Part III: ATM

ATM Physical Layer

ATM Standard

- ATM Forum standard: the UNI 3.1 Specification (authoritative text on almost everything discussed in this section of the class).
- Available in book format from most bookstores.
- Available for downloading:

```
ftp://ftp.atmforum.com/pub/approved-specs/
    af-uni-0010.002.pdf.tar.Z  (Acrobat)
    af-uni-0010.002.ps.tar.Z   (PostScript)
    af-uni-0010.002.rtf.tar.Z  (RTF)
```

ATM Physical Layer

- Divided into two sublayers:
  - Physical Media Dependent Sublayer (PMD)
    - Physical Medium, Bit Timing, Line Coding
    - Uses existing technologies
  - Transmission Convergence Sublayer (TCS)
    - Specific for each PMD
    - Functions:
      - Cell delineation
      - Cell rate decoupling (inserting empty cells during idle periods)
      - Scrambling

Cell Delineation and Rate Decoupling

- Some data communication channels can be idle or transmitting
  - The medium has separate states for “sending 1”, “sending 0”, or “not sending anything”.
  - Example: Ethernet.
- Other digital communication channels are always active; at any point in time, they are either sending a 0 or a 1
  - Example: synchronous serial channels
- The latter type presents the following issues:
  - How to identify the beginning of a cell or packet? (cell delineation)
  - What to send when the device has nothing to send? (cell rate decoupling)
- These issues are dealt with by the Transmission Convergence Sublayer.

Cell Delineation

- Delimiters:
  - Framing: Cells are incorporated within a frame structure.
    - Frame may contain a pointer that identifies the location of cell boundaries.
    - Cells may be placed at fixed locations within the frame.
  - HEC: Cell boundaries can be found based on the HEC (checksum) field in the cell header. As the data stream is received, each group of 5 octets is checked to see if the fifth octet is a valid HEC value for the previous 4 octets.
    - If so, the 5 octets are the header of a cell
    - The same check is repeated on what is presumed to be the next cell header.
    - After a sequence of some number of correct HEC values has been detected, the cell boundaries are assumed to have been located.

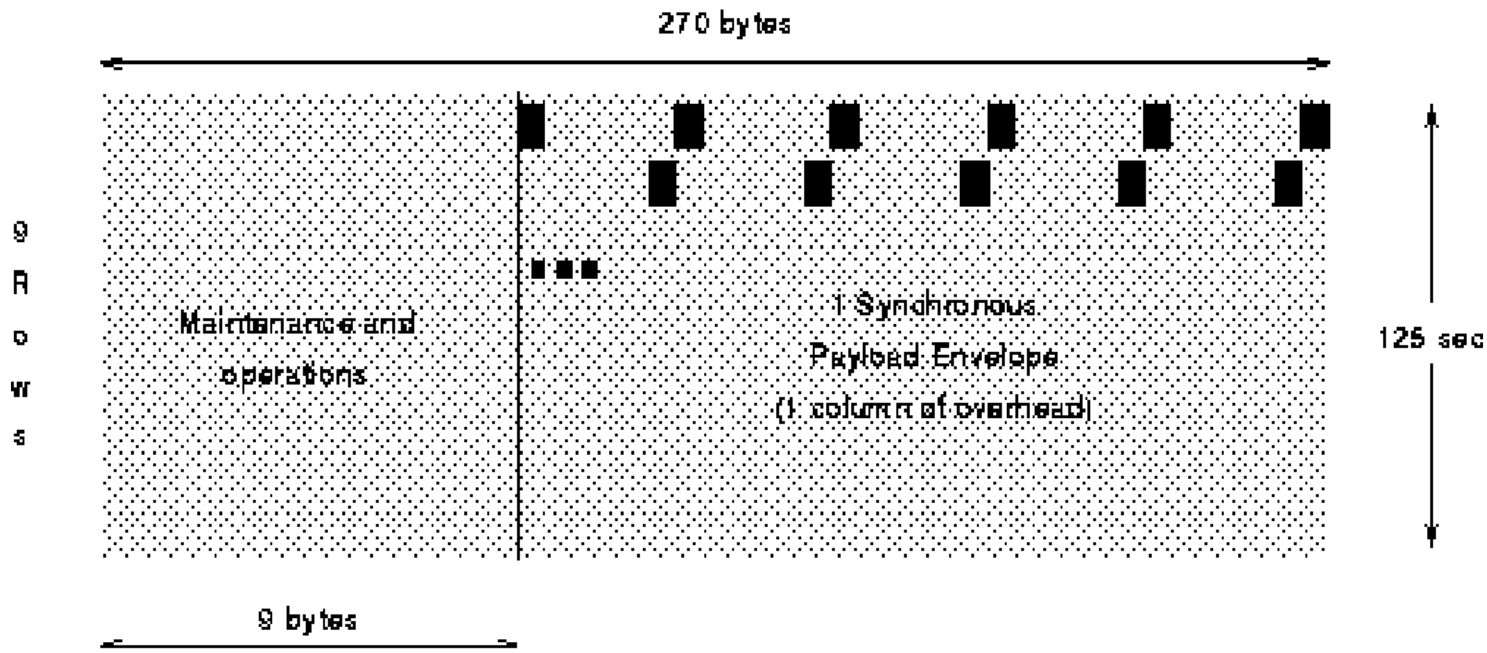
Scrambling

- A line carrying a sequence of bits requires a clock to be read (the clock indicates when to read the bit level).
- Transmission systems do not carry a separate clock line; it must be recovered from the data.
- Depending on the line encoding, long sequences of ones and/or zeros may cause problems in clock recovery.
  - Example: AMI code
    - Send zero for bit zero, and alternate +V and -V for bit one.
    - Long sequences of zeros cause loss of clock.
- Scrambling: modifying the data in such a way that pulse density is maintained.

Types of Physical Layers

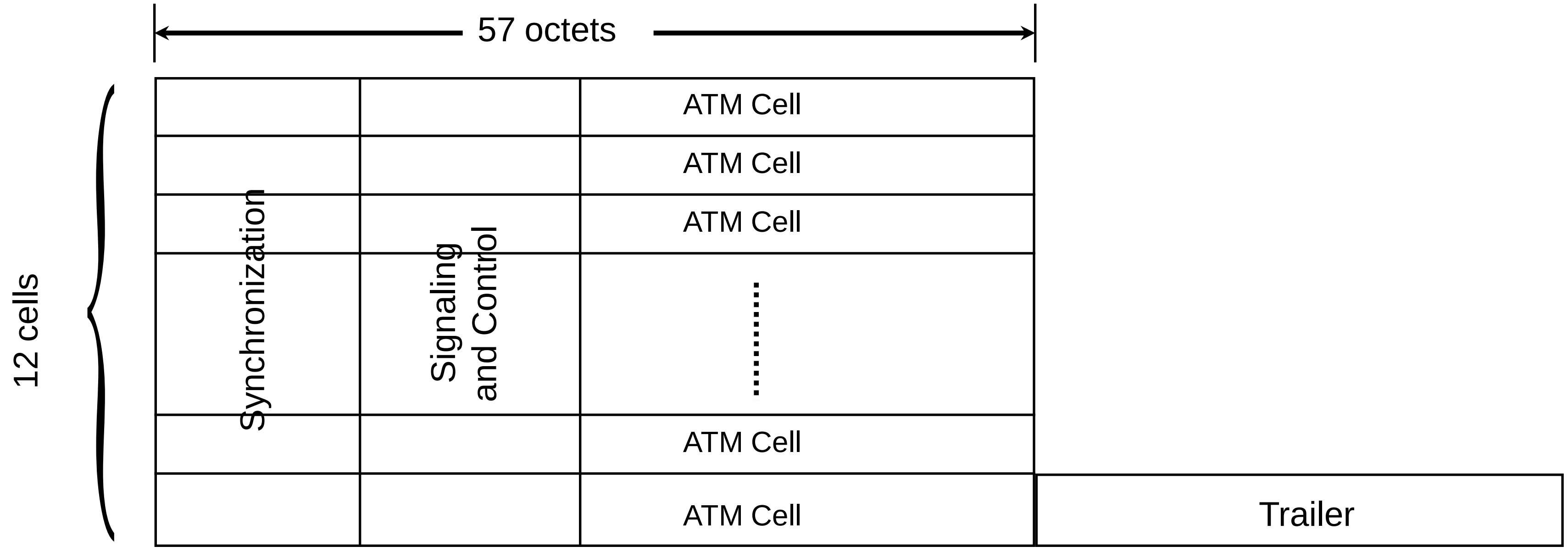
- SONET STS-3C at 155 Mb/s
- DS3 at 44 Mb/s
- Multimode Fiber at 100 Mb/s
- 155 Mb/s
  - Fiber
  - Shielded Twisted Pair
- 25.4 Mb/s twisted pair (not in UNI 3.1)
- Other Alternatives

SONET STS-3C



- Cells are sent back-to-back in the SONET payload
- Cell delineation is done by using the HEC (CRC) field in the cell header
- Scrambling is also provided
- 135.63 Mb/s cell payload

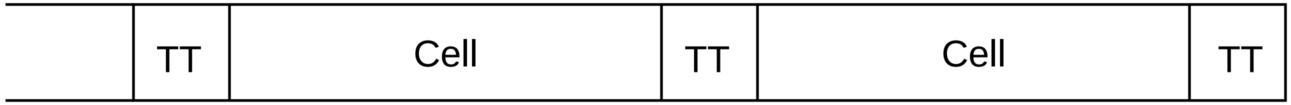
44 Mb/s, DS3



- Cell delineation is provided by a PLCP (Physical Layer Convergence Protocol)
- Scrambling may be provided
- 36.864 Mb/s cell payload

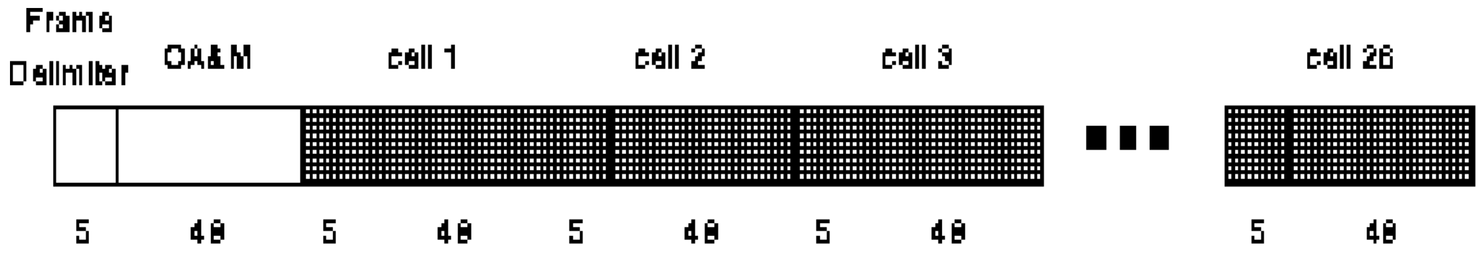
100 Mb/s Multimode Fiber

- Based on the FDDI physical layer
- Uses 4B/5B encoding --- scrambling is not needed
- Cell delineation is provided by the TT symbol
- 88.89 Mb/s cell payload



155 Mb/s FIBER or STP

- Physical Media:
  - Fiber up to 2 km
  - Shielded Twisted Pair up to 100 m
- Uses 8B/10B Fiber Channel encoding --- scrambling not needed
- Cell delineation via a transmission frame
- 135.63 Mb/s cell payload (same as SONET)



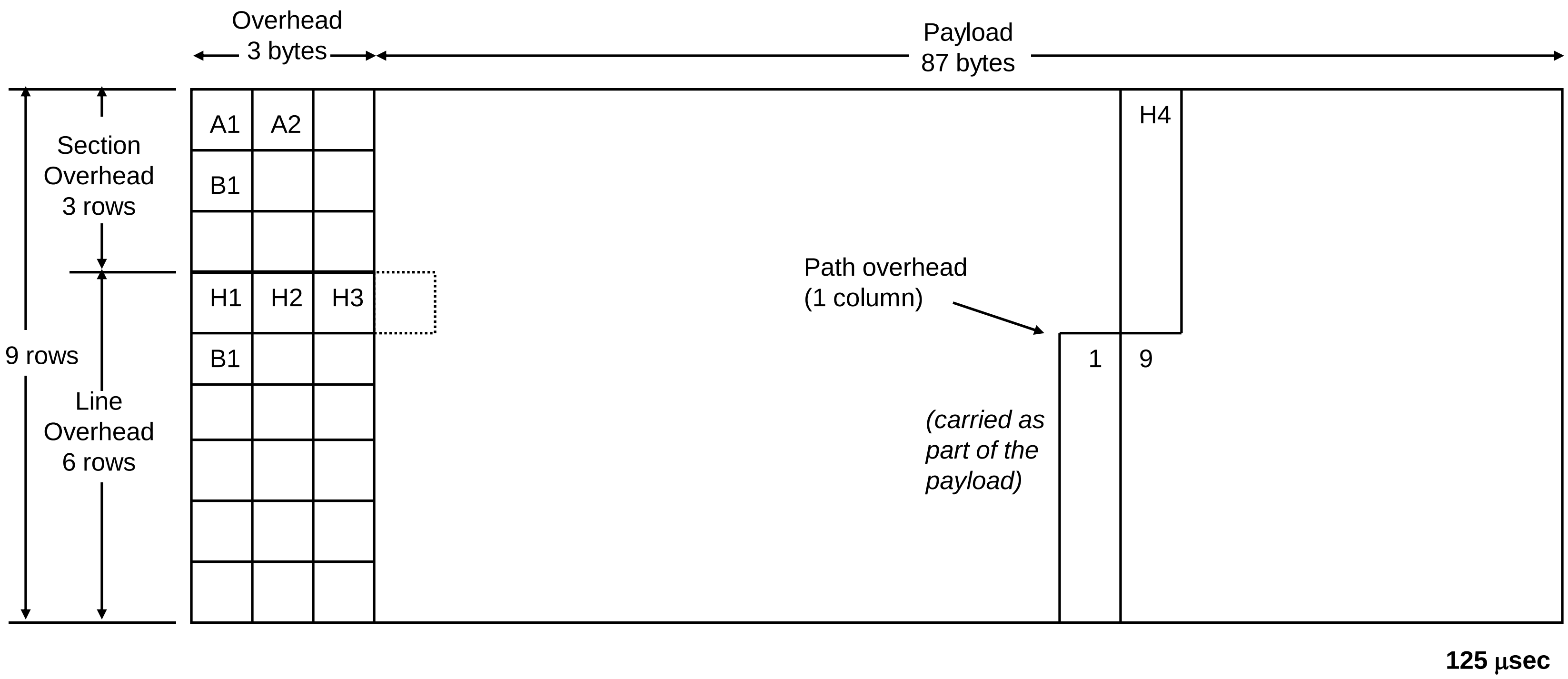
Other Alternatives

- Category 3 UTP
  - 52 Mb/s
- Category 5 UTP
  - 155 Mb/s
- European Hierarchy
  - 34.368 Mb/s
  - 139.264 Mb/s
- Low speed
  - 1.544 Mb/s (T1)
  - 2.048 Mb/s (E1)

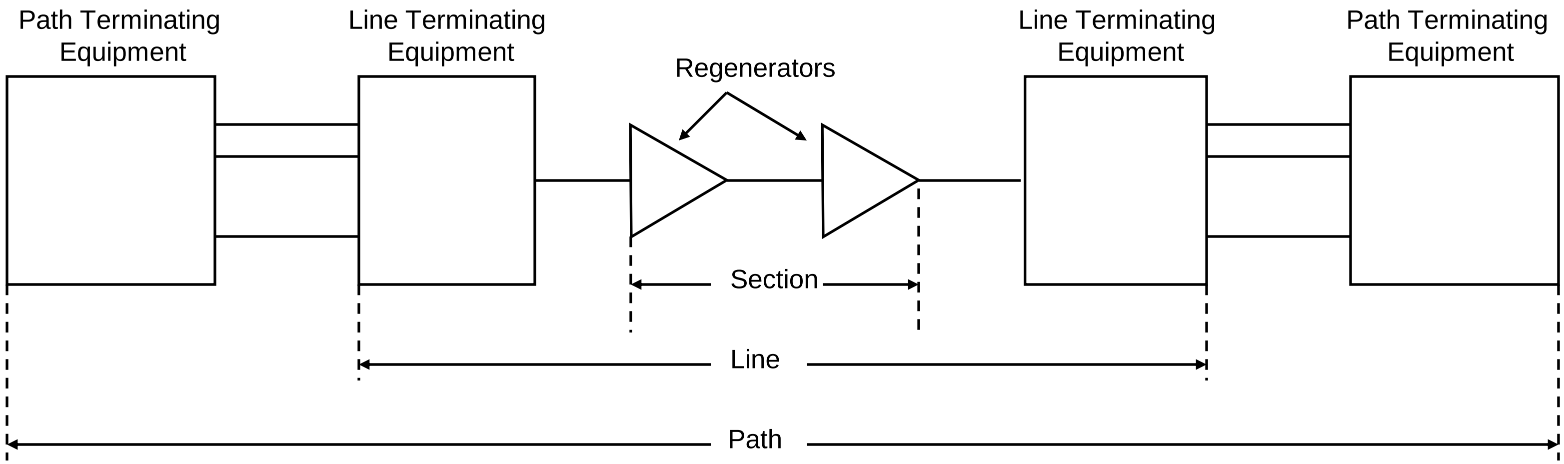
SONET Basics

- **S**ynchronous **O**ptical **NET**work
  - Synchronous bit transport on the whole network
  - Flexible payload
  - Bandwidth concatenation by synchronous multiplexing
  - Standard maintenance channels provided

SONET STS-1 Frame Structure (1)



SONET STS-1 Frame Structure (2)

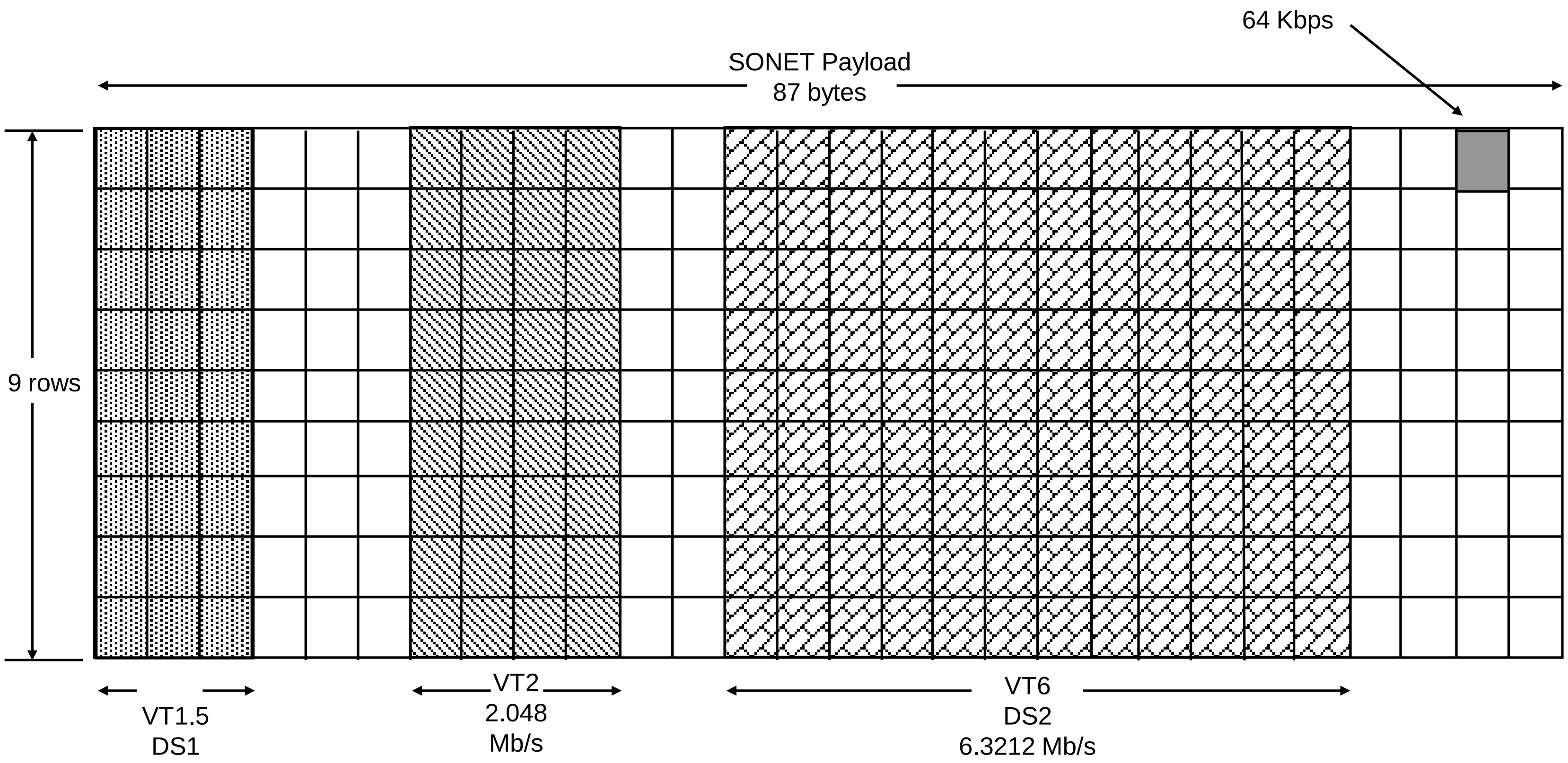


- The overhead bits are processed in a hierarchical fashion
- Section equipment processes only the section overhead
- Line equipment processes both the section and the line overheads
- Path overhead equipment us processed only by the payload terminating equipment

SONET STS-1 Frame Structure (3)

- **Section Overhead** bytes are used for physical synchronization, error monitoring and maintenance communication channels
- **Line Overhead** bytes are used to indicate the start of the payload on the frame, error monitoring, and additional maintenance communication channels
- **Path Overhead** bytes are used for end-to-end payload error monitoring, payload type identification and a pointer to allow de-multiplexing of ATM cells, if present

Multiplexing STM into SONET



VT = virtual tributary

Multiplexing STS-1 into STS-n

- It is possible to multiplex n STS-1 channels in order to obtain an STS-n channel
- Since the network is synchronous, there is no need for extra stuffing bits; the rate of the STS-n channel is n times higher than the rate of the STS-1 channel
- The STS-n channel is obtained by byte-interleaving n STS-1 channels.

SONET Bit Rates

Signal	Signal Rate	Net Payload
STS-1	51.84 Mbit/s	49.536 Mbit/s
STS-3c	**155.52 Mbit/s**	**149.76 Mbit/s**
STS-6c	311.04 Mbit/s	300.096 Mbit/s
STS-9c	466.56 Mbit/s	450.432 Mbit/s
STS-12c	**622.08 Mbit/s**	**600.768 Mbit/s**

ATM Payload Rates

Signal	Signal Rate	Net Payload	ATM Payload
STS-1	51.84 Mbit/s	49.536 Mbit/s	
STS-3c	**155.52 Mbit/s**	**149.76 Mbit/s**	**135.6317 Mbit/s**
STS-6c	311.04 Mbit/s	300.096 Mbit/s	
STS-9c	466.56 Mbit/s	450.432 Mbit/s	
STS-12c	**622.08 Mbit/s**	**600.768 Mbit/s**	**544.09 Mbit/s**