Wireless LAN, Mobile Internet Connectivity, and Personal Area Network

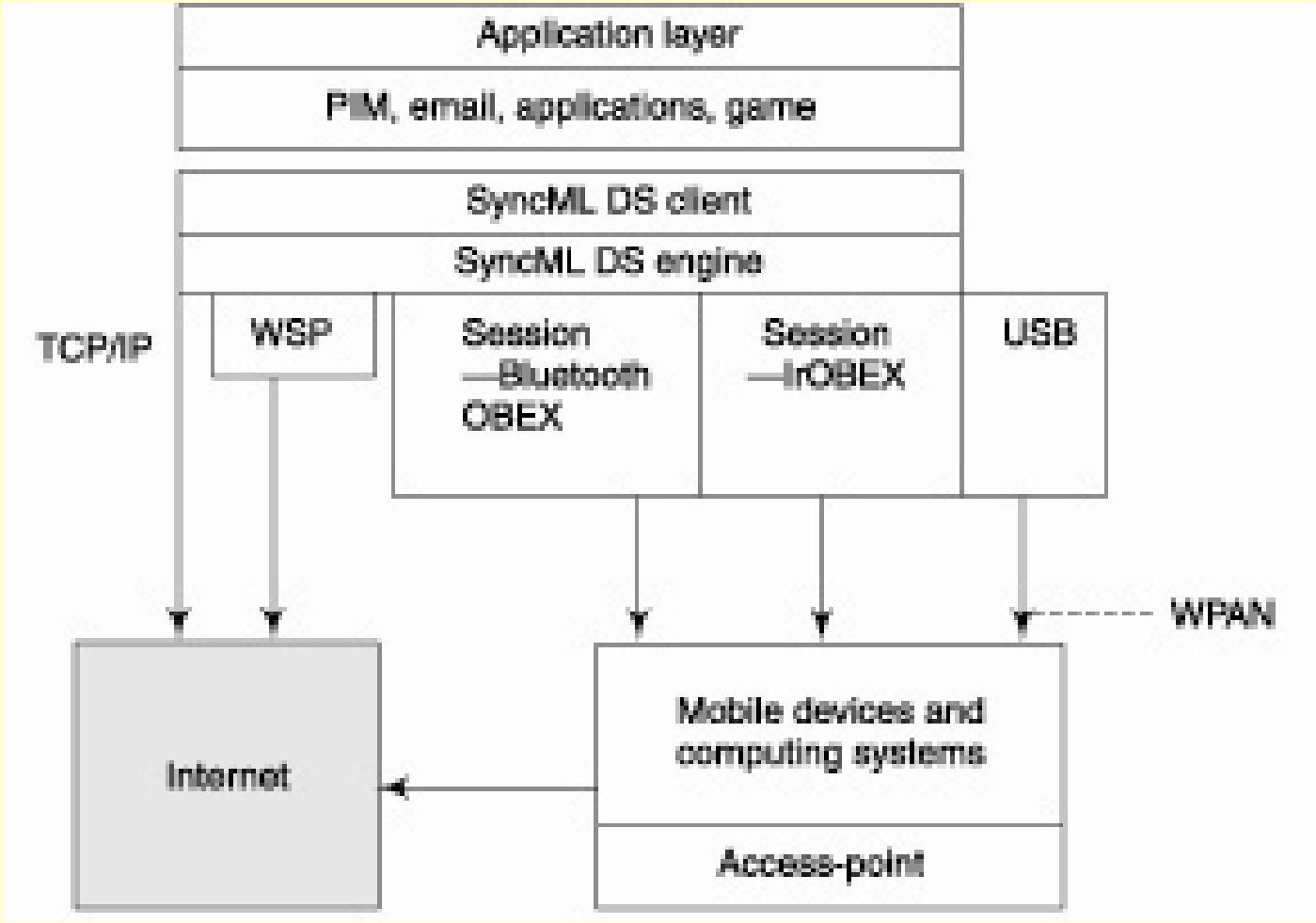
Lesson 07

Bluetooth Enabled Devices Network

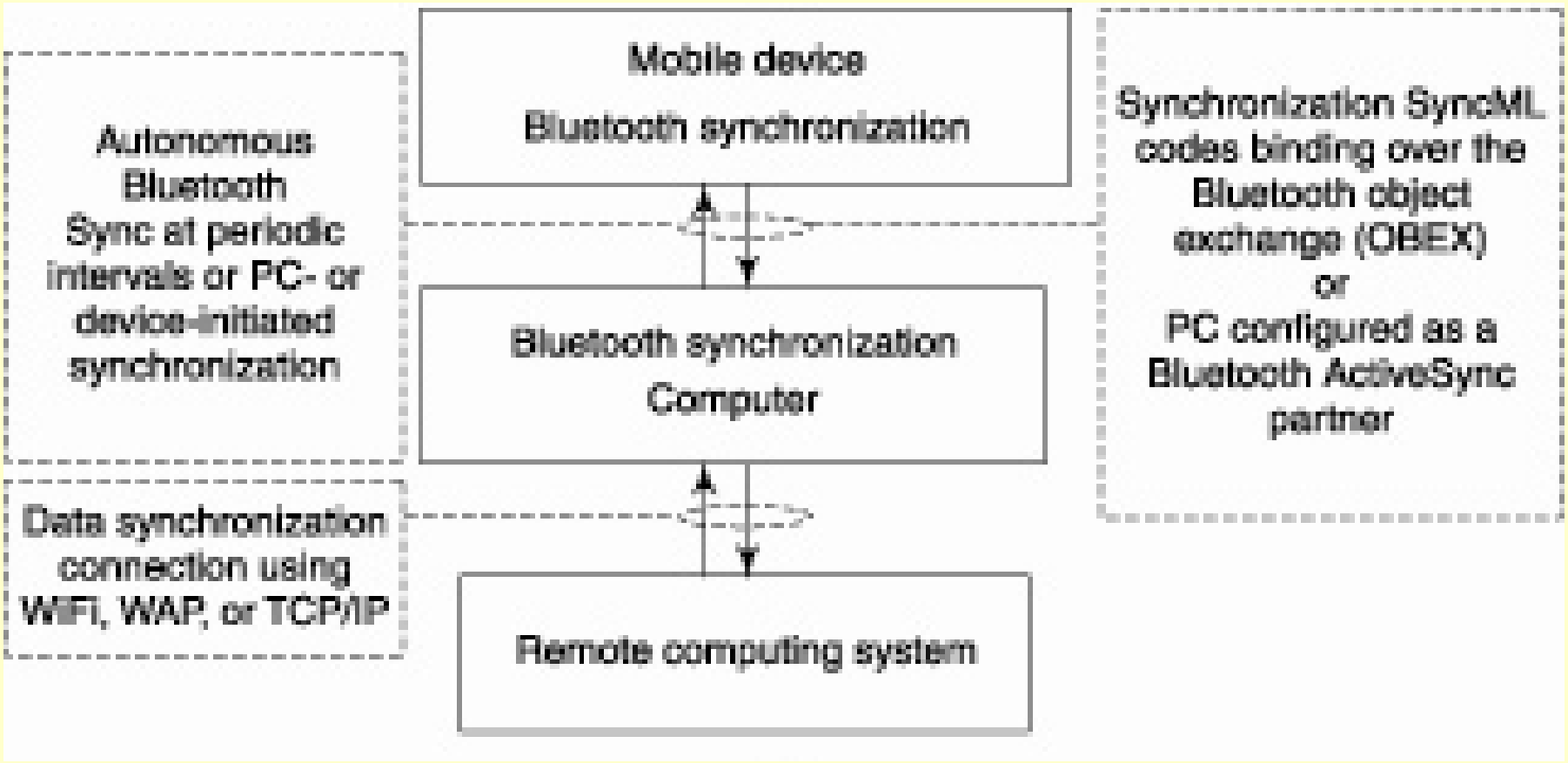
Bluetooth

- Derived from the name of a Danish king
- The king Harald Blatand which means Bluetooth in English reigned before 1000 A.D.

Data synchronisation between the mobile devices and computing systems in a WPAN



Synchronisation of remote system with the Bluetooth devices



Bluetooth devices network

- Any device can function as master or slave
- The device which first establishes a piconet becomes master and others which discover the master become slaves in the piconet
- Slave means that the clock of the master functions as reference for synchronization

Master

- Synchronizes all active devices and there are identical hopping sequences of their frequencies for each device's radio (transmitter)
- A hopping sequence defines one channel
- There can be a maximum of eight devices with a master in piconet and a maximum of 79 channels in Bluetooth networks

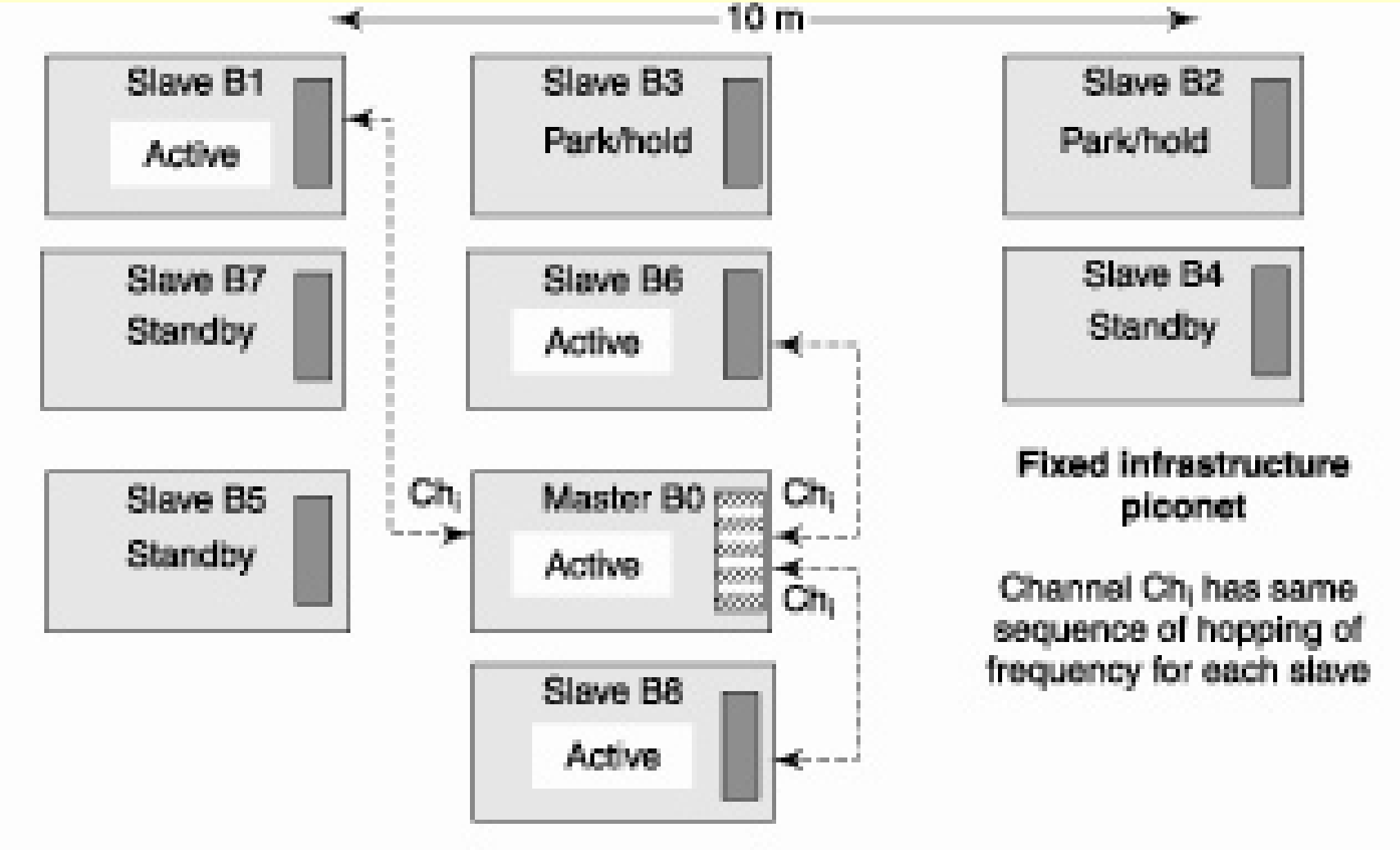
Piconet and scatternet

- Piconet– Bluetooth devices network with the devices within a distance of about 10 m
- Scatternet– an ad-hoc network formed by various piconets within 100 m through a Bluetooth-enabled bridging device

Example of Piconet of 3 active Bluetooth devices and a master

- Each device synchronised and using same hopping sequence of their frequencies forming a fixed infrastructure network architecture
- Two are in park/hold state and Three are in standby mode

Piconet of 3 active Bluetooth devices and a master



State of devices in a piconet

- Standby
- Active
- Park
- Hold
- Sniff

Standby

- Waiting to discover the master and thus the piconet
- No RF signal communication is taking place)
- Device is yet to be assigned an address in the piconet

Active state– one of the three modes

(a) Inquiring– (carrying out discovery broadcasting in all neighbourhood and listening to the response for finding out a radio channel to connect

(b) Paging – sending a page specifying the relationship with master after discovering the channel

Active state– one of the three modes

(c) Connected and performing data transactions–

- When a device is discovered and becomes an active device
- 3 bit address called AMA (active member address) assigned by the master device
- 000 reserved for use when a broadcast to all active devices takes place

Active state device

- Listens the data in the piconet at short intervals
- The messages are transmitted sixteen hundred times in one second

Park state

- Device already discovered the piconet
- But not communicating at present
- Is held in power-saving mode
- Assigned a 3 bit address called PMA (parked member address) after being released of the AMA
- Retained as a member of piconet
- To save power, it reduces duty cycle of the bit rate (clock frequency)

Hold state

- Hold state retains the AMA but suspends asynchronous connectionless link (ACL)
- It maintains synchronous connection oriented (SCO) link
- Reduces power dissipation for communication in this piconet when there are no packet exchanges with the master

Sniff state

- Retains the AMA
- Operates at high power level
- Sniffing means listening to the existing Bluetooth device in the vicinity
- Sniffs the data of communicating piconet at large programmable intervals as compared to active state short intervals

Example

1. At t_0: A Bluetooth device B0 discovers a device B1 within 10 m
2. At t_1: Then the devices B2, B3, B6, and B8 also reach within 10 m and join the network

Example

- At t_2: After some time, since B2 and B3 are not exchanging objects, they go to park state to save the power
- At t_3: After some time, the devices B7, B5, B4, B9, and B10 move in sequence within 10 m but they have to discover the network

The states, devices, AMAs, PMAs in the piconet

- After t_0: B0 will function as master in the piconet as it first discovered the device B1 in its vicinity
- After t_1: Slaves B1, B6, and B8 will be in active (either inquire, page, or connected) states, master can assign AMAs 001, 100, and 111

The states, devices, AMAs, PMAs in the piconet

- After t_2: Slaves B2 and B3 are in park state, PMAs can be 001 and 010
- After t_3: B7, B5, and B4 are in standby mode waiting to discover the service network, yet to be assigned member address by the master

Other piconet outside the Piconet

- B9 and B10 cannot be a part of this piconet and will form another piconet operating at another channel with another sequence of frequency hops

Master and slave devices moving out to another piconet

- Master becomes slave in a new piconet
- When it moves to another established piconet, the communication in the previous piconet freezes

Master and slave devices moving out to another piconet

- The device which rediscovers another device then becomes master in the previous piconet
- When a slave moves to another area, it communicates its unavailability to its master
- It then synchronizes with a new piconet

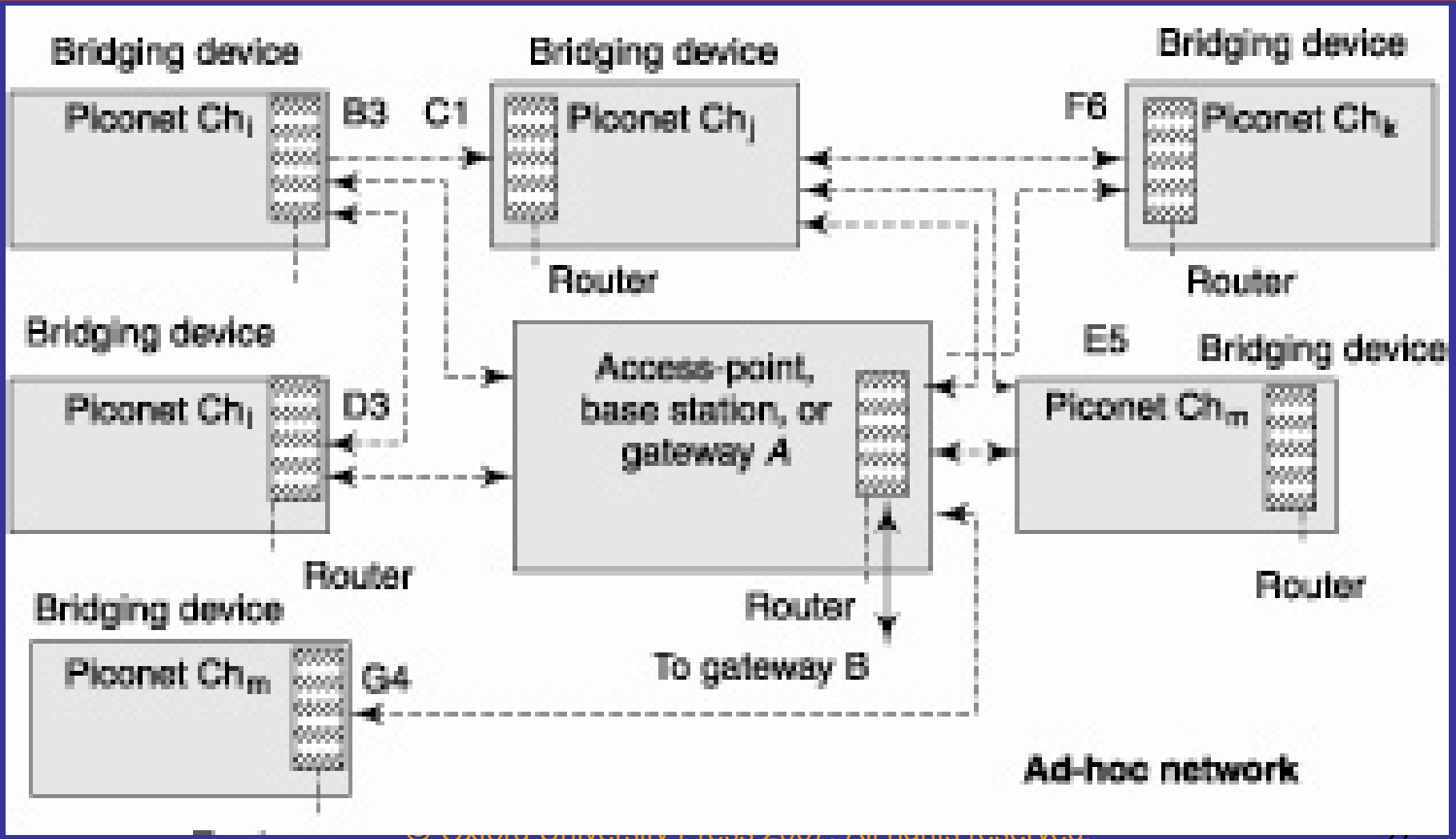
Scatternet

- An ad-hoc network formed by the bridging devices
- A bridging device connects two piconets
- Any Bluetooth device can function as a bridge in order to form the ad-hoc network
- In such a network, two devices in two piconets communicate as in a peer-to-peer communication

Scatternet

- The two devices use two different channels (two different hopping sequences from among the 79 provided)
- Each piconet uses FH-CDMA so that there is a distinct hopping sequence with respect to other piconets in the scatternet
- Therefore, there are no collisions between signals in two piconets

Bluetooth devices ad-hoc network (scatternet) through bridging devices



Ad-hoc network architecture of Bluetooth-enabled devices

- Formed by the bridging devices
- Six piconets consisting of the devices B0, …, B7, C0, …, C7, D0, …, D7, E0, …, E7, F0, …, F7, and G0, …, G7
- Scatternet forms with B3, C1, D3, E5, F6, and G4 as bridging devices

Summary

- Bluetooth devices network
- Piconet– within about 10 m
- Standby, Active, Park, Hold, Sniff states
- Scatternet– an ad-hoc network formed by various piconets within 100 m
- Bridging Devices between the piconets

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…Summary

- Any device can function as master or slave, first establishing device in a piconet becomes master
- Maximum of eight devices with a master in piconet
- Maximum of 79 channels in Bluetooth networks

End of Lesson 07

Bluetooth Enabled Devices Network