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SERIES M: TMN AND NETWORK MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

International transport network

International multi-operator paths, sections and transmission systems fault detection and localization procedures

ITU-T Recommendation M.2120

ITU-T M-SERIES RECOMMENDATIONS

TMN AND NETWORK MAINTENANCE: INTERNATIONAL TRANSMISSION SYSTEMS, TELEPHONE CIRCUITS, TELEGRAPHY, FACSIMILE AND LEASED CIRCUITS

For further details, please refer to the list of ITU-T Recommendations.

ITU-T Recommendation M.2120

International multi-operator paths, sections and transmission systems fault detection and localization procedures

Summary

This Recommendation provides procedures for fault detection and localization with and without in-service monitoring for international multi-operator paths, sections, and transmission systems. Filtering and thresholding of performance information are described for reporting to the TMN. Returning into service and long-term trend analysis are considered. These procedures are applicable whatever the technology used.

Source

ITU-T Recommendation M.2120 was revised by ITU-T Study Group 4 (2001-2004) and approved under the WTSA Resolution 1 procedure on 14 July 2002.

Keywords

Fault detection, filtering, in-service monitoring, localization, long-term trend analysis, path, returning into service, section, thresholding, TMN, transmission system.

FOREWORD

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NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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1 Scope

The TMN, as described in ITU-T Rec. M.3010 [5], is being progressively implemented by many operators. The maintenance procedures described here cover both the case where full In-Service Monitoring (ISM) is available (as in the TMN) and the case where no ISM or partial ISM is available. The latter case is referred to as pre-ISM. Information processing will be more integrated or less integrated depending on the TMN's degree of development.

ISM should be understood as a situation where a dedicated full-time performance monitor exists for a path and/or transmission system. This facilitates performance data collection and storage, scheduled periodic reporting of current and historic data, exception reporting, and setting of thresholds. A pre-ISM situation exists if any condition does not meet the definition of ISM (e.g. existence of time-shared monitoring, no monitoring at all).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; all users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

[1] ITU-T Recommendation G.784 (1999), *Synchronous digital hierarchy (SDH) management*.

[2] ITU-T Recommendation M.20 (1992), *Maintenance philosophy for telecommunication networks*.

[3] ITU-T Recommendation M.60 (1993), *Maintenance terminology and definitions*.

[4] ITU-T Recommendation M.2110 (2002), *Bringing into service international multi-operator paths, sections and transmission systems*.

[5] ITU-T Recommendation M.3010 (2000), *Principles for a telecommunications management network*.

[6] ITU-T Recommendation O.150 (1996), *General requirements for instrumentation for performance measurements on digital transmission equipment*.

[7] ITU-T Recommendation O.151 (1992), *Error performance measuring equipment operating at the primary rate and above*.

[8] ITU-T Recommendation O.161 (1984), *In-service code violation monitors for digital systems*.

[9] ITU-T Recommendation O.162 (1992), *Equipment to perform in-service monitoring on 2048, 8448, 34 368 and 139 264 kbit/s signals*.

[10] ITU-T Recommendation O.163 (1988), *Equipment to perform in-service monitoring on 1544 kbit/s signals*.

[11] ITU-T Recommendation O.181 (2002), *Equipment to assess error performance on STM-N interfaces*.

3 Terms and definitions

General terms and definitions relating to this Recommendation are provided in ITU-T Rec. M.60 [3].

4 Abbreviations

This Recommendation uses the following abbreviations:

BBE	Background Block Error
BIS	Bringing-Into-Service
CRC	Cyclic Redundancy Check
DPL	Degraded Performance Limit
ES	Errored Second
ISM	In-Service Monitoring
ME	Maintenance Entity
NE	Network Element
OOS	Out-Of-Service
RTR	Reset Threshold Report
SDH	Synchronous Digital Hierarchy
SES	Severely Errored Second
STM	Synchronous Transport Module
TMN	Telecommunication Management Network
TR	Threshold Report
UPL	Unacceptable Performance Limit
VC	Virtual Channel

5 Maintenance techniques with ISM

5.1 Relationship with ITU-T Rec. M.20

ITU-T Rec. M.20 [2], *Maintenance philosophy for telecommunications networks*, provides guidance for maintenance operations. This clause expands on the principles given in ITU-T Rec. M.20 [2] with specific application to transmission systems and ISM. Figure 1 includes abridged versions of Figures 7/M.20 [2] and 9/M.20 [2].

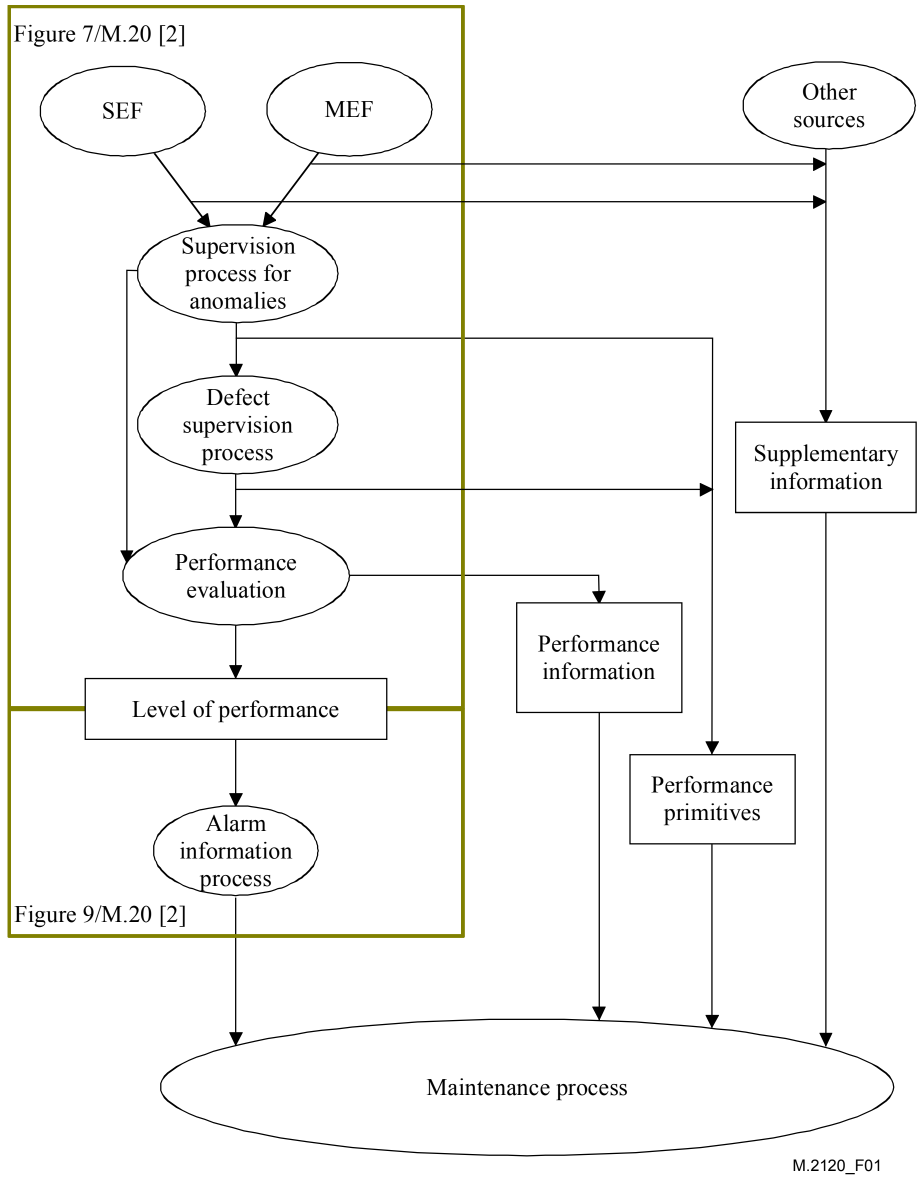

Figure 1/M.2120 – Process of elaboration of information used for maintenance

5.2 Fault localization information

Once an alarm indication is received, the fault localization process must begin. For this purpose several categories of information are required:

– performance information;

– performance level information;

– performance primitives;

– supplementary information.

5.2.1 Performance information

Performance information is in terms of error performance events and is used to calculate the performance levels. Normally it will be time-stamped and stored for correlation analysis and for long-term trend analysis (see clause 9). Error performance events, and the set of them that applies to maintenance and their limits, are defined in specific technology Recommendations.

5.2.2 Performance level information

Performance level information (unacceptable performance limit (UPL), degraded performance limit (DPL), normal performance level) is derived from performance information (or the equivalent performance primitives). It is the information which will start the alarm information process, as shown in Figure 1, when a performance limit is reached. The performance limits are also referred to as alarm thresholds. The alarm generated (i.e. prompt maintenance alarm, deferred maintenance alarm or maintenance event information) determines the urgency of subsequent actions.

5.2.3 Performance primitives information

Performance primitives are the basic information in the form of anomalies and defects used to determine the event counts defined in the specific technology Recommendations. Performance primitives depend on the type of entity being monitored.

5.2.4 Supplementary information

Supplementary information is information other than that obtained from monitoring. It includes derived information such as the identification of a faulty maintenance entity (ME) or subentity, or information from other MEs. It also includes administrative information such as the constitution of a path. Supplementary information also includes such information as direct transmission restoration (protection switching) counts.

5.3 Performance filtering, thresholding, reporting and historical storage

The functions described in this clause can be performed inside or outside the network element (NE).

5.3.1 Events

The evaluation of error performance and availability performance is based on the processing of the performance events. The derivation of these events from standardized signal information is given in specific technology Recommendations.

5.3.2 Transmission states

A path can be in one of two transmission states:

– unavailable state;

– available state.

The transmission state is determined from filtered SES/non-SES data (see 5.3.4 and 5.3.5).

5.3.3 Threshold reports

A Threshold Report (TR) is an unsolicited error performance report from a ME with respect to either a 15-minute or 24-hour evaluation period. TRs can only occur when the concerned direction is in the available state. Several TRs are defined based on filtered error performance events.

5.3.3.1 TRs based on a 15-minute evaluation period

There are one TR15 and one Reset TR15 (RTR15) for each performance event. TR15s occur as soon as the 15-minute threshold is reached or exceeded. RTR15s optionally occur at the end of a 15-minute period in which the count is less than or equal to the "reset" threshold and there has not been any unavailable time during that period. A RTR15 can only occur subsequent to a 15-minute period containing a TR15. Clause 5.3.5.3 gives precise details.

5.3.3.2 TRs based on a 24-hour evaluation period

There is one TR24 for each performance event. TR24s occur as soon as the 24-hour threshold is reached or exceeded. Clause 5.3.5.4 gives precise details. There is no RTR24 for the 24-hour evaluation period defined in this Recommendation, but RTR24 may be implemented in some equipment.

5.3.4 Filter types used for evaluating transmission states and threshold reports

Care needs to be taken with the error performance event counters and the generation of TRs during changes in transmission states. Guidance on this issue is given in 5.3.5.5.

5.3.4.1 Unavailable state and available state filters

The unavailable state filter is a 10-second rectangular sliding window, with 1-second granularity of slide. The available state filter is also a 10-second rectangular sliding window, with 1-second granularity of slide.

5.3.4.2 TR15 and RTR15 filters

The TR15 and RTR15 filters are 15-minute rectangular fixed windows. The start and end time for the 15-minute rectangular fixed windows are the same for all performance events and must occur on the hour and at 15, 30, and 45 minutes after the hour.

5.3.4.3 TR24 filter

The TR24 filter is a 24-hour rectangular fixed window. The start and end time for the 24-hour rectangular fixed windows are the same for all performance events and must occur on a 15-minute window boundary.

5.3.5 Evaluation of transmission states and threshold reports

5.3.5.1 Evaluation of the unavailable and available states

The unavailable state is detected at the end of 10 consecutive SESs. Upon detection, a date/time-stamped unavailable state report should be sent to the performance management centre. The time/date stamp should relate to the first of the 10 consecutive SESs.

The termination of the unavailable state (i.e. reentry to the available state) is detected at the end of 10 consecutive non-SESs. Upon detection, a date/time-stamped termination of unavailability report should be sent to the performance management centre. The date/time-stamp should relate to the first of the 10 consecutive non-SESs.

The unavailable seconds count and the unavailability event count should be calculated either within the network element or within a performance management system.

5.3.5.2 Evaluation of performance levels

Three performance levels are defined:

– The unacceptable performance limit (UPL), which is reached when there is a TR15 for at least one performance event or when there is an unavailable period.

– The degraded performance limit (DPL), which is reached when there is a TR24 for at least one performance event.

– The normal performance level, which corresponds to not being in UPL or DPL state.

5.3.5.3 Evaluation of TR15

The performance events are counted separately, second by second, over each 15-minute rectangular fixed window period. A threshold can be crossed at any second within the 15-minute rectangular fixed window. As soon as a threshold is crossed for one performance event, a TR15 as appropriate should be sent to the performance management centre together with a date/time-stamp. Moreover, performance events should continue to be counted to the end of the current 15-minute period, at which time the current performance event counts are stored in the historical registers and the current performance event registers are reset to zero.

There are two methods for evaluation of TR15: the Transient Condition Method and the optional Standing Condition Method.

5.3.5.3.1 Transient Condition Method

The Transient Condition Method treats each 15-minute measurement period separately. During each period, the value of the event counter is compared to the set threshold on a second-by-second basis and if the count is equal to or greater than the threshold, a TR15 is generated. For this method there is no reset threshold or RTR15 defined.

5.3.5.3.2 Standing Condition Method

The Standing Condition Method raises a standing condition when the set threshold is crossed and clears the standing condition when the count at the end of a subsequent period is below or equal to the reset threshold, provided that there was no unavailable time during that period. For the Standing Condition Method, the ME can be in one of two states: acceptable or unacceptable.

If the ME is in the acceptable state, the value of the event counter is compared to the set threshold on a second-by-second basis. If the event count is equal to or greater than the threshold, a TR15 is generated and the state changes to unacceptable.

If the ME is in the unacceptable state, the value of the counter is compared to the reset threshold at the end of each period. If the count is less than or equal to the reset threshold, and there has been no unavailable time during that period, a RTR15 is generated and the state changes back to acceptable. If there has been unavailable time during the period, the ME remains in the unacceptable state and no RTR15 is generated at the end of the period.

If the Standing Condition Method is used, then no more than one TR15 should be generated per direction of transmission until there has been an RTR15. The generation of a RTR15 is only permitted subsequent to its respective TR15 and, once generated, re-enables the TR15 capability for the relevant event counter and direction of transmission.

5.3.5.3.3 Threshold criteria

There are several TR15s, one for each of the performance event counters. There are several RTR15s (for the Standing Condition Method only), one for each of the performance event counters. The threshold values for TR15s and RTR15s should be programmable for each Termination Point over the following ranges with default values:

– 0 to 900 for all events with 1 second granularity e.g. ES and SES events;
– 0 to $2^{16} - 1$ for the BBE event in the case of VC-11 up to VC-4-16c paths (SDH only);
– 0 to $2^{24} - 1$ for the BBE event in the case of STM-1 up to STM-16 (SDH only, see Note).

The minimum value for TR15 is 1 and the minimum value for RTR15 is 0. Default threshold values for TR15 and RTR15 are given in the specific technology Recommendations.

NOTE – It is recognized that some NEs will be incapable of accommodating a threshold greater than $2^{16} - 1$.

5.3.5.4 Evaluation of TR24

The performance events are counted separately over each 24-hour period. There are several TR24s, one for each performance event. The threshold values should be programmable for each Termination Point over the following ranges with default values:

– 1 to 86 400 for all events with 1 second granularity e.g. ES and SES events (see Note 2);
– 1 to $2^{32} - 1$ for the BBE event in the case of VC-11 up to VC-4-16c paths (SDH only, see Notes 1 and 2);
– 1 to $2^{40} - 1$ for the BBE event in the case of STM-1 up to STM-16 (SDH only, see Notes 1 and 2);

The cases of VC-4-64c and STM-64 are for further study.

NOTE 1 – The maximum values for BBE events for VCs and STM-Ns are smaller than the maximum number of BBEs that could theoretically be detected in a 24-hour period.

NOTE 2 – It is recognized that some NEs will be incapable of accommodating a threshold greater than $2^{16} - 1$.

The NE shall recognize a 24-hour threshold crossing within 15 minutes of its occurrence. The threshold crossing shall be given the date/time-stamp of the moment of recognition. A TR24 as appropriate should be sent to the performance management centre with the date/time-stamp. Moreover, performance events should continue to be counted to the end of the current 24-hour period, at which time the performance events counts are stored in the historical registers and the current performance events registers are reset to zero.

For the evaluation of TR24, only the Transient Condition Method applies. There is no reset threshold or RTR defined for the 24-hour evaluation period. No more than one TR24 should be generated per event counter and per direction of transmission during any 24-hour rectangular fixed window.

5.3.5.5 Threshold report evaluation during transmission state changes

Care should be taken to ensure that threshold reports are correctly generated and performance events counters are correctly processed during changes in the transmission state. This implies that all threshold reports should be delayed by 10 seconds.

5.3.6 Performance history storage in network elements

Requirements for ME performance history storage are:

– Event counts to be stored are defined in the specific technology Recommendations.
– Where the unavailable second count and unavailable event count have been calculated by the NE, the NE must store these counts in addition to the ES, BBE and SES counts.
– There should be a current 15-minute register (which can also facilitate the TR15/RTR15 filter) plus a further *N* 15-minute history registers for each event in each ME. The *N* 15-minute history registers are used as a stack, i.e. the values held in each register are pushed down the stack one place at the end of each 15-minute period, and the oldest register values at the bottom of the stack are discarded. As an example, *N* is greater than or equal to 16 for SDH (see ITU-T Rec. G.784 [1]).
– There should be a current 24-hour register (which can also facilitate the TR24 filter) plus one previous 24-hour register for each event.

5.3.7 Performance history reporting from network elements

Performance data should be reportable to the performance management centre to suit various needs, for example:

– on demand, by request from the performance management centre;
– in a limited and targeted unsolicited format in the case of unavailability/availability transmission state change reports and, when in the available state, TR15/RTR15 or TR24 error performance reports;
– periodically, as part of a network-wide data accumulation task, by the network management centre(s). This may then be used for applications such as preventive maintenance (e.g. longer-term trend analysis) and "poor performer" analysis (see clause 9).

5.3.8 Accuracy and resolution

5.3.8.1 Event counts

All event counts should be actual counts for the 15-minute filtering period. Although all event counts should (ideally) also be actual counts for the 24-hour filtering periods, it is recognized that it might be desirable to limit register sizes. In such cases, register overflow could occur. Should register overflow occur, the registers should hold at their maximum value for the event considered until the registers are read and reset at the end of the 24-hour period. An implementation involving setting and resetting an overflow bit may be used.

5.3.8.2 Date/time-stamping of reports

The date/time-stamping accuracy of reports, together with the method of maintaining the accuracy, is under study. The format for date/time-stamps is as follows:

– 15-minute window will be stamped Day, Month, Year, Hour, Minute;
– 24-hour window will be stamped Day, Month, Year, Hour;
– unavailable time events will be stamped Day, Month, Year, Hour, Minute, Second;
– alarms will be stamped either at the declaration of the alarm by the equipment or at the exact time of the event (to be decided) with Day, Month, Year, Hour, Minute, Second.

Equipment clock accuracy requirements are for further study.

5.3.9 Single-ended monitoring capability

Situations are envisaged where it could be desirable to carry out error and availability performance processing of both directions of path transmission from a single end. The specific technology Recommendations detail standardized signal information, which could be used to facilitate this requirement.

6 Fault localization procedures on transmission systems and multiplex sections

Fault localization largely depends on the fault localization means available to the ME. However, the guidelines in 6.1 and 6.2 can be used.

6.1 Fault localization in a pre-ISM environment

In a pre-ISM environment, a transmission system or multiplex section may not yield standardized events and may not have the capability to record performance history. In this situation, the only opportunity is to monitor on a forward-going basis, probably using proprietary test equipment.

Clearly, this strategy cannot guarantee identification of the source of the original performance problem, particularly if it is of a transient nature.

6.2 Fault localization in an ISM environment

When an unacceptable or degraded performance level is reached, the following should be done:

– immediately send a message to the control stations of the paths carried by the transmission system or the multiplex section;
– store the message for access by those control stations, which do not receive the message directly. The storage will normally be at the fault report point;
– initiate the ME's fault localization capability to find the faulty maintenance sub-entity. This should be done in a time frame appropriate to the prompt or deferred maintenance alarm levels.

For example, the specific technology Recommendations give the UPL and DPL thresholds from the long-term perspective.

7 Fault localization procedures on paths

The efficiency of the fault localization procedure is largely dependent on the type of information available at each bit rate (i.e. CRC information, parity bit, known frame word, etc.).

7.1 Fault localization in a pre-ISM environment or using OOS means

In a pre-ISM environment, the fault localization process will usually start after a user complaint. In this situation, the only opportunity is to monitor after the event. This process cannot guarantee identification of the source of the original performance problem, particularly if it is of a transient nature. The control station responsible for the fault should:

– determine path routing;
– sectionalize the path. If traffic is not totally interrupted, in-service measuring methods as described in ITU-T Recs. O.161 [8], O.162 [9] and O.163 [10] should be placed at various accessible points along the path to determine which part is faulty. These measurements are made at protected monitoring points (see Figure 2);
– coordinate the measurement process so that subcontrol and participating centres start and finish their measurements at the same time;
– centralize results, either at the control station or at the fault report point, and compare to determine the faulty section;
– ensure that there are no monitoring "blind spots" on the path. A "blind spot" is a portion of the path which exists between two monitored portions. For example, cross-connect equipment may not be covered by the monitors of the transmission systems connected to the input and output. Unless such a cross-connect has its own monitoring system, it may be overlooked.

If several sections are faulty, fault localization will normally concentrate first on the most severely degraded section. Where additional maintenance effort is available, the total out-of-service time may be reduced by utilizing this additional effort on less degraded sections. However, control is needed so that the efforts of one technician (or group) do not mask a problem being worked on by another.

If traffic is totally interrupted, or ISM instruments are not available, the same fault localization procedure as before will be used, but with a pseudo-random bit sequence injected (if possible, framed sequence – using a method as described in ITU-T Recs. O.150 [6], O.151 [7] or O.181 [11]). The points of injection and the monitoring locations should be chosen for efficiency of localization. This includes the possibility of loopback.

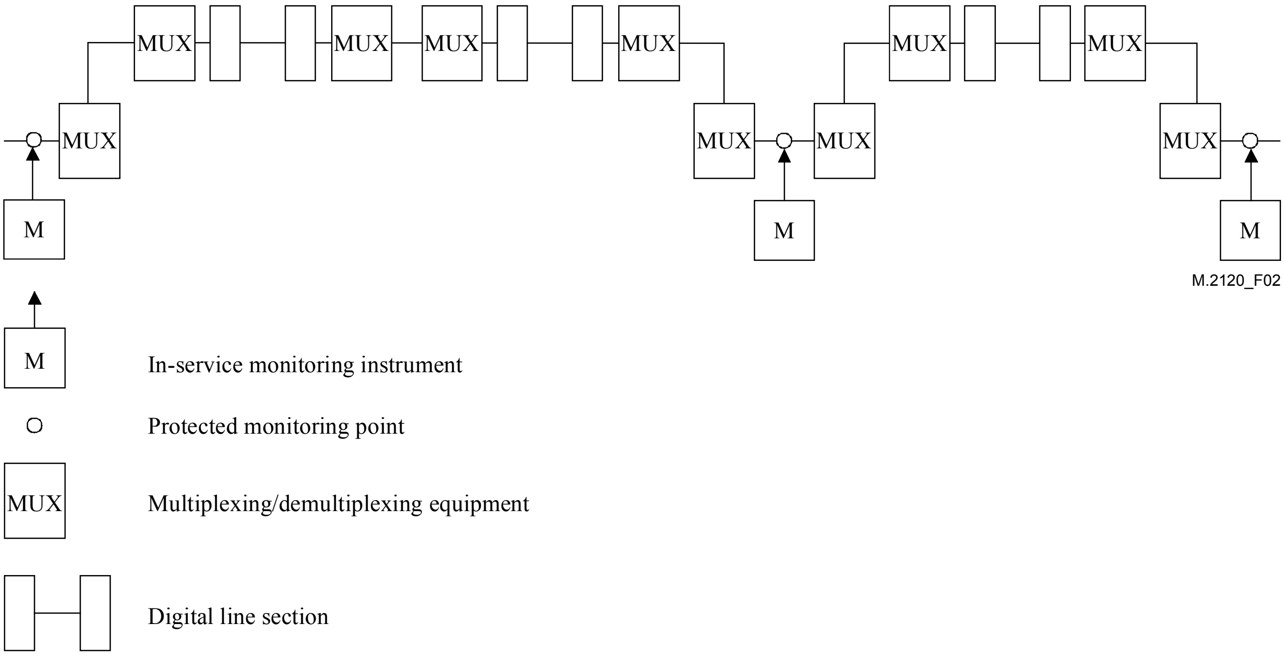

Figure 2/M.2120 – In-service measurement along a path in the pre-ISM environment

7.2 Fault localization in an ISM environment

The path control station is informed of problems by UPL or DPL information, trend analysis, and/or by a user complaint. The path control station should:

– undertake corrective action in a time frame appropriate to the alarm level (prompt or deferred maintenance alarm or special instructions);

– confirm the unacceptable or degraded level of the path by consulting the history (Bringing into service data, etc.) of the path.

Once the procedures of 6.2 are initiated, the control station of the ME concerned is expected to provide supplementary information to the TMN database. The control stations of paths supported by the ME will be able to determine from the database such information as the expected return into service time, taking into consideration information on any other faulty MEs, which affect the path.

If the above procedure cannot be implemented, path routing should be determined and the higher-level path control stations interrogated to determine the origin of the problem. This interrogation can be carried out directly or by consulting databases. The information exchanged must be expressed in terms of performance information, with all events date/time-stamped, and the affected direction indicated. This procedure must lead to assigning the problem to the control station of the ME where degradation exists.

8 Returning a maintenance entity into service

When the repair action on a faulty ME is completed, an appropriate assurance of satisfactory performance should be made. Depending on the type and cause of the fault and the repair process, this assurance may be as simple as the ability to carry a signal, or it may be more complex.

The performance limits for returning an ME into service (after intervention) are given in specific technology Recommendations. In the extreme case, it may be necessary to repeat the BIS tests as in ITU-T Rec. M.2110 [4]. When the path is returned to service, it should be monitored continuously for 24 hours.

9 Trend analysis and signatures

In the interest of providing superior service to users, many operators use, or intend to use, a preventive approach to maintenance and fault localization. Preventive maintenance implies locating and correcting faults before a performance impairment reaches an unacceptable or degraded performance level.

One of the tools of preventive maintenance is trend analysis. Information is gathered from many points in the network, date/time-stamped and stored. Continuing automatic comparisons of measurements from a particular point may indicate, by the trend of the measurements, that there is a potential fault. The results of the trend analysis may generate the equivalent of a low-level deferred maintenance alarm. Economics will determine at what point an operator may decide to take action.

An indication, which may be useful in trend or comparison analysis, is error performance. A path or section which has poorer error performance than similar paths or sections, or which is showing a trend of increasing errors, may become the target of reinforced maintenance.

Trend analysis of this type implies a well-developed TMN with wide deployment of ISM techniques.

A manual technique, which may be useful for either preventive maintenance or fault localization, is the analysis of signatures. A signature is a set of characteristics obtained by measurement, which can be interpreted to indicate the source of a fault or a potential fault. For example, experience on a path transported by submarine cable has shown that a gradually increasing (over several days) number of ES in the absence of SES was indicative of a multiplexer fault, which was not serious enough to generate an alarm. This signature may not appear on other systems.

As signatures may be equipment-dependent and configuration-dependent, and are often ambiguous, their development and use is a matter for consideration by local maintenance forces.

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