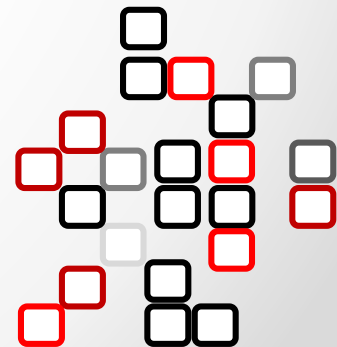
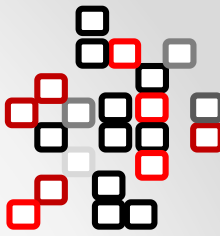


Autonomous Systems

Lecture 04

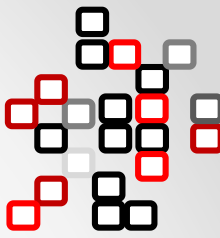
Expert Systems





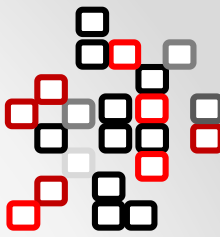
Content of the lecture

- **Knowledge-based system vs. expert system**
- **Expert system definitions**
- **Architecture of the expert system**
- **Methodology of development**
- **Applications of expert systems**



What is the expert system?

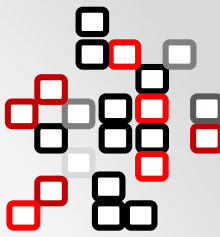
- Knowledge-based system which employs knowledge about particular application domain and uses an inferencing (reasoning) procedure for solving problems that would otherwise require human competence or expertise.
- The power of expert systems stems primarily from the specific knowledge about a narrow domain stored in the expert system's *knowledge base*.



Definition 01

- ***An expert system "is a system that uses human knowledge captured in a computer to solve problems that ordinarily require human expertise."***

(Turban, E., and J. Aronson.(1988) Decision Support Systems and Intelligent Systems. Upper Saddle River, NJ: Prentice Hall, Inc.)



Definition 02 and 03

- ***„An expert system is artificial intelligence software that mimics a person problem solving abilities in a specific field.“***

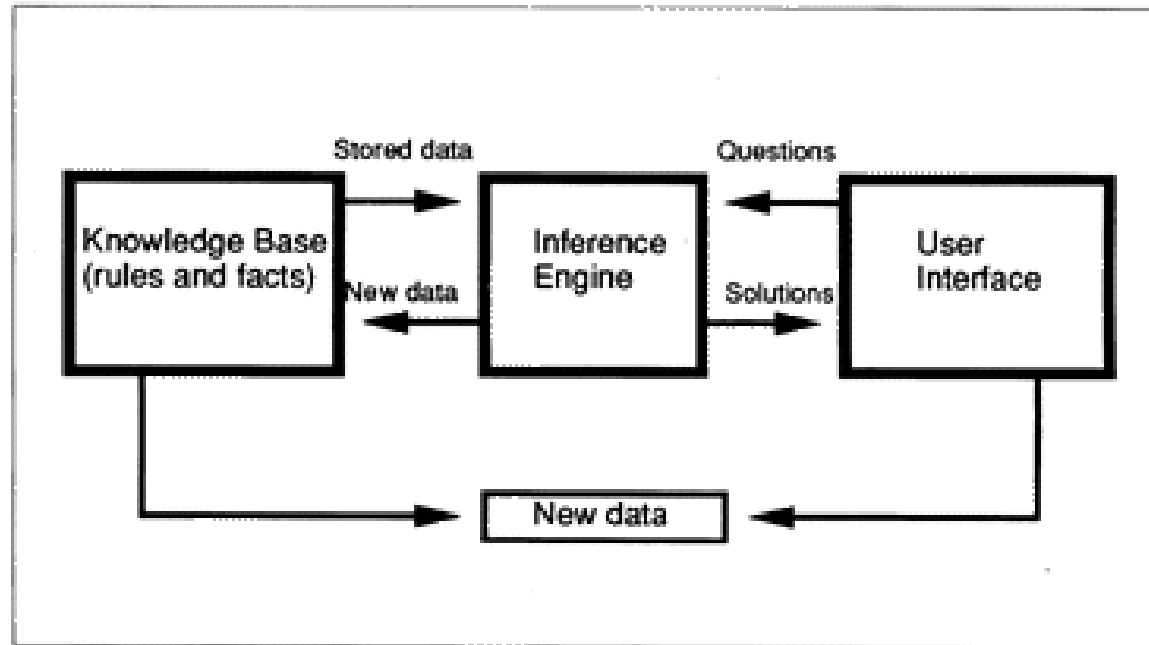
(Expert system by target tech)

- ***„An Expert System is a computer system which emulates the decision-making ability of a human expert.“***

Generation5

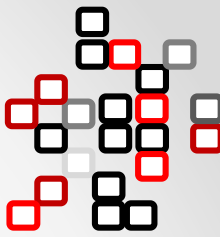
(<http://www.generation5.org/content/2005/MobES.asp>)

Architecture of expert system



Sometimes rules and facts are divided into two modules:

- > Facts base
- > Knowledge base



Facts base

- Facts relates with the particular application domain
- Representation of facts
 - Object-oriented fact base
 - Ontology-based facts base
 - Specific notation (see Clips below)

breed age color of hair weight character

(def facts dogs

 (dachshund 14 brown 5 hunter)

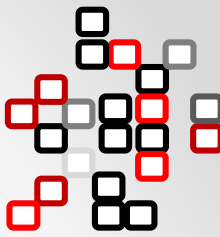
 (pug 2 white 3 social)

 (terrier 2 white 7 hunter social)

 ...

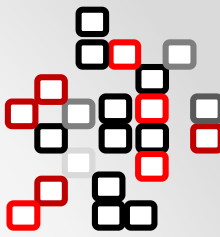
)

written in Clips notation



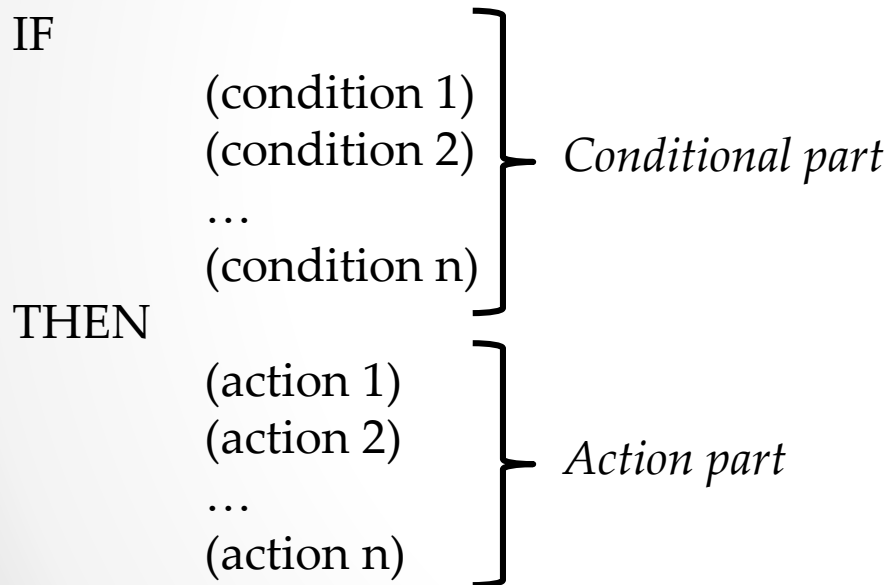
Knowledge base

- An organized collection of pieces of knowledge about the particular application domain
- Knowledge bases must represent notions as actions to be taken under circumstances, causality, time, dependencies, goals and other higher-level concepts.
- Knowledge representation is the method used to organize the knowledge in the knowledge base
- Production rules is a typical example of knowledge representation in the knowledge-based systems
- *Rule-based expert systems* are expert systems in which the knowledge is represented by production rules



Production rule

General form of a production rule



Particular examples

RULE 01	
IF	(it is raining) (it is cold weather)
THEN	(I will bring the umbrella) (I will take warm jacket)

RULE 02	
IF	(I have ≥ 70 points for credits)
THEN	(I will receive credits)

Production rules can influence each other



RULE 01

IF
 (the printing machine is not working)
THEN
 (check the cable)

RULE 03

IF
 (cable is plugged)
THEN
 (check the drivers)

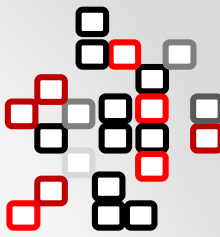
RULE 02

IF
 (cable is not plugged)
THEN
 (plug the cable)

RULE 04

IF
 (drivers are not installed)
THEN
 (install drivers)

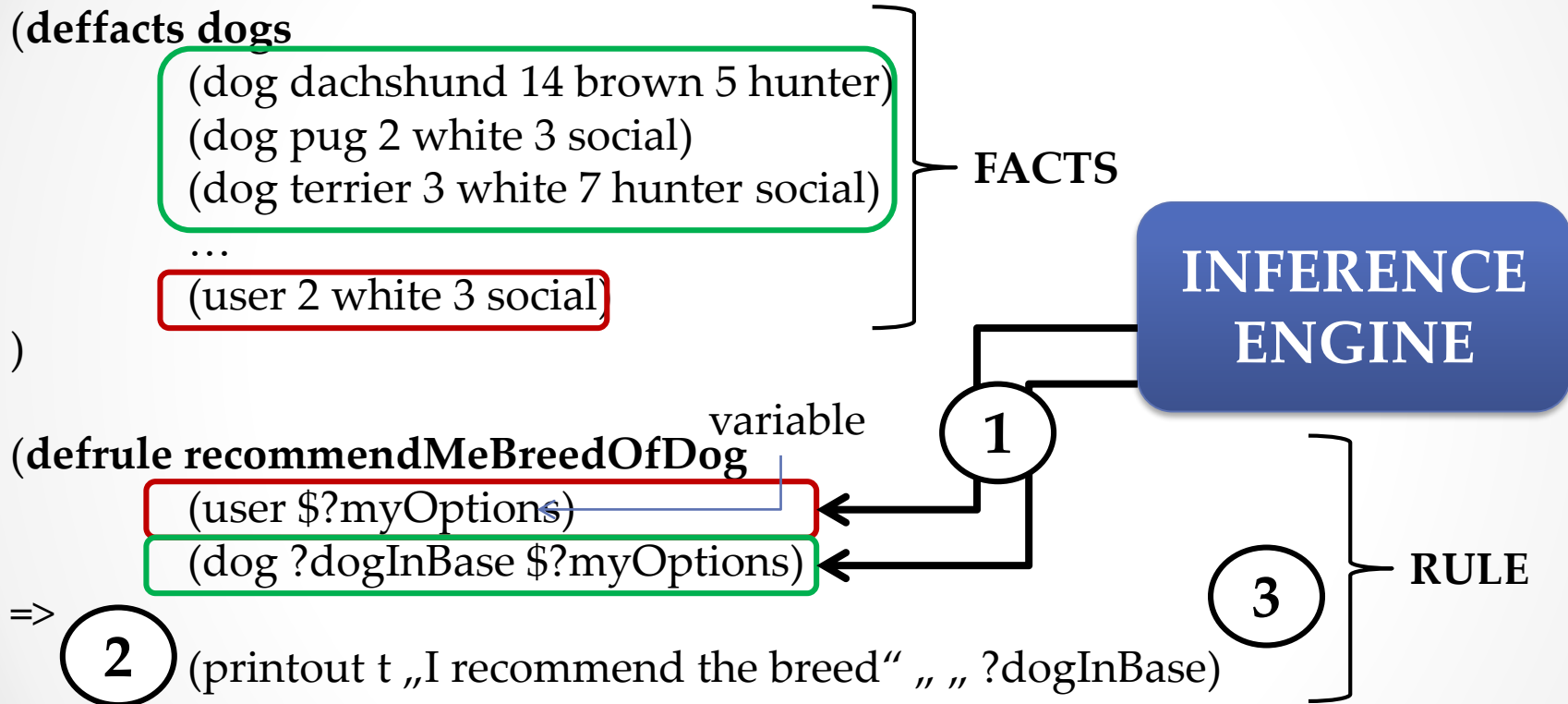
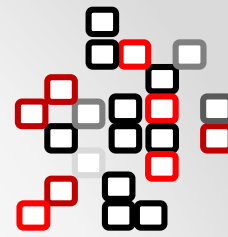
Rules chaining: One rule can activate the other one.



Inference engine

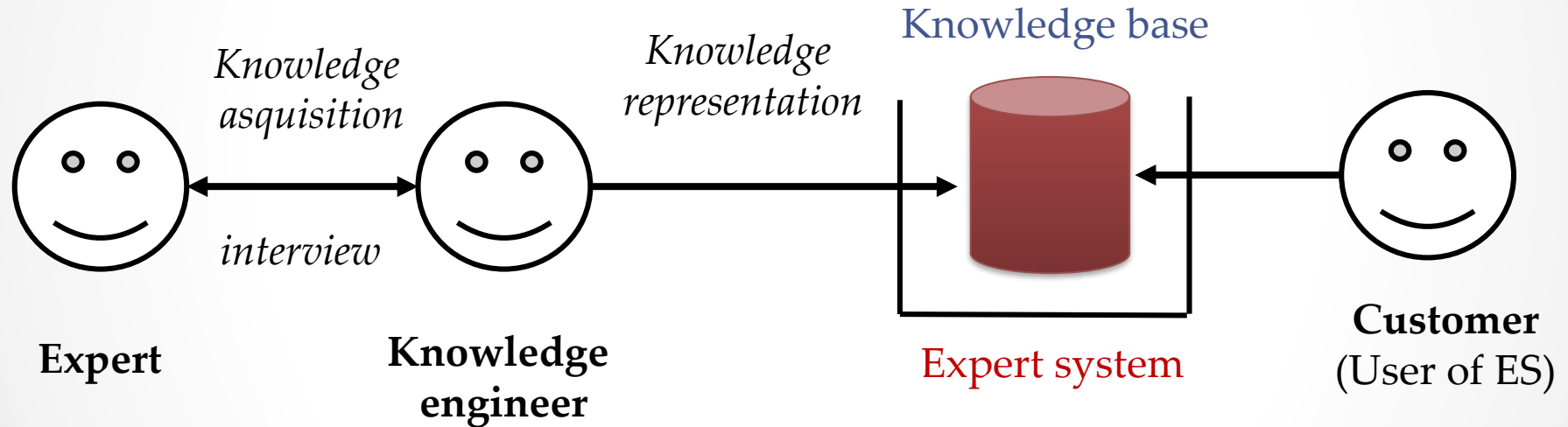
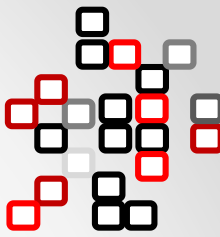
- „Brain“ of the knowledge-based system
- Combines the facts of a specific case with the knowledge (represented by rules) contained in the knowledge base to come up with a recommendation.
- In a rule-based expert system, an inference engine controls the order in which production rules are applied and resolves conflicts if more than one rule is applicable at a given time
- Directs the user interface to query the user for any information it needs for further inferencing

Inference engine: procedure of working



1. Comparision of conditional part of the rule with content of the facts base
2. If all conditions in the conditional part are satisfied (true) then the action is „fired“.
3. For our case, the corresponding dog (dogInBase) is recommended to the user.

Knowledge-based system development



Development stages of expert systems

Phase 01 and 02



- **Phase 01: Problem assesment**
 - Problem which should be solved will be identified
 - Identification of requirements, goals and scope of the project
- **Phase 02: Knowledge acquisition and analysis**
 - Knowledge sources are identified (books, journals, expert)
 - Pieces of knowledge are received and analysed

Development stages of expert systems

Phase 03



- **Phase 03: Design and implementation**
 - This is the phase about a design of an ES including rules, system programming part and the system interface.
 - This phase is very important to the system by judging the successfulness of the whole project
 - Representation schema has to be chosen together with programming language and environment
- ES {
- *Declarative programming* (Prolog, Clips, ...): What do you want to solve? How can we define a maximum number?
 - *Procedural programming* (Java, C++, ...): How do you want to solve a problem? How can we calculate a maximum number?

Development stages of expert systems

Phase 04 and 05



- **Phase 04: Testing**

- Testing of a system is crucial for validation and verification of operations of a system in each stage of the system development

- **Phase 05: Documentation**

- Documentation of the whole development process of the expert system
- A well prepared documentation will give guide to the users and the programmers, so that it is easier to make any adjustment or correction of the system in future

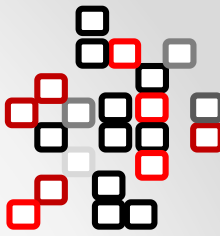
Development stages of expert systems

Phase 06



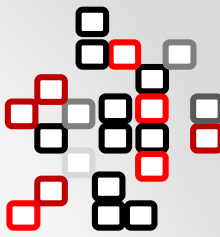
- **Phase 06: Maintenance**

- The last phase of the expert system development
- This is the phase we want to find out if our system works correctly
- The system have to be updated from time to time, depends on the changes of the knowledge sources



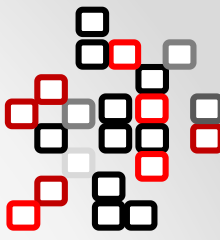
Application areas

- ***Classification*** – identification of an object based on stated characteristics
- ***Diagnosis Systems*** – inference of malfunctions or diseases from observable data
- ***Monitoring*** – comparison of data from a continually observed system to prescribe behaviour
- ***Process Control*** – controlling of a physical process based on monitoring
- ***Design*** – configuration of a system according to specifications
- ***Scheduling & Planning*** – development or modification of a plan
- ***Generation of Options*** – generation of alternative solutions for a problem



Concrete examples

- **Dendral:** ES used for identification of unknown organic molecules, by analyzing their mass spectra and using knowledge of chemistry
- **Mycin:** ES for identification of bacteria causing severe infections and recommendation of suitable antibiotics (about 500 production rules)
- **Prospector:** ES helped to geologists in mineral exploration. The system attempted to represent the knowledge and reasoning process of geological experts. Its primary intended use was to investigate and recommend a possible drilling site.



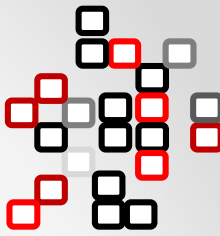
Advantages of expert systems

- Available expertise after hours or in other locations
- An ES can complete tasks much faster than a human expert
- Human expert is expensive
- Expertise is very valuable intellectual capital
- ...



Limitations of expert systems

- **No technology offers an easy and total solution. Large systems are costly and require significant development time and computer resources. ESs also have their limitations which include:**
 - **Problems with knowledge acquisition**
 - **How to encode pieces of knowledge?**
 - **How to deal with complex knowledge?**
 - **...**

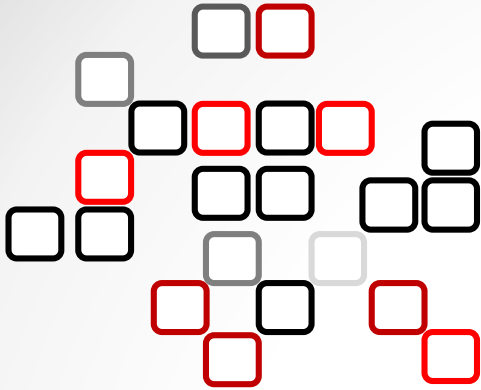


Literature

- **Generation5:**

- <http://www.generation5.org/content/2005/MobES.asp>

- <http://www.umsl.edu/~joshik/msis480/chapt11.htm>



**THANK YOU FOR YOUR
ATTENTION!**

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