

Part 3:

Basic terminology:

Kernel virtual memory: The Linux kernel maps its virtual space on a one to one basis with the physical memory. From the architecture specific areas we get that the current architecture have the following blocks:

ffff880000000000 - ffffc7ffffffff (=64 TB) direct mapping of all phys. memory
fffc900000000000 - ffffe8ffffffff (=45 bits) vmalloc/ioremap space
ffffea0000000000 - ffffea0000000000 (=40 bits) virtual memory map (1TB)
ffffec0000000000 - ffffc00000000000 (=44 bits) kasan shadow memory (16TB)
fffff00000000000 - fffff7ffffffff (=39 bits) %esp fixup stacks
ffffff8000000000 - ffffffffa0000000 (=512 MB) kernel text mapping, from phys 0
fffffffa00000000 - ffffffff5fffff (=1525 MB) module mapping space
ffffffff600000 - ffffffffdfffff (=8 MB) vsyscalls

Now for each of these regions, there can be 3 types of page mappings present in the kernel virtual memory:

- (a) Having a mapping and a physical page backing it.
- (b) Having only a mapping.
- (c) Having no mapping.

The virtual memory sizes are quite large in the 8 areas, especially on a few. Hence, when we search each page in an area, we search until we find a page which is not mapped in that area and terminate our search there only, keeping the assumption in mind that the kernel virtual memory is continuous in nature.

Pseudo code:

For each of the above mentioned 8 kernel areas:

Search each of the pages inside it.

Decipher the logical address in 4 different levels.

Find whether the page is present or only mapped or not mapped at all.

Keep a track of the count of these types.

Break the search for that area whenever we come across a page which is not mapped at all.

Results and Experiment:

The physical address for the kernel virtual areas should also be contiguous. As an experiment, we try to print the physical address of one kernel area to see whether the physical addresses are also contiguous or not.

The physical address for the kernel virtual area ffff880000000000 - ffffc7ffffffffffff (=64 TB) direct mapping of all phys. Memory has been given below:

```
[ 251.281174] Form software walk: Structure Virtual address : ffff88007ff61000 and Physical address : 7ff61000
[ 251.281175] Form software walk: Structure Virtual address : ffff88007ff62000 and Physical address : 7ff62000
[ 251.281176] Form software walk: Structure Virtual address : ffff88007ff63000 and Physical address : 7ff63000
[ 251.281177] Form software walk: Structure Virtual address : ffff88007ff64000 and Physical address : 7ff64000
[ 251.281179] Form software walk: Structure Virtual address : ffff88007ff65000 and Physical address : 7ff65000
[ 251.281180] Form software walk: Structure Virtual address : ffff88007ff66000 and Physical address : 7ff66000
[ 251.281181] Form software walk: Structure Virtual address : ffff88007ff67000 and Physical address : 7ff67000
[ 251.281182] Form software walk: Structure Virtual address : ffff88007ff68000 and Physical address : 7ff68000
[ 251.281183] Form software walk: Structure Virtual address : ffff88007ff69000 and Physical address : 7ff69000
[ 251.281184] Form software walk: Structure Virtual address : ffff88007ff6a000 and Physical address : 7ff6a000
[ 251.281186] Form software walk: Structure Virtual address : ffff88007ff6b000 and Physical address : 7ff6b000
[ 251.281187] Form software walk: Structure Virtual address : ffff88007ff6c000 and Physical address : 7ff6c000
[ 251.281188] Form software walk: Structure Virtual address : ffff88007ff6d000 and Physical address : 7ff6d000
[ 251.281189] Form software walk: Structure Virtual address : ffff88007ff6e000 and Physical address : 7ff6e000
[ 251.281190] Form software walk: Structure Virtual address : ffff88007ff6f000 and Physical address : 7ff6f000
[ 251.281192] Form software walk: Structure Virtual address : ffff88007ff70000 and Physical address : 7ff70000
[ 251.281193] Form software walk: Structure Virtual address : ffff88007ff71000 and Physical address : 7ff71000
[ 251.281194] Form software walk: Structure Virtual address : ffff88007ff72000 and Physical address : 7ff72000
[ 251.281195] Form software walk: Structure Virtual address : ffff88007ff73000 and Physical address : 7ff73000
[ 251.281196] Form software walk: Structure Virtual address : ffff88007ff74000 and Physical address : 7ff74000
[ 251.281197] Form software walk: Structure Virtual address : ffff88007ff75000 and Physical address : 7ff75000
[ 251.281199] Form software walk: Structure Virtual address : ffff88007ff76000 and Physical address : 7ff76000
[ 251.281200] Form software walk: Structure Virtual address : ffff88007ff77000 and Physical address : 7ff77000
[ 251.281201] Form software walk: Structure Virtual address : ffff88007ff78000 and Physical address : 7ff78000
[ 251.281202] Form software walk: Structure Virtual address : ffff88007ff79000 and Physical address : 7ff79000
[ 251.281203] Form software walk: Structure Virtual address : ffff88007ff7a000 and Physical address : 7ff7a000
```

We can find that the physical addresses are also contiguous in nature.

Now we calculate the statistic mentioned above for all the kernel virtual areas.

```
[ 251.286644] =====
[ 251.287071] Mapping for virtual address: ffff880000000000 - ffffc7ffffffffffff
[ 251.287119] Mapped and present pages: 112037
[ 251.287162] Mapped but not present pages: 412251
[ 251.287202] Not mapped pages: 17179344895
[ 251.287238] Total pages in the virtual area: 17179869183
[ 251.287270] =====
[ 251.287373] =====
[ 251.287399] Mapping for virtual address: ffffc90000000000 - ffffe8ffffffffffff
[ 251.287422] Mapped and present pages: 1184
[ 251.287443] Mapped but not present pages: 4448
[ 251.287463] Not mapped pages: 8589928959
[ 251.287481] Total pages in the virtual area: 8589934591
[ 251.287497] =====
[ 251.287589] =====
[ 251.287603] Mapping for virtual address: ffffea0000000000 - ffffeaffffffffffffff
[ 251.287616] Mapped and present pages: 2541
[ 251.287627] Mapped but not present pages: 5651
[ 251.287637] Not mapped pages: 268427263
[ 251.287658] Total pages in the virtual area: 268435455
[ 251.287659] =====
[ 251.287660] =====
[ 251.287662] Mapping for virtual address: ffffec0000000000 - fffffc0000000000
[ 251.287662] Mapped and present pages: 0
[ 251.287663] Mapped but not present pages: 0
[ 251.287664] Not mapped pages: 4294967296
[ 251.287665] Total pages in the virtual area: 4294967296
[ 251.287666] =====
[ 251.287667] =====
```