INTEGRATED COMMUNICATIONS MANAGEMENT OF BROADBAND NETWORKS

Crete University Press, Heraklio, Greece
ISBN 960 524 006 8

Edited by David Griffin

First published in 1996 by
CRETE UNIVERSITY PRESS
Foundation for Research and Technology
P.O. Box 1527, Heraklio, Crete, Greece 711 10
Tel: +30 81 394235, Fax: +30 81 394236
email: pek@iesl.forth.gr

The ICM consortium consists of the following companies:

Alcatel ISR, France
Alpha SAI, Greece
Ascom Monetel, France
Ascom Tech, Switzerland
Centro de Estudos de Telecommunicações, Portugal
Cray Communications Ltd., United Kingdom (Prime contractor)
Danish Electronics, Light & Acoustics, Denmark
De Nouvelles Architectures pour les Communications, France
Foundation for Research and Technology - Hellas, Institute of Computer Science, Greece
GN Nettest AS, Denmark
National Technical University of Athens, Greece
Nokia Corporation, Finland
Queen Mary and Westfield College, United Kingdom
Unipro Ltd., United Kingdom
University College London, United Kingdom
University of Durham, United Kingdom
VTT - Technical Research Centre of Finland

Chapter 7

PON management

Editors: Nazim Agoulmine, Cyril Autant, Richard Lewis
Authors: Johanne Schmidt, Fausto de Carvalho, Patrick Legand,
Nazim Agoulmine, Abílio Carvalho, Kevin McCarthy, Teresa Almeida,
Olivier Chambon, Cyril Autant, Faouzi Ababsa, Jorge Sanchez

Optical technology is expected to be important in future networks. However, until now little research into the management of Optical Networks (ONs) has been performed. The work described in this chapter aims to address this area by studying the applicability of TMN concepts and models to the management of ONs.

After a presentation of the principles of Optical Networks, this chapter describes the network located in Aveiro and operated by CET in association with RACE Project COBRA, and proposes management solutions for this network.

7.1 Introduction to coherent optical transmission

Throughout the history of fibre optic communication the trend in system design and development has been towards transmission over greater distances and for ever higher information carrying capacity. Since the first systems were produced, laser and detector device performance has been enhanced substantially, permitting system improvements. Present day systems, however, still rely upon the same basic modulation and detection principle. Systems based on this simple technique, which is often compared to the early “spark-gap” transmitters used in radio experiments, have significant limitations from the point of view of the sensitivity of the detection process and the data transmission capacity. It has long been recognised that the technique of heterodyne detection, as used in modern radio receivers, if applied to fibre optic communications could yield a major leap in system performance. The attractions lie in the detection of much weaker signals than currently possible and the ability to populate the fibre with optical channels which can be selectively detected with a tuneable optical heterodyne receiver in an analogous manner to that of radio. This provides a technique for accessing the huge potential transmission capacity offered by the fibre medium.

Despite the attractions of the receiver sensitivity gain offered by coherent detection for long distance transmission, the most exciting potential application of coherent systems lies in the area of providing broadband services within the business and private subscriber networks of the future. Two features make coherent transmission attractive in this context. The first is the increased sensitivity of a coherent receiver which enables more users or terminals to be served from a transmitter unit via a passive distribution network. The second relates to the ability to multiplex a large number of optical channels, closely spaced in frequency, on to a single fibre. The frequency selectivity of the heterodyne receiver makes it possible to demultiplex a single channel from the large number available by adjusting the frequency of the local oscillator laser in a similar way to the selection of a particular station by a radio tuner.

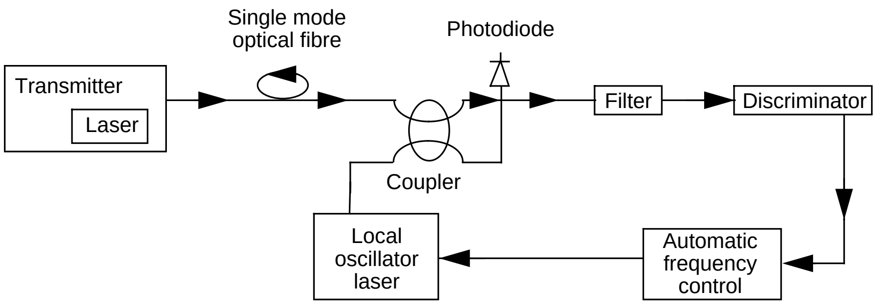

Figure 7.1 Simplified block diagram of an optical coherent system

Centralised and global wavelength management and control is required by networks using Coherent Multi-Channel (CMC) technology in order to explore the high degree of flexibility exhibited as the main advantage of such networks. The inherent flexibility displayed by the CMC technology needs to be matched by the capabilities provided by the management and control system; otherwise the gains in network flexibility may be completely lost because of the lack of an adequate management solution.

CMC networks also have special requirements on security services since all information conveyed in the network is distributed to all users and potentially accessible by all. Authentication procedures for control of channel allocation at the receiver side are an essential element for the management of such networks. Fault management is crucial also for an appropriate network control capability.

7.2 Description of the CET-COBRA demonstrator

The CET-COBRA demonstrator (Figure 7.2) aims to demonstrate the viability of videoconference service provided by means of coherent techniques for the transmission of high quality video signals over a Passive Optical Network (PON) with a star topology.

Terminals are installed in geographically scattered user premises. Bi-directional interactive videoconference services (both point-to-point and point-to-multipoint) are available to business users, allowing tele-learning/training and joint business meetings to be held.

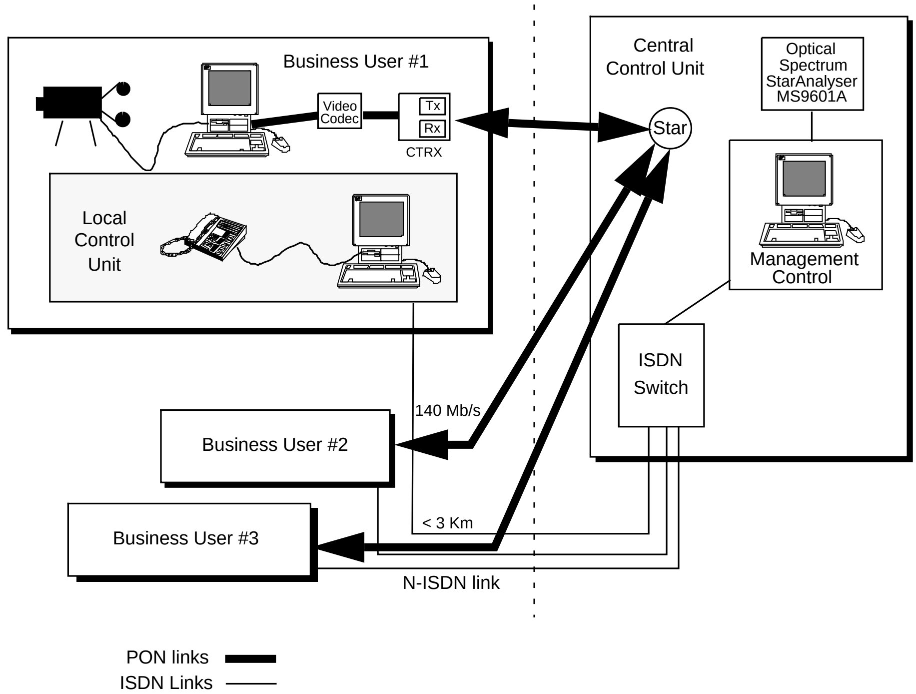

Figure 7.2 CET-COBRA demonstrator - physical architecture

The network is based upon a standard single mode fibre PON transmitting video signals between three sites. For practical reasons only three terminals are deployed in the Aveiro demonstrator. However this is sufficient to validate the commissioning of a flexible broadband network by demonstrating multipoint communications. The PON is configured as a star scheme with one duplex fibre cable per user. For the purpose of system control, one output of the central four-by-four star coupler is monitored by an Optical Spectrum Analyser (OSA), allowing measurement of optical power and frequency stability.

The terminals are controlled, via an overlay N-ISDN network, by a Central Control Unit (CCU) which is responsible for monitoring and control functions of both the PON and the N-ISDN. Monitoring functions include measurements of, for example, the frequency stability of the transmitters and the optical power level in the PON. The control functions include detection and correction of failures in the network elements and procedures for call establishment and call release.

A key feature of this network is the interaction with N-ISDN to obtain an on demand broadband “circuit switched” PON.

7.2.1 User terminals

The user terminal is the set of equipment located at each of the videoconference sites, consisting of:

- coherent optical transmitter (Tx),
- coherent optical receiver (Rx),
- videocodec system,
- Local Control Unit (LCU),
- video camera and TV monitor.

7.2.2 Central Control Unit

The Central Control Unit (CCU) provides centralised frequency control, and interworking between the PON and the ISDN network.

7.2.3 Network infrastructure

The network infrastructure is comprised of:

- optical fibre cable,
- Optical Spectrum Analyser (OSA),
- N-ISDN cable,
- N-ISDN switching exchange.

7.2.4 Mechanisms for connection establishment and control

The network provides a set of communication services for both uni-directional and multi-directional connections: point-to-point, point-to-multipoint and multipoint.

When a user wishes to make a call, the LCU connects to the CCU over the ISDN line, the CCU then connects to the *called* LCU and sets the frequency of the transmit and receive channels in both LCUs. Once both parties’ terminals are tuned to the correct frequencies by the LCUs the call is established and the users may communicate.

There are two kinds of frequency allocation: *Static frequency allocation* where each transmitter is pre-allocated a fixed frequency when the network is initialised; and *Dynamic frequency allocation* where the transmitting frequencies are allocated to coherent transmitters at the beginning of each session.

The CCU maintains a table of all occupied frequencies, which is consulted when there is a new session request, in order to know if there are available resources to attend the request, in which case the table is updated and the frequencies allocated to the involved users. The table is also updated every time there is a session release, releasing the frequencies that where in use in that session.

Temperature can modify the characteristics of the local oscillators and transmitter lasers that generate the optical signals used by the transmit and receive units of each user terminal. This impacts on the value of the central wavelength of these signals and may cause frequency drift.

The OSA is connected to an output fibre of the Optical Transmissive Star Coupler, for monitoring of the signals in the fibres. In this way the OSA can precisely measure the optical frequencies of all signals in the PON. By reading and analysing the data from OSA, CCU detects any frequency drift in the user transmitter units, calculates the frequency difference and corrects it by signalling the corresponding LCU over the ISDN connection; the LCU then signals the transmitter unit which corrects itself using the CCU calculated frequency difference.

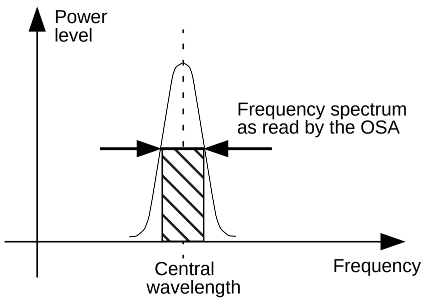

Figure 7.3 Frequency monitoring

7.2.5 Alarms

This section identifies the alarms generated by the PON network which may be accessed by the TMN. The following alarms are raised by the terminals:

- Temperature near minimum,
- Temperature near maximum,
- Bias current near minimum,
- Bias current near maximum,
- Optical power at minimum,
- Optical power below minimum,
- Look up table error (estimated laser bias out of range),
- Command error (unrecognised command or invalid number),
- Command executed successfully but transmitter needs re-calibration, and,
- Request to control to send ACTF information.

A set of general system alarms are identified. These alarms concern the system operation and permit problems in the network equipment to be identified:

- No output power,
- Power density low,
- Tx BER high,
- Output frequency outside preset operating frequency window, and,
- Linewidth broadening.

7.3 PON management requirements

Three management areas are identified: Configuration Management, Alarm Management and Frequency Allocation Management. The latter is specific to PONs.

7.3.1 Configuration Management

The objective of configuration management is to monitor the logical and physical elements comprising the PON with regard to system behaviour and alarms. This type of management does not perform any actions on the network itself.

The goal is to provide the network operator a simple yet comprehensive view of the configuration and behaviour of the PON. The monitored parameters are:

- Current service mode,
- Audio mode,
- Frequency allocation mode (static or dynamic),
- Frequencies in use/available frequencies,
- For each terminal the kind of receiver and the frequency spacing,
- Current users.

The short and long term behaviour of transmitters is monitored to build a picture of transmitter stability and component degradation. Frequency stability depends on the environmental temperature (or transmitter malfunction). Transmitter stability is monitored in order to predict the behaviour of the whole system. For example the TMN can maintain statistics on transmitter behaviour in order to identify failure trends.

7.3.2 Alarm Management

Although the CCU already performs a minimal set of basic alarm management functionality a higher level of functionality is required in the TMN.

In the short term, the TMN detects malfunctions and failures that may have been already detected by the CCU, and simply presents the information to the management operator. However, the main role of the Alarm management functionality in the TMN is the long term prevention of failures. AIP (Advanced Information Processing) techniques can be used. For example an expert system that filters events and store them in a facts base, may warn the operator and suggest actions when incoming alarms indicate a potential problem. The rules used to make these predictions have two origins: some are built in the management system and have been defined from the architecture of the system. Some are dynamically given by the operator who, through the analysis of past situations, establishes correlation between the occurrence of an alarm and an eventual problem in the network.

7.3.3 Frequency Allocation Management

The CCU generates a connection establishment alarm whenever it accepts, releases or refuses a connection. In addition, the CCU generates a connection refused alarm when a user requests a new connection and there are no frequencies available. By monitoring the traffic one can ascertain the network load and determine the number of connections required. By using this information one can pre-allocate frequencies to the transmitters so that they are distributed as evenly in the frequency range as possible. One should consider the issue of allocating the frequencies before the connections are set up so that the controllers can work independently of the TMN.

7.4 Functional architecture and information models

This section details the architecture and design of Configuration Management and Alarm Management using the methodology of ITU-T Recommendation M.3020 [7.9] and Chapter 3. Two management services have been identified for the PON case study: the Configuration Management Service and the Alarm Management Service,

7.4.1 MSCs and MFCs

Based on the management requirements outlined in the previous section, the decomposition process leads to the definition of the following MSCs:

- A Network Physical and Logical Configuration MSC.
- A Network Alarm Management MSC.

The first MSC has both static and dynamic aspects. The static aspect concerns the static configuration of the network components. The dynamic aspect is related to the behaviour of the network and the users.

These two MSCs are directly mapped to corresponding MFCs as follows:

- A Configuration Management MFC.
- An Alarm Management MFC.

These MFCs are allocated to corresponding Operation System Functions of the TMN architecture as described in Figure 7.4.

As shown in the figure, the QAF block is the interface between the TMN system and the network, and that mediation is required in order to provide a q3 view of the underlying information to the Configuration Management OSF.

The information modelling approach adopted in the PON management follows the global approach of the ICM project. The process of modelling was executed at each level of the architecture, hiding unnecessary information from the layer above.

7.4.2 Network Element Functions

As the PON did not have a management interface a SNMP agent was developed a M interface. The PON SNMP agent makes available to the TMN all parameters and thresholds in the CCU. The agent interacts directly with the CCU and maintains a Management Information Base including information about provided services (point-to-point, point-to-Multipoint, videoconference), the current service mode, the current audio mode (ISDN, PON) and the number of real and simulated users. The PON SNMP agent also reports internal events about the operation of the system.

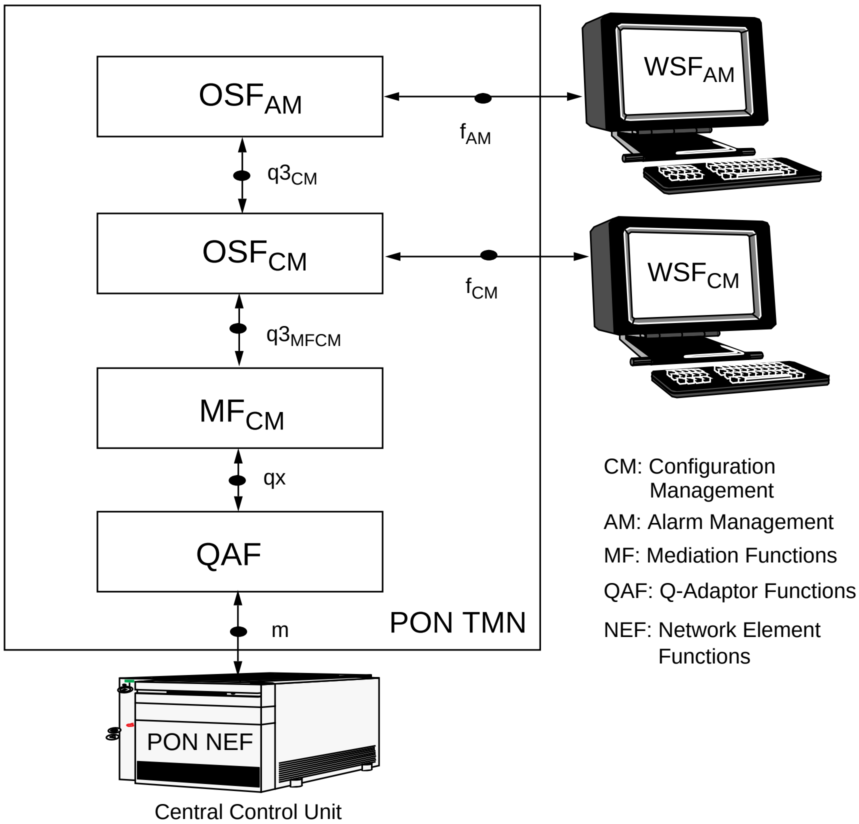

Figure 7.4 PON TMN - functional architecture

7.4.2.1 PON-SNMP group definition

The Management Information Base adopted is composed of 4 groups as depicted in Figure 7.5.

- *ponSystem* group: models information on the PON CCU: provided services, the current service modes, and the number of real and simulated users.
- *ponComponents* group: models the PON elements. The ponCompTable contains information about the type of components such as terminals, OSA and N-ISDN. Terminals have a device-specific table for more detailed information and a current action table for terminal specific actions.
- *ponFrequenciesAlloc* group: contains the frequency allocation table which contains the initial allocated frequencies for each connection.
- *ponOpticalPeaks* group: models the PON optical peaks table where instantaneous values (measured by the OSA) for each connection (frequency, power level and width) are stored.

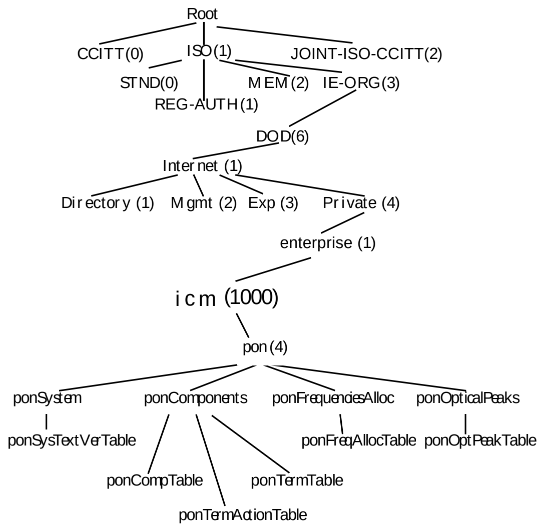

Figure 7.5 PON-SNMP Internet registration tree

Six traps were specified to notify changes within the network to avoid regular polling of the network interface:

- Transmitter Alarms.
- Frequency Allocate/DeAllocated Alarms.
- Optical Peak Alarms.
- Warning Alarms.
- System Alarms.
- Action Confirmation Alarms.

7.4.2.2 SNMP action mechanism

Because SNMP does not allow actions a set of simulated actions were created. These are simulated by one or more SNMP Set operations, followed by a periodic poll on the associated results objects. An action table models the types of actions present in the PON with a uniform representation of input and output parameters.

There are two modes for actions: *Asynchronous actions* permit the initiator to perform other tasks while the action is processed. The termination of the action is signalled by the SNMP agent emitting a trap to the initiator which in turn consults the action table to retrieve the result. *Synchronous actions* put the initiator in an idle state until the action has been completed

7.4.3 Q-Adaptor Functions

The Q-Adaptor Function provides the necessary adaptation mechanisms to interface the TMN to the network. It converts the m reference point information model at the CCU boundary to an equivalent qx information model, or more exactly in this case a SNMP MIB to the equivalent CMIP MIB and vice versa.

The Generic Internet Q-Adaptor (IQA) [7.5] (see Section 10.4.4.2) was used to offer an "OSI view" of the underlying SNMP MIB, and to hide the specific mechanisms used at the SNMP agent level.

The result of the translation of the SNMP MIB to an OSI view at the qx reference point of the underlying MIB is shown in Figure 7.6.

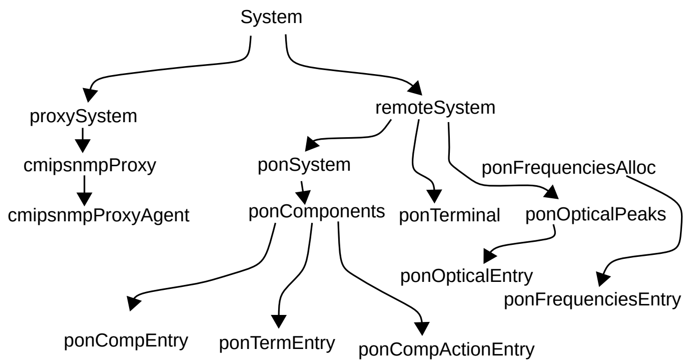

Figure 7.6 PON-IQA containment schema

The activation of an action is performed within the PON IQA agent by the creation of an instance of the ponTermActionEntry class. The constructor of the new created instance allocates and activates a free entry in the action table of the SNMP agent.

In the case of asynchronous actions, the reception of a termination action SNMP trap is translated in the PON IQA into the emission of an InternetAlarm Event-Report. The termination of the action is signalled by SNMP agent to the IQA by sending the ponTermActionConf which in turn consults the corresponding entry in the action table in order to collect the result. The entry is then released by the IQA.

On the other hand, if the action is synchronous, a monitoring object is created in the PON IQA in order to initiate polling of the actions table. When the action completion is detected, a MonitoringObjectAlarm Event-Report is sent to the action initiator. A polling strategy on the ponTermActionActivation field is adopted by the IQA agent to detect completion. This is realised when the ponTermActionActivation is reset to "ok."

7.4.4 Mediation Function

Mediation Functions convert a qx reference point to a q3 reference point. This performs the necessary storage, filtering, thresholds and concentration to convert specific information from one layer to the information model format of the layer above. In our case, mediation provides functionality to simulate actions on top of the qx reference point.

Principally the role of the MF in the PON TMN system is to convert the actions triggered by the upper OSF into the corresponding services in the lower functional blocks.

The MF takes advantage of the mechanisms defined within the Q-Adaptor functions to provide a full q3 reference point to the upper functional blocks. It hides from

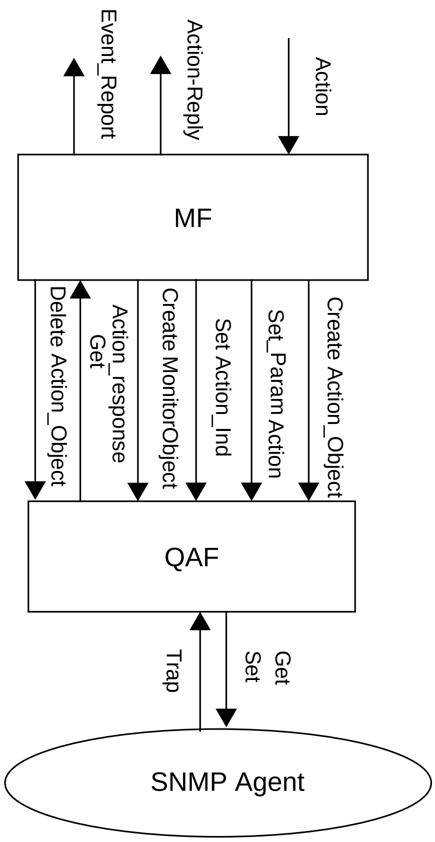

Figure 7.7 MF simulated action

the upper functional block the particular approach used to simulate actions on the SNMP agent.

An action invocation is translated by the MF into a set of requests to the PON SNMP agent through the IQA agent. Two types of action are defined, according to the lower functionality and to the definition of the q3 reference point:

- *confirmed action:* the manager is blocked until an action result is received,
- *non confirmed actions:* it is non blocked action, the manager can perform any other processing until it receives the action response.

A confirmed GDMO action request is interpreted by the MF as follows:

- First an action entry is created in the IQA agent and the corresponding action table entry in the SNMP agent is activated after the SNMP action mode is set up. The choice of the SNMP mode adopted is done internally depending on the action time characteristics and resources constraints.
- If a confirmed action is correctly activated, the MF returns a confirmation reply to the manager and waits for action end. This one is signalled by the reception of InternetAlarm or MonitoringObjectAlarm Event-Report depending on the SNMP action mode adopted (res. asynchronous or synchronous).

- The action result is then collected, and all the corresponding objects in PON IQA and SNMP agents are deallocated. A reply event-report is send back to the initiator.

Anon-confirmed action is interpreted by MF like a confirmed one, except that MF waits for action completion in order to free resources. Consequently, it doesn't try to get action results and thus doesn't send any event-report back to registered OSFs. In case of confirmed action, the MF informs the initiator about the activation.

7.4.5 Configuration Management OSF

The Configuration Management OSF maintains an abstract view of the network through the network model, it provides statistics and maintains logs. The Configuration Management OSF has thus three main roles:

- It offers a dynamic view of the PON in terms of current configuration, connections and frequency allocation.
- It provides connection related statistics
- It acts as a PON event-report relay for the Alarm Management OSF.

The Configuration Manager maintains a conceptual view of the network and its behaviour through an up-to-date network model. A static part contains information concerning the network elements and the system configuration. A dynamic part models network behaviour.

The *Static Network Model* is generated at initialisation by identifying the physical and possible logical configuration of PON network including system information,

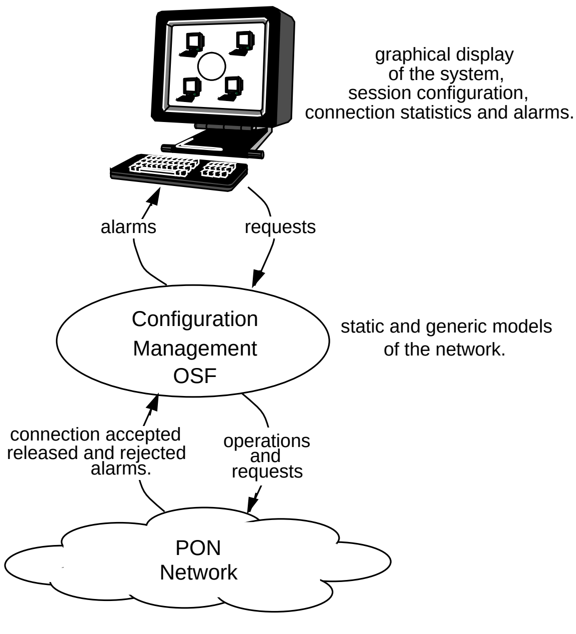

Figure 7.8 PON Configuration Management

existing network components and equipment and possible communication services provided by the network (point-to-point, point-to-Multipoint, Videoconferencing).

The *Dynamic Network Model* takes into account the behaviour of the users and network by keeping up-to-date information about the users, the allocated frequencies, the network components, the connections and the sessions. Its performed by setting values at initial invocation and updating current session and alarms dynamic model information over time according to occurring events.

The Configuration Manager also maintains statistics by calculating a number of parameters for each type of connection (e.g. number of connections, number of refused connection, percentage of accepted and refused connection, mean duration of connection):

The Configuration Management information model is composed of two part: a generic part, and a specific part that reflects the managed object class specialisation according to the generic information model of the ITU-T M3100. The generic part is itself composed of the static and dynamic model. The inheritance hierarchy is shown in Figure 7.9 and the containment schema is shown in Figure 7.10.

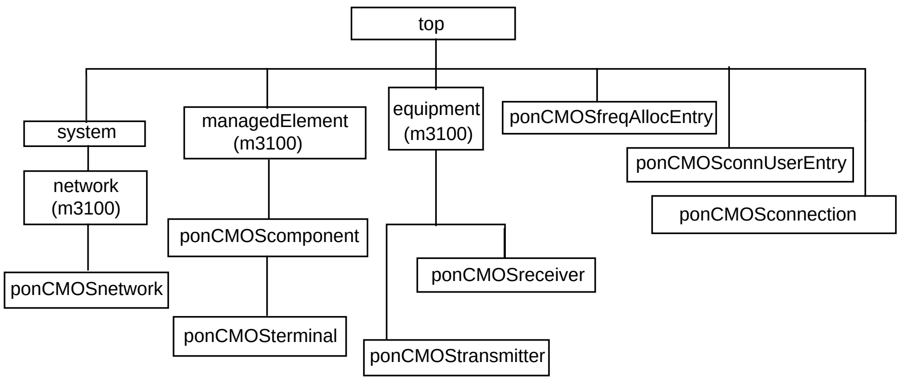

Figure 7.9 Configuration Management inheritance hierarchy

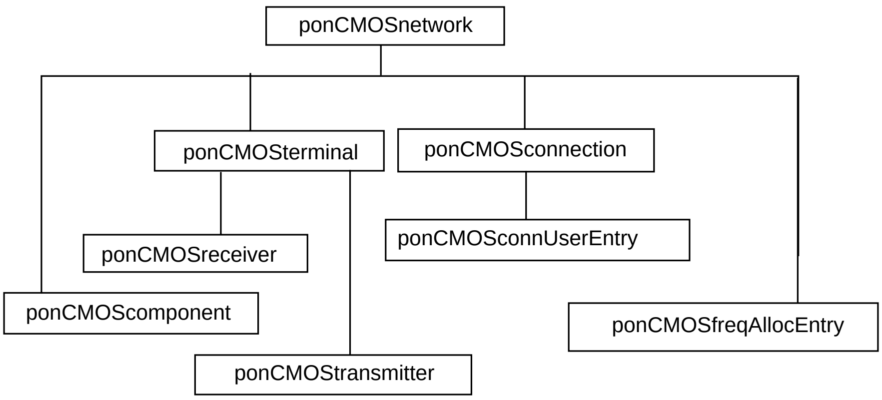

Figure 7.10 Configuration Management containment schema

7.4.6 Alarm Management OSF

The goal of the Alarm Management OSF is to ensure high network availability by quickly recognising (in co-operation with the CCU) equipment failures and problems related to performance degradation, and by initiating controlling functions when necessary. The Alarm Management OSF fulfils the following functionality:

- Logging of alarm conditions and transmitter characteristics such as line width and power levels over time.
- Problem determination, condition diagnosis and attempted problem resolution.

The Alarm Management OSF has a critical role which consists of correlating information from the network to assist and advise the operator. It may also perform actions to improve the state of the managed network. To make this correlation possible, the Alarm Management OSF uses an expert system to draw conclusions a facts base according to rules defined in a rules base.

Figure 7.11 describes the interaction model between the Alarm Management OSF, the Configuration Management OSF, the IQA and the NEF:

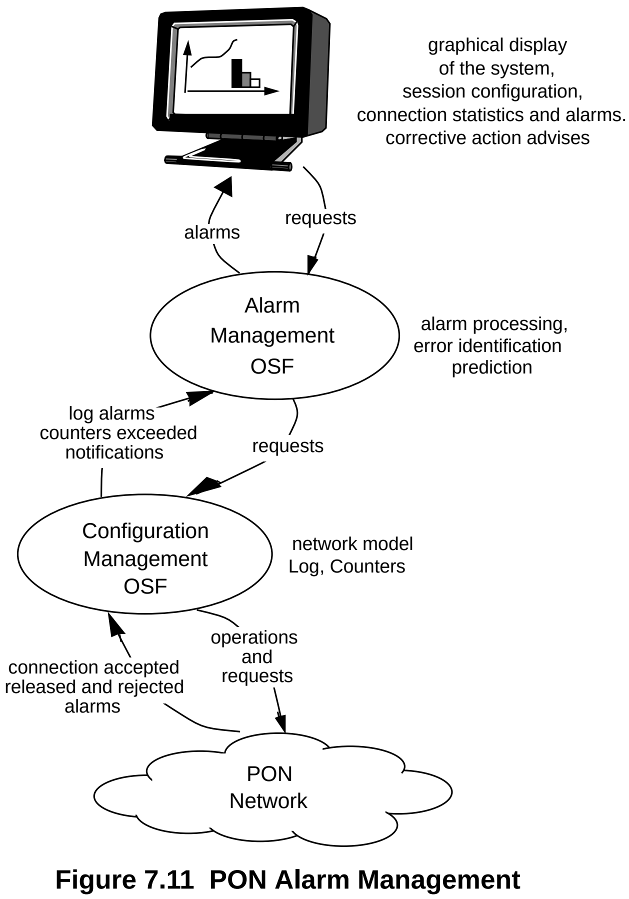

Figure 7.11 PON Alarm Management

7.4.6.1 Alarm Management OSF functional decomposition

The Alarm Management OSF is composed of a set of sub functional blocks that perform a particular aspect of the alarm management process:

Information Handling, is responsible for the handling of all information from the Configuration Management OSF. The information received is stored in the event reports base (operation 1) for later processing. The information handling block decides whether to translate the event report into a fact for the expert system (operation 2).

The event reports, even if they are transformed into facts, are logged into the *Event Reports Base*. The information handling block, in order to get additional information (for example the number of communication alarms over the last ten minutes), may perform queries on this base (operation 3).

All queries are stored in the *Query Base*. Some are loaded at initialisation but they may also be defined by the user (operation 4).

The result of a query (for example the objects created since login) is handled by the *Results Handling* block (operation 5).

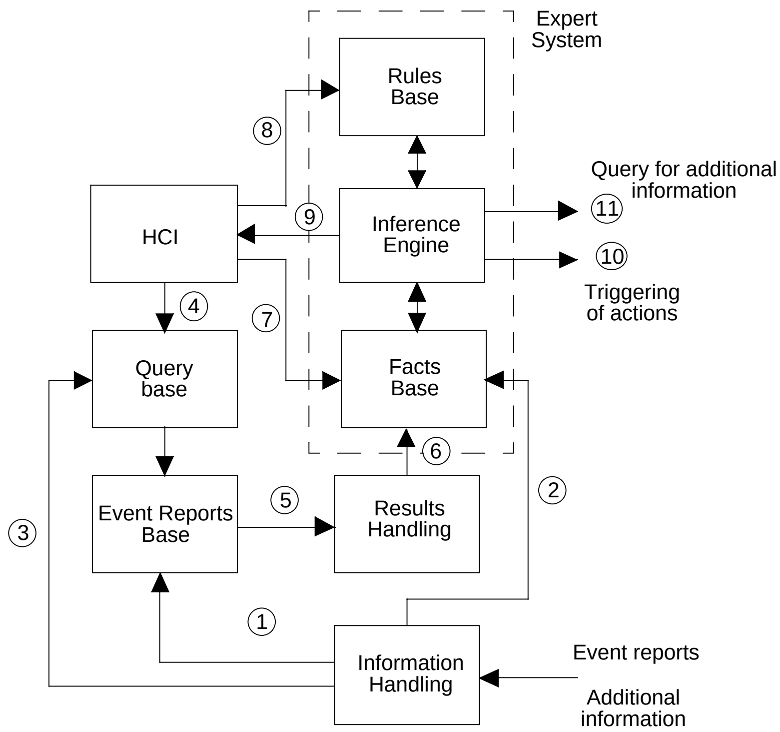

Figure 7.12 Decomposition of the Alarm Management OSF

The information handling block also stores information in the facts base if the received events meet specific requirements previously defined by the operator. For example, after three equipment alarms from the same terminal, we could advise the operator to perform additional tests on this specific equipment. This is done through the assertion of the appropriate fact in the facts base (operation 6).

The *Facts Base, Inference Engine and Rules Base* blocks constitute the expert system used in the Alarm Management OSF. This set of blocks is responsible for advising the operator or performing an action on the managed network (for example to trigger a frequency correction procedure).

The facts base and the rules base are formed from facts and rules defined at initialisation time and dynamically by the user through the HCI (operations 7 and 8). The inference engine draws some conclusions from the defined facts and rules; it may be a message to the operator (operation 9), an action on the other OSs (operation 10) or a query for additional information (for example a get on an attribute defined in the Configuration Management OSF MIB) (operation 11). This additional information is also handled by the information handling block, which translates them into facts that may be used by the inference engine.

Through the above procedure, the Alarm Management OSF performs fault detection and correction, predicts future faults and advises the operator about predicted events. For this purpose, the Alarm Management OSF initiates counters, determines thresholds and filters alarms. It maintain a model of the alarms and calculates statistics, warning and error events mapped from IQA and Configuration Management OSF notifications.

With these alarms presented in a graphically, the TMN gives a view of the state of the network and the Quality of Service being achieved. The TMN can re-establish the threshold values and other parameters to analyse the impact on the network.

A priority mechanism is used by the Alarm Management OSF when handling event reports so that more urgent alarms are processed first. There are three alarm groups:

- Information alarm (priority 0)
- Warning alarm (priority 1)
- Error alarm (priority 2)

According to priority, associated actions are performed immediately at the CCU and within the Alarm Management OSF.

7.4.6.1.1 Information alarms

This type of alarm has no direct consequence, it is used for incrementing counters, for example. One example of this kind of alarm is Linewidth broadening. When this alarm is received, the TMN can begin a monitoring cycle on the characteristics of the signal (power level and width) generated by the respective transmitter. According to the measured values the TMN may conclude that a transmitter is approaching the of its useful life and can recommend that it is replaced.

7.4.6.1.2 Warning alarms

For alarms of this type there is always a subsequent action to be taken by the CCU. The detection of this kind of alarm is made using the readings of the OSA. An example of an alarm of this type is the Frequency Disappear Alarm:

Possible causes:

- Terminal shut-down

- Broken fibre
- Optical component malfunction
- Frequency drift

Actions:

- Verification of transmitter status (laser - on/off).
- If it is off, the TMN can relate this situation with a transmitter shutdown.
- If it is on, the TMN can analyse the spectrum of frequencies.
- If there are no frequencies in the fibre, the reasons for this disappearance can be in a local broken fibre or a connector malfunction. Otherwise, if this frequency is the only one missing, probably the broken fibre or malfunctioning connector is situated between the Terminal and the star coupler.
- If the frequency has deviated, a frequency correction of the associated coherent transmitter is required.

7.4.6.1.3 Error alarms

This type of alarm always results in the LCU shutting down the transmitter. An example of an error alarm is Temperature Near Maximum:

Possible Causes:

- Transmitter internal components damage.
- High environment temperature.

Actions:

- Transmitter shut-down by the terminal itself.
- CCU notification.

Note: there will always be an associated Frequency Disappearance alarm following the shut down of a transmitter, hence there will be a correlation between Temperature Near Maximum and Frequency Disappearance.

7.4.7 Workstation OSF

There are two WS-OSFs presenting the human operator with a view of the configuration of the PON: the Configuration Management WS-OSF and the Alarm Management WS-OSF. Together they provide:

- A topological view of the network and the ability to call up management functions for a given element by pointing at its icon.
- Utilisation Reports, which provide graphical displays of network utilisation and the contribution of individual stations to the utilisation. Real-time reports where a graph is created and updated in real-time, and historical reports where information is retrieved from logs, are provided.
- Graphs of frequency distribution and indications on the types of service that are running on the network (point-to-point, multipoint or videoconference).
- Error Ratio Reports, which provide the operator with graphs of statistics showing network errors.
- Alarm thresholds setting, where the operator can specify values thresholds for certain object. The exceed of these threshold would cause immediate indications to the operator.

7.5 Physical TMN architecture

The TMN function blocks presented in the previous section are mapped to TMN physical blocks as follows:

- the Configuration Management OSF together with the Mediation Function are located in a Configuration Management OS,
- the Alarm Management OSF is placed in an Alarm Management OS,
- the Configuration Management WS-OSF and the Alarm Management WS-OSF are both placed in a single PON Alarm and Configuration WS-OS,
- the Internet QAF is placed in an Internet QA, and,
- the PON SNMP agent is considered to be part of the CCU NE.

7.6 Conclusions

The development of the PON management system required enhancements to the ICM TMN Testbed. This was achieved satisfactorily, showing the extensible nature of the ICM TMN architecture. The implementation has shown that it is possible to reuse the ICM Testbed components to develop a TMN system applied to the management of a network technology with different management requirements to those of ATM.

Conformance to standards simplifies the task of managing heterogeneous networks, demonstrated by adoption of SNMP for management within the PON, with a Q-Adaptor providing the interface to the TMN. With respect to implementation and deployment, the tools developed within the project have reduced the development time and maximised the reliability of the resulting system.

A very important aspect of the ICM work has been the interworking between the network and the TMN. Through this, PON management has proved feasible and desirable, with a considerable amount of value added facilities foreseen in a commercial exploitation of CMC PONs. With the adopted TMN policy, important aspects in broadband (optical) networks, such as flexibility, security, safety have been highlighted. Optical spectrum management, frequency stability control as well as alarm information exchange between the terminals and the Control Unit, with the appropriate control and management actions, have all been considered.

With the integration of the ICM TMN in the CMC system, both the ability to recognise potential problems (dependence upon network availability, effect of network failures, network complexity) as well as the methodology to solve those problems in a time efficient way has proved that management aspects are of importance to achieve a future-proof network in terms of surviveability, upgradeability and cost.

7.7 References

[7.1] J. Schmit, T. Almeida, F. de Calvalho, A. Calvalho and P. Legand (editor), “WP1 Phase 3 PON Case Study Description,” version 1.3, RACE R2059 ICM internal document ICM/WP1/ISR/151, June 1994.

[7.2] N. Agoulmine and D. Truong, “PON TMN System design and architecture,” RACE R2059 ICM internal report, August.1994.

[7.3] K. McCarthy, “Design for the PON Configuration Monitoring Operations System and the Alarm Management WS Operations Systems,” RACE R2059 ICM Internal Report.

[7.4] O. Chambon, “Alarm Management Service Design,” RACE R2059 ICM Internal report, December 1994.

[7.5] J. N. de Souza, N. Agoulmine, “A High Level Design for the Q-Adaptor Function Block in the Telecommunications Management Network (TMN) Architecture,” ICM Internal Report 1993.

[7.6] RACE R2059 ICM Deliverable 14, “Case Studies, Phases 1-4,” R2059/QMW/BM1/DS/P/014/b1, September 1994.

[7.7] RACE 2059 ICM Deliverable 16, “ Updated TMN Architecture and Functions “R2059/DNAC/DPG/DS/016/b1, December 1994.

[7.8] RACE R2059 ICM Deliverable 22, “Evaluation of the TMN interworking experiment in COBRA videoconference demonstrator,” R2059/CET/IAP2/DR/C/0022/b1, R2065/CET/IAP1,2/DR/C/001/b1, Fausto de Carvalho, Richard Lewis, editors, February 1995.

[7.9] ITU-T Recommendation M.3020, “TMN Interface Specification Methodology.”