Fair ATM Charging with Consideration of Traffic Characteristics and QoS Parameters

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3. **Charging of User Goodput**
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Cases for non-negligible error rates in ATM

- ATM services with high statistical multiplexing gain
  - UBR
  - VBR with high multiplexing gain for highly bursty sources (cheap!)
  - ABR with aggressive choice of parameters
  - ABT/IT (important for short data sizes and high bandwidth-delay product; ATM blocks (groups of cells) may be discarded)
  - ABR or ABT for point-to-multipoint communication with non-conservative throughput strategy
- Transmission bit errors
  - wireless links
  - cheap physical layers

Motivation

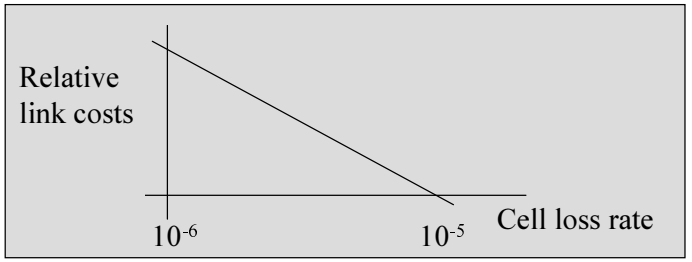
⇨ **Fair Charging in ATM Networks and heterogeneous Internetworks**

- Accounting service functions at
  - UNI (user side **and** network side)
  - NNI (between different service providers)
- Accurate accounting is important for fair charging!
- Goal:
  - hardware-support for high performance accounting management (necessary in ATM, where counting of cells is required)
  - integration within network management
  - implementation framework suitable for complex charging schemes

Performance-Cost Optimisation

ATM cost model

- f(L): Cost ($) per unit bandwidth for given cell loss (specified by ATM service provider)
- Tradeoff:
  - No Sharing (high bandwidth reqirements), low loss
  - Sharing (high multiplexing gain), higher loss
- Optimum strategy depends on error correction overhead



Error Control for Reliable Services

- Protocols for reliable services use ARQ and/or FEC
- Appropriately dimensioned FEC allows to achieve an overall gain (shown e.g. by Biersack 1993)
- Goal: fair charging

  => requirement of distinguishing between
  - user data (transmitted the first time),
  - retransmissions,
  - redundancy

  => complex charging function!

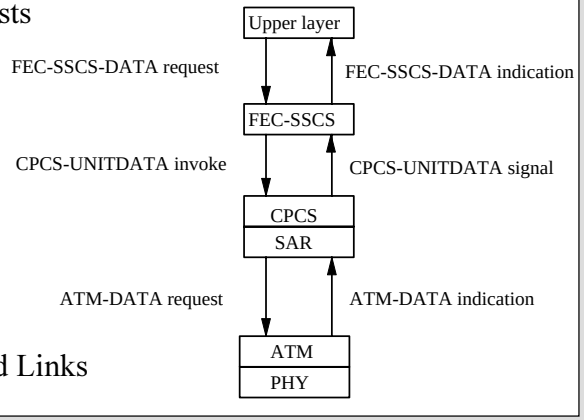
FEC-SSCS

Requirements and Goals

- Parameters adjustable and negotiable
- Variable-length AAL-SDUs
- AAL-SDU Segmentation
- Minimise processing costs
- Error control modes
  bit error / cell loss / both
- loss indication

Advantages over appication-level FEC

- Efficiency
- Latency
- Applicabel for dedicated Links



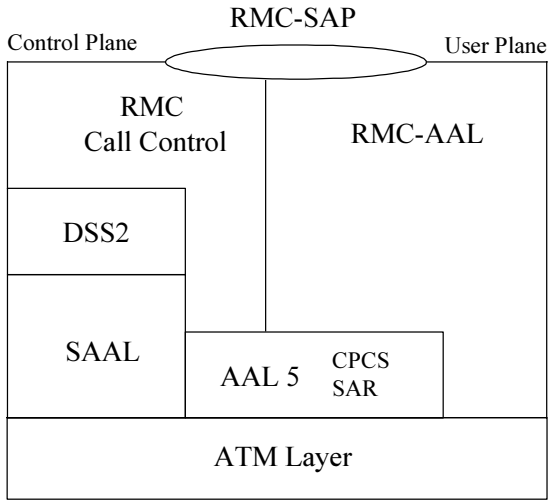
Fair Charging Function

Charging Function:

Cost of ATM connection =

Cost_connection	(service class, traffic parameters, distance)
+ **Cost_reservation**	(service class, traffic parameters, distance) · #cell_times
+ **Cost_ goodput**	(service class, traffic parameters, distance) · #cells
+ **Cost_ retransm.**	(service class, traffic parameters, distance) · #cells
+ **Cost_ redundancy**	(service class, traffic parameters, distance) · #cells

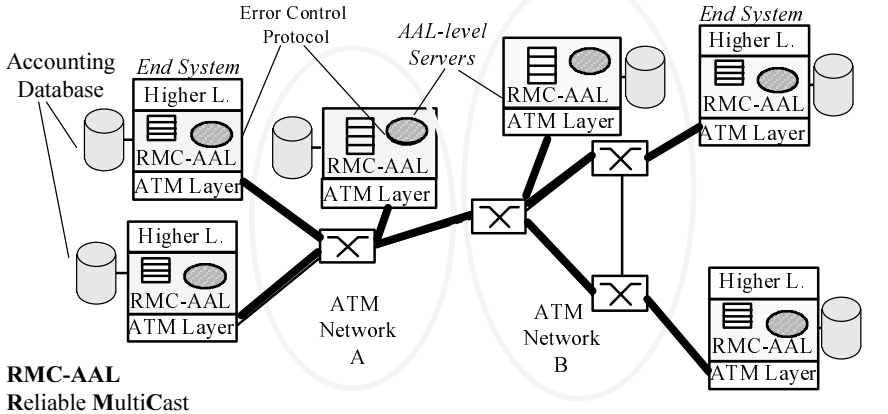
RMC-AAL Protocol Architecture



Error Control Mechanisms of RMC-AAL:

- frame-based ARQ
- cell-based ARQ
- frame-based ARQ + FEC
- cell-based ARQ + FEC

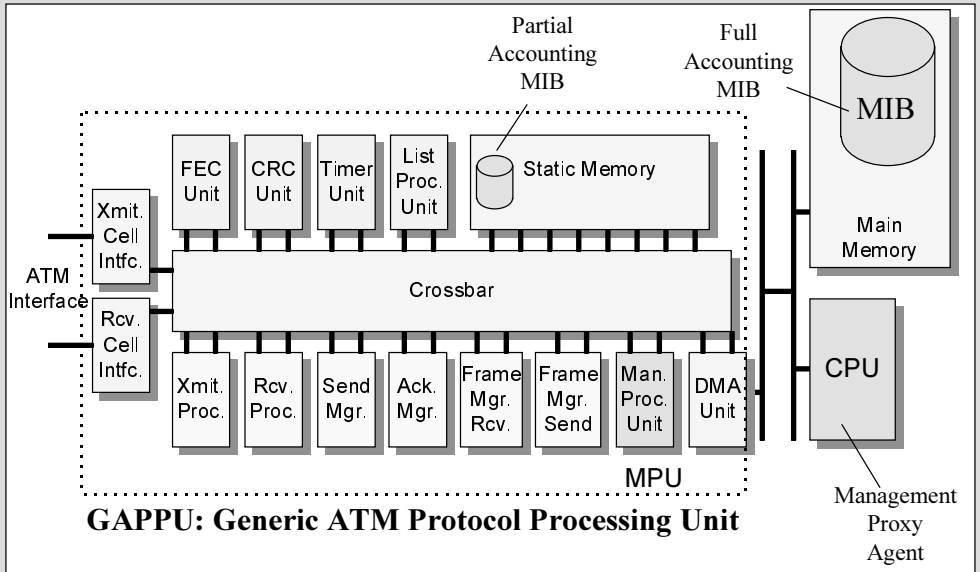
Accounting of User Goodput



RMC-AAL
Reliable **M**ulti**C**ast
ATM **A**daptation **L**ayer
- Frame-based ARQ
- Cell-based ARQ
- FEC

Accounting of user goodput by AAL protocol entities in end systems and servers

Hierarchical Accounting Management



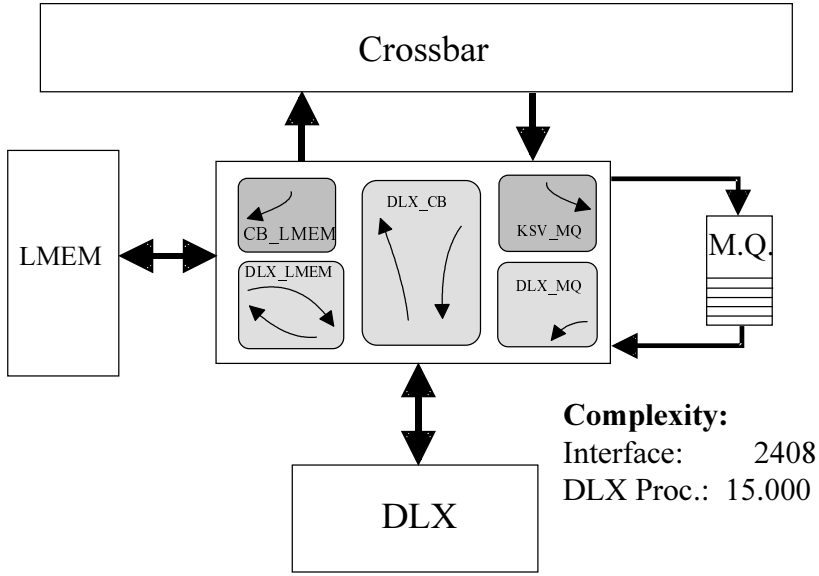
GAPPU: Generic ATM Protocol Processing Unit

Fair charging by accounting of user goodput

Example for MIB object

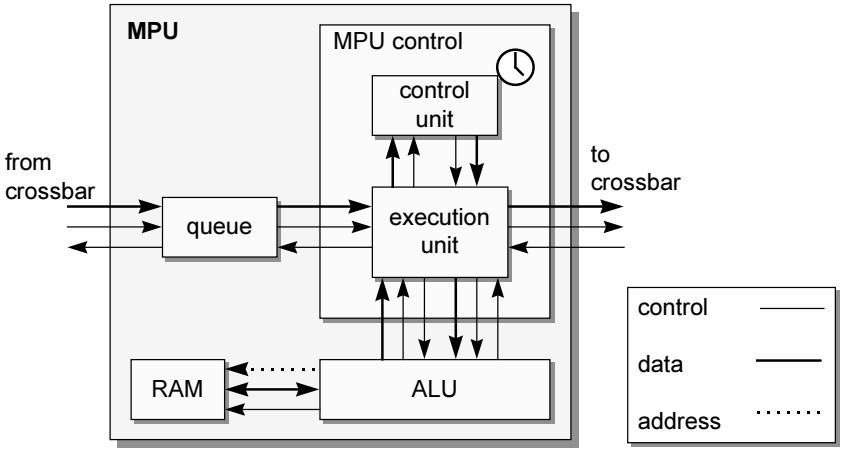
```
fairATMBillingCellCounter OBJECT-TYPE
SYNTAX Integer64
MAX-ACCESS read-only
STATUS current
DESCRIPTION "Cells, which are transmitted for the first time"
::= { fairATMBillingCounters 1}
```


GAPPU Interface for RISC Processor



Complexity:
Interface: 2408 gates
DLX Proc.: 15.000 gates

MPU: Management Processing Unit

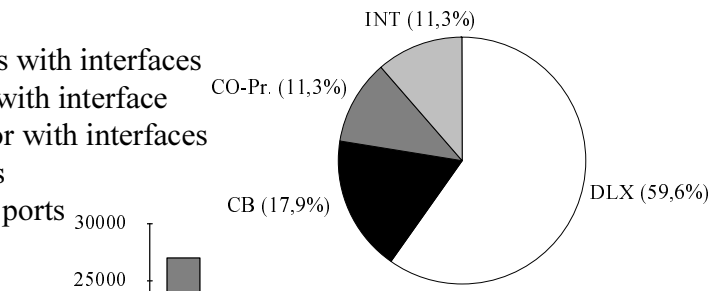


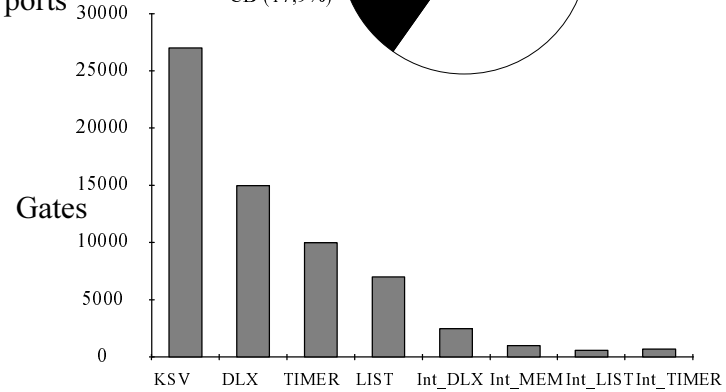
MPU functions:
- mpu_set(connection_id, parameter_id, value)
- mpu_get(connection_id, parameter_id)
- mpu_trap(connection_id, parameter_id, value)

GAPPU Synthesis

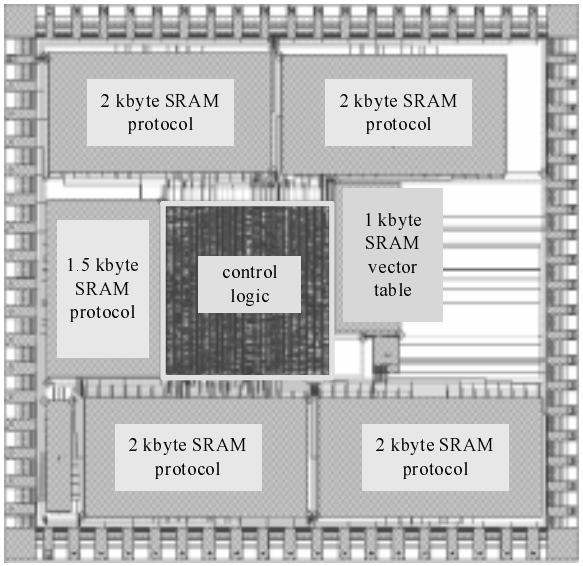
GAPPU with
- 6 DLX processors with interfaces
- List coprocessor with interface
- Timer coprocessor with interfaces
- 2 RAM interfaces
- Crossbar with 14 ports

=> 150.000 gates





Control Unit: Realization as ASIC



Features
- 0.7 µm CMOS
- 2893 standard cells
- 74 pins
- 2.13 mm² control logic
- 11 kbyte SRAM
- 9.6 ns critical path

Conclusions

- **Challenge: Fair charging for low-cost ATM WAN services**
- **Problems:**
  - Low-cost WAN services for bursty sources may have non-negligible cell loss
  - Fair charging requires accounting of user goodput
  - Accounting of user goodput in ATM is computationally demanding
- **Approach:**
  - Fair charging by distinguishing reservation, goodput, retransmissions, and redundancy
  - Generic ATM Protocol Processing Unit (GAPPU) with parallel processing capability
  - Management Processing Unit (MPU): dedicated component for hierarchical accounting management
- **Outlook:**
  - Semi-automatic mapping of different protocol and accounting specifications onto GAPPU architecture