

## Multiple Access

by David G. Messerschmitt

Supplementary section for Understanding Networked Applications: A First Course, Morgan Kaufmann, 1999.

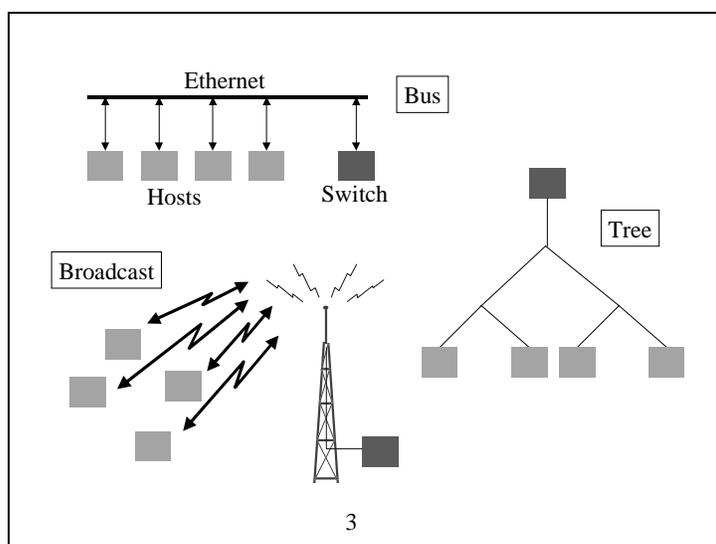
**Copyright notice:** Permission is granted to copy and distribute this material for educational purposes only, provided that this copyright notice remains attached.

The access links to the first packet switch are frequently not point-to-point as described in Chapter 18—rather, multiple hosts may share a *multiple access medium*. This means every packet transmitted by a host is received by all hosts as well as the access switch, and every packet transmitted by the access switch is received by every host.

**Analogy:** Consider a teacher (analogous to an access switch) in a classroom (analogous to the multiple access medium) with 30 students (analogous to the hosts). When the teacher says something, all students hear him. When a student speaks, all the other students as well as the teacher hear her.

Many media used for access are multiple access, including the three examples shown in Figure 1.. These include:

- *Bus*. The original Ethernet uses a single coaxial cable to which all hosts and an access switch are connected. Each time the switch transmits a packet on cable, all hosts receive it. Each time a host transmits a packet on the cable, not only the switch but all the other hosts receive it.
- *Broadcast*. A radio medium is inherently broadcast, meaning that all receivers can listen to all transmissions.
- *Tree*. The cable television coaxial cable is topologically a tree, with the television broadcaster at the root and the residences at the leaves. If this medium is used for packet transmission, hosts in every residence will receive all packets sent by a switch at the root. Like the coaxial Ether-



**Figure 1. Three network multiple access media.**

net, packets sent from one residence will be received by other residences.

In terms of the pattern of communication, all these examples are identical, in that all hosts receive packets transmitted by a switch, and all hosts (as well as the switch) receive packets transmitted by all other hosts.

A multiple access medium introduces several problems:

- The intended recipient must distinguish packets intended for it. Each recipient monitors packet header addresses and ignores packets not addressed to it.
- Since all hosts receive all transmissions, confidentiality is compromised unless encryption is used.
- The most difficult problem is *collisions*. If two or more senders decide to transmit packets concurrently, they typically destroy one another. (This is a severe form of interference.)

The collision problem can be handled by an appropriate protocol to coordinate the access to the medium. That protocol is called a *media access controller (MAC)*, and in a layered protocol architecture the MAC is one of the lowest layers. Examples of techniques used in the MAC are given in Table 1.

**Table 1 Common multiple access protocols.**

Protocol	Description	Analogy
Random access	Each host transmits a packet whenever it wants, without regard to the other hosts. Each host detects a collision and waits a random time before retransmitting (so the same two hosts don't collide again). A refinement (used in Ethernet) requires each host to listen for other packets being transmitted before transmitting its own.	People in a conversation coordinate themselves by trying to avoid talking at once. Each person listens to the conversation and tries to inject himself when others are silent.
Polling	The switch asks each host in turn if it has a packet to transmit. A given host can only transmit when it is authorized by the switch.	The students in a classroom raise their hands, and only talk when one is acknowledged by the teacher.
Token	In a variation on polling, a single token is passed among the hosts. Each host can transmit a packet when it has the token, and when finished forwards the token to another host. This approach is used in "token ring" local-area networks.	In a relay race, a baton is passed from one runner to another. Only the runner with the baton is allowed to run.
Reservation	Each host makes an advanced reservation with the switch before being allowed to transmit packets. The reservation is often made using a random access protocol in a special control channel. This approach is often used in satellite networks.	A doctor can see only one patient at a time, that patient determined by advanced reservation.

Multiple access techniques lower cost by sharing a communication medium over multiple hosts—

a form of statistical multiplexing with distributed control. However, for local-area networks there is a trend away from multiple access, driven by the user demand for more traffic-carrying capacity and easier upgrades and rearrangement.

**Example:** The Ethernet technologies are moving toward a *star topology*, in which there is a point-to-point metallic or optical link to the switch in a central equipment closet. This is done without affecting the network interface card in the host. It eliminates opportunities for sniffing, gives higher traffic capacity, and makes rearrangements and bitrate upgrades on a host-by-host basis simpler.

There are two major exceptions to the trend away from multiple access. The first is wireless, where there is no other option—the basestation will receive packets transmitted all hosts. The second is cable television Internet access, where there is a strong motivation to exploit the existing cable infrastructure in which a medium that is inherently broadcast.

## Discussion

D1 Think of some alternative approaches to a classroom with very inquisitive students that insure that only one student at a time gets to ask a question.

## Review

Many access communications use a shared medium with multiple access. This is inherent in wireless media, and a cost-reducing measure in cable television and local-area networks. A challenge in multiple access is arbitrating the contention of multiple senders, who are coordinated by a media-access layer protocol.

## Concepts

Multiple access

- Media access protocols
- Random access, polling, token passing, and reservation

## Further reading

[Abr92] is a treatise on multiple access techniques written by its premier inventor.

## Exercises

E1. Give one real-world analogy (not given in the chapter) to each of the following:

- The regenerative effect of digital communications
- Multiple access on a bus
- Interference to a radio transmission
- Packet collision on a multiple access medium
- Token access to a multiple access medium
- Reservation access to a multiple access medium

E2. Discuss the relative merits of random access, polling, and reservations under the following conditions:

- Light offered traffic
- Heavy offered traffic, where congestion instabilities might occur

- E3. Under what circumstances is reservation multiple access advantageous relative to polling? (Hint: Reservation multiple access is very popular in satellite networks.)
- E4. In a cable television multiple access medium used for internet access, devise a method that a service provider might use (using techniques described in Chapter 13) to assure customers of confidentiality and to prevent theft of service.