KNOWLEDGE AQUISITION

DEMETRE ARGIALAS

Criteria for Selecting Problem

- Recognized experts exist
- Experts do better than amateurs
- Expert needs significant time to solve it
- Cognitive type tasks
- Skill can routinely taught to neophytes (beginners)
- Domain has high payoff
- Task does not require common sense

Architectural Principles

- Knowledge is power
- Knowledge is often inexact & incomplete
- Knowledge is often poorly specified
- Amateurs become experts slowly
- Expert systems must be flexible
- Expert systems must be transparent
- Separate inference engine and knowledge base (make system easy to modify)

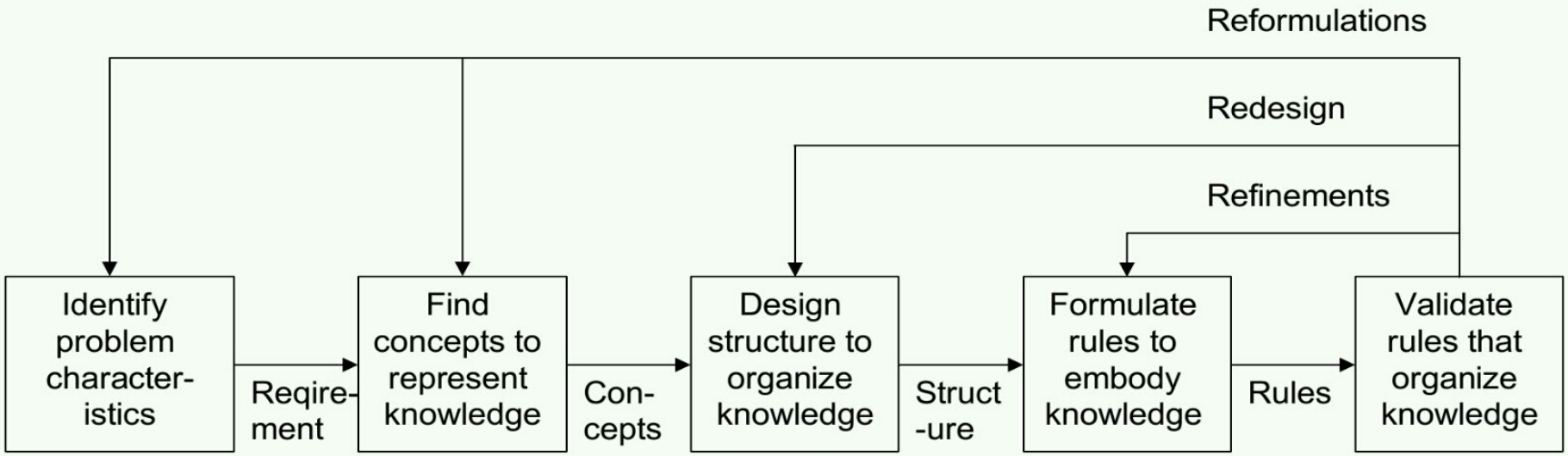
KA Techniques

- Description
  - expert lectures or writes about solving the task
- Observation
  - KE watches domain expert solve the task unobtrusively
- Introspection
  - KE interviews expert after the fact
  - goal-directed KE tries to find out which goal is being accomplished at each step

Difficulties in Knowledge Elicitation

- Technical nature of specialist fields that hinders knowledge elicitation by non-specialist knowledge engineers.
- Experts tend to think less in terms of general principles and more in terms of typical objects and commonly occurring events.
- Difficulties in searching for a good notation for expressing domain knowledge and a good framework for fitting it all together.

Stages of Knowledge Acquisition



Architectural Principles

- Use uniform "fact" representation (reduces number of rules required and limits combinatorial explosion)
- Keep inference engine simple (makes knowledge acquisition and truth maintenance easier)
- Exploit redundancy (can help overcome problems due to inexact or uncertain reasoning)

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KA Phases

- Identification Phase
  - scope of problem
- Conceptualization Phase
  - key concepts are operationalized and paper prototype built
- Formulation Phase
  - paper prototype mapped onto some formal representation and AI tools selected
- Implementation Phase
  - formal representation rewritten for AI tools

KA Phases

- Testing Phase
  - check both "classic" test cases and "hard" boundary’’ cases
  - most likely problems
    - I/O failures (user interface problems)
    - Logic errors (e.g. bad rules)
    - Control strategy problems
- Prototype Revision

Outline

- What is Knowledge Acquisition?
- Why is KA expensive?
- KA Techniques
  - interviews
  - observational techniques
  - intuitive techniques
- The Unwilling Expert

What is Knowledge Acquisition?

- KA=knowledge ***elicitation*** + ***representation***
- knowledge elicitation
  - process of ***extracting*** domain & strategic knowledge from human experts
  - often achieved using specialised interviews between knowledge engineers and domain experts
  - knowledge elicitation is a very important task
- knowledge representation
  - process of representing the extracted knowledge using an appropriate ***formalism***
  - e.g. rules

Knowledge Elicitation

- a cyclical process (i.e. a loop)
- tasks in the loop
  - ***collect*** knowledge (e.g. from expert)
  - determine ***key concepts*** in problem domain
  - establish ***relationships*** between various concepts in problem domain
  - decide h***ow knowledge is represented*** in KBS
  - determine what knowledge needs to be collected in the next cycle

The Knowledge Acquisition Bottleneck

- knowledge elicitation is ***expensive*** and ***slow***
  - only 2~5 rules a day
- knowledge elicitation is slow, because
  - concepts in a specialised field are ***difficult to explain*** to a layman (i.e. the knowledge engineer)
  - facts and principles are not sufficient, also need
    - strategic knowledge
    - experience
    - relevant related knowledge
  - human expertise in a narrow domain often applies wider, ***common-sense knowledge***

Interviews

- who is normally involved?
  - knowledge engineer
  - domain experts
  - possibly the end-user
- how should knowledge engineer prepare?
  - have a clear idea of ***objectives***
  - arrange a suitable time & place
  - plan an ***agenda***
  - ask experts to bring any ***relevant material***
  - plan how to ***record*** the interview
    - e.g. video tape, notes
  - ***prepare for content*** of interview
    - e.g. background reading
- usually a ***kick-off interview*** followed by ***structured/unstructured*** interviews

Observation Techniques

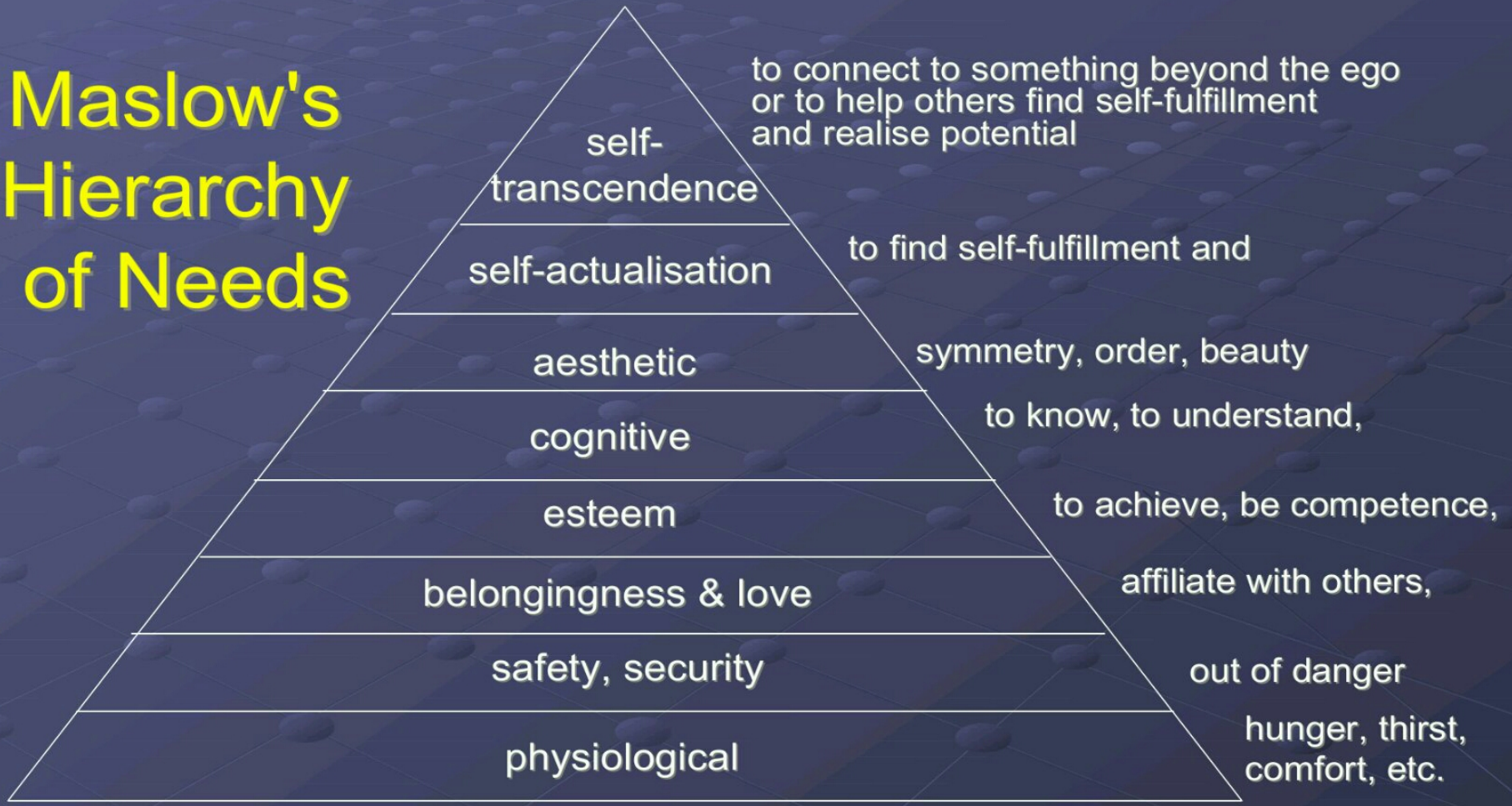
- ***quiet*** on-site observation
  - expert works ***un-interrupted/undisturbed***
  - expert may ***think aloud*** while solving problem
  - KEer gets a feel for magnitude of problem solving process or verifies hypothesized approach
- on-site observation ***with discussion***
  - KEer ***interrupts*** while expert is solving a problem
  - familiar task
    - useful as expert can put more time on explanation
  - unfamiliar task
    - expert may be uneasy, unwilling to solve before KEer
    - otherwise very useful for KEer

Observation Techniques (cont'd)

- exercising the expert
  - expert to solve previous or artificial problem
  - KEer may deliberately make problem more difficult
  - useful for infrequent problem
- problem description and analysis
  - use classical or textbook problems that exhibit domain features
  - expert explains important features of domain

How to Motivate Humans?

Maslow's Hierarchy of Needs



Knowledge Acquisition

- 'the transfer and transformation of potential problem-solving expertise from some knowledge source to a program' - Buchanan 1983
- considered the 'bottleneck' to developing expert systems since 1977

KNOWLEDGE ACQUISITION

- Using the term “knowledge” implies the need to interpret, categorize, apply and revise.
- This goes beyond the definition of information.

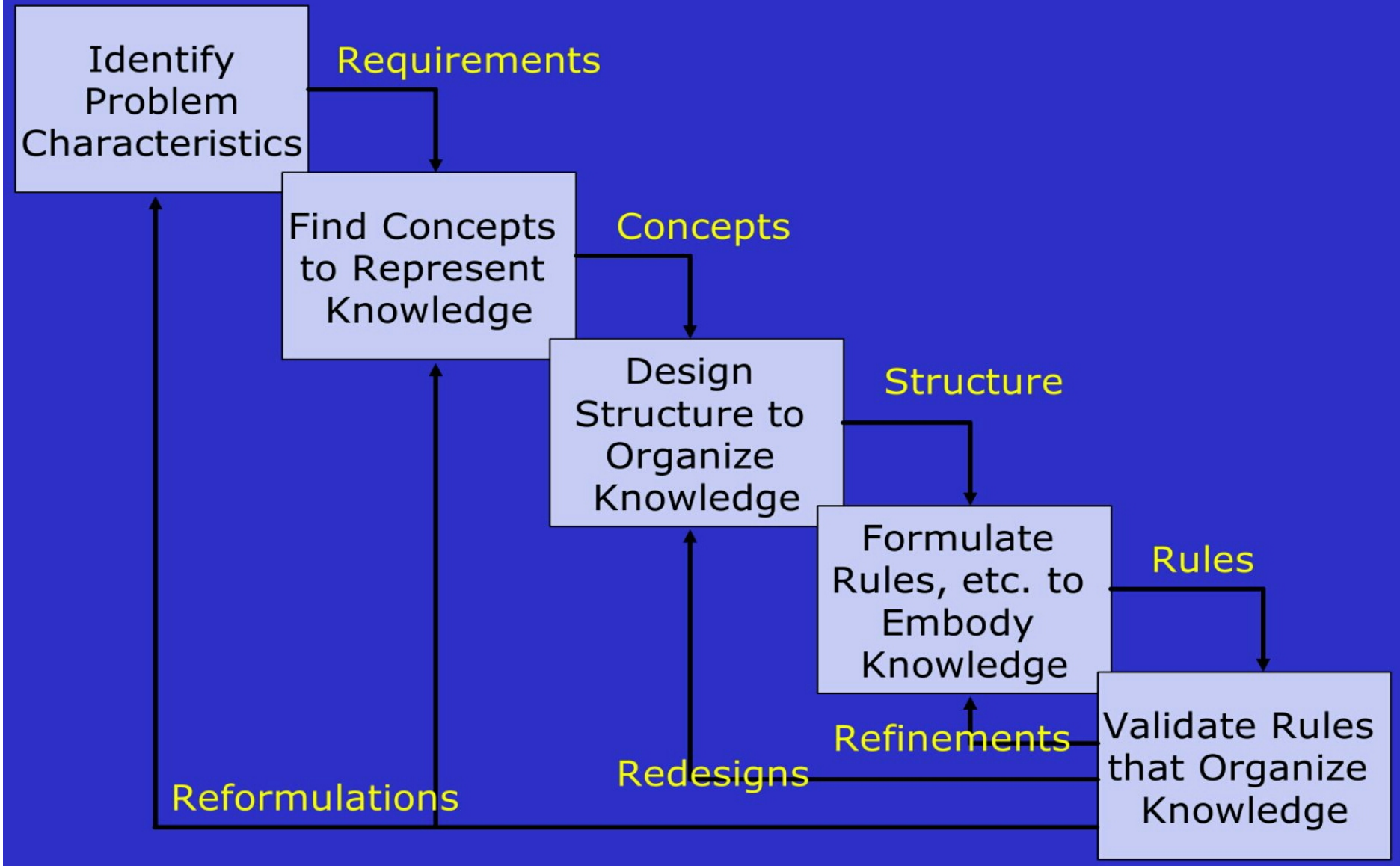
Why Is It Knowledge Acquisition So Difficult?

- *Tacit knowledge* - the concept of "we can know more than we can tell" (Polanyi, 1966).

Why Is It Knowledge Acquisition So Difficult? (cont.)

- *Automation or compiled knowledge* - as one repeatedly use a reasoning process one 'automates' the steps and they become a 'chunk.' Then, one no longer thinks through each step, one 'executes' - similar to a compiled program. Further, when one recognizes a certain pattern, one executes the chunk automatically, without awareness. It is difficult or impossible for one to express compiled knowledge. (Newell and Simon)

Stages of Knowledge Acquisition



Knowledge Elicitation

- direct - direct interaction with the human expert
  - interviews
  - protocol analysis
  - direct observation
- indirect - utilize statistical and other structured techniques to collect and analyze certain types of data.

Types of Questions to Ask During an Interview with a Domain Expert

- What kinds of things do you like to know about when you begin to ponder the problem?
- What facts or hypotheses do you try to establish when thinking about a problem?
- What are the factors that influence how you reason about a problem?
- What types of values can this object have? What range of values is permissible?
- Does this factor depend on other factors? If so, which one?
- Is this factor needed for solving all problems in the domain, or for just some?

Concurrent Think-aloud Protocols

- Most common form of protocol
- The expert is asked to perform a task while "thinking-aloud" as they perform the task.
- The verbalizations are audio (or videotaped) and transcribed for later analysis.

Retrospective Protocol Analysis

- The expert performs the task and afterward is asked to recall their thought process.
- Retrospective protocols have some validity problems, but is useful in situations where thinking-aloud interferes with the task.

Cued-recall Protocol Analysis

- Variation on retrospective
- Problem solving process is recorded. The trace is used as a ‘ cue’ (reminder) for the expert, who observes the trace and then reports their thought process.
- Trace eye-movements. Special equipment tapes what the expert observes. The tape is played back for the expert to aid recall.

Protocol Analysis

Advantages	Limitations
Expert consciously considers decision-making heuristics	Requires that expert be aware of why he or she makes a decision
Expert consciously considers decision alternatives, attributes, values	Requires that expert be able to categorize major decision alternatives
KE can observe and analyze decision-making behavior	Requires that expert be able to verbalize the attributes and values of a decision alternative
KE can record, and later analyze with the expert, key decision points	Requires that expert be able to reason about the selection of a given alternative
	Explanations may not track reasoning
	Subjective view of decision making

Direct Elicitation Methods: Questionnaires

- Don't think of typical survey research questionnaire,
- Develop a questionnaire that asks an expert very specific questions about particular variables.

Direct Elicitation Methods: Questionnaires

- In the context of KBS, they are useful for eliciting very explicit information.
- Therefore, typically used late in the knowledge elicitation process, when the knowledge engineer has a good idea of the information that needs to be elicited.

Indirect Elicitation Methods: Concept Sorting

- Give an expert a set of concepts or examples and ask him or her to sort them.
- The results are analyzed to determine which examples or concepts were placed in the same category.
- Helps one understand the underlying organizational structure of the expert's knowledge.

Indirect Elicitation Methods: Concept Sorting (continued)

- Typically place each concept or example on a single index card, then ask the expert to sort them based on how "they go together".
- It is best not to give the expert much direction, we want to discover his or her structure.

Concept Sorting Experiments

- Chi, Feltovich and Glaser thought experts used "deep structure" to organize their knowledge, so they came up with a set of problems where the "deep structure" was not obvious from the "surface features".
- When experts sorted the problems, they sorted them based on the "deep structure", while the novices used the "surface features".
- Their hypothesis was supported

Knowledge Sources: Empirical data

- Examples:
  - research reports
  - periodicals
  - memos
  - job aids (for instance, parts of a DSS, spreadsheet, flowchart laying out their job)
  - formal documentation
- Can be critical when building systems that "diagnosis and control"
  - MYCIN: empirical data that defined symptoms, treatments, and recoveries, have been useful to build the system.
- Useful stimulus material for the expert to work with during knowledge elicitation sessions

Knowledge Sources

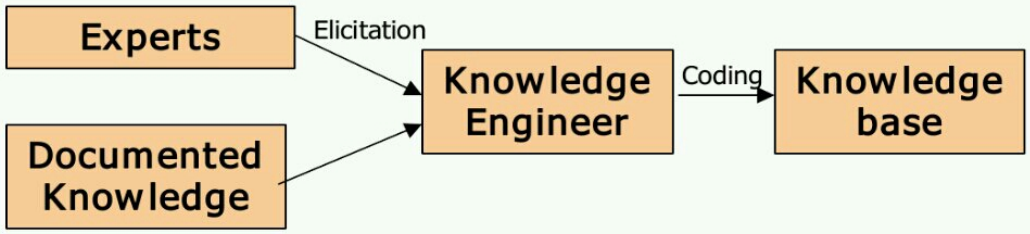
- Research
  - surveys, questionnaires, studies, statistical documentation.
- Computer-based sources
  - Internet
  - NEWSBANK, ABIINFORM, etc. and other types of electronic databases. Tends to be "declarative" - facts and general.
- Formal
  - policies, procedure, rules, and regulations, laws, etc.
  - be careful that information is not out of date.
  - be careful that what is documented reflects actual practices (not a "formal" policies that is not followed).

Knowledge Sources

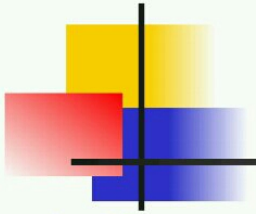
- Documented
- Undocumented
  - From people, from machines
- Databases
- Internet

Manual Methods - Structured Around Interviews

- Interviewing
  - Structured
  - Semistructured
  - Unstructured



- Tracking the Reasoning Process
- Observing
- Manual methods: slow, expensive and sometimes inaccurate



Protocol Analysis

- **Procedure (Kim and Courtney, 1988):**
  - Provide expert with full range of information normally associated with a task
  - Ask the expert to verbalize the task and record the verbalization on tape
  - Make statements by transcribing the verbal protocol
  - Gather the statements that seem to have high information content
  - Simplify and rewrite the collected statements and construct a table of production rules from the collected statements
  - Produce a series of models using the production rules

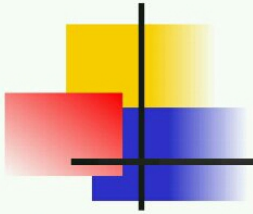
Repertory Grid Analysis (RGA)

I. Identify the important objects in the domain of expertise

II. Identify the important attributes

III. For each attribute, establishes a bipolar scale with traits and their opposites

IV. Select any three of the objects and identify:
   I. The attributes and traits that distinguish any two of these objects from the third
   II. Translate this on a scale of 1-3

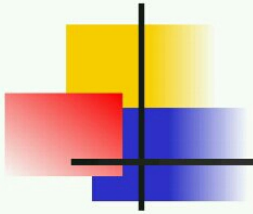


Repertory Grid Analysis (RGA)

V. Continue step 4 for several triplets of objects

VI. Build up the grid

VII. The grid may be used for recommendations



Repertory Grid Analysis (RGA)

Attribute	Orientation	Ease of programming	Training time	Availability
Traits Opposite	Symbolic (3) Numeric (1)	High (3) Low (1)	High (1) Low (3)	High (3) Low (1)
LISP	3	3	1	1
PROLOG	3	2	2	1
C++	3	2	2	3
COBOL	1	2	1	3