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SERIES I: INTEGRATED SERVICES DIGITAL NETWORK

ISDN user-network interfaces – Aspects of ISDN affecting terminal requirements

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1+1 protection switching for cell-based physical layer

ITU-T Recommendation I.480

(Formerly CCITT Recommendation)

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ITU-T Recommendation I.480

1+1 protection switching for cell-based physical layer

Summary

This ITU-T Recommendation, "1+1 protection switching for cell-based Physical Layer", provides architecture and mechanisms for 1+1 protection at the Physical Layer for ATM cell-based transmission systems.

This ITU-T Recommendation defines the transmitter and receiver operation, the synchronization and switching process. It is based on the mechanisms described in ITU-T Recommendation I.432.2 for ATM cell-based transmission systems.

It provides hitless protection switching at the Physical Layer between two sources and sinks of F3 OAM flows.

Source

ITU-T Recommendation I.480 was prepared by ITU-T Study Group 13 (1997-2000) and approved under the WTSC Resolution 1 procedure on 10 March 2000.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSC Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation I.480

1+1 protection switching for cell-based physical layer

1 Scope

This ITU-T Recommendation provides architecture and mechanisms for 1+1 protection at the Physical Layer for ATM cell-based transmission systems.

This ITU-T Recommendation defines the transmitter and receiver operation, the synchronization and switching process. It is based on the mechanisms described in ITU-T Recommendation I.432.2 [1] for ATM cell-based transmission systems.

It provides hitless protection switching at the Physical Layer between two sources and sinks of F3 OAM flows. It applies at the T_B reference point for 155 520 and 622 080 kbit/s cell-based Physical Layer.

2 References

The following ITU-T Recommendations 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 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 listed below. A list of currently valid ITU-T Recommendations is regularly published.

[1] ITU-T Recommendation I.432.2 (1999), *B-ISDN user-network interface − Physical Layer specification: 155 520 kbit/s and 622 080 kbit/s operation*.

[2] ITU-T Recommendation G.826 (1999), *Error performance parameters and objectives for international, constant bit-rate digital paths at or above the primary rate.*

3 Definitions

This ITU-T Recommendation defines the following terms:

3.1 working link: The transmission link which is used for ATM cell transmission in normal operation mode.

3.2 protection link: The transmission link which is used for ATM cell transmission in protection operation mode, that is when the working link is in error.

3.3 global link: This defines the aggregation of the working link and the protection link.

3.4 synchronization process: The process in the receiver which consists in aligning the two cell flows received from the working and the protection link.

3.5 selection process: The process in the receiver which consists in selecting between the two cell flows the block of cells which has the better performance from a transmission point of view.

4 Symbols and abbreviations

This ITU-T Recommendation uses the following abbreviations:

AIS	Alarm Indication Signal
B-ET	Broadband-Exchange Terminal
BIP	Bit Interleaved Parity
B-NT	Broadband-Network Termination
CB-TC	Cell Based-Transmission Convergence
EDC	Error Detection Code
HEC	Header Error Check
OAM	Operation And Maintenance
PMD	Physical Medium Dependent (sublayer)
PSN	Payload Sequence Number
RDI	Remote Defect Indication
REB	Remote Error Block
REB-G	Remote Error Block-Global link
TC	Transmission Convergence (sublayer)
VP	Virtual Path

5 Field of application

This 1+1 protection mechanism is dedicated to cell-based user-to-network physical interfaces at the T_B reference point. This includes both the 155 Mbit/s and the 622 Mbit/s cell-based interfaces, as defined in ITU-T Recommendation I.432.2 [1]. This mechanism offers a physical protection at the cell level without disruption. It is based on 1+1 redundancy which means the transmitted data is duplicated on two separate physical links. This mechanism is intended to be used only in a point-to-point physical configuration. The reference architecture is shown in Figure 1.

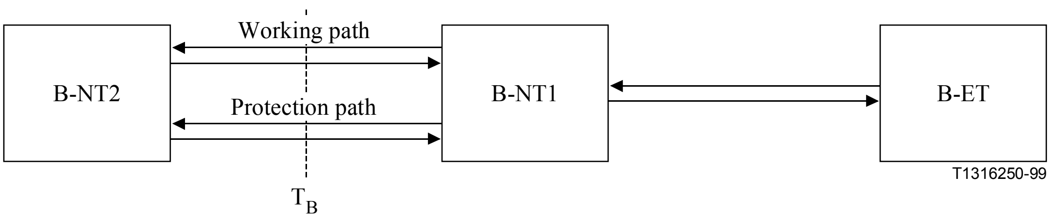

Figure 1/I.480 – Reference architecture

As specified in ITU-T Recommendation I.432.2 [1], the maximum interface reach at the T_B reference point is 2 km on single-mode medium for both the 155 and the 622 Mbit/s interfaces.

The reference model for this mechanism is illustrated in Figure 2. The transmitter sends the same cells on the working and protection entities. These cells are inserted between two F3 OAM cells having the same PSN values.

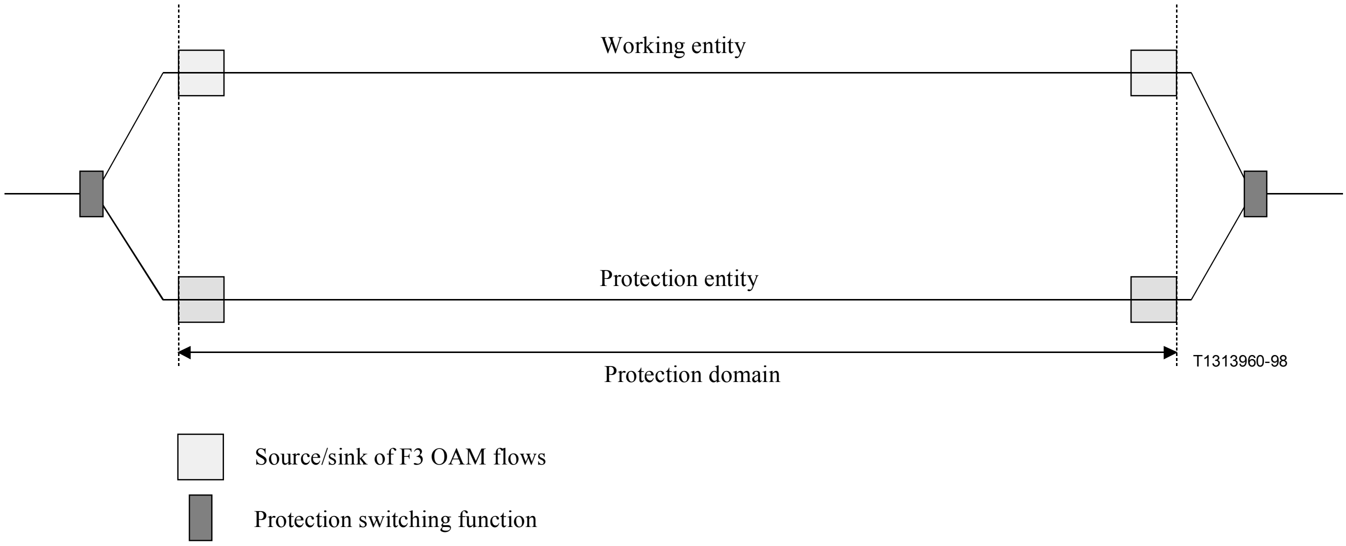

Figure 2/I.480 – Reference model

6 1+1 protection switching principles

This 1+1 protection mechanism covers the Physical Layer; the protection is performed on all the transmitted cells. Consequently all the ATM-VPs supported by the physical interface are protected. This method is specific to the cell-based Physical Layer because it uses the cell structure of the interface and the F3 OAM cells for cell synchronization between the links. It is functionally bit-rate independent so it applies to both the 155 Mbit/s and the 622 Mbit/s cell-based interface.

This mechanism offers a physical protection at the cell level without disruption because the two links are continuously synchronized and each time one errored block is detected on one link, the system selects the corresponding block on the other link.

The positioning of the protection switching mechanism from a layer view is shown in Figure 3; this figure is given for illustration only and it does not imply any particular implementation. Although the protection functions appear as a separate sublayer they are actually included in the Physical Layer of the ATM reference model as well as the TC and the PMD sublayers. In the transmit direction, each TC (CB-TC-A1 and CB-TC-A2) generates the same cell flow which is sent synchronously on the two links. In the receiver, the protection sublayer insures synchronization at the cell level, based on F3 OAM cells, to compensate the length difference between the links. Once the synchronization at the cell level is achieved, the protection sublayer monitors the received blocks of cells and switches between the two links when the blocks received on one link are errored. This process insures that the protection is performed without disruption.

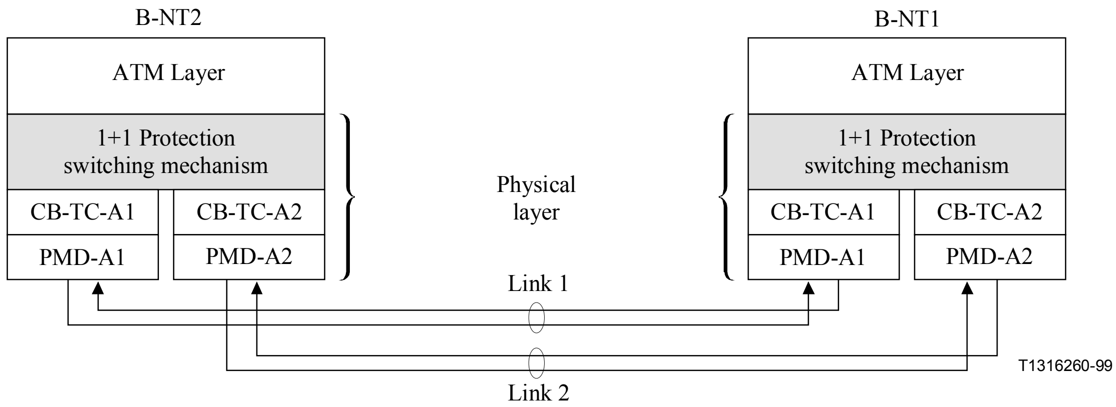

Figure 3/I.480 – Positioning of the protection switching mechanism from a layer view

7 Transmitter operation

7.1 Transmitter block diagram

The transmitter block diagram is shown in Figure 4. All the functional modules indicated in Figure 4 are part of the Physical Layer. Splitting of the protection functions within the Physical Layer is shown for illustration only and does not imply any particular implementation.

The T-SYNC and SELECTION modules are part of the protection sublayer whereas CB-TC-Ax and PMD-Ax modules perform the classic cell-based transmission functions at the TC and PMD sublayers, as defined in ITU-T Recommendation I.432.2 [1]. ATM-Cell signal represents the ATM cells being sent by the ATM Layer to the Physical Layer. The Sync signal corresponds to the synchronization signal of the Physical Layer for the egress direction. The REB-G signal represents the number of errored blocks between two consecutive F3 OAM cells for the global link (this signal is provided by the SELECTION module in the ingress direction). Signals Flow1 and Flow2 indicate the binary flows sent by each TC to the underlying PMD sublayer.

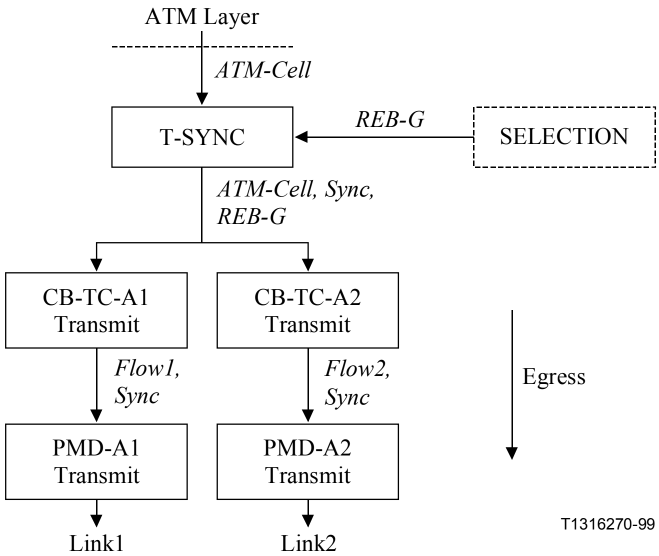

Figure 4/I.480 – Transmitter block diagram

7.2 Synchronization process in the transmitter

The T-SYNC module is responsible for synchronization of the two TC sublayers in the egress direction.

The T-SYNC module receives ATM cells from the ATM layer and sends them synchronously to the two TC sublayers (ATM-Cell signal). To insure synchronization between the links, the T-SYNC module provides a common clock (Sync) to the two TC sublayers (CB-TC-A1 and CB-TC-A2). This synchronization signal can be provided by the ATM layer or by a local oscillator within the Physical Layer. The tolerance on this synchronization signal shall be as defined in ITU-T Recommendation I.432.2 [1], that is ±20 ppm (for both the 155 and the 622 Mbit/s interface).

The synchronization provided by T-SYNC shall also apply at the F3 level which means that CB-TC-A1 and CB-TC-A2 shall generate F3 OAM cells with the same PSN value at the same time. Synchronization at both the cell level, F3 OAM level and physical level (common transmission clock) insures that the cells transmitted on each link between two consecutive F3 OAM cells having the same PSN number are identical. This condition is necessary for the block selection process in the ingress direction.

The T-SYNC module also provides the REB-G information to the two TC sublayers for performance reporting at the far end. This information field is generated by the SELECTION module in the ingress direction.

7.3 TC and PMD operation in the transmitter

The TC operation shall be as defined in ITU-T Recommendation I.432.2 [1]. CB-TC-A1 and CB-TC-A2 are independent from each other although they are synchronized by the same clock (Sync signal) and they receive the same ATM cells from the T-SYNC module. They are also synchronized to insure that F3 OAM cells having the same PSN value are generated at the same time.

CB-TC-A1 and CB-TC-A2 perform the classic cell-based functions in the egress direction (insertion of idle cells, cell scrambling, HEC computation). They also generate F1 and F3 OAM flows for supervision and performance monitoring of the section and transmission path. If there is no regenerator section, the F1 OAM flow shall not be implemented.

The content of F1 OAM cells shall be as defined in ITU-T Recommendation I.432.2 [1]. The content of F3 OAM cells shall be as defined in ITU-T Recommendation I.432.2 [1] except that byte 45 of the F3 OAM payload shall be no longer reserved and shall be allocated to the REB-G information field. The REB-G field contains the number of errored blocks detected in one direction of transmission for the global link, that is the aggregation of the two protected links. This field shall be used in the same way as the individual REB fields (byte 46 of F3 OAM payload) which are dedicated to each transmission link.

For each F3 OAM cell being sent synchronously on the two links, the fields PSN, EDC-B1 to EDC-B8 and REB-G are identical. The other fields (AIS, RDI and REB) are different because they depend on the performance measured on each link.

The PMD sublayer (PMD-A1 and PMD-A2) shall be as described in ITU-T Recommendation I.432.2 [1]. Because the two PMDs (PMD-A1 and PMD-A2) are synchronized by the same clock (Sync) and because the two TCs (TC-A1 and TC-A2) are also synchronized at the cell level, this insures that each block of cells which is sent on one link between two consecutive F3 OAM cells is identical to the corresponding block on the other link.

8 Receiver operation

8.1 Receiver block diagram

The receiver block diagram is shown in Figure 5. All the functional modules indicated in the figure are part of the Physical Layer. Splitting of the protection functions within the Physical Layer is shown for illustration only and does not imply any particular implementation.

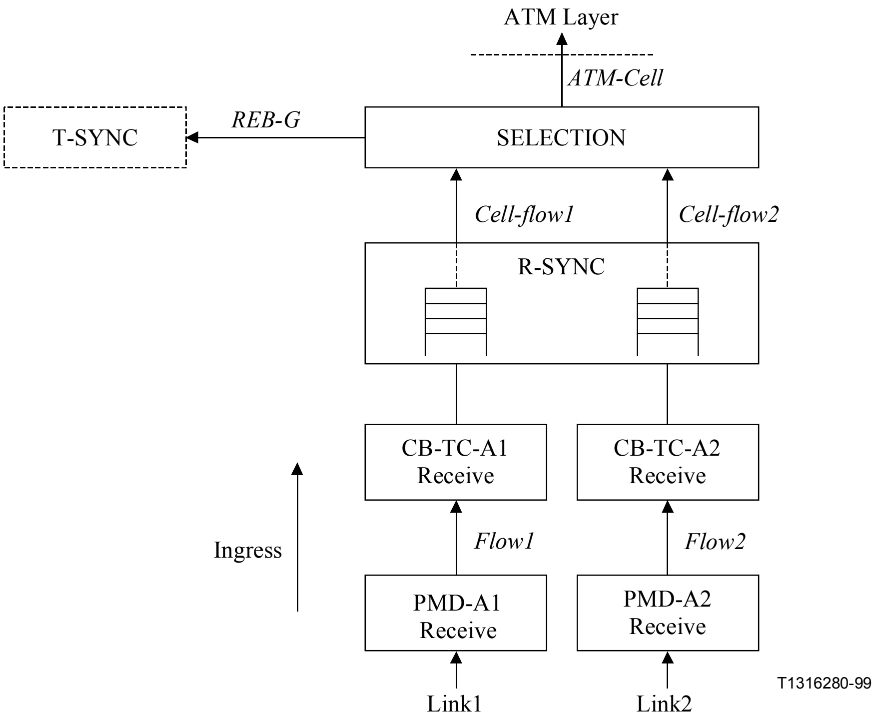

Figure 5/I.480 – Receiver block diagram

The R-SYNC, SELECTION and T-SYNC modules are part of the protection sublayer whereas CB-TC-Ax and PMD-Ax modules perform the classic cell-based receive functions. Signals Flow1 and Flow2 correspond to the binary flows received by the PMD sublayers and sent to the TC sublayers. Signals Cell-flow1 and Cell-flow2 represent the cell stream sent by the TC sublayers to the SELECTION module once the cell alignment has been performed by the R-SYNC function. The ATM-Cell signal corresponds to the cell stream delivered to the ATM Layer. The REB-G signal represents the number of errored blocks measured between two consecutive F3 OAM cells for the global protected link.

8.2 TC and PMD operation in the receiver

The TC and PMD operation for each link shall be as defined in ITU-T Recommendation I.432.2 [1] except that all the cells, including idle cells, F1 and F3 OAM cells, shall be passed by the TC sublayer to the R-SYNC module. This is because the SELECTION module handles monitored blocks of constant length in cells. As defined in ITU-T Recommendation I.432.2 [1], there are eight monitored blocks of cells between two consecutive F3 OAM cells. For the 155 Mbit/s interface, each monitored block contains 27 cells; for the 622 Mbit/s interface, each monitored block contains 54 cells.

Each CB-TC sublayer shall pass all the received cells to the R-SYNC module which means that cells with errored HEC shall not be discarded by the TC sublayer. Physical Layer cells (idle cells, F1 OAM cells and F3 OAM cells) shall also be passed to the R-SYNC module and shall not be discarded.

For each transmission link, the corresponding TC (CB-TC-A1 or CB-TC-A2) shall insure maintenance and performance monitoring functions, as defined in ITU-T Recommendation I.432.2 [1]. This includes both BIP-8 calculation, AIS and RDI defect indication, and calculation of the number of errored blocks (REB field) for each direction of transmission. Performance monitoring enables to detect the number of errored blocks between two consecutive F3 OAM cells. Conditions for considering a monitored block as errored are detailed in Annex D/G.826 [2].

8.3 Link synchronization process

The synchronization process is used to compensate the length difference between the two links. Assuming that Link1 is shorter (in length) than Link2, then a given cell which is emitted at the same time in the transmitter by the two TCs will be received by CB-TC-A1 before being received by CB-TC-A2. To enable protection switching between the links, the R-SYNC module first has to resynchronize the cell flows delivered by CB-TC-A1 and CB-TC-A2.

The synchronization process is achieved by using the properties of F3 OAM cells. These cells are inserted in the cell flow on a recurrent basis (the frequency of insertion of F3 OAM cells depends on the interface rate) and they include a modulo counter in their payload (PSN field) which is used as a time marker.

To perform synchronization at the cell level, the R-SYNC module just has to detect F3 OAM cells having the same PSN (Payload Sequence Number) value on the two links. Once synchronization is achieved, the receiving TC knows that each cell received on Link1 M cells after the F3 OAM cell number P corresponds to the cell received on Link2 M cells after the F3 OAM cell having the same PSN value. This synchronization process is illustrated in Figure 6.

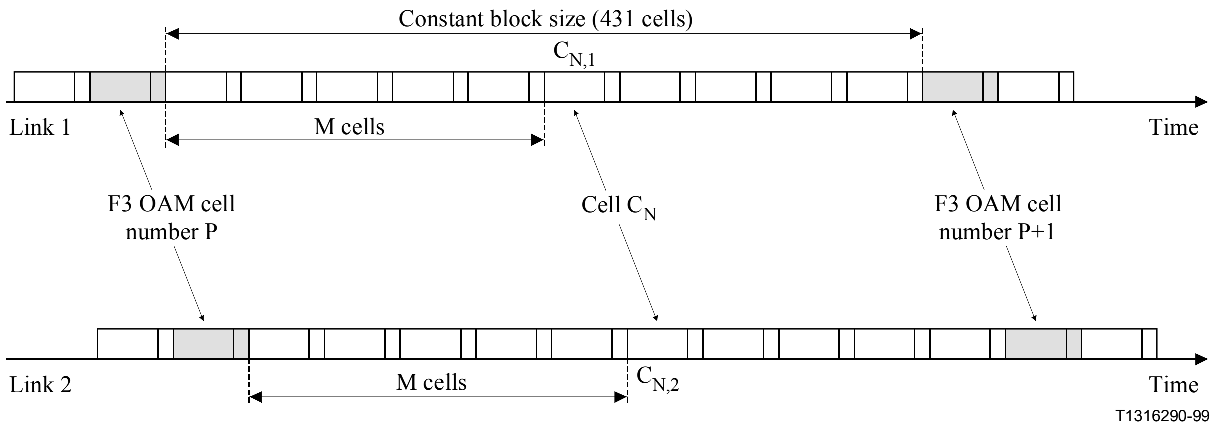

Figure 6/I.480 – Synchronization process by using F3 OAM cell sequence number

To insure that synchronization at the cell level is correctly achieved and maintained, it is necessary to check continuously that the F3 OAM cells received on both links have the expected PSN (Payload Sequence Number) value. This verification should apply only to valid F3 OAM cells (F3 cells received with correct header and correct payload).

If transmission errors occur on one link and result in loss of cell delineation or even loss of signal, the synchronization process shall be maintained by using only the cells received from the valid link. If the two links are in error, the synchronization process shall wait until one link at least recovers from errors and then resynchronize at the F3 OAM cell level as soon as the other link is restored. This means that R-SYNC module shall not stop passing cells from a valid link even if the other link is in error and the R-SYNC module shall insure synchronization at the F3 OAM cell level as soon as the two transmission links are available.

To compensate the length difference between the links, buffering is required to store the cells received from the fastest link. Assuming that the maximum length difference between the links is equal to 2 km (at the T_B reference point) and the propagation time on the physical medium is about 5 µs/km, the buffer size required to compensate the length difference between the links is:

- 155 Mbit/s interface: 4 cells;
- 622 Mbit/s interface: 15 cells.

This buffer size compensates only the length difference between the two transmission links but it is also necessary to buffer all the cells received between two consecutive F3 OAM cells (see 8.4).

This buffer size can also be increased if the protection mechanism is used on higher reach cell-based physical interfaces.

8.4 Block selection process

Once the cell synchronization is achieved (see 8.3), the protection mechanism is performed by selecting block by block the cells coming from the physical link which has the better performance (in real time). The link performance is determined by using the BIP-8 information carried in each F3 OAM cell as well as the number of errors detected in the cell header.

A block of cells is defined as a constant number of contiguous cells on which the BIP-8 calculation is performed, as defined in ITU-T Recommendation I.432.2 [1]. Each F3 OAM cell monitors 8 blocks of cells, as illustrated in Figure 7. For the 155 Mbit/s interface each block contains 27 cells. For the 622 Mbit/s interface each block contains 54 cells.

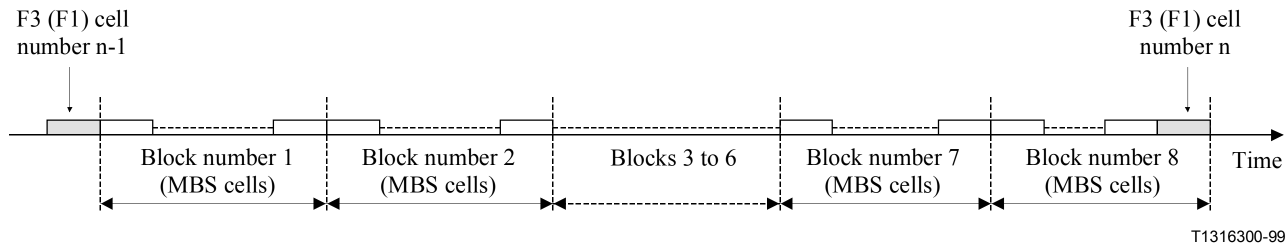

Figure 7/I.480 – Definition of the monitored blocks boundaries

On each link, after receiving F3 OAM cell number N, CB-TC-A1 and CB-TC-A2 can determine how many blocks are errored (from 0 to 8) by using the BIP-8 calculated on each monitored block. When a cell header is corrupted (HEC verification), the corresponding block is also assumed to be errored. The conditions for counting a monitored block as errored are detailed in Annex D/G.826 [2]. The performance monitoring function is performed on the two links in parallel. Each TC (CB-TC-A1 and CB-TC-A2) indicates to the SELECTION module how many errored blocks are detected among the eight monitored blocks.

The protection process consists in selecting for each monitored block on the two links the one which has the less number of errors:

- if monitored block $B_{N,1}$ on link1 and $B_{N,2}$ on link2 are valid the selection process selects either one block or the other;
- if monitored block $B_{N,1}$ on link1 is valid and block $B_{N,2}$ on link2 is errored then $B_{N,1}$ is selected;
- if monitored block $B_{N,2}$ on link2 is valid and block $B_{N,1}$ on link1 is errored then $B_{N,2}$ is selected;
- if both blocks are errored then the selection process selects either one block or the other.

After one monitored block has been selected among $B_{N,1}$ and $B_{N,2}$, all the ATM Layer cells from this monitored block which have a valid header (indicated by the HEC value) are sent to the ATM Layer. All the other cells shall be discarded. Idle cells, F1 and F3 OAM cells especially shall not be passed to the ATM Layer.

If one transmission link is in error, the SELECTION module selects automatically the cells received from the other link. Idle cells, F1 OAM cells, F3 OAM cells and ATM Layer cells having a corrupted header shall not be passed to the ATM Layer.

The SELECTION module also computes the value of the REB-G field which is reported to the T-SYNC module and carried in byte 45 of the F3 OAM payload. The REB-G field indicates to the far end the total number of errored blocks detected in one direction of transmission after the selection process is performed. REB-G is a running counter which is incremented continuously by the number of errored blocks detected between two consecutive F3 OAM cells. The REB-G field behaviour is similar to the REB field behaviour computed on each link.

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