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Title: KBS Project Report Vendor Selection Expert System

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Abstract: The purpose of this Knowledge Based System (KBS) is to aid Procurement Agents and Manufacturing Engineers in the selection of qualified vendors to fabricate company designed parts. Typically, no one has all of the required knowledge needed to select a suitable vendor for a broad range of custom parts. Required knowledge includes the ability to determine the parts' requirements, and knowledge of vendors' capabilities and their current performance. We believe that a KBS can be developed that would centralize all of the experts' knowledge into a common set of rules and procedures that includes feedback methods for vendors' performance.

KBS PROJECT REPORT VENDOR SELECTION EXPERT SYSTEM

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KBS PROJECT REPORT
VENDOR SELECTION EXPERT SYSTEM
(A Proposal)

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1.0 SYSTEM PURPOSE:

1.1 ABSTRACT:

The purpose of this Knowledge Based System (KBS) is to aid Procurement Agents and Manufacturing Engineers in the selection of qualified vendors to fabricate company designed parts. Typically, no one expert has all of the required knowledge to be able to select a suitable vendor for a broad range of custom parts. Required Knowledge includes the ability to determine the parts' requirements, and knowledge of vendors' capabilities and their current performance. We believe that a KBS can be developed that would centralize all of the experts' knowledge into a common set of rules and procedures that includes feedback methods for vendors' performance.

1.2 CURRENT DOMAIN PROBLEMS:

The most outstanding problem with current vendor selection procedures is that the knowledge required to perform this task resides in various organizations such as Manufacturing, Purchasing, Incoming Quality Control, and R&D (Figure 1). The ultimate decision for vendor selection resides in the Procurement department. Unfortunately, the purchasing department does not always have adequate technical expertise to identify the requirements for fabrication of a custom designed part. The purchasing department has useful information on price and delivery lead time of vendors. The Research and Development group has information on materials, tolerances and cosmetic finish specifications. Manufacturing Engineering is most familiar with the manufacturing processes and the equipment that is required to fabricate a custom part. Manufacturing Engineering also possesses knowledge about post fabrication processes such as anodizing, painting, surface finishes, and etc. The Quality Control department collects information on performance of the vendors and their rejection history.

Inter departmental communications are essential to make a good decision regarding vendor selection. However, due to the number of parts versus the production/shipment schedules, it is not always feasible to conduct such communications.

The second problem in the industry is that its vendor base changes dynamically. Also, the vendors constantly have to be judged on basis of delivery, acceptance rate, Overall quality and capability. Today's choice of vendor for a given part may not be tomorrow's choice. Theoretically, one should be able to develop procedures and guidelines for procurement agents to assist them in selecting specific vendors. Such procedure would have to be updated and changed continuously to accommodate new vendors, new performance information, appropriate delivery capabilities (i,e. priorities of the vendor), and etc. The Engineering Change Order loop to modify and edit Vendor Selection Procedures is not efficient.

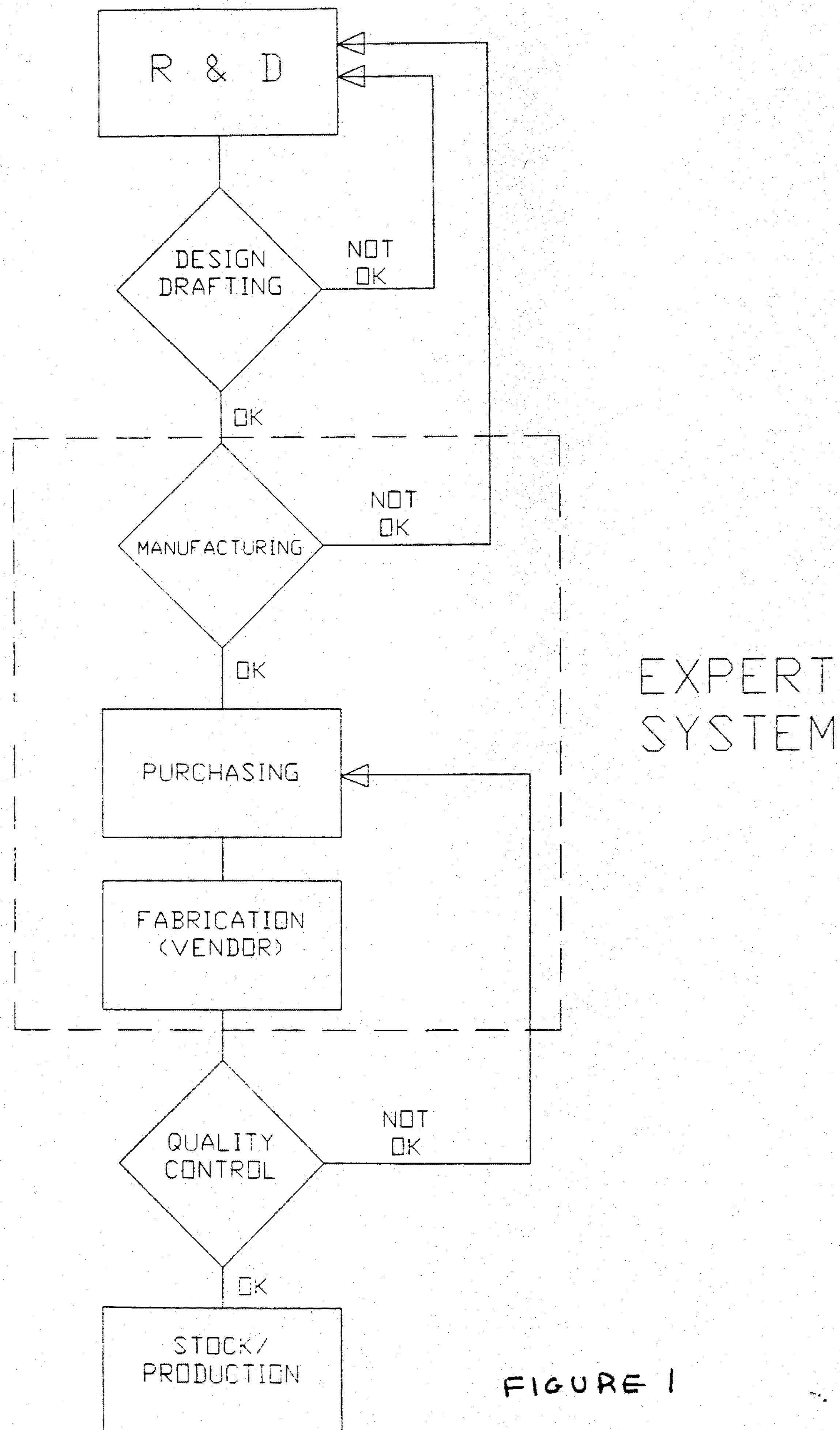
R & D
DESIGN DRAFTING
NOT OK
OK
MANUFACTURING
NOT OK
OK
PURCHASING
FABRICATION (VENDOR)
QUALITY CONTROL
NOT OK
OK
STOCK/ PRODUCTION
EXPERT SYSTEM

FIGURE 1

1.3 WHY KB Systems?

A vendor's capabilities can be categorized or classified as will be described in the later section into a manageable database. This will centralize all of the information that various experts' use in their decision making process into one location. On the other hand, we have found that there is a limited set of standards and specifications that are used throughout all custom designed parts. Experts merely look at various standards that are unique to each drawing. All of the information regarding standards and specifications can be loaded into a manageable and maintainable database . A Knowledge Base System can be developed that will match a parts requirements with a suitable vendors capabilities. The vendors' performance and capabilities can updated by Quality Control information.

The vendor selection process is not an Algorithmic task where a single operator is used to arrive at each goal, rather, the vendor selection process is a Heuristic problem. As we will show in the sample inference section, many possible operators requiring search and record keeping will need to be developed for this proposed KBS.

The Human Expertise in the vendor selection process is scarce. As High Technology industry experience indicates, it is often difficult to hire Purchasing Agents and Manufacturing Engineering experts that are familiar with the Local vendor base. Engineers are often hired from other states therefor not having familiarity with the local vendors. The learning curve in this field is estimated at eight months to one year.

1.4 KBS PLAYERS:

The major players in the Expert System are Manufacturing Engineers, Purchasing Agents, Quality Control Engineers, Vendors, and Consultants such as Computer programmers (Figure 2). The Manufacturing Engineers are the Domain Experts. Maintenance of the system is done by Purchasing as well as by Engineering. The task of Knowledge Engineering is Done by a team of Computer Programmers (Consultants) and Manufacturing Engineers (Experts). the novice users of the system will be the purchasing clerks and the advanced users will be the Manufacturing Engineers. The Quality Control Department will supply Vendor performance reports to the Knowledge Base System.

1.5 EXPECTED BENEFITS:

1.5.1 Lower Costs:

- Lower Rejection Rates:

  The most tangible benefit of this Knowledge Base Systems is reduction of the number of rejections that are caused by the Vendors in a given period. A rejection is reported when a Custom fabricated part does

EXPERT SYSTEM PLAYERS

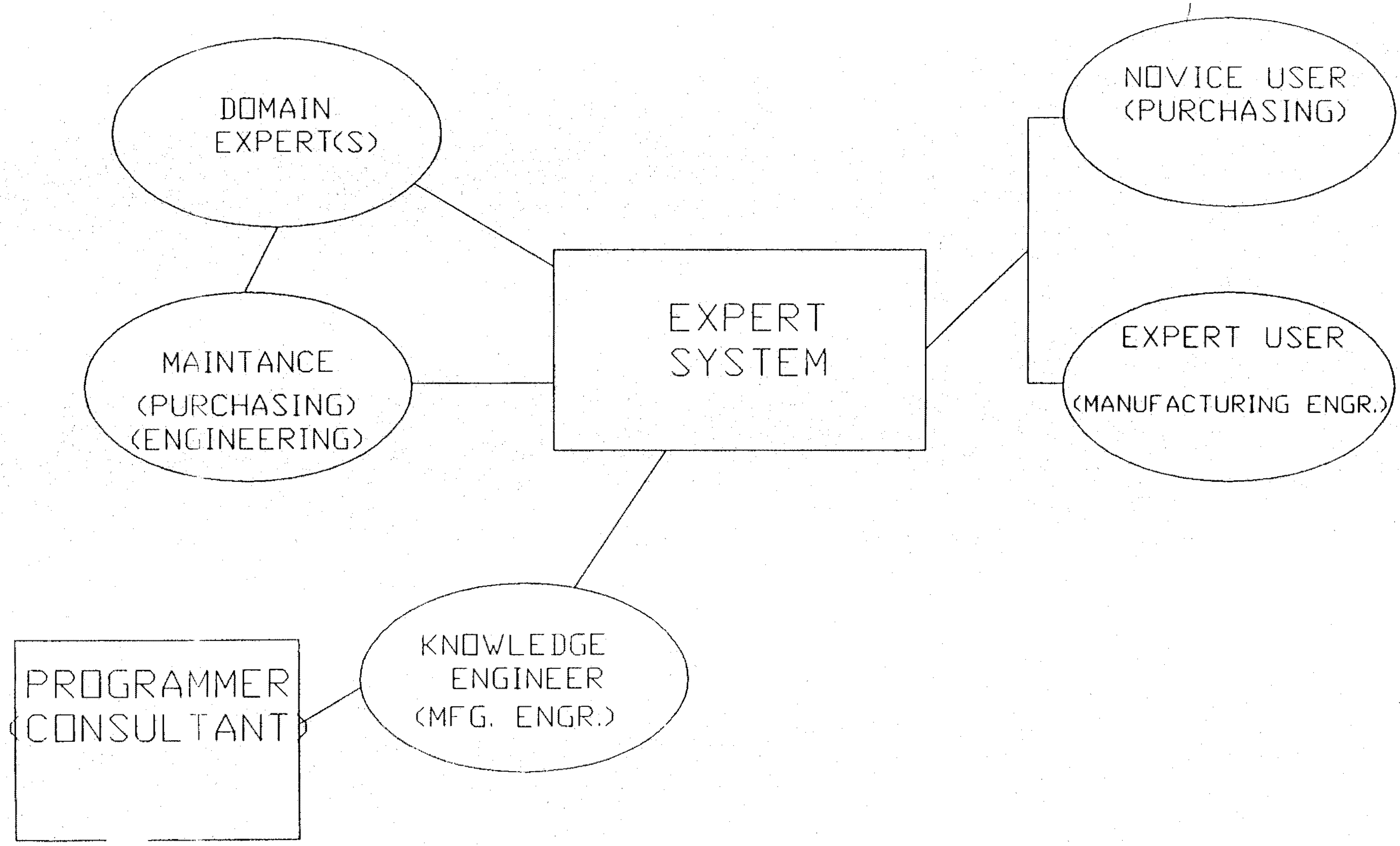

FIGURE 2

not meet all of the specifications on the blueprint. A Sample IQC (Internal Quality control) report indicates 172 rejections of which 141 are caused by the vendors (appendix FB 1), in a 5 month period. An Average cost of generating a rejection report (Non- Conformance Report) is $2000. if Our proposed KBS can reduce the rejections, by choosing correct vendors, by a conservative 50%, then the savings in one year can be estimated at $340,000.

- Lower Material scrap costs:

  A rejection (caused by vendor) is generated when a vendor does not perform a job correctly according to the specifications that are called out. The reason for this is that the vendors are not properly chosen for the right job. A common disposition for Non-Conforming parts is to scrap the part. If an average Cost of a scrapped part is estimated at $1500, with a 50% improvement assumption, our proposed KBS can save up to $12,000/Year.

- Reduction / Duplication of Effort:

  In the processes of vendor selection, various groups of people often search for the same information in order to select a vendor. Also when a different vendor needs to be selected for a particular part, a lot of bookkeeping information is researched and applied for the second or third time. An estimate of 3 hours may be spent right now to select a vendor. If our proposed system can reduce this time to 1.5 hours, and if it used four times daily, the man hour savings per year can range up to $60,000, Assuming $45/ hour for Engineering/Purchasing time.

1.5.2 Faster Reaction:

- Improved ability to react to external changes:

  The vendor leadtimes and capacities are always changing. A KBS can help to keep up with this changing information. The Vendor's quality and delivery should always be monitored and judged as they change due to reasons that not in the control of the company. Pricing information also changes due to various factors. We can use our KBS to respond to these changes more effectively.

- Faster Turn around on decision making loop:

  The decision making loop can be reduced to the manufacturing Engineer (or purchasing Agent) and the Computer. Currently, it seems as if all organizations within the company are involved in the decision making process.

1.5.3 Improved Accuracy:

We believe that this proposed KBS can Reduce error by helping to share information between various groups. We can also use this system to create better information for decision making and incorporate vendor performance feedback

2.0 System Outline

2.1 System functions

The main objective of the knowledge based system (KBS) is to aid in the procurement of internally designed custom parts. This will be accomplished using several different strategies.

- Identify Appropriate Vendors

The KBS will help the user to identify part characteristics and features that require different fabrication techniques and various levels of vendor capabilities. The KBS then matches these part requirements to vendor capabilities and suggests that the part be ordered from one of a list of vendors.

- Better Use of Resources

The KBS will have the capability of accepting input from several users. This will allow clerical staff to enter bookkeeping type information such as the part number, revision, quantity required, due date, and information easily read off of a drawing such as material type, plating requirements, cosmetic requirements, and general title block tolerances. This initial input could be done in a batch mode allowing a group of parts with similar characteristics to be entered into the KBS quickly.

In the next step an expert user would enter additional information into the KBS such as: the tightest tolerances for various features on the part drawing; the necessity of computer controlled equipment to make the part; the requirement of a particular heat treatment process; or the opinion that the part will be turned on a lathe, machined on a multi-axes machining center or can be fabricated on a screw machine.

In the last step of the process a buyer would review the list of vendors recommended by the KBS and then select one for a Purchase Order (PO) or several for a Request For Quote (RFQ).

On subsequent orders of the same part the KBS system would check for the current revision level and then prompt the user to make any necessary changes.

- Feedback

Another objective is to get feedback on vendors performance into the KBS to improve vendor selection. Information that is typically available from Receiving, Incoming Inspection, Quality Control and other groups would allow the KBS to update vendors performance in such areas as: on time deliveries; adherence to quoted prices; and ability to meet part requirements. If the KBS is being run on a stand alone machine, then vendor performance could be collected and periodically (monthly as a minimum) made available to the KBS through the use of a spreadsheet or database software package. If the KBS is on a mainframe it could be programmed to retrieve vendor performance information as required.

- Information Sharing

A long term objective is to have the KBS interact with other systems. If the KBS was on a mainframe and could interact with software packages such as Material Resource Planning (MRP), it would be possible for it to automatically determine such things as: quantity and due date requirements for a particular part; a revision level change to a part that may require additional user input; and a possible change to a vendors performance rating due to past due purchase orders. It would also be possible for it to transfer information to a program that generates purchase orders and requests for quotes after a qualified user has made a selection of a suggested vendor.

2.2 Knowledge Representation

2.2.1 Scope of knowledge

There are three basic types of knowledge that need to be collected in order to perform the system functions.

- Vendor Capabilities

Most companies have a vendor qualification procedure. Initial vendor capabilities will be determined through the use of information obtained during a vendor qualification procedure. Information that is required to determine a vendors capabilities includes: what types of materials do they prefer working with; what kind of machines they have; what purchase order quantities do they typically run; what secondary operations can they provide such as painting, plating, heat treatment, silkscreening or packaging; what tolerances can they hold on various processes; what are their current and typical lead times; what types of inspection equipment do they use; etc. (see Exhibit 2)

- Vendor Performance

Vendor performance knowledge needs to be gathered from within the procurement organization and from outside sources for existing vendors. A method of updating this knowledge for current and future vendors needs to be set up so that appropriate feedback is made to the KBS.

- Procedural Knowledge

The process for procuring custom parts must be defined. This includes determining which users will be authorized to perform which tasks, what kinds of bookkeeping information must be used in the KBS, and what are the minimum input requirements for the KBS to make a selection.

2.2.2 Structure of Knowledge Base

The structure of the knowledge base will be rule based - IF________ THEN_______.

2.3 Example usage

A typical usage of the KBS could be a manufacturing engineer choosing vendors to quote on a new part or an existing part that has been substantially revised. Another typical usage could be a production buyer selecting a new vendor for an existing part.

2.3.1 Sample input

The typical input into the KBS would include: bookkeeping information such as the part number, part name, revision level, quantity required, due date, and buyer code; and part characteristics and requirements such as material type, finish type, cosmetic requirements, tolerance requirements and additional secondary operations required. The user would be presented with a request for information and given a list of choices to choose from.(see Exhibit 3) After all the information had been entered the user would be given an opportunity to review and revise it.

2.3.2 Sample inference

IF material is aluminum AND
IF finish is anodize AND
IF cosmetics are class 1B
THEN vendor code is General Machine Shop

IF flatness tolerance is .002 to .005 OR
IF true position tolerance is .005 to .010 OR
IF form tolerance is .010 to .020 OR
IF perpendicularity tolerance is .005 to .010
THEN tolerance code is Class II

IF lead time is 20 to 30 days
THEN lead time code is Time II

IF quantity required is 51 to 100
THEN quantity code is Qty II

IF vendor code is General Machine Shop AND
IF quantity code is Qty II AND

IF lead time code is Time II AND
IF tolerance code is Class II

THEN Vendor A
Vendor B
Vendor C

2.3.3 Sample Output

The output would be a list of suggested vendors from which to order parts or request quotes.(see Exhibit 4) The user would have the option to store the results, modify the input information, and compare the results. Additional information about individual vendors could be requested and displayed to help the user make a selection. (see Exhibit 5)

2.3.4 Expected benefit of the sample usage.

In this example the user would be able to select a vendor for the fabrication of a internally designed custom part and have a high degree of confidence that the vendor will be able to delivery good quality parts on time.

3.0 SYSTEM DEVELOPMENT:

System development will be guided by decisions made during the planning phase; therefore, it is recommended that a detailed development plan be proposed and agreed upon prior to commencing the development phase and as a minimum contain the following information:

1. hardware and software to be used
2. system specifications
3. personnel to be involved and their responsibilities
4. budget
5. training and support authorized
6. development timetable.[4]

3.1 SOFTWARE SELECTION

Proper software selection during project planning is considered critical to successful system development and will directly affect the time, money and personnel involved in the project. Unfortunately, software is often selected on the sole basis of:

1. cost
2. company hardware
3. product familiarity[1]

A tool for this project should not be too large and complex for the task nor should it be too weak, inflexible or be incapable of adequate knowledge representation. There are, however, factors specific to this project which will impact software selection. First, the company has no previous experience with expert systems, no resident "gurus" or full-time programmers with LISP, PROLOG or other AI languages; therefore, in the language-tool continuum, the selection of a high-level language will add considerable time and cost to system development. Secondly, the problem size and task paradigm (problem-solving approach) appear more suited to a small - fewer than 500 rules- mainly procedural, expert system building tool. The following project decisions will also influence software selection: development by nominally skilled project team, broad usage by individuals with various levels of computer knowledge, as well as training and maintenance costs.[4]

3.1.1 EVALUATION OF EXPERT SYSTEM SHELLS:

The factors listed above should be considered in software selection; however, there are additional required features that the software must possess such as the ability to encode the type of knowledge representation to solve the domain problem and many additional features that will enhance system development and use. Unfortunately, side-by-side comparison of the many and varied software attributes such as graphics capabilities, frames and slots, inheritance, case save, speed, and pruning may make final selection very difficult without clearly defining what features are required and what is desired. Therefore, it is recommended that the development team formulate their requirements prior to product evaluation.[8] Visits to software vendors and product demonstrations are also recommended. Finally, it is not recommended that the project team "start from scratch", but rather take advantage of the information available on expert systems already in use. Examples of product applications received from AI Corporation, Inference Corporation, and IntelliCorp are contained in Appendix 6.

3.2 PROJECT ORGANIZATION:

In this project, the term "knowledge engineer", or "KE", describes that individual assigned the task of knowledge acquisition, knowledge modelling, and knowledge encoding.[4] Although some ES tools are high level and may permit system development by novices, it is felt that one individual should be tasked as the knowledge engineer/system developer. Reasons for this decision include: no resident AI experience, project success is needed to permit future applications and the need for effective inter/intra department coordination. Although the developer/KE should be fairly computer literate, this task should not automatically fall to DP/MIS personnel or the individual with the most computer experience. The goal is to find that individual who can effectively extract the relevant data from domain experts and system users, and capture that knowledge in the computer while at the same time be a competent project manager.[2]

3.2.2 DOMAIN EXPERT:

The search for the domain experts is considered a relatively easy task because of the small number of individuals working in the domain; however, there are some considerations other than level of knowledge that must be considered. First the individual must want to participate, not just be interested, but actually motivated to participate and articulate enough to participate. Although it is felt that domain experts will want to participate once they learn of the system's ability to make their job easier, it is expected that experts will fall into three major categories: promoters, neutrals or resisters.[1] Secondly, the expert must be available to participate.[8] Good people are usually busy! Finally, the chosen expert must truly be an expert. Fortunately, in this project, domain experts are recognized as such by their peers as well as by others within the company. Ultimately, one domain expert will be designated as the primary contact; however, a secondary expert will be assigned to ensure that the non-availability or loss of the primary will not seriously delay the project.[3] Additionally, experts should be formed into panels to evaluate prototypes and the final product.[1]

3.2.3 USERS:

The participation of users in the planning, development, and maintenance phases cannot be over-emphasized.[6] It is helpful to be guided by the maxim "No user participation during development, no participation afterwards."[5] In this project, the users will include domain experts; therefore, involvement should not be difficult but the same reactions and attitudes expected of experts should be expected of users. Users will also want to know what the system will do, whether it will be reliable, how users will know when it is wrong, and if it will threaten job security. Involvement will answer many of these questions, as well as build support for the system.[7] During the planning phase, users can provide information about system requirements and user interface; during development, they can test prototypes as well as the final product and during the maintenance phase, they can provide feedback to maintain system viability.[1]

3.3 DEVELOPMENT PHASE:

3.3.1 PROTOTYPE (initial):

Guidance provided from the development plan should also permit the KE/developer to formulate a conceptual design of the system.[4] From this he can proceed toward a better understanding of the domain and the problem to be solved and commence data collection. Considerable research prior to interviews with experts and users should enhance interactions and information collection. From the data collection, the KE/developer will implement the first symbolic program executable by the inference engine.[7] Building this initial model or prototype will permit:

1. early interact of the development team
2. learning more about the domain
3. early test of system feasibility
4. test assumptions on how to encode facts, relationships and inference strategy
5. First feedback (and criticism!!)
6. better understanding of requirements to build system
7. show quick results.[4]

3.3.2 SYSTEM DEVELOPMENT:

From the lesson learned from the prototype, the KE works towards implementations of the final system. This phase may require many test, feedback and refinement loops to arrive at the final product. This phase has the most potential for problems or failure and will involve the greatest investment of time and money.[7] The ability of software, and development team will be tested during this phase.

3.3.3 FIELD TEST:

Amongst other things, field testing will test the success of the analysis and development phases. If the system has been introduced incrementally, the developer will already have a reasonably sure answer to the question this phase must determine--user acceptance.[4]

3.3.4 IMPLEMENTATION/DELIVERY:

During this phase the system is turned over to the users and the development team disbanded. This will be the first introduction to the system for users not involved in development. Reactions experience earlier in development should be expected. The key item of this phase is the training of users an maintainers. This phase requires advance planning; therefore, a written plan for implementation is recommended.[4]

3.4 MAINTENANCE PHASE:

The final phase of Expert System development, maintenance, is seen as critical to the continued viability of the system. If the system is not updated, it will fail to maintain its credibility and fall into disuse.[1] Accordingly, this phase must continue for the life cycle of the system. Initially, the data base of vendors will updated manually. Later, however, hooks into data bases are desired to make this an automatic function; likewise, the rules are expected to change, although not rapidly or constantly. Additional changes are anticipated as system users detect bugs, faulty logic, and other errors not detected in the development phase. Other software revisions and upgrades should also be anticipated as well as recommendations to modify the user interface and to enhance performance.

Actions taken in the planning phase are anticipated to have beneficial results in the maintenance phase. Software should be selected with particular attention to its capability to be easily modified by non-programmers, to be upward compatible, and allow system "experts" to easily train novice users.[7] Maintenance procedures will also be fully documented and responsibilities designated prior to system implementation, to ensure continuity between the development team and maintainers.

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