KNOWLEDGE-BASED CONTROL AND ENGINEERING SYSTEMS

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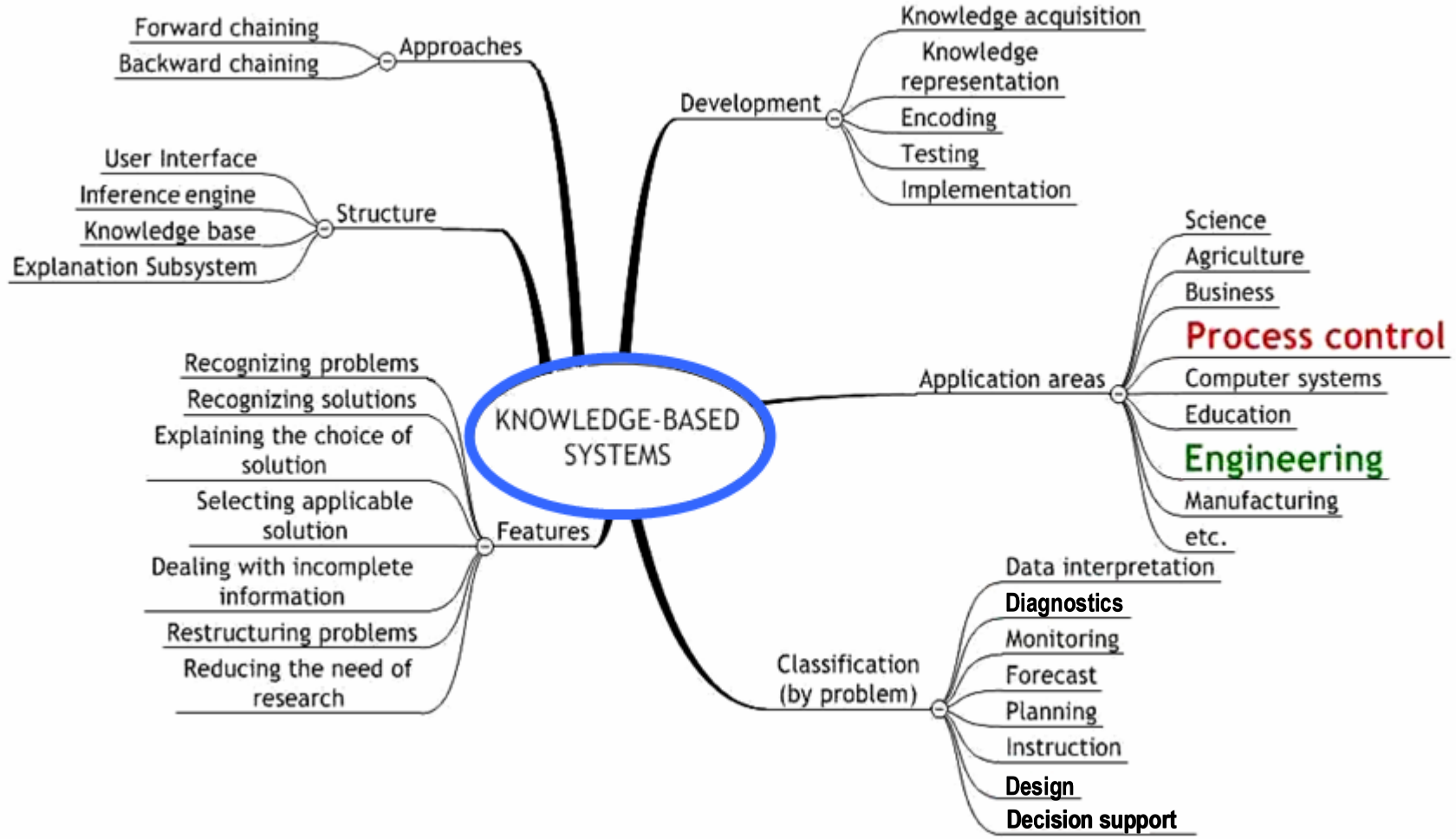
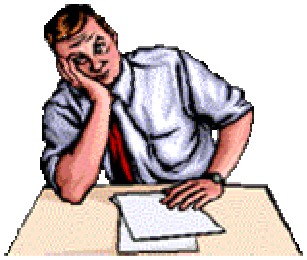
Introduction

Knowledge-based systems are the most mature and widely-used commercial field of artificial intelligence. The spectrum of applications of these systems to industrial and commercial problems is so wide as to defy easy characterization. The applications find their way into most areas of knowledge work. Knowledge-based systems achieve high levels of performance in task areas that, for human beings, require years of special education and training.

Knowledge-Based Systems (Mind Map)

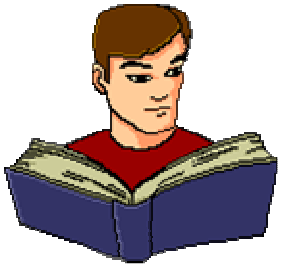


Knowledge and Data



KNOWLEDGE

Rules, concatenating the data and obtained from experience.



DATA

Instances and facts characterizing object's, processes and their properties

Definition

A **knowledge based system**, also known as an **expert system**, is a computer program that contains the knowledge and analytical skills of one or more human experts, related to a specific subject.

A **software** that performs a task that would otherwise be performed by a human expert

History

The Logical Period

1960-1976

Axiomatic approach of solving problems

Heuristic approach

1965: LISP (first symbol processing language)

1973: PROLOG (axiom-based language)

Knowledge Based Period

1976-1990

Conclusion is made from vast amount of previous knowledge collected

DENDRAL

MYCIN

Industrial AI Systems

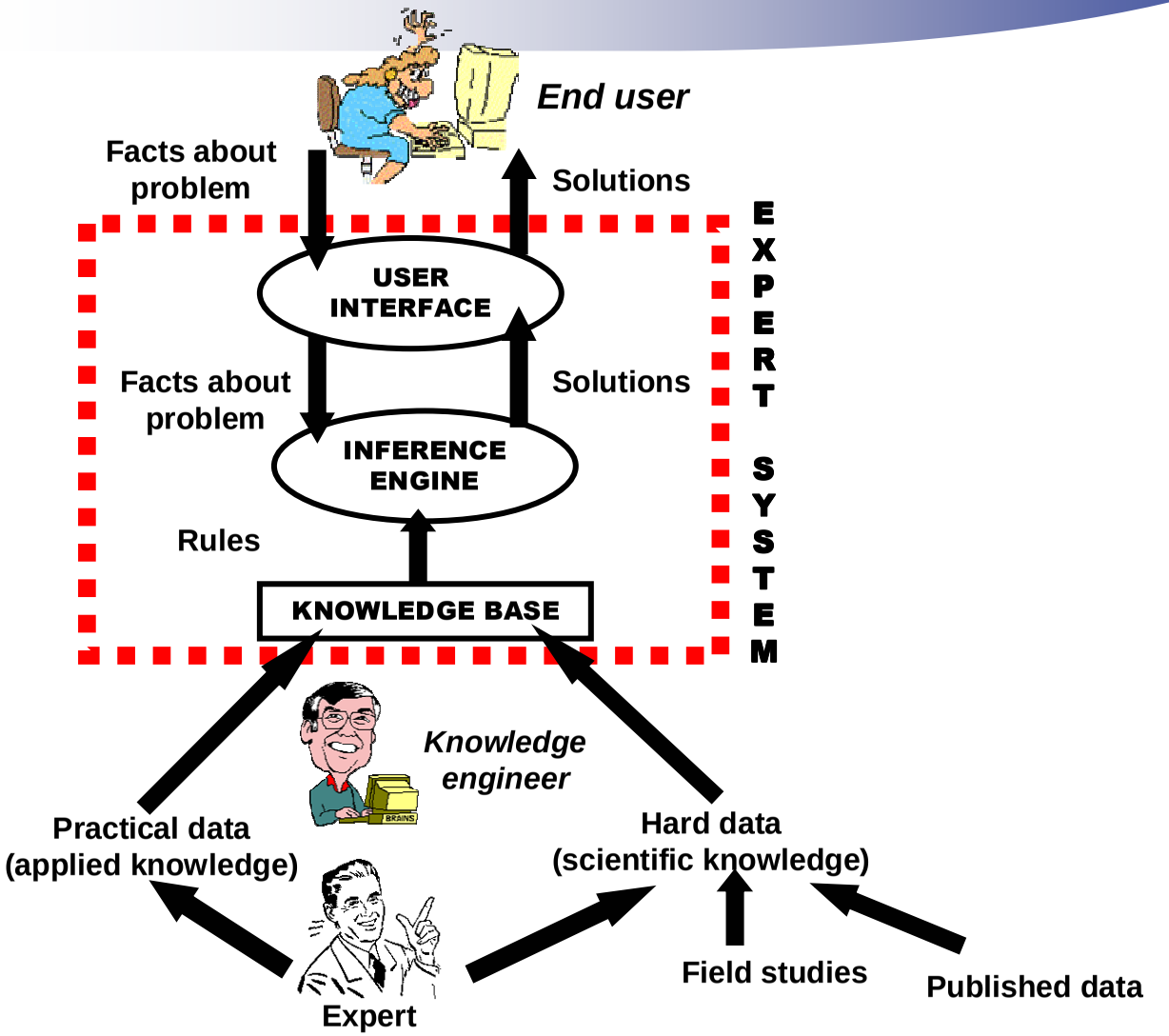
1990-nowadays

Expert systems are applied to a wide variety of areas

The Main Difference From Other Programs

- ES model not the physics of the domain but the way of problem solving by human expert or the way thinking and knowledge processing in this domain.
- ES make all conclusions using Knowledge that is put by expert and knowledge engineer.
- Mathematics is not essential in ES, heuristics and fuzzy methods are more substantial.

Expert System Structure



Main Blocks

KNOWLEDGE BASE consists of sentences which define knowledge with the use of super-high-level languages which are called ***knowledge representation languages.*** It is the kernel of the expert system.

INFERENCE ENGINE is a program which simulates the process of expert ***reasoning*** or decision making.

The function of the **USER INTERFACE** is to present questions and information to the user and supply the user's responses to the inference engine.

Classification

By problem

Data Interpretation

Instruction

CONTROL

Forecast

Planning

DIAGNOSTICS

DESIGN

DECISION SUPPORT

By relation to real time

Static

Quasi-dynamic

Dynamic

By computer type

On supercomputer

On mainframes

On symbolic processors

On workstations

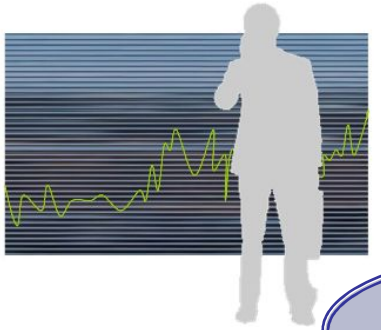
On personal computer

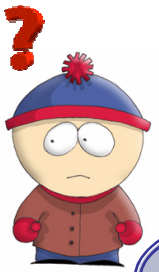
By integration degree

Stand-alone

Hybrid (integrated)

Expert System Life Cycle





Commercial system

Prototype system

Knowledge Representation

Knowledge Acquisition

Problem Definition

Advantages and Disadvantages

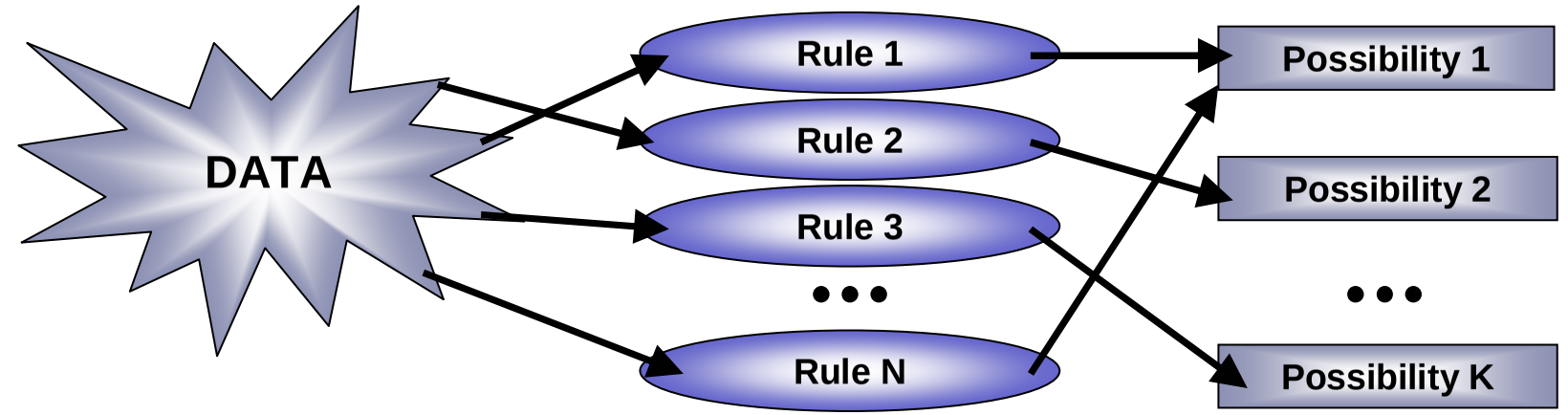
- Provides consistent answers for repetitive decisions, processes and tasks
- Holds and maintains significant levels of information
- Encourages organizations to clarify the logic of their decision-making
- Never "forgets" to ask a question, as a human might

- Lacks common sense needed in some decision making
- Cannot make creative responses as human expert would in unusual circumstances
- Errors may occur in the knowledge base, and lead to wrong decisions
- Cannot adapt to changing environments, unless knowledge base is changed

Forward chaining (Data Driven reasoning)

The system keeps track of the current state of problem solution and looks for rules which will move that state closer to a final solution.

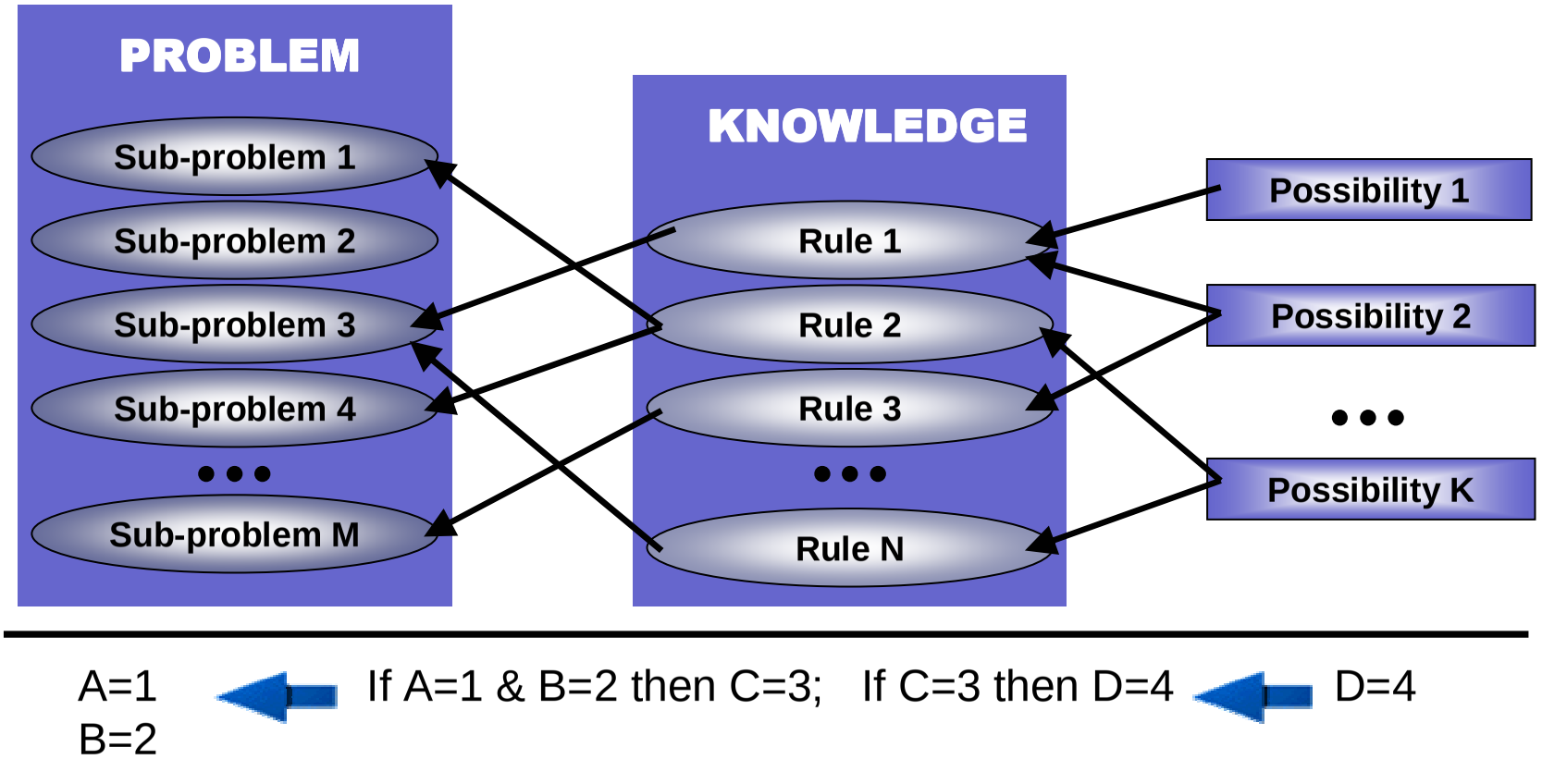
The system must be initially populated with data,
in contrast to the goal driven system which gathers data as it needs it.



A=1
B=2
→ If A=1 & B=2 then C=3; If C=3 then D=4 → D=4

Backward Chaining (Goal-Driven Reasoning)

An efficient way to solve "structured selection" problems.



Case-Studies

Case 1: Blast Furnace Control

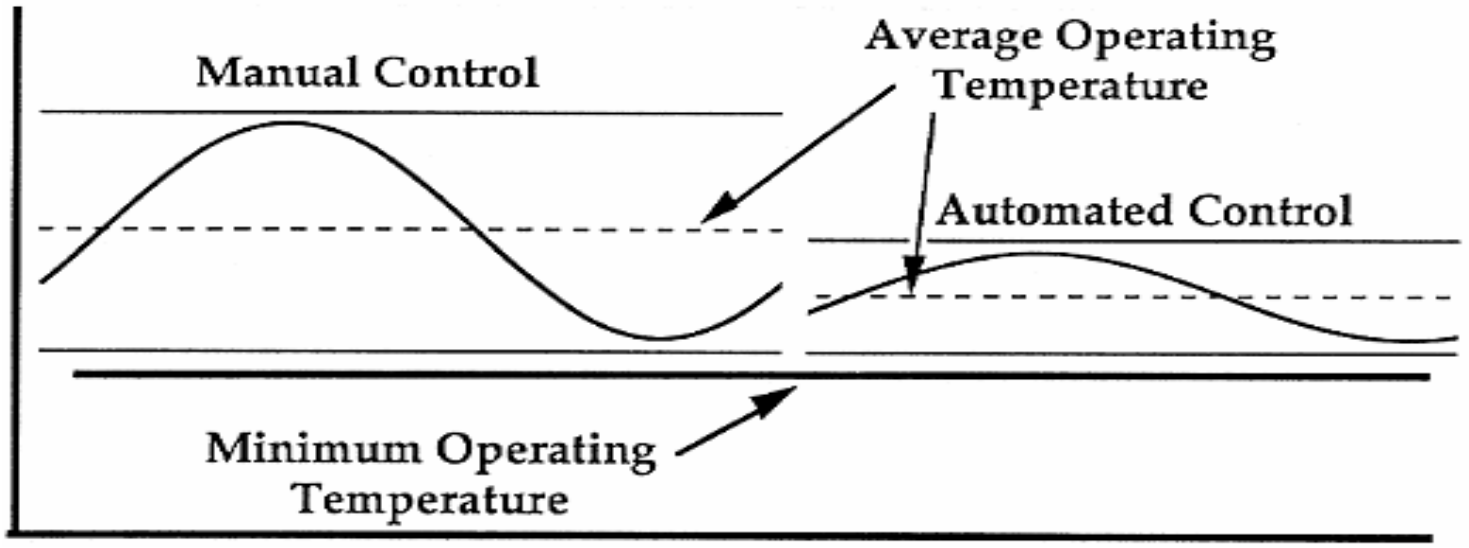
- *The company*: Steel Company's Fukuyama Works, Japan
- *The problem*: Because the blast furnace feeds all other processes in the steel mill, any instability in the operation of the furnace is compounded by the impact on other processes further down the production line.
- *The purpose*: the prediction of abnormal conditions within the blast furnace (to minimize the uncertainty in the operating temperature)

Case 1: Blast Furnace Control

- *Sub-problems*:
  - characterizing the current state of the furnace and projecting the conditions occur several hours;
  - training a skilled blast furnace operator takes many years;
  - the complexity of modeling a blast furnace;
  - there are no symmetries to simplify the geometric modeling;
  - the thermal state of the furnace cannot be measured directly, but must be inferred from various sensor measurements;

Case 1: Blast Furnace Control

Fuel Cost Savings:



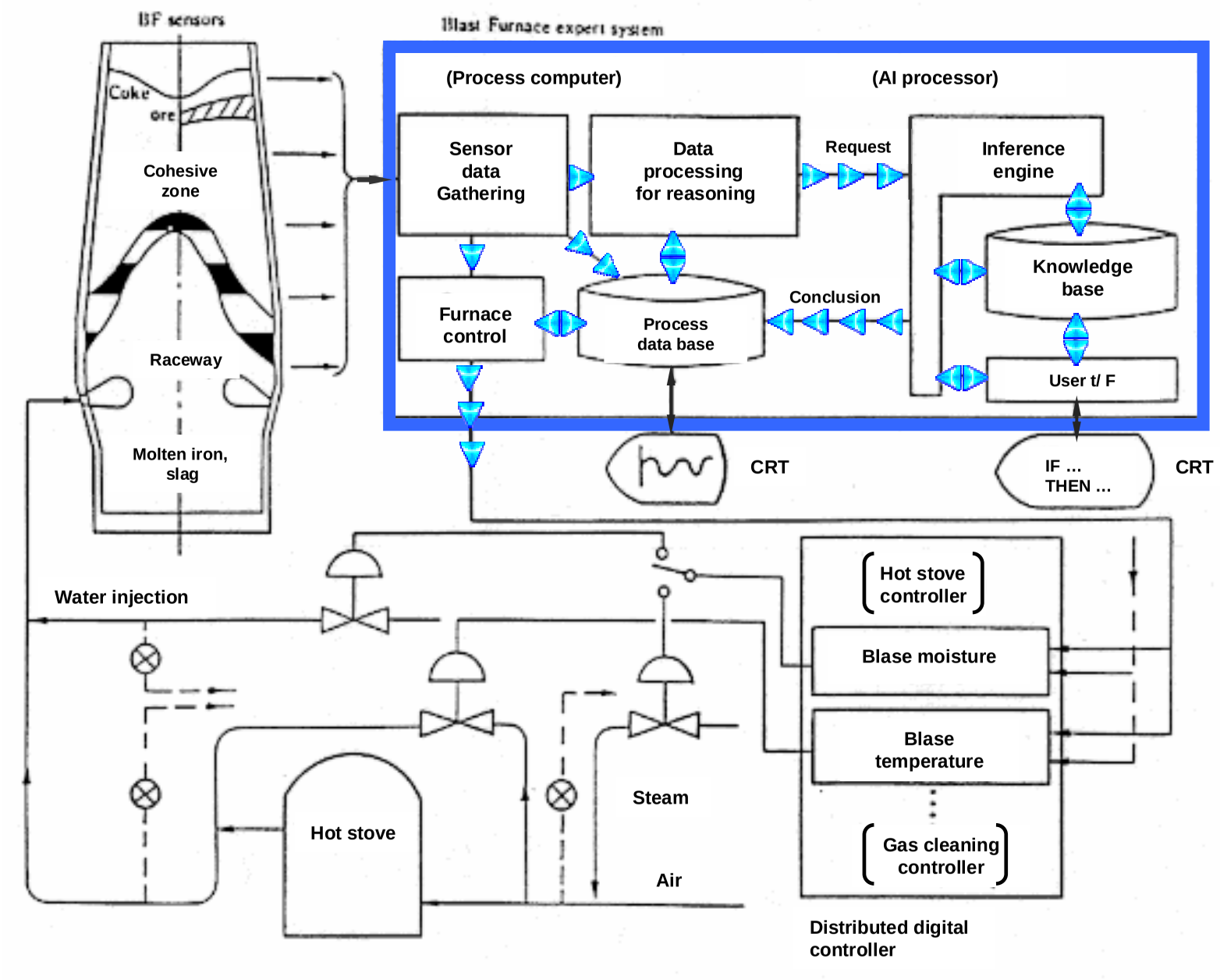
The smaller the uncertainty, the lower the overall temperature needed to produce the pig iron, resulting in very large fuel savings.

Case 1:
Blast Furnace Control

The features of the expert system:

- models the current state;
- predicts future trends with sufficient accuracy to make control decisions;
- makes the control decisions;
- decisions can be implemented automatically or manually

Blast Furnace Expert System:



Case 1: Blast Furnace Control

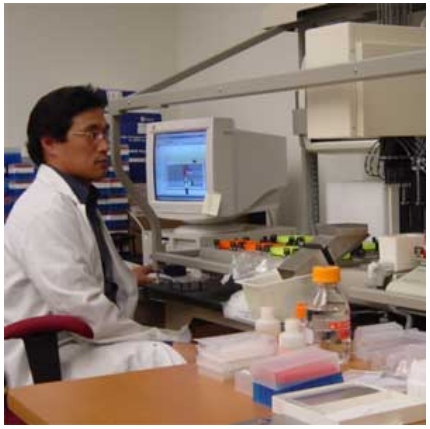
System Components:

- a **process computer** gathers input data from various sensors in the furnace, maintains a process database and generates furnace control information;
- the **AI processor** provides the knowledge and reasoning for assessing and interpreting the sensor data, hypothesizing the internal state of the furnace, and determining appropriate control actions;
- a distributed **digital controller** uses the furnace control data from the process computer to control the actual blast furnace.

Case 1:
Blast Furnace Control

Result:

- Company annual savings of $6 million
- Reduction in staff of 4 people
- Improvement in the quality of the furnace output



Details:

- The system is implemented in LISP with FORTRAN used for data preprocessing
- The knowledge in the AI processor is contained in 400 rules, 350 frames, and 200 LISP procedures
- Fuzzy theory is employed in its inference engine
- The system has a cycle time of 20 minutes, compared to the furnace time constant of six to eight hours.

Case 2: Motherboard Expert System

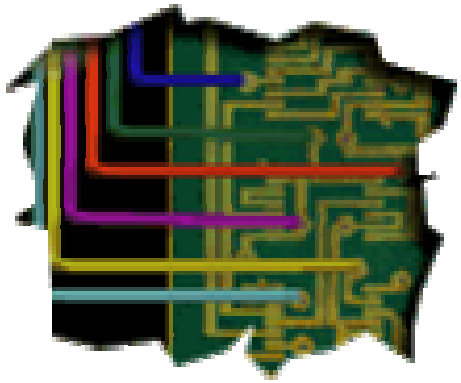
- *The problem*: need to call to the service center to ask for the solution from the technician and be charged for that; hard understanding of the terms written in manual

- *The purpose*: to recognize, manage and fix the motherboard's problem, and provide users with appropriate solution base on the accurate diagnosis

Case 2: Motherboard Expert System

The features of the expert system:

- figures out the main problems of the MSI's motherboard ;
- gives solution regarding to the accurate diagnosis



Case 2: Motherboard Expert System

Methodology:

- Phase 1: Problem Assessment
  - gathering all the information
  - identifying the goals and requirements

- Phase 2: Knowledge Acquisition and Analysis
  - collection of knowledge (interviewing the MSI motherboard structure experts, collection data from the user manual books and the data from the MSI's website).

- Phase 3: Design and Implementation
  - rules, system programming part and system interface

Case 2: Motherboard Expert System

- Phase 4: Testing
  - all the knowledge and rules in the system are totally accurate with the knowledge that collected from the expertise
  - the ability of ***MobES*** on solving the user's problems
  - users are comfortable with the design
  - the system reaches the goals (provides solution and advice to the users so that they can handle their own computer problems)

MobES actually is still under development status, and it still need time and support from the expert to reach it goals.

Perspectives

- Technology will clearly become more helpful in dealing with information overload.

- The current capability of machine intelligence is such that human knowledge will continue to be a valuable resource for the foreseeable future, and technology to help to leverage it will be increasingly valuable and capable.

- However, in many cases experts are being asked to surrender their knowledge and experience— the very traits that make them valuable as individuals.

Conclusion

That was the brief overview of knowledge-based systems for control and engineering. Two different real expert systems were considered – Blast Furnace Control system and Motherboard Expert system. Perspectives of knowledge-based systems development were concluded.

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THANK YOU!