Business Process Modelling
Business Process Lifecycle

Evaluation:
- Process mining
- Analytics/Warehousing

Enactment:
- Operation
- Monitoring
- Maintenance

Administration & Stakeholders

Configuration:
- System selection
- Implementation
- Test & Deployment

Design:
- Business Process Identification & Modelling

Analysis:
- Validation
- Simulation
- Verification

Administration & Stakeholders
Business Process Modelling

- The model of a BP can be described via a specific language and be specified through BP modelling tools (part of a BPMS).
- Can be performed at different levels:
  - Organizational (coarse-grained, textual forms)
  - Operational (fine-grained, semi-structured/formal models)
- Explicit representation:
  - Usually through graphical notations
  - Ideal for internal communication between stakeholders -> flexibility
Various types of languages have been proposed:

- **Procedural**: The procedural aspects determine the order of steps (tasks, events, and gateways) that are needed to achieve the relevant process goals. This is comparable with algorithms or operating instructions (Petri Nets, BPMN, BPEL).

- **Declarative**: Processes are based on declarative elements like complex decisions, relationships between variables, or data constraints. This information is expressed using business rules and some kind of functional or logical language.
Procedural Business Process Modelling
Declarative Business Process Modelling

- If an abstract is submitted, a new paper had been written or will be written. 
- After the paper submission, a confirmation email is sent.
- After the paper submission, the paper will be reviewed; there can be no review without a preceding submission.
- A paper can be accepted only after it has been reviewed.
- After the rejection, no further submission follows.
- Paper cannot be both accepted and rejected.

Source: http://www.slideshare.net/cdc08x/semantical-vacuity-detection-in-declarative-process-mining

= activation task

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EQUIS
Declarative Business Process Modelling
Declarative Business Process Modelling

- Declare is one declarative language
  - Grounded in Linear Temporal Logic (LTL)
  - Finite-trace semantics
  - Each constraint is mapped to an LTL formula using operators such as: always $\square$, eventually $\Diamond$, until $\sqcup$, weak until $\mathcal{W}$ & next time $\circ$

$$\varphi ::= \text{true} \mid a \mid \varphi_1 \land \varphi_2 \mid \neg \varphi \mid \circ \varphi \mid \varphi_1 \mathcal{U} \varphi_2$$

- $a =$ atomic proposition
- $\circ =$ “next”: $\varphi$ is true at next step
- $\mathcal{U} =$ “until”: $\varphi_2$ is true at some point, $\varphi_1$ is true until that time
LTL: Restaurant example

- $c_1 \equiv \neg((\Diamond c) \land (\Diamond d))$: indicates that tasks c and d cannot be true for the same case
- $c_2 \equiv (\neg c) Wa$, $c_3 \equiv (\neg d) Wa$: second task cannot happen before first occurs (but only first can just occur or no task of the two)
- $c_4 \equiv "\Box (b \Rightarrow (\Diamond c \lor \Diamond d))":$ every occurrence of b should be followed by c or d (but not always one-to-one correspondence – b can occur multiple times)
LTL: Traffic Light example

- **System description**
  - Focus on lights in a particular direction
  - Light can be any of three colors: green, yellow, read
  - Atomic propositions = light color

- **Ordering specifications**
  - Liveness: “traffic light is green infinitely often”
    \[ \Box \Diamond \text{green} \]
  - **Chronological ordering**: “once red, the light cannot become green immediately”
    \[ \Box (\text{red} \rightarrow \neg \Diamond \text{green}) \]
  - **More detailed**: “once red, the light always becomes green eventually after being yellow for some time”
    \[ \Box (\text{red} \rightarrow (\Diamond \text{green} \land (\neg \text{green} U \text{yellow}))) \]
    \[ \Box (\text{red} \rightarrow \Diamond (\text{red} U (\text{yellow} \land \Diamond (\text{yellow} U \text{green})))) \]
Formal Business Process Languages

- Have **unambiguous** semantics
- Allow for **BP analysis**
- Require some expertise in Mathematics or Computer Science (wrt the formalism used)
- Abstract from implementation details
- Different formalisms have been employed:
  - Markov Chains, Queuing Networks, Turing Machines, Transition Systems, Petri Nets, Temporal Logic and Process Algebras
Conceptual Business Process Languages

- More comprehensive & easy to use
- Do not have well-defined semantics
- Do not allow for analysis
- The respective specifications cannot be executed
- Approximate description of the desired behaviour
- Examples: Business Process Modelling Notation (BPMN), Event-Driven Process Chains (EPCs), UML Activity diagrams
Business Process Execution Languages

- **Workflow-based languages**
- Provide the appropriate level of detail for making specifications executable
- **Precise definition of the desired behaviour**
- Example: BPEL
Flow Charts

- Formalised graphic representation of a program/work logic sequence
- Sequential flow of actions with no activity breakdown
- Characteristics:
  - Flexibility (various ways for process description)
  - Easy to use – perfect for communication
- Drawbacks:
  - Process boundaries may not be clear
  - Tend to be very big
  - No difference between main & sub-activities
  - Hard to navigate (no sub-layers)
Flow Chart Example

1. Receive Order
2. Distribution Centre
3. Stock?
   - Yes: Print Invoice
   - No: Advise Marketing
4. Shipping
   - Inform customers
Data Flow Diagrams (DFDs)

- Show flow of data/information from one place to another one
- Link processes to data stores & indicate their relation to users and outside world
- Describe what the process will do but not how
- Used for structured analysis
- Characteristics:
  - Comprehensible, verifiable, easy to draw & amend, process breakdown
- Drawbacks: only flow of data is represented
DFD Example

1. Marketing
   - Receive order
   - Customer order
   - No available
   - Verify availability
     - Yes available

2. Distrib.Cent
   - Verify availability

3. Shipment
   - Print invoice

4. Shipment
   - Shipping products

Customer
Role Activity Diagrams (RADs)

- Graphic view of process from perspective of roles
- Focus on roles’ responsibility & their interactions
- Roles include organisational functions, sw systems, customers & suppliers
- Characteristics:
  - Useful in communication
  - Easy & intuitive to use and understand
  - Detailed process view
  - Activity parallelization
- Disadvantages:
  - Business objects exclusion
  - No process decomposition
Role Activity Diagrams (RADs)

Customer

- initial
- enter
- able to select
- select goods
- payment
- able to leave
- leave

Cashier

- signed-off (unable to process customer)
- sign-on
- signed-on (able to process customer)
- process customer
- choose sign-off
- signed-on
- sign-off
- signed-off
- signed-off

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Role Interaction Diagrams (RIDs)

- Resulted from combination of RADs & object interaction diagrams
- Matrix used to connect activities with roles
- Horizontal lines indicate human/role interactions
- Characteristics:
  - Intuitive to understand
  - Easy to use
  - Well-definition of responsibilities
  - Activity breakdown
- Drawbacks:
  - Tend to be messy, hard to build & update, no I/O modelling
RID Example

CUSTOMER ORDER
RECEIVE ORDER
AVAILABILITY CHECK
COMMUNICATE NO AVAILABILITY
RESERVATION IN STOCK
INVOICING

CUSTOMER

MARKETING

DISTRIBUTION

ORDER

ORDER

REJECTED ORDER

PRODUCT PROCESSED
Integrated Definition for Function Modelling (IDEF)

- Family of methods to address modelling needs of an enterprise
- For BP modelling, IDEF0 is used:
  - IDEF0:
    - Structural graphical representation
    - Shows high-level activities & their I/O, control & mechanisms
    - Process decomposition
    - Characteristics: suitable for implementation as computer sw, quick mapping to high-levels due to hierarchical structure
    - Drawback: just activity sequencing can be modelled
IDEF0 Example
Unified Modelling Language (UML) Diagrams

- Object-oriented methods used for modelling
- Collection of engineering practices proven successful for large & complex system modelling
- Covers both conceptual (BPs & system functions) & concrete elements (programming language classes, DB schemas, sw components)
- UML diagrams:
  - Class diagram: system structure (concepts & relations)
  - Statechart diagram: states of a class or system
  - Activity diagram: activities and actions
  - Sequence diagram: messages sent between set of objects
  - Collaboration diagram: complete collaboration between objects
UML class diagrams

- What is a UML class diagram?

  - **UML class diagram**: a picture of the classes in an OO system, their fields and methods, and connections between the classes that interact or inherit from each other.

- What are some things that are not represented in a UML class diagram?

  - details of how the classes interact with each other
  - algorithmic details; how a particular behavior is implemented
Class Diagrams

- class name in top of box
  - write `<<interface>>` on top of interfaces' names
  - use *italics* for an *abstract class* name

- attributes (optional)
  - should include all fields of the object

- operations / methods (optional)
  - may omit trivial (get/set) methods
    - but don't omit any methods from an interface!
  - should not include inherited methods

```
Rectangle
- width: int
- height: int
/ area: double
+ Rectangle(width: int, height: int)
+ distance(r: Rectangle): double
```

```
Student
- name: String
- id: int
- totalStudents: int

#getId(): int
+getName(): String
~getEmail(): String
+ getTotalStudents(): int
```
Relationships between classes

- **generalization**: an inheritance relationship
  - inheritance between classes
  - interface implementation

- **association**: a usage relationship
  - dependency
  - aggregation
  - Composition

- **aggregation**: "is part of"
  - symbolized by a clear white diamond

- **composition**: "is entirely made of"
  - stronger version of aggregation
  - the parts live and die with the whole
  - symbolized by a black diamond

- **dependency**: "uses temporarily"
  - symbolized by dotted line
  - often is an implementation detail, not an intrinsic part of that object's state
A sequence diagram depicts a scenario by showing the interactions among a set of objects in temporal order.

Objects (not classes!) are shown as **vertical bars**. Events or message dispatches are shown as horizontal (or slanted) **arrows** from the sender to the receiver.
UML Sequence Diagram Example
A Statechart Diagram describes the *temporal evolution* of an object of a given class in response to *interactions* with other objects inside or outside the system.

![Statechart Diagram]

**Figure 3-5. Statechart diagram**
Activity diagrams

- Useful to specify software or hardware system behaviour
- Based on data flow models – a graphical representation (with a Directed Graph) of how data move around an information system

![Activity Diagram Example]

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Collaboration diagrams (called *Communication* diagrams in UML 2.0) depict scenarios as *flows of messages* between objects.
Event Process Chains (EPCs)

- Informal notation for representing domain concepts & processes
- Not focused on technical realization
- Part of a holistic modelling approach called the ARIS framework
- Main building blocks: events, functions (low-level of granularity), connectors (process logic) & control flow edges
- Framework also includes interaction flow diagrams (high-level view of organisational entities & their interactions) & function flow diagrams (refinement of interaction flow diagrams with interaction ordering & interaction representation via coarse-grained functions)
- EPC drawbacks:
  - Verbose & quite complex diagrams
  - Semi-formal representation -> problems with transformation to executable format
EPC Example

Order is received

Analyze order

XOR

Order is accepted

Check Stock

Order is rejected
Business Process Modelling Notation (BPMN)

- Based on **flowcharting techniques** for processes
- Graphical BP diagram with **flow** & connecting objects, **swimlanes**, and **artefacts**
- Explicitly indicates organisational information
- Covers both **orchestrations** & **choreographies**
- Characteristics:
  - **Flexibility** (well-structured technique with process breakdown & rich set of control flow constructs)
  - **Ease of use** for both inexperienced and expert stakeholders
  - **Understandability**
  - Supports the construction of **simulation models**
BPMN

- Drawbacks:
  - **Data Handling** (data structures are not covered – could be exploited in conditions)
  - **Message flow** (two-level hierarchy of swimlanes)
  - **No Representation of states**
  - **Under-representation of systems**
  - Not all workflow patterns are covered + for **advanced patterns**, expertise in filling in no graphical information is needed
  - **No formal semantics**
  - **Minimal support to resource modelling**
  - **Missing support for business-specific terms & business rules**
BPMN Example
Enterprise Modeling

- **Enterprise modeling**: description of main constituents, purpose, processes etc. of an organization
  - a representation of the organization’s knowledge about itself
- Creating an enterprise model can reveal anomalies, inconsistencies, inefficiencies and opportunities for improvement
- Once a model is created, it can be used to share knowledge within an enterprise, to formulate and evaluate changes
- Process definitions can be extracted to be input to a workflow management system
- Business process support software can query the enterprise model to obtain information
Formal Business Process Modeling

- A formal approach to enterprise and business process modeling
  - concepts must be defined rigorously and precisely
  - use formal methods to analyze, extract knowledge from them and reason about them
- Advantages of adopting a formal approach:
  - can be verified mathematically
  - can be proven to be self-consistent
  - can be shown to have or lack properties
- Need to establish methodologies for devising formal models of organizations and their processes
Recommended Reading

- M. Ould “Business Processes”, chapters 1, 2
- https://www.youtube.com/watch?v=UfBFIAMOYgg&list=PLrAWWpbaj-7JIEV3_BfBLNYdYKrpgqC68&index=2
- https://www.youtube.com/watch?v=ztZsEi6C-ml
- https://www.youtube.com/watch?v=UfBFIAMOYgg
- https://creately.com/blog/diagrams/class-diagram-relationships/