

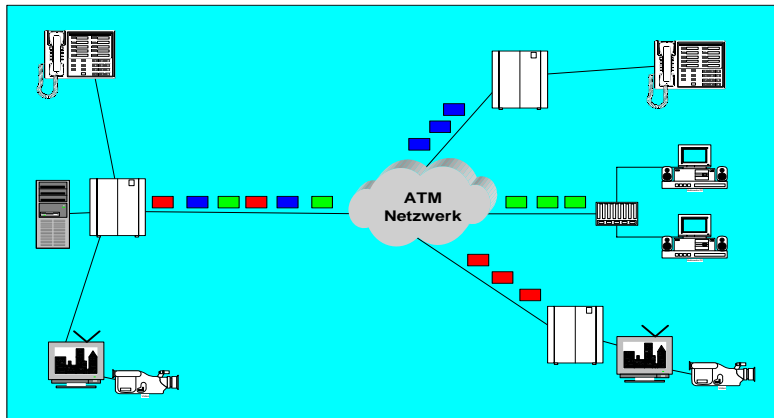
ATM-Einführung

ATM und QoS

Autor & Dozent
Dipl.-Inform. Herbert Almus

Einleitung: ATM's Vision

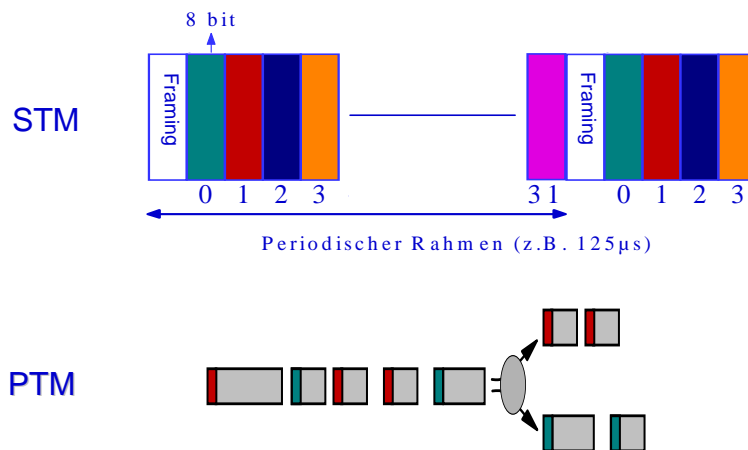
Das Integrierte Dienste-Netzwerk



- ATM-Netze übertragen Zellen (Pakete fester Länge mit geringem Delay und Jitter in hoher Geschwindigkeit)
- Endsysteme führen die Umformung (das Segmentieren und Reassemblieren) zwischen den originalen Datenpaketen und Zellen durch

ATM's Konzept

- Kombination von STM (Synchronous Transfer Mode) und PTM (Paket Transfer Mode)



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ATM's Idee: Die Zelle

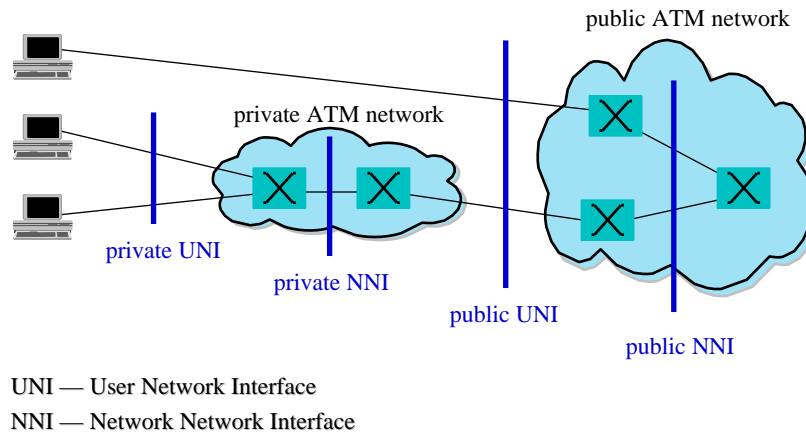


- Verwendung kleiner Übertragungseinheiten
 - ◆ vereinfacht die Übertragung von Audiodaten (z.B. Telefonie)
 - ◆ Verlust einer einzelnen Zelle bedeutet nur geringen Datenverlust
- Header mit kurzem Verbindungs-Identifizier
 - ◆ Statistisches Multiplexing verschiedener Verbindungen über gemeinsame Übertragungsstrecken.
- ATM-Historie
 - ◆ 1986 als Basis für B-ISDN beschlossen
 - ☞ Entwicklung begann 1988 durch CCITT
 - ◆ ATM Forum (gegründet 1991)
 - ☞ Schwerpunkt: ATM als LAN Technologie

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Interfaces / B-ISDN Konfiguration



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Standardisierungs-Organisationen

- ITU-T (International Telecommunications Union, Telecommunications Standardization Sector)
- ANSI (American National Standard Institute, Standards für Nord-Amerika)
- ETSI (European Telecommunications Standards Institute, Europäische Standards)
- TTC (Telecommunications Technology Committee, Japanische Standards)
- IETF (Internet Engineering Task Force RFCs betrifft IP über ATM)
- ATM Forum
 - ◆ Spezifikationen für ATM im lokalen / privaten Bereich

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ATM Spezifikationen (Auswahl)

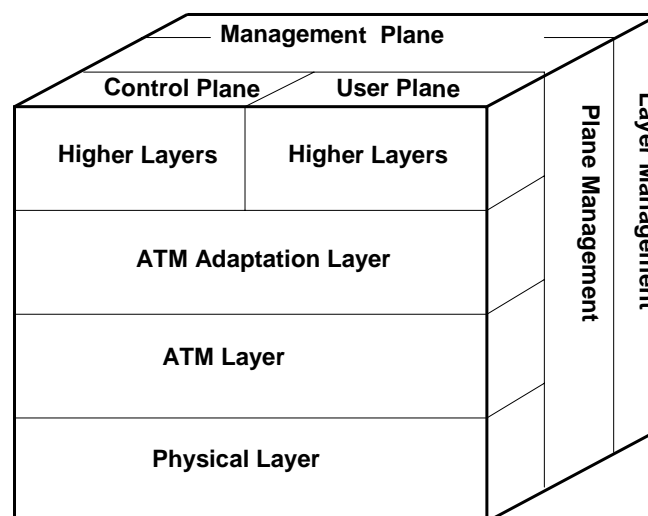
■ ATM Forum

- ◆ UNI 3.0 / 3.1 / 4.0 (User-Network-Interface)
- ◆ ILMI (Integrated Local Management Interface)
- ◆ LAN Emulation V 2.0
- ◆ PNNI V1.0
- ◆ Traffic Management V4.0 / 4.1

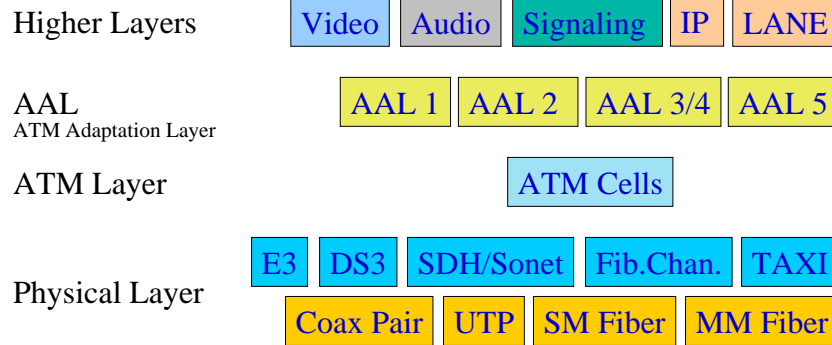
■ IETF

- ◆ IP over ATM (RFC 1483 / RFC 1577 / RFC 1755)
- ◆ Default IP MTU for use over ATM AAL5 (RFC 1626)
- ◆ Ipng Support for ATM Services (RFC 1680)
- ◆ IP over ATM: A Framework Document (RFC 1932)

B-ISDN Protocol Reference Model



B-ISDN Layers / ATM Layer Model



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Higher Layers

- End-to-End Services, Encapsulation, Services Layers
- End-to-End-Services:
 - ◆ Video, Audio, Transport Protocols (TCP/IP, IPX, ...)
- Encapsulation (SNAP, LLC, ...)
- Services
 - ◆ Cell Relay Service, MPEG2, SMDS SIP-3, ILMI, SNMP, Frame Relay, LAN Emulation, ATM Forum UNI / P-NNI, Q.2931, ...

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ATM Adaptation Layer

- assembliert und reassembliert Datenpakete oder Bitfolgen
- definiert verschiedene AAL Protokolle (AAL1, AAL2, AAL3/4, AAL5)
 - ◆ besteht aus einem spezifischen SAR-Sublayer (segmentation and reassembly) und CS-Sublayer (convergence) .
 - ◆ SAR ist zuständig für das Mapping der PDUs (der höheren Layer) in die ATM-Zellen
 - ◆ CS ist dienstespezifisch.
 - ☞ Typische Funktionen: Behandlung von Cell Delay Variation (CDV), clock frequency recovery, transfer of structure information, forward error correction.

ATM Layer

- Multiplexing und Demultiplexing von Zellströme über eine gemeinsame physikalische Leitung
- Generierung bzw. Entfernung der Cell-Header an den Endpunkten der ATM-Verbindungen (ATM-Endsysteme)
- Zuständig für die GFC-Funktion (Generic Flow Control)
 - ◆ existiert nur an der UNI-Schnittstelle
- Umsetzung der ATM-Verbindungsidentifikatoren
- Traffic Management
 - ◆ Sicherstellung der Einhaltung der Übertragungsanforderungen

Physical Layer

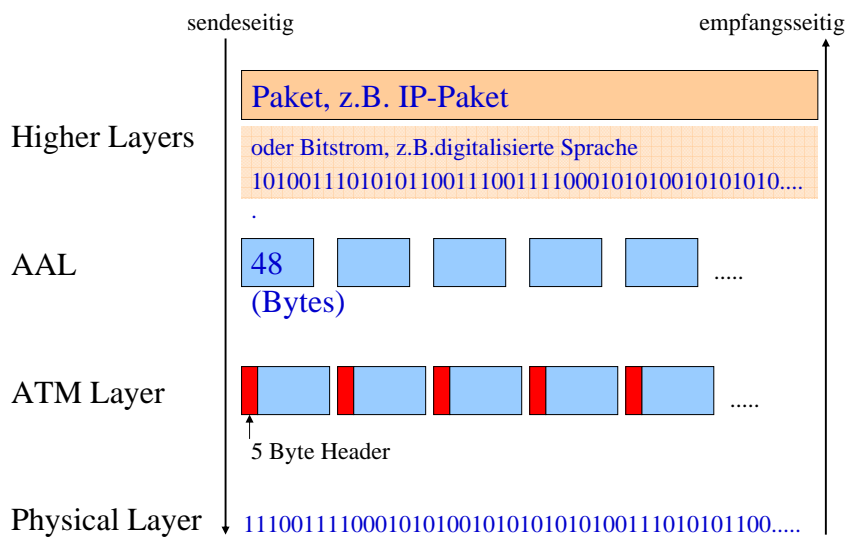
- TC-Sublayer (Transmission Convergence)
- PM-Sublayer (Physical Medium)

- TC sublayer
 - ◆ Senden und Empfangen der transmission frames
 - ◆ Cell delineation (Erkennung der cell boundaries)
 - ◆ HEC-Generierung (Header Error Control)
 - ◆ Cell rate decoupling
- PM sublayer
 - ◆ beinhaltet nur die für das physikalische Übertragungsmedium spezifischen Funktionen
 - ◆ realisiert die physikalische Übertragung inkl. Bit Alignment und, falls erforderlich, des Line Coding und der elektrisch-optischen Umsetzung

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Information / Übertragung



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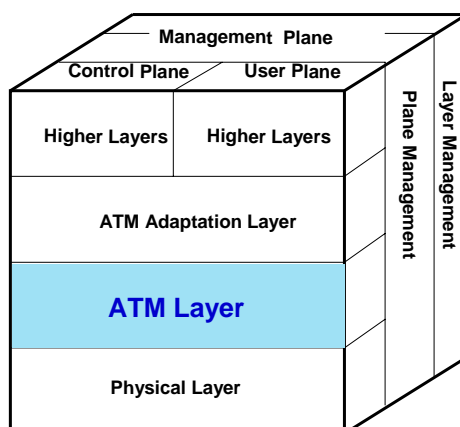
B-ISDN Planes

- Management Plane
 - ◆ Layer management
 - ☞ Layer-spezifische Aufgaben (z.B. OAM-Datenfluß)
 - ◆ Plane management
 - ☞ Management-Funktionen bezüglich Gesamtsystem
 - ☞ Koordinierung zwischen allen Planes
- User Plane
 - ◆ Übertragung der Benutzerdaten (user data)
 - ◆ erforderliche Mechanismen (flow control, error recovery usw.)
- Control Plane
 - ◆ Verbindungs-Kontrolle (call control)
 - ◆ Kontrolle der Verbindungen (connection control)

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ATM-Layer



- Transparente Übertragung der Zellen
 - ◆ Anwendungs-unabhängig, für anwendungsspezifische Aspekte ist der AAL zuständig
- Cell (De)Multiplexing
 - ◆ (De)Multiplexing der ATM-Zellen in/aus einem kontinuierlichen Zellstrom
 - ◆ Einfügung von „idle“ oder „unassigned“ cells (cell rate decoupling)
- Bearbeitung des Cell-Headers
 - ◆ Generierung, Modifizierung und Entfernung

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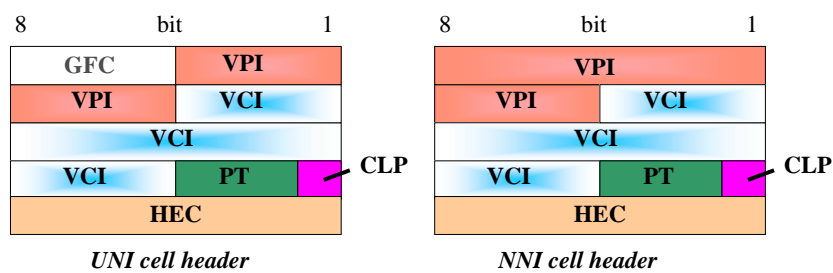
Funktionen des ATM-Layer

- Quality of Service (QoS) Policing für jede Verbindung
 - ◆ QoS wird beim Verbindungsaufbau ausgehandelt
 - ◆ QoS Parameter: peak cell rate, cell delay variation tolerance (CDVT) (optional), sustainable cell rate (optional), burst tolerance (optional)
- Sicherstellung der Einhaltung der QoS-Parameter (Traffic shaping)
 - ◆ Traffic Monitoring, Veranlassung von geeigneten Aktionen bei Überschreitungen (z.B. Verwerfen von Zellen)
- Congestion Control
- Error Management — OAM cells (F4–F5)
- Flow control (GFC) am UNI
- Meta-Signaling

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ATM Zell-Header



- GFC — generic flow control
- VPI / VCI — virtual path / channel identifier
- PT — payload type
- CLP — cell loss priority
- HEC — header error control

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ATM Zell-Header Aufbau

- GFC — generic flow control
 - ◆ definiert für lokale Datenflußkontrolle
 - ◆ Die Nutzung ist noch nicht spezifiziert (Wert daher immer 0).
- VPI — virtual path identifier
 - ◆ 8 Bit-Feld im UNI-Header, 12 bit im NNI-Header
 - ◆ adressiert den Virtual Path einer ATM-Verbindung; der Default-Wert ist 0. Bei „idle cells“, Meta-Signaling- und OAM-Zellen ist der Wert ebenfalls 0.
- VCI — virtual channel identifier
 - ◆ Dieses Feld (16 Bits) adressiert den Virtual Channel einer ATM-Verbindung; der Default-Wert ist 0. Bei „idle cells“ ist der Wert ebenfalls 0. Ansonsten gibt es vordefinierte Werte für besondere Aufgaben.

ATM Zell-Header Aufbau (2)

Payload Type

000	user data cell, congestion not experienced, SDU-type = 0
001	user data cell, congestion not experienced, SDU-type = 1
010	user data cell, congestion experienced, SDU-type = 0
011	user data cell, congestion experienced, SDU-type = 1
100	Segment OAM F5 flow related cell
101	End-toEnd OAM F5 flow related cell
110	Resource Management Cells for Available Bit Rate (ABR)
111	Reserved for future functions

ATM Zell-Header Aufbau (3)

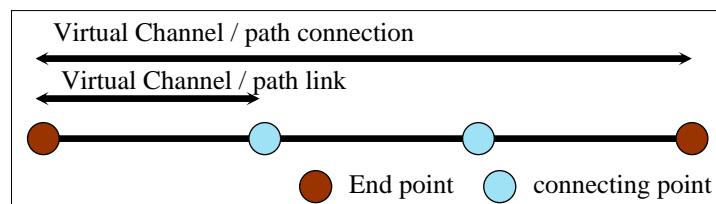
- CLP — Cell Loss Priority
 - ◆ 3 unterschiedene Situationen: cell passing, cell tagging, cell discarding
 - ◆ Beim Auftreten von Congestion werden Zellen mit low priority (CLP=1) als erste verworfen.
 - ◆ Submitted Loss Priority
 - CLP, mit der die Zelle vom AAL an den ATM-Layer übergeben wird
 - ◆ Received Loss Priority
 - CLP, die der ATM-Layer beim Hochreichen der Zelle an den AAL übergibt.
- HEC — Header Error Control
 - ◆ Das HEC-Byte enthält eine 8-Bit CRC-Checksumme über die ersten 4 Bytes des Headers.

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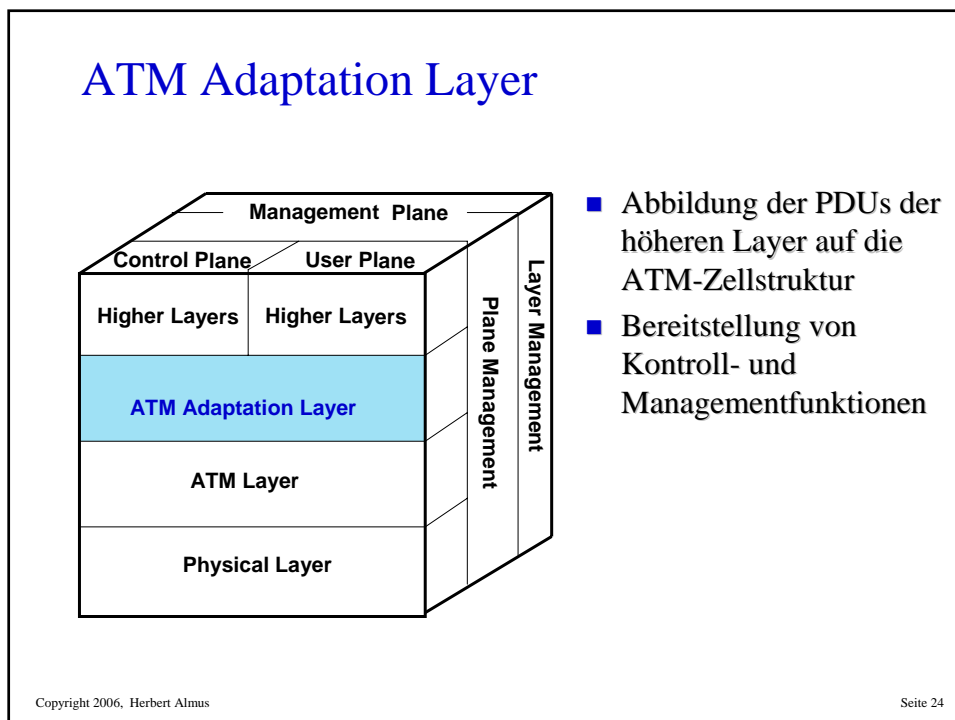
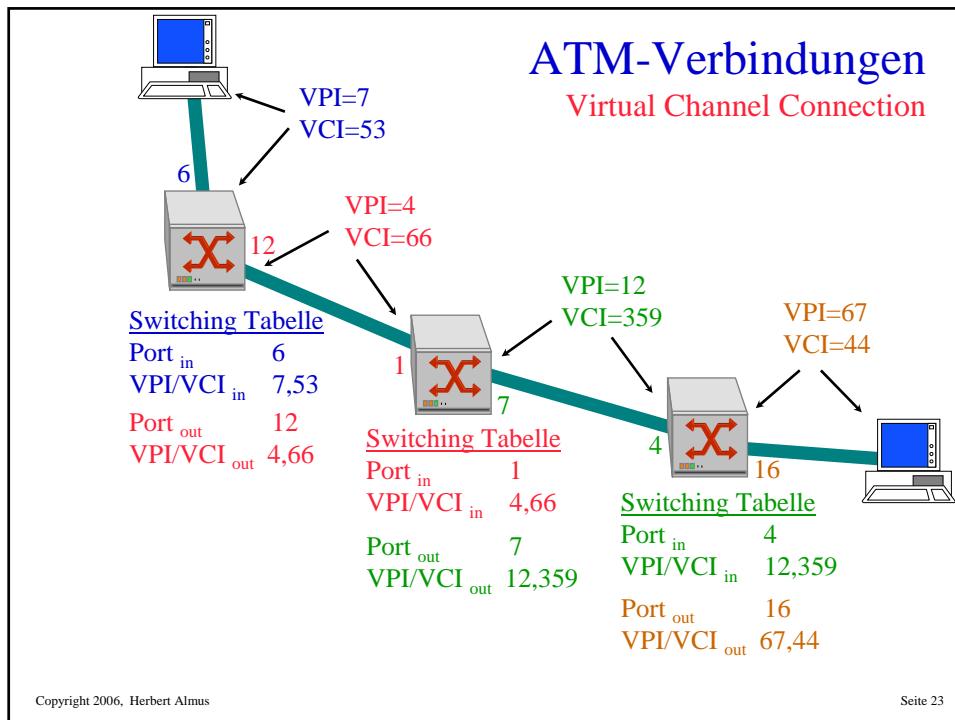
ATM Verbindungstypen

- virtual channel connections
- virtual path connections
- Verbindungsarten
 - ◆ point-to-point
 - ◆ point-to-multipoint
- Verbindungsaufbauarten
 - ◆ statisch (PVC - permanent virtual circuits)
 - ◆ dynamisch (SVC - switched virtual circuits)



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AAL Sublayers

AAL	CS	Convergence Sublayer
	SAR	Segmentation and Reassembling Sublayer

- CS – Convergence Sublayer
 - ◆ Service Specific Convergence Sublayer (SSCS)
 - ☞ dienstespezifischer AAL-SAP
 - ◆ Common Part Convergence Sublayer (CPCS)
- SAR – Segmentation and Reassembly Sublayer
 - ◆ Segmentation und Reassembling des 48-Bytes großen Informationsfelds der ATM-Zelle

AAL Service Classes

Service Classes	Class A	Class B	Class C	Class D
Timing Relation between source and destination	Required		Not required	
Bit rate	Constant	Variable		
Connection mode	Connection-oriented			Conn.-less
Adaptation Type	AAL 1	AAL 2	AAL 3/4 , AAL 5	

- Verbindungsart (connection mode)
 - ◆ Class A: Circuit Emulation; konstante Bitrate, Video
 - ◆ Class B: variable Bitrate , Video und Audio
 - ◆ Class C: verbindungsorientierte Datenübertragung
 - ◆ Class D: verbindungsloser Datentransfer

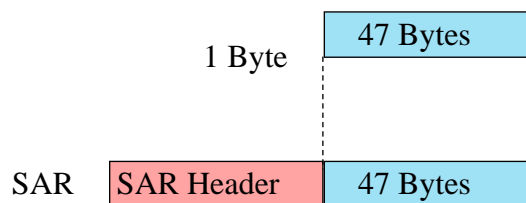
AAL Typ 1

- verbindungsorientierte Übertragung von
 - ◆ SDUs mit constant bit rate
 - ◆ timing information / structure information
- Funktionen
 - ◆ Segmentation and Reassembly
 - ◆ Bitfehlerüberprüfung
 - ◆ Behandlung von
 - ☞ cell delay variation / cell payload assembly delay
 - ☞ lost and misinserted cells / AAL-PCI bit errors
- Rückgewinnung von
 - ☞ source data structure
 - ☞ source clock frequency

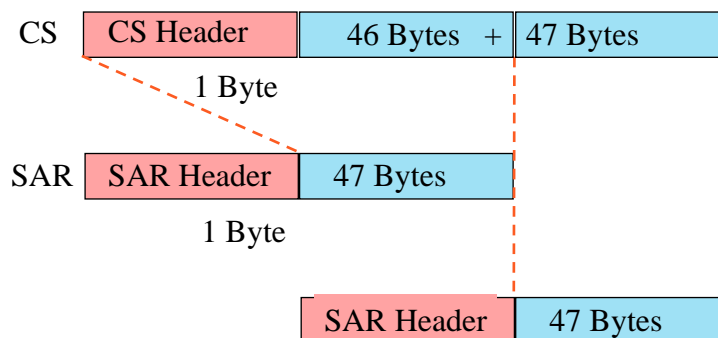
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Unstructured data



Structured data

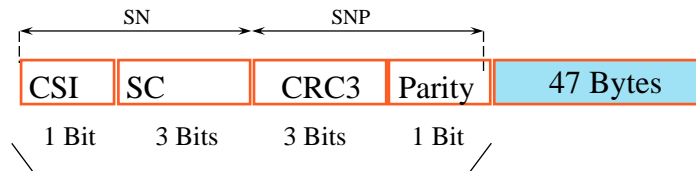


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AAL1 SAR

- 1 Byte SAR Header



- SN – Sequence Number
 - ◆ CSI – CS Indication – 1 Bit
 - ◆ SC – Sequence Count – 3 Bits
- SNP – SN Protection
 - ◆ single-bit error correction
 - ◆ multiple-bit error detection
 - ◆ CRC – Cyclic Redundancy Check
 - ◆ Parity Bit
 - ☞ SAR führt die Berechnung und Überprüfung des SNP zur Fehlererkennung und -behandlung durch

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AAL 1 CS (1)

- Behandlung von
 - ◆ cell delay variation durch Einsatz eines Buffers (Einfügen von Dummy-Bits oder Entfernen von Bits)
 - ◆ lost and misinserted cells (durch Verarbeitung des sequence count, den der SAR liefert)
- Übertragung der user information
 - ◆ circuit (emulation)
 - ◆ video/voice-band signal
 - ☞ 1 Bit AAL-SDUs für Circuit-Transport
 - ☞ 1 Oktett AAL-SDU für Video/Audio
 - ◆ structured data
 - ☞ Information über den Beginn von Datenblöcken
- forward error correction (FEC)
 - ◆ mittels Reed-Solomon (128,124)-Kodierung

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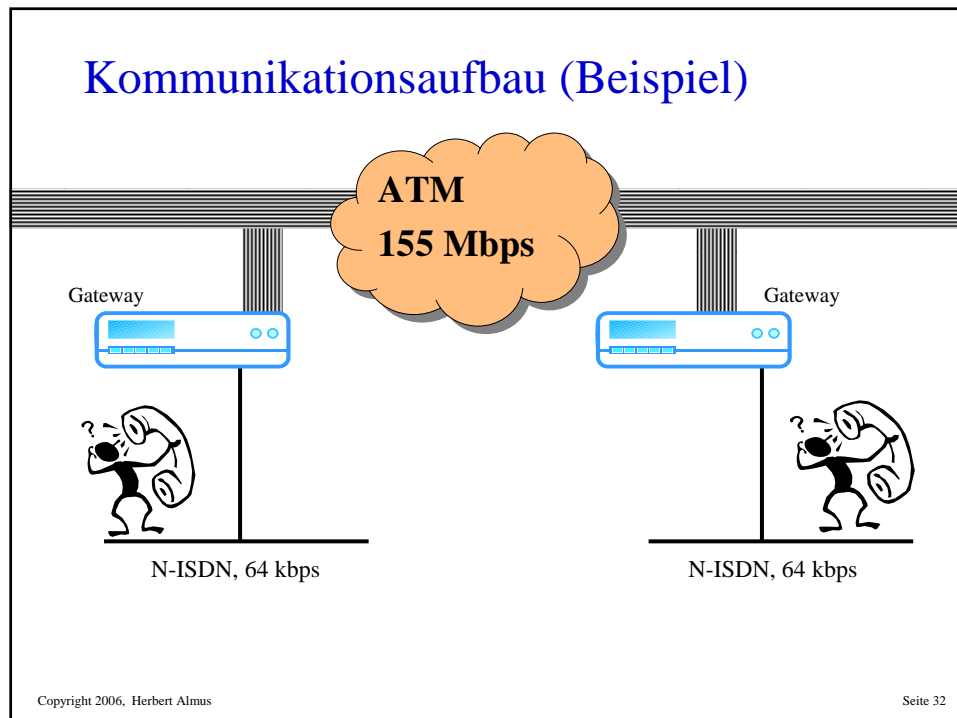
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AAL 1 CS (2)

■ Timing

- ◆ Lieferung der AAL-SDUs mit konstanter Bitrate
- ◆ Source Clock Frequency Recovery:
 - ☞ Synchronous Residual Time Stamp (SRTS) Verfahren
 - Messung und Übertragung der Differenz zwischen der Anwendungsrate (Service-Clock) und der Netzwerkdatenrate (Network-Clock)
 - benutzt das CSI zur Übertragung eines 4-bit RTS
 - ☞ Adaptive Clock Methode
 - Anpassung über Pufferungsverfahren

Kommunikationsaufbau (Beispiel)



Source Clock Frequency Recovery (1)

Synchronous Residual Time Stamp (SRTS)

fs – service clock
 fn – network clock
 fnx – derived network clock
 N – period of RTS in cycles of the service clock of frequency fs
 T – period of RTS in seconds
 M(Mnom, Mmax, Mmin) – number of fnx cycles within a RTS period
 Mq – largest integer smaller than or equal to M

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Source Clock Frequency Recovery (2)

Example: 64 kbit/s ISDN Service

- ISDN service clock frequency: $f_s = 64 \text{ kHz} \pm \Delta f_s$
- period of RTS in cycles of f_s :
 $N = 8 \text{ PDU} \cdot 47 \text{ Byte/PDU} \cdot 8 \text{ bit/Byte} = 3008$
- period of RTS in seconds:
 $T = \frac{N}{f_s} = 47 \text{ ms} \pm \text{tolerance}$
- chosen tolerance of T :
 $\text{max tolerance} = T \cdot \pm 10^{-3} = \pm 47 \mu\text{s}$
- STM-1 common network clock frequency:
 $f_n = 155.52 \text{ MHz}$
- derived network clock frequency:
 $1 < \frac{f_{nx}}{f_s} \leq 2 \Rightarrow f_{nx} = f_n \cdot 2^{-11} = 75.94 \text{ kHz}$
- number of f_{nx} cycles within a RTS period:
 $M_{nom} = \lceil T \cdot f_{nx} \rceil = 3569$
 $M_{min}, M_{max} = M_{nom} \pm \lceil \text{max. tolerance} \cdot f_{nx} \rceil = 3569 \pm 4$

SAR-Header			
CSI	SC	SNP	
X	0	XXXX	
1	1	XXXX	<div style="text-align: right; border: 1px solid black; padding: 2px;">RTS = 1011</div>
X	2	XXXX	
0	3	XXXX	
X	4	XXXX	
1	5	XXXX	
X	6	XXXX	
1	7	XXXX	

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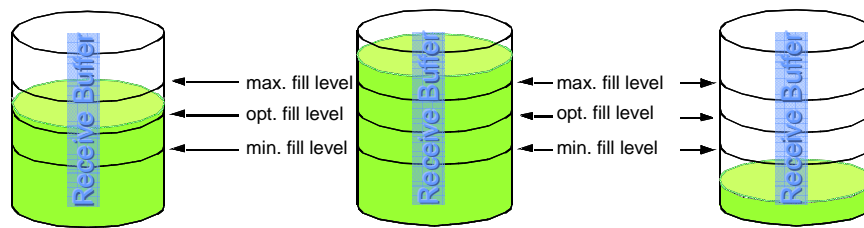
Source Clock Frequency Recovery (3)

Adaptive Clock Method

Service Clock des Ziels läuft

... zu langsam

... zu schnell

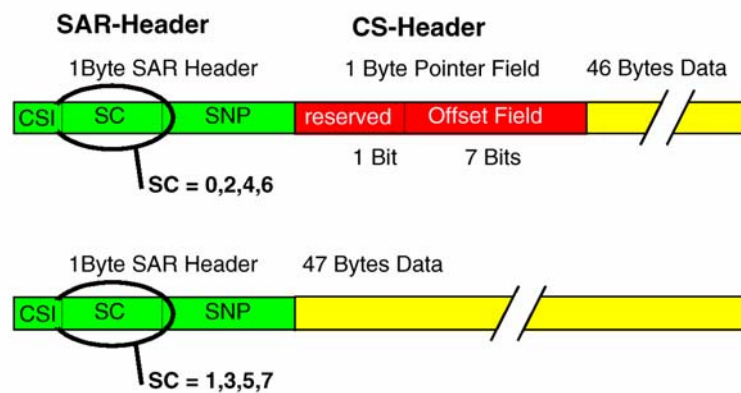


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Übertragung strukturierter Daten

- Beispiele strukturierter Daten:
 - Reed Solomon Code (Forward Error Correction)
 - MPEG Synchronisationsframes

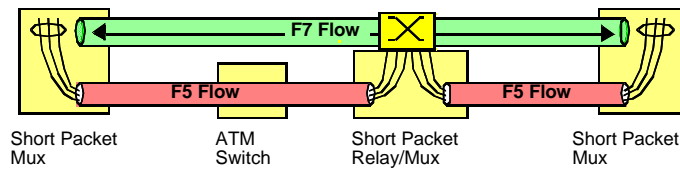


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AAL2 Konzept

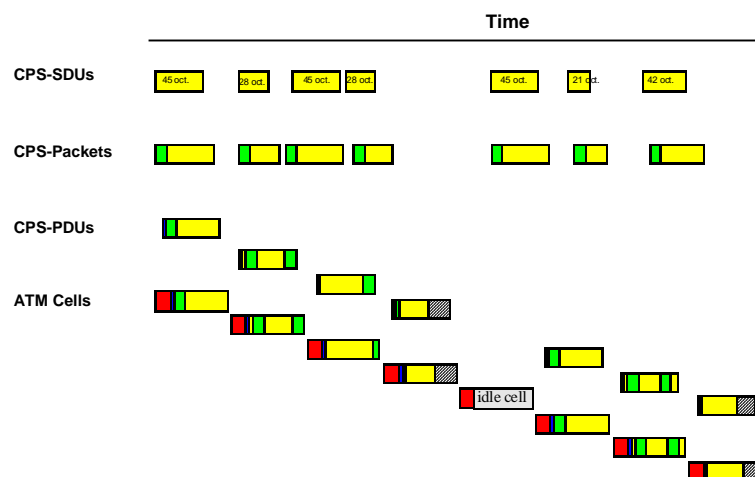
- AAL2 bildet ein „Overlay-Netzwerk zum ATM
- **Short Packet Switching** - Netzwerk
 - ◆ verbindungsorientiert, nur Punkt-zu-Punkt-Verbindungen
 - ◆ Paketgröße festgelegt durch **Negotiation Procedure (ANP)**
 - ☞ 64 Byte fest oder 0 .. 45 Byte variable
 - ◆ Definition eines OAM F7 Fluß für
 - ☞ AAL2 Negotiation Procedure
 - ☞ AAL2 Channel Management



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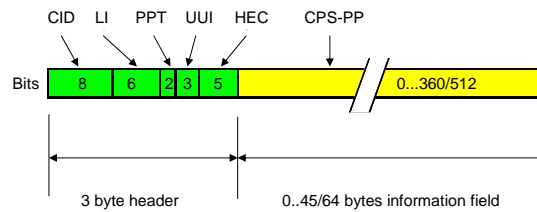
AAL2 Übertragung



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CPS-Packet Format

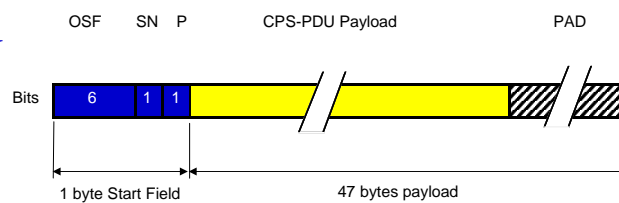


- CPS-PP — CPS Packet Payload
- CID — Channel Identifier
 - ◆ identifiziert den User des AAL2 channel
- LI — Length Indication
 - ◆ Länge der CPS Packet Payload
- PPT — Packet Payload Type
 - ◆ user data, management function
- UII — User-to-User Indication
- HEC — Header Error Control

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CPS-PDU Format



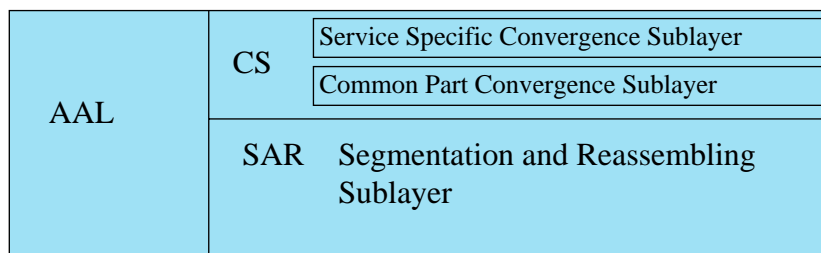
- OSF — Offset Field
 - ◆ offset zwischen Ende des STF und Beginn des ersten CPS-Pakets oder dem Padding
- SN — Sequence Number
- P — Parity
 - ◆ 8 bit parity is odd
- PAD — Padding
 - ◆ Alignment to ATM-SDU

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AAL Typ 3/4

- Message Mode / Streaming Mode
- Garantierte (assured) und nicht garantierte (non-assured) Datenübertragung
- CS unterteilt in Service Specific und Common Part Sublayer
- Point-to-Point und Point-to-Multipoint (ATM layer) Verbindungen (unterstützt durch den CPCS)



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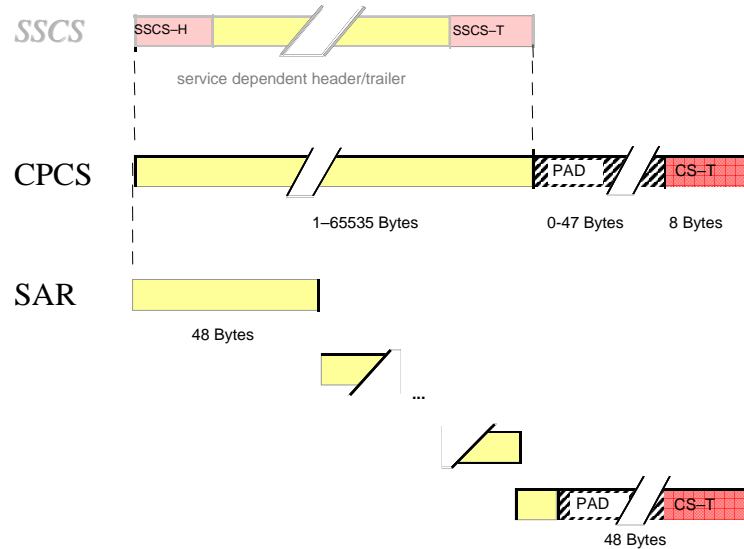
AAL5

- vereinfachter AAL 3/4
- Message-Mode und Streaming-Mode wie in AAL 3/4
- Übertragungsarten (assured / non-assured data transfer) wie in AAL 3/4
- CS unterteilt in Service Specific und Common Part Sublayer (wie in AAL 3/4)
- Point-to-Point und Point-to-Multipoint (ATM layer) Verbindungen (unterstützt durch den SSCS)

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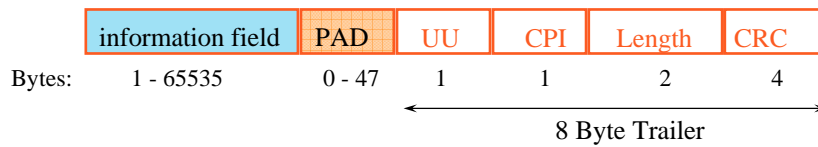
AAAL5 Überblick



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AAAL5 CS



- information field, variable Länge
- PAD - Padding, variable Länge
- UU - CPCS User-to-User Indication
 - ◆ zur Nutzung durch Higher Layers
- CPI - common part indicator
 - ◆ Füll-Byte (kodiert mit 0)
- Length - Länge des information field
- CRC - Cyclic Redundancy Check
 - ◆ über information field, PAD, UU, CPI und Length

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AAL5 CPCS - Funktionen

- Fehlererkennung und Behandlung
 - ◆ Verwerfen der PDU oder Lieferung einer *error indication*
- Behandlung von
 - ◆ congestion information
 - ◆ loss priority information

durch Lieferung der Information an niedrigere / höhere Layer

AAL5 SAR

- SAR-SDU sequence continuity
 - Markierung: begin (0) und end (1) der CPCS-PDU im PT-Feld des ATM-Headers

ATM cell header

GFC	VPI	
VPI	VCI	
VCI		
VPI	PT	CLP
HEC		

Traffic Management



Generelle Zielsetzung

- Realisierung von
 - ◆ Quality of Service (QoS)
 - ◆ Übertragung entsprechend ausgehandeltem Verkehrsvertrag
- Sicherung eines stabilen und zuverlässigen Netzbetriebes
- Behandlung von unerwarteten Netzwerkengpässen
- effiziente, optimale Nutzung von Netzwerk-Ressourcen

- Traffic Management erfolgt auf dem ATM Layer, d.h. nur auf Zell-Ebene

- Standards / Drafts:
 - ◆ ATM Forum UNI 3.1 und Traffic Management 4.0
 - ◆ ITU-T Recommendation I.371

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Elemente des Traffic Management

- Verbindungsaufbau/-abbau
 - ◆ Benutzer wählt Traffic Parameter aus
 - ◆ Connection Admission Control (CAC) überprüft, ob aktuell der Aufbau einer Verbindung mit diesen Parametern möglich ist
- Verbindungs-Phase
 - ◆ Traffic shaping: Benutzer liefert vertragskonformen Datenstrom und setzt / löscht CLP-Bit
 - ◆ Usage Parameter Control (UPC). Netzwerk überprüft Datenstrom auf Einklang mit vereinbarten Verkehrsparametern
 - ◆ Netzwerk markiert / verwirft nicht-konforme Zellen unter Berücksichtigung der Cell Loss Priority
 - ◆ Netzwerk Congestion Control
 - ☞ reduziert den Effekt unerwarteter Engpässe
 - ☞ (optionale) Nutzung der Explicit Forward Congestion Indication

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Traffic Contract

- Ausgehandelt zwischen Benutzer und Netzwerk beim Verbindungsaufbau
- Traffic Contract ist end-to-end-signifikant
- Verbindungsaufbau erfolgt nur bei Einigung
- beinhaltet die ausgehandelten Verkehrsparameter sowie die Quality of Service Class
- beinhaltet implizit
 - ◆ eine Conformance Definition (policing algorithm) und
 - ◆ die Definition der Cell Delay Variation Tolerance (CDVT)

Quality of Service

- definiert auf Basis von End-to-End-Verbindungen,
 - ◆ spezifisch für jeden VPC oder VCC
 - ◆ festgelegt durch QoS-Parameter
 - ☞ cell error ratio, cell loss ratio
 - ☞ cell misinsertion rate
 - ☞ cell delay, mean cell transfer delay, cell delay variation
- QoS Classes (vereinfachte QoS-Klassifizierung)
 - ◆ Class 0 - Unspecified - Best Effort (At Risk)
 - ◆ Class 1 - specified - Circuit Emulation, CBR
 - ◆ Class 2 - specified - VBR Video/Audio
 - ◆ Class 3 - specified - Connection-oriented Data
 - ◆ Class 4 - specified - Connectionless Data
- TM V4.0:
 - ◆ ABR - Available Bit Rate

ATM Layer Service Architektur

Service Category	Example Applications
Constant Bit Rate CBR	Applications sending data streams with constant bit rates: uncompressed videoconferencing ISDN telephony TV programme exchange (studio quality) radio
Real-Time Variable Bit Rate rt-VBR	Applications sending real-time data streams with variable, but well-defined bit rates: compressed videoconferencing (MPEG), remote education and training, compressed telephony, video on demand distribution
Non-Real-Time Variable Bit Rate nrt-VBR	VBR applications without real-time constraints: response time critical transaction processing, e.g. airline reservations, banking transactions
Available Bit Rate ABR (new in UNI4.0)	VBR applications sending data streams with probabilistic (not well-defined) bit rates: high speed interactive service (e.g. CAD/CAM) medical image transfer LAN interconnection remote terminal
Unspecified Bit Rate UBR	Applications without throughput requirements: data file transfer low quality ABR applications

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Zuordnung Attribute zu Service-Kategorien

Attribute		Service Category				
		CBR	rt-VBR	nrt-VBR	ABR	UBR
Traffic Parameters	Peak Cell Rate (PCR) for CLP ^a =0+1	always specified				
	Peak Cell Rate (PCR) for CLP=0	specified if necessary				
	Cell Delay Variation Tolerance (CDVT)	implicitly specified				
	Sustainable Cell Rate (SCR), Maximum Burst Size (MBS)	n/a	specified either for CLP=0+1 or for CLP=0		n/a	
	Minimum Cell Rate (MCR)	n/a			specified	n/a
Quality of Service Parameters	peak-to-peak Cell Delay Variation (CDV)	specified		unspecified		
	mean Cell Transfer Delay (CTD)	unspecified		specified	unspecified	
	maximum CTD	specified		unspecified		
	Cell Loss Ratio (CLR)	specified			specified ^b	unspecified

a.Cell Loss Priority, explained later

b.expect low values for flow-controlled traffic; provision of CLR is network-specific

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Peak Cell Rate

The graph shows bandwidth on the y-axis and time on the x-axis. A red curve represents the bandwidth usage over time. A horizontal line is drawn at the peak of the curve, labeled 'PCR'. Below the x-axis, five intervals are marked with double-headed arrows and labeled T1, T2, T3, T4, and T5. Below these intervals, five points are marked with red text: t0, t1, t2, t3, t4, and t5. Vertical lines connect the T intervals to the t points.

$PCR := 1 / \min \{T_i\}$

In einer UBR-Verbindung wird der Wert zwar gesetzt, hat aber keinerlei Bedeutung!

T_i : inter-arrival time of the requests for all i
t_i : arrival time of a request for sending a cell

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Sustainable Cell Rate / Maximum Burst Size

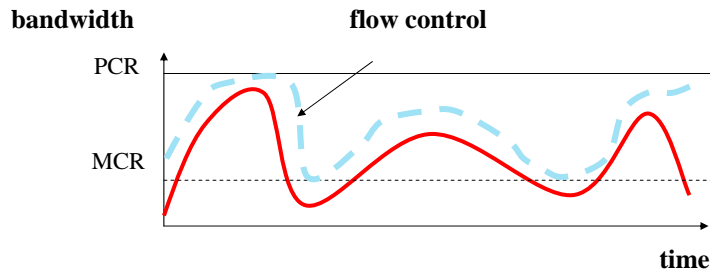
The graph shows bandwidth on the y-axis and time on the x-axis. A red curve represents the bandwidth usage over time. A horizontal dashed line is drawn at a level below the PCR line, labeled 'SCR'. Three yellow brackets are placed under the curve, each labeled 'Burst', indicating periods where the bandwidth usage exceeds the SCR.

- Sustainable Cell Rate (SCR)
 - obere Grenze der durchschnittlichen Zellrate
 - erlaubt *statistisches Multiplexen*
- Maximum Burst Size (MBS)
 - maximale Anzahl aufeinanderfolgender Zellen, die oberhalb der SCR gesendet werden dürfen
 - Generic Cell Rate Algorithm (GCRA) definiert SCR und MBS (formale Definition)
- Burst Tolerance
 - alternative Beschreibung für SCR/MBS

$$BT = \frac{MBS - 1}{\frac{1}{SCR} + \frac{1}{PCR}}$$

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Minimum Cell Rate (MCR)



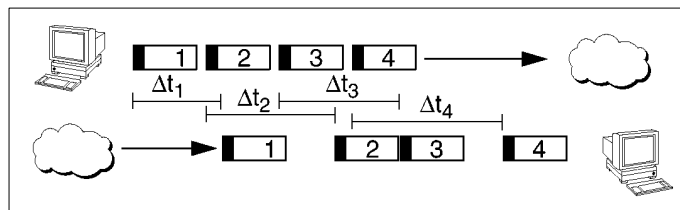
- genutzt bei ABR-Verbindungen
- Netzwerk garantiert MCR
- unterhalb MCR verhält sich die Verbindung wie CBR
- MCR ist immer kleiner gleich PCR, $MCR = 0$ ist zulässig
- Netzbetreiber können MCR begrenzen auf $PCR - \epsilon$

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Quality of Service Parameter

- Cell Loss Ratio
 - ◆ $CLR = \text{Lost Cells} / \text{Transmitted Cells}$
- Mean Cell Transfer Delay (mean CDT)
 - ◆ arithmetisches Mittel der Zeit zwischen Zellversand (source) und Zelleingang (destination)
- Maximum Cell Transfer Delay (max CTD)
- Peak-to-Peak Cell Delay Variation



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Traffic Shaping

Beispiel

- 2 Anwendungen

Multiplexed data (without shaper)

Shaped data

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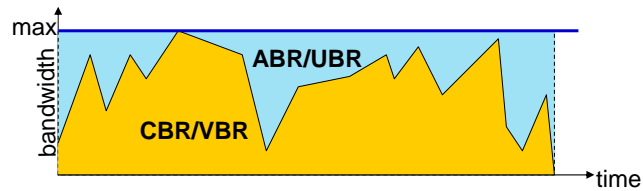
Beispiel: CDVT

Legend:

- Δ : cell duration (time for sending 53 bytes)
- T: nominal interarrival time of a request for sending an ATM cell according to PCR
- $ta(i)$: arrival time
- TAT(i): theoretical arrival time $\star ta(i-1) + T$

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TM4.0 ABR Resource Management



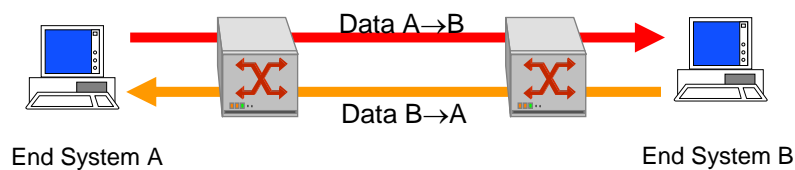
- Ziel
 - ◆ schneller Zugriff auf aktuell ungenutzte Bandbreite
 - ◆ Verbesserung der Ausnutzung des Netzwerk in Umgebungen, in denen VBR (statistisches Multi'plexing) eingesetzt wird
 - ◆ Realisierung einer besseren QoS als sie UBR liefert
 - ☞ Ziel: Minimierung der Zellverluste

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Open vs. Closed Loop

CBR, VBR, UBR: Open Loop



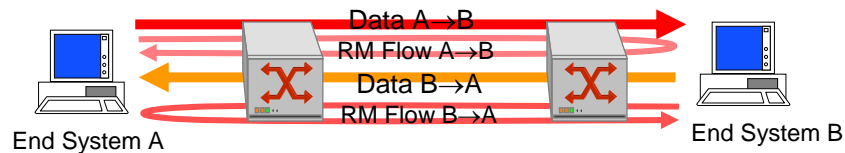
- Kein Feedback
 - ◆ keine Information über Netzengpässe
- Ressourcen-Reservierung zur Zeit des Verbindungsaufbaus
 - ◆ Reservierung von mehr Bandbreite als erforderlich (over-allocation)

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Open vs. Closed Loop

ABR: Closed Loop



- Resource Management (RM) Cell Flows

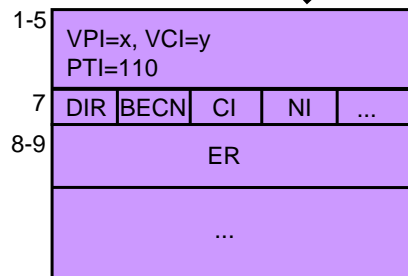
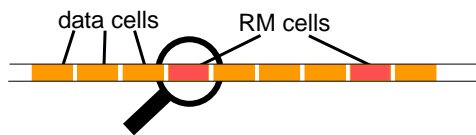
- ◆ Mitteilung der verfügbaren Bandbreite an den Sender
- ◆ RM Cell Flow erfolgt parallel zum Datenfluß
- ◆ Ein RM Cell Flow pro unidirektionalen Datenfluß erforderlich

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Resource Management Cell

- ◆ RM-Zellen sind durch den anderen Payload Type Indicator eindeutig erkennbar
- ◆ RM-Zellen werden alle n Daten-Zellen eingefügt



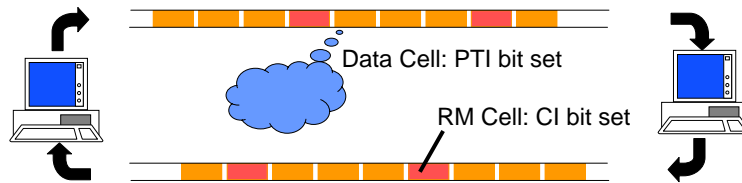
- ◆ DIR: Cell Direction forward/backward
- ◆ BECN: Backward Explicit Congestion Notification
- ◆ CI: Congestion Indicator
- ◆ NI: No Source Rate Increase
- ◆ ER: Explicit Cell Rate

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EFCI Flow Control

Explicit Forward Congestion Indication

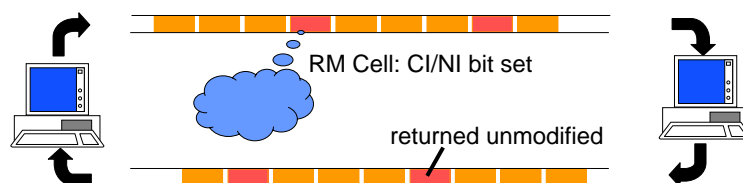


- ◆ Switche kennen kein ABR, setzen nur PTI Congestion Bit
- ◆ Ziel liest PTI congestion bit aus den User-Datenfluß
- ◆ Ziel sendet RM-Zellen mit Congestion Indication (CI) Bit gesetzt, wenn Zellen mit gesetztem PTI Congestion Bit eintreffen
- ◆ Quelle empfängt RM-Zellen und adaptiert entsprechend die Senderate
- ◆ Vorteil: einfach, keine Unterstützung in den Switches erforderlich
- ◆ Nachteil: hohe Latenzzeit, geringe Information (schneller / langsamer)

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Relative Rate Flow Control

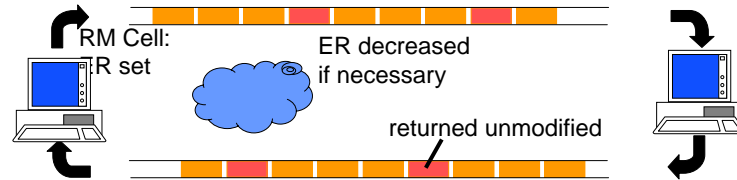


- ◆ Switche setzen Congestion Indication (CI) Bit in RM-Zellen
- ◆ Switches können ebenso No Source Rate Increase (NI) Bit in RM -Zellen setzen
- ◆ Ziel sendet RM-Zellen unmodifiziert zurück
- ◆ Quelle empfängt die RM-Zellen und adaptiert die Übertragungsrate
- ◆ Vorteil: einfach, bessere Performanz als EFCI (early switch action)
- ◆ Nachteil: geringe Information (schneller / langsamer)

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Explicit Rate Flow Control

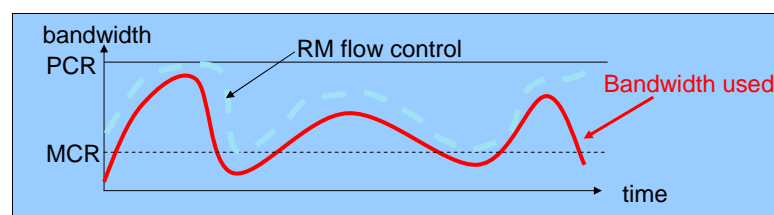


- ◆ Quelle setzt Explicit Cell Rate (ER) auf die gewünschte Bandbreite
- ◆ Switches im Netz reduzieren die ER, falls
- ◆ Ziel sendet RM-Zellen unmodifiziert zurück
- ◆ Quelle adaptiert die Übertragungsrates entsprechend dem empfangenen ER-Wert
- ◆ Vorteil: exakte Information
- ◆ Nachteil: komplex, Switches müssen eine faire Verteilung der Bandbreite unter konkurrierenden ABR-Anforderungen realisieren.

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Minimum Cell Rate (MCR)

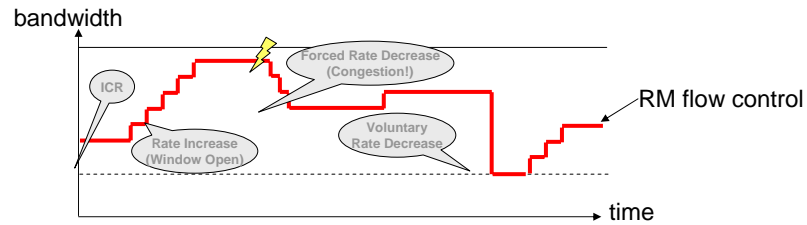


- ◆ Die RM-Flußkontrolle ermittelt nur Werte zwischen **Minimum Cell Rate** und **Peak Cell Rate** ($MCR \leftrightarrow PCR$)
- ◆ Das Netzwerk garantiert, daß mindestens die MCR verfügbar ist.
- ◆ Unterhalb der MCR verhält sich eine ABR-Verbindung wie eine CBR-Verbindung
- ◆ MCR ist maximal identisch mit PCR
- ◆ MCR=0 ist erlaubt

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ABR Parameters



- ◆ ICR (Initial Cell Rate) die anfangs zu nutzende Bandbreite
- ◆ Nrm definiert, nach wie viel Datenzellen eine RM-Zelle gesendet werden darf.
- ◆ Trm definiert den maximalen zeitlichen Abstand zwischen 2 RM -Zellen.
- ◆ RIF (Rate Increase Factor) definiert, mit welcher Rate der Sender die Übertragung erhöhen darf bei Empfang einer "good" RM-Zelle
- ◆ RDF (Rate Decrease Factor) definiert, mit welcher Rate der Sender die Übertragung zu verringern hat bei Empfang einer "bad" RM-Zelle.

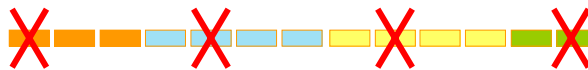
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Frame Discard



Konventionelles Vorgehen: Zellen werden bei Überlast statistisch verteilt verworfen (führt im Beispiel zum Verlust von 66 % der Frames)



Bessere Methode: statt einzelner Zellen komplette AAL5-Frames zu verwerfen.

Führt in diesem Beispiel zu nur 33 % Frame-Verlust (bei gleicher Zellverlustrate)



Realisierung: Switch kontrolliert PTI-Feld zur Bestimmung der Framegrenzen (SDU-Type = 1 kennzeichnet letzte Zelle eines AAL5-Frames)

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Herzlichen Dank!



Fragen?

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Anhänge

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CES Referenzen

- UNI 3.1, ATM Forum User-Network Interface (UNI) Specification
- af-bici-0013.003, ATM Forum Broadband Inter-carrier Interface (B-ICI) Specification v2.0
- ANSI T1.630-1993, B-ISDN ATM Adaptation Layer CBR Services
- ANSI T1.627-1993, B-ISDN ATM Layer Functionality and Specification
- ITU-T I.356-1993 B-ISDN ATM layer cell transfer performance
- ITU-T I.362-1993 B-ISDN ATM adaptation layer (AAL) functional description
- ITU-T I.363.1 1996, B-ISDN ATM Adaptation Layer (AAL) Specification, Types 1 and 2

- ANSI T1.101-1994, Synchronization Interface Standard
- ANSI T1.102-1993 Revised - Digital Hierarchy - Electrical Interfaces
- ANSI T1.107-1995, Digital Hierarchy - Formats specifications
- ANSI T1.403-1995, Carrier-to-Customer Installation - DS1 Metallic Interface
- ANSI T1.404-1994, Carrier-to-Customer Installation - DS3 Metallic Interface Specification
- ANSI T1.408-1990, Integrated Services Digital Network (ISDN) Primary Rate -- Customer Installation Metallic Interfaces Layer 1 Specification
- ANSI T1.510-1994, Network Performance Parameters for Dedicated Digital Services - Specifications.

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CES Referenzen (2)

- ITU-T G.824-1993, The control of jitter and wander within digital networks which are based on the 1544 kbit/s digital hierarchy
- Bellcore TR-NWT-000170, Issue 2, January, 1993, Digital Crossconnect System Generic Requirements and Objectives

- ITU-T G.702-1988 Digital hierarchy bit rates
- ITU-T G.703-1991 Physical/electrical characteristics of hierarchical digital interfaces
- ITU-T G.704-1995 Synchronous frame structures used at 1544, 6312, 2048, 8488 and 44736 kbit/s hierarchical levels
- ITU-T G.707-1996 Network node interface for the synchronous digital hierarchy (SDH)
- ITU-T G.823-1993, The control of jitter and wander within digital networks which are based on the 2048 kbit/s digital hierarchy

- IETF RFC1573, Evolution of Interfaces Group of MIB-II, January 1994.
- IETF RFC TBD, Definitions of Managed Objects for the DS3/E3 Interface Type, Date TBD.
- IETF RFC TBD, Definitions of Managed Objects for the DS1, E1, DS2 and E2 Interface Types, Date TBD.

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CES Referenzen (3)

- IETF RFC TBD, Definitions of Managed Objects for the DS0 and DS0 Bundle Interface Types, Date TBD.
- IETF RFC1595, Definitions of Managed Objects for the SONET/SDH Interface Type, March 1994.
- TTC Recommendation JT-G.704, Synchronous Frame Structures Used at Primary and Secondary Hierarchical Levels.
- TTC Recommendation JT-G.703a, Secondary Rate User-Network Interface of Leased Line - Layer 1 Specification.
- ISO/IEC 11573 (1994), Synchronization methods and technical requirements for Private Integrated Services Networks.

ATM Standards and recommendations

- The following organizations are working in the field of ATM standardization
- ITU-TS
 - ◆ (formerly CCITT), focus on international standards
- ETSI
 - ◆ (European Telecommunication Standardization Institute) development of European standards
- Specifications are developed by:
- ATM Forum
 - ◆ vendor driven organization with different technical groups
 - ◆ groups are established only on demand
- IETF -> RFC's
 - ◆ one of the task forces of the Internet Activities Board
 - ◆ small group of core participants
 - ◆ document result: RFC
 - ◆ interim reports in IETF Proceedings
- ITU-TS
 - The ATM related standards are in the following series:
 - ◆ E - General provisions concerning Administrations, users, accounts
 - ◆ G - International telephone connections and international telephone circuits
 - ◆ I - ISDN - General structure - Terminology
 - ◆ M - Principles of maintenance and maintenance organization
 - ◆ Q - Signaling in international services

ITU ATM related recommendations

- E.164 - addressing
- G.702 - Digital Hierarchy Bit Rates
- G.703 - Physical/electrical Characteristics of Hierarchical Digital Interfaces
- G.704 - Synchronous Frame Structure used at Primary and Secondary Hierarchical Levels
- G.706 - Frame Alignment and Cyclic Redundancy Check (CRC) Procedures relating to Basic Frame Structures defined in Recommendation G.704
- G.707 - Synchronous Digital Hierarchy Bit Rates
- G.708 - Network-Node Interface for the Synchronous Digital Hierarchy
- G.709 - Synchronous Multiplexing Structure
- I.113 - Vocabulary of Terms for Broadband Aspects of ISDN
- I.121 - Broadband Aspects of ISDN
- I.142 - B-ISDN Meta-Signaling
- I.150 - B-ISDN ATM Functional Characteristics
- I.211 - B-ISDN Service Aspects
- I.311 - B-ISDN General Network Aspects
- I.321 - B-ISDN Protocol Reference Model and its Application
- I.327 - B-ISDN Network Functional Architecture
- I.350 - Quality of Service (QoS) for Bearer Service and Tele Service
- I.356 - B-ISDN ATM Layer Cell Transfer Performance
- I.361 - B-ISDN ATM Layer Specification
- I.362 - B-ISDN ATM Adaptation Layer (AAL) Functional Description
- I.363 - B-ISDN ATM Adaptation Layer (AAL) Specification
- I.364 - Support of broadband connectionless data service on B-ISDN
- I.371 - Traffic and Congestion control in B-ISDN
- I.413 - B-ISDN User-Network Interface
- I.414 - Overview of Recommendations on layer 1 for ISDN and B-ISDN customer accesses
- I.430 - Layer 1 Specification at the Basic Rate
- I.431 - Layer 1 Specification at the Primary Rate User-Network Interface
- I.432 - B-ISDN User-Network Interface Physical Layer Specification
- I.441 - ISDN User-Network Interface Data Link Layer Specification

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ITU ATM related recommendations

- I.600 - Application of Maintenance Principles to ISDN Subscriber Access and Subscriber Installation
- I.610 - OAM Principles of B-ISDN Access
- M.20 - Maintenance Philosophy for Telecommunications Network
- M.30 - Principles for a Telecommunication Management Network
- M.36 - Principles for the Maintenance of ISDNs
- Q.2010 - General Introduction to Signaling in B-ISDN
- Q.2100 - B-ISDN Signaling AAL, overview
- Q.2110 - AAL, SSCOP
- Q.2120 - Meta-Signaling Protocol
- Q.2130 - SSCF at UNI
- Q.2140 - SSCF at NNI
- Q.2931 - Signaling in B-ISDN

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ETSI ATM related recommendations

- European standards developed by ETSI:
 - User Network Interface
 - ◆ pr ETS 300 299
 - ◆ pr ETS 300 300
 - ATM Layer
 - ◆ pr ETS 300 298-1
 - ◆ pr ETS 300 298-2
 - Resource Management / Traffic Control
 - ◆ pr ETS 300 301
 - ATM Adaptation Layer
 - ◆ DE / NA - 52617 (AAL 1)
 - ◆ DE / NA - 52618 (AAL 3/4)
 - ◆ DE / NA - 52619 (AAL 5)
 - ◆ DE / NA - 52620
 - Operating and Maintenance
 - ◆ DE / NA - 52209
 - ◆ DTR / NA - 52204
 - ◆ DE / NA - 52806
- User Network Interface Signaling
 - ◆ DE / SPS - 5024 (Basic Calls)
 - ◆ DE / SPS - 5034 (Supplementary service)
- Signaling AAL
 - ◆ DE / SPS - 5026 -1
 - ◆ DE / SPS - 5026 -2
- Address ETSI:
 - ETSI Secretariat
 - 06921 Sophia Antipolis
 - Route des Lucioles, Vallebonne
 - Tel.: +33.92944200
 - Fax: +33.93654716

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ATM Forum

- Goal:
 - Acceleration of ATM products and services deployment through rapid convergence on interoperability specifications and promotion of industry cooperation.
- Characterization:
 - ◆ world-wide non-profit organization
 - ◆ vendor driven, founded by Northern Telecom, US Sprint, Cisco and Adaptive Corp. in 1991
 - ◆ more than 800 members (spring 1997)
- principal members
 - ◆ get all information, are expected to contribute full time people
 - ◆ pay \$10.000 per year
- auditing members / user members
 - ◆ get a lot of information (especially all draft specifications), can attend plenary or general meetings
 - ◆ pay \$1.500 per year
- Approved ATM-Forum Specifications
 - WWW-Page to order or download the above specifications:
 - http://www.atmforum.com/atmforum/spec_order.html
- Technical Working Groups
 - ◆ Physical Layer
 - ◆ Signaling
 - ◆ Private NNI
 - ◆ Network Management
 - ◆ Traffic Management
 - ◆ B-ICI
 - ◆ Service Aspects and Applications
 - ◆ LAN Emulation
 - ◆ Testing
 - ◆ Multiprotocol
 - ◆ Residential Broadband
 - ◆ ...
- Groups are established only on demand!

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RFCs

- In the area of ATM networking different Requests for Comment (RFC's) were developed and presented within the framework of the internet engineering task force (IETF):
- RFC 1483 - Multiprotocol Encapsulation over ATM Adaptation Layer 5.
- RFC 1754 - IP over ATM Working Group's Recommendations for the ATM Forum's Multiprotocol BOF. Version 1. January 1995
- RFC 1577 - Classical IP and ARP over ATM.
- RFC1755 - UNI Signaling Support for IP over ATM
- RFC 1626 - Default IP MTU for use over ATM AAL5.
- RFC 1680 - IPng Support for ATM Services.
- RFC 1695 - Definitions of Managed Objects for ATM Management Version 8.0 using SMI v2.
- RFC 1821 - Integration of realtime services in IP ATM
- RFC 1932 - IP over ATM: A Framework Document

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Abkürzungen

- | | |
|--|--|
| <ul style="list-style-type: none"> ■ AA - administrative authority ■ AAE - abgesetzte ATM Einheit ■ AAL - ATM adaptation layer ■ ABR - Available Bitrate ■ ADM - add/drop multiplexer ■ AFI - authority and format identifier ■ AIS - alarm indication signal (SDH) ■ AL - alignment ■ AMS - audiovisual multimedia services ■ ANP - AAL2 negotiation procedure (AAL2) ■ ANSI - american national standard institute ■ APS - automatic protecting switching ■ ARP - address resolution protocol ■ ASC - american standards committee ■ ASN.1 - abstract syntax notation one ■ ATDM - asynchronous time division multiplexing ■ ATE - ATM terminating equipment ■ ATM - asynchronous transfer mode ■ ATMR - ATM Ring ■ ATV - advanced television ■ AU - administrative unit OR access unit | <ul style="list-style-type: none"> ■ BALI - Berlin ATM LAN Interconnection ■ BAsize buffer allocation size ■ BCD - binary coded digit ■ BCOB - Broadband Connection Oriented BearerB-ICI - Broadband Intercarrier Interface ■ B-ISDN - broadband integrated services digital network ■ B-ISUP broadband ISDN user part ■ BE - beginning-end-tag ■ BECN - backward explicit congestion notification ■ Bellcore - Bell Communication Research ■ BER - bit error rate ■ B-ET - exchange termination for B-ISDN ■ BGREJ - begin reject ■ BIP - bit interleave parity ■ B-ISDN - broadband integrated service digital network ■ B-LT - line termination for B-ISDN ■ B-NT1 - network termination equipment type 1 for B-ISDN ■ B-NT2 - network termination equipment type 2 for B-ISDN |
|--|--|

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Abkürzungen

- BOC - Bell operating company
- BOM - begin of message
- bps - bits per second
- BRI - basic rate interface
- BT - burst tolerance
- Btag - begin tag
- B-TA - terminal adapter for B-ISDN
- B-TE1 - terminal equipment type 1 for B-ISDN
- B-TE2 - terminal equipment type 2 for B-ISDN
- BUS - broadcast and unknown server

- CAC - connection admission control
- CBDS - connectionless broadband data service
- CBOS - connectionless broadband data service
- CBR - constant bit rate
- CC - connection control timer
- CCITT - Comité Consultatif International Téléphonique et Telegraphique
- CCR - Current Cell Rate
- CDV - cell delay variation
- CDVT - CDV tolerance
- CEO - customer equipment

- CEPT - conference of european postal & telecommunication administration
- CER - cell error ratio
- CIR - committed information rate
- CL - connectionless (service)
- CLDS - connectionless data service
- CLNAP - connectionless network access protocol
- CLNIP - connectionless network interface protocol
- CLNP - connectionless network protocol
- CLNS - connectionless network service
- CLP - cell loss priority
- CLR - cell loss ratio
- CLS - connectionless server
- CLSF - connectionless service-function
- CMI - coded mark inversion
- CMIP - common management information protocol
- CMIS - common management information service
- CMISE - CMIS element
- CMR - cell misinsertion rate
- CN - customer network
- CNM - customer network management

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Abkürzungen

- CO - connection oriented (service) OR central office
- COM - continuation of message
- CONS - connection oriented network services
- CPCS - common part convergence sublayer (AAL)
- CPE - customer premises equipment
- CPI - common part identifier
- CPS - Common Part Sublayer (AAL2)
- CPS-PP - CPS packet payload (AAL2)
- CRC - cyclic redundancy check
- CRF(VC) - virtual channel connection related functions
- CRF(VP) - virtual path connection related functions
- CS - convergence sublayer
- CSA - canadian standards association
- CSI - CS Indication
- CSU - channel service unit
- CSMA/CD - carrier sense multiple access with collision detection
- CVs - coding violatons

- DA - destination address
- DACS - digital access and cross-connect system
- dB - decibel
- dBm - decibel (referencing 1 mW)
- DFI - domain specific part format identifier
- DCC - data communication channel
- DCC - data country code
- DCE - data circuit terminating equipment
- DCS - digital cross-connect system
- DE - discard eligible
- DLCI - data link connection identifier
- DNA - digital network architecture
- DoD - department of defense
- DQDB - distributed queue dual bus
- DSP - digital signal processor
- DSS - distributed sample scrambler
- DSU - data service unit OR digital switching unit
- DSX - digital signal cross-connect
- DS-x - digital signal x (i.e. x=3, DS-3)
- DTE - data terminal equipment
- DTMF - dual tone multifrequency
- DXC - digital cross-connect
- DXI - data exchange interface

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Abkürzungen

- EA - extended address
- ECSA - exchange carriers standards association
- EDFG - Edge Device Functional Group
- EFCI - explicit forward congestion indication
- EFI - errored frame indicator (DS3)
- EMA - enterprise management architecture
- END - end
- ENDAK - end acknowledgment
- EOC - embedded operations channel
- EOM - end of message
- ES - errored seconds
- ESI - end system identifier
- ET - exchange termination
- Etag - end tag (AAL3/4)
- ETSI - european telecommunications standards institute
- FCS - frame check sequence
- FC - forward congestion indicator
- FDDI - fiber distributed data interface
- FDM - frequency division multiplexing
- FEBE - far end block error (PDH)
- FEC - forward error correction
- FECN - forward explicit congestion notification
- FERF - far end receive failure (SDH)
- FFOL - FDDI follow-on-LAN
- FG - Functional Group
- FIFO - first in first out
- FOT - fiber optic terminal
- fps - frames per second
- FR - frame relay
- FRM - fast resource management
- FTAM - file transfer access and management
- FTP - file transfer protocol
- FTTC - fiber to the curb
- FTTH - fiber to the home
- GCRA - generic cell rate algorithm
- GFC - generic flow control
- GPS - Navstar global positioning satellite
- GSM - global system for mobile communications
- GW - gateway

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Abkürzungen

- HBFG - Host Behavior Functional Group
- HEC -header error control
- HDLC - high-level data link control
- HDTV - high definition television
- HIPPI - high performance parallel interface
- HSC - header check sequence
- HSLAN - high speed LAN
- HSSI - high speed service interface
- Hz - Hertz (cycles per second)
- IAB - internet activity board
- ASG - Internetwork Address Sub-Group
- IASGid - Internetwork Address Sub-Group Identifier
- IBSG - Internetwork Broadcast Sub-Group
- IBUFG - Internetwork Broadcast/Unknown Functional Group
- ICD - international code designator
- ICFG - IASG Coordination Function Group
- ICI - interexchange carrier interface
- ICMP - internet control message protocol
- IDLC - integrated digital loop carrier
- IDMR - inter domain multicast routing
- IDU - interface data unit
- IE - information element
- IEEE - institute of electrical and electronic engineers
- IETF - internet engineering task force
- IISP - interim interswitch Signaling protocol
- ILMI - integrated local management interface
- IN - intelligent network
- InARP - inverse address resolution protocol
- IP - internet protocol
- I-PNNI - integrated private network-network interface
- IPX - internetwork packet exchange
- ISDN - integrated services digital network
- ISO - international standards organization
- ISSI - inter-switching system interface
- ISUP - ISDN user part
- ITU - international telecommunication union
- ITU-TS - telecommunication standardisation sector of ITU
- IUT - implementation under test
- IWU - interworking unit

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Abkürzungen

- JPEG - joint photographic experts group
- LAN - local area network
- LANE - LAN Emulation
- LAP-B - link access procedure balanced (X.25)
- LAP-D - link access procedure D (ISDN)
- LAP-F - link access procedure F
- LATA - local access and transport area
- LBA - leaky bucket algorithm
- LE - layer entity
- LEC - LANE client (LANE)
- LEC - local exchange carrier
- LECS - LANE configuration server
- LEN - local exchange node
- LES - LANE server (LANE)
- LGN - logical group node
- LI - length indication
- LIS - logical IP subnet (Classical IP)
- LLC - logical link control
- LL-ID - loopback location identification
- LME - layer management entity
- LMI - local management interface
- LOCS - loss of cell synchronization (SDH)
- LOF - loss of framing (SDH)
- LOH - Line overhead
- LOP - loss of pointer (SDH)
- LOPS - loss of PRBS synchronization (SDH)
- LOS - loss of signal
- LSB - least significant bit
- LSCR - loss of scrambler synchronization (SDH)
- LT - line termination
- LTE - line terminating equipment (SDH)
- LUNI - LANE UNI
- MAC - media access control
- MAN - metropolitan area network
- MARS - multicast address resolution server
- MAU - media access unit
- MBS - maximum burst size
- MCR - Minimum Cell Rate
- MIB - management information base
- MID - multiplexing identifier (ATM) OR message identifier (DQDB)
- MIS - management information system

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Abkürzungen

- MMF - multi mode fiber
- MPDU - management protocol data unit
- MPEG - motion picture experts group
- MPOA - Multiprotocol over ATM
- MS - multiplexer section
- MSB - most significant bit
- MSOH - multiplexer section overhead
- MSVC - meta-Signaling virtual channel
- MT - message type
- MTP - message transfer part
- MTU - maximum transmission unit
- MUX - multiplexer
- NRZ - non-return-to-zero code
- NSAP - network service access point
- NT - network termination
- NTSC - national television standards committee
- OAM - operation and maintenance
- OCD - out of cell delineation
- OC-x - optical carrier level x
- ODI - open data interface
- OH - overhead
- OOF - out of frame
- OS - operating system
- OSI - open system interconnection
- OSPF - open shortest path first
- OTDR - optical time domain reflector
- OUI - organizationally unique identifier
- NCP - network control point
- NDIS - network device interface specification
- NE - network element
- NFS - SUN network file system
- NI - network interconnect
- N-ISDN - narrowband ISDN
- NMS Network Management System
- NNI - network-network-interface
- NPC - network parameter control
- PABX - private automatic branch exchange
- PAD - packet assembler/disassembler
- PBX - private branch exchange
- PC - protocol control
- PCM - puls code modulation

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Abkürzungen

- PCN - personal communications network
- PCO - point of control and observation
- PCR - peak cell rate
- PDH - plesichronous digital hierachy
- PDN - public data network
- PDU - protocol data unit
- PG - peer group
- PGL - peer group leader
- PHY - physical layer
- PICS - protocol impelmentation conformance statements
- PID - protocol identification
- PIXIT protocol implementation eXtra information for testing
- PLCP - physical layer convergence protocol
- PM - physical medium
- PMD- physical medium dependent
- PNNI - private network-network interface
- POH - path overhead
- PRI - primary rate interface
- PRN - pseudo random noise
- PSPDN - packet switched public data network
- PSTN - public switched telephone network
- PT - payload type
- PTE - path terminating equipment (SDH)
- PTSE - PNNI topology state element (PNNI)
- PTSP - PNNI topology state packet (PNNI)
- PTT - postal, telegraph & telephone
- PTI - payload type indicator
- PVC - permanent virtual channel
- PVCC - permanent virtual channel connection
- PVPC - permanent virtual path connection
- QoS - quality of service
- RARP - reverse address resolution protocol
- RBOC - regional Bell operating company
- RD - routing domain
- RDI - remote defect indicator (SDH)
- RFC - request for comments
- RIP - routing information protocol
- RM - Resource Management
- ROLC - routing over large clouds
- RPC - remote procedure call

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Abkürzungen

- RSOH - regenerator section overhead (SDH)
- RSFG - Route Server Functional Group
- RT - router
- RTS - residual time stamp (AAL1)
- SA - source address
- SAAL - Signaling ATM adaptation layer (AAL)
- SAP - service access point
- SAPI - service access point identifier
- SAR - segmentation and reassembly sublayer (AAL)
- SC - sequence count (AAL)
- SCR - sustainable cell rate
- SDH - synchronous digital hierachy
- SDLC - synchronous data link control
- SDU - service data unit
- SEAL - simple and efficient AAL
- SECB - severely errored cell block ratio
- SEL - selector
- SES - severely errored seconds
- SIP - SMDS interface protocol
- SIR - sustained information rate
- SLC - subscriber loop carrier
- SMDS - switched multimegabit data service
- SMF - single mode fiber
- SN - sequence number
- SNA - system network architecture
- SNAP - subnetwork access protocol
- SNDCF - Sub-Network Dependent Convergence Function
- SNI - subscriber network interface
- SNMP - simple network management protocol
- SNP - sequence number protection
- SOH - section overhead
- SONET - synchronous optical network
- SPE - synchronous payload envelope
- SPF - shortest path first protocol
- SR - source routing
- SRTS - synchronous residual time stamp (AAL1)
- SSAP - source service access point
- SS - SMDS switching system
- SSCF - service specific coordination function
- SSCOP - service specific connection oriented protocol (SAAL)

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Abkürzungen

- SSCS - service specific convergence sublayer (AAL)
- SSS - self synchronizing sample scrambler
- SS7 - Signaling system number 7
- STDm - synchronous time division multiplexing
- STE - section terminating equipment
- STF - start field (AAL2)
- STM - synchronous transfer mode
- STM-x - synchronous transport module level x (i.e. x=1, STM-1)
- STP - shielded twisted pair OR spanning tree protocol
- STS-x - synchronous transport signal level x (i.e. x=3, STS-3)
- STS-xC - STS-x concatenated (i.e. x=3, STS-3C)
- SUT - system under test
- SVC - Signaling virtual channel
- TA - terminal adapter
- TAT - theoretical arrival time
- TC - transmission convergence sublayer (Physical Layer)
- TCP - transmission control protocol
- TDM - time division multiplexing
- TE - terminal equipment
- TM - traffic management
- TP4 - transport protocol class 4
- TTCN - tree and tabular combined notation
- TU - tributary unit
- TUG - tributary unit group
- UBR - Unspecified bitrate
- UDP - user datagram protocol
- UME - UNI Management Entity
- UNI - user-network-interface
- UPC - usage parameter control
- UPT - universal personal telecommunications
- UTP - unshielded twisted pair
- UU - user-to-user indication
- VBR - variable bit rate
- VC - virtual channel
- VC-n - virtual container n
- VCC - virtual channel connection
- VCI - virtual channel identifier

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Abkürzungen

- VLAN - virtual LAN
- VP - virtual path
- VPC - virtual path connection
- VPCI - VPC identifier
- VPI - virtual path identifier
- VPN - virtual private network
- VSA - virtual scheduling algorithm
- VT - virtual tributary
- VTG - virtual tributary group
- VTOH - virtual tributary overhead
- WAN - wide area network
- XTP - express transfer protocol

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