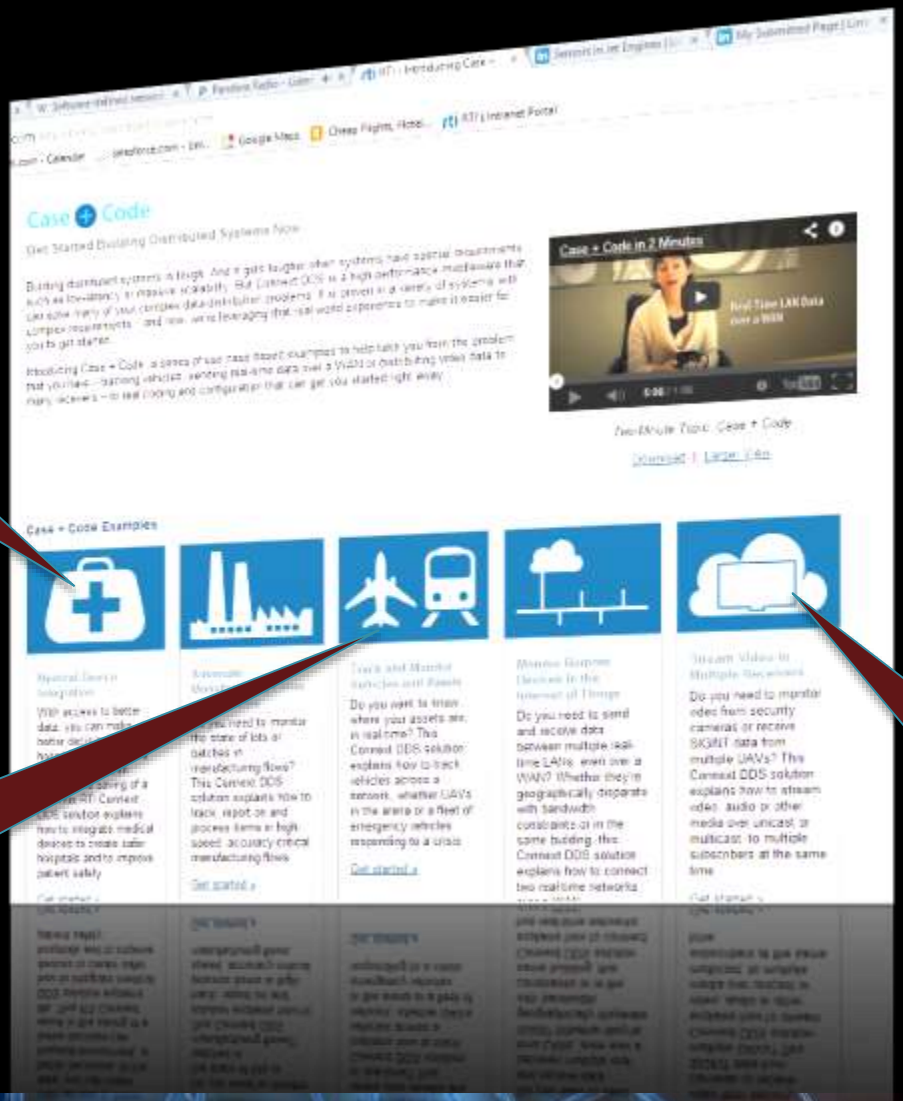
DDS in Medical

- Imaging & Treatment Systems
  - Compelling problem: fast device integration
- Surgical Systems
  - Compelling problem: feedback, video, patient monitoring
- Connected Medical Devices
  - Compelling problem: Patient safety, multi-device platform, hospital integration





Connext Case + Code



The Future of Medicine

- Connected
  - Local, hospital, cloud
- Capable
  - Real-time waveforms
  - Location transparency
  - Vendor plug-n-play
- Systems-level thinking

Systems-Level Communications

- Reliable Operation
- Real-Time Delivery
- System of Systems Integration
- Connect any OS, Language, Transport
- Crisp Interface Design
- Easy Tech Upgrades
- Multi-Channel Flow
- Plug & Play Discovery
- Open Architecture
- Wireless Links
- Fine-Grain Security
- Physics-Speed Response
- Scalability
- Database Integration
- High Throughput
- Hyper-Efficient Filtering
- Reliable Uptime
- System Evolution Support
- Small Device Connection
- Safety-Critical Certification
- Large Fan In/Out
- Real-Time and IT Integration
- Standards Based

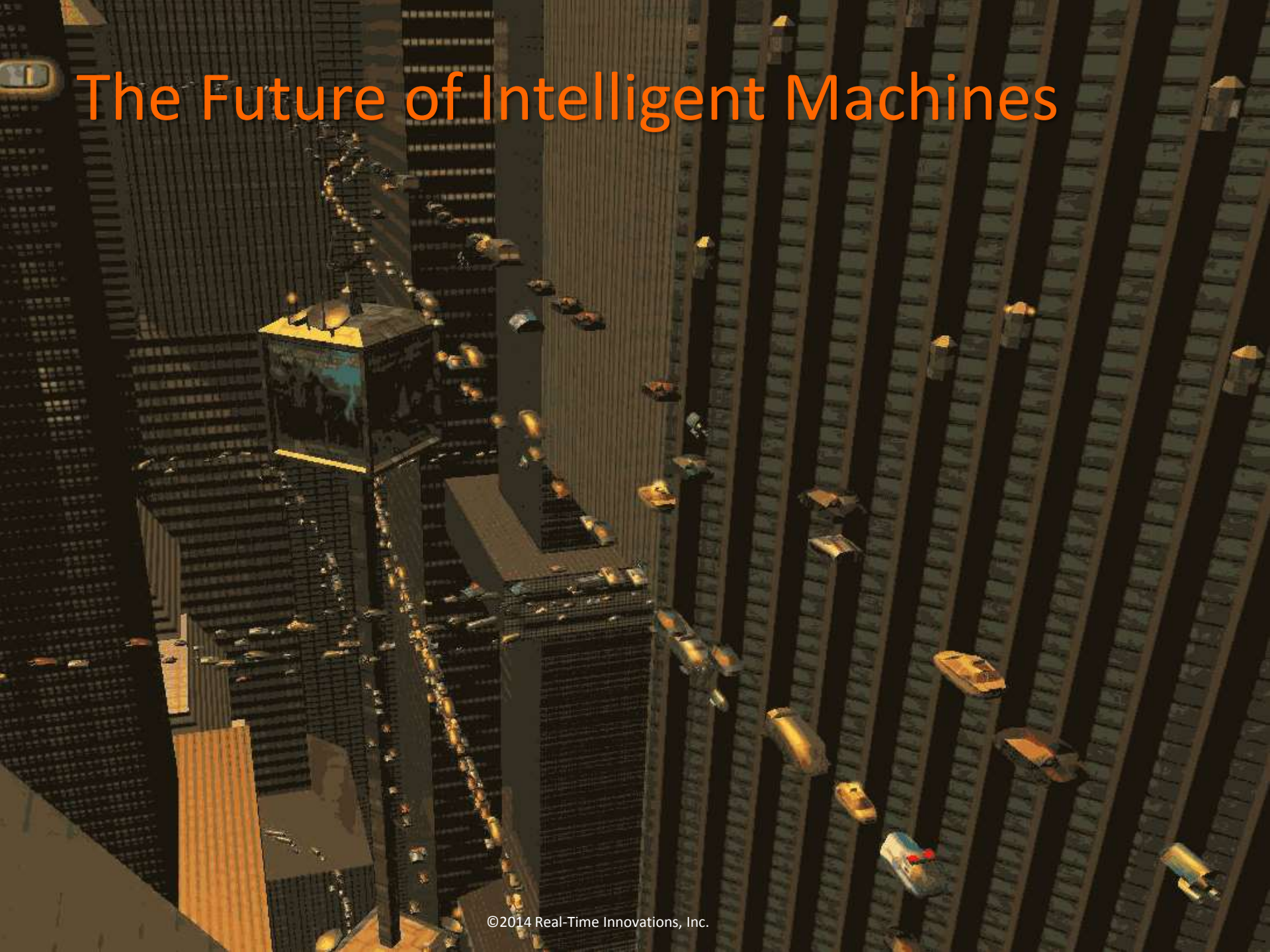
About RTI

- Market Leader
  - Over 70% DDS mw market share[1]
  - Largest embedded middleware vendor[2]
  - 2013 Gartner Cool Vendor for technology *and* Open Community Source model
- Standards Leader
  - Active in 15 standards efforts
  - OMG Board of Directors
  - DDS authors, chair, wire spec, security, more
  - Launch member of Industrial Internet Consortium
- Real-Time Pedigree
  - Founded by Stanford researchers
  - High-performance control, tools history
- Maturity Leader
  - 750+ designs; by far the most-used DDS
  - Used in TRL 9 systems

[1]*Embedded Market Forecasters*
[2]*VDC Analyst Report*

Global Support and Distribution

The Future of Intelligent Machines



Some Resources

- Papers, C+C, community: www.rti.com
- Wired article: http://blogs.rti.com/2013/11/18/a-day-in-your-life-with-the-internet-of-things/
- EDN on patient safety: http://electronicdesign.com/communications/internet-things-can-save-50000-lives-year
- PBRT system: http://www.barnesjewish.org/news/?id=5032&sid=2&nid=3068
- Video: http://goo.gl/WnO5LE