Your systems.
Working as one.

# Trends and Technical Direction

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Chief Technology Officer, RTI

# The IIoT Disruption

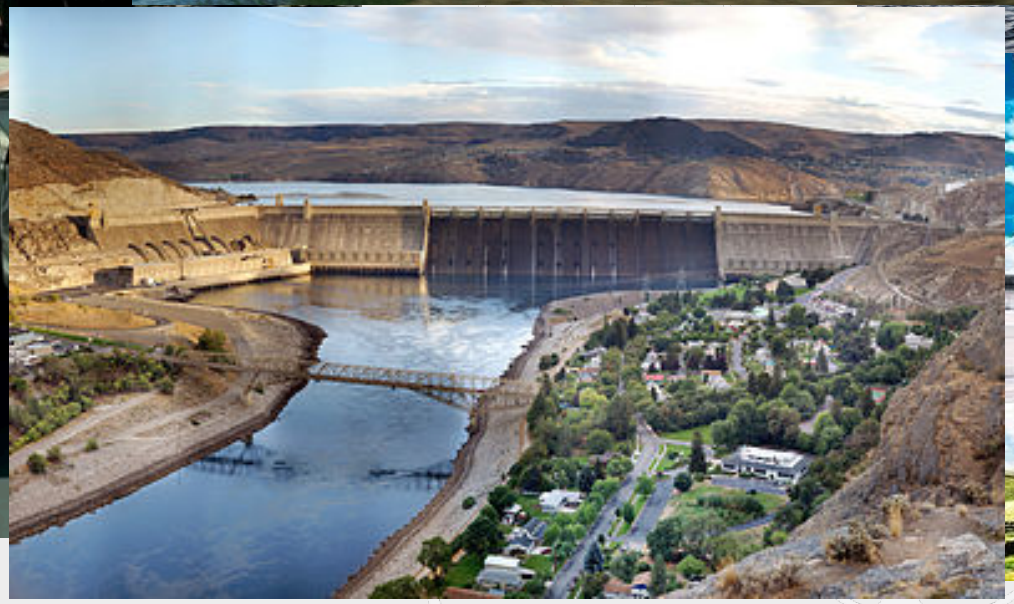
*The IIoT lives at the **intersection** of functional **artificial intelligence** and **pervasive networking***



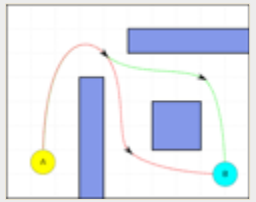
**The real value is a common architecture that connects sensor to cloud, interoperates between vendors, and spans industries**

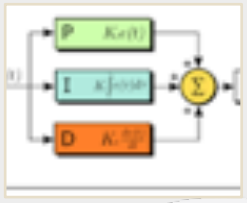
# Help users build amazing & challenging applications solving the problems that matter the most

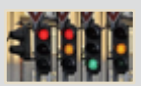


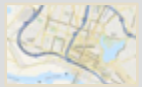



# Connext DDS databus







Traffic

Maps

CONNEXT DDS DATABUS

Situation Awareness

Planning

Vehicle Control

Logging

Error Management

CONNEXT DDS DATABUS

Sensing

Cameras, LIDAR, Radar…

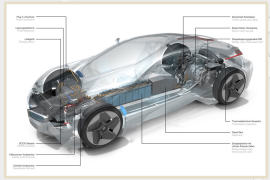
Data Fusion

Localization

Vehicle Platform

Visualization

Navigation



# DDS "virtual" Data-Centric Global Data Space

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

CRUD operations

Persistence Service

Recording Service

# Connext 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

Industrial Internet Connectivity Framework

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

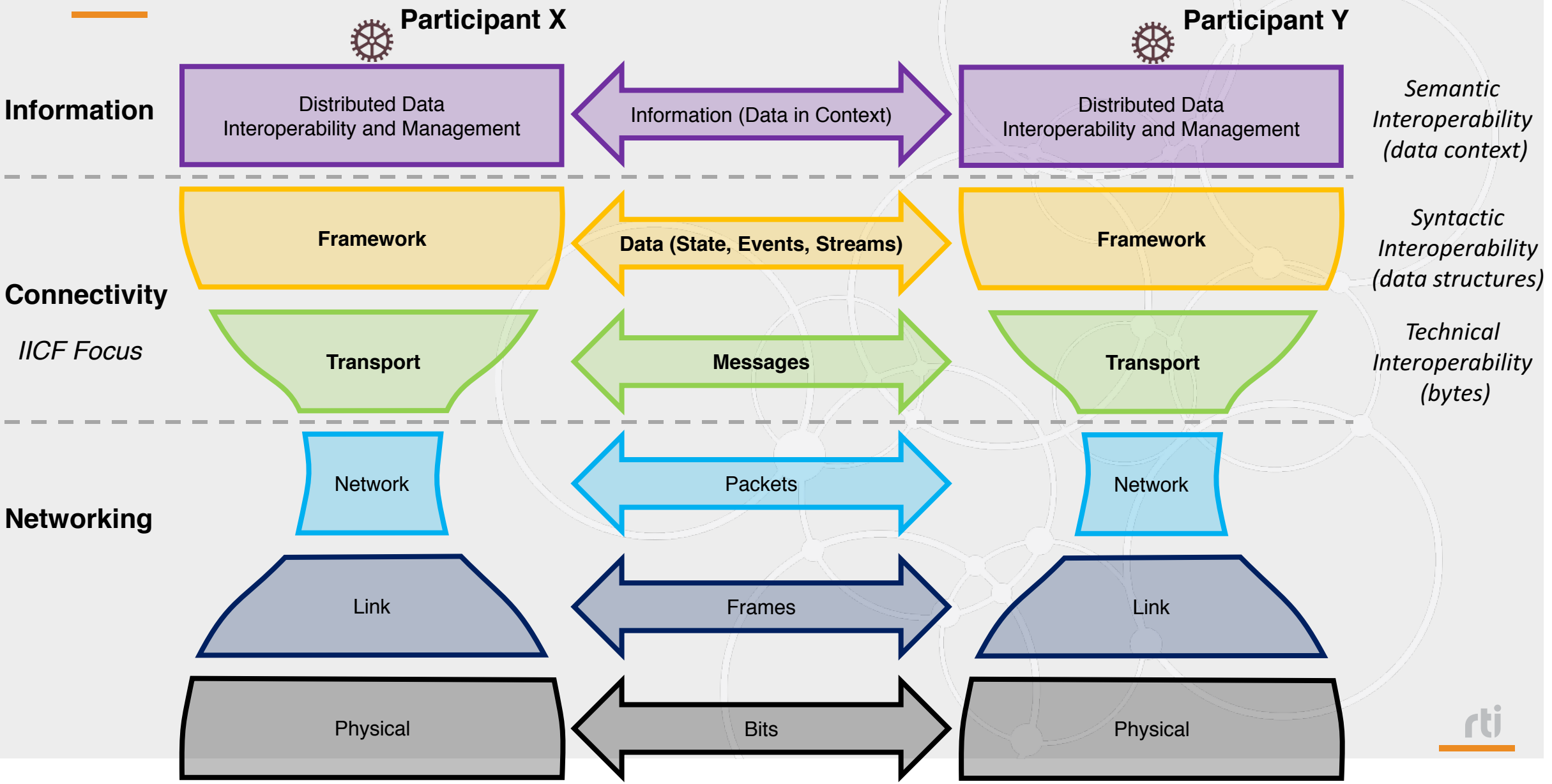
# IIC releases Connectivity Reference Architecture


DDS anointed the

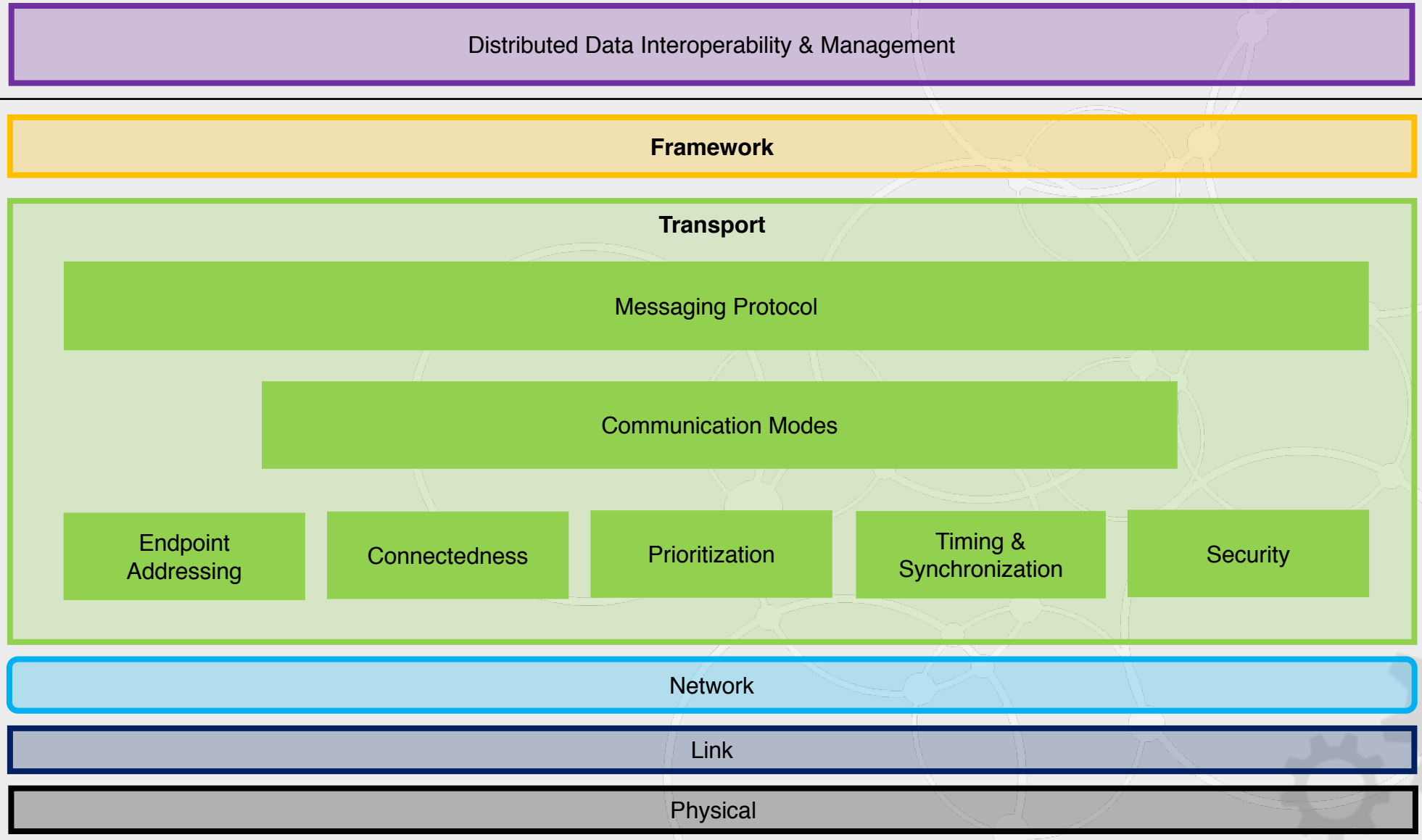
**Core connectivity**

**Databus**

# IIoT Connectivity Stack Model



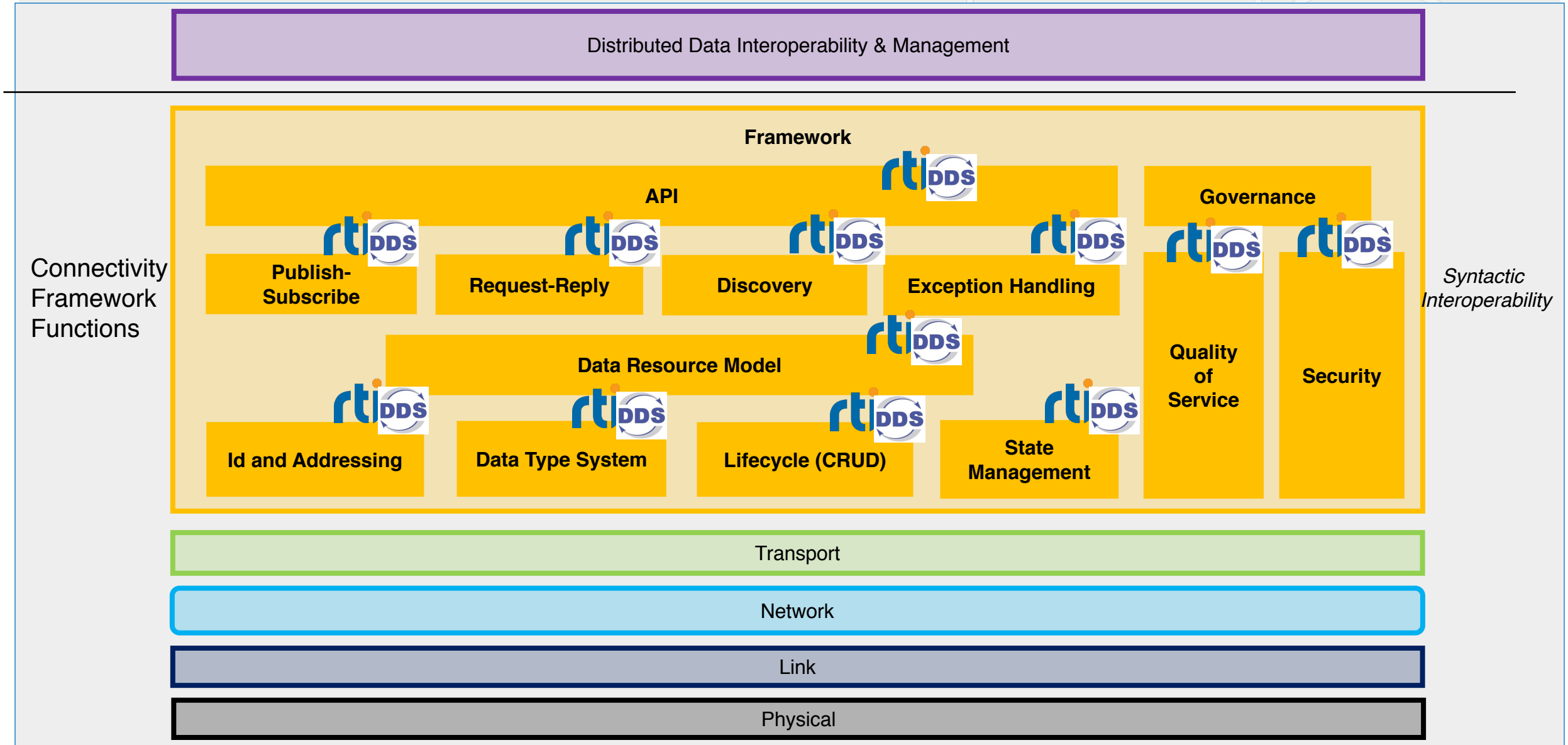
# Connectivity Transport Layer



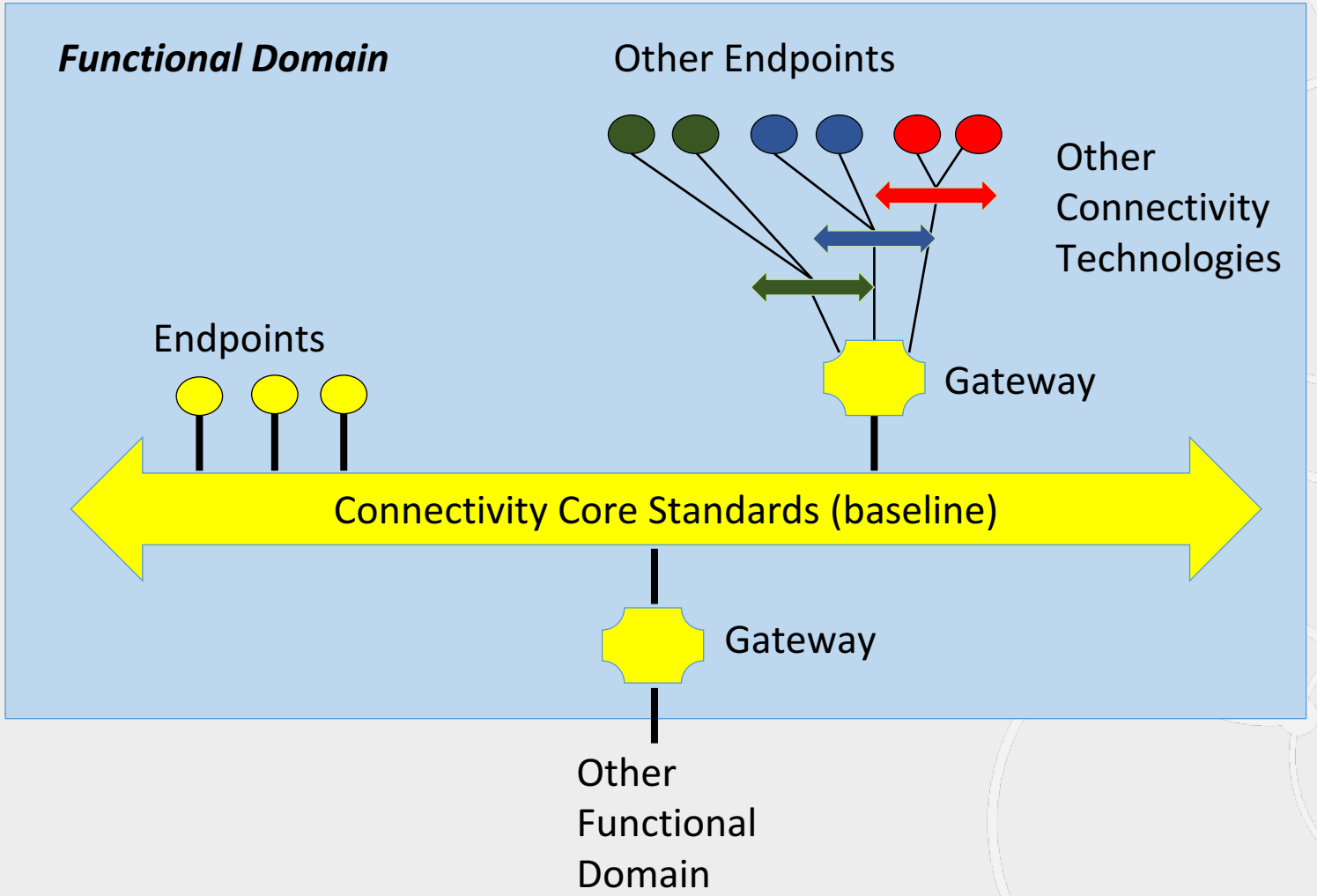

Connectivity Transport Functions

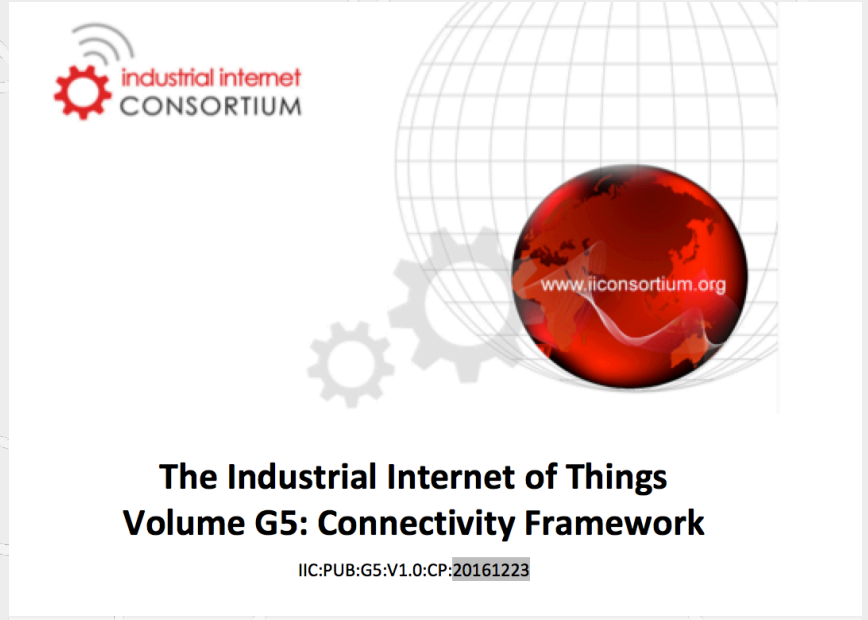
*Technical Interoperability*

# Connectivity Framework: Core Functions

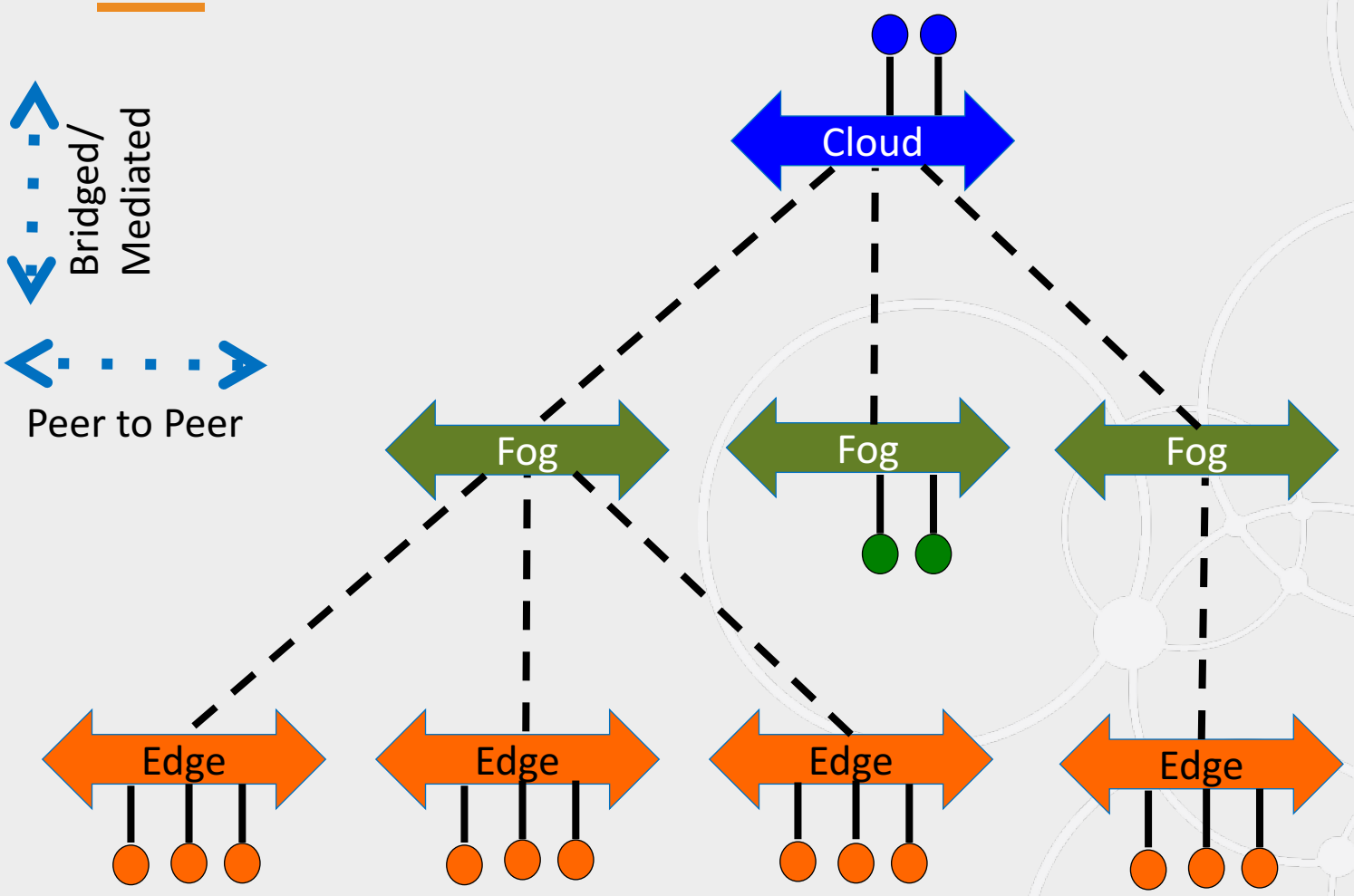


# IIC Layered Databus architecture



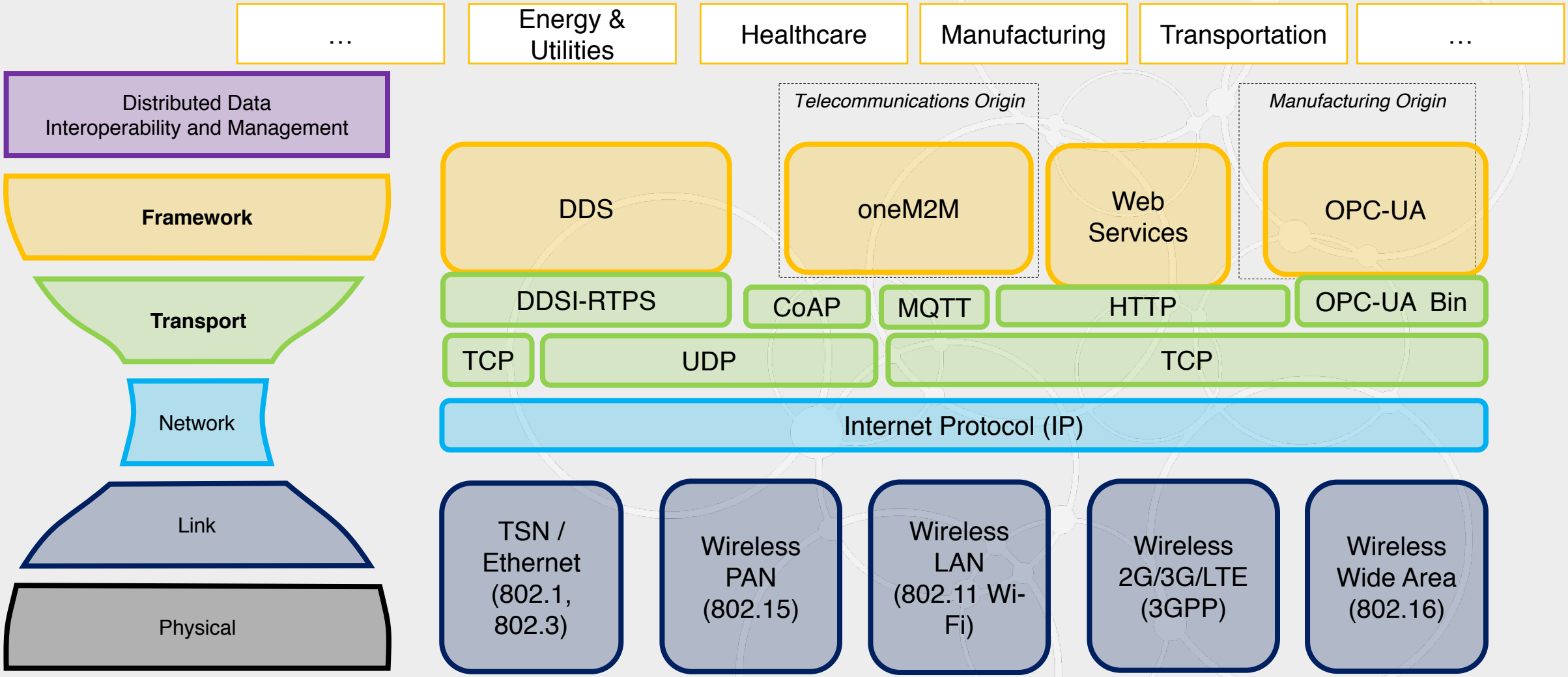



# Layered Databus spans Edge to Cloud




- 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

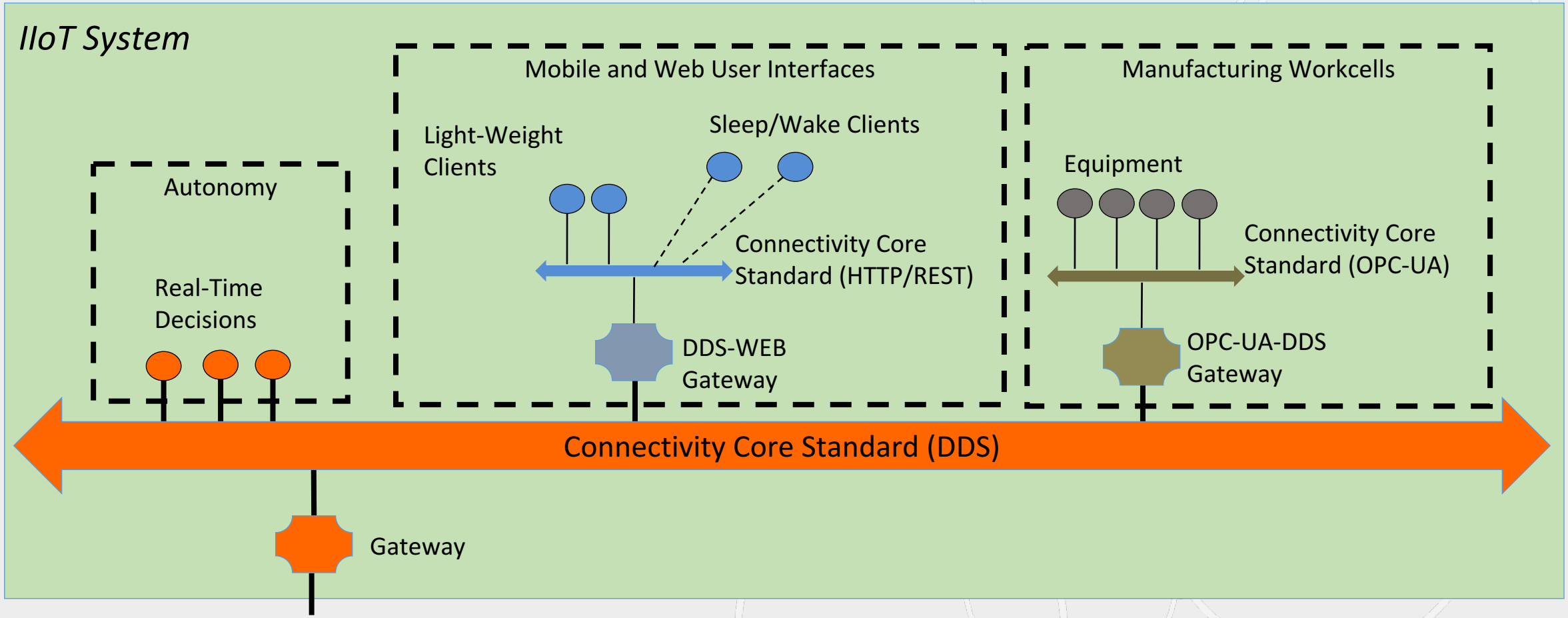
- Platform constraints
- Incremental upgrades

| | Core Standard Criterion  | DDS | Web Services | OPC-UA | oneM2M |
|---|---|---|---|---|---|
| 1 | Provide **syntactic interoperability** | ✔ | **Need XML or JSON** | ✔ | ✔ |
| 2 | Open standard with strong **independent, international** governance | ✔ | ✔ | ✔ | ✔ |
| 3 | **Horizontal** and neutral in its applicability across industries | ✔ | ✔ | ✔ | ✔ |
| 4 | **Stable** and **proven** across multiple vertical industries | **Software Integration & Autonomy** | ✔ | **Manufacturing** | **Home Automation** |
| 5 | Have **standards-defined *Core Gateways*** to *all* 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 **functional** requirements | ✔ | | **Pub-Sub in Development** | ✔ |
| 7 | Meet **non-functional** requirements of performance, scalability, reliability, resilience | ✔ | | **Real-Time in development** | **Reports not yet documented or public** |
| 8 | Meet **security** and safety requirements | ✔ | ✔ | ✔ | ✔ |
| 9 | Not require any single component from any single vendor | ✔ | ✔ | ✔ | ✔ |
| 10 | Have readily-available SDKs both **commercial** and **open source** | ✔ | ✔ | ✔ | ✔ |

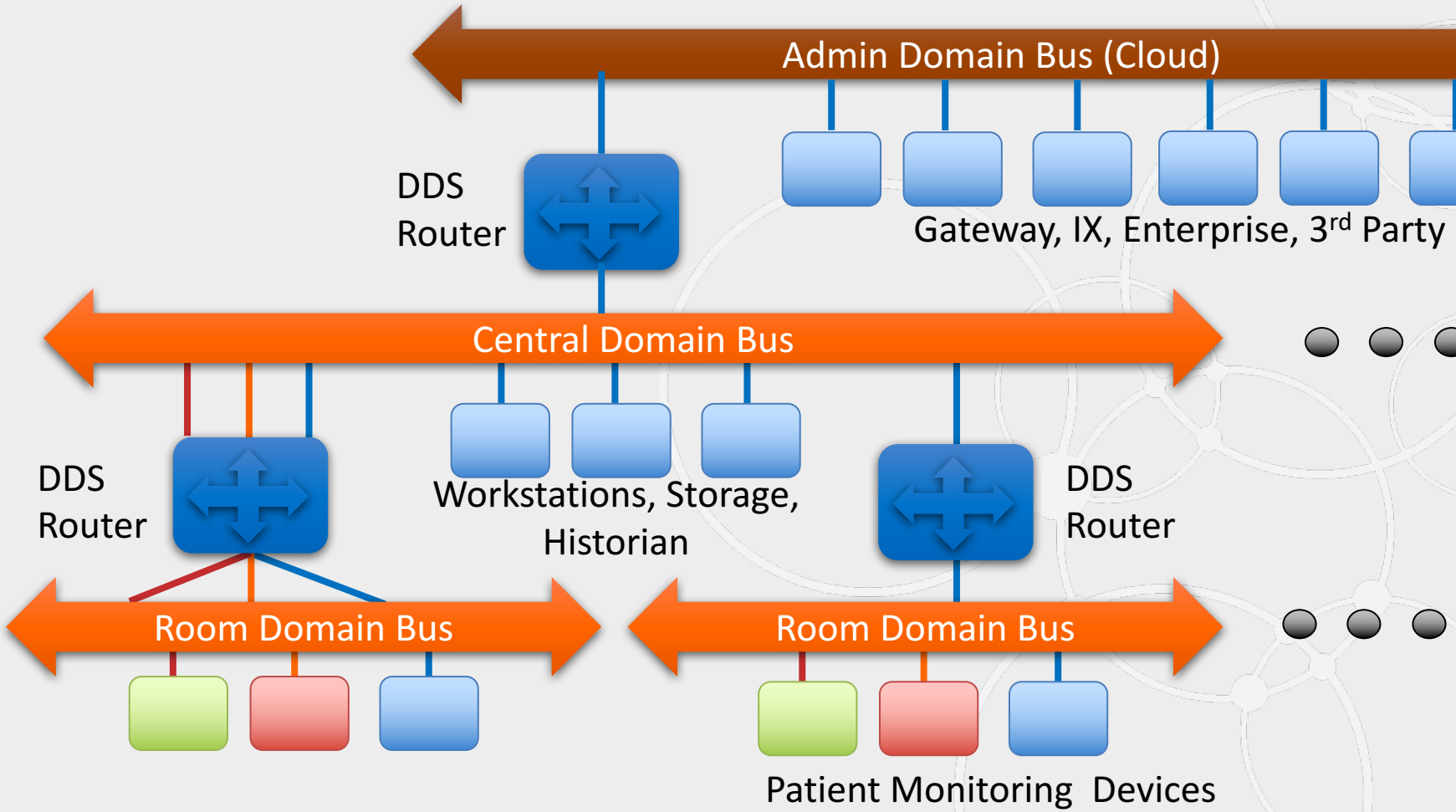
***** = work in progress **blank** = No P = partial

GREEN = Gating Criteria

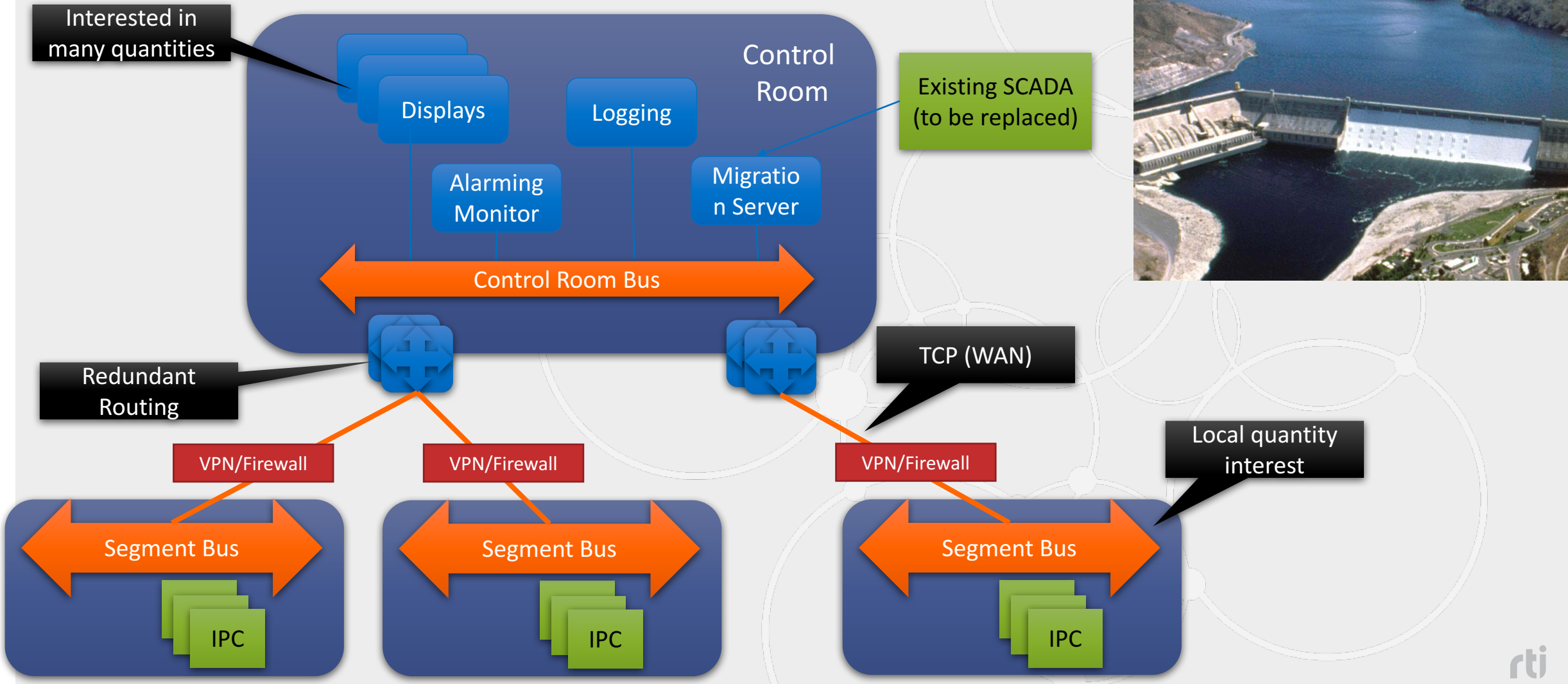
# DDS–Based Integration



# Example: Clinical Decision System Architecture




# Example: Grand Coulee Dam



# Standards Update

# Key standards we are focusing on

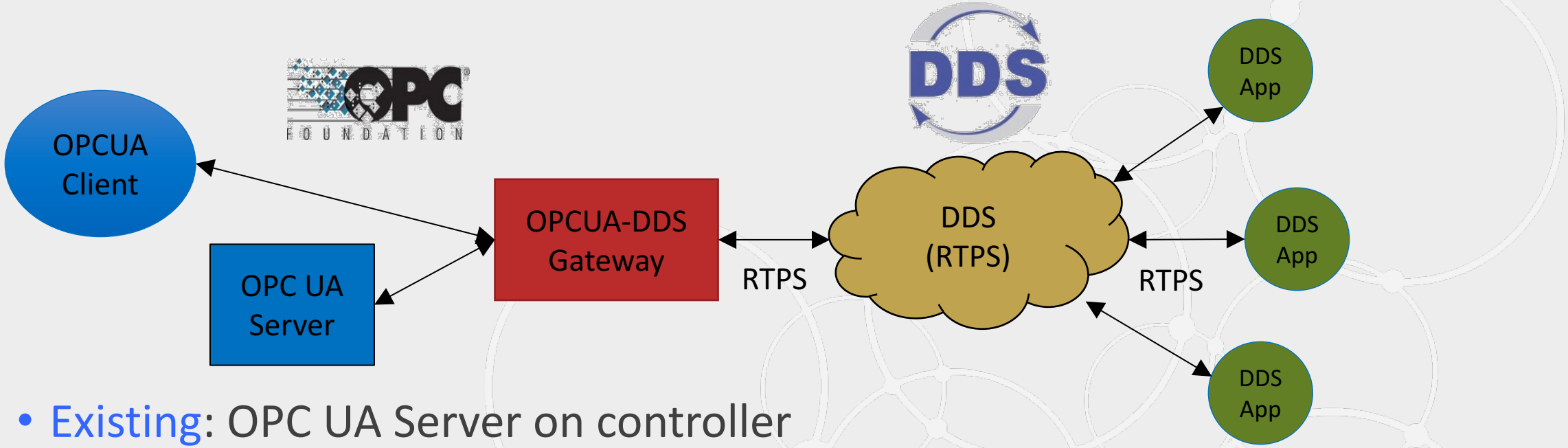
## High Priority:

| | | |
|---|---|---|
| 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 |

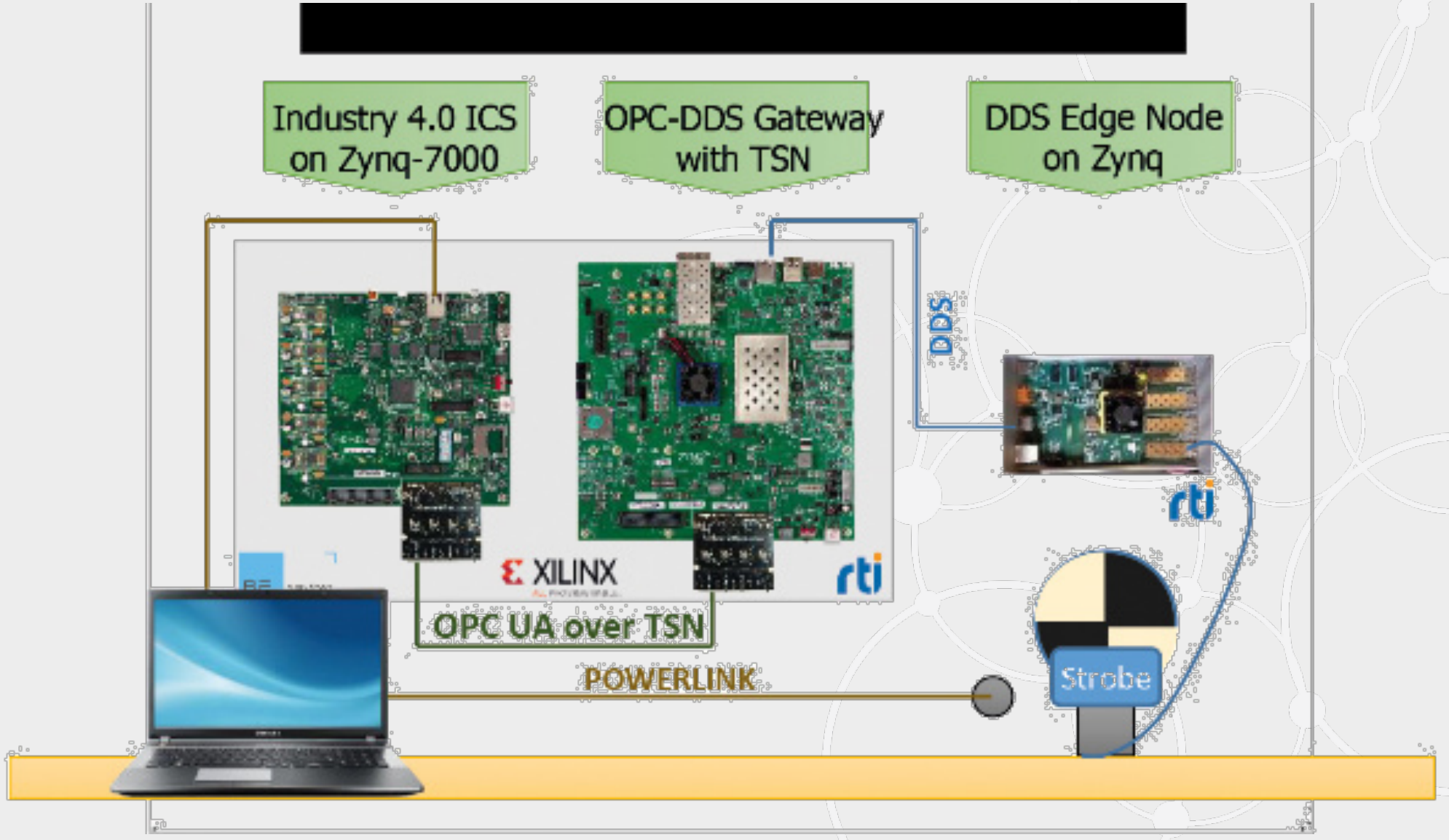
# DDS to OPCUA Bridge




- Existing: OPC UA Server on controller
- Existing: OPC UA Client applications
- Existing: DDS App
- New: OPCUA-DDS Gateway– Maps “operations” on OPCUA to DDS

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/)


rti Your systems. Working as one.

KONGSBERG

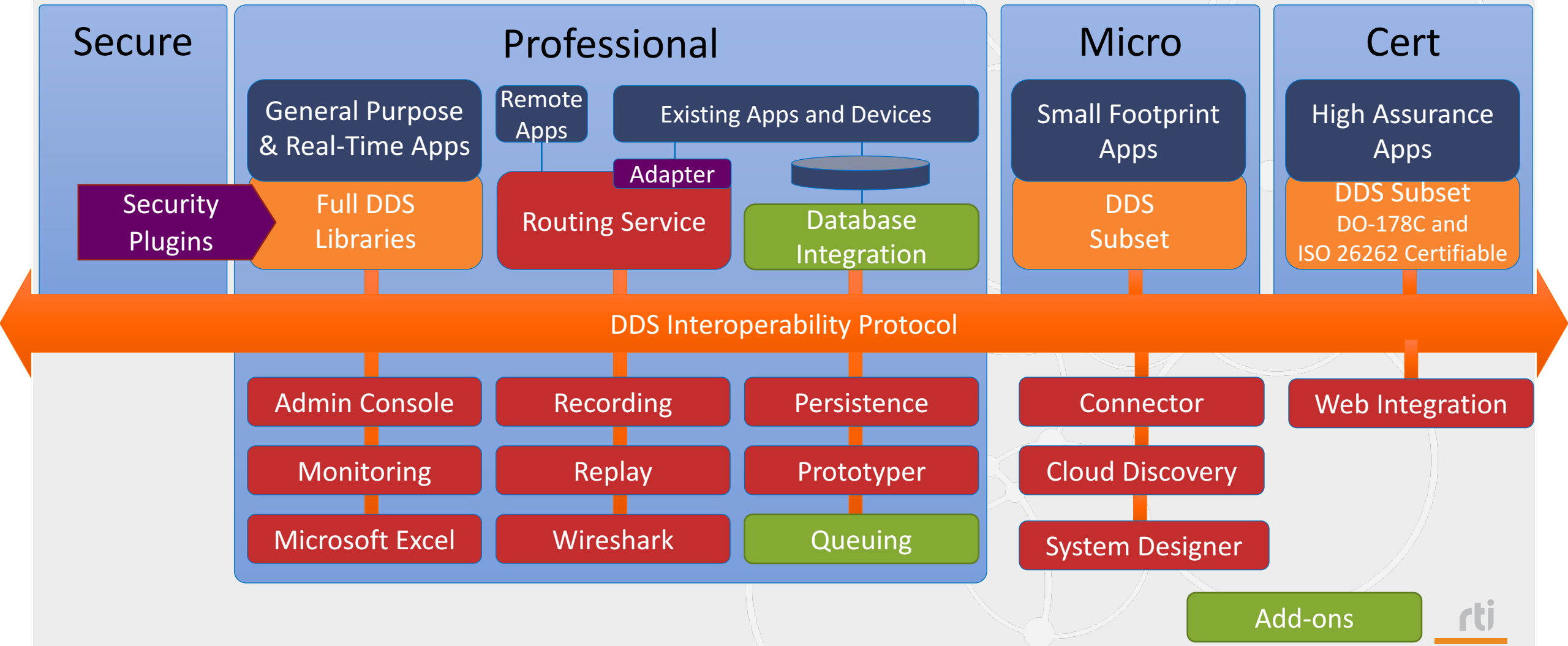
TWINOAKS COMPUTING INC.
PRACTICAL MIDDLEWARE EXPERTISE

# Product Update

# Three pillars

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

# RTI Connext DDS Product Family



# RTI Web Integration Service(*)

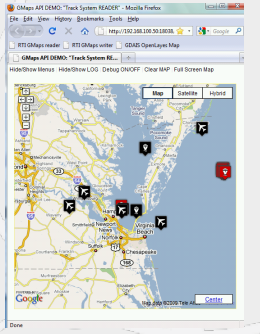
Operational Data

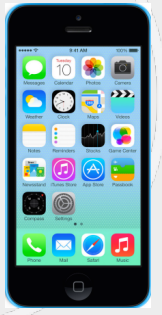
DDS/ RTPS

Connectivity Core Standards

DDS-WEB Service

HTTP/ HTTPS

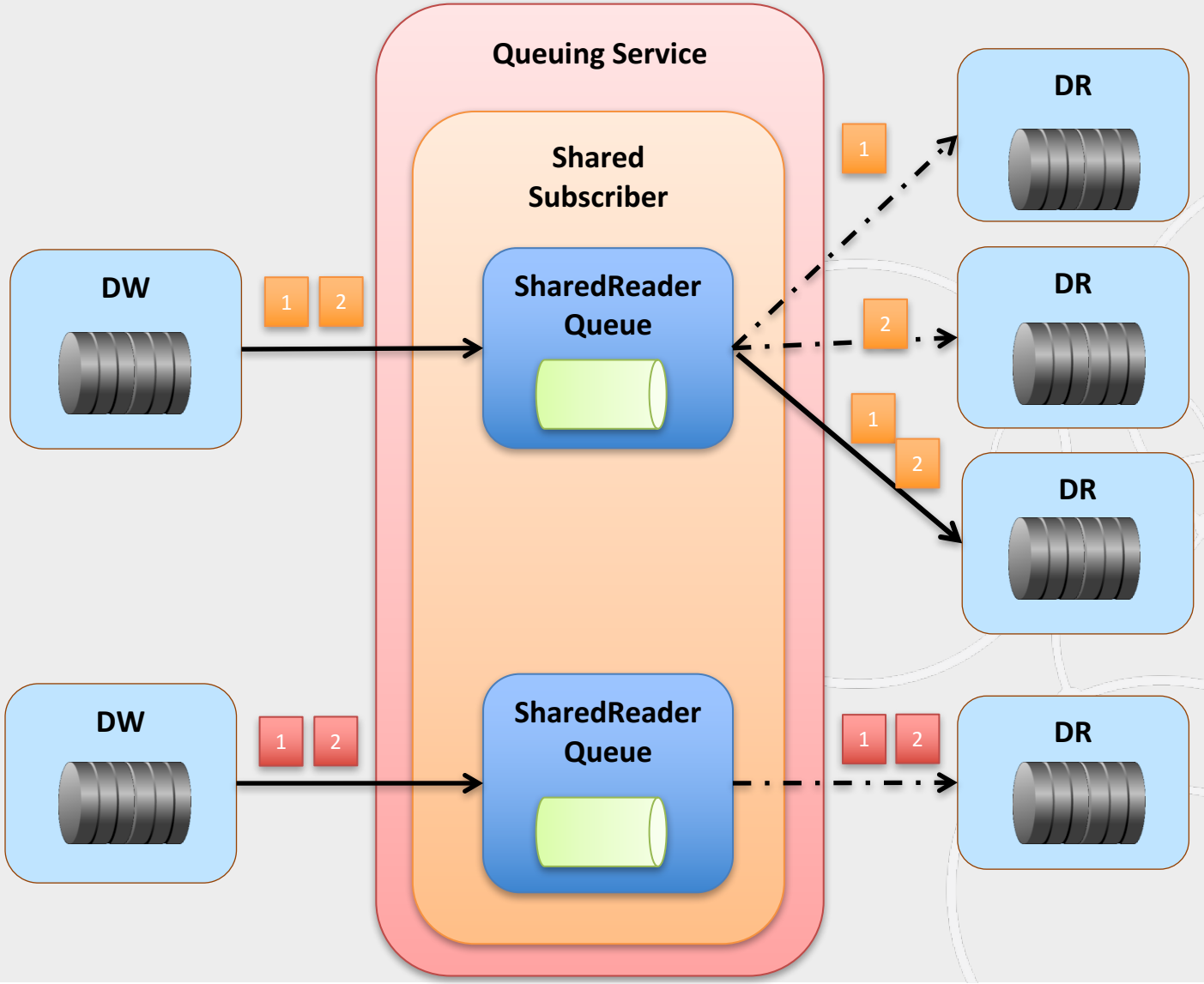




GUARD

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

# RTI Queuing Service

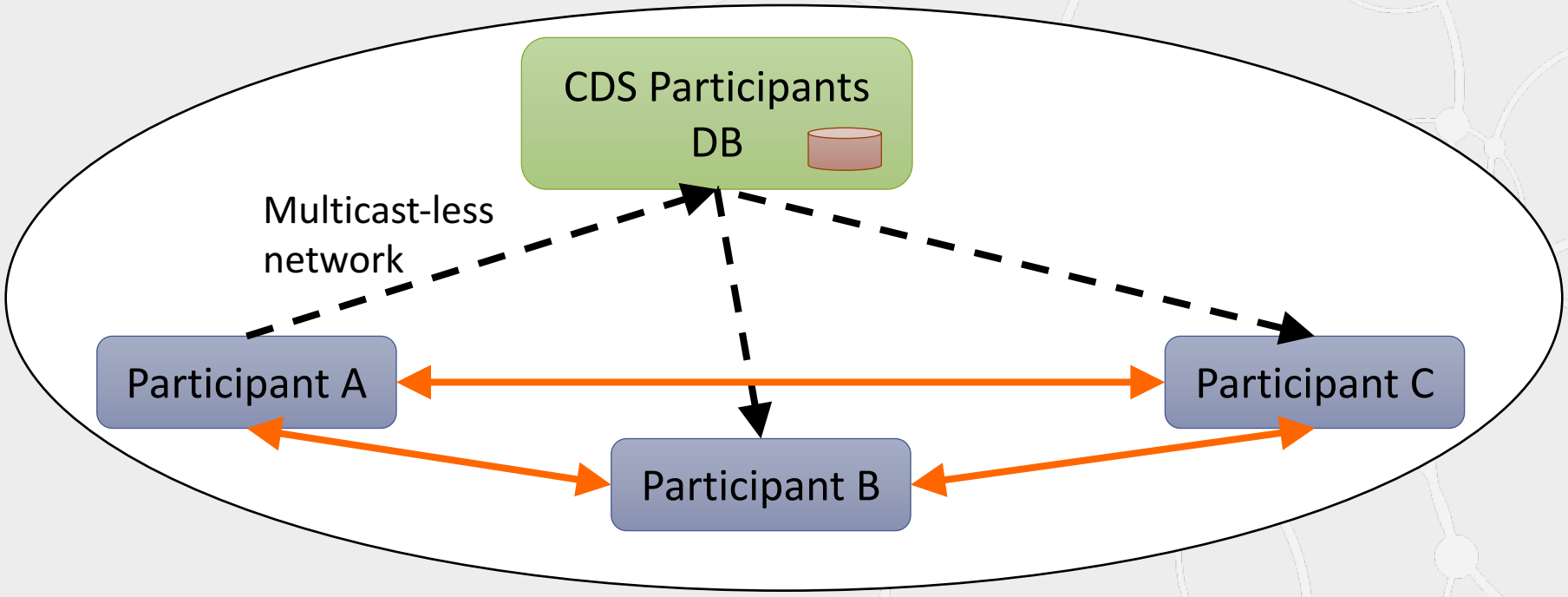



- Merges Queue and Pub-Sub
- Topic and Content-aware Queuing(*)
- Works natively with DDS APIs and Qos

# 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*

XML DDS Application Description

*Configure*

Connect()

*Join DDS*
*Create all Entities*

Input1
Input2
Output1
Output2

DDS

*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("shapesize", 30);
    o.instance.setString("color", "BLUE");
    o.write();
    time.sleep(2)
```

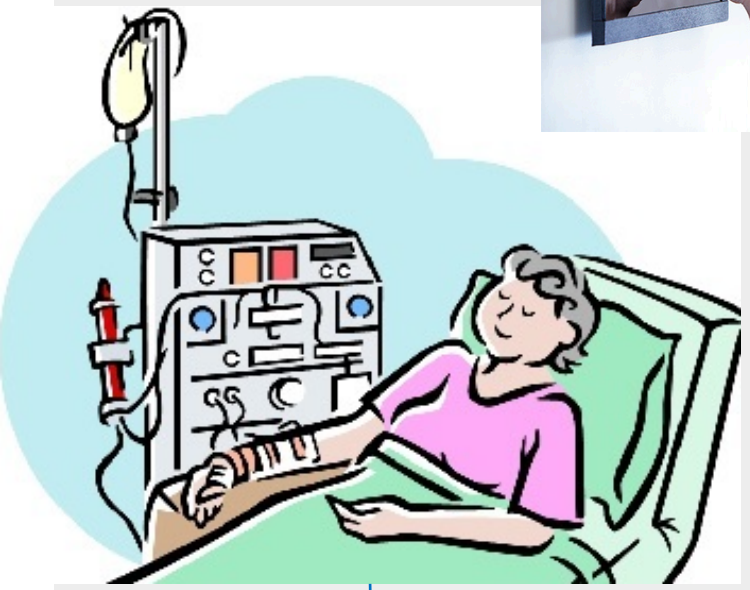

```
var conn = new
rti.Connector("MyParticipantLib::Zero”,
              "./ShapeExample.xml");

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("shapesize",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.shapesize = 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



Last 4 Hours?

**Mobility**

**Security**


Routing Service

Routing Service

CONNEXT DDS SECURE

CONNEXT DDS SECURE

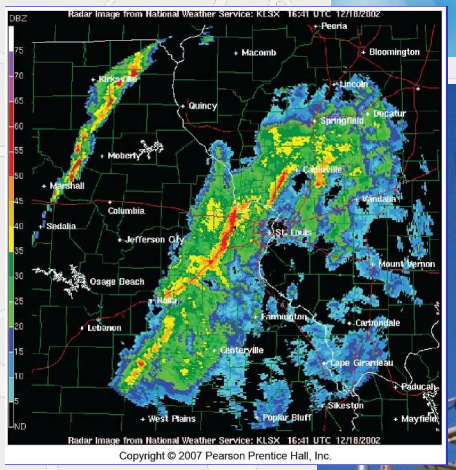
# Large Data scenarios

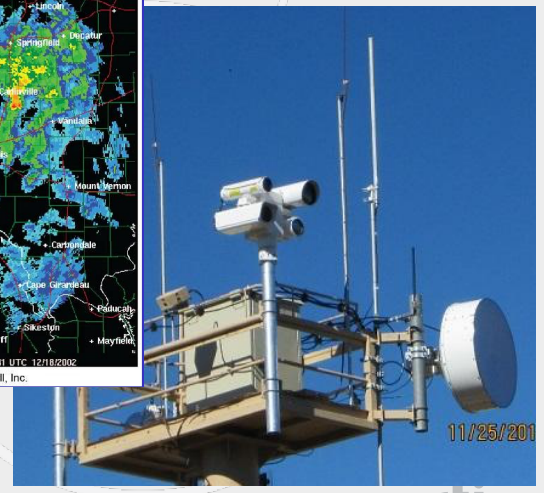
Lidar:

Radar:

Medical Scanners (CT, PET)


Images: Video, Radar, …



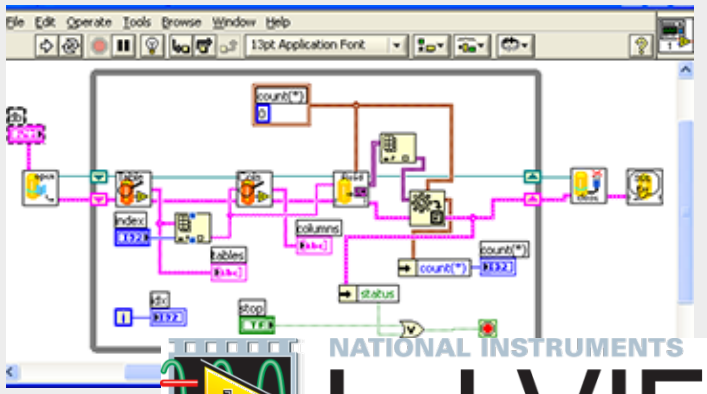



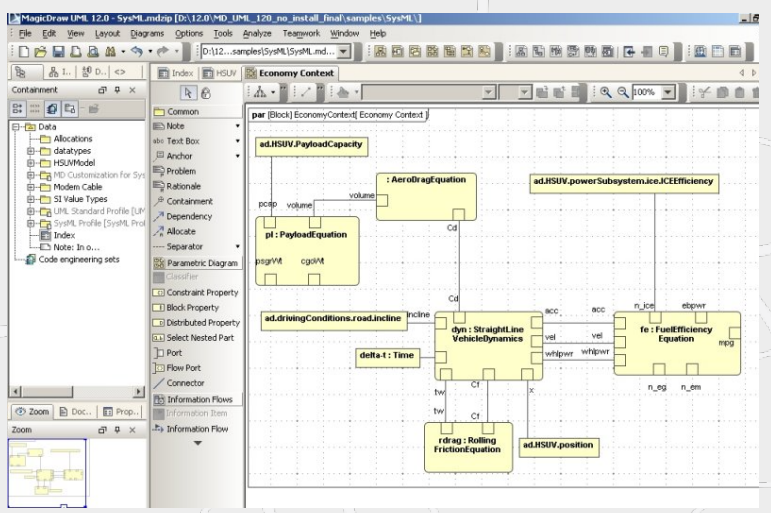
# Connext DDS Micro: Many new features

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

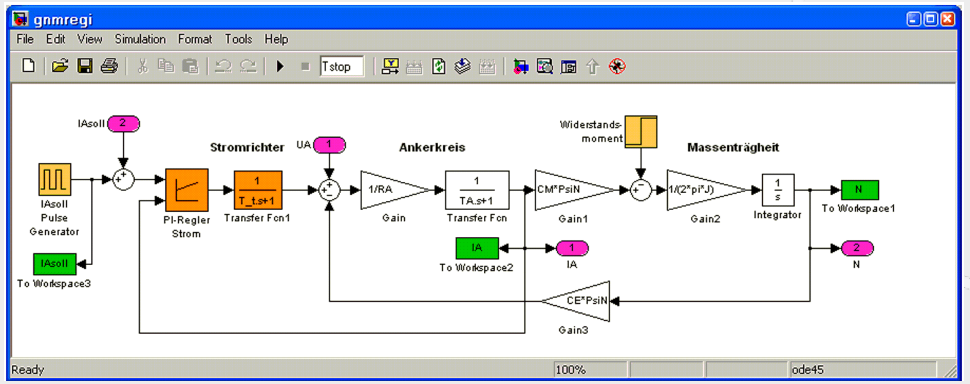

**IS NEVER ENOUGH**

# Integrating 3rd party tooling



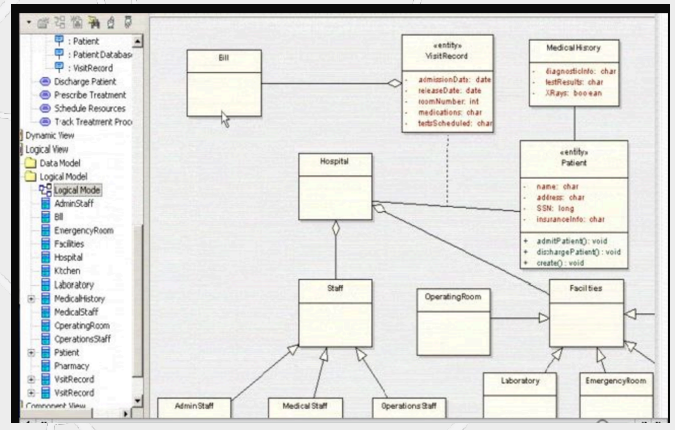



ENTERPRISE ARCHITECT




magicdraw

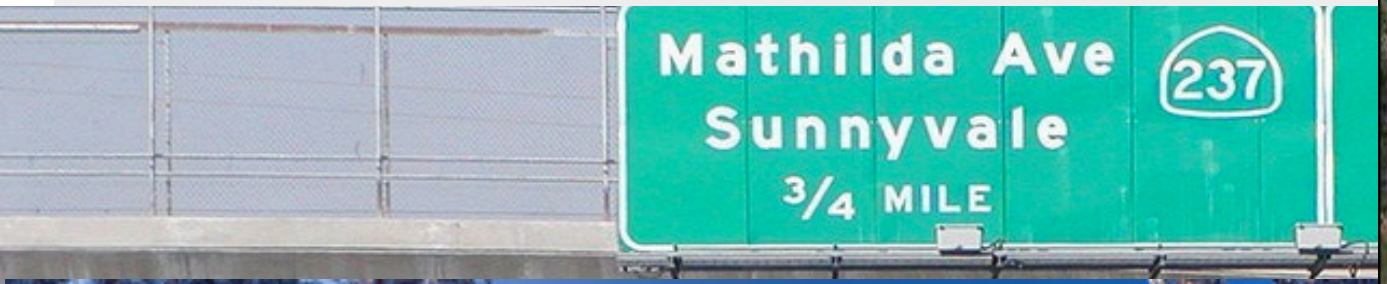
SysML

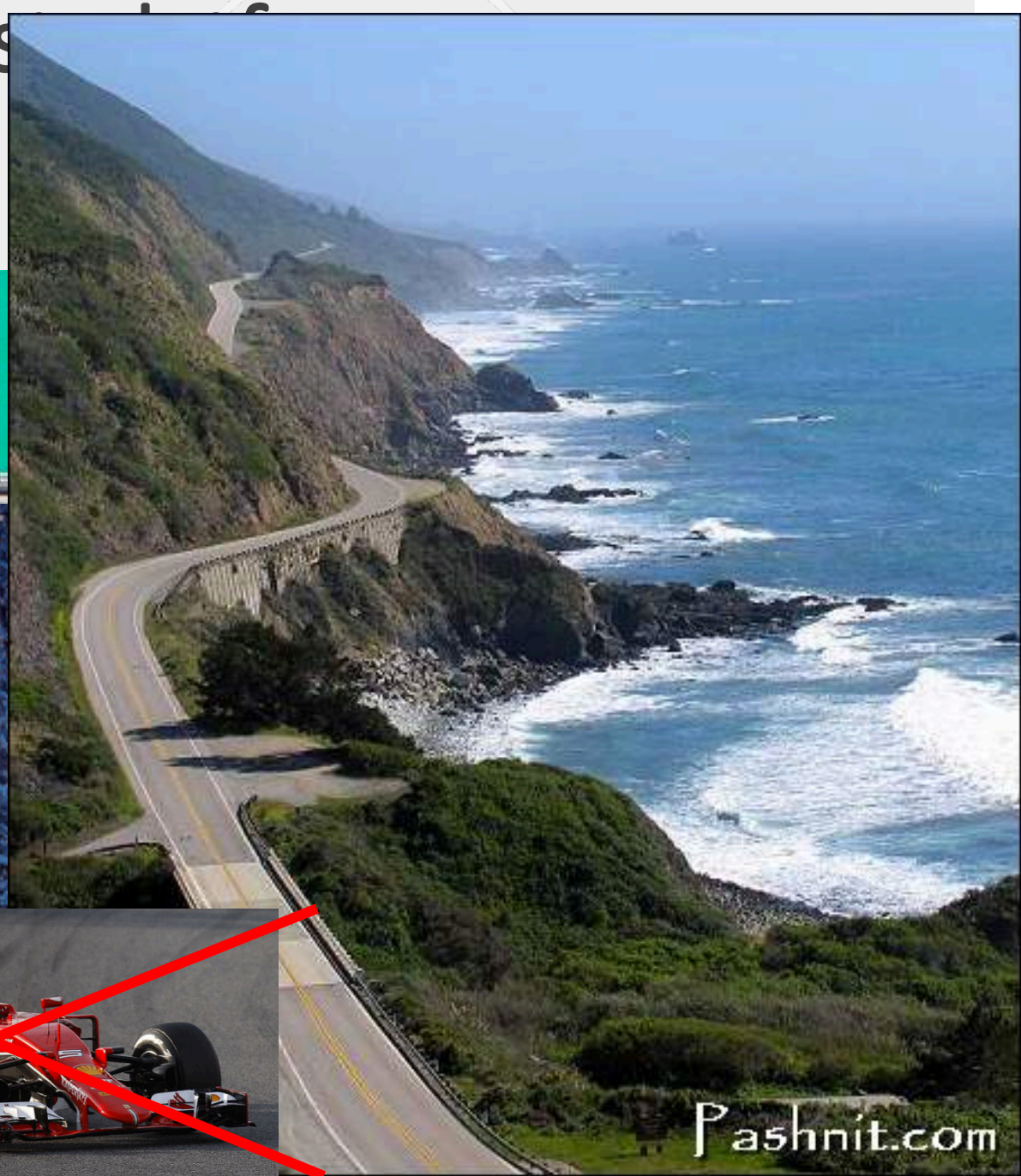


MATLAB SIMULINK

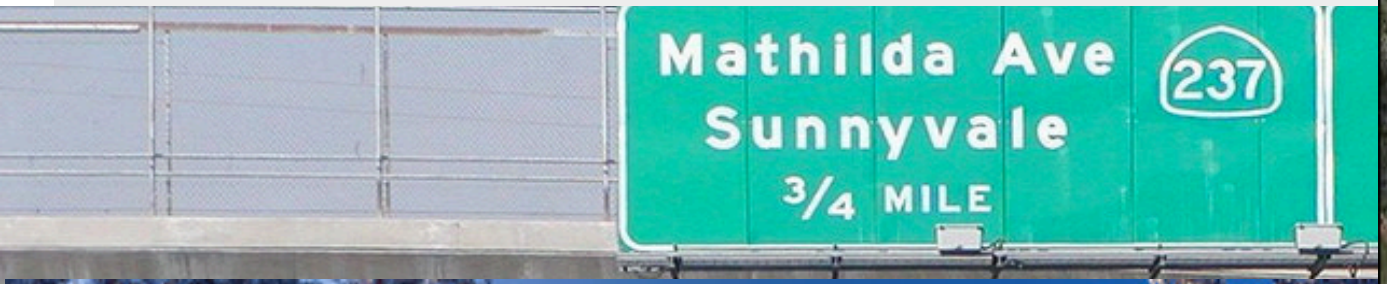
# Robustness

# Building the bes




# Building the bes





# 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

# Active funded research areas

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

# Securing Medical Device Systems

## Development Scope

- RTI Connext 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

Object Security
Secure technology

DOCBOX

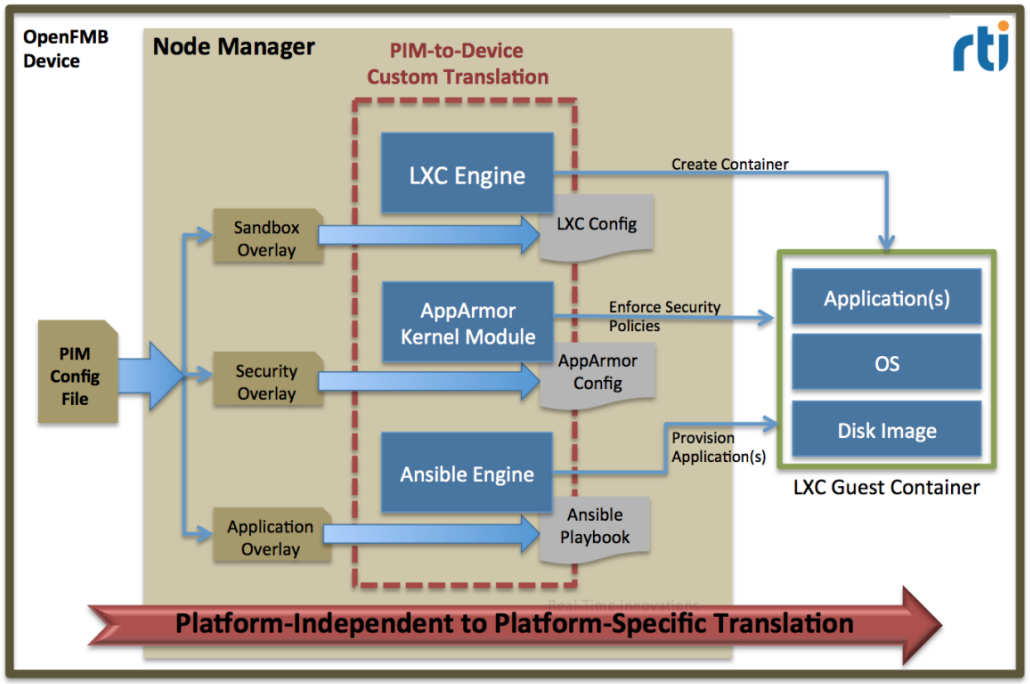
MD PnP
Getting Connected for Patient Safety

rti

# Energy SmartGrid

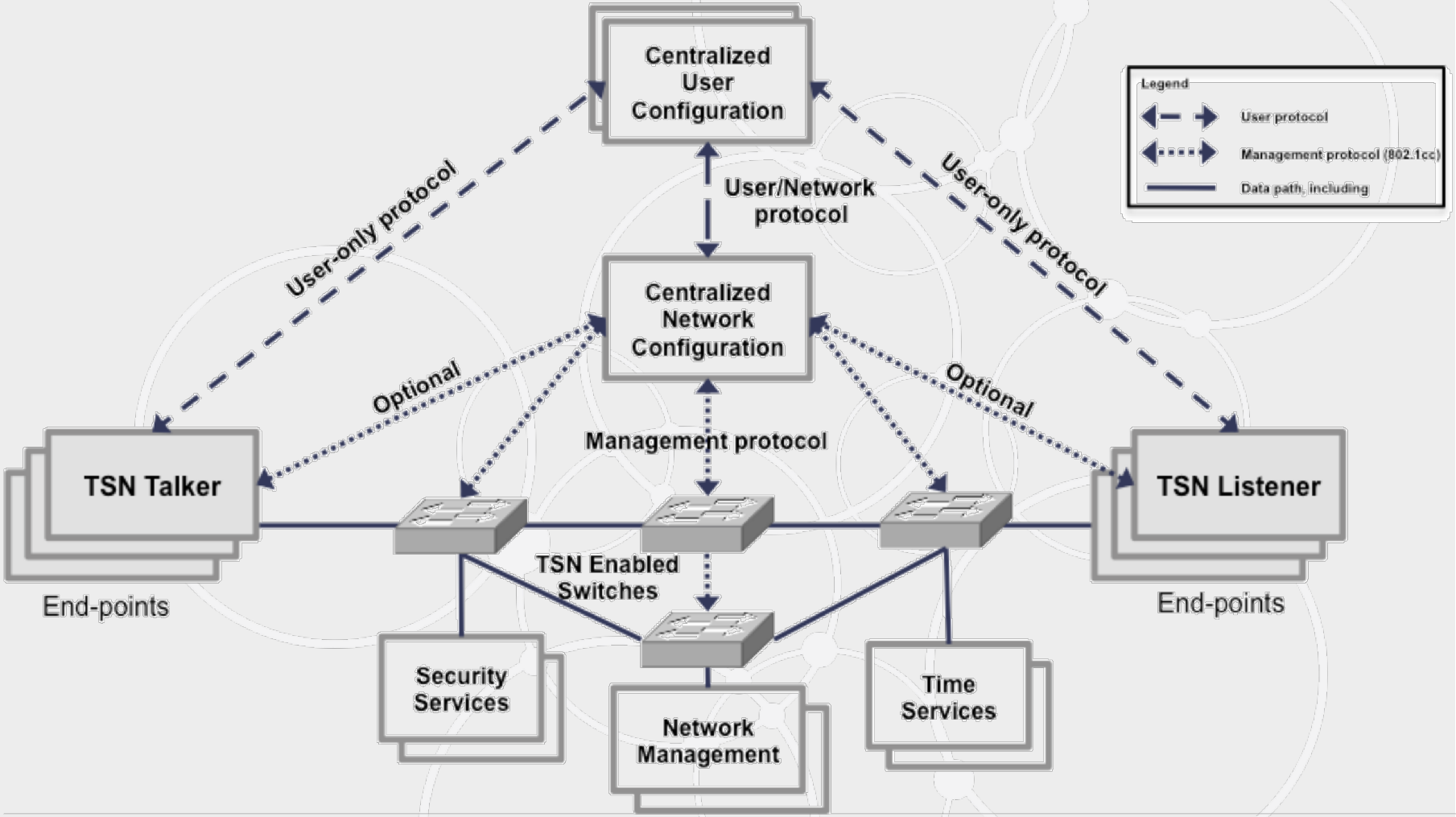
- **Scope**
  - Device Configuration & Updates
    - Containers, Applications, Security
  - Real-Time Device Health Status Monitoring
  - Certificate Provisioning & Management
  - **Aligned with OpenFMB**
- Demo planned at Duke's Rankin facility (8/2019)
- We will establish an Industry Advisory Board

Remote Node Management for DDS Systems



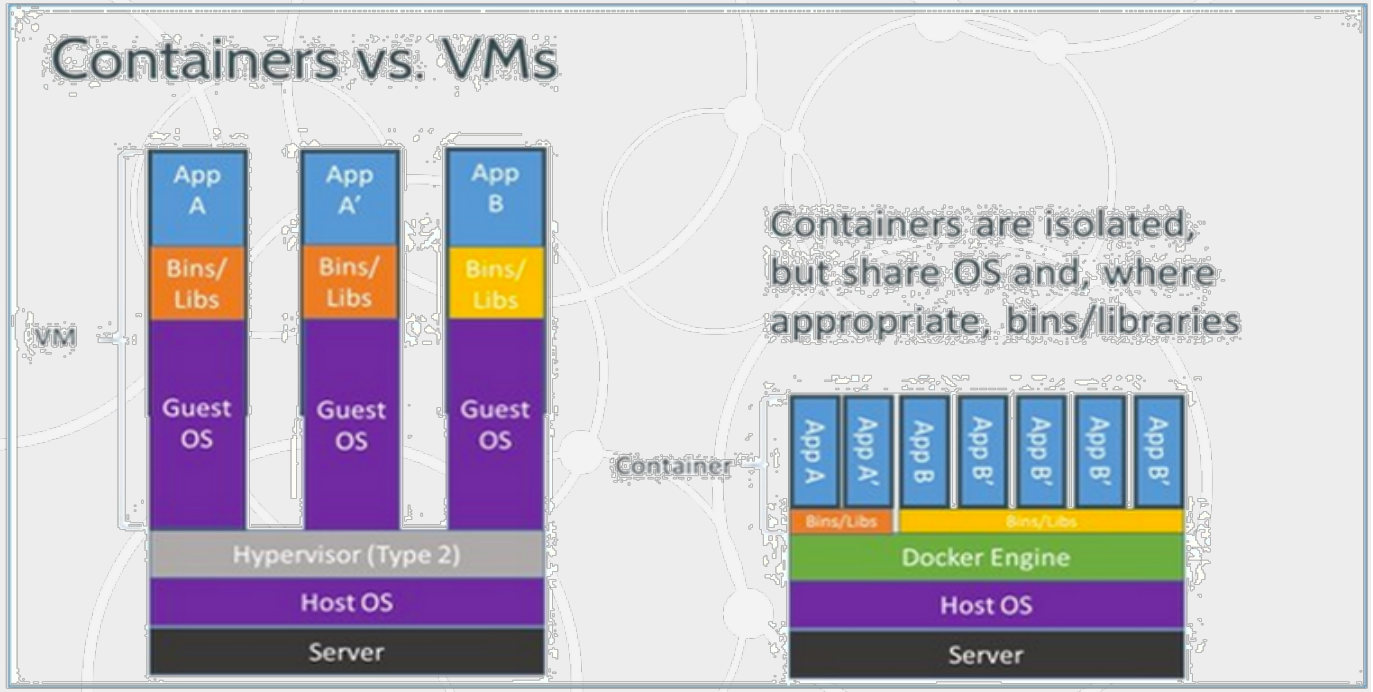
# Time Sensitive Networks

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



# Virtualization & Light-Weight Container deployments

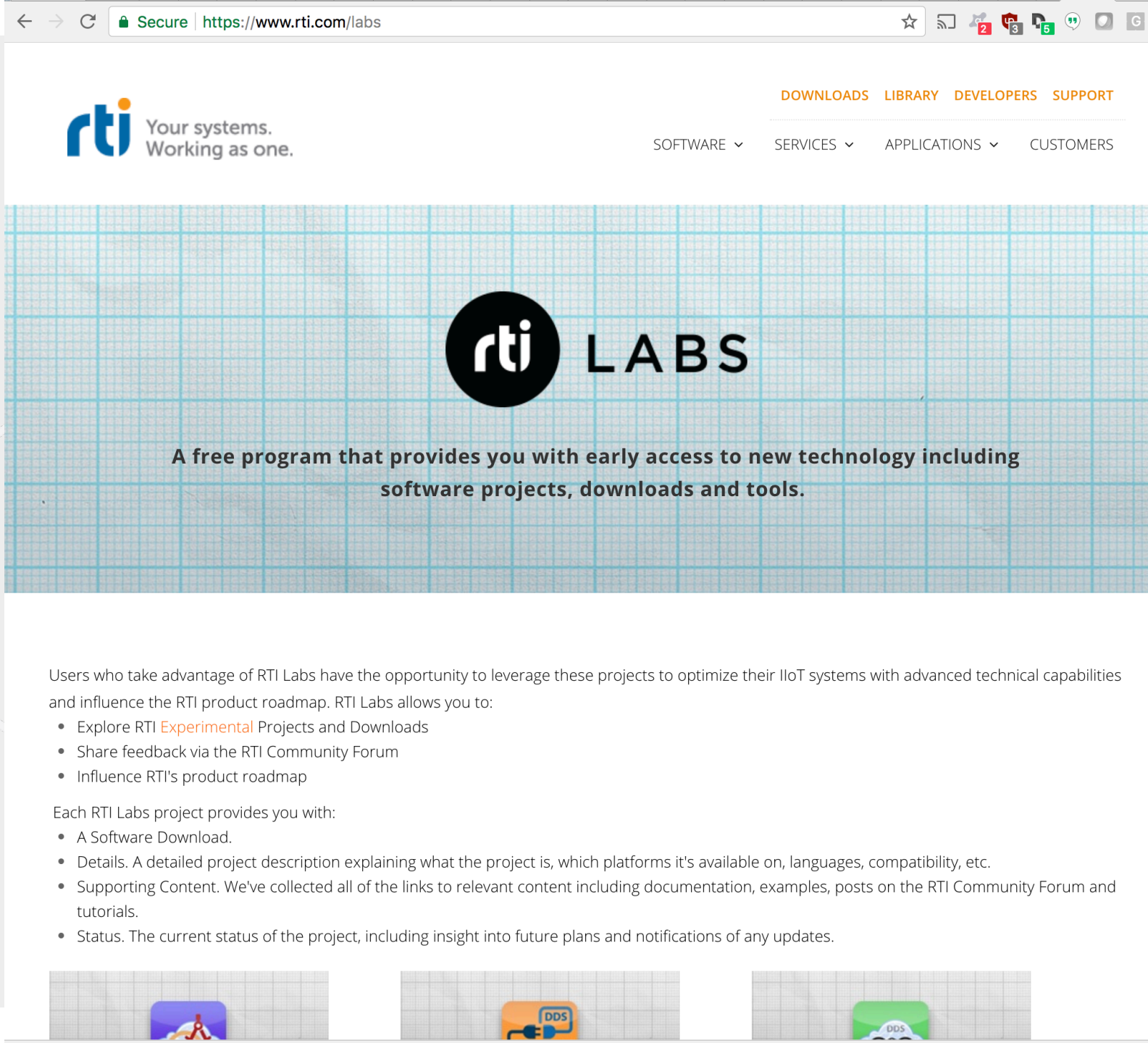
- Modularization
- Packaged App deployment
- Optimal transport
  - e.g. shared memory within host



# RTI Labs

# RTI Labs

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



# RTI Labs Technologies now available


**SYSTEM DESIGNER**

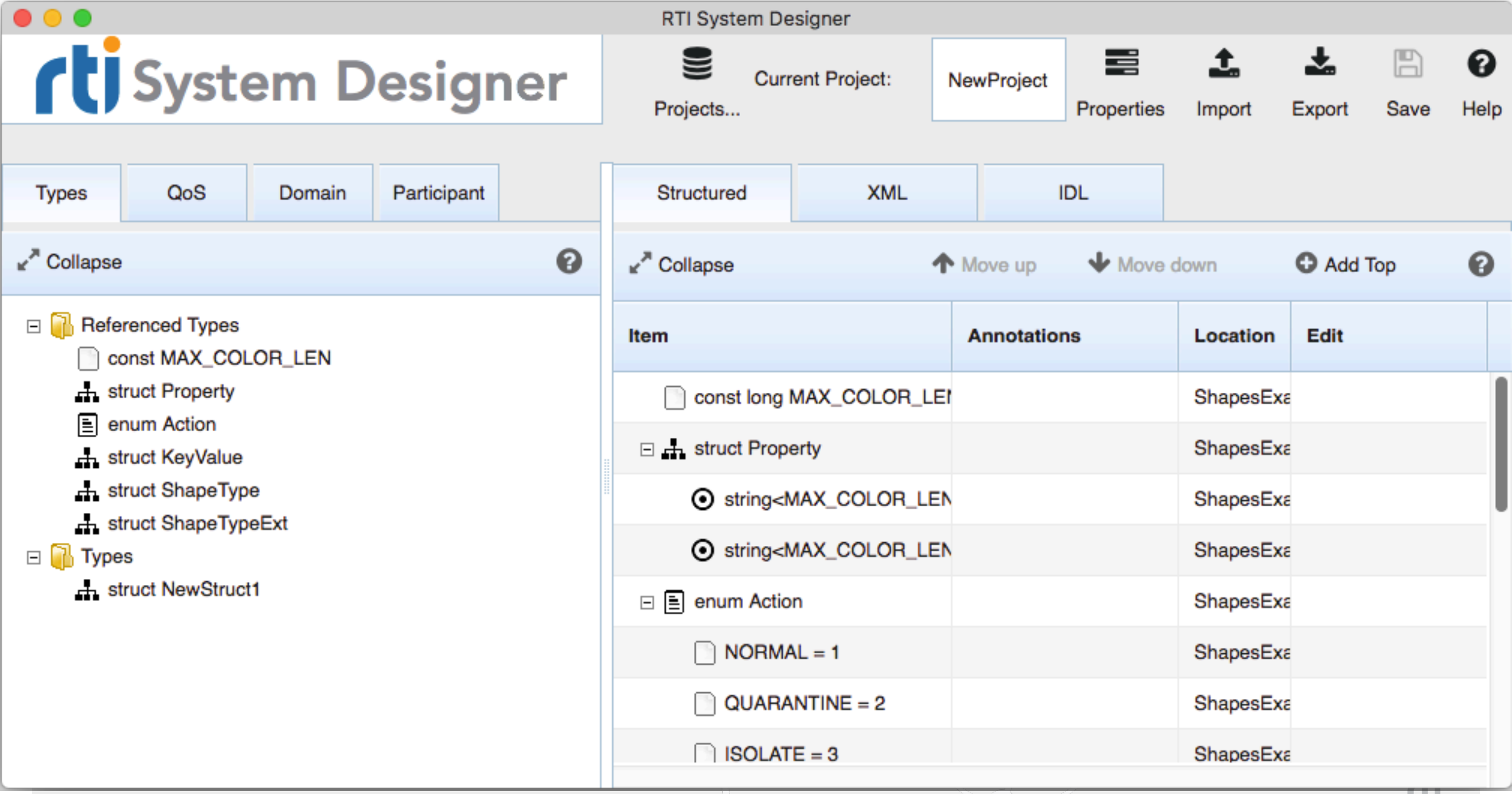
A UI Tool that simplifies the creation of XML files, allowing you to graphically design and configure your Connext DDS systems. Learn more.


**CONNECTOR**

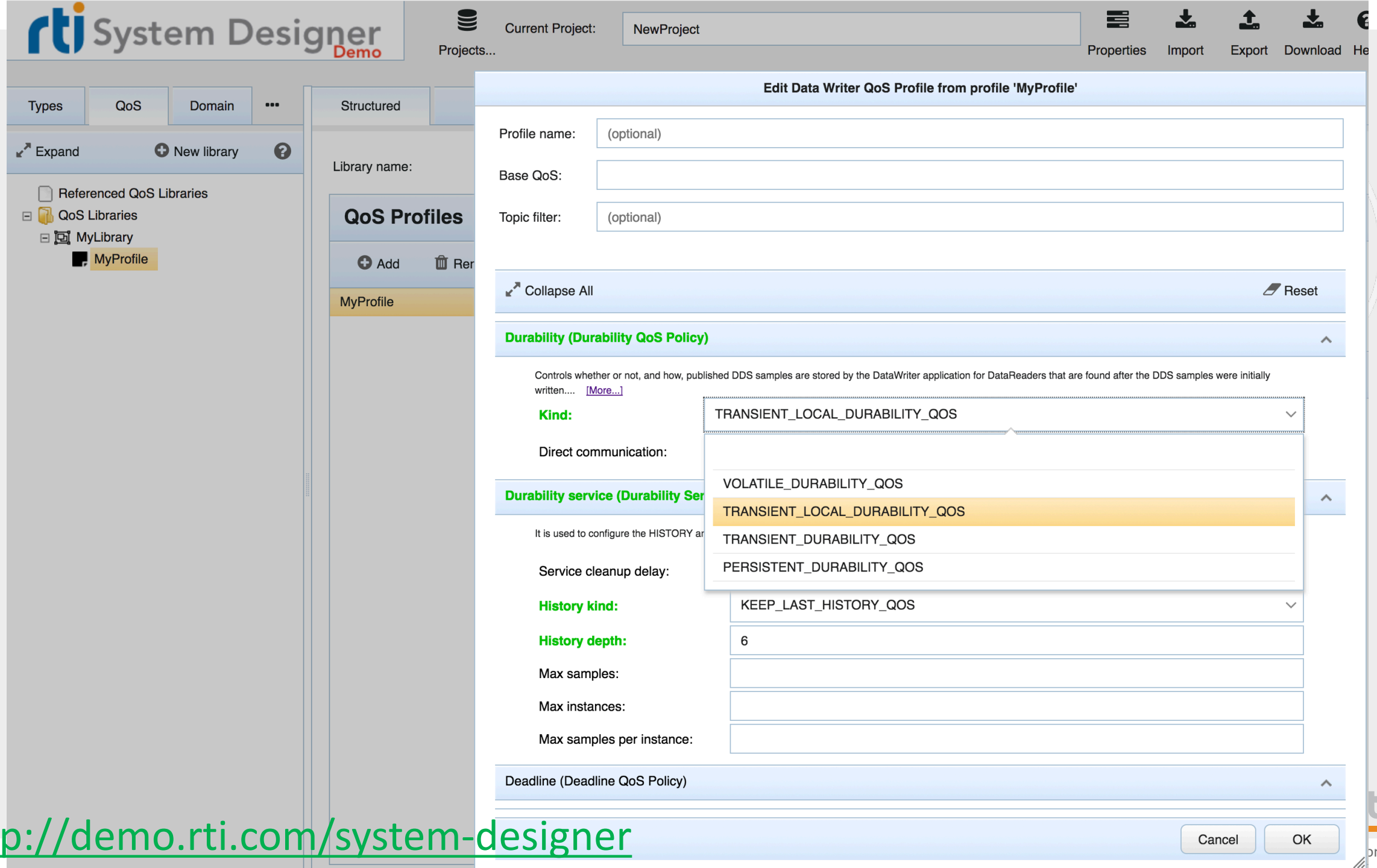
Publish and subscribe to data on the Connext Databus using scripting languages. Get Started.


**CLOUD DISCOVERY SERVICE**

A stand-alone application for deploying Connext DDS applications in dynamic environments, including where UDP/IP multicast is not available. Learn more.




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




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

# Conclusion

# We are helping you meet the most critical application challenges

# Thank You!