The Rise of the Robot Overlords: Clarifying the Industrial IoT Part 2: How to Choose the Right Connectivity Technology

Speaker:

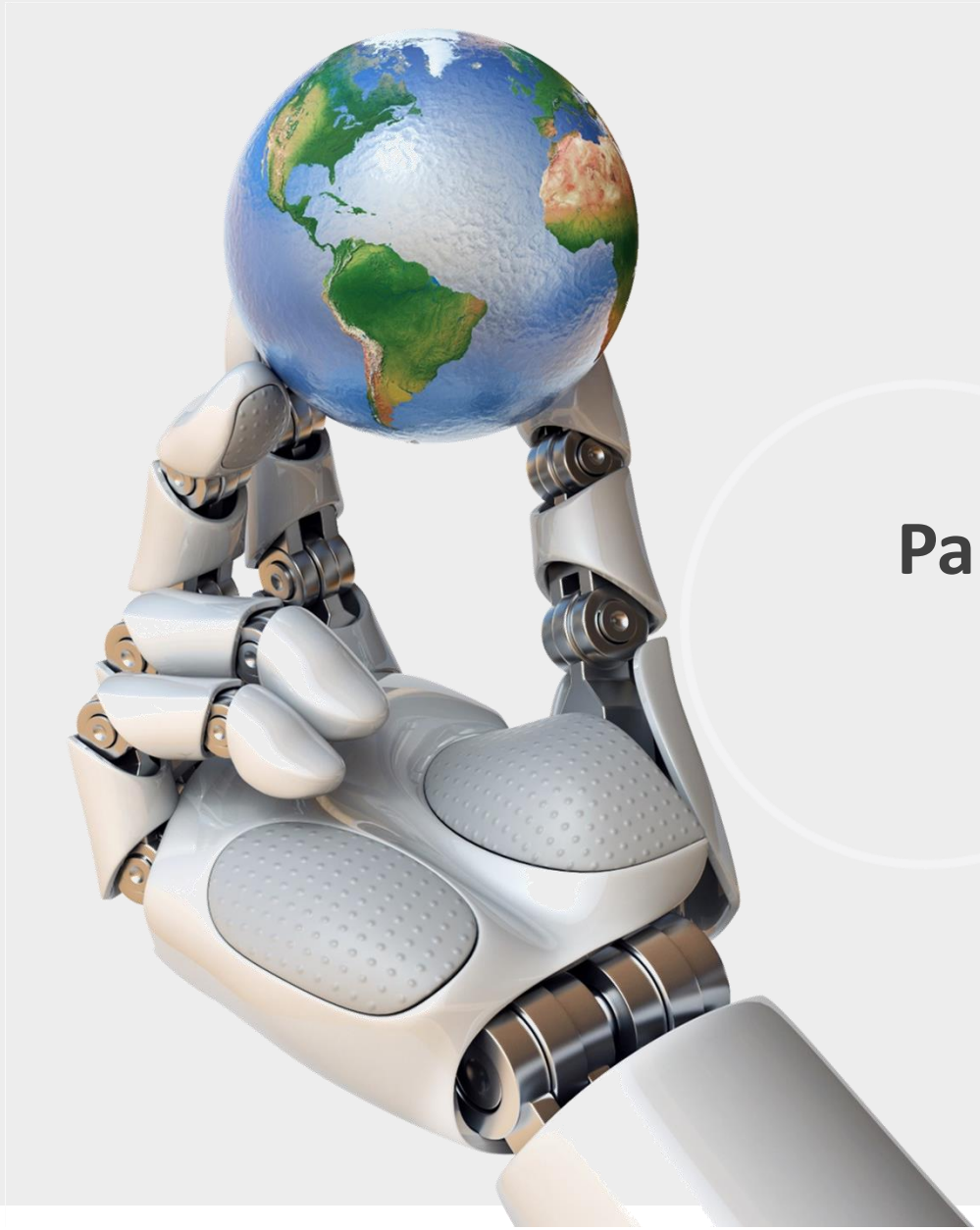
Stan Schneider, Ph.D.
CEO,
Real-Time Innovations, Inc. (RTI)

Moderator:

Curt Schwaderer, OpenSystems Media

Agenda

- Housekeeping
- Presentation
- Questions and Answers
- Wrap-up



The Rise of the Robot Overlords

Clarifying the Industrial IoT

Part 2: A Practical Guide to Connectivity

Stan Schneider, PhD
RTI CEO
IIC Vice Chair

The Big Picture

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Education
- Colleges & Universities
- Conferences & Workshops
- Laboritories
- Publication
- Schools
- Trade Schools

Aerospace & Defense
- Air Force
- Arrmy
- Aviation
- Home Land Security
- Military
- Navy
- Space Flight

Energy & Utilities
- Chemicals
- Electric
- Mining
- Oil & Gas
- Petro-Chemicals
- Power
- Renewable
- Sewer
- Water

Transportation
- Aeronautics
- Airport
- Cargo Handling
- Cruise Industry
- Fleet Management
- Freight Management
- Logistics
- Mobility
- Pipelines
- Postal & Delivery Services
- Public Transportation
- Rail
- Roads
- Shipping

Manufacturing
- Apparel
- Beverage & Tobacco Product
- Chemicals
- Computer & Electronic Products
- Electrical Equipment & Components
- Fabricated Metal Products
- Factory
- Food
- Furniture & Related Products
- Industrial Automation
- Leather & Allied Products
- Machinery
- Nonmetallic Mineral Products
- Paper
- Petroleum & Coal
- oducts
- facturing
- upport Activities
- oment

Near Space & New Space
- Closed Loop Ecological Systems
- Closed Loop Living Systems
- Constellation Controllers
- Consumer Traffic Analytics
- Ecological Planning
- Environmental Monitoring
- Hyper-Local Agriculture
- Hyper-Local Construction
- Hyper-Spectral Imaging
- In-Flight Satelite Servicing
- On-Site Materials Analytics and Inventory
- On-Site Materials Optimization
- Parametric City Planning
- Parametric Construction Planning
- Remote Maintenance and Diagnostics
- Space Based Planning
- Weather Pattern Analytics

Environment
- Air Pollution Control
- Biodiversity
- Eco-construction
- Environmental Monitoring & Instrumentation
- Environmental Research & Development
- Heat & Energy Saving and Management
- Metrology
- Nature Protection
- Noise & Vibration Control
- Oceanography
- Recycled Materials
- Remediation & Clean Up of Soil & Groundwater
- Renewable Energy Production
- Waste Management & Recycling
- Waste Water Treatment
- Water Supply

Consumer & Home
- Automotive
- Commercial Cooking
- Consumer Products
- Day Care
- Elder Ca
- Entert
- Food a
- Food T
- Groce
- Home
- Hospit
- Pet Ca
- Pharm
- Photogra
- Recreation Services
- Restaurants
- Sporting Events
- Street Vendors
- Tourism
- Travel

Agriculture
- Farming
- Fishing
- Forestry
- Hydrology
- Life Sciences
- Ranching
- Weather

Retail
- Apparel Retailers
- Broadline Retailers
- Drug Retailers
- Food Retailers & Wholesalers
- Home Improvement Retailers
- Specialized Consumer Services
- Specialty Retailers

The IIoT will have a multi-trillion-dollar impact across all industries

There are many, many use cases in the IIoT

Buildings & Facilities
- Apartments
- Building & Construction
- Building Maintenance
- Building Security
- Commercial Buildings
- Construction
- Engineering
- Home
- Housing Authorities
- HVAC
- Office
- Real Estate

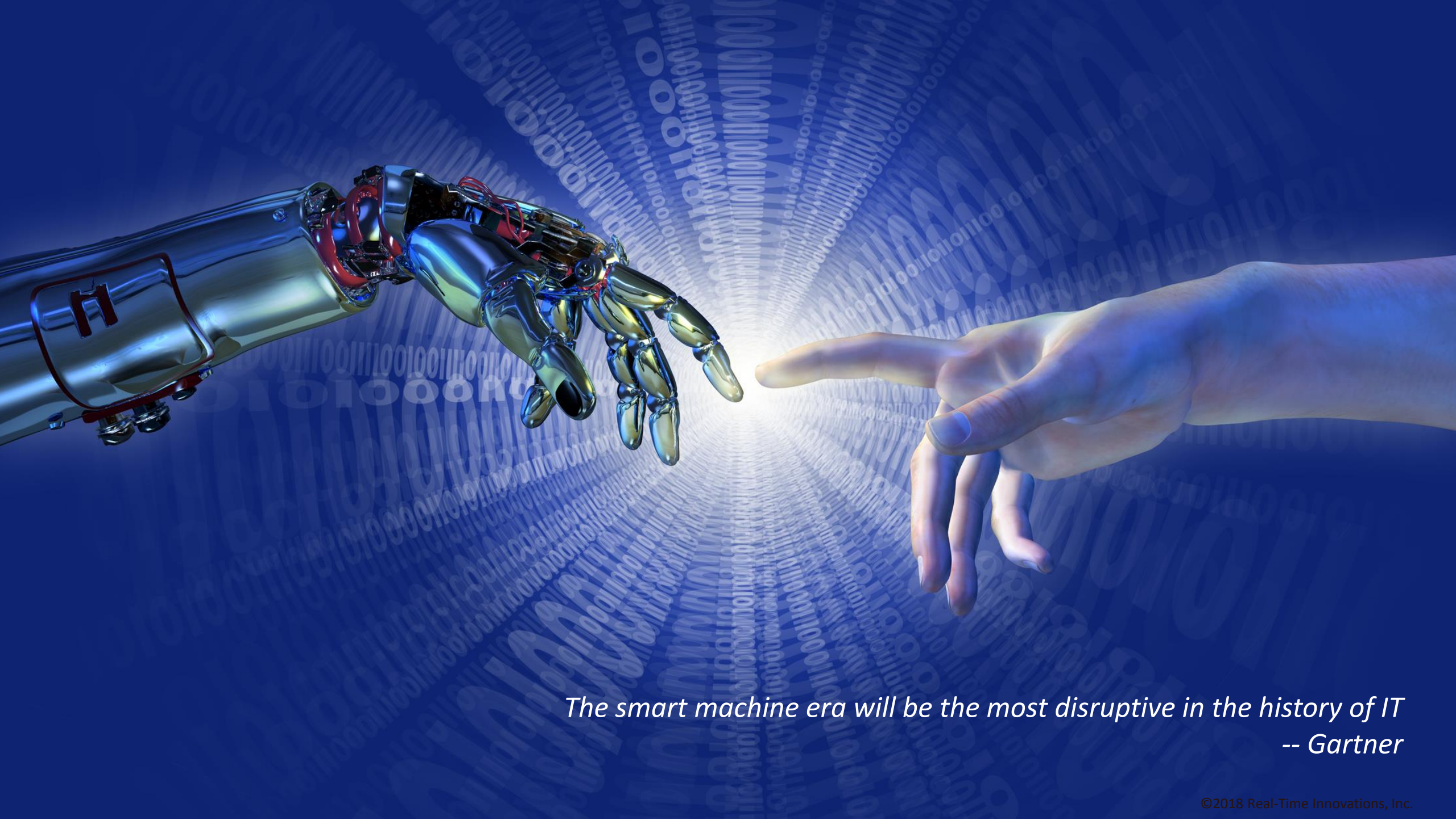
Media & Communication
- Cable Providers
- Computers
- Entertainment
- Global Media
- Phones
- Satellite TV
- Telecommunications Carriers
- Televisions
- Video Recorders
- Wireless Services

Finance & Banking
- Accounting Systems
- ATM Systems
- Credit Card Systems
- Point of Sales
- Retail Banking

Public Safety
- Disaster Prevention
- Education
- Emergency & Crisis Response
- Environment
- Fire
- Law Enforcement & Police
- Municipalities & Counties
- Public Safety
- Public Security
- Surveillance
- Transportation
- Waste Management
- Water

hcare
- Clinical Trials
- Connected Medical Devices
- Continuous Patient Monitoring
- Dentistry
- Disease Diagnosis
- Home Healthcare
- Hospitals
- Life Sciences
- Medical Offices
- Medical Therapy
- Pharma
- Pharmacies

Mining & Metals
- Aluminum
- Coal
- Diamonds & Gemstones
- General Mining
- Gold
- Iron & Steel
- Nonferrous Metals
- Platinum & Precious Metals



The smart machine era will be the most disruptive in the history of IT
-- Gartner

A *Better* Smart Machine World

You don’t compete against competitors.
You compete against market transitions.
– John Chambers

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

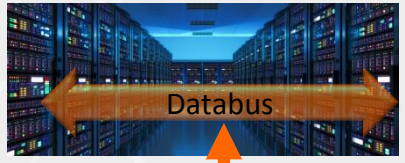
Rise of the Robot Overlords Webinar Series

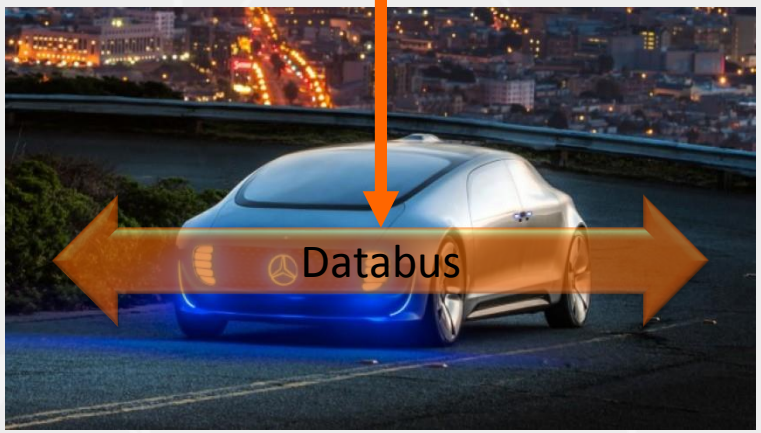
- Part 1: What is the IoT, Anyway?
- Part 2: A Practical Guide to IIoT Connectivity
  - How to choose between DDS, OPC UA, MQTT, RESTful HTTP, OneM2M and CoAP
- Part 3: Data-Centric vs Device-Centric Integration: Theory and Practice
  - How to compare, contrast, and integrate DDS and OPC UA.
- Part 4: Why a Databus is so Unique
- Part 5: The IIoT Security Challenge
- Part 6: A deeper IIoT example: Autonomous Vehicles (Carbots)
- Part 7: The Age of the Robot Overlords

Industrial IoT Application Categories

Device
Monitoring

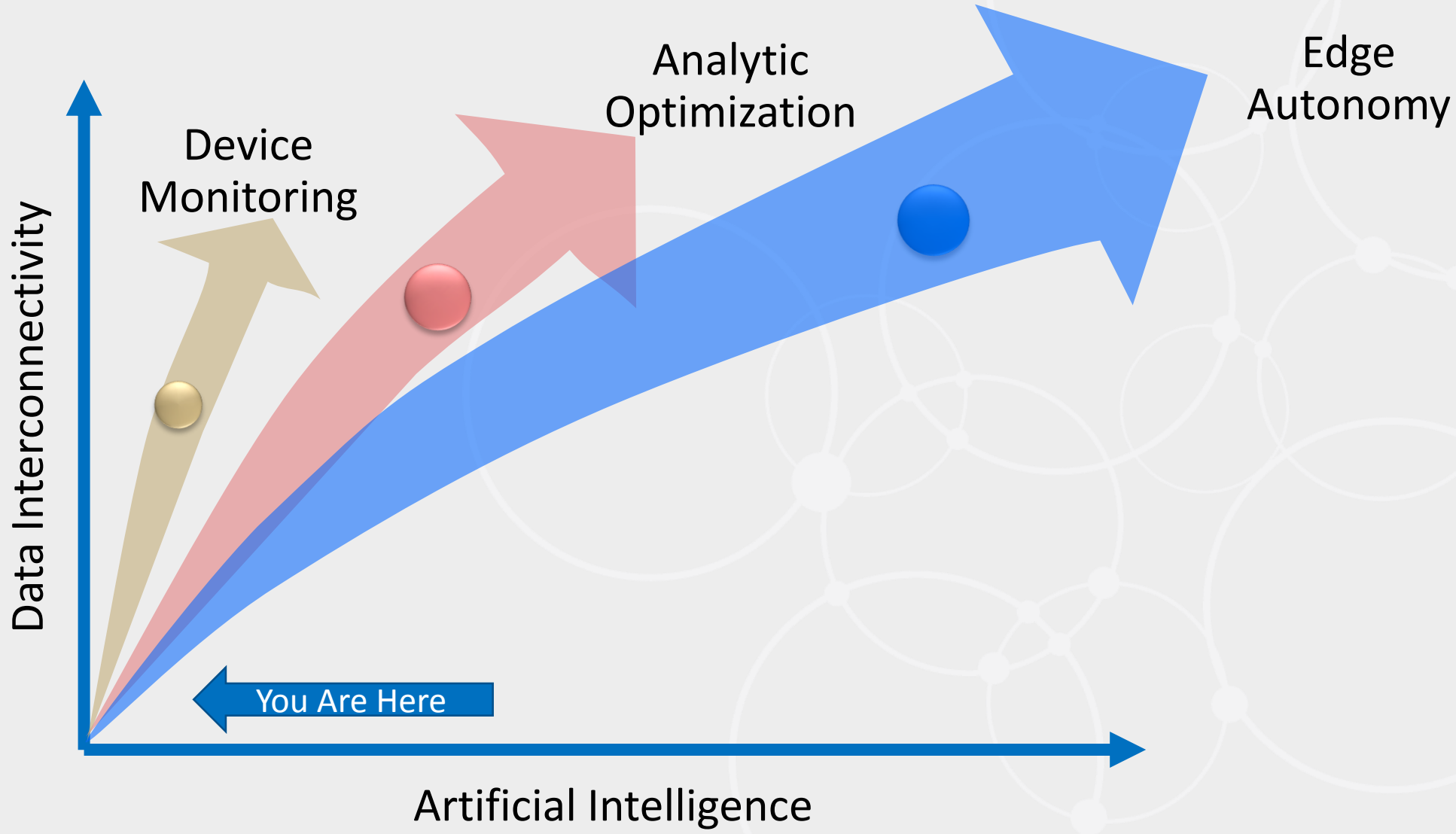
Analytic
Optimization



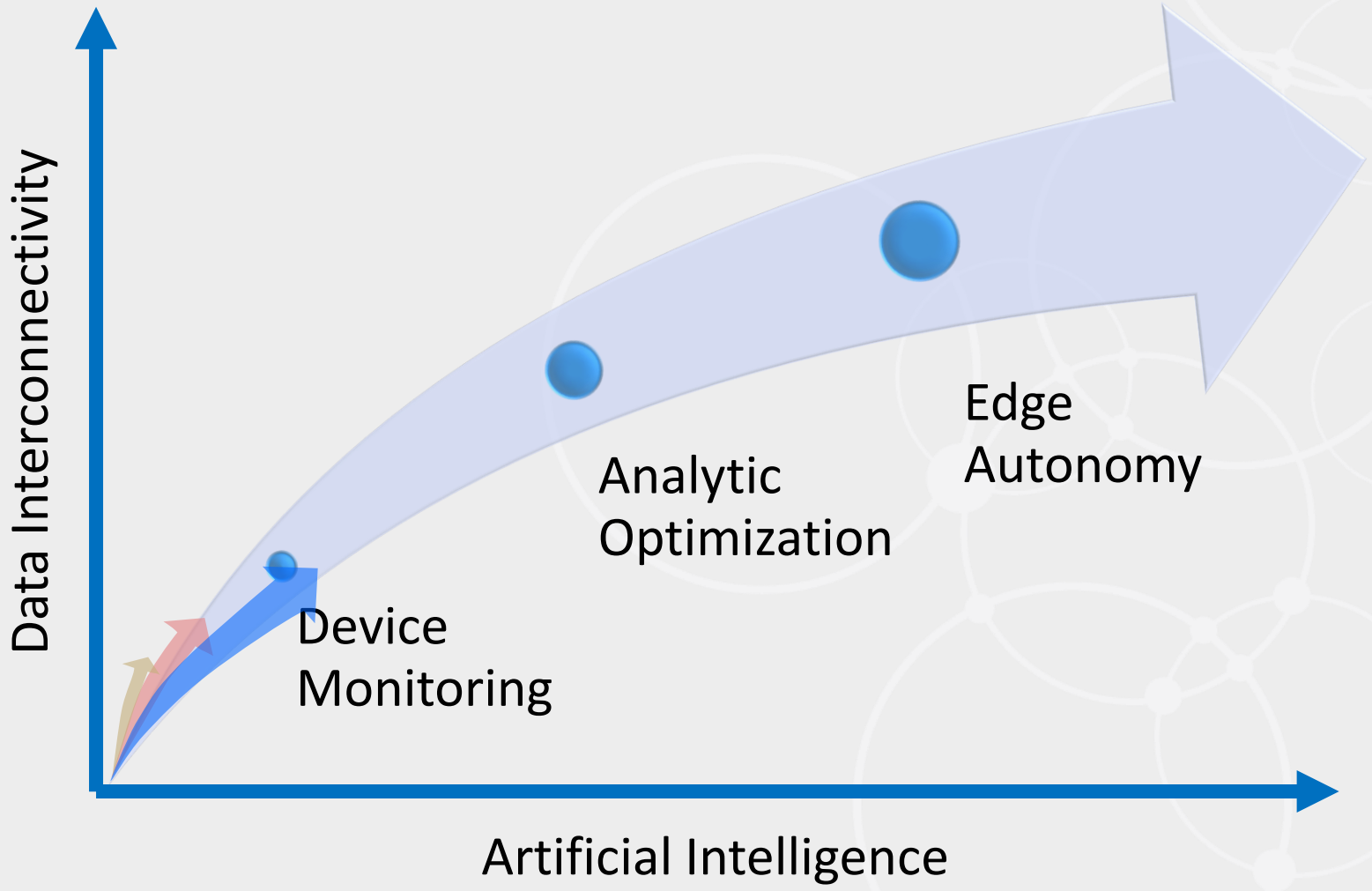


Edge
Autonomy

Industrial IoT Market Evolution

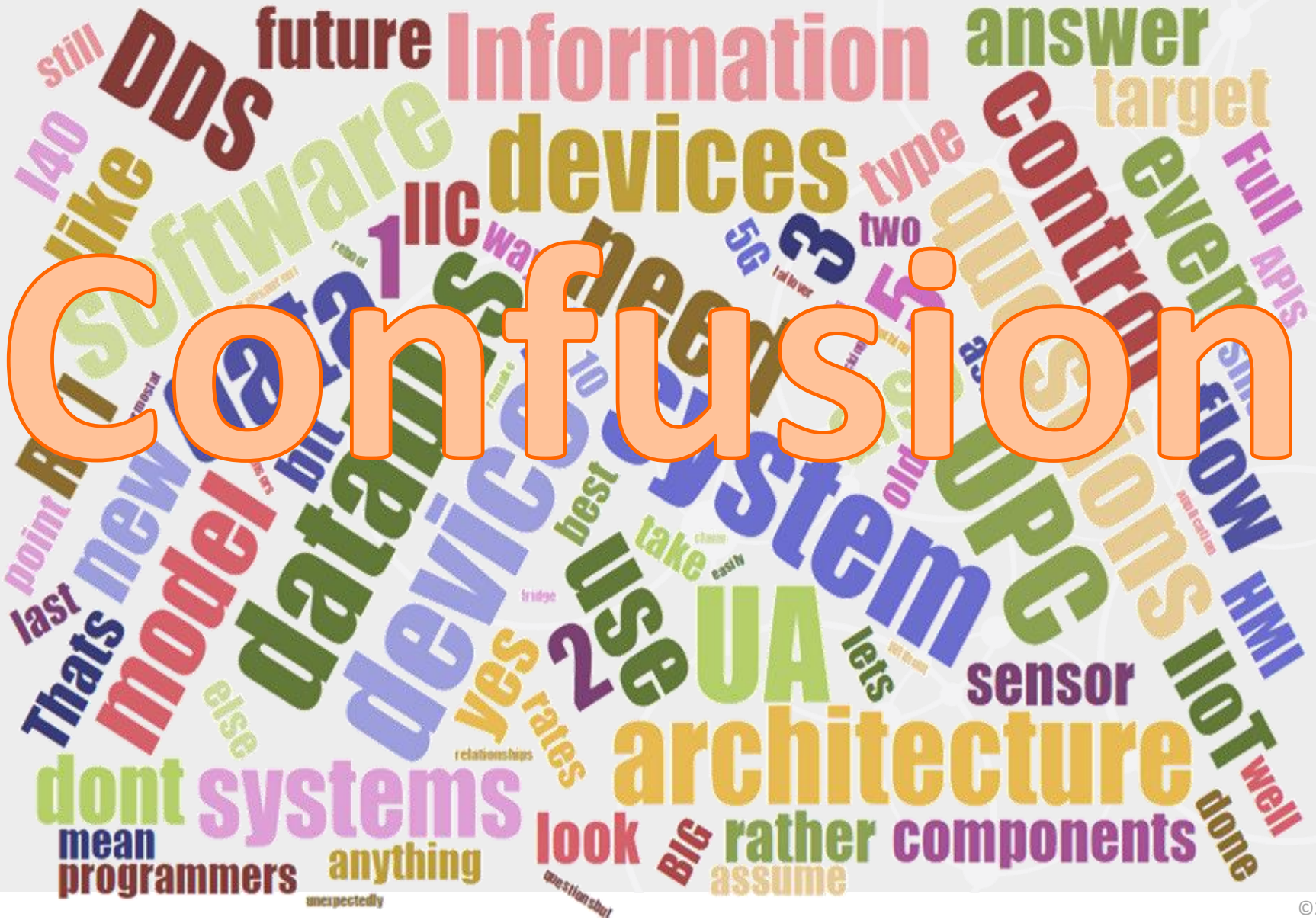


Industrial IoT Long-Term Evolution



This is not the evolution of one use case, but the progress of categories of use cases

IIoT #1 Blocker



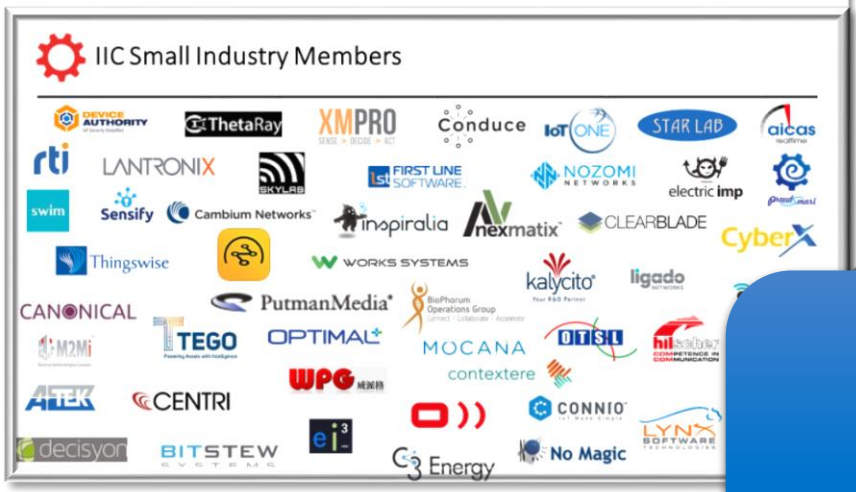
Industrial Internet Consortium

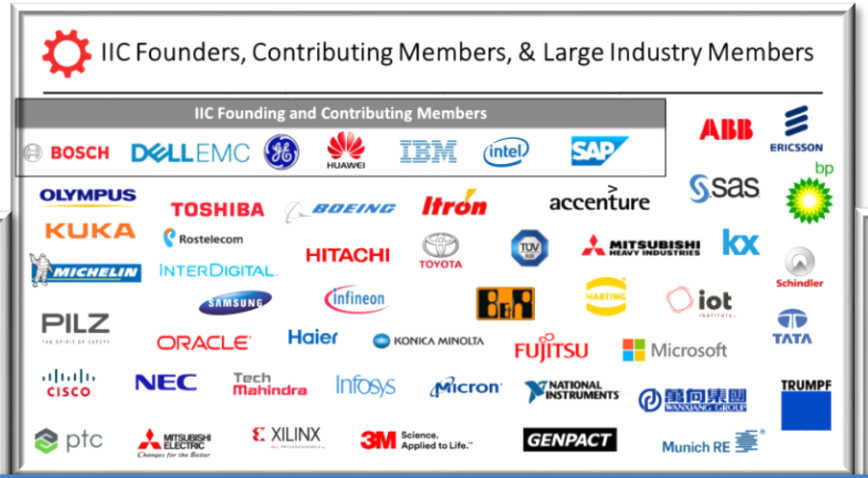
***Vision**: The Industrial Internet Consortium is the world's leading organization transforming business and society by accelerating the Industrial Internet of Things (IIoT).*

***Mission**: To deliver a trustworthy IIoT in which the world's systems and devices are securely connected and controlled to deliver transformational outcomes.*

The IIC is an open, neutral "sandbox" where industry, academia and government meet to collaborate, innovate and enable.

industrial internet CONSORTIUM



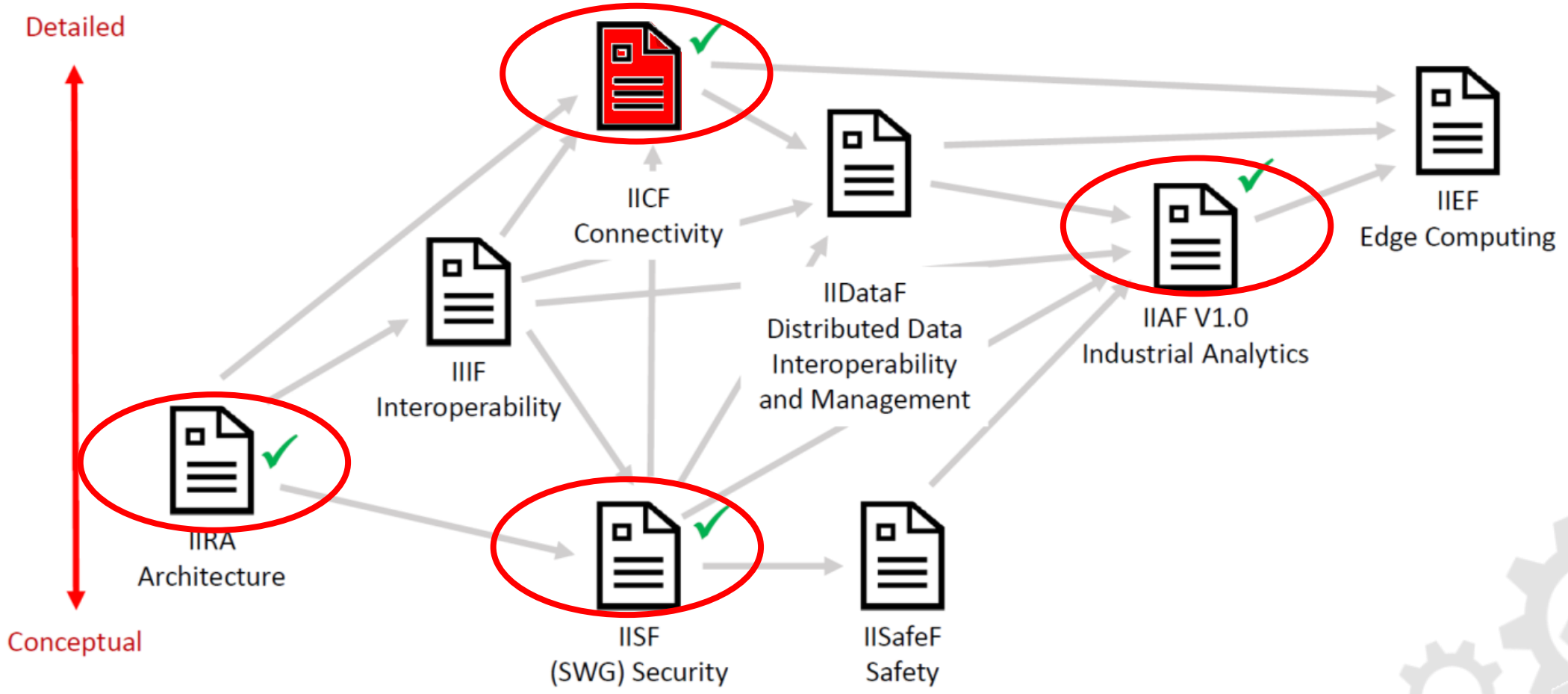


industrial internet CONSORTIUM

The World's Largest IoT Consortium

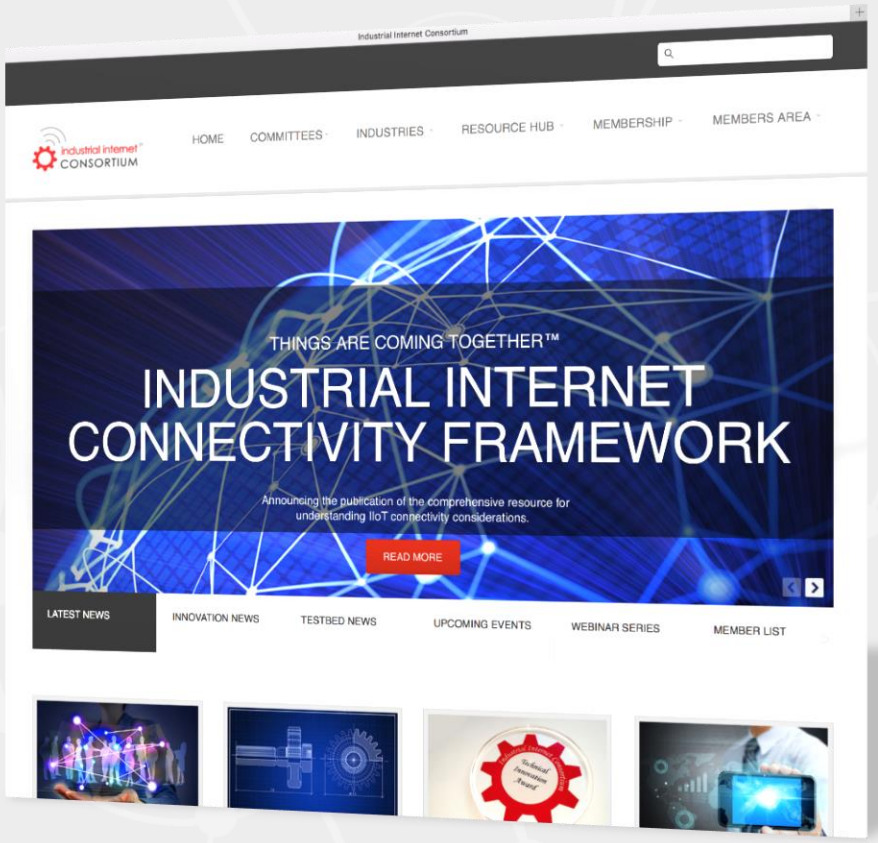
The IIC created the IIoT market

Great Technical and Business Guidance



The Industrial Internet Connectivity Framework

- The industry's only detailed analysis of IIoT Connectivity Technologies
- Architecture
- Assessment
- Standards
  - DDS
  - OPC UA
  - OneM2M
  - HTTP
  - MQTT
  - CoAP
- Examples & selection guidance
- Years of work by many architects across industries, standards, & technologies



IICF Goals

Guide map to the rich but often confusing landscape of IIoT connectivity

Clarity

Stable long term foundation for IIoT interoperability

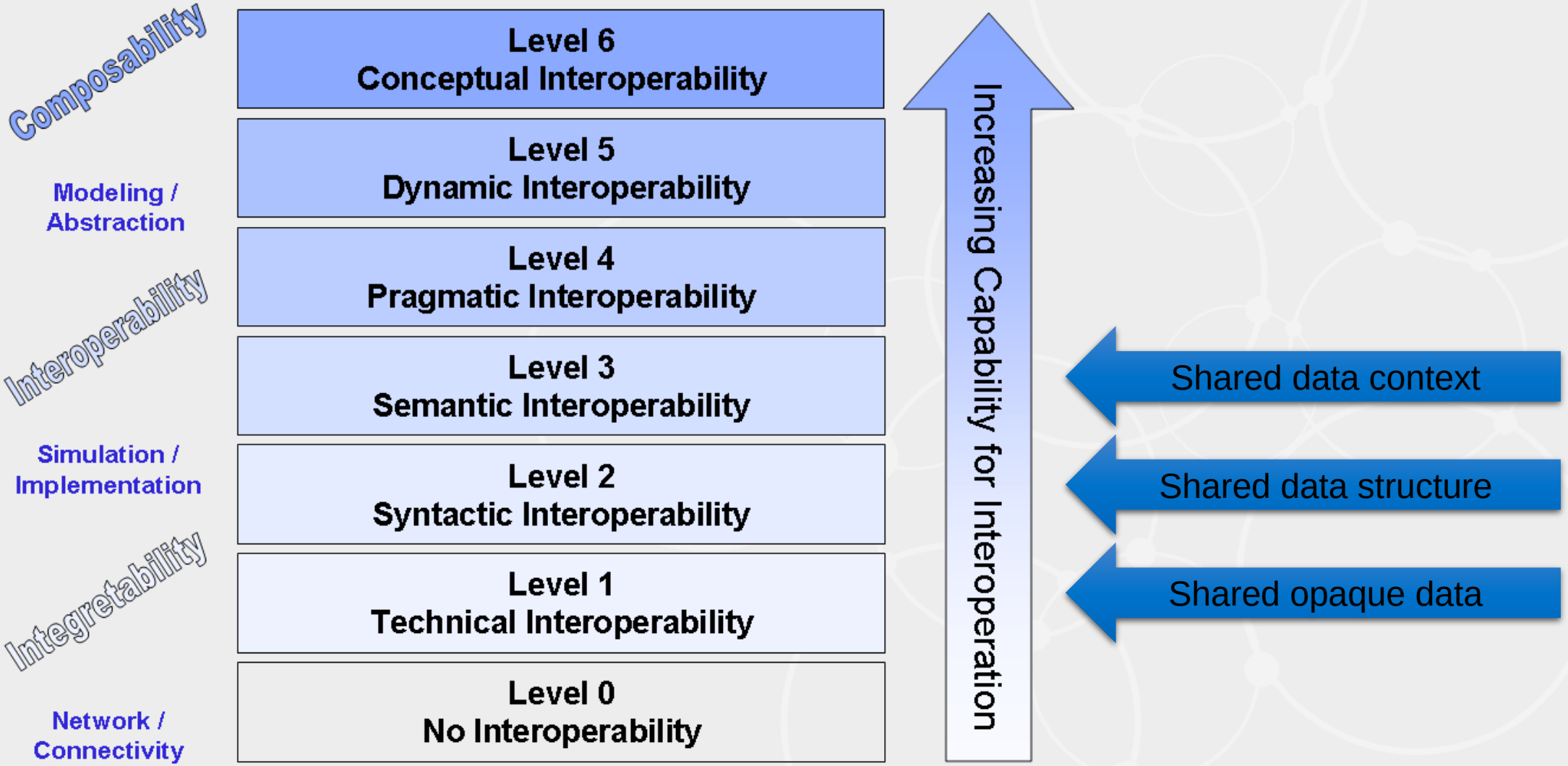
Industry Connectivity Architecture

Useful, practical, tangible guidance for requirements assessment, technology evaluation and selection

Foundation

Guidance

Levels of Interoperability

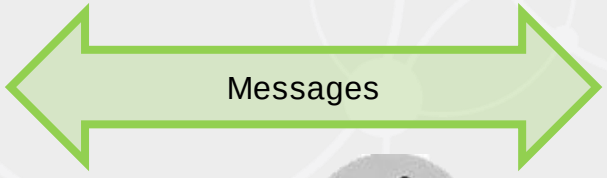


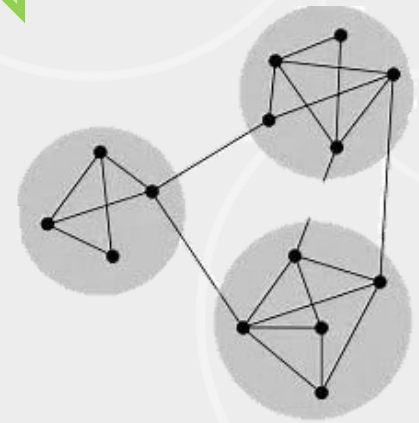
http://en.wikipedia.org/wiki/Conceptual_interoperability

Technical Interoperability Example…

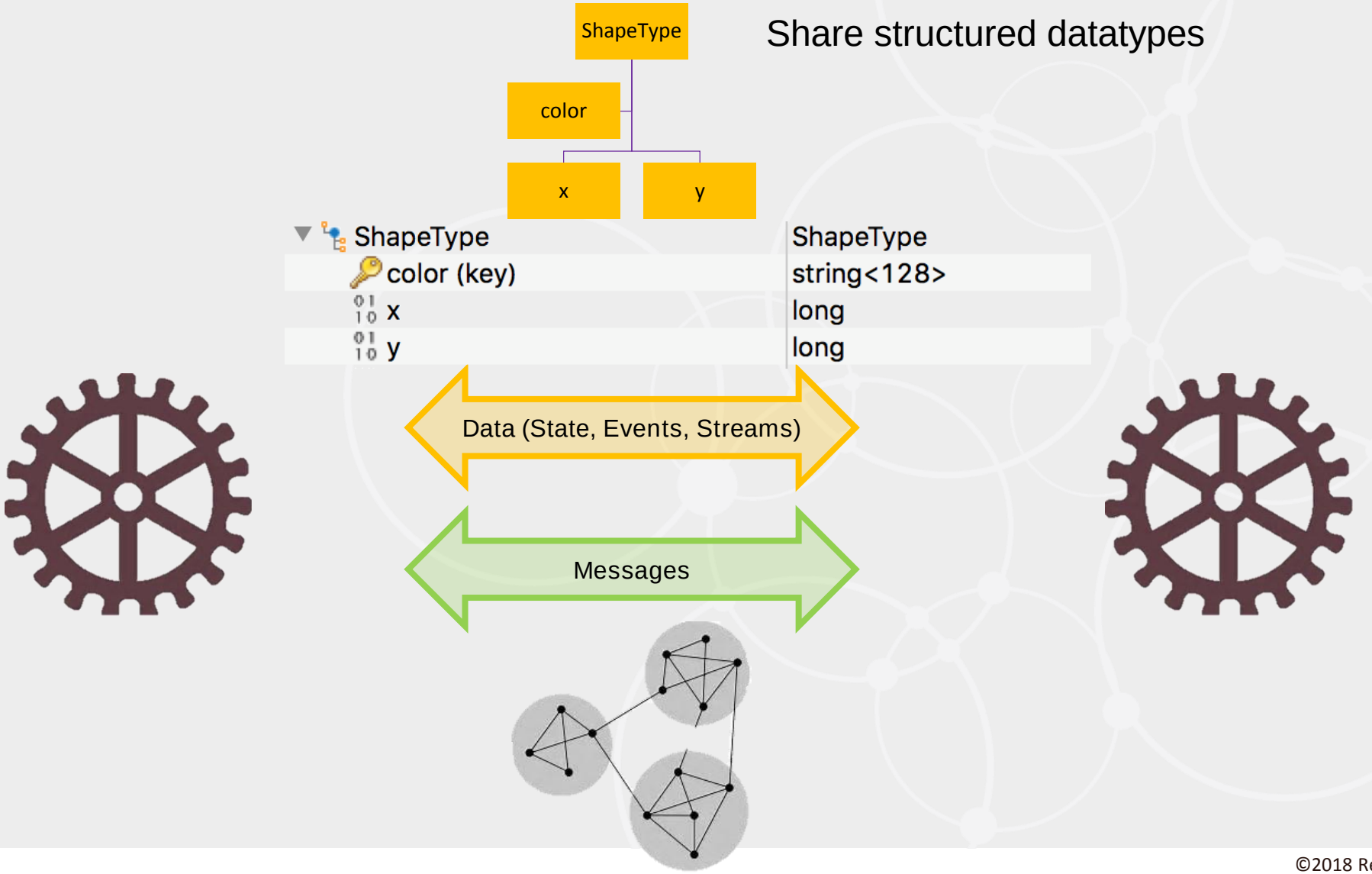
Share opaque data (byte sequences)

```
0000  54 a0 50 cf b6 80 14 10  9f e2 3a 05 08 00 45 00   T.P..... ..:...E.
0010  00 90 4a ec 00 00 40 11  07 d4 c0 a8 59 e6 0a 00   ..J...@. ....Y...
0020  03 0f f4 22 1c f3 00 7c  f3 13 52 54 50 53 02 01   ..."...| ..RTPS..
0030  01 01 c0 a8 59 e6 00 00  49 03 00 00 00 01 09 01   ....Y... I.......
0040  08 00 1a b6 c9 58 d6 7f  2b f1 15 07 50 00 00 00   .....X.. +...P...
0050  10 00 00 00 00 00 80 00  00 02 00 00 00 00 59 02   ........ ......Y.
0060  00 00 70 00 10 00 ca c2  17 c3 18 36 3f 8e f1 16   ..p..... ...6?...
0070  0e ee de f9 e8 86 01 00  01 00 00 01 00 00 05 00   ........ ........
0080  00 00 42 4c 55 45 00 00  00 00 55 00 00 00 f1 00   ..BLUE.. ..U.....
0090  00 00 1e 00 00 00 00 00  00 00 00 00 00 00        ........ ......
```

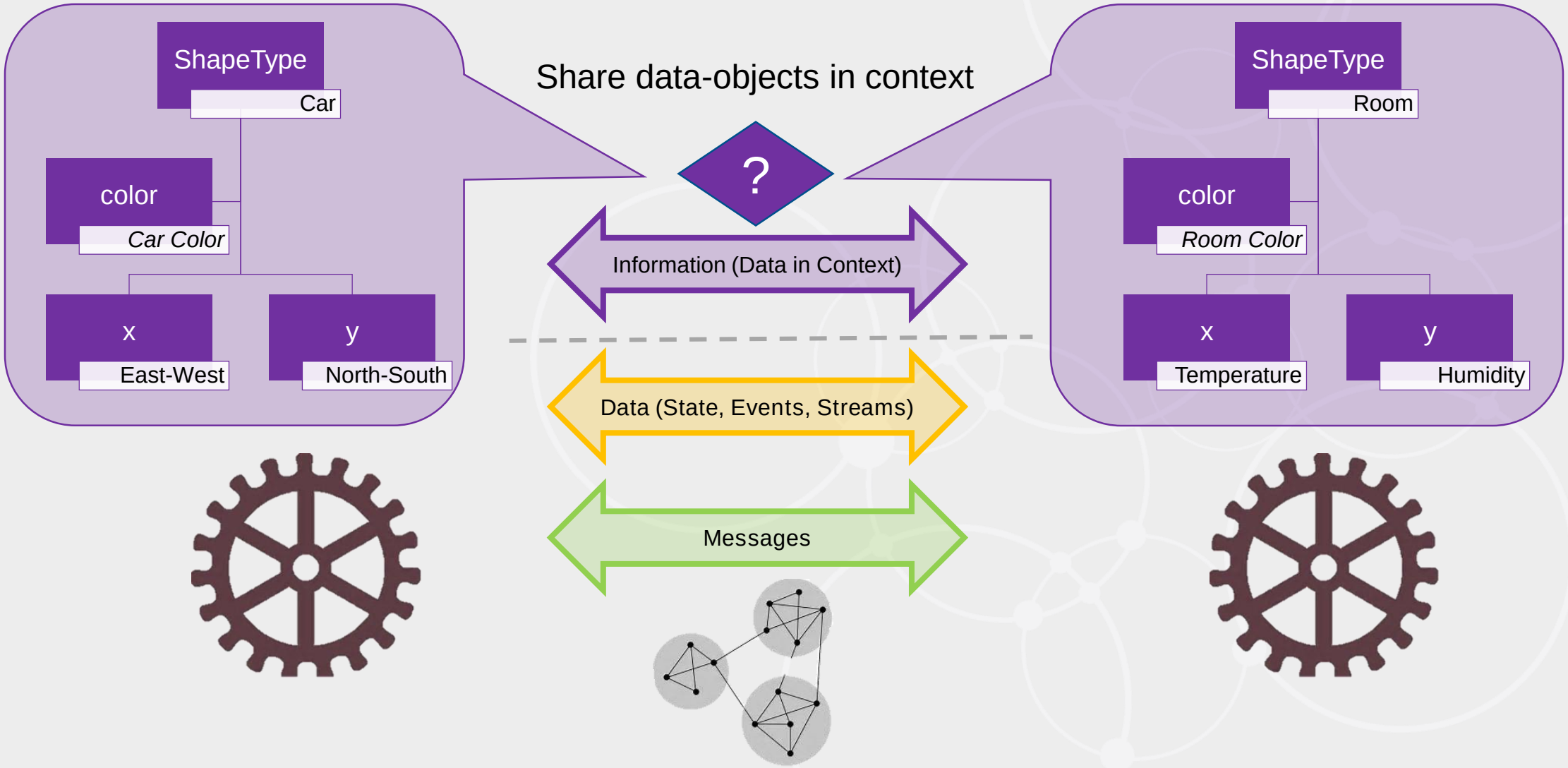




Syntactic Interoperability Example…

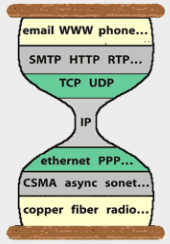


Semantic Interoperability Example…

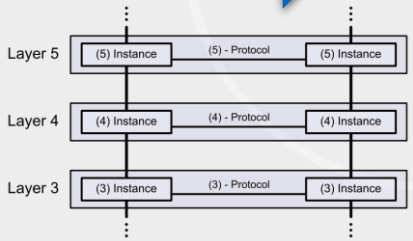


Evolution of the IIoT Connectivity Stack

4-Layer Internet Stack Model (1970s)

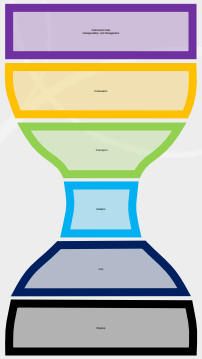


7-Layer OSI Stack Model (1984)

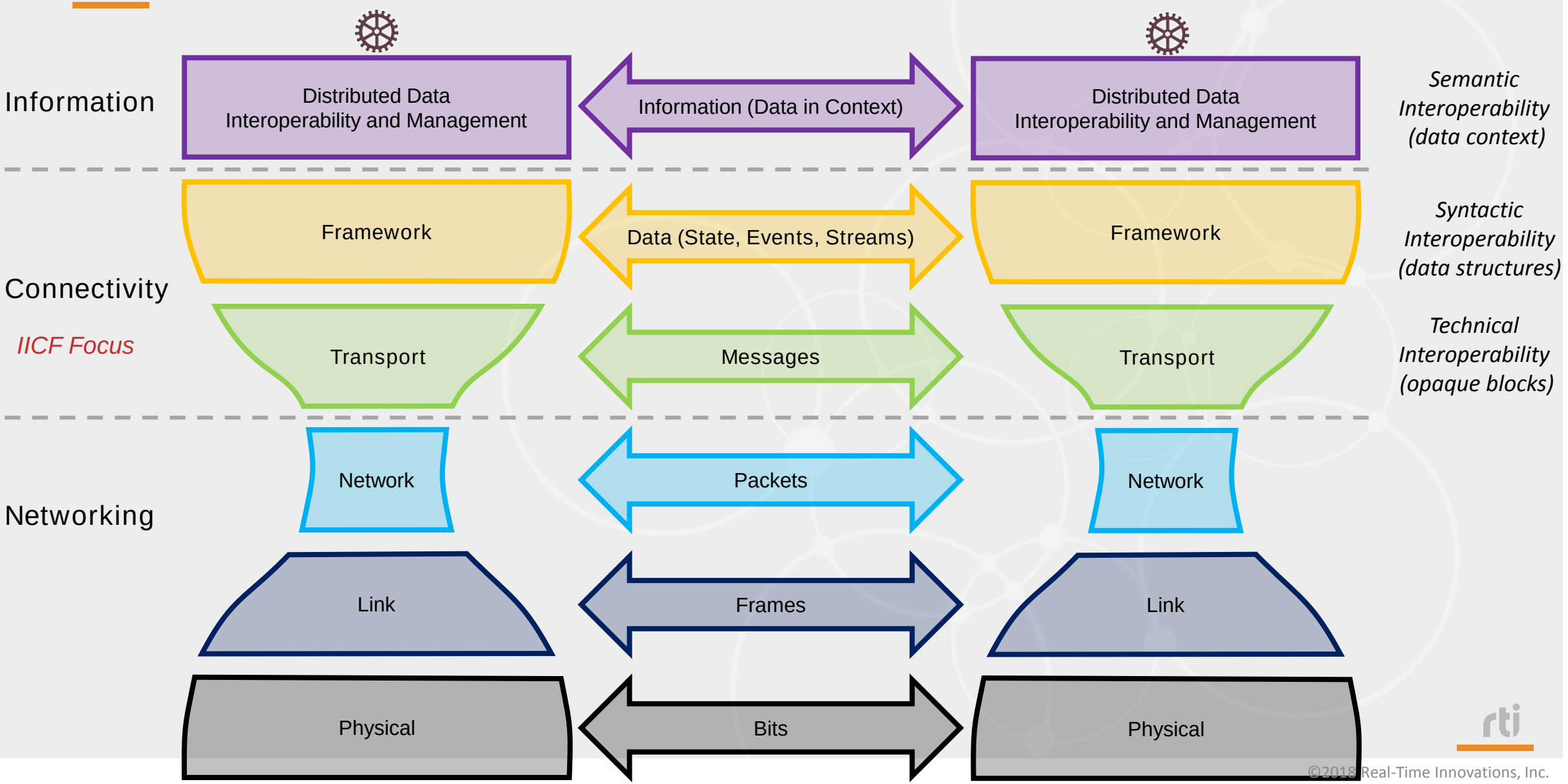


Industrial IoT (2014)

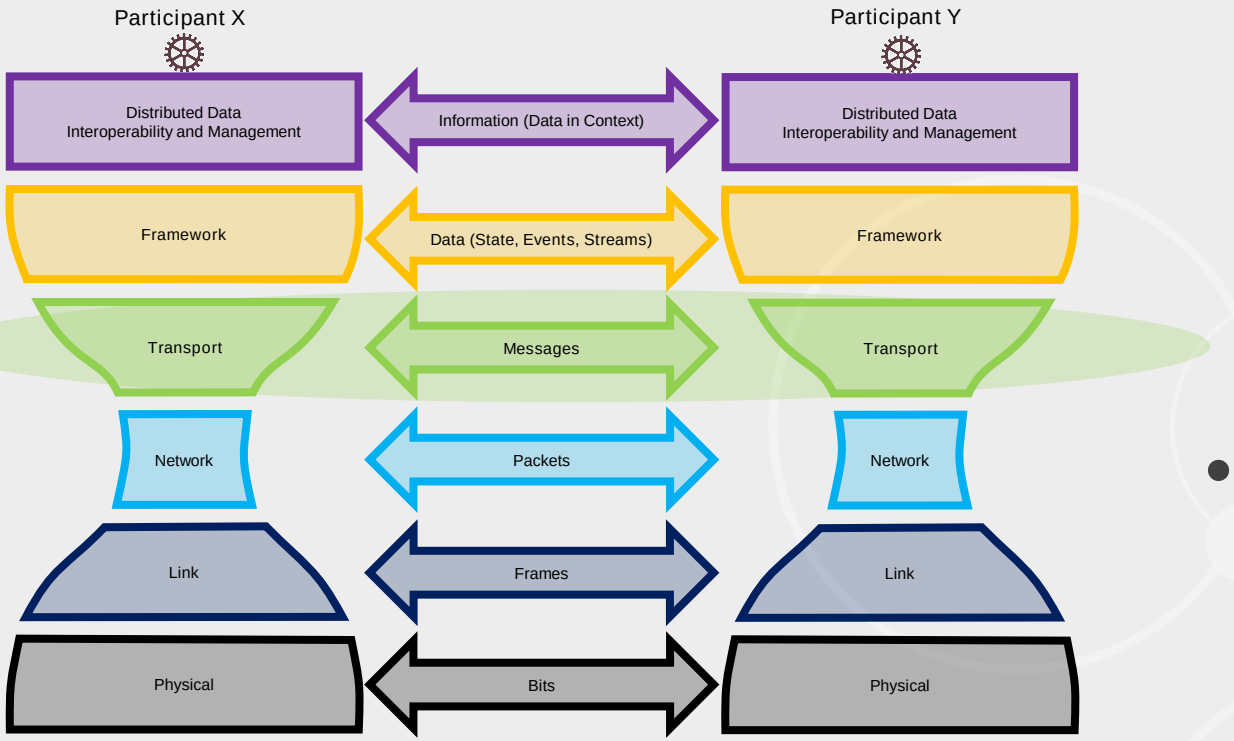
IIoT Connectivity Stack Model (2017)



IIoT Connectivity Stack Model

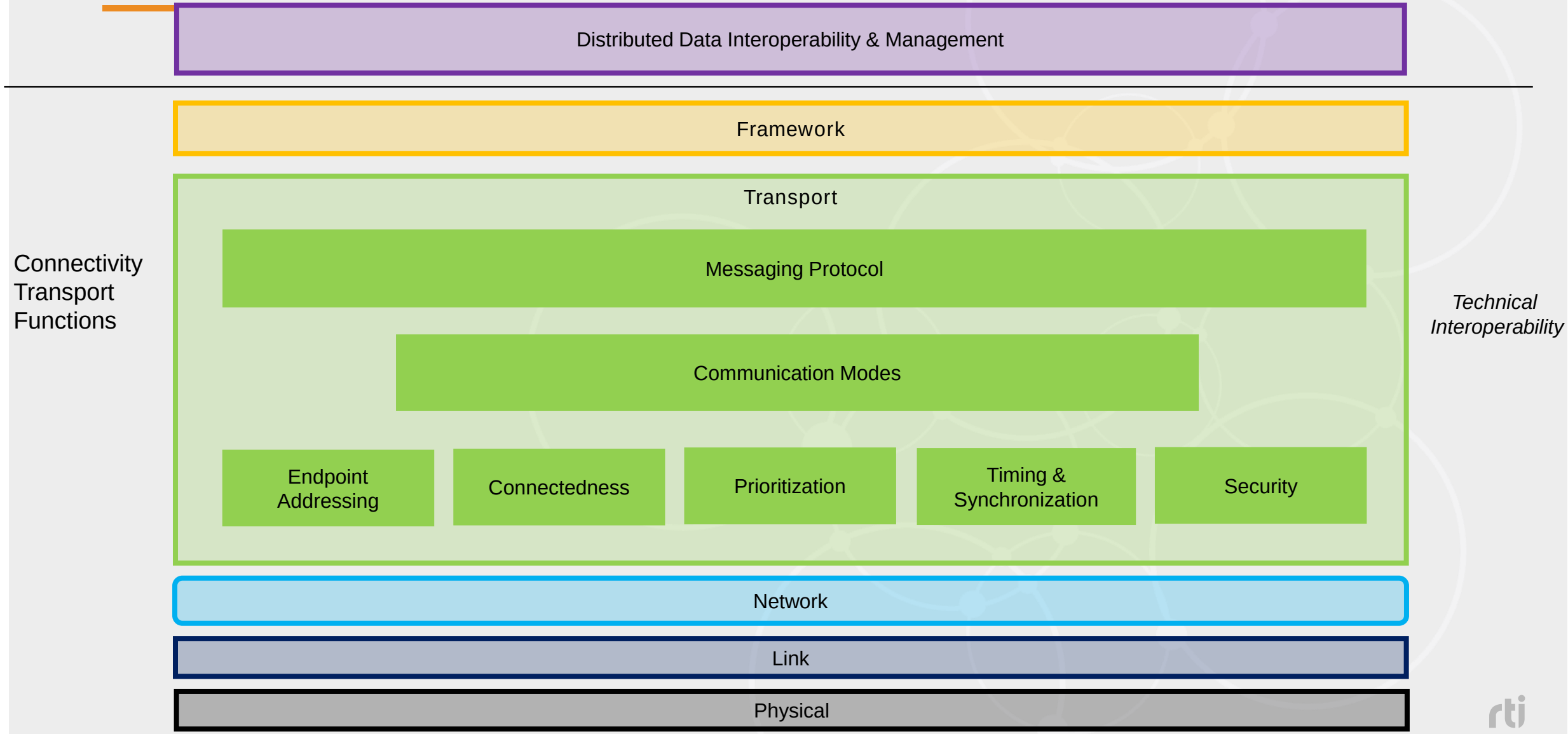


Connectivity Transport Layer

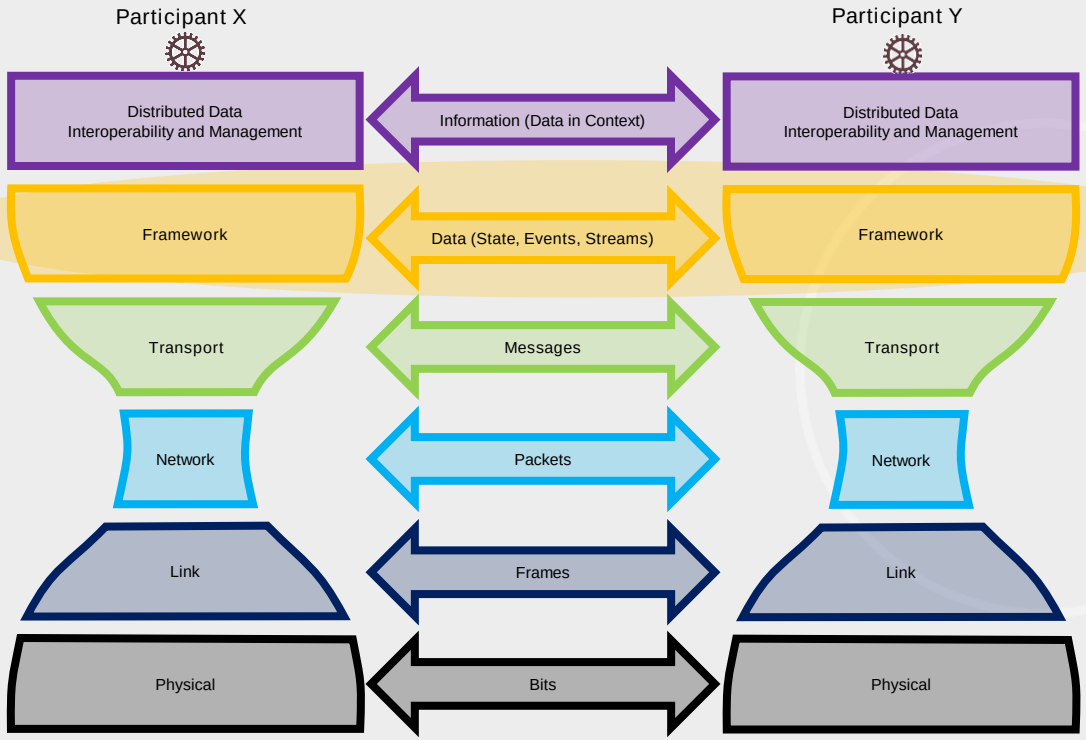


- Above: Technical Interoperability
  - Share byte sequences
  - Opaque data
- Below: Byte protocol
  - Any computing platform
  - Byte flows & optimize byte sequence sharing and delivery

Connectivity Transport Layer

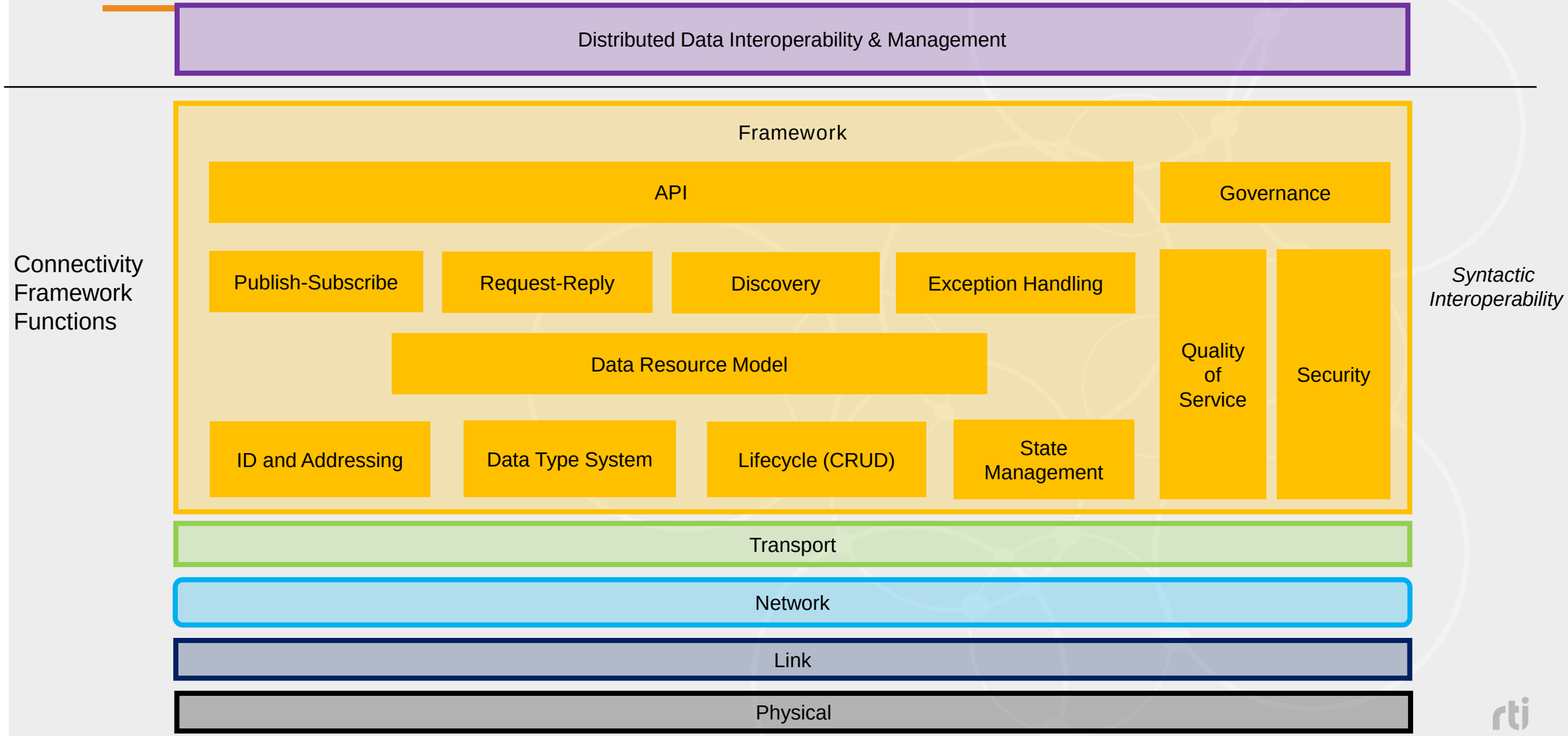


Connectivity Framework Layer



- Above: Syntactic Interoperability
  - Share structured datatypes
  - Common and unambiguous data format
- Below: Opaque Data
  - Any programming environment
  - Any computing platform
  - May observe data flows & optimize datatype sharing and delivery

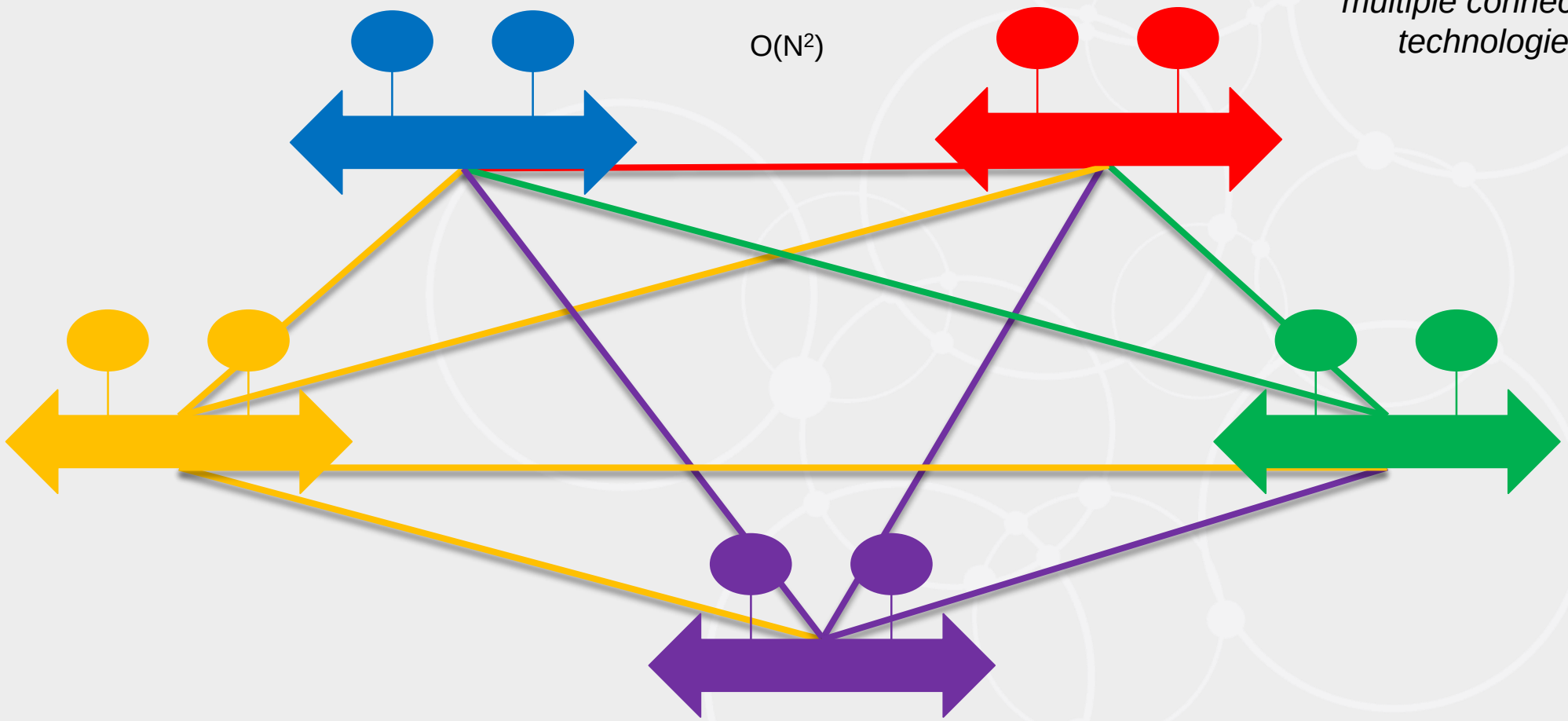
Connectivity Framework Layer



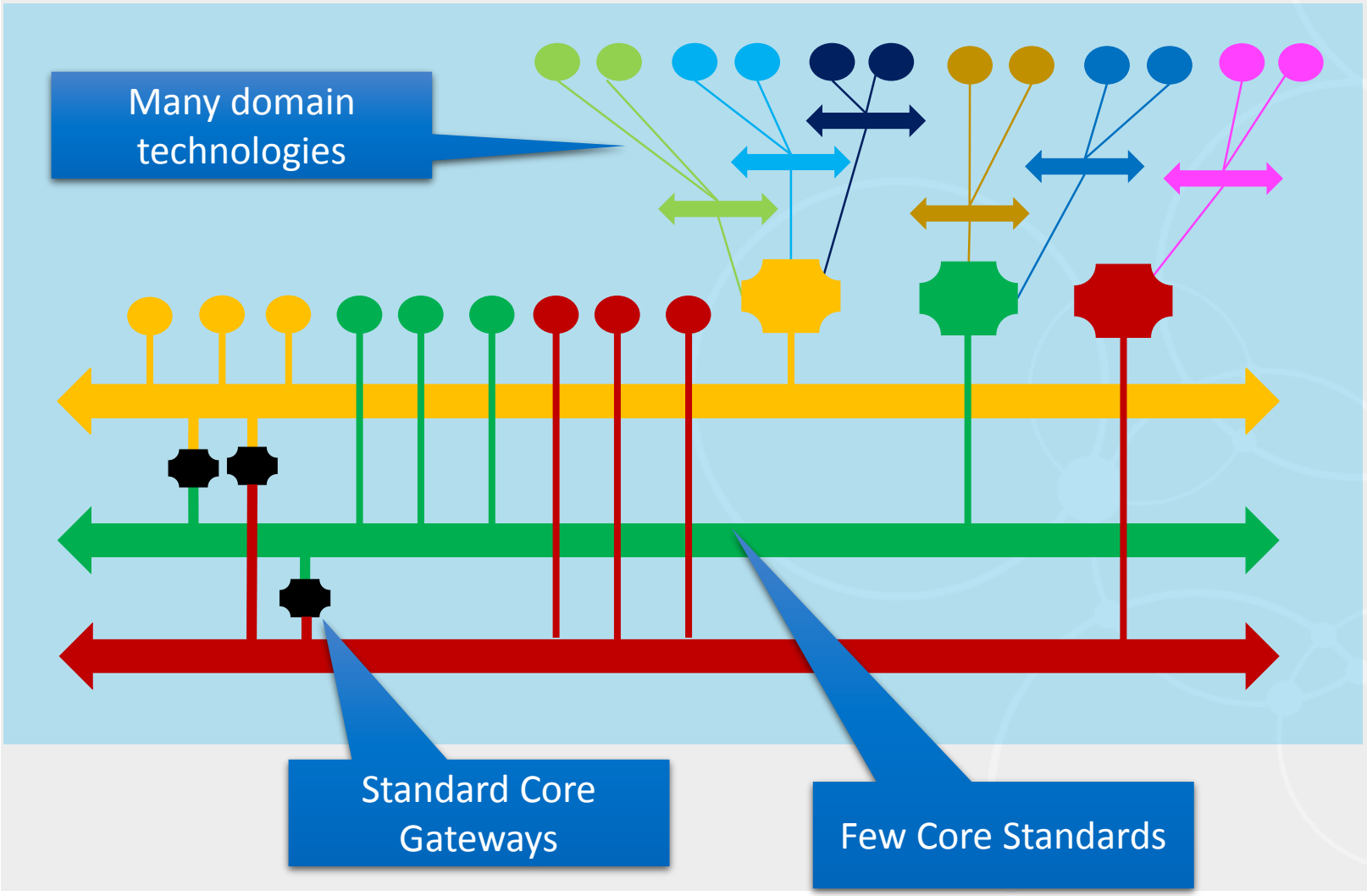
Fundamental N^2 Connectivity Challenge

Reality Check

Accept that there will be multiple connectivity technologies

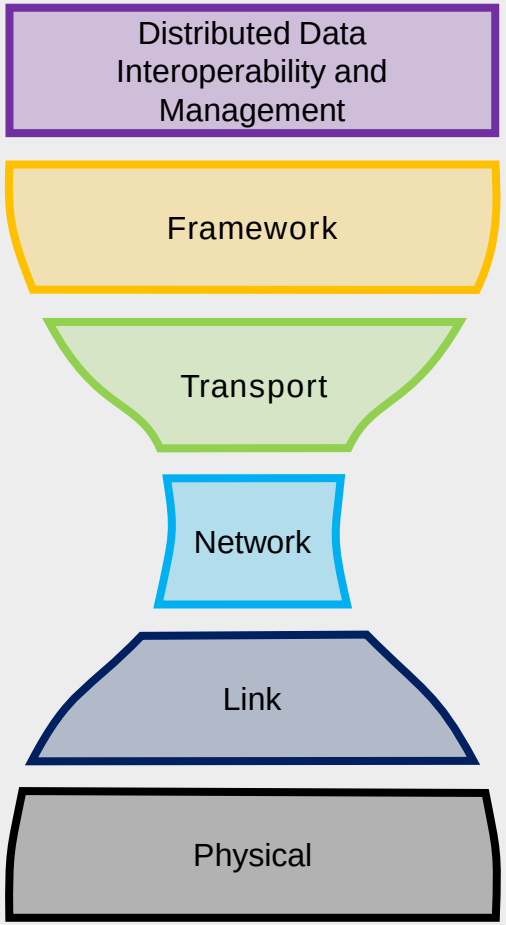


Connectivity Core Standards Architecture



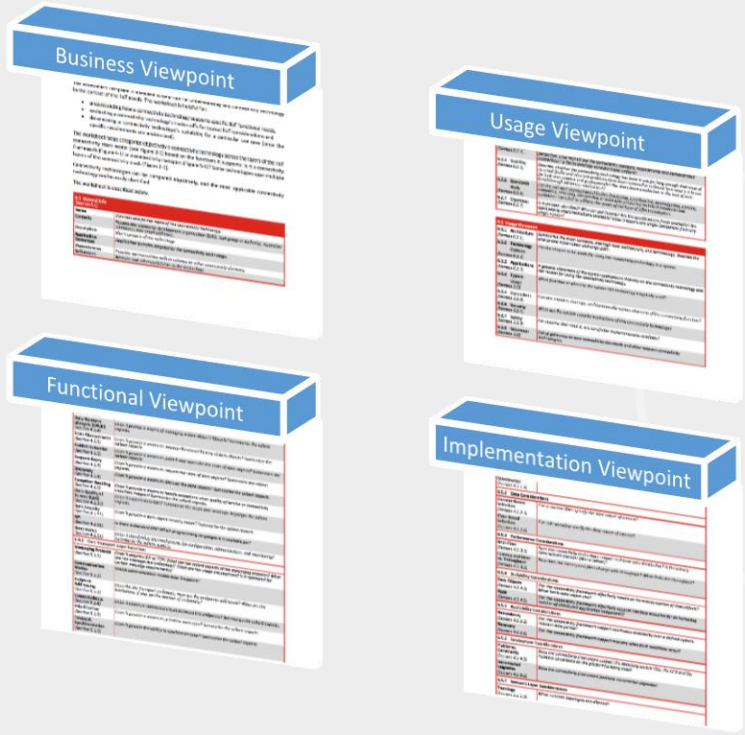
- Connectivity Core Standards
  - Provide syntactic interoperability
  - Stable, deployed, open standard
  - Standard *Core Gateways* to all other CCS
- Domain-Specific Connectivity Technologies
  - Connect via non-standard gateway to any connectivity core standard

Assessment Template



- Which layers(s) of the Connectivity Stack does it provide?
- What Core Functions does it provide?
- How does it rank against the Typical Considerations (of the layers spanned) ?
- How does it impact system Architectural Qualities?
- Does it fit Connectivity Core Standard Criteria?

IICF Catalog of Connectivity Standards

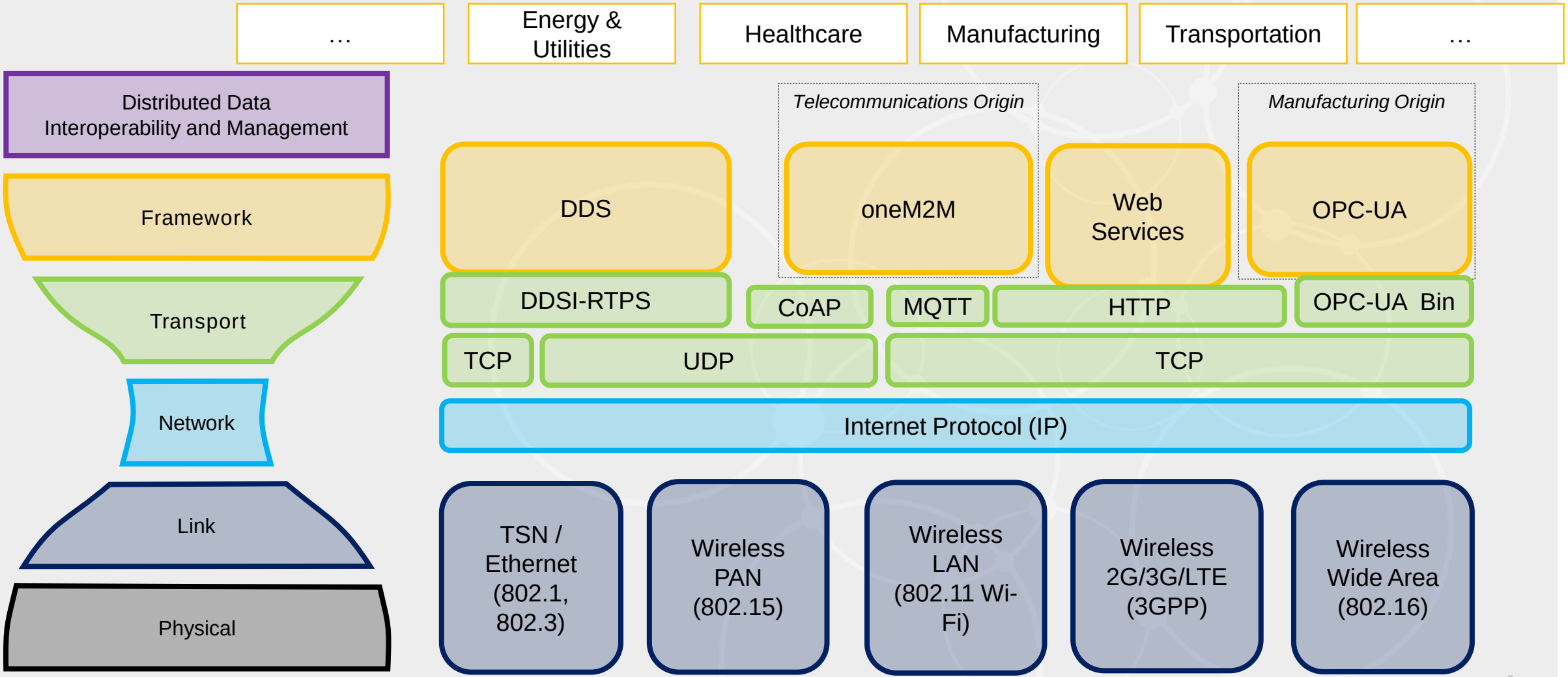


Assessment Template Worksheets

- Frameworks
- DDS
- OPC-UA
- oneM2M

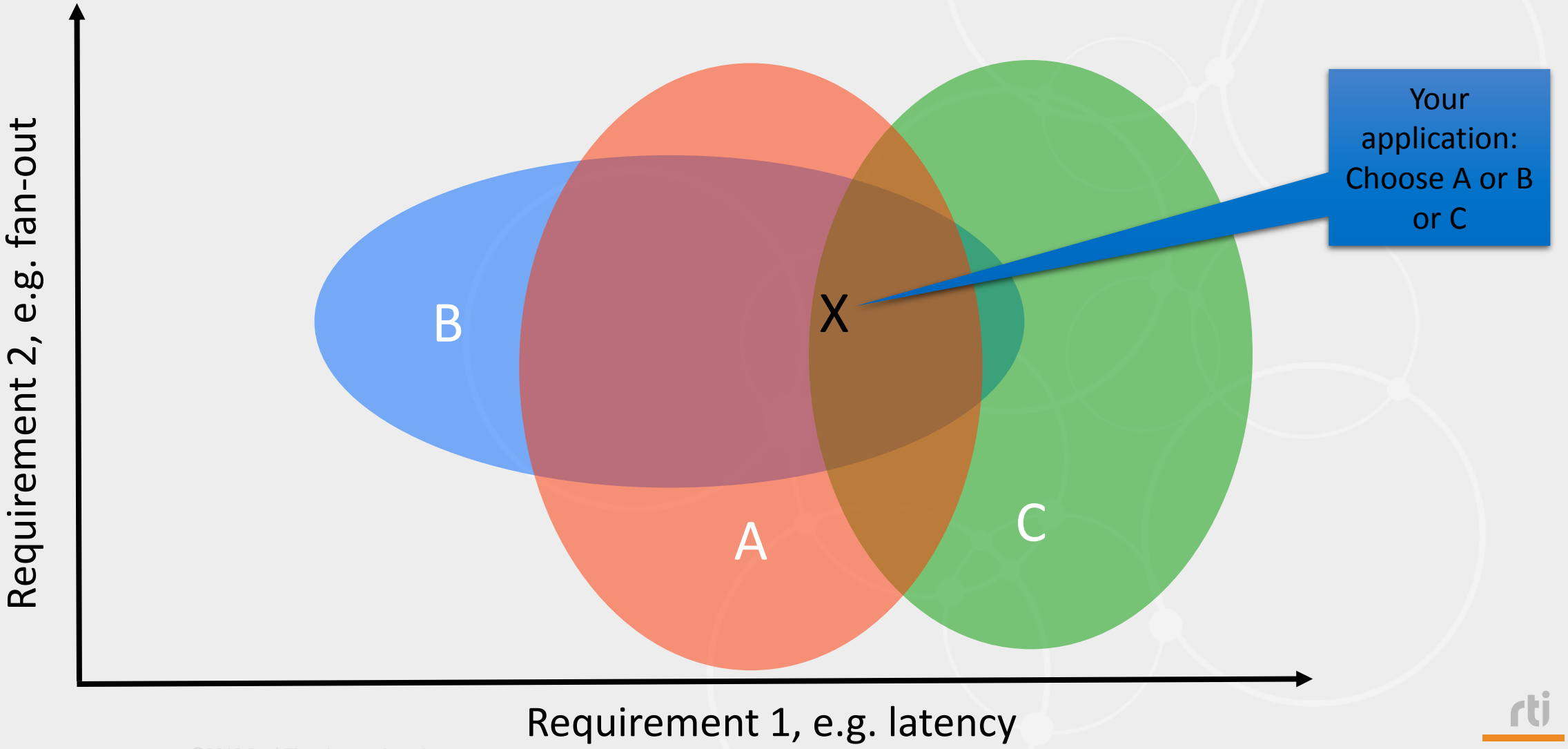
- Transports
- HTTP
- MQTT
- CoAP

Connectivity Standards

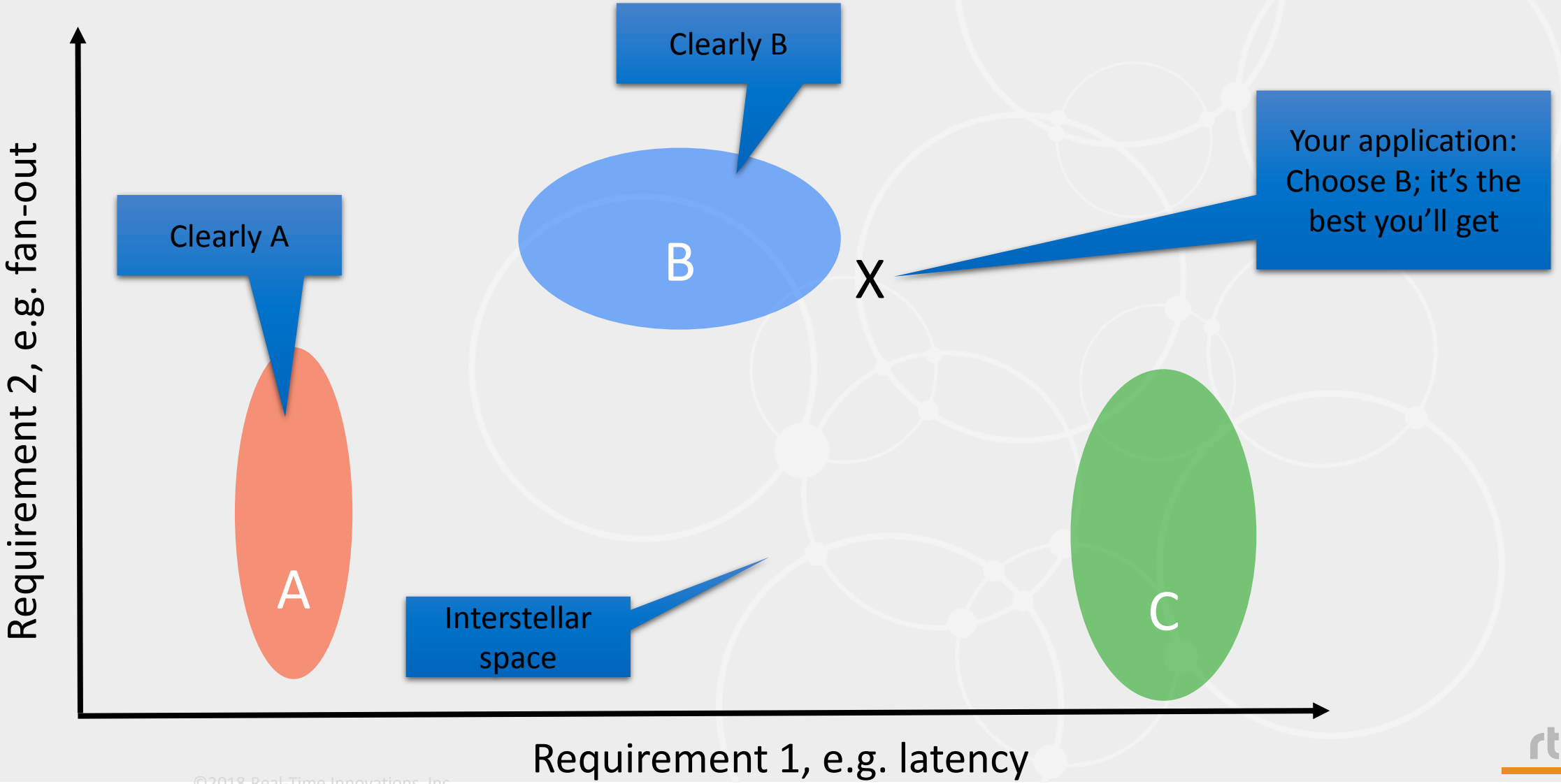


Choosing a Connectivity Standard

IIoT Connectivity Perception



IIoT Connectivity Reality

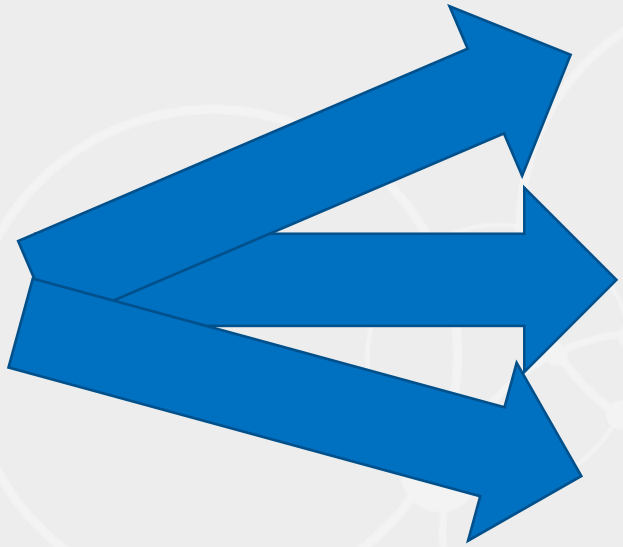


How to Choose?

System Aspect	Example User	Approach	Standard
Software Integration & Autonomy	Software Architect integrating components	Data-centric	DDS
Device interchangeability	Device manufacturer selling devices to technicians	Device-centric	OPC-UA
Web & Mobile User I/F	App builder supporting back-end services	RESTful	Web services/HTTP
ICT integration	Wide-area wireless telecom integrator	Common services layer	oneM2M

Selection Guide

Simple Diagnostic Questions



CoAP
RFC 7252

MQTT.ORG

http://

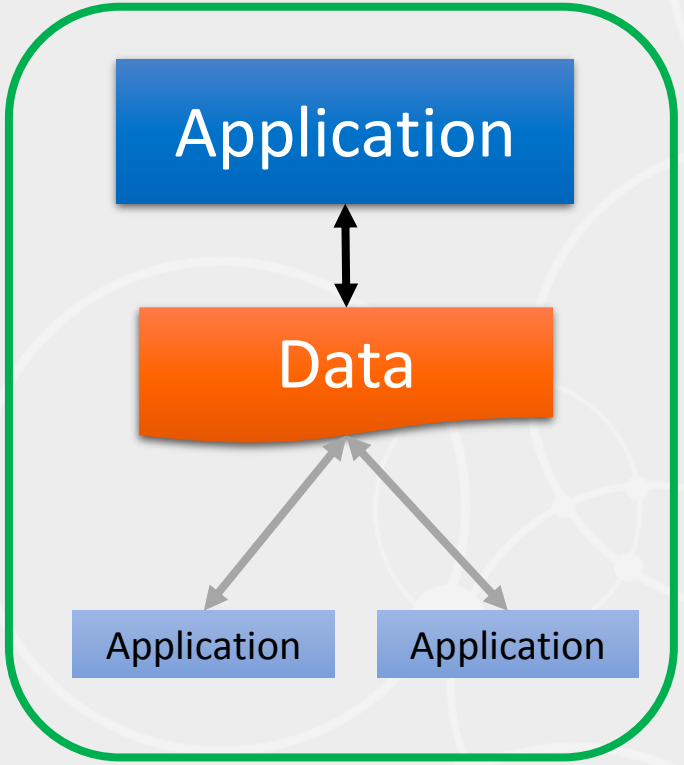
oneM2M

DDS

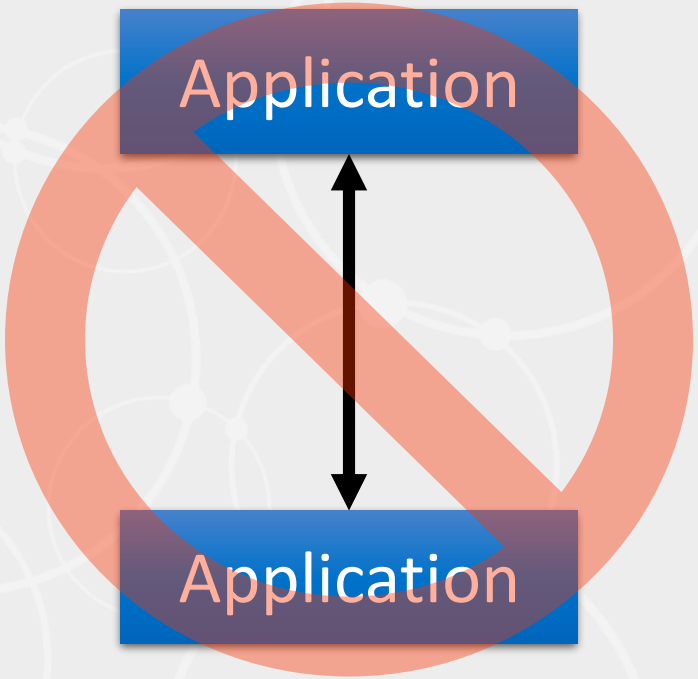
OPC UA

The DDS *Databus*

DDS is the standard that defines a databus

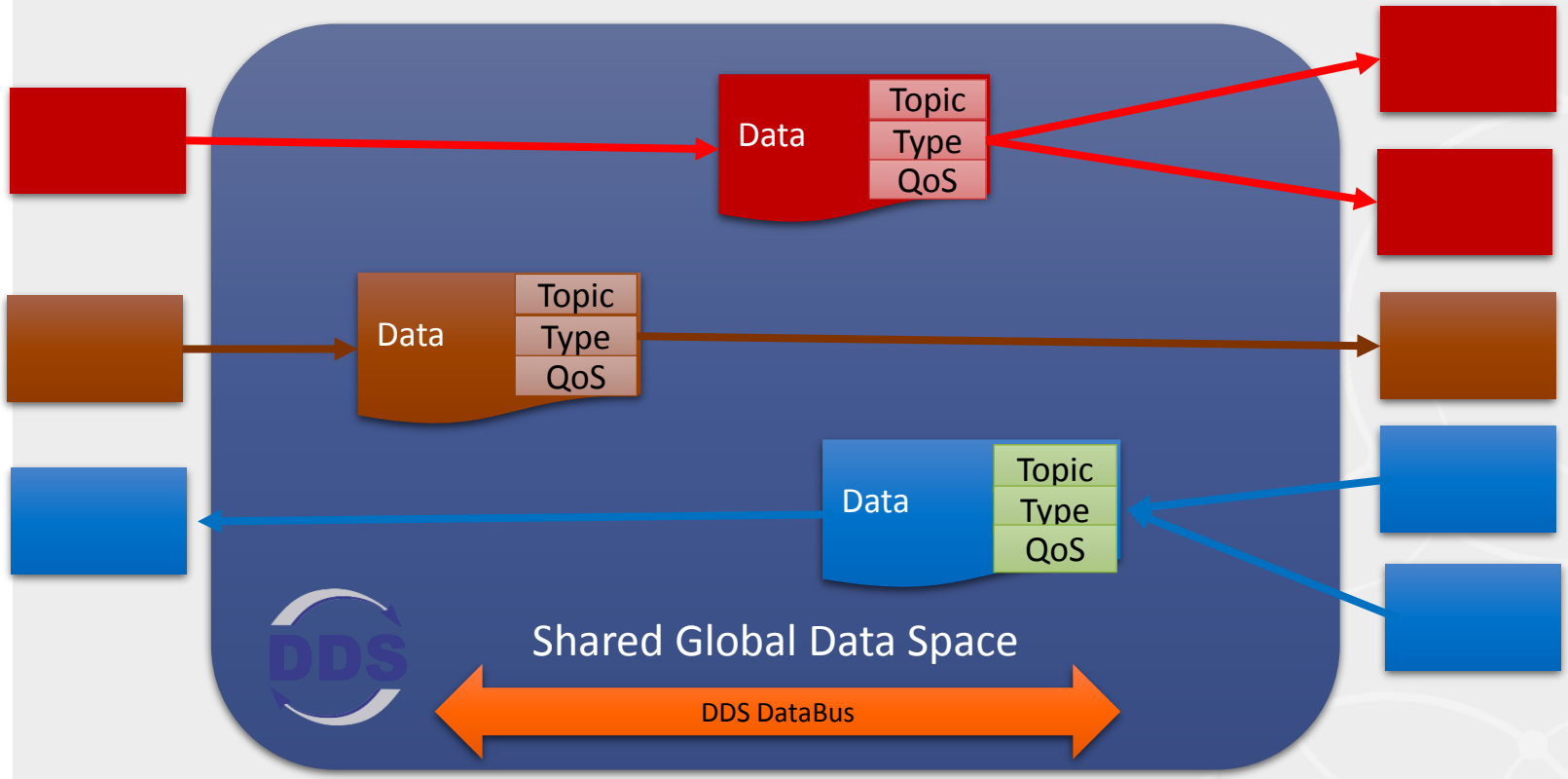


Data-centric technology connects applications to the data, not to each other



Message centric
Client/Server
Remote Objects
Publish-subscribe
SOA

DDS "Data Everywhere" Abstraction

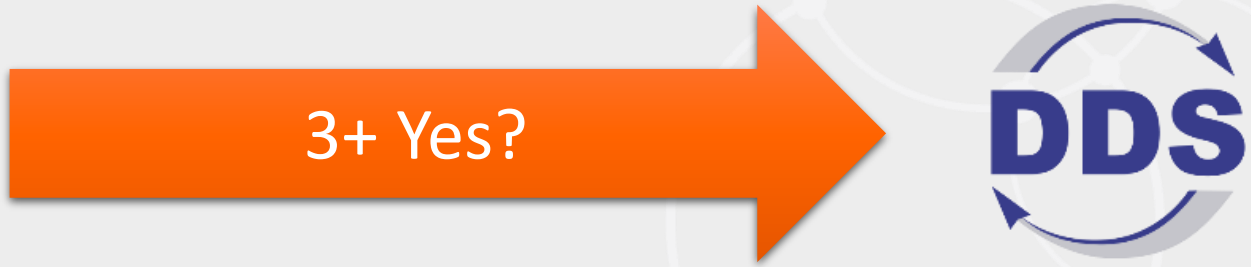


- Doesn't actually send all data…
- Every application gets everything it needs, when it needs it
  - Applications declare needs and capabilities
  - Databus delivers data
- Applications interface only to data
  - Every app speaks its own language
  - Databus maps language, CPU, OS, transport
- No servers
- Fast, reliable, scalable

Naturally parallel virtual shared memory

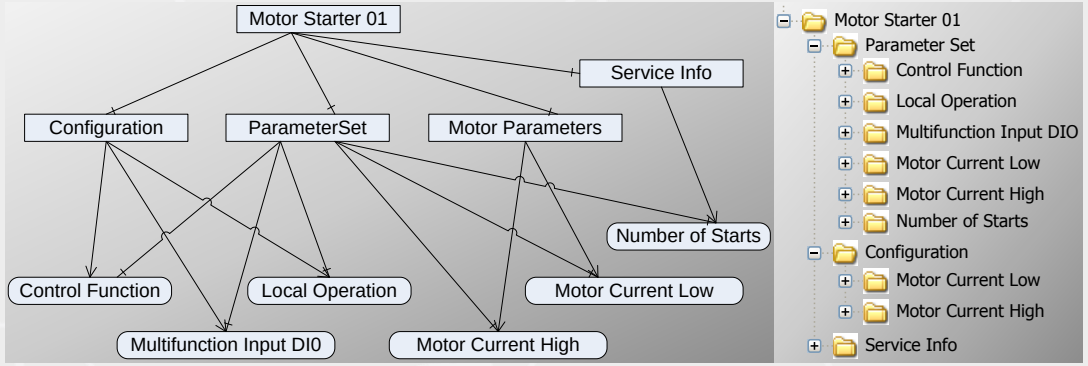
Choose DDS?

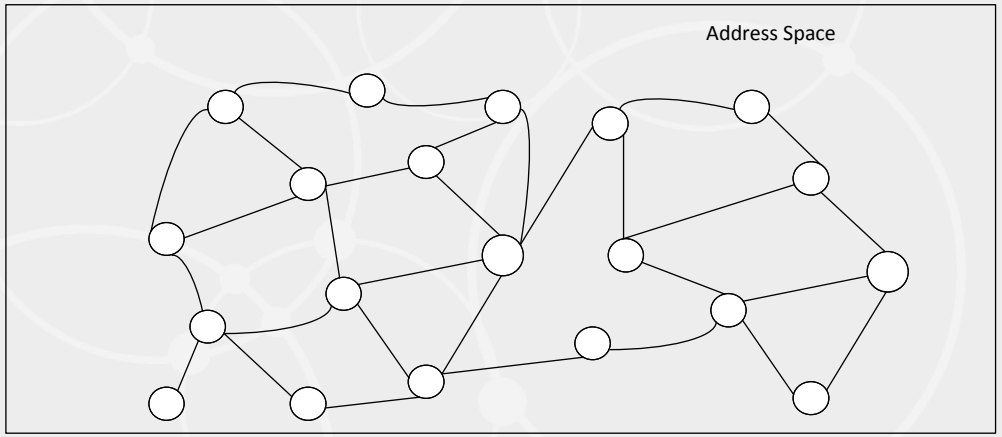
- Are there severe consequences of short-time failure (min/sec)?
- Have you said “millisecond” in the last 2 weeks?
- Do you have more than 10 software engineers?
- Does your data have many destinations?
- Are you building a next-generation IIoT design?



OPC UA

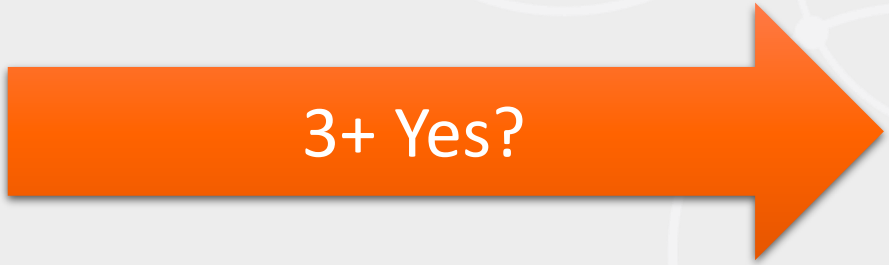
- Device-Centric Object-Oriented Framework
  - Device models for common devices
  - Integrate devices into workcells
  - Client-server architecture
  - Browsable address space
  - New simple UDP pub-sub





Choose OPC UA?

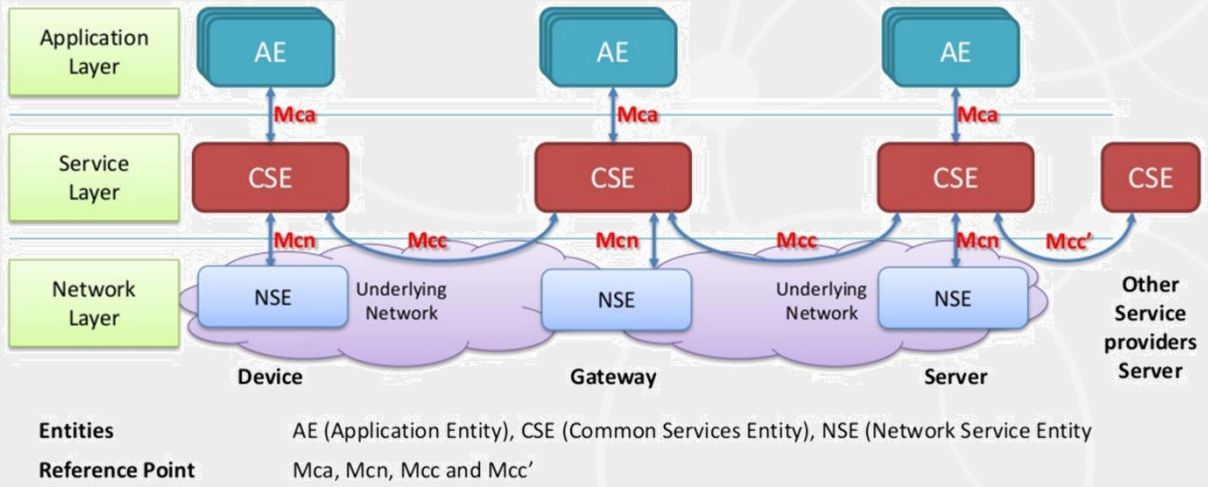
- Are you in in discrete manufacturing?
- Are you associated with the German Plattform Industrie 4.0?
- Are you building a device that will be integrated by industrial or control engineers and technicians, rather than software engineers?
- Will your product be used in different applications in different systems, as opposed to a single (type of) system where you control the architecture?
- Have you said the word “workcell” in the last two weeks?



OneM2M

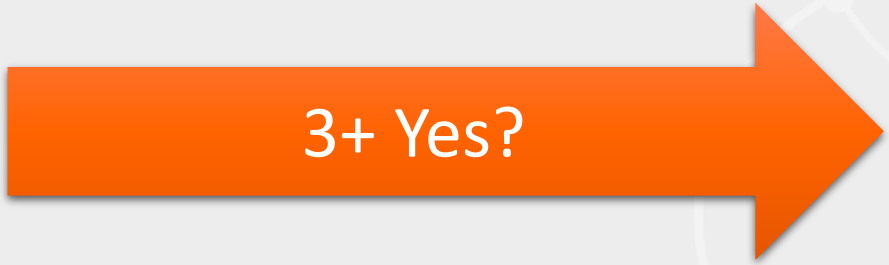
- Common Service Layer Architecture
  - Services provided by telco
  - Platform Tier (cloud) applications can seamlessly connect to diverse IoT devices over many protocols
- Targets home automation, large mobile systems

- Typical uses
  - Register and connect to devices and applications
  - Charge an account for service
  - Manage application and devices
  - Monitor systems



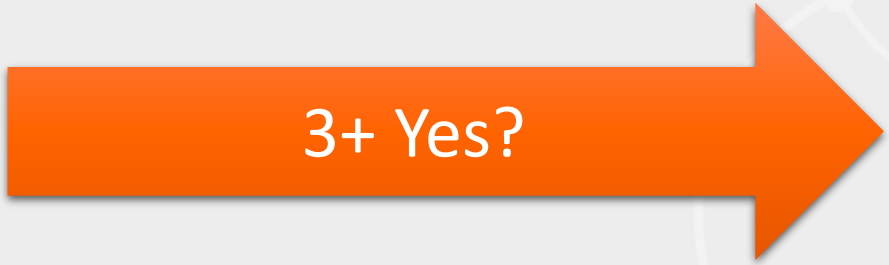
Choose OneM2M?

- Do you know what “ICT” stands for, and is that you?
- Is the cellular network your primary connection technology?
- Are your target applications largely composed of moving parts?
- Can the components of your system tolerate intermittent connections and loosely-controlled latencies?
- Will you use services provided by a communications provider such as a telco?



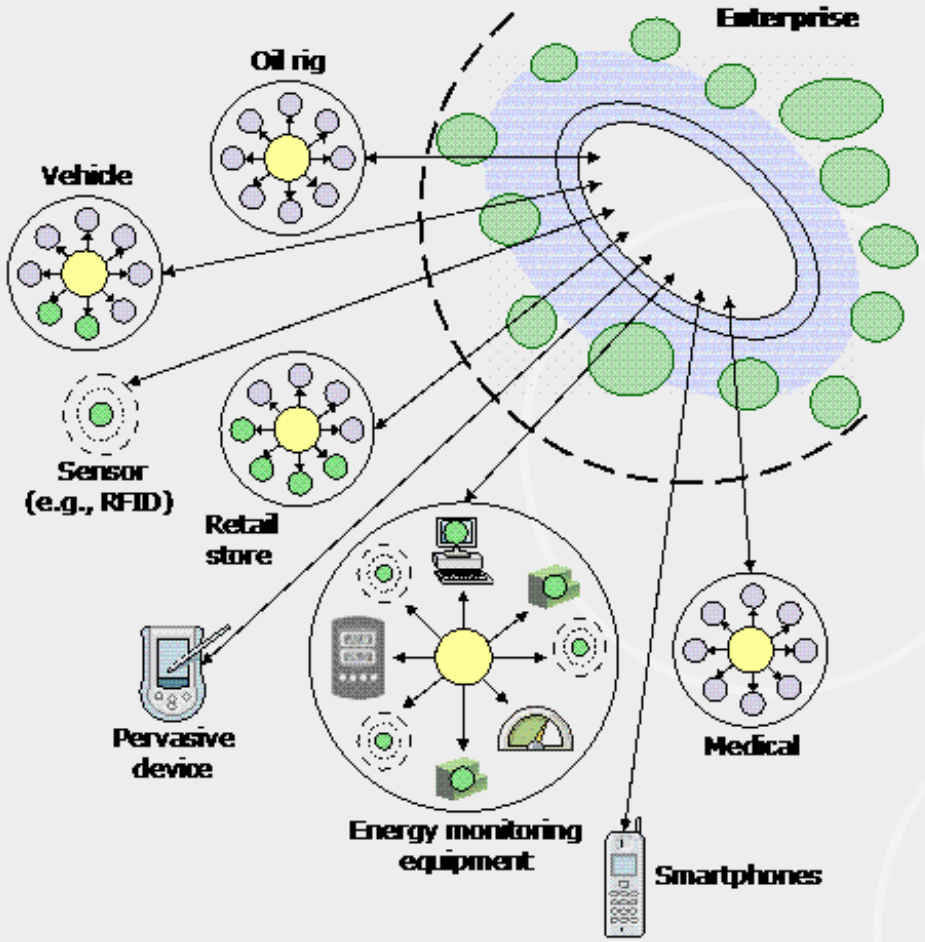
Choose RESTFul HTTP?

- Are you connecting independent devices to a single web service API?
- Are you building an HMI interface to an IoT device or service?
- Does your application only need to be fast enough for human interaction?
- Must your dataflow cross firewalls that you do not control?
- Is there no device-to-device communication?



http://

MQTT: Collect Device Data

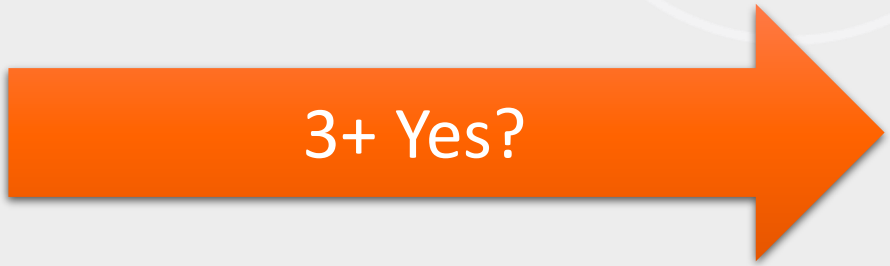


Message Queuing Telemetry Transport (MQTT)

Collect data from sensors For cloud

Choose MQTT?

- Do you think of your application as data collection?
- Is there little device-device communications?
- Is interoperability not a consideration?
- Do you have many small devices?
- Is software a minor challenge?



Choose CoAP?

- Are you running on a low-powered device?
- Does your device have limited ROM/RAM?
- Does your network have high package error rates and only need throughput in a range of 10-100 kbit/s?
- Do you need direct machine to machine communication, but not real-time?
- Is your goal to connect your devices to a RESTful HTTP system?

Are They Really That Different?

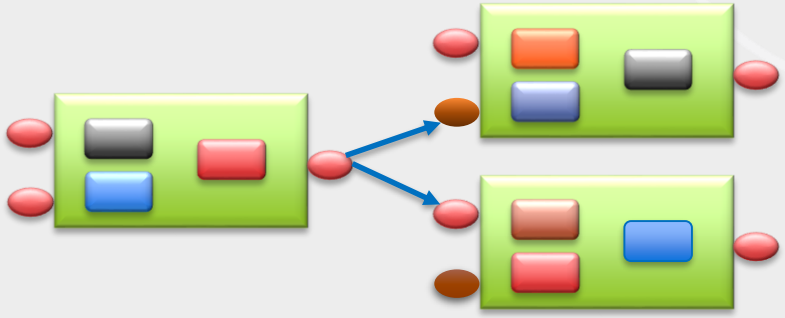
How to Choose?

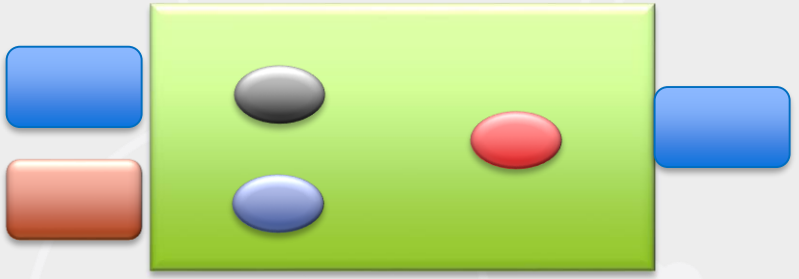
System Aspect	Example User	Approach	Standard
Software Integration & Autonomy	Software Architect integrating components	Data-centric	DDS
Device interchangeability	Device manufacturer selling devices to technicians	Device-centric	OPC-UA
Web & Mobile User I/F	App builder supporting back-end services	RESTful	Web services/HTTP
ICT integration	Wide-area wireless telecom integrator	Common services layer	oneM2M

Data Centric is the Opposite of OO

Object Oriented

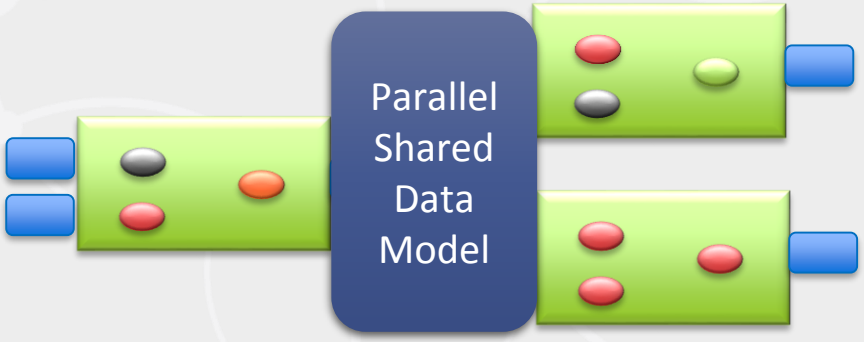
- Encapsulate data
- Expose methods
- Sequential execution



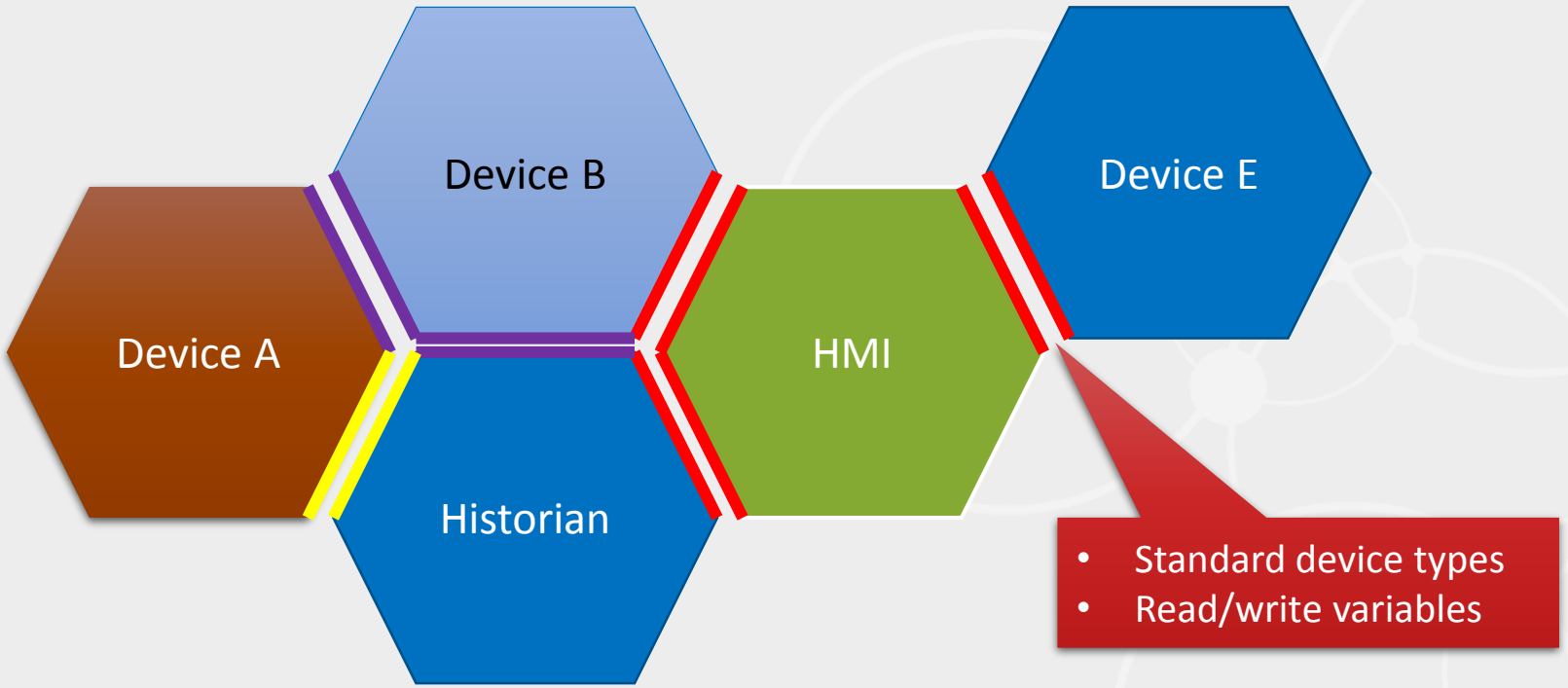


Data Centric

- Encapsulate methods
- Expose *data*
- Parallel updates



Device Integration



- Challenges
  - Interoperate between vendors
  - Assembled by engineers or technicians
- Components
  - Devices
  - Reusable software products (e.g. HMI)
- Interfaces
  - Standard device models
  - Dynamic address space rollup
  - Read/write variables

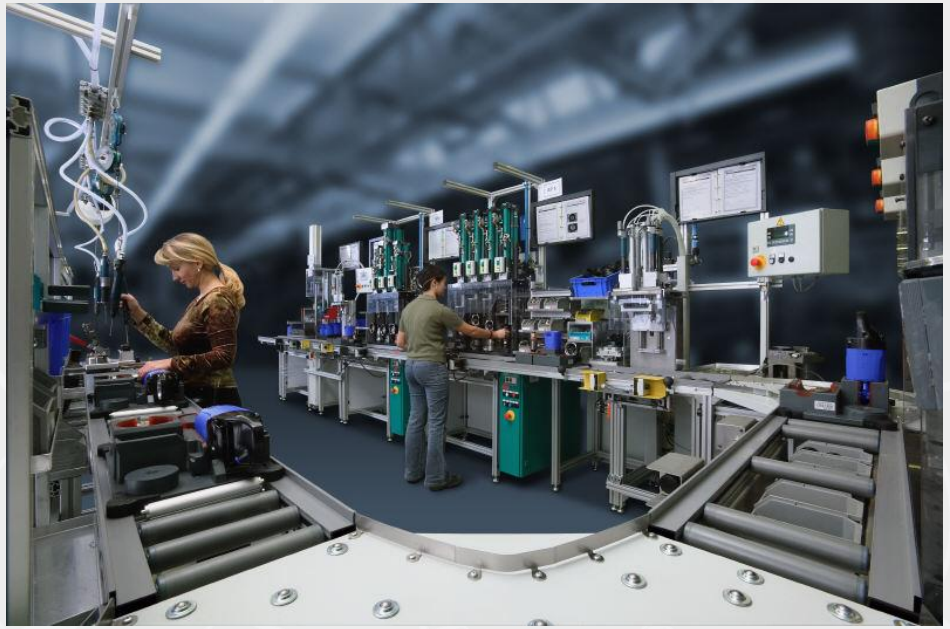
Software Integration

- Custom data model
- Dynamic types
- Dataflow control

- Challenges
  - Interface many software teams
  - Interoperate between software modules
  - Version matching
- Components
  - Custom software
  - AIs, libraries
- Interfaces
  - Global data abstraction
  - Dataflow control
  - Common system data model

Users and Applications are Very Different!

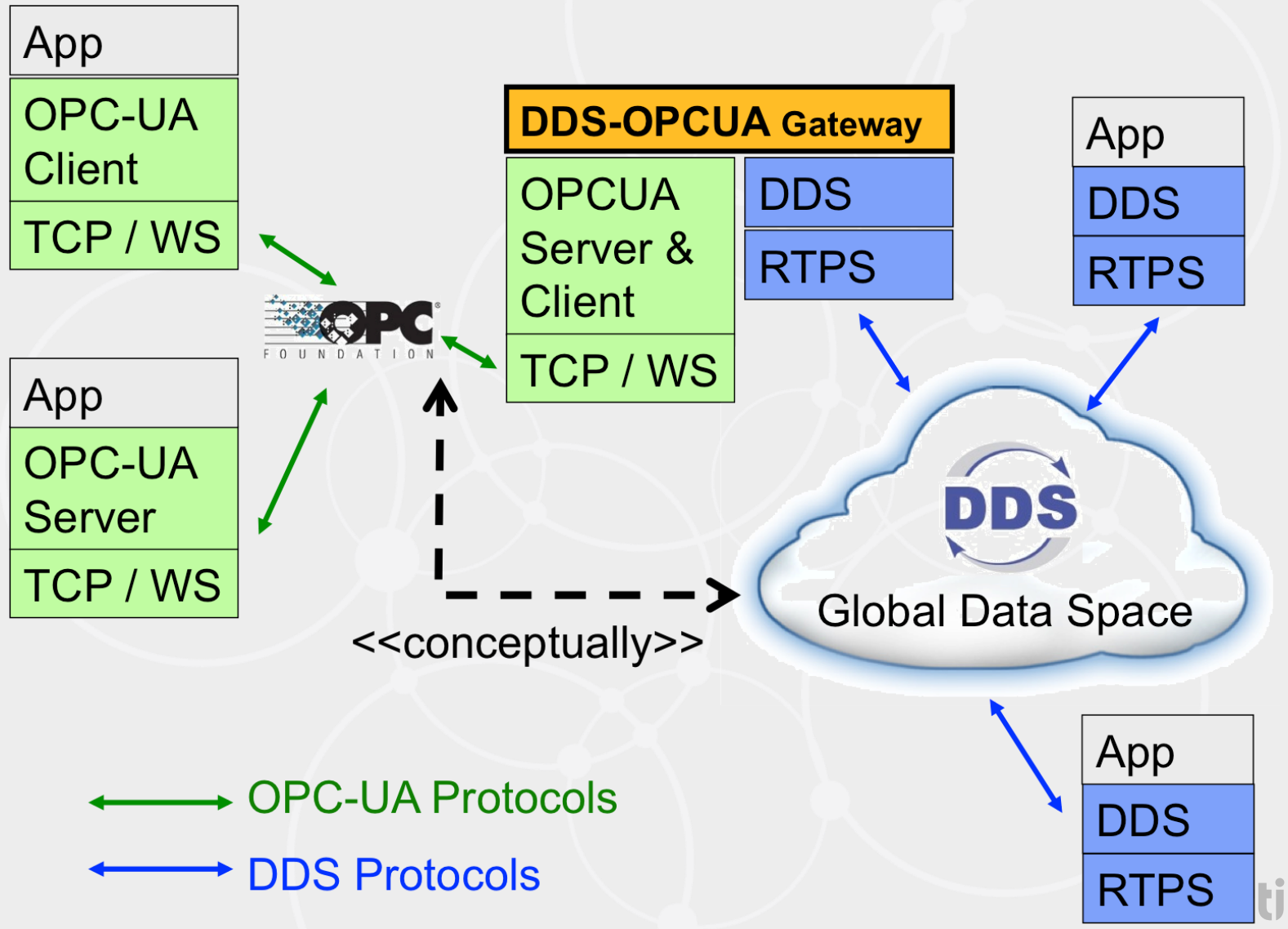
- You are a software architect. You:
- Manage & integrate software development teams
- Design & control architecture & data model
- Face challenges in defining software module interfaces, implementing redundancy, complex data flow



- You are a device manufacturer. You:
- Build a device for many applications
- Do not control the installation data architecture
- Face challenges of device vendor interoperability, users who are not software experts

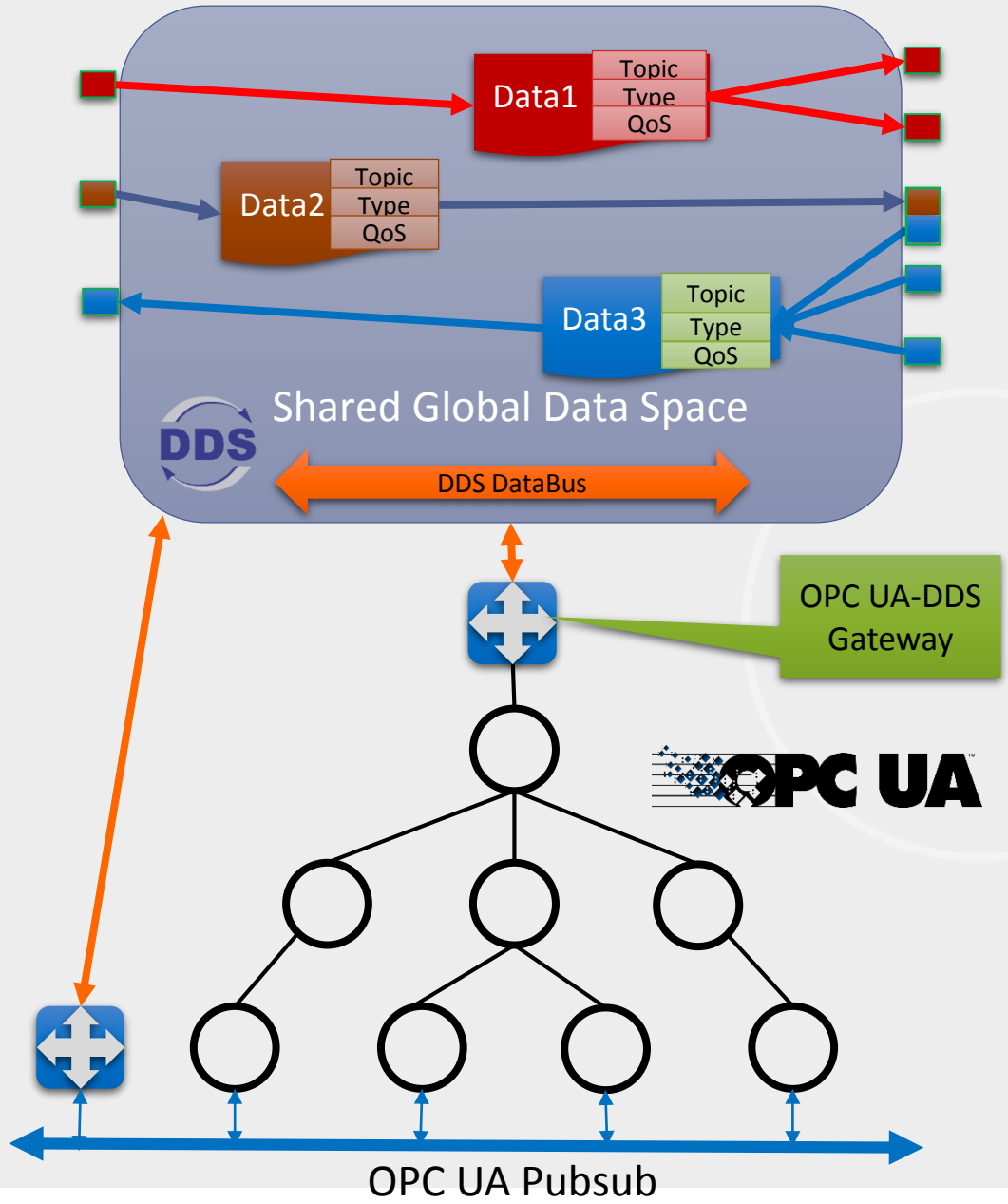
OPC-UA/DDS Gateway Standard

Provide transparent interoperability between *existing* DDS and OPC UA applications.



OMG mars/2018-02-01

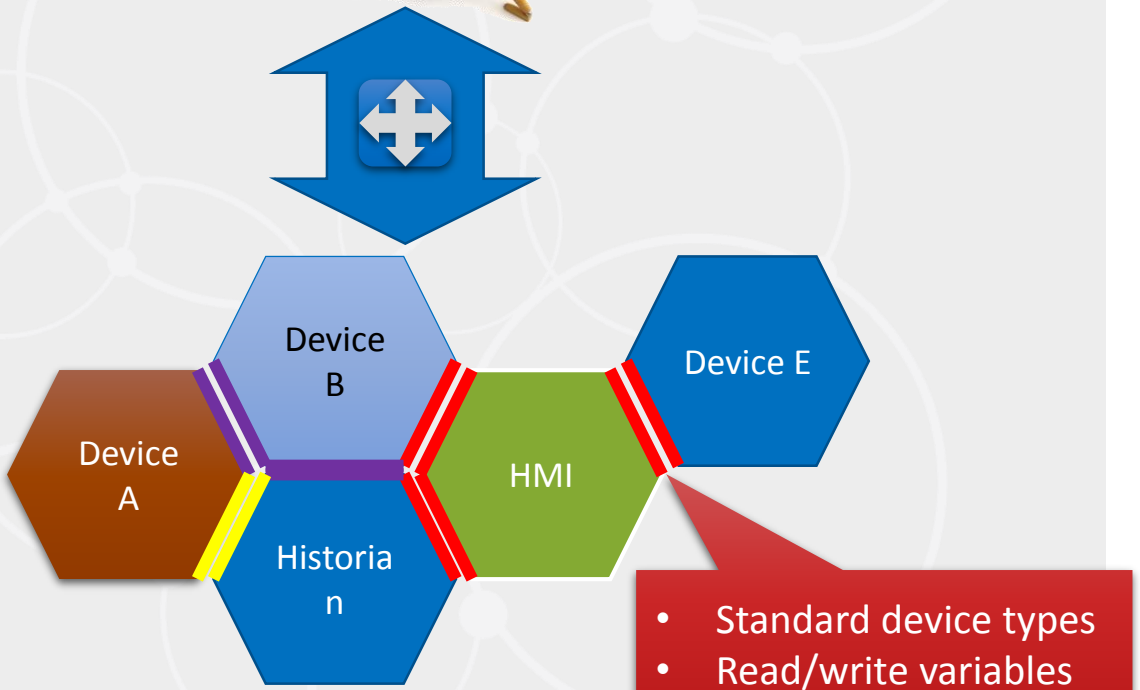
Conceptual Architecture



Integration Approach

- Custom data model
- Dynamic types
- Dataflow control

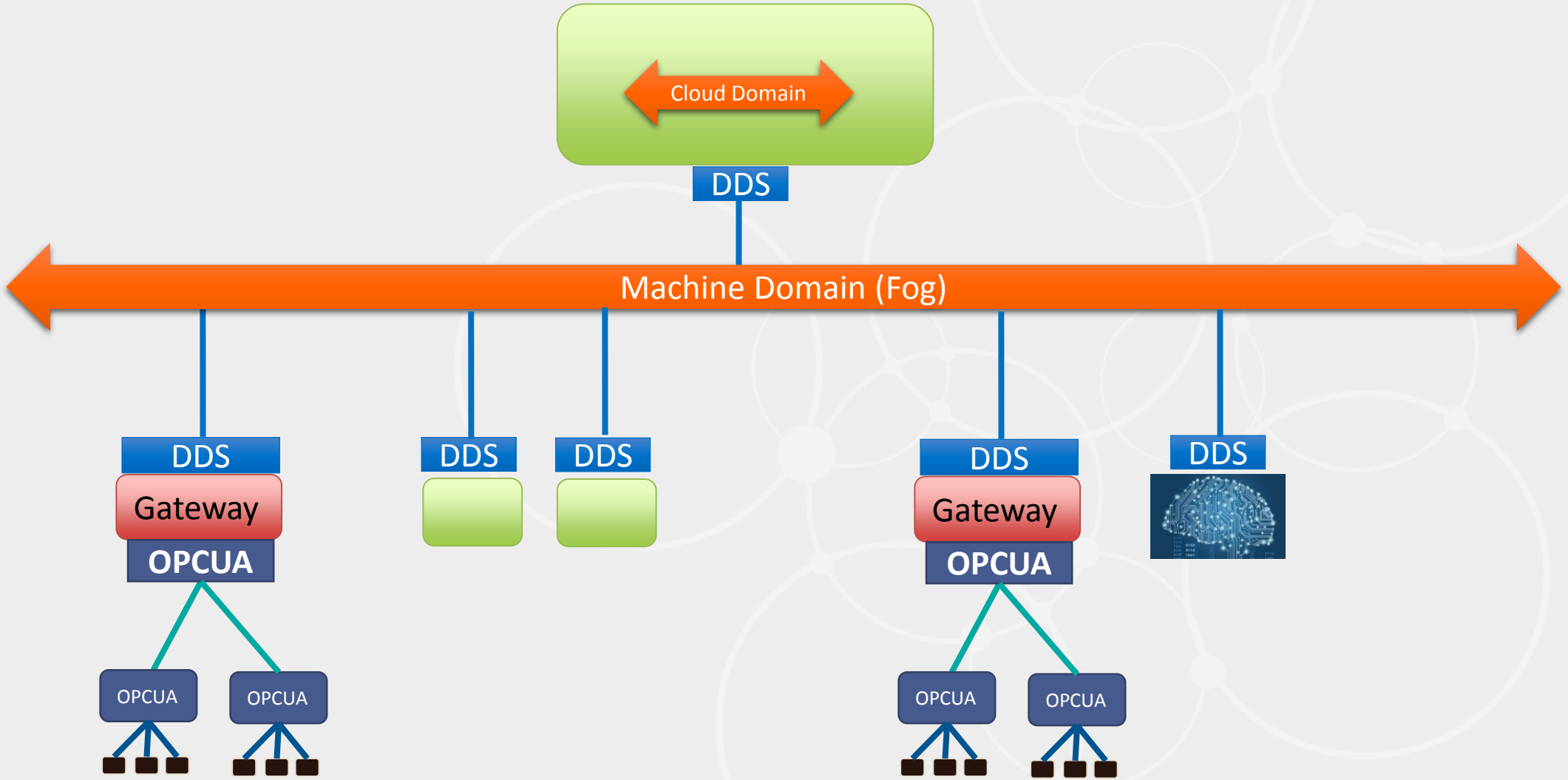
DDS **Software integration**



- Standard device types
- Read/write variables

OPC UA **Device Integration**

Core Connectivity Architecture Scales Edge to Cloud



What if Nothing Fits?

If Nothing Fits…

Education
- Colleges & Universities
- Conferences & Workshops
- Laboritories
- Publication
- Schools
- Trade Schools

Aerospace & Defense
- Air Force
- Arrmy
- Aviation
- Home Land Security
- Military
- Navy

Energy & Utilities
- Chemicals
- Electric
- Mining
- Oil & Gas
- Petro-Chemicals
- Power

Transportation
- Aeronautics
- Airport
- Cargo Handling
- Cruise Industry
- Fleet Management
- Freight Management
- Postal & Delivery Services
- Public Transportation
- Rail
- Roads
- Shipping
- Traffic Infrastructure
- Transportation
- Trucking
- Vehicle
- Wholesale & Distribution

Manufacturing
- Apparel
- Beverage & Tobacco Product
- Chemicals
- Computer & Electronic Products
- Electrical Equipment & Components
- Fabricated Metal Products
- Factory
- Food
- Furniture & Related Products
- Industrial Automation
- Leather & Allied Products
- Machinery
- Nonmetallic Mineral Products
- Paper
- Petroleum & Coal
- Plastics & Rubber Products
- Primary Metal Manufacturing
- Printing & Related Support Activities
- Textile Mills
- Textiles

Near Space & New Space
- Closed Loop Ecological Systems
- Closed Loop Living Systems
- Constellation Controllers
- Consumer Traffic Analytics
- Ecological Planning
- Environmental Monitoring
- Hyper-Local Agriculture
- Hyper-Local Construction
- Hyper-Spectral Imaging
- In-Flight Satelite Servicing
- On-Site Materials Analytics and Inventory
- On-Site Materials Optimization
- Parametric City Planning
- Parametric Construction Planning
- Remote Maintenance and Diagnostics
- Space Based Planning
- Weather Pattern Analytics

Envi...
- Air Pollution Control
- Biodiversity
- Eco-construction
- Environmental Monitoring & Instrumentation
- Environmental Research & Development
- Heat & Energy Saving and Management
- Metrology
- Nature Protection
- Noise & Vibration Control
- Oceanography
- Recycled Materials
- Remediation & Clean Up of Soil & Groundwater
- Renewable Energy Production
- Waste Management & Recycling
- Waste Water Treatment
- Water Supply

Consumer & Home
- Automotive
- Commercial Cooking
- Consumer Products
- Day Care
- Elder Care
- Entertainment
- Food and Beverage
- Food Trucks
- Grocery
- Home Products
- Hospitality
- Pet Care
- Pharmacies
- Photography
- Recreation Services
- Restaurants
- Sporting Events
- Street Vendors
- Tourism
- Travel

Agriculture

Retail
- Apparel Retailers
- ...oadline Retailers
- ...ug Retailers
- ...od Retailers & ...holesalers
- ...me Improvement ...tailers
- ...ecialized Consumer ...rvices
- ...ecialty Retailers

Buildings & Facilities
- Apartments
- Building & Construction
- Building Maintenance
- Building Security
- Commercial Buildings
- Construction
- Engineering
- Home
- Housing Authorities
- HVAC
- Office
- Real Estate

Media & Communication
- Cable Providers
- Computers
- Entertainment
- Global Media
- Phones
- Satellite TV
- Telecommunications Carriers
- Televisions
- Video Recorders
- Wireless Services

Finance & Banking
- Accounting Systems
- ATM Systems
- Credit Card Systems
- Point of Sales
- Retail Banking

- Public Safety
- Public Security
- Surveillance
- Transportation
- Waste Management
- Water

- Life Sciences
- Medical Offices
- Medical Therapy
- Pharma
- Pharmacies

- General Mining
- Gold
- Iron & Steel
- Nonferrous Metals
- Platinum & Precious Metals

The IIoT is Big. Really big.

You may think you can pick DDS or OPC UA or MQTT or OneM2M and it won't really matter.

It does matter
Understand the differences
Choose the best fit

Where Can I Learn More?

RTI & The Industrial IoT

- RTI is the largest embedded middleware vendor
- 1000+ designs, many real-world programs across industries
- Full DDS, tools, services, support, secure & certified versions

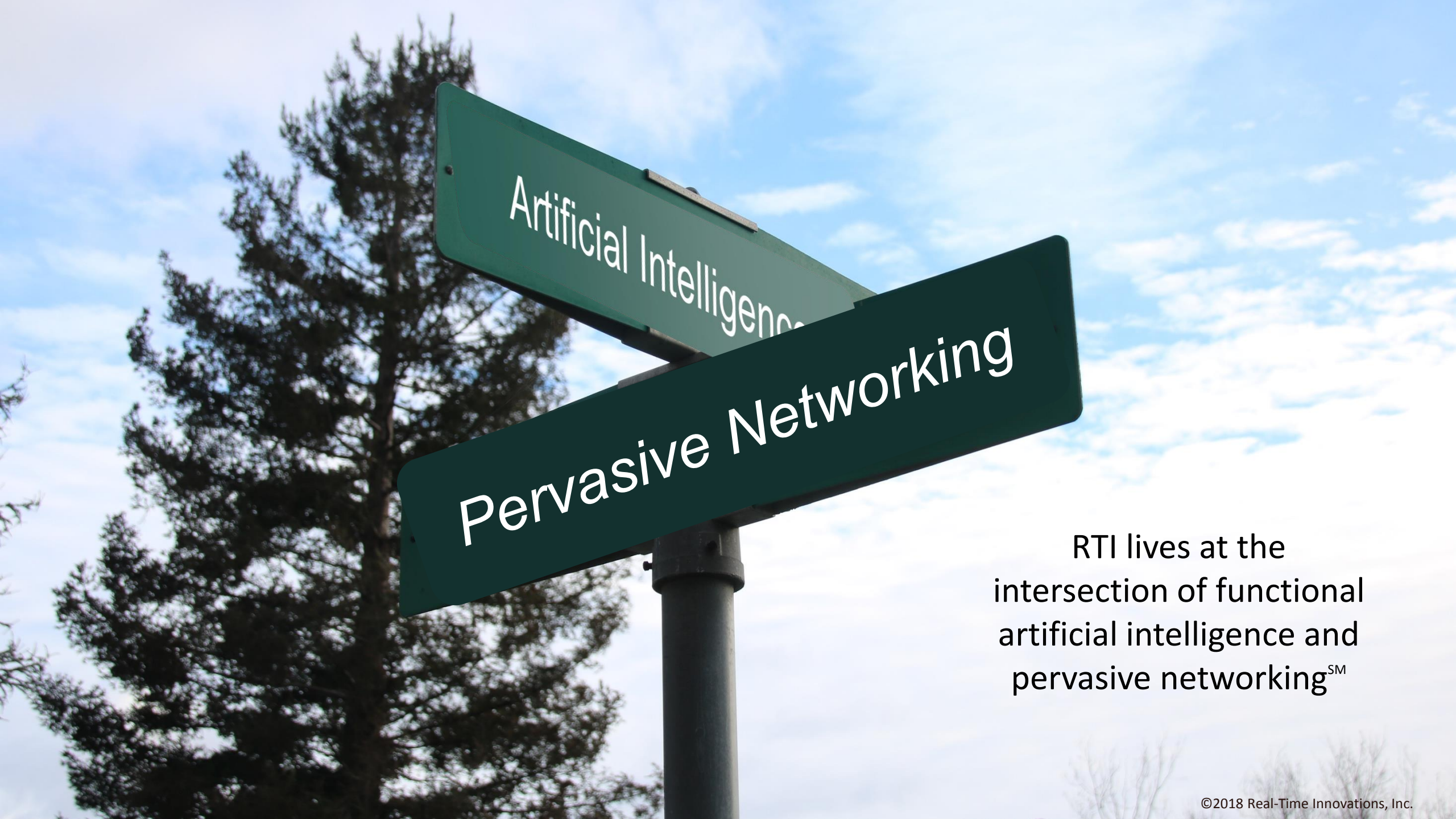









DDS
OSA
AUTOSAR
ROS
MD PnP
Getting connected for patient safety
OpenFog
industrial internet CONSORTIUM
OMG
OBJECT MANAGEMENT GROUP
FACE
Future Airborne Capability Environment
THE OPEN GROUP
OPEN PROCESS AUTOMATION™ FORUM
Smart Electric Power Alliance
ICE Alliance
Integrating Clinical Environments
AVNU
rti

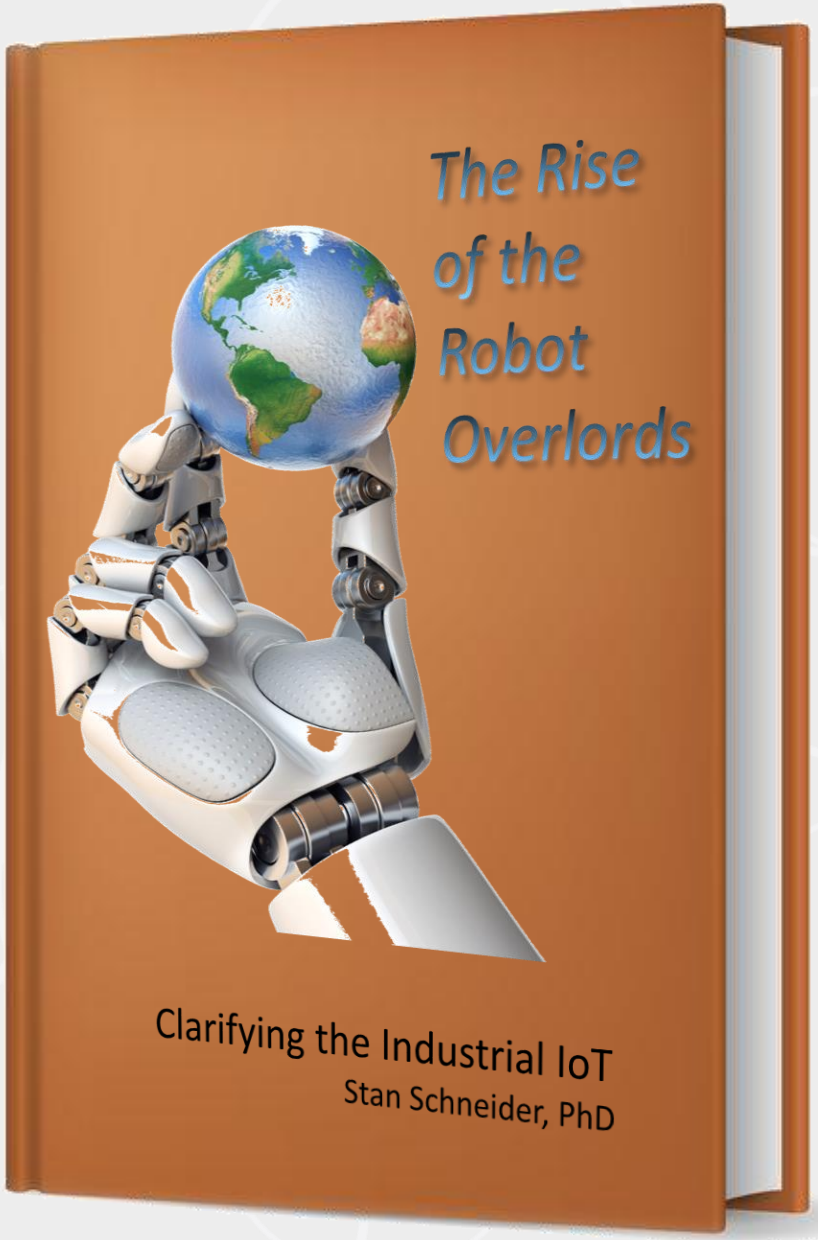


RTI lives at the intersection of functional artificial intelligence and pervasive networking[SM]

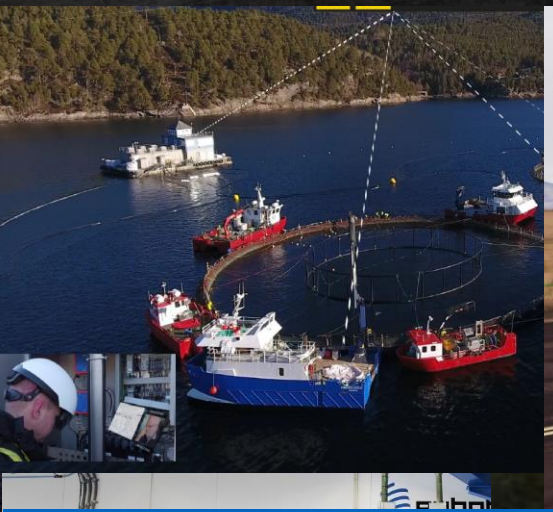
Further Information

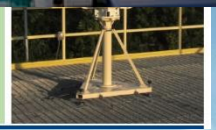
- Industrial Internet Connectivity Framework (IICF): www.iiconsortium.org/IICF.htm
- Guide to IIoT Connectivity: http://www.iiconsortium.org/journal-of-innovation.htm

- eBook:
  - www.rti.com/resources /eBooks



RTI Applications Span the IIoT





Connect!!

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  - IIC Steering Committee Vice Chair
    - Past Chair, Testbed Subcommittee
    - Co-chair Ecosystem Task Group
  - Advisory Board, IoT SWC
  - Top-10 Global IIoT Influencer
  - PhD, EE/CS, Stanford

Audience Q & A

Stan Schneider, Ph.D.
CEO,
Real-Time Innovations, Inc. (RTI)

OpenSystems media

Thanks for joining us

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