Memory (Part II)

Professor Travis Peters
CSCI 460 Operating Systems
Fall 2019

Some slides & figures adapted from Stallings instructor resources.

Some slides adapted from Adam Bates's F'18 CS423 course @ UIUC
https://courses.engr.illinois.edu/cs423/sp2018/schedule.html

Goals for Today

Learning Objectives

- Understand basics of memory management, including
  - memory partitioning and common techniques
  - paging and segmentation — what they are, and their relative advantages and disadvantages
- Understand basics of loading and linking

Announcements

- Use Google Sheet to share info about your project:

  https://docs.google.com/spreadsheets/d/1uMk0pcho_B2v8_7t_E3S-IpsdUfhjBKsT5XdBcfPOBI/edit?usp=sharing

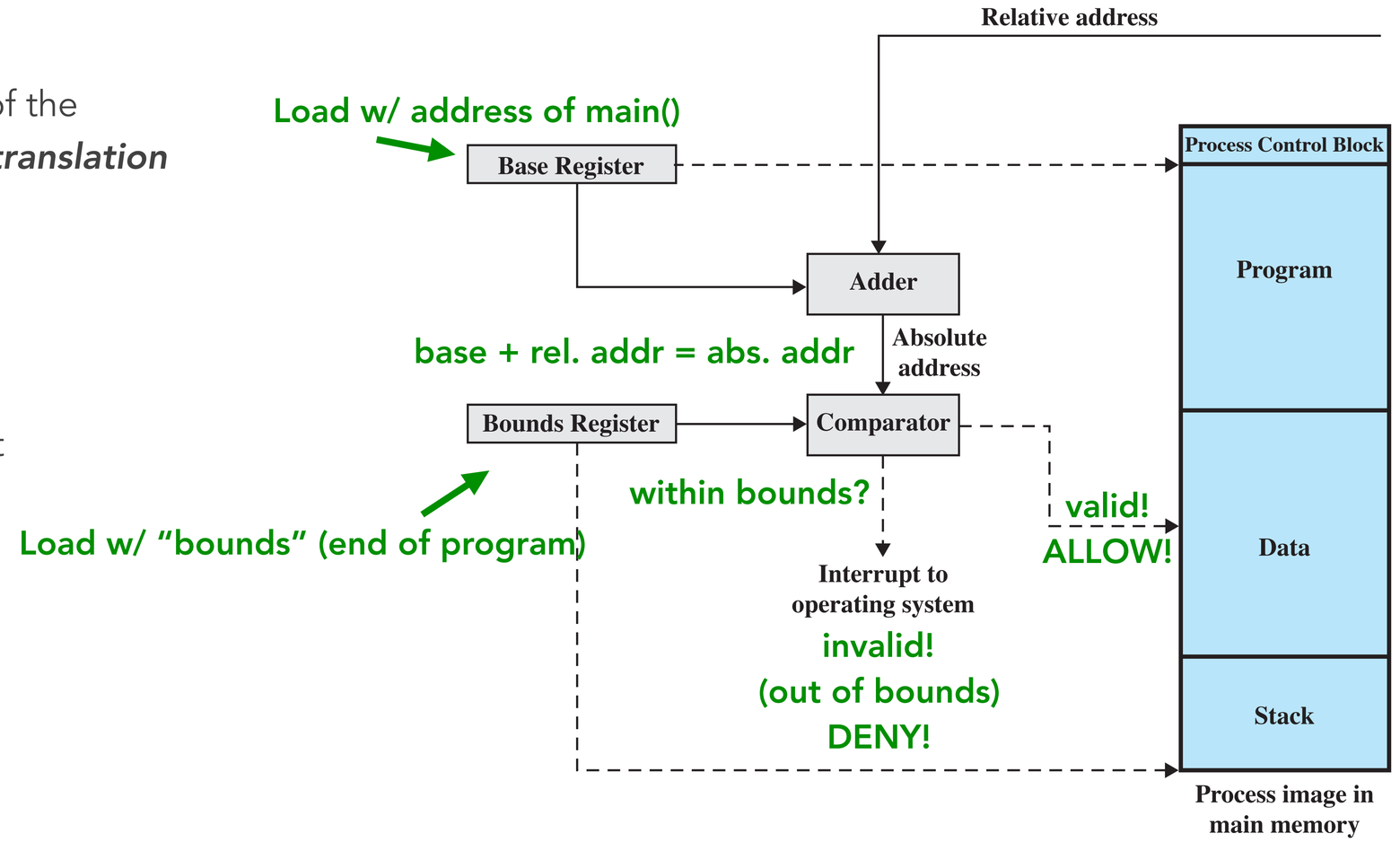
- PA2 posted later this week…

Relocation of Processes into Partitions

- Logical Address
  a reference to a memory location independent of the current assignment of data to memory → need ***translation***

- Relative Address
  An example of a logical address.
  Address = relative location to some known point (e.g., value in register)

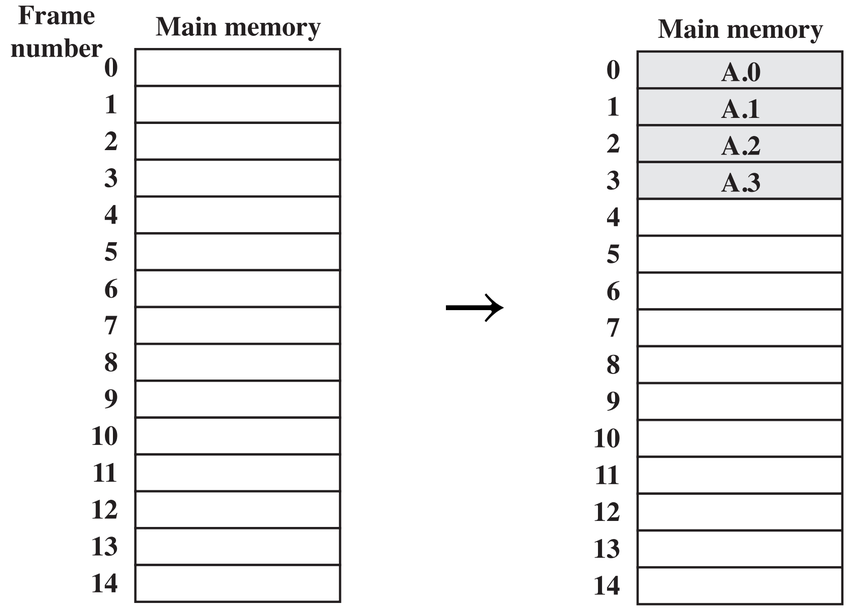
- Physical Address
  The actual location in main memory

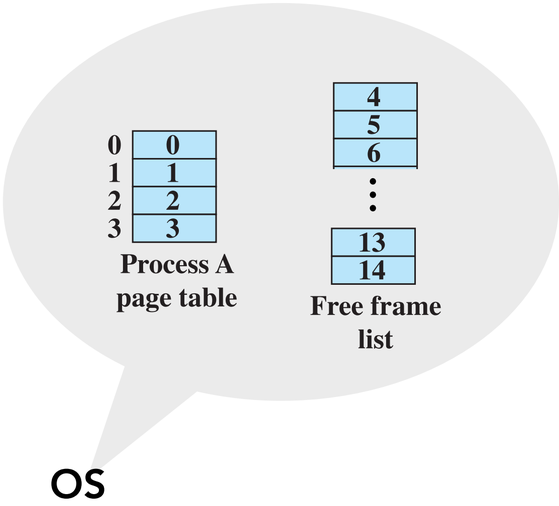


Paging

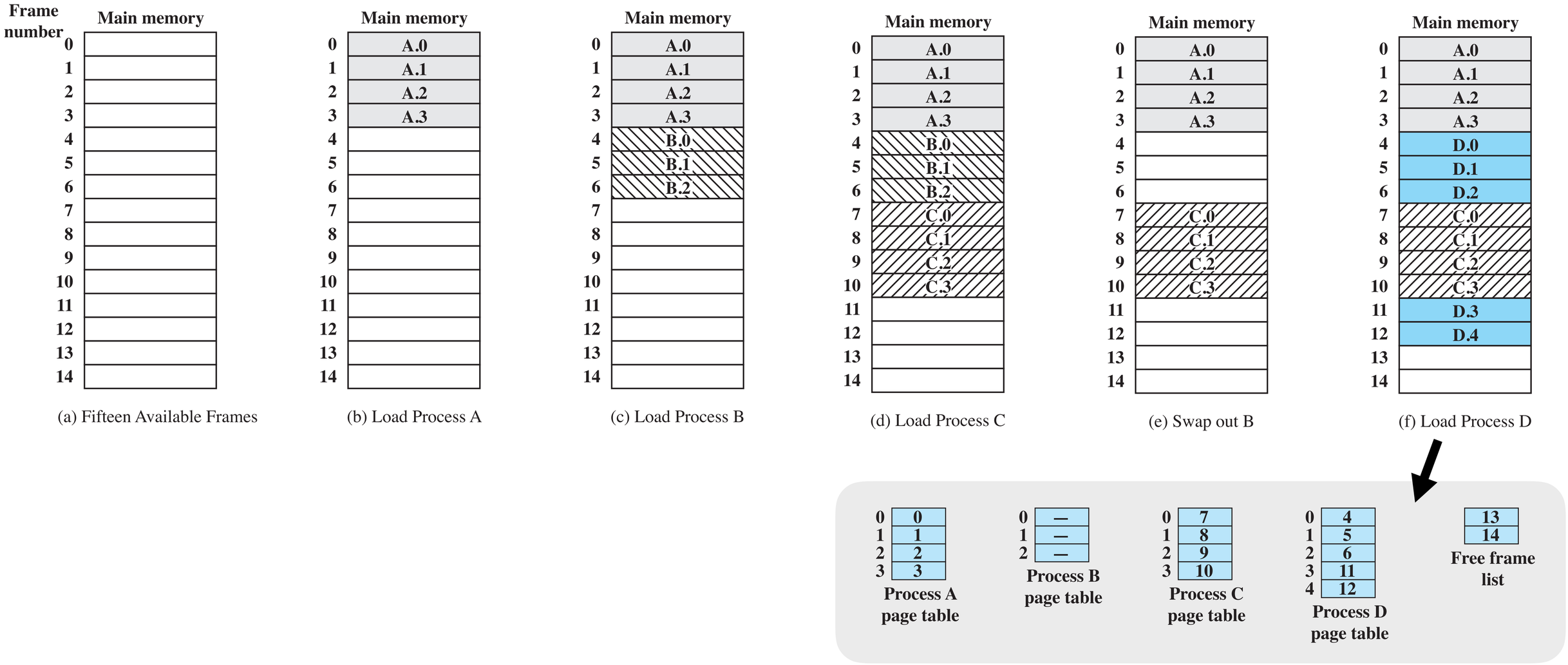
Basic Idea

- Partition main memory into **small fixed-sized chunks** of the same size
- Assign chunks of processes **(pages)** into available chunks of main memory **(frames)**
- Small processes need fewer pages; larger processes need more pages
- No more external fragmentation
- Minimal internal fragmentation → *only part of the last page of a process*





Paging — Example: Assigning Process Pages to Free Frames



Paging — Logical Addressing

HW assists with logical addressing when using paging — HW must know how to access page table

$n + m$ bit addresses where

- n = # bits for page number (leftmost bits)
- m = # bits for offset within page (rightmost bits)

  → PAGESIZE = 2^m

NOTE: In general, we set page/frame size to be a power of 2

→ relative address == logical address

Example:

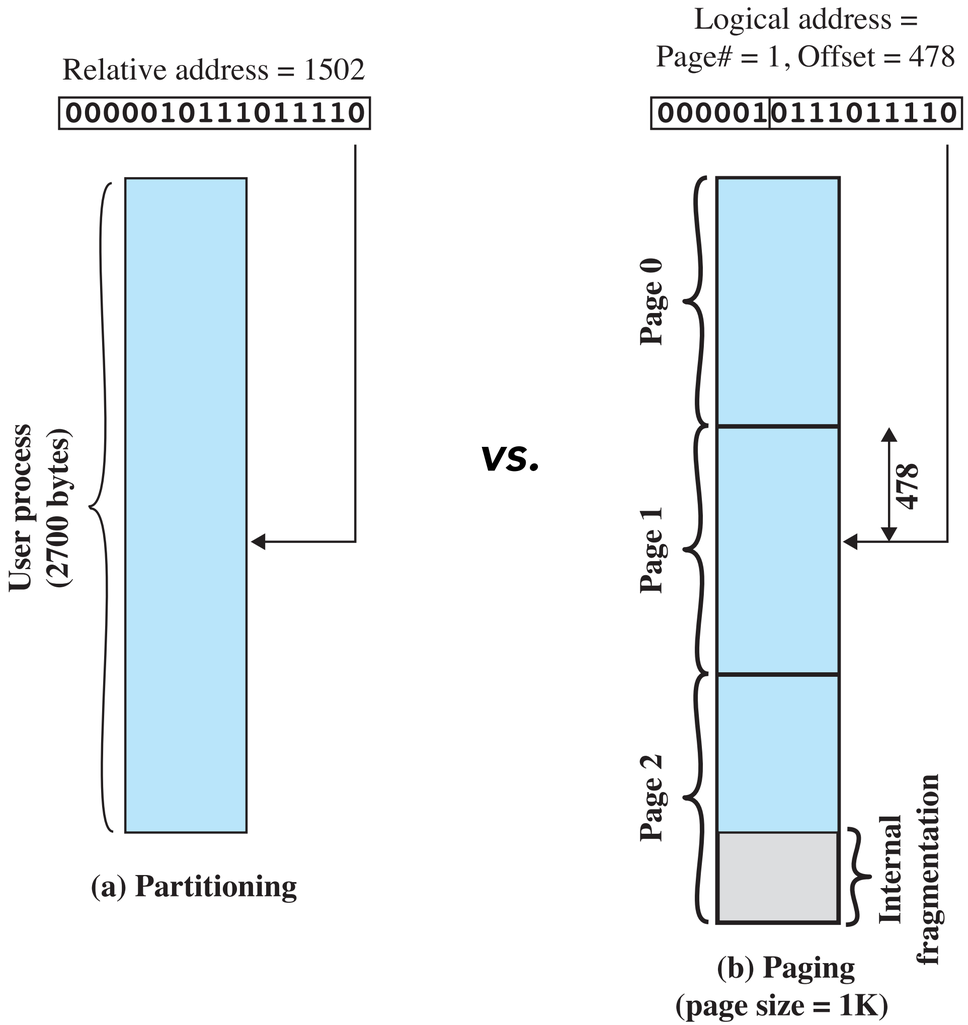
- 16-bit addresses
- Page Size = 1K (1024 Bytes)

Q: *How many bits are needed to accommodate pages/frames of size 1K?*

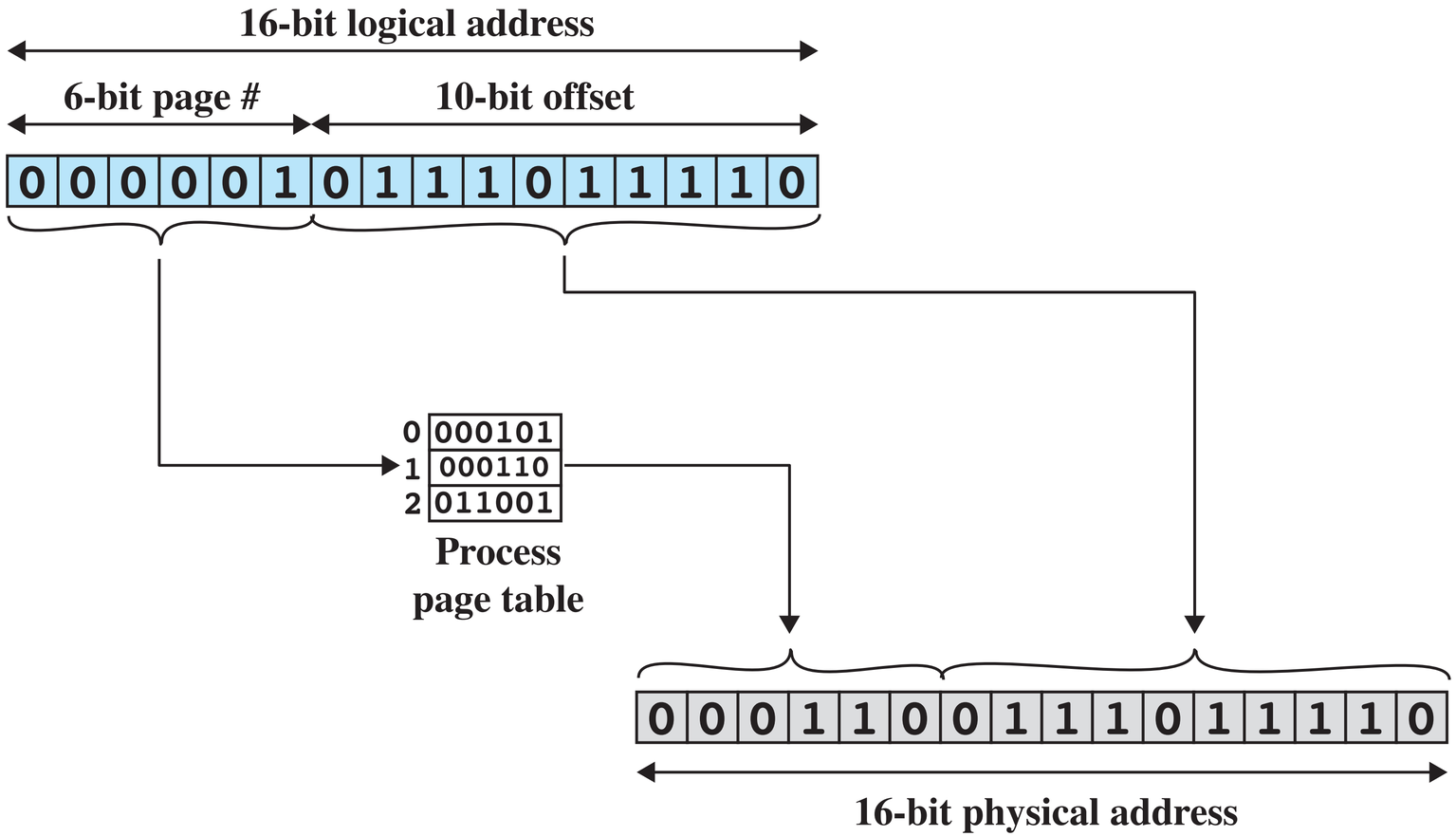
→ *10 bits needed for offset field →* $1K = 2^{10}$

Q: *How many pages are possible with 6-bits available for page numbers?*

→ 6 bits left over for page # field → 64 pages



Paging — Example of Logical-to-Physical Address Translation



Segmentation

Basic Idea

- Programs can be broken up into ***segments*** that need not be in contiguous memory; may occupy more than one segment
- Partition main memory into ***unequally-sized segments***
  - *Similar to dynamic partitioning… but not the same*
- Assign segments of processes into chunks of main memory allocated on demand
- No internal fragmentation
- Potential for external fragmentation

Segmentation — Logical Addressing

- Each segment needs to provide
  - starting address of segment
  - segment length
- Load address of segment table into register when process starts running

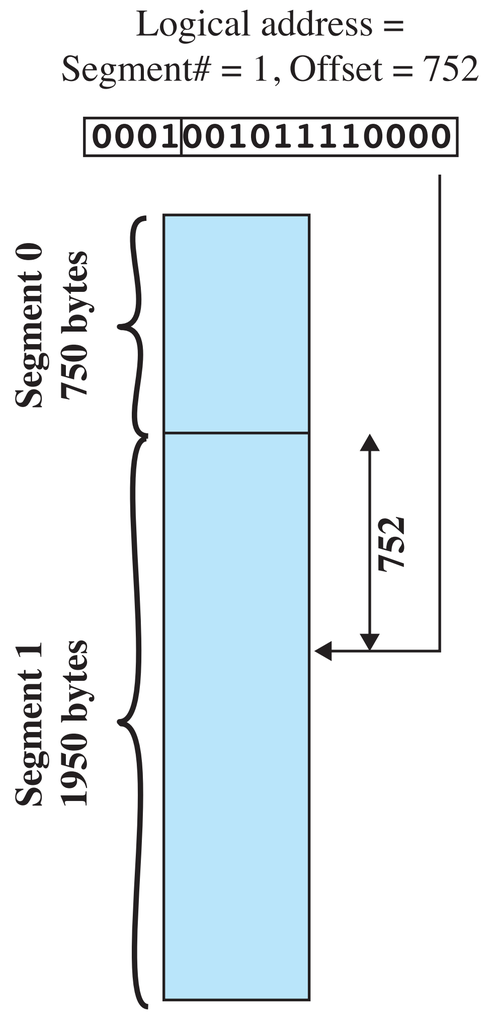
- $n + m$ bit addresses where
  - n = # bits for segment number (leftmost bits)
  - m = # bits for offset within segment (rightmost bits)

Example:

- 16-bit addresses
  - n = 4 bits
  - m = 12 bits

Q: *What is the maximum size of a segment?*
→ $4K = 2^{12}$

Q: *How many segments are possible?*
→ 4 bits used for segment #→ 16 pages



Segmentation — Example of Logical-to-Physical Address Translation