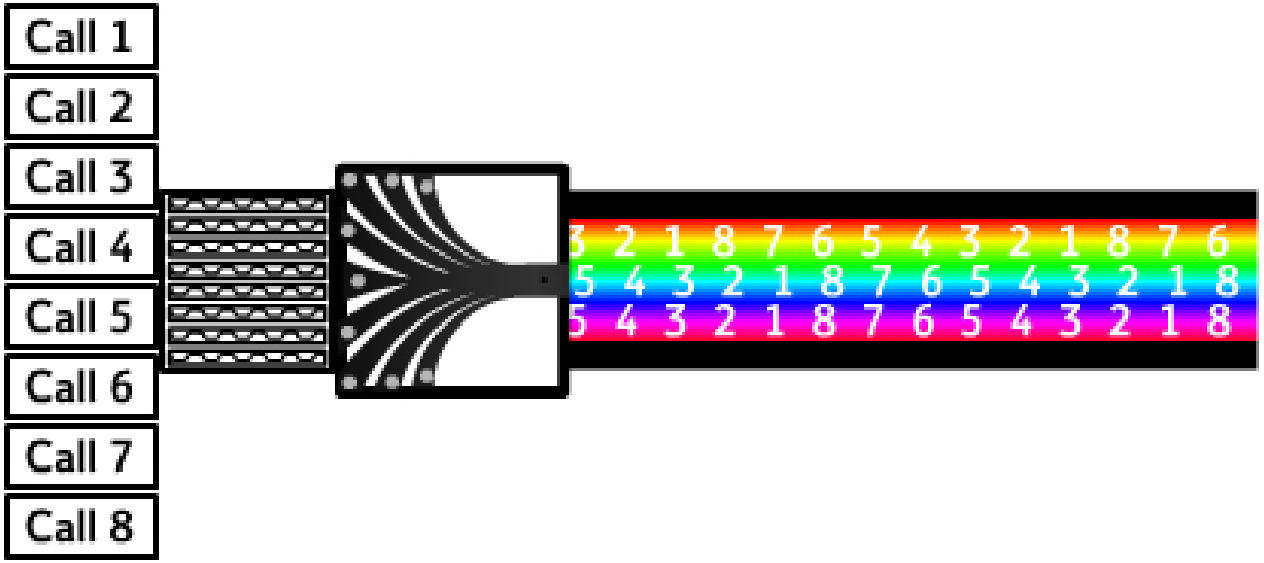
Chapter 7

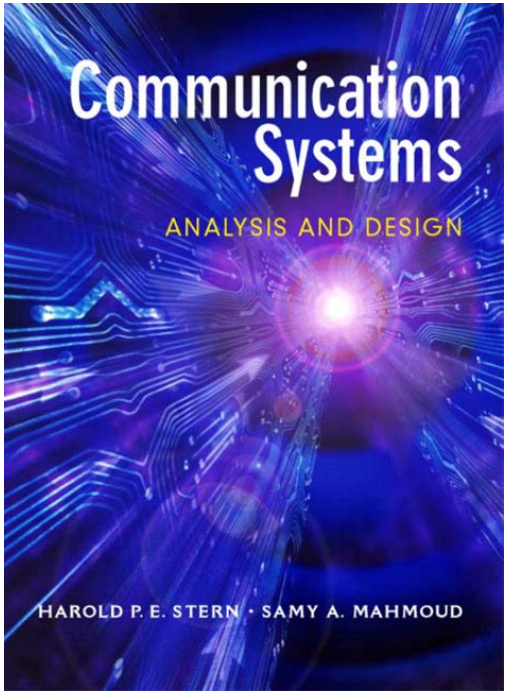
Multiplexing Techniques



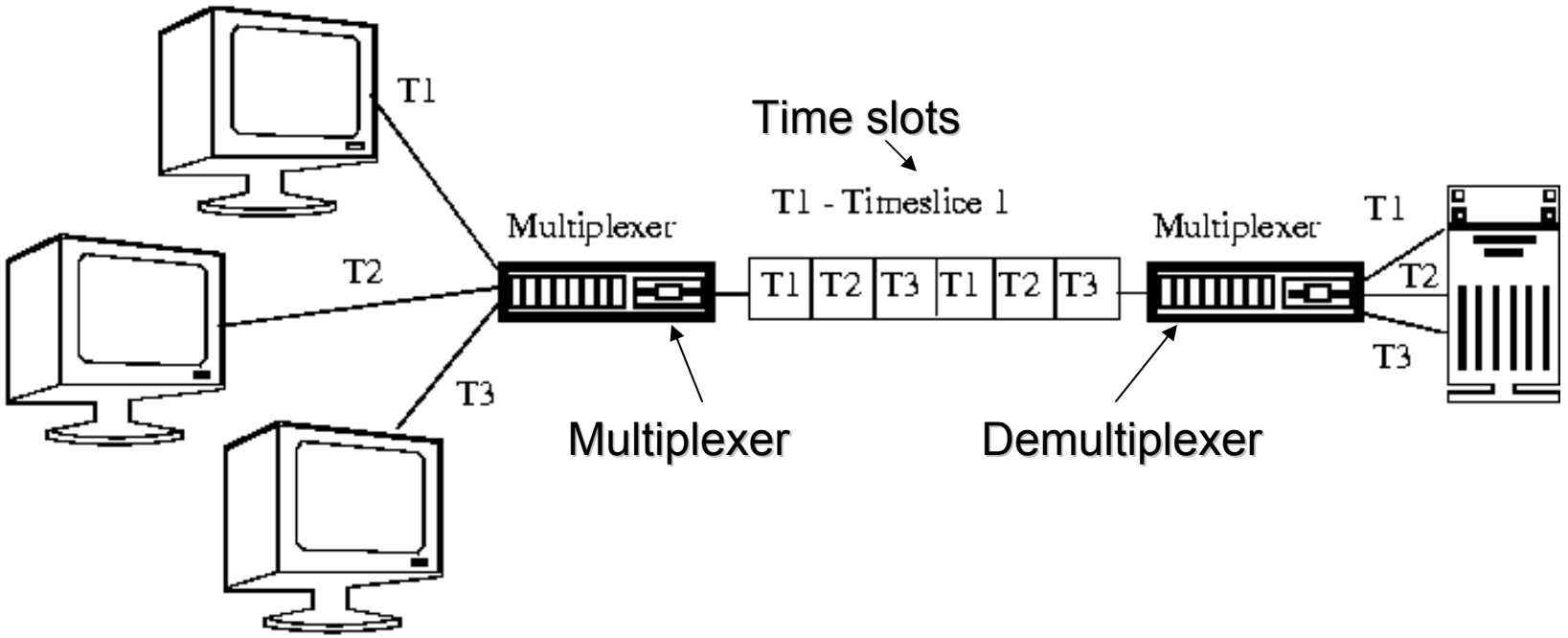
Chapter 7

Multiplexing Techniques

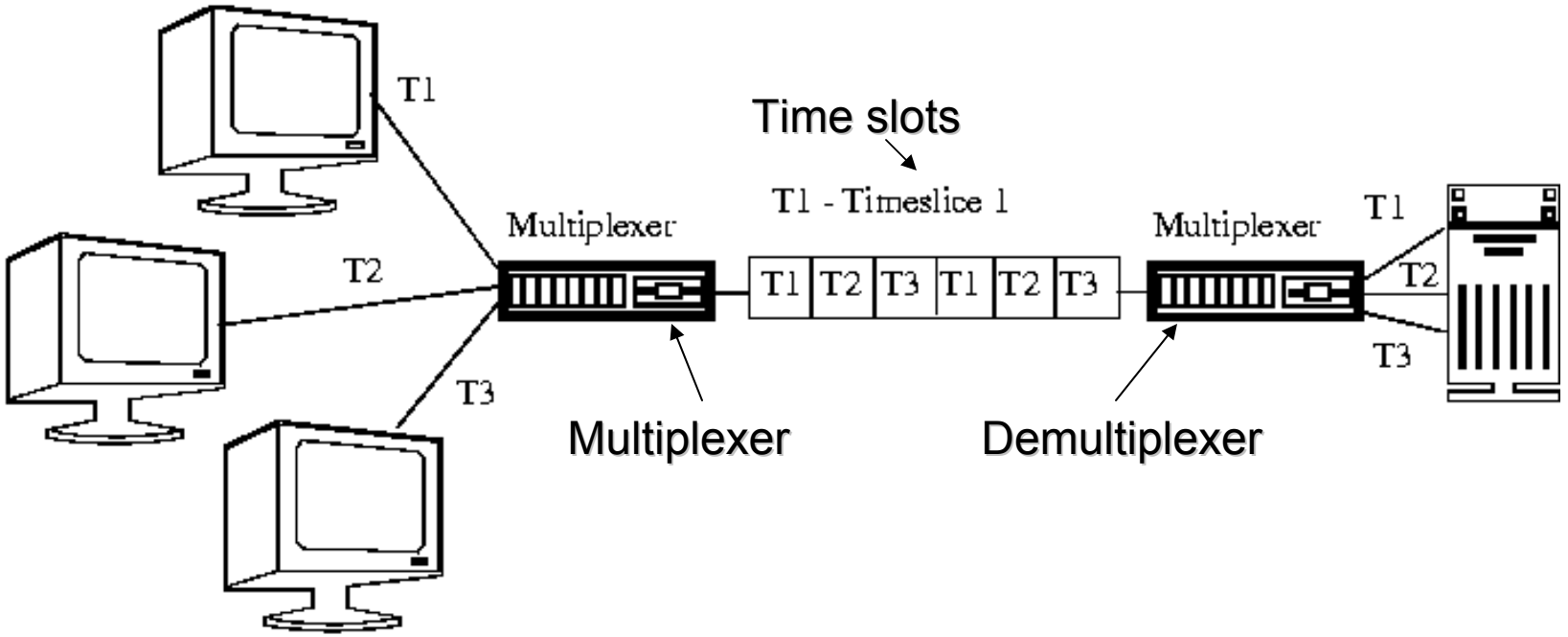
- *Time Division Multiplexing*
- Pages 364-368



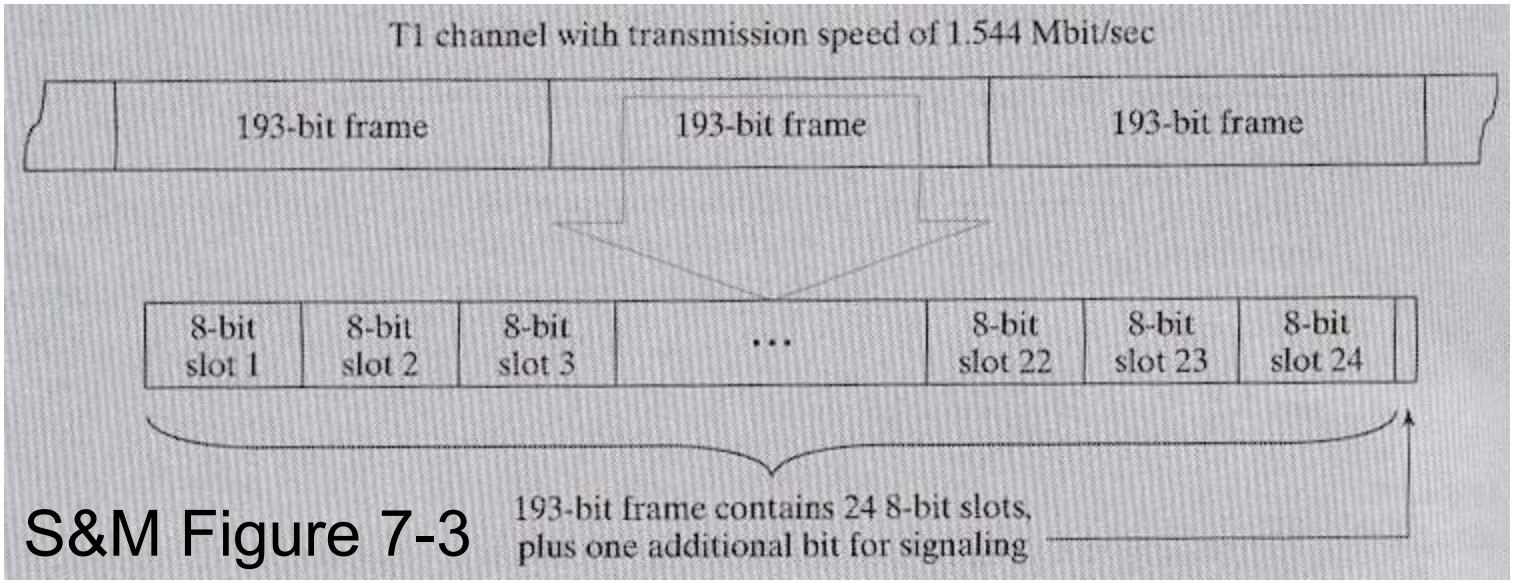
- *Time division multiplexing* (TDM) combines several low, fixed and predefined bit rate sources into a single high speed bit stream for transmission over a single digital communication channel:



- The TDM time slots have to be chosen properly. If the time slots are too small (for example, 1 bit) then the multiplexer and demultiplexer must switch rapidly. If the time slots are too large (for example, 64 Kb) then the data must be *buffered* and *delay* would be produced. TDM is used for baseband (*not* bandpass) data transmission.



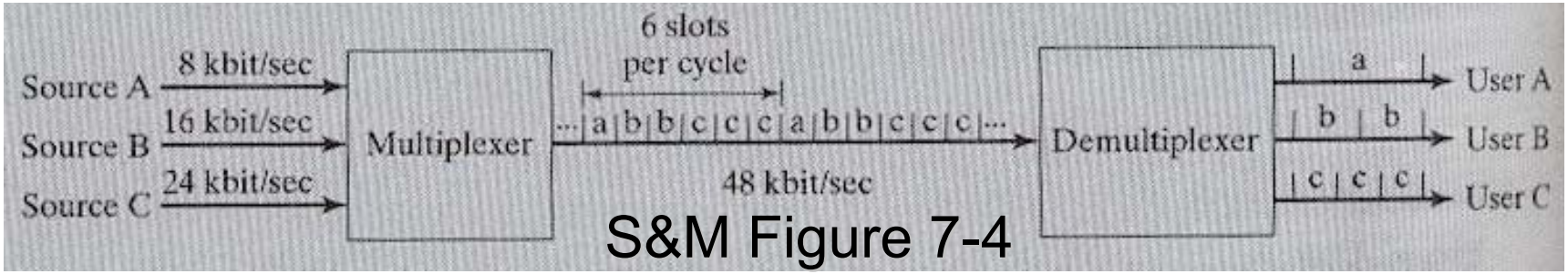
- The T1 TDM system for telephone networks uses a 193 bit *frame* where each frame has 24 8-bit *slots* and 1-bit in each frame for signaling. The T1 bit rate r_b = 1.544 Mb/sec.



S&M Figure 7-3

The duration of each frame T_f = 193 b / 1.544 Mb/sec = 125 μsec or 8 k samples/sec. Here all the data sources have the same data rate.

- If the data sources have different rates a *multiplexer scheme* must reconcile the disparate rates.

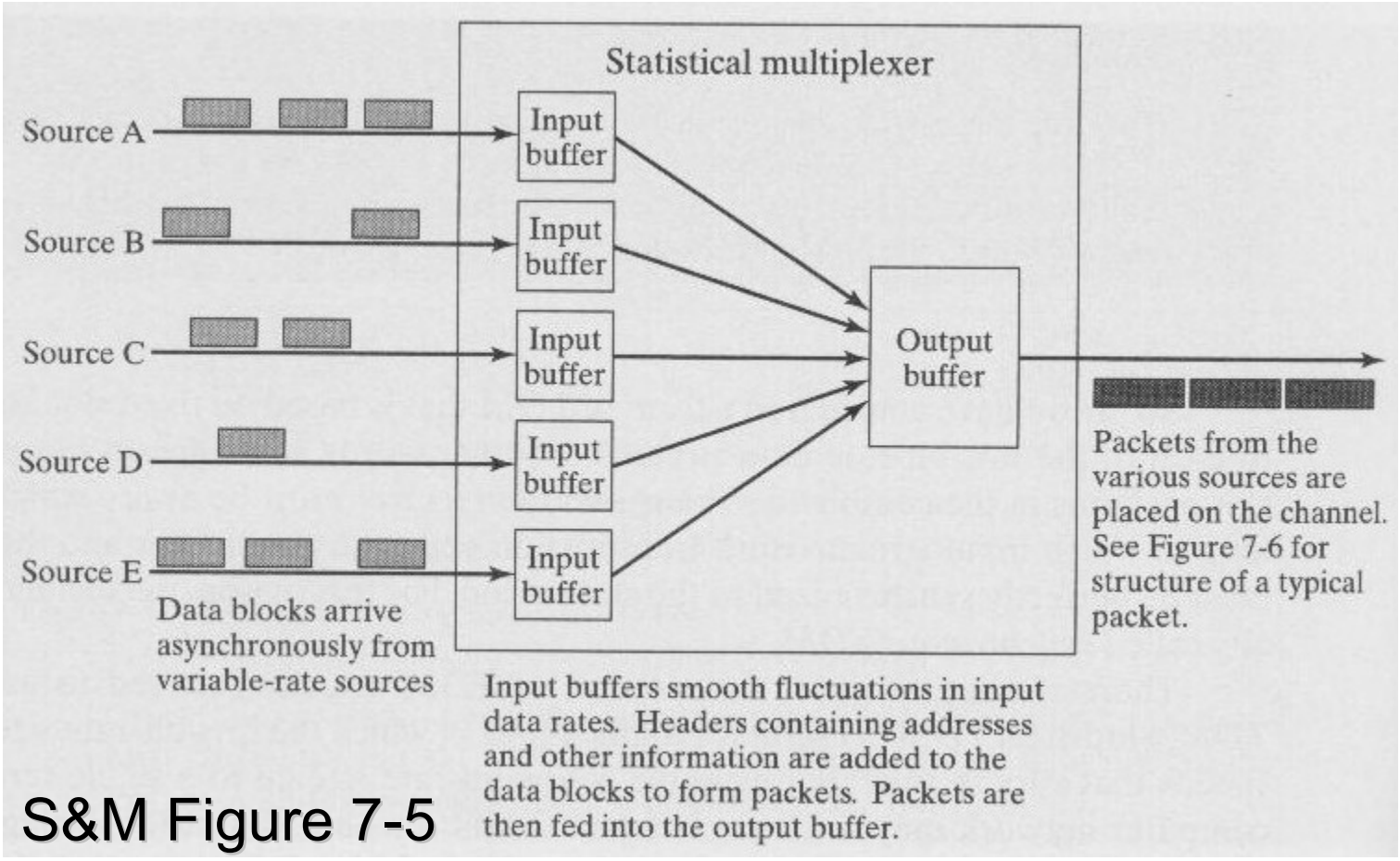


S&M Figure 7-4

The data rates are in the lowest possible ratio of 8:16:24 or 1:2:3 for a total of 1 + 2 + 3 = 6 slots. The slots are apportioned to the channels as: *a b b c c c* and the channel data rate is 48 kb/sec.

Another example is data rates of 10, 15, 20, and 30 Kb/sec which reduces to 2:3:4:6 (the LCD is 5) for 2 + 3 + 4 + 6 = 15 slots and the channel data rate is 45 kb/sec.

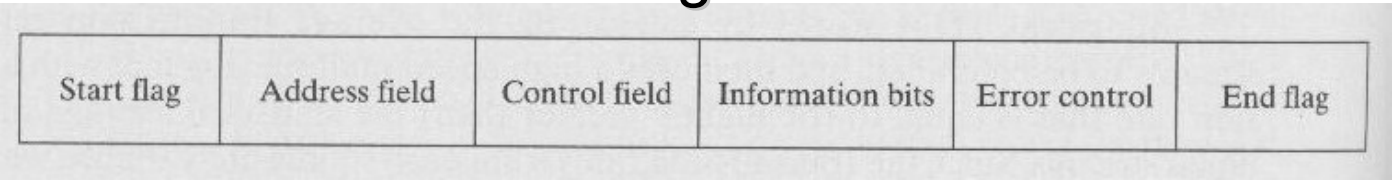
- If data arrives *asynchronously* from variable rate sources, a *statistical multiplexer* with input buffers is used. The design is performed by observation and tested in simulation.

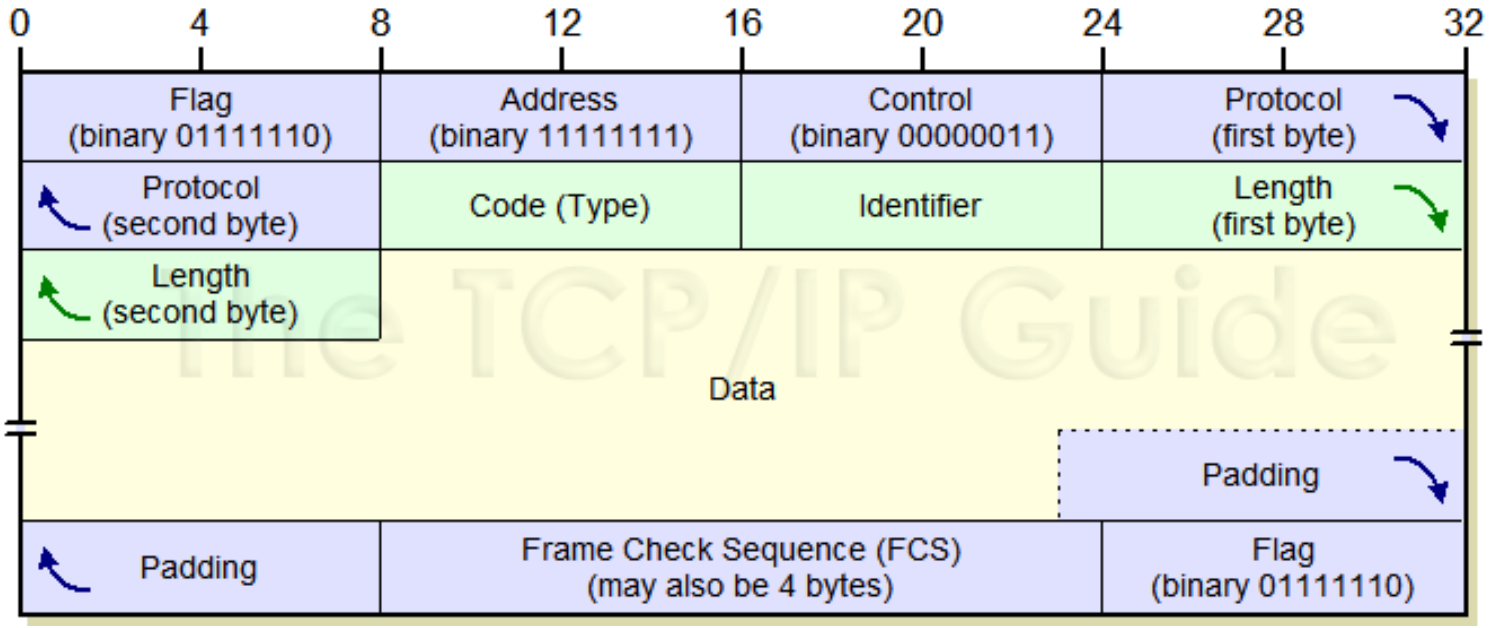


S&M Figure 7-5

- The statistical TDM packet consists of a *start flag*, *address field*, *control field*, *information bits*, *error control,* and an *end flag.*

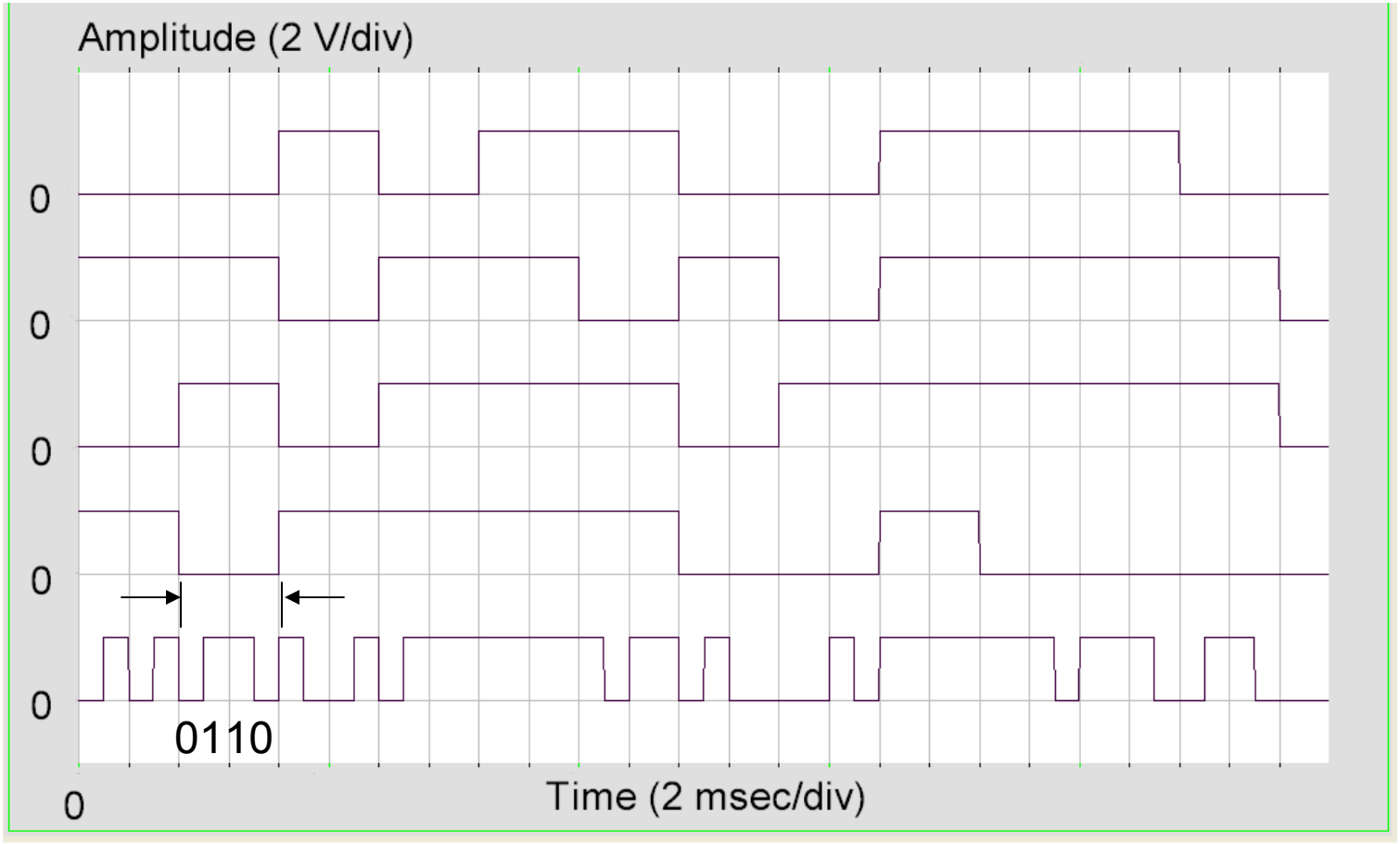
S&M Figure 7-6



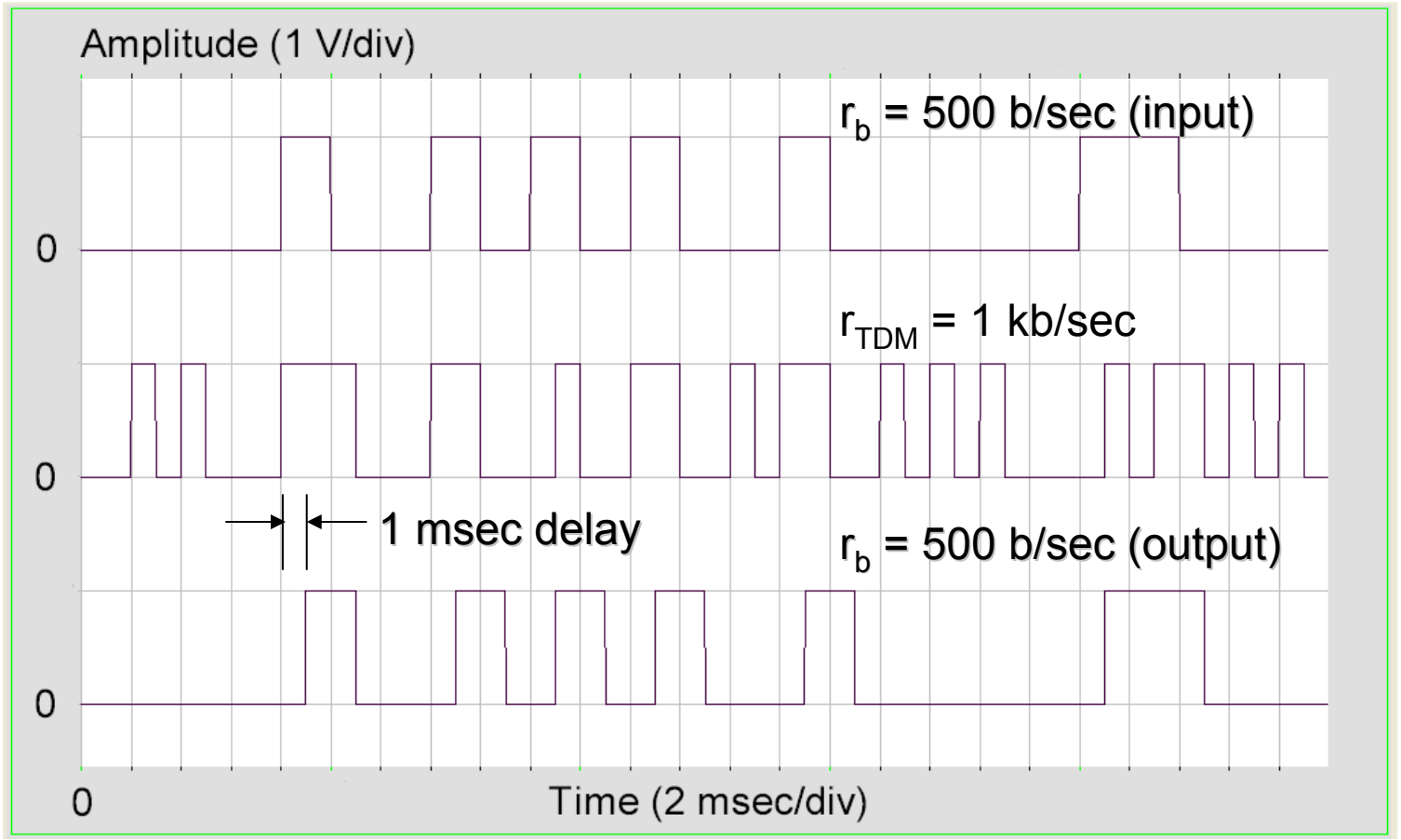


TCP/IP data packet

- TDM with four equal data rate sources r_b = 250 b/sec and a transmission rate r_{TDM} = 1 kb/sec



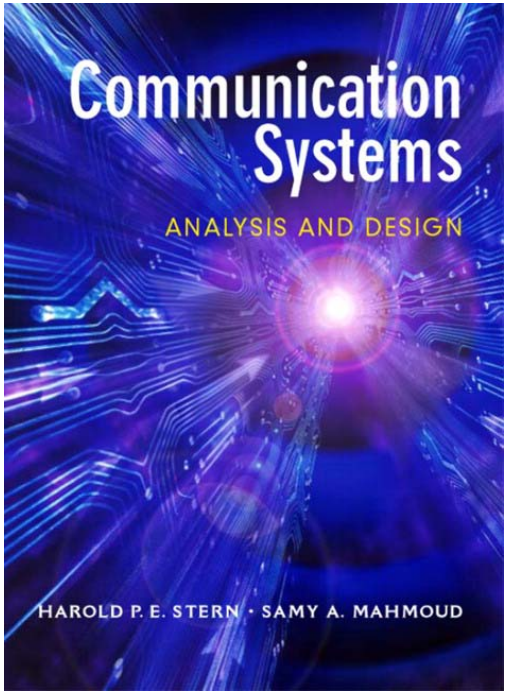
- TDM with unequal data rate sources r_b = 250, 250 and 500 b/sec and a transmission rate r_{TDM} = 1 kb/sec



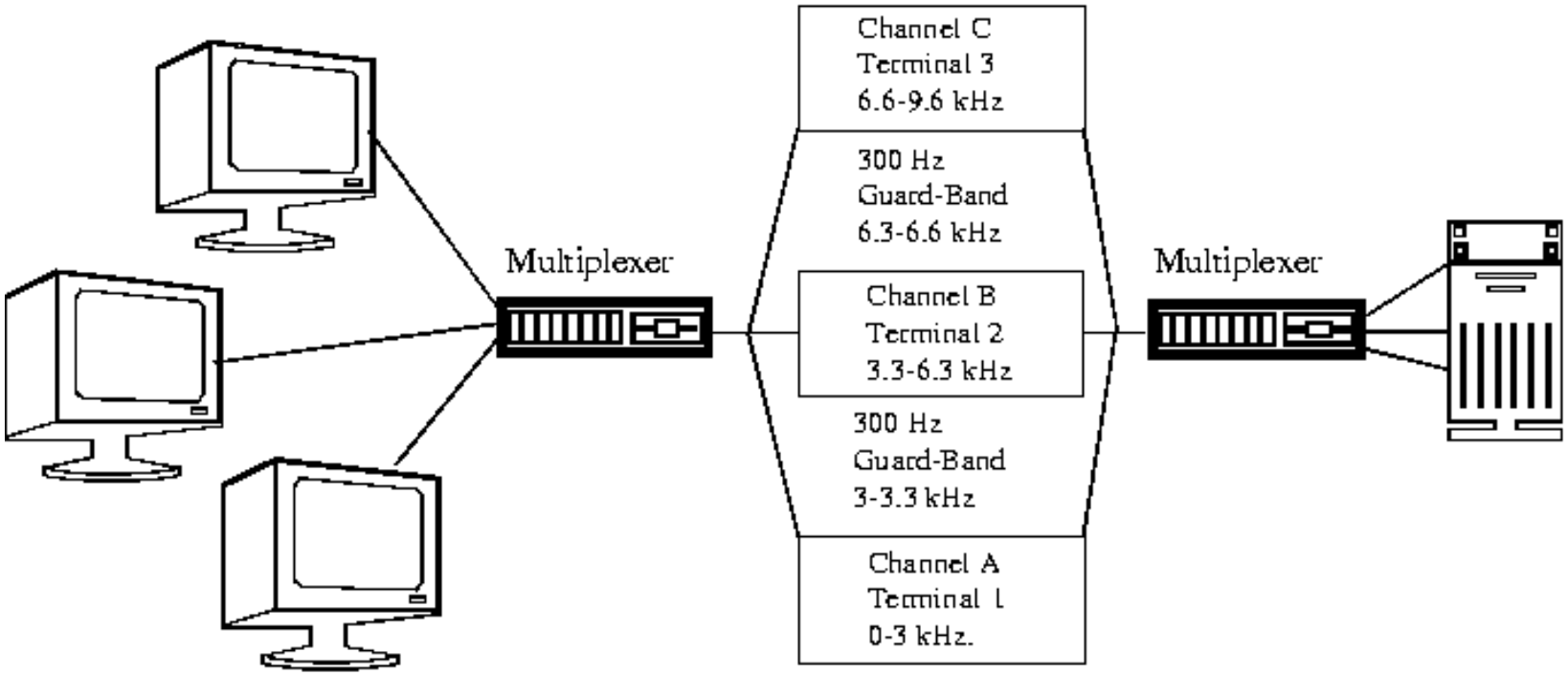
Chapter 7

Multiplexing Techniques

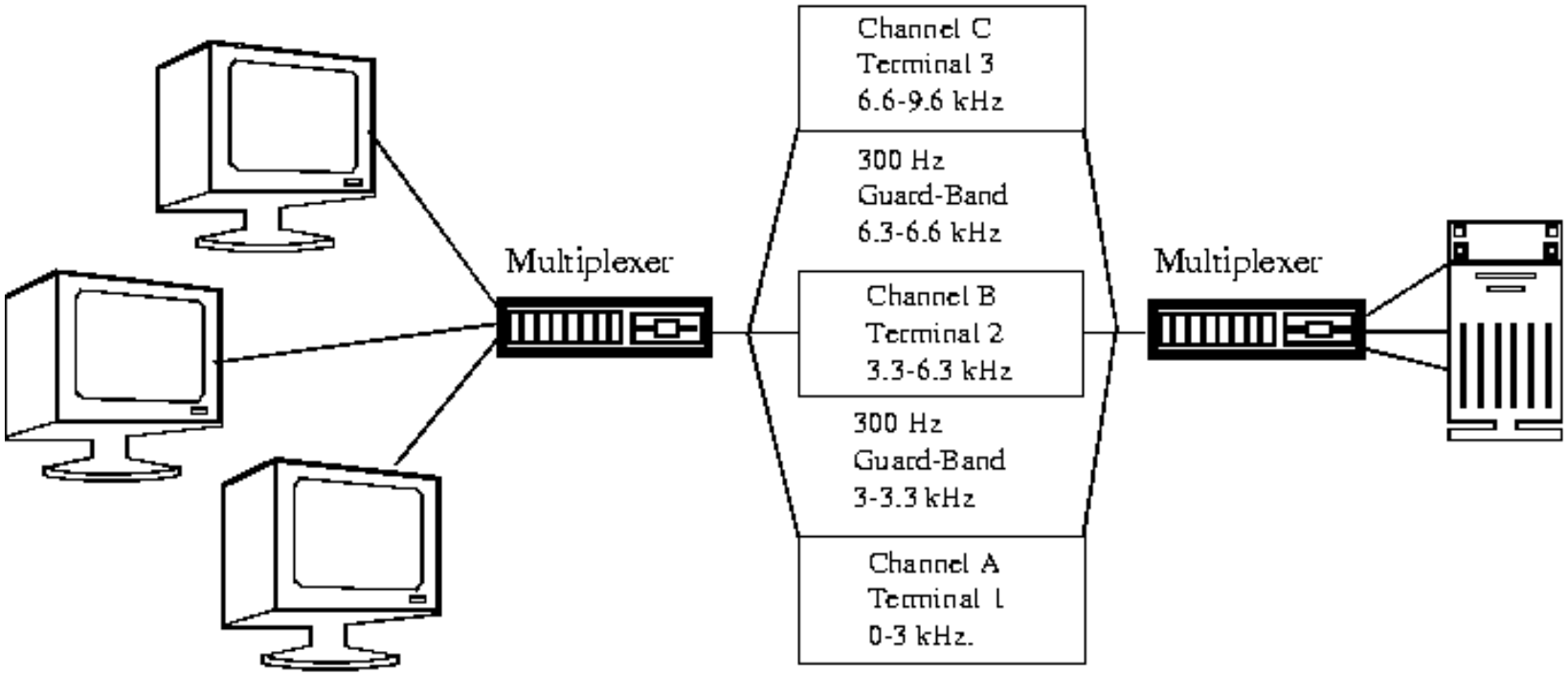
- *Frequency Division Multiplexing*
- Pages 368-370



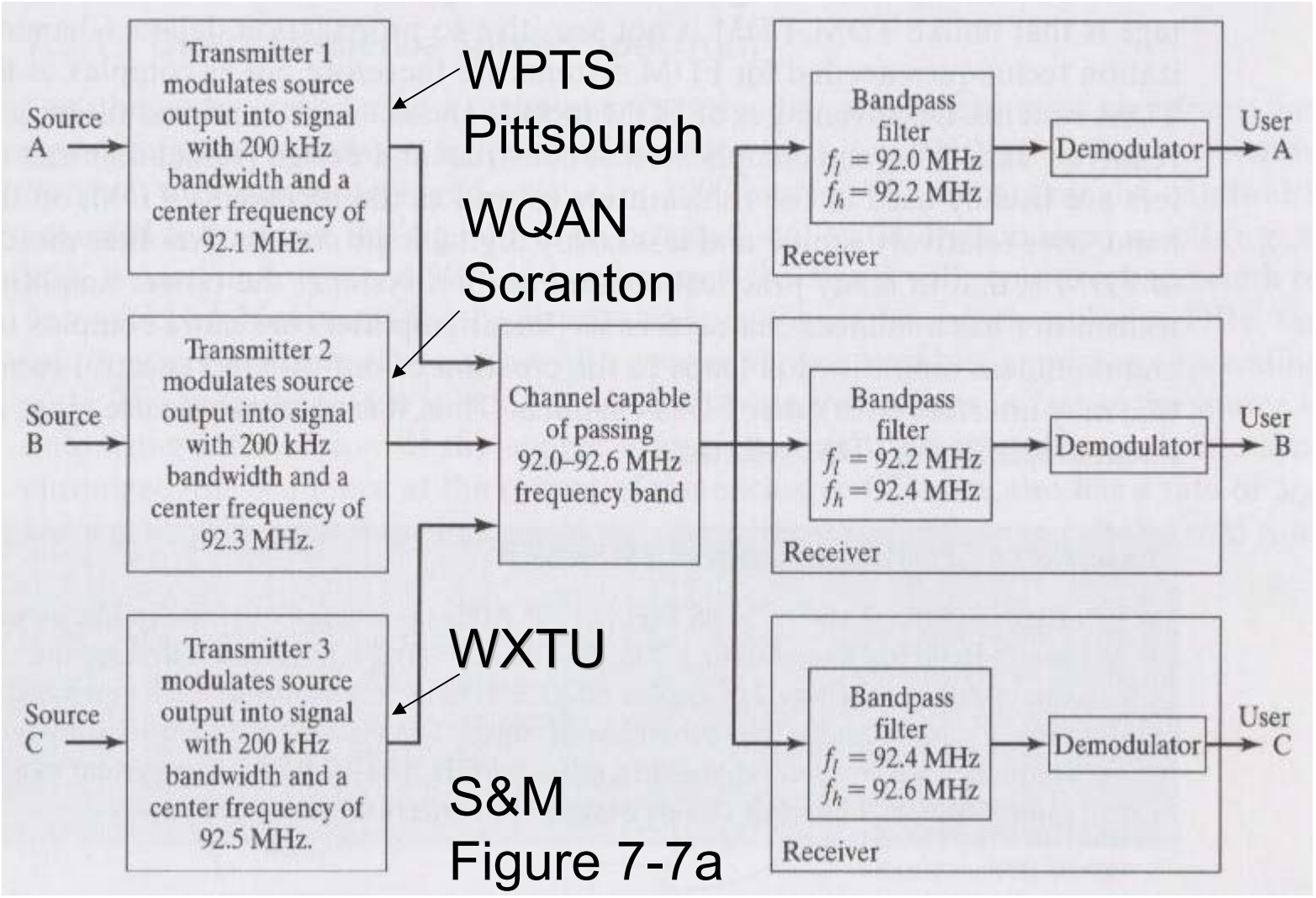
- *Frequency division multiplexing* (FDM) divides the total bandwidth available to the system into *non-overlapping* frequency sub-bands for transmission over a single digital communication channel.



- FDM usually utilizes *guard bands* to separate the digital data transmissions. FDM is used for bandpass (*not* baseband) data transmission



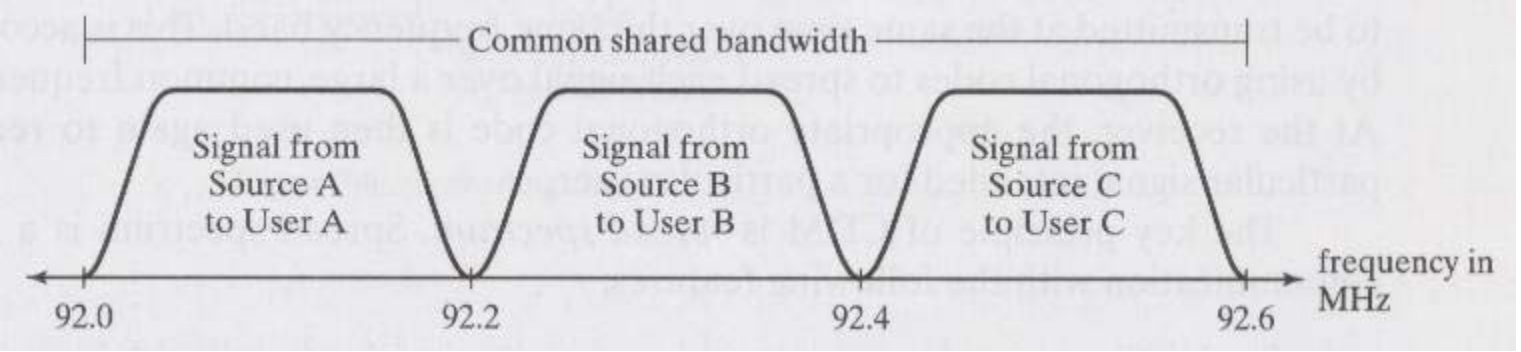
- FDM for *FM broadcasting* over a cable system:

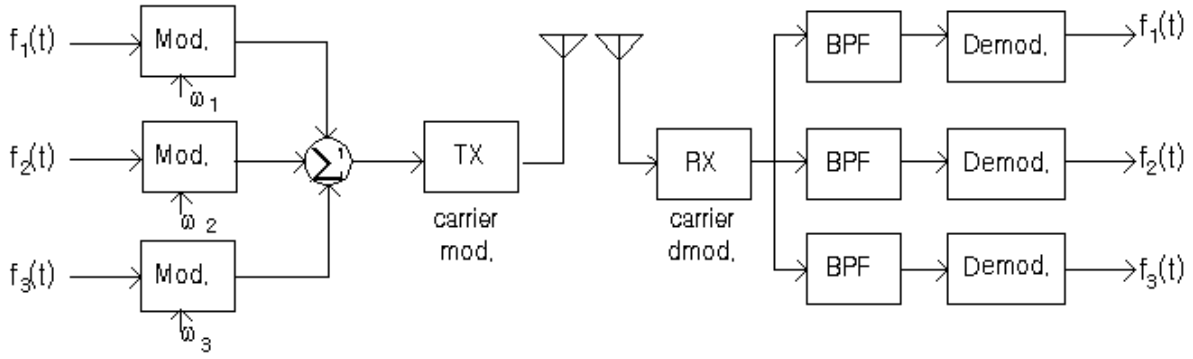


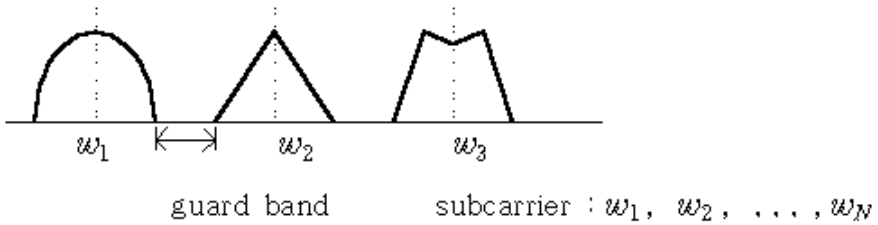
S&M Figure 7-7a

- FDM employs a common shared bandwidth but here with no apparent guard bands.

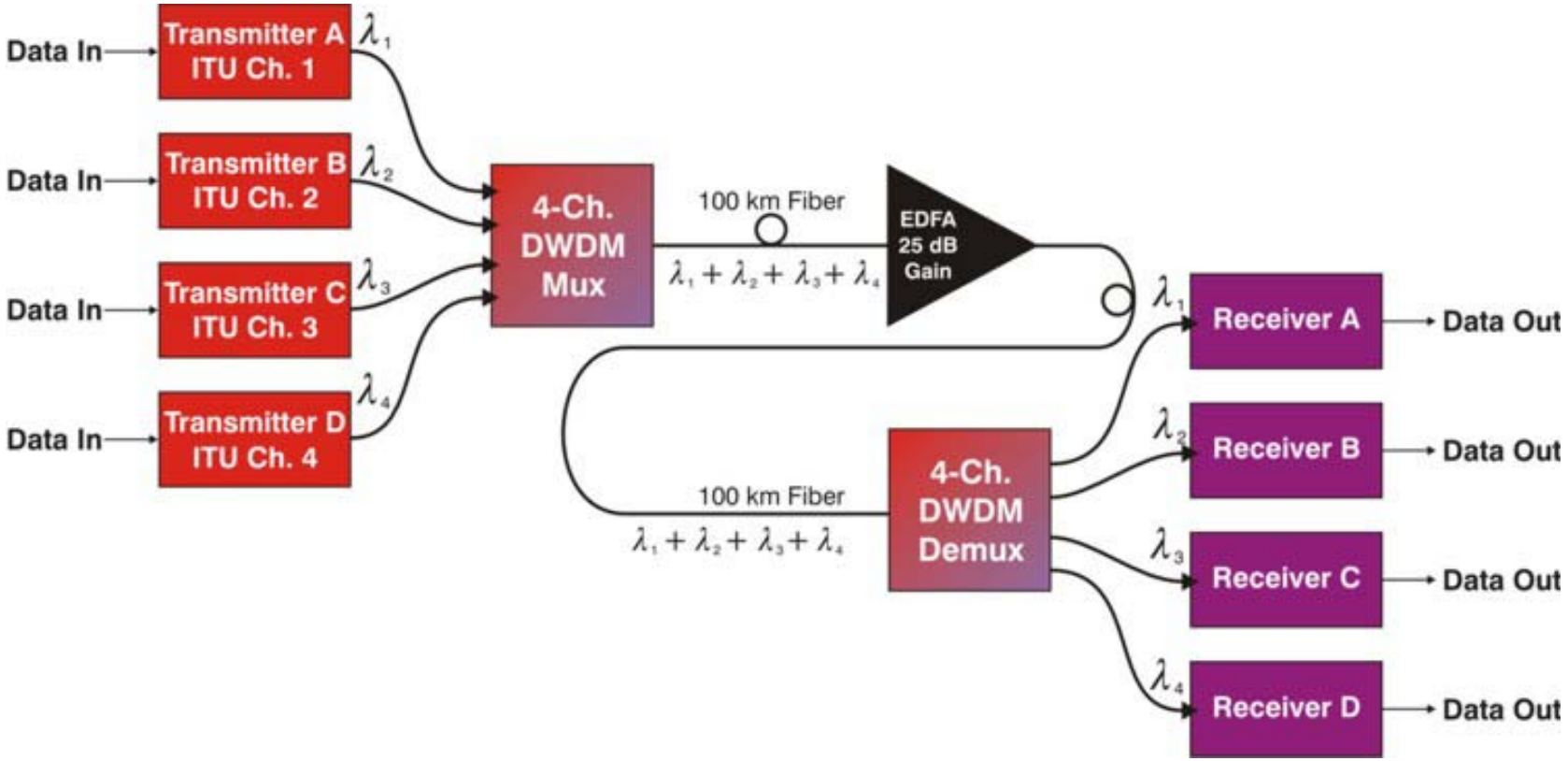
S&M Figure 7-7b



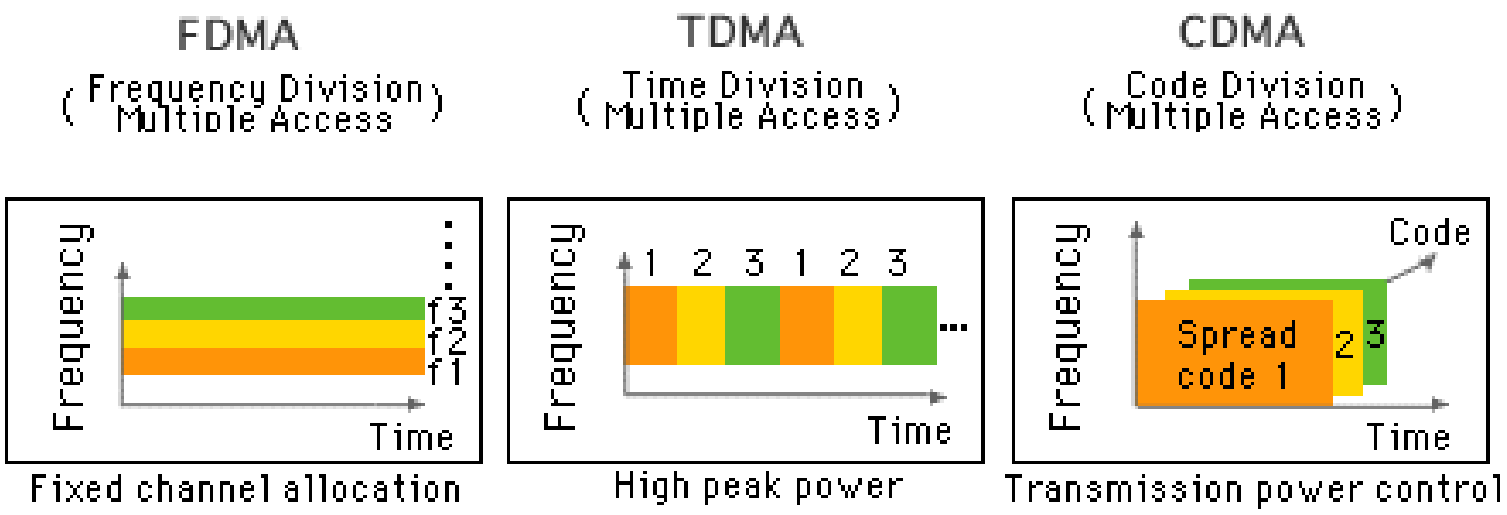




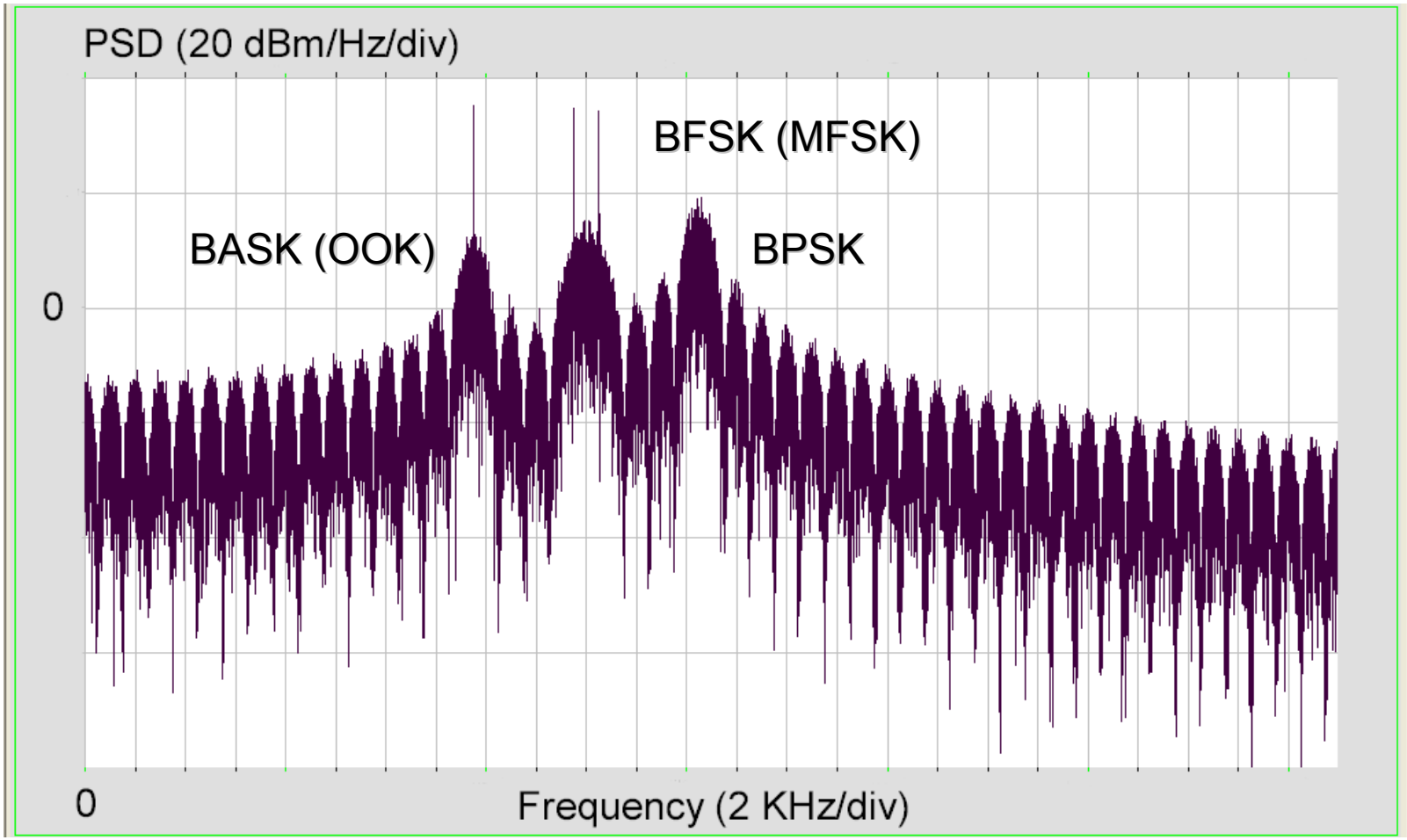
- Optical FDM is usually called *wavelength division multiplexing* (WDM) and utilizes separate wavelengths (λ) of light.



- TDM is used for baseband and FDM for bandpass data transmission. FDM requires the assignment and coordination of carrier frequencies which can be problematic. *Code division multiple access* (CDMA) utilizes spread spectrum modulation over the same frequency band. CDMA is considered in EE4542 Telecommunications Engineering.



- FDM PSD with three equal data rate sources r_b = 1 kb/sec and three carrier frequencies of 15.5, 20 and 24.5 kHz.



End of Chapter 7

Multiplexing Techniques