كلية المنصور الجامعة
نظم المعلومات و الحاسبات
شبكات/المرحلة الرابعة
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Lecture No.: 2 # Multiplexing

Introduction:

Whenever the transmission capacity of a medium linking two devices is **greater** than the transmission needs of the devices, the link ***can be shared***

Multiplexing is the set of techniques that allows the simultaneous transmission of multiple signals *across* a single data link.

#As data- and telecommunications usage increases, so does ***traffic***.

#We can accommodate this increase by adding individual lines each time a ***new channel*** is needed, or we can ***install higher*** capacity links and use each to carry multiple signals.

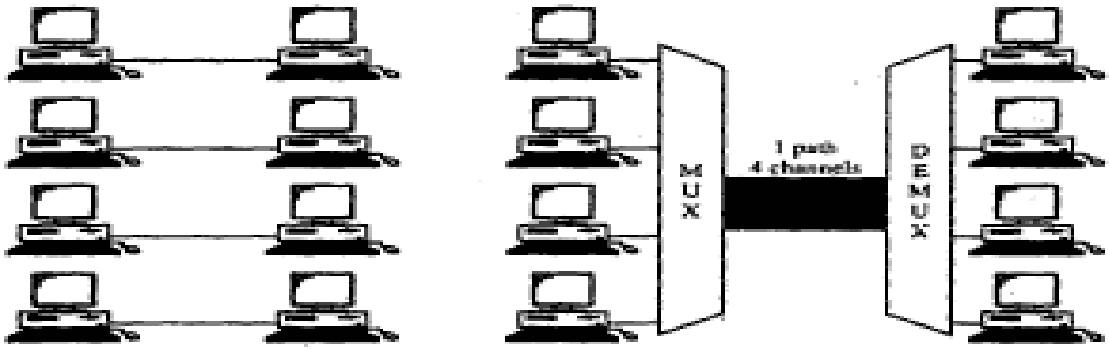
If the transmission capacity of a link is greater than the transmission needs of the devices connected to it, the excess capacity is ***wasted.***

An efficient system maximizes the utilization of all facilities. In addition, the expensive technology involved often becomes cost-effective only when links are shared.

In Figure 1a, each pair has its own link, If the full capacity of each link is not being utilized, a portion of that capacity is being wasted,

In Figure 1b, transmissions between the pairs are multiplexed; the same four pairs share the capacity of a single link.

1a. No multiplexing **1b. Multiplexing**



MANY TO ONE/ONE TO MANY:

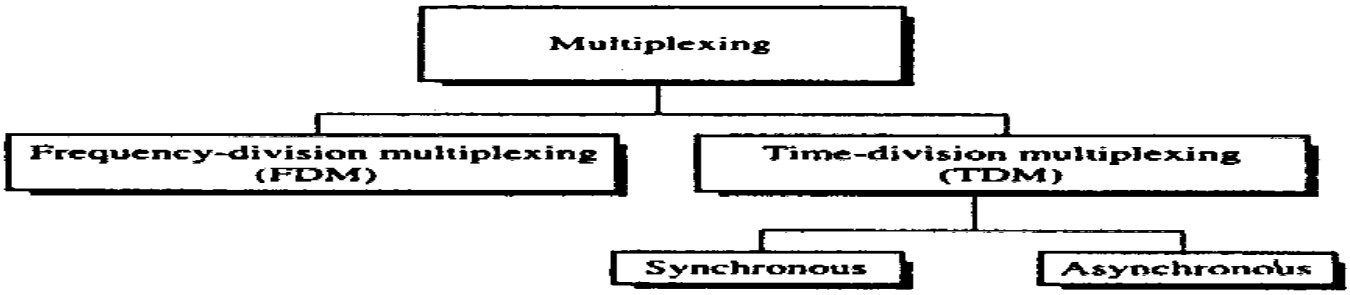
In a multiplexed system, n devices share the capacity of one link.

The four devices on the left direct their transmission streams to a **multiplexer (MUX)** which **combines them** into a single stream.

At the receiving end, that stream is fed into a **demultiplexer (DEMUX),** which separates the stream back into its component transmissions (one to many) and direct them to their intended receiving devices.

In Figure lb the word ***path*** refers to the physical link. The word ***channel*** refers to a portion of a path that carries a transmission between a given pair of devices. One path can have many *(n)* channels.

TYPES OF MULTIPLEXING



1) Frequency-Division Multiplexing (FDM)

* Frequency-division multiplexing (FDM) ***is analog technique*** that can applied when the bandwidth of a link is greater than the combined bandwidth of the signals to be transmitted.

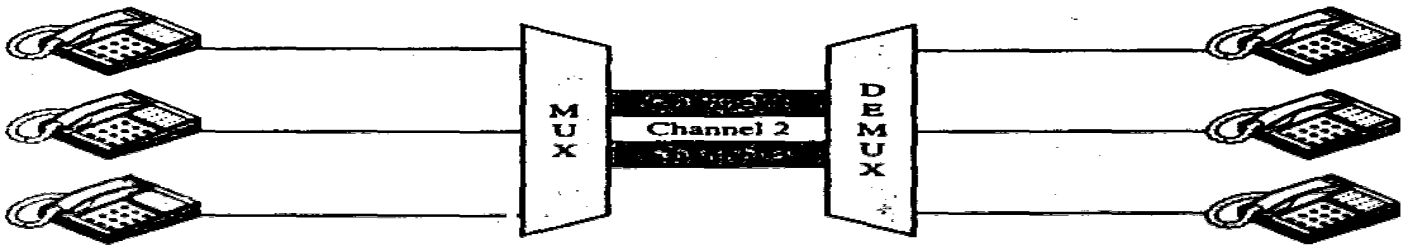
* In FDM, ***signals generated by*** each sending device **modulate different carrier frequencies**.

* These modulated signals are then ***combined into*** a **single** signal that can be transported by the link.

* Carrier frequencies are ***separated by enough bandwidth*** to accommodate the modulated signal.

* Channels must be separated by strips of unused bandwidth (***guard bands***) to **prevent** signals from overlapping.

* the path as ***divided spatially*** into separate channels, actual channel divisions are achieved by frequency rather than by space.



The FDM Process:

FDM is an **analog process** and we show it here using telephones as the input and output devices.

Each telephone generates a **signal of a similar frequency range**.

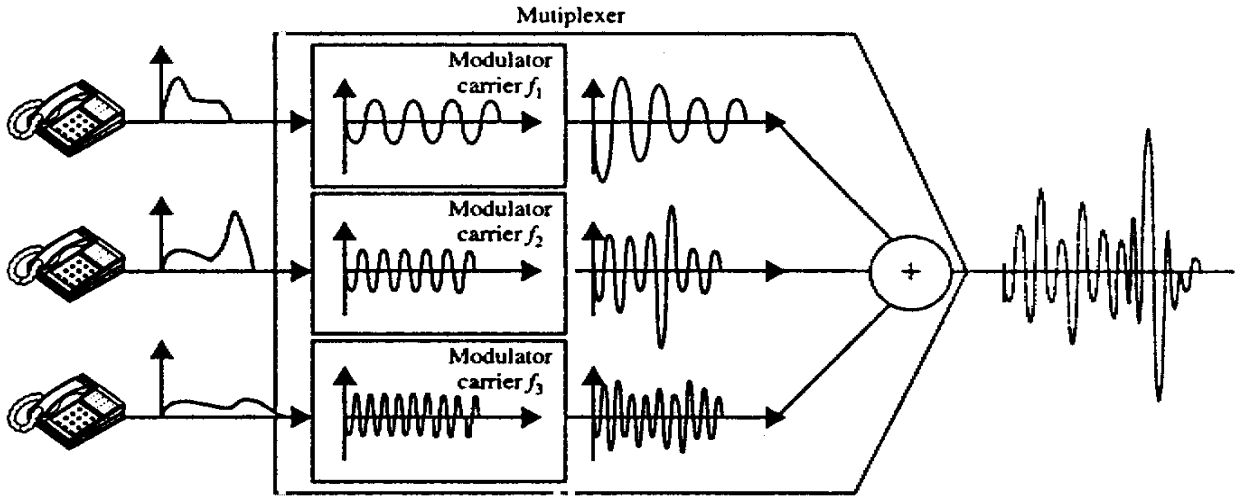
Inside the multiplexer, these similar signals are **modulated onto different carrier frequencies (f_1,f_2, and f_3).**

The resulting modulated signals are then **combined into a single signal that is sent out over a media link that has enough bandwidth to accommodate it**.

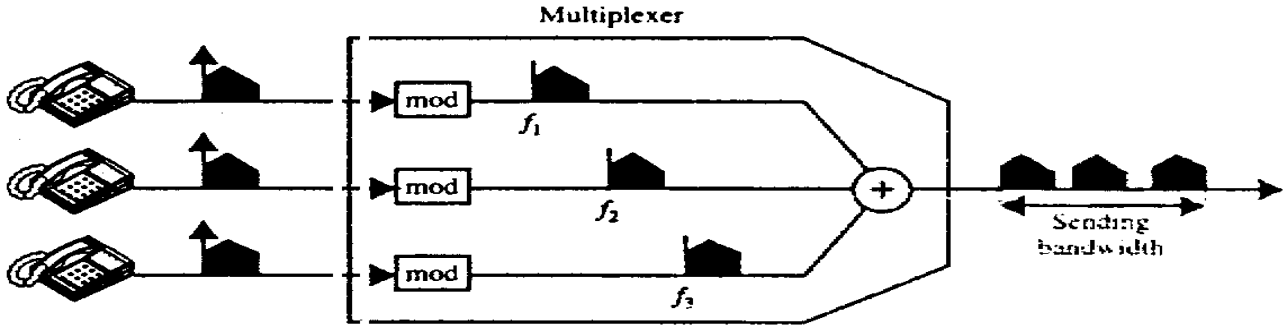
Figure 5 is the frequency-domain illustration for the same concept. (Note that the

horizontal axis of this figure denotes **<u>frequency, not time</u>**. All three carrier frequencies exist at the same time within the bandwidth.) In FDM, signals are modulated onto separate carrier frequencies *(f_1, f_2* and *f_3)* using either AM or FM modulation.

FDM multiplexing process, time-domain



FDM multiplexing process, frequency-domain



<u>Demultiplexing</u>

The demultiplexer ***uses*** a series of ***filters*** to decompose the multiplexed signal into its constituent component signals.