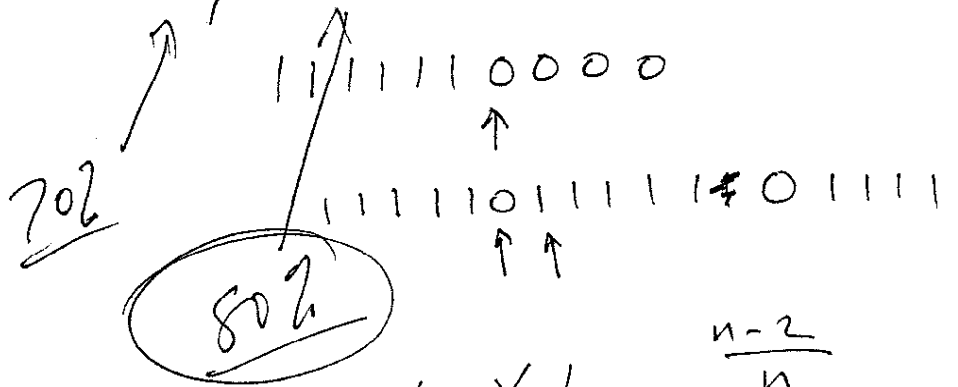


Br. Red

Compile time
Run time

BTFN
LT, 26 CTR

11 Feb / 1



Tse-Yu Yeh

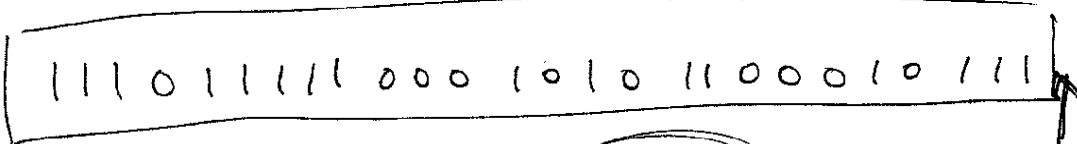
$$\frac{n-2}{n}$$

2-level Adaptive Predictor Micro 1991

$$\frac{n-1}{n}$$

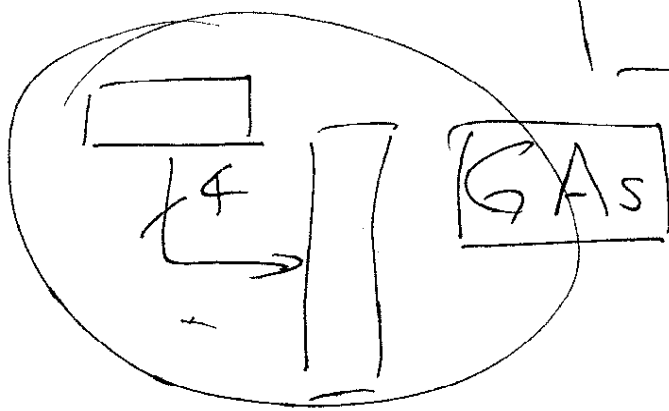
BHR

11101110 11101



972

26 bits



111

SPEC 1989 Predict

GAs

PAP

SAs

Alpha 21264

SCOREBOARD / TOMASULO

S S D

- ① MUL R1, R2, R3
- ② ADD R3, R4, R5
- ③ ADD R2, R6, R7
- ④ ADD R8, R9, R10
- ⑤ MUL R7, R10, R11
- ⑥ ADD R5, R11, R5

F	D	E1	E2	E3	E4	E5	E6	WB
F	D	E1	E2	E3	E4	WB		

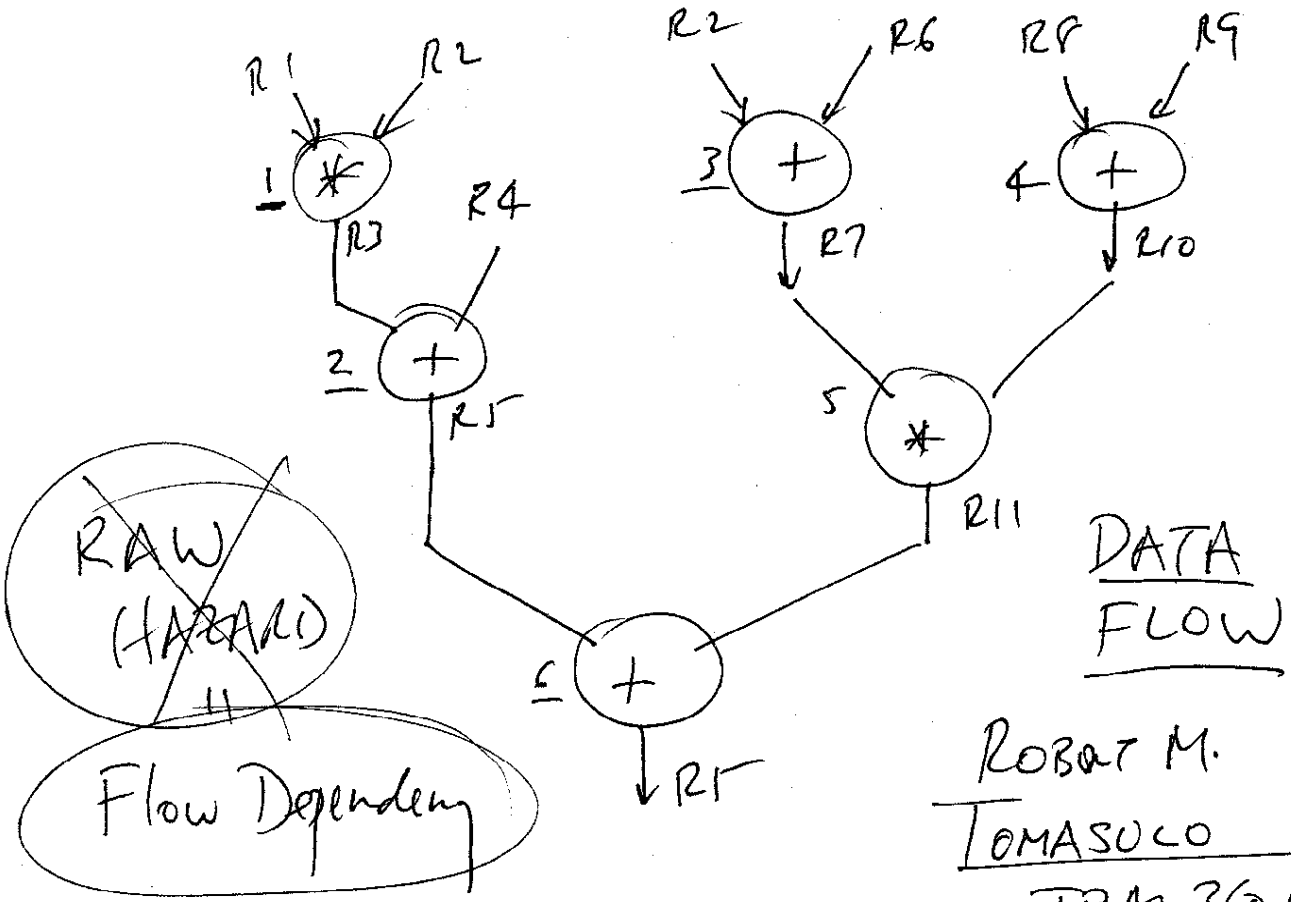
IN-ORDER (SCOREBOARD)

	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
①	F	D	✓	✓	✓	✓	✓	✓	✓												
②		F	D							✓	✓	✓	✓								
③			F							D	✓	✓	✓	✓							
④										F	D	✓	✓	✓	✓	✓					
⑤										F	D	D	D	D	D	✓	✓	✓	✓	✓	✓
⑥										F											

OUT-OF-ORDER (TOMASULO)

	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	
①	F	D	✓	✓	✓	✓	✓	✓													
②		F	D							✓	✓	✓	✓								
③			F	D	✓	✓	✓	✓													
④				F	D	✓	✓	✓													
⑤					F	D				✓	✓	✓	✓	✓							
⑥						F	D														

OUT-OF-ORDER (WITH DATA FORWARDING)



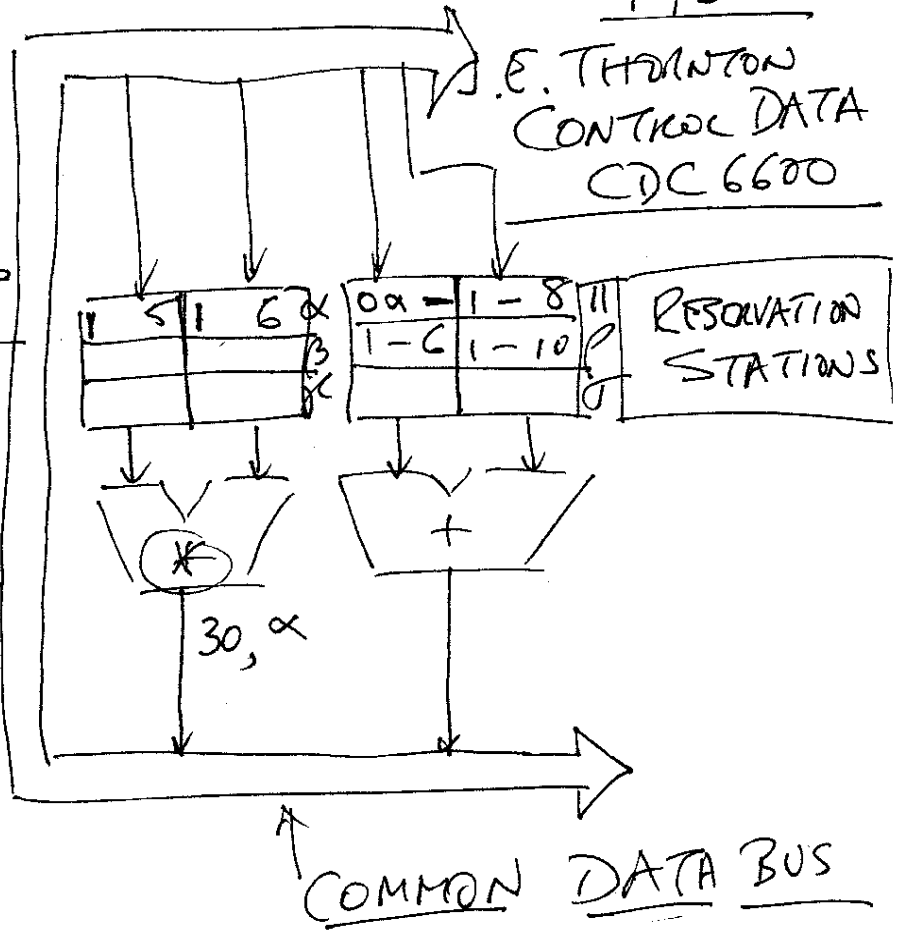
~~RAW (HARD)~~
Flow Dependency

DATA FLOW

ROBERT M. TOMASULO
IBM 360/91
1965

REGISTER ALIAS TABLE

R1	1		5
2	1		6
3	0	α	7
4	1		8
5	0	π	9
6	1		10
7	0	p	11
8	1		12
9	1		13
10	1		14
11	1		15



COMMON DATA BUS