CCITT SGXV
Working Party XV/1
Experts Group for ATM Video Coding

AVC-172

DSM/ATM WORKSHOP

November 20, 1991
Kurihama

OBJECTIVES

- Mutual understanding between DSM oriented and ATM oriented experts
- Common understanding on the storage media and ATM transport characteristics
- To incorporate necessary elements in the audio & video coding algorithm for coping with particular properties of the storage media or transport method

/

ATM TRANSPORT

CCITT SGXV
EXPERTS GROUP
FOR ATM VIDEO CODING

1. Michael Biggar (Australia Telecom)

BROADBAND ISDN DEVELOPMENT

2. Olivier Poncin (RTT Belgium)

ATM NETWORK CHARACTERISTICS

3. Tomoaki Tanaka (NTT, Japan)

VBR ASPECTS

4. Geoff Morrison (BT, United Kingdom)

VIDEO CODING TECHNIQUES
SUITABLE FOR UTILIZING ATM
NETWORK CHARACTERISTICS

Related Documents

MPEG91/		
321	J	Cell loss recovery by coding algorithm
322	J	Interworking of the H.32X terminals
323	J	Considerations on processing delay with hybrid coding
324	GB	Cell loss resilience in a two-layer coding scheme
333	EUR	Network models
334	EUR	Statistical multiplexing gains for variable bit rate
?	EUR	ATM Compendium
?	NL	Features of MUP COS

Broadband ISDN

Evolution

Network Developments

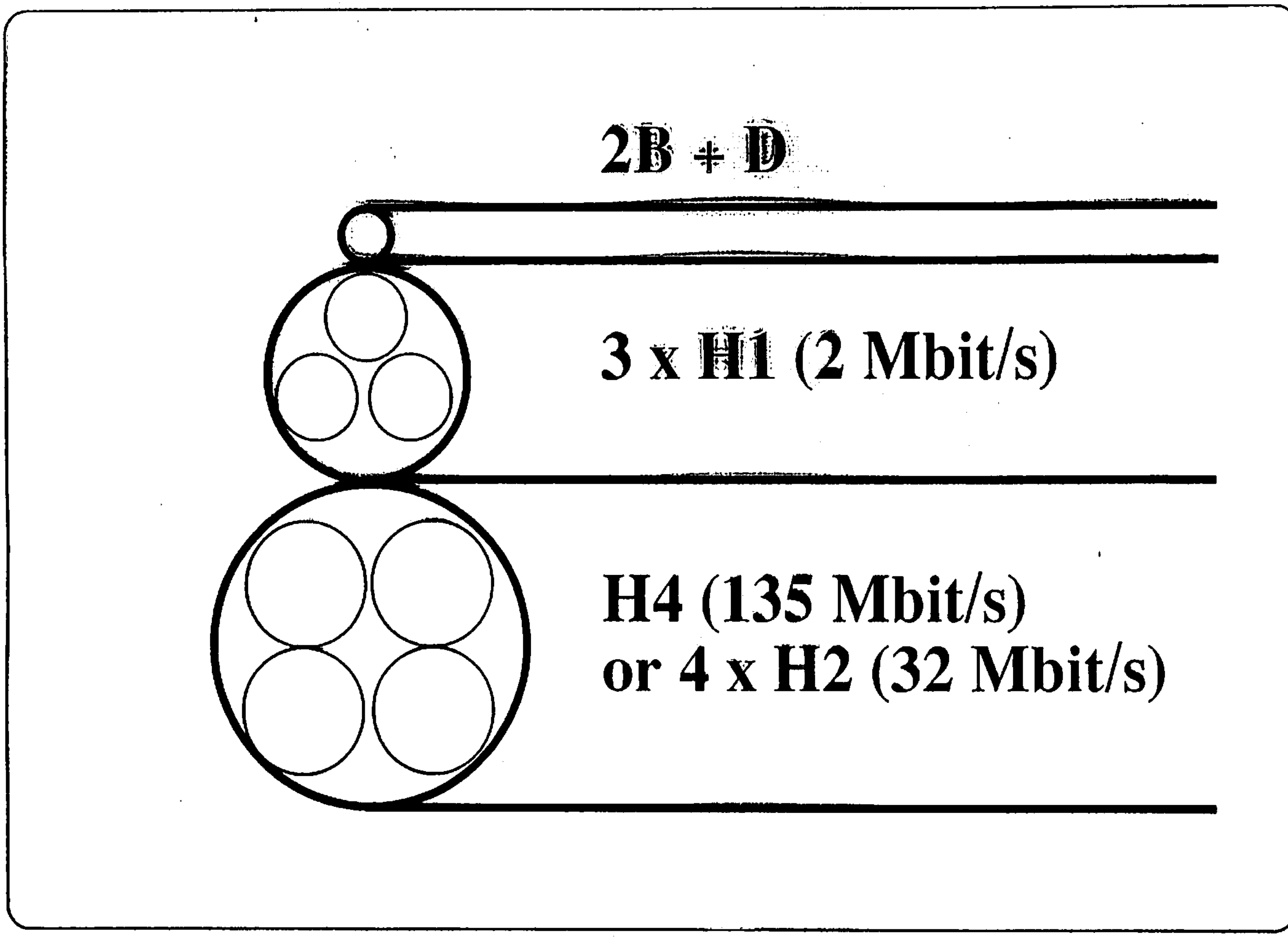
- Optical fibre
- Large capacity transmission
- High speed switching

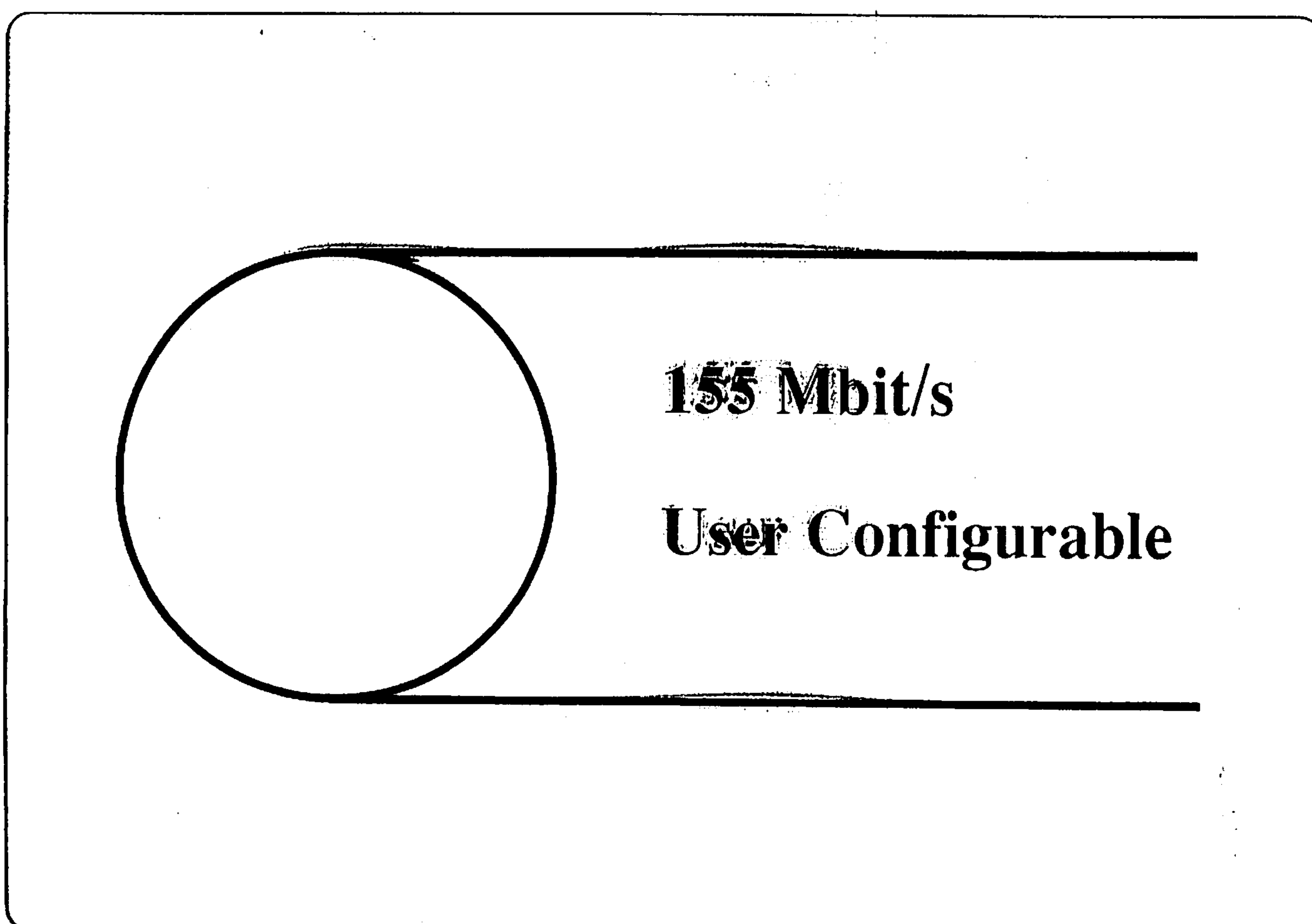
High rate data

- LAN Interconnect
- Virtual Private Networks
- Fast file / image transfer
- Image retrieval
- CAD

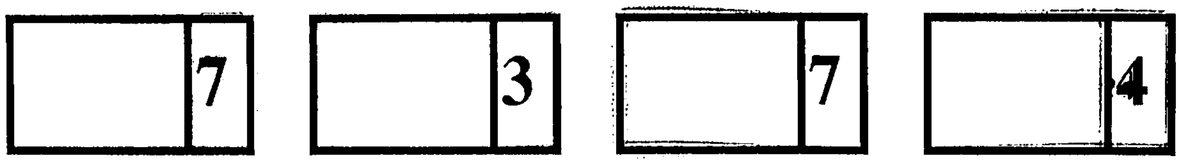
Video applications

- Videoconferencing
- Videophone
- Remote education
- Video retrieval
- Corporate TV
- Entertainment
- Multimedia


2B + D
3 x H1 (2 Mbit/s)
H4 (135 Mbit/s)
or 4 x H2 (32 Mbit/s)

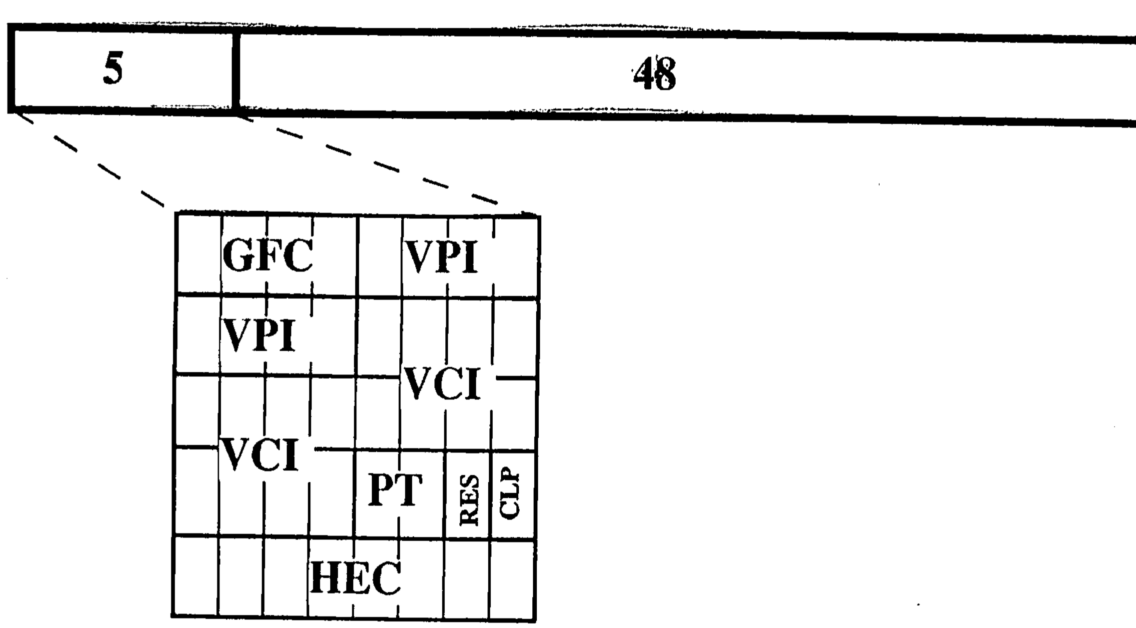

155 Mbit/s
User Configurable

Packet Multiplexing

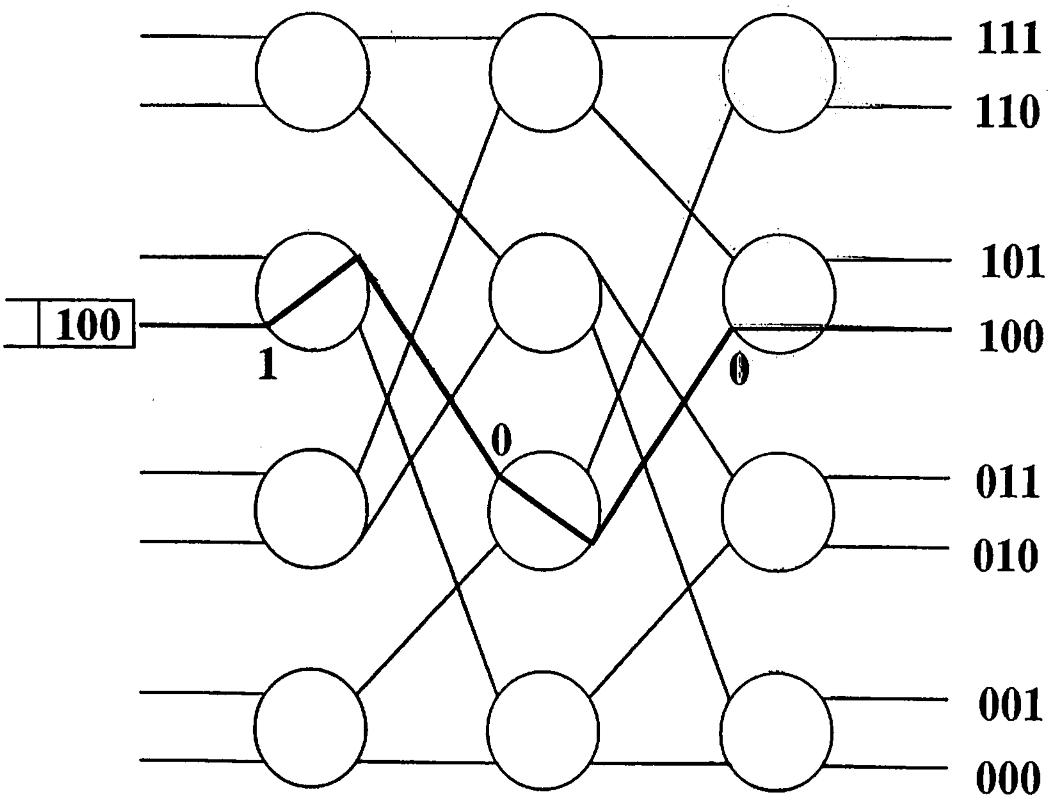


- Label identifies info. stream
- Wide range of bit rates
- Bursty services

ATM Header



ATM Binary routing switch



Standards timetable (SGXVIII)

- **1992**
  CBR and VBR support
  Bandwidth allocation
  Relationship b/w CLP and QOS

- **1994**
  Multimedia
  Distribution / Multipoint

B-ISDN Integration

- Physical delivery
- Transport (ATM cells)
- Call and connection control

Hence Integrated Video Services (IVS) initiative

ATM NETWORK CHARACTERISTICS

RTT BELGIUM

CONTENTS

- OPPORTUNITIES OFFERED BY ATM
- ATM NETWORK IMPAIRMENTS
- DETAILED ANALYSIS & IMPACT ON VIDEO CODING
- IN CONCLUSION

OPPORTUNITIES OFFERED BY ATM

- AVAILABILITY OF HIGH BANDWIDTHS (600Mbps)
- FLEXIBILITY IN BANDWIDTH USAGE
- VARIABLE BIT RATE CAPABILITY => STATISTICAL MULTIPLEXING
- FLEXIBILITY IN MULTIMEDIA MULTIPLEXING OR MULTIPLE CONNECTIONS
- SERVICE INTEGRATION

ATM NETWORK IMPAIRMENTS

- CELL LOSS
- CELL DELAY JITTER
- PACKETISATION DELAY
- NEED FOR USAGE PARAMETER CONTROL

CELL LOSS - THE PROBLEM

- CAUSES
  - Uncorrectable bit errors in cell header
  - Queue overflow in network

- DESIGN GOAL: 1E-8 - 1E-9 END TO END

- AVERAGE PERIOD BETWEEN CELL LOSS (48 BYTE CELLS, 1E-8)
  - 64 kbps : 7 days
  - 140 Mbps : 4 minutes

=> IMPORTANT FOR HIGH RATE, HIGH QUALITY SERVICES

CELL LOSS - ARTIFACTS

- TIME DISCONTINUITY : LOSS OF SYNCHRONIZATION

- INFORMATION ERASURE : LARGE BURST ERROR

- LOSS OF VARIABLE LENGTH CODE SYNCHRONIZATION

  => ERROR PROPAGATION

CELL LOSS - HOW TO COPE WITH

- DETECTION OF CELL LOSS : CELL NUMBER

- FORWARD ERROR CORRECTION

    - 2-dimensional parity
    - Interleaving & Reed-Solomon Codes

- CONCEALMENT

    - Substitution (previous frame)
    - Layered coding

CELL DELAY JITTER

- AMBIGUITY ON CELL ARRIVAL INSTANCES

- RESULT OF VARYING OCCUPANCY LEVEL OF NETWORK QUEUES

- VALUE : AROUND 250microsec FOR MULTISTAGE NETWORK (STATISTICAL DISTRIBUTION)

- VIDEO : STRINGENT REQUIREMENTS ON CLOCK STABILITY (PICTURE BLURRING,...)

=> DEJITTERING BUFFER

CELL DELAY JITTER - CONT'D

- SERVICE SYNCRONISATION
  - Skipping of primary frames
  - Buffer filling level (only CBR)
  - Time stamps
    - Insert time references at encoder
    - Detect arrival instance of time reference at decoder
    - Difference expected/actual arrival : PLL feedback
    - Filtering of cell delay jitter

PACKETISATION DELAY

- SOURCES : CELL FILLING + EMPTYING DELAY
  - Delay = 384 / bit rate
- SIGNIFICANT FOR LOW BIT RATE SERVICES
  - 64 kbps voice : 6msec
- CROSS SYNCHRONISATION BETWEEN DIFFERENT MEDIA (AUDIO, VIDEO, ...)
- VARIABLE BIT RATE => NON CONSTANT PACKETISATION DELAY

USAGE PARAMETER CONTROL - THE PROBLEM

- CALL SETUP : TERMINAL PROVIDES BANDWIDTH PARAMETERS TO NETWORK => **BANDWIDTH CONTRACT**

- CONTRACT CAN BE EXCEEDED

  - Wrong estimation, unforeseen conditions
  - Malicious users

- NEED FOR USAGE PARAMETER CONTROL

  - Network entrance : verify terminal parameters => REPRESSIVE POLICING
  - In terminal : operate within contract => PREVENTIVE POLICING

IN SUMMARY

- ATM OFFERS A NEW RANGE OF OPPORTUNITIES

- IT ALSO INTRODUCES SOME SPECIFIC IMPAIRMENTS (CELL LOSS, CELL DELAY JITTER, ...)

- CODEC ADAPTATION TO ATM

=> STRONG IMPACT ON VIDEO CODING ARCHITECTURE

CCITT SGXV Experts Group for ATM Video Coding

VBR (Variable Bit Rate) aspects

Cf. CBR (Constant Bit Rate)

Tomoaki Tanaka

NTT Human Interface Laboratories

Necessity of UPC (Usage Parameter Control) (1)

What is UPC :

- Cost of VBR services depends on statistical multiplex gain (SMG).
- SMG is sometimes accompanied by network congestion and information discard (cell loss).

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- A user should declare and keep a set of parameters (traffic descriptors).

→ UPC (policing) can guarantee the transmission quality.

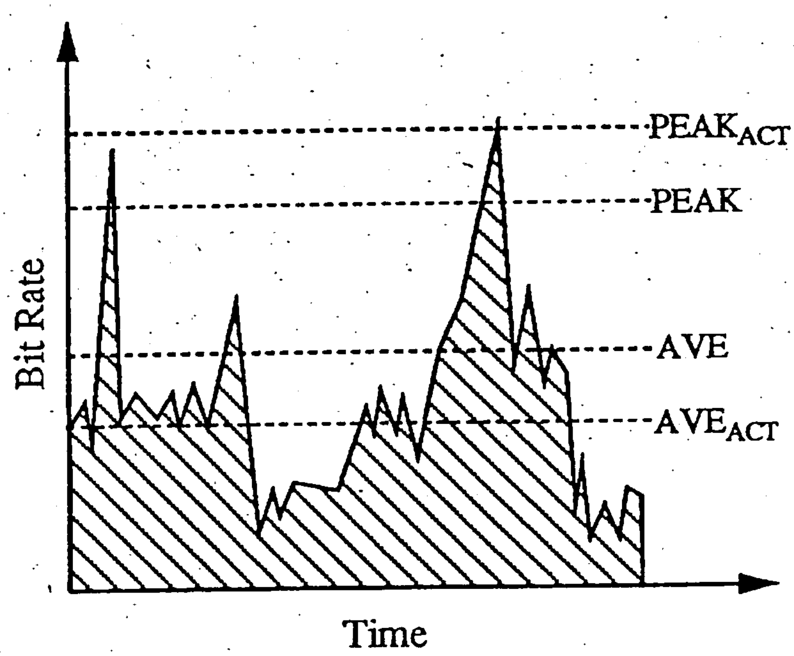


Fig. 1 Video Coding vs. UPC

Implication :

- VBR service does not mean bit rate free but requires an intelligent bit rate control.

Cost of VBR services (1)

Network model :

- Network model is adopted to estimate the cost for VBR services

  note : Bit cost for VBR service is higher than that of CBR's.

$$CLR = Psat / \{CAP/AVE*x/b*\ln((b-1))/(x-1)\} \qquad (1)$$

$Psat = \exp[-(CAP/(b*AVE))*\{\ln(b/x)\}+(x-1)*\ln\{(x-1)b/x/(b-1)\}\}]$

CAP = the network capacity available for VBR services (multiplex size)

$b = PEAK/AVE$ note : $b>1$

$$x = \text{statistical multiplex gain} = \frac{\text{number of acceptable calls with cell loss}}{\text{number of acceptable calls without cell loss}}$$

$BCOST = b/x \quad (1<BCOST<b)$

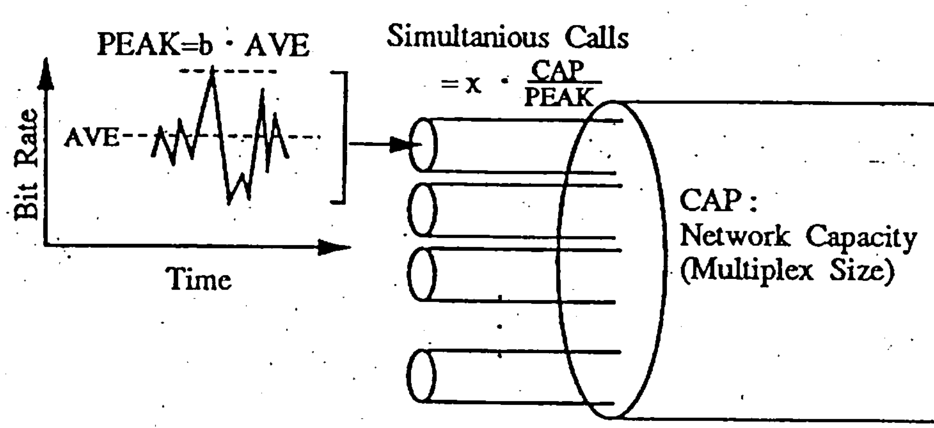
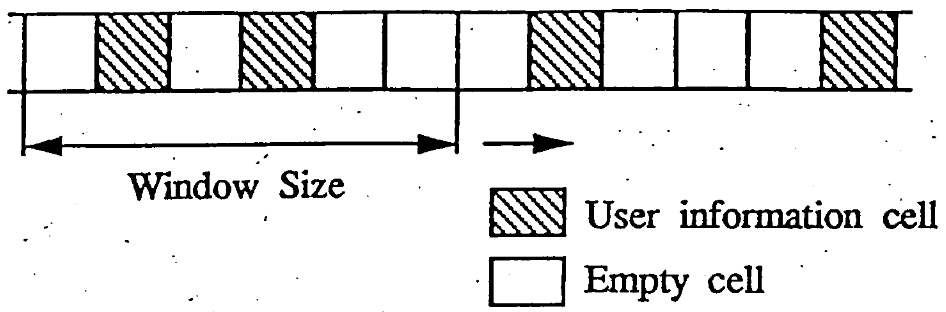


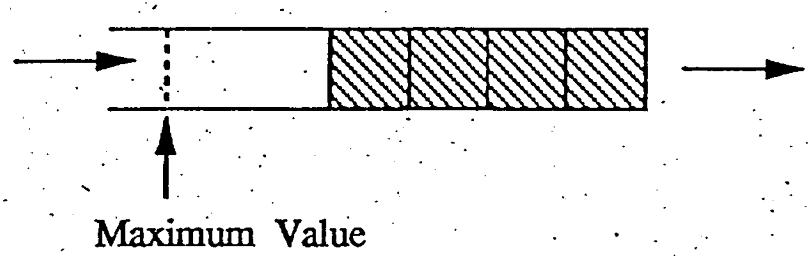
Fig. 2 Statistical Multiplex Gain in VBR Services

Two types of UPC mechanism



Sliding (Moving) window allows X arriving cells in an arbitrary time interval containing Y time slots.

(a) Sliding (Moving) Window



Leaky Bucket is based on a counter which is incremented every time a cell arrives and decremented with a constant rate. When the maximum of the counter value is reached, policing action takes place.

(b) Leaky Bucket

Fig. 4 Two Types of UPC Mechanism

Note :

- If the window size for sliding window or counter for leaky bucket is too small, VBR services lose its merit from video point of view.
- Sliding window is sometimes more restrictive than CBR.

Picture quality (2)

An example of actual control

- VBR is effective for short time burst. (Period 'b')
- Control fails for long time burst (Period 'c')

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- Better picture quality may not be guaranteed for VBR video service as far as sliding window is used.

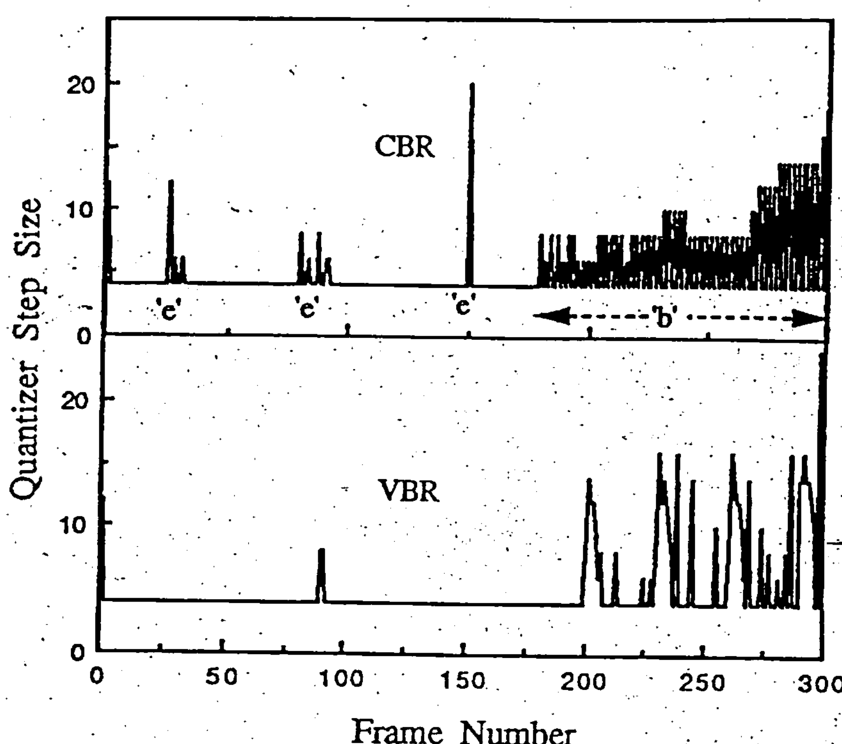

Fig. 6 Fluctuation of Quantizer Step Size

Expectation

- For leaky bucket, we can easily use an conventional bit rate control technique.

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- Better picture quality may be guaranteed.

Conclusion :

What items should we consider? :

1. The current condition of the network is not beneficial to VBR video services from statistical multiplex gain point of view. However, in a long run VBR video services have a chance to provide better picture quality and shorter transmission delay than CBR's at the same average bit rate.

↓

- **Preparation for VBR services.**
  (Mechanism to allow the VBR services)

2. Advantages of VBR video services are depend on the UPC.

↓

- **Clarification of the requirements for UPC**
  (including the traffic descriptors that are also permissable from DSM view point if possible.)

3. Without an intelligent bit rate control, VBR video service is not achievable.

↓

- **Bit rate control mechanism in the coder.**

VIDEO CODING TECHNIQUES SUITABLE FOR UTILISING ATM NETWORK CHARACTERISTICS.

GEOFF MORRISON.

CELL LOSS

BURSTS

FIXING CELL LOSSES SO THAT DECODER DOES NOT KNOW ABOUT THEM.

MAKING DECODER RESILIENT TO CELL LOSS.

LAYERED CODING AND PRIORITIES

WARNING NOTICE:

MANY ASPECTS OF ATM ARE STILL BEING DISCUSSED. VIEWS EXPRESSED IN THIS PRESENTATION SHOULD NOT BE TAKEN AS "OFFICIAL CCITT POLICIES".

CELL LOSS AVOIDED ONLY IF PEAK RATE USED FOR TRAFFIC PLANNING.

OTHERWISE, NON-ZERO CELL LOSS CAN BE MADE AS SMALL AS REQUIRED BUT WITH ECONOMIC CONSEQUENCES (TARIFFS).

AN ATM CELL CONTAINS DATA FROM ONLY ONE SOURCE (VIDEO CODER IN THIS CASE).

CELL CONTAINS ABOUT 45 BYTES OF CODED DATA.

ONE LOST CELL CONCERNS 360 BITS.

NON-TRIVIAL IMPACT ON TRADITIONAL VIDEO COMPRESSION ALGORITHMS.

MORE BAD NEWS

CELLS LIKELY TO BE LOST IN BURSTS.

BURST LENGTH NOT KNOWN YET, BUT THOUGHT THAT MAXIMUM LENGTH ENCOUNTERED WILL BE BETWEEN 4 AND 15 CELLS.

CELL LOSS IS CAUSED WHEN TOTAL BIT RATE OF ALL SOURCES EXCEEDS NETWORK CAPACITY. WHEN SOURCES ARE CONSTANT BIT RATE (CBR) THEN SIMPLE CALL ACCEPTANCE CONTROL (CAC) IS POSSIBLE.

VARIABLE BIT RATE SOURCES ARE DIFFICULT TO PREDICT.

HIGH COMPRESSION VIDEO CODERS ARE INHERENTLY VARIABLE BIT RATE SOURCES

COPING WITH CELL LOSS

2 MAIN APPROACHES TO PROBLEM:

1). FIX CELL LOSS PROBLEM SO THAT DECODER RECEIVES PERFECT DATA.

2). MAKE CODING SCHEME RESILIENT TO CELL LOSS.

H.261 F.E.C.

BCH 493, 511

CORRECTS BURSTS UP TO 6 IN LENGTH

FOR SINGLE CELL LOSS INTERLEAVING RATIO

MUST BE $\frac{384}{6} = 64$

FOR 10 CELL BURST LOSS

NEED 640 CELL DISTRIBUTION.

AT 1 Mbit/s HAVE $\frac{10^6}{384}$ cells/second

$= 2600$

20 $\therefore$ Reordering delay $= 0{\cdot}25$ seconds.

CELL LOSS CORRECTION.

a) FORWARD ERROR CORRECTION TECHNIQUES (BCH, REED-SOLOMON ETC).

NOT USUALLY DIRECTLY ABLE TO CORRECT MANY HUNDREDS OF CONTIGUOUS BITS.

NEED TO INTERLEAVE TO DISPERSE ERRORS INTO MANY CELLS.

BEARING IN MIND CELL LOSS BURST LENGTH, INTERLEAVING MAY NEED TO BE SUBSTANTIAL.

⇒ COMPLEXITY
\+
DELAY WHICH IS MORE SIGNIFICANT AT LOWER BIT RATES.

(MAY BE GOOD SOLUTION FOR BROADCAST CONTRIBUTION CODECS)

b). RETRANSMISSION (ARQ).

- NEEDS ADDITIONAL BUFFER TO ALLOW FOR RETRANSMIT ROUND TRIP TIME
- NEEDS RETURN CHANNEL
- BECOMES INEFFICIENT IN ONE TO MANY DISTRIBUTION APPLICATIONS IN WHICH CELL LOSS DIFFERS TO EACH DECODER.
- MAY MAKE CONGESTION WORSE AND PROLONG CELL LOSS BURSTS – "POSITIVE FEEDBACK".

RESILIENCE TECHNIQUES

a). CONCEALMENT METHODS
(SINGLE-ENDED, DECODER ONLY MODIFIED)

DECODER ATTEMPTS TO REGENERATE DAMAGED AREA BY SUBSTITUTION / INTERPOLATION.

b). LAYERED CODING
(DOUBLE-ENDED, CODER AND DECODER MODIFIED)

UTILISES CELL PRIORITY CAPABILITY OF ATM NETWORKS

IMPORTANT INFORMATION SENT IN HIGH PRIORITY CELLS WHICH HAVE VERY LOW LOSS RATES.

LESS IMPORTANT INFORMATION SENT IN LOWER PRIORITY CELLS WHICH CAN HAVE HIGHER CELL LOSS RATES.

LOW PRIORITY CELLS DISCARDED BY NETWORK IF CONGESTION OCCURS. PROVIDES MECHANISM TO PROTECT HIGH PRIORITY CELLS.

(NEEDS APPROPRIATE BALANCE BETWEEN NUMBER OF CELLS OF EACH PRIORITY).

CCITT SGXVIII HAS AGREED PROVISION OF CELL LOSS PRIORITY BIT IN CELL HEADER. EXACT USE UNDER DISCUSSION.

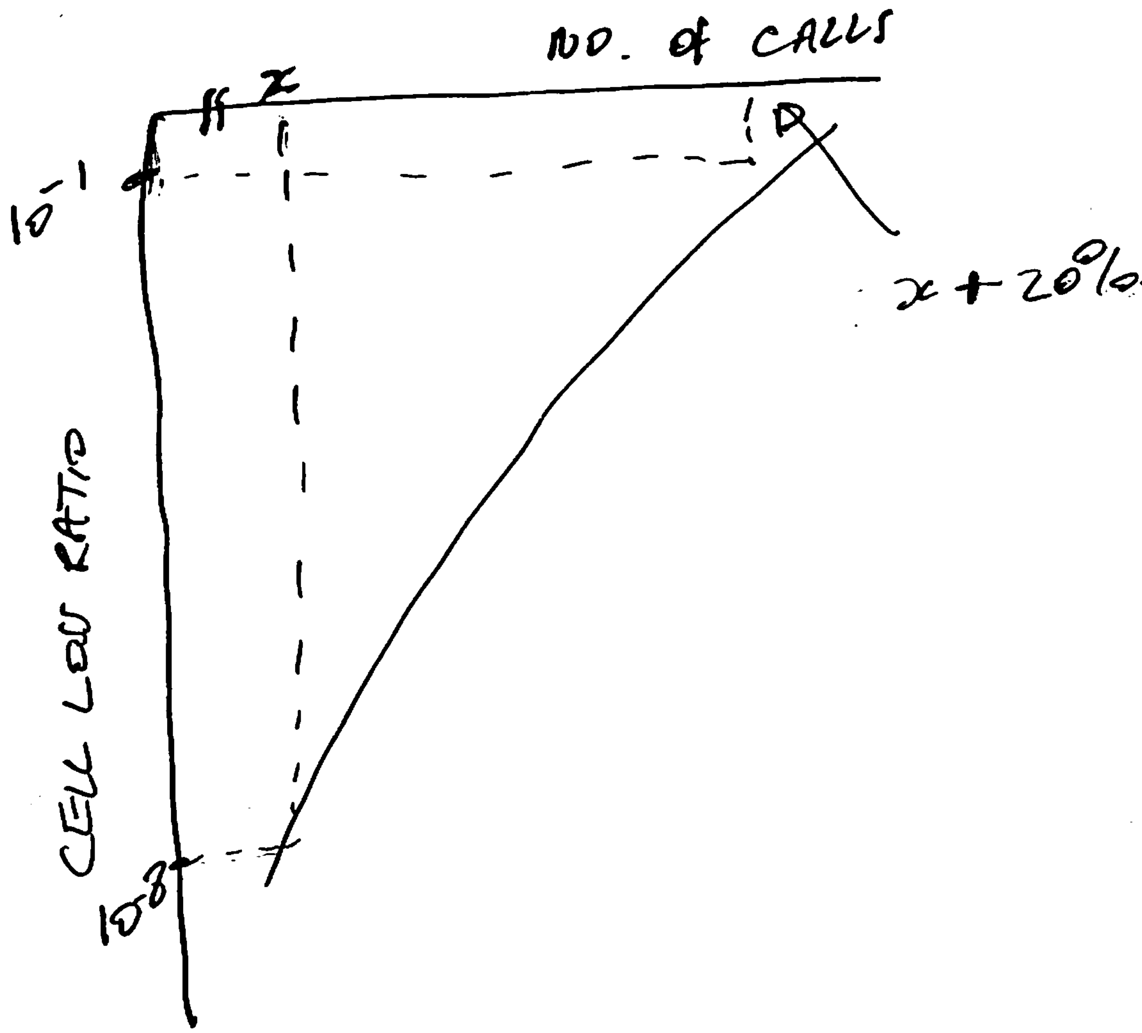
VIDEO CODING SCHEME DESIGNED SO THAT LOSS OF LOW PRIORITY CELLS HAS SMALL ~~EFFECT~~ ON PICTURE QUALITY

E.G. LOW FREQUENCIES IN HIGH PRIORITY CELL
HIGH FREQUENCIES IN LOW PRIORITY CELL

OR COARSELY QUANTISED SIGNALS IN HIGH PRIORITY
FINELY QUANTISED RESIDUALS IN LOW PRIORITY

ETC

SEVERAL PROPOSALS THIS WEEK ARE AMENABLE TO THIS METHOD.



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20% is illustrative only

exact value depends on x

(which depends on $\frac{\text{Network capacity}}{\text{Peak source rate}}$)