Title: A Knowledge Based System for Evaluating New Business Opportunities in Tektronix Federal Systems, Inc.

Course:
Year: 1990
Author(s): A. Herma

Report No: P90033

Abstract: The management of Tektronix's Federal Systems Division is regularly required to evaluate potential new business opportunities for the corporation. Opportunity evaluation requires extensive knowledge and information in a number of areas in order to make a proper decision. A possible solution lies in the creation of a knowledge sharing system. Its output would be a "bid/no bid" recommendation just as a knowledgeable human evaluator would produce given the same information.

A KNOWLEDGE BASED SYSTEM FOR EVALUATING NEW BUSINESS OPPORTUNITIES IN TEKTRONIX FEDERAL SYSTEMS, INC.

A. Herman

EMP - P9033

A KNOWLEDGE BASED SYSTEM FOR EVALUATING NEW BUSINESS OPPORTUNITIES IN TEKTRONIX FEDERAL SYSTEMS, INC.

A Project Report
for

Dr. Kiyoshi Niwa

EMGT 510E
Knowledge Engineering and Management

Portland State University

Submitted by

Al Herman
General Manager

Tektronix Federal Systems, Inc.

13 March, 1991

Executive Summary

The management of Tektronix's Federal Systems Division is regularly required to evaluate potential new business opportunities for the corporation. Opportunity evaluation requires extensive knowledge and information in a number of areas in order to make a proper decision. If critical information or knowledgeable evaluators are unavailable, the evaluation process is unsystematic, incomplete and/or incorrect. Viable opportunities may be rejected erroneously and bad opportunities explored unnecessarily. Often the knowledge required to evaluate an opportunity resides in a fragmented form in the experiences of several people across the corporation and cannot be readily retrieved to focus on a small new business decision. Such occurrences are frustrating to both the sales force and division management and costly to the corporation.

A possible solution lies in the creation of a knowledge sharing system which would ask the necessary questions of the sales representative to gather basic information about a new opportunity and use that information in conjunction with a stored knowledge base to evaluate the attractiveness of the opportunity. Its output would be a bid/no-bid recommendation just as a knowledgeable human evaluator would produce given the same information.

A knowledge based system would permit us to capture the expertise of a number of individuals and draw upon their knowledge, as necessary, without disturbing them in their other responsibilities. This is one of the primary benefits of the system. A second benefit is that the structure that the system imposes upon the evaluation process, and in particular the data gathering process, should significantly improve the quality of the evaluation.

The system inputs consist of answers to a series of questions about the opportunity that are provided by the sales representative, the knowledge bases (discussed above and described in more detail below) and certain run-time parameters used to provide guidance to the system during the inferencing process. System outputs include a recommendation regarding the viability of the opportunity, various explanatory displays and reports, and run-time information to assist the user in running the system.

The knowledge structure will, in general terms, be data-driven consisting of rules in the form "IF NOTICE:X THEN ASSERT (or DENY or PERFORM):Y". This implies a forward-chaining inferencing technique, but possibly employing depth first search.

The system will have two primary users: the sales representatives and the division management. Sales representatives will use the system to insure that they have been thorough in gathering information about the opportunity and to screen opportunities before they are presented to management. Management will use the system as a repository of knowledge and as an adviser, particularly when the bid opportunities are complex. The shared knowledge bases, the explicit representations of what information is missing, and the systematic evaluation process should make the system of significant benefit to even the most experienced user.

Background

The management of Tektronix's Federal Systems Division is regularly required to evaluate potential new contracts for the purpose of determining whether they represent attractive business opportunities for the corporation. New contract opportunities typically are submitted by members of the commercial sales force and require the development of a new technology, product or system for the Federal government. The commercial sales representatives are trained to evaluate prospective commercial product sales. However, the complexities of the Federal procurement process and the risks and uncertainties of quoting on firm fixed price development contracts necessitate that all such opportunities be evaluated and quoted by Federal Systems Division.

The opportunities are communicated to the division by various means including telephone calls, memos, etc. If the initial description of the opportunity indicates that it might be of interest, the opportunity is discussed directly with its discoverer. These conversations usually take the form of a sequence of questions put forth by management in order to determine the attractiveness of the opportunity. The questions deal with the likelihood that we can win the business, the required investment, the strategic "fit", the likelihood that we can perform on the contract if awarded to us, its potential profitability, etc. Based on the information provided, management decides whether we will invest any further time and effort in pursuing the opportunity.

Opportunity evaluation requires extensive knowledge and information in a number of areas in order to make a proper decision. If information or knowledgeable evaluators are not available, the evaluation process is unsystematic and/or incomplete. Sometimes viable opportunities are rejected for lack of information. Sometimes bad opportunities are explored unnecessarily due to a lack of disqualifying information. Often the knowledge required to evaluate an opportunity resides in a fragmented form in the experiences of several people across the corporation and cannot be readily retrieved to focus on a small new business decision. Such occurrences are frustrating to both the sales force and division management and costly to the corporation.

Purpose of the System

A possible solution lies in the creation of a knowledge sharing system which would ask the necessary questions of the sales representative to gather basic information about a new opportunity and use that information in conjunction with a stored knowledge base to evaluate the attractiveness of the opportunity. Its output would be a bid/no-bid recommendation just as a knowledgeable human evaluator would produce given the same information.

The proposed system would consist of a PC based set of programs that could interactively interrogate the discoverer of a new business opportunity gather information and make judgements regarding several general questions:

1. Is the opportunity real?
2. Do we want the job?
3. Can we do the job?
4. Can we win the job?
5. Can we produce a quality proposal?
6. Can we negotiate an acceptable contract?
7. Can we make money on the contract?

Each of the above questions is an abstraction of a set of more specific questions which the system would pose to the sales representative. After the system has been provided with the requested run-time information, it would analyze the data, drawing on the information stored in its internal knowledge base, to reach conclusions and make a recommendation. Explanations of how it reached its conclusions would also be provided.

Justification for Selecting a Knowledge Based System Approach

Arriving at the kinds of conclusions that we are interested in requires the manipulation of data in symbolic form rather than the numeric form of traditional information processing systems. Furthermore, the knowledge required to thoroughly evaluate a broad spectrum of new business opportunities can be quite extensive. Ideally it would include information regarding the capabilities of one's own company, competitors, markets, products, strategies, technologies, finances, contracts, etc. It is this latter requirement that makes a Knowledge Sharing System approach particularly well suited to this task. It is

often difficult to assemble the expertise required to conduct a thorough evaluation of an opportunity. For this reason, evaluations are often carried out in a sequential manner as individuals with the necessary expertise become available. On other occasions, we will manage to get everyone together only to learn immediately that the opportunity is not right for us and we have wasted everyone's time by convening a meeting. A knowledge based system would permit us to capture the expertise of a number of individuals and draw upon their knowledge, as necessary, without disturbing them in their other responsibilities. This is one of the primary benefits of the system.

A second benefit is that the structure that the system imposes upon the evaluation process, and in particular the data gathering process, should significantly improve the quality of the evaluation. In addition, in many cases, the system may be able to conclusively eliminate an opportunity without help from a human evaluator and without conducting an in-depth analysis of competitor capabilities, discounted cash flows, etc. There is often a clear reason why we should not pursue the opportunity. In such cases the system could reject the opportunity by identifying obvious problems, e.g., the procurement may be restricted to small businesses or the proposal may be due in three days. In other cases an opportunity can be immediately recognized as a necessary bid for either legal or competitive reasons.

The system could also provide a significant benefit by assisting a human evaluator in a Human Computer Cooperative System. Sometimes large or complex opportunities can be difficult to evaluate. In such cases the system could assist the human evaluator by conducting its own analysis

and making the results, as well as the reasoning that produced the results, available to the human evaluator for review. This could provide the evaluator with valuable insights which might have otherwise been overlooked. It should be noted that it could also enable a human to assist the system when it encounters problems, particularly when it encounters unstructured problems or problems that enter domains for which the system is unprepared.

System Functions

The proposed system has three primary objectives:

1. Facilitate the acquisition, retention and utilization of knowledge relevant to the evaluation of new business opportunities.

2. Improve the quality of new business pursuit decisions by improving the process by which those decisions are made through the imposition of structure (on both the data and the process)and the application of powerful inferencing tools and object oriented information representation schemes.

3. Increase management and sales force efficiency by reducing the time and effort required to investigate and analyze new business opportunities.

The system can be extended to include a fourth major objective:

4. Create and evaluate business strategies for the company and its competitors.

In additon, a number of secondary objectives could be readily established but that discussion is beyond the scope of this paper.

System Inputs and Outputs

The system inputs consist of answers to a series of questions about the opportunity that are provided by the sales representative, the knowledge bases (discussed above and described in more detail below) and certain run-time parameters used to provide guidance to the system during the inferencing process.

System outputs include a recommendation regarding the viability of the opportunity, various explanatory displays and reports, and run-time information to assist the user in running the system.

System Design

A block diagram depicting the overall design of the system is contained in Appendix A.

A fundamental question in the design of the system has to do with the amount of knowledge and inferencing ability the system will possess.

The questions which the system asks are ordered in a sequence that asks the more easily answered questions first. The rules are prioritized to take advantage of this fact. Later rules use information provided by the sales representative or generated by the system from answers to the earlier questions. This dependency does not prevent the system from reaching a tentative solution when data is missing (although the user must recognize that there may be unverified assumptions underlying the solution.)

The solution process can, in theory, be segmented and answered in pieces. The different pieces lend themselves to knowledge based solution techniques to varying degrees. For example, a question such as "Is the opportunity real" can be answered fairly definitively simply by asking a series of questions specific to that opportunity, assigning scores to the answers and then weighting and summing those scores with a defined threshold score required for concluding that the opportunity is "real". On the other hand, a question such as "Can we win the contract?" requires extensive information regarding our capabilities relative to those of our competitors.

In order to facilitate the evaluation of the answers to the general questions, the system will prompt the user to provide answers to the specific questions in simple, structured forms that lend themselves to simple evaluation techniques. It will offer the user multiple choice answers in most cases to facilitate the symbol (string) matching process. (Appendix B contains sample questions and answers.)

In its initial configuration, the system will be unable to conclusively

resolve some of the general questions. Questions such as "Can we win the contract?" are difficult to evaluate effectively without a large knowledge base. A simplistic analysis is possible but expert assistance will be required to produce a quality answer. Initially such questions will be evaluated by a human expert if the opportunity proves to be otherwise attractive. Eventually, knowledge bases covering a variety of types of opportunities enable a more complete analysis by the system. Since each opportunity will be reviewed by a human before resources are committed, this initial limitation does not render the system useless. It simply requires early users to do more of the analysis manually. The system will still provide a valuable service from the outset with the potential for improvement as more extensive knowledge bases are introduced.

Knowledge Representation

The structural ontology of the knowledge base will include such objects as the program, its requirements, competitors, technologies, resources, etc. Properties of objects will include size, location and strengths of competitors, risk of the program, etc. Relationships will include the program being pursued by competitors, competitors possessing technologies, the program requiring technologies, etc.

The operational or dynamic ontology will include state transformation operators such as competing for position, teaming, acquiring capabilities not previously possessed, etc.

The epistemic ontology will attempt to represent our knowledge of the

competitors' strategies, bid histories, cultures, etc. to heuristically guide the search strategy as the system tries to analyze the situation to predict what the outcome will be.

The system will also need some sort of scheme to indicate its confidence in its conclusions. This can be done by labeling the information with regard to its certainty (strength of belief) and incorporating that into the statement of the conclusion and/or the explanation.

The task of determining that a particular opportunity should be pursued or of predicting a winner in a competitive procurement would best fit the classification paradigm where observations are first categorized and then used to generate hypotheses which are iteratively refined to reach conclusions. This implies that the inferencing strategy employed would be hypothesis-driven search. For example, an initial hypothesis might be that the incumbent (if any) is the predicted winner. This hypothesis would then be tested to determine whether it could be derived from the initial conditions.

The knowledge structure will, in general terms, be data-driven consisting of rules in the form "IF NOTICE:X THEN ASSERT (or DENY or PERFORM):Y". This implies a forward-chaining inferencing technique, but possibly employing depth first search. Some other "opportunistic" technique(s) may also be appropriate. This will require additional analysis during system development.

The knowledge base will initially consist of a limited number of rules entered for the purpose of creating a prototype system with which we can

gain some experience. (A list of the rules included in the first (pre-prototype) implementation are contained in Appendix C.) The second phase of implementation will involve significantly expanding the knowledge base to produce a working prototype system for evaluation purposes. The third phase will involve attaching shared knowledge bases employing knowledge provided by outside experts. This will lead to an implementation of a "beta version" of the system in one of the field offices.

Knowledge acquisition in the first phase will consist primarily of entering my personal knowledge into the system. During the second phase I will consult with other new business evaluators for the purpose of reviewing and critiqueing or supplementing the knowledge base that I create. Functioning as both the "expert" and the knowledge engineer greatly simplifies the knowledge acquisition process and will let me concentrate on rapidly prototyping a system for evaluation purposes. In the third phase, more traditional knowledge engineering will be undertaken. Individuals with special expertise in key areas will be interviewed to capture knowledge which can be combined with information from other knowledgeable individuals for the purposes of creating new domain knowledge bases in particular product, technology, or market areas. The potentially unbounded size of this phase will require clear definition of obtainable objectives prior to undertaking any phase three effort. Hopefully our experience in the first two phases will help us with this task. Our experience could also convince us that we should totally redo the system or abandon it altogether.

Examples

The system will have two primary users: the sales representatives and the division management. Sales representatives will use the system to insure that they have been thorough in gathering information about the opportunity and to screen opportunities before they are presented to management. Management will use the system as a repository of knowledge and as an adviser, particularly when the bid opportunities are complex, poorly described or related to unfamiliar situations. In such cases, the shared knowledge bases, the explicit representations of what information is missing, and the systematic evaluation process should be of significant benefit to even an experienced manager.

An example of the system's use by a sales representative could involve a sales representative in a distant field office who discovers an opportunity for us to bid on a firm-fixed-price level-of-effort contract to develop a surface acoustic wave device for doing image convolution. The value of the contract is approximately $5,000,000 and Secret NOFORN security clearances are specified. A Standard Form 1411 is required and government purpose license rights are retained by the customer.

Without help, most sales representatives would be unable to determine whether this opportunity would be attractive to the corporation or not. After calling around to see if anyone seemed interested in pursuing it, the sales representative would abandon it for something more promising.. Yet there are people in the company who, in the aggregate, have the technical, marketing, strategic, legal and financial backgrounds to evaluate such opportunities and reach a bid decision within minutes.

The proposed system would assist the sales representative in describing the opportunity by prompting him for contract type, technology required, contract value, security requirements, etc. In the above example, the requirement for government purpose license rights would alert the system to ask whether the government wanted those rights for reprocurement purposes. If the sales representative determined that the answer was in the affirmative, then the system would inform the user that the division would not submit a bid. It would explain to him that reprocurement rights in this particular technology would compromise trade secrets in which the corporation had a major investment. The system accomplishes this through a series of rules which basically say that if the customer is a government agency check for data rights claims. If data rights are claimed, determine what type of claim is being made. If government purpose license rights are being claimed, determine whether that includes reprocurement rights. If reprocurement rights are claimed and the technology is proprietary, decline to bid. The sales representative now knows that this opportunity would be declined by management for the same reason it was declined by the system.

A second example might involve a manager trying to determine whether we could win a particular competition for a contract. Answering this question would be beyond the ability of the early version of the system due to the limitations of the knowledge base.

Answering this question is an analytic task and more specifically a prediction task, i.e., predicting who among the expected competitors is the likely winner. Since we ultimately wish to know what must be done

to position Tektronix as the likely winner, the use would suggest a hypothesis or goal for the system such as "Tektronix wins the contract." The system would try to inference (chain) backward from that goal to see if it could reach the initial conditions. Each time it failed, we could iteratively modify the parameters in an effort to construct a scenario wherein Tektronix is projected to win. In this way we could determine what changes would be necessary to make Tektronix the likely winner. Properly constrained, this approach would produce a theoretical winning strategy. The feasibility of the strategy's implementation could, of course, be an entirely different matter. For example, the system might tell us we could win if we bought Sony or IBM. The system would guide the user in deciding what to change next by displaying the network through which it was chaining and indicating which rules failed to provide the necessary links to the original parameters. The user could study all the possible paths and decide what actions to take.

System Development

Myapproach to system development is not the approach I would normally take on a system development. Normally I would set up a user group, determine system functional requirements and data requirements, design the system, sell it to management, build an implementation team, create documentation, develop a prototype, identify, involve and interview the experts, train the users, etc. However, this system is fundamentally a college research project. As such it enjoys greater flexibility and freedom from structure than a normal business project.

I am developing the prototype system in an informal way that avoids many

of the human interface and communication issues normally associated with such efforts. My objective is to automate the process by which I, myself, evaluate opportunities. When I have accomplished this, I will begin to let select people use the system to identify problems and required improvements. When the system can reliably do something of value for a user, I will then distribute a few "beta" copies to gain additional user feedback. This feedback will determine the future of the system. The long term goal is to release the system to the sales force, in general.

Once we have some experience with a working system, we will proceed to implement enhancements. This project will involve one or two full time knowledge engineers working with users and experts to expand the knowledge base and make the system more powerful.

The following schedule was developed for the system at the beginning of the project.

Define system	**January 7, 1991**	**February 1, 1991**
Procure shell	**January 14, 1991**	**February 1, 1991**
Refine definition	**February 1, 1991**	**March 1, 1991**
Install/load shell	**February 1, 1991**	**March 1, 1991**
Develop rule network (knowledge base)	**January 7, 1991**	**March 1, 1991**

Run prototype	**March 1, 1991**	**March 8, 1991**
Enhance prototype	**March 8, 1991**	**April 26, 1991**
Prototype trials	**April 26, 1991**	**Indefinite**

Thus far the development program is about on schedule. Problems with learning to use the commercial shell (Nexpert) on which the system is being developed have slowed progress somewhat resulting in the existence of only a small knowledge base at this point. However I believe those problems are largely resolved and I am proceeding to write rules and create objects in a more efficient manner. Although I have not set a schedule date for implementation I am targeting the end of the calendar year for release of a beta version of the system. I project that general release of the system will take place six months to a year after beta release.