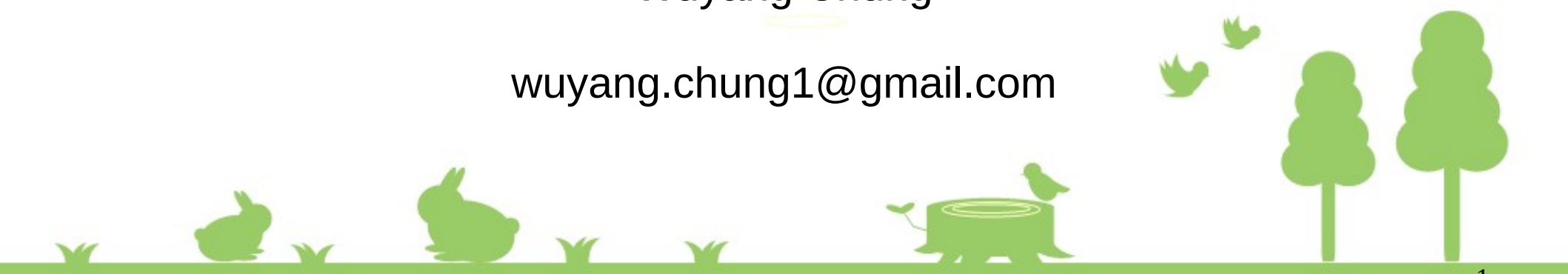
Segmentation Extension Proposal

Mar. 12, 2019

Wuyang Chung

wuyang.chung1@gmail.com



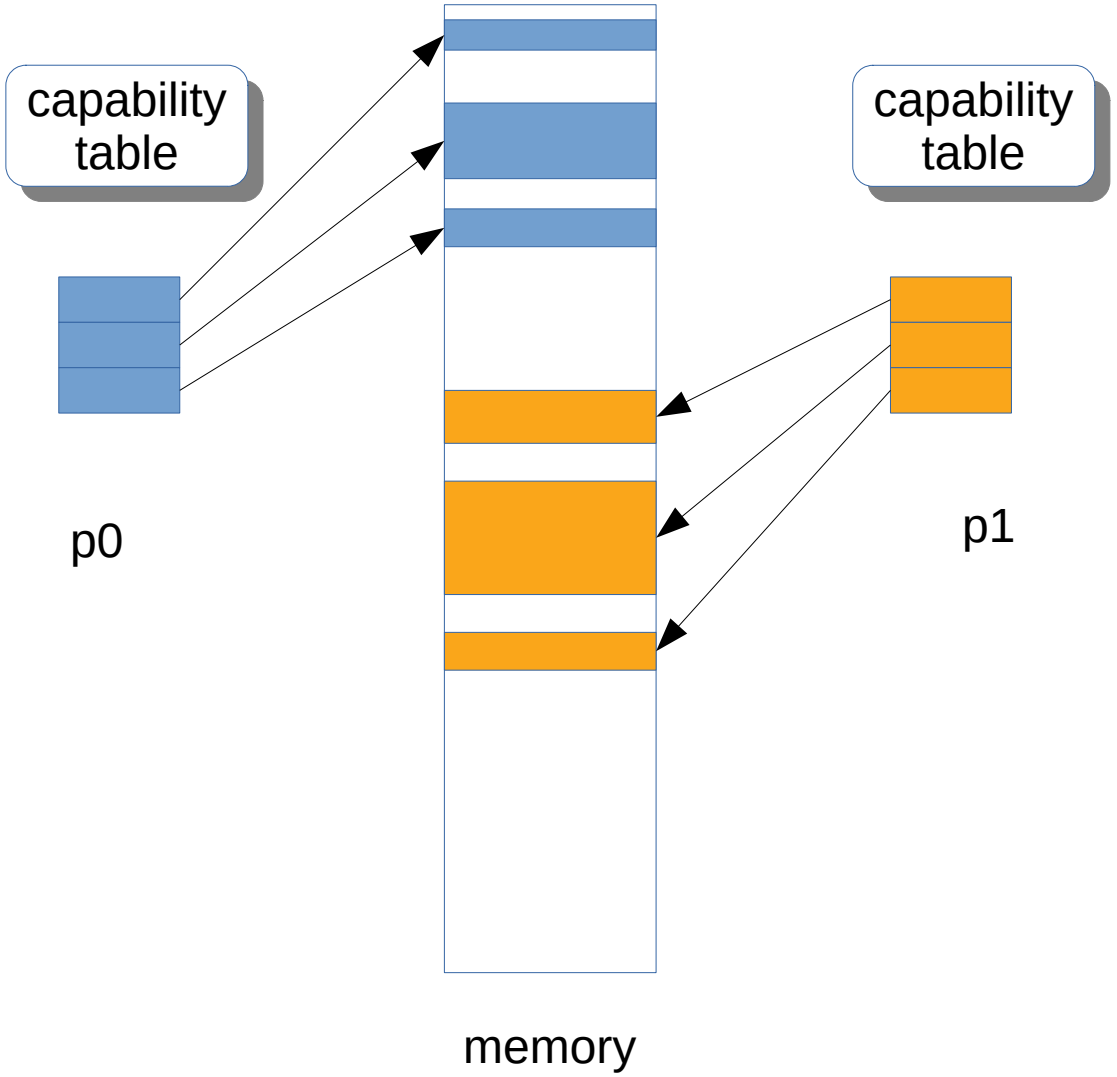
Outline

- Why segmentation
- Segmentation hardware
- New instructions
- Benefits of segmentation
- Misc

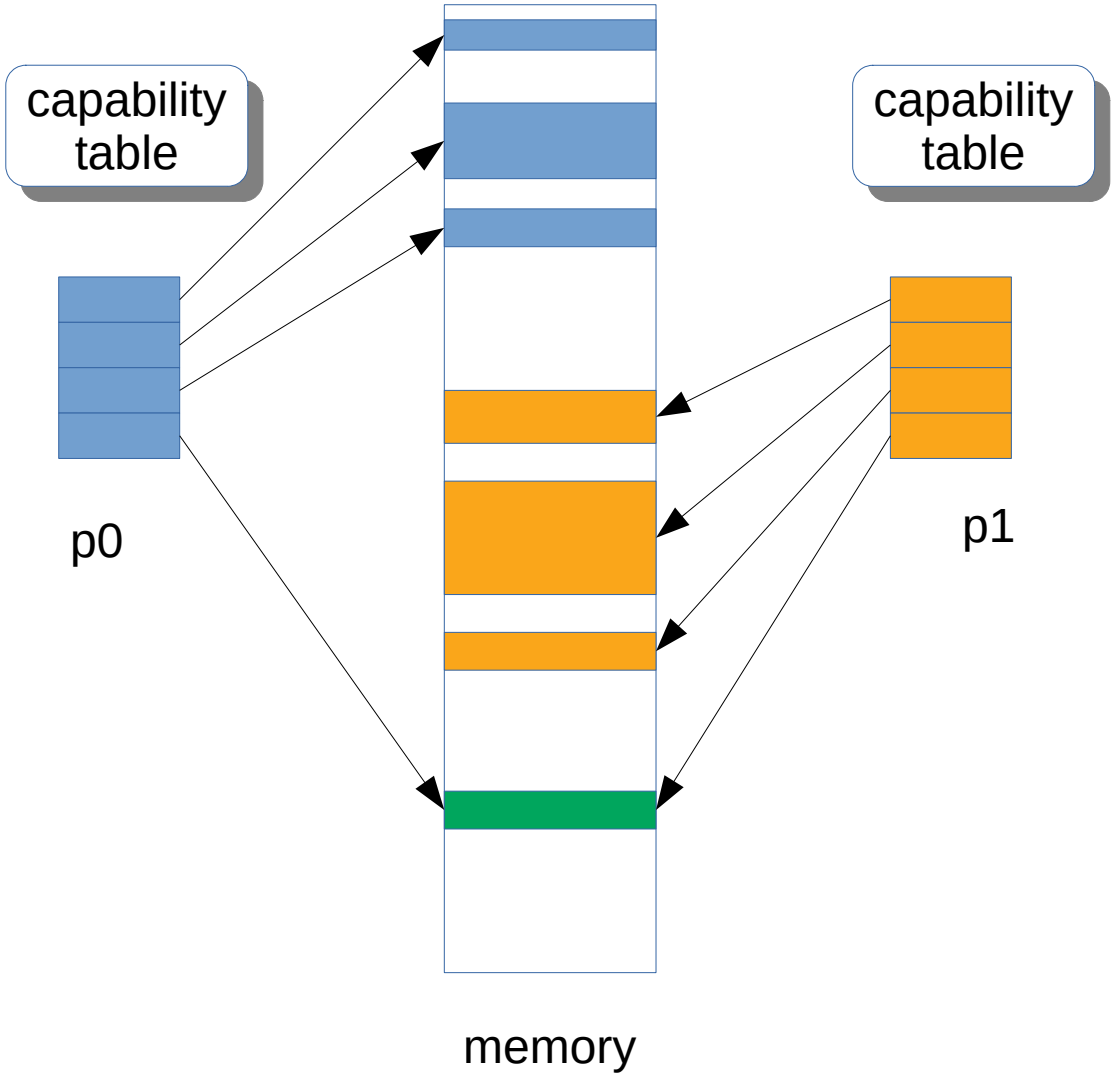
Why Segmentation

- Segmentation can be used to create multiple protection domains on a single address space
  - SASOS: Single Address Space Operating System
  - Reduce context switch overhead
  - Data sharing is easy among processes
  - ...
- Other benefits
  - I/O segment
  - Physical memory segment
  - Software-managed TLB
  - No PIC (Position Independent Code) is needed
  - …

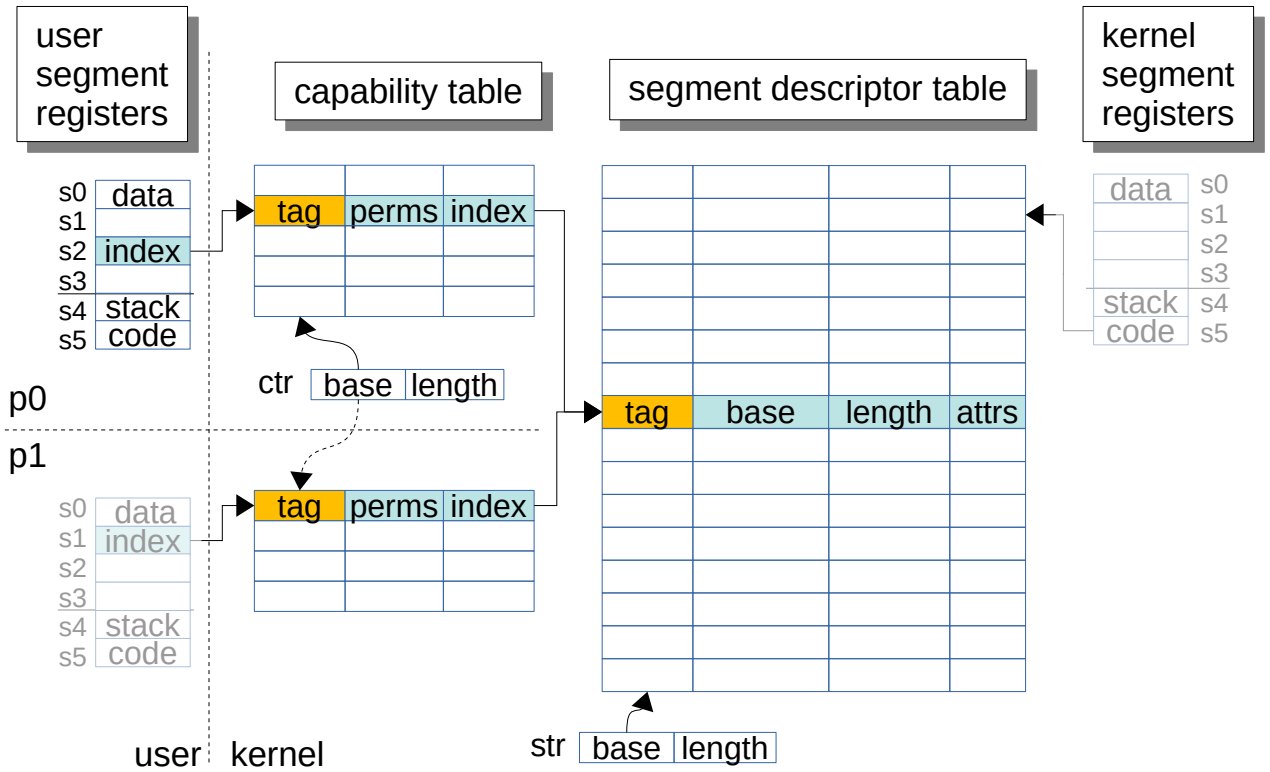
Segmentation Hardware



Segmentation Hardware (2)

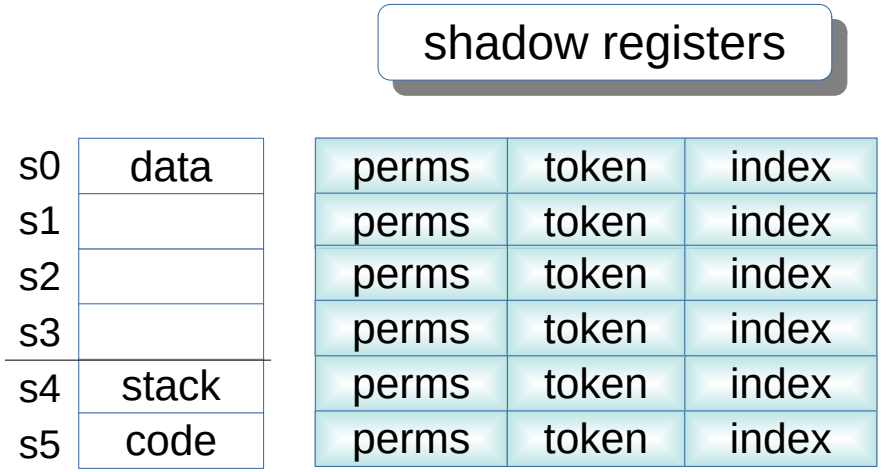


Segmentation Hardware (3)



Segmentation Hardware (4)

- Segment TLB
  - Cache segment descriptors
- Segment shadow register
  - Cache capability



New Instructions

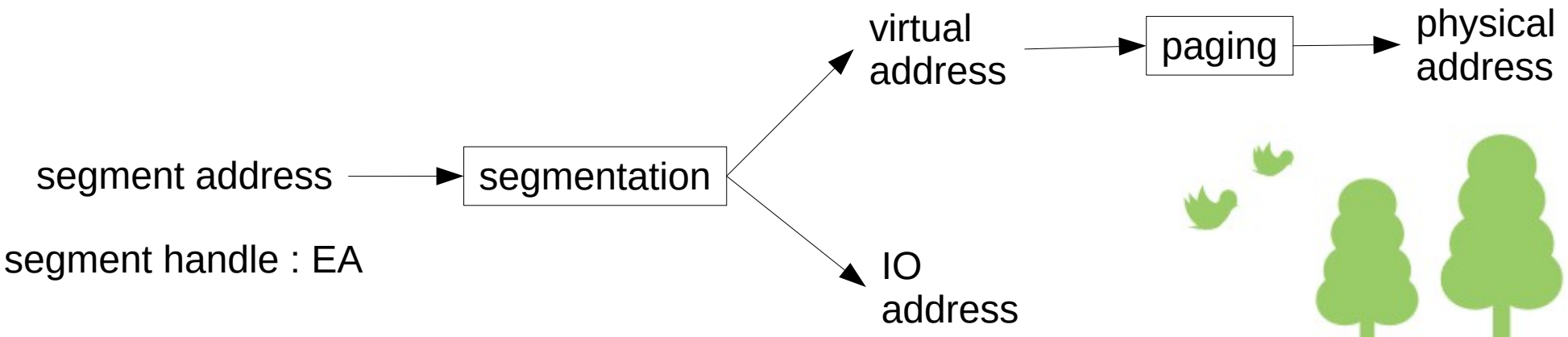
- Load/Store with segment override
  - LW x1, ***s1***:imm[x2]
- Load/Store segment registers, ctr register and str register
  - LSR s0, imm[x1], SSR s0, imm[x1]
  - LCTR imm[x1], LSTR imm[x1]
- Far function call and return
  - For shared library
  - Far call
    - SJAL link_addr, ***callee_seg***, imm
  - Far return
    - SJALR ***caller_seg***, imm[x1]

Benefits of Segmentation

- On systems without paging
  - Segmentation can be used instead of PMP (Physical Memory Protection).
  - It’s more easy to implement shared library with segmentation.

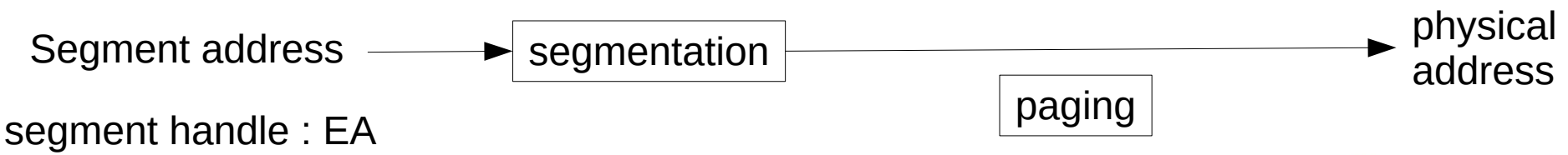
Benefits of Segmentation (2)

- On systems with paging
  - I/O segment
    - No page TLB entry is needed for device driver to access its hardware device.
    - One set of load/store instructions can be used to load/store from/to either memory or I/O.



Benefits of Segmentation (3)

- On systems with paging
  - Physical memory segment
    - Improve the performance of big-memory workloads
      - Arkaprava Basu, Jayneel Gandhi, Jichuan Chang, Mark D. Hill, Michael M. Swift. Efficient virtual memory for big memory servers. In Proc. ISCA, 2013.

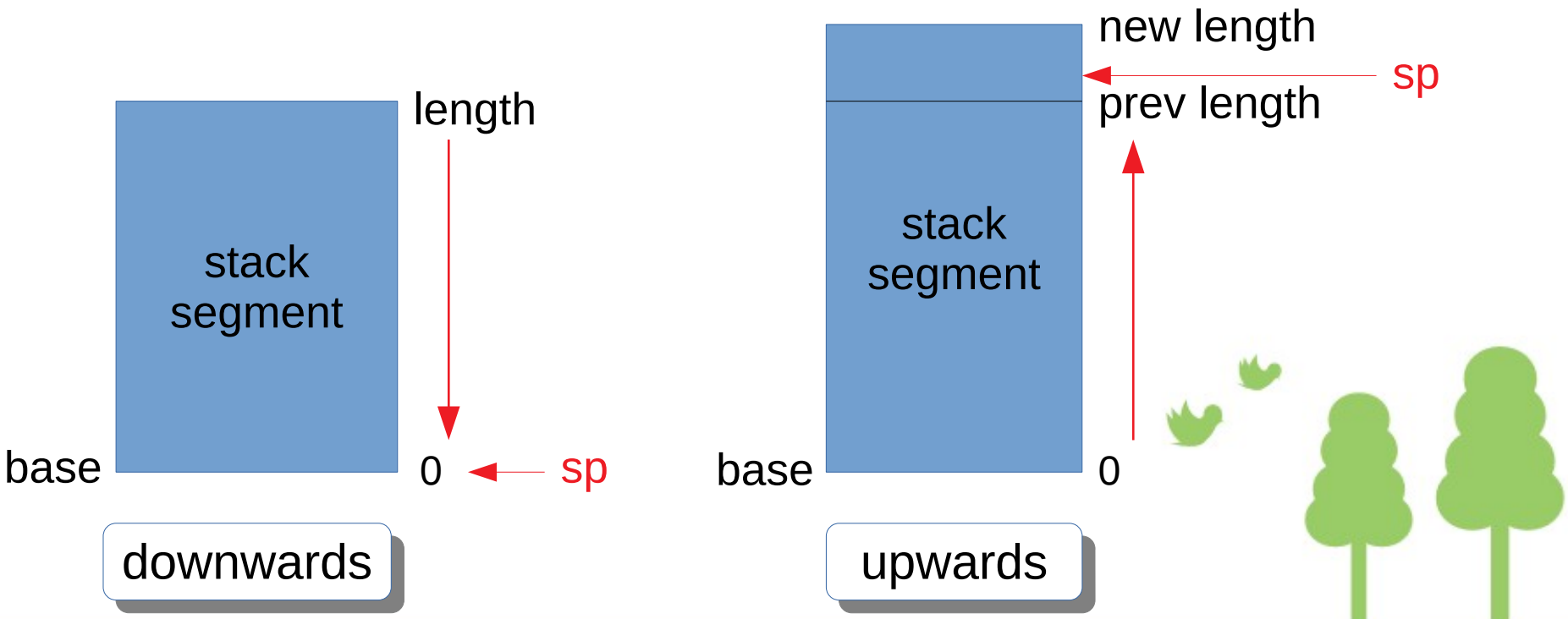


Benefits of Segmentation (4)

- Software-managed TLB
  - Prerequisite
    - Segment/page TLB miss can not happen during TLB miss handling.
  - How
    - Make kernel's code, data and stack segment as physical memory segment.
    - Make kernel's code, data and stack segment descriptors always resident in segment TLB.

Misc.

- Stack growth direction
  - Stack should grow upwards.



Misc. (2)

- Compiler support is needed.
  - Far pointer
  - Shared library
- OS change is needed.
  - MASOS → SASOS

Thanks.

Misc.

- Segment offset space sharing for data and stack segment