SMU School of Engineering

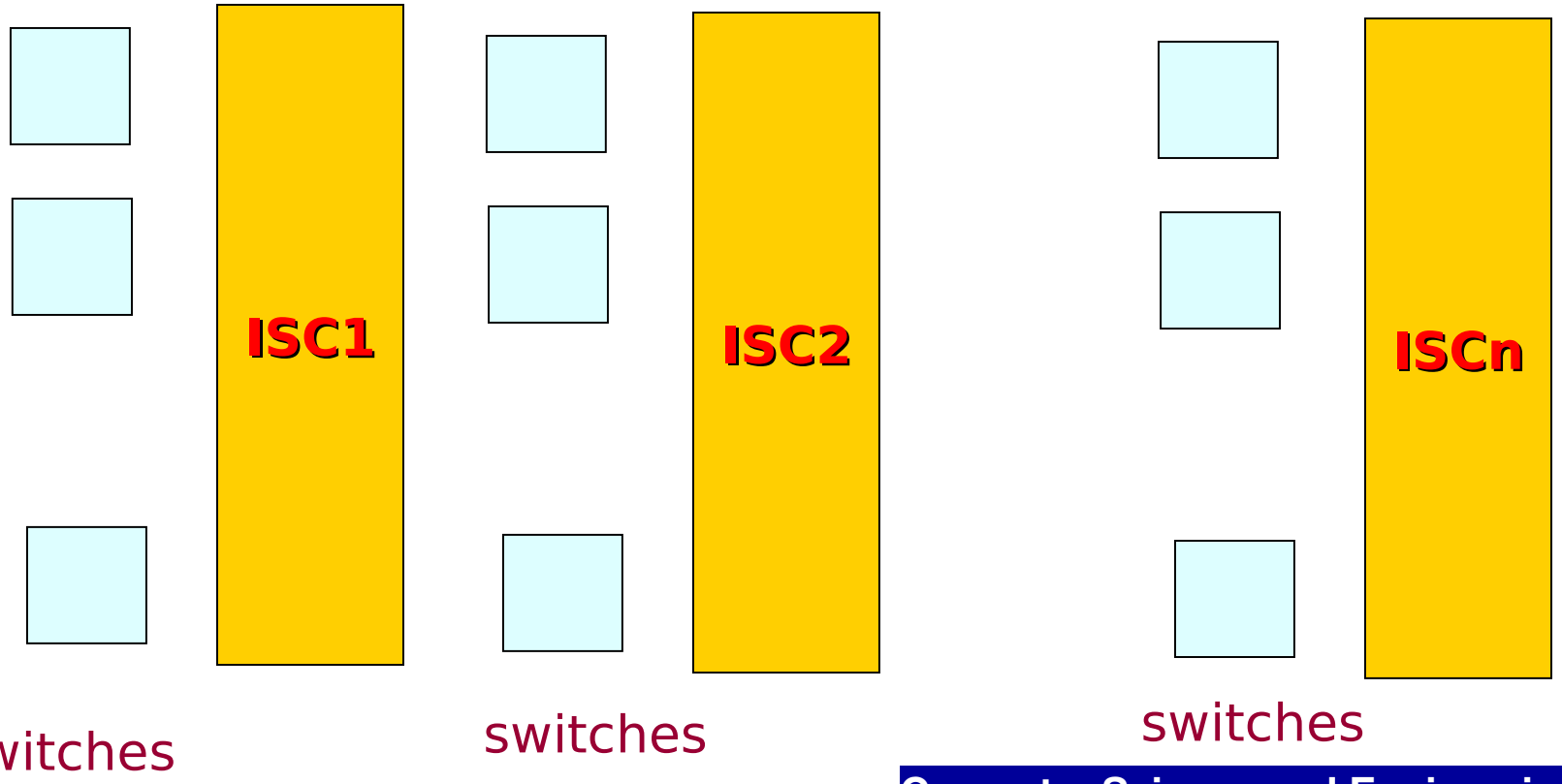
Advanced Computer Architecture

Contents

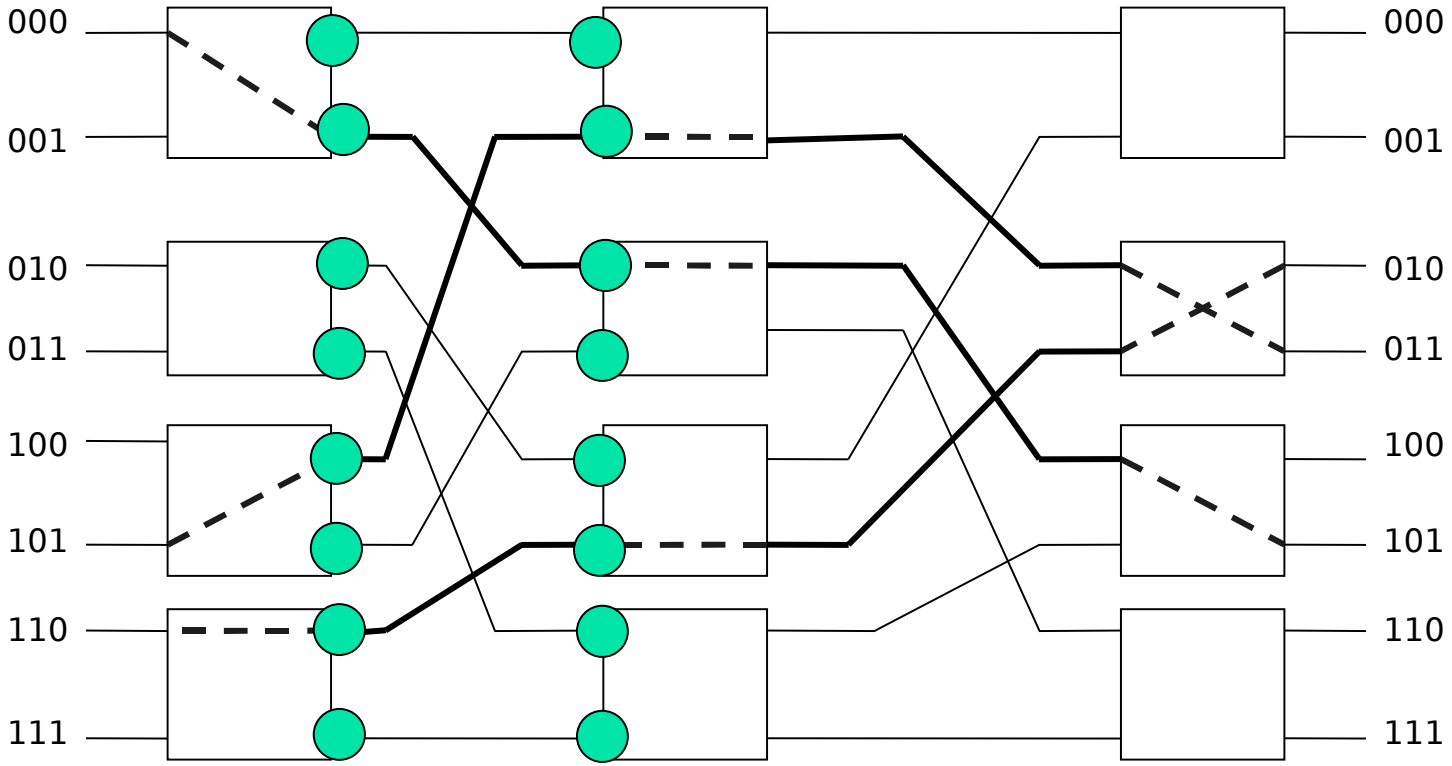
- Dynamic Networks (Cont.)
- Static Networks (Revisited)
- Performance Analysis

Multistage Interconnection Networks

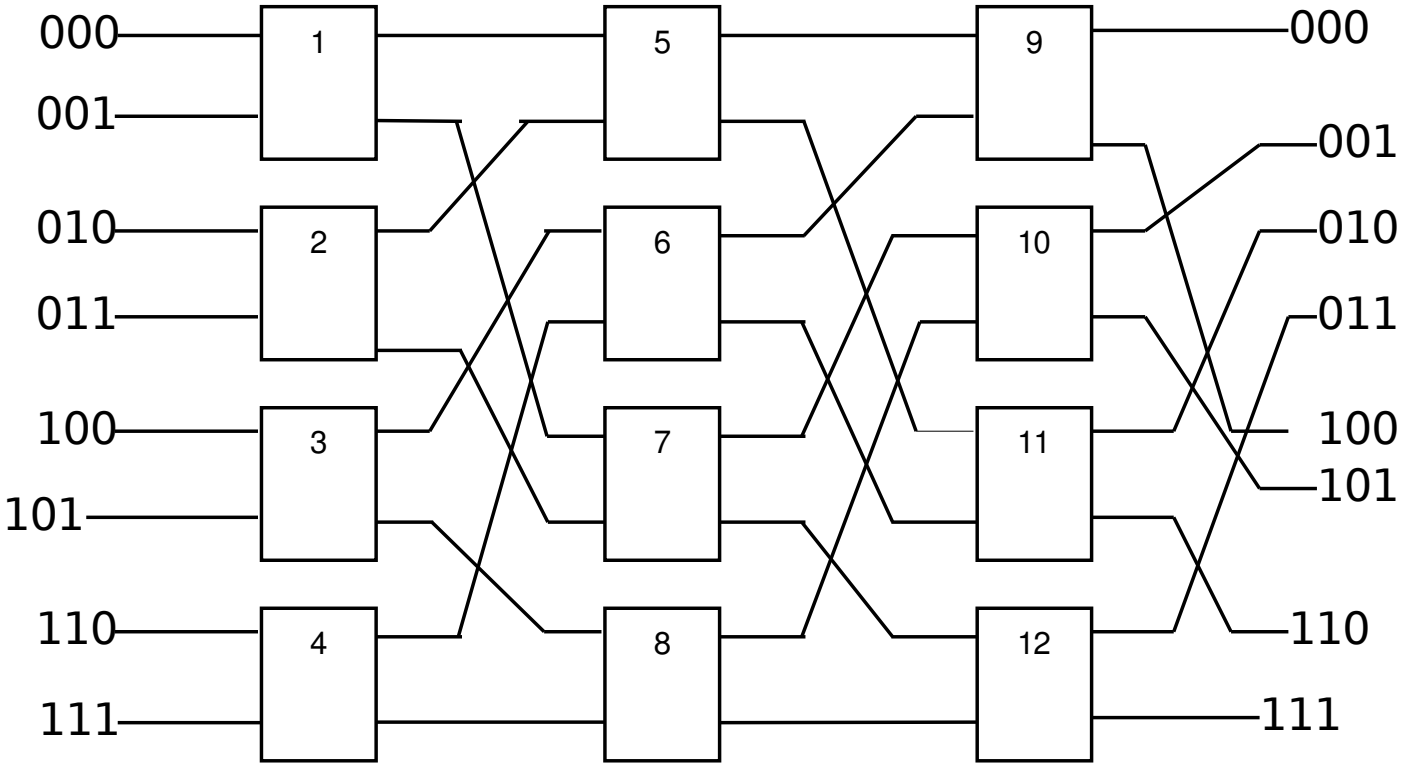
ISC → Inter-stage Connection Patterns



Multi-stage network

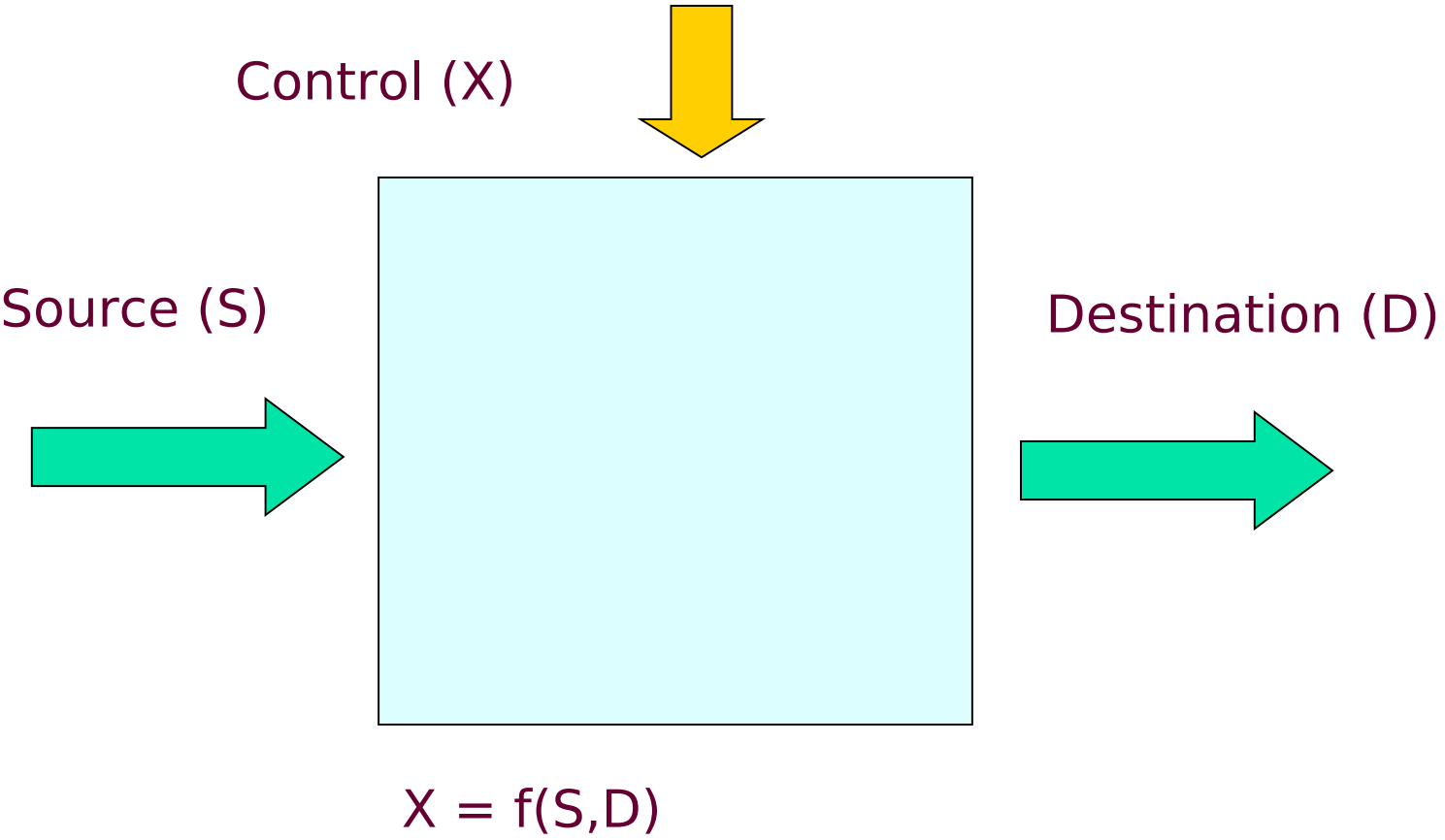


MIN (cont.)

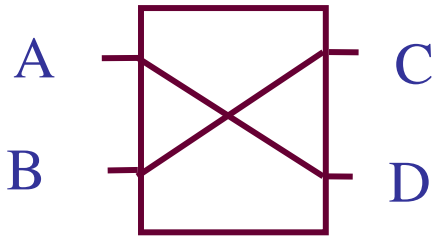


An 8X8 Banyan network

Min Implementation

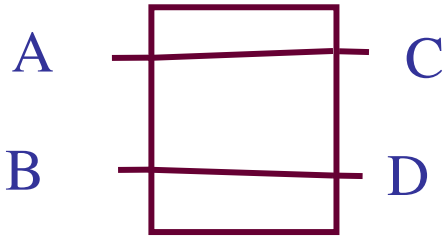


Example



X = 0

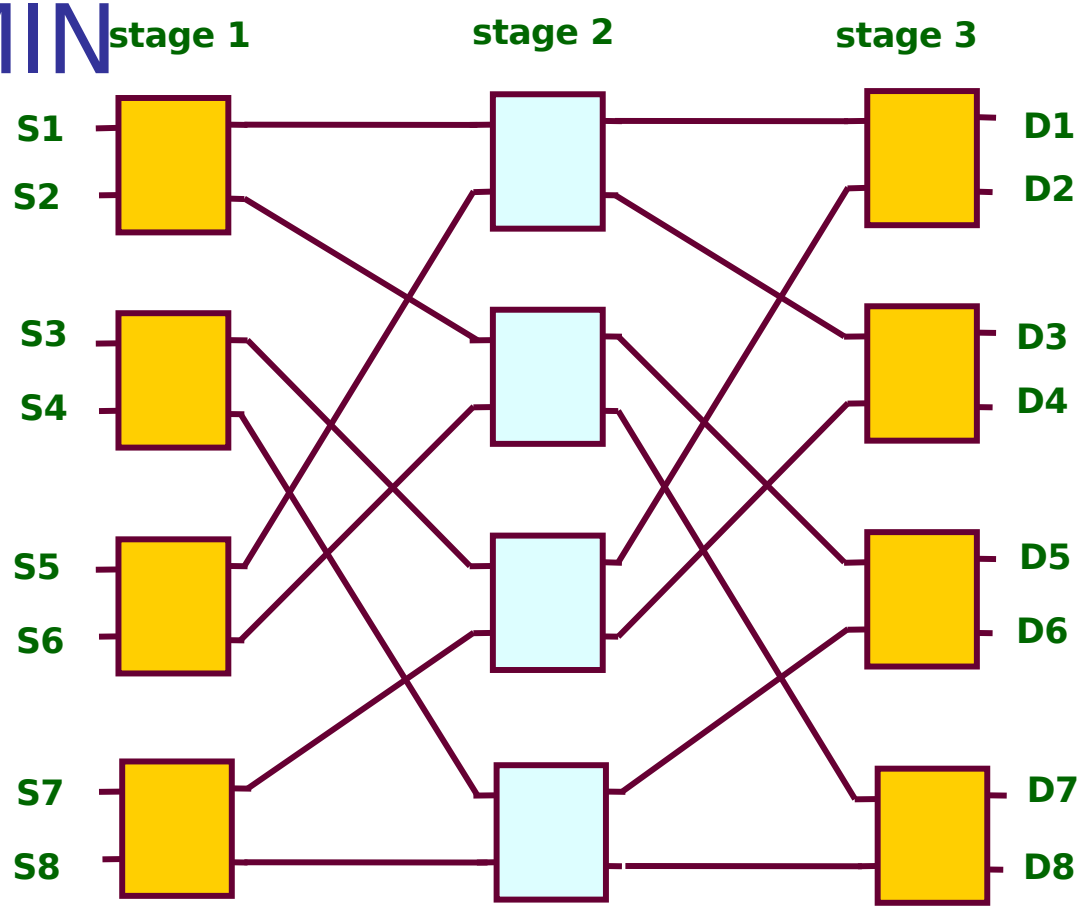
(crossed)



X = 1

(straight)

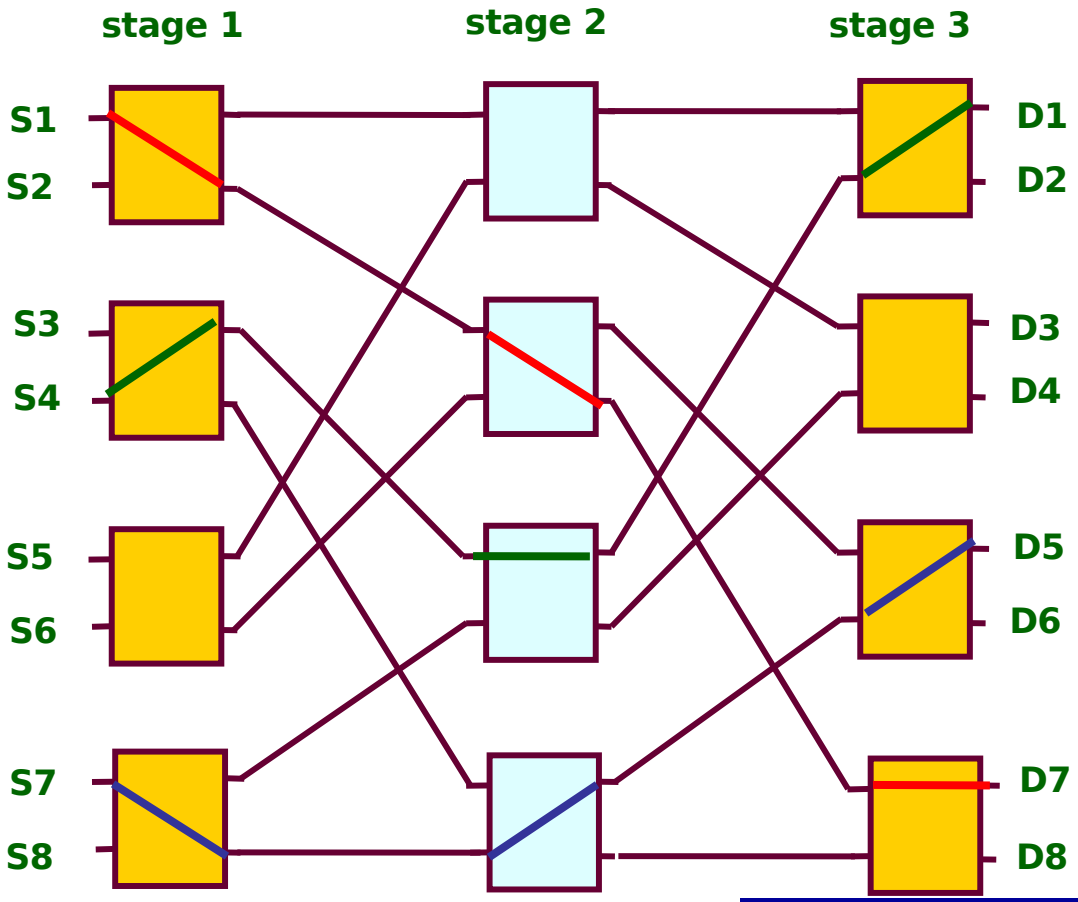
Consider this MIN



Example (Cont.)

- Let control variable be *X1, X2, X3*
- Find the values of *X1, X2, X3* to connect:
  - S1 → D6
  - S7 → D5
  - S4 → D1

The 3 connections

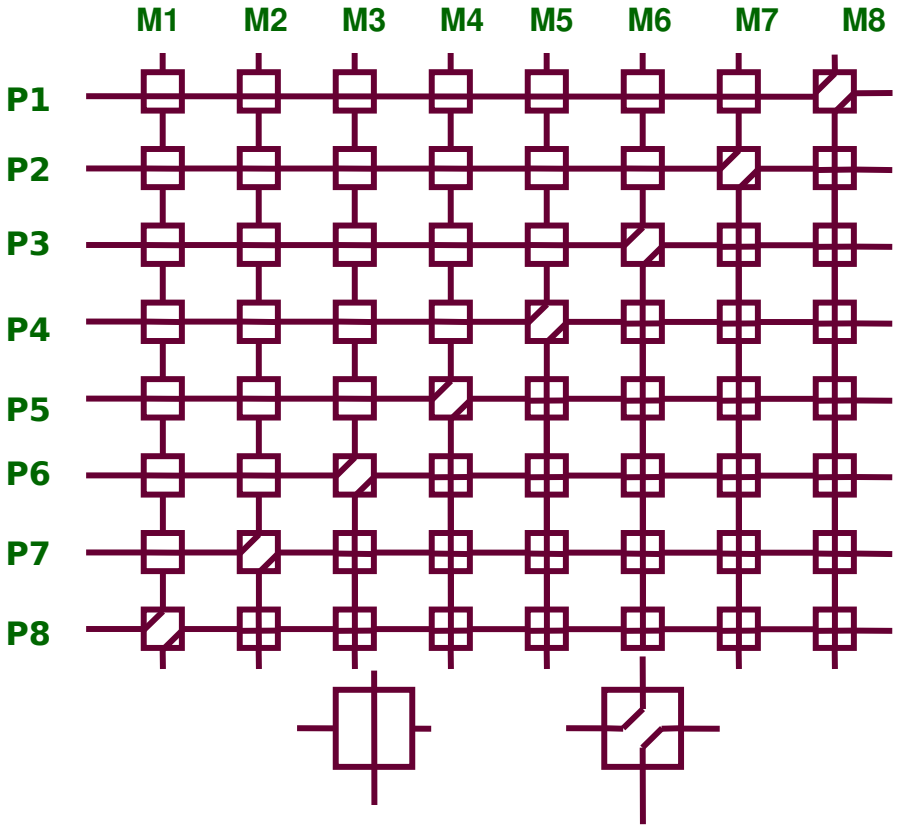


Boolean Functions

- $X = x_1, x_2, x_3$
- $S = s_2, s_2, s_3$
- $D = d_1, d_2, d_3$

- Find $X = f(S,D)$

Crossbar Switch



Analysis and performance metrics

dynamic networks

Networks	Delay	Cost	Blocking	Degree of FT
Bus	O(N)	O(1)	Yes	0
Multiple-bus	O(mN)	O(m)	Yes	(m-1)
MIN	O(logN)	O(NlogN)	Yes	0
Crossbar	O(1)	$O(N^2)$	No	0

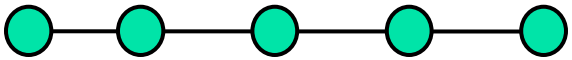
Static Network Analysis (Revisited)

- Graph Representation
- Parameters
  - Cost
  - Degree
  - Diameter
  - Fault tolerance

Graph Review

- G = (V,E) -- V: nodes, E: edges
- Directed vs. Undirected
- Weighted Graphs
- Path, path length, shortest path
- Cycles, cyclic vs. acyclic
- Connectivity: connected, weakly connected, strongly connected, fully connected

Linear Array



N nodes, N-1 edges

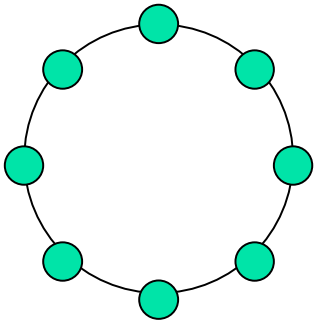
Node Degree:

Diameter:

Cost:

Fault Tolerance:

Ring



N nodes, N edges

Node Degree:

Diameter:

Cost:

Fault Tolerance:

Chordal Ring

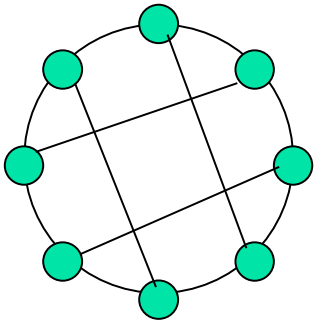
N nodes, N edges

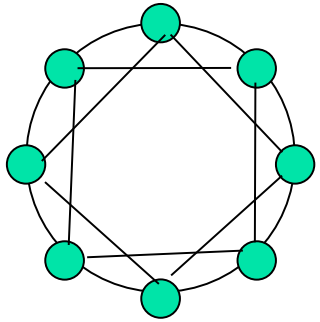
Node Degree:

Diameter:

Cost:

Fault Tolerance:





Barrel Shifter

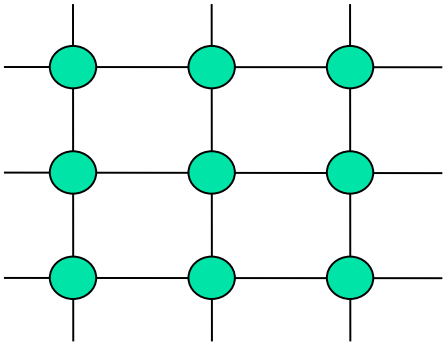
- Number of nodes $N = 2^n$
- Start with a ring
- Add extra edges from each node to those nodes having power of 2 distance
- i & j are connected if $|j-i| = 2^r$, r = 0, 1, 2, …, n-1

Mesh and Torus

N = n*n

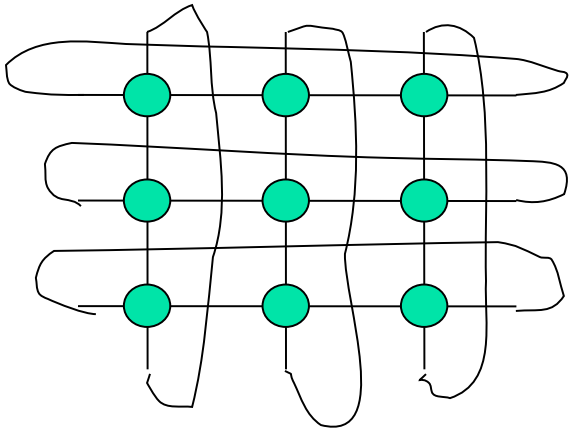
Node Degree:
Internal → 4
Other → 3, 2

Diameter: 2(n-1)



Node Degree:
4

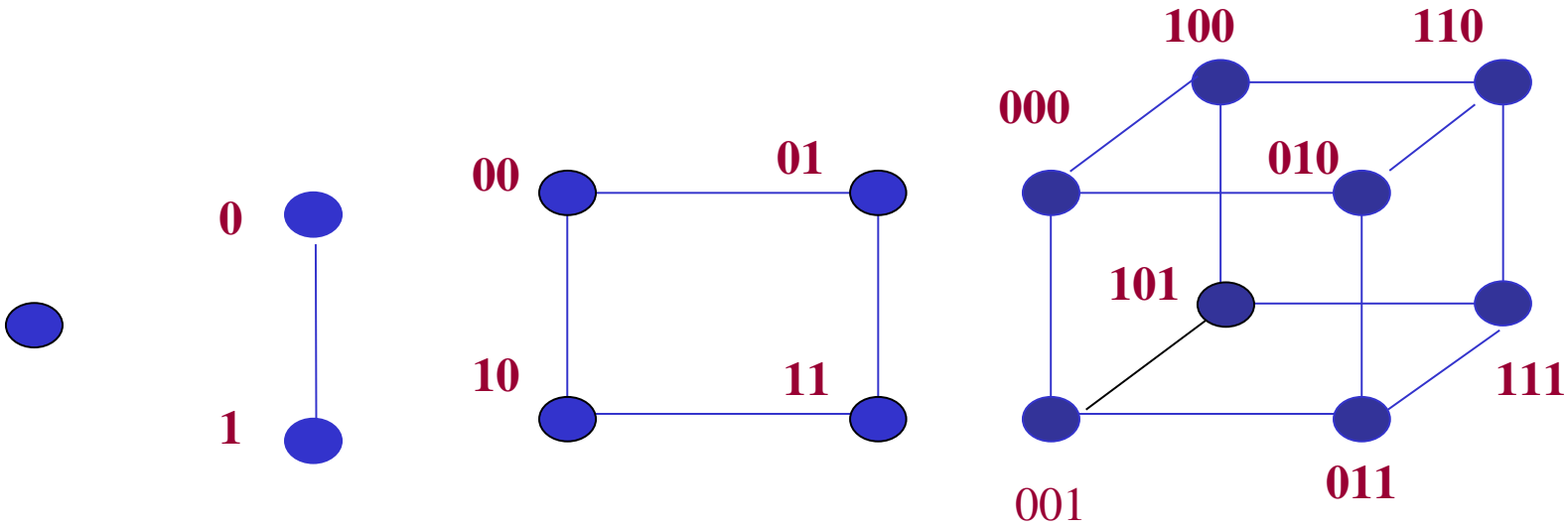
Diameter: 2* floor(n/2)



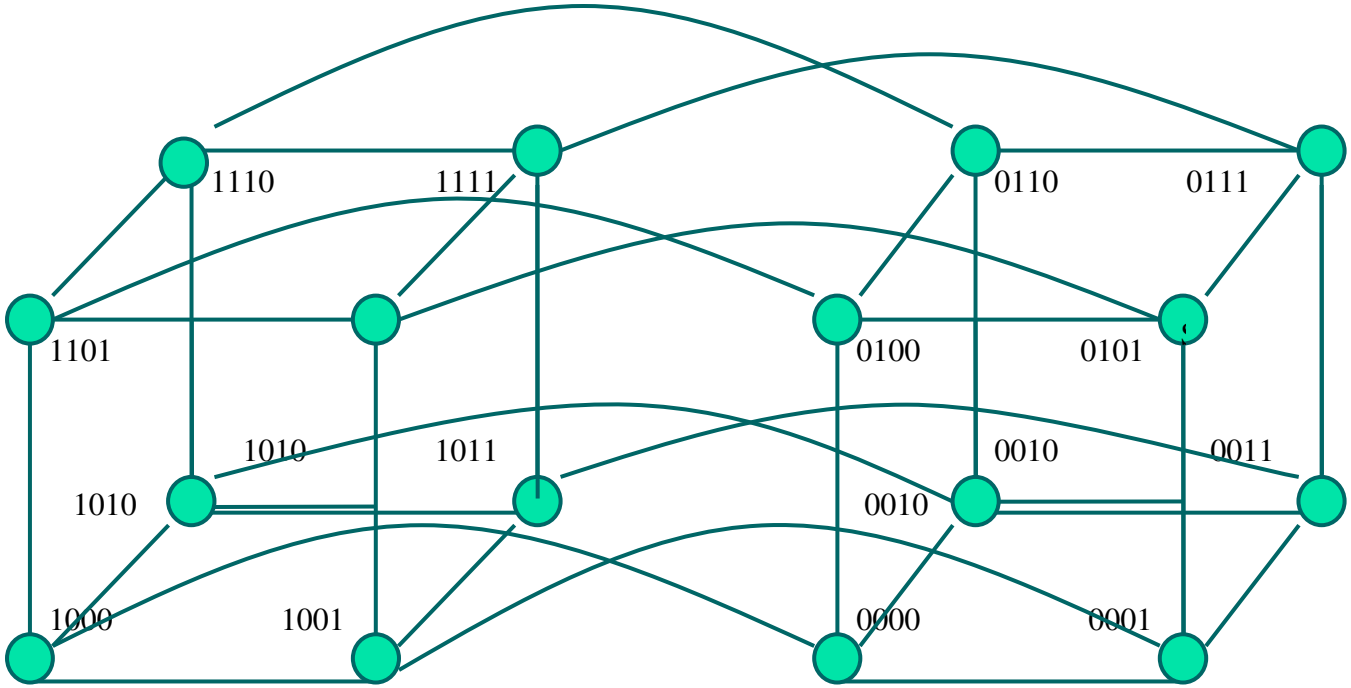
Hypercubes

- $N = 2^d$
- d dimensions ($d = \log N$)
- A cube with d dimensions is made out of 2 cubes of dimension d-1
- Symmetric
- Degree, Diameter, Cost, Fault tolerance
- Node labeling – number of bits

Hypercubes



Hypercubes



d = 4

Hypercube of dimension *d*

$N = 2^d$ $\quad\quad$ $d = \log n$

Node degree = d

Number of bits to label a node = d

Diameter = d

Number of edges = n*d/2

Hamming distance!

Routing