CSIS 625 Week 10
Switching, ISDN

Overview

- Switching
  - Circuit Switching
    - Space
    - Time division
  - Packet Switching
    - Datagram
    - Virtual circuit
- ISDN - Integrated Services Digital Network

Switching (generic)

- A switched network has both end stations or nodes and switching nodes.
- Switching nodes may connect to
  - only other switching nodes -or-
  - other switching nodes and end stations
- Connections between switching nodes can handle multiple circuits or sessions using TDM or FDM
- Often not enough resources in the network for all nodes to be communicating simultaneously.

Switching (generic)

- Switching nodes don't have direct connections to all other switching nodes
- Usually there is more than one way to get between any two switching nodes
  - This improves reliability
- Circuit switching is common in the public telephony networks
- Packet switching is common in data networks.
- Latency - the amount of time it takes a signal to propagate from one node to another.
- Jitter - the amount of variance in the latency

Circuit Switching

- Circuit Switching - A dedicated path is established between two stations for communication
- Once a connection is established it appears to the attached devices as if they are directly connected.
- Switching and transmission resources are reserved for the exclusive use of the circuit for the duration of the connection.

Circuit Switching Networks

- Communication over a dedicated path has 3 parts to it
  - Circuit establishment
  - Data Transfer
  - Circuit disconnect

Circuit Lifespan

- Circuit Establishment
  - Node has to signal to switching nodes who it wants to talk to.
  - Switching node finds and establishes path through network
  - Success or failure of circuit setup is communicated back to originating node
- Data transfer
  - typically full duplex communication of data
- Circuit disconnect
  - Both ends informed of disconnect and resources in network released for another user.

Circuit Switching - pros & cons

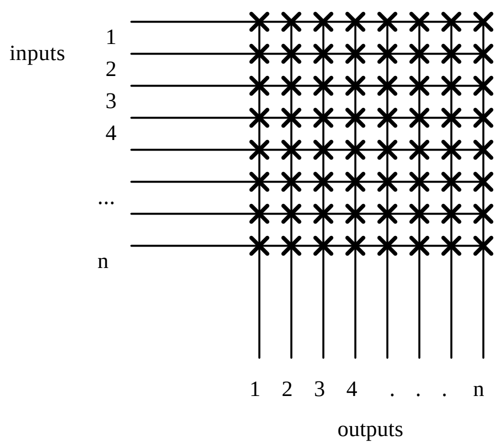
- Pathway in place even if data isn't being sent
  - Not the best efficiency
- There may be some delay in getting a circuit set up, but once done the
  - latency is typically minimal
  - jitter is very small

Space Division Switches

- Space division switching uses space to separate the paths of different circuits
- Cross bar switches have n inputs and m outputs and a switch at every intersection
  - needs n * m switches
- Multistage switches
  - Use multiple smaller crossbar switches

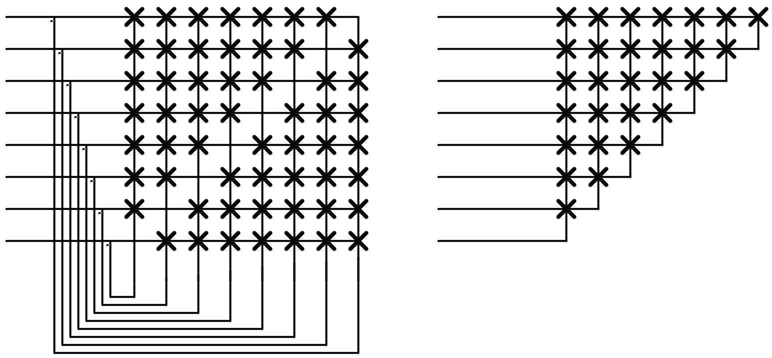
Cross bar switches

- Simplest cross bar has n inputs and m outputs



Folded Cross bar switch

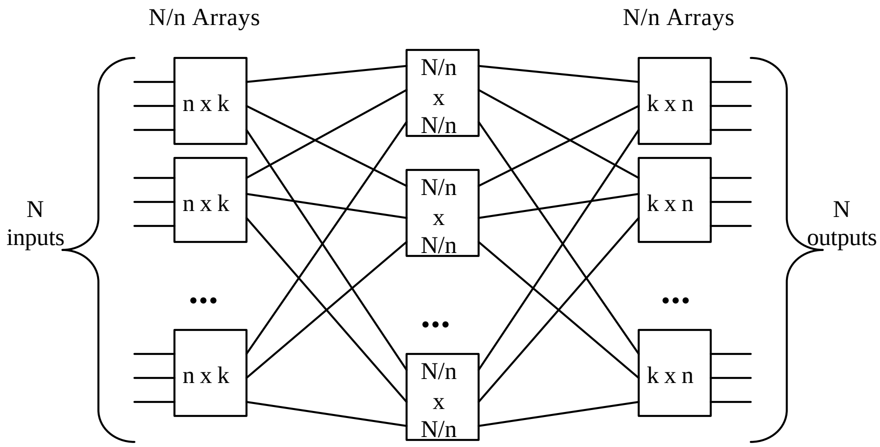
- A folded cross bar switch has inputs and outputs wrapped around to allow full duplex any to any connections.



Multi stage switches

- Combine multiple smaller crossbar switches
- May be blocking or non-blocking based on number of input lines and stages and size of different stages
- Also called Clos switches after Charles Clos of Bell Laboratories who published analysis of these type of switches
- Usually has multiple paths increasing reliability of equipment

Three stage switch Example



Multi-stage switches pros and cons

- Allows for a far greater number of lines to be serviced with a far smaller number of cross connect switches
- If blocking is allowable, even smaller number of switches

Number of Lines	Number of switches for Single Stage Switch	Number of switches for three stage non-blocking switch	Number of switches for three stage, blocking prob=0.002 and input usage of 10%
128	16,256	7,680	2,560
512	261,632	63,488	14,336
2048	4.2 million	516,096	81,920
32768	1 billion	33 million	3.1 million

Time Division circuit switches

- By using TDM techniques, switching can be achieved
- Time-slot Interchange (TSI) technique
  - Mux and demux on ends with the TSI in the middle
  - The TSI buffers all inputs and then re-sends it in a different output
- TDM bus technique
  - Mux and demux are "smart" and can take any timeslot to any I/O port

Time Division pros and cons

- With higher clocking speeds possible with modern silicon, it is possible to build TDM switches much larger and cheaper than crossbar switches
- The clock rates after the TDM operation may get very high when high speed inputs or high number of inputs are used.

Circuit Switches - combinations

- For very large circuit switches a combination of TDM and crossbar switches is often the best.
- Multiple stage switches using different techniques in different stages

Packet Switching

- Packet Switching - a packet of data is transferred from one node to another
- Packet switching is designed to be more efficient for data than circuit switching.
- Datagram Packet Switching - Each packet of data is treated independently from all others
- Virtual Circuit Packet Switching - all packets of data that are part of a session are sent via a single route

Packet switching

- Packets allow for greater usage of trunks between nodes
  - Packets may be queued and transmitted as quickly as possible
  - May create more latency and much more jitter than circuit switched systems
  - Unused Bandwidth in circuit switched networks can be used.
- On circuit switched networks, calls may be blocked, but on packet switching the packets are just delayed

Packet switching - prioritization

- In packet switched networks, some packets can be given higher priority than others.
- This allows for those packets to be sent before lower priority ones reducing their latency and jitter.
- May allow for some packets to be sent different (faster) paths than others.

Datagram packet switching

- Every packet is treated independently.
- Every switching node must examine every packets destination and decide on where to send it next.
- If any node disappears it takes with it a few packets, but data keeps flowing.

Virtual circuit packet switching

- A path is set up that each packet between two nodes always follows the same path
- Makes switching node's job easier because it always knows where to send a packet to next.
- If any node disappears, that session must be torn down and a new one created

Virtual circuit types

- Switched virtual circuit - a virtual circuit is set up for each session independantly
  - Requires a circuit setup before data flows
  - Adds to time required to transfer a message
- Permanent virtual circuit
  - Requires provisioning of path when creating network.
  - May mean that any node failure requires human intervention.

ISDN - Integrated Services Digital Network

- What is ISDN?
  - Circuit-switched digital network
    - In reality, extension of T hierarchy to the subscriber
  - A misfired attempt by the circuit-switched network operators (TELCOs) to get on the "data" bandwagon
    - Implemented based on carrier's perceptions of customer needs
    - Total user panacea (based on TELCO view)
  - Designed to provide fully integrated digital services to the user
    - Broadband, nonswitched
    - Broadband, switched
    - Packet switched
    - Signalling
      - Per-call, per-customer feature selection

ISDN

- ISDN service categories
  - Bearer services
    - Transparent network services (no content modification)
    - Based on the first 3 layers of OSI model
    - Well defined in ISDN standard
    - Provided using circuit-switched, packet-switched, frame relay or cell relay networks
  - Teleservices
    - Correspond to layers 4-7 of OSI model
    - Include telephony, teletex, telefax, videotex, telex, teleconferencing – named, but not standardized
    - Rely on bearer services, accommodate complex user needs
  - Supplementary services
    - Reverse charging
    - Message handling
    - Call waiting
    - Other telecom services

Brief history of ISDN

- Initially, phone networks were analog
  - Local loops were analog as well
  - Modems were developed to allow digital communication over analog networks
- Analog and digital services to subscribers
  - Transition to digital services is gradual
  - Analog services remain in place
  - Customer classification emerged
    - Traditional POT users
    - Modem users
    - Digital service users

Brief history of ISDN

- Integrated Digital Networks - IDN
  - Created to meet customer demands
  - Combination of networks available for different needs
  - Access to IDN
    - Analog local loop
    - Digital local loop (Switched/56)
    - High-speed dedicated pipes (leased lines)
- ISDN
  - Integrates IDN with customer services
  - Replaces Analog Local Loop with digital subscriber loop
    - Voice transmission is digitized at the source
    - Voice, data and digital video can thus be send over any digital network (provided it is capable of handling it)
    - All services are digital, available on customer demand
    - **ISDN also introduced unified, standardized interface for all the services**

Subscriber access to ISDN

- To support flexibility (and sell-ability), ISDN defines 3 channel types of different sizes
  - Bearer – 64 Kbps (clear-channel DS0)
    - Basic user channel
    - Carries any type of digital information in full-duplex mode
    - Supports multiplexing (non-addressable)
    - Carries data end-to-end
  - Data – 16 or 64 Kbps (DS0 or fractional DS0)
    - Carries control information for B channels
      - Implements common-channel signaling
      - Carries control signals for all channels in the given path
      - Used to connect to the network and allocate a B channel
  - Hybrid channels
    - High data rate channels – 384 Kbps, 1536 (H11) Kbps, 1920 Kbps (H12)

Subscriber access to ISDN

- User Interfaces
  - Basic Rate Interface (BRI)
    - 2B+D
      - » 2 B channels (initially 1)
      - » 1 16Kbps D channel
      - » 48 Kbps O/H (sometimes)
    - Total: 192 Kbps
    - All can be used combined, for 192 Kbps pipe with in-channel signalling
    - Designed to meet residential and small (tiny) business offices
    - Line conditioning may be necessary, twisted pair is used

Subscriber access to ISDN

- User Interfaces
  - Primary Rate Interface (PRI)
    - 23 B channels
    - 1 64Kbps D channel
    - 8 Kbps overhead
    - Total: 1.544 Mbps -- Low and behold, a T1 Line!
    - All travel in a single path to an ISDN office
    - PRI can be divided into many different combinations
    - D channel is used to allocate network capacity accordingly

Subscriber Access to ISDN

- Access Device Functional Grouping
  - ISDN defines only functional behavior of each group
    - Network Terminations
      - Type 1
      - Type 2
    - Terminal Equipment
      - Type 1
      - Type 2
    - Terminal Adapters

ISDN Access Devices

- Network Termination 1 (NT1)
  - Controls physical and electrical termination of ISDN at user's premises (ISDN Demarc)
    - Organizes data from user devices into frames
    - Translates frames received from the network for consumption by user devices
    - Performs functions comparable to those defined in OSI Layer 1
  - Performs functions of byte interleaving, but is not a true MUX
    - Synchronizes data stream with frame building process such that multiplexing occurs "automagically"
    - In effect, NT1 is an "implicit" multiplexor

ISDN Access Devices

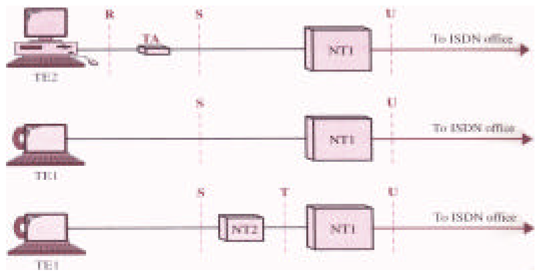
- Network Termination 2 (NT2)
  - Provides functions defined at the physical, data link and network layers of OSI
  - Performs multiplexing, flow control and packetizing
  - Provides intermediate signal processing between data generating devices and NT1
  - Can be implemented in a number of equipment types
    - PBXs
      - Can perform explicit multiplexing
    - LAN devices

ISDN Access Devices

- Terminal Equipment
  - Carries the same semantics as DTE in other protocols
- Terminal Equipment 1 (TE1)
  - ISDN-enabled peripherals
    - Digital phones
    - Integrated voice/data terminals
- Terminal Equipment 2 (TE2)
  - Non-ISDN communications equipment
  - Not compatible with ISDN network
  - Requires Terminal Adapter (TA) to connect to ISDN network
- Terminal Adapter (TA)
  - Interface for non-ISDN equipment

ISDN Access Devices

- ISDN Reference Points
  - Used to identify interfaces between individual ISDN devices
  - R – connection between a TE2 and TA
  - S – connection between a TA or TE1 and NT1 or NT2
  - T – connection between NT2 and NT1
  - U – connection between NT1 and ISDN office



Physical Layer

- Defined by I.430 (BRI) and I.431 (PRI)
  - Define mechanical and electrical specs for interfaces
  - Define encoding
  - Multiplexing
  - Power supply (levels, local vs. network, etc)

BRI Physical Level specifications

- R interface
  - Not defined by ISDN
    - EIA-232, EIA-449, X.21, etc. can be used
- S interface
  - ISO 8887
    - 4, 6 or 8 wire connections
    - Only 4 wires are necessary for FDX transmission, the rest are power-related
  - Pseudoternary signal encoding
    - Version of Bipolar AMI with 0 and 1 levels reversed
    - Single twisted-pair in each direction
- U interface
  - Twisted Pair
  - 2B1Q encoding (four voltage levels, dibits)

BRI Frame

- During each frame:
  - Each B channel is sampled twice (8 bits per sample)
  - D channel is sampled four times (1 bit per sample)
  - The rest of the frame is used for overhead
  - Entire frame, 48 bits, consists of 32 bits for B channel, 4 bits for D channel, 12 bits of overhead
- BRI Topology
  - Can be supported by either Bus or Star topology
  - Distance between devices and NT1 is limited
    - 1000 meters for point-to-point connection
    - 200 meters for multipoint connection
    - Restriction necessary to ensure frame sync – NT1 is not a real MUX
  - Up to 8 devices can be connected to NT1
    - Only 2 can access B channels simultaneously
  - Access to D channel is negotiated through mechanism similar to CSMA

PRI Frame

- B and D channels are multiplexed using STDM to create a PRI frame
- PRI frame is identical to T1 line frame
- Connection and topology considerations are similar to BRI

Data Link Layer

- B Channel
  - Uses LAPB protocol
- D channel
  - Uses LAPD – Link Access Procedure for D channel
    - HDLC with few modifications
      - Acknowledged (w/Sequence Numbering)
      - Unacknowledged (w/o Sequence Numbering)
      - 2-byte addressing
      - 6-bit Service Access Point Identifier
      - TEI – unique address of the TE

Network Layer

- In ISDN, network-layer packet is called a message
  - Encapsulated in LAPD I-frame for transport
  - Contains
    - Protocol Discriminator
      - Identifies protocol in use
    - Call Reference
      - Sequence number of the call
    - Message Type
      - Identifies the purpose of the message
    - Information Elements
      - Specific details about the connection
        - » Either single-byte or multi-byte
      - Addressing is one of IE types
        - » 55 digits