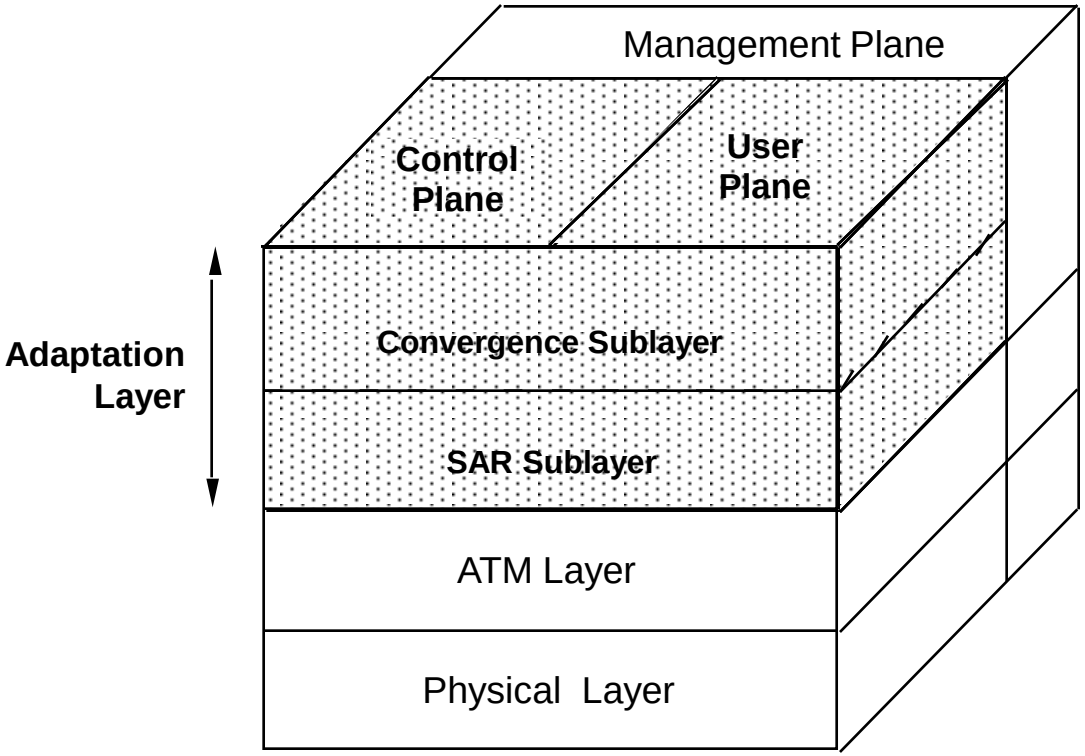
Part III: ATM

ATM Adaptation Layer

ATM Adaptation Layer

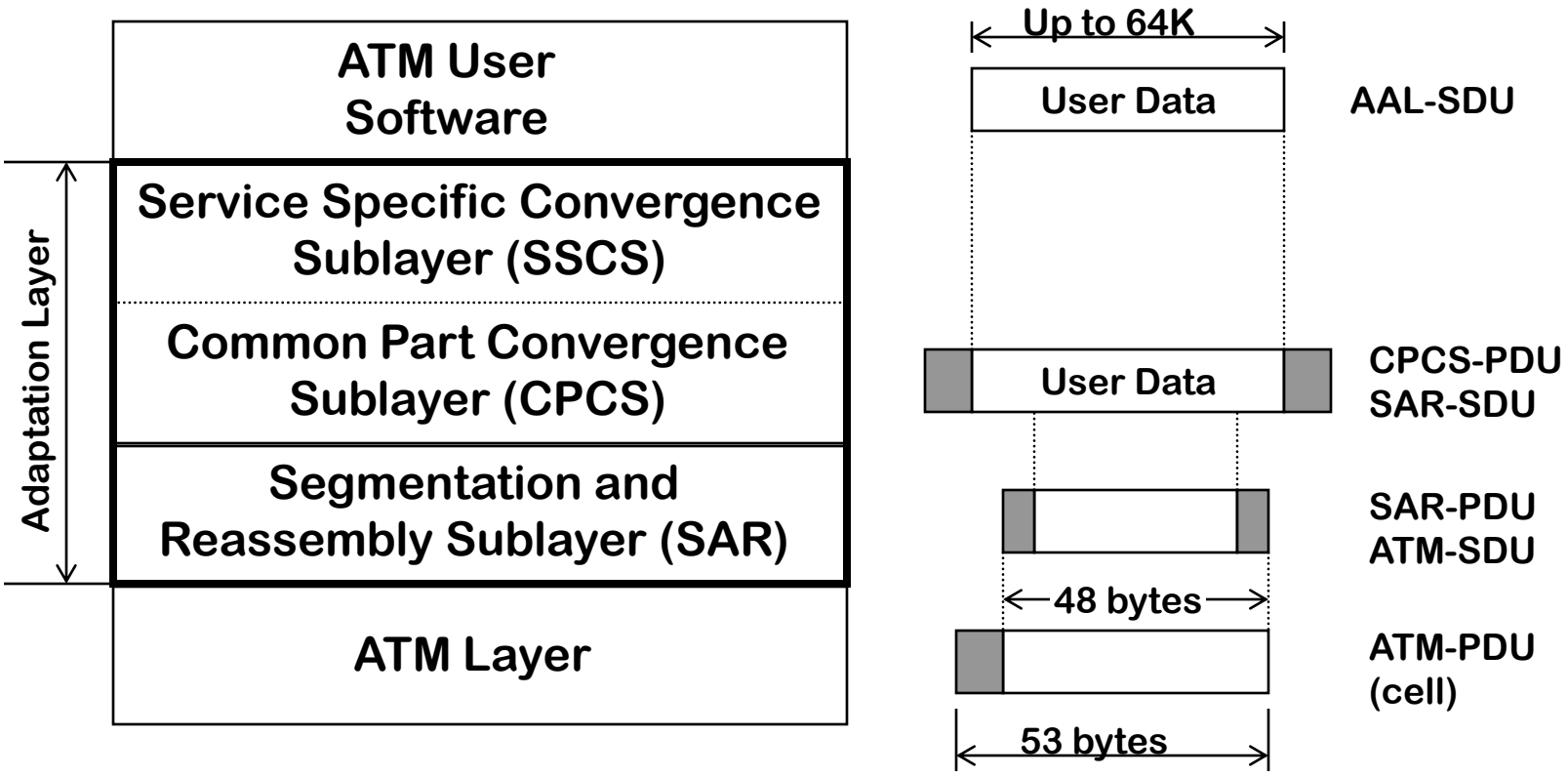


Adaptation Layer Functions

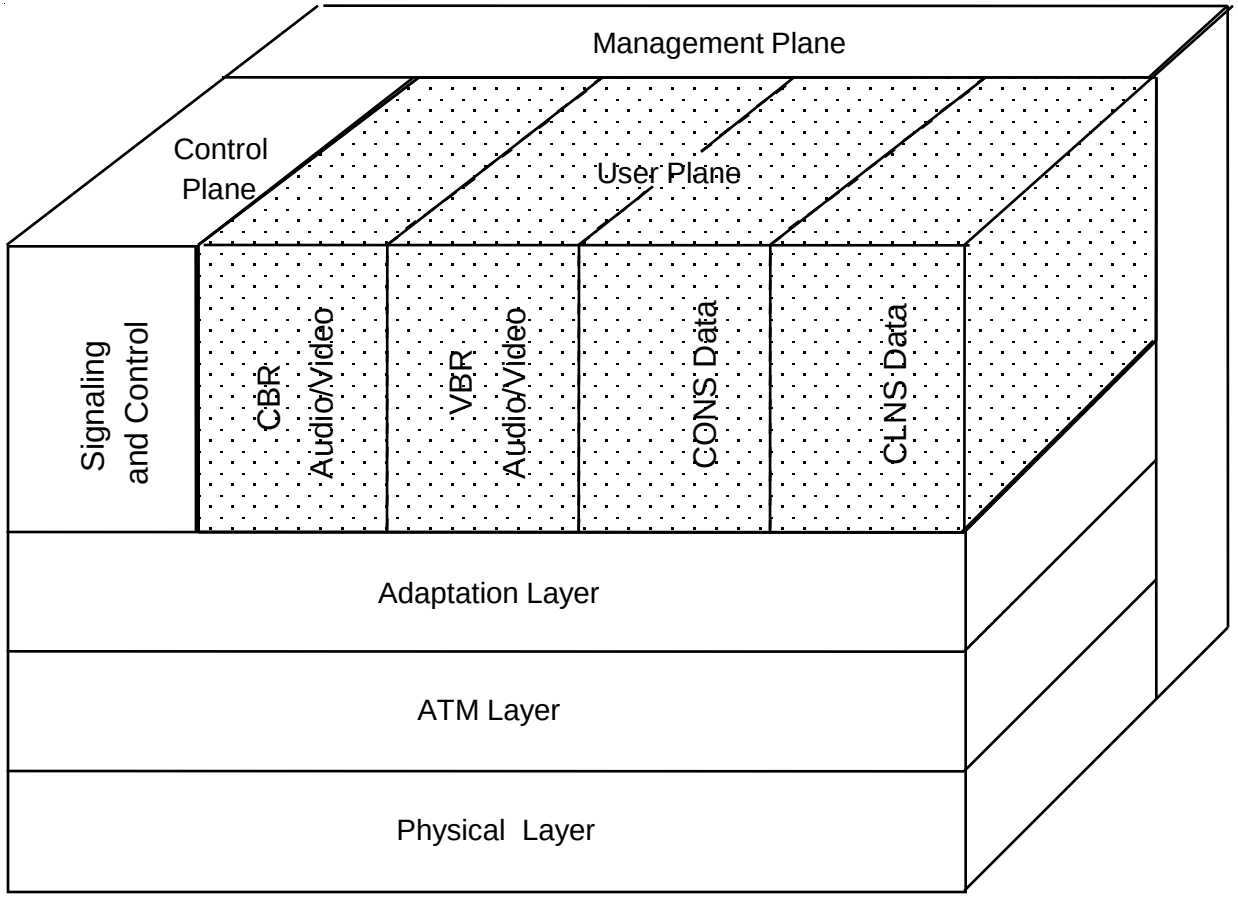
- Convergence Sublayer:
  - Timing control: source-destination synchronization
  - Flow control
  - Forward Error Correction
  - Handling of lost and out-of-order ATM cells

- Segmentation and Reassembly (SAR) Sublayer:
  - Segmentation of messages (AAL-SDUs) into ATM cells, and reassembly
  - Detection of lost and out-of-order ATM cells
  - Detection of bit errors

ATM Sublayer Data Units



BISDN Services



Service Classes

Attributes	Class A	Class B	Class C	Class D
Timing between Source & Destination	Related		Non-Related	
Bit-Rate	Constant	Variable		
Connection Mode	Connection-Oriented			Connectionless

Examples of Services:

Class A: DS1 and DS3 Circuit Emulation,
Constant bit rate audio and video

Class B: Variable Bit Rate Video

Class C: Support of Connection-Oriented Data Transfer

Class D: Support of Connectionless Data Transfer

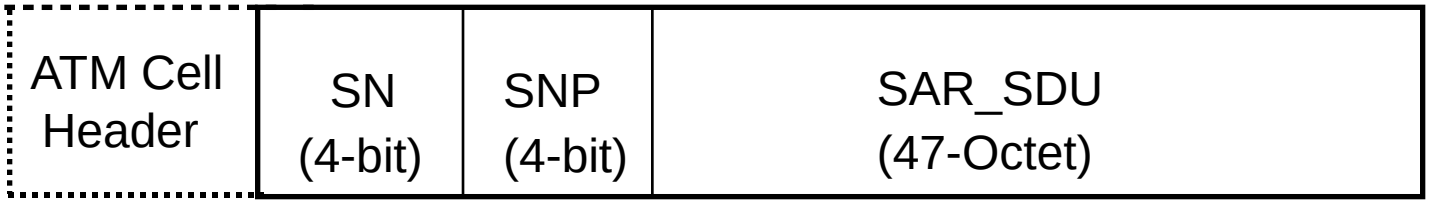
AAL Type 1

- Services provided to the higher layers:
  - Constant bit rate data transfer
  - Transfer of timing information between source and destination
  - Transfer of structure information between source and destination
  - Indication of lost or errored information which is not recovered by AAL-1, if needed

AAL1 - SAR functions

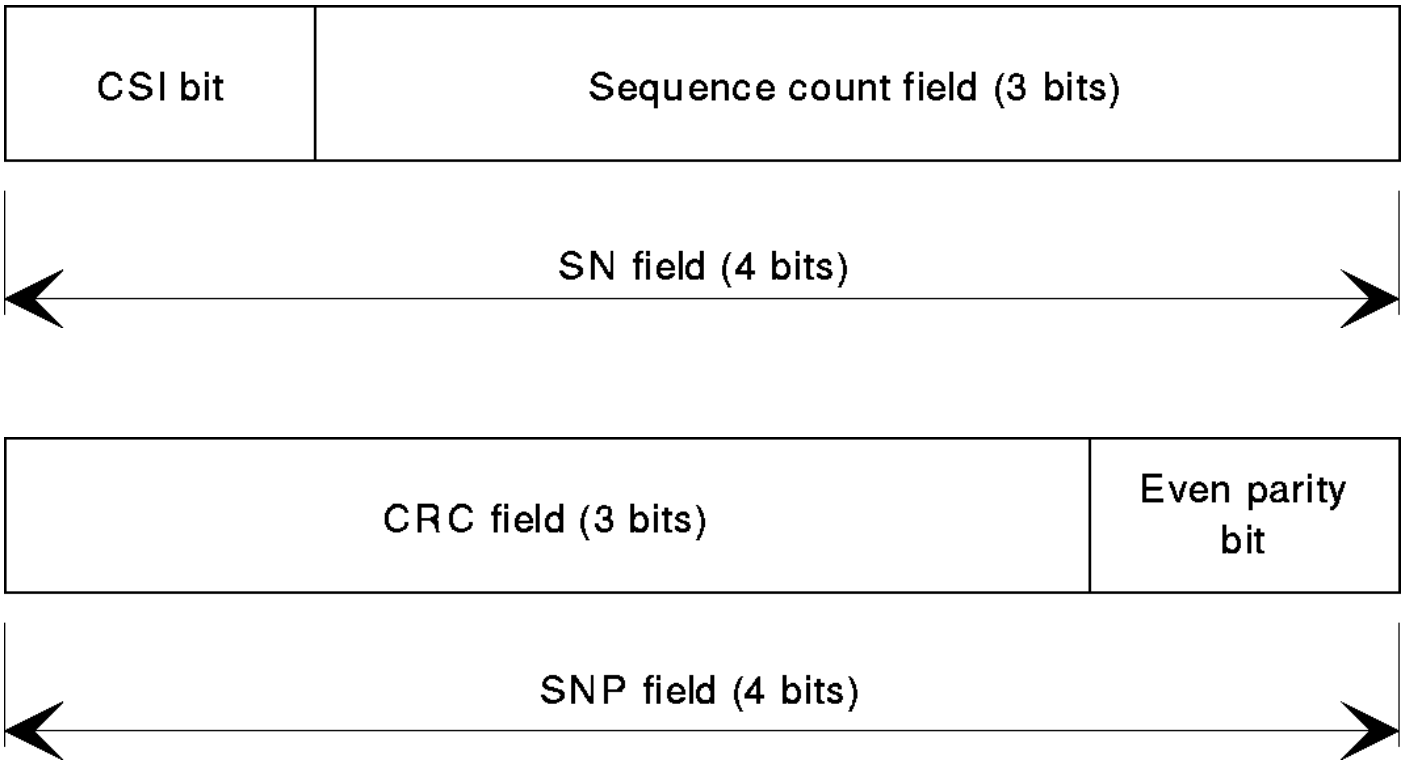
- Mapping between CS-PDU and SAR PDU
  - takes 47-byte blocks from the CS and adds a 1-byte header
- Existence of a CS function (indicated to the peer CS entity by a bit in the header)
  - optional function
- Sequence numbering
- Error protection
  - applies only to the SAR header, which contains the sequence number and CS indication

SAR PDU Format For AAL Type 1

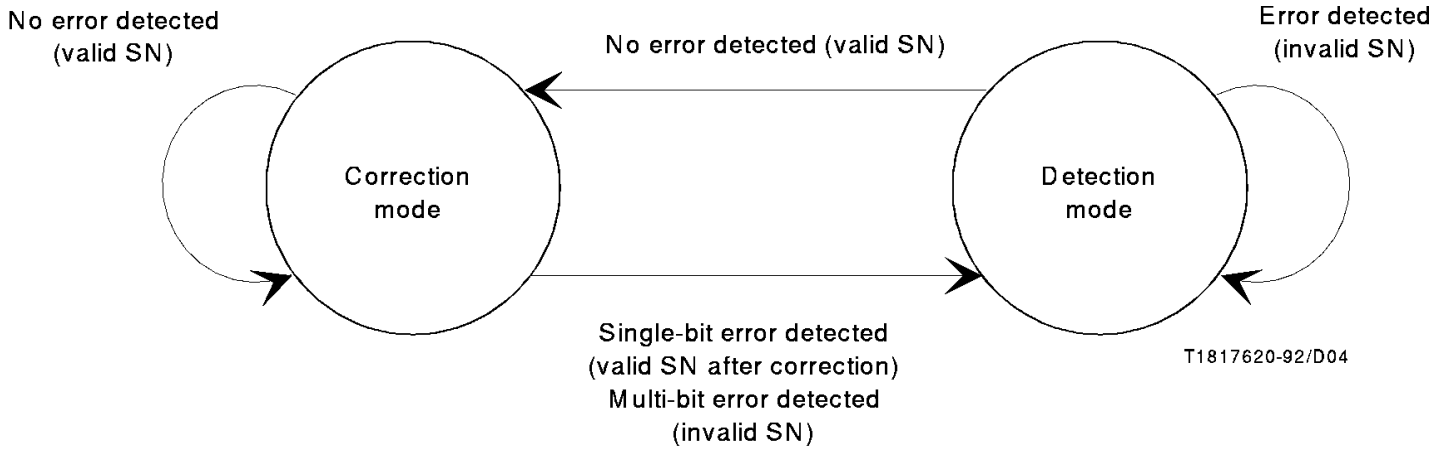


- SN = Sequence Number
- SNP = Sequence Number Protection

SN and SNP fields



SNP: Receiver Modes of Operation



SN Sequence number

- **Correction Mode:**
  - Single-bit errors corrected (uses CRC to correct)
  - Multiple-bit errors detected (CRC correction invalid)
- **Detection Mode:**
  - Both single and multiple-bit errors detected

SN+SNP Operations

CRC	Parity	Meaning	Detection Mode	Correction Mode
zero	ok	Valid header	SN valid, switch to Correction	SN valid
non-zero	fail	Single bit error	SN invalid	Correct SN, switch to Detection
zero	fail	Parity is in error	SN invalid	Correct Parity, switch to Detection
non-zero	ok	Multi-bit error	SN invalid	Switch to Detection

AAL-1 Convergence Sublayer Functions

- Handling of cell delay variation (for CBR delivery)
- Handling of lost and mis-inserted cells
- Recovery of source clock frequency
- Transfer of structure information
- Forward error correction
- Report end-to-end performance
  - events of lost and mis-inserted cells
  - buffer overflow and underflow
  - bit error events

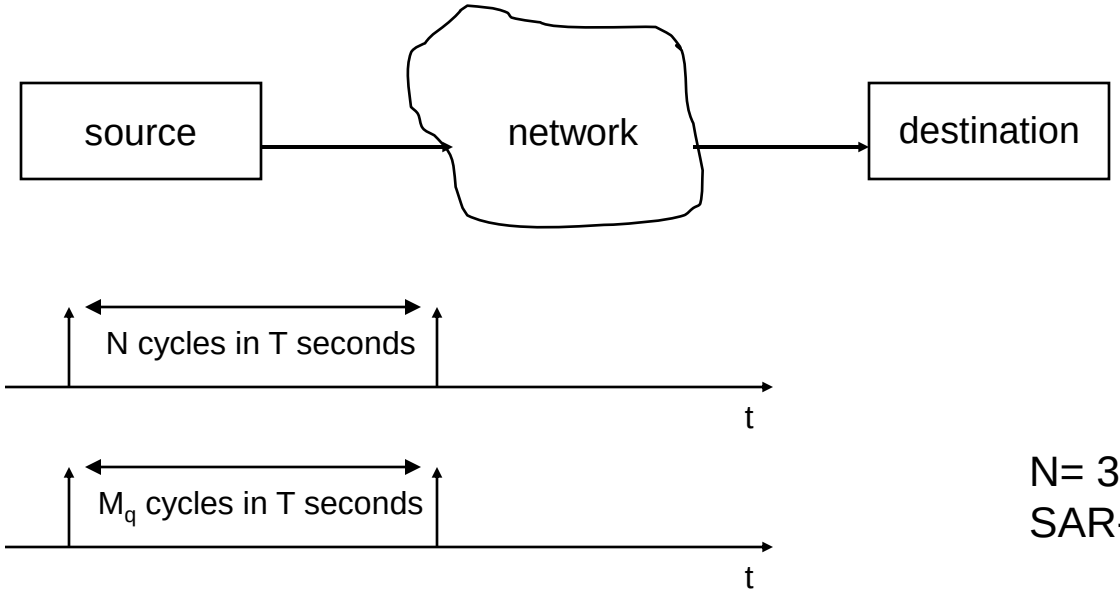
Source Clock Frequency Recovery

- Objective: synchronize the bit clock at the receiver with the bit clock at the transmitter
- Used for synchronous communication
  - Bit clock at the receiver must match the bit clock at the transmitter, otherwise the receiver either "goes dry" or overflows.
- Two methods can be used:
  - Synchronous Residual Time Stamp (SRTS) method
  - Adaptive Clock method

Synchronous Residual Time Stamp

- Assumption: there is a common network clock available both at the receiver and at the transmitter.
- The input data clock (service clock) at the transmitter may not be synchronized to the network clock.
- Basic concept:
  - Count the number of cycles of the network clock during a pre-determined number of cycles of the service clock.
  - Subtract the actual count from the nominal count (based on the known frequencies of each)
  - Send this difference to the receiver, using the CSI bit in the header over multiple cells

Synchronous Residual Time Stamp (SRTS) Method

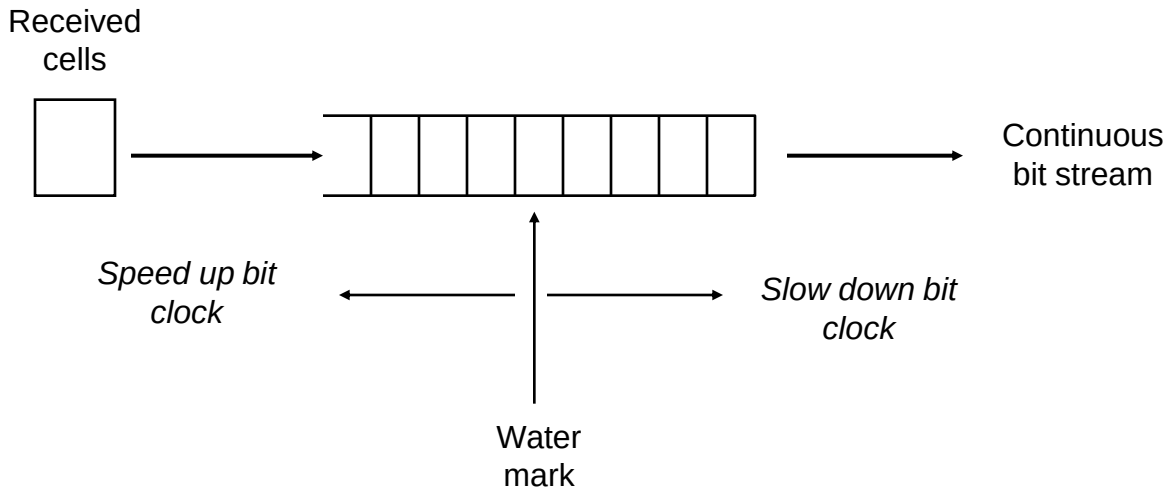


f_s = service clock
f_n = network clock
$f_{nx} = f_n/x$
x: integer such that
$1 < f_{nx}/fs \leq 2$

N= 3008 = number of bits in 8 SAR-PDU payloads

- RTS: Difference between nominal and measured values of M_q in N cycles of f_s
- Represented by 4 bits, carried in the CSI fields of even-numbered SAR-PDUs

Adaptive Clock Method

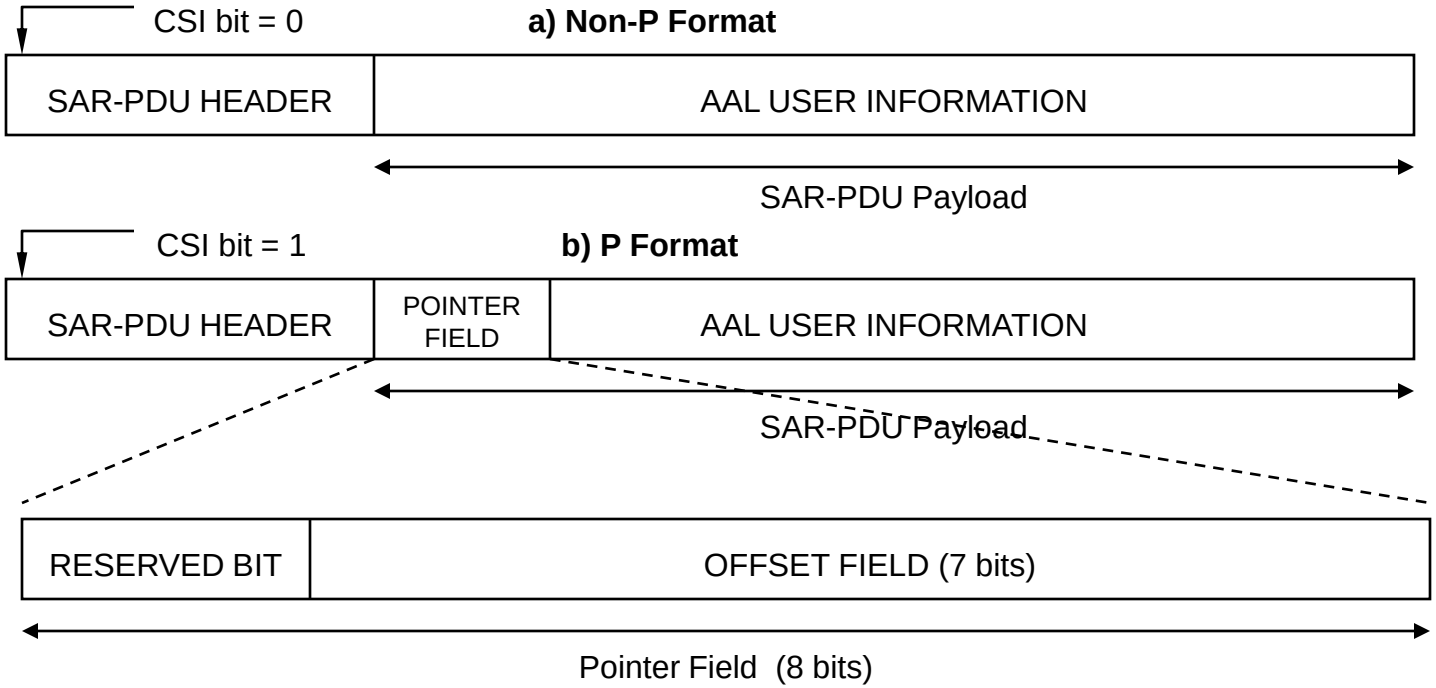


- Local clock is provided by a phase-locked loop driven by the buffer fill level.

Structured Data Transfer

- Non-structured data transfer:
  - The AAL carries a continuous stream of bytes
  - There is no notion of a frame or packet
- Structured data transfer:
  - The AAL carries sequence of fixed-size frames; each frame has an arbitrary number of bytes
  - The AAL is required to delineate the frame at the receiver
  - Example: 8 kHz structures used for voice

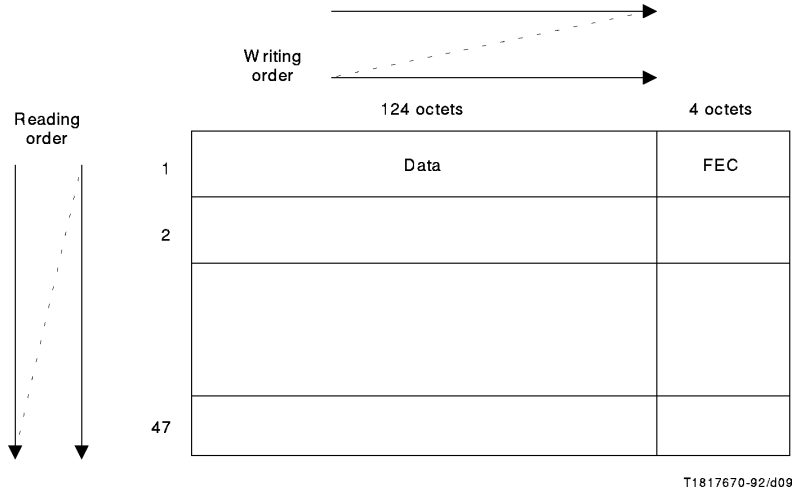
Structured Data Transfer Implementation



- Pointer field: points to the first start of the structured block in the current or next SAR-PDU (range: 0-93)
- SDT can be used with SRTS

Error Correction for Video Services

- Forward Error Correction
- Uses (128,124) Reed-Solomon



- Octet Interleaving
  - CSI bit is set to 1 for the first SAR-PDU payload of the CS-PDU (this precludes the use of structured data transfer)
  - Within any CS-PDU matrix, the following can be corrected:
    - 4 cell losses
    - 2 cell losses and 1 errored octet in each row
    - 2 errored octets in each row if there is no cell loss
  - Overhead is 3.1 %
  - Delay is 128 cells

AAL Type-2

- Services:
  - Transfer of SDUs with a variable source bit rate
  - Transfer of timing information between source and destination
  - Indication of loss or errors
- Functions:
  - Segmentation and reassembly of user information
  - Handling of cell delay variation
  - Handling of lost and mis-inserted cells
  - Source clock frequency recovery at the receiver
  - Source data structure recovery at the receiver
  - Monitoring / handling of bit errors
- Still not completely defined

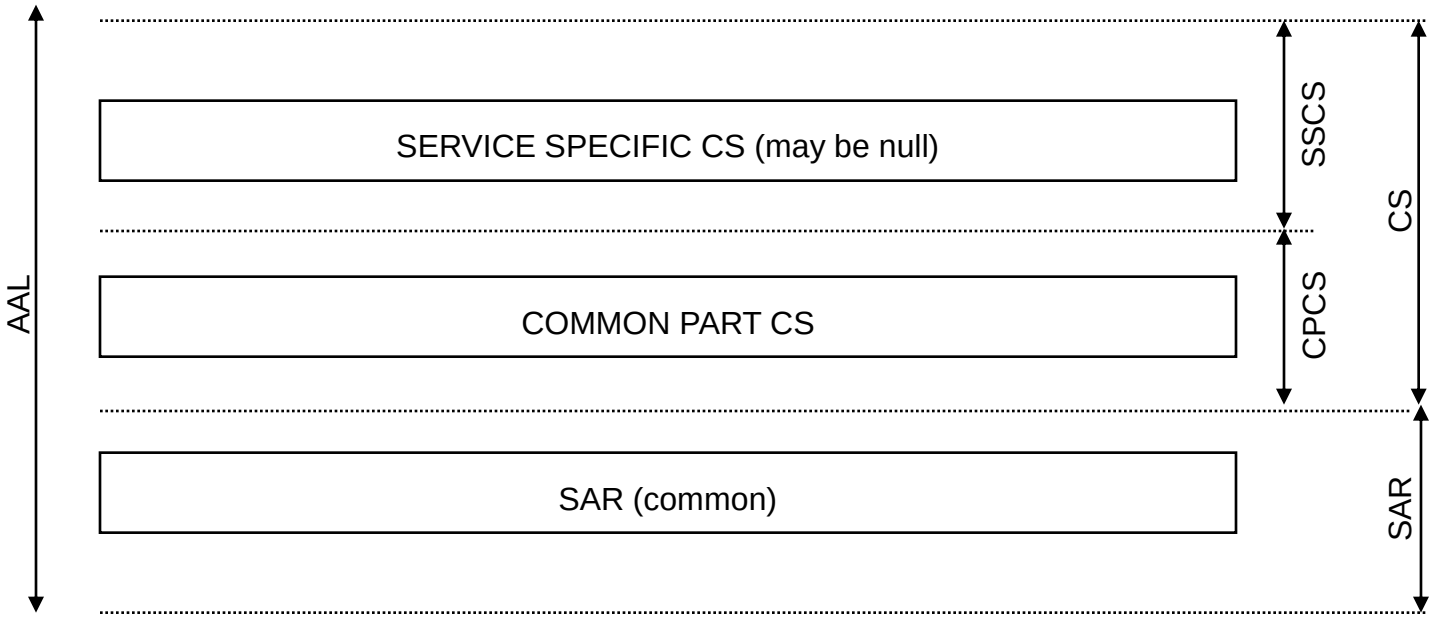
AAL 3/4

- Supports class C and class D services for the transport of computer network traffic
  - Class C: connection-oriented
  - Class D: connectionless
- Traffic characteristics:
  - discrete packets
  - variable rate
  - no timing relationship required

AAL 3/4 (cont.)

- Modes of Service:
  - Message mode
    - AAL-SDU is passed across AAL interface in exactly one AAL-IDU
  - Streaming mode
    - AAL-SDU is passed across AAL interface in one or more AAL-IDU's
- Modes of operation:
  - Assured: retransmission of missing or corrupted SSCS-PDU's
  - Non-assured
- For both modes of service, Assured and Non-assured modes of operation can be provided.

Sublayers of the AAL type 3/4

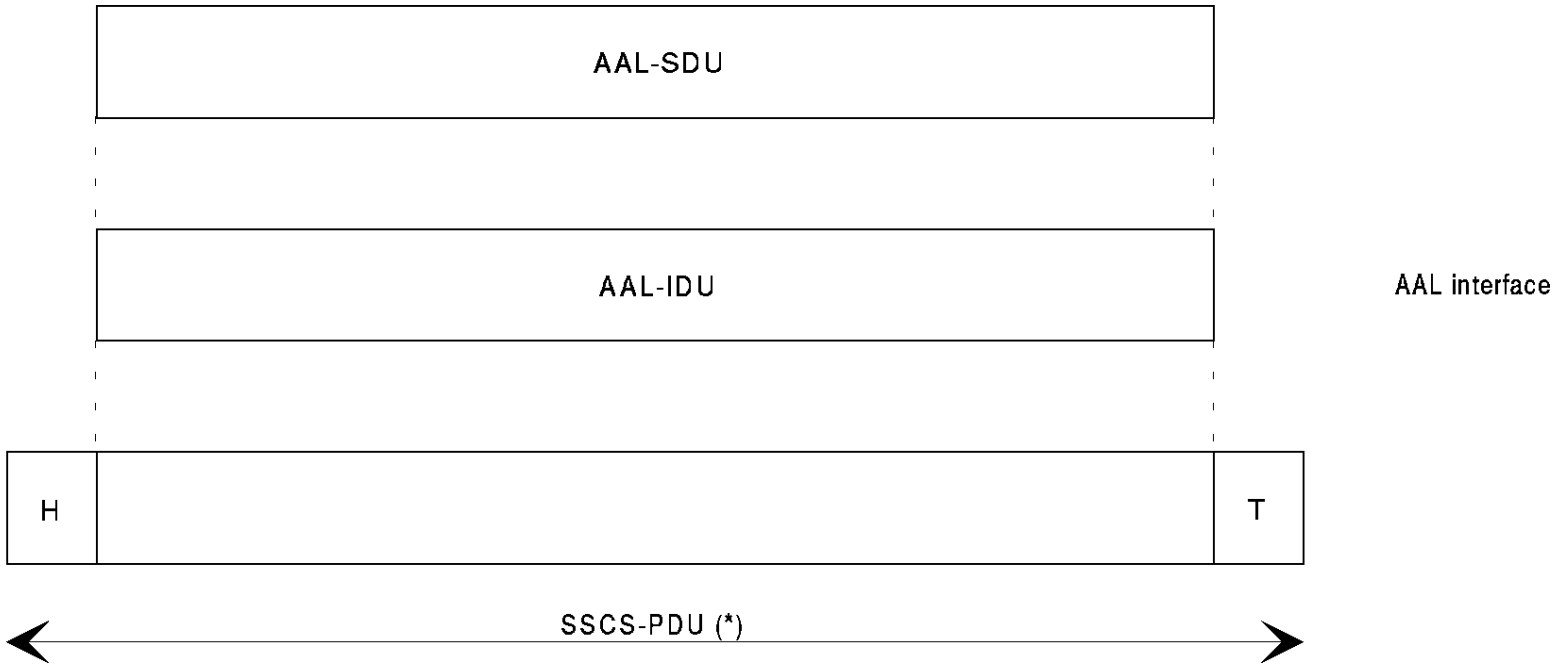


CS	Convergence sublayer
CPCS	Common part convergence sublayer
SAR	Segmentation and reassembly sublayer
SSCS	Service specific convergence sublayer

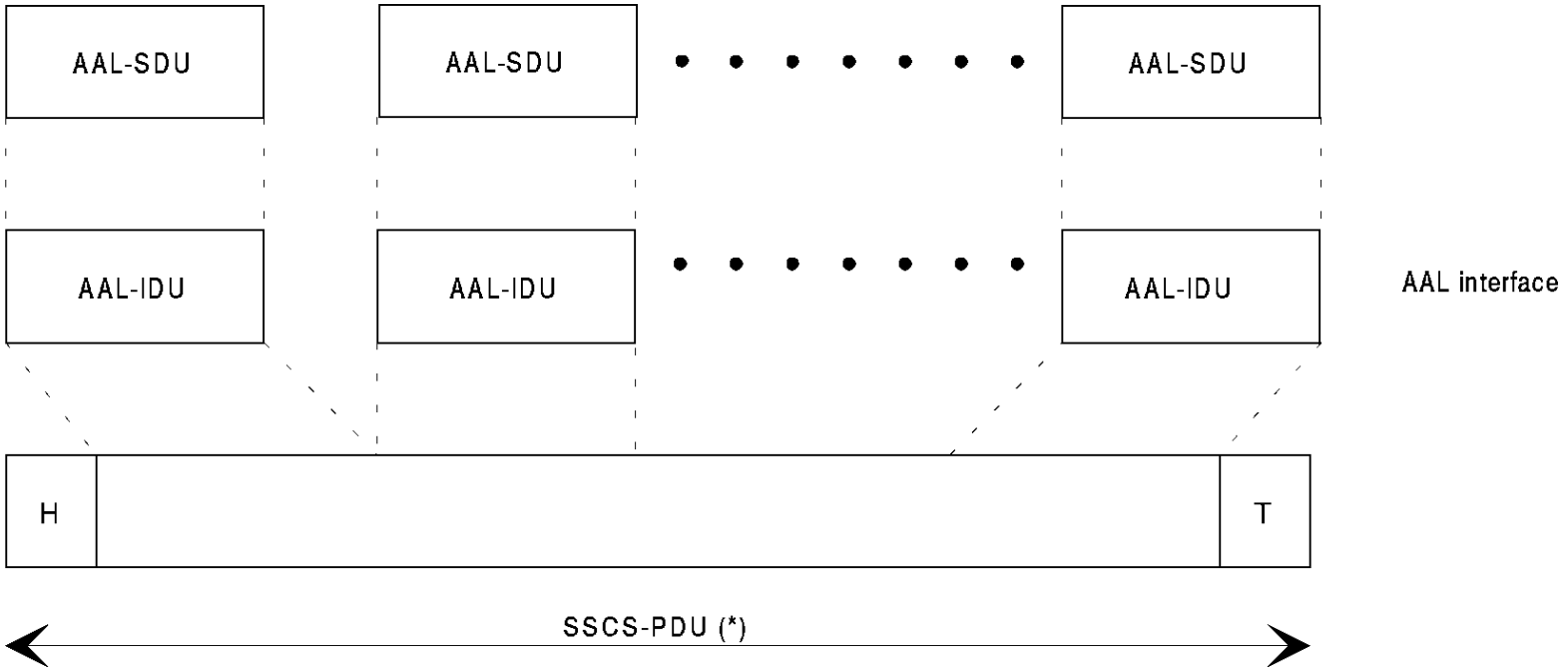
AAL Type 3/4 - CS Functions

- CPCS
  - Basic functionality needed to support a CNL network layer (class D)
  - Preservation of CPCS-SDU
  - Error detection and handling
  - Buffer allocation size (indication to the receiving peer entity)
  - Abort (a partially transmitted CPCS-SDU)
- SSCS
  - SSCS is null when supporting connectionless network layer (Class D)
  - Frame relaying telecommunication service (Class C)

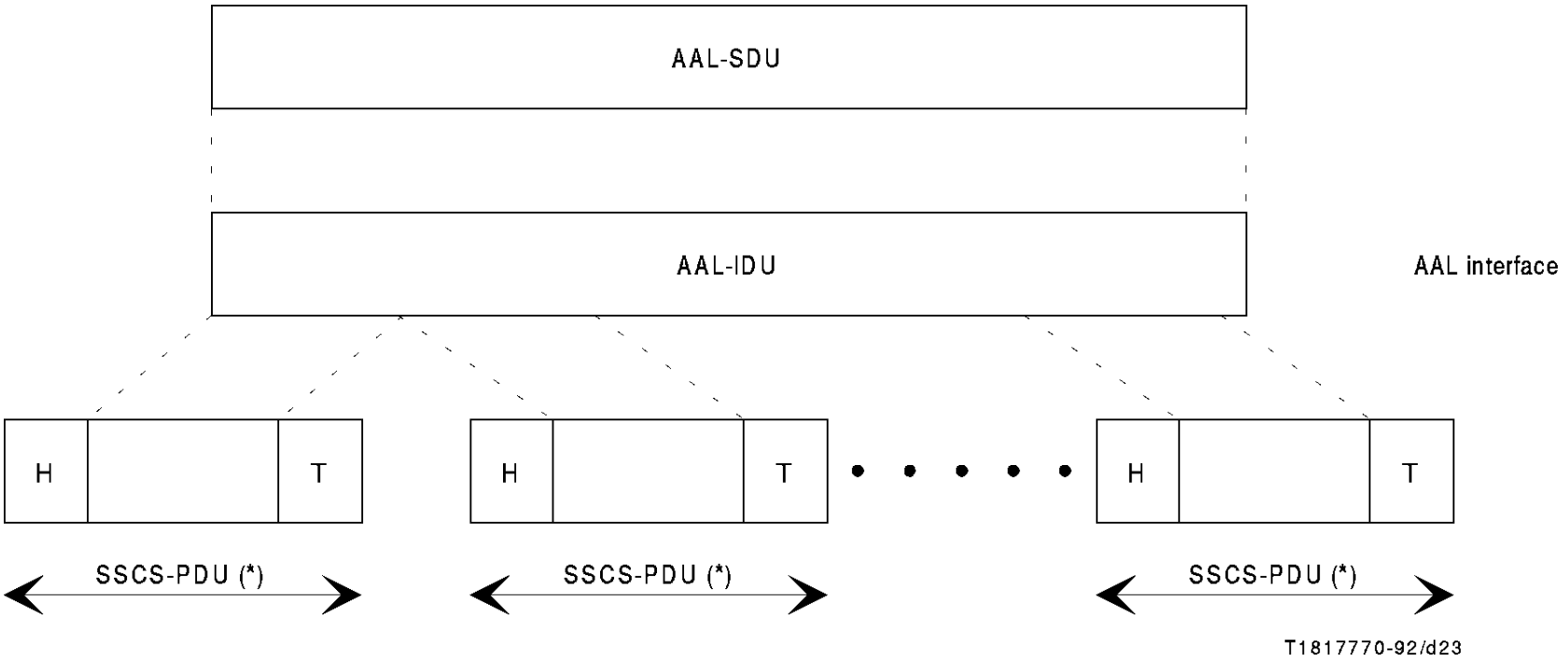
Message Mode Service



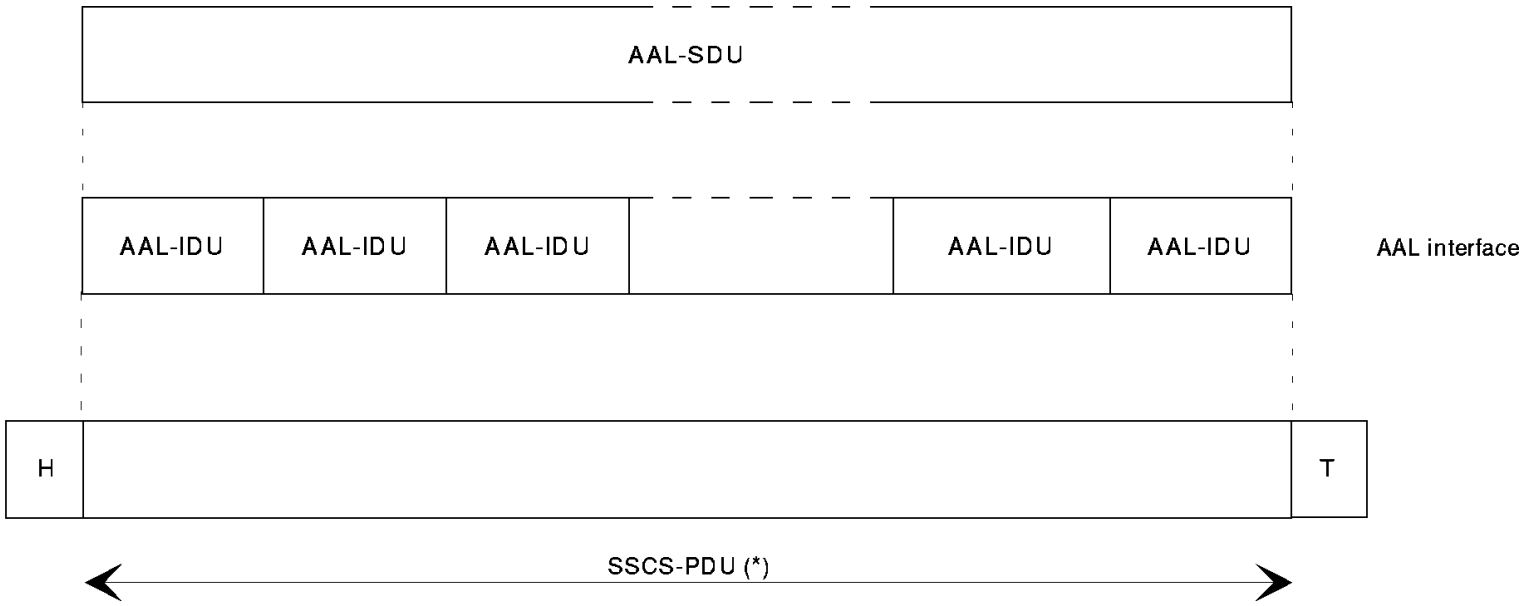
Message Mode Service with Blocking/Deblocking



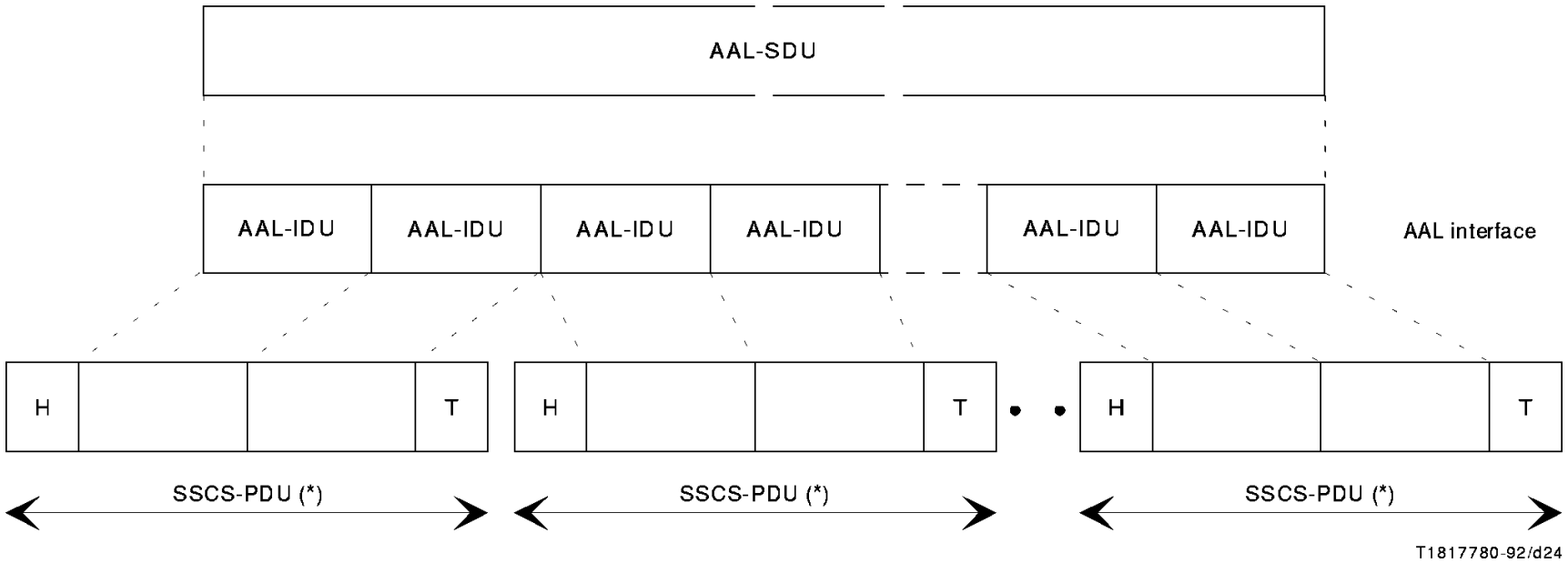
Message Mode Service with Segmentation/Reassembly



Streaming Mode Service



Streaming Mode Service with Segmentation/Reassembly



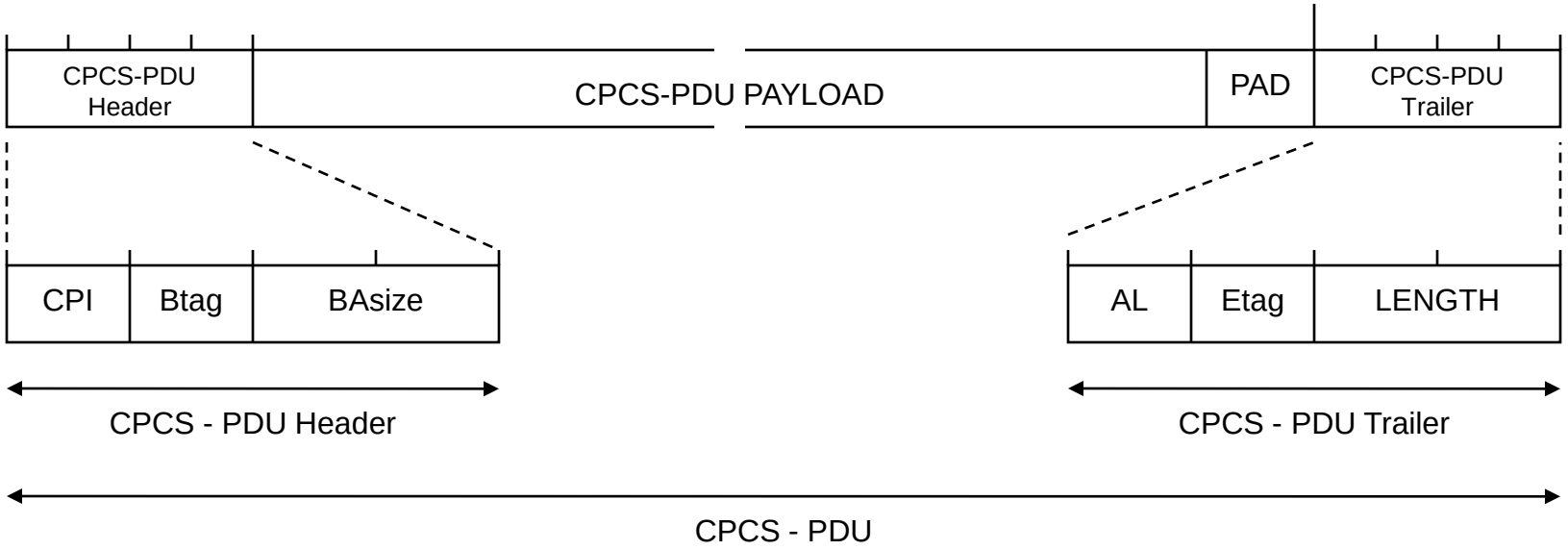
Combination of Service Mode and Internal Function

Combination of service mode and internal function

	AAL-SDU message segmentation/reassembly in the SSCS	AAL-SDU blocking/deblocking in the SSCS	Pipelining
Message			
Option 1	O	N/A	N/A
Option 2	N/A	O	N/A
Streaming	O	N/A	O

Option 1 Long variable size SDUs
Option 2 Short fixed size SDUs
O Optional
N/A Not applicable

CPCS-PDU Format for AAL Type 3/4



CPI	Common part indicator	(1 octet)
Btag	Beginning tag	(1 octet)
BAsize	Buffer allocation size	(2 octets)
PAD	Padding	(0 … 3 octets)
AL	Alignment	(1 octet)
Etag	End tag	(1 octet)
LENGTH	Length of CPCS-PDU Payload	(2 octets)

CPCS-PDU Fields (1)

- CPI, BA Size, Length fields:

CPI Encoding	BAsize field semantics	Length field semantics
00000000	Buffer allocation requirements in octets	Equals length of CPCS-PDU payload in octets
Other values are reserved and are for future standardization	For further study	For further study

- Btag, Etag (Beginning-End Tag) fields:
  - Allows segment loss detection over CPCS-PDU
  - Same tag value transmitted in header and trailer
  - Changed for each CPCS-PDU such that all values (0-255) are cycled through before reused.

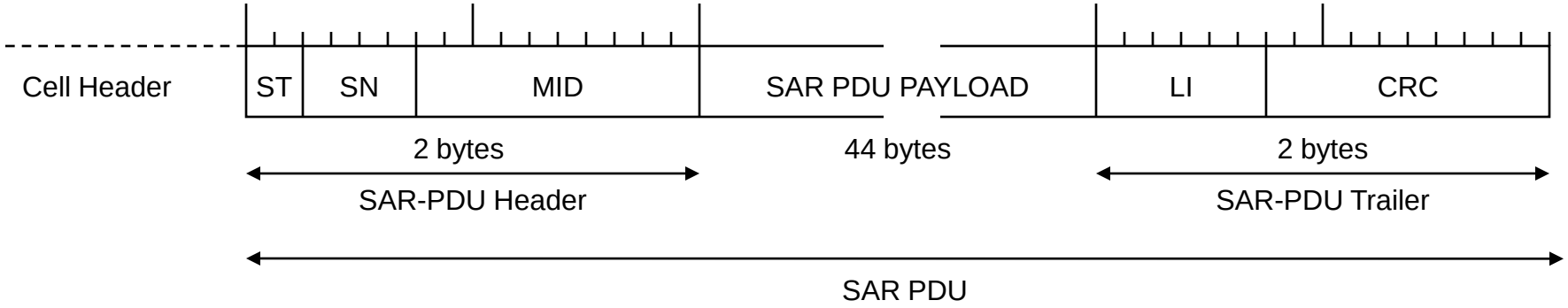
CPCS-PDU Fields (2)

- PAD: Padding
  - 0 to 3 octets set to 0, such that CPCS-PDU is padded out to 32-bit boundary
- AL: Alignment
  - Achieve 32-bit alignment in the CPCS-PDU trailer. Otherwise unused.

AAL 3/4 - SAR Functions

- Preservation of SAR-SDU
- Error detection and handling
  - bit errors
  - lost or gained SAR-PDUs
- SAR-SDU sequence integrity
- Multiplexing / Demultiplexing
- Abort

SAR-PDU Format For AAL Type 3/4



ST	Segment type	(2 bits)
SN	Sequence number	(4 bits)
MID	Multiplexing identification	(10 bits)
LI	Length indication	(6 bits)
CRC	Cyclic redundancy check code	(10 bits)

SAR PDU Fields For AAL Type 3/4 (1)

- Segment Type
  - Used to indicate Beginning Of Message (BOM), Continuation Of Message (COM), End Of Message (EOM), Single Segment Message (SSM)
- Sequence Number
  - To detect lost or mis-inserted cells
  - Sequence number is incremented modulo 16
  - Reset when a new CS-PDU starts
- Multiplexing Identification (MID) Field:
  - Allows interleaving of SAR-PDUs from different SAR-SDUs
  - All SAR-PDUs of a SAR-SDU will have the same MID field value
  - In connection oriented applications, this capability may be used to multiplex multiple SAR connections on a single ATM layer connection on a user-by-user basis

SAR PDU Fields For AAL Type 3/4 (2)

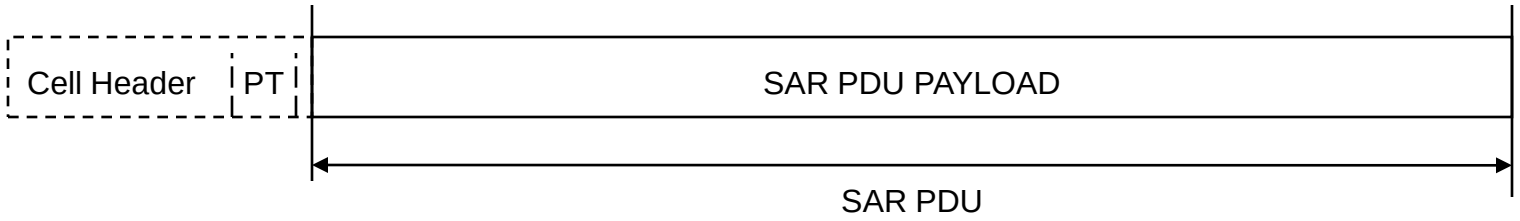
- SAR PDU Payload Field
  - CS-PDU information left justified within SAR-PDU payload field.
  - Part of SAR-PDU format not used for CS-PDU information is coded as 0.
- Payload Length Indication Field
  - For data SAR-PDU, this field must be 44 for BOM and COM, less than or equal to 44 for EOM and SSM
  - Abort SAR-PDU is indicated by segment type=EOM and payload length=63
- CRC Field
  - Value of CRC calculation performed over entire contents of SAR-PDU, including the header and LI field.
  - Polynomial: $x^{10}+x^9+x^5+x^4+x+1$

AAL Type 5

- Provides the same services as AAL Type 3/4
- More efficient SAR
- If multiplexing is used in the AAL, it occurs in the SSCS.

AAL 5 - SAR Functions

- The only function of AAL 5 SAR is to preserve the SAR-SDU



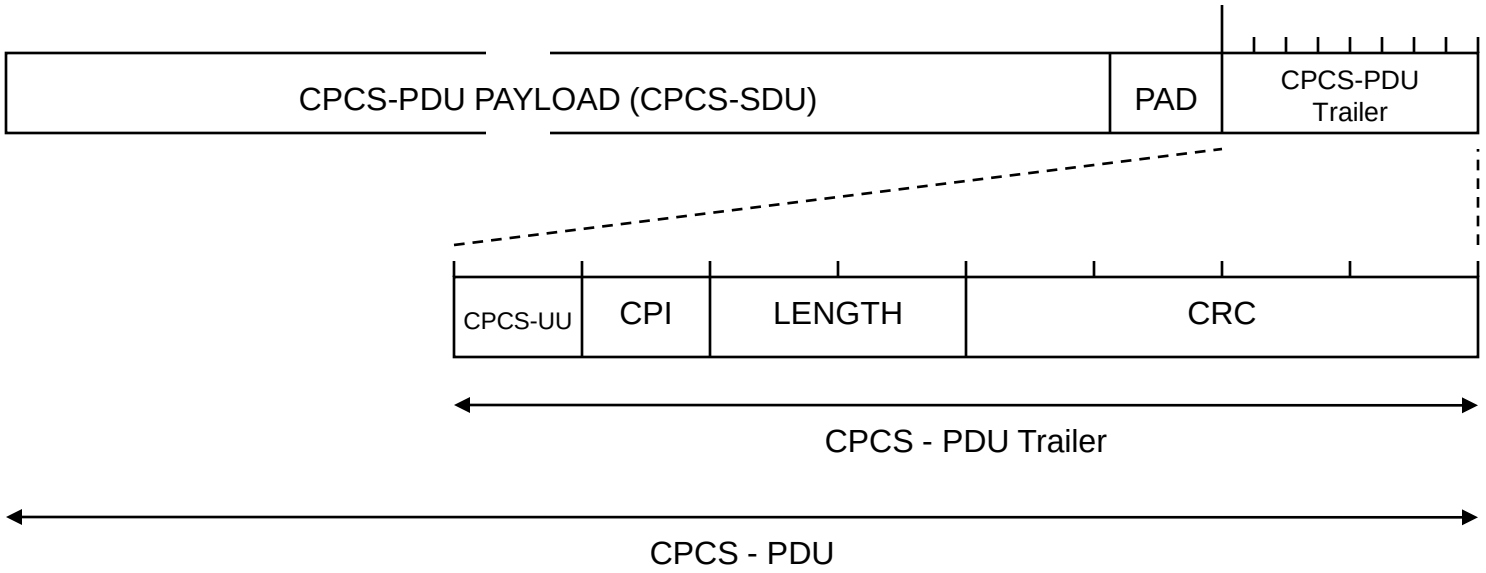
PT: Payload Type

Note: The Payload Type field belongs to the ATM header. It conveys the value of the AUU parameter end-to-end

PT=0: Beginning or continuation of SAR-SDU

PT=1: End of SAR-SDU or single-segment SAR-SDU

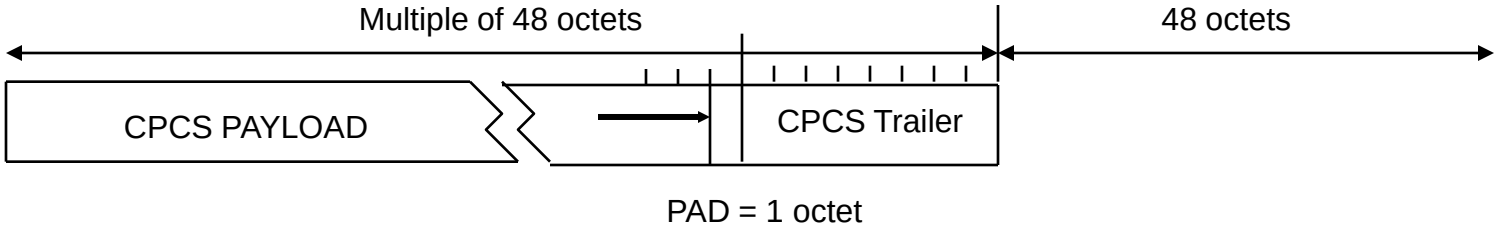
AAL 5- CPCS Structure



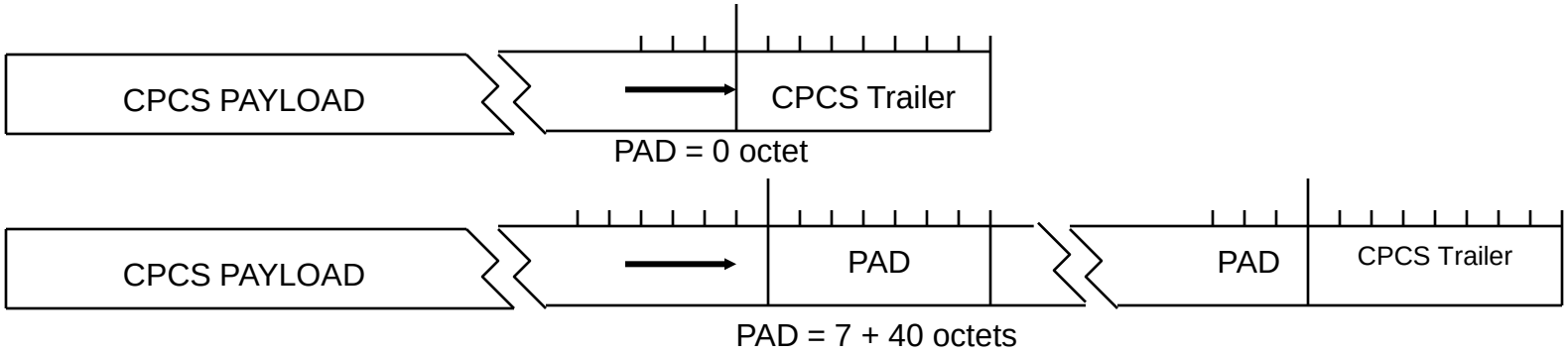
PAD	Padding	(0 … 47 octets)
CPCS-UU	CPCS user to user indication	(1 octet)
CPI	Common part indicator	(1 octet)
LENGTH	Length of CPCS-SDU	(2 octets)
CRC	Cyclic redundancy check code	(4 octets)

AAL5 CPCS-PDU Fields (1)

- PAD: Padding
  - Complements the CPCS-PDU to an integral multiple of 48 bytes



  - Examples:



AAL 5- CPCS-PDU Fields (2)

- CPCS-UU: User-to-user indication
  - This field is used to transparently transfer user-to-user information
- CPI: Common part indicator
  - Aligns the CPCS-PDU trailer to 64 bits
  - Other functions are for further study
- Length:
  - Length of the CPCS-PDU payload field in octets
- CRC:
  - CRC-32 performed over the entire contents of the CPCS-PDU (payload, pad, and the first 4 octets of the trailer)
  - Polynomial: $x^{32}+x^{26}+x^{23}+x^{22}+x^{16}+x^{12}+x^{11}+x^{10}+x^{8}+x^{7}+x^{5}+x^{4}+x^{2}+x+1$