ECE 405 - BASEBAND TRANSMISSION - INVESTIGATION 25
INTRODUCTION TO TIME DIVISION MULTIPLEXING

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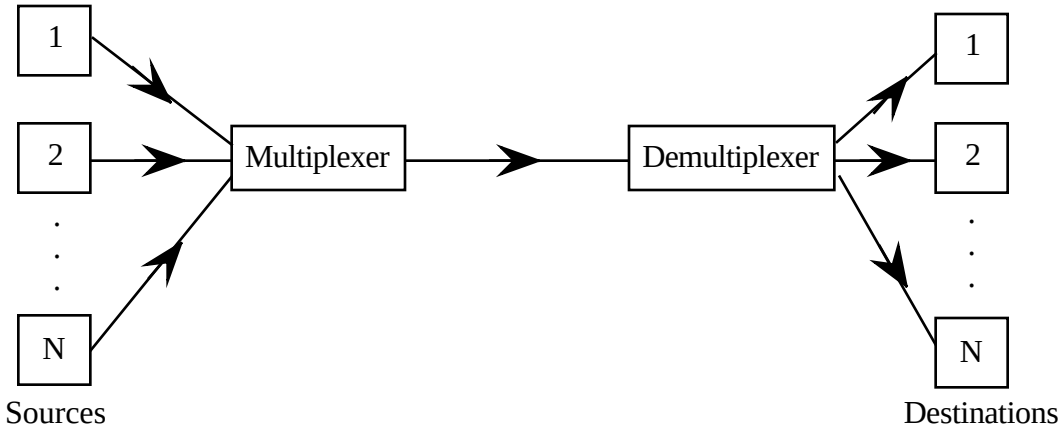
To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

From our Investigations on analog communications we know that AM and FM radio stations as well as TV and a whole host of other signals are all able to transmit into space at the same time as a result of the fact that they transmit at different carrier frequencies. We call this **frequency division multiplexing (FDM)**. And it works well. But to implement this sharing of the spectrum in a telephone network with routing of signals from one arbitrary location to another is more involved. A separate filter is needed for every connection between sender and receiver.

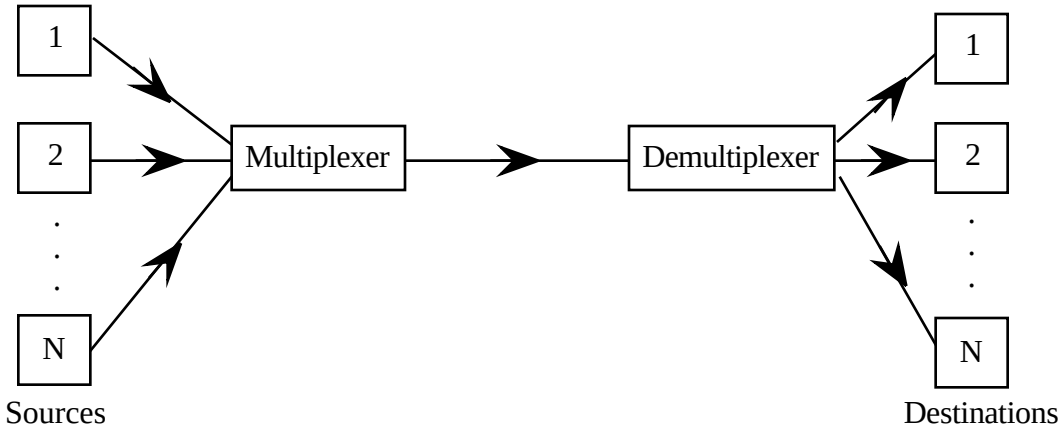
A much easier way to multiplex and route digital signals is with **time division multiplexing (TDM)** in which sources share time on a channel as indicated in the following diagram



For such a system to be feasible the pulses must be narrow enough for large numbers of them to be transmitted in a given time. Which means we need large bandwidths. But this is exactly what we have with fiber optics.

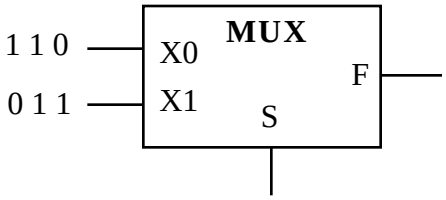
1. In analog communication systems like those for AM, FM and TV we make use of frequency division multiplexing (FDM) to transmit more than one signal at a time. Explain how FDM works.

2. From Problem (1) we know that FDM works well in many applications. But the amount of filtering that would be required for the transmission of millions of phone calls, not to mention music, graphics and video gets pretty large pretty fast. The alternative for digital signals is to use **time division multiplexing (TDM)** where the digital signals from different sources share time on a communication channel as follows

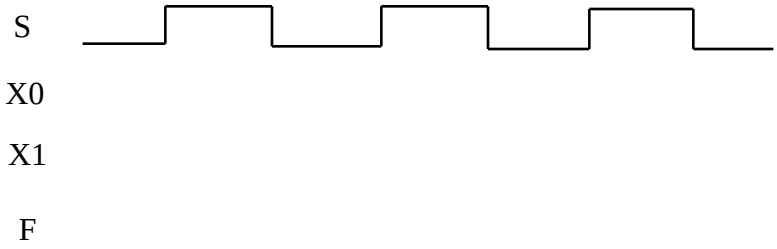


What's the role of the multiplexer and demultiplexer in such a system

3. The objective of this and the next problem is to review the basic operation of multiplexers. Suppose two signals are being time division multiplexed by a multiplexer as follows



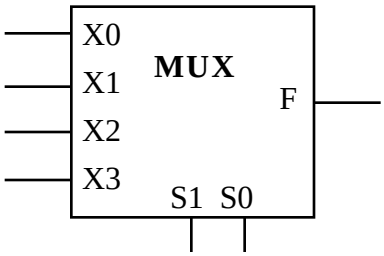
a. Draw a timing diagram for the circuit as follows



with F equal to NRZ_L signal

b. Realize the multiplexer with AND's, OR's AND INVERTERS

4. Generalizing on the result of Problem (2) we have a more general multiplexer as follows



a. Describe in words the operation of the multiplexer - how F is related to the values of the S's and X's

b. Draw a timing diagram for S_1, S_0 and F as S_1S_0 counts from 00 to 11 if $X_0 = 0$, $X_1 = 1$,

$X_2 = 0, \quad X_3 = 1$

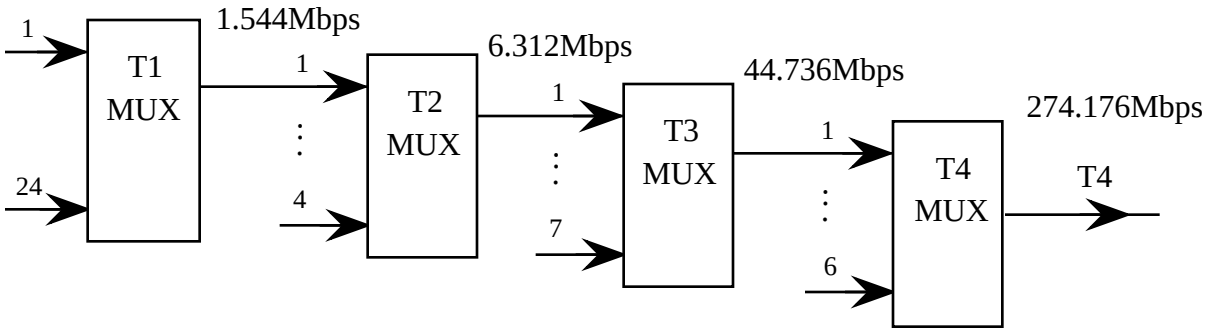
5. Now suppose we want to build a digital system for time division multiplexing the following three signals

   (1) $m_1(t) = 5$ KHz signal
   (2) $m_2(t) = 10$ KHz signal
   (3) $m_3(t) = 10$ KHz signal

   Assume all signals are sampled at their Nyquist rate and then converted to 8 bits. Assume that the multiplexer will transmit 8 bits from each location at its input before moving on to the next

   a. Draw a block diagram of the system
   b. What is the overall bit rate of the system
   c. What is the minimum bandwidth required if we're using raised cosine Nyquist pulses with $r = 1$

6. Time division multiplexing systems are usually organized in hierarchies with individual signals first combined in small groups, then the small groups multiplexed together to form larger groups and so on. In the telephone system put together by AT&T as follows



   the hierarchy is designed specifically to accommodate speech signals sampled at 8000 samples/secs with 8 bits per sample. How many telephone conversations can be serviced simultaneously by a T4 line

7. What is synchronization in a time division multiplexing and why is it important

8. What are advantages of time division multiplexing over frequency domain multiplexing

9. In **Asynchronous Transmission Mode (ATM)** data is sent in packets as it becomes available rather than during assigned time slots in synchronous systems. As a result each packet needs identification in the form of a header of where it came from and where it's going. A typical system would have a 5 byte header and 48 bits of data. What are the tradeoffs between packet switching systems like those used in the internet and synchronous systems like the switched telephone network.