Knockout Switches

HIGH PERFORMANCE SWITCHES AND ROUTERS

Wiley

H. JONATHAN CHAO and BIN LIU

Instructor: Mansour Rousta Zadeh

Outlines

- Introduction
- Single Stage Knockout-Basic Architecture
- Knockout Concentration Principle
- Concentrator Architecture
- Channel grouping Principle
- Generalized Knockout Principle
- MOBAS Switch
- Fault Tolerant Knockout Switches
- Conclusion

Knockout Switches

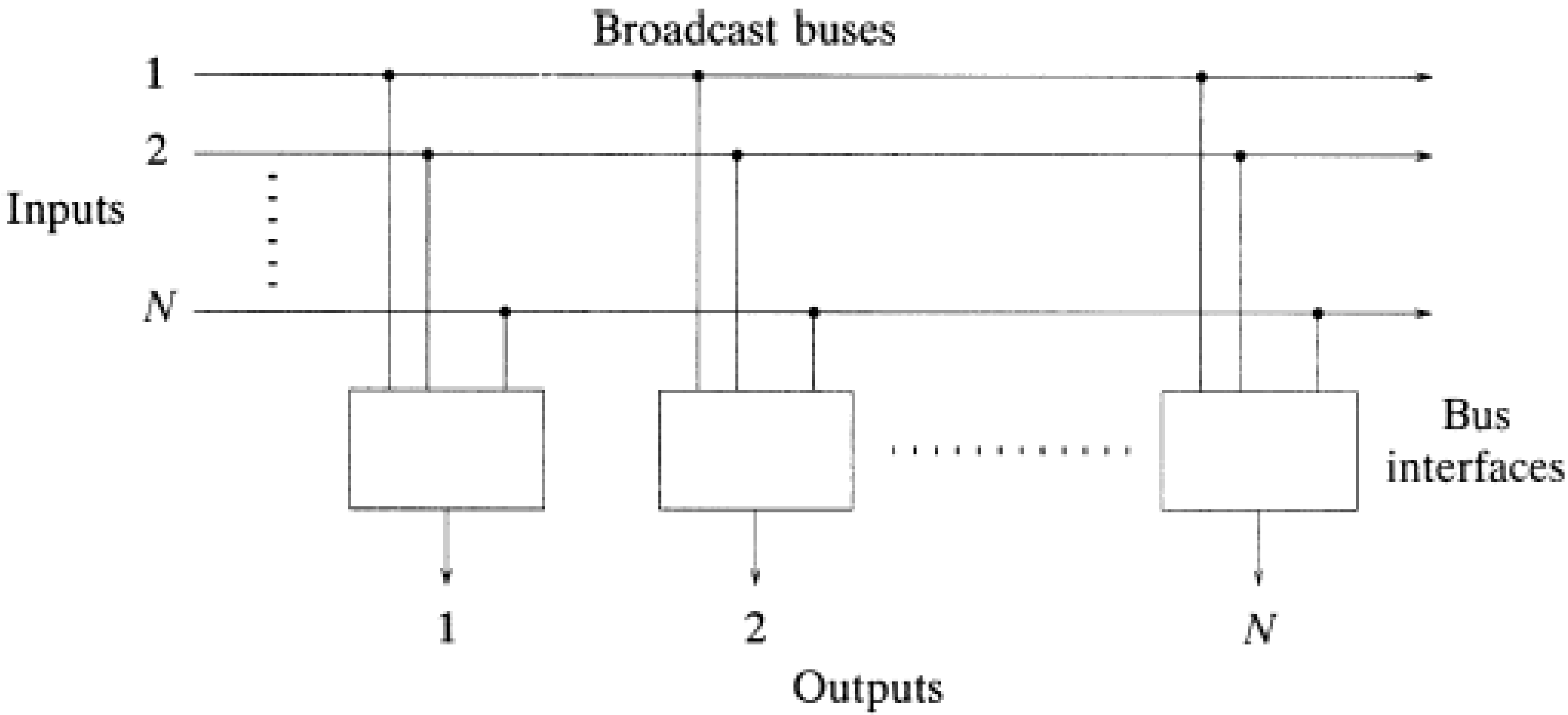
Introduction-1

- Output Buffered Switches: The best delay-throughput performance.
- Problem of Output Buffered Switches:
  - Memory Speed Limitation
- Solution (Knockout Principle)
  - limiting the number of cells that can arrive at an output port in each time slot
  - Other cells are discarded
- Q:How Many?
- Tradeoff between “Cell Loss Ratio” and “Memory Bandwidth”

Introduction-2

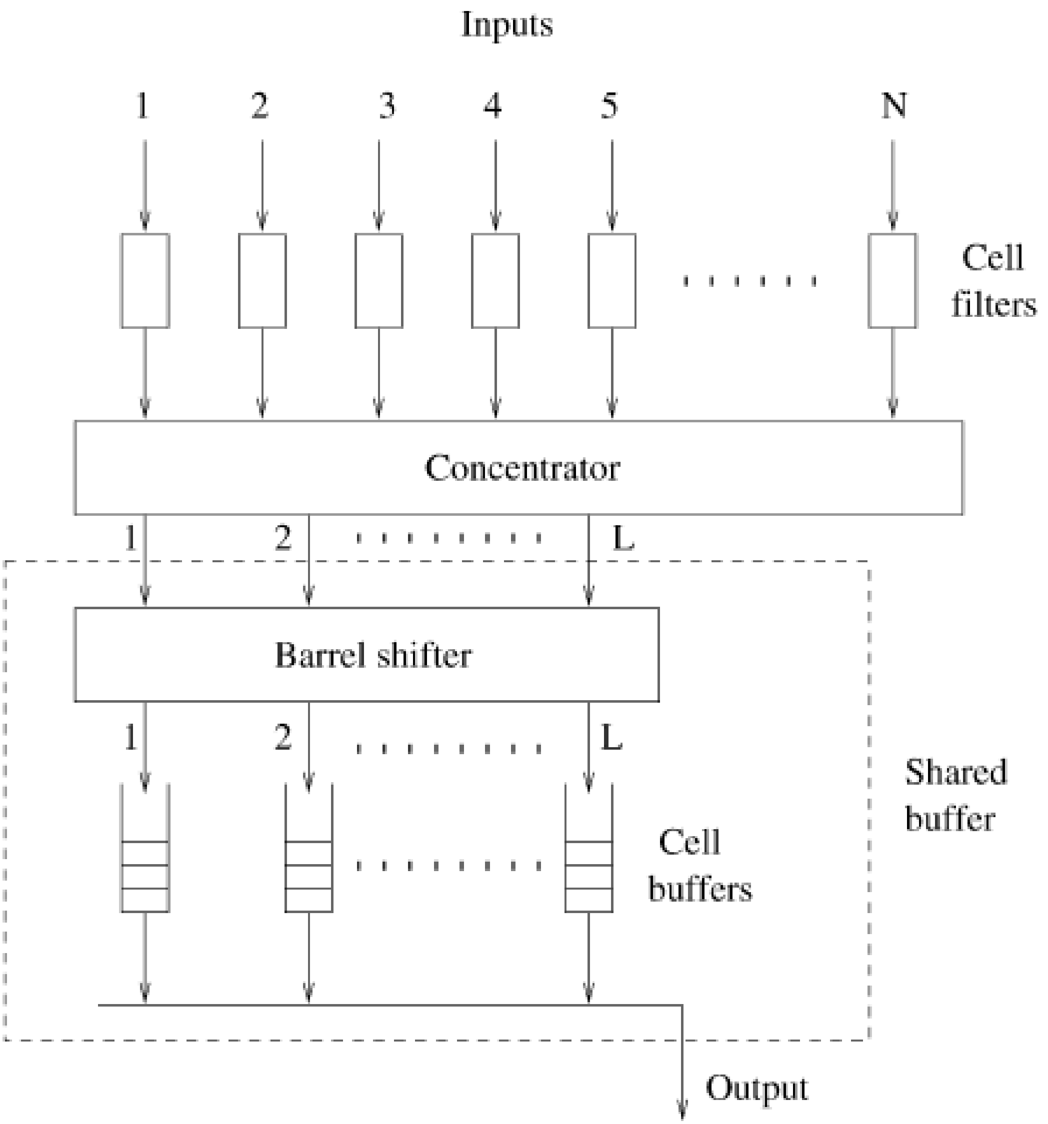
- the memory speed is no longer the bottleneck for the output-buffered switch
- No Commercial Products
  - Why?

Single Stage Knockout-Basic Architecture

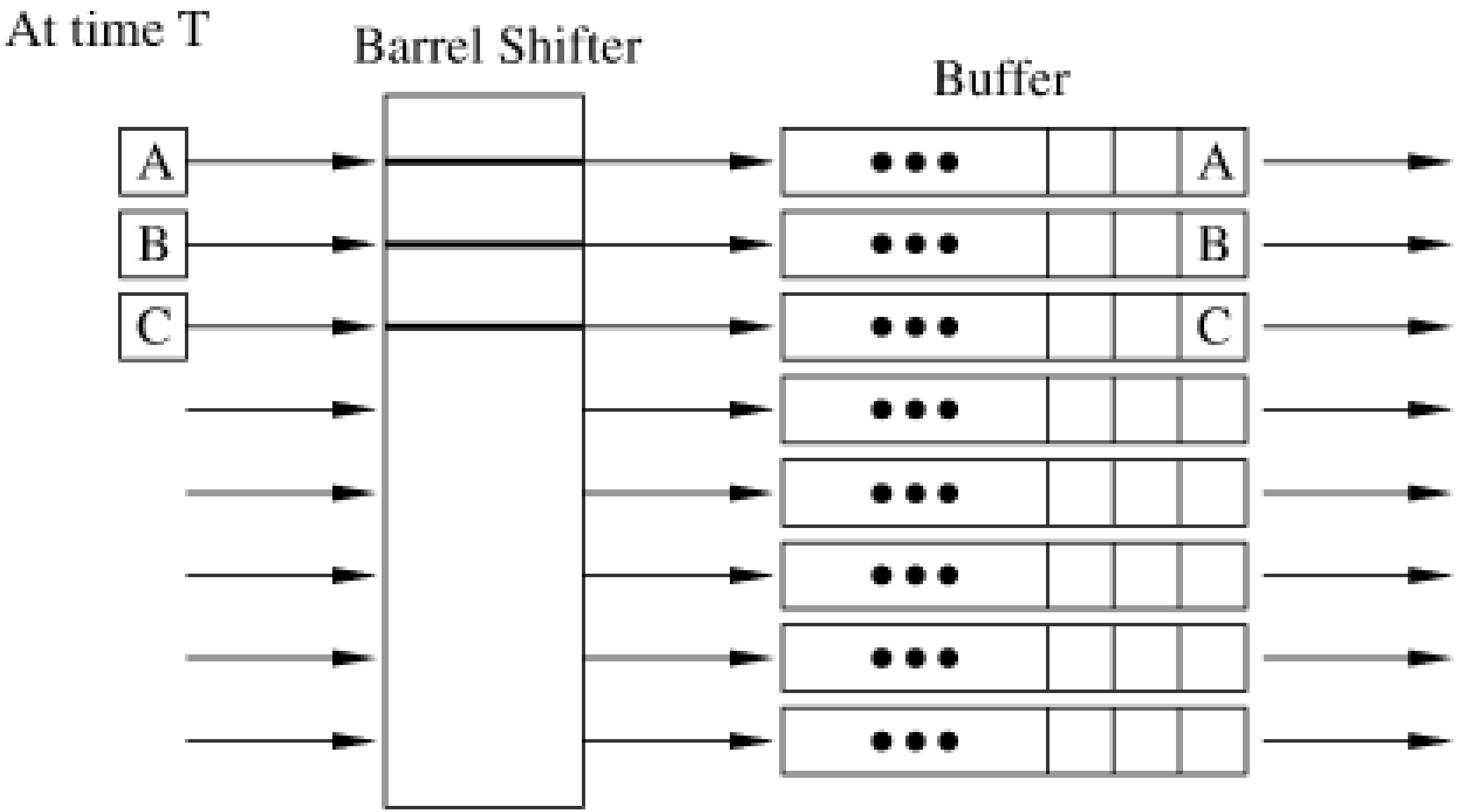


- Knockout switch interconnection fabric

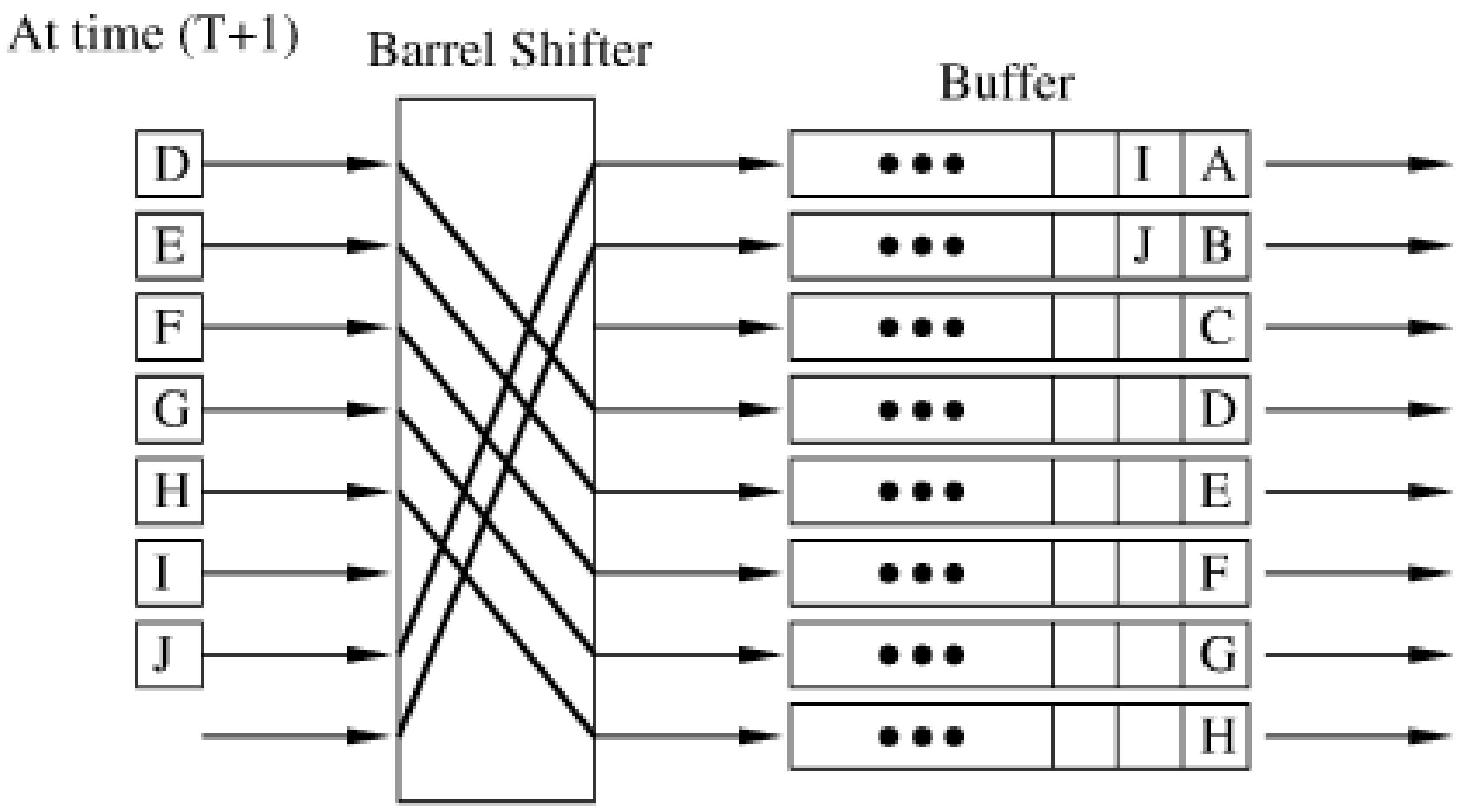
Knockout Switches-Bus Interface



Operation of a Barrel Shifter-1



Operation of a Barrel Shifter-2



Knockout Concentration Principle

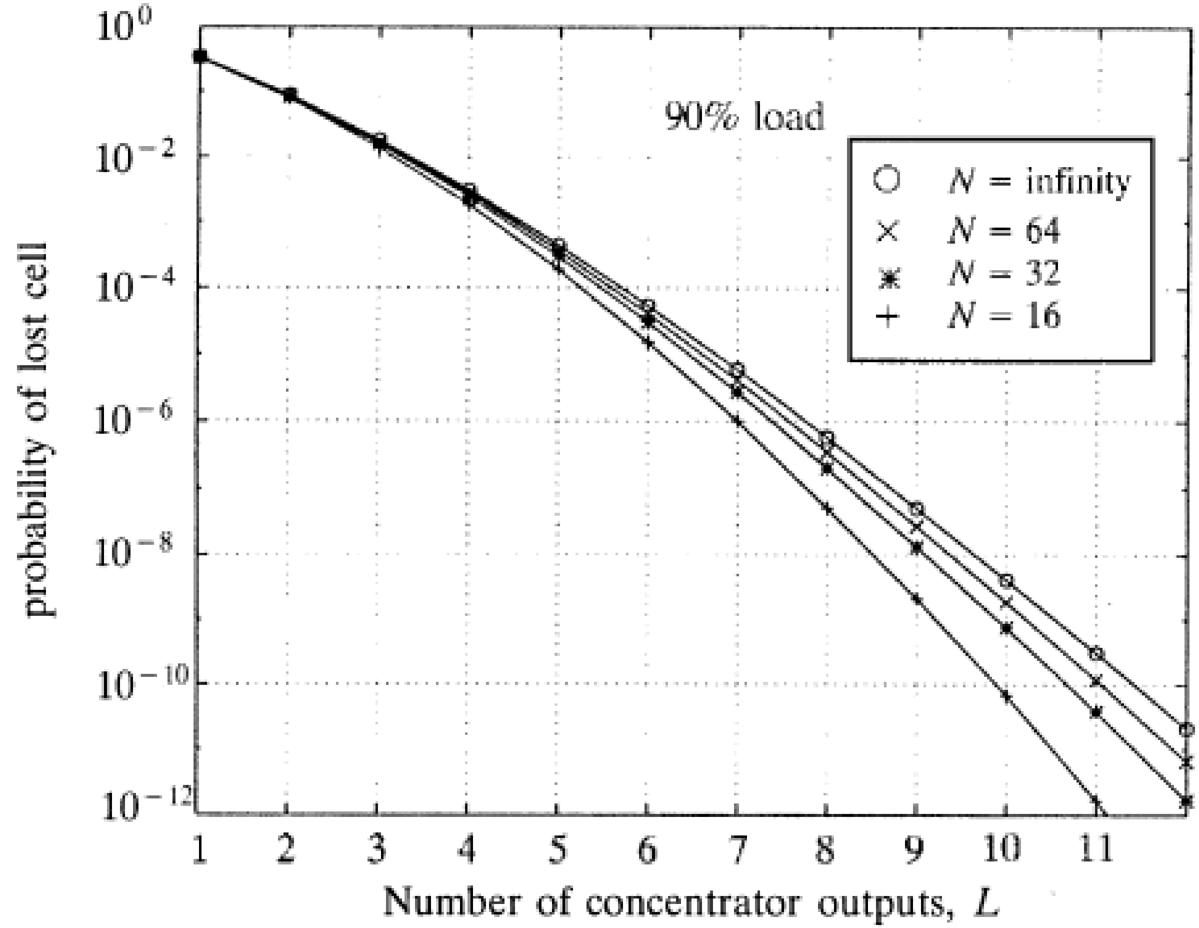
$$P_k = \binom{N}{k}\left(\frac{\rho}{N}\right)^k\left(1-\frac{\rho}{N}\right)^{N-k}, \qquad k = 0, 1, \ldots, N.$$

$$\Pr[\text{cell loss}] = \frac{1}{\rho}\sum_{k=L+1}^{N}(k-L)\binom{N}{k}\cdot\left(\frac{\rho}{N}\right)^k\left(1-\frac{\rho}{N}\right)^{N-k}$$

$$\Pr[\text{cell loss}] = \left(1-\frac{L}{\rho}\right)\left(1-\sum_{k=0}^{L}\frac{\rho^k e^{-\rho}}{k!}\right)+\frac{\rho^L e^{-\rho}}{L!} \qquad N \to \infty;$$

Knockout Switches

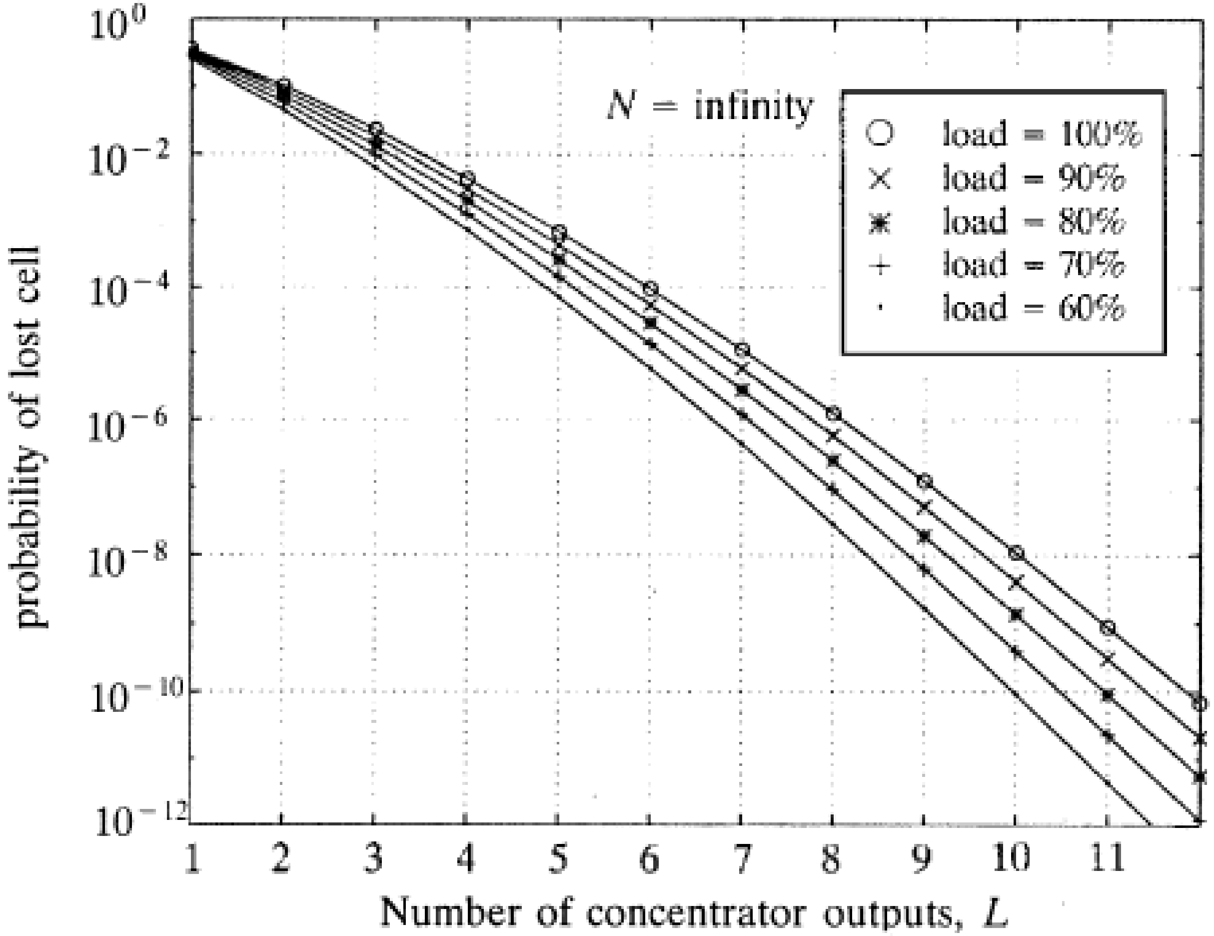
Concentration Cell Loss Performance



(a) with various switch sizes

Knockout Switches

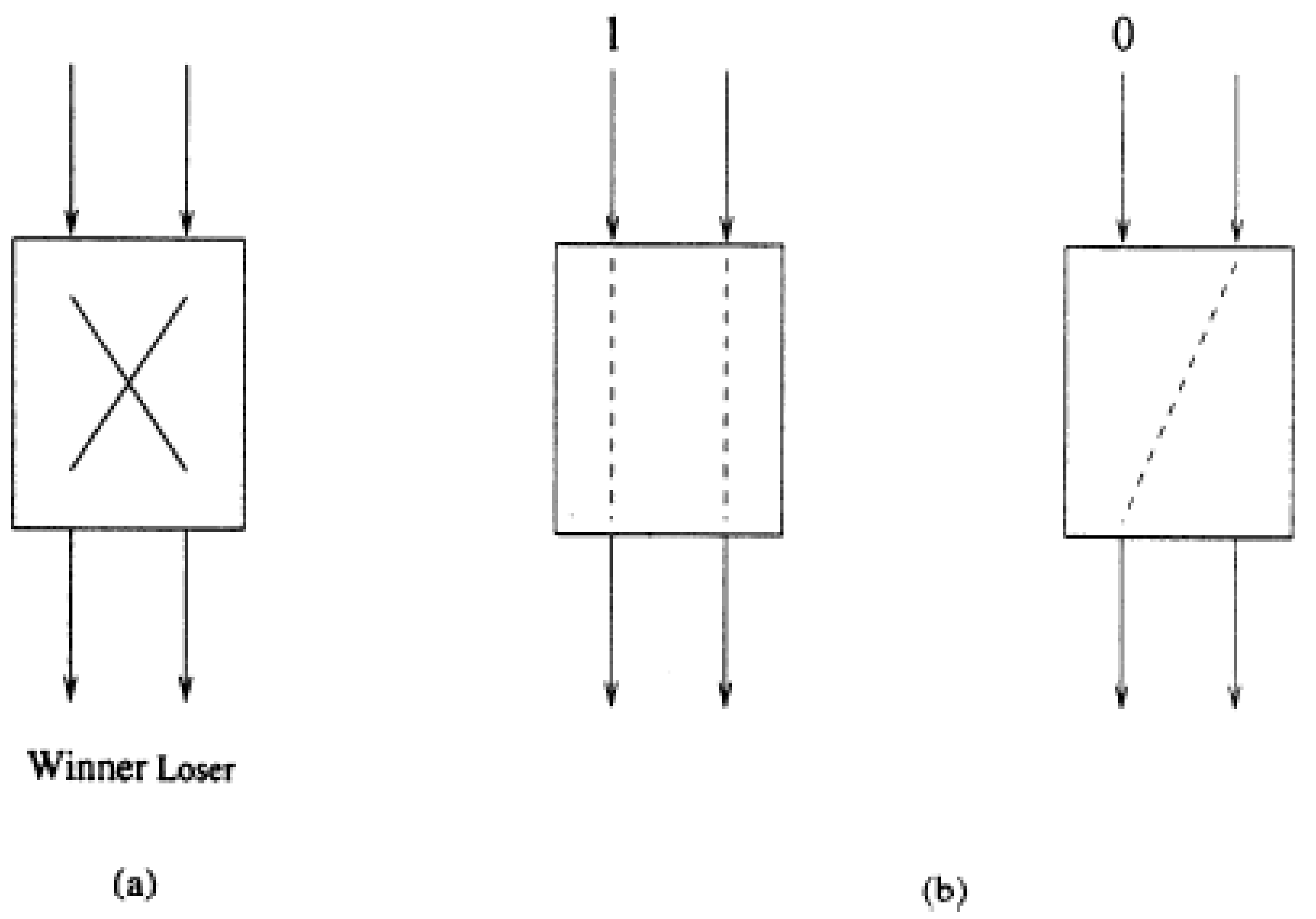
Concentration Cell Loss Performance



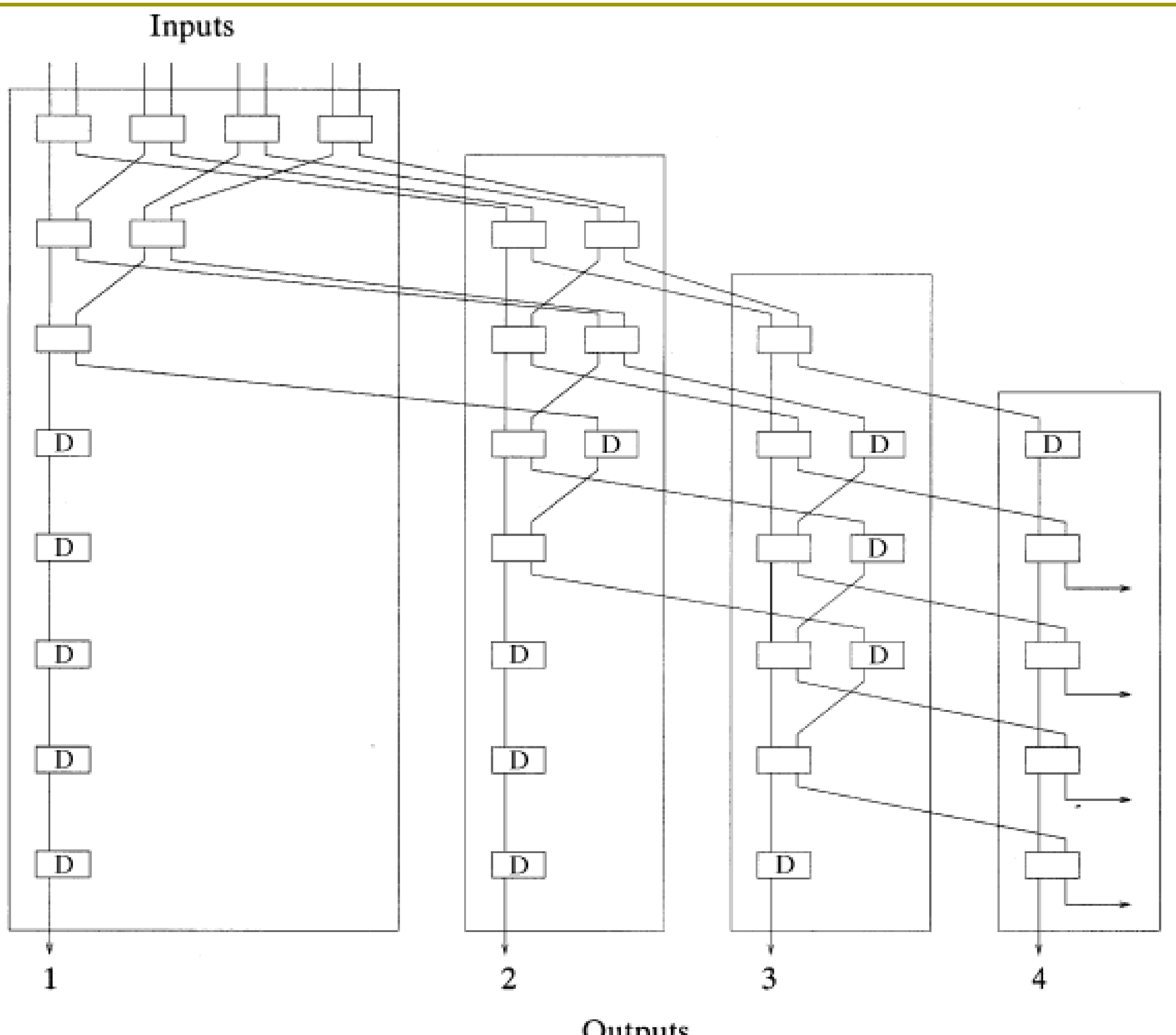
(b) with various loads

Fig. 6.4 Concentrator cell loss performance.

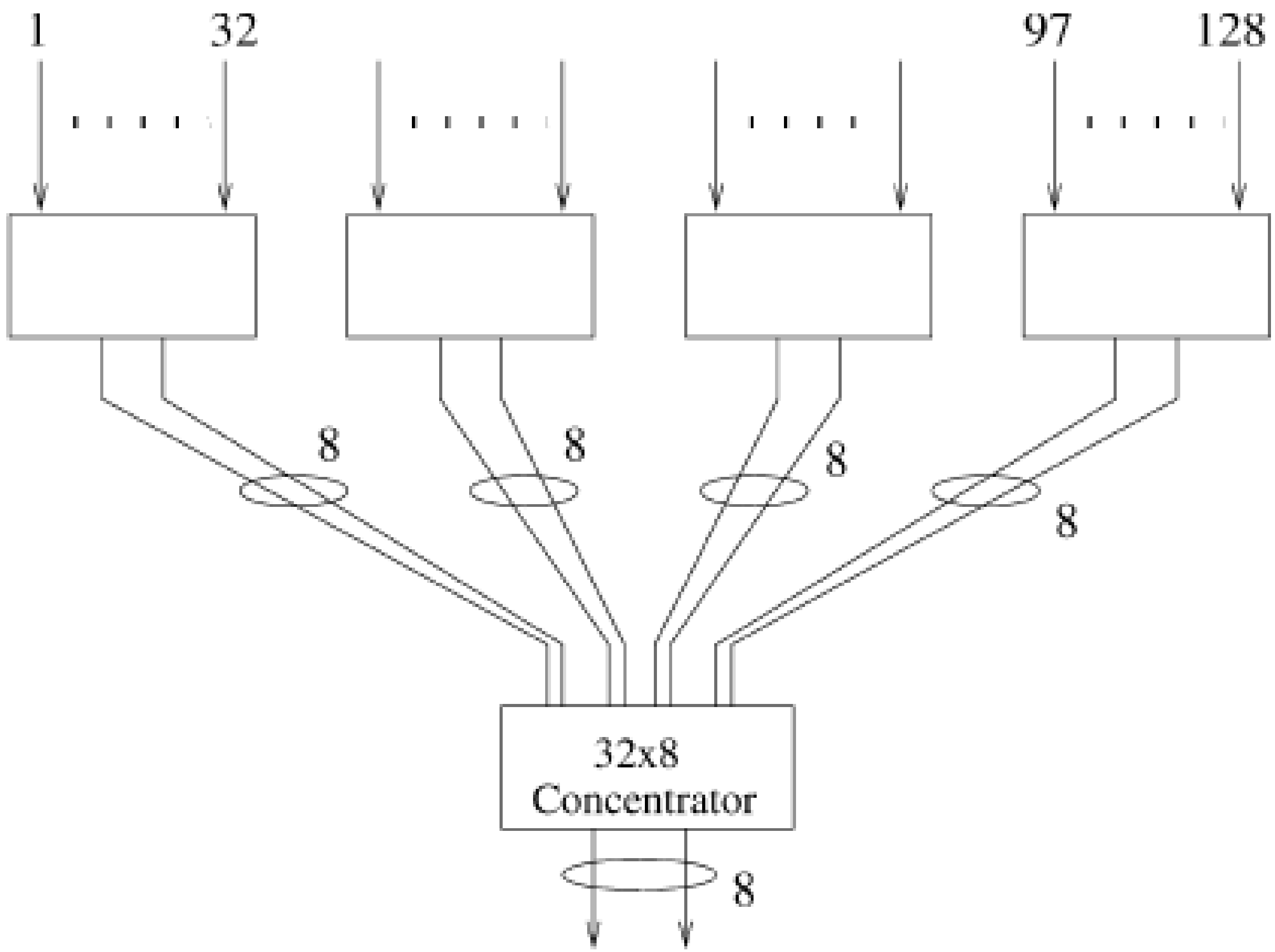
Construction of the Concentrator



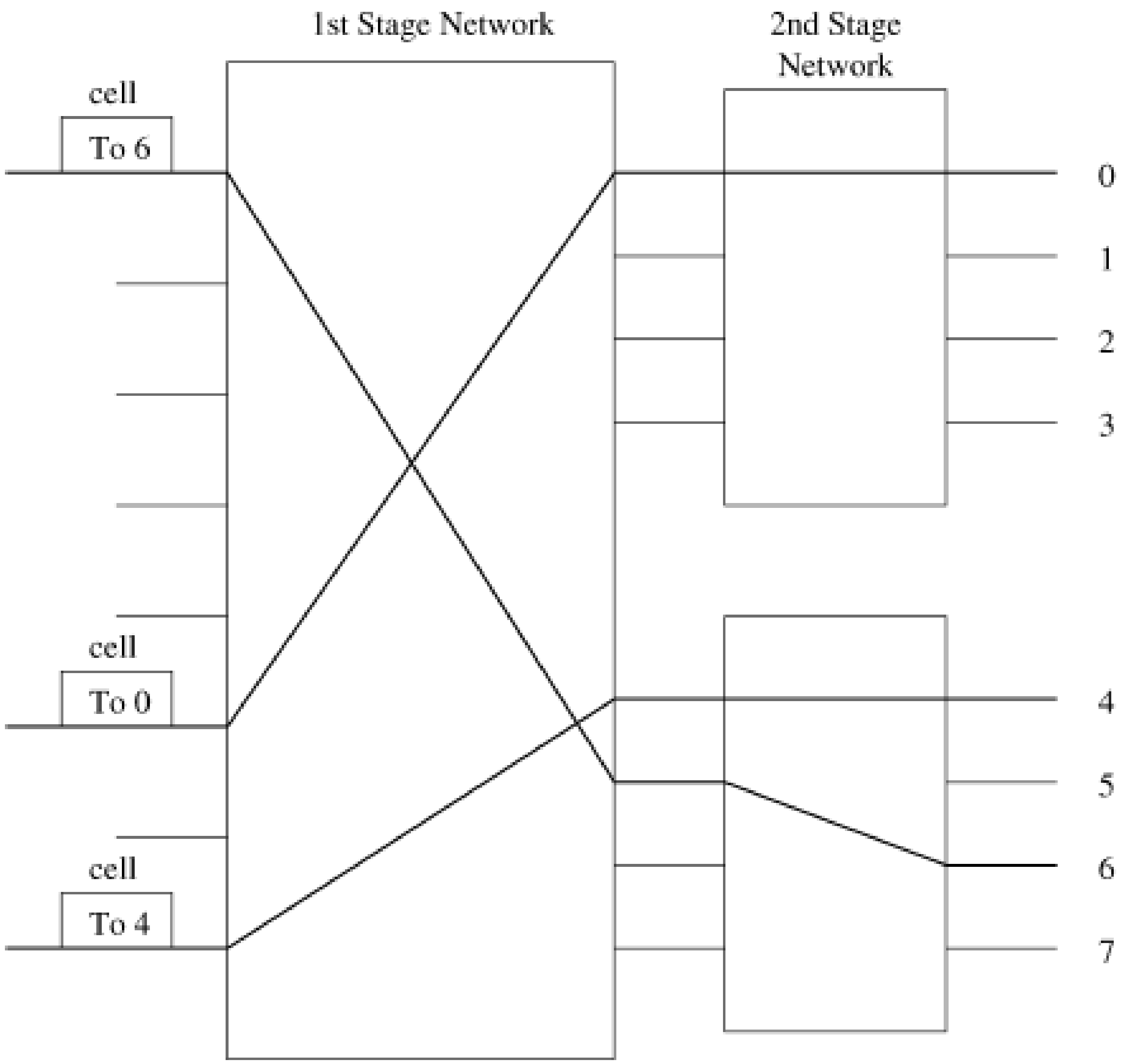
An eight-input to four-output concentrator



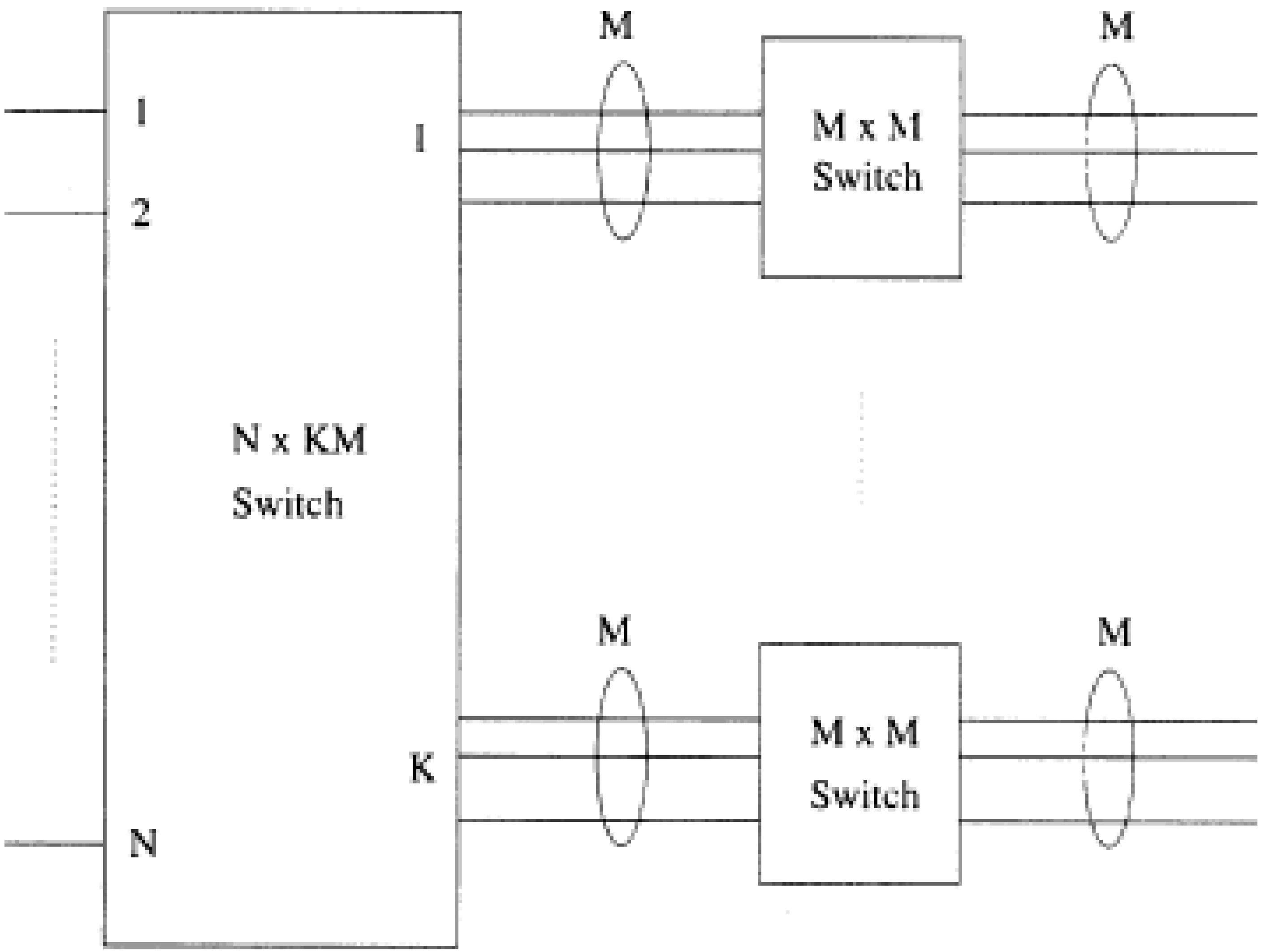
Construction of large Concentrator with Small Concentrators



channel grouping principle



An asymmetric switch with line expansion ratio KM/N



Maximum Throughput

TABLE 6.1 Maximum Throughput with K/N Kept Constant While $K, N \to \infty$

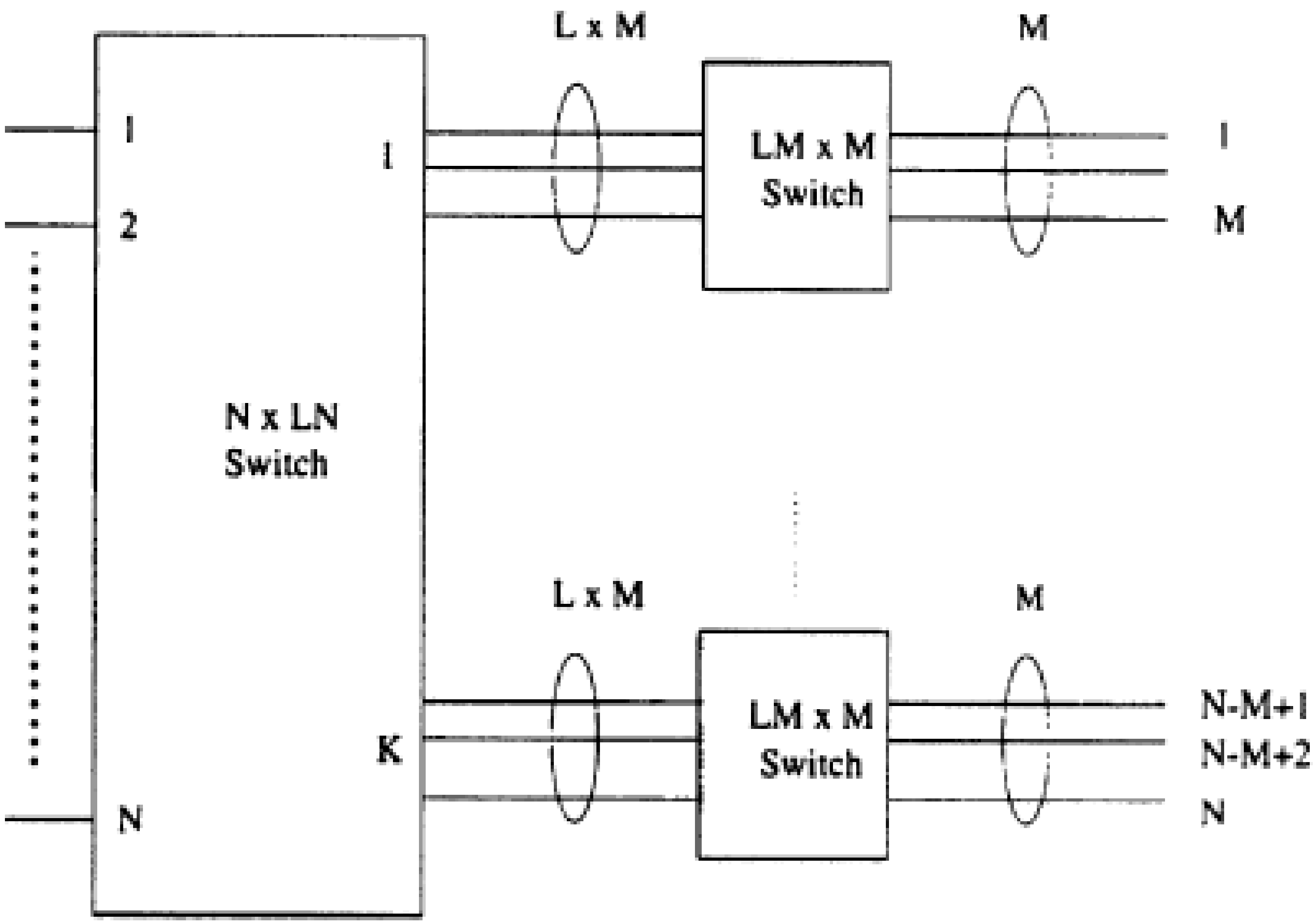
M	Maximum Throughput									
	$K/N =$	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	1	2	4	8	16
1		0.061	0.117	0.219	0.382	0.586	0.764	0.877	0.938	0.969
2		0.121	0.233	0.426	0.686	0.885	0.966	0.991	0.998	0.999
4		0.241	0.457	0.768	0.959	0.996	1.000	1.000	1.000	
8		0.476	0.831	0.991	1.000	1.000				
16		0.878	0.999	1.000						

Knockout Switches

TABLE 6.2 Maximum Throughput with KM/N Kept Constant While $KM, N \to \infty$

M	*Maximum Throughput*						
	$KM/N =$	1	2	4	8	16	32
1		0.586	0.764	0.877	0.938	0.969	0.984
2		0.686	0.885	0.966	0.991	0.998	0.999
4		0.768	0.959	0.996	1.000	1.000	1.000
8		0.831	0.991	1.000			
16		0.878	0.999				
32		0.912	1.000				
64		0.937					
128		0.955					
256		0.968					
512		0.978					
1024		0.984					

Generalized Knockout Principle



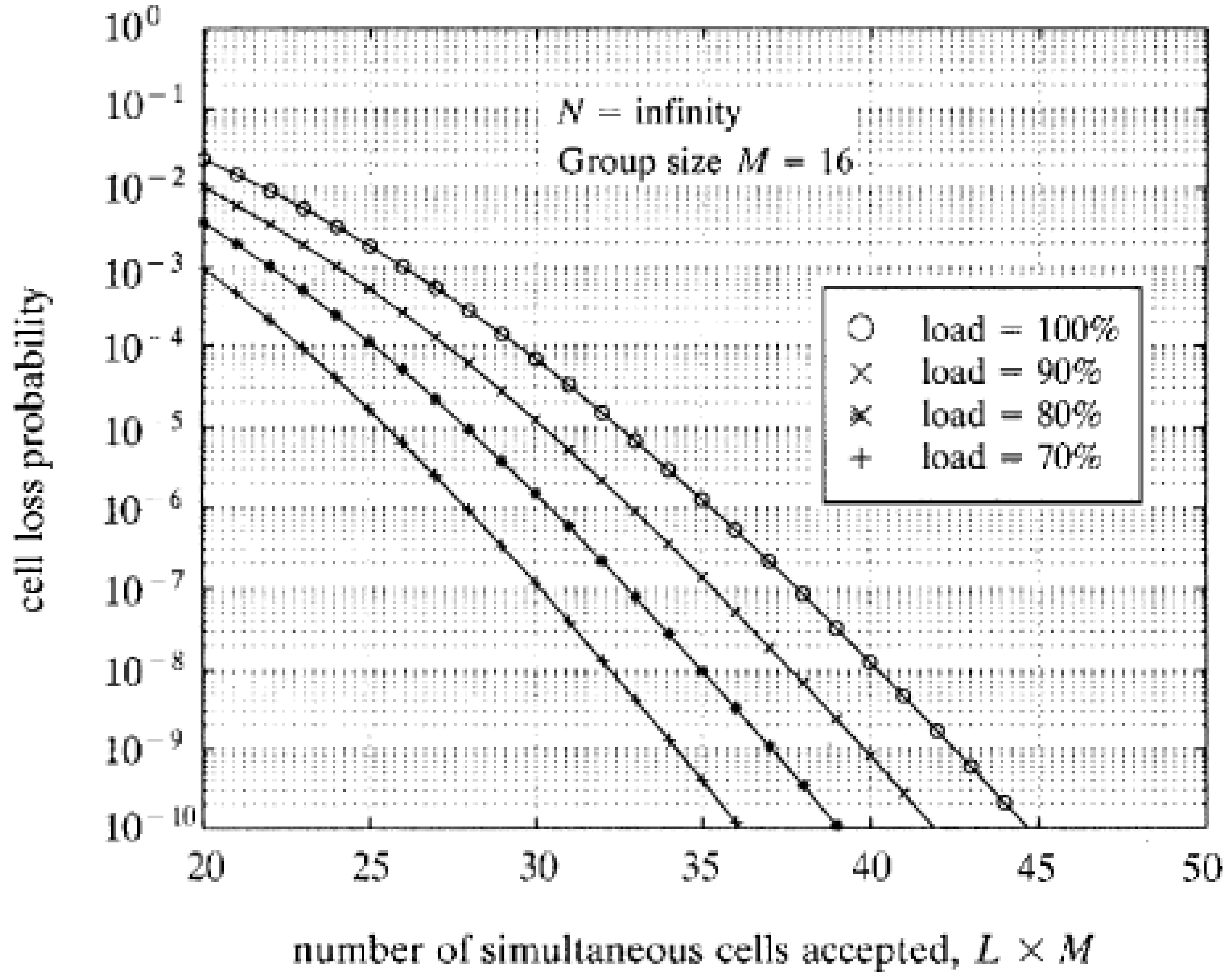
Generalized Knockout Principle

$$\Pr[\text{cell loss}] = \frac{1}{M\rho} \sum_{k=LM+1}^{N} (k - LM) \binom{N}{k} \left(\frac{M\rho}{N}\right)^{k} \cdot \left(1 - \frac{M\rho}{N}\right)^{N-k}$$

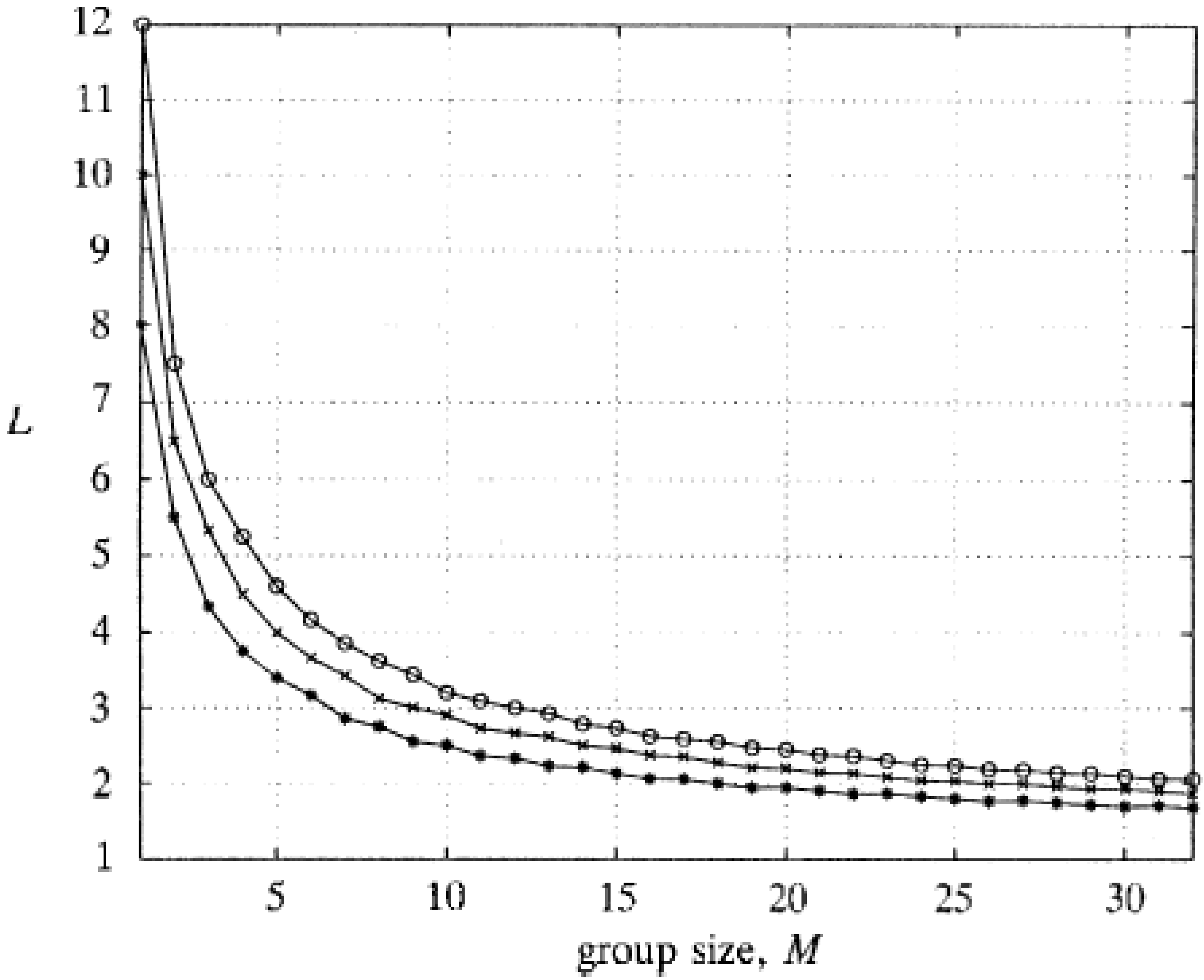
$$\Pr[\text{cell loss}] = \left(1 - \frac{L}{\rho}\right)\left(1 - \sum_{k=0}^{LM} \frac{(M\rho)^{k} e^{-M\rho}}{k!}\right) + \frac{(M\rho)^{LM} e^{-M\rho}}{(LM)!}$$

As $N \rightarrow \infty$

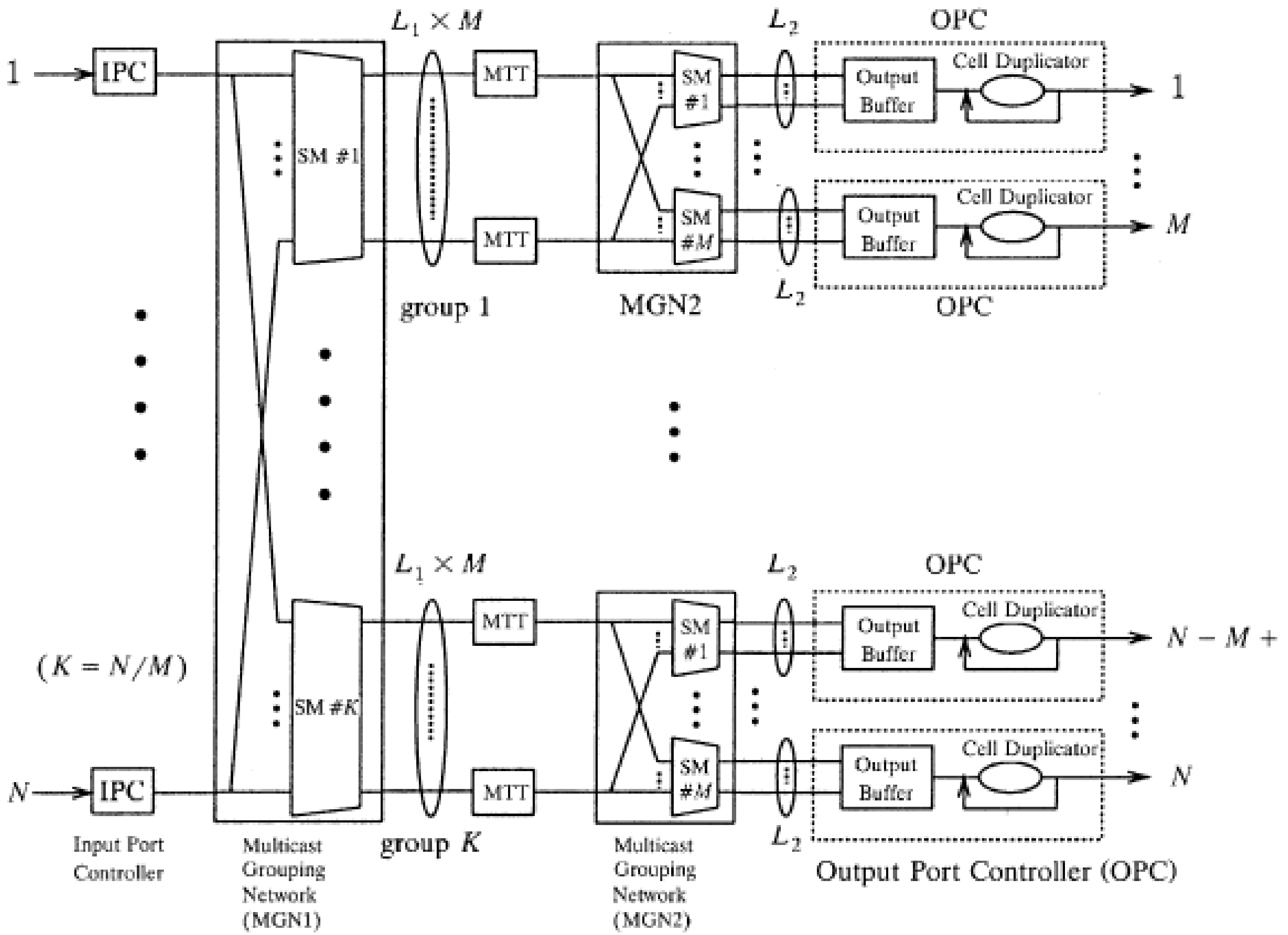
Generalized knockout principle Operation



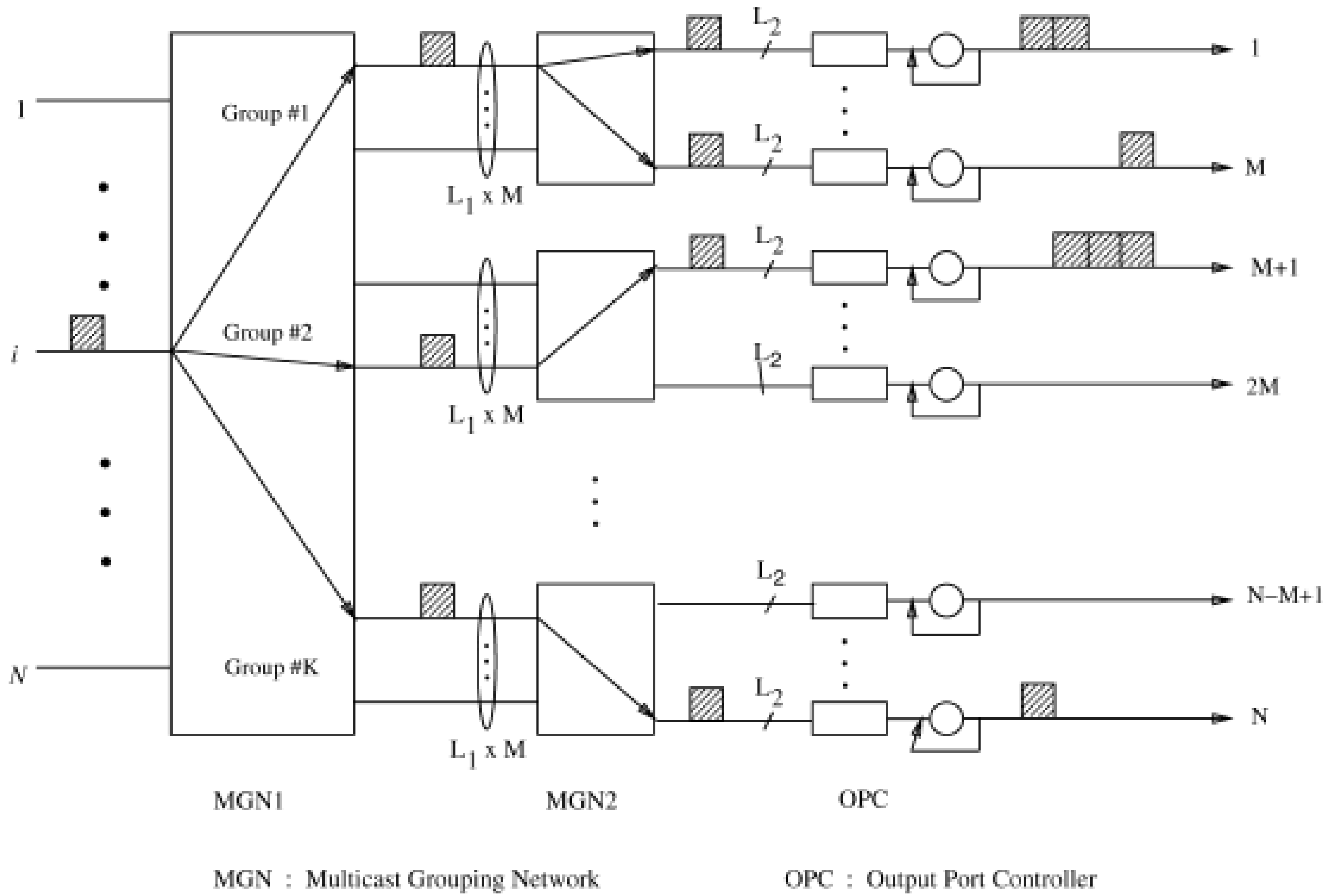
Knockout Switches



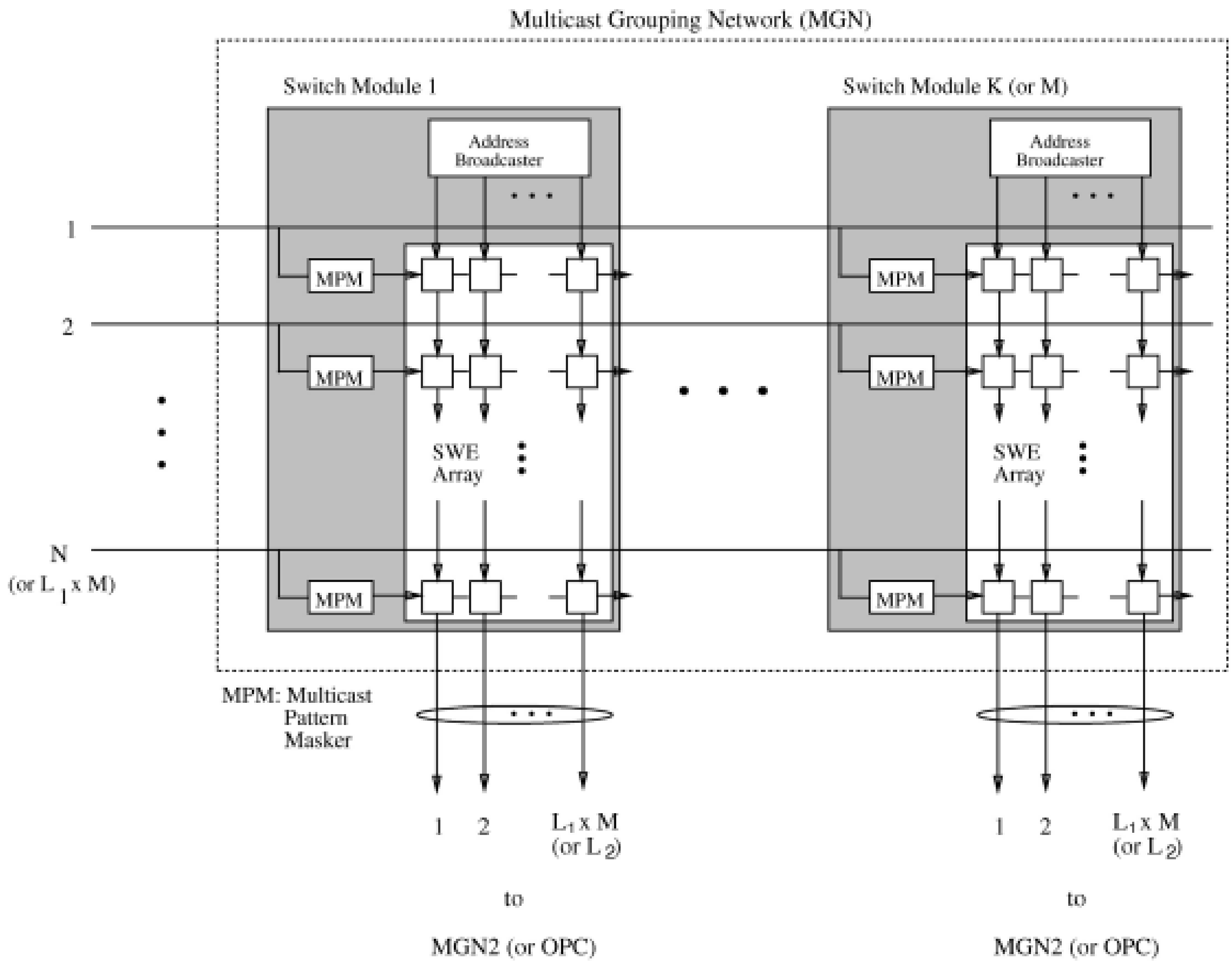
The architecture of a multicast output buffered ATM switch



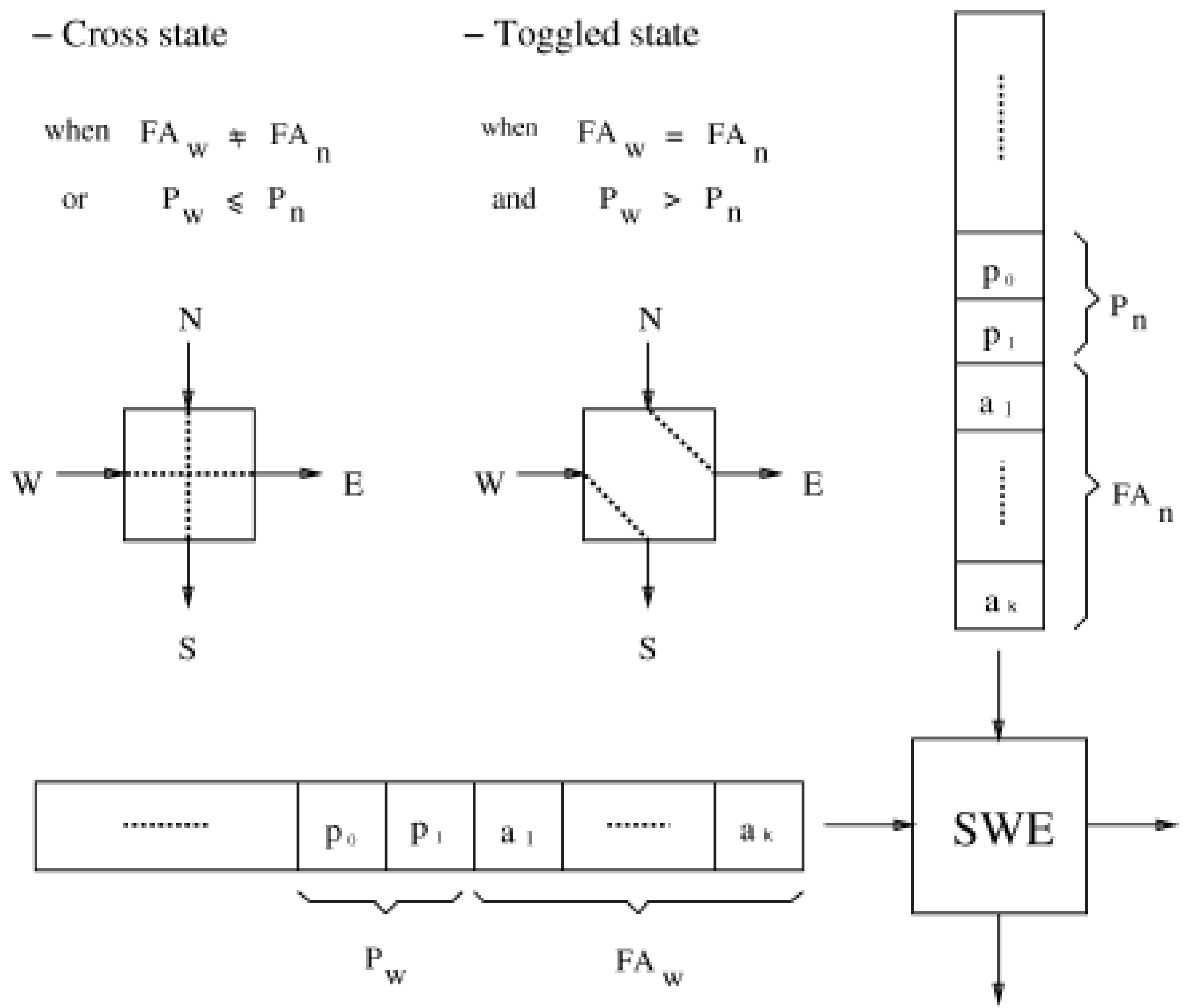
Replicating cells for a multicast connection in the MOBAS



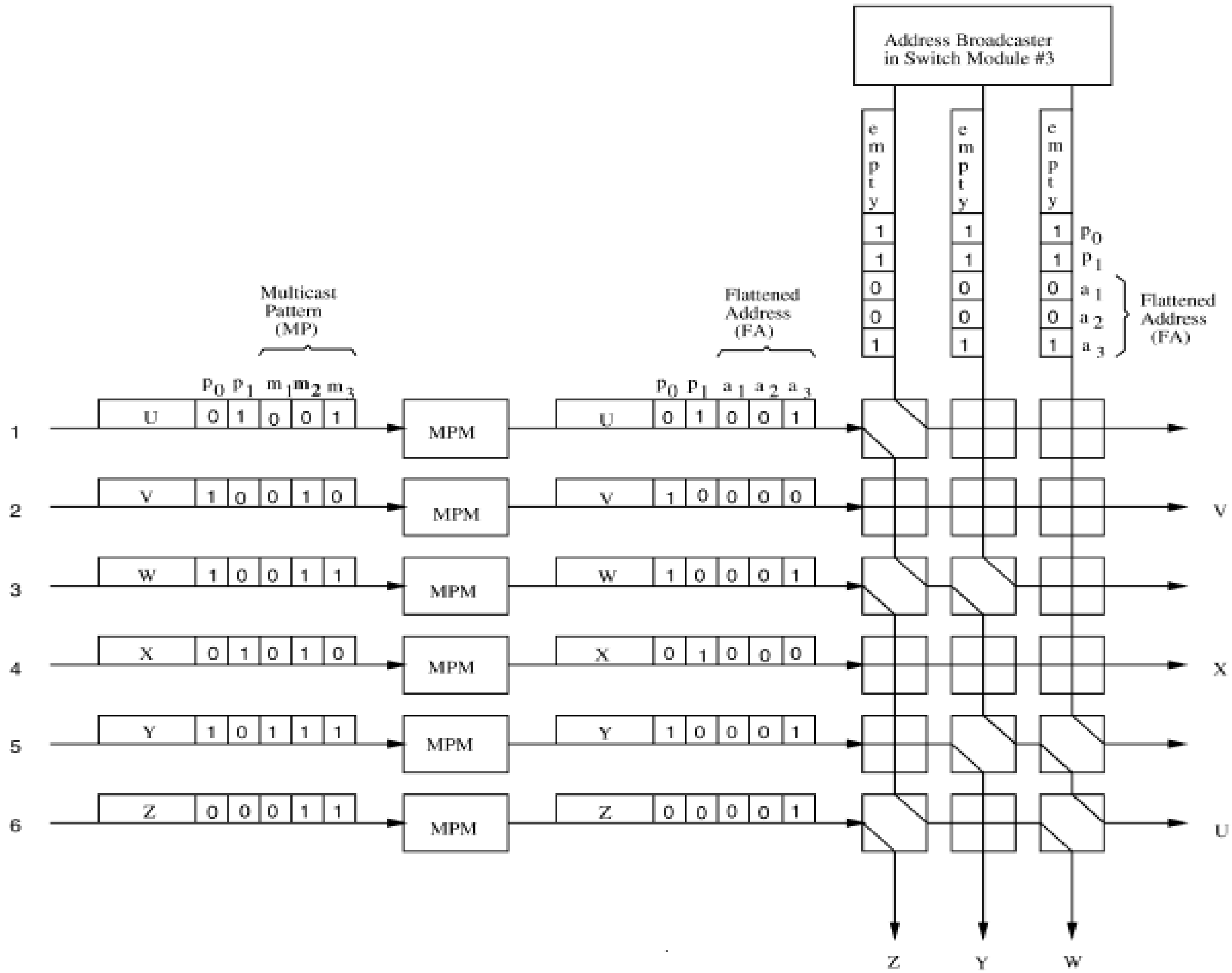
Multicast Grouping Network



Switching condition of the switch element SWE



Routing a multicast cell



Knockout Switches

Translation Tables-1

(a) Unicast translation table entry at IPC1

Arrived VCI	A1	A2	P	New VCI

(b) Multicast translation table entry at IPC1

Arrived VCI	MP1	P	BCN

(c) Multicast translation table entry at IPC2

BCN	MP2

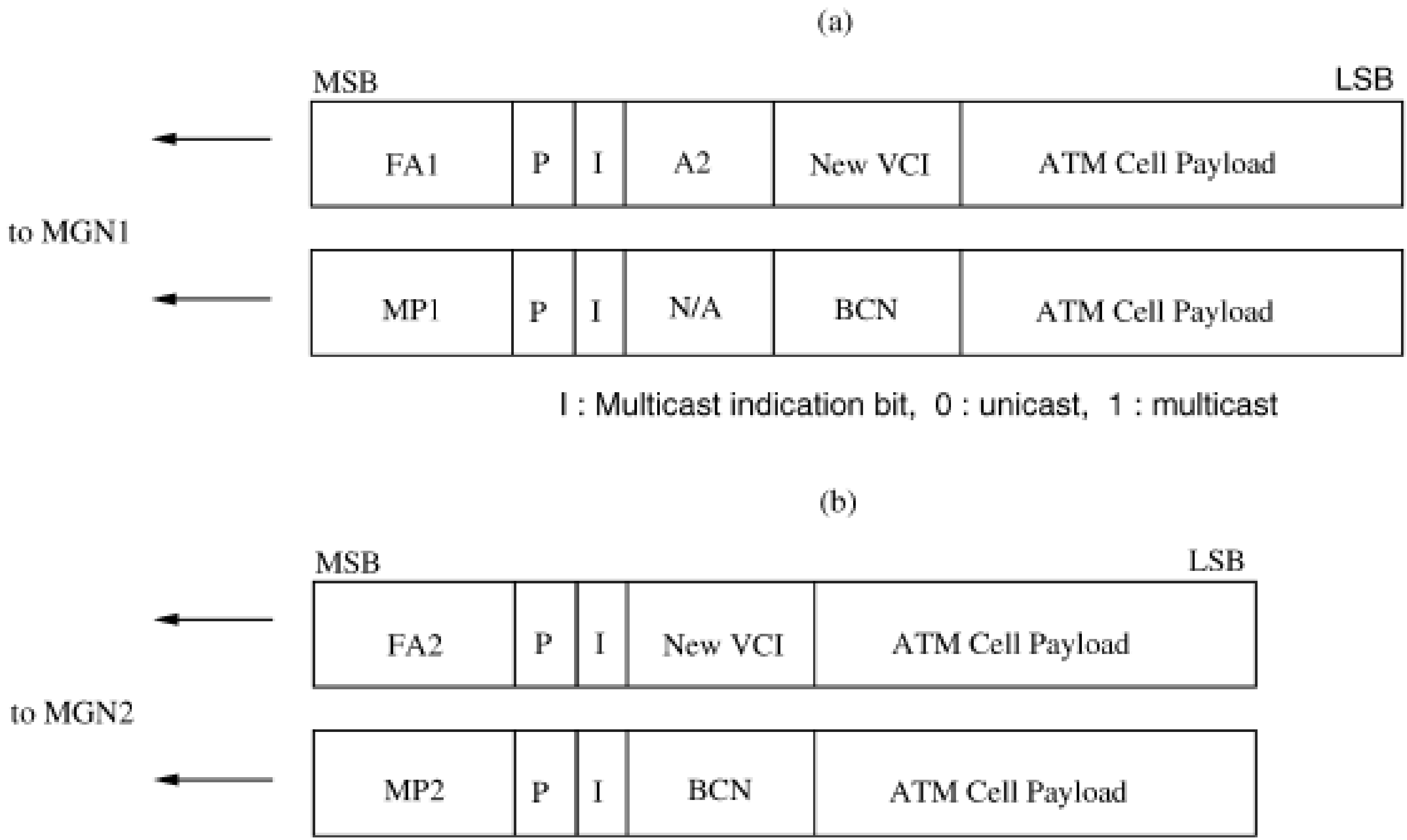
(d) Multicast translation table entry at OPC

BCN	DR	VCI_1	VCI_2	• • •

- VCI : Virtual channel identifier
- BCN : Broadcast channel number
- A1 : Output address of MGN1
- A2 : Output address of MGN2
- MP1 : Multicast pattern in MGN1
- MP2 : Multicast pattern in MGN2
- P : Priority for cell contention
- DR : Number of duplication requests

Knockout Switches

Translation Tables-2



Fault Model of Switching Elements-1

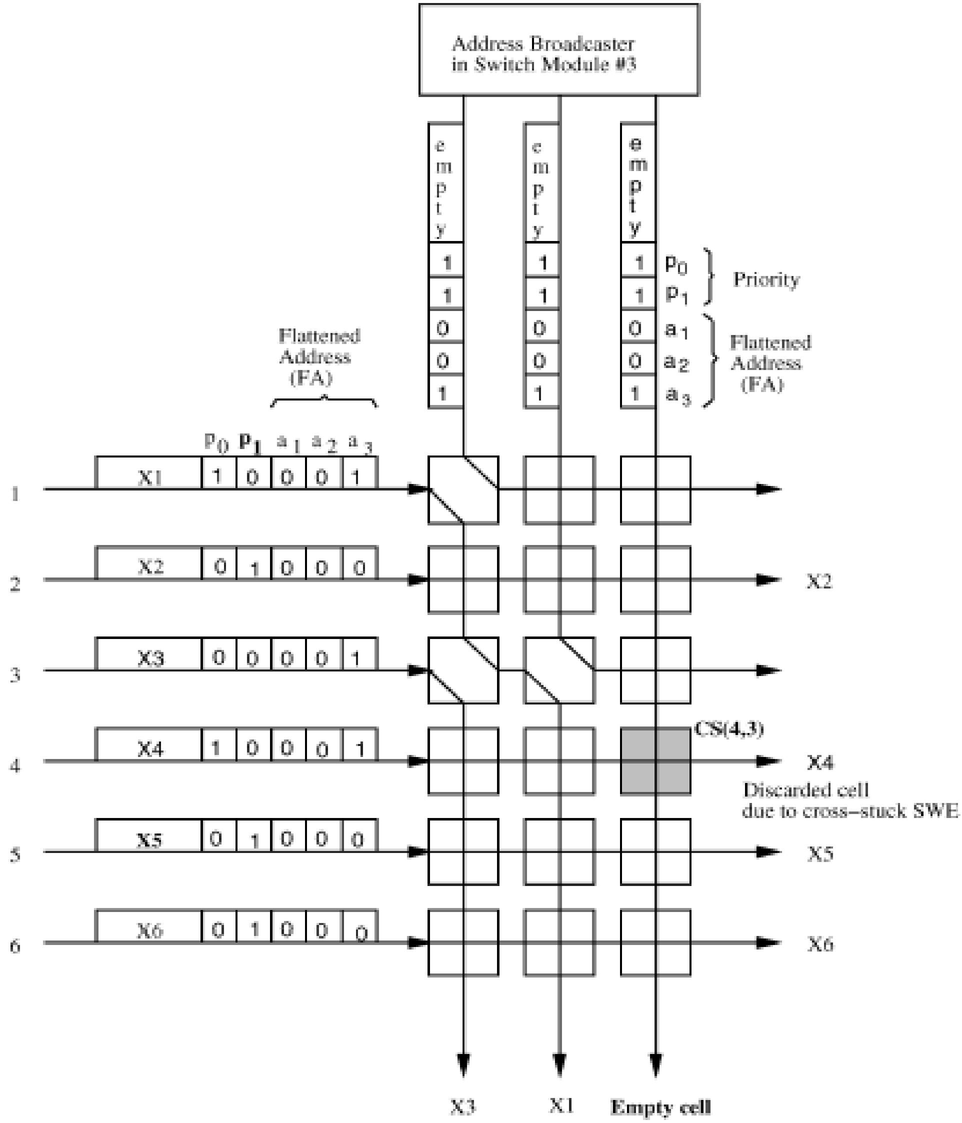
- Need to Reliability
- Redundancy Techniques:
  - Time Redundancy
  - Space Redundancy
- Fault Tolerant Topics
  - Fault Diagnosis
    - Fault Detection
    - Fault Location
  - System Reconfiguration

Fault Model of Switching Elements-2

- Fault Sources
  - In Control Logic Circuit (logic errors)
    - Cross Stuck (Remains in Cross state)
    - Toggle Stuck (Remains in Toggle state)
  - In Data Link of SWE (link errors)
    - Vertical Stuck
    - Horizontal Stuck

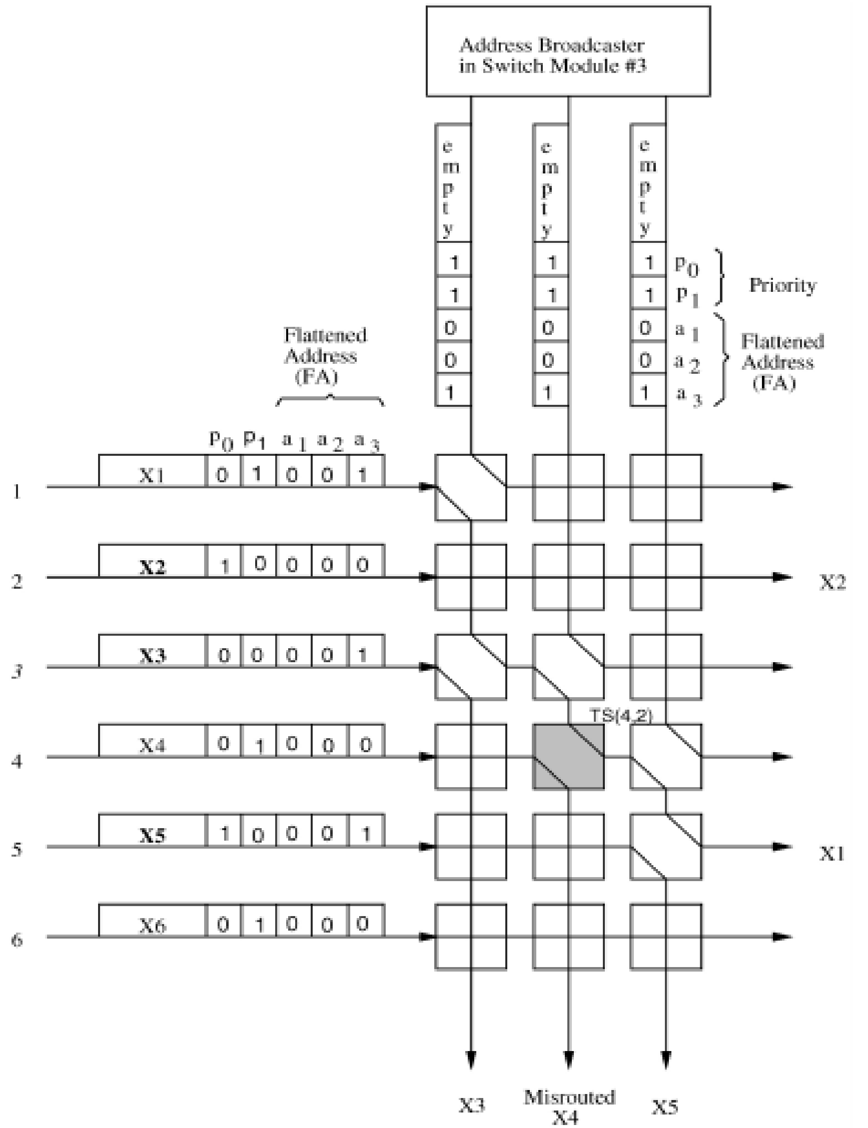
Knockout Switches

Cross-Stuck (CS) Fault



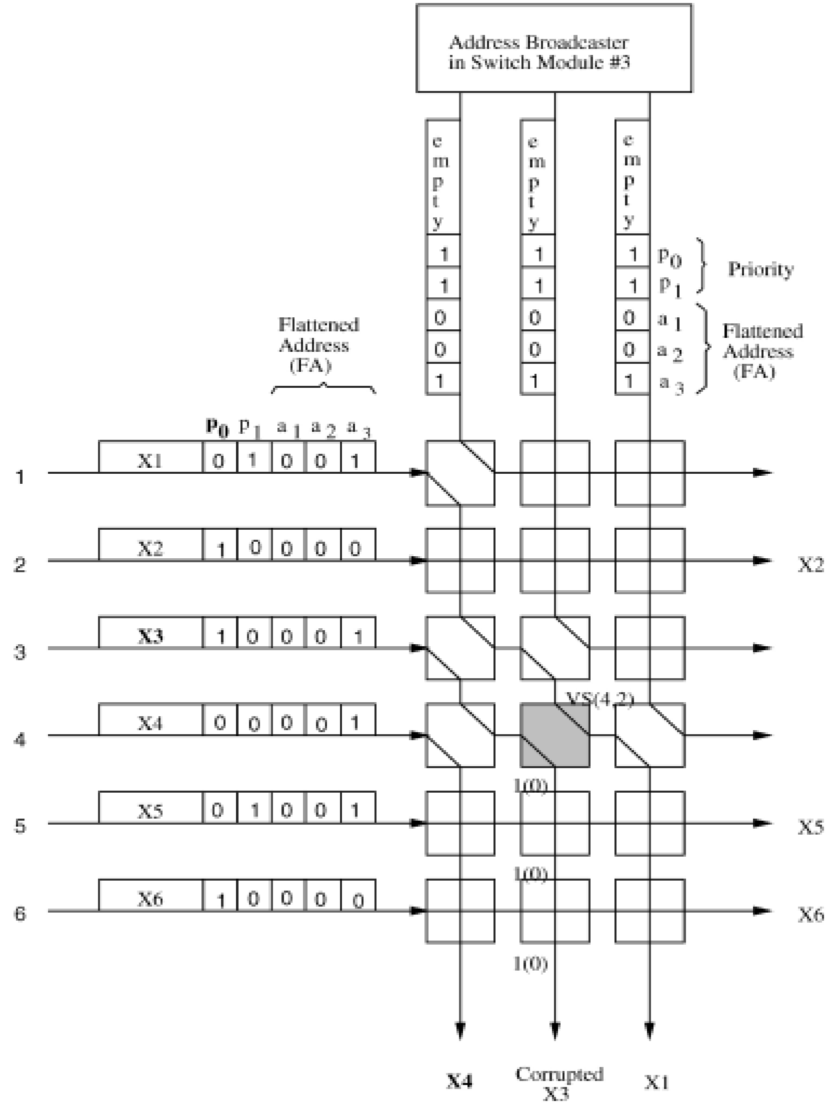
Knockout Switches

Toggle-Stuck (TS) Fault



Knockout Switches

Vertical/Horizontal-Stuck(VS/HS) Fault



Knockout Switches

Fault Detection

- Using FD’s (Fault detector)
- Test Pattern Generation by MPM’s and AB’s
- On Fault Diagnosis:
  - Keeping user packets
  - Doing Tests
  - System Reconfiguration
- Fast, So no interruption in Switch Functionality

Knockout Switches

Cross-Stuck and Toggle-Stuck Fault Detection

- Toggle/Cross Fault Detection?
  - Monitoring FA’s
    - If all 0 -> Fault
- Online Detection?
  - Toggle Stuck –possible!
  - Cross Stuck –Not possible!
- Vertial/Hor. Stuck Fault Detection?
  - Monitoring Switch module
    - If all the same ->Fault

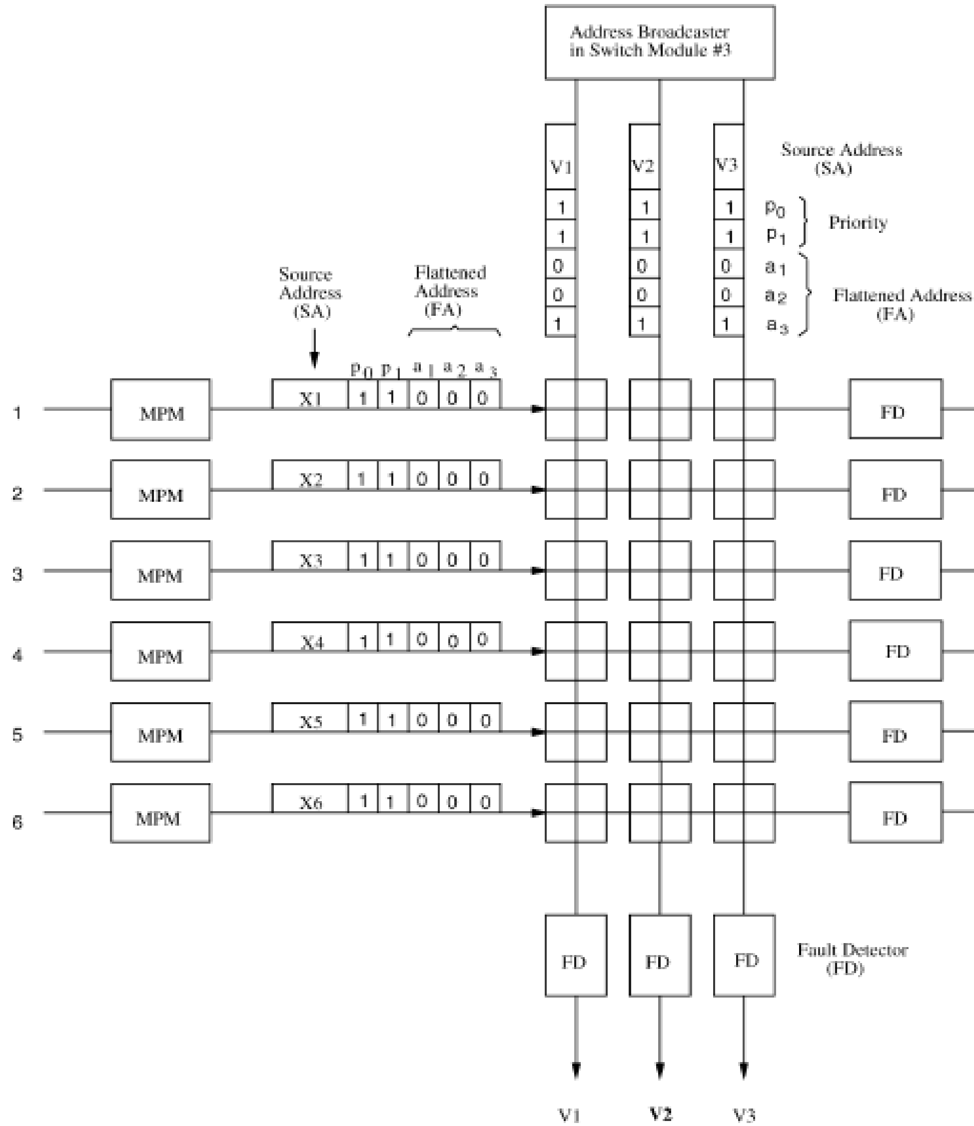
Fault Location and Reconfiguration

- Fault localization after Detection
- System Reconfiguration after localization

- Using test cells
  - Filelds:
    - FA Field
    - New Priority field $\lceil \log_2 2L_1M \rceil$ bits in MGN1
    - Input source field

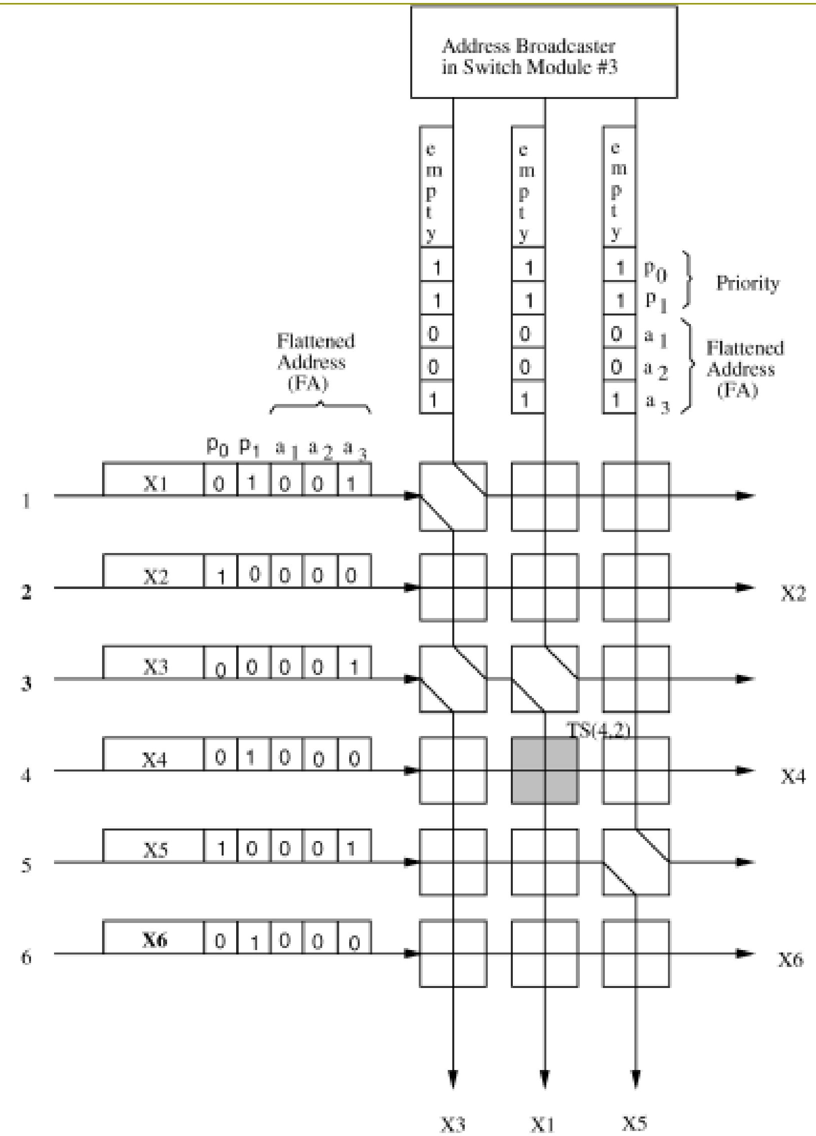
Knockout Switches

Toggle-Stuck and Cross-Stuck Cases

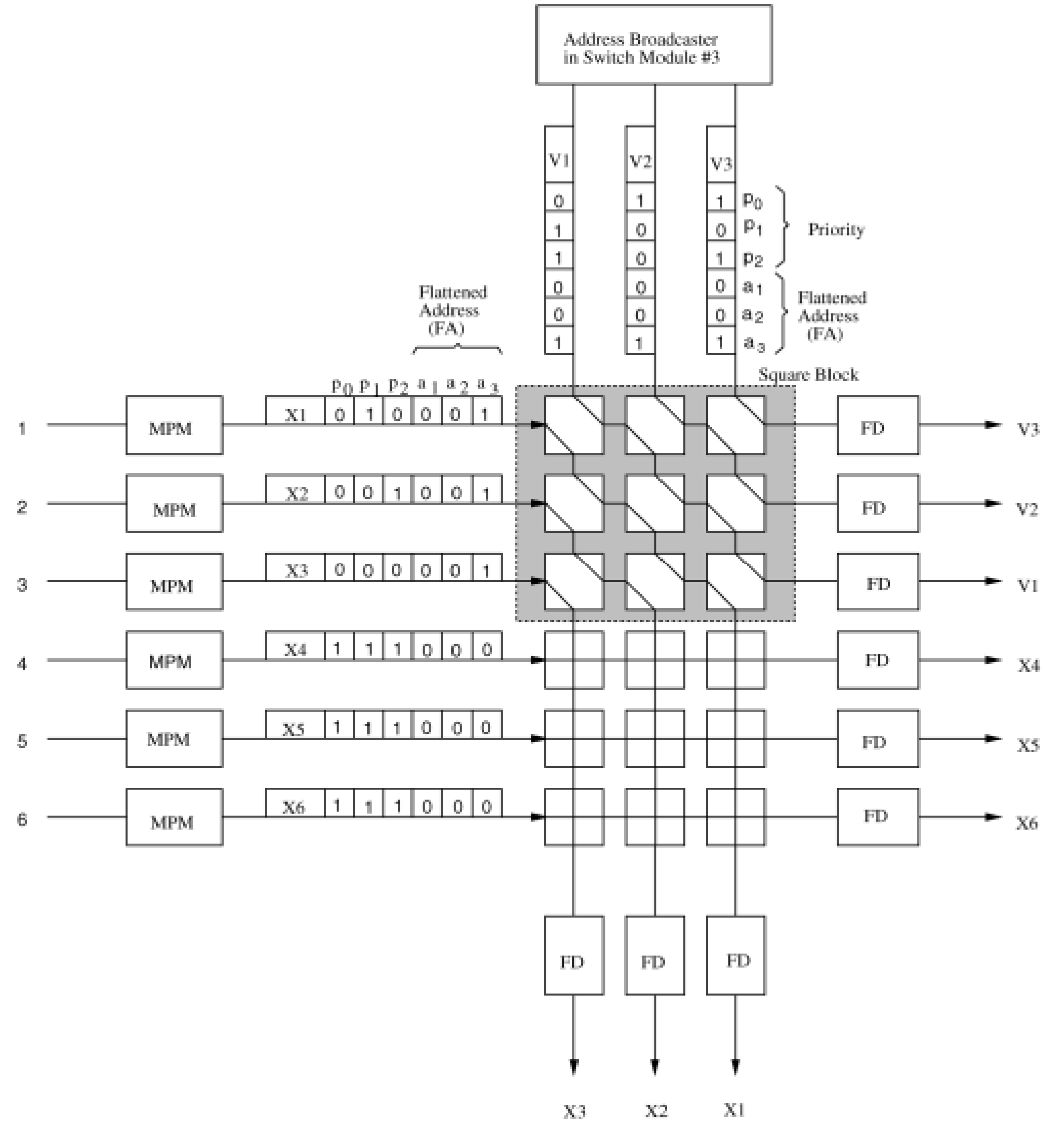


Knockout Switches

Fault Location Test

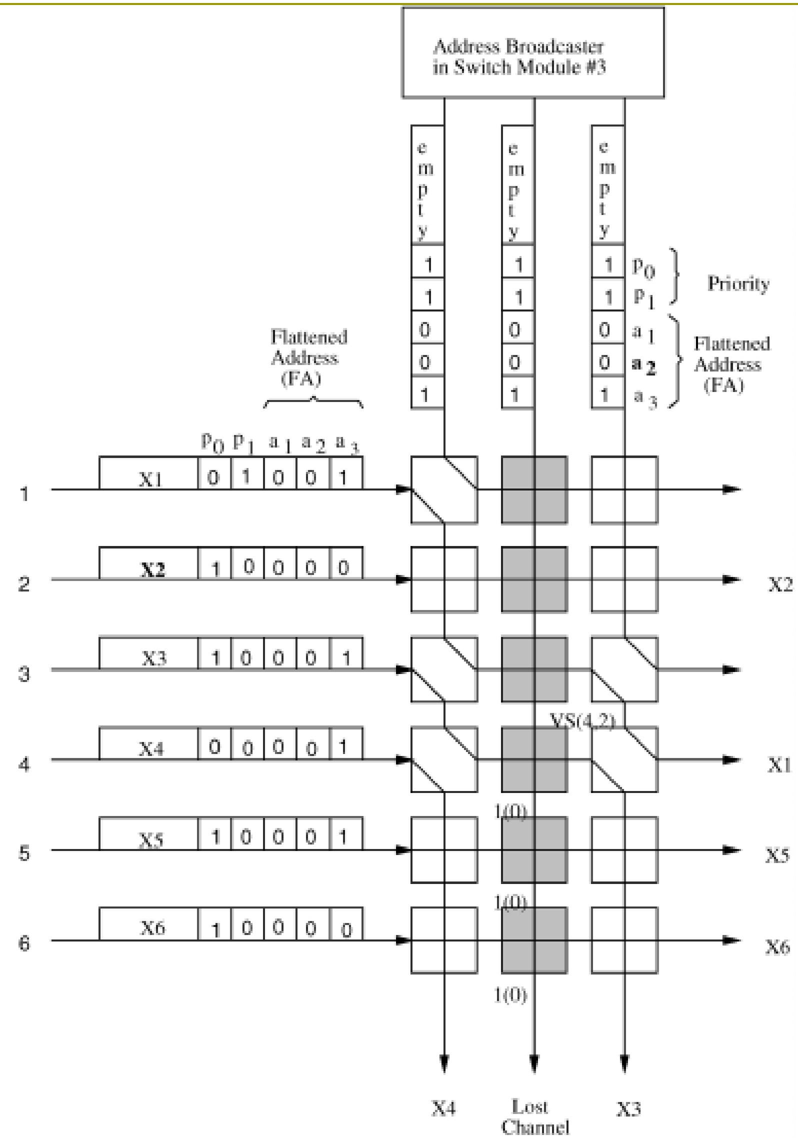


Fault Location of Cross Stuck



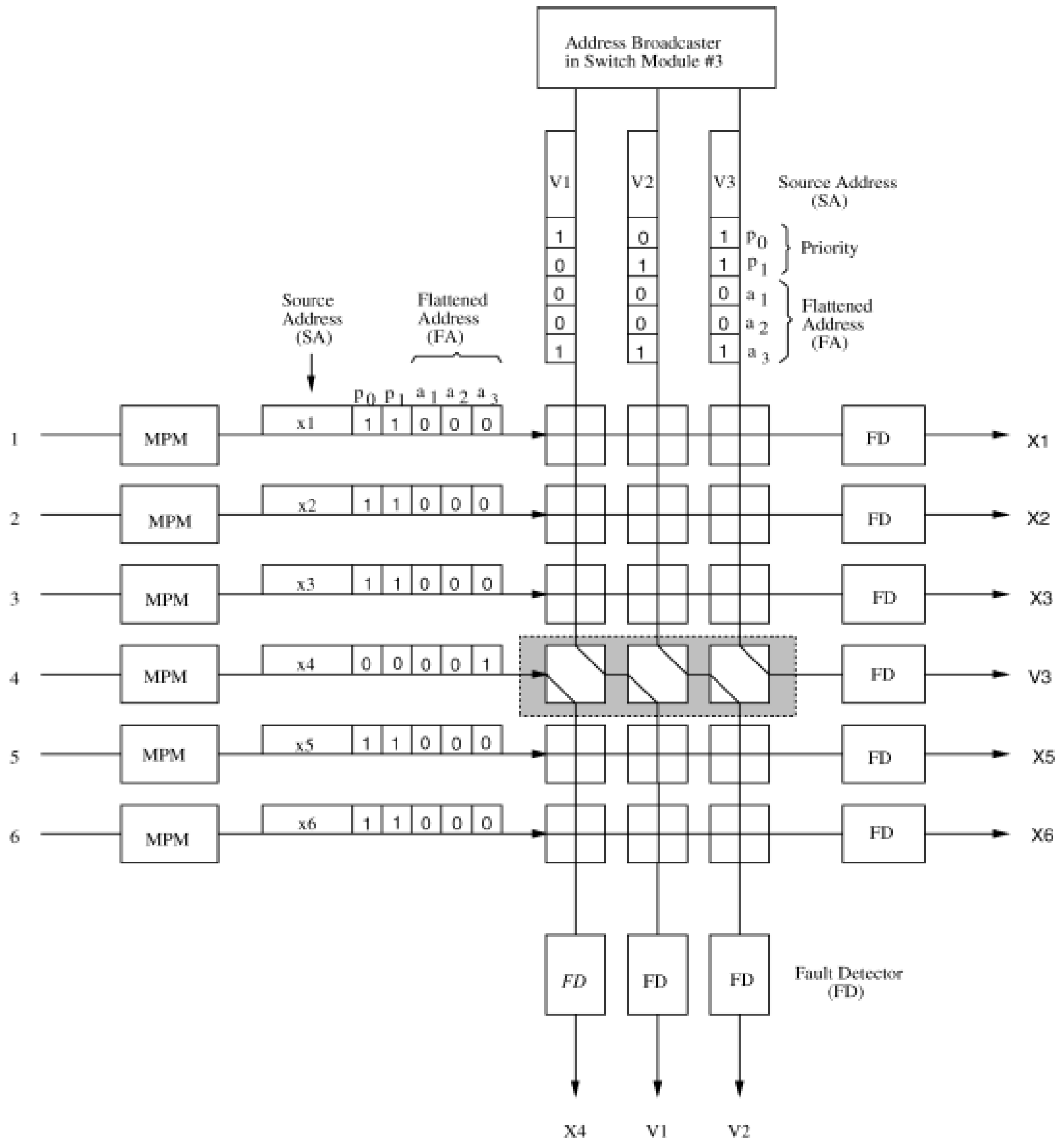
Knockout Switches

Reconfiguration of Vertical Stuck Fault



Knockout Switches

Fault Location Test



Knockout Switches

Reconfiguration