

전문가시스템의 동태와 개발전략

1990년 9월 22일

한국과학기술원 경영과학과

이 재 규

Artificial Intelligence: Imitation of Natural Intelligence

- . Natural Language Processing
- . Vision
- . Voice Recognition
- * Knowledge-based Systems (Expert Systems)
- . Theorem Proving
- . Intelligent Retrieval
- . Machine Learning
- . Neural Networks

father(John,Robert)

father(Robert,Mark)

grandfather(X,Y) if father(X,Z)
and father(Z,Y)

? grandfather(X,Mark)

X = John

? grandfather(John,Mark)

T

WHAT ARE EXPERT SYSTEMS?

1) Purpose

- Simulate the performance of Experts
- But, it may not be possible.

Expert Support Systems

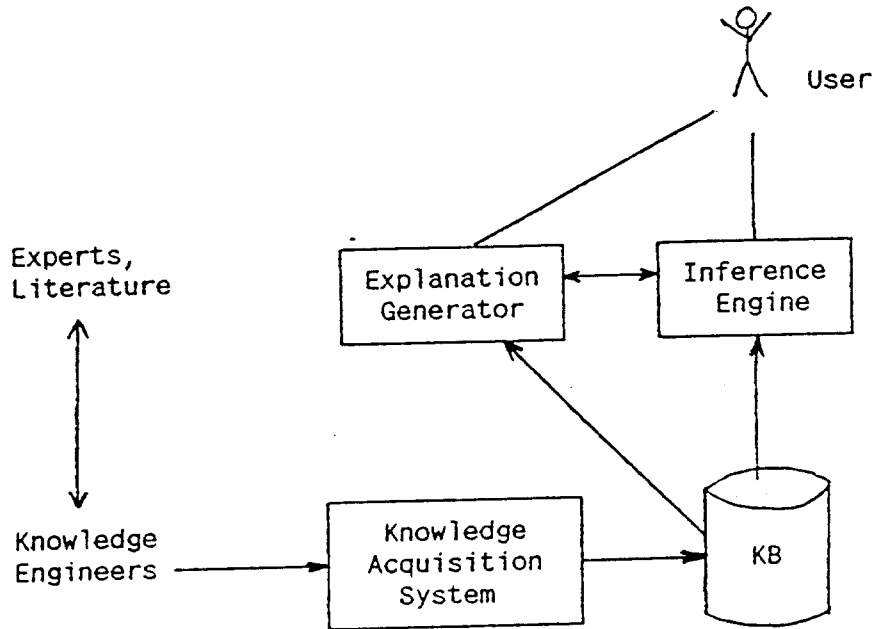
2) What makes "experts" powerful?

- Knowledge is power.
- Logical reasoning provides good conclusions.
- Experts can justify their conclusions and persuade clients

3) What should be ideal architecture of expert systems?

- Knowledge-based Systems

Architecture of Expert Systems



REPRESENTATION OF KNOWLEDGE

- PRODUCTION SYSTEMS (Rule-based Systems)

. IF
 AND _____
 AND _____
 :
 :
 THEN _____
 AND _____

. AND/OR Graph

. OR, ELSE, Variables, etc.

- SEMANTIC NETWORK

- FRAME

P1
If the animal has hair,
then it is a mammal.

P2
If the animal gives milk,
then it is a mammal.

P3
If the animal has feathers,
then it is a bird.

P4
If the animal flies,
and it lays eggs,
then it is a bird.

P5
If the animal is a mammal,
and it eats meat,
then it is a carnivore.

P6
If the animal is a mammal,
it has pointed teeth,
it has claws,
and its eyes point forward,
then it is a carnivore.

P7
If the animal is a mammal,
and it has hoofs,
then it is an ungulate.

P8
If the animal is a mammal,
and it chews cud,
then it is an ungulate,
and it is even toed.

P9

If the animal is a carnivore,
it has a tawny color,
and it has dark spots,
then it is a cheetah.

P10

If the animal is a carnivore,
it has a tawny color,
and it has black stripes,
then it is a tiger.

P11

If the animal is an ungulate,
it has long legs and a long neck,
it has a tawny color,
and it has dark spots,
then it is a giraffe.

P12

If the animal is an ungulate,
it has a white color,
and it has black stripes,
then it is a zebra.

P13

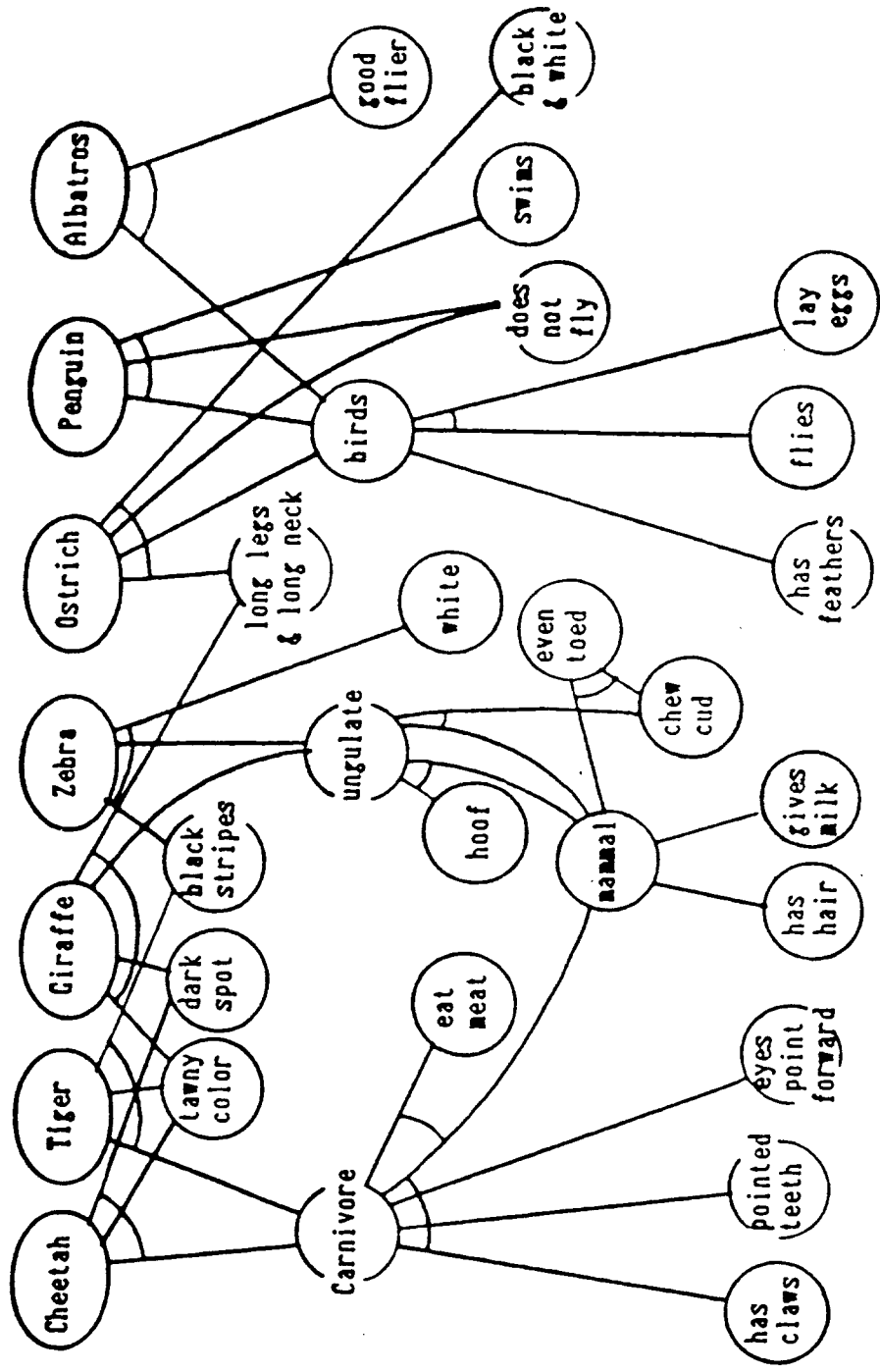
If the animal is a bird,
it does not fly,
it has long legs and a long neck,
and it is black and white,
then it is an ostrich.

P14

If the animal is a bird,
it does not fly,
it swims,
and it is black and white,
then it is a penguin.

P15

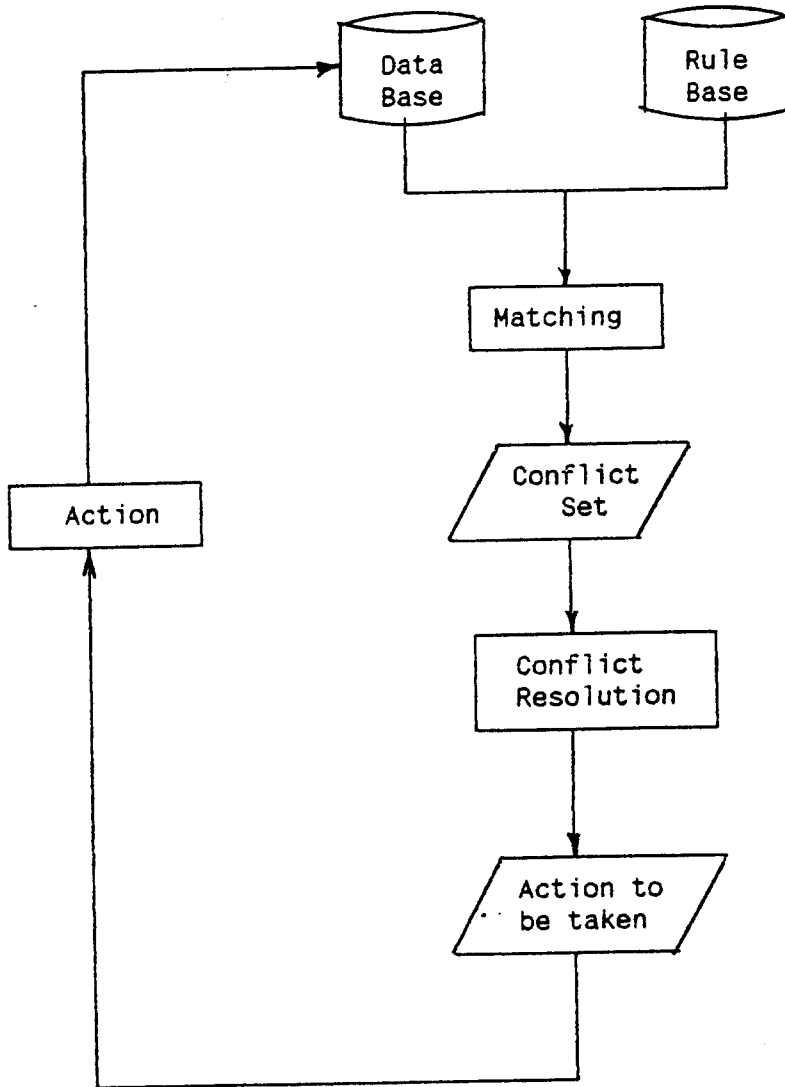
If the animal is a bird,
and it is a good flyer,
then it is an albatross.



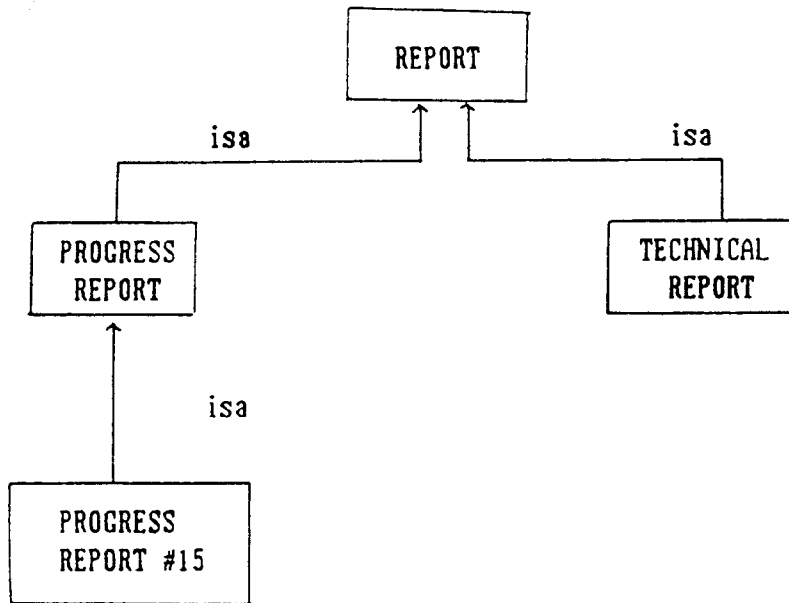
OPS 5

Knowledge Representation: Rule base

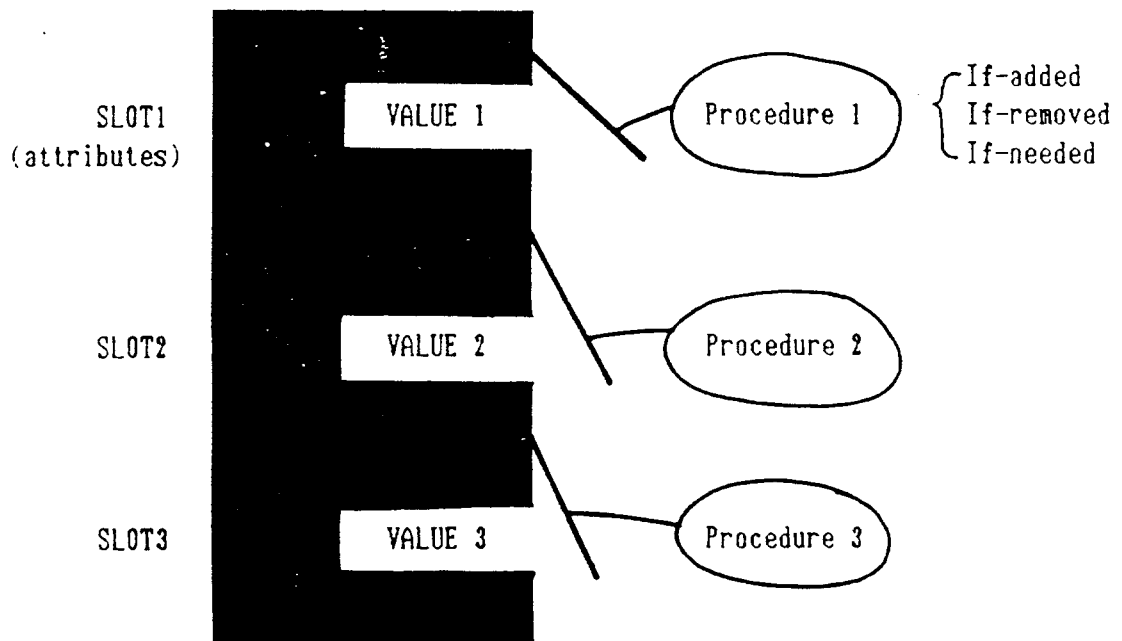
Inference Engine: Forward Chaining (Data Driven)



FRAME



CONCEPT



• Semantic net is a special type of FRAME.

Purpose

Formalism for Strategy Synthesis for Expert Systems
Development

Approach

1. Case-based Learning
2. Rule and Constraint Directed Search

XCON (R1)

1. Why XCON?

Marketing Strategy of DEC

Allow flexibility in component selection

2. Nature of task: 50,000 orders in 1986

XCON performs with 99% accuracy,

and saves \$6 - 8 Millions per year.

Configuration

. Complete function, spatial requirement,

relationships between components

. Error prone, tedious

. Typical order: 50 - 250 components

25 - 125 pieces of info/component

1,000 step to check

3. Purpose of XCON

Replace technical editors

4. Tool Selection

OPS 4 → OPS 5

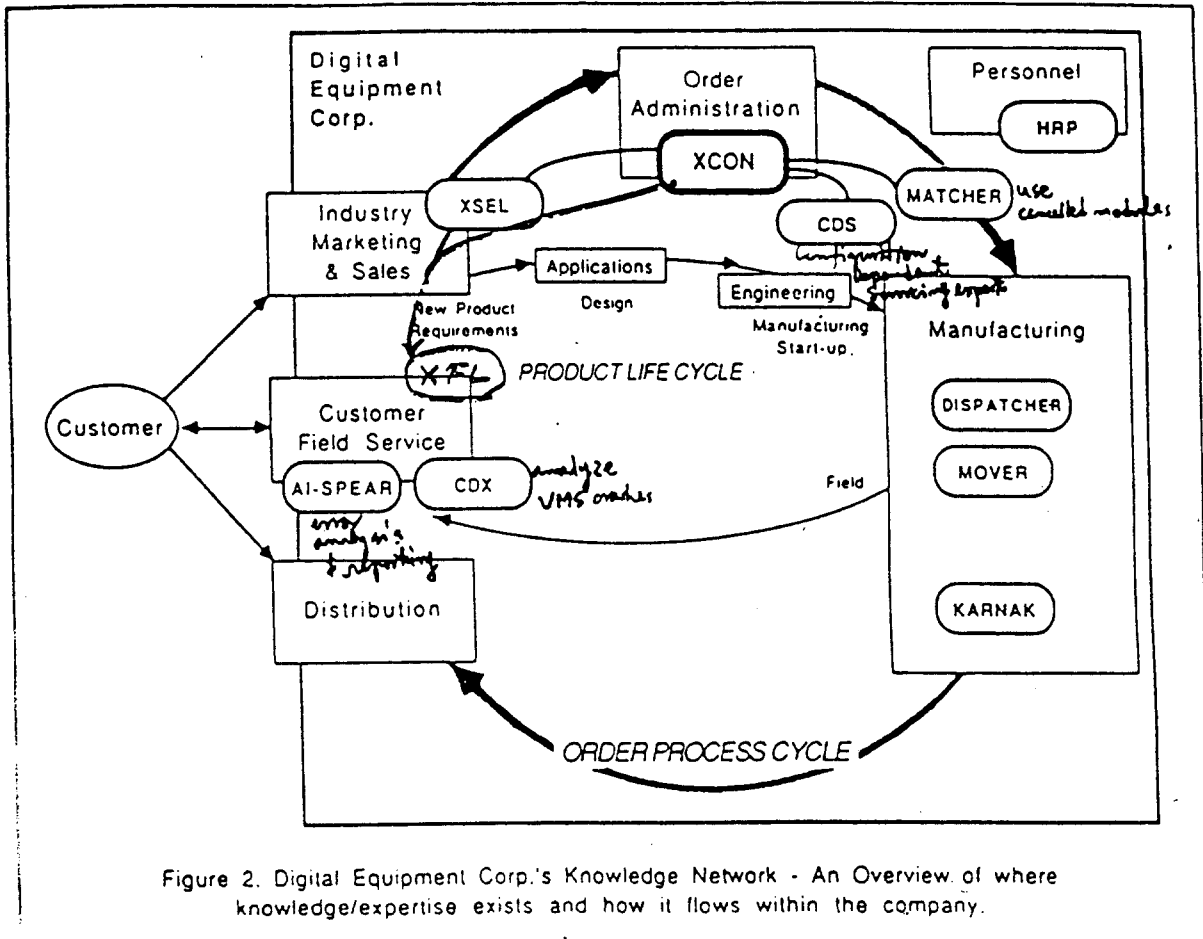


Figure 2. Digital Equipment Corp.'s Knowledge Network - An Overview of where knowledge/expertise exists and how it flows within the company.

5. Development Phases

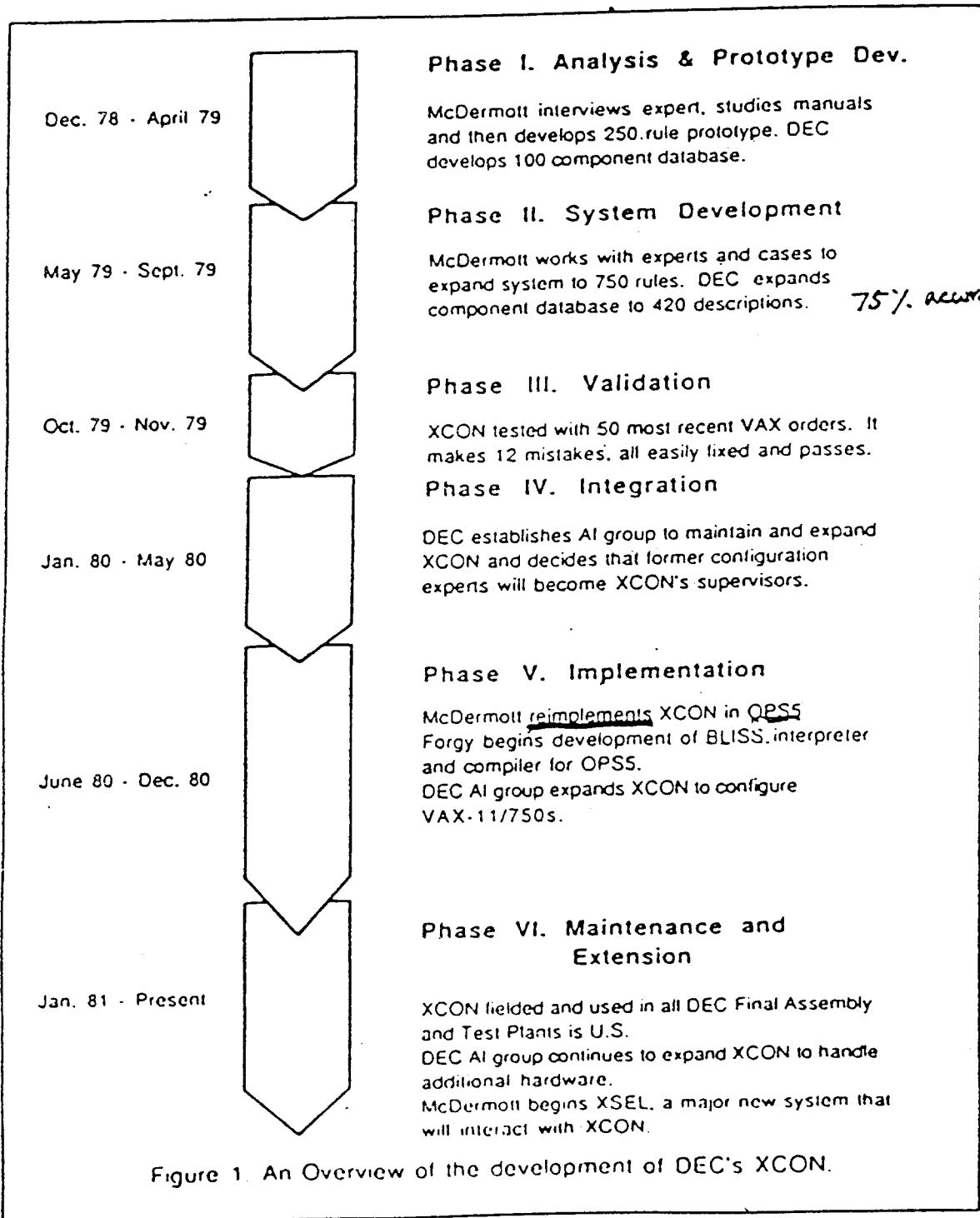


Table 1. The growth of DEC's XCON (aka R1)

DATE	NUMBER OF RULES	PARTS IN DB	EQUIPMENT CONFIGURED
April 79	250	100	VAX-11/780 OPS 4
Oct. 79	750	420	--
March 80	850	--	--
June 80	500	--	(XCON reimplemented in <u>OPSS</u>)
Mar. 81	850	--	VAX-11/750
Jan. 82	1500	--	3/83- VAX-11/730
July 82	1850	--	PDP11/23+
			7-83- Micro-PDP11
			10-83- MicroVax
			11-83- PDP-11/24
			11-83- PDP-11/44
Jan. 84	3250	5500	11-83- VAX-11/725
			1-84- VAX-11/785
Jan. 87	6200	20,000	

5. Knowledge Acquisition Process

- . Development Time
- . Incrementally increased number of rules
- . Changed role of technical editors
- . Effects of Tool Change
- . Difficulty in knowledge maintenance
- . KAS: RIME (SOUR: Domain-specific version)

6. DEC'S AI Organization

- . 300 peoples
- . Intelligent Systems Technology Group: XCON, XSEL
- . AI Applications Group: Internal Use
- . AI Product Group: LISP, OPS 5
- . AI Marketing Group: training, consulting

1. Development Stages

<i>Development Stage</i>	<i>Description</i>
Demonstration prototype	The system solves a portion of the problem undertaken, suggesting that the approach is viable and system development is achievable.
Research prototype	The system displays credible performance on the entire problem but may be fragile due to incomplete testing and revision.
Field prototype	The system displays good performance with adequate reliability and has been revised based on extensive testing in the user environment.
Production model	The system exhibits high quality, reliable, fast, and efficient performance in the user environment.
Commercial system	The system is a production model being used on a regular commercial basis.

Rules

1. Development Stage

IF Stage = Demonstration or Research Prototype
THEN Database = Internal
AND Software = May be isolated
AND Hardware = May be isolated

IF Stage = Field Prototype or Production Model
THEN Database = External
AND Software = Integrated
AND Hardware = Integrated

2. IF Know How = No experience
AND Budget = Very small
AND Purpose = Education
THEN Software = Shell
AND Hardware = PC
[OPS 5, VP-Expert]

IF Know How = Hybrid Tool
AND Budget = Moderate
AND Representation = Frames, Rules
AND Inference = Forward
THEN Software = Hybrid
[KEE]

Constraints

Software	KR	Inference	Hardware	Database Interface	Knowledge Acquisition
OPS 5	Rule	Forward	Mainframe, Mini, LISP m/c Work Station, PC		
VP-Expert	Rule	Backward	PC	Lotus 123	Inductive Learning
KEE	Frames Rule	Forward Backward	LISP m/c, Work Station, PC		
ADS	Rule	Backward	Mainframe, PC	DB2, dBASEIII	
C++	Object	-	Mainframe, Work Station, PC		
LISP	-	-	LISP m/c, Mainframe, Work Station, PC		

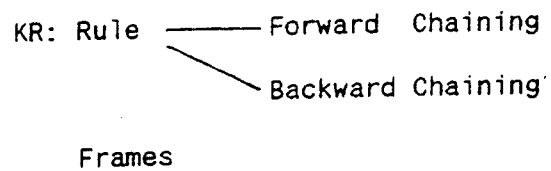
Compatibilities between available hardwares and softwares

Decision Variables

1. Knowledge Representation

- Rules
- Frames

2. Inference Engine



3. Database Interface



4. Software Tool Selection (Portfolio)

- . OPS 5
- . VP-Expert
- . KEE
- . ADS
- . C++
- . LISP

5. Hardware Selection (Portfolio)

Mainframe

Minicomputer

LISP machine

Unix Work Station

PC

6. Who Develops Software (Portfolio)

. Outside Consultants

. Inside AI team

. Inside End Users

7. Knowledge Acquisition Tool

. Rule Diagrams

. Inductive Learning

8. How to Organize AI people

- Centralize

- Decentralize

Environment

- Development Stages

Demonstration Prototype

Research Prototype

Field Prototype

Production Model

Commercial System

- Scope of Knowledge

- Nature of Problem determines

- . Knowledge Representation
- . Inference Method
- . Knowledge Acquisition Method

- Accumulated Know-how

- . No Experience
- . Shell User
- . Hybrid Tool User
- . Tool Developer
- . Automatic Knowledge Acquisition

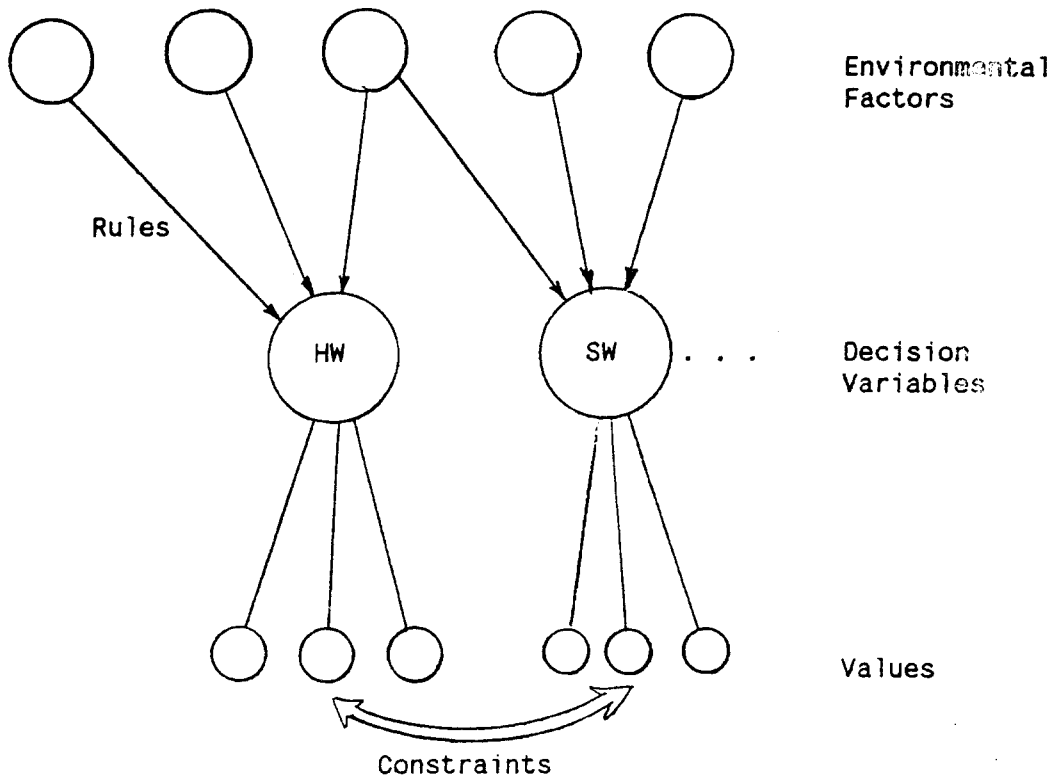
- Commitment

 - . Budget

- Hardware Availability

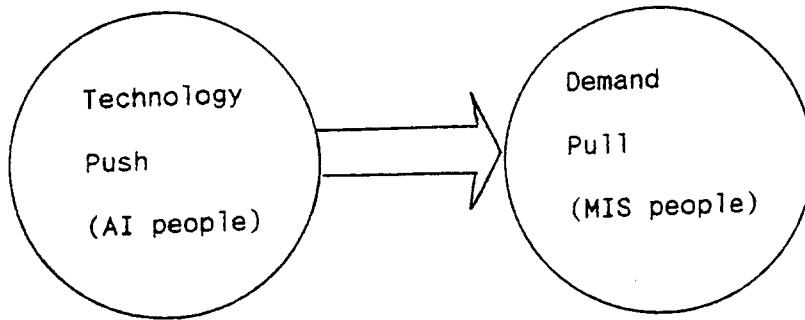
- Software Availability

Rule and Constraint Directed Search



- . Constraint Propagation
- . Compatible Alternative Generation
- . Insistency and Tradeoffs

Market Trends



Hardware: LISP m/c

Hardware: Mainframe

PC

Work Stations

Software: LISP

Software: C

Prolog

General Purpose languages

LISP-based Tools

DBMS

Lotus 123

Focus: Research Oriented

Focus: Data Processing and

Decision Support Oriented

Important Trends

1. LISP Machine (Symbolics, TI)
vs General Purpose Hardware (Unix Work Station, PC, Mainframes)
2. From LISP vs C Language
3. General Purpose Tools vs Problem Specific Tools
4. Rule-based Shells vs Hybrid Tools
5. Isolated Tools vs Integrated Tools (DB, Lotus 123)

Hardware Market

Varions PCs running MS-DOS	20%
Macintoshes with TI or Symbolic Chips	5%
PCs and Unix workstations running Unix	15%
DEC hardware running VMS	15%
IBM mainframes running MVS	15%
Lisp workstations from Symbolics and TI	20%
Other	10%

General Purpose Tools (Sales in 1989)

1. Small Tool on PC or MAC (40,000 units, \$6.5M),
(Price: \$100 - \$1,000)

- * VP - Expert: sold 60,000 copies, \$249
- * Level 5 object
 - . 1st - Class
 - . Exsys
 - . Procedure Consultant
 - . Personal Consultant Easy
 - . OPS - 2000

2. Mid-sized Tools for Work Stations and Minis (3,500 units, \$23.5)
(Price \$2,500 - \$25,000)

- * ADS
 - . Nexpert Object
 - . KBMS
 - . KES II
 - . ART - IM

3. Mainframe (237 units, \$22M)

- . ADS
- . KBMS
- . IBM TIRS, AD/Cycle
- . Level 5 Object
- * Interaction with PC Market

4. LISP-based Tools (900 units, \$20M)

- . KEE
- . ART
- . Knowledge Craft
- . Goldworks II
- . G2

5. Problem and Domain - Specific Tools (about 100 units, \$3M)
(price: a few hundred - \$1M)

ex)

. Carnegie Group

Service Maintenance Planner

Text Categorization System

Cost & Manufacturing Guide

Test Bench (Diagnostic Tool)

. TI

Test Bench

Line Balancer

Technicians Assistant

Air Line Planning and Scheduling

. DEC

XSAFE

CAD/Chem Product

. Syntelligence

Syntel (Financial Applications)

Languages

Lisp

Lucid Lisp: dominant

(IBM, Sun, HP, Apollo, and NCR)

Golden Common Lisp: university market

Franz Lisp

Quintus Prolog

Arity Prolog

Lisp will grow slowly and continue to occupy a highly specialized niche.

The same is also true, to a much lesser degree, of Prolog.

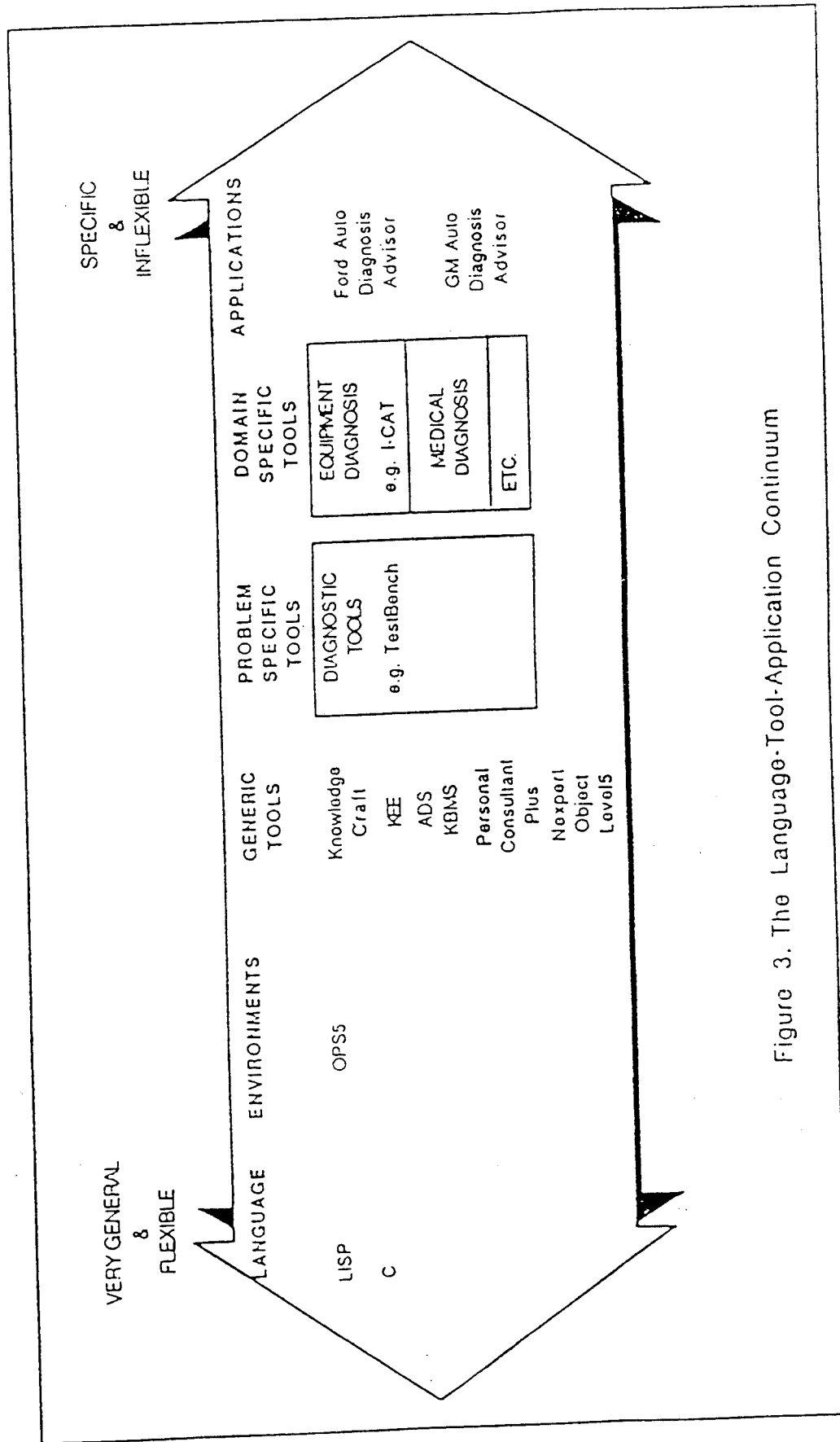


Figure 3. The Language-Tool-Application Continuum

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Guide Lines

1. MIS Perspective:

- . Select Tools Following the Tool Market Trends
- . High Market Share Products are Safer
 - . Use General Purpose Hardware
 - . Use General Purpose Languages
 - . Standardize Tools
 - . Integrate Tools

2. No Tool is Perfect

- . AI capability does not solve all problems
- . AI is a component of problem solving methodologies
- . AI + Operations Research + Statistics +
Information Systems Technologies
- . Analyze problem, and determine the role of AI tools
- . Next Generations of Expert Systems
 - ex) UNIK-PCS
 - UNIK-FCST

3. Research Teams need Technological Niche (Technology Push)

- LISP m/c
- LISP, Prolog - new languages
- Isolated Stations
- New Tools

TOOL (Knowledge Representation) (Vendor)	Price Range	Hardware (Operating System/Language)	Generates SQL	Databases that system can access without writing hook	Memory Requirements RAM/Harddisk
1st-CLASS FUSION (Inductive) (1st-CLASS Expert Systems, Inc)	\$1495-2495	IBM PC's and compatibles, VAX under VMS (Pascal)	No	Lotus 1-2-3, dBASE III, HyperText, ASCII files	Dev.: 512 K HT: 640 K
Crystal (Simple Rule) (Intelligent Environments Ltd.)	\$995-1995	IBM PC's and compatibles (MS-DOS); OS/2, (C)	No	dBASE, Lotus 1-2-3, Lotus Symphony, Presentation Graphics, Business Graphics	PC: 350K OS/2: 2mb RAM Hard Disk recom.
CxPERT (Software Plus)	\$395	MS-DOS	-	-	C Compiler
Easy Expert (Simple Rule) (Park Row Software Inc.)	\$49.95	MS-DOS	No	-	256K
EST (Simple Rule) (Mind Path Technologies)	\$495	IBM PC's and compatibles (Pascal)	No	Lotus 1-2-3	256 K
ExperCommonOPS (OPS) (Expertelligence)	\$625	MAC (Requires ExperCommonLisp) (Lisp)	No	-	1 mb
Experfacts (Simple Rule) (Expertelligence)	\$495	MAC (Requires ExperLisp) (Lisp)	No	-	512 K
ExperOPSS+ (Simple Rule) (Expertelligence)	\$495	MAC (Requires ExperLisp) (Lisp)	No	-	512 K
Expert Edge (Simple Rule) (Helix Expert Systems Ltd.)	\$795	IBM PC's and compatibles (C)	-	Lotus 1-2-3, Multiplan, dBASE	256 K 512 K recom.
Exsys (Simple Rule) (Exsys Inc.)	\$395-7,500	IBM PC/AT and compatibles (MS-DOS), VAX (VMS or Altex), Unix, SUN 3 & 4, (C)	No	dBASE III, Lotus 1-2-3	640 K Hard Drive recom.
flex (Hybrid) (Programming Logic Associates Ltd)	\$295-495	IBM PCs (MS-DOS), MAC (Multi_Finder) Prolog required (\$595)	No	-	512 K 640 K and Hard Drive recom.
Instant Expert (Simple Rule) (Human Intellect Systems)	\$69.95-99.95	IBM PC's and compatibles (MS-DOS), MAC, (Modula II)	No	-	PC: 640 K MAC: 512 K
Instant Expert+ (Simple Rule) (Human Intellect Systems)	\$498	IBM PC's and compatibles (MS-DOS), MAC, (Modula II)	Yes	HyperCard	PC: 640 K MAC: 512 K
Intelligent Developer (Simple Rule) (Hyperpress Publishing Corp.)	\$295	MAC +, SE or II	No	HyperCard, HyperText	1 mb
KDS 2 & 3 (Inductive) (KDS Corp.)	\$970-1,495	IBM PC's and compatibles (MS-DOS), (Assembler)	No	Lotus 1-2-3, dBASE	640 K Hard Drive recom.
KnowledgePro (Simple Rule) (Knowledge Garden Inc.)	\$495	IBM PC/AT and compatibles (MS-DOS), OS/2, (Turbo Pascal)	No	dBASE III, Lotus 1-2-3	640 K Hard Drive recom.
MacSmarts/MacSmarts Professional (Simple Rule) (Cognition Technology)	\$195-495	MAC (Prolog, C)	No	HyperCard, HyperText, SuperCard	512 K 1mb & Hard Drive recommended
Micro Expert (Simple Rule) (McGraw-Hill Book Co.)	\$54.95-64.95	IBM PC/AT and compatibles (MS-DOS), Apple Computers, (Pascal)	No	-	256 K

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Table 1 — Small Tools Available on the PC or Mac

EXPERT SYSTEMS STRATEGIES

TOOL (Knowledge Representation) (Vendor)	Price Range	Hardware (Operating System/Language)	Generates SQL	Databases that system can access without writing hook	Memory Requirements RAM/Harddisk
Magellan (Simple Rule) (Emerald Intelligence)	\$195	Commodore Amiga (Amiga DOS), (C, Assembly)	No	-	528 K
Mahogany Professional (hybrid) (Emerald Intelligence)	\$495	MAC	No	Lotus 1-2-3, dBASE III, Hypercard	1 mb memory
OPS-2000 (OPS) (Intellipro)	\$45-295	MS-DOS	No	Lotus 1-2-3, dBASE III	1 mb memory
PC Expert 2.0 (Simple Rule) (Software Artistry)	\$199.95	MS-DOS (C, Pascal, Modula 2, Ada)	No	-	
PC Expert Professional (Hybrid) (Software Artistry)	\$495	MS-DOS (C, Pascal, Modula 2, Ada)	No	Lotus 1-2-3, dBASE III	512 K, 5mb Hard Disk space
Personal Consultant Easy (Simple Rule) (Texas Instruments)	\$495	IBM /XT/AT or compatibles, PS/2, Explorer or MicroExplorer (PC or MS-DOS), (Scheme, C)	No	dBASE, Lotus 1-2-3	640 K; expanded or extended mem., Hard Drive recom.
Procedure Consultant (Decision Tree) (Texas Instruments)	\$495	IBM /XT/AT or compatibles, PS/2, Explorer or MicroExplorer (PC or MS-DOS), (Scheme, C)	No	DOS files only	640 K; expanded or extended mem., Hard Drive recom.
Sierra OPSS (OPS) (Inference Engine Technologies)	\$795	IBM PC/XT/AT or compatibles (DOS 2.0 or later) PS/2 (OS/2)	No	-	384 K
SuperExpert (Inductive) (Softsync Inc.)	\$199.95	IBM PC's and compatibles (MS-DOS), MAC, PS/2, (Pascal)	No	-	256 K
VP-Expert (Simple Rule/Inductive) (Paperback Software)	\$249	IBM PC's and compatibles (MS-DOS), (C)	No	dBASE 1-4, Lotus 1-2-3, VP-Info	384 K
XI Plus (Simple Rule) (Expertech Ltd.)	\$1,995-17 K	IBM /XT/AT or compatibles (MS-DOS), All MicroVAX workstations, (MicroProlog/ Assembler)	No	dBASE, Oracle	640 K Hard Drive recom.

Table 1 — Small Tools Available on the PC or Mac (cont.)

TOOL (Knowledge Representation) (Vendor)	Price Range	Hardware (Operating System/Language)	Generates SQL	Databases that system can access without writing hook	Memory Requirements RAM/Harddisk
Application Software Expert (Software Artistry)	\$5,000-36 K	OS/400 (Pascal)	No	Any Database on the AS/400	-
AFT-IM (Hybrid) (Inference Corp.)	\$8000-100 K	IBM PC/AT, PS/2 and compatibles (MS-DOS) IBM Mainframes (MVS), SUN 3 & 4 (Unix), DEC (VMS), Apollo (Unix), TI Explorer I & II, Symbolics 3600 series. (C)	No	IMS, DB2, VSAM, Flat files	PC: 640 K 1-2 mb extended memory; 8 mb Hard Disk MF: 3 mb address space for develop.
CLIPS (OPS) (COSMIC)	\$312	IBM PC and compatibles (DOS & Xenix), MAC, VAX, Sun, Apollo, HP9000, CDC Cyber, CRAY (C)	No	-	-
Enterprise Expert (Simple Rule) (Cullinet Software)	\$19 -60 K	IBM Mainframes(OS/2, MV2, MVS/XA, MVS/SP, DOS-VSE ORVM/CMS), VAX/VMS (CICS, IDMS/DC, VCF, (Cobol))	No	DBMS, IDMS, VSAM, IMS, DB2, Oracle, RDB, RMS, Enterprise DB	1mb 25mb Hard Drive recom.
Exsys Professional (Simple Rule) (Exsys Inc.)	\$795-12 K	IBM PC/AT and compatibles (MS-DOS), VAX (VMS or Atrax), Unlx, SUN 3 & 4, (C)	No	dBASE III, Lotus 1-2-3	640 K Hard Drive recom.
GURU (Structured Rule) (MDBS Inc.)	\$6,500	IBM PCs and compatibles (MS or PC-DOS), MicroVAX (VMS), (C)	Yes	dBASE III	PC: 640 K Hard Drive required
KES II/KES/VE (Structured Rule) (Software A&E, Prime Comp., Unisys, Control Data)	\$4,000-60 K	IBM PCs and compatibles (MS-DOS), Workstations, Minis, Mainframes (NOS/VE, MVS/TSO, CICS, IDMS andVM/CMS)	Yes	dBASE, Oracle	PC: 640 K Hard Drive recom.
Laser (Bell Atlantic KnowledgeSystems)	\$900-25 K	PS/2 (OS/2, MAC II, SUN, microVAX (Unix), (C) IBM Mainframe (MVS, VM)	No	-	2 mb
Level5 (Simple Rule) (Information Builders Inc.)	\$685 - \$48-57.6 K - \$1,200-58.4 K	IBM PC's and compatibles, PS/2 (MS-DOS), MAC+ IBM Mainframes (VM/CMS, MVS) Digital VAX (VMS)	No	PC: dBASE II & III MAC: HyperCard, Excel Mainframe: Focus, DB2, SQL/DS VAX: Focus, Rdb, RS1, RMS - CDD	PC: 512 K MAC: 512 K Hard Drive recom.

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Table 2 — Mid-sized Tools for Workstations and Minis

TOOL (Knowledge Representation) (Vendor)	Price Range	Hardware (Operating System/Language)	Generates SQL	Databases that system can access without writing hook	Memory Requirements RAM/Harddisk
Nexpert Object (Hybrid) (Neuron Data)	\$5,000-8,000	IBM PC/AT, PS/2 and 386 and compatibles (MS-DOS), MAC+, SE and II, Dec VAXstations /Dec-stations (VMS and Ultrix), IBM RT, Sun Apollo, HP, VAX (Unix), Mainframe (delivery) - (VM), (C)	Yes	Oracle, Sybase, Ingres, Informix, Lotus 1-2-3, dBASE III, SQL, RDB	IBM: 1mb and 1 mb expanded memory. MAC: 2 mb
Nexus (Hybrid) (Human Intellect Systems)	\$698	IBM PC/AT and compatibles (MS-DOS), MAC, (Modula II)	Yes	dBASE	640 K Hard Disk recom.
OPS/83 (Simple Rule) (Production Systems Technologies Inc.)	\$1,900-25 K	IBM PC's and compatibles (MS-DOS), Apollo, AT&T 3B & 386, Unix 386 (Unix), HP 9000's, VAX, MicroVAX, Sun 3&4, OS/2 or compatible, (C)	No	dBASE III	PC: 640 K; Hard Drive recom.
Personal Consultant Plus (Struct. Rule) (Texas Instruments)	\$2,950	IBM XT/AT or compatibles, PS/2, Explorer or MicroExplorer (PC or MS-DOS), (Scheme, C)	No	dBASE, Lotus 1-2-3, External Lang. Interface to Cobol, Pascal, C	2 mb expanded or extended mem.; KB occupies 640 K
RuleMaster (Inductive) (Radian Corp.)	\$7,500-28 K	IBM PC's and compatibles (MS-DOS, XENIX), VAX and Unix work stations (Unix, VMS)	Yes	-	-
TIMM (Inductive) (General Research)	\$1,900-19 K	IBM PC/AT and compatibles (MS-DOS), IBM Mainframes, (MVS/VM, VMS) Digital VAX, Unix, Primos (Unix), (Fortran)	No	-	640 K 10 mb Hard Disk recom.
VAX Decision Expert (Digital Equipment Corp.)	\$6,000-28 K	Any Dec VAX workstation (VMS), (VAX C)	No	-	16 mb and RD54 Hard Drive Recom.
VaxOPS5 (3.0) (Digital Equipment Corp.)	\$6,000-28 K	All VAXstations, MicroVAX (VMS) (Bliss)	No	RDB	User: 8 mb Develop.: 16 mb

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Table 2 — Mid-sized Tools for Workstations and Minis (cont.)

TOOL (Knowledge Representation) (Vendor)	Price Range	Hardware (Operating System/Language)	Generates SQL	Databases that system can access without writing hook	Memory Requirements RAM/Harddisk
Aion Development System (ADS)(5.1) (Hybrid) (Aion Corp.)	\$7000-85 K	IBM PC's and Mainframes S/370 (MVS/TSO, CICS, IMS, DB/DC, VM/CMS, MS-DOS) (Pascal, COBOL, C)	Yes	DL1, DB2, SOL/OS, OSAM, VSAM	PC: 640 K OS/2: 1.5 mb/RAM Hard Disk recom.
Expert System Environment (ESE) (Struct. Rule) (IBM)	\$23,410- \$60,440	IBM PC's - delivery, Mainframes (MVS/XA, MVS/TSO, VM/CMS, MVS/CICS, MVS/IMS) (Pascal)	Yes	DB2, SOL/OS, VSAM	-
KBMS (Hybrid) (AI Corp., Inc.)	\$9,500 - \$90-225K	IBM PC's 286 & 386 or compatibles (MS-DOS & OS/2) IBM Mainframes (MVS/XA, MVS, VM, CICS, TSO, IMS/DC, CMS), (C)	Yes	DB2, SOL/OS, IDMS, VSAM, ADABAS, IMS	4 mb
Knowledge Tool (OPS) (IBM)	\$950/mo.	IBM Mainframes (MVS/XA/TSO, MVS/ESA/ TSO, IMS/V/S, CICS/OS/V/S, VM/SP/CMS, VM/SP/HPO), (PL/I)	Yes	DB2, DL1, VSAM, SOLDS, PL1 Supp. Struct.	-
TOP-ONE (Simple Rule) (Telecomputing)	\$145 K	Mainframe (MVS/XA, CICS, DOS/VSE) (Transaction Oriented Prolog (TOP))	-	SOL/OS, DB2, DL1	-

Table 3 — Mainframe Tools

TOOL (Knowledge Representation) (Vendor)	Price Range	Hardware (Operating System/Language)	Generates SQL	Databases that system can access without writing hook	Memory Requirements RAM/Harddisk
ART (Hybrid) (Inference Corp.)	\$22.5-30 K	Symbolics (Genera), TI Explorer, DEC work- stations (VMS), Sun, Apollo & HP workstations (Unix), (Lisp)	No	Flat files, Call Facilities	12 mb minimum, 16 mb recom.
Eloquent ((Hybrid) (Eloquent Systems Corp.)	\$50-150 K	TI Explorer (Co-processor equipped) (Lisp), Mac- using Explorer as main file server. (C)	No	-	512 K, 1 mb recom.
G2 Real Time Expert System (Gensym Corp.)	\$18,000	MAC II, Compaq 386, DEC workstations, Symbolics 3260, TI Explorer, Sun, DecVAX, (Lisp)	No	-	8-16 mb
GEST (Generic Expert System Tool) (Georgia Tech. Research Institute)	\$15-45 K	VAX workstations, Sun Micro, Symbolics, Explorer (Lisp)	No	-	-
GoldWorks II (Hybrid) (Gold Hill Computers)	\$7,500	286 PC (Golden Common Lisp)	No	dBASE	6 mb
Joshua (Hybrid) (Symbolics)	\$10,000	Symbolics (Lisp)	-	-	-
KEE (Hybrid) and IBM/KEE (Hybrid) (Intelcorp) (IBM & Intelcorp)	\$9,000- \$98 K or \$4,900 mo.	VAX, Apollo, Sun, Symbolics, Explorer, Micro- Explorer, 386 PC (Lisp)) IBM/KEE: Mainframe (MVS), access via PC	Yes	DB2, IMS/DB	10 mb 100 mb Hard Drive recom.
Keystone (Technology Applications Inc.)	\$4,000	IBM 286 and 386 or compatibles (MS-DOS) (Golden Common Lisp)	No	-	6-8 mb, Hard Drive recom.
KnowledgeCraft (Hybrid) (Carnegie Group)	\$10-70 K	386 PC (Unix), Sun MicroVAX (VAX), Symbolics, Explorer, Mainframe (VAX)	Yes	Oracle, dBASE	8-16 mb recom.
Mercury KBE (Hybrid) AI Technologies	\$21 K	VAX workstations	Yes	Rdb, Sybase, Oracle, DB2, RMS	-
OPSSE (OPS) (Ball Systems Engineering Division)	\$3,000 -10 K	Symbolics 3600, TI Explorer (Lisp)	-	-	-

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Table 4 — Lisp-based Tools

TOOL (Knowledge Representation) (Vendor)	Price Range	Hardware (Operating System/Language)	Problem	Memory Requirements RAM/Harddisk
Diagnostic Reasoning Template (Coherent Thought)	\$19-100 K	Mainframe (MVS/XA/TSO, CICS), IBM PC's, various workstations, (C)	Equipment Diagnosis	-
Genesis V (help/systems Inc.)	\$14,950	System/38	Develops expert frontends for relational databases	-
Intelliform (Mind Path Technologies)	\$495	IBM PC's and compatibles (C)	Intelligent Forms Entry	512 k
ProGenesis (Quantum inKNOWvations)	\$895-4,995	IBM PC's and compatibles, (MS-DOS), (C)	Develops expert frontends for SQL relational databases.	-
TestBench (Texas Instruments/Carnegie Group)	\$35-40 K	TI Explorer, Sun, MicroVAX (Lisp) Delivery via PC (C)	Equipment Diagnosis	8 mb, 2 Hard Disks of 140 mb recom.
Service/Maintenance Planner (Carnegie Group)	\$295 K	Sun-4, TI Explorer, Symbolics (Lisp)	Develops service and maintenance plans and schedules	-

Table 5 — Problem-specific Tools

TOOL (Knowledge Representation) (Vendor)	Price Range	Hardware (Operating System/Language)	Domain	Memory Requirements RAM/Harddisk
CAIS (Rosh Intelligent Systems Inc.)	\$100-200 K	Unix-based or MS- DOS (Prolog)	Troubleshooting for service technicians	PC/AT or higher 640K
Cogensys Judgement Software (Cogensys Corp.)	\$200,000	PC AT, PS/2 or compatibles (DOS) (C, Pascal)	For developing financial applications	512 K memory 20 mb Harddisk recom.
Expert Controller (Umecorp)	\$10,000	Development: IBM Pc's and compatibles (DOS), Runtime on Expert Controller	Automation of process controller programming	PC: 640 K, 10 mb Harddisk recom.
Flexis ToolSet (Savoir Systems Group)	\$35,000	Sun 3 & 4, Sparcstation Xerox 1185 & 1186	Manufacturing control	8 mb
ICAD (ICAD Inc.)	\$40-95 K	Sun 4/110, 4/260, Sparcstation, TI Explorer, Apple microExplorer (Lisp)	Engineering design automation	8 mb
ICAT (Automated Reasoning Corp.)	\$10,000	IBM PC/AT (DOS), MAC II, Apollo, Unix, Sun, DecVAX, (Lisp)	Diagnostic testing of electrical equipment	-
Intelligen (CIMTelligence Corp.)	\$35,000	Digital VAc 2000 or larger (VMS), (Fortran 77)	Generates process plans	2-4 mb
Maingen (OXXO Corp.)	\$195	IBM PC's and compatibles (LevelS)	Maintenance Application Systems	512 K
Operations Planner (Carnegie Group)	\$39,000	IBM PC's and compatibles, (MS-DOS), (Fortran)	Create and compare alternative scenarios of plant operations	640 K Harddisk recom.

Table 6 — Domain-specific Tools

Illustrative Applications of Expert Systems

1. Finance and Insurance
2. Manufacturing / Operations Management
3. Marketing
4. Legal Consulting
5. Medical Consulting

Finance and Insurance

- . 43% of top financial companies use ES (1987)
- . 75% of large insurance companies use ES (1987)

1. Technical Analysis and Reasoning Assistant

- . Manufacture's Honover Trust Co.
- . Real-time
- . Assist foreign currency traders in their decision to buy, sell, or hold market positions
- . Increased Profit

2. Personal Financial Planning System

- . Chase Lincoln First Bank
- . Supplement the high-cost bank personnel developing financial plans for its clients
- . Surpassed other automated financial planning system

3. ANALYST

- . General Motors Acceptance Corp
- . Assist credit analysts perform financial analyses of auto dealerships
- . Savings of \$2 million per year.
- . Fast review time
- . Standardization of review process

4. Intelligent Banking System

- . Citibank
- . Increase the productivity and effectiveness of
a full family of banking transaction applications
- . Reduced data entry errors, increased customer
satisfaction

5. Automated Money Transfer Service

- . MCI International
- . Natural Language Processing
- . Improved Processing Throughout

6. Authorizer's Assistant

- . American Express
- . On-line Credit Authorization
- . Fraud Detection
- . Reduced Staffing Requirement
- . Increased System Up Time

7. Financial Statement Analyzer

- . Developed by Arthur Andersen & Co.
- . for the U.S. Securities and Exchange Commission
- . Used KEE on Symbolics machine
- . Captures information embedded in the financial statements

8. SYNTEL

- . Syntelligence
- . Underwriting Advisory System
and Lend Advisory System
- . Purchased by insurance companies and banks
- . Checklist for Income Loan Transactions
- . Metropolitan Life Insurance Co.
- . Assists attorneys in the closing process
for commercial real estate mortgage loans
- . Faster loan processing

9. Exmarine

- . Developed by Coopers & Lybrand for Internal User
- . Assist junior underwriters in underwriting marine liability
umbrella insurance policies
- . Decide the acceptability of risk and
determine the appropriate premium

10. Mortgage Loan Analyzer

- . Developed by Arthur Andersen & Co.
- . Helps underwriters assess and make decisions about residential mortgage loan applications
- . Used PC-version ADS

11. Loan Probe

- . Developed for internal use by Peat Marwick Main & Co.
- . Helps auditors make an accurate assessment of probable losses in the loan portfolios of lending institutions
- . PC-based

12. Manager's Broker Monitoring System

- . Developed by Coopers & Lybrand for Bear, Stearns & Co.
- . Expedite the monitoring of broker's discretionary accounts
- . Developed using Gold Works with Gold Hill 386 Humming Board, and fielded in Lisp and C.

Manufacturing / Operations Management

1. Logistic Management System

- . IBM
- . Dispatcher for the manufacturing flow
or logistics of semiconductor manufacturing
- . 120% improvement in output \$10 million dollars
in saving

2. Ship Planning System

- . Port of Singapore's Container Terminal
- . Schedule the discharging and loading operations
- . Expediting the planning of single cases,
allowing the human planners to spend more time
on the more complex or exceptional cases

3. Direct Labor Management System

- . Ford Motor Company
- . All aspect of manufacturing planning process
- . Generate detailed plant-floor assembly instructions,
and estimate the associated labor times
- . Effective communication of information throughout
the assembly process

4. CAN BUILD

- . Digital Equipment Corporation
- . Inventory Reduction
- . Determine whether to build up a subassembly,
disassemble it or sell it
- . Beginning Stage

5. Truck Routing Assistant

- . Developed for sale by Arthur Andersen & Co.
- . Design of delivery routes
- . Benefit: increased efficiency
 - decreased distribution center costs
 - increased capacity
 - fewer miles driven
 - easier training of dispatcher and routers
- . Developed with KEE on TI Explorer

Marketing and Retailing

1. Sales Analysis and Inventory Planning

1) Area Sales Manager Expert System Consultants

- . Broadway - Southern California Stores (43 stores)
- . Captures the collective expertise (sales techniques) of top area sales managers who have consistently produced best results
- . IBM's ESE
- . expected sales increase: \$6M

2) Buyer's Workbench

- . Developed by Deloitte & Touche for the grocer Pacific Northwest Chain who provides the buying service to its 400 member supermarkets
- . Captures a seasoned buyer's expertise
- . Used Nexpert Object
- . Works with mainframe DB2 via LAN

3) Merchandizing Coach

- . Hudson Bay Co., Canada's largest retailer
- . Advise on vendor negotiation and sales strategy
- . Used ADS on PC

2. Market Analysis and Promotion Planning

1) Cover Story

- . Information Resources, Inc.
- . Extract information from mainframe scanner database to report on market trends, competitors, etc.
- . Runs on PC

2) TIMES

- . Mediatop
- . To assist advertising media planners to define and construct television media plans
- . Consistent media plan

3. General Management Support

- 1) Interviewer: help to identify prospective employees
- 2) Production Planner
- 3) Labor Scheduler

4. Sales Support

- 1) Warewash Expert Diagnosis System:
 - . Restaurant cleaning requirement
- 2) Package Advisors
 - . Helps users design plastic containers and then select the most cost effective resins from which to fabricate them
- 3) Sophina
 - . Advice on skin problems
- 4) Simplified Needs Assessment Profile
 - . Help computer shoppers assess their computer needs

Legal Consulting

1. ExperTax

- . Internally used by Coopers & Lybrand
- . Applicability of U.S. tax laws to clients
- . Incorporated the knowledge of 40 top partners
of the firm
- . Replaces a written questionnaire of 200 pages
- . Used by junior auditors
- . Used Q-Shell in Golden Common Lisp
- . Costed \$1M to develop, and took 7,000 hr

2. VATIA

- . Developed for internal use by Ernst & Whinney
- . Helps auditors assess client's compliance with
U.K. value added tax laws
- . Used a shell Crystal on PC

3. Latent Damage Advisor

- . Developed by Ernst & Whinney
- . Helps barristers in the United Kingdom determine
if latent negligence liability laws apply
in certain cases
- . Run on PC

Medical Consulting

DHSS Performance Analyst

- . Developed by Coopers & Lybrand for the British
National Health Service
- . 11,200 rules
- . Developed in about four months during 1986
- . Medical judgments
- . Distributed on diskette to local offices

Implication to Functional Area

- . Knowledge-based System as a new methodology

- . What we have so far?

Quantitative Methods

- . OR (Optimization)
- . Statistics
- . Probability Theory
- . Information Systems (System Analysis, Data Base)

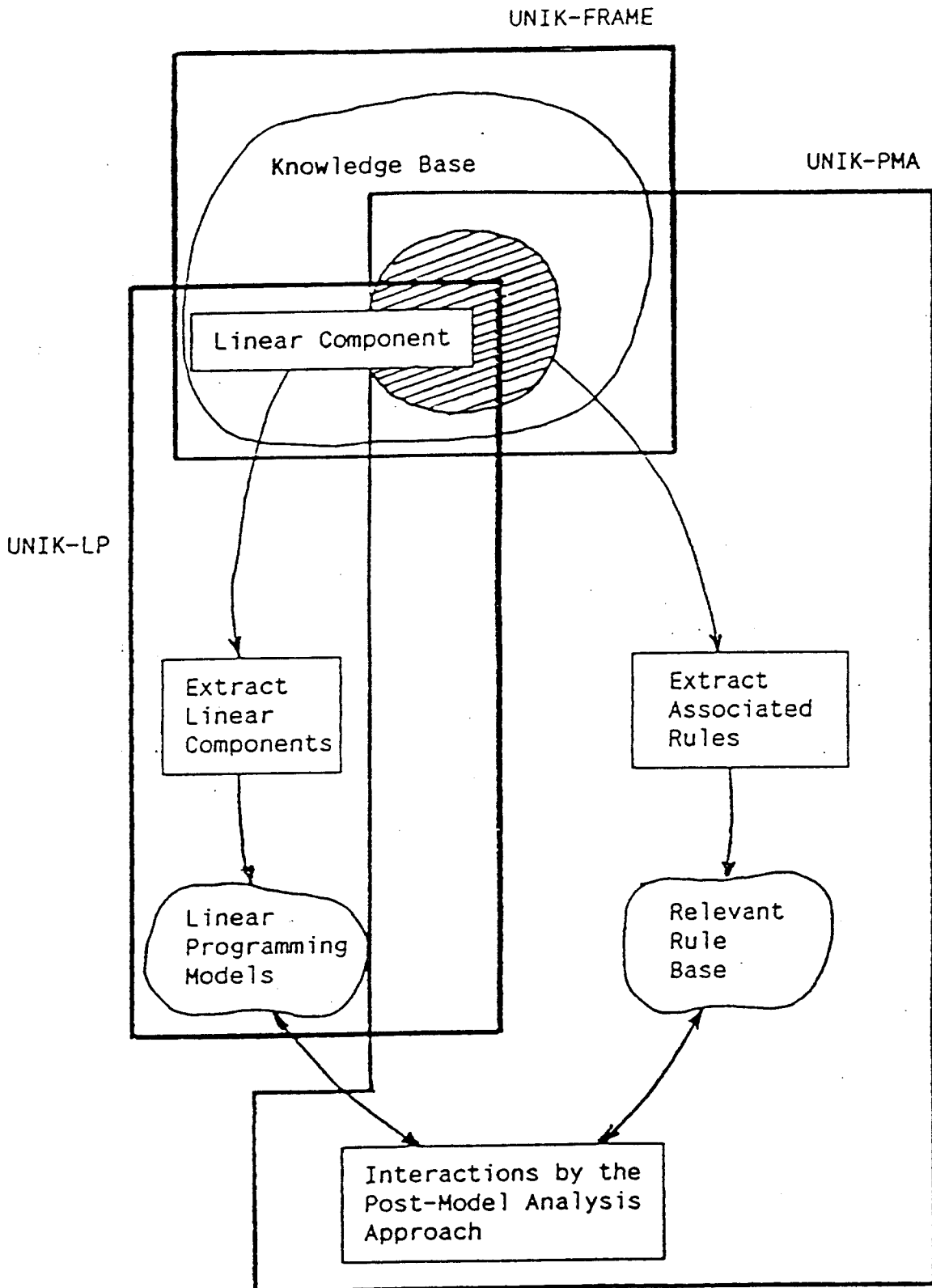
- . Knowledge-based Systems mean

Qualitative Analysis

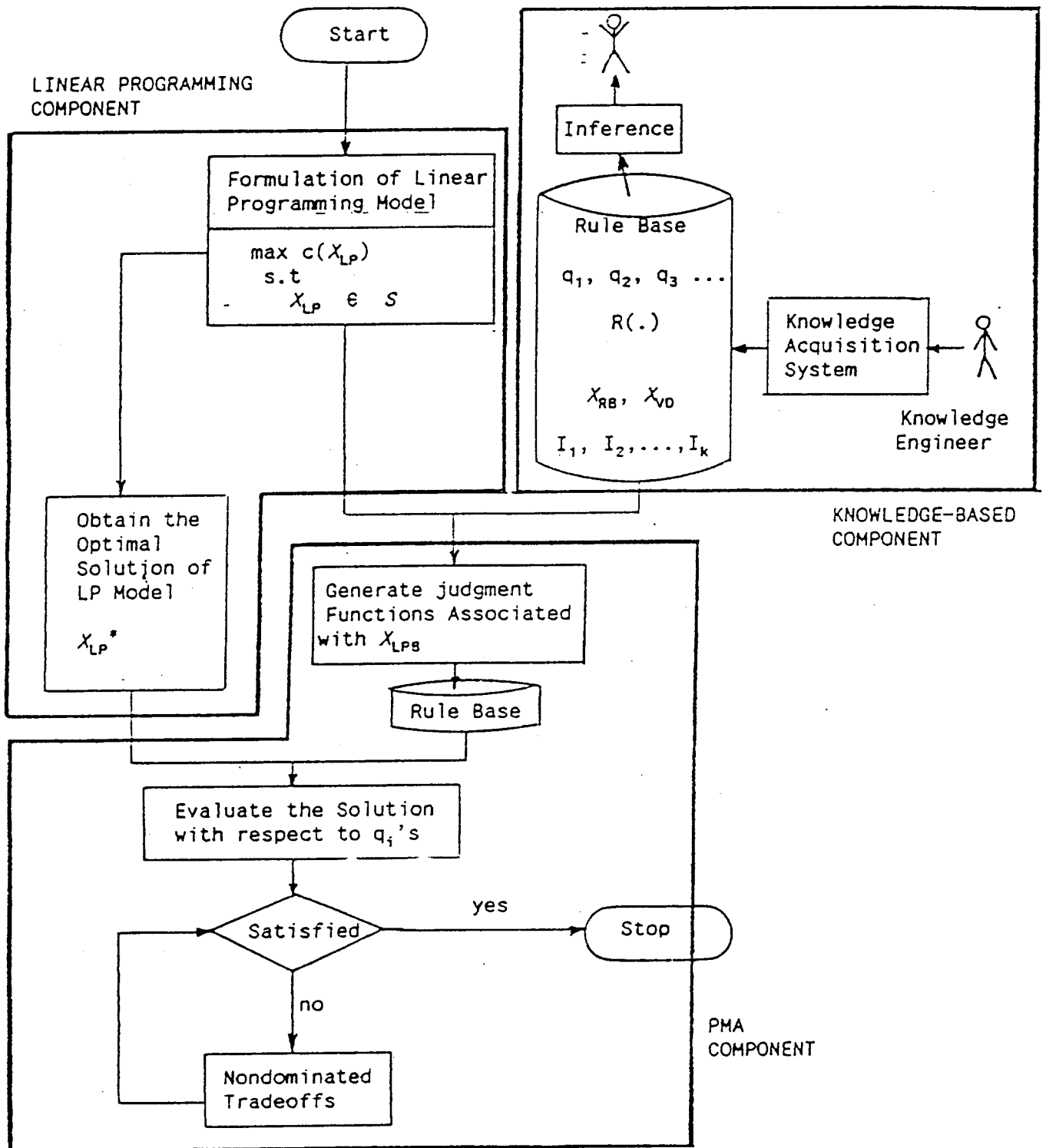
- . Integration with Existing Methodologies

(ex) Knowledge + Optimization

1. Front End: Knowledge-based Formulation Support
2. Integrated Modeling
3. Back End: Explanation Synthesis



Architecture of UNIK



The Procedure of Post-Model Analysis using Rule Base