MUNICH

Connext®
2018

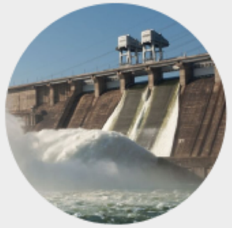
April 24-25

Dr. Gerardo Pardo-Castellote

CTO

gerardo@rti.com

Your systems.
Working as one.

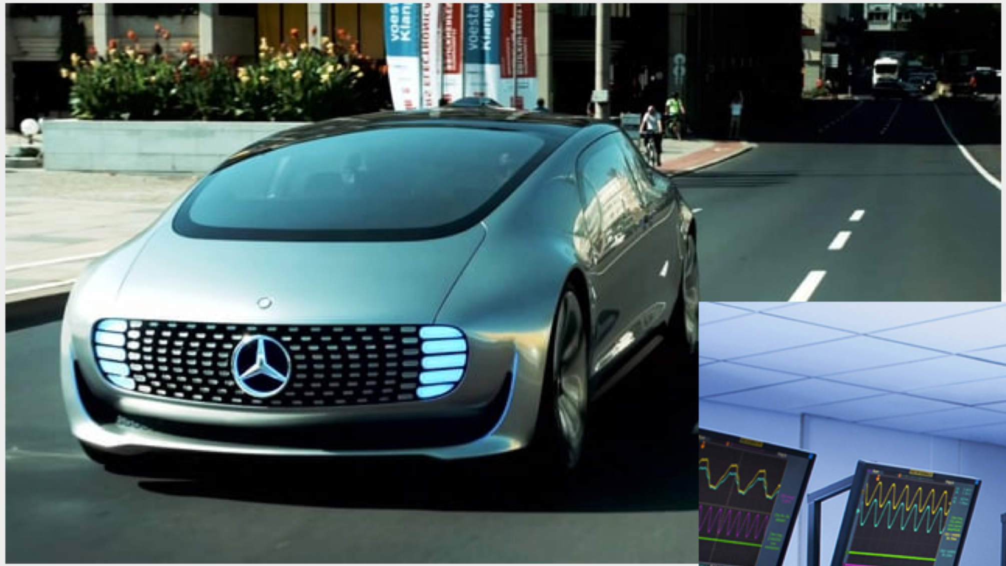
Connecting Autonomous Systems in the IIoT

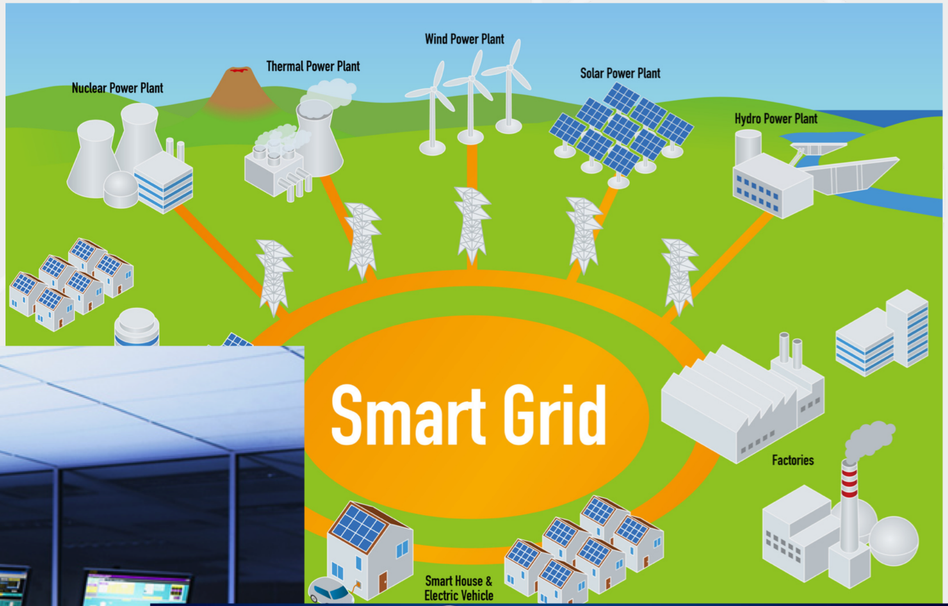
Gerardo Pardo-Castellote, Ph.D.

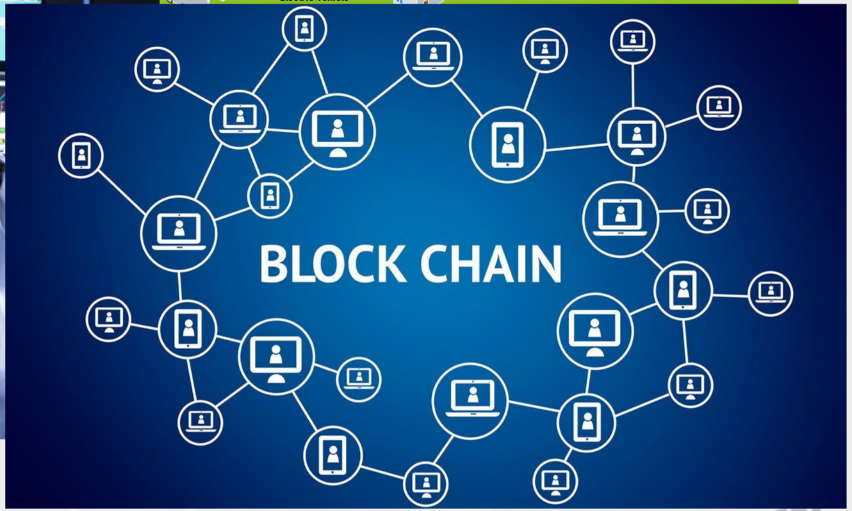
Chief Technology Officer, RTI

Munich Connext Conference
April 2018

What do these have in common?







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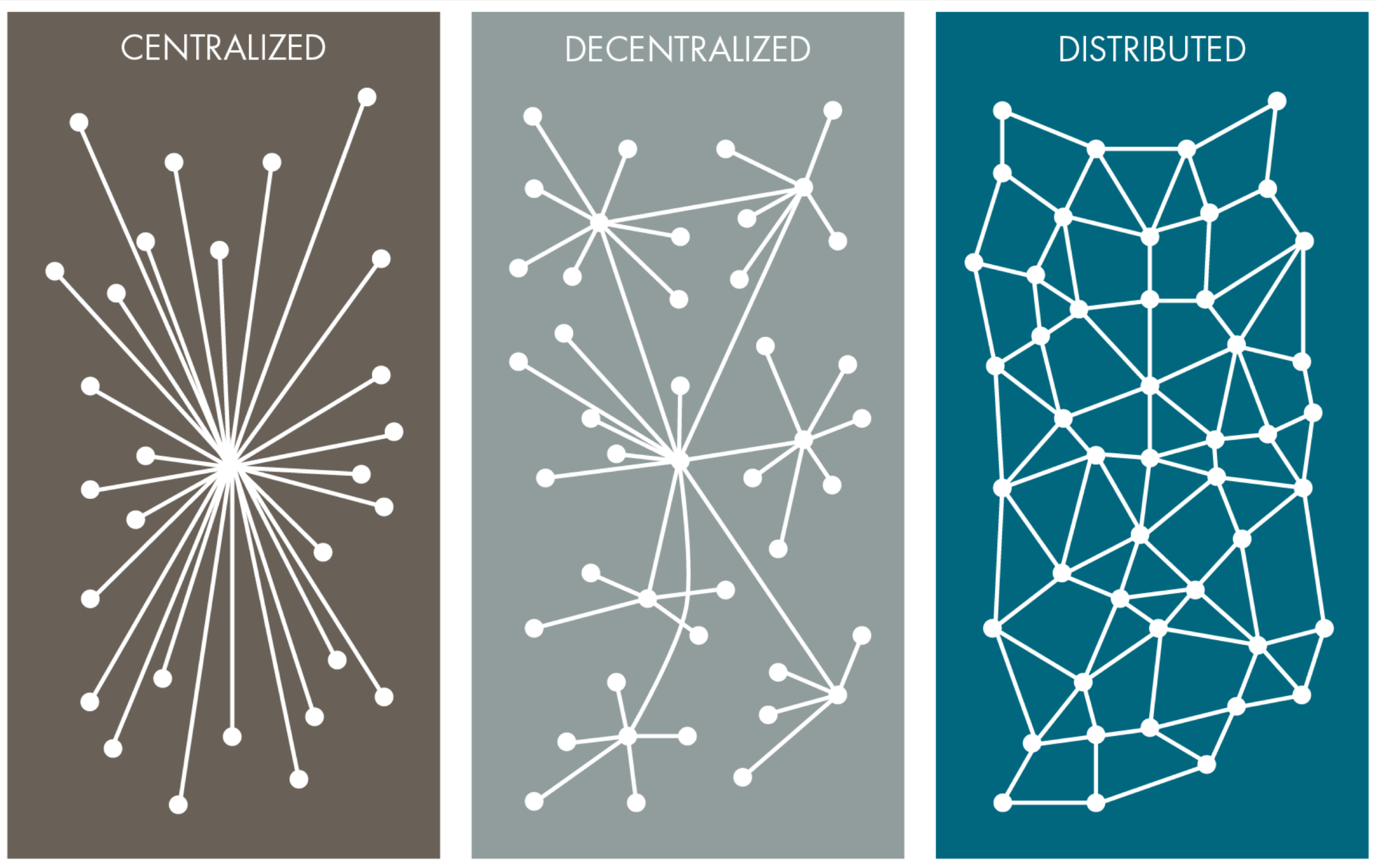
Decentralized Peer to Peer Systems



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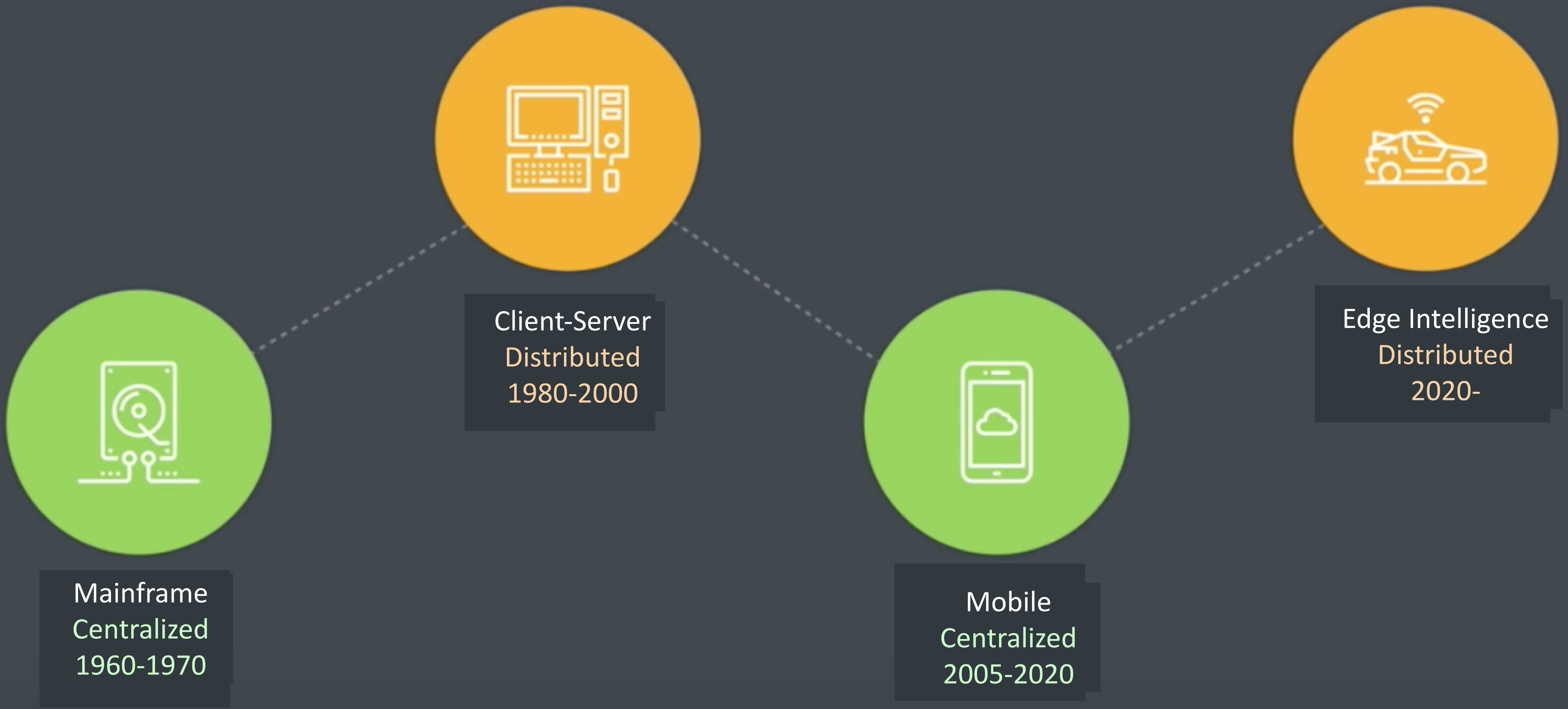
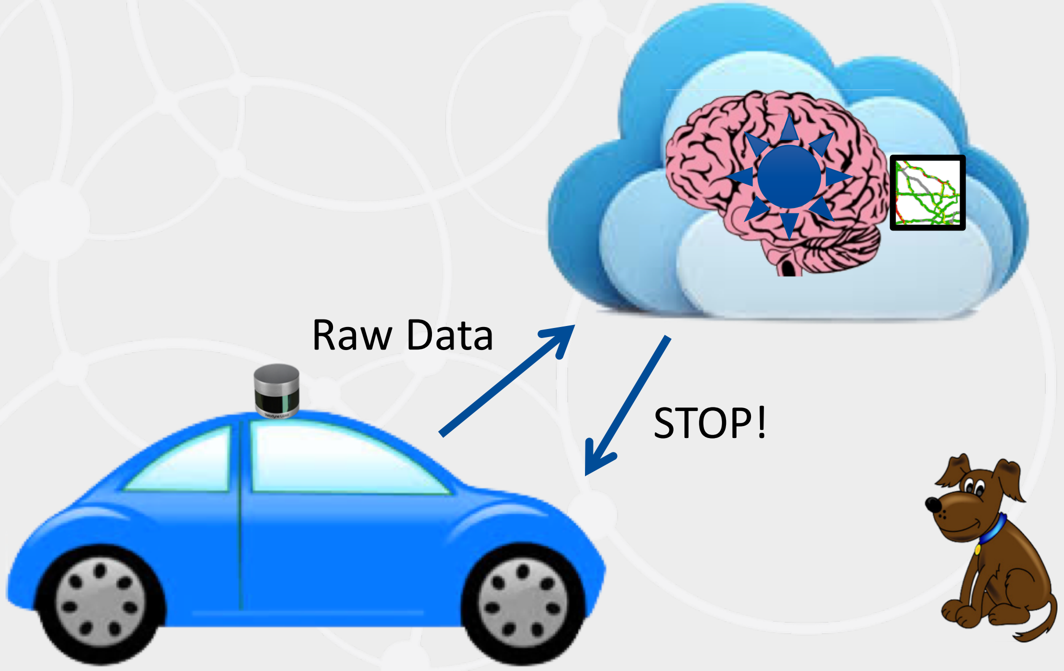
Edge Autonomy



An example

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



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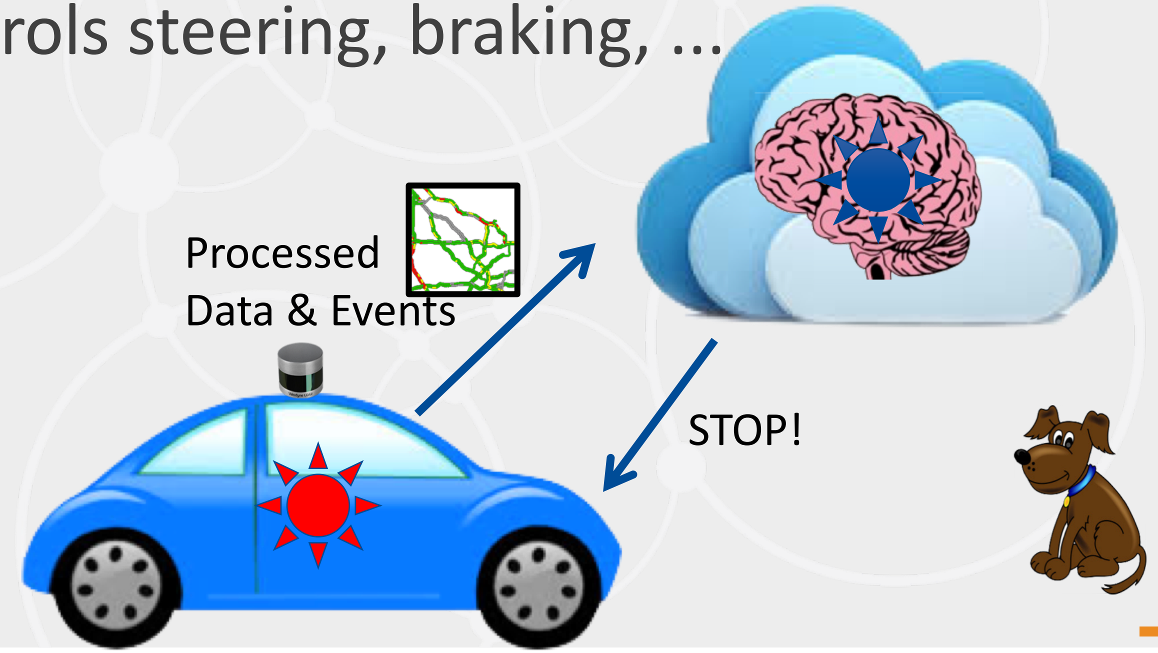
An example

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



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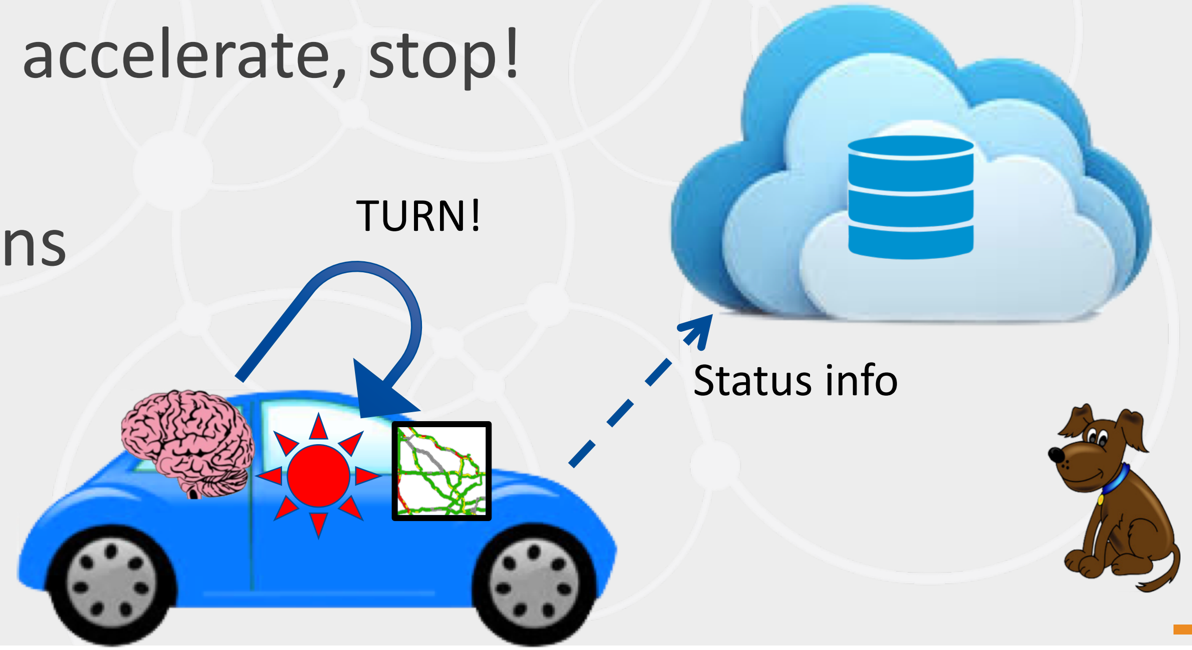
An example

- 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



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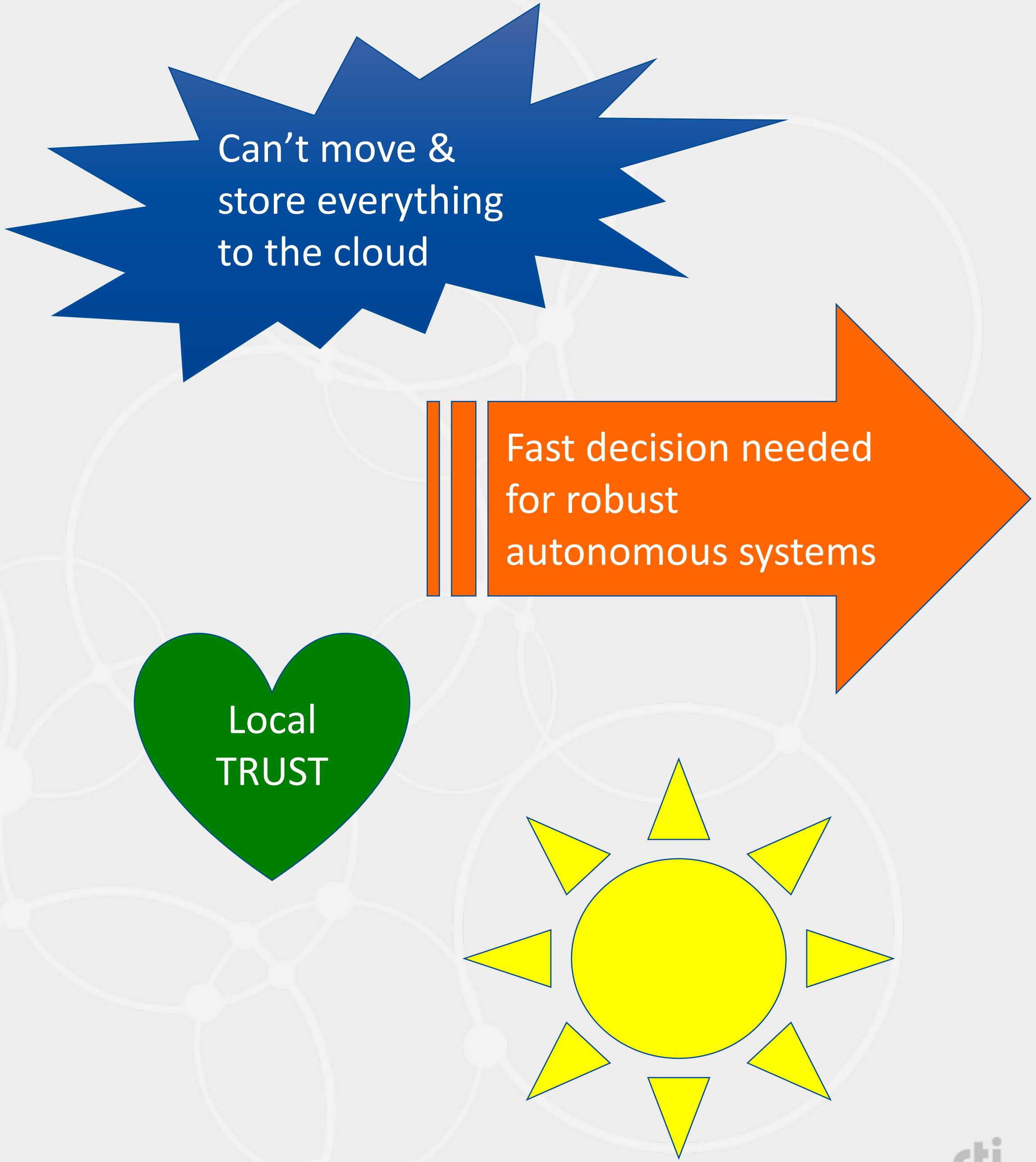
Why Edge Autonomy?

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



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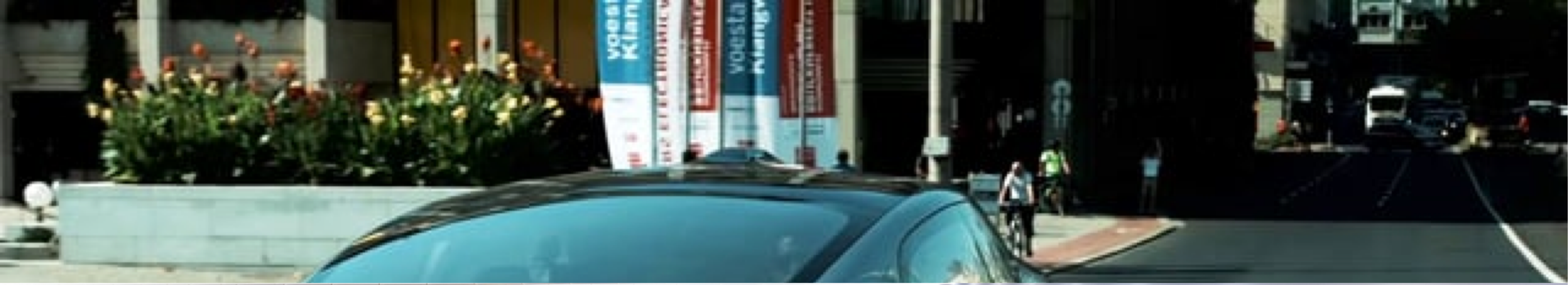
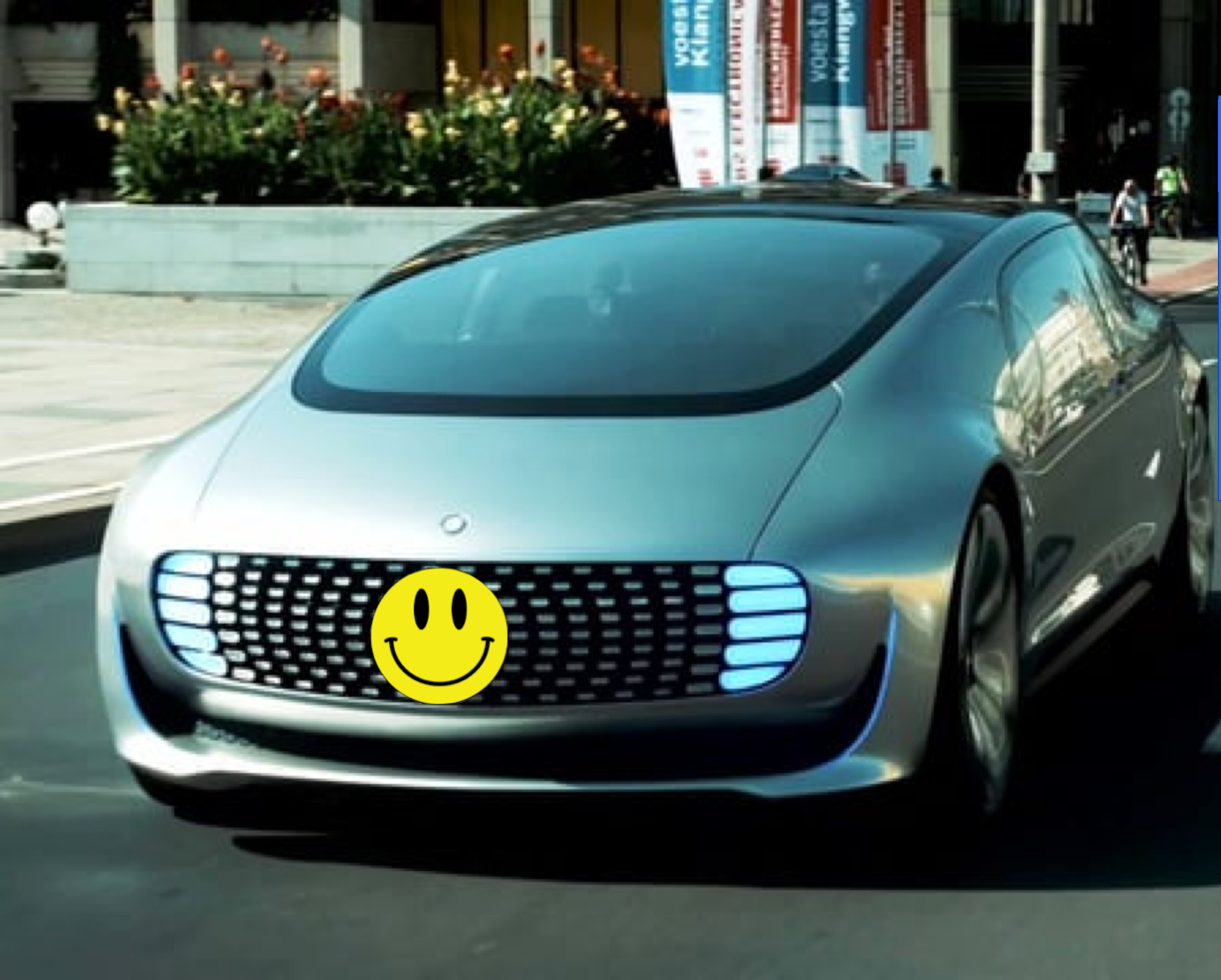
An autonomous car is a “data center” on wheels



NEC
SX-ACE


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

2007 IBM Blue Gene/L, 400 TFOPS



2017-18 Nvidia DGX Station,
480 TFLOPS

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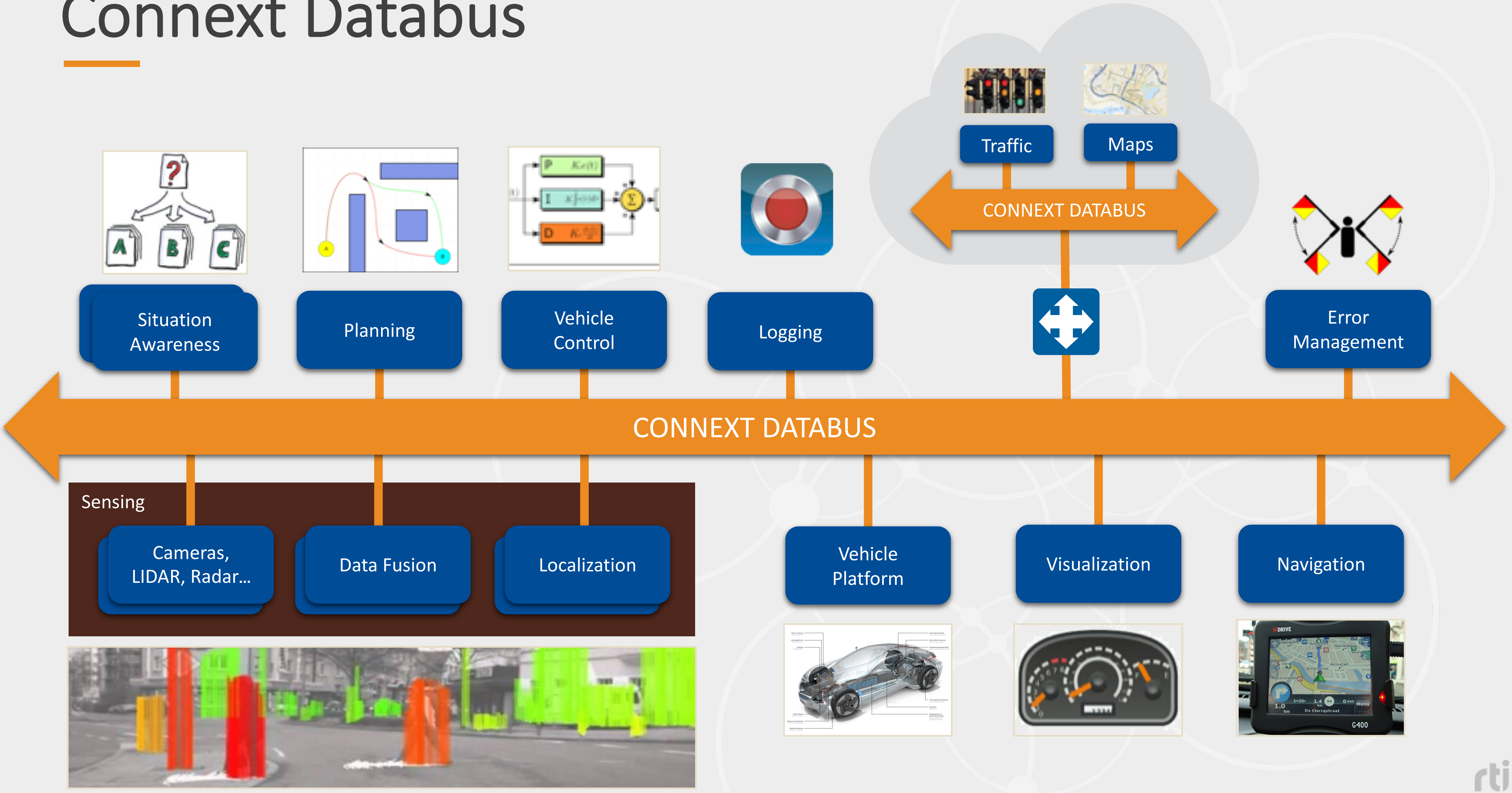
GE Healthcare
BLUE PROTECTOR
2005
2005

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

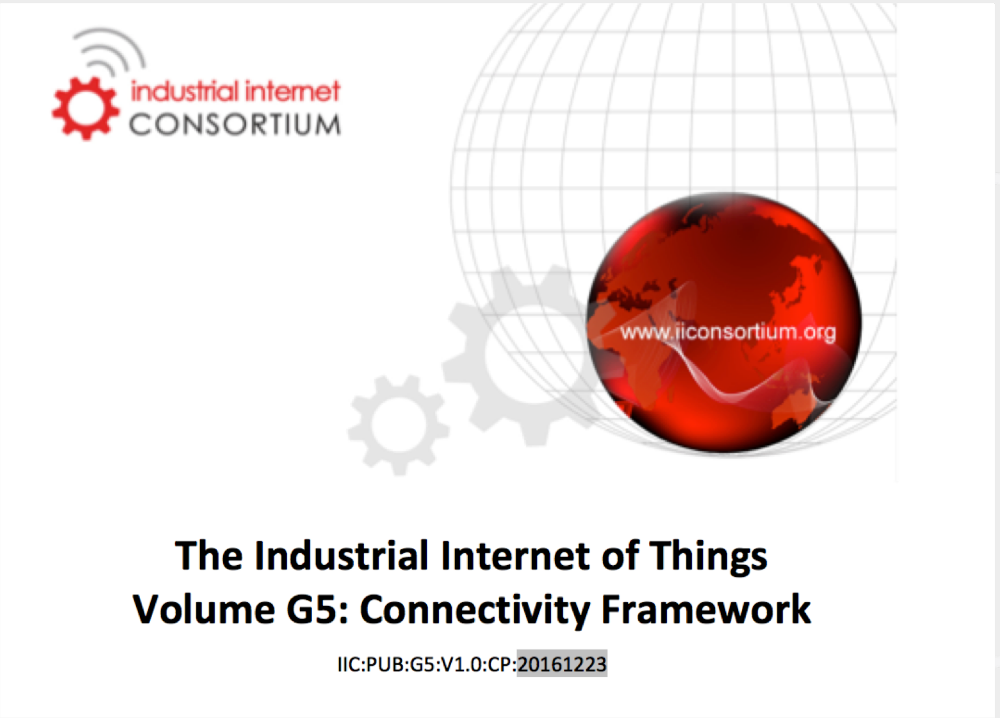
Persistence Service

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


industrial internet CONSORTIUM

www.iiconsortium.org

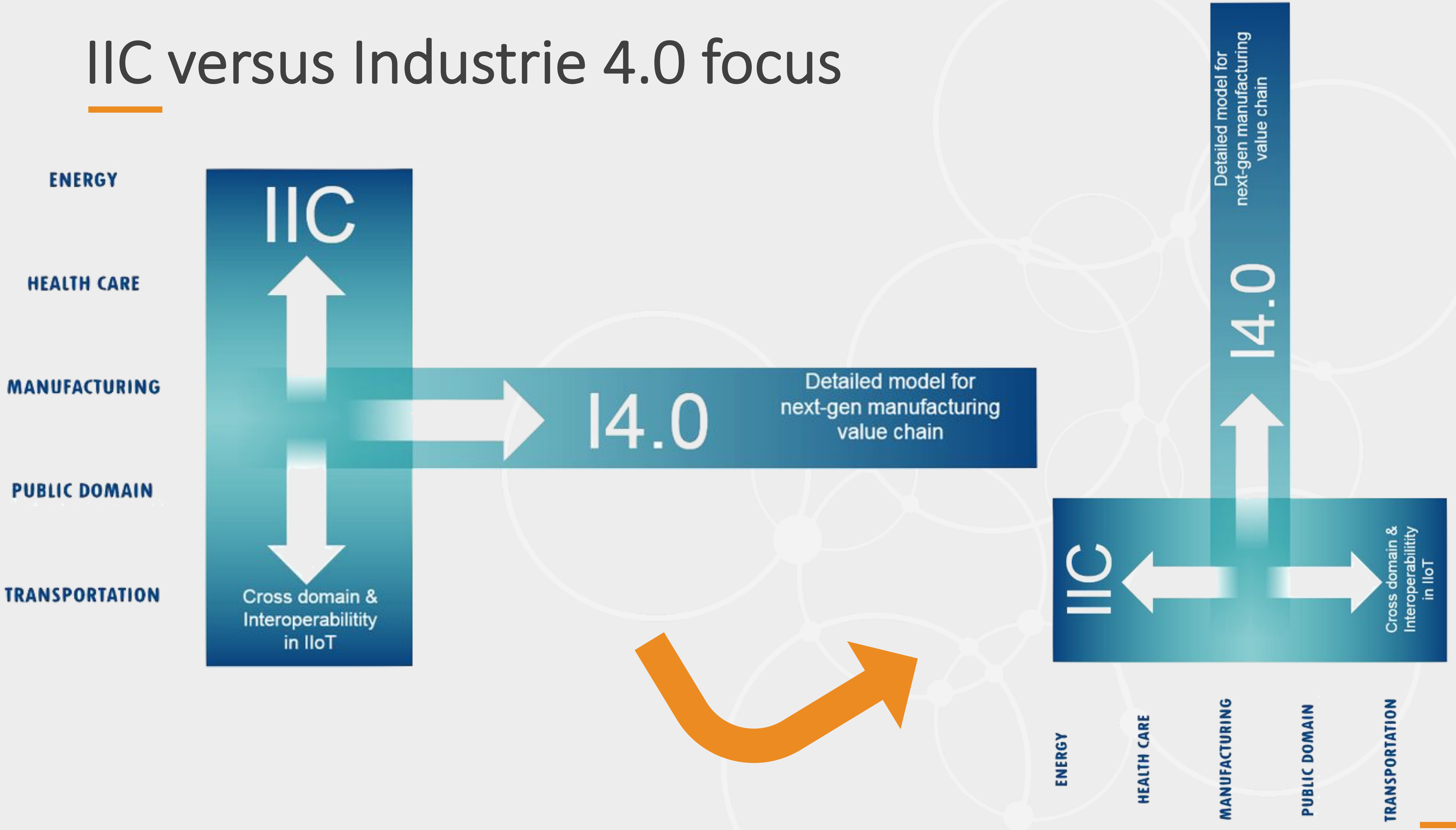
The Industrial Internet of Things
Volume G5: Connectivity Framework

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

DDS anointed the **Core connectivity Databus**

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

IIC versus Industrie 4.0 focus



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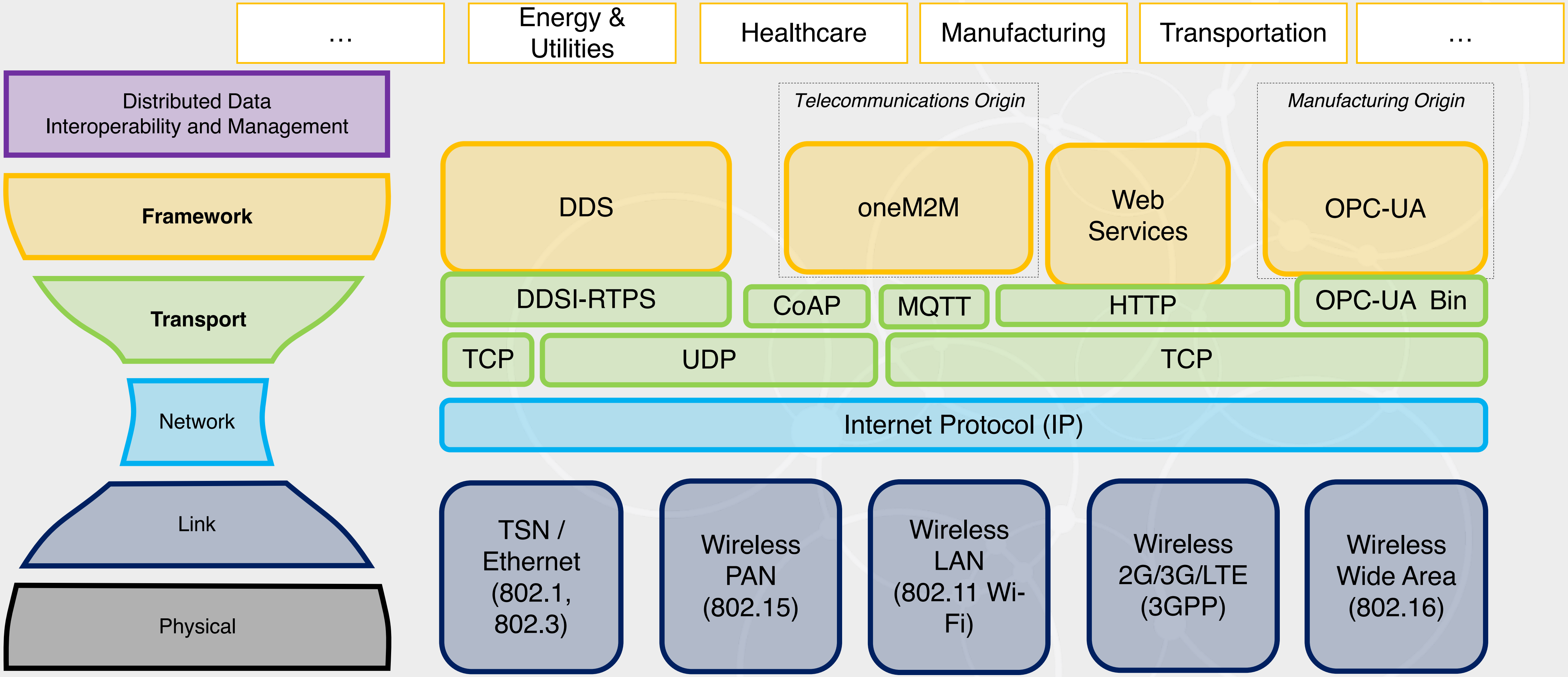
IIoT Connectivity Standards



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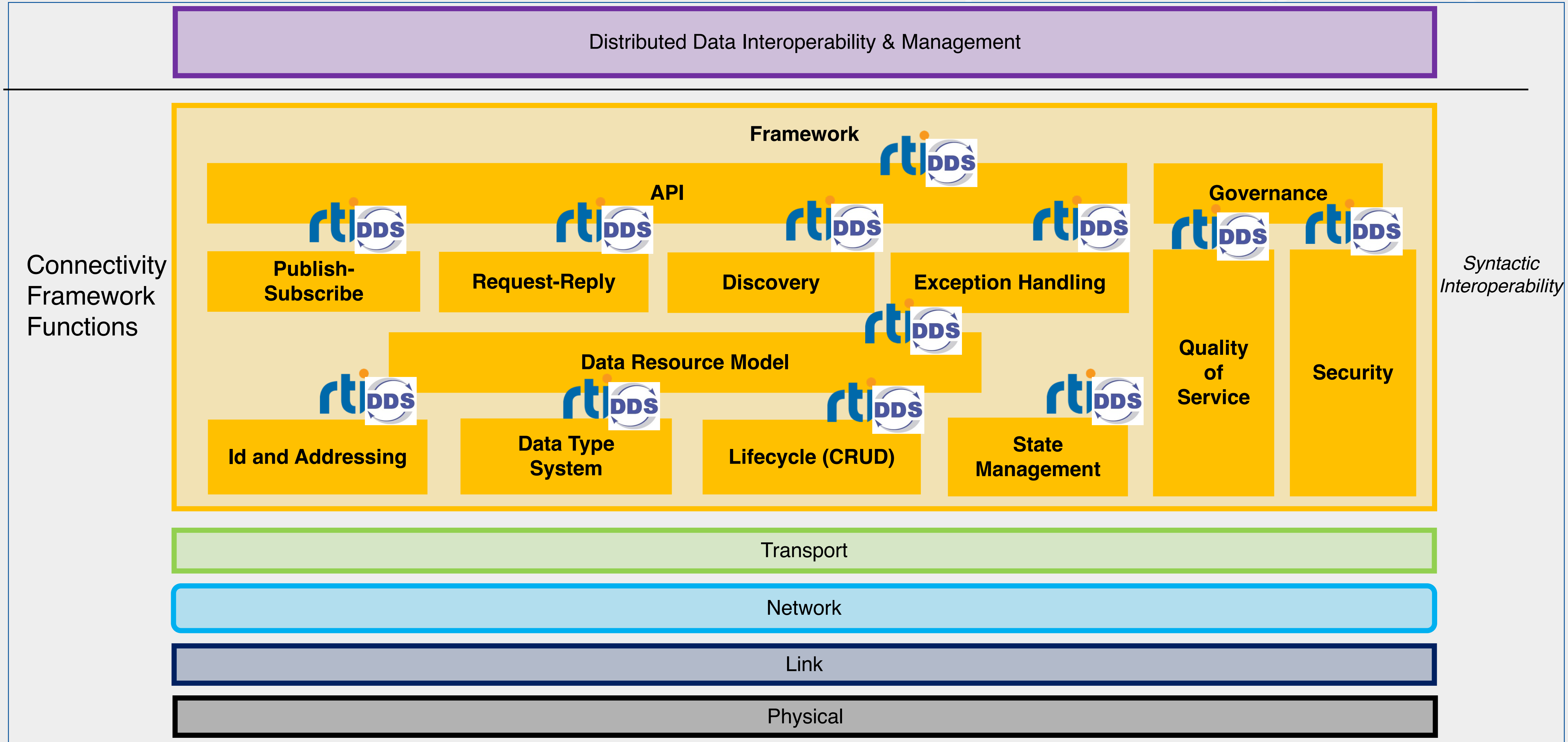
Connectivity Framework: Core Functions



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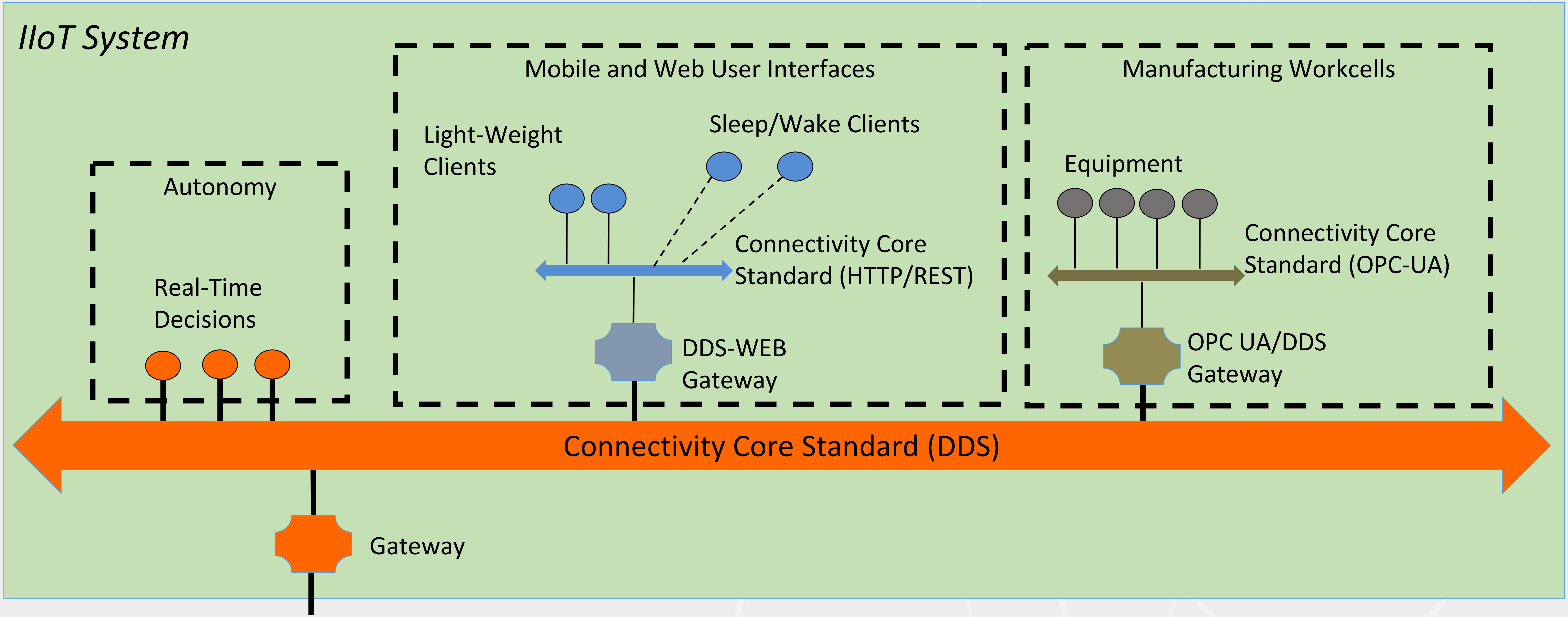
DDS–Based Integration



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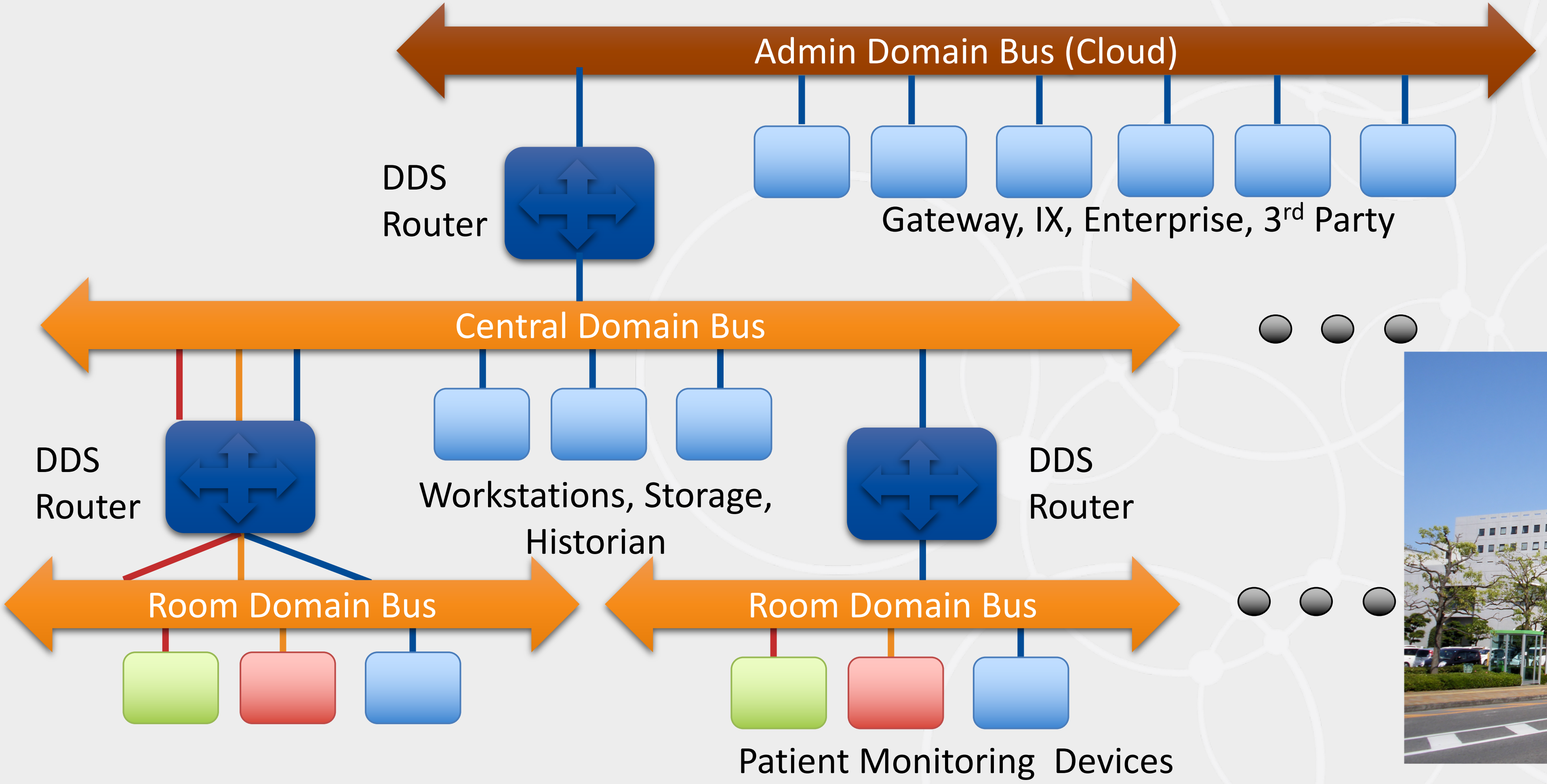
Example: Clinical Decision System Architecture



Standards Update

Key standards we are focusing on

High Priority:

NEW	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

rti

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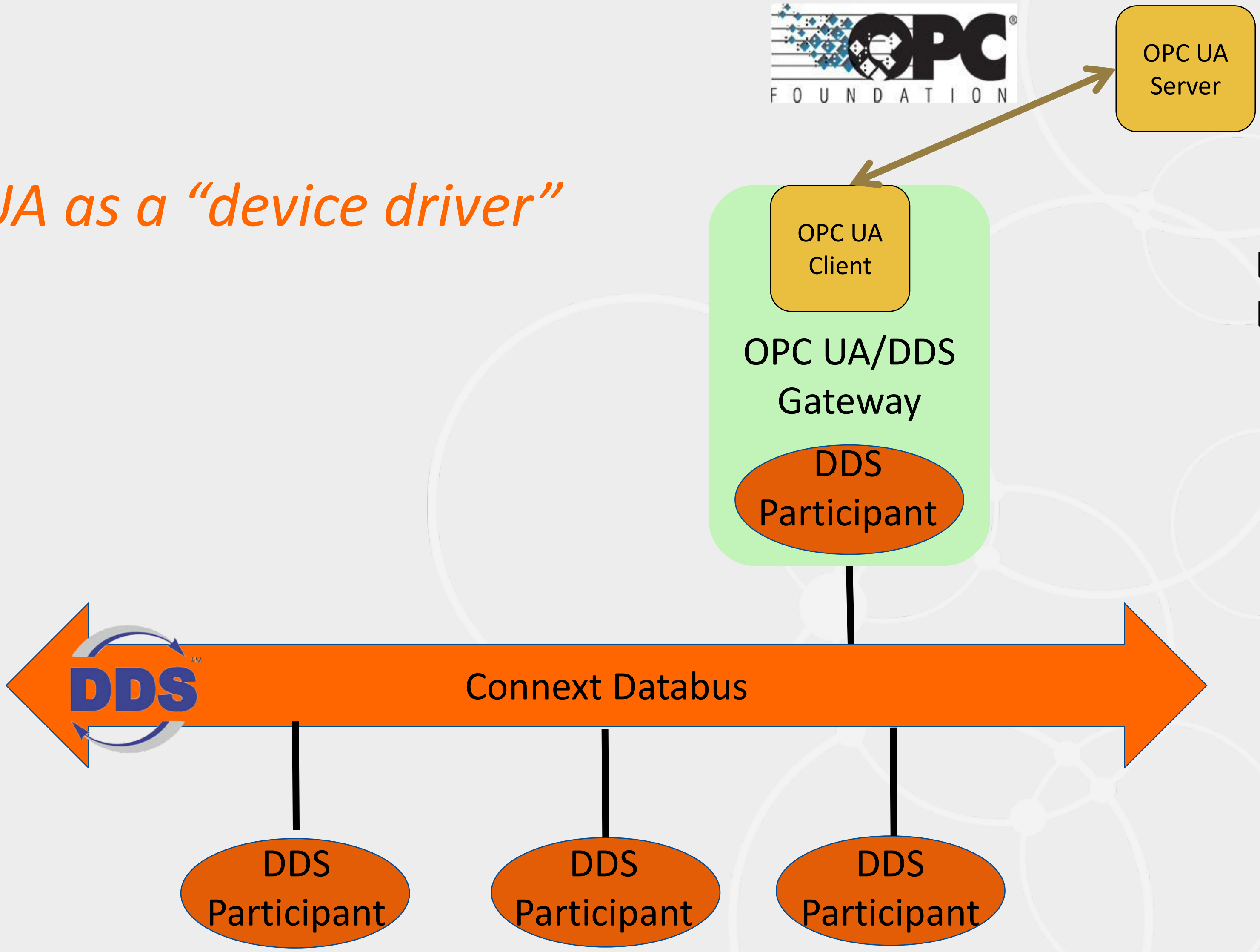
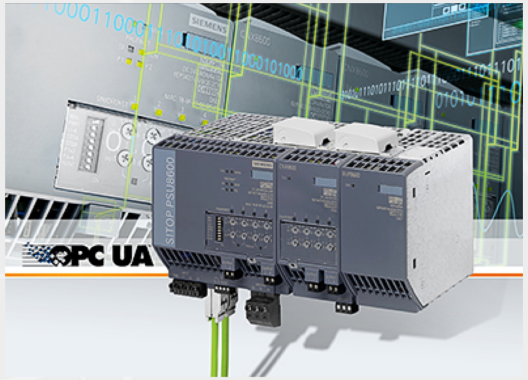
DDS-OPC UA

Example Use-Case

OPC UA as a “device driver”





Device Supporting OPC UA
E.g. Siemens Power Supply

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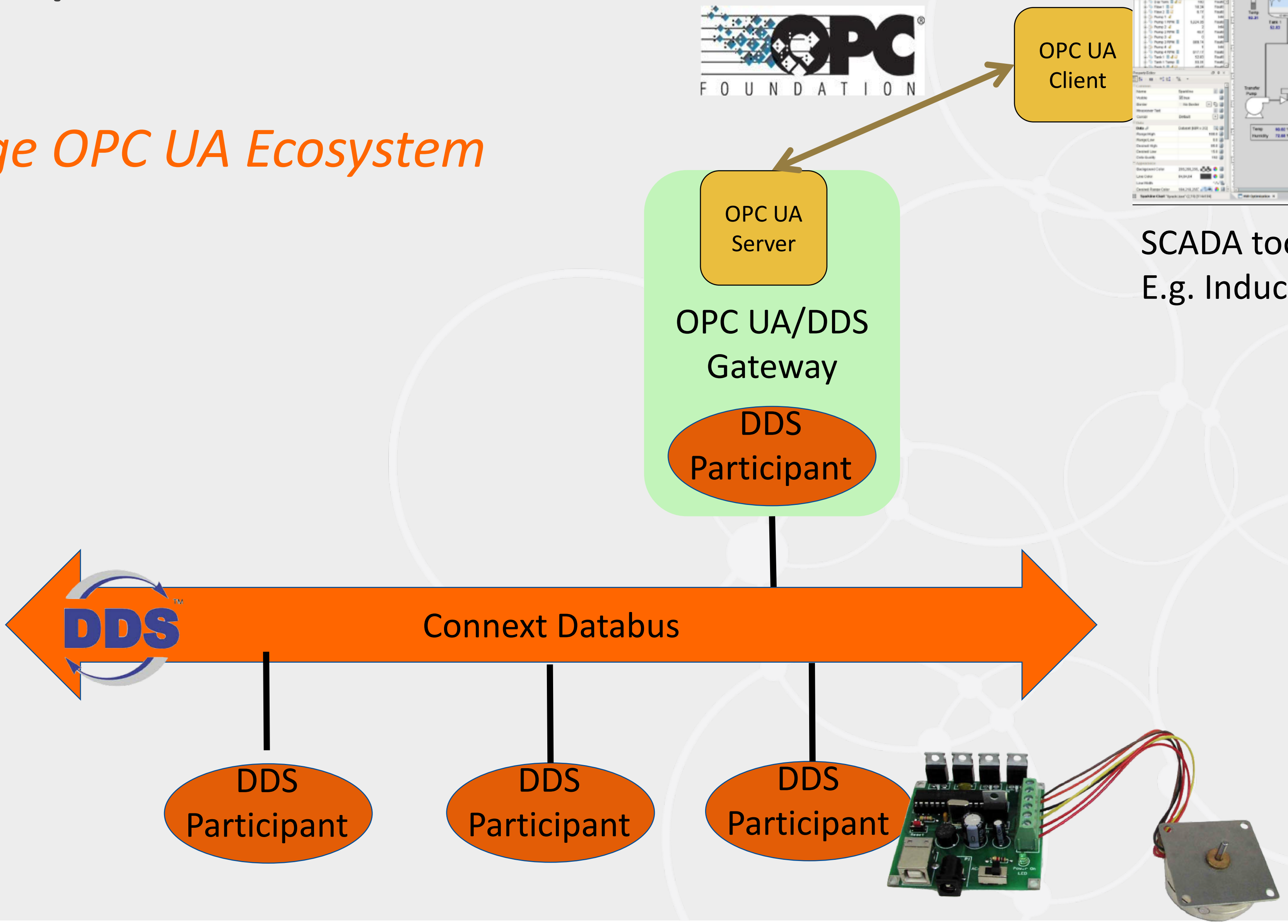
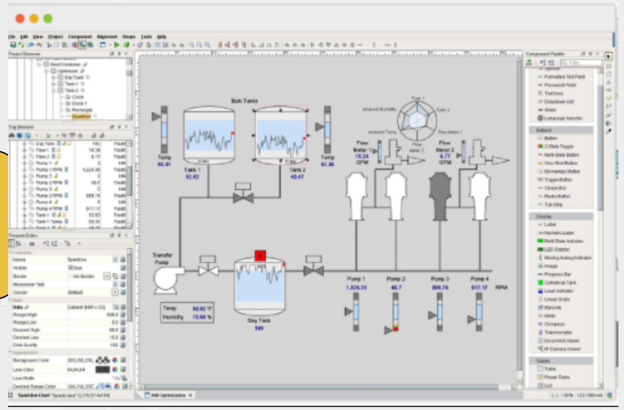
Example Use-Case

Leverage OPC UA Ecosystem Tools





SCADA tools support OPC UA
E.g. Inductive Automation

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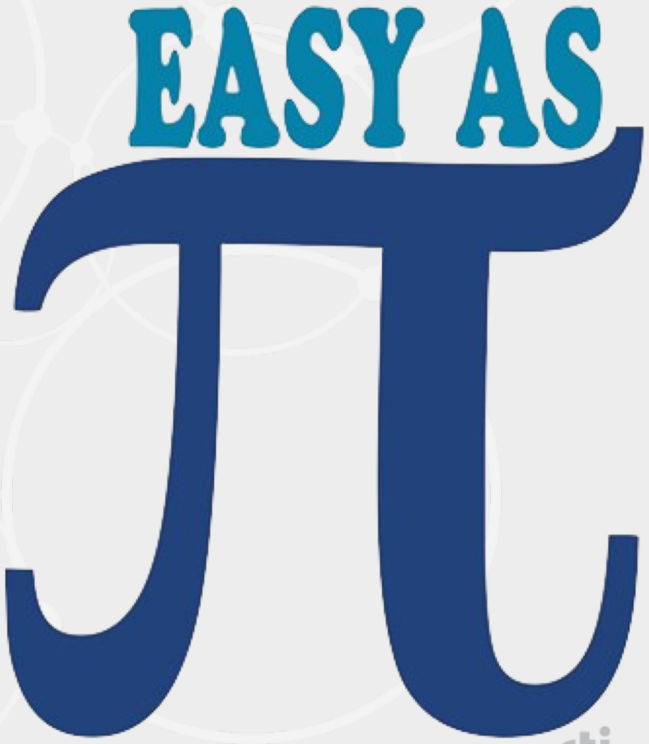
Simple OPC UA Subscription Mapping

- 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!



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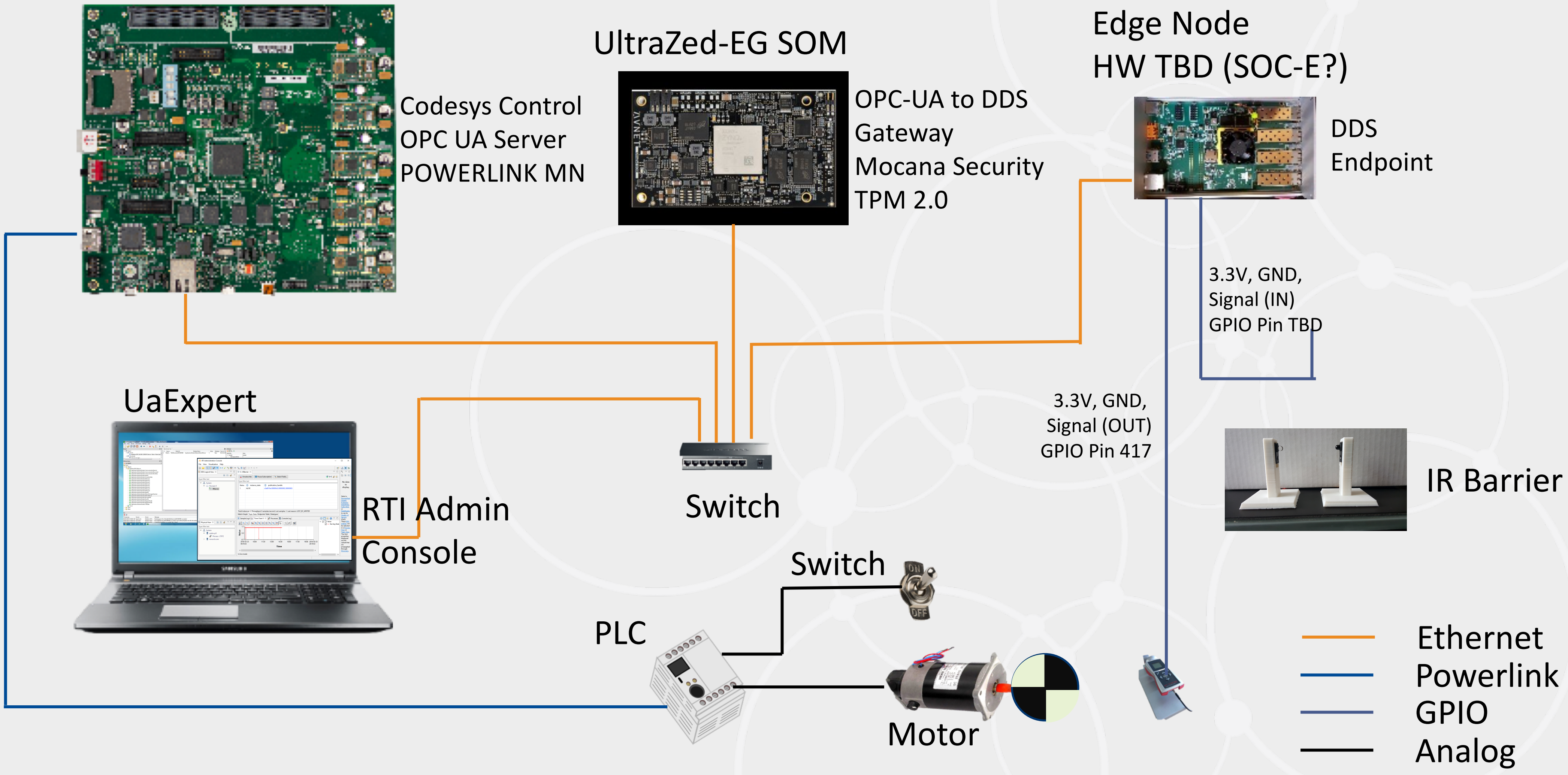
DDS/OPC-UA Prototype and Demo



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

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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"

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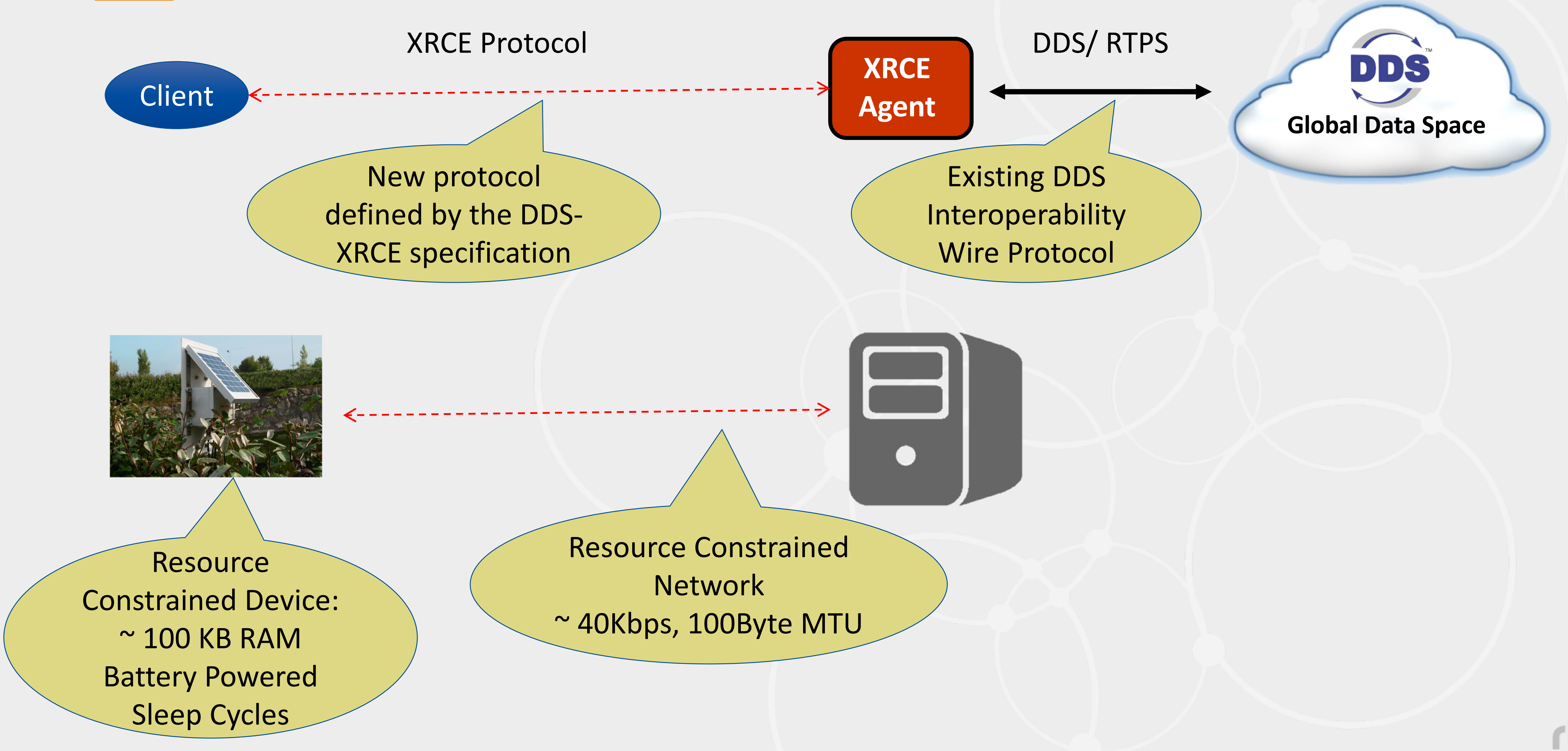
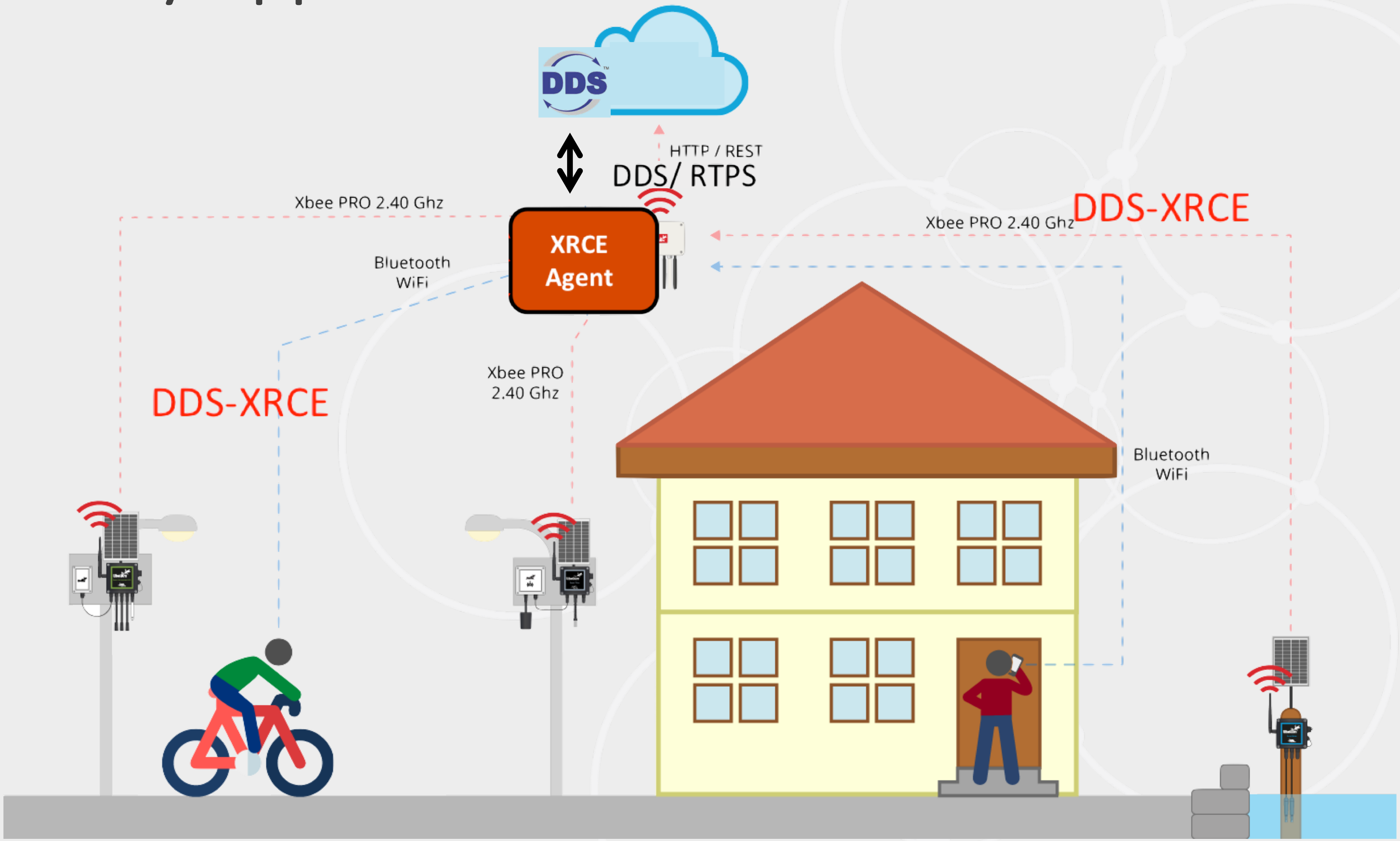
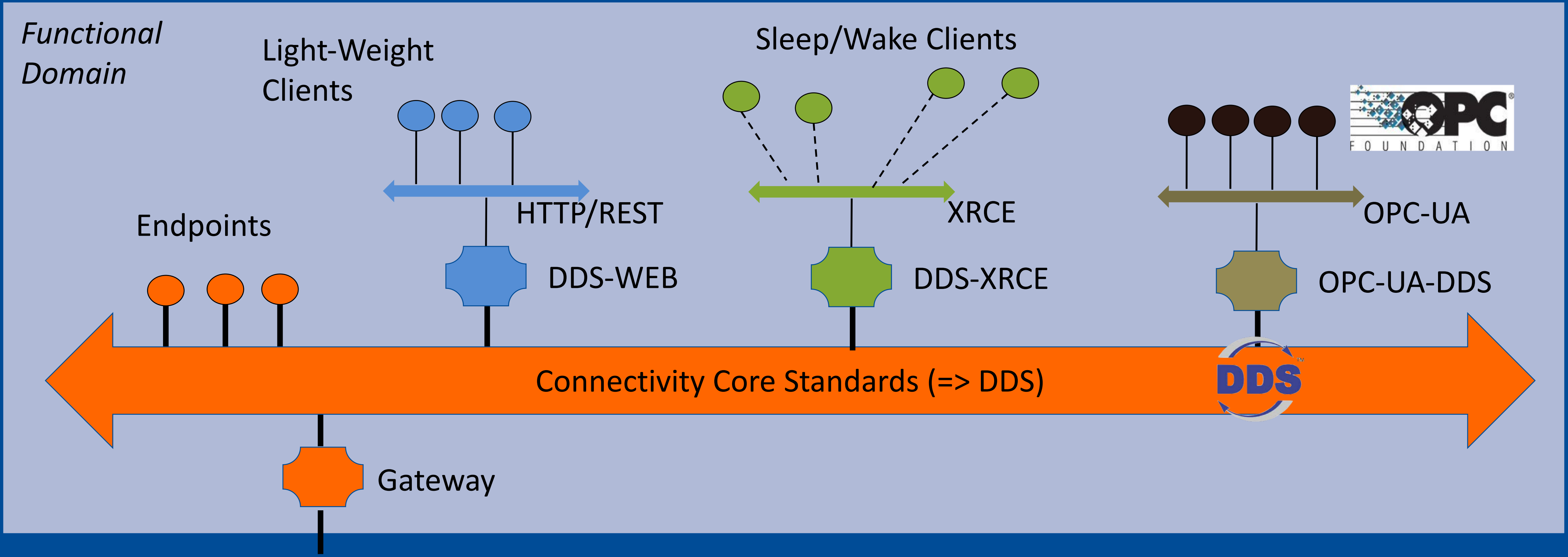
Agent-Based deployment model



Smart City Application



Goal: Make DDS the Core Databus



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Product Update

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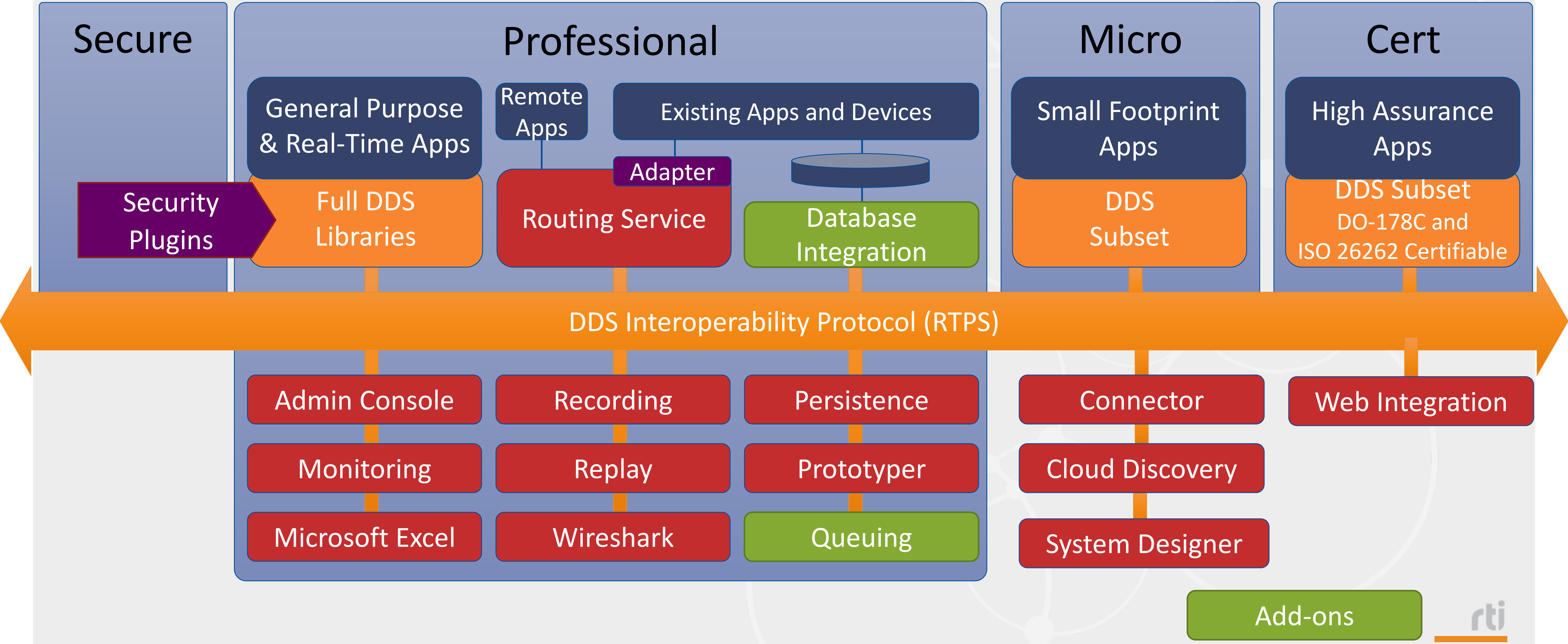
RTI Connext DDS Product Suite



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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

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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

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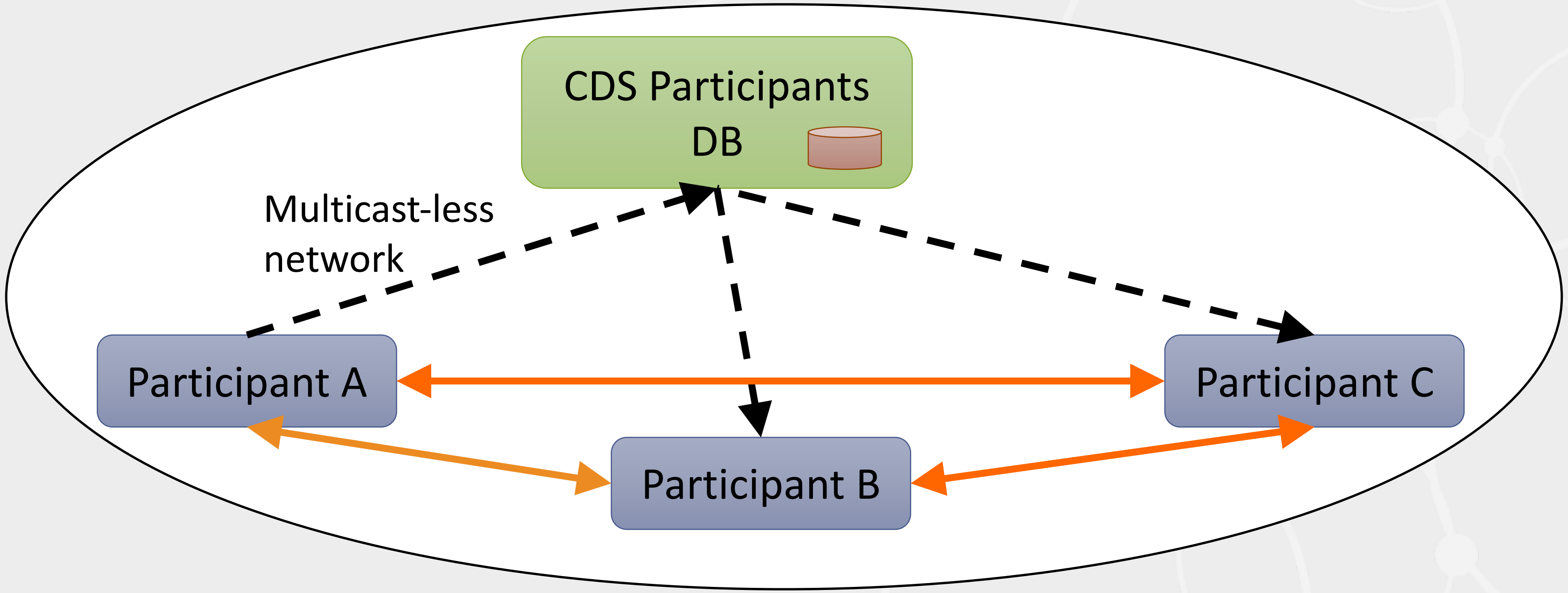
Cloud Discovery Service

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

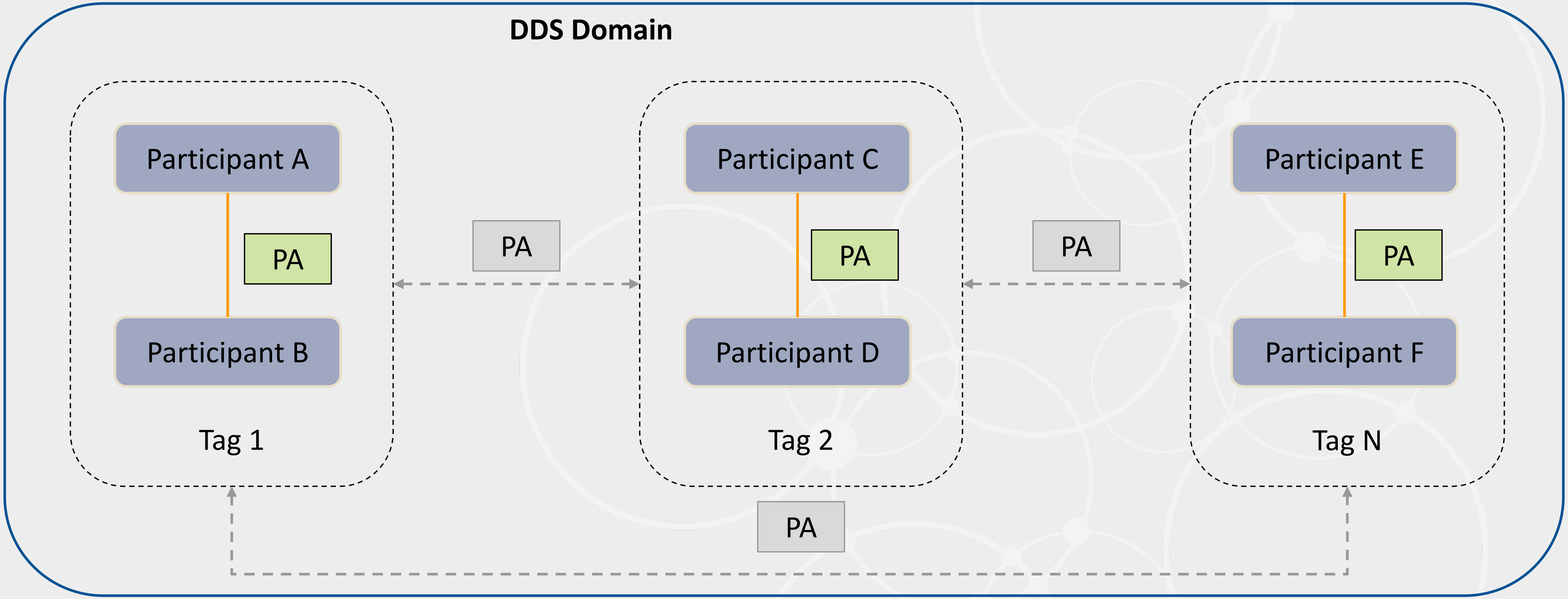
Interoperates with Standard DDS Discovery



Cloud discovery of Participants

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

Domain Tags : Participant Isolation within a Domain



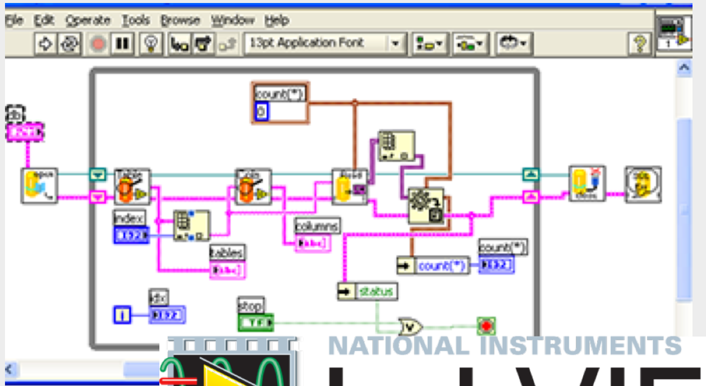
PA Participant announcement

PA Participant announcement (ignored)

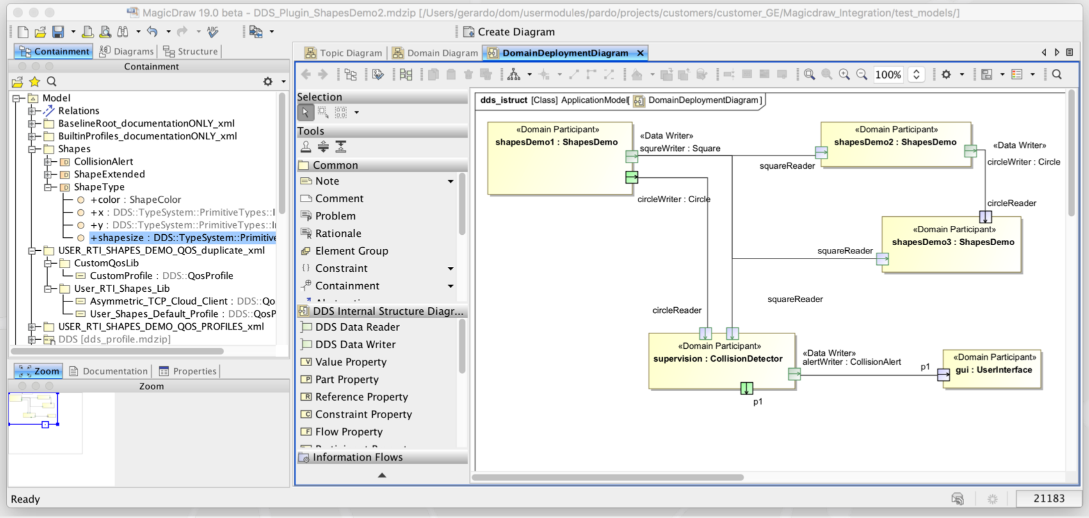
Ignored path

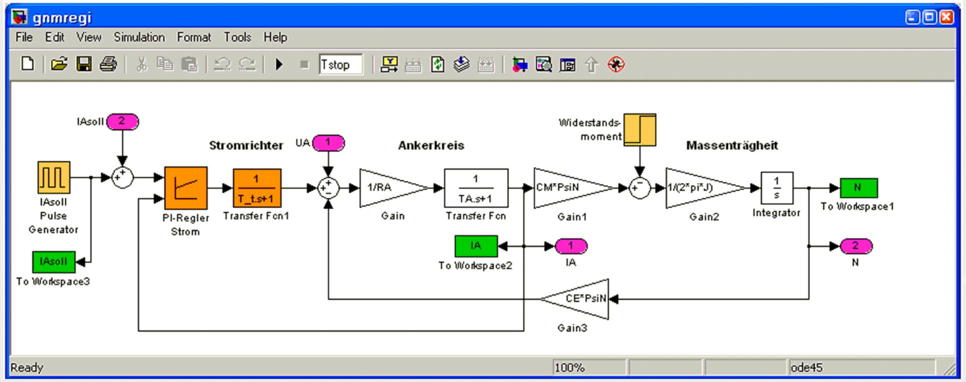
discovery path

Integrating 3rd party tooling



NATIONAL INSTRUMENTS
LabVIEW™

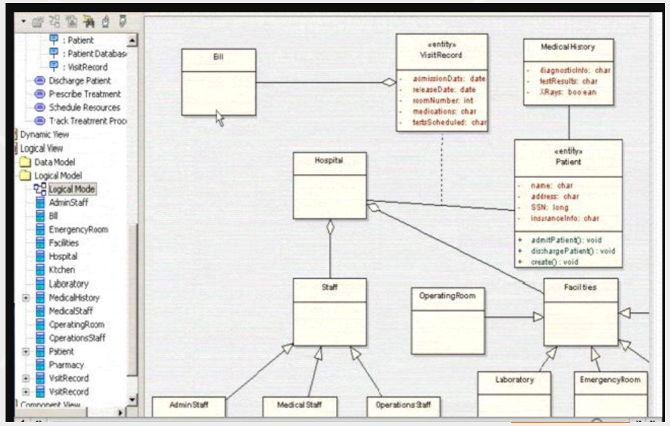




magicdraw

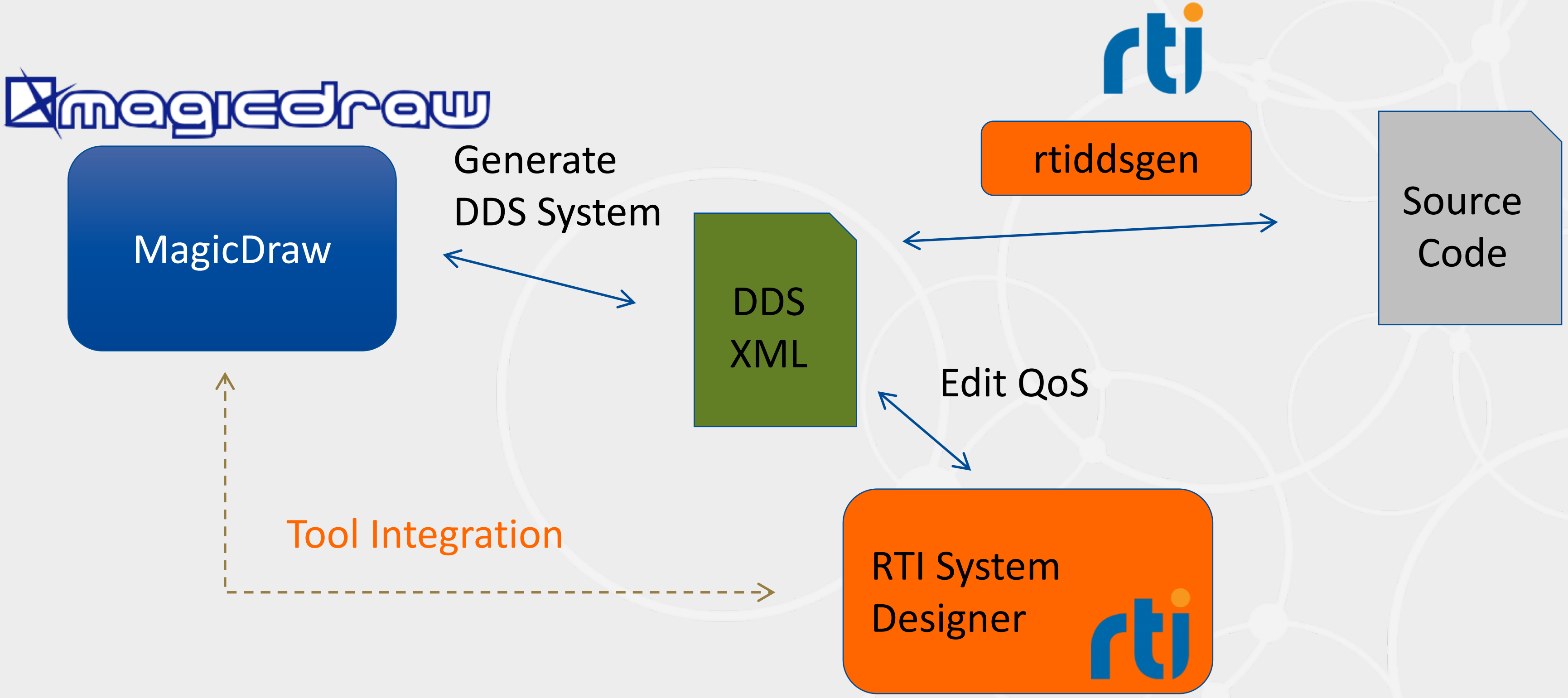
ENTERPRISE ARCHITECT

SysML



MATLAB
SIMULINK

DDS Development with SysML and MagicDraw



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Connext DDS Micro: Many new features

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

IS NEVER ENOUGH

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Robustness

The kind of robustness our users need

me Innovations, Inc.

Research

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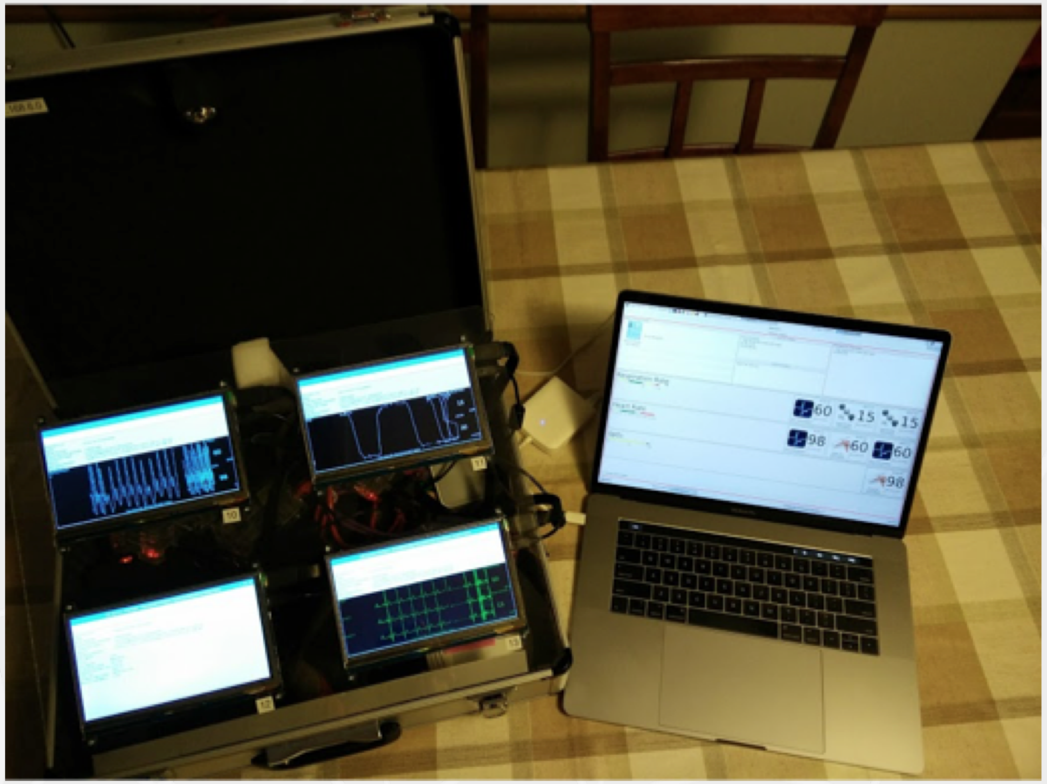
Securing Medical Device Systems



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

ObjectSecurity Secure technology

DOCBOX

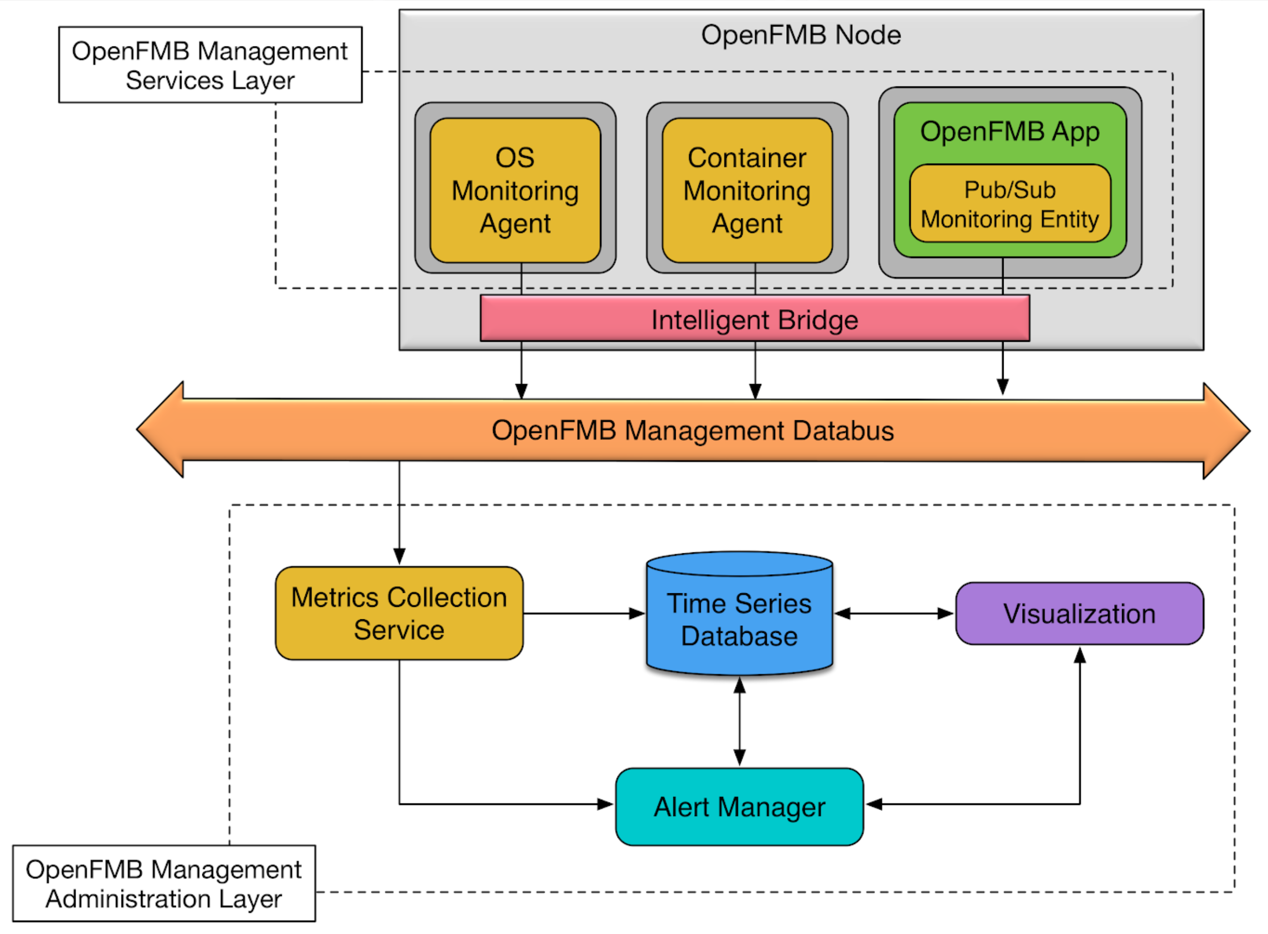
MD PnP™ Getting Connected for Patient Safety™

rti

Energy SmartGrid

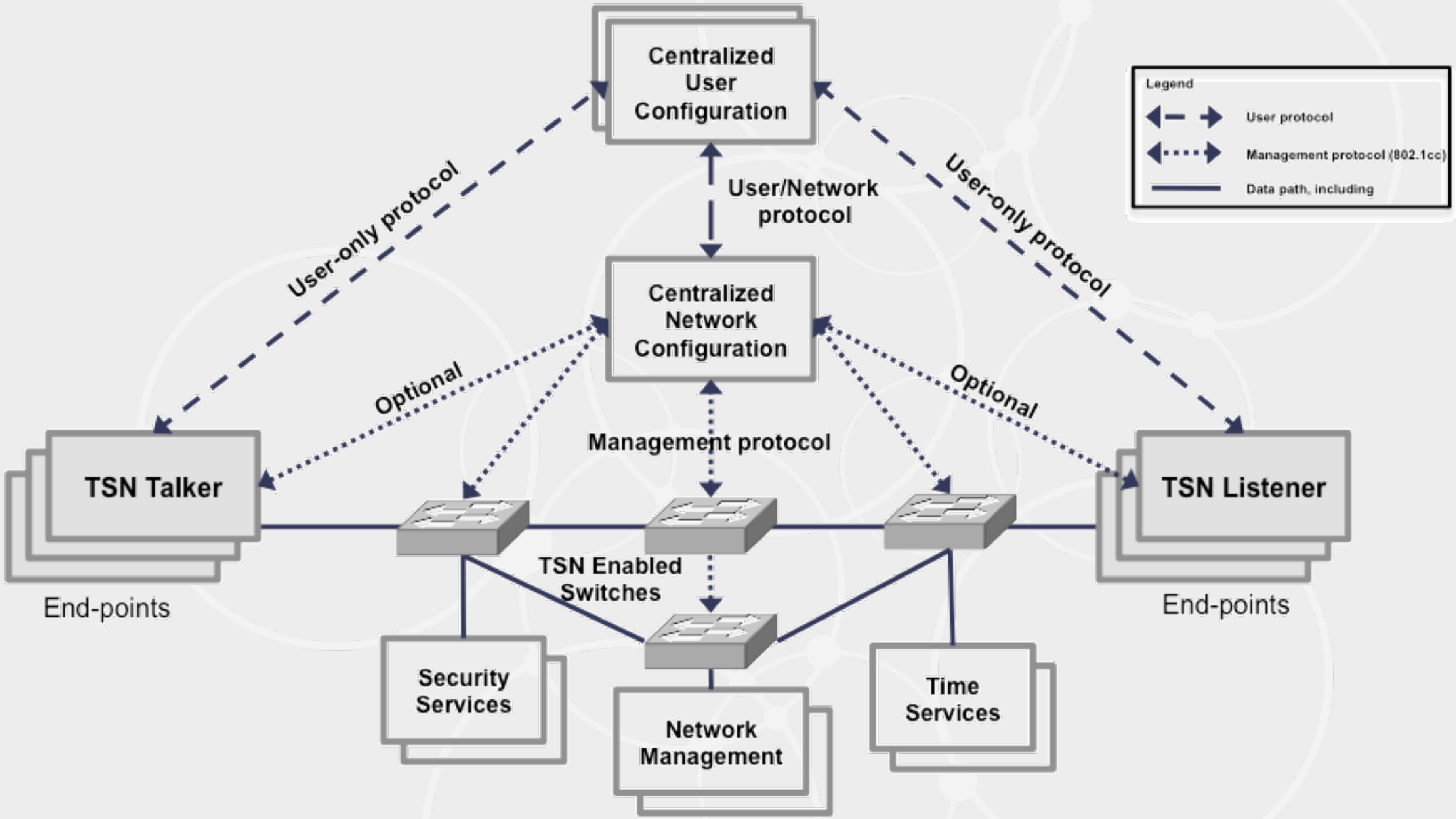
Remote Node Management
for DDS Systems

- **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



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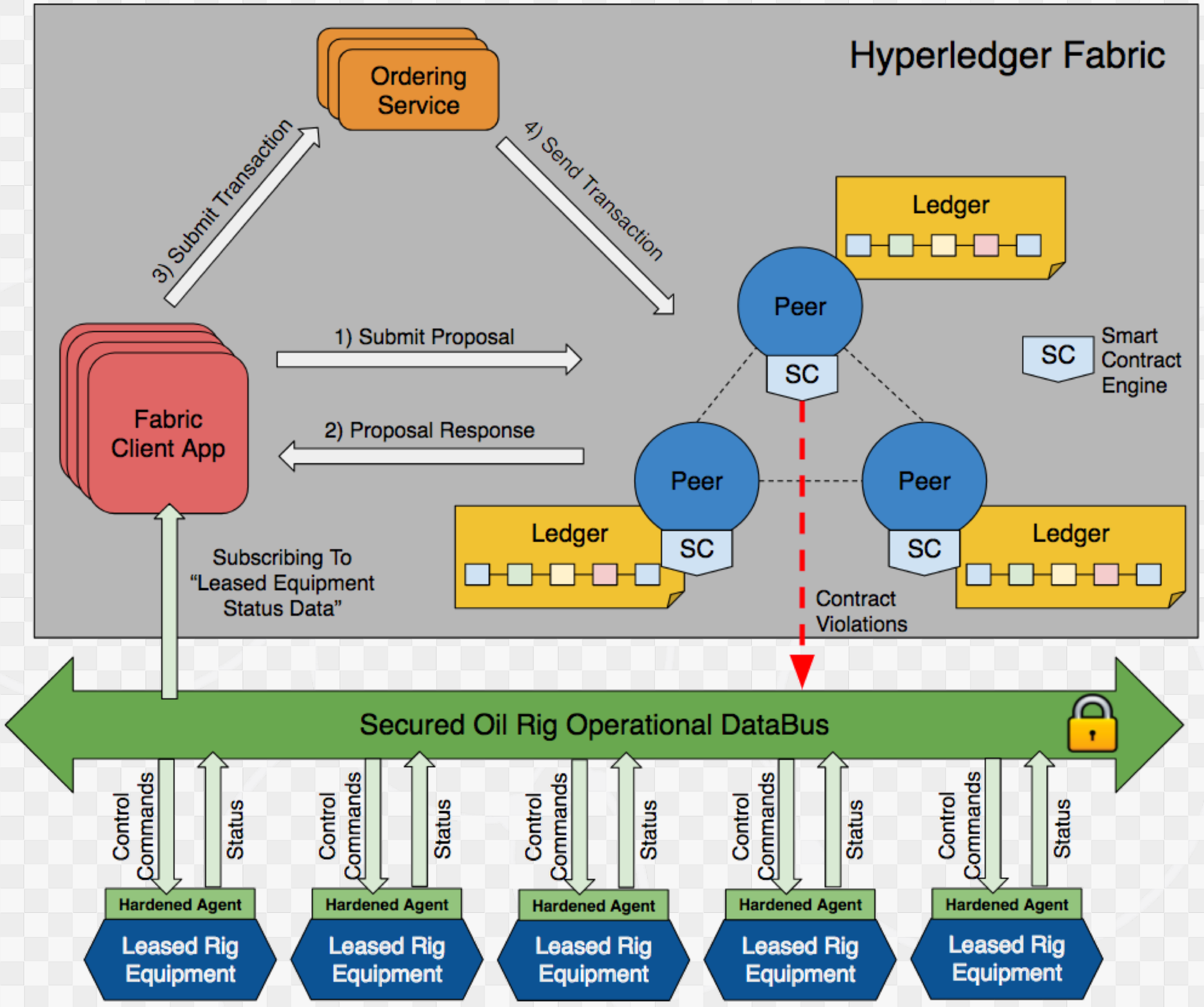
Enabling End-to-End Trustworthiness using Blockchain

- 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)



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RTI Labs

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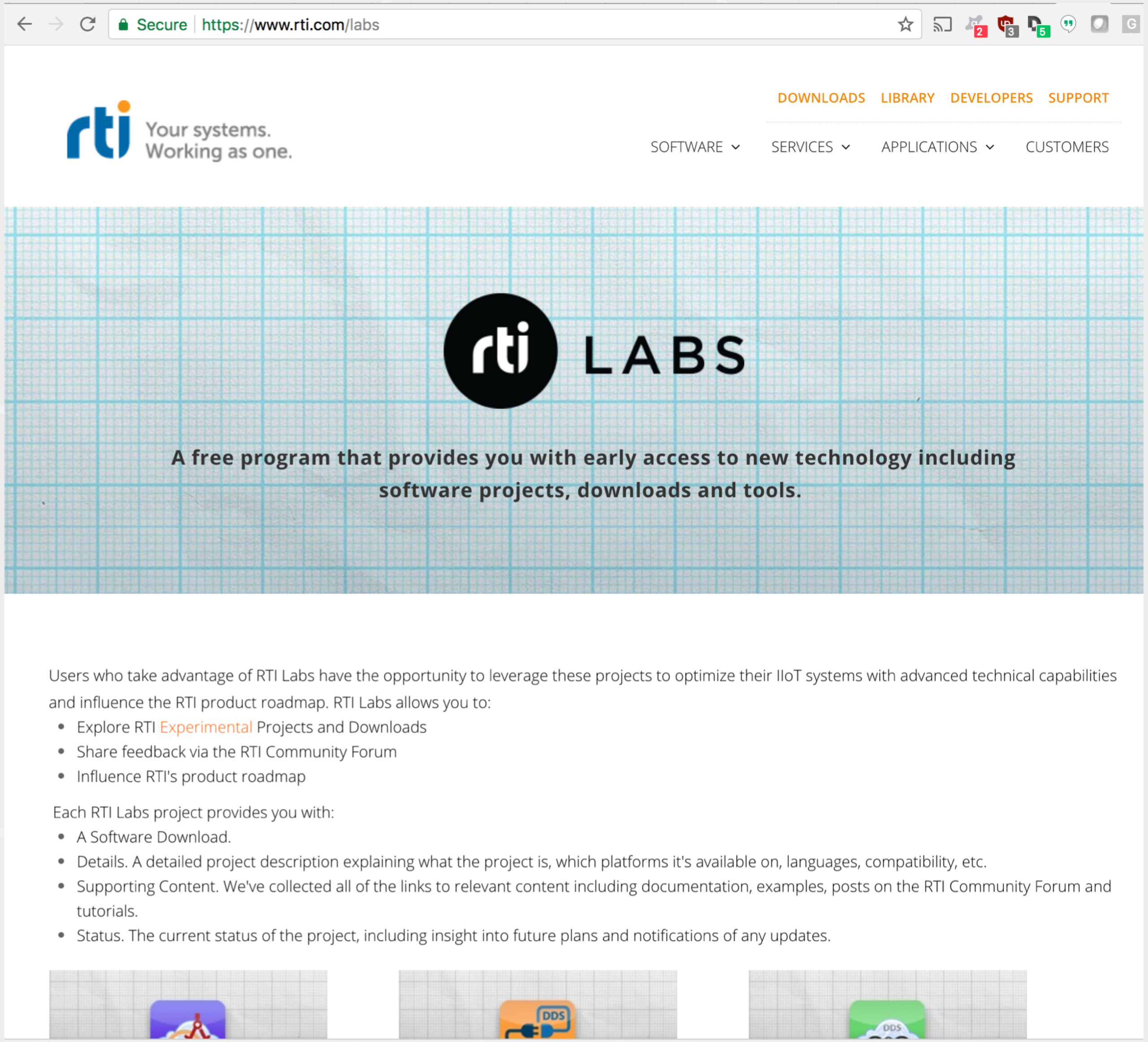
RTI Labs

- 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

XML DDS
Application
Description

Configure

Connect()

Join DDS
Create all Entities

Input1
Input2
Output1
Output2

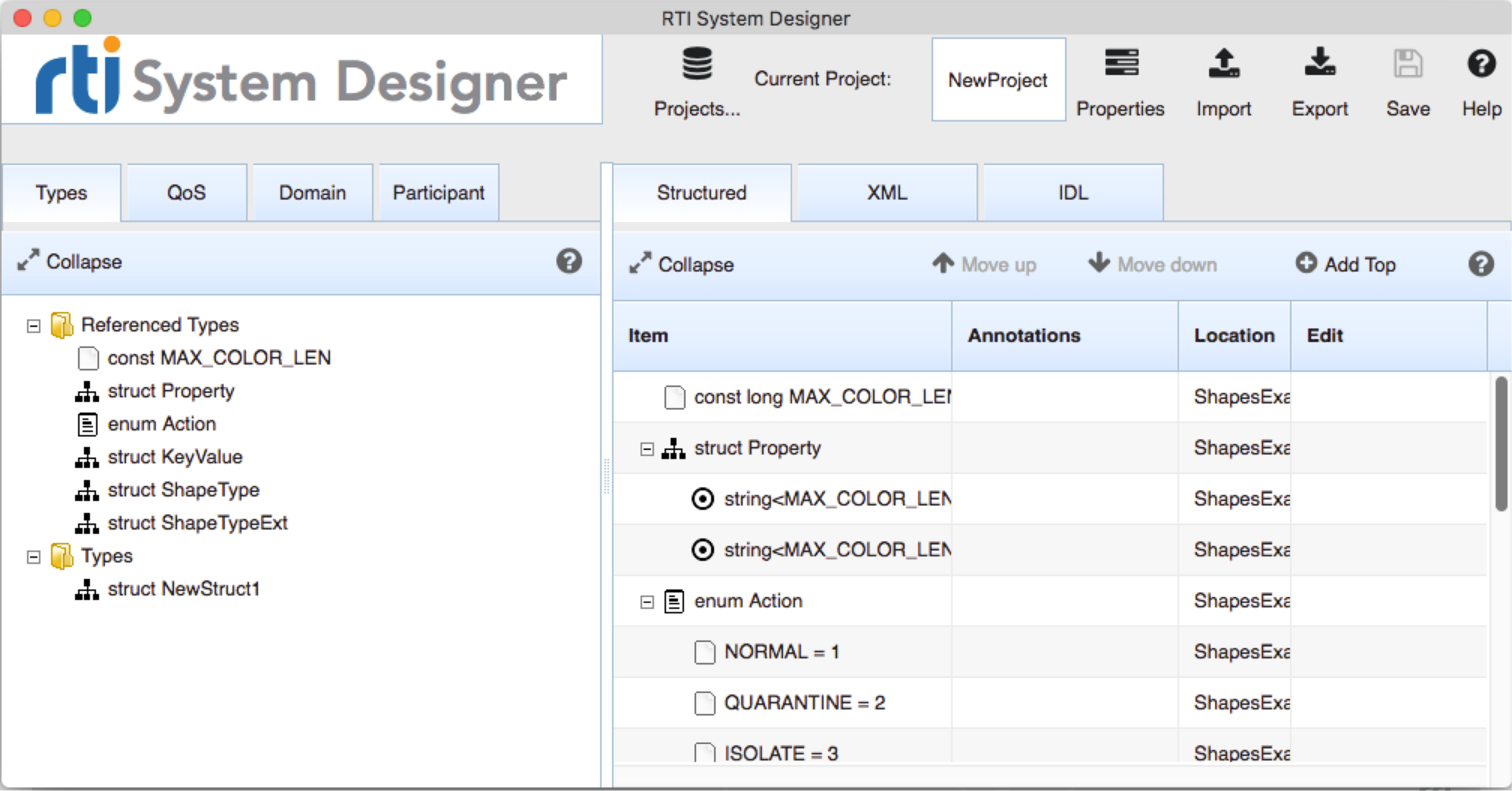
DDS

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



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

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Conclusion

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We are helping you meet the most critical application challenges

Thank You!