TACTICAL NETWORK MANAGEMENT FOR PRESERVING THE QoS
An implementation for an industrial local network

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Abstract
The purpose of this paper is to introduce new concepts to construct tactical network management. In fact, the main concerns in today’s network management is how to be able to analyze large amount of information, give appropriate diagnostic, and try to evaluate and preserve the QoS offered by a system. To do this, threshold values must be set according to a certain concluded QoS. When these values are exceeded, alarms are sent to specific managers. This paper shows how to provide the relevant information to the right manager at the right time. The major contribution of our work is to provide network managers with conceptual supporting tools to find the important information that can helps the diagnostic, and that specifies the responsibilities of every entity in not providing the service or providing a depreciated service.

The conceptual tools that we propose are: the QoS Model, the abstraction of the resources, and the level of visibility. We will show the benefit of studying the system behaviour closely to select the important information to be monitored, and splitting the system into different management levels to designate hierarchical managers. It emphasis on the comprehension of the behaviour of every component of the system, on how to prepare the diagnostic and deduce the appropriate tactical action. This will automates a part of the decision process, and gives the network manager support tools to his work.

Introduction
The challenges in network management today are quantification of the QoS provided and dynamic control to preserve it. In the time of proliferation of services and service providers, it is vital to give the user the means to evaluate the QoS in objective terms. The provider of a service must construct a strategy during the conceptual phase to monitor the evolution of his system, evaluate the effective QoS and take immediate, average time or long term decisions to overcome the gap. The information system must be sufficient and simple enough to induce quickly the solution. Modelling the QoS helps evaluating QoS of heterogeneous components in a homogeneous way. This evaluation allows comparison. Our Model determines in terms of four criteria, that can be evaluated, the quality of service of the information system. These criteria are Availability, Reliability, Capacity and Delay. Each criteria can be expressed in terms of measured parameters.

Abstraction of resources helps identifying common objects that compose a system and grouping them into abstract categories, to restore a homogeneous view of a heterogeneous system. While the level of visibility is another abstraction concept that helps identifying the frontiers between the different management functions that a system can support.

Three levels of management can be implemented: dynamic control by the entity itself or a local manager, tactical management by a more global manager and strategic management by the global manager who’s in charge of the whole system. In the article we will put the emphasis on the way tactical network management decisions are made to preserve the QoS. At this level, we have already implemented a self-management dynamic control for real time decisions. It supports all of the local management of the entity that can be done without knowledge of the whole system state.

We will illustrate in a case study for the Power Plant Control department of EDF, the implementation of Tactical Network Management for maintaining the Quality of the service provided by a system. We will see;
- What is the critical information that describes a Fast Ethernet Switched network.
- How to analyse and use this information.
- What are the tactical decisions that maintain the QoS of the Fast Ethernet Switched network.
- How to implement these decisions into action.

How to preserve the QoS
Let us define the point of view in which we classify this work, preserving the QoS. To manage a network
system, the manager can either planify the preventives actions or prepare the curative actions that should be undertaken when a problem occurs. Maintaining the QoS falls into the first category. Events that can not be avoided, nor predicted in time, aren't taken into consideration in the maintenance scheme. In contrast, preserving the QoS of a given network system means that curative actions must be done when an unexpected event occurs, that individual QoS must be monitored and appropriate action must be taken to overcome every deviation from the contracted QoS.

Four criteria were selected to describes the QoS, they can be expressed in term of parameters. These parameters will be monitored and the information sent to the appropriate manager.

The Conceptual Tools

Abstraction of Resources

The purpose of modelling is to give a common support for evaluation and conception of administrative actions. To do this, we try to find the information that describes the best an object and its management actions. We then propose abstract Network elements (Node, Link and Network) that can describes all of these objects. A Node is a processing capacity while a Link is a transfer capacity where the information flows between the nodes. Finally, a Network is a group of Nodes and Links of the same kind that co-operate to a specific service.

Visibility Level

To establish the importance of different information in describing the critical behaviour of a system, we have to study the different cases in which the service is depreciated. To do this, we have to separate the system into basic services where the management decision can be taken. On behalf of these different level of management decision, we split the service. Each of these levels is called a visibility level. At each level, different elements collaborates to provide the service. To find a support for conceiving management action, these different elements can be considered to be either Nodes, Links, or Networks as we explained it in the abstraction of resources.

The QoS Model

The evaluation of the Quality of Service of certain system is not that simple. There is at least two points of view to be considered. The evaluation of the QoS from the user point of view and from the provider point of view.

- From the user point of view, it is the QoS of the service expected, this QoS is negotiable for each service at each service access point.

- From the provider point of view, the QoS is the quality of operation provided by the system. It is the way the service is thought for the designated QoS, and the means used to make sure it will stay steady.

To help these two points of view have the same measurement facility, and an objective way to establish an evaluation of the QoS, the ENST has proposed a model for evaluating the QoS of a system. Different depreciated services have been used to describe the quality of functioning of a system: The system is not available; The system is available and offering a not reliable service; The system is available, offering an un-reliable service; but the service time is depreciated, the system is available and offering a normal service quality; but its capacity of service is depreciated.

Using this description, the ENST deduced four criteria that can help evaluate the QoS of a system.

These criteria are calculated in terms of parameters that can be measured. They are listed in the table below:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Explanation</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>is the percentage of time the system is functioning.</td>
<td>Accessibility rate, Connection rate, Memory usage rate</td>
</tr>
<tr>
<td></td>
<td>Its capacity to function at every instant</td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td>is the percentage of time the system is functioning without errors.</td>
<td>Error rate (link), Loss rate (node), Duplication of PDU, Frames disorder.</td>
</tr>
<tr>
<td></td>
<td>Its capacity to function well in time interval</td>
<td></td>
</tr>
<tr>
<td>Delay</td>
<td>is the time to flow through the system.</td>
<td>PDU lifetime, PDU round trip time, Processing time, Duplication of PDU, Frames disorder.</td>
</tr>
<tr>
<td>Capacity</td>
<td>is the capacity of service of the system.</td>
<td>Length of PDU, charge rate of the CPU throughput of the link</td>
</tr>
</tbody>
</table>

Each of these different criteria must be evaluated at the different level of abstraction of the system, and for every component. The resulting QoS is function of the aggregation of the individual QoS. It is evaluated according to the architecture of co-operation of the different services. The evaluation of the individual QoS will help us express the different QoS but it is not enough, since it implies the comparison of the each value to the
contractual value. Another way to appreciate the QoS, is to try to calculate a global QoS for the whole system. This aggregation can be done either for each component first and then for all the components or for each service level first and then for all the services. In our case study, we will be using the first method since it can give us the mean for evaluating each component alone. In both cases, the rules that govern the aggregation can be given by the following: If the different services are in series, this means that all the components have to be considered in the evaluation of the QoS. Whereas in the case of services in parallel, only the service that will probably participate must be considered.

This table gives the rules, that we can use to calculate the aggregation according to the architecture of services.

<table>
<thead>
<tr>
<th></th>
<th>Series</th>
<th>Parallel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>Product of Ai</td>
<td>1-product(1-Ai)</td>
</tr>
<tr>
<td>Reliability</td>
<td>Product of Ai</td>
<td>1-product(1-Ai)</td>
</tr>
<tr>
<td>Capacity</td>
<td>Min(Ci)</td>
<td>Min(Ci)</td>
</tr>
<tr>
<td>Delay</td>
<td>ΣDi</td>
<td>Max(Di)</td>
</tr>
</tbody>
</table>

**How to find relevant information for tactical management?**

By splitting the system into basic services, and extracting the information that describes the bad behaviour of a system, we identify the relevant information and the responsibilities. We study the behaviour of each service, and we express it in terms of known parameters. These parameters are either MIB (Management information base) parameters or parameters that must be measured. Then we instantiate the QoS criteria, and evaluates them in terms of known parameters.

Each parameter have a current value, which is the actual measured value, and a bound value which will serve to send alarms, along with a conceptual value. The conceptual values are the bound values allowed by the entity itself when taken alone. The bound values that each parameter must respect are defined in the objective of keeping the desired QoS. They are set also in respect of the management decision to be done and the responsibilities of the manager in charge of that alarm. These parameters will be monitored and the information send to the appropriate manager (local, tactical or global manager). A local manager is implemented in each object, and decisions for which the local manager does not have the authority nor the resources, are taken by the tactical manager. The tactical manager has a view of all the elements that are under its responsibilities. By its relatively global view, the tactical manager can co-ordinate the different curative actions, or the substitution of a service by another equivalent service. The global manager has a vision of the global management scheme and the state of the global system. It must be able to take the appropriate decision where the tactical manager fails, and must take into consideration the long term evolution of the users requirements.

We have just established the information to monitor, and the different manager in charge. Now, we will see how to co-ordinate these different management plans. In fact, in the operational phase of a system, these informations can be measured and used in different ways:

- a real time basis and it is **dynamical network management**.
- a certain time limit basis and it is **tactical network management**.
- a long time basis and it is **strategic network management**.

The first case can be illustrated simply by alarming the local manager when a parameter has a value that is not allowed. The information is individually used in a raw fashion, and it induces an almost automated action. The information is local and can be done in a local treatment leaving to the tactical manager the more complex decisions. For this, we will define the threshold values of the parameters in a way that the object can take management decisions and actions. If the object can not overcome the problem, the tactical manager is informed.

When the tactical manager is informed, according to all the alarms that it has received, its global view of the system, and to its local decision table, it must try to resolve the problem. It has the monitored state of the different components since it asks periodically for the relevant information and is informed for each threshold value exceeded. It can say what is the QoS of each component, which is doing well and which is depreciating the contracted QoS. This analysis of the whole system it is responsible for, helps it take appropriate decision for a specific system state, when an alarms occur. Its decision can be partially automated. With its knowledge of that part of the system, the global manager will consult its decision table to see if the case is already documented and take decisions consequently. The decision table is constructed partially at the conceptual phase, to help conduct some of curative actions. It can be enriched along the lifetime of the system either by predicting the actions that should be taken to stay accurate with the evolution of the system or by capitalising its own experiences.

In the case of strategic management, the manager can use the monitored information, the evaluation of the actual QoS, and consider the expressed need of the user, to
construct the strategic network management for a long term evolution of its system.

Case study

Analysing the system

The network of the case study is an industrial local network that is used to simulate the control machines of the "Electricité de France" for training purposes. Applications with different data priorities run over the network. To overcome the future overload, the network was segmented using a switch. In our first experimentation, we have chosen, the 3com Corebuilder 5000 switch. We have one station per port with a 100BaseFx link cable. We only have one administration domain. To find the information that describes well the network, we have to analyse all the basic service components that compose the global service. The communication between two entities relies on the state of:

- The Switching function (Switching visibility level)
- and the MAC Ethernet segment (MAC visibility level),

The MAC Ethernet segment (MAC visibility level) is composed by the different MAC functions of the switch, of the server and of the stations. They are implemented in the different interface cards, and they communicates via the link segments.

Each interface is supported by an equipment component, and the link segment is supported by the cable component.

So the different levels are: Switching function level (switch), Mac level (switch, server, stations), Physical level (Network cards of the components, links) and the equipment level (switch, server, stations, cable). To give a concise description of the behaviour of the system, we must study these levels of service

In the next paragraphs, we will apply the concepts that we have exposed in the first part of this paper.

Instantiation of the QoS Model

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Node</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability</td>
<td>Nb of instructions that were correctly executed. without error.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physique</th>
<th>Node</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>Percentage of lost frames in reception and transmit because of lack of resources</td>
<td>etherStatsCollisions, etherStatsPkts</td>
</tr>
<tr>
<td>Reliability</td>
<td>Percentage of jabbering</td>
<td>Percentage of CRC errors</td>
</tr>
<tr>
<td>Delay</td>
<td>Delay time in the buffer</td>
<td>Transmission delay</td>
</tr>
<tr>
<td>Capacity</td>
<td>Throughput at the interface</td>
<td>Throughput of the link</td>
</tr>
<tr>
<td>MAC</td>
<td>Node</td>
<td></td>
</tr>
<tr>
<td>Availability</td>
<td>Percentage of rejection ifOperStatus</td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td>Percentage of too short frames etherStatsUndersizedPkts, etherStatsOversizedPkts</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Switching</th>
<th>Node</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>State of the port vtTpPortPercDiscards, ocPktChannelStatSlotTimeouts</td>
</tr>
<tr>
<td>Reliability</td>
<td>Frame loss, Frame errors ocPktChannelStatTransmitFloodDrops, ocPktChannelStatTransmitPoint2PointDrops, ocPktChannelStatReceiveFloodDrops</td>
</tr>
</tbody>
</table>

In the next paragraphs, we will apply the concepts that we have exposed in the first part of this paper.
### Implementation of Tactical Management

After determining the information to monitor for each service, we will illustrate the implementation of the tactical network management by an example.

In the conceptual phase, for each port, the Max memory buffers are set for each priority according to a theoretical amount.

When these values are exceeded, the local manager must try to allocate more memory to the priority in lack of resources. If the maximum memory is allocated to that priority, the local manager which does not have enough authority nor the fundamental information to react, informs the tactical manager.

The tactical manager has the ability to discard the data with less priority. By doing this, it will liberate buffer memory. The local manager will be able then to reallocate its memory. The tactical manager informs the global manager that maximum buffer space was exceeded for statistic reasons.

The global manager, observes the system for a certain period. It may decide to re-define the maximum memory buffer per priority type, according to the different statistics on the behaviour of the configuration or on the new needs of users. For this, the manufacturer, must provide us, the reservation information of the memory ressources.

### Conclusion

Network Management strategies must be constructed to a certain objective. Preserving the QoS of a system is a global objective that includes preserving the delay, the capacity and monitoring the reliability and the availability. To study these criteria, we start by studying closely the behaviour of every basic service component, the reasons of depreciated service, and determine the parameters that help control it. Then we express the four QoS criteria in terms of parameters to monitor. For this specific contracted QoS, we define threshold values to monitor these parameters. When the local manger of the entity can not overcome the event alone, an alarm is sent to a tactical manager. The tactical manager, which is in charge of a group of entities can substitute the depreciated service by another service according to its knowledge of the state of the other components or take some curative actions. The strategic manager is alarmed when the tactical manager can not master the situation and when the decision needs more knowledge of the system. This different actions can be automated, by implementing a decision support tool in each manager.

### References


Corebuilder 5000 mib; Corebuilder 500 SwitchModule Architecture.

Corebuilder 5000 is a trademark of 3Com Corporation.