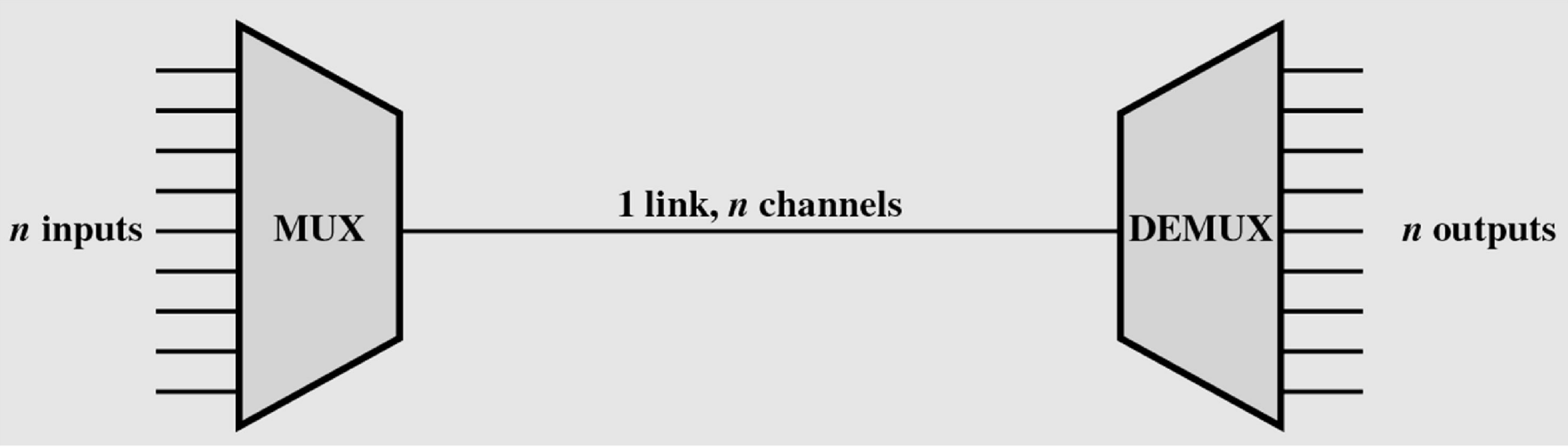
Multiplexing

- It is unlikely that two communicating devices will *utilise* fully the capacity of a transmission link
- This spare capacity can be used by other communicating devices
- The sharing of a data communications facility in this way is called *multiplexing*

Basic Multiplexing Components



Motivations for using Multiplexing

- Multiplexing is common in long distance communications because:
  - Telecommunications equipment is expensive. Hence, the higher the data rate of a transmission system the lower the cost per *kbps*
  - Many communicating devices use relatively modest data rates and so can be mixed together on a higher speed system

Multiplexing Examples

- Cable TV network
  - Many TV and radio signals are multiplexed onto the subscriber cable
- Telecommunications networks
  - Fibre optical, coaxial cable, and microwave links are used between exchanges and towns/cities
  - Each link carries many voice and data transmissions simultaneously

Multiplexing - 2 Main Types

- Frequency-division multiplexing (FDM)
  - Can take *analogue* and *digital* signals with analogue or digital data and produces an *analogue* signal
- Time-division Multiplexing (TDM)
  - Can take digital data carried on *analogue* or *digital* signals and produces a *digital* signal

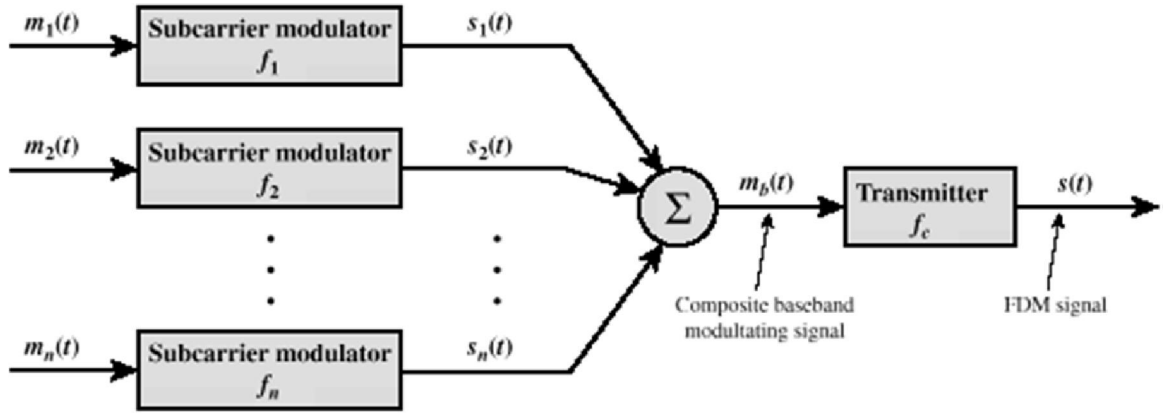
Frequency Division Multiplexing

- Used when the useful BW of a transmission link exceeds the BW of individual signals
- Each signal is modulated onto a different *carrier frequency* (known as a *subcarrier*)
- The *carrier frequencies* are combined to produce a composite analogue signal (known as a *baseband signal*)
- The *baseband signal* is analogue and is transmitted across a single transmission link

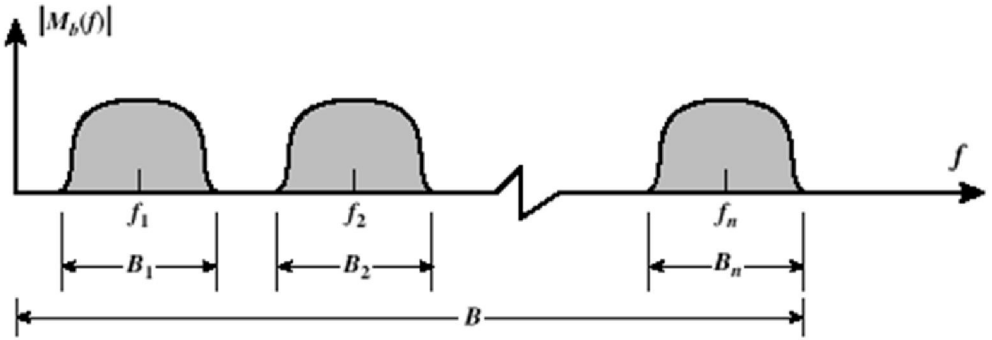
Frequency Division Multiplexing

- The input data may be *analogue* or *digital*
- The BW of the composite signal must be *greater* than the sum of BWs of the individual input signals
- A *guard band* must be inserted between the carrier frequencies to prevent *overlap*

FDM – Transmitter

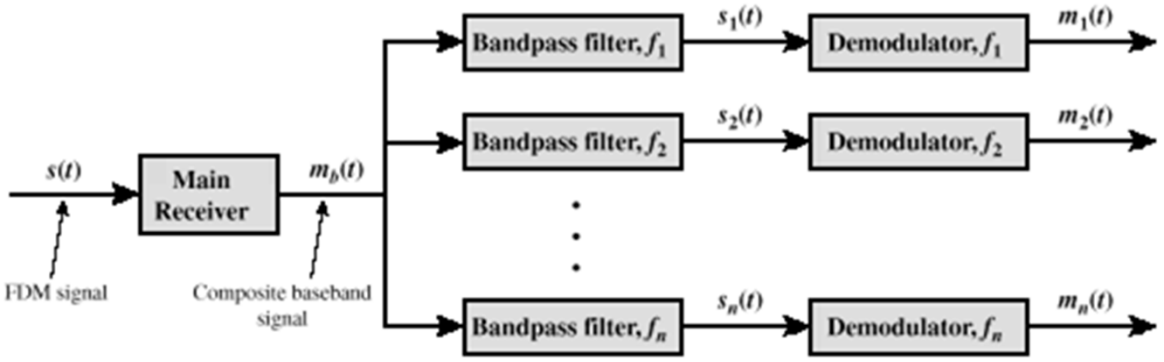


(a) Transmitter



(b) Spectrum of composite baseband modulating signal

FDM – Receiver

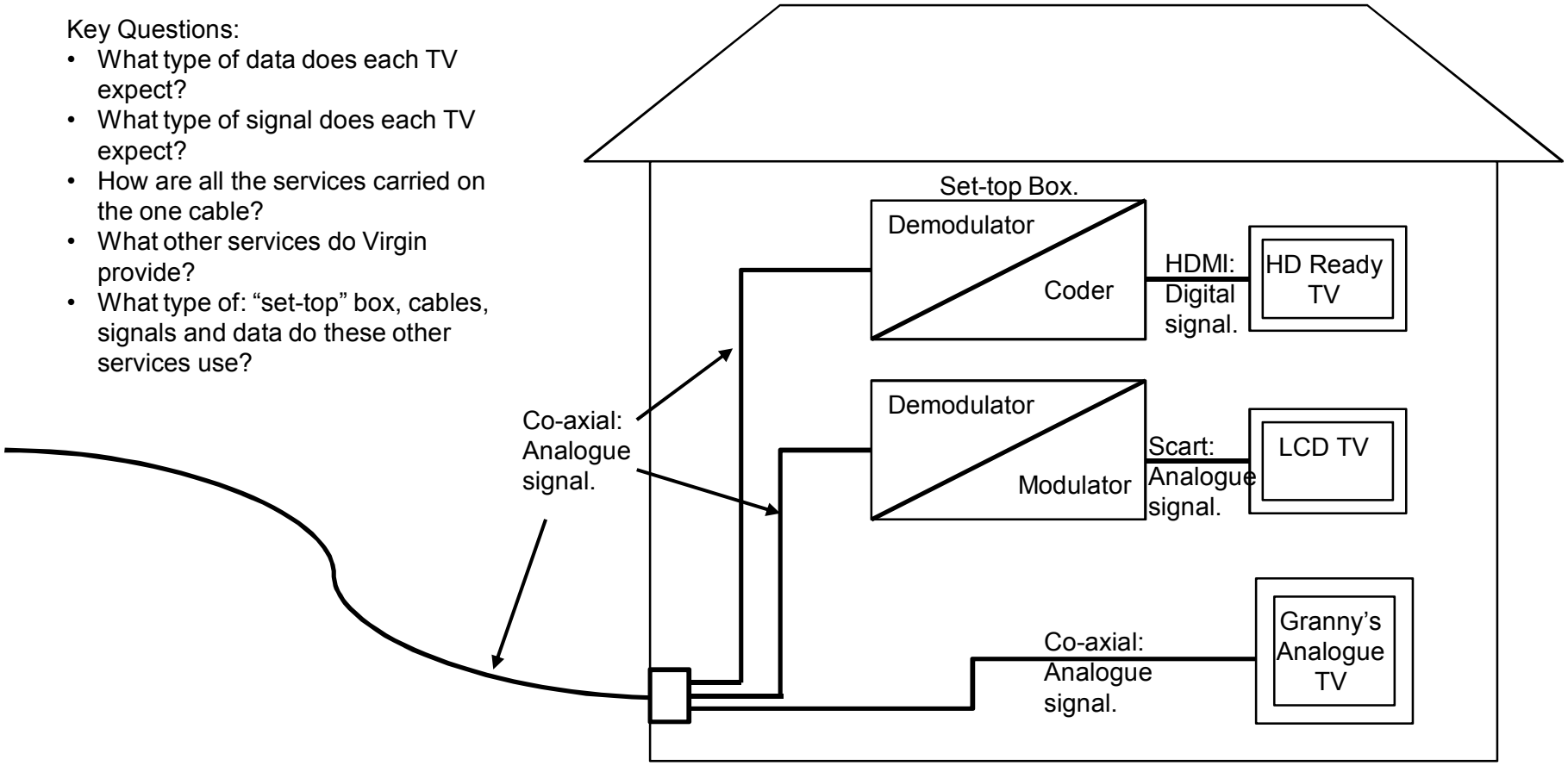


(c) Receiver

FDM Example – Virgin TV services

Key Questions:

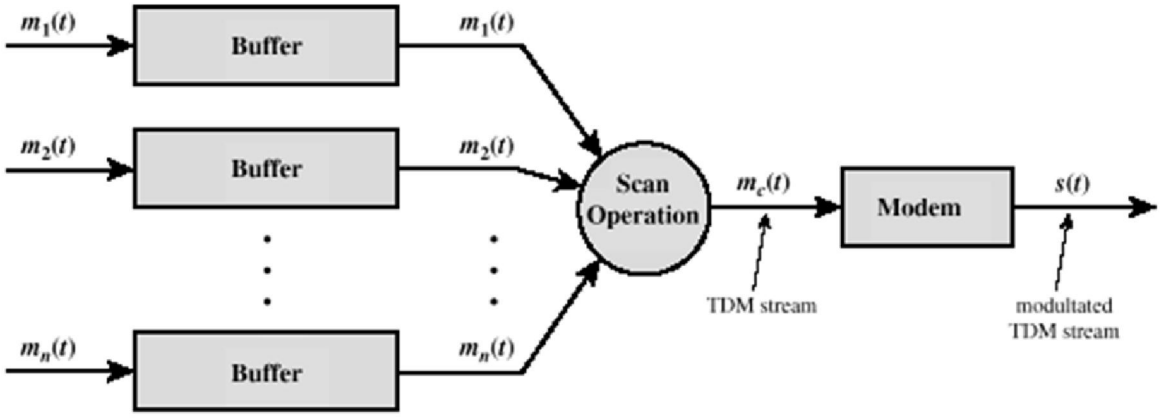
- What type of data does each TV expect?
- What type of signal does each TV expect?
- How are all the services carried on the one cable?
- What other services do Virgin provide?
- What type of: “set-top” box, cables, signals and data do these other services use?



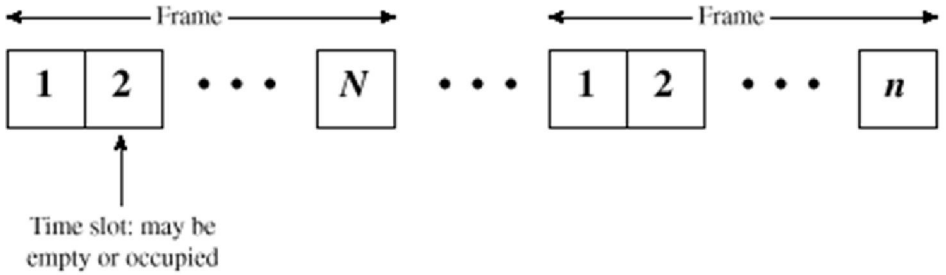
Synchronous Time-Division Multiplexing

- This is the digital equivalent of FDM
- Here portions of each input signal are *interleaved* in time (as opposed to frequency) onto the transmission medium
- Signals can be *analogue* (with encoded digital data) or *digital*
- The interleaving can be at *bit* level or in *blocks* of bytes
  - This determines the size of the input *buffers*

TDM – Transmitter

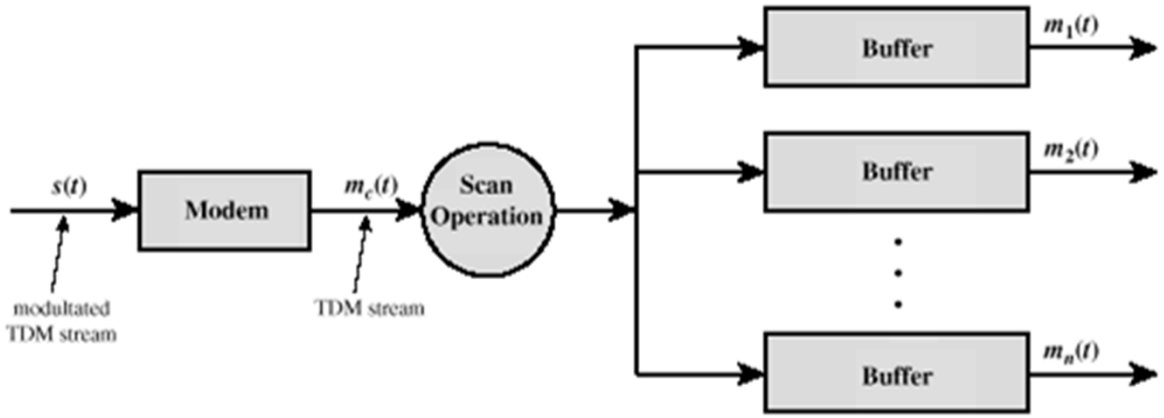


(a) Transmitter



(b) TDM Frames

TDM – Receiver



(c) Receiver

Synchronous Time-Division Multiplexing

- Data are organised into *frames*
- Frames contain a cycle of *time slots*
- One or more *time slots* within a *frame* is dedicated to one pair of data source devices
- The combination of *time slots* across successive frames is called a *channel*
  - Each pair of data source devices is allocated a *channel* for their communication requirements

Synchronous Time-Division Multiplexing

- The system is *synchronous* because:
  - Time slots are pre-assigned to source devices
  - They are transmitted regardless of whether the source devices have data to send or not
- *Frame synchronization* is still required
  - Achieved using a separate *channel*
  - Known as *Added-digit Framing*
- TDM is used as part of the public long-haul telecommunications system