Service-oriented architecture (SOA)

Information systems in industry ELEC-E8113

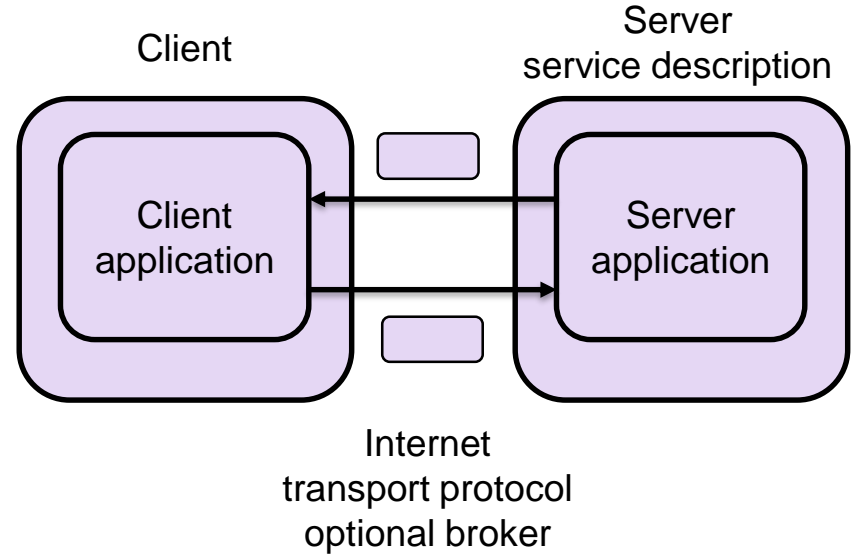*Start at 12.15!*

Contents

- **Service-oriented architecture (SOA)**

- **SOAP services**

- **REST services**

- **SOA in manufacturing, OPC UA**

Rationale of the lecture: SOA is the software architecture of many new information systems in industry and SOAP and REST its basic technologies. It is a good idea to know basic facts about them. OPC UA follows SOA but does not require SOAP or REST.

Situation

- **Client and server applications, the Internet in between**
- **Server has service descriptions with names and arguments**
- **Service request and response are communicated as messages**
- **Transport protocol takes care of message transportation**
- **Message exchange forms a conversation**
- **Optional broker may facilitate message exchange**

Client

Server
service description

Client
application

Server
application

Internet
transport protocol
optional broker

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Basic concepts

- **Service-oriented architecture (SOA) is a software architecture that has been adopted in new information systems in industry.**

- **SOAP was the first common technology used for implementing information systems according to SOA.**

- **REST is later but currently popular technology for implementing information systems according to SOA.**

- **OPC UA is a communication technology particularly designed for data transfer between automation systems and information systems. OPC UA conforms to SOA but does not need SOAP or REST.**

Service-oriented architecture (SOA)

- **SOA consist of three layers:**
  - Business process layer
  - Service interface layer
  - Application layer
- **Services interface layer can be divided into three sublayers:**
  - Orchestration services
  - Business services
  - Application services
- **Business services can be either entity or task centric**
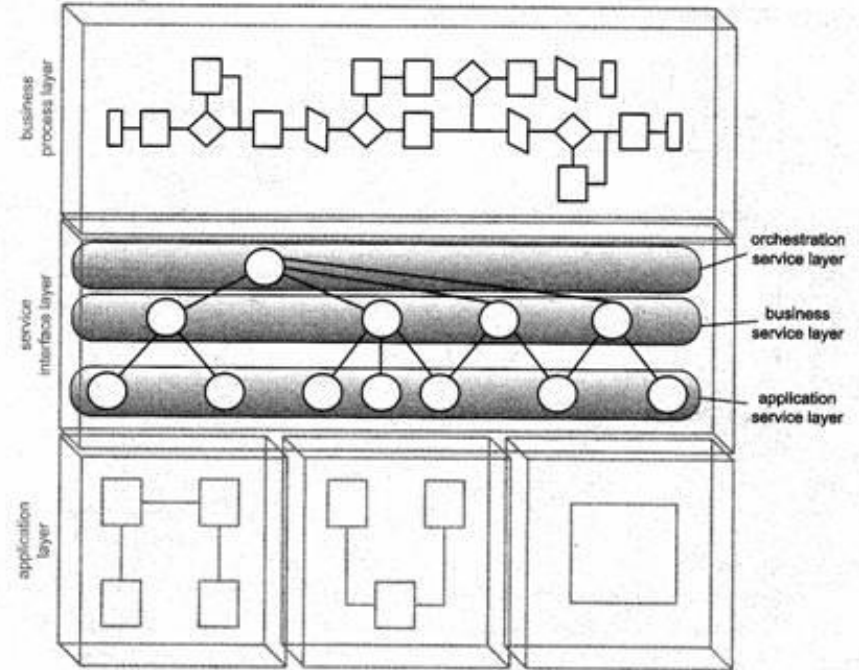
Service composition

- **Service composition means building services utilizing functionality of other services**
- **Service composition can be done e.g. through a service orchestration or choreography**
- **Even in service composition the services remain independent**

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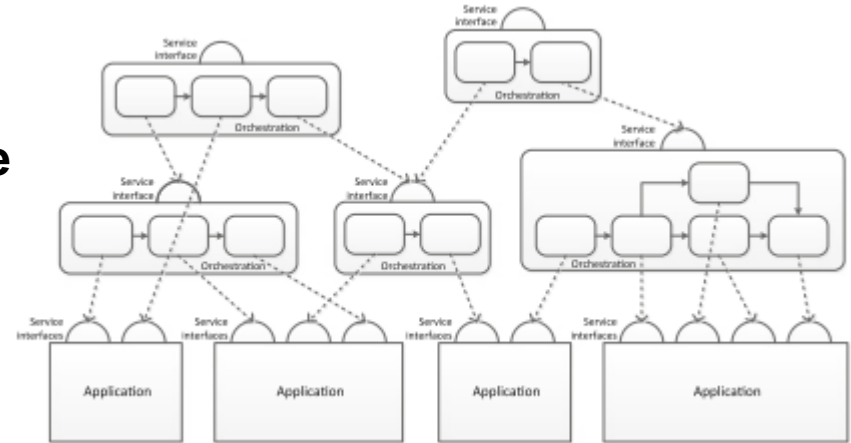
Orchestration & choreoraphy

- **Service orchestration has a central coordinator of the composite service (within an enterprise)**

- **Orchestrations can be defined e.g. with WS-BPEL**

- **Service choreography defines collaboration for multiple cooperating services acting as peers (between enterprises)**

- **Choreographies can be defined with WS-CDL**
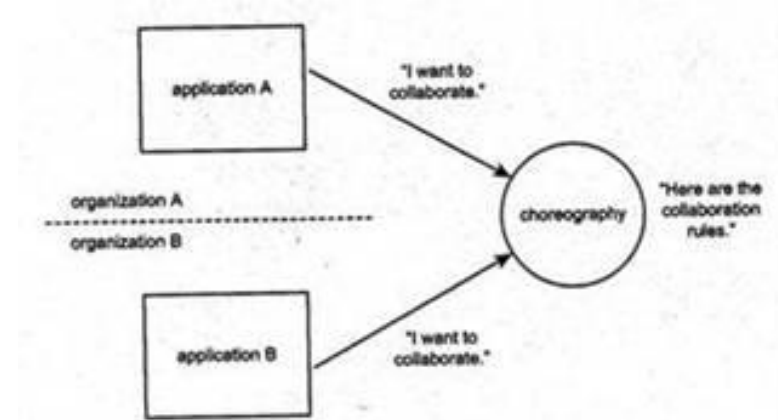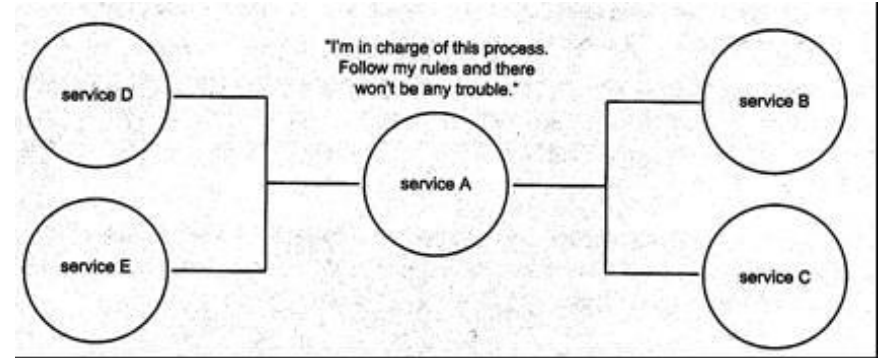
Application services & software components

- **One way to design the application layer of SOA is to use software components**

- **Interfaces of service components would implement services**

- **Components again are often implemented with object-oriented programming**

- **Legacy applications may provide their functionality as services through wrappers**

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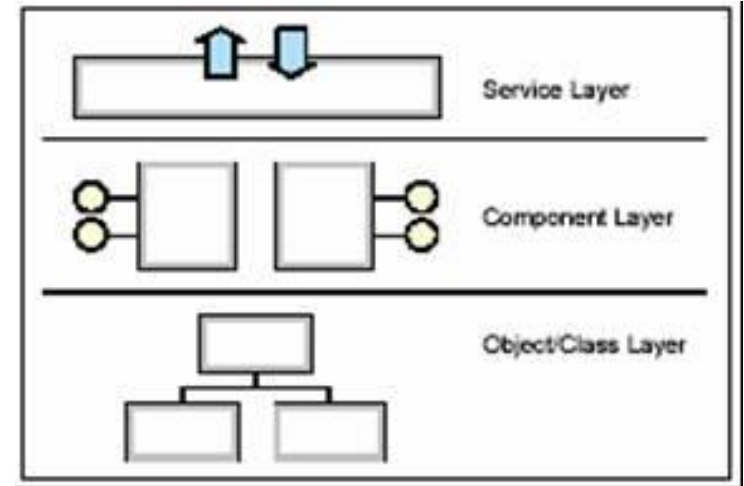
Gateway and micro services in cloud

- **Microservice architecture is an emerging software architecture for service-based systems particularly in the cloud**
- **Services in this architecture are typically quite independent of each other and containerized, e.g. Docker images**
- **Clients access services through so-called API gateway**
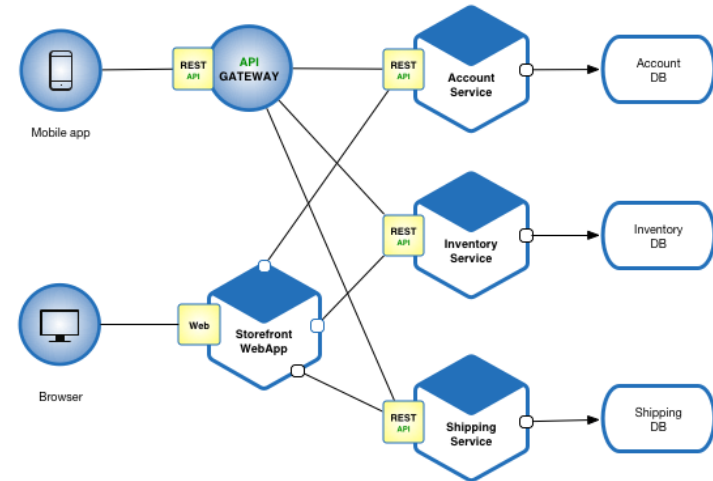
SOAP & WSDL

- **SOAP defines a protocol to exchange messages with web services as XML**
- **HTTP is a common transport method for SOAP messages but not the only one**
- **WSDL is an interface definition language for describing functionality of web services as XML**
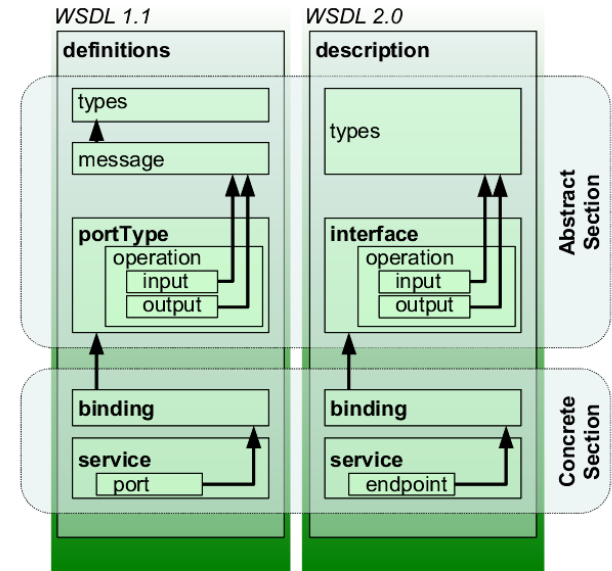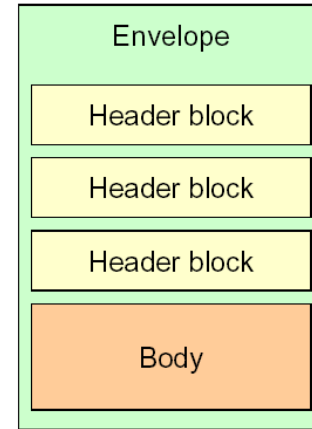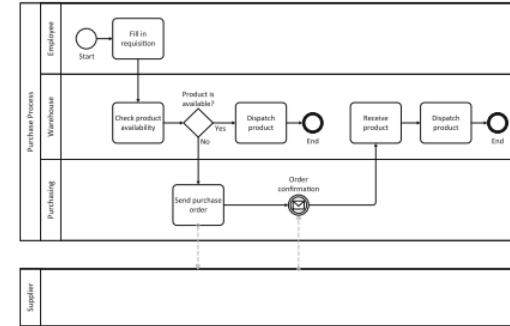
WS-*

- **Several other WS-* specifications have been developed for more advanced aspects of web services, e.g.**
  - WS-Coordination
  - WS-Transaction
  - WS-Notification
  - WS-Security
- **Together the WS-* specifications would enable development of reliable and secure distributed SOA applications**
- **Is this becoming too complex?**
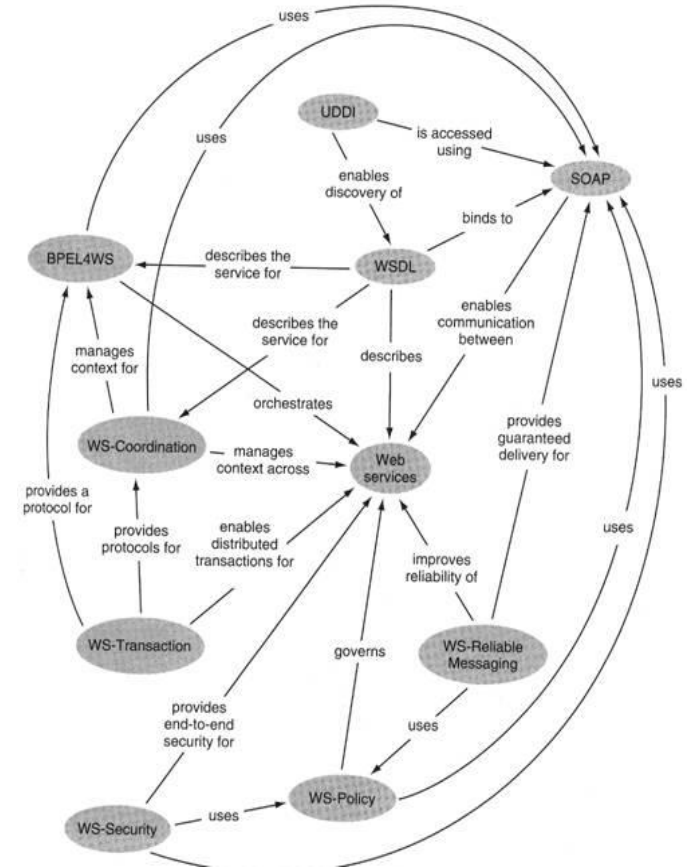
BPMN & WS-BPEL

- **BPMN (Business Process Model and Notation) is a standardized graphical notation for modeling in the business process layer of SOA**

- **BPEL (Business Process Execution Language) is a standardized executable language for business processes accessing web services**


```
<if name="isOrderBiggerThan5000Dollars">
  <condition expression-language="XPath">
    bool-expr: if order > 5000 $
  </condition>
  <invoke name="calculateTenPercentDiscount" … />
  <elseif>
    <condition expression-language="XPath">
      bool-expr: if order > 2500 $
    <invoke name="calculateFivePercentDiscount" … />
  </elseif>
  <else>
    <reply name="sendNoDiscountInformation"… />
  </else>
</if>
```

Enterprise Service Bus (ESB)

- **ESB is a software architecture model facilitating communication between separate applications according to SOA**

- **ESB may have several responsibilities relating to**

  - Messaging: queuing, routing, transformation, monitoring, notifications, transactions, protocol conversion

  - Services: deployment, versioning, security

- **But do you really need an ESB?**

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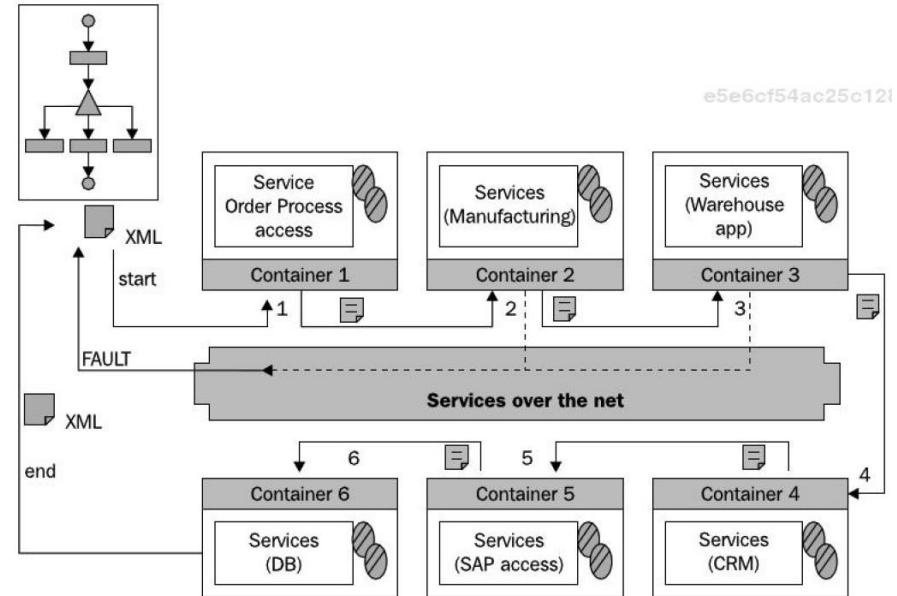
Simple example: Web services access to field devices

- **Rintala, M. Information Integration for Predictive Maintenance: Case Metso Automation, MSc thesis, Helsinki University of Technology, 2009.**

- **Metso FieldCare provides SOAP access to diagnostics information of control valves**

- **Relatively simple WS application is able to transfer the data to a remote information system**
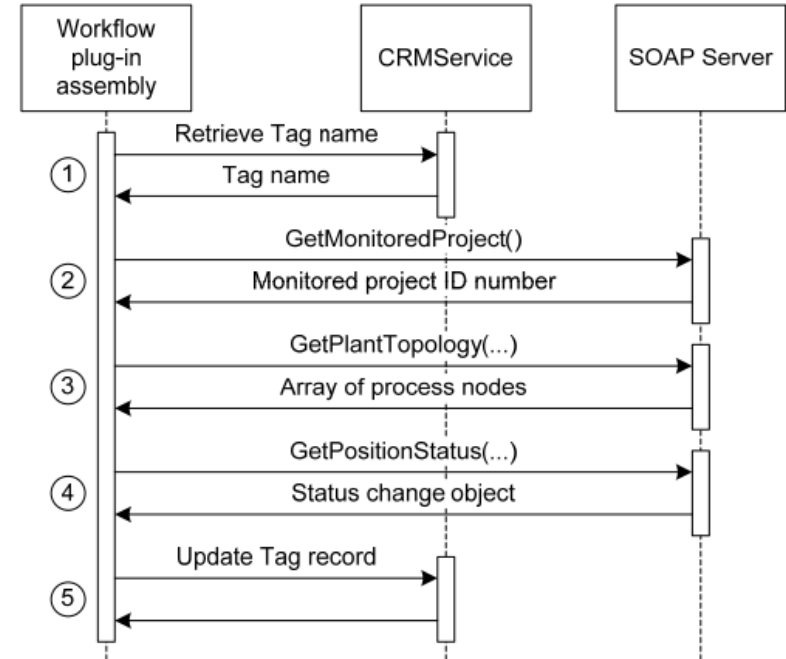
Representational State Transfer (REST)

- **REST is a software architectural style for developing service-oriented applications**

- **REST API defines web services in terms of:**

  - Base URI, e.g. http://example.org/resource

  - HTTP-methods (e.g., GET, PUT, POST, or DELETE)

 - Data type usually JSON (JavaScript Object Notation)
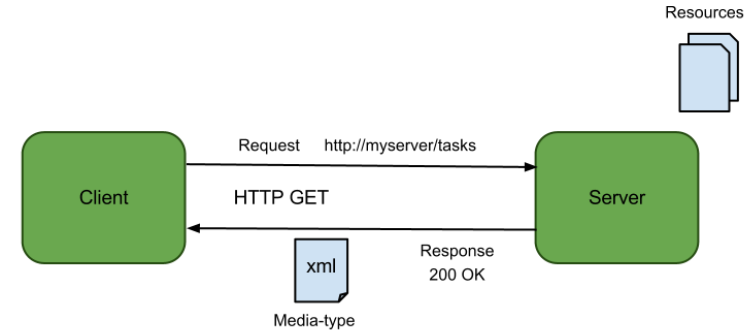
Representational State Transfer (REST)

- **REST services are simpler than SOAP services**
- **REST services follow the original communication model of WWW**
- **REST services are typically accessed with the help of REST client libraries**
- **REST services have become very popular and are a subject of active development, e.g. according to so-called micro service architecture in the cloud**

SOA in manufacturing

- **In a manufacturing enterprise SOA could be applied at multiple levels**
  - Between information systems
  - Between information systems and automation systems
  - Between automation systems
- **At the latter two levels OPC UA based services are likely to be more applicable than SOAP or REST based!**
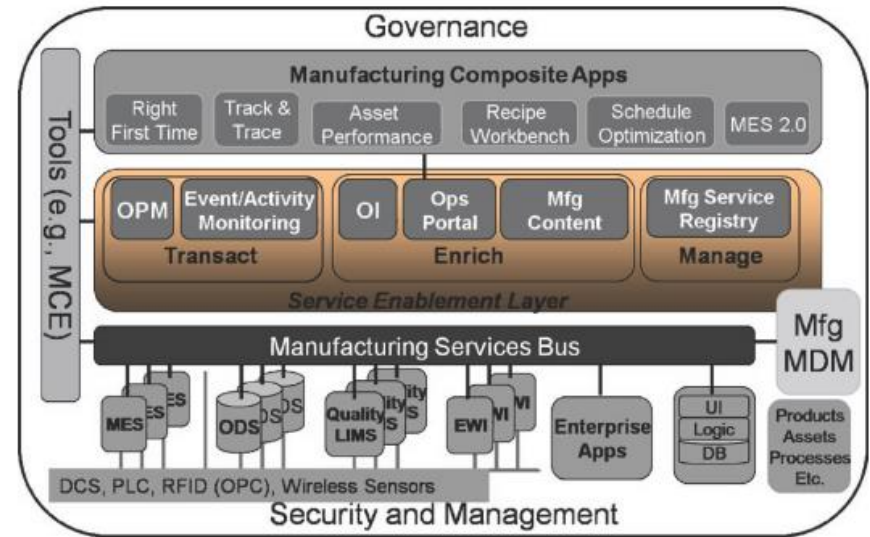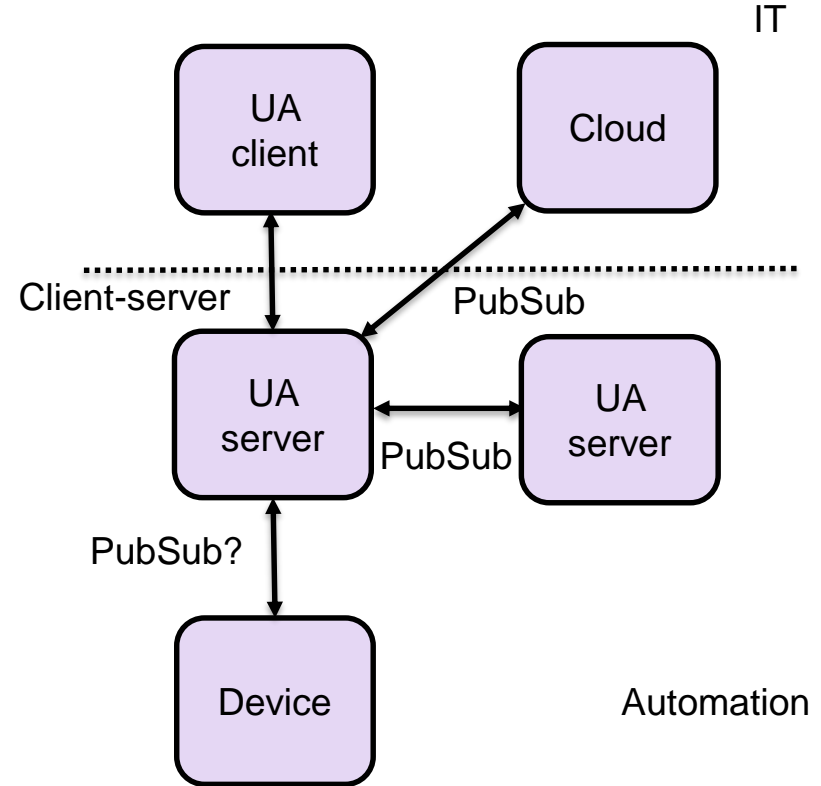
OPC UA

- **OPC UA is a communication technology originally designed for data transfer between automation systems and information systems**

- **SOA and client-server architecture**

- **UA services were originally available also through SOAP. Now this feature has been removed!**

- **OPC UA is usually used through its own transport protocol UA TCP**
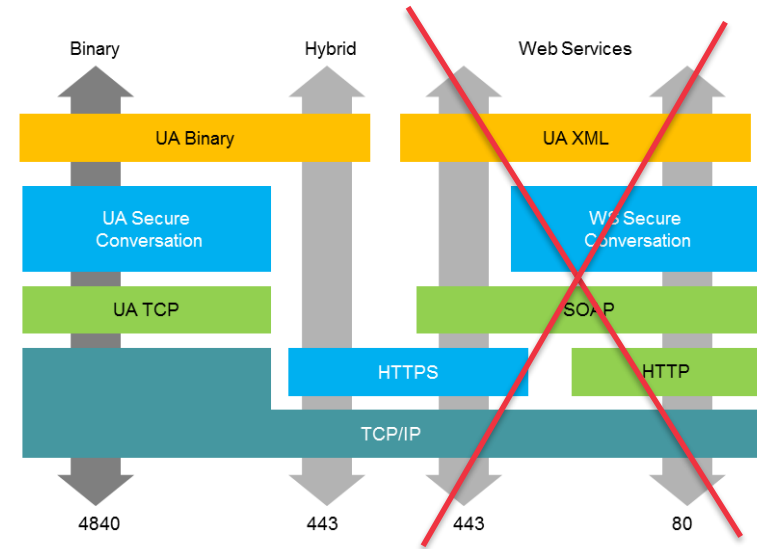
OPC UA PubSub

- **PubSub is a communication technology added to OPC UA afterwards particularly for data transfer to cloud and between automation devices**

- **Message passing architecture**

- **UDP as a tranport protocol between servers, not TCP as in SOA**

- **TSN as a potential transport mechanism to devices**

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Example: REST access to OPC UA

- **Paronen, T. A web-based monitoring system for the Industrial Internet, MSc thesis, Aalto University, 2015.**

- **Service layer brokers between OPC UA protocol to REST**

- **Transforming OPC UA protocol to REST is (currently) not without issues**