



Aalto University
School of Electrical
Engineering

Integration of information systems

Information systems in industry ELEC-E8113

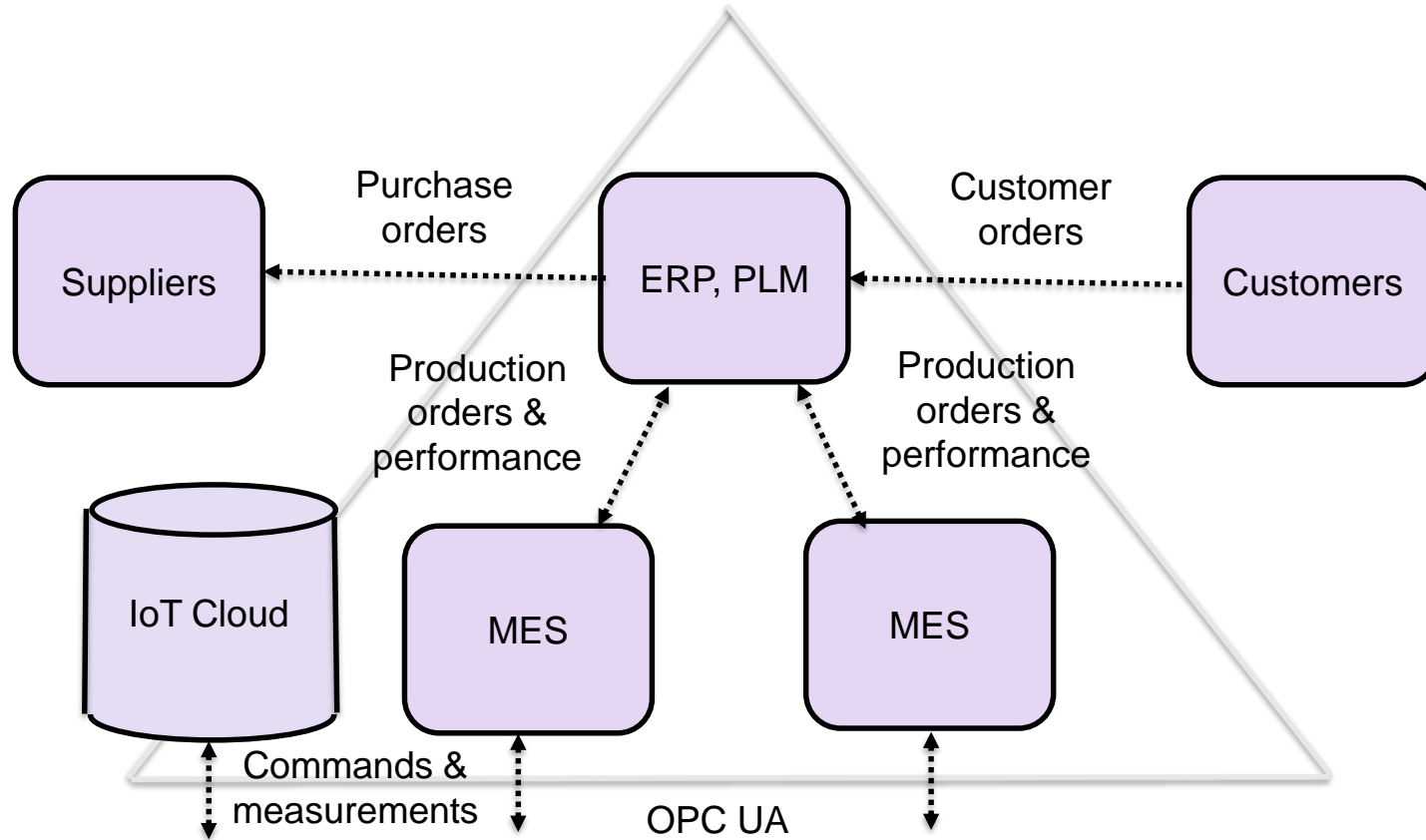
Start at 12.15!

Contents

- Needs and approaches to integration
- Designs and technologies for integration

Rationale of the lecture: Enterprises and enterprise networks have many information and automation systems that are connected to each other to a different extent. Integrating information systems is a very common part of the development of information systems in industry

The situation



Basic concepts

- **Integration of information systems refers to enabling communication between separate information systems, provided by different vendors and often based on different ways of thinking, in order to support business processes requiring utilization of several information systems**
- **Integration of information systems is often a mandatory part of a development project that also affects the software architecture and suitable implementation techniques**
- **The currently popular Industrial Internet of Things (IIoT) also requires integration of information systems and devices**
- **You will need to choose suitable approaches, designs, technologies and systems, and applications for integration**

Need for integration

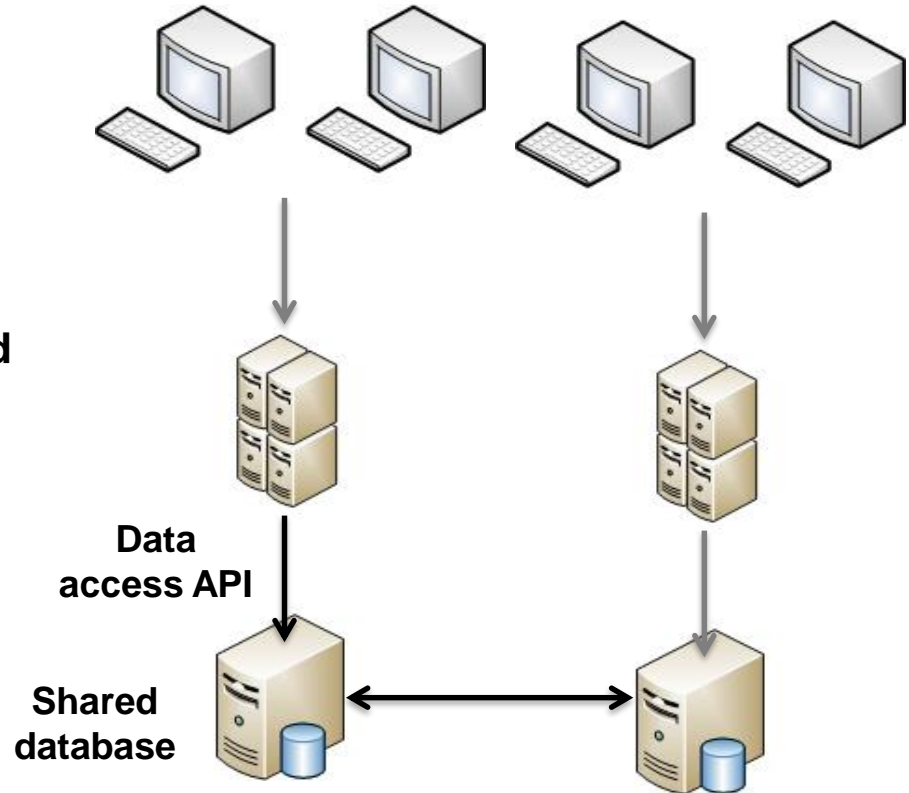
- **Industrial companies have several separate information systems from different vendors that were not particularly designed to work together**
- **Integration of information systems would enable them to exchange data and/or using the services of other systems.**
- **Integration has a quite similar meaning than interoperability, which can be considered as a basic level of loose integration**
- **There is a need for better integration of information and automation systems in industry if some of the development objectives can not be met without it**
- **The lack of integration may be observed through inefficiency of business processes**

Approaches to integration

- **Approaches to integration of information systems can be divided to four basic alternatives. They overlap. Combinations of them are needed.**
 - Data oriented: Make the data in any data source, e.g. a database or a sensor, available to those who need it, e.g. an application or another database. Make the data consistent
 - Service oriented: Use service interfaces to make the application functions and data of applications available to those who need them, e.g. composite services. Make your services interoperable
 - Business process oriented: Make all data and application functions needed by your business processes available to them. Coordinate your business processes
 - Portal oriented: Bring data and application functions of your applications available to users into a portal

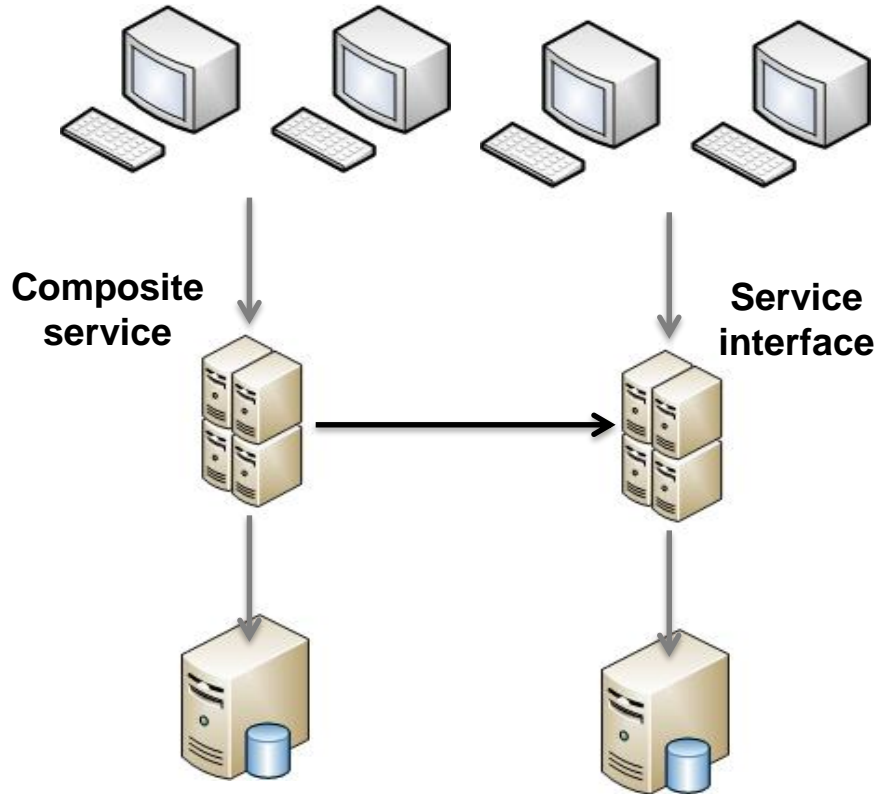
Data oriented integration

- Focus is on data and network viewpoints of EA
- Integration is achieved through specifying data storages, their interfaces to applications and data exchange between data storages and applications
- Applications are independent apart from the data they use
- Most common type of integration, e.g. ERP vs. MES, B2B integration and IIoT, OPC UA in monitoring



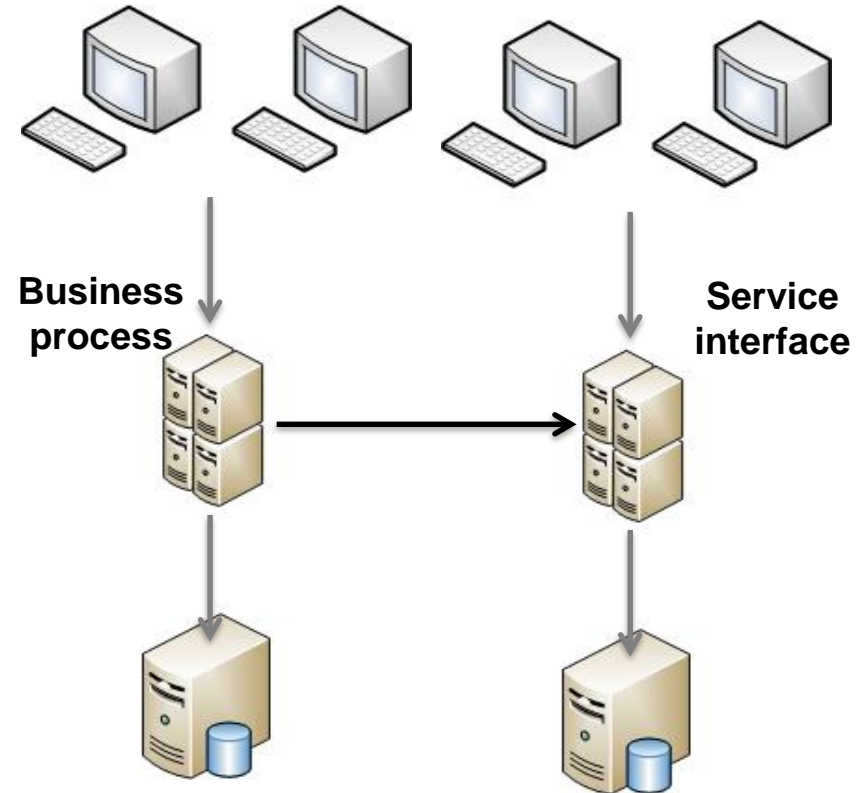
Service oriented integration

- Focus is on function and network (sometimes also data) viewpoints of EA
- Integration is achieved through specifying service interfaces to applications and composite services using them
- Designs of services become dependent on each other
- Increasingly common as SOA has been adopted. May also be achieved without web services (function oriented integration), OPC UA in control



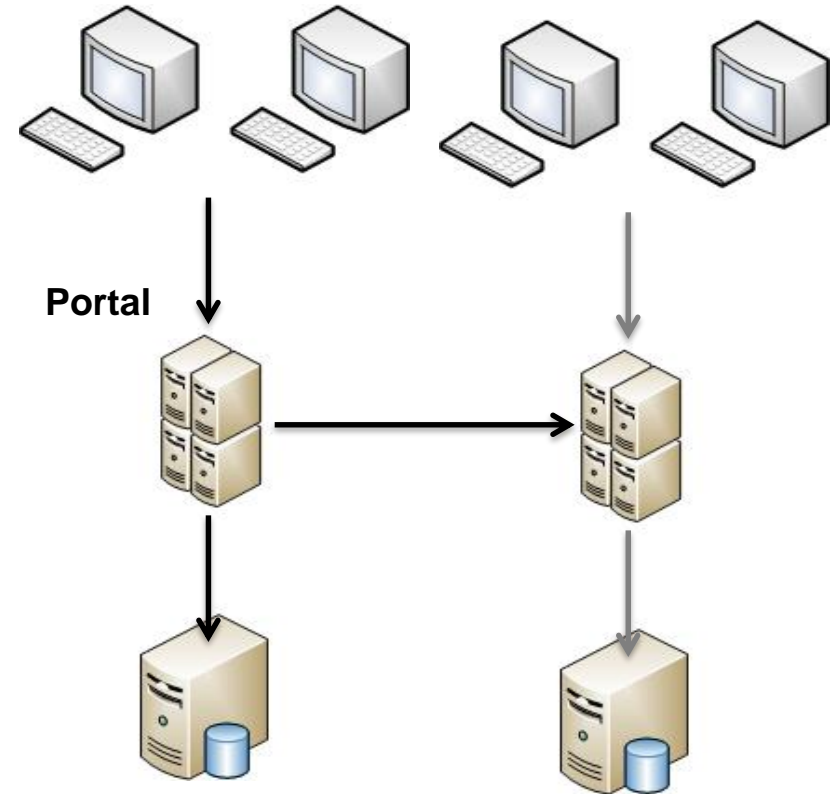
Business process oriented integration

- Focus is on function, network and people viewpoints of EA
- Integration is achieved through business processes that act as composite services
- Designs of services and business processes become dependent on each other
- Extends service oriented integration



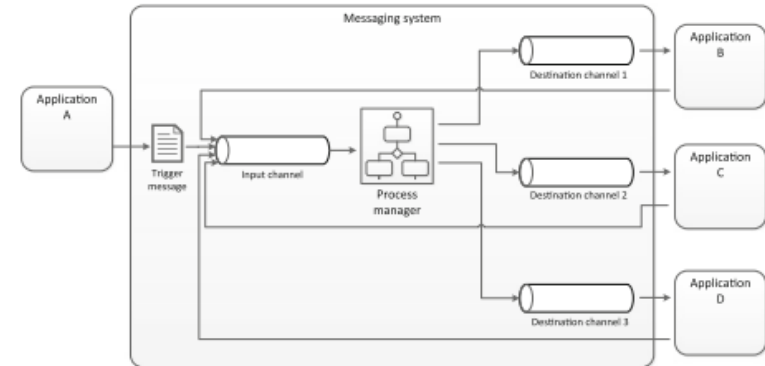
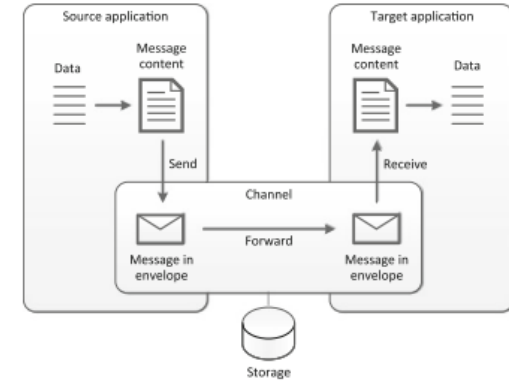
Portal oriented integration

- Focus is on people and network (also function and data) viewpoints of EA
- Integration is achieved through portals that connect users to applications and data
- Designs of applications and the portal become dependent on each other
- Very common type of integration (even trivial?)



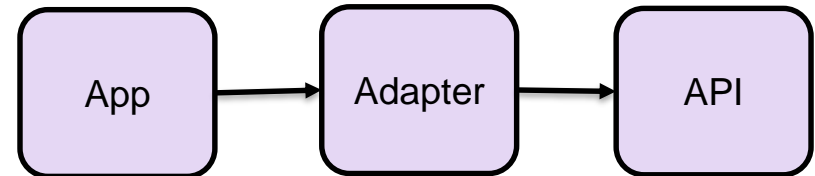
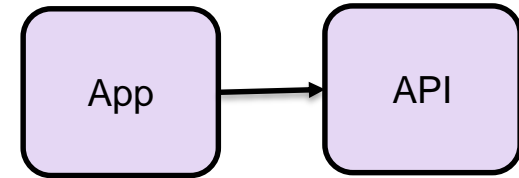
Design: messaging

- **Messaging is a basic design for integration. It may take several different forms:**
 - The architecture of messaging may be simple point-to-point or based on a broker doing routing
 - The conversation between the parties may be simple request/response or more complex
 - Broker-based messaging is typically asynchronous
 - Broker may translate format and contents of messages and coordinate transactions
 - Broker can be customized with a brokering application



Design: interfacing

- **Interfacing is another design for integration. It means how to connect to an information system to be integrated. There are to two basic approaches:**
 - APIs (Application programming interfaces) are provided by integrated systems
 - Adapters may be provided by the system doing the integration, e.g. a message broker
 - Adapters provide an API that makes accessing a group of systems similar
 - In addition to the API the adapter may offer a framework for developing an adapter application

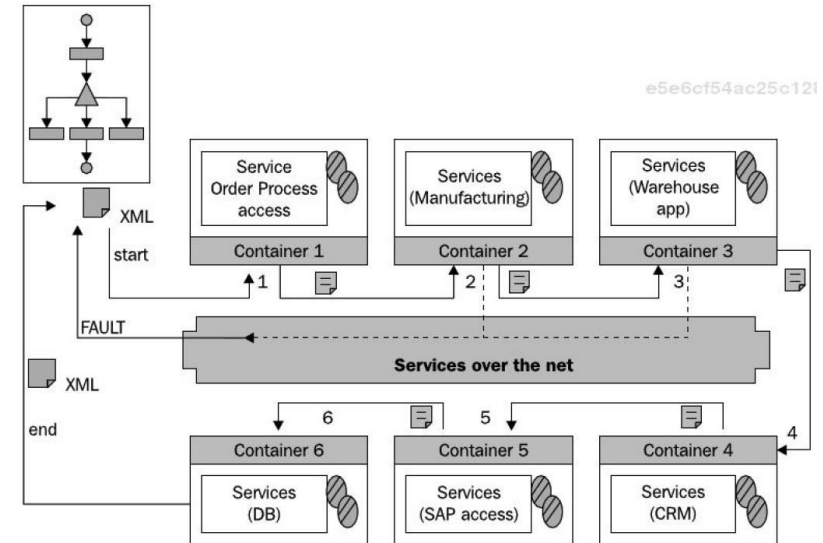


Technology: middleware

- **Due to versatility of messaging several middleware technologies have been developed for different types of messaging. A few basic types of middleware are the following:**
 - Remote procedure call (RPC) is a basic mechanism for making a function call over a (local area) network
 - Object request broker (ORB) is a messaging broker that enables method calls between objects on different computing platforms
 - Message queue (or broker) enables asynchronous messaging between applications on different computing platforms
 - Transaction processor coordinates transactions over separate systems on different computing platforms (multiple coordinated write operations)
 - Web services are an interface technology that can be used with different middleware although HTTP is typical.

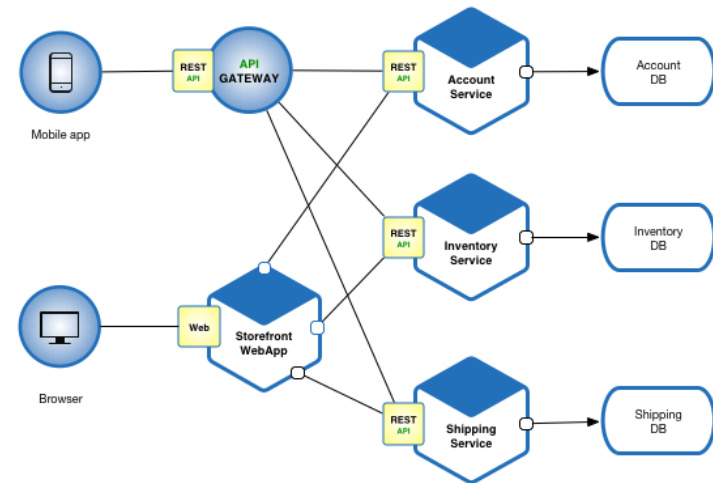
System architecture: ESB for SOA

- SOA is a quite natural architecture for service and business process oriented integration and also as part of data and portal oriented integration
- Integration applications are developed as composite services quite often as orchestrations derived from business processes
- ESB is not always necessary for SOA. Point-to-point communication and simpler message queues are alternatives particularly if the number of connections between the systems is not large



System architecture: microservices 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**
- **Communication between services may be done through so-called Service Mesh which is distributed into the services**



Integration architecture in industry

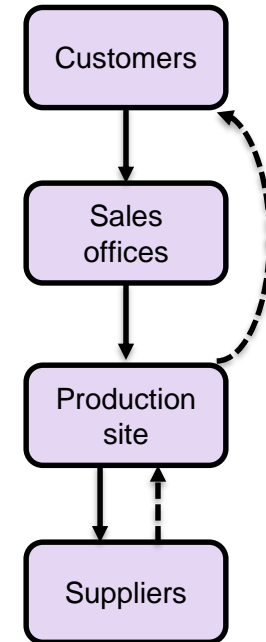
- **Integration architecture refers to the distributed system architecture in EA's network column (given the requirements from the other columns)**
- **Integration architecture can contain both pairwise integration applications and brokers with their applications. The integration architecture is nowadays increasingly but not always based on SOA in different ways.**
- **In the integration architecture of industrial companies ERP typically has a central role. Other systems are usually integrated with ERP. Also B2B integration is typically based on ERP**
- **MES may have a role as a integrating application between automation and ERP**
- **The role of PDM/PLM in integration is to provide product data to any client**

Development of integration

- **Integration of information and automation systems is often an important part of a development project**
- **Integration is to be noted in different phases of development**
 - Possible shortcomings of existing integration applications are a topic while analyzing the current situation
 - A new design of integration is likely to be a part of the target situation
 - Choosing a solution approach may include choice of integration design and technology
 - Some services and applications may have the sole purpose of integrating existing applications. Integration (EAI) patterns and standards (e.g. OPC UA) may be useful tools while developing them.

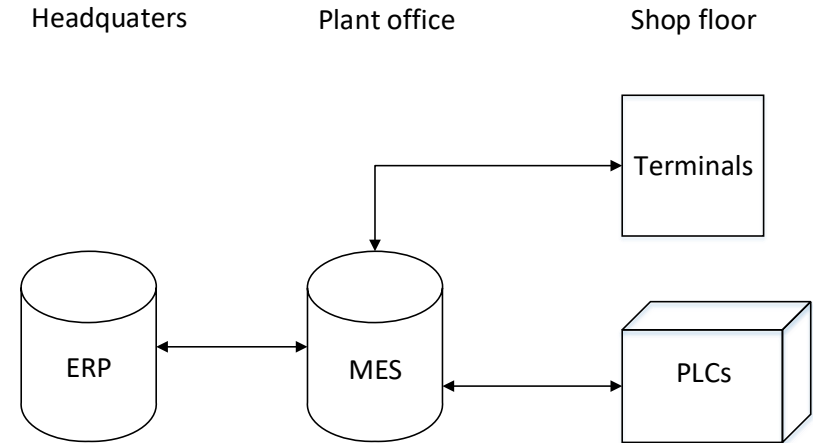
Example: Redesign of a business process in a supply-chain

- Integration of production planning to sales, suppliers and shop-floor are all inadequate
- Integration applications will be needed for sales and shop-floor. Suppliers are handled with different business processes without much additional integration
- Custom integration applications
- The challenging part of the integration application is to model data of customized products in sales configurator and production planning
- Introduction of new products may cause changes in product data model and respective integration



Example: Introducing a new information system

- The new system solves integration needs within MES (detailed scheduling) but requires integration to ERP and production
- Integration applications customized to existing ERP and shop-floor
- Integration applications developed with tools provided by the MES system accessing the interfaces provided by the ERP and shop-floor systems
- Updates to the integration applications will be needed when any of the integrated systems changes



Standards for integration

- **Examples of EAI integration standards:**

- ISA-95 is a standard for MOM/MES. B2MML is an implementation of its data models as XML.
- OPC, OPC UA are standardized technologies for communication between automation and information systems
- Etc.

- **Examples of B2B integration standards:**

- UBL is a standardized library of several business documents (e.g. orders and invoices) represented as XML
- RosettaNet is a standard for B2B data exchange for electronics industry containing several business documents as XML
- Etc.