Redes de Comunicação em Ambientes Industriais
Aula 5

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In the previous episode ...

- ✓ Transmission **control** can be **external** or **autonomous**
- ✓ **TT networks** with **autonomous control** require **judicious use of relative phase** to avoid high delays and jitter → Time-triggered architecture
- ✓ **ET networks** are inherently **flexible** at run-time
- ✓ **TT networks** are typically **static** but can use multiple modes or on-line scheduling of the periodic traffic

In the previous episode ...

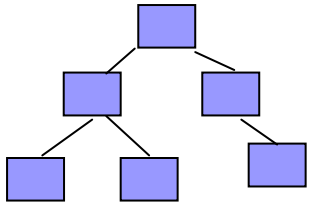
- The **OSI 7 layers** reference model imposes **too much overhead** for real-time networks (mainly in embedded control applications)
- **Real-time** properties must be enforced in **all layers**
- Real-time networks frequently use a **collapsed 3 layers** structure:
  - **physical**, **data link** and **application** layers

Physical layer

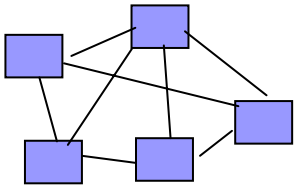
- Issues related with the physical layer:
  - **Interconnection topology**
  - **Physical medium**
  - Coding of digital information
  - **Transmission rate**
  - Maximum interconnection length
  - Max number of nodes
  - Feeding power through the network
  - Immunity to EMI
  - Intrinsic safety

Physical layer

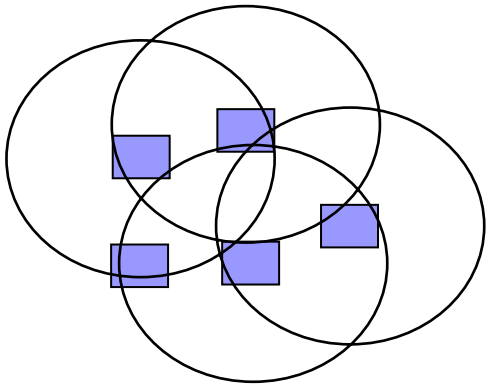
- ✓ **Interconnection topology**



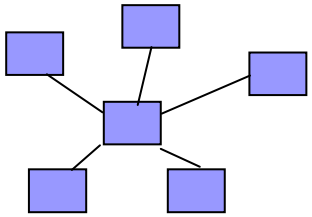
Tree



Mesh
(wired)

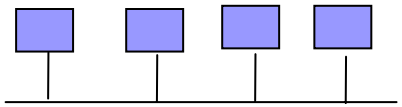


Mesh (wireless-RF)

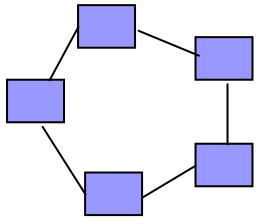


Star

Bus



Ring



Physical layer

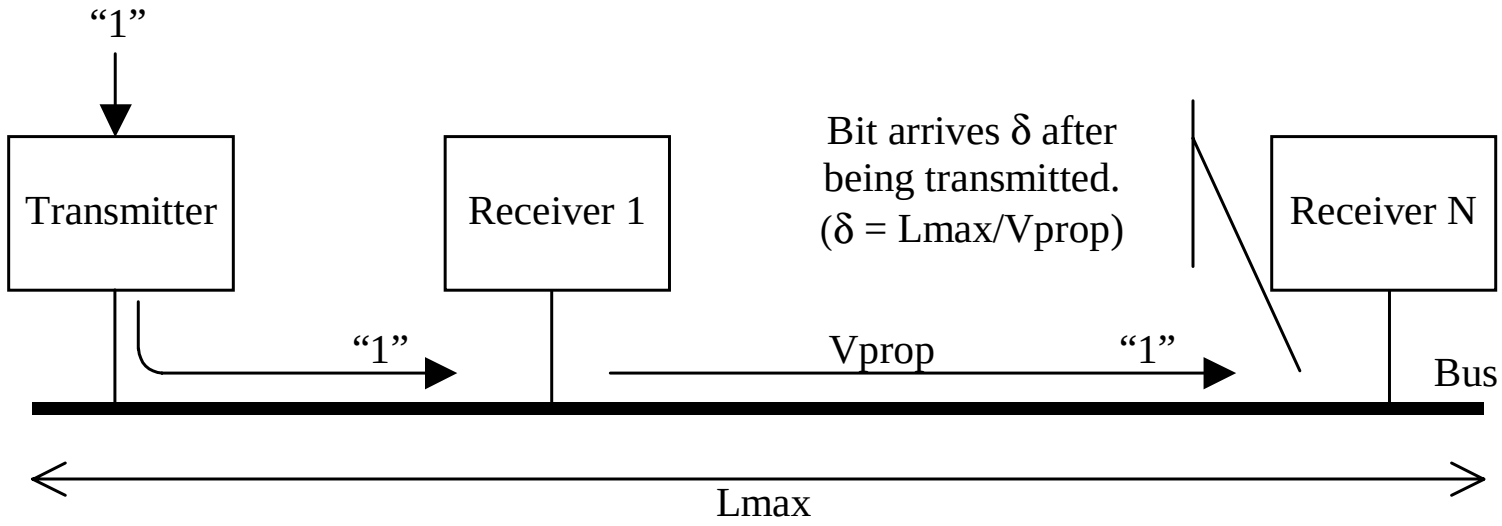
Topology	In favor	Against
Mesh	Point-to-point connections (wired, only). Several alternative paths.	Requires routing. Complex cabling (wired), difficult to maintain. Difficult to enforce total order
Tree (star)	Point-to-point connections. Simultaneous communication in parallel branches.	Requires routing. Potential long paths for deep nodes in different branches. Upper branches are bottlenecks.
Ring	Point-to-point connections. Simplified cabling.	Long path for back-to-back nodes. Depending on protocol, the whole ring is used as shared medium (more complex access control)
Bus	Simplified cabling. Direct communication (no routing)	Shared communication medium (more complex access control)

Physical layer

- **Physical medium**
  - **Copper wiring**
    - Cheaper cables and interfaces (+), suffers EMI (-)
  - **Optical fibers**
    - Immune to EMI, favors safety, wide bandwidth, low attenuation (+), expensive cables and interfaces (-)
  - **Wireless – Radio frequency**
    - Mobility, flexibility (+), very susceptible to EMI (-), multi-path fading (-), attenuation (-), open medium (+/-)
  - **Wireless – Infra-red light**
    - Mobility, flexibility (+), line-of-sight (-), open medium(+/-)

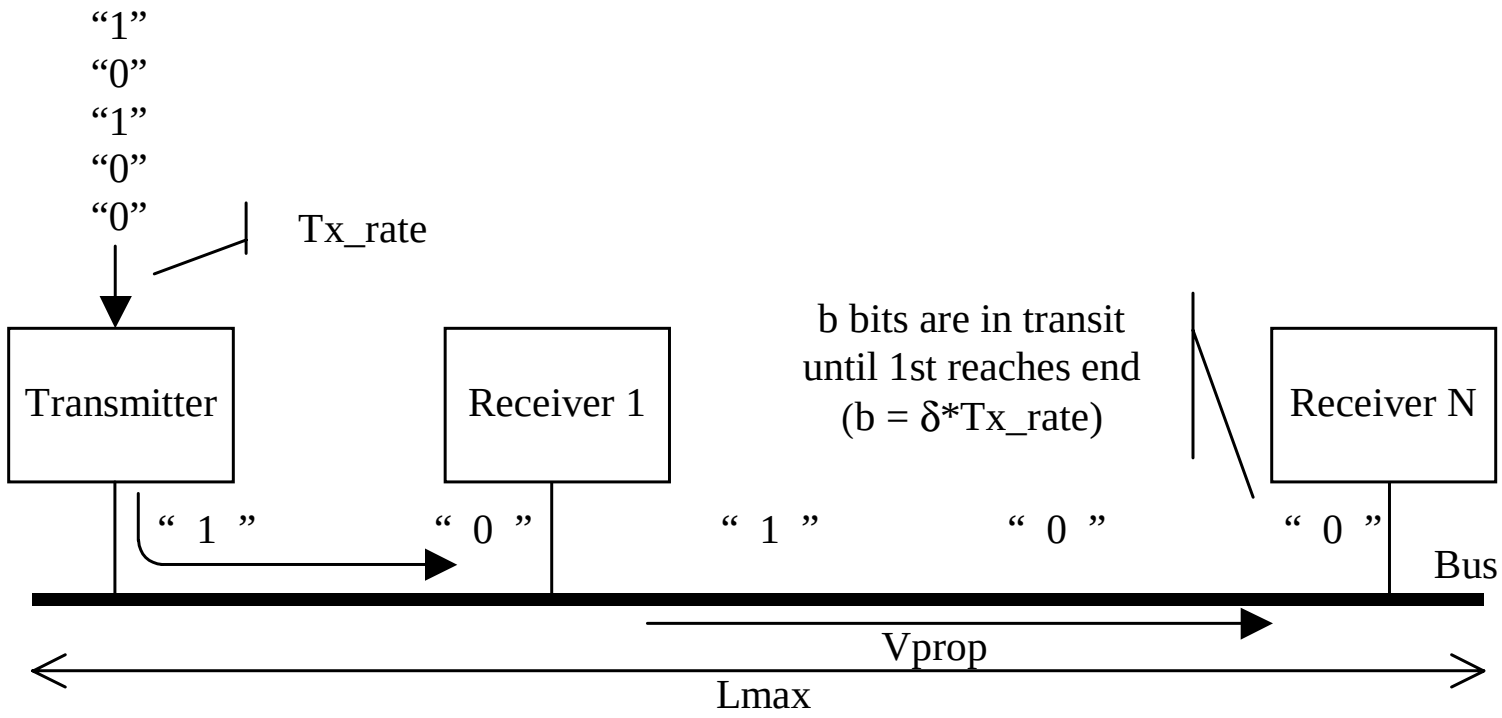
Physical layer

- **Propagation delay** in a bus
  - Time for a bit to traverse the full length of the bus (δ)



Physical layer

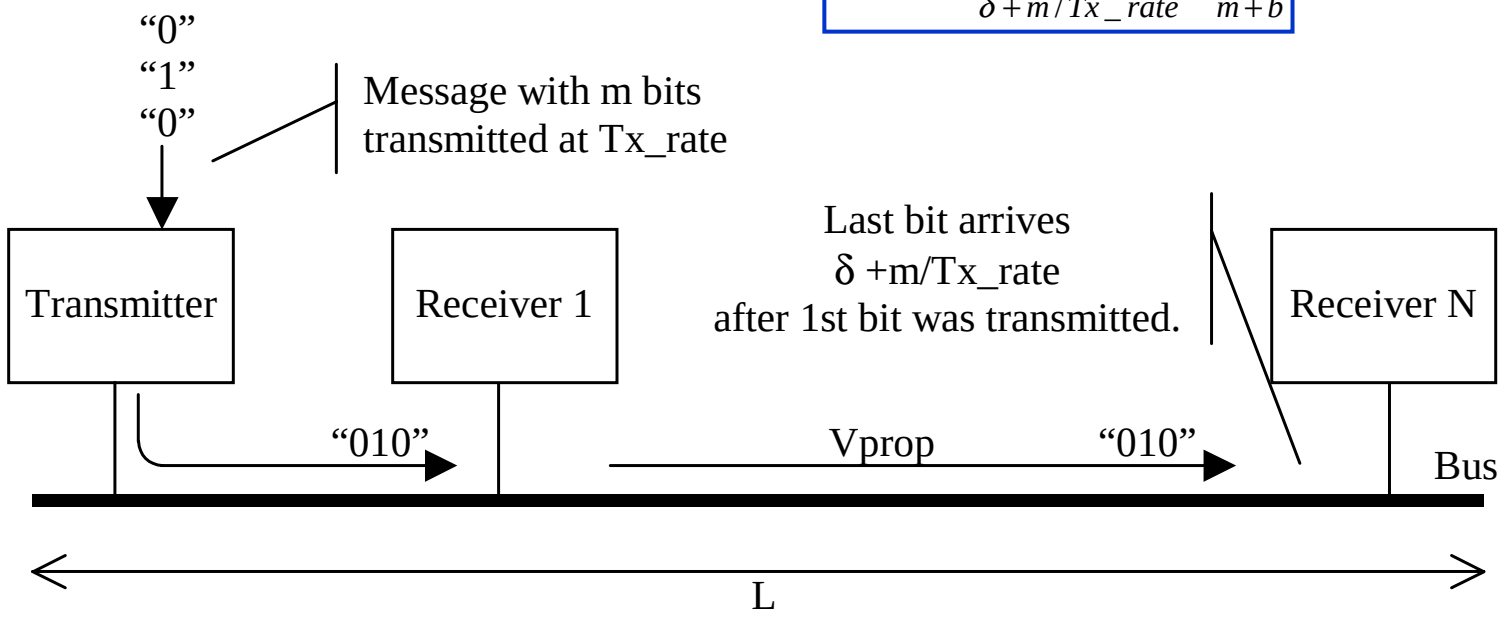
- **Bit length** in a bus
  - Number of bits in transit in the bus (b), given δ and Tx_rate



Physical layer

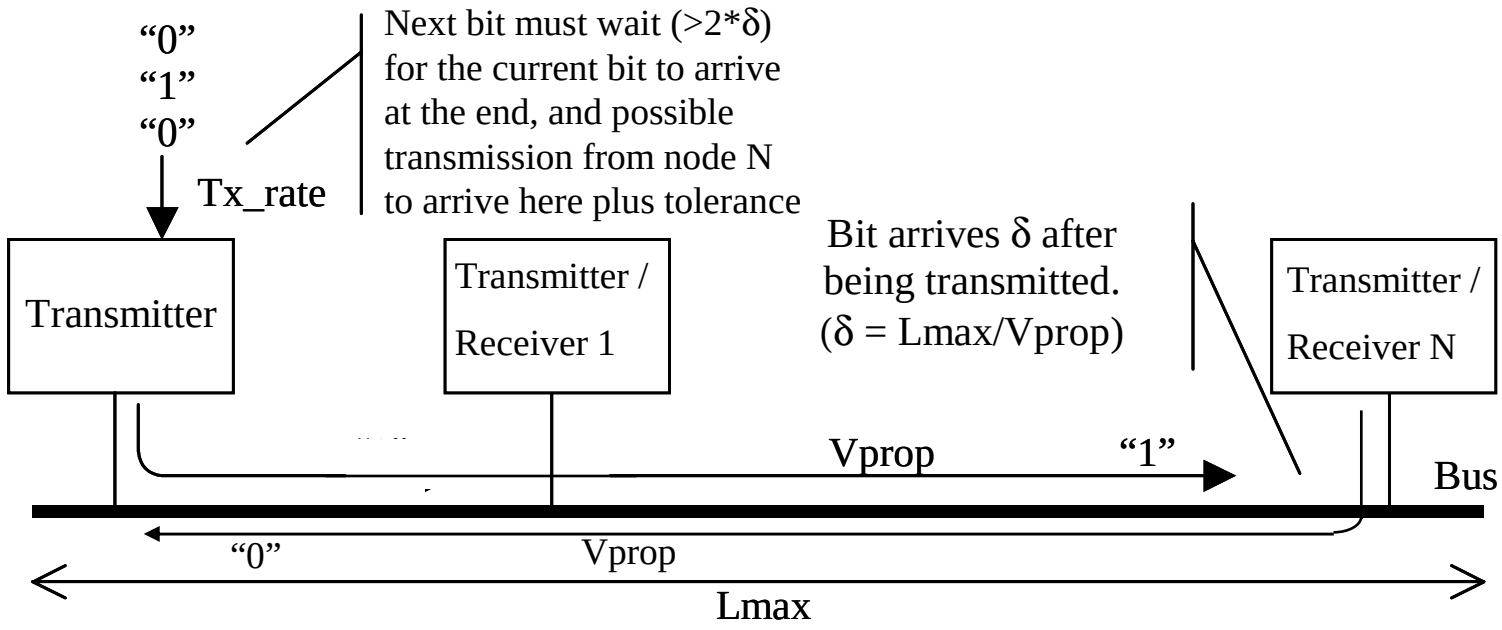
- **Limit to protocol efficiency in a bus**
  - Any message must be flushed from the bus before the next can be transmitted

$$\text{Max\_eff} = \frac{m/Tx\_rate}{\delta + m/Tx\_rate} = \frac{m}{m+b}$$



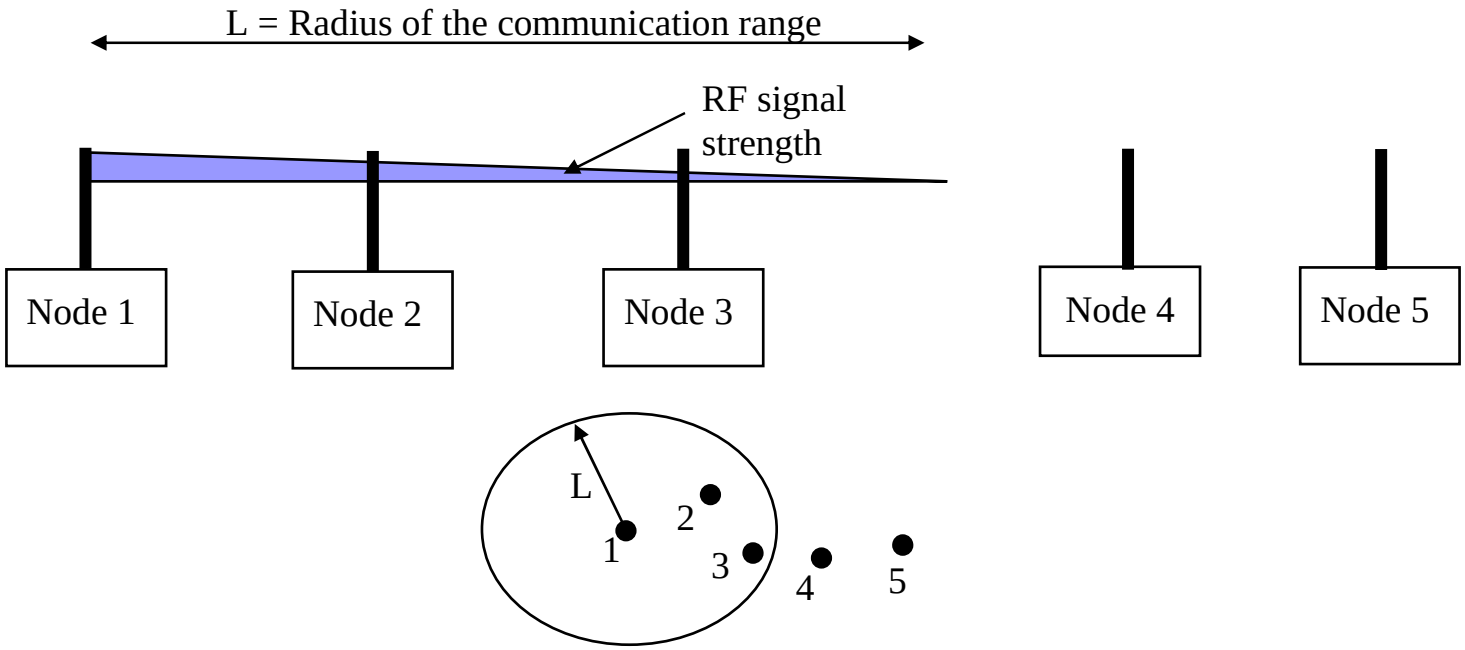
Physical layer

- **Special cases**
  - Some protocols require spatial coherence at the bit level (b=1 => Tx_rate < 1/2δ) (case of CAN)



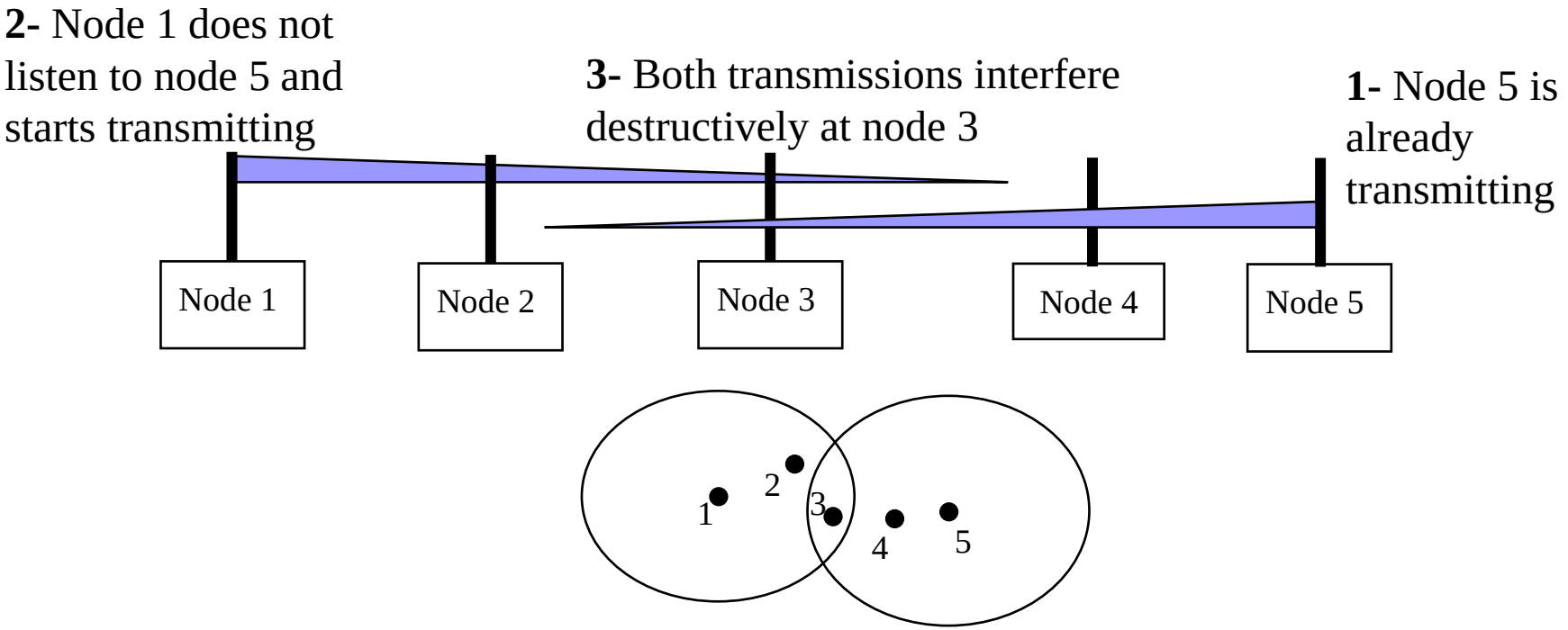
Physical layer

- **Special cases - wireless**
  - In wireless networks the **attenuation** is strong (even worse with obstacles) and transmissions from one node may not reach all nodes in the network.



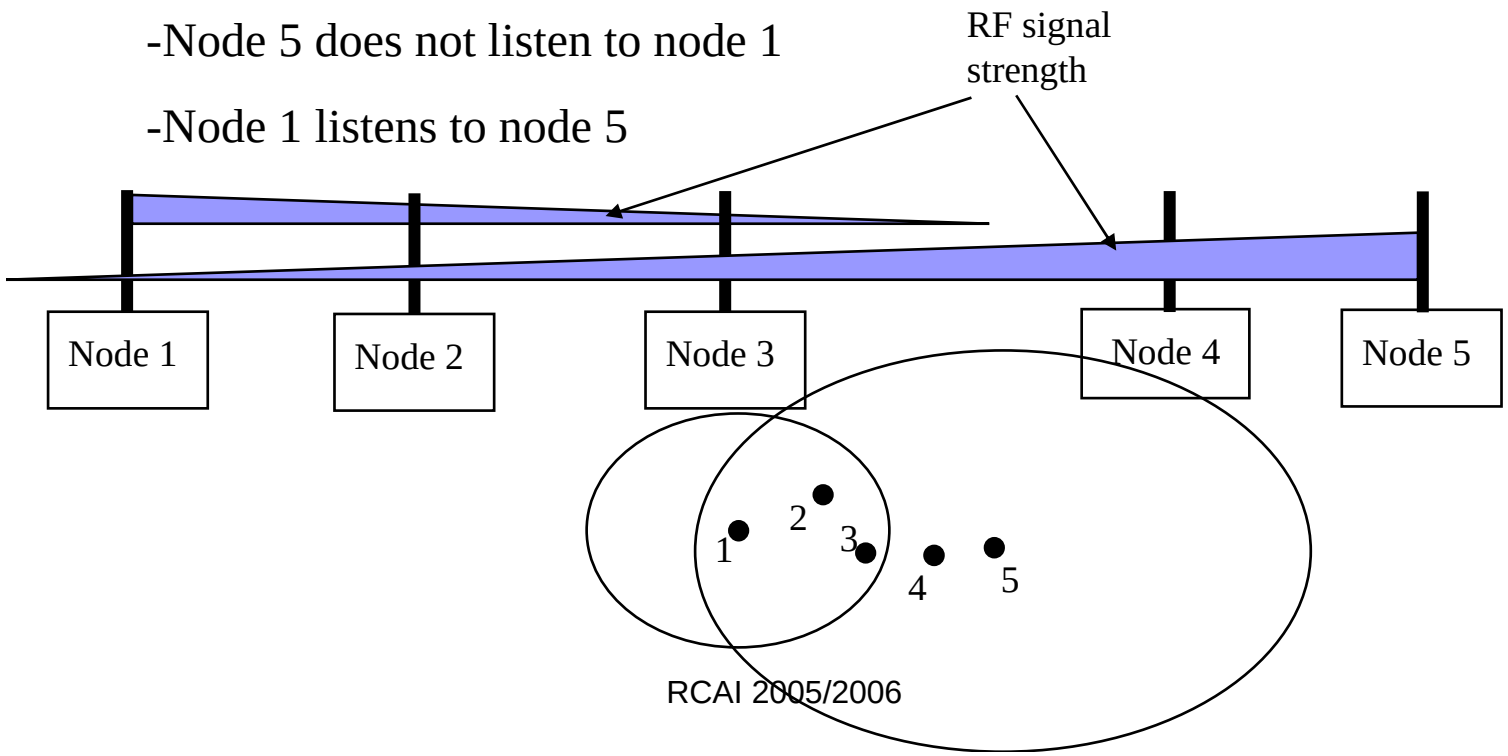
Physical layer

- **Special cases - wireless**
  - **Attenuation** is also responsible for a phenomenon called the **hidden node terminal** that jeopardizes transmission control based on carrier sensing



Physical layer

- **Special cases - wireless**
  - **Transmission power, antenna efficiency** and **local noise** deeply influences the communication range ➔ Differences cause **unidirectional** communication links



Physical layer

- **Detection of collisions**
  - In shared broadcast buses
    - If bit length **b=1**, **send 1 bit and listen**
    - If bit length **b>1**, it is not possible to relate the bit being transmitted with what is sensed on the bus. In this case a **jamming signal** is used
  - In **wireless** transmission it is not common to transmit and receive at the same time (expensive, requires multiple transceivers). **Collisions** can be sensed indirectly by means of **acknowledging**.

Summary:

- ✓ Network topologies comparison:
  - ✓ Mesh, Tree, Ring and Bus
- ✓ Physical medium
  - ✓ Copper, optical and wireless (IR & RF)
- ✓ Effects of the propagation delay in a bus
- ✓ Protocol efficiency in a bus
- ✓ Collision detection