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Addendum 1

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SERIES O: SPECIFICATIONS OF MEASURING EQUIPMENT

Equipment for the measurement of digital and analogue/digital parameters

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Equipment to assess ATM layer cell transfer performance

Addendum 1: Annex D – Measurement of error and availability parameters in the Out-of-Service Mode

ITU-T Recommendation O.191 – Addendum 1

(Previously CCITT Recommendation)

ITU-T O-SERIES RECOMMENDATIONS

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ITU-T RECOMMENDATION O.191

EQUIPMENT TO ASSESS ATM LAYER CELL TRANSFER PERFORMANCE

ADDENDUM 1

ANNEX D

MEASUREMENT OF ERROR AND AVAILABILITY PARAMETERS IN THE OUT-OF-SERVICE MODE

Summary

This Annex (Addendum 1) to Recommendation O.191 deals with the measurement of ATM cell transfer performance in the out-of-service mode. The cell flows to be measured, the cells to be monitored and the test traffic profile are defined. In addition, the processes required to estimate cell transfer performance in the out-of service mode are described.

Source

Addendum 1 to ITU-T Recommendation O.191, was prepared by ITU-T Study Group 4 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 24th of October 1997.

Keywords

ATM cell transfer performance measurements, availability related parameters, error related parameters, estimation processes, measured flows, measurement algorithm, monitored cells, out-of-service mode, traffic profiles.

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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ANNEX D

MEASUREMENT OF ERROR AND AVAILABILITY PARAMETERS IN THE OUT-OF-SERVICE MODE

(Geneva, 1997)

D.1 Scope

This Annex defines the measurement of error and availability related parameters in the Out-of-Service (OOS) mode. It gives practical details describing the complete performance estimation process and indicates exceptional cases and default actions to be taken in particular cases.

D.2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Addendum. All Recommendations are subject to revision; all users of this Addendum 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 I.356 (1996), *B-ISDN ATM layer cell transfer performance*.

[2] ITU-T Recommendation I.357 (1996), *B-ISDN semi-permanent connection availability.*

[3] ITU-T Recommendation I.361 (1995), *B-ISDN ATM layer specification.*

[4] ITU-T Recommendation I.371 (1996), *Traffic control and congestion control in B-ISDN.*

[5] ITU-T Recommendation I.610 (1995), *B-ISDN operation and maintenance principles and functions.*

D.3 Abbreviations

This Annex uses the following abbreviations.

ABR	Available Bit Rate
ABT	ATM Block Transfer
AIS	Alarm Indication Signal
AME	ATM Measuring Equipment
AR	Availability Ratio
BR	Backward Reporting
CC	Continuity Check
CDV	Cell Delay Variation
CLP	Cell Loss Priority

CLR	Cell Loss Ratio
DBR	Deterministic Bit Rate
FM	Forward Monitoring
GFC	Generic Flow Control
LPAC	Loss of Performance Assessment Capability
MTBO	Mean Time between Outages
NPP	Network Performance Parameter
OAM	Operation and Maintenance
OOS	Out-of-Service
PCR	Peak Cell Rate
PM	Performance Management
PTI	Payload Type Identifier
QOS	Quality of Service
RDI	Remote Defect Indication
SBR	Statistical Bit Rate
SECB	Severely Errored Cell Block
SECBR	Severely Errored Cell Block Ratio
SES	Severely Errored Second
SN	Sequence Number
UNI	User-Network Interface
VC	Virtual Circuit
VCC	Virtual Circuit Connection
VCI	Virtual Circuit Identifier
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier

D.4 Measured flows

The performance estimation process performed by the receiver part of the AME is based on the supervision of test cell flows transmitted by the generator part in a measurement configuration such as one of those illustrated in I.1/O.191. Only the forward direction of the connection (i.e. between the generator and the receiver part) is considered in this Annex. To estimate performance of the backward direction of a test connection, the transmit and receive functions can be reversed in both AMEs. As an option, it may be possible to establish a looped connection using one AME which provides transmit and receive functions.

D.4.1 Monitored cells

The AME is capable of measuring error and availability related Network Performance Parameters (NPPs) on either a VCC or a VPC. Tables D.4-1 to D.4-4/O.191 give details about the monitored cells. A VCC under test is identified by a given VPI value and a given VCI value and all cells transmitted on this VCC have the same VPI and VCI. A VPC under test is identified only by a given VPI value and all cells transmitted on this VPC have the same VPI. All VCI values are allowed for the VCCs embedded in the VP although ATM standards require that user VCCs use VCI values greater than 31.

Table D.4-1/O.191 – Monitored cells to determine cell transfer outcomes for a VP connection

Monitored cells	End-to-end VP
Monitored Fx OAM flow	End-to-end F4
Header of monitored Fx OAM cells	GFC (Note 1): BBBB (Note 2) VPI: VPI value of the monitored VPC VCI: 4 PTI (Notes 2, 3): 0B0 CLP (Notes 2, 4): B
Header of monitored test cells	GFC (Note 1): BBBB (Note 2) VPI: VPI value of the monitored VPC VCI: > 31 PTI: BBB (Notes 2, 5) CLP: D (Note 6)
NOTE 1 – Applicable only to measurements at a UNI. NOTE 2 – B indicates the bit is a "don't care bit". NOTE 3 – Recommendation I.361 [3] specifies that the second bit of the PTI can be 0 or 1 and is available for use by the appropriate ATM layer function. NOTE 4 – Recommendation I.361 [3] specifies that the CLP bit can be 0 or 1. As Recommendation I.610 [5] does not give more information about CLP, the AME shall monitor OAM cells regardless of the value of the CLP bit. NOTE 5 – As Recommendation I.610 [5] does not specify any restriction on the value of the PTI for a VPC, the AME shall monitor cells regardless of the PTI value. NOTE 6 – D shall be in accordance with the measured CLP flow (see D.4.2/O.191).	

Table D.4-2/O.191 – Monitored fault management cells for a VP connection

Monitored fault management cells	End-to-end VP
Monitored ATM cells for the forward direction	VP-AIS cells VP-CC cells
Monitored ATM cells for the backward direction	VP-RDI cells (For further study)

Table D.4-3/O.191 – Monitored cells for a VC connection

Monitored cells	End-to-end VC
Monitored Fx OAM flow	End-to-end F5
Header of monitored Fx OAM cells	GFC (Note 1): BBBB (Note 2) VPI: VPI value of the monitored VCC VCI: VCI value of the monitored VCC PTI: 101 CLP (Notes 2, 3): B
Header of monitored test cells	GFC (Note 1): BBBB (Note 2) VPI: VPI value of the monitored VCC VCI: VCI value of the monitored VCC PTI: 0BB (as defined in Recommendation I.610 [5]) CLP: D (Note 4)
NOTE 1 – Applicable only to measurements at a UNI. NOTE 2 – B indicates the bit is a "don't care bit". NOTE 3 – Recommendation I.361 [3] specifies that the CLP bit can be 0 or 1. NOTE 4 – D shall be in accordance with the measured CLP flow (see D.4.2/O.191).	

Table D.4-4/O.191 – Monitored fault management cells for a VC connection

Monitored fault management cells	End-to-end VC
Monitored ATM cells for the forward direction	VC-AIS cells VC-CC cells
Monitored ATM cells for the backward direction	VC-RDI cells (For further study)

D.4.2 CLP flow measurements

Three possible CLP flows on the VCC or the VPC under test are to be distinguished: The CLP = 0 flow, the CLP = 1 flow and the aggregate flow (CLP = 0 + 1). Depending on the CLP flow for which the NPPs are to be measured, cells transmitted on the connection under test and cells extracted from the connection under test for further analysis shall comply with the requirements given in Table D.4-5/O.191.

With regard to QOS objectives defined in Recommendation I.356 [1], it is not required to estimate the performance of CLP = 1 flows only. However, it is useful to measure the performance of this flow from a network performance point of view.

Table D.4-5/O.191 – Requirements related to the measured CLP flow

CLP flow for which NPP is to be measured	Transmitted flow	Requirements for the cells transmitted on the test connection	Requirements for the cells extracted from the test connection
CLP = 0	CLP = 0 only	The cell stream shall consist only of test cells having a CLP set to 0. The SN field shall be incremented at each cell transmission.	Only cells with a CLP equal to 0 shall be analyzed by the measurement algorithm. (Note 4)
CLP = 0 + 1	CLP = 0 + 1	The cell stream shall consist of test cells having a CLP set either to 0 or to 1. The SN field shall be incremented at each cell transmission regardless of the CLP value. (Note 3)	All cells shall be analyzed by the measurement algorithm regardless of the CLP value.
CLP = 0	CLP = 0 + 1	The cell stream shall consist of a mix of test cells having a CLP set to 0 and of other cells having a CLP set to 1. The SN shall be incremented at each transmission of a test cell with a CLP set to 0. (Note 1)	Only cells with a CLP equal to 0 shall be analyzed by the measurement algorithm.
CLP = 1	CLP = 0 + 1	The cell stream shall consist of a mix of test cells having a CLP set to 1 and of other cells having a CLP set to 0. The SN shall be incremented at each transmission of a test cell with a CLP set to 1. (Notes 1, 2)	Only cells with a CLP equal to 1 shall be analyzed by the measurement algorithm.
CLP = 1	CLP = 1 only	The cell stream shall consist only of test cells having a CLP set to 1. The SN field shall be incremented at each cell transmission.	Only cells with a CLP equal to 1 shall be analyzed by the measurement algorithm.

NOTE 1 – "Other cells" can have a format different from standard test cells because they are not part of the measured flow.

NOTE 2 – This method is not applicable to traffic contracts using the tagging option. Measurement of tagged cells is for further study.

NOTE 3 – It shall be possible to transmit CLP = 0 (or CLP = 1) cells only but still analyze an aggregate CLP = 0 + 1 flow. This allows, for example, the detection of misinserted cells regardless of whether the CLP bit is set to 0 or 1.

NOTE 4 – In the context of this Annex, the term "measurement algorithm" refers to the "Basic out-of-service cell transfer outcome measurement algorithm" as described in Annex B/O.191.

Both generator and receiver part of the AME need to be aware of the flow to be measured.

It should be noted that, for the time being, the test cell format and the performance estimation process (including the measurement algorithm) do not allow a simultaneous measurement of more than one CLP flow. This issue is for further study.

D.5 Test traffic profile

In case the AME generator reduces its cell rate, it shall transmit at least (see 7.1.1.2/O.191):

- one test cell per second of the CLP flow to be measured; or
- one continuity check cell per second.

NOTE 1 – The SES_{ATM} estimation process can be improved if the transmitted test traffic profile of the CLP flow to be measured comprises more than 1 test cell per second.

An AME shall be able to generate traffic for at least two VP or VC connections. For example, it shall generate traffic on the connection under test and background traffic on at least one other VP or VC connection. It shall be possible to control separately the transmitted traffic profile for these connections (test and background traffic). When multiplexing test and background traffic, the test traffic shall have priority with the result that the actual background traffic profile could be affected.

Recommendation I.371 [4] defines different types of traffic contracts. The AME shall generate traffic for both Deterministic Bit Rate (DBR) and Statistical Bit Rate (SBR) ATM transfer capability. Specific traffic profiles for ATM Block Transfer (ABT) and Available Bit Rate (ABR) ATM transfer capability are for further study.

Traffic is controlled using the three profile parameters:

1) maximum cell rate (see Note 2);
2) mean cell rate;
3) burst size (i.e. the number of cells per burst) (see Note 3).

NOTE 2 – The maximum cell rate can be set by the user of the AME and can differ from the peak cell rate negotiated in the traffic contract. For instance, it can be higher or lower than the peak cell rate negotiated in the traffic contract.

NOTE 3 – The burst size parameter has no more meaning when maximum cell rate is equal to mean cell rate. In that case the generated traffic is an ideal constant bit rate traffic.

Cells shall be generated in regular bursts of constant burst size as illustrated in Figure D.5-1/O.191.

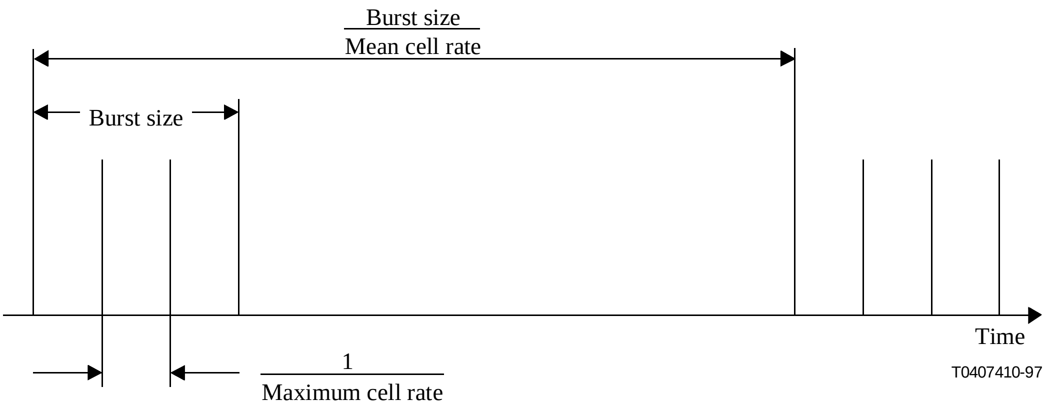

Figure D.5-1/O.191 – Traffic profile parameters

The cell delay variation of transmitted traffic can be derived from the traffic profile parameters as follows:

$$\text{Cell Delay Variation} = (\text{Burst Size} - 1) \times \left(\frac{1}{\text{Mean Cell Rate}} - \frac{1}{\text{Maximum Cell Rate}} \right)$$

These traffic profile parameters may have different meaning depending on whether they are used to define the traffic profile for a DBR contract or an SBR contract. For example, in the case of a DBR contract, maximum cell rate can be set to the maximum ATM cell rate on the physical path, mean cell rate can be set to PCR, burst size can be set so as to have CDV less than or equal to τ_{PCR}. In the case of an SBR contract, maximum cell rate can be set to PCR, mean cell rate can be set to SCR, burst size can be set to MBS or equivalently burst size can be set so as to have CDV less than or equal to τ_{IBT}.

When test traffic is mapped onto the link, additional CDV may be generated. This additional CDV characterizes the difference between the nominal traffic profile parameters set by the user of the AME and the actual traffic profile available at the physical output connector of the AME generator part. The maximum value of the additional CDV is for further study.

NOTE 4 – The additional CDV should be taken into account when setting up the AME if it is required to keep the generated test traffic within the conformance limits of the traffic contract.

The resolution available for setting the traffic profile parameters (i.e. maximum cell rate, mean cell rate, burst size) shall be sufficient to comply with the set of values of the coding scheme defined in Recommendation I.371 for cell rate coding. Setting accuracy is for further study.

In the case where CLP = 0 + 1 cells are generated by an AME, it shall be possible to set the traffic profile for each flow (i.e. the CLP = 0 and the CLP = 1 subflows resulting in the aggregate CLP = 0 + 1 flow) so as to generate test traffic as required by the conformance definition for ATM transfer capability given in Recommendation I.371.

D.6 Measurement process of error and availability network performance parameters for the Out-of-Service mode

D.6.1 Principle of the Out-of-Service measurement process

The performance measurement process estimates the performance parameters and the connection availability defined in Recommendations I.356 [1] and I.357 [2], respectively. This process is performed by the receiver part of the AME which analyzes the cells belonging to the cell flow to be measured. The complete Out-of-Service (OOS) measurement process is summarized in Figure D.6-1/O.191. It comprises four processes and two complementary functions. The three main processes, namely the cell monitoring process, the outcome monitoring process and the availability monitoring process, are working each at a different level, the cell level, the cell block level and a one-second interval level respectively. The Figure illustrates the interactions between processes and functions. The processes and functions are quite similar to those described in Recommendations I.356 [1] and I.357 [2] for the In-Service mode. Practical details and default actions specific to the OOS mode are given in the next subclauses.

Subclause D.4.1 specifies the cells that shall be monitored for the given VP or VC connection under test.

Clause 7/O.191 addresses Out-of-Service measurements and specifies the basic tools (test cell format and outcome measurement algorithm) required to provide an estimation of errored, misinserted and lost cell counts. This estimation is included in the "cell monitoring process" in Figure D.6-1/O.191. This process shall also monitor the fault management flow in order to detect continuity check cells and the AIS defect.

Counts of outcomes provided by the measurement algorithm are accumulated in per block counters within the "outcome monitoring process". Based on the per block counts of lost, errored and misinserted cells, the Severely Errored Cell Block is determined according to the definition given in Recommendation I.356 [1].

Per block outcome counts are accumulated in per second counters within the per second outcomes and events monitoring function to assess the performance observed during a one-second time interval. The per second outcome counts are used to determine SES_{ATM} and the unavailable state within the "availability monitoring" process according to the definitions given in Recommendation I.357 [2].

The "storage control process" block allows or inhibits the storage in performance registers of outcomes observed during periods of time considered as available or unavailable.

These stored performance results are used to calculate the Network Performance Parameters as defined in Recommendation I.356 [1].

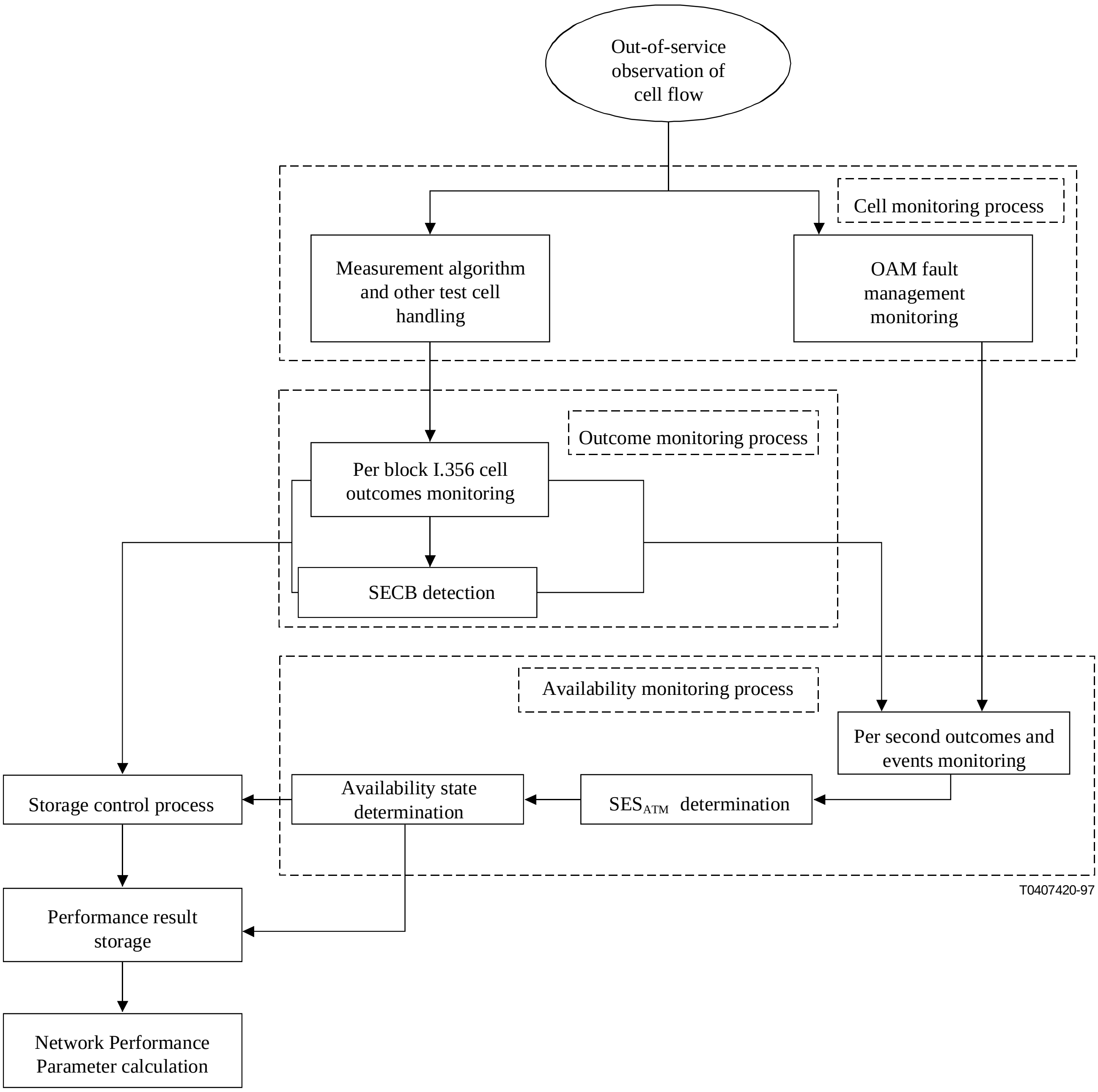

Figure D.6-1/O.191 – Out-of-Service performance estimation process

D.6.2 Cell monitoring process

The cell monitoring process includes the measurement algorithm described in Annex B/O.191. This algorithm provides the number of lost cells, misinserted cells or errored cells depending on the information derived from the test cells. Every time the measurement algorithm takes a decision it notifies the outcome monitoring process along with the numbers of lost, errored and misinserted cells estimated at the time of decision. The process shall also pass to the outcome monitoring process sufficient information (test cell sequence number value) to enable a correct detection of the cell block boundaries and correct estimation of the number of test cells transmitted since the beginning of the block (see D.6.3.1/O.191 for details). The performance measurement algorithm shall also indicate to the availability monitoring process whether it was possible to take a decision during the current one-second time interval.

If the algorithm is no longer capable of measuring performance outcomes during a period of time greater than 10 seconds, it enters the Loss of Performance Assessment Capability (LPAC) state (see Annex A/O.191). The 10-second period before entering the LPAC state and periods in the LPAC state are considered to be part of the unavailable time. The LPAC state is not directly forwarded to the unavailability determination but is considered in the SES_{ATM} determination and therefore is implicitly integrated in the unavailable time determination.

In addition, the outcome monitoring process shall observe the end-to-end OAM fault management flow corresponding to the measured test cell flow (see D.4.1/O.191). Depending on the connection under test, the VP-AIS or VC-AIS defect defined in Annex A/O.191 shall be detected and the existence of a defect within any one-second time interval shall be reported to the availability monitoring process. The arrival of end-to-end VP or VC continuity check cells shall be monitored and the arrival of a continuity check cell within the current one-second time interval shall be reported to the availability monitoring process (see D.6.4.1/O.191 for more details).

D.6.3 Outcome monitoring process

D.6.3.1 Per block estimation of lost, misinserted and errored cell outcomes

D.6.3.1.1 Cell block boundary definition and detection

Default block sizes are a function of the Peak Cell Rate (PCR) of the connection. They are given in Recommendation I.356 [1], and are listed in Table 7-1/O.191. Cell blocks have a size $N = 2^p$ cells, p being equal to 7 for a block size of 128, 8 for a block size of 256 and so on. For a given cell block of size $N = 2^p$, a cell block shall be considered to begin with the cell having the p least significant bits of the SN all equal to zero and shall be considered to end with the cell having these p bits all equal to one, the (32-p) most significant bits keeping the same value.

However, errors and losses can affect cells which delineate cell blocks and it is not always possible to detect the actual block end. Therefore, a check is made for the beginning of a cell block every time the measurement algorithm described in Annex B/O.191 takes a decision. The (32-p) most significant bits of the SN of the test cells are used to denote the block number Bx. Checking for the beginning of a new cell block is achieved by comparing the value B2 of the current test cell for which the algorithm has taken the last decision and the value B1 of the test cell for which the algorithm took the previous decision. Three cases can be distinguished:

1) B2 = B1: the currently received test cell belongs to the same cell block as the previous test cell.
2) B2 = B1 + 1: one cell block boundary is detected.
3) B2 > B1 + 1: several cell block boundaries are detected.

The difference between B2 and B1 gives the number of block ends (NbBE) which are detected.

How to determine whether cell blocks, for which boundaries have been detected, are SECBs or not is described in the following subclauses.

D.6.3.1.2 Per block outcome counts

To determine the SECB outcome, it is required to have per block counts of outcomes observed within the cell block. Outcomes estimated by the measurement algorithm before a new block is detected are accumulated in the corresponding per block counters as follows:

- NbETC is the number of errored test cells observed within the block by the measurement algorithm.
- NbLTC is the number of lost test cells observed within the block by the measurement algorithm.
- NbMTC is the number of misinserted cells observed within the block by the measurement algorithm.

To determine the SES_{ATM},

- NbTC, the total number of test cells transmitted since the beginning of the block is required. This can be estimated, for example, by evaluating the Sequence Number of the received cells.

Counter processing is described in the next subclause.

D.6.3.2 SECB outcome determination

The Severely Errored Cell Block (SECB) is defined in Recommendation I.356 [1]. A block of size N shall be declared as an SECB if the sum of errored, lost and misinserted cells observed within the block is greater than N/32. This condition can be tested using per block counters defined above by:

$$\mathrm{NbETC} + \mathrm{NbLTC} + \mathrm{NbMTC} > \frac{N}{32}$$

When the end of a cell block is not impaired, the above condition shall be used to determine whether the previous cell block is an SECB or not. All per block counters are reset after being processed in order to accumulate outcomes of the next cell block.

When the end of a cell block is impaired by errors or is lost, it is only possible to take a decision concerning the status of this cell block at the next time the measurement algorithm is able to take a decision. This situation can occur when a degradation period spans one or more cell block boundaries. In this case, it is not possible to get the exact count of the outcomes observed within each block. The following rules are used to apportion outcomes between impaired cell blocks. It is then determined whether the block(s) is (are) SECB(s) or not. Two cases are considered depending on the number of cell block boundaries impaired.

- If only one cell block boundary is impaired by degradation (NbBE = 1), 50% of each outcome estimated by the measurement algorithm are assigned to each impaired cell block. 50% of each outcome are accumulated within the current value of the corresponding per block counters and it is then decided, using these per block counters, whether the previous cell block is an SECB or not. All per block counters are then reset before the remaining 50% of each outcome are assigned to the corresponding per block counter for the next cell block.
- If the division process described above results in non-integers, assignments are rounded up for the previous block and rounded down for the next block.
- If more than one cell block boundary falls within a degradation period (NbBE > 1), all NbBE blocks are considered to be SECBs. Outcomes estimated by the measurement algorithm are not processed and per block counters are reset.

When the cell block is not considered to be an SECB, the contents of per block counters shall be added to the contents of corresponding temporary counters called Set1s and Set10s. These sets of temporary counters are defined in D.6.4.1/O.191 and D.6.5/O.191, respectively.

Set1s is a set of temporary counters accumulating outcomes observed during the current one-second period.

Set10s is a set of temporary counters accumulating each outcome observed during at most ten consecutive one-second intervals. Ten seconds correspond to the maximum period before triggering a possible unavailable state.

When the cell block is considered to be an SECB, a temporary counter called Set1s_SECB (defined in D.6.4.1/O.191) is increased by "NbBE". Set1s_SECB is the count of SECBs observed during the current one-second interval.

D.6.4 Availability monitoring process

D.6.4.1 Per second outcome count

In order to determine SES_{ATM} as defined in Recommendation I.357 [2], the total count of lost cells and SECBs observed during the current one-second time interval must be known. This is the purpose of the set of the following temporary counters called Set1s.

- Set1s_LC is the total count of lost test cells observed within the current one-second time interval excluding those counted in blocks declared as SECBs. It is updated by per block counter NbLTC when a block end is detected and if the block is not determined as SECB.
- Set1s_SECB is the total count of SECBs observed within the current one-second time interval. It is incremented each time a block is declared as SECB within the current one-second time interval.
- Set1s_Block is the total count of complete blocks observed within the current one-second time interval. It is incremented each time a block end is detected within the current one-second time interval.
- Set1s_AIS has a Boolean value and indicates whether an AIS defect (see Annex A/O.191) has existed within the current one-second time interval.
- Set1s_Decision has a Boolean value. It indicates whether the measurement algorithm was able to take a decision within the current one-second time interval. This flag is set by the cell monitoring process (see D.6.2/O.191) and is reset at the end of each one-second time interval.
- Set1s_CC has a Boolean value and indicates whether an end-to-end continuity check cell has been received within the current one-second time interval. This flag is set by the cell monitoring process and is reset at the end of each one-second time interval.

The per block counts of outcomes accumulated within the per second counters shall correspond only to cell blocks whose end has been observed within the current one-second time interval. In other words, outcomes accumulated in the per block counters for the current cell block shall not be added to the per second counters before the end of this current cell block is detected within the outcome monitoring process and the SECB determination is made. When one cell block spans over two one-second time intervals, the per block counts for this cell block are taken into account in the second time interval.

Per second counters shall then be reset for the next one-second time interval. An example of per second counter management is given in Figures D.6-2 and D.6-3/O.191, respectively.

D.6.4.2 SES_{ATM} determination

For each one-second time interval, the AME shall determine whether the elapsed second was an SES_{ATM} or not. One-second time intervals shall be consecutive and are not synchronized to any ATM event. One-second time intervals can be derived by the AME from a free running clock, a clock synchronized through the physical layer to a network reference clock or a clock synchronized to a UTC reference distribution system.

From a network perspective of availability (see Recommendation I.357 [2]), a given one-second time interval is considered to be an SES_{ATM} if CLR > 1/1024 or the SECB ratio is greater than 1/32, where CLR and SECBR are computed over the considered time interval. A given one-second interval is also considered to be an SES_{ATM} if the connection is unable to provide acceptable cell transfer performance because an interruption has occurred within the connection, even if test cells are not transmitted during this period of time. In order to detect an interruption, an AME shall send at least one test cell or continuity check cell per second (see 7.1.1.2/O.191).

A given one-second interval is also considered being an SES_{ATM} if an AIS defect has existed within the current one-second time interval.

If the block size N is selected in accordance with Recommendation I.356 [1], the maximum number of cell blocks per second is limited to 25. Therefore, if only one SECB is observed within a one-second time interval, this interval shall be declared an SES_{ATM}.

The per block counts of outcomes relevant to determine the SES_{ATM} shall correspond to cell blocks whose end has been detected within the one-second time interval (see D.6.4.1/O.191). However, a decision about SES_{ATM} determination shall be taken every second, even if no block end has been detected within a one-second time interval (this may occur in case of high degradation or when a block spans several one-second time intervals). In this particular case, the SES_{ATM} determination for the considered one-second time interval is based upon the current value of the per block counters and/or per second flag.

From a network perspective of availability, two cases are distinguished depending on whether a cell block end is detected within the one-second time interval or not.

When at least one cell block end is observed during the one-second time interval (Set1s_Block > 0), counts of lost cells (Set1s_LC) and number of SECBs (Set1s_SECB) related to cell blocks ending within this one-second time interval (Set1s_Block) shall be taken into account for the SES_{ATM} determination. Conditions to declare a one-second time interval an SES_{ATM} are:

a.1) $\mathrm{Set1s\_LC} > \dfrac{\mathrm{Set1s\_Block} - \mathrm{Set1s\_SECB}}{1024} \times \mathrm{N}$; or

a.2) $\mathrm{Set1s\_SECB} > 0$; or

a.3) $\mathrm{Set1s\_AIS} = \mathrm{TRUE}$.

If there is no block end detected within a one-second time interval (Set1s_Block = 0), the per block counters shall not be reset but shall be used to determine the SES_{ATM} as follows:

b.1) On condition that the measurement algorithm is able to make a decision during the one-second time interval (Set1s_Decision = TRUE), an SES_{ATM} is declared if:

b.1.1) $\mathrm{NbLTC} > \dfrac{\mathrm{NbTC}}{1024}$; or

b.1.2) $\mathrm{NbLTC} + \mathrm{NbETC} + \mathrm{NbMTC} > \dfrac{\mathrm{NbTC}}{32}$; or

b.1.3) $\mathrm{Set1s\_AIS} = \mathrm{TRUE}$.

b.2) On condition that the measurement algorithm is not able to make a decision during the one-second time interval (Set1s_Decision = FALSE), an SES_{ATM} is declared if:

b.2.1) If Set1s_CC = FALSE; or

b.2.2) If Set1s_AIS = TRUE.

NOTE 1 – If the transmitted test traffic profile comprises more than 1 test cell per second, the SES_{ATM} estimation process can be improved.

NOTE 2 – If the duration of the block is longer than one second, the SES_{ATM} estimation may be inaccurate.

At the end of SES_{ATM} determination, the per second temporary counters and flags are all reset.

This approach ensures that a decision about SES_{ATM} is always taken, even in the specific case when a block spans several one-second time intervals. In this particular case, the SES_{ATM} outcome is determined based on known information at the end of each one-second time interval.

The service perspective of availability is for further study.

D.6.4.3 Unavailability determination

According to Recommendation I.357 [2], the unavailable state shall be declared after ten consecutive SES_{ATM}. During the unavailable state, performance outcomes estimated by the measurement algorithm shall not be considered for cell transfer performance parameter calculation. The storage control process, described in D.6.5, allows/inhibits the storage of outcomes in the global counters used to compute performance parameters, depending on the available state. An example of the available/unavailable state determination and storage control process is provided in Figures D.6-2 and D.6-3/O.191, respectively.

LPAC is not directly considered in the availability determination process. This state, which is determined by the measurement algorithm, is implicitly considered in the SES_{ATM} determination by using the Set1s_Decision flag.

D.6.5 Storage control process

The storage control process inhibits/allows the storage of per block outcomes in final performance registers (so called Globalcount), depending on the available state. I.356 [1] outcomes observed are only stored in this performance register when the connection is in the available state. For this purpose, a set of temporary counters called Set10 is required.

Set10s registers are incremented with corresponding per block counters, when a cell block end is detected and allow to accumulate the I.356 outcomes observed during either the 10 first SES_{ATM} triggering the unavailable state, or the 10 last seconds not SES_{ATM} triggering the available state. These counts allow to exclude, from performance parameter estimation, outcomes observed during the 10 first SES_{ATM} belonging to the unavailable state, and to consider, in performance parameter estimation, outcomes observed during the 10 last seconds not SES_{ATM} belonging to the available state. "Set10s" should include the following counters:

- Set10s_LC is the total count of lost test cells observed during the considered time interval excluding those counted in blocks declared as SECBs. It is updated by the per block counter NbLTC when a block end is detected and if the block is not declared as SECB.
- Set10s_EC is the total count of errored test cells observed during the considered time interval excluding those counted in blocks declared as SECBs. It is updated by the per block counter NbETC when a block end is detected and if the block is not declared as SECB.
- Set10s_MC is the total count of misinserted test cells observed during the considered time interval excluding those counted in blocks declared as SECBs. It is updated by the per block counter NbMTC when a block end is detected and if the block is not declared as SECB.

- Set10s_SECB is the total count of SECBs observed during the considered time interval. It is incremented each time a block is determined as SECB.
- Set10s_Block is the total count of complete blocks observed during the considered time interval. It is incremented each time a block end is detected.

When a decision is taken concerning the availability status, either the Set10s counters are reset, if the corresponding seconds are considered to be part of unavailable time, or the Set10s counters are first added to corresponding performance result registers (Globalcount), if the corresponding seconds are considered to be part of available time, prior to being reset.

Therefore, Set10s counters can be reset before 10 consecutive seconds. For example, if a connection is in the available state, and a performance degradation produces 8 consecutive SES_{ATM} and the next second is not considered as SES_{ATM}, the contents of these Set10s counters are added to the corresponding performance result registers, Globalcount, before being reset.

Figures D.6-2 and D.6-3/O.191 provide an algorithm which describes the storage control process and the associated unavailability determination process. This algorithm is based on monitoring, for each cell slot, relevant events (arrivals of cells on the connection) and some time-outs, based on a one-second clock. The first part of the algorithm (Figure D.6-2/O.191) processes different sets of outcome counters for available periods of time, and checks every second the unavailable state according to Recommendation I.357 [2]. The second part of the algorithm (Figure D.6-3/O.191) inhibits the accumulation of I.356 [1] outcome counts during the unavailable time and checks, every second, the available state.

NOTE – This algorithm describes one part of the performance estimation process and does not imply any specific implementation.

In Figures D.6-2 and D.6-3/O.191, the box "cell monitoring process" is described in D.6.2/O.191. Process of box "per block counts of outcomes" is described in D.6.3/O.191. The diamond box < Cell arrival? > checks at the cell link rate whether a cell to be processed has arrived or not. The diamond box < SES_{ATM} ? > checks whether the one-second time interval is considered as SES_{ATM} or not. This test and relevant processes are described in subclause D.6.4.2/O.191.

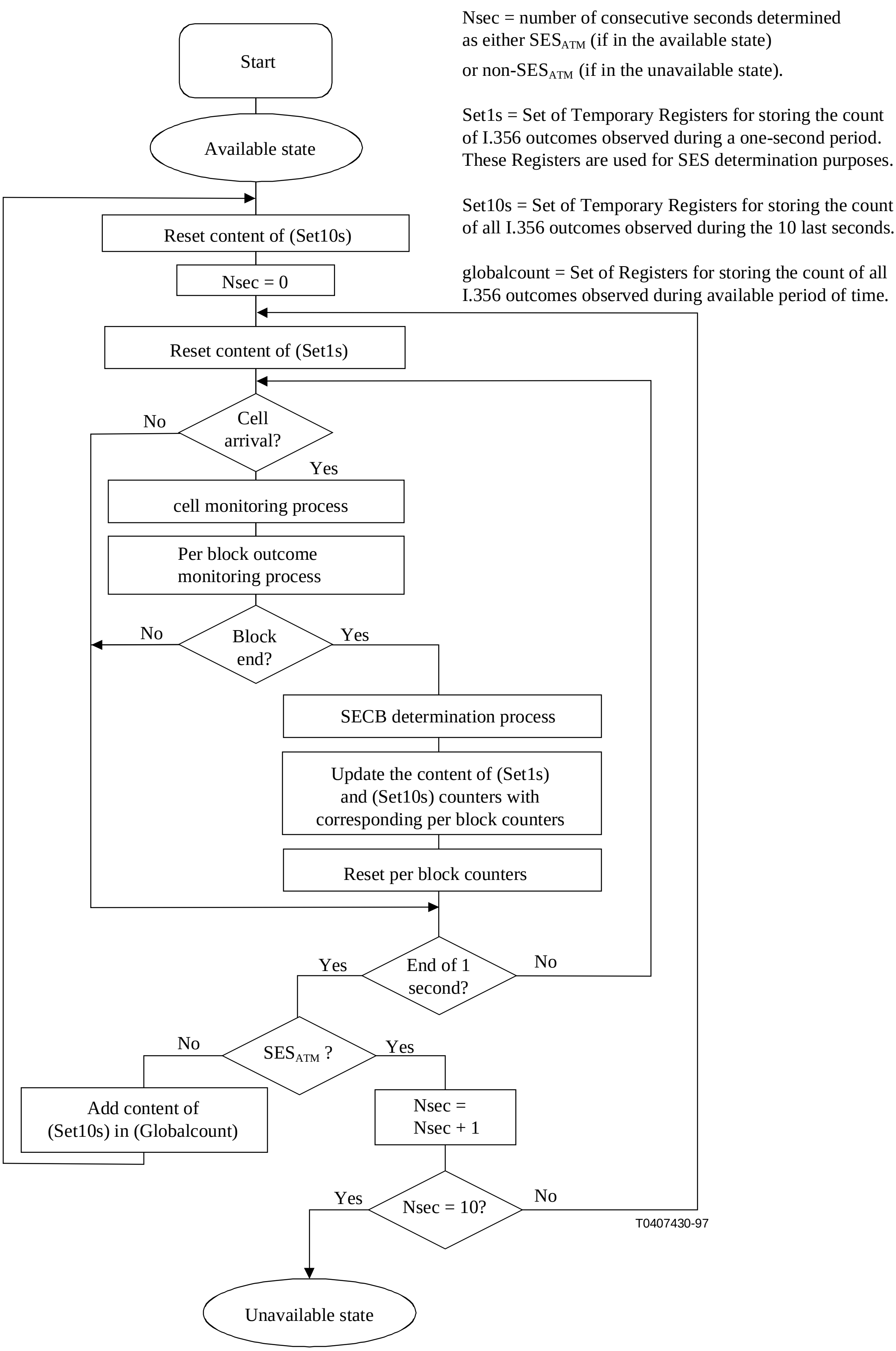

Figure D.6-2/O.191 – Example of the part of an algorithm applicable in available time

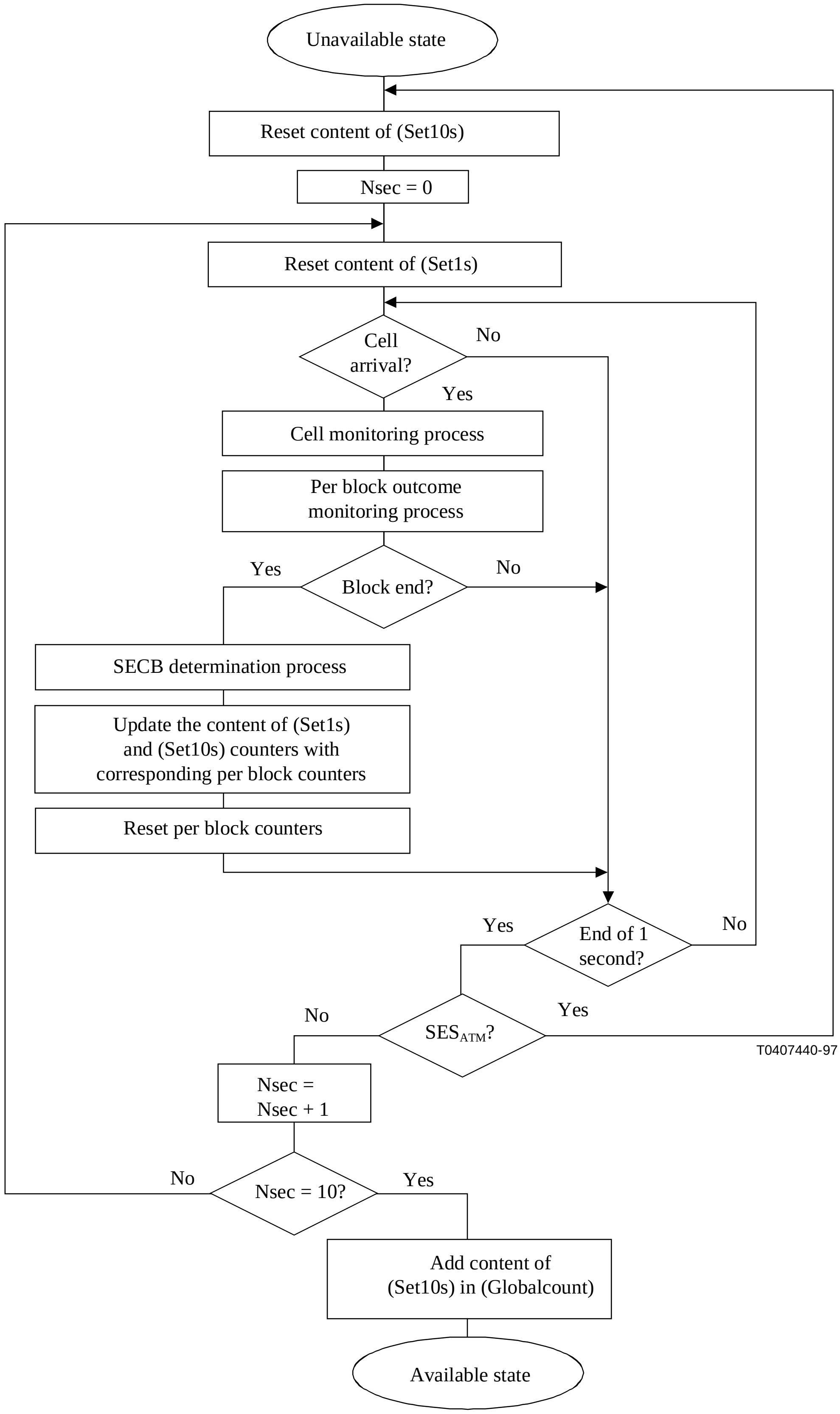

Figure D.6-3/O.191 – Example of the part of an algorithm applicable in unavailable time

D.6.6 Performance result storage

The set of performance registers (Globalcount) is used to compute cell transfer performance parameters according to Recommendation I.356 [1]. This set includes the following registers:

- Globalcount_LC is the total count of lost test cells observed during available periods of time. It is updated by counter Set10s_LC as shown in both Figures D.6-2 and D.6-3/O.191.
- Globalcount_EC is the total count of errored test cells observed during available periods of time. It is updated by counter Set10s_EC as shown in both Figures D.6-2 and D.6-3/O.191.
- Globalcount_MC is the total count of misinserted test cells observed during available periods of time. It is updated by counter Set10s_MC as shown in both Figures D.6-2 and D.6-3/O.191.
- Globalcount_SECB is the total count of SECBs observed during available periods of time. It is updated by counter Set10s_SECB as shown in both Figures D.6-2 and D.6-3/O.191.
- Globalcount_Block is the total count of complete blocks detected during available periods of time. It is updated by counter Set10s_Block as shown in both Figures D.6-2 and D.6-3/O.191.

In order to compute unavailability performance parameters, each occurrence of an unavailable period of time shall be recorded in a specific unavailability "history" register. Each record should identify the time stamped information related to the unavailability beginning and ending times.

NOTE – As an option, other counters for parameters not defined in Recommendations I.356 [1] and I.357 [2] may be provided for maintenance purposes. For example, the number of observed SES_{ATM} outcomes could be evaluated.

D.6.7 Network Performance Parameter calculation

The Cell Loss Ratio, Cell Error Ratio, Cell Misinsertion Rate and Severely Errored Cell Block Ratio are cell transfer performance parameters defined in Recommendation I.356 [1]. They are calculated over the measurement period.

D.6.7.1 Cell Loss Ratio

The Cell Loss Ratio for the measured flow is the ratio:

$$\frac{\mathrm{Globalcount\_LC}}{\mathrm{N} \times (\mathrm{Globalcount\_Block} - \mathrm{Globalcount\_SECB}) - \mathrm{Globalcount\_LC}}$$

where N is the number of cells within a cell block (see D.6.3.1.1/O.191).

D.6.7.2 Cell Error Ratio

The Cell Error Ratio for the measured flow is the ratio:

$$\frac{\mathrm{Globalcount\_EC}}{\mathrm{N} \times (\mathrm{Globalcount\_Block} - \mathrm{Globalcount\_SECB})}$$

D.6.7.3 Cell Misinsertion Rate

The Cell Misinsertion Rate for the measured flow is the ratio:

$$\frac{\mathrm{Globalcount\_MC}}{\mathrm{Duration\_of\_available\_state}}$$

where Duration_of_available_state is the sum of the available periods of time during the observation period.

D.6.7.4 Severely Errored Cell Block Ratio

The Severely Errored Cell Block Ratio for the measured flow is the ratio:

$$\frac{\text{Globalcount\_SECB}}{\text{Globalcount\_Block}}$$

D.6.7.5 Availability Ratio

The network Availability Ratio (AR) is defined in Recommendation I.357 [2], as the proportion of time that the connection is in the available state over an observation period. The network AR is calculated by dividing the total network available time during the observation period by the duration of the observation period. Network AR can be estimated taking into account the time stamp information indicating beginning and ending times of unavailability.

The measurement of service AR is for further study.

D.6.7.6 Mean Time between Outages

The network Mean Time between Outages (MTBO) is defined in Recommendation I.357 [2], as the average duration of a continuous time interval during which the connection is available from the network perspective. Network MTBO can be estimated taking into account the time stamp information indicating beginning and ending times of unavailability.

The measurement of service MTBO is for further study.

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