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Good Relationships Are Pivotal in Nuclear Databases

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A. Sharif Heger
University of New Mexico

We expound the importance of effective use of information in the nuclear industry. We have received several requests for a full paper on this subject for which we are thankful. In fact, this article will start with segments of that letter and its tenet is that valuable information is stored in our nuclear experience databases that must be captilized for enhanced operation of our plants, training, and rule makings. Due to large volume of data, certainly the development of an automated information retrieval is prefred to other means. To this end, after an introduction a method of adaptive information retrieval based on neural network methdology is introduced. A few example will follow and future plans will also be discussed.

Introduction

The Information Revolution has aggressively championed the information technology as the key to effective operation and competitiveness. Information, they insist, is a "strategic asset," with which we agree.[1] Indeed in the nuclear power industry, the

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increased interest in improved plant safety and performance and mandated probabilistic risk assessments have demonstrated the need for quality data in the form of information. The Holy Grail of the information technology advocates is the seamless integration of hardware, software, and telecommunications technology into networks where engineers and risk analysts can get whatever information they need whenever they need it. We agree to the necessity of this component of information technology but also point out that it is not sufficient.

Our experience has shown that this approach can be very confusing. This web of technological wonders has led to the inundation of end users to the point that they refuse to access the system. These users can be plant engineers, regulators, and other decision makers. These are the people that make important decisions that may affect the safety of a large segment of the society.

In the real world, information is not just a compilation of data that is based on experience. The molding of these data into meaningful "relationships" creates knowledge. Conventionally, this information has been formed by a network of formal and informal network of colleagues who exchange their experience and knowledge. This has been particularly true in the nuclear power industry. For example, The American Nuclear Society (ANS), Institute of Nuclear Power Operations (INPO), and NRC through different programs have advocated this mode of information development and, in some areas, they have been very successful. With the advent of large central databases a new dimension has been added to this relationship and that is the interface between the computer and the user. So far, the computer has played the role of a powerful but dumb partner in this relationship. This is one of the reasons why the human side of this partnership is frustrated. To alleviate this problem, the computer must put on some human-like behaviour; it must adapt to its user by learning the characteristics of its human counterpart. So, while data is important, it is the information - the meaning imbedded in the data and the interaction between man and machine - that really governs how effectively we run a plant or manage an organization.

Problems Associated with Large Centralized Databases

While it has become easier to retrieve a piece of data from large databases, it often has become difficult to find the true meaning imbedded in its data. Due to the large sizes of these databases, it is often impossible for the end user to "see" what actually is in those databases and how to link the related piece of data. The sizes of the central databases keep growing and the quality of the data flowing through the computer networks increases. The result is that, in most power generation organizations, technology is bestowing better quality data and a declining quality of information.

Effectively, the Information Revolution crowd has been looking through the wrong end of the telescope.[1] For example, it loves to point to the NRC Sequence Coding and Search System (SCSS) as a model of successful design. That is undoubtedly true; NRC's SCSS does a tremendous job of tracking and coordinating hundreds of thousands pieces of LER data every day.[2,3] It is a superb example of an effective data management system.

Yet, the real impact of SCSS has not been explored. With its data, what SCSS should do is to track patterns in its database. Patterns that may be of safety concern to the nuclear power industry. It should do what safety experts are doing manually. By following the patterns of concern, the system should be able to identify "precursor events," alert its users, and also alter its focus to important and relevant data entries in the database.

So the real value of SCSS and its supporting technology is in the "information" that is imbedded not only in the database but also in the interaction with its user. It is in the relationships between the massive number of entries in the database and the individual users of the database. The same principle holds true with the way technology has spawned new relationships in financial service networks and news media.[1] Increasingly, the value resides in the communities of shared interest, not in the reams of data these technologies create.

Intelligent Information Retrieval Systems

Information is the derivative of the relationship, not the other way around. IBM, Corporation for National Research Initiatives (NRI), and MIT Media Lab understand this principle. They have used their vast arsenal of technologies to develop intelligent "software robots" to assist users to tap into nationwide library of online databases.[4,6] MIT Media Labs, for example, has developed an adaptive electronic newspaper called NEWSPEEK.[6] This system, through a feedback technique that is based on artificial intelligence, captures the topics that its user is interested in. Based on this information, the system learns the habits of its user by discovering the underlying patterns and collects and presents related news topics from its accessible resources. Based on a similar principle, the Universities of Texas and New Mexico have developed a knowledge robot (KNOWBOT) that works with nuclear databases.[7] Both NEWSPEEK and KNOWBOT exploit the information that is imbedded in their interactions with their users to adapt themselves to the needs and wants of their users. Both systems are based on the principle that management of data is secondary to management of relationship between them and their users.

Information in KNOWBOT is represented as units and their connections. These units participate in a cooperative environment, in which information is encoded in the connection patterns among them. In general, the units may correspond to conceptual primitives, or they may have no particular meaning as individuals. The connection of the units reflect the association among them. Each connection is assigned a weight, which encodes the knowledge of how the units fit together in some domain.

This epistemic model is a directed acyclic graph (DAG) whose nodes represent the units of information, Figure 1. Each unit $v \in V$ forms a node with a set of 'parent' nodes $Pa(v)$, where V is the set of all node in the network and for each $w \in pa(v)$ there exists a directed link $w \rightarrow v$. Conditional probability statements, $p(V|W)$, that are assigned to each link define the relationship of each node with its neighbors in the network.

Within this framework, then, the epistemic state of the system may be represeted by $P = \{D, T, C, T^{+}\}$, where [1]

$D = \{d_1, d_2, \cdots, d_n\}$ represents the set of all possible events of interest (e.g., shutdown, scram, etc.),

$T = \{t_1, t_2, \cdots, t_m\}$ represents the set of all possible manifestations that are reported to the database (e.g., reports in the database),

C is a relation that consists of of ordered pairs of causes and manifestations with $\{d_i, t_j\} \in C$, and

T^{+} represents the manifestations that have been instantiated for a given circumstance.

The goal of KNOWBOT is to find the probability of each $d_i \in D$ given M^{+}. Once the set is instantiated, the nodes in the network exchange a series of messages to updates their states and that of the network. The framework for this update process is the Bayes' theorem as follows:

$$p(d_i \mid T^{+}) = \frac{p(T^{+} \mid d_i)\, p(d_i)}{p(T^{+} \mid d_i)\, p(d_i) + p(T^{+} \mid \overline{d}_i)\, p(\overline{d}_i)}.$$

The impact of each new piece of *evidence* is viewed as a perturbation that propagates through the network via message-passing between neighboring variables.[23] The design of KNOWBOT is, in principal, based on this exemplar and that a user is normally

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1A more general description of the system state may actually be given by $P = \{D, T, C, T^{+}, T^{-}\}$, where T^{-} represents the varialbes that are instantiated for their lack of existence. Therefore, $T^{+} \cup T^{-}$ represents the complete set of variables that are instantiated.

concerned with a small subset of a large database which is highly reflective of his domains of interest. Two additional design requirements are the availability of a computer at the user site for the retrieval and capture of the data, and the possibility of its continuous operation.

KNOWBOT is, therefore, an evolving environment that consists of the autonomous processors (the nodes in the DAG) and their interconnections. The evolution of this environment is a continual process of

- the development of new or modification of existing units as novel information arrives,
- communication of the units in the environment, and
- the removal of inactive units that are no longer needed.

Example

In extension of this associative information retrieval system to relational databases, the units correspond to the *attribute-value* pairs that form the *tuples* in a given table. For example, two tuples of Table 1 are shown in Figure 2. Further, each tuple in the table represents a *relationship* among a set of values.[14] Each value is a member of a domain that is defined for each column (attribute) of the table. Therefore, the node "Target-Rock" in Figure 2 represents a value that appears in the MANUFACTURE column of the table. The information about the associations that exist among the tuples and the attribute-value pairs is preserved in the connections among the units. The unit "Target-Rock," for example, is connected to both tuples 1 and 2 in Figure 2.

Test Database (NPRDS-PRV)

NPRDS-PRV was assembled in order to experiment with the interface and to investigate its robustness. The data for the database was extracted from a Department of Energy report on the analysis of the pressure-relieving valve failures using the NPRDS data.[30] The database consists of one relation, PRV-failure, with the following scheme

PRV-failure-scheme = (plant-name, manufacturer, model-number, description)

The database instance contains 82 tuples. A partial display of the relation is shown in Table 1.

Case Study : Induction and Personalization

One of the intended usages of NPRDS, LER or other similar nuclear databases is to facilitate the identification of those individual events or generic situations that warrant additional analysis and evaluation. One way an expert identifies a pattern or trend is by the *a priori* postulation of a concern. This concern could be entirely hypothetical. For example, the expert may wonder what the experience with the PRVs has been. On the other hand, he could postulate the concern based on a non-specific recall of information. For instance, he may remember observing a lot of failure of the PRVs at a given time period. Under these conditions, the expert collects and reviews the relevant data in order to identify and isolate the events that relate to that concern. After understanding the surrounding circumstances, he can evaluate the safety significance of the pattern.[31]

KNOWBOT with its induction feature can facilitate this objective, as it will be demonstrated in this case study. Suppose a user is concerned about the failure events of the PRVs caused by leakage. One possible method is to access NPRDS-PRV for reports of PRV failures due to leakage. NPRDS-PRV has 22 tuples whose descriptions have direct references to the word leak or any combination of it (e.g., leak, leaks, leakage, etc.). There are, however, additional 27 tuples that imply the failure of the PRVs due to leakage. For example, the improper seating of the valve disks, or their steam cutting imply that they had leaked. A conventional interface will retrieve the 22 records. The result of this search showing the PRV manufacturers, their model numbers and the description of the failure events is shown is Table 1.

An expert, on the other hand, may review this data and consequently access the database with a refined query. For example, he may decide to search for those PRV failure reports that were due to steam cut, or improper seating. This modified query will produce additional reports that are indeed related to leak as the cause of failure. In a recursive process, the expert may retrieve all of the 49 reports from NPRDS-PRV. This extended study may in turn lead to the discovery of precursor events that may be cause for concern.

With a conventional database interface the entire burden of this recursive search is on the human expert.

With KNOWBOT, on the other hand, the majority of this process can be carried out automatically. After the initial selection of the keys that directly relate to leak, the interface displays all of the 22 reports, as shown in Table 1. But it, in an iterative process, continues to interrogate its environment for other related events. The screen will be updated to reflect the discovery of new records. At each update, the records are sorted in the order of their correlation to the user request. The result of the search after 3 iterations by the interface is shown in Table 2. At any given instance the user has the opportunity to redirect the search process by selecting new keys. This additional input represents his belief in the new discovery and acts as a positive reinforcement for KNOWBOT for its next iteration and search of the database. At the same time, KNOWBOT continues its iterative search and display of its new findings, Table 3.

This inductive feature of KNOWBOT shares with the expert the burden of recursive searches in the database. This case study shows that this feature can be a major contribution in discovering the patterns of concern in the database. It is, therefore, an effective solution to the interface problem. The experiment is also a manifestation of the personalization attribute of KNOWBOT. This property offers a sound remedy to the dimensionality problem, because the search process becomes more specialized on the user needs with repeated interactions.

CONCLUSIONS

Probably one of the most useful applications of NPRDS is to identify those individual events or generic situations that warrant additional analysis and evaluation. To this end, the expertise and natural pattern-recognition talents of human experts have been the two most important resources. The generalization feature of the associative information retrieval systems provides similar pattern-recognition capabilities. This capability can be utilized in cooperation with the human experts or in lieu of them. In order to realize these benefits, KNOWBOT has been developed.

That is a distinctly a minority approach. The unpleasant reality is that most database management systems are more interested in getting the needed data out in pleasant formats and disregard the risk of user frustration and misunderstanding or missing the true message that may be hidden in the data. They do not take advantage of the dynamic source of information of user-system interface to adapt their systems to the needs of the users.

Instead of asking, "What is the data that matters and how do we most effectively manage it?"; these database management systems must start asking, "What are the relationships that matter and how can the technology most effectively support them?"[1] That requires a totally different systems designs emphasis similar to those of NEWSPEEK and KNOWBOT. Most technologist would rather focus on data management because it is so much easier than working with the users and on their needs. It is time for the nuclear industry to recognize where the real potential and value of its databases lie.

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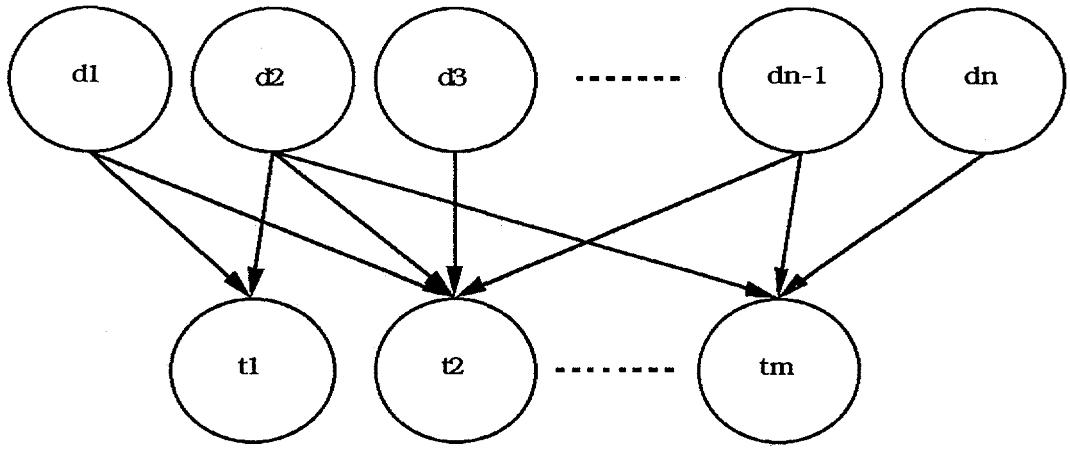

Figure 1: The DAG that represents the structure of knowledge representation in KNOWBOT.

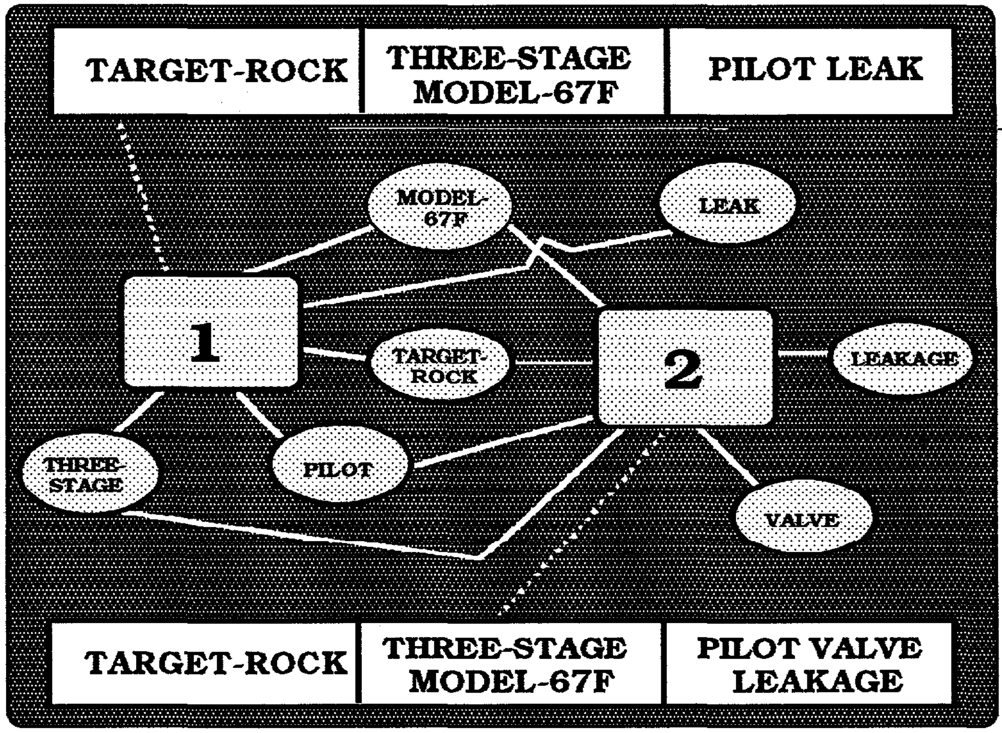

FIGURE 2. Internal representation of tuples, their elements and their interconnections in the associative information retrieval environment.

Table 1. Partial listing of the NPRDS-PRV database

PLANT	MANUFACTURER	MODEL NUMBER	DESCRIPTION
NINE-MILE-POINT-1		ELECTROMATIC	LEAK PROBABLE SPRING FATIGUE
NINE-MILE-POINT-1		ELECTROMATIC	LEAK LAPPED AND REBUILT
BROWNS-FERRY-3	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAKAGE
NINE-MILE-POINT-1		ELECTROMATIC	VALVE FLANGE GASKET LEAK
BRUNSWICK-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	BELLOWS LEAKS
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PEACH-BOTTOM-3	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
HATCH-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
DRESDEN-2	ELECTROMATIC		FAILED PART LEAKING SEAL RINGS
BROWNS-FERRY-1	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAKS WIRE DRAWN
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT VALVE LEAKAGE
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAKS FOREIGN MATERIAL
BRUNSWICK-2	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAK STEAM CUTTING
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAK OXIDATION CLEANED LAPPED
QUAD-CITIES-1	ELECTROMATIC		MAIN DISC ASSEMBLY EXCESSIVE L ...
QUAD-CITIES-2	ELECTROMATIC		DISC GUIDE CORROSION BOTH POSSIBLE ...
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	BELLOWS O-RING LEAK SUSPECTED
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK STEAM CUTTING
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT VALVE DISK LEAKAGE MACHINED ...

Table 2. The result of an inductive search by KNOWBOT in the NPRDS-PRV database for leak-related failure reports.

PLANT	MANUFACTURER	MODEL NUMBER	DESCRIPTION
NINE-MILE-POINT-1		ELECTROMATIC	LEAK PROBABLE SPRING FATIGUE
NINE-MILE-POINT-1		ELECTROMATIC	LEAK LAPPED AND REBUILT
BROWNS-FERRY-3	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAKAGE
NINE-MILE-POINT-1		ELECTROMATIC	VALVE FLANGE GASKET LEAK
BRUNSWICK-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	BELLOWS LEAKS
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PEACH-BOTTOM-3	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
HATCH-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
DRESDEN-2	ELECTROMATIC		FAILED PART LEAKING SEAL RINGS
BROWNS-FERRY-1	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAKS WIRE DRAWN
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT VALVE LEAKAGE
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAKS FOREIGN MATERIAL
BRUNSWICK-2	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAK STEAM CUTTING
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAK OXIDATION CLEANED LAPPED
QUAD-CITIES-1 LEAKAGE ...	ELECTROMATIC		MAIN DISC ASSEMBLY EXCESSIVE
QUAD-CITIES-2 ...	ELECTROMATIC		DISC GUIDE CORROSION BOTH POSSIBLE
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	BELLOWS O-RING LEAK SUSPECTED
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK STEAM CUTTING
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT VALVE DISK LEAKAGE MACHINED ...
NINE-MILE-POINT-1		ELECTROMATIC	VALVE RINGS SCORED
BROWNS-FERRY-3	TARGET-ROCK	THREE-STAGE MODEL-67F	DID NOT RESEAT
BROWNS-FERRY-1	TARGET-ROCK	THREE-STAGE MODEL-67F	WIRE DRAWN MAIN SEAT
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT STEAM CUTTING
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT BLOW BY
HATCH-1	TARGET-ROCK	THREE-STAGE MODEL-67F	FAILED BELLOWS PRESSURE SWITCH

PLANT	MANUFACTURER	MODEL NUMBER	DESCRIPTION
BRUNSWICK-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	BELLOWS LEAKS
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PEACH-BOTTOM-3	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
HATCH-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK
DRESDEN-2	ELECTROMATIC	FAILED PART LEAKING SEAL RINGS	
BROWNS-FERRY-1	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAKS WIRE DRAWN
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT VALVE LEAKAGE
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAKS FOREIGN MATERIAL
BRUNSWICK-2	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAK STEAM CUTTING
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	LEAK OXIDATION CLEANED LAPPED
QUAD-CITIES-1	ELECTROMATIC	MAIN DISC ASSEMBLY EXCESSIVE LEAKAGE ...	
QUAD-CITIES-2	ELECTROMATIC	DISC GUIDE CORROSION BOTH POSSIBLE ...	
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	BELLOWS O-RING LEAK SUSPECTED
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT LEAK STEAM CUTTING
PEACH-BOTTOM-2 MACHINED ...	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT VALVE DISK LEAKAGE
NINE-MILE-POINT-1	ELECTROMATIC	VALVE RINGS SCORED	
BROWNS-FERRY-3	TARGET-ROCK	THREE-STAGE MODEL-67F	DID NOT RESEAT
BROWNS-FERRY-1	TARGET-ROCK	THREE-STAGE MODEL-67F	WIRE DRAWN MAIN SEAT
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT STEAM CUTTING
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT BLOW BY
HATCH-1	TARGET-ROCK	THREE-STAGE MODEL-67F	FAILED BELLOWS PRESSURE SWITCH
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	STEAM CUTTING
PEACH-BOTTOM-2	TARGET-ROCK	THREE-STAGE MODEL-67F	GALLED STEAM BINDING IN BUSHING

Table 3. The result of an inductive search by KNOWBOT in the NPRDS-PRV database for leak-related failures, after several iterations and additional user input

PLANT	MANUFACTURER	MODEL NUMBER	DESCRIPTION
MONTICELLO STEAM ...	TARGET-ROCK	THREE-STAGE MODEL-67F	PILOT DID NOT SEAT CORRECTLY
MONTICELLO SEATING ...	TARGET-ROCK	THREE-STAGE MODEL-67F	FOREIGN MATERIAL ON PILOT
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	STEAM CUTTING
BRUNSWICK-2	TARGET-ROCK	THREE-STAGE MODEL-67F	DIRTY AND PITTED PILOT DISC
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	CRUD ON PILOT SEAT
PEACH-BOTTOM-3	TARGET-ROCK	THREE-STAGE MODEL-67F	DC SYSTEM GROUNDS
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	STEAM CUT
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	DISK STEAM CUT
HATCH-1	TARGET-ROCK	THREE-STAGE MODEL-67F	DID NOT RESEAT
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	FOREIGN MATERIAL UNDER SEAT
BRUNSWICK-2	TARGET-ROCK	THREE-STAGE MODEL-67F	ELECTRICAL
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	DELAMINATED DIAPHRAGM
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	NITROGEN SETPOINT
PILGRIM	TARGET-ROCK	THREE-STAGE MODEL-67F	LOCKTITE ON PLUNGER
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	MAIN DISK STEAM GALLED
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	STEAM ERODED
QUAD-CITIES-1	ELECTROMATIC		DISC RINGS WORE GROOVE LOCKING VALVE...
BROWNS-FERRY-2	TARGET-ROCK	THREE-STAGE MODEL-67F	DID NOT RESEAT
QUAD-CITIES-2	ELECTROMATIC		DISC RINGS VIBRATION WORE GROOVE
PILGRIM	TARGET-ROCK	TWO-STAGE MODEL-7567	FOREIGN MATERIAL LODGED BETWEEN ...
HATCH-1	TARGET-ROCK	THREE-STAGE MODEL-67F	SETPOINT DRIFT
HATCH-1	TARGET-ROCK	THREE-STAGE MODEL-67F	STICKING SOLENOID
MONTICELLO	TARGET-ROCK	THREE-STAGE MODEL-67F	SETPOINT DRIFT
BRUNSWICK-2 PLUNGER SEAT	TARGET-ROCK	THREE-STAGE MODEL-67F	DISLODGED O-RING BURR ON
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	WORN PRELOAD SPACER
MILLSTONE-1	TARGET-ROCK	THREE-STAGE MODEL-67F	CRACKED SENSING TUBE