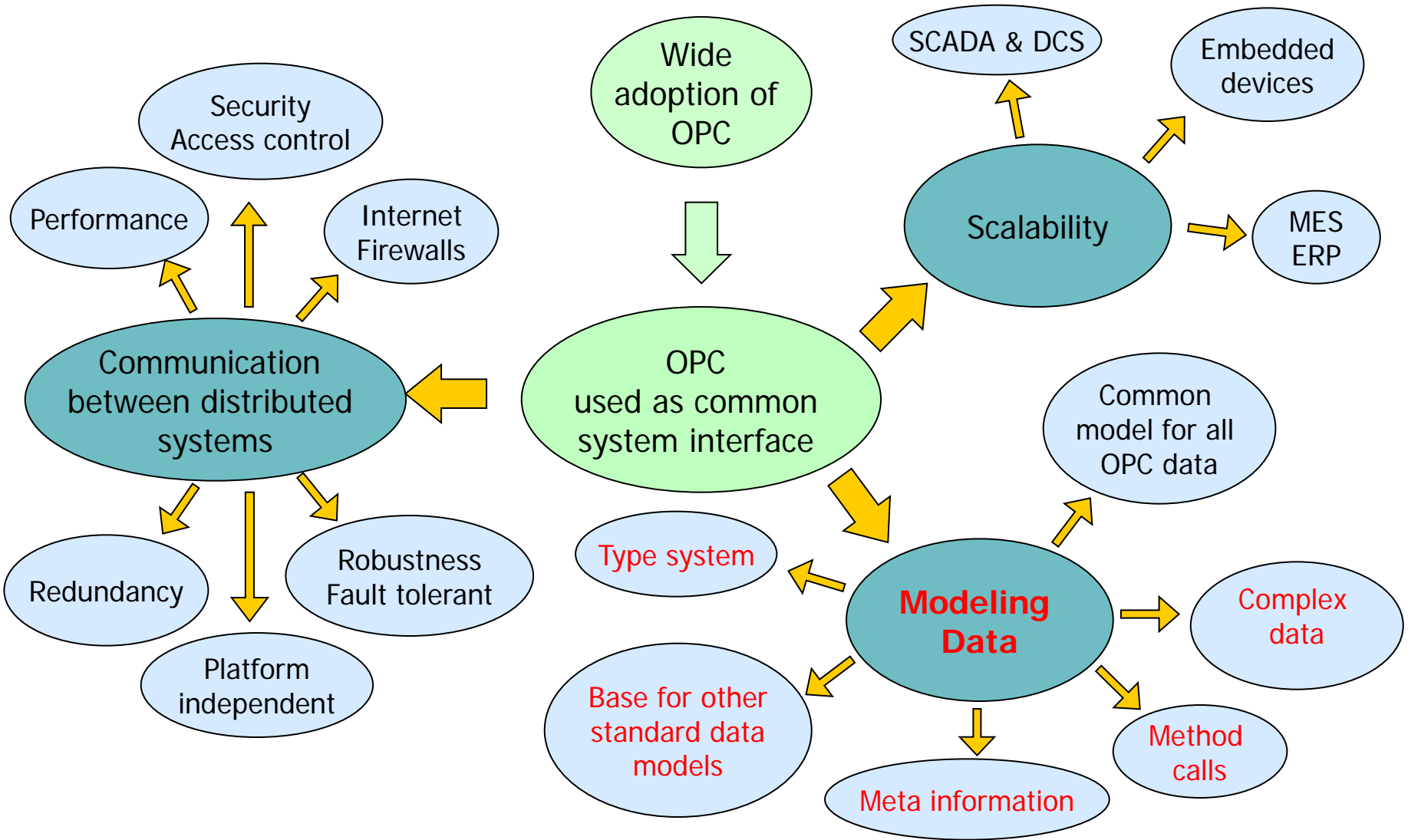# Information vs Data

OPC UA – Information Model

Security Access control

Performance

Internet Firewalls

Communication between distributed systems

Redundancy

Platform independent

Robustness Fault tolerant

Wide adoption of OPC

OPC used as common system interface

SCADA & DCS

Embedded devices

Scalability

MES ERP

Common model for all OPC data

Type system

Modeling Data

Complex data

Base for other standard data models

Meta information

Method calls

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UA Information Modeling

Vendor Specific Models	← **Controls company, Oil Company...**
Information Models / Companion Specification	← **ISA-95, IEC 61859, MTConnect**
DA **HA** **A&C** **Prog**	← **OPC Information Models**
OPC UA Base Services	← **Base Services**
Transport **OPC UA Data Model**	← **OPC UA Base**

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UA Information Modeling

Vendor Specific Models	Controls company, Oil Company...
Information Models / Companion Specification	ISA-95, IEC 61859, MTConnect
DA / HA / A&C / Prog	OPC Information Models
OPC UA Base Services	Base Services
Transport / OPC UA Data Model	OPC UA Base

Modeling in Specifications

Base Concepts For Modeling

Entry Points Address Space

OPC defined Types

Information Models

OPC Unified Architecture Specifications

Core Specification Parts

- Part 1 - Concepts
- Part 2 - Security Model
- Part 3 - Address Space Model
- Part 4 - Services
- Part 5 - Information Model
- Part 6 - Service Mappings
- Part 7 - Profiles

Access Type Specification Parts

- Part 8 - Data Access
- Part 9 - Alarms and Conditions
- Part 10 - Programs
- Part 11 - Historical Access

Part 12 - Discovery

Part 13 - Aggregates

Nodes and References

- Everything in the UA Address Space is a Node
- UA defines a none extensible list of 8 Node Classes

- Each Node Class has a defined set of Attributes
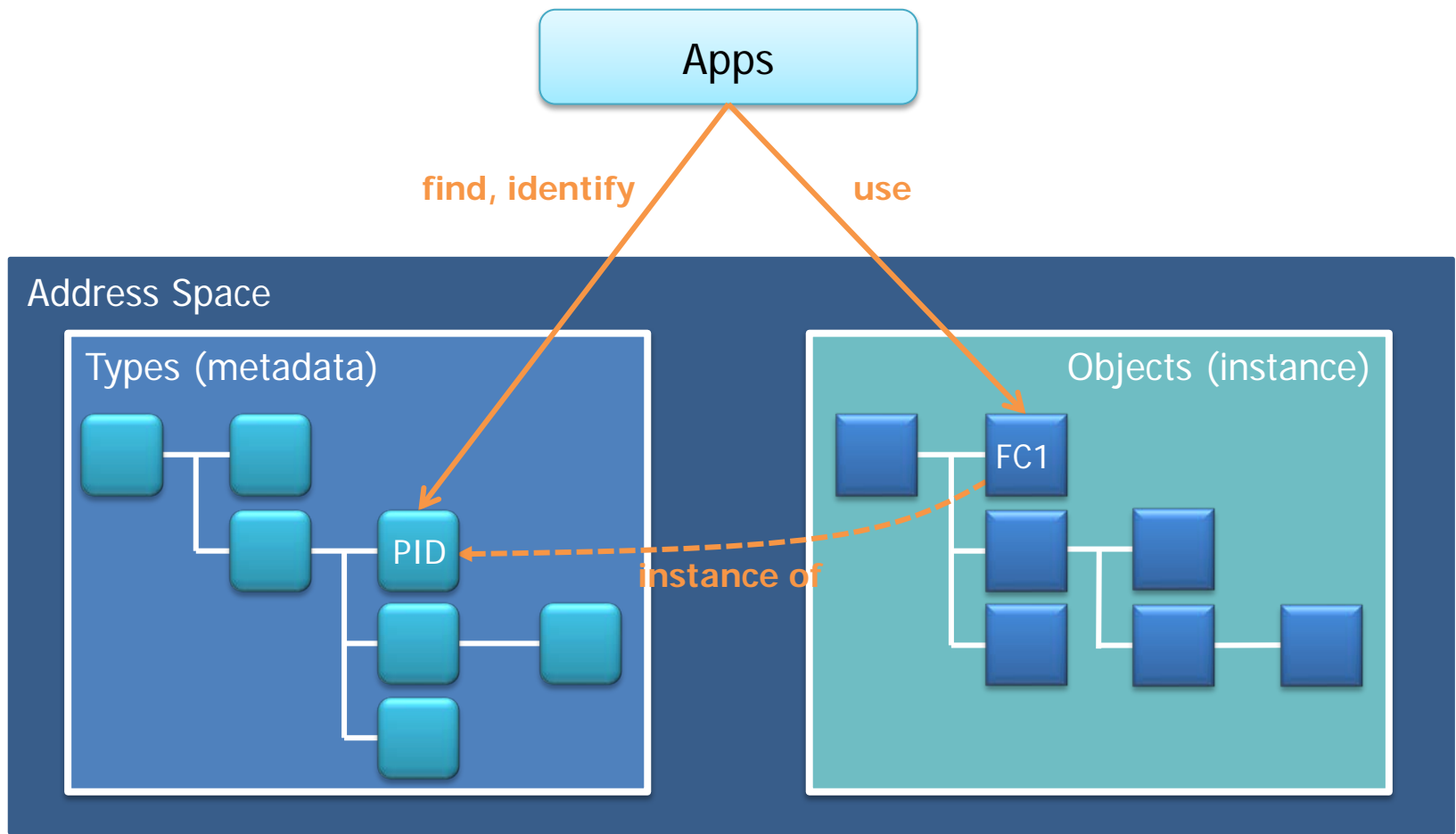- Nodes are connected by References

BaseNode

+NodeId : NodeId
+NodeClass : NodeClass
+BrowseName : QualifiedName
+DisplayName : LocalizedText
+Description : LocalizedText

Object

+EventNotifier : Byte

Variable

+Value
+DataType : NodeId
+ValueRank : Int32
+ArrayDimensions : Int32
+AccessLevel : Byte
+UserAccessLevel : Byte
+MinimumSampleInterval : Int32
+Historizing : Boolean

Method

+Executable : Boolean
+UserExecutable : Boolean

View

+ContainsNoLoops : Boolean
+EventNotifier : Byte

ObjectType

+IsAbstract : Boolean

ReferenceType

+IsAbstract : Boolean
+Symmetric : Boolean
+InverseName : LocalizedText

VariableType

+Value
+DataType : NodeId
+ArraySize : Int32
+IsAbstract : Boolean

DataType

+IsAbstract : Boolean

Unified Object Model

- Allows to combine all known OPC information types in one object
- Address space contains instances and <u>types</u>
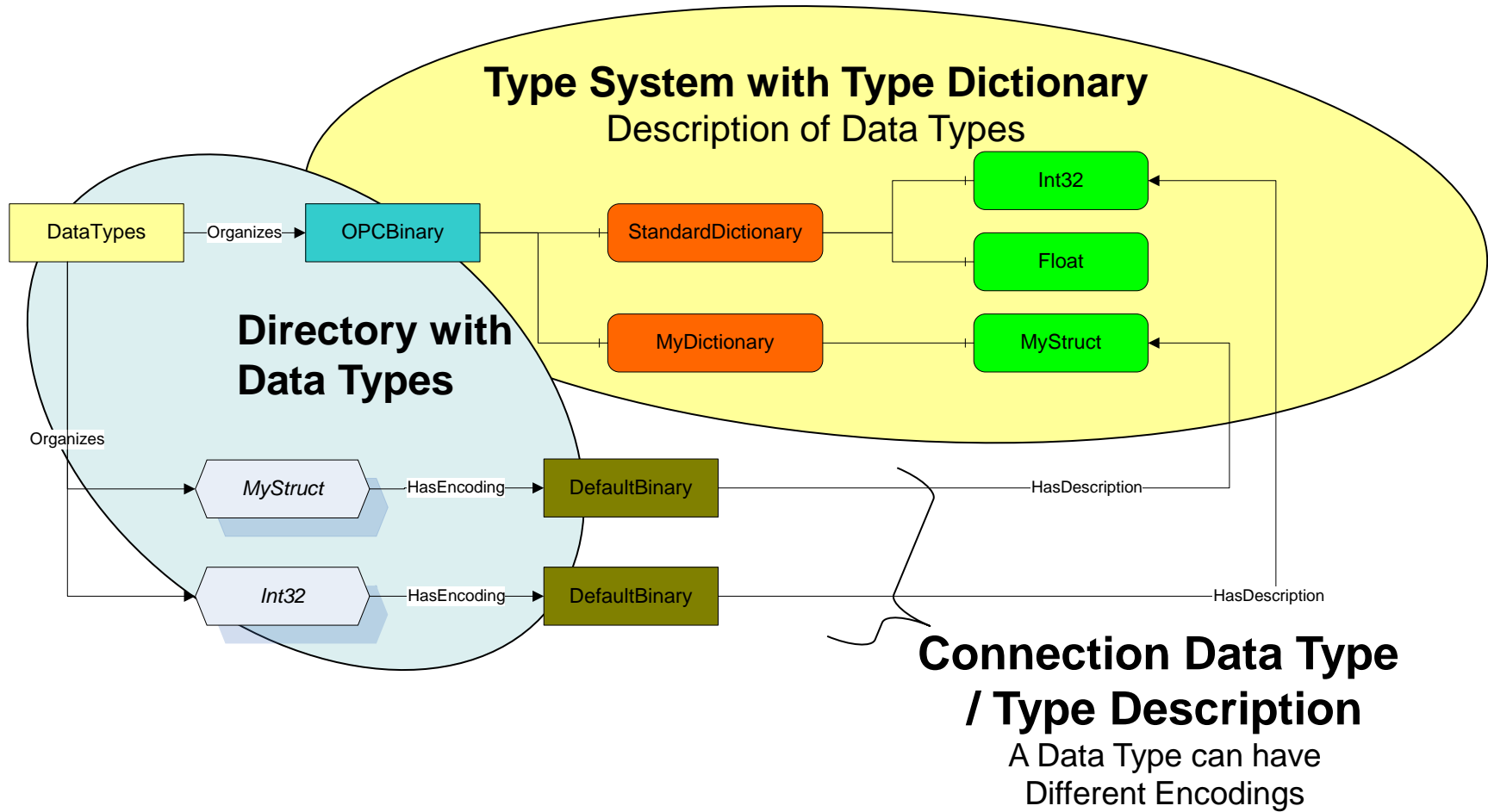- Allows to expose a whole data model in one address space

OPC DA and HDA

OPC UA Object

OPC Commands

Variables

Methods
___()
___()
___()

Events

OPC A&E

YOKOGAWA
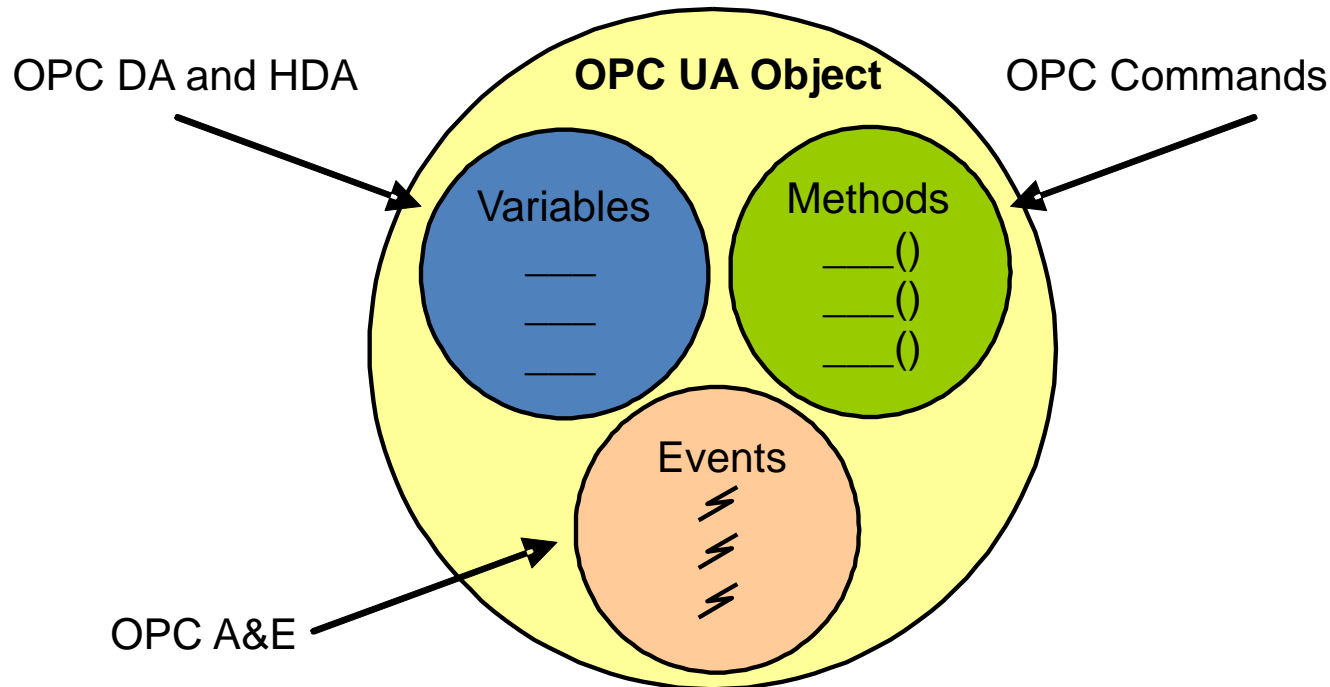
Address Space Representation

⋯ Disclose both metadata and instances

Apps

find, identify   **use**

Address Space

Types (metadata)

PID

Objects (instance)

FC1

instance of

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DataType NodeClass and Complex Data

Type System with Type Dictionary
Description of Data Types

Int32

Float

StandardDictionary

DataTypes —Organizes→ OPCBinary

Directory with Data Types

MyDictionary

MyStruct

Organizes

MyStruct —HasEncoding→ DefaultBinary —————— HasDescription

Int32 —HasEncoding→ DefaultBinary —————— HasDescription

Connection Data Type / Type Description
A Data Type can have Different Encodings

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Subtyping

Standard Faceplate
is working with components
of base type
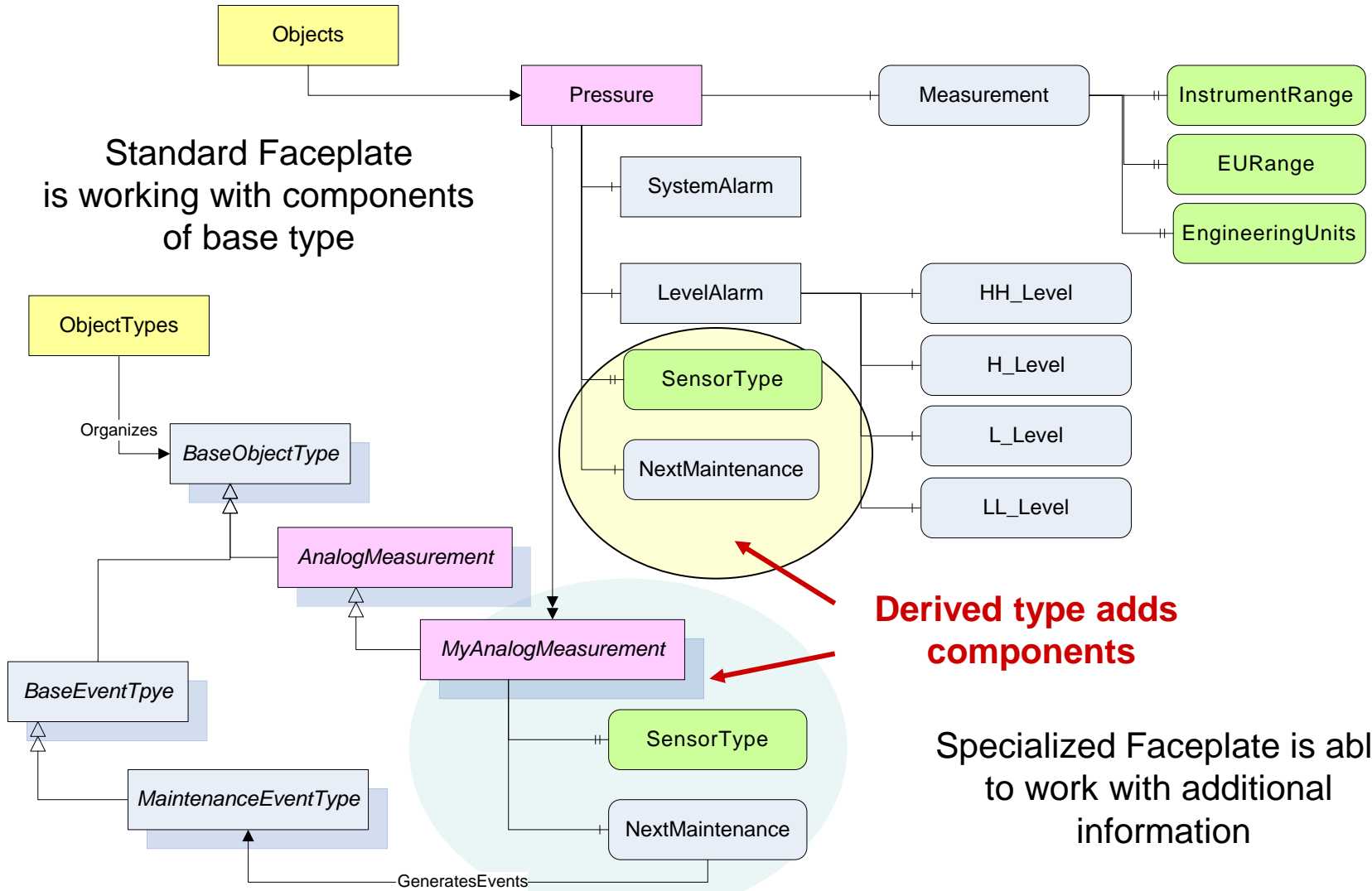
**Derived type adds
components**

Specialized Faceplate is able
to work with additional
information

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Views

- Allow the address space to be subset
- Typically Server Provided
- Common views
  - Engineers
  - Operator
  - Management
  - Maintenance

OPC Provided Models

❖Data Access
❖Programs
❖Historical Data
❖Alarms & Conditions

➢ Alarm conditions are available as Condition State Machines at the Objects

➢ States can be read or

➢ State change of the Alarm can be received using Events

➢ Alarm conditions can be acknowledged at the condition

➢ Event hierarchies can be made visible using References HasEventSource and HasNotifier

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UA Information Modeling

Companion specification
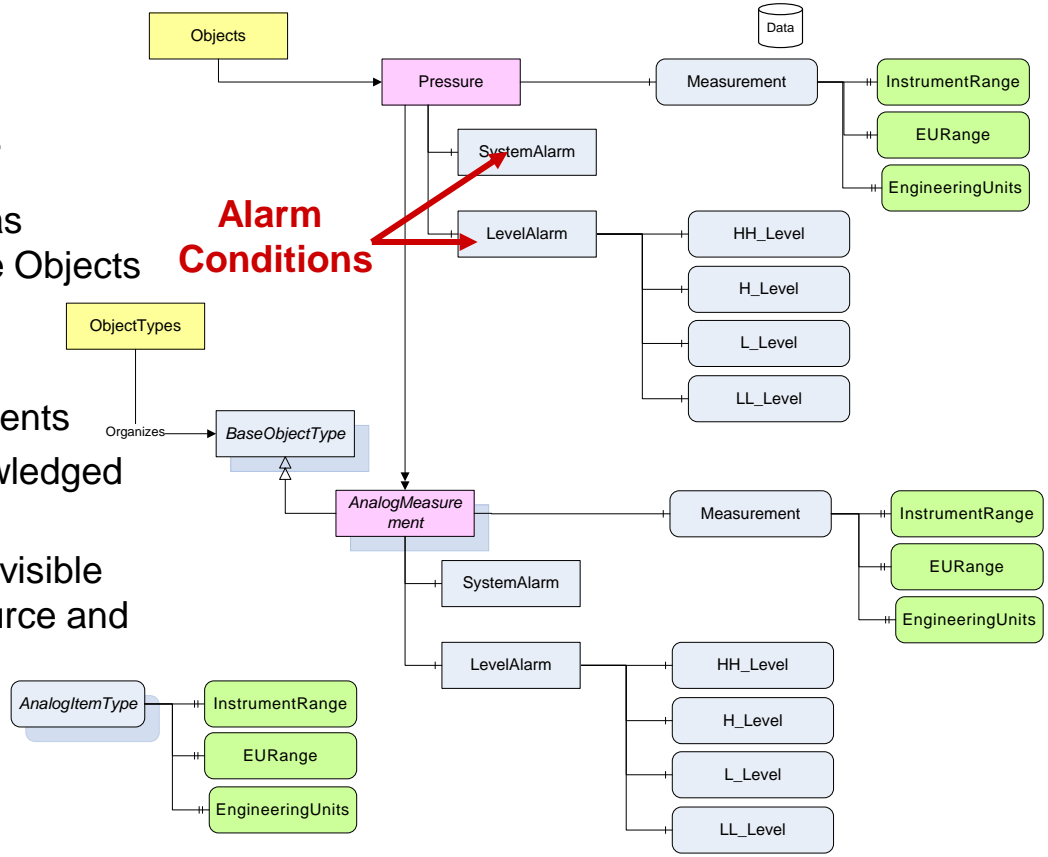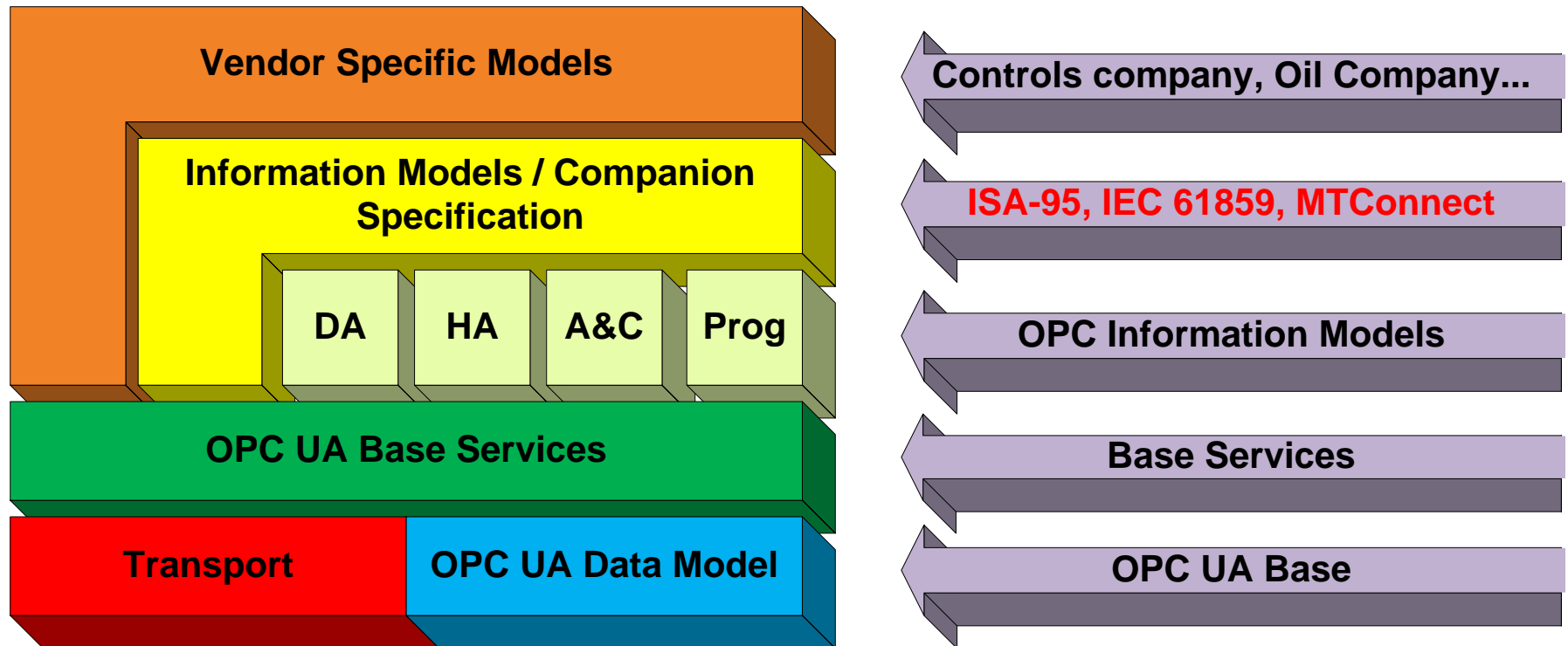
- Own group does all – maybe with help of consultant. Published by group

- Joint group – runs organization, publish by all members?

- OPC Foundation working group

- What do they provide:
  - Introduction
  - Overview of model
  - Object Types
  - Variable Types
  - References
  - Methods
  - Data Types
  - Any defined instances
  - Profiles / conformance units

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Industrial Automation Collaboration

OPC Unified Architecture Specifications

Part 5 – Information Model

Part 8 – Data Access

Part 9 – Alarms and Conditions

OPC UA for Devices (DI)

ISA 95

FDT

MTConnect

MDIS

Analyzer Devices (ADI)

61850 / 61970

DSA-TS

Field Device Integration (FDI)

PRODML/WITSML

TIA

OPC UA for IEC 61131-3 (PLCopen)

ODVA / Sercos / OPC

BACNet

V2 Features

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MDIS

OIL & Gas Platforms

- Topside controls
- Subsea controls
- Multiple vendors
- Integration is key challenge

Operating Companies - Want standard communication interface between:

- Subsea gateway,
- MCS (Master Control Station)
- DCS (Distributed Control System)

MDIS - **M**CS-**D**CS **I**nterface **S**tandardization

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- **Information Model**
  - Valve
  - Choke
  - Instrument
  - Discrete
  - CIMV
  - DHPT
  - MPFM
  - EPU
  - SEM
  - Motor
  - Manifold

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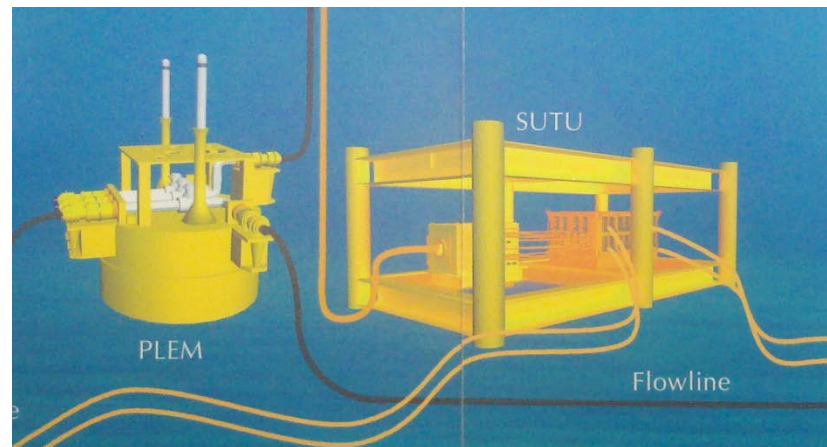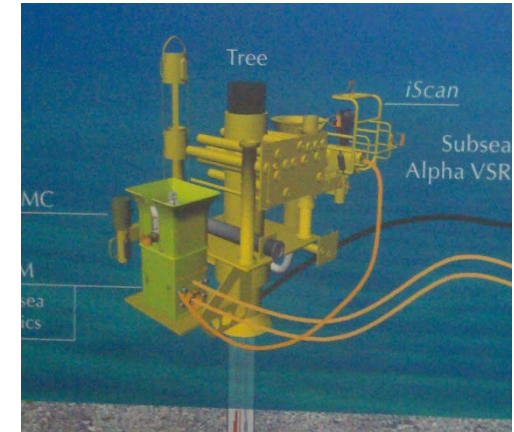
MTConnect

- Universal factory floor communications protocol
- Intended for the shop floor environment
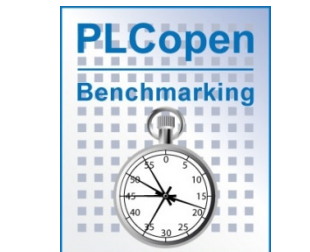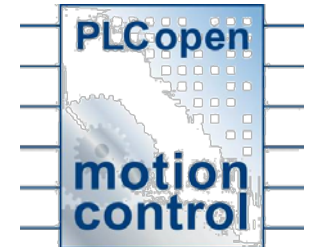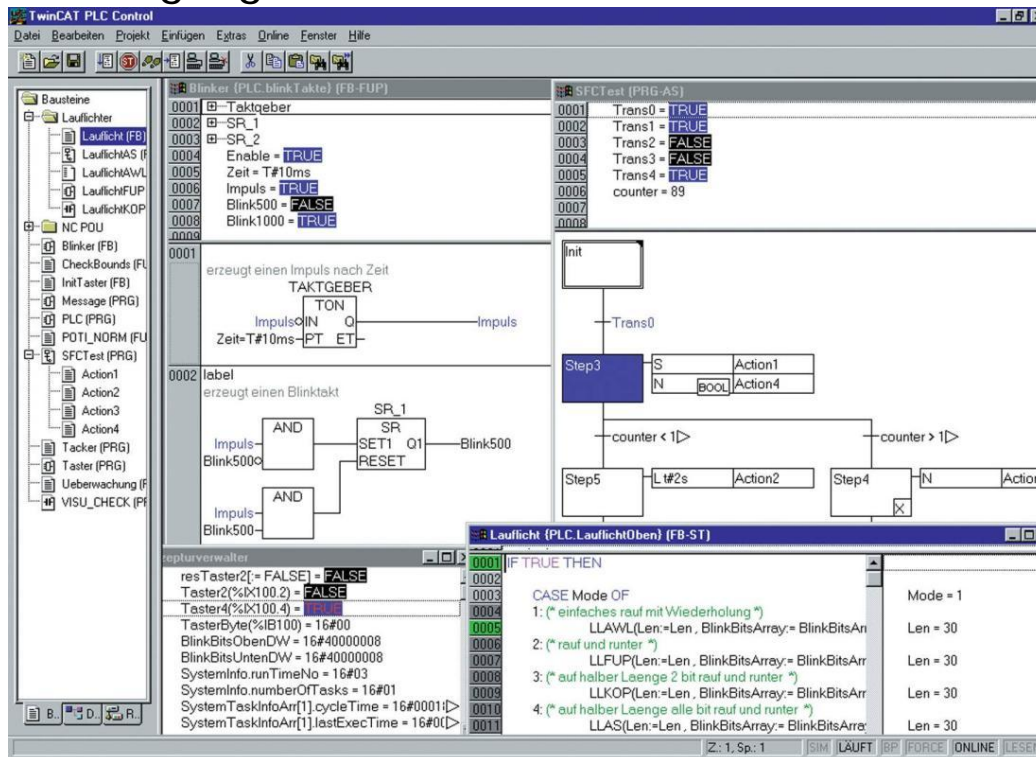- Defines a "dictionary" for manufacturing data

Cutting Tool

| Cutting Item | Tool Item | Adaptive Item | Assembly Item |

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MTConnect - Summary of Model
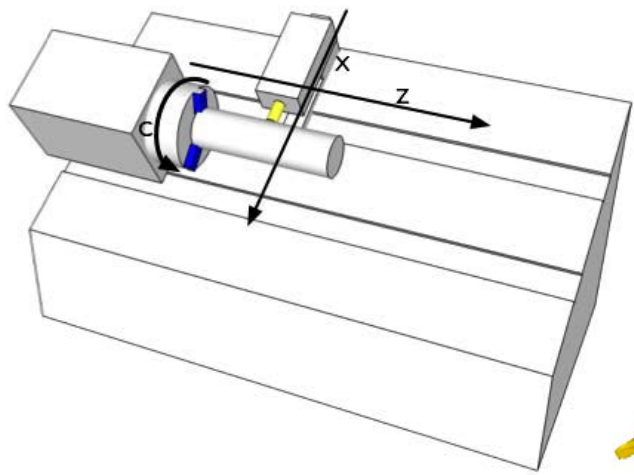
- • Includes the following MTConnect items:
  - – Device
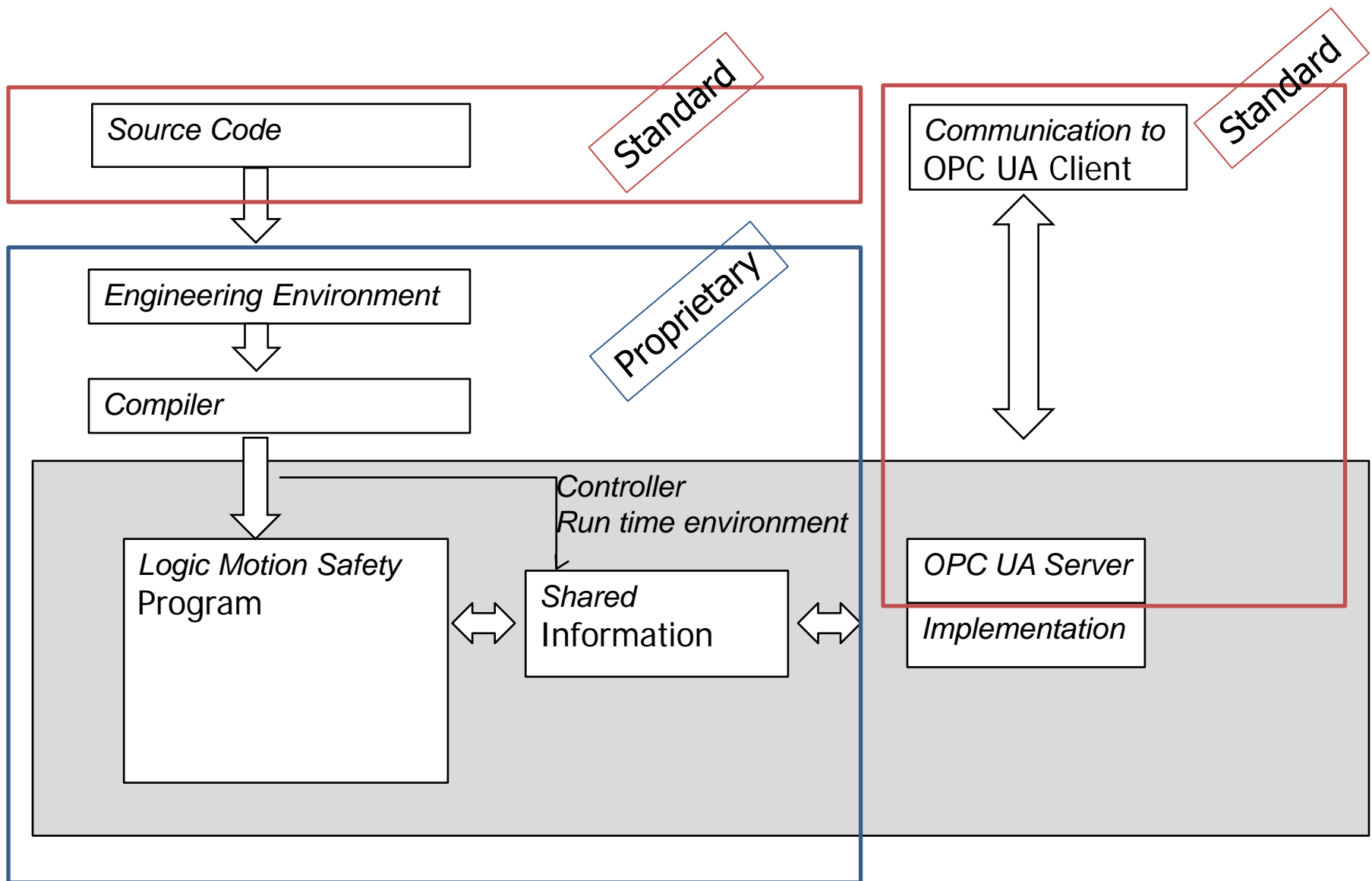 - – Component
  - – Sensors
  - – Conditions
  - – Events
  - – Assets
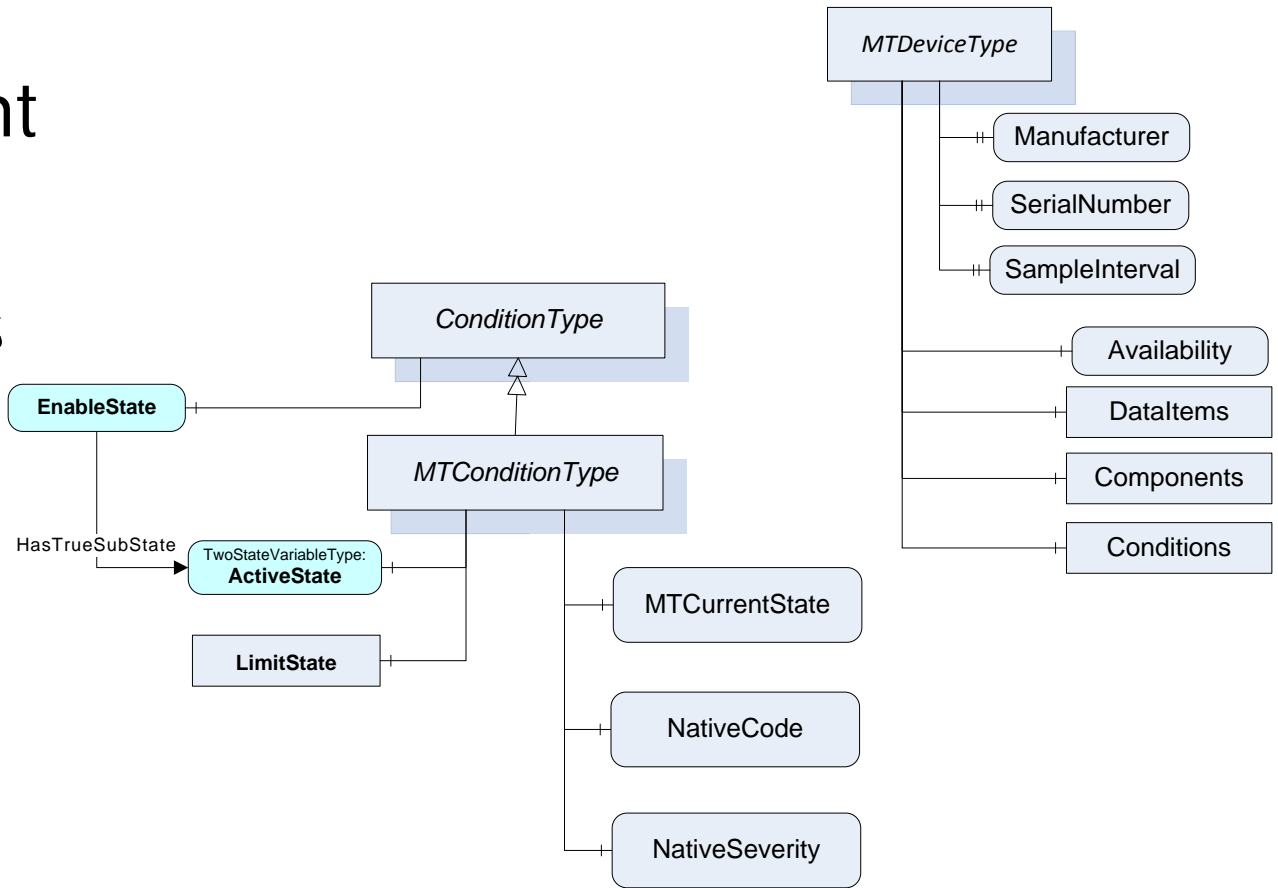
PLCopen Overview

- ## PLCopen : www.plcopen.org
  - IEC6-1131-3
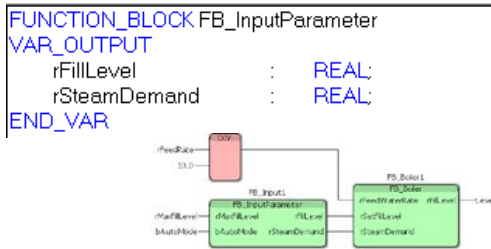 - Global standard for Industrial Control Programming
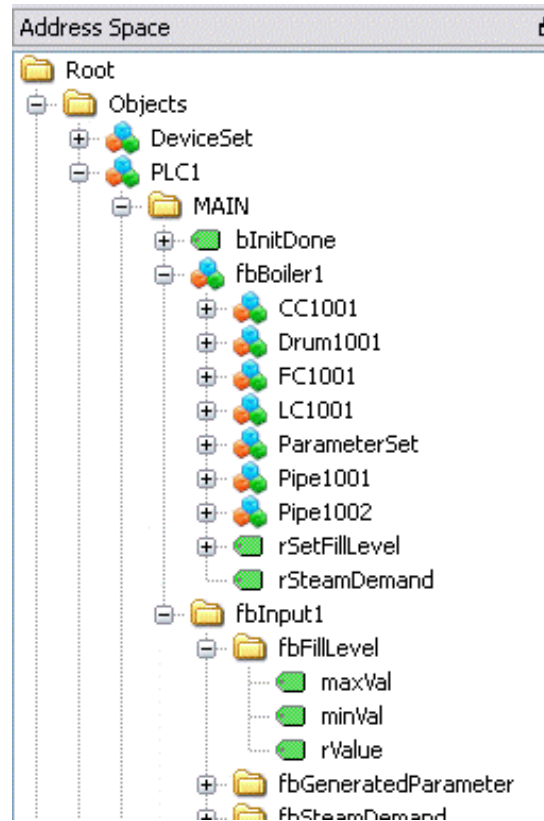 - Languages: ST, IL, LD, FBD

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PLCopen & OPC Group:

Source Code

Standard

Communication to
OPC UA Client

Standard

Engineering Environment

Proprietary

Compiler

Controller
Run time environment

Logic Motion Safety
Program

Shared
Information

OPC UA Server

Implementation

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PLCopen & OPC

PLCopen:

Content „WHAT"

All information about

IEC61131-3 project:

- FB's
- POU's
- Structures
- Tasks / Resources..

OPC-UA-Server:

Communication „HOW"

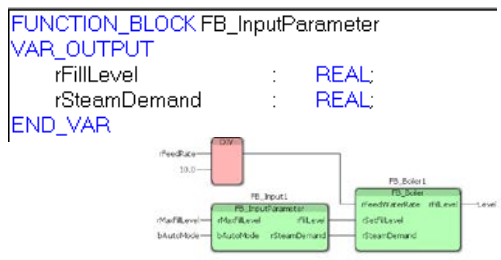**UA-Clients:** SCADA/MES/ERP

Presentation
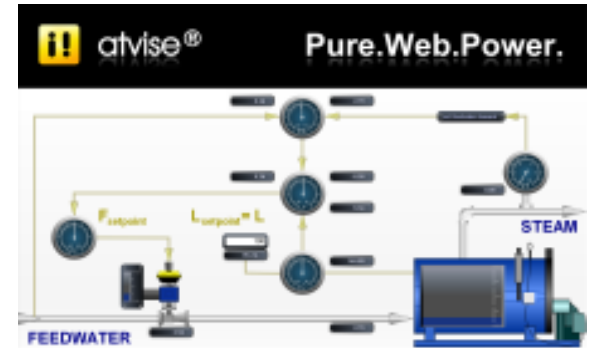
- Standardized UA access
- Identical namespace
- Complete information model

Advantages:
- Re-useable HMI Faceplates"
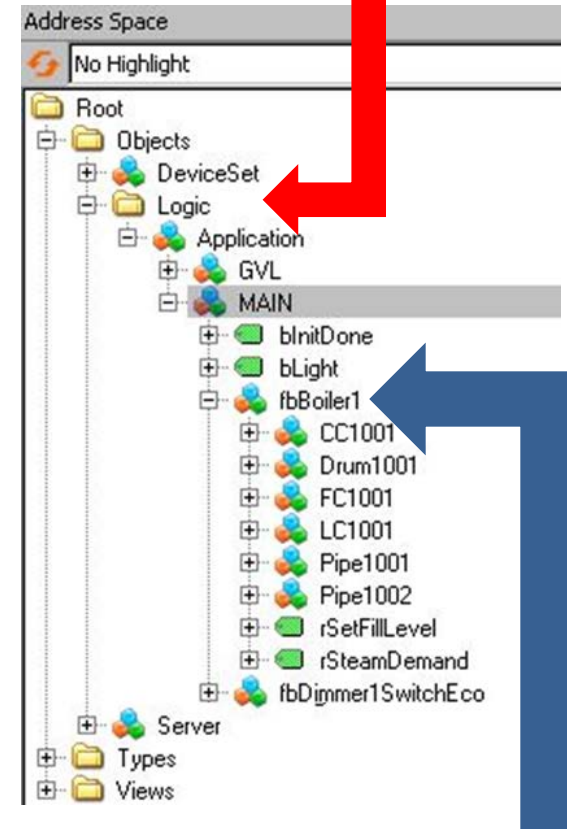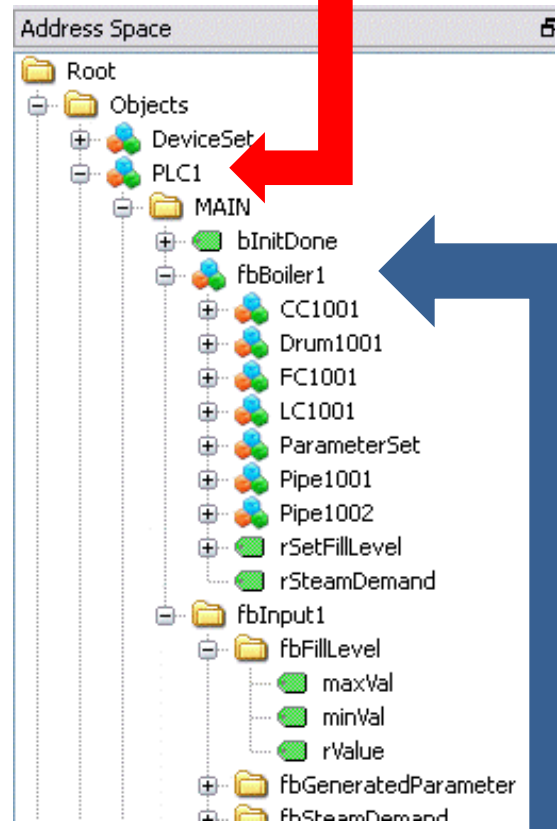- Rapidly engineering
- Transparent PLC controller

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PLCopen & OPC Group: Results

Beckhoff

Bosch-Rexroth

PLCopen:

Content „WHAT"

„PLC1"

„Logic"

Different entry point

```
FUNCTION_BLOCK FB_InputParameter
VAR_OUTPUT
    rFillLevel        :    REAL;
    rSteamDemand      :    REAL;
END_VAR
```
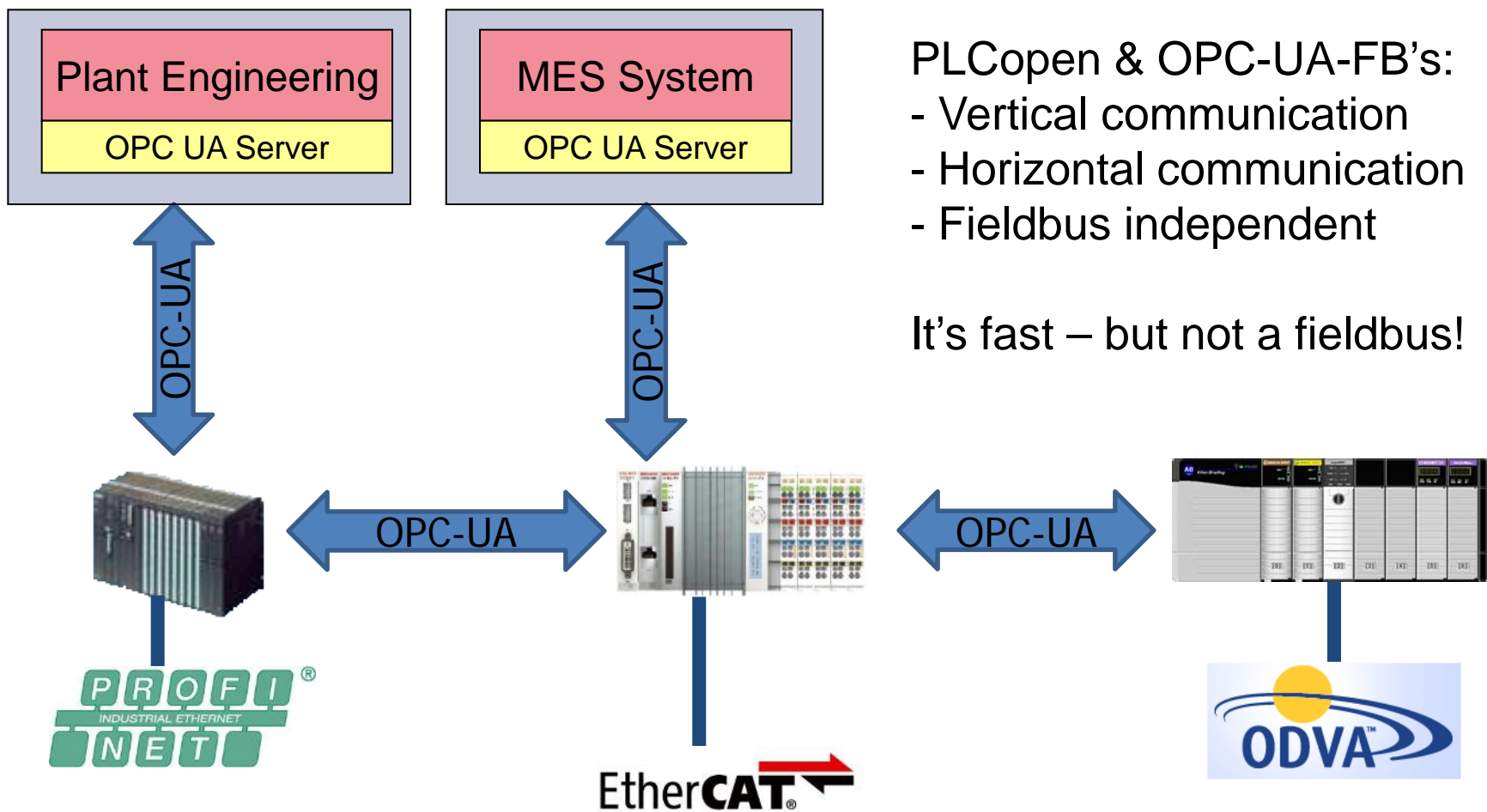
All information about

IEC61131-3 project:

- FB's
- POU's
- Structures
- Tasks / Resources..

… but semantic identical objects!

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PLCopen & OPC: Goals v2

Scenarios for data communication:

Plant Engineering
OPC UA Server

MES System
OPC UA Server

OPC-UA

OPC-UA

OPC-UA

OPC-UA

PLCopen & OPC-UA-FB's:
- Vertical communication
- Horizontal communication
- Fieldbus independent

It's fast – but not a fieldbus!

PLCopen & OPC
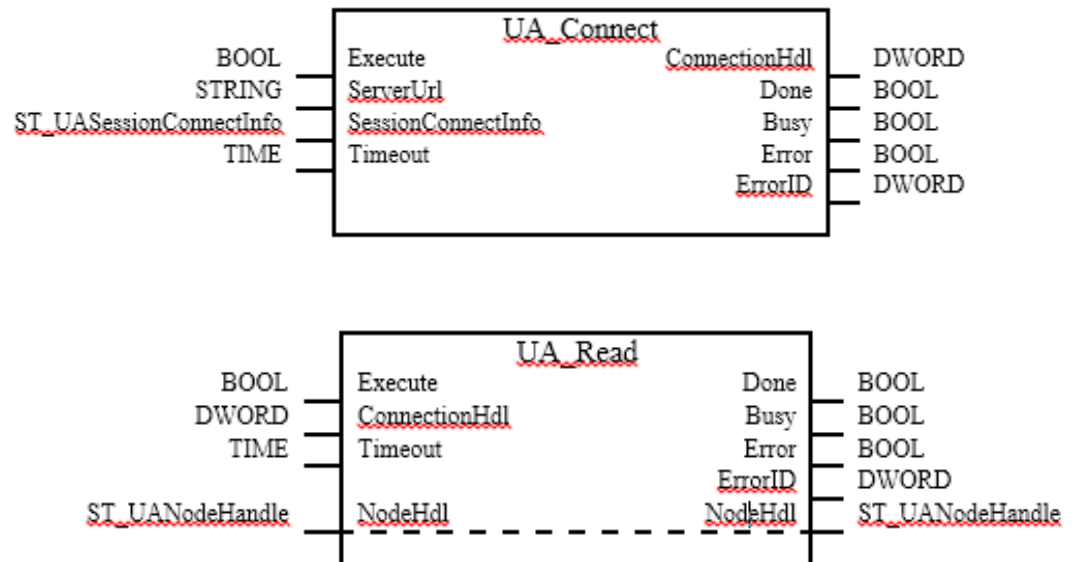
FB's for Data Communication

Prototype implementation of all FB's done !

UaConnect
UaNodeGetHandle
UaNodeReleaseHandle
UaNodeGetInfo
UaMonitoredItemCreate
UaMonitoredItemDelete
UaRead / UaReadList
UaWrite / UaWriteList
UaMethodGetHandle
UaMethodReleaseHandle
UaMethodGetInfo
UaMethodCall

Diagnosis
UaConnectionGetStatus

UA_Connect

BOOL	Execute	ConnectionHdl	DWORD
STRING	ServerUrl	Done	BOOL
ST_UASessionConnectInfo	SessionConnectInfo	Busy	BOOL
TIME	Timeout	Error	BOOL
		ErrorID	DWORD

UA_Read

BOOL	Execute	Done	BOOL
DWORD	ConnectionHdl	Busy	BOOL
TIME	Timeout	Error	BOOL
		ErrorID	DWORD
ST_UANodeHandle	NodeHdl	NodeHdl	ST_UANodeHandle

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Horizontal: From controller to contoller

Device to device communication based on PLCopen OPC-UA-FB's

Beckhoff, Bosch-Rexroth, B&R, Rockwell, Siemens, ….

Vertical: From controller to MES

„From shop floor controller to top floor"
Vertical connection from controller into MES iTAC

- MES as UA server providing a method
- Controller as UA client calling PLCopen method in MES
- Benefit: Performance & Data consistance

MES/ERP level

UA_MethodCall		
BOOL	Execute	Done	BOOL
DWORD	MethodHdl	Busy	BOOL
TIME	Timeout	Error	BOOL
		ErrorID	DWORD
ANY	InputArguments	InputArguments	ANY
ANY	OutputArguments	OutputArguments	ANY

Machine level
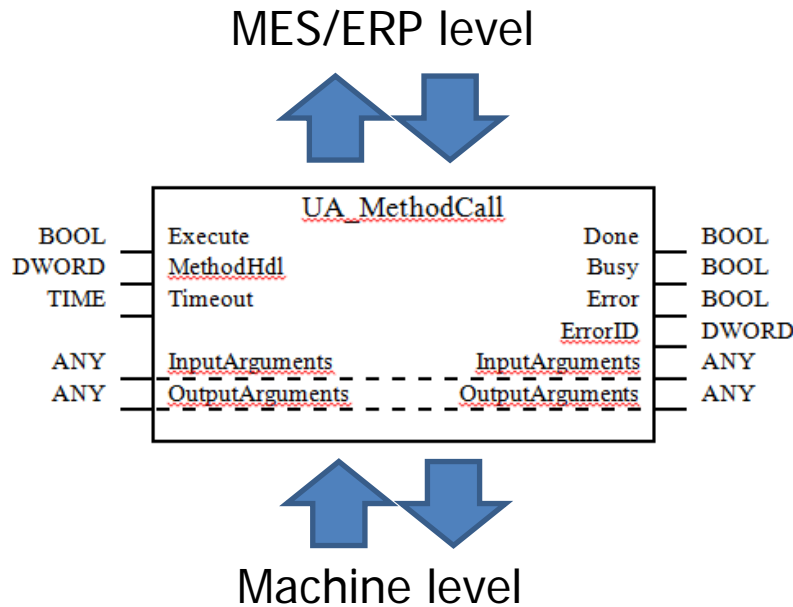
From shop floor controller to MES & cloud
Vertical communication based on standards

OPC UA MethodCall: From PLC to MES

- PLCopen Functionblock invokes UA-method
  PLC as UA client integrated in controller

- MES as UA server provides UA method

- Consistent data exchange
  Secured, fast communication
  Easy engineering

Runtime: PLCopen Function Blocks for OPC-UA method call

```
fb_OpcUaOpen(
              bExecute := TRUE,
              sUrl := 'opc.tcp://ew2013.cloudapp.net:4840',
              tTimeout := T#15s,
              hSession => hSessionHandle);
...
fb_OpcUaMethodCall(
              bExecute := TRUE,
              sParam := 'INSERT INTO table VALUES(ID, Time, Val)',
              tTimeout := T#15s,
              hSession := hSessionHandle,
              hMethod := hMethodHandle);
```

Database

Virtual machine

Database Server

OPC-UA Server

OPC-UA

Windows Azure

amazon web services

ISA-95 Industry Model

Level 4

Business Planning & Logistics
Plant Production Scheduling, Operational Management, etc

4 - Establishing the basic plant schedule - production, material use, delivery, and shipping. Determining inventory levels.

Time Frame
Months, weeks, days, shifts

Level 3

Manufacturing Operations Management
Dispatching Production, Detailed Production Scheduling, Reliability Assurance, ...

3 - Work flow / recipe control to produce the desired end products. Maintaining records and optimizing the production process.

Time Frame
Shifts, hours, minutes, seconds

Level 2

Manufacturing Control
Basic Control, Supervisory Control, Process Sensing, Process Manipulation,...

2 - Monitoring, supervisory control and automated control of the production process

Level 1

1 - Sensing the production process, manipulating the production process

Level 0 Production Process

0 - The physical production process

Five Resource Object Models

People → Personnel resources managed for operations

Equipment → Role of equipment managed for operations

Physical Asset → Physical equipment managed for operations

Materials → Material resources managed for operations

Process Segments → Business view of operations processes
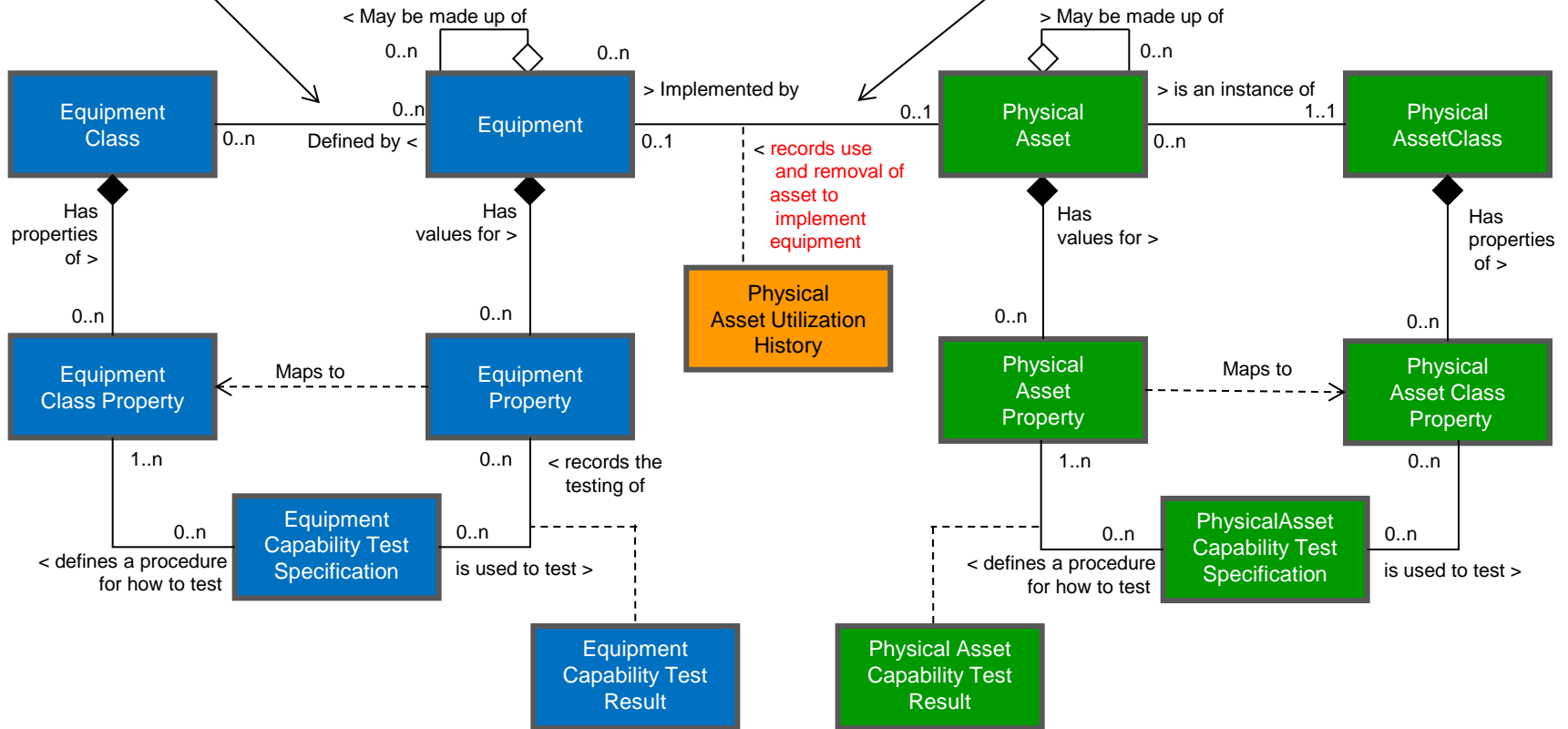
YOKOGAWA
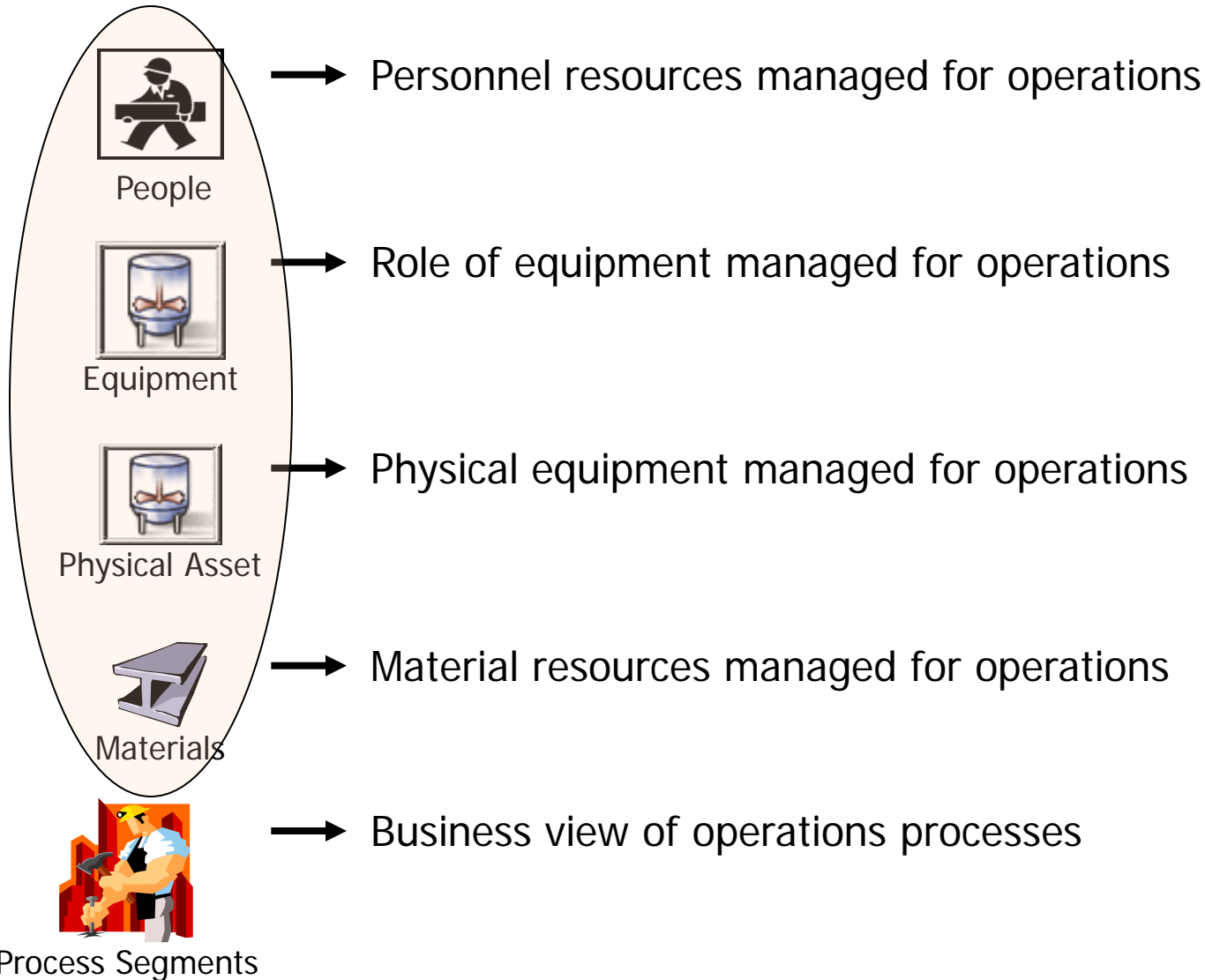
Full Equipment/Physical Asset Model

User can create instance of Equipment that consists of functionalities defined by multiple Equipment Class.
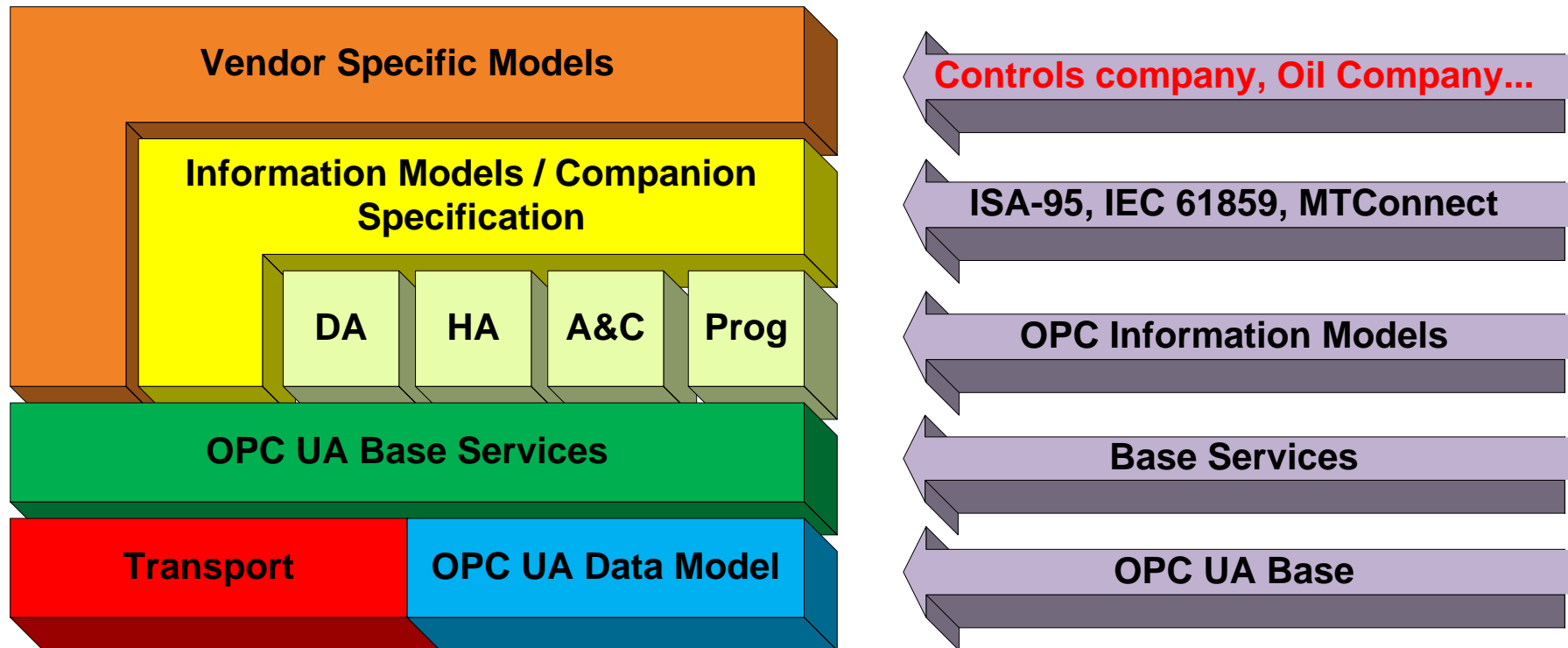(It is not multiple inheritance as OOD.)

The Equipment Object is used to build the Equipment Hierarchy Model

Relationship between Equipment and Physical Asset is described

< May be made up of
0..n   0..n

> May be made up of
0..n

Equipment Class

Equipment

> Implemented by

Physical Asset

> is an instance of
1..1

Physical AssetClass

0..n   0..n
Defined by <

0..1

< records use and removal of asset to implement equipment

0..1   0..n

Has properties of >

Has values for >

Has values for >

Has properties of >

0..n

0..n

Physical Asset Utilization History

0..n

0..n

Equipment Class Property

Maps to

Equipment Property

Physical Asset Property

Maps to

Physical Asset Class Property

1..n

0..n
< records the testing of

1..n

0..n

0..n

0..n

Equipment Capability Test Specification

0..n
is used to test >

< defines a procedure for how to test

< defines a procedure for how to test

0..n

PhysicalAsset Capability Test Specification

0..n
is used to test >

Equipment Capability Test Result

Physical Asset Capability Test Result

B2MML

OSA-EAI CCOM

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UA Information Modeling
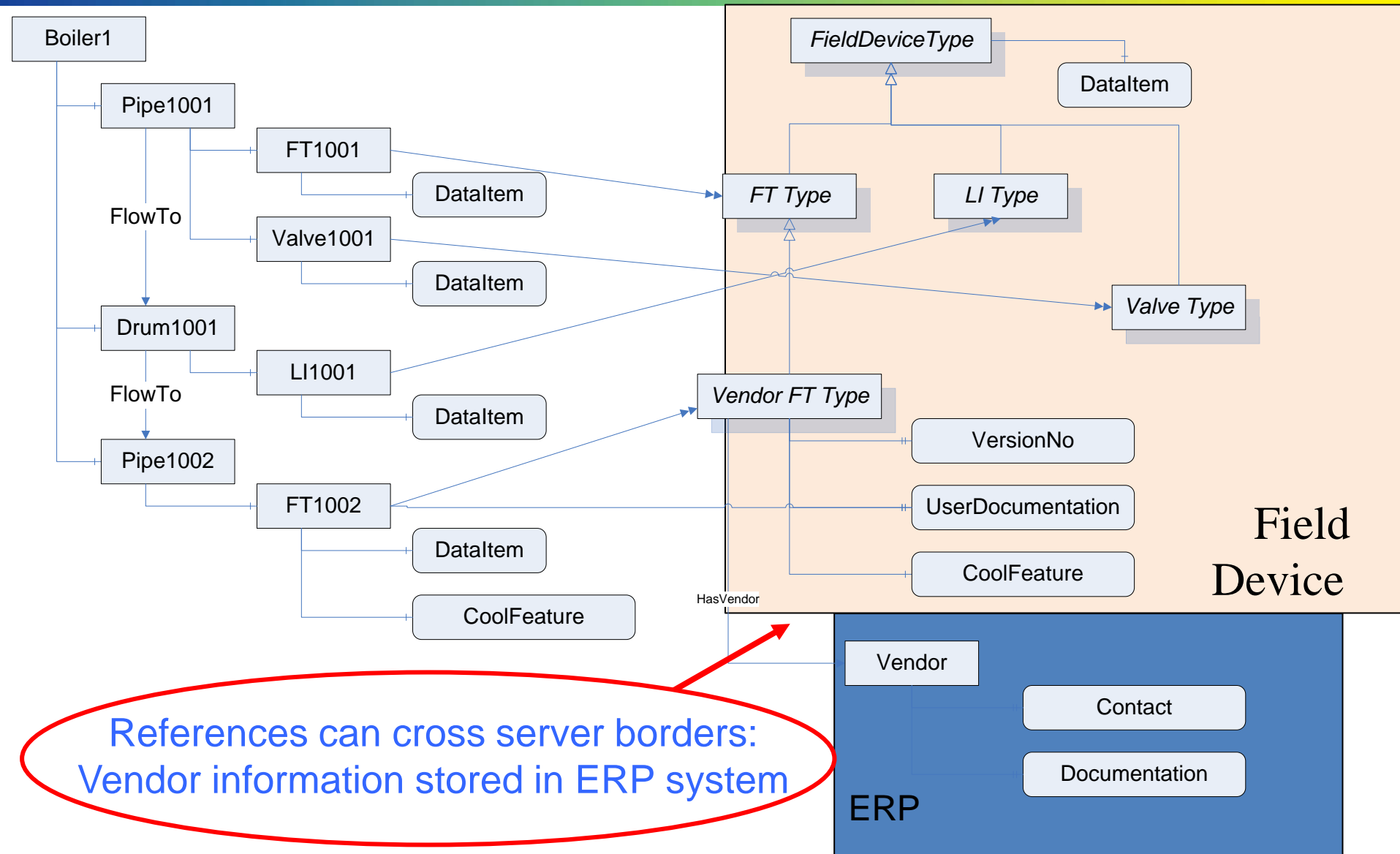
Yokogawa – Proof of concept

- Calculation engine
  - Java Script based
  - Runtime User define able Calculation
  - Includes native UA aggregates
 - Include Condition/Alarm triggers
  - Includes value change triggers

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Yokogawa – Proof of concept

- • Centum System Status Summary
   - – Used for Mobil Application demonstration
    - – Collects System Status data and summarizes it
    - – Could base server securely can collect it.
    - – Distributes it to mobile client applications

Relate metadata of different systems.

References can cross server borders:
Vendor information stored in ERP system

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Manufacturing Intelligence
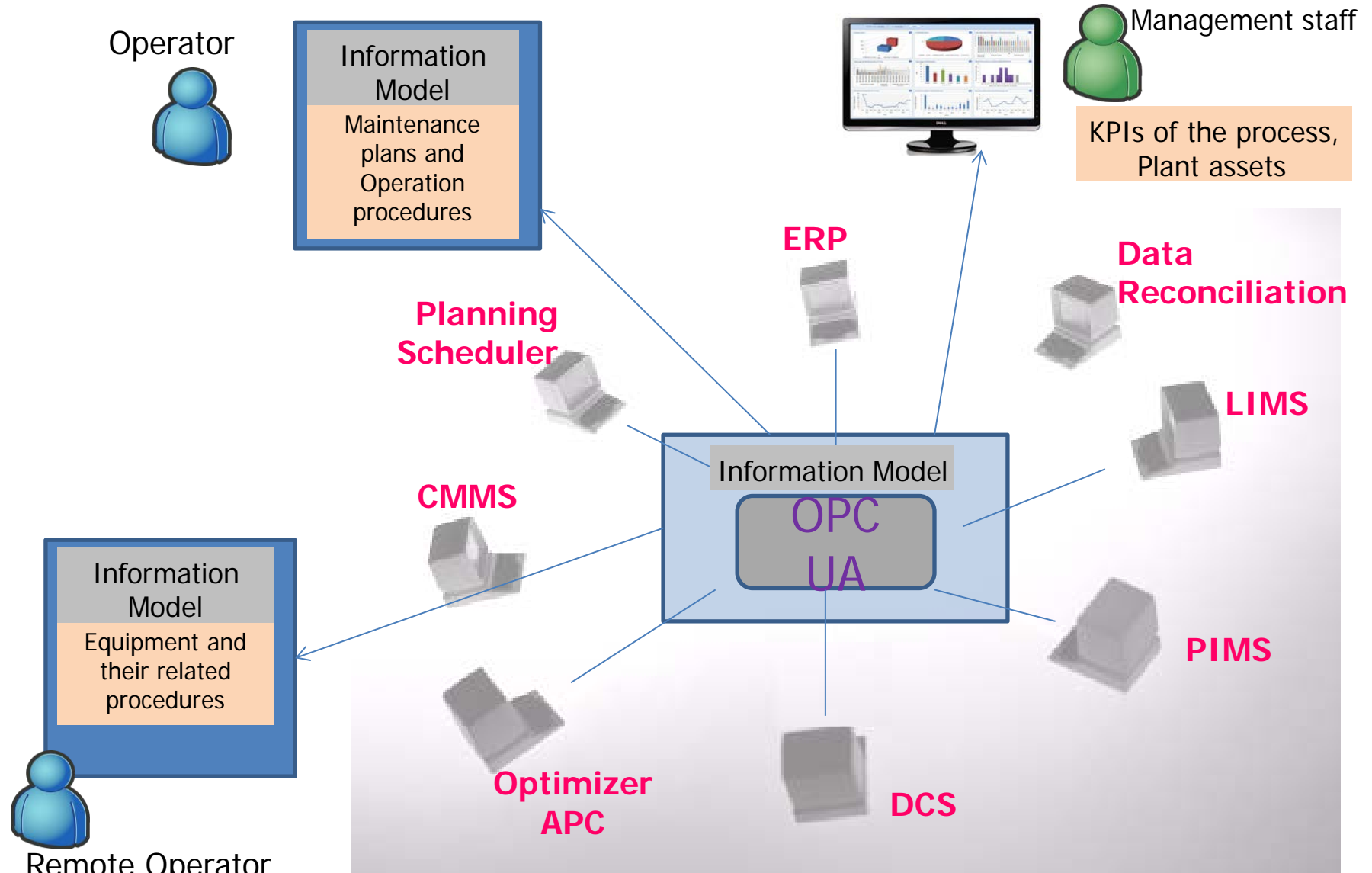
- **Manufacturing intelligence**
  - enables productivity and profit.
  - enables organizations take consistent decisions at right time.
  - tracks the real-time overall production status
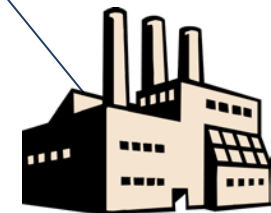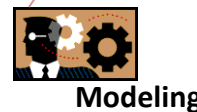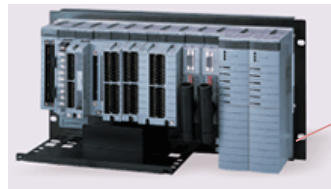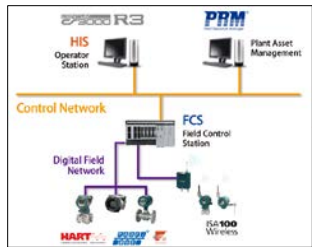
- **Manufacturing intelligence is**
  - Transforming data into information
  - Introducing a relevant context.
  - Enabling users to have the right information irrespective of data source

Modeling

Multiple Players

Operator

Management staff

Information Model
Maintenance plans and Operation procedures

KPIs of the process, Plant assets

ERP

Data Reconciliation

Planning Scheduler

Information Model

OPC UA

LIMS

CMMS

Information Model
Equipment and their related procedures

PIMS

Optimizer APC

DCS

Remote Operator

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Unified System

with Performance Indicators, Alerts....

Production Supervisor

Plant Manager

Manual Data Entry

KPI Display on Role-based Portal Window and Drill Down Analysis

KPI Alert/Alarm

KPI Calculation Function Block Template

KPI DB with Historian

KPI Monitoring

KPI Calculation

Periodical Data Acquisition

Key Performance Index

KPI Alert/Alarm Setting

OPC UA

OPC I/F

RDB I/F

DCS or other systems

PIMS

LIMS

Production Management

ERP

Conclusion

- OPC UA Supports Information Models
  - Easy to build
  - Any model can be represented
  - Challenge is to define what the model target is.

- Collaborations
  - Many organization are creating companion specifications
  - Use OPC UA to transmit their information using secure reliable communication

- Vendor Specific Information models
  - Allow unique applications
  - Allow aggregating data from multiple sources

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- Calculation engine
- MDIS
- ISA-95

Questions

- **Paul Hunkar**
- Technical Director
- Paul.Hunkar@DSInteroperability.com

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Extra