ADVANCED KNOWLEDGE ENGINEERING

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Subject's Outline

- **Topic 1:** An Overview of Knowledge Engineering
- **Topic 2:** An Overview of Knowledge-based Systems
- **Topic 3:** Knowledge Acquisition
- **Topic 4:** Knowledge Representation and Reasoning

Mid-term assessment

- **Topic 5:** Ontology
- **Topic 6:** Knowledge Graphs
- **Topic 7:** Expert Systems
- **Topic 8:** Uncertain Reasoning
- **Topic 9:** Hybrid Knowledge-based Systems
- **Topic 10:** Automated AI Planning

Group projects for the advanced topics

KNOWLEDGE ACQUISITION

Objectives of this topic

By the end of this topic, you will be able to:

- ✓ define knowledge acquisition
- ✓ explain how knowledge is acquired from a human expert
- ✓ explain the purpose and types of interviews in obtaining knowledge
- ✓ explain why it is necessary to record the results of interviews using techniques such as repertory grids (phương pháp tổ chức tư duy dạng bảng/ma trận)

Agenda

- Introduction to Knowledge Acquisition
- Knowledge Acquisition Issues and Difficulties
- Knowledge Elicitation (khai thác) Techniques
- Knowledge Modeling

Introduction to Knowledge Acquisition

- Knowledge acquisition is the process of acquiring knowledge from a human expert or a group of experts for the development of knowledge-based systems

- It comprises a set of techniques and methods that attempt to elicit knowledge of a domain specialist through some form of direct interaction with the expert .

Knowledge Acquisition Issues and Difficulties

- Key issues
  - The end-product must be useful to the end-users
  - To be useful, the end-product must be full of high-quality knowledge that is correct, complete, and relevant, and stored in a structured manner
  - The project must be run in an efficient way making the most use of the available resources
  - The project should not unduly disrupt the normal running of the organization, hence should not involve too much time from experts

Knowledge Acquisition Issues and Difficulties

- Experts can find it difficult to:
  - Express their expertise in a manner that is fully comprehensible to the knowledge engineer
  - Ascertain what the knowledge engineer actually wants
  - Give the right level of detail
  - Present ideas in a clear and logical order
  - Explain all of the jargon and the domain-specific terminology
  - Recall everything that is relevant to the project
  - Avoid drifting off to talk about irrelevant things
- Knowledge engineers can find it difficult to
  - Understand everything the expert says
  - Note down everything the expert says
  - Keep the expert talking about relevant issues
  - Maintain the high level of concentration required to take in a mass of new knowledge

Knowledge Elicitation Techniques

- Interview
- Protocol analysis
- Laddering
- Concept sorting
- Repertory grids
- Structural assessment

Interviewing

- The interview is the most commonly used knowledge-elicitation technique (kỹ thuật khai thác tri thức)
- Planning the interview
  - Read background material
  - Establish interviewing objectives
  - Decide whom to interview
  - Prepare the interviewee
  - Decide on structure and question types

Interview Structure

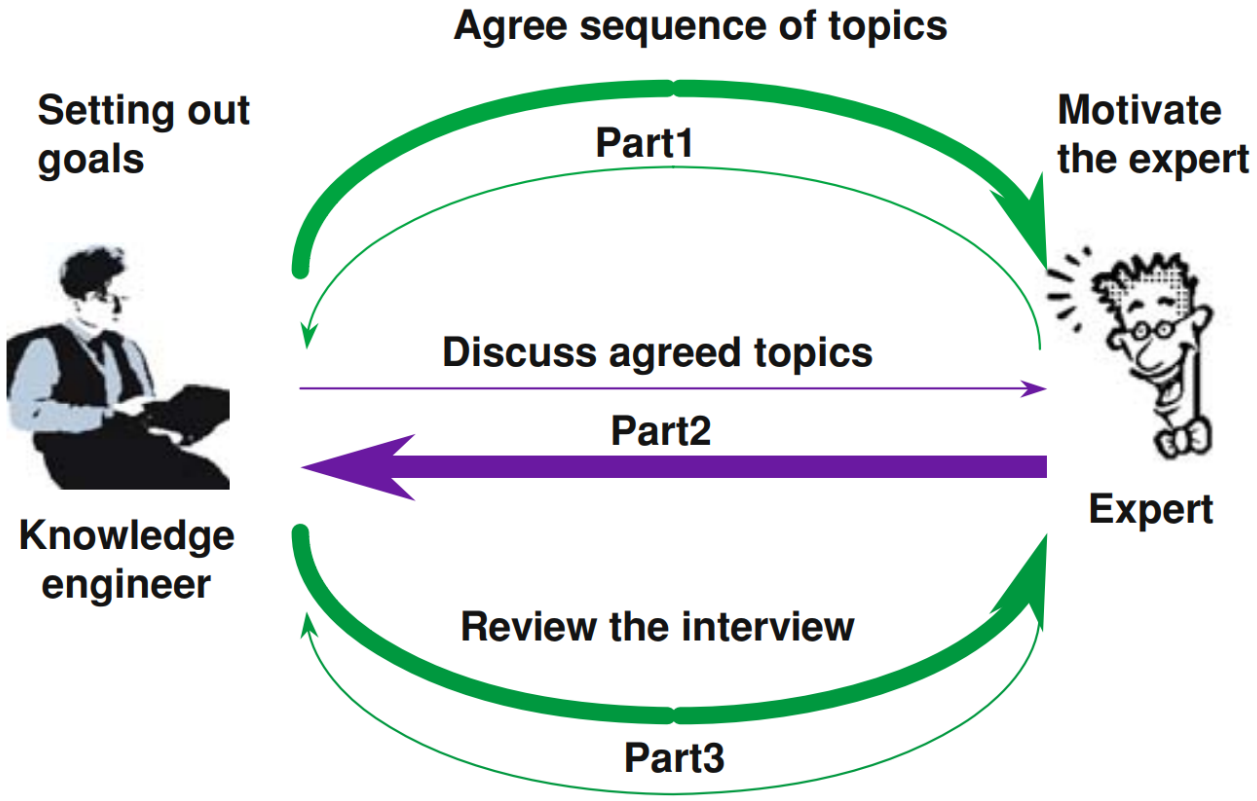
- Interview Type
  - Unstructured interview
    - often the first interview to be conducted
    - used in the early stages of knowledge acquisition
    - enable the knowledge engineer to gain an understanding of the knowledge domain
    - invite the expert to talk about the knowledge domain in high-level terms
    - consist of free-flowing dialogue, mainly from the expert
    - rarely provide a complete or well-organized description of the knowledge and processes involved
    - little prior planning carried out regarding the content of the interview
    - interviews tend to take on a 'life of their own'
    - can introduce important topics that could otherwise be neglected in an interview that was too structured

Interview Structure

- Interview Type
  - Structured interview
    - focused on the specific area of knowledge
    - relaxed to enable the expert to answer questions clearly and at an appropriate level of details
    - unhurried so as not to place the expert under time pressure
    - interesting so both the knowledge engineer and expert can relate to the subject and increase retention of information for the knowledge engineer
    - usually conducted after several unstructured interviews and the knowledge engineers have to analyze the knowledge provided in the unstructured interviews
    - focus on why a certain actions are taken, to obtain an understanding how the expert makes decisions

Interview Structure

- Interview Type
  - Structured interview



Interview Structure

- Interview Type
  - Event-recall interview
    - In an event recall interview, a particular case study will be discussed effectively
    - describing how experts dealt with a particular event – i.e., observing themselves in the past
    - helps in understanding how experts apply rules in complex situations
    - revealing the decision-making process itself; i.e., the sequence of thought processes
    - checking completeness of the knowledge acquisition sessions
    - learn the sequence of essential questions will be asked in the particular case-study
    - Is often used when other methods of knowledge collection are unreliable or when the knowledge domain is too complex for experts to easily explain their problem-solving processes

Interview Structure

- Interview Type
  - Thinking aloud interview
    - attempt to capture the thinking behind a problem-solving process
    - In event recall, the problem-solving process is in the past; in thinking aloud, it is in the present
    - encourage the experts to explain how they are thinking through a specific situation
    - fill any gaps in knowledge following the structured interview
    - validate knowledge already obtained as well as obtain information about the sequence of steps taken by an expert in solving a problem
    - normally discuss actual cases

Interview Structure

- **Exercise:** Find the appropriate interview type for the following situations:

1. A car manufacturer wishes to know what a few famous people think about their cars.
2. A software manufacturer needs to obtain information on whether some software meets the detailed performance requirements expected of it
3. A novice chef wants to understand the process of planning a menu
4. Information on a certain soap powder is required from 5,000 different people in one country

Interview Structure

- Question sequence (thứ tự câu hỏi)
  - **Pyramid (dạng kim tự tháp):** starting with specific questions and working toward general questions.
  - **Funnel (dạng phễu):** starting with general questions and working toward specific questions.
  - **Diamond:** starting with specific, moving toward general, and ending with specific questions.

Useful questions

- Begin the interview process:
  - Can you give me an overview of the subject?
  - Can you describe the last case you dealt with?
  - What facts or hypotheses do you try to establish when thinking about a problem?
  - What kinds of things do you like to know about when you begin to think about a problem?
  - Leading on to find a little more detail; tell me more about how this is achieved?
  - What do you do next?
  - How does that relate to . . . ?
  - How, why, when do you do that?
  - Can you describe what you mean by that?
- Closing the interview
  - reviewing the information obtained
  - Informing the expert to the need for further interviews

Question Types and Pitfalls

- Question types
  - Open-ended questions
  - Closed questions
  - Probing questions (*Câu hỏi làm rõ hơn vấn đề*)

- Question pitfalls (*Sai lầm khi đặt câu hỏi*)
  - Leading questions (*câu hỏi dẫn dắt*): suggests or implies a specific answer from the respondent, rather than allowing them to think and respond freely based on their own perspective. E.g, *Do you agree that ….?*
  - Ambiguous wording (*từ ngữ mơ hồ*)
  - Double-barreled questions (*câu hỏi kép*): asks about two or more issues within a single question. Example, *Do you like watching movies and reading books?*

Useful Probing Questions

- Why would you do that?
  - Converts an assertion into a rule
- How would you do that?
  - Generates lower-order rules
- When would you do that? IS <the rule> always the case?
  - Reveals the generality of the rule and may generate other rules
- What if it were not the case that <currently true condition>?
  - Generates rules for when current condition does not apply
- Can you tell me more about <any subject already mentioned>?
  - Used to generate further dialogue

Tips for Conducting the Interview

- ✓ One day before the interview, confirm times and places.
- ✓ Dress appropriately.
- ✓ Arrive a little early.
- ✓ Remind your interviewee that you will record important points
- ✓ Pick up on vocabulary and jargon.
- ✓ Double check to ensure correct understanding.
- ✓ Be aware of time limit.
- ✓ End with a final checking question.
- ✓ Thank the interviewee. Send a thank-you card.
- ✓ Write the interview report.

Protocol Analysis

- Analysis of the expert actually solving problems in the domain
  - Online protocol analysis
    - Self-report (also called think-aloud)
    - Shadowing : obsevering the experts to deal with daily tasks or activities, recording in detail what the they do, say, and experience
  - Offline protocol analysis
    - Retrospective verbalization of the problem-solving
- Particularly useful in analyzing dynamic reasoning behaviors
- Potential pitfalls
  - Unstructured transcripts
  - Limited scope of the knowledge
  - Inaccurate verbalization

Laddering (kỹ thuật leo thang)

- The expert and the knowledge engineer construct a graphical representation of the domain in terms of the relations between domain and problem solving elements.
  - This method results in a qualitative, two-dimensional graph where nodes are connected by labeled arcs.
  - The graph takes the form of a hierarchy of trees.
- Laddering is most useful in the early phases of domain exploration.
  - starting with asking specific questions about the expert's behaviors or decisions, and then gradually 'climbs' to explore the deeper values, processes, causes, and motivations related to that behaviors or decisions.

Concept Sorting

- In its simplest version an expert is presented with a number of cards on each of which a concept word is printed. The cards are shuffled and the expert is asked to sort the cards into either a fixed number of piles or into any number of piles the expert finds appropriate. This process is repeated many times.
- It can uncover how an expert sees relationships between a fixed set of concepts. It is particularly helpful in constructing a domain schema in unfamiliar domains.
- It requires prestructuring of the data

Repertory Grids (Phương pháp tổ chức tư duy dạng lưới/ma trận)

- Technique is useful when trying to uncover the structure of an unfamiliar domain
- The aim of producing the grid is to show in what ways objects in the domain are alike (or differ)
- reveal a conceptual map of a domain
- Recording an expert's view of a particular problem
  - The *elements* of the problem are recorded across the top of the grid: a list of people, objects or situations familiar to the expert
  - The rows in the grid contain the *constructs* relevant to the elements
  - A construct represents a bipolar characteristic that each element in the grid has
    - E.g., a person has a specific weight and eye colour

Repertory Grids (Phương pháp tổ chức tư duy dạng lưới/ma trận)

- Grids are prepared in the following way:
  - Stage 1: Define the Domain
  - Stage 2: State the elements
    - The elements are a representative sample taken from the domain
    - Elements of the domain: Countries

Britain	Chile	USA	Canada	Brazil	France	India

  - Stage 3: Define the Constructs
    - Constructs provide the means of differentiating between the different elements in the grid

	Britain	Chile	USA	Canada	Brazil	France	India
Hot					X	X	X
Holiday destination			X	X		X	
English speaking	X		X	X			

Repertory Grids (Phương pháp tổ chức tư duy dạng lưới/ma trận)

- Grids are prepared in the following way:
  - Stage 4: Ranking the Elements
    - indicating which elements are/or are not members of each set: the elements can be ranked in order, starting with one

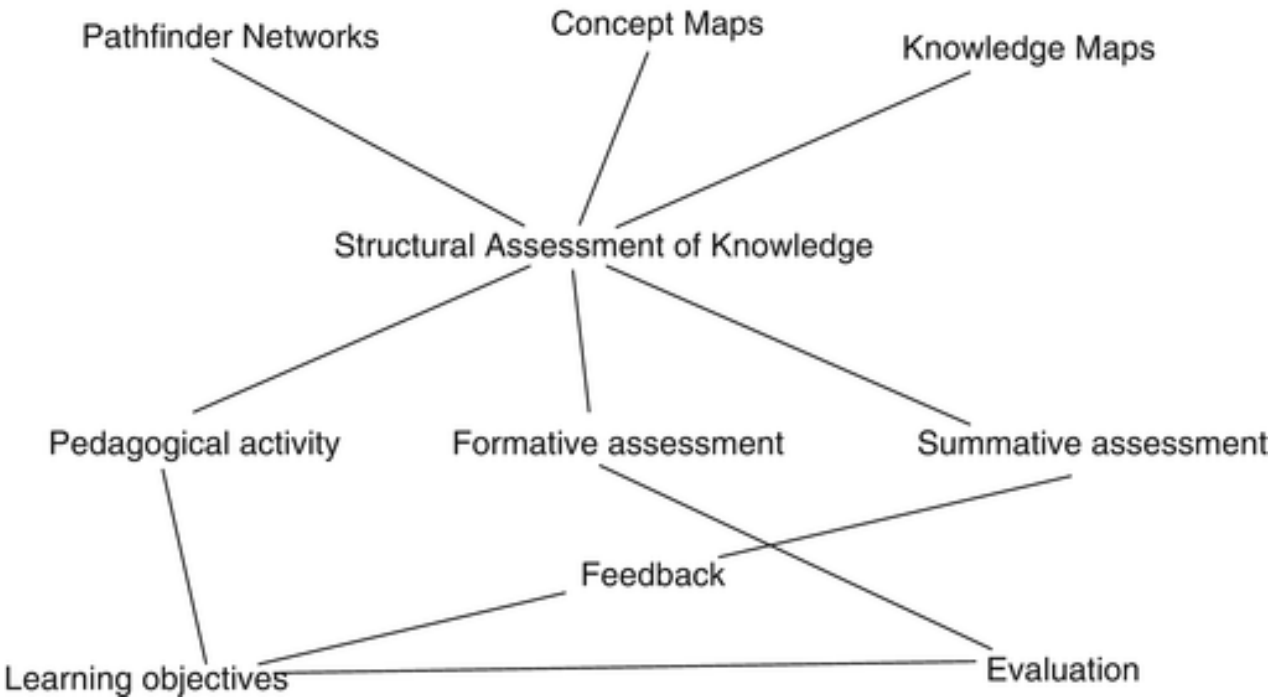
	Britain	Chile	USA	Canada	Brazil	France	India
Hot	5	7	4	6	3	2	1
Holiday destination	4	5	1	2	6	3	7
English speaking	1	4	3	2	6	7	5

  - Stage 5: Analyzing the Grid
    - Try to identify the differences and similarities between constructs
    - Where similarities are discovered, then this information can be used to show how the different elements relate to each other in the specific domain

Structural Assessment

- Formalized by Goldsmith and Johnson (1990)
- Structural assessment (SA) steps
  - Define a referent structure of knowledge structure
    - Identify a set of central concepts and obtain experts' judgments of relatedness between pairs of these concepts to define the referent structure
  - Elicit judgments of relatedness
    - Elicit an individual's judgments of the relationships among the selected concepts.
  - Derive representations of knowledge
    - Transform the relatedness ratings to a more meaningful, interpretable representation
    - Scaling methods: Multidimensional scaling (MDS), cluster analysis, Pathfinder
  - Evaluate the representations
    - Evaluate an individual's cognitive structure
    - Pathfinder's primary index: closeness, coherence

An Example of Structural Assessment



Pathfinder network on structural assessment of knowledge derived from ratings of relatedness:

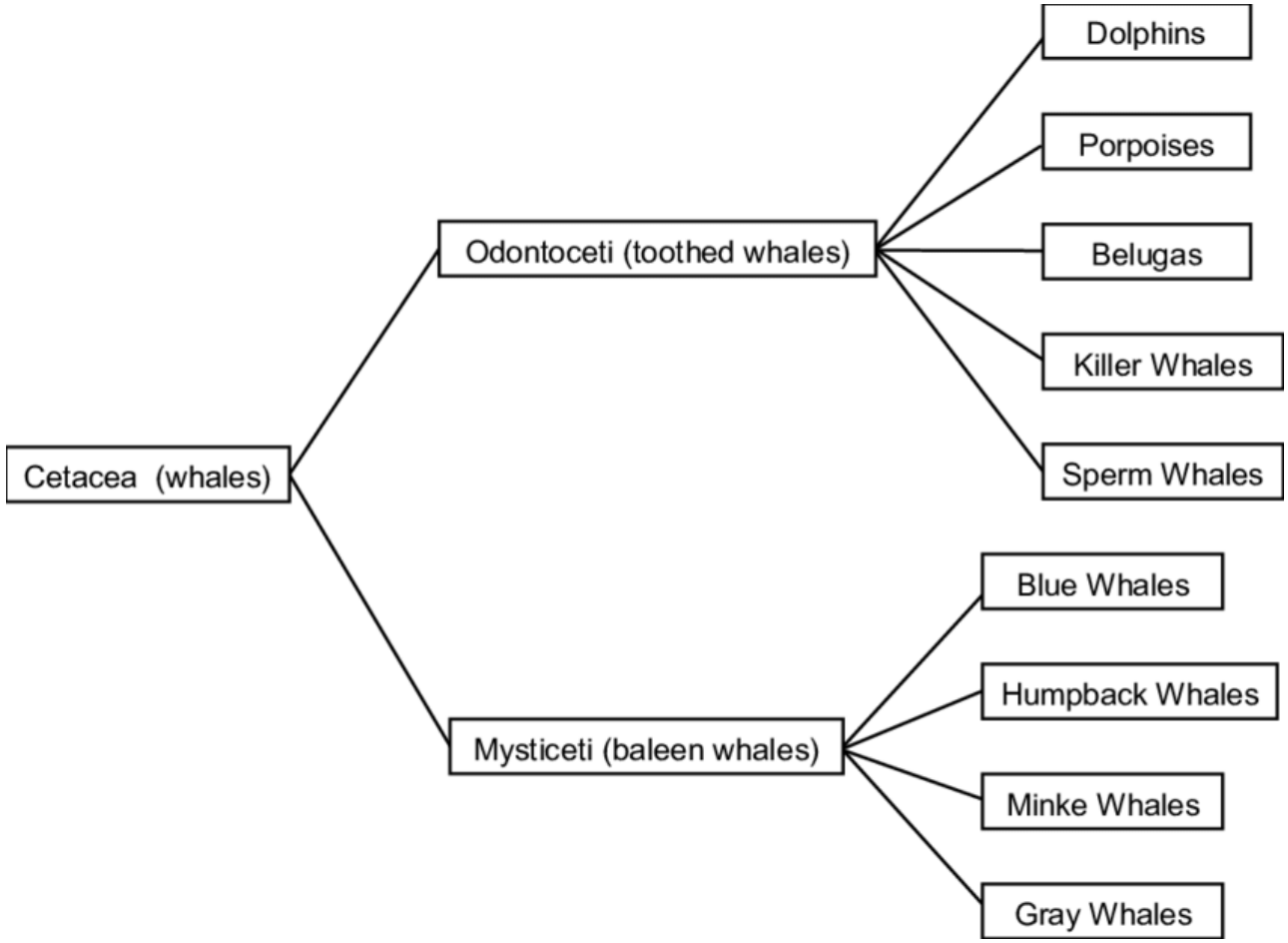
* Ten concepts associated with the varieties and uses of Structural assessment of knowledge

Knowledge Modeling

- Concept tree
- Matrices
  - Attribute matrix
  - Relationship matrix
- Maps
  - Concept map
  - Process map
- Pathfinder network
- Timeline
- Frame

Knowledge Modeling

- Concept tree



Knowledge Modeling

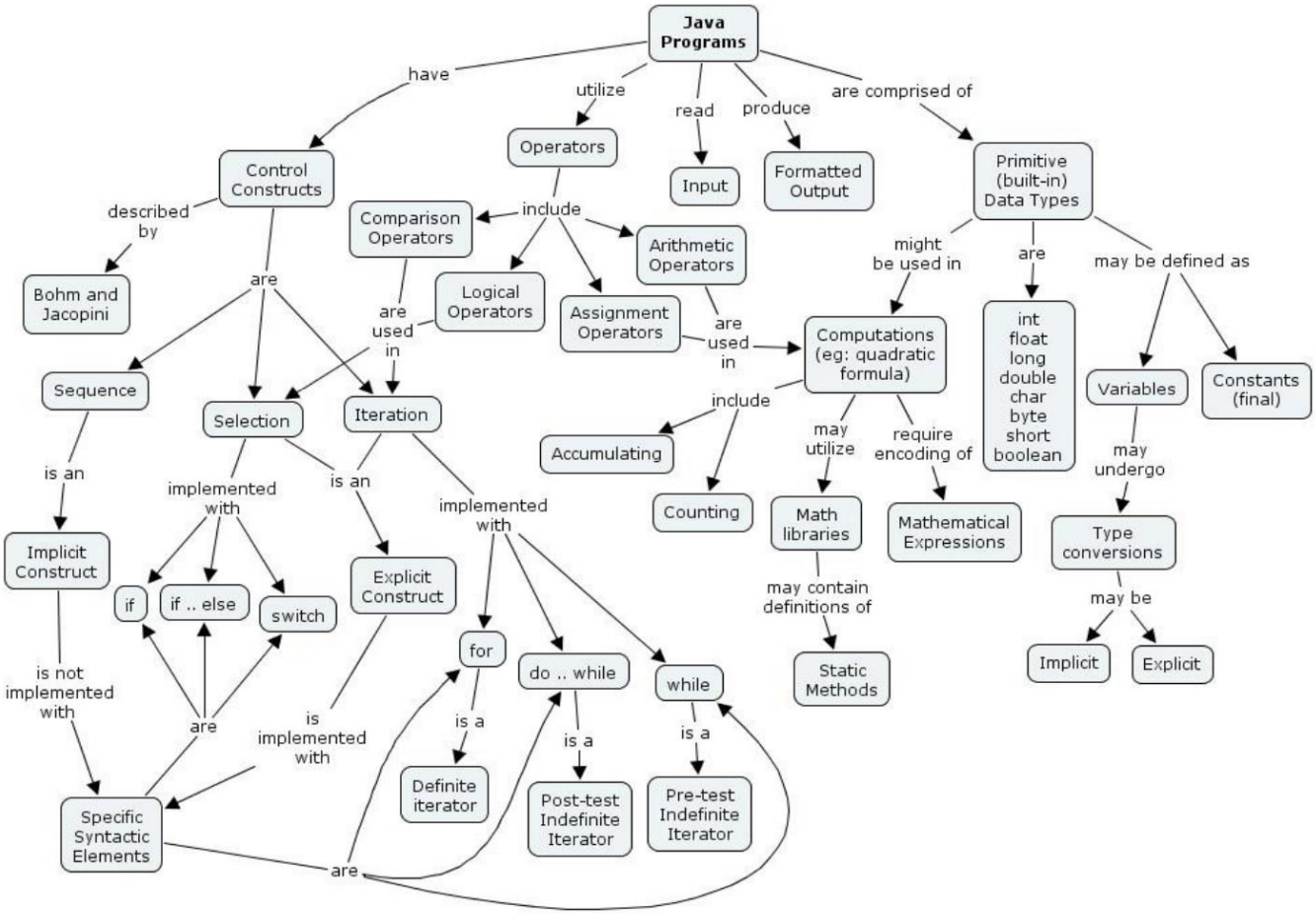
- Matrix example

Team: Administration				Manager: Reg			Date:	
		Research skills			Presentation skills			
Team	Job	Census	BMD	Wills & Probate	Writing	Page Layout	Image rework	Individual score
Jez	Coordinator	2	2	2	2	2	2	12/12
Alun	Agent	2	2	1	1	2	1	912
Tess	Agent	2	1	1	1	1	0	6/12
Patti	Agent	1	1	1	2	2	0	7/12
Zhen	Assistant	1	1	1	0	0	0	3/12
Sally	Trainee	0	0	0	0	0	0	0/12
Task score		8/12	7/12	6/12	4/12	7/12	3/12	
# People required to have this skill		6	6	6	6	3	1	

Key: 0 - no skills; 1 - learned; 2 - expert

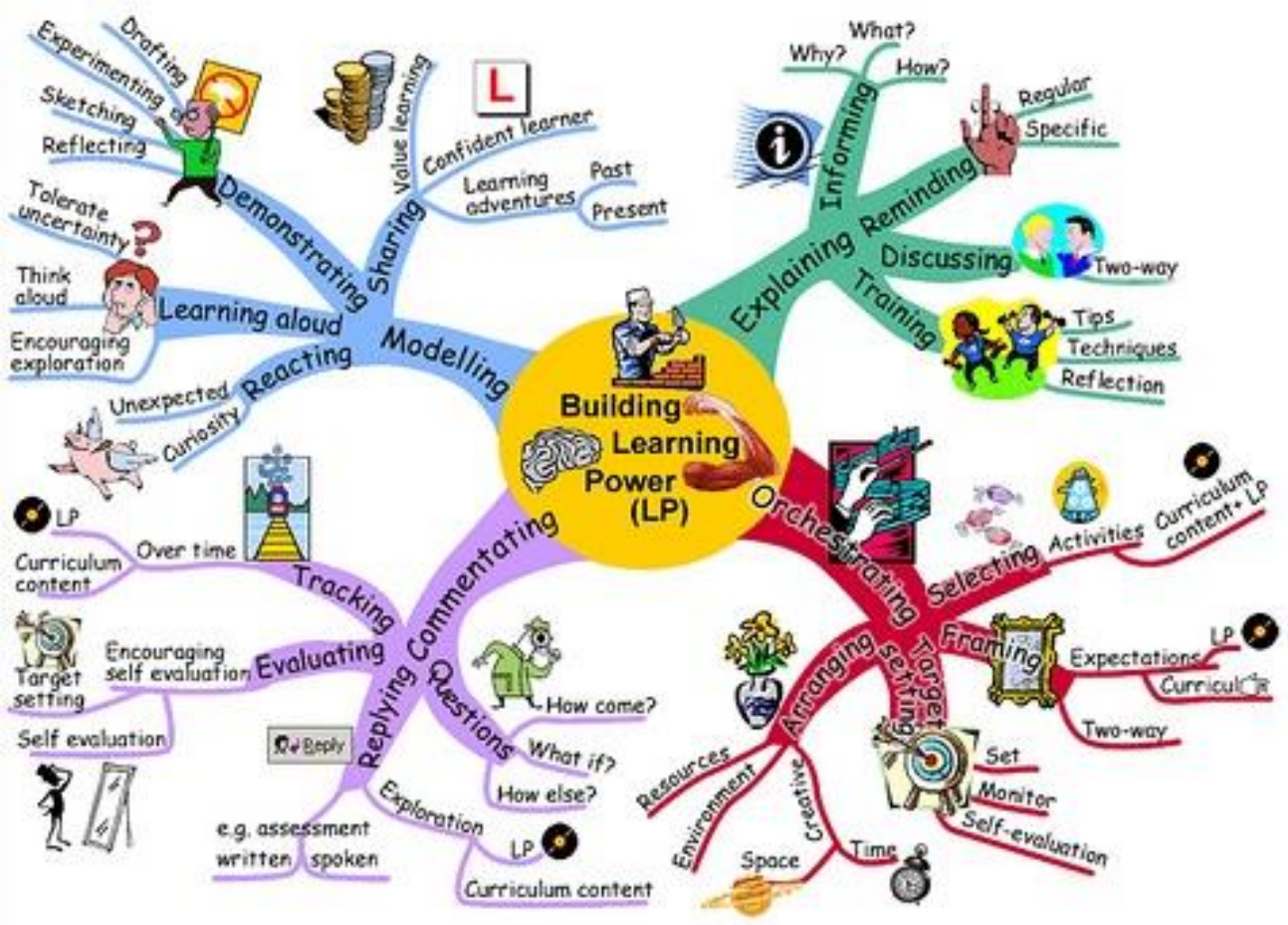
Knowledge Modeling

- Concept mapping example



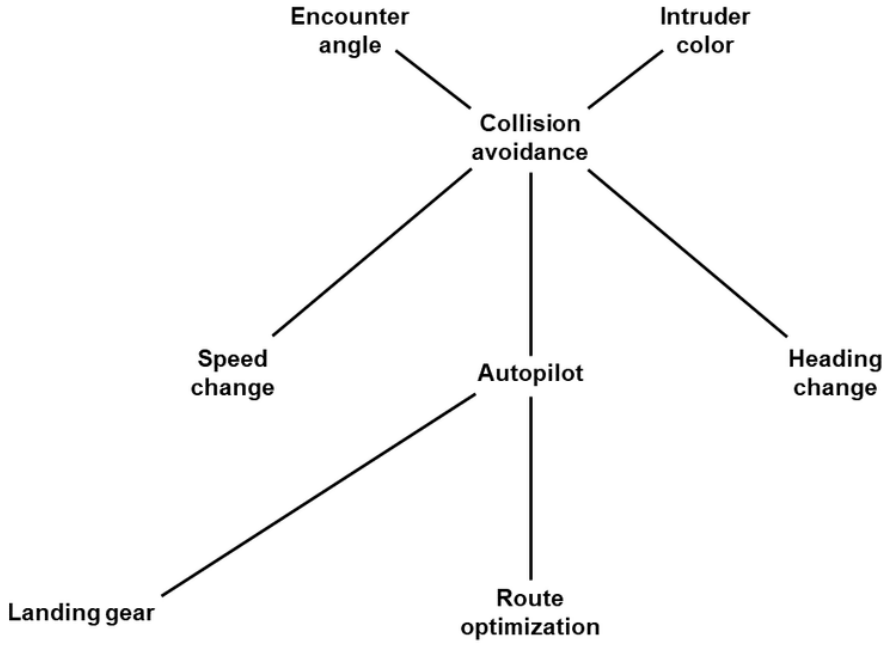
Knowledge Modeling

- Concept mapping example



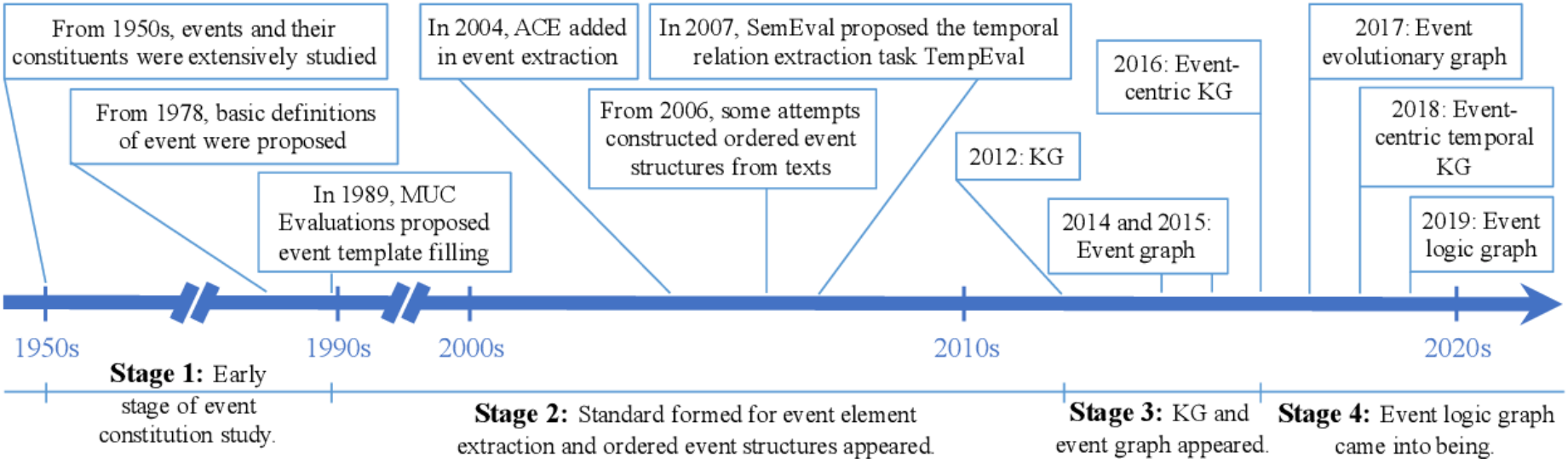
Knowledge Modeling

- Pathfinder Network example
  - It is designed to identify the most important relationships between concepts or data points without losing the overall integrity of the structure
  - minimizing the links between data points or concepts, retaining only the most robust and meaningful connections. This helps to highlight important relationships without overcomplicating the network.



Knowledge Modeling

- Timeline example



Knowledge Modeling

- Frame example

Coffee mug FRAME	
IS_A	Mug
COLOUR	
CAN_HOLD_LIQUID	True
NUMBER_OF-HANDLES	Default = 1
SIZE	Range: Small, Medium, Large
PURPOSE	Value : drinking coffee
COST	Demon (£ needed)
MATERIAL	Default = pottery