Your systems.
Working as one.

DDS - The Proven Data Connectivity Standard for the Industrial IoT (IIoT)

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Co-chair OMG DDS SIG

September 2016

The *Industrial* IoT is Smart Machine Infrastructure

Consumer Internet of Things (CIoT)

Industrial Internet of Things (IIoT)

Industrial IoT Key System Characteristics

Large scale, heterogeneous, built with multi-vendor components, often broadly distributed and evolving

- Reliability
- Scalability
- Safety
- Security
- Resiliency









Increased Technical Challenges

- Rapid evolution
- Heterogeneous systems
- Complex dataflows
- Robustness, Availability
- Scalability
- Security, Safety, and Certification
- Software dominates a (formerly) mechanical world

The Industry is facing disruption

IIoT Transformations

What Drives IIoT Systems across Industries?

The IIoT Disruption

Common technology that spans industries brings bold new approaches and enables fast change

The real value is a common architecture that connects sensor to cloud, interoperates between vendors, and spans industries

industrial internet CONSORTIUM

240+ companies strong

Goal: build and prove a common architecture that spans sensor to cloud, interoperates between vendors, and works across industries

Industrial Internet Consortium (IIC)

The goal of the IIC is to drive innovation through better integration of the physical and digital worlds.

Testbeds
Innovation to drive new products, processes, services

Technology & Security
Architectural frameworks, standards requirements, interoperability, use cases, privacy & security of Big Data

Community
Companies joining together to advance innovation, ideas, best practices, thought leadership and insights

Source: http://iiconsortium.org/tx-14/presentations/Soley_Opening_Keynote-9-15-14.pdf

IIC Members

As of April 2016

240+ Companies, 25 Countries

Apple and Google Dominat

www.forbes.com/sites/brucerogers/2014/07/08/apple-and-google-dominate-internet-of-things-influence-with-home-automation-efforts/

Apps Main www.omg.org/issues MIT OCW Video Lectures | Stru

Forbes | PayPal's Braintree Moves To Be The Cash Register For Every App *Active on LinkedIn* | Search companies, people and lists

Bruce Rogers
Forbes Staff

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Comment Now

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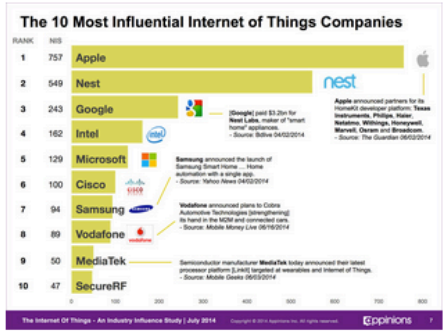
LEADERSHIP 7/08/2014 @ 8:52AM | 3,774 views

Apple and Google Dominate 'Internet of Things' Influence with Home Automation Efforts

+ Comment Now + Follow Comments

It's early days for the *Internet of Things*, but the largest technology players are moving quickly to stake out the territory. In just the past month, Apple AAPL +0.04% announced a new 'smart home' platform, and Google GOOGL +0.85% made a similar announcement for Android and purchased Nest for $3.2 billion – moves that pushed both companies quickly to the head of the 'Top 10 Most Influential Companies' in a new Influence Study focusing on the Internet of Things, released today by Appinions.

The study reveals an increase of almost 70% in the volume of influential conversations about IoT between late March and early July. Within this time frame there was activity from Intel (which modified their managerial structures to increase IoT focus), Cisco (who made three strategic investments), Zebra (who purchased Motorola's enterprise business for nearly $3.5 billion), and many others. As the study documents, these moves got a lot of attention and reaction, with influence scores skyrocketing around each announcement.



iOT Top10 Companies

CenturyLink*Voice*: How Mining Data About Employees Could Give

The 10 Most Influential Internet of Things Companies

RANK	NIS	
1	757	Apple
2	549	Nest
3	243	Google
4	162	Intel
5	129	Microsoft
6	100	Cisco
7	94	Samsung
8	89	Vodafone
9	50	MediaTek
10	47	SecureRF

0 100 200 300 400 500 600 700 800

Apple announced partners for its HomeKit developer platform: **Texas Instruments**, **Philips**, **Haier**, **Netatmo**, **Withings**, **Honeywell**, **Marvell**, **Osram** and **Broadcom**.
- *Source: The Guardian 06/02/2014*

[**Google**] paid $3.2bn for **Nest Labs**, maker of "smart home" appliances.
- *Source:* Bdlive 04/02/2014

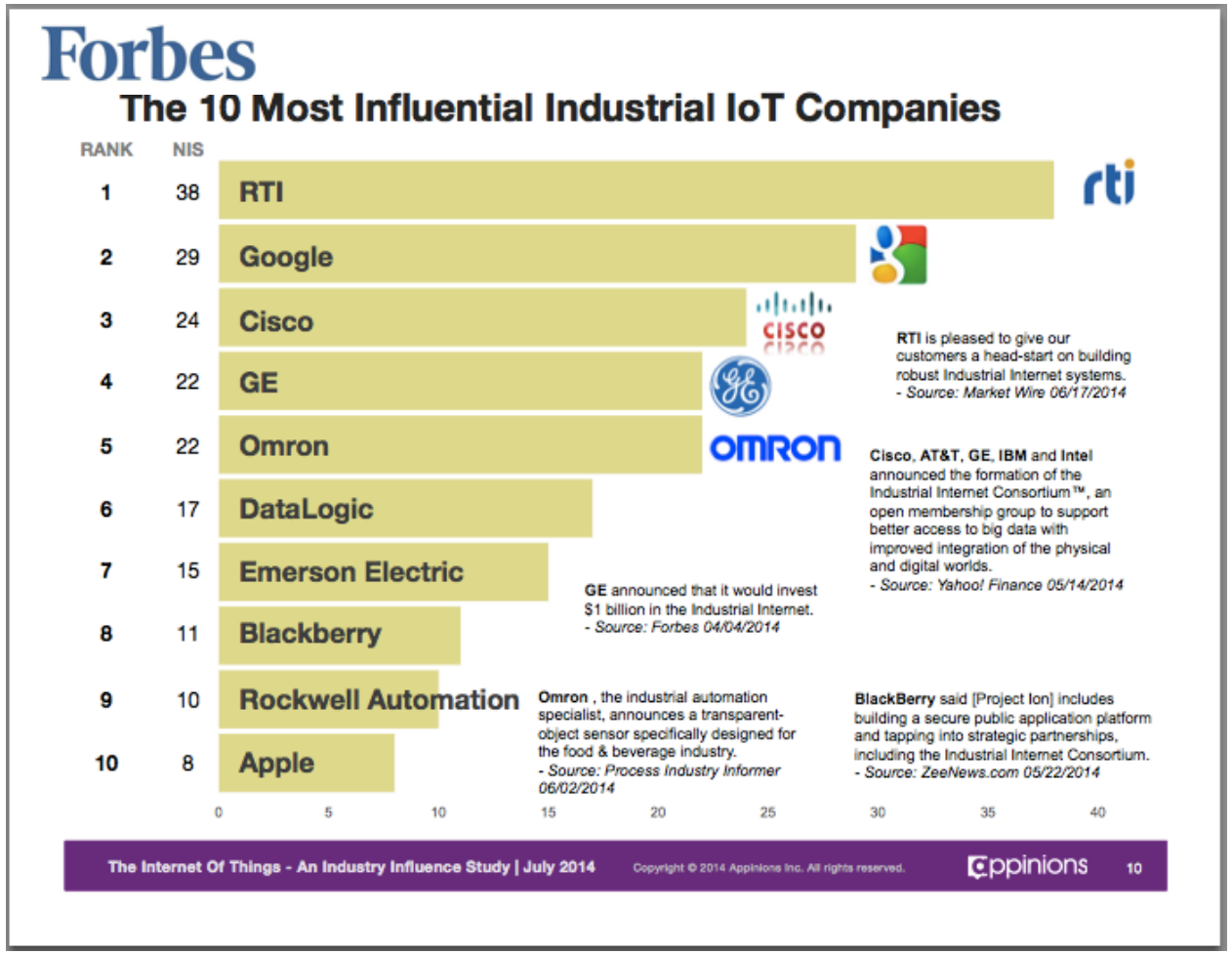
Samsung announced the launch of Samsung Smart Home … Home automation with a single app.
- *Source: Yahoo News 04/02/2014*

Vodafone announced plans to Cobra Automotive Technologies [strengthening] its hand in the M2M and connected cars.
- Source: *Mobile Money Live 06/16/2014*

Semiconductor manufacturer **MediaTek** today announced their latest processor platform [LinkIt] targeted at wearables and Internet of Things.
- *Source: Mobile Geeks 06/03/2014*

The Internet Of Things - An Industry Influence Study | July 2014 Appinions 7

RTI Named Most Influential IIoT Company



RTI's Experience

- ~1000 Projects
  - Healthcare
  - Transportation
  - Communications
  - Energy
  - Industrial
  - Defense
- 15+ Standards & Consortia Efforts
  - Interoperability
  - Multi-vendor ecosystems



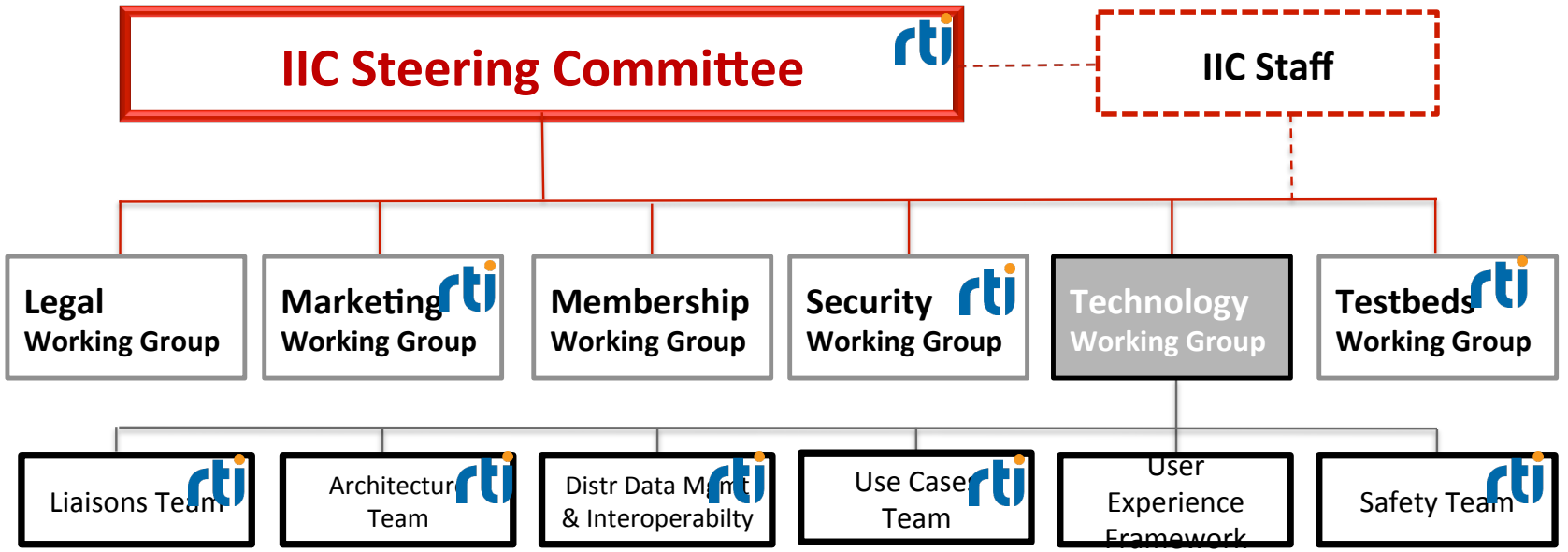






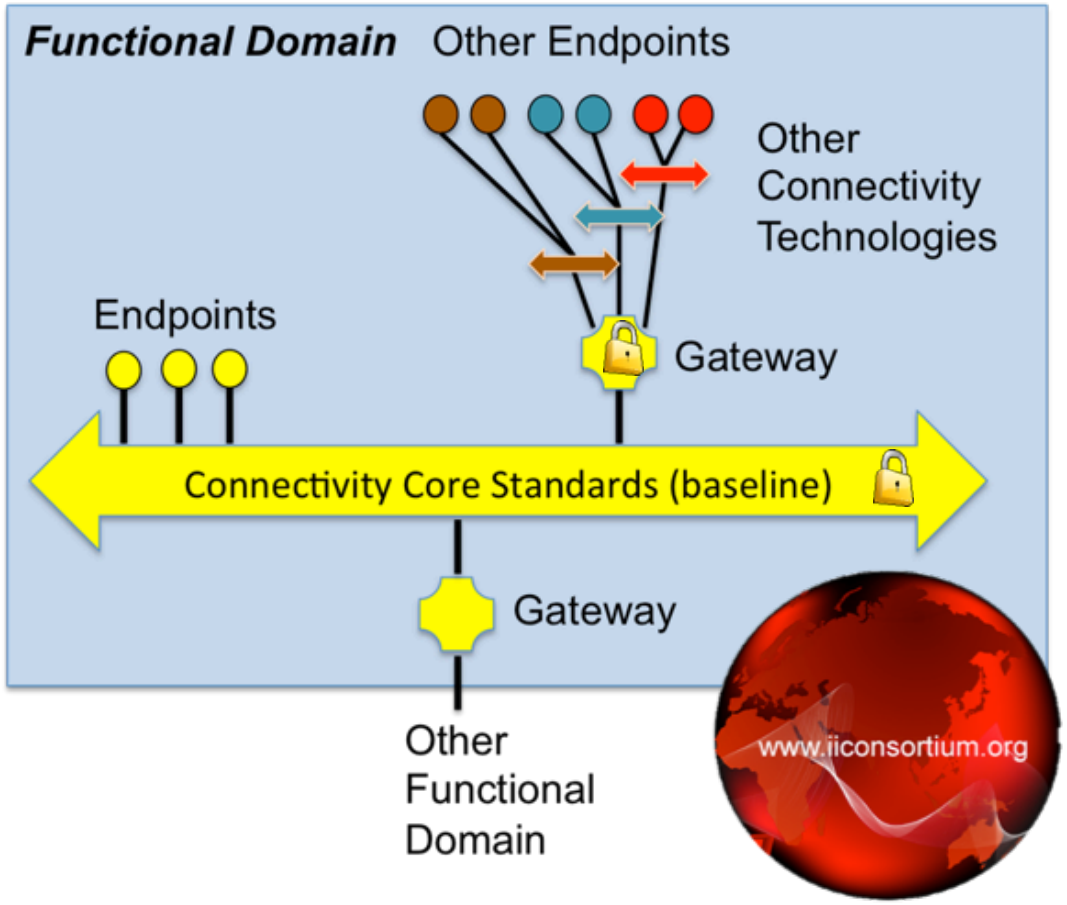

DDS
OMG OBJECT MANAGEMENT GROUP
OSA
FACE Future Airborne Capability Environment
OPEN INTERCONNECT CONSORTIUM
SGIP SMART GRID INTEROPERABILITY PANEL
MD PnP Getting connected for patient safety
ICE Alliance
industrial internet CONSORTIUM
OpenFog
OPC FOUNDATION

IIC Organization



IIRA "Core Connectivity Standard" Approach

- "Core connectivity standards" that link with "gateways"
  - Delivers performance with flexibility
  - Scales linearly (only have to map each "other" to one "core")
  - Supports natural security
- Choose the core standard that matches system needs



IIC Security Framework being released

Being voted. Should be released at the next IIC meeting!

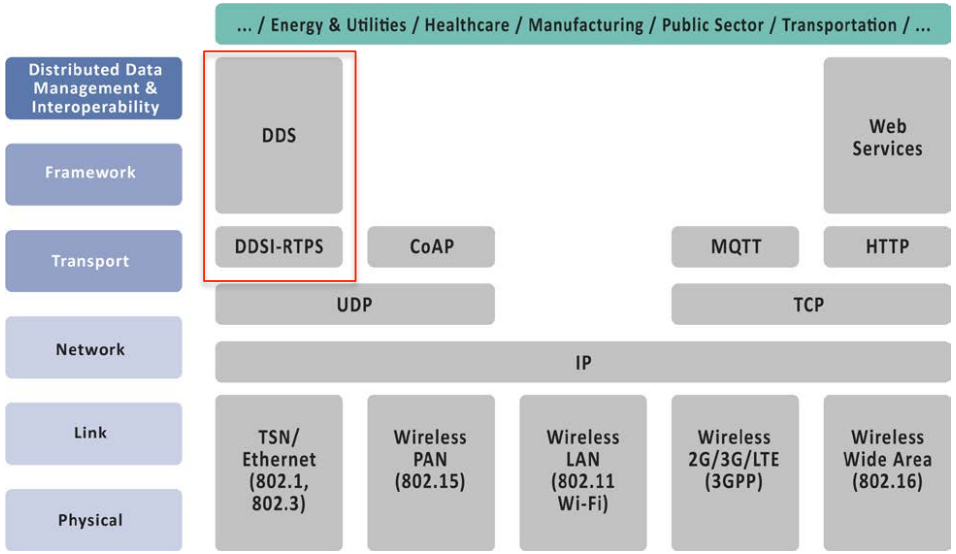
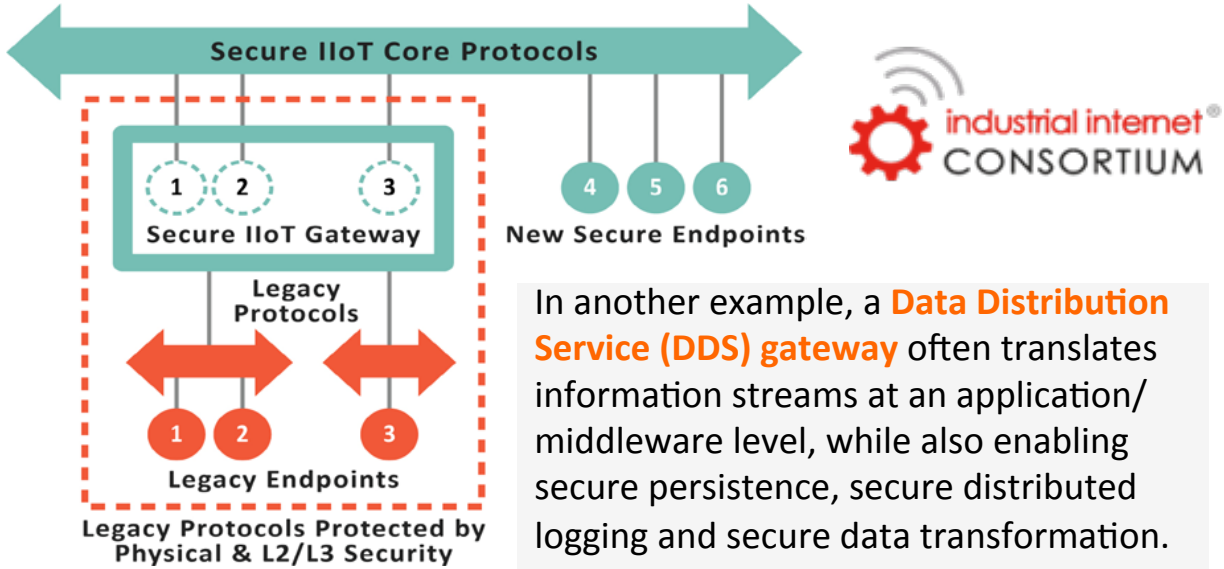


Figure 9-3: Example of IIoT core Communication & Connectivity Standards



In another example, a **Data Distribution Service (DDS) gateway** often translates information streams at an application/ middleware level, while also enabling secure persistence, secure distributed logging and secure data transformation.

A security model specifies allowed and prohibited relationships between subjects and objects and therefore can define security policies more concretely. For example, the security model for Linux file system specifies what subjects (i.e. processes) can perform what operations (e.g. read, write, execute) on what objects (e.g. files). **Similar security models exist for IIoT communications and connectivity protocols such as DDS**.

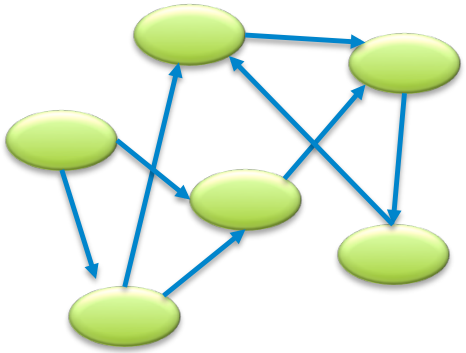
The primary types of threats for *publish-subscribe communication pattern* are unauthorized subscription, unauthorized publication, tampering and replay and unauthorized access to exchanged data. Some implementations of this pattern (e.g., classic MQTT and AMQP) rely on intermediary message brokers store-and-forward messages, **but the message broker could be a single point of failure. An alternative approach is broker-free, peer-to-peer implementations such as the DDS standard**.

How does a common Connectivity Platform Work?

Technology

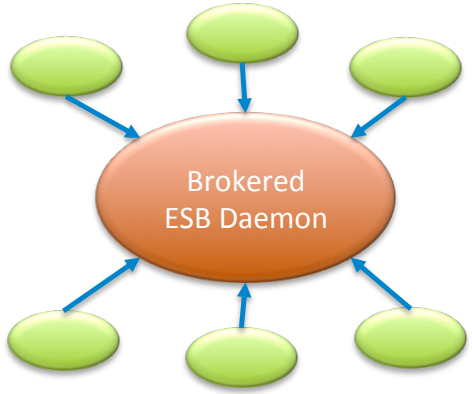
Data-Distribution Service (DDS)
Data-Centric (Layered Databus) model

Point-to-Point
Client/Server



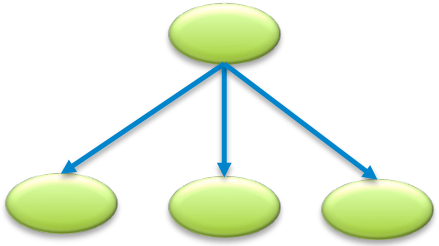
TCP, REST, WS*, OPC

Brokered
Publish/Subscribe
Queuing



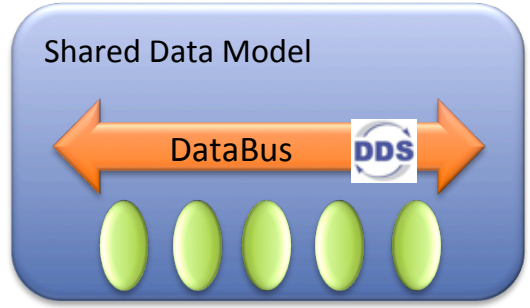
MQTT, XMPP, AMQP

Broadcast
Publish/Subscribe



Fieldbus, CANbus

Data-Centric
Publish-Subscribe



Data-Centric, DDS
Layered Databus

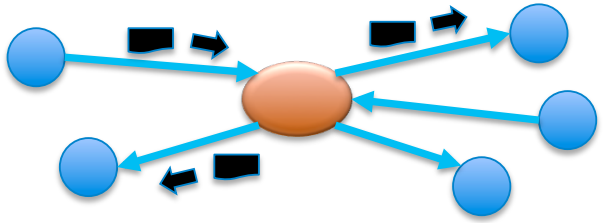
Systems Are About the *Data*

Unstructured files

Data Centricity

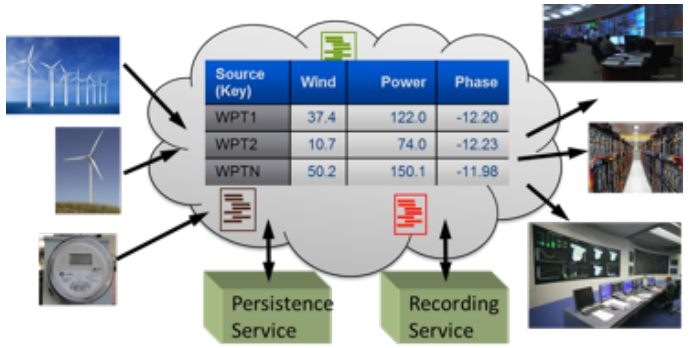
Database

Data at Rest



Messaging middleware

Data Centricity



DataBus

Data in Motion

Data centricity enables interoperation, scale, integration

Virtual Global Data Space

CRUD operations

DDS DOMAIN

Topic A — QoS

Topic B : "Turbine State" — QoS

Source (Key)	Speed	Power	Phase
WPT1	37.4	122.0	-12.20
WPT2	10.7	74.0	-12.23
WPTN	50.2	150.07	-11.98

Topic C — QoS

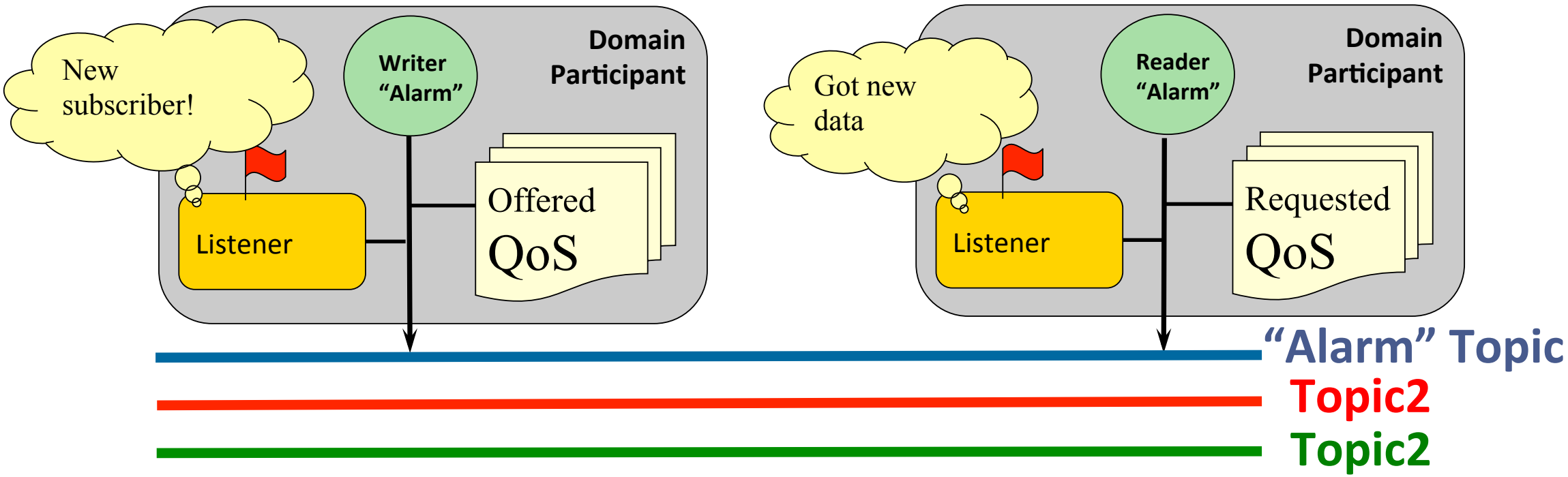
Topic D — QoS

DDS

Persistence Service

Recording Service

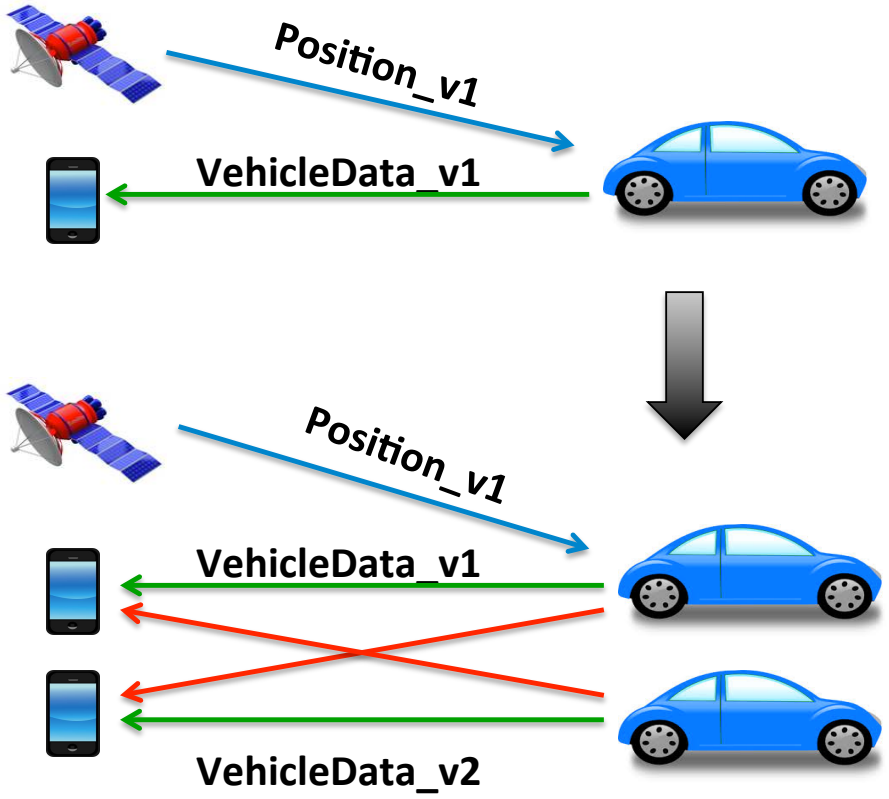
Data-Centric Communications Model



- **Participants** scope the global data space (domain)
- **Topics** define the data-objects (collections of subjects)
- **DataWriters** publish data on Topics
- **DataReaders** subscribe to data on Topics
- **QoS Policies** are used configure the system
- **Listeners** are used to notify the application of events

Request <= Offered QoS compatibility checking and run-time monitoring

Type Evolution is Supported (XTYPES)

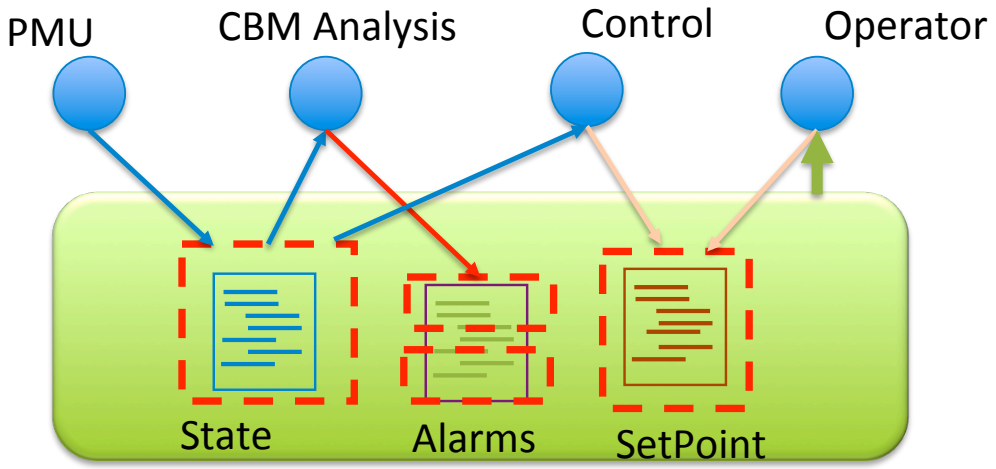



```
struct Position_v1 {
    double latitude;
    double longitude;
};
struct VehicleData_v1 {
    @key long vehicleID;
    Position position;
};
```

```
struct Vehicle_v2 {
    @key long vehicleID;
    string model;
    Position position;
    double speed;
};
```

Build Security In from the Start with DDS

- Dataflow-Level Security
  - Control r,w access to each data item for each function
  - Ensures proper dataflow operation
- Complete Protection
  - Discovery authentication
  - Data-centric access control
  - Cryptography
  - Tagging & logging
  - Non-repudiation
  - Secure multicast
- No code changes!
- Plugin architecture for advanced uses

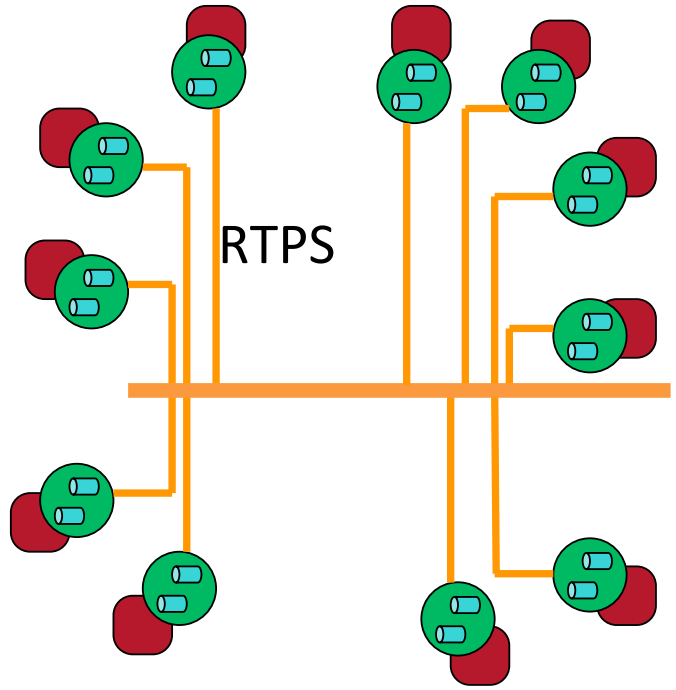


Topic Security model:

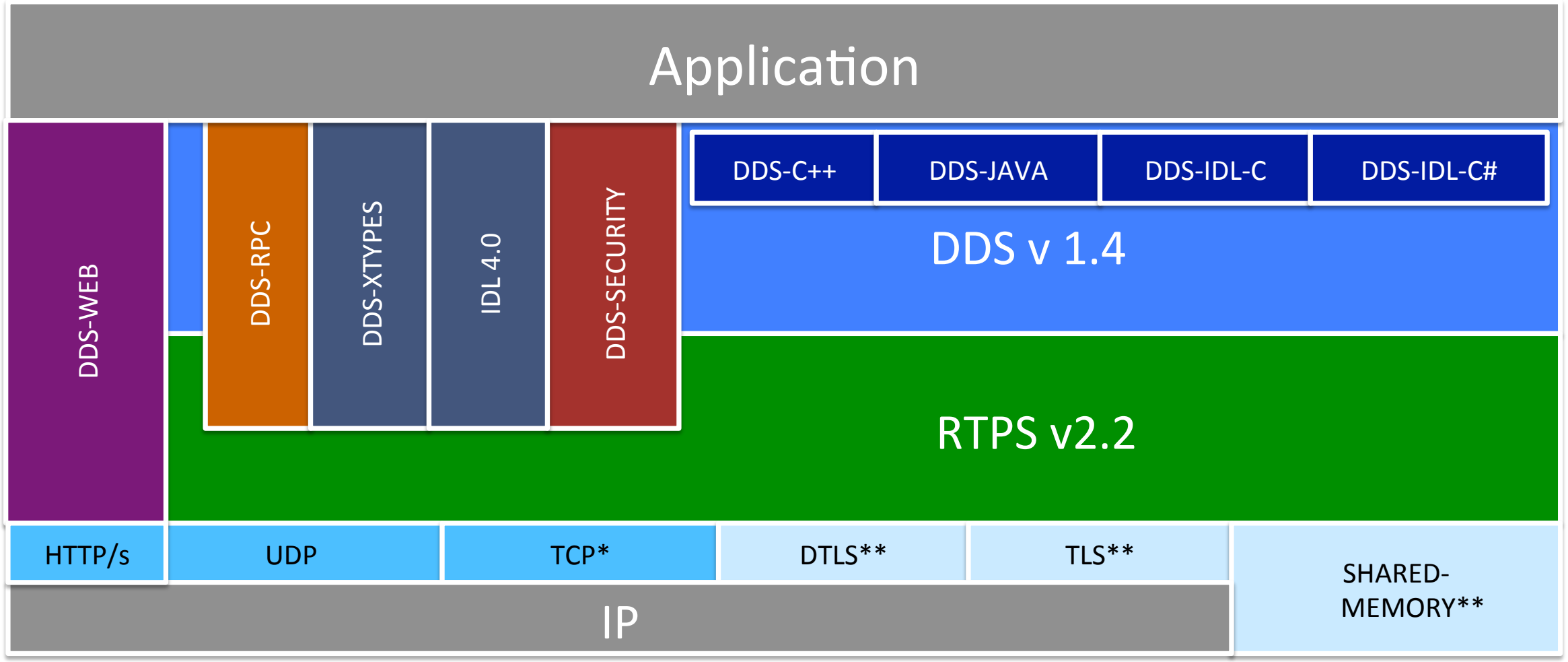
- PMU: State(w)
- CBM: State(r); Alarms(w)
- Control: State(r), SetPoint(w)
- Operator: *(r), Setpoint(w)

Wire Protocol Optimized for IIOT

- Peer to peer no brokers or servers
- Adaptable QoS, including prioritization
- Reliable even over multicast!
- Any size data automatic fragmentation
- Automatic Discovery and Presence without configuration
- Decoupled execution start/stop apps in any order
- Redundant sources, sinks, paths, networks
- Efficient data encapsulation
- High performance near-native “wire” speeds
- Scalable no N^2 network connections



Approved DDS Standards



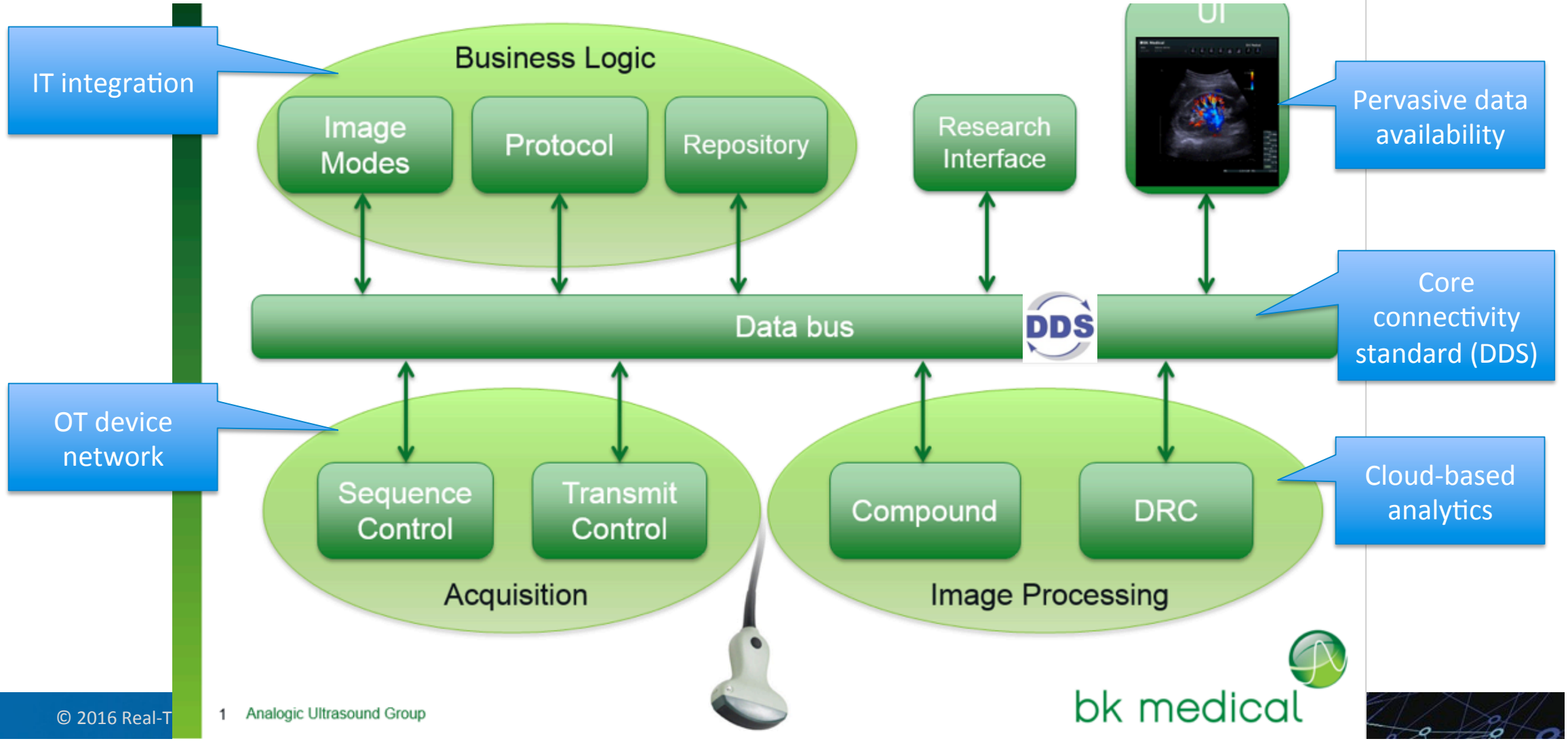
How is IIoT changing Medical systems?

The Internet Didn't Change Most Industries

1991

2015

Industry Terminology



bk medical

Disruption: Distributed Architecture

Private cloud

Public cloud

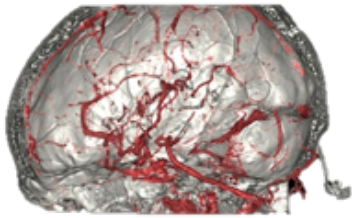
DataBus

Raw
Image
Secure

Common Platforms

"GE Healthcare chose the DDS standard because it can handle many classes of intelligent machines.
DDS satisfies the demanding requirements of our devices and supports standardization on a single communications platform across product lines."

Revolution®



-- J Gustavo Perez, General Manager for MI&CT Engineering

Disruption: Cross-Vendor Interoperability

- Hospital error is the 3rd leading cause of death
- The Integrated Clinical Environment (ICE) standard specifies interoperability for medical devices
- RTI Connext DDS ties together devices, services, and displays in real time

CIMIT® Center for Integration of Medicine & Innovative Technology

MD PnP Getting Connected for Patient Safety™

THE HARVARD MEDICAL SCHOOL

DOCBOX

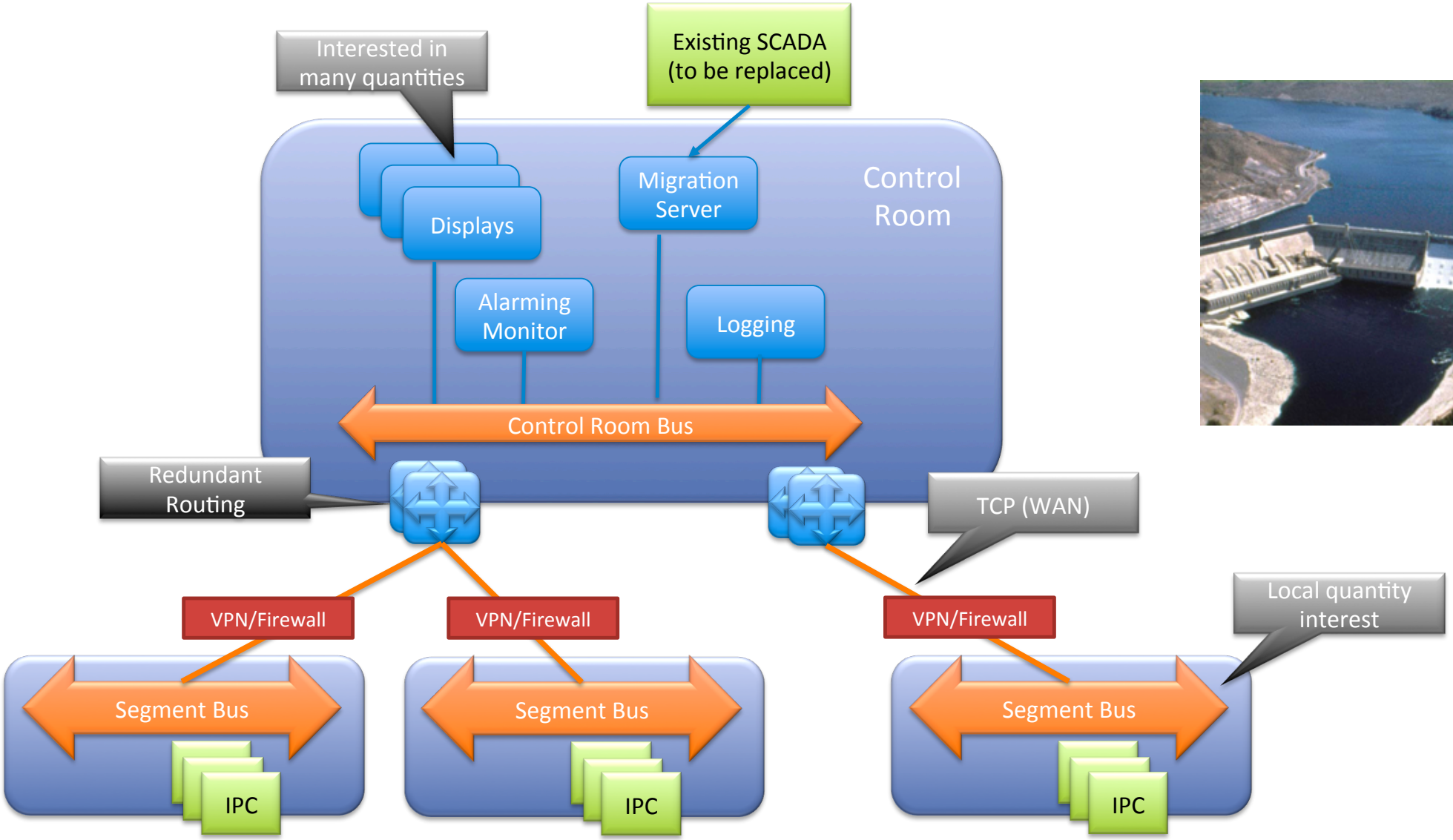
How is IIoT changing Energy and SCADA systems?

Critical Distributed Reliability

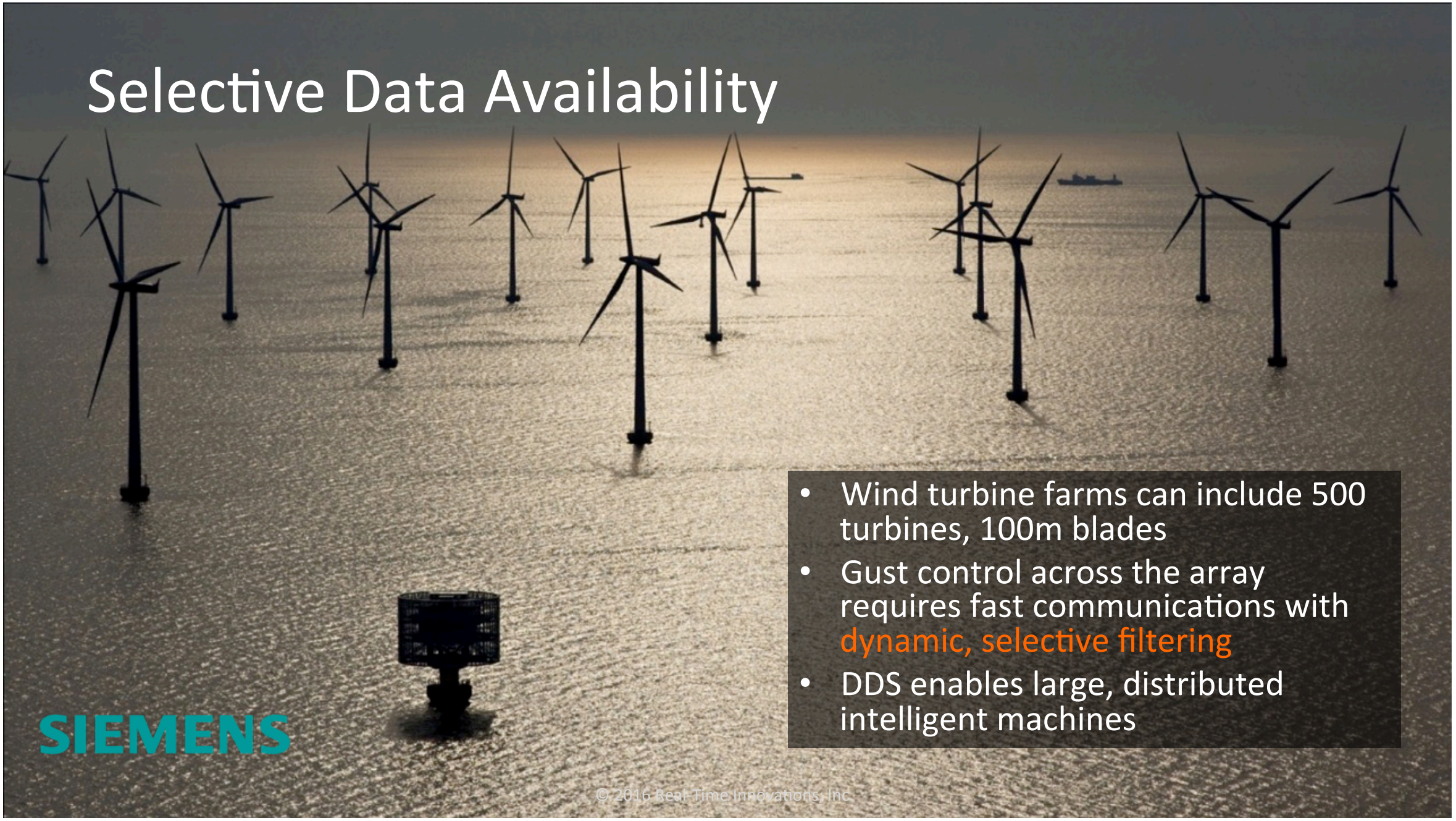
- DDS controls the 6.8 GW GC Dam
  - Largest power plant in North America
  - Fastest-responding major power source on the Western Grid
  - Requires 24x7 operation
- Connext DDS met the challenges
  - Extreme availability
  - Wide area communications
  - Multi-level routing
  - High security
  - 300k data values
- RTI system live since Jan 2014

U.S. Army Corps of Engineers®

Example: GDC Ultra Available Plant Control



Selective Data Availability

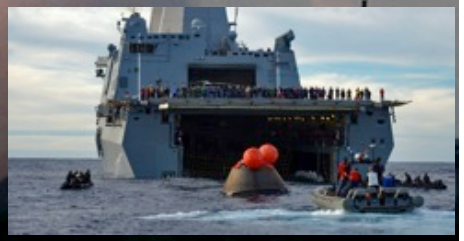


- Wind turbine farms can include 500 turbines, 100m blades
- Gust control across the array requires fast communications with dynamic, selective filtering
- DDS enables large, distributed intelligent machines

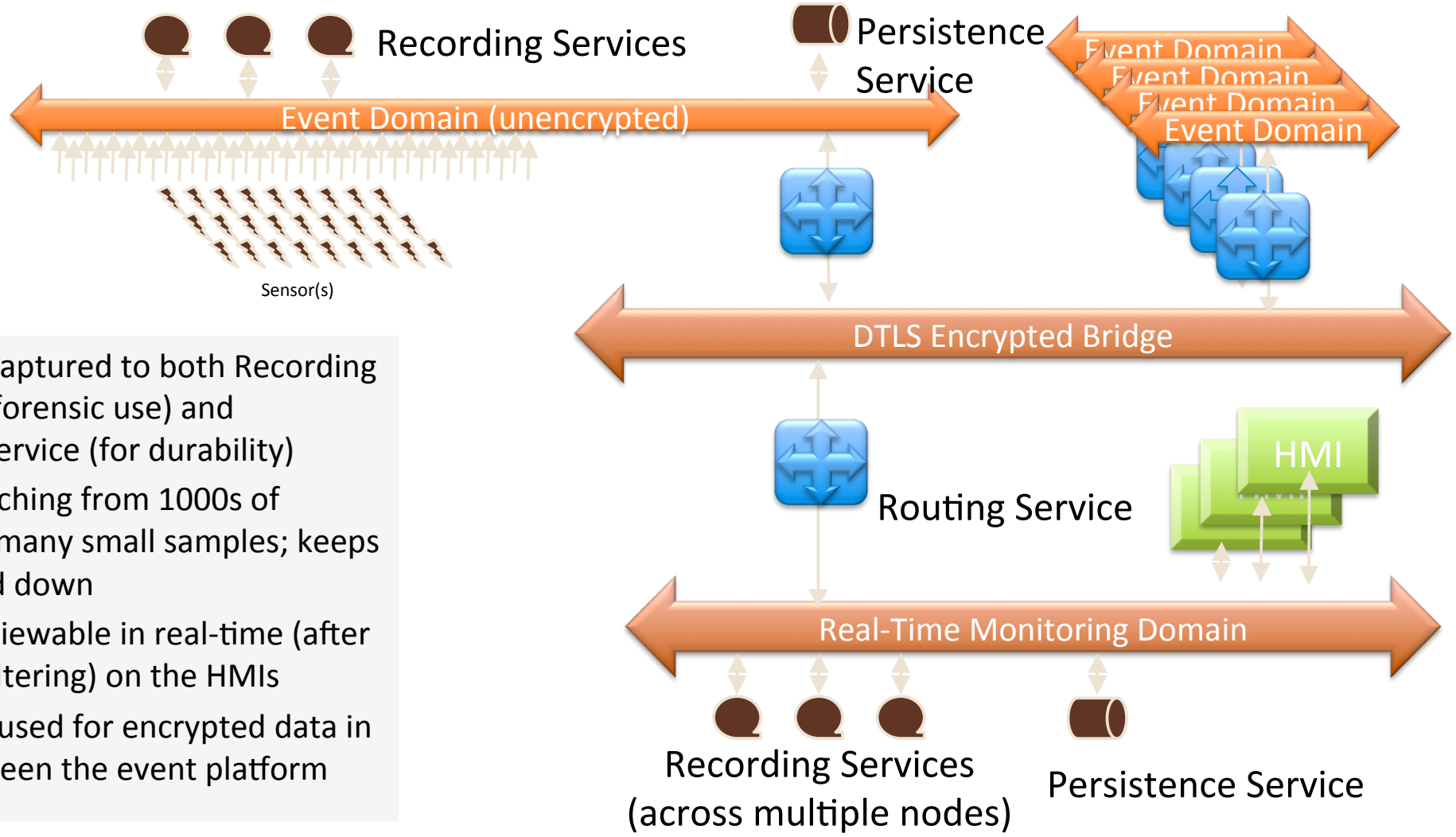
SIEMENS

Large-Scale SCADA

- The NASA KSC launch control is the world's largest single-system SCADA
- It combines 300k points, at 400k msgs/sec
- RTI Connext DDS powers launch control, in-flight monitoring, UAV reentry-tracking ground station, and the recovery ship



Large-Scale SCADA



- Sensor data captured to both Recording Services (for forensic use) and Persistence Service (for durability)
- Multicast batching from 1000s of sensors with many small samples; keeps interrupt load down
- Sensor data viewable in real-time (after time-based filtering) on the HMIs
- RS-RS bridge used for encrypted data in motion, between the event platform and control

Duke Energy Adds Microgrids to Its Grid Edge Plans

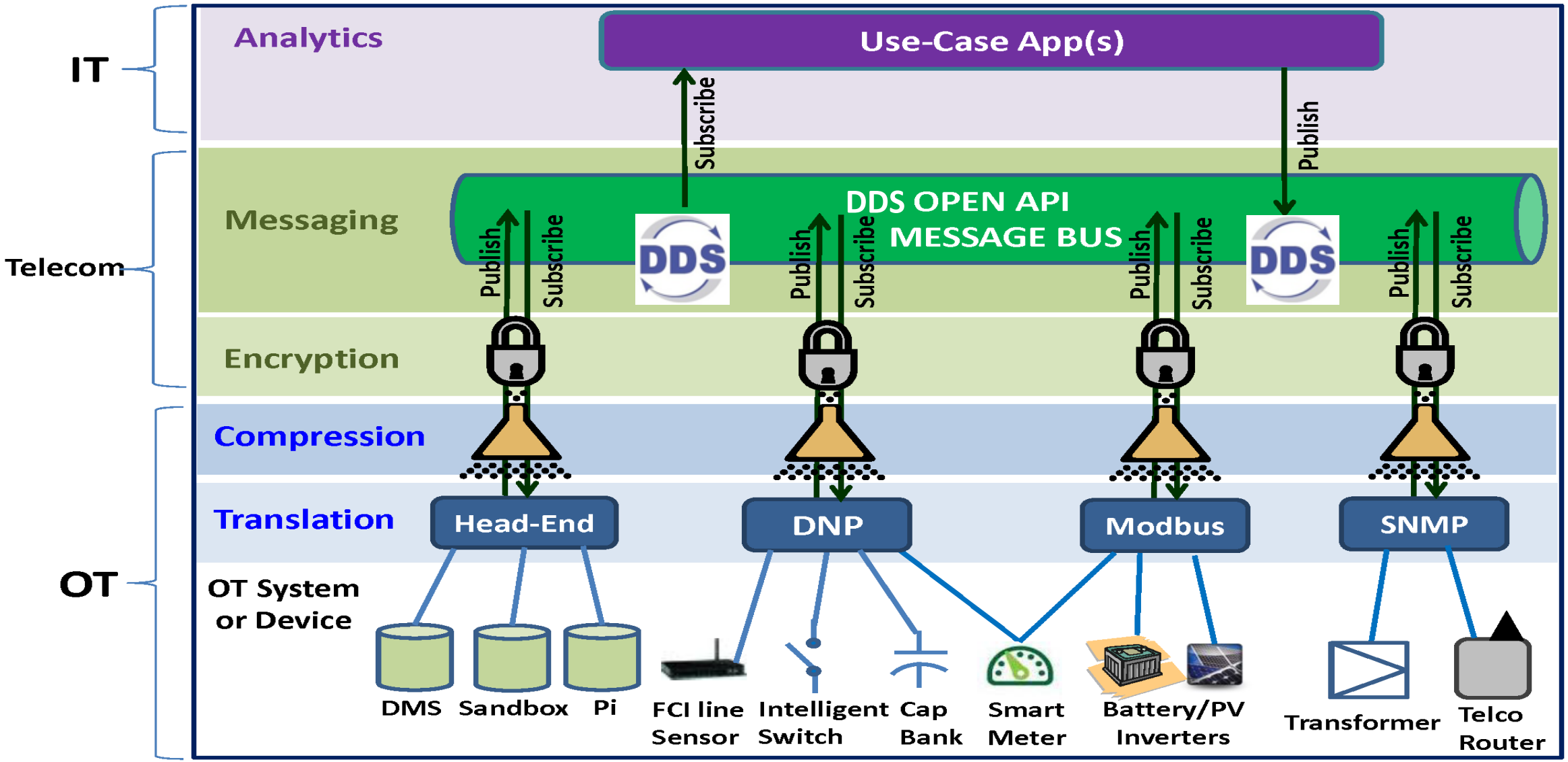
More vendors join Duke's "Coalition of the Willing" for distributed energy intelligence and control

For its new project, Duke is planning to use a technology known as Data Distribution Service (DDS), a secured publish-subscribe messaging protocol originally developed by the U.S. Navy, as the protocol to link its devices, Laval said.

For the past year, Duke Energy has been pushing the envelope on grid interoperability with its Coalition of the Willing (COW) -- a group of six vendors that have opened their systems and devices to share data with one another in order to coordinate and automate their responses to changing conditions on the edges of the grid.

Now Duke is expanding that coalition of vendor partners, and turning its attention to the next grid-edge integration challenge: microgrids.

Practical Connectivity Requires Normalization



How is IIoT changing Transportation systems?

Disruption: Autonomy

- Autonomous vehicles span land, sea, and air
- Safety certification will allow UAS in class-A National Air Space in 2016

- DDS enables advanced reactive systems in transportation

RTI DDS manages data logging

Real time

Data logging

Data source	Data type	Data Volume	Data Frequency
Cameras	video stream		
Lidar	data list		
Radar	point clouds matrix		
GPS	data message		
Control Cmd	data message		
Error Context	text strings		

Heterogeneous data source

with various volume and frequency

Status Feb 2016

Integrate Intelligence

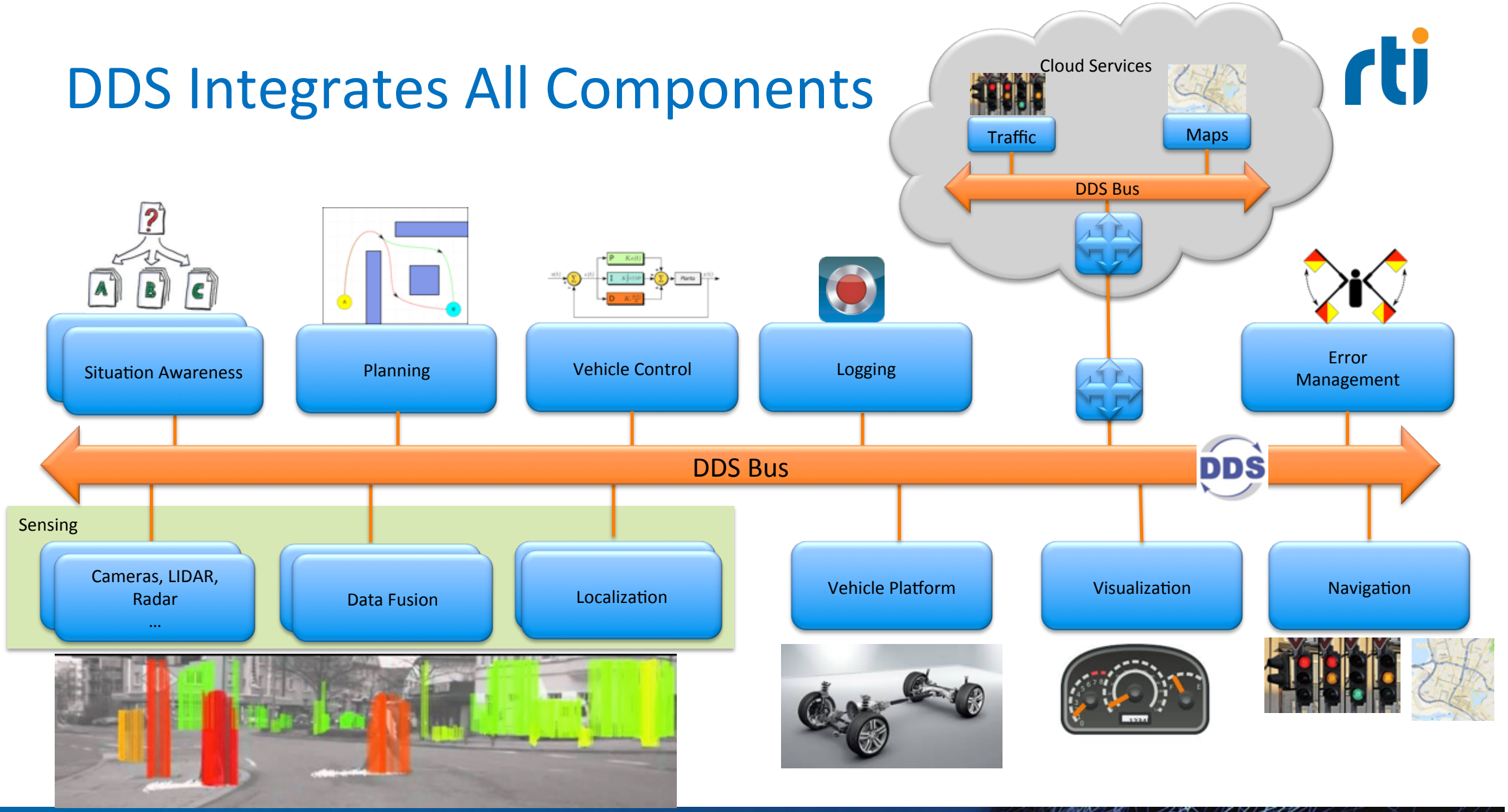
http://www.youtube.com/watch?v=7xQfKTAtyNU

- ADAS (level 2)
  - The VW Driver Assistance and Integrated Safety system combines radars, proximity sensors, and video to assist safe operation
  - It helps avoid obstacles, detect lane departures, track eye activity, and safely negotiate bends
- Autonomy (level 4)
  - The V-Charge program demoed an auto-charging and parking vehicle in 2014

Plug-n-Play Across Vendors

- Audi's hardware-in-the-loop simulation feeds realistic data to components to test hundreds of ECUs
- The system offers plug-n-play between multiple vendor solutions
- RTI DDS enables a modular environment that scales to test entire vehicles and complex scenarios

DDS Integrates All Components



Vehicle/Cloud/Infrastructure Systems

Physio-Control supplies emergency response medical equipment to 60% of the world's emergency vehicles

"Physio-Control is utilizing RTI Connext DDS to exchange critical patient care information throughout the system of care."

-- Dale Pearson, VP Data Solutions

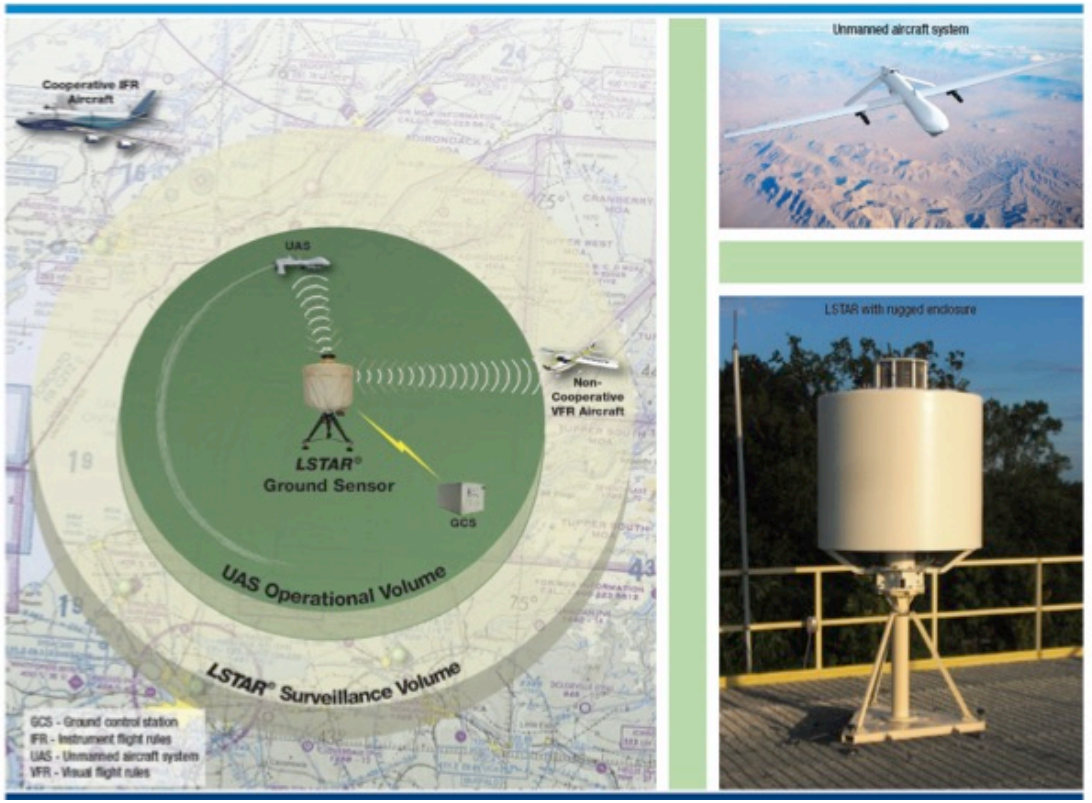
We envision a society in which no person dies from acute, treatable medical events

Wide-Area Coordinated Operations

DDS is in operation at Shanghai PVG ground control since 2015.
Expanding to air operations and between PuDong and Hongqiao.
Future expansion to entire South East China region.

Enable UAS Flight in National Air Space

- The Ground Based Sense and Avoid system allows autonomous planes in US National Air Space
  - Repositioning
  - Training & testing
  - Disaster relief
  - Forest monitoring and fire suppression
- DO178C safety certified
- Operational with RTI Connext DDS in 2016



Management: US Army UAS Project Office
System integrator: SRC, Inc.

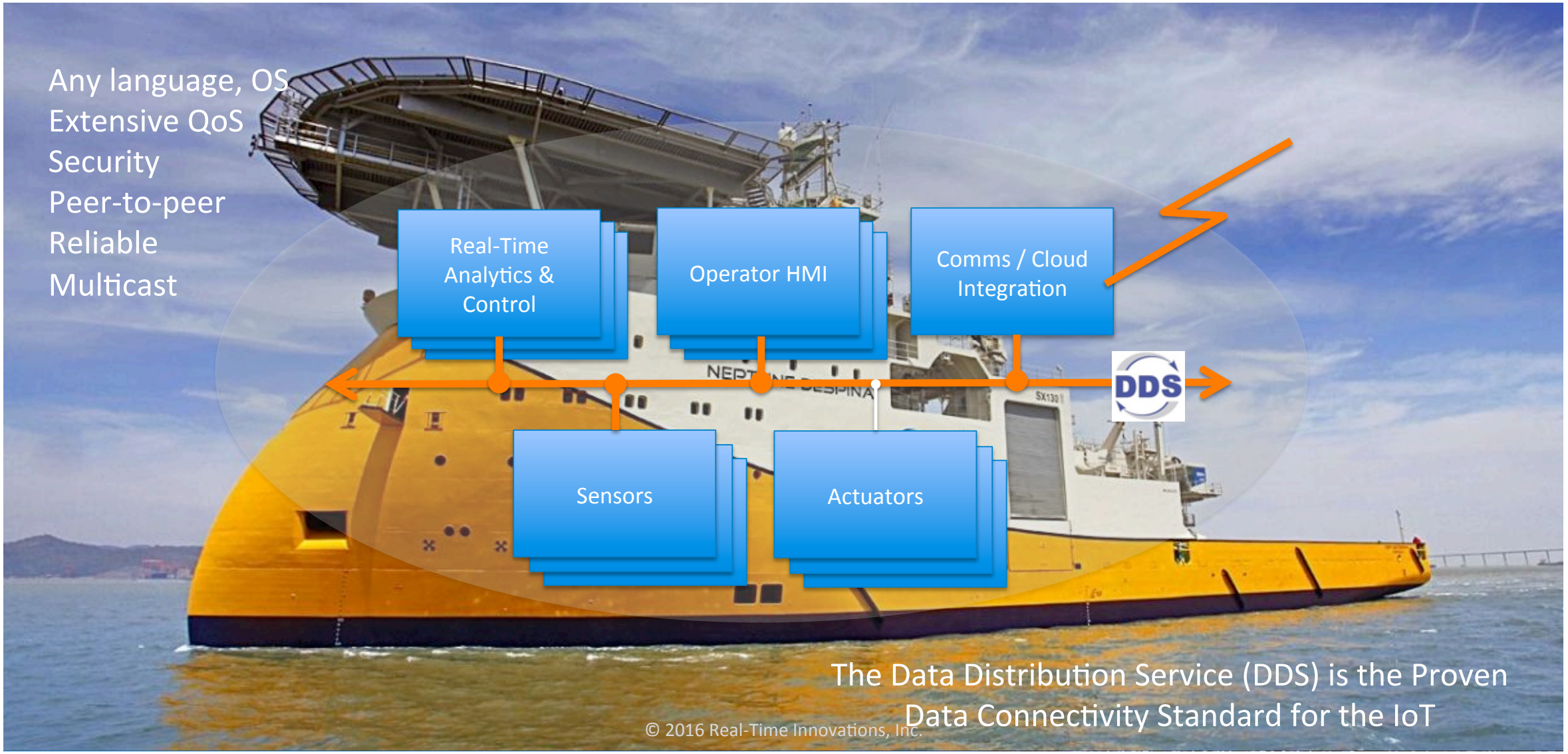
How is IIoT changing Ship systems?

Modernize Ship Architecture

Ulstein Next-Gen Bridge:

- 360 degree sensing
- Modern bridge controls
- Advanced HMI
- Redundant networking
- Assisted maneuvering

Use of DDS Standard in Ship control



System Scalability & Evolution

- Raytheon uses RTI Connext DDS to control the new Zumwalt DDG 1000 destroyer
- DDS coordinates and manages complex, diverse onboard hardware and software systems
- The system connects hundreds of computers, 1500 teams building thousands of applications, and more than 10m publish-subscribe pairs
- Data centric middleware extends real-time scalability

Summary

- The IIoT will the most disruptive technology in the history of mankind
  - Huge opportunities and challenges
- Real value is a common architecture that connects sensor to fog to cloud
- The IIC leads this technical revolution
- Watch for IIC Reference Architecture, Core Connectivity and Security Standards

Find out more…

dds.omg.org

www.omg.org

www.rti.com

community.rti.com

blogs.rti.com

Thank You!