

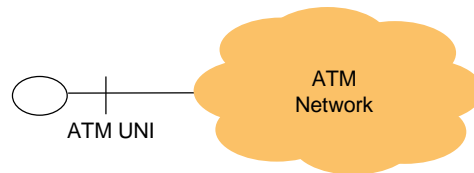
# ATM and Frame Relay Services

Computer Science Department  
University of Crete  
HY536 - Network Technology Lab II  
2000 - 2001

## Broadband Application Requirements

Application Type	Bandwidth (Mbps)	Average delay (msec)	Delay Variation (msec)	Information Loss Rate
File transfer	up to link speed	Insensitive	Insensitive	Very sensitive ( $<10^{-9}$ )
Voice	.064	Very sensitive	Very sensitive	Moderately sensitive ( $10^{-5}$ )
Videoconferencing	nX.064	Very sensitive	Very sensitive	Moderately sensitive ( $10^{-7}$ )
Compressed video (Standard MPEG-1)	1-5	Moderately sensitive	Very sensitive	Moderately sensitive ( $10^{-8}$ )
Compressed video (High Quality)	5-60	Moderately sensitive	Very sensitive	Sensitive ( $<10^{-9}$ )

## ATM Layer Service Categories



- Offered at ATM UNI (User-Network Interface)

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## ATM Forum Service Categories

	Service Category	Typical Application
Real-Time :	Constant Bit Rate (CBR)	Circuit emulation, videoconferencing,
	Real-Time Variable Bit Rate (rt-VBR)	Compressed video/audio
Non-Real-Time:	Non-Real-Time Variable Bit Rate (nrt-VBR)	Critical data
	Available Bit Rate (ABR)	LAN interconnection,
	Unspecified Bit Rate (UBR)	File transfer, message transfer

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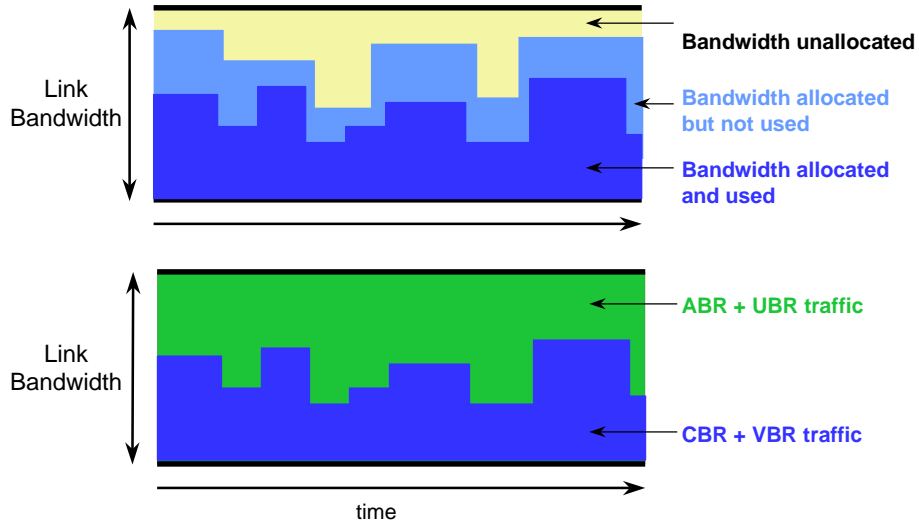
## ATM Forum Real-Time Service Categories

- Constant Bit Rate (CBR):
  - real-time applications requiring a static amount of bandwidth
  - Quality of Service (QoS) in terms of delay, delay variation, cell loss
- Real-Time Variable Bit Rate (rt-VBR):
  - real time applications with “bursty” traffic
  - Quality of Service (QoS) in terms of delay, delay variation, cell loss

## ATM Forum Non-Real-Time Service Categories

- Non-Real-Time Variable Bit Rate (nrt-VBR):
  - non-real-time applications with bursty traffic
  - cell loss bound but no delay bounds
- Available Bit Rate (ABR):
  - “elastic” applications which can adapt their traffic rate
  - closed loop flow control supported
- Unspecified Bit Rate (UBR):
  - non-real-time applications, no service guarantees

## Bandwidth Usage



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## ATM Forum vs. ITU-T Services

ATM Forum "ATM Service Category"	ITU-T "ATM Transfer Capability"	Typical Application
Constant Bit Rate (CBR)	Deterministic Bit Rate (DBR)	Real-time, QoS guarantees
Real-Time Variable Bit Rate (rt-VBR)	(for further study)	Statistical mux, real-time
Non-Real-Time Variable Bit Rate (nrt-VBR)	Statistical Bit Rate (SBR)	Statistical mux
Available Bit Rate (ABR)	Available Bit Rate (ABR)	Resource exploitation, feedback control
Unspecified Bit Rate (UBR)	(no equivalent)	Best-effort, no guarantees
(no equivalent)	ATM Block Transfer (ABT)	Burst level feedback control

ITU-T: International Telecommunication Union,  
Telecommunication Sector

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## Traffic Contract Negotiation

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**Traffic Contract:**

**Traffic parameters:** peak rate, sustainable cell rate, burst size, minimum cell rate

**QoS parameters:** cell delay, cell delay variation, cell loss ratio

**Conformance definition:** Generic Cell Rate Algorithm (GCRA)



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## Traffic Parameters

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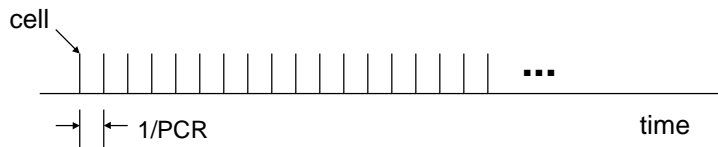
Traffic parameters describe inherent characteristics of a traffic source

- **Peak Cell Rate (PCR):** Maximum instantaneous rate
- **Sustained Cell Rate (SCR):** Average cell rate measured over some long interval
- **Maximum Burst Size (MBS):** Maximum burst size that can be sent at the peak rate
- **Minimum Cell Rate (MCR):** Minimum cell rate user is allowed to send

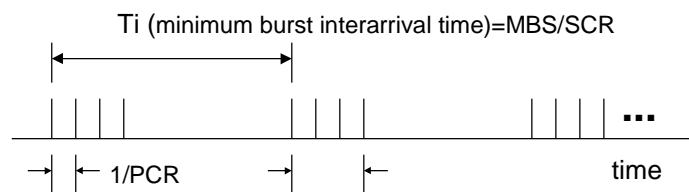
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## Traffic parameters (cont.)

Peak Cell Rate (PCR):



Peak Cell Rate (PCR), Sustainable Cell Rate (SCR),  
Maximum Burst Size (MBS):



$T_b$  (maximum burst duration  
at PCR) =  $(MBS-1)/PCR$

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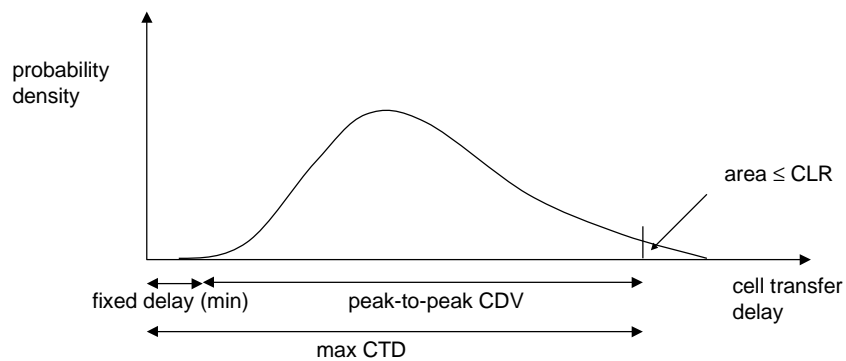
## ATM Quality of Service (QoS) Parameters

**ATM QoS parameters** characterise performance of an ATM layer connection

- **Max Cell Transfer Delay (CTD):** Delay experienced by a cell between network entrance and exit points
- **peak-to-peak Cell Delay Variation (CDV):** max - min cell transfer delay
- **Cell Loss Ratio (CLR):** Percentage of cells that are lost
- The above are user negotiable
- Also, a number of additional, *non-negotiable* QoS parameters have been defined

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## ATM QoS parameters (cont.)



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## Conformance Definition

**Conformance definition** defines conformity at an interface with respect to traffic contract according to one or more instances of GCRA

- GCRA: Generic Cell Rate Algorithm
- Above applies to CBR, VBR, and UBR
- ABR is a special case (includes feedback)

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## Service Category Attributes and Guarantees

Service Category	Traffic Description	Guarantees			Feedback Control
		Min Loss (CLR)	Delay/Variance	Bandwidth	
CBR	PCR	✓	✓	✓	NO
rt-VBR	PCR, SCR, MBS	✓	✓	✓	NO
nrt-VBR	PCR, SCR, MBS	✓	NO	✓	NO
ABR	PCR, MCR+ behavior	✓	NO	✓	✓
UBR	(PCR)	NO	NO	NO	NO

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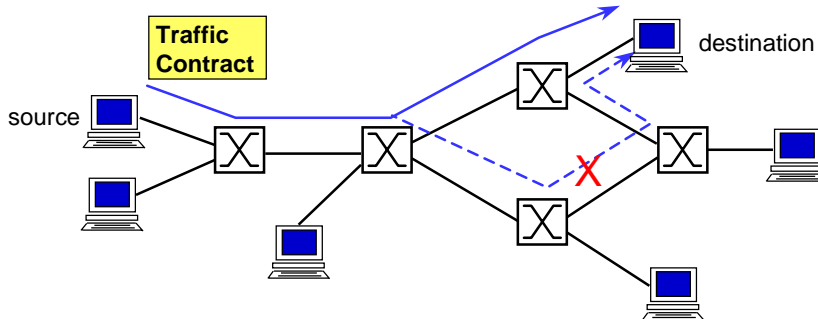
## Traffic Control in ATM

- Connection Acceptance Control (CAC)
- Routing
- Usage Parameter Control (UPC) or Source Policing
- Shaping
- Priorities, scheduling
- Feedback control
- Other (e.g. pricing)

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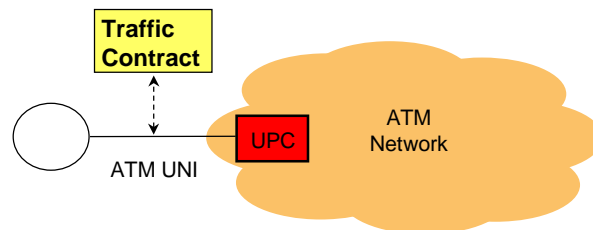
## Control for connection-oriented services



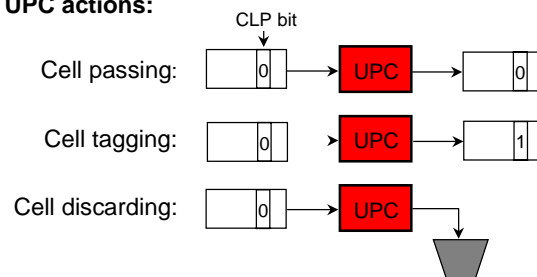
- Connection set-up: use signaling to set-up state (labels + resource reservation) in intermediate switches
- Routing: find path from source to destination that fulfils user requirements (bandwidth, QoS)
- Call Admission Control (CAC): performed at every switch, determines whether there are enough resources to accept a call
- Issues: minimize blocking

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## Usage Parameter Control (UPC) or Source Policing

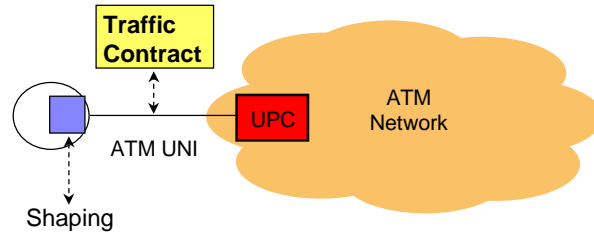


### UPC actions:

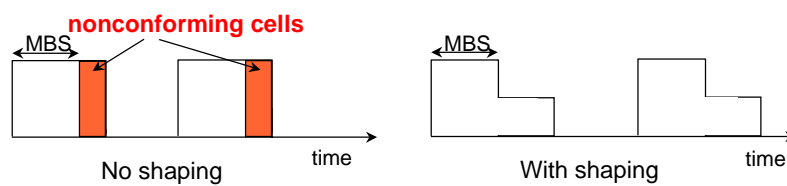


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## UPC and Traffic Shaping



- Traffic shaping at source prevents loss due to policing



MBS: maximum burst size

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## UPC (or Source Policing) Functions

- Algorithm implemented at UNI for ensuring that user traffic adheres to traffic contract.
- Generic Cell Rate Algorithm (GCRA):
  - "Leaky bucket" type algorithm
  - Open loop algorithm

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## Generic Cell Rate Algorithm

**GCRA( $T, \tau$ )**

$t$ : cell arrival time

$tat$ : theoretical arrival time

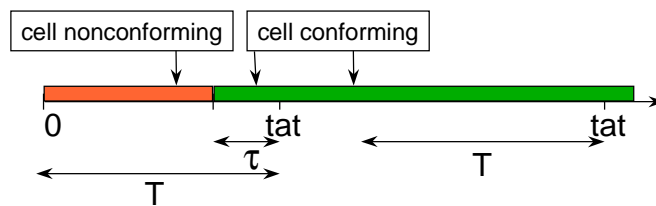
if ( $t < tat - \tau$ )

cell nonconforming

else

cell conforming

$tat = \max(t, tat) + T$



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## GCRA examples

- GCRA(10,2)

- Cell arrival times: 0 10 18 28 42 50

$t$	0	10	18	28	42	50
$tat - \tau$	0-2	10-2	20-2	30-2	40-2	52-2
result	C	C	C	C	C	C
$tat$ after	10	20	30	40	52	62

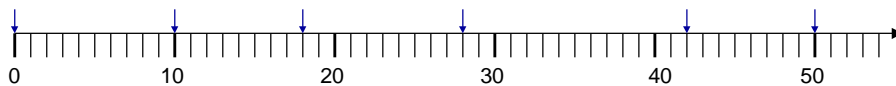
if ( $t < tat - \tau$ )

cell nonconforming

else

cell conforming

$tat = \max(t, tat) + T$



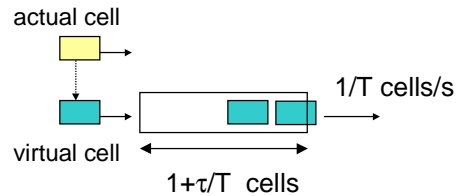
- Cell arrival times: 0 10 15 25 35

$t$	0	10	15	25	35
$tat - \tau$	0-2	10-2	20-2	20-2	35-2
result	C	C	NC	C	C
$tat$ after	10	20	20	35	45

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## Leaky Bucket Algorithm

- Bucket size =  $1 + \tau/T$
- Leak rate =  $1/T$  cells/s
- Bucket contents increased by 1 for each conforming cell

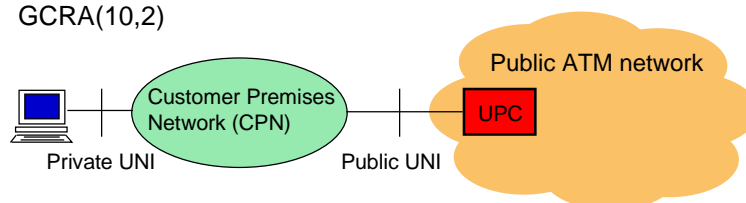


B: bucket contents  
 If  $B+1 > 1 + \tau/T$   
 cell nonconforming  
 else  
 cell conforming  
 $B = B+1$

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## Traffic Contract for CBR

- For each CBR connection:
  - PCR (Peak Cell Rate)
  - CDVT (Cell Delay Variation Tolerance): takes care of slotted nature of ATM, physical overhead, ATM layer function overhead
- Connection must conform to  $GCRA(R/PCR, CDVT)$ , where R is ATM layer rate
  - PCR = 15 Mbps, CDVT = 2, ATM Layer Rate = 150 Mbps  $\Rightarrow$   $GCRA(10, 2)$

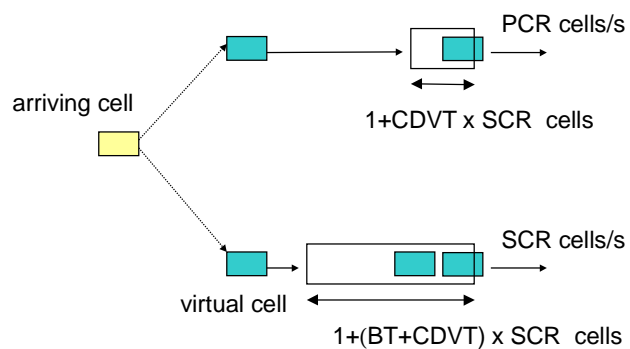


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## Traffic Contract for VBR

- For each VBR connection:
  - PCR, CDVT
  - SCR, MBS, CDVT
  - $BT=(MBS-1)(R/SCR-R/PCR)$ , where R: ATM Layer Rate
- Connection must conform to
  - GCRA(R/PCR,CDVT) AND
  - GCRA(R/SCR, BT+CDVT)

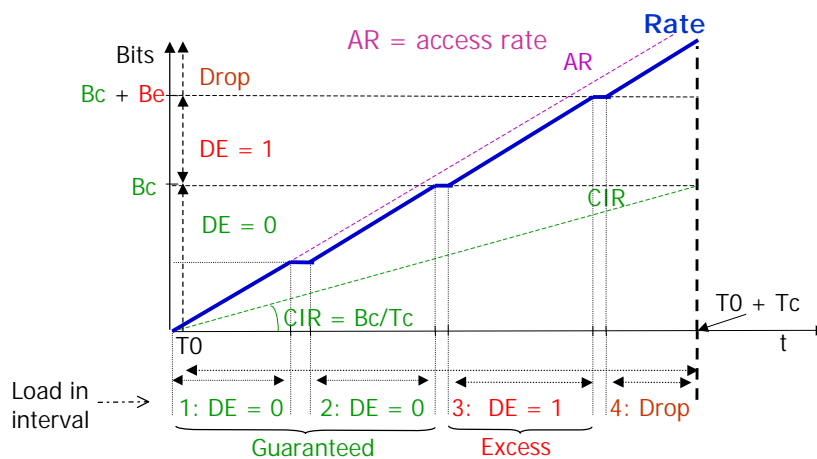
## Leaky buckets for SCR and PCR policing



## Frame Relay Traffic Parameters

- Committed Information Rate (CIR)
- Committed Burst Size (Bc)
  - Measurement interval  $T = Bc / CIR$
- Excess Burst Size (Be)
  - Excess Information Rate (EIR):  $EIR = Be / T$
- If bits in interval T
  - between Bc and Bc+Be => Mark Discard Eligible (DE) bit in frame
  - over Bc+Be => Discard frame

## Frame Relay conformance checking



## Frame Relay/ATM Traffic Parameter Conversion

- Different methods using 2 or 3 GCRA's
  - Method 1: 3 GCRA's to characterize
    - peak (= frame relay access line rate)
    - CIR, Bc
    - EIR, Be
  - Method 2: 2 GCRA's to characterize
    - first GCRA: peak (= frame relay access line rate)
    - second GCRA: CIR, Bc
- or
- first GCRA: CIR+EIR
  - second GCRA: CIR, Bc
- 
- Need to take into account the cell overhead (tax)