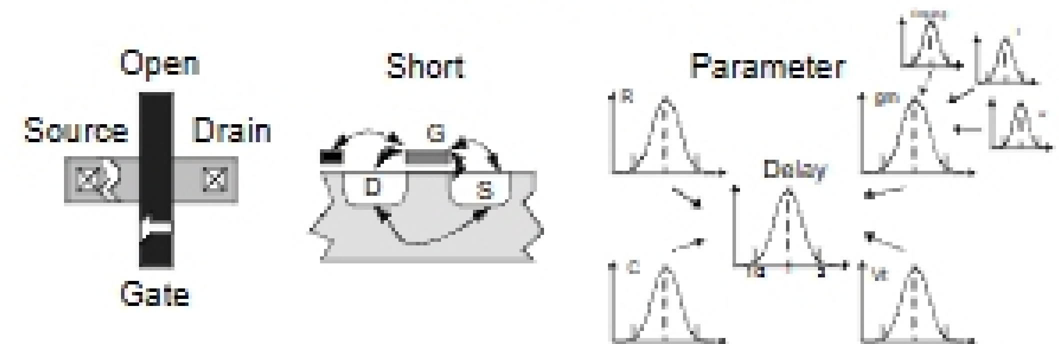
Lecture 37: Testing

- Fault models
- Test Combinational circuits
- Test Sequential circuits

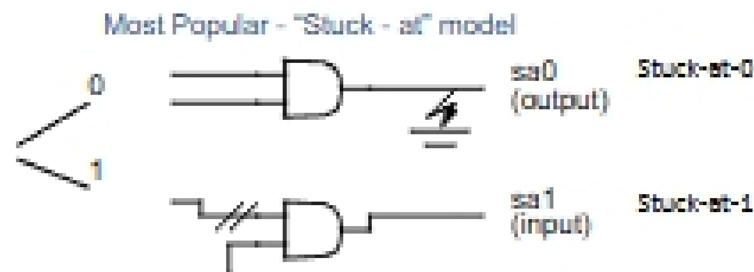
Defect and Faults

Fault types: Functional.
Timing.

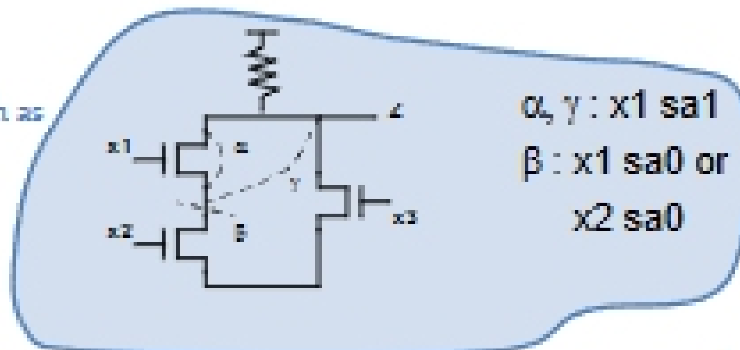
Abstraction level: Transistor. (layout)
Gate. (netlist)
Macro (functional blocks).



Logical-level fault model

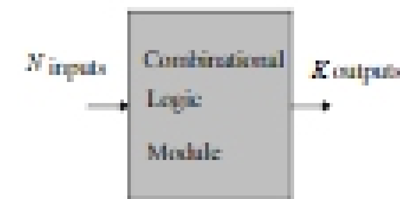


Covers many other occurring faults, such as opens and shorts.

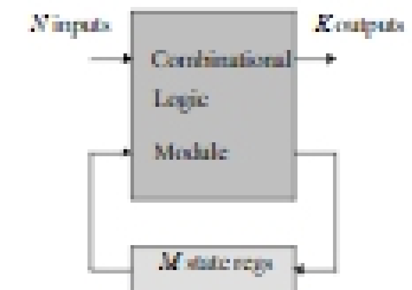


Testing Approaches

1. **Exhaustive Algorithm**
   - For n-input circuit, generate all 2^n input patterns
   - Infeasible, unless circuit has < 20 inputs



(a) Combinational function



(b) Sequential engine

2^N patterns

2^{N+M} patterns

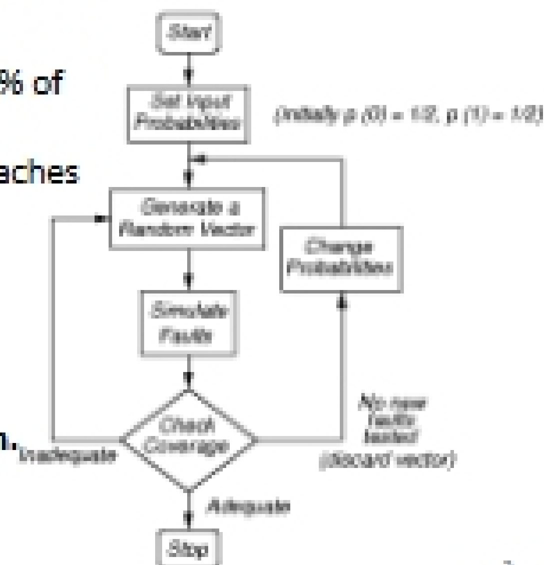
Testing Approaches

2. Random Pattern Generation

- Flow chart for method
- Use to get tests for 60-80% of faults, then switch to D-algorithm or other approaches for the rest

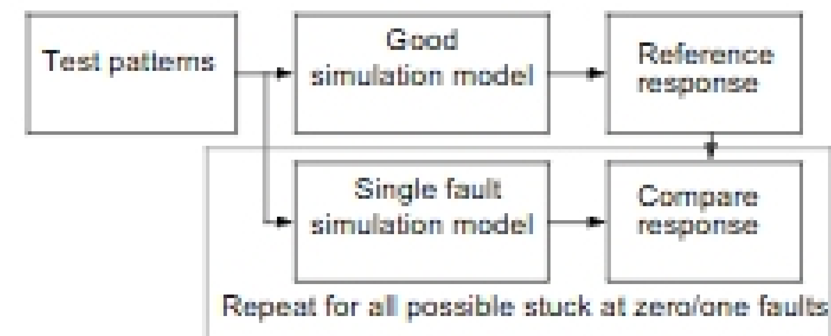
Q: How to estimate fault coverage?

A: Through Fault Simulation.



Fault Simulation

Fault coverage found by fault simulations

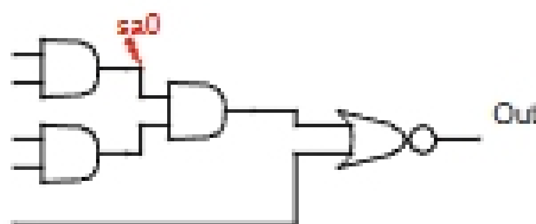


Requires long simulation times !.

Toggle test (counts how many times each node has changed) can be used to get a first impression of fault coverage.

Fault Simulation

- **Basic Terms:**
  - **Controllability**: the ease of controlling the state of a node
  - **Observability**: the ease of observing the state of a node
- **Goal:** determine input pattern that
  - makes a fault controllable (triggers the fault)
  - makes its impact visible at the output nodes



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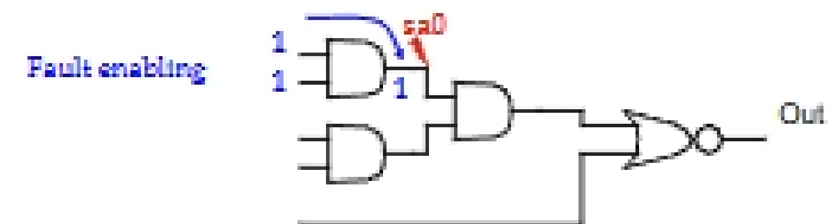

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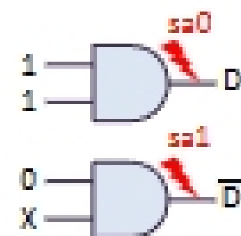
Technique Used: D-algorithm

D-algorithm

- Models circuit faults
  - Stuck-at-0
  - Stuck-at-1
- 5-Value Logic
  - 0 – binary 0 in both good and fault circuit
  - 1- binary 1 in both good and fault circuit
  - X – don't care
  - D – binary 1 in good circuit, 0 in bad circuit
  - $\overline{D}$ – binary 0 in good circuit, 1 in bad circuit

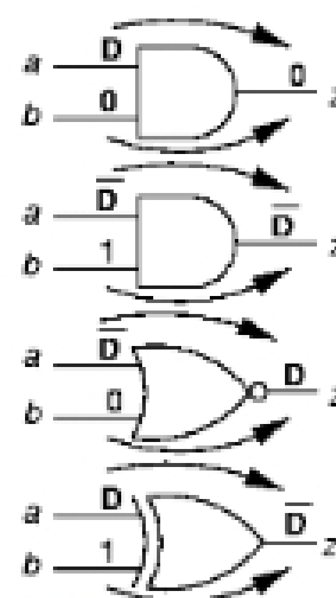
D-algorithm

- *Primitive D-Cube* of Failure
  - AND Output sa0: "1 1 D"
  - AND Output sa1: "0 X $\overline{D}$ "
    or "X 0 $\overline{D}$ "
  - Wire sa0: "D"



- *Propagation D-cube* – models conditions under which fault effect propagates through gate

Forward Implication



- Results in logic gate inputs that uniquely determine the output
- AND gate forward implication table:

a \ b	0	1	X	D	$\overline{D}$
0	0	0	0	0	0
1	0	1	X	D	$\overline{D}$
X	0	X	X	X	X
D	0	D	X	D	0
$\overline{D}$	0	$\overline{D}$	X	0	$\overline{D}$