



# Communications & Connectivity

Industrial Internet Innovation Forum

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Principal Solution Architect, Real-Time Innovations Inc (RTI)



**2017 March 20**  
**Thu, 15:00 EST**  
**Reston, VA, USA**

# Agenda

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1. How do we go from here to there?
  - Internet of People → Things
  - Connectivity vs. Communications vs. Interoperability
2. Evolution of the IIoT connectivity stack
  - Connectivity Framework
  - Connectivity Transport
3. Defining a long term stable IIoT architecture strategy
  - Embracing the old and the new
  - Connectivity core standards criteria
4. Selecting the right connectivity technology
  - Assessment template worksheets
  - Connectivity standards



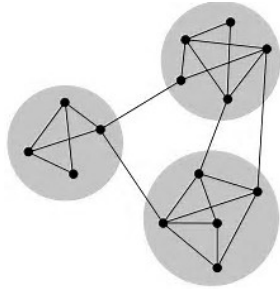


How do we go from here to there?

**Internet of People → Things**  
**Connectivity vs. Communications**  
**vs. Interoperability**



# How do we go from here to there?



People



Internet of

Things



# Communicate

## com·mu·ni·cate

/kə'myoʊnə,kāt/ 

*verb*

verb: **communicate**; 3rd person present: **communicates**; past tense: **communicated**; past participle: **communicated**; gerund or present participle: **communicating**

1. share or exchange information, news, or ideas.  
"the prisoner was forbidden to **communicate with** his family"  
*synonyms*: be in touch, be in contact, have dealings, [interface](#), [interact](#), [commune](#), [meet](#), [liaise](#);  
[More](#)
- impart or pass on (information, news, or ideas).  
"he **communicated** his findings **to** the inspector"  
*synonyms*: [convey](#), [tell](#), [impart](#), [relay](#), [transmit](#), pass on, [announce](#), [report](#), [recount](#), [relate](#),  
[present](#); [More](#)
- convey or transmit (an emotion or feeling) in a nonverbal way.  
"the ability of good teachers to communicate their own enthusiasm"
- succeed in conveying one's ideas or in evoking understanding in others.  
"a politician must have the ability to communicate"  
*synonyms*: get one's message across, explain oneself, be understood, [communicate](#),  
"learn how to communicate better"
- (of two people) be able to share and understand each other's thoughts
- pass on (an infectious disease) to another person or animal.  
*synonyms*: [transmit](#), [transfer](#), [spread](#), [carry](#), pass on  
"the disease is communicated easily"
- transmit (heat or motion).  
"the heat is communicated through a small brass grating"
- (of two rooms) have a common connecting door.  
"he went into the communicating room to pick up the phone"  
*synonyms*: connect with, join up with, open on to, lead into  
"each bedroom communicates with a bathroom"



*verb*

**Share  
or  
Exchange  
Information**

Use over time for: communicate



# Communication(s)

## com·mu·ni·ca·tion

/kə,myoʊnə'kāSH(ə)n/

*noun*

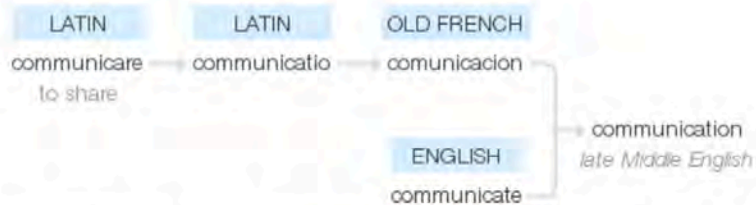
noun: **communication**

1. the imparting or exchanging of information or news.  
"direct communication between the two countries will produce greater understanding"  
*synonyms*: [transmission](#), [conveyance](#), [divulgence](#), [disclosure](#); [More](#)
  - a letter or message containing information or news.  
plural noun: **communications**  
*synonyms*: [message](#), [statement](#), [announcement](#), [report](#), [dispatch](#), [communiqué](#), [letter](#), [bulletin](#), [correspondence](#)  
"an official communication"
  - the successful conveying or sharing of ideas and feelings.  
"there was a lack of **communication between** Pamela and her parents"
  - social contact.  
"she gave him some hope of her return, or at least of their future communication"  
*synonyms*: [contact](#), [dealings](#), [relations](#), [connection](#), [association](#), [socializing](#), [intercourse](#); [More](#)
2. means of connection between people or places, in particular.  - the means of sending or receiving information, such as telephone lines or computers.  
plural noun: **communications**  
"satellite communications"
  - the means of traveling or of transporting goods, such as roads or railroads.  
"a city providing excellent road and rail communications"
  - the field of study concerned with the transmission of information by various means.



**Sharing  
or  
Exchanging  
of  
Information**

### Origin



late Middle English: from Old French *comunicacion*, from Latin *communicatio(n)-*, from the verb *communicare* 'to share' (see [communicate](#)).

### Use over time for: communication



## con·nec·tiv·i·ty

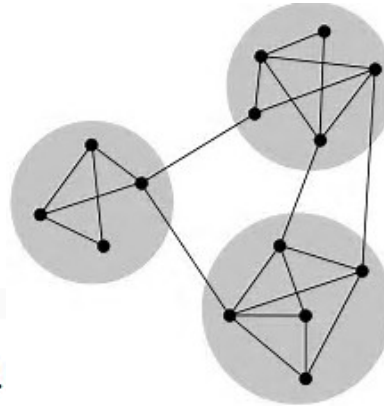
/kəˌnekˈtɪvədəˌkəˌnekˈtɪvədə/

*noun*

noun: **connectivity**

the state or extent of being connected or interconnected.

- **COMPUTING**  
capacity for the interconnection of platforms, systems, and applications.  
"connectivity between Sun and Mac platforms"



Use over time for: connectivity



## in·fra·struc·ture

/'ɪnfərəˌstrʌk(t)ʃhər/

*noun*

noun: **infrastructure**; plural noun: **infrastructures**

the basic physical and organizational structures and facilities (e.g., buildings, roads, and power supplies) needed for the operation of a society or enterprise.

Use over time for: infrastructure



# Interoperability

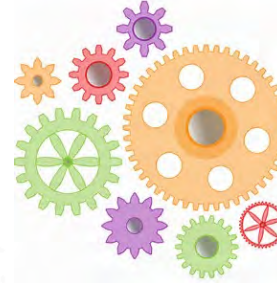
in·ter·op·er·a·bil·i·ty

/,ɪn(t)ər,äp(ə)rə'bilədē/

*noun*

the ability of computer systems or software to exchange and make use of information.  
"interoperability between devices made by different manufacturers"

- the ability of military equipment or groups to operate in conjunction with each other.  
"staff believe interoperability between forces is crucial to effectiveness"



Use over time for: interoperability

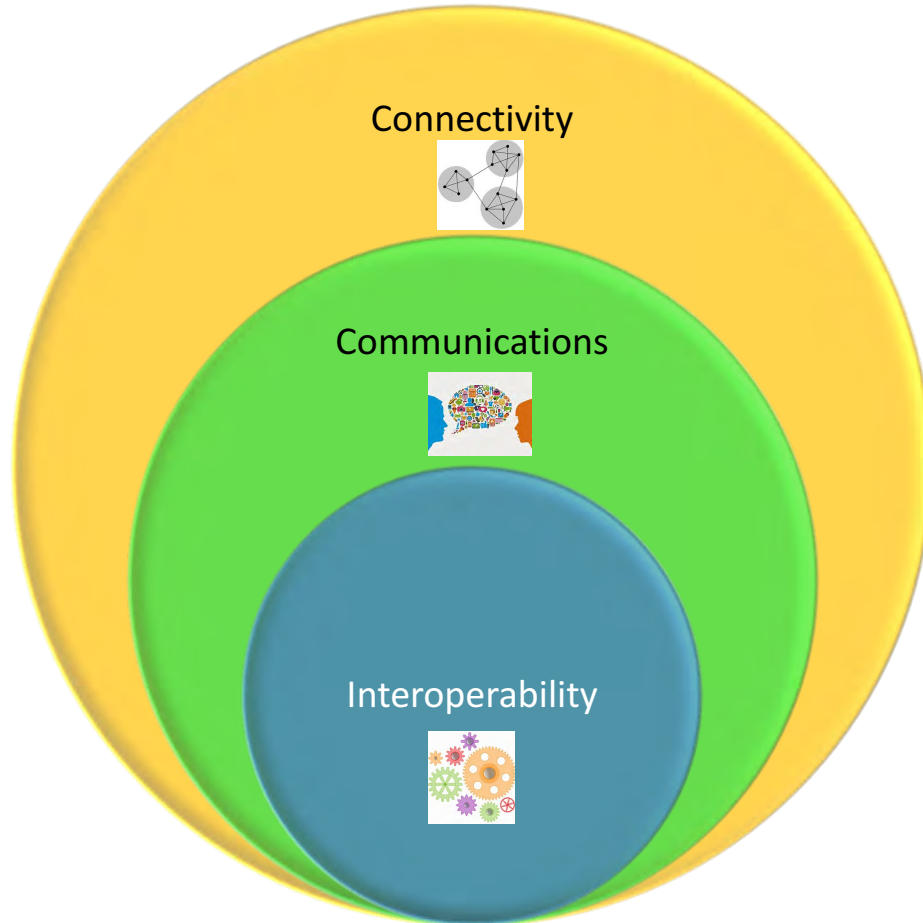


**Ability  
to  
Exchange  
and  
Make Use  
of  
Information**

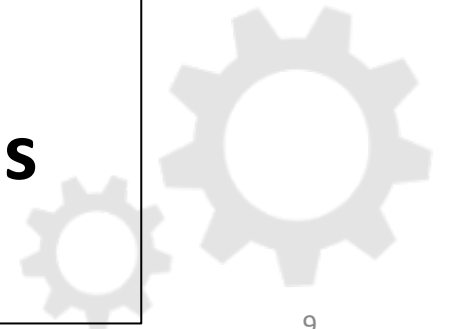




Connectivity → Communications → Interoperability

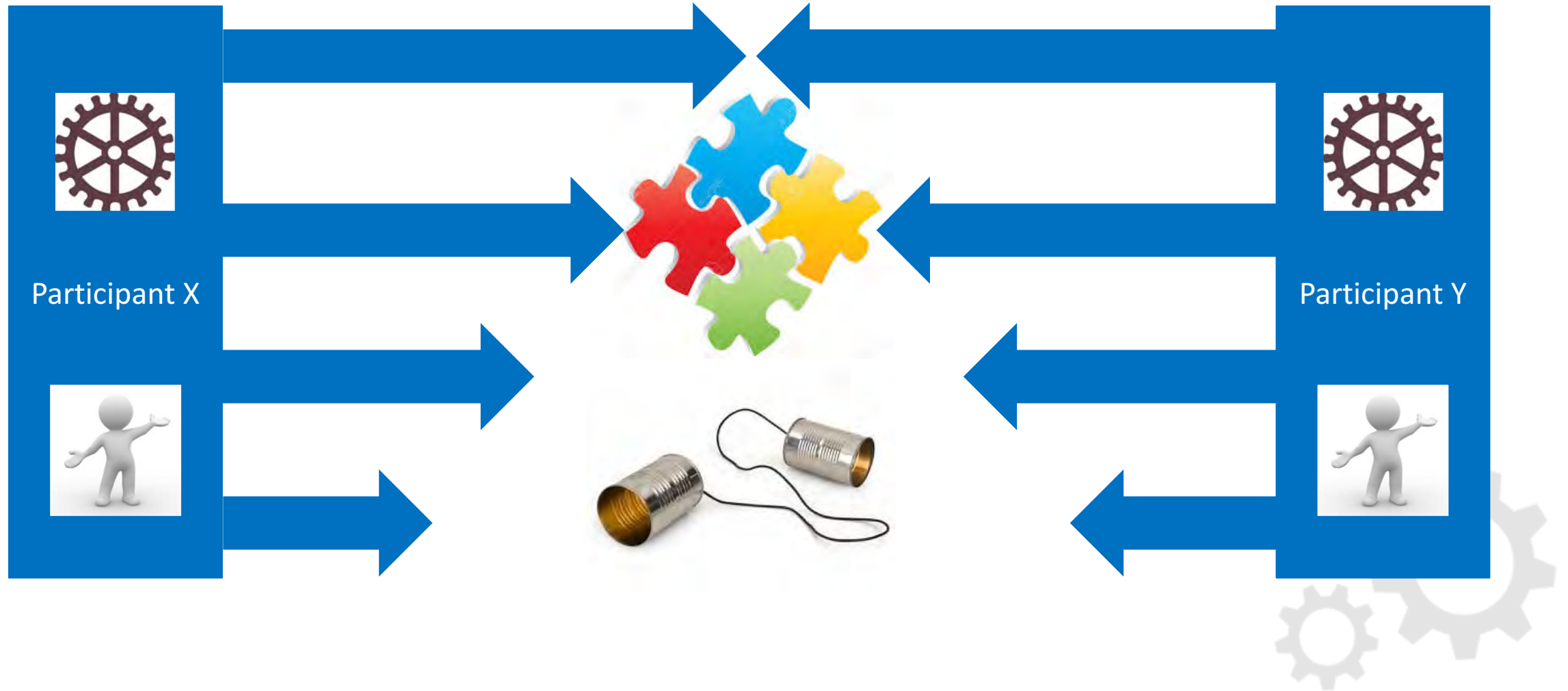


**Interoperability  
requires  
a  
Suitable  
Connectivity  
Infrastructure  
for  
Meaningful  
Communications  
between...**



# People vs. Things...

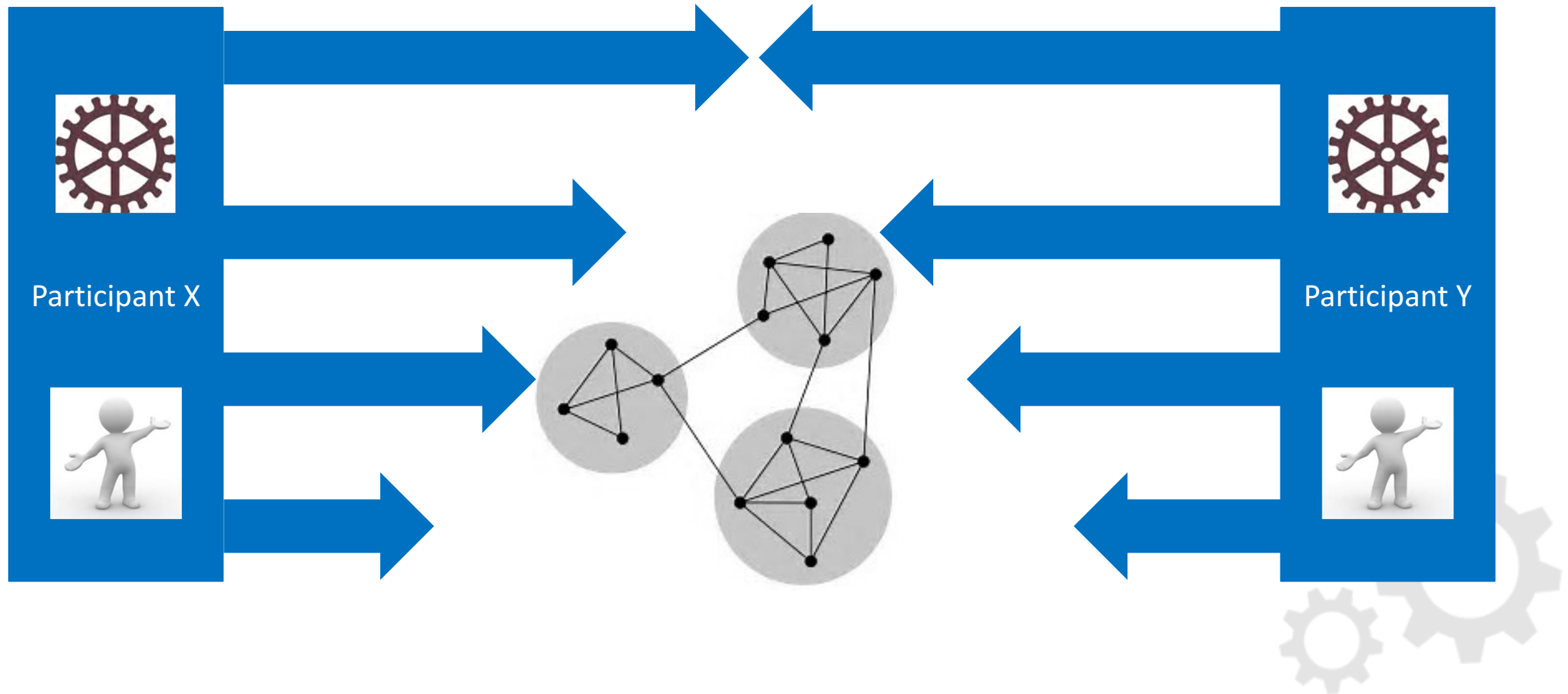
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# Connectivity infrastructure provides support for Interoperability

Directly impacts ease of integration, interoperability, and composability



# So, how do we go from here to there?

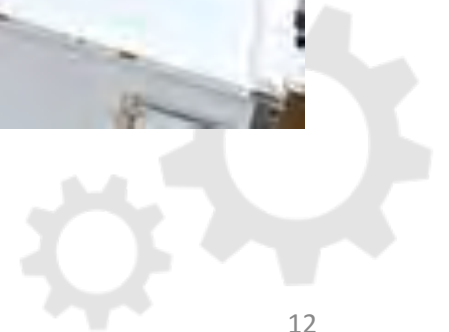


People

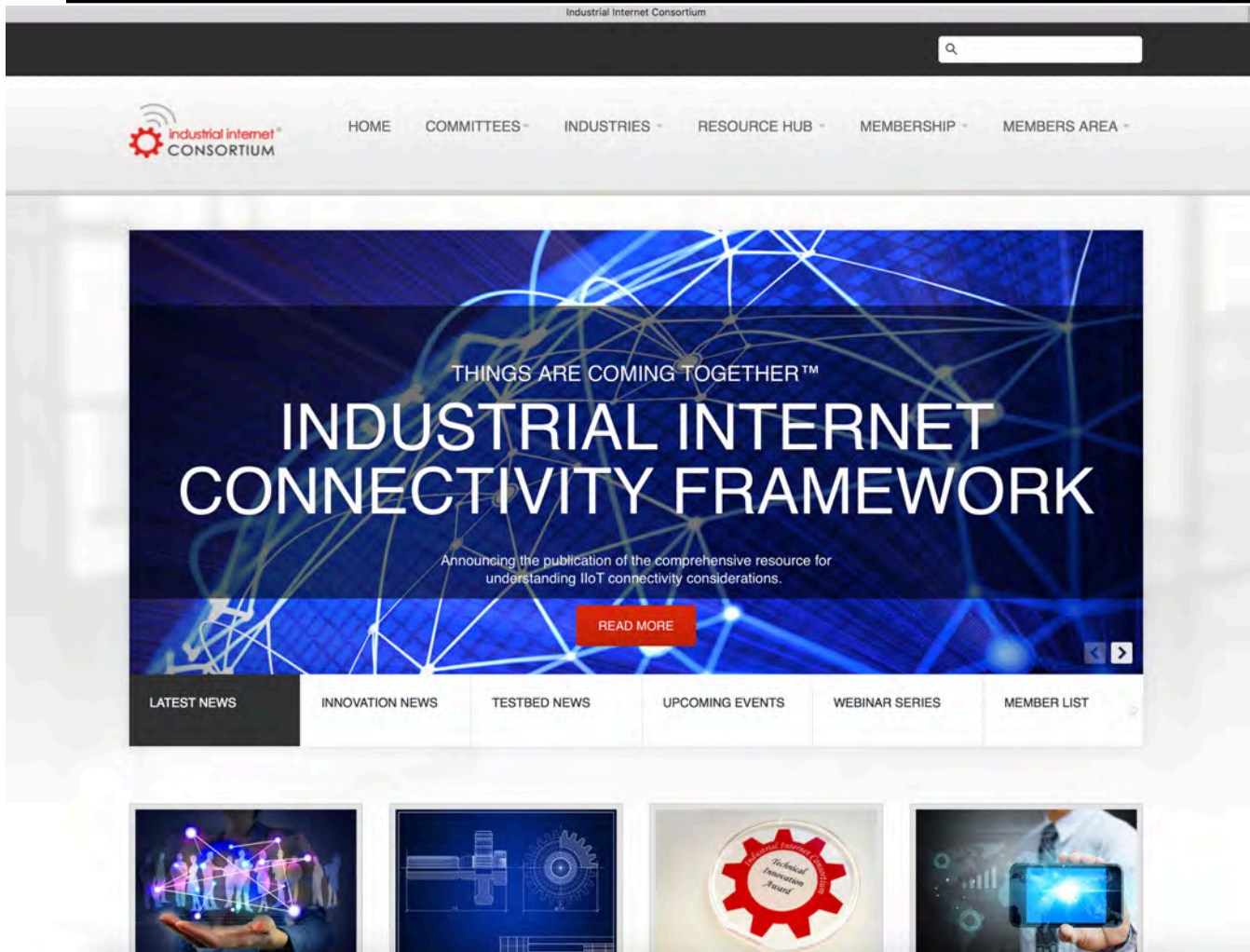


Internet of

Things



# Industrial Internet Connectivity Framework (IICF): Feb 28, 2017



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

Comprehensive  
treatment of  
connectivity

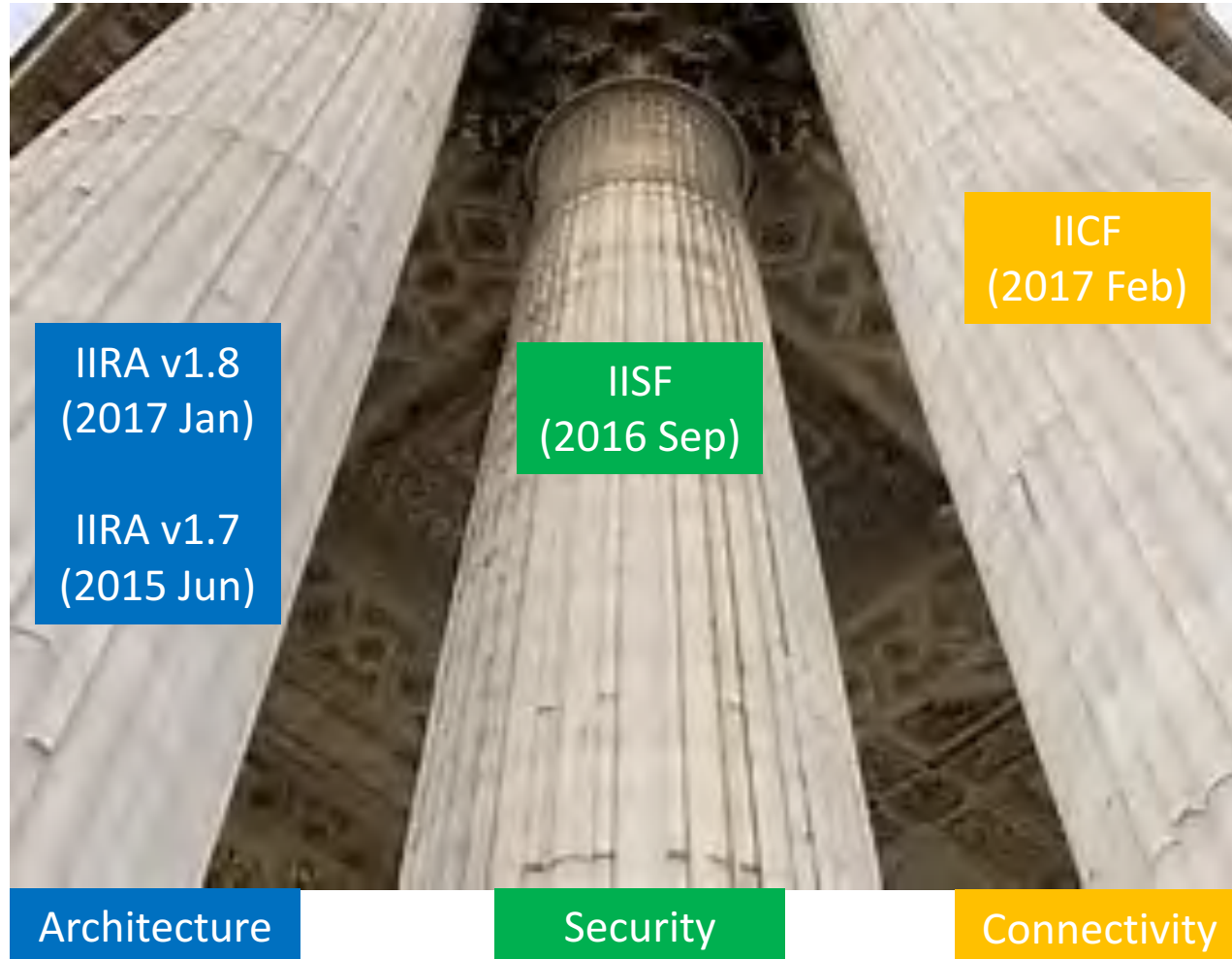
As a means of  
building interoperable  
IIoT systems

DOWNLOAD PDF

IICF FAQ



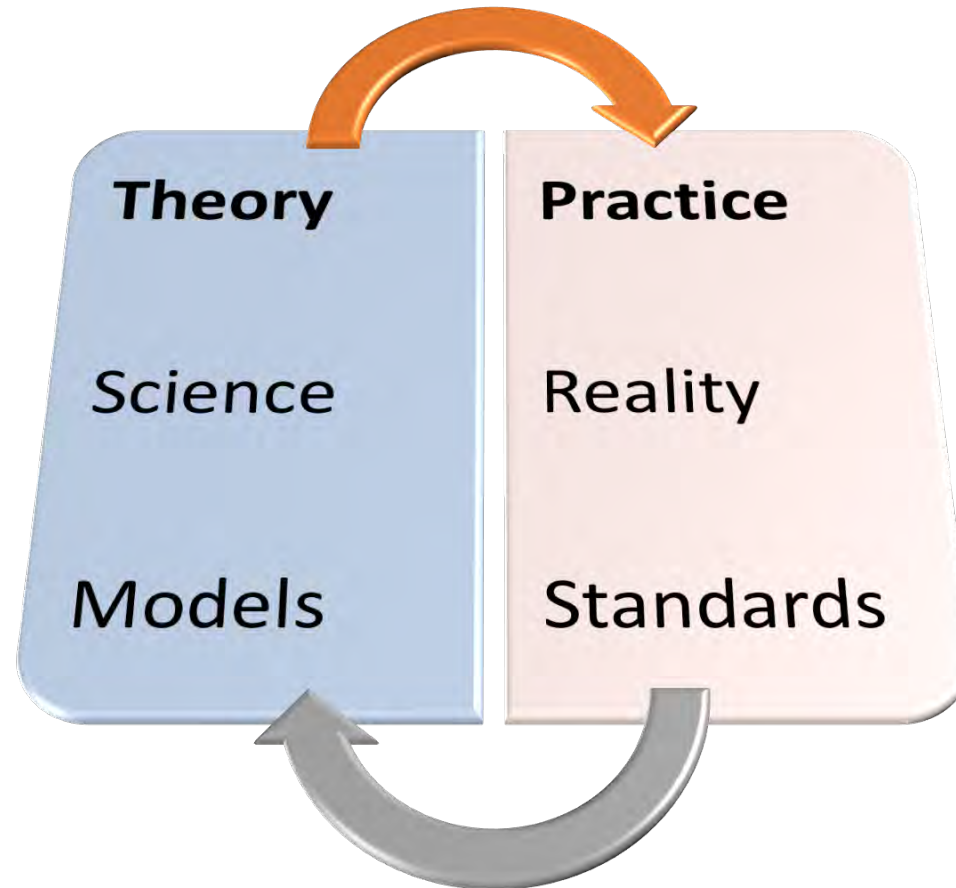
# IIoT Technical Foundation...Things are Coming Together!





# IICF: Theory + Practice = Useful Guidance

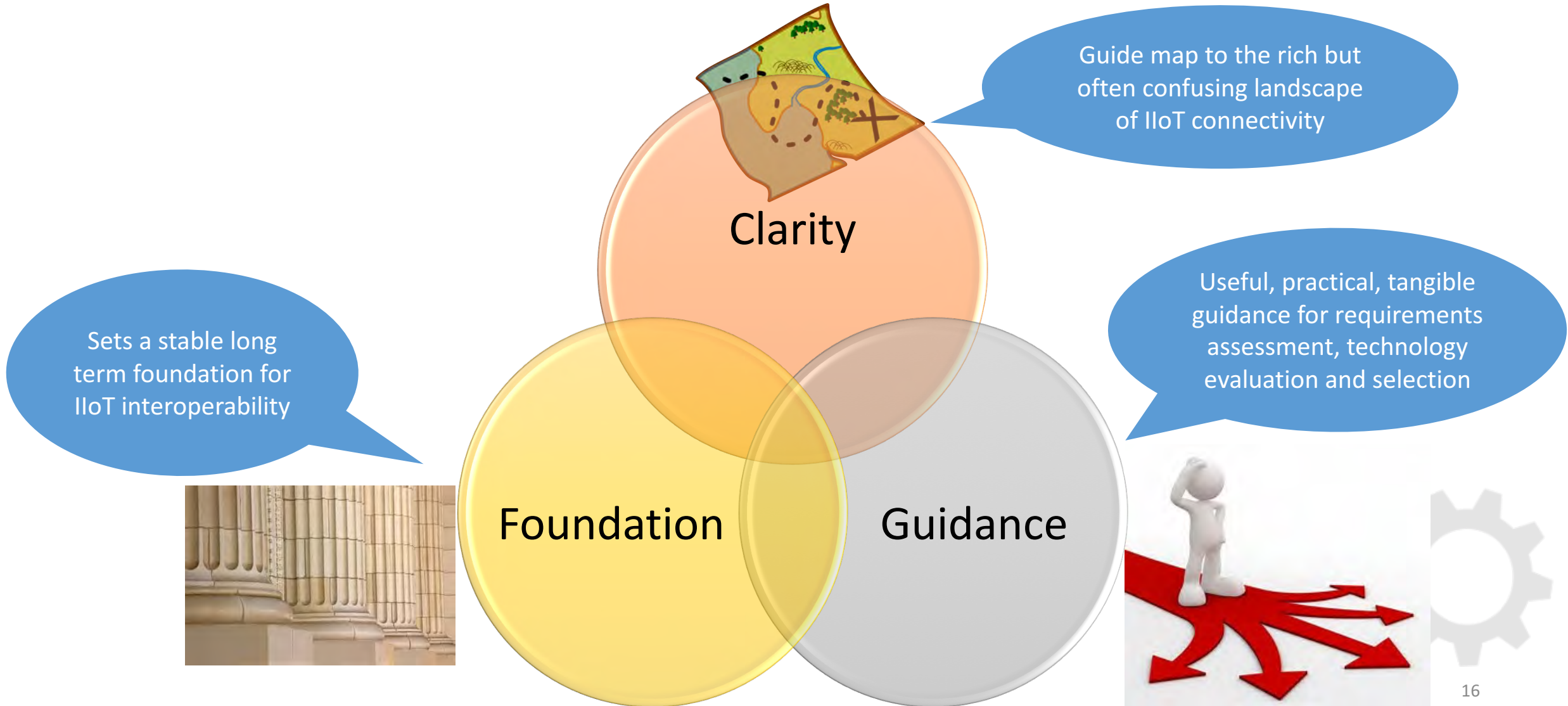
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# Industrial Internet Connectivity Framework (IICF) Goals

*Accelerating IIoT*





# Evolution of the IIoT Connectivity Stack



**Connectivity Framework**

**Connectivity Transport**

**Core Functions & Typical Considerations**



# Levels of Interoperability

*Composability*

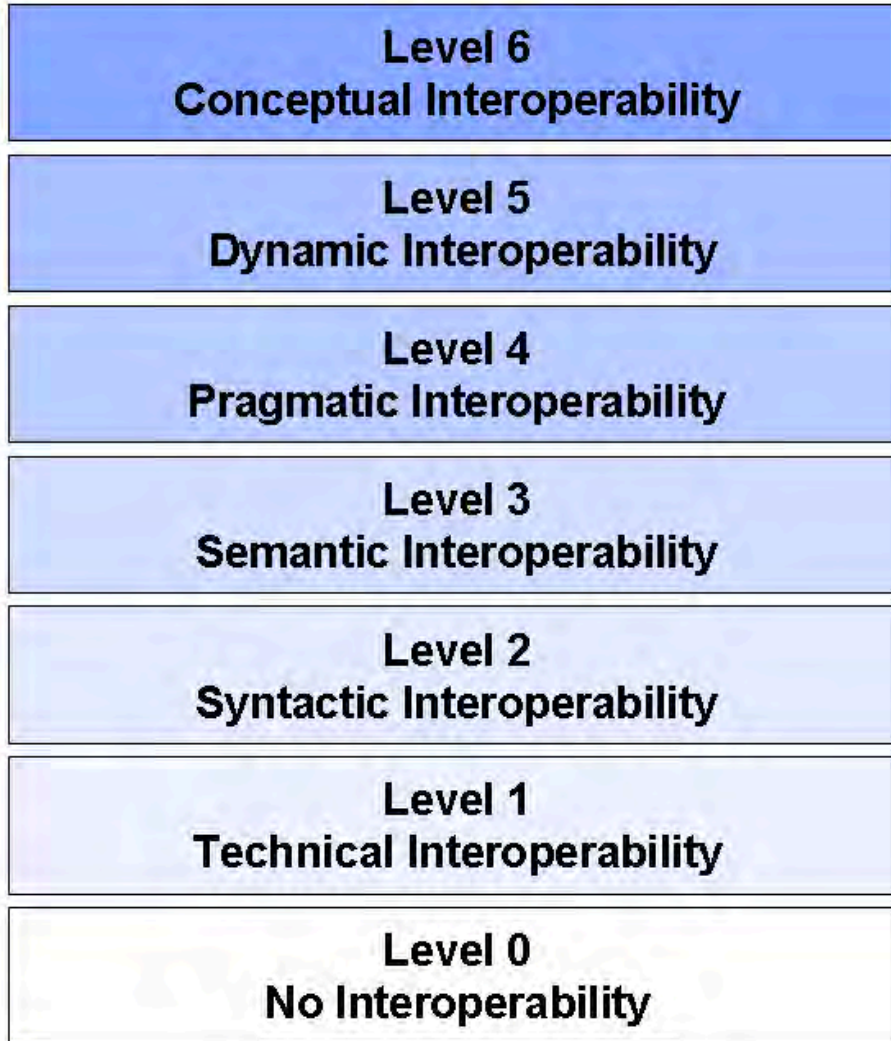
Modeling /  
Abstraction

*Interoperability*

Simulation /  
Implementation

*Integrability*

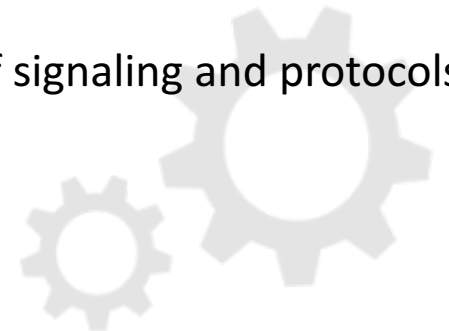
Network /  
Connectivity



**Context** of data objects is also shared

**Structure** of data is also shared

**Compatible** means of signaling and protocols





# Historically: Vertical silos of interoperability

*Composability*

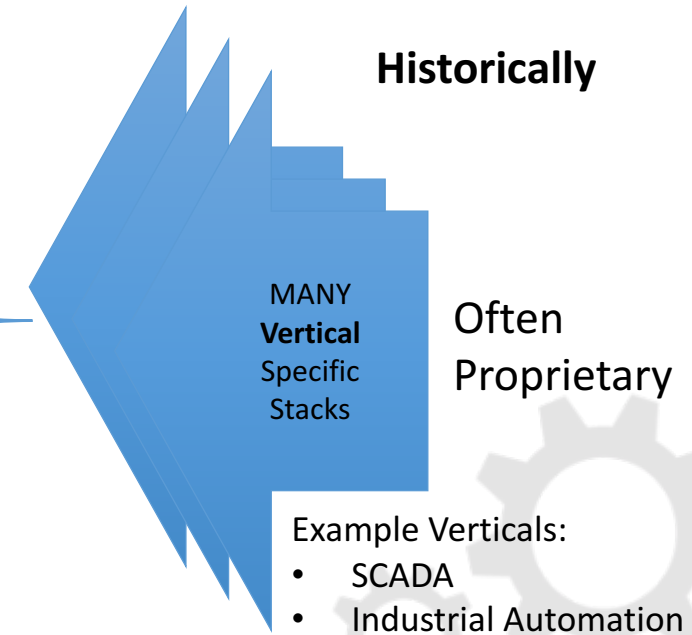
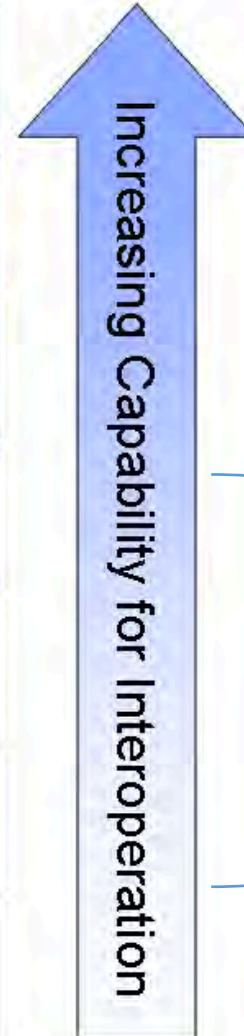
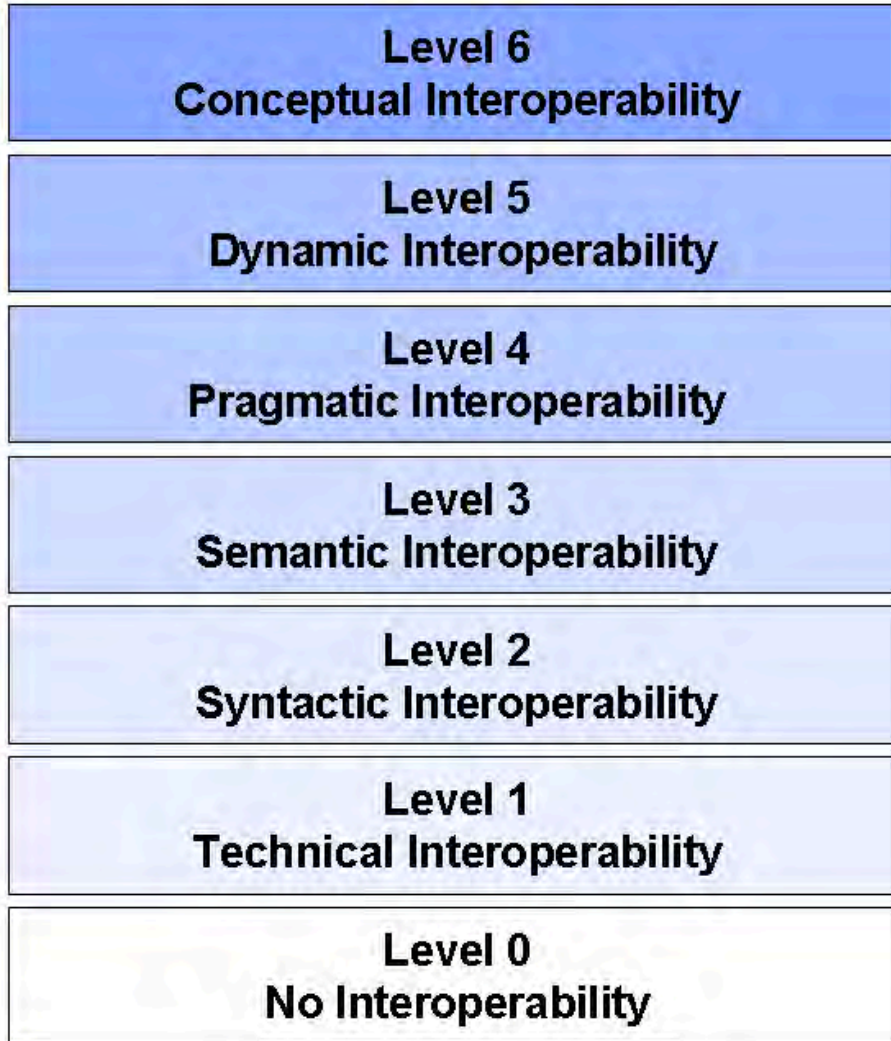
Modeling /  
Abstraction

*Interoperability*

Simulation /  
Implementation

*Integrability*

Network /  
Connectivity



# Future: Horizontal interoperability

*Composability*

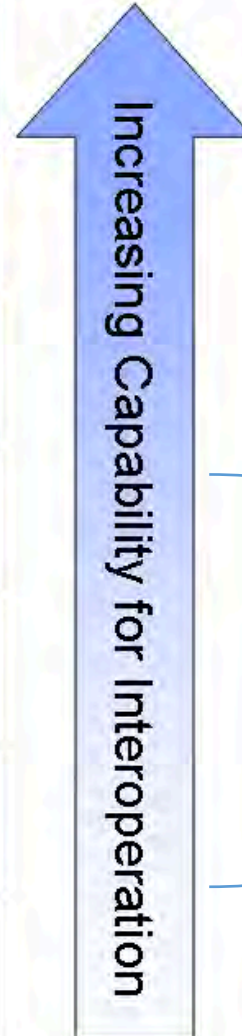
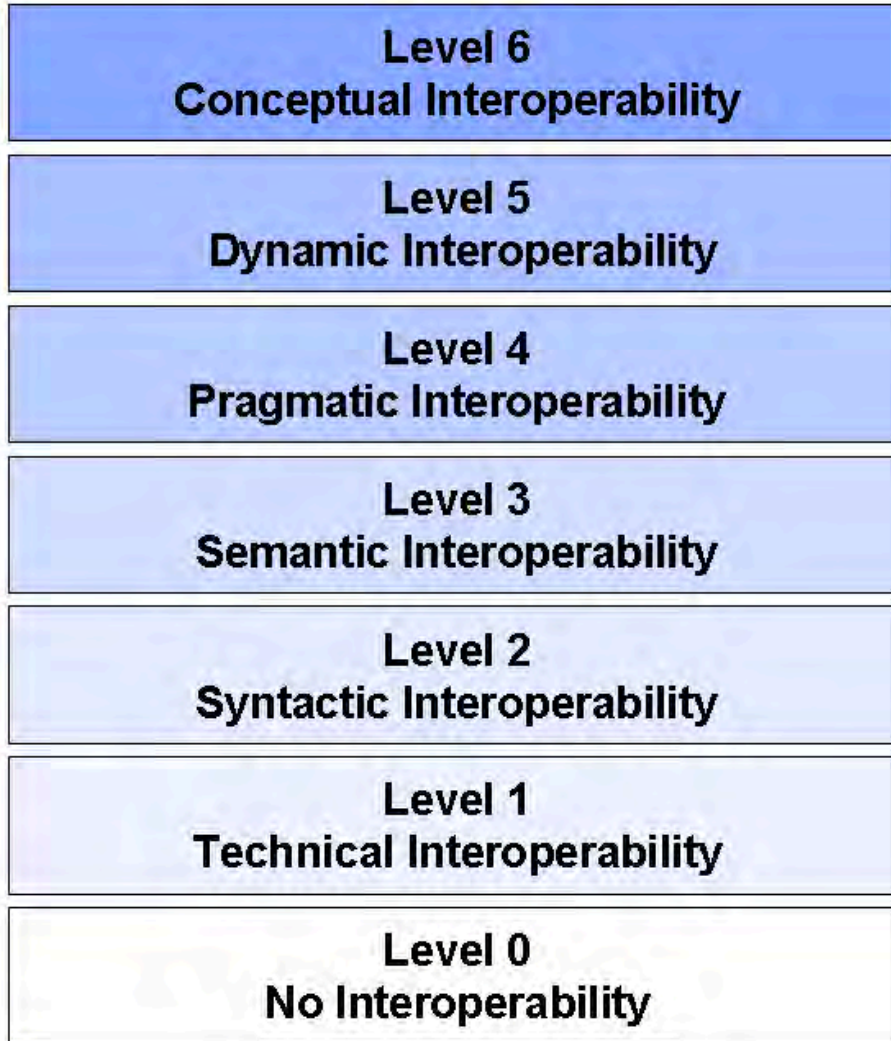
Modeling /  
Abstraction

*Interoperability*

Simulation /  
Implementation

*Integrability*

Network /  
Connectivity



**Industrial Internet (IIoT)**

Vertical Industry Data Models

Connectivity Framework

Connectivity Transport

Horizontal stack  
that can span  
across verticals!



# Technical Interoperability Example...

Share byte sequences

```

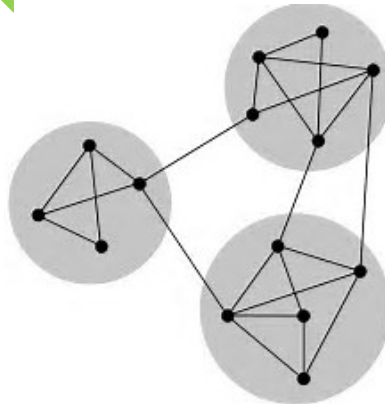
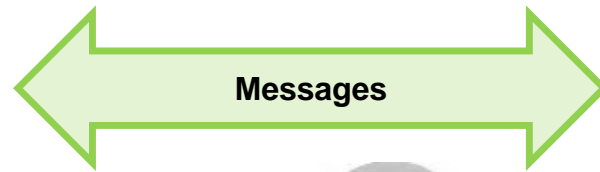
0000 54 a0 50 cf b6 80 14 10 9f e2 3a 05 08 00 45 00
0010 00 90 4a ec 00 00 40 11 07 d4 c0 a8 59 e6 0a 00
0020 03 0f f4 22 1c f3 00 7c f3 13 52 54 50 53 02 01
0030 01 01 c0 a8 59 e6 00 00 49 03 00 00 00 01 09 01
0040 08 00 1a b6 c9 58 d6 7f 2b f1 15 07 50 00 00 00
0050 10 00 00 00 00 00 80 00 00 02 00 00 00 00 59 02
0060 00 00 70 00 10 00 ca c2 17 c3 18 36 3f 8e f1 16
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
0090 00 00 1e 00 00 00 00 00 00 00 00 00 00 00 00

```

```

T.P..... :...E.
..J...@. ....Y...
..."...| ..RTPS..
....Y... I.....
.....X.. +...P...
.....Y.
..p..... ..6?...
..BLUE.. ..U.....
.....

```





# Technical Interoperability Example...

Share byte sequences

```

0000 54 a0 50 cf b6 80 14 10 9f e2 3a 05 08 00 45 00
0010 00 90 4a ec 00 00 40 11 07 d4 c0 a8 59 e6 0a 00
0020 03 0f f4 22 1c f3 00 7c f3 13 52 54 50 53 02 01
0030 01 01 c0 a8 59 e6 00 00 49 03 00 00 00 01 09 01
0040 08 00 1a b6 c9 58 d6 7f 2b f1 15 07 50 00 00 00
0050 10 00 00 00 00 00 80 00 00 02 00 00 00 00 59 02
0060 00 00 70 00 10 00 ca c2 17 c3 18 36 3f 8e f1 16
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
0090 00 00 1e 00 00 00 00 00 00 00 00 00 00 00 00

```

```

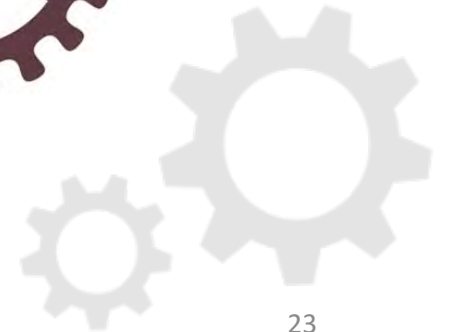
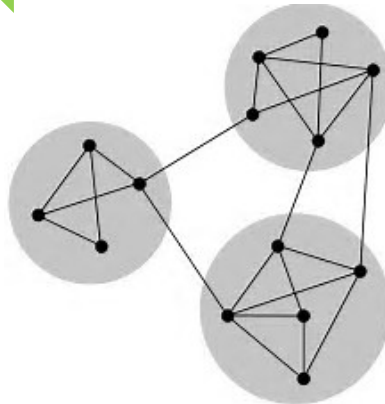
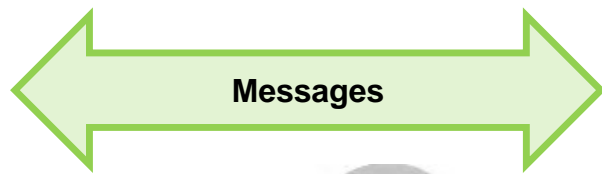
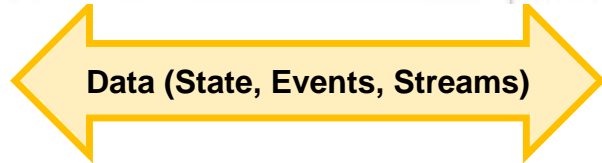
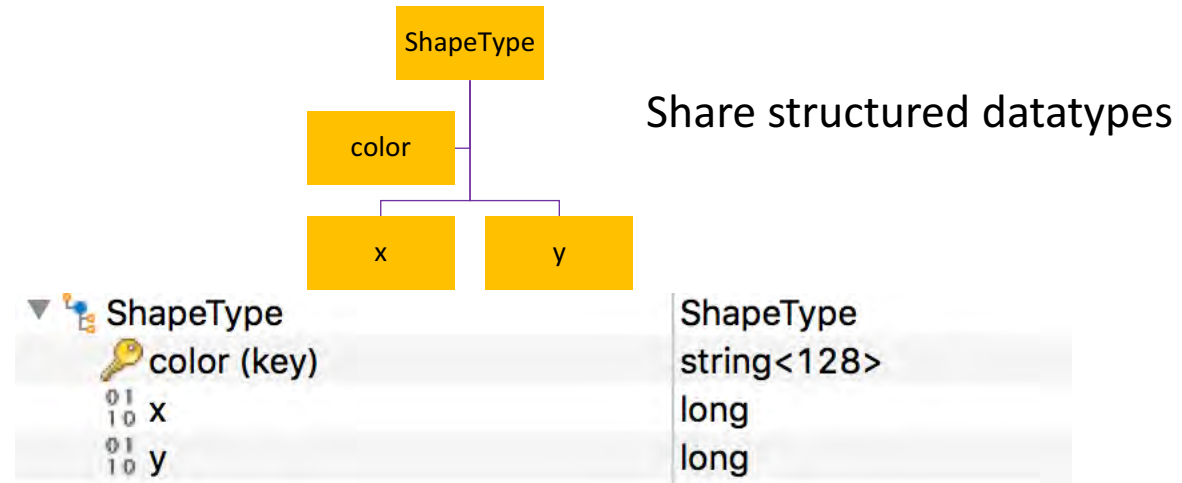
T.P..... :...E.
..J...@. ....Y...
..."...| ..RTPS..
....Y... I.....
.....X.. +...P...
.....Y.
..p..... ..6?...
..BLUE.. ..U.....
.....

```



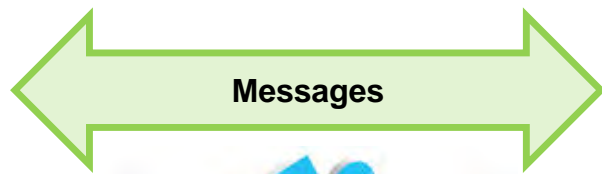
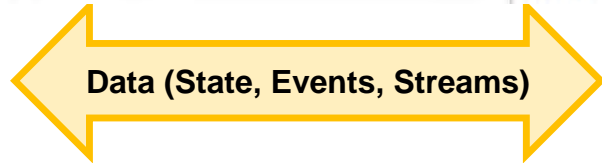
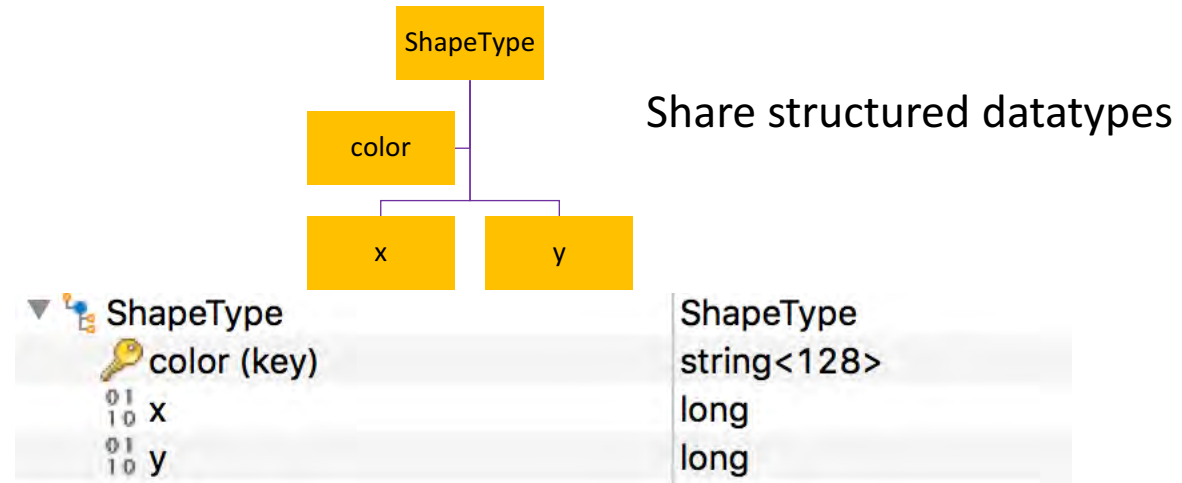


# Syntactic Interoperability Example...





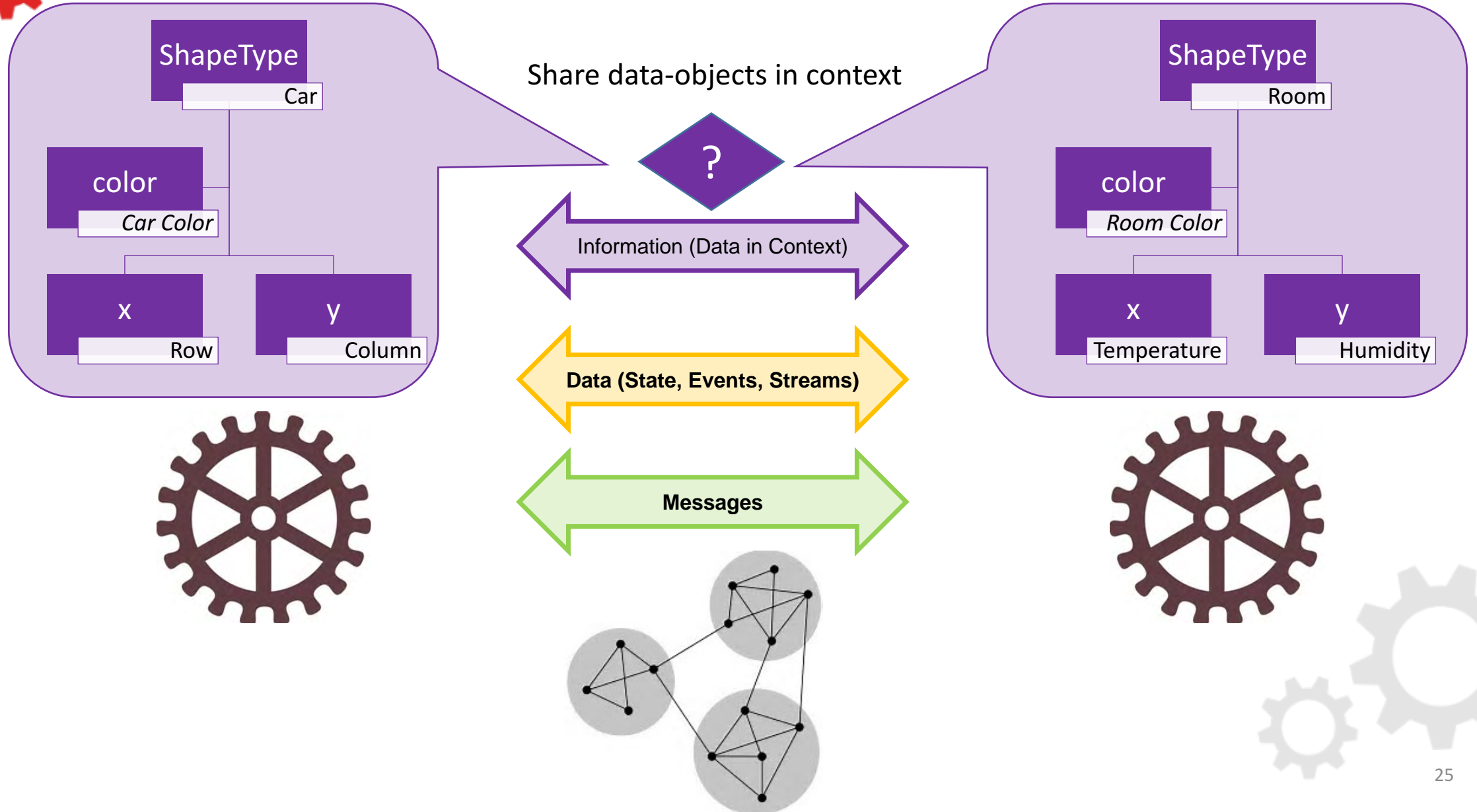
# Syntactic Interoperability Example...





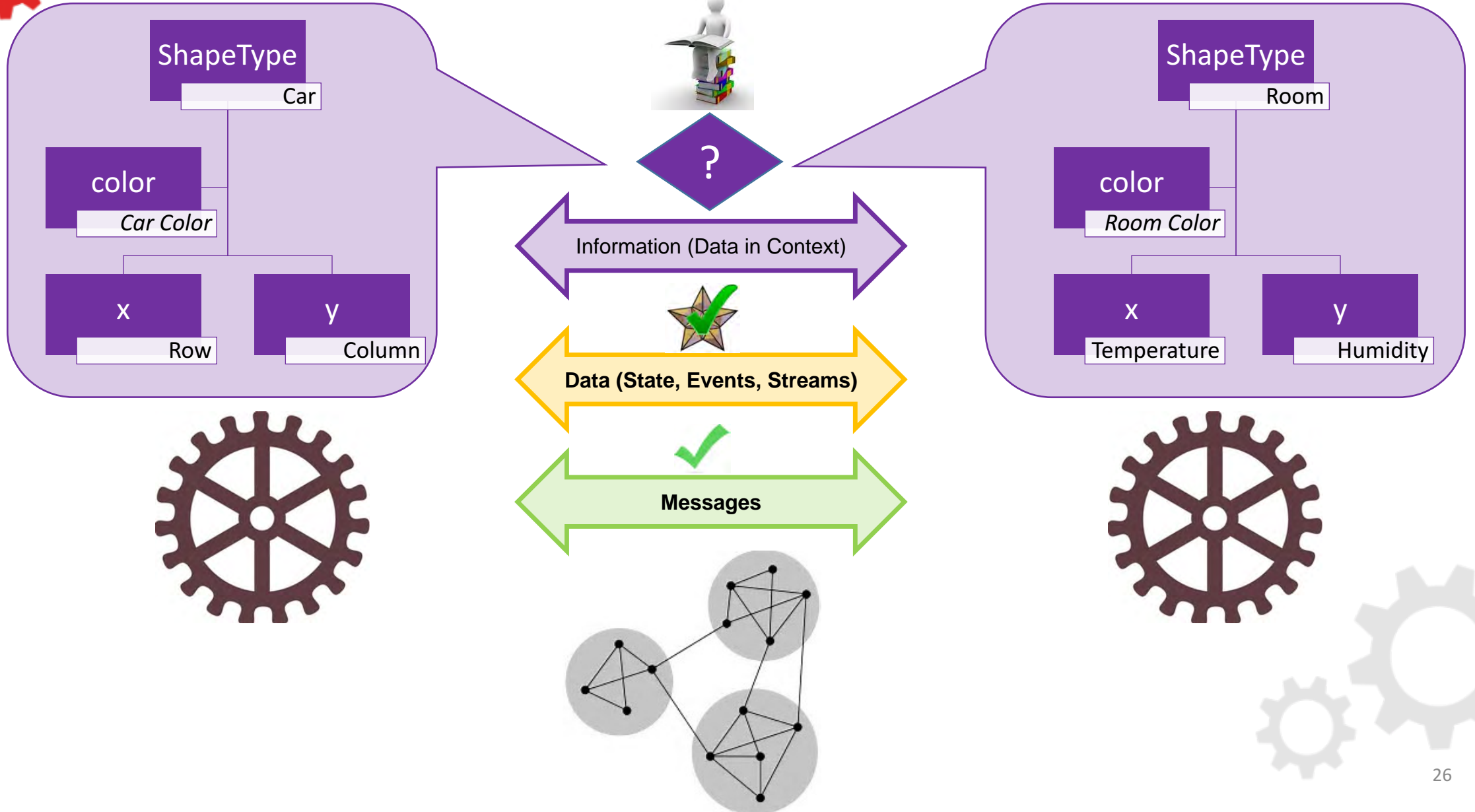


# Semantic Interoperability Example...



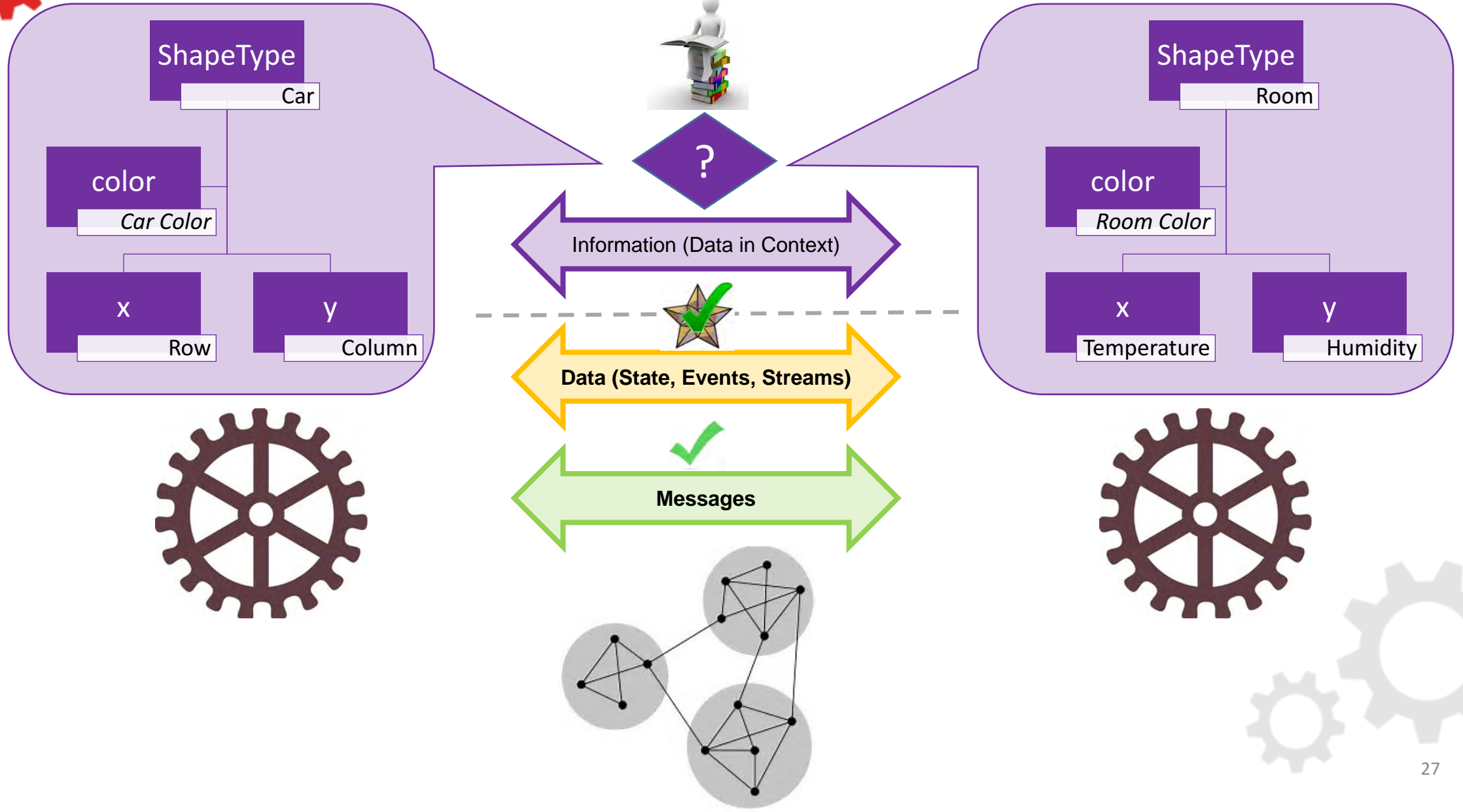


# Where do we draw the line?



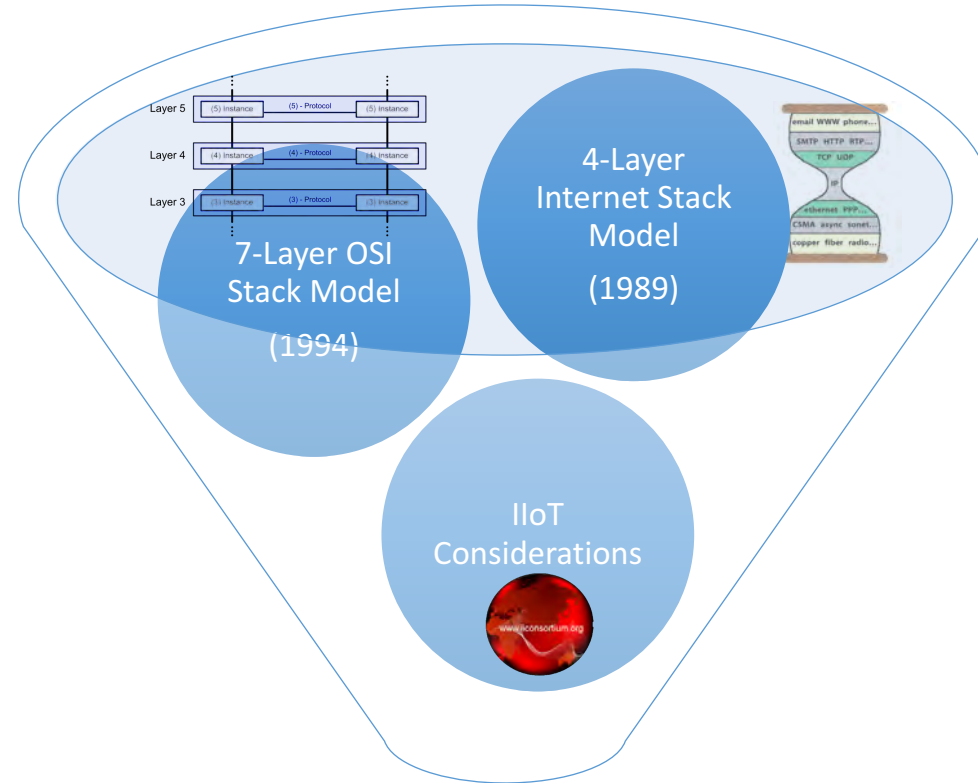


# Where do we draw the line?





# Evolution of the IIoT Connectivity Stack

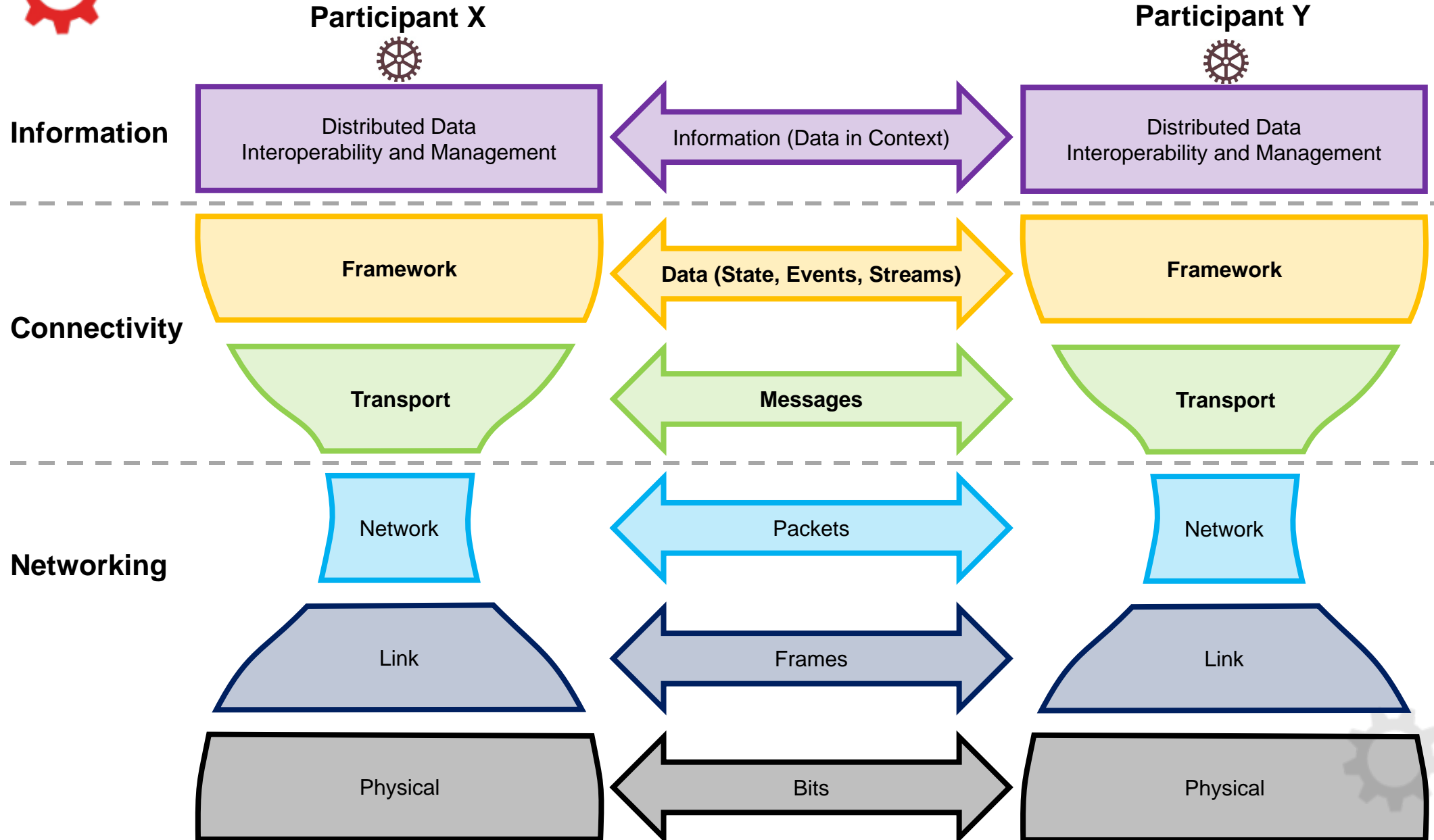


IIoT Connectivity Stack Model (2017)





# IIoT Connectivity Stack Model





# IIoT Connectivity Stack Model

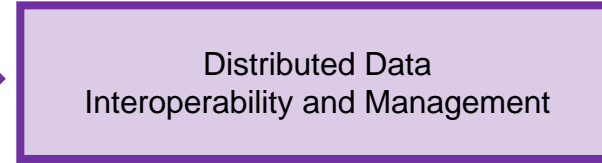
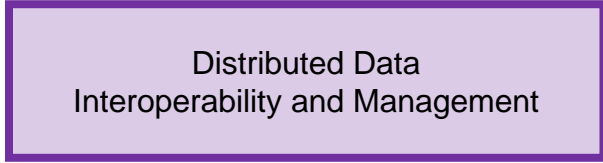
Participant X



Participant Y



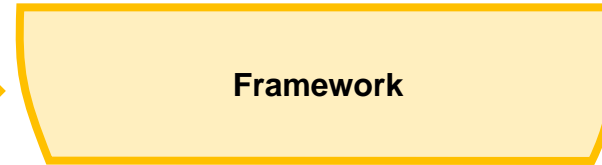
**Information**



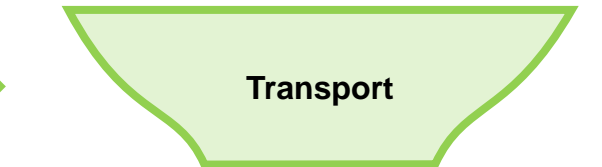
*Semantic Interoperability (Level 3)*

**Connectivity**

*Connectivity Task Group  
• Document Focus*



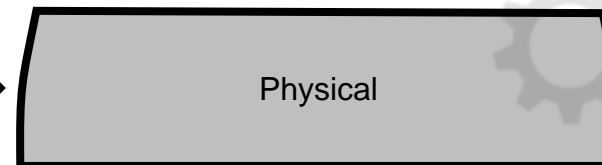
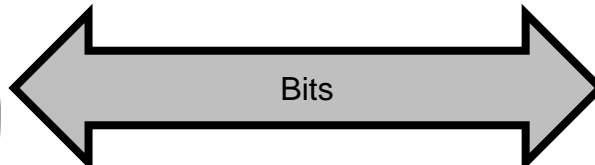
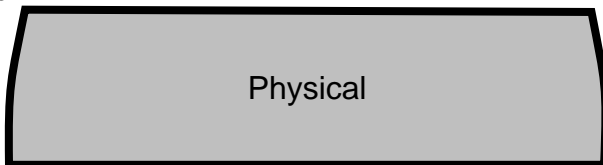
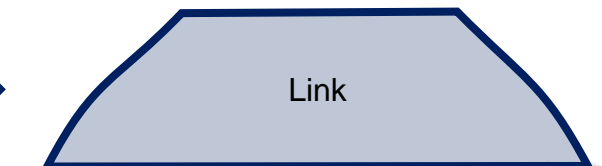
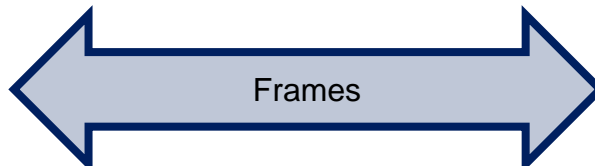
*Syntactic Interoperability (Level 2)*



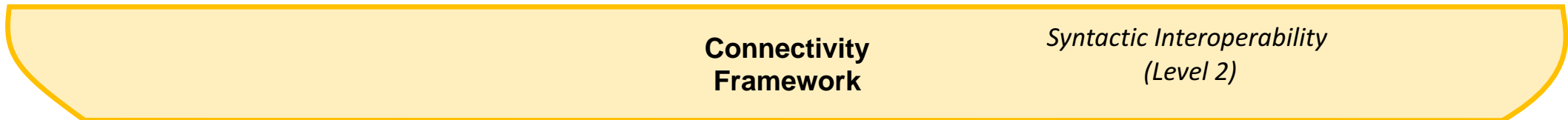
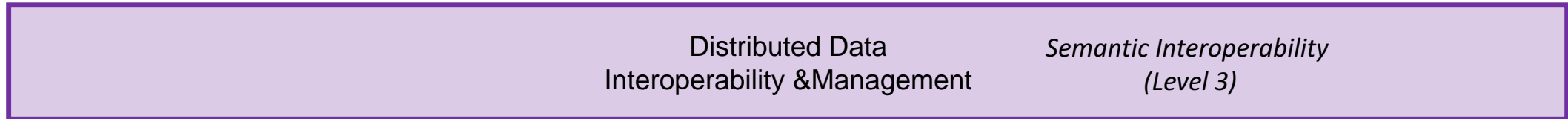
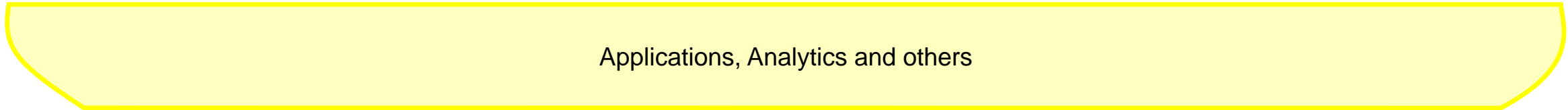
*Technical Interoperability (Level 1)*

**Networking**

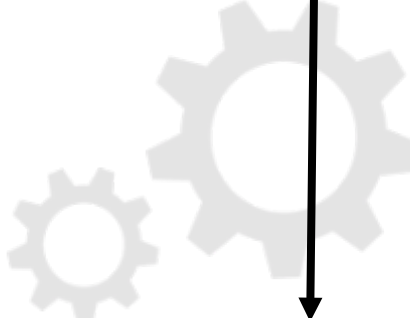
*Connectivity Task Group  
• Generally understood  
• Beyond current scope*



# IIoT Horizontal Interoperability

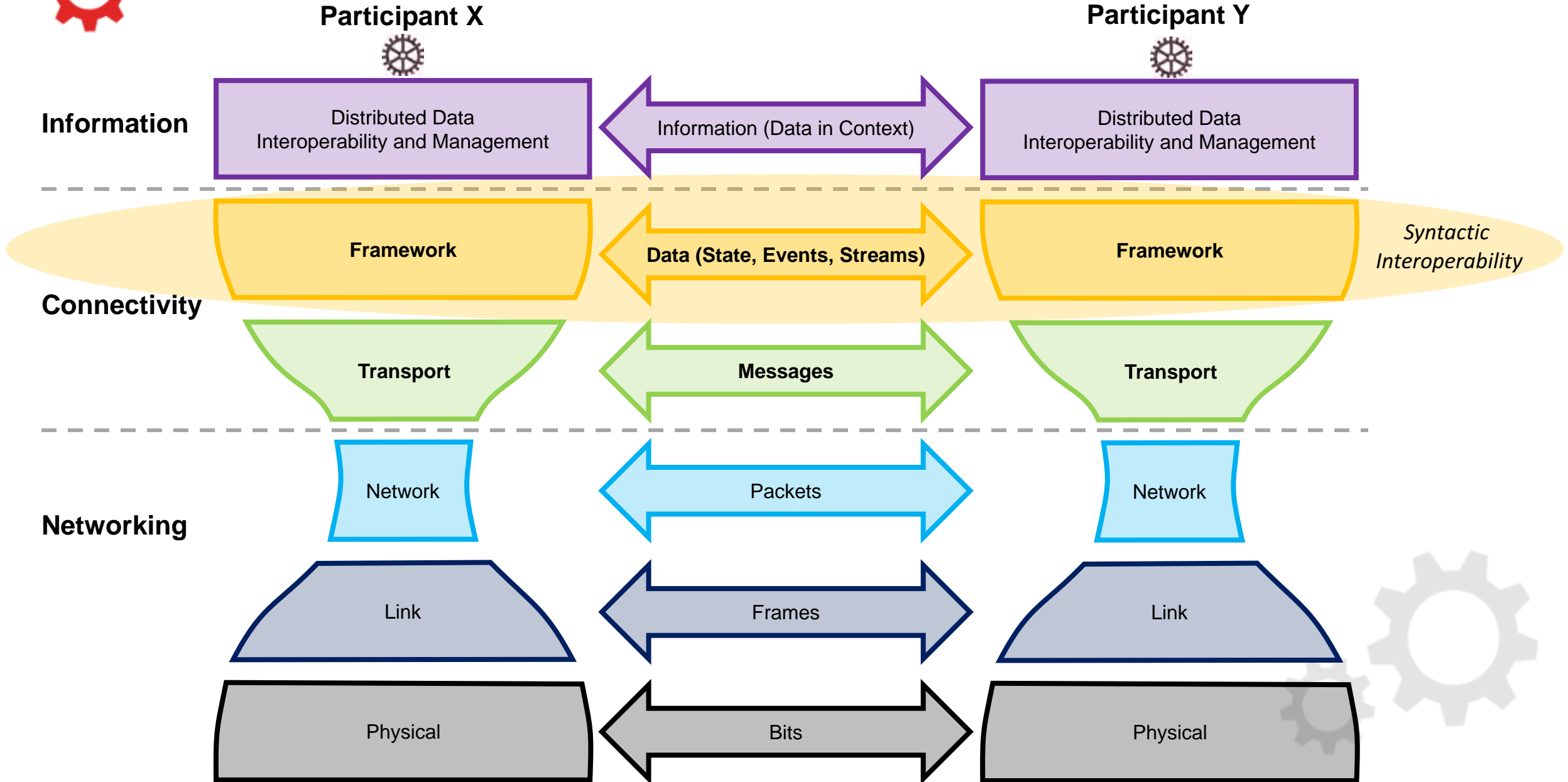


**Connectivity Crosscutting Function**





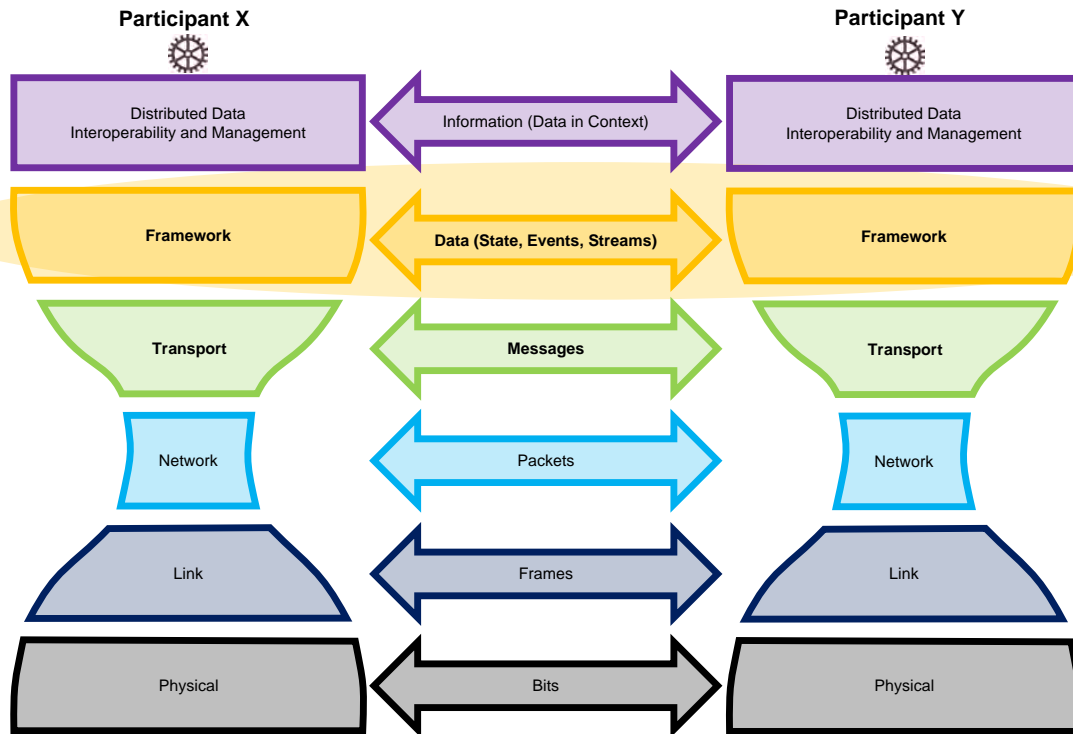
# IIoT Connectivity Stack







# Framework Layer : Syntactic Interoperability



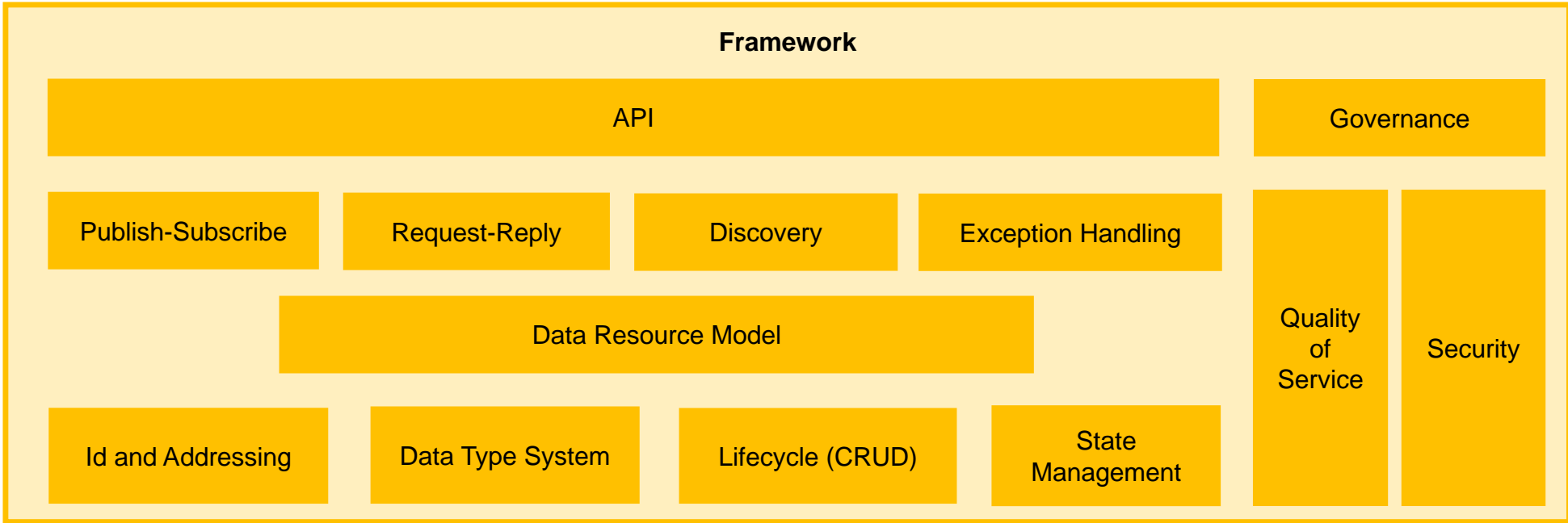
## Connectivity Framework Layer

- Provides ***syntactic interoperability*** between endpoints
  - Share structured datatypes
    - Information is structured in a common and unambiguous data format
  - Meaning (interpretation of datatypes in context) is beyond the scope of this layer
- Connectivity Framework Layer Infrastructure
  - Any programming environment
  - Any computing platform
  - May observe data flows & optimize datatype sharing and delivery



# Connectivity Framework Layer

Distributed Data Interoperability & Management



Connectivity Framework Functions

*Syntactic Interoperability*

Transport

Network

Link

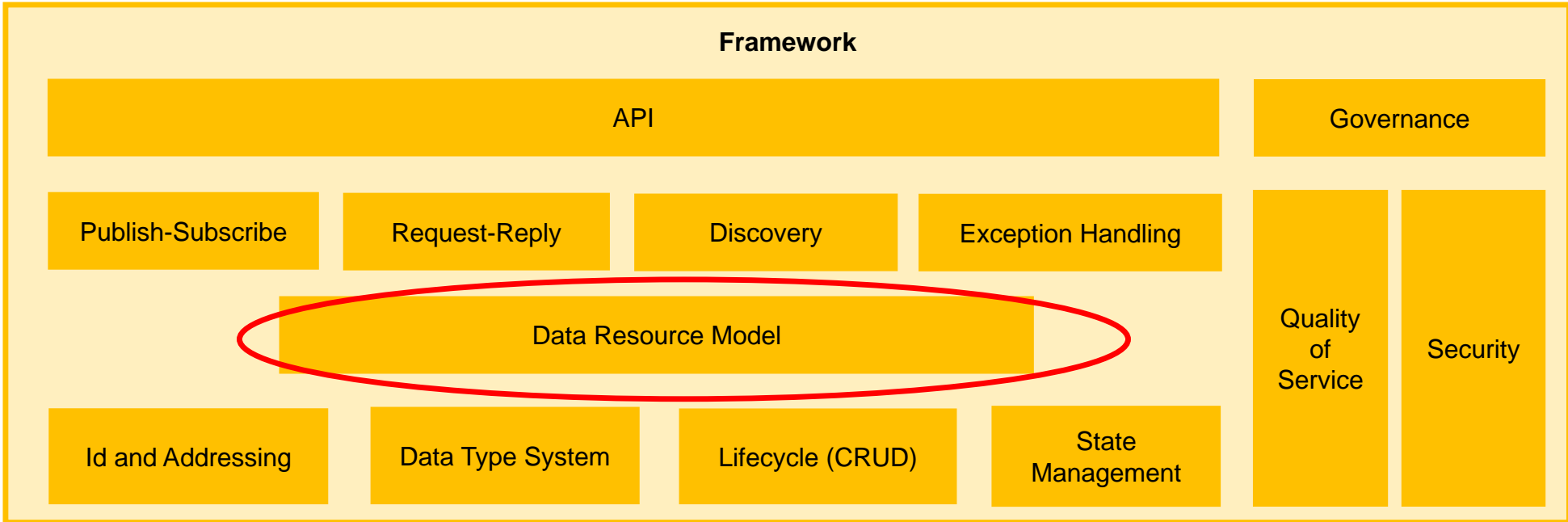
Physical





# Connectivity Framework Layer

Distributed Data Interoperability & Management



Connectivity Framework Functions

*Syntactic Interoperability*

Transport

Network

Link

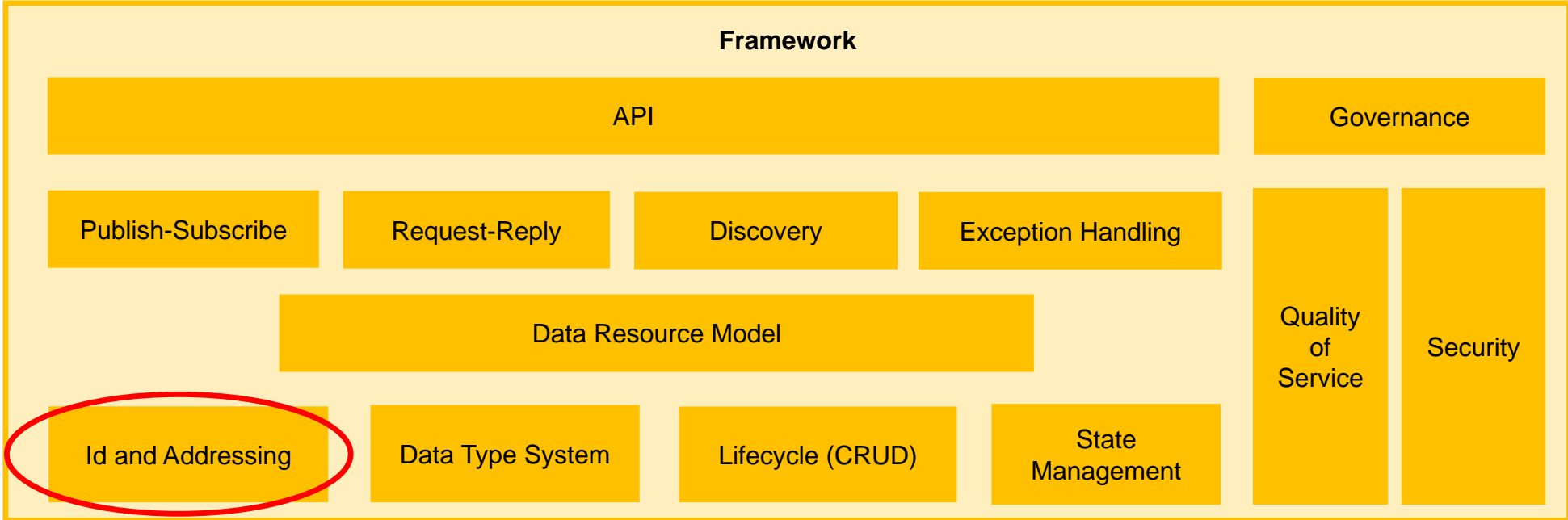
Physical





# Connectivity Framework Layer

Distributed Data Interoperability & Management



Connectivity Framework Functions

*Syntactic Interoperability*

Transport

Network

Link

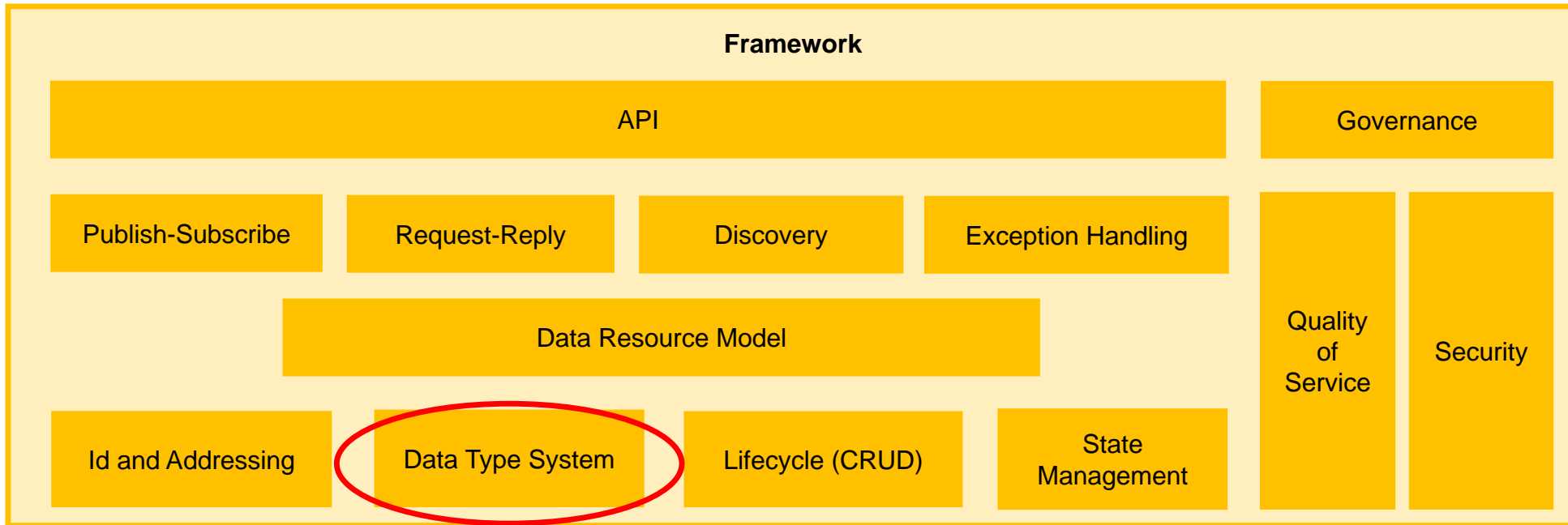
Physical





# Connectivity Framework Layer

Distributed Data Interoperability & Management

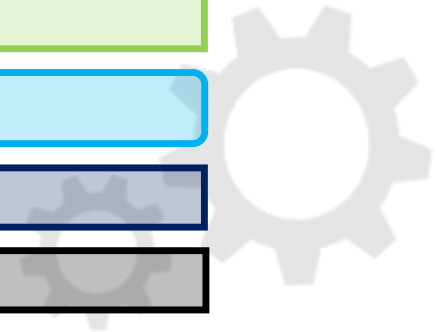


Transport

Network

Link

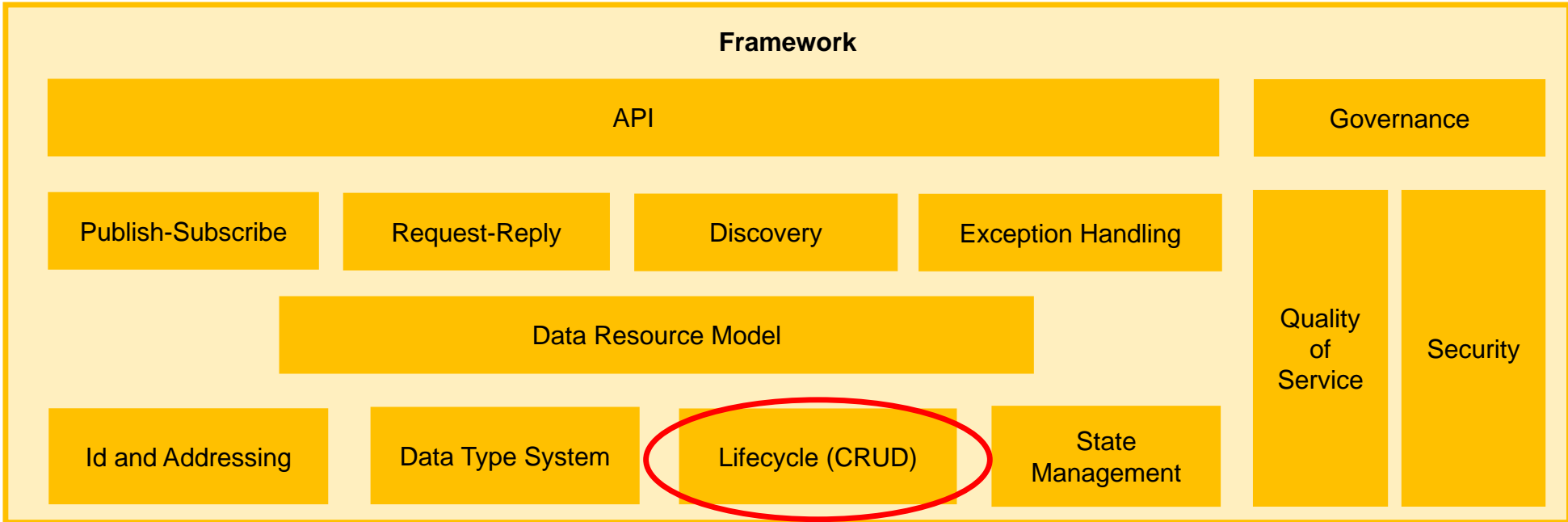
Physical





# Connectivity Framework Layer

Distributed Data Interoperability & Management



Connectivity Framework Functions

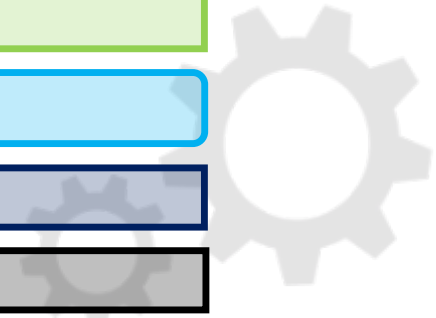
*Syntactic Interoperability*

Transport

Network

Link

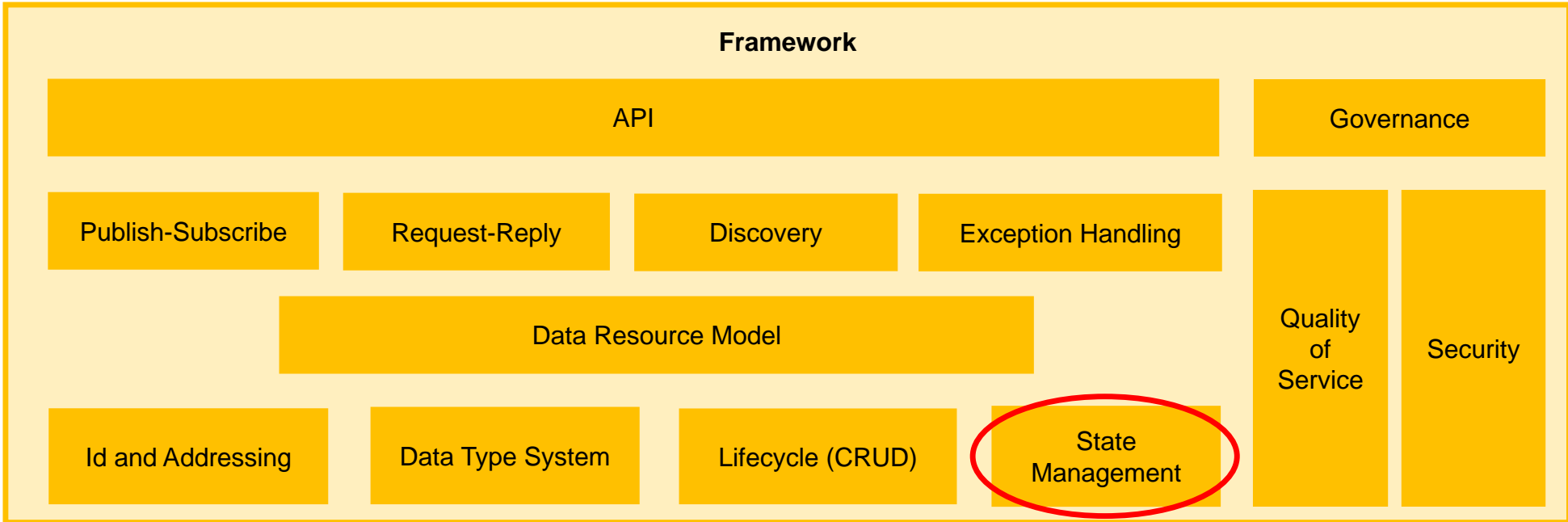
Physical





# Connectivity Framework Layer

Distributed Data Interoperability & Management



Connectivity Framework Functions

*Syntactic Interoperability*

Transport

Network

Link

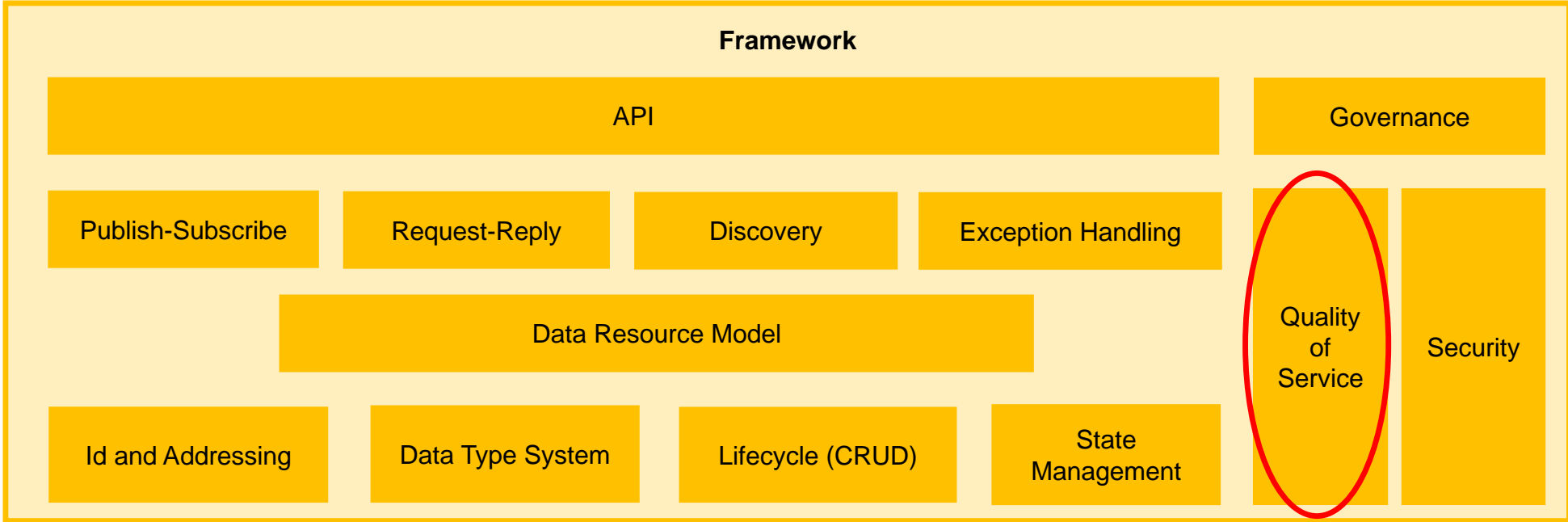
Physical





# Connectivity Framework Layer

Distributed Data Interoperability & Management



Connectivity  
Framework  
Functions

*Syntactic  
Interoperability*

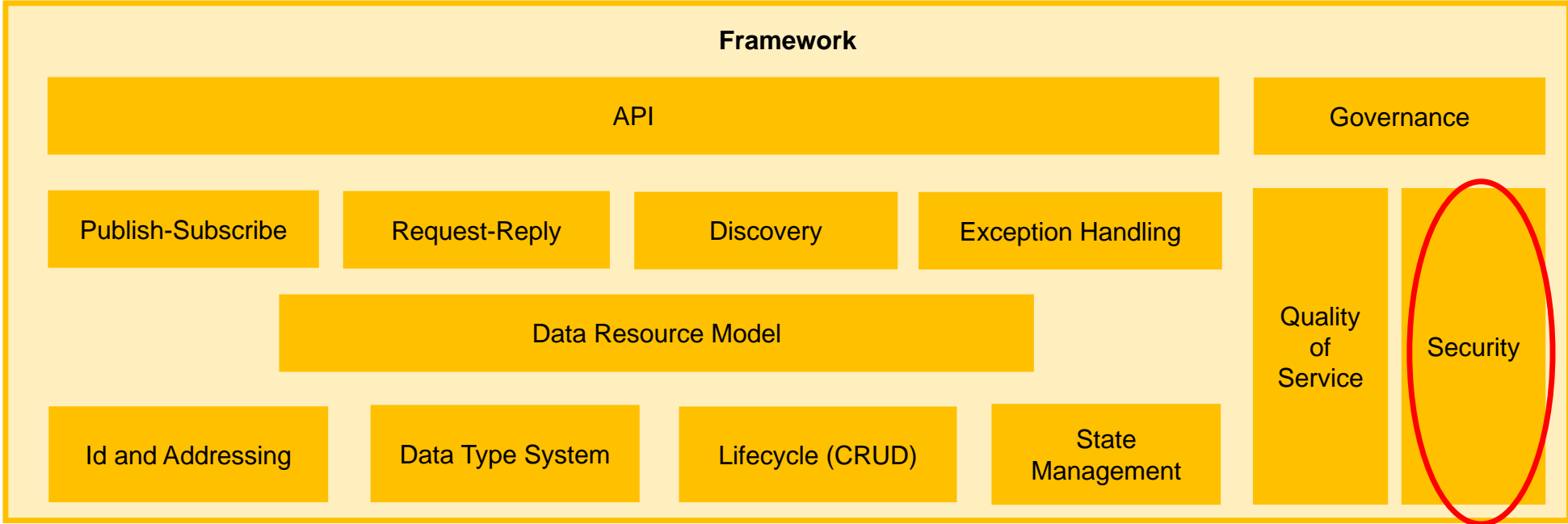






# Connectivity Framework Layer

Distributed Data Interoperability & Management



Connectivity Framework Functions

*Syntactic Interoperability*

Transport

Network

Link

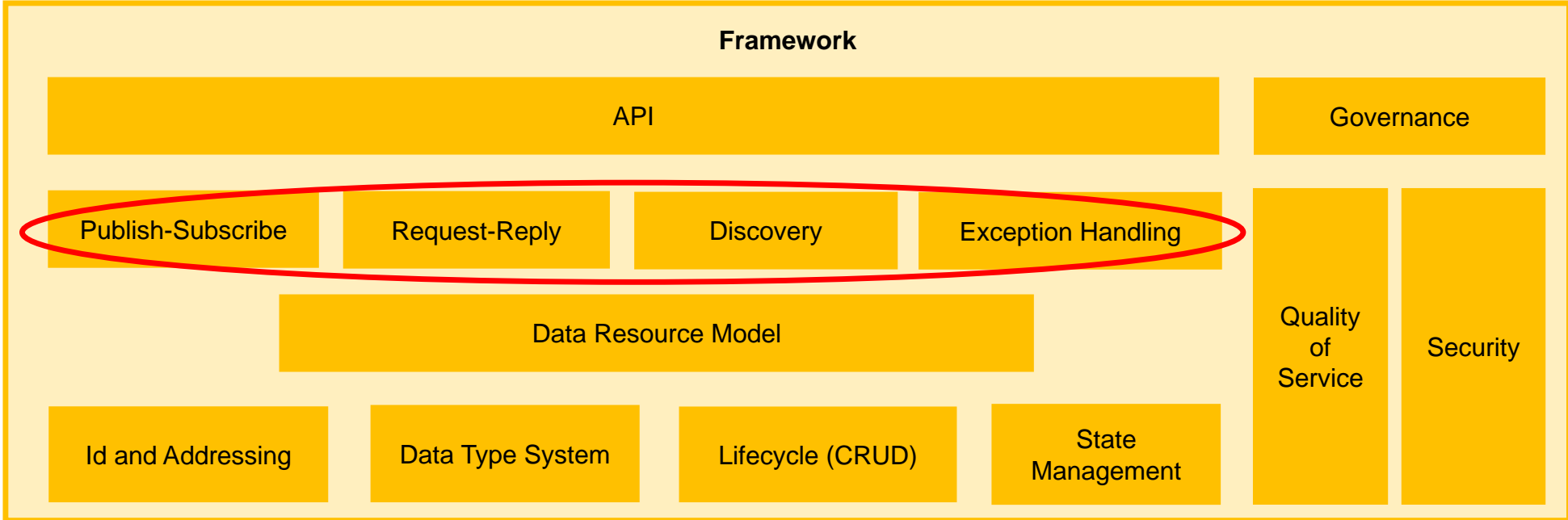
Physical





# Connectivity Framework Layer

Distributed Data Interoperability & Management



*Syntactic Interoperability*

Transport

Network

Link

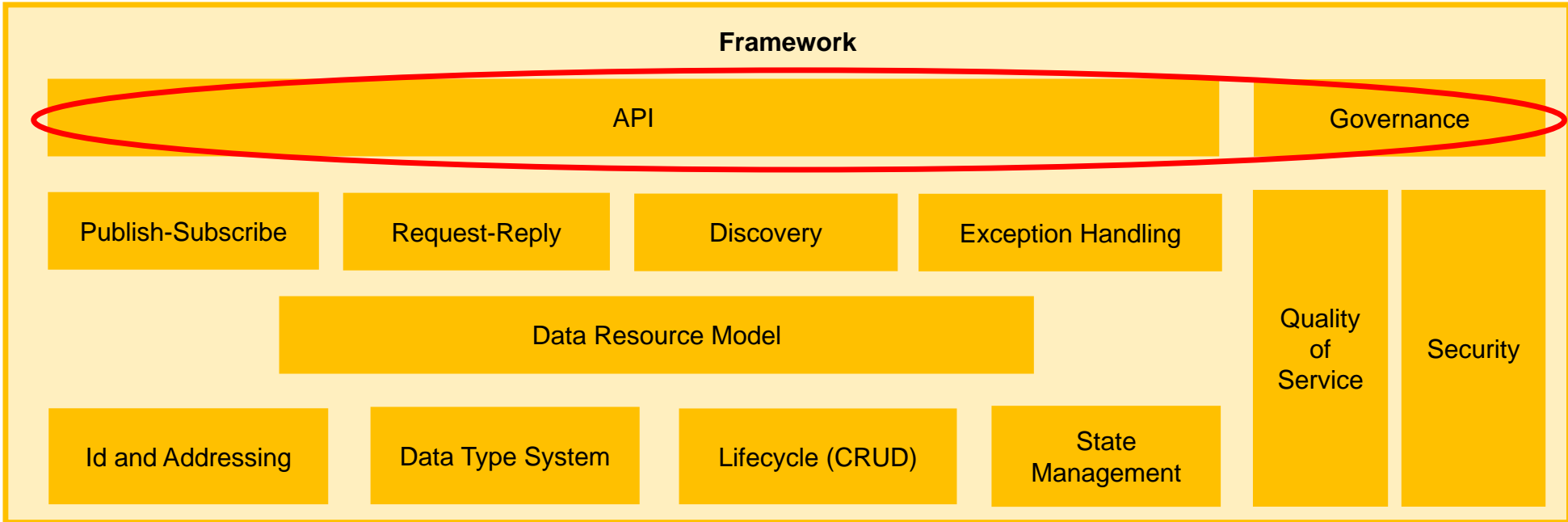
Physical





# Connectivity Framework Layer

Distributed Data Interoperability & Management



Connectivity Framework Functions

*Syntactic Interoperability*

Transport

Network

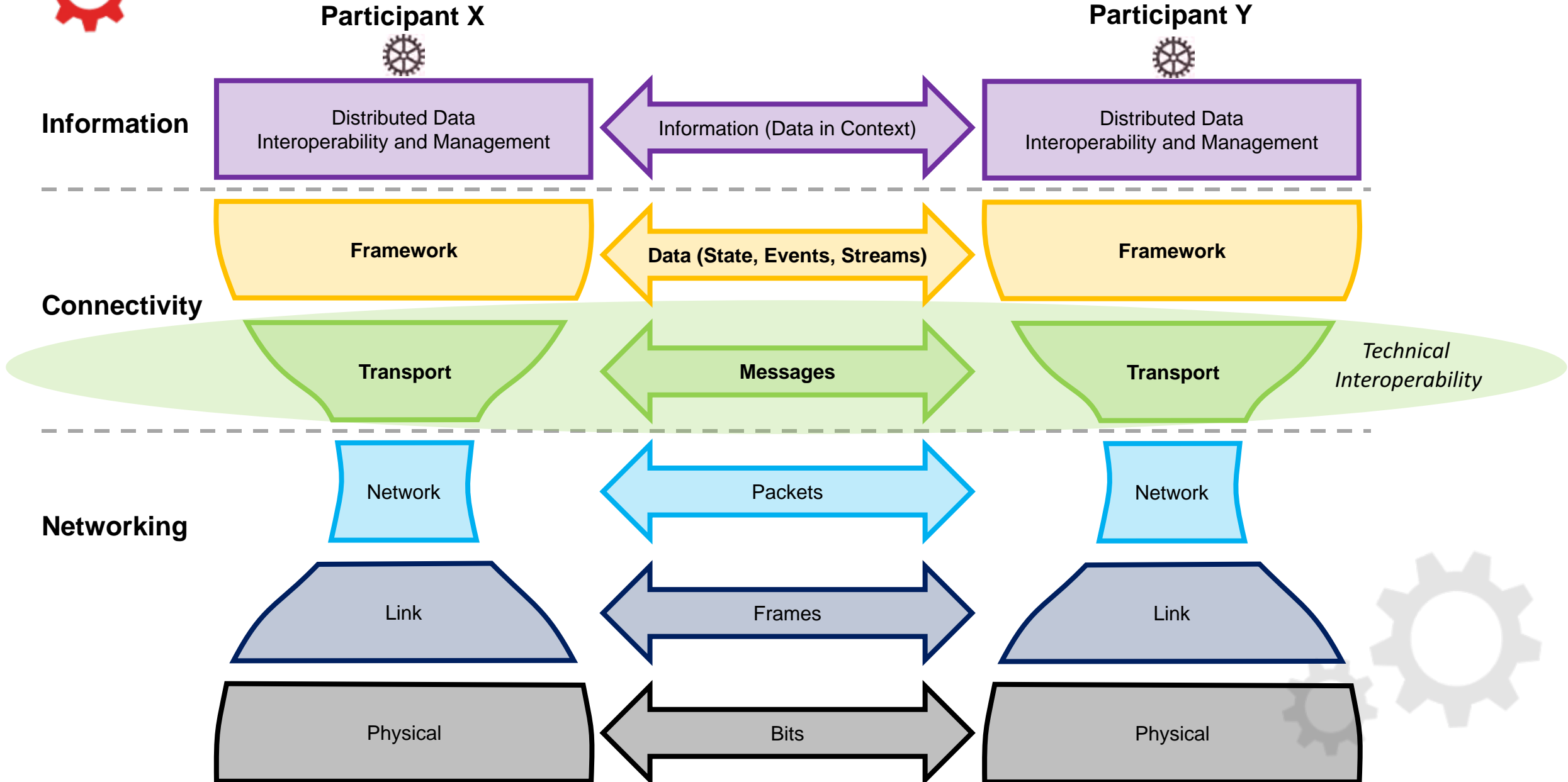
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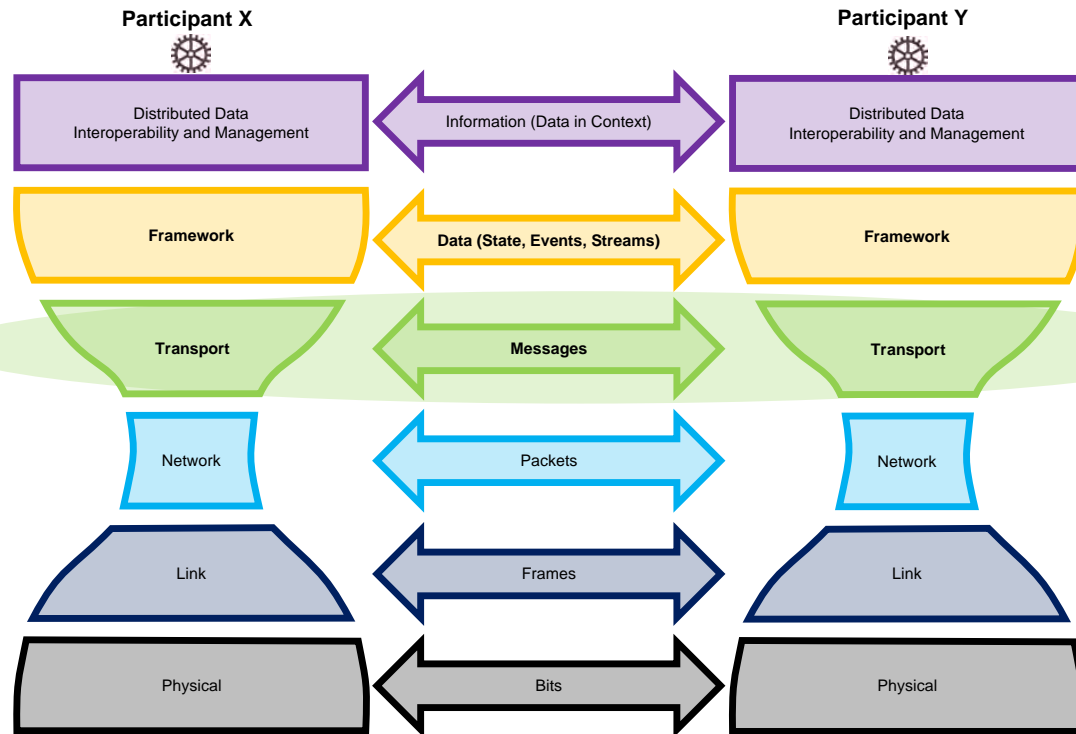




# IIoT Connectivity Stack



# Transport Layer : Technical Interoperability



## Connectivity Transport Layer

- Provides ***technical interoperability*** between endpoints
  - Share byte sequences
  - Structure (interpretation of bytes in context) is beyond the scope of this layer
- Connectivity Transport Layer Infrastructure
  - Any computing platform
  - May observe byte flows & optimize byte sequence sharing and delivery



# Connectivity Transport Layer

Distributed Data Interoperability & Management

Framework

**Transport**

Messaging Protocol

Communication Modes

Endpoint Addressing   Connectedness   Prioritization   Timing & Synchronization   Security

Connectivity  
Transport  
Functions

*Technical  
Interoperability*

Network

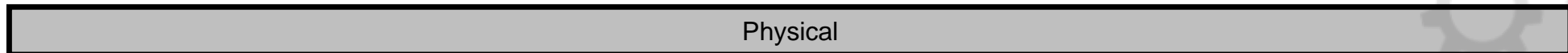
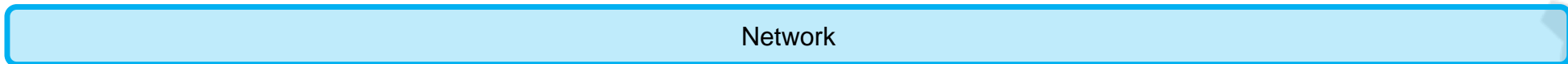
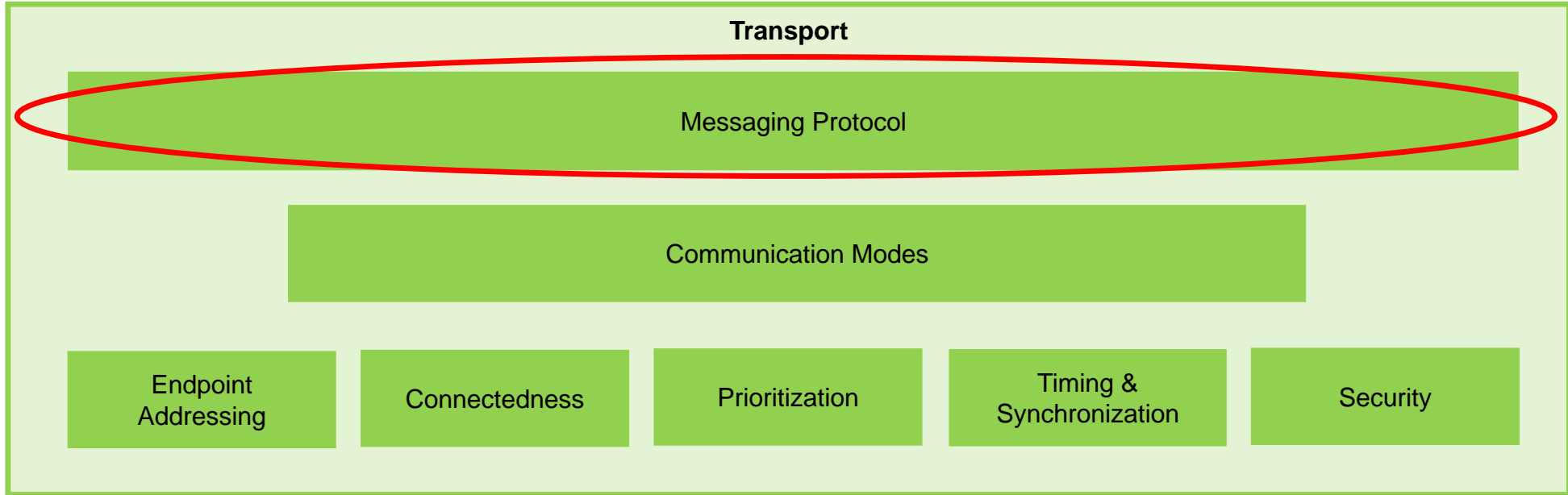
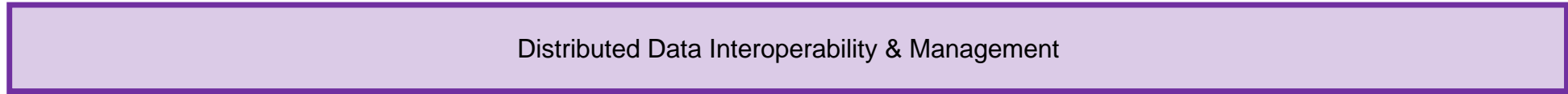
Link

Physical



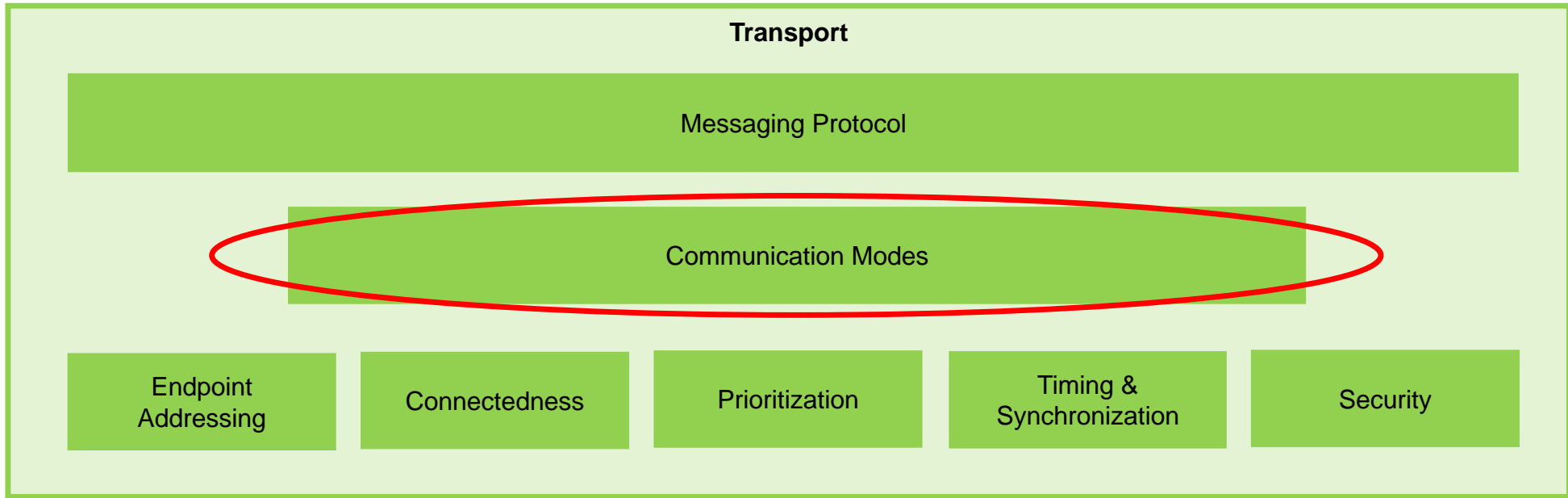
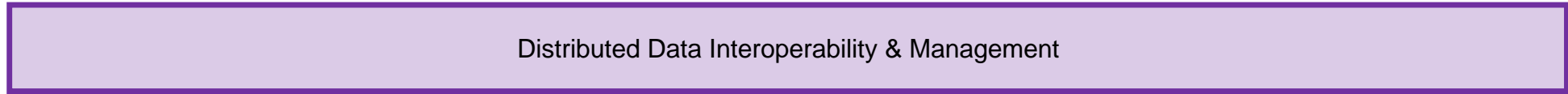


# Connectivity Transport Layer

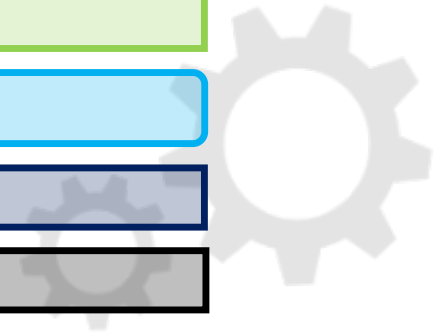
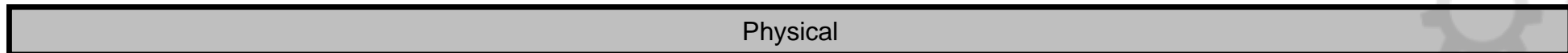
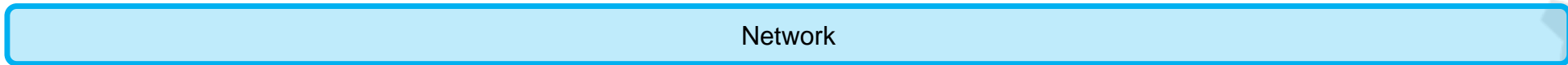




# Connectivity Transport Layer



Connectivity  
Transport  
Functions



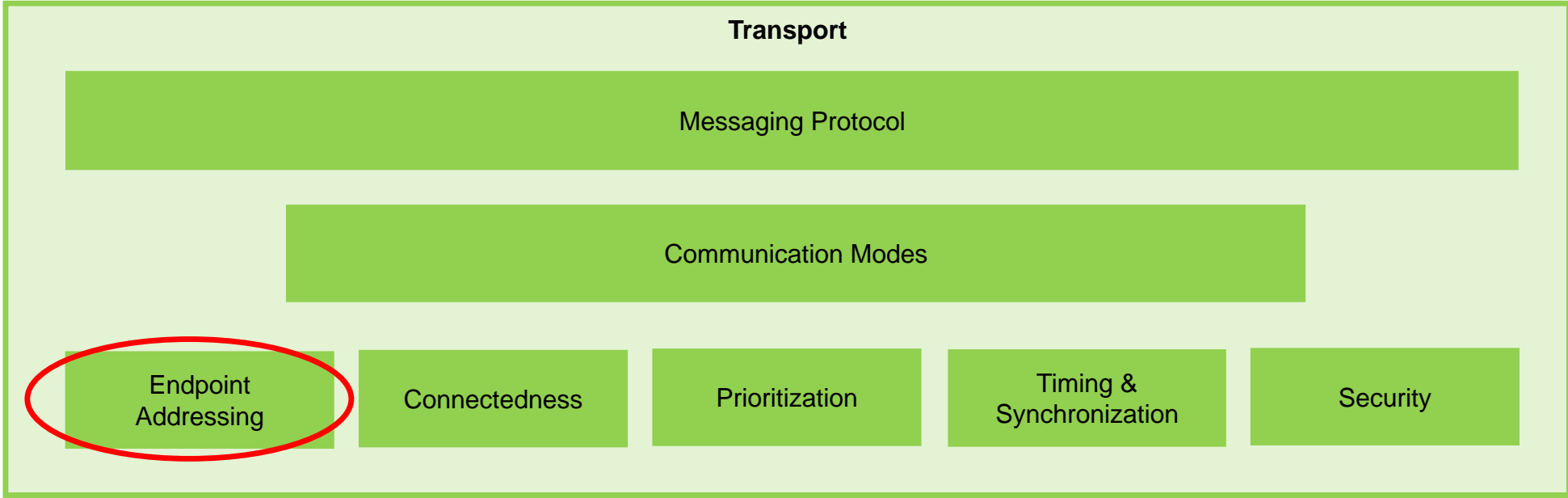




# Connectivity Transport Layer

Distributed Data Interoperability & Management

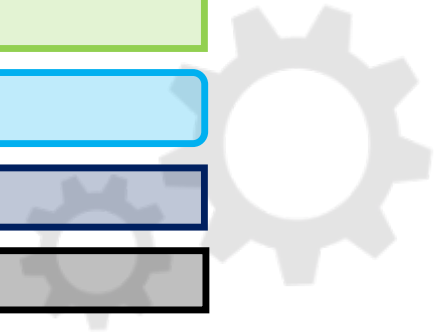
Framework



Network

Link

Physical

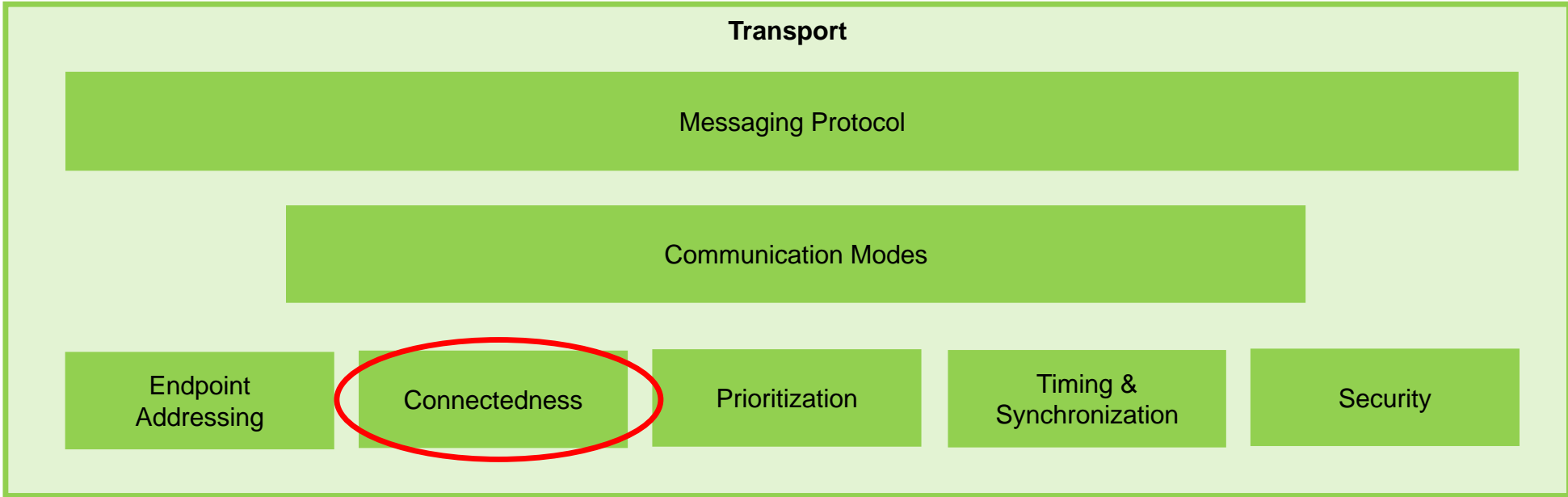




# Connectivity Transport Layer

Distributed Data Interoperability & Management

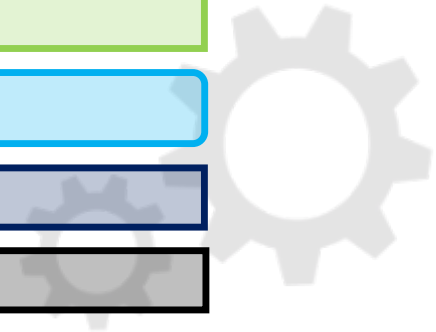
Framework



Network

Link

Physical

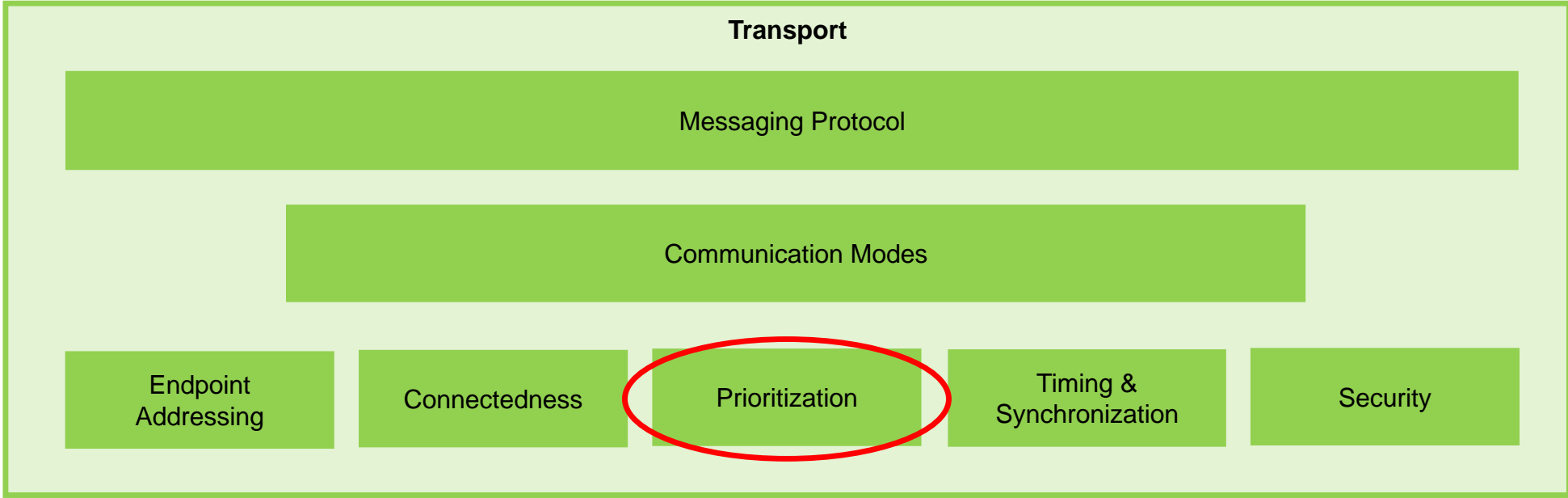




# Connectivity Transport Layer

Distributed Data Interoperability & Management

Framework



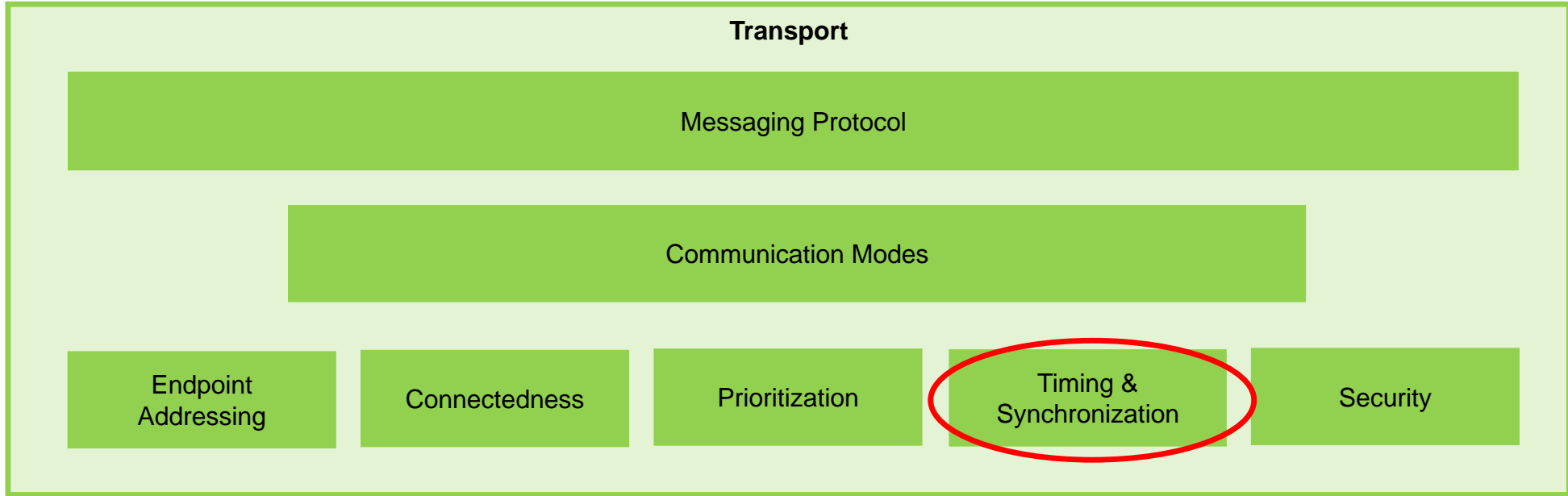
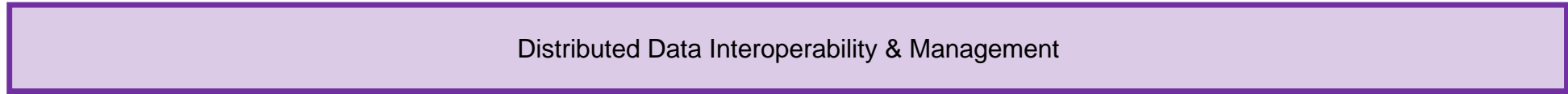
Network

Link

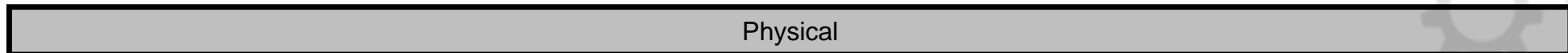
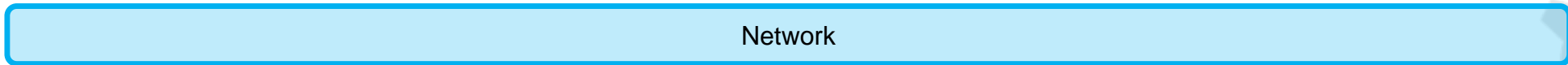
Physical



# Connectivity Transport Layer



Connectivity  
Transport  
Functions





# Connectivity Transport Layer

Distributed Data Interoperability & Management

Framework

Connectivity Transport Functions

**Transport**

Messaging Protocol

Communication Modes

Endpoint Addressing   Connectedness   Prioritization   Timing & Synchronization   **Security**

Technical Interoperability

Network

Link

Physical





# Defining a long term stable IIoT architecture strategy

**Embracing the old and the new**  
**Connectivity core standards criteria**

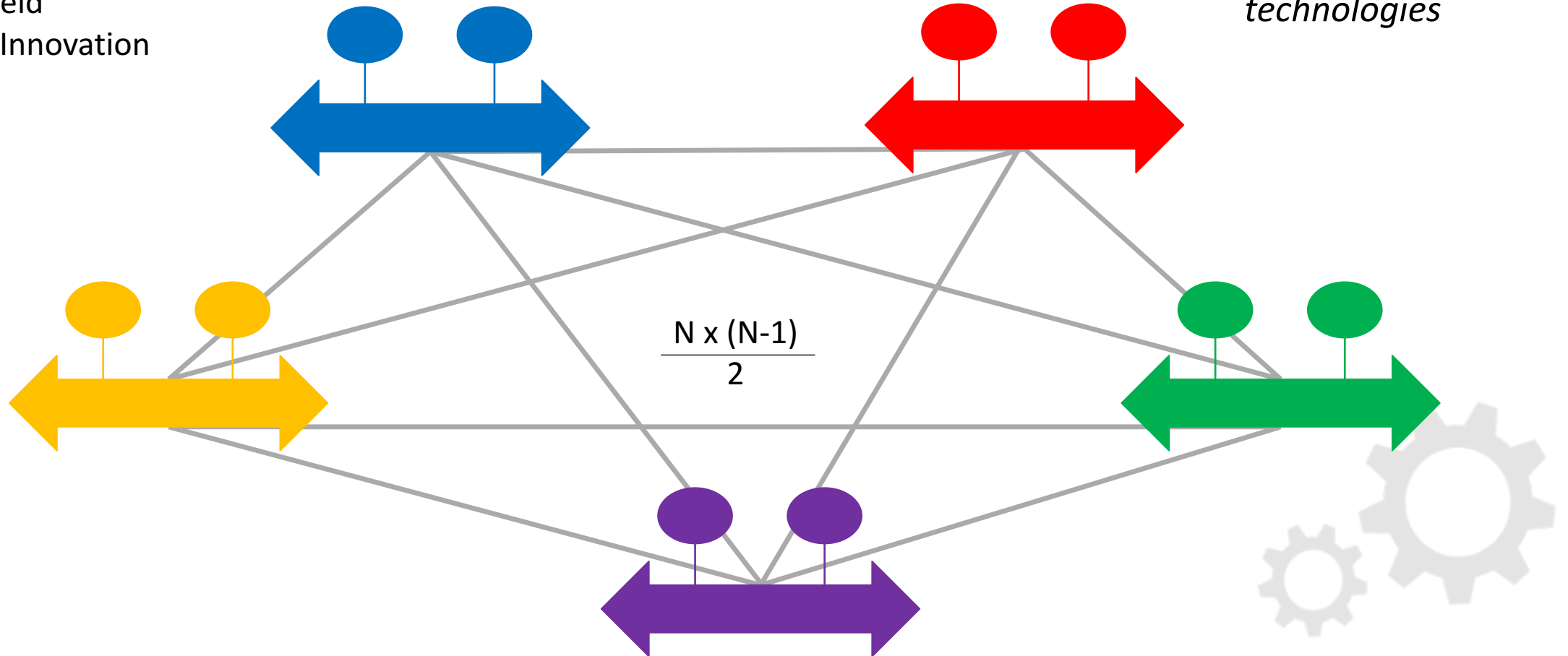


# Fundamental $N^2$ Connectivity Challenge

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

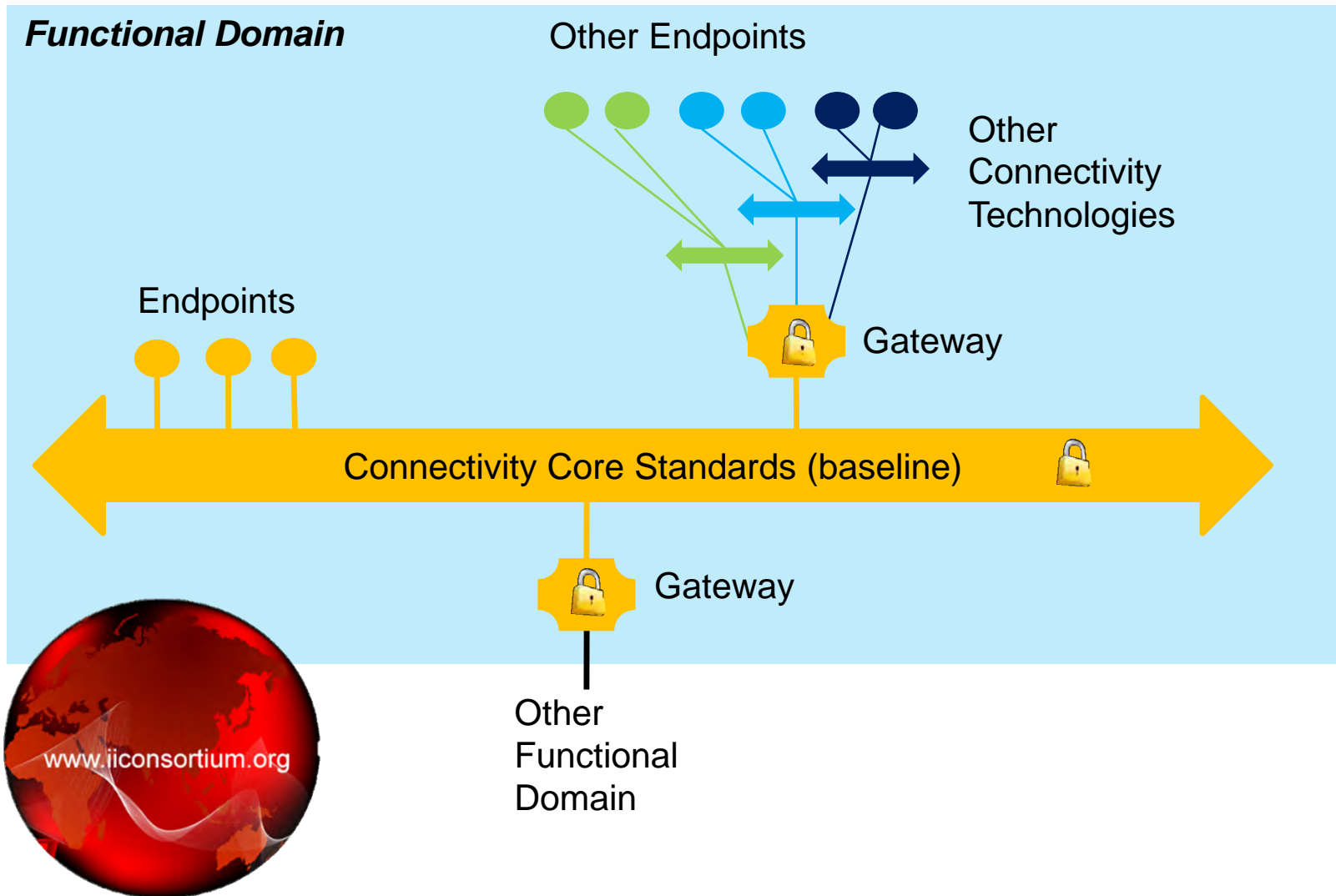
$$O(N^2)$$

**Reality Check**  
*Accept that there will be multiple connectivity technologies*





# Connectivity Reference Architecture



Gateways bridge to core connectivity standards:

- Delivers performance with flexibility
- Scales linearly (only have to map each "other" to one "core")
- Supports dataflow security

Choose core standards that matches system needs







## Connectivity Core Standards: “lingua franca” for IIoT interoperability

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*lin·gua fran·ca*

*/,liNGgwə 'fraNGkə/*

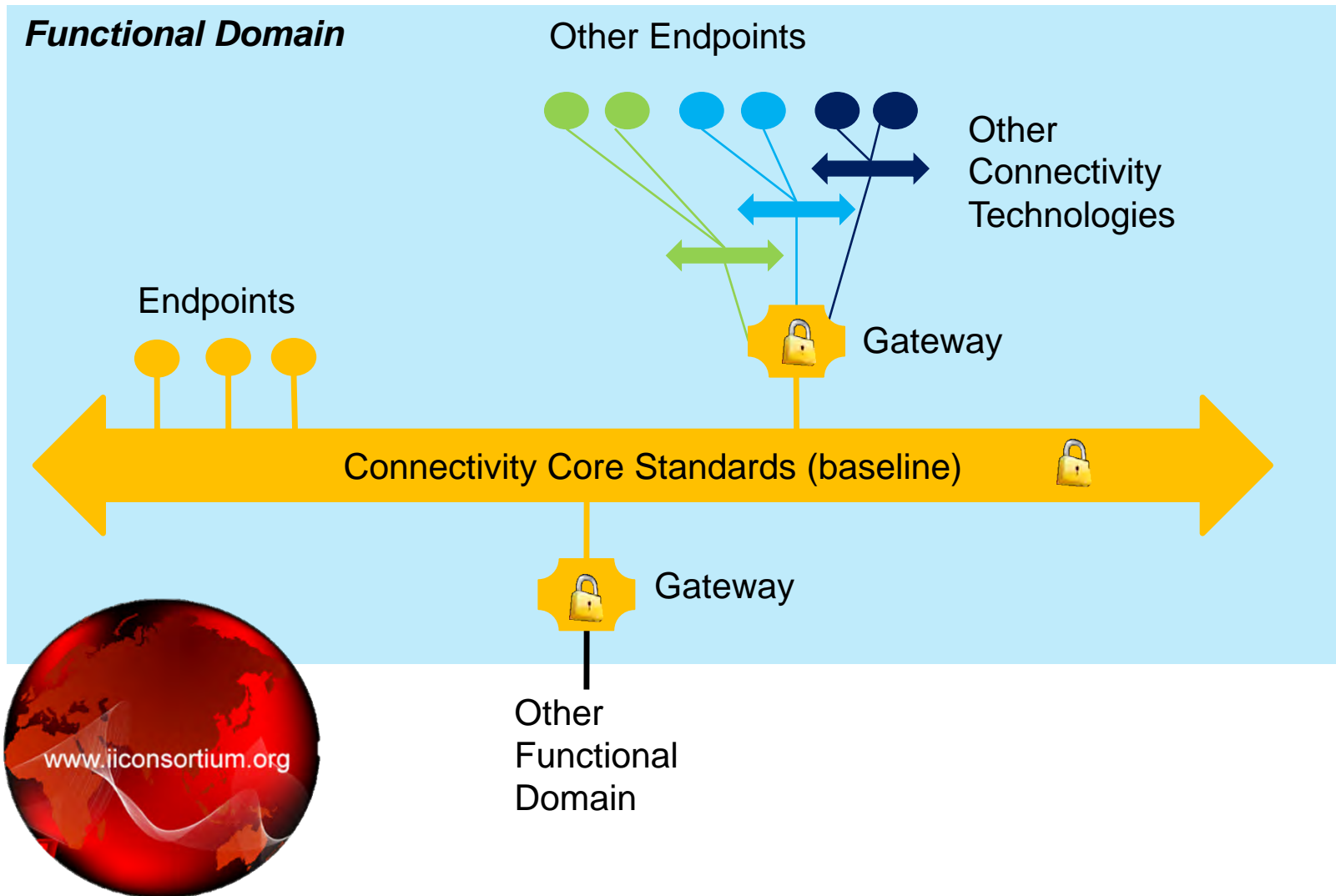
*noun: **lingua franca**; plural noun: **lingua francas***

a language that is adopted as a common language between speakers whose native languages are different





# Connectivity Reference Architecture



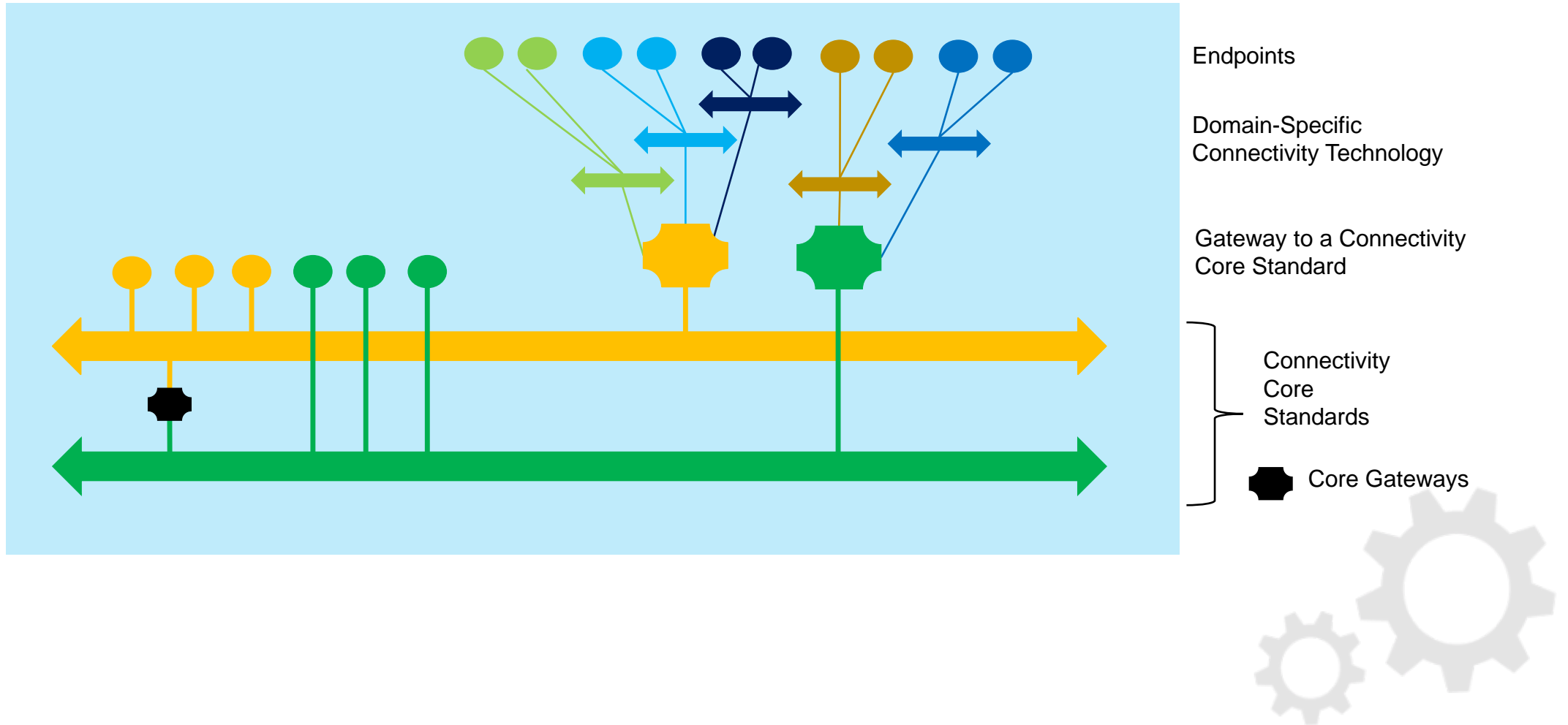
Must not compromise:

- Syntactic Interoperability
- Functional Requirements
- Non Functional Requirements
  - Performance
  - Scalability
  - Reliability
  - Resilience
  - Security
  - Safety





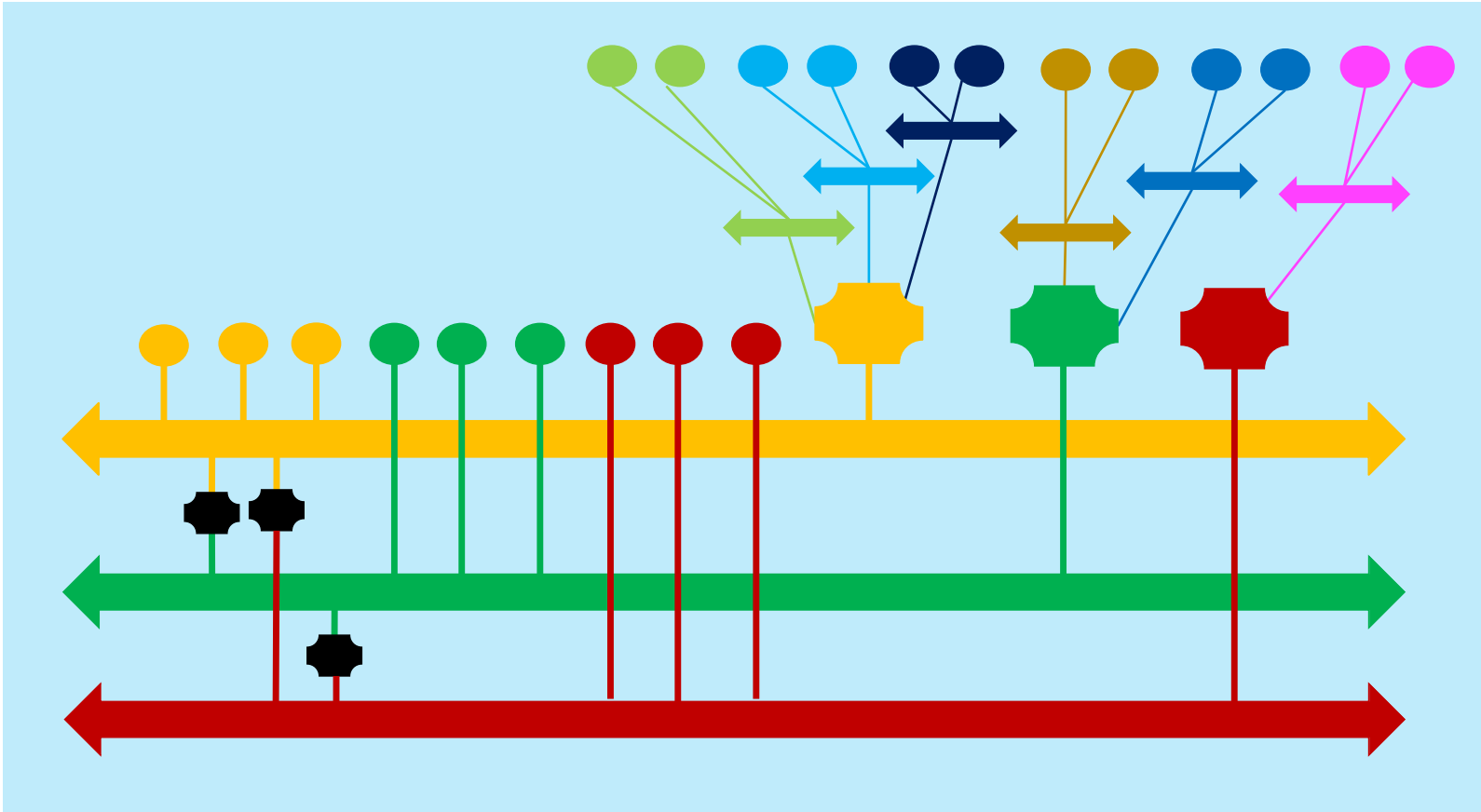
# Core Gateway Standards between Core Connectivity Standards





# Core Gateways enable Horizontal Interoperability

*Few Core, Many Domain-Specific Standards*



- Many Domain-Specific Connectivity Technologies
  - Common or de-facto connectivity technology or standard for a relevant industry or functional domain
  - Gateway will be needed to one of the core connectivity standards
  - Lots of these!
- Few Connectivity Core Standards
  - K Core Connectivity Standards
    - $K*(K-1)/2 + (N-K)$
    - when  $K \ll N$ ,  $O(N^2) \rightarrow O(N)$
  - Must meet the *Connectivity Core Standards Criteria*



# Connectivity Core Standards Criteria

Definition

Core Standard Criterion	
1	Provide <b>syntactic interoperability</b>
2	Open standard with strong <b>independent, international</b> governance
3	<b>Horizontal</b> and neutral in its applicability across industries
4	<b>Stable</b> and <b>deployed</b> across multiple vertical industries
5	Have <b>standards-defined Core Gateways</b> to <i>all</i> other core connectivity standards

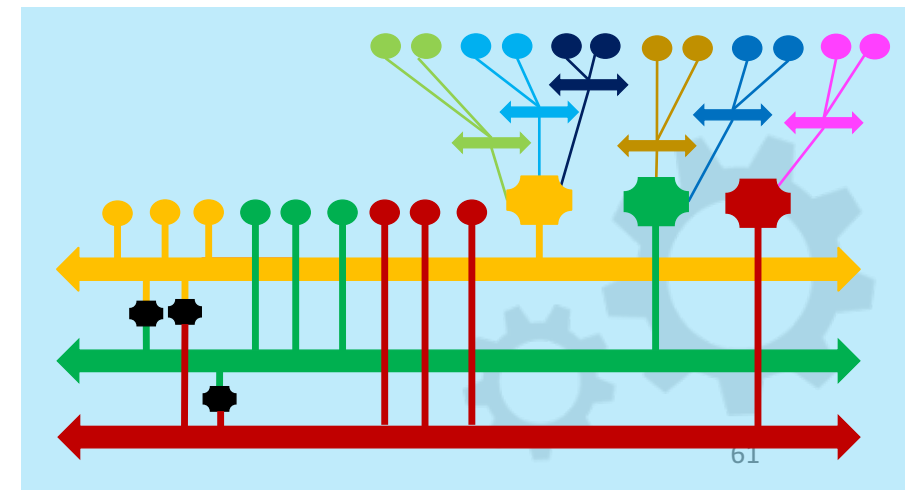
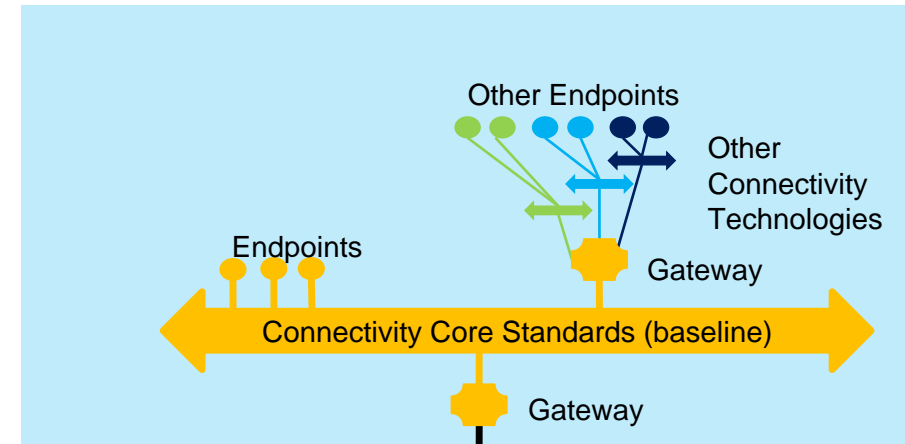
Technical


6	Meet the connectivity framework <b>functional</b> requirements
7	Meet <b>non-functional</b> requirements of performance, scalability, reliability, resilience
8	Meet <b>security</b> and safety requirements

Business

9	Not require any single component from any single vendor
10	Have readily-available SDKs both <b>commercial</b> and <b>open source</b>

GREEN = Gating Criteria



The background features a light gray grid representing latitude and longitude lines over a white background. In the lower right foreground, there is a semi-circular, red-tinted image of the Earth, showing continents and oceans. The text is overlaid on this background.

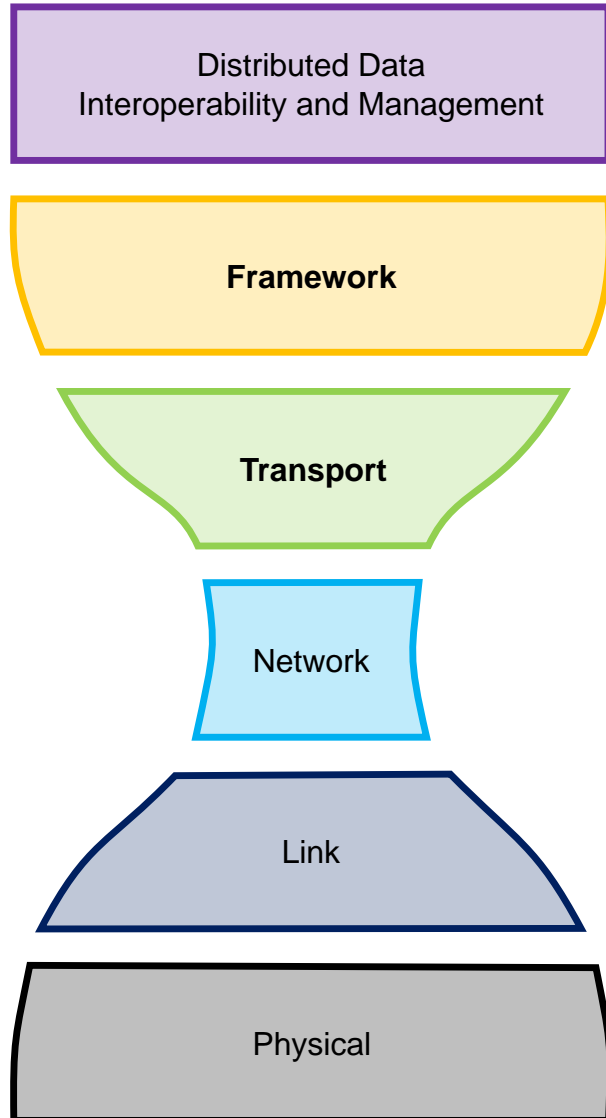
# Selecting the right connectivity technology

**Assessment Template Worksheets**

**Connectivity Standards**



# 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 impact system **Architectural Qualities**?
  - Prioritize the qualities for your use case
- How does it fit **Core Connectivity Criteria**?
  - Is a gateway to a Core Connectivity Standard available?
  - Is the gateway standardized?





# Assessment Template Worksheets

## Business Viewpoint

and usage viewpoints are described below.  
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,
- determining a connectivity technology's suitability for a particular use case when specific requirements are understood.

The worksheet helps categorize objectively a connectivity technology across the layer connectivity stack model (see Figure 2-1) based on the functions it supports: is it a framework (Figure 4-1) or a connectivity transport (Figure 5-1)? Some technologies in the layers of the connectivity stack (Figure 2-1).

Connectivity technologies can be compared objectively, and the most applicable technology can be easily identified.  
The worksheet is described below.

6.1 Domain Info (Section 6.1)	
Name	Common and formal name of the connectivity technology.
Contacts	Responsible standard development organization (SDO), task group or author (company and email addresses).
Description	Short synopsis of the technology.
Application Domain(s)	Application domains targeted by the connectivity technology.
Dependencies	Possible components with or reliance on other connectivity elements.
References	Website and other useful links to the technology.

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

## Usage Viewpoint

6.2.3) Estimate the technology maturity, state of development and readiness relative to capabilities in the field (consistent and undemonstrated).  
6.2.4) Describe whether the technology (consistent and undemonstrated) for both non-experts and architects? Has there been a reduction in the rate of new breakthrough influences related to it?  
6.2.5) List the relevant organizational bodies developing, coordinating, promoting, or setting, refining, improving or otherwise producing technical standards or open source implementations available? Does it require any single component?  
6.2.6) Is it an open standard? Who can participate? Are the specifications freely available?  
6.2.7) List of partners to core connectivity standards and other relevant connectivity technologies.

6.3 Usage Viewpoints (Section 6.3)  
6.3.1 Architecture (Section 6.3.1) Summarize the main concepts, and high-level architecture, and terminology, and end-to-end information exchange path.  
6.3.2 Technology Options (Section 6.3.2) List the choices to be made for using the connectivity technology in a system.  
6.3.3 Applications (Section 6.3.3) A general statement of the typical applications that rely on this connectivity technology and the reason for using the connectivity technology.  
6.3.4 Typical Usage (Section 2.2) What function or where in the system this technology is typically used?  
6.3.5 Operations (Section 2.1.1) Can one monitor, manage, and dynamically reconfigure elements of the connectivity technology?  
6.3.6 Security (Section 2.3.5) What are the system security implications of this connectivity technology?  
6.3.7 Safety (Section 2.3.9) For systems that need it, are certifiable implementations available?  
6.3.8 Gateways (Section 3.3) List of partners to core connectivity standards and other relevant connectivity technologies.

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

## Functional Viewpoint

6.4 Data Type System (Section 4.1.5) Does it provide a data type system? Summarize the salient aspects.  
6.4.1 Data Resource Lifecycle (DRL) (Section 4.1.6) Does it provide a means of managing a data object's lifecycle? Summarize the salient aspects.  
6.4.2 State Management (Section 4.1.7) Does it provide a means to manage the recent history of data objects? Summarize the salient aspects.  
6.4.3 Publish-Subscribe (Section 4.2.6) Does it provide a means to publish and subscribe the state of data objects? Summarize the salient aspects.  
6.4.4 Request-Reply (Section 4.2.7) Does it provide a means to request the state of data objects? Summarize the salient aspects.  
6.4.5 Discovery (Section 4.2.8) Does it provide a means to discover the data objects? Summarize the salient aspects.  
6.4.6 Exception Handling (Section 4.1.9) Does it provide a means to handle exceptions when quality of service or compliance violations happen? Summarize the salient aspects.  
6.4.7 Data Quality of Service (QoS) (Section 4.1.10) Does it support QoS? Summarize the scope and coverage. Highlight the salient aspects.  
6.4.8 Data Security (Section 4.2.11) Does it provide a data object security model? Summarize the salient aspects.  
6.4.9 API (Section 4.1.12) Is there a standard API? Which programming languages is it available for? Summarize the salient aspects.  
6.4.10 Governance (Section 4.2.13) Does it standardize the mechanisms for configuration, administration, and monitoring? Summarize the salient aspects.

6.4.2 Core Transport Layer Functions (Section 5.1)  
6.4.2.1 Messaging Protocol (Section 5.1.1) Does it require UDP or TCP? What are the salient aspects of this messaging protocol? What are the message size limitations? What are the usage assumptions? Is it optimized for certain communication modes?  
6.4.2.2 Communication Modes (Section 5.1.2) Describe the transport endpoints. How are the endpoints addressed? What are the limitations, if any, on the number of endpoints?  
6.4.2.3 Endpoints (Section 5.1.3) Does it require a connected circuit between the endpoints? Summarize the salient aspects.  
6.4.2.4 Addressing (Section 5.1.4) Does it provide a means to prioritize messages? Summarize the salient aspects.  
6.4.2.5 Prioritization (Section 5.1.5) Does it provide the ability to synchronize time? Summarize the salient aspects.  
6.4.2.6 Timing & Synchronization (Section 5.1.6)

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

## Implementation Viewpoint

6.5.1 Explicit vs. Implicit Governance (Section 4.2.3) Is the governance explicit and shareable?  
6.5.2 Data Considerations (Section 4.2.2) Can a content filter specify the data subset of interest?  
6.5.3 Content-Based Selection (Section 4.2.2) Can sub-sampling specify the data subset of interest?  
6.5.4 Time-Based Selection (Section 4.2.2) Can sub-sampling specify the data subset of interest?  
6.5.5 Performance Considerations (Section 4.2.3) Does the connectivity technology support real-time data distribution? Is the deterministic (smaller jitter is better)?  
6.5.6 Latency and Jitter vs. Throughput (Section 4.2.3) How does the latency and jitter change with throughput? What limits the throughput?  
6.5.7 Scalability Considerations (Section 4.2.4) Can the connectivity framework effectively handle an increasing number of data objects?  
6.5.8 Data Objects (Section 4.2.4) What limits data object size?  
6.5.9 Apps (Section 4.2.4) Can the connectivity framework effectively support an increasing number of distributed application components?  
6.5.10 Availability Considerations (Section 4.2.5) Can the connectivity framework support continuous availability over a defined relevant time period?  
6.5.11 Resiliency (Section 4.2.5) Can the connectivity framework support recovery when fault conditions occur?  
6.5.12 Recovery (Section 4.2.5) Can the connectivity framework support recovery when fault conditions occur?  
6.5.13 Platform Considerations (Section 4.2.6) Does the connectivity framework support the operating system (OS), the CPU and the hardware?  
6.5.14 Constraints (Section 4.2.6) Does the connectivity framework facilitate incremental upgrades?  
6.5.15 Incremental Upgrades (Section 4.2.6) Does the connectivity framework facilitate incremental upgrades?  
6.5.16 Network Layer Considerations (Section 5.2.1) What network topologies are allowed?

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

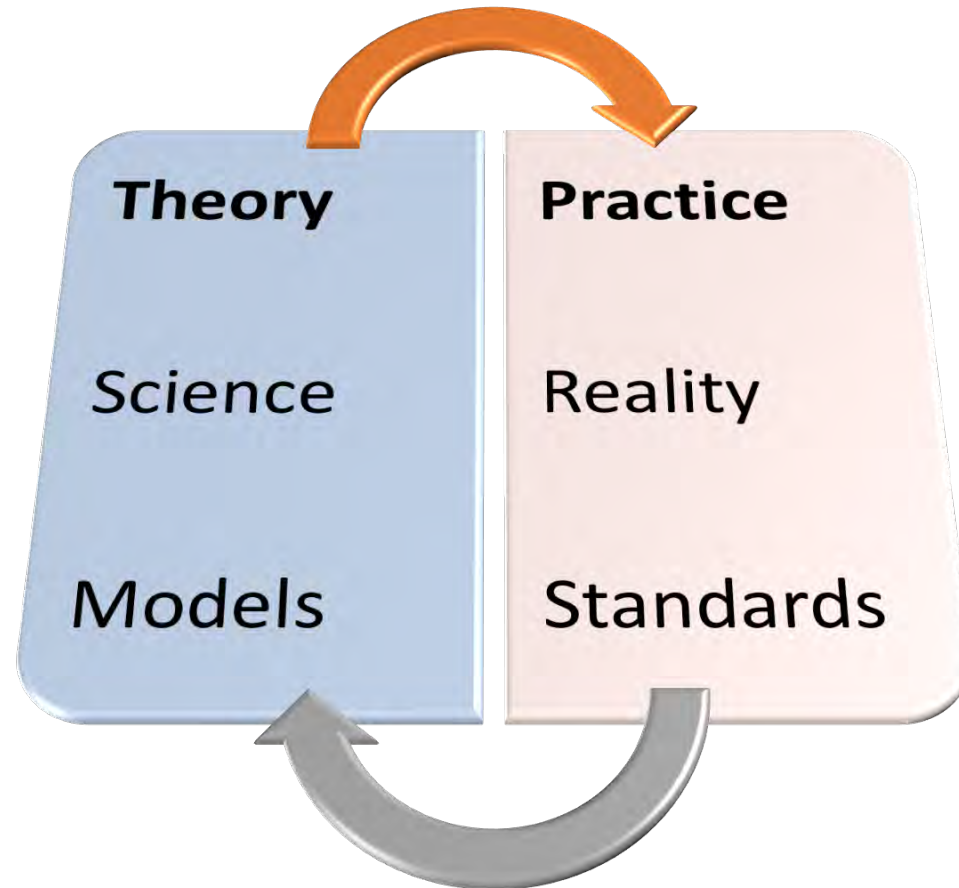






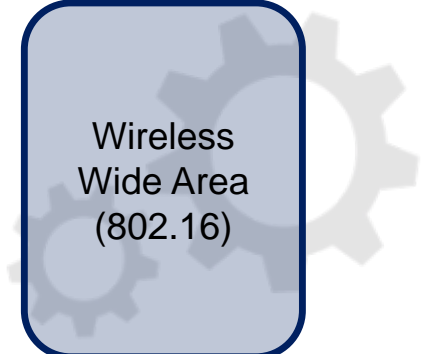
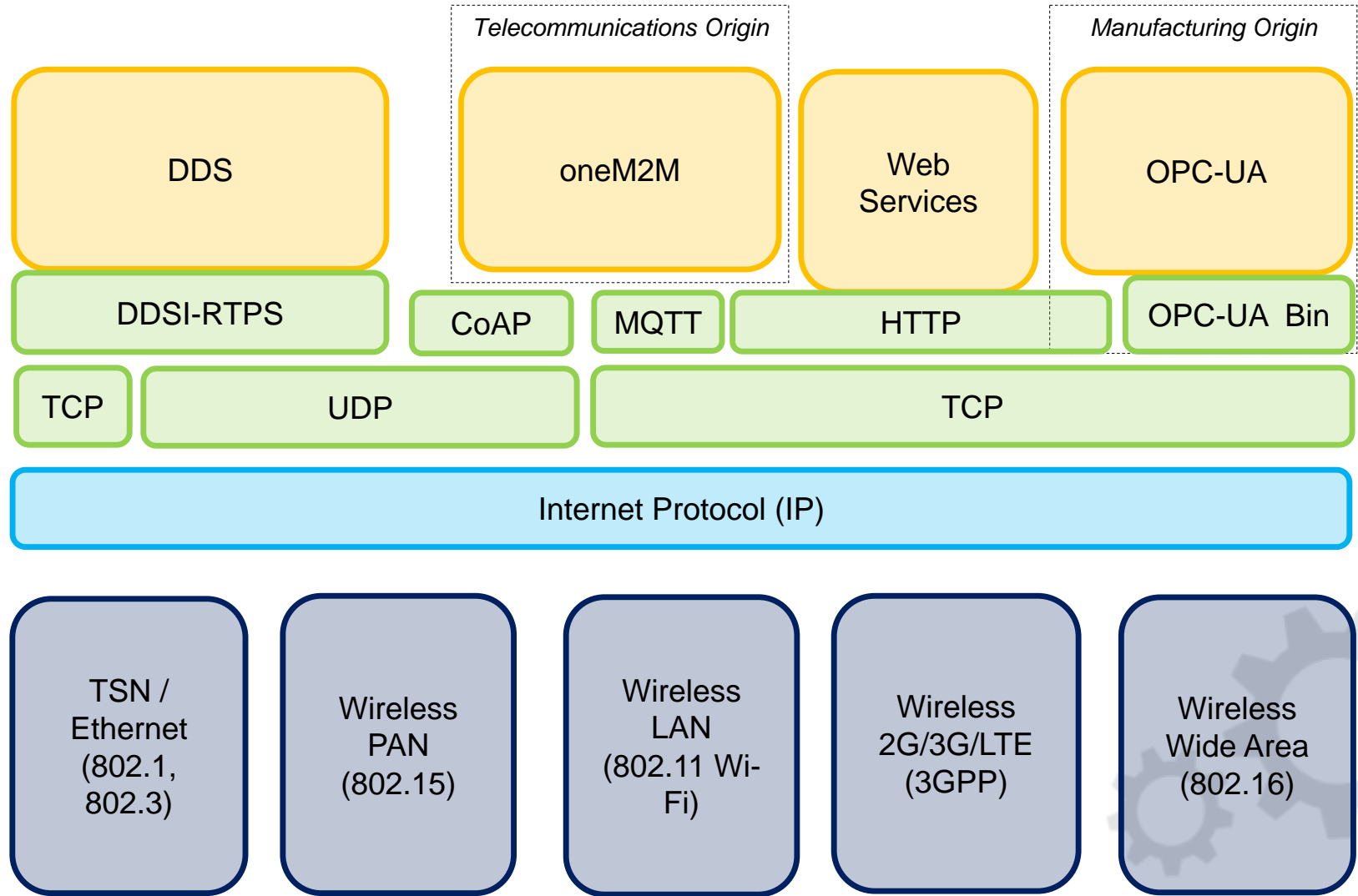
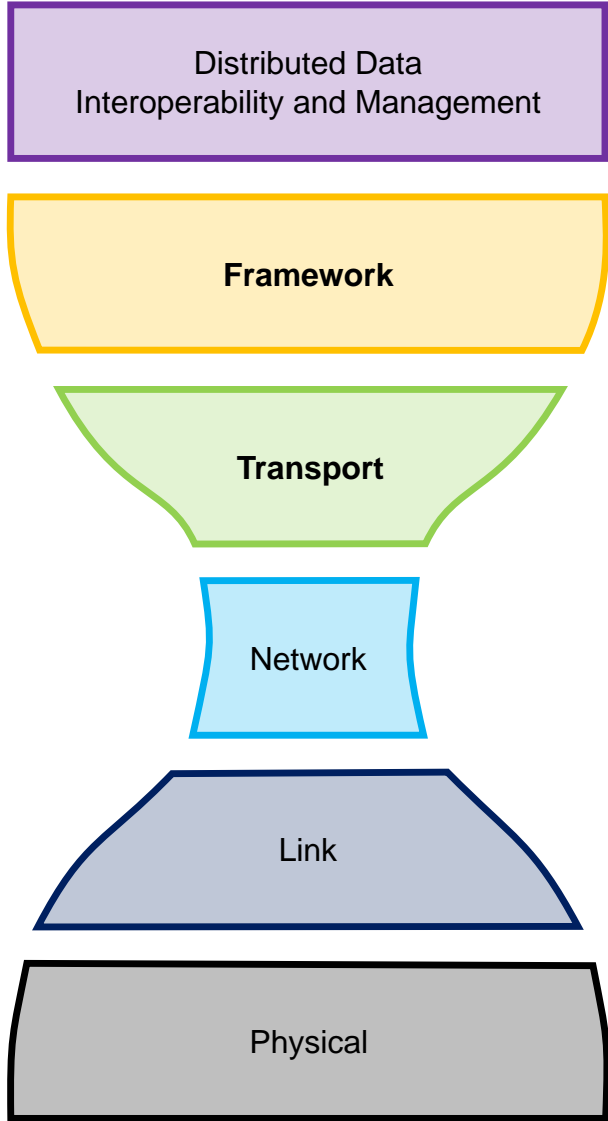
# Theory meets Practice!

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# Relevant Connectivity Standards





# Connectivity Core Standards Criteria Applied

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

GREEN = Gating Criteria

\* = work in progress

✓ = supported, ✗ = not supported



## Non-overlapping system aspect examples targeted by potential IIoT connectivity core standards

System Aspect	Example User	Approach	Targeting Standard
Software Integration and Autonomy	You are a software architect. You are building a system or product line, and you control the architecture. You critically need to integrate components written by different programmers or even entire teams.	A data centric approach will define the interfaces, capture the dataflow, enable module evolution, and enforce interoperation between teams. This approach also eases redundancy, fast complex data flow, and selective data filtering.	DDS
Device Interchangeability	You are a device manufacturer, with the goal of making devices that will sell into many applications. The device offers services, such as configure, start, stop, etc. You have no idea how the device will eventually be used. Your users are likely not software experts; they just want to add or integrate the device into a workcell.	A device-centric approach will allow the device users to write generic software that will interoperate with competitor's devices.	OPC-UA
Web and Mobile User Interfaces	You are building mobile apps or web browser based applications to provide the human machine interface. You need an easy way to support clean human interaction and access to backend services.	A RESTful approach will make it easy to connect to many types of enterprise systems and UI devices.	Web Services
Information & Communications Technology (ICT) Integration	You are building a wide-area wireless system that needs to allow applications and devices to share data and information. The devices use various technology and domain-specific protocols. The applications and devices you integrate rely on leveraging the services provided by the communications provider network.	A common, standard services-layer approach enables applications and device to share data and information without forcing the application to understand multiple protocols implemented on the devices. The applications can thus run in the Platform Tier and seamlessly connect to diverse IoT devices in the field.	oneM2M

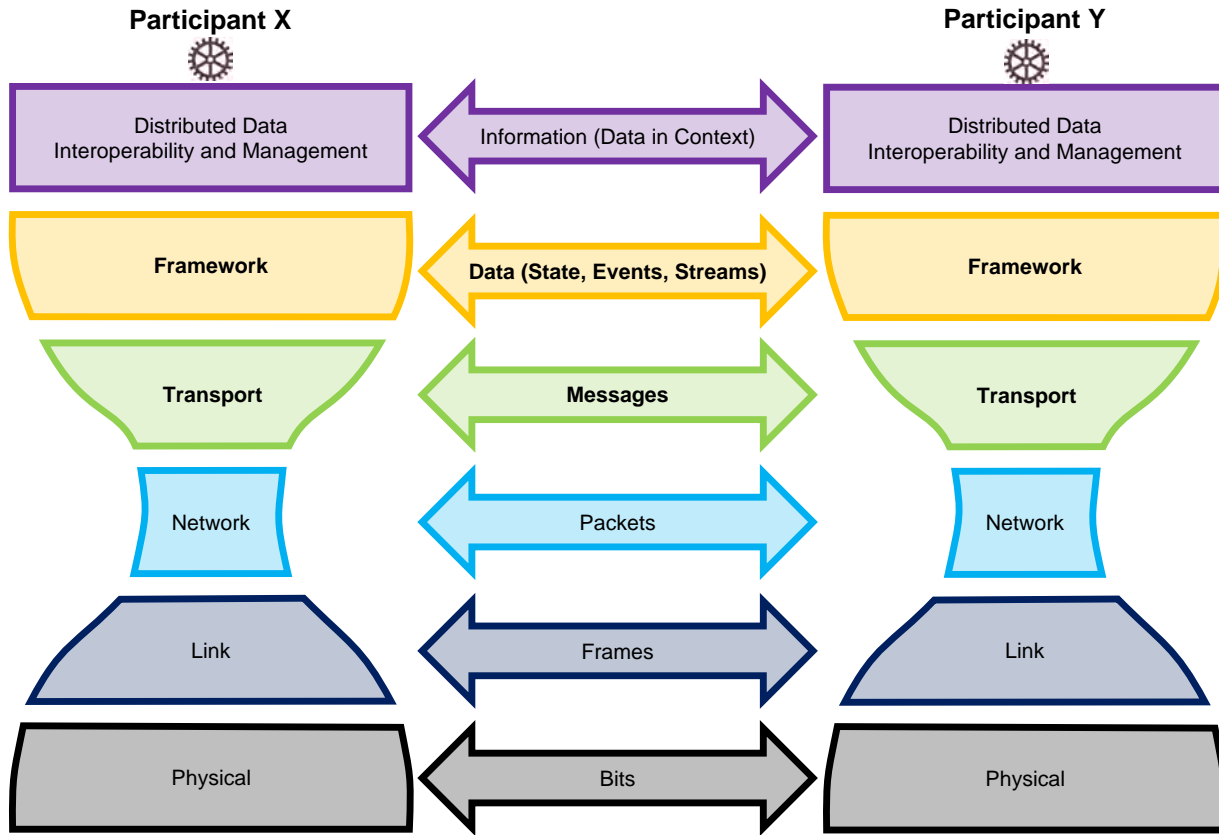
# Summary

**Accelerating IIoT**

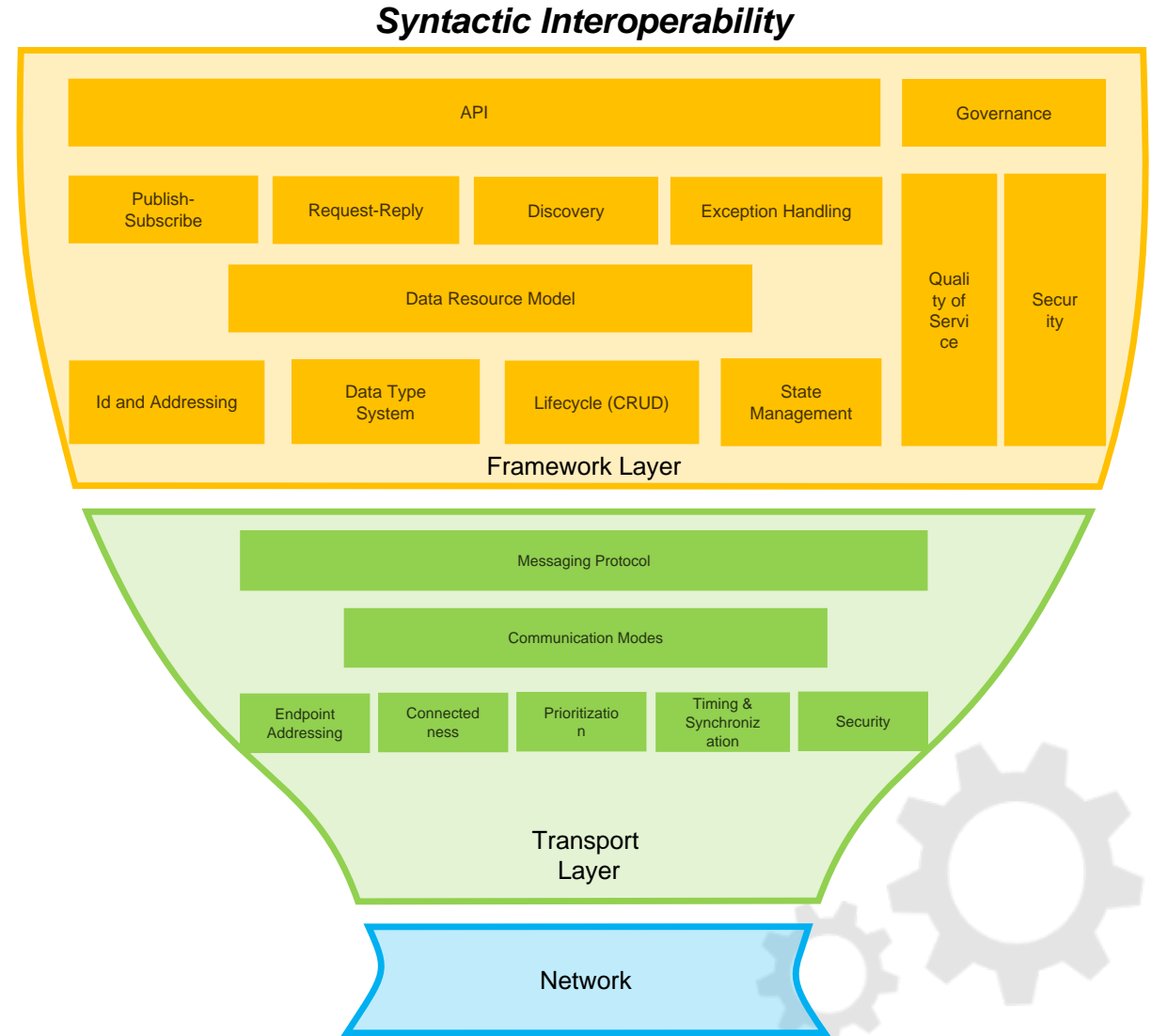




# Industrial Internet Connectivity Framework (IICF)



*IIoT Connectivity Stack*





# Accelerate Your IIoT...

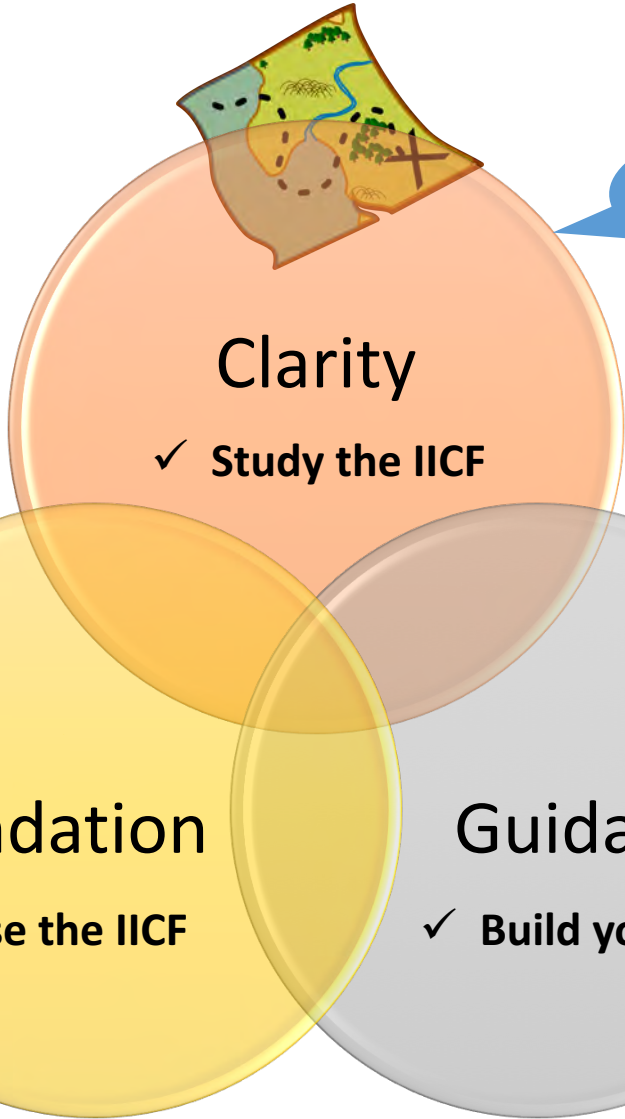


Sets a stable long term foundation for IIoT interoperability



**Foundation**

✓ Use the IICF



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

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

**Guidance**

✓ Build your IIoT





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

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

DOWNLOAD PDF

IICF FAQ





The background features a light gray grid of latitude and longitude lines on a white background. In the lower right foreground, there is a semi-circular, red-tinted image of the Earth, showing continents and oceans.

**Thank You!**

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