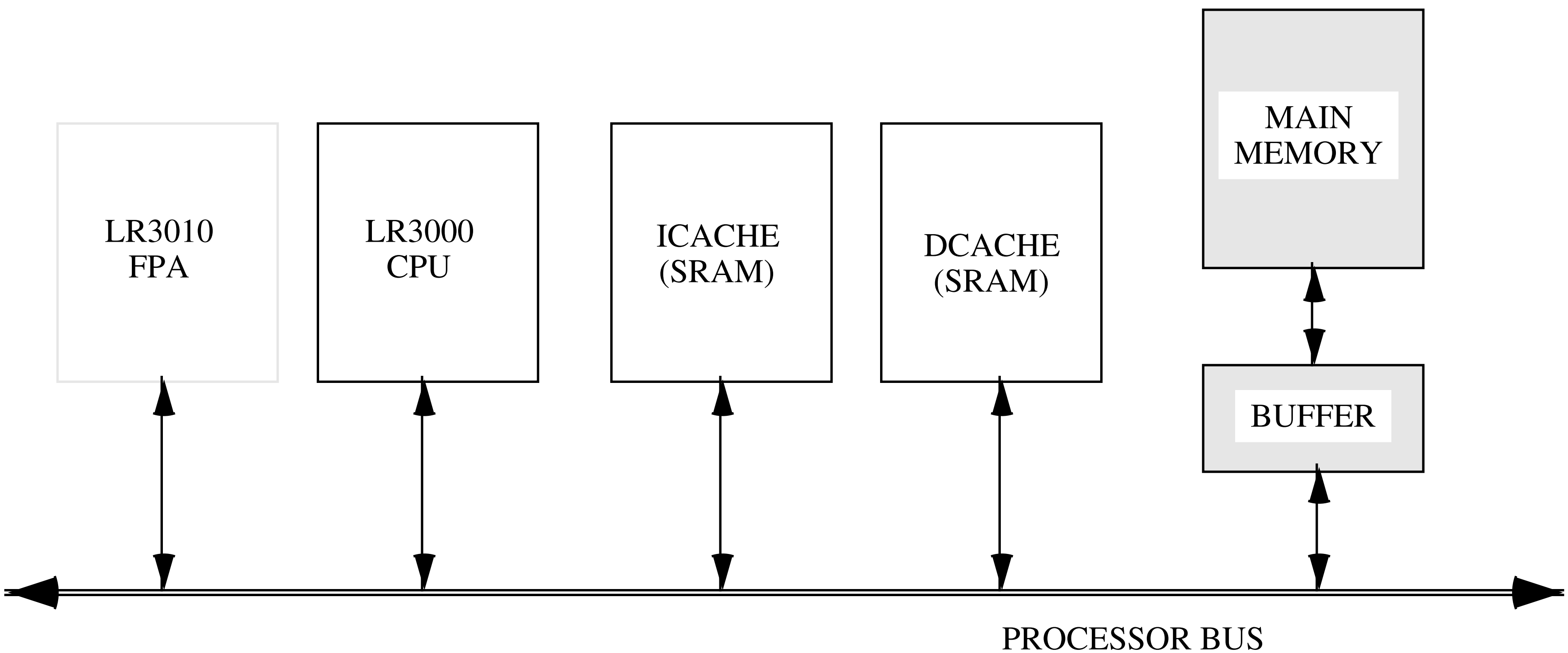
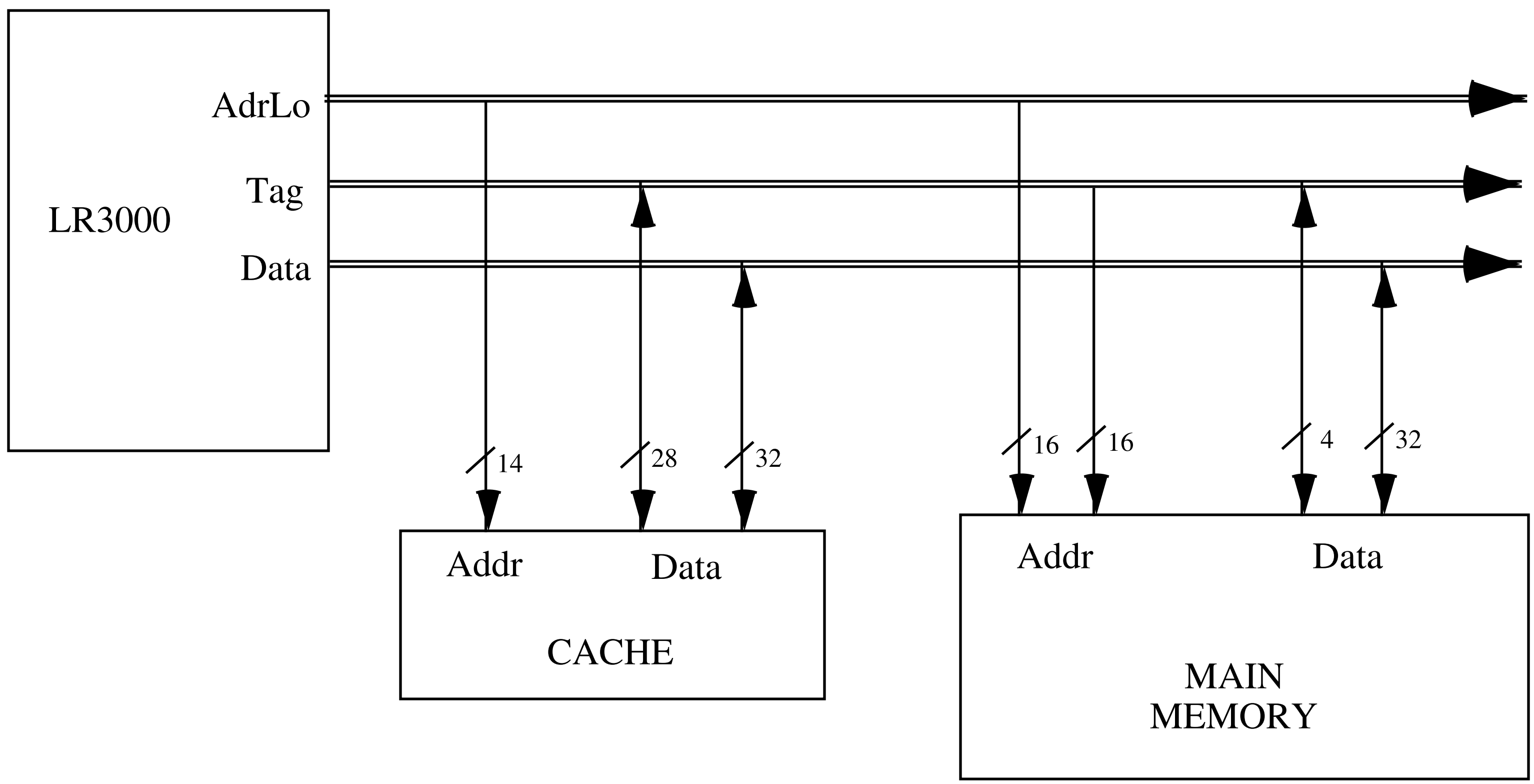
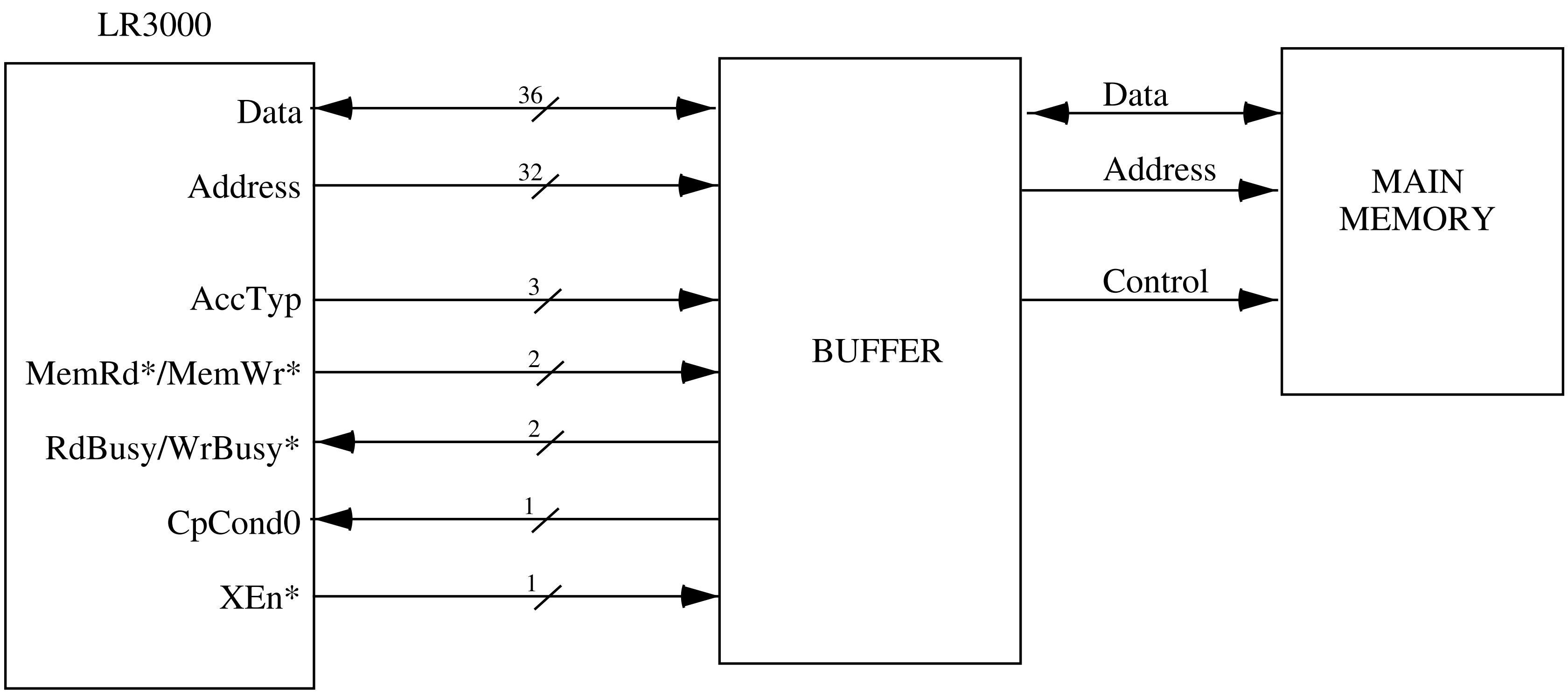
A TYPICAL LR3000 BASED SYSTEM



MAIN MEMORY INTERFACE



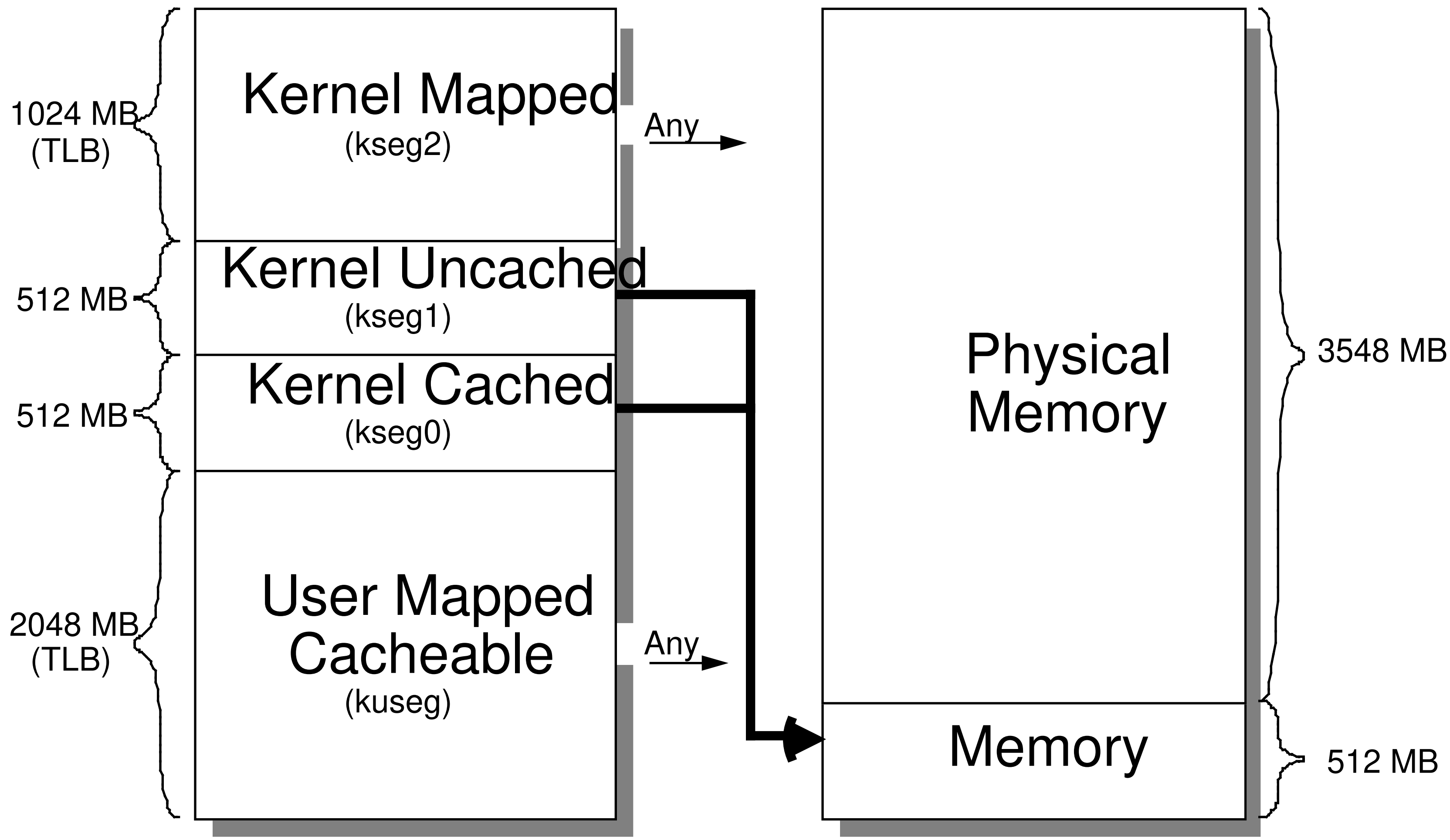
MEMORY INTERFACE SIGNALS



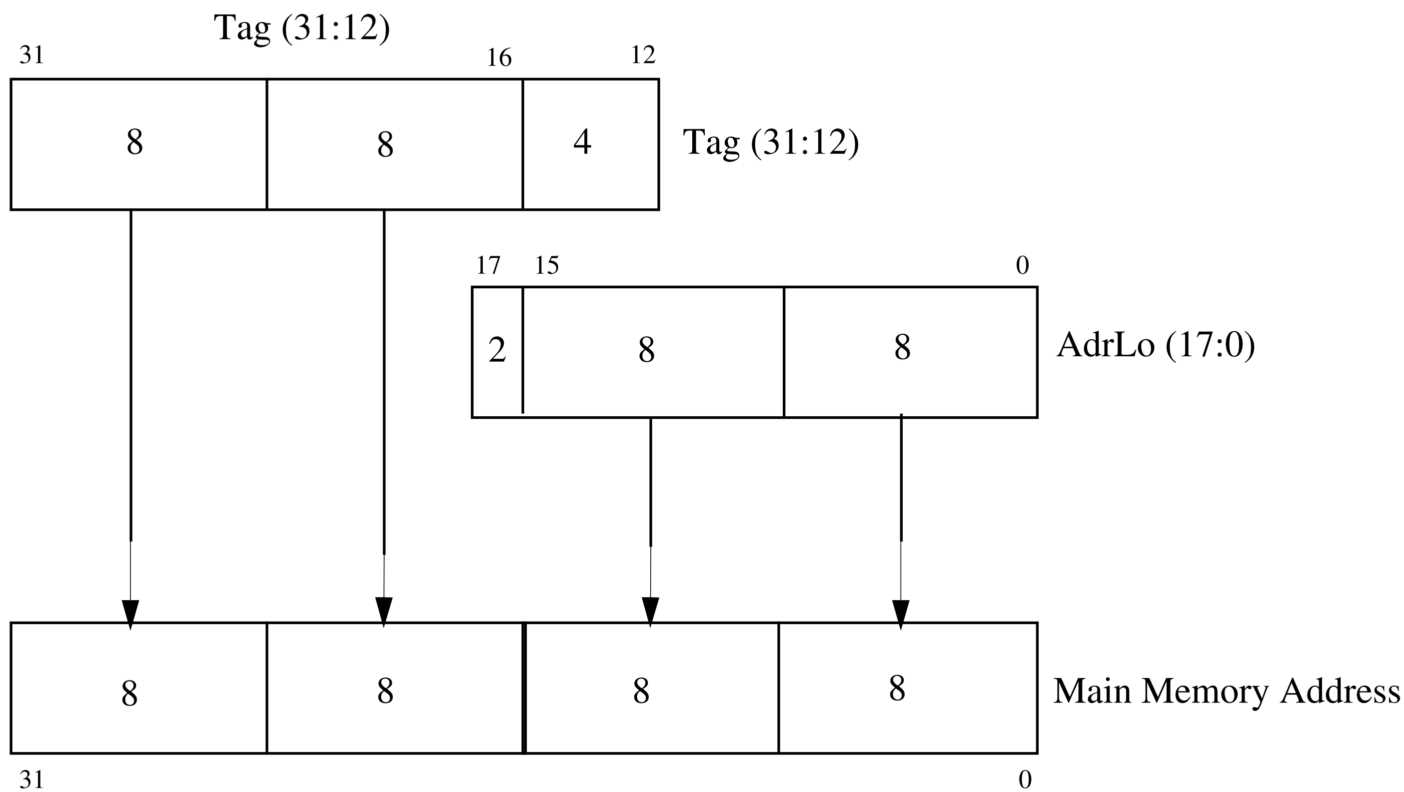
R3000 MEMORY MAP

MMU Address Translation

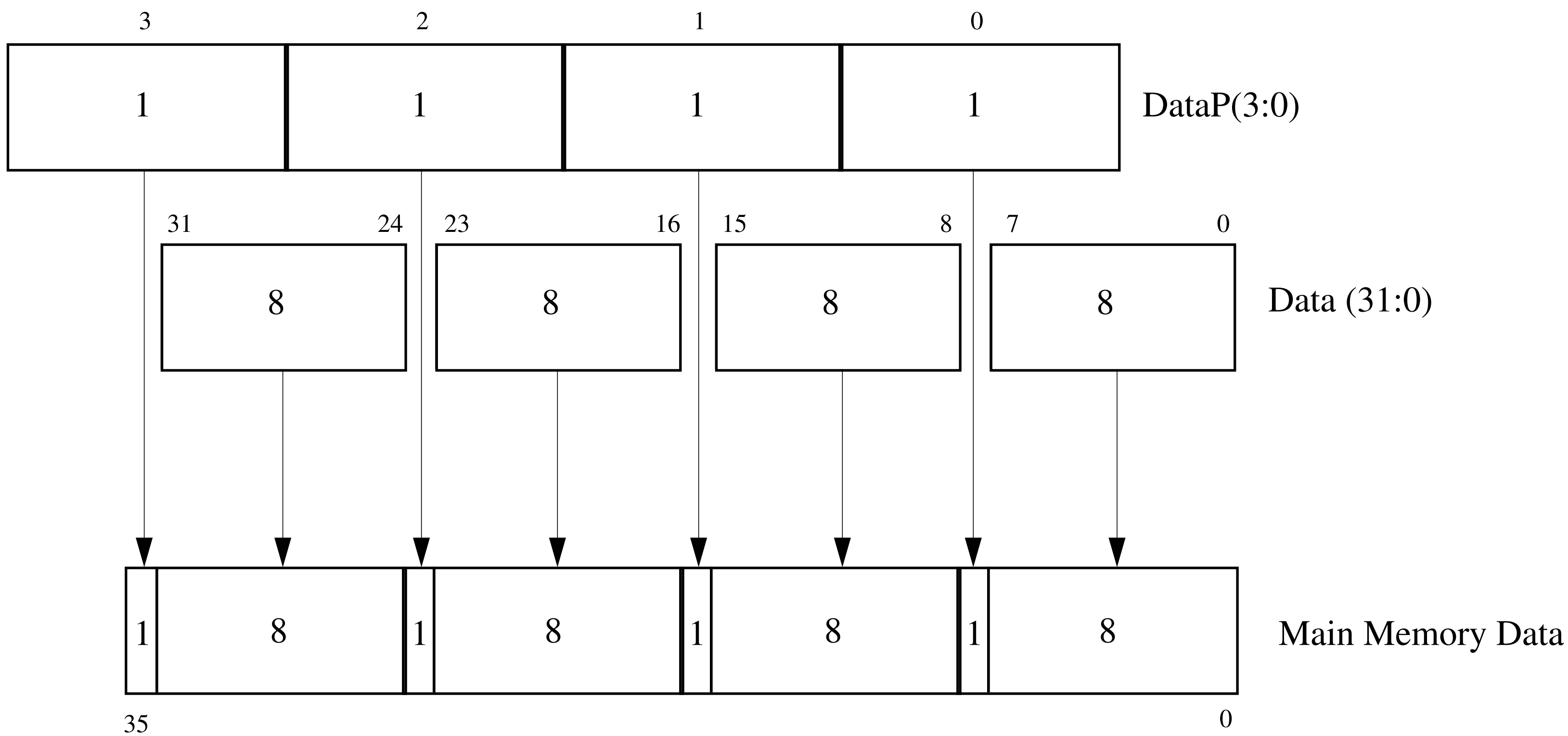
Virtual -> Physical



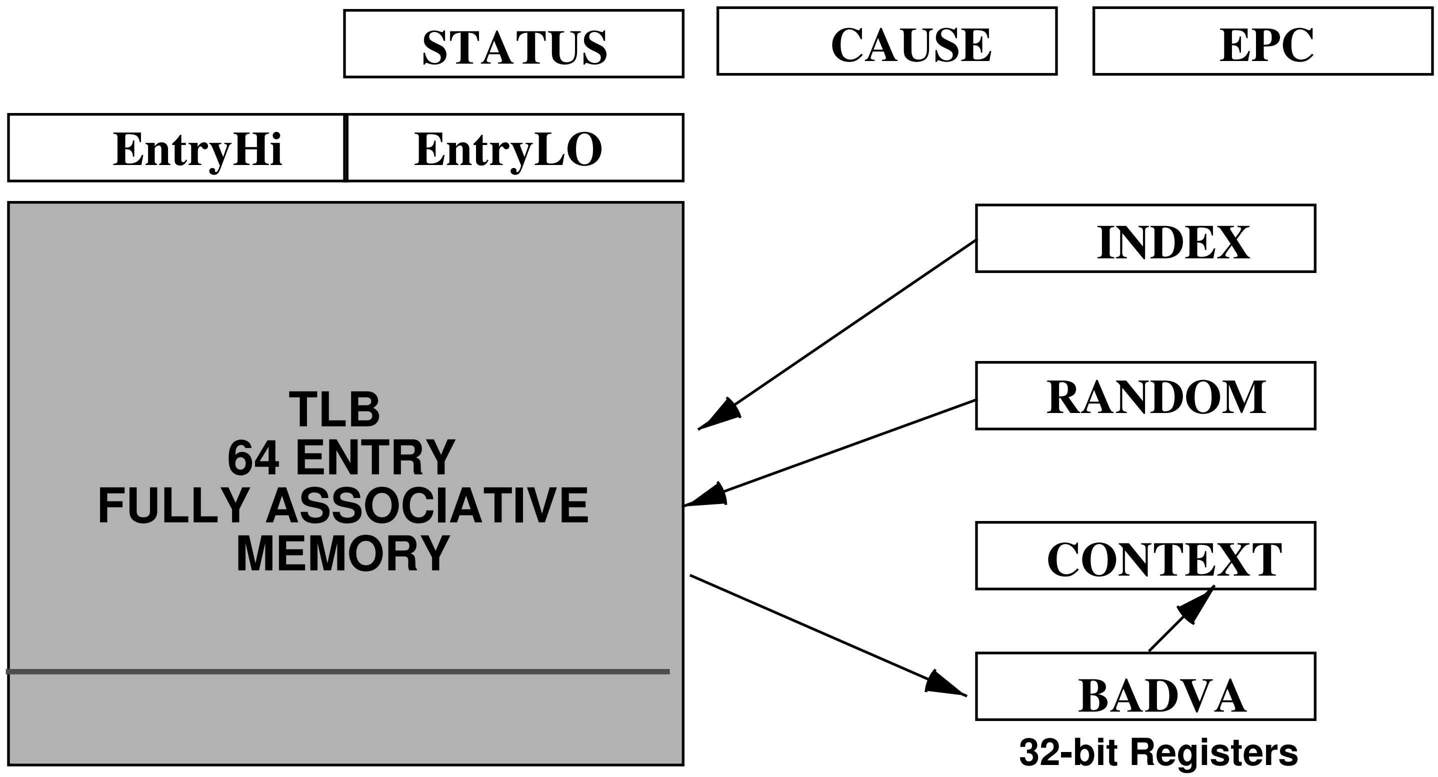
MAIN MEMORY ADDRESS



MAIN MEMORY DATA

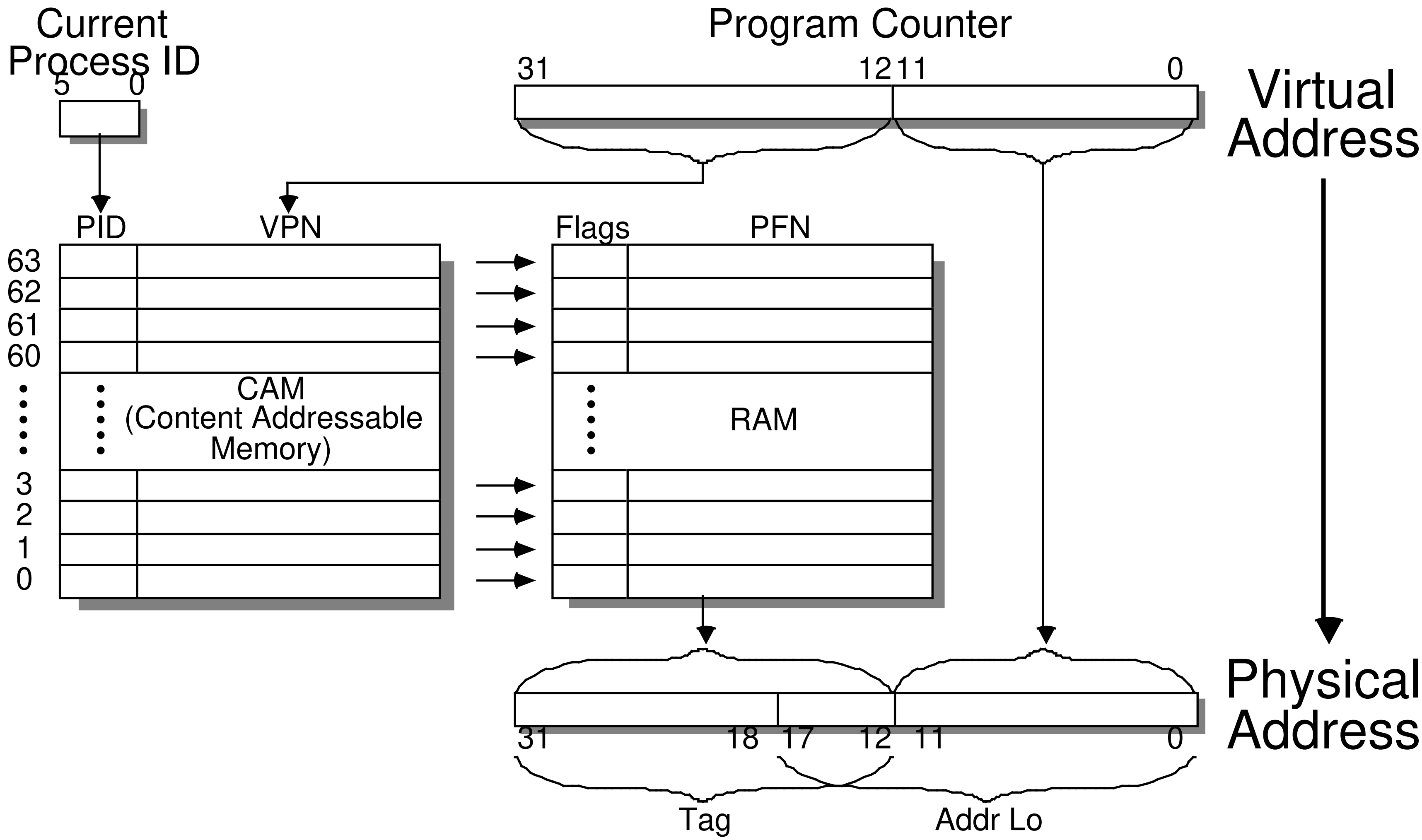


CP0 REGISTERS

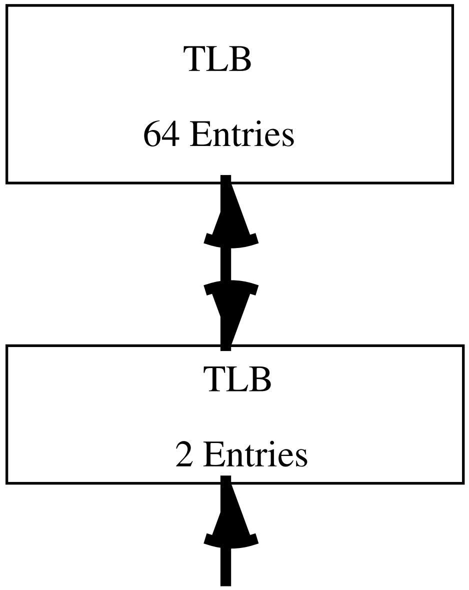


CAREFUL SPLIT: HARDWARE vs SOFTWARE

TLB OPERATION



TRANSLATION LOOKASIDE BUFFERS
(TLB AND TLB)



- Both TLBs Fully Associative
- LRU Replacement on TLB Miss
- TLB Hit Rate > 99.9%
- TLB Access 1/4 Cycle on Hit
- All TLB Access Check TLB First
- Two Entries in TLB, Eliminate TLB Misses during Loops that Cross Page Boundaries
- Entries 0 - 7 "safe" in TLB

TLB ENTRY FORMAT

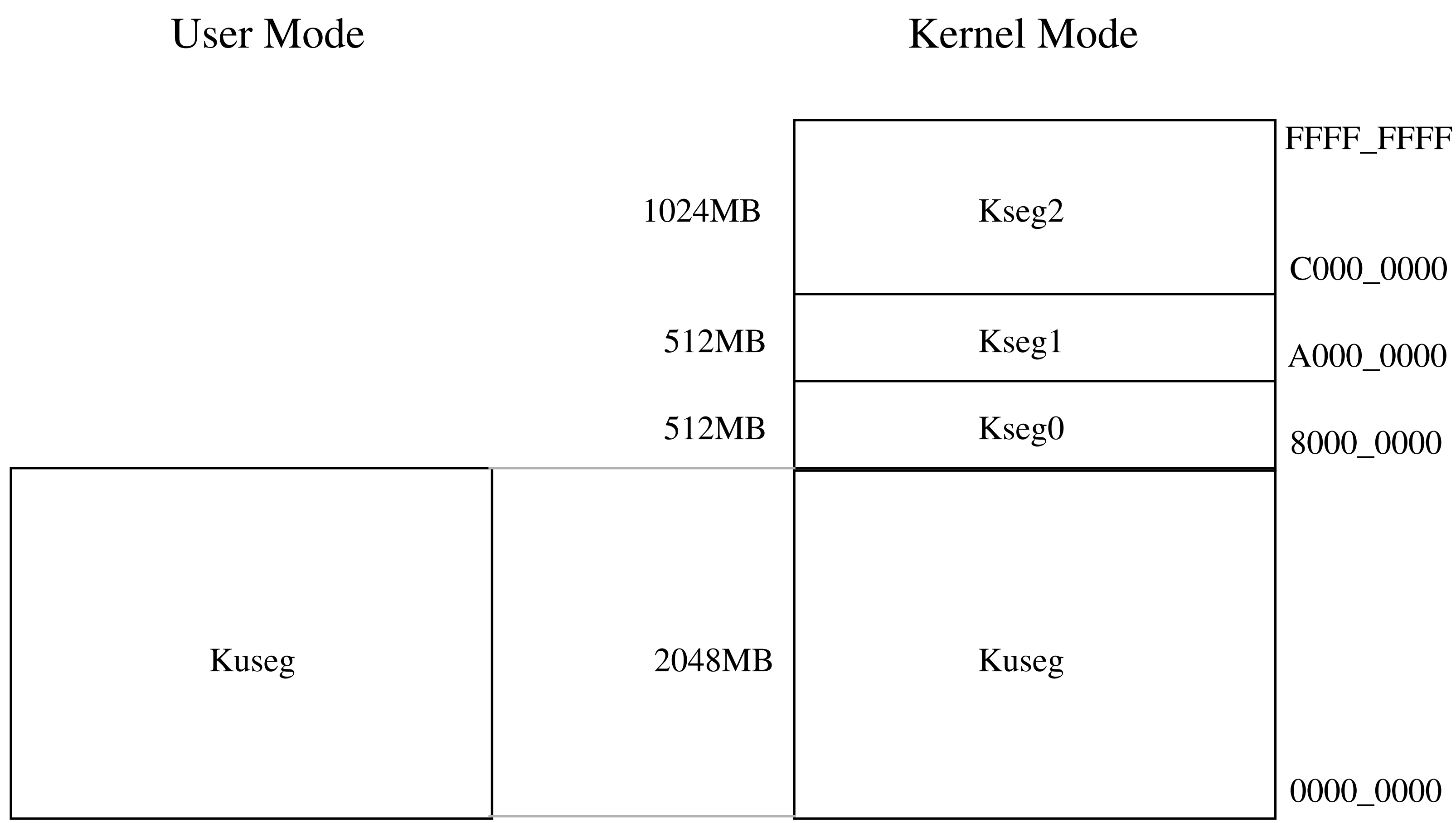
Non Cacheable (Set by OS)

63 ... 0

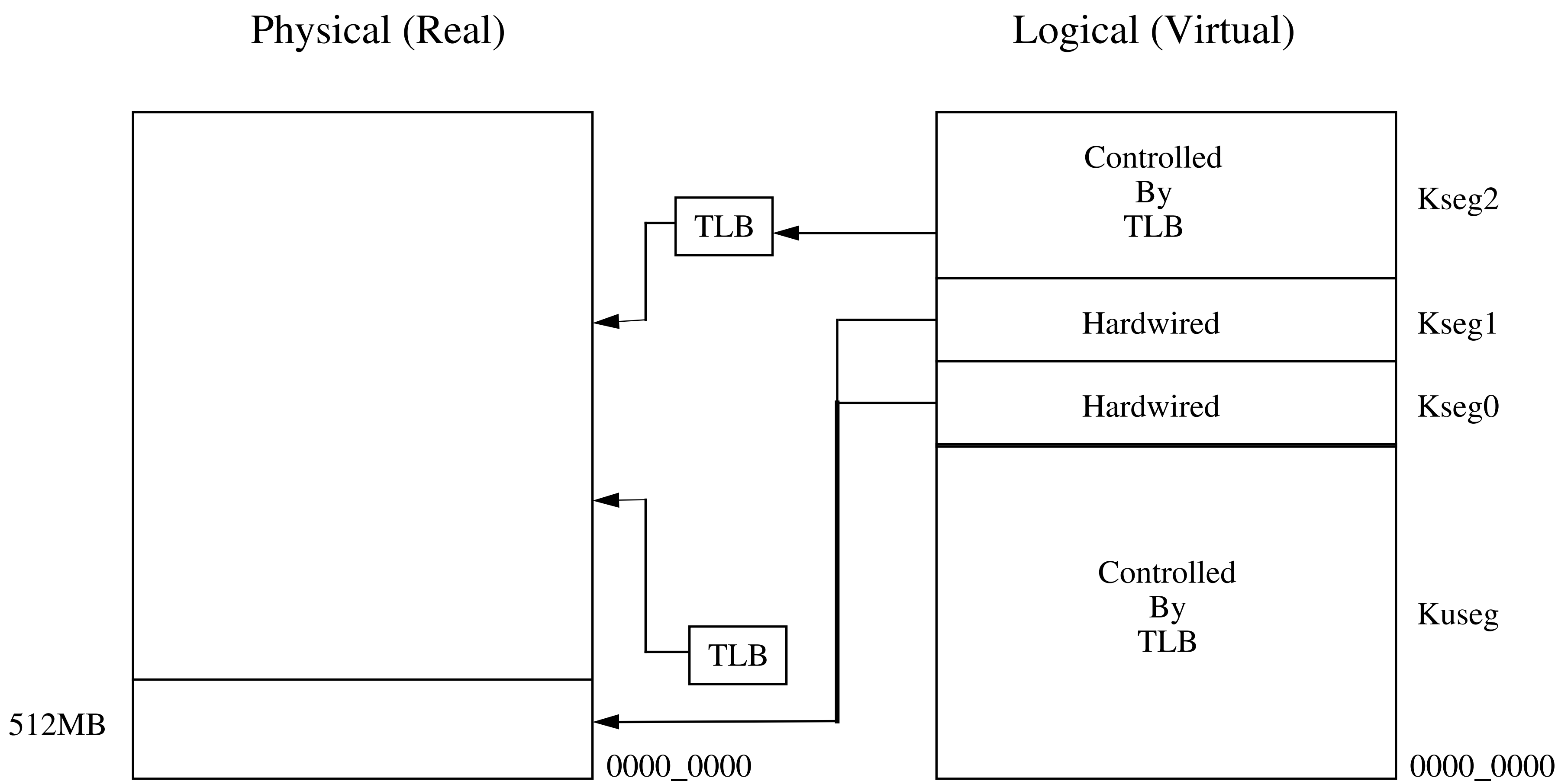
VPN	PID	0	PFN	N	D	V	G	0
20	6	6	20					8

VPN	Virtual Page Number. Bits 31..12 of Virtual Address
PID	Process ID Field
PFN	Page Frame Number. Bits 31..12 of Physical Address
N	Non Cacheable
D	Dirty (Write Enable)
V	Valid
G	Global. Ignore PID Field

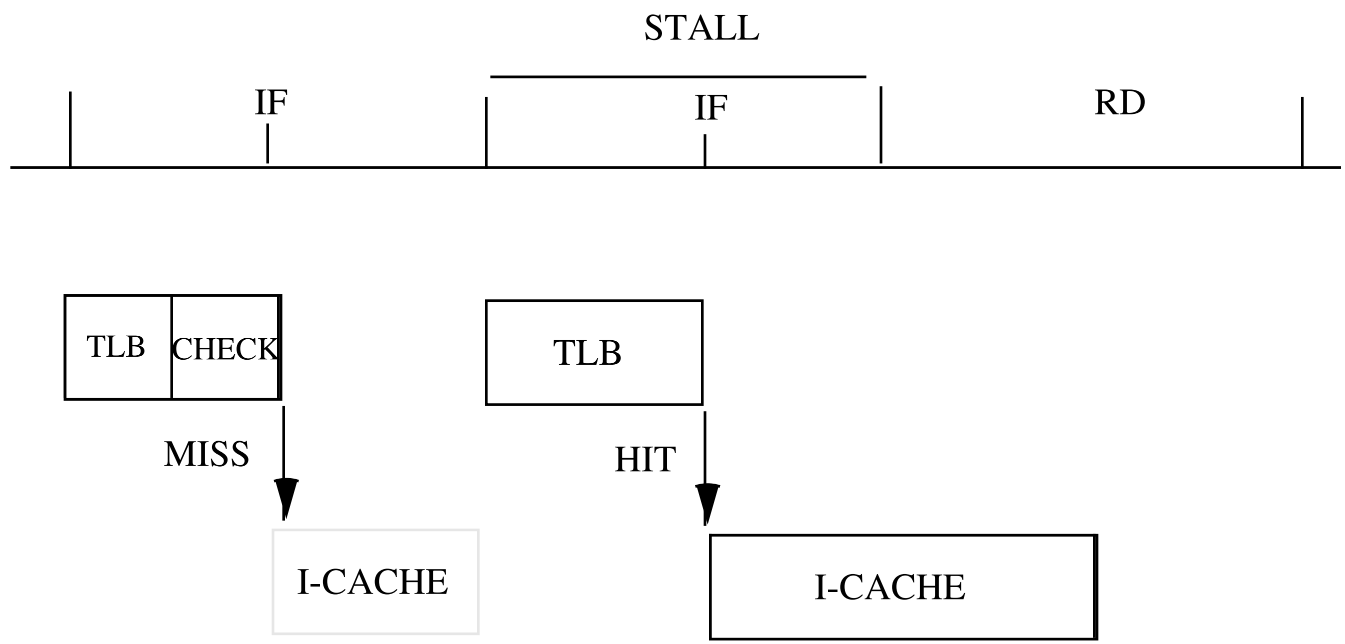
VIRTUAL ADDRESS SPACE



ADDRESS MAPPING

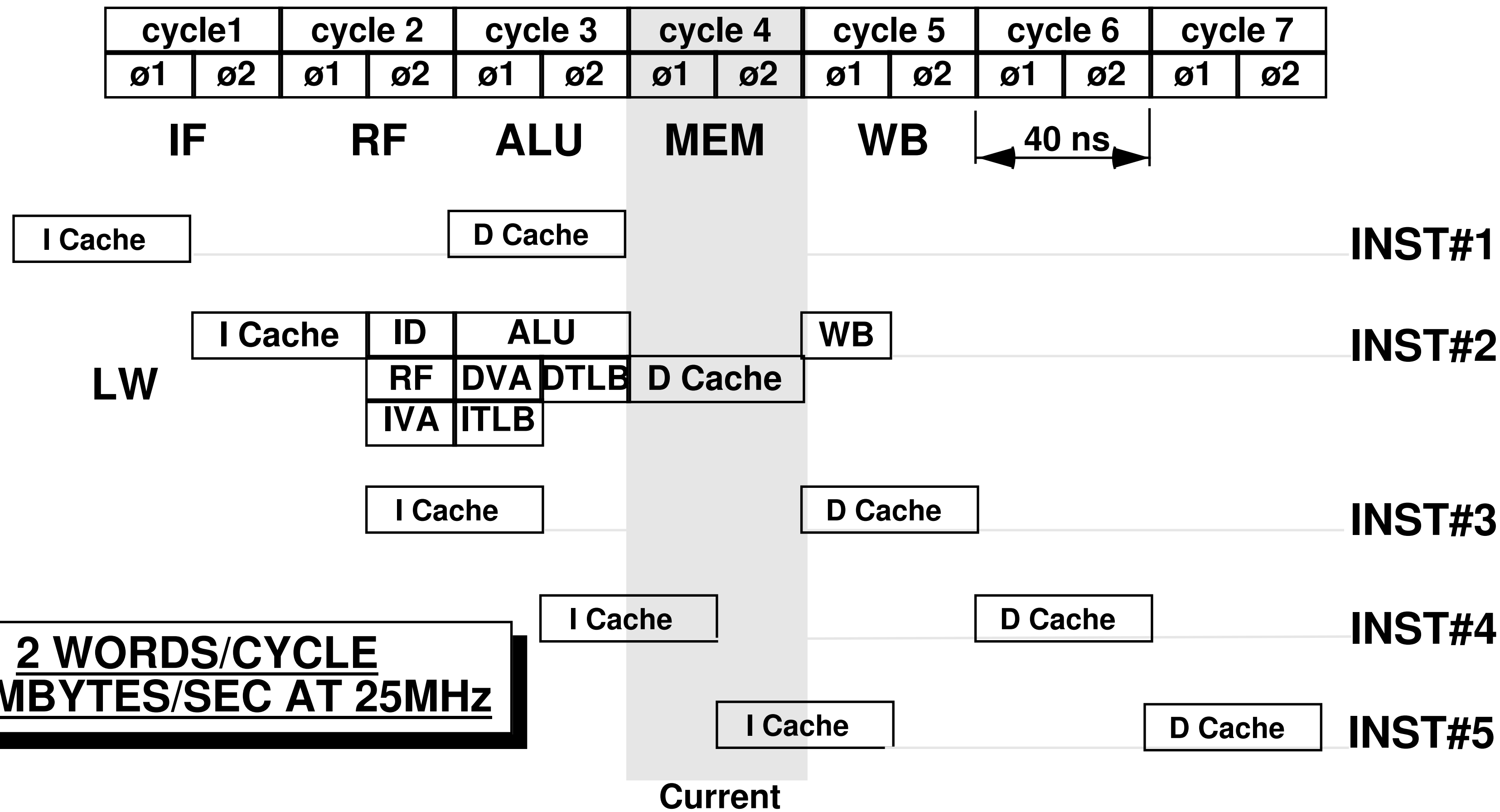


TLB MISS ST ALL



- This Stall Requires no Fixup Cycle

MEMORY BANDWIDTH



2 WORDS/CYCLE
200 MBYTES/SEC AT 25MHz

PERFORMANCE COMPARISONS

PROC	CLOCK (MHz)	WDS/CYC (4 Bytes)	BNDWTH (MB/sec)	CPI (MHz/VUP)	VAX-MIPS (VUPs)
68020	20	1/3	27	7.0	3
68030	20	1/2	33	6.0	4
68030 (Sun3/200)	25	1/3	40	6.2	4
80386	25	1/2	50	6.0	5
68030	33	1/2	67	5.5	6
SPARC (Sun4/200)	16	1/1	67	2.1	8
29000	25	2/1	200	2.0	12
R2000 (M/120)	16	2/1	134	1.5	12
88000	20	2/1	160	1.5	13
SPARC	33	1/1	134	2.1	16
88000	25	2/1	200	1.5	17
R3000 (M/2000)	25	2/1	200	1.2	20

MMU Comparisons

MIPS

- INTEGRATED MMU ON CHIP WITH CPU
- MINIMUM HARDWARE TO SUPPORT SYSTEM SW

SPARC

- SUN USES SRAM + LOGIC TO BUILD MMU
- SUN's MMU AND REFERENCE MMU ARE DIFFERENT,
  KERNEL SOFTWARE WILL BE DIFFERENT
- CYPRESS & FUJITSU NOW OFFER MMUs, BUT DIFFERENT;
  NEITHER SUN NOR SOLBOURNE USE THESE MMUs

MOTOROLA

- INTEGRATED MMU ON CHIP WITH CACHE
- LOCK INTO ONE SUPPLIER FOR LARGE $ PARTS