

Chapter 9



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Chapter 9: Process and Function Modeling

DTU course 02264

Agenda

Abstract

- In this chapter, we will complement models of system structures and information items by description of processes, that is, behaviors that occur across entities and sub-systems rather than within them.
- We will use Activity diagrams to describe such processes.
- We will also discuss layout of diagrams and consistency of models.

Contents

1. Business Process Overviews
2. Business Process Details
3. Business Process Templates
4. Business Rules
5. Organizational Structure
6. Alternative Process Modeling Notations



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Chapter 9.1:

Business Process Overviews

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Process Models

- **In information models, one may express a limited degree of behavior by**
 - adding operations to classes documenting the services they offer, and by
 - adding state machines to express the relationships between these services.
- **In system structure models, the black-box behavior of subsystems could be specified by**
 - protocol roles, i.e., protocol state machines, and
 - protocol interactions, i.e., interaction models between protocol roles.
- **With process models, we allow modeling of crosscutting behavior, that is, behavior not contained in one entity, and not restricted to the outside of subsystems.**
 - Unlike state machine models, process models may be concurrent and distributed, that is, they have the capacity to capture the behavior of several cooperating entities.

Business Processes

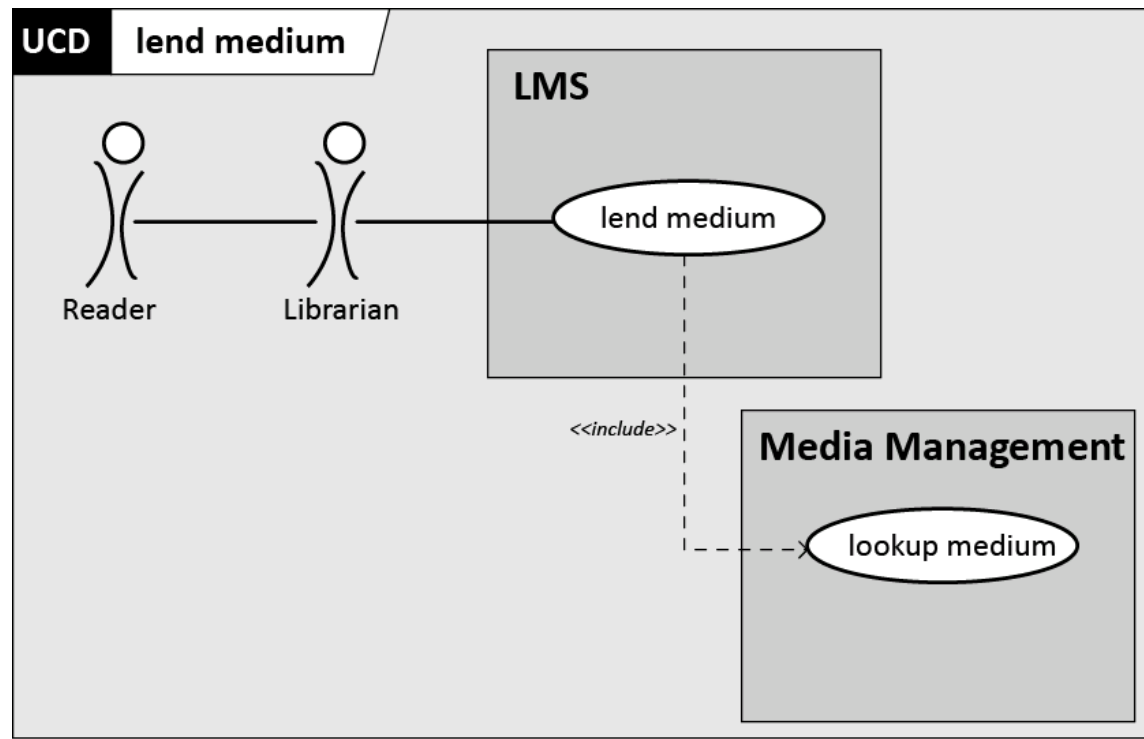
- **Any organization carries out some activities which by convention are called business processes.**
 - Business process modeling abstracts from concrete instances of processes to process types.
 - “Stig Hansen leases copy #2 of ‘War & Peace’ on October, 1th, 2010” → “Lease medium”
- **In contrast to individual functions or services, business process typically have the following properties:**
 - they involve more than one person, possibly even several organizations, and often several different IT systems;
 - they may be interrupted and often last for considerable time (days or weeks), possibly up to decades (cf. life insurances);
 - they are rarely fully automatic but combine manual and automatic steps;
 - they often have many variants, special cases, and exceptions.
- **The ultimate purpose of all Information Systems is to support, improve, or automate (some of) these activities.**
- **Thus, understanding and capturing the organizational structure and the business processes is an important part of requirements engineering for information systems.**

Business Process Templates

- **While many organizations need explicit models of their processes, most of them have not achieved a high level of methodological sophistication.**
 - Often, it is too far out to do full-scale modeling as the first process modeling activity. It may be a lot easier to let people describe processes in plain text.
 - However, prose descriptions have many disadvantages (see e.g., chapter 6).
- **One straightforward and commonly encountered way of improving over prose descriptions of processes are templates.**
 - These templates look suspiciously like Use Case Templates – because they are just a special case (the RUP introduced the term “Business Use Cases”).
 - By extension, this means that UseCase Diagrams could be used as high-level descriptions of Business Process Landscapes.
 - In fact, Domain Architecture Diagrams are a variant of UseCase Diagrams.

Process Overview Models

- The use case diagrams are often quite simple. It is helpful to draw them anyway:
 - for inclusion in a report,
 - for allowing easier access to your models, and
 - because even these trivial diagrams do get complex in large models.
- Besides, if it is so simple, drawing it is no effort.
- One could call this diagram the local context of the process.



Collecting a Processes Directory

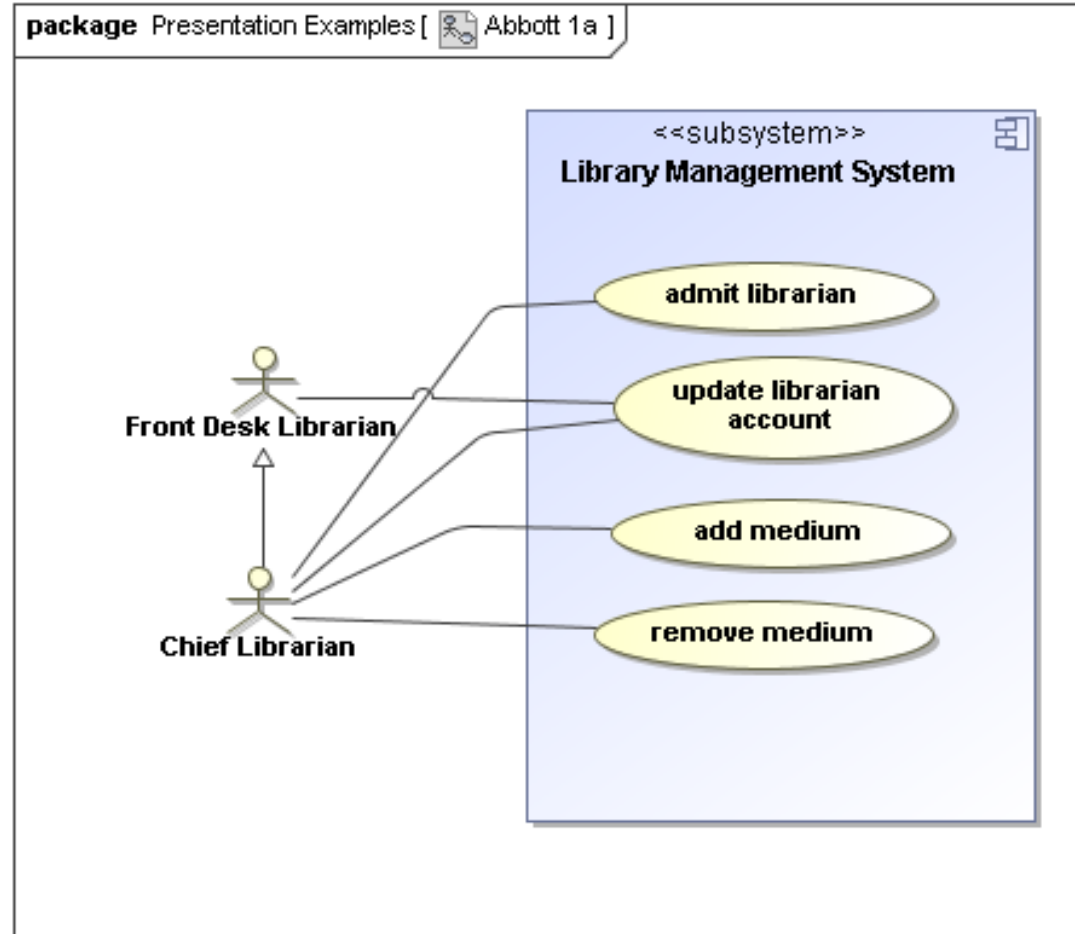
- **Eliciting the set of processes may be guided by the same techniques used for eliciting requirements:**
 - role plays and frequent validation with domain experts,
 - analysis of work & system processes, and
 - collecting individual traces to be abstracted later on.
- **In the classroom we can also go back to the usage scenario once more and mine it for systems, actors, and some of the processes.**
 - Since the scenario is written from a users point of view, the activities described there correlate pretty well to use cases.
- **Of course, we may also already have lists of the processes from earlier steps (i.e. the domain architecture) which provides a good starting point.**

Collecting a Processes Directory

- Consider once more the LMS usage scenario.

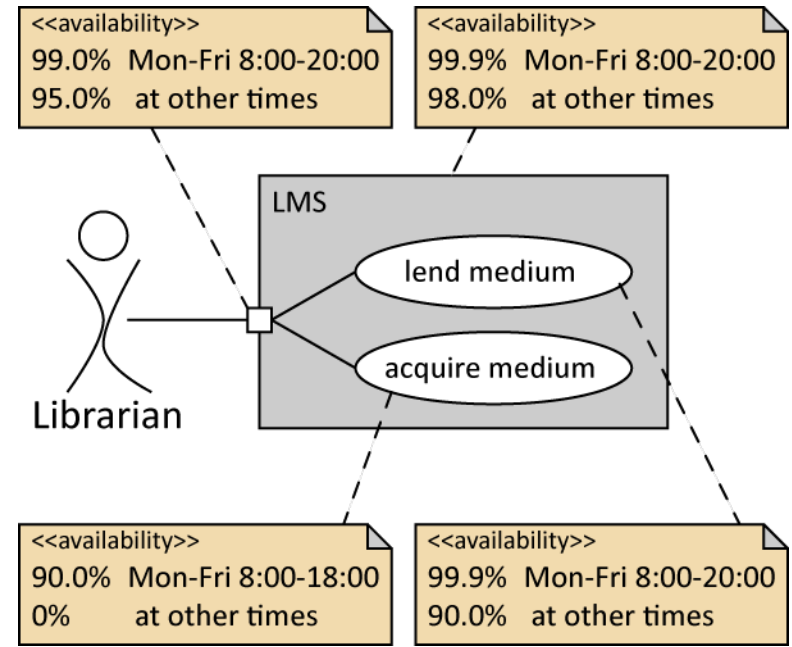
“Anders Nielsen, the **chief librarian** of the new Tarbaek Community Library (TCL), walks into the office on Monday morning. The first thing he does is to start **LMS, the Library Media System**, his main tool at work. Today, Bjarne Stroustrup is supposed to join the library staff as a new **front desk librarian**. Anders logs in to LMS, and creates a **new account** for Bjarne, [...]

[...] **buying new books**, and, sadly, **taking them out of the catalog** when they have been stolen, misplaced, or badly damaged.”



Specifying availability in models

- **Availability requirements may be specified using annotations of many UML model elements, e.g.**
 - (sub)systems → Component
 - services → Use Case
 - interfaces → Port
- **Appropriate UML profiles exist, but are largely ignored in practice.**
 - Availability requirements may simply be specified as comment boxes.
 - Similar annotations may be used to specify other reliability requirements, and in fact, other quality attributes.



- **In this example, the availability of „lend medium“ is much higher than of „acquire medium“ because the latter is not as urgent.**

Example Business Process (Overview)

BP_1	Admit New Reader	
Description	<i>A new reader is admitted to the library management system</i>	
Actors	<i>1: Reader 2: Librarian</i>	
Trigger	<i>Reader asks to be admitted at the front desk in person</i>	
Parameter	-	
Preconditions	-	
Regular Scenario	<div> <div> 1. <i>Personal data of new reader are entered and saved.</i> 2. <i>Due fees are paid, depending on business rules and reader type.</i> 3. <i>Reader card is printed, issued, and handed over.</i> </div> <div> Variants a) <i>Reader is not eligible (too young, can't be present in person etc.), but written proof of his/her and signed consent is presented. → proceed as normal</i> b) <i>Reader already has an account or had one in the past. → reactivate account if no fees are due.</i> </div> </div>	
Postconditions	<i>A new reader account is created. It's balance and loan record are empty, and the reader is entitled to take out media.</i>	
Result	-	
Incidence	<i>three times a day</i>	
Duration	<i>5 Minutes</i>	
References	-	
Remarks	-	

Example Business Process (Scenario)

- **Most reasonable business processes have a “regular” scenario (the normal case), and some variants (e.g., rare/exceptional cases, errors).**
- **Mostly individual steps must be refined, e.g. simply by indented text.**
- **Frequently, it is not clear to non-domain experts what level of refinement to use.**
 - As a general rule, it is better to cover all business processes in a given set breadth-first, i.e., maintaining approximately the same degree of detail.
 - Different purposes may require different levels of refinement (e.g., make vs. buy).
- **On the right, we refine the draft scenario shown before.**

1. Personal data of new reader are entered and saved.
2. Due fees are paid, depending on business rules and reader type.
3. Reader card is printed, issued, and handed over.

Refine

1. Personal data of new reader are entered and saved.
 1. Create new Reader in Database.
 2. Enter Name, Address, and Birthday.
 3. Ask for and enter account type.
 4. Save new Reader record.
2. Due fees are paid, depending on business rules and reader type.
 1. Determine discounts (age, employment status).
 2. Compute admission fee.
 3. Collect fee from client reader and book into system.
3. Reader card is printed, issued, and handed over.
 1. Print reader card body.
 2. Stamp and sign.
 3. Laminate card.
 4. Print application/receipt form.
 5. Let reader sign, file signed receipt.
 6. Hand out card.

Business Process Networks

- **Business processes usually involve several parties/organizations, who see only part of the overall business, and perceive the same process quite differently.**
 - Consider buying something in an online shop, and how the different roles see different parts.

Perspective	Normal Scenario	Exceptions
Buyer	find product in catalog order product receive shipment & bill pay bill	out of stock Wrong/unwanted product product damaged no/late delivery
Retailer	receive order ship product receive payment	out of stock no/late payment shipment returned because of...
Mail Provider	accept package transport package deliver package	package damaged package lost package not accepted no receiver at address



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Chapter 9.2:

Business Processes Details

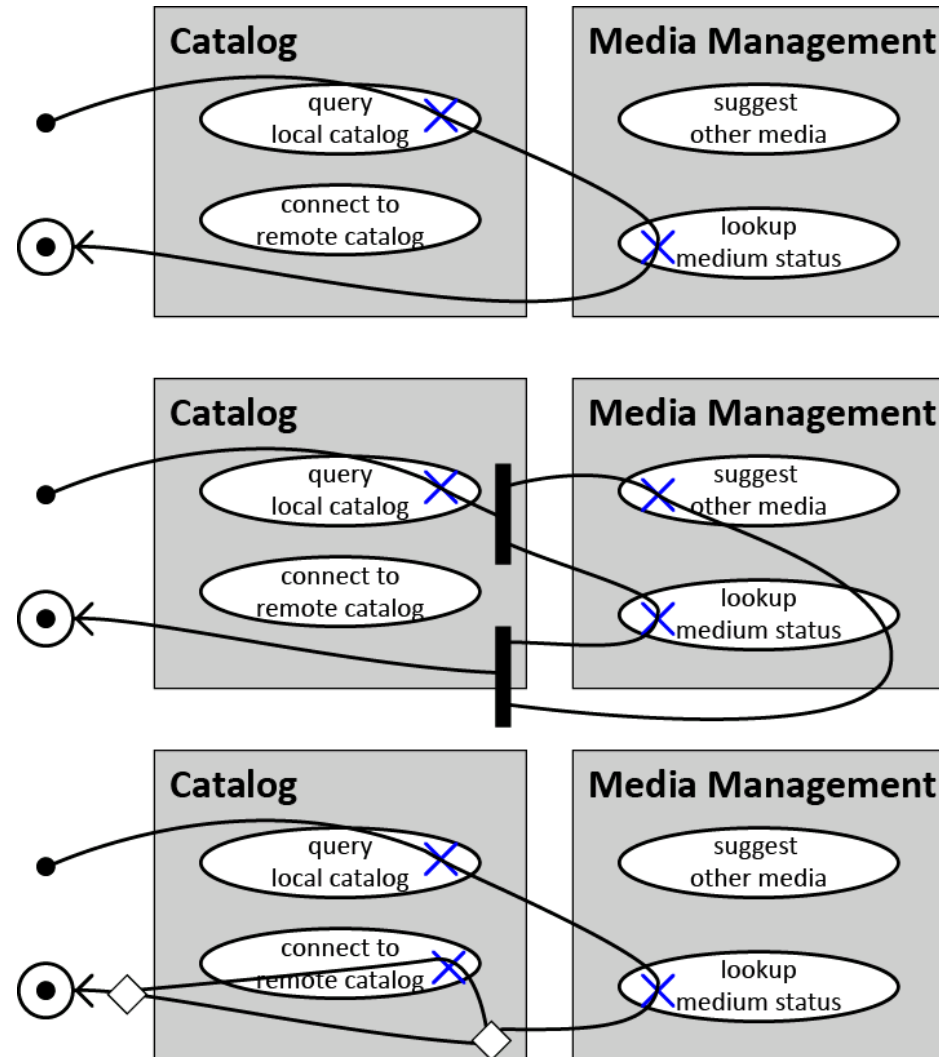
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Describing flows of business processes

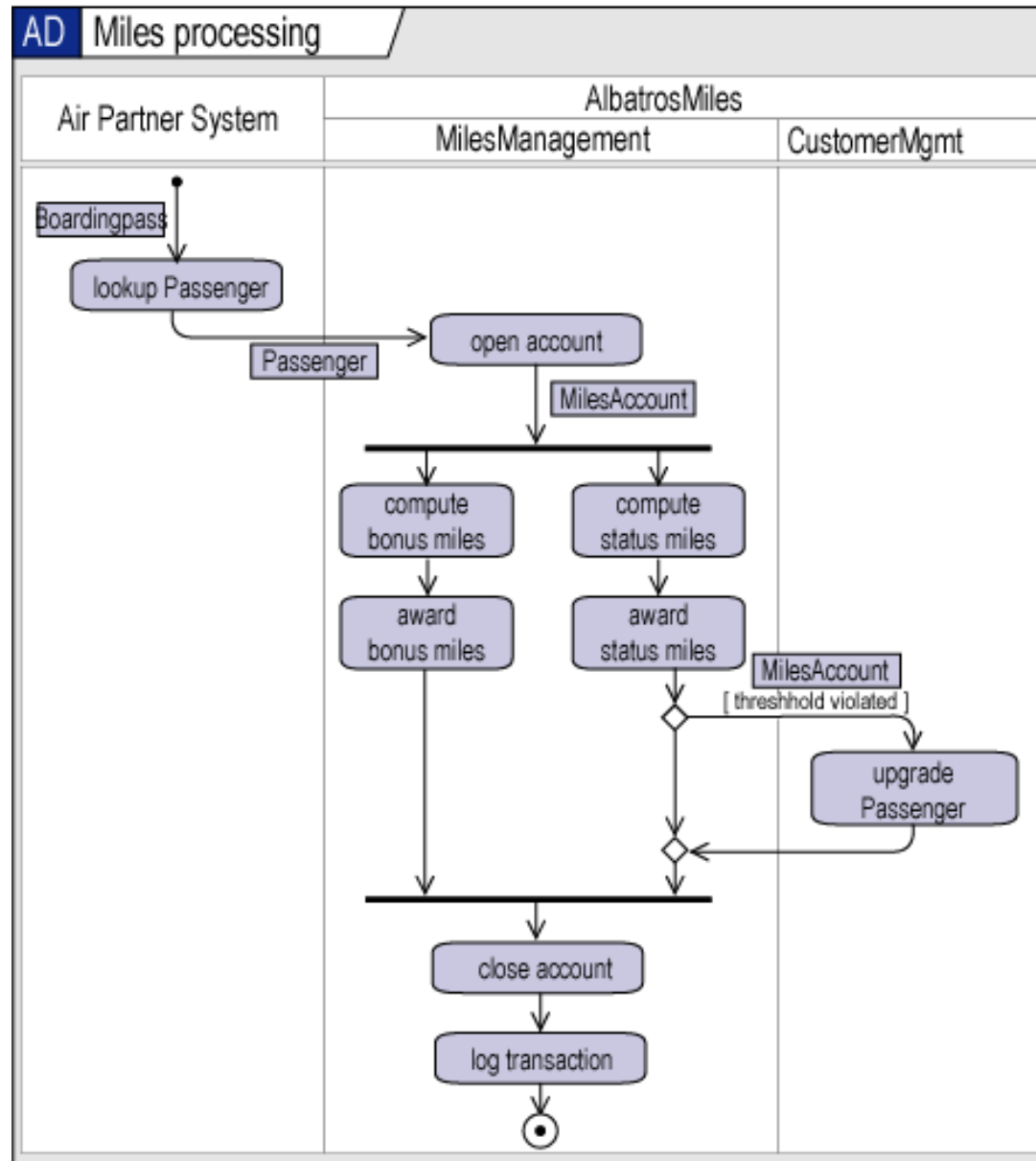
- **Getting the right flows is probably the single most tricky task in modeling.**
 - Many notations have been proposed, and are used in various places.
- **Among the many problems are these:**
 - There may be very many variants of the process, some of which may be necessary, and some of which should be discarded – but which are which?
 - Distributing a big process over a tree of refinements is difficult, and changing it afterwards (i.e., refactoring of models) is not well supported by (all?) tools (including MagicDraw).
 - The notation of UML activity diagrams has great expressive power which makes it difficult to use in appropriate ways for novices and casual users.
 - There is no clear criterion where to stop the refinement, because as of 2012, there is no execution semantics for Activities (though that might change with ALF).

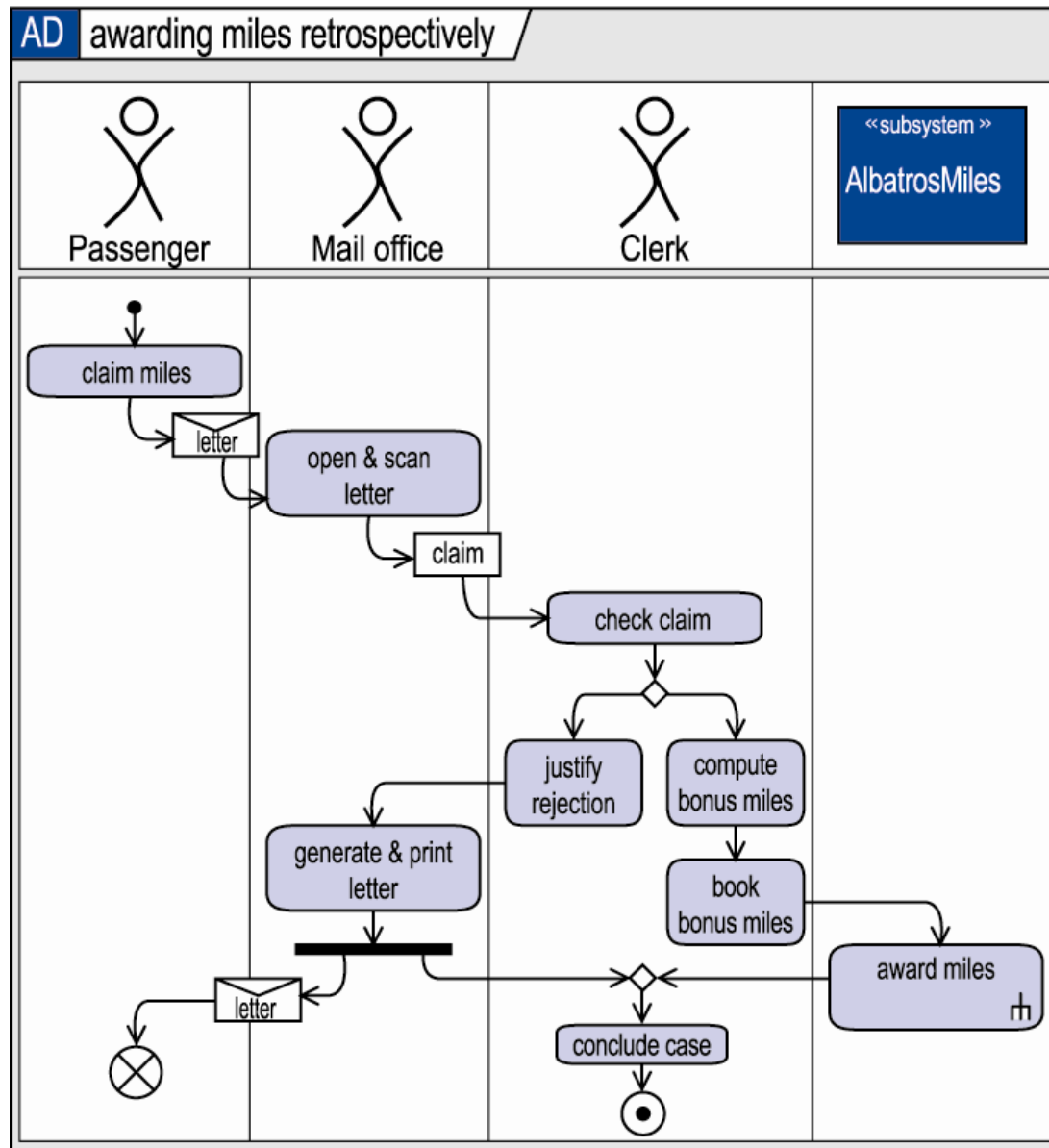
Use Case Maps

- **Use Case Maps project flows onto domain architectures.**
 - This way, the system structure and interfaces are emphasized
- **They feature the basic concepts known from activity diagrams:**
 - start/end points, and and/xor-joins;
 - Swimlanes are replaced by the responsible system as such;
 - Actions along a flow are replaced by the system's use cases.
- **To the right, 3 flows are shown that**
 - query, then lookup status of medium
 - query medium, then simultaneously suggest other media and lookup status,
 - query medium, then alternatively connect to remote catalog and lookup status.
- **The blue crosses denote points of responsibility.**

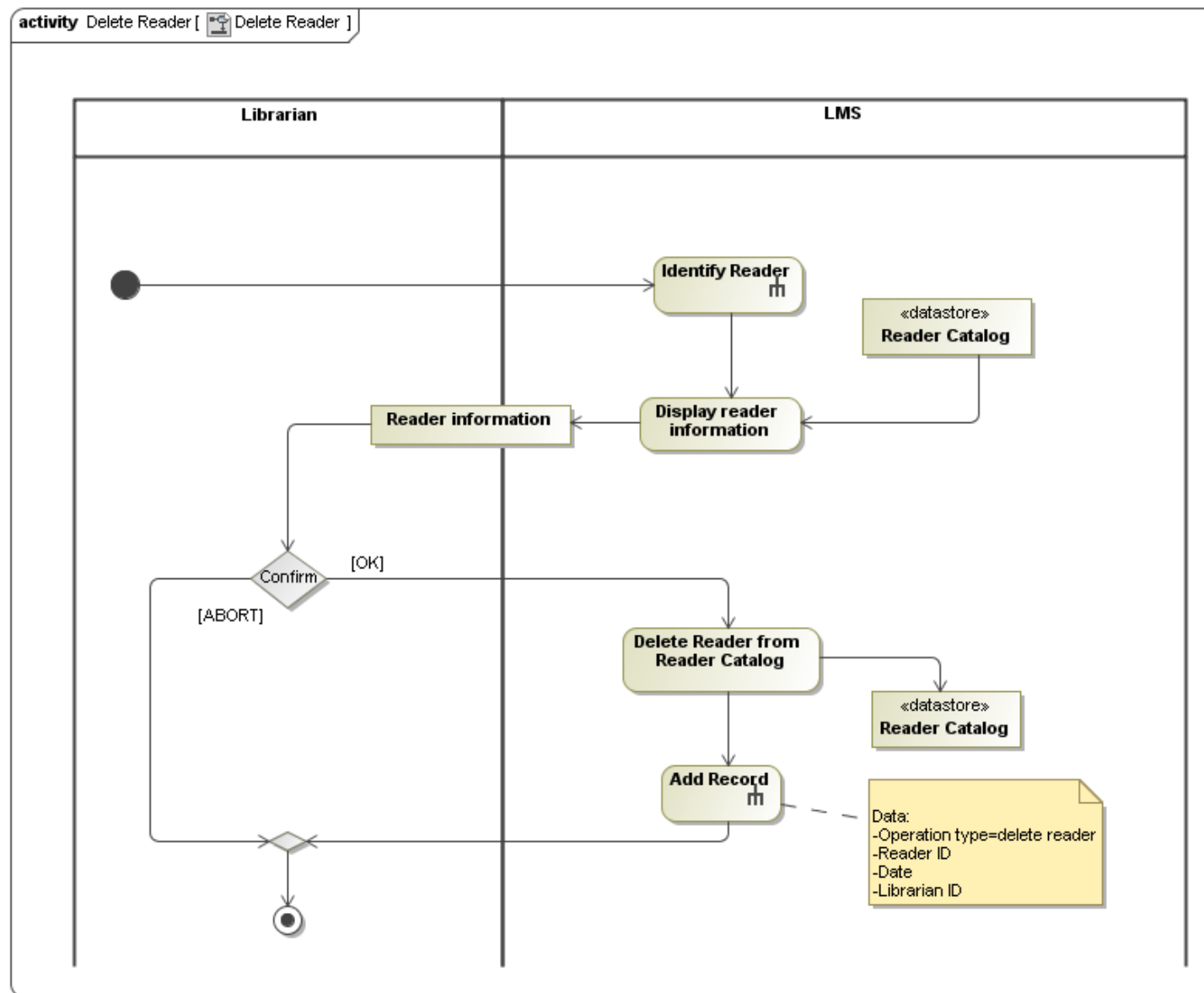


Partitions (“Swimlanes”)

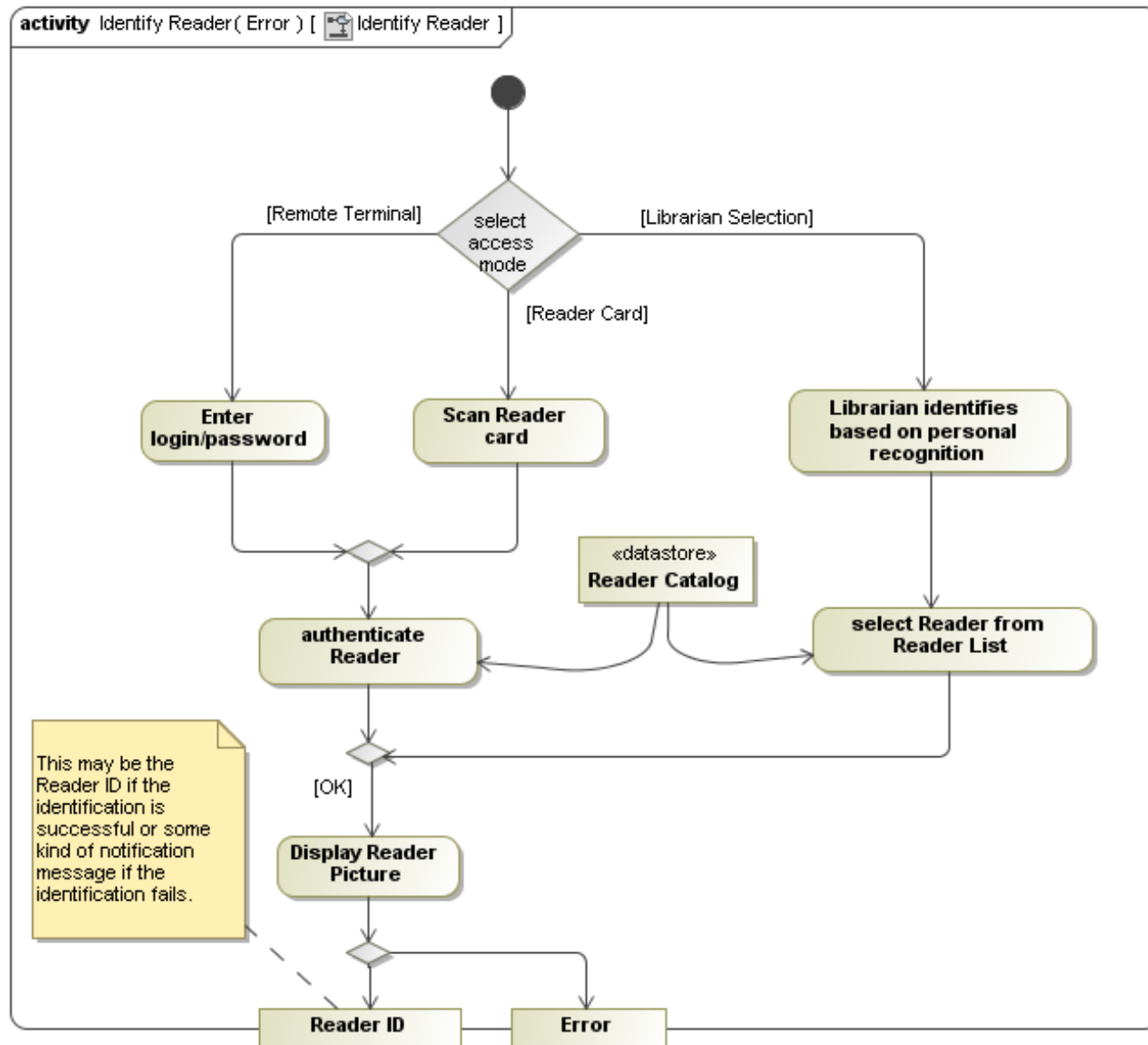




Wanted Implicit Synchronization

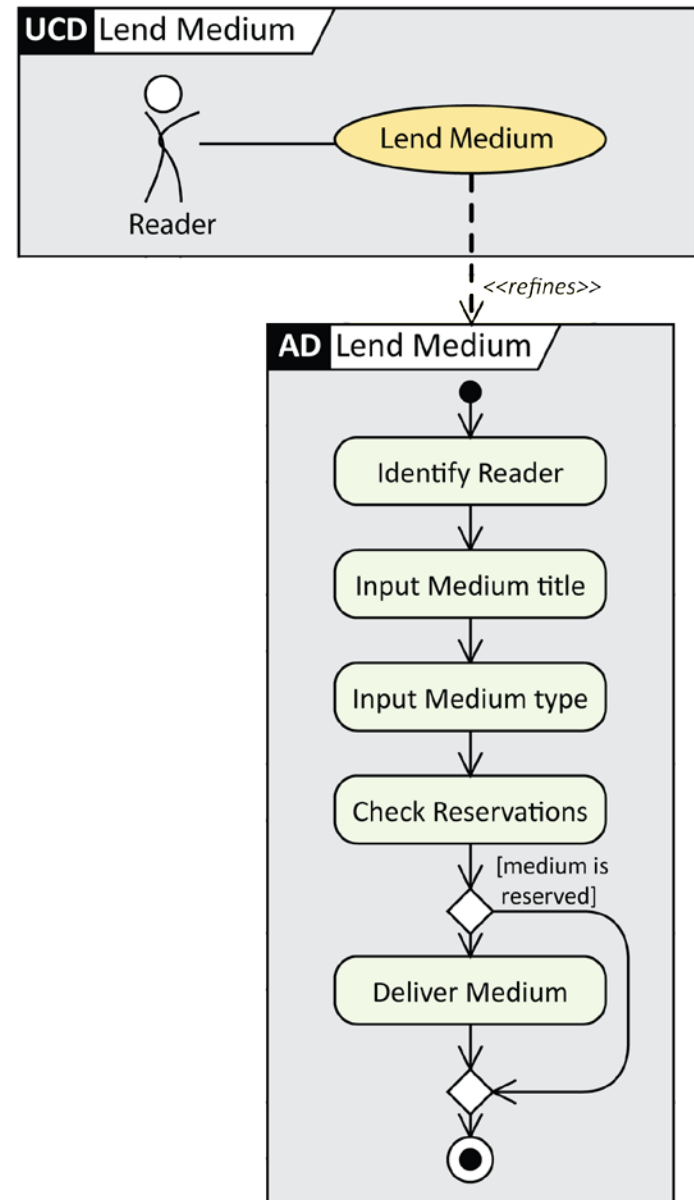


No Implicit Synchronization



Structuring Process Models

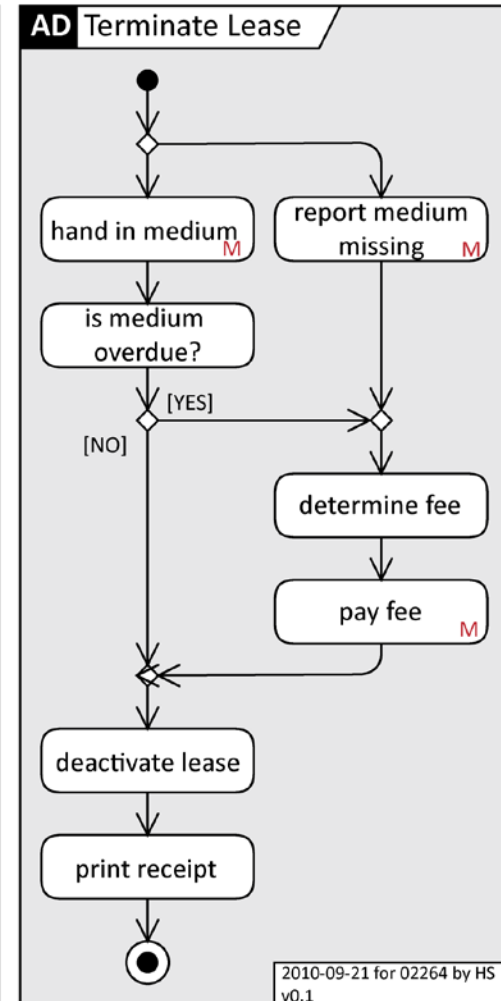
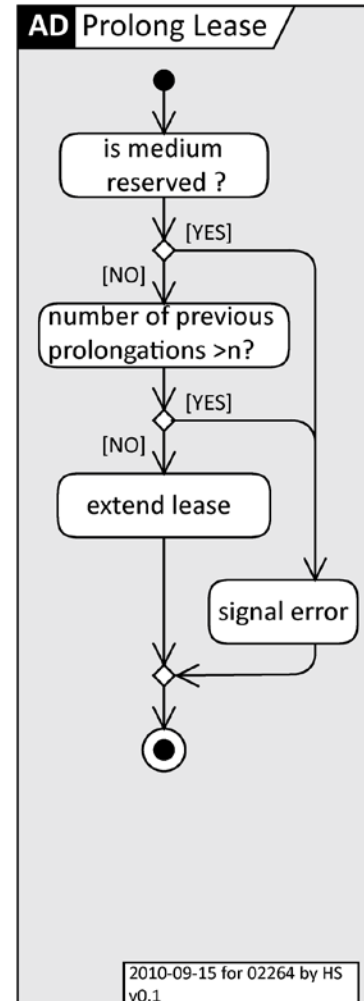
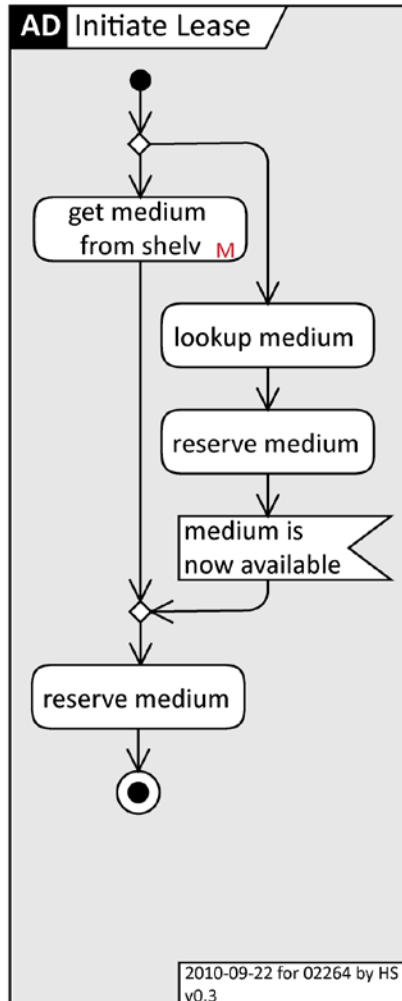
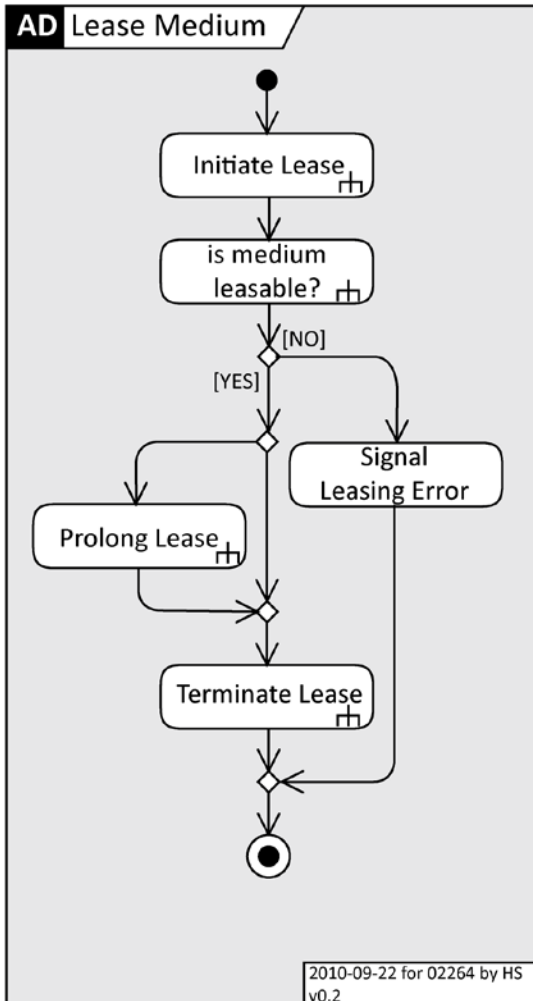
- A process model should consist of
 - a use case diagram to provide the overview, and
 - a set of activity diagrams for the detailed flow.
 - The Use Case, the Activity, and the diagrams should all have the same name.



Structuring Process Models

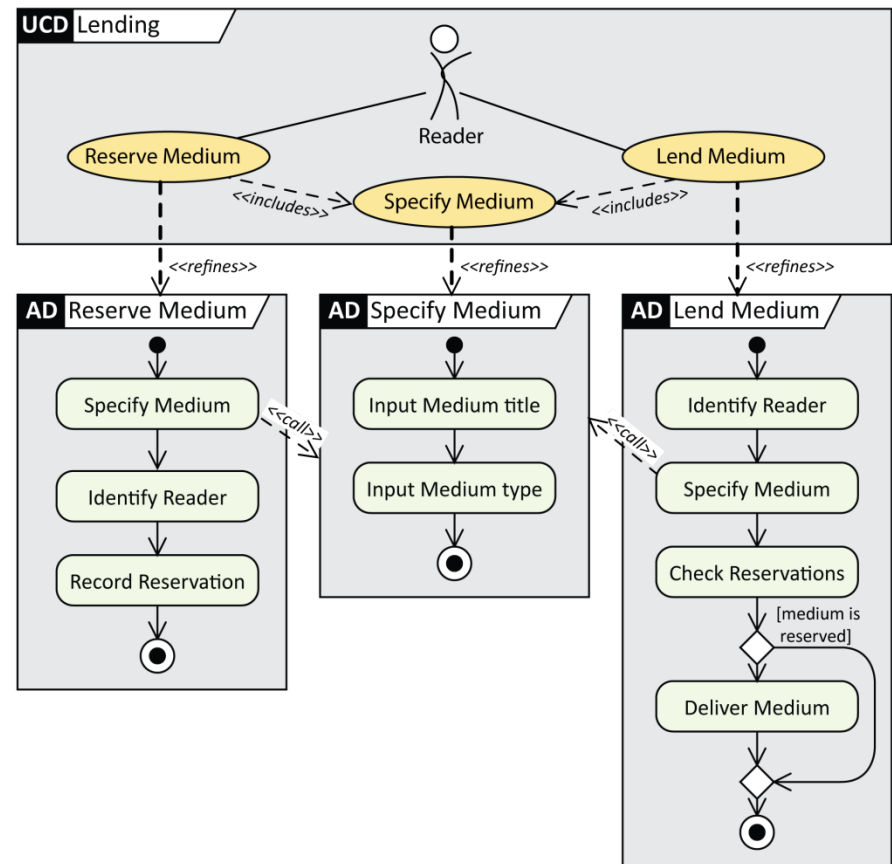
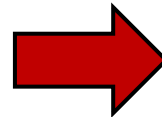
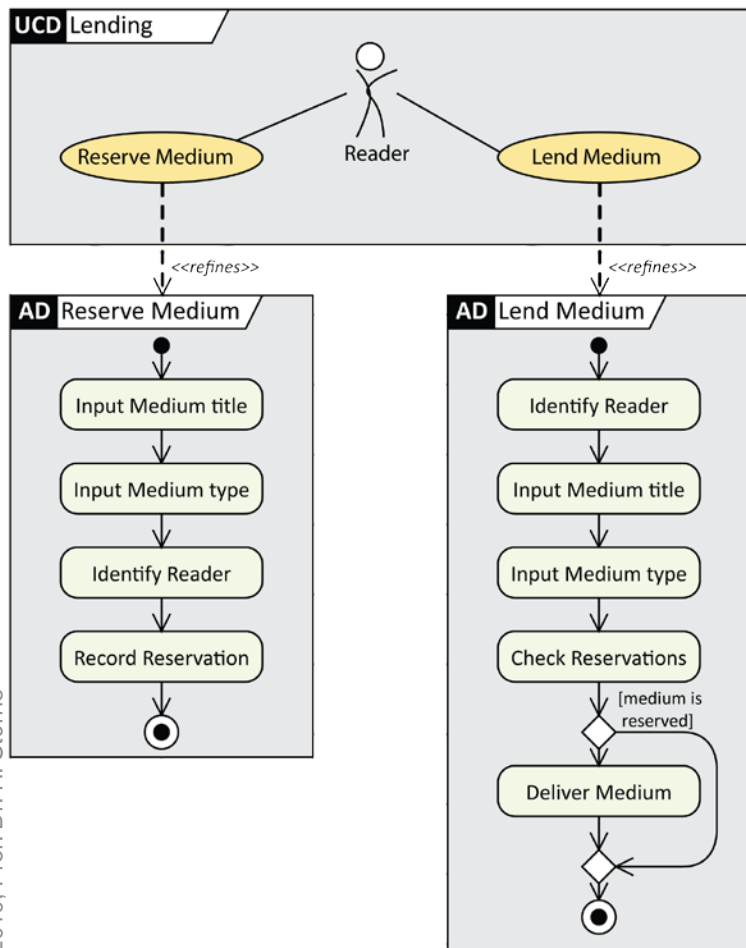
- **The overall structure of a process model should reflect the system structure.**
- **Each subsystem should be modeled by a package that contains exactly the use case and activity diagrams belonging to that subsystem.**
 - The package structure should be isomorphic or identical to the subsystem structure.
- **For each use case diagram, there should be an activity diagram of the same name (implied to specify the flows of the main use case).**
- **For very large processes, it may even make sense to have single package just for one process, its use case diagram and a tree of activities describing its flows.**

Refinement



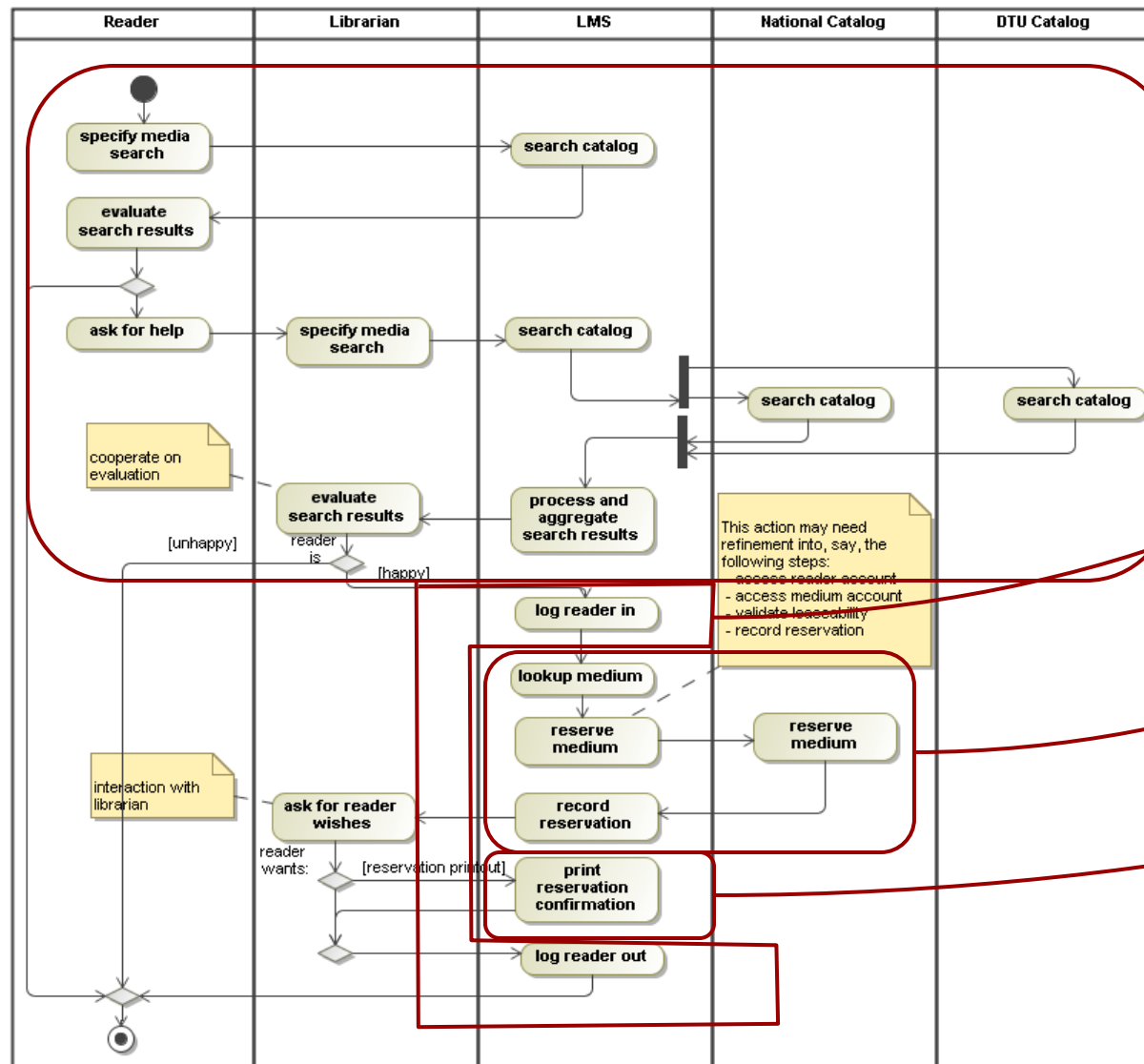
Factoring Out Sub-Scenarios

- Factoring out common sub-scenarios can help reduce the overall model size, but may add some more complexity.

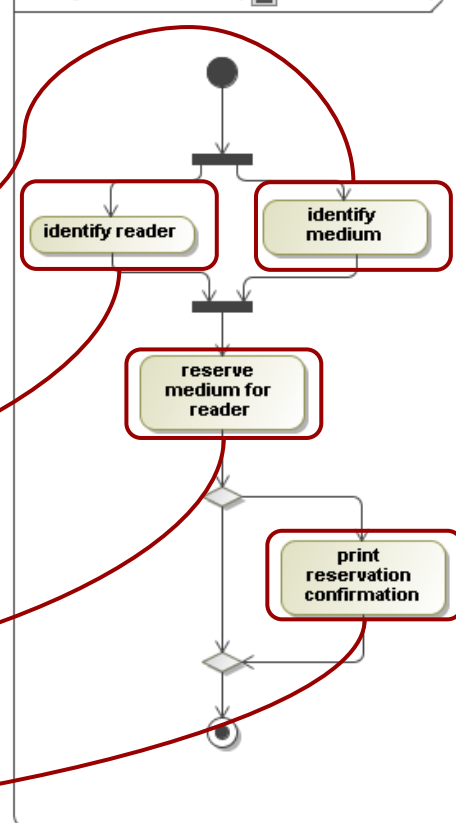


Finding the Right Level of Abstraction

activity find and reserve book at remote library [find and reserve book at remote library]



activity reserve a medium [reserve a medium]





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Chapter 9.4:

Business Rules

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Business Rules

- **A business rule expresses some policy of how to run the business in question.**
 - This applies to all business processes, automated or not.
 - Frequently, rules are about deadlines and case distinctions (e.g. „reservation times out after 7 days“ or „if reader owes more than 100 DKK, block the account“).
- **Business rules provide constraints for the design of the new system, specifying**
 - when and how operations can happen,
 - the state space of objects, and
 - the transitions/transformations performed by operations/use cases.
- **Business rules can easily capture crosscutting features or general constraints, so they might imply a great amount of effort. Consider the following rule.**
 - “Readers must identify themselves upon registration with a valid picture ID.”*
 - This unduly excludes customers: Suppose, a kid is ill and wants a book to pass time.
 - “Readers must be identified upon registration by a valid picture ID.”*
 - However, this allows fraud.
 - “Readers must be identified upon registration by a valid picture ID presented in person or by a legal representative.”*

Expressing Business Rules

- **Business rules are an important aspect of domain models that usually lack a straightforward diagrammatic representation.**
- **Business rules can be specified in different textual ways.**
 - Natural Language rules are ambiguous but can be applied by ordinary people.
 - Structured/Controlled language rules remove ambiguity but are difficult to create.
 - Logical rules (e.g. Temporal Logics, Object Constraint Language) are even more complex to create than controlled language, but lend themselves to code generation.
 - Decision Tables/Trees strike a good compromise between expressiveness, ambiguity, and simplicity.

Advice on Good Textual Business Rules

- **Business rules must be practical.**
 - A duly authorized and capable person must be able to understand and enforce it.
- **Business rule should describe business, not IT-based implementation.**
 - The rule should make sense for every kind of implementation, including non-computer-based ones.
- **Business rules must be expressed in business language.**
 - A business person must be able to understand it without significant training or experience in IT or a given application (potentially) implementing the rule.
- **Business rules must be under business “jurisdiction”.**
 - The rules is defined and changed by business people to address business goals.
- **Business rules remove a degree of freedom.**
 - Rules that suggest guidance but don’t remove leeway might be useful advice, but they are not rules.

LMS Business Rules

- **Only the simplest rules can be expressed as commands.**
 - Switch off mobile phones in the lecture hall!
 - Do not remove reference books from the library!
- **Business rules with a single trigger can be represented by if-then-rules.**
 - If a reader owes 10€ in fees or more, no new leases may be issued to that reader.
 - If a reader account expires, all lent books are due immediately.
- **Rules with more than one trigger can often be expressed as a decision tree or a condition/outcome table.**
 - Typical examples are fees, lending limits, lease durations and so on. Here is a set of LM business rules differentiated by account type, and expressed compactly in a single table.

Limit	Lindgren	Bachmann	Mann	Proust
maximum number of leased items	10	15	25	50
maximum number of reservations	5	5	10	50
lease period for books and periodicals (weeks)	3	3	3	5
lease period for Games, CDs and DVDs (weeks)	1	1	2	4
number of consecutive prolongations	1	1	2	5
Reservation expiration (days)	5	5	5	10
MDR pickup deadline	n.a.	n.a.	3	10

More LMS Business Rules

Item	Lindgren	Bachmann	Mann	Proust
Becoming a new member of TCL (includes issuing of first reader card)	100,-	100,-	200,-	1000,-
1 year TCL membership (new or prolongation)	50,-	100,-	100,-	500,-
upgrading to next level	50,-	250,-	500,-	n.a.
re-issuing a TCL reader card	20,-	20,-	20,-	free
SMS notification service (per message)	n.a. ⁴	n.a.	2,-	free
mail notification service (per message)	25,-	25,-	25,-	10 free, then 25,-
late returning of an unreserved paper item (per started week)	5,-	7,-	10,-	free
late returning of a reserved paper item (per started week)	10,-	20,-	20,-	5,-
late returning of an unreserved electronic medium (per started week)	10,-	15,-	20,-	free
late returning of a reserved electronic medium (per started week)	30,-	45,-	60,-	10,-
damage to medium	assessed by librarian			
loss of medium	twice the original price			
remote lending (per item)	n.a.	50,-	50,-	free

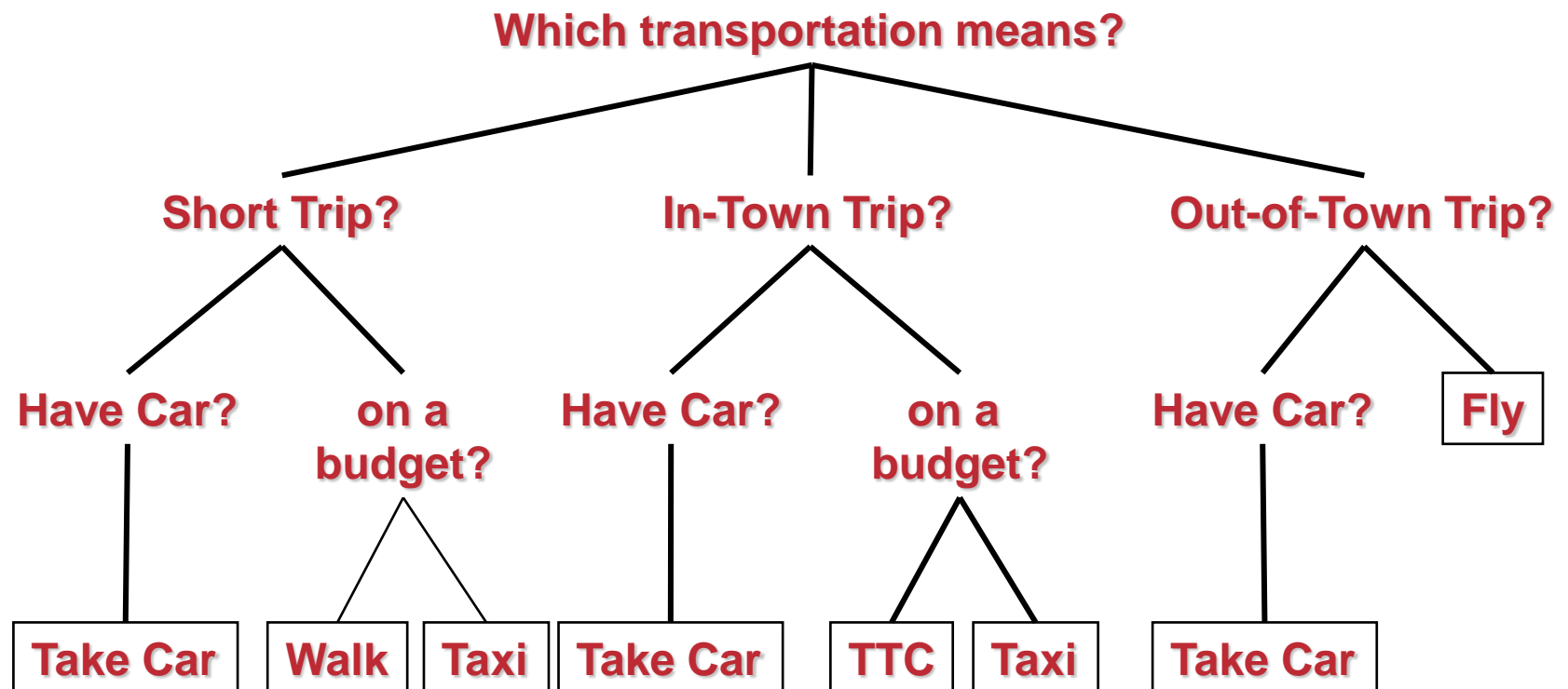
Decision Tables

- For more complex business rules, decision tables might be better to present complex relationships.
- Consider this snippet that is adapted from the specification of the International Space Station (ISS).
 - *“The system shall report to the operator all faults that originate in critical functions or that occur during execution of a critical sequence and for which there is no fault recovery response.”*
- It is easier to see what ought to happen in a binary decision table.
 - Also, this allows for checking whether this rule set is complete and consistent.

a: originate in critical functions	N	Y	N	Y	N	Y	N	Y
b: occur during critical sequence	N	N	Y	Y	N	N	Y	Y
c: no fault recovery response	N	N	N	N	Y	Y	Y	Y

Decision Trees

- A decision tree can represent input parameters (questions) as inner nodes of a tree, and outputs (actions) as leafs.
 - Allows arbitrary output type, not just binary decisions.
 - Branches might be weighted (e.g., annotated by probabilities, costs, etc.)





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Chapter 9.5: Organizational Structures

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Business Processes

- **Typical enterprises may be divided into three domains of Business Processes:**
 - Customer Relationship Management (CRM),
 - Product Lifecycle Management (PLM),
 - Supply Chain Management (SCM).
- **Another widely used classification is to distinguish between Core, Management, and Support processes (as in ISO 12207/15504).**
- **These are then divided further and further, often aligned with the organizational structure of an enterprise.**
- **At the lowest level, the activities relate to either manual tasks performed by members of the organization or automatic tasks performed by systems.**
 - The latter may be described as System Use Cases.

Organizational Structures vs. Processes

- **According to our definition, business processes are the activities of organizations so it is quite natural that changes to the organization structure will influence the IT process support, and vice versa.**
- **Since the organization is the “engine” running the business processes, looking at the organization chart can thus help understand these processes.**
 - The top level of an organization often closely corresponds to the top level of the business processes, because the tasks assigned to groups of people are likely to be independent of the sets of tasks assigned to other groups of people.

Common Contemporary Organizational Structures

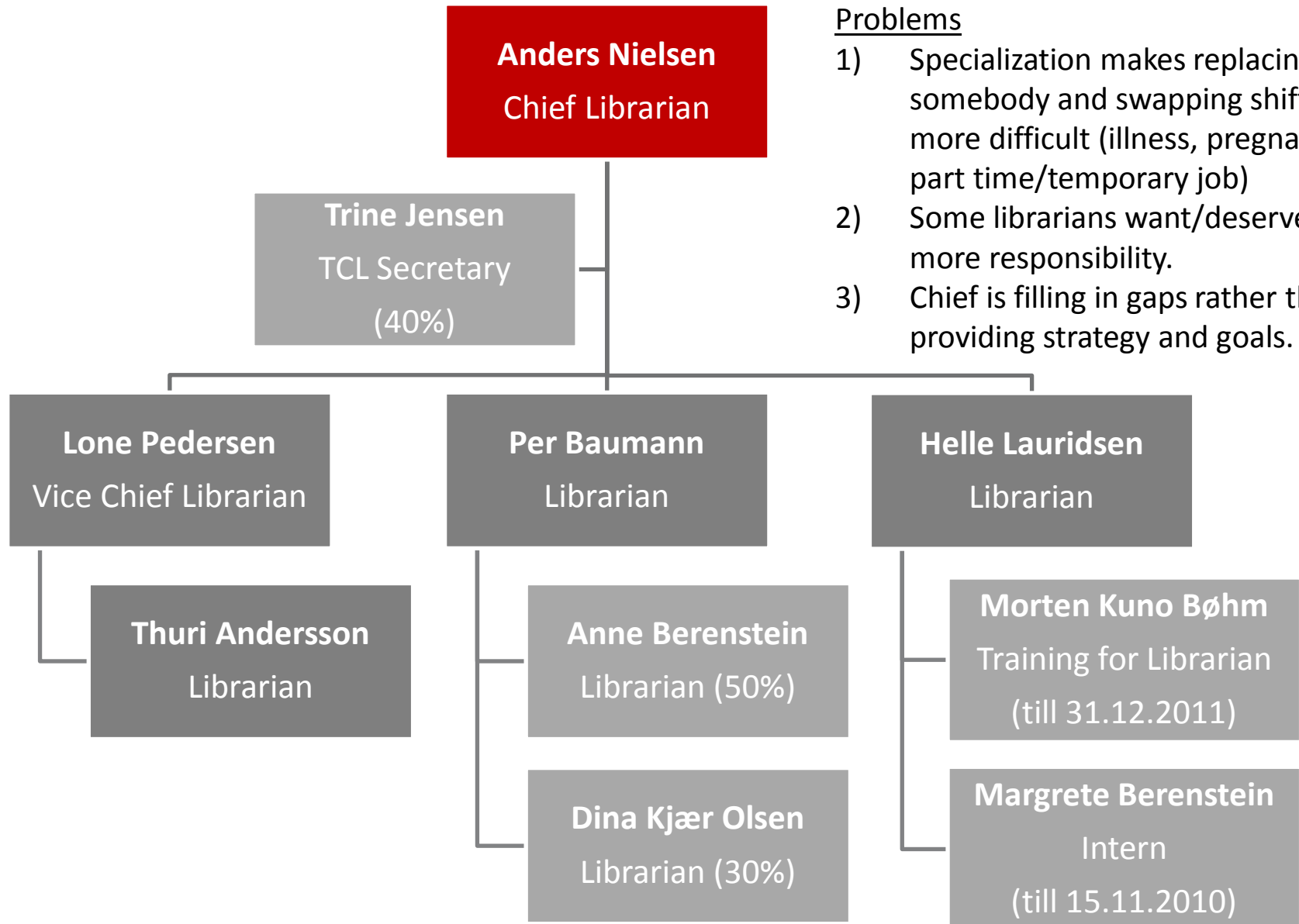
- **Traditionally, organizations used to have strict hierarchical organizations (e.g. catholic church, military).**
 - Today, other forms of organizations (see below) are also commonly found.
- **Project organization**
 - While many organizations technically still have a hierarchical structure that is used for HR purposes or for continuous business lines, there is often a superimposed project structure, demanding very flexible collaboration support.
- **Flat hierarchies**
 - Flat hierarchies come with a greater level of freedom at lower ranks which allows for agility both in individual cases and to market changes (faster responses, case based customization), but also requires more education at lower ranks and makes unwanted deviation from standard likely.
- **Virtual organizations**
 - Virtual Organizations are frequently found in the automotive industry. The car manufacturer as such creates between 20-50% of the net added value with only 10-15% of manufacturing penetration. This is made possible by very long and sophisticated supply chains.
 - Managing such supply chains is more of a coordination task than classical business process management.

- **Obviously, when changing the process support by the IT system, the organization and the people in it will have to adapt.**
 - Luckily, most people are quite flexible so that even large changes will be accommodated, although IT changes without adequate roll-out and support may result in business problems (read: slow and erroneous processes, unhappy employees and customers, and, ultimately, financial loss).
- **Conversely, changes to the organization or its context ask for changes to the IT system supporting it.**
 - Consider changes in laws, tax regulations, economic situation, or mergers.
- **Today, the dependency on IT systems to support business processes is so large, that they effectively dictate business decisions.**
 - Whether or not IT support is beneficial in the long run is a much debated issue.

Organization Chart

- **Organization charts show the structure of an organization, that is,**
 - departments, their names and dependencies,
 - positions and the people that fill them (maybe including stand-ins), and
 - the reporting dependency between positions/departments,
 - the tasks assigned to positions.
- **Organization charts are bad at depicting non-traditional organizational structures.**
 - For instance, in a project structured organization (as is common in most IT development firms and departments), there are several org charts: one for the official structure, one for the project structure (or more if there are several projects at the same time).
 - One of the consequences is that you may have several bosses with conflicting goals (e.g. „do extra hours to finish the project!“ vs. „take your residual holidays to clear my balance sheet!“).

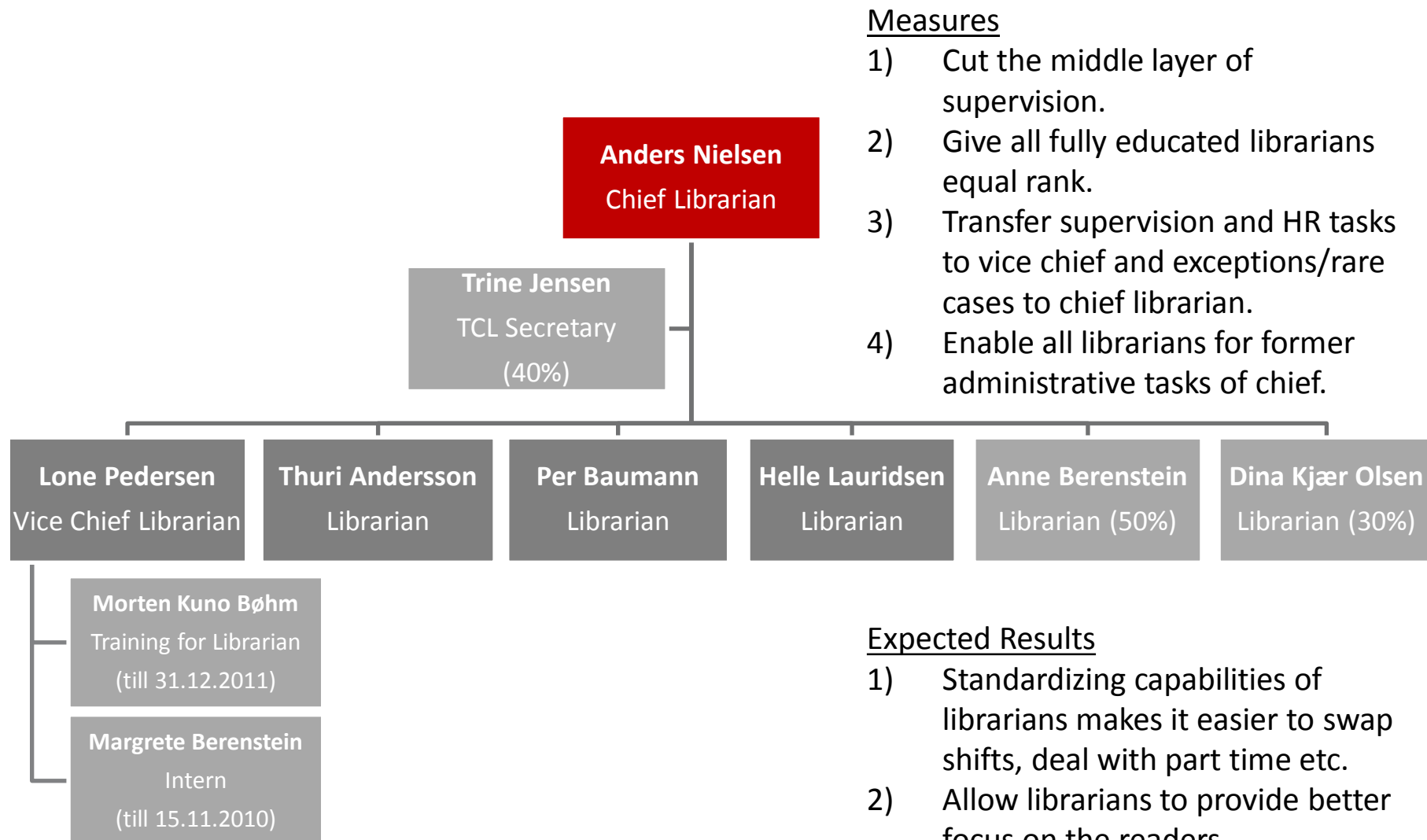
Organization Chart of TCL (Status Quo)



Problems

- 1) Specialization makes replacing somebody and swapping shifts more difficult (illness, pregnancy, part time/temporary job)
- 2) Some librarians want/deserve more responsibility.
- 3) Chief is filling in gaps rather than providing strategy and goals.

Organization Chart of TCL (Reorganized)



TCL Reorganization Impact for IT Support by the future LMS

- **Obviously, the new organizational structure will also require some changes to the IT system:**
 - The capabilities will have to be changed such that now the processes and functions related to wishlist and accession can be performed by all librarians.
 - Also, user management is now done exclusively by the vice chief rather than primarily by the chief librarian.
- **Cutting the middle layer is only possible because**
 - most librarians take on more responsibility and
 - readers do some of the job themselves (i.e. basic functions of lending traffic).
- **However, there is now more time available to interact with readers, e.g.**
 - when introducing them to the library,
 - to help readers with special needs or handicaps,
 - or when helping them with more complex problems.
- **This is likely to be perceived by all parties involved as being a more valuable service than simple leasing tasks.**



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Chapter 9.6 : Alternative Process Modeling Notations

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Alternative Notations for process flows

- **The Flows of business and system processes (business and product UseCases) may be expressed in a number of notations other than UML Activity Diagrams.**
 - When creating models in a UML setting, using anything but activity diagrams does not make much sense, since there is no (easy) way of linking UML models with other models – the integration would be difficult, or lost.
 - However, there are good reasons to look at alternative notations.
 - In a project, there may be existing models, or models contributed by other parties that use different notations, or there may be future additions to the UML, or other model types highlight interesting modeling aspects.
 - In order to broaden our view, let's have a look at those notations, too.
- **For business process modeling, (extended) Event-Process-Chains and Role-Activity-Diagrams could be used instead of UML Activity Diagrams.**
- **For product use cases, IDEF 3, BPMN, and Use Case Maps could be used instead of UML Activity Diagrams.**

Alternatives

- **EPC Probably the most widely used notation for business process modeling are (extended) Event-Process-Chains**
 - EPCs date back to the late 80'es when they have been introduced with the ARIS modeling tool, closely related to the R/3 ERP software.
 - While appealing to business line organizations, EPCs have only restricted expressiveness, and their semantics is rather difficult to define.
- **RAD Another interesting alternative are Role-Activity-Diagrams with their concepts for collaboration. Tool support and industrial adoption are disappointing so far.**
- **BPMN For product use cases, the most widely used alternatives to UML Activity diagrams today are BPMN.**
 - BPMN has received rather a lot of attention in the last few years, but so far, adoption, standardization, and tool support have been rather weak.
 - BPMN offers the same expressiveness as basic Activities, and it is not clear why it has been picked up by the OMG in the first place.
- **UCM Use Case Maps offer some interesting concepts currently not other present in other languages.**

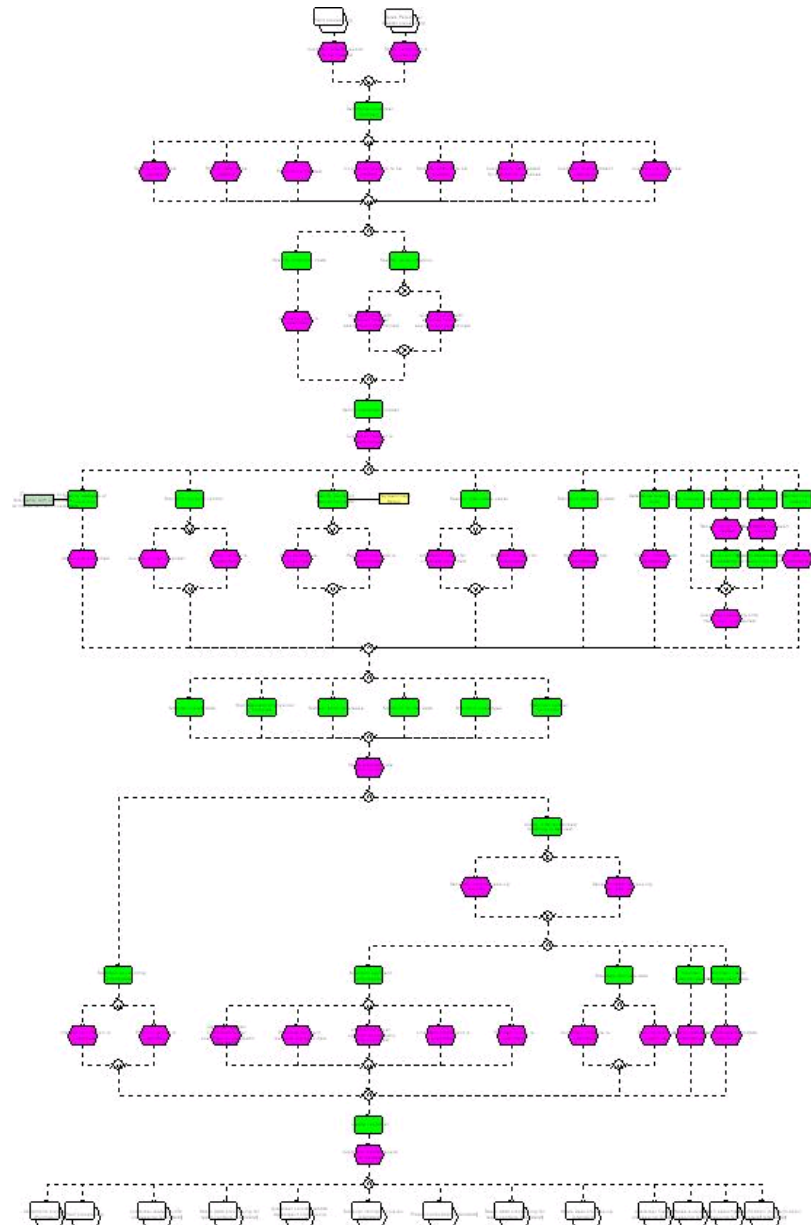
Event Process Chains

- **Event Process Chains (EPCs) have been introduced by Scheer in the late 1970'es in the context of ERP software like SAP R/3.**
 - Today, it is probably the one language with the largest base of modeled organizational process.
 - In some business-oriented communities, EPC-modeling and process modeling are considered identical.
- **An EPC is directed graph of alternating events, possibly interspersed with connectors (and/or/xor).**
- **Extended EPCs (eEPCs) may also be annotated by roles, resources, organizational units etc.**



Event Process Chains

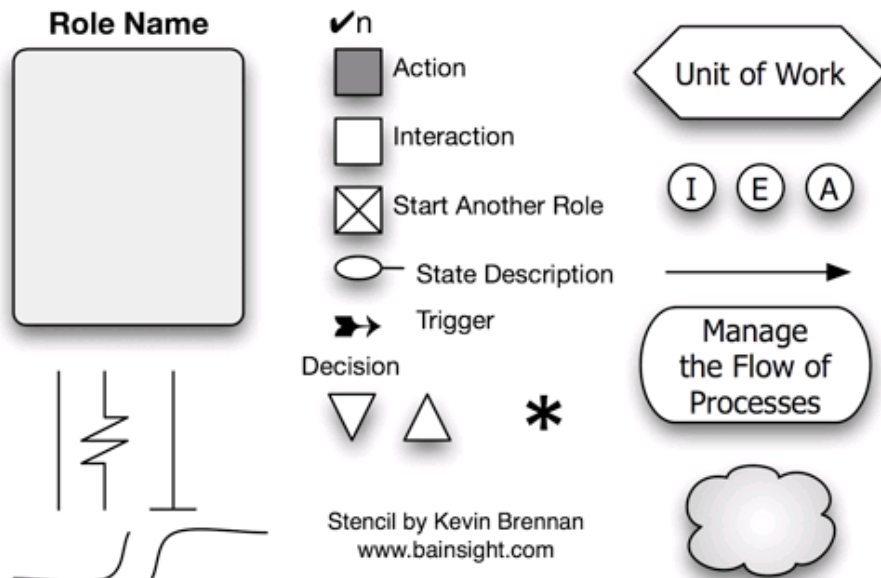
- Some of the largest models in the world are EPC models, most notably the SAP R/3 process reference model, a model that contains all the processes implemented in the R/3 standard, that is, a complete description of the main supportive processes of any medium size to large corporation, worldwide.
- A great deal of work has been devoted to understanding the semantics and pragmatics of EPCs, with mixed results.
- Due to their simple and restricted set of concepts, EPCs are good at modeling business processes, but bad at describing technical detail, as is needed for system flows.



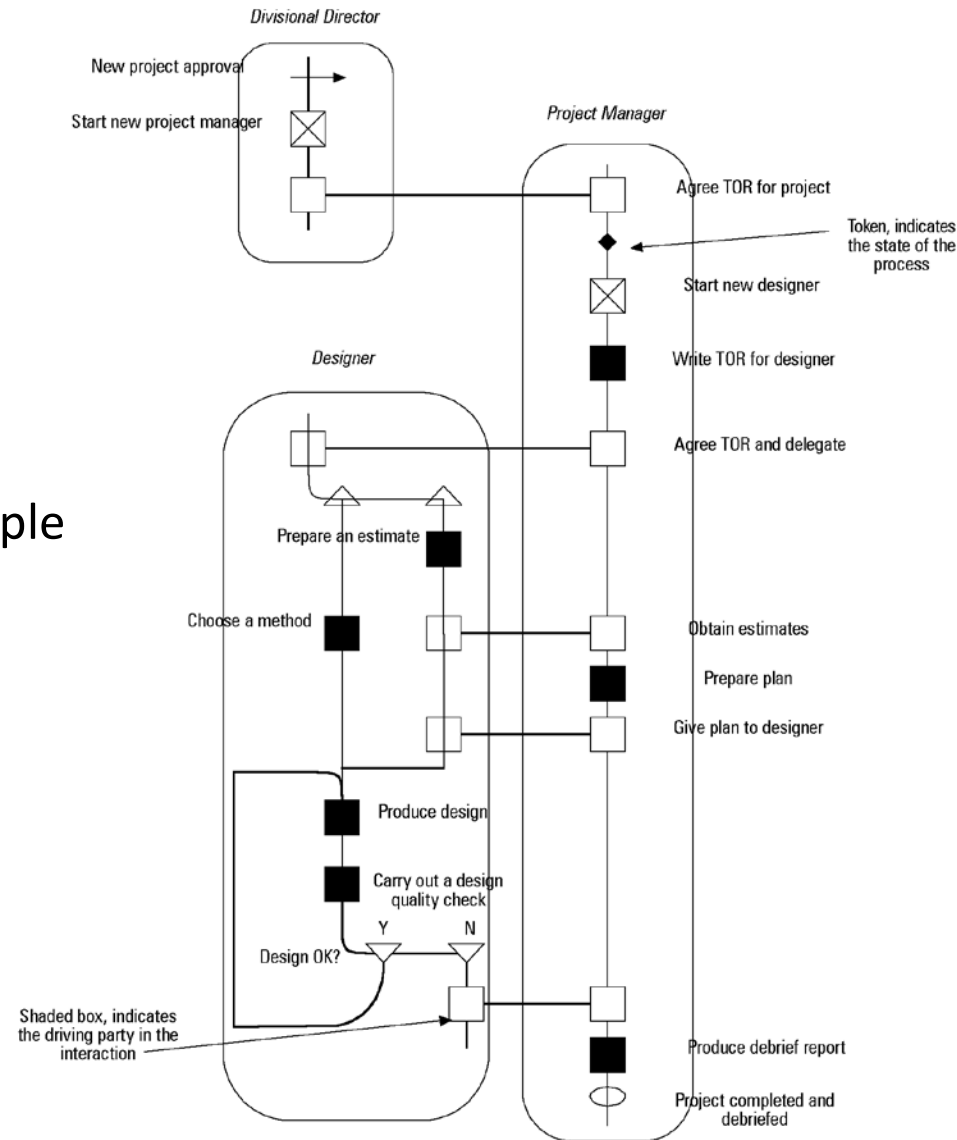
Role Activity Diagrams

- Role Activity Diagrams (RADs) are somewhat more expressive than EPCs and focus more on the interactions between humans.
- So far, they lack tool support and industrial adoption, but they provide a number of interesting concepts.

Notation



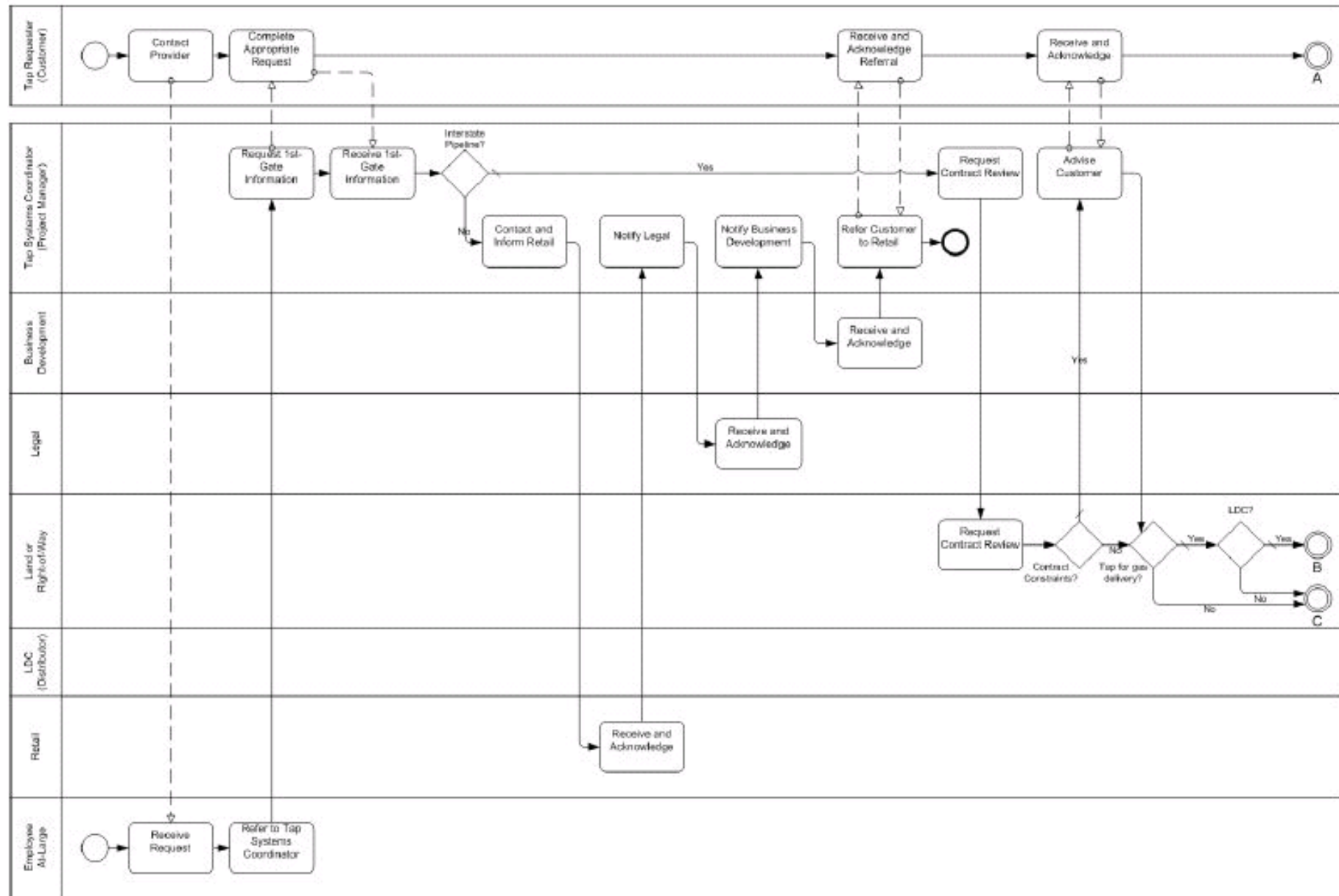
Example



Business Process Modeling Notation

- **In recent years, the OMG has taken up an initiative by IBM to create a new process flow notation. Despite its name, it is entirely rooted at the technical level, focusing on workflow descriptions.**
 - In fact, it is defined to be isomorphic to BPEL, a low level workflow language.
 - In other words, BPMN visualizes low level process descriptions in BPEL.
- **The relationship between UML and BPMN is undefined.**
 - While there are few to no features of BPMN that are not also readily available in activity diagrams, the opposite is not true at all.
- **Still, many EAI manufacturers have taken up the trend and are producing (incompatible) BPMN/BPEL tools.**
 - Even IDS Scheer, manufacturer of the ARIS tool have recently integrated BPMN into ARIS (the quasi standard for EPCs).
 - Also, MagicDraw provides BPMN as a diagram type.
- **Here comes an example.**

BPMN Example



Comparing process modeling languages

Languages Properties	ARIS EPC	RAD	BPMN / BPEL	UC Maps	UML AD	DSLs
Focus	domain	domain	technology	both	both	any
Expressiveness ¹⁾ [depths of detail, scope of topics]	+ / +	+ / +	+ / --	++ / ++	++ / ++	++ / ++ ²⁾
Adaptability, Flexibility	--	--	--	+	+	++
available methodologies	-	--	--	-	+	--
Tool support ³⁾ [amount, quality]	- / ++	-- / --	-- / --	-- / --	++ / -	-- / -- ⁴⁾
Availability & Adoption ⁵⁾ [business line departments, IT-shops]	++ / --	-- / --	-- / -	-- / -	-- / ++	-- / --
Maturity [standardisation, case studies]	-- / ++	-- / -	+ / -	- / +	++ / ++	-- / -
State of research [amount, relevance ⁶⁾]	++ / +	-- / --	- / --	- / -	++ / -	- / -

Remarks

¹⁾ for BusProc. modeling & SE

²⁾ definiable ad lib

³⁾ for modeling tasks

⁴⁾ Meta-CASE tools

⁵⁾ in practice

⁶⁾ for „GPM 2.0“

Legend

++ very

+

-

-- very

much/good

much/good

little/bad

little/bad