Valid	Tag	PPN
1	12	13
1	4	9
1	5	11
01	06	14

VPN	Valid	Physical Page / Disk
0	1	5
1	01	13
2	0	Disk
3	1	6
4	1	9
5	1	11
6	01	14
7	1	4
8	0	Disk
9	0	Disk
10	1	3
11	1	12

$\left[\frac{\text{Address}}{8KB}\right]$ = VPN

8KB = 13 offset bits

Address	VPN	TLB H/M	Page Table H/M	Page Fault
4669	0	M	H	N
2227	0	H	–	–
13916	1	M	M	Y
34587	4	M	H	N
48870	5	M	H	N
12608	1	H	–	–
49225	6	M	M	Y

Advantages of larger page size: decrease time it takes to go from PPN to VPN
Less number of TLB misses

Disadvantages: Worse locality of reference

8KB = 13 bit offset

2-way / Direct

Address in Hex			Hex	TLB	Page	Fault
1230	=	0001 0010 0011 0000	230	M/M	M/M	Y/Y
08B3	=	0000 1000 1011 0011	8B3	M/H	H/-	-/-
365C	=	0011 0110 0101 1100	65C	H/M	-/H	-/-
871B	=	1000 0111 0001 1011	71B	M/M	M/M	Y/Y
BEE6	=	1011 1110 1110 0110	EE6	M/M	H/H	-/-
3140	=	0011 0001 0100 0000	140	H/M	-/H	-/-
C049	=	1100 0000 0100 1001	049	M/M	M/M	Y/Y

VPN | Tag | Index | offset

2-Way TLB

Index	Val	Tag	PPN	Val	Tag	PPN
0	1	6	15	0	5	14
1	1	2	12	1	3	4

Direct

Index	Val	Tag	PPN
0	1	02	14
1	1	01	6
2	1	1	15
3	0	2	12

2 bits of index
1 bit of tag

A TLB at high performance helps the CPU quickly lookup the address in physical memory.
Without a TLB the system would have to look up the memory's physical address which can take longer.

2.0.1 Page offset : $\log_2 4\ KiB = 12$ bytes

# of Virtual pages : $2^{48-12} = 2^{36}$ PTE needed

Memory needed : $2^{36} \times 2^2 = 2^{38}$ bytes

2.02 $\frac{4\ KB}{page} \mid \frac{page\ entry}{8\ bytes} = 512$ entries

$\log_2 512 = 9$ bits for address

$\frac{36\ PTEs}{9} = 4$ levels

Cost of address translation = Cost of Page Table Lookup + Prob(TLB miss) * Cost of page lookup table