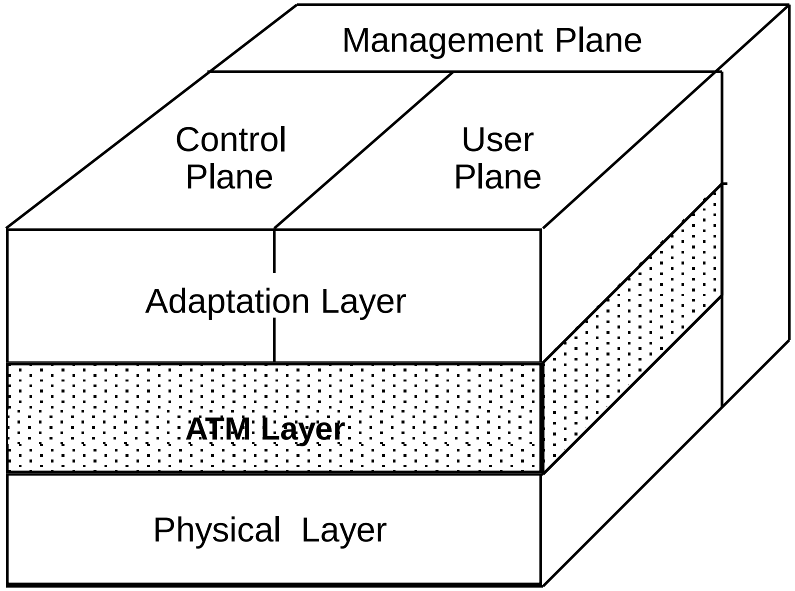
Part III: ATM

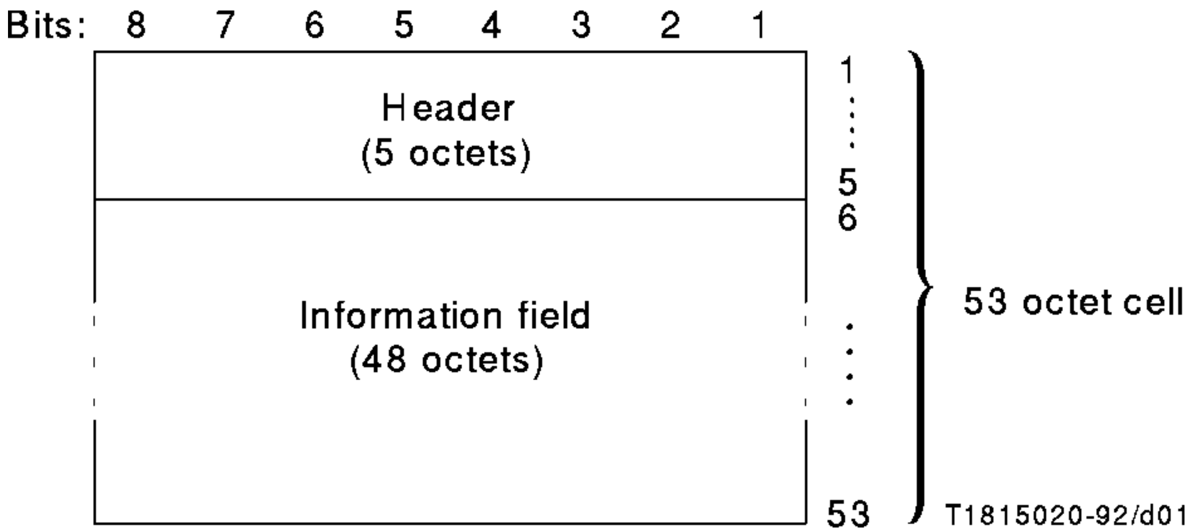
ATM Layer

ATM Layer



- Functions:
  - Cell Transport
  - Traffic and Congestion Control

ATM Cell

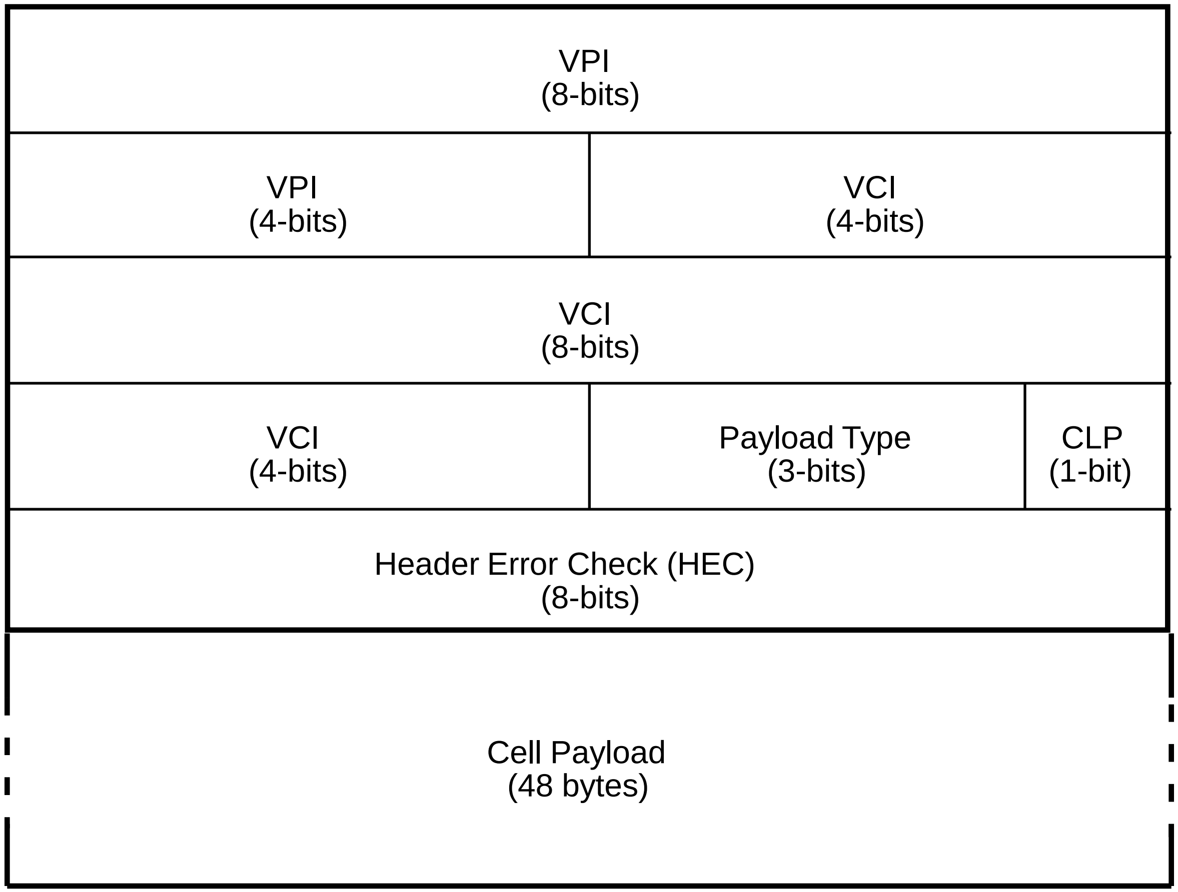


- Unique cell size for all kinds of services
- Low delay requirement for audio services requires small cell size
- Ratio of header to payload should be small => Tradeoff: 53-byte cell size, 5-byte header

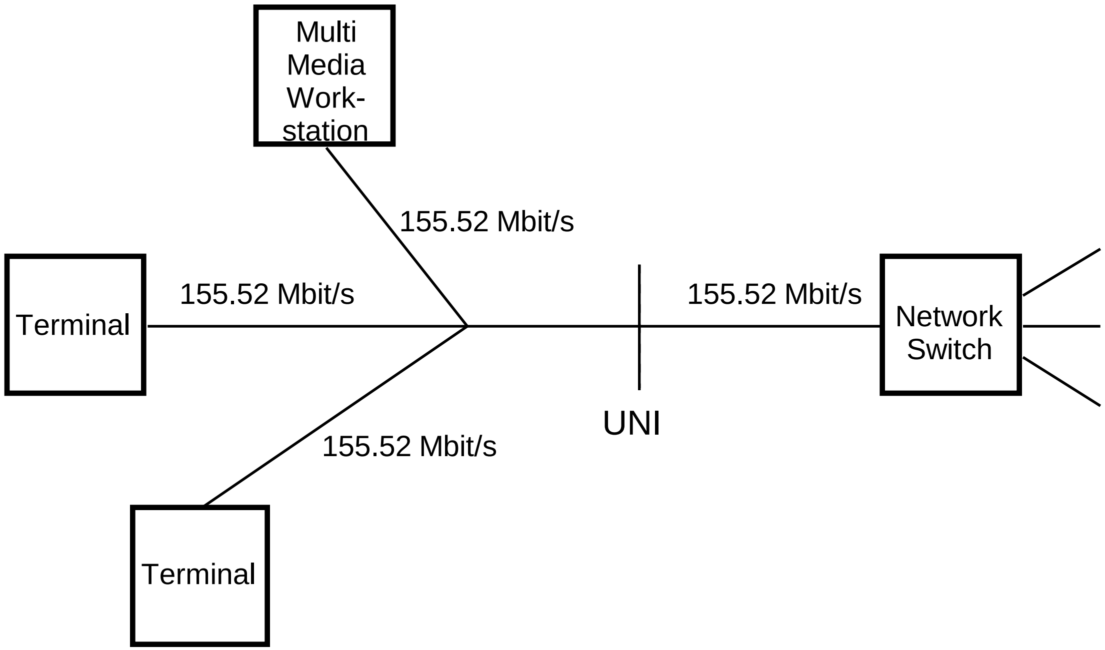
ATM Cell Format of UNI

Generic Flow Control (GFC) (4-bits)	VPI (4-bits)	
VPI (4-bits)	VCI (4-bits)	
VCI (8-bits)		
VCI (4-bits)	Payload Type (3-bits)	CLP (1-bit)
Header Error Check (HEC) (8-bits)		
Cell Payload (48 bytes)		

ATM Cell Format of NNI

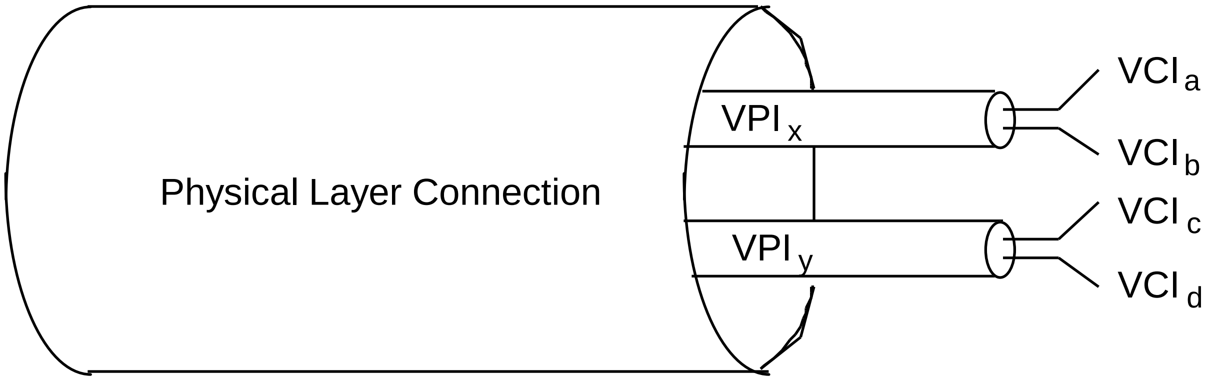


Generic Flow Control Field



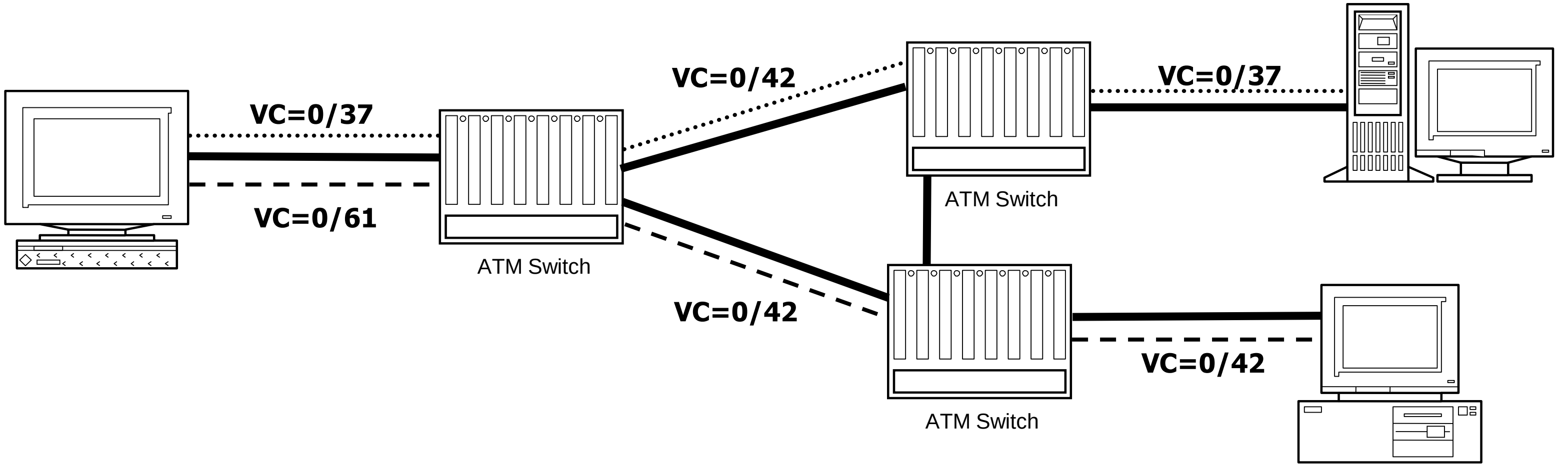
- In the ATM Forum's UNI Specification V3.0, only 0000 is allowed in this field; UNI 3.1 allows other values but does not specify them.
- Possible future uses are flow control and access control

Virtual Paths and Virtual Channels

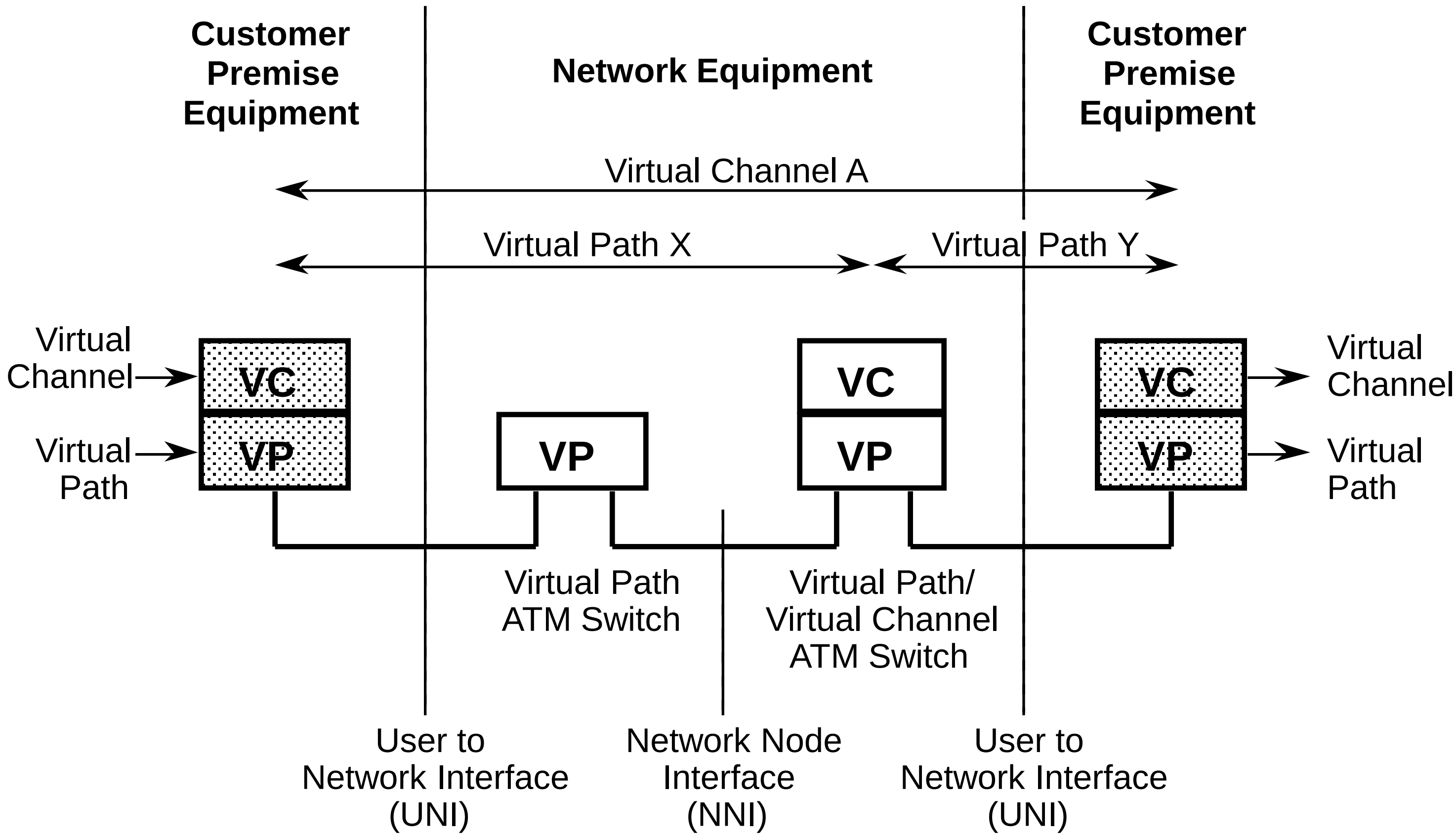


- Hierarchical VC numbering:
  - **VPI:** Identifies a bundle of virtual channels for routing purposes.
  - **VCI:** Identifies a particular channel within a bundle.
  - For a given connection, the values of VCI and VPI may change as the cell traverses through the network.

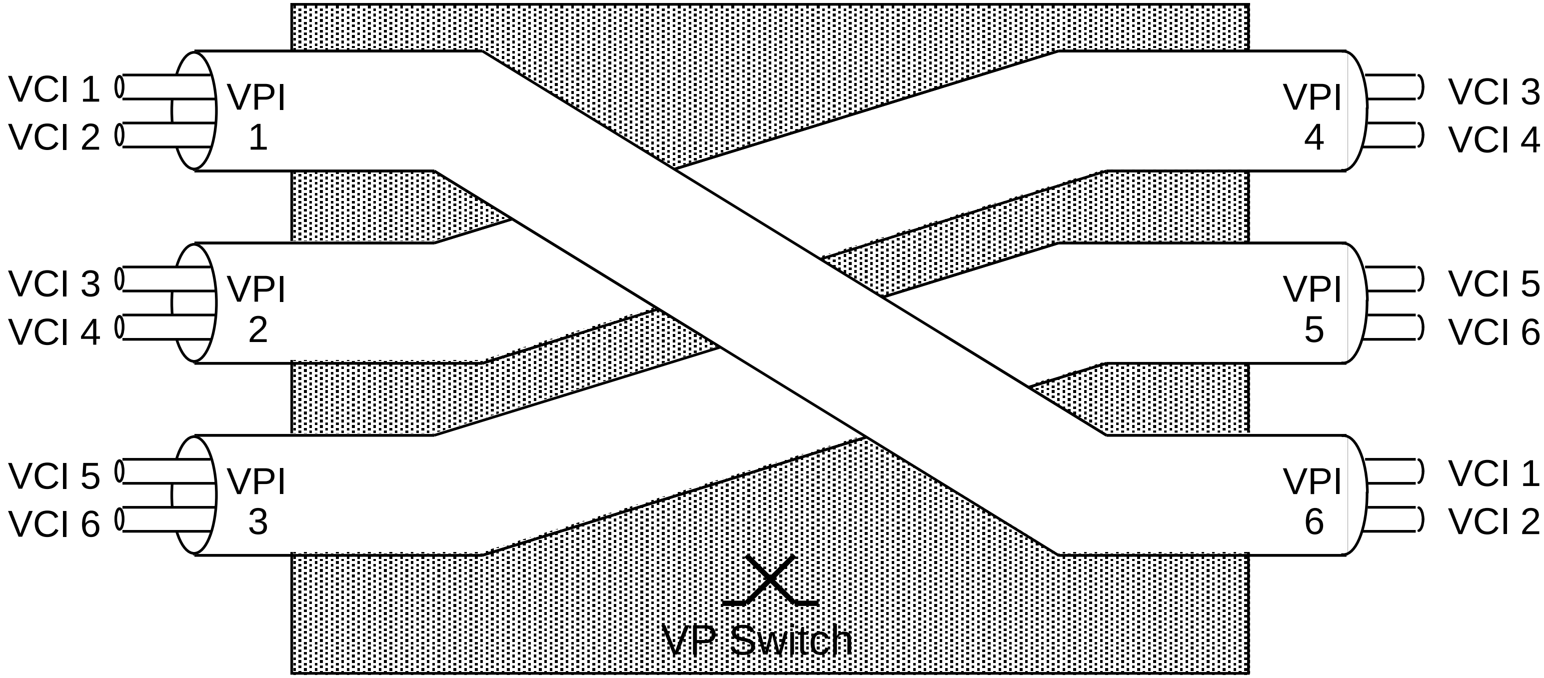
Example


VC=0/37
VC=0/61
ATM Switch
VC=0/42
VC=0/42
ATM Switch
VC=0/37
ATM Switch
VC=0/42

Hierarchical Routing Using VPIs and VCIs



Virtual Path ATM Switch



Virtual Path/Virtual Channel ATM Switch

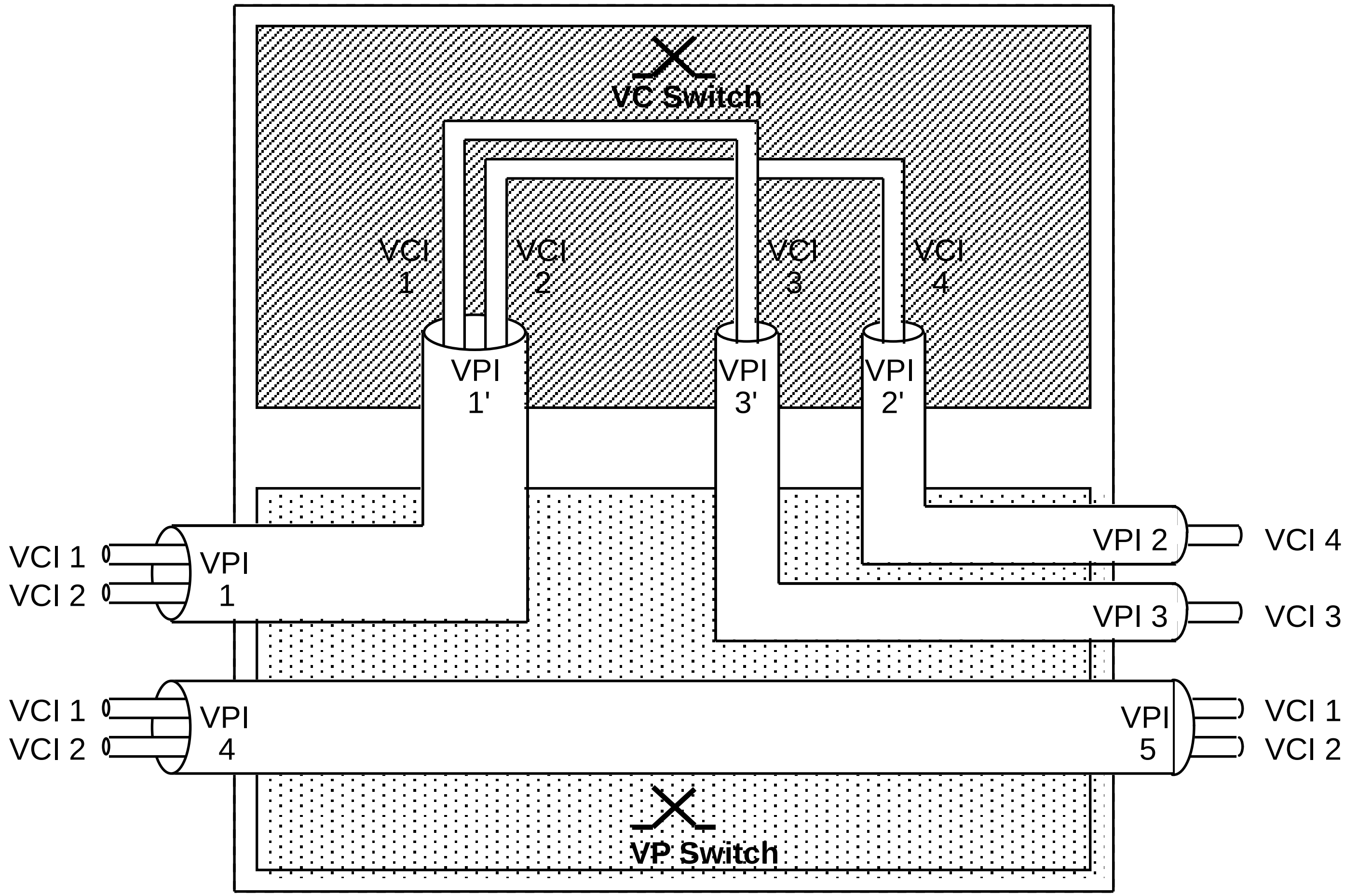
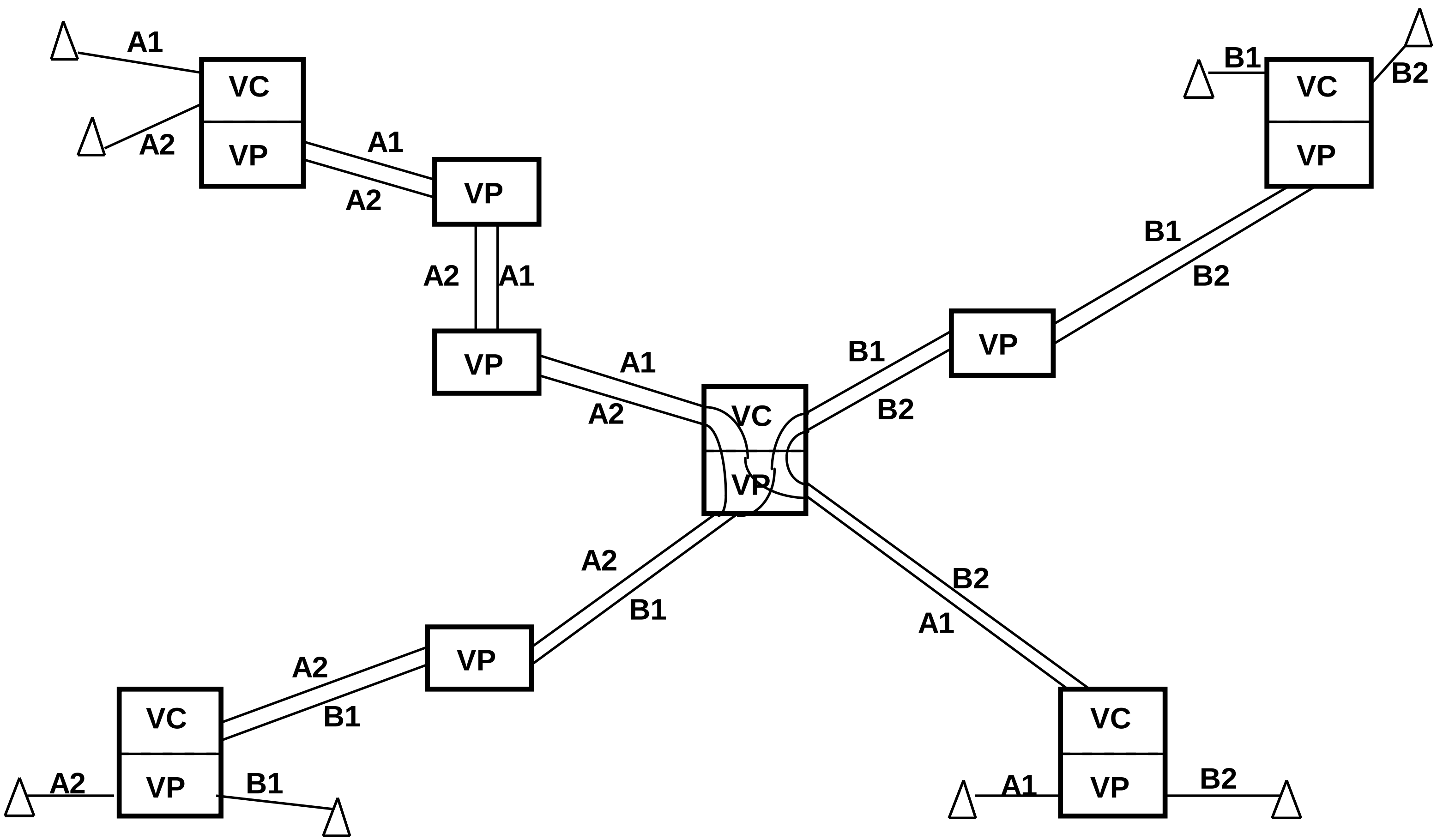


Illustration of Hierarchical Routing



Benefits of VP/VC Scheme

- Aggregation of VCs to simplify traffic management
  - Reduction of size of routing tables in ATM VP switches
  - Allocation of bandwidth on the basis of VPs

CLP and HEC Fields

- CLP = Cell Loss Priority
  - 0: High priority (shouldn't loose), 1: Low priority (may loose)
- HEC = Header Error Check
  - Header CRC (computed only over the cell header)
  - Polynomial: $x^8 + x^2 + x + 1$
  - Used by the SONET physical layer for cell delineation

Management Data Flows

- Defined in ITU-T Recommendation I.610
- Can be in the segment (one ATM hop) or end-to-end
- F4 flow: management at the VP level
- F5 flow: management at the VC level

Payload Type Field

PTI Coding	Interpretation
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 F5 flow related cell
101	End-to-end F5 flow related cell
110	Reserved for future traffic control/resource management
111	Reserved for future functions

- Main Purposes of PTI:
  - Distinguish user cells from non-user cells
  - Indicate congestion in data cells
  - Carry a single-bit flag to be used by AAL5

Pre-Defined Header Values

Use	Notes	GFC	VPI	VCI	PT	CLP
Unassigned cell indication		0	0	0	any	0
Meta-signalling (default)	1	0	0	1	0r0	c
Meta-signalling	2	0	non-0	1	0r0	c
General Broadcast signalling (default)	1	0	0	2	0aa	c
General Broadcast signalling	2	0	non-0	2	0aa	c
Point-to-point signalling (default)	1	0	0	5	0aa	c
Point-to-point signalling	2	0	non-0	5	0aa	c
Invalid Pattern		any	0	0	any	1
Segment F4 flow cell		0	any	3	0r0	a
End-to-end F4 flow cell		0	any	4	0r0	a

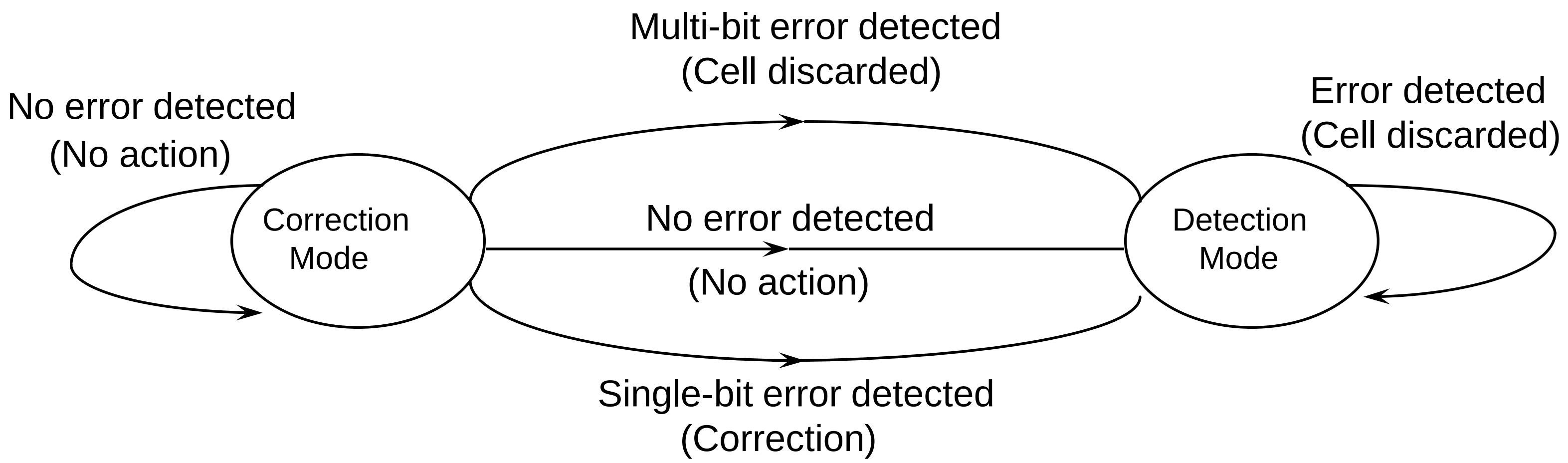
Notes:
1: Reserved for user signalling with the local exchange.
2: Reserved for signalling with other entities (remote).
Bit Key:
a: Available for use by the appropriate layer.
c: Originator sets to zero, network may change.
r: Originator sets to zero, receiver must ignore.

VPI/VCI Fields

- The meta-signaling cells are used to negotiate on signaling VCI and signaling resources.
- General broadcast signaling cells carry information which has to be broadcast to all terminals at the UNI.
- The point-to-point signaling header is used for signaling on a UNI or NNI featuring a point-to-point configuration at the ATM layer, i.e. the network only sees one signaling entity at the other side.
- The segment and end-to-end F4 flows are coded by VCIs 0003_h and 0004_h within the Virtual Path for which they carry maintenance.
- The segment and end-to-end F5 flows are coded by PTs 4_h and 5_h within the Virtual Channel for which they carry maintenance.
- Value 6_h of the PT is reserved for (Fast) Resource Management on the Virtual Channel.

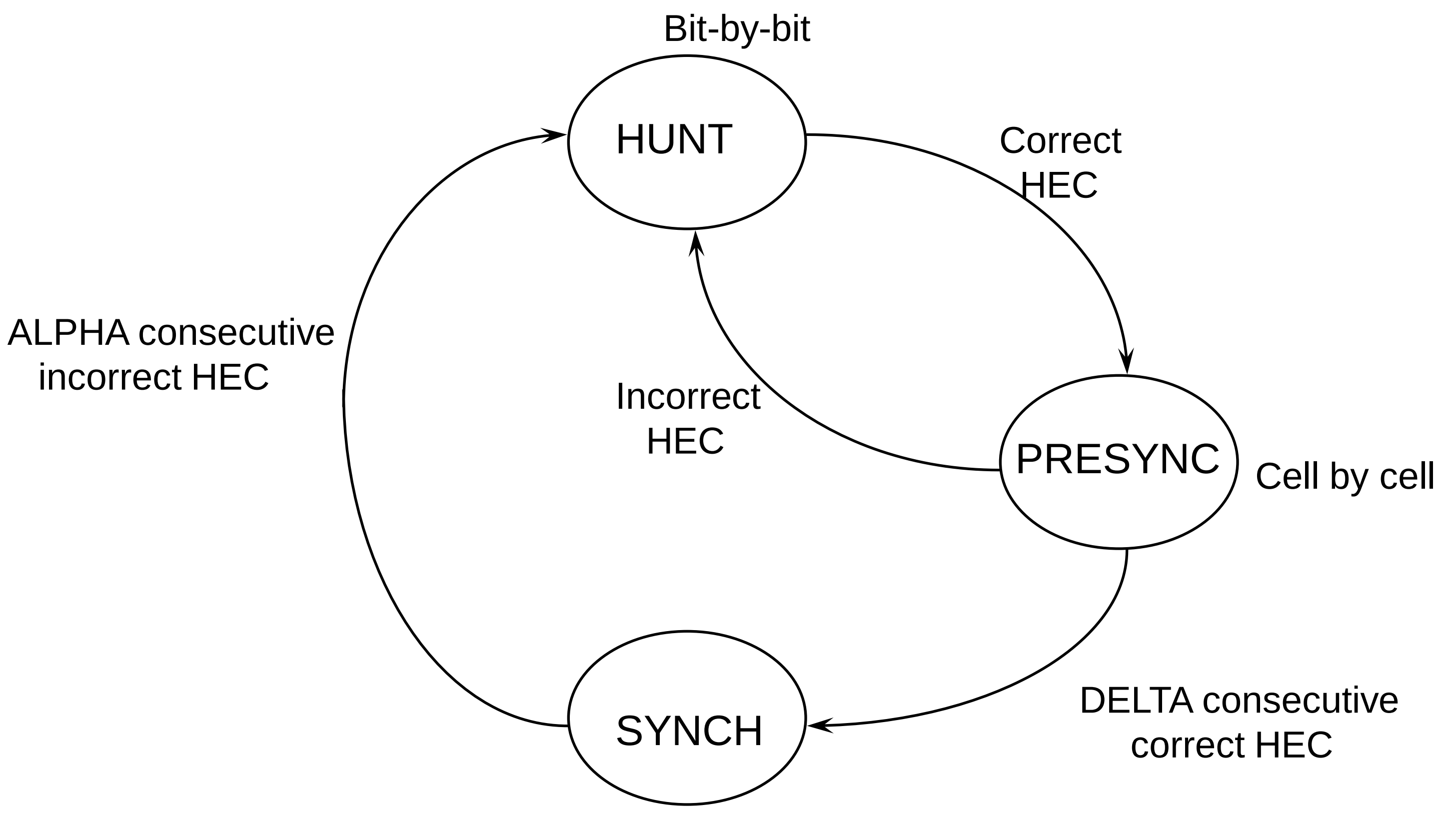
HEC Algorithm

- Dual Mode Operation of the HEC Algorithm



HEC State Diagram

- Cell Delineation State Diagram



Traffic and Congestion Control

- ATM layer congestion $\Rightarrow$ Network is not able to meet negotiated performance objectives
  - Traffic Control: actions taken by network to avoid congestion
  - Congestion Control: actions taken by network to minimize the intensity, spread and duration of congestion

Traffic/Congestion Control Objectives

- Objectives:
  - Support a set of Quality of Service (QoS) classes for all foreseeable B-ISDN services
  - Be independent of AAL or higher layer protocols
  - Minimize network and end-system complexity while maximizing network utilization

Traffic/Congestion Control Functions

- Functions:
  - Network Resource Management
  - Connection Admission Control
  - Feedback Control
  - Usage Parameter Control (make sure that the user traffic abides by the traffic contract)
  - Priority Control (using the CLP bit)
  - Traffic Shaping
  - Other control functions are for further study

Quality Of Service (QoS)

- ATM Performance Parameters:
  - Cell Error Ratio
  - Severely-Errored Cell Block Ratio
    - measures multiple errors in a block of pre-defined size
  - Cell Loss Ratio
  - Cell Misinsertion Rate
    - cells that belong to a different VCI/VPI pair
  - Cell Transfer Delay
  - Mean Cell Transfer Delay
    - mean over several connections and over several cells
  - Cell Delay Variation

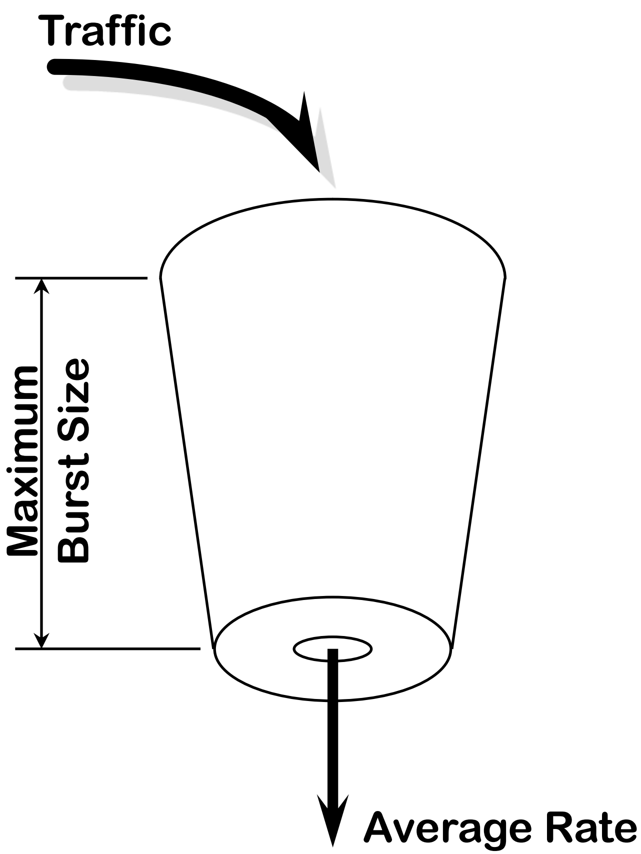
QoS Classes

- A QoS class is pre-defined set of QoS parameters (a template)
- Values of performance parameters are defined by the network provider for each specified QoS class
- Specified QoS Classes
  - Class 1: Support of Circuit Emulation, CBR
    - same performance as a current digital private line
  - Class 2: Support of VBR audio/video
    - intended for packetized audio/video and multimedia
  - Class 3: Support of Connection-Oriented Data
    - support for connection-oriented protocols such as frame-relay
  - Class 4: Support of Connectionless Data
    - connectionless protocols such as IP
- Unspecified QoS Class: let the network provider decide.

Traffic Parameters

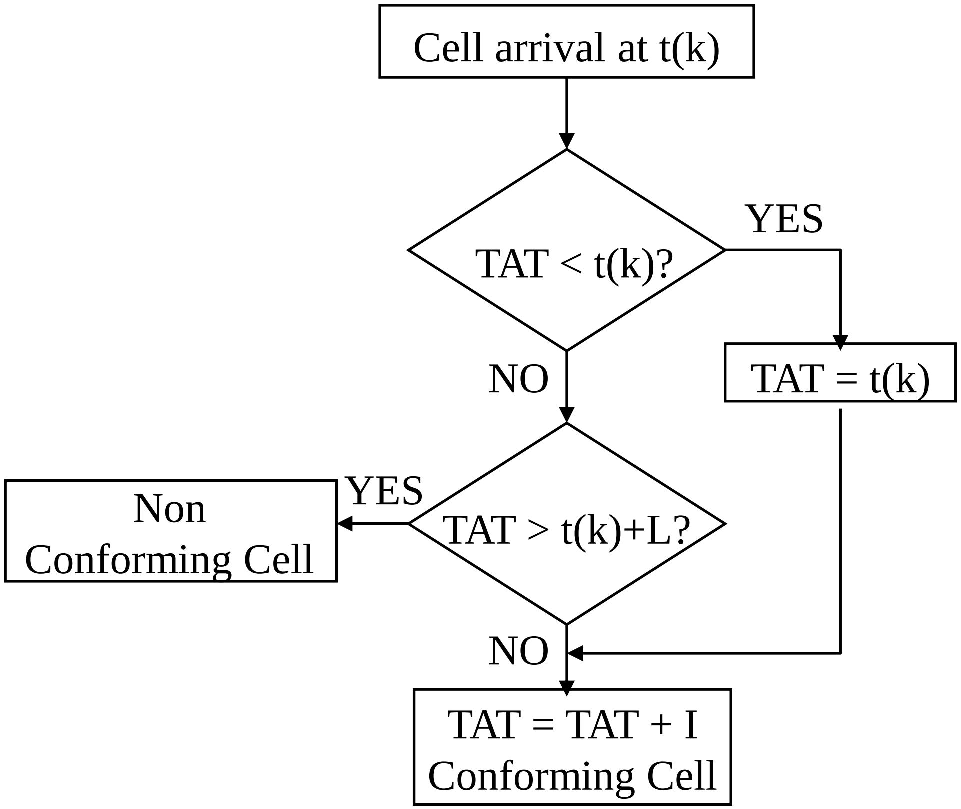
- Peak Cell Rate (CCITT, ATM Forum)
- Sustainable Cell Rate (ATM Forum)
- Burst Tolerance (ATM Forum)
- User-Network Traffic Contract:
  - If the user-traffic complies with its traffic parameters, then the network guarantees to meet the performance parameters defined by the QoS class

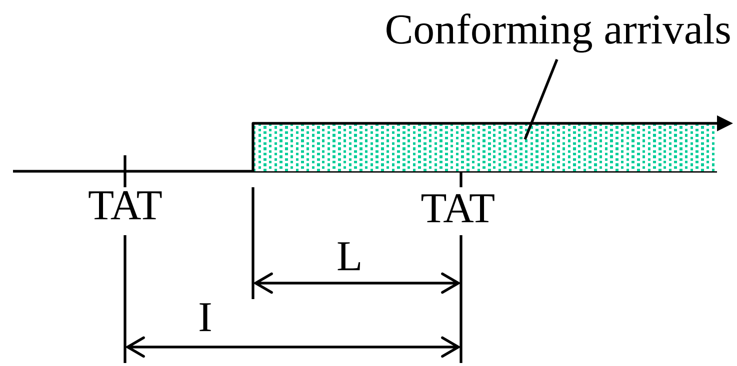
The "Leaky Bucket" Algorithm



- Bits are added to the bucket as they arrive (for transmission).
- The bucket is emptied at a constant rate.
- If the bucket overflows, that data is non-compliant.
- The rate at which the bucket is emptied is the average rate; the bucket size is the maximum burst size.

Generic Cell Rate Algorithm





t(k) = time of arrival of cell k

TAT = Theoretical Arrival Time

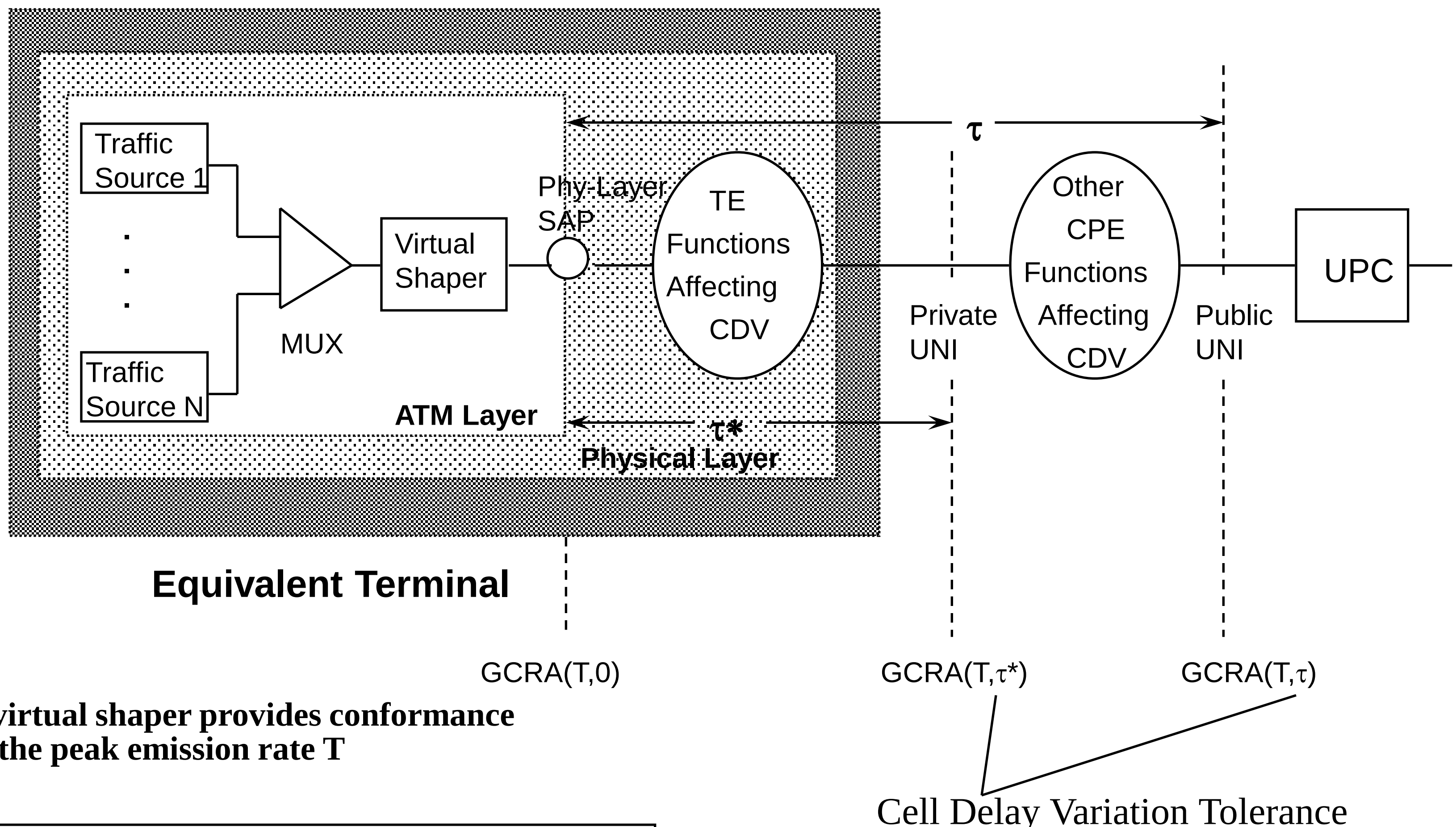
I = Increment

L = Limit

Generic Cell Rate Algorithm

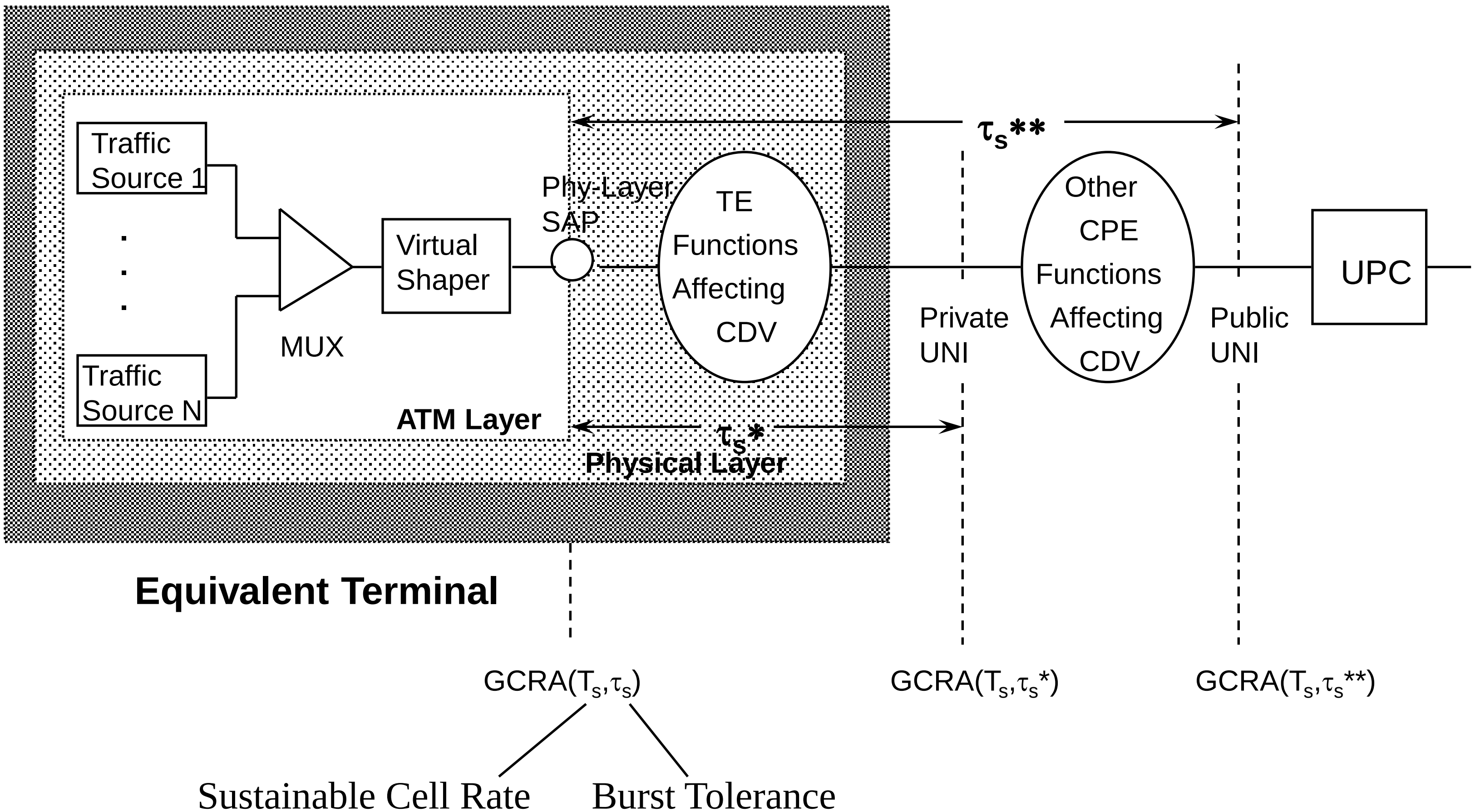
- For a sequence of cell arrival times, $\{t_k\}$, determines which cells conform to the traffic contract
- Counter scheme based on two parameters: GCRA(I,L)
  - I: Increment parameter
    - affects cell rate
  - L: Limit parameter
    - affects cell bursts
- A cell that would cause the buffer to overflow is non-conforming

PCR Reference Model



The virtual shaper provides conformance with the peak emission rate T

Sustainable Cell Rate and Burst Tolerance Reference Model



Maximum Burst Size

- When exchanging traffic parameters, the node actually specifies the Maximum Burst Size instead of the Burst Tolerance.
- The Maximum Burst Size is the maximum number of cells that can be emitted at the peak rate R=1/T and still satisfy the GCRA(T_s,τ_s).
- It can be (easily) shown that the MBS in cells is:

$$MBS = \left\lfloor 1 + \frac{\tau_s}{T_s - T} \right\rfloor$$

(integer part)