Fundamentals of RE

Chapter 2

Domain Understanding & Requirements Elicitation

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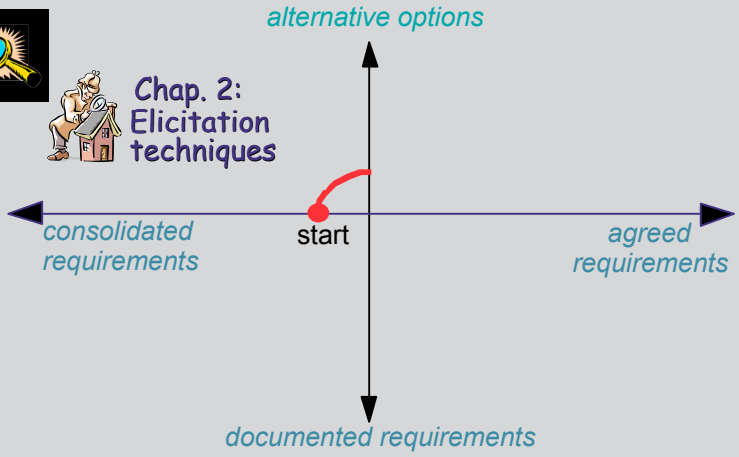
Chap.1: RE products and processes



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A great deal of **knowledge acquisition** is involved: as introduced in Chapter 1 ...

- Studying the system-**as-is**
  - Business organization: structure, dependencies, strategic objectives, policies, workflows, operational procedures, ...
  - Application domain: concepts, objectives, tasks, constraints, regulations, ...
  - Analysis of problems with system-as-is: symptoms, causes, consequences
- Analyzing technology opportunities, new market conditions
- Identifying the system **stakeholders**
- Identifying improvement **objectives**; organizational & technical **constraints** on system-to-be; **alternative options** for satisfying objectives, for assigning responsibilities; **scenarios** of hypothetical software-environment interaction; **requirements** on software, **assumptions** on environment

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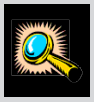

Domain analysis & requirements elicitation: outline

- (1) Identifying **stakeholders** & interacting with them
- **(2) 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
- **(3) Stakeholder-driven** elicitation techniques
  - Interviews
  - Observation and ethnographic studies
  - Group sessions

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Stakeholder analysis

- Stakeholder cooperation is essential for successful RE
  - Elicitation = cooperative learning
- Representative sample must be selected to ensure adequate, comprehensive coverage of the problem world
  - dynamic selection as new knowledge is acquired
- Selection based on ...
  - 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

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Knowledge acquisition from stakeholders is difficult

- Distributed sources, conflicting viewpoints
- Difficult access to key people & data
- Different background, terminology, culture
- Tacit knowledge, hidden needs
- Irrelevant details
- Internal politics, competition, resistance to change, ...
- Personnel turnover, changes in organization, in priorities, ...

⇒ **Needed:**

- Communication skills: for talking to, listening from diverse people
- Trust relationship
- Knowledge reformulation & restructuring (review meetings)

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(2) 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

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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

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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)

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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

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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*"

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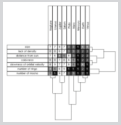

Card sorts & repertory grids (2)

- **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

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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

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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 (see Chap. 4)

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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**

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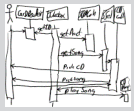

Types of scenario

- **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

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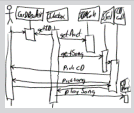

Scenarios: pros & cons

- ☺ 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

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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, ...

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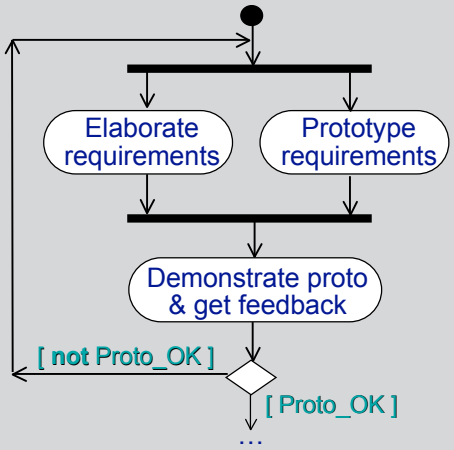
Requirements prototyping



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

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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, stubb 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

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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

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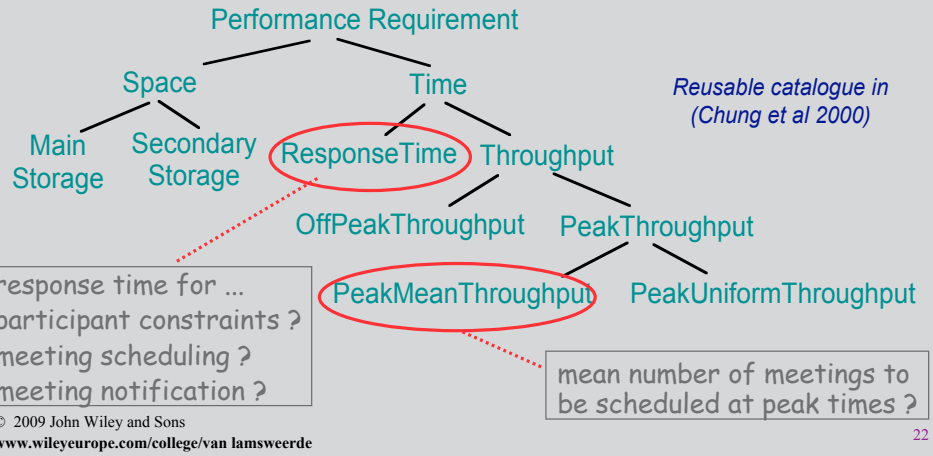
Reuse of domain-independent knowledge: requirements taxonomies

- For each leaf node in available req taxonomies:
  "Is there any system-specific req instance from this class?"
- More specific taxonomy => more focussed search



Reusable catalogue in (Chung et al 2000)

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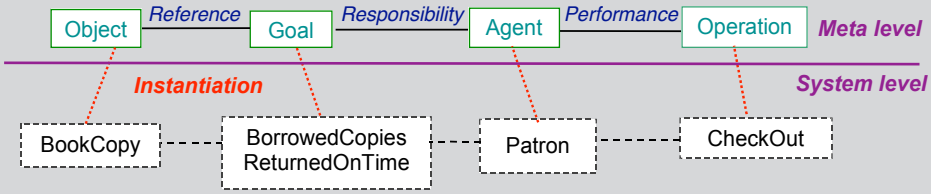
Reuse of domain-independent knowledge: RD meta-model

- **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



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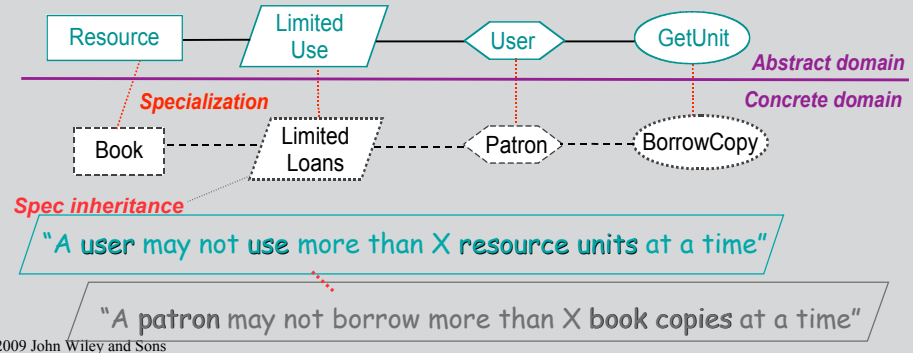
Reuse of domain-specific knowledge

- **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)



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Reuse of domain-specific knowledge (2)

- Same abstract domain may have multiple specializations
  e.g. resource management <-- library loan management,
  videostore 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)

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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

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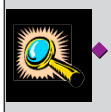
Domain analysis & requirements elicitation: outline

- Identifying stakeholders & interacting with them
- 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



- **Stakeholder-driven elicitation techniques**
  - **Interviews**
  - Observation and ethnographic studies
  - Group sessions

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(3) 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*

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Types of interview

- **Structured** interview: predetermined set of questions
  - specific to purpose of interview
  - some open-ended, others with pre-determined answer set

  => more focussed 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 ...
  - start with structured parts
  - shift to unstructured parts as felt necessary

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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*

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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
  - backgound study first
  - predesign 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

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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 ...
  - opiniated 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
(see Part 2 of the book)

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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

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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

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Group sessions

- More perception, judgement, 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, ...

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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

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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

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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.

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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 (see Part 2 of the book)

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