Problem 1 Connections in a Full Mesh Network (20 points)

Consider a full mesh network (as presented in Lecture 2, see Slide 32) with seven nodes.

(a) How many connections are needed to form a full mesh network?

Solution:

\[
\begin{align*}
&6 \text{ links} + 5 \text{ links} + 4 \text{ links} + 3 \text{ links} + 2 \text{ links} + 1 \text{ link} \\
&= 6 + 5 + 4 + 3 + 2 + 1 = 21 \text{ connections}
\end{align*}
\]

(b) Write an expression for the number of connections \( C \) for a full mesh network with \( N \) nodes.
Solution:

Number of connections \( C = \sum_{k=1}^{N-1} k = \sum_{k=1}^{N-1} (N - k) \)

Also, \( C = \frac{N(N - 1)}{2} \)

Problem 2 Comparing the Bus and Ring Networks (16 points)

Examine both the bus network and the ring network each with a total of five nodes. Identify the advantages and disadvantages for both the bus and ring networks (at least two for each category). You can use the Internet to do this if you wish.

Advantages of bus network:
1. Easy to connect another node to the linear bus network.
2. Uses least length of cable to connect all nodes.

Disadvantages of bus network:
1. As more nodes are added the communication time gets longer. Entire bandwidth is shared among all users.
2. Entire network shuts down if there is a break in the main cable.
   Note: Generally a bus is not used as a stand alone network.

Advantages of ring network:
1. All data moves in one direction (reduces chance of data collisions).
2. Easy to add new nodes around the ring.
3. Doesn’t need a network server to control data flow.
4. Equal access to network resources.

Disadvantages of ring network:
1. A single break in the cable can cause disturbance in the entire network.
2. All data over ring network passes through each node, which is often lower than a star topology.
Problem 3 Most Reliable Network  (10 points)

Of all the network topologies presented in class (in Lecture 2, Slide 32), which network topology do you think would the most reliable when a single node fails?
Answer: The Full Mesh network. It is a fully redundant network and is the most reliable of all networks.

Problem 4 Hybrid Network Topology  (14 points)

We did not discuss the hybrid network topology in class. Look up the hybrid network topology on the Internet. Give a definition of the hybrid network and sketch an example of a hybrid network with 10 nodes.

Definition:

A hybrid network is any computer network that uses more than one type of connecting technology or topology.

Example:

An example using the star, bus and ring network topologies is (but with 18 nodes shown for good measure):

Obviously, many examples exist which are correct (any one of which will do).
Problem 5  Loss in a Twisted pair Loop  (20 points)

The telephone company uses a twisted pair wire (0.5 mm diameter AWG 24 copper wire) to deliver the last mile of a digital subscriber line (DSL) to the home or office is expressed by the relationship,

\[ B \text{ (bits per second)} = k \cdot L^{-1.5} , \]

where \( L \) is the reach of the line in meters and \( k \) is a constant that depends upon wire resistance, condition of the twisted pair, moisture content of the environment where the line is positioned, and several other factors. Given the experimental data for a twisted pair loop in the figure shown below, find the value of the constant \( k \) for this data set.

Answer: We assume the red line is the best fit to the data. We take the point of \( B = 10^8 \) bits per second and \( L = 100 \) meters because it is the easiest point to read off the graph and fits the best fit to the data. Pay special attention to the units in determining the value of \( k \). This gives the equation:
\[ B = k \cdot L^{-1.5} \Rightarrow 1 \times 10^8 \text{ bits/sec} = k \cdot (100 \text{ meters})^{-1.5} \]
\[ k = \frac{1 \times 10^8 \text{ bits/sec}}{(100 \text{ meters})^{-3/2}} = \frac{10^8 \text{ bits} \cdot \text{(meters)}^{3/2}}{0.0010 \text{ sec}} \]
\[ k = 1 \times 10^{11} \frac{\text{bits} \cdot \text{(meters)}^{3/2}}{\text{sec}} \]

or any numerical value sufficiently close to \(1 \times 10^{11}\).

**Problem 6  Mixing Topologies in a Network  (10 points)**

For the network shown below, list the generic network topolgies used in building this network.

![Network Diagram]

Answer: Bus and Star topologies (some might include the tree topology which is also counted as correct).

**Problem 7  Folded Bus Topology  (10 points)**

Given the folded bus topology shown below. Each node consists (a total of \(N\) nodes) of a transmitter (\(\text{Tx}^N\)) and a receiver (\(\text{Rx}^N\)). The ring only transports data in the clockwise direction. Discuss what you think are its
strongest attributes \textit{(i.e., advantageous properties)} and its weakest attributes.

\begin{center}
\begin{tikzpicture}
\node at (0,0) {	extbf{Transmit Bus}};
\node at (0,-2) {	extbf{Receive Bus}};
\draw[->] (0,0) -- (0,-2);
\node at (0,0) {	extbf{Rx}^1 \hspace{1cm} \textbf{Tx}^1 \hspace{1cm} \textbf{Rx}^2 \hspace{1cm} \textbf{Tx}^2 \hspace{1cm} \textbf{Rx}^3 \hspace{1cm} \textbf{Tx}^3 \hspace{1cm} \ldots \ldots \hspace{1cm} \textbf{Tx}^{N-1} \hspace{1cm} \textbf{Rx}^{N-1} \hspace{1cm} \textbf{Tx}^N \hspace{1cm} \textbf{Rx}^N};
\draw[->] (0,-2) -- (0,0);
\end{tikzpicture}
\end{center}

\textbf{Answer:}

\textbf{Advantages:} (many answers were accepted)
1. It is a very simple network.
2. Relatively easy to add transceivers when $N$ is small.
3. No server is required.

\textbf{Disadvantages:} (many answers were accepted)
1. If the bus line breaks at any point around the loop the part of the network fails.
2. Good for a few nodes, otherwise excessive delays can build up.

Another problem is timing such that a transmitter does not send a message when another is present on the bus. This is a significant problem with a large number of transceivers making the network very slow for large $N$.

\textbf{Note:} This is not a widely used configuration for the above reasons.