University of BRISTOL

Computer Systems B

COMS20012

Introduction to Operating Systems and Security

bristol.ac.uk

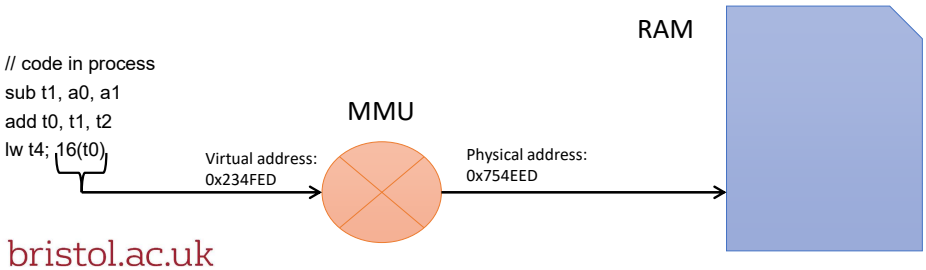
University of BRISTOL

Segmented Virtual Memory

bristol.ac.uk

Memory-mapping Unit (MMU)

- MMU is a piece of hardware
  - Translate virtual addresses to physical addresses
  - Only configurable by a privileged process (i.e. the kernel)
- Virtual addresses are what a process uses
- Physical addresses is what the CPU present to the RAM

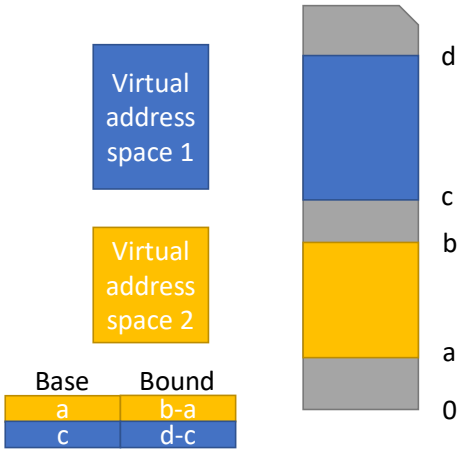


bristol.ac.uk

Early attempt: base + bound

- Associate virtual address with base and bound register
- Base: where the physical address space start
- Bound: the length of the address space (both virtual and physical)
- MMU formula:

```
if (virtual_add > bound)
    error()
else
    physical_add = virtual_add + base
```



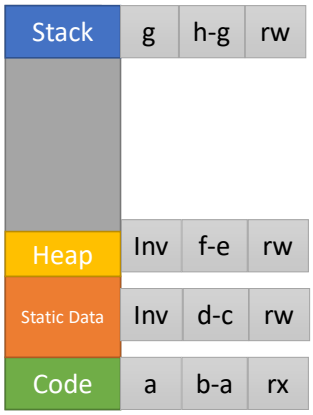
Base + Bound pros and cons

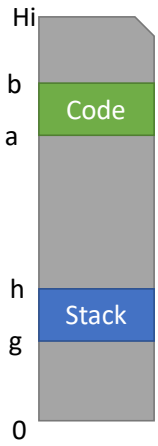
- Allow each virtual address space to be of different size
- Allow each virtual address space to be mapped into any physical RAM of sufficient size
- Straightforward isolation: just ensure no overlap!
- Waste physical memory if the virtual address space is not fully used (i.e. hole between stack and heap)
- Same privilege everywhere read/write/execute
- Sharing memory can only happen by overlapping top and bottom of two spaces (if need to be shared by more than 2?)

Segmentation

- A single address space has multiple logical segement
  - Code: read/execute, fixed size
  - Static data: read/write, fixed size
  - Heap: read/write, dynamic size
  - Stack: read/write, dynamic size
- Each segment is associated with privilege + base + bound
  - At a given time some segment may not be mapped into the physical RAM
  - When not mapped they are **swapped** to disk (more on this later)

Segmentation






```
seg = find_seg(virtual_add)
if (offset(vritual_add) > seg.bound)
      error()
else
      physical_add = offset(virtual_add) + seg.base
```

Defining find_seg an offset:

– Partition approach 

  - High order bits for segment
  - Low order bits for offset

– Explicit approach
  - Virtual address as offset
  - Instruction needs segment to be explicit

bristol.ac.uk

Segmentation Advantages

- Shared advantage with base + bound
  - Small address space metadata (few segments, few information about those segments)
  - Isolation is easy just ensure there is no overlap
  - Can map segment in any large enough region of physical RAM
- Advantage over base + bound
  - Can share memory at the segment granularity
  - Waste less memory (i.e. hole between heap and stack doesn't need to be mapped)
  - Enables segment granularity memory protection

Segmentation Disadvantages

- Segment may be large
  - Need to map the whole segment into memory even to access a single byte
  - Cannot map only the part of the segment that is utilized
- Need to find free physical memory large enough to accommodate a segment
  - Several algorithm can be used **first fit, worst fit, best fit** (see exercises)
  - All have **trades-off**
- Explicit segment management is not very elegant (better with partitioned address)

bristol.ac.uk

University of BRISTOL

Thank you

bristol.ac.uk