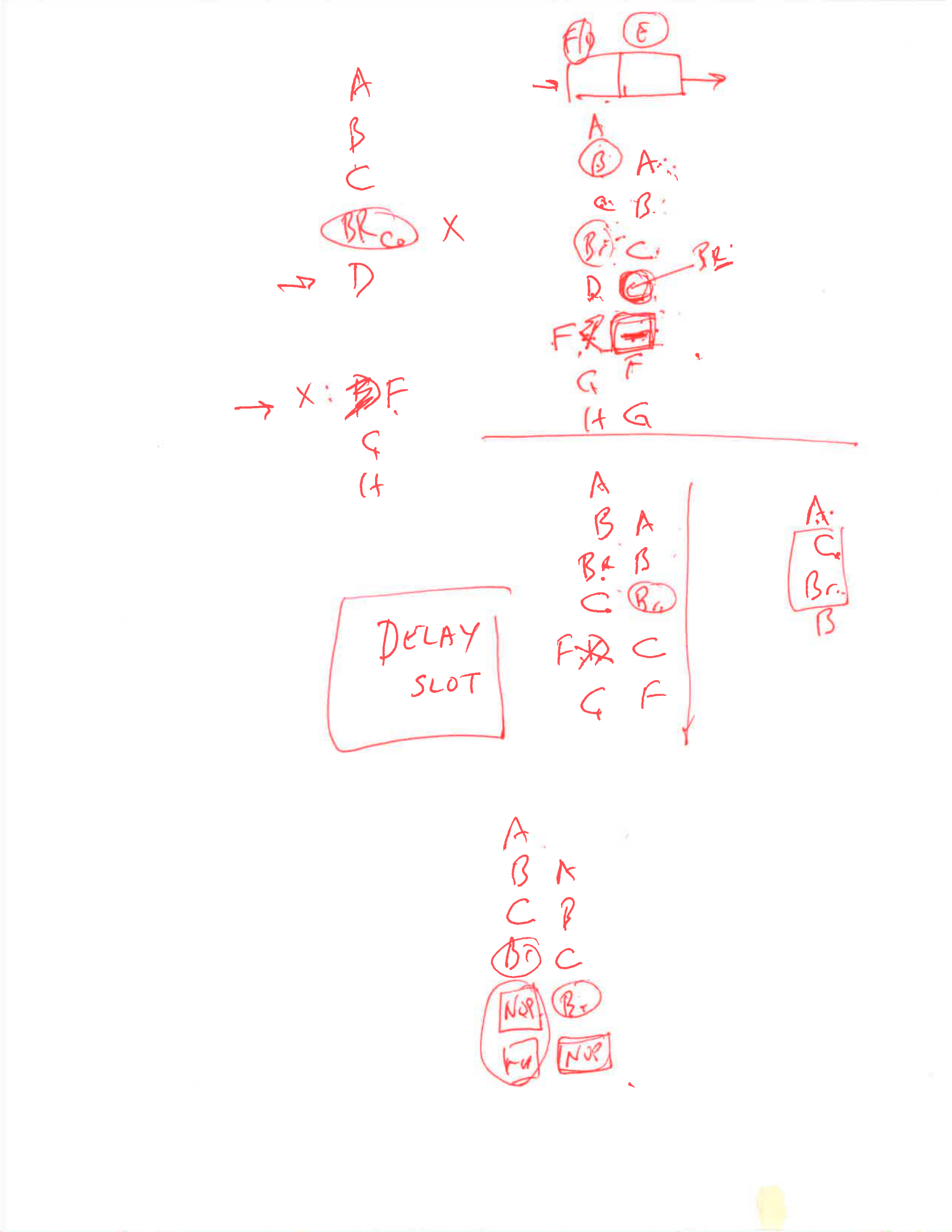
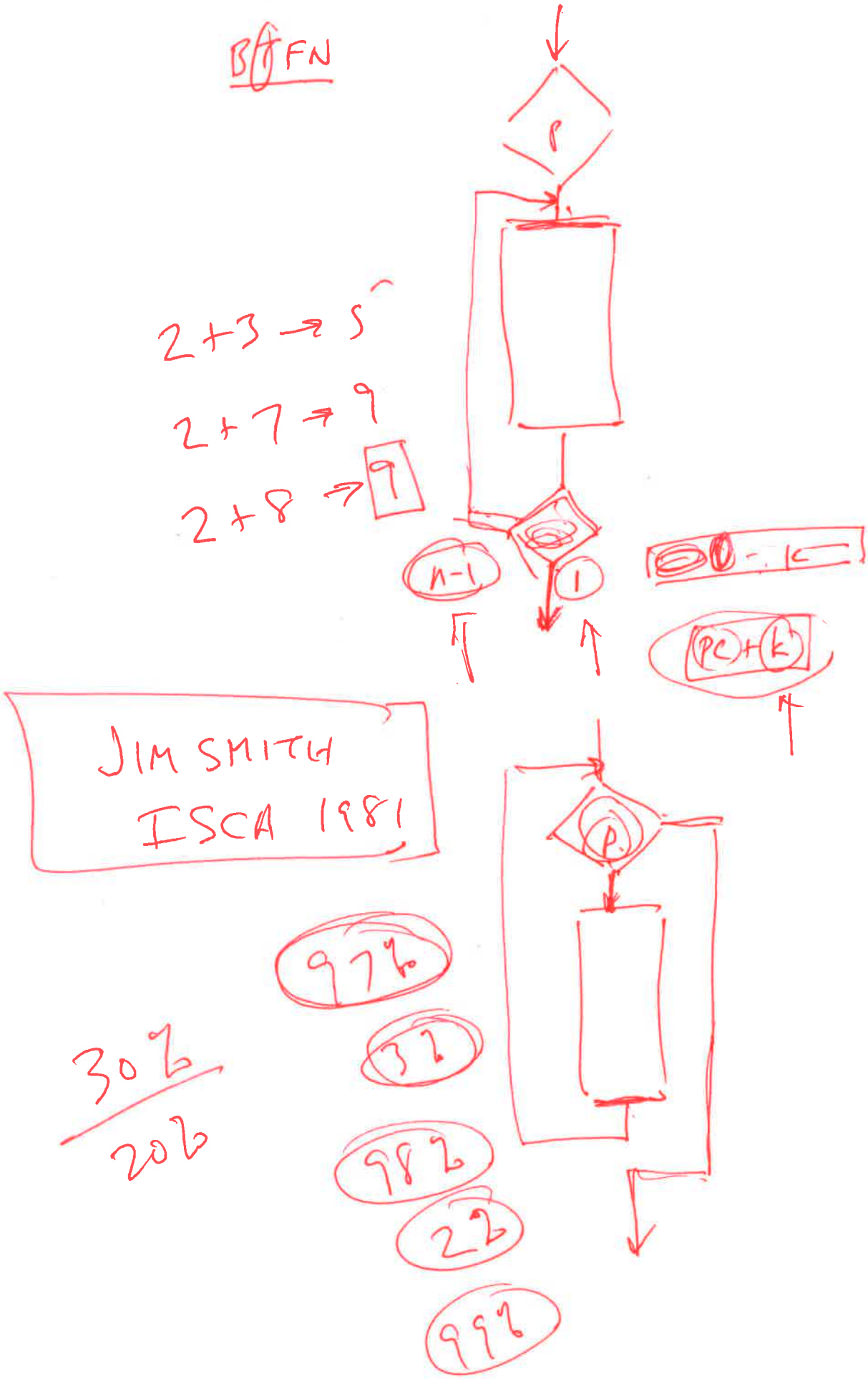
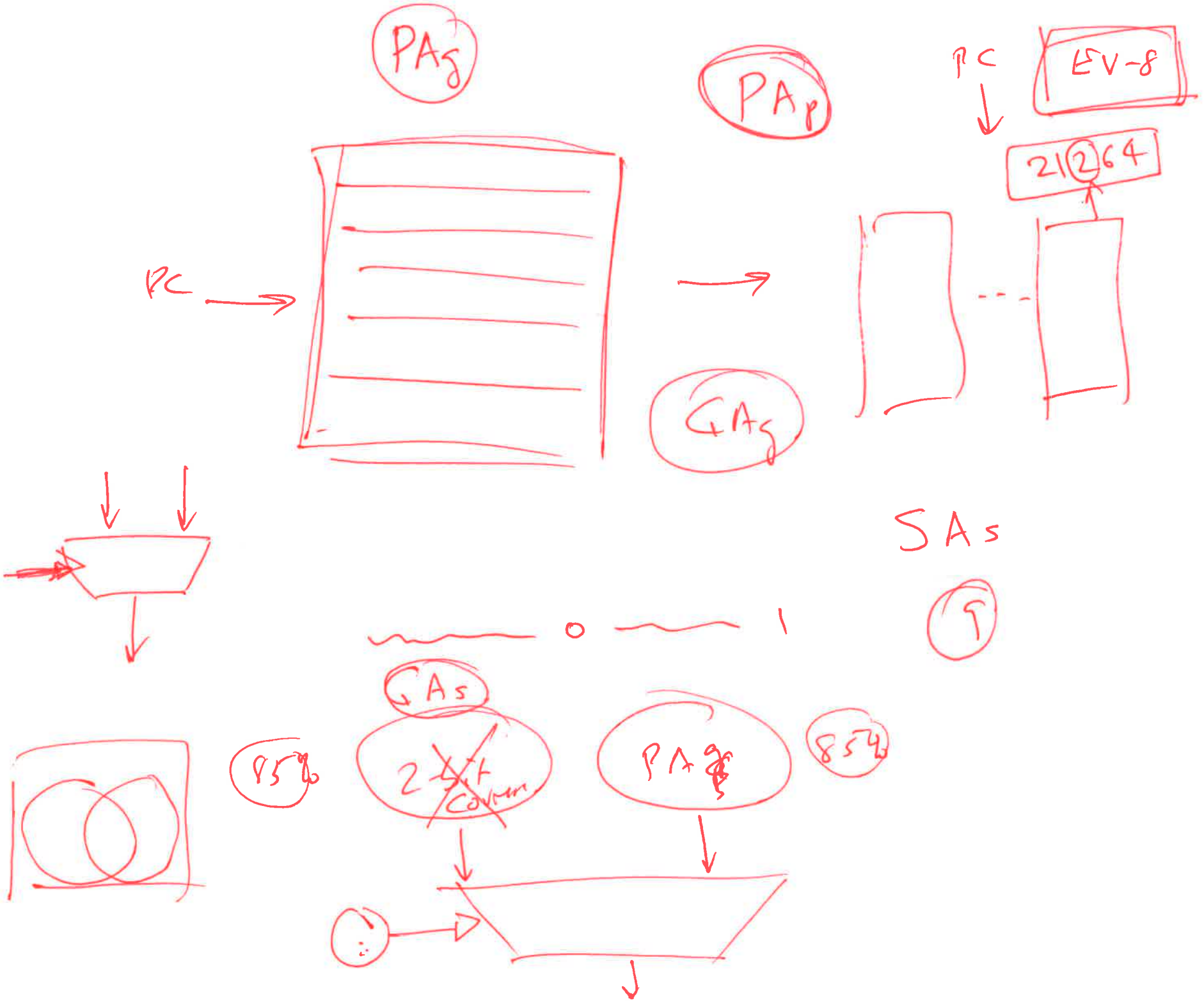
Mechanisms: Run-time and Compile-time

Mechanisms

- *Conditional Branches*
- *Trace Cache*
- *Block-Structured ISA*
- *Wish branches*

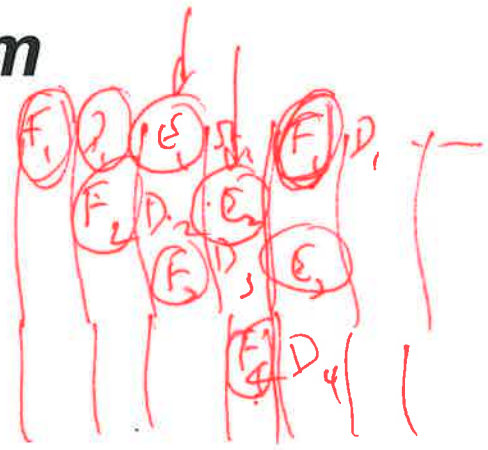

A
B
C
BR
X
D
X:
F
G
It
F
E
A
B
A:
B:
C:
BR:
D
F
F
G
It G
A
B A
B B
C
C
F C
G F
A:
C
Br
B
DELAY
SLOT
A
B A
C B
B C
NOP
Br
NOP

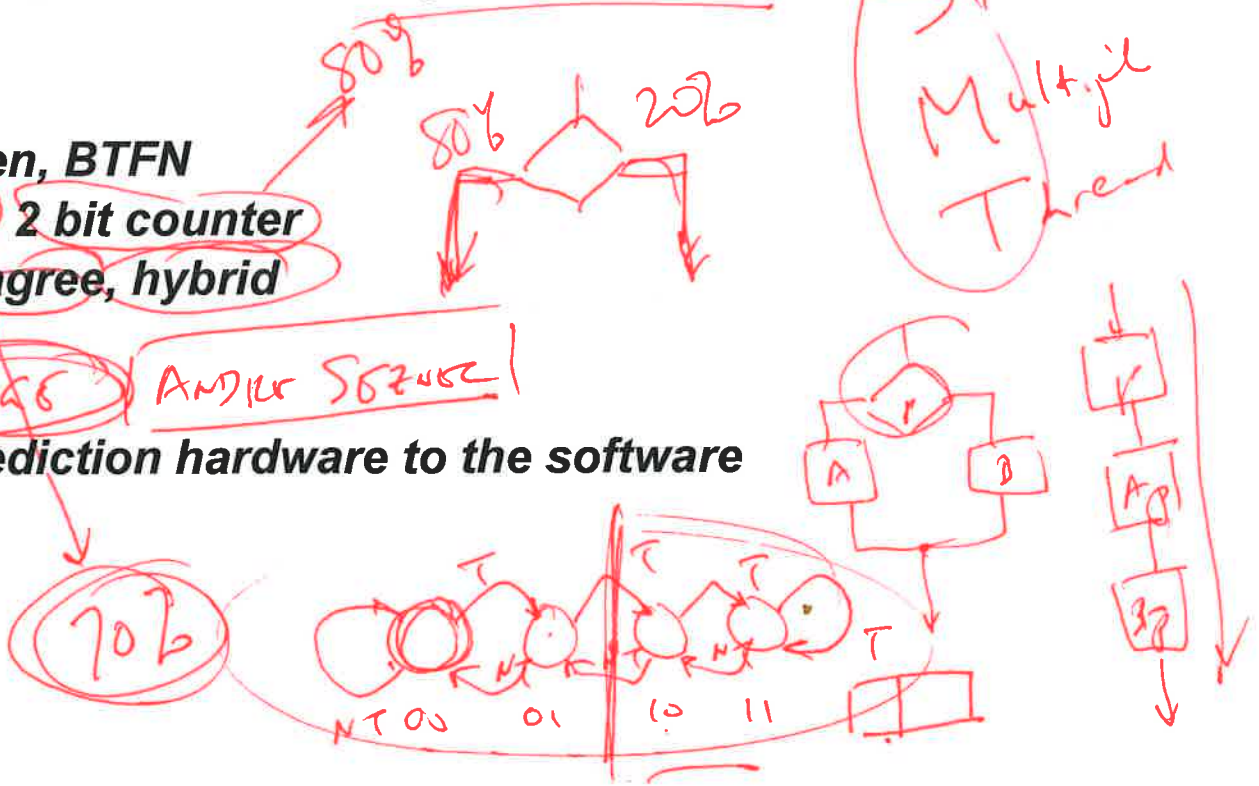

BF FN
P
2+3 → 5
2+7 → 9
2+8 → 9
n-1
1
JIM SMITH
ISCA 1981
P
97%
3%
98%
2%
99%
30%
20%


PAg
PAp
PC
EV-8
21264
PC
GAg
SAs
0
1
GAs
PAg
85%
15%

The Conditional Branch Problem

- *Why? Because there are pipelines. (Note: HEP)*
- *Mechanisms to solve it*
  - *Delayed branch*
  - *Take both paths*
  - *Eliminate branches (predication, compound predicates)*
- *Branch Prediction*
  - *Static: Always taken, BTFN*
  - *Early dynamic: LT, 2 bit counter*
  - *2 level → gshare, agree, hybrid*
  - *Indirect jumps*
  - *Perceptron*
  - *Expose branch prediction hardware to the software*
  - *Wish branches*

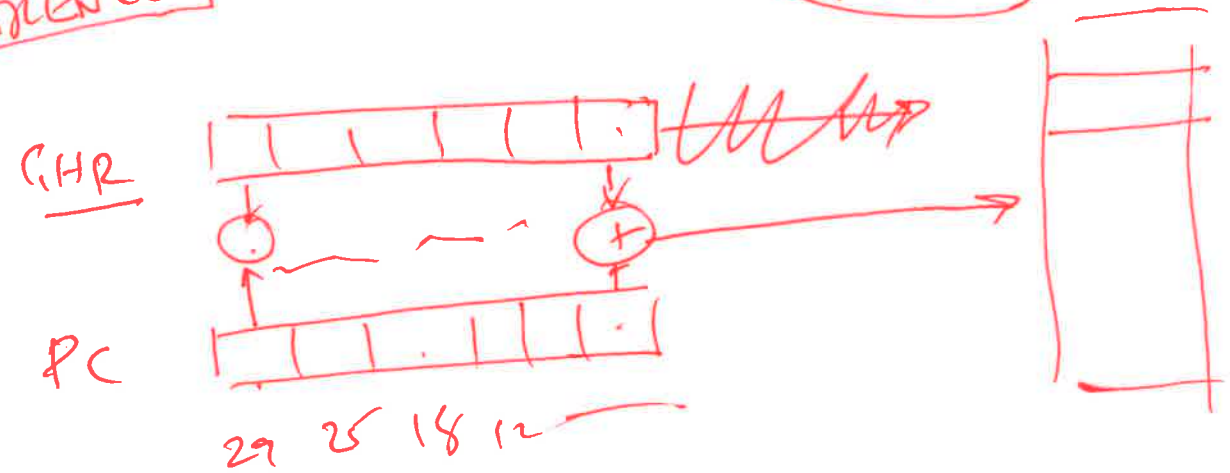




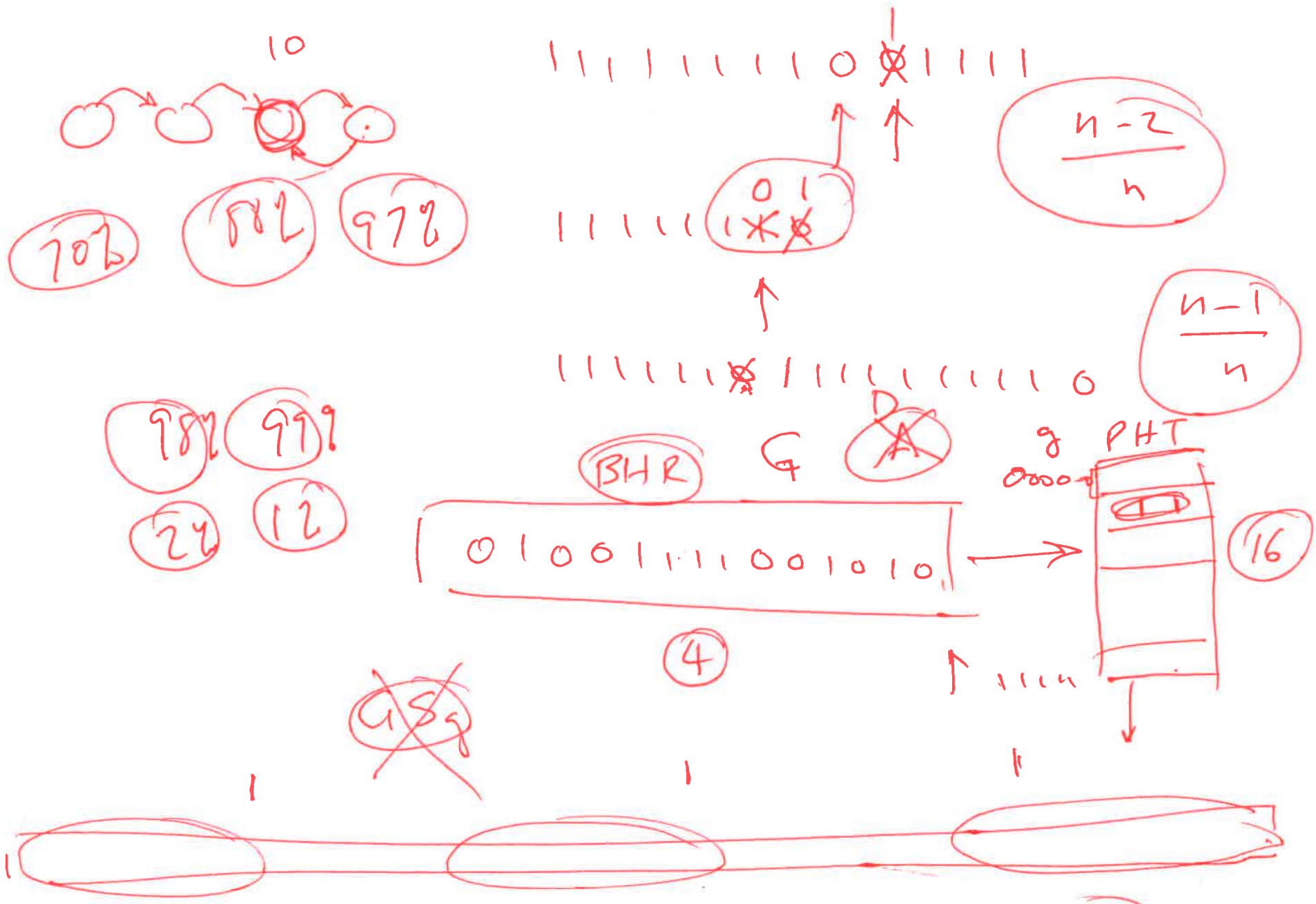
INTERFERENCE

Scott McFarling (John Hennessy)

1993

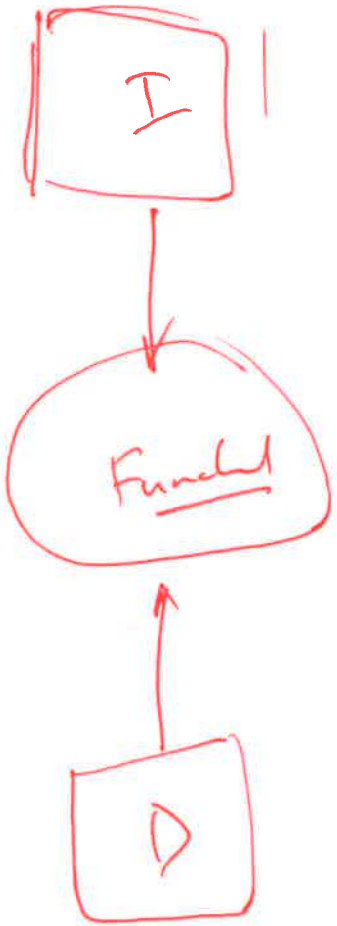


GSHARE



KIMMING So → ASPLOS 1992 OCT 1992

YNP → MICRO 1991 NOV 1991

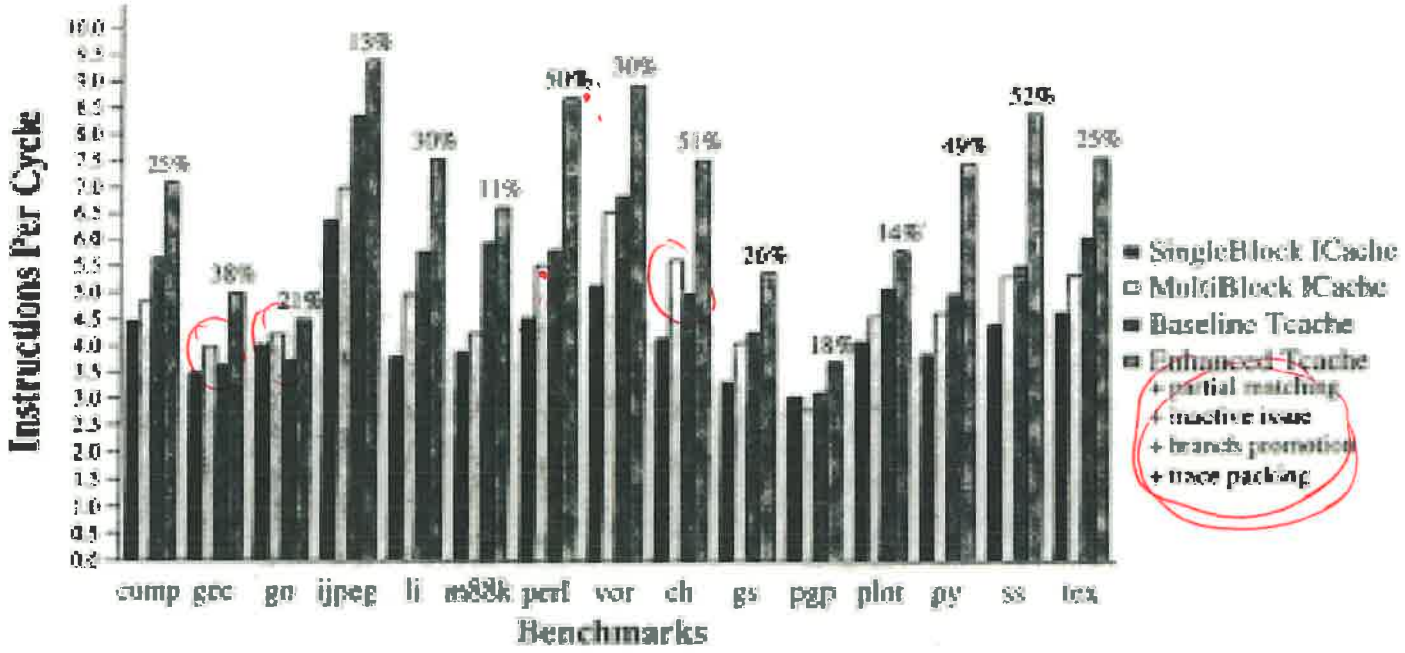


Prefetch

100% BP accuracy

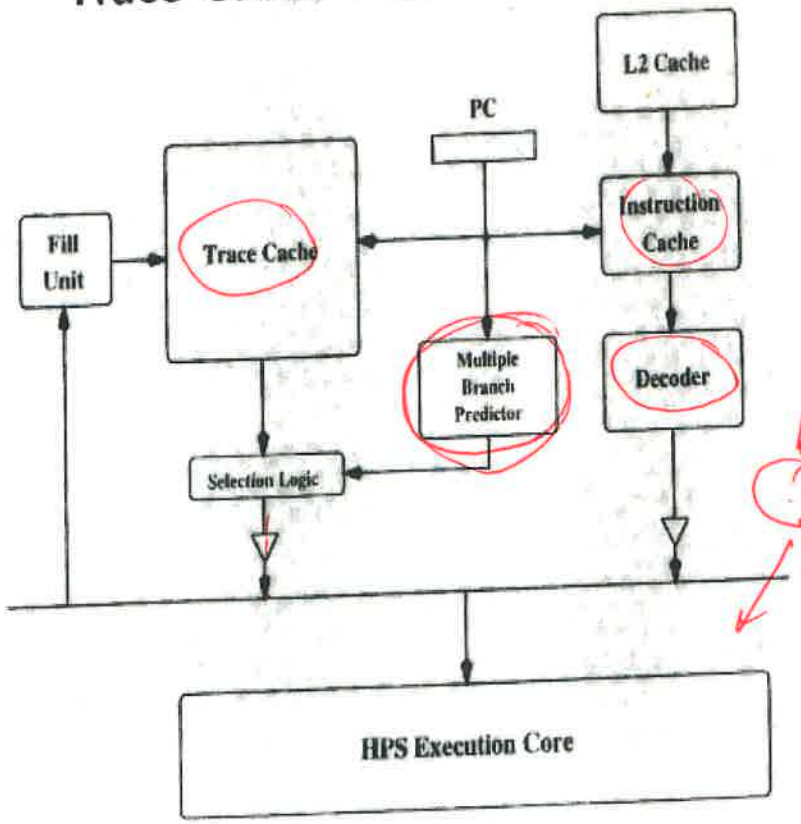
No Packet breaks

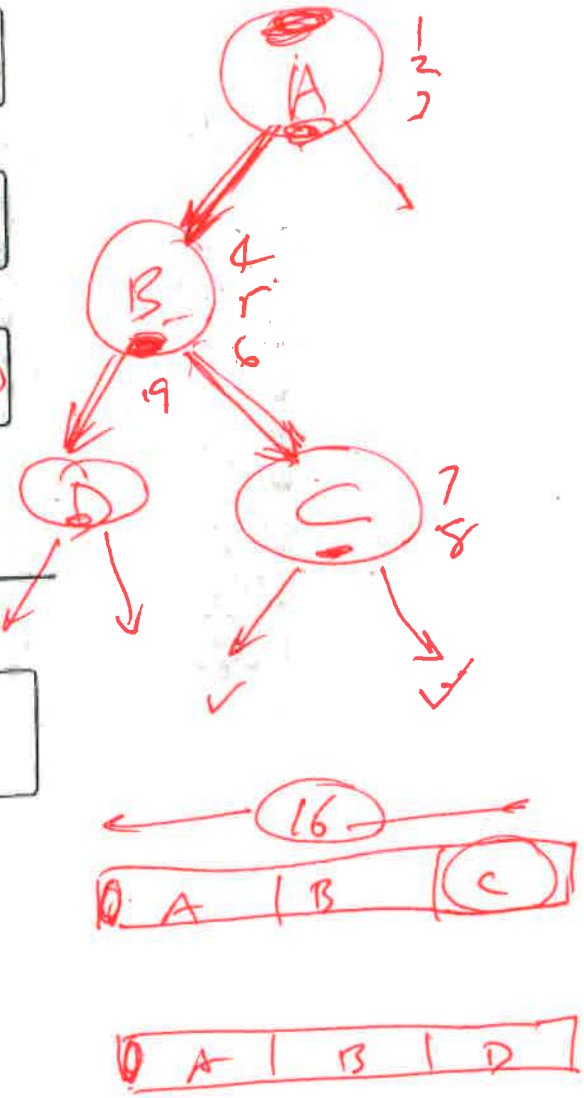
Overall Performance (aggressive core)



Jim Smith
Eric Rotenberg

Trace Cache Fetch Mechanism



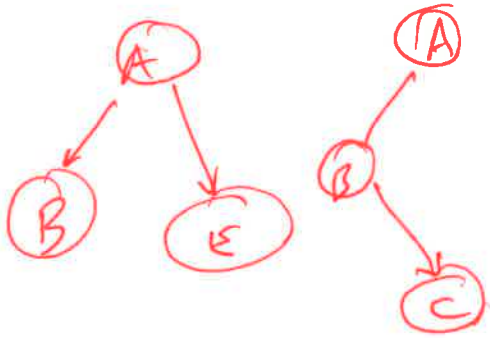


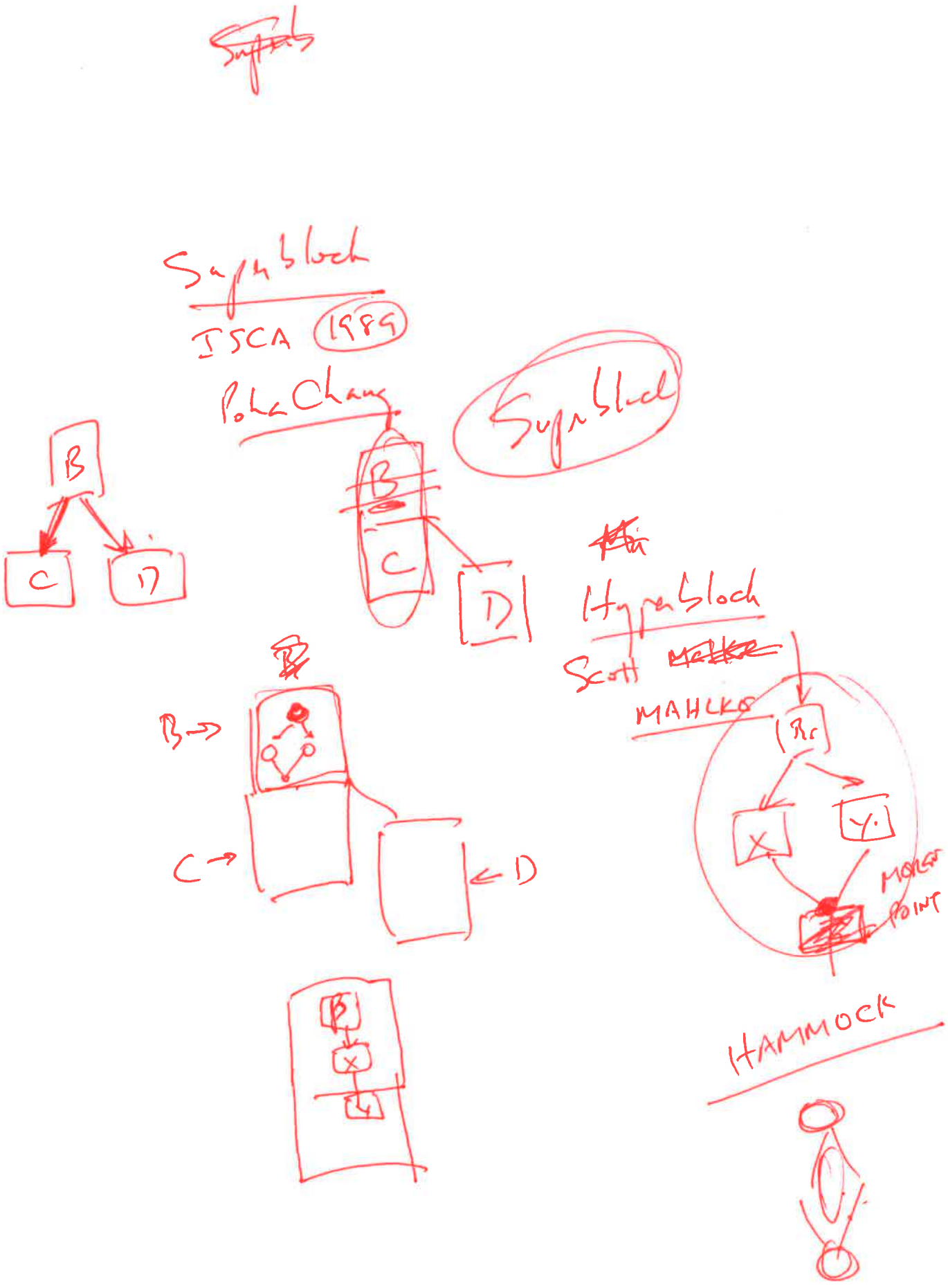
1989 | Uri Weiser Alex Peleg 1989

Trace Cache Issues

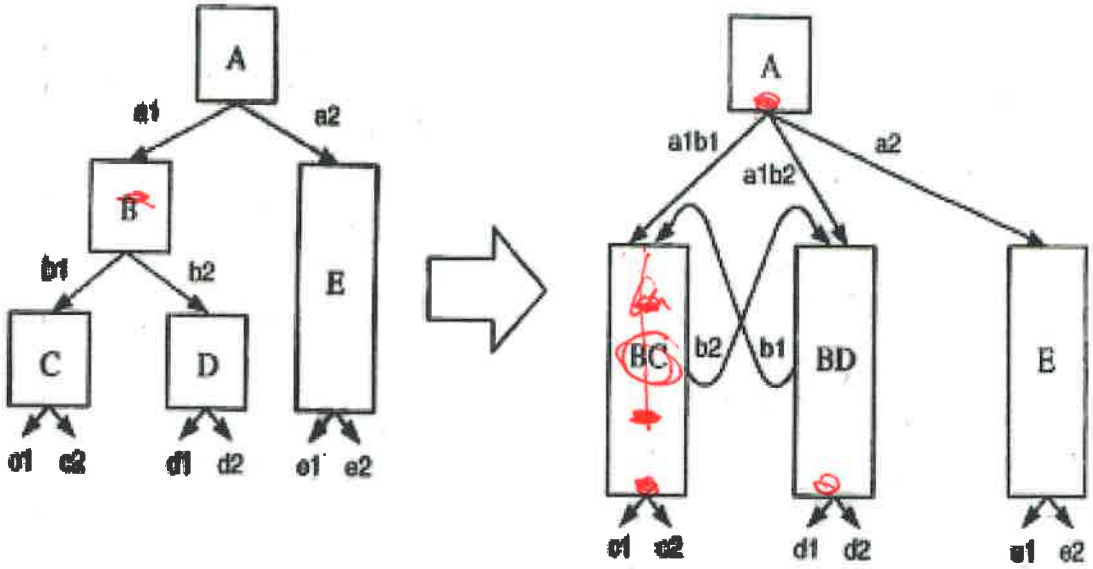
- Storage partioning
- Set Associativity
- Path Associativity
- Block Collection (retire vs. Issue)
- Fill Unit Latency
- Partial Matching
- Inactive Issue
- Dual Path Segments
- Branch Promotion
- Trace Packing

4-way Set Assoc. Cache




Superblock
ISCA 1989
Pohua Chang
B
C
D
Superblock
HyperBlock
Scott
MAHLKE
B
C
D
X
Y
HAMMOCK

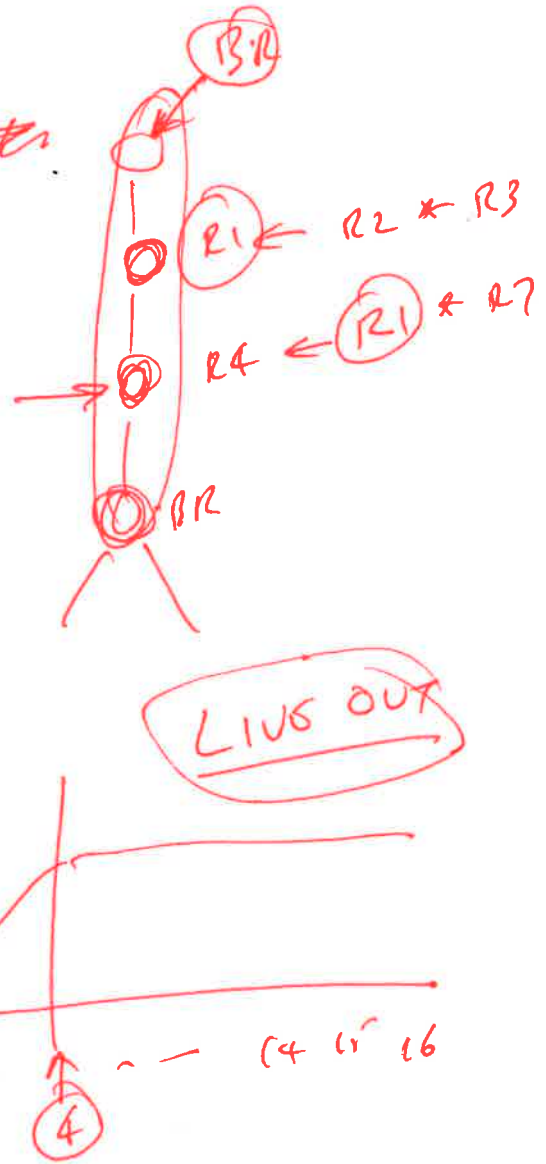
Enlarging Basic Blocks



Block-Structured ISA

- References:
  - -- Stephen Melvin (PhD, Berkeley, 1991)
  - -- Eric Hao (PhD, Michigan, 1997)
  - -- ISC paper, Melvin and Patt, 1989
  - -- ISCA paper, Melvin and Patt, 1991
  - -- Micro-29, Hao, Chang, Evers, Patt, 1996

- The Atomic Unit of Processing
- Enlarged Blocks
- Savings on Register Pressure
- Faulting Branches, Trapping Branches
- Serial Execution on Exception
- Comparison to Superblocks, Hyperblocks



Wish Branches

- ***Compile-time and Run-time***

- ***At compile time:***
  - ***Does predication even make sense***
  - ***If no, regular branch and branch prediction***
  - ***If yes, mark wish branch and defer to run-time***

- ***At run time:***
  - ***Prediction accuracy low: predicate***
  - ***Prediction accuracy high: branch predict***