
INSTITUT TEKNOLOGI BANDUNG
1920

Modul 5: Knowledge-based System

01 What & Why

Masayu Leylia Khodra
(masayu@informatika.org)

KK IF – Teknik Informatika – STEI ITB

Inteligensi Buatan
(*Artificial Intelligence*)

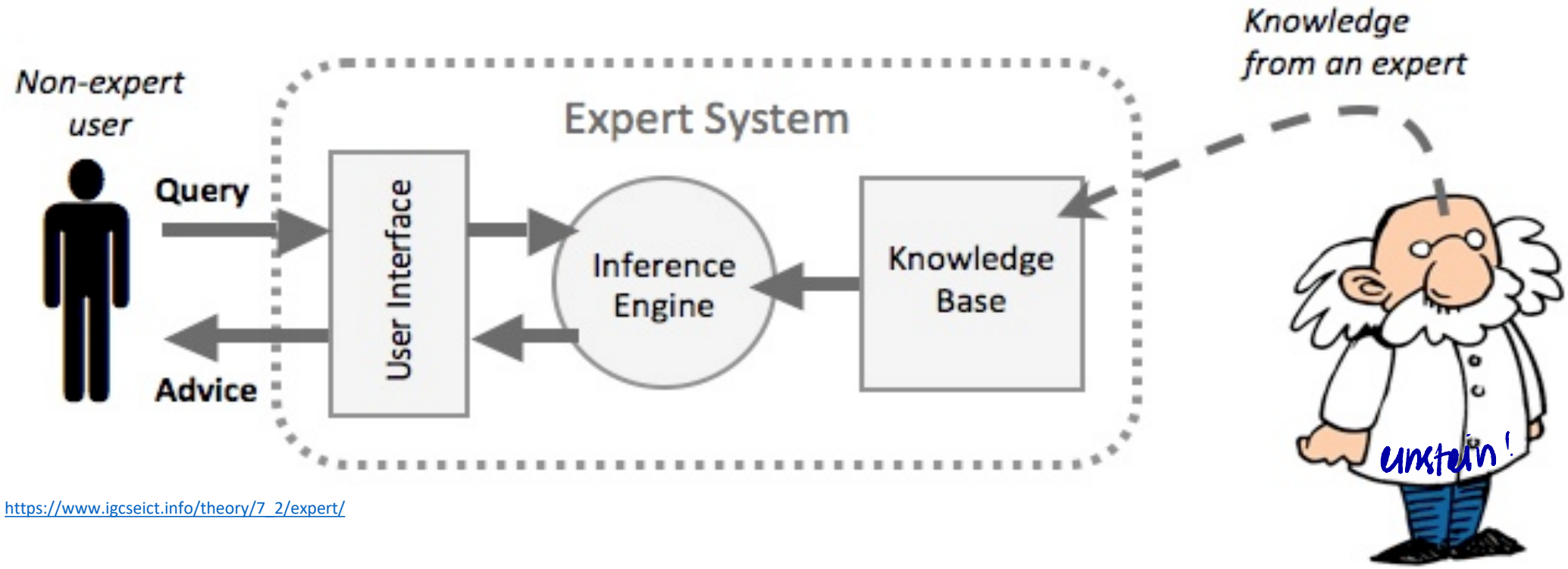
Knowledge-based System (KBS): What

Apply knowledge
in solving problem

Reconstruct expertise and reasoning capabilities of qualified specialists within limited domains

Logical reasoning

Knowledge-based System ≠ Expert System



https://www.igcseict.info/theory/7_2/expert/

Knowledge-based System (KBS): Why

Approach in developing AI agent

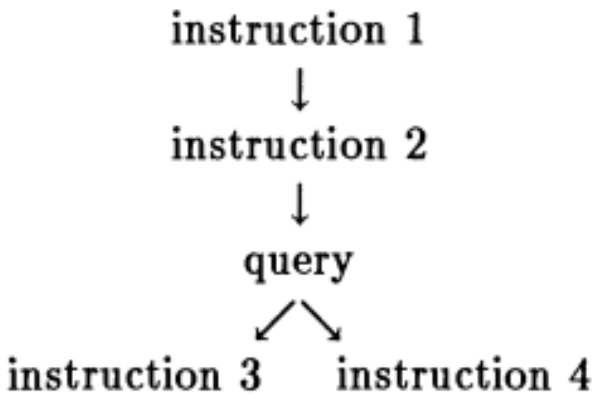
Logical reasoning: thinking rationally

- Template-based pattern recognition
- Statistical-based pattern recognition
- Structural/syntactic pattern recognition
- Deep learning-based pattern recognition

pengenalan berbasis neural network

KBS	Conventional Program
persoalan sudah buat dr awal terstruktur, gbs eksplisit tau dia persoalan apa Ill-structured problem (cth: CSP / apalah yg lain)	Well-structured problem
Expert determine actions, but execution order by interpreter	Programmer determines actions and execution order
Problem solving method + domain knowledge + data	Algorithm + data

1. Instruction-based programming style:
   program = sequence of instructions and queries



   The programmer determines what is done and in what order it is done.

2. Rule-based programming style:
   program = set of rules and rule interpreters

   Rule 1: If situation X1, then action Y1.
   Rule 2: If situation X2, then action Y2.
   Rule 3: If situation X3, then action Y3.

   The expert determines what is done, and the rule interpreter determines the order.

Puppe, F. (1993). *Systematic Introduction to Expert Systems* . Springer, Berlin, Heidelberg.

Problem Characteristics

Well-formed problem

- Exact / certain solution
- Explicit goal
- Explicit operator

Ill-structured problem

- Uncertain solution
- Undefined goal
- Unknown operator

Summary

What is KBS

KBS ≠ ES

Why KBS

KBS vs conventional

Reasoning in Knowledge-based Agent

Modul 5: Knowledge-based System

02 Knowledge-based Agent

Masayu Leylia Khodra
(masayu@informatika.org)

KK IF – Teknik Informatika – STEI ITB

Inteligensi Buatan
(*Artificial Intelligence*)

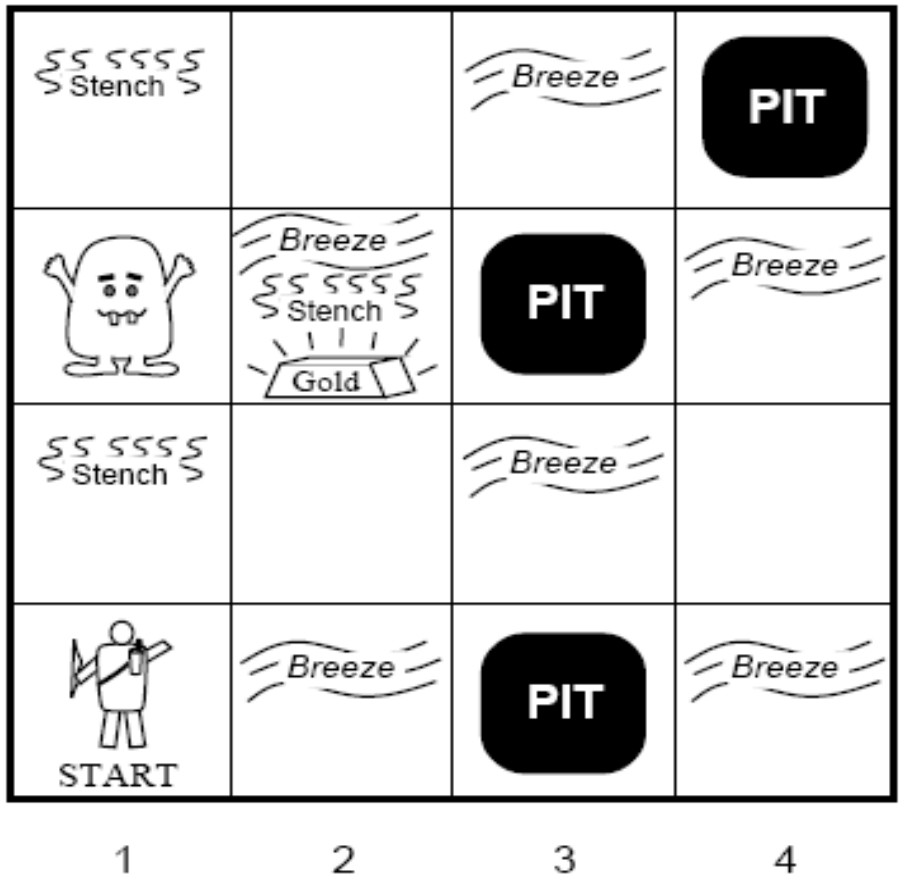
Knowledge-based Agent

Fundamental properties of logical reasoning

In each step, the agent draws a conclusion from available information

Conclusion is **guaranteed** to be correct if the available information is correct

Wumpus World



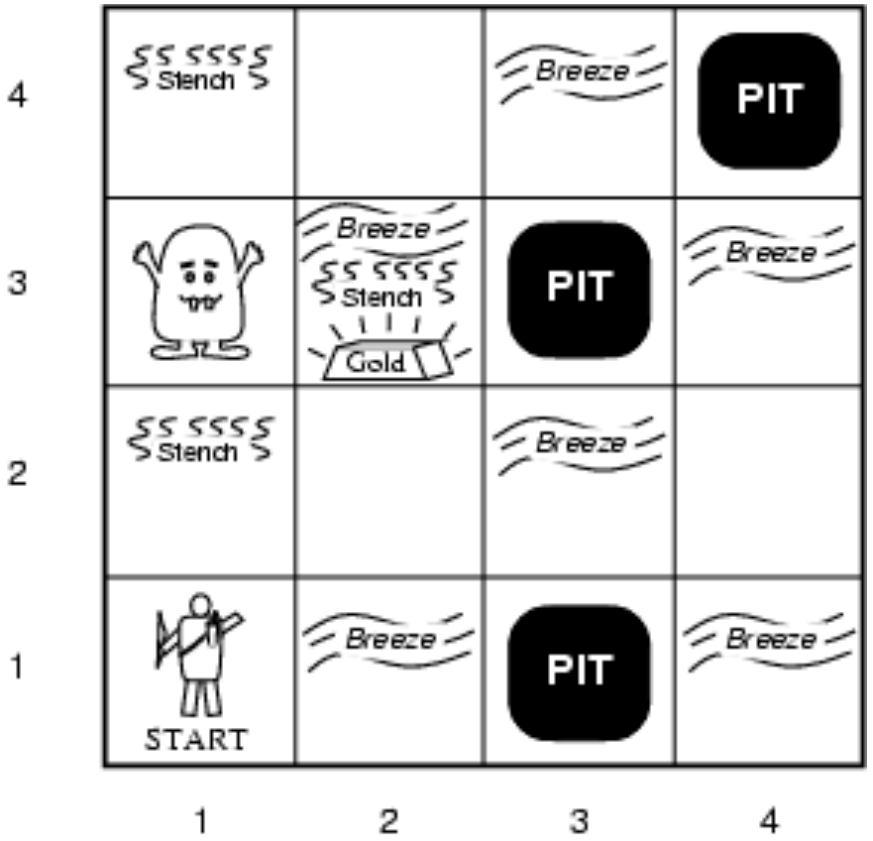
Performance Measure: gold +1000, death -1000, -1 per step, -10 for using the arrow

Environment: cave, rooms, Wumpus, gold

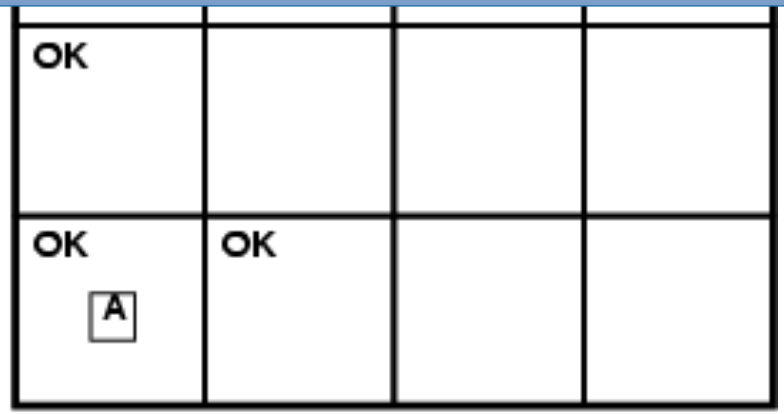
Actuators: motor to move Left, Right, Forward, hands to Grab, Release, and Shoot arrow

Sensors: sensor to capture [Stench, Breeze, Glitter, Bump, Scream]

Exploring a wumpus world

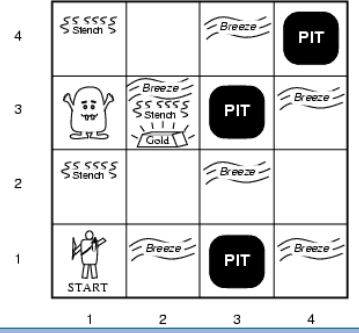


Percept [1,1] : [None, None, None, None, None]
No stench in [1,1] : No wumpus in [1,2] and [2,1]
No breeze in [1,1]: No pit in [1,2] and [2,1]
Action: forward to [2,1]



[1,1] : OK (safe)

Exploring a wumpus world (2)



1,4	2,4	3,4	4,4
1,3	2,3	3,3	4,3
1,2 OK	2,2	3,2	4,2
1,1 A OK	2,1 OK	3,1	4,1

(a)

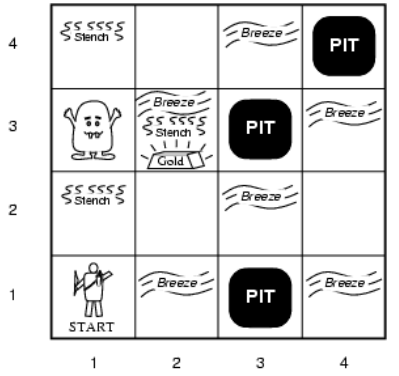
A
B
G
OK
P
S
V
W

1,2 OK	2,2 P?	3,2	4,2
1,1 V OK	2,1 A B OK	3,1 P?	4,1

(b)

Percept [2, 1] : [None, Breeze, None, None, None]
No stench in [2,1] : No wumpus in [3,1] and [2,2]
Breeze in [2,1]: there must be a pit in [3,1] or [2,2]
Set action: go back to [1,1] and forward to [1,2]

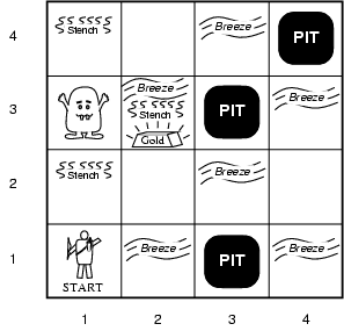
Exploring a wumpus world (3)



1,4	2,4	3,4	4,4
1,3 W!	2,3	3,3	4,3
1,2 A S OK	2,2 OK	3,2	4,2
1,1 V OK	2,1 B V OK	3,1 P!	4,1

Percept [1,2] : [Stench, None, None, None, None]
Stench in [1,2] : a wumpus in [1,3] or [2,2] or [1,1]
No wumpus in [1,1] and No stench in [2,1]
→ wumpus in [1,3]
No breeze in [1,2]: No pit in [1,3] and [2,2]
→ pit in [3,1] and [2,2] OK
Set action: go to [2,2]

Exploring a wumpus world (4)



1,4	2,4 P?	3,4	4,4
1,3 W!	2,3 A S G B	3,3 P?	4,3
1,2 S V OK	2,2 V OK	3,2	4,2
1,1 V OK	2,1 B V OK	3,1 P!	4,1

Percept [2,2] : [None, None, None, None, None]
No stench in [2,2] : No wumpus in [2,3] and [3,2]
No breeze in [2,2]: No pit in [2,3] and [3,2]
Set action: go to [2,3]

Percept [2,3]: [Stench, Breeze, Glitter, None, None]
Action: Grab

Generic Knowledge-based Agent

Domain knowledge
→ static

working memory
→ dynamic

function KB-AGENT(*percept*) **returns** an *action*

persistent: KB, a knowledge base

t, a counter, initially 0, indicating time

TELL(KB, MAKE-PERCEPT-SENTENCE(*percept*, t)) {assert percept}

action ← ASK(KB, MAKE-ACTION-QUERY(t)) {reasoning}

TELL(KB, MAKE-ACTION-SENTENCE(*action*, t)) {assert action}

$t \leftarrow t + 1$

return *action*

Knowledge-based Agent Development

notes :
proposisi : sesuatu yg bisa ditentukan kebenarannya (true/false)

Knowledge Representation

A language (to represent knowledge/ information)
a set of syntactic and semantic conventions that makes it possible to describe things, and a way of manipulating expression in language

Syntax: a description of what you're allowed to write down, what the expressions are, that are legal in a language.

+

Semantic: which is some story about what those expressions mean.

Requirements of Knowledge Representation

- No contradiction
- Each symbol must be unique
- Explain certain objects, relations and attributes
- Efficient manipulation in computer system

Production rules

Semantic networks dan frames

Selecting Knowledge Representation

Suitable for problem domain	• Decision tree for classification • Skeletal construction for construction • Rule for all problem domain
Suitable for the tasks (inference)	• Decision tree including interview process • Probability model for decision with uncertainty
Suitable for users (man or machine)	• Semantic network for user • rule for machine

Summary

Logical reasoning

Reasoning in Wumpus world

Generic knowledge-based agent

KB agent development

Knowledge representation

KR: requirement & selection

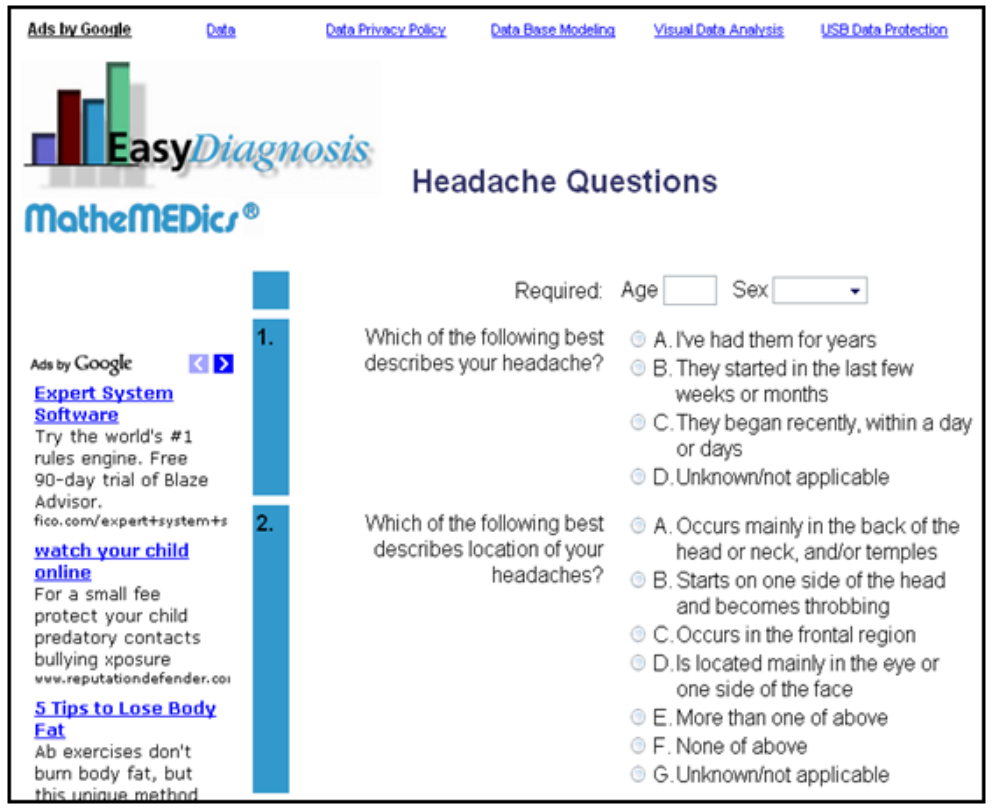
KBS Architecture

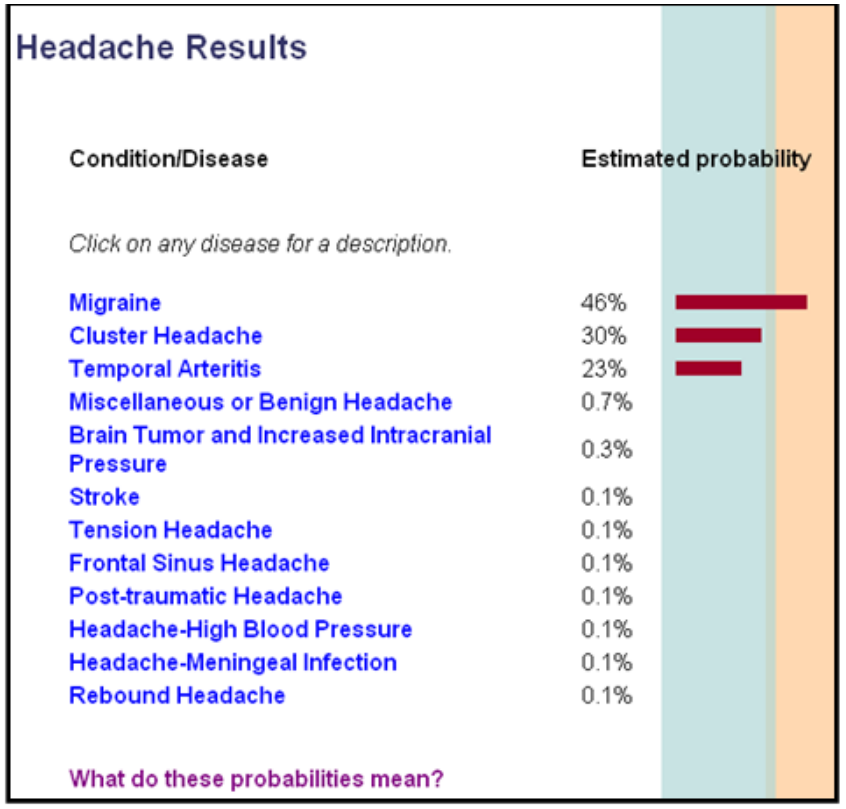
KBS Examples

Contoh Aplikasi

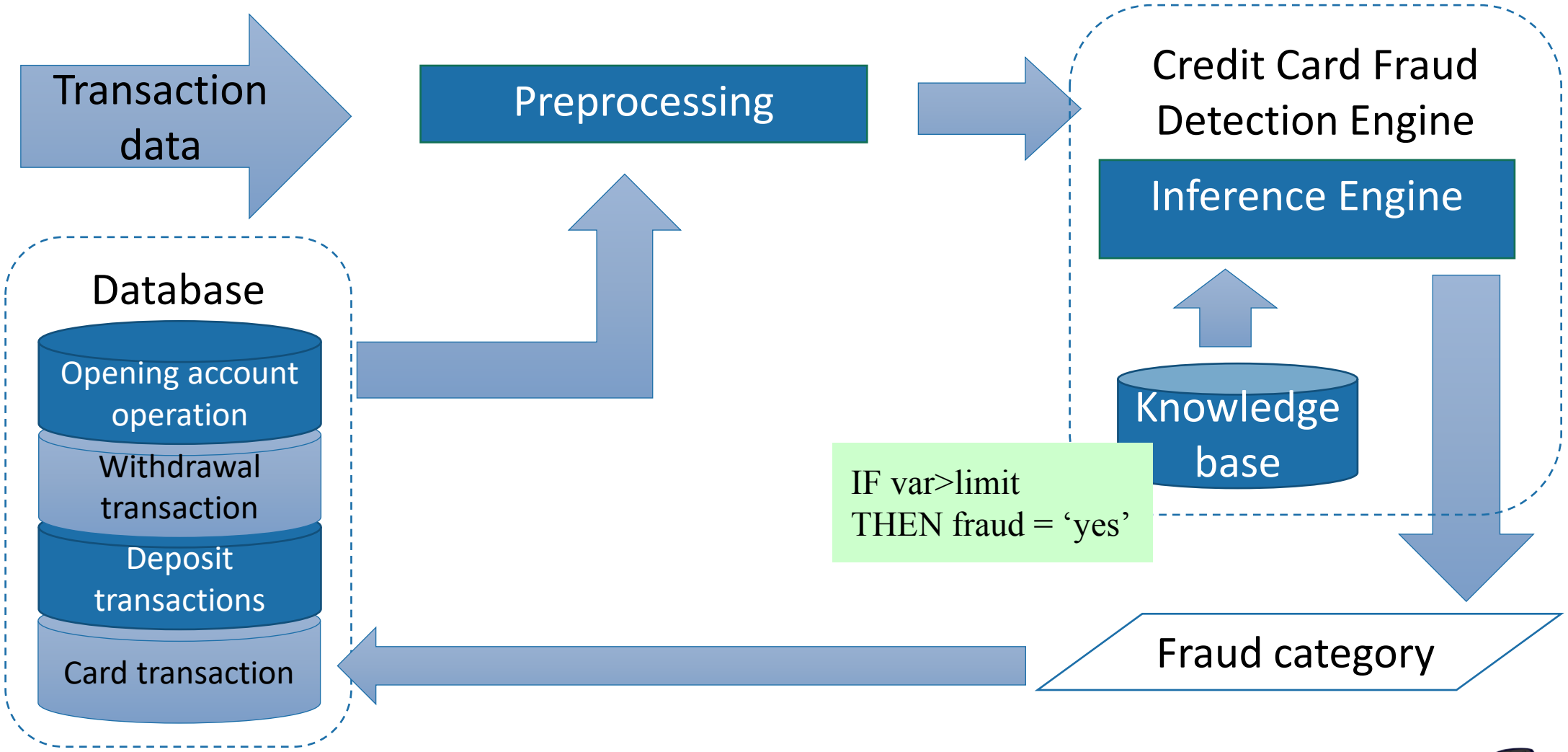
- Kesehatan: BAL2000, LISA, ISABEL, CTSHIV, DxPlain, MedWeaver, The Analyst, FuzzyFluid, Casnet, PUFF, Centaur, EasyDiagnosis, CLEM, VIE-PNN
- Lingkungan: ESS-WWTP, CREWS, CORMIX, HITERM, GCES, Oncologic
- Jaringan: NIDES, AudES, eXpert-BSM, Expert Advisor, Online ES (listrik)
- ITS: ActiveMath, TEST, ELM-ART, SID2002 Math ES, Chest
- Komputer/HW: DART, PEARL, PDAmum
- Manajemen: DXMAS, CESA, FINEVA
- Permainan: FRES, Rogomatic
- Geologi: PROSPECTOR II, DAS
- Pertanian: EXSEL, HABES, DSS4Ag
- Biologi: RIH, PSORTb
- NASA: Weather ES, SHINE
- Lainnya: TTA (teroris), ACAS-PRO (kartu kredit), USLIMITS 2, CATD-RT, HWYCON, SHYSTER (hukum)

EasyDiagnosis Medical Expert System





Credit Card Fraud Detection



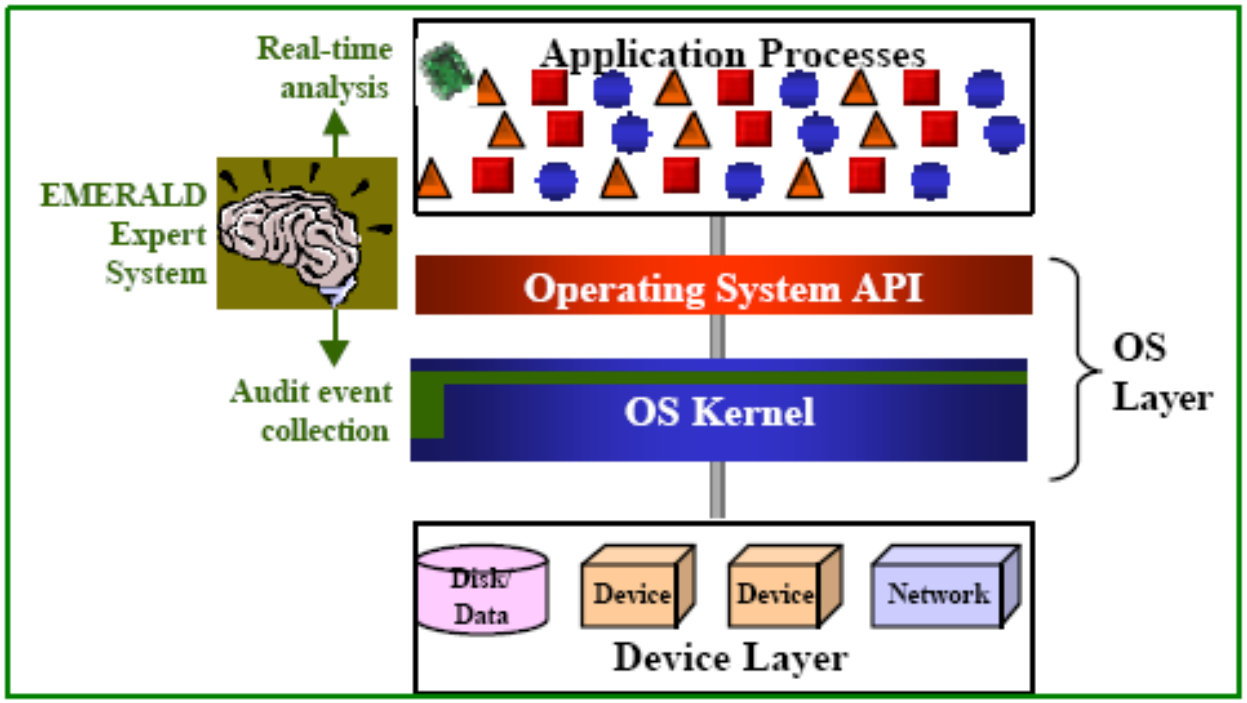
Ogwueleka, F. N. (2011). Data mining application in credit card fraud detection system. *Journal of Engineering Science and Technology*, *6*(3), 311-322.

Green Chemistry Expert System (GCES)

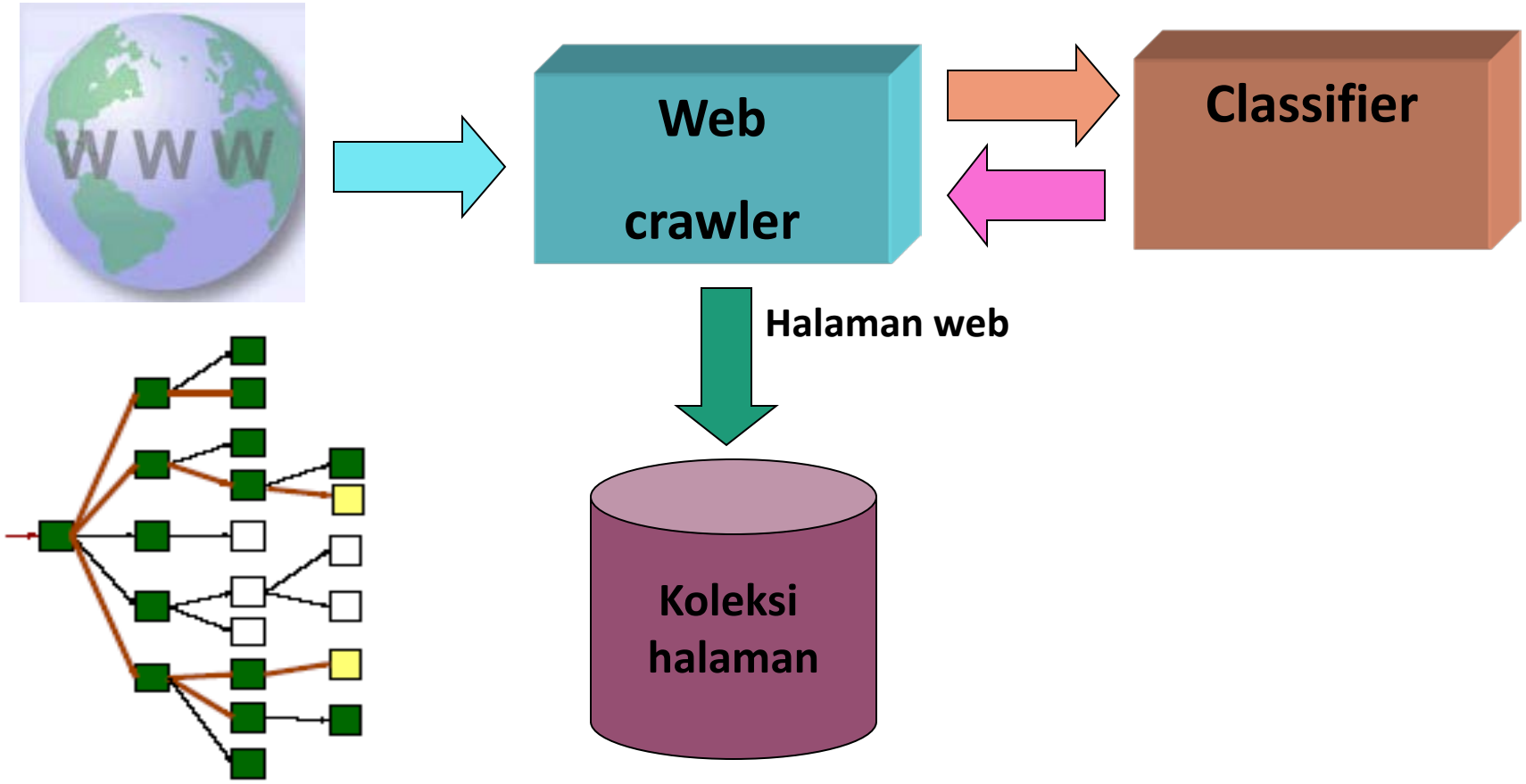
- Developer: EPA (*Evironmental Protection Protection Agency*) Amerika Serikat
  - MS Access, DBMS
- untuk menilai substansi yang berbahaya dalam reaksi kimia sehingga polusi dapat dicegah
- http://www.epa.gov/greenchemistry/pubs/gces.html

eXpert-BSM

- Intrusion Detection Solution for Sun Solaris
- Output: hasil analisis dan alert adanya intrusi pada audit trail dari Sun Solaris
- Sub sistem Emerald ES

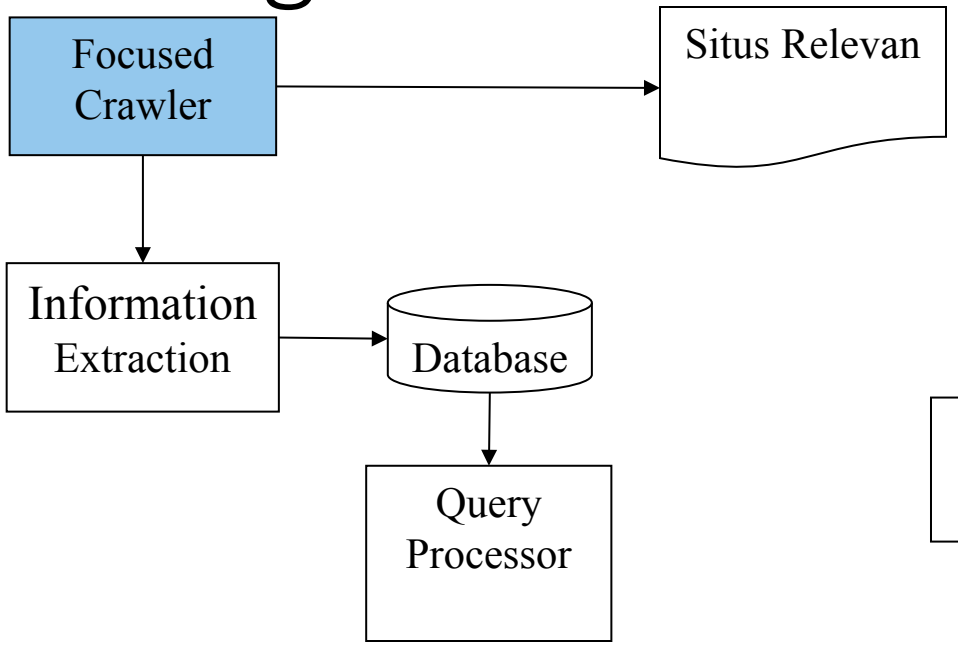


Focused Crawler Domain X



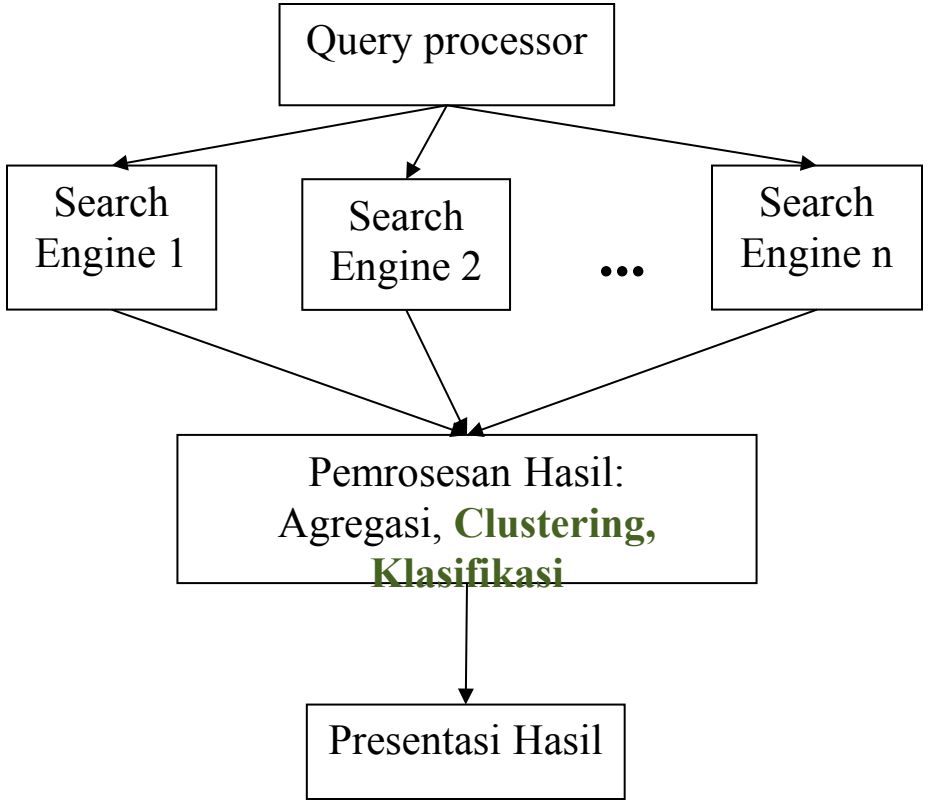
Vertical Search Engine

Search Engine: Architecture



Vertical search engine

Meta search engine



Modul 5: Knowledge-based System

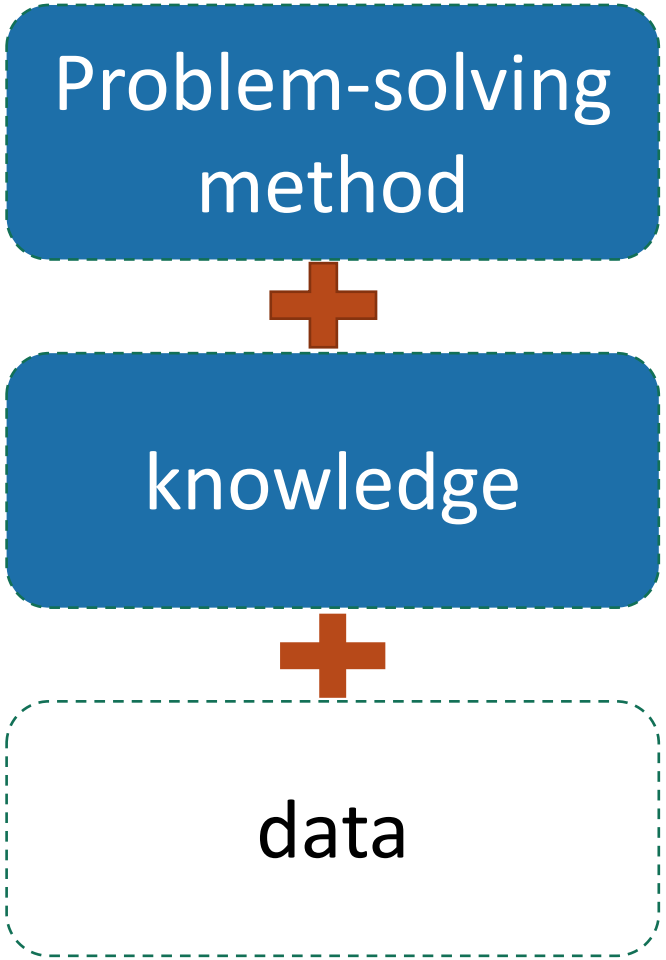
03 Architecture

Masayu Leylia Khodra
(masayu@informatika.org)

KK IF – Teknik Informatika – STEI ITB

Inteligensi Buatan
(*Artificial Intelligence*)

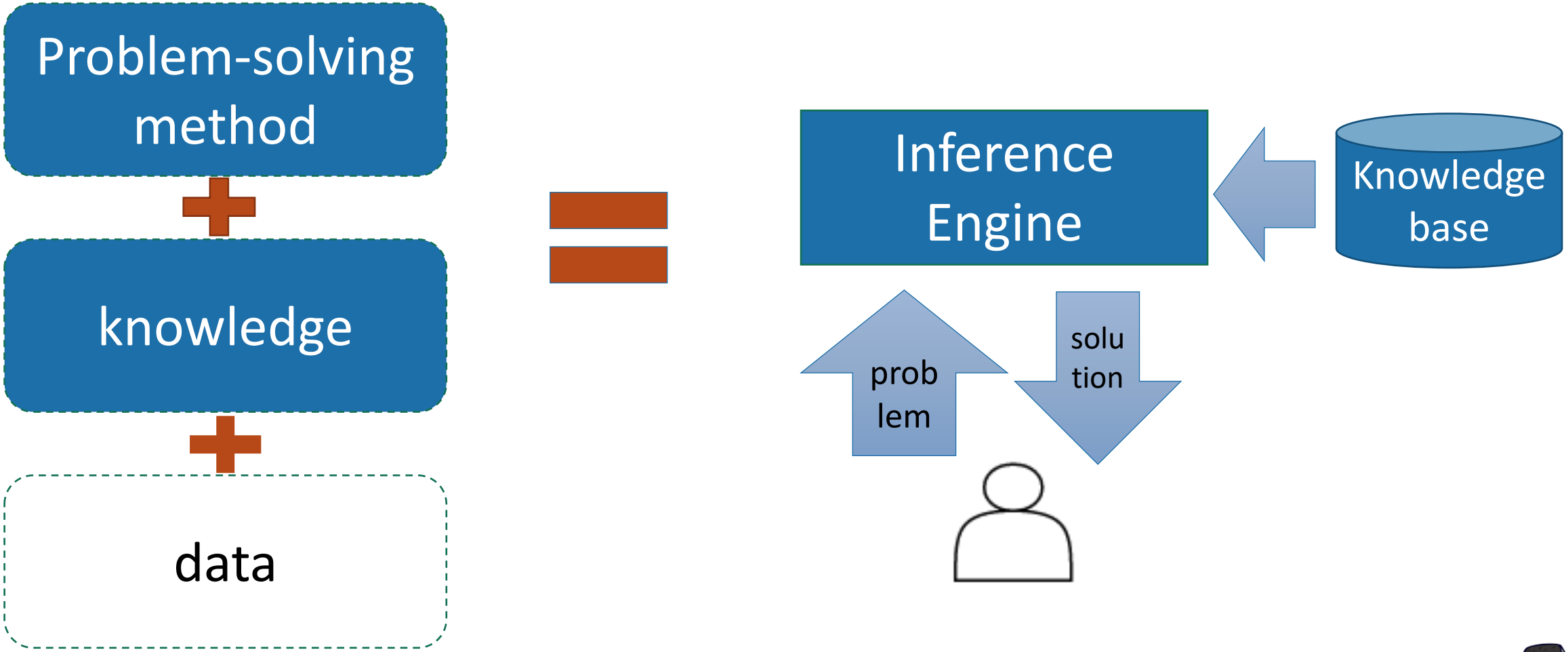
Knowledge-based System



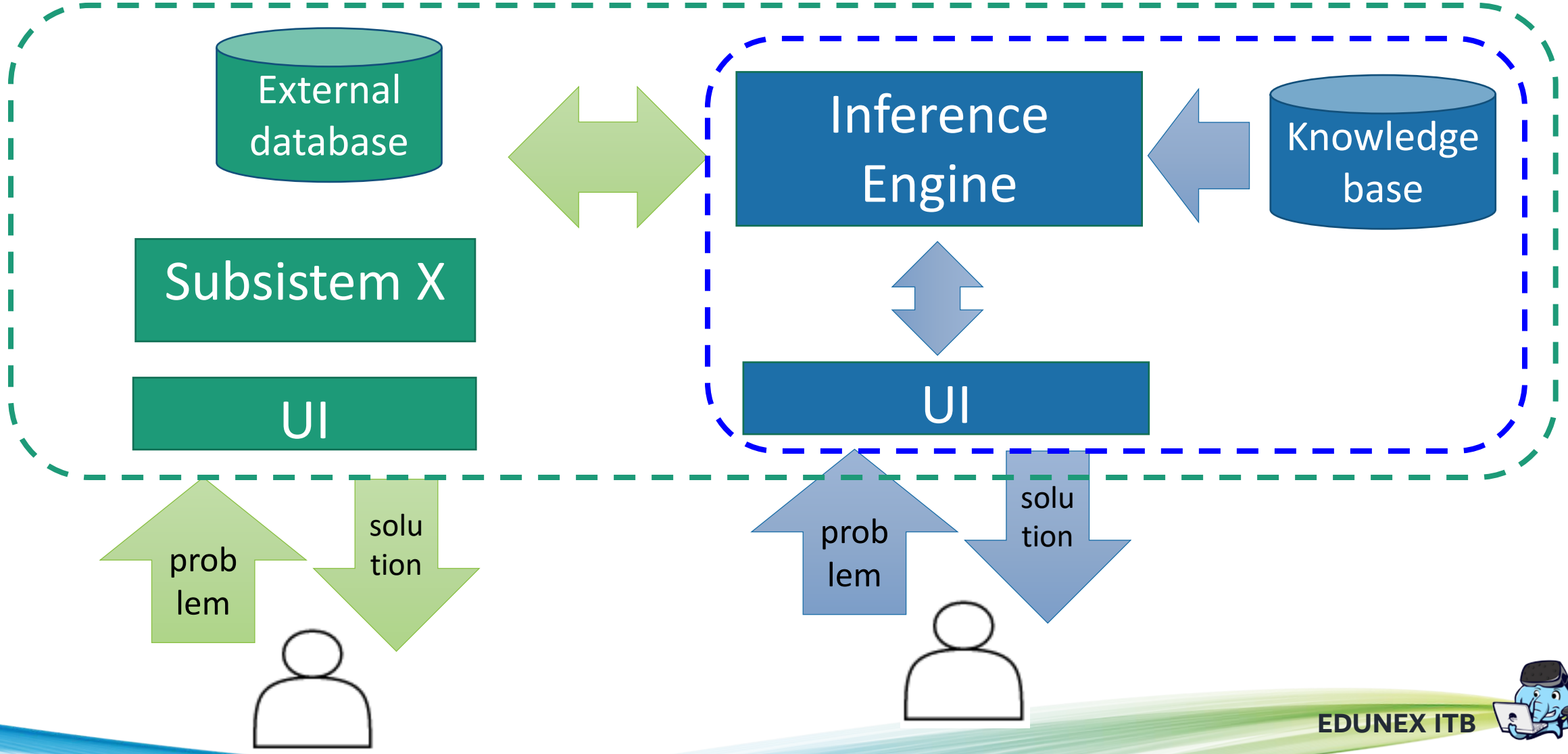
Problem-solving method is an algorithm which determines how domain-specific knowledge is used for solving problems (Puppe, 1993)

Example: knowledge reasoning methods (e.g. forward chaining for rule), general procedures (e.g. partially order plan)

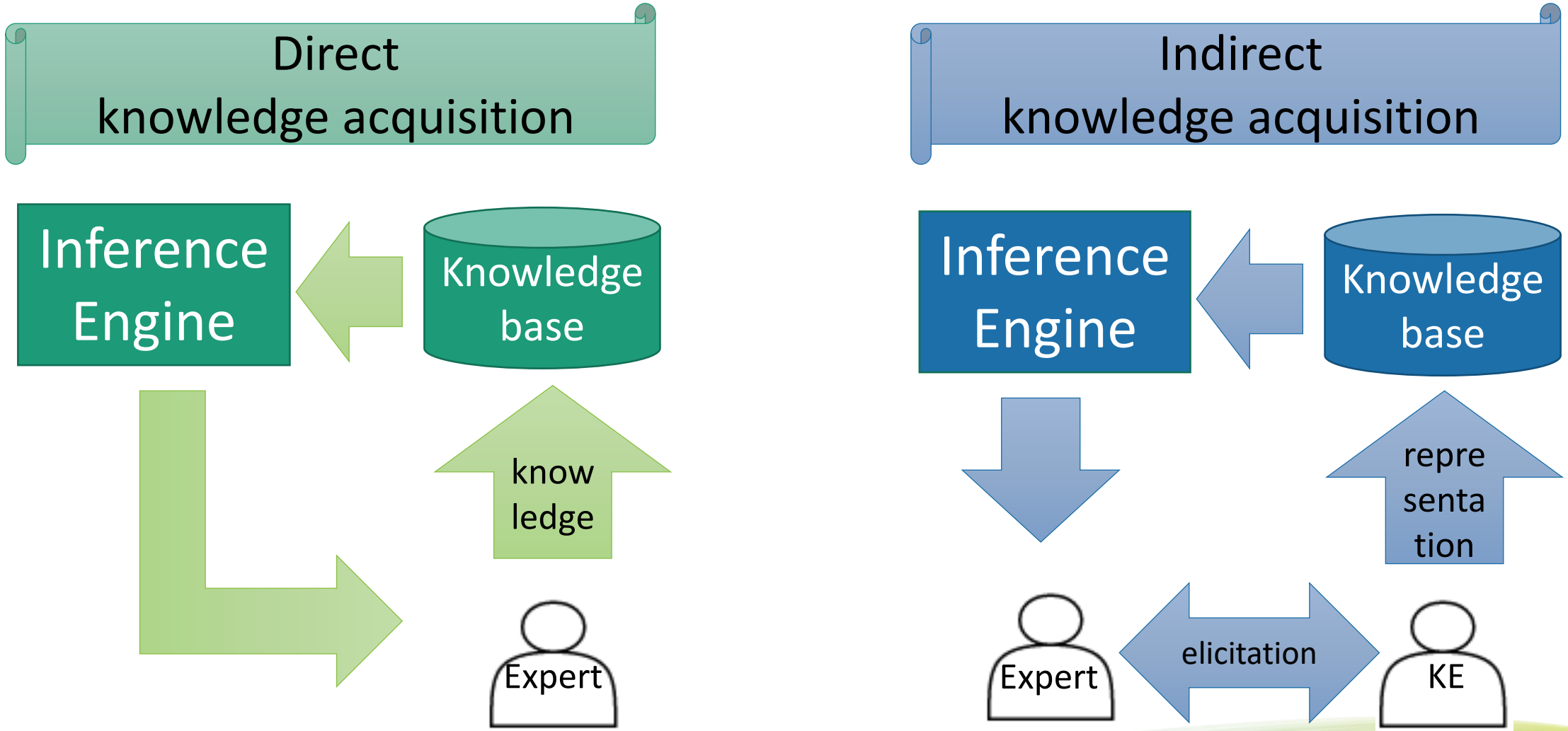
Knowledge-based System: Terminology



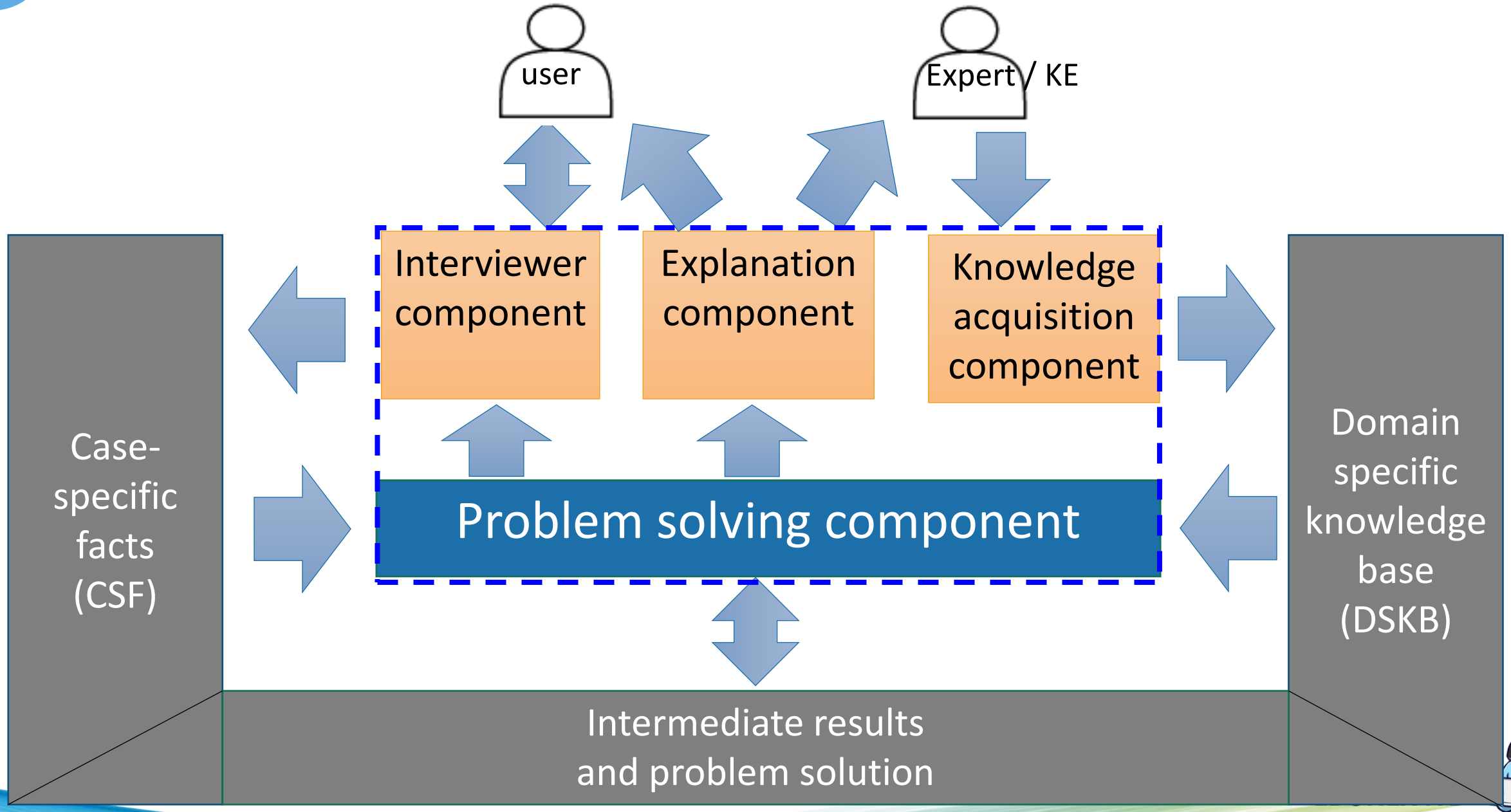
Interactive vs Embedded KBS



Knowledge Acquisition

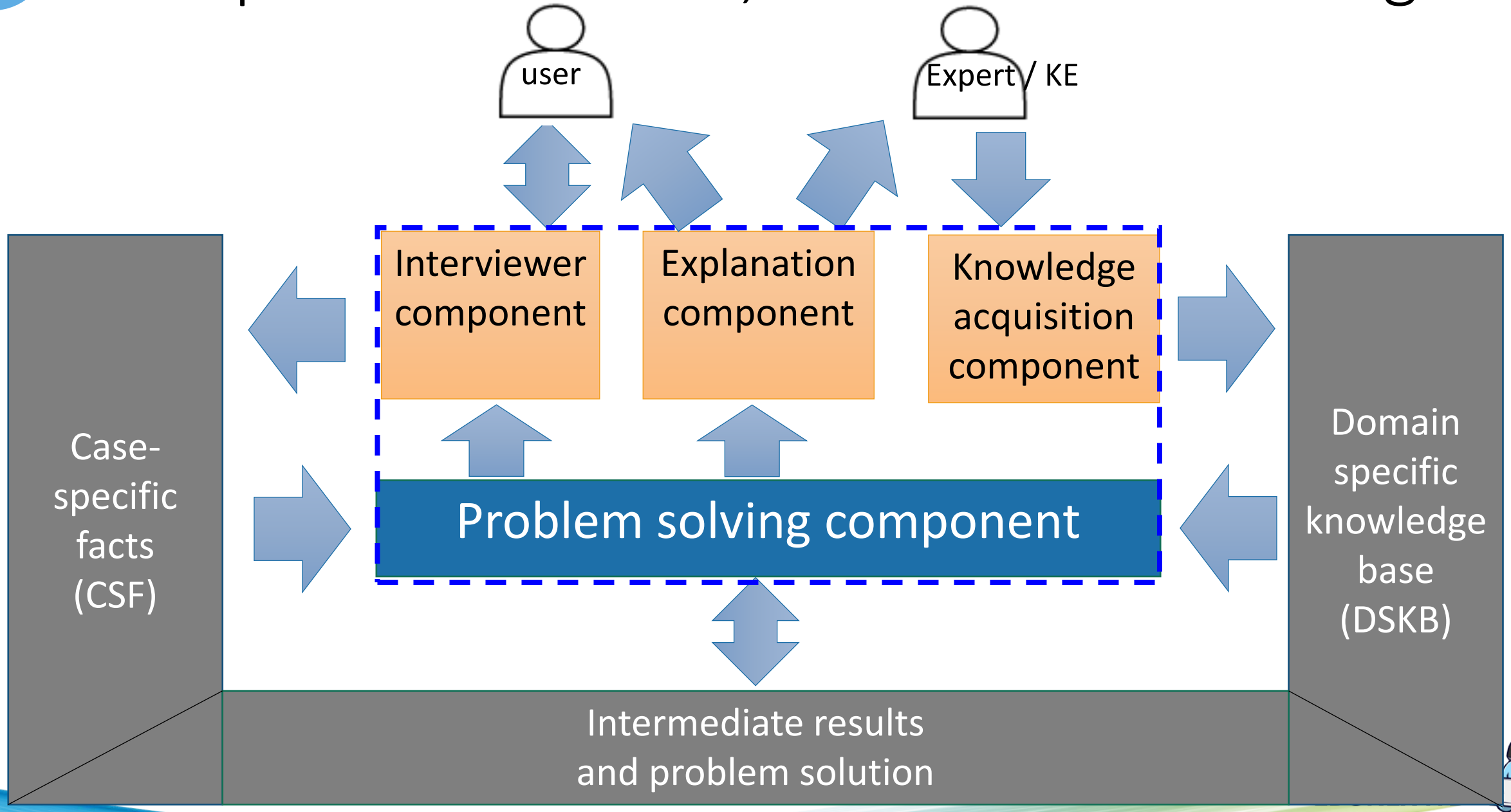


General Architecture of KBS



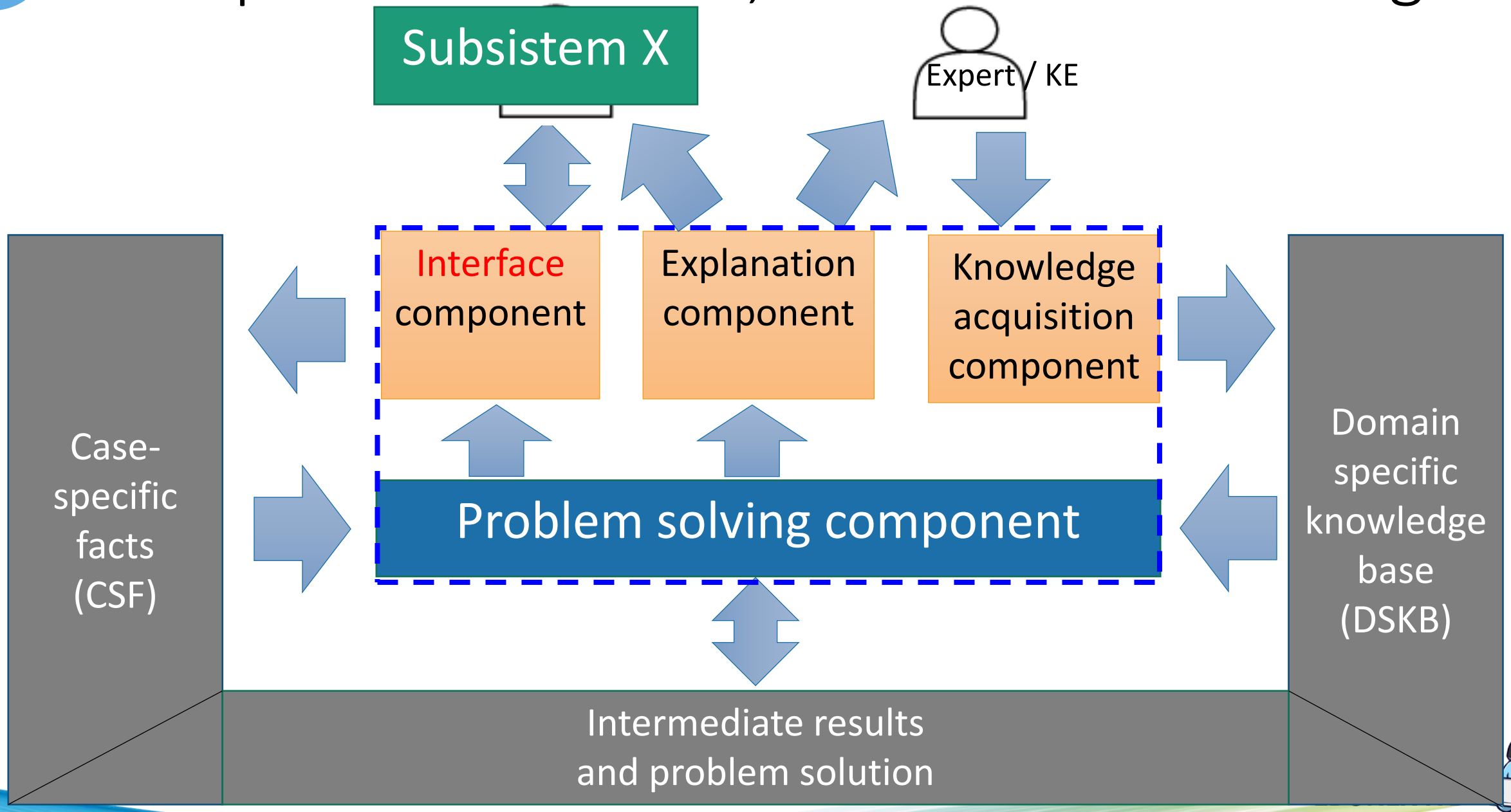
Puppe, F. (1993). *Systematic Introduction to Expert Systems* . Springer, Berlin, Heidelberg.

Example 1: Interactive, No Update Knowledge



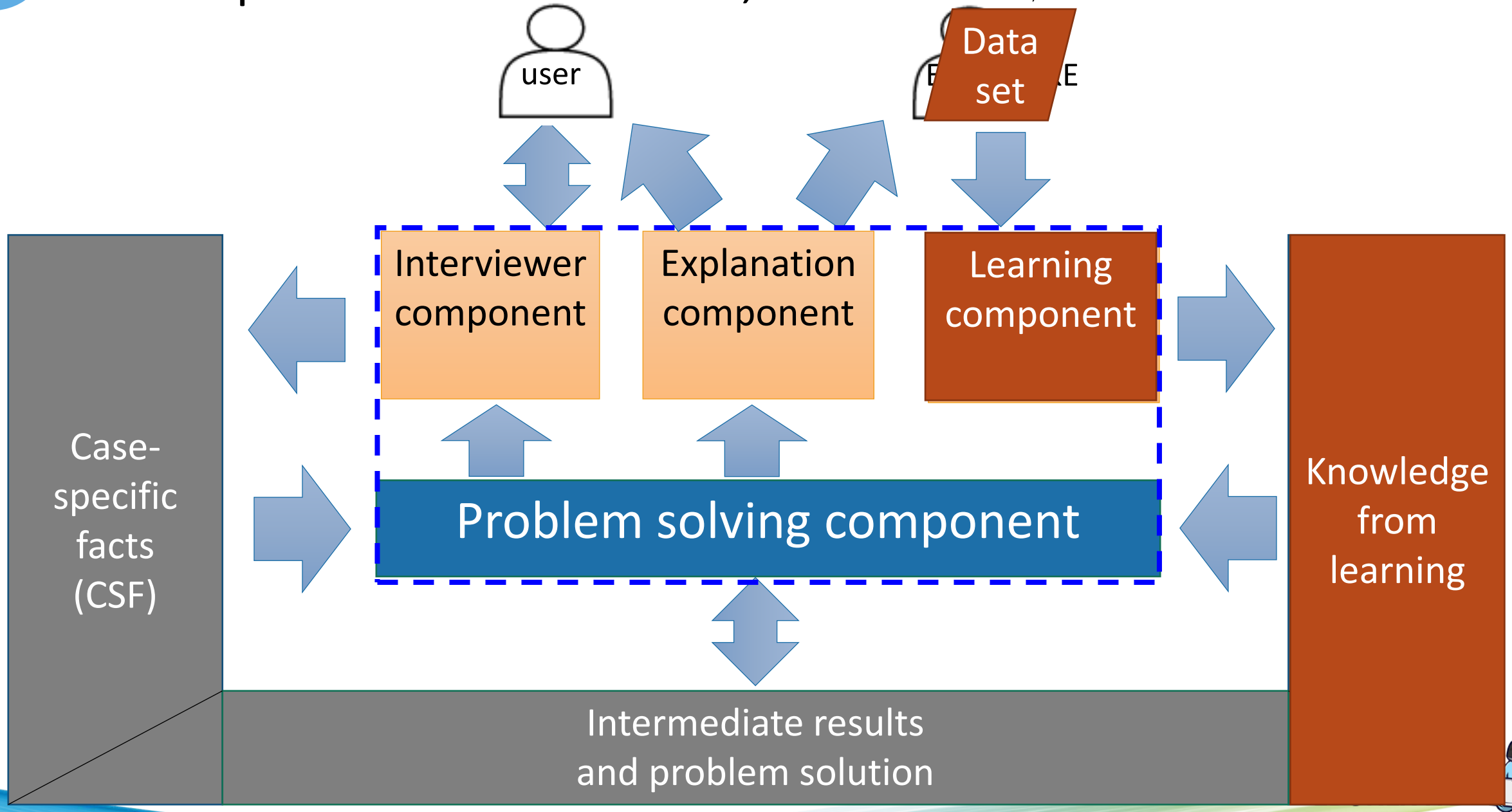
Puppe, F. (1993). *Systematic Introduction to Expert Systems* . Springer, Berlin, Heidelberg.

Example 2: Embedded, No Update Knowledge



Puppe, F. (1993). *Systematic Introduction to Expert Systems* . Springer, Berlin, Heidelberg.

Example 3: Interactive, Learning



Puppe, F. (1993). *Systematic Introduction to Expert Systems* . Springer, Berlin, Heidelberg.

Summary

KBS=PSM+ knowledge+ data

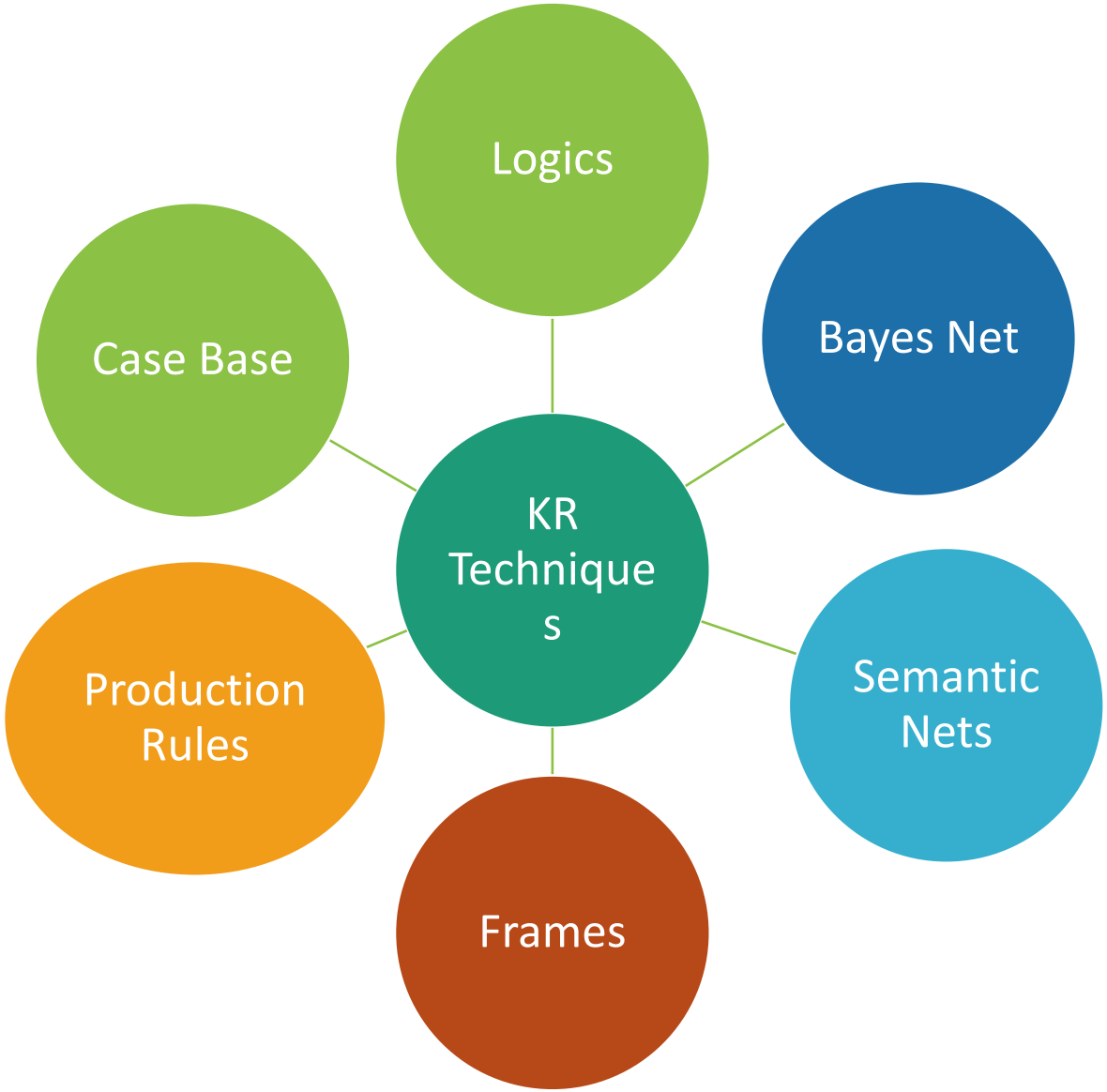
Inference Engine, Knowledge base

Knowledge Acquisition

General Architecture of KBS

Examples of Architecture

Knowledge Representation


Logics
Case Base
Bayes Net
KR Techniques
Production Rules
Semantic Nets
Frames

Propositional and Predicate Logic

- Sistem berbasis pengetahuan yang menggunakan **logika proposisional atau predikat** untuk merepresentasikan pengetahuan umumnya melibatkan aturan IF-THEN, hubungan antar objek dan kuantifikasi objek.
- Contoh:

a. Smart Building Contol System: menggunakan sensor untuk mendeteksi kondisi lingkungan dan membuat keputusan otomatis berdasarkan aturan logika proposisional. Jika sensor mendeteksi bahwa tidak ada orang di ruangan, lampu akan dimatikan secara otomatis.

b. Automated Theorem Proving: Menggunakan logika predikat untuk membuktikan validitas teorema matematika dengan cara otomatis, seperti dalam program **Prolog** yang dapat menjawab pertanyaan-pertanyaan logis berbasis fakta dan aturan yang sudah ada.

Semantic Networks (Ontology)

- **Semantic Networks** merepresentasikan pengetahuan dalam bentuk graf, di mana konsep atau objek diwakili sebagai node, dan hubungan di antara konsep tersebut diwakili sebagai edge.
- Contoh:

a. Google Knowledge Graph: untuk pencarian berbasis semantik,

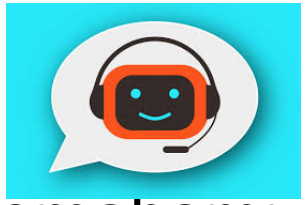
b. PayPal Fraud Detection System: memanfaatkan ontologi untuk memahami pola transaksi yang berpotensi fraud. Sistem ini menganalisis relasi antara akun, lokasi, jenis transaksi, dan sejarah pembayaran untuk mendeteksi aktivitas yang mencurigakan.

c. Penelitian medis: menemukan hubungan baru antara penyakit, gen, dan obat-obatan, yang dapat mendukung penelitian pengobatan baru.

Frames

hotel room
specialization of: room
location: hotel
contains: (hotel chair hotel phone hotel bed)

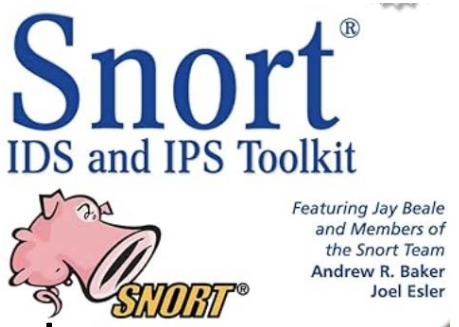
- **Frames** adalah struktur data yang digunakan untuk merepresentasikan pengetahuan dalam bentuk slot (tempat penyimpanan informasi) dan filler (nilai atau informasi yang mengisi slot).
- Contoh:



a. Chatbot dan Asisten Virtual: menggunakan frame untuk memahami konteks pertanyaan pengguna dan menjawab sesuai konteks.

b. Robotic Navigation Systems: frames digunakan untuk merepresentasikan pengetahuan tentang lingkungan robot dan tindakan yang bisa diambil oleh robot, misalnya robot pembersih, robot industri manufaktur.

Production Rule



- **Production rule** adalah representasi pengetahuan dalam bentuk aturan berbasis kondisi dan aksi, atau sering disebut dengan **if-then rules**.
- Contoh: Medical Expert Systems

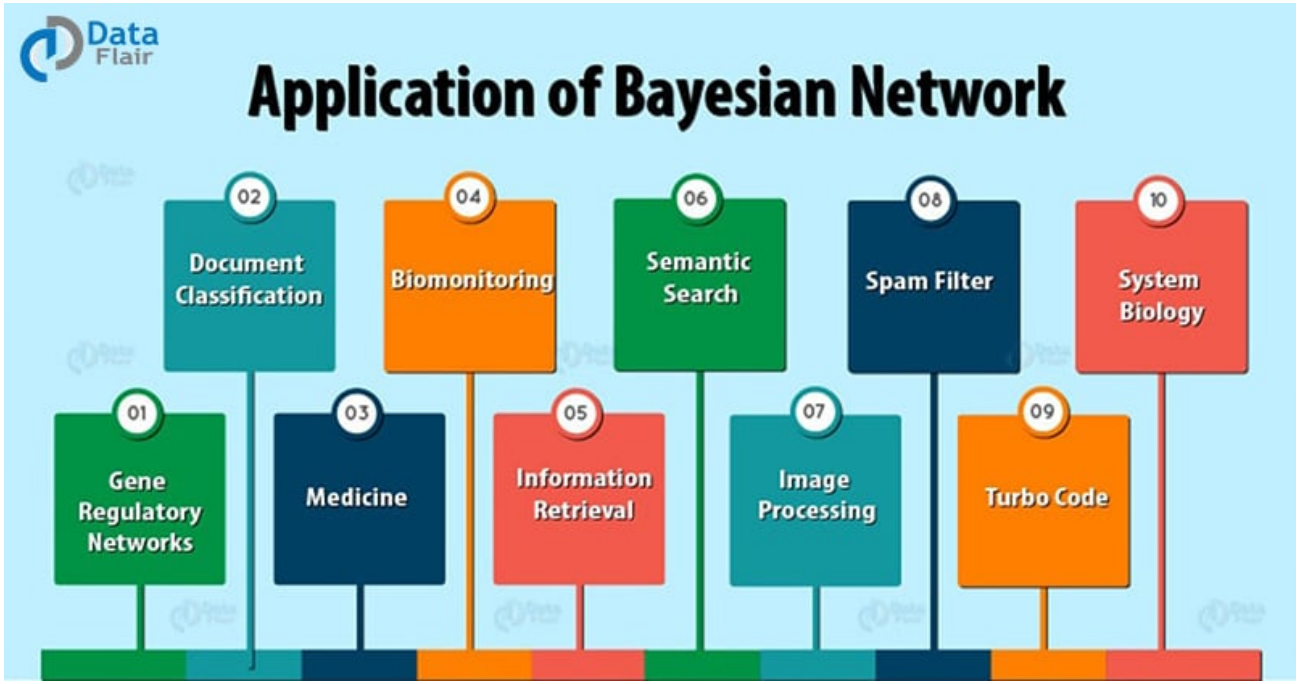
a. **MYCIN:** Sistem pakar medis MYCIN yang dikembangkan pada tahun 1970-an untuk mendiagnosis infeksi bakteri menggunakan production rules. MYCIN bekerja dengan aturan-aturan seperti "If pasien memiliki gejala X dan hasil tes Y, then infeksi bakteri Z terindikasi.“

b. **Snort:** Snort adalah salah satu sistem deteksi intrusi open-source yang populer dan menggunakan production rules untuk mendeteksi aktivitas mencurigakan atau serangan dalam jaringan komputer. Aturan-aturan ini dapat disesuaikan untuk mendeteksi berbagai jenis ancaman seperti serangan DDoS, brute force, atau malware.

Case-Based Reasoning

- **Case-Based Reasoning (CBR)** adalah metode representasi pengetahuan di mana solusi dari masalah-masalah sebelumnya (kasus) digunakan kembali untuk memecahkan masalah baru yang serupa. Penalaran ini bergantung pada basis data kasus yang mencakup solusi atau keputusan yang diambil dalam skenario sebelumnya.
- Contoh:
- **Case-Based Radiology System:** Beberapa sistem radiologi berbasis CBR membantu ahli radiologi untuk mendiagnosis gambar medis berdasarkan kasus-kasus gambar yang telah didiagnosis sebelumnya, seperti mendeteksi kanker atau kerusakan organ.
- **HelpDesk Systems:** Banyak perusahaan teknologi menggunakan sistem CBR untuk memberikan dukungan teknis kepada pelanggan. Saat pelanggan melaporkan masalah teknis, sistem CBR mengacu pada kasus-kasus teknis yang telah dipecahkan sebelumnya dan menyarankan solusi.

Bayes Network



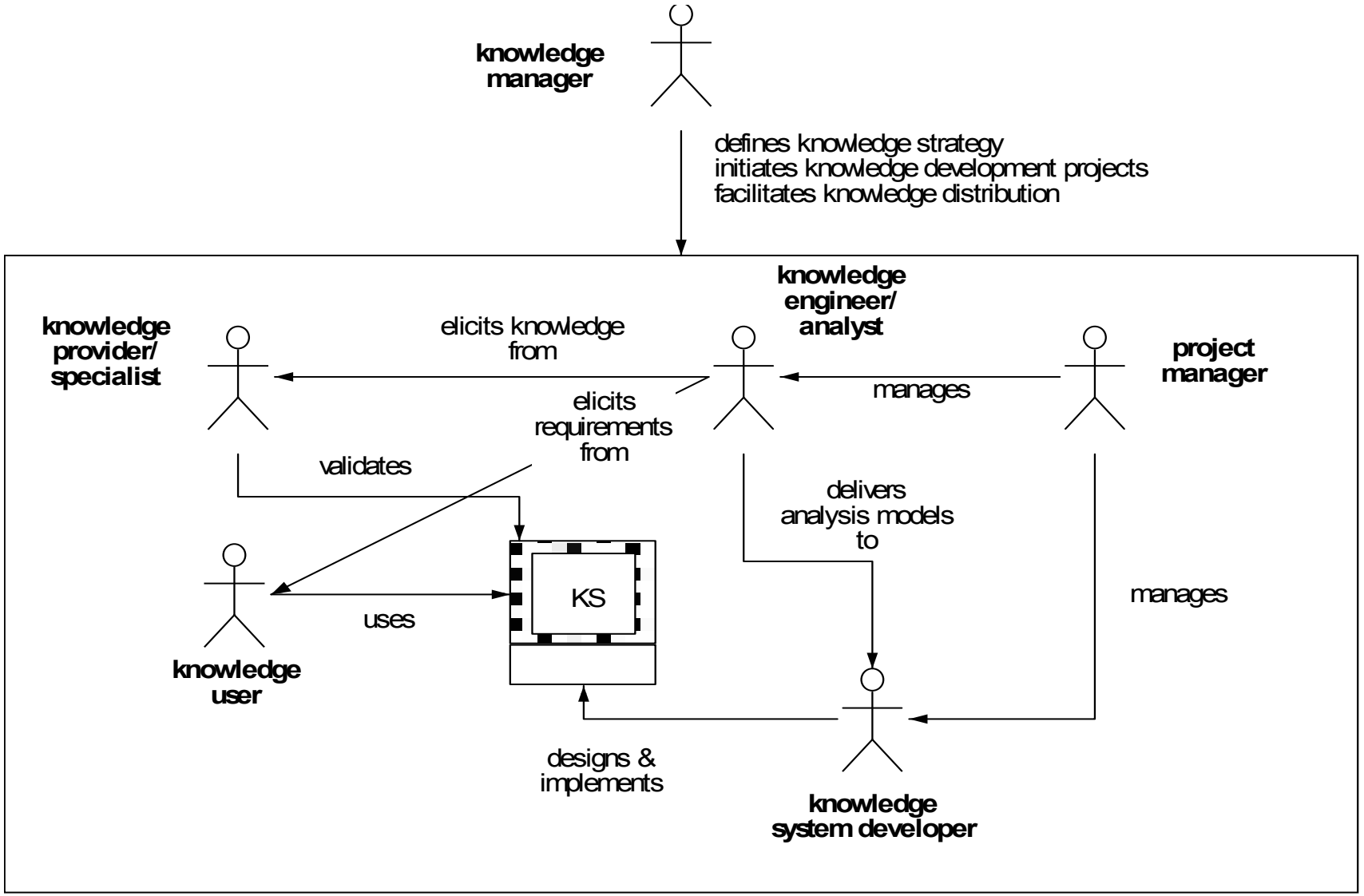
Source: https://data-flair.training/blogs/bayesian-network-applications/

- Reasoning under uncertainty
- Represent uncertainty not only by disjunction (Logic), but also likelihood (probability)

→ Next Course

Knowledge Engineering

KBS Developer



Rekayasa Pengetahuan

- Akuisisi pengetahuan dalam suatu domain dari satu atau lebih sumber non-elektronik dan konversinya ke dalam suatu bentuk yang dapat digunakan oleh komputer untuk memecahkan persoalan yang umumnya hanya dapat dipecahkan oleh pakar domain tersebut.

Akuisisi Pengetahuan (KA)

- KA=knowledge ***elicitation*** + ***representation***
- knowledge elicitation
  - Proses ekstraksi pengetahuan domain dan strategik dari pakar
  - Interview antara KE dan pakar
  - a cyclical process
- Knowledge representation
  - Proses merepresentasikan pengetahuan hasil ekstraksi ke suatu bentuk formal

Task dalam Knowledge Elicitation

- Pada setiap iterasi:
  - ***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

Tahapan Akuisisi Pengetahuan

- Identification
  - Identifikasi karakteristik masalah
- Conceptualization
  - Menemukan konsep2 untuk merepresentasikan pengetahuan
- Formalization
  - Design struktur untuk mengorganisasikan pengetahuan
- Implementation
  - Formulasi pengetahuan ke bentuk runnable program
- Testing
  - Validasi pengetahuan

Teknik Akuisisi Pengetahuan

- Manual:
  1. Interview
  2. Observasi
  3. Intuitive: tukar peran Knowledge Engineer dan pakar
- Otomatis:
  - Menggunakan tools untuk memfasilitasi akuisisi
  - Tools untuk pakar
  - Tools machine learning


INSTITUT TEKNOLOGI BANDUNG
1920