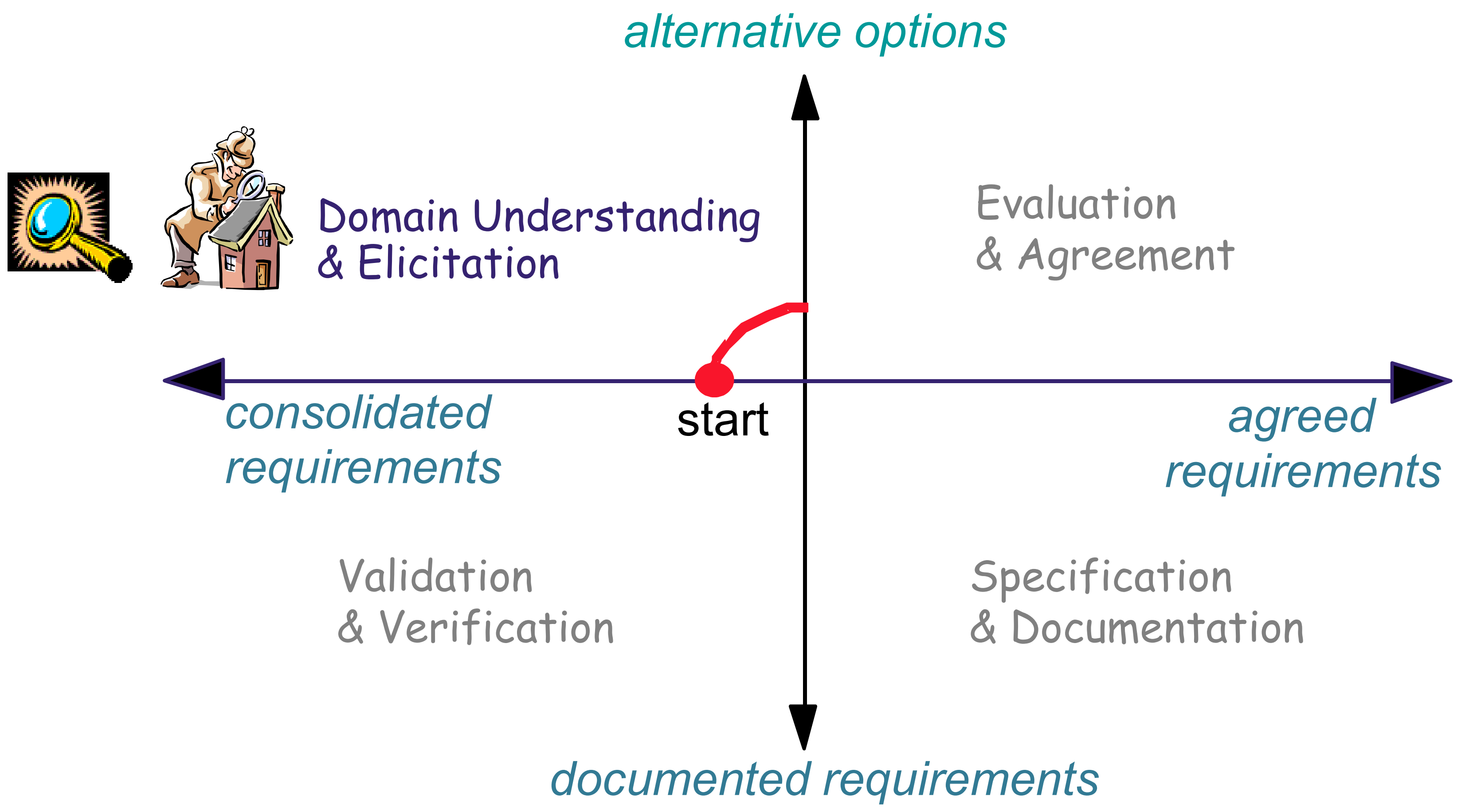
Requirements Engineering

Lecture 04:

Domain Understanding & Requirements Elicitation


alternative options
Domain Understanding
& Elicitation
Evaluation
& Agreement
consolidated
requirements
start
agreed
requirements
Validation
& Verification
Specification
& Documentation
documented requirements

Objectives & Knowledge Acquisition

- Objectives
  - Understand the system-as-is and its context
  - Identify the problems and opportunities calling for a new system
  - Discover the real needs of stakeholders w.r.t. the new system
  - Explore alternative ways in which the new system could address those needs
- Knowledge Acquisition
  - Knowledge about the organization - its structure, business objectives, policies, roles and responsibilities
  - Knowledge about the domain in which the problem world is rooted - the concepts involved in this domain, the objectives specific to it, the regulations that may be imposed on it.
  - Knowledge about the system-as-is - its objectives, the actors (i.e. active entities) and resources involved the tasks and workflows, and the problems raised in this context.

Identifying Stakeholder and Interacting with them

- Stakeholder analysis
  - relevant position in the organization
  - role in making decisions, reaching agreement
  - type of contributed knowledge, level of domain expertise
  - exposure to perceived problems
  - personal interests, potential conflicts
  - influence in system acceptance

Identifying Stakeholder and Interacting with them (2)

- Handling obstacles to effective knowledge acquisition
  - Distributed and conflicting knowledge sources
  - Difficult access to sources
  - **Obstacle to good communication** - important, often underestimated!
  - *Tacit knowledge and hidden needs* - important, difficult to get!
  - Socio-political factors Unstable conditions
- Interacting with stakeholders - **difficult, important, often underestimated**!
  - Communication skills: for talking to, listening from diverse people
  - Trust relationship
  - Knowledge reformulation & restructuring (review meetings)

Elevator System

Example (More Specific Case)

- Assume the system-to-be is an elevator system in 15 floors five stars hotel with an outdoor swimming pool on the last floor, two restaurants on 14 floor, spa, gym and indoor pool on floor -1, shops and reception on ground floor, conference rooms on floor 2 and parkings on floors -2 and -3.
- The chain does not have a similar hotel, the closes one that can be used as a system-as-is has only 6 floors, indoor swimming pool on 6th floor, restaurant on ground floor, gym and spa in the basement and parking is outdoor.

Elevator System

Example (Stakeholders Identification)

Stakeholders are people, groups, organizations that might be affect by the outcome of a project. At the hotel, the installment of new elevator system can result in some massive changes in terms of management. Hence the stakeholders include:

- **Hotel Owner/Manager** the person who will be approving the new project.
- **The architect of the building** An architect plays a vital role in installing the elevator system in any hotel or a building. They are helpful providing with the current status of the load on an elevator and can tell the maximum amount weight a single elevator could carry without harming the structure or the tower.
- **Restaurant manager** find out the estimated traffic for the restaurant floor

Elevator System

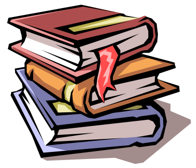
Example (Stakeholders Identification)

Stakeholders are people, groups, organizations that might be affect by the outcome of a project. At the hotel, the installment of new elevator system can result in some massive changes in terms of management. Hence the stakeholders include:

- **Front desk / Community Relations Manager / Business analysts** knows how many people would check in every day and what the peak season occupancy is
- **Head maid** knows the times the maids need the lift Restaurant manager knows the times the restaurant workers need the elevators
- **Security head / Elevator repair contractor / Maintenance manager** knows the relevant safety details for the elevator systems

Artifact-driven elicitation techniques

- Background study
- Data collection, questionnaires
- Repertory grids, card sorts for concept acquisition
- Scenarios, storyboards for problem world exploration
- Prototypes, mock-ups for early feedback
- Knowledge reuse: domain-independent, domain-specific



Background study

- Collect, read, synthesize documents about...
  - the organization: organizational charts, business plans, financial reports, meeting minutes, etc
  - the domain: books, surveys, articles, regulations, reports on similar systems in the same domain
  - the system-as-is: documented workflows, procedures, business rules; exchanged documents; defect/complaint reports, change requests, etc.
- Provides basics for getting prepared before meeting stakeholders
  => prerequisite to other techniques
- Data mining problem: huge documentation, irrelevant details, outdated info
- Solution: use meta-knowledge to prune the doc space
  - know what you need to know & what you don't need to know

Data collection

- Gather undocumented facts & figures
  - marketing data, usage statistics, performance figures, costs, ...
  - by designed experiments *or* selection of representative data sets from available sources (use of statistical sampling techniques)
- May complement background study
- Helpful for eliciting non-functional reqs on performance, usability, cost etc.
- Difficulties:
  - Getting reliable data may take time
  - Data must be correctly interpreted

Questionnaires

- Submit a list of questions to selected stakeholders, each with a list of possible answers (+ brief context if needed)
  - Multiple choice question: one answer to be selected from answer list
  - Weighting question: list of statements to be weighted...
    - qualitatively ('high', 'low", ...), or
    - quantitatively (percentages)

    to express perceived importance, preference, risk etc.
- Effective for acquiring subjective info quickly, cheaply, remotely from many people
- Helpful for preparing better focused interviews (see next)

Questionnaires should be carefully prepared

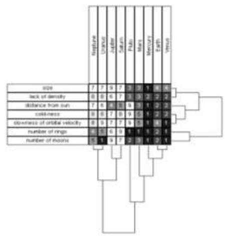
- Subject to ...
  - multiple biases: recipients, respondents, questions, answers
  - unreliable info: misinterpretation of questions, of answers, inconsistent answers, ...

=> Guidelines for questionnaire design/validation:

  - Select a representative, statistically significant sample of people; provide motivation for responding
  - Check coverage of questions, of possible answers
  - Make sure questions, answers, formulations are unbiased & unambiguous
  - Add implicitly redundant questions to detect inconsistent answers
  - Have your questionnaire checked by a third party

Card sorts & repertory grids

- Goal: acquire further info about concepts already elicited
- Card sort: ask stakeholders to partition a set of cards ...
  - Each card captures a concept textually or graphically
  - Cards grouped into subsets based on stakeholder's criteria
  - For each subset, ask...
    - ? implicit shared property used for grouping ?
    - ? descriptive, prescriptive ?
  - Iterate with same cards for new groupings/properties
- Example: meeting scheduling system
  - Iteration 1: "Meeting", "Participant" grouped together
    => "participants shall be *invited to* the meeting"
  - Iteration 2: "Meeting", "Participant" grouped together
    => "participant *constraints* for the meeting must be *known*"



Card sorts & repertory grids (2)

- Repertory grid: ask stakeholders to characterize target concept through attributes and value ranges

  => concept-attribute grid

  e.g. (Date, *Mon-Fri*), (Location, *Europe*)

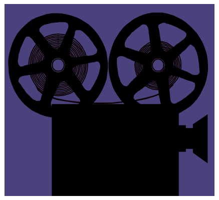
  for grid characterizing Meeting concept

- Conceptual laddering: ask stakeholders to classify target concepts along class-subclass links

  e.g. subclasses RegularMeeting, OccasionalMeeting of Meeting

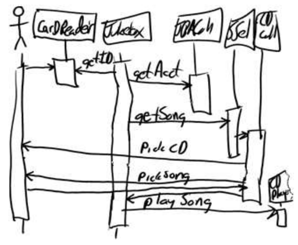
☺ Simple, cheap, easy-to-use techniques for prompt elicitation of missing info

☹ Results may be subjective, irrelevant, inaccurate



Scenarios & storyboards

- Goal: acquire or validate info from concrete examples through narratives
  - how things are running in the system-*as-is*
  - how things should be running in the system-*to-be*
- Storyboard: tells a story by a sequence of snapshots
  - Snapshot = sentence, sketch, slide, picture, etc.
  - Possibly structured with annotations
  - WHO are the players, WHAT happens to them, WHY this happens, WHAT IF this does / does *not* happen, etc
  - Passive mode (for validation): stakeholders are told the story
  - Active mode (for joint exploration): stakeholders contribute

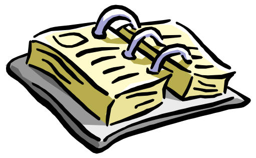


Scenarios

- Illustrate typical sequences of interaction among system components to meet an implicit objective
- Widely used for...
  - explanation of system-*as-is*
  - exploration of system-*to-be* + elicitation of further info ...

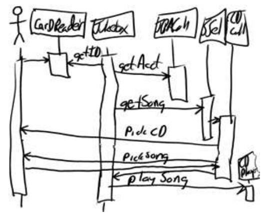
    e.g. WHY this interaction sequence ?

    WHY among these components ?
  - specification of acceptance test cases
- Represented by text or diagram (*formal or informal*)



Scenario example: meeting scheduling

1. The initiator *asks* the scheduler for planning a meeting within some date range. The request includes a list of desired participants.
2. The scheduler checks that the initiator is entitled to do so and that the request is valid. It *confirms* to the initiator that the requested meeting is initiated.
3. The scheduler *asks* all participants in the submitted list to send their date and location constraints back within the prescribed date range.
4. When a participant *returns* her constraints, the scheduler validates them (e.g., with respect to the prescribed date range). It *confirms* to the participant that the constraints have been safely received.
5. Once all valid constraints are *received*, the scheduler determines a meeting date and location that fit them.
6. The scheduler *notifies* the scheduled meeting date and location to the initiator and to all invited participants



Types of scenario

- Positive scenario = one behavior the system should cover (example)
- Negative scenario = one behavior the system should exclude (counter-example), e.g.
  1. A participant returns a list of constraints covering all dates within the given date range
  2. The scheduler forwards this message to all participants asking them for alternative constraints within extended date range
- Normal scenario: everything proceeds as expected
- Abnormal scenario = a desired interaction sequence in exception situation (still positive)

  e.g. meeting initiator not authorized
  participant constraints not valid

Elevator System

Example (Positive or Normal Scenario)

1. The user request for an up-elevator from the ground floor by pressing the button. Up button illuminates.
2. The elevator visits the ground floor and the doors open. The up button's illumination is cancelled. The user steps into the elevator. The doors close.
3. The user requests to go to the 10th floor by pressing button 10. The button 10 illuminates.
4. The elevator visits the 10th floor and the door open. The button 10's illumination is cancelled the user step out of the elevator. The door close.

Elevator System

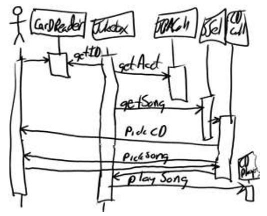
Example (Negative Scenario)

1. The user requests for an up-elevator from the ground floor by pressing the up button. Up button illuminates.
2. The elevator visits the ground floor and the door open. The up button's illumination is cancelled. The user steps into the elevator. The door close.
3. The user request to go to the 10th floor by pressing button 10. The button 10 illuminates
4. The elevator visits the 9th floor and the doors open. The button 10th illumination is cancelled. The user step out of the elevator. The doors close.

Elevator System

Example (Abnormal Scenario)

1. The elevators must switch to “out of service” in the case of fire. Only firemen should be able to operate the elevators in this condition.
2. The user requests for an elevator from the 10th floor by pressing the up button. Up button illuminates.
3. The elevator visits the ground floor and doors open. The Up buttons illumination is cancelled. The user step into the elevator. There is already a second user in the elevator with the button 13 illuminated. The door closed.
4. The first user requests to ground floor by pressing button G. The button G illuminates
5. The elevator visits the 13th floor and the doors open. The button 13th illumination is cancelled. The second user step out of the elevator when the doors close.
6. The elevator visits the ground floor and the doors open. The button G’s illumination is cancelled. The first user steps out of the elevator when the doors close.



Scenarios: pros & cons

☺ Concrete examples/counter-examples

☺ Narrative style (appealing to stakeholders)

☺ Yield animation sequences, acceptance test cases

☹ Inherently partial (cf. test coverage problem)

☹ Combinatorial explosion (cf. program traces)

☹ Potential overspecification: unnecessary sequencing, premature software-environment boundary

☹ May contain irrelevant details, incompatible granularities from different stakeholders

☹ Keep requirements implicit

cf. confidentiality req in negative scenario example

Concrete scenarios naturally jump in anyway...
invaluable as initial elicitation vehicles

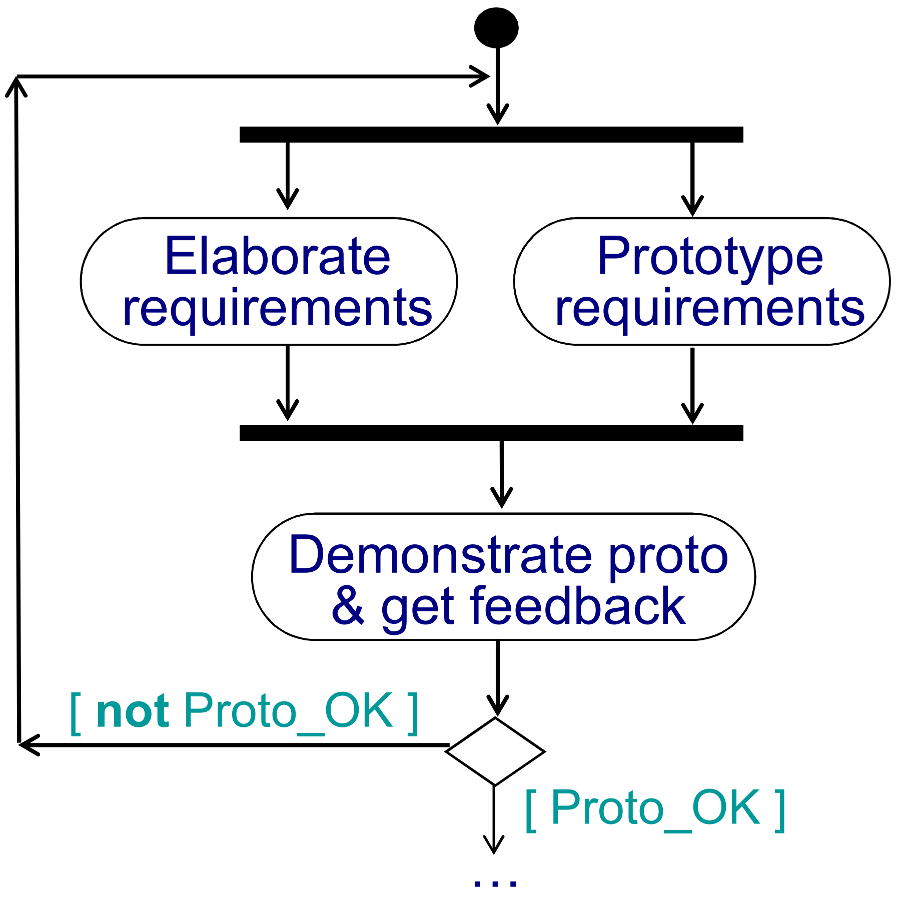
Prototypes & mock-ups

- Goal: check req adequacy from direct user feedback, by showing reduced sketch of software-to-be in action
  - focus on unclear, hard-to-formulate reqs to elicit further
- Prototype = quick implementation of some aspects ...
  - Functional proto: focus on specific functional reqs

    e.g. initiating meeting, gathering participant constraints
  - User interface proto: focus on usability by showing input-output forms, dialog patterns

    e.g. static/dynamic interaction to get participant constraints
- Quick implementation: by use of very high-level programming language, executable spec language, generic services, ...

Requirements prototyping



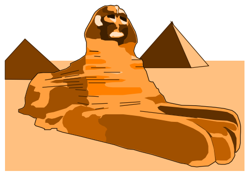
- Mock-up: proto is thrown away (product = adequate reqs)
- Evolutionary proto: transformed towards efficient code

Prototypes & mock-ups: pros & cons

- ☺ Concrete flavor of what the software will look like

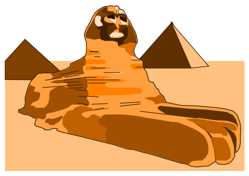
  => clarify reqs, elicit hidden ones, improve adequacy, understand implications, ...
- ☺ Other uses: user training, stub for integration testing, ...

- ☹ Does not cover all aspects
  - missing functionalities
  - ignores important non-functional reqs (performance, cost, ...)
- ☹ Can be misleading, set expectations too high
- ☹ 'Quick-and-dirty' code, hard to reuse for sw development
- ☹ Potential inconsistencies between modified code and documented reqs



Knowledge reuse

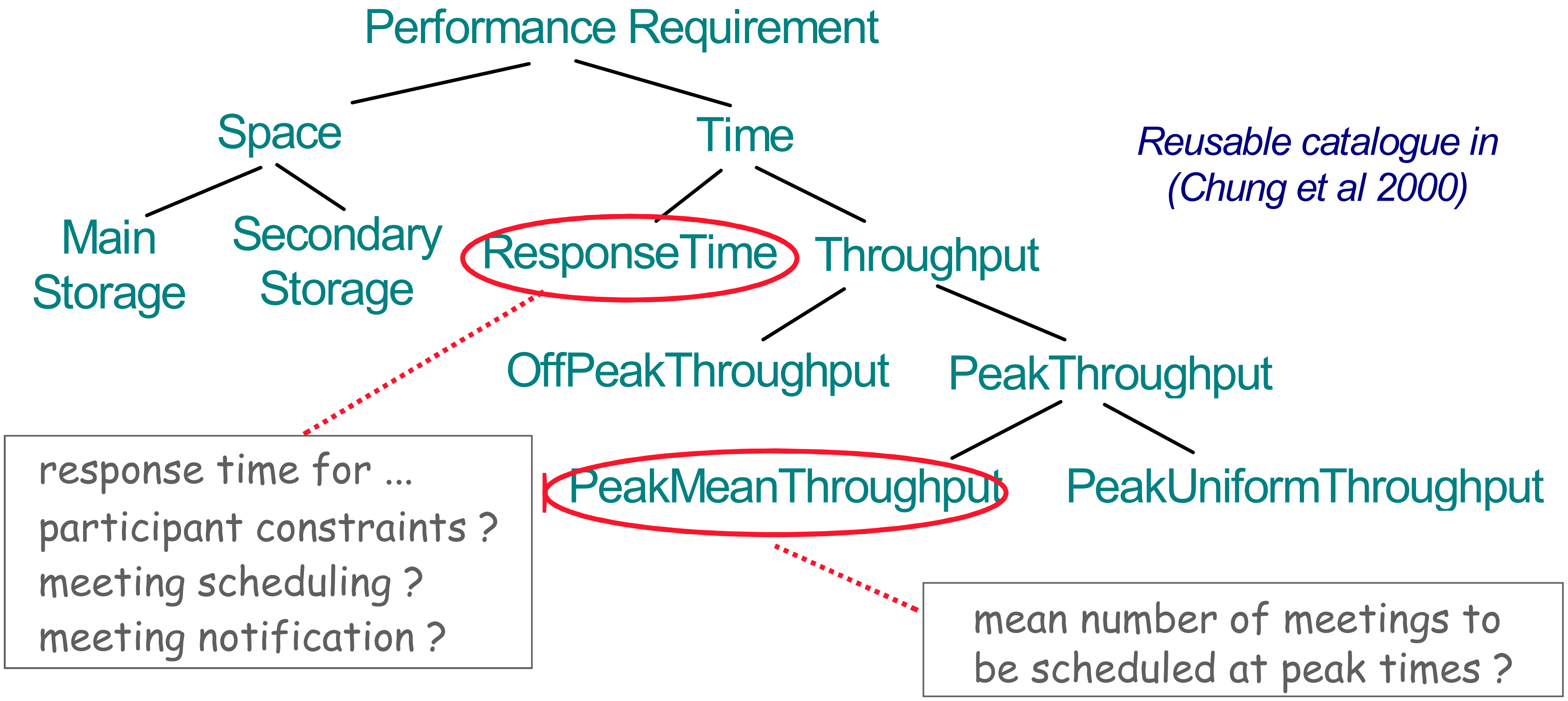
- Goal: speed up elicitation by reuse of knowledge from experience with related systems
  - knowledge about similar organization, domain, problem world: requirements, assumptions, dom props, ...
- General reuse process:
  1. RETRIEVE relevant knowledge from other systems
  2. TRANSPOSE it to the target system
  3. VALIDATE the result, ADAPT it if necessary & INTEGRATE it with the system knowledge already acquired
- Transposition mechanisms:
  - instantiation (memberOf)
  - specialization (subClassOf) + feature inheritance
  - reformulation in vocabulary of target system



Reuse of domain-independent knowledge: requirements taxonomies

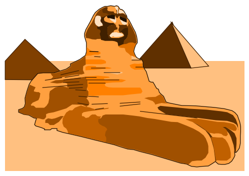
- For each leaf node in available req taxonomies:

  "Is there any system-specific req instance from this class?"
- More specific taxonomy => more focussed search



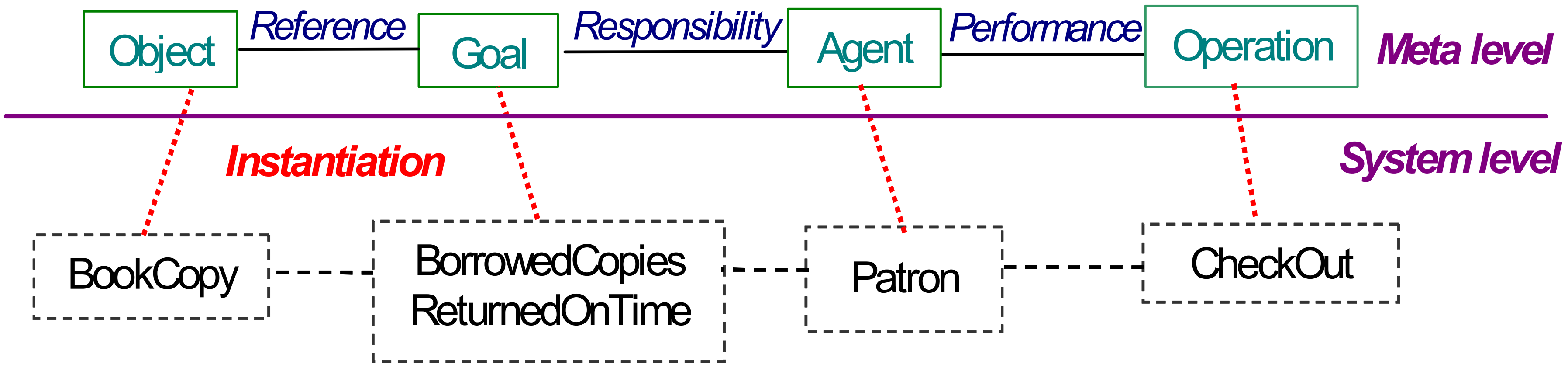
response time for ...
participant constraints ?
meeting scheduling ?
meeting notification ?

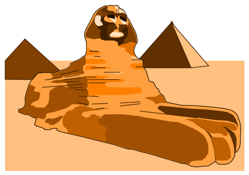
mean number of meetings to be scheduled at peak times ?



Reuse of domain-independent knowledge: RD meta-model

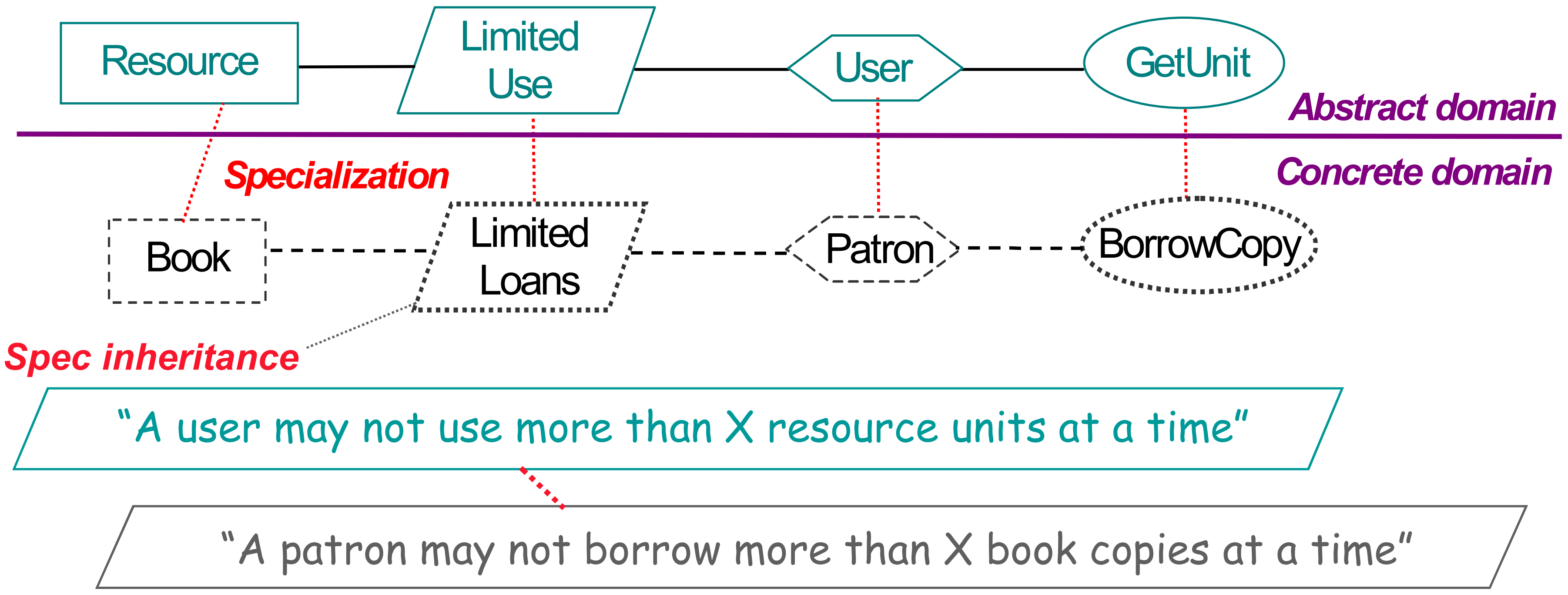
- RD meta-model = concepts & relationships in terms of which RD items are captured
- Elicitation by meta-model traversal
- RD items are acquired as instantiations of meta-model items

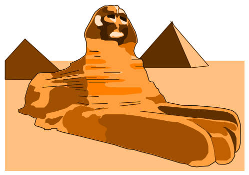




Reuse of domain-specific knowledge

- Abstract domain = concepts, tasks, actors, objectives, reqs, dom props abstracting from a class of domains
- RD items acquired as specializations of abstract items to target system (feature inheritance + system-specific renaming)





Reuse of domain-specific knowledge (2)

- Same abstract domain may have multiple specializations

  e.g. resource management <-- library loan management,
  video store management, flight or concert seat allocation, ...

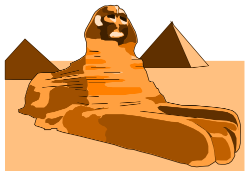
- Same concrete domain may specialize multiple abstract domains

  e.g. library management:
  loan management --> resource management
  book acquisition --> e-shopping
  patron registration --> group membership management

- More adequate RD items elicited by reuse of more structured, more accurate abstract domains

  e.g. resource management: returnable *vs.* consumable resource
  sharable *vs.* non-sharable resource

  => "A book copy can be borrowed by one patron at a time"
  (dom prop for non-sharable, returnable resource)



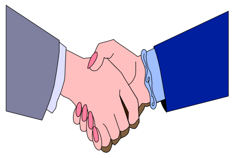
Knowledge reuse: pros & cons

- ☺ Expert analysts naturally reuse from past experience
- ☺ Significant guidance and reduction of elicitation efforts
- ☺ Inheritance of structure & quality of abstract domain spec
- ☺ Effective for completing RD with overlooked aspects

- ☹ Effective only if abstract domain sufficiently “close”, accurate
- ☹ Defining abstract domains for significant reusability is hard
- ☹ Validation & integration efforts
- ☹ Near-matches may require tricky adaptations

Stakeholder-driven elicitation techniques

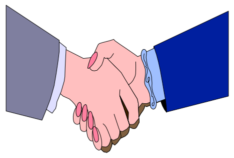
- Interviews
- Observation and ethnographic studies
- Group sessions



Interviews

- Primary technique for knowledge elicitation
  1. Select stakeholder specifically for info to be acquired
     (domain expert, manager, salesperson, end-user, consultant, ...)
  2. Organize meeting with interviewee, ask questions, record answers
  3. Write report from interview transcripts
  4. Submit report to interviewee for validation & refinement
- Single interview may involve multiple stakeholders
  - ☺ saves times
  - ☹ weaker contact; individuals less involved, speak less freely
- Interview effectiveness:

  (*utility* x *coverage* of acquired info) / acquisition *time*

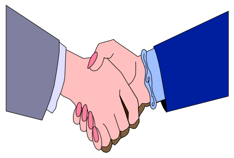


Types of interview

- Structured interview: predetermined set of questions
  - specific to purpose of interview
  - some open-ended, others with pre-determined answer set
  - => more focused discussion, no rambling among topics
- Unstructured interview: no predetermined set of questions
  - free discussion about system-as-is, perceived problems, proposed solutions
  - => exploration of possibly overlooked issues

=> Effective interviews should mix both modes ...

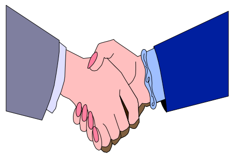
1. start with structured parts
2. shift to unstructured parts as felt necessary



Interviews: strengths & difficulties

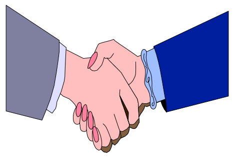
- ☺ May reveal info not acquired through other techniques
  - – how things are running *really*, personal complaints, suggestions for improvement, ...
- ☺ On-the-fly acquisition of info appearing relevant
  - – new questions triggered from previous answers
- ☹ Acquired info might be subjective (hard to assess)
- ☹ Potential inconsistencies between different interviewees
- ☹ Effectiveness critically relies on interviewer's attitude, appropriateness of questions

=> *Interviewing guidelines*



Guidelines for effective interviews

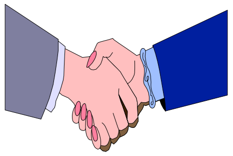
- Identify the right interviewee sample for full coverage of issues
  - different responsibilities, expertise, tasks, exposure to problems
- Come prepared, to focus on right issue at right time
  - background study first
  - pre-design a sequence of questions for this interviewee
- Centre the interview on the interviewee’s work & concerns
- Keep control over the interview
- Make the interviewee feel comfortable
  - *Start:* break ice, provide motivation, ask easy questions
  - Consider the person too, not only the role
  - Do always appear as a trustworthy partner



Guidelines for effective interviews (2)

- Be focused, keep open-ended questions for the end
- Be open-minded, flexible in case of unexpected answers
- Ask *why*-questions without being offending
- Avoid certain types of questions ...
  - opinionated or biased
  - affirmative
  - obvious or impossible answer for this interviewee
- Edit & structure interview transcripts while still fresh in mind
  - including personal reactions, attitudes, etc
- Keep interviewee in the loop
  - co-review interview transcript for validation & refinement

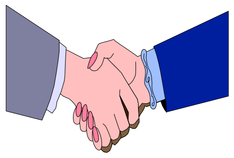
Model-driven interviews may help structure them



Elevator System

Example (The purpose of the interview and the type of information to be acquired)

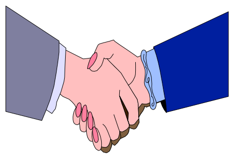
- **Hotel Owner/ Manager**: Interview to discuss constraints of the project such as max cost, time for completion, max time for elevator to arrive. Additionally, this interview could be used to find out any extra features, such as if a service elevator or express elevator will be needed.
- **The Architect of the building**:
  - *Purpose of the interview:*
    1. To understand what services they need.
    2. To know how to use the system as is.
    3. To know all issues that they have the system as is.
    4. To understand the system to be.
  - *Type of information:*
    1. building load and elevator size
    2. usage information
    3. system as-is: an issue



Elevator System

Example (Sample Questions)

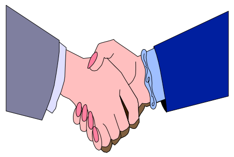
- **Hotel Owner/ Manager**:
  - What is the maximum cost of the elevator system project?
  - What is the maximum time to complete the project?
  - Can you authorize us to take the source code from the previous hotels elevator system?
- **The Architect of the building**:
  - How many bellpersons would you expect to need at the new hotel?
  - What hours are you at average load?
  - How many other people could fit inside the elevator when a bellperson is using it with the luggage cart?



Elevator System

Example (Sample Questions)

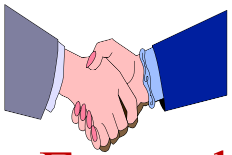
- **Front desk / Community Relations Manager / Business analysts:**
  - What times of year are you at average capacity?
  - What times of year are you at maximum capacity?
- **Head maid:**
  - What times of the day would the maids be using the elevator?
  - How many other passengers could comfortably fit in the elevator along with a maid and their maid cart?
- **Restaurant manager:**
  - What times and days would you need to take food and supplies up the elevator?
  - How many other passengers could comfortably fit in the elevator along with a worker and their food cart?
- **Security head / Elevator repair contractor / Maintenance manager:**
  - What are the expected functionalities in case of emergencies?
  - What incidents have happened in the past with the elevator system?



Elevator System

Example (Open tracks that might be worth exploring at the end of the interview)

- **Hotel Owner/ Manager**:
  - Are there any features you would like to see in the elevator system?
  - Elaborate on a time when customer satisfaction was diminished due to the handling of the previous elevator system.
- **The Architect of the building:**
  - Please provide some examples of when your job was slowed down due to the nature of the past elevator system.
  - What would you suggest to improve your experience on the elevators?
- **Front desk / Community Relations Manager / Business Analysts:**
  - Please describe complaints you have received about the previous elevator system.
  - How were the issues raised resolved?
  - How could the issues be resolved faster, or better?



Elevator System

Example (Open tracks that might be worth exploring at the end of the interview)

- **Head maid:**
  - What frustrations have you had as a result of the old elevator system?
  - How could we eliminate those frustrations in the new system?
- **Restaurant manager:**
  - What struggles do you have with getting deliveries up the elevator to the restaurant?
  - How could the elevator system be changed to eliminate these struggles?
- **Security head / Elevator repair contractor / Maintenance manager:**
  - What would you advise to make the elevators even safer?
  - What would you advise to speed up the elevator task response algorithm?

Observation & ethnographic studies

- Focus on task elicitation in the system-as-is
- Understanding a task is often easier by observing people performing it (rather than verbal or textual explanation)
  - cf. tying shoelaces
- Passive observation: no interference with task performers
  - Watch from outside, record (notes, video), edit transcripts, interpret
  - Protocol analysis: task performers concurrently explain it
  - Ethnographic studies: over long periods of time, try to discover emergent properties of social group involved
    about task performance + attitudes, reactions, gestures, ...
- Active observation: you get involved in the task, even become a team member

Observation & ethnographic studies: pros & cons

- ☺ May reveal ...
  - tacit knowledge that would not emerge otherwise

    e.g. ethnographic study of air traffic control => implicit mental model of air traffic to be preserved in system-to-be
  - hidden problems through tricky ways of doing things
  - culture-specific aspects to be taken into account
- ☺ Contextualization of acquired info
- ☹ Slow & expensive: to be done over long periods of time, at different times, under different workload conditions
- ☹ Potentially inaccurate (people behave differently when observed)
- ☹ Data mining problem, interpretation problem
- ☹ Focus on system-*as-is*

Some of the interviewing guidelines are relevant

Group sessions

- More perception, judgment, invention from interactions within group of diverse people
- Elicitation takes place in series of group workshops (a few days each) + follow-up actions

  audiovisuals, wall charts to foster discussion, record outcome
- Structured group sessions:
  - Each participant has a clearly defined role

    (leader, moderator, manager, user, developer, ...)
  - Contributes to req elaboration according to his/her role, towards reaching synergies
  - Generally focused on high-level reqs
  - Variants: focus groups, JAD, QFD, ...

Group sessions (2)

- Unstructured group sessions (brainstorming):
  - Participants have a less clearly defined role
  - Two separate stages ...
    1. Idea generation to address a problem: as many ideas as possible from each participant without censorship/criticism
    2. Idea evaluation: by all participants together according to agreed criteria (e.g. value, cost, feasibility) to prioritize ideas

Group sessions: pros & cons

☺ Less formal interactions than interviews

=> may reveal hidden aspects of the system (as-is or to-be)

☺ Potentially ...

- wider exploration of issues & ideas
- more inventive ways of addressing problems

☺ Synergies => agreed conflict resolutions

☹ Group composition is critical ...

- time consuming for key, busy people
- heavily relying on leader expertise & skills
- group dynamics, dominant persons => biases, inadequacies

☹ Risk of ...

- missing focus & structure => rambling discussions, little concrete outcome, waste of time
- superficial coverage of more technical issues

Combining techniques

- Elicitation techniques have complementary strengths & limitations
- Strength-based combinations are more effective for full, adequate coverage
  - artifact-driven + stakeholder-driven
- Examples
  - Contextual Inquiry: workplace observation + open-ended interviews + prototyping
  - RAD: JAD group sessions + evolutionary prototyping (with code generation tools)
- Techniques from other RE phases support elicitation too
  - Resolution of conflicts, risks, omissions, etc.

Domain analysis & requirements elicitation: summary

- Identifying the right stakeholders, interacting the right way
- Artifact-driven elicitation techniques
  - Background study as a prerequisite
  - Data collection, questionnaires for preparing interviews
  - Repertory grids, card sorts for concept characterization
  - Scenarios, storyboards for concrete exploration
  - Prototypes, mock-ups for early feedback & adequacy check
  - Knowledge reuse brings a lot: domain-independent, domain-specific
- Stakeholder-driven elicitation techniques
  - Interviews are essential - structured, unstructured, cf. guidelines
  - Observation, ethnographic studies for hidden knowledge
  - Group sessions for broader, more inventive acquisition & agreement

Model-driven elicitation provides focus & structure for what needs to be elicited