Softwaretechnik / Software-Engineering

Lecture 3: Software Project Management

2019-05-02

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Topic Area Project Management: Content

VL 2	• **Software Metrics**
	• Metrics, Properties of Metrics
⋮	• Software Metrics
	• Software Metrics Issues
	• **Cost Estimation**
	• (Software) Economics in a Nutshell
VL 3	• Software Cost Estimation
	• Expert's / Algorithmic Estimation
⋮	• **Project Management**
	• Project
	• Process and Process Modelling
VL 4	• Procedure Models
	• Process Models
⋮	• **Process Metrics**
	• CMMI, Spice

Content

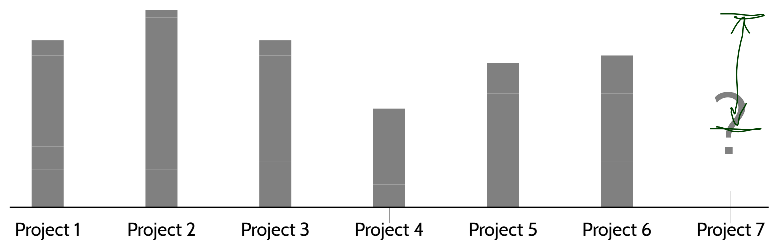
Software Cost Estimation Cont'd

In the end, it's **experience**, **experience**, **experience**:

> "Estimate, document, estimate better." (Ludewig and Lichter, 2013)

Example:

- Assume these were the overall costs of previous, all similar projects:



- What could be an estimate of the new (also similar) Project 7?

Principles of Software Cost Estimation

In the end, it's **experience**, **experience**, **experience**:

> "Estimate, document, estimate better." (Ludewig and Lichter, 2013)

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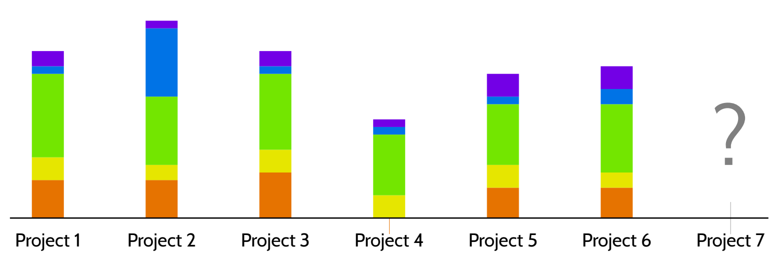


- What could be an estimate of the new (also similar) Project 7?

- For a better estimate: analyse what costs are composed of.
  Maybe, Project 4 could re-use parts of Project 3, maybe Project 2 is the only one with a new customer. For Project 7 check: can we re-use parts? Is it a new customer?

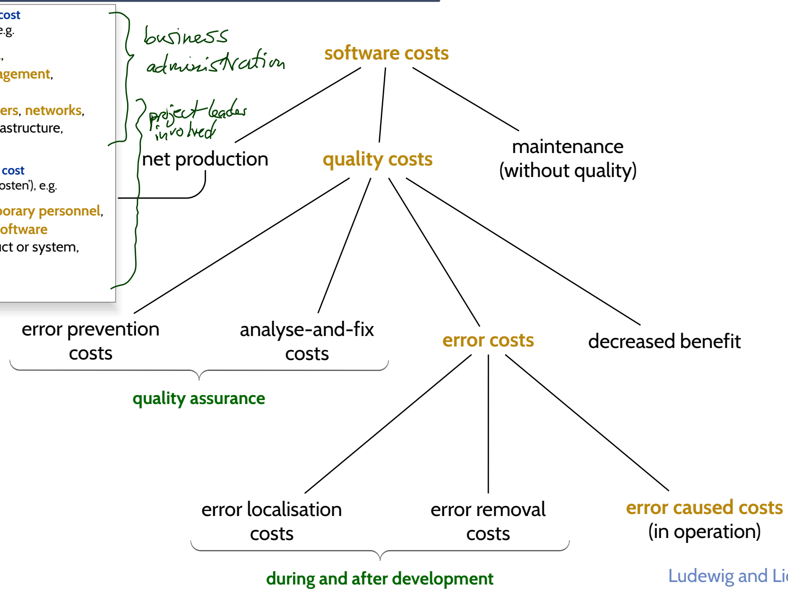
A Classification of Software Costs

Distinguish **current cost** ('laufende Kosten'), e.g.

- fixed **personnel**,
- (business) **management**, **marketing**,
- **rooms**, **computers**, **networks**, **software** as infrastructure,
- …

and **project-related cost** ('projektbezogene Kosten'), e.g.

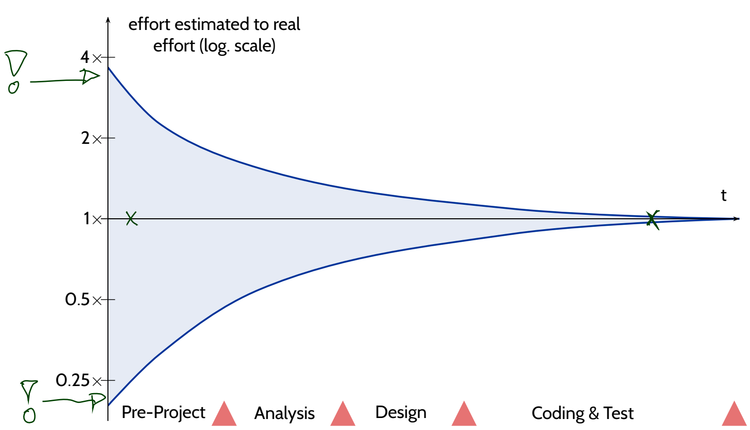
- additional **temporary personnel**,
- **hardware and software** as part of product or system,
- **contract costs**,
- …



Ludewig and Lichter (2013)

– 3 – 2019-05-02 – Sswcostest –

The "Estimation Funnel"



Uncertainty with estimations (following (Boehm et al., 2000), p. 10).

Visualisation: Ludewig and Lichter (2013)

– 3 – 2019-05-02 – Sswcostest –

Approaches to Software Cost Estimation

- **Expert's Estimation**

  For example,

  - **Delphi Method**

- **Algorithmic Estimation**

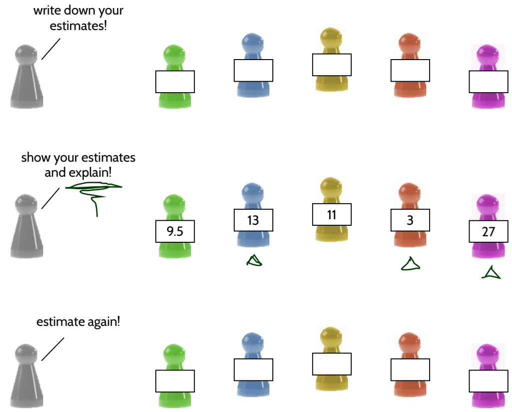
  For example,

  - **COCOMO**
  - **Function Points**

Expert's Estimation

One approach: the **Delphi** method.

- Step 1:
- Step 2:
- Step 3:



- Then take the median, for example.

Algorithmic Estimation: COCOMO

Algorithmic Estimation: COCOMO

- **Co**nstructive **Co**st **Mo**del:
  Formulae which fit a huge set of archived project data (from the late 70's).
- Flavours:
  - COCOMO 81 (Boehm, 1981): variants **basic**, **intermediate**, **detailed**
  - COCOMO II (Boehm et al., 2000)
- All flavours are based on estimated program size S measured in DSI (Delivered Source Instructions) or kDSI (1000 DSI).
- Factors like security requirements or experience of the project team are mapped to values for parameters of the formulae.

- COCOMO examples:
  - textbooks like Ludewig and Lichter (2013) (most probably made up)
  - an exceptionally large example:
    COCOMO 81 for the Linux kernel (Wheeler, 2006) (and follow-ups)

COCOMO 81

Characteristics of the Type				a	b	Software Project Type
Size	Innovation	Deadlines/ Constraints	Dev. Environment			
Small (<50 KLOC)	Little	Not tight	Stable	3.2	1.05	Organic
Medium (<300 KLOC)	Medium	Medium	Medium	3.0	1.12	Semi-detached
Large	Greater	Tight	Complex HW/ Interfaces	2.8	1.20	Embedded

estimation

10^3 delivered source instruction

Basic COCOMO:

- **effort required**: $E = a \cdot (S/kDSI)^b$ [PM (person-months)]
- **time to develop**: $T = c \cdot E^d$ [months]
- **headcount**: $H = E/T$ [FTE (full time employee)]
- **productivity**: $P = S/E$ [DSI per PM] (← use to check for **plausibility**)

Intermediate COCOMO:

$$E = M \cdot a \cdot (S/kDSI)^b \quad \text{[person-months]}$$

$$M = RELY \cdot CPLX \cdot TIME \cdot ACAP \cdot PCAP \cdot LEXP \cdot TOOL \cdot SCED$$

COCOMO 81: Some Cost Drivers

$$M = RELY \cdot CPLX \cdot TIME \cdot ACAP \cdot PCAP \cdot LEXP \cdot TOOL \cdot SCED$$

	factor	very low	low	normal	high	very high	extra high
RELY	required software reliability	0.75	0.88	1	1.15	1.40	
CPLX	product complexity	0.70	0.85	1	1.15	1.30	1.65
TIME	execution time constraint			1	1.11	1.30	1.66
ACAP	analyst capability	1.46	1.19	1	0.86	0.71	
PCAP	programmer capability	1.42	1.17	1	0.86	0.7	
LEXP	programming language experience	1.14	1.07	1	0.95		
TOOL	use of software tools	1.24	1.10	1	0.91	0.83	
SCED	required development schedule	1.23	1.08	1	1.04	1.10	

- **Note**: what, e.g., "extra high" TIME means, may depend on project context. (Consider data from previous projects.)

COCOMO II (Boehm et al., 2000)

Consists of

- **Application Composition Model** – project work is configuring components, rather than programming
- **Early Design Model** – adaption of **Function Point** approach (in a minute); does not need completed architecture design
- **Post-Architecture Model** – improvement of **COCOMO 81**; needs completed architecture design, and size of components estimatable

COCOMO II: Post-Architecture

$$E = 2.94 \cdot S^X \cdot M$$

- **Program size**: $S = (1 + REVL) \cdot (S_{new} + S_{equiv})$
  - **requirements volatility** $REVL$:
    e.g., if new requirements make 10% of code unusable, then $REVL = 0.1$
  - S_{new}: estimated size minus size w of **re-used code**,
  - $S_{equiv} = w/q$, if writing new code takes q-times the effort of re-use.
- **Scaling factors**:
  $X = \delta + \omega, \quad \omega = 0.91, \quad \delta = \frac{1}{100} \cdot (PREC + FLEX + RESL + TEAM + PMAT)$

	factor	very low	low	normal	high	very high	extra high
PREC	**precedentness** (experience with similar projects)	6.20	4.96	3.72	2.48	1.24	0.00
FLEX	**development flexibility** (development process fixed by customer)	5.07	4.05	3.04	2.03	1.01	0.00
RESL	**Architecture/risk resolution** (risk management, architecture size)	7.07	5.65	4.24	2.83	1.41	0.00
TEAM	**Team cohesion** (communication effort in team)	5.48	4.38	3.29	2.19	1.10	0.00
PMAT	**Process maturity** (see CMMI)	7.80	6.24	4.69	3.12	1.56	0.00

COCOMO II: Post-Architecture Cont'd

$$M = RELY \cdot DATA \cdot \cdots \cdot SCED$$

group	factor	description
Product factors	RELY	required software reliability
	DATA	size of database
	CPLX	complexity of system
	RUSE	degree of development of reusable components
	DOCU	amount of required documentation
Platform factors	TIME	execution time constraint
	STOR	memory consumption constraint
	PVOL	stability of development environment
Team factors	ACAP	analyst capability
	PCAP	programmer capability
	PCON	continuity of involved personnel
	APEX	experience with application domain
	PLEX	experience with development environment
	LTEX	experience with programming language(s) and tools
Project factors	TOOL	use of software tools
	SITE	degree of distributedness
	SCED	required development schedule

(also in COCOMO 81, new in COCOMO II)

Algorithmic Estimation: Function Points

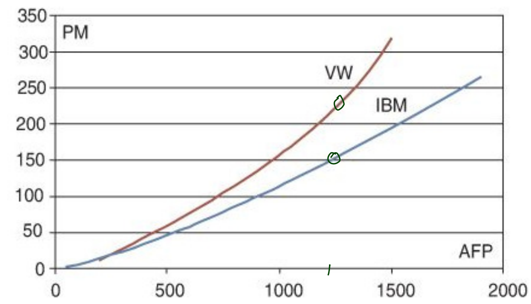
Algorithmic Estimation: Function Points

Type	Complexity low	medium	high	Sum
input	____ $\cdot 3 =$	____ $\cdot 4 =$	____ $\cdot 6 =$	
output	____ $\cdot 4 =$	____ $\cdot 5 =$	____ $\cdot 7 =$	
query	____ $\cdot 3 =$	____ $\cdot 4 =$	____ $\cdot 6 =$	
user data	____ $\cdot 7 =$	____ $\cdot 10 =$	____ $\cdot 15 =$	
reference data	____ $\cdot 5 =$	____ $\cdot 7 =$	____ $\cdot 10 =$	
Unadjusted function points		UFP		
Value adjustment factor		VAF		
Adjusted function points		AFP = UFP · VAF		

UFP

$$VAF = 0.65 + \frac{1}{100} \cdot \sum_{i=1}^{14} GSC_i,$$

$$0 \leq GSC_i \leq 5.$$



IBM and VW curve for the conversion from AFPs to PM according to (Noth and Kretzschmar, 1984) and (Knöll and Busse, 1991).

Type	Co			
	low	me		
input	$\_\_\_\_ \cdot 3 =$	$\_\_\_\_$		
output	$\_\_\_\_ \cdot 4 =$	$\_\_\_\_$		
query	$\_\_\_\_ \cdot 3 =$	$\_\_\_\_$		
user data	$\_\_\_\_ \cdot 7 =$	$\_\_\_\_$		
reference data	$\_\_\_\_ \cdot 5 =$	$\_\_\_\_ \cdot 7 =$	$\_\_\_\_ \cdot 10 =$	
Unadjusted function points		UFP		
Value adjustment factor		VAF		
Adjusted function points		AFP = UFP · VAF		

$$VAF = 0.65 + \frac{1}{100} \cdot \sum_{i=1}^{14} GSC_i,$$

$$0 \leq GSC_i \leq 5.$$

Discussion

Cost Estimation is Everywhere

- For example: **Bachelor's Thesis**

  Estimation Task: Which results can I promise to deliver in 3 months time?

- **Suggestion**: start to **quantify** your experience **now**.
  - **Take notes on your projects**:
    (e.g., Softwarepraktikum, Bachelor Projekt, Bachelor's Thesis, Master Projekt, Master's Thesis, …)
    - timestamps,
    - size of program created,
    - number of errors found,
    - number of pages written,
    - etc. …
  - **Try to identify factors**: what hindered productivity, what boosted productivity, …
  - Which **detours and mistakes** were **avoidable** in hindsight? How?

Content

Project

Vocabulary: Project

project – A **temporary activity** that is characterized by **having**

- a **start date**,
- specific **objectives and constraints**,
- established **responsibilities**,
- a **budget and schedule**, and
- a **completion date**.

If the objective of the project is to develop a software system, then it is sometimes called a **software development project** or **software engineering project**. **R. H. Thayer** (1997)

We could refine our earlier definition as follows: a project is **successful** if and only if

- **started** at start date,
- **achieved** objectives,
- **respected** constraints,
- **adheres** to budget and schedule,
- **stops** at completion date.

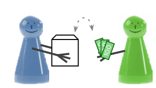
Whether, e.g., objectives have been achieved can still be **subjective** (→ customer/user happy).

Project Management

Goals of Project Management

- **Main and general goal**:
  Have a **successful** project,
  i.e. the project delivers
  - defined **results**
  - in demanded **quality**
  - within scheduled **time**
  - using the assigned **resources**.

  There may be **secondary goals**, e.g.,
  - build or strengthen good **reputation** on market,
  - acquire **knowledge** which is useful for later projects,
  - develop **re-usable components** (to save resources later),
  - be attractive to **employees**.
  - …



Common Activities of Project Management

Without plans, a project cannot be managed.
Note: mistakes in planning can be hard to resolve.

Distribute information between project participants (project owner, customer, developers, administration).

Work results and project progress have to be **assessed** and **compared to the plans**; it has to be observed whether participants stick to agreements.

- **Planning**
- **Assessment and Control**
- **Recognising and Fighting Difficulties as Early as Possible**

- **Communication**
- **Leading and Motivation of Employees**
- **Creation and Preservation of Beneficial Conditions**

Leading means: going ahead, showing the way, "pulling" the group.
Most developers want to achieve good results, yet need orientation and feedback (negative **and** positive).

Unforeseen difficulties and problems in projects are not exceptional but usual.
Therefore, project management needs to constantly "screen the horizon for icebergs", and, when spotting one, react timely and effectively.
In other words: **systematic risk management**.

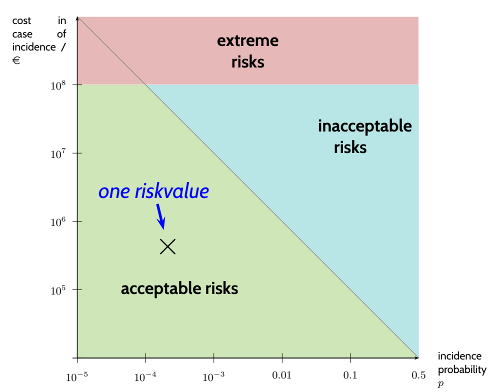
Provide necessary **infrastructure** and **working conditions** for developers
(against: demanding customers, imprecisely stated goals, organisational restructuring, economy measures, tight office space, other projects, etc.).

Quick Excursion: Risk and Riskvalue

> **risk** – a problem, which did not occur yet, but on occurrence threatens important project goals or results. Whether it will occur, cannot be surely predicted.
>
> **Ludewig & Lichter (2013)**

$$\text{riskvalue} = p \cdot K$$

p: **probability** of problem occurrence,
K: **cost** in case of problem occurrence.



- **Avionics** requires: "Catastrophic Failure Conditions have Average Probability per Flight Hour of 10^{-9} (or 'Extremely Improbable')" (AC 25.1309-1).
- "problems with $p = 0.5$ are not risks, but environment conditions to be dealt with"

Content

Software Development Process

Vocabulary: Software Project

(Software) Project – Characteristics:

- **Duration** is limited.
- Has an **originator** (person or institution which initiated the project).
  - The **project owner** is the originator or its representative.
  - The **project leader** reports to the project owner.
- Has a **purpose**, i.e. pursues a bunch of goals.
  - The most important goal is usually to create or modify software; this software is thus the result of the project, the **product**.

    Other important goals are extension of know-how, preparation of building blocks for later projects, or utilisation of employees.

  The project is called **successful** if the goals are reached to a high degree.
- Has a **recipient** (or will have one).
  - This recipient is the **customer**.
  - Later **users** (conceptionally) belong to the customer.
- **Connects** **people**, **results** (intermediate/final products), and **resources**.

  The **organisation** determines roles of and relations between peoples/results/resources, and the **external interfaces** of the project.

Ludewig & Lichter (2013)

Process

Process –

(1) A sequence of steps performed for a given purpose; for example, the software development process.

(2) See also: task; job.

(3) To perform operations on data.

IEEE 610.12 (1990)

Software Development Process –
The process by which user needs are translated into a software product.
The process involves **translating** user needs into **software requirements**, **transforming** the software requirements into **design**, **implementing** the design in **code**, **testing** the code, and sometimes, **installing and checking out** the software for **operational use**.

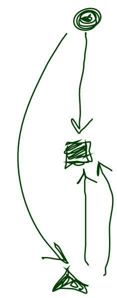
IEEE 610.12 (1990)

- The **process** of a software development **project** may be
  - implicit,
  - informally agreed on, or
  - explicitly prescribed (by a **procedure** or **process model**).
- **Note**: each software development project **has** a process!

Describing Software Development Processes

Over time, the following **notions** proved useful to describe and model (→ in a minute) software development processes:

- **role** – has responsibilities and rights, needs skills and capabilities.
  In particular: has responsibility for **artefacts**, participates in **activities**.
- **artefact** (or **product**) – all documents, evaluation protocols, software modules, etc.; all products emerging during a development process.
  Is processed by **activities**, may have **state**.
- **activity** – any processing of artefacts, manually or automatic; solves tasks.
  Depends on **artefacts**, creates/modifies **artefacts**.



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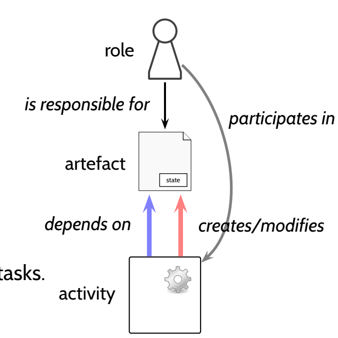
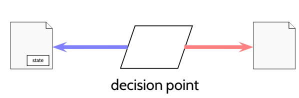


- **decision point** – special case of activity: a decision is made based on **artefacts** (in a certain state), creates a **decision artefacts**.
  Delimits phases, may **correspond to milestone**.



The Concept of Roles

In a software project, at each point in time,
there is a set R of (active) **roles**, e.g. $R = \left\{ \boxed{\text{mgr}}, \boxed{\text{prg}}, \boxed{\text{tst}}, \boxed{\text{ana}} \right\}$.

A role has **responsibilities** and **rights**, and necessary skills and capabilities.

For example,

- $\boxed{\text{mgr}}$: project manager
  - has the **right** to raise issue reports
  - is **responsible** for closing issue reports
- $\boxed{\text{prg}}$: programmer
  - has the **right** to change the code
  - is **responsible** for reporting unforeseen problems to the project manager
  - is **responsible** for respecting coding conventions
  - is **responsible** for addressing issue reports
- $\boxed{\text{tst}}$: test engineer
  - has the **right** to raise issue reports
  - is **responsible** for quality control

The Concept of Roles Cont'd

Given a set R of roles, e.g. $R = \left\{ \boxed{\text{mgr}}, \boxed{\text{prg}}, \boxed{\text{tst}}, \boxed{\text{ana}} \right\}$,
and a set P of people, e.g. $P = \{$  $\}$, each with **skills** or **capabilities**.

An aspect of project management is to assign (a set of) people to each role:

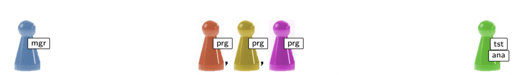
$$assign : R \to 2^P$$

such that each person $p \in assign(r)$ assigned to role r
has (at least) the skills and capabilities required by role r.

Note: $assign$ may change over time, there may be different assignments for different phases.

Sanity check: ensure that $assign(r) \neq \emptyset$ for each role r.

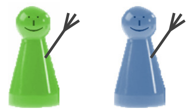
- **Example**:



one person, one role — multiple persons, one role — one person, multiple roles

$assign = \{ \boxed{\text{mgr}} \mapsto \{$  $\}, \boxed{\text{prg}} \mapsto \{$  $\}, \boxed{\text{tst}} \mapsto \{$  $\}, \boxed{\text{ana}} \mapsto \{$  $\} \}$

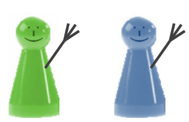
Useful and Common Roles

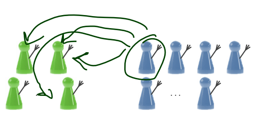


Recall: **roles** "Customer" and "Developer" are assumed by **legal persons**, which often represent many people.

The same legal person may act as "Customer" and "Developer" in the same project.

Useful and Common Roles





Recall: **roles** "Customer" and "Developer" are assumed by **legal persons**, which often represent many people.

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Useful and common roles in software projects:

- **customer**, **user**
- **project manager**
- **(sytems) analyst**
- **software architect**, **designer**
- (**lead**) **developer**
  programmer, **tester**, ...
- **maintenance engineer**
- **systems administrator**
- **invisible clients**: legislator, norm/standard supervisory committee

Describing Software Development Processes

Over time, the following **notions** proved useful to describe and model (→ in a minute) software development processes:

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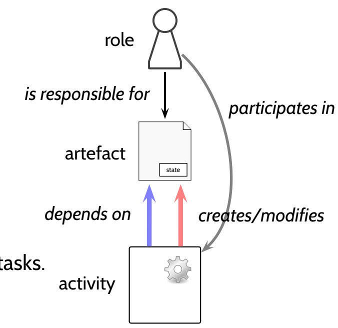

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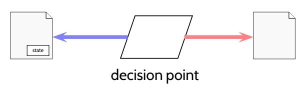
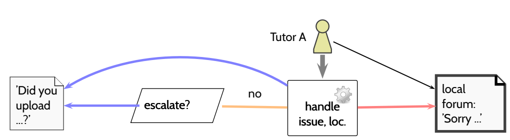


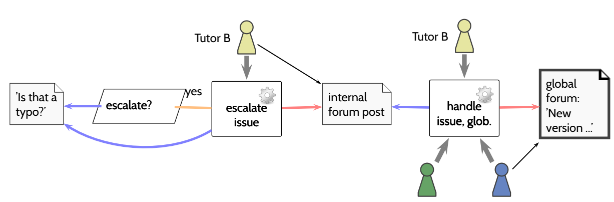
Describe Processes

Example: Forum Work of the Course

- A particular post is handled locally by Tutor A:
  - Friday, 2019-05-10, 19:37: a new post appears in the group forum: 'Did you upload the notes?'
  - 20:03: Tutor A decides that the issue can be handled locally (by uploading the forgotten notes);
  - 20:21: Tutor A writes a local forum post 'Sorry, forgot! Thanks for reminding.'

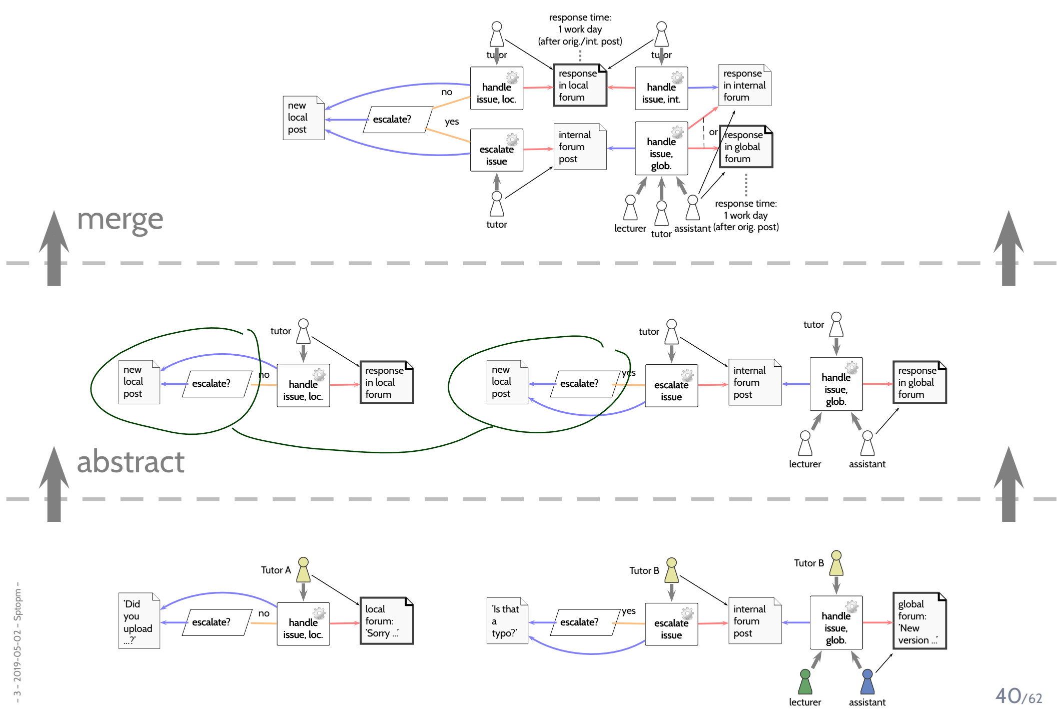


- A particular post needs to be escalated:
  - Monday, 2019-05-13, 14:01: a new post appears in the group forum: 'Is that a typo?'
  - Tuesday, 2019-05-14, 9:59: Tutor B decides that the issues needs to be escalated.
  - Tuesday, 2019-05-14, 10:03: Tutor B writes a post to the internal forum
  - Tuesday, 2019-05-14, 12:47: Teaching Assistant contacts Lecturer
  - …
  - Tuesday, 2019-05-14, 13:59: Teaching Assistant writes a global posts 'New version is uploaded, sorry.'

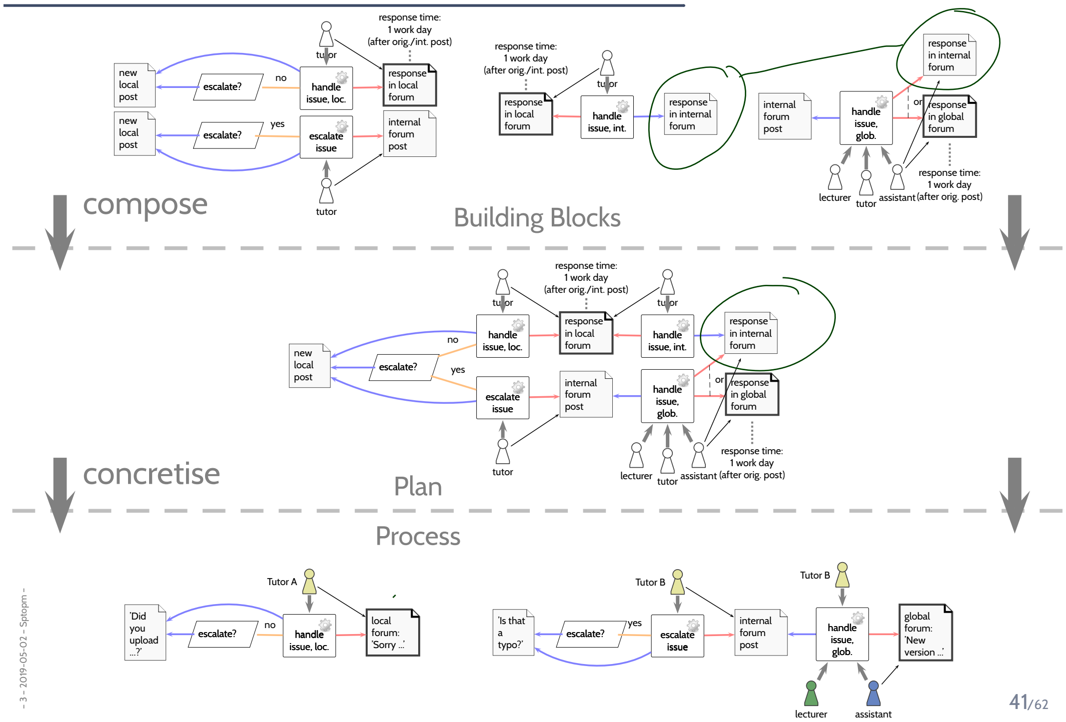


Software Project Planning: Process Modelling

From Concrete Process to Process Model



From Process Model to Concrete Process

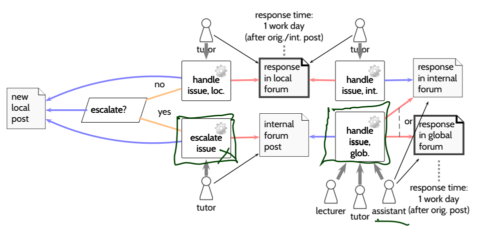


How to Read a Process Model

- A **process model** (as discussed so far) **defines dependencies**.

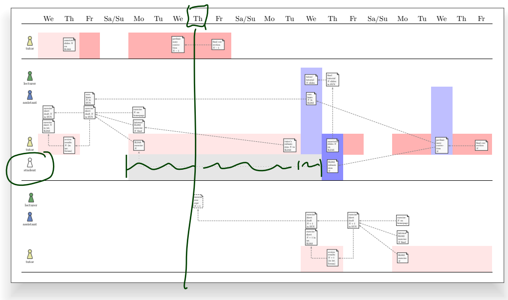
  → which artefacts needs to be available **before starting** which activity.
- A **process model does not**
  - define when (date/time) an activity starts.
  - say that Activity A must be completed before (depending) Activity B.

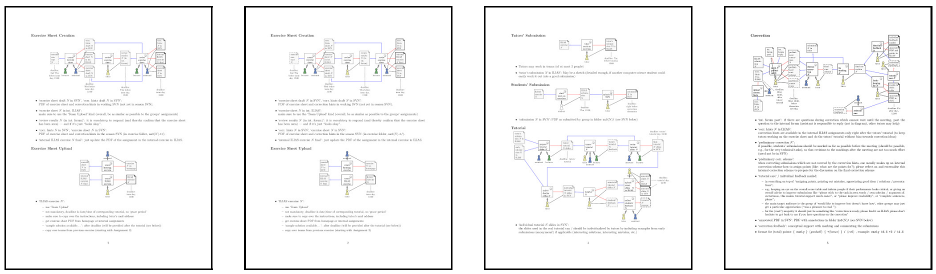
Example:



- Tuesday, 2019-05-14, 10:03: Tutor B writes a post to the internal forum:
  "This is what I know so far. I'll get back to the students and post more information later."
  → Activity '**escalate issue**' **started** (and **continues**)
- Tuesday, 2019-05-14, 12:47: Teaching Assistant contacts Lecturer
  → Activity '**handle issue glob.**' **started** (and **continues**)
- Tuesday, 2019-05-14, 12:54: Tutor B posts further information
  → Activity '**escalate issue**' **continues** (Tutor B is available for further questions)
- Tuesday, 2019-05-14, 13:03: Teaching Assistant writes to Tutor B: "Okay, thanks, we got it."
  → Activity '**escalate issue**' **completed**.

Example: Process Model of Tutorials





Tell Them What You've Told Them. . .

- Cost Estimation
  - It's about **experience** (and based on data obtained with metrics), and often a **well-kept business secret**.
  - **Algorithmic Cost Estimations** "just" **shift** the estimation.
  - Cost estimation is **everywhere** (→ tutorials).
- **Project** has (among others)
  - **project owner** and **leader**; **goals** (Excursion: **Risk**)
  - **process** – each project has one
- A **process model** relates
  - **roles**, **artefacts**, **activities**, **decision points**
  - relations: **responsibility**, **dependency**, **creation/modification**.
- **Use** process models
  - **descriptive** ("we did it like that"), or
  - **prescriptive** ("please do it like that")
- A process model can allow us to (→ exercises)
  - devise a **schedule** ('who does what when')
  - estimate and control **phases** and **deadlines**.
- Distinguish **process** and **procedure model**.

References

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