OpenSplice DDS in Transportation

Dr. Angelo Corsaro ***[angelo.corsaro@prismtech.com]***

OpenSplice DDS Product Marketing Manager, PrismTech

Angelo co-chairs the OMG Data Distribution Service (DDS) Special Interest Group and the Real-Time Embedded and Specialized Services (RTESS) Task Force. He is a well known figure in the distributed real-time and embedded systems middleware community and has a wealth of experience in hard real-time embedded systems, large-scale and very large-scale distributed systems, such as defense, aerospace, homeland security and transportation systems. Prior to joining PrismTech, he worked for the SELEX-SI CTO Directorate, a FINMECCANICA company, where his responsibilities included mapping business requirements to technology capabilities, strategic standardization and technology innovation.

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Productivity Tools & Middleware

OpenSplice|DDS in Transportation

The Right Data to the Right Place at the Right Time
-- All the Time --

Agenda

- Challenges Ahead
- Addressing the Challenges
- Use Cases
- What's Next
- Concluding Remarks

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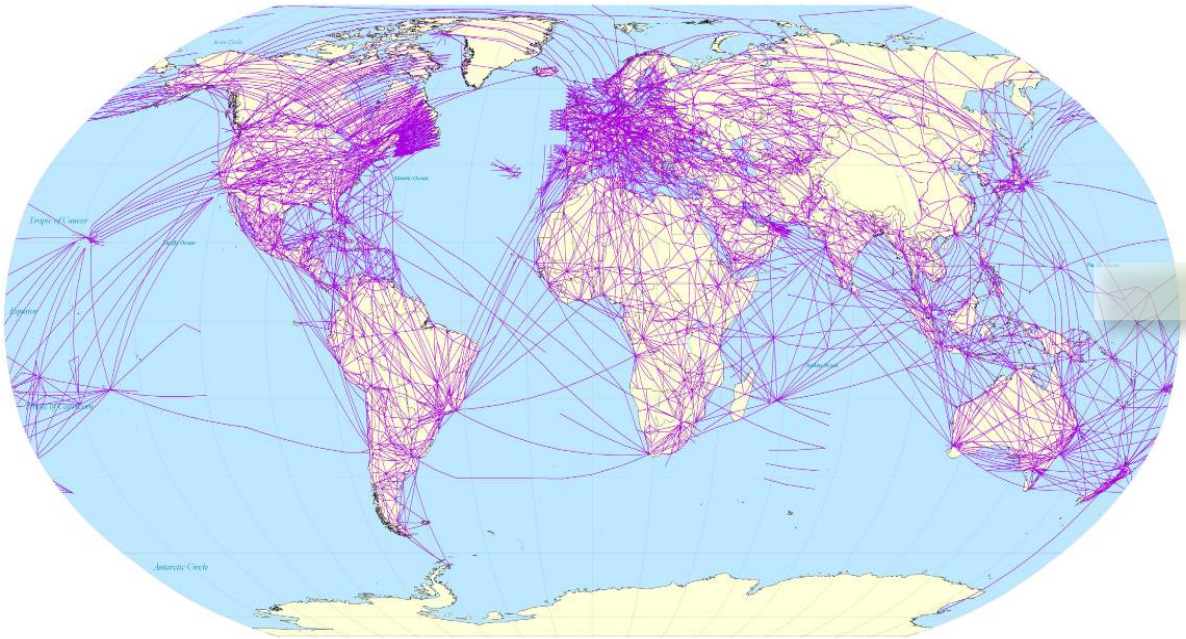
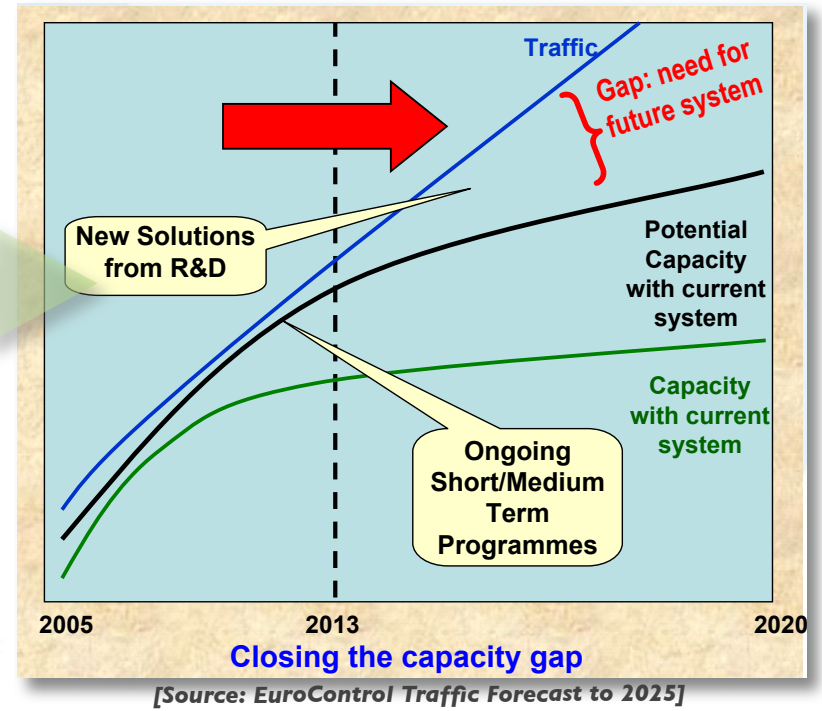
Air Traffic Control/Management[1/3]

Increasing Traffic Volumes

- By 2025 it is estimated that traffic volumes will double!
- Current solutions won't be able to keep-up with the traffic's growth
- Urge to move from airspace-based to performance and trajectory based ATM/C

Today **2025**





[Source: EuroControl Traffic Forecast to 2025]

Air Traffic Control/Management[2/3]

New Operational Requirements

- System Wide Interoperability is a key enabler
- Real-Time shared common operational picture

Air Traffic Control/Management[3/3]

Airborne Networks

- Peer-to-Peer, mobile, ad hoc communication networks between established between airborne elements, such as airplanes, UAVs, etc.
- Self regulating, self-managed air-traffic
- Better air-space utilization

Metropolitan Traffic Management [1/2]

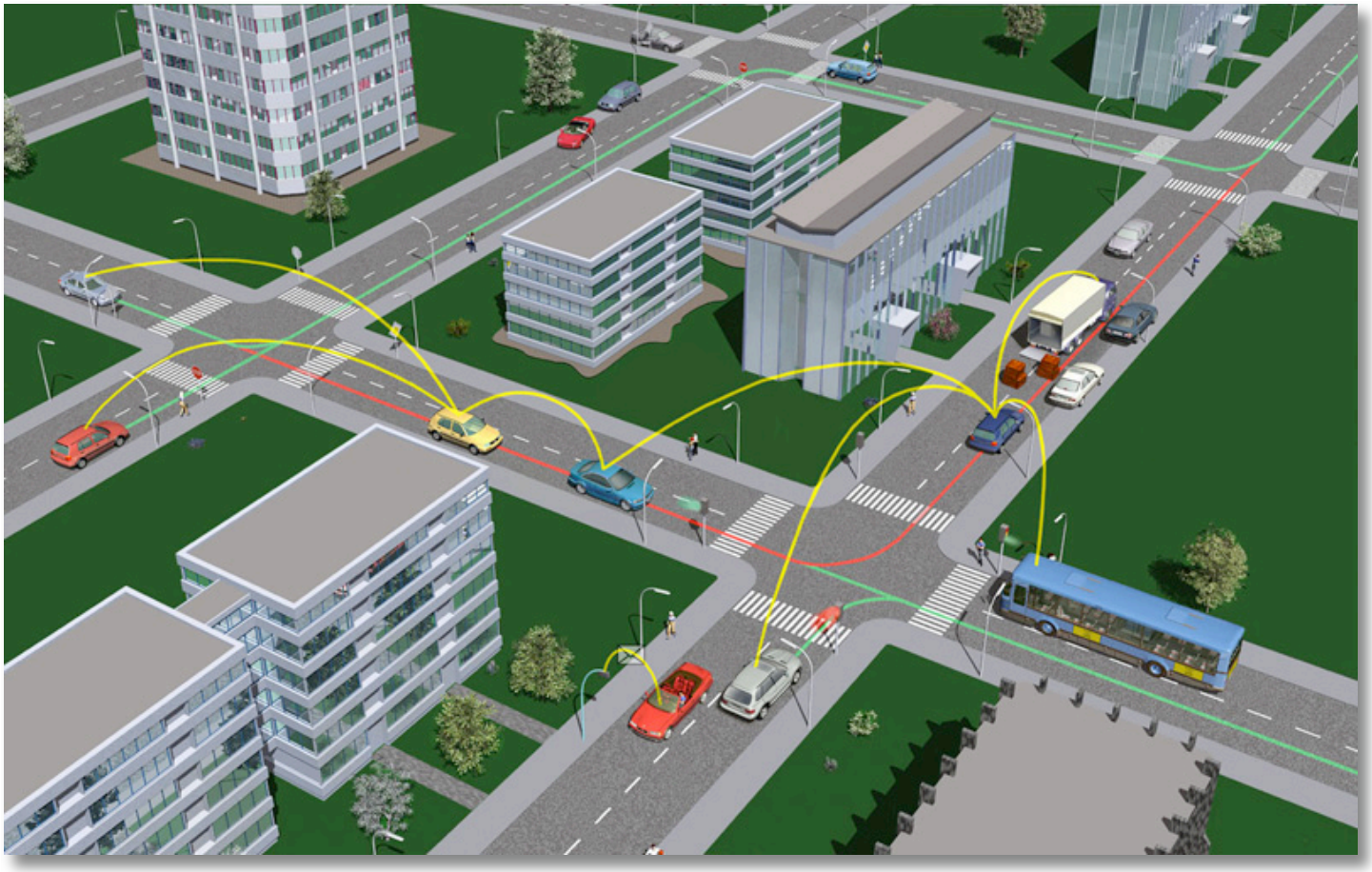
Traffic Management

- With the increase in motorization, more and more cities are increasingly experiencing disarming **Traffic Congestion**
- In many cases this traffic congestion could be prevented if more real-time information was available to both traffic engineers, as well as drivers

Metropolitan Traffic Management [2/2]

Vehicular Networks (VANETs)

- Peer-to-Peer, mobile and ad hoc vehicular networks
- VANETS are intended to be one of the enabling technologies for safer driving, dynamic route planning, and in-vehicle entertainments



Rail-Based Traffic Management/Monitoring [1/2]

Safety

- Real-Time monitoring and control of every single element in a railway system is of ultimate importance
- Increasing scale is posing challenges with respect to the achievable performance

Rail-Based Traffic Management/Monitoring [2/2]

Unmanned Rail-Based Transportation

- Several examples of unmanned rail-based transportation exist at a small scale
- Effectively supporting unmanned rail-based transportation will require a more pervasive availability of data
- This will result in a massive increase in the data volumes that will have to be distributed

Common Problems

Shared Operational Picture

- Increasing need in real-time access to the common operational picture

Increased Data Volumes

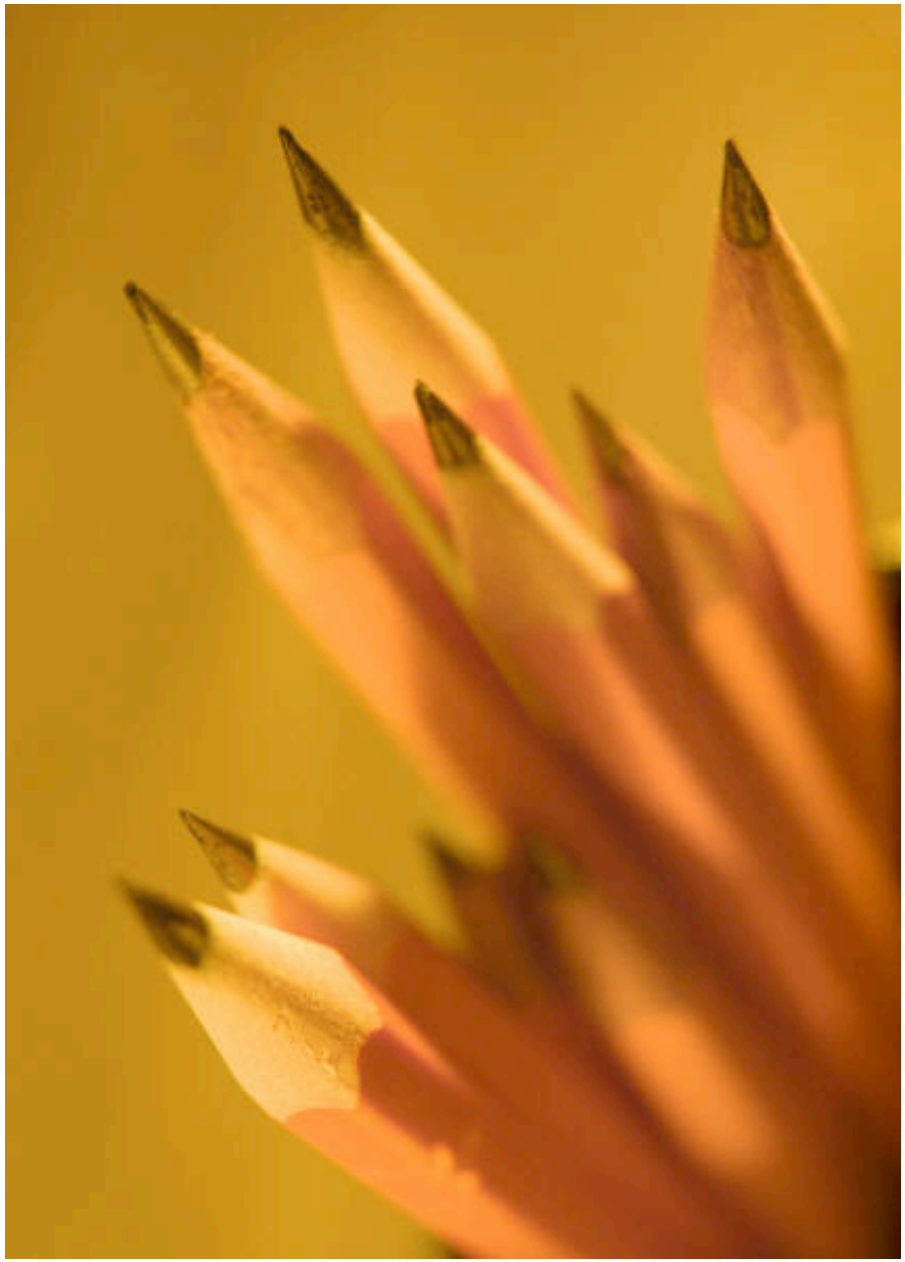
- Real-time dissemination of massive data volumes, often over large scale

Loosely Coupled & Plug and Play

- Ability to fully support, and cope with, environment such as MANET, VANET, etc., and in general time and space decoupling

Interoperability

- Need to share information end-to-end, in the new and emerging systems of systems. Interoperability is a key enabler for achieving better performance and enabling new operational requirements



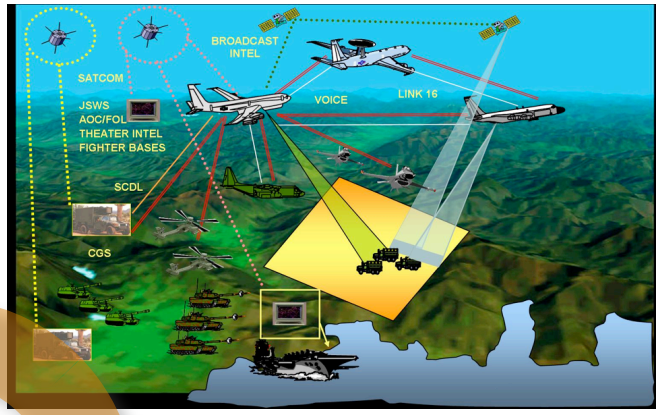
Emerging Convergence

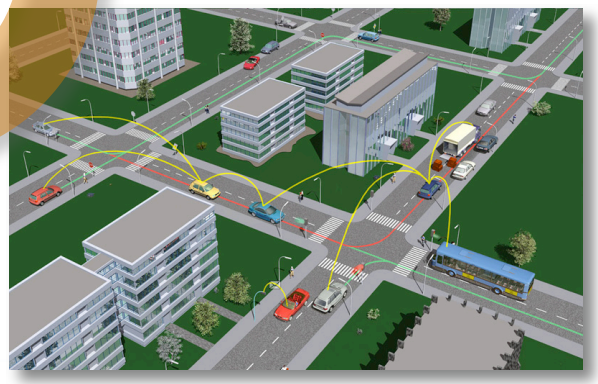
Domain Problems Convergence

- Defense and Transportation are nowadays being challenged by very similar problems
- Recently, concrete moves were made in order to share experience and technologies emerged in these distinct domains
- As an example FAA recently joined the NCOIC in order to exploit NCW-derived technologies for next generation ATM/C

Technologies Convergence

- Technologies, such as the DDS, which have evolved to address DoD NCW-like scenarios are now being adopted in major transportation programs





DDS

OpenSplice DDS

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Agenda

- Challenges Ahead
- **Addressing the Challenges**
- Use Cases
- What's Next
- Concluding Remarks

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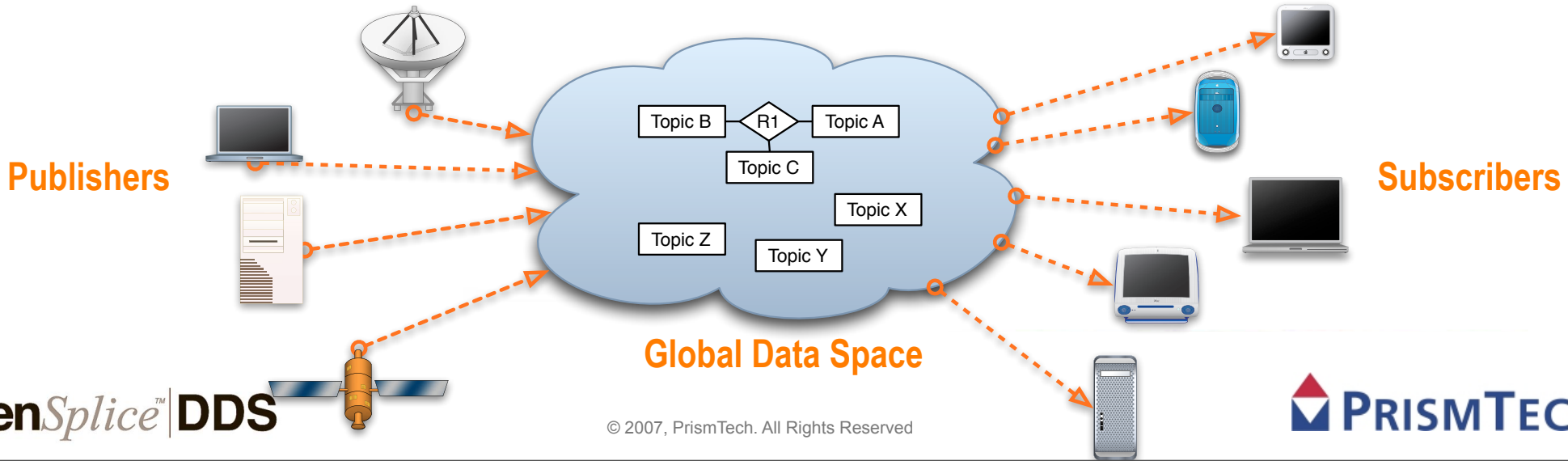
OpenSplice DDS

- **An High Performance Real-Time Data-Centric Publish/Subscribe Middleware**
  - *The right data, at the right place, at the right time -- all the time!*
  - *Fully distributed, high performance, highly scalable, and high availability architecture*
- **Perfect Blend of *Data-Centric* and *Real-Time Publish/Subscribe* Technologies**
  - *Content based subscriptions, queries, and filters*
  - *Fine grained tuning of resource usage and data delivery and availability QoS*
  - *Optimal networking and computing resources usage*
- **Loosely coupled**
  - *Plug and Play Architecture with Dynamic Discovery*
  - *Time and Space Decoupling*
- **Open Standard**
  - *Complies with the full profile of the OMG DDS v1.2*



OpenSplice DDS

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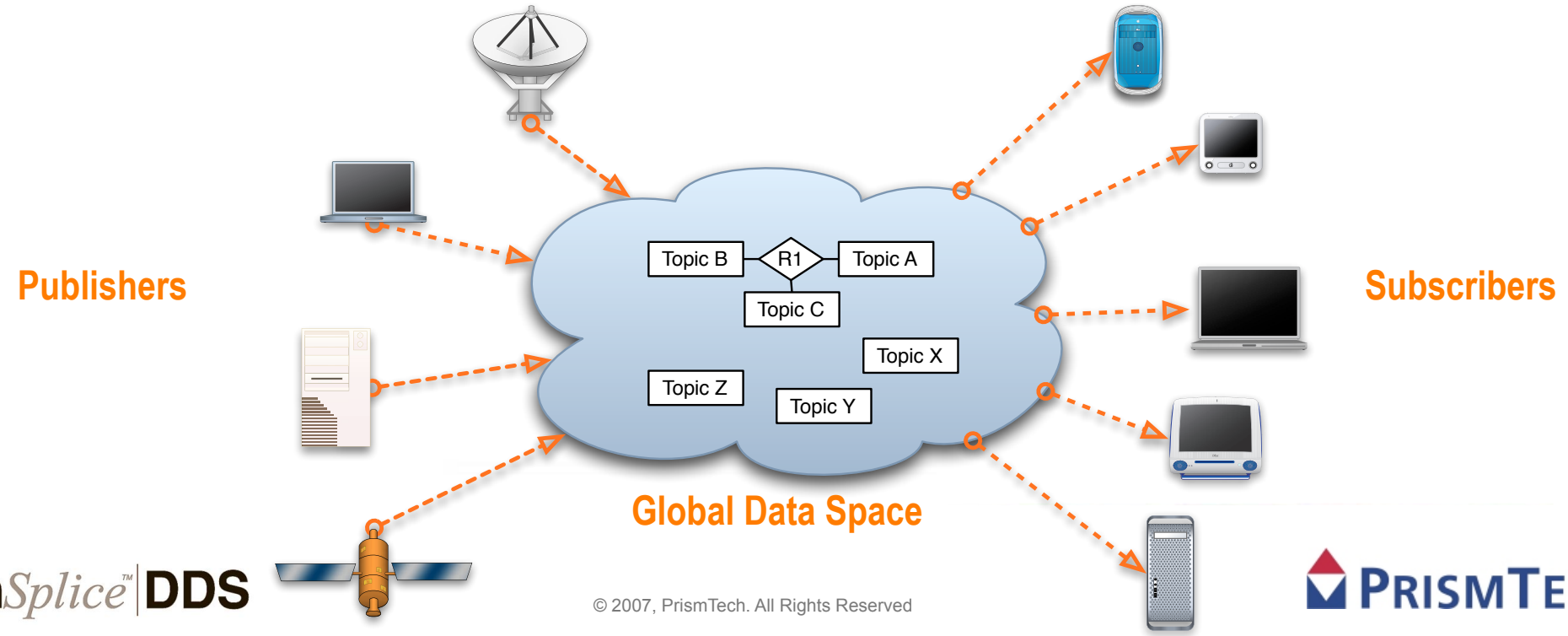
OpenSplice DDS: Foundational Abstractions

- **Information Model.** Defines the structure, relations, and QoS, of the information exchanged by the application. DDS supports both **Relational (**DCPS) and **Object Oriented Modeling** (DLRL)
- **Typed Global Data Space.** A logical data space in which applications *read* and *write* data **anonymously** and **asynchronously**, decoupled in space and time
- **Publisher/Subscriber.** Produce/Consume information into/from the Global Data Space
- **QoS.** Regulates the non-functional properties of information in the Global Data Space, *e.g.*, reliability, availability, and timeliness, etc.



OpenSplice DDS

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Shared Operational Picture

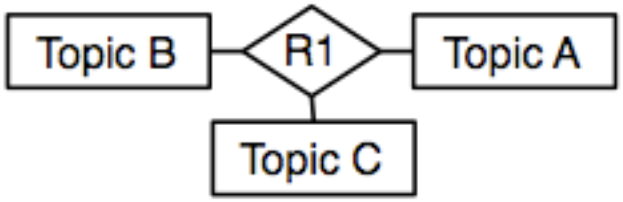
OpenSplice DDS Information Modeling

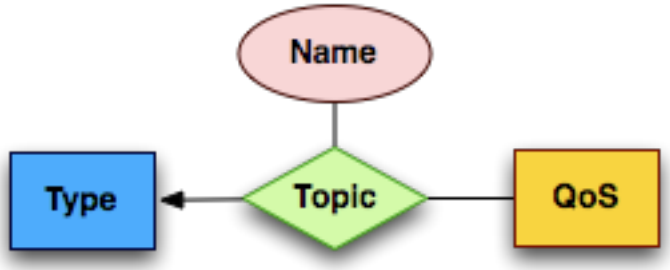
Challenges

- **Shared Operational Picture =>** ***Information Modeling, Global Data Space***
- Increased Data Volumes
- Loosely Coupled & Plug and Play
- Interoperability

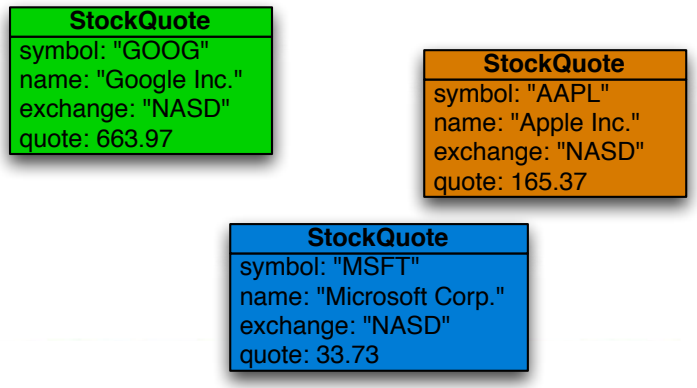
Relational Modeling with DDS

- **Modeling.** As in a Relational DB, a DCPS information model can be represented by means of Entity Relationship (ER) diagrams
- **Topics.** The entities, represented by means of Topics, are in turns an association between a data **type** and a set of **QoS** and identified by a unique name (like tables in an RDBMS)
- **Data Types.** The data type associated to a Topic must be a structured type expressed in IDL
- **Instances.** Key values in a datatype uniquely identify an instance (like rows in table)
- **Correlation.** SQL Expressions can be used to correlate information by means of key values





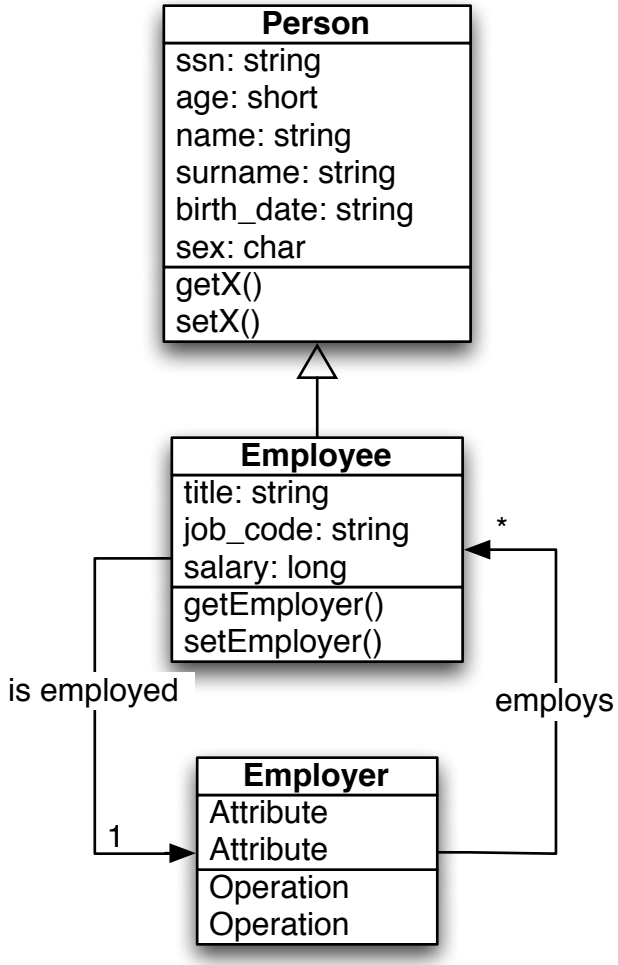

```
struct StockQuote {
    string symbol;
    string name;
    sting  exchange;
    float  quote;
};
#pragma keylist StockQuote symbol
```



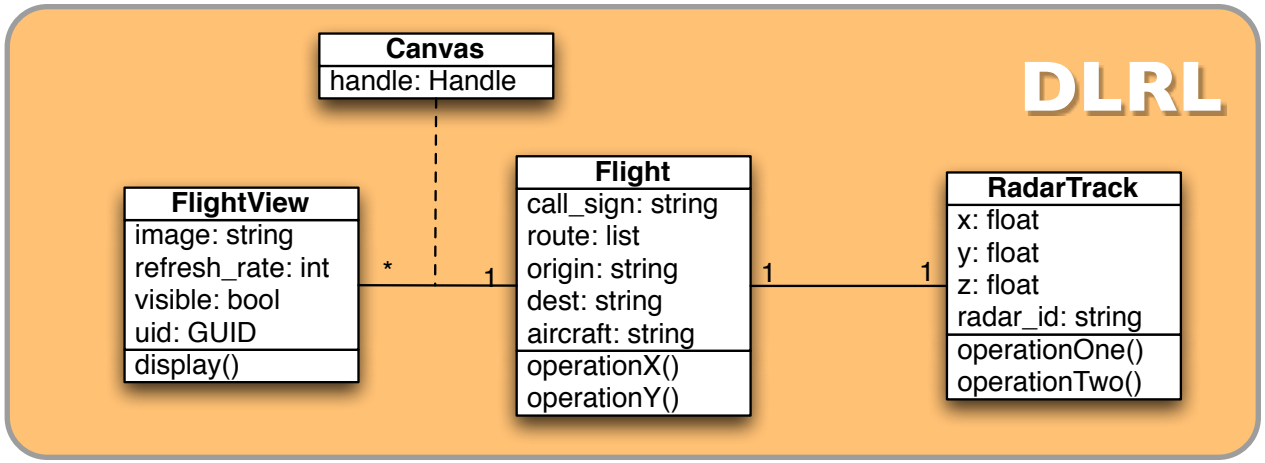
Object Oriented Modeling with DDS

The DDS supports Object Oriented Information Modeling by means of the DLRL layer

- **Automatic Instance Management**
  - Instances are supported as first class citizen and don't need emulation by means of keys
- **Encapsulation**
  - Attributes are only accessible through dedicated getter/setter operations
- **Local Operations**
  - Besides getters/setters, all other kind of manipulations can be done using custom operations
- **Inheritance**
  - Only single inheritance between DLRL objects
- **Navigable Relationships**
  - Single Relationships
  - Multi Relationships (Set, Map, List)



Sample DLRL/DCPS Mapping



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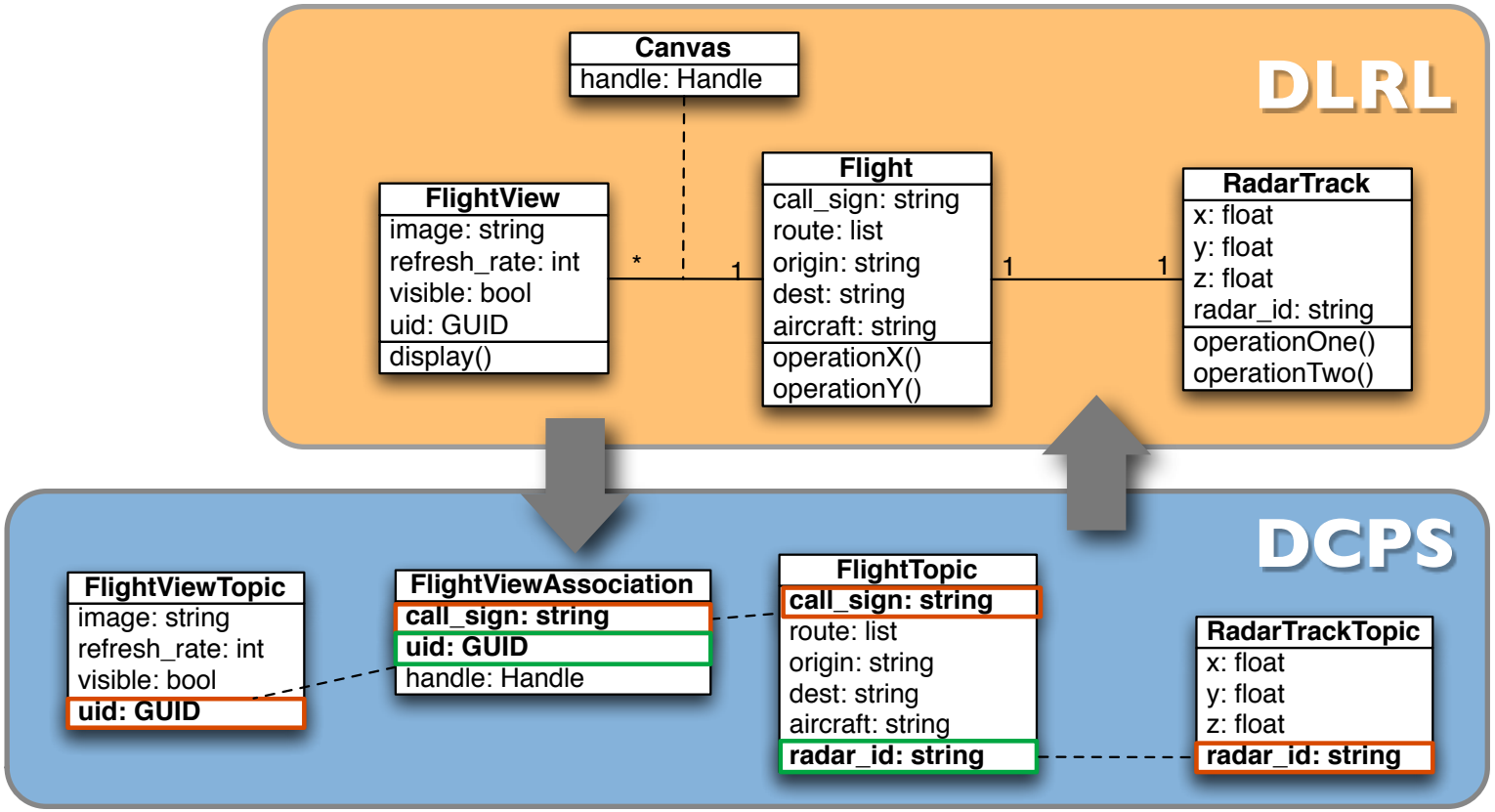
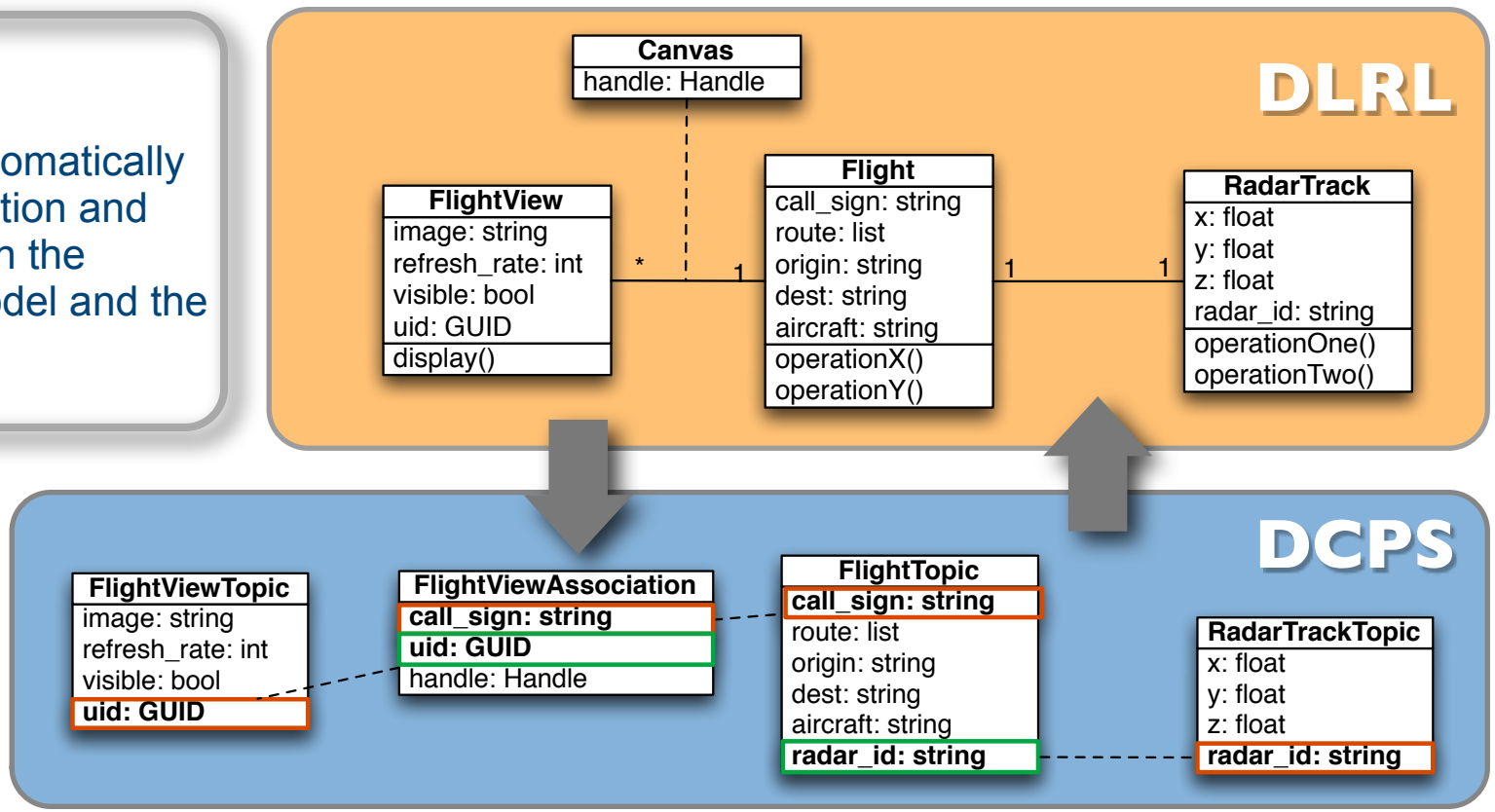


Sample DLRL/DCPS Mapping

DLRL ➡ DCPS

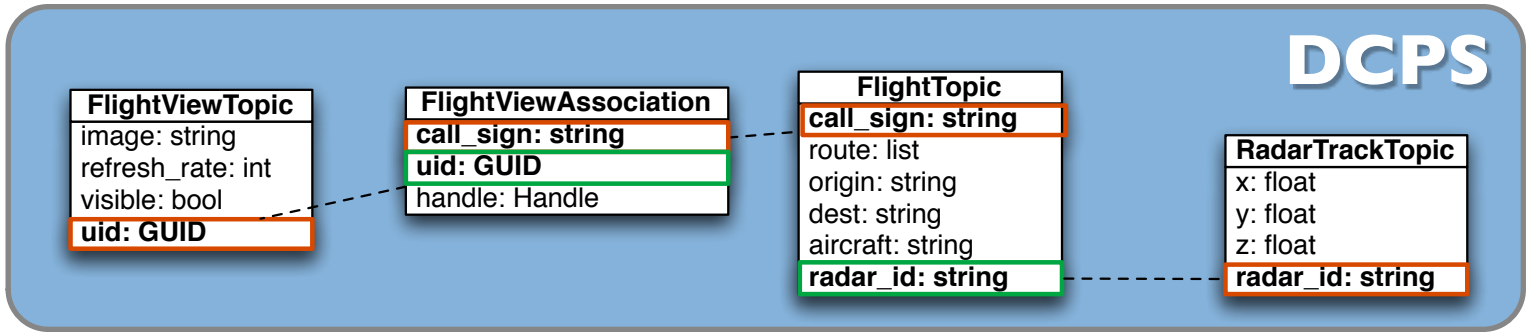
- Middleware can automatically manage the generation and association between the Object-Oriented Model and the Relational Model



DCPS ➡ DLRL

- The Relational Model can be mapped to an Object Oriented model
- The mapping is under control of the architect

Multiple Mappings



Multiple Mappings

- Allow different, Object-Oriented, ***local reconstruction*** of the same underlying relation model
- The state is shared across all the ***local reconstruction***

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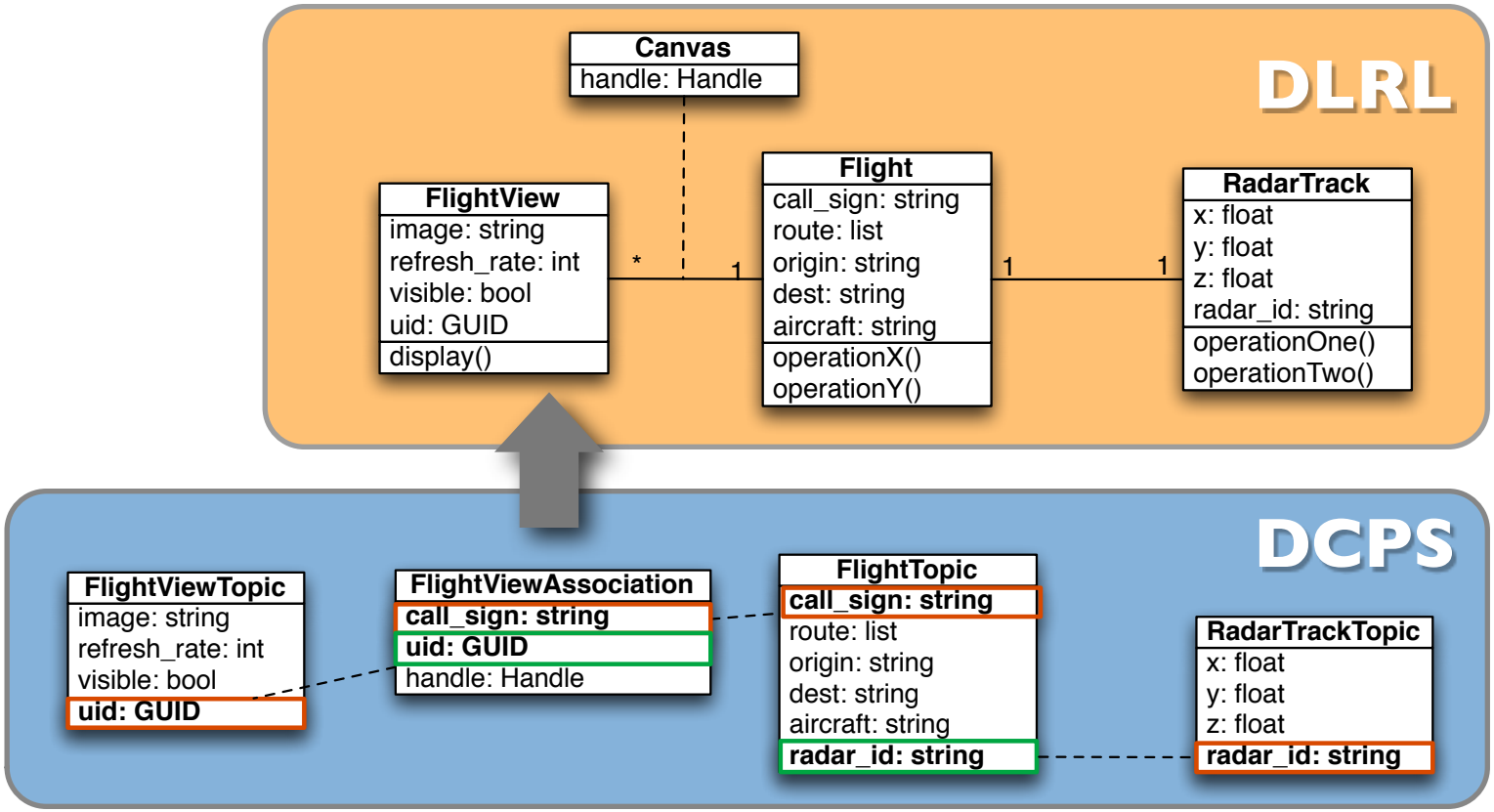

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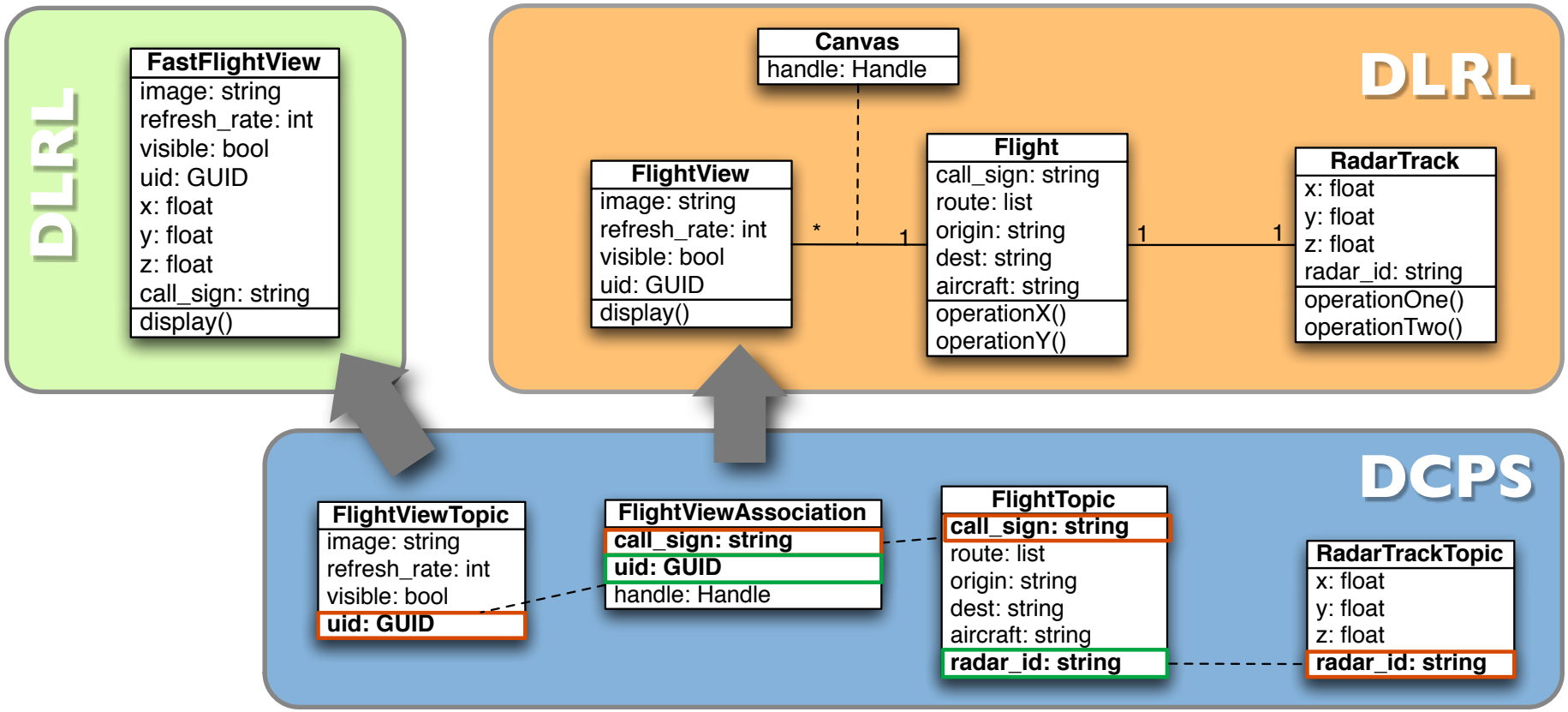

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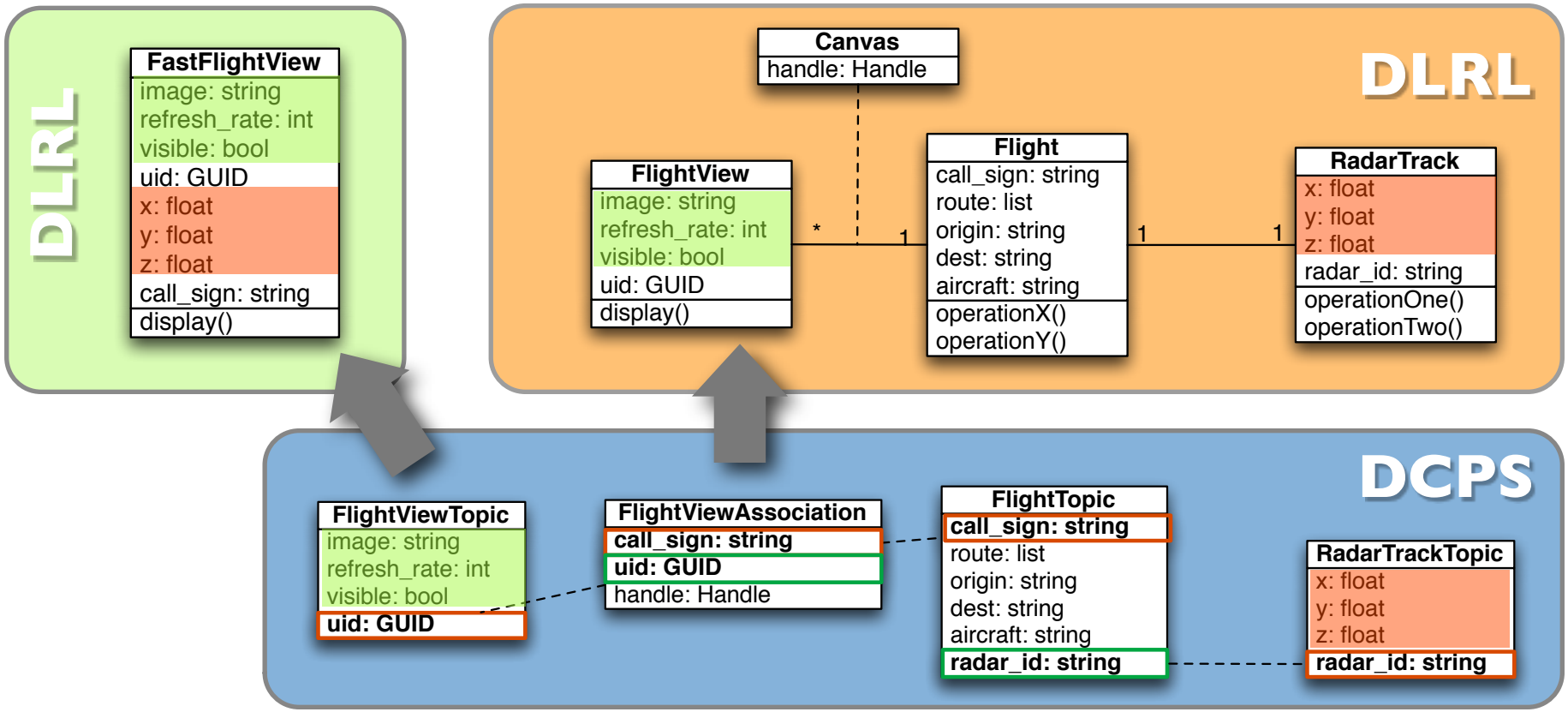
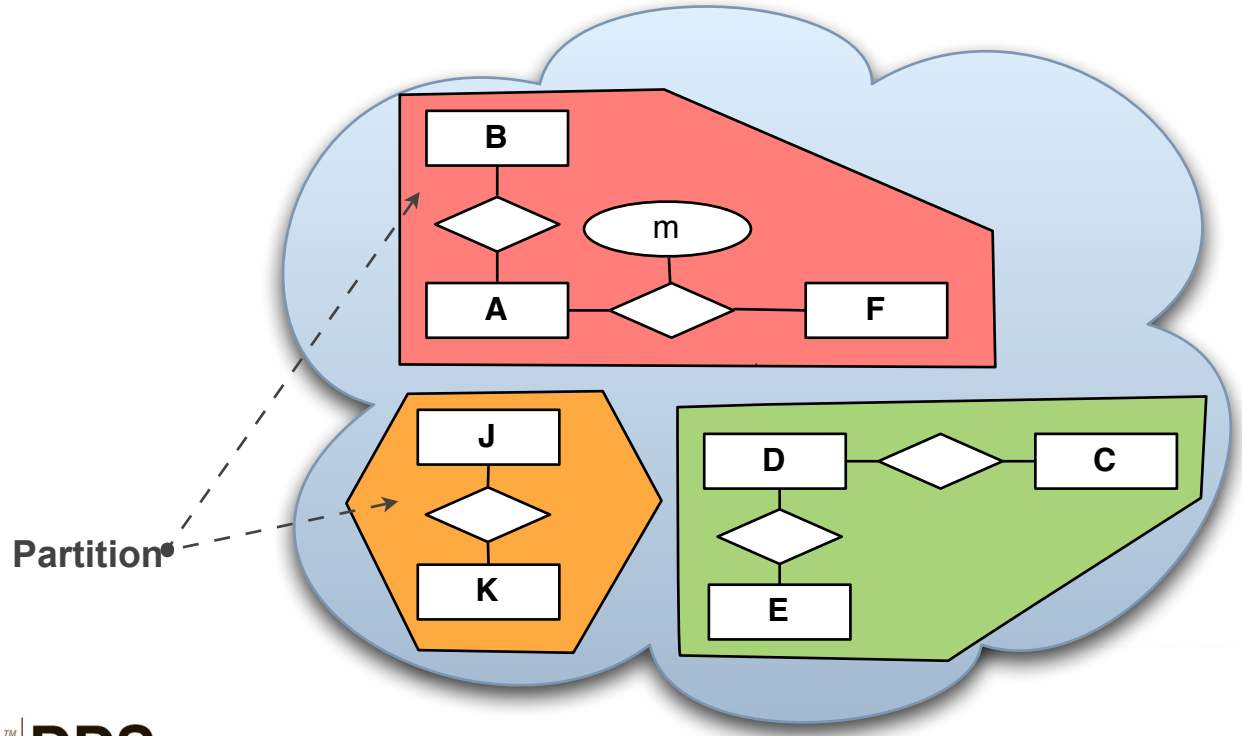


Multiple Mappings

- Allow different, Object-Oriented, ***local reconstruction*** of the same underlying relation model
- The state is shared across all the ***local reconstruction***

Global Data Space

- The Global Data space can be divided into **domains** which in turns can have **partitions**
- The availability of data and its **consistency model** depends on QoS that can be set at a Topic level and overridden by the writer
- The stronger consistency model that can be supported for the global data space is **eventual consistency**



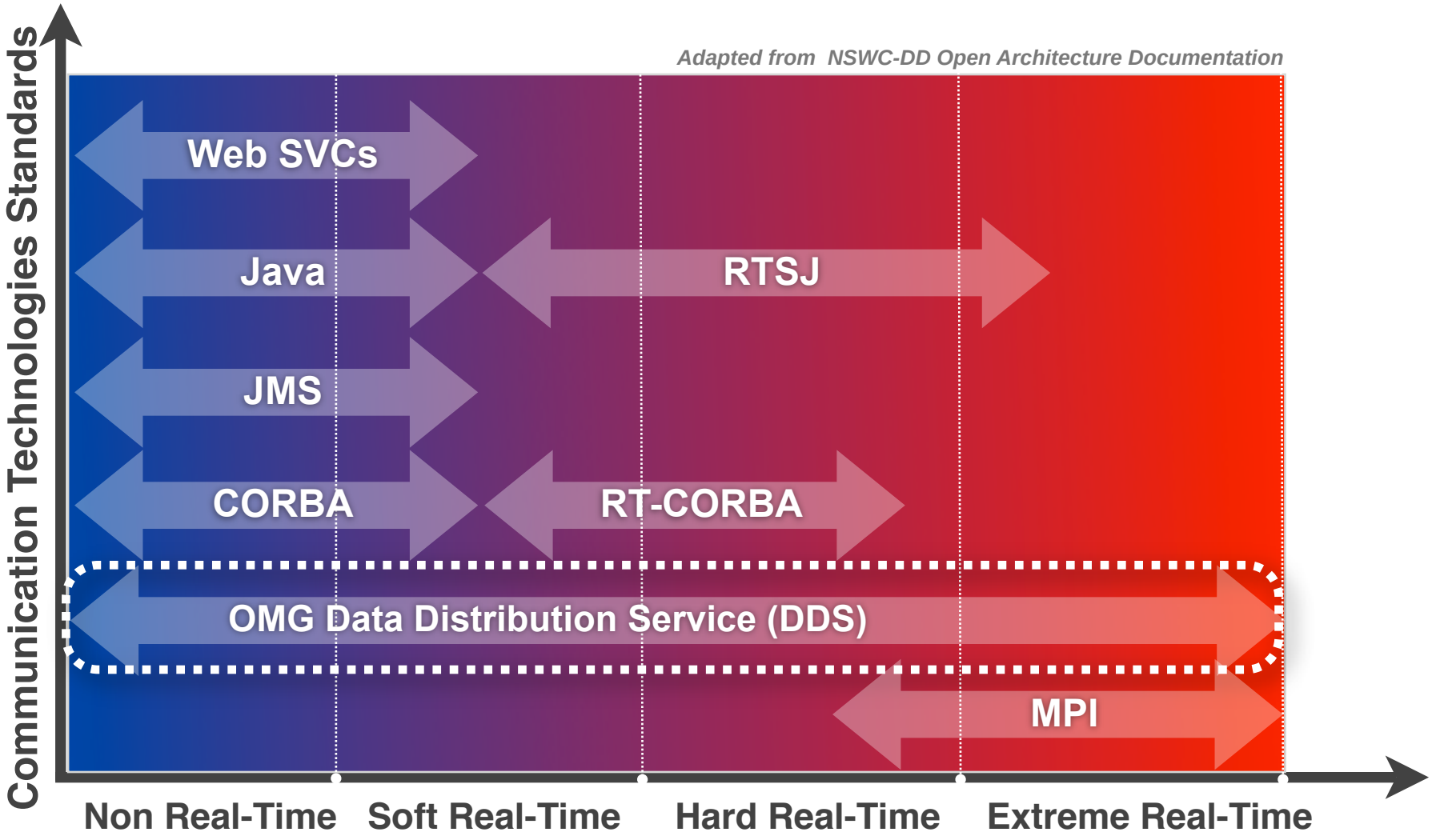
Increased Data Volumes

OpenSplice DDS Performance and Scalability

Challenges

- Shared Operational Picture
- **Increased Data Volumes =>** ***High Performance, Rich QoS Support***
- Loosely Coupled & Plug and Play
- Interoperability

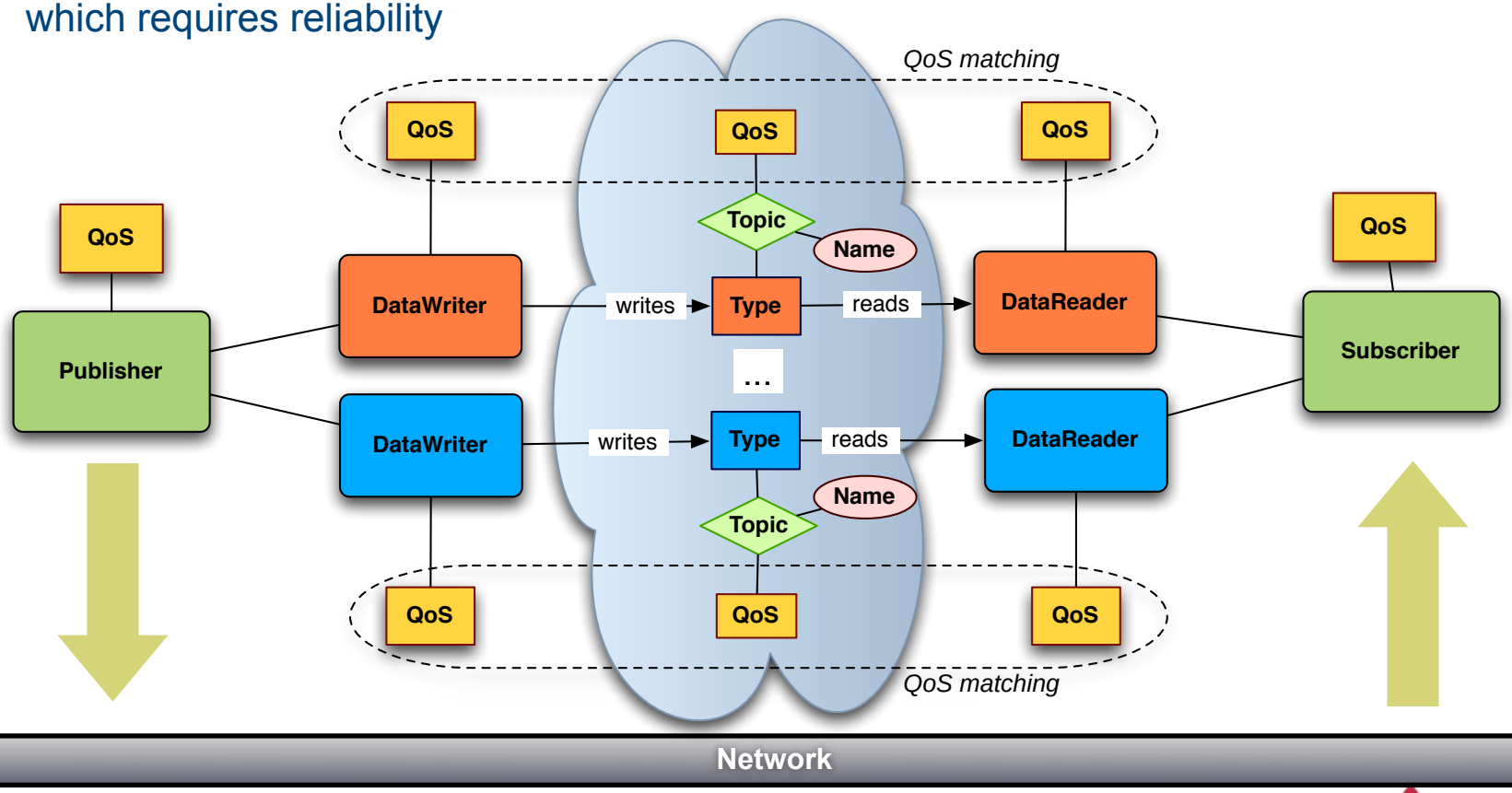
DDS Applicability



The DDS is the only technology that spans across the board -- It guarantees exceptional real-time behavior, while providing unparalleled level of throughput !

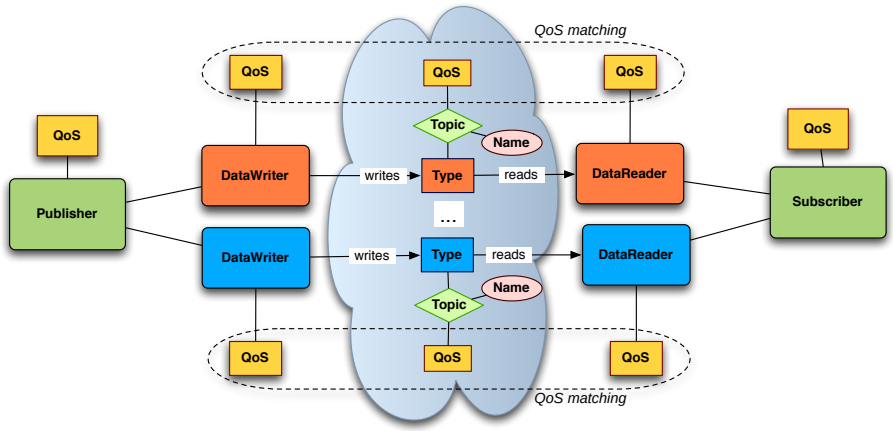
QoS Model

- QoS can associated with all relevant OpenSplice DDS entities
- Some QoS are matched based on a **Request vs. Offered Model**
- Publications and Subscriptions match only if the declared and requested QoS are compatible
  - *e.g.*, it is not possible to match a publisher which delivers data unreliably with a subscriber which requires reliability



QoS

QoS Policy	Applicability	RxO	Modifiable	
DURABILITY	T, DR, DW	Y	N	Data Availability
DURABILITY SERVICE	T, DW	N	N	
LIFESPAN	T, DW	-	Y	
HISTORY	T, DR, DW	N	N	
PRESENTATION	P, S	Y	N	Data Delivery
RELIABILITY	T, DR, DW	Y	N	
PARTITION	P, S	N	Y	
DESTINATION ORDER	T, DR, DW	Y	N	
OWNERSHIP	T, DR, DW	Y	N	
OWNERSHIP STRENGTH	DW	-	Y	
DEADLINE	T, DR, DW	Y	Y	Data Timeliness
LATENCY BUDGET	T, DR, DW	Y	Y	
TRANSPORT PRIORITY	T, DW	-	Y	
TIME BASED FILTER	DR	-	Y	Resources
RESOURCE LIMITS	T, DR, DW	N	N	
USER_DATA	DP, DR, DW	N	Y	Configuration
TOPIC_DATA	T	N	Y	
GROUP_DATA	P, S	N	Y	



- Rich set of QoS allow to configure several different aspects of data availability, delivery and timeliness
- QoS can be used to control and optimize network as well as computing resource

Loosely Coupled & Plug and Play

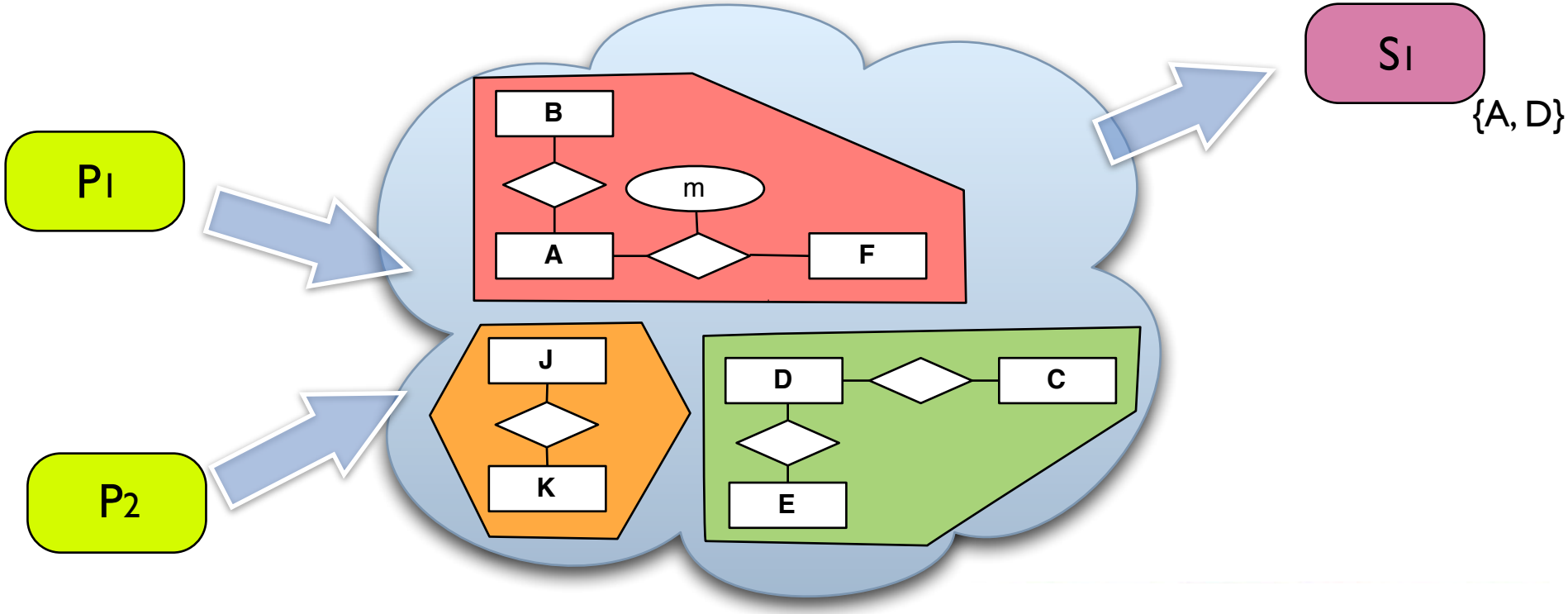
OpenSplice DDS Performance and Scalability

Challenges

- Shared Operational Picture
- Increased Data Volumes
- **Loosely Coupled & Plug and Play =>** ***Time+Space Decoupling, Dynamic Discovery***
- Interoperability

Dynamic Discovery & Data Availability

- OpenSplice DDS' publisher and subscriber dynamically discover each other
- Time and Space decoupling is highly configurable by relying on OpenSplice DDS' rich set of QoS such as Availability, Life-Span, etc.



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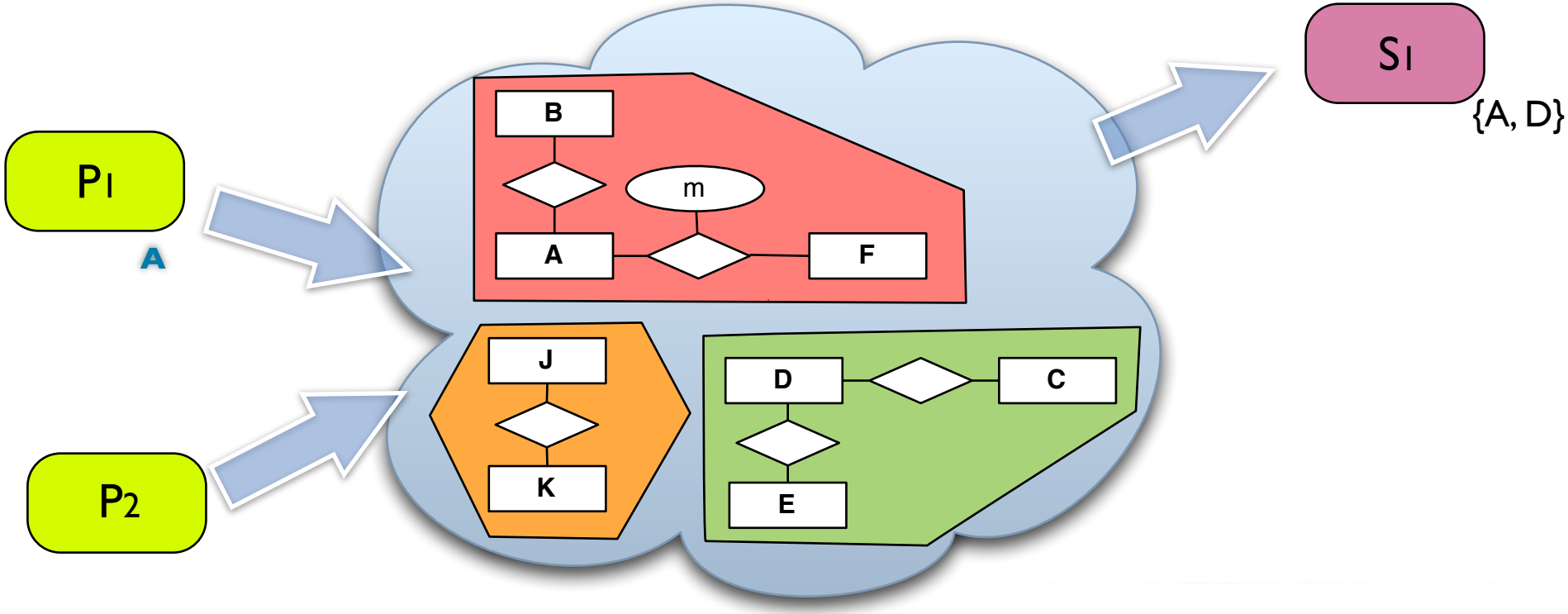

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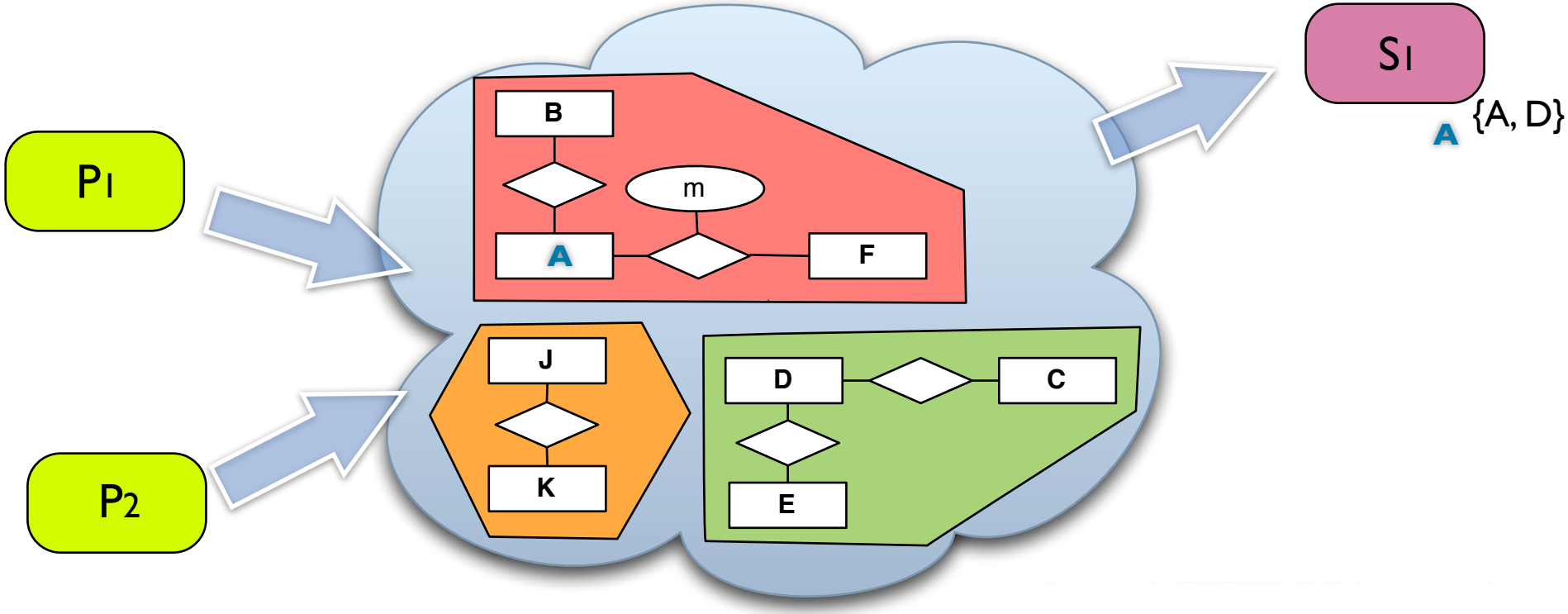

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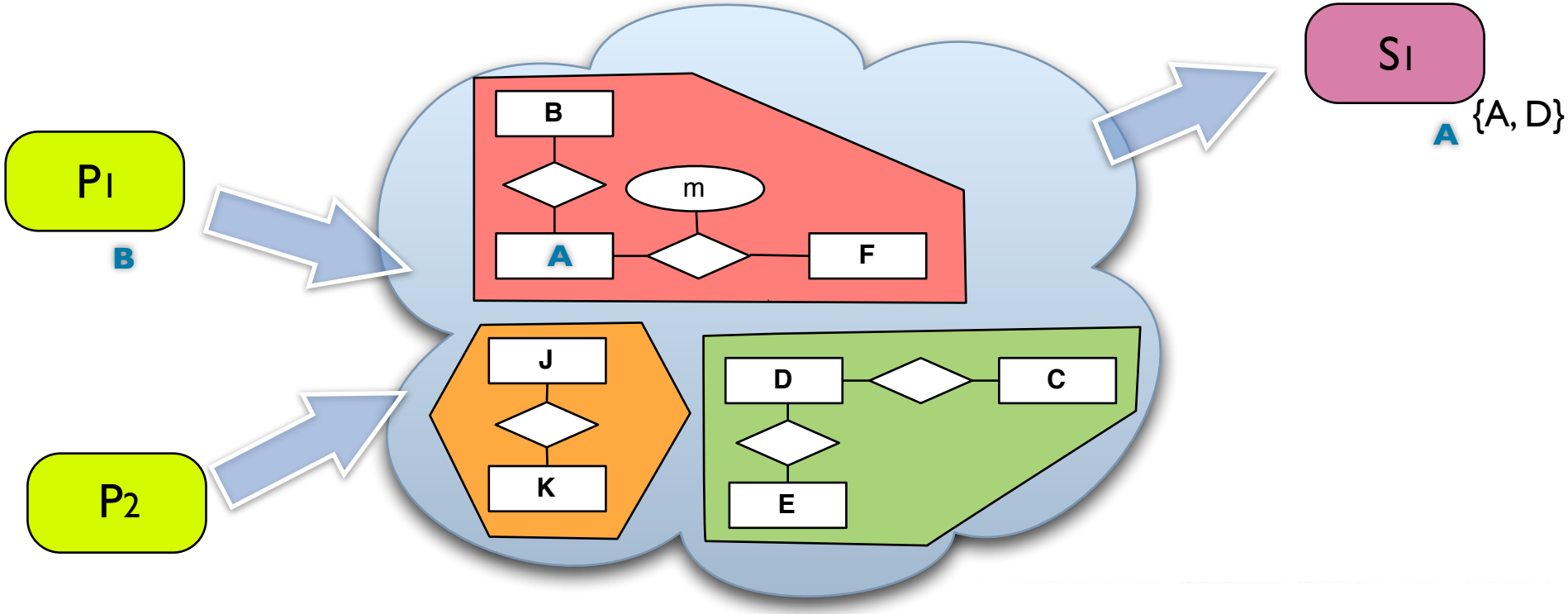

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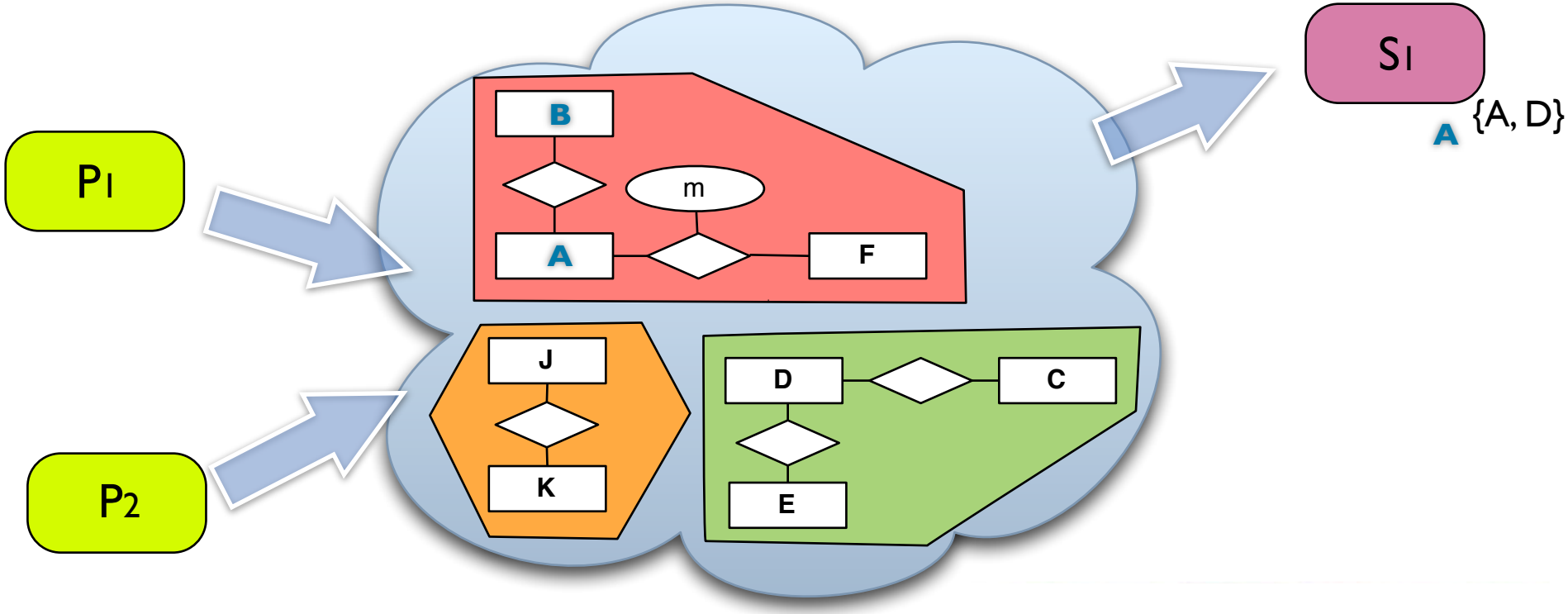

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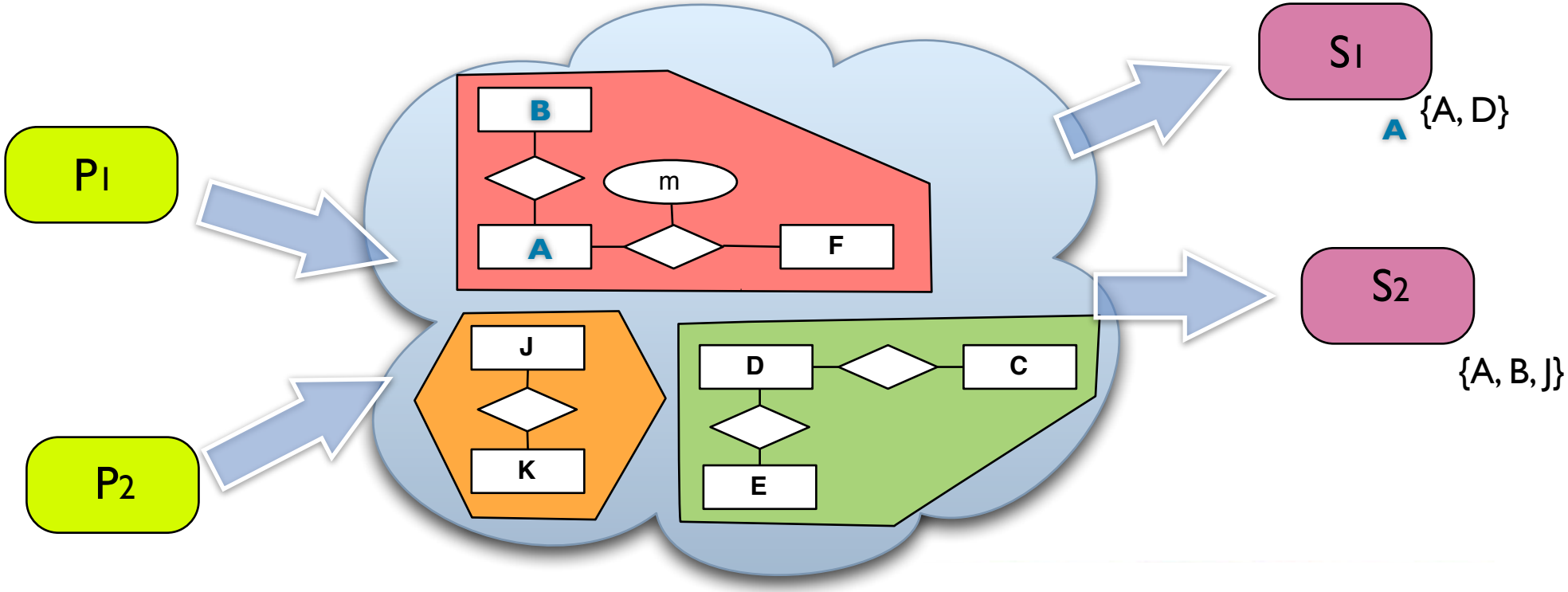

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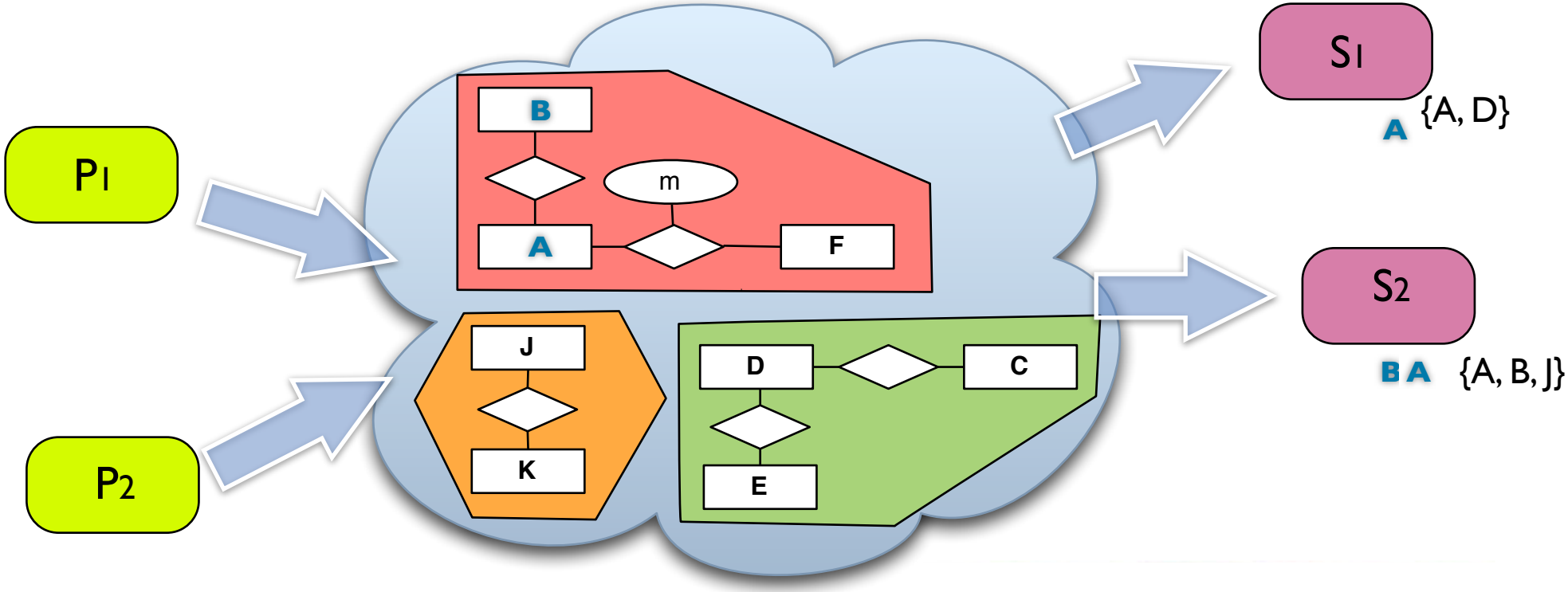

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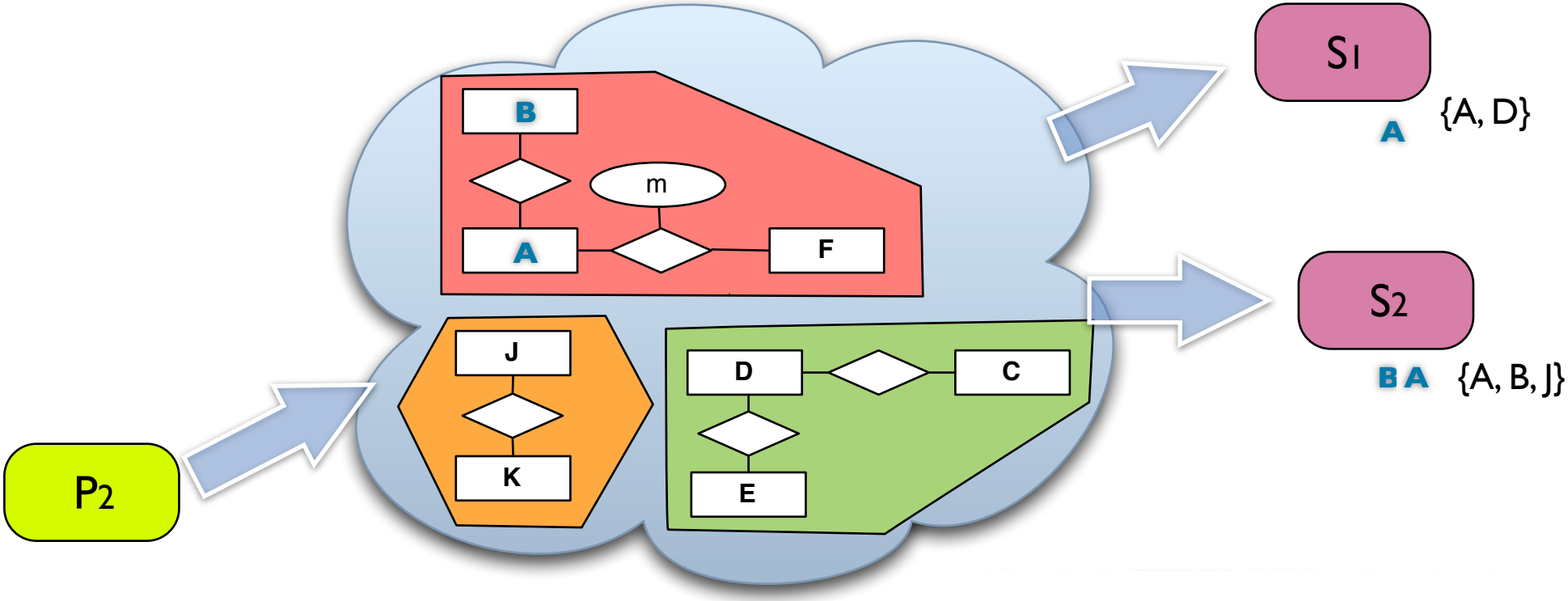

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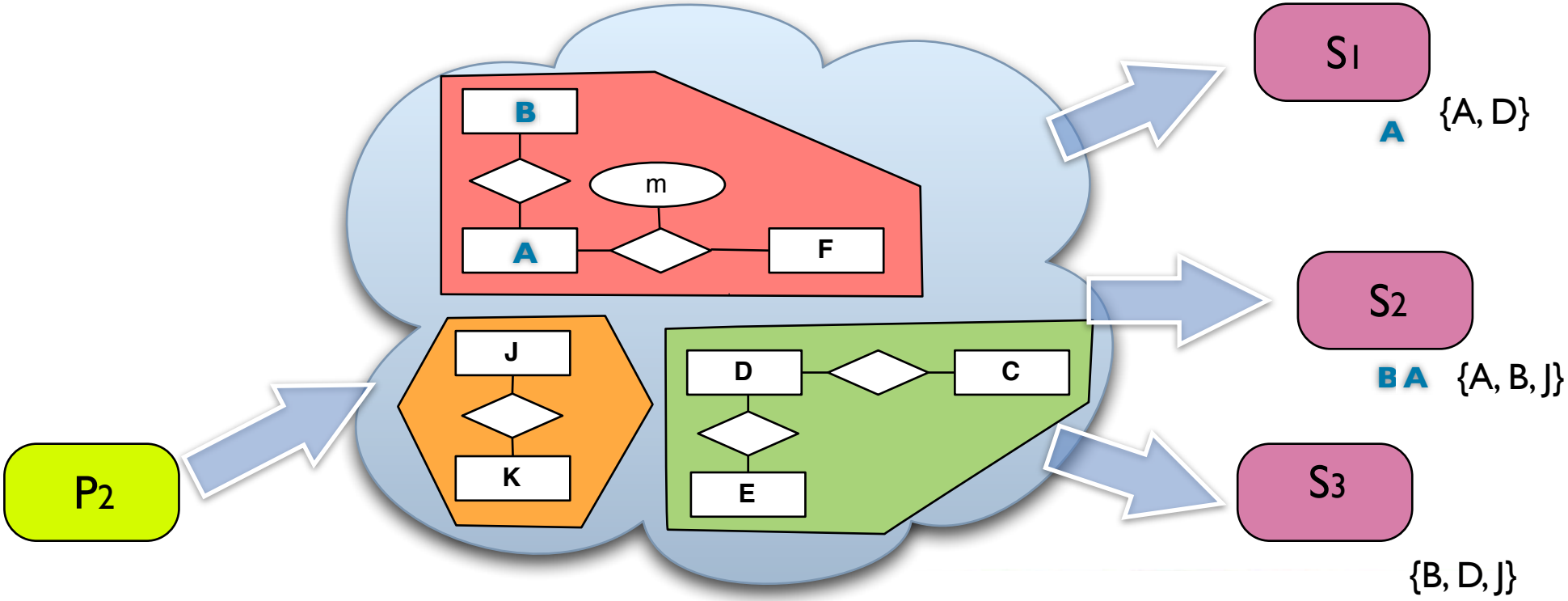

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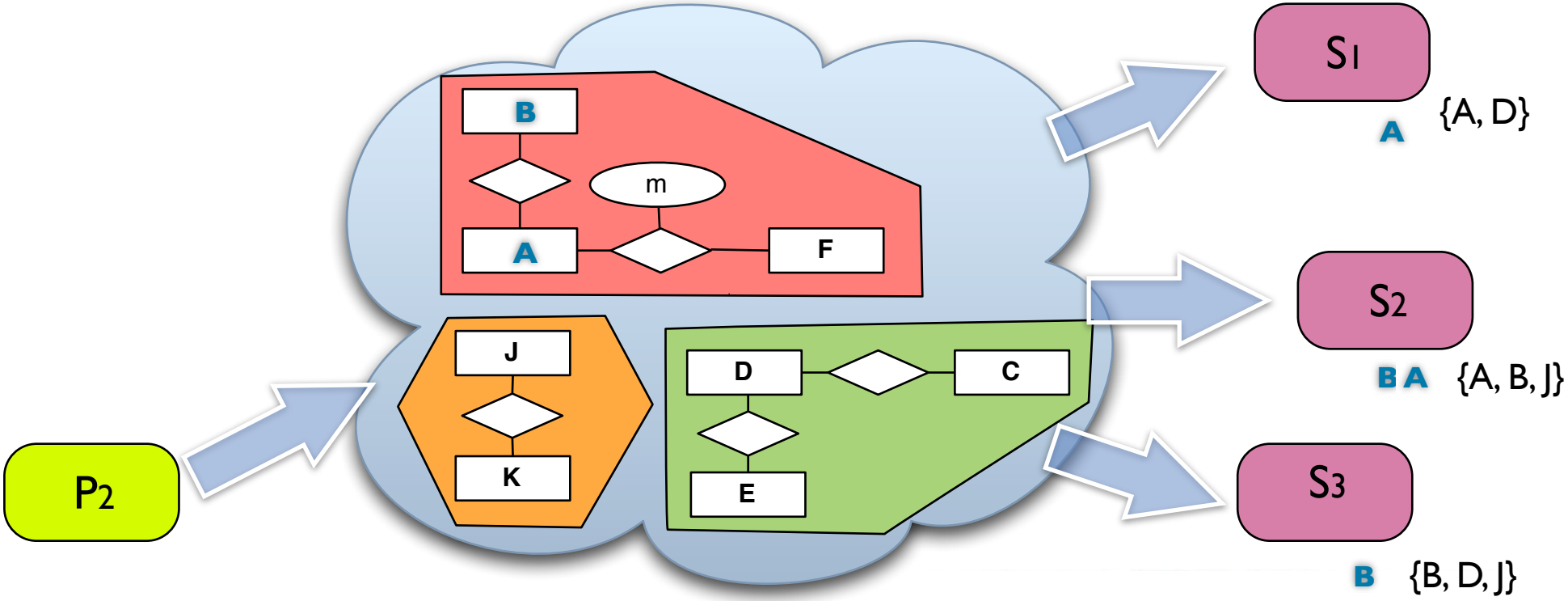

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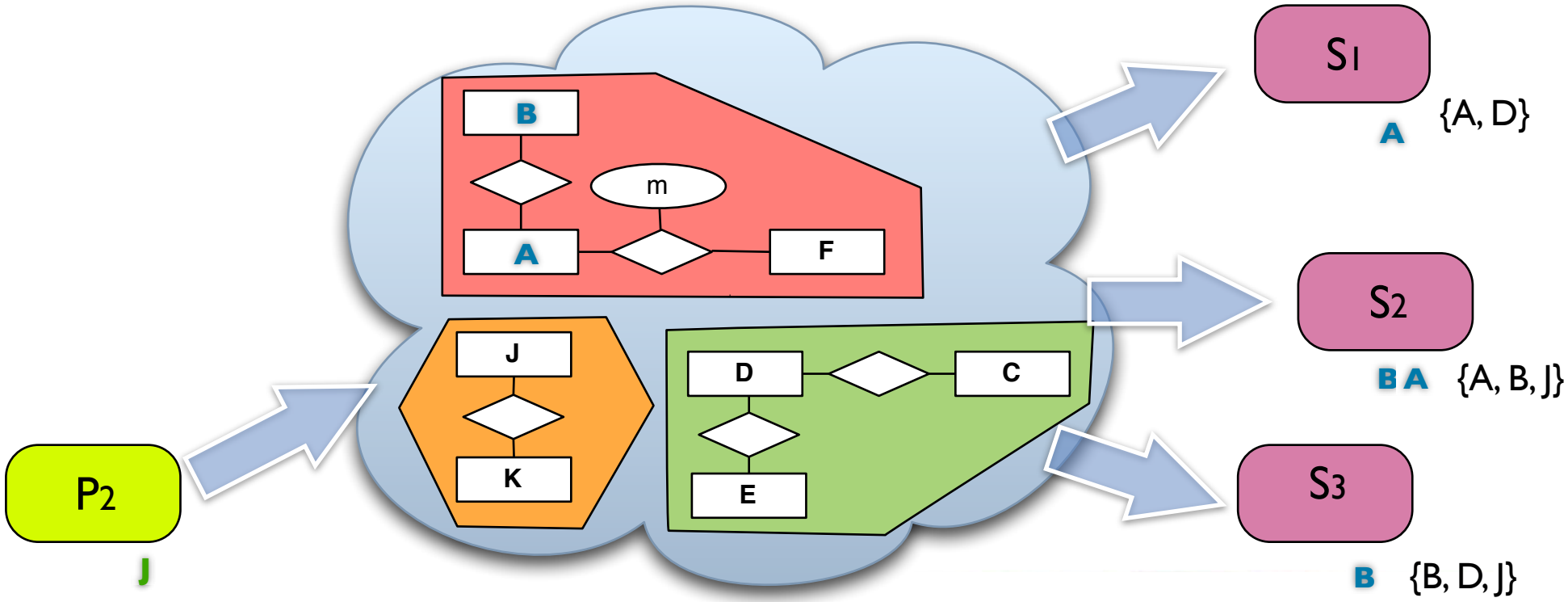

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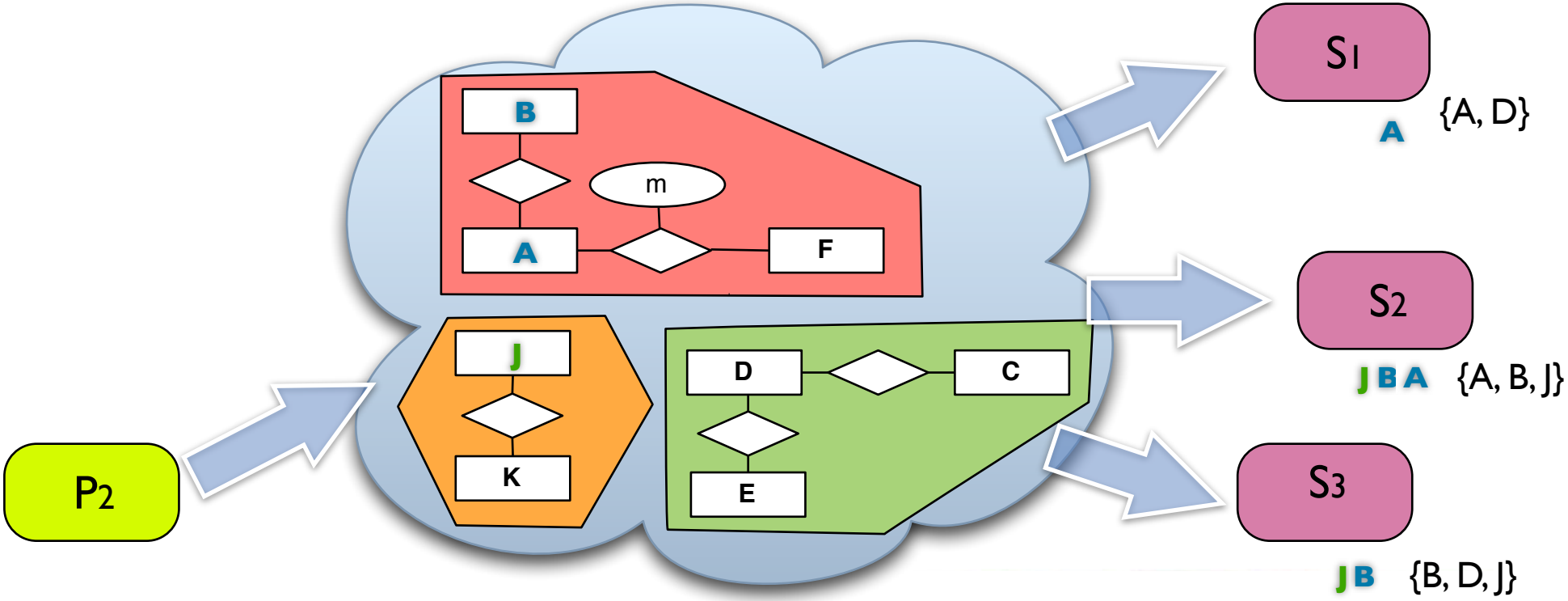

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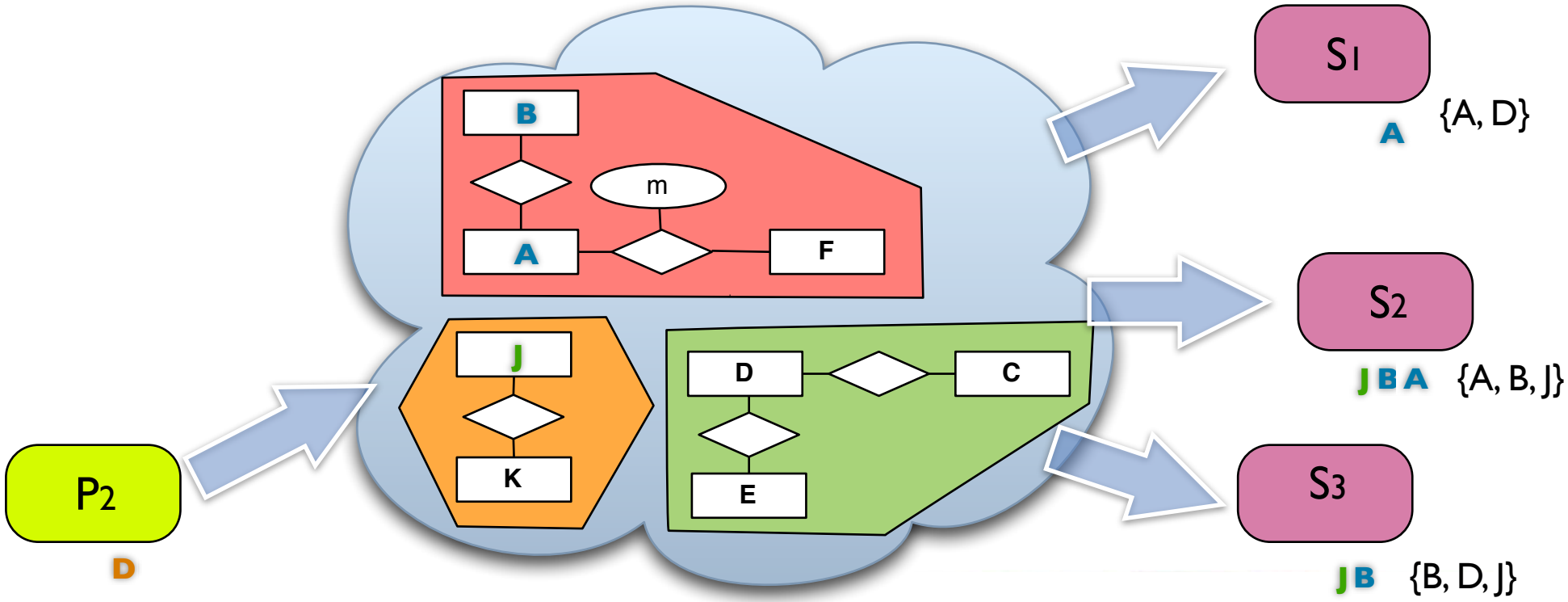
- Time and Space decoupling is highly configurable by relying on OpenSplice DDS' rich set of QoS such as Availability, Life-Span, etc.



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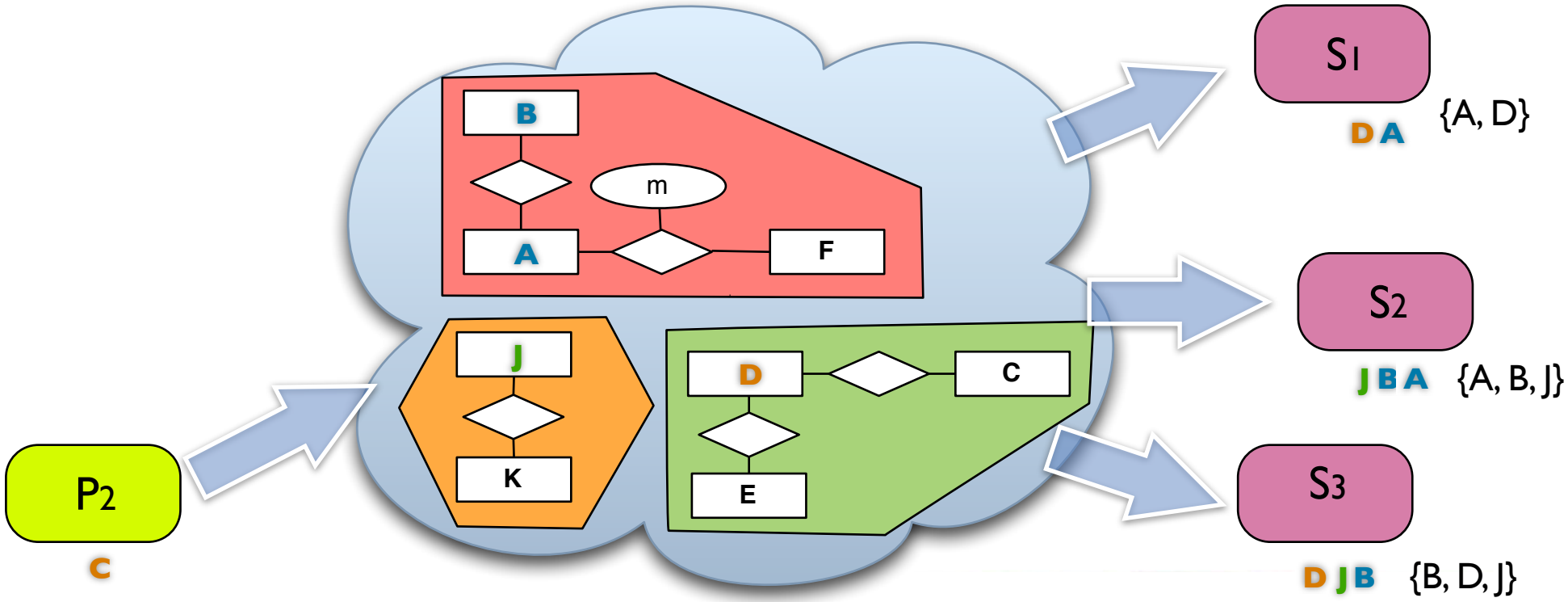

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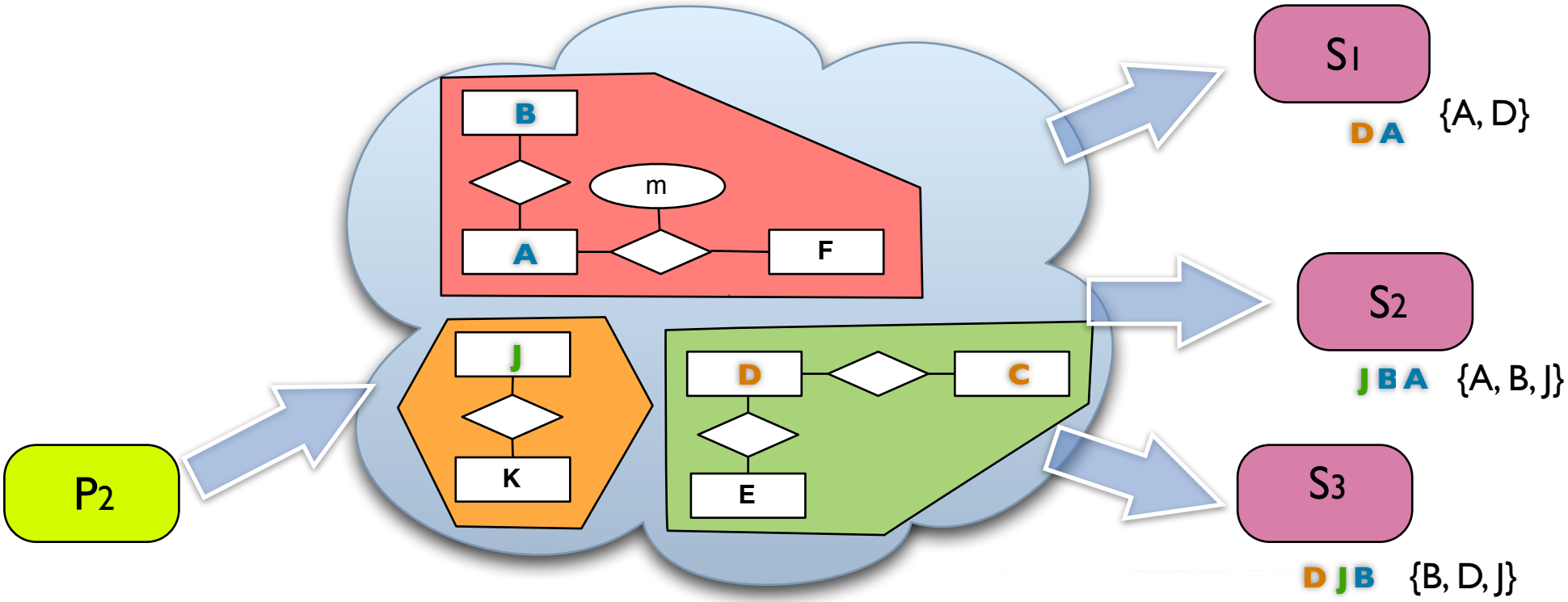

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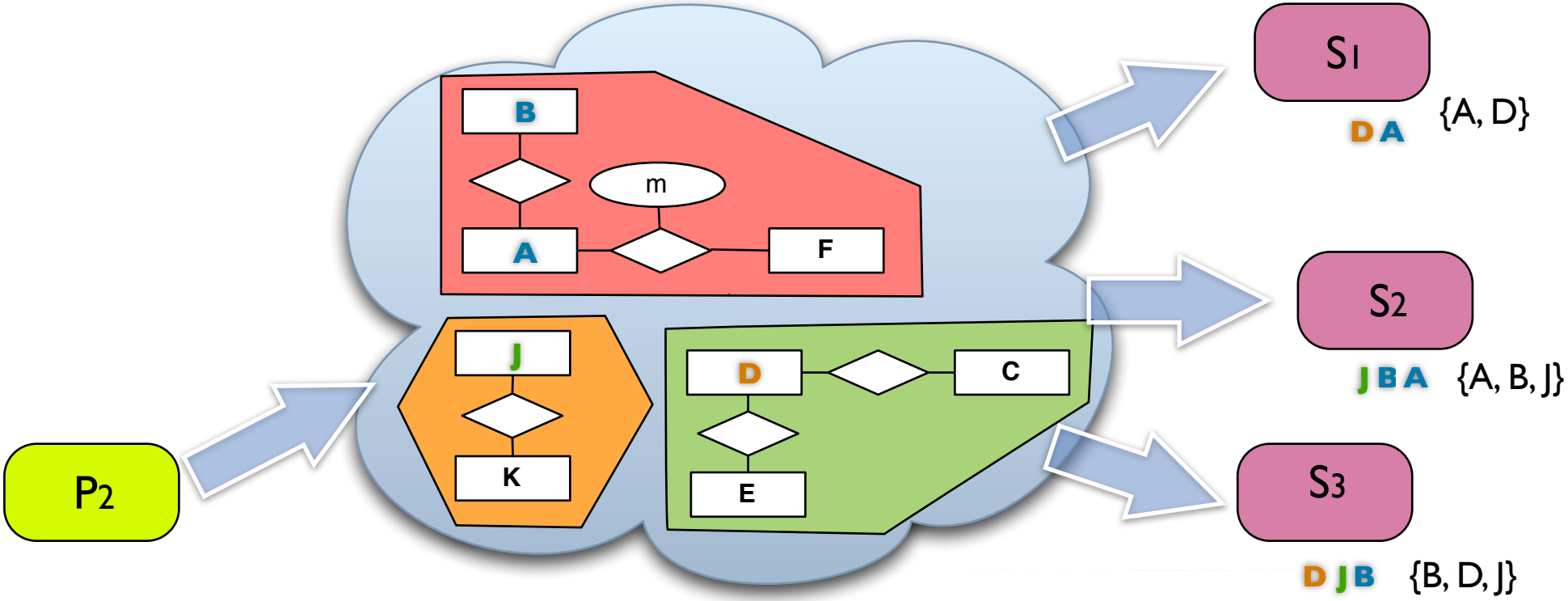


Interoperability

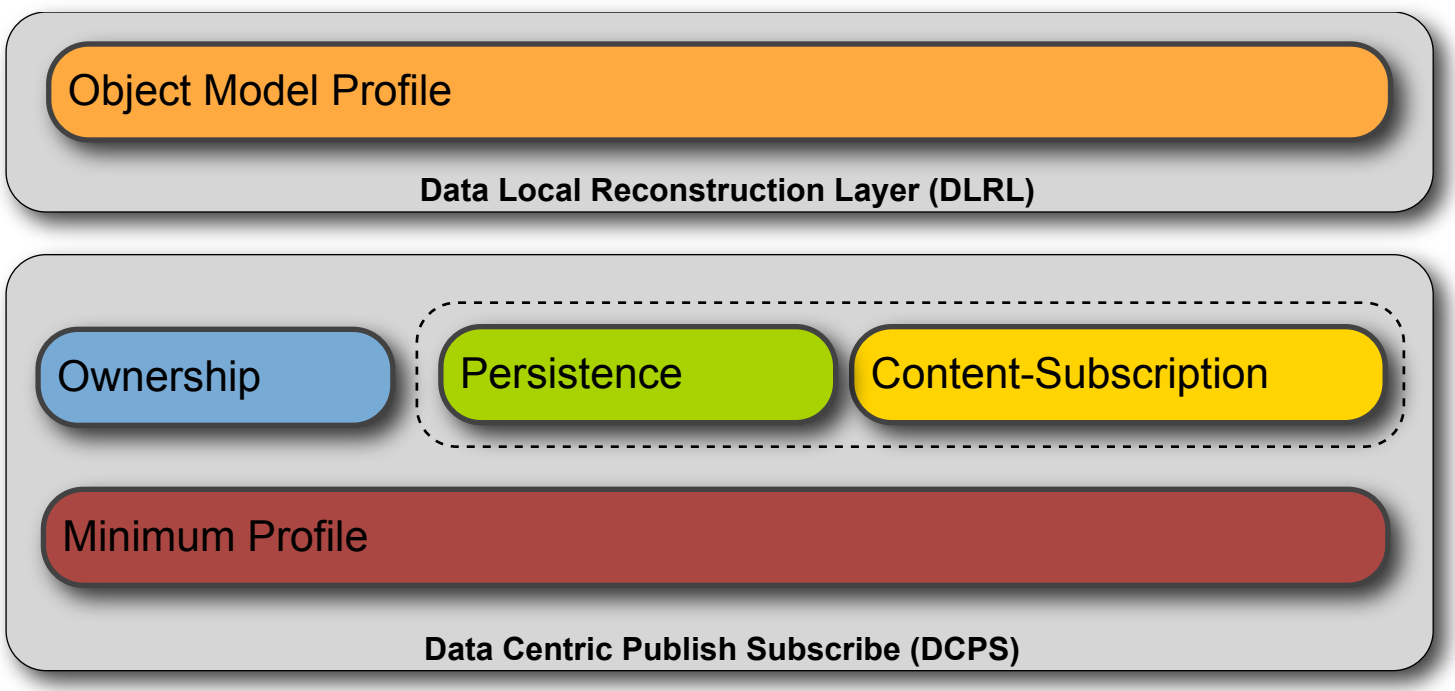
OpenSplice DDS Standard Compliance

Challenges

- Shared Operational Picture
- Increased Data Volumes
- Loosely Coupled & Plug and Play
- **Interoperability => *API + Wire Interoperability Standard***

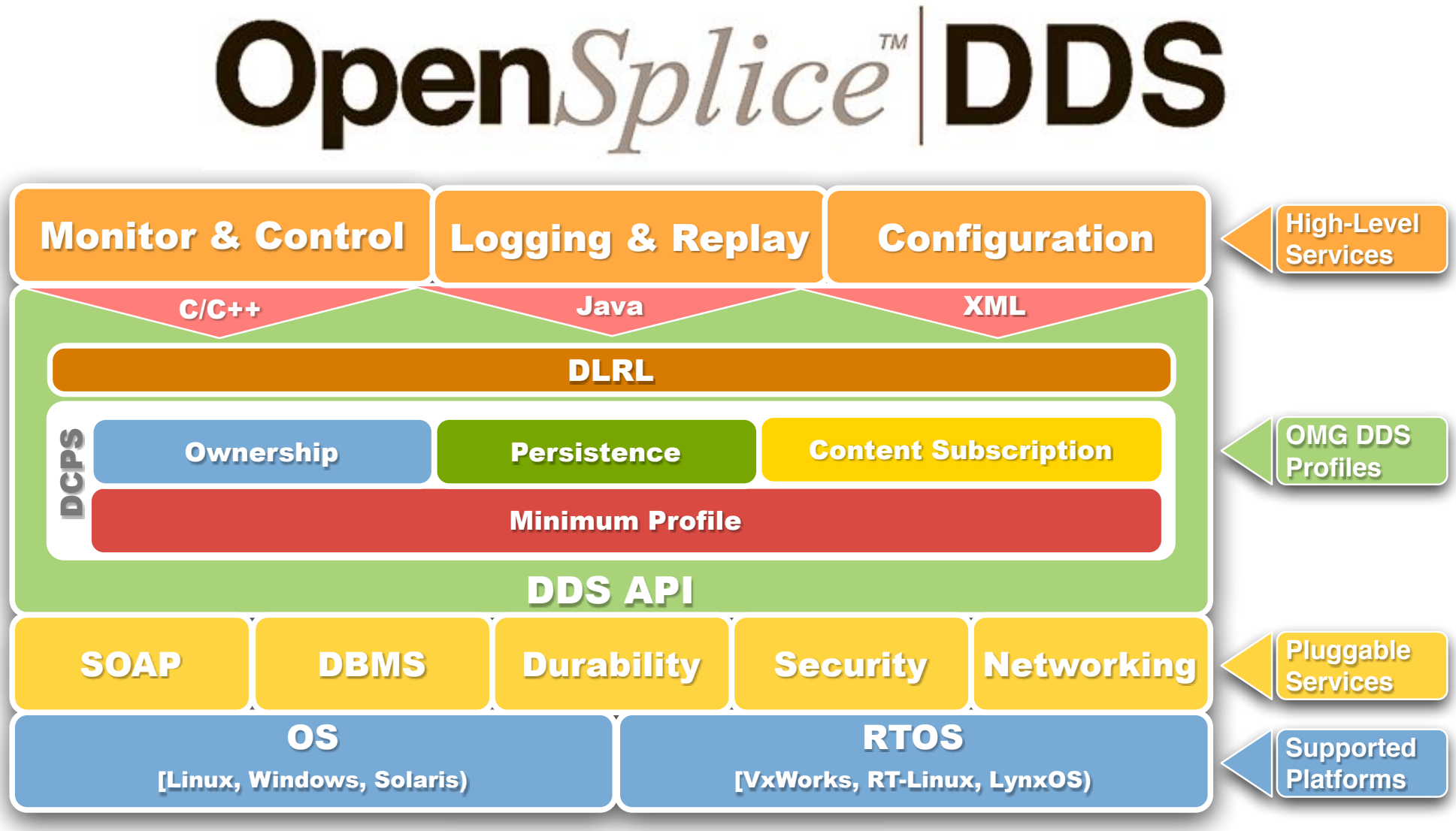
Standard Compliance

- OpenSplice DDS complies with the full profile specified in the OMG DDS Specification v1.2
- Standard wire protocol for interoperability between vendors implementation of the standard



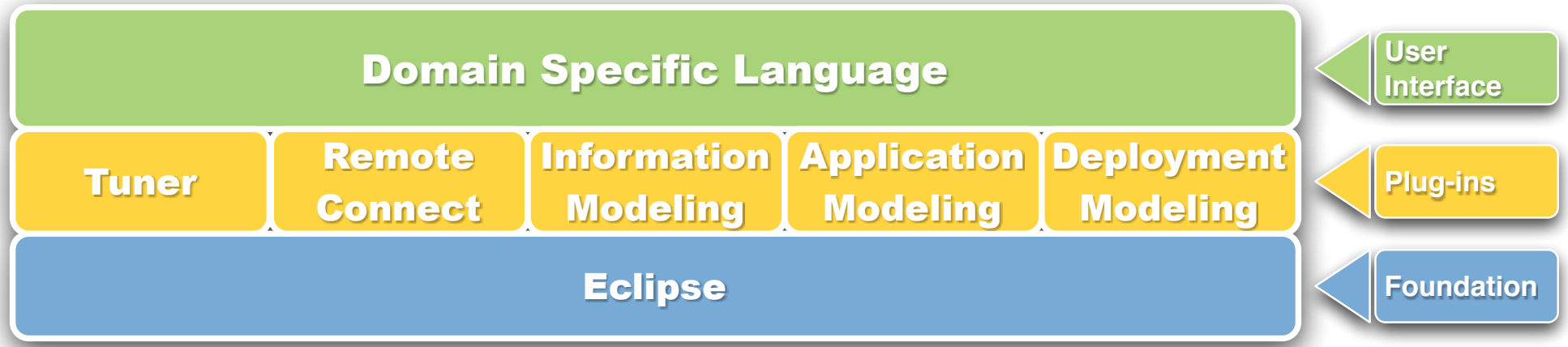
OpenSplice™ DDS

OpenSplice™ DDS



OpenSplice DDS PowerTools

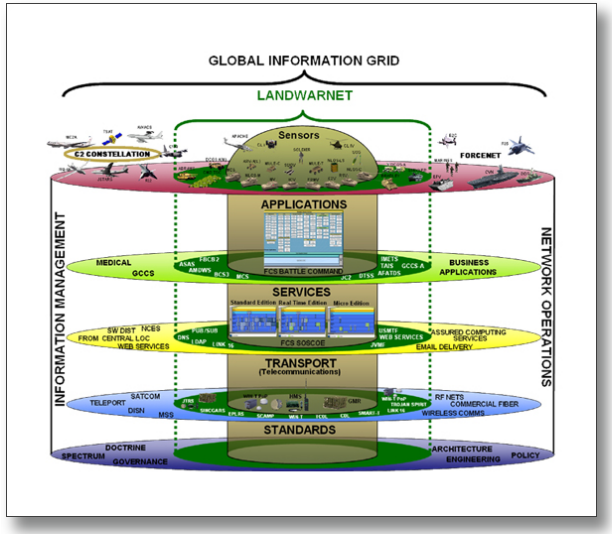
OpenSplice™ DDS



Who is using OpenSplice DDS

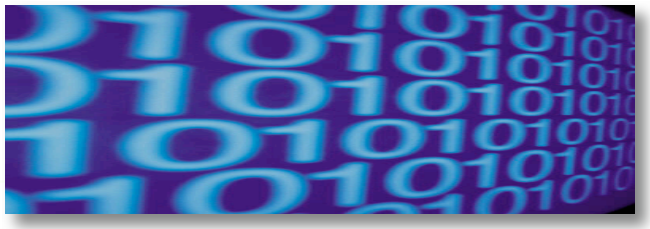
Defense

- **TACTICOS-CMS:** THALES Naval Netherlands' CMS, 26 ships classes, >100 ships
  - > 2.000 deployed runtimes (running on Solaris-servers, Linux-consoles, and vxWorks embedded subsystems)
  - 15 Navies worldwide (Netherlands, Germany, Turkey, Greece, Oman, Qatar, Portugal, South Korea, Japan, Poland,…)
- **USA programs**: LCS/GD, ENFMC/NG, LHA-LHD/DRS
- **Brazilian Navy**
- **Australia: DSTO**, ADI (Australia)
- THALES Naval NL's Flycatcher system
  - 4 army's, >400 deployments
- **NSWC**: Open Architecture Test Facility (OA-TF)



Tactical networks

- **Ultra Electronics** (US, UK): OpenSplice DDS selected over competition for superior scalability and fault-tolerance



OpenSplice™ DDS

PRISMTECH

Who is using OpenSplice DDS

Transportation

- **Amsterdam Metro**
- **CoFlight** Flight-plan management system upgrades for France, Italy, Switzerland

Aerospace

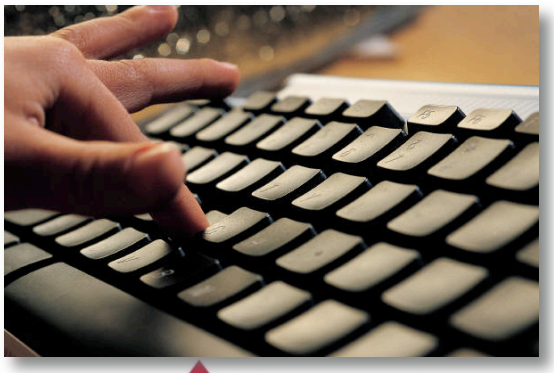
- **NASA Kennedy Space Center**: Constellation Program for next generation ARES Rocket Launch System

SCADA

- **Chemtech/Siemens** in Brazil: since 2006

Homeland Security

- **IDA**: 'Cybercrime Defense' in WAN environment



OpenSplice DDS -- In Summary

OpenSplice™ DDS

Functionality

- Full OMG DDS v1.2 specification coverage
- High Performance, Fault-Tolerant, and Secure Information Backbone
- Wide Technology co-habitation and Integration
- Support for MDE with Power Tools

Performance

- **Great Scalability** in the number of nodes, applications, and Topics
- **Real-Time Determinism** with priority and latency budget driven network scheduling
- **Fault-Tolerant** architecture, with no single point of failure, and safe isolation between application and critical resources, *e.g.*, network

Pedigree

- **Maturity**. Proven, and fielded in more than 15 navies worldwide
- **Fractal Architecture**. Large-scale, real-time, fault-tolerant, embedded, all in 1 system
- **High Standards of Quality Assurance.** Process/procedures, QA-artefacts and regression testing w.r.t. number of applications as well as computing nodes and topics

Agenda

- Challenges Ahead
- Addressing the Challenges
- Use Cases
  - ATM
  - Metropolitan Railway
- What's Next
- Concluding Remarks

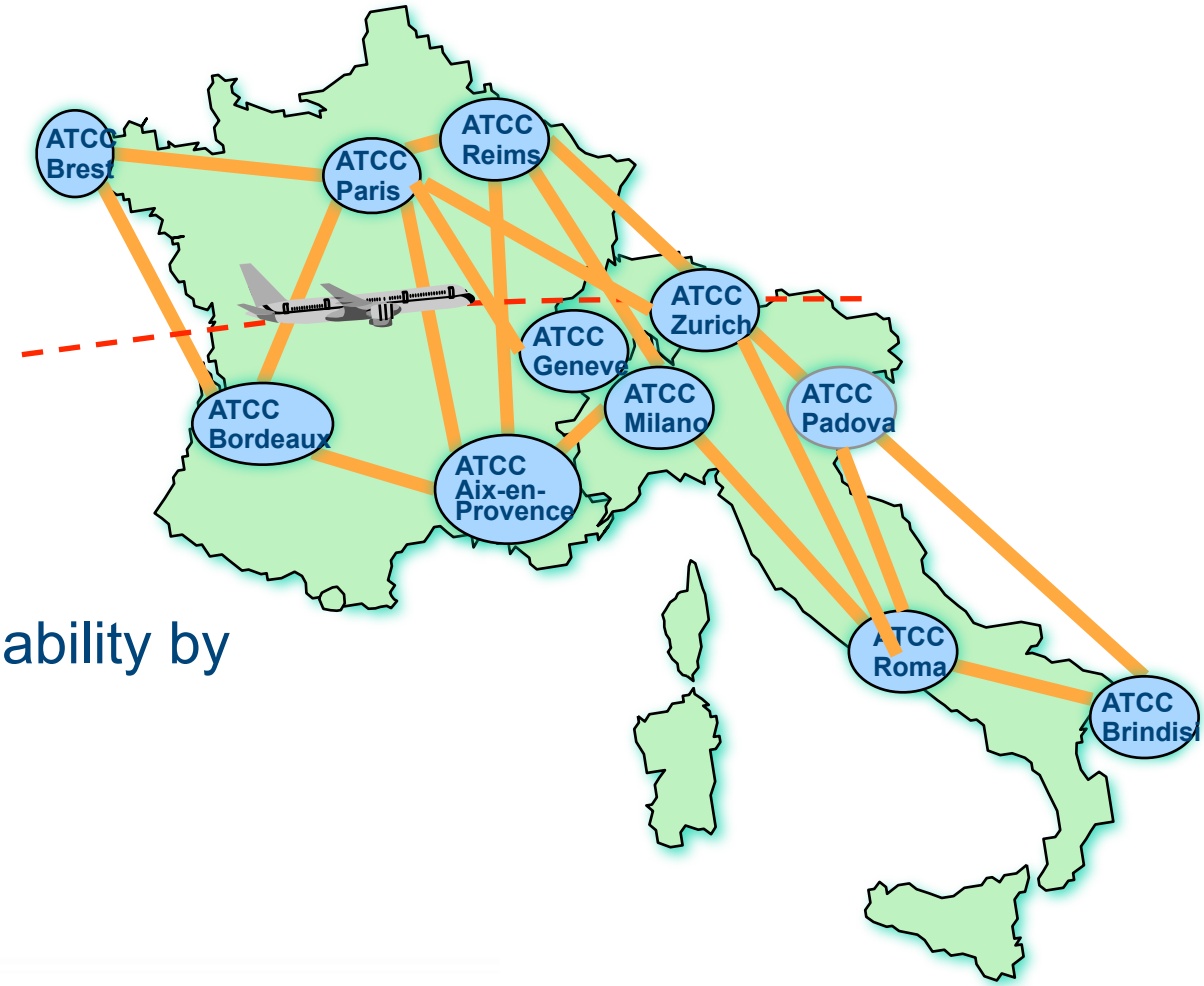
Dr. Angelo Corsaro

Coflight eFDP

CoFlight Program

- Large program to replace existing Flight Data Processors (FDPs)
  - 5 Centers in France
  - 4 Centers in Italy
  - 2 Centers in Switzerland

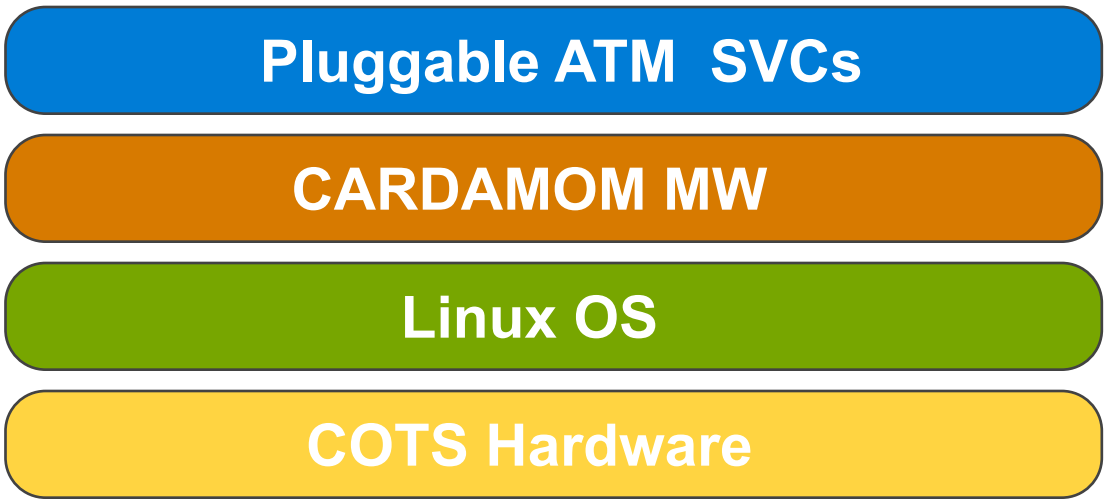
Coflight eFDP



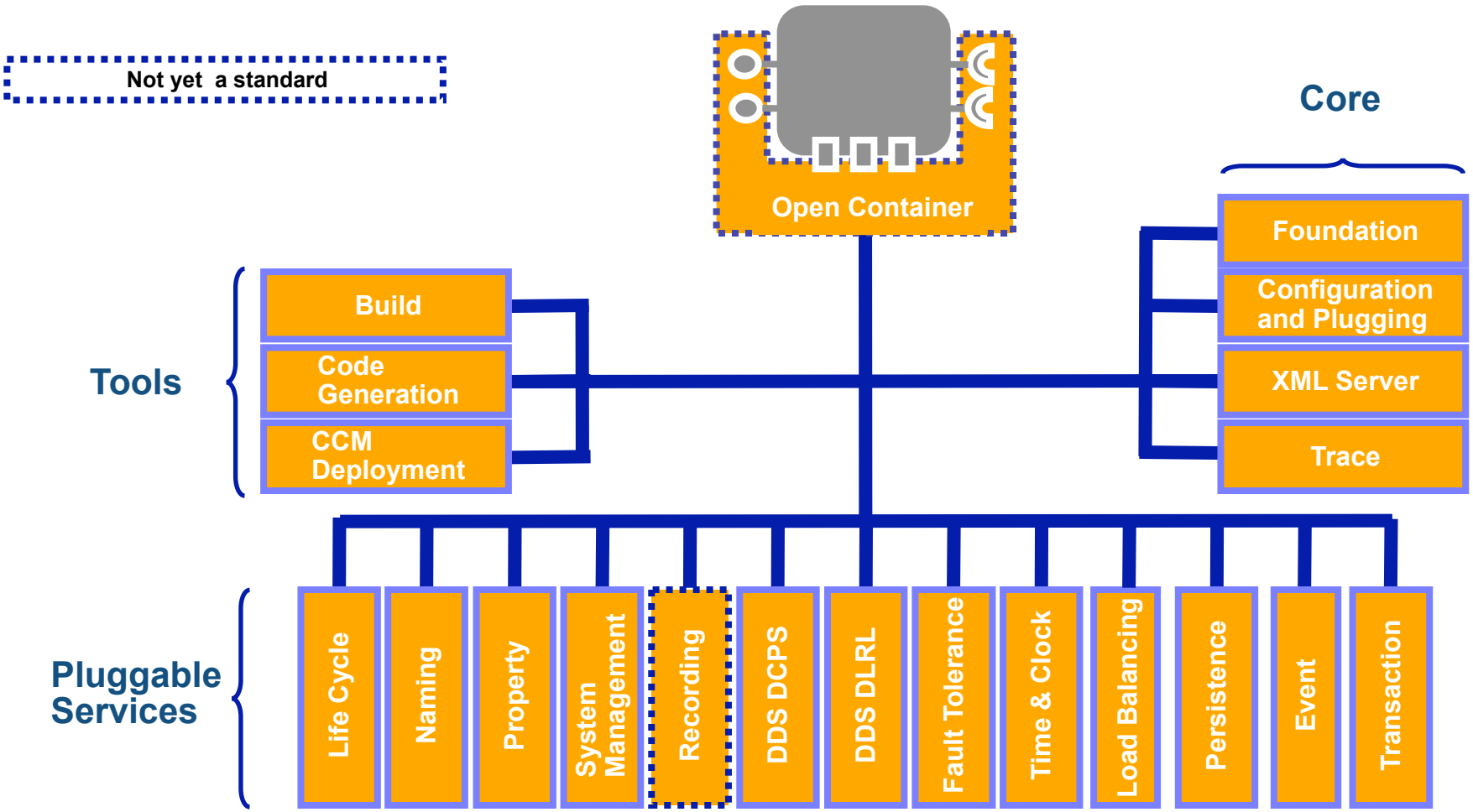
- Initial Operational Capability by 2009

CoFlight System Architecture

- Evolution from centralized architecture towards a **fully distributed and open architecture based on modular components**
- CoFlight makes use of a new **Open Middleware**:CARDAMOM



CARDAMOM



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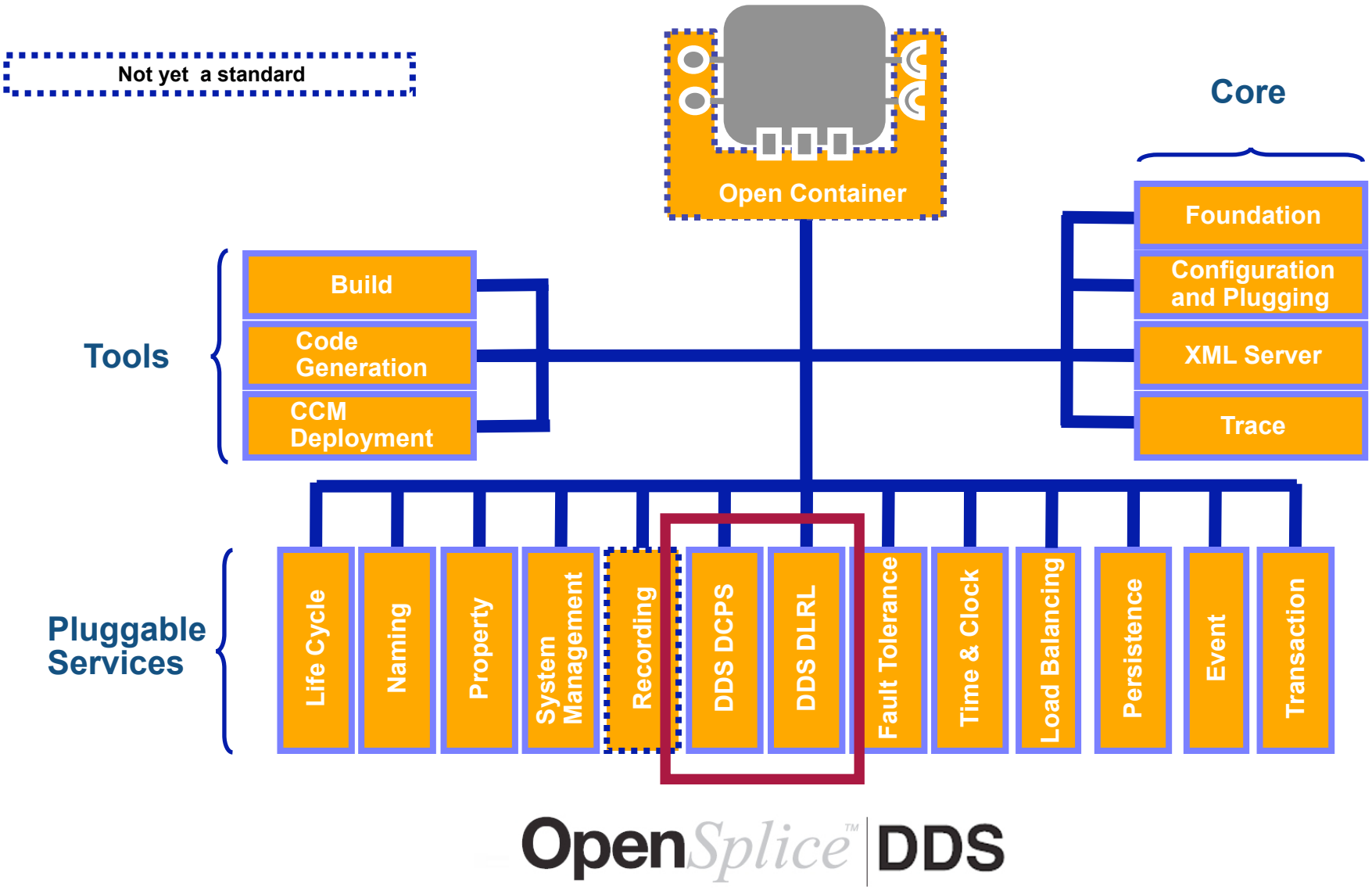


CoFlight and DDS

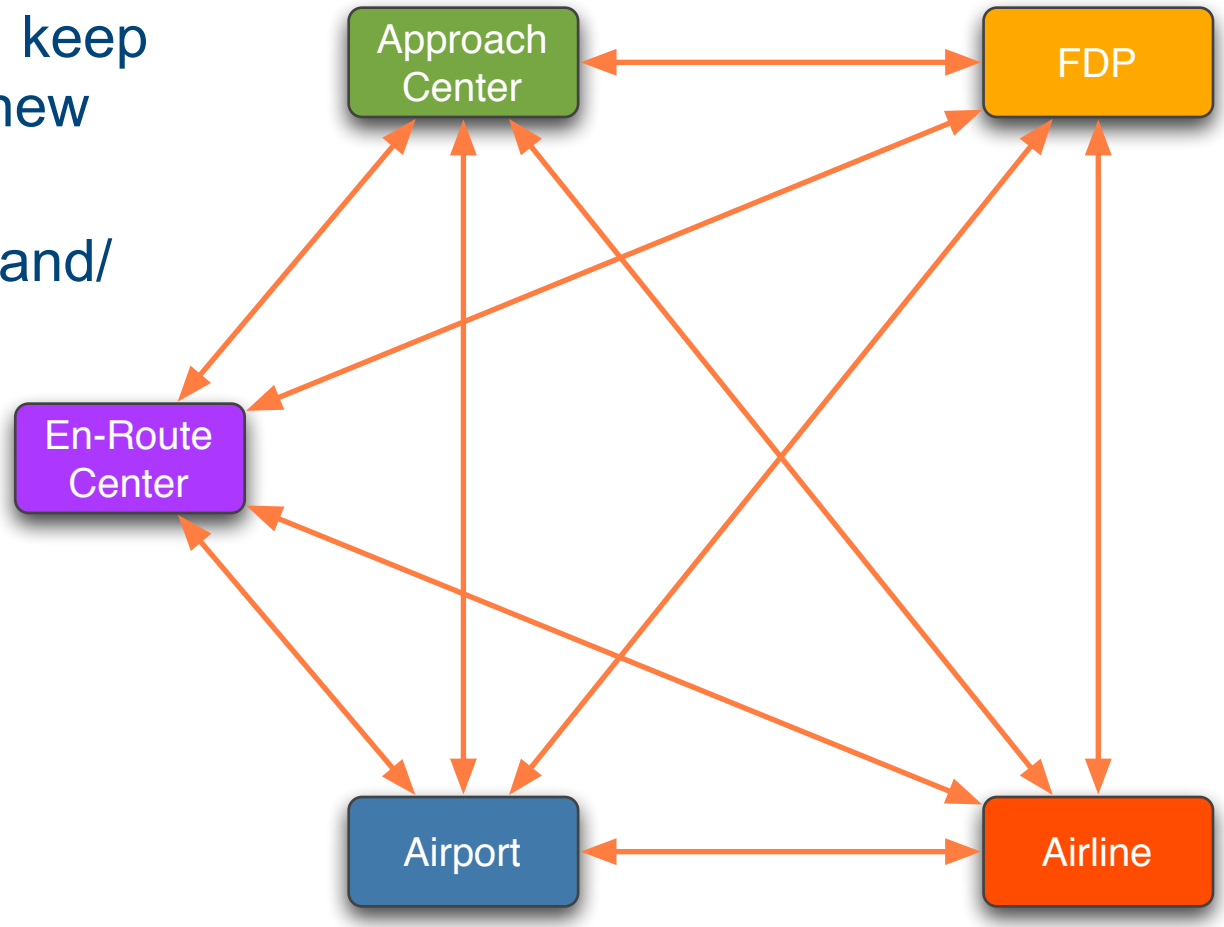
- Pervasive use of DDS
- DDS is used as the key mechanism for distributing Flight Data Plans
  - Within the FDP core
  - To CWPs
- As CoFlight has been built ready for **Operational Interoperability**, it also relies on DDS for inter-center data exchange

Interoperability

Toward ***Single Sky***

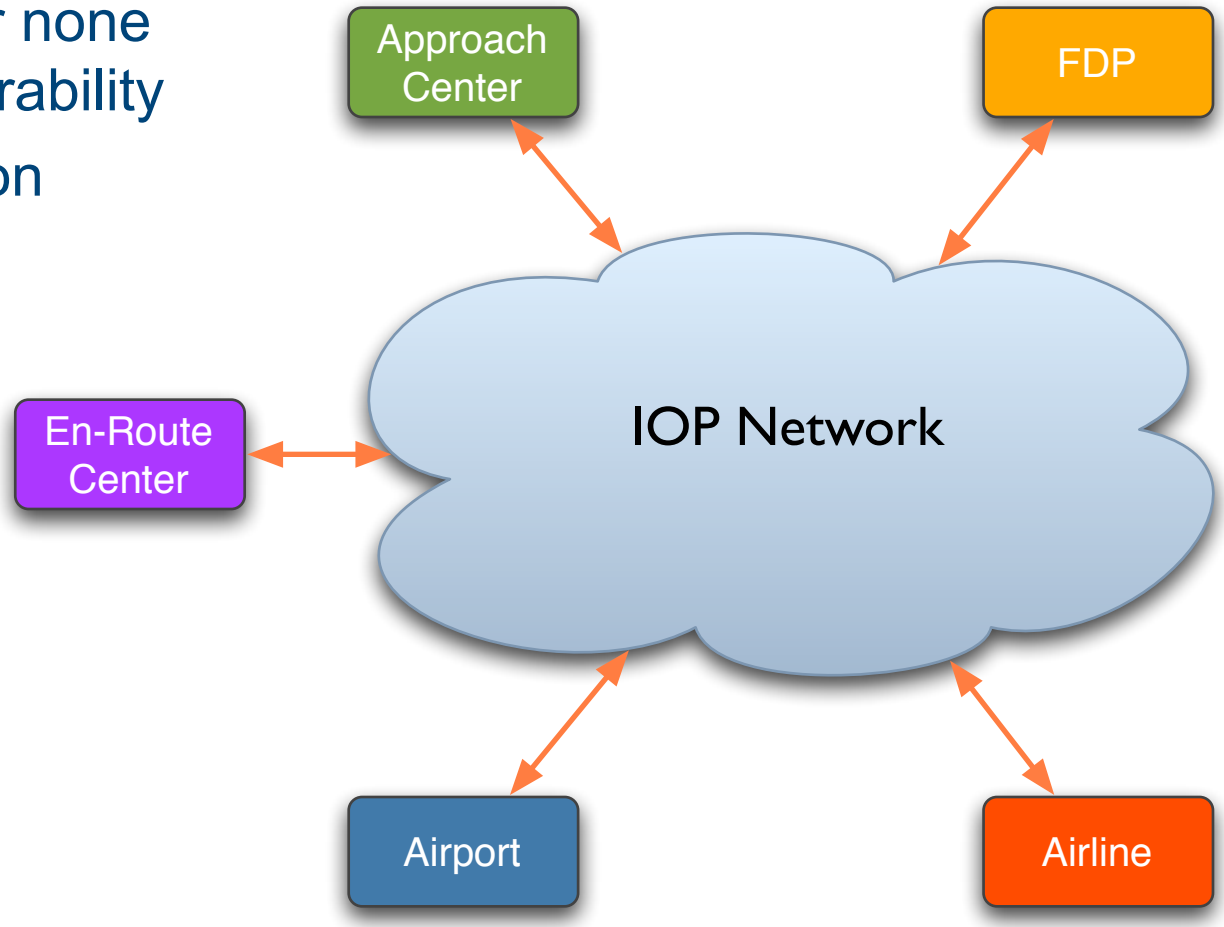
Today...

- Tightly coupled, brittle architectures are pervasive
- It is hard to extend scale, keep up with throughput, add new operational features
- Interoperability is limited and/ or requires major human intervention



...Tomorrow

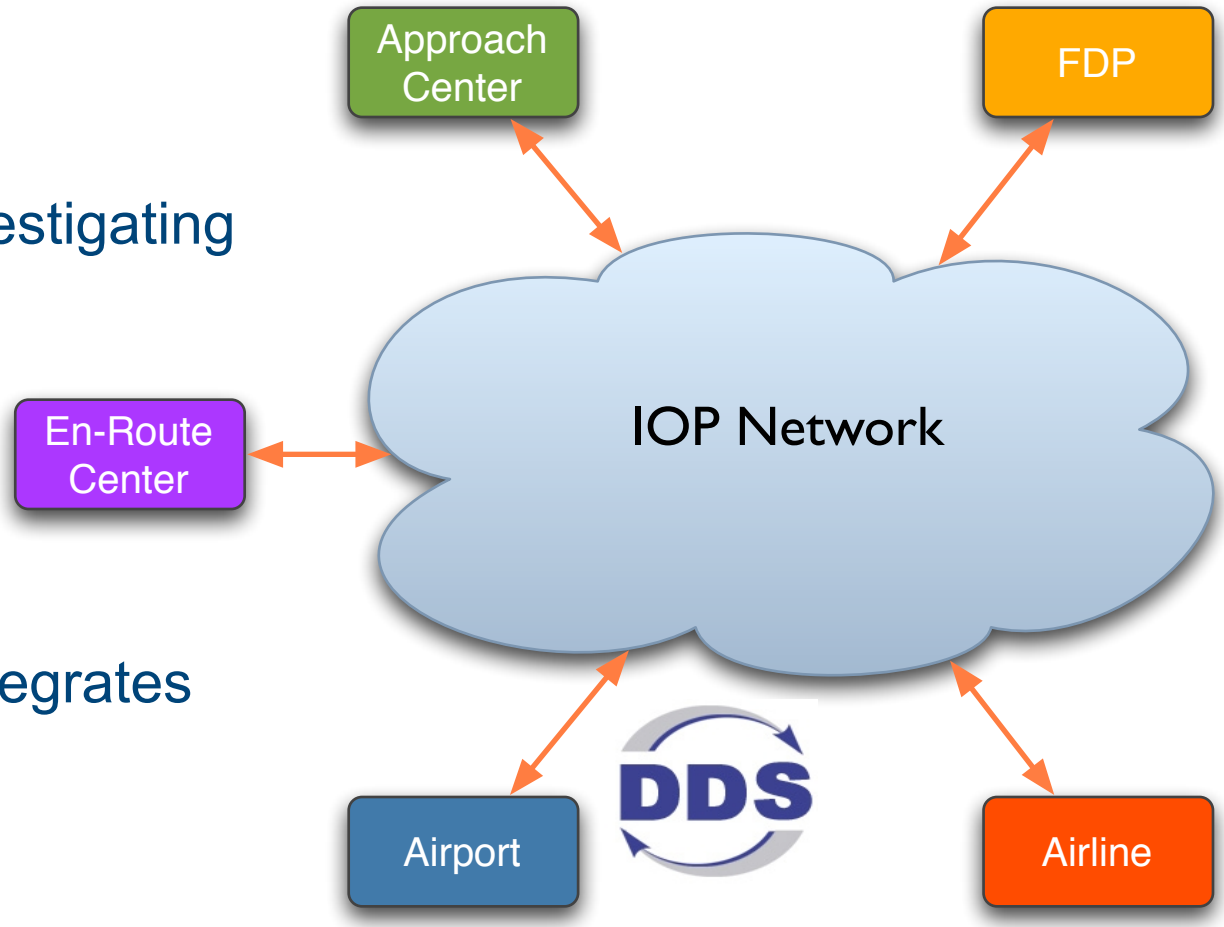
- **Loosely Coupled Extensible Architecture**
- **Autonomous.** Limited or none human-assisted interoperability
- Full operational integration
  - Single Sky
  - Gate-to-Gate
  - SESAR



DDS and Interoperability

- DDS has been selected as the data distribution mean for interoperability by projects as:
  - CoFlight
  - ICOG 2
- US/EU SWIM is also investigating DDS

OpenSplice™ DDS



- CoFlight's middleware, CARDAMOM already integrates OpenSplice DDS

DDS is going to be the back-bone of EU's ATC/ATM Interoperability Network

Agenda

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Metro Equipment Management

The Equipment Management System

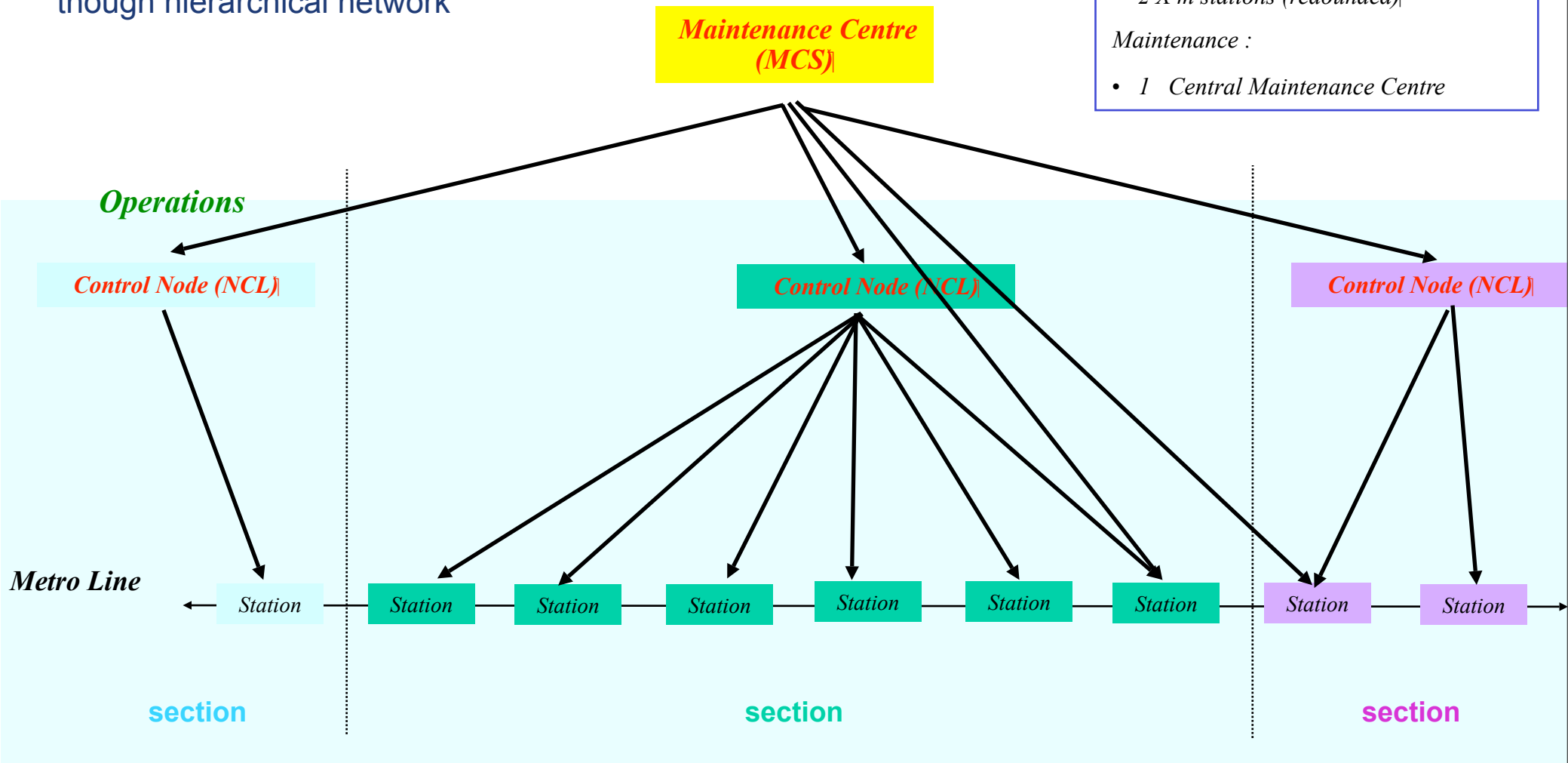
- Thousands of equipments supervised though hierarchical network

Operations :

- *2 x n NCL (redounded)*
- *2 X m stations (redounded)*

Maintenance :

- *1 Central Maintenance Centre*



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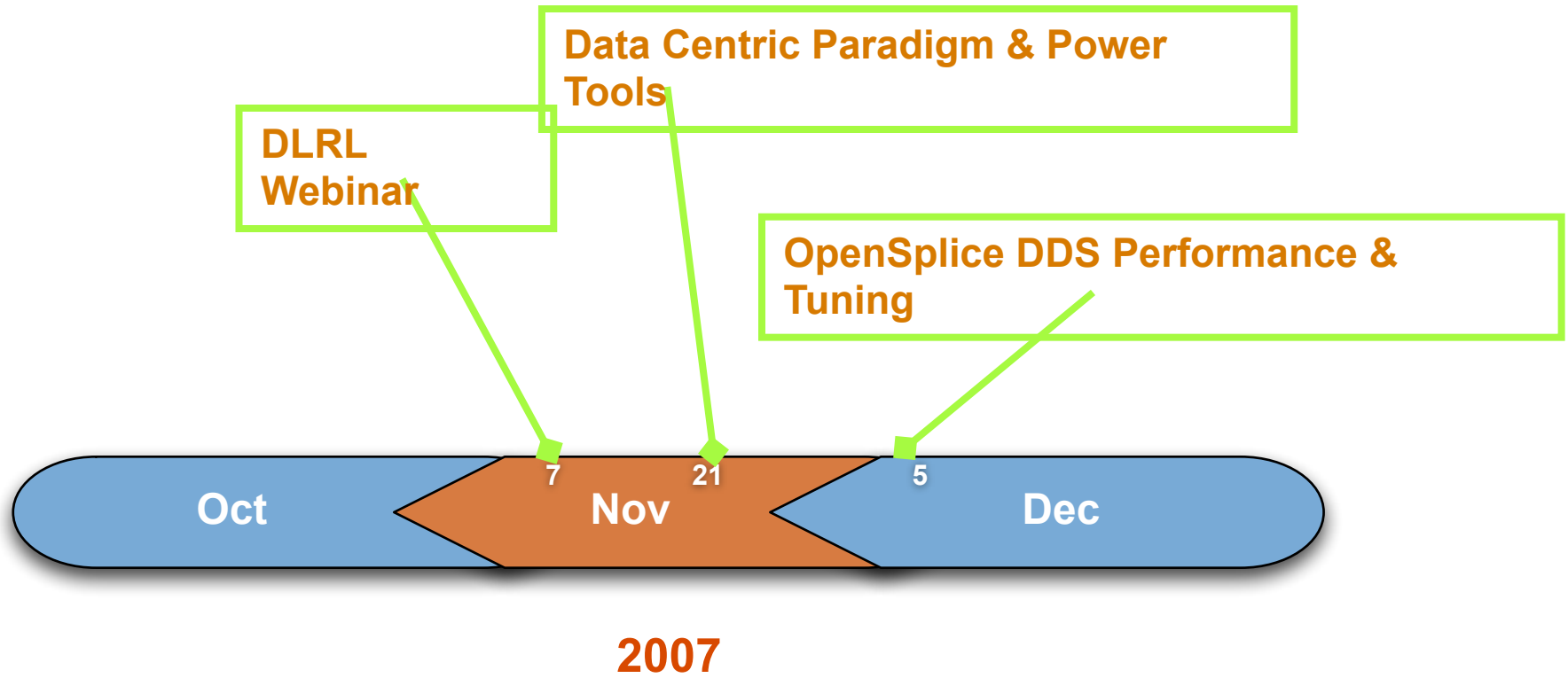
Upcoming Webinars



Registration: http://www.prismtech.com/section-item.asp?id=731&sid=29&sid2=15&sid3=289

Agenda

- Challenges Ahead
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Concluding Remarks

Applicability

- OpenSplice DDS uniquely addresses some of the key requirements for next generation Transportation Systems
- Thanks to its architecture, OpenSplice DDS it delivers extremely high performance, high availability and reliability, and retains predictability even under burst of activities

Open Architecture

- OpenSplice DDS is the only implementation in the world which fully implements the OMG DDS v1.2 standard

Technology Ecosystem

- Seamless cohabitation with CORBA (Java+C++) and RTSJ
- DBMS Integration
- Security Plug-in

OpenSplice DDS is the best solution available on the market for solving your data distribution problems!

Contact Us

OpenSplice™ DDS

- OpenSpliceDDS Resource Center
  - http://www.prismtech.com/opensplice-dds/
- Evaluate OpenSplice DDS
- Training and Consulting
  - sales@prismtech.com
- OMG DDS Information
  - http://www.dds-forum.org/
  - http://portals.omg.org/dds/

Thank You!