Chapter 6

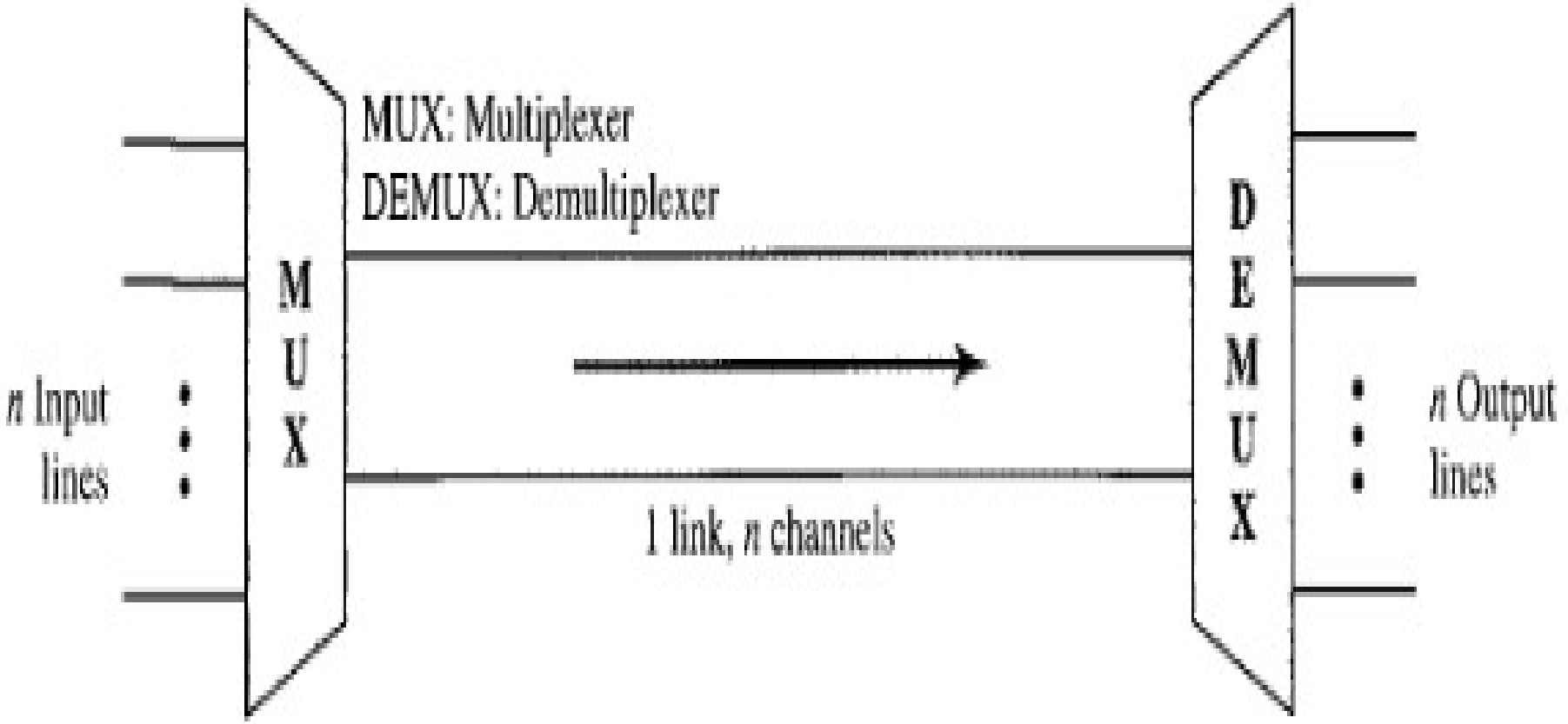
Multiplexing and Spreading

- Multiplexing: combine several channels into one
- Spreading: privacy and anti jamming, expand the bandwidth

Multiplexing

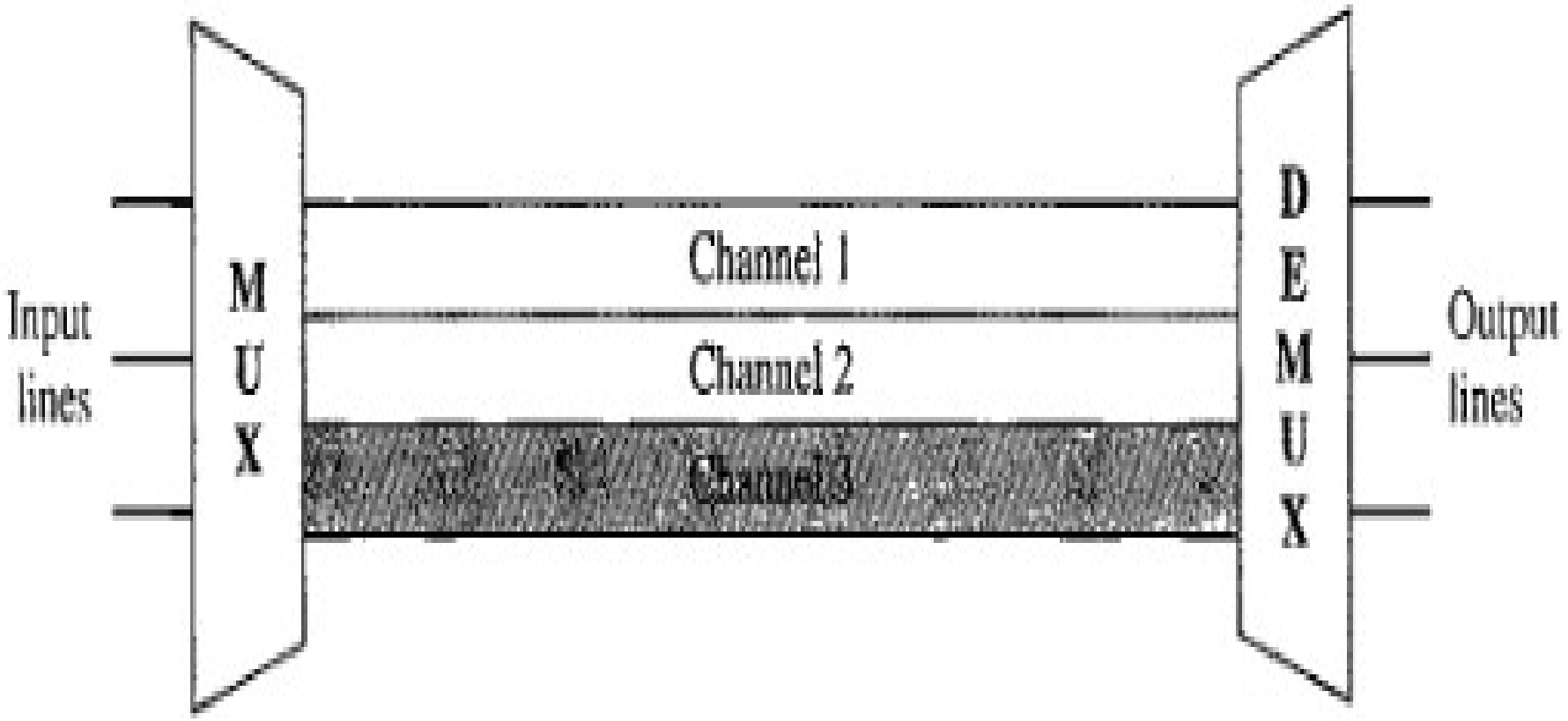
- Bandwidth of medium is greater than bandwidth needs of connected devices, link can be shared
- Allows the simultaneous transmission of multiple signals across a single data link

Multiplexing

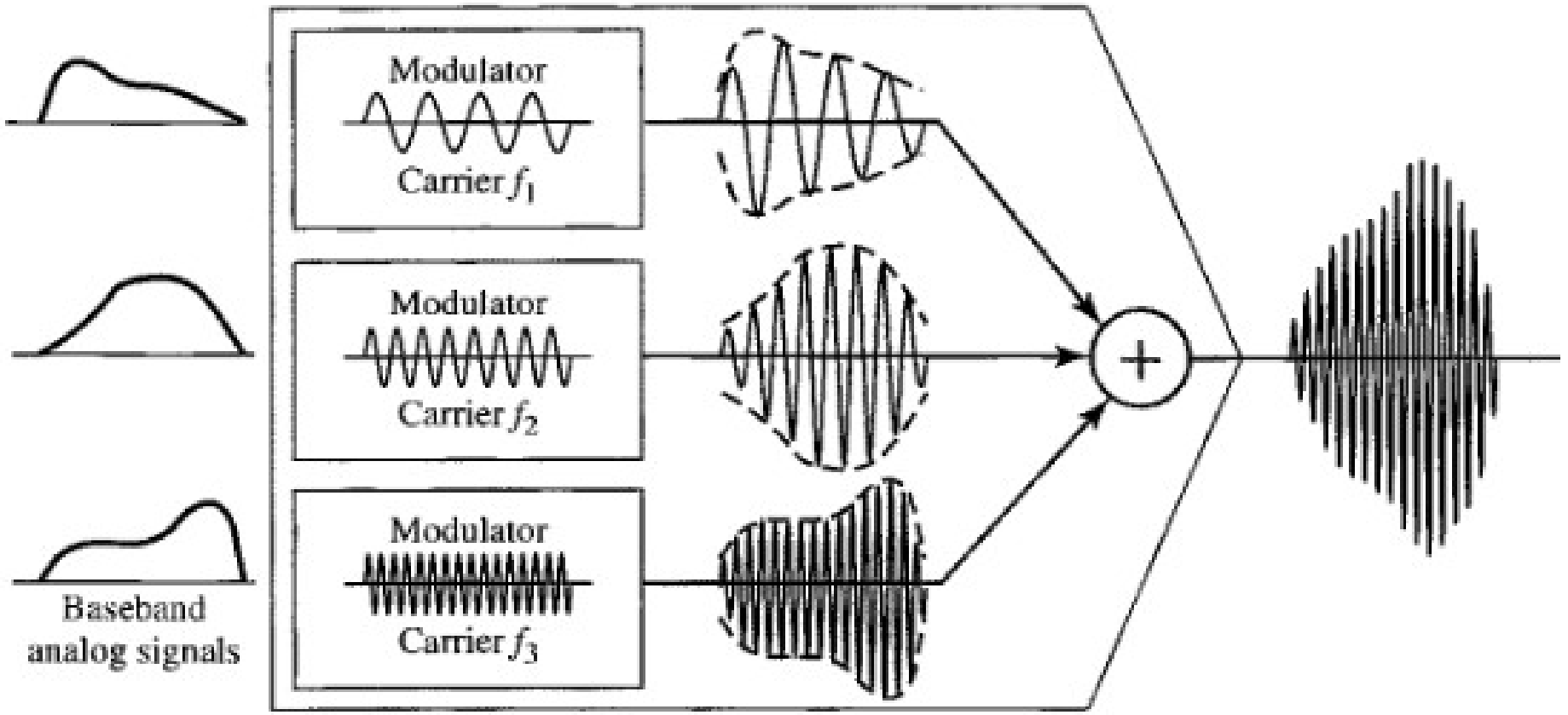


Frequency Division Multiplexing (FDM)

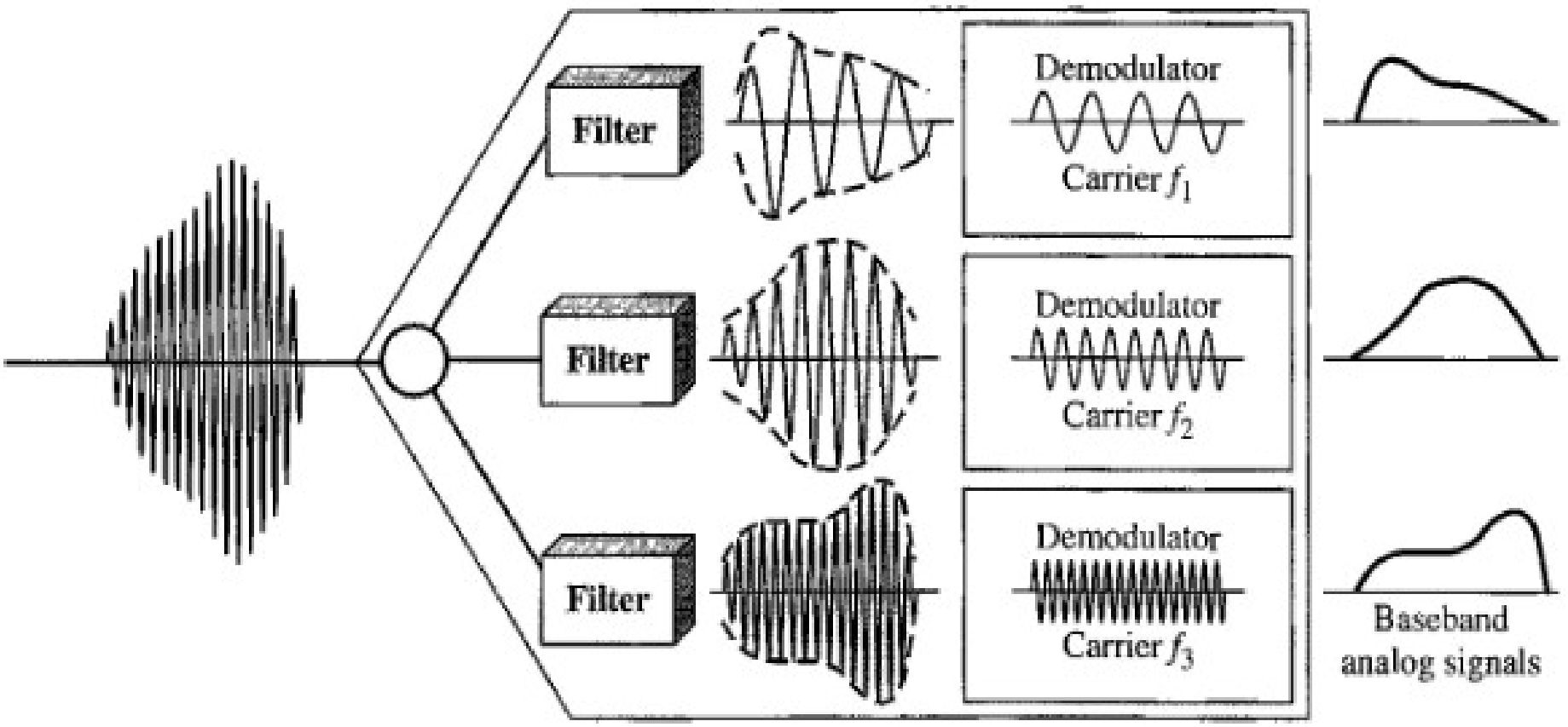
- Analog



Frequency Division Multiplexing (FDM)

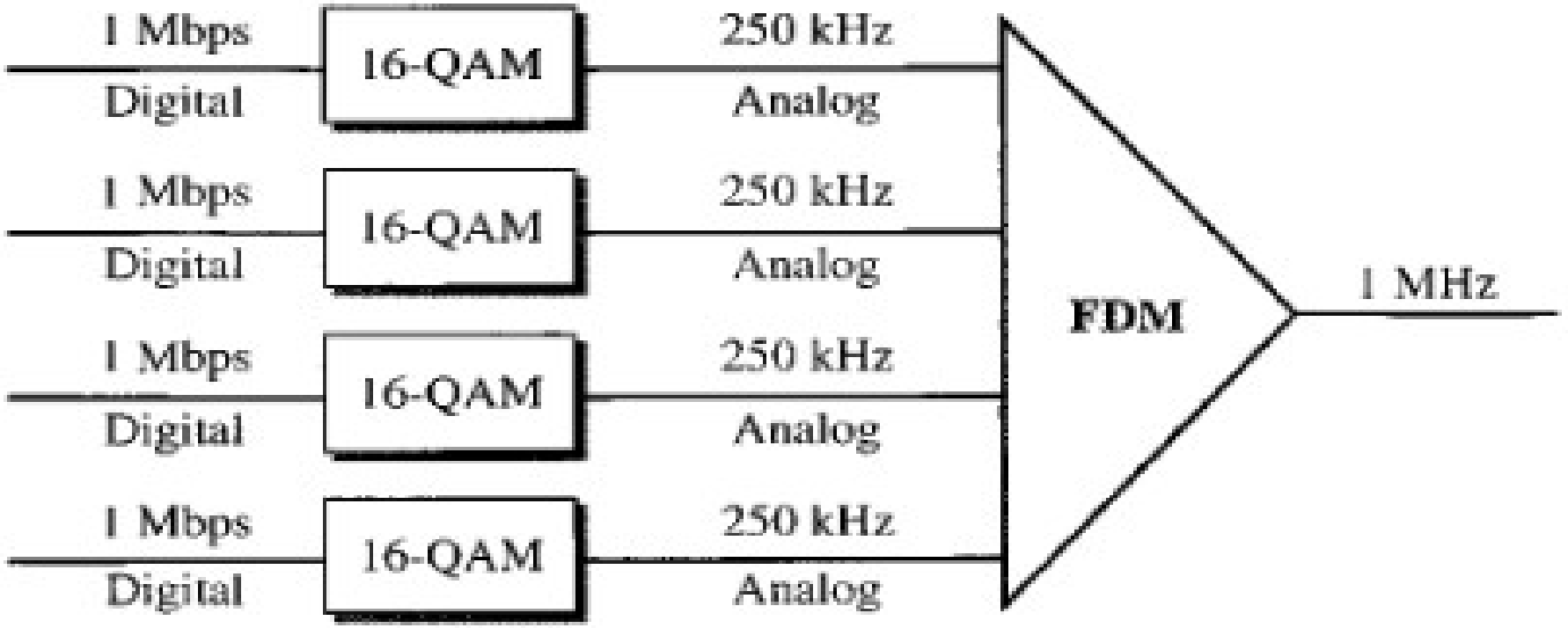


Frequency Division Multiplexing (FDM)

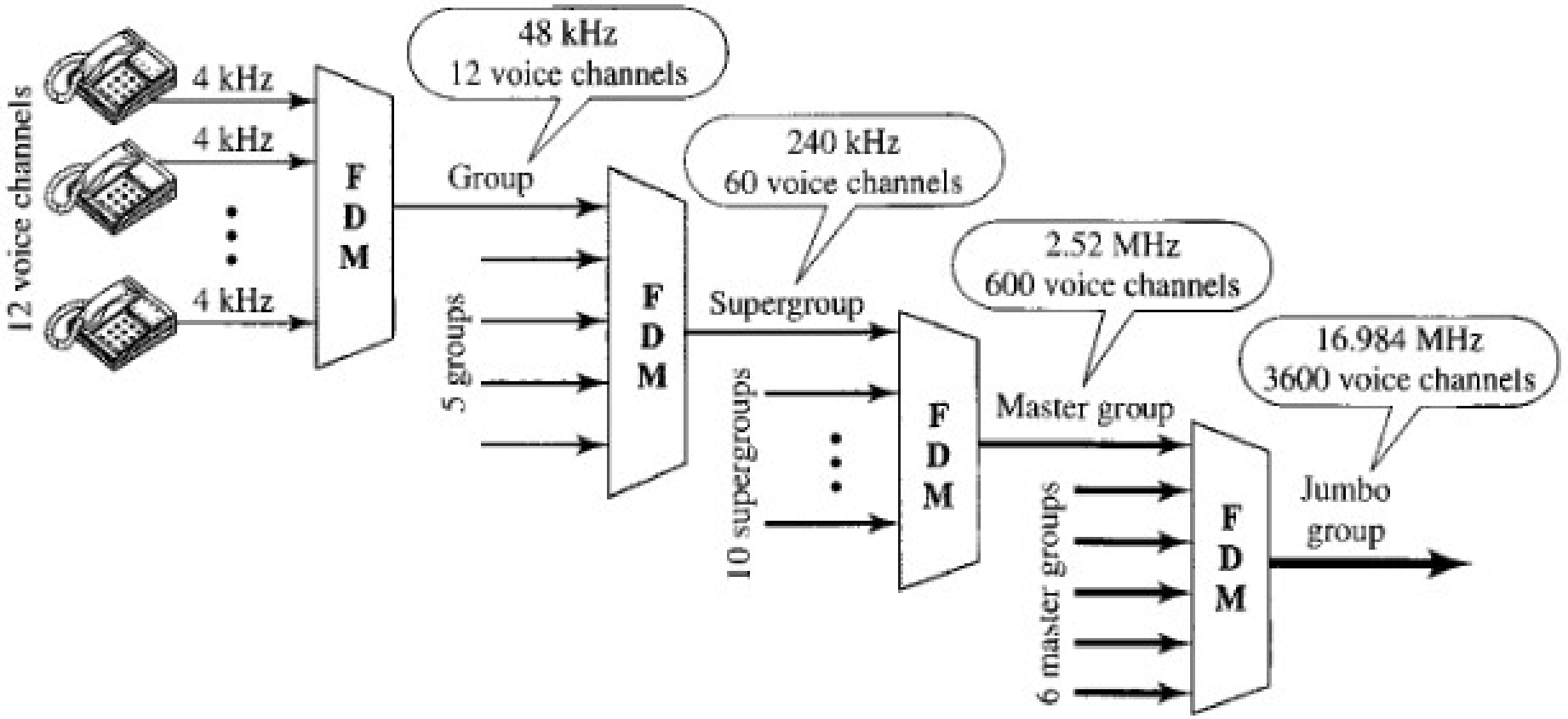


The Analog Carrier System

- Configuration of a satelling using 1 MHz analog from four digital

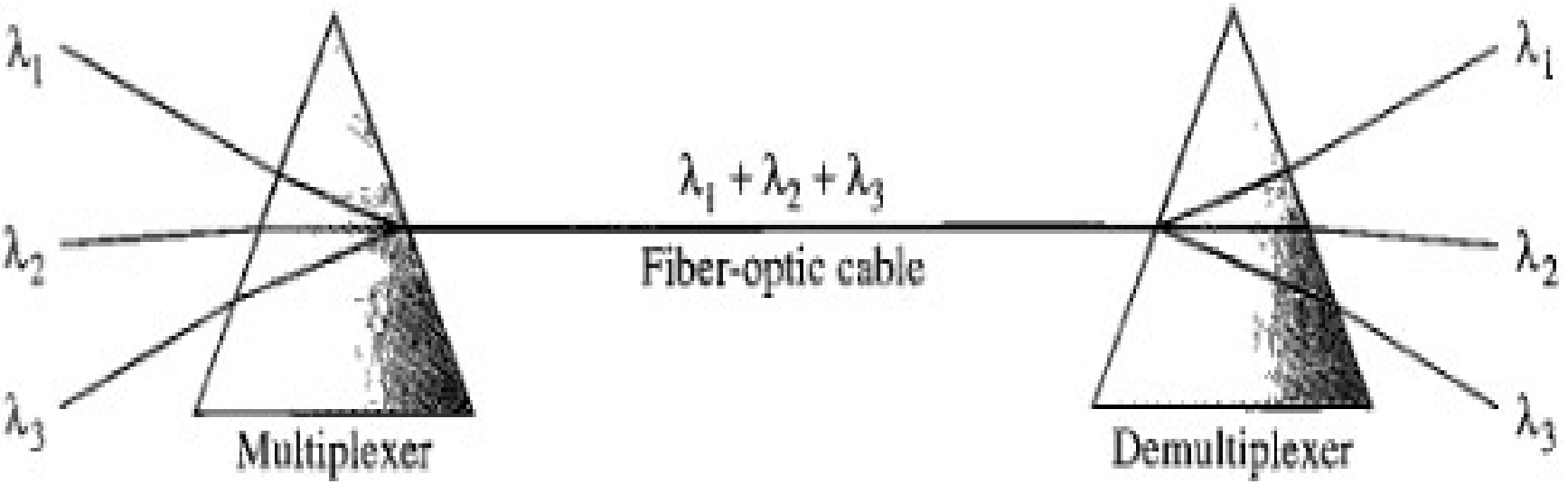


The Analog Carrier System



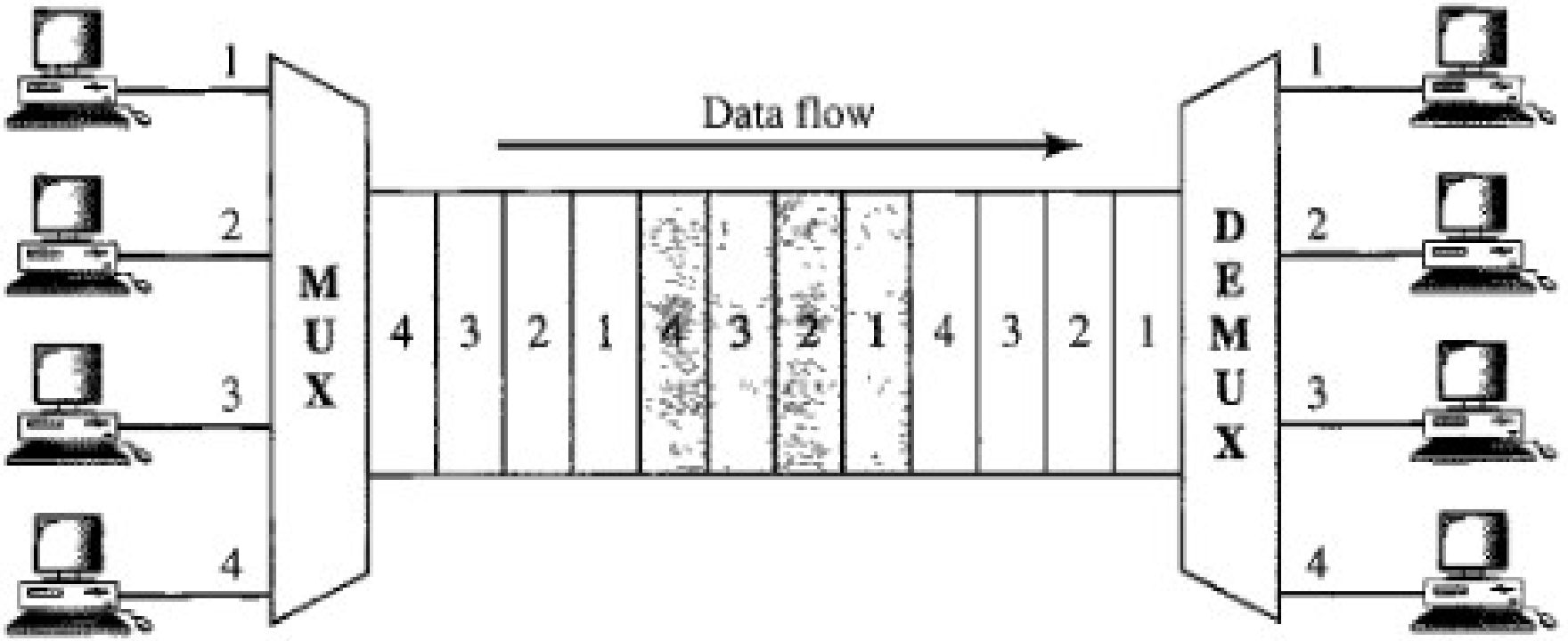
Wavelength-Division Multiplexing

- Analog, uses fiber-optic cable



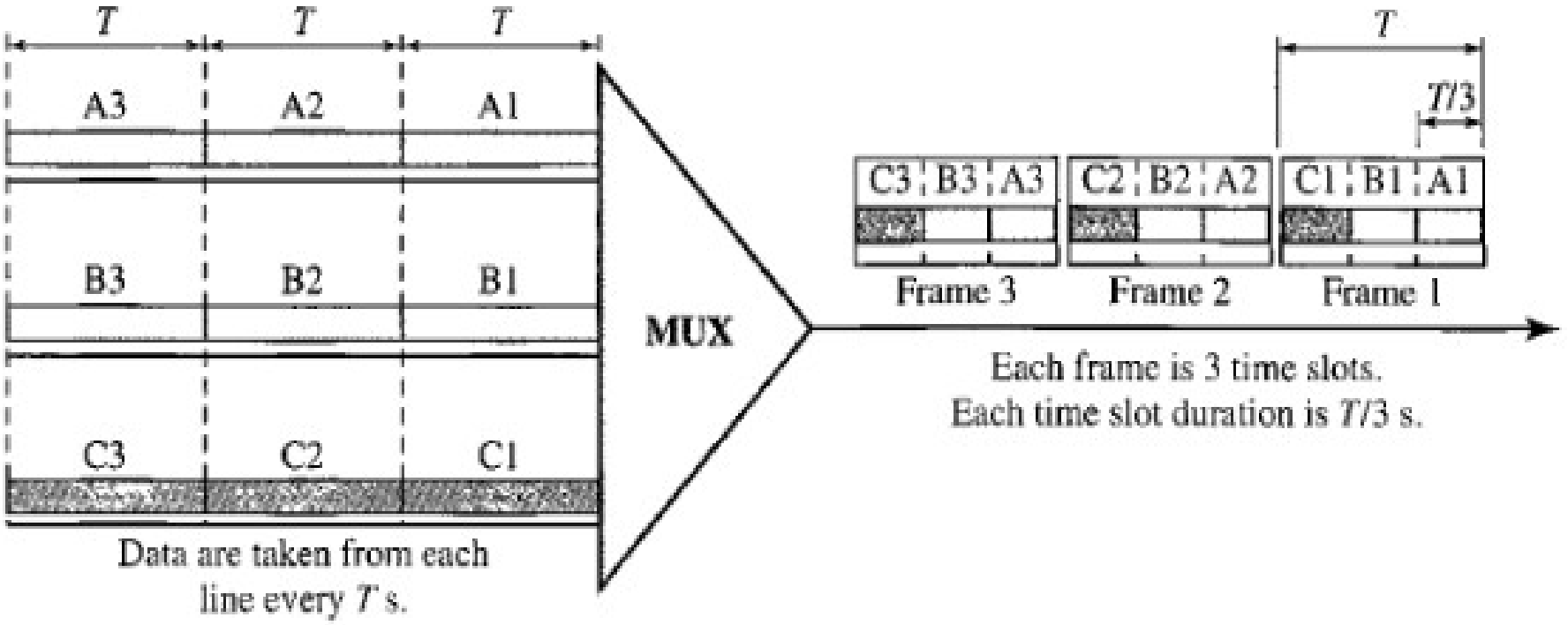
Time-Division Multiplexing(TDM)

- Digital



Synchronous TDM

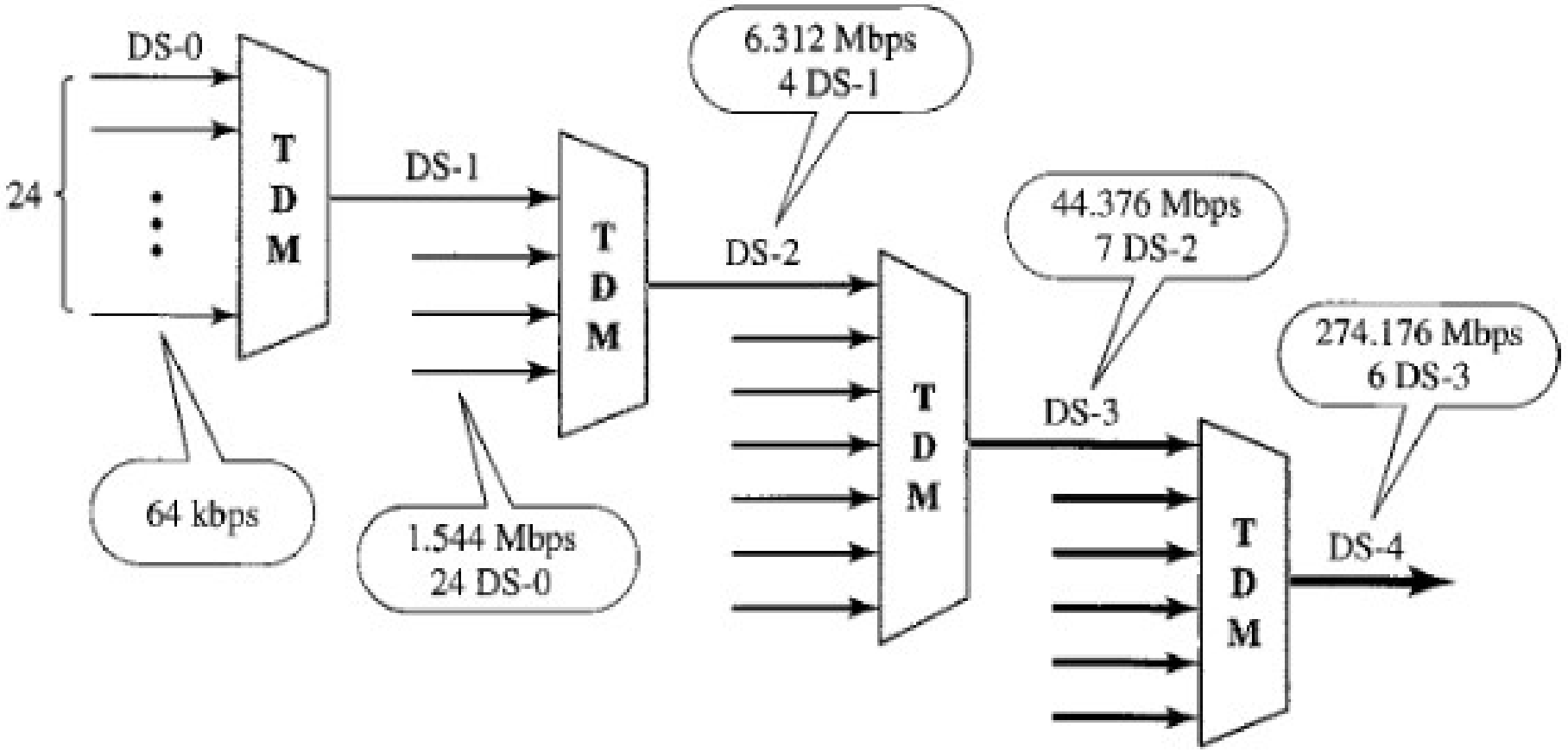
- Each input connection has an allotment in the output even if it is not sending data



Synchronous TDM

- What if the data rates of the inputs are different?
  - Multilevel multiplexing – data rate of input is multiple of others inputs
  - Multiple-slot allocation – more than one slot per input
  - Pulse stuffing – add dummy bits to lower data rate of inputs
- Framing bits allows synchronization

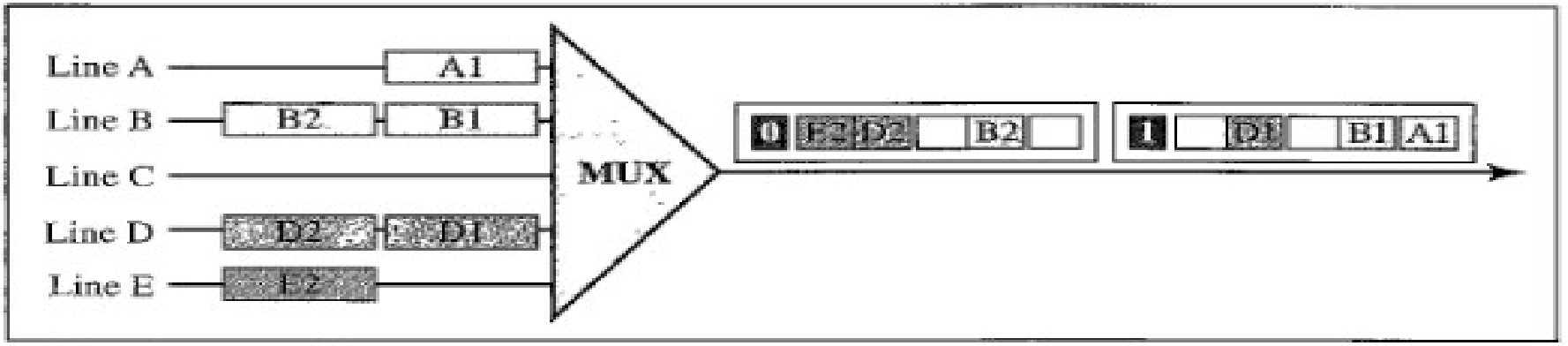
Digital Signal Service



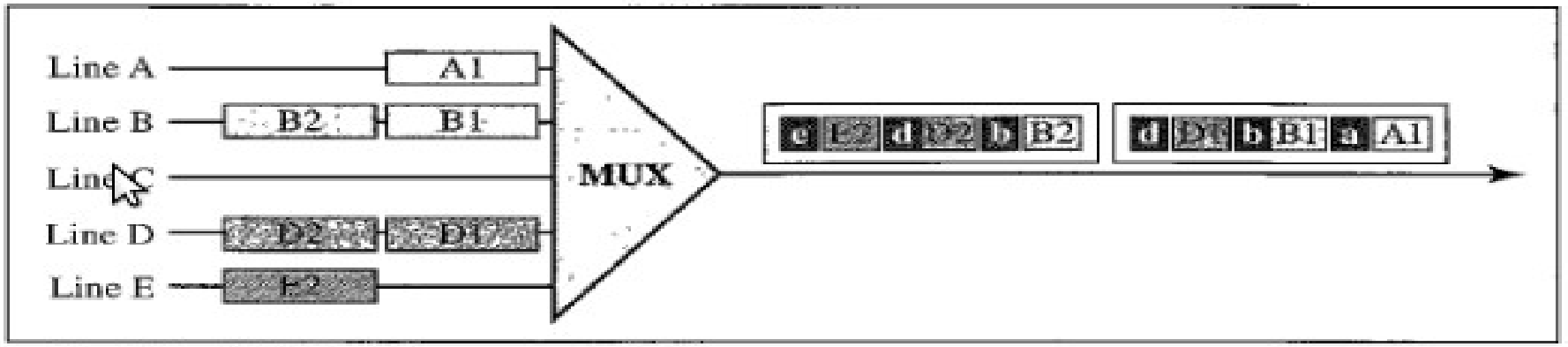
Statistical TDM

- Slots are dynamically allocated to improve bandwidth efficiency
- Number of slots in each frame is less than the number of input lines
- Address field is needed in each frame
- Data size-to-address size ratio must be reasonable
- No synchronization bits

Statistical TDM



a. Synchronous TDM

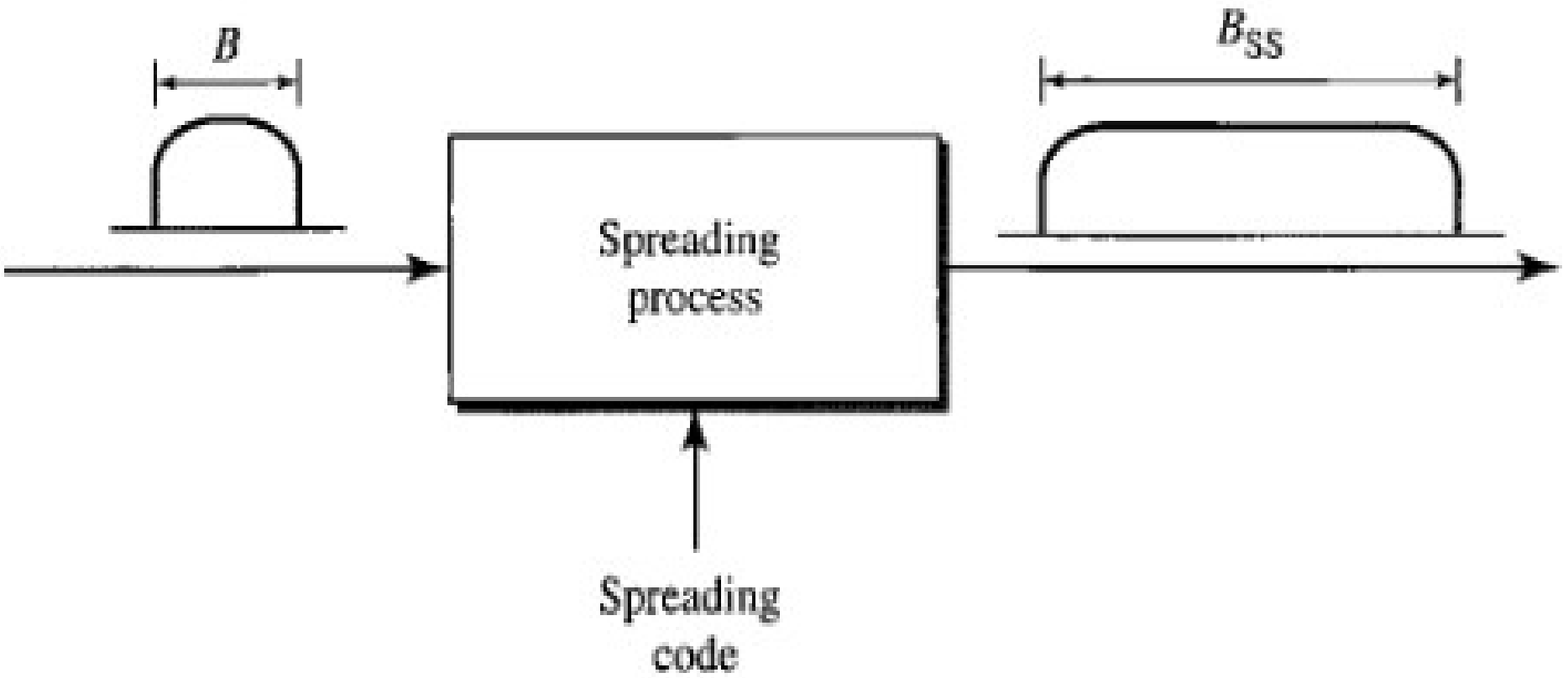


b. Statistical TDM

SPREAD SPECTRUM

- For wireless applications
- Must protect from eavesdroppers and jammers
- Main technique is to add redundancy: if required bandwidth is B, $B_{SS} > B$
- Spreading process must occur after the signal is created by the source

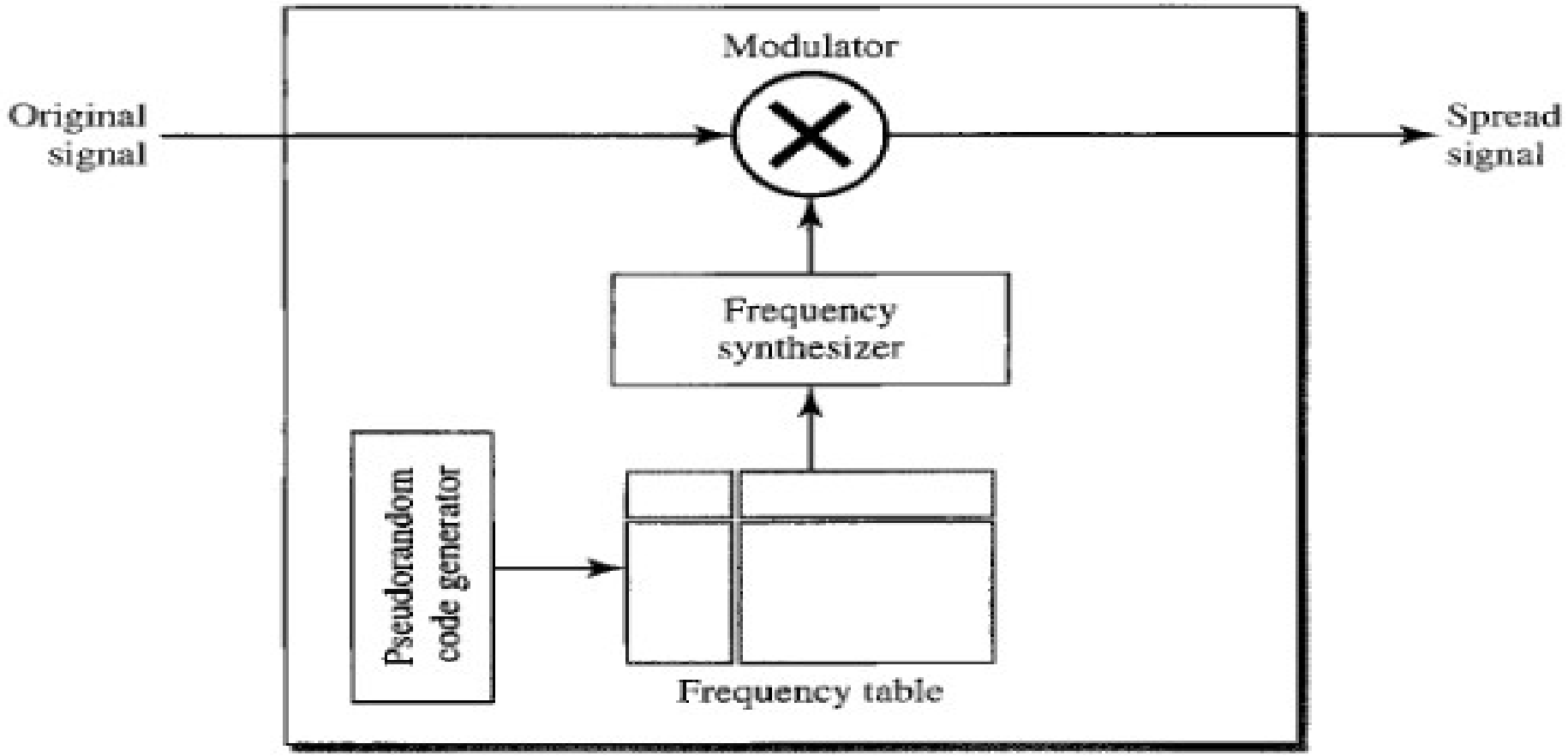
Spread Spectrum



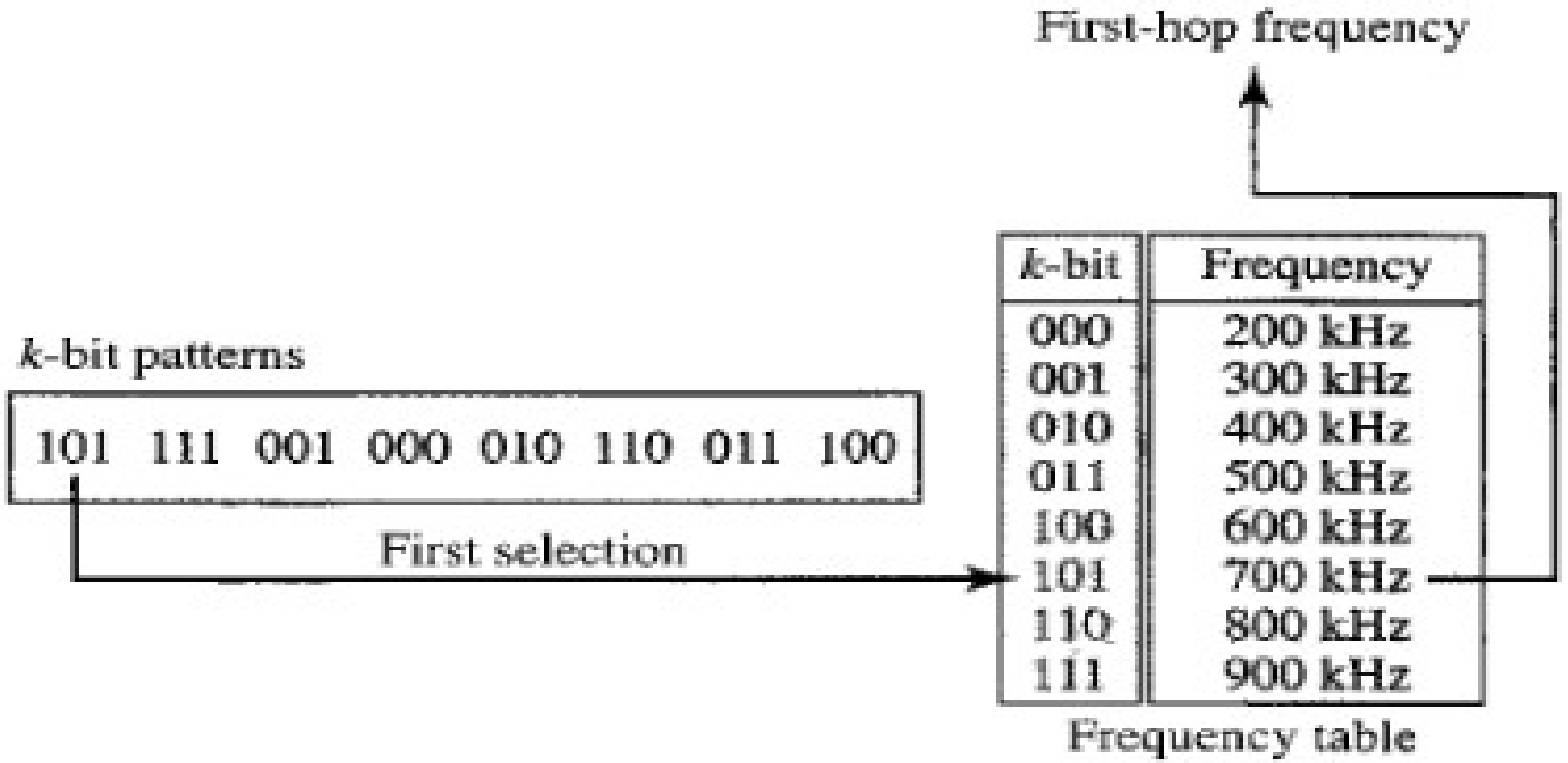
Frequency Hopping Spread Spectrum (FHSS)

- Uses M carrier frequencies modulated by the source signal
- Modulation happens one carrier frequency after another
- Pseudorandom noise (PN) creates a k-bit pattern for every hopping period T_h
- The frequency table uses the pattern to find the frequency to be used for a hopping period and passes it to the frequency synthesizer
- Frequency synthesizer creates the carrier signal of the selected frequency

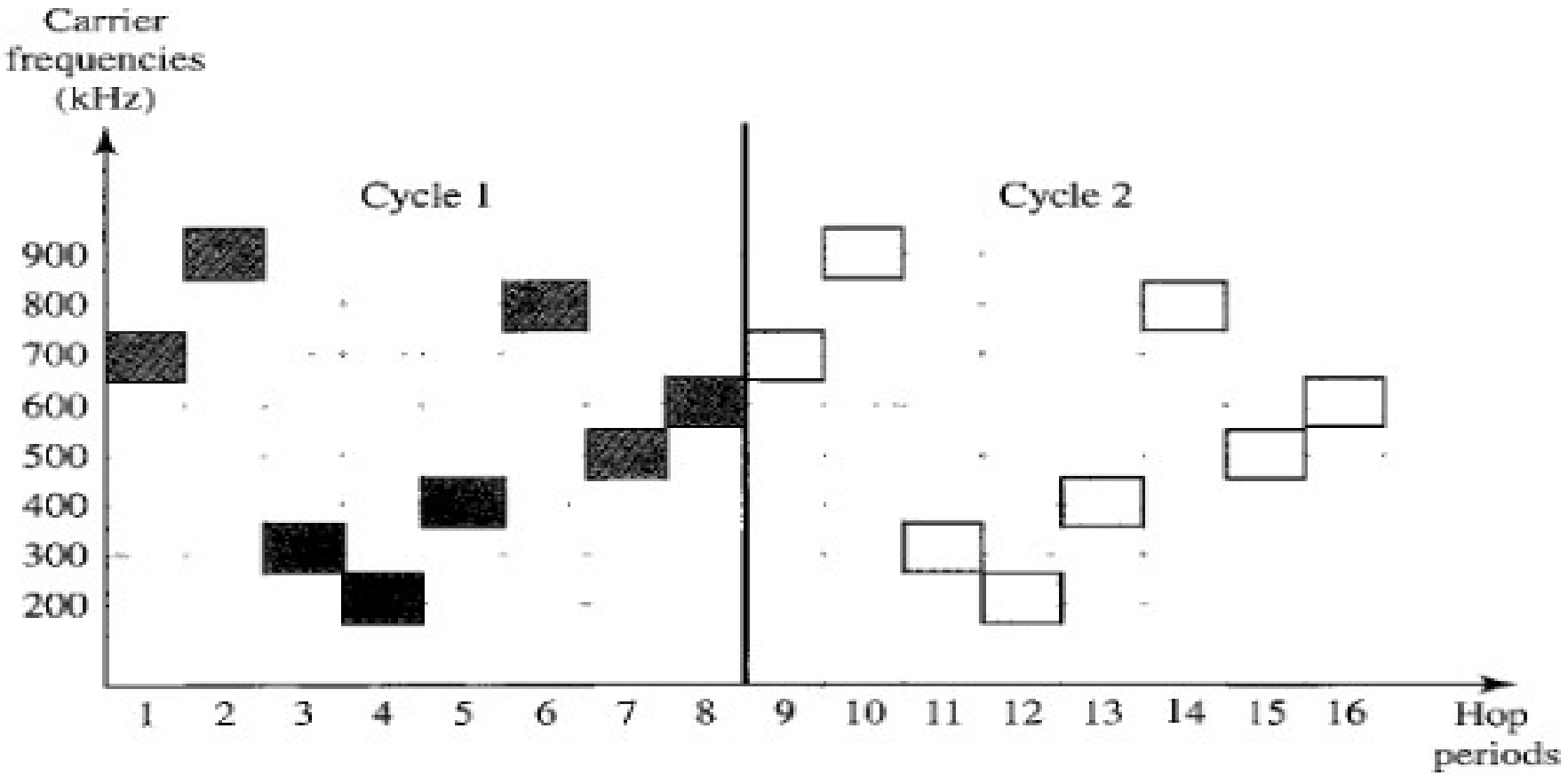
Frequency Hopping Spread Spectrum (FHSS)



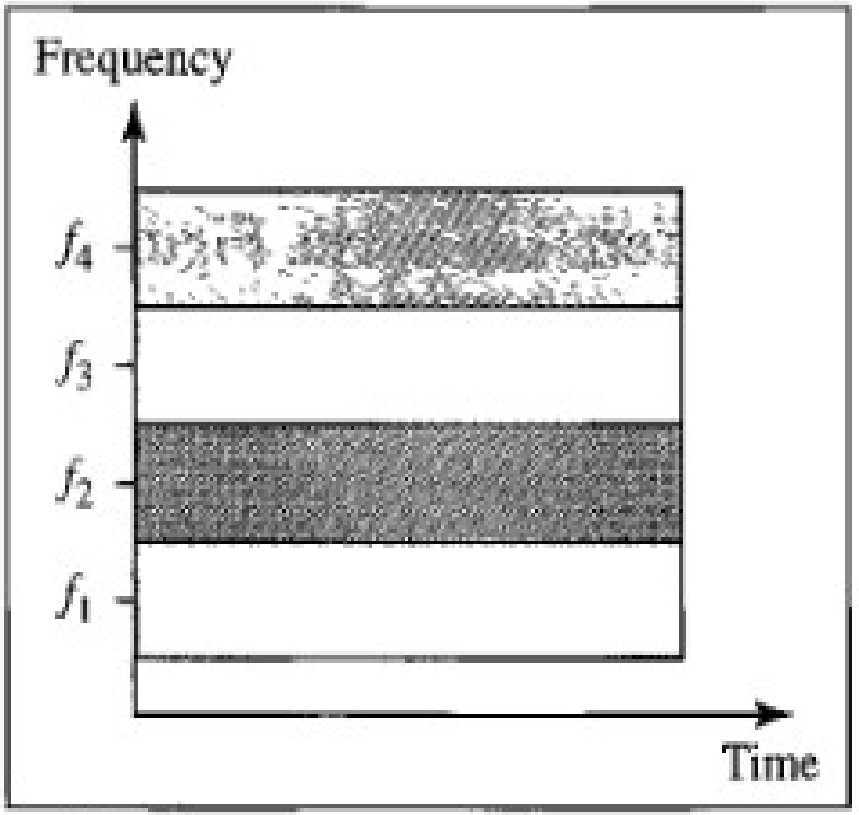
Frequency Hopping Spread Spectrum (FHSS)



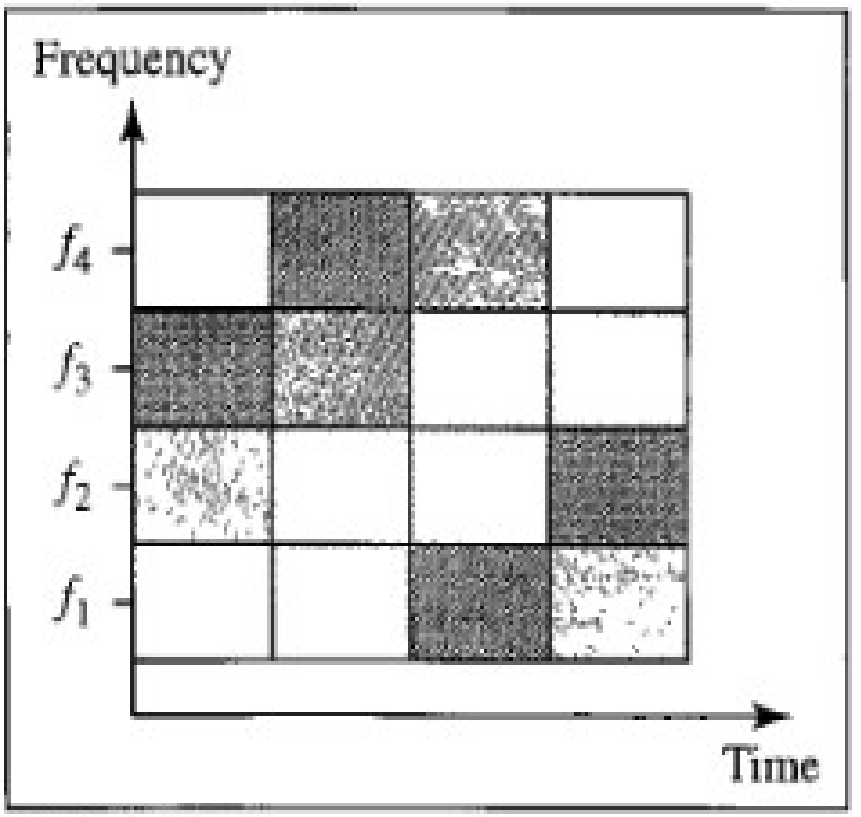
Frequency Hopping Spread Spectrum (FHSS)



Frequency Hopping Spread Spectrum (FHSS)



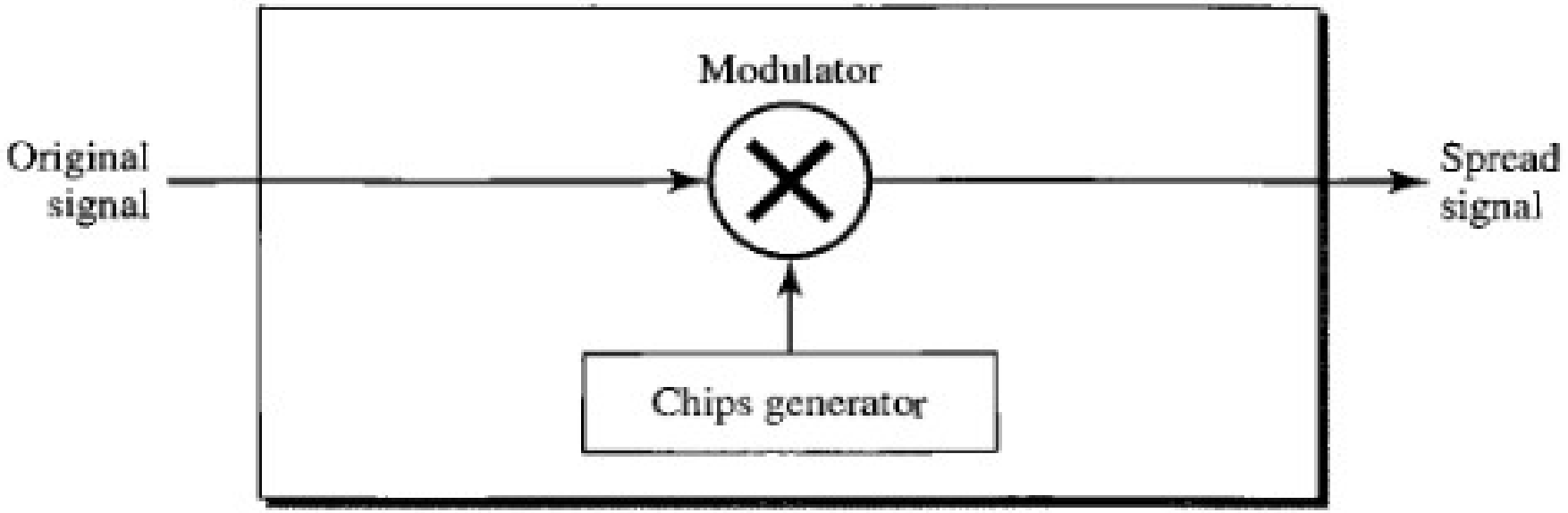
a. FDM



b. FHSS

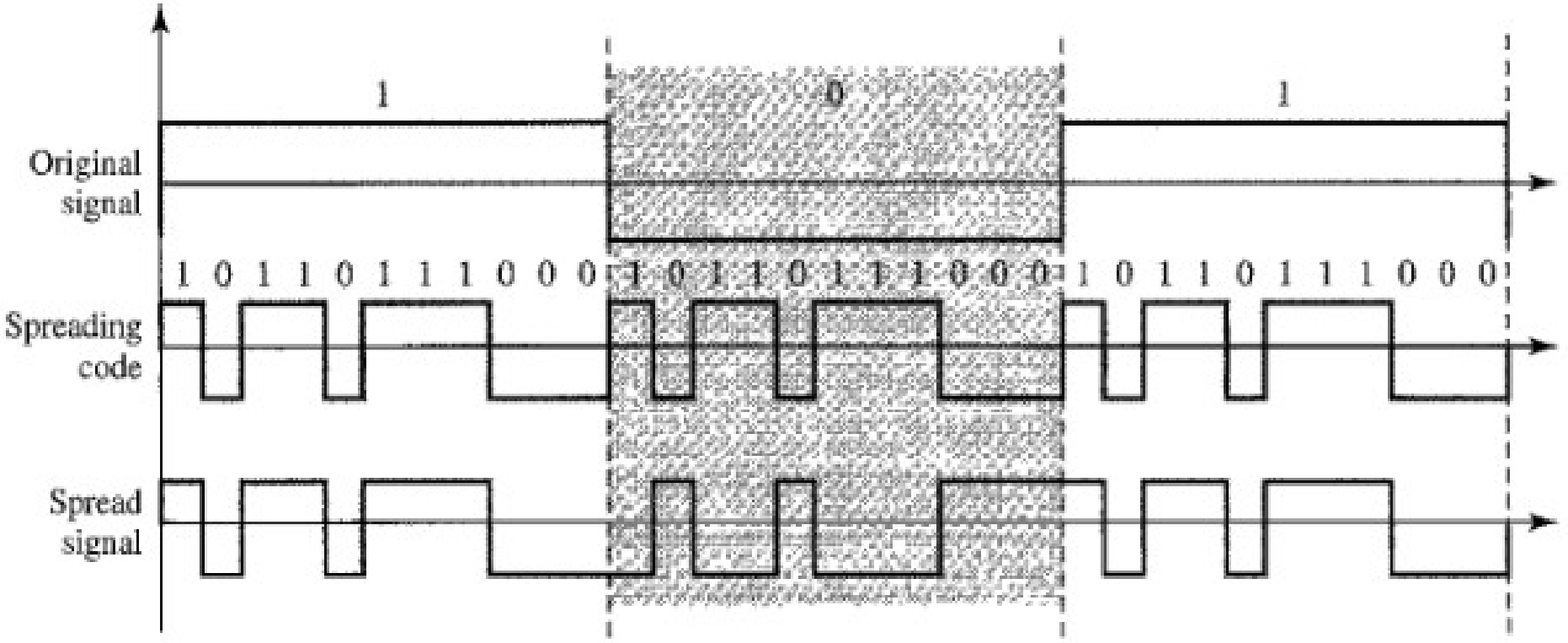
Direct Sequence Spread Spectrum (DSS)

- Replace each data bit with n bits using a spreading code, called chips
- Chip rate is n times that of the data bit



Direct Sequence Spread Spectrum (DSS)

- Barker sequence, 11 bits



Enjoy! :)