

UNIT 1

Introduction

(6 Hours) — Knowledge Engineering (CACS458)

⚠ Please Note

These notes are generated to help with revision and **may contain errors or omissions**. Please verify important definitions, formulas and examples against your textbook, lecture notes and the official TU syllabus before relying on them in an exam.

1.1 Overview of Data, Information and Knowledge

The three terms **data**, **information** and **knowledge** are closely related but not identical. Together with **wisdom** they form the DIKW hierarchy, which explains how raw facts are gradually turned into something useful for decision-making.

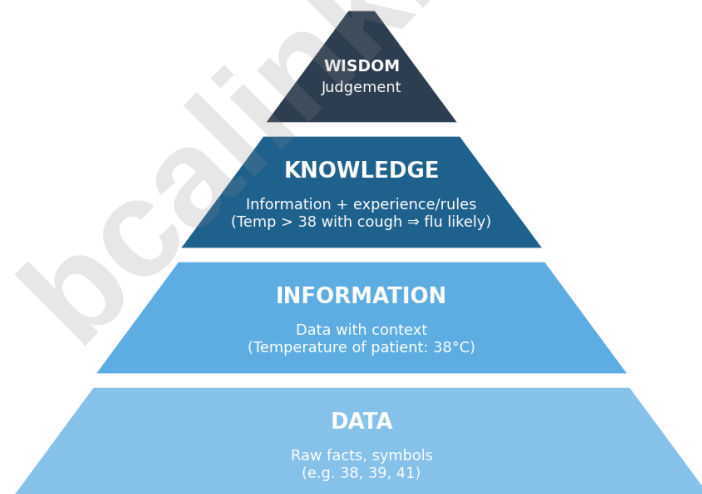


Figure 1.1: The DIKW pyramid — from raw data to wisdom.

Aspect	Data	Information	Knowledge
Meaning	Raw, unprocessed facts and figures	Processed data that has meaning and context	Information combined with experience, rules and understanding
Nature	Objective, unorganised	Organised, structured	Interpreted, actionable
Example	45, 60, 38	Marks of three students are 45, 60, 38	Students scoring below 40 should be given extra classes

Aspect	Data	Information	Knowledge
Question answered	What?	Who / what / where / when?	How / why?
Dependency	Independent	Depends on data	Depends on information

Types of Knowledge

- **Tacit knowledge** — personal, experience-based, hard to write down (e.g. a doctor's intuition, riding a bicycle).
- **Explicit knowledge** — documented and easily shared (manuals, books, databases).
- **Declarative knowledge** — “knowing that” (facts: Kathmandu is the capital of Nepal).
- **Procedural knowledge** — “knowing how” (steps to install an OS).
- **Heuristic knowledge** — rules of thumb from experience that usually, but not always, work.
- **Meta-knowledge** — knowledge about knowledge (knowing which rule to use when).

Example 1.1 — DIKW in a hospital

Data: 38.5, 39.0, 40.2 (numbers from a thermometer).

Information: the temperature of Patient A over three days was 38.5, 39.0 and 40.2 °C.

Knowledge: a rising fever for three days together with cough suggests infection and needs antibiotics test.

Wisdom: choosing the most appropriate treatment given the patient's age, allergies and history.

1.2 Knowledge Engineering and Knowledge Management

Knowledge Engineering (KE)

Knowledge engineering is the discipline of building intelligent, knowledge-based systems by acquiring, representing, validating and using the knowledge of human experts. The person who performs this work is the **knowledge engineer**; the source of knowledge is the **domain expert**.

Main stages of the KE process:

- **Problem identification** — decide the scope and suitability of the problem.
- **Knowledge acquisition** — collect knowledge through interviews, observation, documents and data.

- **Knowledge representation** — encode it using rules, frames, semantic networks, logic or ontologies.
- **Implementation** — build the knowledge base and inference engine.
- **Validation and testing** — compare system answers with expert answers.
- **Maintenance** — update knowledge as the domain changes.

Knowledge Management (KM)

Knowledge management is the organisational process of creating, capturing, storing, sharing and applying knowledge so that an organisation can improve performance and avoid repeating mistakes. KM is concerned with people, processes and technology, whereas KE is concerned mainly with building computer systems that embody knowledge.

Basis	Knowledge Engineering	Knowledge Management
Focus	Building knowledge-based systems	Managing organisational knowledge assets
Main actors	Knowledge engineer, domain expert	Managers, employees, KM officers
Techniques	Knowledge acquisition, representation, reasoning	Documentation, communities of practice, repositories
Output	Expert system / KBS	Shared knowledge culture and repositories
Scope	Technical, system-oriented	Organisational, people-oriented

KM cycle: Create → Capture → Organise/Store → Share/Distribute → Apply → Update. The SECI model by Nonaka and Takeuchi describes knowledge conversion: *Socialisation* (tacit→tacit), *Externalisation* (tacit→explicit), *Combination* (explicit→explicit) and *Internalisation* (explicit→tacit).

1.3 Artificial Intelligence in Knowledge Engineering

Artificial Intelligence (AI) provides the methods that make knowledge engineering possible. Early AI research on expert systems showed that *domain knowledge*, rather than general problem-solving power alone, produces expert-level performance.

- **Knowledge representation & reasoning** — logic, rules and frames allow machines to store and infer knowledge.
- **Machine learning** — automatically acquires knowledge (rules, patterns) from data, reducing the acquisition bottleneck.

- **Natural language processing** — extracts knowledge from text documents and enables human-like interaction.
- **Search and planning** — helps inference engines explore possible solutions.
- **Ontologies and semantic technologies** — give shared meaning to knowledge so different systems can reuse it.
- **Uncertainty handling** — probability and fuzzy logic deal with incomplete or imprecise knowledge.

Note: The knowledge acquisition bottleneck — the difficulty of extracting knowledge from experts — is one of the main reasons AI techniques such as machine learning are used in KE today.

1.4 Knowledge-Based Systems and Their Applications

A **knowledge-based system (KBS)** is a computer program that uses a knowledge base of facts and rules, together with an inference mechanism, to solve problems that normally require human expertise. An **expert system** is the best-known type of KBS.

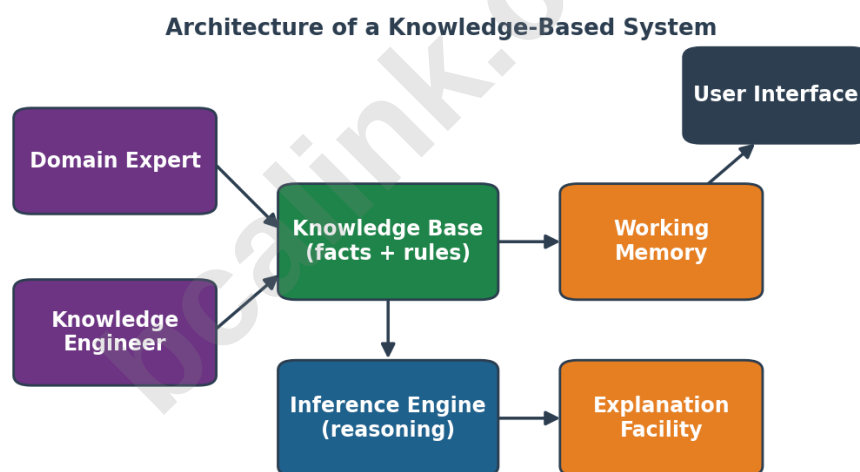


Figure 1.2: Components of a knowledge-based system.

Component	Role
Knowledge base	Stores domain facts and rules (long-term knowledge).
Inference engine	Applies reasoning (forward / backward chaining) on the knowledge base to derive conclusions.
Working memory	Holds facts of the current problem or session.
User interface	Lets the user enter queries and see results.
Explanation facility	Explains how and why a conclusion was reached, building trust.

Component	Role
Knowledge acquisition module	Helps the knowledge engineer add or modify knowledge.

Characteristics of a KBS

- Separates knowledge from the program that uses it, so knowledge can be updated easily.
- Can explain its reasoning.
- Handles uncertain and incomplete information.
- Provides consistent, always-available expertise.
- Is usually limited to a narrow domain.

Advantages and Limitations

Advantages	Limitations
Preserves scarce expertise	Knowledge acquisition is slow and costly
Consistent and available 24x7	Lacks common sense and creativity
Reduces cost of consulting experts	Narrow domain; fails outside its knowledge
Can explain decisions	Maintenance of large rule bases is difficult

Applications of KBS

Domain	Example system / use
Medicine	MYCIN — diagnosing bacterial infections; clinical decision support
Chemistry	DENDRAL — identifying molecular structure
Computing	XCON/R1 — configuring computer systems (DEC)
Finance	Credit scoring, fraud detection, loan approval advice
Agriculture	Crop disease diagnosis and fertiliser advice
Education	Intelligent tutoring systems
Customer support	Help-desk expert systems and chatbots

Example 1.2 — A simple rule-based KBS

Rule 1: IF fever = high AND cough = yes THEN suspect = flu.

Rule 2: IF suspect = flu AND breathing difficulty = yes THEN advice = consult doctor immediately.

Facts supplied by user: fever = high, cough = yes, breathing difficulty = yes.

Reasoning by the inference engine

Step 1: Facts match Rule 1, so the system adds *suspect = flu* to working memory.

Step 2: Now Rule 2's conditions are satisfied, so advice = *consult doctor immediately*.

This chaining of rules from facts to a goal is called **forward chaining**.

Key Takeaways — Unit 1

- ✓ Data → Information → Knowledge → Wisdom is the DIKW hierarchy; knowledge adds context, experience and rules.
- ✓ Knowledge engineering builds knowledge-based systems; knowledge management organises knowledge in an organisation.
- ✓ AI techniques (representation, ML, NLP, ontologies) support acquiring and using knowledge.
- ✓ A KBS = knowledge base + inference engine + working memory + user interface + explanation facility.
- ✓ KBS applications include medical diagnosis, configuration, finance, agriculture and education.

— End of Unit 1 —