Distributed Computing

Network Topologies:

In choosing a network topology the following factors must be taken into account:

Set-up Cost

This is the financial cost required to set-up a network. The cost of the computers, extra hardware, cabling etc.

Expansion Cost

After the initial set-up, adding another host will have extra costs associated with it.

Flexibility

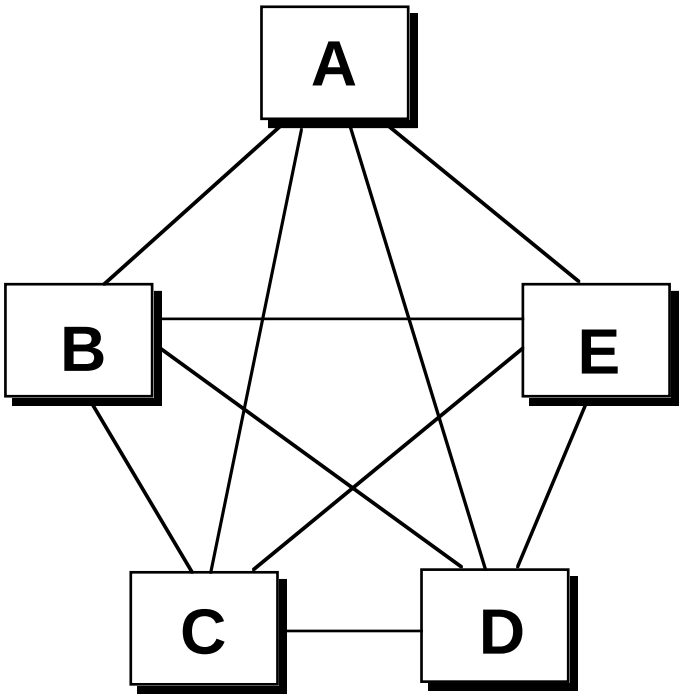
Flexibility refers to the ease with which the topology can be expanded.

Reliability

Any network whose functionality is threatened by the failure of a single device is considered unreliable.

Topologies:

Complete Interconnection



Pros:

High Throughput: Since each node is connected directly to every other node, the sending node doesn't have to wait on any of the other nodes in order to send its messages since its transmission line is not shared. Different Nodes sending to different destinations will also be able to communicate simultaneously.

Reliability: Since each node has a direct connection to every other node, the failure of a single line will only affect communications between the two nodes it connects. Every other node will be unaffected, and the two nodes connected together by the failed line will only be preventing communicating with each other (not with any of the other nodes).

If a particular node fails, only nodes wishing to communicate directly with it will be affected.

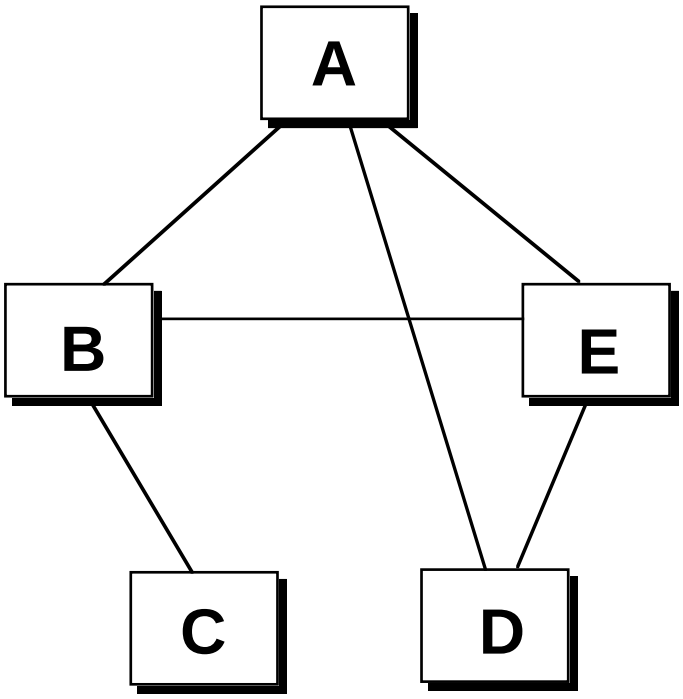
Cons:

Expensive: Set-up costs can be prohibitive. Given a network with N nodes, (N-1)N/2 lines will be required for the network. Similarly,

each node will be required to be able to connect to N-1 other nodes. This will require extra hardware for each node in the network.

Difficult to Expand: These networks are probably the least flexible. Adding a new node to the network will require 1) Wires connecting the new node to each node in the network, 2) The physical capability to connect to all the machines in the network, and 3) each node in the network will have to be altered so that they can connect to one more node. This will be both expensive and difficult.

Mesh (Partial Interconnection)



Pros:

Reliable: Communication in a Mesh is more complex than with total interconnection. In the example above communication between A and E is as before, using the direct link. Communication between A and C, however, must go through B. The Node at B must be aware of the nodes connected to it. For example, it must know that communication from A that may be intended for D must be passed on to E (which will pass it on to D). It must also know that communication to C must be passed on along its connection to C, etc. This is known as *routing* information.

This routing system has an impact on the reliability of the network. In the example above all communication to C must pass through B. If B fails or if the line from B to C fails, C is completely cut off from the rest of the network. However, communication from A to D is more reliable. Consider the failure of the direct line from A to D. In the total interconnection example, this would mean they were disconnected (since most total interconnections protocols don't need routing). In the example above, the failure of the A-to-D line doesn't necessarily mean they can't communicate since A can also use the following routes: A-B-E-D and A-E-D.

Lower Cost: Since the number of connections is smaller (6 in the example above as compared to 10 in the total interconnection example) the wiring costs are smaller too. The number of communication ports needed by each node is also smaller (C only needs one in the mesh example and four in the total interconnection example.)

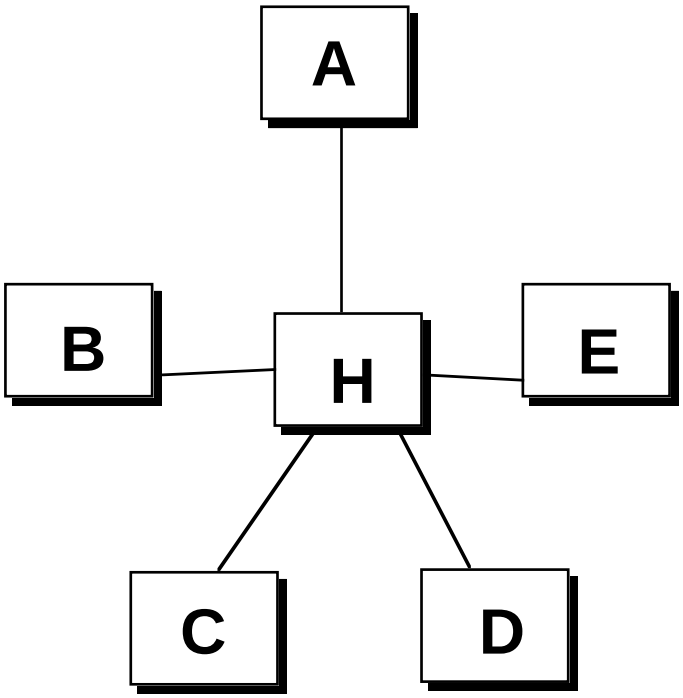
Flexible: The minimum requirements of adding a node are a single wire connection to any one of the nodes in the existing network and the updating of the routing information stored by each node.

Cons:

Complex Protocols: In order to support the routing aspects of the protocols the software required to keep the network running will be more complex.

Delays, Reduced Throughput: Since many of the routes between nodes now share certain lines (e.g. A-to-C and B-to-C and E-to-C all use the B-to-C line), some communications will have to wait until the line is free (if it is in use by another node).This will slow the operation of the network in some instances.

Star



Pros:

Low Set-up Cost: The Star topology involves sending all messages to a central node (sometimes called a Hub - "H" in the example above). If A was sending a message to C it would send the message to H which would pass it on to C. The advantage of this approach is that each node needs only one communication port in order to be connected to the network. The central node will have several communication ports and is normally dedicated to the routing of messages.

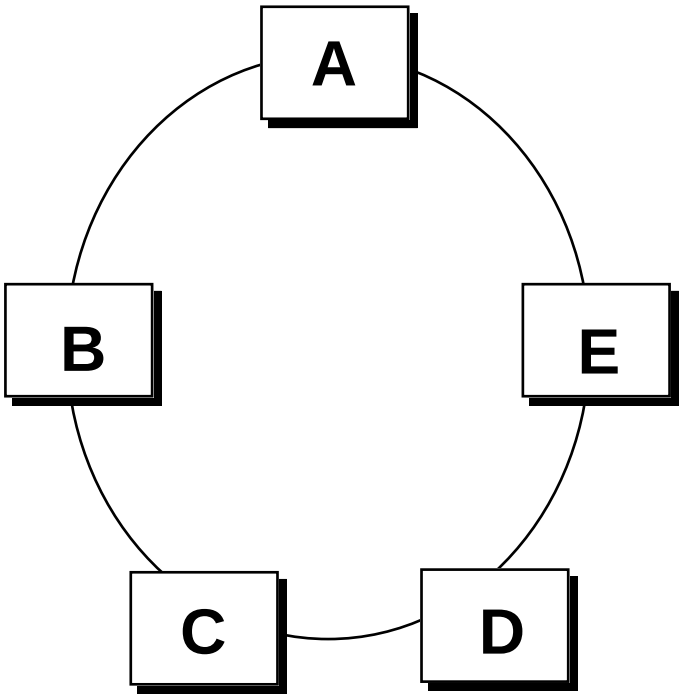
Flexible: Adding a node to this network only requires connecting a machine with one communication port to the hub, and updating the hub's routing information. This is in contrast to the mesh approach where every node needed its routing information updated.

Cons:

Bottleneck: The main disadvantage of this approach is that every single communication must pass through the central node. In a busy

network the central node can become overloaded with heavy traffic and bring the whole network to a halt (or slow it down considerably). This is called a *bottleneck*.

Ring



Pros:

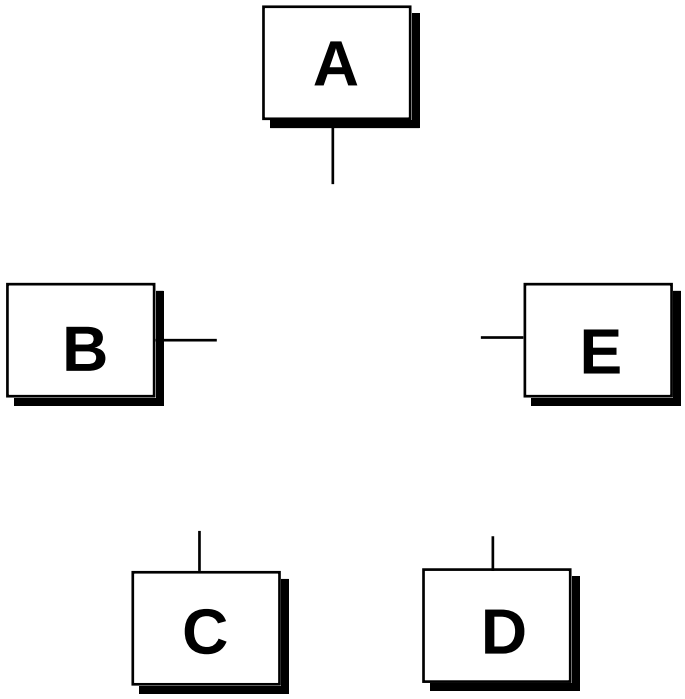
Cheap: All that is required for the ring topology is two ports (incoming and outgoing) for every node, without the extra expense of a central node that a star requires.

Cons:

Not Easily Expanded: Adding a node to the network is not trivial. A new node has to be inserted between two nodes that are already connected together (e.g. between B and C in the example above). Rings are an older topology and therefore their wiring is not always easy to access making expansion difficult. The entire network is brought down whenever a new node is added.

Not Reliable: Due to the nature of the protocols used with rings, any one node or connection that fails will bring down the entire network.

Wireless



Pros:

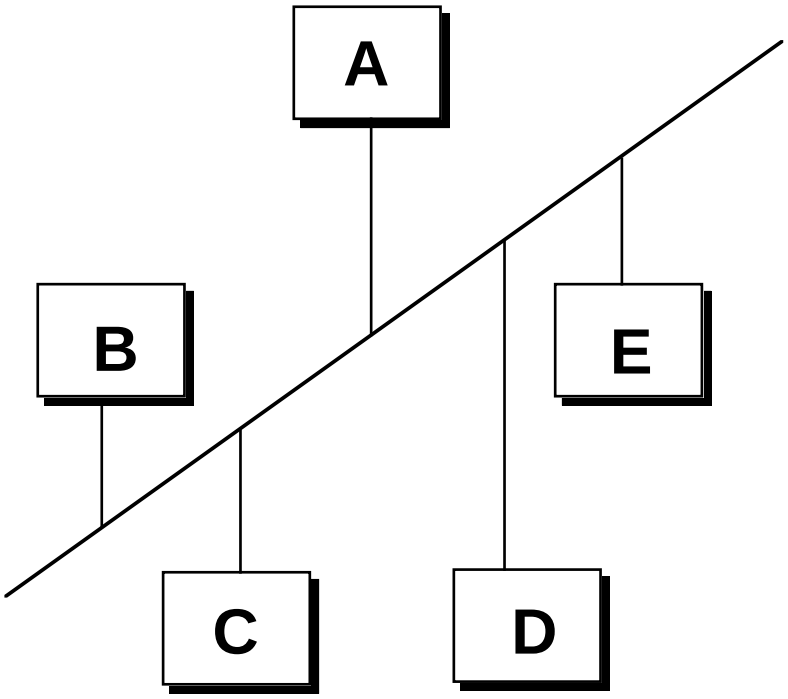
No Wiring: This allows greater freedom in positioning the nodes in a network. It also allows for greater mobility of those nodes.

Cons:

Expensive: These networks usually require expensive technologies to connect the nodes.

Interference: Wireless technologies tend to be susceptible to interference (weather conditions, birds flying between transmitters, etc.)

Bus



Pros:

Cheap: This topology requires connecting a node to a shared wire (the bus). Only one communications port is needed.

Easily Expanded: Adding a node only requires connecting it to the wire. No changes have to be made to any of the other nodes (unlike the mesh and ring.)

Cons:

Faults Difficult to Isolate: If a fault develops in the wire it can be difficult to find.

Unreliable: Even though this type of network can survive the failure of individual nodes, one fault in the wire can disconnect one half of the network from the other.