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# Evaluating Knowledge Management Techniques to Augment Network Fault Diagnosis

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## ABSTRACT

This research in progress proposes to evaluate the effectiveness of using Knowledge Management (KM) approaches in conjunction with Decision Support Systems (DSS). The authors performed a preliminary field survey at a global optical telecommunications network that is characterized by dispersed groups of collaborating engineers and other stakeholders. The results indicate alarm correlation has been a major challenge for telecommunications systems. A DSS should theoretically be able to leverage expert engineering knowledge using KM techniques to alleviate these challenges. This research will evaluate two specific DSS/KM approaches for capturing and sharing this engineering knowledge across independent network nodes. A rule-based approach allows local field engineers to expand the system's knowledge base. In addition, the organization's Research & Development engineers will distribute a knowledge base model that includes a behavioral model of the equipment. The models will then be combined with an inference engine to perform root-cause analysis of network faults.

## Key Words

Knowledge Management, Decision Support Systems, Network Management Systems

## INTRODUCTION

The effective management of knowledge promises to counteract growing organizational and industry complexity in many sectors. Decision Support Systems (DSS) are used in all mission-critical infrastructures (e.g., telecommunications). Major telecommunications networks are prone to problems known as network faults. The size and complexity of the networks increases the probability that network faults will require more time to diagnose. Even with today's increased automation and sophisticated computing infrastructure, there is no substitute for a well-trained technician (Lo, Chen, and Lin, 2000). The explosion of bandwidth demand due to Internet traffic has increased telecommunications network complexity. Global optical networks are becoming more diverse as operators include equipment from different suppliers based on criteria such as cost and service offerings.

Telecommunications firms have also come to rely on global information systems to aid in these activities. Flynn et al discuss DSS design challenges in the rapidly changing telecommunications industry (Flynn, Curran, and Lunney, 2002). They point out that one of the major challenges has been the growth of networks and the inability of DSS to remain relevant. In the area of fault diagnosis, one way to cope with these emerging changes is to utilize Knowledge Management (KM) techniques. The proposed DSS design will attempt to address these constraints through a new set of KM capabilities intended to augment the operational management of these networks. The Alarm Correlator Tool (ACT) is currently under development. ACT will be deployed and evaluated at several global optical telecommunications network field sites in mid 2004. We also present various methods for capturing expert knowledge that will be measured for effectiveness in the proposed system. This paper describes the research objectives after presenting a review of related work in Section 2; the domain relevant background information for the design in Section 3, and; the technical process and design details in Section 4.

## RELATED WORK

Researchers have shown increased interest in KM techniques because it advances the capabilities of DSS (Holsapple, 2001). "Knowledge is defined as a justified belief that increases an entity's capacity for effective action" (Alavi, and Leidner, 2001). ACT is a Knowledge-Driven DSS (KDDSS), similar to such systems as a tax advising system for lawyers (TAXADVISOR), or an expert configurator for VAX systems (Xcon) (Power [2], 2000) that combine the abilities of Expert Systems (ES), DSS, and KM Systems (KMS). Knowledge is stored in KDDSS as rules, facts and algorithms (Power 2000).

Shim et al. point current research in the right direction by explaining that future DSS work should “exploit advancing software tools to improve the productivity of working and decision making time” (Shim, Warkentin, Courtney, Power, Sharda, and Carlsson, 2002). Nevertheless, the design must still address the four main capabilities defined by Sprague in 1980:

- (1) Handling less-structured, under-specified problems.
- (2) Combining models or analytical techniques with traditional data access and retrieval functions.
- (3) Ease of use during
- (4) Emphasizing flexibility and adaptability. (Sprague, 1980).

KM systems research has presented knowledge as a process of applying expertise (Alavi, and Leidner, 2001; Milchram, and Hasler, 2002). We attempt to capture this process of applying engineering expertise using ACT. Alavi and Leidner also describe a number of knowledge taxonomies, of which tacit and procedural knowledge will be investigated in our proposed research. Procedural knowledge (know-how) is the basis for any diagnostic process. Intuition and experience are considered tacit knowledge. Various methods exist for capturing this expert knowledge (Table 1).

Expert knowledge is gained in an incremental, experiential process requiring continuous expert system’s knowledge base updating (Bobrow, Mittal, and Stefik, 1986). This continuous updating of dispersed knowledge bases effectively shares and distributes knowledge, a function equally as critical as knowledge acquisition. One of the main functions of ACT, in addition to capturing and distributing engineering knowledge, is to provide alarm correlation abilities to network operators. Meira provides an extensive review of the various correlation algorithms available in the literature (Meira, 1997), which are summarized in Table 1. While these algorithms are being discussed as alarm correlation solutions, they are not unique to this application, but largely apply to all KDDSS (Power [2], 2000).

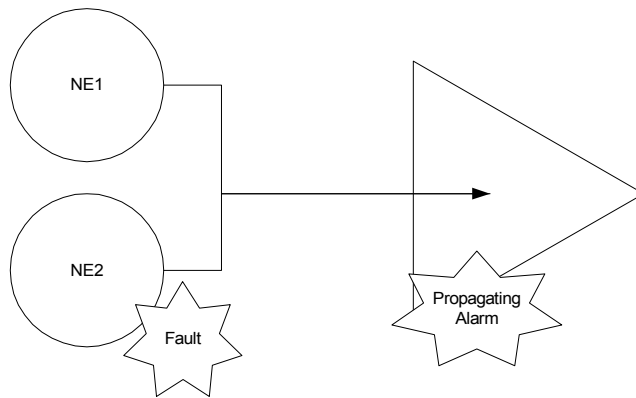
Correlation Algorithms	Description
<b>Rule-Based</b>	<b>Knowledge stored as user-programmed rules. All incoming alarms are compared to these Boolean rules.</b>
Fuzzy Logic	Fuzzy sets are created. Alarms have a degree of membership in a set.
Bayesian Networks	Direct acyclic graphs connecting alarms using the associated conditional probabilities.
<b>Model-Based Reasoning</b>	<b>Functional and structural models of the system are programmed into the system. These are then used to represent the occurred faults.</b>
Intelligent Filtering	Filter incoming alarms from being displayed to the user.
Case-Based Reasoning	Storing of complete scenarios to be used for comparison against current alarms.
Coding	Matrix solution of alarms vs. root causes with probability for root cause scenario.
Proactive Correlation	Use of data mining to learn patterns that may assist in future fault diagnosis.
Artificial Neural Networks	Alarms are nodes in a neural network causing excitation in neighboring neurons to arrive at a root cause.

**Table 1: Correlation Algorithms**

**DOMAIN BACKGROUND**

The field site operates a global telecommunications undersea optical network comprised of optical Network Elements (NEs). A Network Management Systems (NMS) for maintaining this network provides data used for proactive maintenance and network capacity planning through a single comprehensive, graphically integrated view of the network topology. The NEs may generate multiple alarms during a network fault scenario. The NMS provides fault management capabilities (Sabet, and Klashner 2003) that include the manipulation and storage of fault indicators associated with NE Quality of Service (QoS) alarms. Network management activities are coordinated at Network Management Centers (NMC). Top-level NMC operators “drill-down” into individual nodes and/or NE views using the NMS.

Network nodes are “cable stations” housing multiple NEs that may be automated or staffed with highly trained engineers/technicians. There may be dozens of cable stations across the globe operating in various countries (e.g. the Americas, Asia, and Middle East). The cable station field personnel are responsible for maintaining the local equipment, and therefore have access to the NMS screens pertaining to their “jurisdiction”. NEs report alarms and faults to the relevant NMS. However, an equipment failure often creates undesired extra alarms to occur in “downstream” equipment (Figure 1)



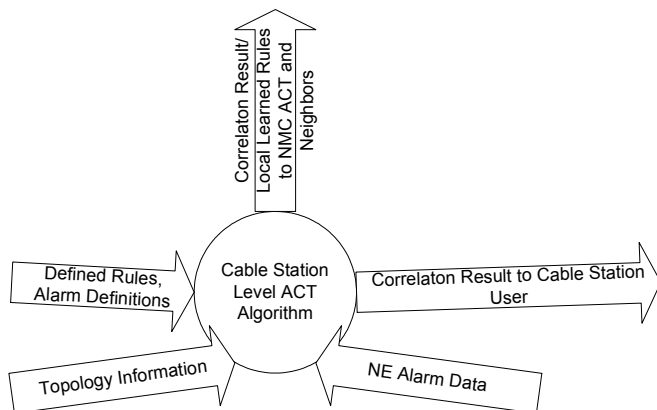
**Figure 1 – Network Fault Propagation**

existing system). In addition, interviews were conducted with three (3) NMC personnel. They also noted that this feature is not currently addressed well in the field. In the next section, we discuss a DSS /KMS tool design that addresses these problems with typical NMS currently deployed.

**ACT DESIGN CONSIDERATIONS**

A high-level requirement of ACT is to assist NMS with alarm diagnosis and tracking. ACT is a DSS/KMS that uses a rule-based approach to identify the root cause of a fault scenario and report the best corrective action if one exists. In addition, it utilizes a model-based algorithm to diagnose the failures using knowledge programmed by the research and development (R&D) engineers for the system.

A particular set of coexistent alarms indicates to human experts a likely scenario for where the actual problem is located in the network. After these scenarios have been defined, ACT uses them in a rules module. Correlation algorithms parse the defined rules and apply them to the analyzed alarm data. Thus, boolean-based rules can be used to define how the tool will treat a scenario. Applying a set of rules to the alarm data will result in a likely causal scenario, pinpointing the failures. The expert may override the result and enter a list of possible corrective actions for future use. This new knowledge captured will then be shared across the network to facilitate learning across nodes (Figure 2).



**Figure 2: ACT Knowledge Exchange**

faults. Users may change the NE and topology models in the field. These changes may also be shared across nodes to facilitate further learning.

During an alarm scenario local experts program new knowledge into the tool allowing it to report the correct correlation result in future scenarios, ACT then distributes knowledge across nodes in the form of rules and/or model changes (Figure 2). ACT has two distinct roles in a distributed NMS architecture, as shown in Figure 3. The first role is at the local cable stations

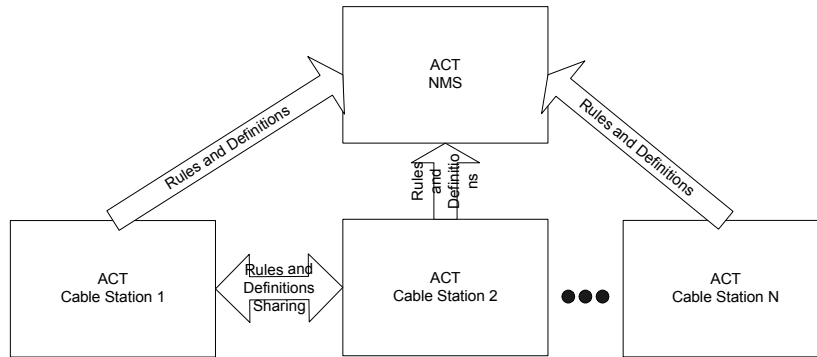
causing confusion. Current approaches maintain a centralized decision process that often excludes expert knowledge distributed throughout the cable stations. Field engineers acquire local NE knowledge and use it to intuitively filter out any unimportant events. However, this acquired knowledge has not been leveraged across the entire network.

The authors distributed a preliminary questionnaire to fourteen (14) distributed global network engineers to evaluate the current NMS feature set. The ability to perform root cause analysis on network faults is one of the most important features in the NMS according to field personnel responding to the pilot survey (64% respondents indicated this would be a good feature to add to the

ACT also uses a model-based approach to perform root cause analysis. The supplier’s R&D engineers have programmed an inference engine as part of the tool. A NE behavioral model is combined with the network topology model to diagnose the failure. The topology information will define the non-coincidental relationships between the various NEs so that it can be combined with the generic rules and NE behavioral model to analyze the alarm data acquired from the NMS. Both models will be released to all the field sites as part of the ACT tool.

The inference engine captures the knowledge gained by the designers of the actual NE equipment. Since designers have intimate knowledge of the NE behavior, they are able to program the algorithm defining causal effects of NE

where it will be used as a DSS for operator engineers/technicians in diagnosing local equipment problems. The rules, topology configurations, and alarm definitions are confined to the immediate jurisdiction of the cable station. This allows



**Figure 3 – ACT Node Sharing and Reporting Structure**

local engineers to use the tool and modify the knowledge base with their local experiential knowledge. Neighboring nodes will then have the opportunity of replicating this knowledge to take advantage of the gained expertise.

The second role addresses the top-level NMC. ACT knowledge is used to interpret rules and failure definitions at the links connecting multiple nodes, allowing network trails (end-to-end connections pertaining to a specific customer circuit) to be managed. The NMC is solely responsible for this trail

management.

The proposed ACT knowledge exchange pattern achieves a number of previously unattainable features; namely:

1. Provides a mechanism to leverage local field personnel's intimate knowledge of the cable station layout and equipment. This knowledge can then be used to diagnose network level problems.
2. Facilitates distributed knowledge acquisition and sharing through a single tool interface.
3. Learned scenarios become shared knowledge by dynamically distributing them to all cable stations and the NMC for decision-making.

## FIELD EVALUATION

The evaluation will measure perceived effectiveness by field personnel. ACT will be deployed to a number of cable stations in the network field site. Once installed, the effect of the system on the separate engineering units will be evaluated. To evaluate the appropriateness of the correlation methods, a phased introduction of each algorithm is expected. The first phase introduces a strict model-based system with the inference engine distributed by the R&D engineers. The second phase introduces support for customized rule-based programming of engineering knowledge. After each phase, a field survey shall be distributed to measure the perceived effectiveness of the KM approach.

This research adapts Gold et al's "item measures of organizational effectiveness" (Gold, Malhotra, and Segars, 2001). This is a 7-point likert scale of 14 items that measure organizational effectiveness. Gold et al use this survey to measure the relationship between KM capability and organizational effectiveness. Therefore, all things being equal, a change in organizational effectiveness between the two phases equates to a change in KM capability; i.e. algorithm to knowledge type fit. In addition, the tool itself will create a log of all knowledge items created. Knowledge items replicated to other nodes of the network will also be logged. Analyzing these logs after a period of deployment can be used to determine the frequency of system use and the extent to which knowledge sharing techniques were utilized by field personnel. Finally, users evaluating the system can be interviewed and observed during their use to gain more insight into the actual effectiveness of the correlation tool.

## SUMMARY

Many organizations utilize DSS to accomplish various engineering tasks. Researchers have argued that combining KMS features with these systems increases the DSS's efficiency. This ongoing effort is utilizing empirical data from a complex infrastructure domain to research the correlation between KM and DSS approaches. Although, KM techniques exist for capturing and distributing organizational knowledge, it is still unclear what tool design characteristics will dominate when they are combined with DSS. We are examining which technique provides a better implementation solution based on the type of knowledge being captured, in an attempt to empirically quantify these relationships. The results of this research may also be used to guide the design of future DSS in other engineering fields.

**REFERENCES:**

1. Alavi, Maryam, and Leidner, Dorothy E. (2001) Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues, *MIS Quarterly*, 25, 1, 107-136.
2. Bobrow, Daniel G., Mittal, Sanjay, and Stefik, Mark (1986) Expert Systems: Perils and Promise, *Communications of the ACM*, 29, 9, 880-894.
3. Flynn, P., Curran, K., and Lunney, T. (2002) A Decision Support System for Telecommunications, *International Journal of Network Management*, 12, 69-80.
4. Gold, Andrew H., Malhotra, Arvind, and Segars, Albert H. (2001) Knowledge Management: An Organizational Capabilities Perspective, *Journal of Management Information Systems*, 18, 1, 185-214.
5. Holsapple, C. W. (2001) Knowledge Management Support for Decision Making, *Decision Support Systems*, 31, 1-3.
6. Lo, Chi-Chun, Chen, Shing-Hong and Lin, Bon-Yeh (2000) Coding-based schemes for fault identification in communication networks, *International Journal of Network Management*, 10, 3, 157-164.
7. Meira, Dilmar Malheiros (1997) A Model for Alarm Correlation in Telecommunications Networks, Ph.D. Thesis, Federal University of Minas Gerais.
8. Milchrahm, Elisabeth and Hasler, Arnulf (2002) Knowledge Transfer in Recycling Networks: Fostering Sustainable Development, *Journal of Universal Computer Science*, 8, 5, 546-556.
9. Power, D. J. (2000) Web-Based and Model-Driven Decision Support Systems: Concepts and Issues, *Proceedings of the 2000 Americas Conference on Information Systems*, Long Beach, CA.
10. Power, Dan [2], (2000) Building Knowledge-Driven DSS and Mining Data, *Decision Support Systems*, HyperBook.
11. Sabet, Sameh and Klashner, Robb (2003) Helping Network Managers Meet Service Demands Using DSS, *SIGDSS Pre-ICIS Workshop*.
12. Shim, J. P., Warkentin, M., Courtney, J. F., Power, D. J., Sharda, R., and Carlsson, C. (2002) Past, Present, and Future of Decision Support Technology, *Decision Support Systems*, 33, 111-126.
13. Sprague, R. H. Jr. (1980) A Framework for the Development of Decision Support Systems, *MIS Quarterly*, 4, 4, 1-26.