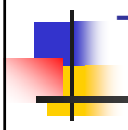


Testing Digital Systems I

Lecture 10:
Boolean Testing Using Fault Models (FAN)

Instructor: M. Tahoori

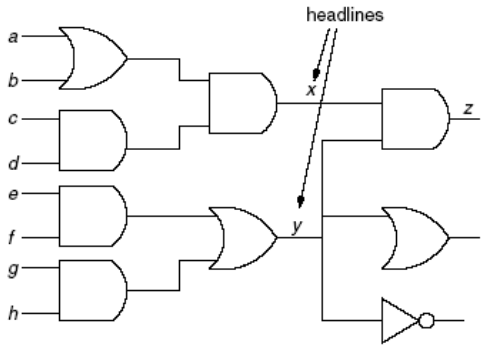
FAN

- Internal and Input values assigned (FAN)
- New features
  - Stop Backtraces at Head Lines
    - Input Lines or Internal Lines that Cannot Cause Conflict
    - To reduce the number decisions
  - Immediate Implication
    - Both Forward and Backward
  - Unique Sensitization
  - Multiple rather than Single Backtrace
    - Multiple Objectives to reduce later conflicts

Headlines

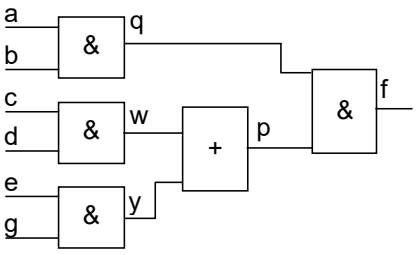
- Output signals of fanout-free cones
- Any value on headlines can always be justified by the PIs

We only need to backtrace to the headlines to reduce the number of decisions



Fanout-Free Network

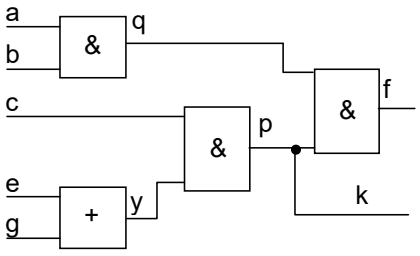
- Justify logic value 1 on f
  - Justify 1 on p and q
    - a = b = c = d = 1
- Justify logic value 0 on f
  - a = 0
- A fanout-free logic network with no redundancy
  - the logic value at the output of the logic network can always be justified without any backtracking



Head-Lines

- Bound Line
  - Any signal line which directly or indirectly fed by a fanout branch
- Free Line
  - Line that is Not Bound
- Head Line:
  - Free Line, and
  - Fanout Stem or Input of a Gate with Bound Output,

Head-Lines



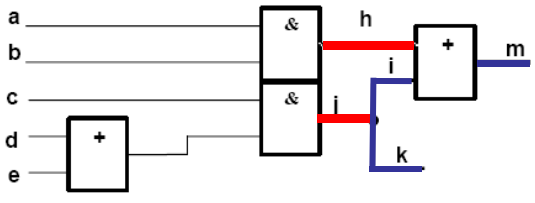
- f, f2 and k are the bound lines
- a, b, q, c, e, g, y and p are free lines
- p and q are head lines
  - p is a fanout stem and q is the only free signal line which is an input of a gate whose output is a bound line (f)

How to mark?

- Start at the primary inputs of the logic network which are marked as free lines and move forward towards the output
- Whenever encounter a fanout
  - Mark each fanout branch as a bound line
- If the fanout stem is a free line
  - Mark it as a head line
- When encounter a logic gate,
  - The output of that gate is a bound line if and only if any of the inputs of that gate is a bound line;
  - Otherwise, the output of the logic gate is a free line
- If the logic gate output is a bound line
  - Any input of that gate which is a free line is marked as a head line

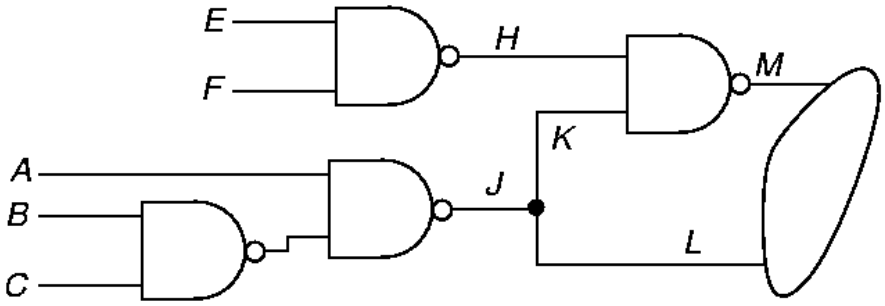
Head Lines

- PODEM
  - Objective: j=1, Set d=1
  - Objective: j=1, Set c=1
  - Imply — j=1,No Test Possible
  - Set c=0, Imply j=0
- FAN
  - Objective: j=1, Set j=1
  - Imply — j=1,No Test Possible
  - Set j=0

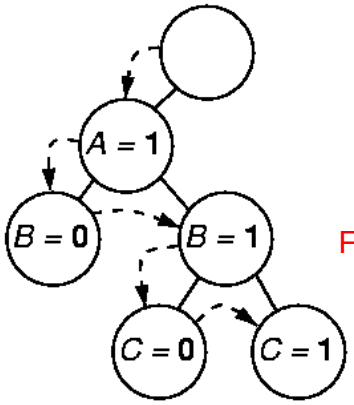


Head line Bound line

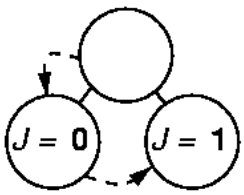
Headlines



Contrasting Decision Trees



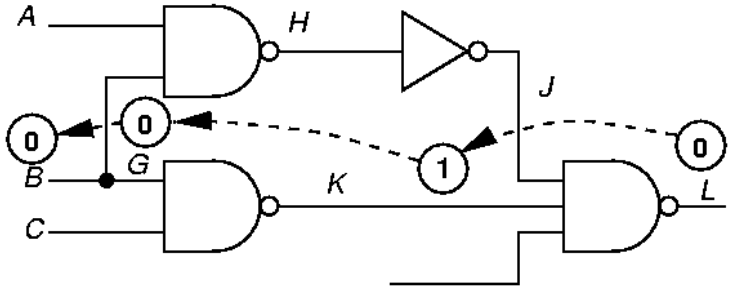
PODEM decision tree



FAN decision tree

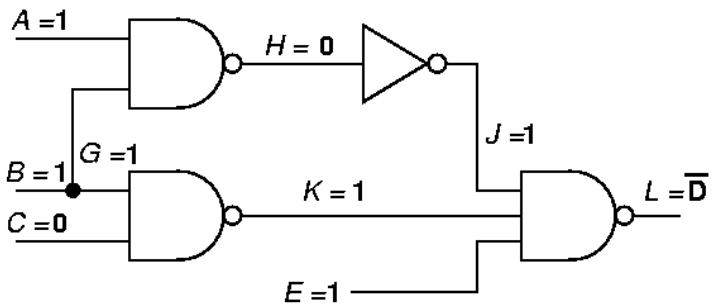
Immediate Implication

- PODEM Fails to Determine Unique Signals
- Backtracing operation
  - fails to set all 3 inputs of gate L to 1
  - Causes unnecessary search



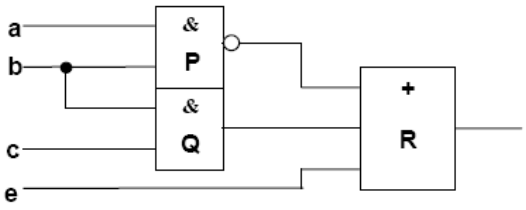
Immediate Implication

- FAN -- Early Determination of Unique Signals
- Determine all unique signals implied by current decisions immediately
  - Avoids unnecessary search



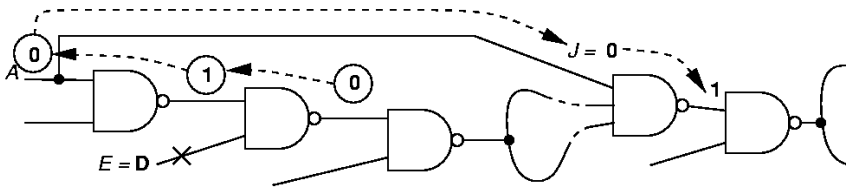
Example Of Immediate Implication

- PODEM
  - Objective r=0,
    - Backtrace to b, Set b=0
  - Imply p=1, r=1
    - No Test Possible
  - Retry: Set b=1
- FAN
  - Objective, r=$\overline{D}$,
    - Assign r=0
  - Imply e=q=p=0, a=b=1, c=0



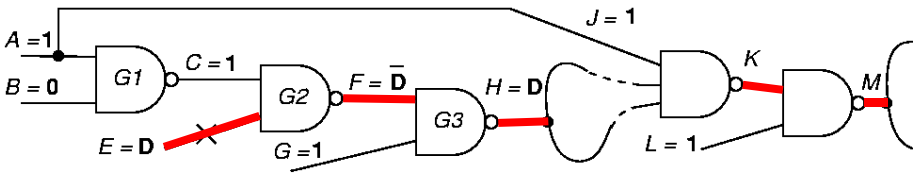
Unique Sensitization

- PODEM Makes Unwise Signal Assignments
- Blocks fault propagation due to assignment J = 0



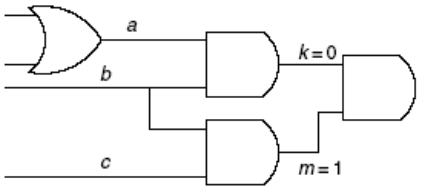
Unique Sensitization

- Unique Sensitization of FAN with No Search
- FAN immediately sets necessary signals to propagate fault



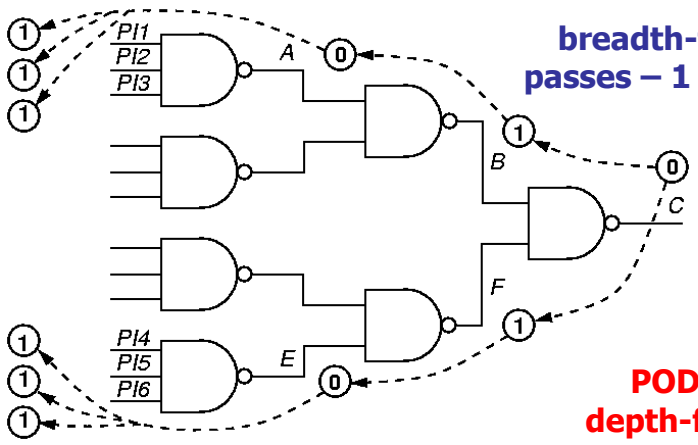
Path over which fault is uniquely sensitized

Multiple Objectives



- Objectives: {k=0, m=1}
- Backtrace from k=0 may favor b=0, but simulate(b=0) would violate the second objective m=1!
- Makes backtrace more intelligent to avoid future conflicts

Multiple Backtrace



FAN
breadth-first
passes – 1 time

PODEM
depth-first
passes – 6 times