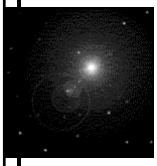
**CS 4/54201 Computer**

**Communication Network**


# Kent State University

Dept. of Computer Science

www.mcs.kent.edu/~javed/class-NET06F/

A Course on Networking and

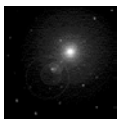
# Computer Communication

# ATM CELL SWITCHING



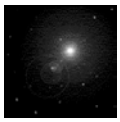
## Cells

- ATM (*Asynchronous Transfer Mode*) is a connection-oriented, packet switched network.
- Governed by ATM Forum.
- The objective was to develop a technology which can serve various forms of applications.
- At the heart of this technology lies the concept of fixed sized packets called cells.



# Why Fixed Length Packets?

- Easier to Build Hardware Switches:
  - Easier to build hardware to do simple task.
  - Processing of task is simple if the length is known.
- Scalability:
  - If all thew jobs are of same size, parallel switching elements can be built.
- Improved Queueing Behavior
  - fixed delay per packet.
  - Smaller queue

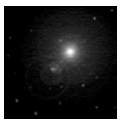






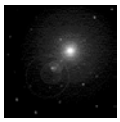
# Example

- Packet size 4KB. Link speed is 100 Mbps.
  - Time to transmit = 4096x8 /100=327.68 microsec.
  - A high priority packet may have to wait that long.
  - Jitter is even more problematic.
  - In contrast a 53 byte packet will take 4.24 microsec.
- Queue Size
  - A queue need to receive the full packet, before it can forward it.
  - For two 4KB packets, it have to wait 327.68 microsec before it can start sending even the first byte.
  - For two 4KB data divided into ATM cells, the first byte can leave the switch right after 4.24 microsec.



# What Should be the Right Size?

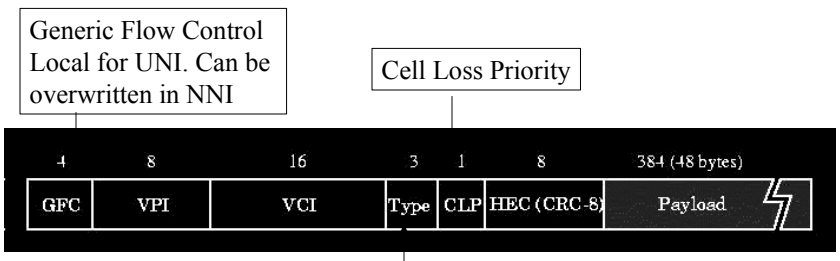
- Too short packet means:
  - too many headers, low channel utilization.
  - Too much work for network adapter.
- Too big a packet means:
  - long delay.
  - Voice samples are 64Kbps ( 8 bits x8 KHz)
  - 1 byte is sampled in every 125 microsec.
  - For 1KB packet it will take 125ms to fill up the packet.
  - Too long for voice..
- Compromise:
  - 32+64/2 = 48 bytes



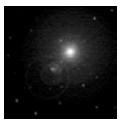




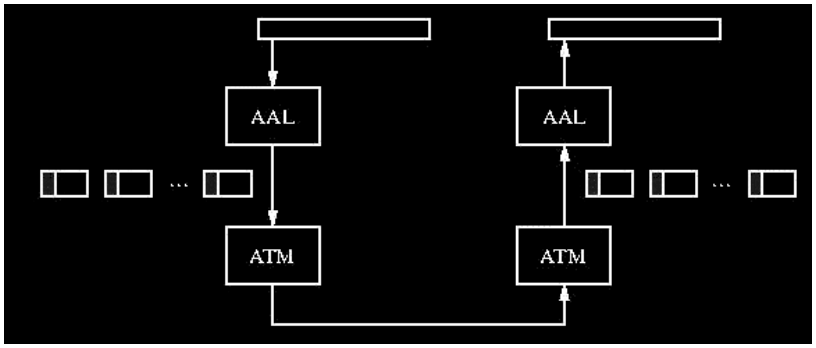
# Cell Format (UNI)

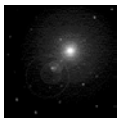



| Payload type | Meaning |
|---|---|
| 000 | User data cell, no congestion, cell type 0 |
| 001 | User data cell, no congestion, cell type 1 |
| 010 | User data cell, congestion experienced, cell type 0 |
| 011 | User data cell, congestion experienced, cell type 1 |
| 100 | Maintenance information between adjacent switches |
| 101 | Maintenance information between source and destination switches |
| 110 | Resource Management cell (used for ABR congestion control) |
| 111 | Reserved for future function |



# Segmentation and Reassembly



COMPUTER COMMUNICATION NETWORK



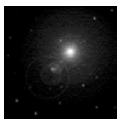
# AAL 3/4 PDU

CPI: CS Version

Buffer Allocation Size

Length


Btag: Begin of PDU
Etag: End of PDU
Should be same.



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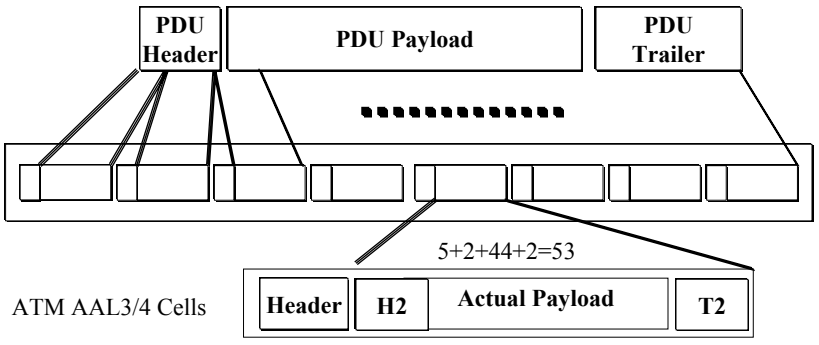
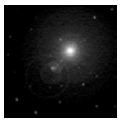
# AAL3/4 Packing



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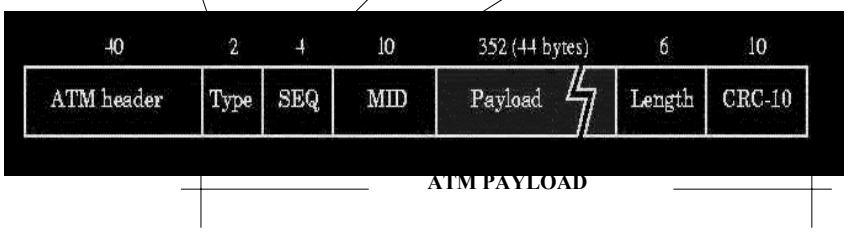
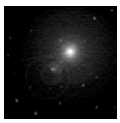
# AAL 3/4 ATM CELL

Type:
10: Begin of Message
00: Continuation
01: End of message
11: Single Segment Message

Sequence

Multiplexing Identifier



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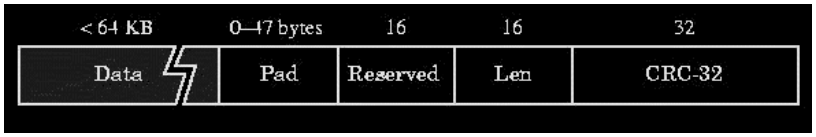
# ATM AAL5 PDU



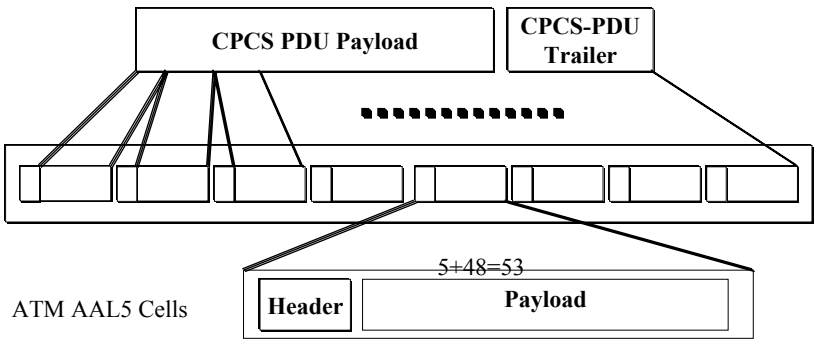

- Simpler Format
- No Multiplexing
- SAR is done via 1 bit 'User Signaling' field.
- CRC-32 is more powerful. 16 lost packets can be trapped. While 4 bit sequence number cannot.

AAL 3/4 PDU

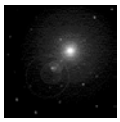




# Data Packing



# Connection Setup



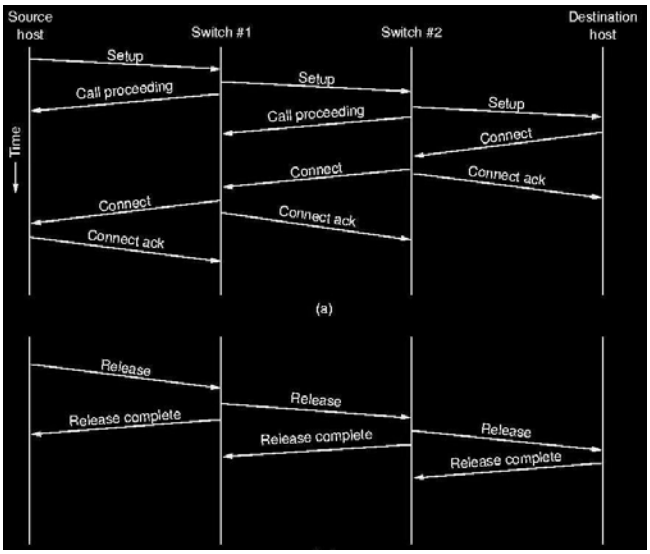


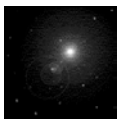
- Acquire a Virtual Circuit (VC) for signaling. Generally VP:VC =0:5 is used for sending such request.
- The protocol uses following six messages:

| Message | Meaning when sent by host | Meaning when sent by network |
|---|---|---|
| SETUP | Please establish a circuit | Incoming call |
| CALL PROCEEDING | I saw the incoming call | Your call request will be attempted |
| CONNECT | I accept the incoming call | Your call request was accepted |
| CONNECT ACK | Thanks for accepting | Thanks for making the call |
| RELEASE | Please terminate the call | The other side has had enough |
| RELEASE COMPLETE | Ack for RELEASE | Ack for RELEASE |

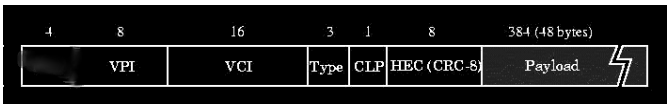


# ATM Connection Setup & Release

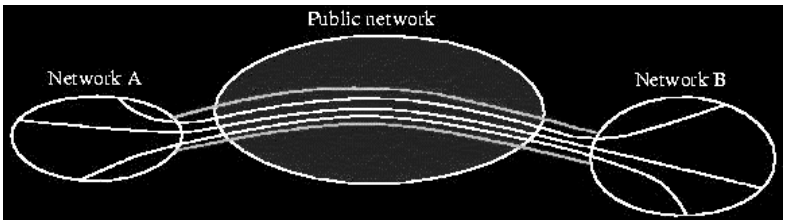


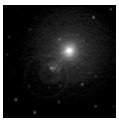



# Addressing




- Local Switches use VCI (16 bits)
- Public Network Switches only use VPI. (12 bits)
  - Simpler public routing
  - Smaller public routing table.



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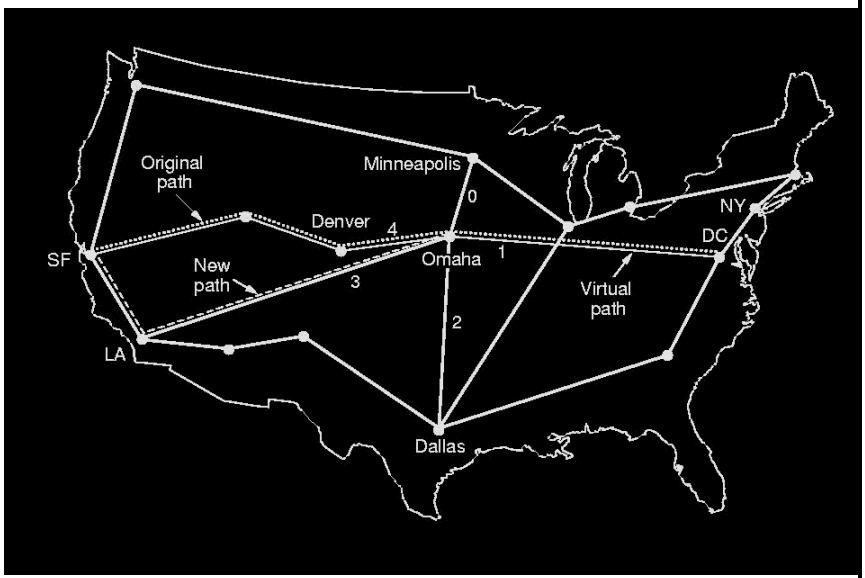
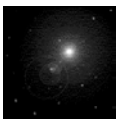
# Routing



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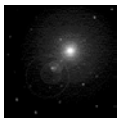
# Some Routes Through Omaha Switch

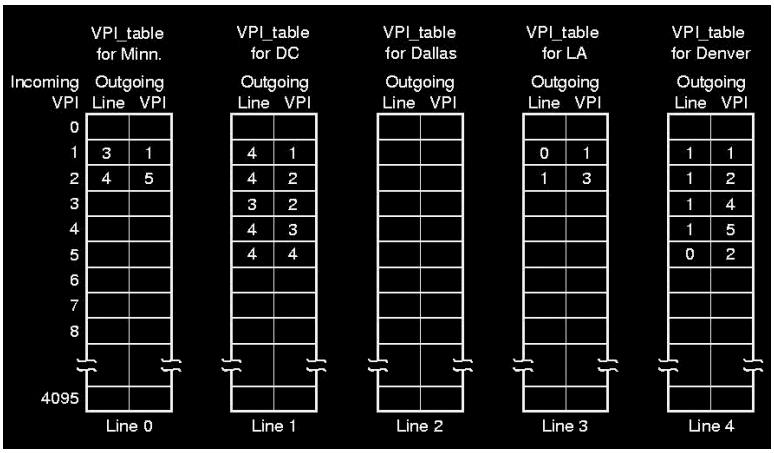
| Source | Incoming line | Incoming VPI | Destination | Outgoing line | Outgoing VPI | Path: |
|---|---|---|---|---|---|---|
| NY | 1 | 1 | SF | 4 | 1 | New |
| NY | 1 | 2 | Denver | 4 | 2 | New |
| LA | 3 | 1 | Minneapolis | 0 | 1 | New |
| DC | 1 | 3 | LA | 3 | 2 | New |
| NY | 1 | 1 | SF | 4 | 1 | Old |
| SF | 4 | 3 | DC | 1 | 4 | New |
| DC | 1 | 5 | SF | 4 | 4 | New |
| NY | 1 | 2 | Denver | 4 | 2 | Old |
| SF | 4 | 5 | Minneapolis | 0 | 2 | New |
| NY | 1 | 1 | SF | 4 | 1 | Old |

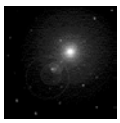




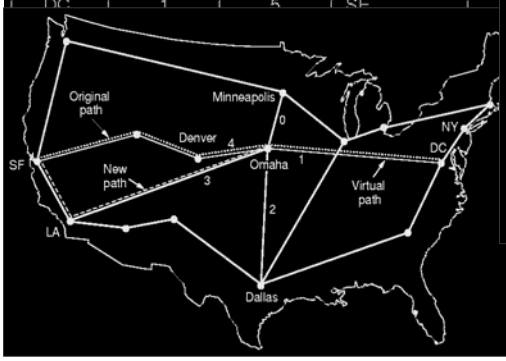


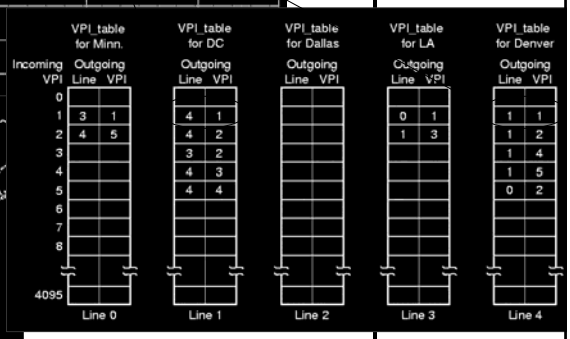
# The VPI Tables



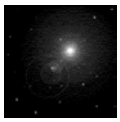



| Source | Incoming line | Incoming VPI | Destina-tion | Outgoing line | Outgoing VPI | Path: |
|---|---|---|---|---|---|---|
| NY | 1 | 1 | SF | 4 | 1 | New |
| NY | 1 | 2 | Denver | 4 | 2 | New |
| LA | 3 | 1 | Minneapolis | 0 | 1 | New |
| DC | 1 | 3 | LA | 3 | 2 | New |
| NY | 1 | 1 | SF | | | |
| SF | 4 | 3 | DC | | | |
| DC | 1 | 5 | SF | | | |




For every path there are two VPI_table entries.



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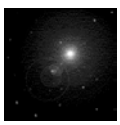
# Service Categories

| Class | Description | Example |
|---|---|---|
| CBR | Constant bit rate | T1 circuit |
| RT-VBR | Variable bit rate: real time | Real-time videoconferencing |
| NRT-VBR | Variable bit rate: non-real time | Multimedia email |
| ABR | Available bit rate | Browsing the Web |
| UBR | Unspecified bit rate | Background file transfer |



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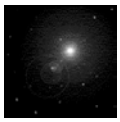
# Service Characteristics



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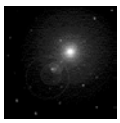
| Service characteristic | CBR | RT-VBR | NRT-VBR | ABR | UBR |
|---|---|---|---|---|---|
| Bandwidth guarantee | Yes | Yes | Yes | Optional | No |
| Suitable for real-time traffic | Yes | Yes | No | No | No |
| Suitable for bursty traffic | No | No | Yes | Yes | Yes |
| Feedback about congestion | No | No | No | Yes | No |



# Quality of Service



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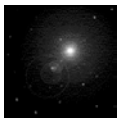
| Parameter | Acronym | Meaning |
|---|---|---|
| Peak cell rate | PCR | Maximum rate at which cells will be sent |
| Sustained cell rate | SCR | The long-term average cell rate |
| Minimum cell rate | MCR | The minimum acceptable cell rate |
| Cell delay variation tolerance | CDVT | The maximum acceptable cell jitter |
| Cell loss ratio | CLR | Fraction of cells lost or delivered too late |
| Cell transfer delay | CTD | How long delivery takes (mean and maximum) |
| Cell delay variation | CDV | The variance in cell delivery times |
| Cell error rate | CER | Fraction of cells delivered without error |
| Severely-errored cell block ratio | SECBR | Fraction of blocks garbled |
| Cell misinsertion rate | CMR | Fraction of cells delivered to wrong destination |

# Class Mechanics



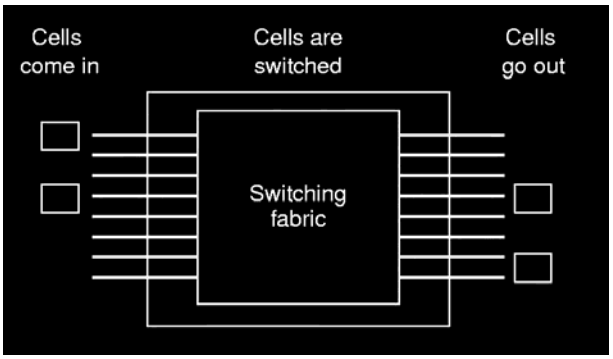
COMPUTER COMMUNICATION NETWORK

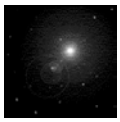
- Presentation of Special Topics: Graduate Students & Interested UG):
  - Multicast Routing (Em, Nov 16)
  - Internet Multicasting (Ren, Nov 16)
  - Routing for Mobile Host (Wenjie Ding, Nov 16)
  - Congestion Control For Multicasting (Cheng Liu, Nov 30)
  - Digital Cellular Radio
  - Mobile IP
  - Gigabit Ethernet (Sam, Dec 02)
  - Iridium Project (Shouqian Liu, Dec 02)



# ATM SWITCH ARCHITECTURE

# An ATM Switch



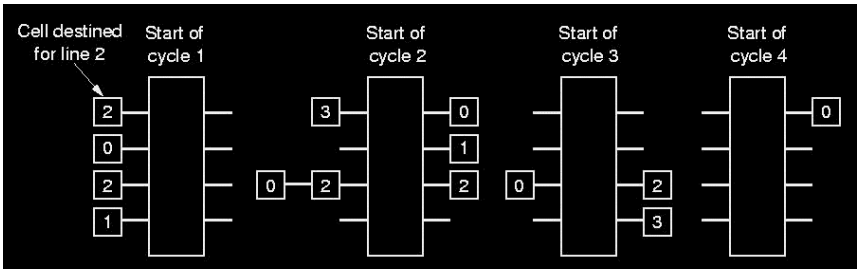
COMPUTER COMMUNICATION NETWORK

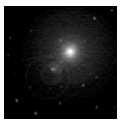
•Drop rate should be low (1 in 1 million million)
•Never reorder a cell in a VC.

- At 150 Mbps 360,000 cell/sec arrive in each port at 2.7 μs.
- A commercial swithc has 16 to 1024 input lines.
- At 622 Mbps the time is 700 ns.



# Input Queuing



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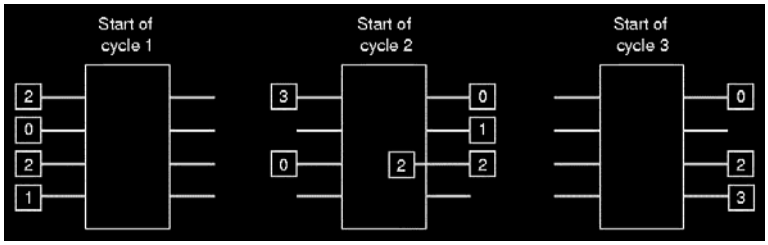
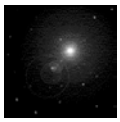
# Output Queuing

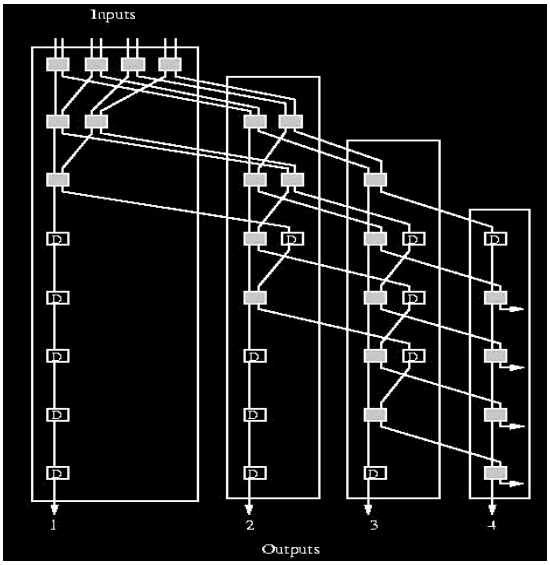




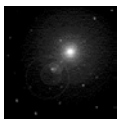


# Knockout Switch

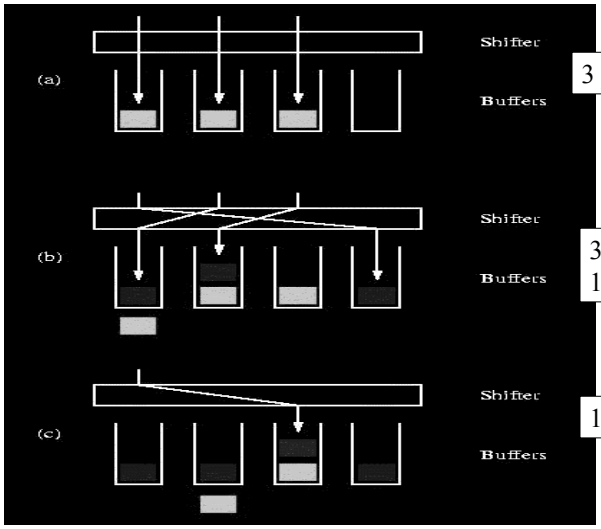



Selects l packets from those destined for one of n destinations.

Requires O(lxn) elements.



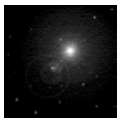
# Shared Buffering




3 packets arrive

3 more arrive.
1 leaves.

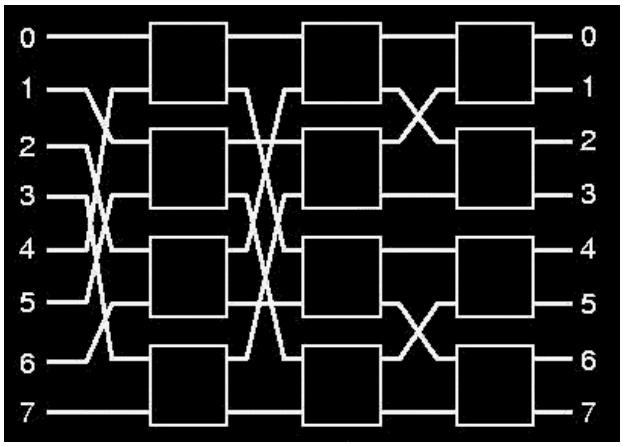
1 arrives, 1 leaves.



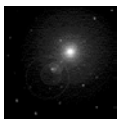
COMPUTER COMMUNICATION NETWORK



# Banyan Switch

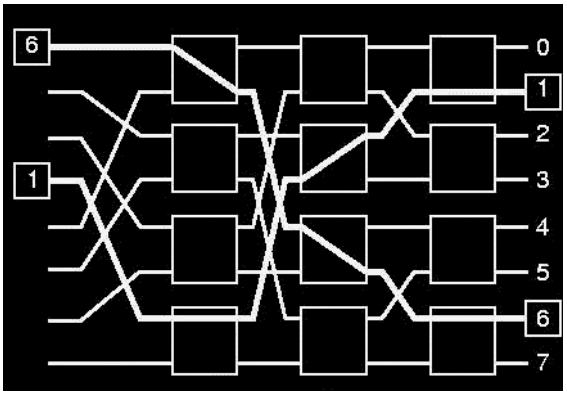


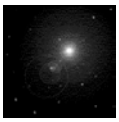

Requires O(n log n) elements.



COMPUTER COMMUNICATION NETWORK

# Banyan Switch

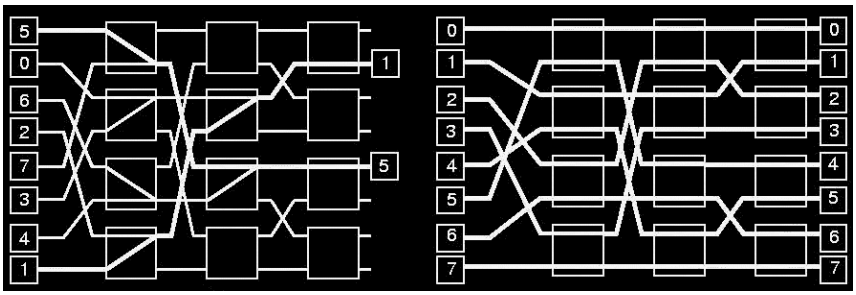


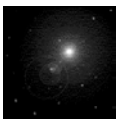





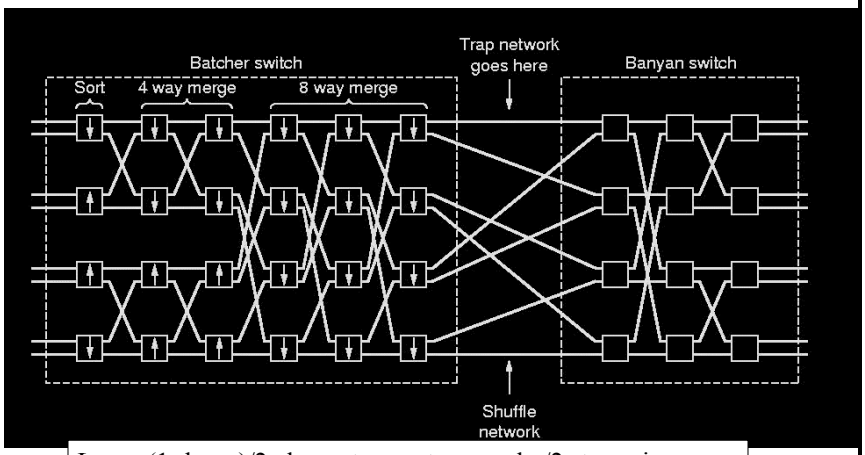


# Conflict in Banyan Switch

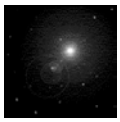


# Batcher Banyan Switch



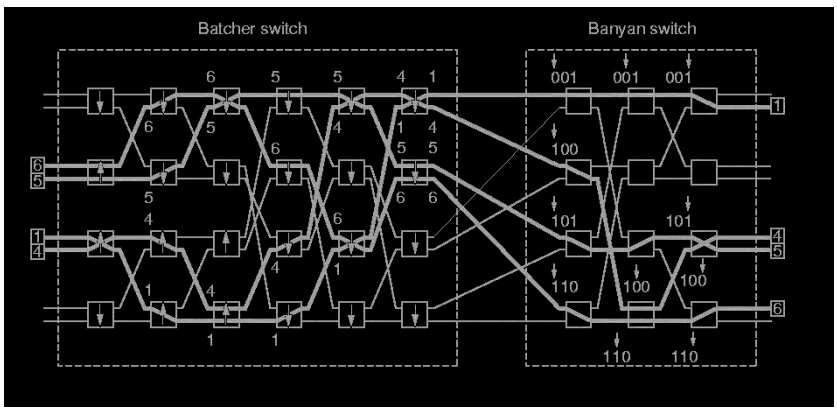

Log n (1+log n)/2 elements per stage, and n/2 stages in Batcher network. Thus there are O( n $\log^2$ n) elements.

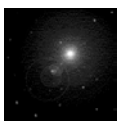




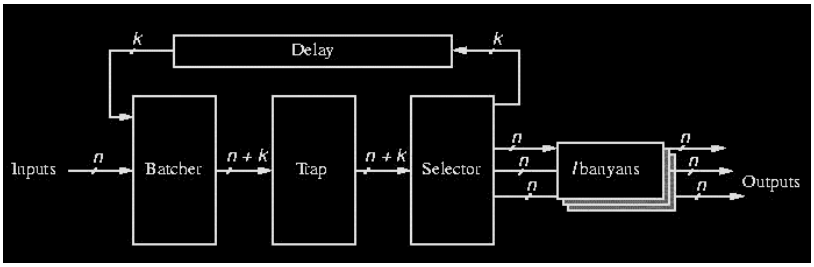


# Conflict Free Routing in BB Switch

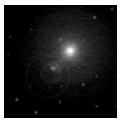


# Sunshine Switch



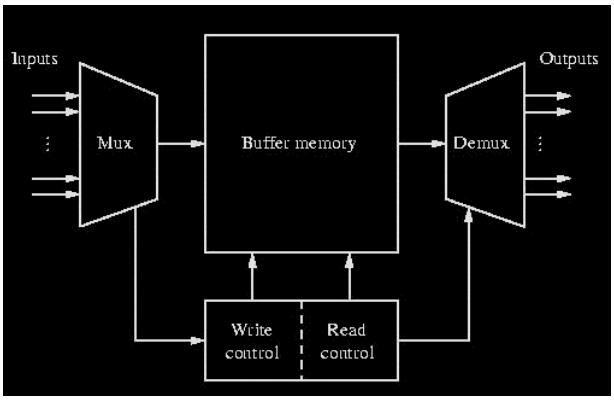

Batcher + Trap+Selector+ l parallel Banyans
Trap marks l packets which will be able to exit via one port.
Seletor redirects the excess packest via Delay Unit.



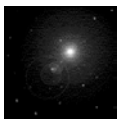




# Shared Memory Switch

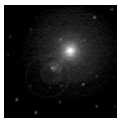



One big buffer.
These are a shared media network collasposed in a box.
On arrival each input cell is place in the buffer, as well as a link-list for the destination port is updated.



# Few Future Switches (INTERNET2)

- Juniper M40 Router Switch:
  - 40 Gbps Modular Shared Memory
  - 8- OC-48 SONET, 32 C-12 SONET, 64 OC-3 ATM or 24 Gigabit Ethernet
  - Can perform 4M lookups per second in a table of 1M IPv4
- Packet Engine PowerRail 5200
  - 52 Gbps Non-Blocking Fabric
  - 37 M packets per second
  - 14 slots







# NEXT CLASS
# INTERNETWORKING