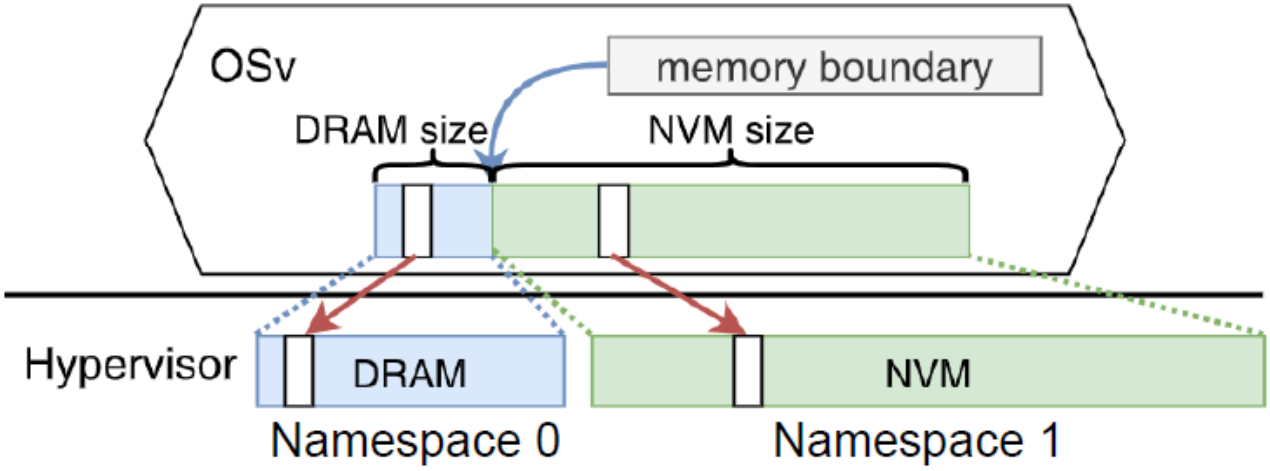
UCat: Heterogeneous Memory Management for Unikernels

Chong TIAN, Haikun LIU, Xiaofei LIAO, Hai JIN

Frontiers of Computer Science, DOI: 10.1007/s11704-022-1201-y

Problems & Ideas

- Problems of heterogeneous memory management for unikernels:
  - Unikernels (i.e., VMs) do not support NUMA and namespaces, making the visibility of heterogeneous memories to unikernels difficult.
  - Unikernels usually suffer from high performance penalty due to two-layer address translations in the virtualization environment.
- Ideas: We map two memory regions in a unikernel to host-managed DRAM and NVM namespaces, respectively, and exploit large pages and slab allocation to reduce the cost of address translations in virtualization environments.



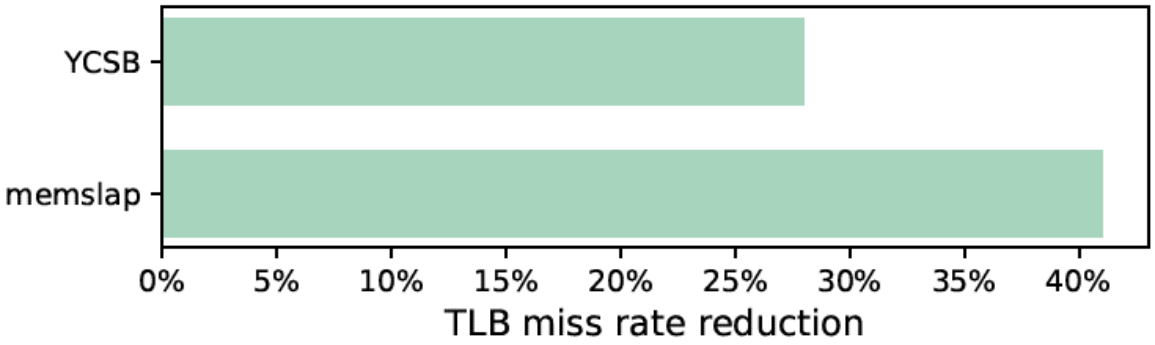
The front-end/back-end cooperative address space mapping

Main Contributions

- Contributions:
  - We manage heterogeneous memories in unikernels by mapping different memory regions in unikernels to different host-managed namespaces;
  - We design a multi-grained memory allocation mechanism in unikernels by taking the advantage of both large pages and slab memory allocation.
  - Ucat is the first work to support heterogeneous memory management for unikernels. It can reduce unikernels' memory consumption by 50% and TLB miss rate by 41%.

Mechanism	Memory Consumed	Memory Wasted
OSv	19.7 GB	13.5 GB
UCat	9.8 GB	3.6 GB

Memory consumed and wasted compared with the ideal condition.



The TLB miss rate reduced by UCat, all relative to OSv