

Data and Process Modelling

7. Business Process Management

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Dynamic Constraints

- Structural conceptual models capture the relevant information of a given domain.
- They make almost no assumption about *how* this information is used.
- In particular, they miss to capture the intended information dynamics, apart from precedence dependencies implicitly induced by subset constraints (FKs).
- Hence, **dynamic constraints** are not tackled by structural conceptual schemas.
- On the other hand, they are as important as static constraints!
 - ▶ activities to be performed;
 - ▶ interaction with external stakeholders and customers;
 - ▶ use cases;
 - ▶ law and external norms;
 - ▶ internal policies and best practices;
 - ▶ object lifecycles;
 - ▶ organizational issues;
 - ▶ ...
- These aspects are tackled by **Business Process Management (BPM)**.

Process Elicitation

Example

Brian wants to travel to Sydney. He decides to call a cab to get from his apartment to the airport in Frankfurt. After 10 minutes, the cab arrives at his apartment. Then, the cab needs 1.5 hours for the 20 km to terminal C. Once arrived, Brian checks in using the Self-Check-In terminal and receives his boarding pass. Of course, he could have also checked in at the Check-In counter. Since he has no baggage to check in, he goes directly to the security screening that is located around 100 m left of the departure hall. Luckily, the queue is not very long. Already after 5 minutes he can go to the gate. Instead of relaxing in the frequent flyer lounge, he checks out the duty-free shops and buys a newspaper, before returning to the gate 15 minutes later. Another 10 minutes later, he boards the airplane.

Depict the dynamics of the scenario graphically, so that it is easy to understand.

- Consider not only the actual course of execution by Brian, but explore also the alternative possibilities mentioned in the text.

Processes Everywhere

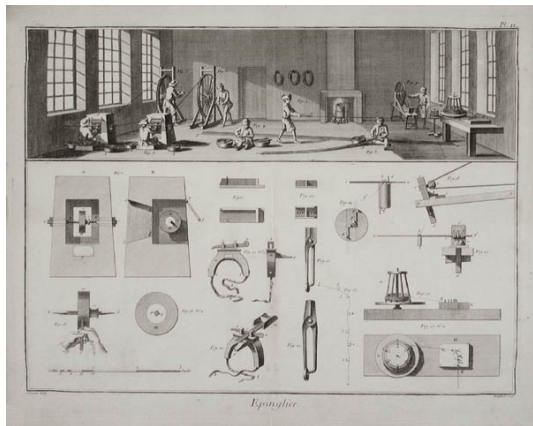
Business processes are everywhere:

- Products and services are provided by activities.
- Execution of activities requires coordination.
- Success of this coordination influences costs, time, and quality of products and services.

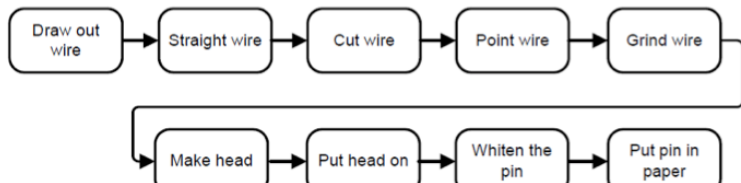
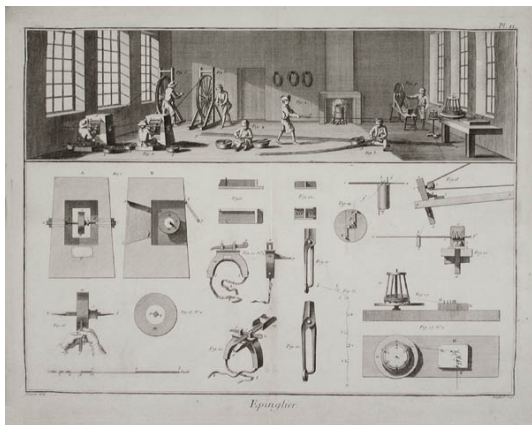
Business Process Management (Weske)

BPM includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of BPs.

The Pin Factory (1751–1766)



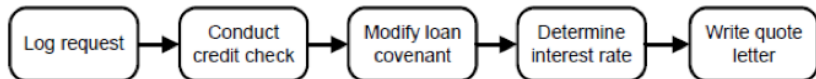
The Pin Factory (1751–1766)



Financing



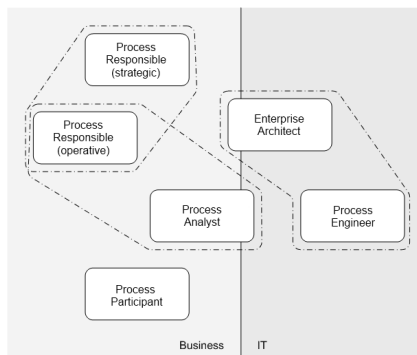
Financing



Goals

- Understand how an organization works.
- Understand key activities/tasks in an organization, and how they relate to each other.
- Understand how to embed such activities in an organisational and technical context.

Potential for improving the business processes, and increasing automation.



Waves of Process Orientation

Taylor (1911)

Scientific Management applied to work.

Hammer & Champy, Davenport (1990s)

Business Process re-engineering and innovation.

Smith & Fingar (2000s)

BPM - the third wave.

Now

Business Process lifecycle.

Taylor

- Starting point: organizations are not based on solid principles.
- It is impossible to *measure* quality and efficiency of the produced outputs.
- Idea: apply the *scientific method* to organization management.
 - ▶ Decomposition of work into elementary units.
 - ▶ Scientific analysis of each element of work, fixing its boundaries and rules.
 - ▶ Train and teach workers according to the identified rules.
 - ▶ Assure that work is conducted according to the rules.
 - ▶ Divide and conquer: management plans/controls, workers perform.

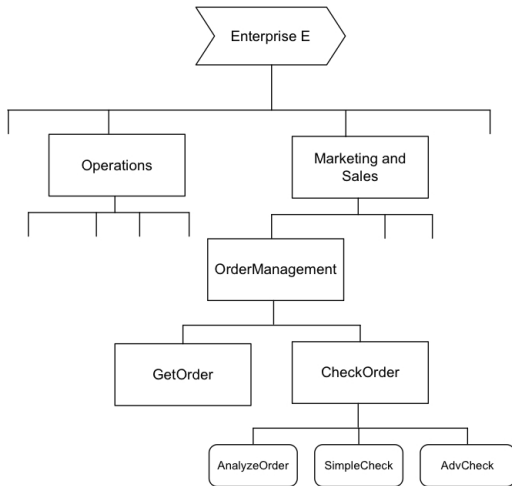
Results:

- ▶ Fine-granular division of labour.
- ▶ Emphasis on isolated activities, not on their coordination.

Business Functions and Refinement into Activities



Hierarchy of business functions follows the **aggregation abstraction**. Leaf business functions are the **activities**.



Business Process Re-Engineering

Starting point:

- Business processes had grown to be very bureaucratic and fragmented.
- Focus too much on individual activities.

Re-Engineering:

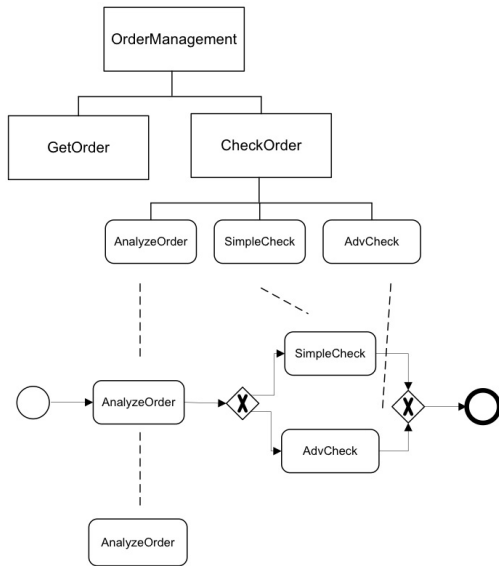
- Focus on overall goal of a process.
- Processes are radically changed.

Hammer & Champy

It is no longer necessary or desirable for companies to organize their work around Adam Smith's division of labor. Task-oriented jobs in today's world of customers, competition, and change are obsolete. Instead, companies must organize work around processes.

Functional Decomposition and Business Processes

To understand *how the enterprise works*, and to model *how it is expected to work*, dynamic constraints over the execution of activities are made explicit in terms of BPs: control-flow.



Business Processes

(Davenport, 1992)

A set of logically related tasks performed to achieve a defined business outcome for a particular customer or market.

(Hammer & Champy , 1993)

A collection of activities that take one or more kinds of input and create an output that is of value to the customer.

(Weske, 2011)

A BP consists of a set of activities that are performed in coordination in an organizational and technical environment. These activities jointly realize a business goal. Each BP is enacted by a single organization, but it may interact with BPs performed by other organizations.

Business Process Lifecycle

Starting point:

- Radical changes work out only under specific conditions.
- Re-engineering neglects continuous changes of environment.

BPM Lifecycle:

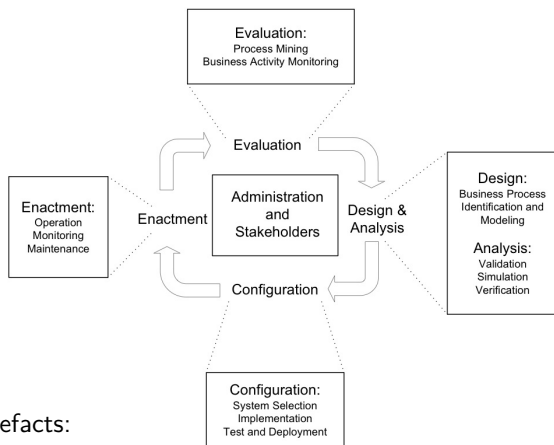
- Continuous evaluation and monitoring of a process.
- Incremental improvements.

Recall the definition of BPM:

Business Process Management (Weske)

BPM includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of BPs.

Business Process Lifecycle



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Produced artefacts:

- design&analysis → conceptual schema, process model;
- configuration → database schema, executable process;
- enactment → event log, with execution traces of multiple cases;
- evaluation → feedback, reports, process reengineering.

Types of Business Processes

Organizational vs Operational Organizational BPs are high-level BPs describing inputs, outputs, expected results, and dependencies on other organizational BPs in a coarse-grained way. One organizational BP corresponds to many operational BPs, which make activities and their relationships explicit.

Intra vs Inter-organizational Intra-organizational BPs are internal to the company, and describe relevant activities that are internally **orchestrated** to produce a good or deliver a service. Inter-organizational BPs describe interactions among multiple processes running in different cooperating organizations, in terms of **choreographies**.

Degree of automation and presence of human activities.

Degree of repetition which is important to check whether the explicit modeling of BPs really deserves the effort.

Degree of structuring ranging from predictable, repetitive BPs (**production workflow**) to unpredictable, adaptive BPs with **ad-hoc** activities and creativity of the experts (**knowledge-intensive**).

Intensional vs Extensional Knowledge

As for structural conceptual schemas, we distinguish an intentional level and an extensional level.

- Extensional level: focuses on a specific execution of the process, called **process instance** or **case**.
 - ▶ A case is a tangible (house, car, computer) or abstract (loan, insurance claim, service) relevant entity produced, manipulated and evolved by correlated activities.
 - ▶ Each case has a start and (eventually) an end, and has a **trace** constituted by events marking the execution of activities by actual resources, using specific data and at concrete timestamps.
 - ▶ Each case is distinct from the other cases (ideal situation, at least).
 - ▶ The number of “procedures”, i.e., different actual sequences chosen to evolve the cases, is (ideally) smaller than the number of cases to be handled.
- Intensional level: combine all such “procedures” together into a unique blueprint, called **process model** (or **process schema**, or simply **process** . . .).

Classification

From cases ...

- Singular sequence of activities observed in time and space.
- Instance level, also process instance.

... to processes ...

- A process model classifies related cases
- Type level, also process schema
- Types of activities / documents / persons (roles)

Classification

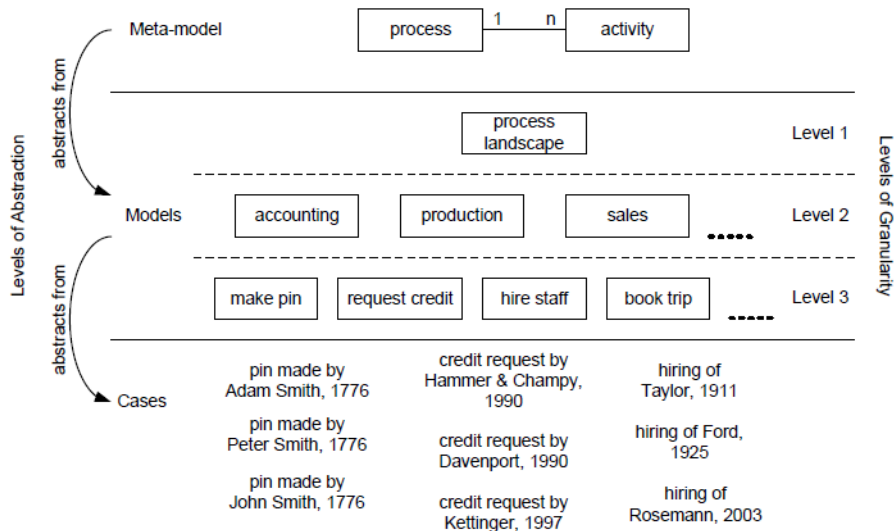
... and beyond

- Classification of process model yields meta-model.
- Defines element types used to construct process model.
- Specification of a business process modelling language.

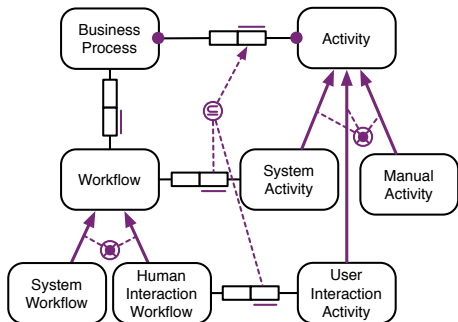
Granularity as an abstraction principle:

- Many detailed elements vs. few coarse-granular elements.
- Organisation of process models using process architectures.
- Typically at least 3 levels of granularity.
- Orthogonal to classification.

Abstraction in BPM



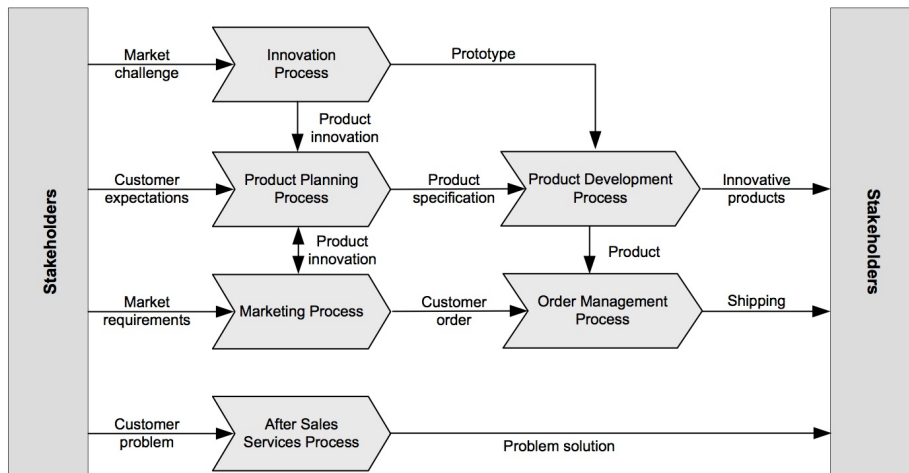
Business Process Metamodel



Activity: unit of work performed towards the achievement of the business goal.

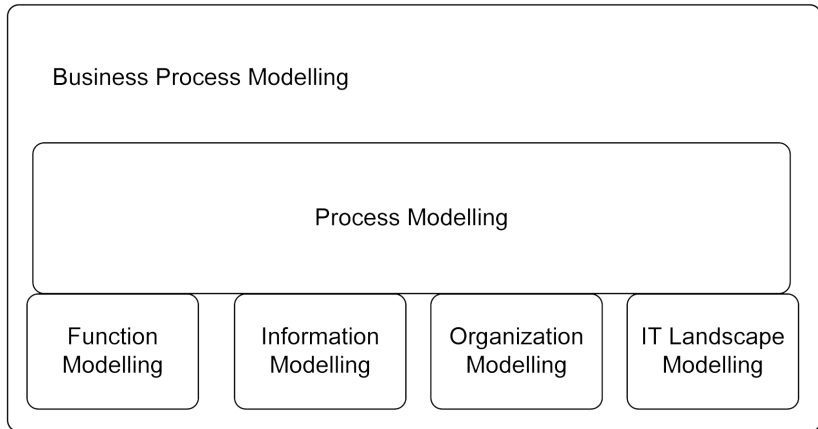
- System activity is executed by the information system (IS), in autonomy.
- Human interaction activity arises when a human interacts with the IS.
- Manual activity is not supported by the IS, unless it is attached to a notification in the form of human interaction activity.
- Certain parts of a BP can be enacted by a workflow, which ensures the desired order for activities and manages the execution of system activities as well as user interaction.

Process Landscape

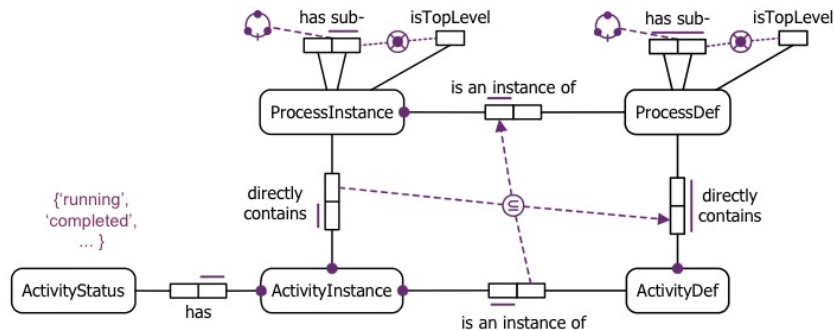


Vertical Abstraction in BPM

Several interconnected modeling areas are targeted by a BP model at the same time.

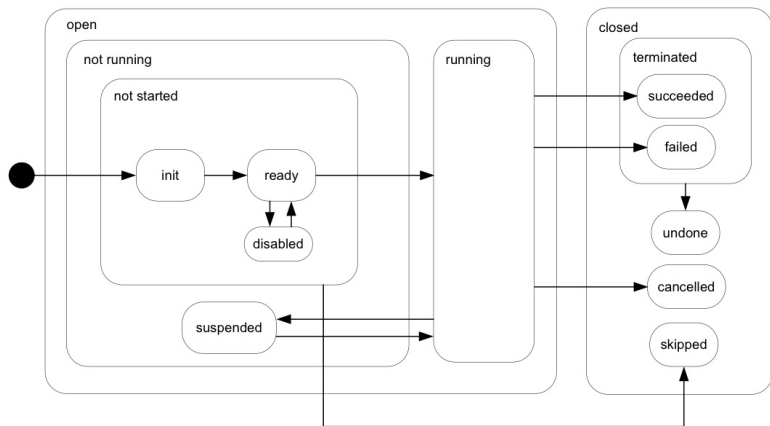


Activity Model and Instance



- To attack the complexity of the domain and for the sake of re-use, some activities could be decomposed into (sub) processes.
- System activities can be attached to software components or services.
- As a process model is a blueprint for (similar) process instances, an activity model is a blueprint for similar activity instances.
- Activity instances span over time, passing through different **states**. The executed transitions are triggered by **events** that collectively represent the **trace** of each process instance

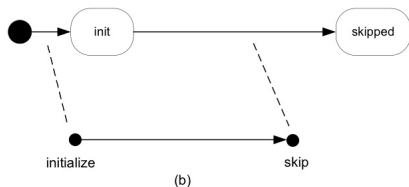
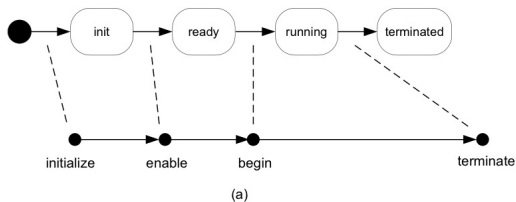
Activity Lifecycle



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- For each activity instance, the ways moving from one state to the other are constrained.
- These causal orderings characterize the temporal dependencies among states, and how specific **events** trigger a state change.
- **UML state diagrams** can be used to model this temporal evolution.

Activity Instances and Events

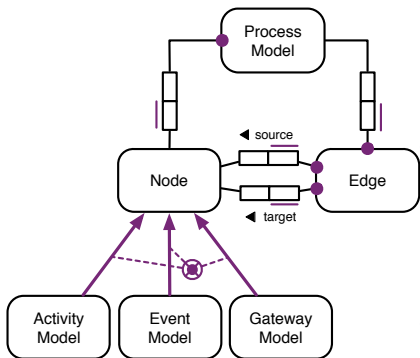


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- Each activity instance execution is then traced by means of a sequence of **atomic events**.
- Each event carries information about **data** and **resources**.
- These events are typically stored (audits, quality assurance, internal analysis).

Process Model (Standard MOF)

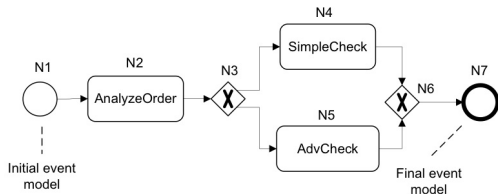
MOF (Meta-Object Facility) representation of a process model.



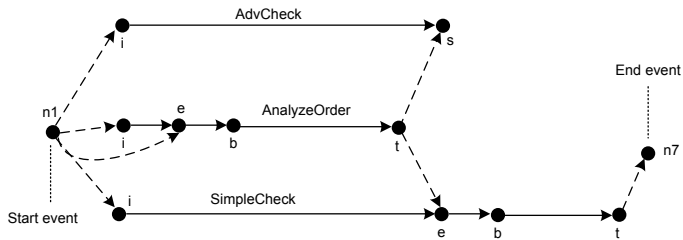
- Nesting of process model not represented.
- Activity models represent activities (for simplicity, each activity can appear only once in a process model).
 - ▶ This can be relaxed using identifiers.
- Event models capture the occurrence of states relevant for a business process.
 - ▶ Constraint: process instances start and end with events, so process models start and end with event models.
- Gateways are used to express control flow constructs, including sequences, as well as split and join nodes.

In an intra-organizational setting, a unique engine is needed to coordinate the execution: **process orchestration**.

Process Model and Instance



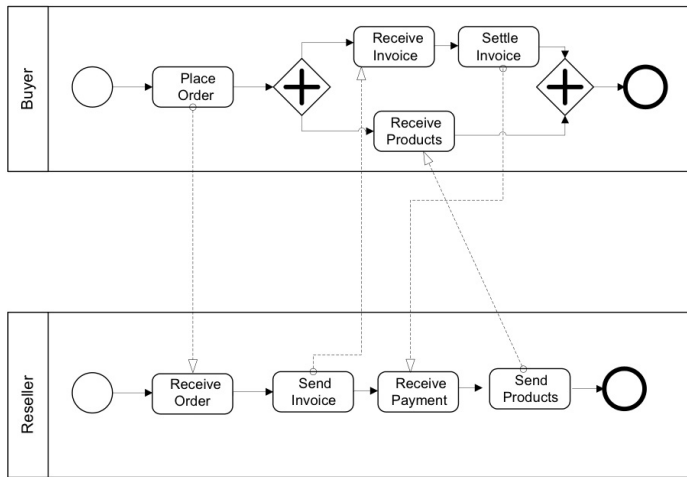
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Process Interactions

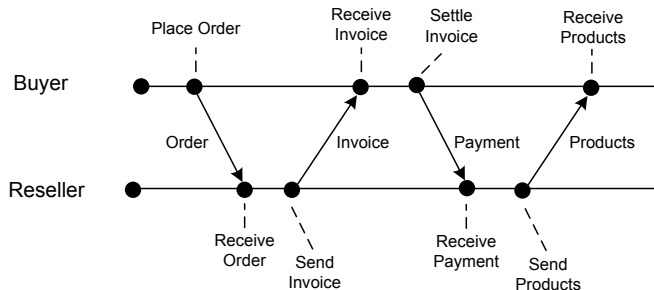
Contain events representing messages exchange between different process orchestrations running in parallel: **message flow** and **control flows**.



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Message Flow Event Diagrams

Different perspective on the evolution of the system in case of interacting processes: events corresponding to exchanged messages.



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The Three BPM Pillars

Starting from atomic units of work (activities/tasks), BPs tackle three main types of information:

Control-flow captures the allowed orderings induced by the relevant dynamic constraints over the events that trace the execution of activity instances.

Data that are produced, transferred and manipulated by the activity instances, in accordance to the constraints of a conceptual schema that models the domain.

Resources and the organizational structure enable the execution of BPs, following specific allocation strategies and policies that define responsibilities and duties of the involved stakeholders.

Data Modeling

The same conceptual schema development procedures seen so far can be used to elicit and model the relevant entities and data manipulated by BPs.

Conceptual schemas induce **data dependencies** among the activities of the BPs.

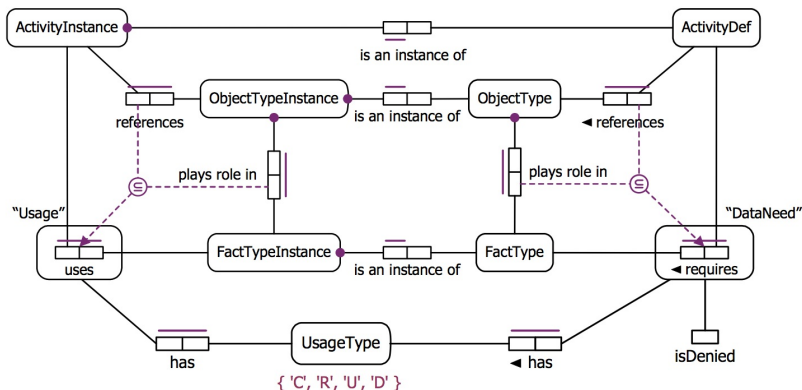
- The transfer of data among activities is called **data flow**.
- Data can be coupled with the process following different paradigms (**workflow data patterns**).

Conceptual modeling is also the first step towards **data integration** and reconciliation of heterogeneous information.

- This is particularly important in B2B scenarios and collaborative / inter-organizational BPs.

Activities and Data

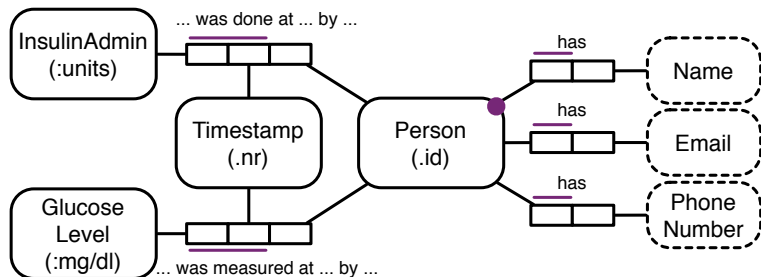
Activity definitions reference object and fact types that constitute the conceptual schema of the domain.



The reference represents *data manipulation*.

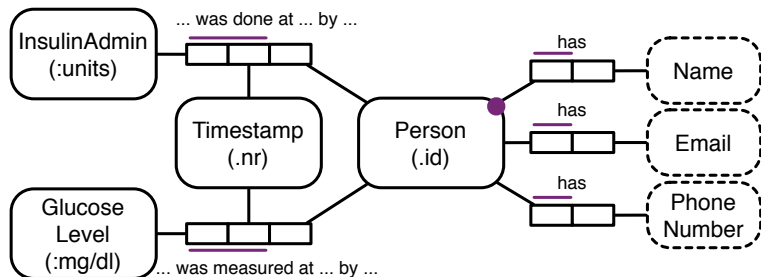
- Specification of *how* a certain object/fact type is manipulated: **CRUD**.
- Also negative constraints: *denial* of a certain operation.
- See workflow data visibility patterns for a generalization.

Example: Diabetic Person



Definition of activity Do glucose test.

Example: Diabetic Person



Definition of activity Do glucose test.

Fact Type	Data Usage
Person identified by Id	R
Person has Name	R
Person has Email	-
Person has PhoneNumber	-
Glucose level was measured at Timestamp by Person	C
InsulinAdmin was done at Timestamp by Person	-
...	...

Workflow Data Patterns

Recurrent paradigms used to specify how BPs handle data.

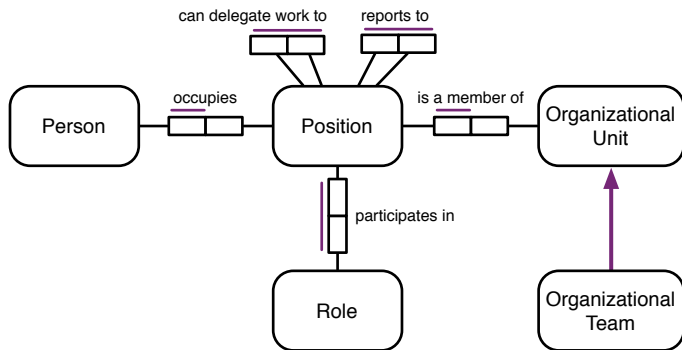
- **Data visibility:** definition of the scope of data in a BP.
 - ▶ *Task data:* data local to a specific activity.
 - ▶ *Block data:* data visible to all activities of a given sub-process.
 - ▶ *Workflow data:* data visible to all activities of a BP, with access determined by the BP model.
 - ▶ *Environment data:* data part of the execution environment in which the BP is enacted; they can be accessed at runtime.
- **Data interaction:** modalities of communication of data objects.
 - ▶ Communication between activities and activities/sub-processes of the same BP, communication between activities of different BPs (message passing), communication between the BP and the management system.
- **Data transfer:** how data objects are communicated.
 - ▶ Passing values vs passing references.
- **Data-based routing:** how data affect the enactment of a BP.
 - ▶ Enablement of an activity based on data, data-aware conditions and data-driven choices.

See <http://workflowpatterns.com/patterns/data/>

Organizational Modeling

The work (execution of activities) must be coordinated inside a company.

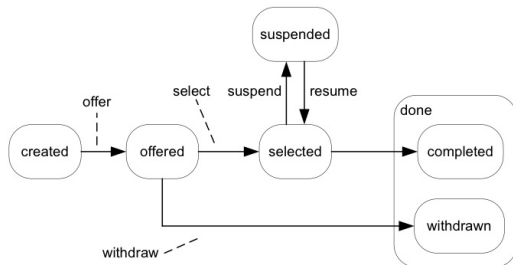
- **Resources** (humans, devices, trucks, warehouses) are entities that can perform work for the company.
- Persons are part of an organization, and work to fulfill the business goal of the company.
- **Position** is used to decouple the person and duties/privileges.



Work Items

Link between activity instance to be performed and knowledge workers that can perform it.

- Activity instance in ready state is *offered* as a work item to a set of workers.
- Selection is then done following specific *resource allocation mechanisms*.
- In human interaction workflows, work items have a transition diagram that evolves as a result of their manipulation by humans.

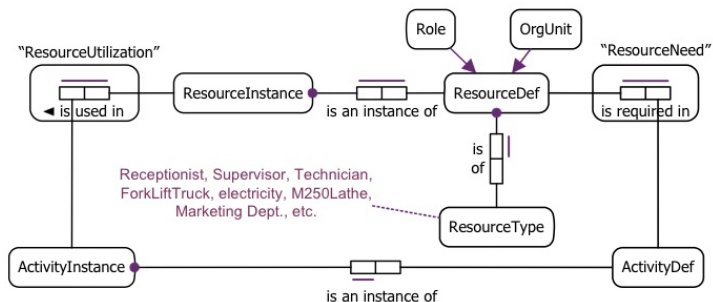


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Workflow Resource Patterns

Recurrent allocation strategies of work items to resources.

The decision is on how to interconnect the organizational model and the activities of the BP.



Sample Resource Patterns

Direct allocation all activity instances of an activity to a single, specific person.

Role-based allocation activity bound to a role, all members of the role will be candidate for the execution of its instances.

Role resolution is dynamically applied to determine the members of the role.

Two possibilities: dynamic allocation to only one member of the role, or instance offered to all members, then selection + withdrawn of work items for the other members (remember the state diagram of a work item).

Deferred allocation Decision completely taken at runtime.

Authorization Allocation based on the persons' positions.

Separation of duties Imposes an exclusive constraint between the person selected in different allocations.

History-based Allocation based on what the persons worked on previously.

Process Orchestration and Control-Flow

Once made **executable**, processes can be given to process engine for **orchestration**.

- The process engine presents current work items to resources, collects information about the executed events, and handles the corresponding evolution of the process instance.
- The evolution is driven by taking into account all the control-flow constraints imposed by the BP model, and by the lifecycle constraints of each activity instance.
- Control-flow constraints are modeled in a BP using **gateways**.
- As for activities, gateways are instantiated during the execution, and each gateway instance imposes a set of ordering constraints over events associated to the interconnected activity instances.
- External events are seamlessly handled so as to coordinate with external systems/processes.

Control-Flow Patterns

Recurrent ordering constraints (gateways) in BP models.

- We are going to introduce some typical control-flow patterns when presenting BPMN (next slides).
- A list of control-flow patterns can be found in Weske's book (Section 4.1).
- See <http://workflowpatterns.com/> for patterns and animations.