MIPS R4000
Memory Management
Virtual Address Space

Hard-wired segments (top 3 bits)

- KSEG0, KSEG1 – identity mapping
- KUSEG, KSEG2, KSEG3 – TLB

### Diagram

- **Virtual address space**
  - 4 GiB
    - KSEG3
  - 3 GiB
    - KSEG2 / KSSEG
    - KSEG1 (uncached)
  - 2 GiB
    - KSEG0 (cached)
  - 0 GiB
    - KUSEG

- **Physical address space**
  - 3.5 GiB
  - 512 MiB
Translation Lookaside Buffer (TLB)

- 48 records (software-managed), each entry contains:
  - Page size mask (from 4 KiB up to 16 MiB)
  - Two virtual pages (stored as VPN2)
  - Two frame addresses (FPN)
  - ASID
  - Extra bits: global, dirty, valid

- Translation
  - Match entry based on ASID (EntryHi) and virtual address
  - On miss
    - TLB exception (usually “refill”)
    - Entry added (OS searches its data structures, e.g. hierarchical page tables)
    - Instruction restarted
MIPS R4000 TLB

virtual address

page number (VPN)

offset

BadVAddr

ASID

VPN2 (VPN >> 1)

G

ASID

frame number (PFN even)

V

D

frame number (PFN odd)

V

D

EntryHi

EntryLo0

EntryLo1

page size (mask)

frame number (PFN)

offset

physical address