

# Trends and Technical Direction

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Chief Technology Officer, RTI

# The IIoT Disruption



*The IIoT lives at the **intersection** of functional **artificial intelligence** and **pervasive networking***



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





Help users build amazing & challenging applications  
solving the problems that matter the most

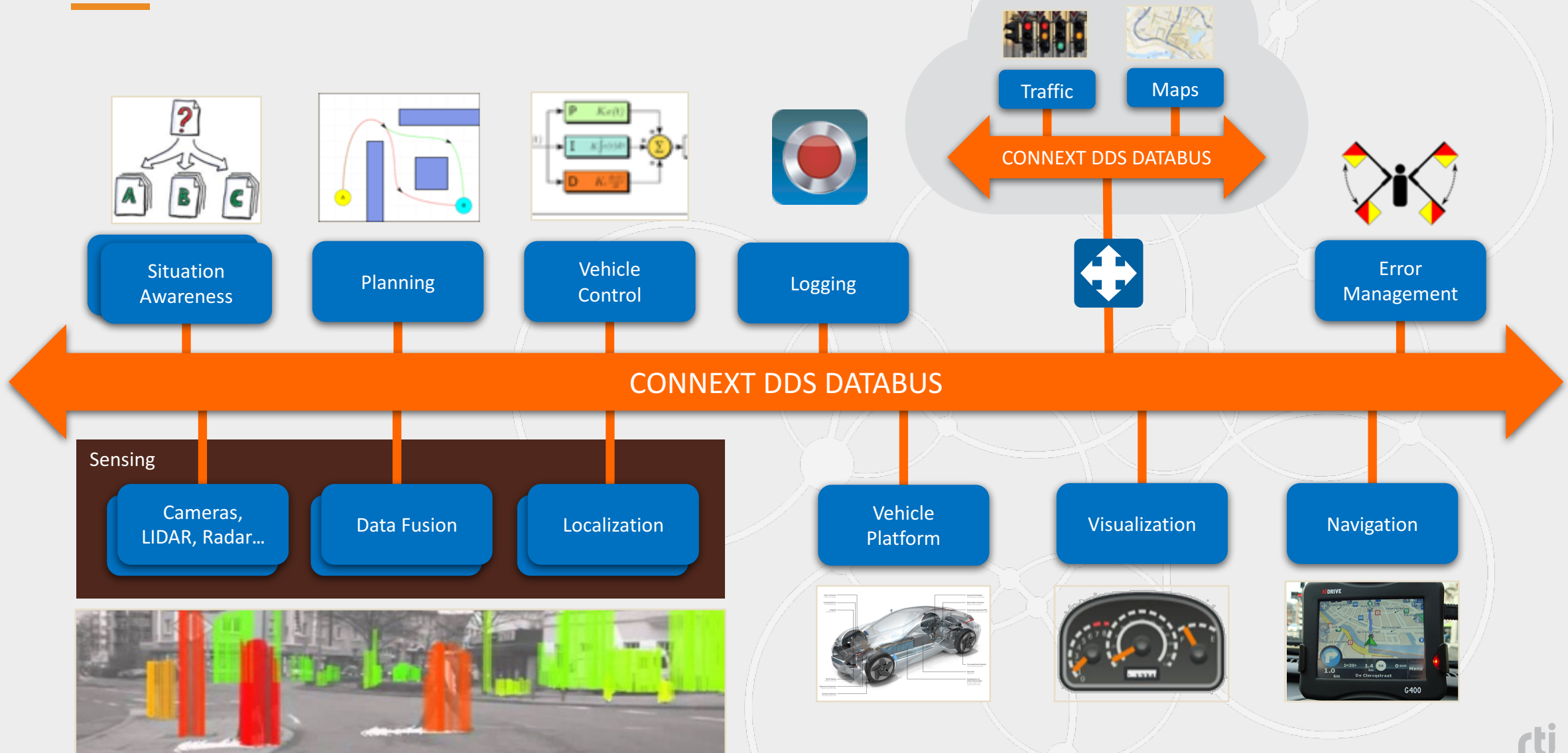






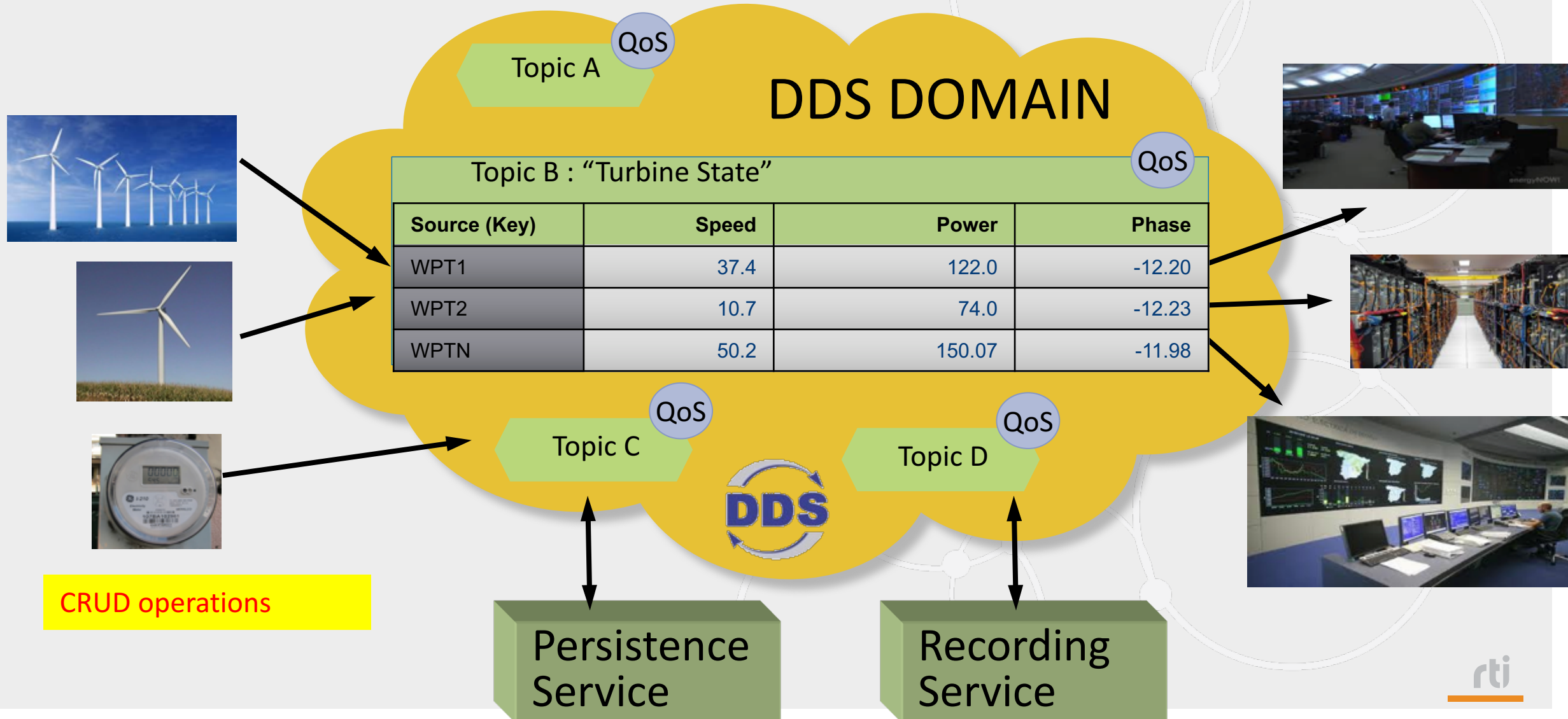


# Connex DDS databus





# DDS “virtual” Data-Centric Global Data Space



# Connex DDS factsheet

- **Architecture:** Peer-to-Peer, no Broker, Layered (Hierarchical) Databus.
- **Communication Patterns:** Publish/Subscribe, Request/Reply, Queuing
- **Payload:** Strongly-defined types, opaque, mixed. Static/Dynamic.
- **Filtering:** Content filter, time filter, supports Publisher side filtering.
- **Quality of Service:** Extensive (Reliability, History, Liveliness, etc.)
- **Transports:** UDP (multicast), TCP, TLS, DTLS, shared memory, pluggable custom. Transparent Mobility.
- **Security:** Fine grained security per Topic, transport-level security.
- **Languages:** C, C++, Java, .NET, ADA. Via connector: JS, Python, Lua.

# IICF

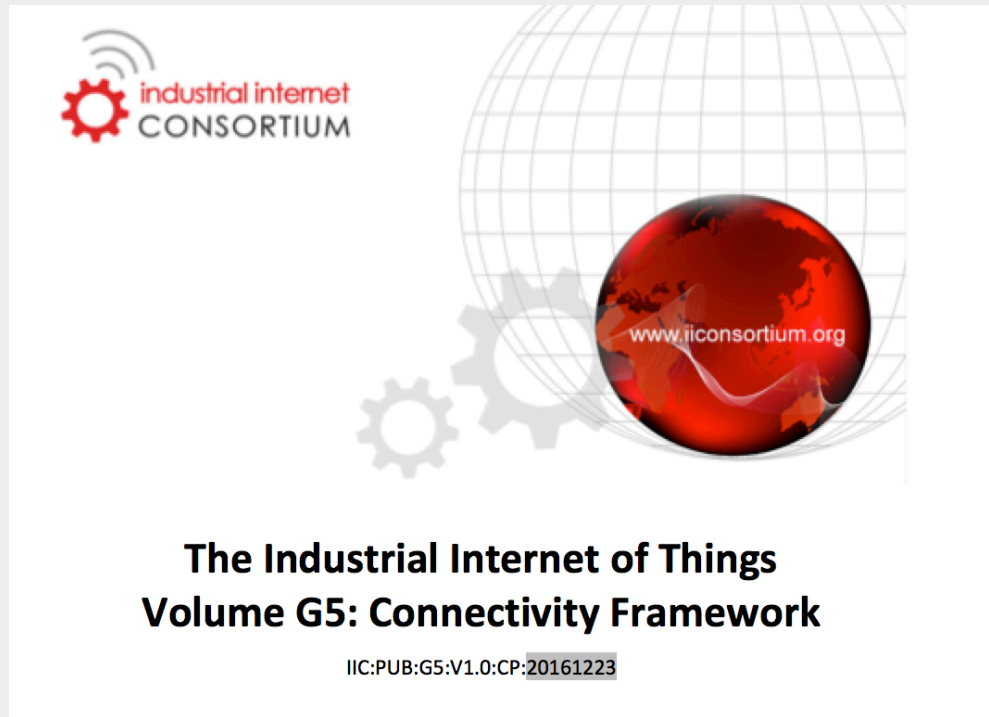
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Industrial Internet Connectivity Framework

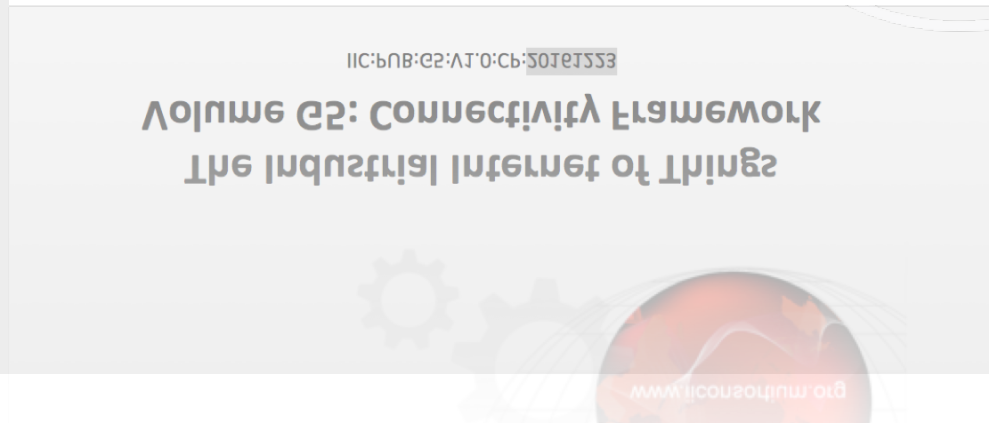
<https://www.iiconsortium.org/IICF.htm>



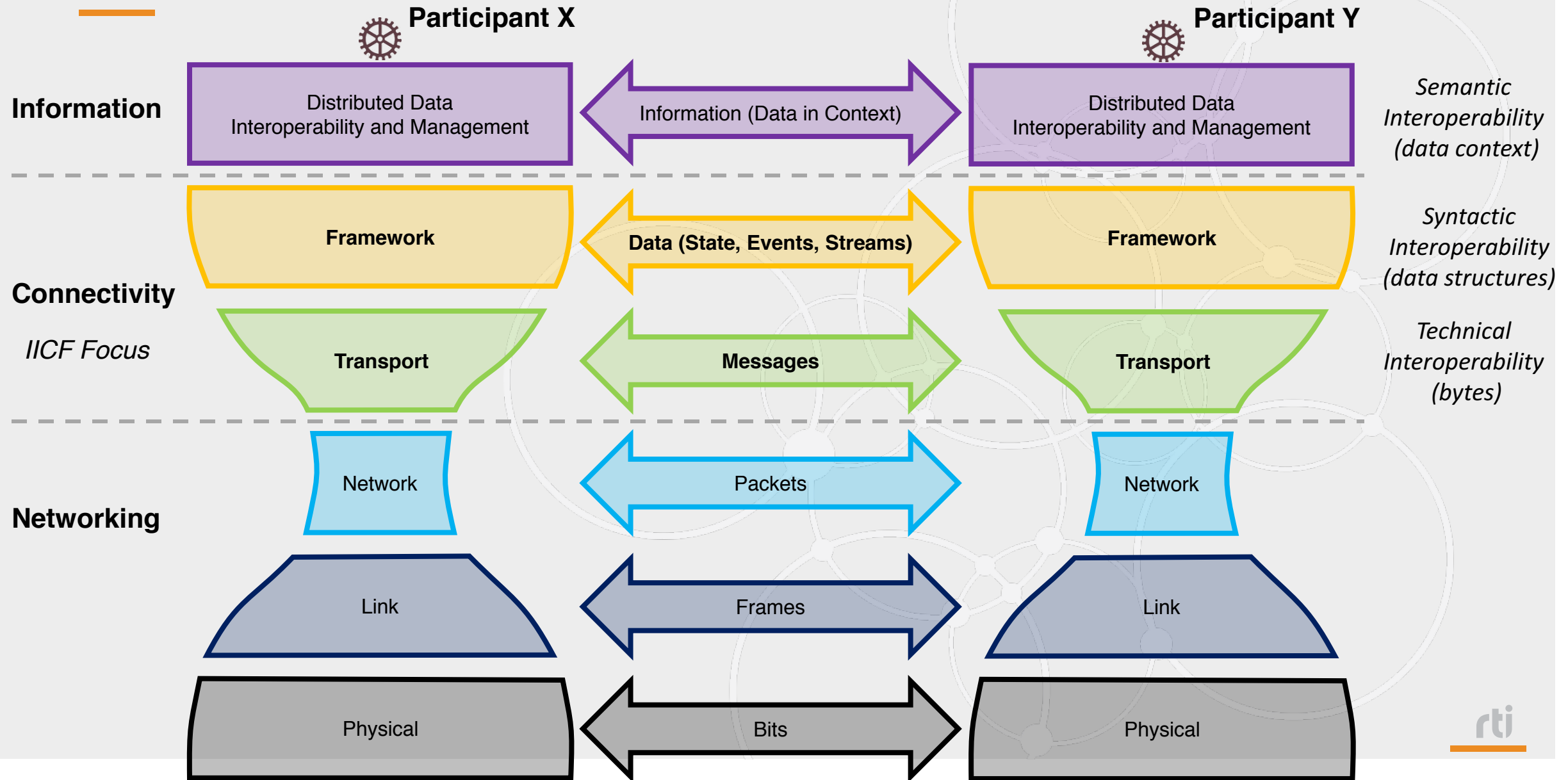
# IIC releases Connectivity Reference Architecture



DDS anointed the  
**Core connectivity  
Databus**

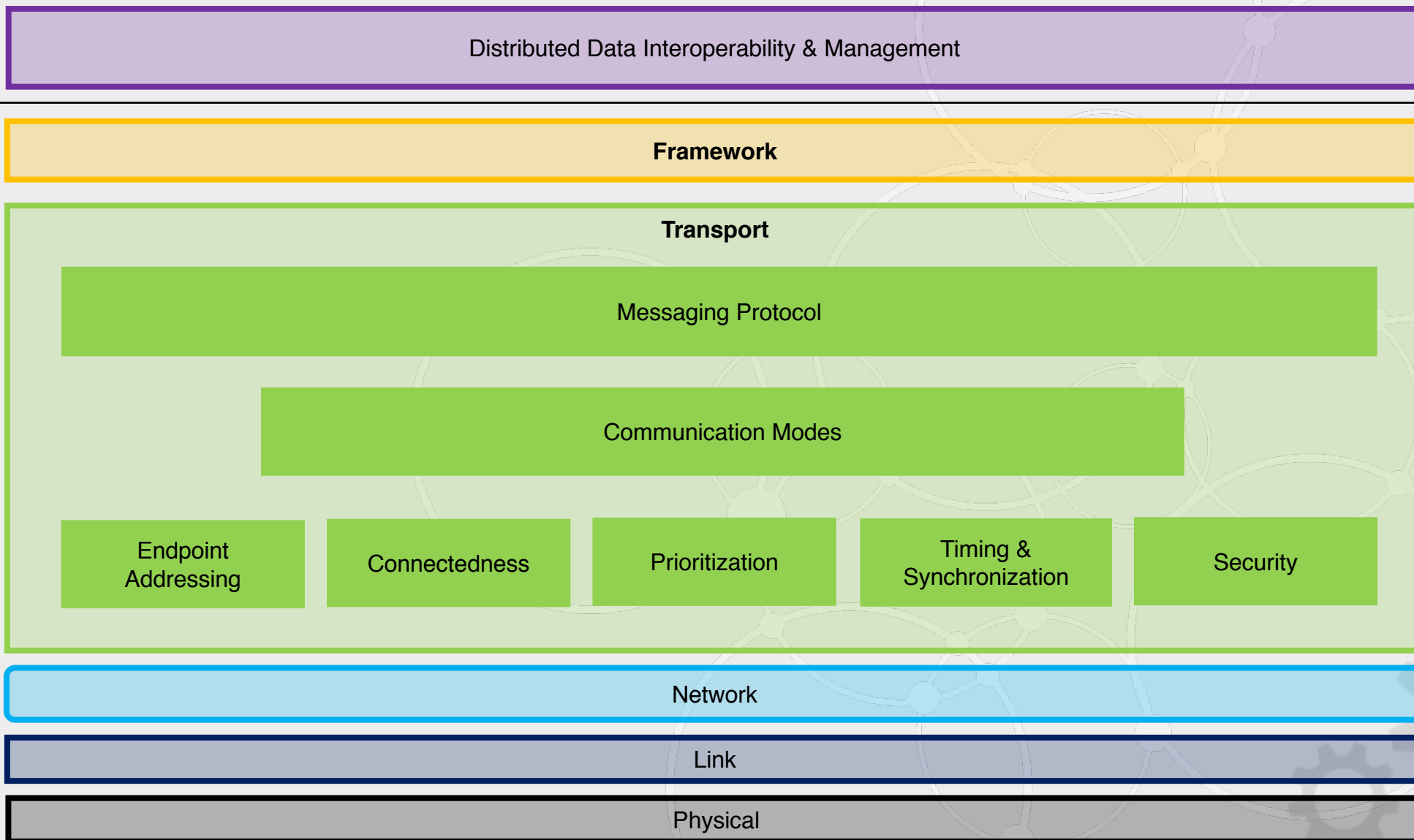


# IIoT Connectivity Stack Model





# Connectivity Transport Layer

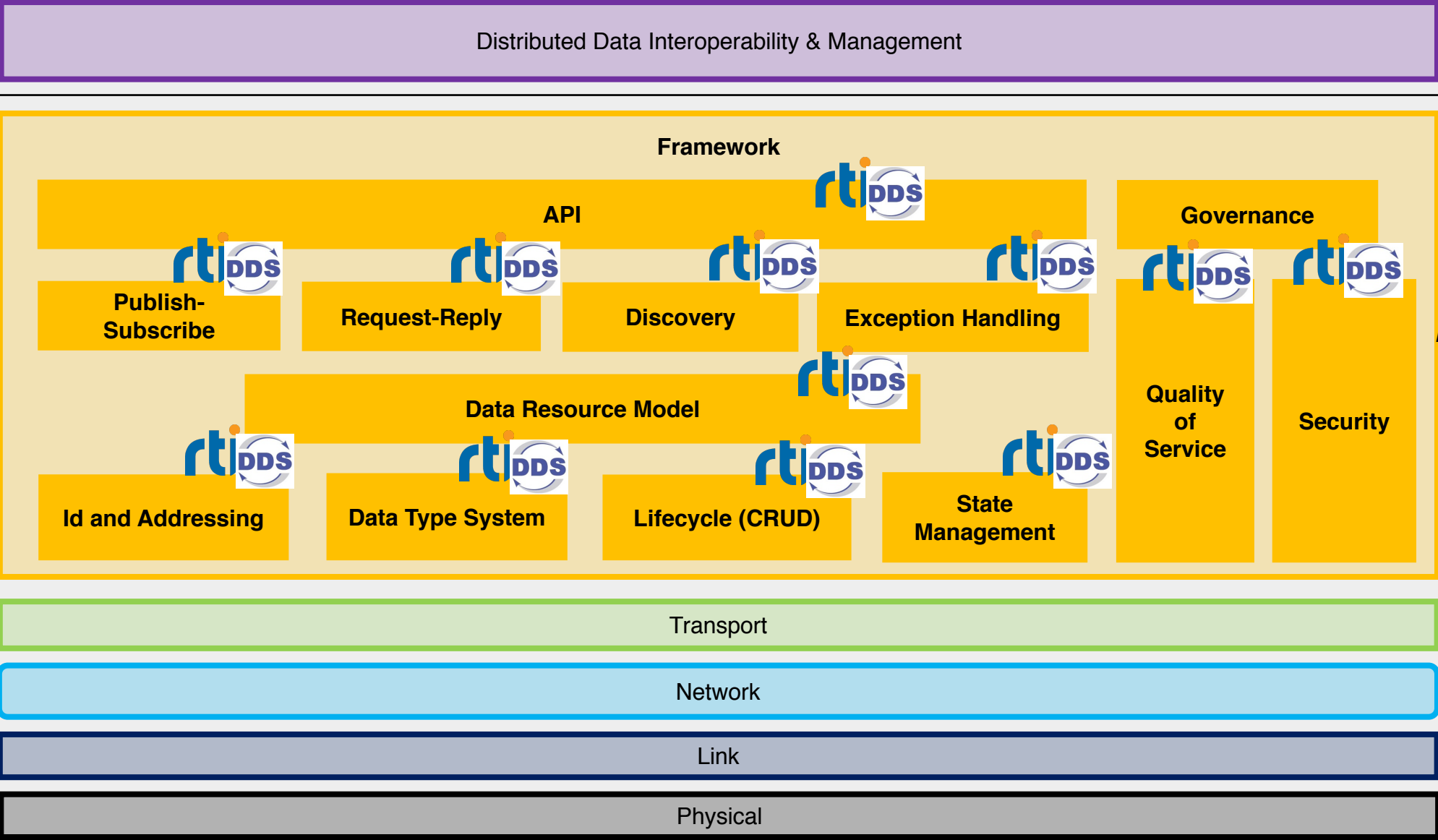


Connectivity  
Transport  
Functions

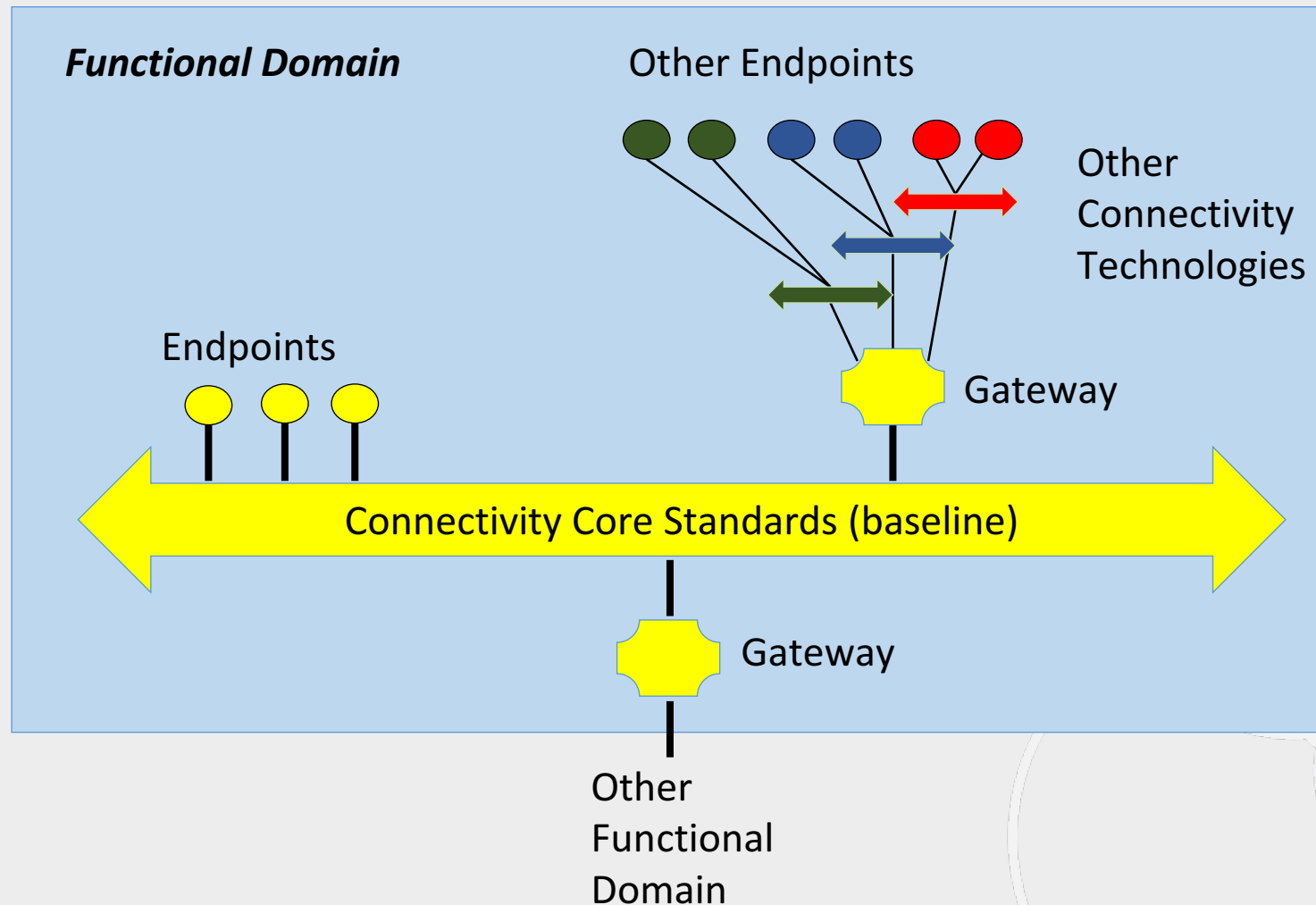
*Technical  
Interoperability*



# Connectivity Framework: Core Functions



# IIC Layered Databus architecture



## The Industrial Internet of Things Volume G5: Connectivity Framework

IIC:PUB:G5:V1.0:CP:20161223

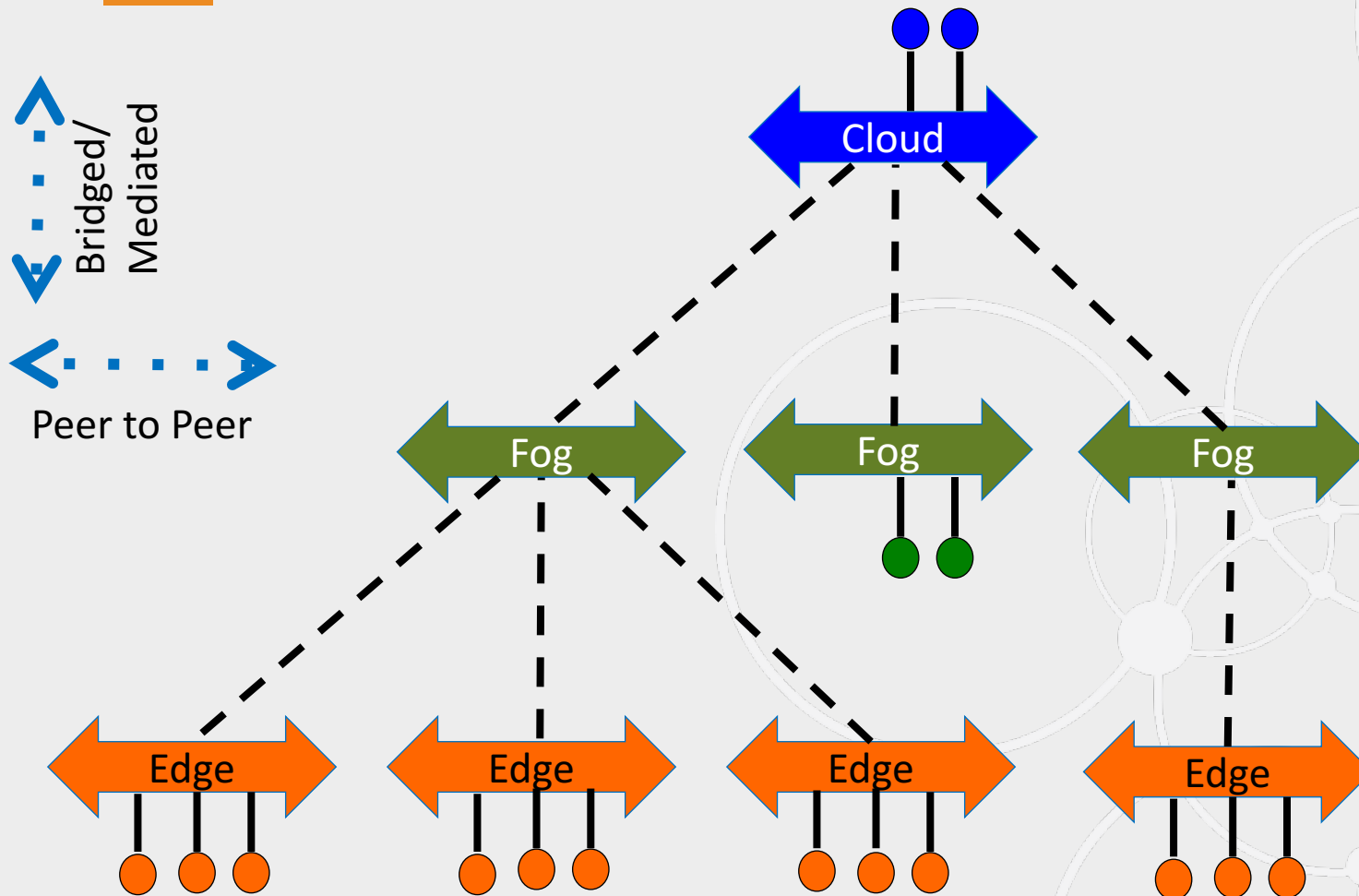
IIC:PUB:G5:V1.0:CP:20161223

## Volume G5: Connectivity Framework The Industrial Internet of Things

www.iiconsortium.org



# Layered Databus spans Edge to Cloud



- Cloud:

- Datacenter
- Elasticity, Provisioning, Management, Analytics

- Fog:

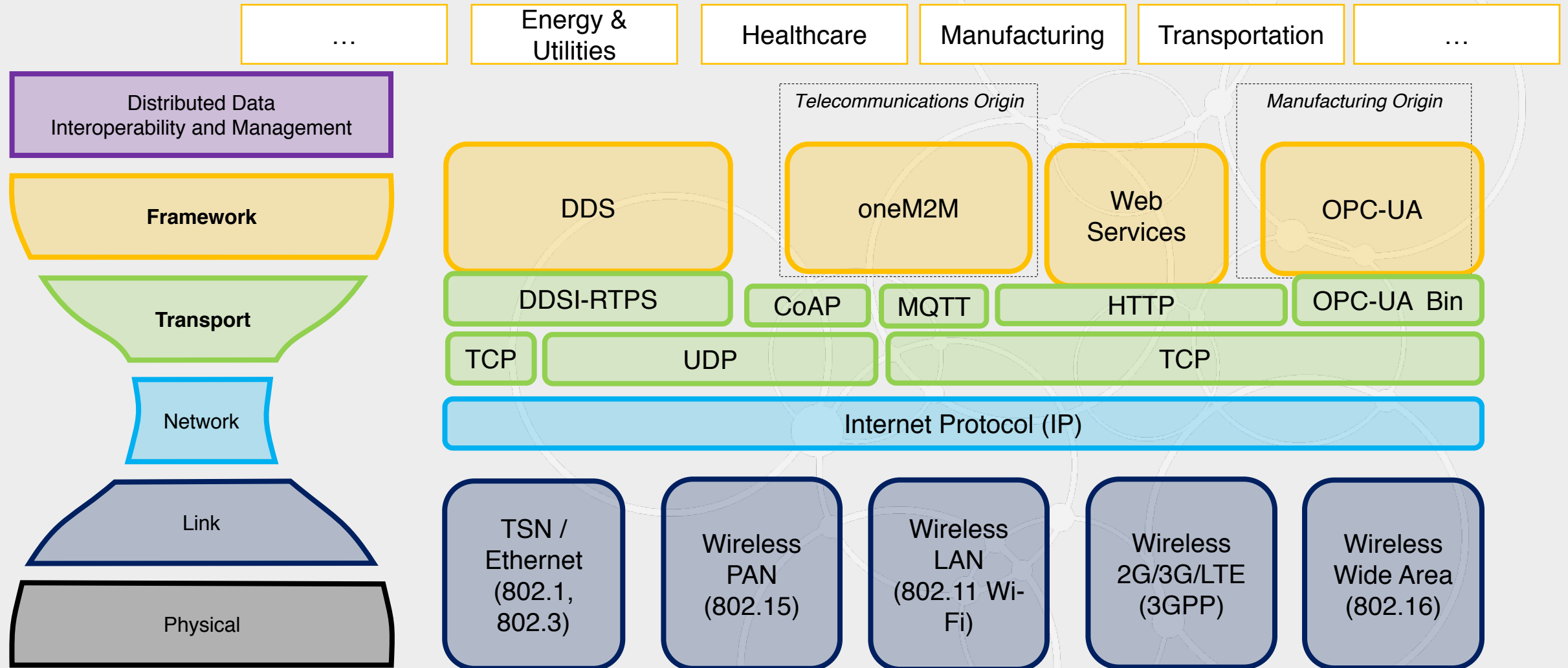
- Distributed computing
- Processing “close to the edge”
- Latency, Robustness, availability

- Edge:

- Locality
- Information Scoping



# IIOT Connectivity Standards



# Considerations for a IIOT Connectivity Framework

## System Architecture

- Peer to Peer vs Broker
- Data-Centric vs App Centric
- Explicit/Implicit Governance
  - Types
  - Data flows
  - Qos
  - Security

## Data selection

- Content-Based selection
- Time-Based selection

## Performance

- Real-time
- Latency, Jitter, Throughput

## Scalability


- Large number of data-objects
- Large number of applications

## Availability

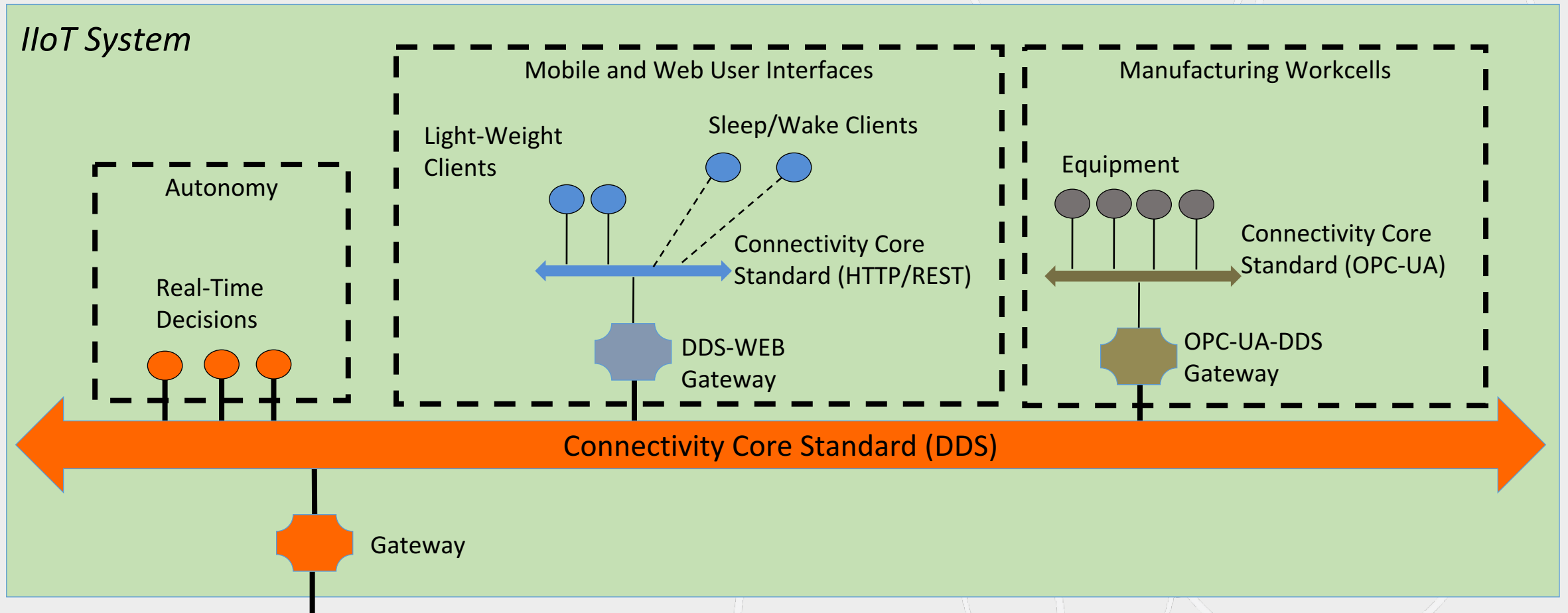
- Redundancy
- Recovery

## Deployment

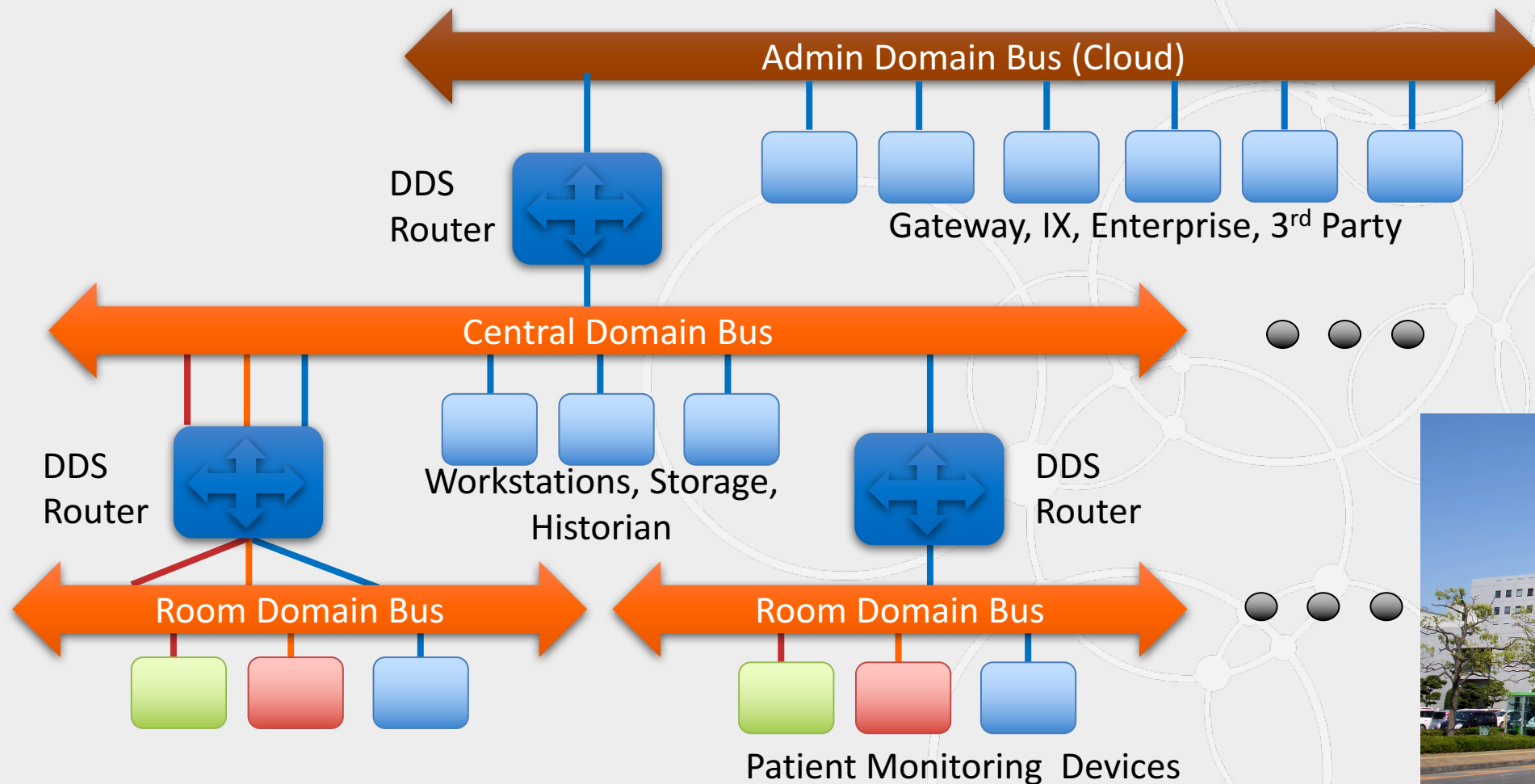
- Platform constraints
- Incremental upgrades

	Core Standard Criterion	 DDS	Web Services	OPC-UA	oneM2M
1	Provide <b>syntactic interoperability</b>	✓	Need XML or JSON	✓	✓
2	Open standard with strong <b>independent, international</b> governance	✓	✓	✓	✓
3	<b>Horizontal</b> and neutral in its applicability across industries	✓	✓	✓	✓
4	<b>Stable</b> and <b>proven</b> across multiple vertical industries	Software Integration & Autonomy	✓	Manufacturing	Home Automation
5	Have <b>standards-defined Core Gateways</b> to <i>all</i> other core connectivity standards	Web Services, OPC-UA*, oneM2M*	DDS, OPC-UA, oneM2M	Web Services, DDS*, oneM2M*	Web Services, DDS*
6	Meet the connectivity framework <b>functional</b> requirements	✓		Pub-Sub in Development	✓
7	Meet <b>non-functional</b> requirements of performance, scalability, reliability, resilience	✓		Real-Time in development	Reports not yet documented or public
8	Meet <b>security</b> and safety requirements	✓	✓	✓	✓
9	Not require any single component from any single vendor	✓	✓	✓	✓
10	Have readily-available SDKs both <b>commercial</b> and <b>open source</b>	✓	✓	✓	✓
* = work in progress <b>blank</b> = No <b>P</b> = partial		GREEN = Gating Criteria			

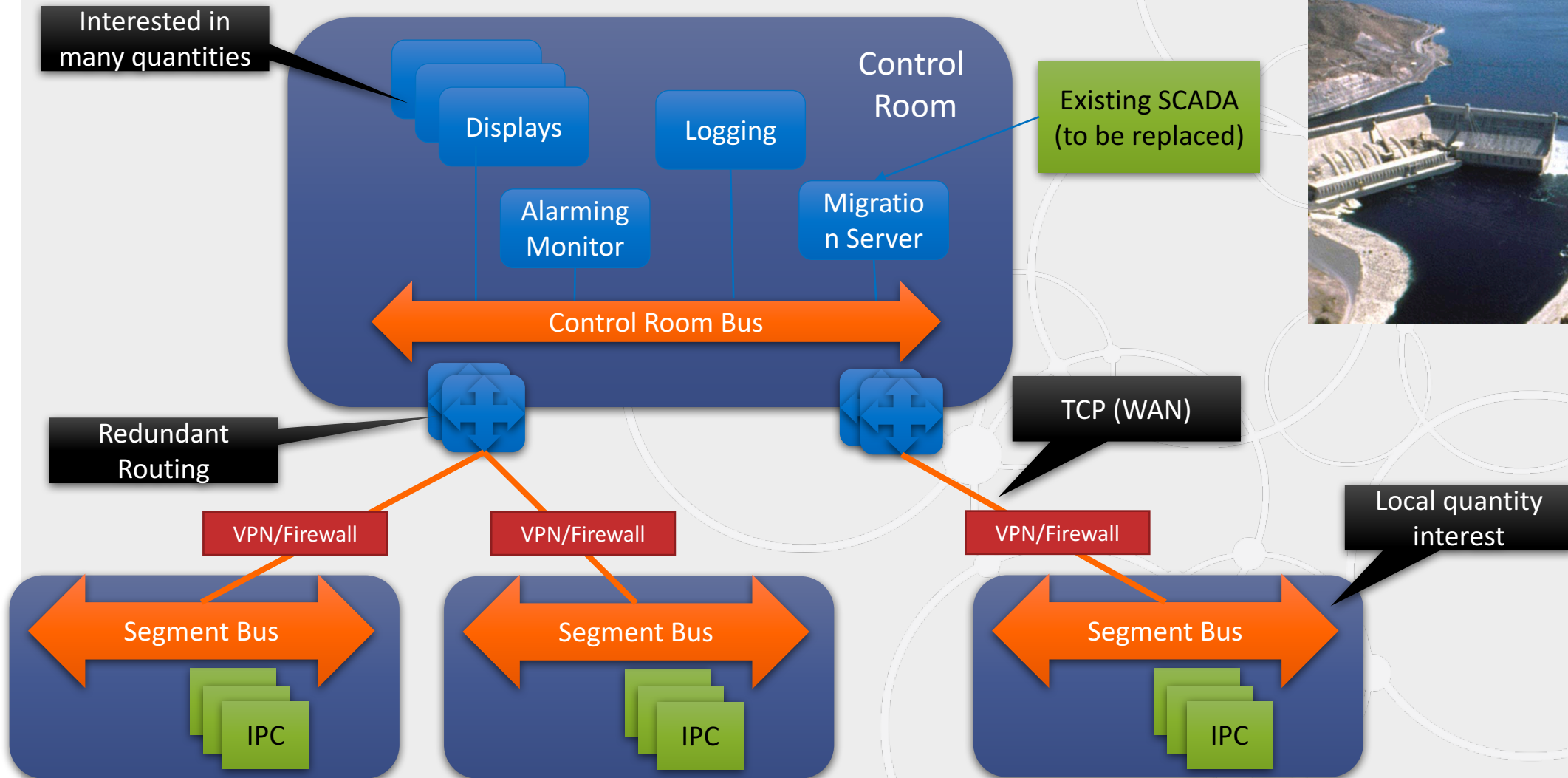
# DDS-Based Integration



# Example: Clinical Decision System Architecture



# Example: Grand Coulee Dam





# Standards Update

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# Key standards we are focusing on

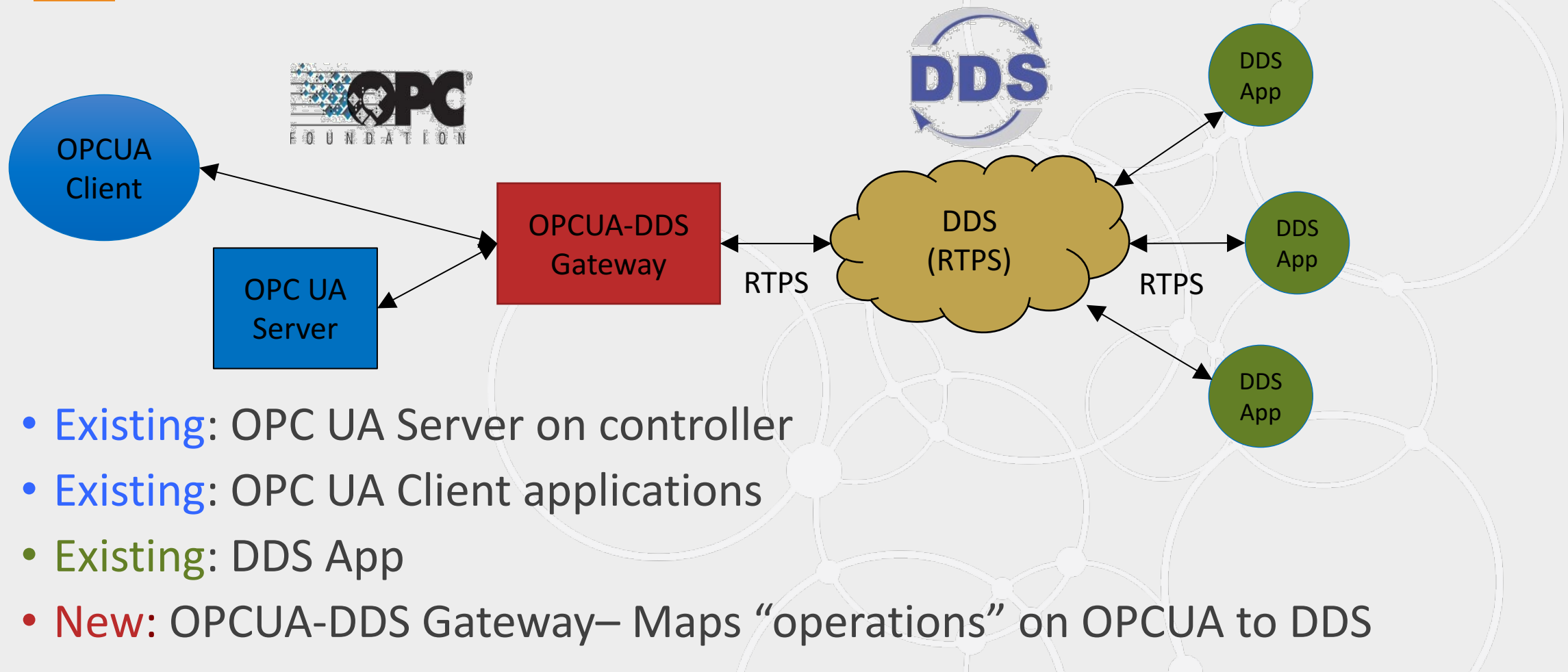
## High Priority:

DDS-Security	1.1	9/2017
DDS-XTYPES	1.2	3/2017
DDS-XML	Beta	6/2017
IDL	4.2	9/2017
DDS-OPCUA	Beta	3/2018
DDS-XRCE	Beta	3/2018
Adaptive AUTOSAR		2018

## Slower burner:

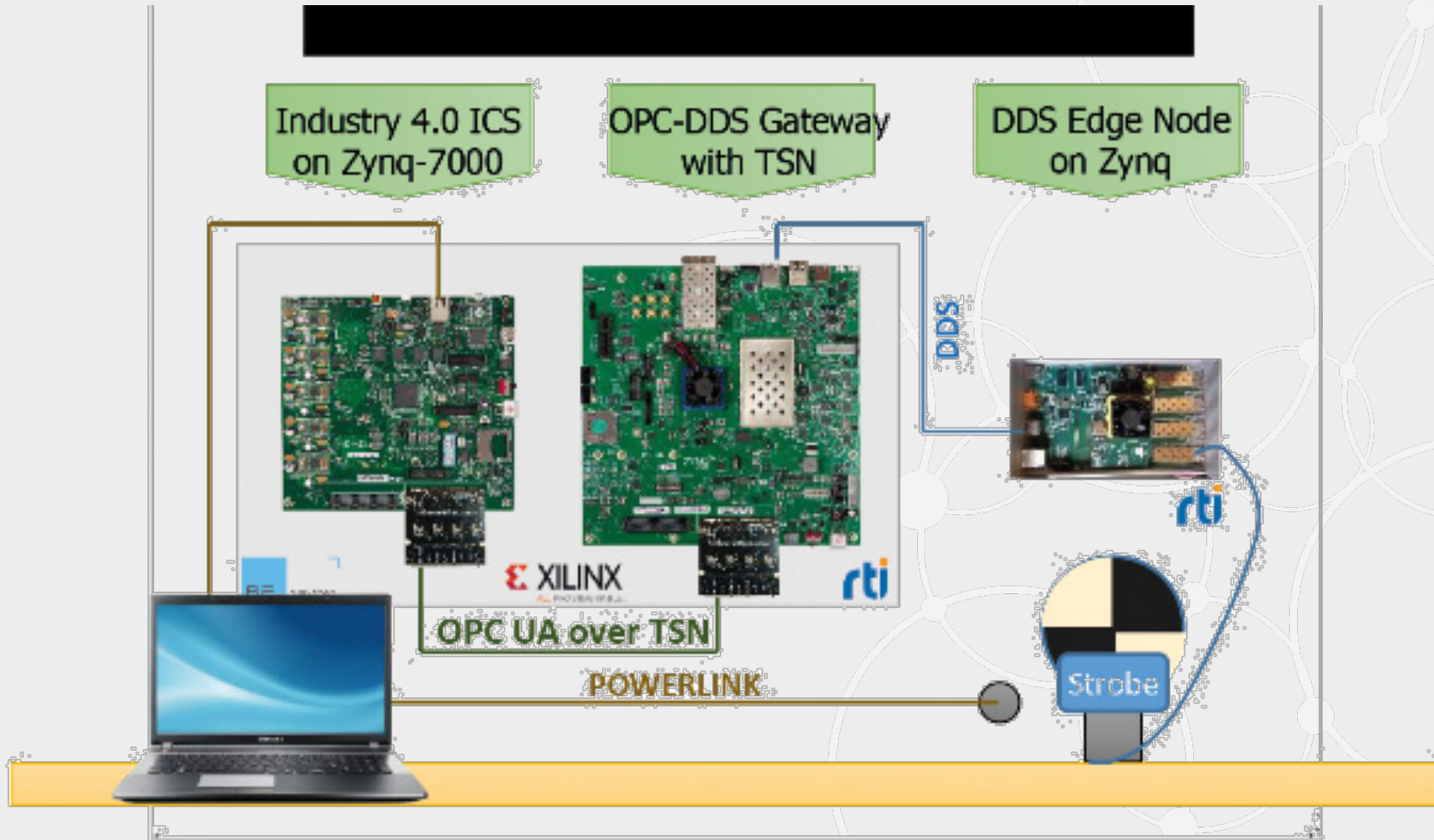
DDS-RTPS	2.3	2018
DDS	1.5	2018
DDS-PSM-TCP	Beta	2018
C++ PSM	1.1	2018
Java5 PSM	1.1	2018
DDS-RPC	1.1	2018
IDL to C#	Beta	TBD
IDL to Java	Beta	TBD

# DDS to OPCUA Bridge



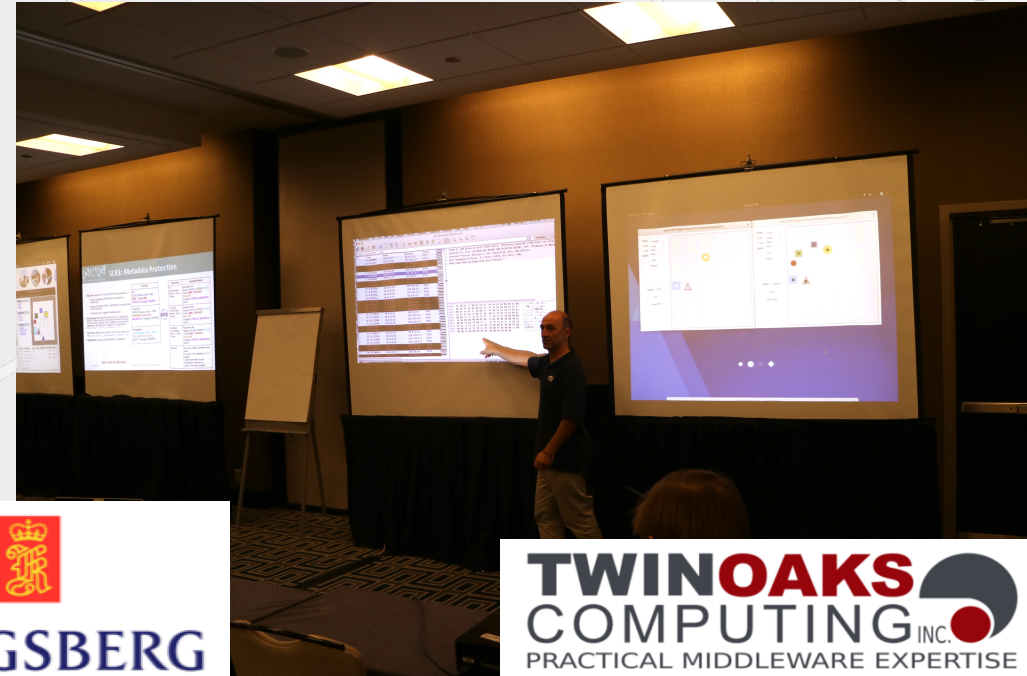
NOTE: OPC foundation also working on a “Pub-Sub” mechanism for OPCUA. Plan is to make “DDS” one of the 3 supported “communication” models for pub-sub.

# DDS/OPC-UA Prototype and Demo Available



# 2017 DDS-Security Interoperability Demo

- 3 vendors (RTI, TwinOaks, Kongsberg)
- 7 Scenarios (see [presentation](#))
- Code available on GitHub (<https://github.com/omg-dds/>)



# Product Update

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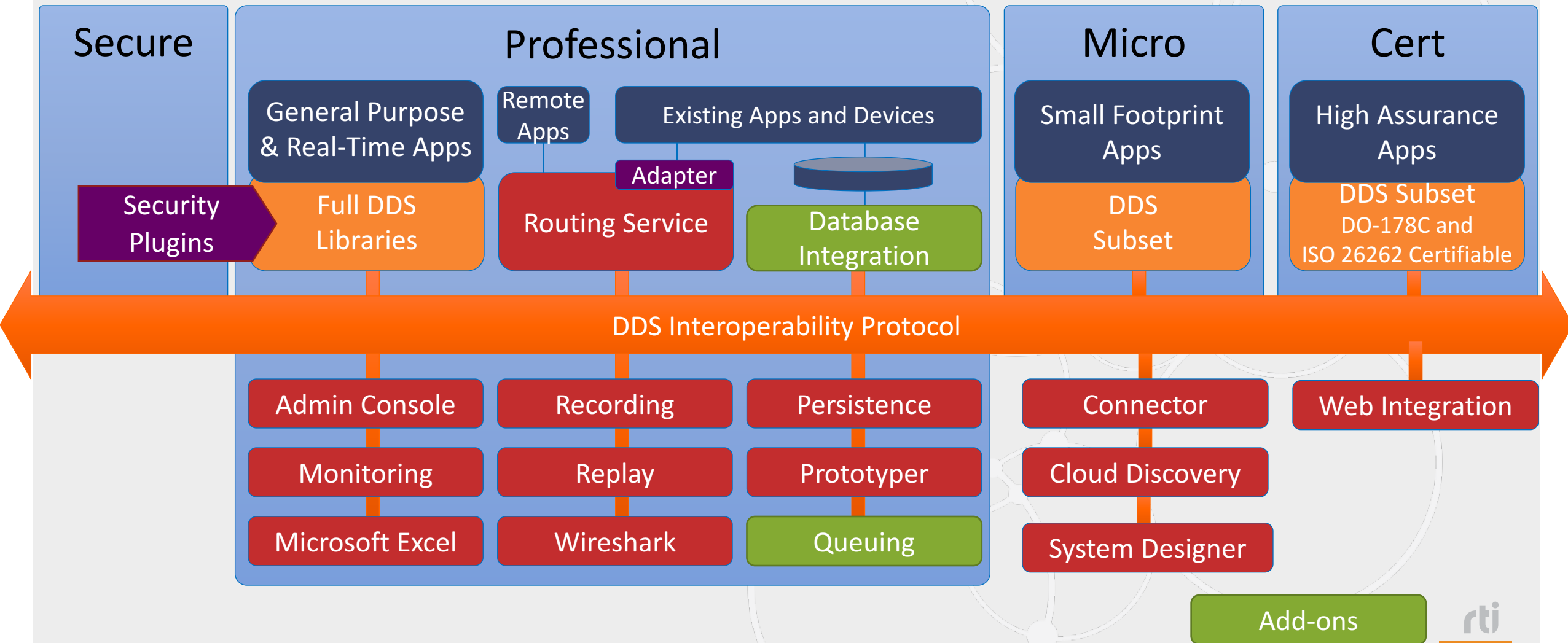
# Three pillars

- Features
- Usability
- Robustness, Scalability & Performance, Quality

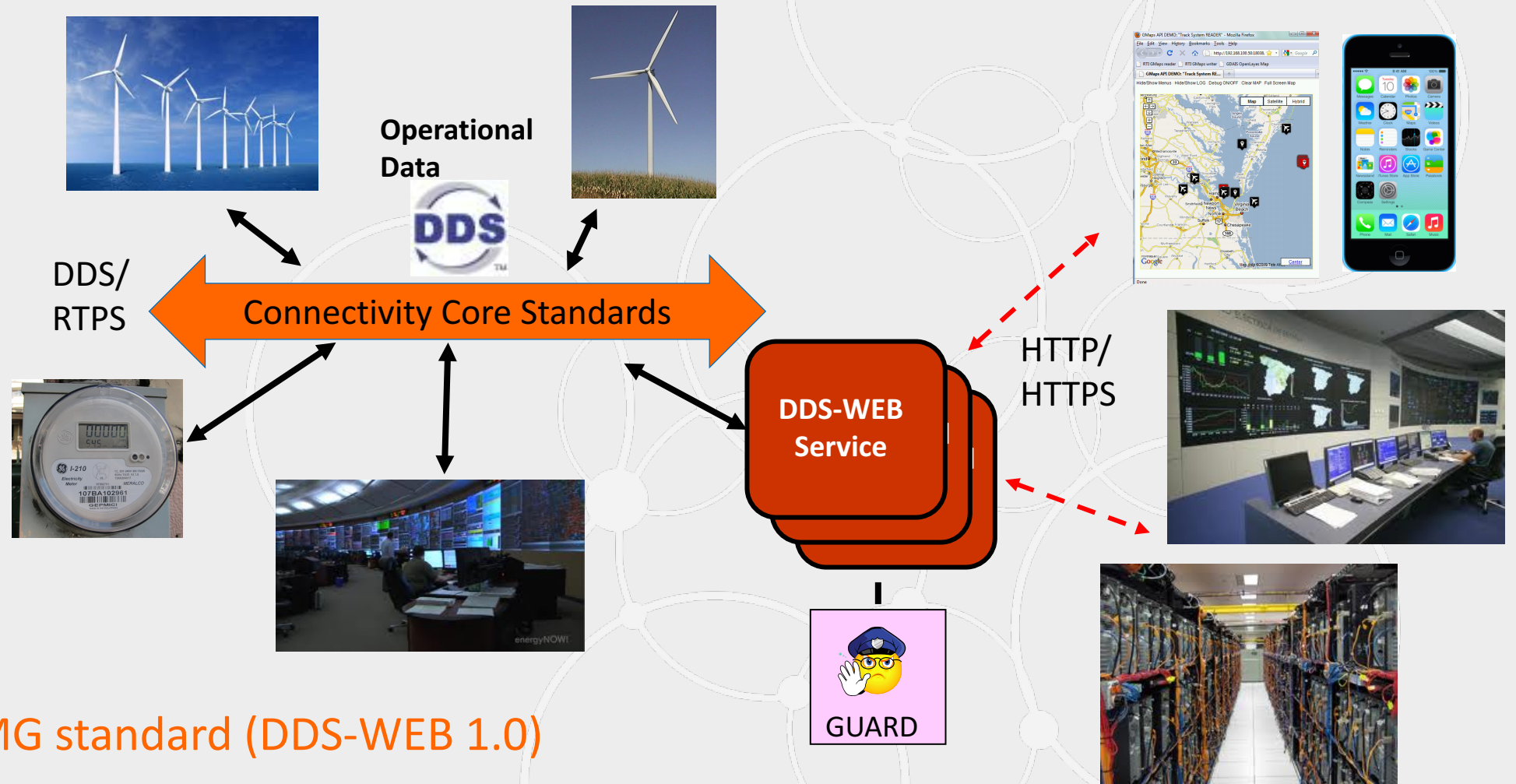




# RTI Connex DDS Product Family

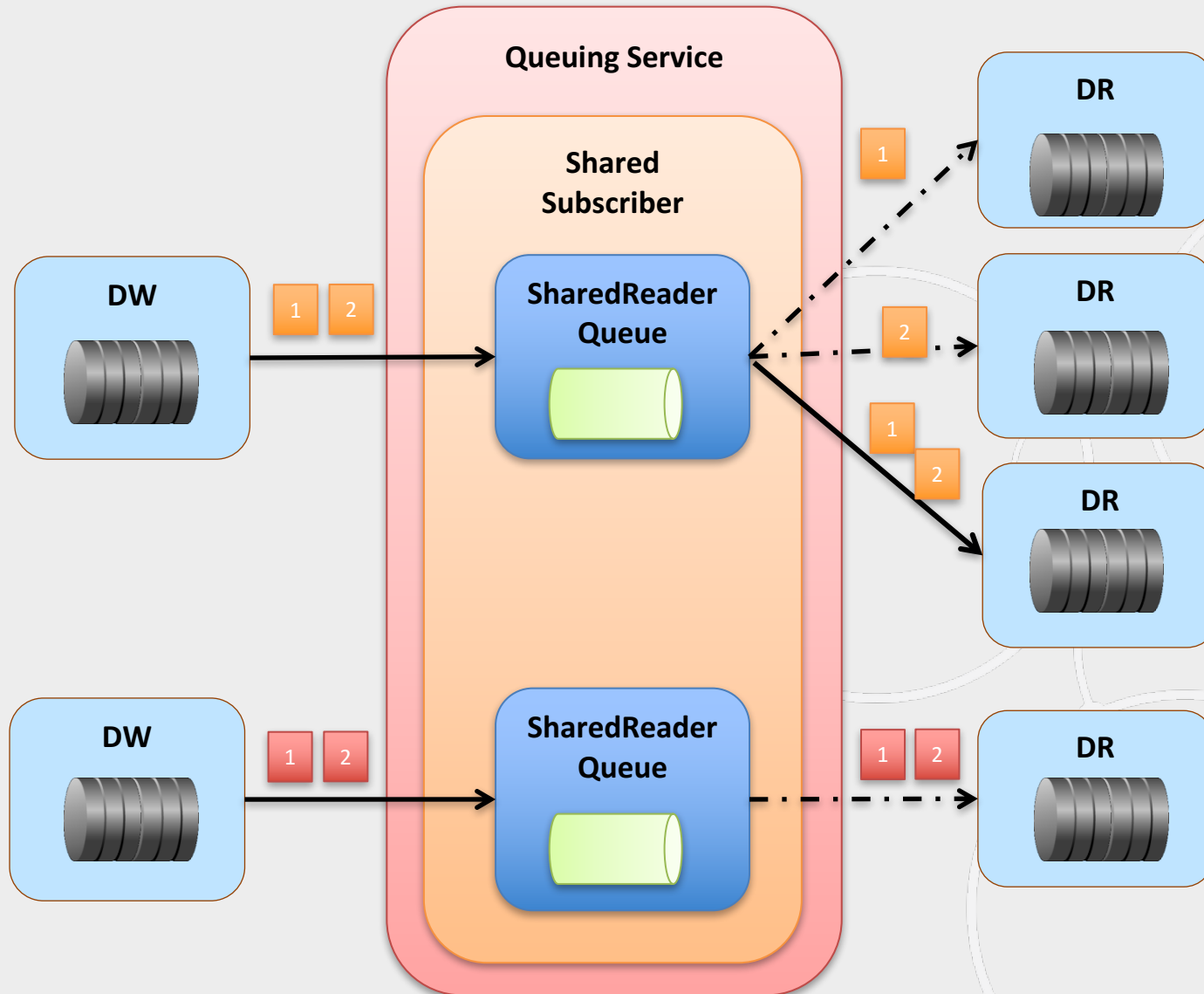


# RTI Web Integration Service(\*)



(\*) Also an OMG standard (DDS-WEB 1.0)

# RTI Queuing Service

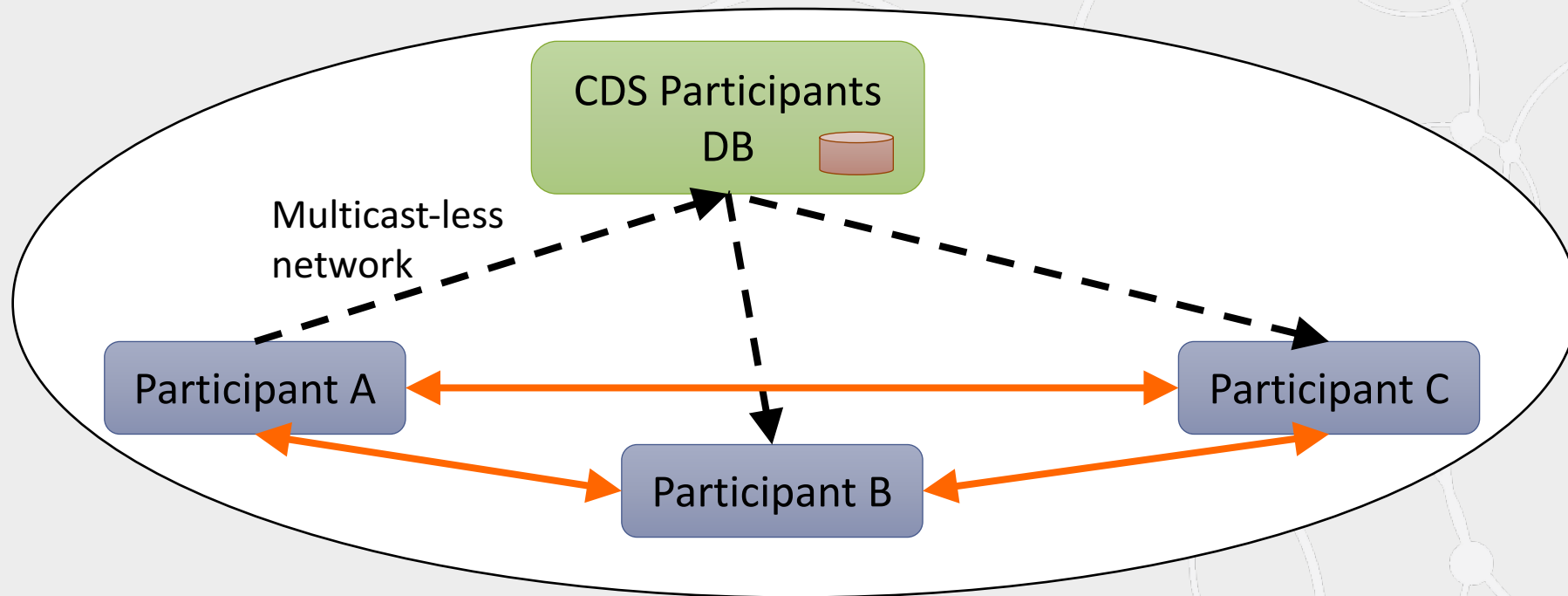


- Merges Queue and Pub-Sub
- Topic and Content-aware Queuing(\*)
- Works natively with DDS APIs and Qos

# Cloud Discovery Service

- Deploy DDS in environments with no multicast (e.g. cloud)

Interoperates with Standard DDS Discovery

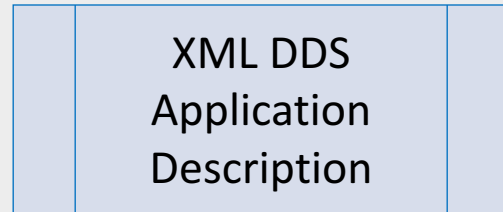


Cloud discovery of Participants

Peer-to-peer discovery of Endpoints (DataWriters and DataReaders)

# RTI Connector

*App Definition is Simple XML*

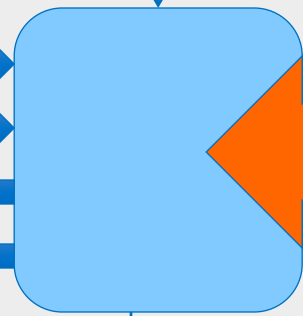


*Configure*

**Connect()**

*Join DDS  
Create all Entities*

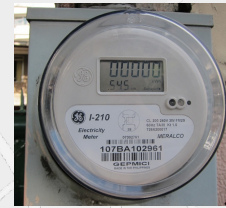
Input1  
Input2  
Output1  
Output2



*Program API  
Is simple reads/writes*

```
getInput("Input1").read();  
getOutput("Output1").write();
```

*Use your favorite Language:*



- Fast “wrapper” API
- Supports Data-Centric programming
- Separates configuration & Logic

# Connector Example



```
conn =
rti.Connector("MyParticipantLib::Zero",
              "./ShapeExample.xml");

o = conn.getOutput("Pub::SqWriter");

for i in range(1,500):
    o.instance.setNumber("x", i);
    o.instance.setNumber("y", i*2);
    o.instance.setNumber("shapsize", 30);
    o.instance.setString("color", "BLUE");
    o.write();
    time.sleep(2)
```



```
var conn = new
rti.Connector("MyParticipantLib::Zero",
              "./ShapeExample.xml");

var o =
conn.getOutput("Pub::SqWriter");

var i;
for (i=0; i<500; i++) {
    o.instance.setNumber("x",i);
    o.instance.setNumber("y",i*2);
    o.instance.setNumber("shapsize",30);
    o.instance.setString("color",
"BLUE");
    o.write();
    sleep.usleep(1000);
}
```



```
conn =
rti.Connector("MyParticipantLib::Zero",
              "./ShapeExample.xml");

o = conn.getOutput("Pub::SqWriter");

for (i=0; i<500; i++) {
    o.instance.x = i;
    o.instance.y = i*2;
    o.instance.shapsize = 30;
    o.instance.color = "BLUE";
    o.write();
    sleep.usleep(1000);
}
```



# New Feature Highlights

- Mobility
  - Your data always finds you
- Topic Query
  - Past data as you want it, on demand
- Security
  - Fine grain protection for critical data...
- Tools
  - Admin Console, System Designer, ...
- Routing Service 3.0
  - Multiple inputs & outputs
  - C++ Adapter API
- Large Data / Zero Copy





# Topic Query



**Mobility**



Last 4  
Hours?



Routing  
Service

Routing  
Service

**Security**



CONNEXT DDS SECURE



CONNEXT DDS SECURE

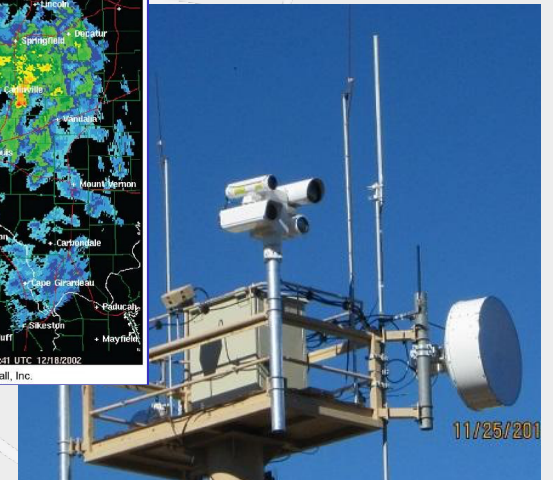
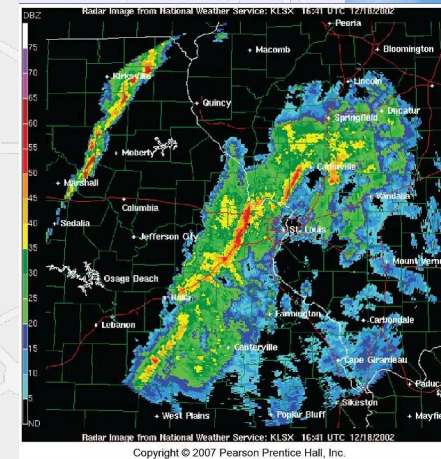
# Large Data scenarios

Lidar:

Radar:

Images: Video, Radar, ...

Medical Scanners (CT, PET)



11/25/2011

rti

# Connex DDS Micro: Many new features

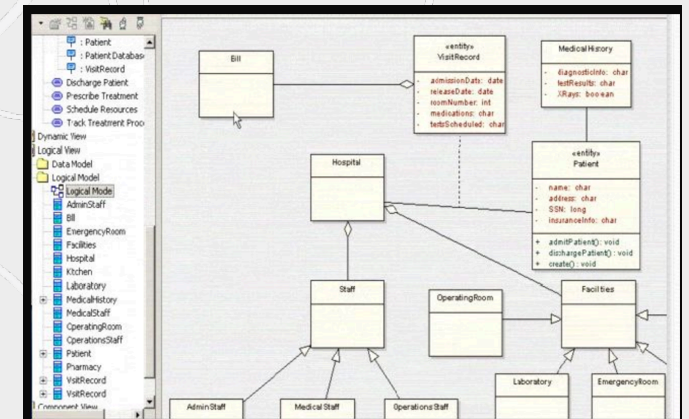
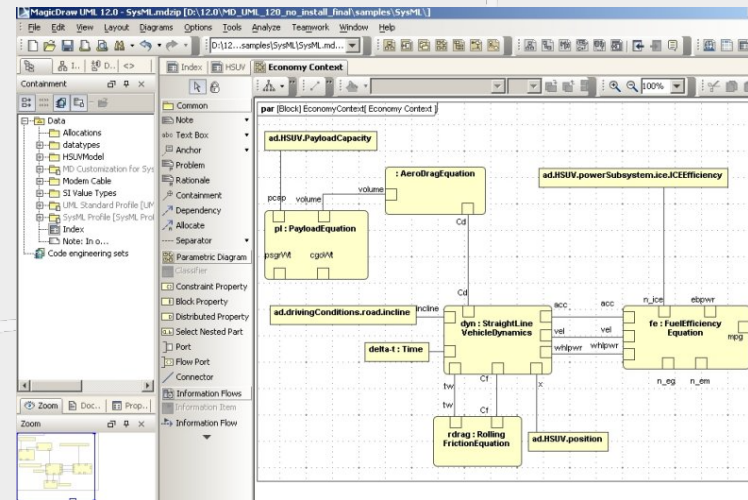
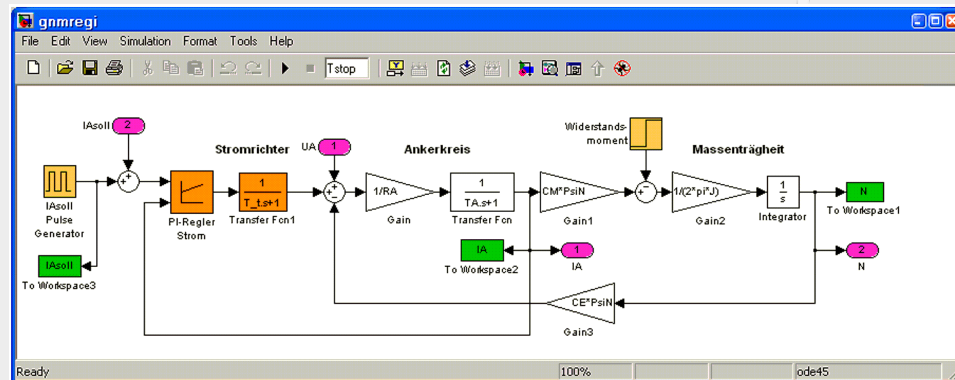
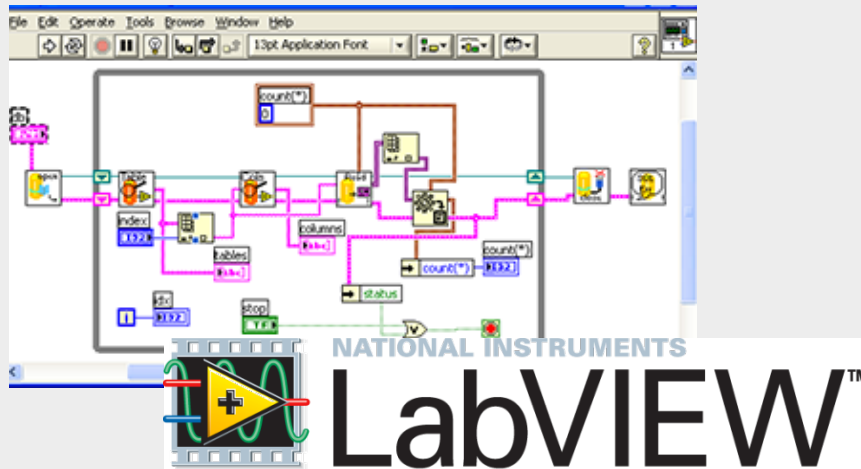
- Security
- Extensible Types
- XML Qos
- Robustness
- Formal verification
- Platforms (including ARINC 653)
- Performance & scalability testing



**IS NEVER ENOUGH**



# Integrating 3<sup>rd</sup> party tooling

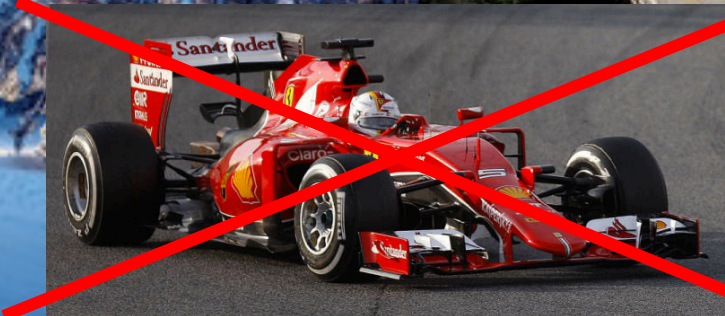
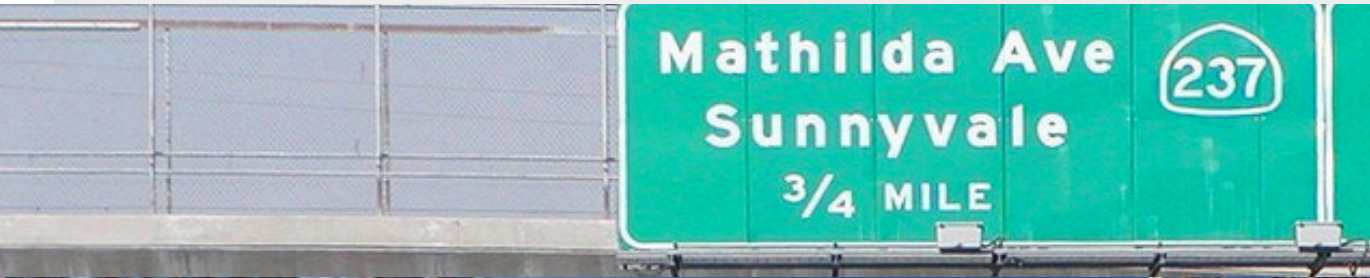


# Robustness

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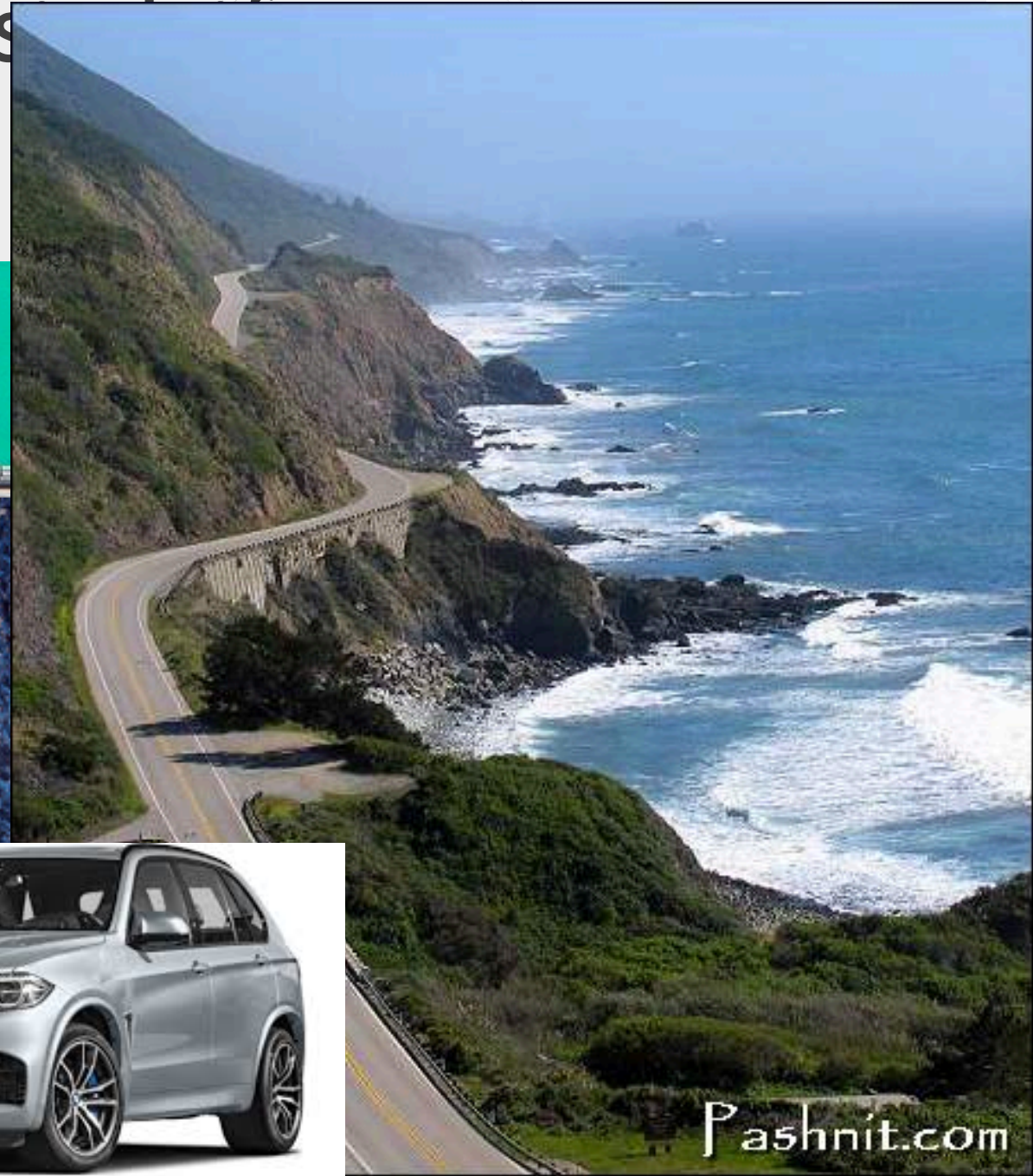
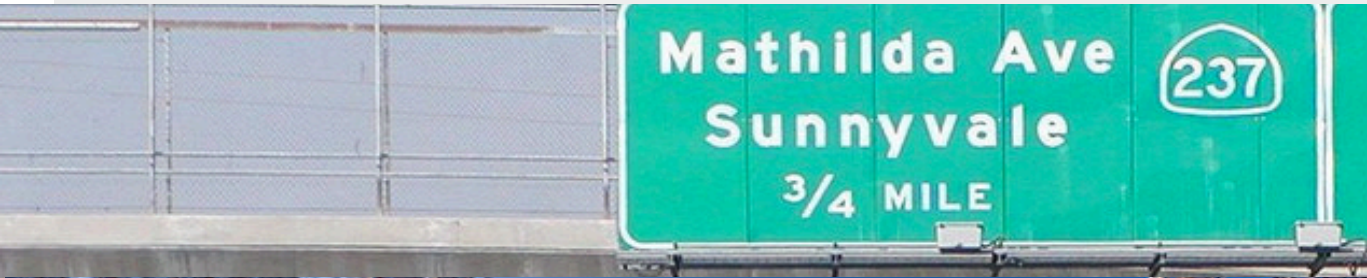


# Building the best





# Building the best



Pashnit.com



# Building the best platform





The kind of robustness our  
users need





# Robustness

- Heap Monitoring
- Static Analysis
- Endurance Testing
- Continuous Benchmarking
  - Memory
  - 10Gb performance
  - Multicast Scalability
  - Content Filter Topic Scalability
  - Discovery Scalability

120 rPis (120 cores)

32 Xeon blades (128 cores) + 4 TI PPC boards ( 24 cores)



# Research

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# Active funded research areas

Topic	Funding	Start/Finish	Technologies
<b>DDS Data Generator</b>	~\$1M	6/2015- 6/2017	<b>RTI System Designer</b>
<b>Recording &amp; Reconstruction</b>	~\$1M	3/2016- 3/2018	<b>Next-Gen Data Recorder</b>
<b>A Secure Distributed Computing Middleware for seL4</b>	~\$1M	6/2016- 6/2018	<b>DDS-Security for Connext Micro, Formal SW Verification</b>
<b>Securing Medical Device Systems</b>	~\$1M	8/2016- 8/2018	<b>Using Hardware TPM with DDS-Secure</b>
<b>Safety Critical Micro</b>	~\$1M	9/2016- 9/2018	<b>Safety Critical, Advanced Micro Tools</b>
<b>Energy SmartGrid</b>	~\$1M	8/2017- 8/2019	<b>Remote Management, Monitoring &amp; Provisioning of DDS Nodes</b>
<b>Security Monitoring</b>	~ \$200K	12/2016-6/2017	<b>Tools for monitoring the security of DDS systems</b>
<b>CyberTools Mgmt Framework</b>	~ \$200K	9/2017- 2/2018	<b>Remote Management &amp; Provisioning of Cyber Tools</b>
<b>Mission Resilience through Virtualization</b>	~ \$200K	9/2017- 2/2018	<b>Making DDS systems resilient to cyber attacks.</b>
<b>Blockchains for Industrial Systems</b>	~ \$200K	7/2017- 7/2018	<b>Exploring how to leverage blockchain and ledgers in secure DDS Systems</b>

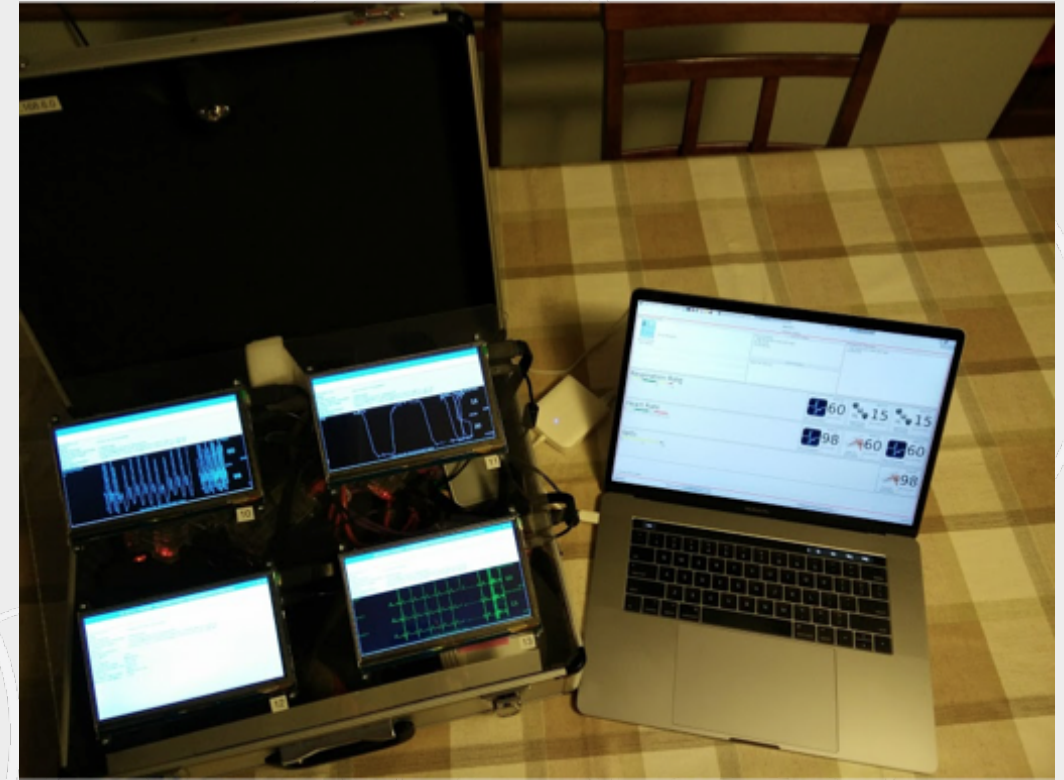
# Securing Medical Device Systems

## Development Scope

- RTI Connex DDS Secure Development
  - OMG DDS Security Spec Compliant Software
  - Interoperability Testing
- RTI Security Tools
  - Security Provisioning & Configuration
  - Secure IP Mobility

## Research Scope

- Hardware Security - Trusted Platform Modules (TPMs)
- Medical Device Security
- Collaboration with Harvard/MGH
- Clinical Device Security Policy Management
- FDA Engagement

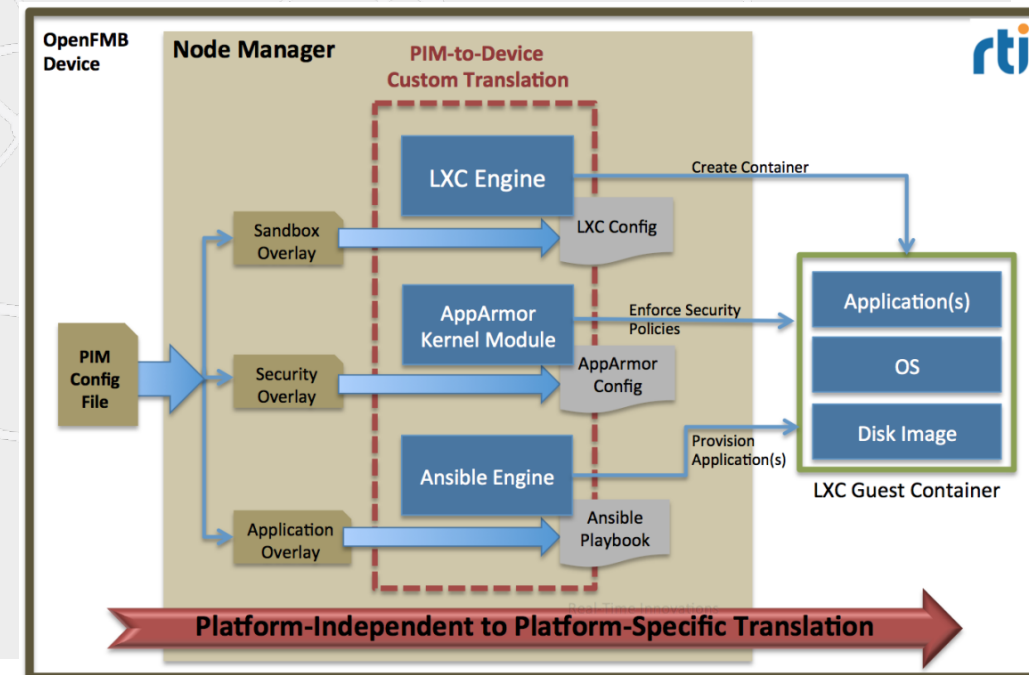


# Energy SmartGrid



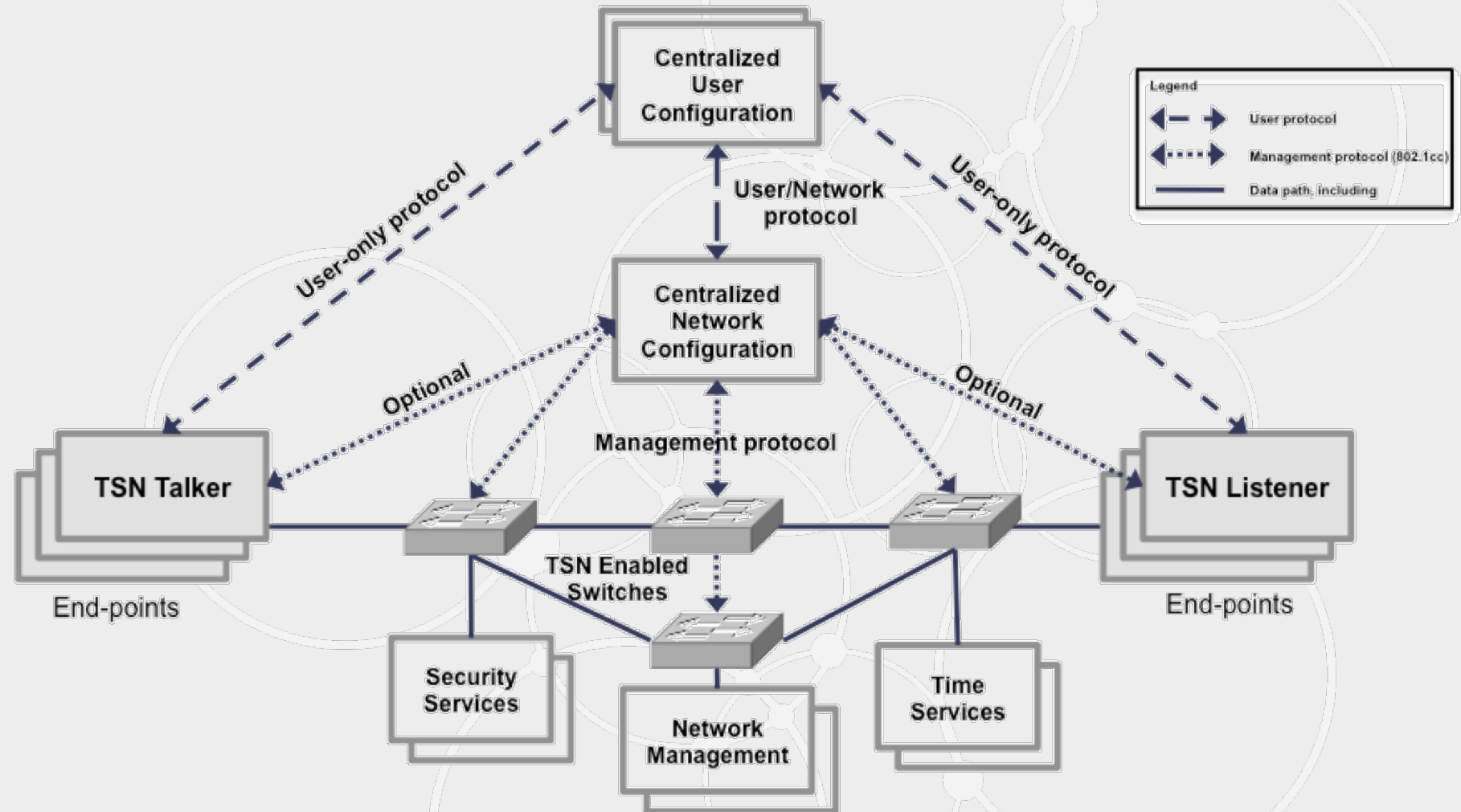
- **Scope**
  - Device Configuration & Updates
    - Containers, Applications, Security
  - Real-Time Device Health Status Monitoring
  - Certificate Provisioning & Management
  - **Aligned with OpenFMB**
- Demo planned at Duke's Rankin facility (8/2019)
- We will establish an Industry Advisory Board

*Remote Node  
Management for DDS  
Systems*



# Time Sensitive Networks

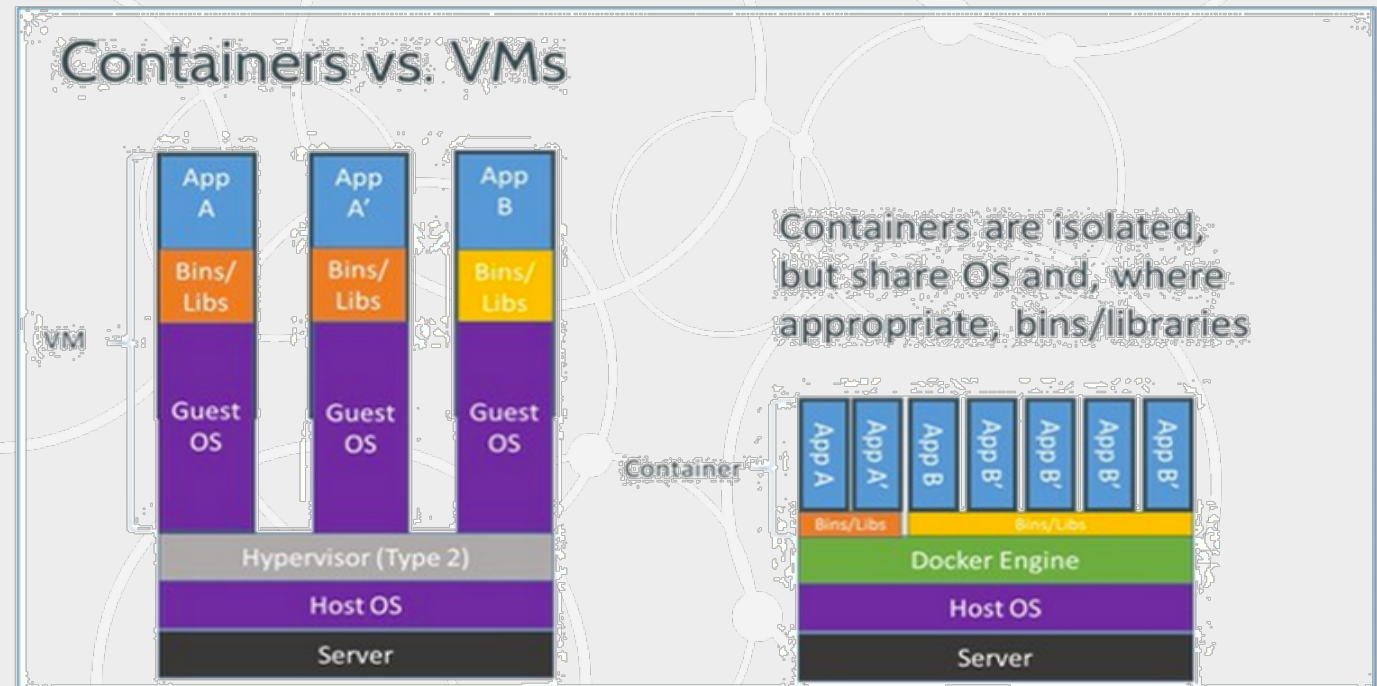
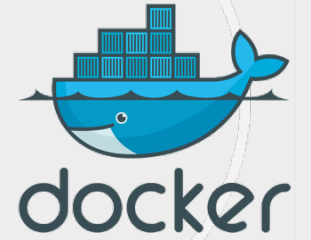
- New set of IEEE standards
- Deterministic packet delivery on standard Ethernet





# Virtualization & Light-Weight Container deployments

- Modularization
- Packaged App deployment
- Optimal transport
  - e.g. shared memory within host



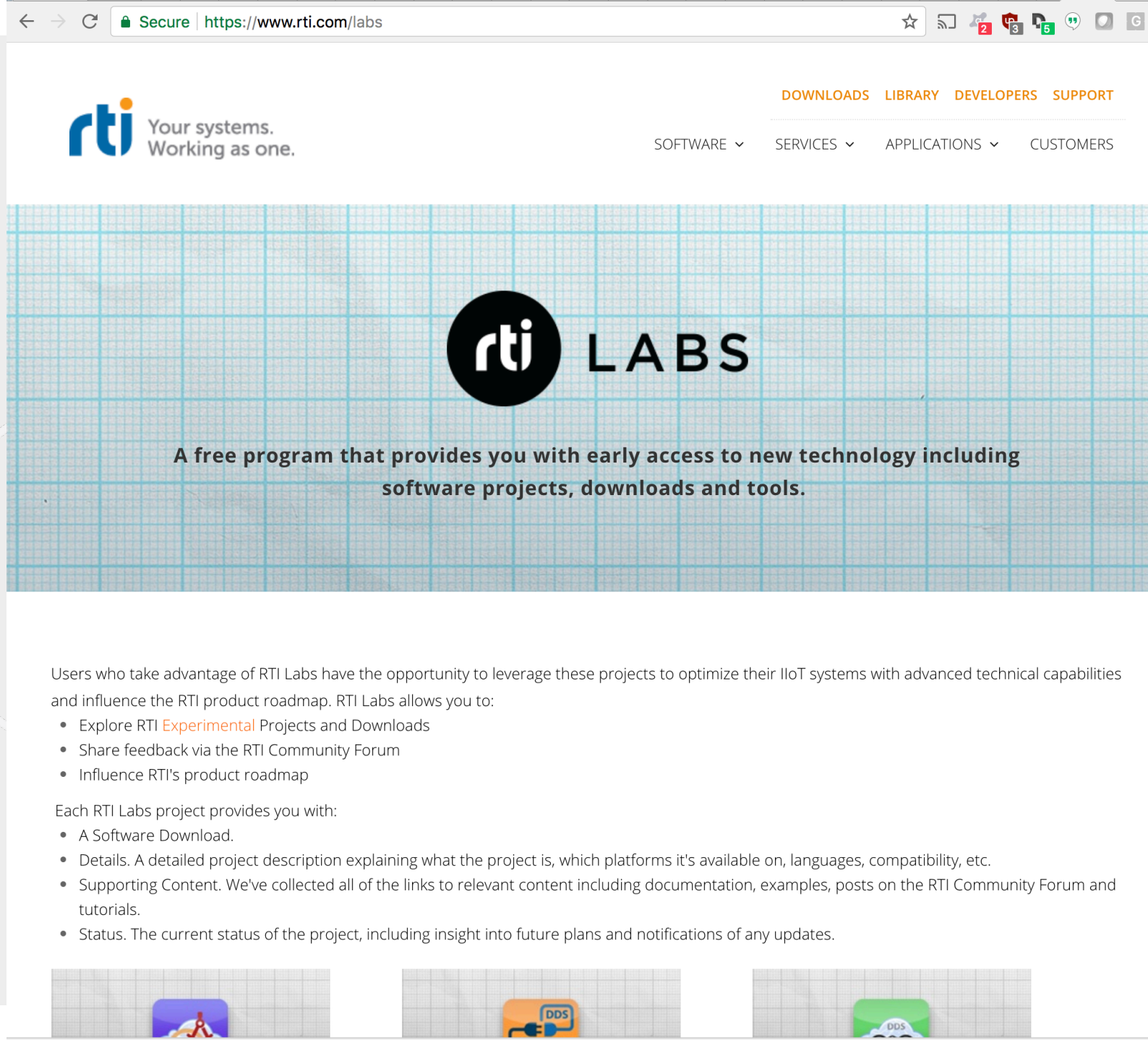
# RTI Labs

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# RTI Labs

- Provide early access to new RTI technology
- Empower users to guide RTI
- Free program



The screenshot shows the RTI Labs website. At the top, the browser address bar displays 'Secure | https://www.rti.com/labs'. The RTI logo is on the left, with the tagline 'Your systems. Working as one.' To the right, a navigation bar includes links for 'DOWNLOADS', 'LIBRARY', 'DEVELOPERS', and 'SUPPORT'. Below this, a secondary navigation bar lists 'SOFTWARE', 'SERVICES', 'APPLICATIONS', and 'CUSTOMERS', each with a dropdown arrow. The main header features the 'rti LABS' logo on a blue grid background. Below the logo, a text box states: 'A free program that provides you with early access to new technology including software projects, downloads and tools.' The main content area explains that users can leverage projects to optimize IIoT systems and lists three benefits: exploring experimental projects, sharing feedback, and influencing the product roadmap. It then details what each project provides: a software download, a detailed project description, supporting content, and status updates. At the bottom, three project cards are partially visible, each with a different icon (a red figure, a blue DDS icon, and a green DDS icon).

Secure | https://www.rti.com/labs

rti Your systems. Working as one.

DOWNLOADS LIBRARY DEVELOPERS SUPPORT

SOFTWARE ▾ SERVICES ▾ APPLICATIONS ▾ CUSTOMERS

## rti LABS

A free program that provides you with early access to new technology including software projects, downloads and tools.

Users who take advantage of RTI Labs have the opportunity to leverage these projects to optimize their IIoT systems with advanced technical capabilities and influence the RTI product roadmap. RTI Labs allows you to:

- Explore RTI **Experimental** Projects and Downloads
- Share feedback via the RTI Community Forum
- Influence RTI's product roadmap

Each RTI Labs project provides you with:

- A Software Download.
- Details. A detailed project description explaining what the project is, which platforms it's available on, languages, compatibility, etc.
- Supporting Content. We've collected all of the links to relevant content including documentation, examples, posts on the RTI Community Forum and tutorials.
- Status. The current status of the project, including insight into future plans and notifications of any updates.

# RTI Labs Technologies now available



## SYSTEM DESIGNER

A UI Tool that simplifies the creation of XML files, allowing you to graphically design and configure your Connex DDS systems. [Learn more.](#)



## CONNECTOR

Publish and subscribe to data on the Connex Databus using scripting languages. [Get Started.](#)



## CLOUD DISCOVERY SERVICE

A stand-alone application for deploying Connex DDS applications in dynamic environments, including where UDP/IP multicast is not available. [Learn more.](#)



RTI System Designer

Projects...

Current Project: NewProject

Properties

Import

Export

Save

Help

Types

QoS

Domain

Participant

Collapse

Referenced Types

const MAX\_COLOR\_LEN

struct Property

enum Action

struct KeyValue

struct ShapeType

struct ShapeTypeExt

Types

struct NewStruct1

Structured

XML

IDL

Collapse

Move up

Move down

Add Top

Item	Annotations	Location	Edit
const long MAX_COLOR_LEN		ShapesExa	
struct Property		ShapesExa	
string<MAX_COLOR_LEN		ShapesExa	
string<MAX_COLOR_LEN		ShapesExa	
enum Action		ShapesExa	
NORMAL = 1		ShapesExa	
QUARANTINE = 2		ShapesExa	
ISOLATE = 3		ShapesExa	

<http://demo.rti.com/system-designer>

©2017 Real-Time Innovations, Inc

Types QoS Domain ...

Expand + New library ?

Referenced QoS Libraries

QoS Libraries

MyLibrary

MyProfile

Library name:

QoS Profiles

+ Add - Remove

MyProfile

### Edit Data Writer QoS Profile from profile 'MyProfile'

Profile name: (optional)

Base QoS:

Topic filter: (optional)

Collapse All

Reset

#### Durability (Durability QoS Policy)

Controls whether or not, and how, published DDS samples are stored by the DataWriter application for DataReaders that are found after the DDS samples were initially written.... [More...](#)

Kind:

TRANSIENT\_LOCAL\_DURABILITY\_QOS

Direct communication:

#### Durability service (Durability Service QoS Policy)

It is used to configure the HISTORY and

Service cleanup delay:

History kind:

KEEP\_LAST\_HISTORY\_QOS

History depth:

6

Max samples:

Max instances:

Max samples per instance:

#### Deadline (Deadline QoS Policy)

Cancel

OK

# Conclusion

---





We are helping you meet the most critical  
application challenges





# Thank You!

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