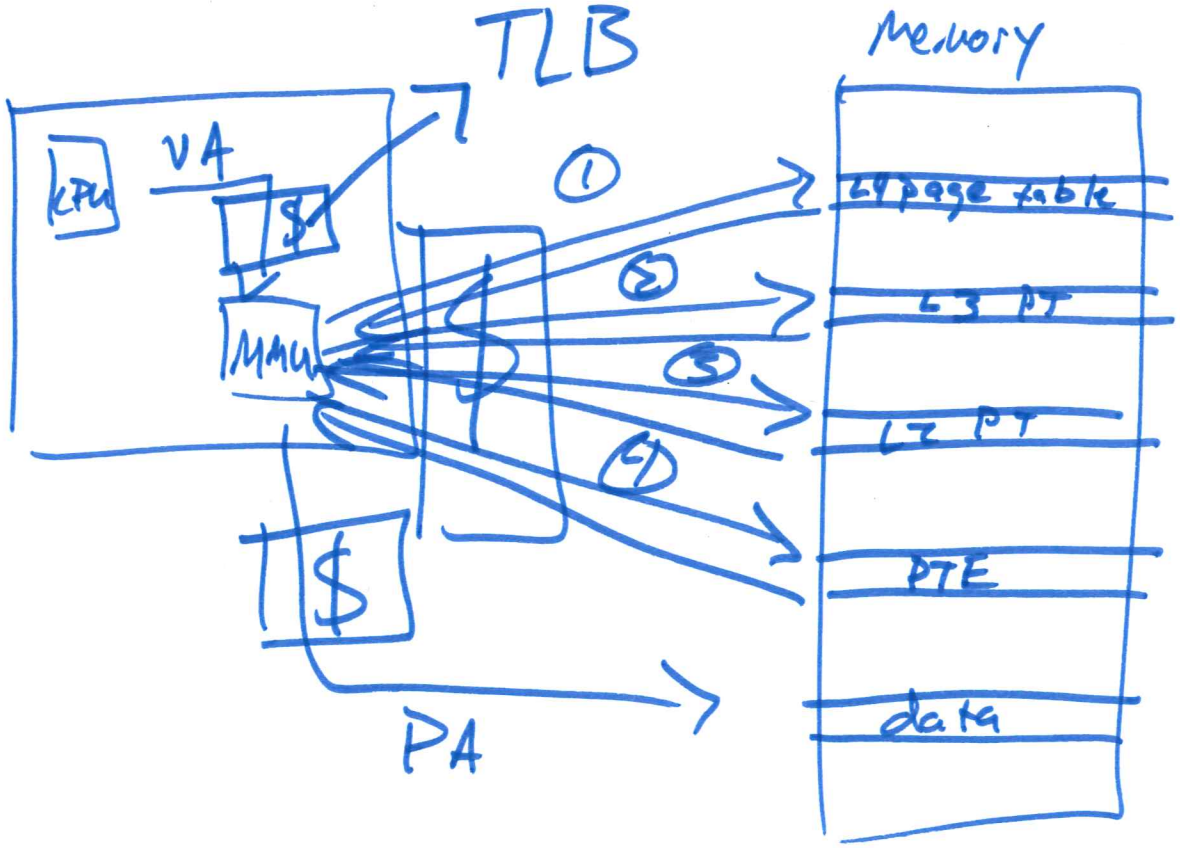
Increasing performance of address translation



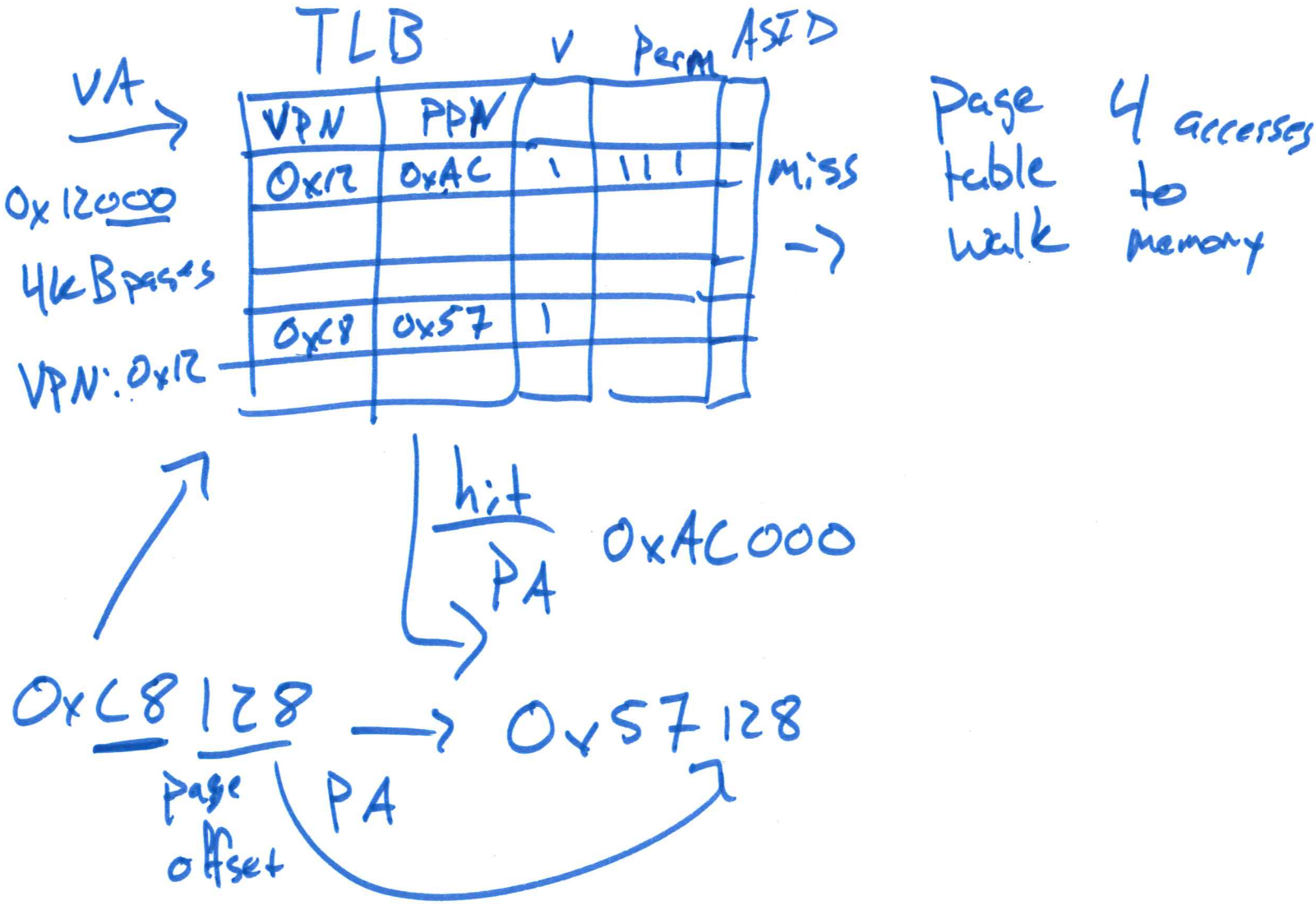
x86-64 up to 4 accesses per ld/st

Add a ~~cache~~ cache

TLB → translation look-aside buffer

↳ cache our address translations

↳ indexed by virtual address



if TLB is SA the bits in VPN give the set # / set index

TLB takes advantage of temporal and spatial locality

→ accessing same data

→ if accessing other data within the same page

is the TLB is direct-mapped?
Set-associative?
Fully-associative?

fully-associative → want highest hit rate possible
→ ~~get's~~ gets rid of all conflict misses

TLB must be very fast
it's on the critical path to L1 cache

TLBs are small 16-64 maybe 96 entries

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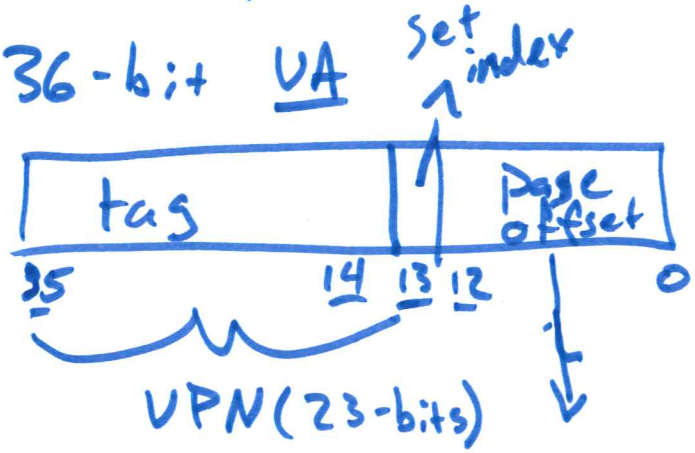
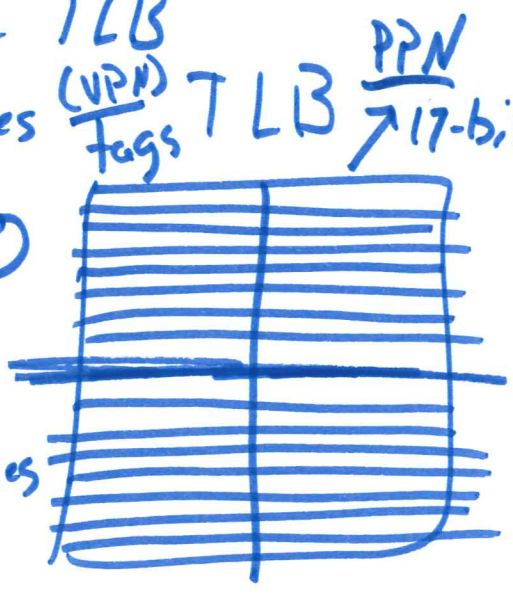
indexing a set associative TLB

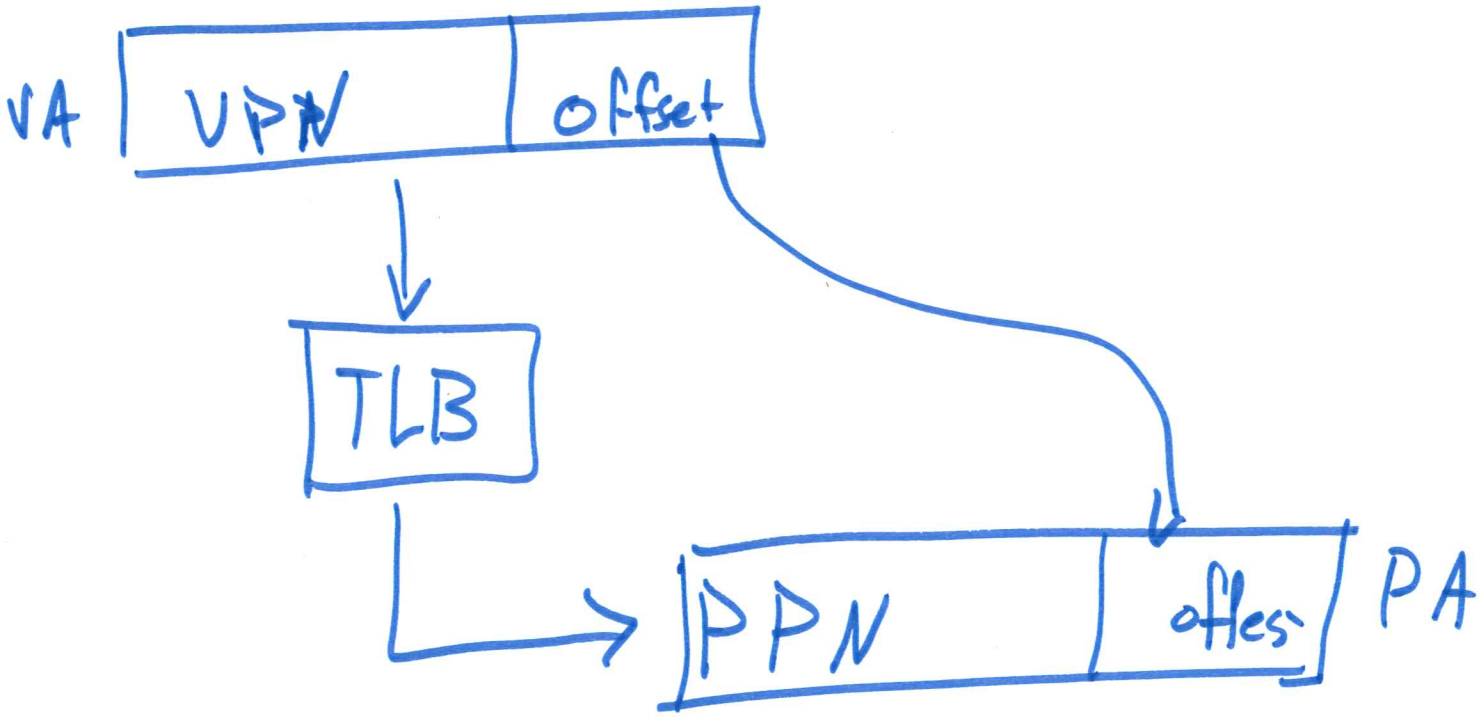
36-bit VA



8KB pages



Phy. Address size
↳ 30 bits - 13 bits (Page offset)


VA
VPN
offset
TLB
PPN
offset
PA

movl 0x03010004, %ebx %ecx? = 71.2 ebx = 0x00023790
movl (%ebx), %ecx

VA 0: 0x03010004
VA 1: 0x00023790
VA 2: 0x
VA 3: 0x

ld/st unit

PA 0: 0x02C72004
PA 1: 0x8588A3790
PA 2: 0x
PA 3: 0x

Virtual address

Virtual page number (16-bits)	Page offset (16)
31	15 0

L2 Index (8)	L1/PTE Index (8)
31 24	23 16

Page table entry

Physical page number (22 bits)	Valid	Present
21	2	1 0

16-bit in Page offset -> 36-16 = 20

MMU

CR3 register: 0x7A2300000

TLB

VPN	PPN	V
0x0002	0x8588A	1
0x0301	0x02C72	1
0xABCD	0x741AC	1

VPN 0301
VPN 0002

2-level page table
256 entry L2 page table
256 entry L1 page table
64 KB pages

Physical address

Cache tag (36)	Set index (8)	Block offset (8)
35	43 37	0

Cache (4-bytes words)

	V	Tag	Word 0	Word 1
0	1	0x8588A479	71.2	13.9
	1	0x8588A400	16.7	56.0
	1	0x02C72000	0x2DB007B4	0x00023790
	1	0x9A525000	7	8
1	1	0x9A525000	9	10
	1	0xB0BB1000	r l d /0	a b c d
	1	0xB79E5000	0x03020010	0.117
	0			

4-way SA

Physical Memory (shown as 4-byte words)

0x813B80000	0x7492B2F4	0xD1ACB0000	0x813B8 00
	0xD411F7D4		0x8588A 11
	0x7C32B114		0x9A525 11
	0xFBAB80E4		0xB0BB1 11
	0x280BA0000		a b c d
	0		r l d /0
	0		o _ w o
0x7A2300000	0xD1ACB0000	0xB0BB10000	h e l l
	0xB94E4758		0.117
	0xF9A7F898		0x03020010
	0x57691828		0.153
0x5E1F90000	0x986DFAEC	0xB79E50000	0x03020008
	0x6336C1BC		0
	0xDEE932A4		0
	0x4368AD88		0
0x417E30000	0x525D7838	0xAC2620000	0
	0x5E1F9 10		10
	0xB79E5 11		9
	0x02C72 11		8
0x280BA0000	0xAC262 00	0x9A5250000	7
	0xA445B1F0		1.29
	0x1B58C68		2.8
	0x00023790		13.9
0x02C720000	0x2DB007B4	0x8588A0000	71.2

0x8588A3790