



# Lecture (03)

## Circuit switching

---

Dr. Ahmed ElShafee

1

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

## Agenda

---

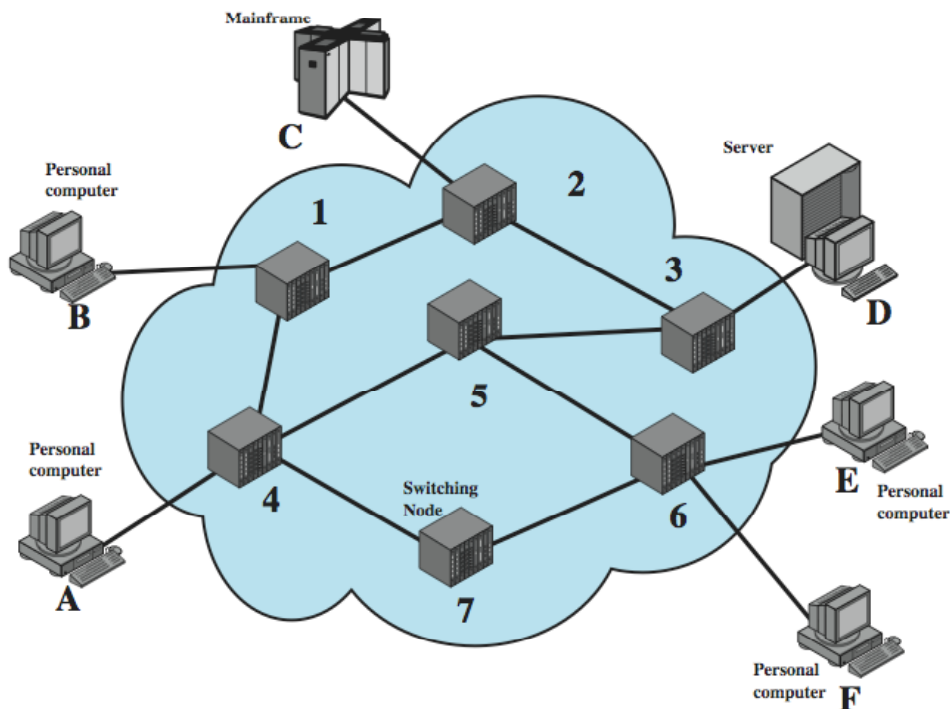
- Switched communication network
- Circuit switching technology

2

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

# switched communication network

---



3

## switched communication network (cont,..)

---

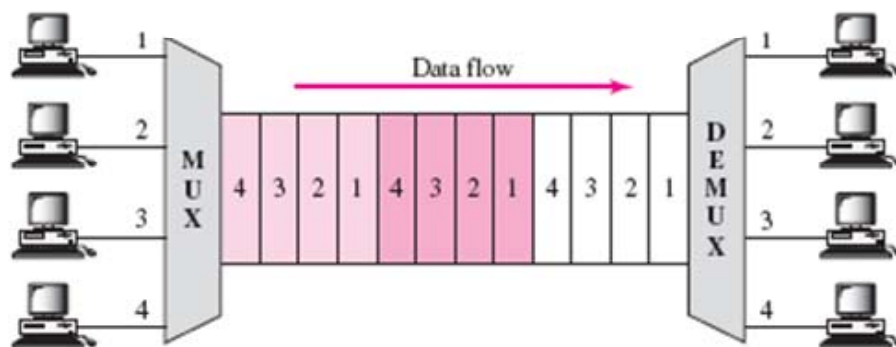
### Terminologies:

- For transmission of data beyond a local area, communication is achieved by transmitting data from source to destination through a network of intermediate switching nodes;
- The switching nodes are not concerned with the content of the data their purpose is to provide a switching facility that will move the data from node to node until they reach their destination.
- **Stations:** The devices attached to the network, computers, terminals, telephones, or other communicating devices
- **Node:** switching devices whose purpose is to provide communication
- **transmission links:** connection between nodes and terminals

## switched communication network (cont,..)

- Node-node links are usually multiplexed, using either frequency division multiplexing (FDM) or time division multiplexing (TDM).

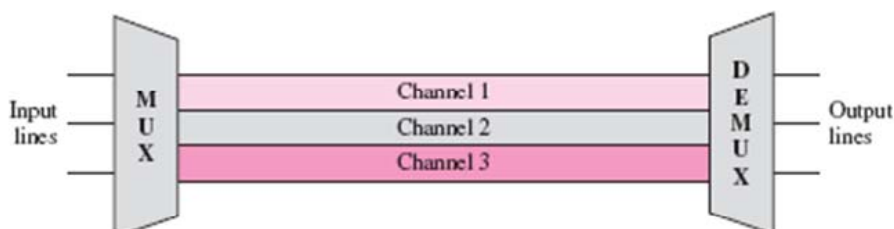
### *TDM*



Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

## switched communication network (cont,..)

### *Frequency-division multiplexing*



Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

# switched communication network (cont,..)

---

## *How it works?*

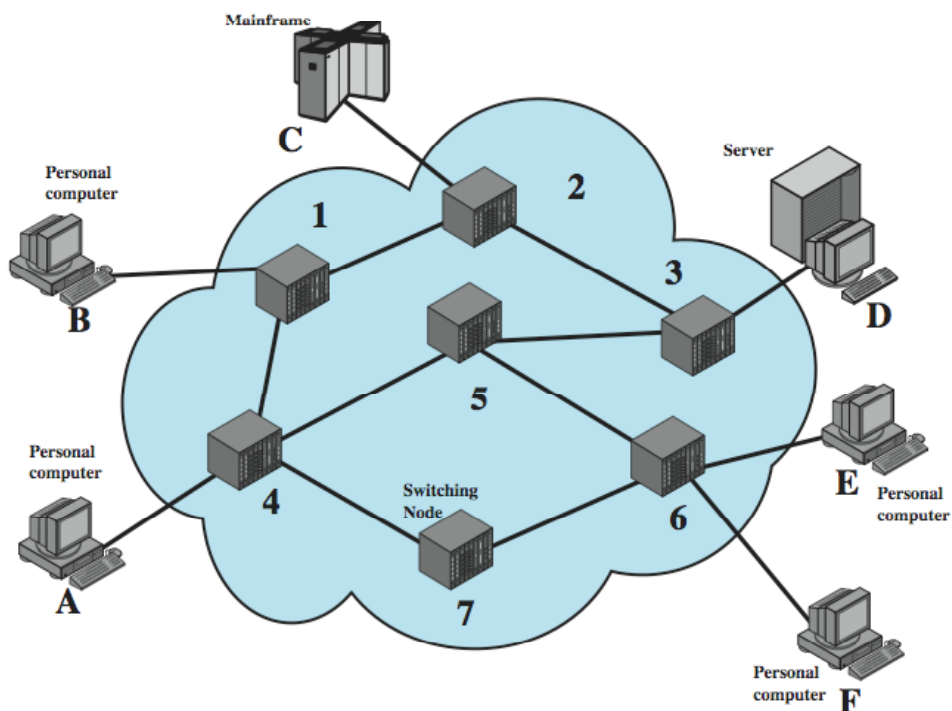
- data entering the network from a station are routed to the destination by being switched from node to node.
- data from station A intended for station F are sent to node 4.
- They may then be routed via nodes 5 and 6 or nodes 7 and 6 to the destination.

7

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

# switched communication network (cont,..)

---



8

# switched communication network (cont,..)

---

## Topology:

- Each station attaches to a node
- Some nodes connect only to other nodes (eg., 5 and 7 on previous slide). (sole task is the internal (to the network) switching of data.)
- Other nodes have one or more stations attached as well (such nodes accept data from and deliver data to the attached stations.)
- It's recommended that each connection has more than one possible path through the network for each pair of stations.
- This enhances the reliability of the network.

# switched communication network (cont,..)

---

## Switching technologies

- Two different technologies are used in wide area switched networks: circuit switching and packet switching.
- These two technologies differ in the way the nodes switch information from one link to another on the way from source to destination.

# Circuit switching technology

---

- there is a dedicated communication path between two stations.
- That path is a connected sequence of links between network nodes.
- On each physical link, a logical channel is dedicated to the connection.
- Communication via circuit switching involves three phases:
  - **Circuit establishment**
  - **Data transfer**
  - **Circuit disconnect**

## Circuit switching technology (cont,..)

---

### **Circuit establishment –**

- Before any signals can be transmitted, an end-to-end (station-to-station) circuit must be established.

### **Data transfer –**

- Data can now be transmitted through the network between these two stations.
- The transmission may be analog or digital, depending on the nature of the network.
- As the carriers evolve to fully integrated digital networks, the use of digital (binary) transmission for both voice and data is becoming the dominant method.
- Generally, the connection is full duplex.

## Circuit switching technology (cont,..)

---

### **Circuit disconnect –**

- After some period of data transfer, the connection is terminated, usually by the action of one of the two stations.
- Signals must be propagated to the intermediate nodes to deallocate the dedicated resources.

## Circuit switching technology (cont,..)

---

### **Disadvantages**

- Circuit switching inefficient.
- Channel capacity is dedicated for the duration of a connection, even if no data are being transferred
- For a voice connection, utilization may be rather high, but it still does not approach 100%.
- For a client/server or terminal-to-computer connection, the capacity may be idle during most of the time of the connection.
- there is a delay prior to signal transfer for call establishment.

# Circuit switching technology (cont,..)

---

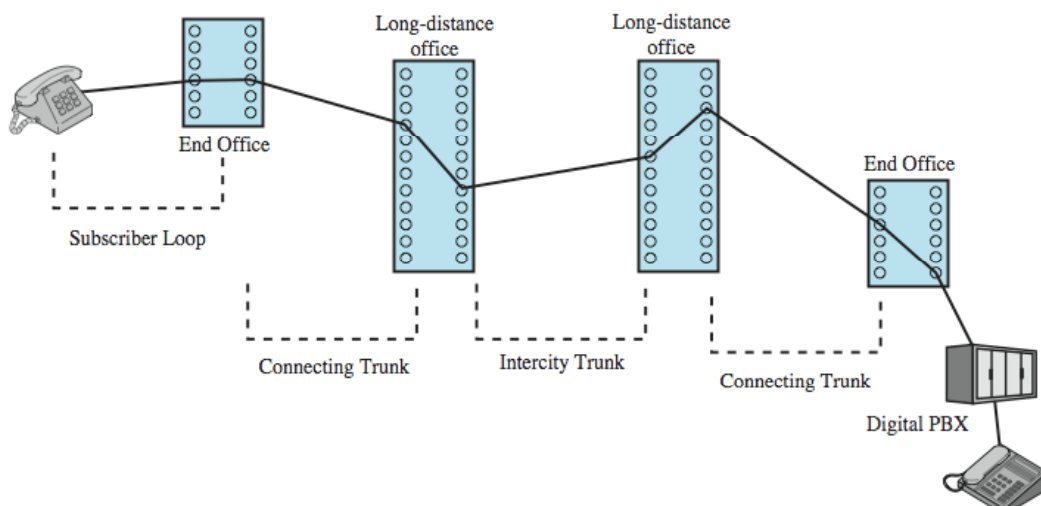
## Advantages

However, once the circuit is established, the network is effectively transparent to the users.

# Circuit switching technology (cont,..)

---

## Public Switched Telephone network





## Circuit switching technology (cont,..)

---

- Circuit switching was developed to handle voice traffic but is now also used for data traffic.
- The best-known example of a circuit-switching network is the public telephone network
- collection of national networks interconnected to form the international service.
- A public telecommunications network can be described using four generic architectural components:

## Circuit switching technology (cont,..)

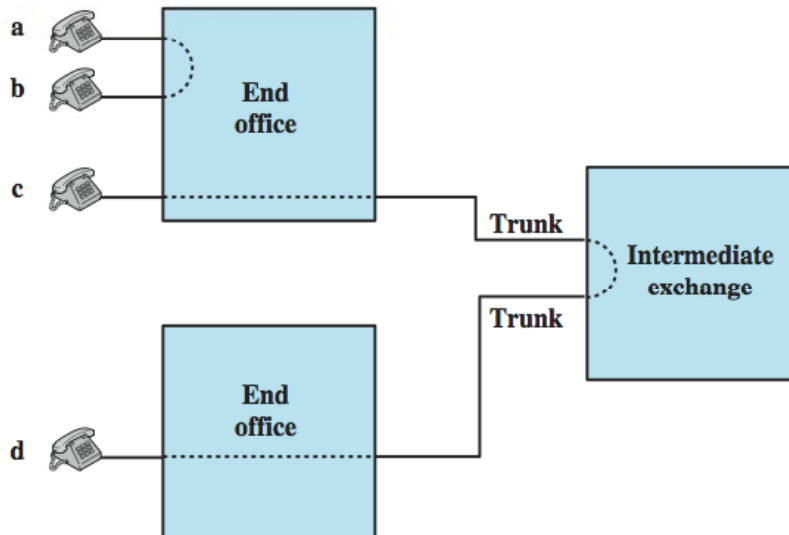
---

- **Subscribers:** The devices that attach to the network, typically telephones, percentage of data traffic increases year by year.
- **Subscriber line:** The link between the subscriber and the network, also referred to as the ***subscriber loop** or **local loop***, mostly using twisted-pair wire.
- **Exchanges:** The switching centers in the network. A switching center that directly supports subscribers is known as an end office.
- **Trunks:** The branches between exchanges. Trunks carry multiple voice frequency circuits using either FDM or synchronous TDM

# Circuit switching technology (cont,..)

---

## Circuit Establishment



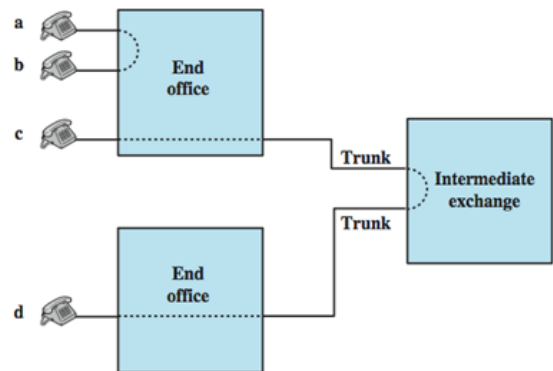
# Circuit switching technology (cont,..)

---

- Subscribers connect directly to an end office, which switches traffic between subscribers and between a subscriber and other exchanges.
- The other exchanges are responsible for routing and switching traffic between end offices.
- To connect two subscribers attached to the same end office, a circuit is set up between them.
- If two subscribers connect to different end offices, a circuit between them consists of a chain of circuits through one or more intermediate offices.

## Circuit switching technology (cont,..)

- “a” connection is established between lines “a” and “b” by simply setting up the connection through the end office.
- The connection between “c” and “d” is more complex.
- In “c”'s end office, a connection is established between line “c” and one channel on a TDM trunk to the intermediate switch.
- In the intermediate switch, that channel is connected to a channel on a TDM trunk to “d”'s end office. In that end office, the channel is connected to line d.



21

Dr. Ahmed ElShafee, ACU Spring 20

## Circuit switching technology (cont,..)

### key requirements for voice traffic

- there must be virtually no transmission delay
- certainly no variation in delay.
- A constant signal transmission rate must be maintained
- The quality of the received signal must be sufficiently high to provide, at a minimum, intelligibility.

These requirements are necessary to allow normal human conversation.

22

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

# Circuit switching technology (cont,..)

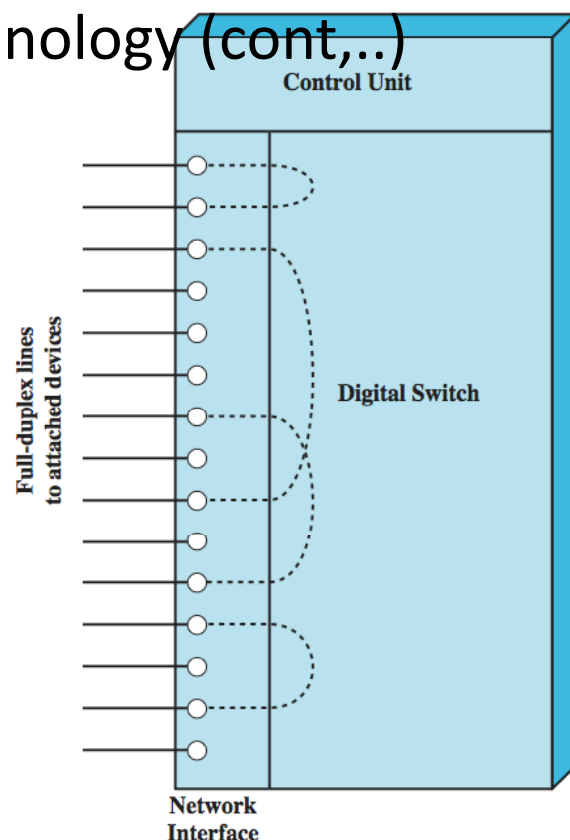
## Conclusion

- Circuit switching , well suited to the analog transmission of voice signals
- In today's digital world, Circuit switching is inefficient , although
- Circuit switching will remain an attractive choice for both local area and wide area networking.

# Circuit switching technology (cont,..)

## Circuit Switch Elements (digital switch)

- A network built around a single circuit-switching node consists of a collection of stations attached to a central switching unit.
- The central switch establishes a dedicated path between any two devices that wish to communicate.



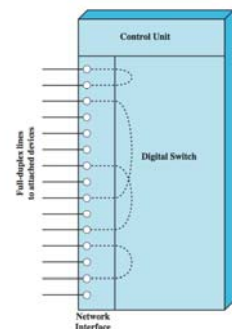
# Circuit switching technology (cont,..)

- The dotted lines inside the switch symbolize the connections that are currently active.

- The heart of a modern system is a **digital switch**.

## digital switch

- The function is to provide a transparent signal path between any pair of attached devices.
- The path is transparent to the attached pair of devices that there is a direct connection between them.
- connection must allow full-duplex transmission.



25

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

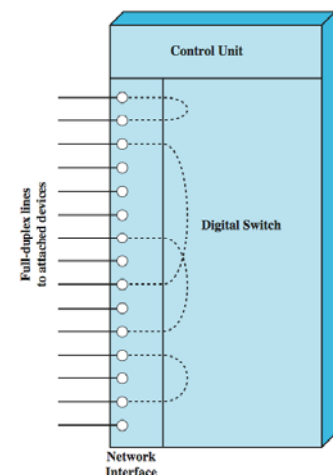
# Circuit switching technology (c

## Components

- network interface
- Control unit

### 1. network interface

- element represents the functions and hardware needed to connect digital devices, such as data processing devices and digital telephones, to the network.
- Analog telephones can also be attached if the network interface contains the logic for converting to digital signals.
- Trunks to other digital switches carry TDM signals and provide the links for constructing multiple-node networks.



26

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

# Circuit switching technology (cont,..)

---

## 2. control unit

performs three general tasks:

1. Establishes connections; as requested by the attached device.
2. Maintains the connection; because the digital switch uses time division principles, this may require ongoing manipulation of the switching elements.
3. Tear down the connection; either in response to a request from one of the parties or for its own reasons.

# Circuit switching technology (cont,..)

---

## Blocking and non-blocking characteristic :

- Blocking occurs when the network is unable to connect two stations because all possible paths between them are already in use.
- nonblocking network permits all stations to be connected (in pairs) at once and grants all possible connection requests as long as the called party is free.

## Voice network point of view:

- When a network is supporting only voice traffic, a blocking configuration is generally acceptable, because it is expected that most phone calls are of short duration and that therefore only a fraction of the telephones will be engaged at any time.

# Circuit switching technology (cont,..)

---

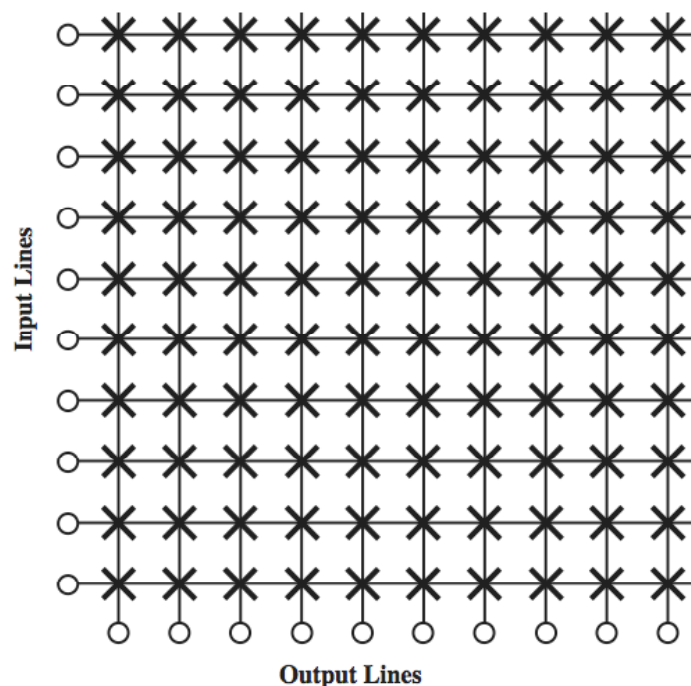
## Data network point of view:

- Not accepted, as data entry application, a terminal may be continuously connected to a computer for hours at a time.
- Specially if some sensitive operation is performed like money transfer (ATM machine and bank server)
- for data applications, there is a requirement for a no blocking or "nearly no blocking" (very low probability of blocking) configuration.

# Circuit switching technology (cont,..)

---

## Space Division Switch



## Circuit switching technology (cont,..)

---

- Space division switching was originally developed for the analog environment and has been carried over into the digital realm.
- Each connection requires the establishment of a physical path through the switch that is dedicated solely to the transfer of signals between the two endpoints.
- The basic building block of the switch is a metallic crosspoint or semiconductor gate that can be enabled and disabled by a control unit.
- Figure shows simple crossbar matrix with 10 full duplex I/O lines.

## Circuit switching technology (cont,..)

---

- The matrix has 10 inputs and 10 outputs; each station attaches to the matrix via one input and one output line.
- Interconnection is possible between any two lines by enabling the appropriate cross point.
- Note that a total of 100 cross points is required.



# Circuit switching technology (cont,..)

---

## Advantages

- Non blocking system
- Simple control scheme

# Circuit switching technology (cont,..)

---

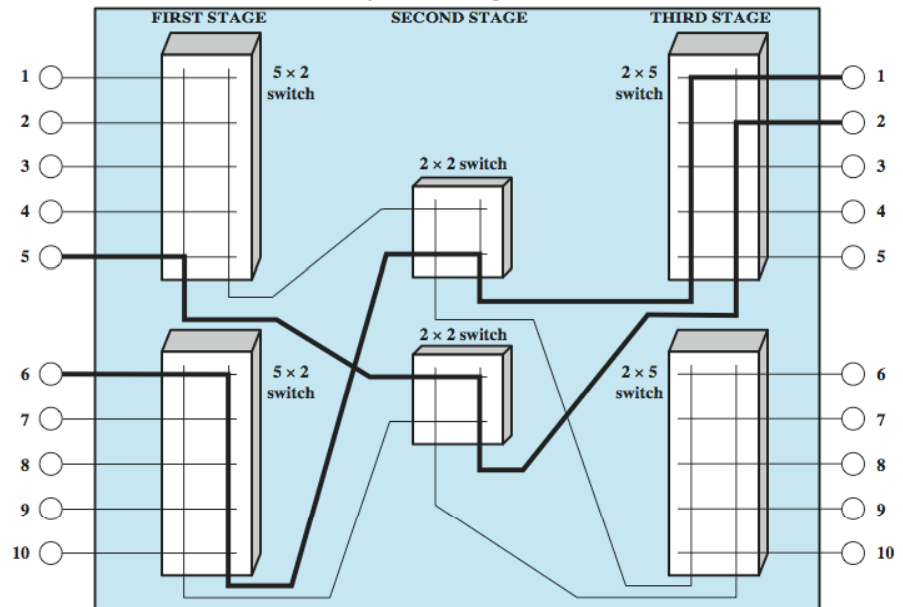
## Disadvantages

- The number of cross points grows with the square of the number of attached stations.
- This is costly for a large switch.
- The loss of a cross point prevents connection between the two devices whose lines intersect at that cross point.
- The cross points are inefficiently utilized; even when all of the attached devices are active, only a small fraction of the cross points are engaged.

# Circuit switching technology (cont,..)

## multiple-stage switches

- To overcome these limitations, multiple-stage switches are employed.



35

# Circuit switching technology (cont,..)

## Advantages

1. The number of cross points is reduced,
  2. increasing crossbar utilization.
  3. Multiple paths/connections
- In the example, the total number of cross points for 10 stations is reduced from 100 to 48.
  - There is more than one path through the network to connect two endpoints, increasing reliability.

36

# Circuit switching technology (cont,..)

## Disadvantages:

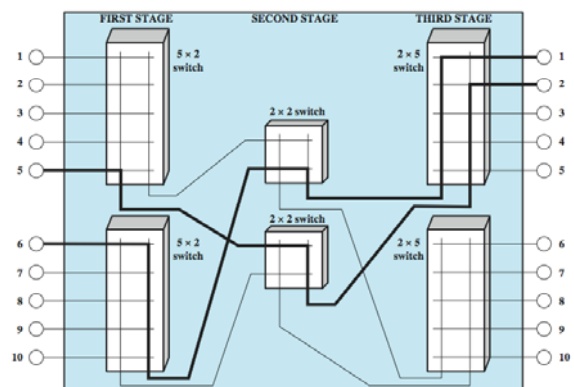
- System have some blocking probability.
- requires a more complex control scheme (free path through the stages must be determined and the appropriate gates enabled).

37

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

# Circuit switching technology (cont,..)

- The heavier lines indicate the lines that are already in use.
- In this state, input line 10, for example, cannot be connected to output line 3, 4, or 5, even though all of these output lines are available.
- A multiple-stage switch can be made non-blocking by increasing the number or size of the intermediate switches, but of course this increases the cost.



38

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

# Circuit switching technology (cont,..)

## Time Division Switching

- Instead of relatively dumb space division systems, modern digital systems rely on intelligent control of space and time division elements.
- Virtually all modern circuit switches use virtual time division techniques for establishing and maintaining "circuits."
- Time division switching involves the partitioning of a lower-speed bit stream into pieces that share a higher-speed stream with other bit streams.
- The individual pieces, or slots, are manipulated by control logic to route data from input to output.

39

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

# Circuit switching technology (cont,..)

*TDM*



40

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I

## Circuit switching technology (cont,..)

---

### Soft switches:

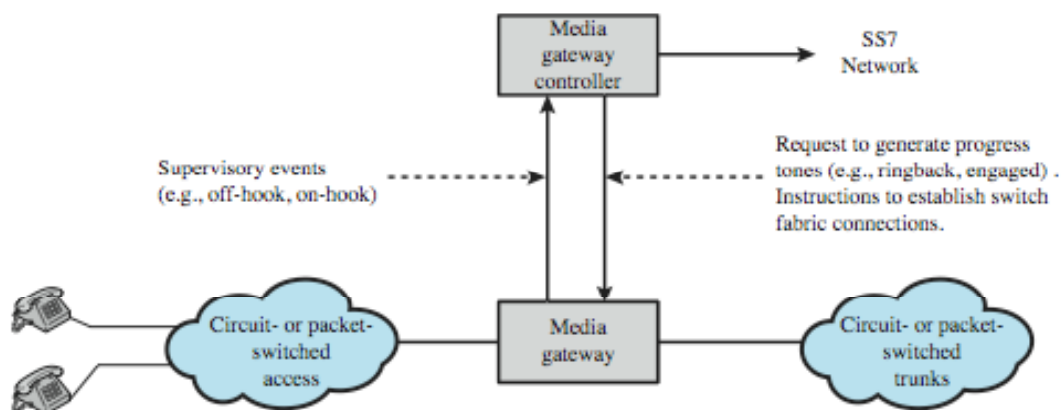
A soft switch is a central device in a telecommunications network which connects telephone calls from one phone line to another phone line or terminal PC, typically via the internet, entirely by means of software running on a computer system.

This work was formerly carried out by hardware, with physical switchboards to route the calls.

generally it handles IP-to-IP phone calls,

## Circuit switching technology (cont,..)

---



(b) Softswitch architecture

# Circuit switching technology (cont,..)

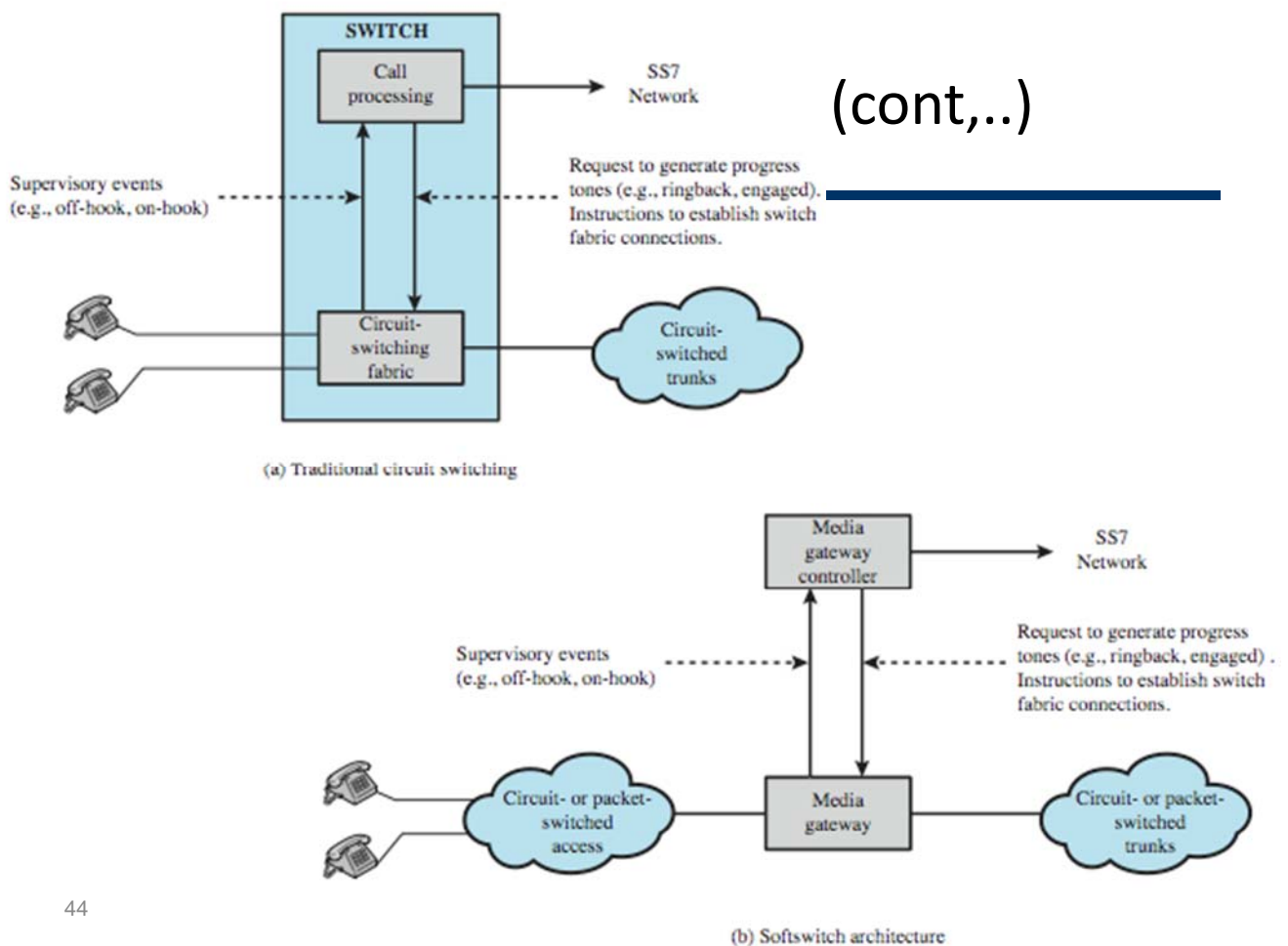
**Soft switch consists of two components:**

**Media gateway:** which is the equivalent software version of physical/ virtual connection matrix.

**Media gateway controller:** which is the equivalent software version of switch controller.

43

Dr. Ahmed ElShafee, ACU Spring 2011, Networks I



44

---

Thanks,...