



Industrial Internet Connectivity Framework (IICF)

IIC Liaison Workshop with oneM2M

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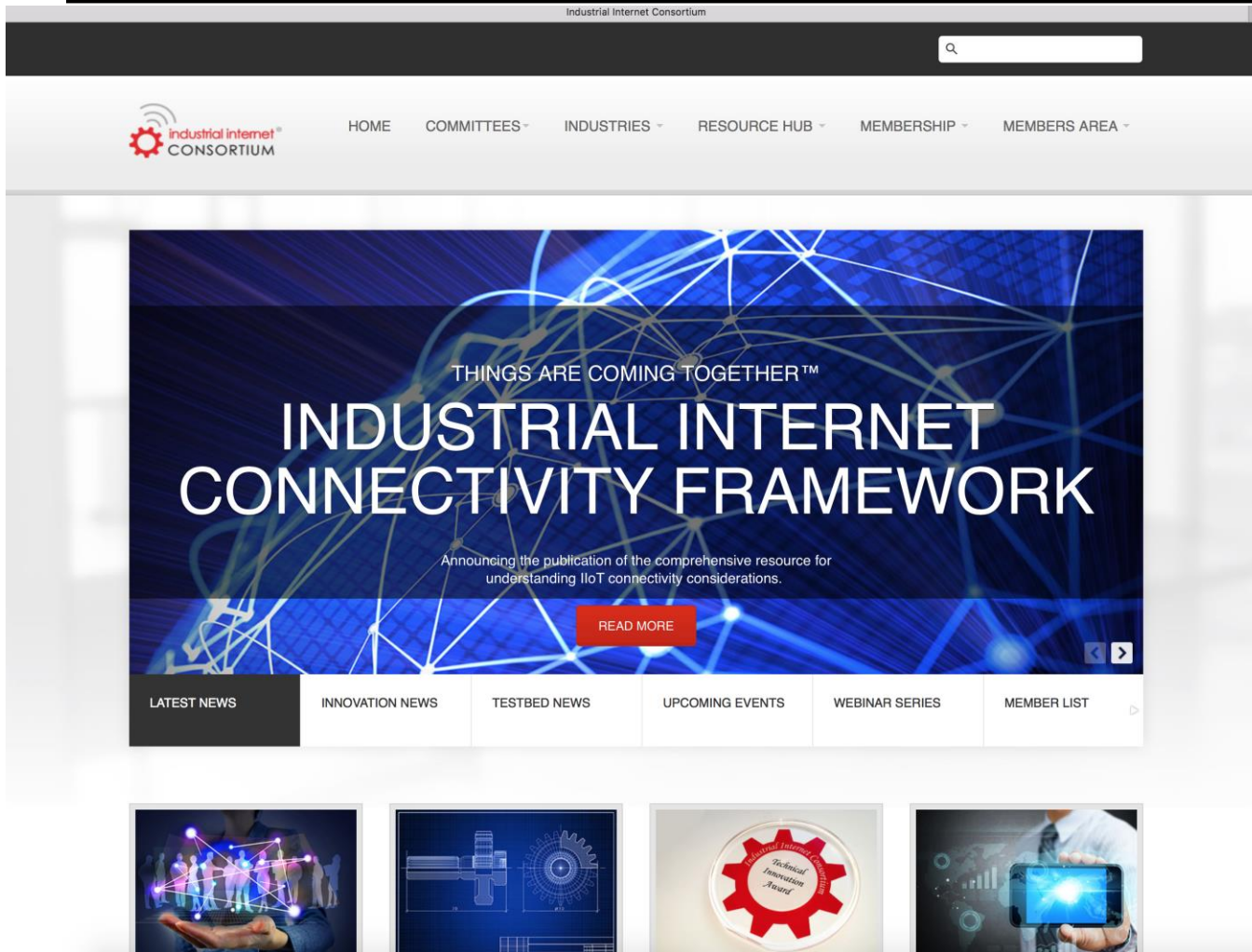
2018 Feb 08

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Industrial Internet Connectivity Framework (IICF)

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

Comprehensive
treatment of
Connectivity

as a means of

Building Interoperable
IIoT systems

DOWNLOAD PDF

IICF FAQ



IICF : A Roadmap for IoT Practitioners & System Architects



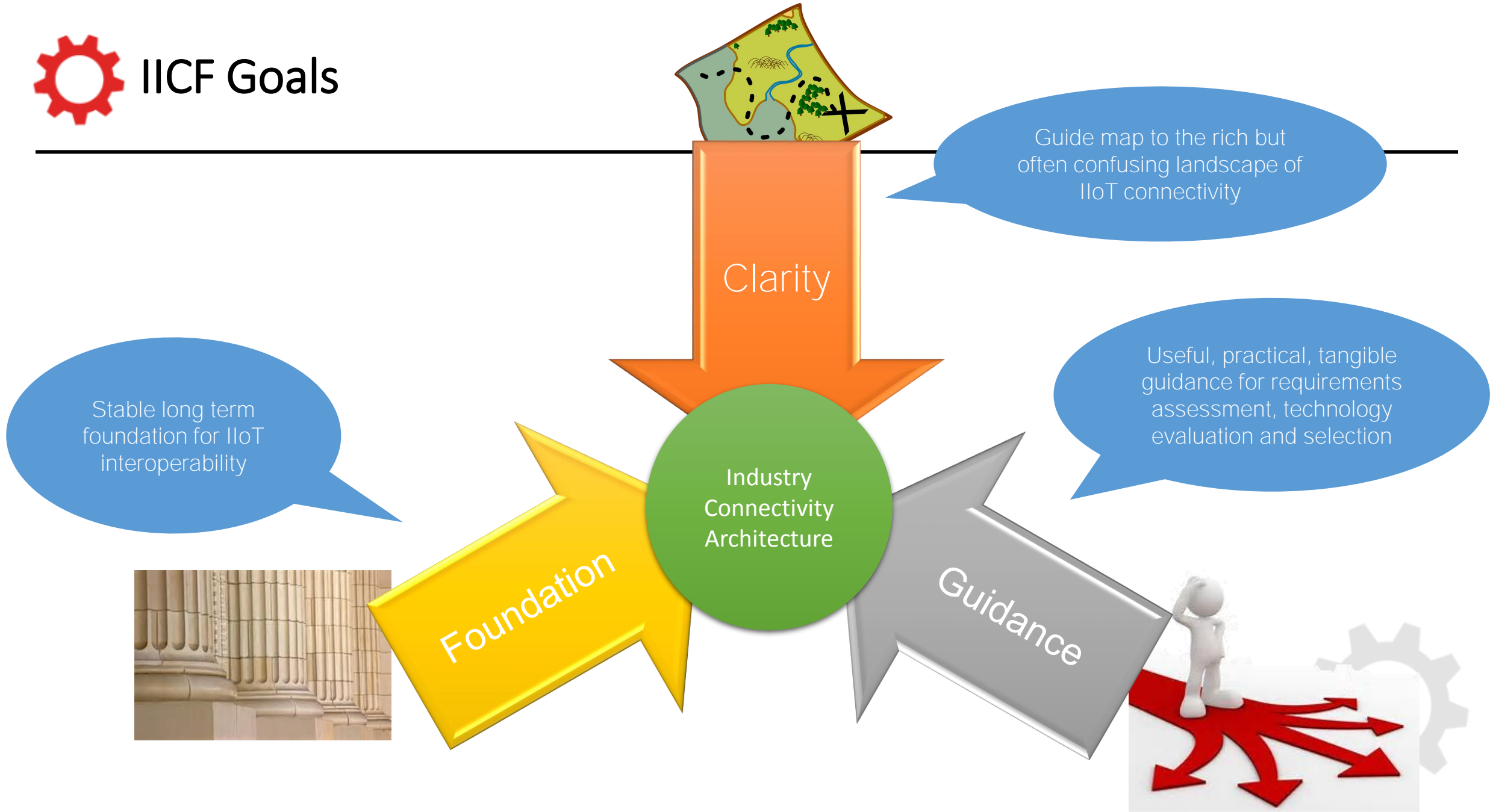
Rich Landscape of Connectivity

Guide Map

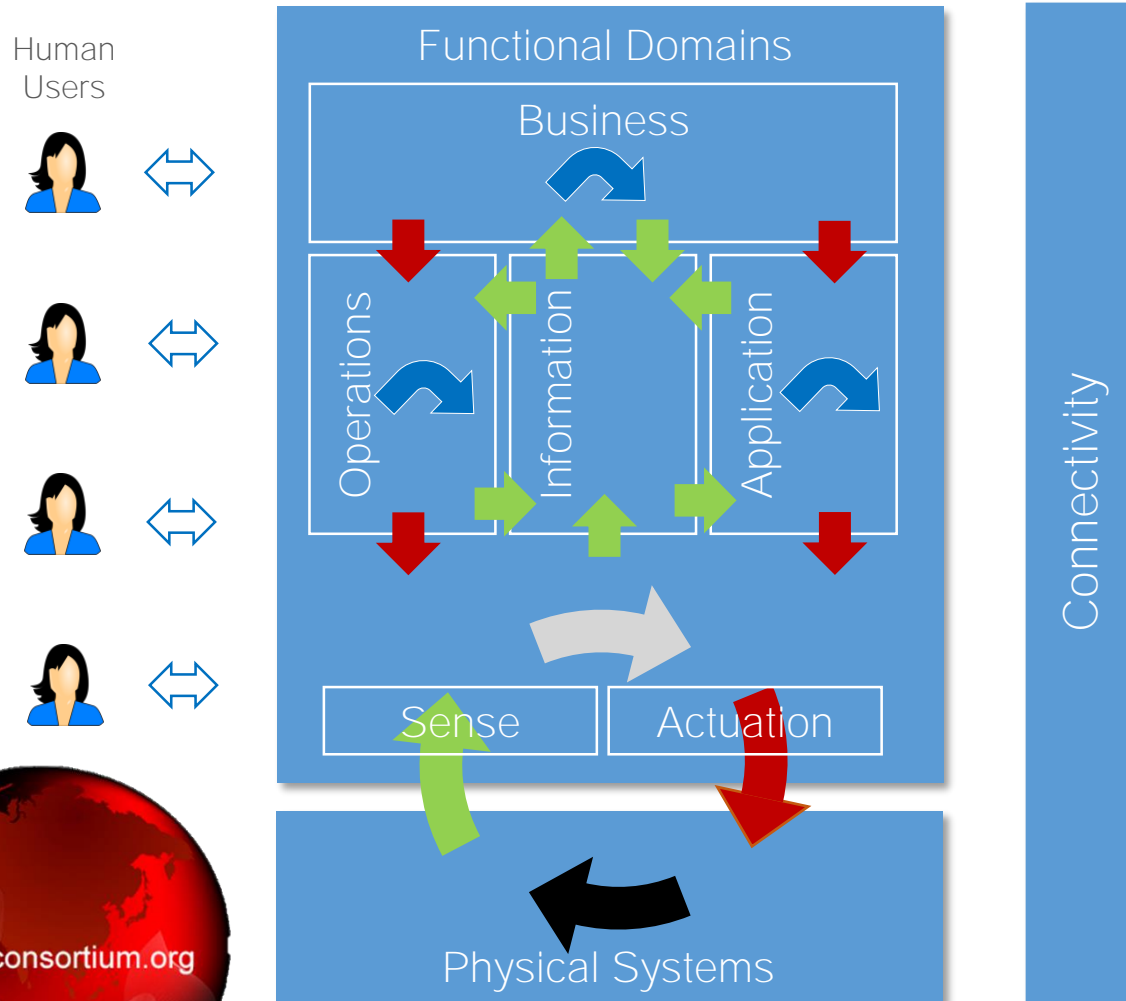
- What is the role of connectivity in an IIoT architecture?
- What connectivity layers does an IIoT system need, and what are each layer's core functions, considerations and trade-offs?
- How can communication extend from a generic IIoT design to participants using a domain-specific connectivity technology?
- What must core connectivity standards provide?
- How to categorize and evaluate a given connectivity technology?
- How to assess suitability of a connectivity technology against system requirements?
- How to choose the right core connectivity standard for a problem domain?



IICF Goals



IIoT Connectivity Function



Green Arrows: Data/Information Flows
Grey/White Arrows: Decision Flows
Red Arrows: Command/Request Flows

Ability to exchange information among endpoints in a system of interest

- sensor updates
- commands
- alarms
- events
- status changes
- configuration updates
- ...





Levels of interoperability

Composability

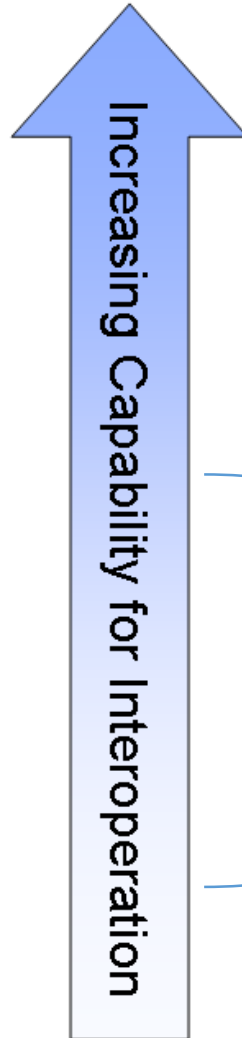
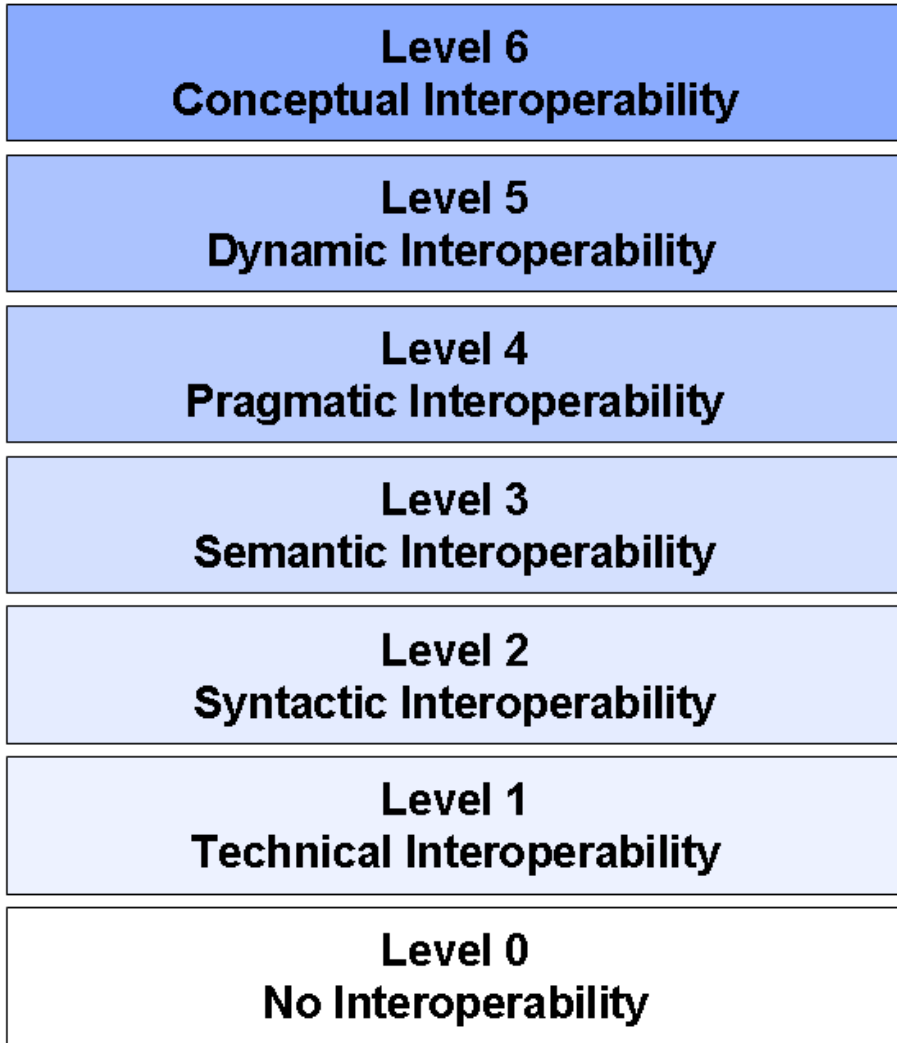
Modeling /
Abstraction

Interoperability

Simulation /
Implementation

Integrability

Network /
Connectivity



Industrial Internet (IIoT)



Horizontal stack
that can span
across verticals!

Industrial Internet Connectivity Stack



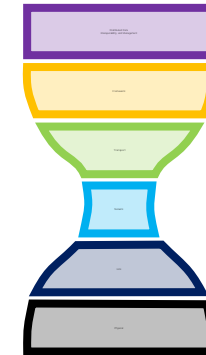
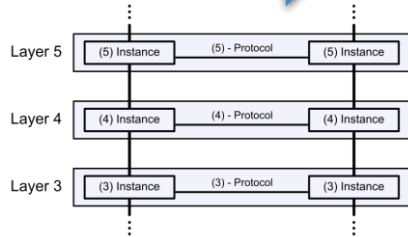
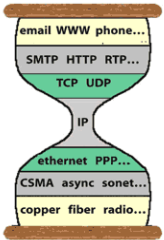
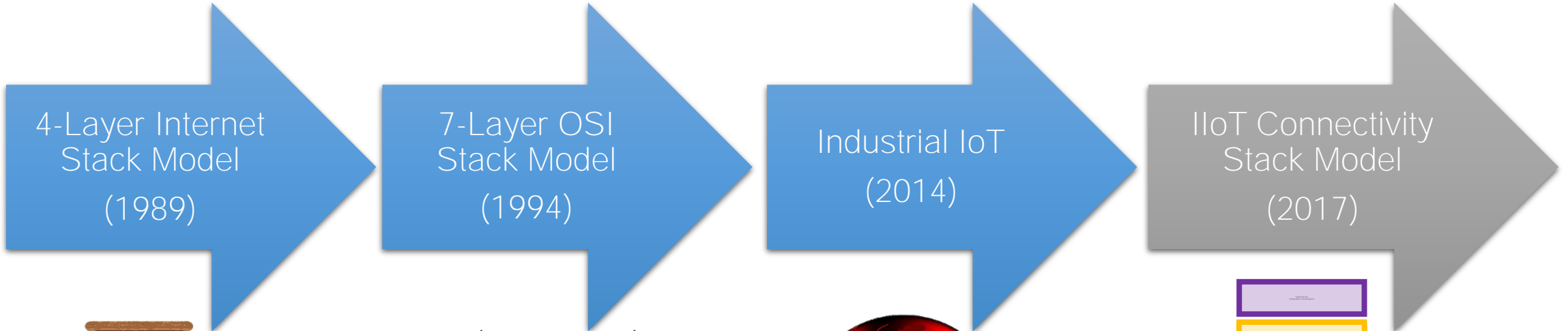
Layers

Core Functions

Typical Considerations



Evolution of the IIoT Connectivity Stack

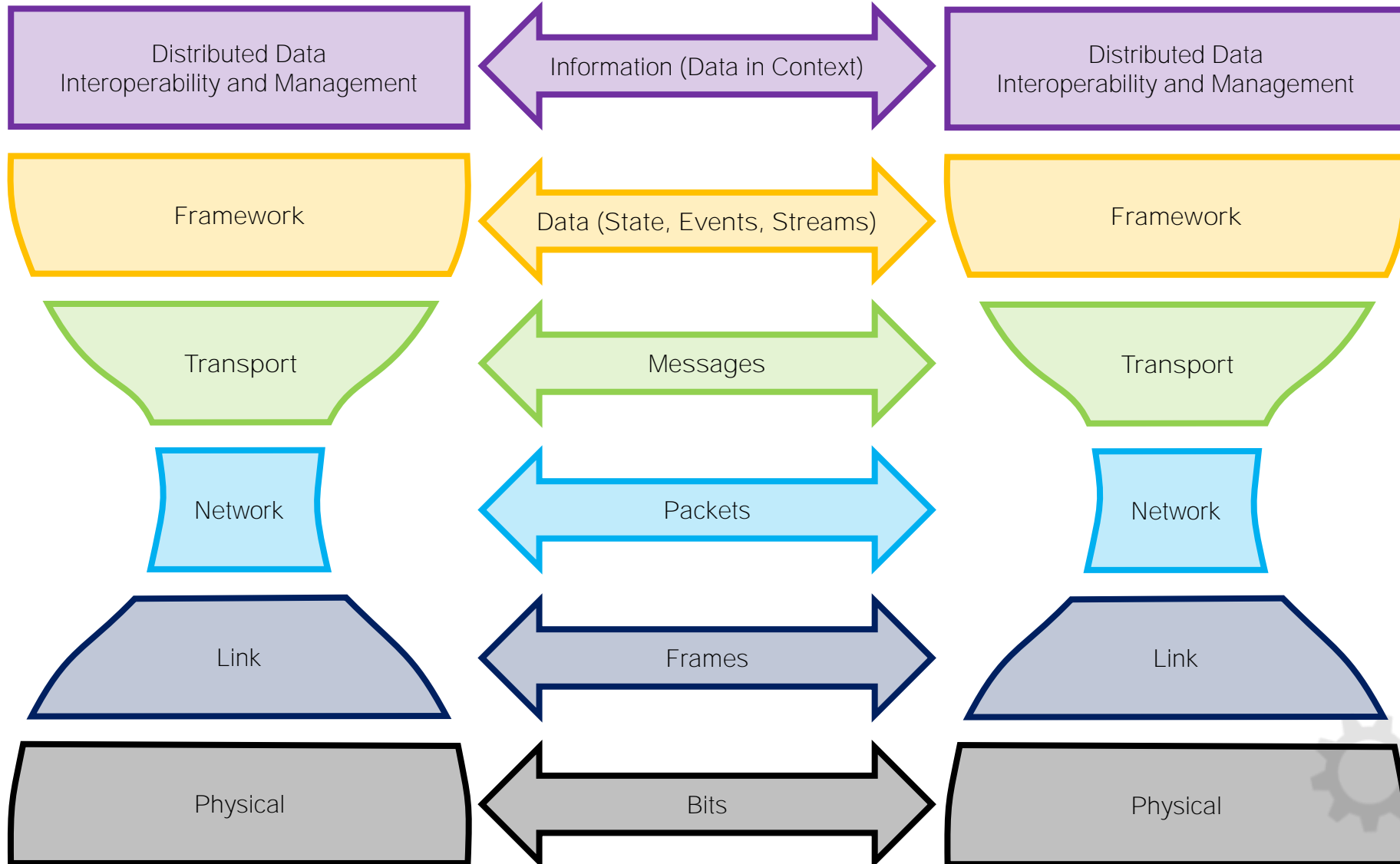




Industrial Internet Connectivity Stack

Participant X

Participant Y

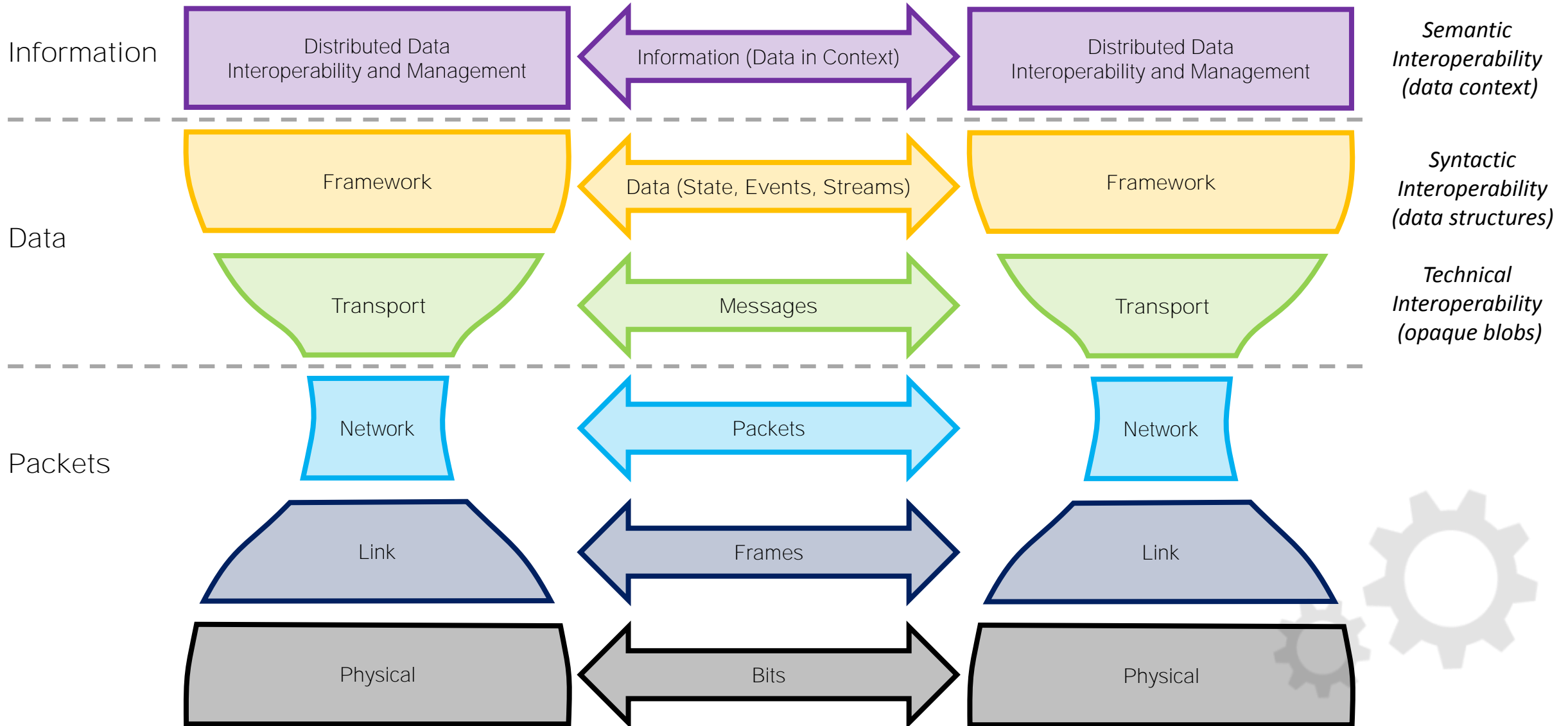




Industrial Internet Connectivity Stack

Participant X

Participant Y

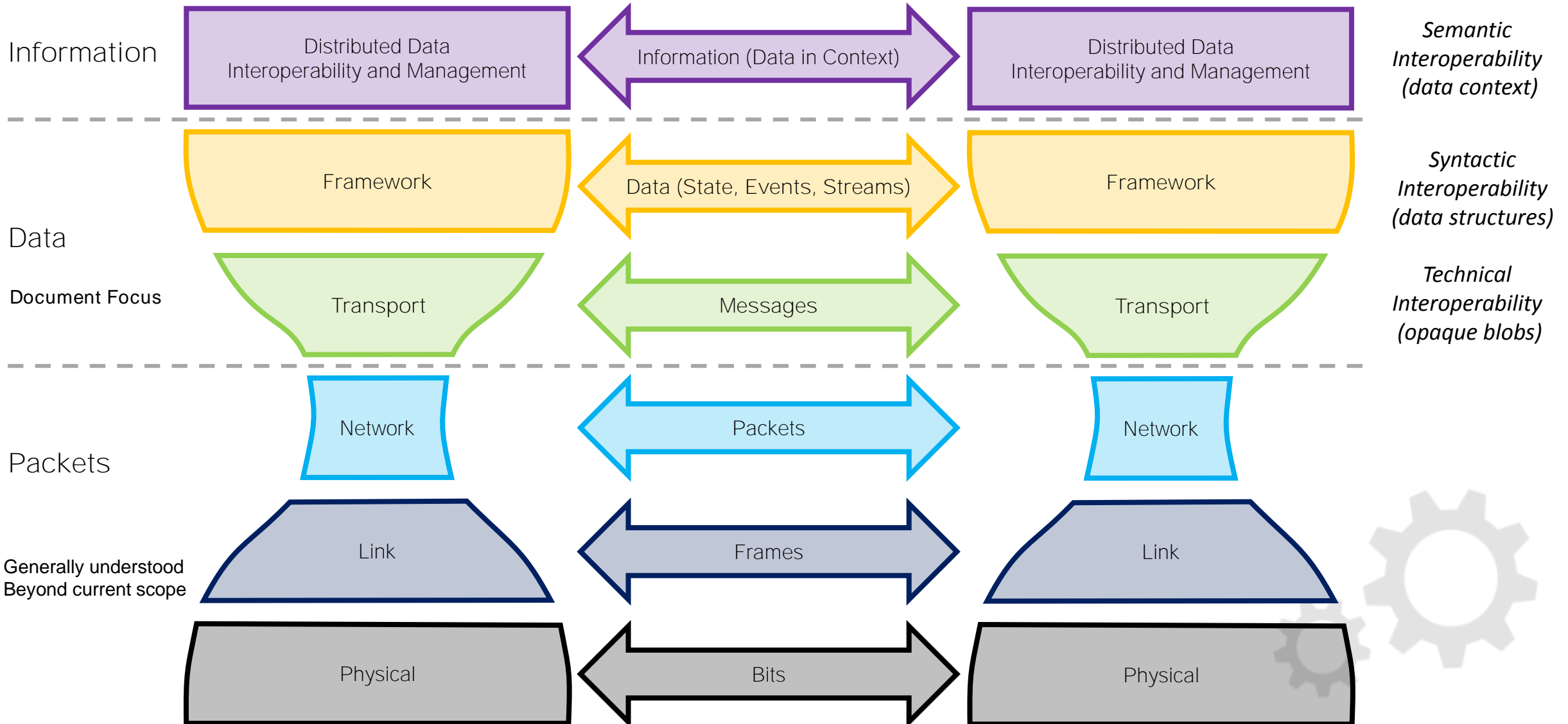




IICF Document Focus

Participant X

Participant Y



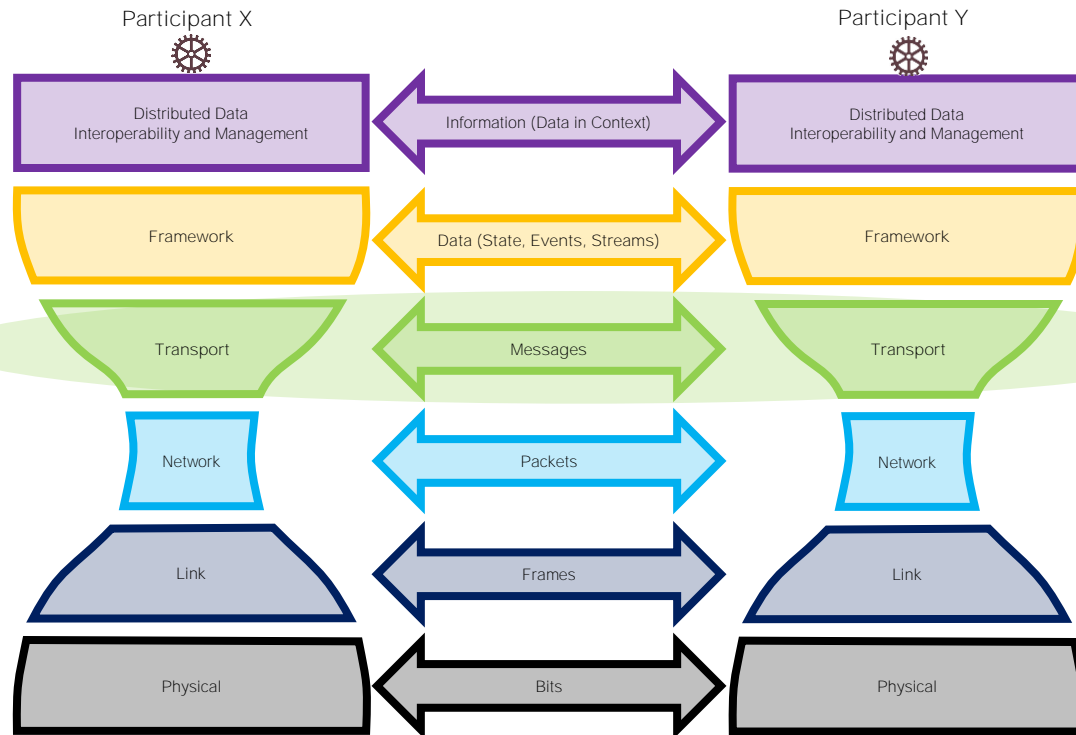


Connectivity Transport Layer

Core Functions

Typical Considerations

Connectivity Transport Layer



Above: Technical Interoperability

- Share byte sequences
- Opaque data

Below: Byte protocol

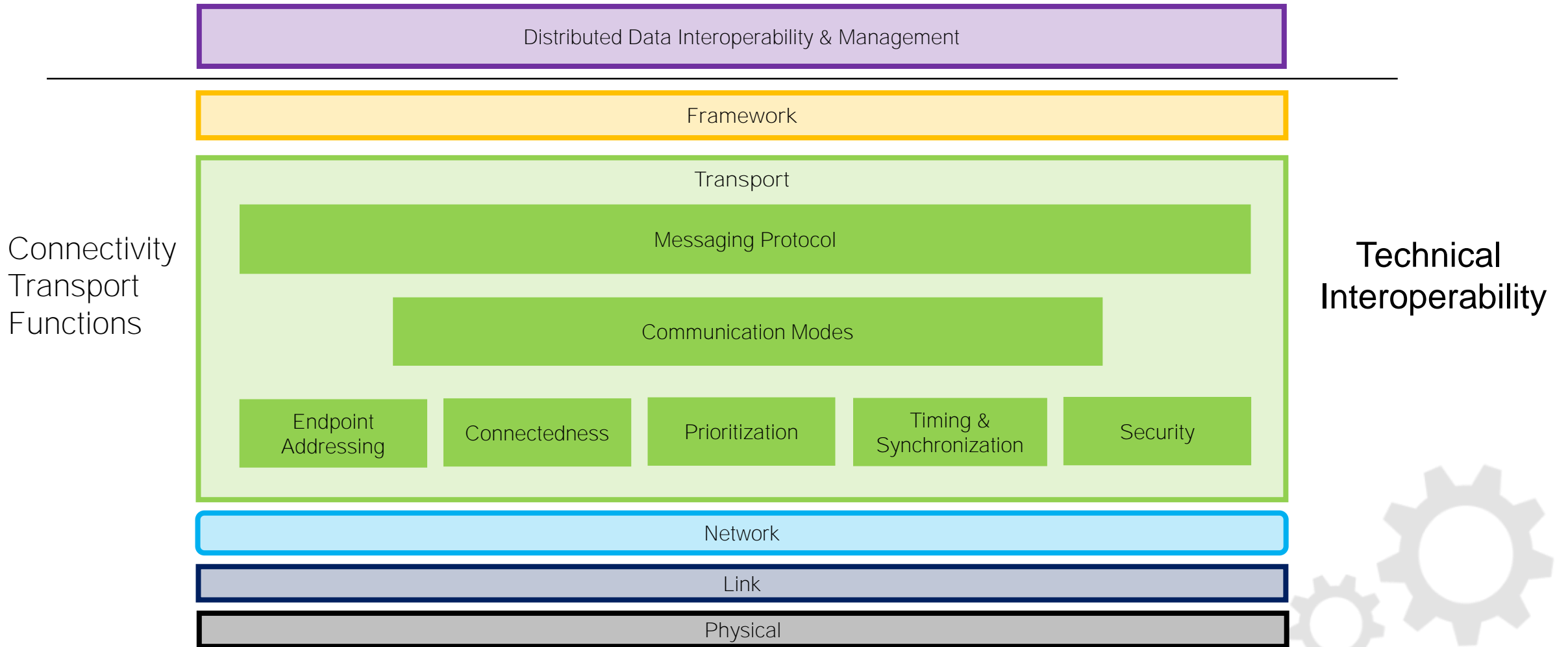
- May observe byte flows & optimize byte sequence sharing and delivery

Any computing platform





Connectivity Transport Layer



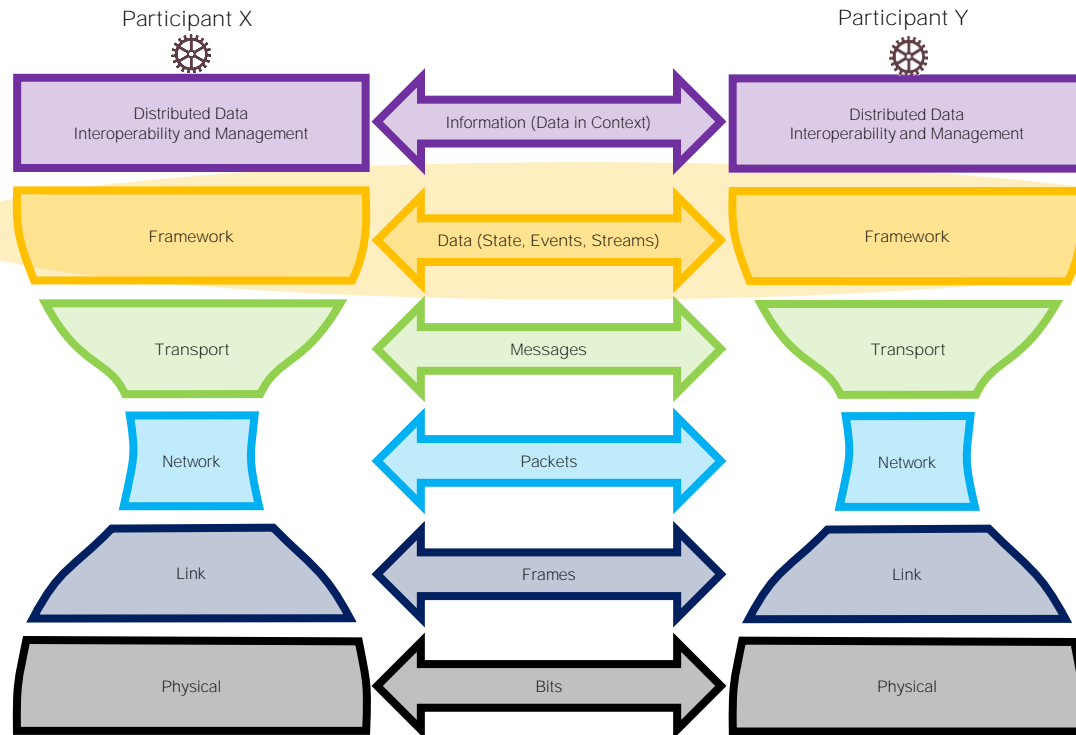


Connectivity Framework Layer

Core Functions

Typical Considerations

Connectivity Framework Layer



Above: Syntactic Interoperability

- Share structured datatypes
- Common and unambiguous data format

Below: Opaque Data

- May observe data flows & optimize datatype sharing and delivery

Any computing platform

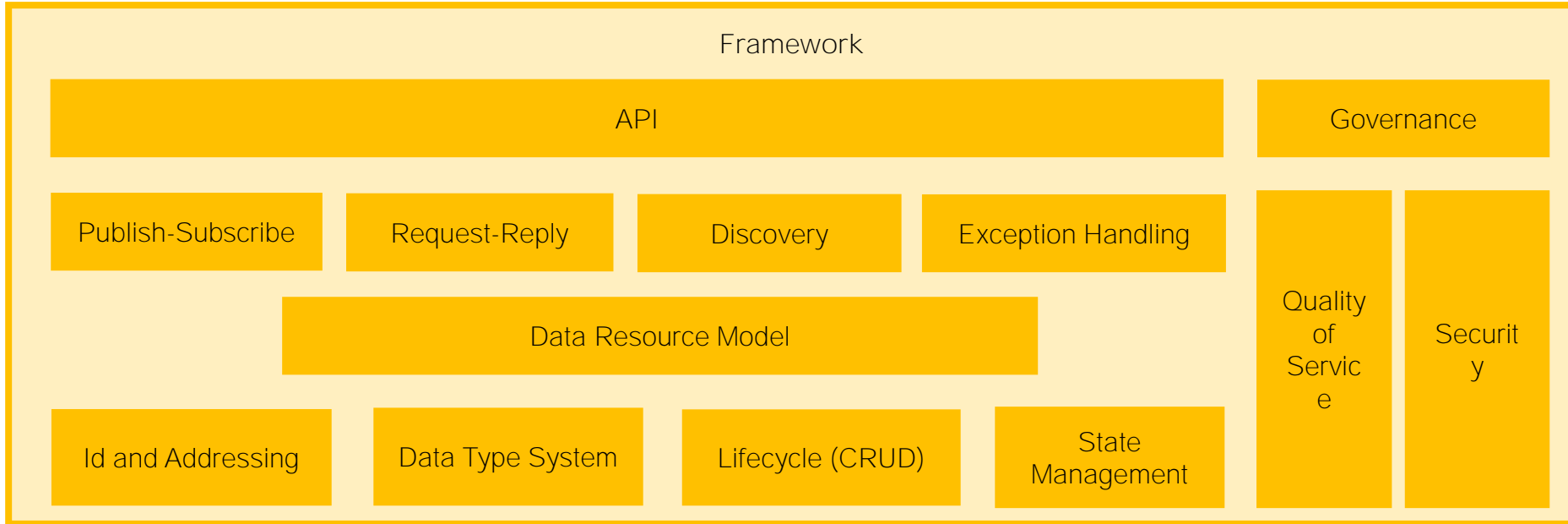
Any programming environment





Connectivity Framework Layer

Distributed Data Interoperability & Management



Syntactic Interoperability

Transport

Network

Link

Physical

Connectivity Reference Architecture



Standards & Gateways

Core Connectivity

Core Standards Criteria

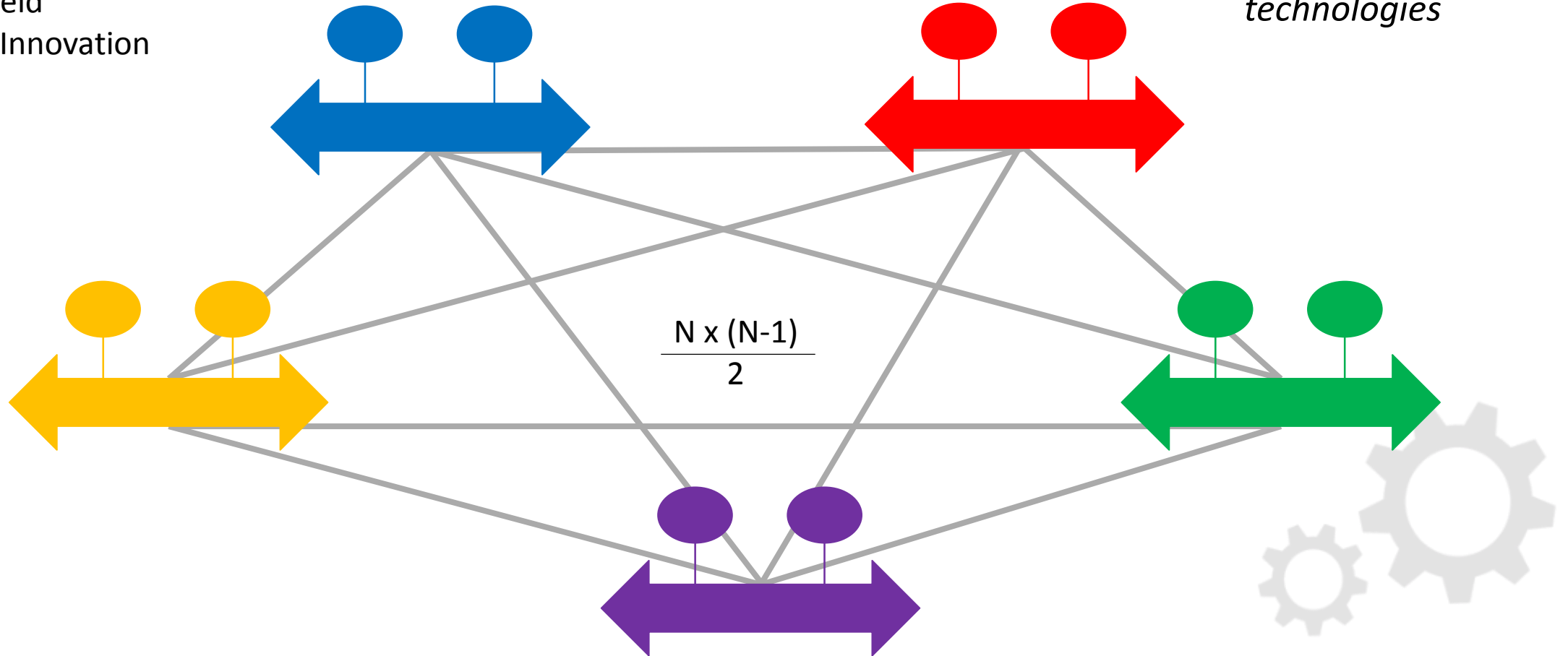


Fundamental N^2 Connectivity Challenge

- Brownfield
 - Existing technologies
 - May be specific to verticals
- Greenfield
 - Innovation

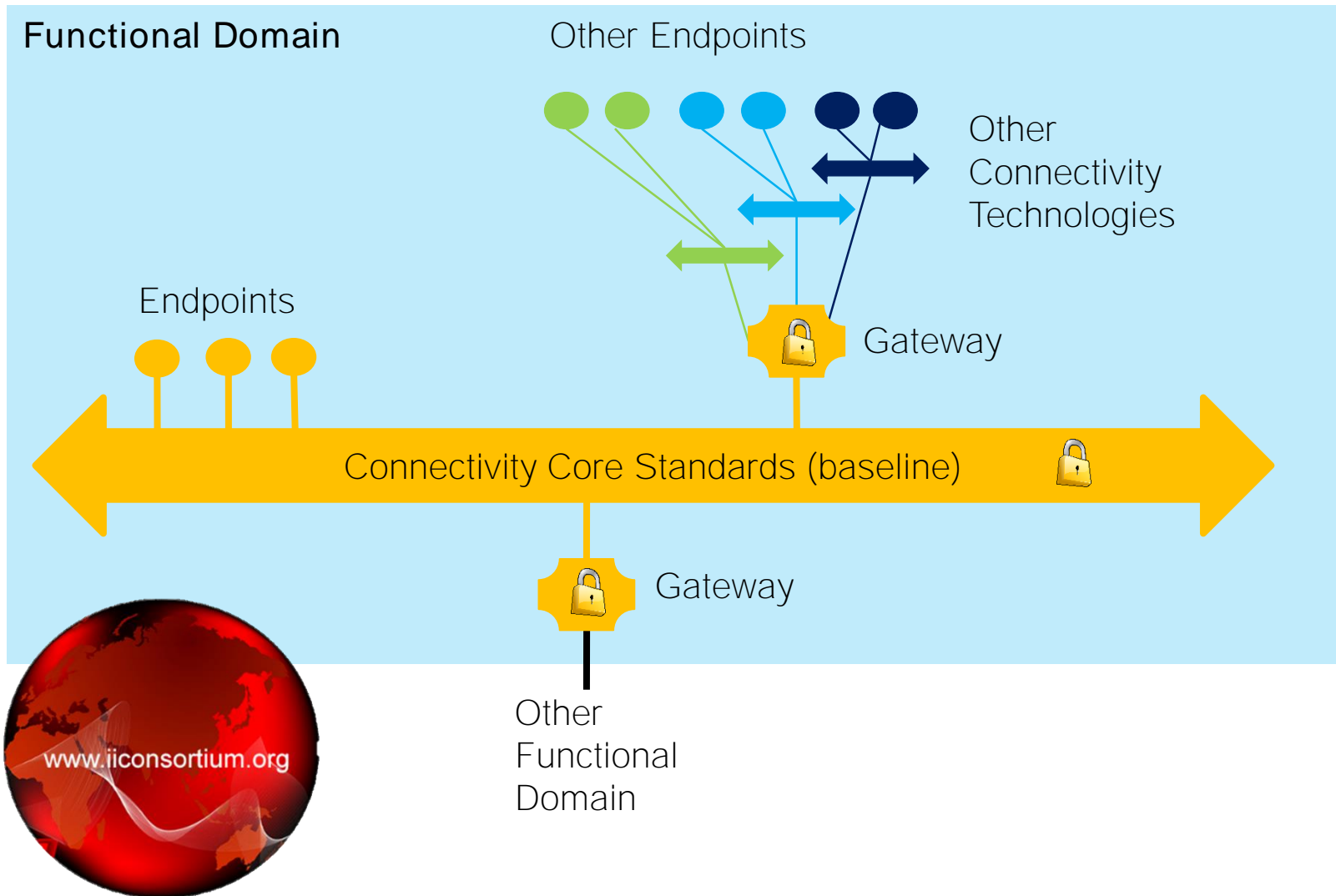
$$O(N^2)$$

Reality Check
Accept that there will be multiple connectivity technologies





Connectivity Reference Architecture

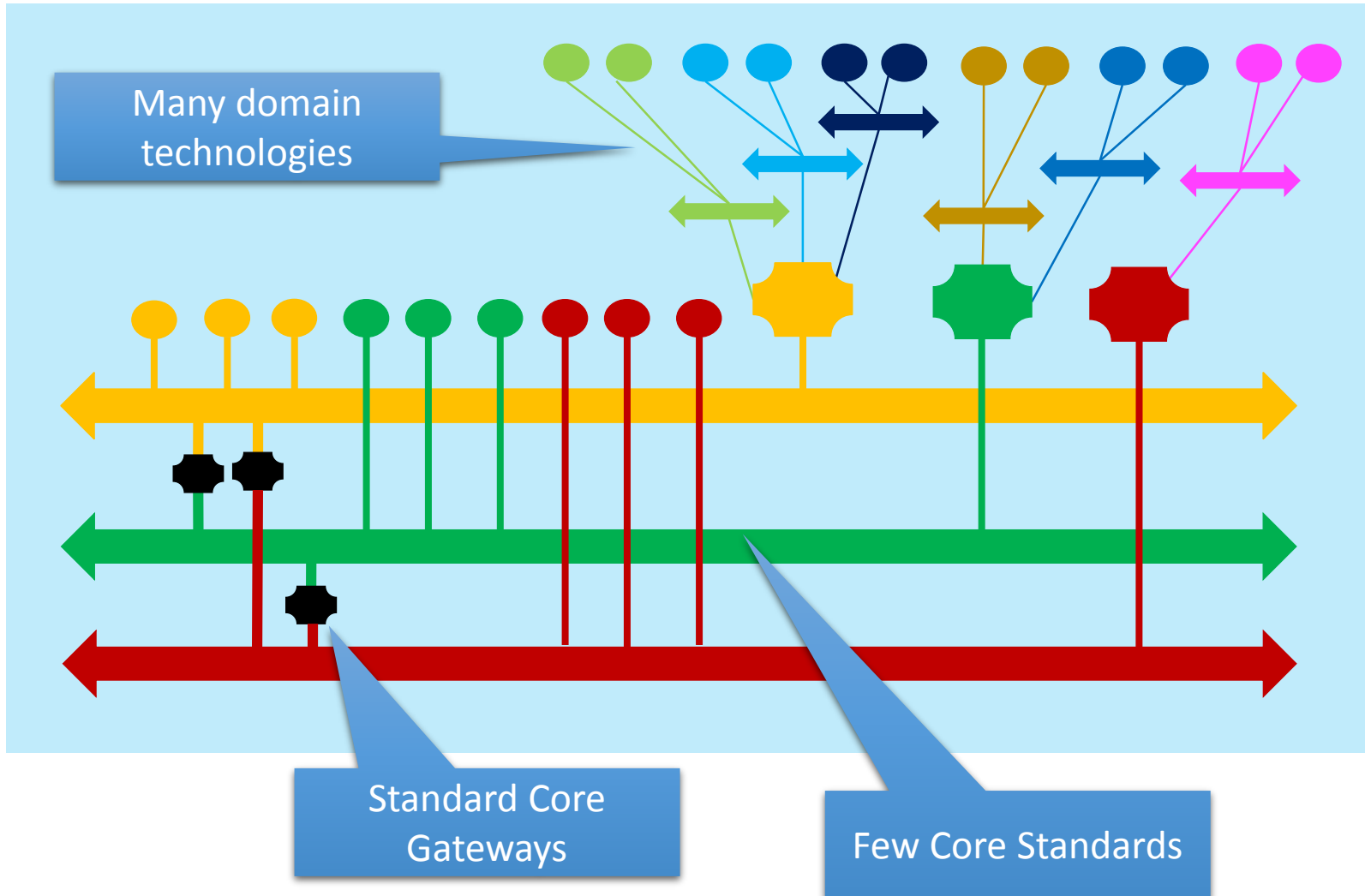


- Gateways bridge domain specific connectivity technologies to Core Standards
- Core Standards enable data sharing with domain other domain-specific connectivity technology endpoints
- Choose a core standard that best matches system needs





Connectivity Reference 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





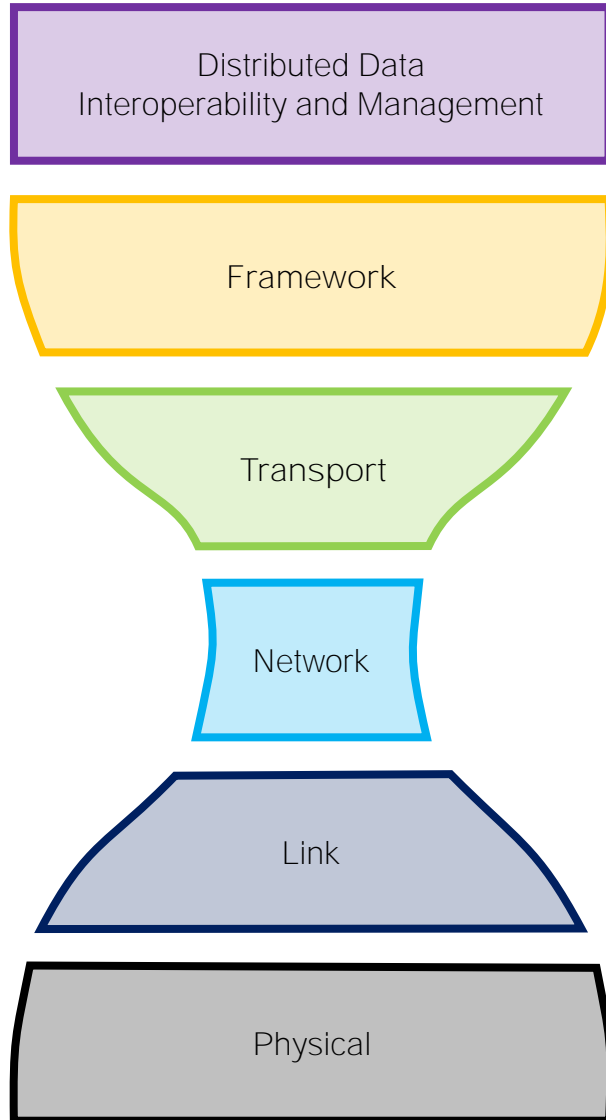
How to Assess a Connectivity Technology?

Assessment Template Worksheet

**Business, Usage, Functional,
Implementation Viewpoints**



Assessment Template



- Which layer(s) of the **Connectivity Stack** does it provide?
 - May span multiple layers
- What **Core Functions** does it provide?
 - Prioritize the functions for your use case
- How does it rank against the **Typical Considerations** (of the layers spanned) ?
 - Prioritize the considerations for your use case
- How does it support the **Architectural Qualities**?
 - Prioritize the qualities for your use case
- Does it fit **Connectivity Core Standards Criteria**?
 - Is a gateway to a Core Connectivity Standard available?
 - Is the gateway standardized?





Assessment Template Worksheets

Business Viewpoint

and usage viewpoints are considered herein.

The assessment template is intended to be a tool for understanding any connectivity technology in the context of the IoT needs. The worksheet is helpful for:

- understanding how a connectivity technology supports specific IoT functional needs,
- evaluating a connectivity technology's trade-offs for typical IoT considerations and specific requirements are understood.

The worksheet helps categorize objectively a connectivity technology across the IoT framework (Figure 4-1) or a connectivity transport (Figure 5-1). Some technologies in the connectivity stack (Figure 2-1) can be compared objectively, and the most applicable technology can be easily identified.

The worksheet is described below.

2.1. Related Info	
Section 6.1.1	
Name	Common and formal name of the connectivity technology.
Contacts	Responsible individuals, development organization (OOO), lead vendor or vendor.
Description	Short synopsis of the technology.
Application Domains	Application domains targeted by the connectivity technology.
Dependencies	Provide connectivity with or relies on other connectivity elements.
References	Website and other useful links to the technology.

- Purpose
- Pedigree
- Variants
- Maturity
- Stability
- Standards Body
- Openness

Usage Viewpoint

6.2.4 Maturity (Section 6.2.4)	Estimate the technology maturity, state of development and readiness relative to capabilities? Is the technology consistent and consistent?
6.2.5 Stability (Section 6.2.5)	Describe whether the connectivity technology has been mature for long enough that most of its bugs and other problems have been removed or resolved. How long is it to use? How much advance - related to?
6.2.6 Standards (Section 6.2.6)	List the relevant organizational bodies developing, coordinating, promulgating, enforcing, revising, interpreting or otherwise producing technical standards.
6.2.7 Openness (Section 6.2.7)	Is it an open standard? Are you permitted? Are the specifications freely available? Are source implementations available? Does it require any single company's vendor?
6.3 Use/References (Section 6.3)	Summarize the main concepts, and high-level architecture, and terminology that are used in the connectivity technology.
6.3.1 Architecture (Section 6.3.1)	List the choices to be made for using the connectivity technology in a system.
6.3.2 Technology Options (Section 6.3.2)	A general overview of the typical applications that rely on this connectivity technology.
6.3.3 Applications (Section 6.3.3)	What function(s) are in the system that technology is typically used?
6.3.4 Typical Usage (Section 6.3.4)	Can one monitor, manage, and dynamically replace elements of the connectivity technology?
6.3.5 Operations (Section 6.3.5)	What are the system security implications of this connectivity technology?
6.3.6 Security (Section 6.3.6)	For systems that need it, are verifiable implementations available?
6.3.7 Safety (Section 6.3.7)	List of gateway to any connectivity standards and other relevant connectivity technologies.
6.3.8 Gateways (Section 6.3.8)	

- Architecture
- Options
- Applications
- Usage
- Operations
- Security
- Safety
- Gateways

Functional Viewpoint

4.1 Data Type System (Section 4.1.1)	Does it provide a data type system? Summarize the salient aspects.
4.2 Data Management (Section 4.2.1)	Does it provide a means of managing a data object's lifecycle? Summarize the salient aspects.
4.3 Public Subscribe (Section 4.3.1)	Does it provide a means to manage the recent history of data objects? Summarize the salient aspects.
4.4 Review (Section 4.4.1)	Does it provide a means to publish and subscribe the state of data objects? Summarize the salient aspects.
4.5 Discovery (Section 4.5.1)	Does it provide a means to request the state of data objects? Summarize the salient aspects.
4.6 Transport (Section 4.6.1)	Does it provide a means to discover the state of data objects? Summarize the salient aspects.
4.7 Data Quality (Section 4.7.1)	Does it provide a means to handle exceptions when quality of service or other aspects are impacted? Summarize the salient aspects.
4.8 Data Security (Section 4.8.1)	Does it support data QoS? Summarize the scope and coverage. Highlight the salient aspects.
4.9 API (Section 4.9.1)	Does it provide a data object security model? Summarize the salient aspects.
4.10 Governance (Section 4.10.1)	Is there a standard API which programming languages is available? Summarize the salient aspects.
4.11 Core Transport Layer Functions (Section 4.11.1)	Does it formalize the mechanisms for configuration, administration, and management? Summarize the salient aspects.
4.12 Core Transport Layer Functions (Section 4.12.1)	Does it support QoS? What are the salient aspects of the managing? What are the management requirements? What are the change considerations? Is it?
4.13 Core Transport Layer Functions (Section 4.13.1)	Does it require a connection between the endpoints? What are the salient aspects? Summarize the salient aspects.
4.14 Core Transport Layer Functions (Section 4.14.1)	Does it provide a means to prioritize messages? Summarize the salient aspects.
4.15 Core Transport Layer Functions (Section 4.15.1)	Does it provide the ability to synchronize data? Summarize the salient aspects.

- Core Framework Layer Functions
- ...
- Core Transport Layer Functions
- ...

Implementation Viewpoint

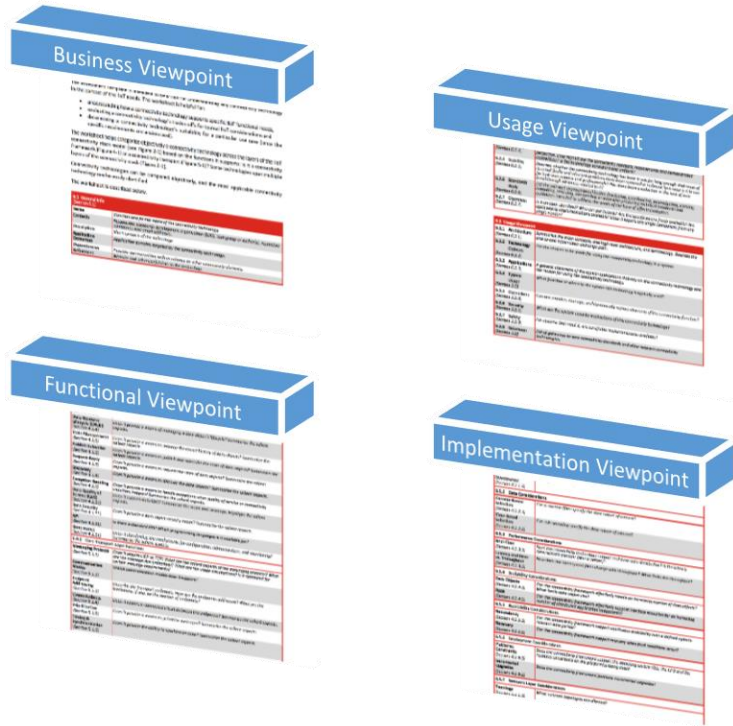
6.4.1 Governance (Section 6.4.1)	Is the governance explicit and observable?
6.4.2 Data Considerations (Section 6.4.2)	Can a constant filter specify the data subset of interest?
6.4.3 Data Sampling (Section 6.4.3)	Can sub-sampling specify the data subset of interest?
6.4.4 Performance Considerations (Section 6.4.4)	Does the connectivity technology support real-time data distribution to the endpoints? How does the latency and/or jitter change with throughput? What limits the data rate?
6.4.5 Scalability Considerations (Section 6.4.5)	Can the connectivity framework effectively handle an increasing number of endpoints? How does the latency and/or jitter change with throughput? What limits the data rate?
6.4.6 Availability Considerations (Section 6.4.6)	Can the connectivity framework support graceful degradation for individual endpoints? Can the connectivity framework support recovery when fault conditions are observed?
6.4.7 Network Layer Considerations (Section 6.4.7)	Does the connectivity framework support the searching system (DS), the gateway (GS), and the endpoint (EP)?
6.4.8 Network Layer Considerations (Section 6.4.8)	Does the connectivity framework facilitate incremental upgrades?
6.4.9 Network Layer Considerations (Section 6.4.9)	What release strategies are allowed?

- System Architecture Considerations
- Data Considerations
- Performance Considerations
- Availability Considerations
- Deployment Considerations
- Network Layer Considerations





IICF Catalog of Connectivity Standards!



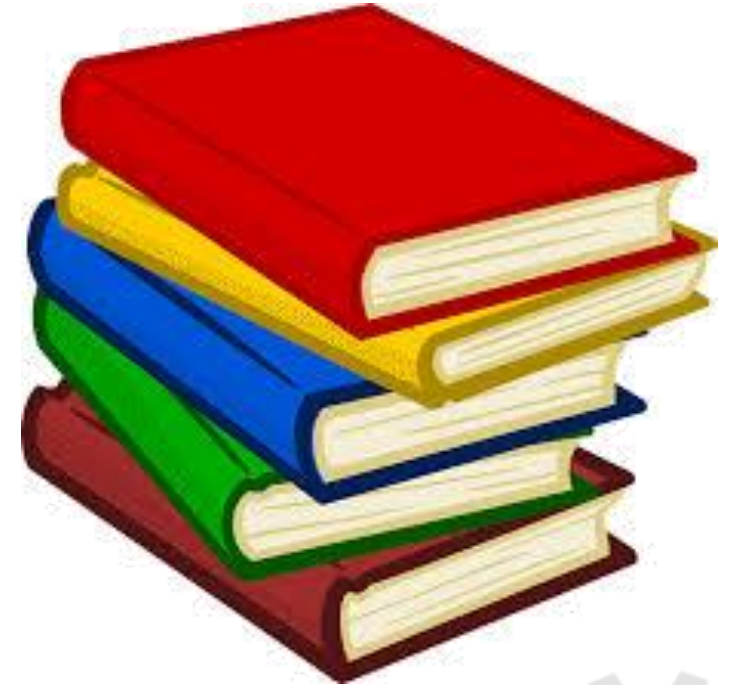
Assessment Template Worksheets

Frameworks

- DDS
- OPC-UA
- oneM2M

Transports

- HTTP
- MQTT
- CoAP



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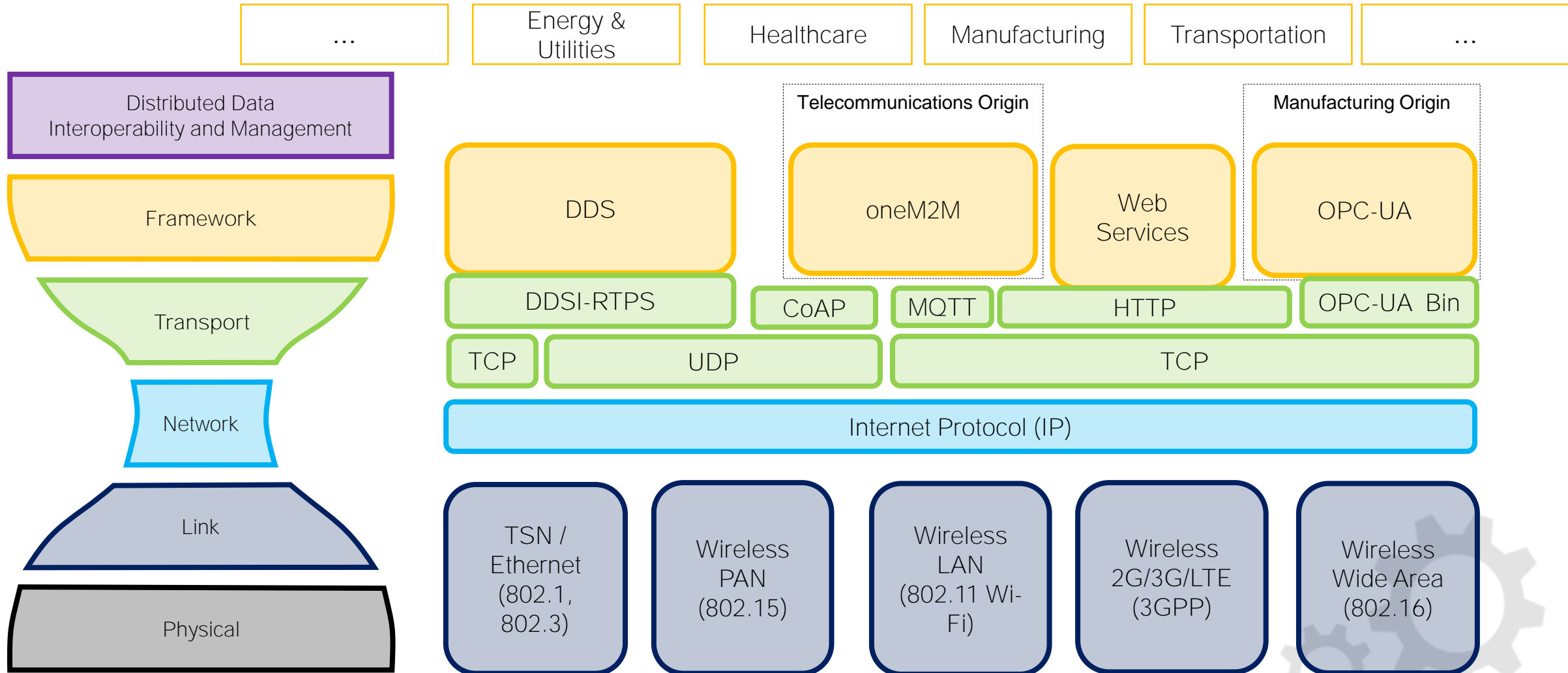
Connectivity Standards : Putting it all Together

Relevant Connectivity Standards

Assessment Template Applied

Potential Core Connectivity Standards

Connectivity Standards





Connectivity Core Standards Criteria Applied

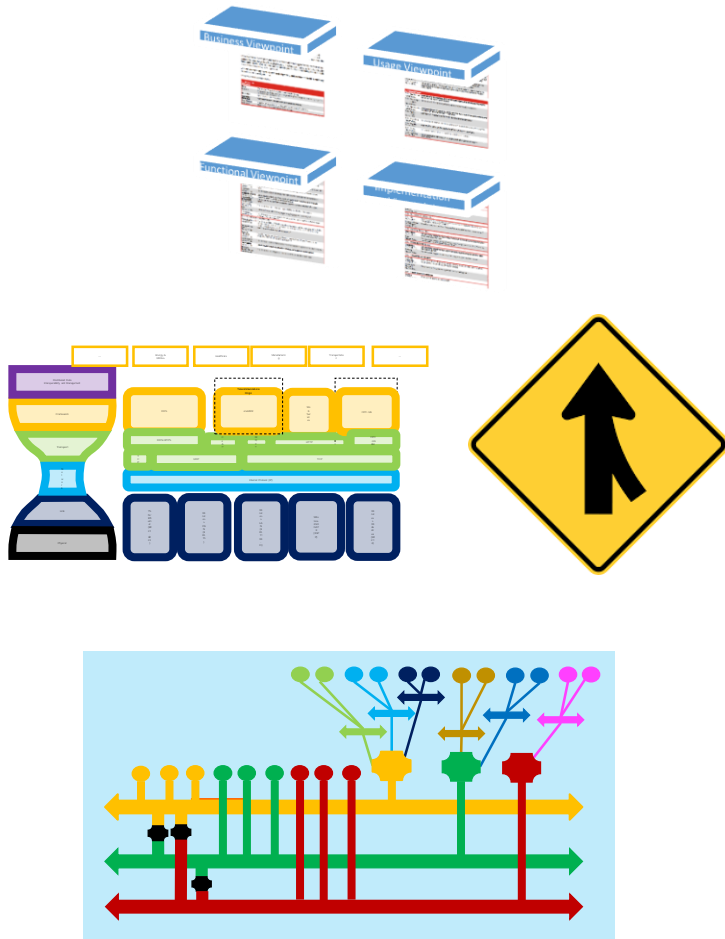
	Core Standard Criterion	DDS	Web Services	OPC-UA	oneM2M
1	Provide syntactic interoperability	✓	Need XML or JSON	✓	✓
2	Open standard with strong independent, international governance	✓	✓	✓	✓
3	Horizontal and neutral in its applicability across industries	✓	✓	✓	✓
4	Stable and deployed across multiple vertical 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, OPC-UA*, 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	✓	✓	✓	✓

GREEN = Gating Criteria

* = work in progress

✓ = supported, ✗ = not supported

IICF Architecture Process



- Use assessment template worksheet to determine your system requirements
- Pick the potential connectivity core standard best aligned with your system requirements
- Build a gateway for other domain-specific connectivity technologies



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

Summary

Accelerating IIoT





Accelerate Your IIoT...



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

Clarity

Stable long term foundation for IIoT interoperability

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

Industry
Connectivity
Architecture

Foundation

Guidance





1. Introduction
2. Connectivity Framework
3. Connectivity Reference Architecture
4. Connectivity Framework Layer
5. Connectivity Transport Layer
6. How to Assess a Connectivity Technology?
7. Connectivity Standards
8. Core Connectivity Standards
9. Other Connectivity Standards
10. Assessment Templates



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Thank You!

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