PM7322

RCMP
TECHNICAL OVERVIEW

Issue 1: October 16, 1995

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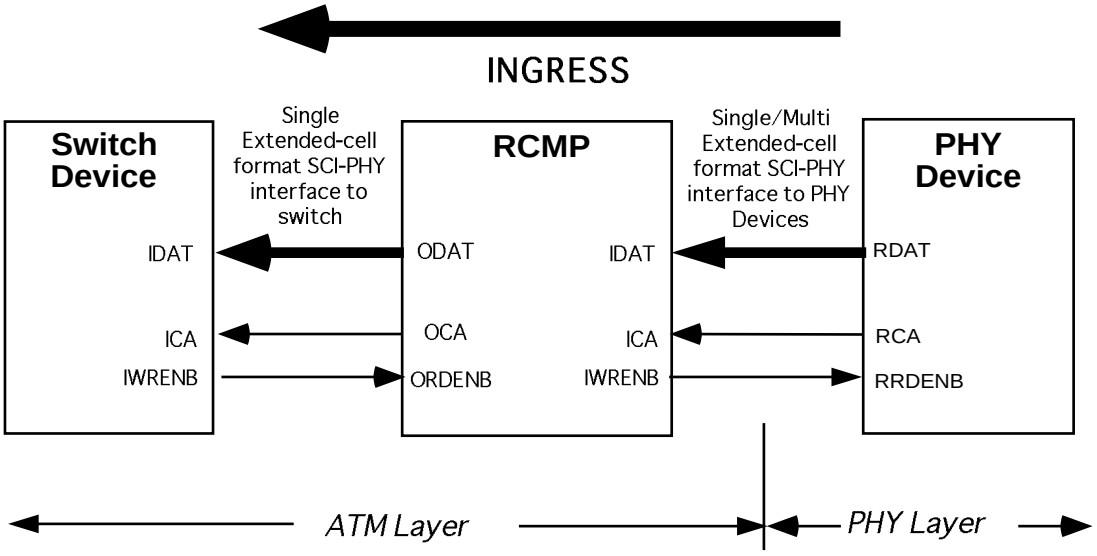
PRODUCT SUMMARY

The RCMP performs ATM Layer functions: 1) Header translation and cell append for Routing, 2) Policing, 3) Cell counting and 4) OAM cell processing and routing, for 64K VC's. It provides extended-cell format SCI-PHY interface at both the physical and the switch sides. Multicasting is supported. The RCMP also provides cell insert/extract through the microprocessor interface and DMA access. The RCMP supports the Ingress function primarily, but can be configured for use in the Egress direction in single-PHY applications.

Main application areas for the RCMP are in the WAN and WAN access equipment: 1) Edge Switches, 2) Enterprise Switches, 3) Core Switches and 4) Access Muxes and Residential Broadband Switches.

The RCMP is fabricated in a 0.6 micron, 5v technology and housed in a 240-pin copper slugged plastic quad flat pack (PQFP) package.

Fig. 1 Use of RCMP



TYPICAL APPLICATIONS

Main motivator for equipment vendors to use RCMP: **Standards Compliance**

- Provide policing and traffic statistics to enable the network to achieve the Quality of Service and to perform tariffing
- Allow better fault isolation through Performance Monitoring
- Provide more diagnostic tools: loopback, continuity-check
- Reduce system design effort by providing industry-standard SCI-PHY interfaces at both the physical layer side and the switch core side.

Applications found mostly in network equipment, such as:

- **ATM Edge Switches**
- **ATM Enterprise Switches**
- **ATM Core Switches**
- **Access Muxes and Residential Broadband Switches**

Target Application	Product
Self-Routing Switch Architectures	All Switches
Policing at UNI	Access Mux,Enterprise Switch (eg. WAN access)
Policing at NNI	Edge Switch
Performance Monitoring at NNI	Edge Switch, Core Switch
ABR Services at UNI	Edge Switch

Self-Routing Switch Architectures:
For adding routing tags (up to 10 octets) to the 53-octet ATM cell. The switch fabric would simply need to route the cell to the correct output port according to the tags.

Policing at UNI:
For customer to control the bandwidth usage so as not to violate the traffic contract before entering the network. Also for the network carrier to police incoming traffic.

Policing at NNI
For network carrier to regulate the traffic within the network.

Performance Monitoring at NNI:
For network carrier to monitor integrity, to perform fault diagnosis/isolation. Especially important for inter-network operation in a connection failure situation, where the network carrier can quickly isolate the fault, or prove to others that its own network is fine.

ABR Services at UNI:
RCMP supports Resource Management cell insertion/extraction, but does not generate/process the information contained in the RM cell.

MAIN FEATURES

Routing

- Address Translation: Individual VPI/VCI Processing (up to 64K VC connections)
- Prepend/Postpend routing octets (up to 64 octets in a cell)
- Microprocessor cell insertion/extraction[1]
- Logical Multicasting

OAM (Operations, Administrative and Maintenance)

- F4 (VPC), F5 (VCC) OAM cell monitor/termination
- Fault Mgmt: Extract and process (optional) AIS, RDI, Continuity Check(CC), Loopback
- Performance Mgmt (PM): Monitors/Generates PM cells[2]
- Resource Mgmt (RM): RM cell extraction for ABR service[3]

Policing

- Cell Rate Policing using two successive leaky bucket algorithms
- Optionally tags non-compliant cells by setting CLP = 1
- AAL5 Tagging/Dropping

Cell Counting

- Per VC counts on high, low priority, non-compliant cells
- Per VC PM counts on lost, misinserted cells, BIP-16 errors, severely errored cell blocks
- Device counts on total input and output cells, OAM cells, corrupted OAM cells, invalid VPI/VCIs, discarded cells, physical layer idle cells

Congestion Control

- All low priority cells discarded if CONG pin asserted by switch core

RAM access through generic microprocessor port

- Supports DMA control

Cell Interface

- Supports extended-cell format SCI-PHY Interface[4] on both the Physical layer side and the Switch side

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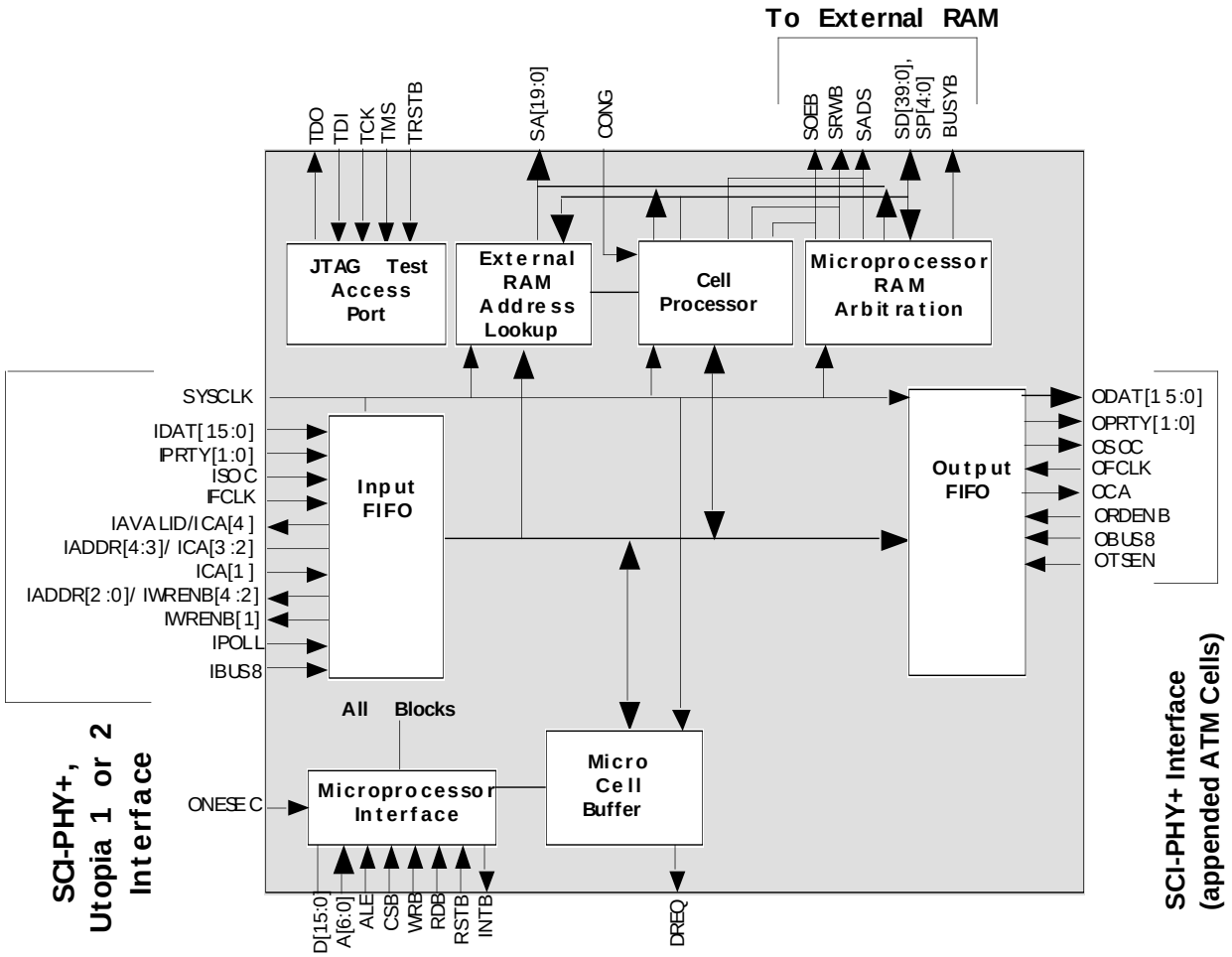
[1]Can only extract cells that the RCMP can recognize. Currently, the RCMP can extract F4/F5 OAM cells, Resource Management cells and entire VC's.

[2]Three types of PM cells: 1) Forward Monitoring, 2) Backward Reporting and 3) Monitoring & Reporting. RCMP extracts 1,2 & 3; only generates 1 & 2. Also, RCMP supports Activation/Deactivation cells for PM and CC.

[3]ABR standards are still churning, therefore RM cell processing is not included in current RCMP

[4]For the 8-bit interface, only a total of 10 octets can be appended, not 11 as stated in the SCI-PHY+ spec.

Fig. 2 Block Diagram



MODES OF OPERATION

Single-PHY vs Multi-PHY

Single-PHY

The RCMP can interface with a single PHY device with a maximum of STS-12c/STM-4 rate (622Mb/s). The actual bus interface can handle 800Mb/s (16 bits @ 50 MHz) to accomodate the pre/postpend octets.

Multi-PHY

The RCMP can interface using direct addressing to up to 4 PHY devices (eg. four STS-3/STM-1 PHY's).

The RCMP can interface with up to 32 PHY devices using addressing polling, with the same maximum aggregate bandwidth as in the single-PHY application. An example would be interfacing with 32 DS1 PHY's.

[Refer to the Reference Design Section for more details]

8-bit vs 16 bit

The RCMP can operate in either 8 or 16 bit mode in the SCI-PHY interfaces, as controlled by the IBUS8 and OBUS8 pins. 8-bit mode is used to support aggregate rates of 200 Mb/s or lower (eg. 4 x T3), and 16-bit mode is used to support aggregate rates of 800Mb/s (eg. STS-12, 622 Mb/s plus pre/postpend).

Direct Access vs Address Polling

In single-PHY mode, the RCMP uses direct access (ie. individual ICA and IWRENB signals) to a maximum of 4 PHY devices.

In multi-PHY mode, the RCMP uses address polling to determine which PHY devices (out of a maximum of 32 PHY's) will source the next cell transfer.

Multicast

The RCMP can perform logical multicasting[5]. A single received cell can result in an arbitrary number of cells on the output, each with its own unique VPI/VCI value and appended bytes, but with the same cell payload. Note that incoming cells can be back-pressured during multicasting (which has higher priority than incoming cells). If a large enough number of cells are created by multicasting, a FIFO overflow can occure in the PHY device feeding the RCMP input.

[5]Logical multicast means broadcasting copies of a VC to the same physical port. This is in contrast with spacial multicast where there are multiple physical ports for the VC copies to go to.

Ingress vs Egress

The RCMP is intended to be used in the Ingress direction, interfacing between the PHY devices and the switch core.

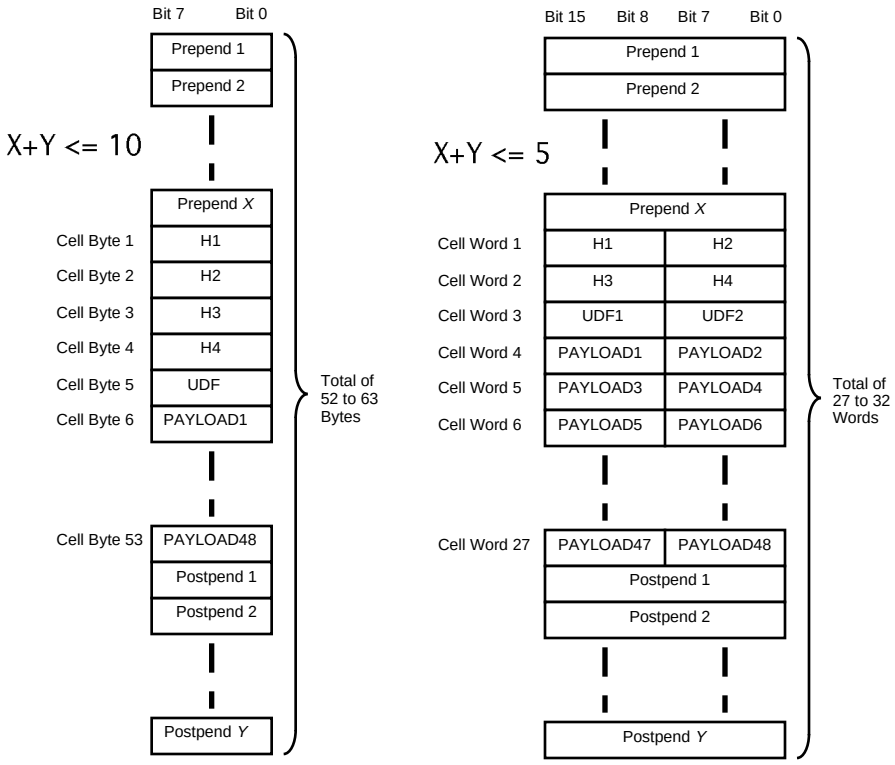
It is possible to employ the RCMP in the Egress direction only to provide header translation and OAM processing. This might require some glue logic to resolve certain SCI-PHY control issues, depending on the interface implementation. Note that the RCMP does not perform traffic shaping and RM cell insertion, which are part of the Egress function.

FEATURE DESCRIPTION

Header Translation

- RCMP does not physically route cells
- RCMP performs header translation: in particular, the VPI/VCI address is replaced with a new one, which, together with the extra octets appended, will instruct the switch core to perform the physical routing
- No restriction on VPI/VCI address range, ie. complete address flexibility (Key feature)
- Can be configured to sustain a cell rate from a STS-12 source without dropping cells or signalling the source to slow down.
- At both the input and output cell interface, the ATM cell size can range from 52 to 63 octets (8-bit format), or 26 to 32 words (16-bit format)
- Extended-cell format SCI-PHY Interface:
    - UTOPIA compatible
    - Multi-PHY support
    - Data parity mandatory
    - Cell Extensions (Append) for switching
- Cell Append:
    8-bit mode: Up to 10 octets before and/or after the ATM cell
    16-bit mode: Up to 5 words before and/or after the ATM cell, plus the UDF2 octet (total of 11 octets)

Fig.3 ATM cell organization



Note: In 8-bit mode, the UDF (User-defined) octet takes the place of the HEC, since HEC is not used in the ATM layer. This UDF octet can be omitted, making the ATM cell 52 octets long. In 16-bit mode, UDF1 takes the place of HEC; both UDF1 and UDF2 are user-defined octets. UDF1 and UDF2 can be omitted, making the ATM cell 26 words long.

Policing

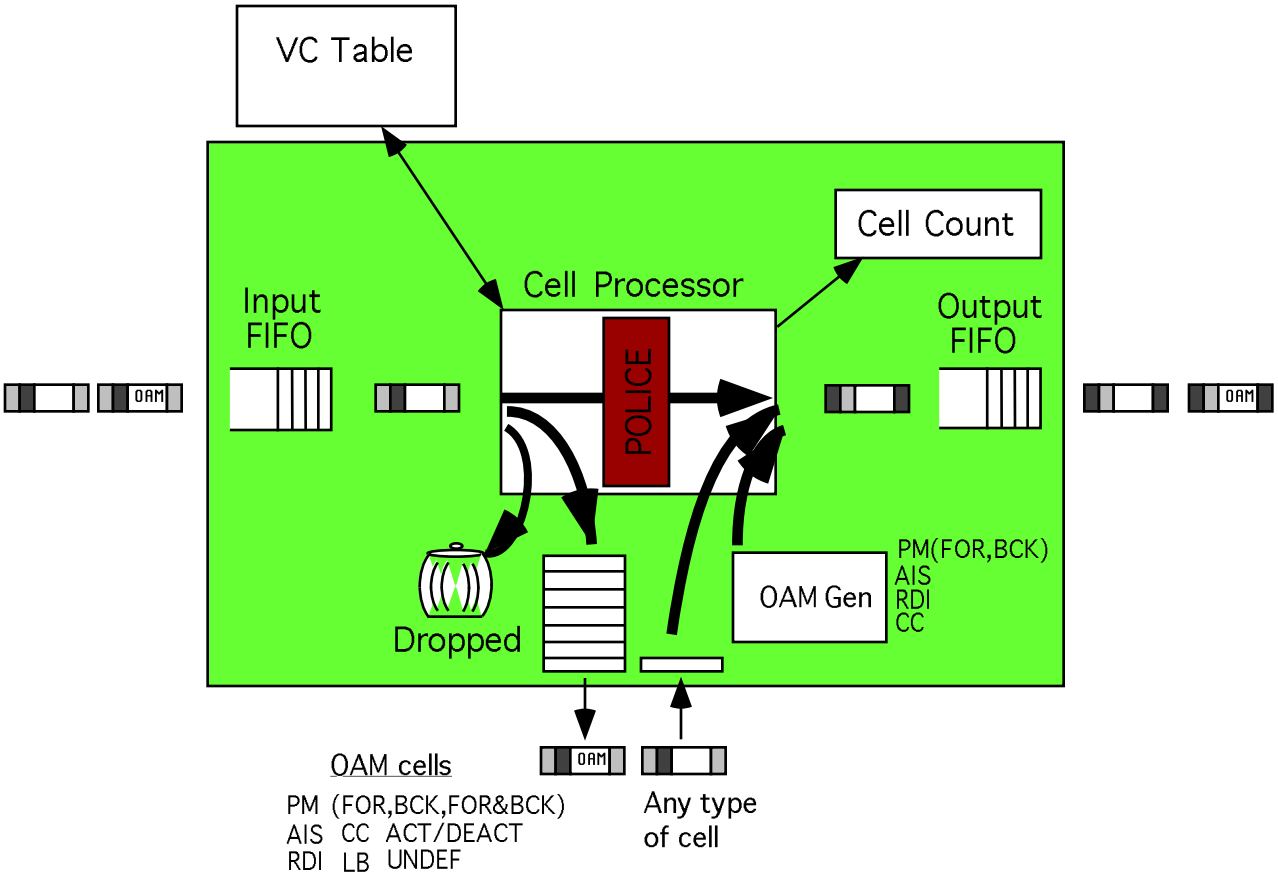
- Uses the Virtual Scheduling Algorithm (Continuous-State Leaky Bucket) as specified in ITU-T Recommendation I.371 and ATM Forum UNI 3.0
- Per-VC Policing done to adhere to parameters negotiated at connection set up:
  CBR:
    - Peak Cell Rate (PCR): Maximum cell rate
    - Cell Delay Variation Tolerance (CDVT): Maximum variation from ideal cell arrival time

  VBR: (in addition to the CBR parameters)
    - Sustained Cell Rate (SCR): Average cell rate
    - Burst Tolerance (BT): Maximum size of a burst of cells
- Policing done on a programmable combination of cell types: user cells, OAM cells, RM cells, high or low priority cells
- Different cell type combination for VBR/CBR and ABR connections
- Per-VC programmable Policing actions on Violating cells:
    - Keep count
    - Tag: change to low priority
    - Discard
- Two successive policing instances on each VC to allow flexibility in testing different cell types. (eg. For CBR and ABR, only need one policing instance to check for (PCR,CDVT) conformance; for VBR, need one policing instance to check for (PCR,CDVT) conformance, and another for (SCR,BT) conformance)
- All cells in an AAL5 Packet can be tagged or dropped if a cell is dropped by policing.

OAM Processing

- ITU-T Recommmendation I.610, Bellcore TR-1248, Bellcore GR-1113-CORE
- Incoming OAM cells are terminated, passed to output FIFO or microprocessor interface
- Outgoing OAM cells sourced from automatic OAM generation circuitry (AIS, RDI, forward/backward PM, CC cells), input FIFO or microprocessor interface
- A special feature to facilitate the Egress function:
  Backward routing of OAM cells and RM cells without going through the switch core. This is done by an external processing device that would recognize a special tag on these cells so that they can be extracted and routed to the egress direction immediately.

Fig. 4 OAM processing and routing in RCMP



PM: Performance Monitoring. Three types: Forward Monitoring, Backward Reporting, and Monitoring & Reporting. Contains total transmitted cell count, block parity, lost/misinserted cell count, and severely errored cell block count.

AIS: Alarm Indication Signal cells are used to indicate to the downstream equipement of a problem in the connection.

RDI: Remote Defect Indication. Sent to the far end of a connection end-point to indicate unavailability. RCMP can be programmed to send RDI cells every second 1) if AIS received, or 2) if Continuity Check alarm is on, or 3) all the time.

CC: Continuity Check cells checking connection integrity.

LB: Loopback cells for diagnostics.

FRM: Forward Resource Management cells, sent along with traffic towards the destination of connection. RM cells are intended to implement the ABR control mechanism, by conveying the congestion indication and available rates at each switch along the connection.

BRM: Backward Resource Management cells, sent along with traffic towards the source of connection.

ACT/DEACT: Activation/Deactivation cells are used by the management entity to implement the handshaking necessary for the starting/stopping of the performance monitoring and continuity check processes.

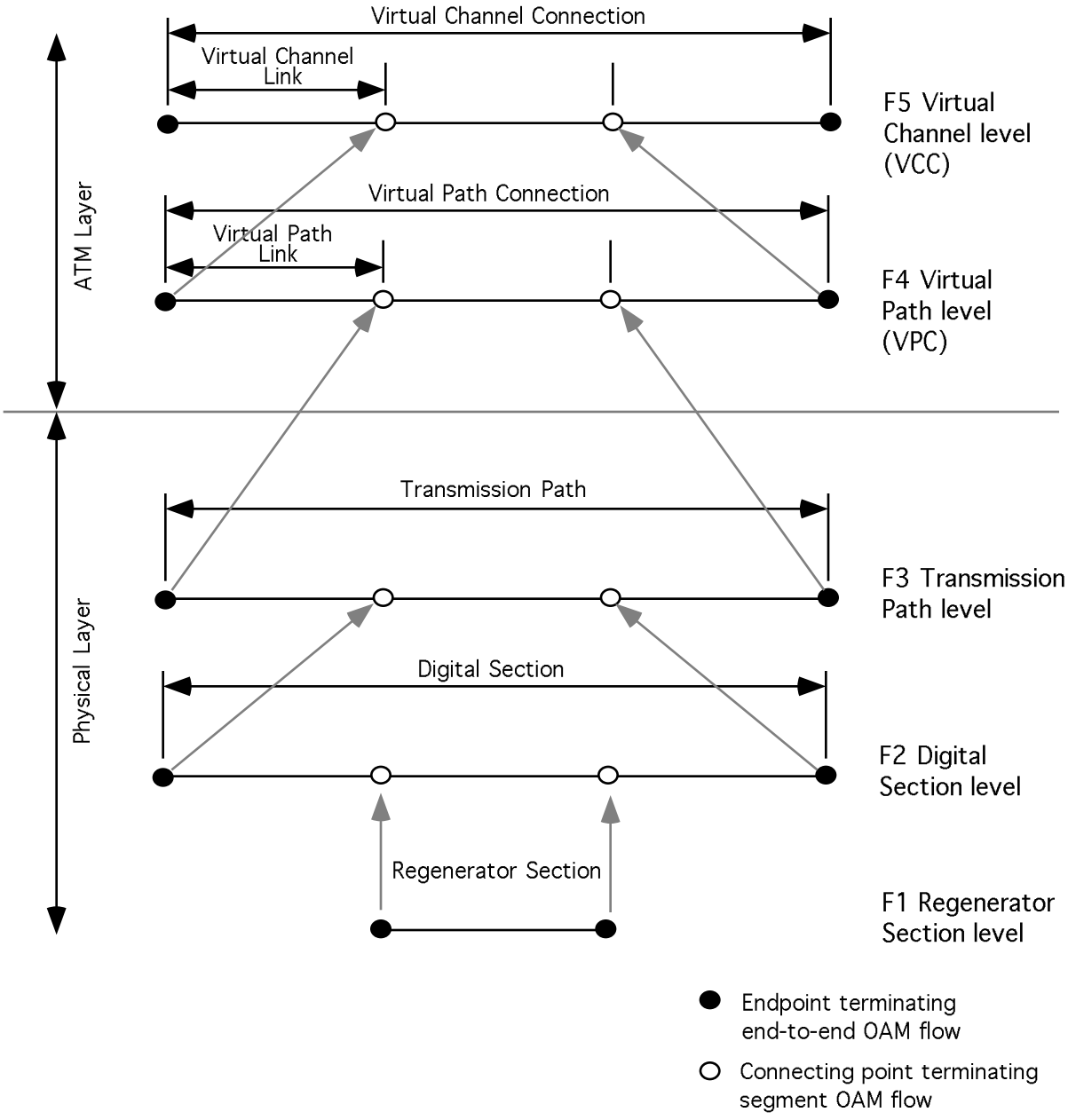
UNDEF: Undefined OAM cell types.

NOTE: The RCMP only processes the following OAM cell types:
PM, AIS, RDI and CC. All other cells are either dropped, passed to the output FIFO or to the microprocessor interface.

NOTE: All RCMP-generated backward flow OAM cell (RDI,backward PM), all RM cells may be marked for easy identification by an external processing device for fast routing to the egress direction without going through the switch core.

Note: Cell insertion to output FIFO priority: 1) PM cells have highest priority, 2) uP inserted cells and user cells have equal priority, 3) Fault Management cells (AIS,RDI,CC) have lowest priority.

Fig. 5 Different types of OAM flow in a network



Cell Counting

The following table describes the various cell counts performed in the RCMP for performance monitoring purposes:

Per-VC counts	High priority cells	No. of cells processed with the CLP bit set to 0
	Low priority cells	No. of cells processed with the CLP bit set to 1
	Non-compliant cells	No. of cells found violating by the two successive policing functions
	Lost cells	No. of cells *less* than the expected no. carried in the PM cell sent on a periodic basis
	Misinserted cells	No. of cells *more* than the expected no. carried in the PM cell sent on a periodic basis
	Block BIP errors	No. of BIP parity mismatches between calculated BIP and that carried in the PM cell
	Severely Errored Blocks	Incremented every time the lost, misinserted counts, BIP errors exceed pre-set thresholds
Aggregate cell counts	Input cell count	No. of cells read from the Input FIFO
	Output cell count	No. of cells read from the Output FIFO
	Valid OAM cells	No. of OAM cells received
	Errored OAM cells	No. of OAM cells received with either incorrect CRC, undefined OAM type, or function type.
	Invalid cells	No. of cells with unprovisioned VPI/VCI, or undefined PTI values
	Dropped cells	No. of cells dropped due to congestion indicated by the assertion of the CONG pin
	PHY layer idle cells	No. of Physical layer cells arriving at the Input FIFO and discared; they do belong to the ATM layer

USE OF RCMP DATA

The OSI model for Network Management specifies the following requirements:

1. Fault Management (Guaranteeing a working network)
2. Performance Management (Guaranteeing a *high-quality* working networking)
3. Configuration Management (including Capacity planning)
4. Security Management (including Disaster planning/recovery)
5. Accounting Management (Billing)

The RCMP provides status/control on the network and on each VC, in particular for Items 1, 2 and 5.

1. Fault Management

- Alarm Surveillance (AIS, RDI)
- Connectivity verification (Continuity Check, Loopback)

2. Performance Management

ITU-T I.356 specifies the following cell transfer parameters:

- Cell Loss Ratio
- Cell Misinsertion Rate
- Severely Errored Cell Block Ratio
- Cell Transfer Delay
- Cell Delay Variation

These parameters can be computed using statistics collected by the RCMP.

5. Billing

[Ref: GR-1110-CORE (Bellcore), BICI Spec. (ATM Forum)]

Parameters such as total number of cells transferred, total number of high-priority cells transferred, in both the Ingress and Egress directions, are recorded intervals ranging from 15 minutes to a day, with a default of an hour. The recording interval depends on whether the connection is a PVC or SVC.

STANDARDS COMPLIANCE

- ATM Forum - ATM User-Network Interface Specification, V3.0, October, 1993
- ITU-T Recommendation I.361 - "B-ISDN ATM Layer Specification", March 1993
  - ATM Header Definitions for all cell types at UNI and NNI
- ITU-T Recommendation I.371 - "Traffic Control and Congestion Control in B-ISDN", March 1993
  - Policing Mechanisms (leaky bucket algo., cell discard/tagging), Resource Mgmt.
- ITU-T Recommendation I.610 - "B-ISDN Operation and Maintenance Principles and Functions", Helsinki, March 1993.
- Bell Communications Research - Broadband Switching System (BSS) Generic Requirements, GR-1110-CORE, Issue 1, September 1994.
  - UNI cell processing, Traffic Control and Congestion Control
- Bell Communications Research -Asynchronous Transfer Mode (ATM) and ATM Adaptation Layer (AAL) Protocols, GR-1113-CORE, Issue 1, July 1994.
  - ATM Header Definition, OAM processing
- Bell Communications Research - Generic Requirements for Operations of Broadband Switching Systems, TA-NWT-001248, Issue 2, October 1993.
  - OAM processing
- IEEE 1149.1 - Standard Test Access Port and Boundary Scan Architecture, May 21, 1990.
- PMC-940102, ATM_SCI_PHY, "SATURN Compliant Interface For ATM PHY Layer and ATM Layer Devices, Level 2", October 1995, Issue 3.
  - Extended-cell format SCI-PHY cell extensions, Multi-PHY operation, Cell Identification and Routing
- ATM Forum/95-0013R2, Draft Version 3.0 of ATM Forum Traffic Management Specification Version 4.0, April 15, 1995
  - Policing (overlaps with I.371), ABR

RCMP APPLICATIONS

Fig. 6 RCMP Single-PHY application

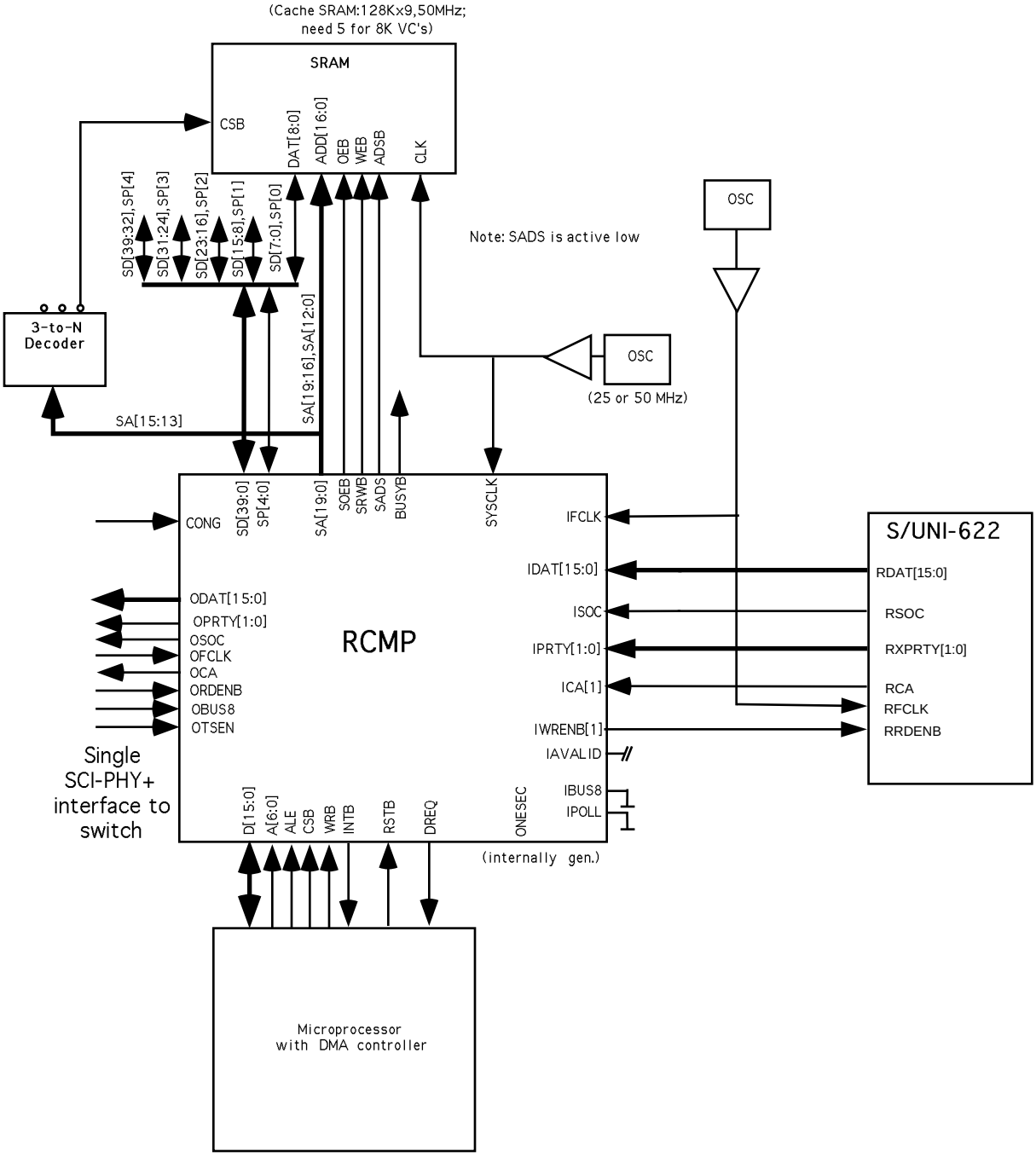
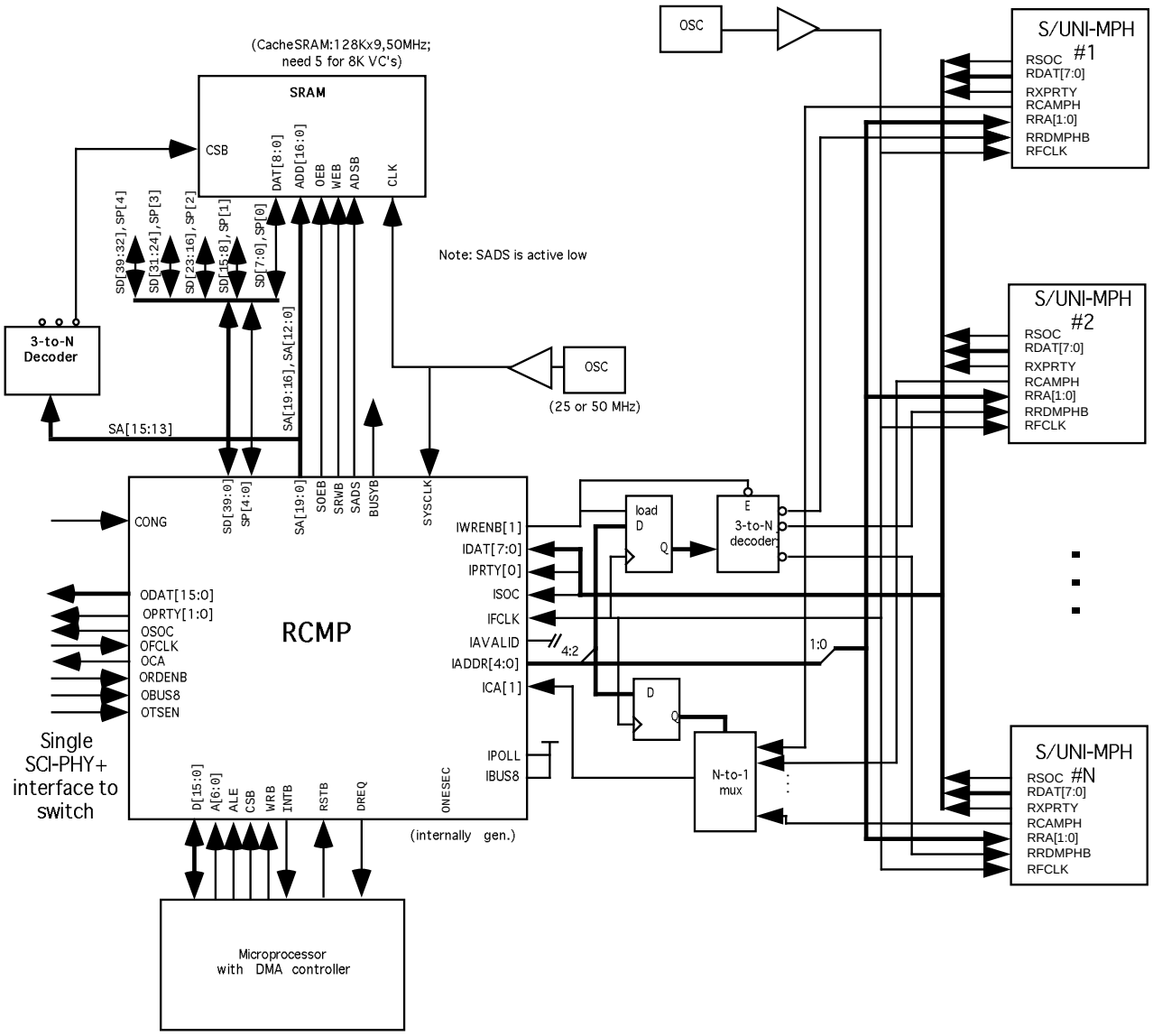


Fig. 7 RCMP Multi-PHY application



ABBREVIATIONS

ABR	Available Bit Rate service
AIM	ATM Inverse Mux
AIS	Alarm Indication Signal
BT	Burst Tolerance
CBR	Constant Bit Rate service
CC	Continuity Check
CDV	Cell Delay Variation
CLP	Cell Loss Priority
GCRA	Generic Cell Rate Algorithm for policing
LB	Loopback
OAM	Operations, Administrative and Maintenance
PCR	Peak Cell Rate
PM	Performance Monitoring
QoS	Quality of Service
RDI	Remote Defect Indication
RM	Resource Management
SATURN	SONET/ATM User Network
SCI	SATURN Compliant Interface
SCR	Sustained Cell Rate
SMDS	Switched Multi-megabit Data Service
SVC	Switched Virtual Connection
VBR	Variable Bit Rate service
VCC	Virtual Channel Connection
VPC	Virtual Path Connection

APPENDIX 1: ABR (AVAILABLE BIT RATE) OVERVIEW

[Ref: 1) atmf 95-0013R4; 2) upcoming UNI 4.0]

To provide a datacom service[6] that allows the user to adapt the bandwidth based on feedback by the network. Maximizes bandwidth usage, especially for bursty and unpredictable traffic. Competes with WAN services like Frame Relay, and LAN services like Switched Ethernet. Basically, a more reliable UBR (Unspecified Bit Rate) service.

Key differences from other services categories (CBR,UBR,VBR):

1. User bandwidth adaptation based on network congestion feedback, so as to avoid cell loss due to congestion. End-terminals needs to be smart and fast.
2. Maintains low cell loss ratio (CLR) but uncontrolled cell delay variation (CDV); therefore not intended for real-time applications
3. Rather complicated rate-based congestion feedback mechanism; early version of ABR is backwards compatible with EFCI (Explicit Forward Congestion Indication) mechanism on legacy switches.

Feedback mechnisms:
1. Explicit Forward Congestion Indicator (EFCI) used by legacy switches to indicate congestion; EFCI is indicated by the second bit of the PTI field.
2. Explicit Rate (ER) mechanism in Resource Mgmt. (RM) cell, inserted at any point in connection and looped back to the source. The source then adjusts the transmission rate according to the ER field[7], using sophisticated back-off algo[8]. Note there can be significant delay in the control loop, making it difficult to maintain stability.

Important RM Cell fields:

CI: Cong. Indication. Similar to EFCI.
ER: Explicit Rate, initialized to PCR or less, can only be decreased by switch
MCR: Minimum Cell Rate

Note: The RCMP supports both credit & rate-based control, through generic RM cell insertion/extraction, but no processing. RM cells are sent once every 32 data cells.

[6] To emulate shared-LAN
[7] The source uses Dynamic GCRA to check rate conformance. It differs from GCRA in that the increment I changes with time, as determined by ABR feedback info.
[8] Hardware will be needed to perform all the real-time functions such as processing RM cells, comparing ER, and adjusting the transmission rate accordingly.

APPENDIX 2: TRAFFIC CONTROL AND CONGESTION CONTROL IN B-ISDN

[Ref: I.371; I.211 for applications]

Traffic control: Actions to prevent congestion
Congestion control: Actions to remedy congestion

Objective:
- To support a set of QoS classes
- Solely an ATM Layer function
- Minimize network and end-system complexity and maximize network utilization

Generic Functions:
1. Network Resource Mgmt: provisioning to allocate network resources for different service characristics (VPC allocation)
2. Connection Admission Control (CAC): determines connection feasibility based on traffic contract and network conditions
3. Policing: UPC/NPC (Usage/Network Parameter Control: monitors cell compliance and acts on violations), Feedback controls
4. Priority Control: CLP

Traffic Contract: (negotiated at connection setup)
- Source Traffic Descriptor : a group of traffic parameters: PCR, SCR, Burst Tolerance (BT), Minimum Cell Rate (MCR), Cell Delay Variation Tolerance (CDVT)
- QoS class
- Cell conformance definition (eg. allowing a certain % of non-conforming cells to pass through)
- Tagging option at UNI

Examples of:
Traffic control: Network Resource Mgmt, CAC, UPC/NPC, CLP and Selective Cell Discard, Traffic Shaping, Feedback using RM cells (ABR)
Congestion control: Selective Cell Discard, EFCI

APPENDIX 3: RCMP FUNCTIONAL BLOCK SUMMARY

alcp: ATM Layer Cell Processor

Central command of traffic flow, using handshake with cram. Header translation. Prepend/Postpend. Policing. OAM processing. SRAM interface

cram: Cache RAM Controller

VC address search. Regulates uP SRAM access. Outputs directly to o/p I/F.

alpm: ATM Layer Performance Monitor

Accumulation of various cell counts.

iocif: Input/Output Cell Interface

Input, output cell I/F FIFO. 4 cell deep. Generic.

mcif: Microprocessor Cell Interface

Generic uP I/F between the board uP (16bit) bus and the CBI (Common Bus I/F) inside. Insert FIFO (1 cell) and Extract FIFO (16 cells). DMA support.

APPENDIX 4: RCMP ANALOGY

Entering the ATM Layer = Crossing the border into another country

RCMP	Analogy
ATM Cells	Cars
Cell Header Translation Translates to new header	Driver Change to new driver with the new destination
Cell Append Either/both before after ATM cell	License Plates Meaningful only in current country
FIFO	Car Queue Waiting at the border crossing
Routing in Switch Fabric	Directing the cars to the correct destination according the info on the license plates
Policing according to negotiated rates	Checking against Quotas
Cell Tagging (CLP bit)	Black Listing (Stamp on the driver's forehead)
Cell Dropping	Impounding
OAM Carrying administrative info	Police Cars (no radio, have to 'carry' the message)
Cell Count	Border Records
VC Table	Driver Database
Multi-PHY Arbitration	Multiple Roads with Traffic Cop Control
Multicast	??

APPENDIX 5: QUALITY OF SERVICE (QOS) SUMMARY

QoS classes:

Class 1 Stringent cell loss requirements
(eg. DS3 Circuit Emulation)

Class 3 Low latency, connection-oriented data transfer

Class 4 Low latency, connectionless data transfer
(eg. SMDS)

Note: Class 2 is not well defined now; it is intended for VBR service

QoS parameters:

Negotiated:

- Peak-to-peak Cell Delay Variation
- Maximum Cell Transfer Delay
- Mean Cell Transfer Delay
- Cell Loss Ratio

Non-negotiated:

- Cell Error Ratio
- Severely Errored Cell Block Ratio
- Cell Misinsertion Rate

NOTES

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