Review of ATM for 3G RAS 06

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Learning Element Objectives

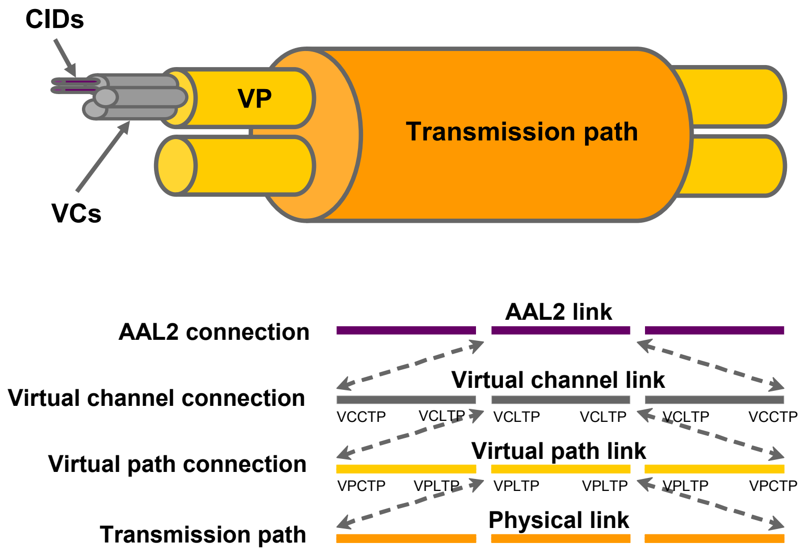
Objective of this Learning Element is to introduce essential ATM information for 3G networks using examples

- Why ATM is used for UMTS
- VP/VC structure
- AAL2/AAL5
- IMA, ATM over STM-1 VC-4
- Cross connection at VP and VC level
- ATM service categories - CBR, UBR, UBR+
- Traffic descriptor parameters
- Policing/shaping

Why ATM is used in UMTS

- Growth of mobile Internet and other mobile services will result in increasing demand for higher data transmission capacity
- UMTS is one of the evolving 3G mobile communications systems designed to meet this demand and uses ATM as transmission technology
- ATM, (Asynchronous Transfer Mode) is a compromise between circuit- and packet switched technologies
- ATM is the standardized transmission technique for assuring QoS and for supporting the variety of services offered by UMTS
- ATM will be in the future replaced by pure IP first for data services, but ATM will probably remain in the networks for some time

Hierarchy



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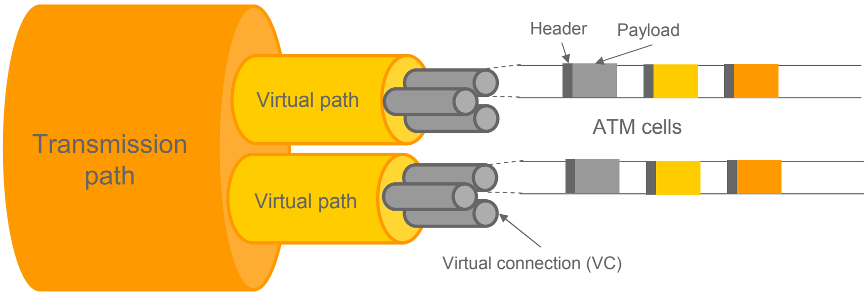
The concept of Virtual Channels and Virtual Paths



- An ATM multiplexer continuously generates ATM cells an maps traffic in or fills with dummy content
  - In ATM any data is mapped into an ATM cell with the accordant ATM adaptation layer
- The ATM cell belongs to a specific Virtual Channel
  - The Virtual Channel is only terminated at application layer, in our case the WAM or FTM in BTS or the A2SU in RNC
- The ATM Virtual Channel is mapped into a Virtual Path
  - The Virtual Path is only terminated at any VC-Cross Connection Point
- The ATM Virtual Path is mapped into a Physical Interface
  - The physical media can be a PDH link, an IMA group or an SDH link
- The identifiers for VP and VC are part of the ATM cell header. At any switching point only the ATM cell header is read and the cell is processed accordingly. The payload remains untouched until VC is terminated

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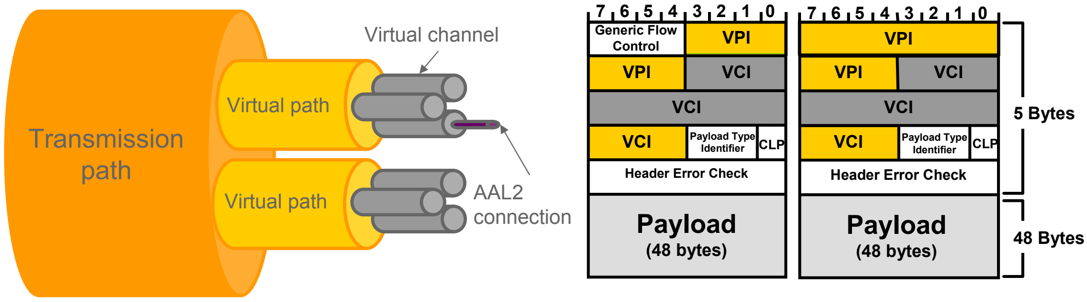
VP and VC Identifiers



- Channel identifier (CID) is unique within an AAL2 VCC (only if AAL2 is used; handled later on)
- VCI is unique within VPC
  - Each VPC can contain numerous VCCs, identified by their VCI, depending on the allocated bits.
  - ATM defines a maximum of 16 bits. The maximum of allocated bits is 13 in the RNC and 12 in the AXC (AXC Compact 7 bits fixed).
- VPI is unique within physical interface
  - Each physical interface connection can contain numerous VPCs, identified by their VPI, depending on the allocated bits.
  - ATM defines a maximum of 8 (UNI) respectively 12 (NNI) bits for VPI numbering.
  - Available bits depend on available maximum of network element and assigned bits for VCI
- Note: AXC provides a maximum of 13 bits the RNC a maximum of 14 bits for VPI/VCI numbering

Identifiers have only local significance between two termination points

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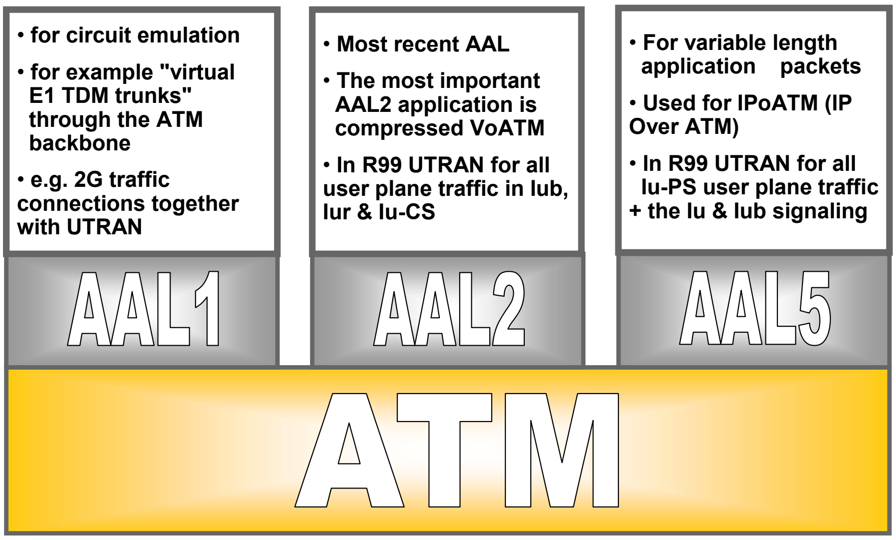
ATM adaptation layers: AAL 1 / 2 / 5



- Provides mapping of applications to ATM service of the same type
- Segments/reassembles into 48 payloads
- Hands 48 byte payloads to ATM layer

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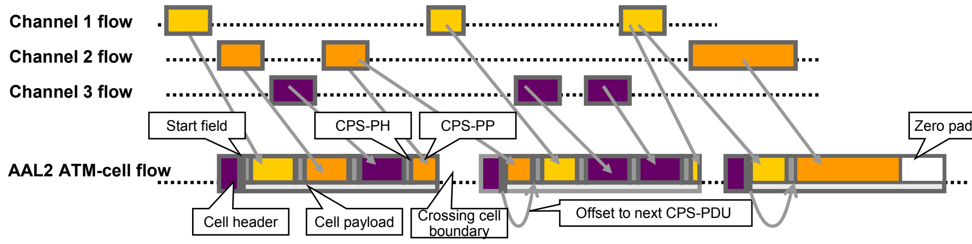
ATM Adaptation Layer 2 (AAL2)



- One AAL2 cell flow consists of variable length "mini-cells" that are concatenated as a continuous stream into the 48-byte payload areas of ATM-cells
- One AAL2 flow can carry up to 248 channels, which are multiplexed by inserting channel data into mini-cell payloads
- The "mini-cells" are officially called CPS-packets (Common Part Sublayer) divided into packet header (PH) and packet payload (PP) parts
- Mini-cells have a "mini-header" (CPS-PH) to identify the channel and length of the mini-cell
- Mini-cell payload size can be anything from 1 to 45 bytes
- Channels can be multiplexed in any order desired, mini-cells can cross ATM-cell boundaries, cells can be padded
- All AAL2 ATM-cells begin with a start field which indicates the offset to 1st complete mini-cell within the ATM-cell

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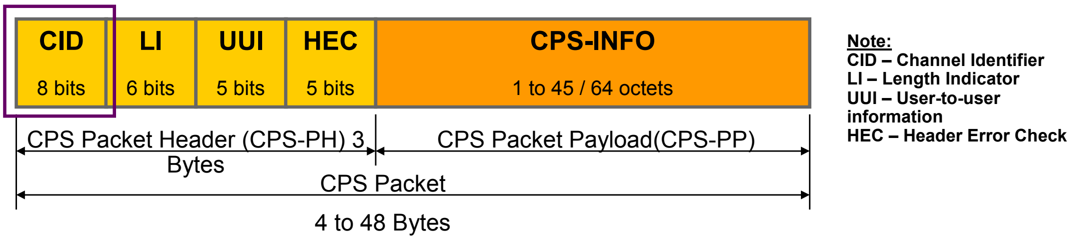
ATM Adaptation Layer 2 (AAL2)



- When AAL2 is used, 248 AAL2-connections can be mapped simultaneously in the same VCC
- Each of these AAL2-channels is identified by its Channel Identifier (CID).
- CID identifies user channel 8-255;   CID 0-7 are reserved for Layer Management purposes.
  - The reserved CID and capacity within the VCC is a dynamic issue
  - That means CID and capacity is available again after termination of specific connections
  - Identifiers and capacities for VC and VP are static!
- CID is unique within an AAL2 VCC
- On Iub and Iur each active connection requires 2 CIDs (DTCH + DCCH)
- On Iu-CS each active connection requires 1 CID

Channel Identifier (CID)

The CID value identifies the AAL type 2 CPS user of the channel. The AAL type 2 channel is a bidirectional channel. The same value of channel identification shall be used for both directions.

The value "0" is not used for channel identification because the all zero octet is used for the padding function (see 9.2.2). The values "1" .. "7" are reserved for use by the AAL type 2 and are specified in this Recommendation (see Table 4).

The values "8" .. "255" are used to identify the users of the AAL type 2 CPS; further discrimination between the two types of users, i.e. SSCS and Layer Management, is provided by the UUI field (see item c) below).

Length Indicator (LI)

The LI field is binary encoded with a value that is one less than the number of octets in the CPS-Packet Payload. The default maximum length of the CPS-Packet Payload is 45 octets; otherwise, the maximum length can be set to 64 octets.

The maximum length is channel specific, i.e. its value need not be common to all AAL type 2 channels. However, for a given CID value, all CPS-Packet payloads must conform to a common maximum value. This maximum length is set by signalling or management procedures.

When the maximum length is 45 octets, LI values 45 ... 63 are not allowed.

User-to-User Indication (UUI)

The UUI field serves two purposes:

• to convey specific information transparently between the CPS users, i.e. between SSCS entities or between Layer Management; and

• to distinguish between the SSCS entities and Layer Management users of the CPS (see range of permissible values in Tables 2 and 3).

The 5-bit UUI field provides for 32 codepoints, "0" .. "31". Codepoints "0" .. "27" are available for SSCS entities, codepoints "30" .. "31" are available to Layer Management, and codepoints "28" .. "29" are reserved for future standardization.

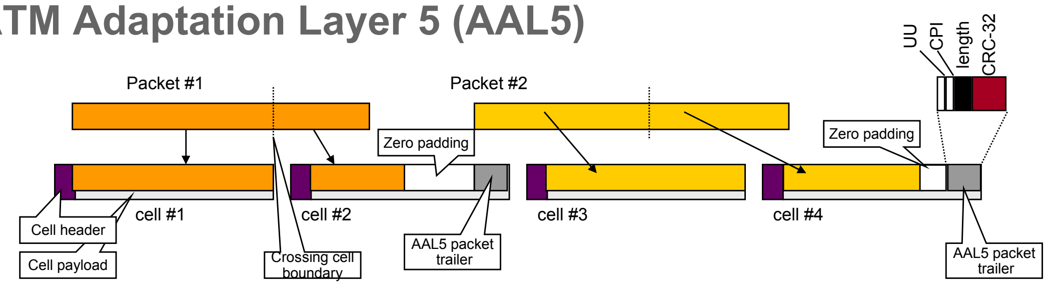
The contents of the UUI field are used to transport the UUI parameters of the CPS-UNITDATA and MAAL-UNITDATA primitives.

Header Error Control (HEC)

The transmitter shall calculate the remainder of the division (modulo 2), by the generator polynomial x5 + x2 + 1, of the product of x5 and the contents of the first 19 bits of the CPS-PH. The coefficients of the remainder polynomial shall be inserted in the HEC field with the coefficient of the x4 term in the most significant bit of the HEC field.

The receiver uses the contents of the HEC field to detect errors in the CPS-PH.

ATM Adaptation Layer 5 (AAL5)



- AAL5 ATM Adaptation layer is designed to carry fast streams of longer packets over ATM as simply as possible
- AAL5 doesn't provide any multiplexing itself, it is assumed that the packets carried identify themselves to higher protocol layers (like TCP/IP)
- AAL5 is also known as SEAL (Simple Efficient Adaptation Layer)
- Packets are simply segmented into 48-byte fragments of ATM-cell payloads, the last cell is padded and terminated with AAL5 trailer of 8 bytes
- AAL5 trailer indicates packet length & has 32-bit CRC
- Packets can be up to 64 Kbytes and are aligned to cell boundaries
- The last cell of a packet is indicated by setting the PT[0] bit in cell header

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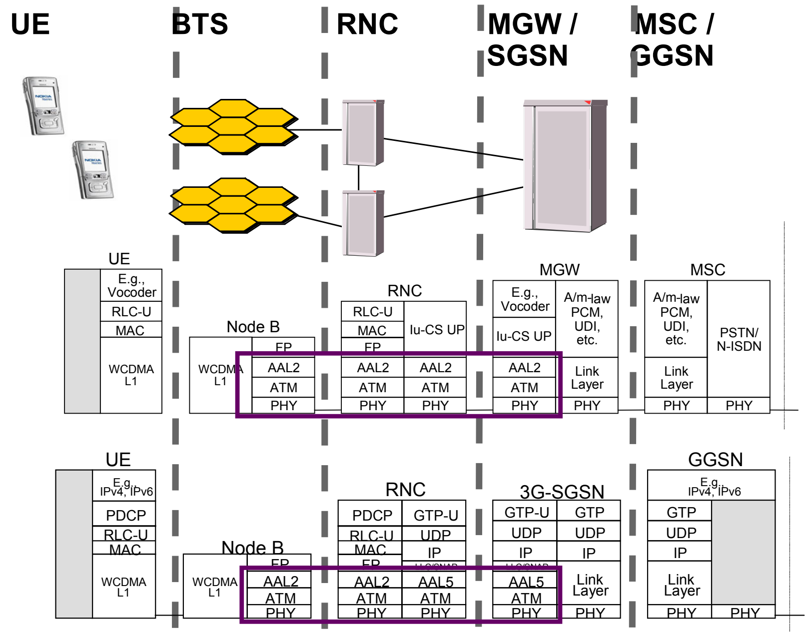
Protocol Stacks of User Plane for CS/PS services



Also for NRT services AAL2 is used on ATM as Transport Layer

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ATM over PDH – ATM capacity on PDH

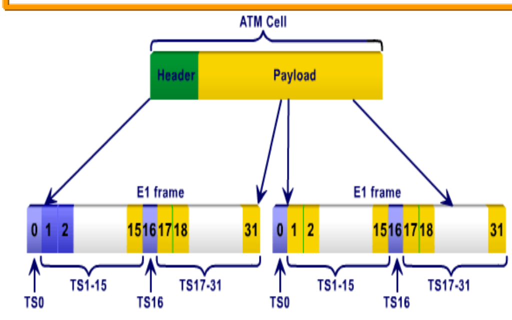
- Most common transport for BTSs
- To transmit ATM traffic over an E1 link, the ATM cell is segmented
- Segments are simply mapped bit by bit into TS 01-15 and TS 17-31 and transmitted in the timeslot structure of an E1 frame
- Time slots 0 is used for frame alignment
- The transportation of ATM cells over an E1 link allows you to re-use the current PDH transmission network
- E1 links are also used to supply ATM-traffic to ATM network

Total **ATM capacity** in an E1 frame:

- 30 bytes with ATM payload in a frame
- Frame repetition rate is 125 us
- 30 bytes/125 us = 240 000 bytes/s
- One ATM cell has 53 bytes/cell

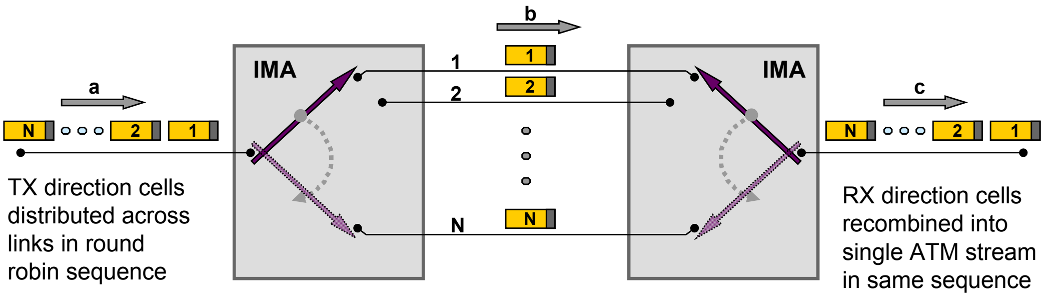
The ATM traffic capacity in a 2 Mbps frame is:

- **240000 bytes/s/53 bytes = 4528 cps = 1.92 Mbps**



ATM over E1

IMA – Inverse Multiplexing for ATM



- It is not possible to split a logical interface among several physical interfaces
- Several physical E1 links are combined to one higher bandwidth logical interface known as IMA Group
- The purpose of Inverse Multiplexing for ATM (IMA) is to provide inverse multiplexing of an ATM cell stream over multiple physical links and to retrieve the original stream at the far-end from these links
- The ATM Inverse Multiplexing technique involves inverse multiplexing and de-multiplexing of ATM cells on a cell-by-cell basis in a cyclic fashion among links grouped to form a higher bandwidth logical link.

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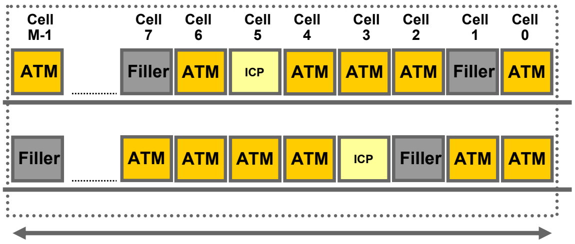
IMA frame - ICP cell, Filler cell



IMA frame	capacity	loss in %
no IMA	1920,000	0,00
32	1859,092	3,17
64	1889,078	1,61
128	1904,070	0,83
256	1911,567	0,44

- An IMA Frame
  - M consecutive cells transmitted on each link within the IMA group
  - M can be 32, 64, 128 or 256. Nokia default: 128
- The ICP (IMA Control protocol) cell is sent once per IMA frame on each link with a different offset between different links, to adjust for differential link delays
  - ICP fields contain e.g. link ID, IMA ID, IMA Frame Sequence Number, ICP Cell Offset
- If there are no ATM layer cells to be sent the transmit IMA sends Filler cells.
- Note: IMA is not saving bandwidth but enables to utilize the available bandwidth more efficiently and protects from link and interface failure!

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In AXC all E1 links of an IMA group must belong to the same IFU in AXC.

IMA configurations:

- •IFUA: 1 to 4 IMA groups, with 1 to 8 E1/JT1/T1 links per IMA group
- •IFUD: 1 to 4 IMA groups, with 1 to 8 E1 links per IMA group
- •IFUE: 1 to 8 IMA groups, with 1 to 8 E1 links per IMA group
- •IFUF: 1 to 16 IMA groups, with 1 to 32 VC-12 links per IMA group
- •AXCC: 1 to 4 IMA groups, with 1 to 8 E1/JT1/T1 links per IMA group
- •AXCD: 1 to 4 IMA groups, with 1 to 8 E1 links per IMA group

Flexi BTS has one transmission sub-module per BTS.

The IMA functionality of the transmission sub-modules can be configured as follows:

- •FTPB: 1 to 4 IMA groups, with 1 to 8 E1/T1/JT1 links per IMA group
- •FTEB: 1 to 4 IMA groups, with 1 to 8 E1 links per IMA group
- •FTIA: 1 to 2 IMA groups, with 1 to 4 E1/T1/JT1 links per IMA group
- •FTFA: 1 to 4 IMA groups, with 1 to 8 E1 links per IMA group
- •IMA needs a licensed in Flexi.

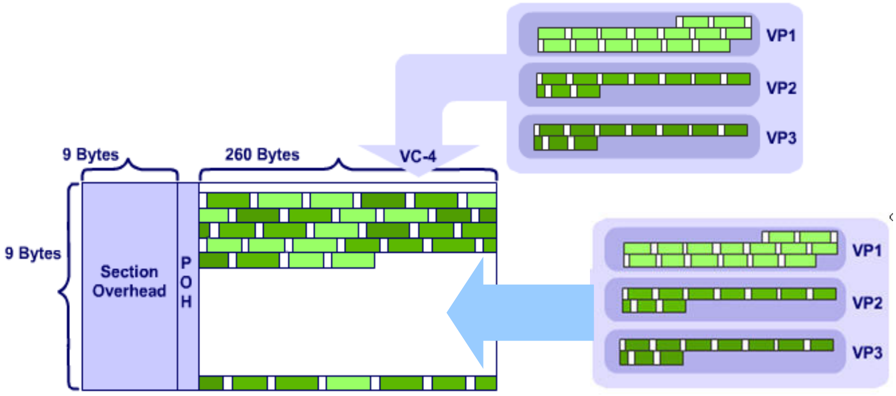
RNC-NIP up to 8 IMA groups with 2-8 E1 each

IMA failure case

- Upon the failure of one or more links or interfaces of an IMA group, the IMA Engine is able to recover and reassign the distribution of ATM cells to the remaining working PDH links within the IMA group.
  - Only the capacity of this IMA group is reduced but the IMA group remains operational.
- The recovery time of the IMA engine upon PDH link failure is 2 s, all existing calls will be terminated.
- The minimum number of active IMA links that enable a group remaining active is specified by an IMA parameter and simultaneously the bandwidth available for that IMA group.
  - The parameter “minimum number of links” can be set in in AXC as well in RNC
  - This parameter describes until what limit the IMA group continuous working in case one or more E1s drop out.
- Example:
  - IMA group with 4 E1 links
  - An ATM interface with a VP of 17000 cps is assigned to that group
  - Note: IMA group with 4 E1s provides a capacity of 17961 cps
  - Minimum number of links is set to 2
  - In case 1 or 2 E1s drop out the IMA group continuous operating after restart with a limited bandwidth even if the logical interface cannot provide anymore the assigned VP capacity
  - In case traffic increases available capacity cells are dropped, active connections might be released due to cell loss.

ATM over SDH (STM-1 / VC4)

- When SDH is used as transport media the ATM cells are simply mapped Byte by Byte into the virtual container
- STM-1 has a transmission capacity of 155.52 Mbps.
- Each frame of STM-1 is organized into a 9 rows x 270 columns byte array
- 260 columns out of 270 carry the actual payload.



STM-1 (155,52 Mbps) can fit 44.15 cells per frame -> 353 207 cells per second.

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ATM Capacity in STM-1 VC-4 Frame

- Payload of the STM-1 frame can accommodate 1 Virtual Container Level-4 (VC-4)

  - Total ATM capacity in a SDH frame:
  - Payload per virtual container: 260x9 = 2340 bytes
  - Frame repetition rate is 125 us.
  - 2340 bytes/125 us = 18 720 000 bytes/s
  - One ATM cell has 53 bytes/cell .
  - The ATM traffic capacity in a SDH frame is:
    - **18 720 000 bytes/s/53 bytes = 353 207 cps**

- In case STM-0 is used (3x VC3 within STM-1) 114113 cps are available per logical interface

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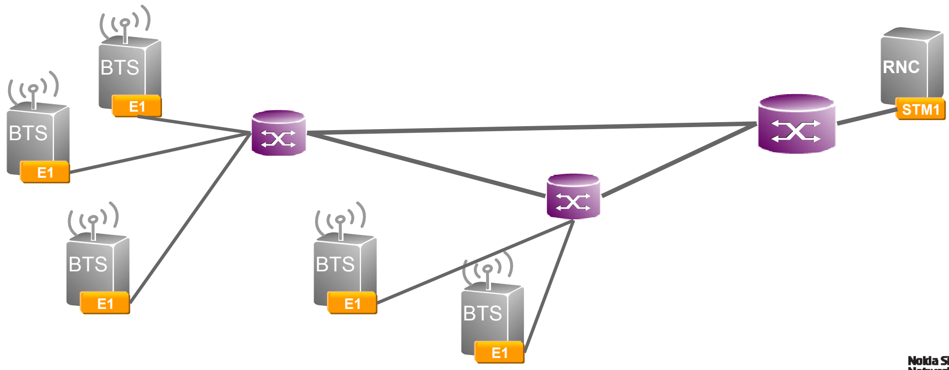
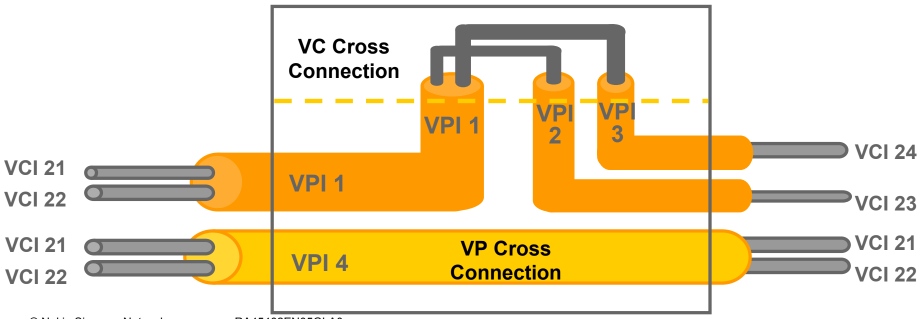
ATM Cross Connection

- From the origin to the termination of a Virtual Channel Trail there can be multiple intermediate Nodes where ATM Cross Connections might occur
- Traffic is collected from different origins to same destination
  - Statistical multiplexing gain can be achieved



VP and VC Cross Connections

- ATM cross connections can be performed at VP or VC level
  - VP level switching is preferred in some cases as it makes management and configurations easier
- The physical link is terminated at any intermediate Node
- Virtual Paths can be cross connected to any Physical Interface
- Virtual Channels can be cross connected to any Virtual Path
- Which layer is terminated depends on the Cross Connection Level
- Cross Connections are carried out according to a Cross Connection Table



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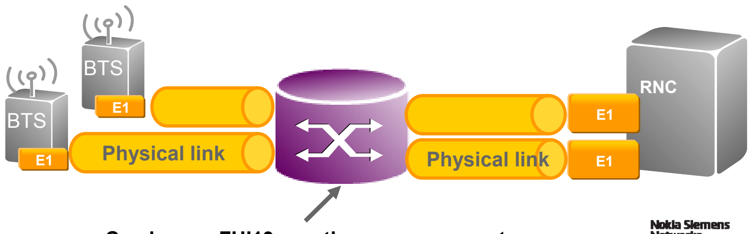
1. Physical layer Cross-Connection

- Simply E1 mapping
- Recommended solution, if site already has cross-connection equipment (e.g. MW radio indoor units in Site Support cabinet). An ideal solution from network evolution viewpoint would be FIU 19
- BTSs are separated in different physical lines so network management is easy
- Loop protection on physical layer is possible (not with FIU 19)
- No statistical multiplexing gain is available
- Also used if e.g. only channelized SDH is available. E1s are mapped into VC12.
- No effect on ATM layer, no changes in VPI/VCI numbering
- IMA group members can have separate routes

Physical link can be:
SDH: STM-1(VC4 / VC3 / VC12)
PDH: E1 or IMA group



Can be e.g. FUI19 or other cross connect

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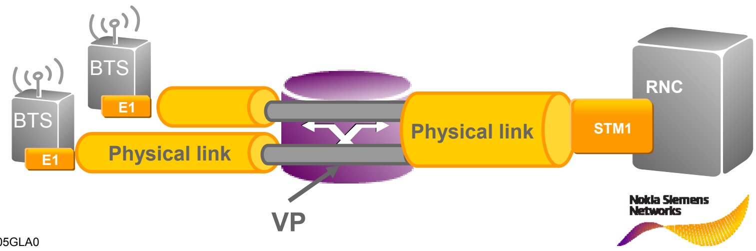
2. VP level Cross-Connection

- Physical link is terminated
- VPs can be mapped into any other physical interface when bandwith requirements are met
- In this example BTSs are separated in different virtual paths so the network management is easy
- When configuration is changed, only few settings are needed
- Only VP layer is affected, new VPI to be assigned
- Virtual Channel remains transparently within VP
- Statistical multiplexing gain in case of UBR overbooking
- Most common Cross Connection Level in intermediate Nodes in RAN

Physical link can be:
STM-1(VC4 / VC3 / VC12
E1 or IMA group



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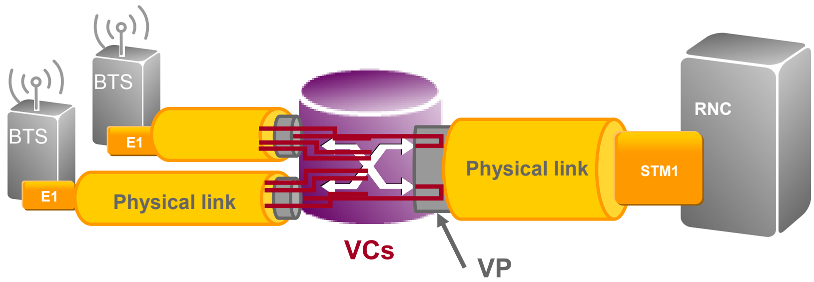
Additional information related VP switching in S-AXC

- In case there are CBR and UBR VCCs inside CBR VP, S-AXC is not able to prioritize by dropping UBR cells first
  - All cells in VP will be handled the same and drops will occur randomly
  - VC switching would be needed to overcome the problem
- In case of VP switching, AXC first drops cells from UBR VP
- In case of congestion UBR VPs with low PCR will be affected more and UBR VPs with high PCR less.

3. VC level Cross-Connection

- Physical and virtual paths are terminated
- Virtual Channels can be mapped into any other VP
- New created VPs can be mapped into any physical interface
- New VPIs and VCIs to be assigned
- All user traffic in one VP may not be best solution if something goes wrong on ATM level
- Complex configuration work and high risk of mess when changes have to be done
- Statistical multiplexing gain in case of UBR-VCCs
- The AAL2 connections are not affected on this level!



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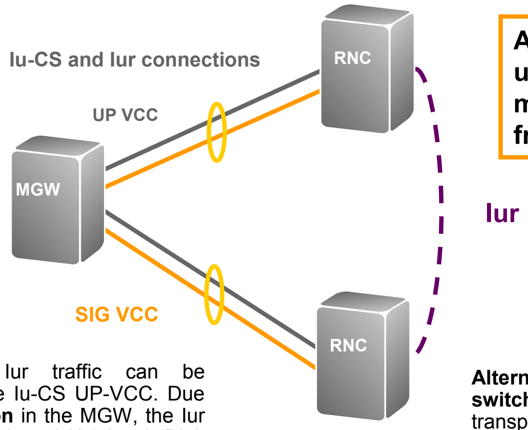
4. AAL2 Switching

Nodal function in Media Gateway (MGW) for Iur connections



AAL2 switching also used in Ultrasite BTS multiplexing traffic from different WAMs

AAL2 switching: Iur traffic can be transported within the Iu-CS UP-VCC. Due to the **Nodal Function** in the MGW, the Iur traffic can be switched on AAL2 level (Digit Analysis Tree) within the MGW to the other RNC.

Alternative is to use VCC switching. The Iur traffic can be transported in it's own VCC together with the Iu-CS traffic. In this case the **MGW acts like a Cross-Connect**

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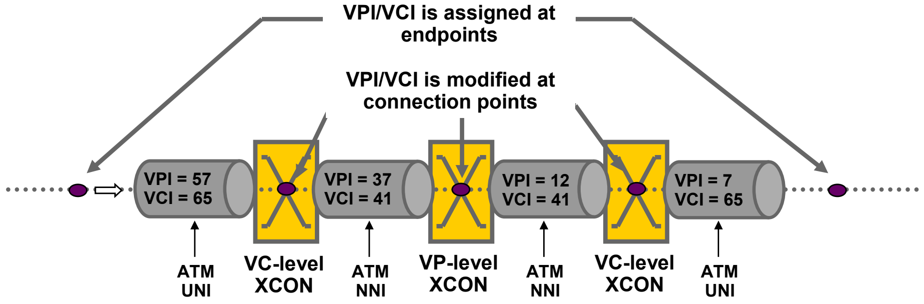
VPI and VCI values



VPI re-use

- One VPI value can be used once in the same ATM interface. Can be re-used in another ATM interface

VCI re-use

- One VCI value can be used only once within the same VP, but can be re-used in another VP

VP Cross Connection:

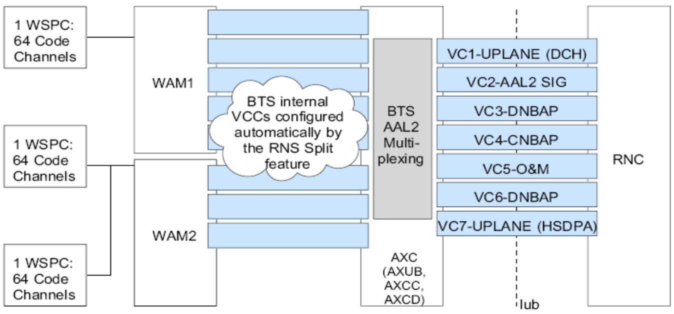
- VPIs will be re-assigned on the other interface, but could have previous value if available.
- VCIs remain the same

VC Cross Connection

- The VP will be terminated
- The VCI will be re-assigned on the VP but could have previous value if available.

Virtual Channels and Paths in the Iub Interface

- AAL2 channels remain with their CID in their dedicated VCC until VCT is terminated
  - VCT is terminated only in RNC (A2SU) and in BTS (WAM or FTM)
- VCCs remain with their VCI in their dedicated VPC until VPT is terminated
- VPCs remain with their VPI in their dedicated physical interface until terminated
- On the Iub side VC numbering starts from VCI32 up to limitation regarding to assigned bits
- In case AAL2mux is used, VCT is also terminated in AXC



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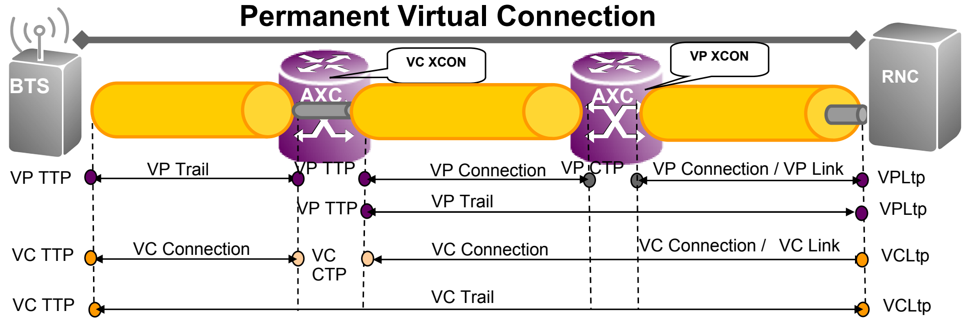
ATM terminology for AXC and RNC



AXC Terminology	RNC Terminology
VPC TP = Virtual Path Connection Termination Point VPTTP = Virtual Path Trail Termination Point	VPLtp: Virtual Path Link Termination Point
VCCTP = Virtual Channel Connection Termination Point VCTTP = Virtual Channel Trail Termination Point	VCLtp: Virtual Channel Link Termination Point
Virtual Path Connection	Virtual Path Link
Virtual Path Trail	Virtual Path Connection
Virtual Channel Connection	Virtual Channel Link
Virtual Channel Trail	Virtual Channel Connection

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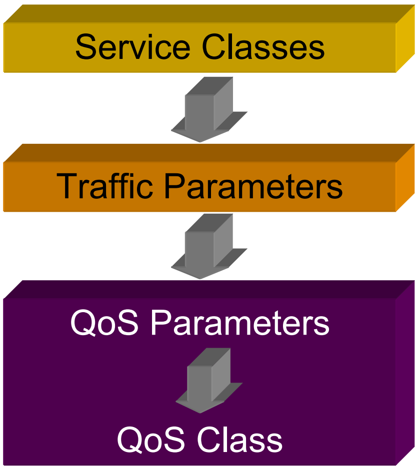
Quality of Service

To guarantee the required QoS, there is a method defined to describe connections behavior



Service category classifies connections as CBR, UBR or UBR+

Traffic parameters define mainly the bandwidth requirements e.g. PCR / MCR

QoS parameters define finally the QoS of the Connection such as delay, cell loss etc.

The combination of the Traffic Class and the set of Traffic and QoS parameters constitute the Connection **Traffic Descriptor** of an ATM connection

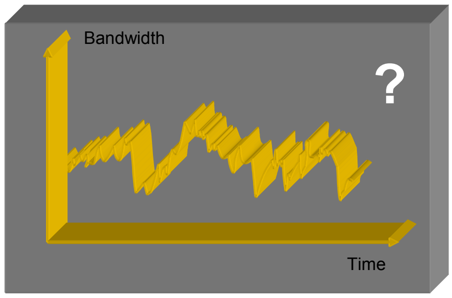
ATM service categories - CBR

- CBR – Constant Bit Rate
  - Used for constant (maximum) bandwidth services
  - For the connections that request a fixed (static) bandwidth, that is continuously available during the connection lifetime
  - Is intended to support real-time applications requiring tightly constrained delay variation
  - The applications are e.g. video, audio, circuit emulation, but use of CBR does not restricted to those applications
  - Source may emit cells at or below the PCR at any time and for any duration (or may be silent)
  - PCR is guaranteed
  - Until RAS06 all user plane VCCs were CBR in Iub

Prior to RAS06, all user plane VCCs were CBR. In RAS06, if path selection is used, CBR is recommended for RT DCH or DCH traffic as well as for CNBAP, DNBAP and AAL2 signalling.

ATM service categories - UBR

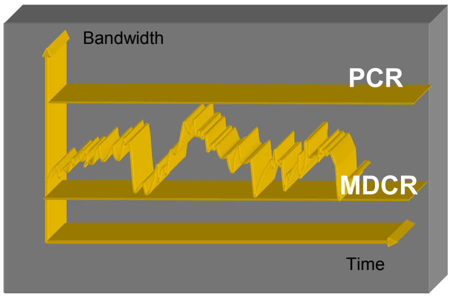
- UBR – Unspecified Bit Rate
  - Is intended for non-real-time applications, i.e., those not requiring tightly constrained delay and delay variation.
  - Examples of applications are traditional computer communication applications, such as file transfer and email
  - Service does not specify traffic related guarantees
  - Sources are expected to transmit non-continuous bursts of cells
  - PCR is not guaranteed and can send more use more capacity than PCR
  - Traditionally DCN and Iu-PS connections have been UBR



UBR traffic is used for O&M.

ATM service categories – UBR+

- UBR+ – Unspecified Bit Rate +
  - Is intended for non-real-time applications, i.e., those not requiring tightly constrained delay and delay variation.
  - Examples of applications are traditional computer communication applications, such as file transfer and email
  - Specified with PCR and MDCR
  - MDCR is guaranteed and traffic can be transmitted up to PCR
  - Picture is indicating that even though the MDCR is reserved for the traffic, the traffic can reach up to the PCR, if there is free capacity to be used e.g. in the shaped VPC or Bundle



Note! UBR+ has also UBRshare proprietary parameter that is used to share excess capacity between different UBR+ VCC in the line card

UBR+ functionality

•Instead of reserving capacity in the RNC interfaces based on HSDPA peak rates, reservation can be done based on average throughputs as capacity can be shared between BTSs

•Savings also in the RNC Gateway Node

•UBR+ ’guarantees’ some bandwidth compared to UBR

•If Minimum Desired Cell Rate (MDCR) = 0, then UBR+ is equal to UBR

•UBR+ can be used for user plane VCCs - for dedicated (e.g. NRT DCH or HSPA) user plane VCCs as well as for Shared VCCs.

•MDCR is used as reference for AAL2 CAC and ATM CAC

•In RNC the UBR+ VCC is shaped to the PCR

UBRshare

•UBRShare allows to prioritization among UBR connections

•UBRShare is proprietary parameter to give more freedom to determine UBR+ behavior

•UBRShare parameter defines a weight to share the excessive bandwidth among the UBR+ connections

•Interpretation of UBRShare depends whether the VPC is shaped or not

•If shaped the share is calculated over VPC

•If not shaped the share is calculated over ATM interface

Do not mix the UBRshare with the Excess Bandwidth Share defined for VCC Bundle. VCC Bundle is used, if dynamic scheduling is used for NRT DCH or HSDPA traffic in the RNC to prevent RNC AAL2 buffers from overflowing. NRT DCH, HSDPA HSUPA or HSPA VCCs need to be UBR+ type in order to put them in to the Bundle. UBRshare is used in the line card for scheduling and VCC Bundle in the AAL2 scheduling.

Traffic and QoS Parameters

Traffic parameters describe traffic in terms of:

- PCR - Peak Cell Rate
  - Maximum bandwidth in any situation
- MDCR - Minimum Desired Cell Rate
  - Parameter defines the guaranteed cell rate

QoS Parameter:

- CDVT - Cell Delay Variation Tolerance
  - This parameter is set according to network element requirements (details follow!)
- CLR - Cell Loss Ratio:
  - Describes the ratio of lost cells to transmitted cells
  - The CLR parameter is the value that the network agrees to offer as an objective over the lifetime of the connection
  - If value will be exceeded an alarm will be raised or possibly further action will be triggered depending on parameter settings
  - Usual values between 10^{-3} to 10^{-9}

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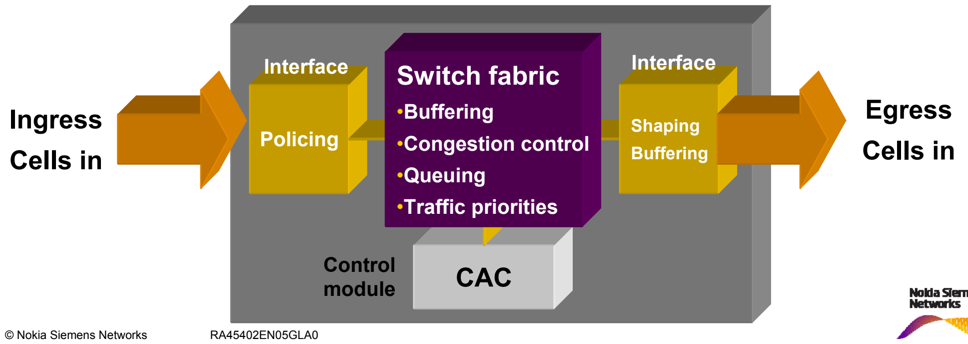
Traffic Management

- Traffic management is needed in order to comply to the QoS requirements
- QoS is guaranteed as long as the connection is compliant with the Traffic contract
- The traffic offered to the network can be variable and therefore end-to end participation of network elements is required
- Traffic management functions with in ATM node are distributed among different elements



Traffic Contract

- Traffic contract is negotiated during connection establishment
- It's an agreement between a user and a network, where the network guarantees a specific QoS if the user's cell flow conforms to a negotiated set of traffic parameters
- A traffic contract can be also a written contract between an Operator and e.g. a backbone / Leased Line provider.
- Traffic contract of includes:

- **Definition of a Compliant Connection**
- **QoS class**
- **Traffic Descriptor**
  - Conformance Definition
  - Cell Delay Tolerance
  - Cell Loss Ratio
  - Peak Cell Rate
  - Service Category

Definition of a Compliant Connection

- QoS is guaranteed as long as the connection is compliant with the traffic contract
- Committed to provide the agreed QoS to all cells conforming the traffic contract, the network needs to police the traffic to detect non-conforming cells
- Network takes appropriate actions to prevent non-conforming cells from affecting the QoS of the conforming cells of the other connections
  - The network could drop cells.
- Conformance test performed on the traffic stream, defined in the traffic description
  - CBR.1 for CBR (only available for CBR)
  - UBR.1 for UBR (default), cell will be discarded if non-conformant
  - UBR.2 for UBR, cell will be tagged (CLP bit set to 1) and forwarded
  - If conformance definition is UBR.1 then packets violating the traffic contract will be discarded.
  - For UBR.2 non-compliant cells will be first tagged (CLP) and then discarded when recognized again as non-compliant.

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CDVT – Cell Delay Variation Tolerance

- Individual cell stream cannot exceed its access line rate
- PCR can be occasionally be exceeded for a short time and the cell stream can still remain with its Traffic contract
- Ideally there should be no cell delay variance and the function of shaping is to smooth out these variations
- Cell Delay Variation Tolerance decides if the cell stream is conforming to its Traffic descriptor
  - Positive CDV occurs when the space separating the cells has been compressed
  - Negative CDV is occurs when the space is expanded

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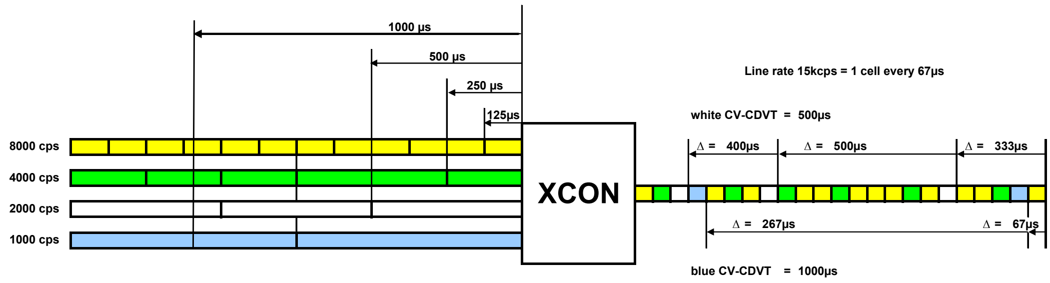
CDVT – Cell Delay Variation Tolerance



- In this example we assume only 4 VCCs with a low capacity, mapped into an interface of a little higher capacity.
- Imagine a SDH-interface with a 23 times higher capacity, where hundreds of VCCs are mapped in.

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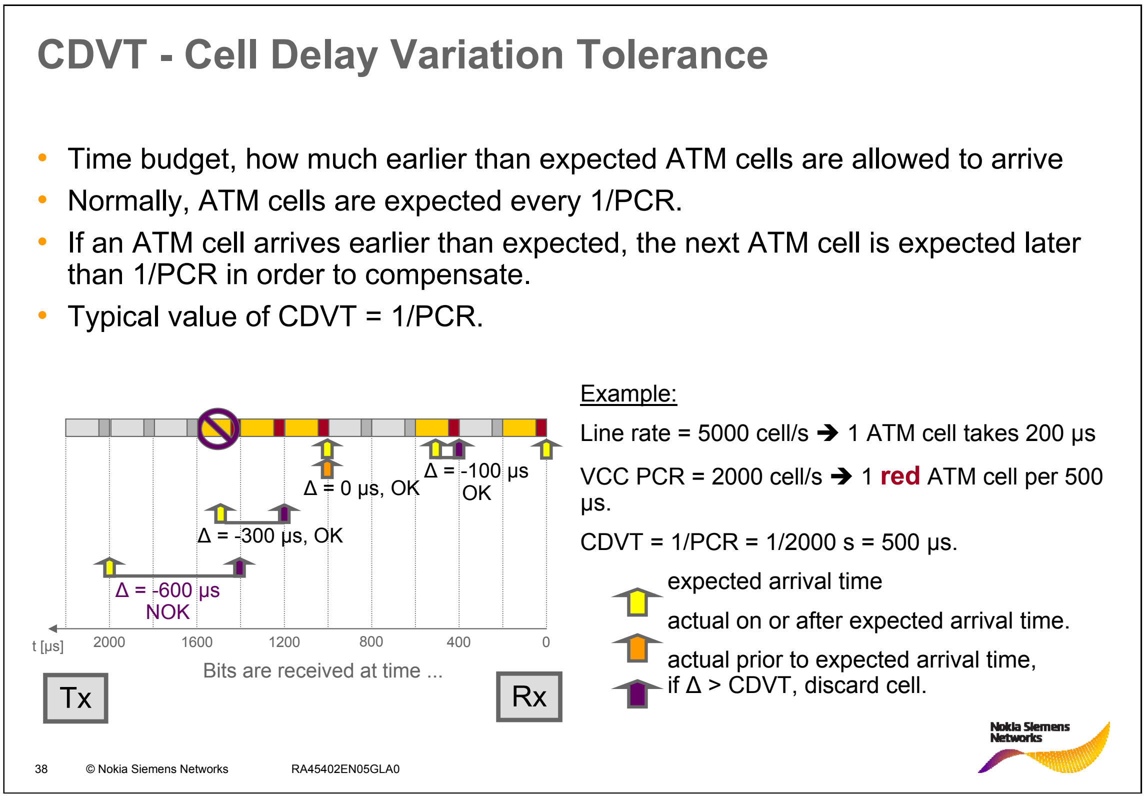


VCC = Virtual Channel Connection

The picture describes the Generic Cell Rate Algorithm GCRA.

The expected arrival time is usually called TAT, theoretical arrival time.

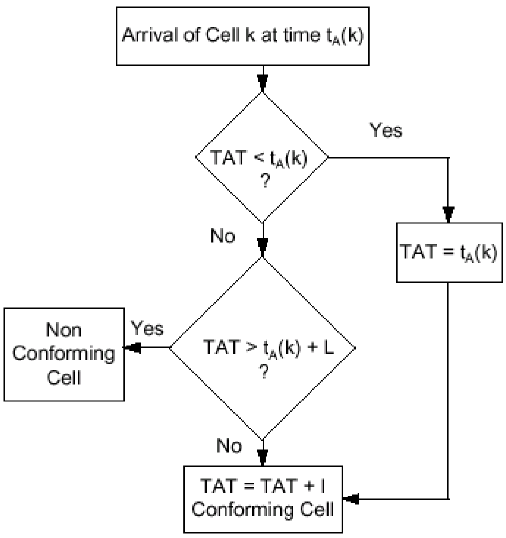
The actual arrival time of ATM cell k is called $t_A(k)$.

The limit L is usually the CDVT value.

The increment I is usually 1/PCR.

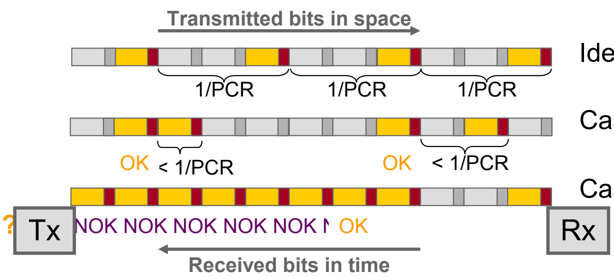
The algorithm can be transformed to say:

> The TAT(k+1) is set to either "TAT(k) + 1/PCR" or "$t_A(k)$ + 1/PCR", whichever is later in time.



ATM Policing

- Receiver expects ATM cells at the speed of a Peak Cell Rate PCR = X cell/s, i. e. 1 ATM cell every 1/X seconds
- Receiver measures the time lag from one ATM cell to the next and compares it to the expected gap of 1/PCR



Ideal case: 1 **red** ATM cell every 1/PCR.

Case 1: Normal cell delay variation (CDV)

Case 2: Sender abuses receiver

- Two main reasons for a too short time lag, how do decide?
  1. Normal ATM Cell Delay Variation (~ jitter) ➔ let pass.
  2. The sender sends faster than allowed PCR ➔ discard.

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VCC = Virtual Channel Connection.

Automatic CDVT Calculation in RNC

CDVT not specified for UBR/UBR+

For CBR traffic, VCC & Shaped VPC

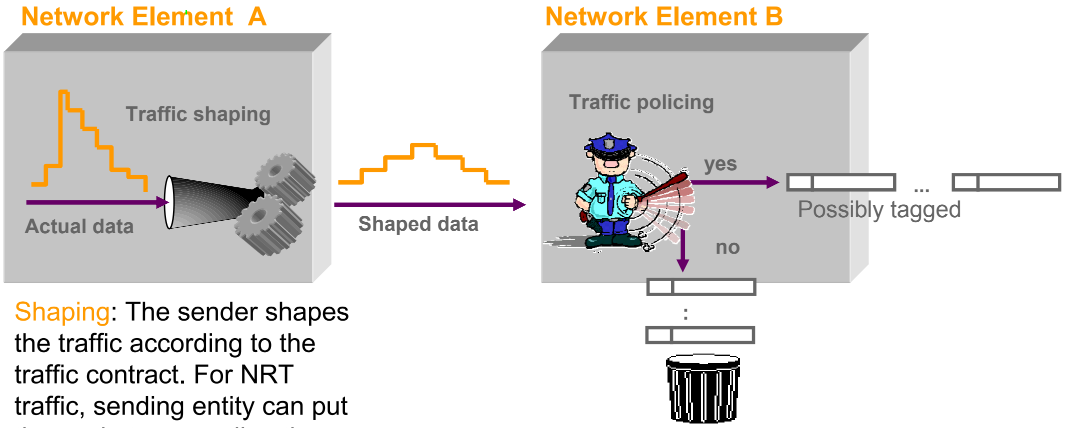
- A basic value for CDVT for the receiving side for a single VCC comes from the idea that the receiving side will allow the sending side a burst of 2 ATM cells being sent back-to-back.
- To compensate such a burst, thereafter a longer pause is needed between 2 ATM cells in order not to exceed the average PCR (peak cell rate).
- In order to allow this burst, the CDVT value on the receiving side (RNC) is set to:
    - CDVTvc = 1/PCRvc (Note: 1.7/PCRvc when PDH connection is used!)
- If VP level traffic shaping is used at the sending side, the whole VPC acts – as seen from the traffic management functions – similar to a single VCC.
- In this case the CDVT value for the receiving side (RNC) for a single VPC can also be set to:
    - CDVTvp = 1/PCRvp (Note: 1.7/PCRvc when PDH connection is used!)

For CBR Traffic, non shaped VPC

- Basic Rule is
    - CDVTvp = (2 * N – 1)/PCRvp (N=amount of VCC within VP)
- Also the CDVTvc rule is applicable for CDVTvp when biggest VCC is taken into account

Default values for CDVT in AXC for CBR VCCs is 5000 µs and for UBR VCCs 20 000 µs.

Traffic management – Shaping / Policing



Shaping: The sender shapes the traffic according to the traffic contract. For NRT traffic, sending entity can put the packets exceeding the max. allowed bit rate to queue in order to maintain the traffic in the limits of the virtual connection.

Policing: The receiver checks that the sender doesn't violate the traffic contract.

Violating cells may be discarded or tagged.

Also known as usage/network parameter control (UPC/NPC)

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They have to be planned in a consistent way for all Nokia equipment and any 3rd party ATM network or equipment attached to it, otherwise the result may be an unwanted loss of ATM cells.

Traffic management in BTS
Shaping and Policing

BTS and AXC:

- Uses source level traffic shaping
  - AXC shapes CBR cross-connections on both VP and VC level
  - Traffic shaping is performed with respect to the Peak Cell Rate (PCR) specified in the traffic descriptor of the CBR connection
  - UBR traffic from IP-Router is shaped according to PCR specified in Traffic Descriptor
  - BTS/AXC shapes the PCR of UBR/UBR+ VCCs applied for DCN and signaling VCCs
  - BTS/AXC shapes the PCR of user plane UBR/UBR+ VCC in case of BTS AAL2 multiplexing disabled, does not shape user plane UBR/UBR+ VCCs if BTS AAL2 multiplexing enabled
- For AXC policing may be switched on or off for all connections in an interface
  - Default value for CDVT is 5000 μs for CBR and 20000 μs for UBR

FLEXI/FTM:

- Flexi supports shaping functionality on VC level
  - Traffic shaping is performed with respect to the Peak Cell Rate (PCR) specified in the traffic descriptor of the CBR connection
- For UBR/UBR+ connections, shaping is not supported

Regarding UBR+ shaping in BTS and the RNC

•UltraSite WCDMA BTS/AXC

❑Shapes the PCR of UBR/UBR+ Virtual Channel Connections applied for DCN, AAL2 signaling, NBAP signaling and Neighbor Node Discovery (user plane has different network element internal HW termination point).

❑Shapes the PCR of user plane UBR/UBR+ Virtual Channel Connection in case of BTS AAL2 multiplexing disabled.

❑Does not shape the PCR of user plane UBR/UBR+ Virtual Channel Connection in case of BTS AAL2 multiplexing enabled.

•FlexiBTS does not shape the PCR of any UBR/UBR+ connections

•RNC shapes the PCR of all UBR+ Virtual Channel Connections

Traffic management in RNC
Shaping and Policing

RNC:

- Shaping
  - No shaping on VC level (source level shaping for CBR)
  - No shaping for UBR
    - UBR is limited by the ATM interface
  - Shaping is performed to the PCR of all UBR+ VCCs
  - VP level shaping may be switched on or off for CBR VPs
    - Limited amount of shapers available
- The policing service is available only for ingress CBR connections
  - Policing is either ON or OFF for all CBR connections within one interface
  - Even if policing is ON, UBR/UBR+ connections are not policed
    - If CBR connection going over packet network, shaping should be enabled towards RNC or policing should be turned off

PCR, line rate, shaping, policing, CDV and CDVT need to be consistent!

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The theoretical maximum number of shaped VPs per NIS1/NIS1P unit can be calculated as follows:

Maximum number = 2 * x + 5 * 13 + 3 * (16 - x)

Where x is the number of configured ATM interfaces on the network interface unit (4 with STM-1/VC-4 mapping, and 12 with STM-1/3xVC-3 mapping).

However, the actual maximum number of shaped VPs may be lower than the theoretical maximum number due to scheduler resource granularity. This depends on how many ATM interfaces are configured to the unit and how the shaped VPs are distributed between the configured interfaces.

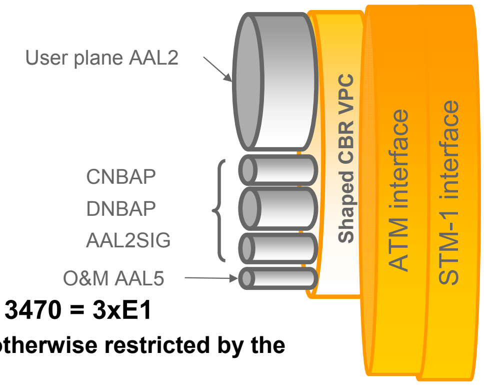
More information is found in the RNC Product Documentation and RAS06 System documentation

1. VP/VC link termination points
2. ATM Layer description
3. ATM Resource Management in RNC (DN02142996)

Example on Traffic Management Parameters in the RNC

User plane, signaling and O&M in RNC in an STM-1 interface

- **CBR VCC PCR**
  - CNBAP 236 cps
  - DNBAP 472 cps
  - AAL2SIG 236 cps
  - User plane 12375 cps
- **CDVTvc = 1/PCR**
- **UBR VCC PCR**
  - O&M 151 cps



- **Shaped CBR VPC PCR = sum of VCC PCRs = 13470 = 3xE1**
  - **O&M traffic cannot grow over shaped VP PCR, otherwise restricted by the ATM interface only**
- **CDVTvp = 1/PCR = 74 µs**
- **Policing (UPC/NPC) ON for ingress traffic (only CBR)**
  - **Policing in CBR in RNC/BTS could be a problem, if packet network is used for transport increasing delay variation (HSUPA throughput low)**

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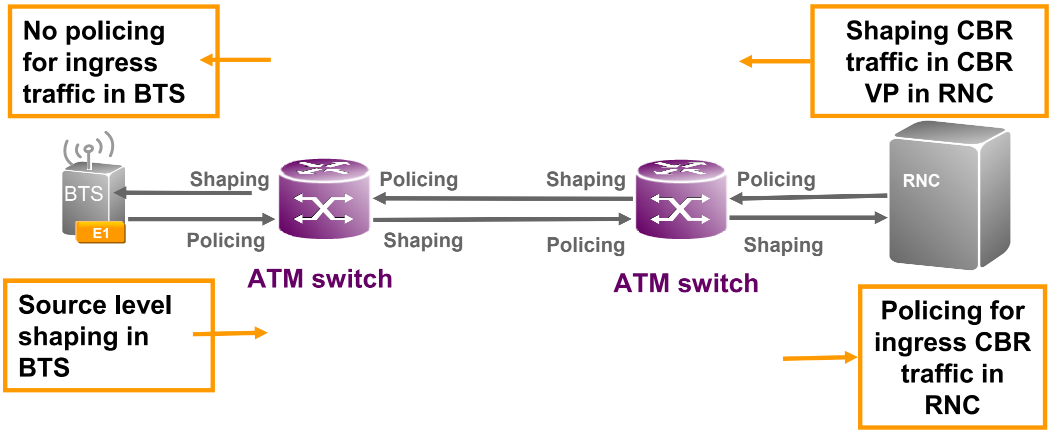
Example on Traffic Management Parameters

- **In the transport network e.g. AXC polices the ingress traffic and shapes the egress traffic**

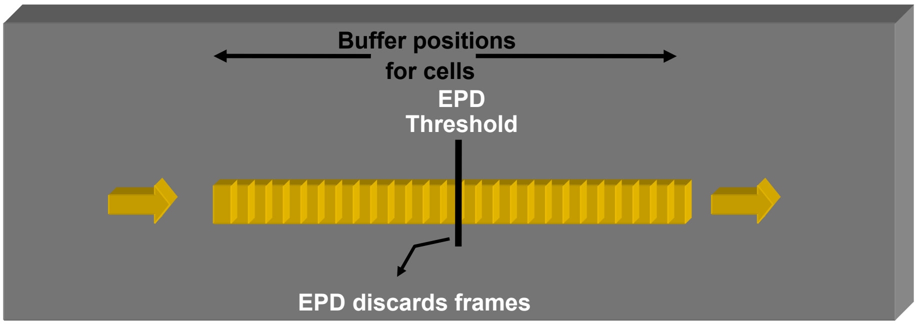


Traffic Management
Buffer Management Schemes

- Cell loss priority bit in ATM cell header can be used to generate different priority cell flows within a virtual path connection or virtual channel connection
- Selective cell discard buffer management method ensures
  - lower priority (CLP=1) ATM cells are dropped before higher priority CLP=0 cells in congestion situation
- When buffer occupancy reaches preconfigured threshold value, buffer management starts to discard incoming lower priority CLP=1 cells

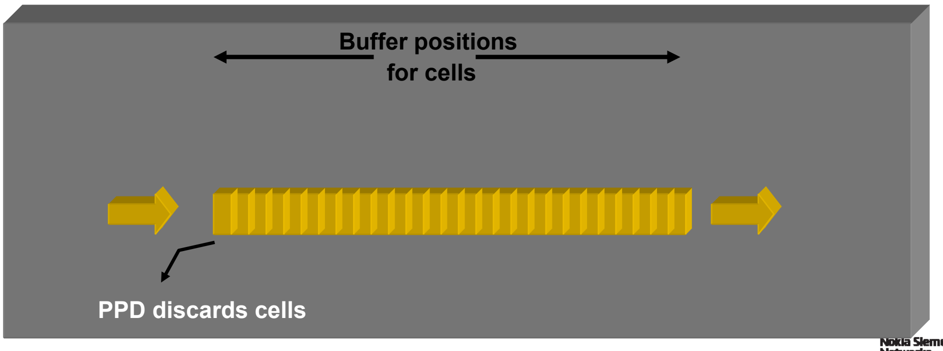
Buffer Management Schemes Early Packet Discard (EPD)

- The EPD threshold is evaluated before a new AAL5 frame is admitted to the buffer
  - If the buffer threshold is exceeded, all cells from the AAL5 frame are discarded
- When the buffer level exceeds the EPD threshold, the cells of one or more specific PDUs will be selectively discarded from the buffer.
- In case the last cell of the PDU has already entered the buffer it will be transmitted
- The EPD function usually works hand in hand with the PPD function



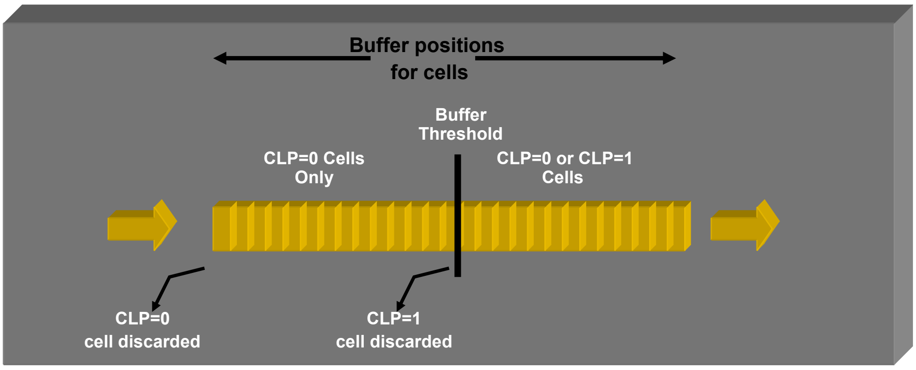
Buffer Management Schemes
Partial Packet Discard (PPD)

- PPD occurs if a user cell is discarded because of policing violations, a cell loss priority (CLP1 or CLP0+1) threshold violation or if no free buffer space is available
- PPD discards all remaining user cells of the AAL5 frame except for the last cell of the frame.
- These processes have not only the task to prevent buffer from overflow, it also signals the TCP schedulers to reduce output.



Buffer Management Schemes
Selective Cell Discard (SCD)

Network may discard CLP=1 flow cells while meeting the QoS on both CLP=0 and CLP=1 flows



Buffer Management Schemes Summary

EPD/PPD:

- The AXC features both EPD and PPD for VC connections carrying AAL5 traffic.
- EPD starts when buffer reaches a specific threshold
- PPD is the subsequent process. All cells belonging to a PDU whose cells where already dropped from the buffer, will be discarded to hinder their entering of the buffer.
- In both cases the last ATM-Cell of the dropped PDU will be transferred.

SCD: For UBR.2 class

- Any cell of this class which is involved in any congestion will be tagged, respectively CLP (Cell Loss Priority) is set from 0 to 1 and forwarded
- If this cell appears on its way at any other critical traffic point again then it will be discarded
- Also in this case PPD as the subsequent process will drop all following cells which belong to the same PDU

UBR.2 is typically used together with Partial Packet Discard (PPD).