Enhance memory utilization with DMEMFS

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Agenda

- Background
- Design
- Future works

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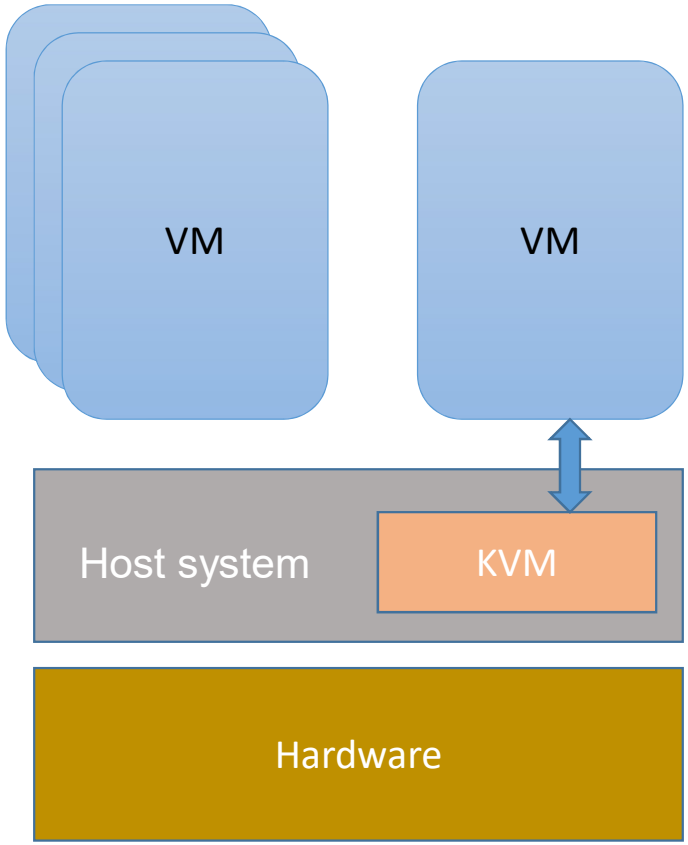
Background

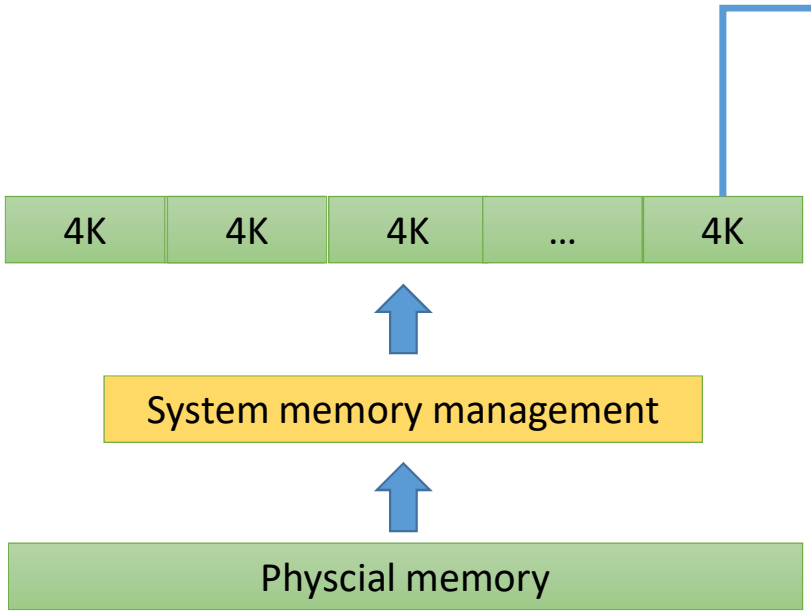


Host system memory overhead

HOST memory	Available memory
384G	375G
512G	501G
768G	753G

Background

In current system each physical memory page is associated with a page structure which is used to track the usage of this page.




```
struct page {
        unsigned long flags;
        atomic_t _count;
        atomic_t _mapcount;
        struct address_space *mapping;
        pgoff_t index;
        struct list_head lru;
};
```

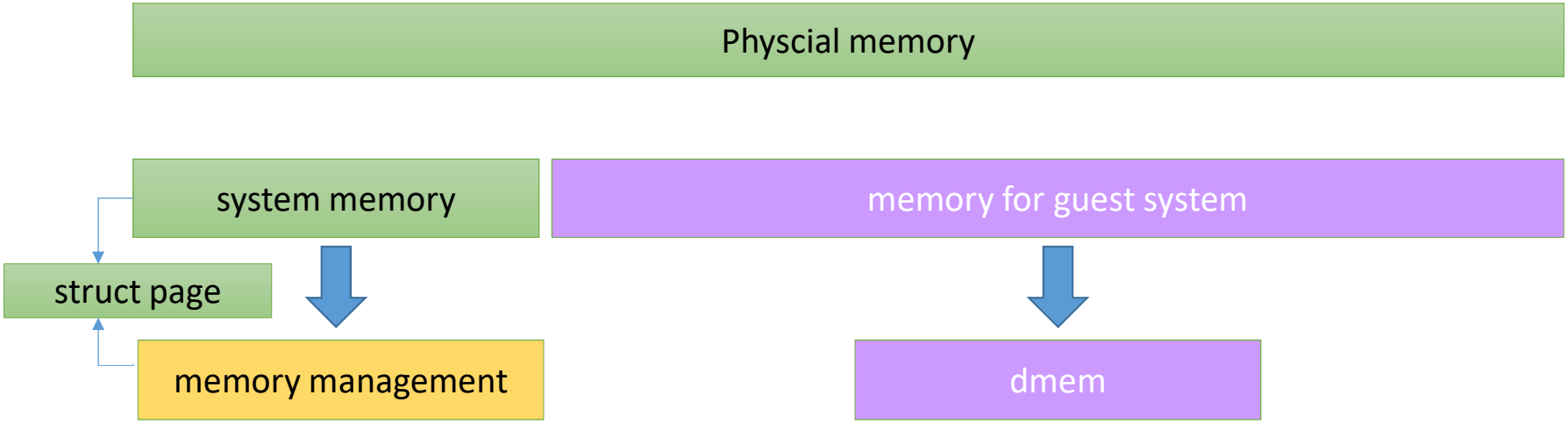
Existing approach

- kernel parameter “mem=“ to reserve memory for host system
- mmap the remaining system memory with /dev/mem to user space for usage which doesn’t have struct-page backed

Limitation for existing approach

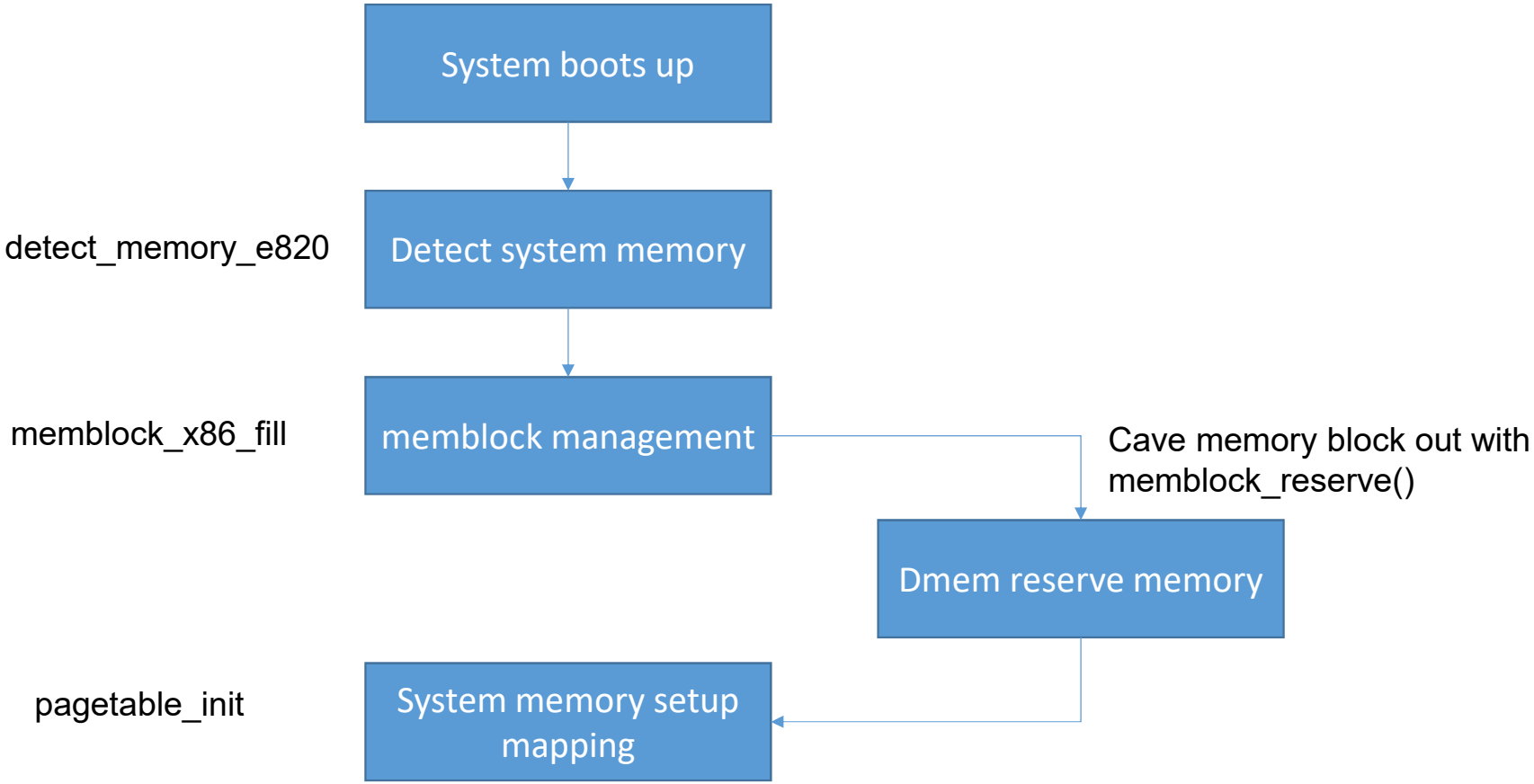
1. Access to /dev/men is restricted due to the security requirement, but usually applications are unprivileged processes.
2. what we get from /dev/mem is a whole block of memory, as dynamic applications running on /dev/mem will cause memory fragment, it needs additional logic to manage the allocation and recovery to avoid wasted memory.
3. Can’t support hugepage with different page size granularity.
4. MCE recovery is missing.

Our proposal – Dmem(direct memory management)



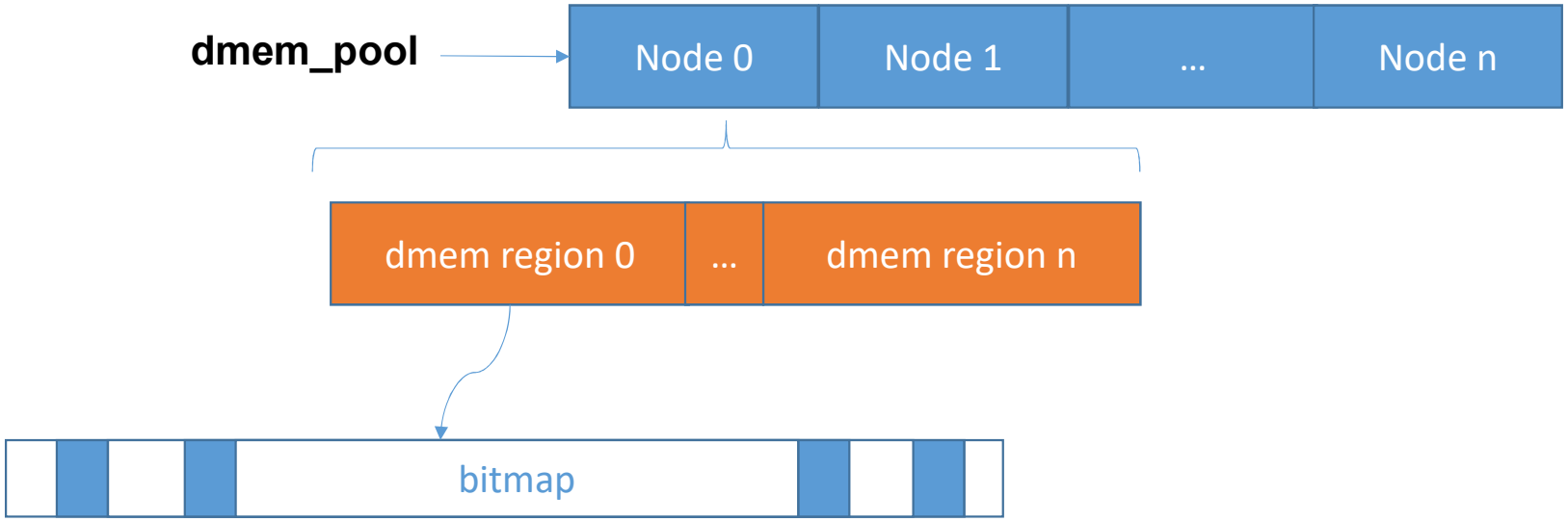
Framework Overview – Memory Reservation

Reserve the memory from host kernel when system boots up with kernel parameter dmem=size

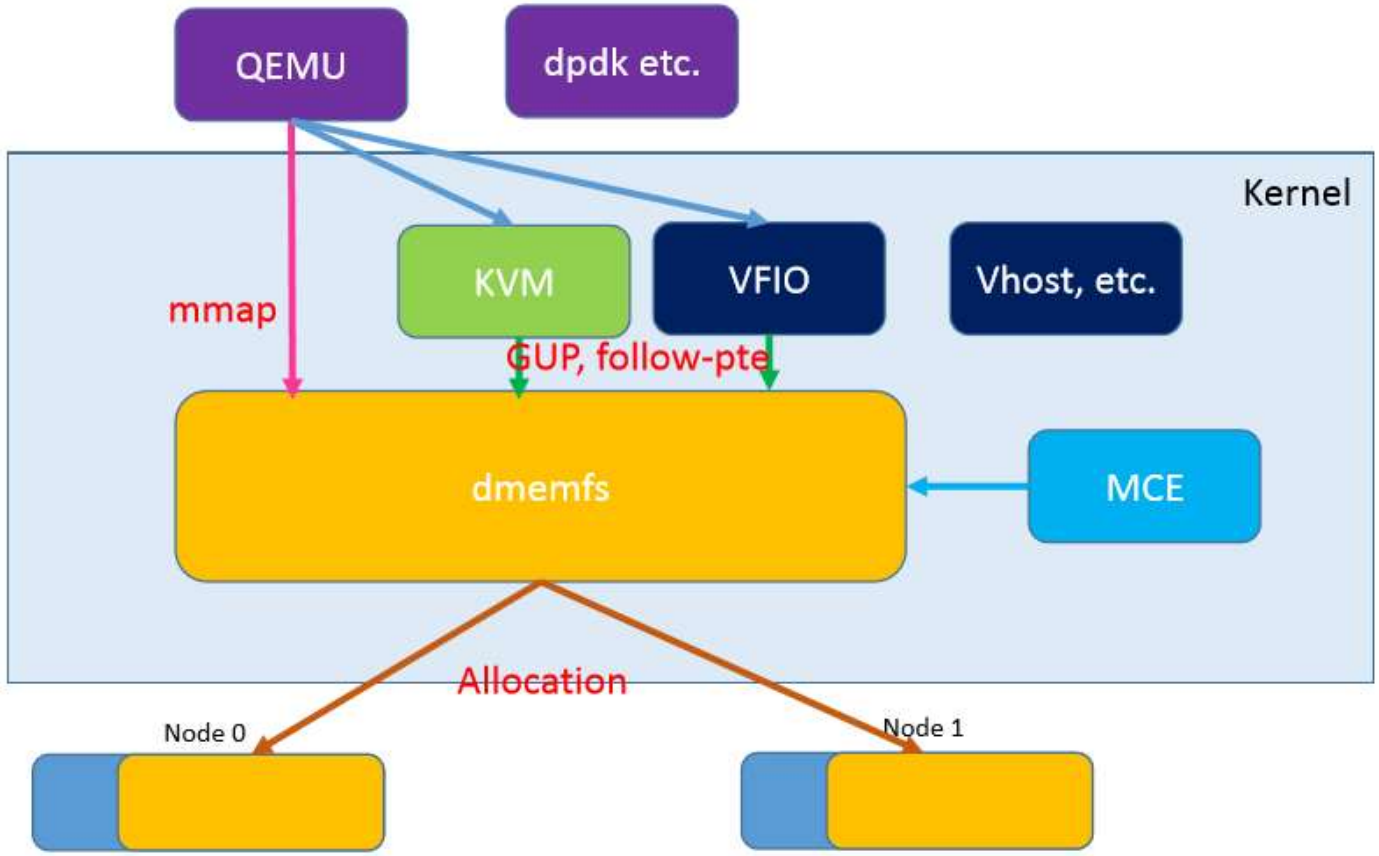


Framework Overview – Direct Memory Management

Manage the allocation and recovery in dmem_pool -> node-n -> region-n



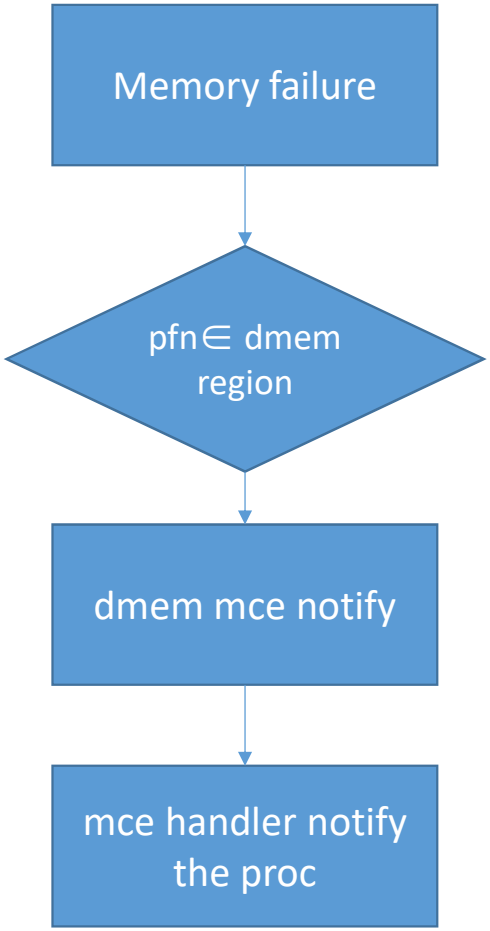
Framework Overview -- Direct Memory Management file system



Dmemfs Introduce

- Support mmap, mkdir and create regular files
- Hugepage support
  - 2M, 1G
- Numa allocation
  - MPOL_PREFERRED
  - MPOL_BIND
- Debugfs
- MCE

MCE support


Memory failure
pfn∈ dmem region
dmem mce notify
mce handler notify the proc

Usage

Dmemfs supports mapping ``4K``, ``2M`` and ``1G`` size of pages to the userspace, for example :

```
# mount -t dmemfs none -o pagesize=4K /mnt/
```

Then it can create the backing storage with 4G size :

```
# truncate /mnt/dmemfs-uuid --size 4G
```

To use as backing storage for virtual machine starts with qemu, just need to specify the memory-backed-file in the qemu command line like this :

```
# -object memory-backend-file,id=ram-node0,mem-path=/mnt/dmemfs-uuid \
    share=yes,size=4G,host-nodes=0,policy=preferred -numa node,nodeid=0,memdev=ram-node0
```

Benefit with dmem

sizeof(struct page) = 64 byte

for dmem manage 400g reserved memory :

Totally save 64 *100 * 2^20 ~= 6.25G physical memory

Link to the patchset

https://lkml.org/lkml/2020/10/8/139

Future works

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Future works

- Dmemfs region dynamic adjustment
- COW(copy on write) support
- Upstream the feature

Q&A

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