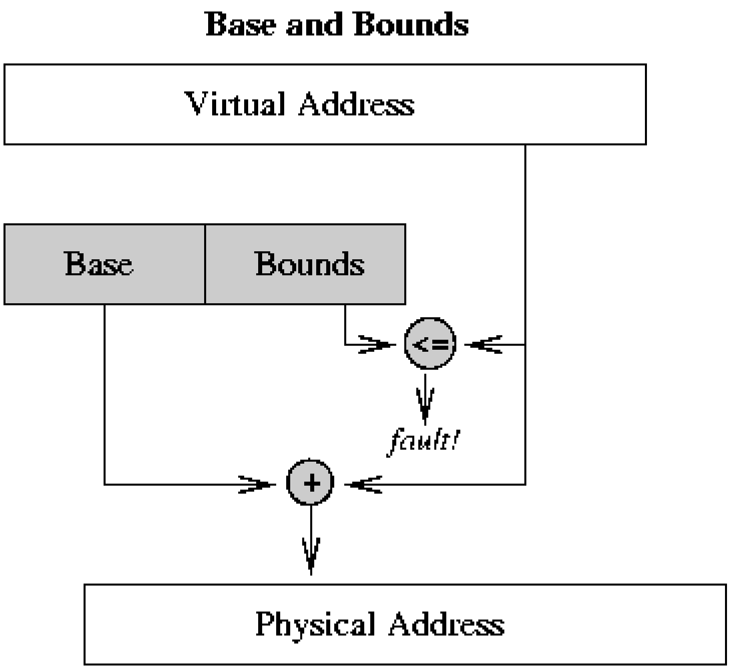
CS 537 Notes, Section #15: Base and Bounds, Segmentation

Base & bounds relocation:

- Two hardware registers: base address for process, bounds register that indicates the last valid address the process may generate.



Each process must be allocated contiguously in real memory.

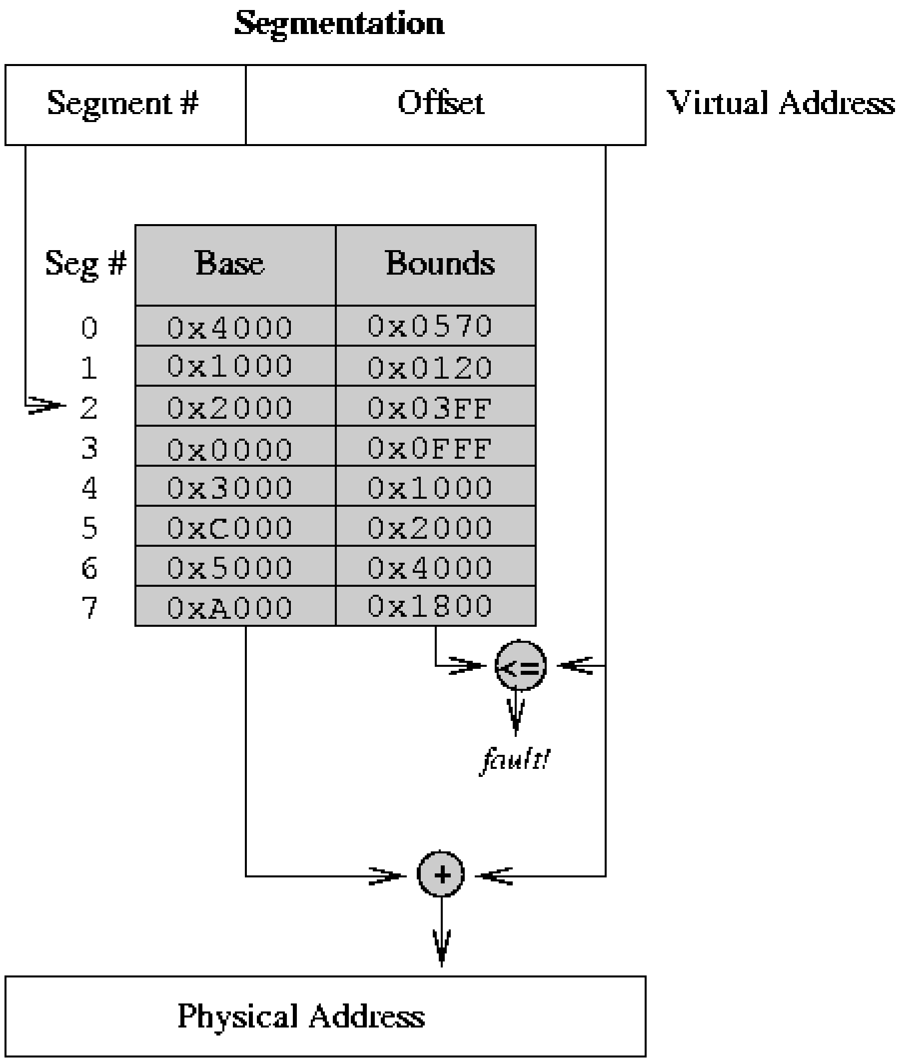
- On each memory reference, the virtual address is compared to the bounds register, then added to the base register. A bounds violation results in an error trap.
- Each process appears to have a completely private memory of size equal to the bounds register plus 1. Processes are protected from each other. No address relocation is necessary when a process is loaded.
- Typically, the OS runs with relocation turned off, and there are special instructions to branch to and from the OS while at the same time turning relocation on and off. Modification of the base and bounds registers must also be controlled.
- Base & bounds is cheap -- only 2 registers -- and fast -- the add and compare can be done in parallel.
- Explain how swapping can work.
- Examples: CRAY-1.

Problem with base&bound relocation:

- Only one segment. How can two processes share code while keeping private data areas (e.g. shared editor)? Draw a picture to show that it cannot be done safely with a single-segment scheme.

Multiple segments.

- Permit process to be split between several areas of memory. Each area is called a *segment* and contains a collection of logically-related information, e.g. code or data for a module.



- Use a separate base and bound for each segment, and also add a protection bit (read/write).
- Each memory reference indicates a segment and offset in one or more of three ways:
    1. Top bits of address select segment, low bits the offset. This is the most common, and the best.
    2. Or, segment is selected implicitly by the operation being performed (e.g. code vs. data, stack vs. data).
    3. Or, segment is selected by fields in the instruction (as in Intel x86 prefixes).

(The last two alternatives are kludges used for machines with such small addresses that there is not room for both a segment number and an offset)

- Segment table holds the bases and bounds for all the segments of a process.
- Show memory mapping procedure, involving table lookup + add + compare. Example: PDP-10 with high and low segments selected by high-order address bit.

Segmentation example: 8-bit segment number, 16-bit offset.

- Segment table (use above picture -- all numbers in hexadecimal):
- Code in segment 0 (addresses are virtual):
- `0x00242:        mov  0x60100,%r1`
- `0x00246:        st   %r1,0x30107`
- `0x0024A:        b    0x20360`
- Code in segment 2:
- `0x20360:        ld   [%r1+2],%r2`
- `0x20364:        ld   [%r2],%r3`
- `                 ...`
- `0x203C0:        ret`

Advantage of segmentation: segments can be swapped and assigned to storage independently.

Problems:

- External fragmentation: segments of many different sizes.
- Segments may be large, have to be allocated contiguously.
- (These problems also apply to base and bound schemes)

Example: in PDP-10's when a segment gets larger, it may have to be shuffled to make room. If things get really bad it may be necessary to compact memory.
