

NATIONAL DEFENSE UNIVERSITY

The National War College

STRATEGIC STUDIES PROJECT



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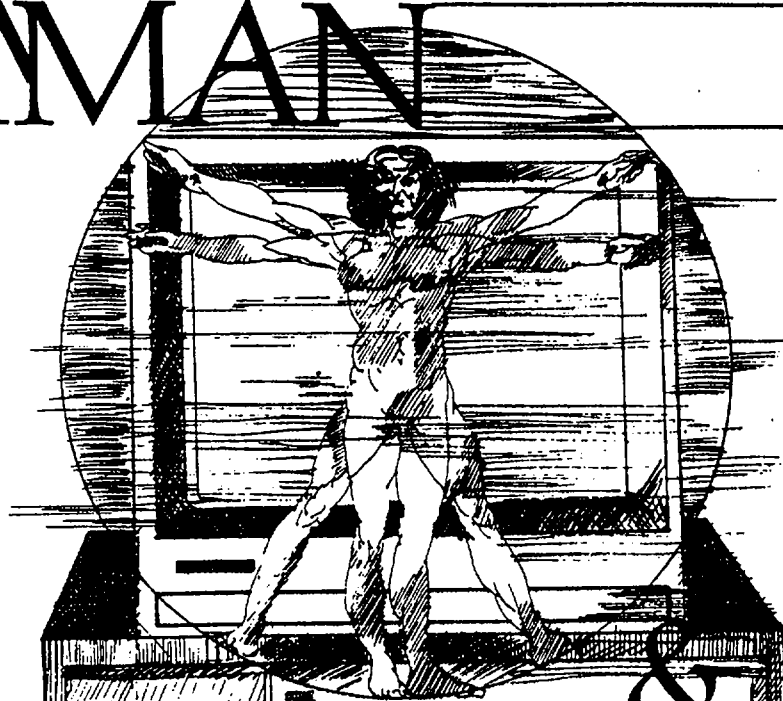
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National Defense University
Department Of Defense
Computer Institute



ARTIFICIAL INTELLIGENCE and EXPERT SYSTEMS

MAN



&
MACHINE
MACHINE

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THE NATIONAL WAR COLLEGE
STRATEGIC STUDIES REPORT ABSTRACT

TITLE: Artificial Intelligence and Expert Systems for
Government Executives

AUTHOR: Charles A. Stevenson, Commander, USN

DATE: February 1986

This report consists of the syllabus, instructor lesson guides, viewgraphs, and bibliography for a course of instruction taught by the author as an elective at The National Defense University during the spring semester of 1986. The course is designed to acquaint senior level decision makers with the rapidly advancing field of artificial intelligence and the first practical use of this new technology commonly know as expert systems. The course consists of lectures, demonstrations, and guest speakers to give the senior executive a feel for the state-of-the-art in computer technology as well as to demonstrate potential applications of this new tool. It also provides the students an opportunity to develop a small expert system using a "shell" or "tool" on a microcomputer.

BIOGRAPHICAL SKETCH

Commander Charles A. Stevenson, USN (BS, Electrical Engineering, University of Missouri, 1970; MS, Aeronautical Engineering, Naval Postgraduate School, 1979; AeE, Aeronautical Engineer, Naval Postgraduate School, 1979; MBA, National University, 1981), has been interested in computer technology since working as a design engineer designing MOS/LSI circuits for Texas Instruments in 1970. He is an avid computer hobbyist who has read extensively on the subject. He has also served as an adjunct professor of mathematics and computer science at San Diego Community College and Capital Institute of Technology, and holds an instructor credential in mathematics, computer and related technologies, and other disciplines from the Board of Governors, California Community Colleges. Commander Stevenson is an Associate Member of SIGMA XI and a graduate of The National War College, Class of 1986.

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13.140-2/SH
SPRING 86

COURSE 140

ARTIFICIAL INTELLIGENCE AND EXPERT COMPUTER SYSTEMS

for

GOVERNMENT EXECUTIVES

SYLLABUS

SPRING 86

INTRODUCTION: Largely due to innovation in the private sector, the United States has enjoyed a great technological advantage over our allies as well as potential adversaries since the end of World War II. In no field has this advantage been more evident than in the field of computer technology. However, for a variety of reasons, other industrialized nations are challenging the American leadership position narrowing our once seemingly insurmountable lead. For example, three years ago the Japanese publicly stated a national goal to become the world leader in computer technology by being the first to develop a new generation of computers based on artificial intelligence (AI) technology, commonly referred to as the fifth generation of computers. "Expert Systems" are considered the first practical application of this new technology. What are Artificial Intelligence and Expert Systems? How do they differ from today's computers? Are there potential military applications of this new technology? What are the United States, Japan and other nations doing in the field? Is it feasible that the Japanese will develop a fifth generation computer first? If so, what effect, if any, will this breakthrough have on the national security interest of the United States?

METHODOLOGY: This course is designed to acquaint senior level decision makers with the rapidly advancing field of artificial intelligence and the first practical use of this new technology commonly know as Expert Systems. As such, the course makes use of lectures, demonstrations, and guest speakers to give the senior executive a feel for the state-of-the-art in computer technology as well as to demonstrate potential applications for this new tool. In addition, the student will be given an opportunity to develop a small expert system using a "shell" or "tool" ¹ on an IBM compatible sixteen bit microcomputer. A research paper is not required.

PREREQUISITES: There are no prerequisites for this course. However, a rudimentary computer background including familiarity with either the MS or PC DOS, or CP/M operating system would be helpful.

1. Tools are computer software packages that simplify the effort involved in building application programs much like a spreadsheet simplifies computerizing of numerical data.

COURSE OBJECTIVES:

- to introduce the rapidly developing field of practical artificial intelligence emphasizing the most successful area of practical applications, knowledge based expert computer systems
- to define, clarify, and make sense of the claims, promises, and realities of practical AI applications
- to acquire an understanding of and appreciation for the application, capabilities, and limitations of expert computer systems
- to acquaint senior executives with the state-of-the-art in computer technology while giving him/her an appreciation for future potential applications
- to explore the difficulties associated with the development of an expert system
- to explore current and future applications for this new technology

TEXT:

A. Paul Harmon and David King, Expert Systems, Artificial Intelligence in Business, John Wiley & Sons, Inc, 1985

B. Tom Nagy, Dick Gault, and Monica Nagy, Building Your First Expert System, Ashton-Tate Publishing Group, 1985

INSTRUCTORS: CDR Chuck STEVENSON, USN (51728) from the National War College and LTC Steve KNODE, USAF (51980) from the Decision Support Systems Department of the Department of Defense Computer Institute.

COURSE OUTLINE/ASSIGNMENTS

PHASE 1 - INTRODUCTION/OVERVIEW

SESSION I - INTRODUCTION TO ARTIFICIAL INTELLIGENCE

- A. Overview of course
- B. Demonstration = Meet "Eliza"
- C. Computers and Computer Technology
 - 1. Why should managers study computer science?
 - 2. What is a computer?
 - 3. Evolution of computers/computer technology
 - 4. Where are we today and where are we going?
- D. What is artificial intelligence?
 - 1. Definition
 - 2. The AI Family Tree
 - 3. History of AI
 - 4. Why so much hoop-la about AI?
- E. Current and Future Applications of AI
- F. Technical Problems Yet to be Overcome
- G. Assignment
 - 1. Harmon - Forward, Preface, and Chapter 1, skim Chapter 2
 - 2. See Bibliography for supplemental reading

SESSION II - KNOWLEDGE BASED EXPERT SYSTEMS OVERVIEW

- A. Basic concepts and techniques
 - 1. Computer Aided Decision Making
 - 2. Human problem solving
 - 3. Architecture of Expert Systems
 - 4. Processing Model
 - 5. Strategies of Representing Knowledge
 - 6. Drawing inferences
- B. Strengths/Weaknesses, Advantages/Disadvantages, Promises/Myths of Expert Systems

1. Problem Domain of Existing Techniques
2. Advantages/Disadvantages

C. Assignment

1. Harmon - Chapters 3 through 5, skim Chapter 6
2. Note: basic concepts and techniques will be more easily understood if Chapters 4 and 5 are studied prior to class presentation.
3. See Bibliography for supplemental readings

SESSION III - EXISTING EXPERT SYSTEMS AND TOOLS

A. Languages, Tools and Systems

1. Basic concepts
2. AI languages
3. Tools or Shells

B. Tools or Shells

1. Categories of Tools
2. Consultation Paradigms
3. Problem Solving Strategies

C. Existing Expert Systems

D. Demonstrations of Expert Ease and SYSEX

E. Assignment

1. Harmon - Chapters 7 and 8 (skim last half of both chapters)
2. See Bibliography for supplemental reading
3. Note: text and supplemental reading on Expert Ease and EXSYS will maximize your return from the demonstrations.

SESSION IV - NRL Tour

A. Navy Research Lab (NRL) Tour

B. Assignment

1. Clifton, Pat O., "ARTIFICIAL INTELLIGENCE - A 'USER FRIENDLY' INTRODUCTION", Air University Press (Research Report No AU-ARI-85-1), March 1985 (report in your professional library)
2. See Bibliography for supplemental reading

PHASE 2 - DEVELOPING AN EXPERT SYSTEM

SESSION V - DEVELOPING EXPERT SYSTEMS, AN OVERVIEW

- A. Prerequisites for Development
 - 1. Suitability
 - 2. Possible Design Goals
 - 3. Feasibility
 - 4. Critical Aspects of a Problem
 - 5. How to Pick a Problem
- B. Six Steps in Building a Small Expert System
- C. A Case Study = XCON
- D. Assignment
 - 1. Harmon - Chapter 11
 - 2. See Bibliography for supplemental reading

SESSION VI - BUILDING A SMALL EXPERT SYSTEM, Part I

- A. Microcomputer Familiarization
- B. Where Are We Going?
- C. "Building Your First Expert System"
 - 1. The Text
 - 2. The Program = MICRO-PS
- D. Building Your First Expert System
 - 1. Review
 - 2. Building An Expert System with MICRO-PS
- E. Assignment
 - 1. Nagy - skim Chapters 1-4, Chapter 5
 - 2. Harmon - skim Chapters 9 and 10
 - 3. See Bibliography for supplemental reading

SESSION VII - BUILDING A SMALL EXPERT SYSTEM, Part II

- A. Review DEMO1
- B. Attachments and The Attachment Section

1. General
 2. Nondeclared Attachments
 3. Declared Attachments
- C. Some User Friendly Features
1. Many - for example:
 2. Error Detection
- D. More on Commands/Knowledge Base Structure
1. "message" Command Revisited
 2. "askfor" Command
 3. "justify" Command
 4. Commands for Screen Control
 5. "if-then-endif" and "if-then-else-endif" Structures
- E. Demonstrate DEMO2
- F. Computer Lab Session
- G. Assignment
1. Nagy - Chapter 6, skim Chapter 7
 2. Harmon - skim Chapter 12
 3. See Bibliography for supplemental reading

SESSION VIII - BUILDING A SMALL EXPERT SYSTEM, PART III

- A. Computer Lab Session
- B. Assignment
1. Nagy - skim Chapters 8 and 9
 2. Harmon - skim Chapter 15
 3. See Bibliography for supplemental reading

SESSION IX - Guest Speaker/TITAN Demonstration

- A. Guest speaker - Mr Ron Shattuck
- B. Assignment
1. Harmon - Chapter 13
 2. See Bibliography for supplemental reading

PHASE 3 - THE WORLDWIDE CHALLENGE

SESSION X - THE GAME AND THE PLAYERS

A. The Game

1. The Fifth Generation Challenge
2. At Stake
3. The Response

B. The Players

1. ICOT - Institute for New Generation Computer Technology
2. MCC - Microelectronics and Computer Technology Corporation
3. DARPA - Defence Advanced Research Project Agency
4. Others

C. Potential Military Applications of AI Technology

1. Types of Intelligent Weapons and Battle Management Aids
2. Potential Applications
3. Problems to Overcome
4. Case Study - DARPA's Strategic Computer Initiative

D. Assignment

1. See Bibliography for supplemental reading

SESSION XI - The Military's Role in the Future of AI

A. Guest speaker - DARPA

C. Assignment

1. Harmon - Chapter 14
2. See Bibliography for supplemental reading

PHASE 4 - COURSE SUMMARY

SESSION XII - SUMMARY

- A. Advantages and disadvantages of AI
- B. Future of Knowledge Systems
- C. Preparing for the Knowledge System Revolution
- D. Course Highlights
 - 1. Phase 1 = Introduction and Overview
 - 2. Phase 2 = Developing an Expert System
 - 3. Phase 3 = The Worldwide Challenge
 - 4. Phase 4 = Course Summary
- E. Review of Course Objectives
- F. Course Critique
- F. Assignment
 - 1. Harmon - Chapters 14 and 16
 - 2. See Bibliography for supplemental reading

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION I - INTRODUCTION TO ARTIFICIAL INTELLIGENCE

GOALS & OBJECTIVES

1. **Purpose.** To introduce the course and the field of study.
2. **Objectives**
 - A. To introduce course methodology and objectives.
 - B. To motivate the student in his/her study of computer science.
 - C. To introduce the rapidly developing field of practical artificial intelligence emphasising the most successful area of practical applications - knowledge based expert computer systems.
 - D. To stimulate the student's imagination by introducing current and potential applications for this new technology.
 - E. To acquaint the student with the history of the development of the computer, artificial intelligence, and the state-of-the-art in computer technology.

COORDINATION

1. **Student Handouts**
 - A. Course Syllabus (13.140-2/SH)

B. Course Bibliography (13.140-3/SH)

2. Classroom Setup Requirements

A. Viewgraph

B. Specified number of KAYPRO Computers in appropriate classroom with "Eliza" program disk for each.

3. IRC Support Requirements. Computer/program setup.

LESSON OUTLINE

1. Lecture

A. Overview of Course (VG I-1)

1. Introduce instructor(s)
2. Conduct informal survey of class' computer expertise
3. State Course Objectives (VG I-2)

- course for managers NOT "techies"
- to increase awareness NOT teach mechanics

4. Review Course Outline, Assignments, and Bibliography

- voluminous reading assignments optional for student edification
- many assigned articles short, easy reading

5. Other administrative items

- computer jargon - DON'T LET ME!
- questions - PLEASE!

B. Demonstration - Meet "Eliza"

- developed in 1965's by Joseph Weizenbaum of MIT as demonstration of AI
- NOT an expert system, merely clever programming
- see article in this week supplemental reading for more information

C. Computers and Computer Technology

1. Why should managers study computer science? (VG I-3)
2. What is a computer? (VG I-4)

- parts
- hardware vs software
- bits/bytes into usefulness
- Von Nuemann (John Von Neumann) architecture
- algorithm

3. Evolution of the computer (VG I-5)

- note acceleration of technology over last 10 years
- emphasize military's role in pushing the state-of-the-art due to need

4. Where are we today and where are we going?

- chip technology - LSI to VLSI to VHSIC
- memory - 64 X 1 K to 1 Megabyte chip to CD
- interface - papertape to punch cards to CRT to natural language
- software - machine language to spreadsheets to expert systems

D. What is Artificial Intelligence?

1. Definition (VG I-6)

- define "inference" (the process by which new facts are derived from know facts)
- "modus ponens" = basic rule of logic that asserts: if A implies B and A is fact, then B can be assumed, example:

Rule 1 - If the sky is black, then it is night.
Known fact - The sky is black.
New fact - It is night (from rule 1).

2. The AI Family Tree (VG I-7)
3. History of AI (VG I-8)
4. Why so much hoop-la about AI? (VG I-9)

E. Current and Future Applications of AI

1. Current Applications (VG I-10)
2. Potential Applications (VG I-11)

F. Problem Areas (VG I-12)

G. Next Week - Session II - Knowledge Based Expert Systems

- What are they?
- How do they differ from today's computer software?
- What good are they?
- How do they work?

2. **Demonstration.** Meet "Eliza"

3. **Practical Exercise.** None

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EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION II - KNOWLEDGED-BASED EXPERT SYSTEMS OVERVIEW

GOALS AND OBJECTIVES

1. **Purpose.** To introduce and familiarize the student with knowledge-based expert computer systems.

2. **Objectives**

A. To define, clarify, and make sense of the claims, promises, and realities of practical AI applications.

B. To acquire an understanding of and appreciation for the applications, capabilities, and limitations of expert computer systems.

C. To compare and contrast human problem solving with the state-of-the-art computer problem solving.

COORDINATION

1. Student Handouts. None
2. Classroom Setup Requirements. Viewgraph
3. IRC Support Requirements. None

LESSON OUTLINE

1. Lecture

A. Basic Concepts and techniques

1. Computer Aided Decision Making (Steven W. Oxman 1985) (VG II-1)

a. Data-based Systems = software system that includes data base

1) Data Base Management System (DBMS)

- software that manages data in data base
- example = dBase II

2) Management Information System (MIS)

- software that stores, processes, retrieves, and disseminates information in DBMS
- examples = report generation and telecommunication packages

3) Decision Support Systems (DSS)

- software that enhances decision makers effectiveness in using data from DBMS or MIS
- often presents information in graphs or charts
- two categories = user interface support and models
- example = trend or forecasting analysis packages

b. Knowledge-based Systems = software systems that includes knowledge data base (data and meaning of data)

1) Natural Language Systems

- software that acts as user interface to communicate in flexible framework common to user

2) Expert Systems

- software that uses knowledge (rules about the behavior of elements of a

particular subject domain), facts, and inference techniques (reasoning) to solve problems that normally require the abilities of human experts

- names (VG II-2)
- goals (VG II-3)
- common properties, characteristics, and features (VG II-4)

2. Human Problem Solving (Paul Harmon, David King 1985)

a. Human Information Processing (VG II-5)

1) Input

- cognitive processor (like CPU) cycles to obtain information from sensory buffer and transfers it to working memory (like "fetch-execute" cycle)
- for simple tasks = cognitive system to motor output with little or no thought
- for complex tasks = must use long term memory

2) Memory = stored symbols with complex indexing system

- simple model
 - . "scripts" = like how to meet someone
 - . "chunks" = clusters of symbols or pattern of stimuli hierarchically organize to form vast network
 - . learning = linking and revising links between these chunks of data
- short term memory (working space)
 - . 3 to 7 activated chunks due limited resources of human cognitive processes
 - . "focus" on certain chunks like screen on spreadsheet program
- long term memory
 - . holds individuals mass of accumulated knowledge
 - . trick not storing but retrieving info
 - . take 7 seconds per chunk to link info in long term memory

3) Output

- after scanning and searching memory,

information sent to motor system resulting in some observable activity

b. Problem Solving

- 1) Divergent vs Convergent Reasoning (VG II-6)
- 2) Varieties of Knowledge

- surface knowledge = heuristics (rules of thumb) from experience
- deep knowledge = principles, axioms, and laws from books

- 3) Varieties of Problems

- well and ill-defined problems

- 4) Varieties of techniques

- familiar problem = systematically gather relative information, build prototype solution, ignore irrelevant details, revise hypothesis in light of restraints
- unfamiliar problem = struggle, guess, experiment
- both cases = good theory of problem solving, good heuristics will help

c. Expert Knowledge (VG II-7)

- An expert = individual who is widely recognized as being able to solve a particular type problem that most cannot solve as efficiently or effectively
- 50-100K chunks of heuristic information
- takes about 10 years to acquire
- most expert systems include only surface knowledge to limit size of knowledge base

3. Architecture of a Knowledge-based Expert System (Steven W. Oxman 1985) (VG II-8)

- Knowledge Base contains rules and facts that
- Working Memory embody the system's knowledge

. kinds of knowledge in a knowledge base (VG II-9)

- Inference Engine = a computer program that

contains the inference strategies and controls that manipulate the facts and rules of the knowledge base

- User Interface computer program(s) that allow user to enter facts
- Explanation Subsystem and rules, and ask questions
- Knowledge Acquisition Facility = a computer program that provides a dialogue between the system and the human expert for acquiring knowledge and places rules in knowledge base

4. Production System as a Processing Model

- compare and contrast rule vs fact
- "Modus ponens" = basic rule of logic (If A implies B (rule) and A is the case (fact) then we can assume B), example:
 - . Rule 1 = Nov 28th is Susan's birthday
 - . Fact = Today is Nov 28th
 - . New Fact = Today is Susan's birthday
- so, apply production rule (if-then statement) to working memory (facts), if they succeed, then contribute new fact to memory!
- powerful model because discrete, simple, flexible

5. Strategies for Representing Knowledge (VG II-10)

a. Semantic Networks

- network of nodes connected by links
- nodes used to represent objects or descriptors
- links relate objects and descriptors
- example = (VG II-11)
 - . objects can be nouns or conceptual entities (acts, events, or abstract categories)
 - . links can represent class/instance relationship (is-a), properties (has-a), heuristic knowledge (causes), or be definitional (wears)
- advantages = flexible, inheritance (one node inherits characteristics of another)
- disadvantage = difficulty in handling exceptions (what is Wilson = one armed man?)

b. Object-Attribute-Value (O-A-V) Triplets

- objects = physical (door) or conceptual (bank loan) entities
- attributes = general characteristics or properties associated with objects (size, shape, interest rate)
- value = specific nature of attribute in particular situation (green, 12%)
- example = (VG II-12)
- some features:
 - . remove value = from dynamic to static instance
 - . order/relationship of objects = trees
 - . can modify with "certainty" factor to handle uncertainty

c. Rules (VG II-13)

- each part of "premise" called "expression" or "if clause"
- "conclusion" contains "expression(s)" or "then clause(es)"
- logical operators, "and" and "or"
- certainty factor applicable to rules too

d. Frames (VG II-14)

- frame = description of object which contains "slots" for all information associated with object
- slot = may contain values, point to other frames, sets of rules, or procedures to obtain values
- advantage = allow for richer representation of facts
- disadvantage = more complex and more difficult to develop than O-A-V/Rule systems
- NOTE: (VG II-15)
 - . frames, O-A-V, and rule systems are special cases of semantic network
 - . same facts can be represented in any one of three systems

e. Logical Expressions

- two common forms = propositional logic and predicate calculus
- propositional logic
 - . = statements that are true or false (if A, then C)

- . can link with AND/OR (if A and B, then C)
- predicate calculus
 - . = extension of propositional logic to force true or false statement ("(is-red (ball) = a ball is red)")
 - . note - statement true or false
 - . can address multiple objects ("daughter-of (Emily, Susan)" = Emily is the daughter of Susan)
 - . can link with Boolean AND/OR ("daughter-of (Emily, Susan) AND (daughter-of (Karen, Susan))")
 - . can "nest" predicates ("condition (sleeve (coat), shiny)")
- Note - logical formulations represent knowledge differently than other methods, facts retrieved only by asking true/false question

6. Drawing Inferences

a. Inference Engine

- stands between user and knowledge base
- two tasks
 - . examines existing facts and rules, and adds new facts when possible
 - . decides in which order inferences are made
- the heart of the expert system but quite simple because human inference is simple but combines great knowledge base and well-chosen heuristics allowing expert to quickly cut problem domain to manageable size

b. Guiding Inference

- modus ponens = most common inference strategy
 - . simple rule, easily understood
 - . certain valid implications cannot be drawn using this rule (if B is false, most systems cannot reach the conclusion that A is therefore false, called "modus tollens")
- reasoning with uncertainty
 - . rule false if fact(s) unknown
 - . rules included in knowledge base to provide knowledge about incomplete information (cf less than 0.2 = false or

- if unknown, ask)
- "resolution" = a modus ponens of logical systems
- c. Control
 - two problems
 - . where to start
 - . way to resolve conflict when alternative lines of reasoning emerge
 - search strategies (Frederick Hayes-Roth 1985)
 - . back-chaining (or goal-directed) = begin with goal and successively examine any rule(s) with matching conclusion
 - . forward-chaining (stimulus or data-driven) = rule "fires" when working memory facts match premise
 - . depth-first vs breadth-first searches (VG II-16)
 - . combination = like humans
 - monotonic vs nonmonotonic reasoning
 - . mono = true facts remain true
 - . nonmono = true facts may be retracted
 - . most of today's systems use monotonic reasoning because complication of undoing process

B. Strengths/Weaknesses, Advantages/Disadvantages, Promises/Myths of Expert Systems

1. Problem Domain of Existing Techniques (VG II-17) (Paul Harmon, David King 1985)
 - the barriers
 - . hardware = existing computers not fast enough (solution = parallel processing systems or fifth generation computers)
 - . software = handle nonmonotonic problems with great difficulty (solution = machine that can learn from own experience, "machine learning")
 - both problems will limit knowledge system development over next several years
2. Advantages/Disadvantages (Mike Turner 1985)
 - a. Advantages
 - financial
 - . productivity improvements
 - . increased business volume

- quantifiable
 - . faster turnaround
 - . faster response time
 - . time saved on routine tasks
 - . time saved in learning or coping with new working methods
 - . faster access to expertise
- qualitative
 - . improved knowledge quality and accessibility
 - . changes to ability of staff to perform work effectively
 - . improved quality of services

b. Disadvantages

- financial, cost of:
 - . equipment purchases
 - . system software development
 - . specialist staff and support structure

C. Next Week = Session III - Existing Expert Systems and Tools

- a look at AI languages, programming environments, and Tools
- including demonstrations of Expert-Ease and SYSEX, two expert system tools available for microcomputers

2. Demonstrations. None

3. Practical Exercises. None

13.140-3/IG
SPRING 86

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION III - EXISTING EXPERT SYSTEMS AND TOOLS

GOALS & OBJECTIVES

1. **Purpose.** To familiarize the student with the current state-of-the-art in the development of Expert Systems and Tools.

2. **Objectives**

A. To acquaint the senior executive with AI computer languages and programming environments with emphasis on commercially available expert system tools for microprocessors.

B. To explore the difficulties associated with the development of an expert system.

C. To give the senior executive an appreciation for future potential applications for AI technology.

COORDINATION

1. **Student Handouts.** None

2. **Classroom Setup Requirements**

A. Viewgraph

B. A 16-bit computer and projector in specified classroom with copies of EXPERT EASE and EXSYS software.

3. **IRC Support Requirements.** Computer/software setup.

LESSON OUTLINE

1. Lesson

A. Languages, Tools and Systems (Paul Harmon, David King 1985)

1. Basic Concepts - Levels of Software (between human problem and computer hardware) (VG III-1)

- machine language = binary code
- operating system = handles utility functions
- high-level languages
 - . examples: FORTRAN, BASIC
 - . interpreter vs compiler
- programming environment = special packages
 - . example: FORTRAN library of subroutines
- tools (or shells) = to facilitate rapid development of useful "systems"
 - . examples: spreadsheet, EXPERT EASE
- system = combination of tool and knowledge in specific problem domain

2. Tools (VG III-2) (Mike Turner 1985)

a. Knowledge Acquisition Products

- generate rules from user-provided examples
- rules form knowledge base for subsequent consultations

b. Expert System Shells (or Tools)

- expert system without knowledge base (example: EMYCIN from MYCIN)
- designed to facilitate rapid development of knowledge systems (example: spreadsheet)
- HOWEVER, usually designed to address specific class of problem
- advantages (VG III-3)

c. AI Languages and Programming Environments

3. AI Languages

- most AI programming done in one of two high-level languages = LISP or PROLOG
- AI language constructs facilitate developing

- symbolic computing programs just as iterative constructs are useful for numerical programming
- LISP (LISt Processing)
 - . invented in 1960's by John McCarthy
 - . second oldest computer programming language still in use (first = FORTRAN)
 - . consist of operations that facilitate creation of programs that manipulate list
 - PROLOG (PROgramming LOGic)
 - . invented in 1972 by Alain Colmerauer (U of Marseilles)
 - . language of Japanese Fifth Generation Project
 - . contains constructs that make it easy to write programs that manipulate logical expressions

B. Tools or Shells

1. Categories of Tools (or Shells) (Paul Harmon, David King 1985)

- small system building tools
 - . for personal computers
 - . less than 400 rules
 - . examples = EXPERT EASE, EXSYS
- large, narrow system building tools
 - . 500 to several thousand rules
 - . run on LISP machines or larger
 - . constrained to 1 general consultation paradigm
 - . examples = S.1, TIMM
- large, hybrid system building tools
 - . 500 to several thousand rules
 - . run on LISP machines or larger
 - . include features of several different consultation paradigms
 - . examples = KEE, LOOPS

2. Consultation Paradigms

- paradigm = describes generic types of problem-solving scenarios (example = diagnosis/prescription paradigm, used in most commercial tools)
- typical paradigms = (VG III-4)

3. Problem Solving Strategies (VG III-5)

- the problem to be solved will often dictate the knowledge representation, inference, and control strategies (software techniques) to be used
- two extremes:

- . use available tool
- . use custom-assembled technique - no tool or standard paradigm (longer development, higher cost but problem might not fit available techniques)

B. Existing Expert Systems (Mike Turner 1985)

1. PROSPECTOR

- a system which acts as a geological advisor
- credited with finding \$100 million molybdenum deposit in Washington State in 1982

2. DRILLING ADVISOR

- diagnoses drilling problems and offers recommendations for corrective action
- pays back its research and development costs each few times it is used

3. INDUCE

- by using knowledge about how to learn from examples has become the world's primary authority on soya bean disease diagnosis

4. XCON

- configures minicomputer lay-outs for Digital Equipment
- correct over 99% of cases, record better than human configuration specialists
- case study of XCON in Session V

5. STEAMER

- teach Navy personnel how to operate shipboard steamplants
- simulates a frigate steamplant on color display
- enables user to experiment with various operating procedures
- can explain its operation and terminology

C. Demonstrations

1. EXPERT EASE

2. EXSYS

- D. Next Week = SESSION IV - NAVY RESEARCH LAB TOUR
 - meet in front of NWC building at 1530 hours

2. Demonstrations.

- A. EXPERT EASE
- B. SYSEX

3. Practical Exercise. None

13.140-5/IG
Spring 86

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION V - DEVELOPING EXPERT SYSTEMS, AN OVERVIEW

GOALS & OBJECTIVES

1. **Purpose.** To familiarize the senior executive with the difficulties associated with the development of an expert system.

2. **Objectives**

A. To acquire an understanding of and appreciation for the capabilities and limitations of expert computer systems.

B. To explore the difficulties associated with the development of an expert system.

C. To further clarify the promises and realities of practical AI applications.

COORDINATION

1. **Student Handouts.** None
2. **Classroom Setup Requirements.** Viewgraph
3. **IRC Support Requirements.** None

LESSON OUTLINE

1. Lesson

A. Prerequisites for Development (Mike Turner 1985)

1. Suitability

- must first determine if expert system techniques are applicable (or are conventional methods better suited?)
- positive and negative indicators (VG V-1)
 - . NOT DOABLE USING CONVENTIONAL TECHNIQUES - must use uncertain data or knowledge, or computationally infeasible
 - . NON-COMPUTER STAFF - English-like form of knowledge base makes editing easier
 - . EXPLANATION REQUIRED - intrinsic to expert systems
 - . USE KNOWLEDGE MORE THAN ONE WAY - can change inference module, from doing to teaching)
 - . RULES EASIER THAN EQUATIONS - example = sets of regulations

2. Possible Design Goals (VG V-2)

3. Feasibility (VG V-3)

- expert constraints
 - . must exist and must have ready access
 - . expert must be enthusiastic about cooperating in development
 - . expert must be able to explain his special knowledge and experience and method used to apply to particular problem
- problem constraints
 - . problem domain must be well bounded and reasonably narrow
 - . problem solving in domain should not require the use of common sense reasoning
 - . primary source of expert's ability must be special knowledge, judgement, and experience
 - . problem should typically take an expert between a few minutes and a few hours to solve
- technology constraints
 - . knowledge must be efficiently represented in

- current knowledge representation languages
- . explanations tend to be rather stylised and limited
- . most time-consuming to construct
- . difficult to maintain consistency and resolve conflicts within knowledge base
- . difficult to handle or identify problems at boundaries of knowledge base

4. Critical Aspects of a Problem (VG V-4)

a. Reliability of Data and Knowledge

- no noise (extraneous data) nor errors which might lead to inconsistencies or incorrectness

b. Time Dependency of Data

- whether data is static or not
- if task's history or currentness of data important, then the system must be able to cope with time

c. Size of the Search Space

- in many systems desired solution called "goal", then the set of possible steps leading from initial condition to goal is viewed as a "search space"
- simplest form of search space viewed as tree structure or network
- search space considered "small" if feasible to predefine inference network
- if searching large space, specially tailored search spaces must be generated for each application problem (can use heuristics)

5. How to Pick a Problem

- data and knowledge certain
- data are static
- search space is small
- in general small-scale successful applications have been:
 - . a classificatory or diagnostic problem
 - . modest goals
 - . management prepared to champion project
 - . enthusiastic human expert available
 - . no requirement that development be cost

justified

B. Six Steps in Building a Small Expert System (VG V-5)
(Paul Harmon, David King 1985)

- select a Tool
 - . implicitly commit to particular consultation paradigm
 - . software techniques (knowledge representation, inference and control strategies)
 - . ease of use
 - . fit problem
 - . cost of software/additional hardware (if required)
- identify the problem/analyze knowledge
 - . problem before Tool in real world
 - . knowledge acquisition phase
- design system
 - . design on paper w/ flow diagrams and few rules
 - . from analysis to design
- develop a prototype
 - . create knowledge base and test
- expand, test and revise
- maintain and update
 - . continues for life of system
 - . on small systems can be done by people who create and use them

C. Case Study = XCON (Mike Turner 1985 and Paul Harmon, David King 1985)

1. XCON

- operational expert system that routinely configures and checks for completeness of Digital Equipment Corporation's (DEC) VAX-11/780 computer systems
- manages more complex planning (rather than classificatory or diagnostic) task by:
 - . avoidance of uncertainty of data problem by checking for incompatible or missing components
 - . avoidance of uncertainty in configuration knowledge, components either fit together or do not
 - . defining reasonable small problem domain with clearly defined limits
 - . avoids need to try alternative configurations by careful step by step procedures so partial configuration can always be extended into final correct configuration

2. Development (VG V-6)

3. Current Status of XCON

- grown from 250 rule to 3300 rule system able to configure all VAX and PDP systems sold in significant volumes
- performs at very high level of competence, as good as configuration experts
- system now managed and kept current entirely by DEC personnel
- spin-offs:
 - . XSEL - salesperson's assistant
 - . PTRANS = manufacturing management assistant
 - . both using same knowledge base!

4. Benefits to DEC

- determines completeness of customer's orders soon after receipt (approximately 1.5 CPU minutes per)
- more rapid turnaround of orders
- reduced number of unconfigurable systems delivered to customers
- savings of around \$10 million per annum, roughly equal to development cost
- an overall improved level of customer service
- human experts now free to focus almost entirely on various specialized configuration problems

D. Next Week = SESSION VI - BUILDING AN EXPERT SYSTEM, Part I

- application of the methodology discussed today

2. **Demonstration.** None

3. **Practical Exercise.** None

13.140-6/IG
SPRING 86

**EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE**

SUBJECT: SESSION VI - BUILDING A SMALL EXPERT SYSTEM, PART I

GOALS & OBJECTIVES

1. **Purpose.** To familiarize the student with the 16-bit microcomputer systems being used and to introduce the Expert System Tool, MICRO-PS.

2. **Objectives**

A. To familiarize the student with the 16-bit microcomputer Disk Operating System.

B. To introduce the Expert System Tool, MICRO-PS.

C. To equip the student with sufficient knowledge concerning MICRO-PS so that he/she can begin to formulate a problem to which the student can employ the Tool.

D. To explore the difficulties associated with the development of an expert system through practical application.

COORDINATION

1. **Student Handouts.** MS DOS Gouge (13.140-5/SH)

2. **Classroom Setup Requirements**

A. Viewgraph

B. Twelve 16-bit microprocessors, printers and one projector (for the instructor) in specified classroom.

3. IRC Support Requirements. Computer setup.

LESSON OUTLINE

1. Lesson

A. Microcomputer Familiarization (use Student Handout)

- ON/OFF, Printer, Keyboard (include <CR>)
- DOS, Prompts, Commands (include "DIR")
- How to backup your work (make working copy of MICRO-PS)
- Supplemental Text Editor (if available)

B. Where are we going?

- familiarization with computer and MICRO-PS (1 1/2 wks)
- build your own Expert System using MICRO-PS
 - . practical experience is the goal
 - . use prudence in selecting your problem (ie, very small, almost trivial)
 - . start to formulate your problem as we learn the program

C. "Building Your First Expert System"

1. The Text

- learning guide/manual for the expert system Tool, MICRO-PS
- text divided into four parts:
 - . Part 1 - Chapters 1-3 = Introduction
 - . Part 2 - Chapters 4-9 = How to
 - . Part 3 = MICRO-PS Manual
 - . Part 4 = Glossary & Appendices

2. The Program = MICRO-PS

- scaled down, training version of Knowledge Engineering System (KES) with significant limitations (see Appendix C, page 277)
- "PS" = Production System, means built on if-then rules
- we'll brush through Part 1 and part of Part 2 this week, next week we'll look at the rest of Part 2, then you are on your own (explain computer lab procedures/hours of operation)

D. Building Your First Expert System

1. Review

- a. An Expert System (VG VI-1)
 - review parts (include Parser)
 - define Domain Expert (as opposed to KBA) = expertise behind Expert System, can be person, book, etc.
 - define Knowledge Engineer = writes program
- b. Hallmarks of an Expert System (VG VI-2)
 - RELIABILITY = to keep user's confidence
 - INTELLIGENT QUESTIONING =
 - . explain Attribute = a variable or data element, basic building block of knowledge base
 - . explain Attachment = note "attached" to various parts of your MICRO-PS program
 - . how? (VG VI-3)
 - JUSTIFYING CONCLUSIONS =
 - . enables user to assess rationality of advice
 - . helps user reason like expert
 - . powerful for debugging during development
 - NONNUMERICAL REASONING = full system can do both
 - USER FRIENDLINESS =
 - . criteria = minimal time to learn, relearn, and use
 - . features:
 - helps determine if appropriate for user's problem
 - determines what information needed
 - explains questions
 - leads user to appropriate answer
- c. Most Suitable Applications (VG VI-4)

2. Building an Expert System with MICRO-PS

- a. Demonstrate "DEMO1"
 - for illustration use very limited, non-user friendly Expert System which advises user how to change default disk drives
 - with DOS loaded type "A>micro-ps demo1"
 - step students through options on their micros
 - will use DEMO1 to illustrate MICRO-PS's structure/features

- b. Steps to Build an Expert System (VG VI-5)
 - ANALYSIS = analyse goals, source(s) of knowledge, knowledge level of user, potential gain, difficulty to build and test, methodology to use
 - DESIGN = describe knowledge base
 - . four sections of MICRO-PS knowledge base:
 - THE ATTACHMENTS SECTION = to make program more user friendly
 - THE ATTRIBUTES SECTION = declare attributes
 - . Attribute Hierarchy (VG VI-6)
 - Input Attribute = value from user
 - Inferred Attribute = value from rules
 - THE RULES SECTION = lay out relationship between attributes
 - THE ACTION SECTION
 - . Action Flow Chart for DEMO1 (VG VI-7)
 - . OK, how does it work?

1-Action Sections instructs Inference Engine (IE) to "Obtain" attribute (Operation) which becomes goal
2-IE checks to see if value of Operation known
3-if not, IE looks for rule(s) with Operation as consequent (if none, assumes Operation = Input Attribute and asks for value)
4-then IE tests rule(s), if antecedent unknown sets new intermediate goal of antecedent, etc.

- IMPLEMENT = write Attributes, Rules and Action Sections
- VERIFY = test ALL possibilities

c. One "Section" at a Time

1) The Attributes Section

- used to declare variables (attributes) to be used in system (ie, establish set of storage locations which have names, types, and value sets)
- an attribute must have a unique name, up to 10 words with 10 letters/numbers
- two types, nonnumeric (smlt) and interger (int)
- syntax/example (VG VI-8)
- in DEMO1 (VG VI-9)
- limitations (VG VI-10)

2) The Rules Section

- parts = antecedent - if part
consequent - then part

- must have unique name, up to 10 words with 10 letters/numbers
- Rational Indicators and Connectors (VG VI-11)
- syntax/example (VG VI-12)
- order rules in same pattern established in Attribute Section (exception page 125)
- non Attribute user responses = "UNKNOWN" & "NONE" (see page 216)
- in DEMO1 (VG VI-13)

3) The Action Section

- Commands = askfor, message, stop, obtain, display, etc.
- syntax differ (see Section 5, p227)
- DEMO1 commands (VG VI-14)
 - . "obtain" command
 - syntax
 - "obtain" in lowercase
 - <attribute name> must match & appear in consequent of at least one rule
 - . "message" command
 - syntax
 - "message" in lowercase
 - each line enclosed by double quotes
 - text limited to four lines
 - stand alone message ends with period
 - . "display" command
 - syntax
 - "display value" in lowercase
 - <attribute name> enclosed in parentheses, must match, and appear as consequent of at least one rule

4) Summary of Sections (VG VI-13)

E. Next Week - SESSION VII - BUILDING A SMALL EXPERT SYSTEM, PART II

- will have opportunity to begin working on your first expert system during the next class period so any preparation between now and then will be time well spent

2. **Demonstrations.** DEMO1 (Tom Nagy, Dick Gault, and Monica Nagy, Building Your First Expert System, Ashton-Tate Publishing Group 1985, pp43-45)

3. Practical Exercises. None

13.140-5/SH
SPRING 86

MS DOS GOUGE

GETTING STARTED

1. Place the MS DOS (or Working) Disk into Disk Drive A (on left hand side).
2. Close the door on the disk drive.
3. Turn on computer (ON/OFF switch is located on the left hand side of the computer).
. . . after some buzzing and whirling,
4. Answer cues (ie, time, date), pressing Return Key after each.
 Note: syntax for time is <hour>:<minutes>
 syntax for date is <month>-<day>-<year>
. . . you have successfully "booted" the Operating System (MS DOS in this case) when the prompt "A>" appears. You may now instruct the computer to execute any DOS command or to run a program.

Note: this procedure may be employed to boot the Operating System during subsequent sessions by substituting your MICRO-PS Working Disk for the MS DOS disk in the above procedure.

FORMATING A WORKING DISK¹

1. Place the MS DOS disk in Disk Drive A.
2. Place a blank disk in Disk Drive B.
3. Close both disk drive doors.
4. After the prompt "A>" type "FORMAT B: /S" and press the return key.
 Note: the "/S" portion of the DOS Format Command instructs the computer to copy the Operating System onto the disk being formatted. This will allow the user to boot the Operating System without the use of the DOS Disk during future operations (see Note 1).
5. Follow the cues.
. . . the prompt "A>" will return when the blank disk has been formatted.
6. Label the newly formatted disk "MICRO-PS WORKING COPY".

COPYING A FILE

1. Place the MS DOS Disk in Disk Drive A and your Working Disk in Drive B.

Note: the following procedures will copy a file on the disk in Drive A to the disk in Drive B.

2. Close both disk drive doors.
3. After the prompt "A>" type "COPY A:<filename> B:" and press the return key.

Note: in place of "<filename>" in the above command type the name of the file you wish to copy including the extension. For example, if you want to copy the file "EDLIN.COM" type "COPY A:EDLIN.COM B:".

4. The computer will cue you when the file has been copied.

COPYING A DISK

1. Place the original MICRO-PS Disk in Disk Drive A.
2. Place your Working Disk in Disk Drive B.
3. Close the doors on both disk drives.
4. After the prompt "A>" type "COPY A:*. * B:" and press the return key.

Note: this command will copy all the files on the disk in Drive A onto the disk in Drive B.

5. Follow the cues.
 6. Return the original MICRO-PS disk to its cover.
- . . . you now have a working copy of the MICRO-PS disk which should be used on all subsequent instructions.

EXECUTING A MICRO-PS KNOWLEDGE BASE

1. Place MICRO-PS Working Disk in Drive A.
2. After the prompt "A>" type "MICRO-PS <filename>" and press the return key.

Note: in place of "<filename>" in the above command type the name of the MICRO-PS Knowledge Base you wish to execute. For example, if you want to execute the Knowledge Base named "DEMO1" type "MICRO-PS DEMO1" and press the return key.

3. To stop the execution of a MICRO-PS Knowledge Base type "stop" after the MICRO-PS prompt "= ?".

CONSTRUCT/EDIT A KNOWLEDGE BASE USING EDLIN²

1. Place your MICRO-PS Working Disk into Disk Drive A. Ensure the disk drive door are closed.
Note: this procedures only works if the file "EDLIN.COM" and the file containing your Knowledge Base are on your working disk.
2. After the prompt "A>" type "EDLIN <filename>" and press the return key.
Note: in place of "<filename>" in the above command type the name of the Knowledge Base you wish to create/edit. For example, if you wish to create/edit a Knowledge Base named "First" type "EDLIN FIRST" and press the return key.
3. Use the Insert Lines Command (see EDLIN Command handout) to begin entering your first Knowledge Base. That is, type "I" after the EDLIN prompt ("*") and press the return key. The computer will automatically number the lines of your Knowledge Base.
4. For subsequent editing, any of the EDLIN commands (see EDLIN Command handout) may be executed by typing it after the EDLIN prompt ("*"). For example, to list an existing file type "L" after the prompt "*" and press the return key.
Note: the End Edit Command ("E") stores the file before returning to the Operating System. The Quit Edit Command ("Q") returns to the Operating System without storing the file WHICH COULD RESULT IN LOST WORK. Be careful!

TO PARSE A KNOWLEDGE BASE

1. Place your MICRO-PS Working Disk (with the new Knowledge Base) in Disk Drive A and close the door.
2. Follow the instructions for Executing A Knowledge Base listed above. For example, to parse the Knowledge Base First type "MICRO-PS FIRST" and press the return key.
3. The MICRO-PS Parser will display error messages as it attempts to execute the new Knowledge Base.
Note: an example of parsing a new Knowledge Base can be found in the Nagy text (Figure 5-21 p65).
4. Follow the cues.
Note: it will be helpful to have a printed copy of your Knowledge Base to refer to as it is being parsed.

PRINTING A KNOWLEDGE BASE

1. Ensure the printer is turned on (ON/OFF switch located on right hand side of printer), that it is connected to the computer you are using, and that it is not out of paper.
2. Place your MICRO-PS Working Disk in Disk Drive A and close the door.
3. While holding the Control Key ("Ctrl") press the letter "P".
Note: pressing the "Ctrl-P" keys simultaneously acts as a toggle switch to turn the printer's echo function on and off.
4. After the prompt "A>" type "TYPE <filename>", where "<filename>" is explained above.
Note: the DOS command "TYPE" can be used to display any file.
. . . the printer will echo whatever is displayed on the monitor.
5. Press "Ctrl-P" to exit the echo mode.
Note: the "PrtSc" key can always be used to obtain a hardcopy of the current display on the monitor ("PrtSc" works in conjunction with the "Shift" key).

13.140-7/IG
SPRING 86

**EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE**

SUBJECT: SESSION VII - BUILDING A SMALL EXPERT SYSTEM, PART II

GOALS & OBJECTIVES

1. **Purpose.** To advance the students knowledge of the MICRO-PS expert system Tool and to provide the student an opportunity to start working on his/her first expert system while the instructor is immediately available for consultation.
2. **Objectives**
 - A. To advance the students knowledge of the MICRO-PS expert system Tool.
 - B. To provide the student an opportunity to begin working on his/her first expert system.
 - C. To continue to explore the difficulties associated with the development of an expert system through practical application.

COORDINATION

1. **Student Handouts.** None
2. **Classroom Setup Requirements**
 - A. Viewgraph
 - B. Twelve 16-bit microprocessors, printers and one projector (for the instructor) in specified classroom.
3. **IRC Support Requirements.** Computer setup.

LESSON OUTLINE

1. Lesson

A. Review DEMO1 (VG VI-13)

B. Attachments and The Attachment Section

1. General

- Attachments = groupings of text which can be "attached" to the various parts of MICRO-PS program to:
 - . provide information to user
 - . make your ES more usable and valuable to user
- first of the four sections in a MICRO-PS knowledge base (Attachments, Attributes, Rules, Action), only section not required in KB
- format same as other sections (will cover in a minute)
- two types of attachments = Nondeclared/Declared

2. Nondeclared Attachments

- "question" Attachment
 - . available even if knowledge base does not have an Attachment Section
 - . allows text to be attached to an attribute or value name in the Attribute Section = text displayed to user rather than name
 - . syntax/example (VG VII-1)
 - placed in Attribute Section
 - enclosed in square brackets
 - word "question" in lowercase followed by colon
 - each line of text, including question mark, enclosed in double quotation marks
 - text up to 79 characters including brackets
 - note use of commas and periods for value attachments (if more than 1 attachment, "question" Attachment first without punctuation between consecutive attachments)

3. Declared Attachments

- can "attach" text to names, values, and rules
- declare (names of) attachments (except "question" Attachments) in Attachment Section, text of attachment in other section(s)

- syntax/example (VG VII-2)
 - . name = 1 word of 10 letters/numbers with no punctuation
 - . maximums = 10 attachments, 3 per attribute/value/rule, 4 lines per, total text 100 lines
 - . in rules = follow rule name before "if"
 - . names must match declared name in Attachment Section
 - . note can provide user format for calling attachment and attachment name as part of "question" attachment

C. Some User Friendly Features

1. Many - for example:
 - ability to input any user command (ie, next, continue, stop, display, justify) at any prompt
 - parser error messages
 - many features can be used by KBA to increase
2. Error Detection
 - informs user when inappropriate value to question is chosen
 - example (VG VII-3)

D. More On Commands/Knowledge Base Structure

1. "message" Command Revisited
 - as greetings or instruction message
 - could be used to help user to decide usefulness of system or to issue instructions to user
 - example (VG VII-4)
 - . place in Action Section
 - . word "message" in lowercase
 - . each line enclosed in double quotation marks
 - . limit of 4 lines
 - . end with period, comma, or "endif"
2. "askfor" Command
 - used to display unattached attribute (not mentioned in any rule) to user
 - used in Action Section
 - syntax/example (VG VII-5)
 - . word "askfor" in lowercase
 - . attribute name matches
 - . end with period, comma, or "endif"
3. "justify" and "display" Commands
 - enables user to justify and/or display conclusions/advice, system will reply with

message that identifies the rule name and its final value (display command can then be use to display the appropriate rule)

- and/or KBA can use to increase user confidence in system
- syntax/example (VG VII-6)
 - . word "justify" and "display" in lowercase
 - . variable/rule name must be declared, match, and be determined by a rule in the Rules Section

4. Commands for Screen Control (VG VII-7)

- a. Mark Command
 - used in system which will be used repeatedly
 - commands in Action Section before "mark" executed only once
 - syntax = lowercase followed by comma, percent sign, period, or "endif"
- b. Wait and Pause Commands
 - used to control amount of information on screen
 - syntax = ibid
- c. Example = (see viewgraph)

5. "if-then-endif" and "if-then-else-endif" Structures

- used in Action Section like rule in Rule Section but consequent is a command or series of commands
- syntax/example (VG VII-8)
 - . attribute names/values must be declared and match
 - . consequent can have series of commands separated by commas
 - . last command followed by "endif"
 - . preferred method = complicated "if-then-else-endif" can be accomplished with series of "if-then-endif" statements (VG VII-9)

E. Demonstrate DEMO2 (VG VII-10)

F. Next Week - SESSION VIII - BUILDING A SMALL EXPERT SYSTEM, PART III

- lab session to afford student opportunity to write first expert system (review Computer Lab hours/procedures)

G. Lab Session = remainder of period for individual student study

2. **Demonstrations.** DEMO2 (Tom Nagy, Dick Gault, and Monica Nagy, Building Your First Expert System, Ashton-Tate Publishing Group 1985, pp72-95)

3. **Practical Exercises.** None

13.140-8/IG
SPRING 86

**EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE**

SUBJECT: SESSION VIII - BUILDING A SMALL EXPERT SYSTEM, PART III

GOALS & OBJECTIVES

1. **Purpose.** To provide the student an opportunity to start working on his/her first expert system while the instructor is immediately available for consultation.

2. **Objectives**

A. To provide the student an opportunity to begin working his/her first expert system.

B. To continue to explore the difficulties associated with the development of an expert system through practical application.

COORDINATION

1. **Student Handouts.** None

2. **Classroom Setup Requirements**

A. Viewgraph

B. Twelve 16-bit microprocessors, printers and one projector (for the instructor) in specified classroom.

3. **IRC Support Requirements.** Computer setup.

LESSON OUTLINE

1. Lesson

A. Computer Lab Session

B. Next Week - SESSION IX - GUEST SPEAKER/DEMONSTRATION FROM
TITAN

2. Demonstrations. None

3. Practical Exercises. None

13.140-10/IG
SPRING 86

**EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE**

SUBJECT: SESSION X - THE GAME AND THE PLAYERS

GOALS & OBJECTIVES

1. **Purpose.** To familiarize the student with the potential social, economic, and military implications as well as the possible utility of the field of artificial intelligence.

2. **Objectives.**

A. To introduce the game, the stakes and the players in what has been called the "war" for AI supremacy.

B. To give senior executives an appreciation for future potential application of artificial intelligence technology.

C. To explore current and future applications for this new technology with emphasis on future military applications.

COORDINATION

1. **Student Handouts.** None
2. **Classroom Setup Requirements.** Viewgraph
3. **IRC Support Requirements.** None

LESSON OUTLINE

1. Lesson

A. The Game

1. The Fifth Generation Challenge

- issued in autumn 1981 by Japanese Ministry of Internal Trade and Industry (MITI) by launching Institute for New Generation Computer Technology (ICOT)
- initial \$2 million 1982 budget, \$450 million 10 year program
- goal = Knowledge Information Processing System (KIPS)
- spring 1982 = 40 computer "whiz kids" (average age 30) started work
- March 1983 = Edward A. Feigenbaum and Pamela McCordick published "The Fifth Generation, Artificial Intelligence and Japan's Computer Challenge to the World" publicizing challenge
- Japanese government total allocation of capital for computer development = \$4.57 billion

2. At stake

- war in AI supremacy will be won between now and end of 20th century
- domestic sales, jobs, prestige
- implication to national defense . . .
- value of the market (VG X-1)
- could revolutionize both warfare and civilian economy in next century

3. The Response

- National Corporate Research Act of 1984 = timely relaxation of real and perceived barriers to corporate research
- sweetener = 25 percent tax credit giving companies incentive to bolster high tech R&D
- total U.S. high tech R&D budget

1983	\$ 6 billion (mostly companies, IBM, DEC, etc)
1984	97 billion (IAW National Science Foundation)
1985	107 billion (IAW Battelle Memorial Institute)
- applicability of AI to military significant, DOD plays single most influential role setting advanced computer goals and establishing R&D projects

1984	50% of \$104 million in federal funding for

basic computer research from DOD
60% of \$146 million for applied computer
research from DOD

B. The Players (VG X-2)

1. ICOT - Institute for New Generation Computer Technology

- already discussed Japanese Fifth Generation Project
- eight companies, heavily supported by government
- Hitachi, Nippon Electric, Mitsubishi, Sharp, Toshiba, Fujitsu, Oki
- Japanese goal both social and economic
- promised approximately \$42 million/year, actual:
 - . 1984 \$22 million
 - . 1985 \$20 million
 - . 1986 estimate \$21 million

2. MCC - Microelectronic and Computer Technology Corporation

- created to maintain U.S. technology preeminence and international competitiveness in microelectronics and computers
- consortium of approximately 21 U.S. companies including Boeing, Eastman Kodak, Martin Marietta, 3M, NCR, Control Data, Digital Equipment
- founded Jan 1983, approximately 350 employees
- CEO = ADM Bobby R. Inman, USN (ret)
- governed by Board of Directors composed of representatives of each shareholder company
- stockholder companies have exclusive rights to proprietary information for 3 years then MCC license rights to other users
- corporate objectives (VG X-3)
- programs = four long-range advanced technology programs are intended to make significant technology advances within 5-10 years (VG X-4)
 - . PACKAGING = advance the state-of-the-art in semiconductor packaging and interconnect technology
 - . SOFTWARE TECHNOLOGY = develop new techniques, procedures, and tools that can be used to improve the productivity of the software development process 1-2 orders of magnitude
 - . VLSI/COMPUTER-AIDED DESIGN = improve computer-aided design technology and develop an integrated set of tools that can have

particular application to complex systems and the very complex VLSI chips from which they will be built

- . ADVANCED COMPUTER ARCHITECTURE = the most complex and ambitious program, 10-year effort will focus on:
 - PARELLEL PROCESSING = develop languages and architectures to allow computers to perform tasks simultaneously instead of sequentially
 - DATABASE SYSTEM MANAGEMENT = improve database design, storage methods, and capacities to permit flexible storage and faster retrieval of broader range of complex information
 - HUMAN FACTORS TECHNOLOGY = improve man-machine interface using improved voice or character recognition or natural language
 - AI/KNOWLEDGE-BASED SYSTEMS = develop new ways to represent human knowledge and thought concepts as well as new engineering models and tools to apply human expertise to wide range of problems
- . all programs are interrelated and focus upon the last, most important program: artificial intelligence

3. DARPA - Defense Advanced Research Project Agency

- founded as ARPA in 1958 (result of Sputnik) with mission to ensure U.S. would never again be caught so flat-footed by an adversary
- approximately 125 employees, no labs, relative small budget
 - . 1985 \$700 million
 - . 1986 estimate \$776 million
- venture capitalists of the Defense Department
- sets pace and direction for development of future computer technology by distributing funds to university, company and national laboratories
- MIT computer professor (Dertouzos), "70-80 percent of major discoveries in computer science can be traced to DARPA"
- success = phased-array radar, composite materials, laser holography forward-swept-wing aircraft
- Strategic Computer Initiative
 - . 10 year R&D push in specific computer technologies that would eventually find use in wide spectrum of military (and civilian) engineering
 - . AND develop massive infrastructure of

- distributed research centers, supporting agencies, databases, networks, project managers
- . AND to build massively parallel VLSI-based computer eventually with GaAs in next 10 years (gallium arsenide = low power, high speed, radiation hardness)
- . MORE ABOUT SCI IN A MINUTE

4. Others

a. U.S. Governments and Agencies

- federal government
 - . establishing four national supercomputer centers
 - . Cornell, Princeton, U. of Ill, and U. of Calif in San Diego
- National Security Agency . . .
- Microelectronics Center of North Carolina (MCNC)
 - . state effort of approximately \$43 million
 - . Neighboring industries contributing to total budget through 1985 of \$50 million
 - . target = VLSI design system, advanced silicon wafer fabrication facility, fast prototyping capacity for building experimental architecture

b. Individual Companies, Consortia and Joint Ventures

- IBM = \$2.5 billion in 1983 for R&D
- IBM, EXXON, AT&T and Lockheed cooperating to construct supercomputer
- Semiconductor Research Cooperative (SRC)
 - . founded 1981
 - . IBM, DEC, Burroughs, Control Data, GE, Intel, Westinghouse Electric, Xerox, others
 - . 1984 budget greater than \$13 billion for "pure research"
 - . over 50 contracts with 30 universities, 100 faculty, 125 graduate students working
 - . research areas = microstructure science, system components, design tools, new approaches to manufacturing and engineering

c. Other Governments

- ESPRIT - European Strategic Programme for Research and Development
 - . fully underway in 1984
 - . Common Market funds for knowledge engineering
 - . bidding agreements for programs must include members from at least two European countries
- Alvey Computer Research Program
 - . British government + member companies
 - . Science and Engineering Research Council, and Departments of Industry and Defense
 - . \$500 million, 5 year program (British government = \$300M, member companies = \$200M)
 - . target = VLSI, software engineering, intelligent knowledge-based systems, and user-friendly interfaces
- Germany
 - . \$40 million per year
 - . 50/50 between government and industry
- Agency for Information Technology
 - . French government "pure research"
 - . approximately \$15 million first year
 - . software engineering, workstation, and computer-aided design for VLSI
- Soviets
 - . late 1983 = 3rd 5 year plan for computing
 - . initially \$100 million
 - . collaboration with USSR and 6 East European partners in Council for Economic Mutual Assistance
 - . claim civilian activity and not a military initiative
 - . pointed at fifth generation computing

C. Potential Military Applications

1. Types of Intelligent Weapons and Battle Management Aids

- collaborative
 - . = closely assist human operators
 - . example = fighter co-pilot, battle management
 - . advantages = tireless, relieve human of mundane tasks, no bad days, faster

- autonomous
 - . = function without human intervention
 - . example = smart bomb/cruise missile
 - . advantages = survivability (in hostile, high radiation environment)
 - . disadvantage = danger of completely autonomous system
- 2. Potential Application (VG X-5)
- 3. Problems to Overcome (VG X-6)
- 4. Case Study = DARPA's Strategic Computer Initiative
 - goal = set of specific military applications that exploit new generation computing technology (VG X-7)
 - funding between \$600 million to \$1 billion (VG X-8)
 - three projects
 - . AUTONOMOUS LAND VEHICLE (VG X-9)
 - autonomous vehicle to support deep-penetration reconnaissance, rear area re-supply, ammunition handling, and weapons delivery
 - . PILOT'S ASSOCIATE SYSTEM (VG X-10)
 - combat pilots personal assistant
 - . NAVAL BATTLE MANAGEMENT SYSTEM (VG X-11)
 - battle management system to aid in management of large enterprise

D. Next Week = SESSION XI - The Military's Role in the Future of AI

- Guest Speaker from DARPA

- 2. Demonstrations. None
- 3. Practical Exercises. None

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EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION XII - COURSE SUMMARY

GOALS & OBJECTIVES

1. **Purpose.** To explore the future of AI and expert systems, and to review and critique this course.

2. **Objectives**

A. To make sense of the claims, promises, and realities of future AI applications.

B. To explore future applications for this new technology.

C. To impart an understanding of and appreciation for future capabilities and limitations of expert computer systems.

D. To review and critique the course.

COORDINATION

1. **Student Handouts.** None

2. **Classroom Setup Requirements.** None

3. **IRC Support Requirements.** None

LESSON OUTLINE

1. Lesson

A. Advantages and Disadvantages of AI (Software A&E 1985)

- Comparison of Natural and Artificial Intelligence (VG XII-1)
- Human vs Computer Problem Solving (VG XII-2)

B. Future of Knowledge Systems (Paul Harmon, David King 1985)

- The Computer EVOLUTION (vice revolution) (VG XII-3)
- Applications in the 1980's (VG XII-4)
- Market Impact of Different Types of Systems (VG XII-5)
 - . Large, hybrid and narrow systems
 - . Professional workstations
 - . Small-scale systems
 - Smart generic software (Tools, off-the-self)
 - Smart hardware (integrated in lab testing, diagnosis)

C. Preparing for the Knowledge System Revolution

- keep abreast of state-of-the-art
- push technology when chance arises

D. Course Highlights (VG XII-6)

1. Phase 1 = Introduction and Overview

- hardware/software, bits/bytes
- algorithm/Von Neumann architecture
- state-of-the-art (VHSIC, CD, natural language interface, expert systems)
- AI family tree
- meet "Eliza"
- data-based systems (DBMS/MIS/DSS) and knowledge-based systems (natural language, expert systems)
- languages, Tools, systems
- existing systems = demonstrations of Expert Ease and SYSEX
- Navy Lab tour

2. Phase 2 = Developing an Expert System

- problem suitability and feasibility, goals
- six steps

- case study = XCON
- built small expert system using MICRO-PS
- TITAN demonstration

3. Phase 3 = The Worldwide Challenge

- the challenge, stakes, response
- players = ICOT, MCC, DARPA, others
- military applications
- case study = DARPA's SCI
- guest lecturer = DARPA

4. Phase 4 = Course Summary

E. Review of Course Objectives (VG XII-7)

F. Course Critique

2. **Demonstrations.** None

3. **Practical Exercises.** None

1. This and subsequent procedures will assume that the Operating System has already been booted.

2. A MICRO-PS Knowledge Base may also be constructed using any Wordprocessing Program that will create an ASCII file.

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

LIST OF VIEWGRAPHS

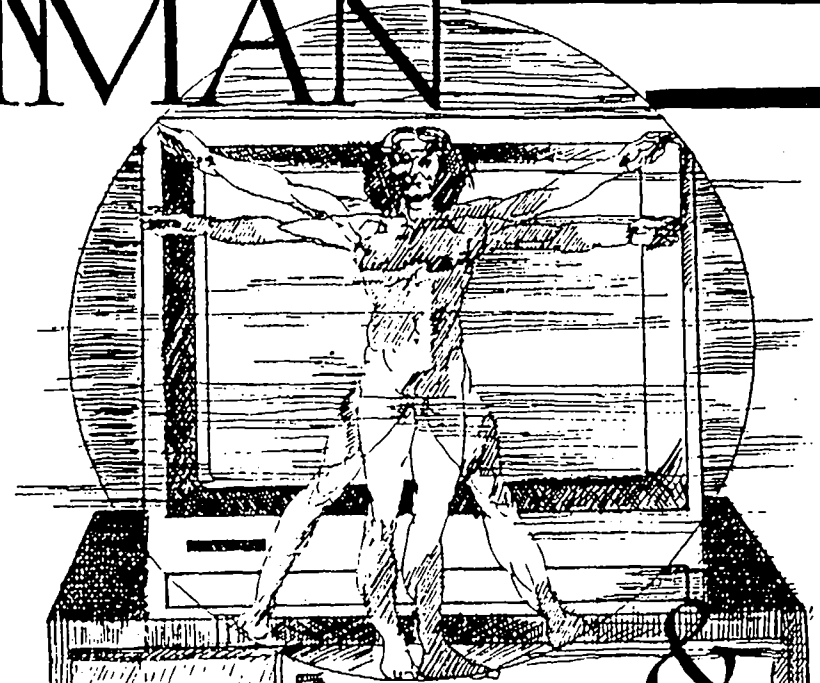
SESSION NUMBER/DODCI NUMBER	TITLE (Source)
I	
1/1026	Expert Computer Systems for Government Executive
2/1027	Course Objectives
3/1028	Why Study Computer Science?
4/1029	Block Diagram of a Computer
5/1030	Evolution of the Computer
6/1031	Definition of Artificial Intelligence
7/1032	The AI Family Tree
8/1033	History of AI (Harmon Table 1.1 p4)
9/1034	So What's all the Hoopla about AI?
10a-c/ 1035, 1090-1091	Current Applications of AI
11/1036	Potential Applications of AI
12/1037	Technical Hurdles Yet to Overcome
II	
1/1038	Computer Aided Decision Making
2/1039	. . . By Any Other Name . . .
3/1040	Goals of Expert Systems
4a-c/ 1041-1043	Common Properties, Characteristics and Features of Expert Systems
5/1045	Overview of Human Information Processing System (Harmon Fig 3.1 p23)
6/1046	Divergent and Convergent Reasoning
7/1047	Definition of Expertise
8/1048	Architecture of Knowledge-based Expert Systems (Harmon Fig 4.1 p34)
9/1049	Knowledge Base Knowledge
10/1050	Strategies for Representing Knowledge
11/1051	Semantic Network (Harmon Fig 4.2 p36)
12/1052	Object-Attribute-Value Triplet (Harmon Figs 4.4, 4.6, and 4.7 p39-40)
13/1053	Rules (Harmon p42 bottom)
14/1054	Frames (Harmon Fig 4.12 p44)
15/1055	Semantic Nets, O-A-V Triplets and Frames (Harmon Fig 4.15 p47)
16/1056	Inference Engines Search Strategies (Harmon Fig 5.7 p57)
17/1057	Problem Domain of Existing Knowledge Engineering Techniques (Harmon Fig 5.8 p59)

III	1/1058	Levels of Software (Harmon Fig 7.1 and 7.2 p80-81)
	2/1059	Tools for Building Expert Systems
	3/1060	Advantages of Expert Tools
	4/1061	Typical Consultation Paradigms (Harmon Fig 8.3 p95)
	5/1062	Problem Solving Strategies (Harmon Fig 8.1 p93)
V	1/1063	Suitability of Expert System Techniques
	2a-b/	Expert Systems Can . . .
1064-1065		
	3/1066	Application Constraints
	4/1067	Critical Aspects of a Problem
	5/1068	Building a Small Expert System
	6/1089	Overview of the Development of XCON (Harmon Fig 10.1 p156)
VI	1/1092	An Expert System
	2/1093	Hallmarks of an Expert System
	3/1094	How Attachments Work (Nagy Fig 5-1 p39)
	4/1095	Most Suitable Applications
	5/1096	Design Steps
	6/1097	Attribute Hierarchy for DEMO1 (Nagy Fig 5-5 p48)
	7/1098	Action Flow Chart for DEMO1 (Nagy Fig 5-6 p49)
	8/1099	Nonnumeric Attribute Syntax & Example (Nagy Fig 3-1 p189, Example 3-2 p190)
	9/1100	Attribute Section of DEMO1 (Nagy Fig 5-7 p51)
	10/1101	Illegal Keywords and Characters for MICRO-PS (Nagy Figs 5-8, 5-9 p52)
	11/1102	Rational Indicators and Connectors
	12/1103	Rule Syntax & Example
	13/1104	DEMO1's Knowledge Base (Nagy Fig 5-22 p68-69)
	14/1105	Command Syntax & Examples

VII	1/1106	Question Attachment Syntax & Example (Nagy Figs 6-8, 6-9 p79+)
	2a-b/	Declared Attachments Syntax & Examples (Nagy Example 2-6 p185-187+)
	1107-1108	
	3/1109	Example of Error Detection (Nagy Fig 6-1 p73)
	4/1110	Message Command Syntax & Example (Nagy Figs 6-3, 6-4 p75+)
	5/1111	Askfor Command Syntax & Example (Nagy Example 5-1 p228-229+)
	6a-b/	Justify Command Syntax & Example (Nagy Figs 6-13, 6-14, 6-15 p83-87-)
	1112-1113	
	7a-b/	Mark, Wait, and Pause Commands Syntax & Example (Nagy Example 5-11 p253-254+)
	1114-1115	
	8/1116	If-then-else-endif Structure Syntax & Example (Nagy Example 5-4 p233-234+)
	9/1117	If-then-endif Structure (Nagy Example 5-5 p234-235)
	10a-d/	DEMO2 Knowledge Base (Nagy Fig 6-19 p91-95)
	1118-1121	
X	1/1069	Value of AI Market
	2/1070	The Players
	3/1071	MCC's Corporate Objectives
	4/1072	MCC's Programs
	5/1073	Military Applications
	6/1074	Problems to Overcome
	7/1075	DARPA's SCI Program Structure and Goals
	8/1076	DARPA's SCI Cost Summary
	9a-d/	DARPA's Autonomous Land Vehicle
	1077-1080	
	10/1081	DARPA's Pilot's Associate System
	11a-b/	DARPA's Naval Battle Management System
	1082-1083	
XII	1/1084	Comparison of Natural and Artificial Intelligence (Building Expert Systems p6-6)
	2/1085	Human vs Computer Problem Solving (Building Expert Systems p6-7)
	3/1086	The Computer EVOLUTION
	4/1087	Applications in the 1980's (Harmon Fig 14.1 p228)
	5/1088	Market Impact of Various Types of Systems (Harmon Fig 14.2, 3, and 4 p229, 232)
	6/1188	Course Highlights
	7	Course Objectives (see VG I-2)

**ARTIFICIAL
INTELLIGENCE
and
EXPERT SYSTEMS**

MAN



&
MACHINE
MACHINE
MACHINE

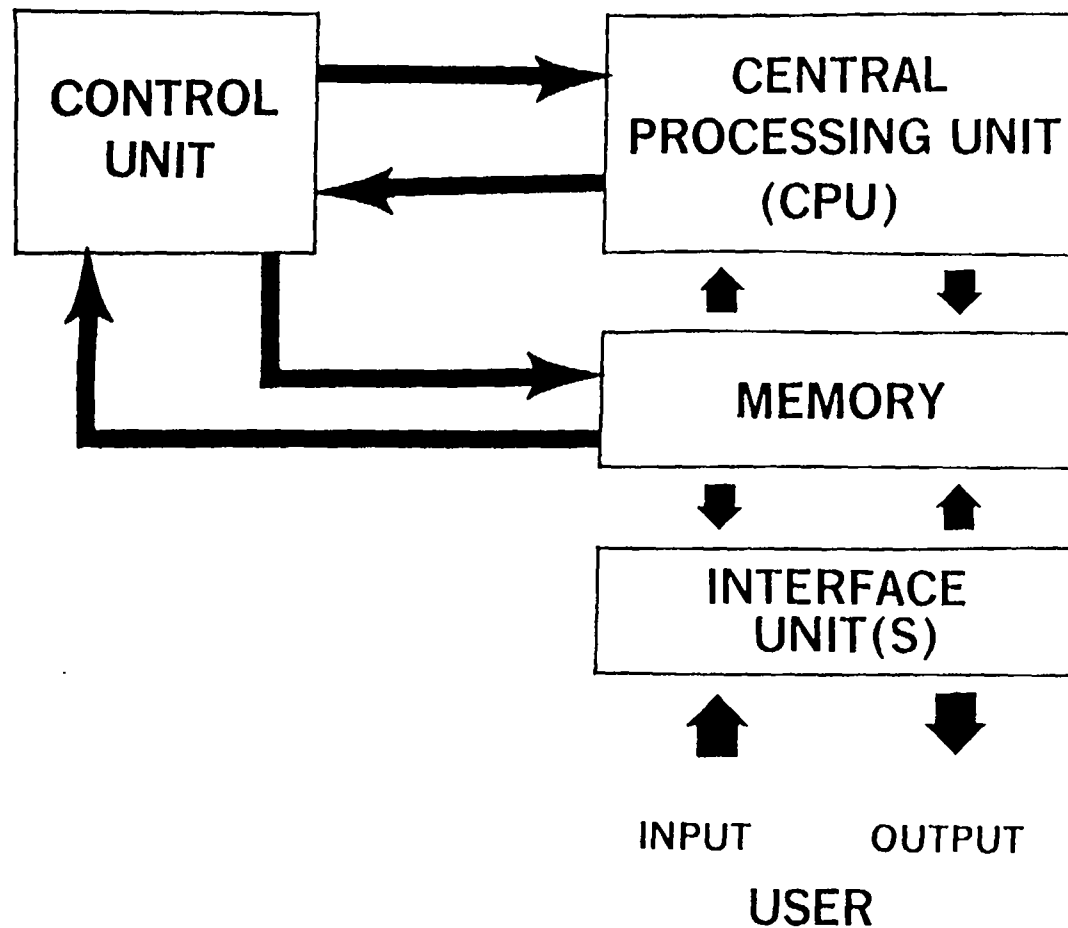
COURSE OBJECTIVES

- TO INTRODUCE THE RAPIDLY DEVELOPING FIELD OF PRACTICAL ARTIFICIAL INTELLIGENCE EMPHASIZING THE MOST SUCCESSFUL AREA OF PRACTICAL APPLICATIONS—KNOWLEDGE BASED EXPERT COMPUTER SYSTEMS.
- TO DEFINE,CLARIFY AND MAKE SENSE OF THE CLAIMS,PROMISES AND REALITIES OF PRACTICAL AI APPLICATIONS.
- TO ACQUIRE AN UNDERSTANDING OF AND APPRECIATION FOR THE APPLICATION, CAPABILITIES AND LIMITATIONS OF EXPERT COMPUTER SYSTEMS.
- TO ACQUAINT SENIOR EXECUTIVES WITH THE STATE—OF—THE—ART IN COMPUTER TECHNOLOGY WHILE GIVING HIM/HER AN APPRECIATION FOR FUTURE POTENTIAL APPLICATIONS.
- TO EXPLORE THE DIFFICULTIES ASSOCIATED WITH THE DEVELOPMENT OF AN EXPERT SYSTEM.
- TO EXPLORE CURRENT AND FUTURE APPLICATIONS FOR THIS NEW TECHNOLOGY.

WHY MANAGERS SHOULD STUDY COMPUTERS

- TECHNOLOGY ILLITERACY vs EFFICIENT AND EFFECTIVE USE
- INFORMATION AGE-COMPUTER CAN BE ANYTHING FROM TOOL TO TERRORIST DEVICE
 - BUREAUCRATIC ITIOM-"INFORMATION IS POWER"
 - SUN TZU (IN THE ART OF WAR)-KNOWLEDGE IS POWER AND PERMITS THE WISE SOVEREIGN AND BENEVOLENT GENERAL TO ATTACK WITHOUT RISK.CONQUER WITHOUT BLOODSHED,AND ACCOMPLISH DEEDS SURPASSING ALL OTHERS"
 - DUELING COMPUTERS-MY PC-GENERATED ANALYSIS CAN WHIP YOUR PC-GENERATED ANALYSIS
 - ABILITY TO COLLECT INFORMATION HAS OUTSTRIPPED OUR ABILITY TO PROCESS IT
- KEEP FROM BECOMING A "HAS BEEN"
- ANSWER YOUR 10 YEAR OLDS QUESTION ABOUT "GIGAFLIPS"

BLOCK DIAGRAM OF A COMPUTERS



- **HARDWARE INTERFACE**
- CRT/KEYBOARD
- **SOFTWARE INTERFACE**
- HIGHER LEVEL LANGUAGES

FIVE GENERATIONS OF COMPUTER TECHNOLOGY

GENERATION	TIME PERIOD	TECHNOLOGY	COMPUTERS
FIRST	1948-1956	VACUMN TUBE 2 KBYTE MEMORY	ENIAC IBM 659 UNIVAC
SECOND	1957-1963	TRANSISTORS 32 KBYTE MEMORY	NCR 501 IBM 7094 CDC 6600
THIRD	1970's	INTEGRATED CIRCUIT 2 MBYTE MEMORY 5 MIPS ²	DEC PDP-11 CRAY 1 CYBER 205 IBM 360/370
FOURTH	1980's	VLSI ² CIRCUIT 8 MBYTE MEMORY 30 MIPS ¹	CRAY XMP IBM 308 AMDAHL 580
FIFTH	1990's(?)	1 GIGA(BILLION) IPS or 1 TETRA(TRILLION)IPS ● VHSIC(VERY HIGH SPEED INTEGRATED CIRCUITS) ● PARALLEL ARCHITECTURE ● CONCURRENT LANGUAGES, FUNCTIONAL PROGRAMMING AND SYMBOLIC PROCESSING¹	

¹ MIPS-MILLION(OR MEGA) INSTRUCTIONS PER SECONDS

²VLSI-VERY LARGE SCALE INTEGRATION

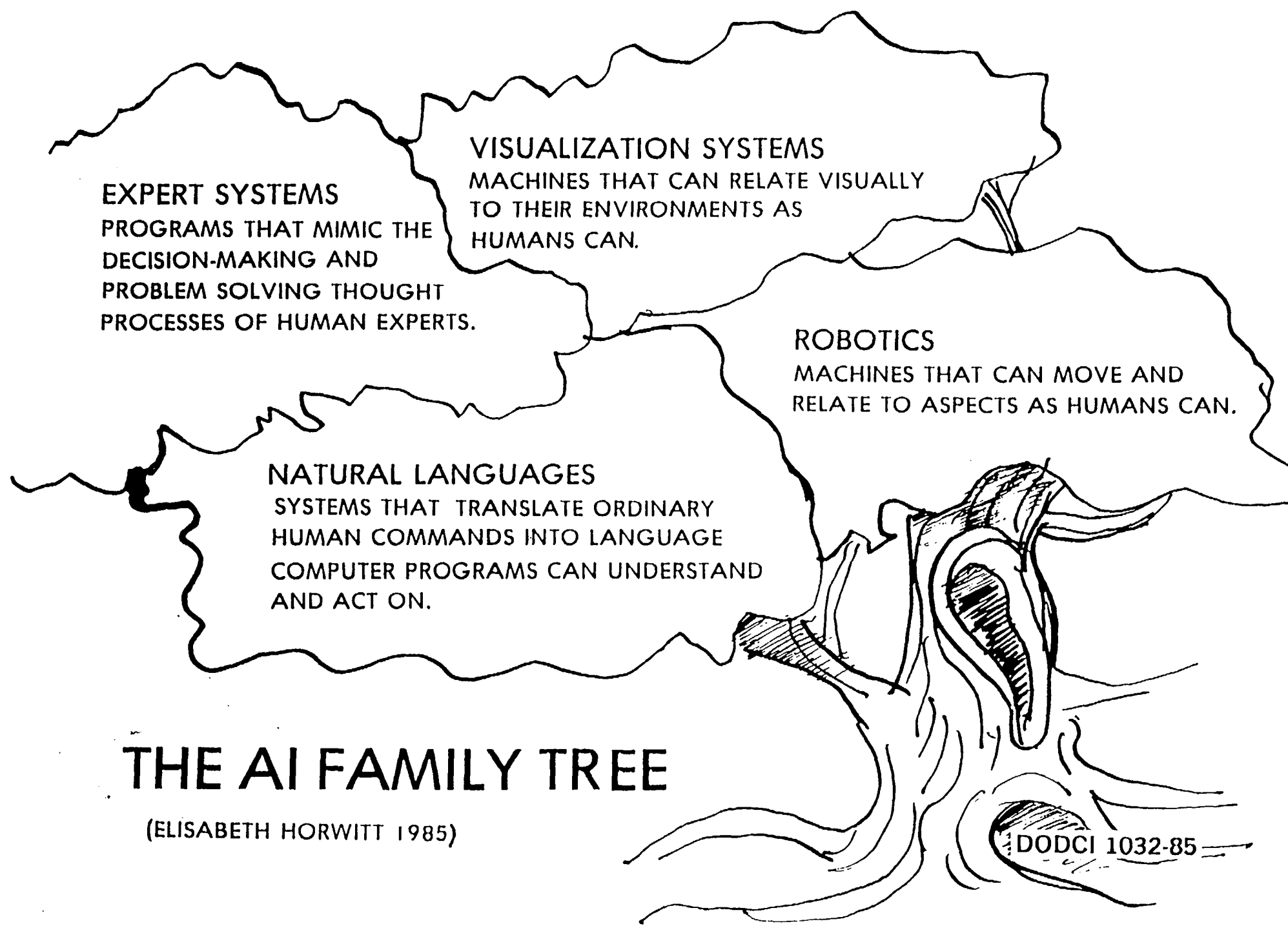
³SPEAK.SEE.PLAN AHEAD

DODCI 1030 85

ARTIFICIAL INTELLIGENCE. “A SUBFIELD OF COMPUTER SCIENCE CONCERNED WITH THE CONCEPTS AND METHODS OF SYMBOLIC INFERENCE BY A COMPUTER AND THE SYMBOLIC REPRESENTATION OF THE KNOWLEDGE TO BE USED IN MAKING INFERENCES. A FIELD AIMED AT PURSUING THE POSSIBILITY THAT A COMPUTER CAN BE MADE TO BEHAVE IN WAYS THAT HUMANS RECOGNIZE AS INTELLIGENT BEHAVIOR IN EACH OTHER”

(FEIGENBAUM and McCORDUCK)

DODCI 1031-85



EXPERT SYSTEMS

PROGRAMS THAT MIMIC THE
DECISION-MAKING AND
PROBLEM SOLVING THOUGHT
PROCESSES OF HUMAN EXPERTS.

VISUALIZATION SYSTEMS

MACHINES THAT CAN RELATE VISUALLY
TO THEIR ENVIRONMENTS AS
HUMANS CAN.

ROBOTICS

MACHINES THAT CAN MOVE AND
RELATE TO ASPECTS AS HUMANS CAN.

NATURAL LANGUAGES

SYSTEMS THAT TRANSLATE ORDINARY
HUMAN COMMANDS INTO LANGUAGE
COMPUTER PROGRAMS CAN UNDERSTAND
AND ACT ON.

THE AI FAMILY TREE

(ELISABETH HORWITT 1985)

DODCI 1032-85

HISTORY OF ARTIFICIAL INTELLIGENCE

PERIOD	KEY EVENTS
PRE—WORLD WAR II ROOTS	FORMAL LOGIC COGNITIVE PSYCHOLOGY
POSTWAR YEARS 1945-1954 PRE-AI	FIRST AI PAPERS
FORMATIVE YEARS 1955-1960 INITIATION OF AI RESEARCH	
YEARS OF DEVELOPMENT AND REDIRECTION 1961-1970 SEARCH FOR GENERAL PROBLEM SOLVERS	SMALL LABORATORY SYSTEMS FIRST PROTOTYPES EXPERT SYSTEM
YEARS OF SPECIALIZATION AND SUCCESS 1971-1980 THE DISCOVERY OF KNOWLEDGE-BASED SYSTEMS	WHOLE RANGE OF PROTOTYPE EXPERT SYSTEMS END OF DECADE-FIRST COMMERCIAL USES
THE RUSH TO APPLICATIONS 1981- INTERNATIONAL COMPETITION AND COMMERCIAL VENTURES	SEVERAL HUNDRED EXPERT SYSTEMS VENTURE CAPITAL HEAVILY INVESTED JAPANESE FIFTH GENERATION PROJECT

WHY AI NOW?

- TECHNOLOGY BECOMING AVAILABLE-LOWER COST/AWARENESS
- INCREASING COST OF HUMAN EXPERTS
- QUALITY IMPROVEMENTS ANTICIPATED-FEWER MISTAKES, MORE CONSTANT
- NEED-ESPECIALLY FOR MILITARY APPLICATIONS
- SHORTCOMINGS OF CONVENTIONAL PROGRAMMING TECHNIQUES (COMPATIBILITY WITH HUMAN PROBLEM SOLVING TECHNIQUES)
- MYSTIQUE -"SCIENCE MARCHES ON"
- SPIN-OFFS?

DODCI 1034-85

CURRENT APPLICATIONS OF AI

- **EQUIPMENT FAULT DIAGNOSIS**
- **INVESTMENT MANAGEMENT**
- **MILITARY TACTICS**
- **MEDICAL DIAGNOSIS**
- **CRISIS MANAGEMENT**
- **CLAIMS ASSESSMENT**
- **DISTRIBUTION PLANNING**
- **COMMODITY BROKER**
- **TECHNICAL TRANSLATION**
- **ENERGY MANAGEMENT**
- **VEHICLE SCHEDULING**
- **PROCESS PLANT MONITORING**

(TURNER 1985)

DODCI 1035-85

CURRENT APPLICATIONS IN AI

SOME EXPERT SYSTEMS

EXPERT SYSTEM	GENERAL FUNCTION	SPECIFIC AREA
MECHO	Analysis	Mechanical Problems
TECH	Analysis	Naval Task Force Threats
SPERIL	Analysis	Earthquake Damage Assessment
CRITTER	Analysis	Digital Circuitry
PHOENIX	Automatic Programming	Oil Well Log Modeling
PROSPECTOR	Data Analysis	Geology
DENDRAL	Data Analysis	Chemistry
CRYSLIS	Data Analysis	Protein Crystallography
ELAS	Data Analysis	Oil Well Logs
SYN	Design	Circuitry Synthesis
XCON/R1	Design	Computer System Configuration
SYNCHEM	Design	Chemical Synthesis
MEDAS	Diagnosis	Critical Care Medicine
DELTA	Diagnosis	Locomotive Troubleshooting
MYCIN	Diagnosis	Medical
DART	Diagnosis	Computer Faults
REACTOR	Diagnosis	Nuclear Reactor Accidents
INTERNIST/CADUCEUS	Diagnosis	Medical
XSEL	Intelligent Assistance	Computer Sales
CSA	Intelligent Assistance	Nuclear Power Plant Configuration
RAYDEX	Intelligence Assistance	Radiology
VISIONS	Image Understanding	Vision
IMS	Management	Automated Factory Management
CALISTO	Management	Project Management
NOAH	Planning	Robotics
OP-PLANNER	Planning	Erand planning
KNOBS	Planning	Tactical Mission Planning
MOLGEN	Planning	Molecular Genetics

CURRENT APPLICATIONS IN AI

Continued

SOME NATURAL LANGUAGE SYSTEMS

NATURAL LANGUAGE SYSTEM	GENERAL FUNCTION	SPECIFIC AREA
LADDER	Machine Translation/ Interfacing	Ship Identification & Location
SAM	Machine Translation/ Interfacing	Generic Story Understanding
TDUS	Interfacing	Electromechanical Repair
SHRDLU	Interfacing	Location & Manipulation of Three Dimensional Figures
EXPLORER	Interfacing	Map Generation & Display
INTELLECT	Interfacing	Data Base Management
NATURALLINK	Interfacing	Dow Jones Data Retrieval & Display
TEAMS	Generic Interfacing	Data Base Management
MARKETEER	Interfacing	Market Analysis
POLITICS	Inference Making	Ideological Belief System Simulation
BROKER	Interfacing	Standard & Poor's Data Base Management System
STRAIGHT TALK	Interfacing	Word Processing/ Microcomputer Workstations

POTENTIAL APPLICATION OF AI

- OFFICE AUTOMATION
- BANKING AND FINANCE
- INDUSTRY
- DEFENSE
- GOVERNMENT
- EDUCATION and TRAINING

(Mike Turner, 1985)

DODCI 1036-85

THE HURDLES TO BE OVERCOME

- LACK OF PROCESSING POWER IN EXISTING COMPUTERS (VHSIC, PARALLEL PROCESSING?)
- "KNOWLEDGE-REPRESENTATION" LANGUAGE (LISP, PROLOG?)
- INTERFACE (NATURAL LANGUAGE INTERFACE, KNOWLEDGE ENGINEERING?)
- EXPERTS UNWILLING TO IMPART THEIR EXPERTISE

DAVID HARVEY 1984

DODCI 1037-85

Computer Aided Decision Making

Data-based System

- Data Base Management System (DBMS)
- Management Information System (MIS)
- Decision Support System (DSS)

Knowledge-based System

- Natural Language System
- Expert System

... BY ANY OTHER NAME ...

- **Knowledge-based Expert System**
- **Rule-based System (RBS)**
- **Intelligent Knowledge-based System**
- **Pattern-directed Inference System**
- **Production System**
- **Blackboard System**

(Mike Turner, 1985)

GOALS OF EXPERT SYSTEM

- **Substitute for unavailable human expert**
- **Assimilate knowledge of multiple human experts**
- **Train new experts**

(Paul Harmon, David King 1985)

Common Properties/Characteristics/ Features of Expert Systems

- **Properties:**

- **Incorporate human knowledge in conditional If-Then rules**
- **Skill increases at a rate proportional to enlargement of knowledge base**
- **Can solve wide range of complex problems by selecting relevant rules and combining results in appropriate ways**
- **They adaptively determine best sequence of rule execution**
- **Can explain conclusion by retracing lines of reasoning in natural language**

Common Properties/Characteristics/ Features of Expert Systems (Cont.)

- **Characteristics:**

- Existing knowledge can be refined and new knowledge added (For incremental improvements in system performance)
- System able to explain reasoning (Making their logic practically transparent)

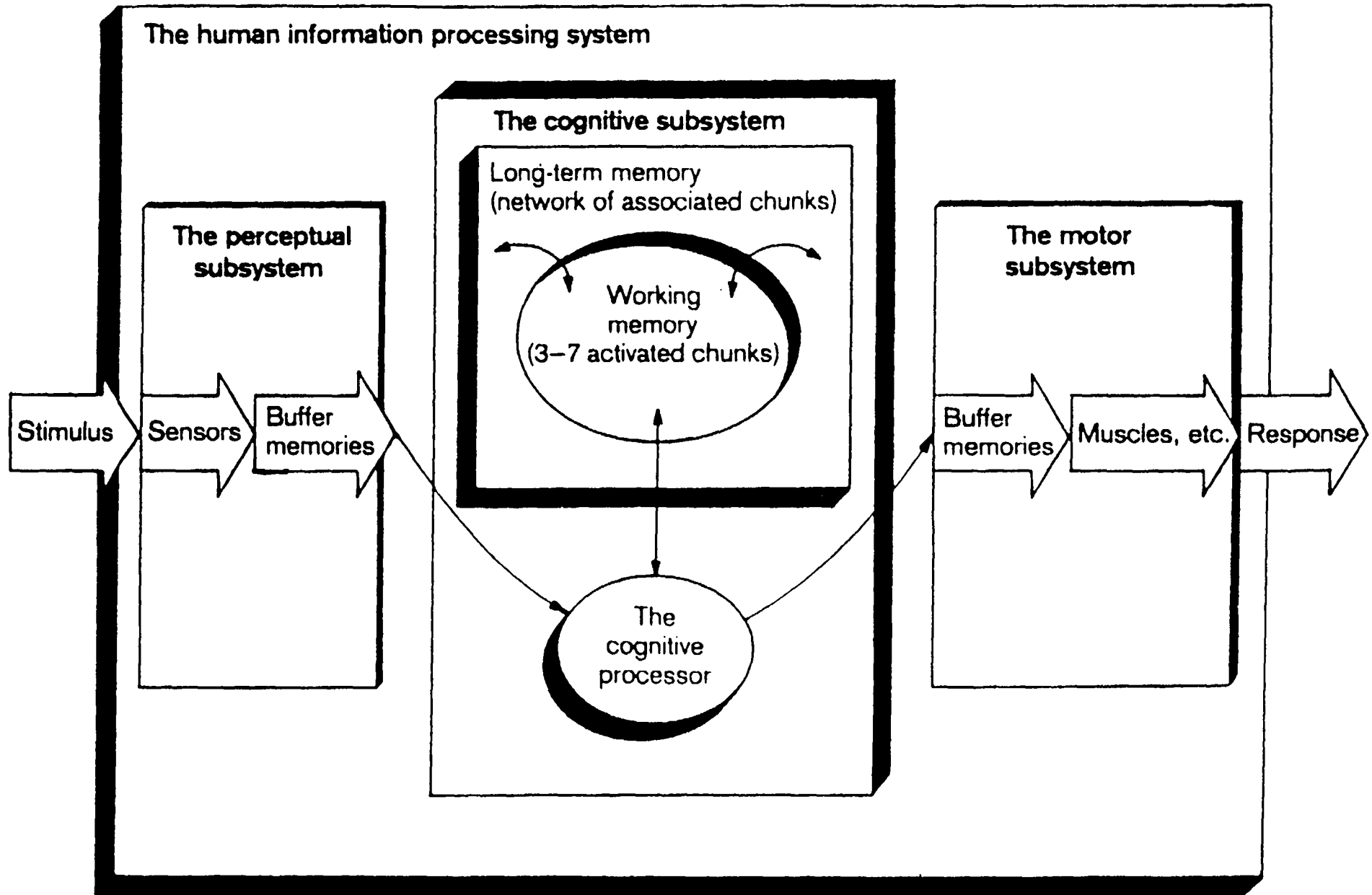
Common Properties/Characteristics/ Features of Expert Systems (Cont.)

- **Features :**
 - **Modular know-how**
 - **Knowledge base for storing rules/facts that determine decision**
 - **Capacity for incremental development with steady performance improvements**
 - **Explanation of results, lines of reasoning, and questions asked**
 - **Intelligibly encoded beliefs and problem-solving techniques**
 - **Inference chains assembled dynamically by built-in control procedures that can often perform efficient searches**

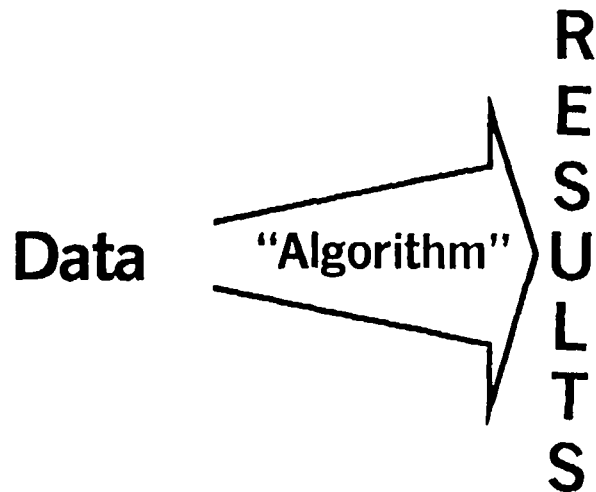
(Frederick Hayes-Roth 1985)

An overview of the human information processing system.

The environment

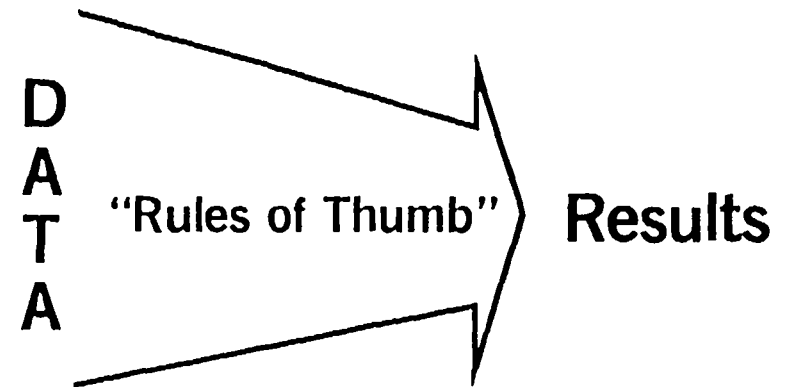


DIVERGENT VS CONVERGENT REASONING



Divergent Reasoning

- Small amount of data → Lots of results
- "Von Nuemann" Computer
- Example = Payroll Program



Convergent Reasoning

- Massive amount of data → Few results
- Parallel processing computer
- Example = A woman mulls a lifetime of romantic experience before answering her suitor's marriage proposal with a simple "yes".

DEFINITION OF EXPERTISE

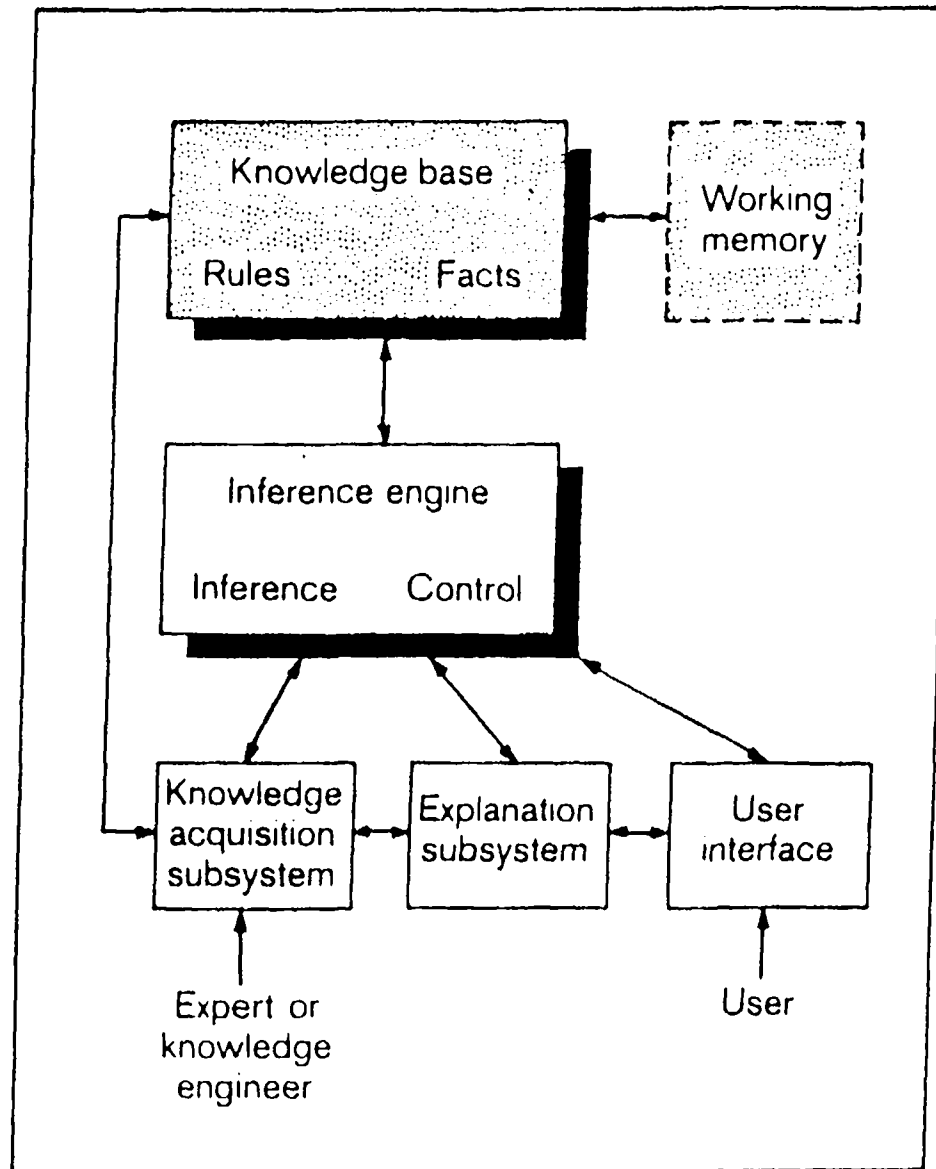
Human experts are:

- Problem solvers
- Explainers of results
- Learners from experience
- Knowledge structurers
- Rule seekers (if necessary)
- Relevance deciders
- Less motivated as knowledge runs out

(David Harvey, Mar. 84)

DODCI 1047-85

The architecture of a knowledge-based expert system.
(The knowledge base is shaded for emphasis.)



DODCI 1048-85

KINDS OF INFORMATION IN KNOWLEDGE-BASE

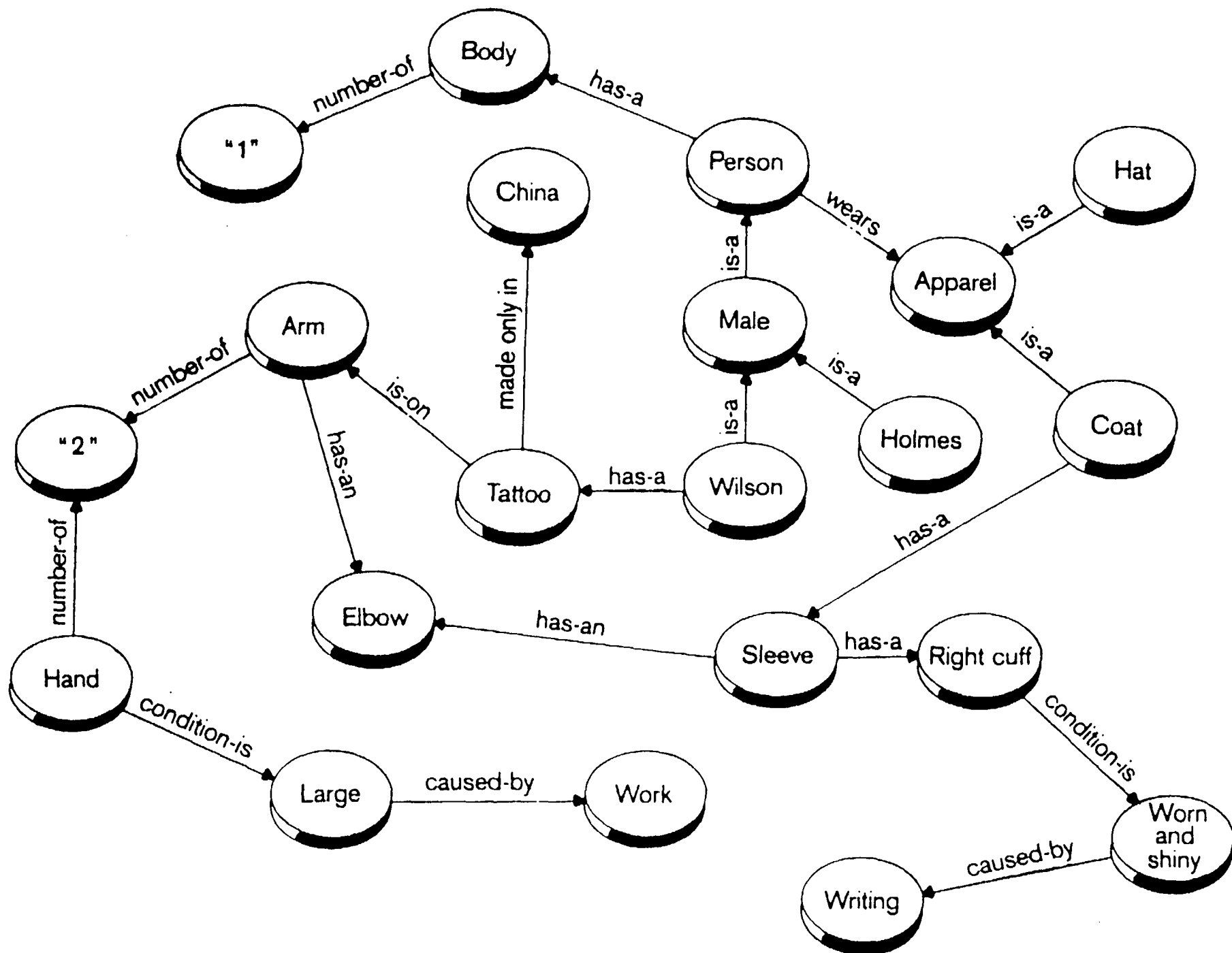
- Specific inferences that follow from specific observation
- Abstractions, Generalizations, and Categorizations of given data
- Necessary and sufficient conditions for achieving some goal
- Likeliest places to look for relevant information
- Preferred strategies for eliminating uncertainty or minimizing other risks
- Likely consequences of hypothetical situation
- Probable causes of symptoms

(Frederick Hayes-Roth 1985)

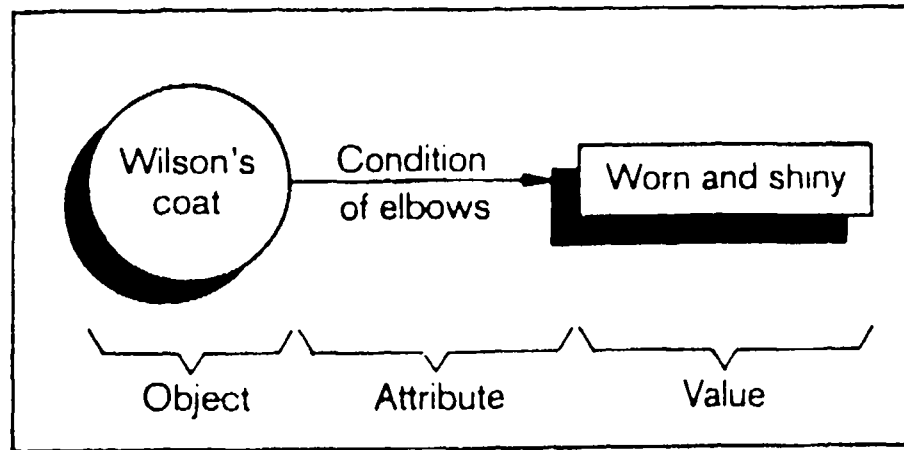
STRATEGIES FOR REPRESENTING KNOWLEDGE

- Semantic Networks
- Object-Attribute-Value-Triplet
- Rules
- Frames
- Logical Expression

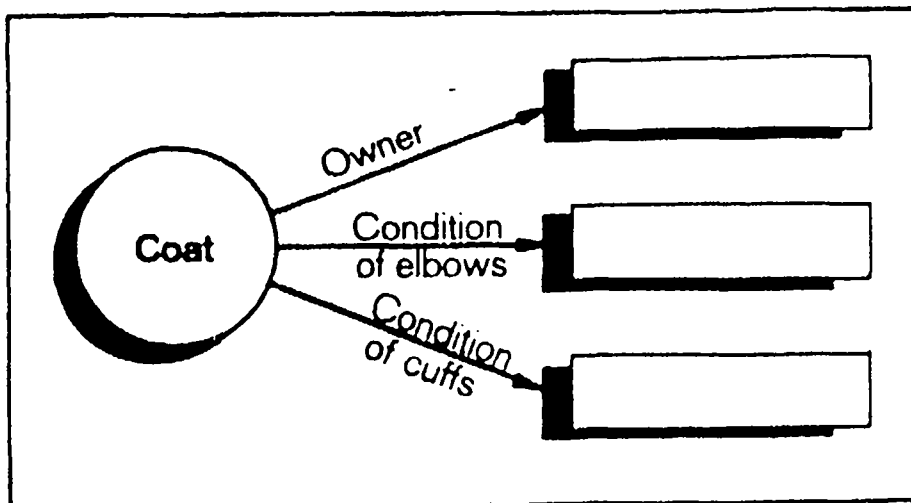
SEMANTIC NETWORK



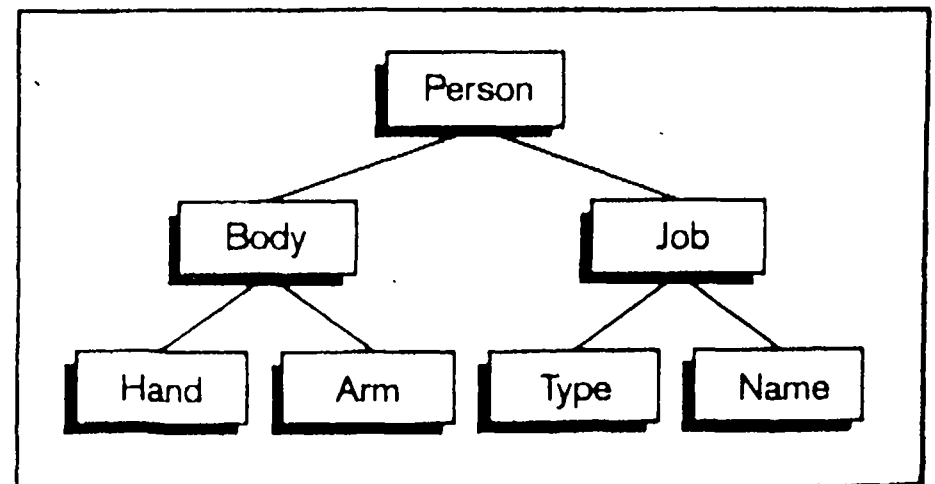
An object-attribute-value triplet.



The static portion of an O-A-V triplet.



Object tree for a detective's knowledge base. (No values have been assigned to any objects or attributes.)



Rule:

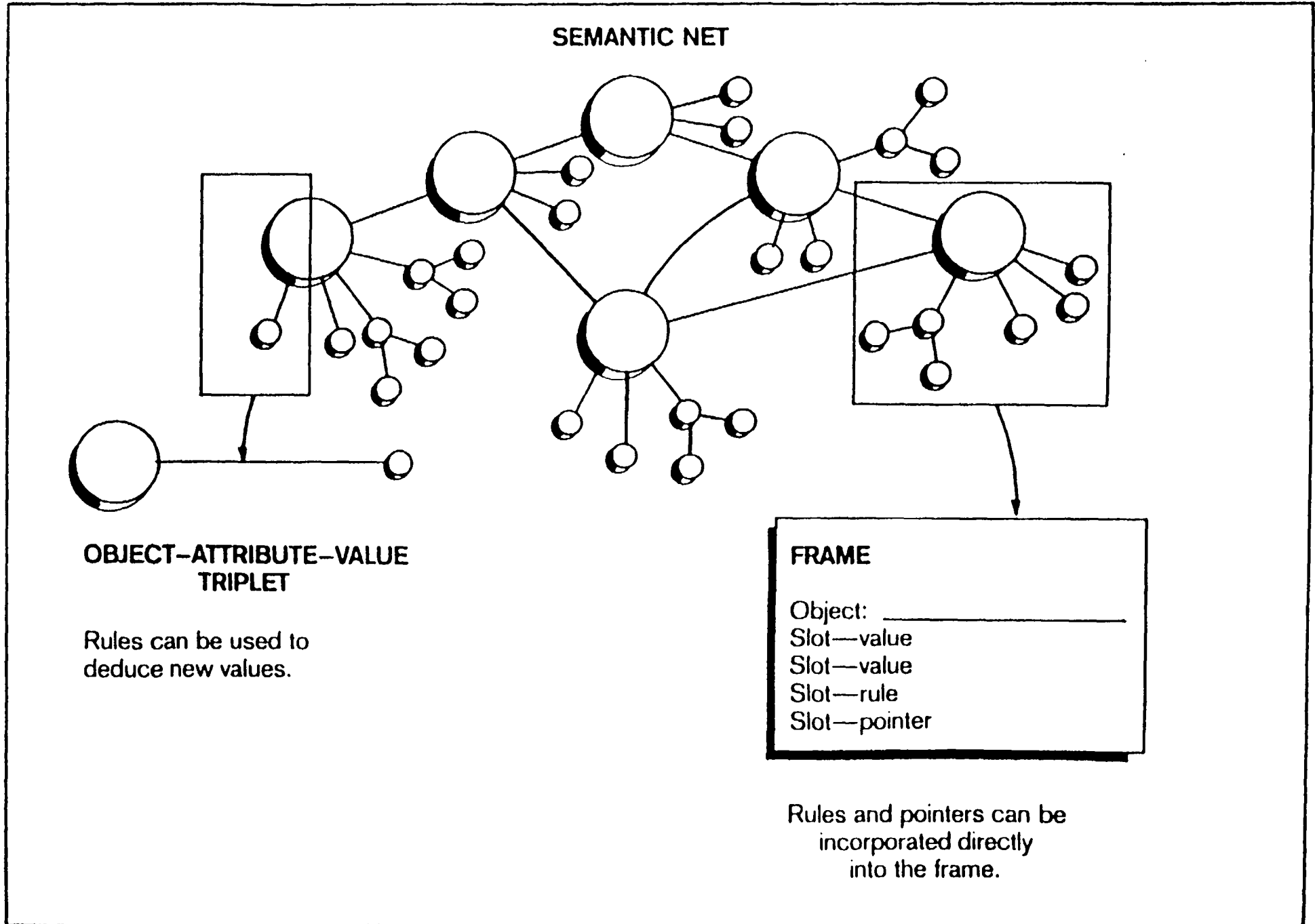
Premise { If the site of the culture is blood, and
the morphology of the organism is rod, and
the gram stain of the organism is gramneg, and
the patient is a compromised host,

Conclusion { Then there is suggestive evidence (.6) that the identity
of the organism is Pseudomonas-aeruginosa.

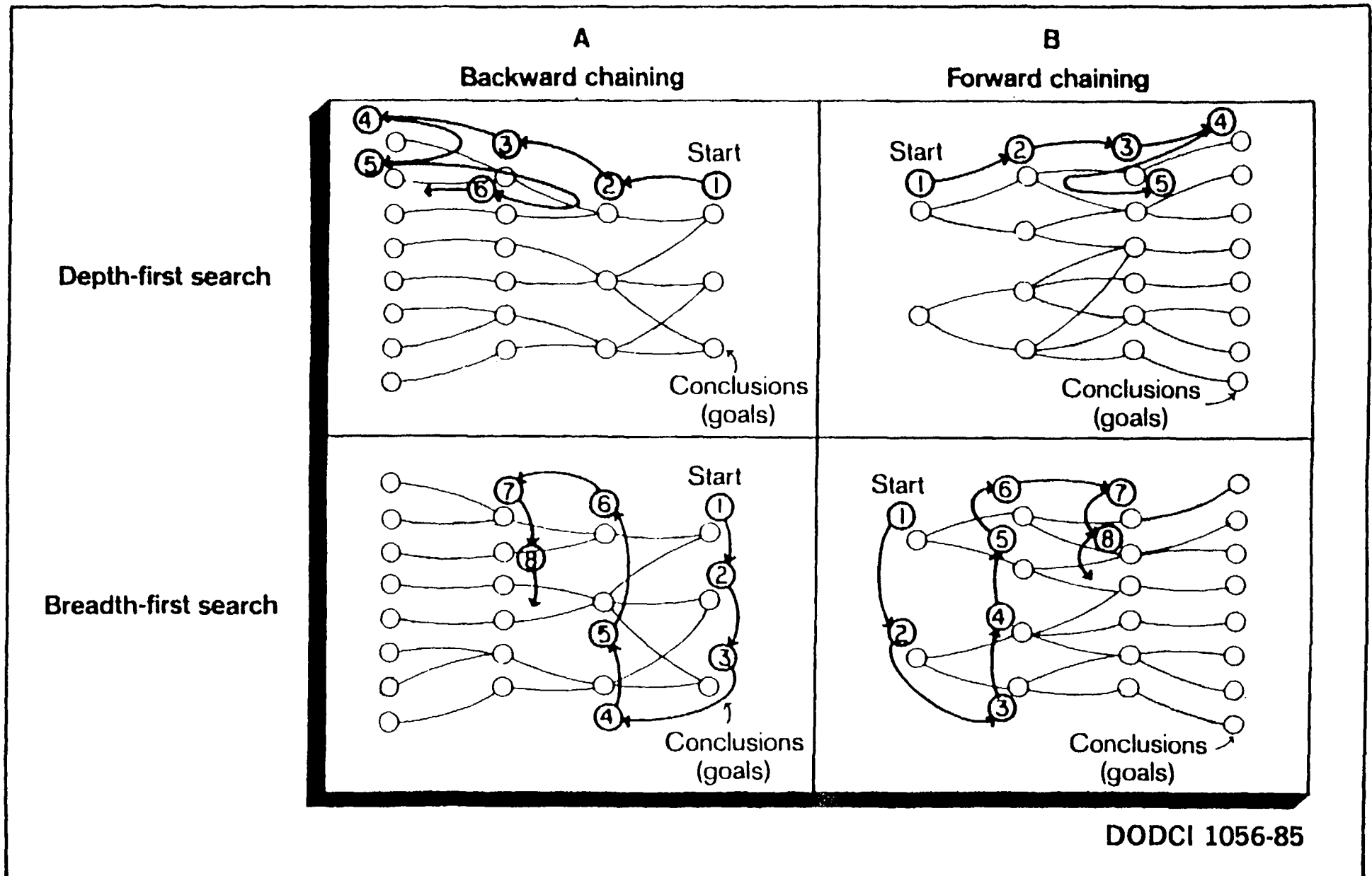
Frame for Wilson's coat.

COAT	
Slots:	Entries:
Owner	Wilson
Condition	Rumpled
Condition of cuffs	Worn, shiny
Condition of elbow	Worn, shiny
Number of arms	Default: 2
Fabric	Default: wool
Pockets?	Default: yes
Size:	If needed, find owner's height and weight, and compare to Table X.
Style:	If needed, find out collar:, pockets:, and length:; then look in Table Y.

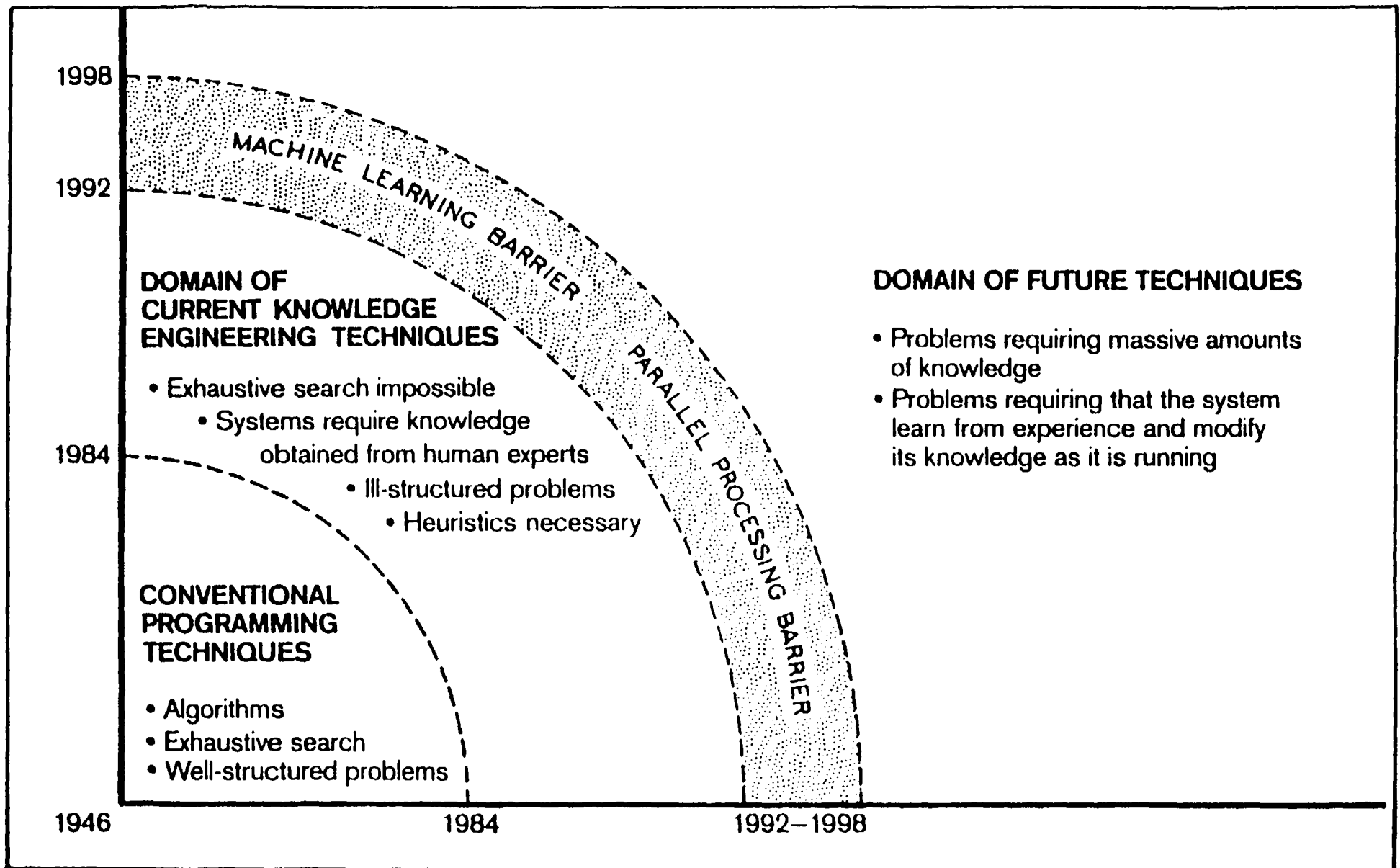
Semantic nets, object-attribute-value triplets and frames.



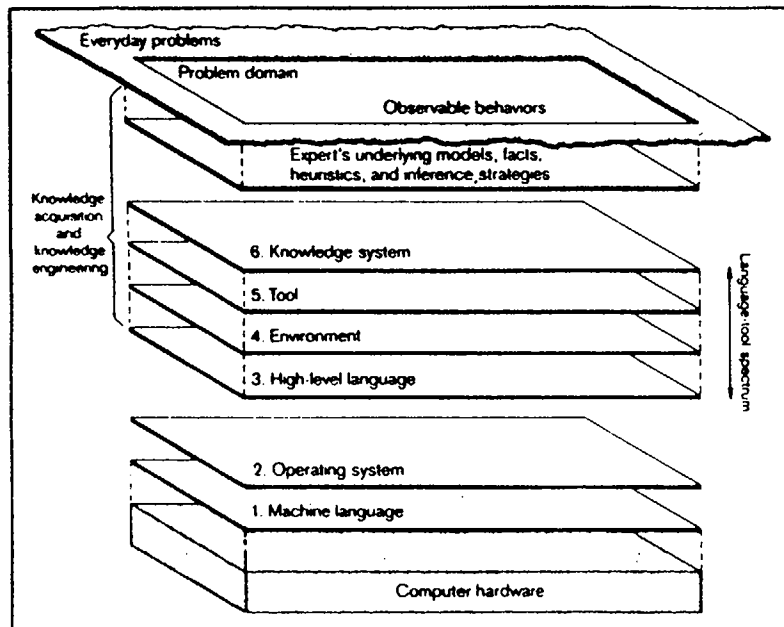
Major categories of search strategies used by inference engines.



Problem domain of existing knowledge engineering techniques.

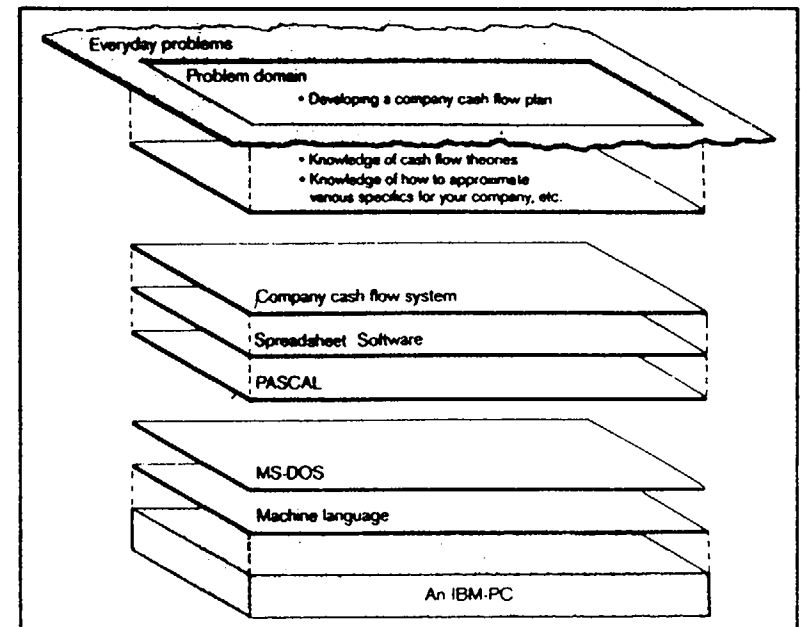


The six levels of software between human problems and computer hardware.



Knowledge-Based System

The levels of software between a company cash flow problem and a personal computer.



Data-Base System

TOOLS FOR BUILDING EXPERT SYSTEMS

- **Knowledge acquisition products**
- **Expert system shells (or tools)**
- **AI Languages and programming environments**

(Mike Turner 1981)

DODCI 1059-86

ADVANTAGES OF EXPERT SYSTEM TOOL OR SHELLS

- **Rapid System Development**
- **Lower Development Cost**
- **Contain specific techniques for**
 - **Handling knowledge representations**
 - **Inference**
 - **Control**
- **Help knowledge engineer to model particular class of problems**
- **Makes Expert System techniques available to less experienced users for small problems**

(Paul Harmon, David Key 1985)

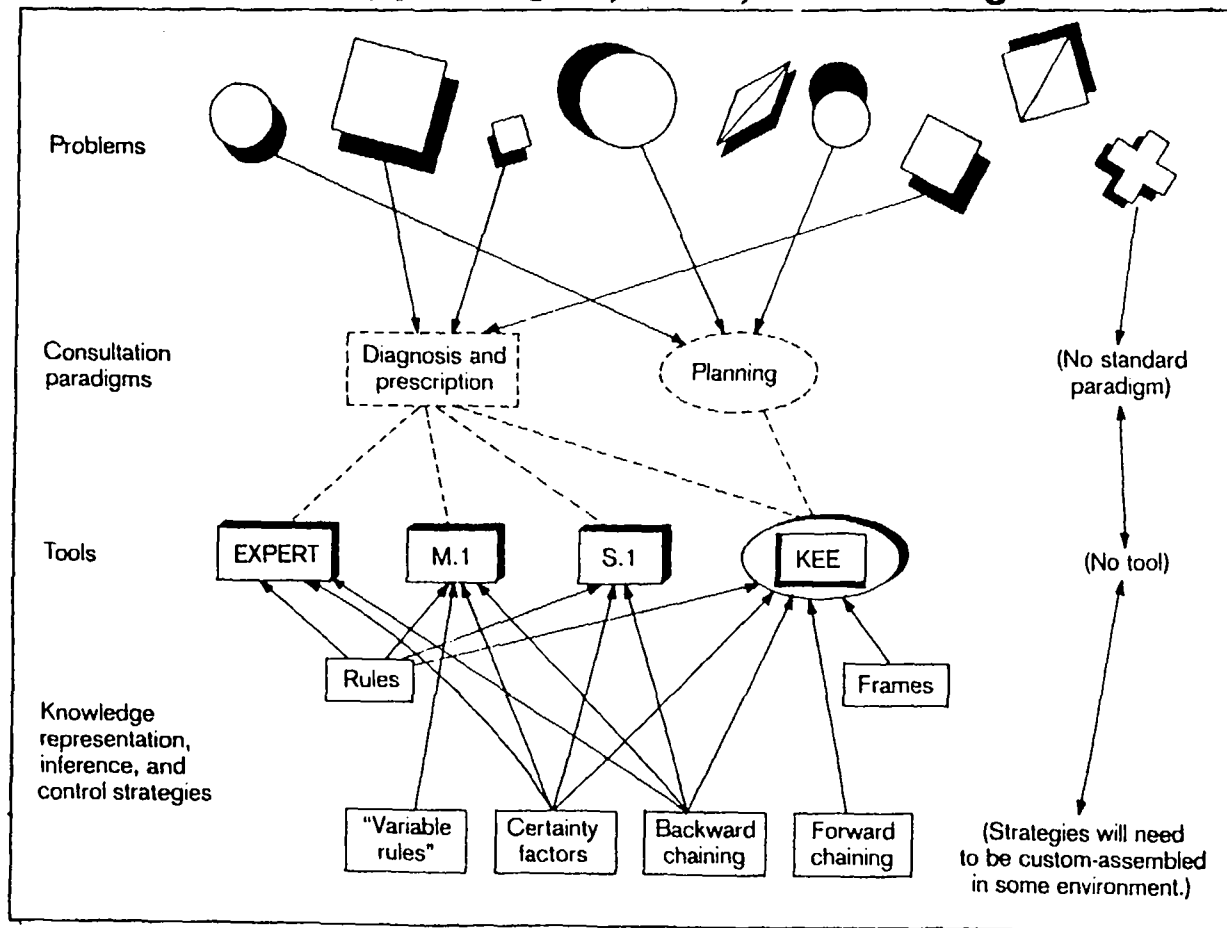
Consultation Paradigms Typical of Various Tools

Environment or Tool	Consultation Paradigm*		
	Diagnosis/ Prescription	Planning	Design
EMYCIN	●		
ES/P ADVISOR	●		
Expert-Ease	●		
INSIGHT	●		
M.1	●		
Personal Consultant	●		
EXPERT	●		
KES	●		
OPS5	●	●	
S.1	●		
TIMM	●		
ART	●		
KEE	●	●	
LOOPS	●		

● Filled circle indicates that the tool is good at the consultation.

DODCI 1061-86

Problems, paradigms, tools, and strategies.



DODCI 1062-86

SUITABILITY OF EXPERT SYSTEM TECHNIQUES

Positive Indicators

- **Not obviously doable using conventional techniques**
- **Maintenance and updating to be done by non-computer staff**
- **Explanation of conclusions required**
- **System's knowledge to be used in more than one way**
- **Knowledge maps more easily onto rules than equations**

Negative Indicators

- **Knowledge more available in algorithmic form**
- **Problem-solving methods can be completely specified in advance of implementation**
- **Problem adequately and efficiently solved using conventional techniques**

EXPERT SYSTEMS CAN. . .

Benefit

- Free experts for hard problems
- Provide surrogate experts
- Ensure Methodological/Exhaustive evaluation
- Explain particular conclusions
- Provide interface to complex systems
- Provide competitive edge

Examples

Processing tax returns

Equipment fault Diagnosis
Social Security Entitlements

Medical Diagnosis
Crisis handling

Any advising, predicting, planning
Diagnosing System

Battle management
Three Mile Island
DBMS

EXPERT SYSTEMS CAN. . .

Continued

Benefit

- Make expertise explicit
- Reduce equipment cost
- Provide breadth of expertise
- Facilitate user Maintenance/Upkeep
- Disseminate knowledge
- Continuous concentration
- Eliminate individual bias/prejudice
- Teach

Examples

Knowledge/Rare skills archiving

Robotics

Combine knowledge of several experts

Equipment monitoring

Application of regulations

“Steamer”

APPLICATION CONSTRAINTS

- **The source of the expertise
(usually a human expert)**
- **The problem characteristics**
- **The state of the available technology**

(Mike Turner 1985)

DODCI 1066-86

CRITICAL ASPECTS OF A PROBLEM

- **The reliability of the data and knowledge**
- **Time dependency of data**
- **The size of the search space**

(Mike Turner 1985)

DODCI 1067-86

BUILDING A SMALL EXPERT SYSTEM

- **Select a tool**
- **Identify the problem/analyze the knowledge**
- **Design the system**
- **Develop a prototype and test**
- **Expand test and revise system**
- **Maintain and update the system**

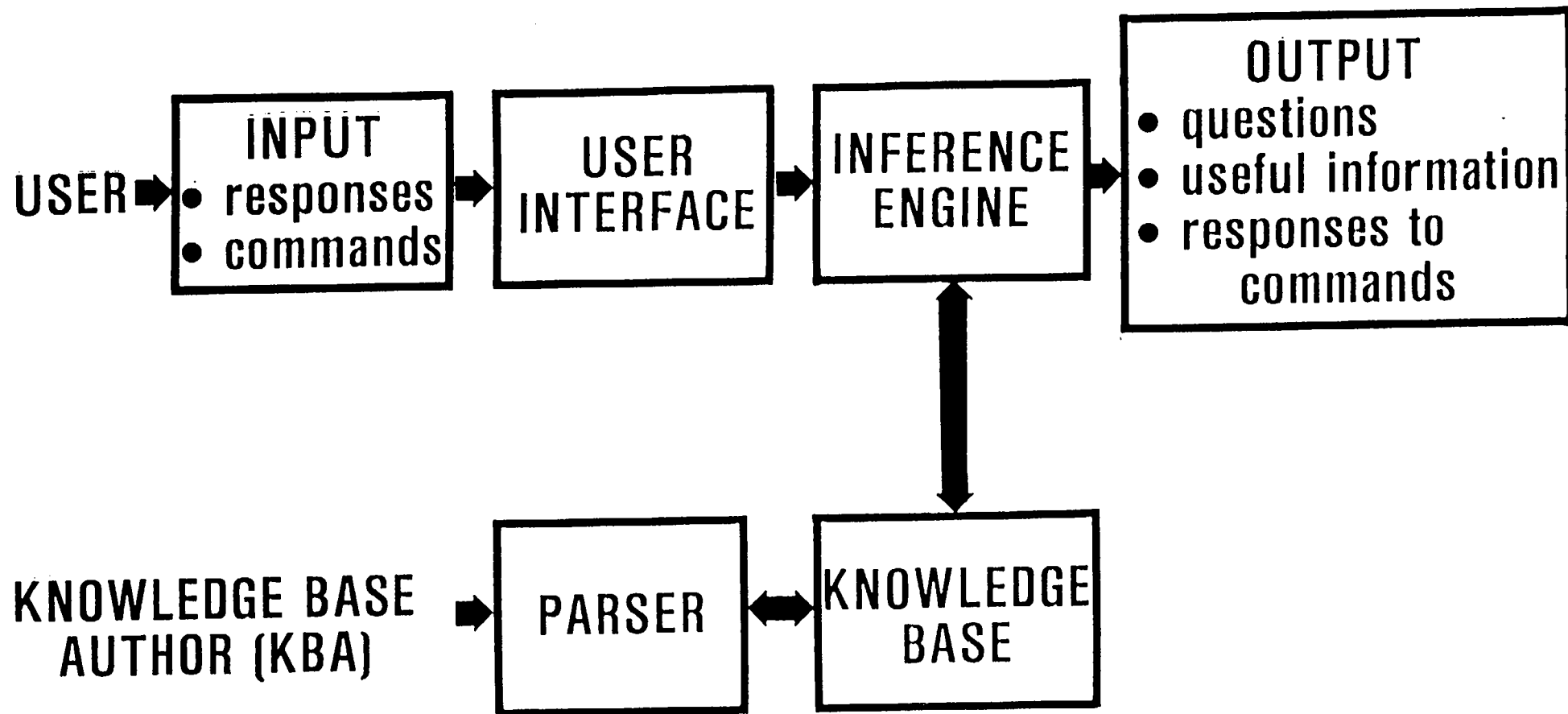
(Paul Harmon, David King 1985)

DODCI 1068-86

OVERVIEW OF DEVELOPMENT OF XCON

<u>STAGE</u>	<u>PERIOD</u>	<u>ACTIVITY</u>
1-Design/Prototype	Dec 78 - Apr 79	•Strategy for attacking problem developed •250 rule prototype developed
2-Development	May - Sep 79	•Build knowledge BASE (750 Rules) •Goal = Configure 75% of orders correctly
3-Validation	Oct - Nov 79	•XCON/Human performance comparisons (50 orders configured by XCON & 6 experts) •Mistakes (12) corrected
4-Implementation Planning	Jan - May 80	•Plans to integrate into DEC •Reimplemented XCON in OPS5
5-Implementation	Jun - Dec 80	•Integration plan implemented •Continued to improve knowledge base
6-Maintenance & Extension	Jun 81 - Present	•Use & maintenance of system

AN EXPERT SYSTEM



HALLMARKS OF AN EXPERT SYSTEM

- **RELIABILITY** —producing accurate and complete advice
- **INTELLIGENT QUESTIONING**
- **EXPLAINING AND JUSTIFYING ANY CONCLUSIONS OR
ADVICE**
- **REASONING WITH WORDS, NOT JUST NUMBERS**
- **USER FRIENDLINESS**

HOW ATTACHMENTS WORK

What is your file's extension?
[display definition(file extension)]

- 1) BAS
- 2) TXT
- 3) COM
- 4) THE FILE HAS NO EXTENSION
- 5) OTHER

= ? display definition(file extension)
DEFERRING CURRENT QUESTION [Type CONTINUE to resume question]
A file's extension consists of the characters to the RIGHT of the period in a file name. If your file name is statecap.bas then bas is the extension. If it is wordproc.com then the extension is com.

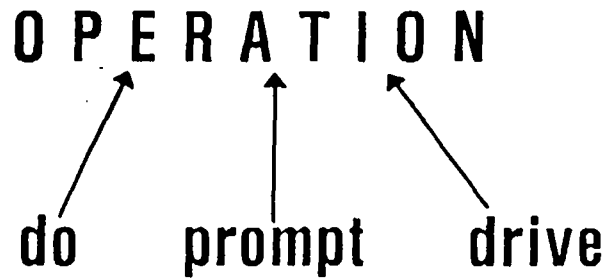
MOST SUITABLE APPLICATION

- TOPICS WHICH REQUIRE SPECIALIZED KNOWLEDGE
- SMALL, IMPORTANT TASK
- ORGANIZED SOURCE MATERIAL
- TESTABLE

DESIGN STEPS

- ANALYSIS
- DESIGN
- IMPLEMENTATION
- VERIFICATION

ATTRIBUTE HIERARCHY FOR DEMO1



Inferred Attribute
(value computed by
expert system)

Input Attributes
(values supplied by the user)

ACTION FLOW CHART FOR DEMO1

FLOWCHART

Obtain the Value of the inferred
Attribute, operation.

Display the Message: "The operation
or operations you need to do are:"

Display the Value of the Inferred
Attribute, operation.

MEANING

The OBTAIN command tells the inference engine to determine the value of the attribute with the name, operation. It does this by sending questions to the screen for the user to answer based on the rules.

The MESSAGE command sends the text of a message to the screen for viewing by the user.

The DISPLAY command retrieves the value of the attribute that the inference engine has determined and sends it to the screen for viewing.

NONNUMERIC ATTRIBUTE SYNTAX & EXAMPLE

SYNTAX:

attribute name
[attachments: "attachment text"]
[smlt]: value-1, value-2, value-n.

EXAMPLE:

attributes:

ATTRIBUTE TYPES
(smlt): nonnumeric, integer.
...%

user session for this attribute would be:

ATTRIBUTE TYPES
1)NONNUMERIC
2)INTEGER
=?

ATTRIBUTE SECTION OF DEMO1

attributes:

do

(smlt):

change default drive,
other.

◆ Keyword

◆ Attribute name

◆ Attribute value type

◆ Attribute values

prompt

(smlt):

a,
b.

◆ Attribute name

◆ Attribute value type

◆ Attribute values

drive

(smlt):

a,
b.

◆ Attribute name

◆ Attribute value type

◆ Attribute values

operation

(smlt):

cannot perform that now,
type a colon and hit enter key,
type b colon and hit enter key,
the default drive is ok so do not do anything

◆ Attribute name

◆ Attribute value type

◆ Attribute values

ILLEGAL KEYWORDS AND CHARACTERS FOR MICRO-PS

MICROPS Keywords that cannot be used in names.

endif
from
if
then
thru
to

Characters that cannot be used in names.

\ {} \$ @ # % * () ! - . ? / : ; ^ & = + < > = ~ ^ \

RATIONAL INDICATORS & CONNECTORS

RATIONAL INDICATOR

=	equal
#	does not equal
ge	greater than or equal to
gt	greater than
le	less than or equal to
lt	less than

CONNECTORS

&(ampersand)	LOGICAL AND
/(backslash)	LOGICAL OR
,(comma)	CONNECTOR

RULE SYNTAX & EXAMPLE

SYNTAX:

(Rule Name)		-NAME
if (attribute name) (rational indicator) value 1,	}	-Antecedent
(connector) (attribute name) (rational indicator) value 2,		
... value n,		
then (attribute name) (rational indicator) value a,	}	-Consequent
(connector) (attribute name) (rational indicator) value b,		
... value z.		

EXAMPLE:

Consequent Location Status Rule
if Consequent Location = After Last Antecedent,
then Consequent Location Status = Proper.

Consequent Thenn Status Rule
if Consequent Thenn = Missing,
/ Consequent Thenn = Misspelled,
then Consequent Thenn Status = Improper,
& MICRO-PS response = Error Message.

DEMO1's KNOWLEDGE BASE

attributes:

do

{smlt):
change default drive,
other

prompt

{smlt):
a.
b.

drive

{smlt):
a.
b.

operation

{smlt):
cannot perform that now,
type a colon and hit enter key.
type b colon and hit enter key.
the default drive is ok so do not do anything

%

rules:

r1

if do = change default drive.
& prompt = a.
& drive = b.
then operation = type b colon and hit enter key.

r2

if do = change default drive.
& prompt = b.
& drive = a.
then operation = type a colon and hit enter key.

r3

if do = change default drive
& prompt = a.
& drive = a.
then operation = the default drive is ok so do not do anything.

r4

if do = change default drive.
& prompt = b.
& drive = b.
then operation = the default drive is ok so do not do anything.

r5

if do = other,
then operation = cannot perform that now

%

actions:

obtain operation.

message "the operation or operations you need to do are:"
display value (operation)

%

COMMAND SYNTAX & EXAMPLES

OBTAIN

SYNTAX: obtain (attribute name)

MESSAGE

SYNTAX: message "{(text of the message)}"
 "{(text of the message)}".

DISPLAY

SYNTAX: display value [(attribute name)]

EXAMPLE: actions:
 obtain operation.
 message "The operation or operations you"
 "need to do are:"

 display value (operation)
 %

QUESTION ATTACHMENT

Syntax & Example

SYNTAX:

```

<Attribute Name>
[question: "<text of question>"
"<text of question?>"]
(smlt):
value 1
[question: "<text>"],
value 2
[question: "<text>"], ...
.
.
.
value n
[question: "<text>"].
    
```

```

-attribute name
-attachment

-attribute type
-attribute value
-attachment
.
.
.
    
```

EXAMPLE:

```

prompt
[question: "Which prompt is on your CRT(screen)?"]
(smlt):
    a
      [question: "A>"],
    b
      [question: "B>"].
    
```

```

      name
  ◆ Question attachment

      ◆ Attribute value
  ◆ Question attachment
      ◆ Attribute value
  ◆ Question attachment
    
```

User session for these attachments would be:

Which prompt is on your CRT(screen)?

1(A>

2) B>

= ?

DECLARED ATTACHMENTS

SYNTAX & EXAMPLES

SYNTAX:

attachment:	Name 1	Name 2	...Name n	-Attachment Section
%				
{(attachment name):	"(text of message)"			-Attachment
"(text of message)"				

EXAMPLE:

```
attachments: explain reference rationale
%

attributes:

USER FRIENDLY FEATURES
[question: "Have you included an explanation of how the user"
" gains access to attachments in the actions section?"
"(display reference rationale(USER FRIENDLY FEATURES)))]

[reference: "Nagy,Gault,Nagy: Building Your First Expert"
"System"]

[rationale: "Expert systems should be user friendly and"
"attachments are user friendly features of MICRO-PS."]

(smlt): yes, no.

USER FRIENDLY FEATURES STATUS
(smlt): present, absent
%

rules:

FRIENDLY FEATURES PRESENT
IF USER FRIENDLY FEATURES = yes,
then USER FRIENDLY FEATURES STATUS = present.

FRIENDLY FEATURES ABSENT
IF USER FRIENDLY FEATURES = no,
then USER FRIENDLY FEATURES STATUS = absent
%

actions:

message "Online help is available for questions with this feature:"
"{(display reference (USER FRIENDLY FEATURES)) For example, type:"
"display reference(USER FRIENDLY FEATURES) when you are prompted"
"to answer a question."

obtain USER FRIENDLY FEATURES STATUS.

pause %
```

DECLARED ATTACHMENTS

Syntax & Examples (continued)

User session for this portion of actions would be:

Executing the knowledge base. . .

Online help is available for questions with this feature:

{display reference (USER FRIENDLY FEATURES)} For example, type:
display reference(USER FRIENDLY FEATURES) when you are prompted to answer
a question.

Have you included an explanation of how the user gains access to attachments in the actions
section?

{display reference rationale(USER FRIENDLY FEATURES)}

1) YES

2) NO

= ? display reference(USER FRIENDLY FEATURES)

DEFERRING CURRENT QUESTION [Type CONTINUE to resume question]

Nagy,Gault,Nagy: Building Your First Expert System

DEFERRING CURRENT QUESTION [Type CONTINUE to resume question]

ready for command: display rationale(USER FRIENDLY FEATURES)

Expert systems should be user friendly and attachments are user friendly features of
MICRO-PS.

DEFERRING CURRENT QUESTION [Type CONTINUE to resume question]

ready for command: CONTINUE

Have you included an explanation of how the user gains access to attachments in the actions
section?

{display reference rationale(USER FRIENDLY FEATURES)}

1) YES

2) NO

EXAMPLE OF ERROR DETECTION

DO
1)CHANGE DEFAULT DRIVE
2)OTHER
= ? 3
Execution error:
illegal selection-try again

DO
1)CHANGE DEFAULT DRIVE
2)OTHER
= ?

MESSAGE COMMAND

Syntax & Example

SYNTAX:

```
message "<text of message>"  
"<text of message>".
```

EXAMPLE:

actions:

```
message " "  
"          WELCOME TO THE PC"  
"          FILE OPERATIONS EXPERT SYSTEM".  
message "This expert system will assist you in determining if"  
"you need to change the default disk drive. It will prompt you"  
"for answers which you should enter by typing in the number and"  
"a carriage RETURN. For example, 2{<--'}. [{<--'} is RETURN.]".
```

User session for this Message Command would be:

```
          WELCOME TO THE PC  
          FILE OPERATIONS EXPERT SYSTEM
```

This expert system will assist you in determining if you need to change the default disk drive. It will prompt you for answers which you should enter by typing in the number and a carriage RETURN. For example, 2{<--'}. [{<--'} is RETURN.]

ASKFOR Command

Syntax & Example

SYNTAX:

askfor (attribute name).

EXAMPLE:

attributes:

MAIN MENU

[question: "Which section would you like to work on first?"
"Please enter only one value."]

(smlt):

Attachment section,
Attribute section,
Rule section,
Action section.

...%

rules:

...%

actions:

askfor MAIN MENU.

...%

User session for this portion of actions would be:

Which section would you like to work on first? Please enter only one value.

(1) ATTACHMENT SECTION

(2) ATTRIBUTE SECTION

(3) RULE SECTION

(4) ACTION SECTION

= ?

Justify Command

Syntax & Example

SYNTAX:

justify (variable name)

EXAMPLE

attribute:

```
...  
do now  
  [question "What do you want to do now?"]  
  (smlt):  
  justify [question: "Justify the steps the expert"  
    "system recommend?"]  
  again [ ...
```

actions:

```
...  
if do now = justify  
  then justify operation,  
...%
```

JUSTIFY COMMAND

Syntax & Example (continued)

User session for this portion of actions would be:

What do you want to do now?

1) Justify the steps the expert system recommend?

2) ...

= ? 1

Justification for the current value of OPERATION:

the value was inferred using the following rule(s):

R1

Use the DISPLAY command with the above names to get the actual rules.

PAUSE command encountered.

Entering interactive command execution mode.

Use the CONTINUE command to resume knowledge base execution.

ready for command: display r1

R1: IF DO = CHANGE DEFAULT DRIVE &

PROMPT = A &

DRIVE = B THEN

OPERATION = TYPE B COLON AND HIT ENTER KEY.

Mark, Wait and Pause Commands

Syntax & Example

SYNTAX:

mark. wait. pause.

EXAMPLE:

```
...%  
actions:  
message "This expert system checks your usage of the commands for"  
"screen control. Since you do not need to see this"  
"information a second time, it is appropriate to follow this"  
message with mark."
```

wait.

mark.

```
obtain Screen Control Command Usage Status.  
message "Your use of screen control commands appear to be"
```

```
display value(Screen Control Command Usage Status).
```

```
message "If you would like to repeat this system, type"
```

```
    "next"
```

```
"in response to the prompt ready for command:".
```

```
pause%
```

Mark Want and Pause Commands

Syntax & Example

(continued)

User session for this portion of actions would be:

The expert system checks your usage of the commands for screen control. Since you do not need to see this information a second time, it is appropriate to follow this message with mark.

Executing a WAIT command. . . .processing temporarily suspended.
Type carriage-return to continue processing (note: the screen will be cleared when processing resumes). Waiting. . . . :

Have you written mark in lowercase?

(1)yes

(2)no

= ? 2

...

Your use of screen control commands appear to be incorrect.

If you would like to repeat this system, type

next {<--'}

in response to the prompt ready for command:

PAUSE command encountered.

Entering interactive command Execution mode.

Use the CONTINUE command to resume knowledge base execution.

Ready for command: next

Have you written mark in lowercase?

(1) yes

(2) no

= ?

...

IF-THEN-ELSE-ENDIF Structure

Syntax & Example

SYNTAX:

```
if <attribute name> <rational indicator> value 1,  
then <command> <attribute name>, <command> <attribute name>, . . . ,  
  
else if <attribute name> <rational indicator> value 2,  
then <command> <attribute name>,  
  
else if <attribute name> <rational indicator> value 3,  
then <command> <attribute name>,  
.  
.  
.  
  
endif      endif      . . .      endif.
```

EXAMPLE:

```
if MAIN MENU = none,  
then message "Thank you for considering our system to solve"  
"your problem.",  
stop,  
    else if MAIN MENU = Attachment section,  
        then obtain Attachment Section Status,  
        else if MAIN MENU = Attribute Section  
            then obtain Attribute Section Status,  
            else if MAIN MENU = Rule section,  
                then obtain Rule Section Status,  
                else if MAIN MENU = Action section,  
                    then obtain Action Section Status,  
                    endif  
                endif  
            endif  
        endif  
    endif  
endif  
...%
```

IF-THEN-ENDIF STRUCTURE

actions:

askfor MAIN MENU

**if MAIN MENU = Stop,
then message "Thank you for considering our system to solve"
"your problem."
stop
endif.**

**if MAIN MENU = Attachment section,
then obtain Attachment Section Status
endif.**

**if MAIN MENU = Attribute section,
then obtain Attribute Section Status
endif.**

**if MAIN MENU = Rule section,
then obtain Rule Section Status
endif.**

**if MAIN MENU = Actions section.
then obtain Actions Section Status
endif.
...%**

DEM02

KNOWLEDGE BASE

attachments: definition why
%

attributes:

begin

[question: "Do you wish to begin?"]

{smlt):
yes,
no.

do now

[question: "What do you want to do now?"]

{smlt):
justification
[question: "Justify the steps the expert system"
"recommends."],
again
[question: "Get assistance for another case."],
end
[question: "End-I'm finished with the expert"
"system."].

and now

[question: "What do you want to do now?"]

{smlt):
again
[question: "Get assistance for another case."],
end
[question: "End-I'm finished with the expert"
"system."].

do

[question: "What operation do you wish to do?"]
{smlt):
change default drive,
other.

prompt

[question: "Which prompt is on your CRT(screen)?"
"{display definition(prompt))"}]
[definition: "The prompt refers to the letters and symbols"
"that occur at the left margin of the last line"
"on your CRT(screen)."]
{smlt):
a
[question: "A>"].
b
[question: "B>"].

DEMO2
Knowledge Base
(continued)

drive

[question: "Which drive do you want to use as the default"]

"drive? {display definition why(drive)}"]

[definition: "The default drive is the one that the operating

"system refers to automatically for commands that require a disk"

"to be searched for a file, such as, dir(ectory) or type."]

[why: "The expert system must know which drive you want to be"

"your default drive before it can determine the correct"

" operation."]

(smlt):

a

[question: "a {display definition(drive = a)}"]

[definition: "The drive on the left."],

b

[question: "b {display definition(drive = b)}"]

[definition: "The drive on the right."]

operation

(smlt):

cannot perform that

[question: "This cannot assist you with other tasks."]

{display why(operation - cannot perform that)}]

[why: "This expert system is only for changing the"

"default drive."],

type a colon and hit enter key

[question: "type a{<—}"],

type b colon and hit enter key

[question: "type b{<—}"],

the default drive is ok so do not do anything

[question: "The default drive is correct. You need not"

"perform any operations."]

...%

DEM02
Knowledge Base
(continued)

rules:

r1

if do = change default drive,
 & prompt = a ,
 & drive = b,
then operation = type b colon and hit enter key .

r2

if do = change default drive,

 & prompt = b,
 & drive = a,
then operation = type a colon and hit enter key .

r3

if do = change default drive
 & prompt = a,
 & drive = a,
then operation = the default drive is ok so do not do anything.

r4

if do = change default drive,
 & prompt = b,
 & drive = b,
then operation = the default drive is ok so do not do anything.

r5

if do = other,
then operation = cannot perform that

%

DEMO2 Knowledge Base

(continued)

actions:

```
message "                WELCOME TO THE PC"
"                FILE OPERATIONS EXPERT SYSTEM".
message "This expert system will assist you in changing the"
"default disk drive. The system will prompt you for answers"
"which you should enter by typing in the number and a carriage"
"RETURN. For example, 2 {<--}. {{<--}} is carriage RETURN.)"
wait.
message "Online assistance is available for those questions"
"with a line like: {display definition why(prompt)}. By typing"
"display and ONE of the words BEFORE the parentheses with the"
"word in parentheses, the addition text will appear."
message "For example you would type in:"
"display definition(prompt) {<--}"
```

askfor begin.

```
if begin = no.
then stop
endif.
```

mark.

obtain operation .

```
message "the operation or operations you need to do are:".
display value {operation}.
pause.
askfor do now.
```

```
if do now = justification.
then justify operation.
pause.
askfor and now
endif.
```

```
if do now = again.
then next
endif.
```

```
if do now = end.
then stop
endif.
```

```
if and now = again.
then next
endif.
```

```
if and now = end.
then stop
endif
```

0%

Value of the AI Market

	1983	1985	1993
Intelligent Robotic Systems	-	50 Million	600 Million
Expert Systems	-	10 Million	1.5 Billion
AI Computer Systems	22 Million	25 Million	400 Million
<u>TOTAL HARDWARE</u>	22 Million	85 Million	2.5 Billion
Programming Languages and Support	5 Million	10 Million	1.5 Million
Natural Language Interfaces	10 Million	2.5 Million	2 Billion
Expert System Software Packages	2 Million	10 Million	1.5 Million
Robotic Programming	-	-	200 Million
Computer Aided Instruction	2 Million	5 Million	100 Million
<u>TOTAL SOFTWARE</u>	19 Million	50 Million	5.3 Billion
<u>TOTAL SERVICES</u> (Education, Training Custom System Design, Time Sharing Services)	25 Million	85 Million	.7 Billion

THE PLAYERS

- ICOT – Institute for New Generation Computer Technology
- MCC – Microelectronic and Computer Technology
- DARPA – Defense Advanced Research Project Agency
- Others in US
 - National Supercomputer Centers
 - National Security Agency
 - MCNC-Microelectronic Center of North Carolina
 - Individual companies and universities
 - SRC-Semiconductors Research Cooperative
- OTHERS ABROAD
 - ESPRIT-European Strategic Programme for Research and Development-Common Market
 - ALVEY Computer Research Program-BRITISH
 - Germany
 - Agency for Information Technology-FRENCH
 - Great Britain
 - Soviets & East Europeans

Microelectronics Computer Technology Corporation (MCC) Objectives

- Concentrate scarce financial and intellectual resources individual companies can not otherwise deploy alone
- Develop technology to allow its founding and future shareholders to devise products and services of their own conception and design
- Compete in markets of their own choice
- Help U.S. computer and semiconductor firms meet the challenge from government-support R&D programs that have allowed Japanese and Western European firms to target U.S. industries

DODCI 1071-85

Microelectronics & Computer Technology(MCC) Programs

Parallel Processing

- Packaging
- Software Technology
- VLSI/Computer-Aided Design
- Advanced Computer Architecture
 - Parallel Processing
 - Data Base System Management
 - Human Factors Technology
 - AI/Knowledge based systems

Military Applications

- Computerized weapon systems able to see, reason, and plan as well as control action
- Military assessment system that are able to see, listen, understand, interpret and represent information
- Autonomous system able to take instruction, navigate and carry out a military mission

John Markoff 1984

DODCI 1073-85

Problems to Overcome

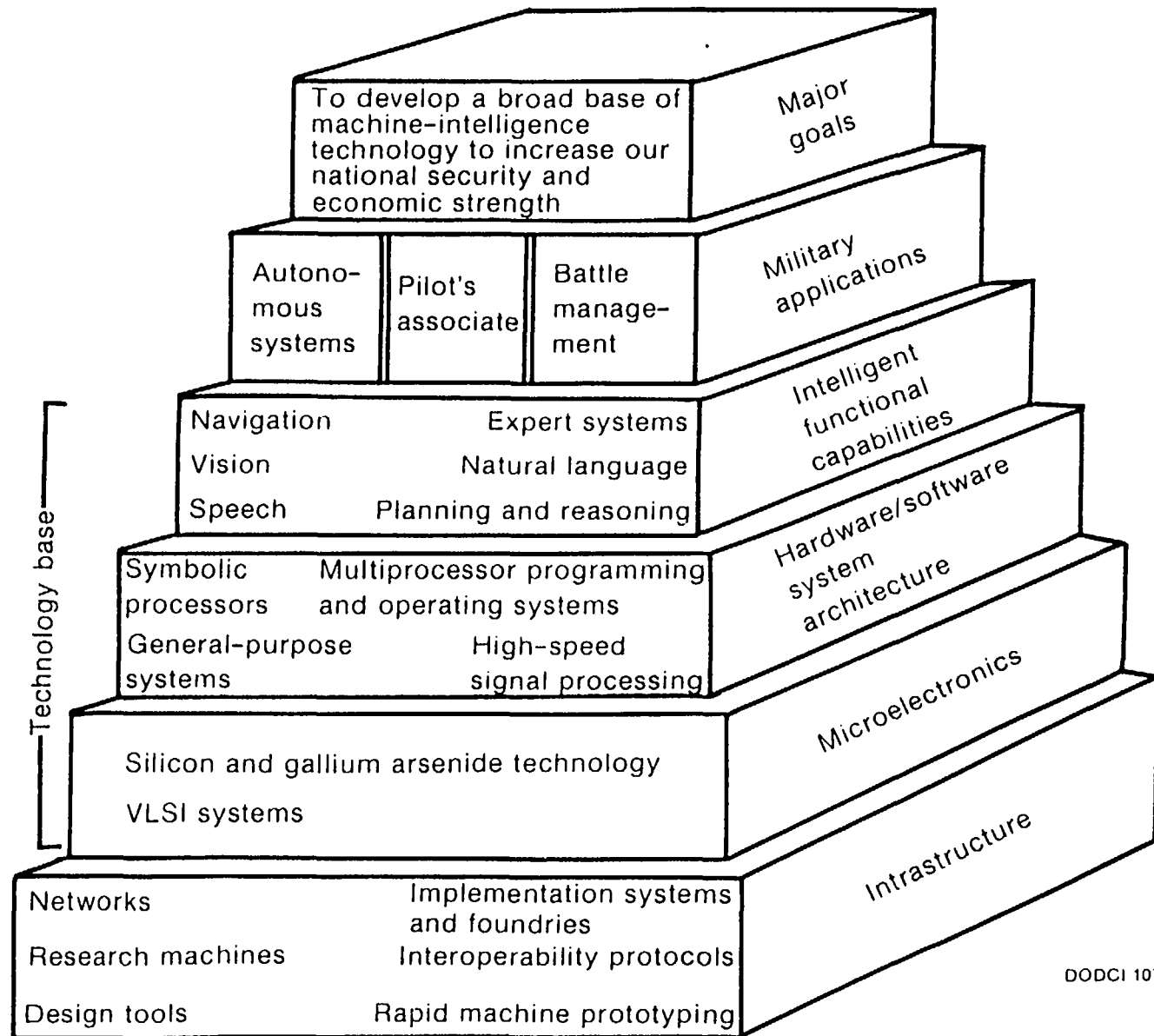
- Lack of Processing Power
- Lack of Knowledge-representation languages
- Interacting with Computer in terms a computer can understand (natural language interface)
- Lack of experienced people

(David Harvey, Mar 84)

DODCI 1074-85

Defense Advanced Research Project Agency (DARPA)

SCI Program Structure and Goods



Defense Advanced Research Project Agency Strategic Computing Cost Summary (in \$Millions)

	FY84	FY85	FY86	FY87	FY88
Total Military Application	6	15	27	TBD	TBD
Total Technology Base	26	50	83	TBD	TBD
Total Infrastructure	16	27	36	TBD	TBD
Total Program Support	2	3	4	TBD	TBD
TOTAL	50	95	150	TBD	TBD

- FIVE YEAR TOTAL ESTIMATED AT \$600m (Approx \$150 million per year)
- TOTAL OVER NEXT DECADE ESTIMATED TO BE \$1 BILLION

(Strategic Computing 1983)

Defense Advanced Research Project Agency

Autonomous Land Vehicle

Capability:

- Sense and interpret environment
- Plan and reason using sensed and other data
- Initiate action
- Communicate with human and other systems

DODCI 1077-85

Defense Advanced Research Project Agency

Autonomous Land Vehicle Continued

Specifications:

- Cross country at 60 KPH
- Navigate to point 50 Kilometers away visually
- Detect obstacles
- Locate and identify landmarks
- Map terrain

DODCI 1078-85

Defense Advanced Research Project Agency

Autonomous Land Vehicle Continued

Technology:

NEEDED

- 10-100 billion IPS
- 10 gigabytes of memory
- 6500 navigation rules
- firing rate-7000 rules/sec

TODAY'S CAPABILITY

30-40 million IPS
10-30 megabytes
2000 rules
50-100 RPS

Size/weight/power: 6-15 cubic feet/ less than 500 lbs/ less than 1 kw of power
(1-4 orders of magnitude reduction in weight, space, and power)

Defense Advanced Research Project Agency

Autonomous Land Vehicle

(continued)

Use of Technology:

- “Smart” Monitors
- cruise missiles
- robotics for handling, manufacturing
- underwater robots
- munitions handling

(Strategic Computing 1983)

DODCI 1080-85

Defense Advanced Research Project Agency

Pilot's Associate System

- Objective

- Off load lower-level chores like regulation of oil temperature
- Perform special functions like detect/diagnosis impending malfunctions

- Characteristics

- Trained by pilot
- “Know” wealth of general knowledge
- “Know” advanced tactics from best pilots
- Knowledge base easily updated in dynamic environment
- Exchanges knowledge with other associates
- Several thousand rules with graphics/speech

Defense Advanced Research Project Agency

Naval Battle Management System

- CVBG Battle Management System (CVBG BMS)

- Integrated into CWC Defense System

- Graphically represents battle area with:

- Enemy/Friendly OOB
 - EW Environment
 - Strike Plan
 - Weather
 - Other factors

Defense Advanced Research Project Agency

Naval Battle Management System

Continued

- Generate prioritized estimate of enemy intent
 - Explain reasoning/sources/probabilities
 - Generate potential courses of action with likely outcomes/
relative attractiveness
 - Prepare/disseminate operations plan
 - “Learn” from each engagement
-
- Limited System on USS Carl Vinson (CVN 70)
 - Requires 20,000 Rules/10 BIPS
 - Will utilize graphics/speech

INTELLIGENCE

NATURAL

- CREATIVE
- CAN ACQUIRE
KNOWLEDGE
- SENSORY INPUT
- WIDE, WIDE CONTEXT
- TRANSITORY
- APPRENTICESHIP
- MORE EXPENSIVE
- ERRATIC
- SLIPSHOD
- NOT EASILY
DOCUMENTED

ARTIFICIAL

- UNINSPIRED
- MUST BE
GIVEN KNOWLEDGE
- SYMBOLIC INPUT
- NARROW CONTEXT
- PERMANANCE
- EASILY DUPLICATED
- LESS EXPENSIVE
- CONSISTENT
- THOROUGH
- DOCUMENTABLE

HUMAN vs COMPUTER PROBLEM SOLVING

- HIGH LEVEL
PERFORMANCE

- BROAD
- SELF CORRECTING

- EMOTION
- FATIGUE
- UNAVAILABLE
- BIAS
- IMPERIAL

- HIGH LEVEL
PERFORMANCE

- NARROW
- NOT PROTECTED

- STABLE (COLD)
- INDEFATIGABLE
- AVAILABLE
- LESS BIAS
- IMPERSONAL

THE COMPUTER EVOLUTION

- Computer Revolution or Evolution?

1951 Vacuum tube powered UNIVAC I delivered to U.S. Census Bureau

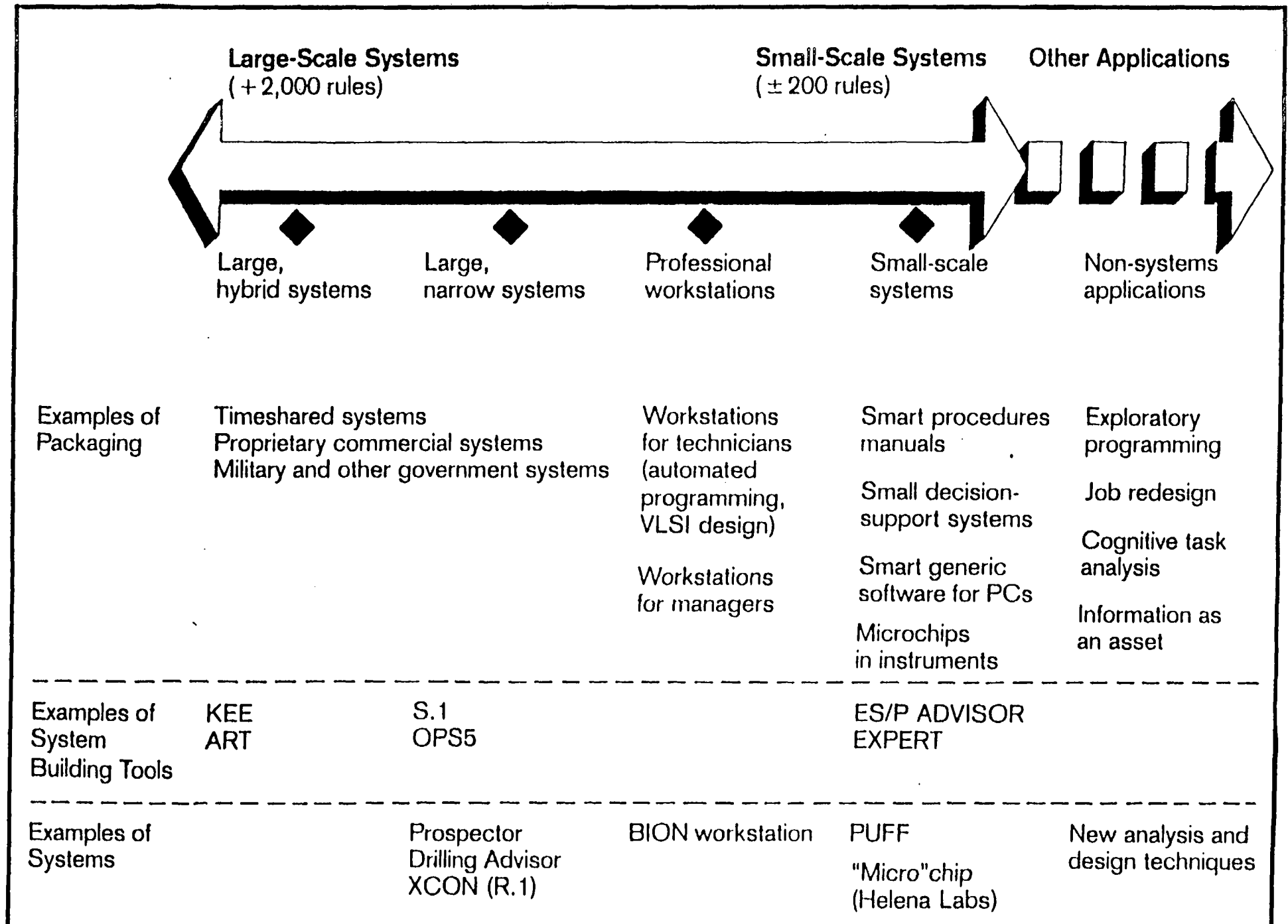
1985 Transparent computers in carburetors, calculators, clocks, dishwashers, microwave ovens, automatic bank tellers, etc.

1951 Single transistor cost \$10, Cadillac limousine cost \$7,600

1985 If Limo had followed semiconductor cost curve (fall 30–40% per year), it would sell for 3¢ instead of \$40,000

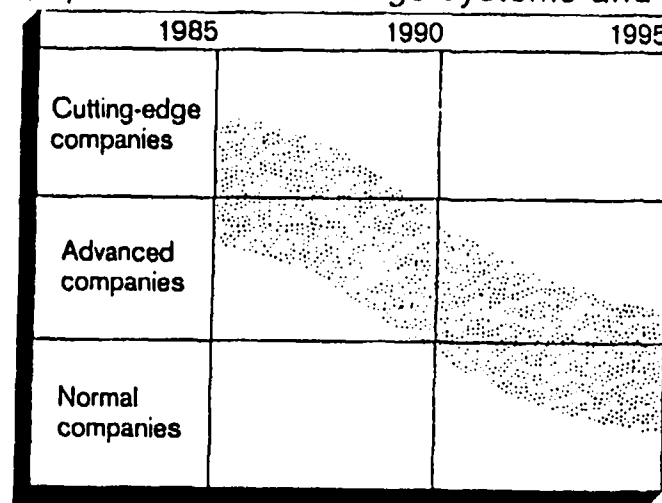
- Can we over sell AI?

A range of expert systems applications to expect in the 1980s.

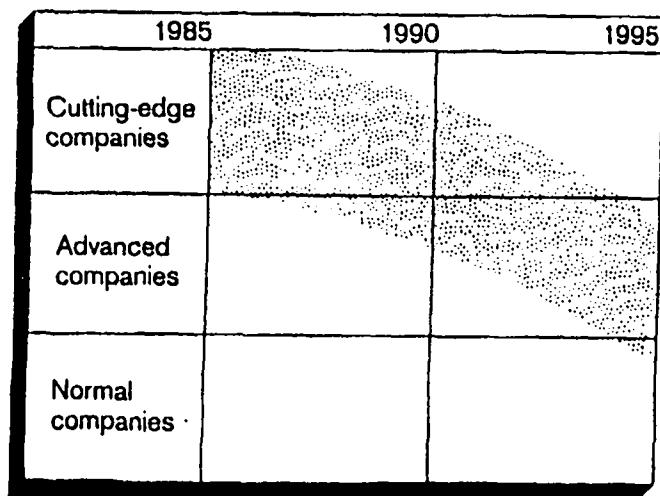


Market Impact of Various Types of Systems

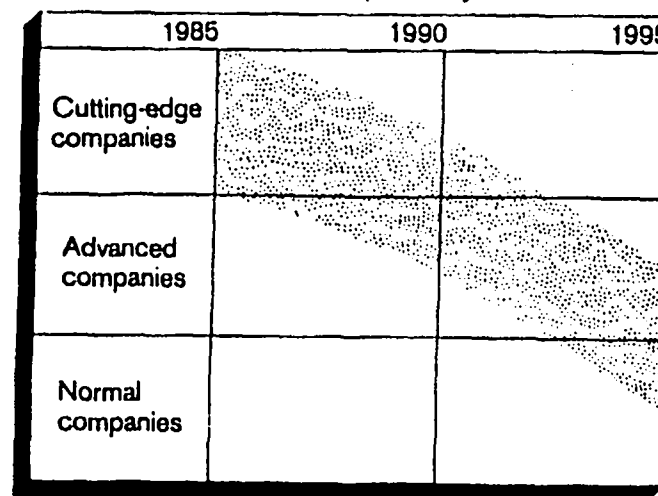
Small, specialized knowledge systems and tools



Large-scale, hybrid expert systems and tools



Large-scale, narrow expert systems and tools



The bands indicate where the action will be over the next ten years

COURSE HIGHLIGHTS

PHASE	TOPIC
1.	Introduction and Overview
2.	Developing an Expert System
3.	The Worldwide challenge
4.	Course Summary

**ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS
FOR
GOVERNMENT EXECUTIVES**

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Roth, Terence, "FINISHED AT FORTY", The Wall Street Journal Sept 16, 1985 p43C, 52C

ABSTRACT: Are 35 to 45-year-old managers who fear computer technology in danger of becoming "has-beens"?

Gottschalk, Earl C. Jr., "EXECUTIVE COMPUTING", The Wall Street Journal Sep 16, 1985 p23C, 37C

ABSTRACT: How a few top executives are using their personal computers.

Zehr, Leonard, "THE PAPER PALACE", The Wall Street Journal Sept 16, 1985 p40C

ABSTRACT: Addresses the myth of "the paperless office".

SESSION I - INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Andriole, Stephen J., "ARTIFICIAL INTELLIGENCE COMES OF AGE", National Defense Dec 1984 p43-46, 50-52

ABSTRACT: A discussion about the applicability of AI to the military addressing its scope and methods, the players, its role in national defense, the net effect, and a prognosis.

Schemmer, Benjamin F., "MICROELECTRONICS ADVANCES WILL PACE DRAMATIC CHANGES IN FUTURE WARS", Armed Forces Journal International 122/2 Sep 1984 p86-88, 91

ABSTRACT: A relatively non-technical look at state-of-the-art in computer technology through the eyes of ADM Bobby Inman.

Williamson, Mickey, "THE HISTORY OF ARTIFICIAL INTELLIGENCE - PART 1", PC Week Oct 1, 1985 p51-53

ABSTRACT: Excerpt from Williamson's book (Artificial Intelligence for Microcomputers, The Guide for Business Decisionmakers) explaining how AI emerged in the computer industry to set the stage for the movement of technology into the microcomputer arena.

Hayes-Roth, Frederick, "RULE-BASED SYSTEMS", Communication of ACM 28/9 Sep 1985 p921-931

ABSTRACT: Good overview of how "rule-based systems" automate problem solving know-how, provide a means for capturing and refining human expertise, and are proving to be commercially viable.

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ABSTRACT: Excerpt for Williamson's book (Artificial Intelligence for Microcomputers, The Guide for Business Decisionmakers) describes Eliza, a natural-language interface developed in 1965.

SESSION II - KNOWLEDGE BASED EXPERT SYSTEMS OVERVIEW

Oxman, Steven W., "EXPERT SYSTEMS REPRESENT ULTIMATE GOAL OF STRATEGIC DECISION MAKING", Data Management 23/4 Apr 1985 p36-38

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ABSTRACT: Introduces expert systems as the first truly useful application of artificial intelligence.

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Tello, Ernie, "THE LANGUAGES OF AI RESEARCH", PC Magazine Apr 16, 1985 p173-189

ABSTRACT: Introduction to LISP and PROLOG including strengths and weaknesses of both in insert article.

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Fertig, Robert T., "SMALL EXPERT SYSTEMS OK-AS FAR AS THEY GO", Management Information Systems Week May 22, 1985 p24-25

ABSTRACT: A critical review of capabilities of microcomputer expert systems. Discusses Expert Ease, TIMM, Personal Consultant, and M.1.

Kinnucan, Paul, "SOFTWARE TOOLS SPEED EXPERT SYSTEM DEVELOPMENT", High Technology Mar 1985, p16-20

ABSTRACT: Good overview of shell programs currently available including a discussion of their strengths and weaknesses.

Derfler, Frank J. Jr., "EXPERT-EASE MAKES ITS OWN RULES", PC Magazine Apr 16, 1985 p119-124

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Julian, Ken, "DEFENSE PROGRAM PUSHES MICROCHIP FRONTIERS: U.S. INDUSTRY CHALLENGED TO CREATE FASTER, DENSER INTEGRATED CIRCUITS FOR FUTURE MILITARY SYSTEMS", High Technology 5/5 May 1985 p49-55,57

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ABSTRACT: Pretty heavy article which discusses, among other things, robotics, low-level vision, natural language processing and knowledge-based expert systems and their uses for education, science, and technology.

PHASE 2 - DEVELOPING AN EXPERT SYSTEM

SESSION V - DEVELOPING EXPERT SYSTEMS, AN OVERVIEW

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Popular Computing Apr 1985 p75-80

ABSTRACT: Article reviews four types of specialized problem-solving software for microcomputers giving examples of each. Good overview of software aids available (including expert systems) for problem solving.

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ABSTRACT: Technical introduction to expert systems including definitions, methods for building, and a review of computer resources needed to build and run them.

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ABSTRACT: Excerpt from Williamson's book (Artificial Intelligence for Microcomputers, The Guide for Business Decisionmakers) which describes a do-it-yourself approach to building knowledge-based or expert systems. It also explains why every problem or task cannot be handled by an expert system and includes pointers that can help you select the right targets for an AI-based solution.

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ABSTRACT: Examines the threshold being crossed by personal computers allowing users to diagnose problems, reason through possible causes and find solutions. Reviews several Tools currently available. Excellent insert articles, An Expert whose Brain Was Drained, A First Look at Paradox - An AI Data Base, The Inner Workings of Expert Systems, A Sampling of Artificial Intelligence Software.

SESSION VII - BUILDING A SMALL EXPERT SYSTEM, Part II

SESSION VIII - BUILDING A SMALL EXPERT SYSTEM, PART III

SESSION IX - GUEST SPEAKER/DEMONSTRATION BY TITAN

PHASE 3 - THE WORLDWIDE CHALLENGE

SESSION X - THE GAME AND THE PLAYERS

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ABSTRACT: Describes DARPA's role in pushing the U. S. toward revolutionary technologies that are neglected or even opposed by the military services and leading industries.

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ABSTRACT: Looks at how expert systems can increase the rate at which decisions are made on the modern NATO battlefield and improve the overall accuracy of those decisions.

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ABSTRACT: Short article discussed the problems the Japanese are having with their Fifth Generation Project.

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ABSTRACT: Status report on Japan's Fifth Generation Project. Mentions ESPRIT and U.S. efforts.

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ABSTRACT: Report prepared by Rand Corporation for USAF which examines how anticipated improvements in computer technology, specifically knowledge based systems, will affect the USAF mission over the next 25 years. In addition to discussing the present state of the technology, the report discusses fifth generation machines, VLSI, and the Japanese Fifth Generation Project. A comprehensive evaluation of near term risks and opportunities is also included.

PHASE 4 - COURSE SUMMARY

SESSION XII - SUMMARY

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ABSTRACT: Optimistic look at enormous potential of the computer revolution.

Williamson, Mickey, "THE FUTURE OF ARTIFICIAL INTELLIGENCE - PART 4", PC Week Oct 22, 1985 p47-48

ABSTRACT: Excerpt from Williamson's book (Artificial Intelligence for Microcomputers, The Guide for Business Decisionmakers) which describes a wish list for AI computers along with the technical advances that are needed to reach these goals.

Report # 86-400
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STRATEGIC STUDIES PROJECT



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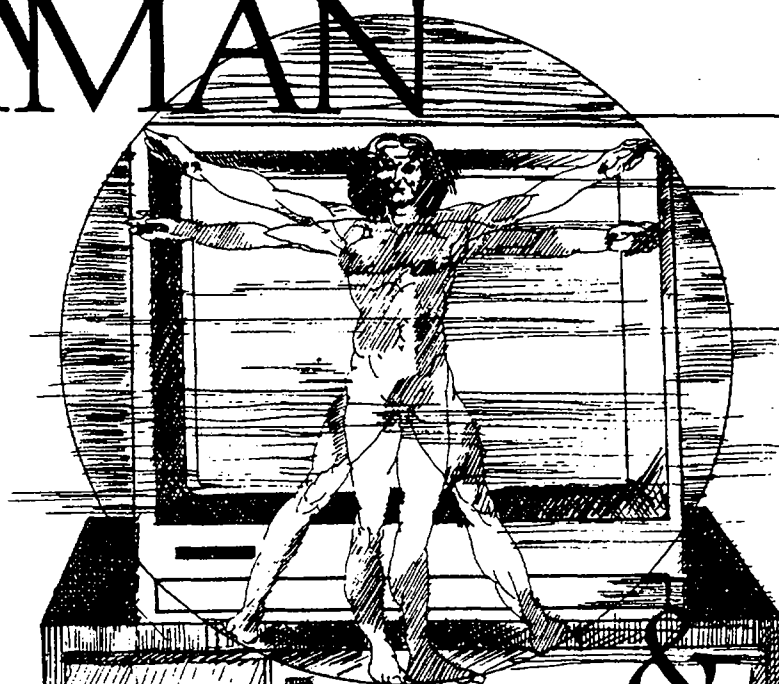
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National Defense University
Department Of Defense
Computer Institute



ARTIFICIAL INTELLIGENCE and EXPERT SYSTEMS

MAN



&
MACHINE
MACHINE

THE NATIONAL WAR COLLEGE
NATIONAL DEFENSE UNIVERSITY
STRATEGIC STUDY

A course entitled:
ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS
for
GOVERNMENT EXECUTIVES

BY

Charles A. Stevenson, 498-52-0379/1230
Commander, USN

A RESEARCH REPORT SUBMITTED TO THE FACULTY
IN
FULFILLMENT OF THE RESEARCH
REQUIREMENT

Research Supervisor: Lieutenant Colonel Charles S. Knode, USAF

THE NATIONAL WAR COLLEGE

February 1986

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THE NATIONAL WAR COLLEGE
STRATEGIC STUDIES REPORT ABSTRACT

TITLE: Artificial Intelligence and Expert Systems for
Government Executives

AUTHOR: Charles A. Stevenson, Commander, USN

DATE: February 1986

This report consists of the syllabus, instructor lesson guides, viewgraphs, and bibliography for a course of instruction taught by the author as an elective at The National Defense University during the spring semester of 1986. The course is designed to acquaint senior level decision makers with the rapidly advancing field of artificial intelligence and the first practical use of this new technology commonly know as expert systems. The course consists of lectures, demonstrations, and guest speakers to give the senior executive a feel for the state-of-the-art in computer technology as well as to demonstrate potential applications of this new tool. It also provides the students an opportunity to develop a small expert system using a "shell" or "tool" on a microcomputer.

BIOGRAPHICAL SKETCH

Commander Charles A. Stevenson, USN (BS, Electrical Engineering, University of Missouri, 1970; MS, Aeronautical Engineering, Naval Postgraduate School, 1979; AeE, Aeronautical Engineer, Naval Postgraduate School, 1979; MBA, National University, 1981), has been interested in computer technology since working as a design engineer designing MOS/LSI circuits for Texas Instruments in 1970. He is an avid computer hobbyist who has read extensively on the subject. He has also served as an adjunct professor of mathematics and computer science at San Diego Community College and Capital Institute of Technology, and holds an instructor credential in mathematics, computer and related technologies, and other disciplines from the Board of Governors, California Community Colleges. Commander Stevenson is an Associate Member of SIGMA XI and a graduate of The National War College, Class of 1986.

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13.140-2/SH
SPRING 86

COURSE 140

ARTIFICIAL INTELLIGENCE AND EXPERT COMPUTER SYSTEMS

for

GOVERNMENT EXECUTIVES

SYLLABUS

SPRING 86

INTRODUCTION: Largely due to innovation in the private sector, the United States has enjoyed a great technological advantage over our allies as well as potential adversaries since the end of World War II. In no field has this advantage been more evident than in the field of computer technology. However, for a variety of reasons, other industrialized nations are challenging the American leadership position narrowing our once seemingly insurmountable lead. For example, three years ago the Japanese publicly stated a national goal to become the world leader in computer technology by being the first to develop a new generation of computers based on artificial intelligence (AI) technology, commonly referred to as the fifth generation of computers. "Expert Systems" are considered the first practical application of this new technology. What are Artificial Intelligence and Expert Systems? How do they differ from today's computers? Are there potential military applications of this new technology? What are the United States, Japan and other nations doing in the field? Is it feasible that the Japanese will develop a fifth generation computer first? If so, what effect, if any, will this breakthrough have on the national security interest of the United States?

METHODOLOGY: This course is designed to acquaint senior level decision makers with the rapidly advancing field of artificial intelligence and the first practical use of this new technology commonly know as Expert Systems. As such, the course makes use of lectures, demonstrations, and guest speakers to give the senior executive a feel for the state-of-the-art in computer technology as well as to demonstrate potential applications for this new tool. In addition, the student will be given an opportunity to develop a small expert system using a "shell" or "tool" ¹ on an IBM compatible sixteen bit microcomputer. A research paper is not required.

PREREQUISITES: There are no prerequisites for this course. However, a rudimentary computer background including familiarity with either the MS or PC DOS, or CP/M operating system would be helpful.

1. Tools are computer software packages that simplify the effort involved in building application programs much like a spreadsheet simplifies computerizing of numerical data.

COURSE OBJECTIVES:

- to introduce the rapidly developing field of practical artificial intelligence emphasizing the most successful area of practical applications, knowledge based expert computer systems
- to define, clarify, and make sense of the claims, promises, and realities of practical AI applications
- to acquire an understanding of and appreciation for the application, capabilities, and limitations of expert computer systems
- to acquaint senior executives with the state-of-the-art in computer technology while giving him/her an appreciation for future potential applications
- to explore the difficulties associated with the development of an expert system
- to explore current and future applications for this new technology

TEXT:

A. Paul Harmon and David King, Expert Systems, Artificial Intelligence in Business, John Wiley & Sons, Inc, 1985

B. Tom Nagy, Dick Gault, and Monica Nagy, Building Your First Expert System, Ashton-Tate Publishing Group, 1985

INSTRUCTORS: CDR Chuck STEVENSON, USN (51728) from the National War College and LTC Steve KNODE, USAF (51980) from the Decision Support Systems Department of the Department of Defense Computer Institute.

COURSE OUTLINE/ASSIGNMENTS

PHASE 1 - INTRODUCTION/OVERVIEW

SESSION I - INTRODUCTION TO ARTIFICIAL INTELLIGENCE

- A. Overview of course
- B. Demonstration = Meet "Eliza"
- C. Computers and Computer Technology
 - 1. Why should managers study computer science?
 - 2. What is a computer?
 - 3. Evolution of computers/computer technology
 - 4. Where are we today and where are we going?
- D. What is artificial intelligence?
 - 1. Definition
 - 2. The AI Family Tree
 - 3. History of AI
 - 4. Why so much hoop-la about AI?
- E. Current and Future Applications of AI
- F. Technical Problems Yet to be Overcome
- G. Assignment
 - 1. Harmon - Forward, Preface, and Chapter 1, skim Chapter 2
 - 2. See Bibliography for supplemental reading

SESSION II - KNOWLEDGE BASED EXPERT SYSTEMS OVERVIEW

- A. Basic concepts and techniques
 - 1. Computer Aided Decision Making
 - 2. Human problem solving
 - 3. Architecture of Expert Systems
 - 4. Processing Model
 - 5. Strategies of Representing Knowledge
 - 6. Drawing inferences
- B. Strengths/Weaknesses, Advantages/Disadvantages, Promises/Myths of Expert Systems

1. Problem Domain of Existing Techniques
2. Advantages/Disadvantages

C. Assignment

1. Harmon - Chapters 3 through 5, skim Chapter 6
2. Note: basic concepts and techniques will be more easily understood if Chapters 4 and 5 are studied prior to class presentation.
3. See Bibliography for supplemental readings

SESSION III - EXISTING EXPERT SYSTEMS AND TOOLS

A. Languages, Tools and Systems

1. Basic concepts
2. AI languages
3. Tools or Shells

B. Tools or Shells

1. Categories of Tools
2. Consultation Paradigms
3. Problem Solving Strategies

C. Existing Expert Systems

D. Demonstrations of Expert Ease and SYSEX

E. Assignment

1. Harmon - Chapters 7 and 8 (skim last half of both chapters)
2. See Bibliography for supplemental reading
3. Note: text and supplemental reading on Expert Ease and EXSYS will maximize your return from the demonstrations.

SESSION IV - NRL Tour

A. Navy Research Lab (NRL) Tour

B. Assignment

1. Clifton, Pat O., "ARTIFICIAL INTELLIGENCE - A 'USER FRIENDLY' INTRODUCTION", Air University Press (Research Report No AU-ARI-85-1), March 1985 (report in your professional library)
2. See Bibliography for supplemental reading

PHASE 2 - DEVELOPING AN EXPERT SYSTEM

SESSION V - DEVELOPING EXPERT SYSTEMS, AN OVERVIEW

- A. Prerequisites for Development
 - 1. Suitability
 - 2. Possible Design Goals
 - 3. Feasibility
 - 4. Critical Aspects of a Problem
 - 5. How to Pick a Problem
- B. Six Steps in Building a Small Expert System
- C. A Case Study = XCON
- D. Assignment
 - 1. Harmon - Chapter 11
 - 2. See Bibliography for supplemental reading

SESSION VI - BUILDING A SMALL EXPERT SYSTEM, Part I

- A. Microcomputer Familiarization
- B. Where Are We Going?
- C. "Building Your First Expert System"
 - 1. The Text
 - 2. The Program = MICRO-PS
- D. Building Your First Expert System
 - 1. Review
 - 2. Building An Expert System with MICRO-PS
- E. Assignment
 - 1. Nagy - skim Chapters 1-4, Chapter 5
 - 2. Harmon - skim Chapters 9 and 10
 - 3. See Bibliography for supplemental reading

SESSION VII - BUILDING A SMALL EXPERT SYSTEM, Part II

- A. Review DEMO1
- B. Attachments and The Attachment Section

1. General
 2. Nondeclared Attachments
 3. Declared Attachments
- C. Some User Friendly Features
1. Many - for example:
 2. Error Detection
- D. More on Commands/Knowledge Base Structure
1. "message" Command Revisited
 2. "askfor" Command
 3. "justify" Command
 4. Commands for Screen Control
 5. "if-then-endif" and "if-then-else-endif" Structures
- E. Demonstrate DEMO2
- F. Computer Lab Session
- G. Assignment
1. Nagy - Chapter 6, skim Chapter 7
 2. Harmon - skim Chapter 12
 3. See Bibliography for supplemental reading

SESSION VIII - BUILDING A SMALL EXPERT SYSTEM, PART III

- A. Computer Lab Session
- B. Assignment
1. Nagy - skim Chapters 8 and 9
 2. Harmon - skim Chapter 15
 3. See Bibliography for supplemental reading

SESSION IX - Guest Speaker/TITAN Demonstration

- A. Guest speaker - Mr Ron Shattuck
- B. Assignment
1. Harmon - Chapter 13
 2. See Bibliography for supplemental reading

PHASE 3 - THE WORLDWIDE CHALLENGE

SESSION X - THE GAME AND THE PLAYERS

A. The Game

1. The Fifth Generation Challenge
2. At Stake
3. The Response

B. The Players

1. ICOT - Institute for New Generation Computer Technology
2. MCC - Microelectronics and Computer Technology Corporation
3. DARPA - Defence Advanced Research Project Agency
4. Others

C. Potential Military Applications of AI Technology

1. Types of Intelligent Weapons and Battle Management Aids
2. Potential Applications
3. Problems to Overcome
4. Case Study - DARPA's Strategic Computer Initiative

D. Assignment

1. See Bibliography for supplemental reading

SESSION XI - The Military's Role in the Future of AI

A. Guest speaker - DARPA

C. Assignment

1. Harmon - Chapter 14
2. See Bibliography for supplemental reading

PHASE 4 - COURSE SUMMARY

SESSION XII - SUMMARY

- A. Advantages and disadvantages of AI
- B. Future of Knowledge Systems
- C. Preparing for the Knowledge System Revolution
- D. Course Highlights
 - 1. Phase 1 = Introduction and Overview
 - 2. Phase 2 = Developing an Expert System
 - 3. Phase 3 = The Worldwide Challenge
 - 4. Phase 4 = Course Summary
- E. Review of Course Objectives
- F. Course Critique
- F. Assignment
 - 1. Harmon - Chapters 14 and 16
 - 2. See Bibliography for supplemental reading

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION I - INTRODUCTION TO ARTIFICIAL INTELLIGENCE

GOALS & OBJECTIVES

1. **Purpose.** To introduce the course and the field of study.
2. **Objectives**
 - A. To introduce course methodology and objectives.
 - B. To motivate the student in his/her study of computer science.
 - C. To introduce the rapidly developing field of practical artificial intelligence emphasising the most successful area of practical applications - knowledge based expert computer systems.
 - D. To stimulate the student's imagination by introducing current and potential applications for this new technology.
 - E. To acquaint the student with the history of the development of the computer, artificial intelligence, and the state-of-the-art in computer technology.

COORDINATION

1. **Student Handouts**
 - A. Course Syllabus (13.140-2/SH)

B. Course Bibliography (13.140-3/SH)

2. Classroom Setup Requirements

A. Viewgraph

B. Specified number of KAYPRO Computers in appropriate classroom with "Eliza" program disk for each.

3. IRC Support Requirements. Computer/program setup.

LESSON OUTLINE

1. Lecture

A. Overview of Course (VG I-1)

1. Introduce instructor(s)
2. Conduct informal survey of class' computer expertise
3. State Course Objectives (VG I-2)
 - course for managers NOT "techies"
 - to increase awareness NOT teach mechanics
4. Review Course Outline, Assignments, and Bibliography
 - voluminous reading assignments optional for student edification
 - many assigned articles short, easy reading
5. Other administrative items
 - computer jargon - DON'T LET ME!
 - questions - PLEASE!

B. Demonstration - Meet "Eliza"

- developed in 1965's by Joseph Weizenbaum of MIT as demonstration of AI
- NOT an expert system, merely clever programming
- see article in this week supplemental reading for more information

C. Computers and Computer Technology

1. Why should managers study computer science? (VG I-3)
2. What is a computer? (VG I-4)
 - parts
 - hardware vs software
 - bits/bytes into usefulness
 - Von Nuemann (John Von Neumann) architecture
 - algorithm
3. Evolution of the computer (VG I-5)
 - note acceleration of technology over last 10 years
 - emphasize military's role in pushing the state-of-the-art due to need
4. Where are we today and where are we going?
 - chip technology - LSI to VLSI to VHSIC
 - memory - 64 X 1 K to 1 Megabyte chip to CD
 - interface - papertape to punch cards to CRT to natural language
 - software - machine language to spreadsheets to expert systems

D. What is Artificial Intelligence?

1. Definition (VG I-6)
 - define "inference" (the process by which new facts are derived from know facts)
 - "modus ponens" = basic rule of logic that asserts: if A implies B and A is fact, then B can be assumed, example:

Rule 1 - If the sky is black, then it is night.
Known fact - The sky is black.
New fact - It is night (from rule 1).

2. The AI Family Tree (VG I-7)
3. History of AI (VG I-8)
4. Why so much hoop-la about AI? (VG I-9)

E. Current and Future Applications of AI

1. Current Applications (VG I-10)
2. Potential Applications (VG I-11)

F. Problem Areas (VG I-12)

G. Next Week - Session II - Knowledge Based Expert Systems

- What are they?
- How do they differ from today's computer software?
- What good are they?
- How do they work?

2. **Demonstration.** Meet "Eliza"

3. **Practical Exercise.** None

13.140-2/IG
SPRING 86

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION II - KNOWLEDGED-BASED EXPERT SYSTEMS OVERVIEW

GOALS AND OBJECTIVES

1. **Purpose.** To introduce and familiarize the student with knowledge-based expert computer systems.

2. **Objectives**

A. To define, clarify, and make sense of the claims, promises, and realities of practical AI applications.

B. To acquire an understanding of and appreciation for the applications, capabilities, and limitations of expert computer systems.

C. To compare and contrast human problem solving with the state-of-the-art computer problem solving.

COORDINATION

1. Student Handouts. None
2. Classroom Setup Requirements. Viewgraph
3. IRC Support Requirements. None

LESSON OUTLINE

1. Lecture

A. Basic Concepts and techniques

1. Computer Aided Decision Making (Steven W. Oxman 1985) (VG II-1)

a. Data-based Systems = software system that includes data base

1) Data Base Management System (DBMS)

- software that manages data in data base
- example = dBase II

2) Management Information System (MIS)

- software that stores, processes, retrieves, and disseminates information in DBMS
- examples = report generation and telecommunication packages

3) Decision Support Systems (DSS)

- software that enhances decision makers effectiveness in using data from DBMS or MIS
- often presents information in graphs or charts
- two categories = user interface support and models
- example = trend or forecasting analysis packages

b. Knowledge-based Systems = software systems that includes knowledge data base (data and meaning of data)

1) Natural Language Systems

- software that acts as user interface to communicate in flexible framework common to user

2) Expert Systems

- software that uses knowledge (rules about the behavior of elements of a

particular subject domain), facts, and inference techniques (reasoning) to solve problems that normally require the abilities of human experts

- names (VG II-2)
- goals (VG II-3)
- common properties, characteristics, and features (VG II-4)

2. Human Problem Solving (Paul Harmon, David King 1985)

a. Human Information Processing (VG II-5)

1) Input

- cognitive processor (like CPU) cycles to obtain information from sensory buffer and transfers it to working memory (like "fetch-execute" cycle)
- for simple tasks = cognitive system to motor output with little or no thought
- for complex tasks = must use long term memory

2) Memory = stored symbols with complex indexing system

- simple model
 - . "scripts" = like how to meet someone
 - . "chunks" = clusters of symbols or pattern of stimuli hierarchically organize to form vast network
 - . learning = linking and revising links between these chunks of data
- short term memory (working space)
 - . 3 to 7 activated chunks due limited resources of human cognitive processes
 - . "focus" on certain chunks like screen on spreadsheet program
- long term memory
 - . holds individuals mass of accumulated knowledge
 - . trick not storing but retrieving info
 - . take 7 seconds per chunk to link info in long term memory

3) Output

- after scanning and searching memory,

information sent to motor system resulting in some observable activity

b. Problem Solving

- 1) Divergent vs Convergent Reasoning (VG II-6)
- 2) Varieties of Knowledge

- surface knowledge = heuristics (rules of thumb) from experience
- deep knowledge = principles, axioms, and laws from books

3) Varieties of Problems

- well and ill-defined problems

4) Varieties of techniques

- familiar problem = systematically gather relative information, build prototype solution, ignore irrelevant details, revise hypothesis in light of restraints
- unfamiliar problem = struggle, guess, experiment
- both cases = good theory of problem solving, good heuristics will help

c. Expert Knowledge (VG II-7)

- An expert = individual who is widely recognized as being able to solve a particular type problem that most cannot solve as efficiently or effectively
- 50-100K chunks of heuristic information
- takes about 10 years to acquire
- most expert systems include only surface knowledge to limit size of knowledge base

3. Architecture of a Knowledge-based Expert System (Steven W. Oxman 1985) (VG II-8)

- Knowledge Base contains rules and facts that
- Working Memory embody the system's knowledge

. kinds of knowledge in a knowledge base (VG II-9)

- Inference Engine = a computer program that

contains the inference strategies and controls that manipulate the facts and rules of the knowledge base

- User Interface computer program(s) that allow user to enter facts
- Explanation Subsystem and rules, and ask questions
- Knowledge Acquisition Facility = a computer program that provides a dialogue between the system and the human expert for acquiring knowledge and places rules in knowledge base

4. Production System as a Processing Model

- compare and contrast rule vs fact
- "Modus ponens" = basic rule of logic (If A implies B (rule) and A is the case (fact) then we can assume B), example:
 - . Rule 1 = Nov 28th is Susan's birthday
 - . Fact = Today is Nov 28th
 - . New Fact = Today is Susan's birthday
- so, apply production rule (if-then statement) to working memory (facts), if they succeed, then contribute new fact to memory!
- powerful model because discrete, simple, flexible

5. Strategies for Representing Knowledge (VG II-10)

a. Semantic Networks

- network of nodes connected by links
- nodes used to represent objects or descriptors
- links relate objects and descriptors
- example = (VG II-11)
 - . objects can be nouns or conceptual entities (acts, events, or abstract categories)
 - . links can represent class/instance relationship (is-a), properties (has-a), heuristic knowledge (causes), or be definitional (wears)
- advantages = flexible, inheritance (one node inherits characteristics of another)
- disadvantage = difficulty in handling exceptions (what is Wilson = one armed man?)

b. Object-Attribute-Value (O-A-V) Triplets

- objects = physical (door) or conceptual (bank loan) entities
- attributes = general characteristics or properties associated with objects (size, shape, interest rate)
- value = specific nature of attribute in particular situation (green, 12%)
- example = (VG II-12)
- some features:
 - . remove value = from dynamic to static instance
 - . order/relationship of objects = trees
 - . can modify with "certainty" factor to handle uncertainty

c. Rules (VG II-13)

- each part of "premise" called "expression" or "if clause"
- "conclusion" contains "expression(s)" or "then clause(es)"
- logical operators, "and" and "or"
- certainty factor applicable to rules too

d. Frames (VG II-14)

- frame = discription of object which contains "slots" for all information associated with object
- slot = may contain values, point to other frames, sets of rules, or procedures to obtain values
- advantage = allow for richer representation of facts
- disadvantage = more complex and more difficult to develop than O-A-V/Rule systems
- NOTE: (VG II-15)
 - . frames, O-A-V, and rule systems are special cases of semantic network
 - . same facts can be represented in any one of three systems

e. Logical Expressions

- two common forms = propositional logic and predicate calculus
- propositional logic
 - . = statements that are true or false (if A, then C)

- . can link with AND/OR (if A and B, then C)
- predicate calculus
 - . = extension or propositional logic to force true or false statement ("(is-red (ball) = a ball is red)")
 - . note - statement true or false
 - . can address multiple objects ("daughter-of (Emily, Susan)" = Emily is the daughter of Susan)
 - . can link with Boolean AND/OR ("daughter-of (Emily, Susan) AND (daughter-of (Karen, Susan))")
 - . can "nest" predicates ("condition(sleeve (coat), shiny)")
- Note - logical formulations represents knowledge differently than other methods, facts retrieved only by asking true/false question

6. Drawing Inferences

a. Inference Engine

- stands between user and knowledge base
- two tasks
 - . examines existing facts and rules, and adds new facts when possible
 - . decides in which order inferences are made
- the heart of the expert system but quite simple because human inference simple but combine great knowledge base and well-chosen heuristics allowing expert to quickly cut problem domain to manageable size

b. Guiding Inference

- modus ponens = most common inference strategy
 - . simple rule, easily understood
 - . certain valid implications cannot be drawn using this rule (if B is false, most systems cannot reach the conclusion that A is therefore false, called "modus tollens")
- reasoning with uncertainty
 - . rule false if fact(s) unknown
 - . rules included in knowledge base to provide knowledge about incomplete information (cf less than 0.2 = false or

- if unknown, ask)
- "resolution" = a modus ponens of logical systems

c. Control

- two problems
 - . where to start
 - . way to resolve conflict when alternative lines of reasoning emerge
- search strategies (Frederick Hayes-Roth 1985)
 - . back-chaining (or goal-directed) = begin with goal and successively examine any rule(s) with matching conclusion
 - . forward-chaining (stimulus or data-driven) = rule "fires" when working memory facts match premise
 - . depth-first vs breadth-first searches (VG II-16)
 - . combination = like humans
- monotonic vs nonmonotonic reasoning
 - . mono = true facts remain true
 - . nonmono = true facts may be retracted
 - . most of today's systems use monotonic reasoning because complication of undoing process

B. Strengths/Weaknesses, Advantages/Disadvantages, Promises/Myths of Expert Systems

1. Problem Domain of Existing Techniques (VG II-17) (Paul Harmon, David King 1985)
 - the barriers
 - . hardware = existing computers not fast enough (solution = parallel processing systems or fifth generation computers)
 - . software = handle nonmonotonic problems with great difficulty (solution = machine that can learn from own experience, "machine learning")
 - both problems will limit knowledge system development over next several years
2. Advantages/Disadvantages (Mike Turner 1985)
 - a. Advantages
 - financial
 - . productivity improvements
 - . increased business volume

- quantifiable
 - . faster turnaround
 - . faster response time
 - . time saved on routine tasks
 - . time saved in learning or coping with new working methods
 - . faster access to expertise
- qualitative
 - . improved knowledge quality and accessibility
 - . changes to ability of staff to perform work effectively
 - . improved quality of services

b. Disadvantages

- financial, cost of:
 - . equipment purchases
 - . system software development
 - . specialist staff and support structure

C. Next Week = Session III - Existing Expert Systems and Tools

- a look at AI languages, programming environments, and Tools
- including demonstrations of Expert-Ease and SYSEX, two expert system tools available for microcomputers

2. Demonstrations. None

3. Practical Exercises. None

13.140-3/IG
SPRING 86

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION III - EXISTING EXPERT SYSTEMS AND TOOLS

GOALS & OBJECTIVES

1. **Purpose.** To familiarize the student with the current state-of-the-art in the development of Expert Systems and Tools.

2. **Objectives**

A. To acquaint the senior executive with AI computer languages and programming environments with emphasis on commercially available expert system tools for microprocessors.

B. To explore the difficulties associated with the development of an expert system.

C. To give the senior executive an appreciation for future potential applications for AI technology.

COORDINATION

1. **Student Handouts.** None

2. **Classroom Setup Requirements**

A. Viewgraph

B. A 16-bit computer and projector in specified classroom with copies of EXPERT EASE and EXSYS software.

3. **IRC Support Requirements.** Computer/software setup.

LESSON OUTLINE

1. Lesson

A. Languages, Tools and Systems (Paul Harmon, David King 1985)

1. Basic Concepts - Levels of Software (between human problem and computer hardware) (VG III-1)

- machine language = binary code
- operating system = handles utility functions
- high-level languages
 - . examples: FORTRAN, BASIC
 - . interpreter vs compiler
- programming environment = special packages
 - . example: FORTRAN library of subroutines
- tools (or shells) = to facilitate rapid development of useful "systems"
 - . examples: spreadsheet, EXPERT EASE
- system = combination of tool and knowledge in specific problem domain

2. Tools (VG III-2) (Mike Turner 1985)

a. Knowledge Acquisition Products

- generate rules from user-provided examples
- rules form knowledge base for subsequent consultations

b. Expert System Shells (or Tools)

- expert system without knowledge base (example: EMYCIN from MYCIN)
- designed to facilitate rapid development of knowledge systems (example: spreadsheet)
- HOWEVER, usually designed to address specific class of problem
- advantages (VG III-3)

c. AI Languages and Programming Environments

3. AI Languages

- most AI programming done in one of two high-level languages = LISP or PROLOG
- AI language constructs facilitate developing

- symbolic computing programs just as iterative constructs are useful for numerical programming
- LISP (LISt Processing)
 - . invented in 1960's by John McCarthy
 - . second oldest computer programming language still in use (first = FORTRAN)
 - . consist of operations that facilitate creation of programs that manipulate list
 - PROLOG (PROgramming LOGic)
 - . invented in 1972 by Alain Colmerauer (U of Marseilles)
 - . language of Japanese Fifth Generation Project
 - . contains constructs that make it easy to write programs that manipulate logical expressions

B. Tools or Shells

1. Categories of Tools (or Shells) (Paul Harmon, David King 1985)

- small system building tools
 - . for personal computers
 - . less than 400 rules
 - . examples = EXPERT EASE, EXSYS
- large, narrow system building tools
 - . 500 to several thousand rules
 - . run on LISP machines or larger
 - . constrained to 1 general consultation paradigm
 - . examples = S.1, TIMM
- large, hybrid system building tools
 - . 500 to several thousand rules
 - . run on LISP machines or larger
 - . include features of several different consultation paradigms
 - . examples = KEE, LOOPS

2. Consultation Paradigms

- paradigm = describes generic types of problem-solving scenarios (example = diagnosis/prescription paradigm, used in most commercial tools)
- typical paradigms = (VG III-4)

3. Problem Solving Strategies (VG III-5)

- the problem to be solved will often dictate the knowledge representation, inference, and control strategies (software techniques) to be used
- two extremes:

- . use available tool
- . use custom-assembled technique - no tool or standard paradigm (longer development, higher cost but problem might not fit available techniques)

B. Existing Expert Systems (Mike Turner 1985)

1. PROSPECTOR

- a system which acts as a geological advisor
- credited with finding \$100 million molybdenum deposit in Washington State in 1982

2. DRILLING ADVISOR

- diagnoses drilling problems and offers recommendations for corrective action
- pays back its research and development costs each few times it is used

3. INDUCE

- by using knowledge about how to learn from examples has become the world's primary authority on soya bean disease diagnosis

4. XCON

- configures minicomputer lay-outs for Digital Equipment
- correct over 99% of cases, record better than human configuration specialists
- case study of XCON in Session V

5. STEAMER

- teach Navy personnel how to operate shipboard steamplants
- simulates a frigate steamplant on color display
- enables user to experiment with various operating procedures
- can explain its operation and terminology

C. Demonstrations

1. EXPERT EASE

2. EXSYS

- D. Next Week = SESSION IV - NAVY RESEARCH LAB TOUR
 - meet in front of NWC building at 1530 hours

2. Demonstrations.

- A. EXPERT EASE
- B. SYSEX

3. Practical Exercise. None

13.140-5/IG
Spring 86

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSION GUIDE

SUBJECT: SESSION V - DEVELOPING EXPERT SYSTEMS, AN OVERVIEW

GOALS & OBJECTIVES

1. **Purpose.** To familiarize the senior executive with the difficulties associated with the development of an expert system.

2. **Objectives**

A. To acquire an understanding of and appreciation for the capabilities and limitations of expert computer systems.

B. To explore the difficulties associated with the development of an expert system.

C. To further clarify the promises and realities of practical AI applications.

COORDINATION

1. **Student Handouts.** None
2. **Classroom Setup Requirements.** Viewgraph
3. **IRC Support Requirements.** None

LESSON OUTLINE

1. Lesson

A. Prerequisites for Development (Mike Turner 1985)

1. Suitability

- must first determine if expert system techniques are applicable (or are conventional methods better suited?)
- positive and negative indicators (VG V-1)
 - . NOT DOABLE USING CONVENTIONAL TECHNIQUES - must use uncertain data or knowledge, or computationally infeasible
 - . NON-COMPUTER STAFF - English-like form of knowledge base makes editing easier
 - . EXPLANATION REQUIRED - intrinsic to expert systems
 - . USE KNOWLEDGE MORE THAN ONE WAY - can change inference module, from doing to teaching)
 - . RULES EASIER THAN EQUATIONS - example = sets of regulations

2. Possible Design Goals (VG V-2)

3. Feasibility (VG V-3)

- expert constraints
 - . must exist and must have ready access
 - . expert must be enthusiastic about cooperating in development
 - . expert must be able to explain his special knowledge and experience and method used to apply to particular problem
- problem constraints
 - . problem domain must be well bounded and reasonably narrow
 - . problem solving in domain should not require the use of common sense reasoning
 - . primary source of expert's ability must be special knowledge, judgement, and experience
 - . problem should typically take an expert between a few minutes and a few hours to solve
- technology constraints
 - . knowledge must be efficiently represented in

- current knowledge representation languages
- . explanations tend to be rather stylised and limited
- . most time-consuming to construct
- . difficult to maintain consistency and resolve conflicts within knowledge base
- . difficult to handle or identify problems at boundaries of knowledge base

4. Critical Aspects of a Problem (VG V-4)

a. Reliability of Data and Knowledge

- no noise (extraneous data) nor errors which might lead to inconsistencies or incorrectness

b. Time Dependency of Data

- whether data is static or not
- if task's history or currentness of data important, then the system must be able to cope with time

c. Size of the Search Space

- in many systems desired solution called "goal", then the set of possible steps leading from initial condition to goal is viewed as a "search space"
- simplest form of search space viewed as tree structure or network
- search space considered "small" if feasible to predefine inference network
- if searching large space, specially tailored search spaces must be generated for each application problem (can use heuristics)

5. How to Pick a Problem

- data and knowledge certain
- data are static
- search space is small
- in general small-scale successful applications have been:
 - . a classificatory or diagnostic problem
 - . modest goals
 - . management prepared to champion project
 - . enthusiastic human expert available
 - . no requirement that development be cost

justified

B. Six Steps in Building a Small Expert System (VG V-5)
(Paul Harmon, David King 1985)

- select a Tool
 - . implicitly commit to particular consultation paradigm
 - . software techniques (knowledge representation, inference and control strategies)
 - . ease of use
 - . fit problem
 - . cost of software/additional hardware (if required)
- identify the problem/analyze knowledge
 - . problem before Tool in real world
 - . knowledge acquisition phase
- design system
 - . design on paper w/ flow diagrams and few rules
 - . from analysis to design
- develop a prototype
 - . create knowledge base and test
- expand, test and revise
- maintain and update
 - . continues for life of system
 - . on small systems can be done by people who create and use them

C. Case Study = XCON (Mike Turner 1985 and Paul Harmon, David King 1985)

1. XCON

- operational expert system that routinely configures and checks for completeness of Digital Equipment Corporation's (DEC) VAX-11/780 computer systems
- manages more complex planning (rather than classificatory or diagnostic) task by:
 - . avoidance of uncertainty of data problem by checking for incompatible or missing components
 - . avoidance of uncertainty in configuration knowledge, components either fit together or do not
 - . defining reasonable small problem domain with clearly defined limits
 - . avoids need to try alternative configurations by careful step by step procedures so partial configuration can always be extended into final correct configuration

2. Development (VG V-6)

3. Current Status of XCON

- grown from 250 rule to 3300 rule system able to configure all VAX and PDP systems sold in significant volumes
- performs at very high level of competence, as good as configuration experts
- system now managed and kept current entirely by DEC personnel
- spin-offs:
 - . XSEL - salesperson's assistant
 - . PTRANS = manufacturing management assistant
 - . both using same knowledge base!

4. Benefits to DEC

- determines completeness of customer's orders soon after receipt (approximately 1.5 CPU minutes per)
- more rapid turnaround of orders
- reduced number of unconfigurable systems delivered to customers
- savings of around \$10 million per annum, roughly equal to development cost
- an overall improved level of customer service
- human experts now free to focus almost entirely on various specialized configuration problems

D. Next Week = SESSION VI - BUILDING AN EXPERT SYSTEM, Part I

- application of the methodology discussed today

2. **Demonstration.** None

3. **Practical Exercise.** None

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**EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE**

SUBJECT: SESSION VI - BUILDING A SMALL EXPERT SYSTEM, PART I

GOALS & OBJECTIVES

1. **Purpose.** To familiarize the student with the 16-bit microcomputer systems being used and to introduce the Expert System Tool, MICRO-PS.

2. **Objectives**

A. To familiarize the student with the 16-bit microcomputer Disk Operating System.

B. To introduce the Expert System Tool, MICRO-PS.

C. To equip the student with sufficient knowledge concerning MICRO-PS so that he/she can begin to formulate a problem to which the student can employ the Tool.

D. To explore the difficulties associated with the development of an expert system through practical application.

COORDINATION

1. **Student Handouts.** MS DOS Gouge (13.140-5/SH)

2. **Classroom Setup Requirements**

A. Viewgraph

B. Twelve 16-bit microprocessors, printers and one projector (for the instructor) in specified classroom.

3. IRC Support Requirements. Computer setup.

LESSON OUTLINE

1. Lesson

A. Microcomputer Familiarization (use Student Handout)

- ON/OFF, Printer, Keyboard (include <CR>)
- DOS, Prompts, Commands (include "DIR")
- How to backup your work (make working copy of MICRO-PS)
- Supplemental Text Editor (if available)

B. Where are we going?

- familiarization with computer and MICRO-PS (1 1/2 wks)
- build your own Expert System using MICRO-PS
 - . practical experience is the goal
 - . use prudence in selecting your problem (ie, very small, almost trivial)
 - . start to formulate your problem as we learn the program

C. "Building Your First Expert System"

1. The Text

- learning guide/manual for the expert system Tool, MICRO-PS
- text divided into four parts:
 - . Part 1 - Chapters 1-3 = Introduction
 - . Part 2 - Chapters 4-9 = How to
 - . Part 3 = MICRO-PS Manual
 - . Part 4 = Glossary & Appendices

2. The Program = MICRO-PS

- scaled down, training version of Knowledge Engineering System (KES) with significant limitations (see Appendix C, page 277)
- "PS" = Production System, means built on if-then rules
- we'll brush through Part 1 and part of Part 2 this week, next week we'll look at the rest of Part 2, then you are on your own (explain computer lab procedures/hours of operation)

D. Building Your First Expert System

1. Review

- a. An Expert System (VG VI-1)
 - review parts (include Parser)
 - define Domain Expert (as opposed to KBA) = expertise behind Expert System, can be person, book, etc.
 - define Knowledge Engineer = writes program
- b. Hallmarks of an Expert System (VG VI-2)
 - RELIABILITY = to keep user's confidence
 - INTELLIGENT QUESTIONING =
 - . explain Attribute = a variable or data element, basic building block of knowledge base
 - . explain Attachment = note "attached" to various parts of your MICRO-PS program
 - . how? (VG VI-3)
 - JUSTIFYING CONCLUSIONS =
 - . enables user to assess rationality of advice
 - . helps user reason like expert
 - . powerful for debugging during development
 - NONNUMERICAL REASONING = full system can do both
 - USER FRIENDLINESS =
 - . criteria = minimal time to learn, relearn, and use
 - . features:
 - helps determine if appropriate for user's problem
 - determines what information needed
 - explains questions
 - leads user to appropriate answer
- c. Most Suitable Applications (VG VI-4)

2. Building an Expert System with MICRO-PS

- a. Demonstrate "DEM01"
 - for illustration use very limited, non-user friendly Expert System which advises user how to change default disk drives
 - with DOS loaded type "A>micro-ps dem01"
 - step students through options on their micros
 - will use DEM01 to illustrate MICRO-PS's structure/features

- b. Steps to Build an Expert System (VG VI-5)
 - ANALYSIS = analyse goals, source(s) of knowledge, knowledge level of user, potential gain, difficulty to build and test, methodology to use
 - DESIGN = describe knowledge base
 - . four sections of MICRO-PS knowledge base:
 - THE ATTACHMENTS SECTION = to make program more user friendly
 - THE ATTRIBUTES SECTION = declare attributes
 - . Attribute Hierarchy (VG VI-6)
 - Input Attribute = value from user
 - Inferred Attribute = value from rules
 - THE RULES SECTION = lay out relationship between attributes
 - THE ACTION SECTION
 - . Action Flow Chart for DEMO1 (VG VI-7)
 - . OK, how does it work?
- 1-Action Sections instructs Inference Engine (IE) to "Obtain" attribute (Operation) which becomes goal
 - 2-IE checks to see if value of Operation known
 - 3-if not, IE looks for rule(s) with Operation as consequent (if none, assumes Operation = Input Attribute and asks for value)
 - 4-then IE tests rule(s), if antecedent unknown sets new intermediate goal of antecedent, etc.
- IMPLEMENT = write Attributes, Rules and Action Sections
 - VERIFY = test ALL possibilities
- c. One "Section" at a Time
 - 1) The Attributes Section
 - used to declare variables (attributes) to be used in system (ie, establish set of storage locations which have names, types, and value sets)
 - an attribute must have a unique name, up to 10 words with 10 letters/numbers
 - two types, nonnumeric (smlt) and interger (int)
 - syntax/example (VG VI-8)
 - in DEMO1 (VG VI-9)
 - limitations (VG VI-10)
 - 2) The Rules Section
 - parts = antecedent - if part
consequent - then part

- must have unique name, up to 10 words with 10 letters/numbers
- Rational Indicators and Connectors (VG VI-11)
- syntax/example (VG VI-12)
- order rules in same pattern established in Attribute Section (exception page 125)
- non Attribute user responses = "UNKNOWN" & "NONE" (see page 216)
- in DEMO1 (VG VI-13)

3) The Action Section

- Commands = askfor, message, stop, obtain, display, etc.
- syntax differ (see Section 5, p227)
- DEMO1 commands (VG VI-14)
 - . "obtain" command
 - syntax
 - "obtain" in lowercase
 - <attribute name> must match & appear in consequent of at least one rule
 - . "message" command
 - syntax
 - "message" in lowercase
 - each line enclosed by double quotes
 - text limited to four lines
 - stand alone message ends with period
 - . "display" command
 - syntax
 - "display value" in lowercase
 - <attribute name> enclosed in parentheses, must match, and appear as consequent of at least one rule

4) Summary of Sections (VG VI-13)

E. Next Week - SESSION VII - BUILDING A SMALL EXPERT SYSTEM, PART II

- will have opportunity to begin working on your first expert system during the next class period so any preparation between now and then will be time well spent

2. Demonstrations. DEMO1 (Tom Nagy, Dick Gault, and Monica Nagy, Building Your First Expert System, Ashton-Tate Publishing Group 1985, pp43-45)

3. Practical Exercises. None

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MS DOS GOUGE

GETTING STARTED

1. Place the MS DOS (or Working) Disk into Disk Drive A (on left hand side).
2. Close the door on the disk drive.
3. Turn on computer (ON/OFF switch is located on the left hand side of the computer).
- . . . after some buzzing and whirling,
4. Answer cues (ie, time, date), pressing Return Key after each.
 Note: syntax for time is <hour>:<minutes>
 syntax for date is <month>-<day>-<year>
 . . . you have successfully "booted" the Operating System (MS DOS in this case) when the prompt "A>" appears. You may now instruct the computer to execute any DOS command or to run a program.

Note: this procedure may be employed to boot the Operating System during subsequent sessions by substituting your MICRO-PS Working Disk for the MS DOS disk in the above procedure.

FORMATING A WORKING DISK¹

1. Place the MS DOS disk in Disk Drive A.
2. Place a blank disk in Disk Drive B.
3. Close both disk drive doors.
4. After the prompt "A>" type "FORMAT B: /S" and press the return key.
 Note: the "/S" portion of the DOS Format Command instructs the computer to copy the Operating System onto the disk being formatted. This will allow the user to boot the Operating System without the use of the DOS Disk during future operations (see Note 1).
5. Follow the cues.
 . . . the prompt "A>" will return when the blank disk has been formatted.
6. Label the newly formatted disk "MICRO-PS WORKING COPY".

COPYING A FILE

1. Place the MS DOS Disk in Disk Drive A and your Working Disk in Drive B.

Note: the following procedures will copy a file on the disk in Drive A to the disk in Drive B.

2. Close both disk drive doors.
3. After the prompt "A>" type "COPY A:<filename> B:" and press the return key.

Note: in place of "<filename>" in the above command type the name of the file you wish to copy including the extension. For example, if you want to copy the file "EDLIN.COM" type "COPY A:EDLIN.COM B:".

4. The computer will cue you when the file has been copied.

COPYING A DISK

1. Place the original MICRO-PS Disk in Disk Drive A.
2. Place your Working Disk in Disk Drive B.
3. Close the doors on both disk drives.
4. After the prompt "A>" type "COPY A:*. * B:" and press the return key.

Note: this command will copy all the files on the disk in Drive A onto the disk in Drive B.

5. Follow the cues.
 6. Return the original MICRO-PS disk to its cover.
- . . . you now have a working copy of the MICRO-PS disk which should be used on all subsequent instructions.

EXECUTING A MICRO-PS KNOWLEDGE BASE

1. Place MICRO-PS Working Disk in Drive A.
2. After the prompt "A>" type "MICRO-PS <filename>" and press the return key.

Note: in place of "<filename>" in the above command type the name of the MICRO-PS Knowledge Base you wish to execute. For example, if you want to execute the Knowledge Base named "DEMO1" type "MICRO-PS DEMO1" and press the return key.

3. To stop the execution of a MICRO-PS Knowledge Base type "stop" after the MICRO-PS prompt "= ?".

CONSTRUCT/EDIT A KNOWLEDGE BASE USING EDLIN²

1. Place your MICRO-PS Working Disk into Disk Drive A. Ensure the disk drive door are closed.
Note: this procedures only works if the file "EDLIN.COM" and the file containing your Knowledge Base are on your working disk.
2. After the prompt "A>" type "EDLIN <filename>" and press the return key.
Note: in place of "<filename>" in the above command type the name of the Knowledge Base you wish to create/edit. For example, if you wish to create/edit a Knowledge Base named "First" type "EDLIN FIRST" and press the return key.
3. Use the Insert Lines Command (see EDLIN Command handout) to begin entering your first Knowledge Base. That is, type "I" after the EDLIN prompt ("*") and press the return key. The computer will automatically number the lines of your Knowledge Base.
4. For subsequent editing, any of the EDLIN commands (see EDLIN Command handout) may be executed by typing it after the EDLIN prompt ("*"). For example, to list an existing file type "L" after the prompt "*" and press the return key.
Note: the End Edit Command ("E") stores the file before returning to the Operating System. The Quit Edit Command ("Q") returns to the Operating System without storing the file WHICH COULD RESULT IN LOST WORK. Be careful!

TO PARSE A KNOWLEDGE BASE

1. Place your MICRO-PS Working Disk (with the new Knowledge Base) in Disk Drive A and close the door.
2. Follow the instructions for Executing A Knowledge Base listed above. For example, to parse the Knowledge Base First type "MICRO-PS FIRST" and press the return key.
3. The MICRO-PS Parser will display error messages as it attempts to execute the new Knowledge Base.
Note: an example of parsing a new Knowledge Base can be found in the Nagy text (Figure 5-21 p65).
4. Follow the cues.
Note: it will be helpful to have a printed copy of your Knowledge Base to refer to as it is being parsed.

PRINTING A KNOWLEDGE BASE

1. Ensure the printer is turned on (ON/OFF switch located on right hand side of printer), that it is connected to the computer you are using, and that it is not out of paper.
2. Place your MICRO-PS Working Disk in Disk Drive A and close the door.
3. While holding the Control Key ("Ctrl") press the letter "P".
Note: pressing the "Ctrl-P" keys simultaneously acts as a toggle switch to turn the printer's echo function on and off.
4. After the prompt "A>" type "TYPE <filename>", where "<filename>" is explained above.
Note: the DOS command "TYPE" can be used to display any file.
. . . the printer will echo whatever is displayed on the monitor.
5. Press "Ctrl-P" to exit the echo mode.
Note: the "PrtSc" key can always be used to obtain a hardcopy of the current display on the monitor ("PrtSc" works in conjunction with the "Shift" key).

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**EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE**

SUBJECT: SESSION VII - BUILDING A SMALL EXPERT SYSTEM, PART II

GOALS & OBJECTIVES

1. **Purpose.** To advance the students knowledge of the MICRO-PS expert system Tool and to provide the student an opportunity to start working on his/her first expert system while the instructor is immediately available for consultation.

2. Objectives

A. To advance the students knowledge of the MICRO-PS expert system Tool.

B. To provide the student an opportunity to begin working on his/her first expert system.

C. To continue to explore the difficulties associated with the development of an expert system through practical application.

COORDINATION

1. **Student Handouts.** None

2. Classroom Setup Requirements

A. Viewgraph

B. Twelve 16-bit microprocessors, printers and one projector (for the instructor) in specified classroom.

3. **IRC Support Requirements.** Computer setup.

LESSON OUTLINE

1. Lesson

A. Review DEMO1 (VG VI-13)

B. Attachments and The Attachment Section

1. General

- Attachments = groupings of text which can be "attached" to the various parts of MICRO-PS program to:
 - . provide information to user
 - . make your ES more usable and valuable to user
- first of the four sections in a MICRO-PS knowledge base (Attachments, Attributes, Rules, Action), only section not required in KB
- format same as other sections (will cover in a minute)
- two types of attachments = Nondeclared/Declared

2. Nondeclared Attachments

- "question" Attachment
 - . available even if knowledge base does not have an Attachment Section
 - . allows text to be attached to an attribute or value name in the Attribute Section = text displayed to user rather than name
 - . syntax/example (VG VII-1)
 - placed in Attribute Section
 - enclosed in square brackets
 - word "question" in lowercase followed by colon
 - each line of text, including question mark, enclosed in double quotation marks
 - text up to 79 characters including brackets
 - note use of commas and periods for value attachments (if more than 1 attachment, "question" Attachment first without punctuation between consecutive attachments)

3. Declared Attachments

- can "attach" text to names, values, and rules
- declare (names of) attachments (except "question" Attachments) in Attachment Section, text of attachment in other section(s)

- syntax/example (VG VII-2)
 - . name = 1 word of 10 letters/numbers with no punctuation
 - . maximums = 10 attachments, 3 per attribute/value/rule, 4 lines per, total text 100 lines
 - . in rules = follow rule name before "if"
 - . names must match declared name in Attachment Section
 - . note can provide user format for calling attachment and attachment name as part of "question" attachment

C. Some User Friendly Features

1. Many - for example:
 - ability to input any user command (ie, next, continue, stop, display, justify) at any prompt
 - parser error messages
 - many features can be used by KBA to increase
2. Error Detection
 - informs user when inappropriate value to question is chosen
 - example (VG VII-3)

D. More On Commands/Knowledge Base Structure

1. "message" Command Revisited
 - as greetings or instruction message
 - could be used to help user to decide usefulness of system or to issue instructions to user
 - example (VG VII-4)
 - . place in Action Section
 - . word "message" in lowercase
 - . each line enclosed in double quotation marks
 - . limit of 4 lines
 - . end with period, comma, or "endif"
2. "askfor" Command
 - used to display unattached attribute (not mentioned in any rule) to user
 - used in Action Section
 - syntax/example (VG VII-5)
 - . word "askfor" in lowercase
 - . attribute name matches
 - . end with period, comma, or "endif"
3. "justify" and "display" Commands
 - enables user to justify and/or display conclusions/advice, system will reply with

message that identifies the rule name and its final value (display command can then be use to display the appropriate rule)

- and/or KBA can use to increase user confidence in system
- syntax/example (VG VII-6)
 - . word "justify" and "display" in lowercase
 - . variable/rule name must be declared, match, and be determined by a rule in the Rules Section

4. Commands for Screen Control (VG VII-7)

a. Mark Command

- used in system which will be used repeatedly
- commands in Action Section before "mark" executed only once
- syntax = lowercase followed by comma, percent sign, period, or "endif"

b. Wait and Pause Commands

- used to control amount of information on screen
- syntax = ibid

c. Example = (see viewgraph)

5. "if-then-endif" and "if-then-else-endif" Structures

- used in Action Section like rule in Rule Section but consequent is a command or series of commands
- syntax/example (VG VII-8)
 - . attribute names/values must be declared and match
 - . consequent can have series of commands separated by commas
 - . last command followed by "endif"
 - . preferred method = complicated "if-then-else-endif" can be accomplished with series of "if-then-endif" statements (VG VII-9)

E. Demonstrate DEMO2 (VG VII-10)

F. Next Week - SESSION VIII - BUILDING A SMALL EXPERT SYSTEM, PART III

- lab session to afford student opportunity to write first expert system (review Computer Lab hours/procedures)

G. Lab Session = remainder of period for individual student study

2. **Demonstrations.** DEMO2 (Tom Nagy, Dick Gault, and Monica Nagy, Building Your First Expert System, Ashton-Tate Publishing Group 1985, pp72-95)

3. **Practical Exercises.** None

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**EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE**

SUBJECT: SESSION VIII - BUILDING A SMALL EXPERT SYSTEM, PART III

GOALS & OBJECTIVES

1. **Purpose.** To provide the student an opportunity to start working on his/her first expert system while the instructor is immediately available for consultation.
2. **Objectives**
 - A. To provide the student an opportunity to begin working his/her first expert system.
 - B. To continue to explore the difficulties associated with the development of an expert system through practical application.

COORDINATION

1. **Student Handouts.** None
2. **Classroom Setup Requirements**
 - A. Viewgraph
 - B. Twelve 16-bit microprocessors, printers and one projector (for the instructor) in specified classroom.
3. **IRC Support Requirements.** Computer setup.

LESSON OUTLINE

1. Lesson

A. Computer Lab Session

B. Next Week - SESSION IX - GUEST SPEAKER/DEMONSTRATION FROM
TITAN

2. Demonstrations. None

3. Practical Exercises. None

13.140-10/IG
SPRING 86

**EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES
INSTRUCTOR LESSON GUIDE**

SUBJECT: SESSION X - THE GAME AND THE PLAYERS

GOALS & OBJECTIVES

1. **Purpose.** To familiarize the student with the potential social, economic, and military implications as well as the possible utility of the field of artificial intelligence.

2. **Objectives.**

A. To introduce the game, the stakes and the players in what has been called the "war" for AI supremacy.

B. To give senior executives an appreciation for future potential application of artificial intelligence technology.

C. To explore current and future applications for this new technology with emphasis on future military applications.

COORDINATION

1. **Student Handouts.** None
2. **Classroom Setup Requirements.** Viewgraph
3. **IRC Support Requirements.** None

LESSON OUTLINE

1. Lesson

A. The Game

1. The Fifth Generation Challenge

- issued in autumn 1981 by Japanese Ministry of Internal Trade and Industry (MITI) by launching Institute for New Generation Computer Technology (ICOT)
- initial \$2 million 1982 budget, \$450 million 10 year program
- goal = Knowledge Information Processing System (KIPS)
- spring 1982 = 40 computer "whiz kids" (average age 30) started work
- March 1983 = Edward A. Feigenbaum and Pamela McCordick published "The Fifth Generation, Artificial Intelligence and Japan's Computer Challenge to the World" publicizing challenge
- Japanese government total allocation of capital for computer development = \$4.57 billion

2. At stake

- war in AI supremacy will be won between now and end of 20th century
- domestic sales, jobs, prestige
- implication to national defense . . .
- value of the market (VG X-1)
- could revolutionize both warfare and civilian economy in next century

3. The Response

- National Corporate Research Act of 1984 = timely relaxation of real and perceived barriers to corporate research
- sweetener = 25 percent tax credit giving companies incentive to bolster high tech R&D
- total U.S. high tech R&D budget
 - 1983 \$ 6 billion (mostly companies, IBM, DEC, etc)
 - 1984 97 billion (IAW National Science Foundation)
 - 1985 107 billion (IAW Battelle Memorial Institute)
- applicability of AI to military significant, DOD plays single most influential role setting advanced computer goals and establishing R&D projects
 - 1984 50% of \$104 million in federal funding for

basic computer research from DOD
60% of \$146 million for applied computer
research from DOD

B. The Players (VG X-2)

1. ICOT - Institute for New Generation Computer Technology

- already discussed Japanese Fifth Generation Project
- eight companies, heavily supported by government
- Hitachi, Nippon Electric, Mitsubishi, Sharp, Toshiba, Fujitsu, Oki
- Japanese goal both social and economic
- promised approximately \$42 million/year, actual:
 - . 1984 \$22 million
 - . 1985 \$20 million
 - . 1986 estimate \$21 million

2. MCC - Microelectronic and Computer Technology Corporation

- created to maintain U.S. technology preeminence and international competitiveness in microelectronics and computers
- consortium of approximately 21 U.S. companies including Boeing, Eastman Kodak, Martin Marietta, 3M, NCR, Control Data, Digital Equipment
- founded Jan 1983, approximately 350 employees
- CEO = ADM Bobby R. Inman, USN (ret)
- governed by Board of Directors composed of representatives of each shareholder company
- stockholder companies have exclusive rights to proprietary information for 3 years then MCC license rights to other users
- corporate objectives (VG X-3)
- programs = four long-range advanced technology programs are intended to make significant technology advances within 5-10 years (VG X-4)
 - . PACKAGING = advance the state-of-the-art in semiconductor packaging and interconnect technology
 - . SOFTWARE TECHNOLOGY = develop new techniques, procedures, and tools that can be used to improve the productivity of the software development process 1-2 orders of magnitude
 - . VLSI/COMPUTER-AIDED DESIGN = improve computer-aided design technology and develop an integrated set of tools that can have

particular application to complex systems and the very complex VLSI chips from which they will be built

- . ADVANCED COMPUTER ARCHITECTURE = the most complex and ambitious program, 10-year effort will focus on:
 - PARELLEL PROCESSING = develop languages and architectures to allow computers to perform tasks simultaneously instead of sequentially
 - DATABASE SYSTEM MANAGEMENT = improve database design, storage methods, and capacities to permit flexible storage and faster retrieval of broader range of complex information
 - HUMAN FACTORS TECHNOLOGY = improve man-machine interface using improved voice or character recognition or natural language
 - AI/KNOWLEDGE-BASED SYSTEMS = develop new ways to represent human knowledge and thought concepts as well as new engineering models and tools to apply human expertise to wide range of problems
- . all programs are interrelated and focus upon the last, most important program: artificial intelligence

3. DARPA - Defense Advanced Research Project Agency

- founded as ARPA in 1958 (result of Sputnik) with mission to ensure U.S. would never again be caught so flat-footed by an adversary
- approximately 125 employees, no labs, relative small budget
 - . 1985 \$700 million
 - . 1986 estimate \$776 million
- venture capitalists of the Defense Department
- sets pace and direction for development of future computer technology by distributing funds to university, company and national laboratories
- MIT computer professor (Dertouzos), "70-80 percent of major discoveries in comuter science can be traced to DARPA"
- success = phased-array radar, composite materials, laser holograghy forward-swept-wing aircraft
- Strategic Computer Initiative
 - . 10 year R&D push in specific computer technologies that would eventually find use in wide spectrum of military (and civilian) engineering
 - . AND develop massive infrastructure of

- distributed research centers, supporting agencies, databases, networks, project managers
- . AND to build massively parallel VLSI-based computer eventually with GaAs in next 10 years (gallium arsenide = low power, high speed, radiation hardness)
- . MORE ABOUT SCI IN A MINUTE

4. Others

a. U.S. Governments and Agencies

- federal government
 - . establishing four national supercomputer centers
 - . Cornell, Princeton, U. of Ill, and U. of Calif in San Diego
- National Security Agency . . .
- Microelectronics Center of North Carolina (MCNC)
 - . state effort of approximately \$43 million
 - . Neighboring industries contributing to total budget through 1985 of \$50 million
 - . target = VLSI design system, advanced silicon wafer fabrication facility, fast prototyping capacity for building experimental architecture

b. Individual Companies, Consortia and Joint Ventures

- IBM = \$2.5 billion in 1983 for R&D
- IBM, EXXON, AT&T and Lockheed cooperating to construct supercomputer
- Semiconductor Research Cooperative (SRC)
 - . founded 1981
 - . IBM, DEC, Burroughs, Control Data, GE, Intel, Westinghouse Electric, Xerox, others
 - . 1984 budget greater than \$13 billion for "pure research"
 - . over 50 contracts with 30 universities, 100 faculty, 125 graduate students working
 - . research areas = microstructure science, system components, design tools, new approaches to manufacturing and engineering

c. Other Governments

- ESPRIT - European Strategic Programme for Research and Development
 - . fully underway in 1984
 - . Common Market funds for knowledge engineering
 - . bidding agreements for programs must include members from at least two European countries
- Alvey Computer Research Program
 - . British government + member companies
 - . Science and Engineering Research Council, and Departments of Industry and Defense
 - . \$500 million, 5 year program (British government = \$300M, member companies = \$200M)
 - . target = VLSI, software engineering, intelligent knowledge-based systems, and user-friendly interfaces
- Germany
 - . \$40 million per year
 - . 50/50 between government and industry
- Agency for Information Technology
 - . French government "pure research"
 - . approximately \$15 million first year
 - . software engineering, workstation, and computer-aided design for VLSI
- Soviets
 - . late 1983 = 3rd 5 year plan for computing
 - . initially \$100 million
 - . collaboration with USSR and 6 East European partners in Council for Economic Mutual Assistance
 - . claim civilian activity and not a military initiative
 - . pointed at fifth generation computing

C. Potential Military Applications

1. Types of Intelligent Weapons and Battle Management Aids

- collaborative
 - . = closely assist human operators
 - . example = fighter co-pilot, battle management
 - . advantages = tireless, relieve human of mundane tasks, no bad days, faster

- autonomous
 - . = function without human intervention
 - . example = smart bomb/cruise missile
 - . advantages = survivability (in hostile, high radiation environment)
 - . disadvantage = danger of completely autonomous system

2. Potential Application (VG X-5)

3. Problems to Overcome (VG X-6)

4. Case Study = DARPA's Strategic Computer Initiative

- goal = set of specific military applications that exploit new generation computing technology (VG X-7)
- funding between \$600 million to \$1 billion (VG X-8)
- three projects
 - . AUTONOMOUS LAND VEHICLE (VG X-9)
 - autonomous vehicle to support deep-penetration reconnaissance, rear area re-supply, ammunition handling, and weapons delivery
 - . PILOT'S ASSOCIATE SYSTEM (VG X-10)
 - combat pilots personal assistant
 - . NAVAL BATTLE MANAGEMENT SYSTEM (VG X-11)
 - battle management system to aid in management of large enterprise

D. Next Week = SESSION XI - The Military's Role in the Future of AI

- Guest Speaker from DARPA

2. Demonstrations. None

3. Practical Exercises. None

13.140-12/IG
SPRING 86

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

INSTRUCTOR LESSON GUIDE

SUBJECT: SESSION XII - COURSE SUMMARY

GOALS & OBJECTIVES

1. **Purpose.** To explore the future of AI and expert systems, and to review and critique this course.
2. **Objectives**
 - A. To make sense of the claims, promises, and realities of future AI applications.
 - B. To explore future applications for this new technology.
 - C. To impart an understanding of and appreciation for future capabilities and limitations of expert computer systems.
 - D. To review and critique the course.

COORDINATION

1. **Student Handouts.** None
2. **Classroom Setup Requirements.** None
3. **IRC Support Requirements.** None

LESSON OUTLINE

1. Lesson

A. Advantages and Disadvantages of AI (Software A&E 1985)

- Comparison of Natural and Artificial Intelligence (VG XII-1)
- Human vs Computer Problem Solving (VG XII-2)

B. Future of Knowledge Systems (Paul Harmon, David King 1985)

- The Computer EVOLUTION (vice revolution) (VG XII-3)
- Applications in the 1980's (VG XII-4)
- Market Impact of Different Types of Systems (VG XII-5)
 - . Large, hybrid and narrow systems
 - . Professional workstations
 - . Small-scale systems
 - Smart generic software (Tools, off-the-self)
 - Smart hardware (integrated in lab testing, diagnosis)

C. Preparing for the Knowledge System Revolution

- keep abreast of state-of-the-art
- push technology when chance arises

D. Course Highlights (VG XII-6)

1. Phase 1 = Introduction and Overview

- hardware/software, bits/bytes
- algorithm/Von Neumann architecture
- state-of-the-art (VHSIC, CD, natural language interface, expert systems)
- AI family tree
- meet "Eliza"
- data-based systems (DBMS/MIS/DSS) and knowledge-based systems (natural language, expert systems)
- languages, Tools, systems
- existing systems = demonstrations of Expert Ease and SYSEX
- Navy Lab tour

2. Phase 2 = Developing an Expert System

- problem suitability and feasibility, goals
- six steps

- case study = XCON
- built small expert system using MICRO-PS
- TITAN demonstration

3. Phase 3 = The Worldwide Challenge

- the challenge, stakes, response
- players = ICOT, MCC, DARPA, others
- military applications
- case study = DARPA's SCI
- guest lecturer = DARPA

4. Phase 4 = Course Summary

E. Review of Course Objectives (VG XII-7)

F. Course Critique

2. **Demonstrations.** None

3. **Practical Exercises.** None

1. This and subsequent procedures will assume that the Operating System has already been booted.

2. A MICRO-PS Knowledge Base may also be constructed using any Wordprocessing Program that will create an ASCII file.

EXPERT COMPUTER SYSTEMS FOR GOVERNMENT EXECUTIVES

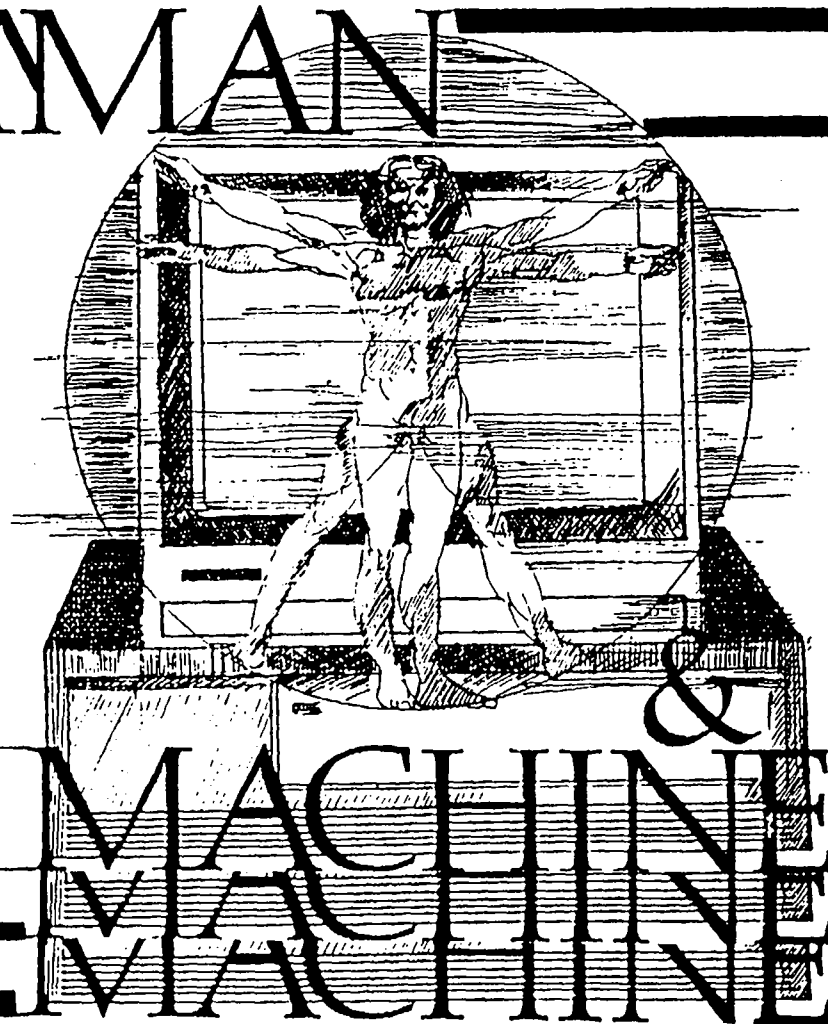
LIST OF VIEWGRAPHS

SESSION NUMBER/DODCI NUMBER	TITLE (Source)
I	
1/1026	Expert Computer Systems for Government Executive
2/1027	Course Objectives
3/1028	Why Study Computer Science?
4/1029	Block Diagram of a Computer
5/1030	Evolution of the Computer
6/1031	Definition of Artificial Intelligence
7/1032	The AI Family Tree
8/1033	History of AI (Harmon Table 1.1 p4)
9/1034	So What's all the Hoopla about AI?
10a-c/ 1035, 1090-1091	Current Applications of AI
11/1036	Potential Applications of AI
12/1037	Technical Hurdles Yet to Overcome
II	
1/1038	Computer Aided Decision Making
2/1039	. . . By Any Other Name . . .
3/1040	Goals of Expert Systems
4a-c/ 1041-1043	Common Properties, Characteristics and Features of Expert Systems
5/1045	Overview of Human Information Processing System (Harmon Fig 3.1 p23)
6/1046	Divergent and Convergent Reasoning
7/1047	Definition of Expertise
8/1048	Architecture of Knowledge-based Expert Systems (Harmon Fig 4.1 p34)
9/1049	Knowledge Base Knowledge
10/1050	Strategies for Representing Knowledge
11/1051	Semantic Network (Harmon Fig 4.2 p36)
12/1052	Object-Attribute-Value Triplet (Harmon Figs 4.4, 4.6, and 4.7 p39-40)
13/1053	Rules (Harmon p42 bottom)
14/1054	Frames (Harmon Fig 4.12 p44)
15/1055	Semantic Nets, O-A-V Triplets and Frames (Harmon Fig 4.15 p47)
16/1056	Inference Engines Search Strategies (Harmon Fig 5.7 p57)
17/1057	Problem Domain of Existing Knowledge Engineering Techniques (Harmon Fig 5.8 p59)

III	1/1058	Levels of Software (Harmon Fig 7.1 and 7.2 p80-81)
	2/1059	Tools for Building Expert Systems
	3/1060	Advantages of Expert Tools
	4/1061	Typical Consultation Paradigms (Harmon Fig 8.3 p95)
	5/1062	Problem Solving Strategies (Harmon Fig 8.1 p93)
V	1/1063	Suitability of Expert System Techniques
	2a-b/	Expert Systems Can . . .
1064-1065	3/1066	Application Constraints
	4/1067	Critical Aspects of a Problem
	5/1068	Building a Small Expert System
	6/1089	Overview of the Development of XCON (Harmon Fig 10.1 pl56)
VI	1/1092	An Expert System
	2/1093	Hallmarks of an Expert System
	3/1094	How Attachments Work (Nagy Fig 5-1 p39)
	4/1095	Most Suitable Applications
	5/1096	Design Steps
	6/1097	Attribute Hierarchy for DEMO1 (Nagy Fig 5-5 p48)
	7/1098	Action Flow Chart for DEMO1 (Nagy Fig 5-6 p49)
	8/1099	Nonnumeric Attribute Syntax & Example (Nagy Fig 3-1 pl89, Example 3-2 pl90)
	9/1100	Attribute Section of DEMO1 (Nagy Fig 5-7 p51)
	10/1101	Illegal Keywords and Characters for MICRO-PS (Nagy Figs 5-8, 5-9 p52)
	11/1102	Rational Indicators and Connectors
	12/1103	Rule Syntax & Example
	13/1104	DEMO1's Knowledge Base (Nagy Fig 5-22 p68-69)
	14/1105	Command Syntax & Examples

- VII 1/1106 Question Attachment Syntax & Example
 (Nagy Figs 6-8, 6-9 p79+)
 2a-b/ Declared Attachments Syntax & Examples
1107-1108 (Nagy Example 2-6 p185-187+)
 3/1109 Example of Error Detection (Nagy Fig 6-1 p73)
 4/1110 Message Command Syntax & Example
 (Nagy Figs 6-3, 6-4 p75+)
 5/1111 Askfor Command Syntax & Example
 (Nagy Example 5-1 p228-229+)
 6a-b/ Justify Command Syntax & Example
1112-1113 (Nagy Figs 6-13, 6-14, 6-15 p83-87-)
 7a-b/ Mark, Wait, and Pause Commands Syntax & Example
1114-1115 (Nagy Example 5-11 p253-254+)
 8/1116 If-then-else-endif Structure Syntax & Example
 (Nagy Example 5-4 p233-234+)
 9/1117 If-then-endif Structure
 (Nagy Example 5-5 p234-235)
 10a-d/ DEMO2 Knowledge Base (Nagy Fig 6-19 p91-95)
1118-1121
- X 1/1069 Value of AI Market
 2/1070 The Players
 3/1071 MCC's Corporate Objectives
 4/1072 MCC's Programs
 5/1073 Military Applications
 6/1074 Problems to Overcome
 7/1075 DARPA's SCI Program Structure and Goals
 8/1076 DARPA's SCI Cost Summary
 9a-d/ DARPA's Autonomous Land Vehicle
1077-1080
 10/1081 DARPA's Pilot's Associate System
 11a-b/ DARPA's Naval Battle Management System
1082-1083
- XII 1/1084 Comparison of Natural and Artificial
 Intelligence (Building Expert Systems p6-6)
 2/1085 Human vs Computer Problem Solving
 (Building Expert Systems p6-7)
 3/1086 The Computer EVOLUTION
 4/1087 Applications in the 1980's (Harmon Fig 14.1 p228)
 5/1088 Market Impact of Various Types of Systems
 (Harmon Fig 14.2, 3, and 4 p229, 232)
 6/1188 Course Highlights
 7 Course Objectives (see VG I-2)

**ARTIFICIAL
INTELLIGENCE
and
EXPERT SYSTEMS**



DODCI 1026-85

COURSE OBJECTIVES

- TO INTRODUCE THE RAPIDLY DEVELOPING FIELD OF PRACTICAL ARTIFICIAL INTELLIGENCE EMPHASIZING THE MOST SUCCESSFUL AREA OF PRACTICAL APPLICATIONS—KNOWLEDGE BASED EXPERT COMPUTER SYSTEMS.
- TO DEFINE,CLARIFY AND MAKE SENSE OF THE CLAIMS,PROMISES AND REALITIES OF PRACTICAL AI APPLICATIONS.
- TO ACQUIRE AN UNDERSTANDING OF AND APPRECIATION FOR THE APPLICATION, CAPABILITIES AND LIMITATIONS OF EXPERT COMPUTER SYSTEMS.
- TO ACQUAINT SENIOR EXECUTIVES WITH THE STATE—OF—THE—ART IN COMPUTER TECHNOLOGY WHILE GIVING HIM/HER AN APPRECIATION FOR FUTURE POTENTIAL APPLICATIONS.
- TO EXPLORE THE DIFFICULTIES ASSOCIATED WITH THE DEVELOPMENT OF AN EXPERT SYSTEM.
- TO EXPLORE CURRENT AND FUTURE APPLICATIONS FOR THIS NEW TECHNOLOGY.

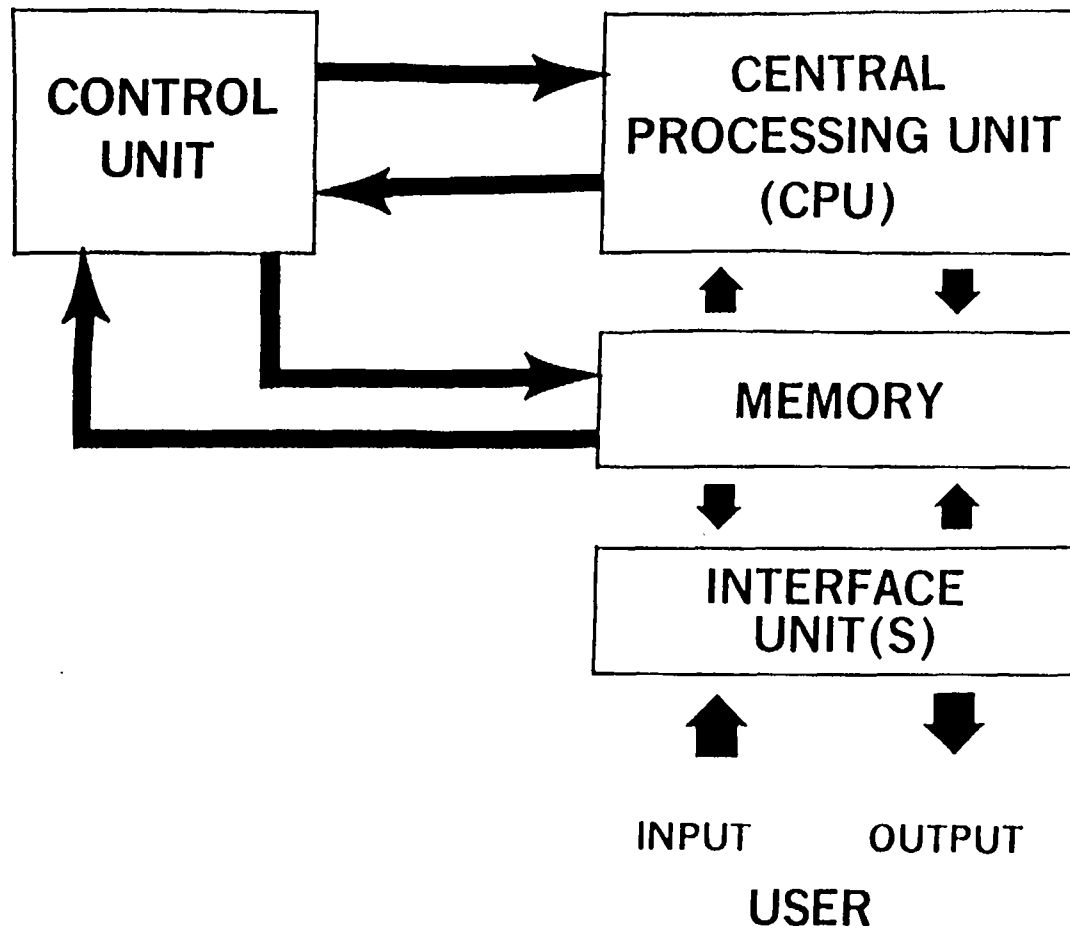
WHY MANAGERS SHOULD STUDY COMPUTERS

- TECHNOLOGY ILLITERACY vs EFFICIENT AND EFFECTIVE USE
- INFORMATION AGE-COMPUTER CAN BE ANYTHING FROM TOOL TO TERRORIST DEVICE
 - BUREAUCRATIC ITIOM-"INFORMATION IS POWER"
 - SUN TZU (IN THE ART OF WAR)-KNOWLEDGE IS POWER AND PERMITS THE WISE SOVEREIGN AND BENEVOLENT GENERAL TO ATTACK WITHOUT RISK.CONQUER WITHOUT BLOODSHED,AND ACCOMPLISH DEEDS SURPASSING ALL OTHERS"
 - DUELING COMPUTERS-MY PC-GENERATED ANALYSIS CAN WHIP YOUR PC-GENERATED ANALYSIS
 - ABILITY TO COLLECT INFORMATION HAS OUTSTRIPPED OUR ABILITY TO PROCESS IT
- KEEP FROM BECOMING A "HAS BEEN"
- ANSWER YOUR 10 YEAR OLDS QUESTION ABOUT "GIGAFLIPS"

DODCI 1028-85



BLOCK DIAGRAM OF A COMPUTERS



- **HARDWARE INTERFACE**
- CRT/KEYBOARD
- **SOFTWARE INTERFACE**
- HIGHER LEVEL LANGUAGES

DODCI 1029-85

FIVE GENERATIONS OF COMPUTER TECHNOLOGY

GENERATION	TIME PERIOD	TECHNOLOGY	COMPUTERS
FIRST	1948-1956	VACUUM TUBE 2 KBYTE MEMORY	ENIAC IBM 659 UNIVAC
SECOND	1957-1963	TRANSISTORS 32 KBYTE MEMORY	NCR 501 IBM 7094 CDC 6600
THIRD	1970's	INTEGRATED CIRCUIT 2 MBYTE MEMORY 5 MIPS ¹	DEC PDP-11 CRAY 1 CYBER 205 IBM 360/370
FOURTH	1980's	VLSI ² CIRCUIT 8 MBYTE MEMORY 30 MIPS ¹	CRAY XMP IBM 308 AMDAHL 580
FIFTH	1990's(?)	1 GIGA(BILLION) IPS or 1 TETRA(TRILLION)IPS ● VHSIC(VERY HIGH SPEED INTEGRATED CIRCUITS) ● PARALLEL ARCHITECTURE ● CONCURRENT LANGUAGES, FUNCTIONAL PROGRAMMING AND SYMBOLIC PROCESSING³	

¹ MIPS: MILLION(OR MEGA) INSTRUCTIONS PER SECONDS

²VLSI: VERY LARGE SCALE INTEGRATION

³SPEAK:SEE,PLAN AHEAD

DODCI 1030 85

ARTIFICIAL INTELLIGENCE. "A SUBFIELD OF COMPUTER SCIENCE CONCERNED WITH THE CONCEPTS AND METHODS OF SYMBOLIC INFERENCE BY A COMPUTER AND THE SYMBOLIC REPRESENTATION OF THE KNOWLEDGE TO BE USED IN MAKING INFERENCES. A FIELD AIMED AT PURSUING THE POSSIBILITY THAT A COMPUTER CAN BE MADE TO BEHAVE IN WAYS THAT HUMANS RECOGNIZE AS INTELLIGENT BEHAVIOR IN EACH OTHER"

(FEIGENBAUM and McCORDUCK)

DODCI 1031-85

EXPERT SYSTEMS

PROGRAMS THAT MIMIC THE
DECISION-MAKING AND
PROBLEM SOLVING THOUGHT
PROCESSES OF HUMAN EXPERTS.

VISUALIZATION SYSTEMS

MACHINES THAT CAN RELATE VISUALLY
TO THEIR ENVIRONMENTS AS
HUMANS CAN.

ROBOTICS

MACHINES THAT CAN MOVE AND
RELATE TO ASPECTS AS HUMANS CAN.

NATURAL LANGUAGES

SYSTEMS THAT TRANSLATE ORDINARY
HUMAN COMMANDS INTO LANGUAGE
COMPUTER PROGRAMS CAN UNDERSTAND
AND ACT ON.

THE AI FAMILY TREE

(ELISABETH HORWITT 1985)

DODCI 1032-85

HISTORY OF ARTIFICIAL INTELLIGENCE

PERIOD	KEY EVENTS
PRE—WORLD WAR II ROOTS	FORMAL LOGIC COGNITIVE PSYCHOLOGY
POSTWAR YEARS 1945-1954 PRE-AI	FIRST AI PAPERS
FORMATIVE YEARS 1955-1960 INITIATION OF AI RESEARCH	
YEARS OF DEVELOPMENT AND REDIRECTION 1961-1970 SEARCH FOR GENERAL PROBLEM SOLVERS	SMALL LABORATORY SYSTEMS FIRST PROTOTYPES EXPERT SYSTEM
YEARS OF SPECIALIZATION AND SUCCESS 1971-1980 THE DISCOVERY OF KNOWLEDGE-BASED SYSTEMS	WHOLE RANGE OF PROTOTYPE EXPERT SYSTEMS END OF DECADE-FIRST COMMERCIAL USES
THE RUSH TO APPLICATIONS 1981- INTERNATIONAL COMPETITION AND COMMERCIAL VENTURES	SEVERAL HUNDRED EXPERT SYSTEMS VENTURE CAPITAL HEAVILY INVESTED JAPANESE FIFTH GENERATION PROJECT

WHY AI NOW?

- TECHNOLOGY BECOMING AVAILABLE-LOWER COST/AWARENESS
- INCREASING COST OF HUMAN EXPERTS
- QUALITY IMPROVEMENTS ANTICIPATED-FEWER MISTAKES,
MORE CONSTANT
- NEED-ESPECIALLY FOR MILITARY APPLICATIONS
- SHORTCOMINGS OF CONVENTIONAL PROGRAMMING TECHNIQUES
(COMPATIBILITY WITH HUMAN PROBLEM SOLVING TECHNIQUES)
- MYSTIQUE -"SCIENCE MARCHES ON"
- SPIN-OFFS?

DODCI 1034-85

CURRENT APPLICATIONS OF AI

- **EQUIPMENT FAULT DIAGNOSIS**
- **INVESTMENT MANAGEMENT**
- **MILITARY TACTICS**
- **MEDICAL DIAGNOSIS**
- **CRISIS MANAGEMENT**
- **CLAIMS ASSESSMENT**
- **DISTRIBUTION PLANNING**
- **COMMODITY BROKER**
- **TECHNICAL TRANSLATION**
- **ENERGY MANAGEMENT**
- **VEHICLE SCHEDULING**
- **PROCESS PLANT MONITORING**

(TURNER 1985)

DODCI 1035-85

CURRENT APPLICATIONS IN AI

SOME EXPERT SYSTEMS

EXPERT SYSTEM	GENERAL FUNCTION	SPECIFIC AREA
MECHO	Analysis	Mechanical Problems
TECH	Analysis	Naval Task Force Threats
SPERIL	Analysis	Earthquake Damage Assessment
CRITTER	Analysis	Digital Circuitry
PHOENIX	Automatic Programming	Oil Well Log Modeling
PROSPECTOR	Data Analysis	Geology
DENDRAL	Data Analysis	Chemistry
CRYSLIS	Data Analysis	Protein Crystallography
ELAS	Data Analysis	Oil Well Logs
SYN	Design	Circuitry Synthesis
XCON/R1	Design	Computer System Configuration
SYNCHEM	Design	Chemical Synthesis
MEDAS	Diagnosis	Critical Care Medicine
DELTA	Diagnosis	Locomotive Troubleshooting
MYCIN	Diagnosis	Medical
DART	Diagnosis	Computer Faults
REACTOR	Diagnosis	Nuclear Reactor Accidents
INTERNIST/CADUCEUS	Diagnosis	Medical
XSEL	Intelligent Assistance	Computer Sales
CSA	Intelligent Assistance	Nuclear Power Plant Configuration
RAYDEX	Intelligence Assistance	Radiology
VISIONS	Image Understanding	Vision
IMS	Management	Automated Factory Management
CALISTO	Management	Project Management
NOAH	Planning	Robotics
OP-PLANNER	Planning	Erand planning
KNOBS	Planning	Tactical Mission Planning
MOLGEN	Planning	Molecular Genetics

CURRENT APPLICATIONS IN AI

Continued

SOME NATURAL LANGUAGE SYSTEMS

NATURAL LANGUAGE SYSTEM	GENERAL FUNCTION	SPECIFIC AREA
LADDER	Machine Translation/ Interfacing	Ship Identification & Location
SAM	Machine Translation/ Interfacing	Generic Story Understanding
TDUS	Interfacing	Electromechanical Repair
SHRDLU	Interfacing	Location & Manipulation of Three Dimensional Figures
EXPLORER	Interfacing	Map Generation & Display
INTELLECT	Interfacing	Data Base Management
NATURALLINK	Interfacing	Dow Jones Data Retrieval & Display
TEAMS	Generic Interfacing	Data Base Management
MARKETEER	Interfacing	Market Analysis
POLITICS	Inference Making	Ideological Belief System Simulation
BROKER	Interfacing	Standard & Poor's Data Base Management System
STRAIGHT TALK	Interfacing	Word Processing/ Microcomputer Workstations

DODCI 1091-85

POTENTIAL APPLICATION OF AI

- OFFICE AUTOMATION
- BANKING AND FINANCE
- INDUSTRY
- DEFENSE
- GOVERNMENT
- EDUCATION and TRAINING

(Mike Turner, 1985)

DODCI 1036-85

THE HURDLES TO BE OVERCOME

- **LACK OF PROCESSING POWER IN EXISTING COMPUTERS (VHSIC,PARALLEL PROCESSING?)**
- **"KNOWLEDGE-REPRENSENTATION" LANGUAGE (LISP,PROLOG?)**
- **INTERFACE (NATURAL LANGUAGE INTERFACE, KNOWLEDGE ENGINEERING?)**
- **EXPERTS UNWILLING TO IMPART THEIR EXPERTISE**

DAVID HARVEY 1984

DODCI 1037-85

Computer Aided Decision Making

Data-based System

- **Data Base Management System (DBMS)**
- **Management Information System (MIS)**
- **Decision Support System (DSS)**

Knowledge-based System

- **Natural Language System**
- **Expert System**

... BY ANY OTHER NAME ...

- **Knowledge-based Expert System**
- **Rule-based System (RBS)**
- **Intelligent Knowledge-based System**
- **Pattern-directed Inference System**
- **Production System**
- **Blackboard System**

(Mike Turner, 1985)

GOALS OF EXPERT SYSTEM

- **Substitute for unavailable human expert**
- **Assimilate knowledge of multiple human experts**
- **Train new experts**

(Paul Harmon, David King 1985)

Common Properties/Characteristics/ Features of Expert Systems

- **Properties:**

- **Incorporate human knowledge in conditional If-Then rules**
- **Skill increases at a rate proportional to enlargement of knowledge base**
- **Can solve wide range of complex problems by selecting relevant rules and combining results in appropriate ways**
- **They adaptively determine best sequence of rule execution**
- **Can explain conclusion by retracing lines of reasoning in natural language**

Common Properties/Characteristics/ Features of Expert Systems (Cont.)

- **Characteristics:**

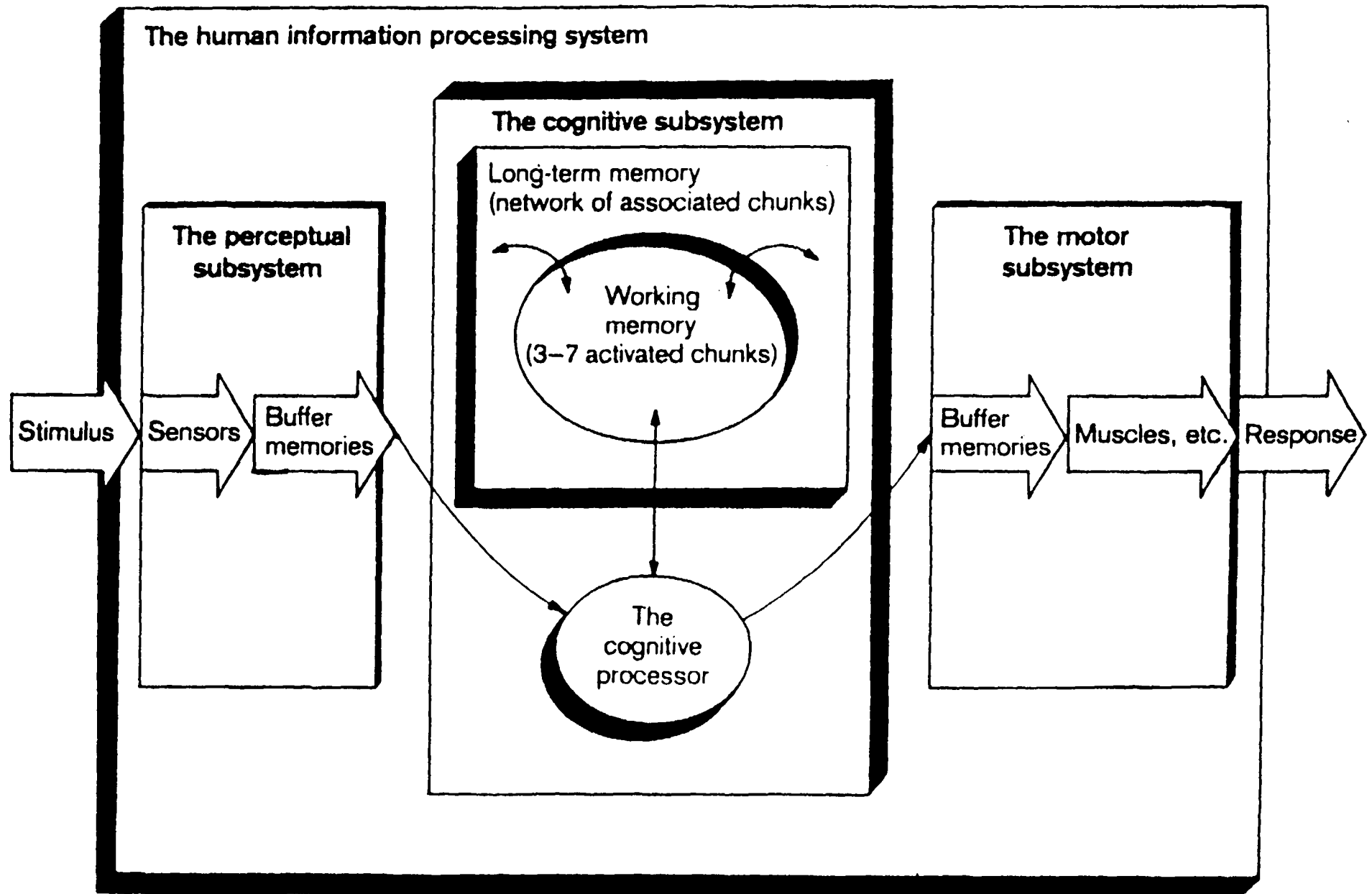
- Existing knowledge can be refined and new knowledge added (For incremental improvements in system performance)
- System able to explain reasoning (Making their logic practically transparent)

Common Properties/Characteristics/ Features of Expert Systems (Cont.)

- **Features :**
 - **Modular know-how**
 - **Knowledge base for storing rules/facts that determine decision**
 - **Capacity for incremental development with steady performance improvements**
 - **Explanation of results, lines of reasoning, and questions asked**
 - **Intelligibly encoded beliefs and problem-solving techniques**
 - **Inference chains assembled dynamically by built-in control procedures that can often perform efficient searches**

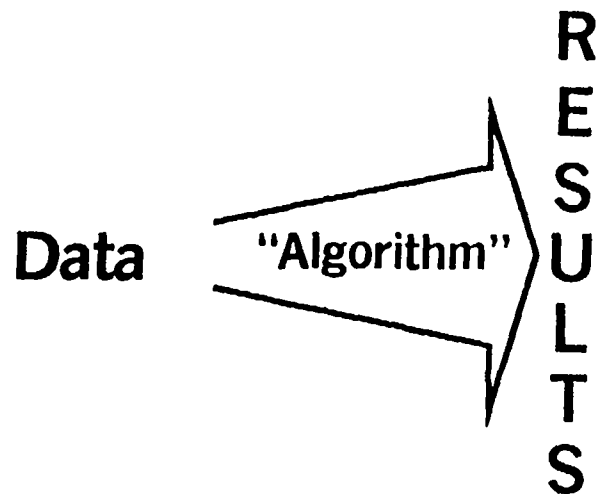
(Frederick Hayes-Roth 1985)

The environment



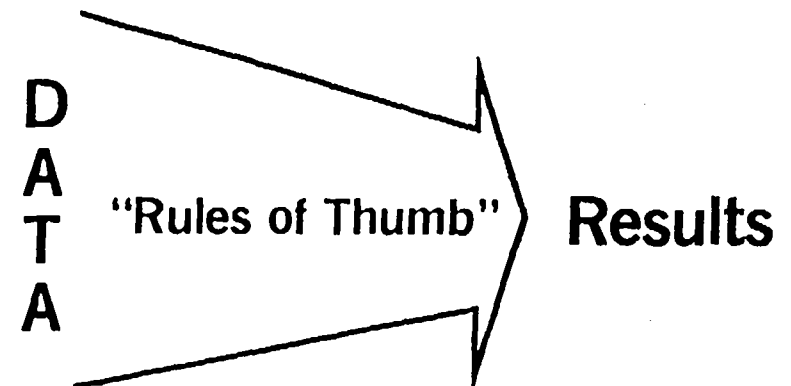
DODCI 1045-85

DIVERGENT VS CONVERGENT REASONING



Divergent Reasoning

- Small amount of data → Lots of results
- "Von Nuemann" Computer
- Example = Payroll Program



Convergent Reasoning

- Massive amount of data → Few results
- Parallel processing computer
- Example = A woman mulls a lifetime of romantic experience before answering her suitor's marriage proposal with a simple "yes".

DEFINITION OF EXPERTISE

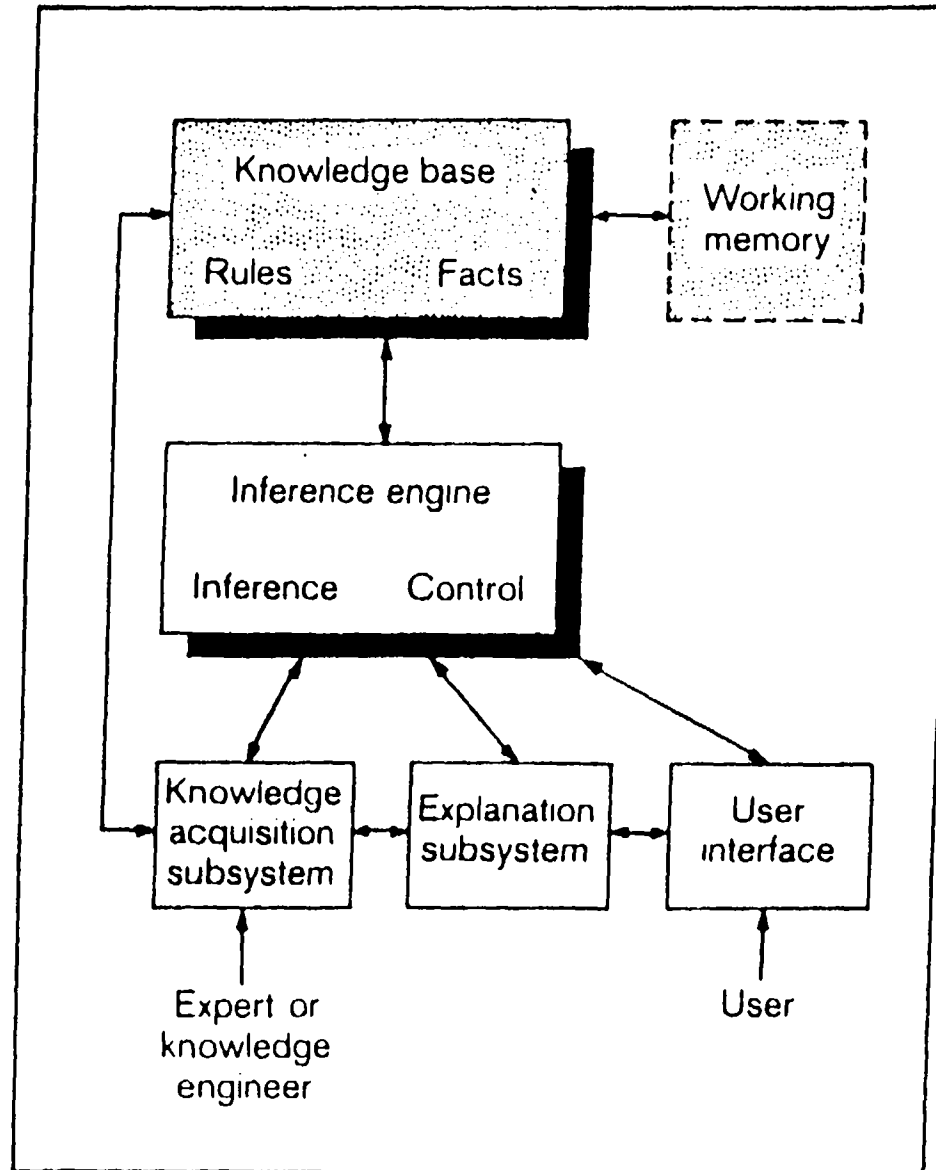
Human experts are:

- Problem solvers
- Explainers of results
- Learners from experience
- Knowledge structurers
- Rule seekers (if necessary)
- Relevance deciders
- Less motivated as knowledge runs out

(David Harvey, Mar. 84)

DODCI 1047-85

**The architecture of a knowledge-based expert system.
(The knowledge base is shaded for emphasis.)**



DODCI 1048-85

KINDS OF INFORMATION IN KNOWLEDGE-BASE

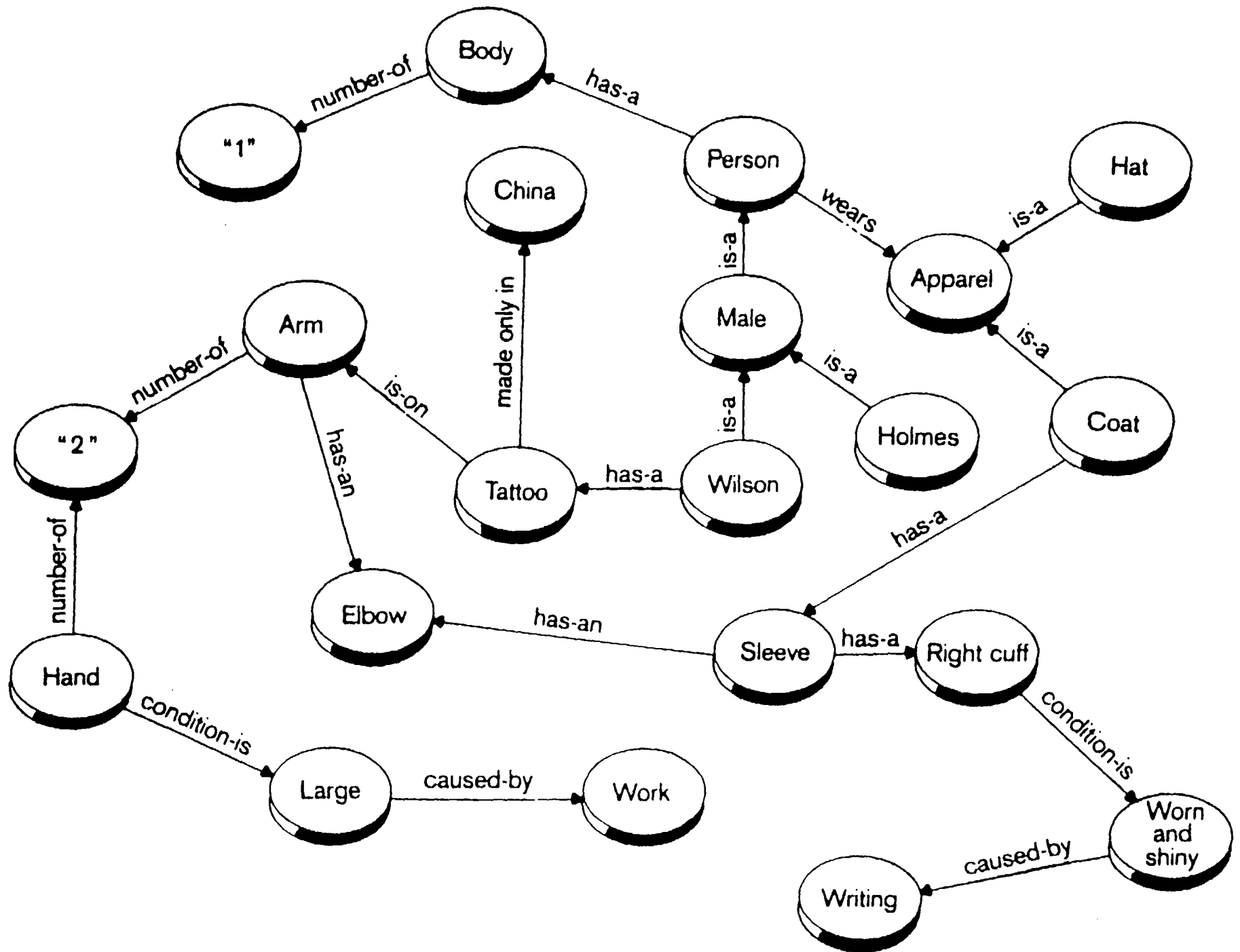
- Specific inferences that follow from specific observation
- Abstractions, Generalizations, and Categorizations of given data
- Necessary and sufficient conditions for achieving some goal
- Likeliest places to look for relevant information
- Preferred strategies for eliminating uncertainty or minimizing other risks
- Likely consequences of hypothetical situation
- Probable causes of symptoms

(Frederick Hayes-Roth 1985)

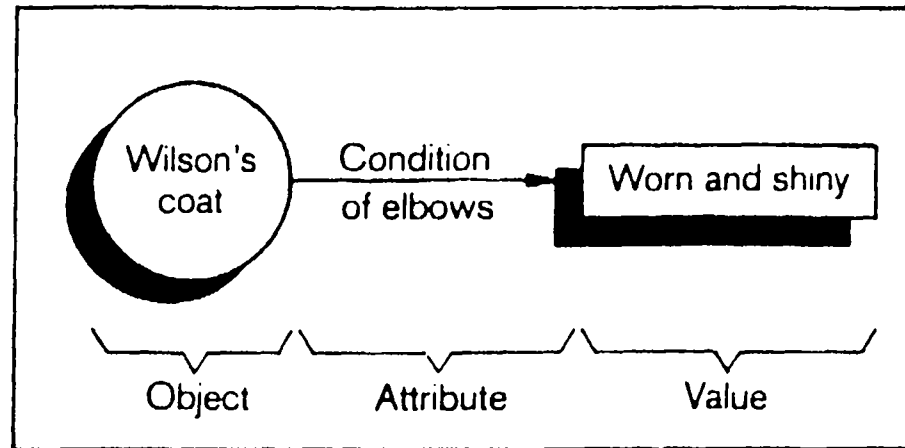
STRATEGIES FOR REPRESENTING KNOWLEDGE

- **Semantic Networks**
- **Object-Attribute-Value-Triplet**
- **Rules**
- **Frames**
- **Logical Expression**

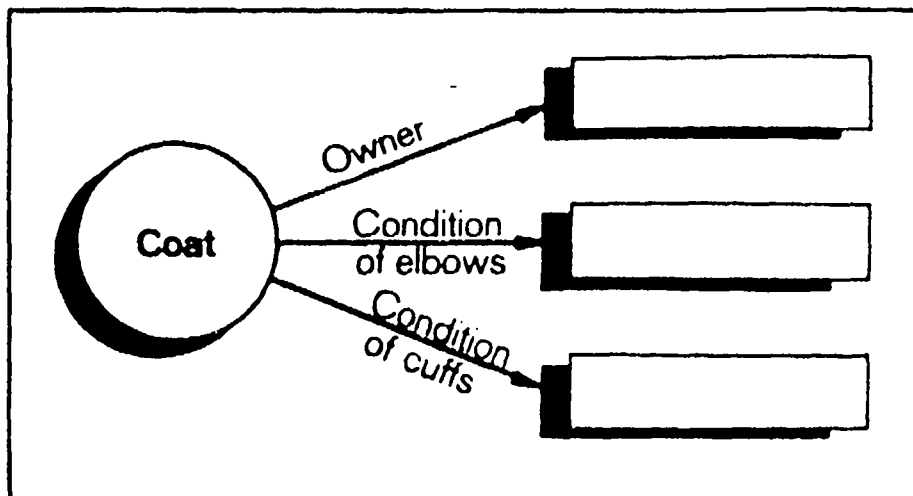
SEMANTIC NETWORK



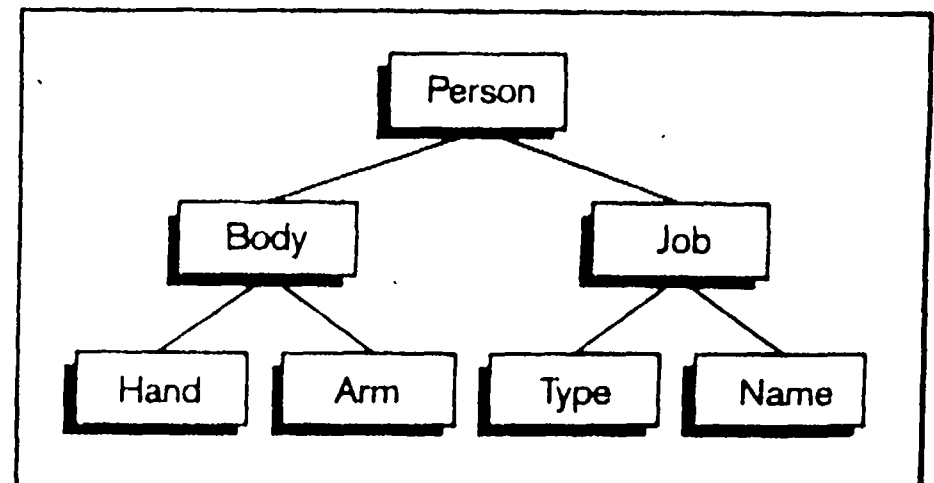
An object-attribute-value triplet.



The static portion of an O-A-V triplet.



Object tree for a detective's knowledge base. (No values have been assigned to any objects or attributes.)



Rule:

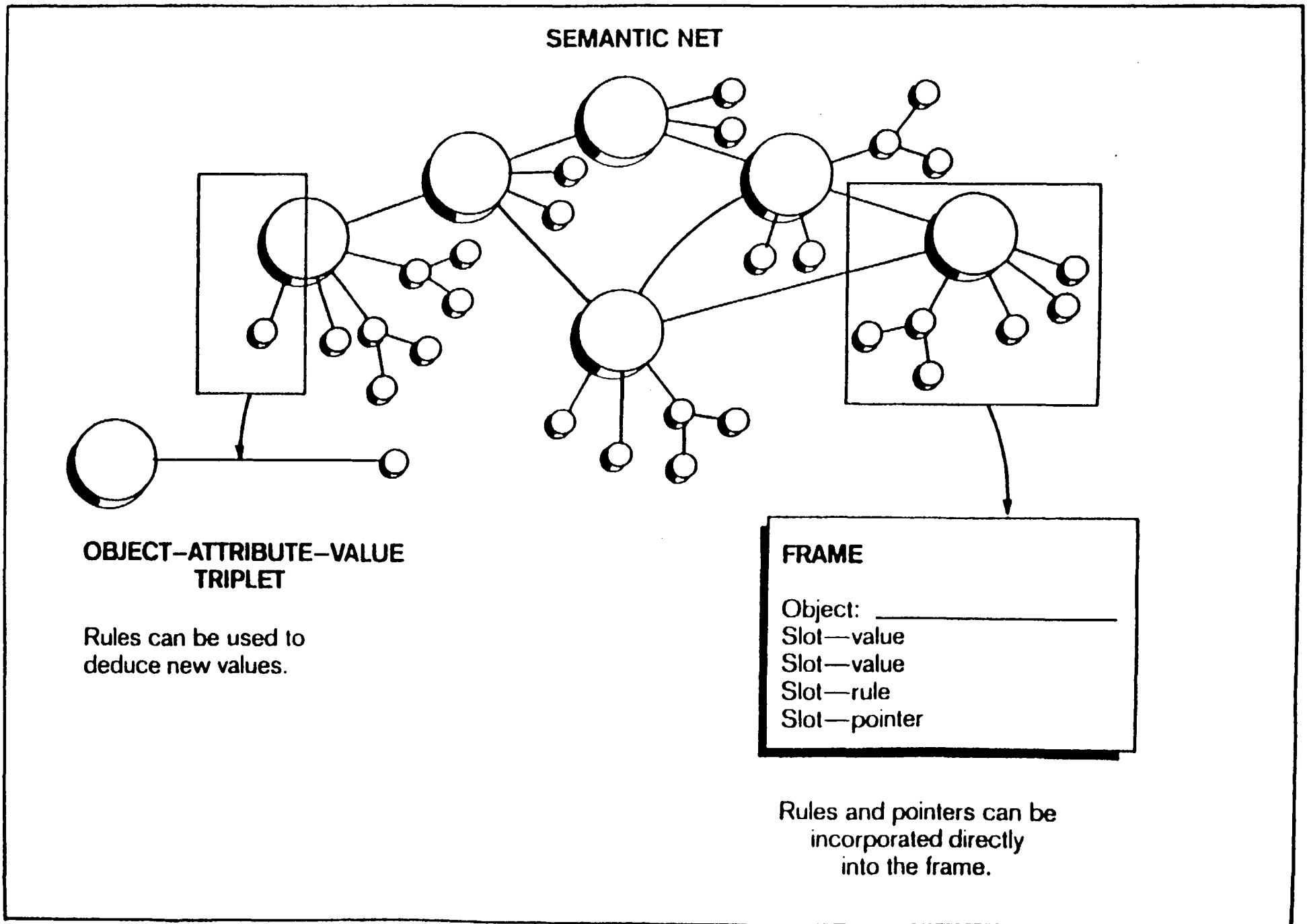
Premise { **If** the site of the culture is blood, and
the morphology of the organism is rod, and
the gram stain of the organism is gramneg, and
the patient is a compromised host,

Conclusion { **Then** there is suggestive evidence (.6) that the identity
of the organism is *Pseudomonas-aeruginosa*.

Frame for Wilson's coat.

COAT	
Slots:	Entries:
Owner	Wilson
Condition	Rumpled
Condition of cuffs	Worn, shiny
Condition of elbow	Worn, shiny
Number of arms	Default: 2
Fabric	Default: wool
Pockets?	Default: yes
Size:	If needed, find owner's height and weight, and compare to Table X.
Style:	If needed, find out collar:, pockets:, and length:; then look in Table Y.

Semantic nets, object-attribute-value triplets and frames.



Major categories of search strategies used by inference engines.

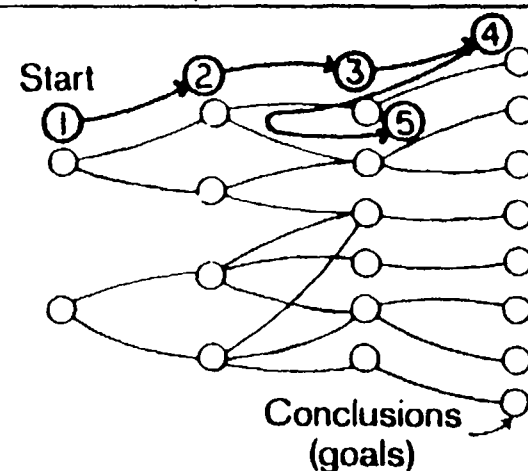
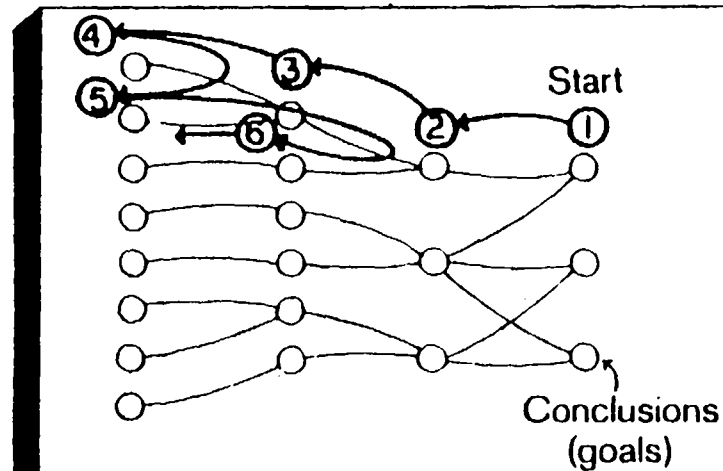
A

Backward chaining

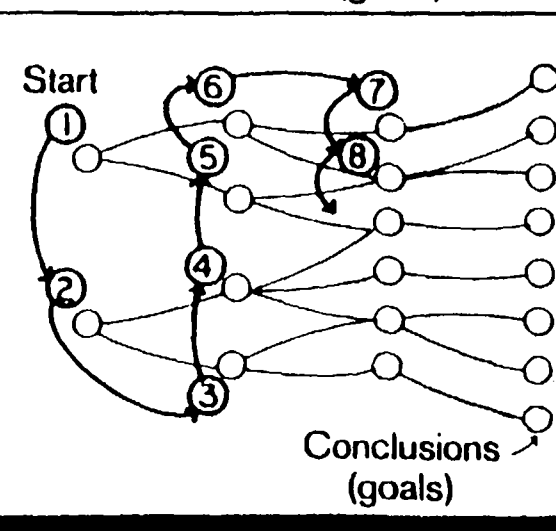
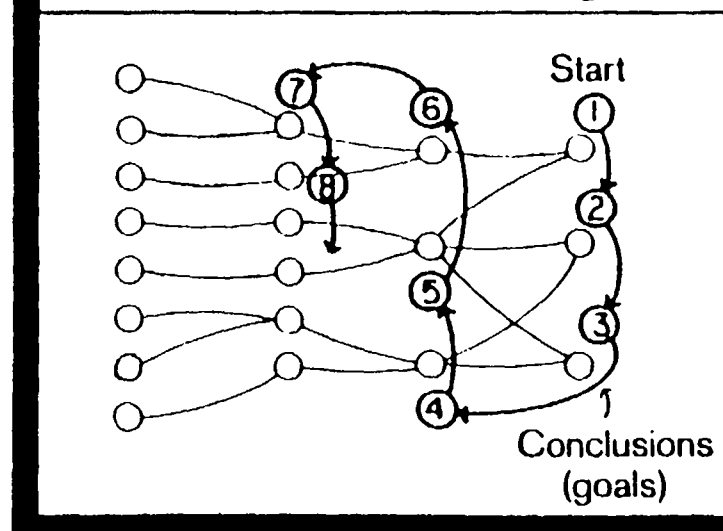
B

Forward chaining

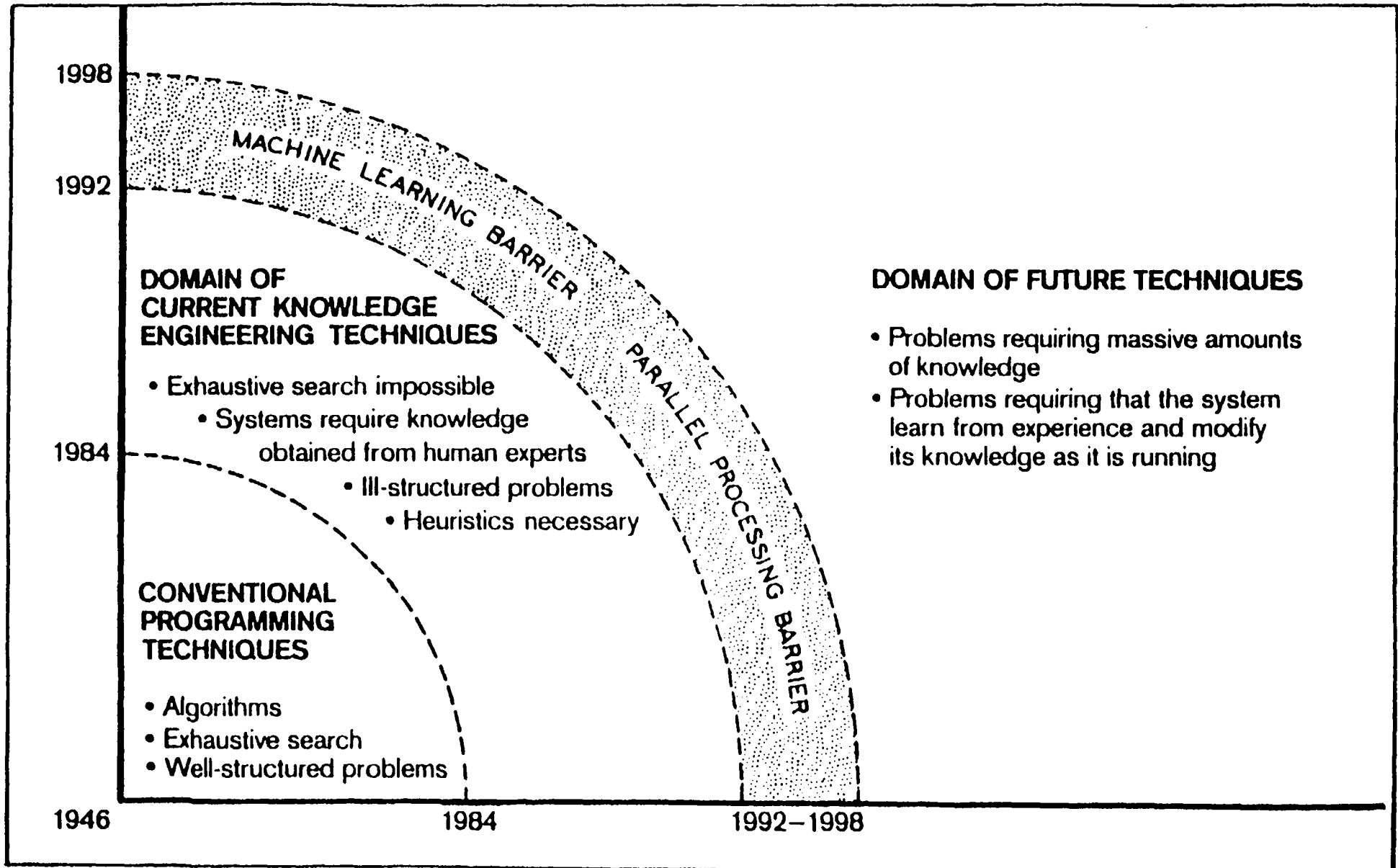
Depth-first search



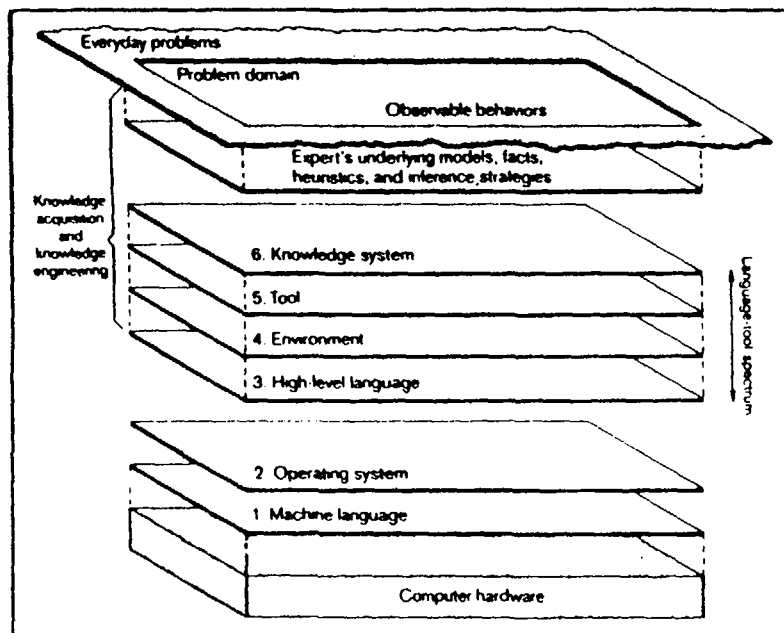
Breadth-first search



Problem domain of existing knowledge engineering techniques.

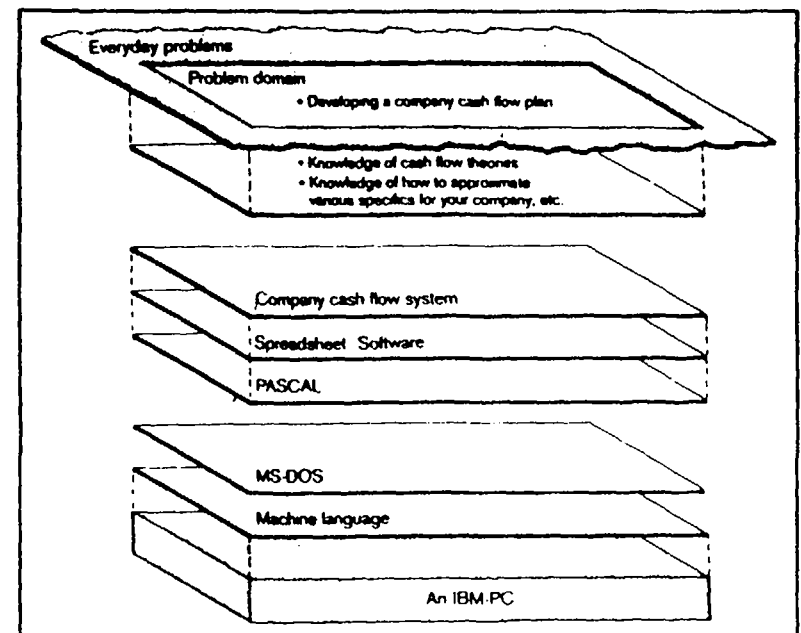


The six levels of software between human problems and computer hardware.



Knowledge-Based System

The levels of software between a company cash flow problem and a personal computer.



Data-Base System



TOOLS FOR BUILDING EXPERT SYSTEMS

- **Knowledge acquisition products**
- **Expert system shells (or tools)**
- **AI Languages and programming environments**

(Mike Turner 1981)

ADVANTAGES OF EXPERT SYSTEM TOOL OR SHELLS

- **Rapid System Development**
- **Lower Development Cost**
- **Contain specific techniques for**
 - Handling knowledge representations
 - Inference
 - Control
- **Help knowledge engineer to model particular class of problems**
- **Makes Expert System techniques available to less experienced users for small problems**

(Paul Harmon, David Key 1985)

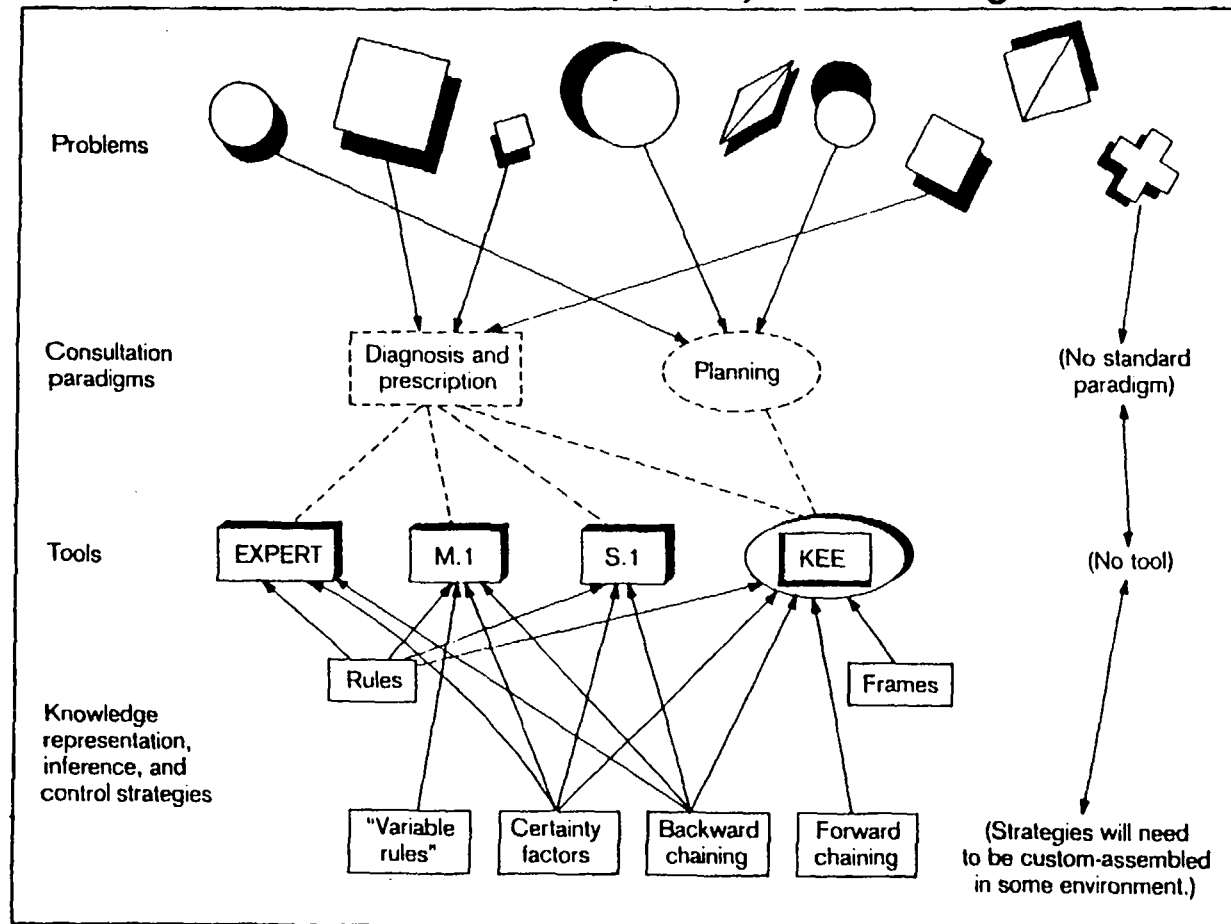
Consultation Paradigms Typical of Various Tools

Environment or Tool	Consultation Paradigm*		
	Diagnosis/ Prescription	Planning	Design
EMYCIN	●		
ES/P ADVISOR	●		
Expert-Ease	●		
INSIGHT	●		
M.1	●		
Personal Consultant	●		
EXPERT	●		
KES	●		
OPS5	●	●	
S.1	●		
TIMM	●		
ART	●		
KEE	●	●	
LOOPS	●		

- Filled circle indicates that the tool is good at the consultation.

DODCI 1061-86

Problems, paradigms, tools, and strategies.



DODCI 1062-86



SUITABILITY OF EXPERT SYSTEM TECHNIQUES

Positive Indicators

- **Not obviously doable using conventional techniques**
- **Maintenance and updating to be done by non-computer staff**
- **Explanation of conclusions required**
- **System's knowledge to be used in more than one way**
- **Knowledge maps more easily onto rules than equations**

Negative Indicators

- **Knowledge more available in algorithmic form**
- **Problem-solving methods can be completely specified in advance of implementation**
- **Problem adequately and efficiently solved using conventional techniques**

EXPERT SYSTEMS CAN. . .

Benefit

- Free experts for hard problems
- Provide surrogate experts
- Ensure Methodological/Exhaustive evaluation
- Explain particular conclusions
- Provide interface to complex systems
- Provide competitive edge

Examples

Processing tax returns

Equipment fault Diagnosis
Social Security Entitlements

Medical Diagnosis
Crisis handling

Any advising, predicting, planning
Diagnosing System

Battle management
Three Mile Island
DBMS

EXPERT SYSTEMS CAN. . .
Continued

Benefit

- **Make expertise explicit**
- **Reduce equipment cost**
- **Provide breadth of expertise**
- **Facilitate user Maintenance/Upkeep**
- **Disseminate knowledge**
- **Continuous concentration**
- **Eliminate individual bias/prejudice**
- **Teach**

Examples

Knowledge/Rare skills archiving

Robotics

Combine knowledge of several experts

Equipment monitoring

Application of regulations

"Steamer"



APPLICATION CONSTRAINTS

- **The source of the expertise
(usually a human expert)**
- **The problem characteristics**
- **The state of the available technology**

(Mike Turner 1985)

DODCI 1066-86

CRITICAL ASPECTS OF A PROBLEM

- **The reliability of the data and knowledge**
- **Time dependency of data**
- **The size of the search space**

(Mike Turner 1985)

DODCI 1067-86

BUILDING A SMALL EXPERT SYSTEM

- **Select a tool**
- **Identify the problem/analyze the knowledge**
- **Design the system**
- **Develop a prototype and test**
- **Expand test and revise system**
- **Maintain and update the system**

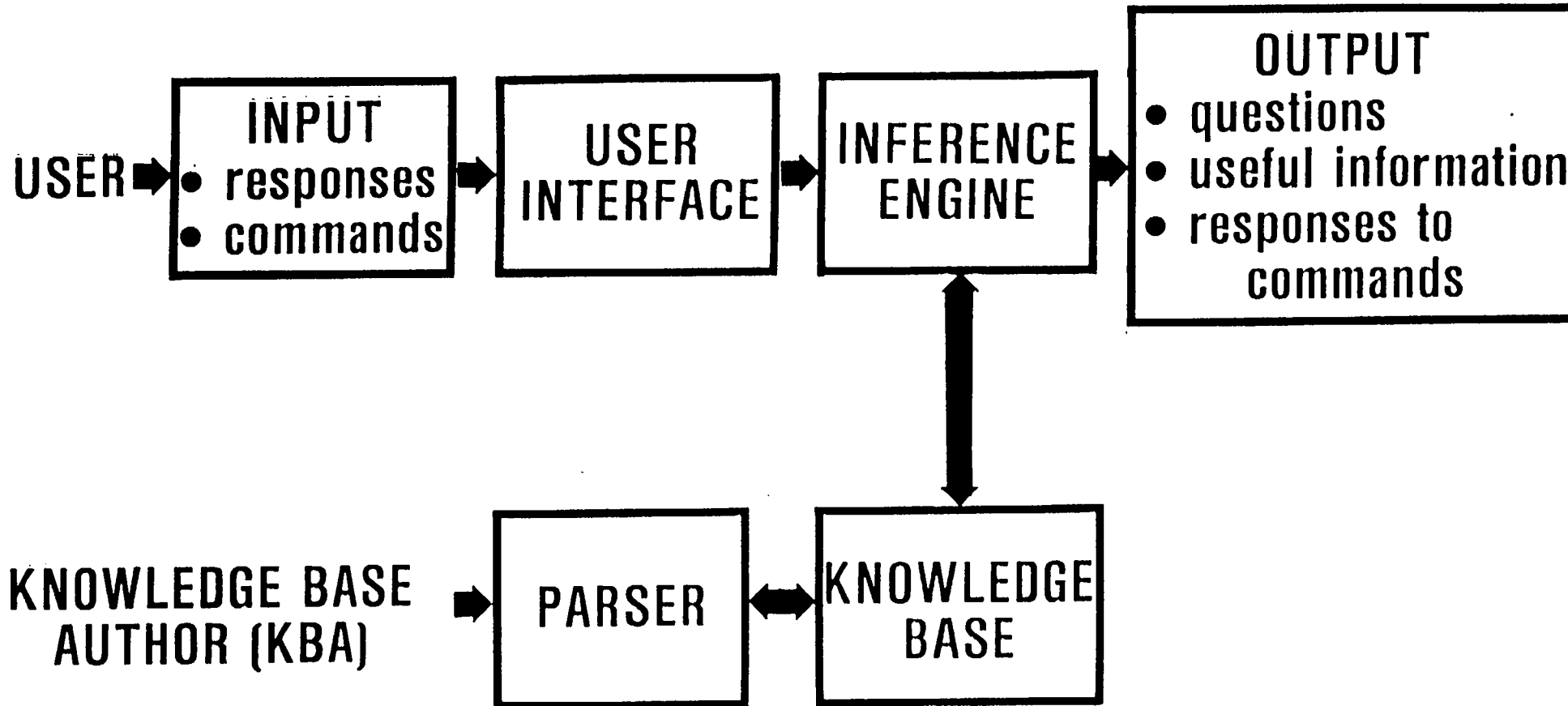
(Paul Harmon, David King 1985)

DODCI 1068-86

OVERVIEW OF DEVELOPMENT OF XCON

<u>STAGE</u>	<u>PERIOD</u>	<u>ACTIVITY</u>
1-Design/Prototype	Dec 78 - Apr 79	•Strategy for attacking problem developed •250 rule prototype developed
2-Development	May - Sep 79	•Build knowledge BASE (750 Rules) •Goal = Configure 75% of orders correctly
3-Validation	Oct - Nov 79	•XCON/Human performance comparisons (50 orders configured by XCON & 6 experts) •Mistakes (12) corrected
4-Implementation Planning	Jan - May 80	•Plans to integrate into DEC •Reimplemented XCON in OPS5
5-Implementation	Jun - Dec 80	•Integration plan implemented •Continued to improve knowledge base
6-Maintenance & Extension	Jun 81 - Present	•Use & maintenance of system

AN EXPERT SYSTEM





HALLMARKS OF AN EXPERT SYSTEM

- **RELIABILITY** —producing accurate and complete advice
- **INTELLIGENT QUESTIONING**
- **EXPLAINING AND JUSTIFYING ANY CONCLUSIONS OR
ADVICE**
- **REASONING WITH WORDS, NOT JUST NUMBERS**
- **USER FRIENDLINESS**

HOW ATTACHMENTS WORK

What is your file's extension?
[display definition(file extension)]

- 1) BAS
- 2) TXT
- 3) COM
- 4) THE FILE HAS NO EXTENSION
- 5) OTHER

= ? display definition(file extension)
DEFERRING CURRENT QUESTION [Type CONTINUE to resume question]
A file's extension consists of the characters to the RIGHT of the period in a file name. If your file name is statecap.bas then bas is the extension. If it is wordproc.com then the extension is com.



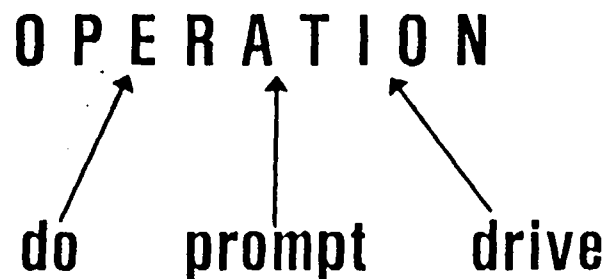
MOST SUITABLE APPLICATION

- TOPICS WHICH REQUIRE SPECIALIZED KNOWLEDGE
- SMALL, IMPORTANT TASK
- ORGANIZED SOURCE MATERIAL
- TESTABLE

DESIGN STEPS

- ANALYSIS
- DESIGN
- IMPLEMENTATION
- VERIFICATION

ATTRIBUTE HIERARCHY FOR DEMO1



Inferred Attribute
(value computed by
expert system)

Input Attributes
(values supplied by the user)

ACTION FLOW CHART FOR DEMO1

FLOWCHART

Obtain the Value of the inferred
Attribute, operation.

Display the Message: "The operation
or operations you need to do are:"

Display the Value of the Inferred
Attribute, operation.

MEANING

The OBTAIN command tells the inference engine to determine the value of the attribute with the name, operation. It does this by sending questions to the screen for the user to answer based on the rules.

The MESSAGE command sends the text of a message to the screen for viewing by the user.

The DISPLAY command retrieves the value of the attribute that the inference engine has determined and sends it to the screen for viewing.



NONNUMERIC ATTRIBUTE SYNTAX & EXAMPLE

SYNTAX:

attribute name
[attachments: "attachment text"]
(smlt): value-1, value-2, value-n.

EXAMPLE:

attributes:

ATTRIBUTE TYPES
(smlt): nonnumeric, integer.
...%

user session for this attribute would be:

ATTRIBUTE TYPES
1)NONNUMERIC
2)INTEGER

ATTRIBUTE SECTION OF DEMO1

attributes:

do

(smlt):

change default drive,
other.

◆ Keyword

◆ Attribute name

◆ Attribute value type

◆ Attribute values

prompt

(smlt):

a,
b.

◆ Attribute name

◆ Attribute value type

◆ Attribute values

drive

(smlt):

a,
b.

◆ Attribute name

◆ Attribute value type

◆ Attribute values

operation

(smlt):

cannot perform that now,
type a colon and hit enter key,
type b colon and hit enter key,
the default drive is ok so do not do anything

◆ Attribute name

◆ Attribute value type

◆ Attribute values

ILLEGAL KEYWORDS AND CHARACTERS FOR MICRO-PS

MICROPS Keywords that cannot be used in names.

endif
from
if
then
thru
to

Characters that cannot be used in names.

\ {} \$ @ # % * () ! - . ? / : ; ^ & = + < > = ~ \

RATIONAL INDICATORS & CONNECTORS

RATIONAL INDICATOR

=	equal
#	does not equal
ge	greater than or equal to
gt	greater than
le	less than or equal to
lt	less than

CONNECTORS

&(ampersand)	LOGICAL AND
/(backslash)	LOGICAL OR
,(comma)	CONNECTOR

RULE SYNTAX & EXAMPLE

SYNTAX:

(Rule Name)		-NAME
if (attribute name) (rational indicator) value 1,	}	-Antecedent
(connector) (attribute name) (rational indicator) value 2,		
... value n,		
then (attribute name) (rational indicator) value a,	}	-Consequent
(connector) (attribute name) (rational indicator) value b,		
... value z.		

EXAMPLE:

Consequent Location Status Rule

if Consequent Location = After Last Antecedent,
then Consequent Location Status = Proper.

Consequent Thenn Status Rule

if Consequent Thenn = Missing,
/ Consequent Thenn = Misspelled,
then Consequent Thenn Status = Improper,
& MICRO-PS response = Error Message.

DEMO1's KNOWLEDGE BASE

attributes:

do

{smlt):
change default drive.
other

prompt

{smlt):
a.
b.

drive

{smlt):
a.
b.

operation

{smlt):
cannot perform that now.
type a colon and hit enter key.
type b colon and hit enter key.
the default drive is ok so do not do anything

%

rules:

r1

if do = change default drive.
& prompt = a.
& drive = b.
then operation = type b colon and hit enter key.

r2

if do = change default drive.
& prompt = b.
& drive = a.
then operation = type a colon and hit enter key.

r3

if do = change default drive
& prompt = a.
& drive = a.
then operation = the default drive is ok so do not do anything.

r4

if do = change default drive.
& prompt = b.
& drive = b.
then operation = the default drive is ok so do not do anything.

r5

if do = other.
then operation = cannot perform that now

%

actions:

obtain operation.

message "the operation or operations you need to do are:"
display value (operation)

%

COMMAND SYNTAX & EXAMPLES

OBTAIN

SYNTAX: obtain (attribute name)

MESSAGE

SYNTAX: message "[text of the message]"
 "[text of the message]".

DISPLAY

SYNTAX: display value [(attribute name)]

EXAMPLE: actions:
 obtain operation.
 message "The operation or operations you"
 "need to do are:"

 display value (operation)
 %

QUESTION ATTACHMENT

Syntax & Example

SYNTAX:

```
<Attribute Name>
[question: "<text of question>"
"<text of question?>"]
{smlt}:
value 1
[question: "<text>"],
value 2
[question: "<text>"], ...
.
.
.
value n
[question: "<text>"].
```

-attribute name
-attachment

-attribute type
-attribute value
-attachment
.
.
.

EXAMPLE:

```
prompt
[question: "Which prompt is on your CRT(screen)?"]
{smlt}:
  a
    [question: "A>"].
  b
    [question: "B>"].
```

name
◆ Question attachment

◆ Attribute value
◆ Question attachment
◆ Attribute value
◆ Question attachment

User session for these attachments would be:

Which prompt is on your CRT(screen)?

1(A>

2) B>

= ?

DECLARED ATTACHMENTS

SYNTAX & EXAMPLES

SYNTAX:

attachment: Name 1 Name 2 ...Name n
%

-Attachment Section

[[attachment name]: "[text of message]"
"[text of message]"]

-Attachment

EXAMPLE:

attachments: explain reference rationale
%

attributes:

USER FRIENDLY FEATURES

{question: "Have you included an explanation of how the user"
"gains access to attachments in the actions section?"

"(display reference rationale(USER FRIENDLY FEATURES))}]

[reference: "Nagy,Gault,Nagy: Building Your First Expert"
"System"]

[rationale: "Expert systems should be user friendly and"
"attachments are user friendly features of MICRO-PS."]

{smlt}: yes, no.

USER FRIENDLY FEATURES STATUS

{smlt}: present, absent
%

rules:

FRIENDLY FEATURES PRESENT

If USER FRIENDLY FEATURES = yes,
then USER FRIENDLY FEATURES STATUS = present.

FRIENDLY FEATURES ABSENT

If USER FRIENDLY FEATURES = no,
then USER FRIENDLY FEATURES STATUS = absent
%

actions:

message "Online help is available for questions with this feature:"
"(display reference (USER FRIENDLY FEATURES)) For example, type:"
"display reference(USER FRIENDLY FEATURES) when you are prompted"
"to answer a question."

obtain USER FRIENDLY FEATURES STATUS.

pause %

DECLARED ATTACHMENTS

Syntax & Examples (continued)

User session for this portion of actions would be:

Executing the knowledge base. . .

Online help is available for questions with this feature:

{display reference (USER FRIENDLY FEATURES)} For example, type:
display reference(USER FRIENDLY FEATURES) when you are prompted to answer
a question.

Have you included an explanation of how the user gains access to attachments in the actions
section?

{display reference rationale(USER FRIENDLY FEATURES)}

1) YES

2) NO

= ? display reference(USER FRIENDLY FEATURES)

DEFERRING CURRENT QUESTION [Type CONTINUE to resume question]

Nagy,Gault,Nagy: Building Your First Expert System

DEFERRING CURRENT QUESTION [Type CONTINUE to resume question]

ready for command: display rationale(USER FRIENDLY FEATURES)

Expert systems should be user friendly and attachments are user friendly features of
MICRO-PS.

DEFERRING CURRENT QUESTION [Type CONTINUE to resume question]

ready for command: CONTINUE

Have you included an explanation of how the user gains access to attachments in the actions
section?

{display reference rationale(USER FRIENDLY FEATURES)}

1) YES

2) NO

EXAMPLE OF ERROR DETECTION

DO
1)CHANGE DEFAULT DRIVE
2)OTHER
= ? 3
Execution error:
illegal selection-try again

DO
1)CHANGE DEFAULT DRIVE
2)OTHER
= ?

MESSAGE COMMAND

Syntax & Example

SYNTAX:

```
message "<text of message>"  
"<text of message>"
```

EXAMPLE:

actions:

```
message " "  
"                WELCOME TO THE PC"  
"                FILE OPERATIONS EXPERT SYSTEM".  
message "This expert system will assist you in determining if"  
"you need to change the default disk drive. It will prompt you"  
"for answers which you should enter by typing in the number and"  
"a carriage RETURN. For example, 2{<--'}. [{<--'} is RETURN.]".
```

User session for this Message Command would be:

```
                WELCOME TO THE PC  
                FILE OPERATIONS EXPERT SYSTEM
```

This expert system will assist you in determining if you need to change the default disk drive. It will prompt you for answers which you should enter by typing in the number and a carriage RETURN. For example, 2{<--'}. [{<--'} is RETURN.]

ASKFOR Command

Syntax & Example

SYNTAX:

askfor {attribute name}.

EXAMPLE:

attributes:

MAIN MENU

[question: "Which section would you like to work on first?"
"Please enter only one value."]

(smlt):

Attachment section,
Attribute section,
Rule section,
Action section.

...%

rules:

...%

actions:

askfor MAIN MENU.

...%

User session for this portion of actions would be:

Which section would you like to work on first? Please enter only one value.

(1) ATTACHMENT SECTION

(2) ATTRIBUTE SECTION

(3) RULE SECTION

(4) ACTION SECTION

= ?

Justify Command

Syntax & Example

SYNTAX:

justify (variable name)

EXAMPLE

attribute:

...

do now

[question "What do you want to do now?"]

(smlt):

justify [question: "Justify the steps the expert"

"system recommend?"]

again [...

actions:

...

if do now = justify

then justify operation,

...%

JUSTIFY COMMAND

Syntax & Example (continued)

User session for this portion of actions would be:

What do you want to do now?

1) Justify the steps the expert system recommend?

2) ...

= ? 1

Justification for the current value of OPERATION:

the value was inferred using the following rule(s):

R1

Use the DISPLAY command with the above names to get the actual rules.

PAUSE command encountered.

Entering interactive command execution mode.

Use the CONTINUE command to resume knowledge base execution.

ready for command: display r1

R1: IF DO = CHANGE DEFAULT DRIVE &

PROMPT = A &

DRIVE = B THEN

OPERATION = TYPE B COLON AND HIT ENTER KEY.

Mark, Wait and Pause Commands

Syntax & Example

SYNTAX:

mark. wait. pause.

EXAMPLE:

```
...%  
actions:  
message "This expert system checks your usage of the commands for"  
"screen control. Since you do not need to see this"  
"information a second time, it is appropriate to follow this"  
message with mark."
```

```
wait.
```

```
mark.
```

```
obtain Screen Control Command Usage Status.  
message "Your use of screen control commands appear to be"
```

```
display value(Screen Control Command Usage Status).
```

```
message "If you would like to repeat this system, type"
```

```
    "next"
```

```
"in response to the prompt ready for command:".
```

```
pause%
```

Mark Want and Pause Commands

Syntax & Example

(continued)

User session for this portion of actions would be:

The expert system checks your usage of the commands for screen control. Since you do not need to see this information a second time, it is appropriate to follow this message with mark.

Executing a WAIT command. . . .processing temporarily suspended.
Type carriage-return to continue processing (note: the screen will be cleared when processing resumes). Waiting. . . .:

Have you written mark in lowercase?

(1)yes

(2)no

= ? 2

...

Your use of screen control commands appear to be incorrect.

If you would like to repeat this system, type

next {<--'}

in response to the prompt ready for command:

PAUSE command encountered.

Entering interactive command Execution mode.

Use the CONTINUE command to resume knowledge base execution.

Ready for command: next

Have you written mark in lowercase?

(1) yes

(2) no

= ?

...

IF-THEN-ELSE-ENDIF Structure

Syntax & Example

SYNTAX:

```
if <attribute name> <rational indicator> value 1,  
then <command> <attribute name>, <command> <attribute name>, . . . ,  
  
else if <attribute name> <rational indicator> value 2,  
then <command> <attribute name>,  
  
else if <attribute name> <rational indicator> value 3,  
then <command> <attribute name>,  
.  
.  
.  
  
endif      endif      . . .      endif.
```

EXAMPLE:

```
if MAIN MENU = none,  
then message "Thank you for considering our system to solve"  
"your problem.",  
stop,  
    else if MAIN MENU = Attachment section,  
        then obtain Attachment Section Status,  
            else if MAIN MENU = Attribute Section  
            then obtain Attribute Section Status,  
                else if MAIN MENU = Rule section,  
                    then obtain Rule Section Status,  
                        else if MAIN MENU = Action section,  
                            then obtain Action Section Status,  
                                endif  
                            endif  
                        endif  
                    endif  
                endif  
            endif  
        endif  
    endif  
    . . . %
```

IF-THEN-ENDIF STRUCTURE

actions:

askfor MAIN MENU

**if MAIN MENU = Stop,
then message "Thank you for considering our system to solve"
"your problem."
stop
endif.**

**if MAIN MENU = Attachment section,
then obtain Attachment Section Status
endif.**

**if MAIN MENU = Attribute section,
then obtain Attribute Section Status
endif.**

**if MAIN MENU = Rule section,
then obtain Rule Section Status
endif.**

**if MAIN MENU = Actions section.
then obtain Actions Section Status
endif.
...%**

DEMO2

KNOWLEDGE BASE

attachments: definition why

%

attributes:

begin

{question: "Do you wish to begin?"}

{smlt):

yes,

no.

do now

{question: "What do you want to do now?"}

{smlt):

justification

{question: "Justify the steps the expert system"
"recommends."}

again

{question: "Get assistance for another case."}

end

{question: "End-I'm finished with the expert"
"system."}

and now

{question: "What do you want to do now?"}

{smlt):

again

{question: "Get assistance for another case."}

end

{question: "End-I'm finished with the expert"
"system."}

do

{question: "What operation do you wish to do?"}

{smlt):

change default drive,

other.

prompt

{question: "Which prompt is on your CRT(screen)?"}

"{display definition(prompt)}"

{definition: "The prompt refers to the letters and symbols"

"that occur at the left margin of the last line"

"on your CRT(screen)."

{smlt):

a

{question: "A>"}

b

{question: "B>"}

DEMO2
Knowledge Base
(continued)

drive

[question: "Which drive do you want to use as the default"]

"drive? {display definition why(drive)}"]

[definition: "The default drive is the one that the operating"]

"system refers to automatically for commands that require a disk"

"to be searched for a file, such as, dir(ectory) or type."]

[why: "The expert system must know which drive you want to be"]

"your default drive before it can determine the correct"

" operation."]

(smlt):

a

[question: "a {display definition(drive = a)}"]

[definition: "The drive on the left."],

b

[question: "b {display definition(drive = b)}"]

[definition: "The drive on the right."]

operation

(smlt):

cannot perform that

[question: "This cannot assist you with other tasks."]

{display why(operation - cannot perform that)}"]

[why: "This expert system is only for changing the"
"default drive."],

type a colon and hit enter key

[question: "type a{<—}"],

type b colon and hit enter key

[question: "type b{<—}"],

the default drive is ok so do not do anything

[question: "The default drive is correct. You need not"
"perform any operations."]

... %

DEM02
Knowledge Base
(continued)

rules:

r1

if do = change default drive,
 & prompt = a ,
 & drive = b,
then operation = type b colon and hit enter key .

r2

if do = change default drive,

 & prompt = b,
 & drive = a,
then operation = type a colon and hit enter key .

r3

if do = change default drive
 & prompt = a,
 & drive = a,
then operation = the default drive is ok so do not do anything.

r4

if do = change default drive,
 & prompt = b,
 & drive = b,
then operation = the default drive is ok so do not do anything.

r5

if do = other,
then operation = cannot perform that

%

DEM02 Knowledge Base

(continued)

actions:

```
message "                WELCOME TO THE PC"
"                FILE OPERATIONS EXPERT SYSTEM".
message "This expert system will assist you in changing the"
"default disk drive. The system will prompt you for answers"
"which you should enter by typing in the number and a carriage"
"RETURN. For example. 2 {<-"}, {{<-"} is carriage RETURN.)"
wait.
message "Online assistance is available for those questions"
"with a line like: {display definition why(prompt)}. By typing"
"display and ONE of the words BEFORE the parentheses with the"
"word in parentheses, the addition text will appear."
message "For example you would type in:"
"display definition(prompt) {<-"}.
```

askfor begin.

```
if begin = no.
then stop
endif.
```

mark.

obtain operation .

```
message "the operation or operations you need to do are:".
display value (operation).
pause.
askfor do now.
```

```
if do now = justification.
then justify operation.
pause.
askfor and now
endif.
```

```
if do now = again.
then next
endif.
```

```
if do now = end.
then stop
endif.
```

```
if and now = again.
then next
endif.
```

```
if and now = end.
then stop
endif
```

%

Value of the AI Market

	1983	1985	1993
Intelligent Robotic Systems	-	50 Million	600 Million
Expert Systems	-	10 Million	1.5 Billion
AI Computer Systems	<u>22 Million</u>	<u>25 Million</u>	<u>400 Million</u>
<u>TOTAL HARDWARE</u>	22 Million	85 Million	2.5 Billion
Programming Languages and Support	5 Million	10 Million	1.5 Million
Natural Language Interfaces	10 Million	2.5 Million	2 Billion
Expert System Software Packages	2 Million	10 Million	1.5 Million
Robotic Programming	-	-	200 Million
Computer Aided Instruction	<u>2 Million</u>	<u>5 Million</u>	<u>100 Million</u>
<u>TOTAL SOFTWARE</u>	19 Million	50 Million	5.3 Billion
<u>TOTAL SERVICES</u>	25 Million	85 Million	.7 Billion
(Education, Training Custom System Design, Time Sharing Services)			

THE PLAYERS

- ICOT – Institute for New Generation Computer Technology
- MCC – Microelectronic and Computer Technology
- DARPA – Defense Advanced Research Project Agency
- Others in US
 - National Supercomputer Centers
 - National Security Agency
 - MCNC-Microelectronic Center of North Carolina
 - Individual companies and universities
 - SRC-Semiconductors Research Cooperative
- OTHERS ABROAD
 - ESPRIT-European Strategic Programme for Research and Development-Common Market
 - ALVEY Computer Research Program-BRITISH
 - Germany
 - Agency for Information Technology-FRENCH
 - Great Britain
 - Soviets & East Europeans

Microelectronics Computer Technology Corporation (MCC) Objectives

- Concentrate scarce financial and intellectual resources individual companies can not otherwise deploy alone
- Develop technology to allow its founding and future shareholders to devise products and services of their own conception and design
- Compete in markets of their own choice
- Help U.S. computer and semiconductor firms meet the challenge from government-support R&D programs that have allowed Japanese and Western European firms to target U.S. industries

Microelectronics & Computer Technology(MCC) Programs

Parallel Processing

- Packaging
- Software Technology
- VLSI/Computer-Aided Design
- Advanced Computer Architecture
 - Parallel Processing
 - Data Base System Management
 - Human Factors Technology
 - AI/Knowledge based systems

Military Applications

- Computerized weapon systems able to see, reason, and plan as well as control action
- Military assessment system that are able to see, listen, understand, interpret and represent information
- Autonomous system able to take instruction, navigate and carry out a military mission

John Markoff 1984

DODCI 1073-85

Problems to Overcome

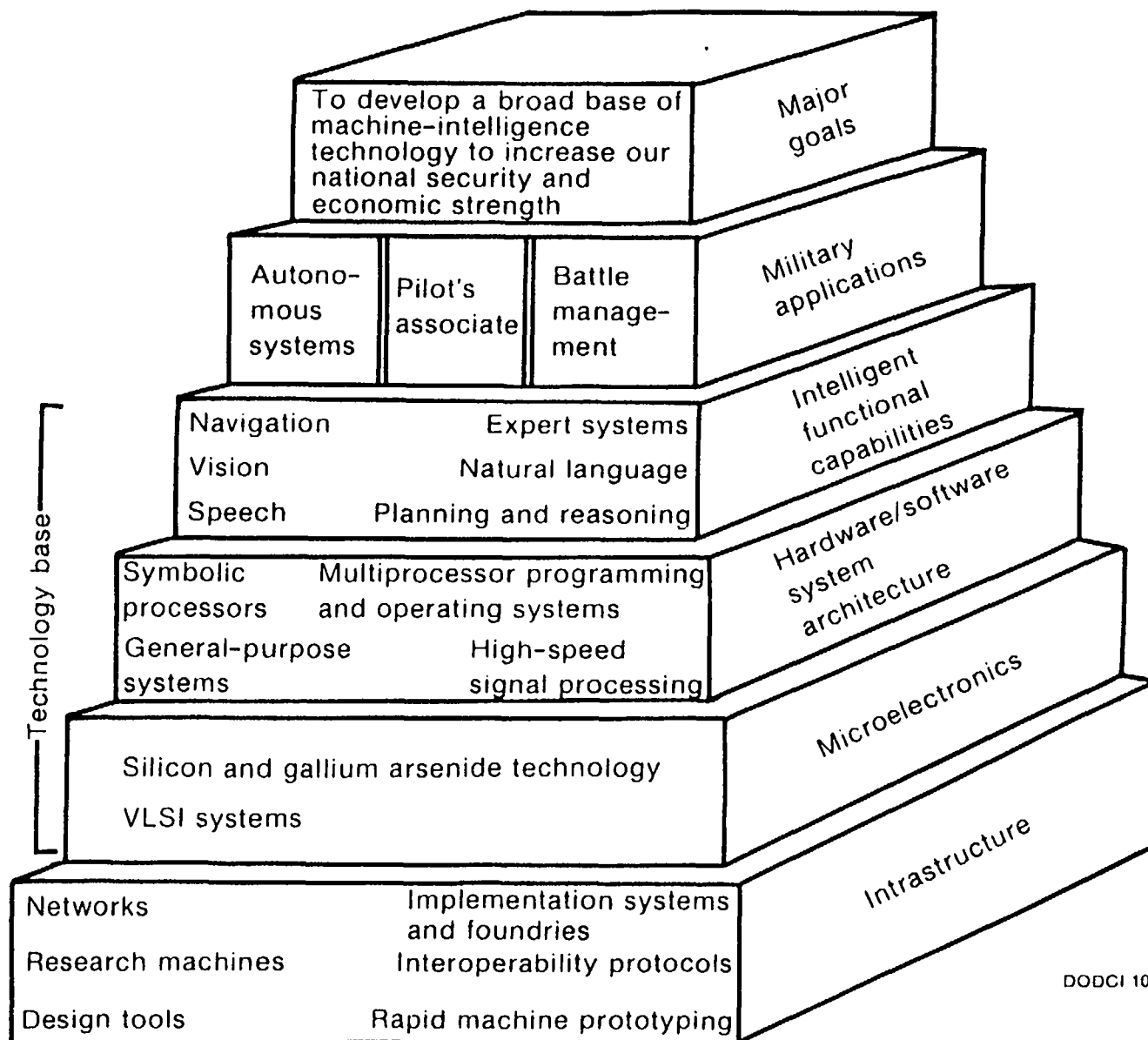
- Lack of Processing Power
- Lack of Knowledge-representation languages
- Interacting with Computer in terms a computer can understand (natural language interface)
- Lack of experienced people

(David Harvey, Mar 84)

DODCI 1074-85

Defense Advanced Research Project Agency (DARPA)

SCI Program Structure and Goods



Defense Advanced Research Project Agency Strategic Computing Cost Summary (in \$Millions)

	FY84	FY85	FY86	FY87	FY88
Total Military Application	6	15	27	TBD	TBD
Total Technology Base	26	50	83	TBD	TBD
Total Infrastructure	16	27	36	TBD	TBD
Total Program Support	2	3	4	TBD	TBD
TOTAL	50	95	150	TBD	TBD

- FIVE YEAR TOTAL ESTIMATED AT \$600m (Approx \$150 million per year)
- TOTAL OVER NEXT DECADE ESTIMATED TO BE \$1 BILLION

(Strategic Computing 1983)

DODCI 1076-85

Defense Advanced Research Project Agency

Autonomous Land Vehicle

Capability:

- Sense and interpret environment
- Plan and reason using sensed and other data
- Initiate action
- Communicate with human and other systems

DODCI 1077-85

Defense Advanced Research Project Agency

Autonomous Land Vehicle Continued

Specifications:

- Cross country at 60 KPH
- Navigate to point 50 Kilometers away visually
- Detect obstacles
- Locate and identify landmarks
- Map terrain

DODCI 1078-85

Defense Advanced Research Project Agency

Autonomous Land Vehicle Continued

Technology:

NEEDED

- 10-100 billion IPS
- 10 gigabytes of memory
- 6500 navigation rules
- firing rate-7000 rules/sec

TODAY'S CAPABILITY

30-40 million IPS
10-30 megabytes

2000 rules
50-100 RPS

Size/weight/power: 6-15 cubic feet/ less than 500 lbs/ less than 1 kw of power
(1-4 orders of magnitude reduction in weight, space, and power)

Defense Advanced Research Project Agency

Autonomous Land Vehicle

(continued)

Use of Technology:

- “Smart” Monitors
- cruise missiles
- robotics for handling, manufacturing
- underwater robots
- munitions handling

(Strategic Computing 1983)

DODCI 1080-85

Defense Advanced Research Project Agency

Pilot's Associate System

- Objective

- Off load lower-level chores like regulation of oil temperature
- Perform special functions like detect/diagnosis impending malfunctions

- Characteristics

- Trained by pilot
- “Know” wealth of general knowledge
- “Know” advanced tactics from best pilots
- Knowledge base easily updated in dynamic environment
- Exchanges knowledge with other associates
- Several thousand rules with graphics/speech

Defense Advanced Research Project Agency

Naval Battle Management System

- CVBG Battle Management System (CVBG BMS)

- Integrated into CWC Defense System

- Graphically represents battle area with:

- Enemy/Friendly OOB
 - EW Environment
 - Strike Plan
 - Weather
 - Other factors

Defense Advanced Research Project Agency

Naval Battle Management System

Continued

- Generate prioritized estimate of enemy intent
 - Explain reasoning/sources/probabilities
 - Generate potential courses of action with likely outcomes/
relative attractiveness
 - Prepare/disseminate operations plan
 - “Learn” from each engagement
-
- Limited System on USS Carl Vinson (CVN 70)
 - Requires 20,000 Rules/10 BIPS
 - Will utilize graphics/speech

INTELLIGENCE

NATURAL

- CREATIVE
- CAN ACQUIRE
KNOWLEDGE
- SENSORY INPUT
- WIDE, WIDE CONTEXT
- TRANSITORY
- APPRENTICESHIP
- MORE EXPENSIVE
- ERRATIC
- SLIPSHOD
- NOT EASILY
DOCUMENTED

ARTIFICIAL

- UNINSPIRED
- MUST BE
GIVEN KNOWLEDGE
- SYMBOLIC INPUT
- NARROW CONTEXT
- PERMANANCE
- EASILY DUPLICATED
- LESS EXPENSIVE
- CONSISTENT
- THOROUGH
- DOCUMENTABLE

HUMAN vs COMPUTER PROBLEM SOLVING

- HIGH LEVEL
PERFORMANCE

- BROAD
- SELF CORRECTING

- EMOTION
- FATIGUE
- UNAVAILABLE
- BIAS
- IMPERIAL

- HIGH LEVEL
PERFORMANCE

- NARROW
- NOT PROTECTED

- STABLE (COLD)
- INDEFATIGABLE
- AVAILABLE
- LESS BIAS
- IMPERSONAL

THE COMPUTER EVOLUTION

- Computer Revolution or Evolution?

1951 Vacuum tube powered UNIVAC I delivered to U.S. Census Bureau

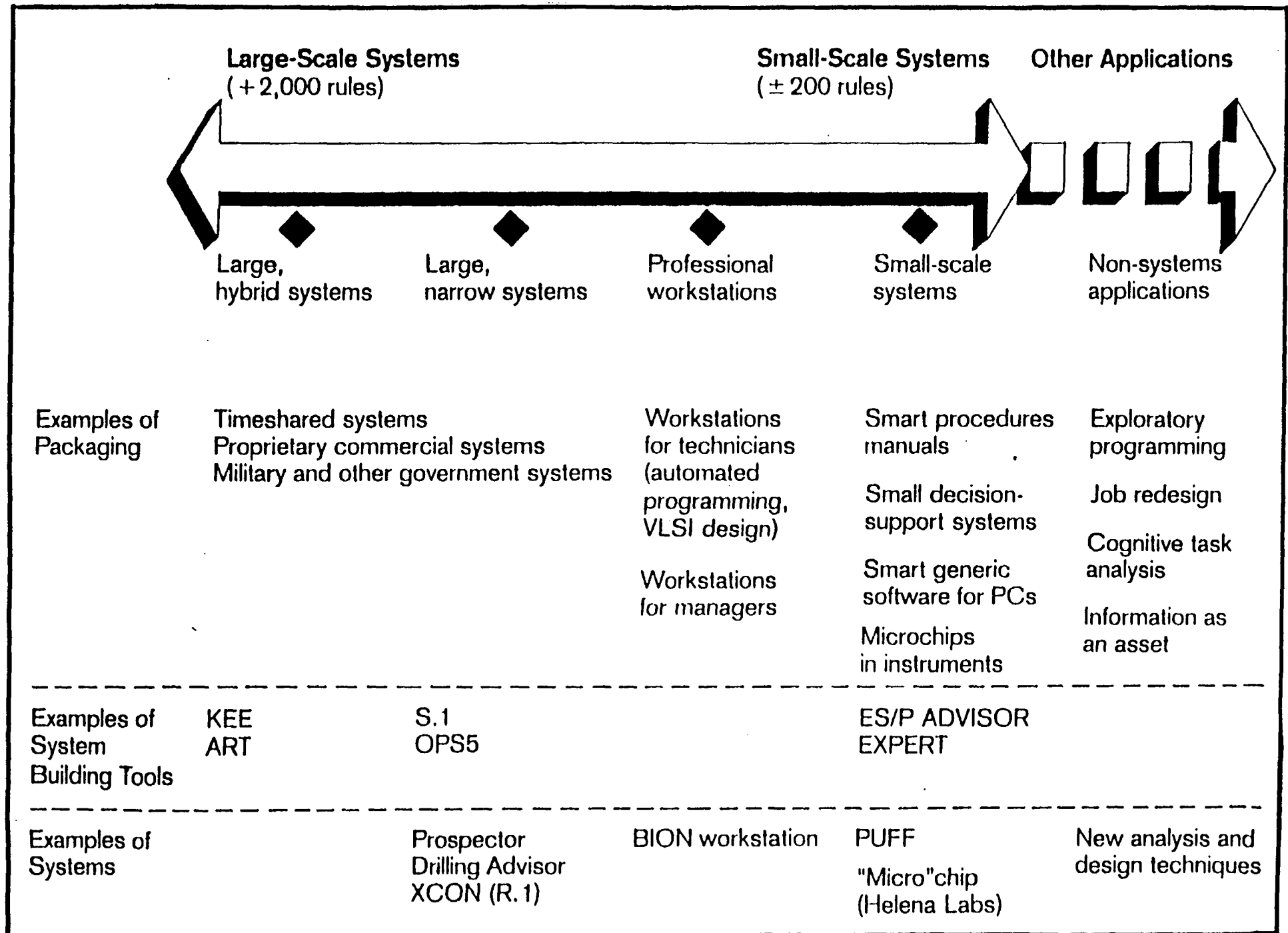
1985 Transparent computers in carburetors, calculators, clocks,
dishwashers, microwave ovens, automatic bank tellers, etc.

1951 Single transistor cost \$10, Cadillac limousine cost \$7,600

1985 If Limo had followed semiconductor cost curve (fall 30-40% per year),
it would sell for 3¢ instead of \$40,000

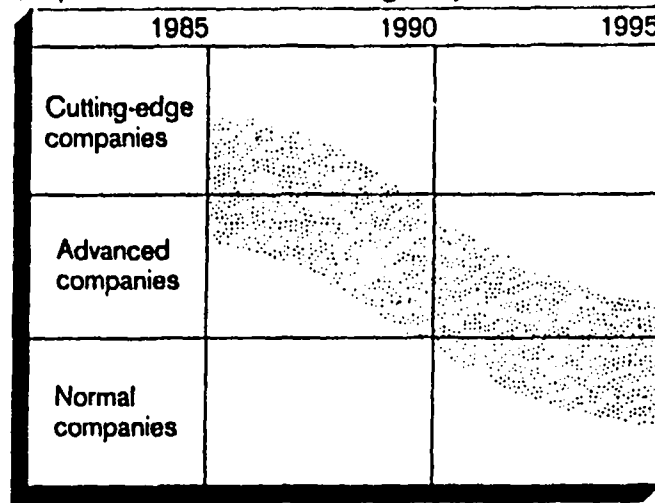
- Can we over sell AI?

A range of expert systems applications to expect in the 1980s.

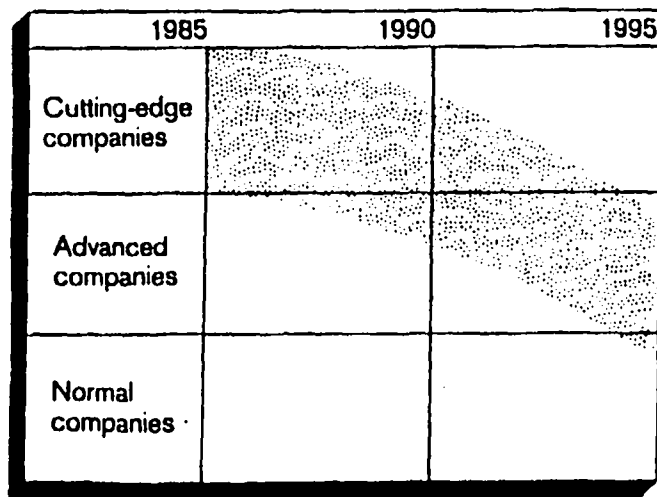


Market Impact of Various Types of Systems

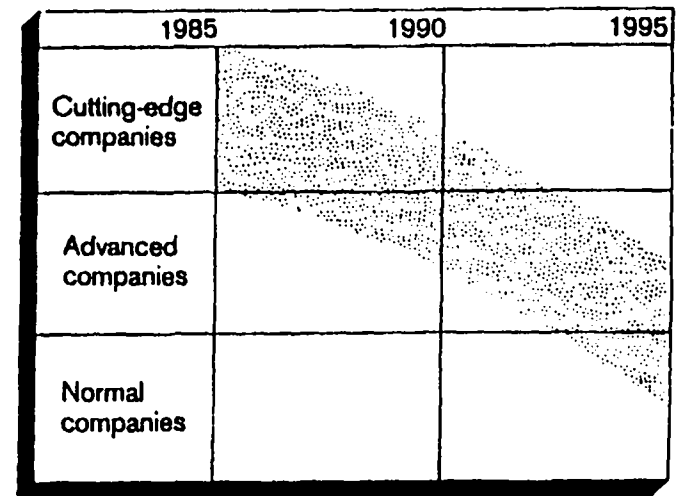
Small, specialized knowledge systems and tools



Large-scale, hybrid expert systems and tools



Large-scale, narrow expert systems and tools



The bands indicate where the action will be over the next ten years

COURSE HIGHLIGHTS

PHASE

TOPIC

1.	Introduction and Overview
2.	Developing an Expert System
3.	The Worldwide challenge
4.	Course Summary

**ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS
FOR
GOVERNMENT EXECUTIVES**

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ABSTRACT: How a few top executives are using their personal computers.

Zehr, Leonard, "THE PAPER PALACE", The Wall Street Journal Sept 16, 1985 p40C

ABSTRACT: Addresses the myth of "the paperless office".

SESSION I - INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Andriole, Stephen J., "ARTIFICIAL INTELLIGENCE COMES OF AGE", National Defense Dec 1984 p43-46, 50-52

ABSTRACT: A discussion about the applicability of AI to the military addressing its scope and methods, the players, its role in national defense, the net effect, and a prognosis.

Schemmer, Benjamin F., "MICROELECTRONICS ADVANCES WILL PACE DRAMATIC CHANGES IN FUTURE WARS", Armed Forces Journal International 122/2 Sep 1984 p86-88, 91

ABSTRACT: A relatively non-technical look at state-of-the-art in computer technology through the eyes of ADM Bobby Inman.

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ABSTRACT: Excerpt from Williamson's book (Artificial Intelligence for Microcomputers, The Guide for Business Decisionmakers) explaining how AI emerged in the computer industry to set the stage for the movement of technology into the microcomputer arena.

Hayes-Roth, Frederick, "RULE-BASED SYSTEMS", Communication of ACM 28/9 Sep 1985 p921-931

ABSTRACT: Good overview of how "rule-based systems" automate problem solving know-how, provide a means for capturing and refining human expertise, and are proving to be commercially viable.

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ABSTRACT: Excerpt for Williamson's book (Artificial Intelligence for Microcomputers, The Guide for Business Decisionmakers) describes Eliza, a natural-language interface developed in 1965.

SESSION II - KNOWLEDGE BASED EXPERT SYSTEMS OVERVIEW

Oxman, Steven W., "EXPERT SYSTEMS REPRESENT ULTIMATE GOAL OF STRATEGIC DECISION MAKING", Data Management 23/4 Apr 1985 p36-38

ABSTRACT: A look at the related goals and classes of use of expert systems, artificial intelligence systems, decision support systems, management information systems, and data base management systems. Dissects the components of expert systems.

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ABSTRACT: Good examples of useful expert systems including STEAMER and PROSPECTOR. Insert articles, "How AI Systems Represent Knowledge" and "Business Outlook: Artificial Intelligence."

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Fertig, Robert T., "SMALL EXPERT SYSTEMS OK-AS FAR AS THEY GO", Management Information Systems Week May 22, 1985 p24-25

ABSTRACT: A critical review of capabilities of microcomputer expert systems. Discusses Expert Ease, TIMM, Personal Consultant, and M.1.

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ABSTRACT: Good overview of shell programs currently available including a discussion of their strengths and weaknesses.

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Popular Computing Apr 1985 p75-80

ABSTRACT: Article reviews four types of specialized problem-solving software for microcomputers giving examples of each. Good overview of software aids available (including expert systems) for problem solving.

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ABSTRACT: Excerpt from Williamson's book(Artificial Intelligence for Microcomputers, The Guide for Business Decisionmakers) which describes a do-it-yourself approach to building knowledge-based or expert systems. It also explains why every problem or task cannot be handled by an expert system and includes pointers that can help you select the right targets for an AI-based solution.

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SESSION VII - BUILDING A SMALL EXPERT SYSTEM, Part II

SESSION VIII - BUILDING A SMALL EXPERT SYSTEM, PART III

SESSION IX - GUEST SPEAKER/DEMONSTRATION BY TITAN

PHASE 3 - THE WORLDWIDE CHALLENGE

SESSION X - THE GAME AND THE PLAYERS

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ABSTRACT: Describes DARPA's role in pushing the U. S. toward revolutionary technologies that are neglected or even opposed by the military services and leading industries.

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PHASE 4 - COURSE SUMMARY

SESSION XII - SUMMARY

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