

Virtual Memory

CS520

Dept. of Computer Science

Univ. of New Hampshire

motivation

allow program to exceed size
of physical memory

support multiple programs
sharing physical memory

↳ efficient use of resources
protection

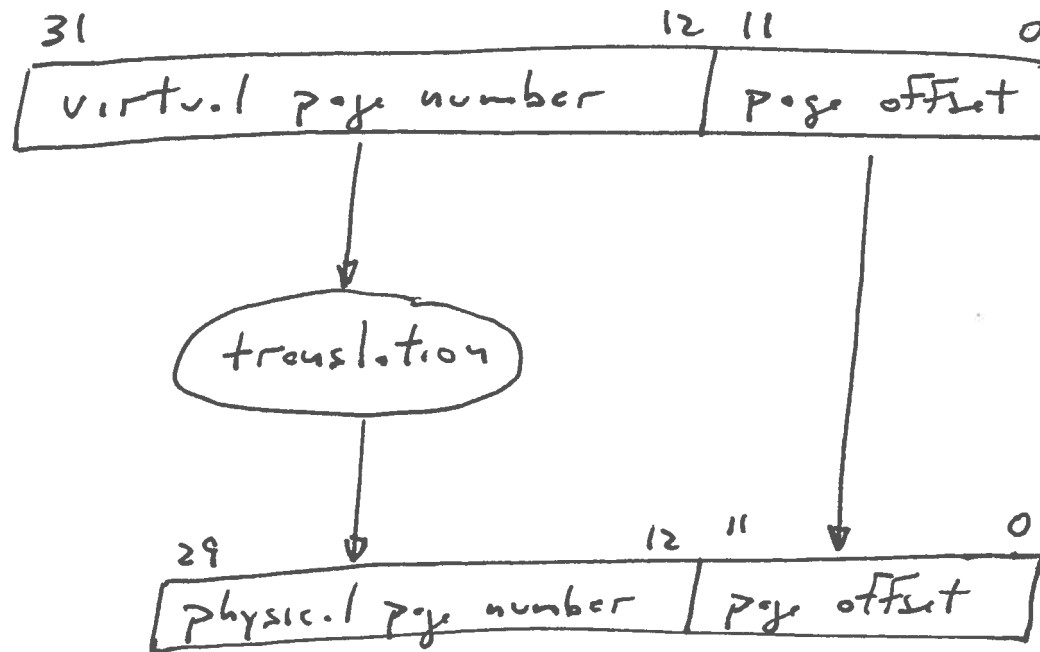
warning

technology is similar for virtual memory
and cache

but terminology is different

cache block \leftrightarrow virtual memory page

cache miss \leftrightarrow virtual memory page fault



Page size $2^{12} = 4\text{KB}$

number of physical pages 2^{18}

physical memory maximum size 1GB (30-bit address)

virtual memory maximum size 4GB (32-bit address)

miss penalty

if virtual page doesn't fit in physical memory,
it is stored on disk.

Large miss penalty!

So

large page size

misses can be handled in software

accumulate writes — don't "write through"

reducing page fault rate is important

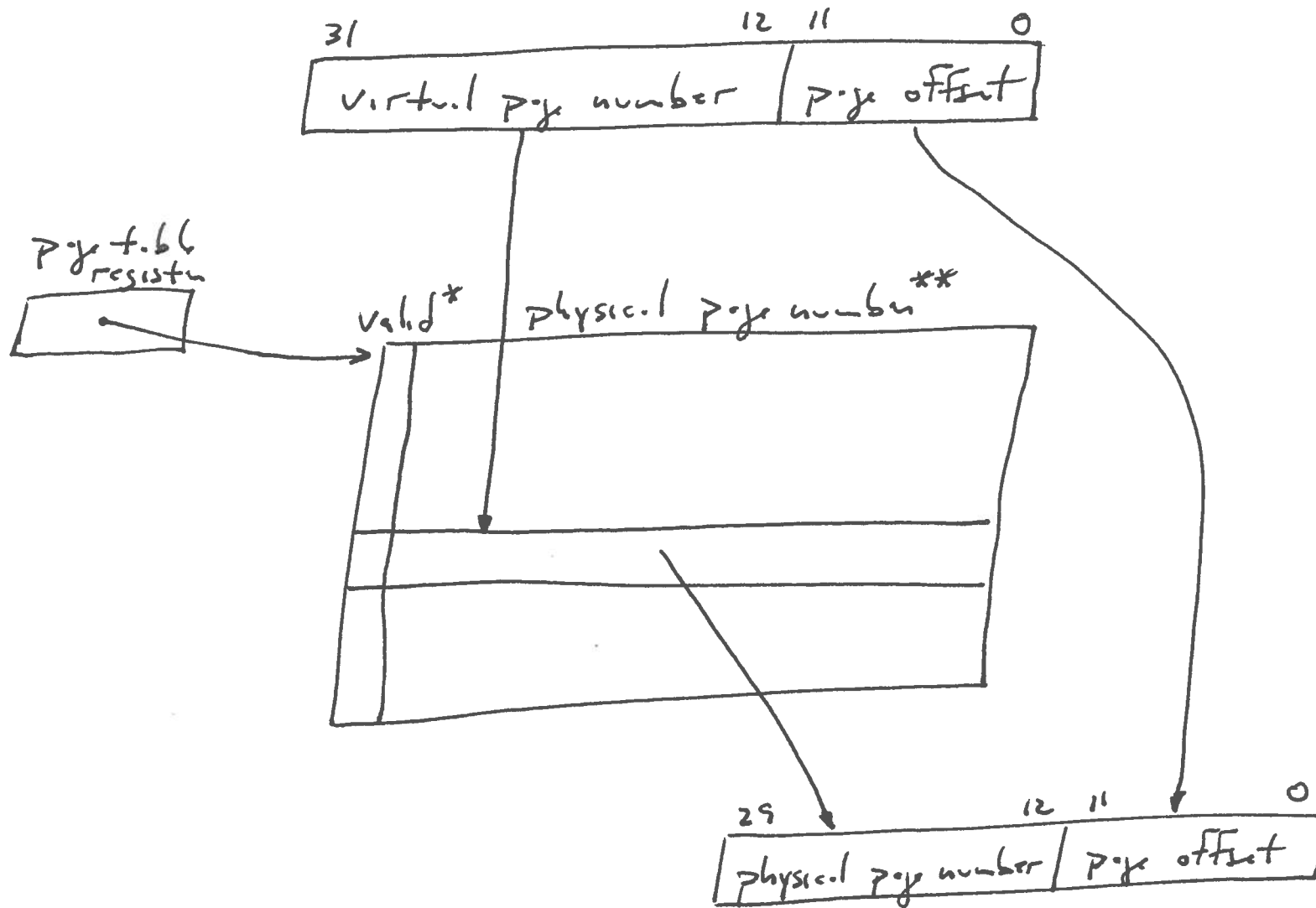
to reduce page fault rate use
associative mapping

allow virtual page to be placed
anywhere in physical memory

use page table to implement
associative mapping

↳ each program has page table

page table is in memory and
is pointed to by page table
register



* if valid flag not set, page is not in memory.

** when valid flag clear, then this field contains disk location of page.

When page fault occurs, Operating System
is given control to get page from disk.

Key problem

If all pages in physical memory are
in use, then which one should be
replaced?

temporal locality \Rightarrow Least Recently Used
(LRU)
Page should be chosen

can be approximated via a reference bit

set when page referenced

O.S. periodically clears all the reference bits

a page with a clear bit is among those
least recently used at page-fault time

writes

"write-back" instead of "write-through"

accumulate changes

write back page only at replacement time

use "dirty" bit to track whether page

has been modified

Tracy Kidder Data Gen. I

The Soul of a New Machine

Page table in memory \Rightarrow

each memory reference requires two
memory operations?!

once to read page table

once to read the requested memory
location

to avoid this cost, systems employ
a special cache to remember
recent virtual-to-physical page
mappings

↳ Translation Lookaside Buffer
(TLB)

memory protection

Page table entry can contain protection information

e.g. Page is read-only