

ATM Physical Layer

Raj Jain

Professor of Computer and Information Science

**Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
<http://www.cse.wustl.edu/~jain/>**

Physical Layer

- ❑ Physical Medium Dependent (PMD) Sublayer:
 - ❑ Fiber, Twisted-Pair, Coax, SONET, DS3
- ❑ Transmission convergence layer:
 - ❑ Convert bit stream to cell stream
 - ❑ Transmission frame adaptation: packing cells into frames
 - ❑ Cell delineation: scrambling and cell recovery after descrambling
 - ❑ HEC generation and verification
 - ❑ Cell rate decoupling: Insertion and suppression of idle cells

B-ISDN Physical Layer

- ❑ I.432 (1993) defines three PHY Interfaces at T_B (NT1-NT2):
 - ❑ Full-duplex 155.52 Mbps
 - ❑ Subscriber to Network at 155.52 Mbps, Network to subscriber at 622.08 Mbps (For video distribution)
 - ❑ Full-duplex 622.08 Mbps
- ❑ Full-Duplex 155.52 Mbps
 - ❑ Coaxial cable pair (100-200 m max) using CMI coding
 - ❑ Single mode fiber pair (800-2000 m max) using NRZ
- ❑ 622.08 Mbps: Single mode fiber pair using NRZ

PHYs for Private UNI

Frame Format	Bit Rate/Line Rate	Media
Cell Stream	25.6 Mbps/ 32 Mbaud	UTP-3
STS-1	51.84 Mbps	UTP-3
FDDI	100 Mbps/ 125 Mbaud	Multimode Fiber
STS-3c, STM-1	155.52 Mbps	UTP-5
STS-3c, STM-1	155.52 Mbps	Single-Mode Fiber, Multimode Fiber, Coax pair
Cell Stream	155.52 Mbps/ 194.4 Mbaud	Multimode Fiber, STP
STS-3c, STM-1	155.52 Mbps	UTP-3
STS-12, STM-4	622.08 Mbps	SMF, MMF

PHYs for Public UNI

Frame Format	Bit Rate	Media
DS1	1.544 Mbps	Twisted pair
DS3	44.736 Mbps	Coax pair
STS-3c, STM-1	155.520 Mbps	Single-mode Fiber
E1	2.048 Mbps	Twisted pair, Coax pair
E3	34.368 Mbps	Coax pair
J2	6.312 Mbps	Coax pair
$N \times T1$	$N \times 1.544$ Mbps	Twisted pair

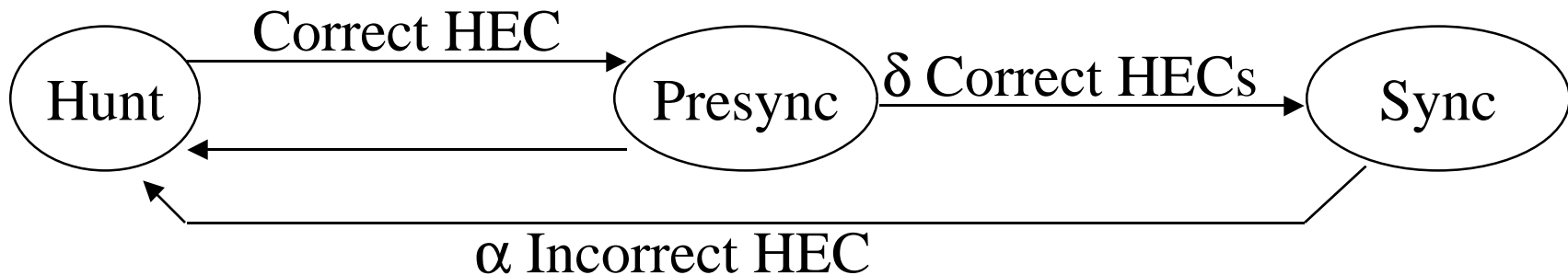
Transmission Structure

- ❑ I.432 specifies two options:
 - ❑ Sequence of cells. Synchronization using HEC.
 - ❑ SONET/SDH payload envelopes

Cell-Stream Phy



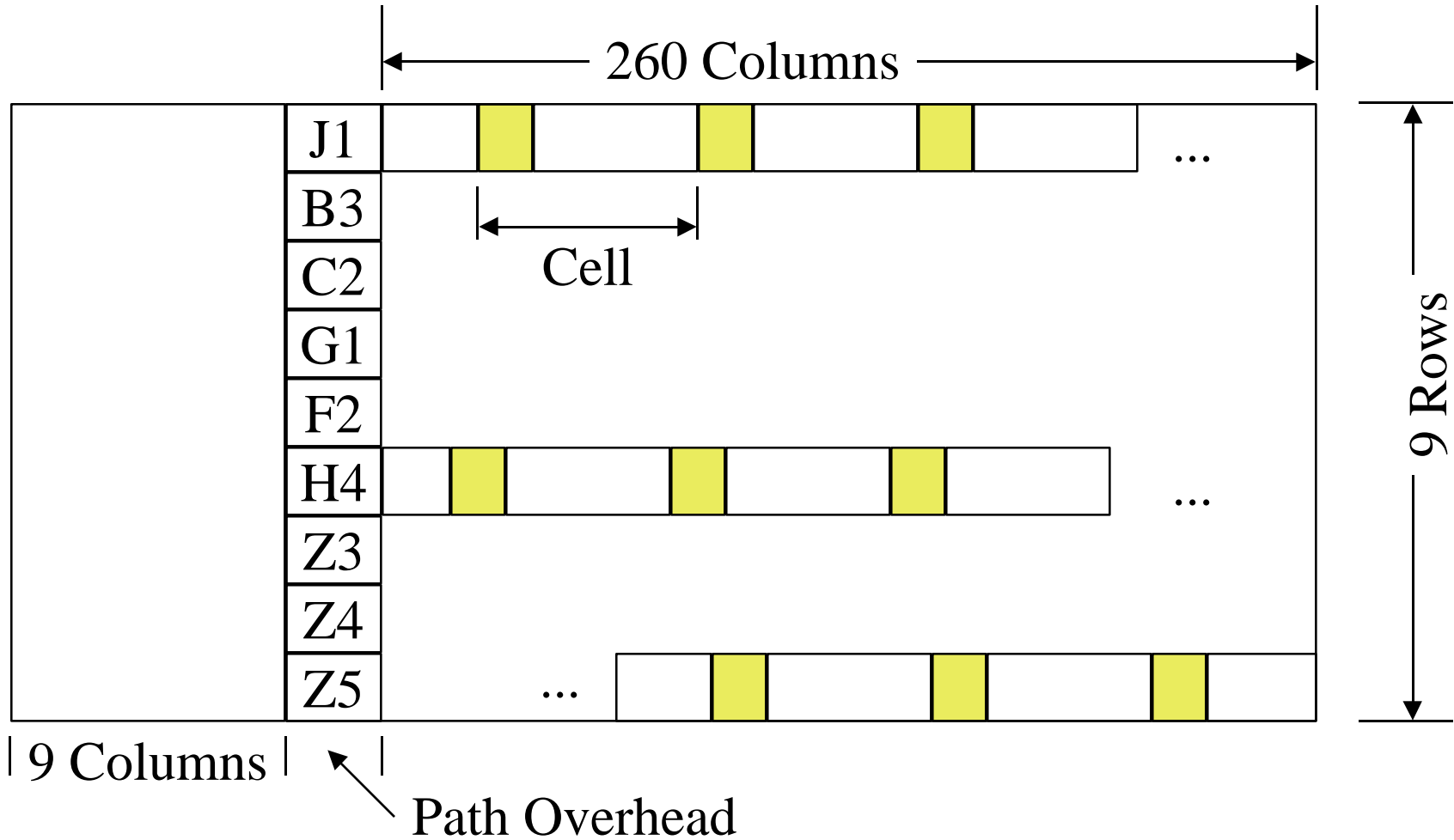
- ❑ Continuous stream of cells. No framing.
- ❑ Hunt bit-by-bit for correct header.
- ❑ Look for δ correct headers before entering synch state
- ❑ α incorrect headers \Rightarrow resynchronize
- ❑ α and δ are parameters.
- ❑ VPI/VCI = 0/9 \Rightarrow Phy layer OAM cells (F1, F2, F3 level)



SONET/SDH Based Phy

- ❑ Allows SONET facilities to be used for ATM and non-ATM
- ❑ Lower speed ATM streams can be multiplexed into higher speed SONET streams
- ❑ H4 octet in the path header indicates offset to the boundary of the first cell following H4
- ❑ Some cell may need to be split between successive SONET frames.
- ❑ OAM information is carried in the SONET overhead octets. F1 and F2 in section overhead. F3 in path overhead.

SONET/SDH Phy



SONET STS-3c

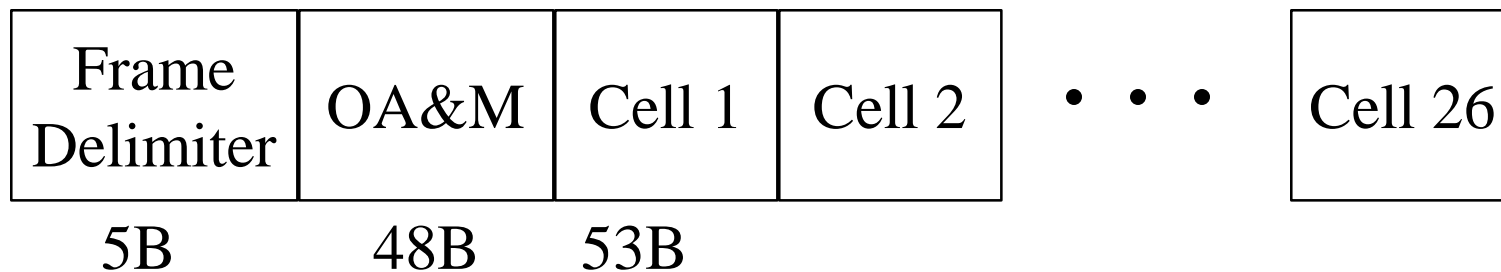
- ❑ Payload rate = $9 \times 260 \times 8/125 = 149.76$ Mbps
- ❑ Cell payload rate = 135.63 Mbps
- ❑ Cell delineation using HEC.
 - ❑ Look for 5-byte blocks with HEC separated by 48 bytes
- ❑ Cells are packed one after another \Rightarrow One can send 127 bits matching the scrambling sequence resulting in all 1's or 0's.
Scramble by dividing by $1 + x^{43}$.
Only one in 2^{43} patterns will cause all 1's or 0's.
- ❑ Self-synchronous scrambler
 - \Rightarrow No need for synchronization.
 - \Rightarrow Each bit error in fiber results in two bit errors after descrambling (multiplication).

ATM on SONET STS-3c

- ❑ The polynomial was chosen because it does not conflict with existing CRCs.
- ❑ Also 43 is larger than header length \Rightarrow Header will not have two-bit errors.

155 Mbps, 8b/10b

- ❑ 8b/10b code used in Fiber Channel
- ❑ 2 km multimode fiber or 100 m shielded twisted pair
- ❑ 155.52 Mbps \Rightarrow 194.4 Mbaud
- ❑ Cells delimited using a transmission frame
- ❑ Cell payload rate = $155.52 \times (26/27) \times (48/53)$
= 135.63 Mbps = STS-3c rate

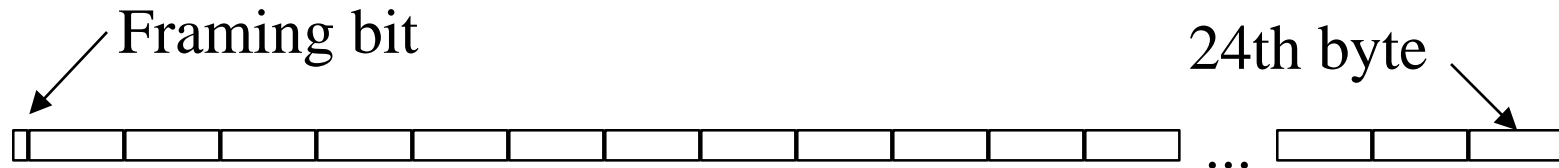


100 Mbps 4b/5b

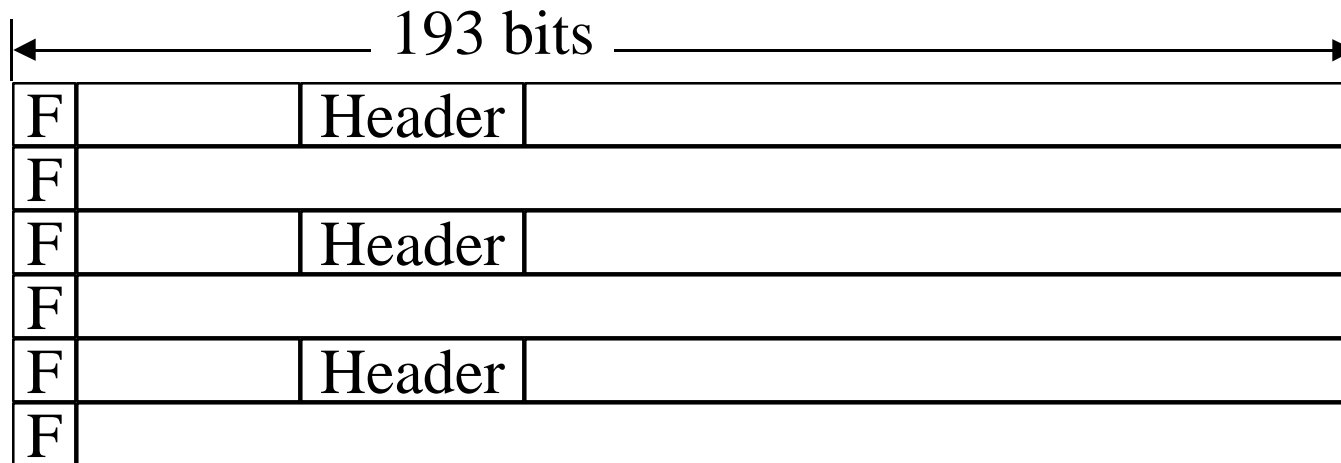
- ❑ 4b/5b used in FDDI
- ❑ 100 Mbps \Rightarrow 125 Mbaud
- ❑ Cells delimited with TT pair
- ❑ Cell = TT + 53 bytes = 2 + 106 = 108 symbols
- ❑ Cell payload rate = $100(53/54)(48/53) = 88.89$ Mbps



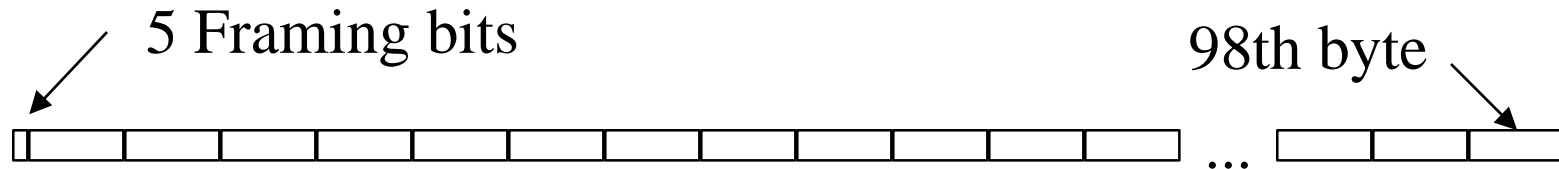
1.5 Mbps DS1



- ❑ Payload rate = 24 bytes/125 ms = 1.536 Mbps
- ❑ Cell delineation by HEC detection
- ❑ Cell payload rate = $1.536 * (48/53) = 1.391$ Mbps



6.312 Mbps



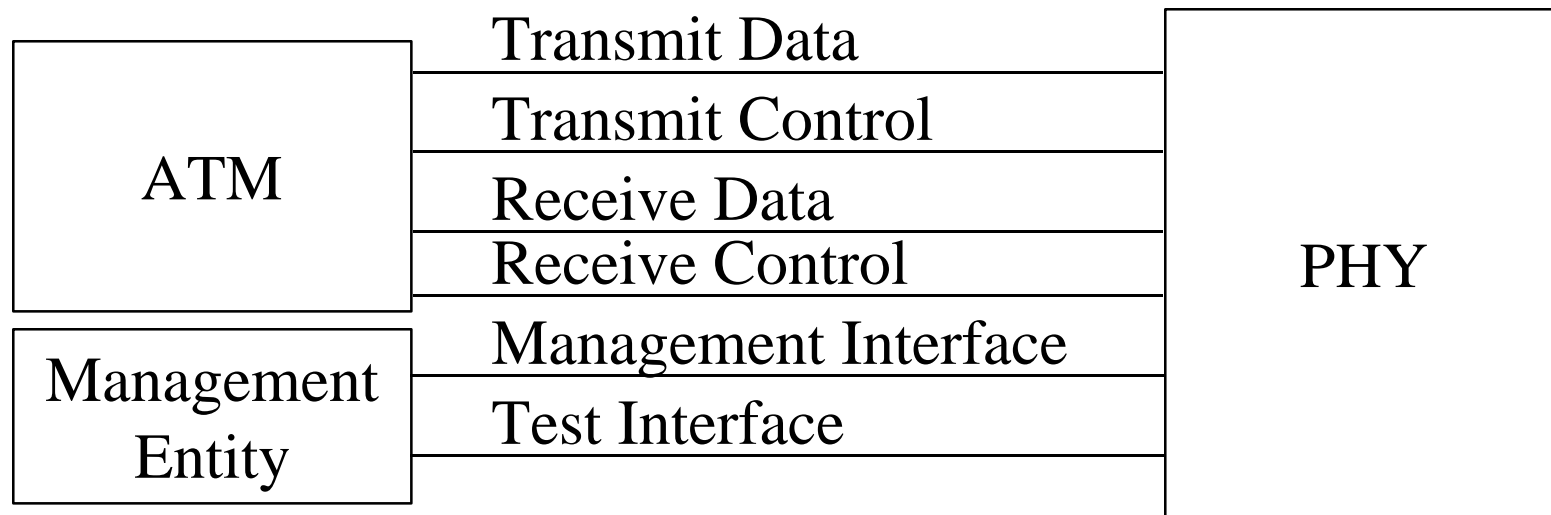
- ❑ Payload rate = 98 bytes/125 μ s = 6.272 Mbps
- ❑ 97th and 98th byte are reserved.
96 Bytes per frame used for cell stream.
- ❑ Cell delineation by HEC detection
- ❑ Cell payload rate = $(48/53)(96 \times 8 / 125 \mu\text{s}) = 5.928$ Mbps

25.6 Mbps UTP

- ❑ Scrambling:
 - ❑ pseudo-random numbers are generated using $x^{10} + x^7 + 1$
 - ❑ Successive 4 bits are XOR'ed with 4-bits of data
 - ❑ All 53 bytes are scrambled
 - ❑ The random number generator is initialized to 3FF upon detection of two consecutive escape (X) nibbles. The two X nibbles (00010) may not be octet-aligned.
- ❑ Coding: 4b/5b + NRZI

UTOPIA

- ❑ Universal Test & Operations PHY Interface for ATM
- ❑ A common PHY-ATM interface over a wide range of PHYs
- ❑ Chip-chip or board-board interface \Rightarrow Industry standard devices
- ❑ PHY-ATM interface not visible outside and so not required for interoperability



UTOPIA

- ❑ UTOPIA Level 1 defines electrical interfaces for:
 - ❑ An 8-bit wide data path using an octet-level handshake at 25 MHz
 - ❑ An 8-bit data path using cell-level handshake at 25 MHz
- ❑ 16-bit and 32-bit wide data paths may be defined for higher speeds
- ❑ UTOPIA Level 2
 - ❑ addresses 33 MHz operation for PCI bus and
 - ❑ 50 MHz operation for 622 Mbps
 - ❑ Multi-PHY operation

References

- ❑ G. Garg, “UTOPIA Level 2 Specification V0.8,” ATM Forum/95-0114R1, April 10, 1995.
- ❑ “UTOPIA, An ATM-PHY Interface Specification, Level 1, V2.01,” March 21, 1994.
- ❑ G.H. Im, et al, “51.84 Mb/s 16-CAP ATM LAN standard,” IEEE JSAC, May 1995, pp. 620-632.
- ❑ W.E. Stephens and T.C. Banwell, “155.52 Mb/s Data Transmission on Category 5 Cable Plant,” IEEE Communications Magazine, April 1995, pp. 62-69.
- ❑ “6,312 kbps UNI Specification”
- ❑ “Physical Interface Specifications for 25.6 Mb/s over Twisted Pair Cable,” June 11, 1995.

- ❑ DS1 Physical Layer Specification, September 1994.
- ❑ E3 (34,368 kbps) Physical Layer Interface, November 28, 1994.
- ❑ E4 (139 264 kbps) Physical Layer Interface, November 28, 1994.
- ❑ “ATM Physical Medium Dependent Interface Specification for 155 Mb/s over Twisted Pair Cable,” AF-PHY-0015.000, September 1994.
- ❑ “Mid-Range Physical Layer Specification for Category 3 Unshielded Twisted Pair,” AF-PHY-0018.000, September 1994.
- ❑ K. Brinkerhoff, et al, “155.52 Mb/s Physical Layer Specification for Category 3 Unshielded Twisted-Pair, Draft 1.2, January 1995.