Your systems.
Working as one.

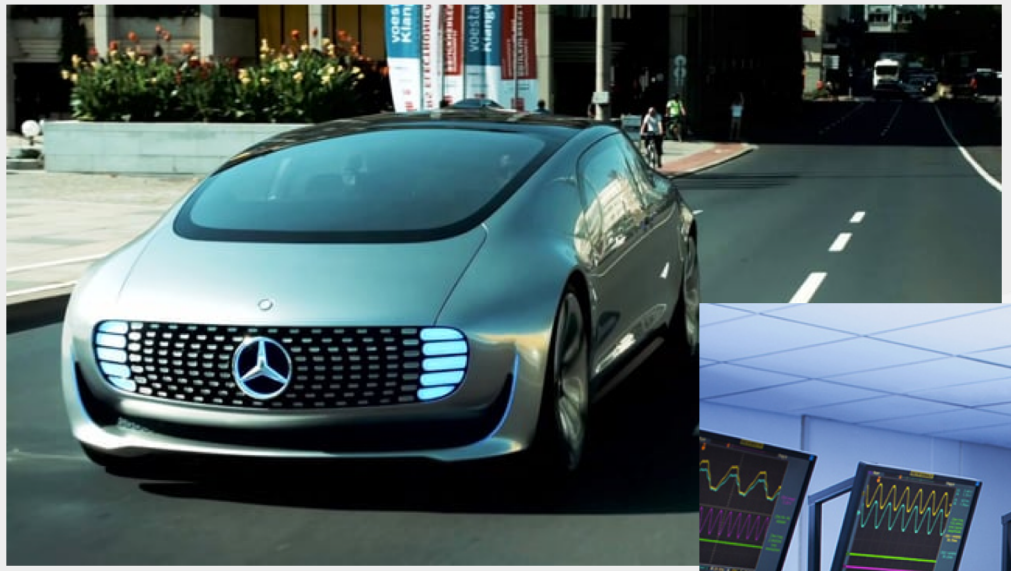
Connecting Autonomous Systems in the IIoT

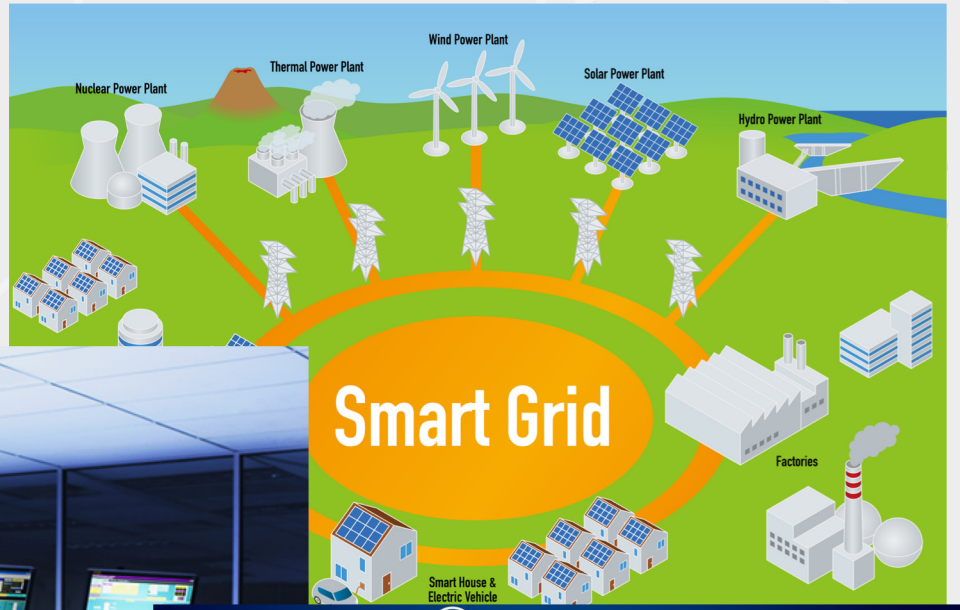
Gerardo Pardo-Castellote, Ph.D.

Chief Technology Officer, RTI

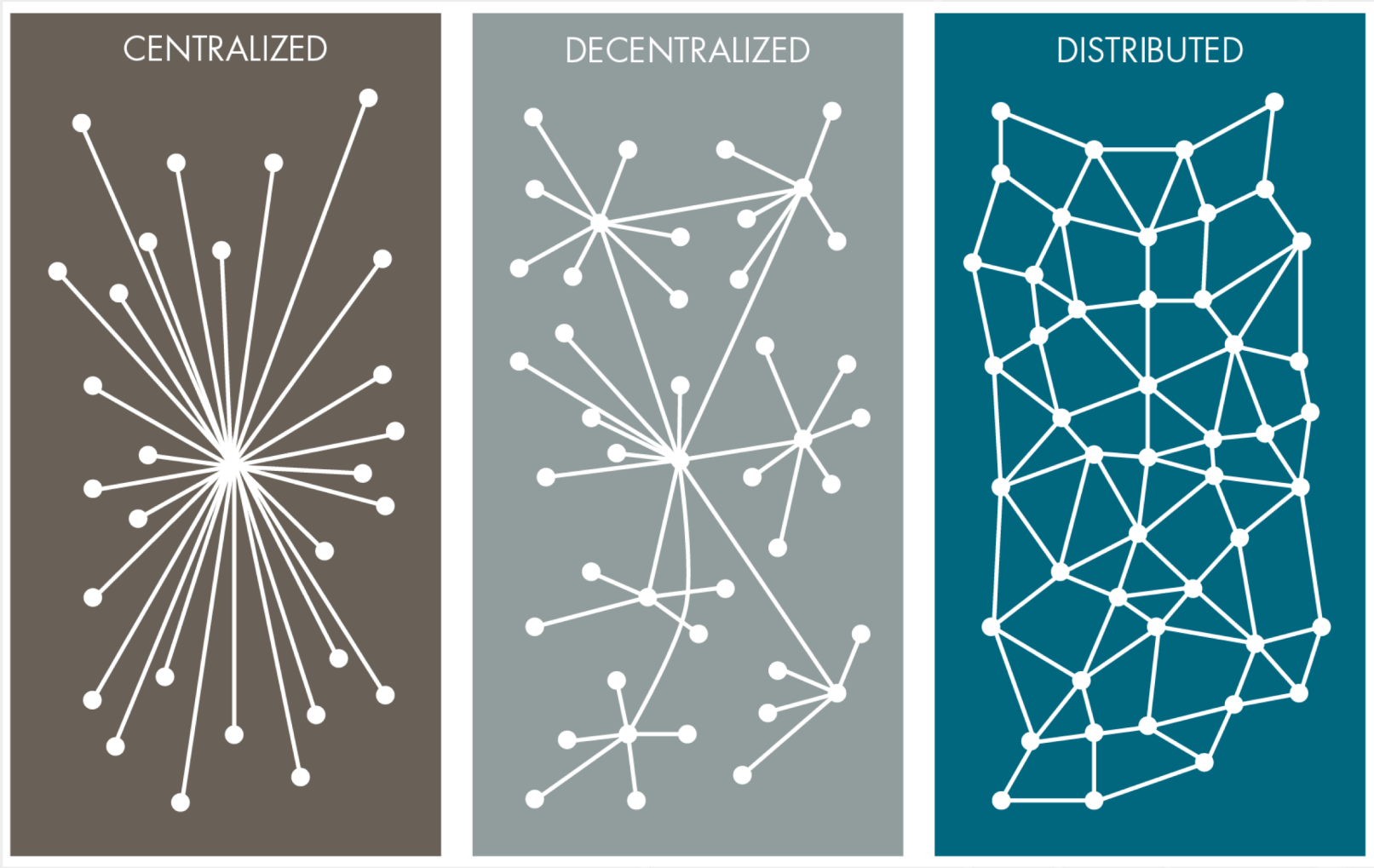
Boston Connext Conference
May 2018

What do these have in common?

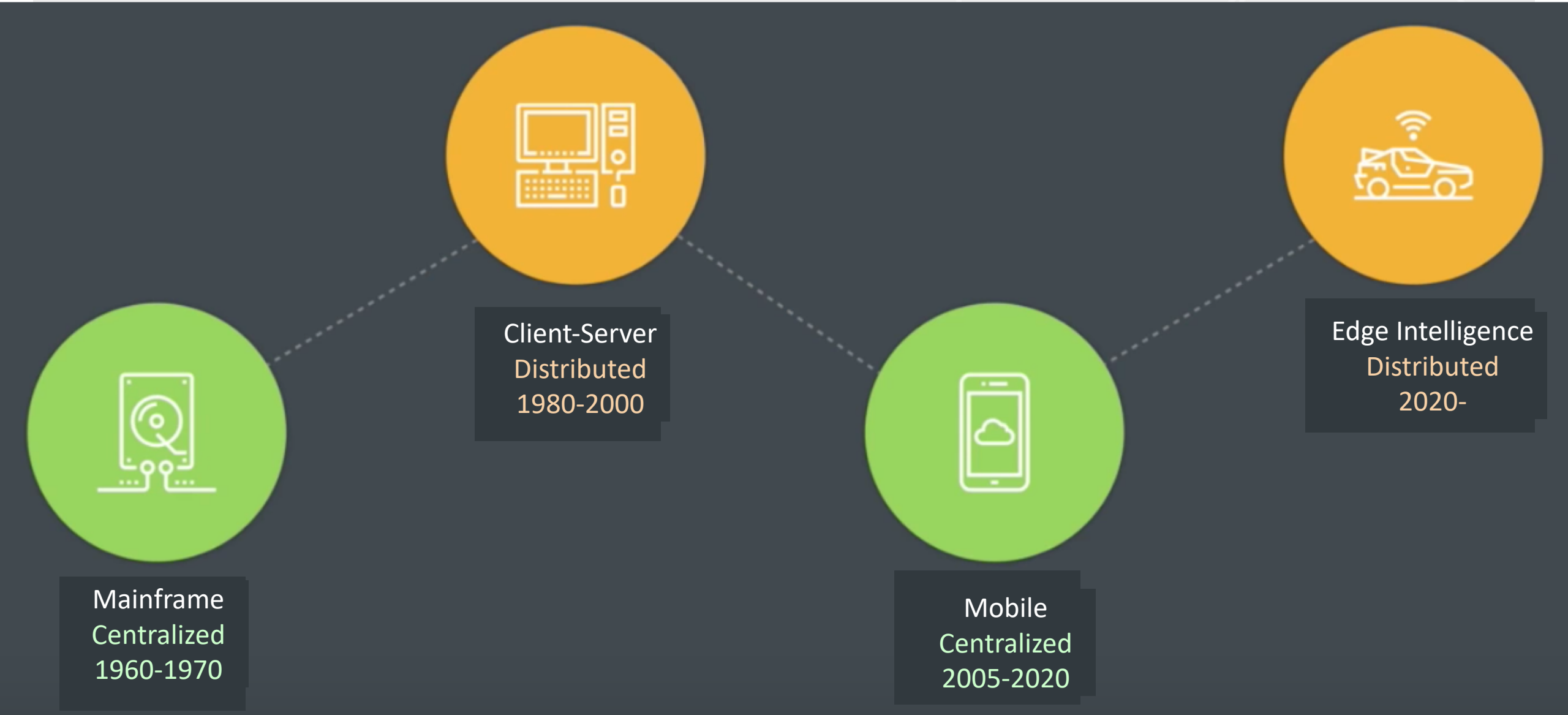




Decentralized Peer to Peer Systems

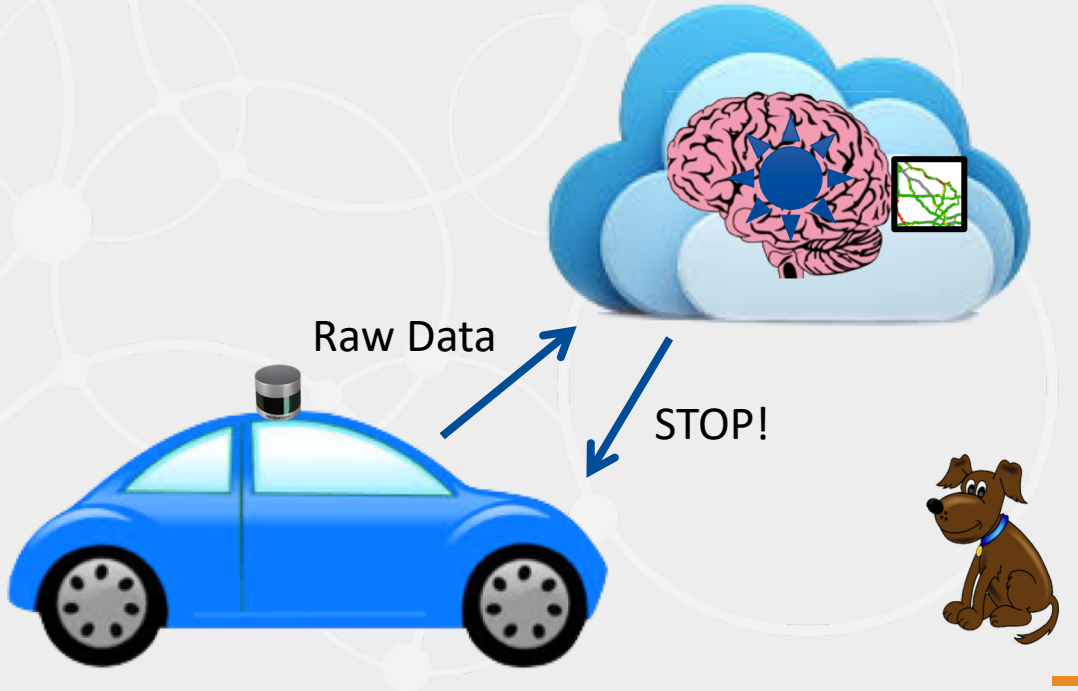


Edge Autonomy



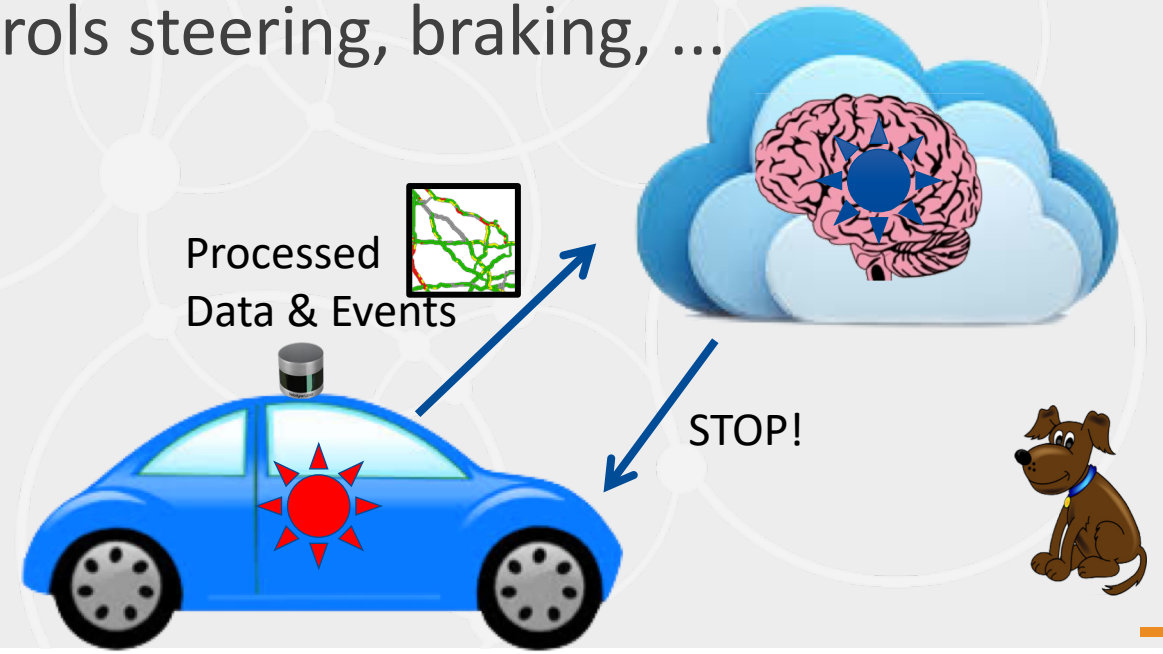
An example

- **Centralized**:
  - Cameras send raw video and lidar to cloud
  - Cloud processes, sends command to steer and brake to car



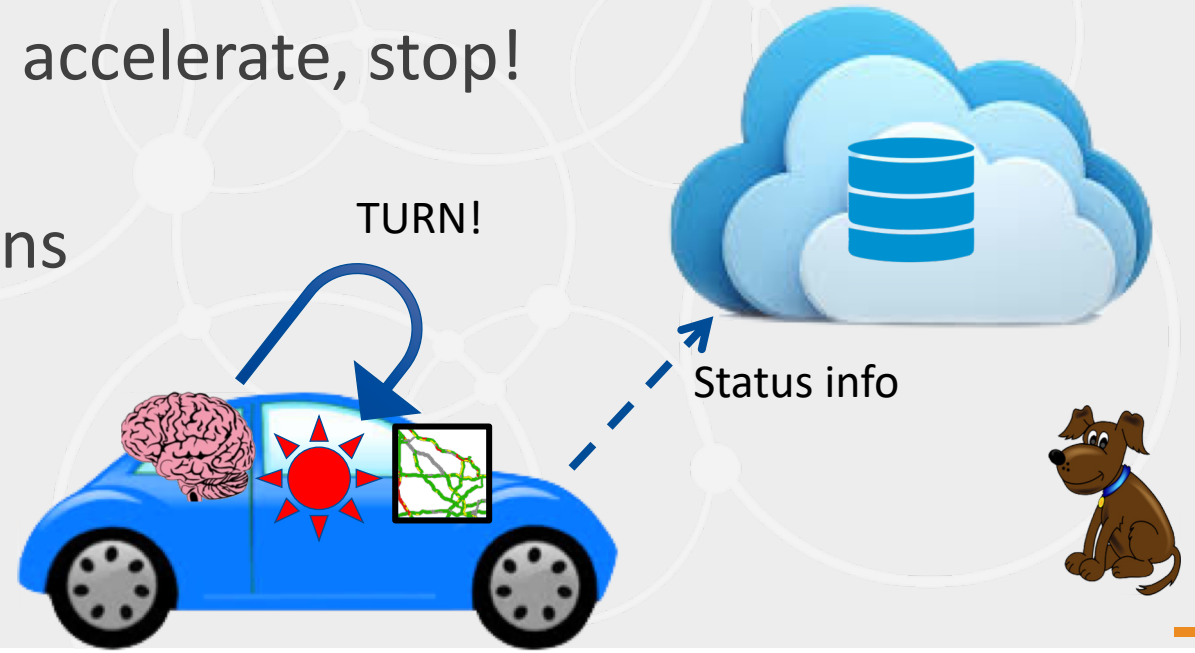
An example

- Centralized:
- **Edge Processing:**
  - Local sensor processing. Detect obstacles, road, ...
  - Car sends environment model events to cloud
  - Cloud makes decisions, controls steering, braking, ...



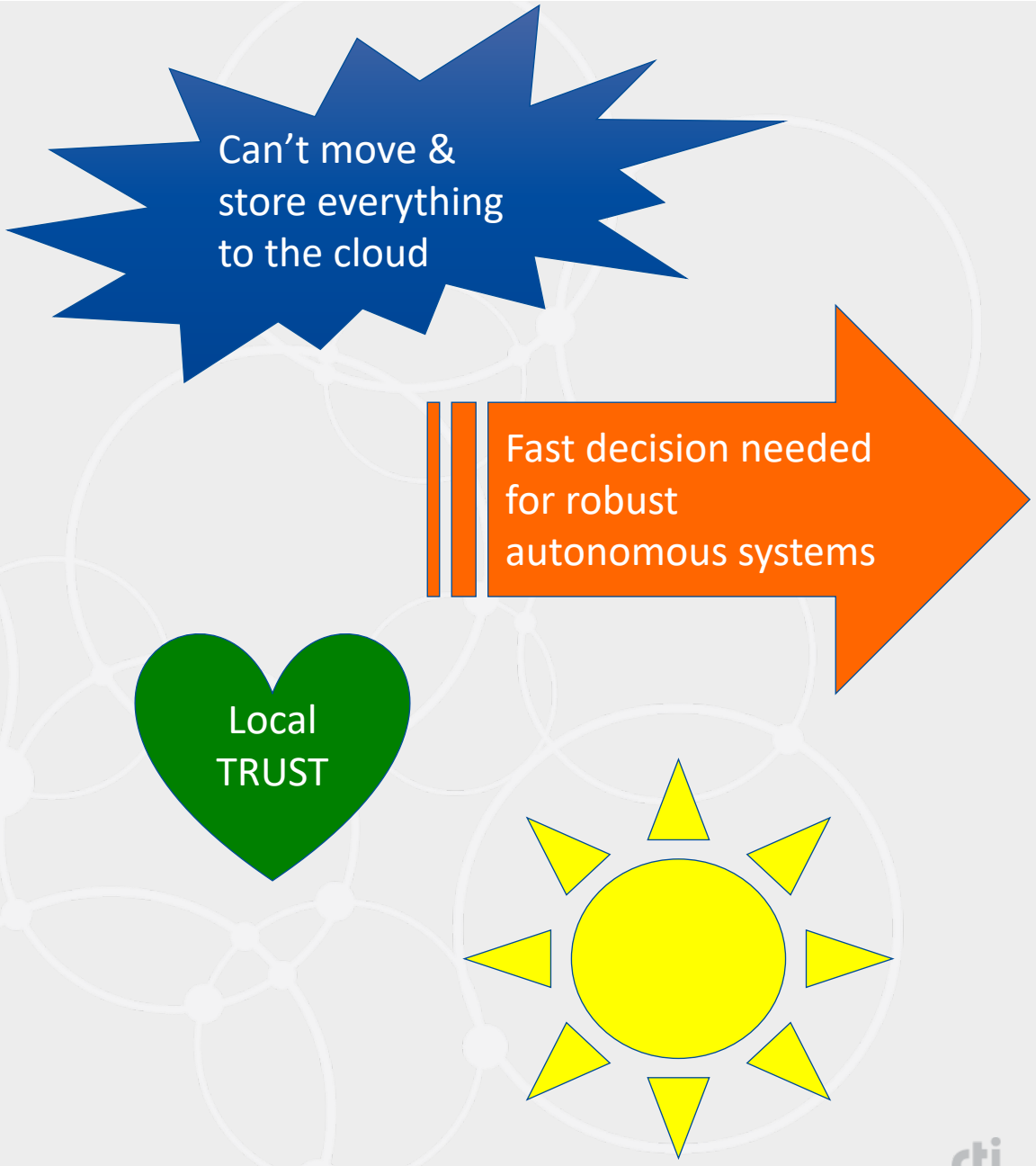
An example

- Centralized:
- Edge Processing:
- **Edge Autonomy**
  - Local sensor processing. Detect obstacles, road, ...
  - Car makes decisions! Turn, accelerate, stop!
  - Car to Car communication
  - Cloud stores, analyzes, learns

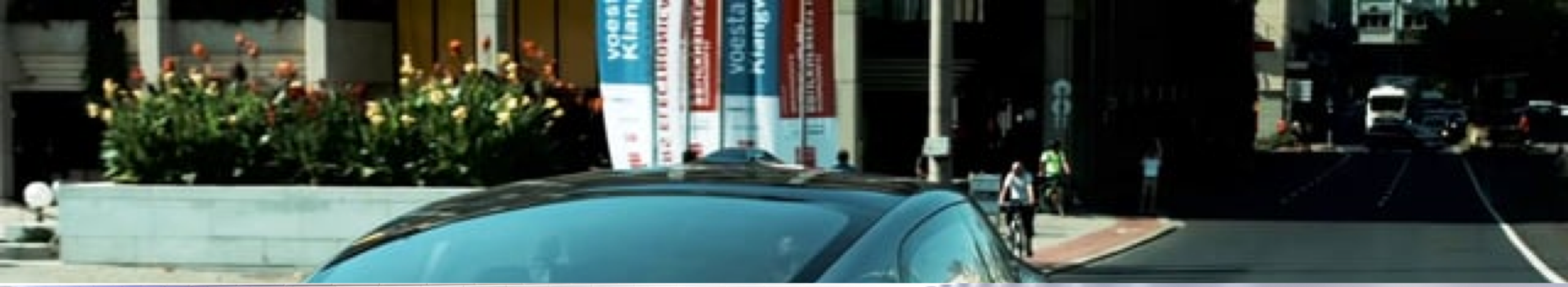


Why Edge Autonomy?

- Scalability
- Real-Time / Real-World Performance
- Safety, Robustness & Availability
- Security/Privacy
- Entirely new applications based on AUTONOMY



An autonomous car is a “data center” on wheels




NEC
SX-ACE
NEC
NEC

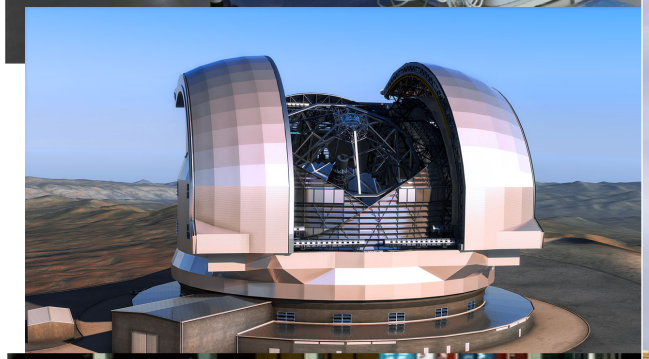
40 TFLOPS Data Center circa 2002 (NEC Earth Simulation Computer)

2007 IBM Blue Gene/L, 400 TFOPS

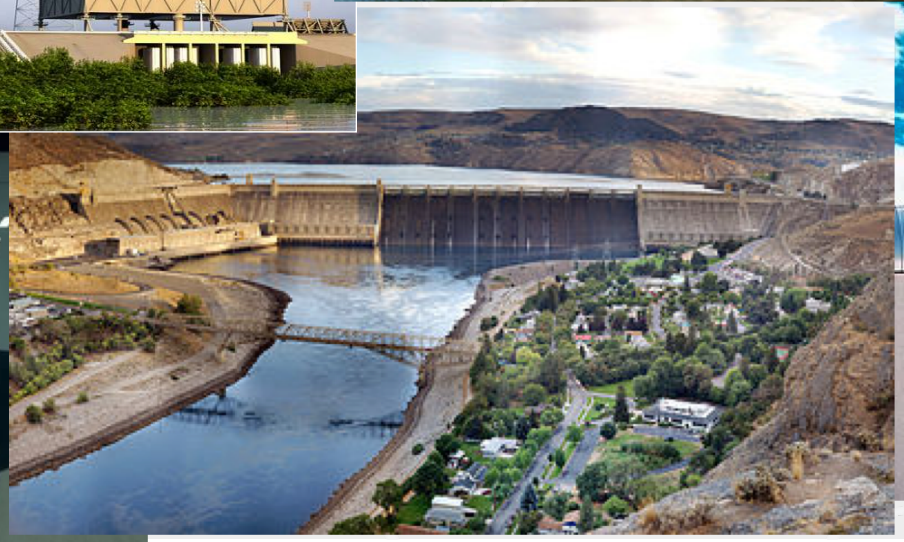
2017-18 Nvidia DGX Station,
480 TFLOPS

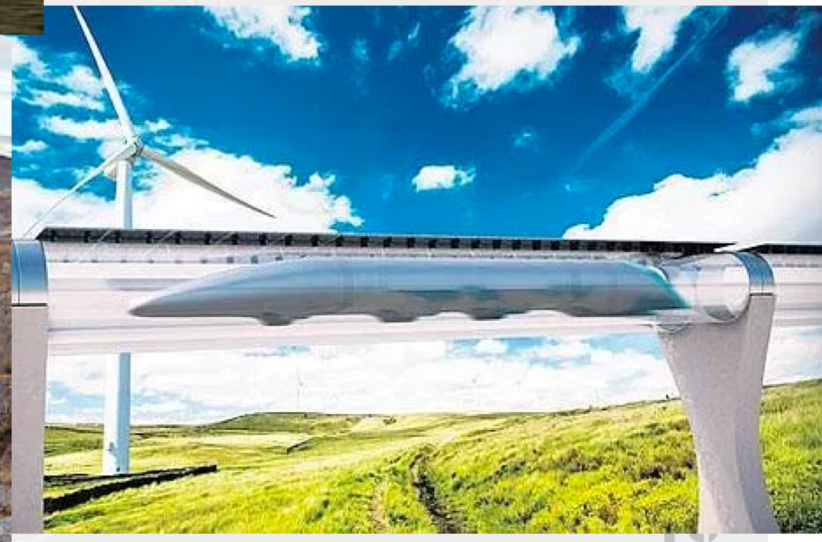

GE Healthcare


BLUE PROTECTOR



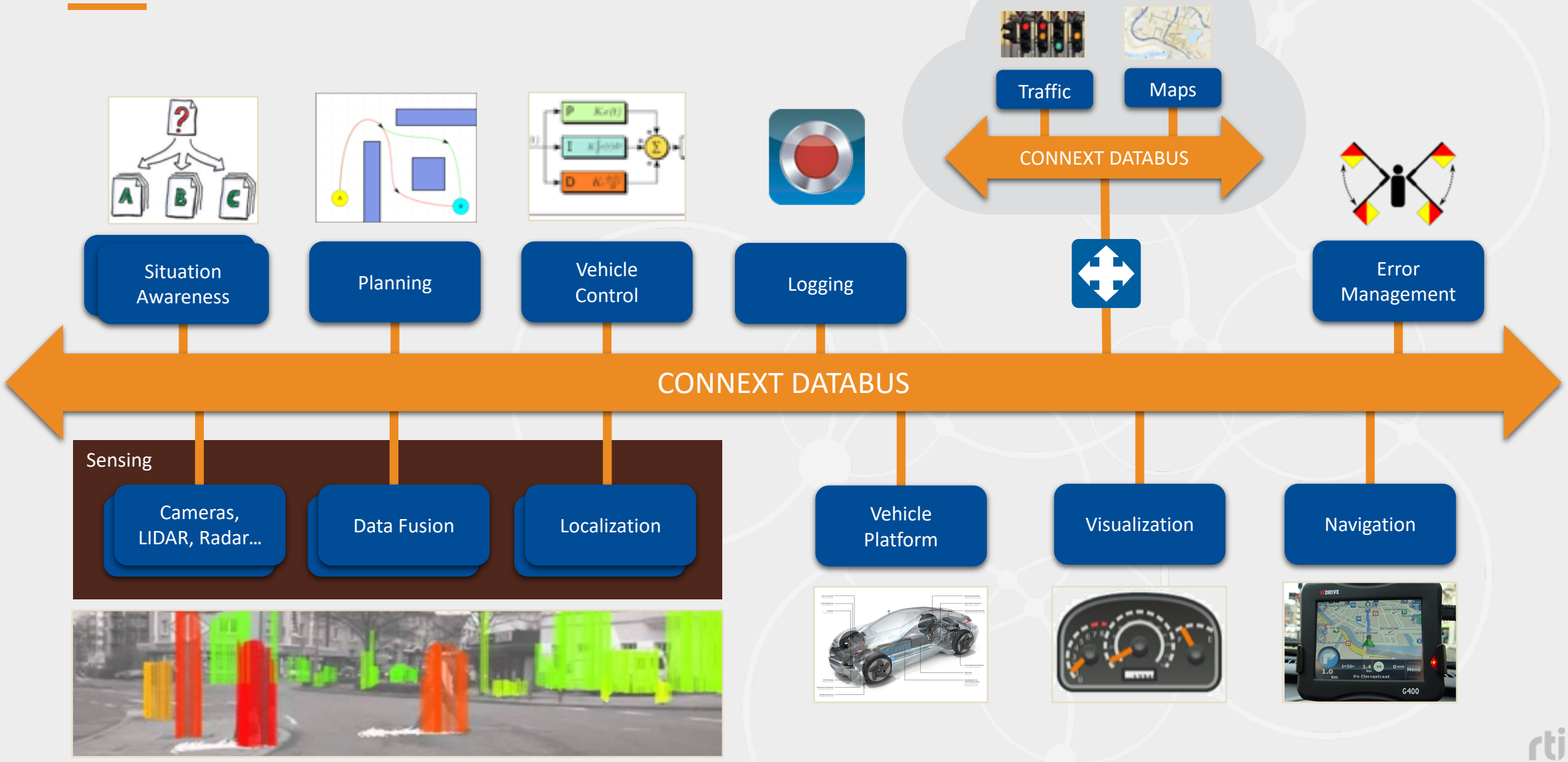

2005
2005





Connext Databus

Connext Databus



DDS "virtual" Data-Centric 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

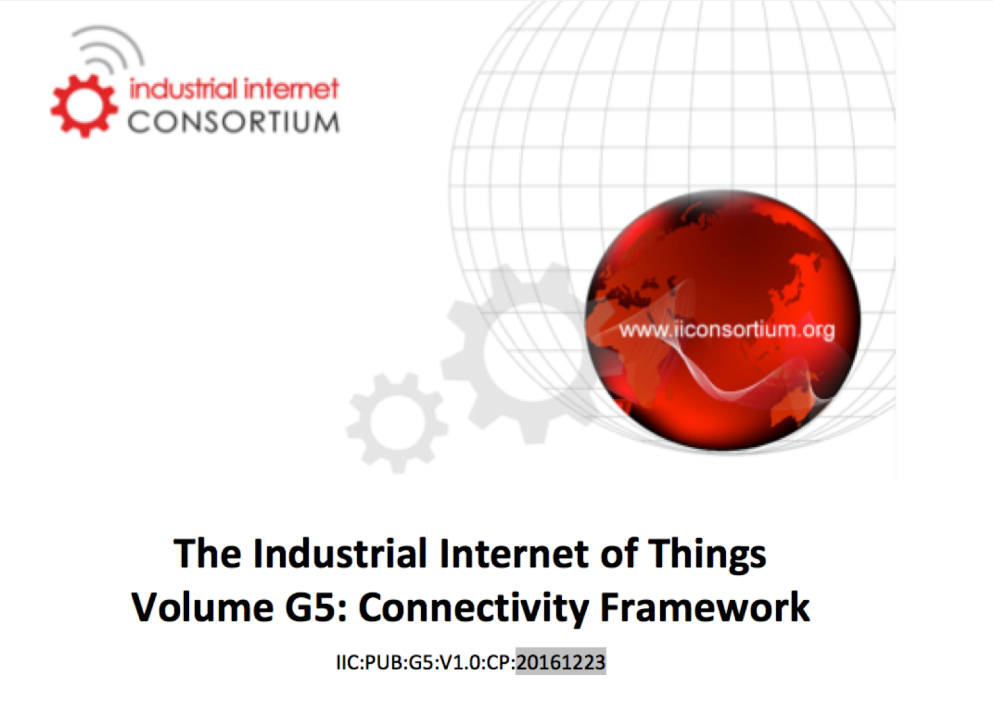
Persistence Service

Recording Service

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.

IIC Releases Connectivity Reference Architecture



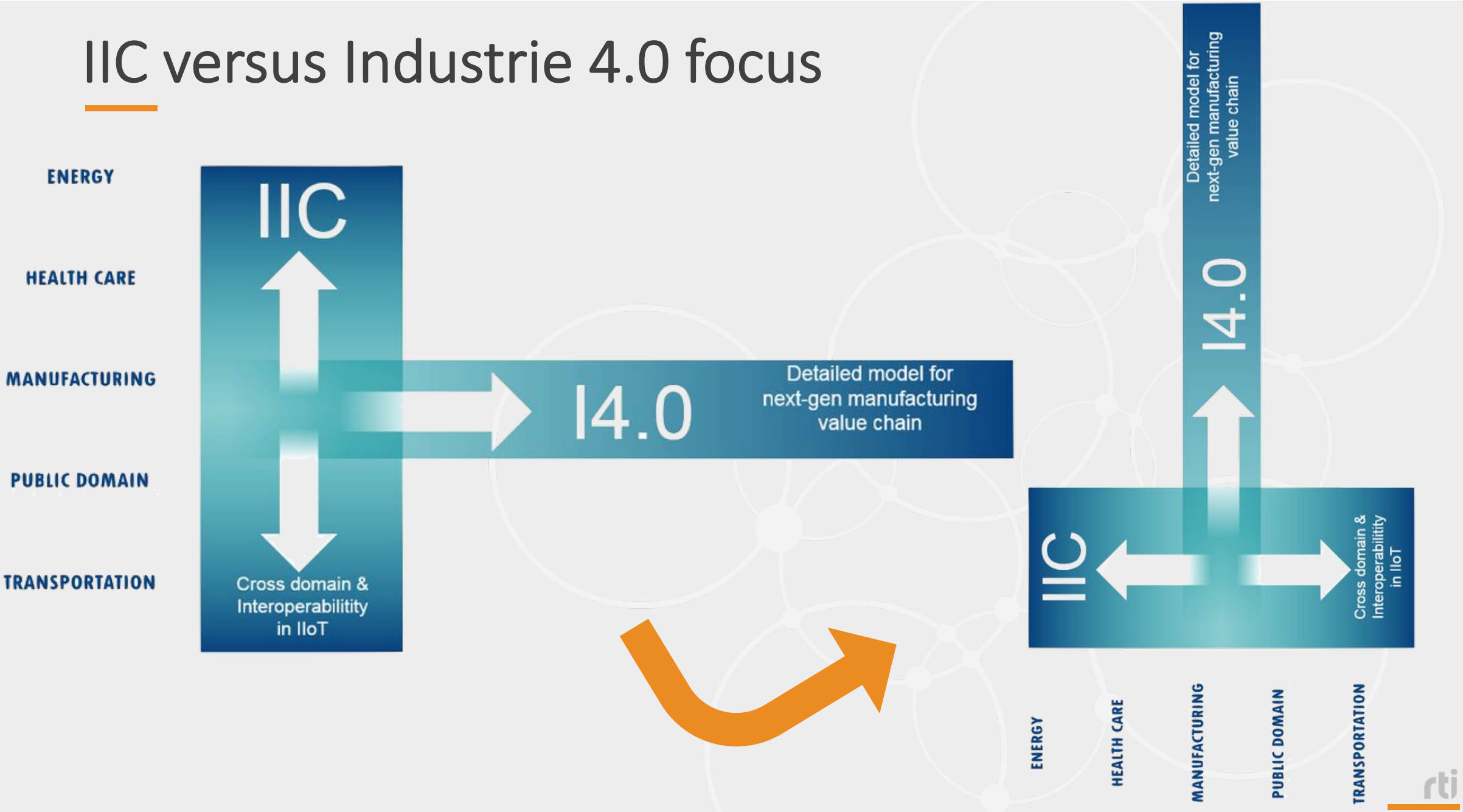
DDS anointed the

Core connectivity

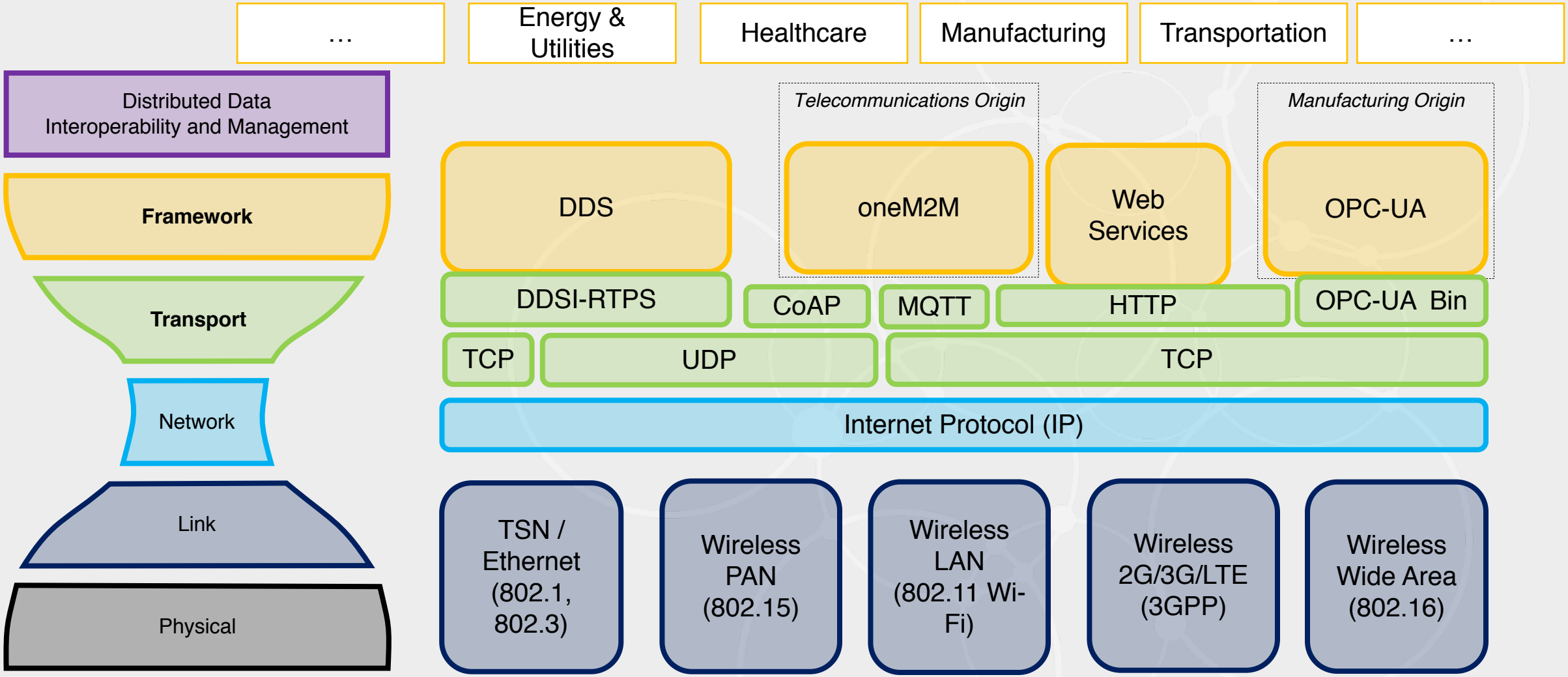
Databus

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

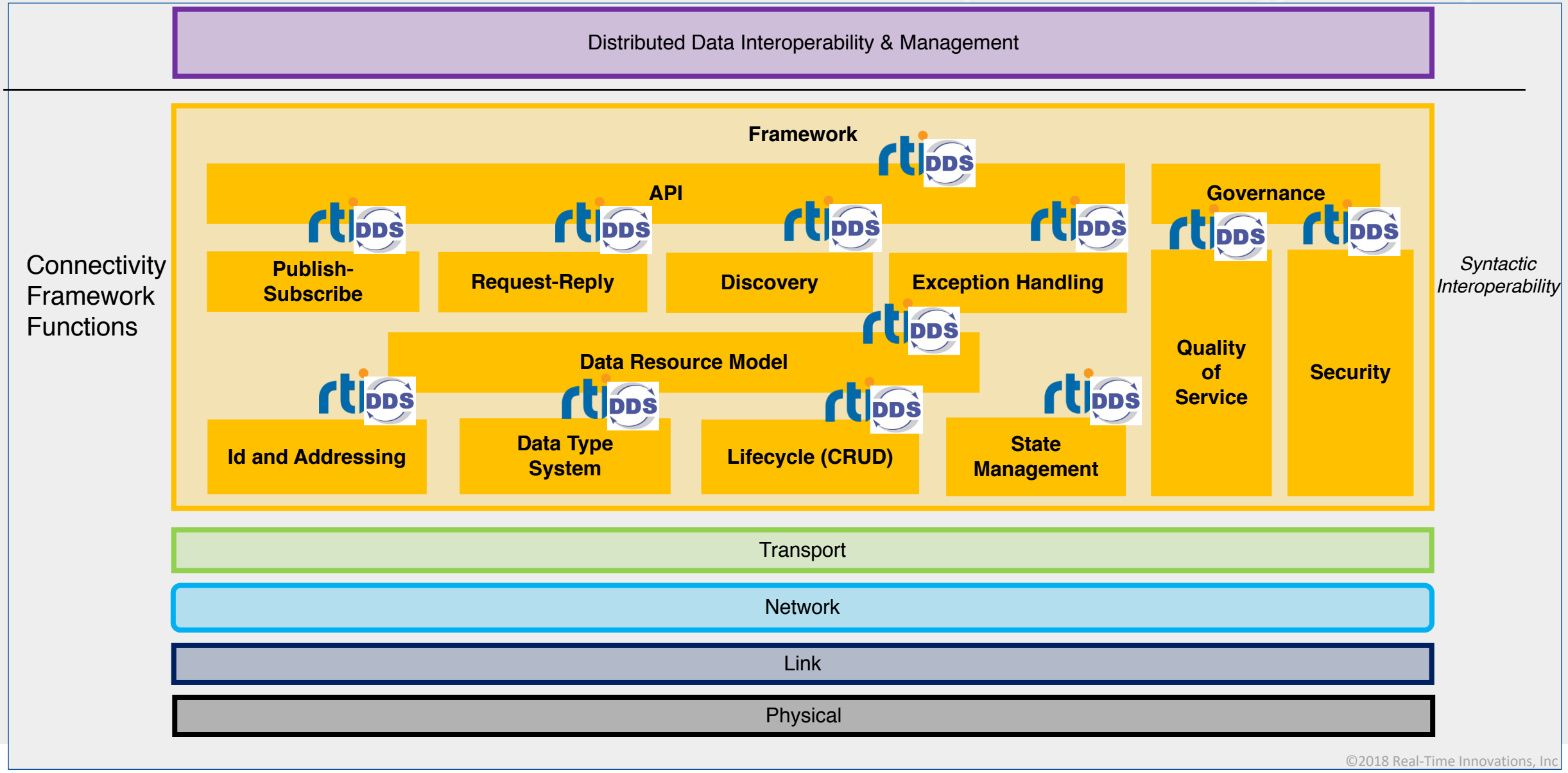
IIC versus Industrie 4.0 focus



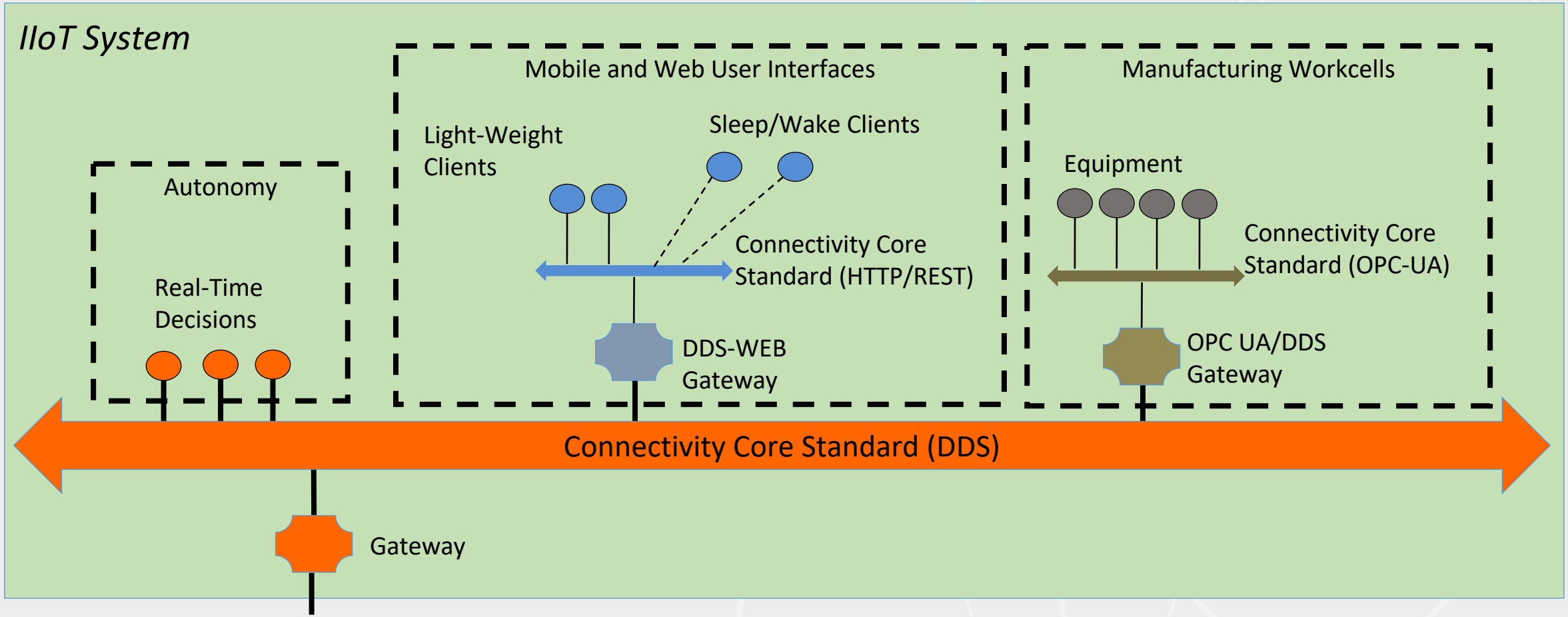
IIoT Connectivity Standards



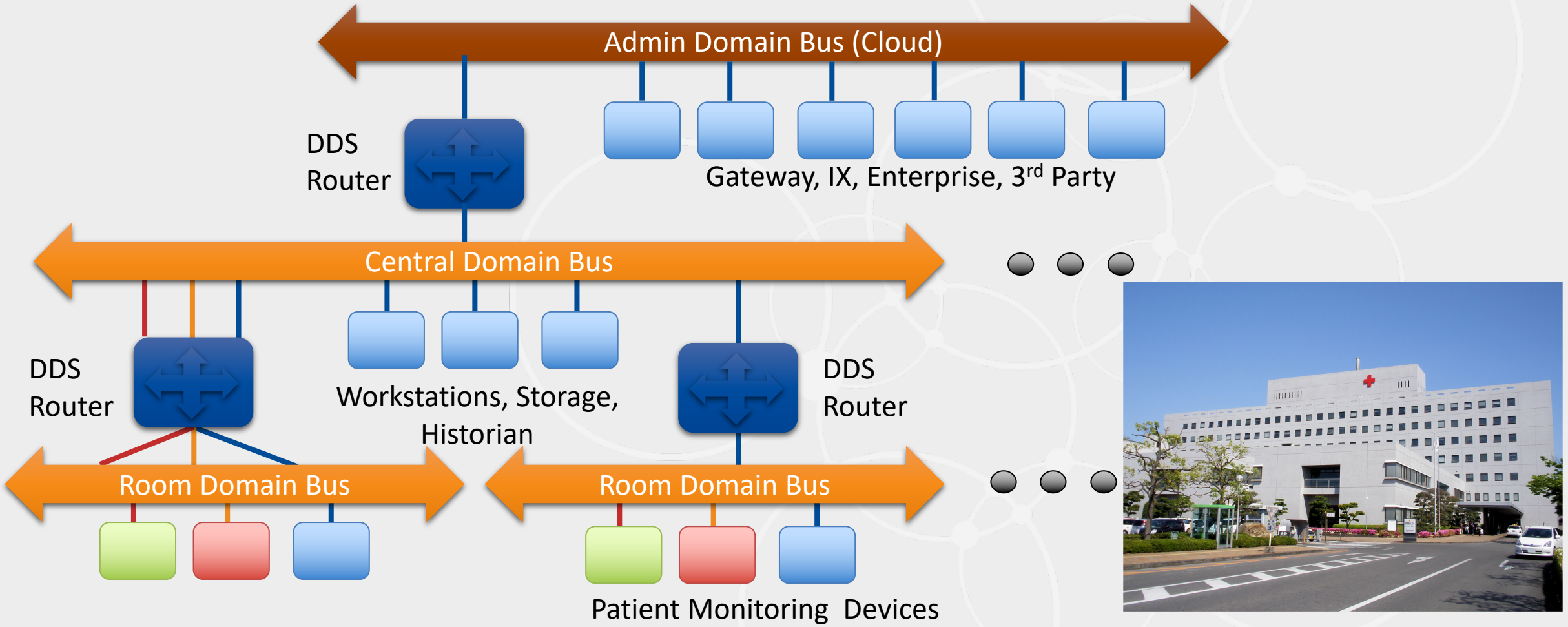
Connectivity Framework: Core Functions



DDS–Based Integration



Example: Clinical Decision System Architecture



Standards Update

Key standards we are focusing on

High Priority:

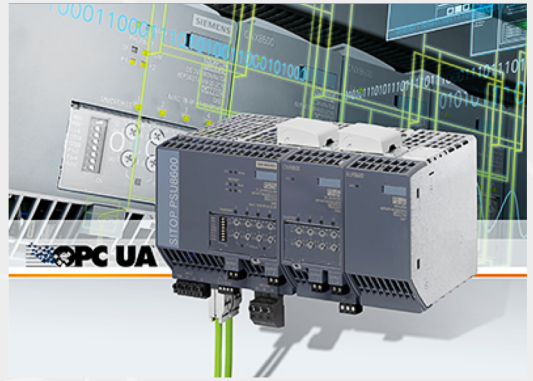
	DDS-Security	1.1	9/2017
	DDS-XTYPES	1.2	3/2017
	DDS-XML	1.0 Beta	6/2017
	IDL	4.2	9/2017
NEW	DDS-OPCUA	1.0 Beta	3/2018
NEW	DDS-XRCE	1.0 Beta	3/2018
COMING SOON	Adaptive AUTOSAR		

DDS-RTPS	2.3	2018
DDS	1.5	2019
DDS-PSM-TCP	Beta	2018
C++ PSM	1.1	2018
Java5 PSM	1.1	2018
DDS-RPC	1.1	2019
IDL to C#	Beta	2019
IDL to Java	Beta	2018

DDS-OPC UA

Example Use-Case

OPC UA as a "device driver"



Device Supporting OPC UA
E.g. Siemens Power Supply

OPC UA Server

OPC UA Client

OPC UA/DDS Gateway

DDS Participant

Connext Databus

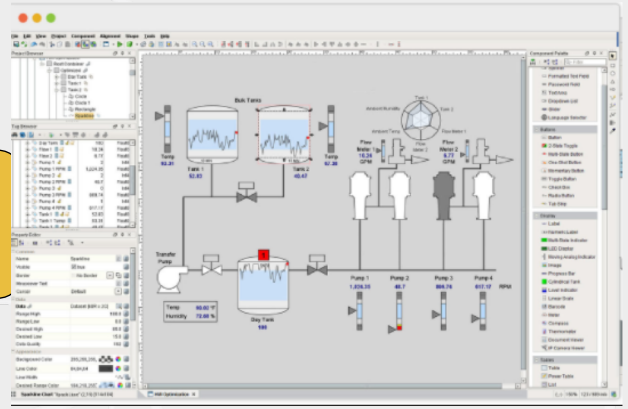
DDS Participant

DDS Participant

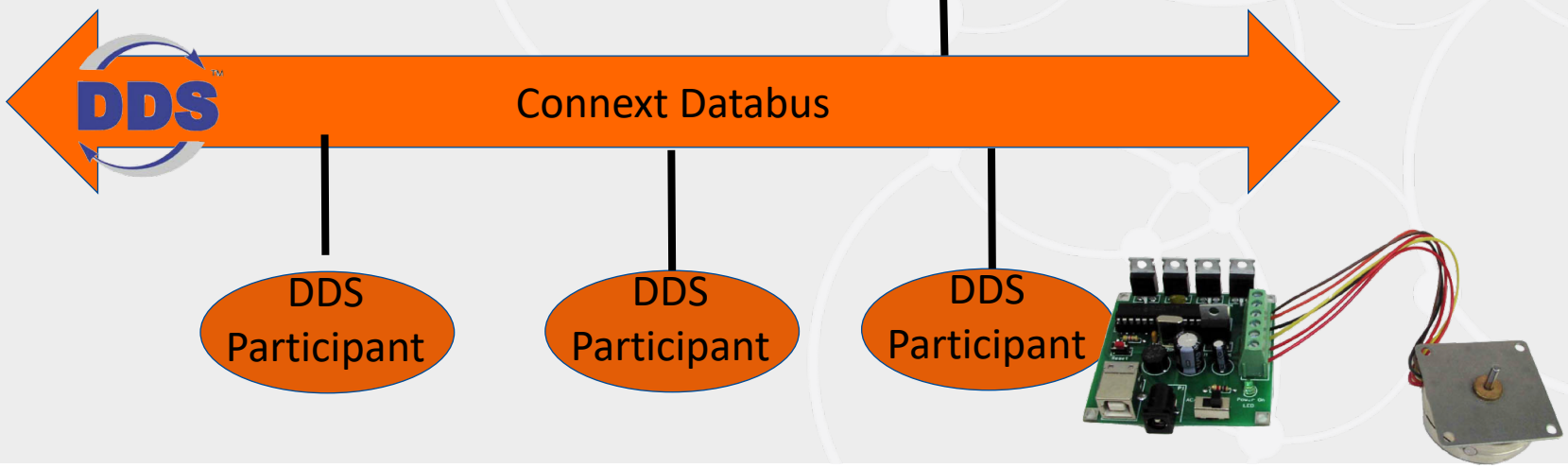
DDS Participant

Example Use-Case

Leverage OPC UA Ecosystem Tools



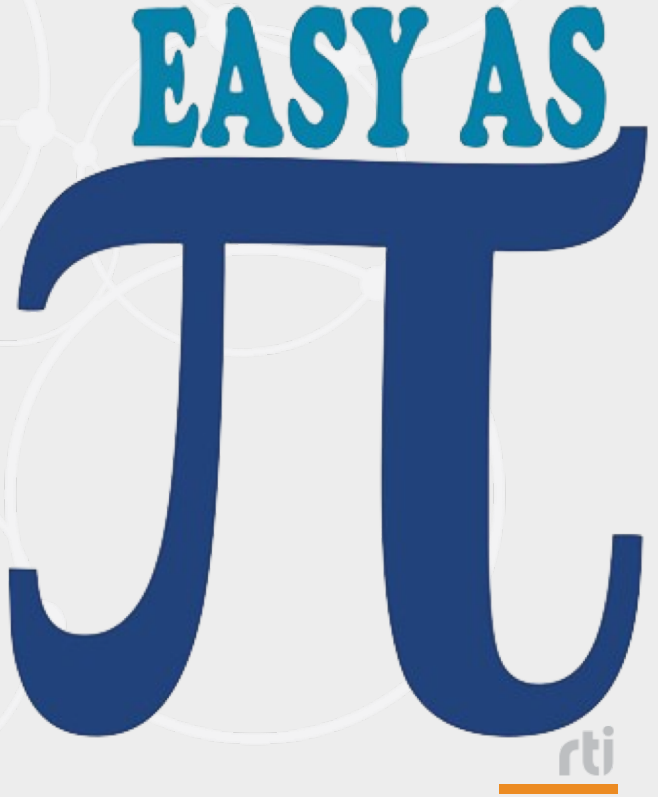
SCADA tools support OPC UA
E.g. Inductive Automation



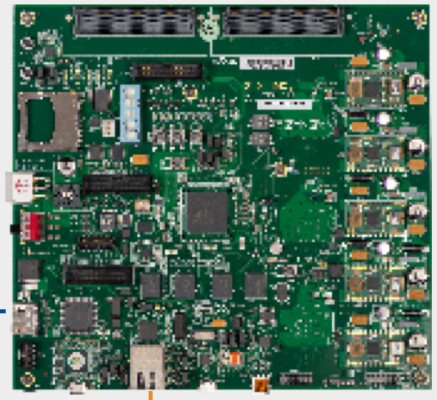
Simple OPC UA Subscription Mapping

- Normally using OPC UA subscriptions is quite complex…
  - Define subscription
  - Define Monitored Items
  - Read data as an array of “Variants,” address via indices
  - Use untyped API’s…

- With the DDS Gateway it is simple!
  - Define the DDS data-types in XML
  - List the OPC UA monitored items in the XML file
  - Map each monitored item to a field in the DDS data type
  - Use DDS API to subscribe to the Topic…
  - Voila!

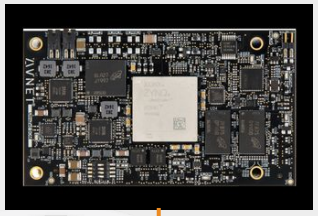


DDS/OPC-UA Prototype and Demo



Codesys Control
OPC UA Server
POWERLINK MN

UltraZed-EG SOM



OPC-UA to DDS
Gateway
Mocana Security
TPM 2.0

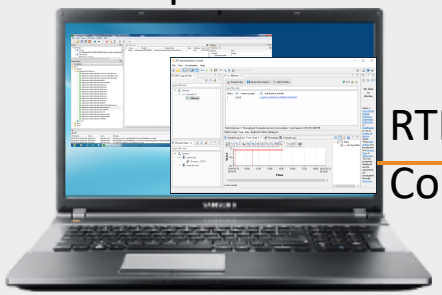
Edge Node
HW TBD (SOC-E?)

DDS
Endpoint

3.3V, GND,
Signal (IN)
GPIO Pin TBD

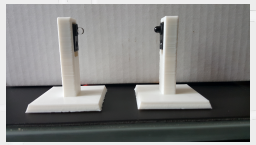
3.3V, GND,
Signal (OUT)
GPIO Pin 417

UaExpert



RTI Admin
Console

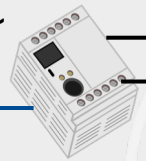
Switch



IR Barrier

Switch

PLC



Motor

Ethernet
Powerlink
GPIO
Analog

https://www.rti.com/blog/announcing-the-opc-ua-dds-gateway-standard

DDS Security 1.1

DDS Security 1.1

- Updates required for vendor interoperability
- More efficient cryptography
- Enhanced authentication and key derivation
- Strengthen some edge cases:
  - Mobility, Changes in QoS, Timing/Race conditions
- Basis for Interoperability Tests:
  - https://github.com/omg-dds/dds-security

Most all already included in Connext 5.3

DDS XTYPES 1.2 & IDL 4.2

IDL 4.2 + XTYPES 1.2

- IDL as **strong data & interface modeling language**
  - DDS **data-modeling extensions**
    - Keys, ranges, optional members, ...
  - **General annotation support for extensibility**
  - Support for DDS-RPC
- Enables “platform-independent” information model
  - Lingua franca for IIOT data models
    - vs. XSD, JSON, YAML, ProtoBufs, ROS-IDL, Ad-hoc …
  - 3rd party tooling support - UML, Matlab, LabVIEW, …
- Enhanced **performance**
  - Serialization dynamic data, discovery

```
@appendable
struct ShapeType {
  @key           string color;
  @range(0,250) int32  x;
  @range(0,260) int32  y;
  @max(100)     uint32 size;
};

@appendable
struct ShapeTypeExt : ShapeType
{
  int32 angle;
};
```

DDS-XRCE

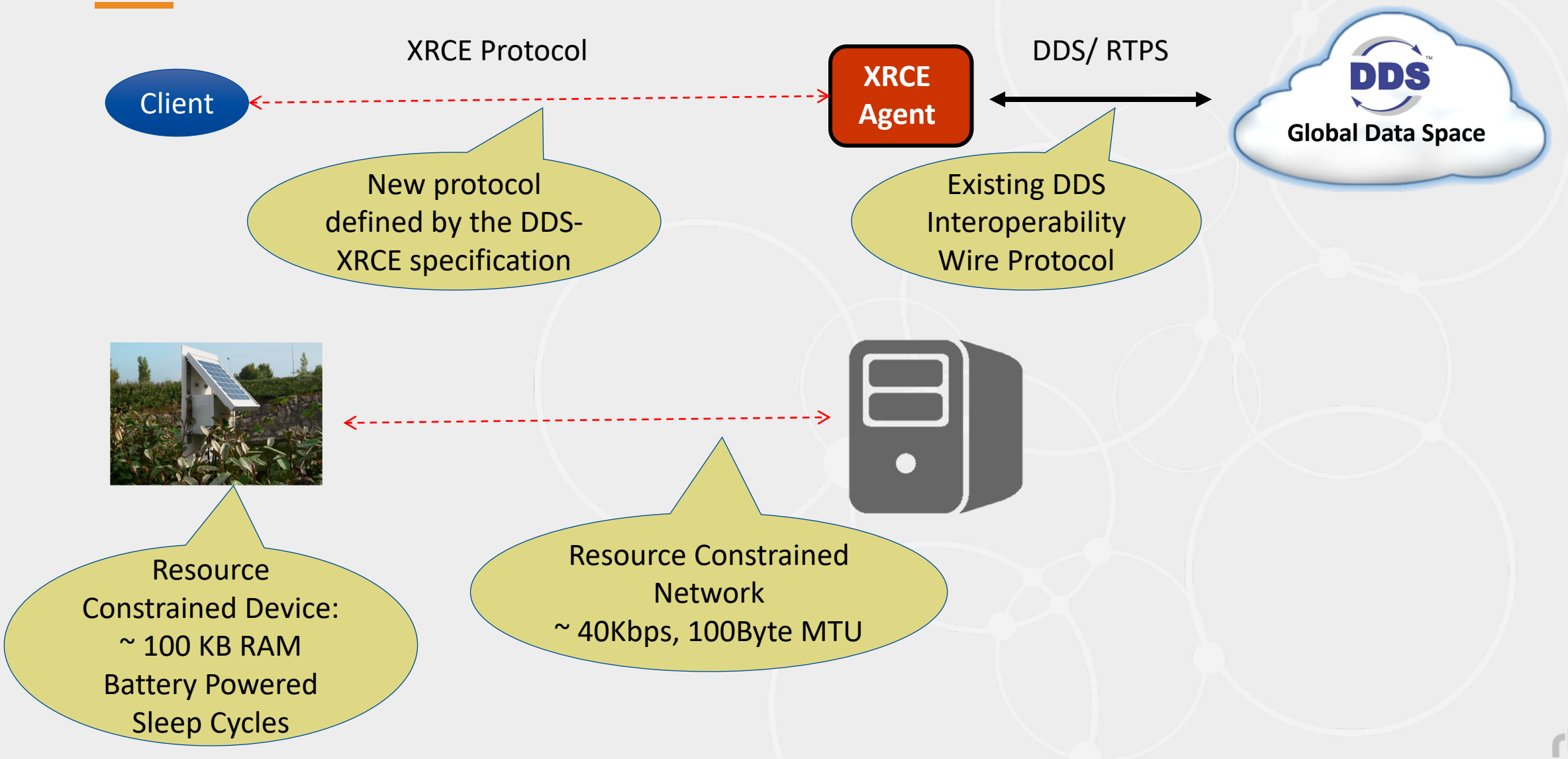
DDS for eXtremely Resource Constrained Environments

Goals

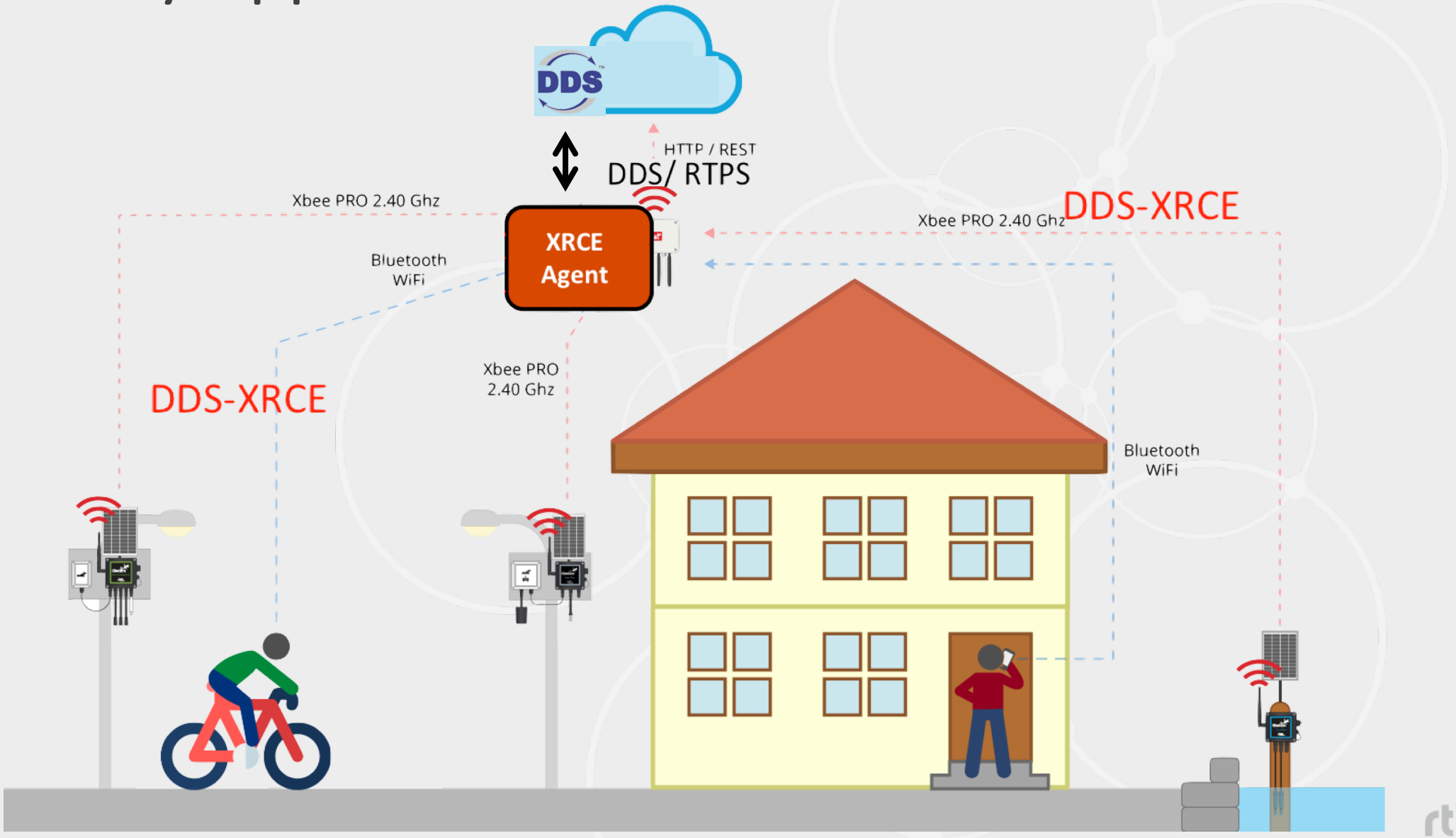
- Extend DDS to Extremely “Resource Constrained” Devices
- Kinds of resource constraints:
  - Network MTU. E.g. 100 Byte. MTU
  - Network Bandwidth. Less than 1 KByte/second
  - Processors. E.g. 32 bit microcontrollers
  - Memory. E.g. 32 KB maximum RAM
  - Power. E.g. devices that go into sleep cycles

DDS cannot extend to these devices today. DDS Protocol has too much overhead and is not friendly to “sleep cycles”

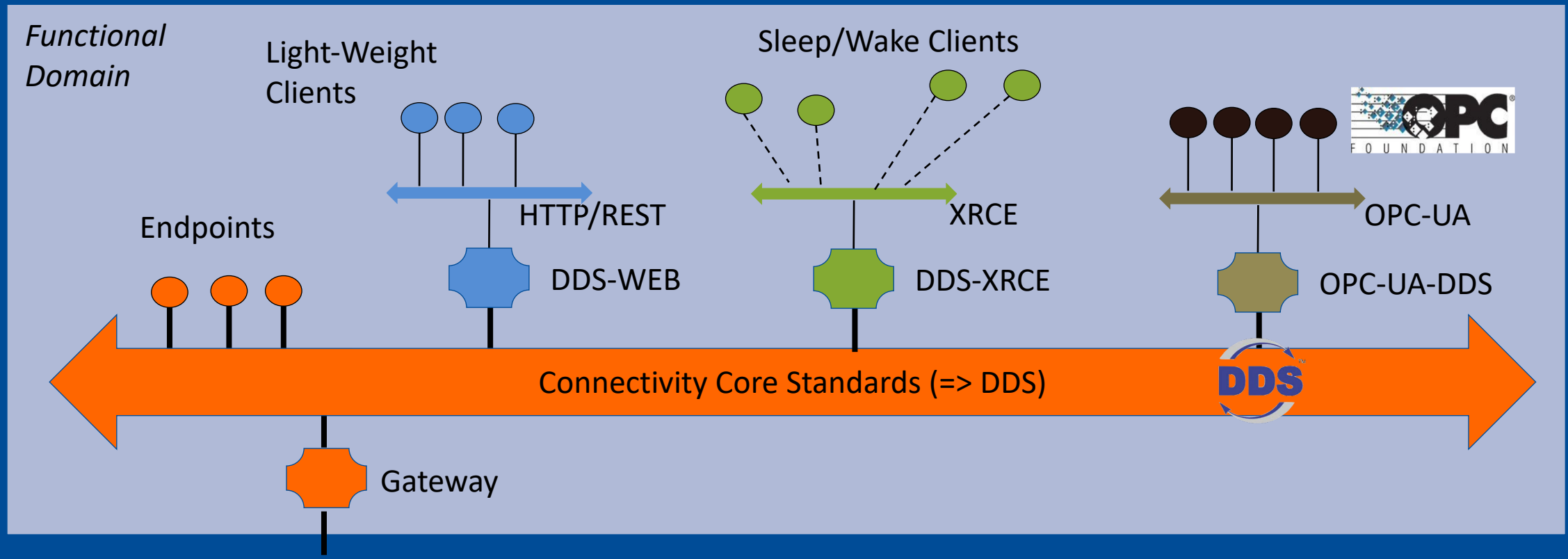
Agent-Based deployment model



Smart City Application

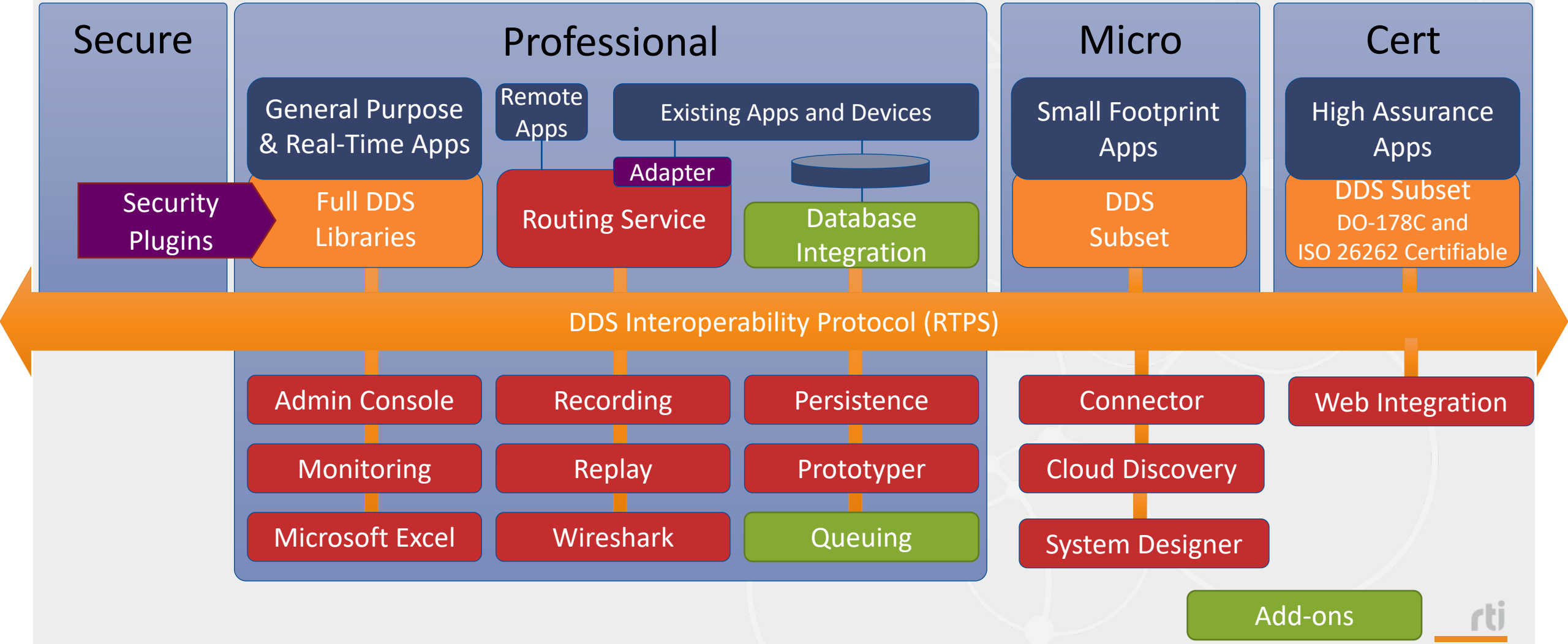


Goal: Make DDS the Core Databus



Product Update

RTI Connext DDS Product Suite



New Feature Highlights

- Mobility
- Topic Query
  - Past data as you want it, on demand
- Security
  - Fine grain protection for critical data…
- Tools
  - Admin Console, System Designer
  - Cloud Discovery Service

Connext DDS 5.3.0 Secure

DDS Security 1.1 compliance
Improved Performance

Platform:

- CPU: Intel i7 6-core CPU 3.33GHz, 12 GB RAM
- NIC: Intel I350 Gigabit
- CentOS Linux 7.1
- C++ API

1 to 1 latency

Data Size	No Security	Sign Message	Sign Message Encrypt Data
256 Bytes	40 usec	50 usec	53 usec
1024 Bytes	54 usec	64 usec	69 usec

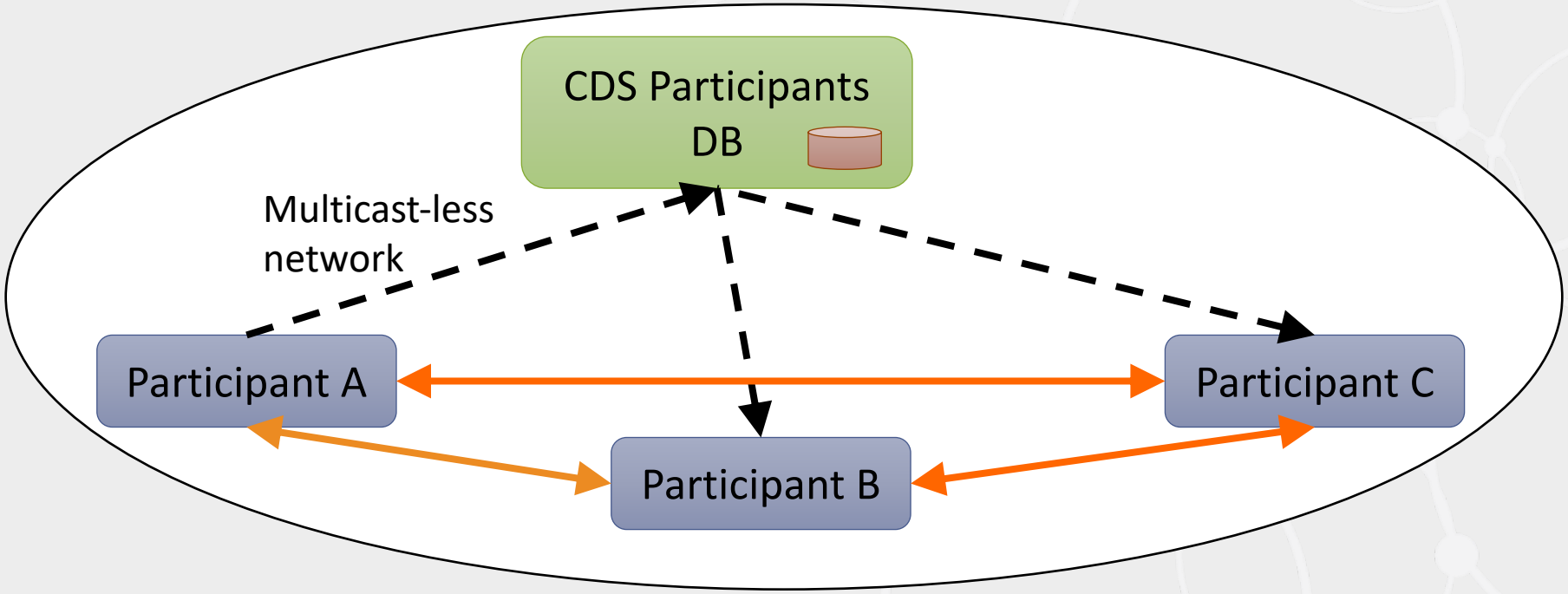
1 to 1 throughput

Data Size	No Security	Sign Message	Sign Message Encrypt Data
256 Bytes	953 Mbits/sec	945 Mbits/sec	810 Mbits/sec
1024 Bytes	974 Mbits/sec	966 Mbits/sec	924 Mbits/sec

Cloud Discovery Service

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

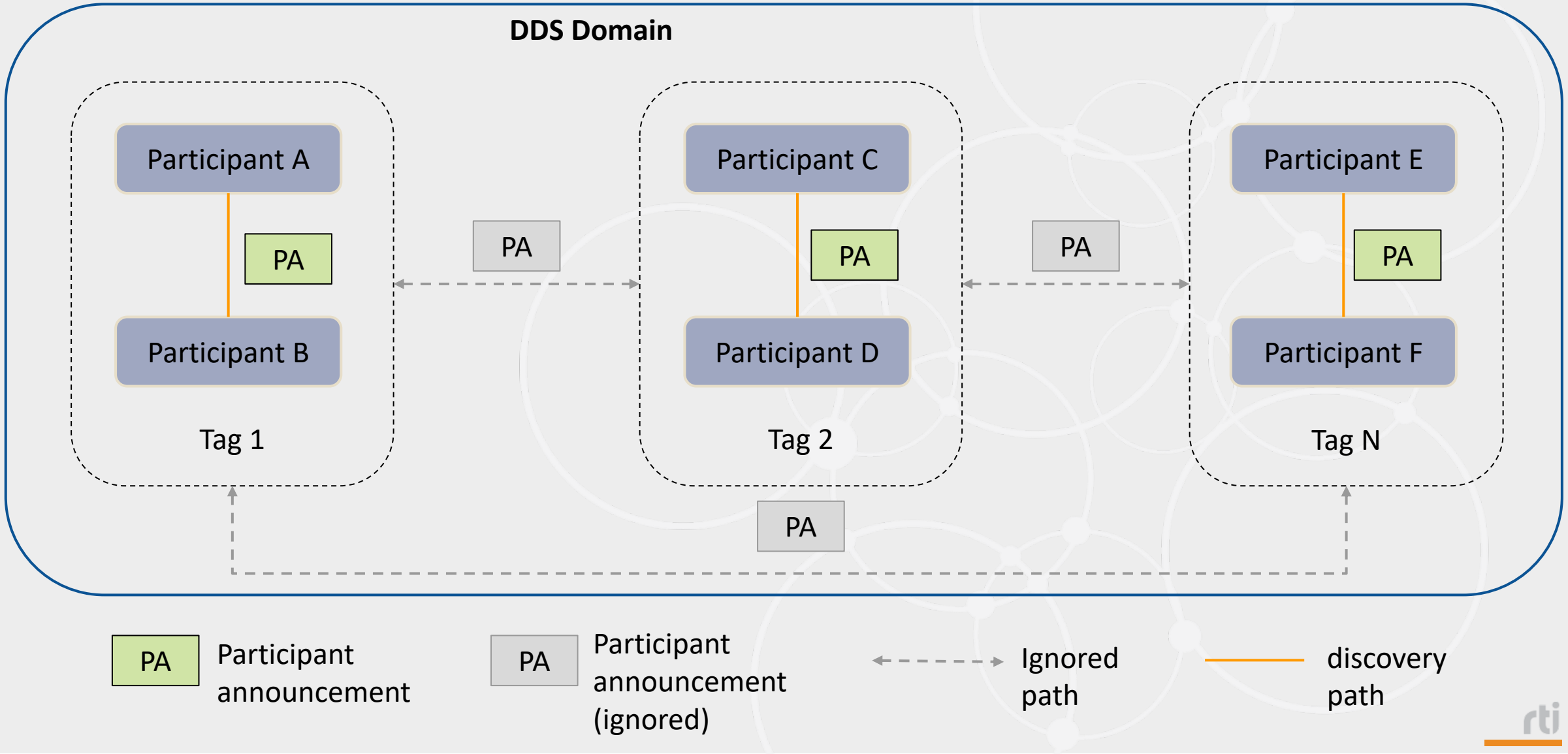
Interoperates with Standard DDS Discovery



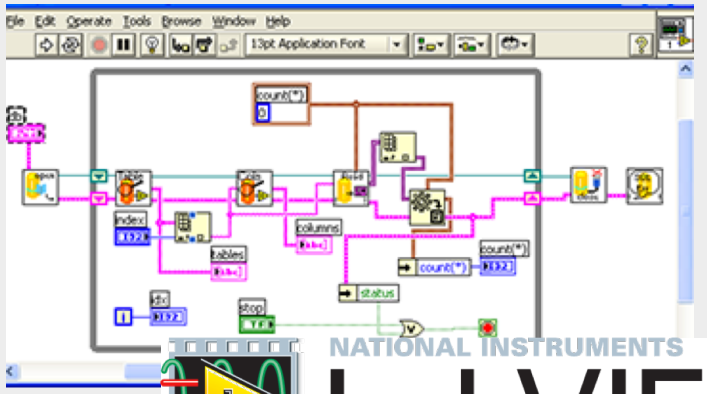
Cloud discovery of Participants

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

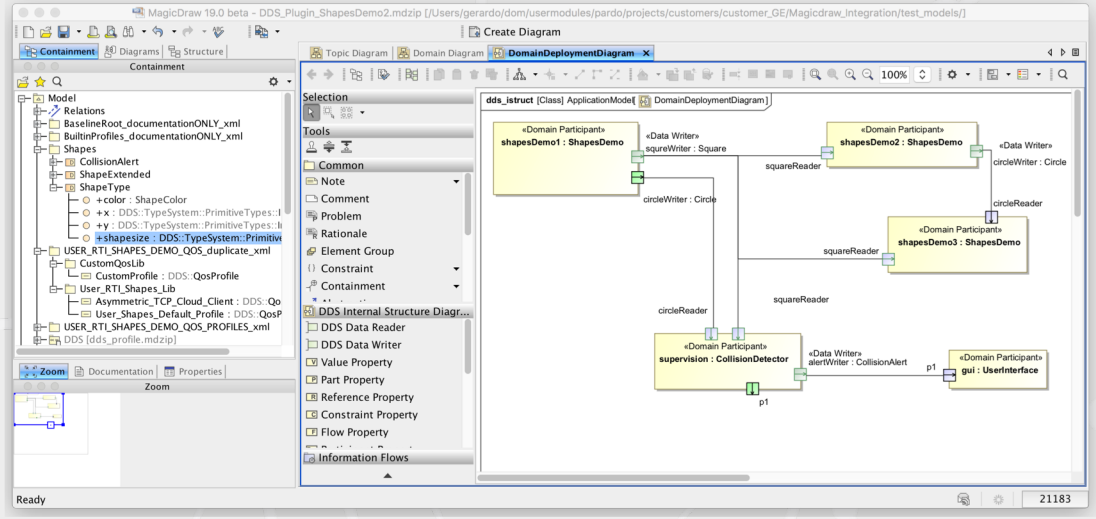
Domain Tags : Participant Isolation within a Domain

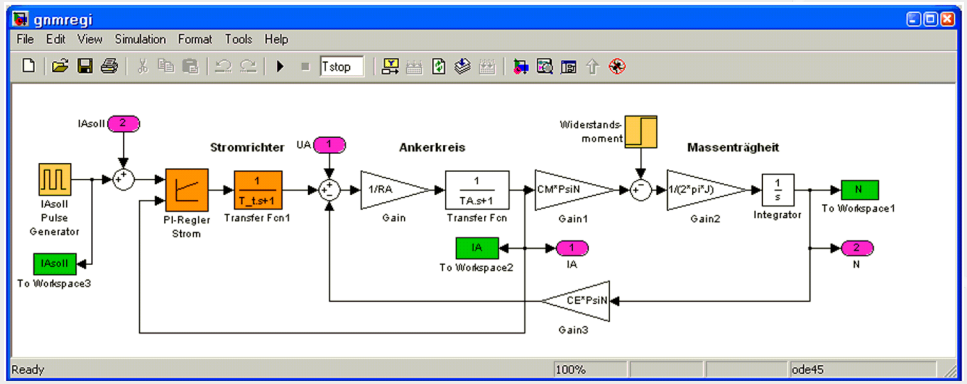


Integrating 3rd party tooling



NATIONAL INSTRUMENTS
LabVIEW™

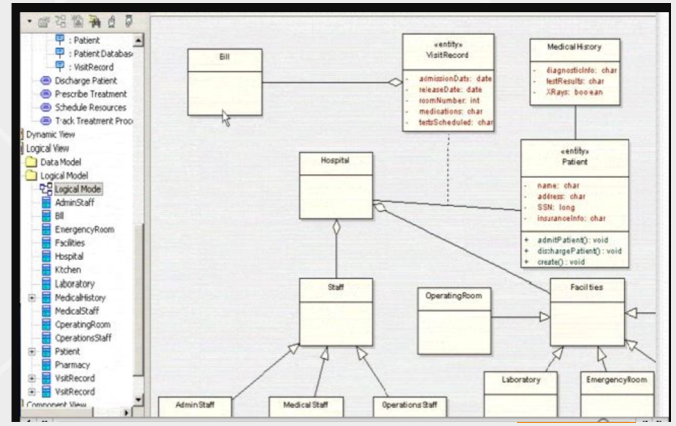




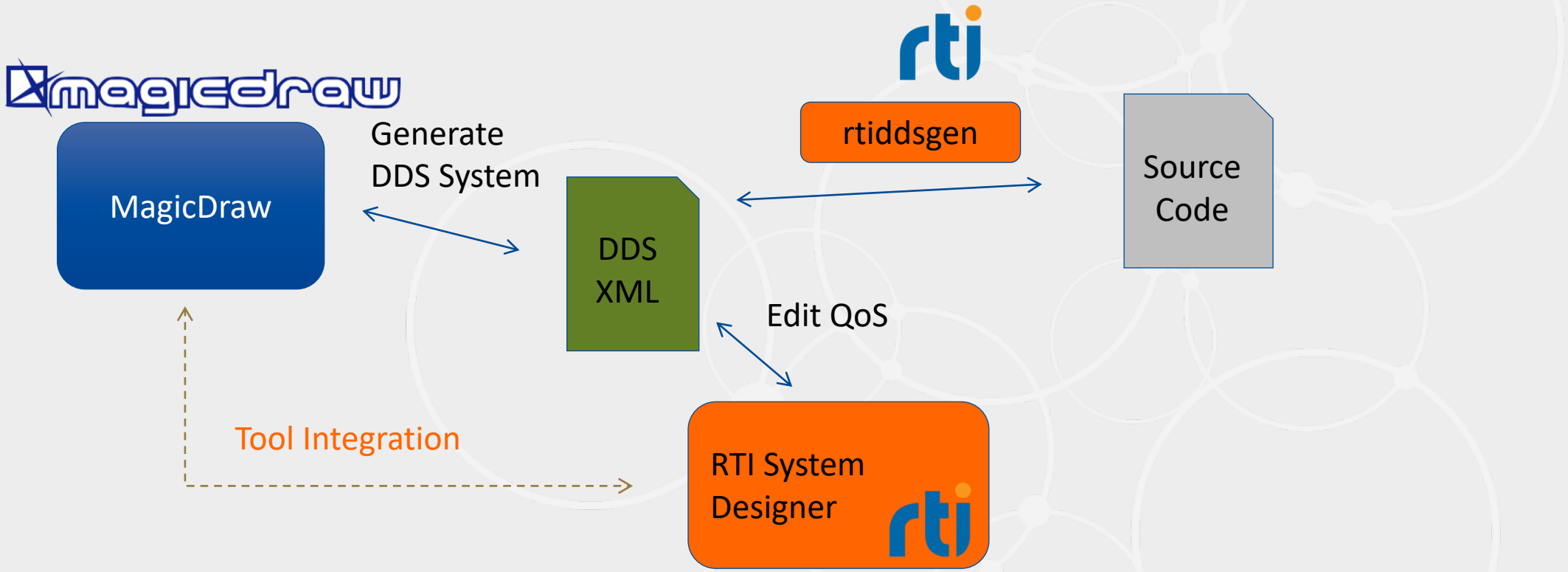
MATLAB
SIMULINK

magicdraw
SysML

ENTERPRISE ARCHITECT



DDS Development with SysML and MagicDraw



Connext DDS Micro: Many new features

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

IS NEVER ENOUGH

Robustness

The kind of robustness our users need

Research

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

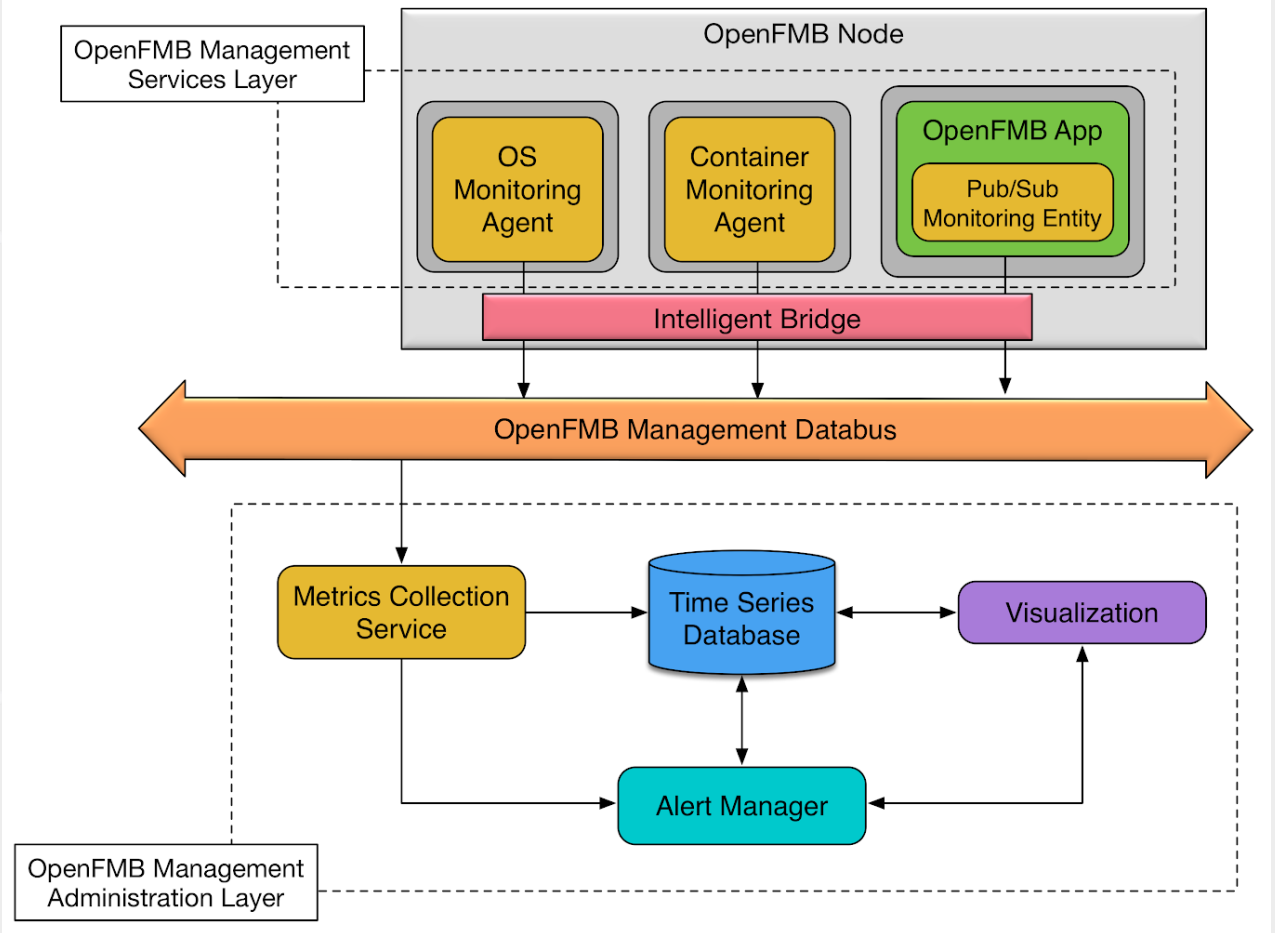
MD PnP™
Getting Connected for Patient Safety™

rti

Energy SmartGrid

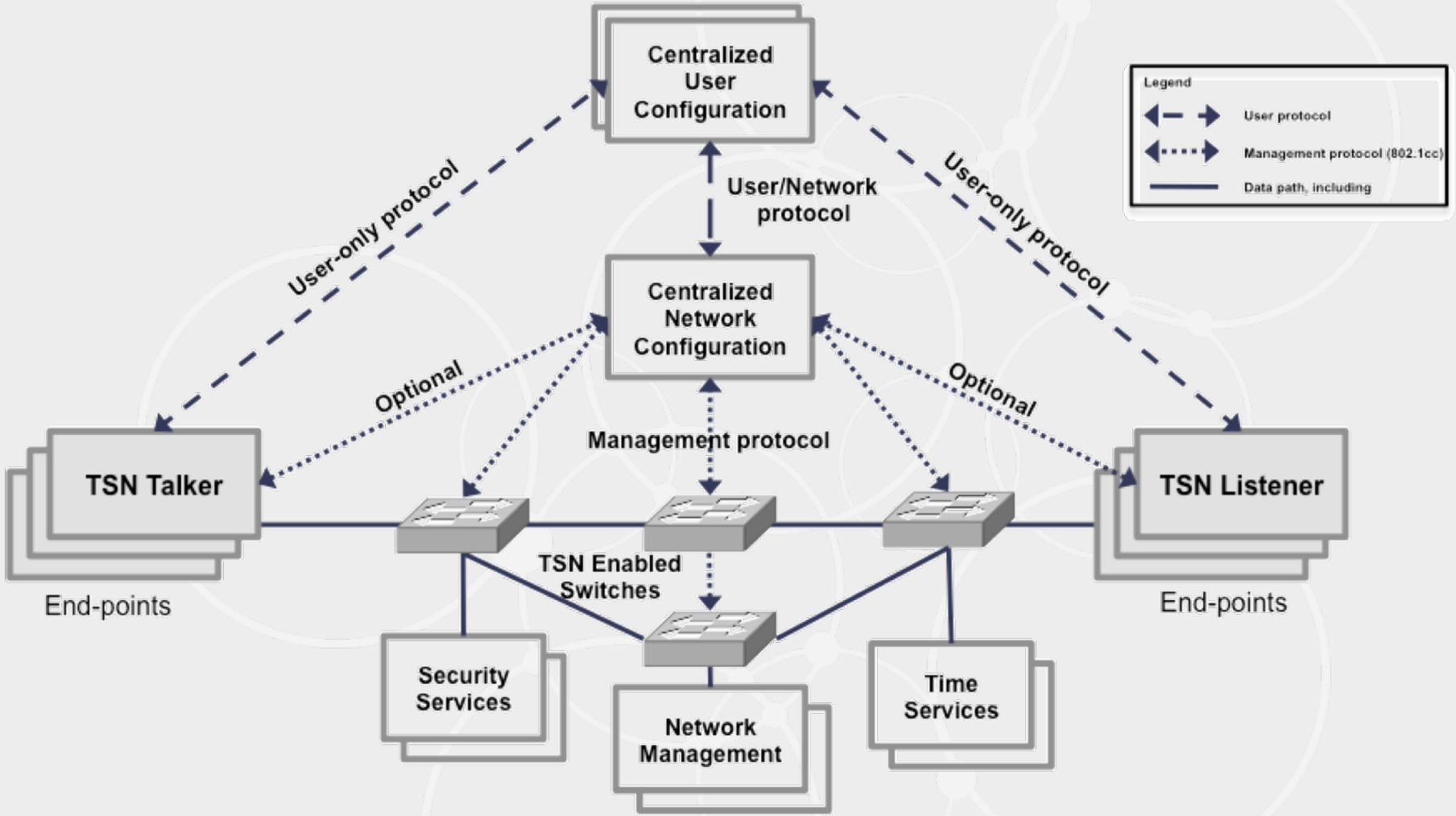
Remote Node Management
for DDS Systems

- **Scope**
  - Device Configuration & Updates
    - Containers, Applications, Security
    - Using Docker / Kubernetes
  - Real-Time Device Health Status Monitoring
  - Integrated with InfluxDB
  - **Go Language Binding**



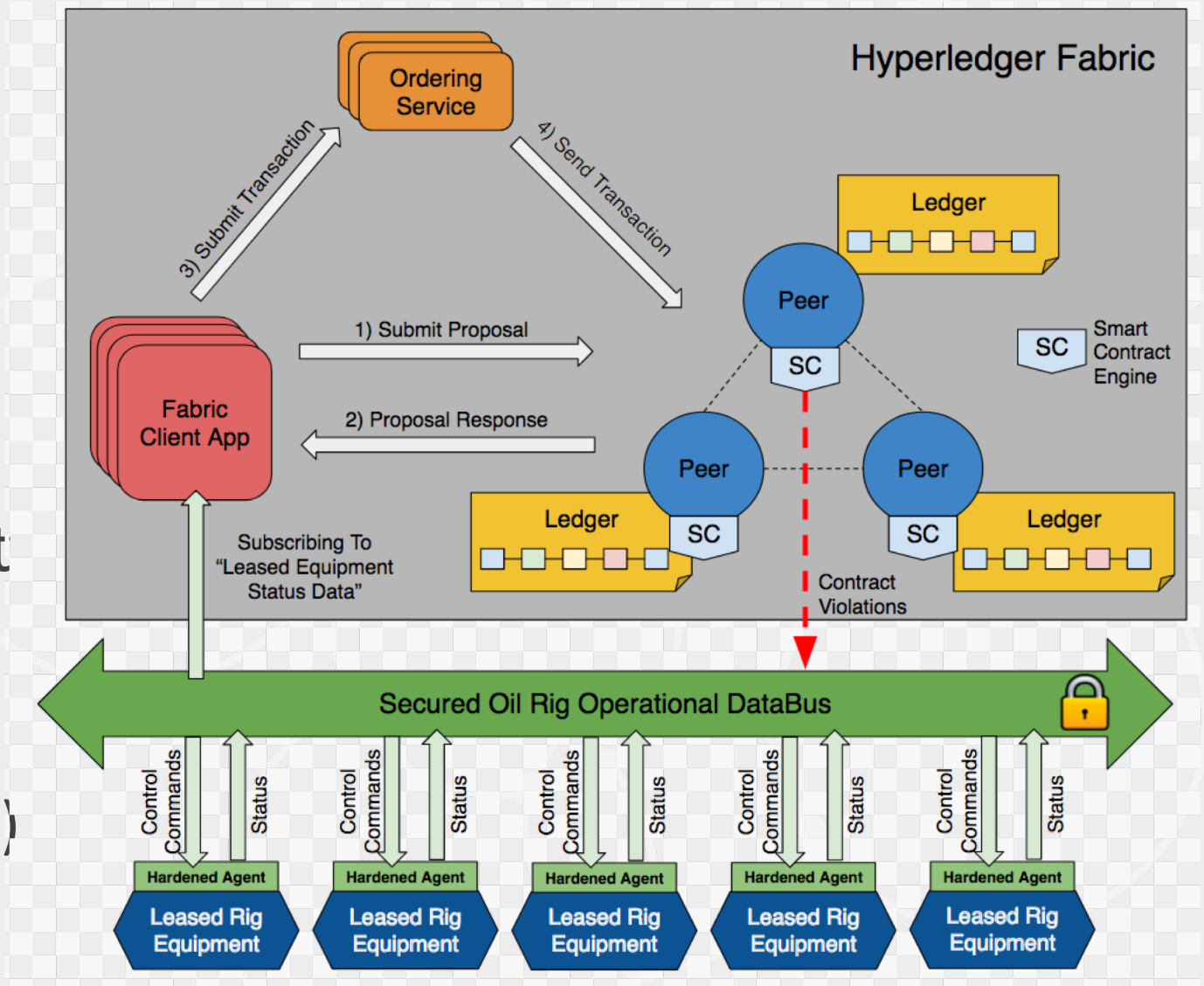
Time Sensitive Networks

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



Enabling End-to-End Trustworthiness using Blockchain

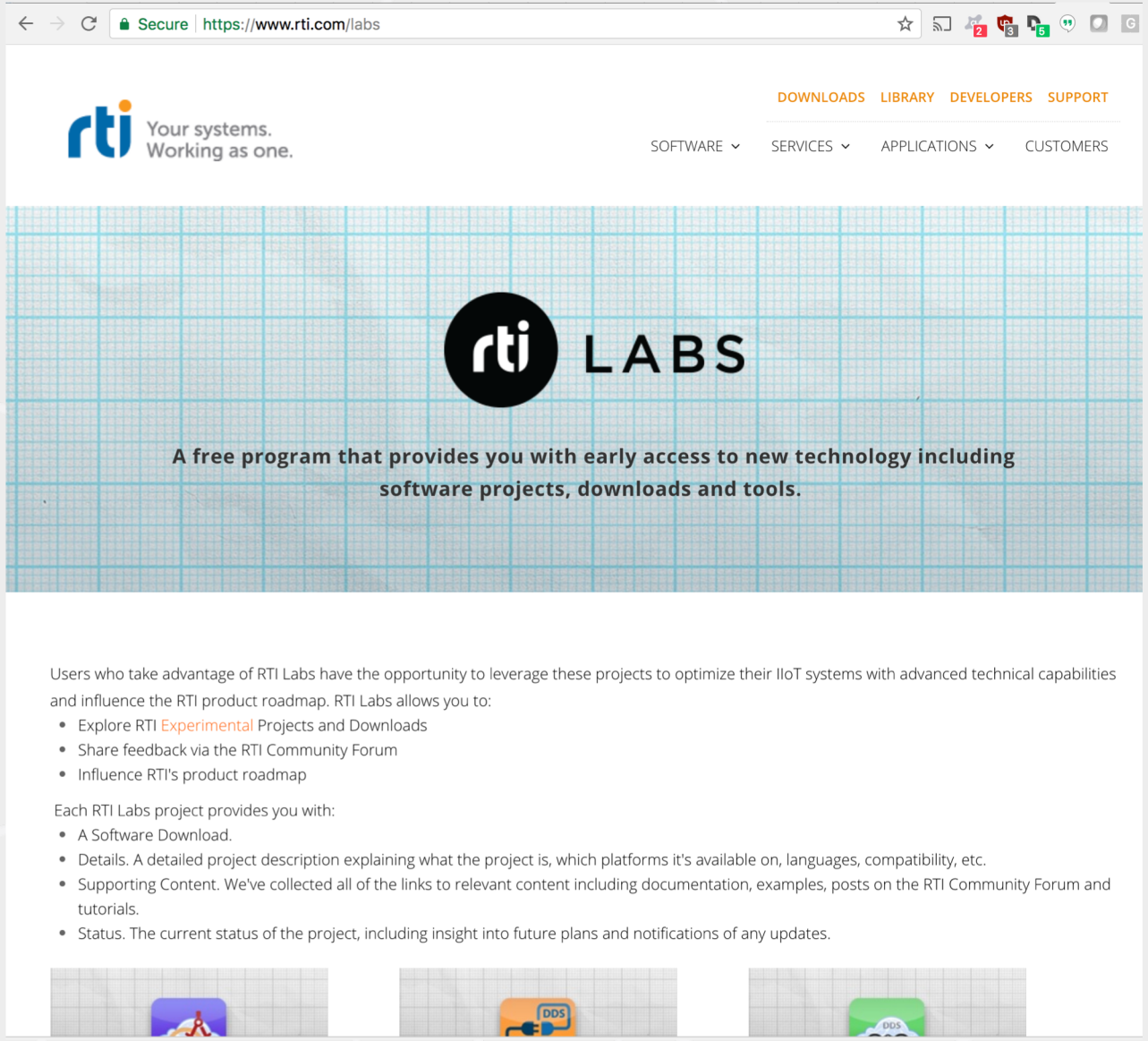
- Trustworthiness
  - Hardened Agents/RS
  - Secure DDS
  - Blockchain
- Will enable real-time *trusted* process automation using Smart Contracts
  - for multi-party systems (like oil, gas, medical, transportation V2I, V2V)



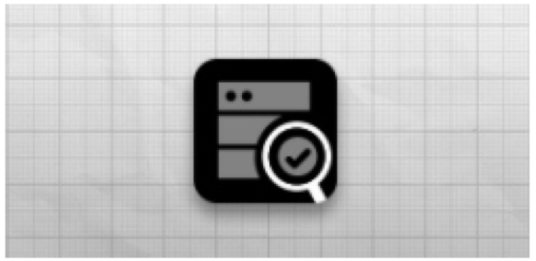
RTI Labs

RTI Labs

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

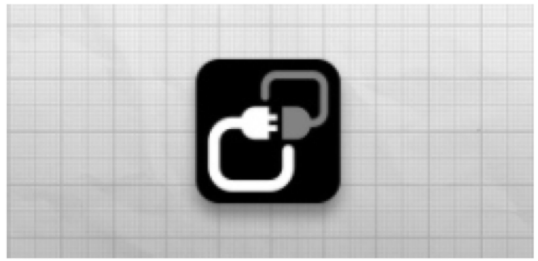


RTI Labs Technologies now available



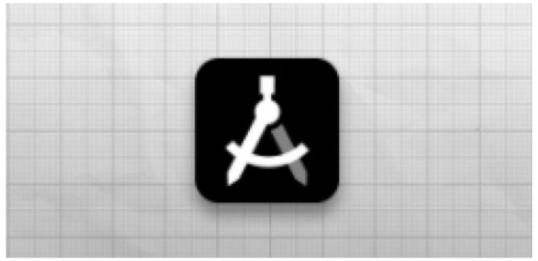
LOG PARSER

A command-line tool that processes and enhances RTI Connext® DDS and RTI Connext DDS Micro log messages, making it easier to debug applications. Learn more.



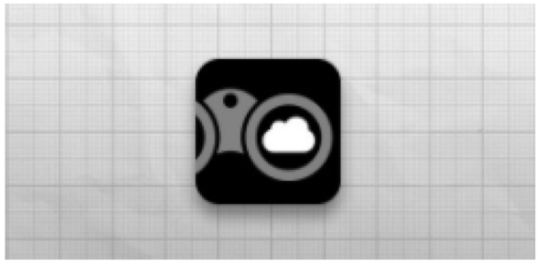
CONNECTOR

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



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.



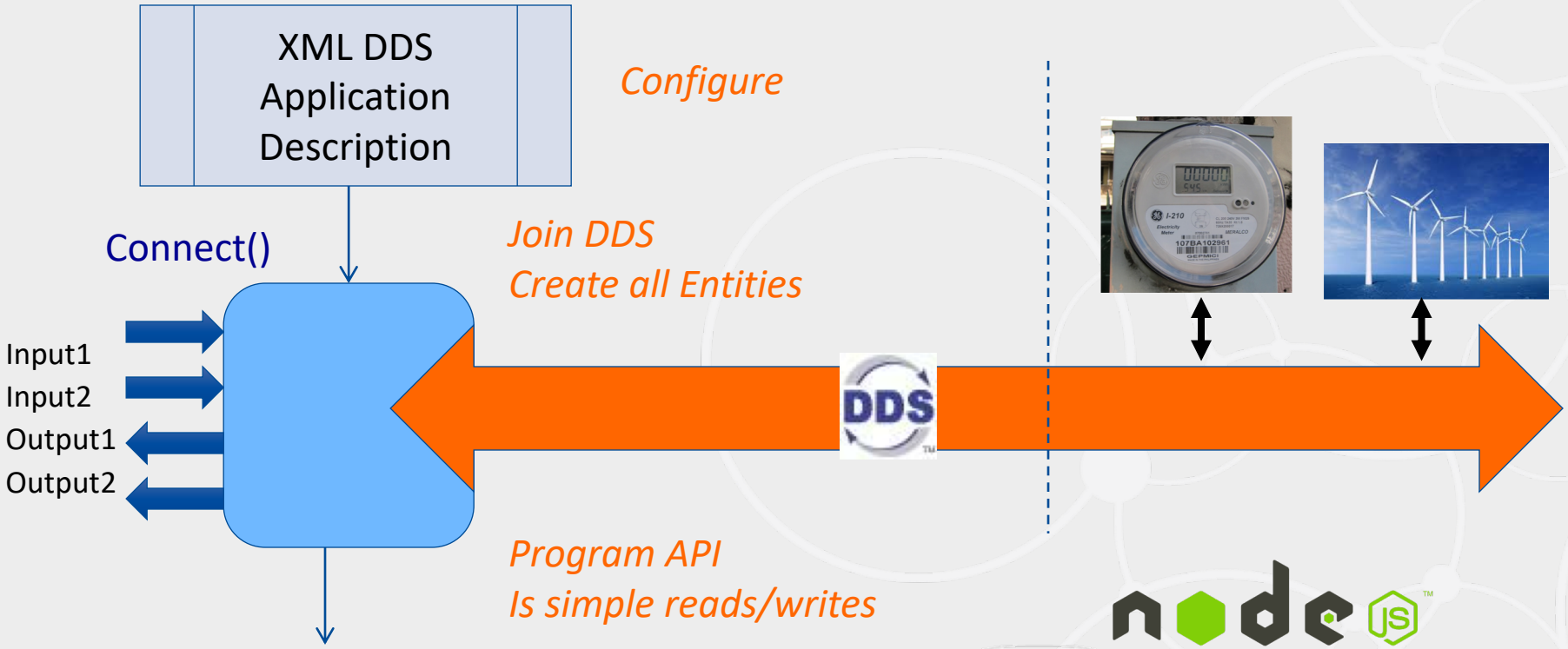
CLOUD DISCOVERY SERVICE

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

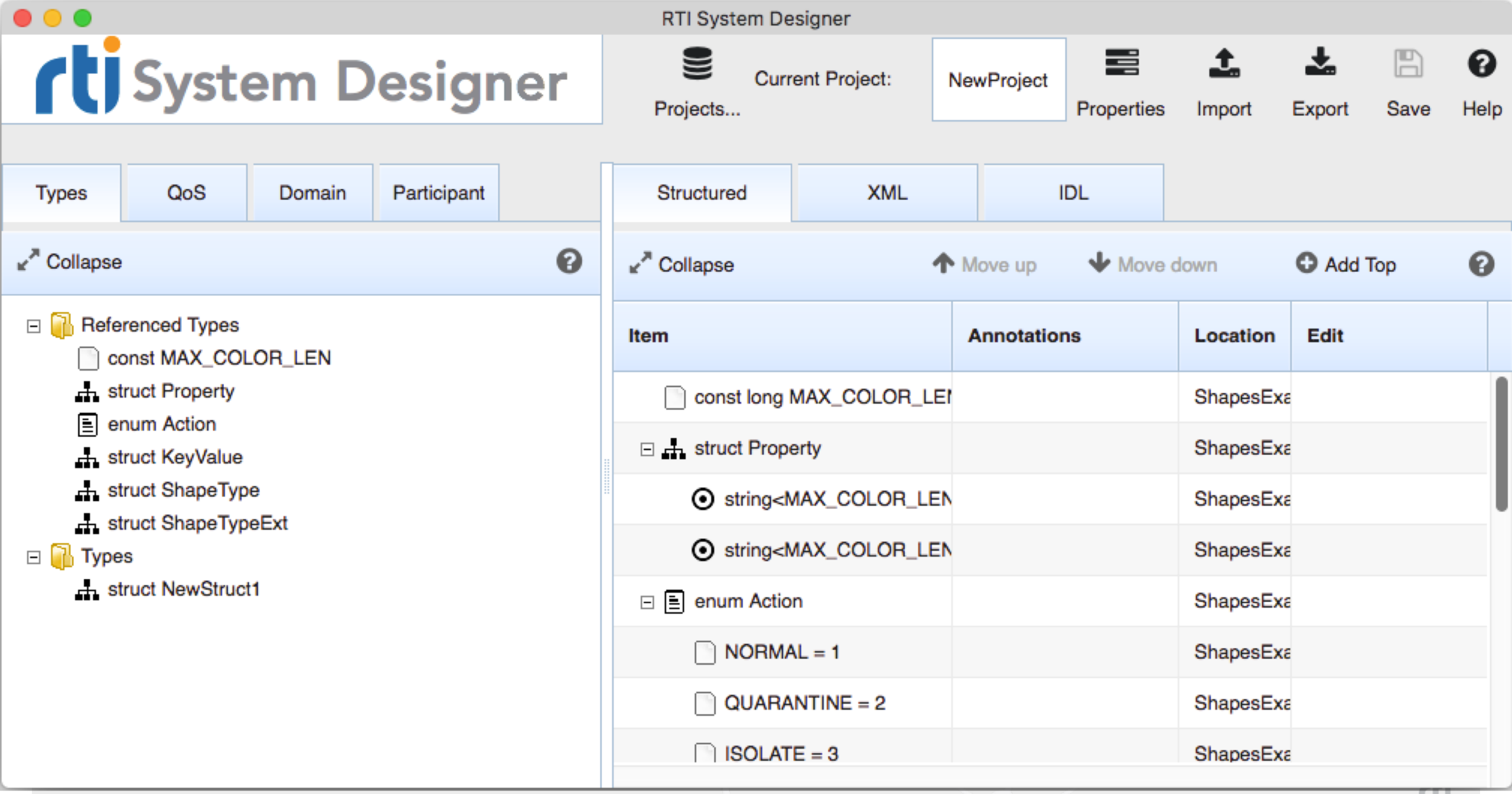
https://www.rti.com/labs

RTI Connector

App Definition is Simple XML



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



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

Conclusion

We are helping you meet the most critical application challenges

Thank You!

Stay Connected

rti.com
Free trial of Connext DDS

rtisoftware

@rti_software

connextpodcast

@rti_software

rti.com/blog