CSE-308: Digital System Design

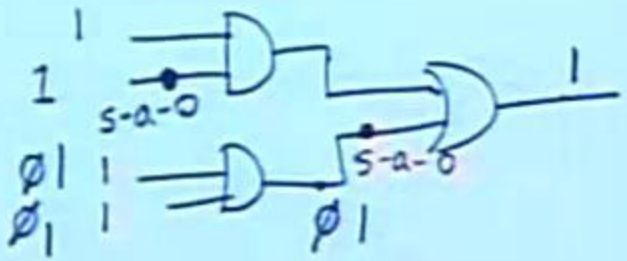
Lecture 9

Test Generation

Basic Idea

- Given the description of a circuit and a fault set under an assumed fault model, determine
  - the set of test vectors required to detect faults in the set.
  - the undetected faults.

- What is required actually?
  - Set a reverse logic value at the site of the fault.
  - Justify primary inputs accordingly.
  - Set / modify primary input values so that any change in logic value at the site of the fault may propagate to the primary output.

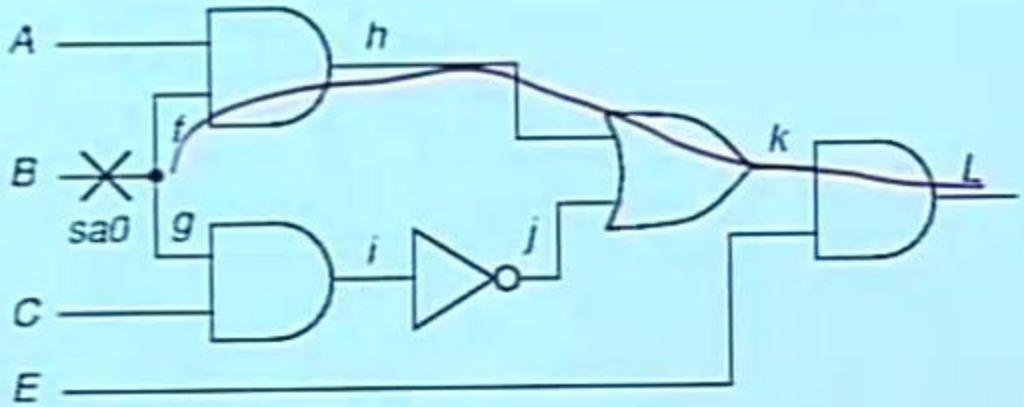


Test Generation Algorithms

- Many algorithms exist:
  - Boolean difference method
  - D-algorithm
  - PODEM
  - FAN
  - etc etc etc

Path Sensitization

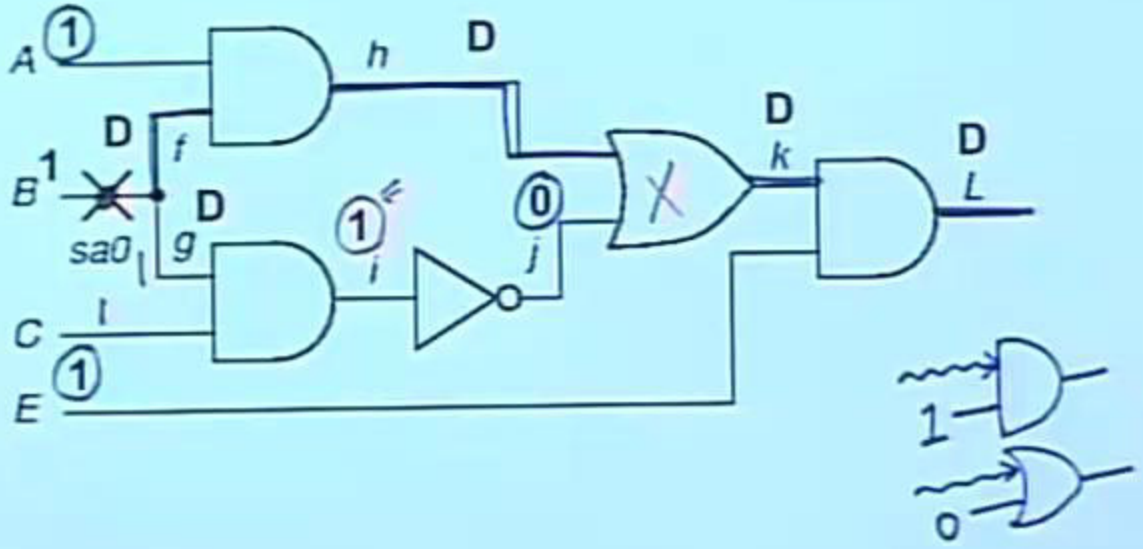
- Three steps:
  - Fault sensitization
  - Fault propagation
  - Line justification



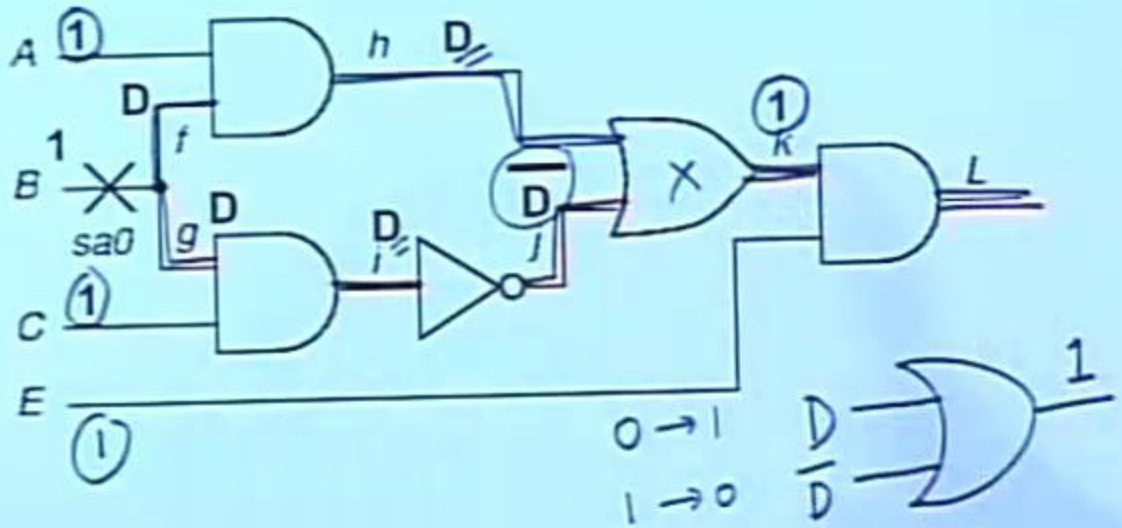
D :: a change (0 → 1)

$\bar{D}$ :: 1 → 0

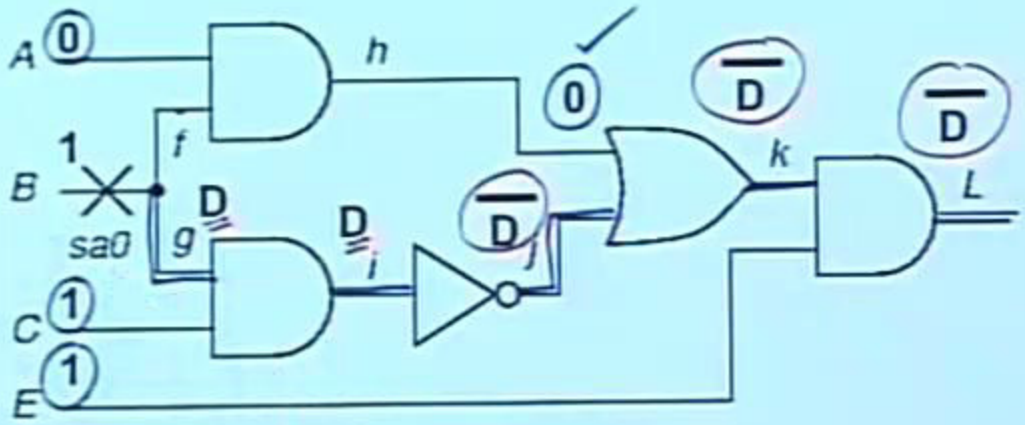
- Try path $f - h - k - L$. This path is blocked at j, since there is no way to justify the 1 on i



- Try simultaneous paths $f - h - k - L$ and $g - i - j - k - L$. These paths blocked at k because *D-frontier* (chain of D or $\overline{D}$) disappears



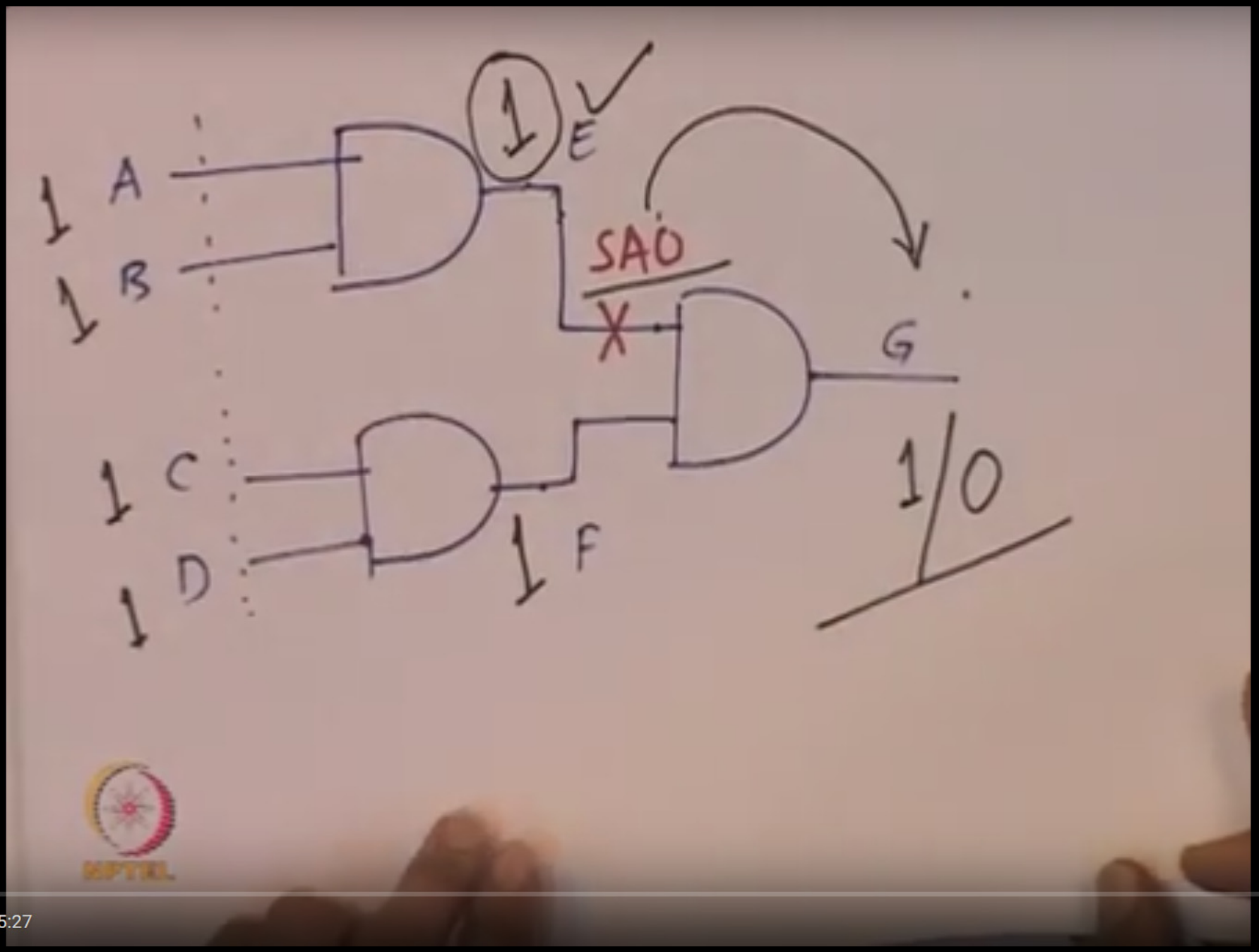
- Final try: path $g - i - j - k - L$ – test found!



ATPG - Algorithmic

- Path Sensitization Method
  - Fault Sensitization
  - Fault Propagation
  - Line Justification

- Path Sensitization Algorithms
  - D- Algorithm (Roth)
  - PODEM (P. Goel)
  - FAN (Fujiwara)
  - SOCRATES (Schultz)
  - SPIRIT (Emil & Fujiwara)

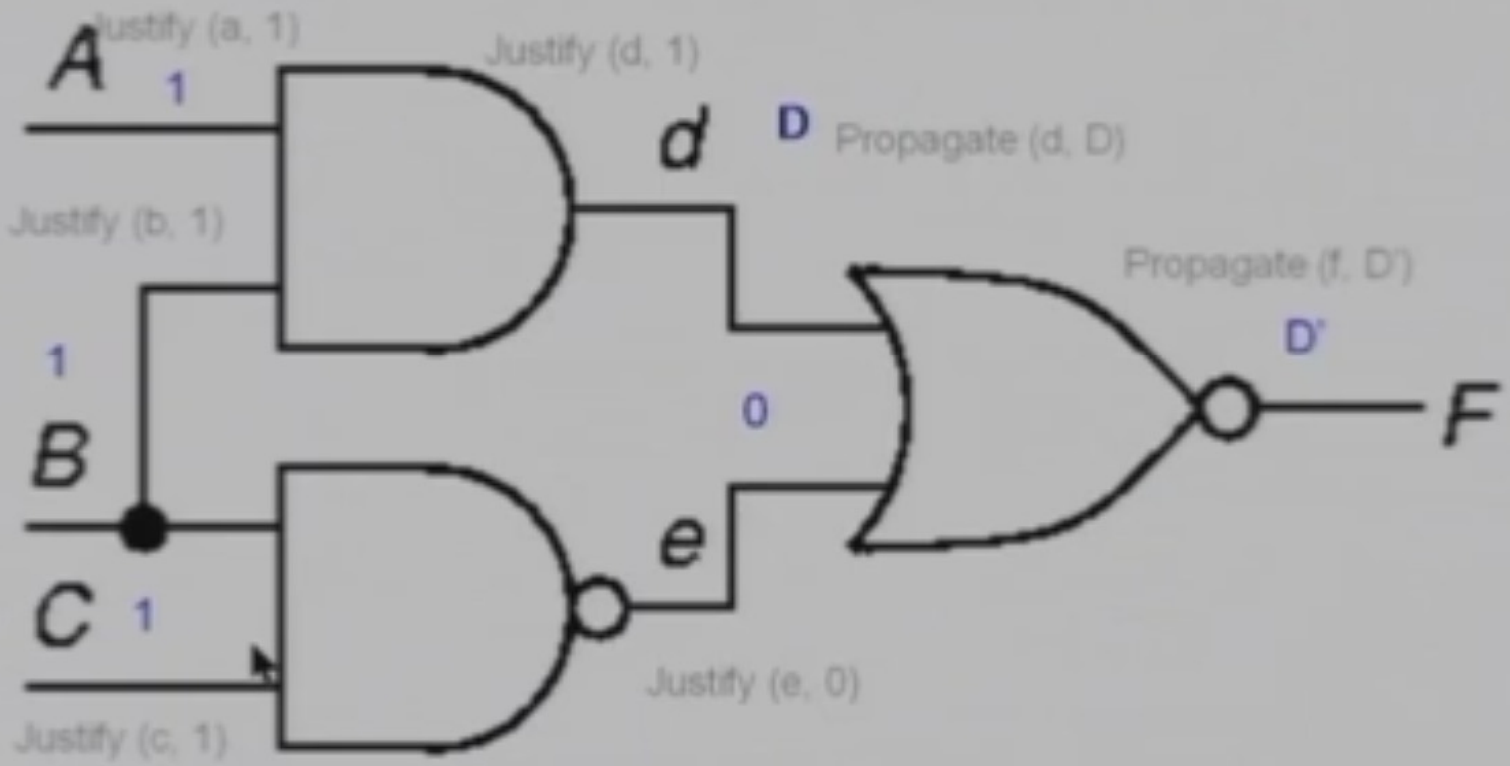


Path Sensitization

General Structure of TG Algorithm

```
begin
    set all values to x
    Justify (l, v)
    if (v = 0) then Propagate (l, D)
    else Propagate (l, D')
end
```

Path Sensitization



TG: Common Concept

- Fault Activation problem → a LJ Problem
- The Fault Propagation problem →
  1. Select a FP path to PO → Decision
  2. Once the path is selected → a set of LJ problems
- The LJ Problems → Decisions or Implications

To justify c = 1 → a = 1, b = 1 (Implication)

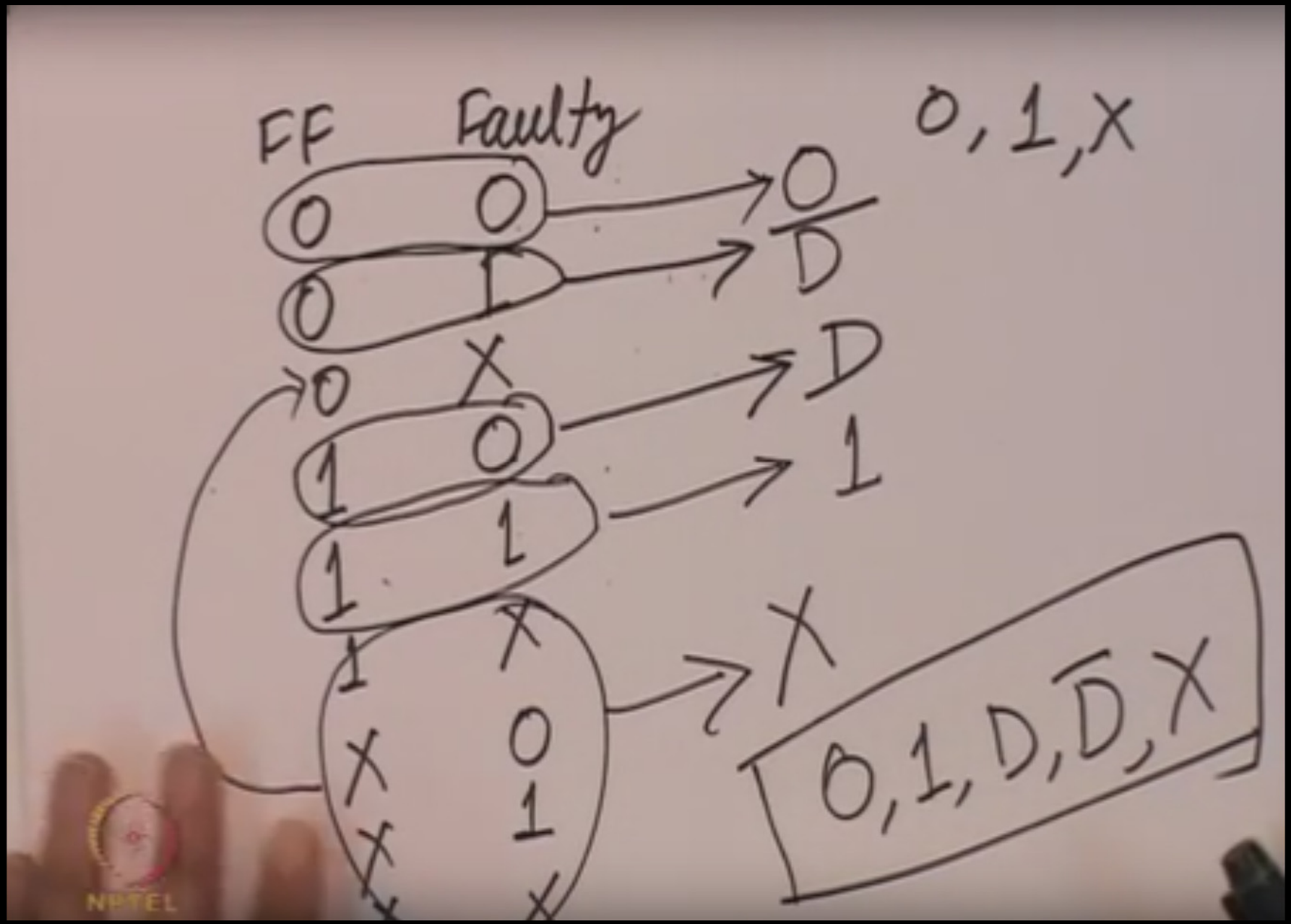
To justify c = 0 → a = 0 or b = 0 (Decision)

- Incorrect decision → Backtrack → Another decision

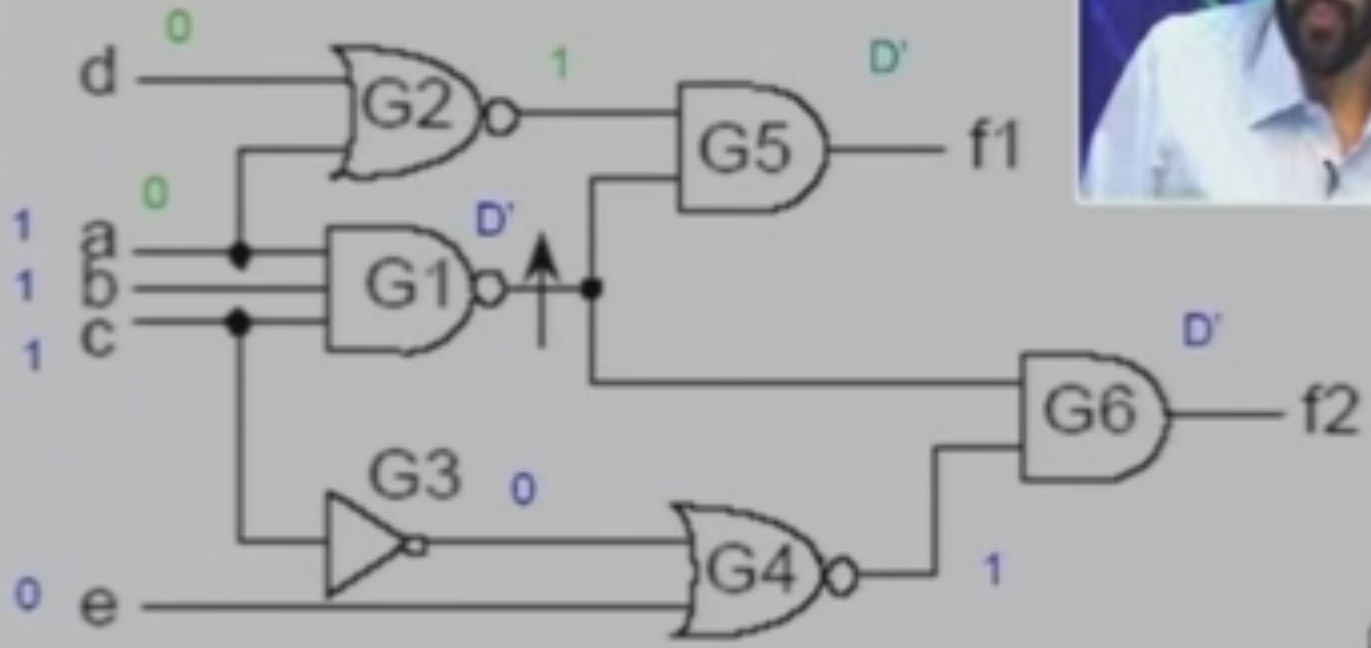
D-Algorithm

Roth (IBM) - 1966

- Fundamental concepts invented:
  - First complete ATPG algorithm
  - D-Calculus (5 valued logic) – Composite value
    - 0 (0/0)
    - 1 (1/1)
    - D (1/0)
    - D′ (0/1)
    - X (x/0, x/1, 1/x, 0/x, x/x)
  - Implications – forward and backward
  - Implication stack
  - Backtrack
  - Test Search Space

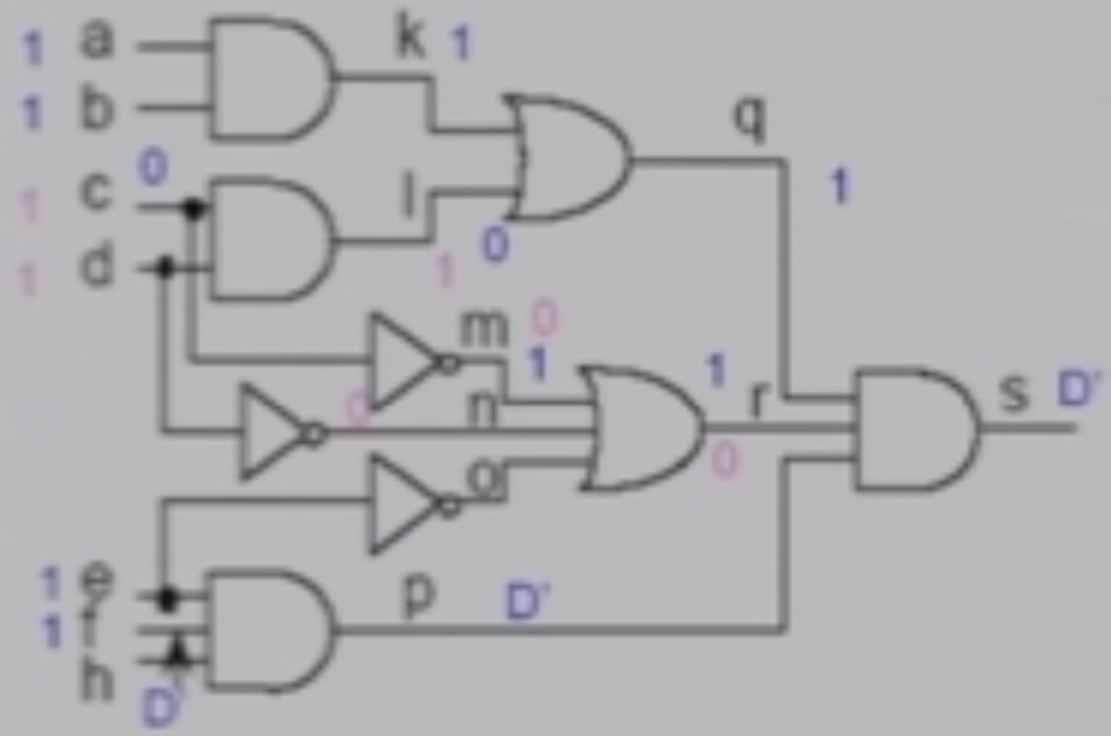

FF
Faulty
0, 1, X
0
0
0
D
0
X
D
1
0
1
1
1
1
X
X
0
1
X
0, 1, D, D̄, X

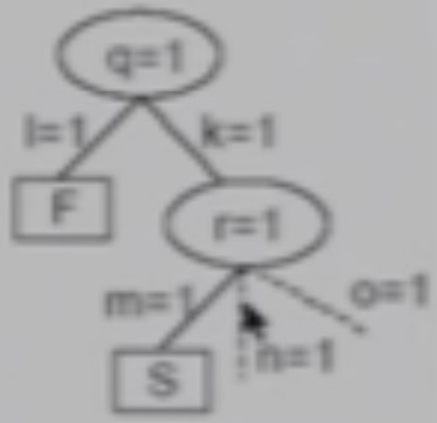
Decisions during FP



D – frontier: The set of all gates whose output value is currently x but have one or more fault signals on their inputs

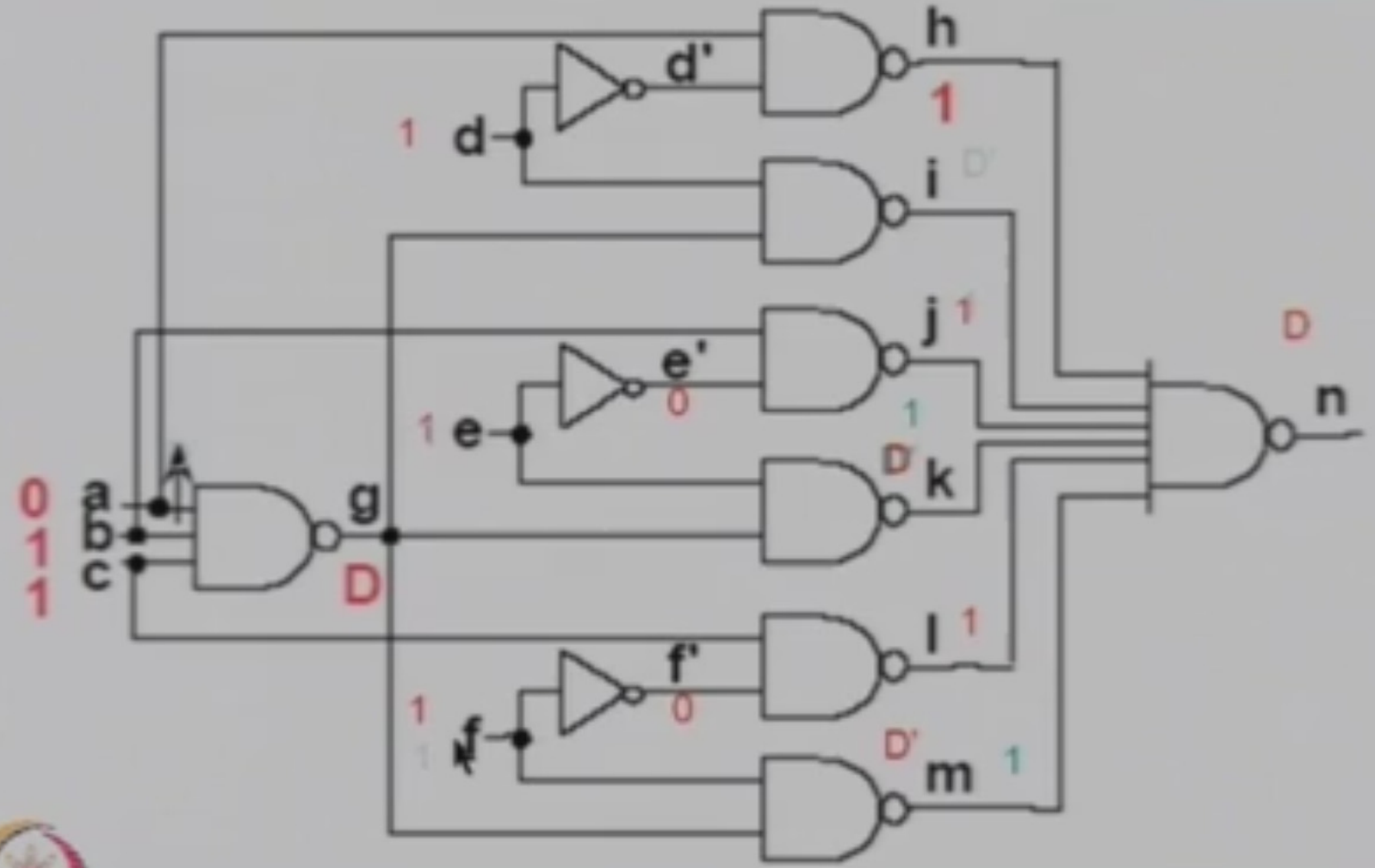
Decisions during LJ



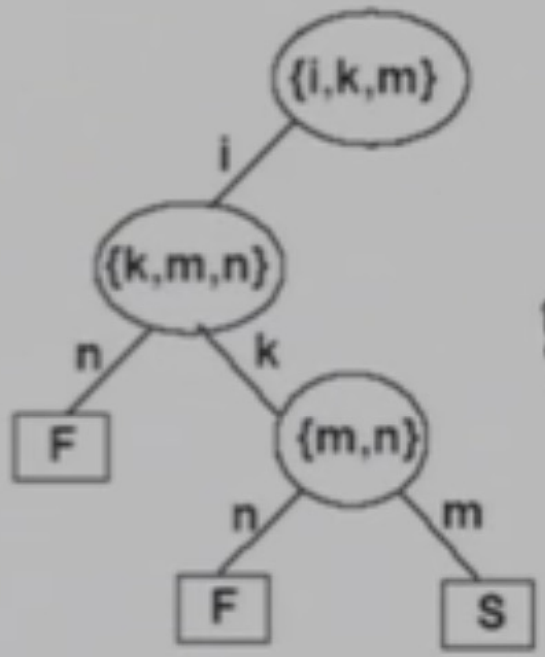


J – Frontier : A set of all gates whose output value is known but not implied by its input value

D-Algorithm : Example



Decision Tree



Two times of backtracking!!