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Design and Implementation of an Expert Network Manager

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1 Introduction

In order to monitor and control increasingly large and complex computer networks, today's network manager should be smart enough to handle diverse problems intelligently and efficiently. In a large networking environment, the network manager needs to analyse a vast amount of data, to handle simultaneously a variety of problems and to take logical decisions as quickly as possible. The task can be eased and automated if the Expert System technology is introduced to help a manager in routine network monitoring, diagnosing common network faults, analysing performance of the network etc. The introduction of Expert System thus seems to eliminate the increasing demand of a technically expert operator on-site. In this paper a network management system is proposed in which the human operator is assisted by an Expert System in management tasks.

In section 2, the general architecture of the system is given, section 3 deals with the Expert System, section 4 presents a case study followed by the conclusion in section 5.

2 Network Management System : Proposed Architecture

Figure 1 represents the proposed model of the Network Management System. In this model a number of network elements are grouped and one of them acts as the management agent which is responsible for collecting various network information and building the Management Information Base for that group. Several such groups may reside in the network. The Network Manager has the following components:

- Human-Computer interface programme via which the human operator communicates with the Management Programme.
- Management Programme which has two components.
 1. The conventional Application Programme which does the routine job i.e. collects network information from management agents to build the global Network Information Base, does some routine statistical analysis, displays network status information via human/computer interface programme & inter-

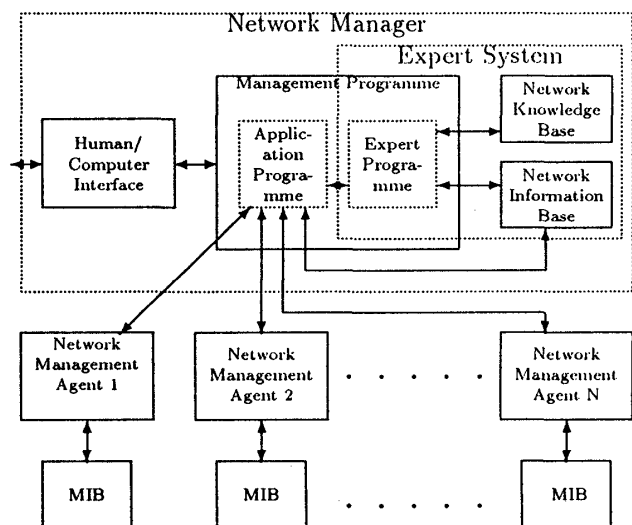


Figure 1: Network Management System : Proposed Model

acts with the Expert Programme whenever needed.

2. The Expert Programme which solves critical problems related to the network with the help of Network Management Knowledge base developed beforehand in consultation with Network Experts.
- Network Information Base containing the relevant network informations such as traffic, various incoming and outgoing packet counts, routing information etc. and the Management Knowledge Base containing the expert knowledge for detecting and repairing faults, monitoring alarming conditions etc. in the rule form.

3 Expert System

The Expert System consists of the Expert programme, the Knowledge Base and the data base. The expert programme written in *C language* actually contains the interface software to the application programme and the inference engine i.e. the programme that determines the problem solving strategy. The expert knowledge is incorporated in the system as *facts* and the *rules* in the knowledge base. Facts are represented as objects and objects having similar properties are grouped into classes though an object can be a member of more than one classes. Rules are condition/action pairs. When

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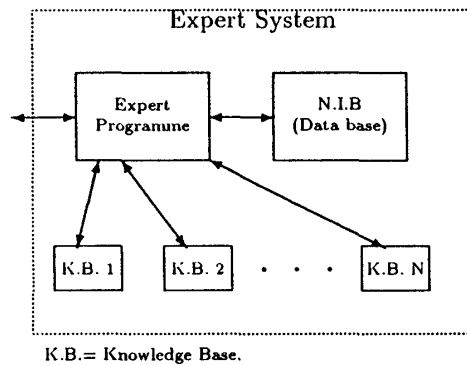


Figure 2: Expert System : Inner View

a condition occurs, as described by facts, the action portion of a rule is executed. Rules may create new facts, thereby activating other rules. Rule activation is controlled by the *inference engine*. In the course of processing, if the property value of any object is needed to be known, it is supplied from the network information base.

In the proposed model, the Knowledge base is developed in different modules and submodules for representing the necessary knowledge for solving different category of problems. Different modules of the knowledge base may share common objects and rules.

The Expert System acts in two ways :

- When the human manager needs to consult the Expert, he or she calls the Expert programme from the application programme. The Expert programme loads the appropriate knowledge base module, activates proper rules and communicates the suggestion/conclusion to the human manager via the application programme.
- For some specified problems which need immediate human intervention the Expert programme executes some routine checking at pre specified regular interval and notifies any alarming condition to the human manager via the application programme.

Figure 2 represents the architecture of the Expert System.

4 Implementation

The implementation has been done by writing different knowledge bases using an off-the-shelf Expert tool. Let us explain how the Expert System helps a human manager for example in ICMP analysis. The Expert programme polls the NIB for getting ICMP packet counts at regular intervals. Whenever the packet count exceeds some user defined limit it starts ICMP analysis.

The Expert programme calls the application programme to fetch the contents of ICMP packets. It then deciphers the packets, gets the source and the destination addresses causing the ICMP from datagram header, determines the type of problem from the type field code of ICMP packet and then loads the appropriate knowledge base to solve the problem. For example, if the type field code is 3, *network unreachable* message is sent. Knowing the source and destination addresses, Expert System finds out the reason of the failure with

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RULE : Rule 1
If
code_value is precisely equal to 3
Then network_unreachable
is confirmed.
And Execute "check_route"(@TYPE=EXE;)
And Execute "gateway_down"(@TYPE=EXE;)

RULE : Rule 2
If
Execute "check_rout_table"(@TYPE=EXE;)
And dest_add_avail is precisely equal to 0
Then routing_problem
is confirmed.
And Execute "Adjust_route"(@TYPE=EXE;)

RULE : Rule 3
If
Execute "check_gateway"(@TYPE=EXE;)
And there is evidence of gateway_down
Then gateway_problem
is confirmed.
And Show "gateway_down" @KEEP=FALSE;

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Figure 3: Knowledge base : Network Unreachable

the help of knowledge base (where expert knowledge on this problem is written in simple rules) and communicates the action to be taken, if any, to human manager via application programme. Thus the manager need not bother to know the problem and its remedy. The rules in the knowledge base for this particular problem is represented in Figure 3.

Among other problems which have been implemented so far Traffic Analysis can be taken as another example. The Expert programme monitors the traffic data and communicates alarm when the traffic at any part of the network exceeds the pre-defined limit.

5 Conclusion

In this work an Expert Network Management model is designed and implemented in some specific areas. The model is flexible to accommodate solution for any new problem that can occur in future by adding another knowledge base module. Furthermore, any new knowledge that are obtained in course of operation may be incorporated to update the knowledge base without changing the Expert programme i.e. the inference engine.

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