Cairo University
Faculty of Engineering
Computer Department

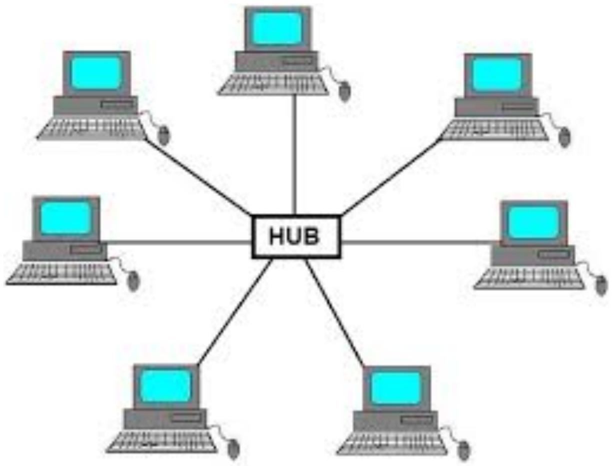
Computer Networks-1
CMP405-A /CMPN405
Fall 2023

Network topologies with omnet++

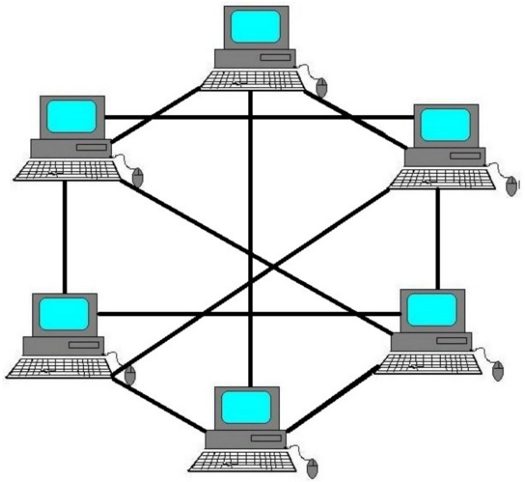
Today's goal

- Build a LAN of an arbitrary N nodes.
- Any 2 nodes can send messages to each other (directly or indirectly).
- Experiment with different network topologies

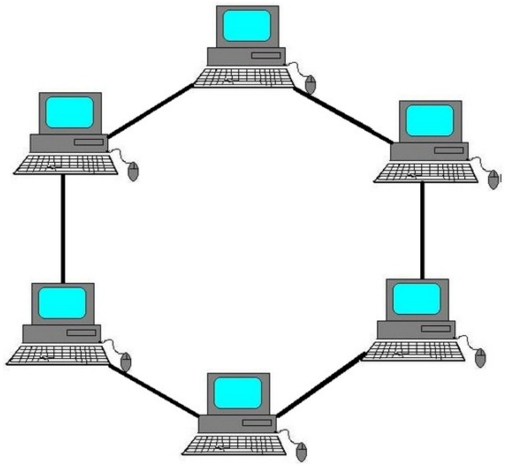
Star



Mesh



Ring



We'll learn about

1. Gate vectors
2. Dynamic connections
3. Sampling from random distributions
4. Self messaging

4

Gate vectors

Building gates of different sizes

Gate vectors

- We can create single gates and gate vectors.
- Gate vectors follow the square brackets syntax "[]"
- The size of a gate vector can be specified or left empty.
- If left empty, the size is inferred from the connections, or is determined when instantiated as a submodule.
- You can find out the size of a gate by calling *gateSize(<gate_name>)*

```
simple Node
{
    gates:
        output outs[5];
        input in;
}
```

Gate vector

Gate

```
gateSize("outs"); //Returns 5
```

in c++

If size is left empty

Size is inferred

```
simple Node
{
    gates:
        inout port[];
}

network Network
{
    submodules:
        node1: Node;
        node2: Node;
        node3: Node;
    connections:
        node1.port++ <--> node2.port++;
        node1.port++ <--> node3.port++;

}
```

Node1 has gate size 2, nodes 2 & 3 have a size of 1

Size is specified when instantiated

```
network Network
{
    submodules:
        node1: Node {
            gates:
                port[2];
        }
        node2: Node {
            gates:
                port[1];
        }
        node3: Node {
            gates:
                port[1];
        }
    connections:
        node1.port++ <--> node2.port++;
        node1.port++ <--> node3.port++;
}
```

if inout port isn't used just in portin and out portout
node1.portout-->node2.portin
node2.portout-->node1.portin
node1.portout-->node3.portin
node3.portout-->node1.portin

Gate vectors cont.

- Gate vectors can accommodate and expand to grow their pre-determined size.
- This code runs properly without any errors.
- All nodes have a gate size of 2

```
network Network
{
    submodules:
        node1: Node {
            gates:
                port[2];
        }
        node2: Node {
            gates:
                port[1];
        }
        node3: Node {
            gates:
                port[1];
        }
    connections:
        node1.port++ <--> node2.port++;
        node1.port++ <--> node3.port++;
        node2.port++ <--> node3.port++;
}
```

Gate vectors

- Use the square brackets syntax.
- Used with the “++” operator
- This automatically expands the size of our gate accordingly.

```
simple Node
{
    gates:
        inout port[];
}

network Network
{
    submodules:
        node1: Node;
        node2: Node;
        node3: Node;
    connections:
        node1.port++ <--> node2.port++;
        node1.port++ <--> node3.port++;
        node2.port++ <--> node3.port++;
}
```

Gate vectors cont.

- Omnetpp by default doesn't allow for a gate to be unconnected.
- An error will be produced when attempting to run with a gate that is unconnected.
- We can work around this by using the *@loose* property

```
simple GridNode {
    gates:
        inout neighbour[4] @loose;
}
```

Gate vectors cont.

We can also specify the size by sub-classing.

```
simple TreeNode {
    gates:
        inout parent;
        inout children[];
}

simple BinaryTreeNode extends TreeNode {
    gates:
        children[2];
}
```

Dynamic connections

Dealing with dynamic networks

- We can use “for loops” and “if conditions” inside *connections* to deal with arbitrarily large modules and add some logic to our topology.

```
network Network
{
    parameters:
        int N = default(4);
    submodules:
        nodes[N]: Node;
    connections:

}
```

??

For loops and if statements in ned (1)

- If statement

```
if p>0 {
    a.out --> b.in;
    a.in <-- b.out;
}
```

For loops and if statements in ned (2)

- For loop

```
for i = 0..count-2 {
        node[i].port[1] <--> node[i+1].port[0];
}
```

Line connection (open loop)

For loops and if statements in ned (3)

- For loop and if statement inside it

```
for i=0..sizeof(c)-1, if i%2==0 {
    c[i].out --> out[i];
    c[i].in <-- in[i];
}
```

For loops and if statements in ned(4)

- One line for loop and if statement inside it

```
a.out --> b.in;
c.out --> d.in if p>0;
e.out[i] --> f[i].in for i=0..sizeof(f)-1, if i%2==0;
```

For loops and if statements in ned (5)

- Nested loops and if statement inside it

```
for i=0..sizeof(e)-1, for j=0..sizeof(e)-1 {
    e[i].out[j] --> e[j].in[i] if i!=j;
}
```

For loops and if statements in ned (5)

- Nested loops and if statement inside it “another way to write it”

```
for i=0..sizeof(d)-1, for j=0..sizeof(d)-1, if i!=j {
    d[i].out[j] --> d[j].in[i];
}
```

Dealing with dynamic networks

- We can use for loops and if conditions inside *connections* to deal with arbitrarily large modules and add some logic to our topology.

```
network Network
{
    parameters:
        int N = default(4);
    submodules:
        nodes[N]: Node;
    connections:
        for i=0..N-1 {
            nodes[i].port++ <--> nodes[i+1].port++ if i < N-1;
            nodes[i].port++ <--> nodes[0].port++ if i == N-1;
        }
}
```

N-1 is inclusive

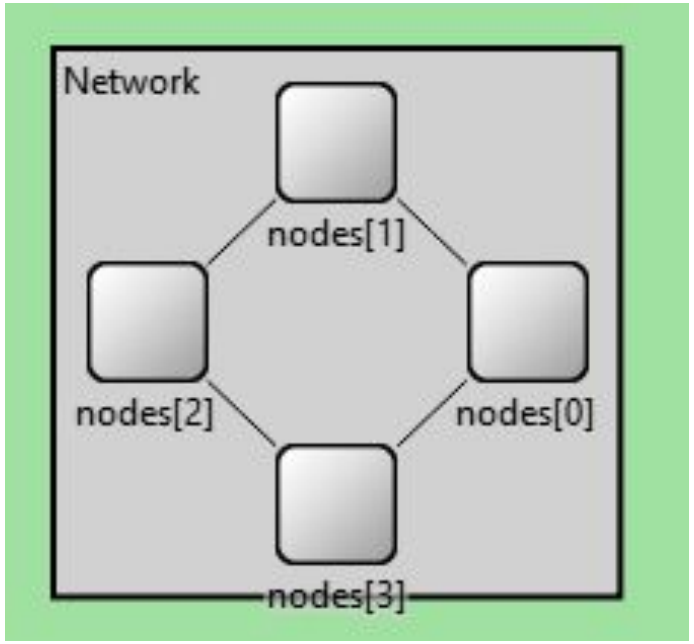
closed circle

Which topology is this?

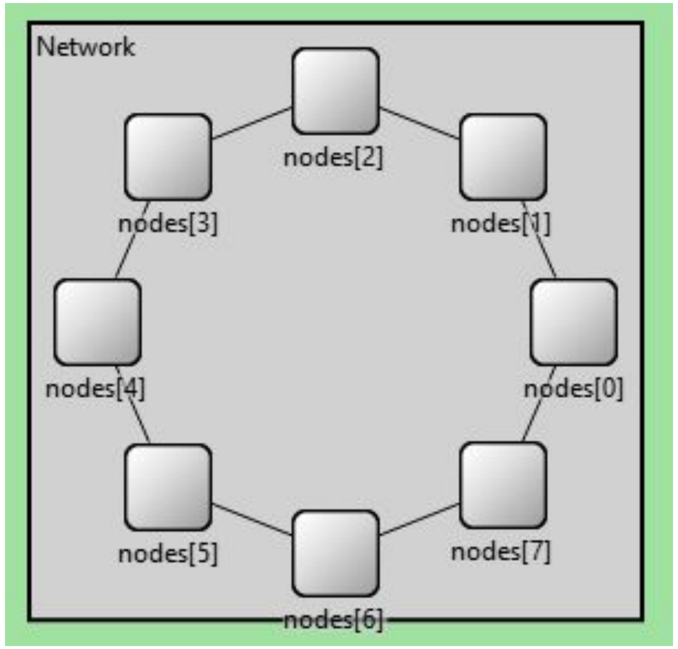
Dynamic ring network

We put N as a parameter “defined in the Network system module and initialized in the .ini file.

N=4 (default)



N=8



Nested loops

```
connections:
    for i=0..N-1, for j=i+1..N-1
    {
        nodes[i].port++ <--> nodes[j].port++;
    }
```

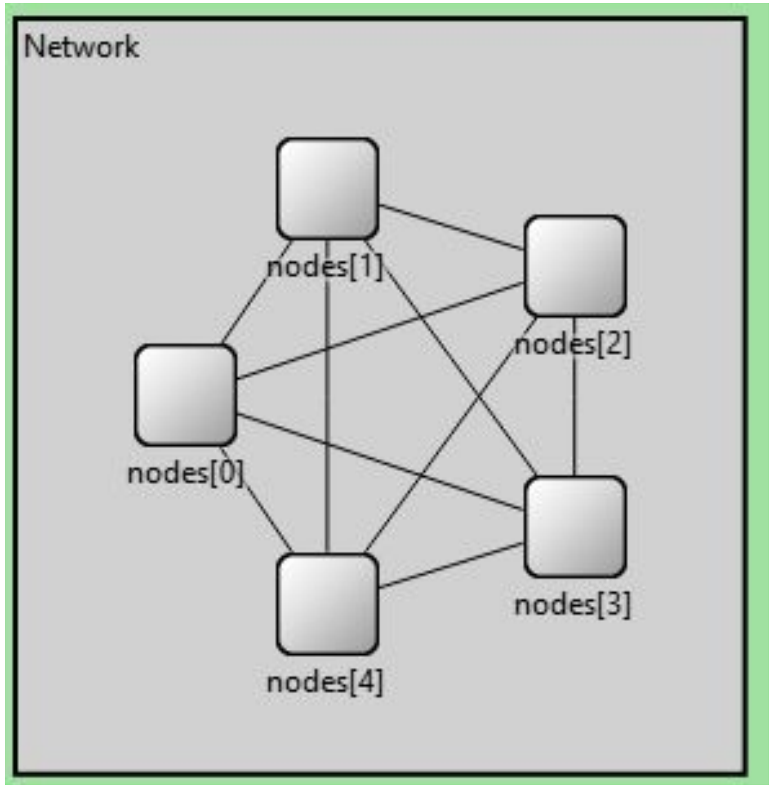
Which topology is this?

Mesh

[0]<-->[1]
[0] <-->[2]

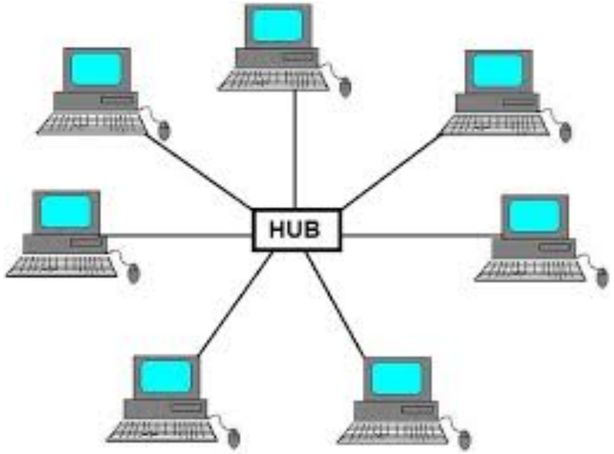
Mesh topology

```
connections:
    for i=0..N-1, for j=i+1..N-1
    {
        nodes[i].port++ <--> nodes[j].port++;
    }
```



Today's lab:

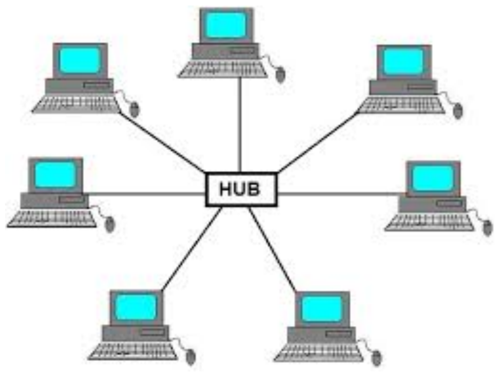
What about the star topology ?



Star

Today’s lab requirement number 1/2:

- Create a Star network topology consisting of one Hub and N nodes.
- N should be configurable in the .ini file.
- Each node is connected only to the hub.
- Before starting, every node prints to the console a message “ Starting Node i”, where i is the node index.
- The hub starts by sending to a random node “m” a message “Hello from Hub”.
- The node “m” is selected randomly.
- The node “m” should respond with “Hi from node” to the Hub.
- After a random time, the Hub selects another random node “m” to send the same message to it.
- The node responds with the same response …. etc.



Star

How to do this?

Exponential function

- We want the Hub to send messages to the nodes after a random time from receiving a triggering message.
- We can use the function *exponential* to do this.

double interval= exponential(2.0)

- We need to send ourselves a message in the future, to trigger the sending at the appropriate time.
- We treat this like a self timer and so we use the self messages in ned.

Self messaging

- The *scheduleAt(t, msg)* function allows us to send ourselves a message that will be received at simulation time *t*.
- The *simTime()* functions returns the current simulation time.
- We can combine this with our samples interval to send ourselves a message as follows:

```
scheduleAt(simTime() + interval, new cMessage(""));
```

Self messaging cont.

- Then, inside the *handleMessage(cMessage *msg)* function, we can check if this is a self message or not using the *isSelfMessage()* function

```
if (msg->isSelfMessage()) {
    //This is a self message. Create and send a new packet.
}
else {
    //This msg was sent by another node.
}
```

Uniform function and parent module

- Upon sending a message to the node, the hub selects a random node m.
- We sample the node index from a *Uniform* distribution .

Int m = int(uniform(0,n))

- How to get n ??? Remember that n is a parameter defined in the **network** (the compound system module).

getParentModule()->par(“n”)

- Call this inside Hub.c. It returns a pointer to the parent module Network, and then we can use this pointer to access any parameter in the parent module

Sending a packet through a gate array

- Finally, we can use the send(msg, gatename, gateindex) function to send our message on the proper gate to our destination node.

Send(msg, “outs”, 1);

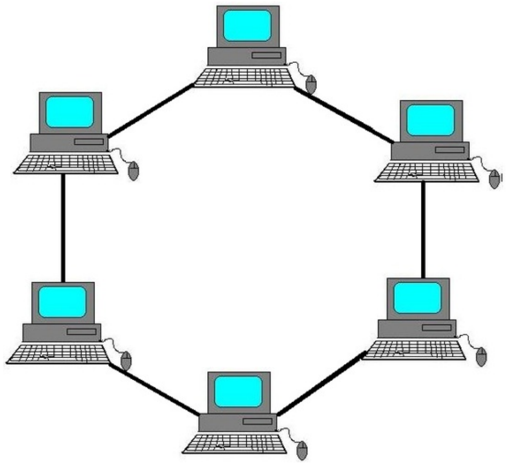
Useful functions

- **gateSize("outs")** //inside c, returns the size of the "out" gate array
- **getIndex()** // inside c, returns the current node index
- **getParentModule()->par("n")** //inside node.c, returns a pointer to the parent module Mesh, and then we can use this pointer to access any parameter in the parent module.
- **Network.n** // inside .ini where Network is the system module.
- **int=getKind(), setKind(int)** In the cMessage class, there is a data member called "Kind" a short int , can be used as an identifier for the message. The "Kind" has setter and getter functions just like the "Name" data member.

Today's lab requirement number 2/2:

- Create a ring network topology consisting of N nodes.
- N should be configurable in the .ini file.
- Before starting, every node prints to the console a message " Starting Node i", where i is the node index.
- In a way to imitate what happens in real world dynamic networks, we want to enable Node 0 to explore the topology and find the number of the connected nodes in the network through messages exchanging. [without the use of getParent() for the parameter N here].
- After a complete exploration phase , Node 0 , should print to the console the number of nodes in the network N and finish the simulation.

Ring



Submission

- Work in pairs
- Delivery in two weeks
- Submit two .zip project folders for each problem starts with p1_ or p2_ then your names.
- In the private comments write your names and Id's.
- We will need a discussion for this lab.