Memory Management in Modern Systems

Advanced Operating Systems Final Project

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Spring 1402

Overview

Inconsistent results? here's why!

- **Fixed kernel** version and **page size** on **fixed machines.**
- 5 applications on 5 configurations?
  - 5 * 5 = **only 25 Runs!**
  - **Too sprawled out**! Results are **unreliable**, **Hard** to analyze

➔ Our solution is a **more focused**, **more reliable** approach

➔ Select fewer applications but **cover every possible configuration!**

➔ **3**(Three **machines**)**x3**(Three **kernel versions**)**x3**(3 **page sizes**) = **27 different configs!**

Overview

- **More** than **60 tests** so far!
- **More** than **150 hrs** of runtime
- About **4 gigabytes** worth of **resulting traces** in text files

Setup

2MB HugeTLBs Configuration

/etc/sysctl.conf :

```
# Uncomment the next line to enable packet forwarding for IPv6
#  Enabling this option disables Stateless Address Autoconfiguration
#  based on Router Advertisements for this host
#net.ipv6.conf.all.forwarding=1
#vm.nr_hugepages = 400
# 400 * 2048 kb = 800 mb
#vm.hugetlb_shm_group = 1001
```

sudo sysctl -p

Setup

1GB HugeTLBs Configuration

/etc/default/grub :

```
GRUB_DEFAULT="linux-image-unsigned-4.19.283-0419283-generic"
GRUB_TIMEOUT_STYLE=hidden
GRUB_TIMEOUT=0
GRUB_DISTRIBUTOR=`lsb_release -i -s 2> /dev/null || echo Debian`
GRUB_CMDLINE_LINUX_DEFAULT="maybe-ubiquity default_hugepagesz=1G hugepagesz=1G hugepages=2"
GRUB_CMDLINE_LINUX=""
```

sudo update-grub

- **We have to reboot (allocation at boot time)**

Setup

Double Check :)

- cat /proc/meminfo | grep Huge

```
(base) user01@user01:~$ cat /proc/meminfo | grep Huge
AnonHugePages:         0 kB
ShmemHugePages:        0 kB
HugePages_Total:       4
HugePages_Free:        4
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:    1048576 kB
Hugetlb:         4194304 kB
```

```
(base) user01@user01:~$ cat /proc/meminfo | grep Huge
AnonHugePages:         0 kB
ShmemHugePages:        0 kB
FileHugePages:         0 kB
HugePages_Total:    1000
HugePages_Free:     1000
HugePages_Rsvd:        0
HugePages_Surp:        0
Hugepagesize:       2048 kB
Hugetlb:         2048000 kB
```

Sys calls

- **Doesn’t change** with **kernel version** or **page size.**
- **Changing the machine** however impacts the **numbers of syscalls**

	mmap	munmap	msync	madvise	mprotect	mincore
Low tier	56	73	0	4	37	0
Medium tier	85	75	0	4	67	0
High tier	164	189	0	4	145	0

keras Sys calls

- **Doesn’t change** with **kernel version** or **page size.**
- **Changing the machine** however impacts the **numbers of syscalls**

	mmap	munmap	msync	madvise	mprotect	mincore
BM	320	380	0	4	337	0

geek Sys calls

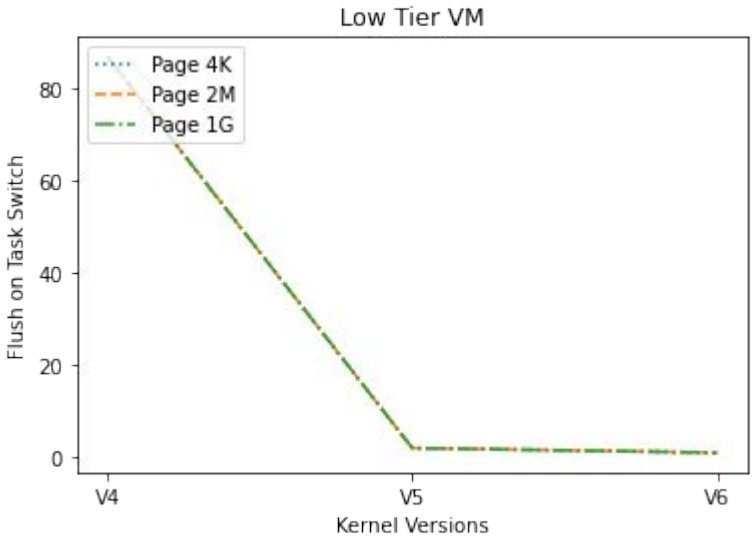
- **Doesn’t change** with **kernel version** or **page size.**
- **Changing the machine** however impacts the **numbers of syscalls**

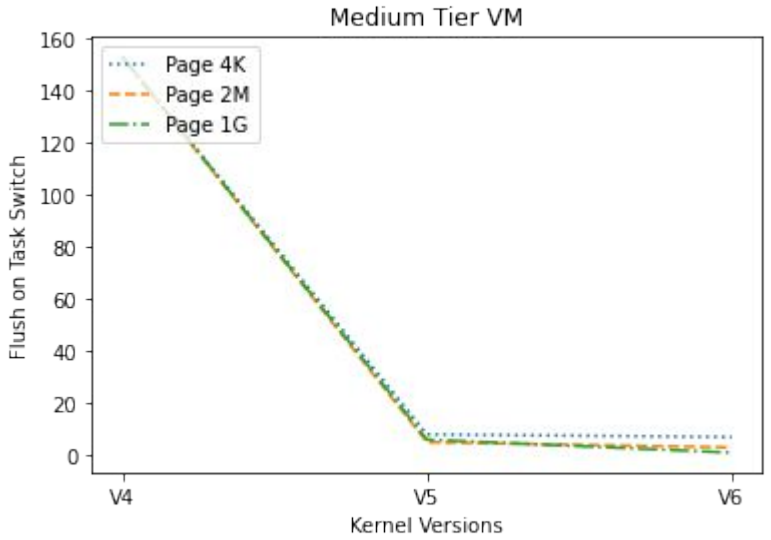
	mmap	munmap	msync	madvise	mprotect	mincore
BM	518	549	0	0	429	0

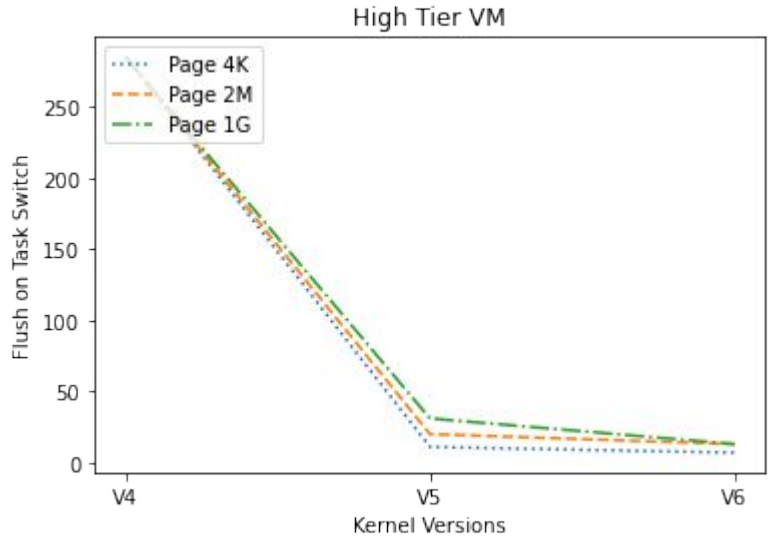
Plots and Analysis

TLB Shootdowns

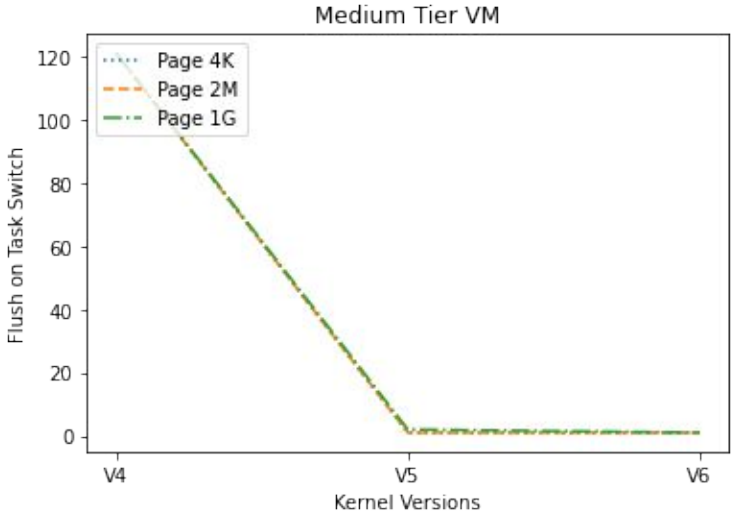
Geekbench

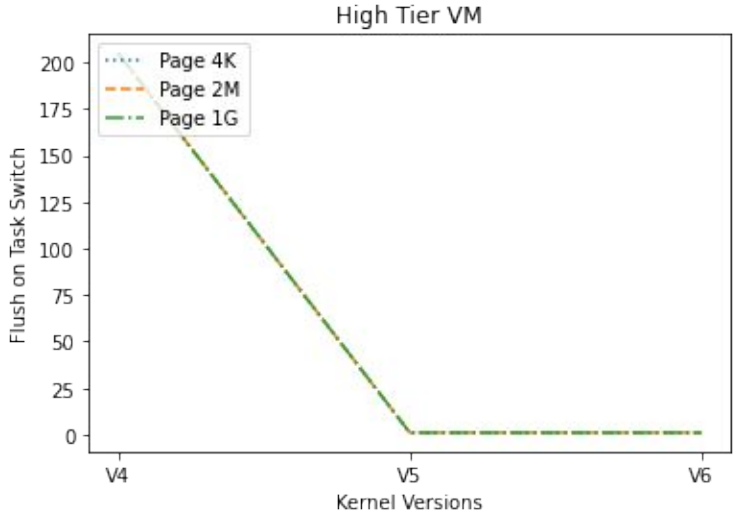


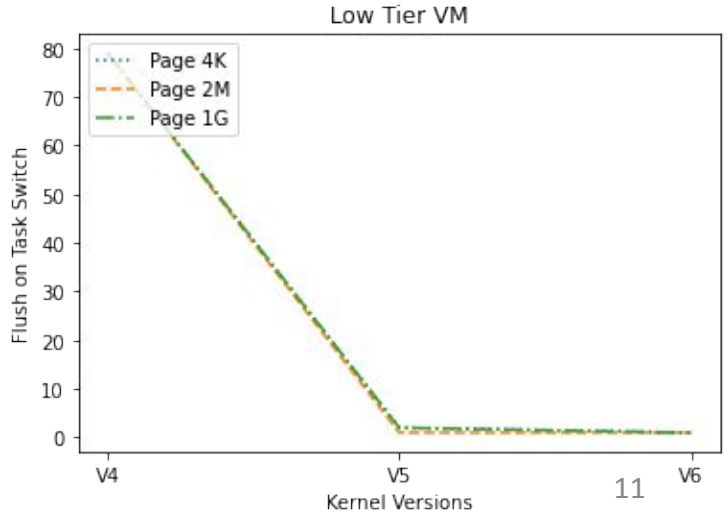




Keras







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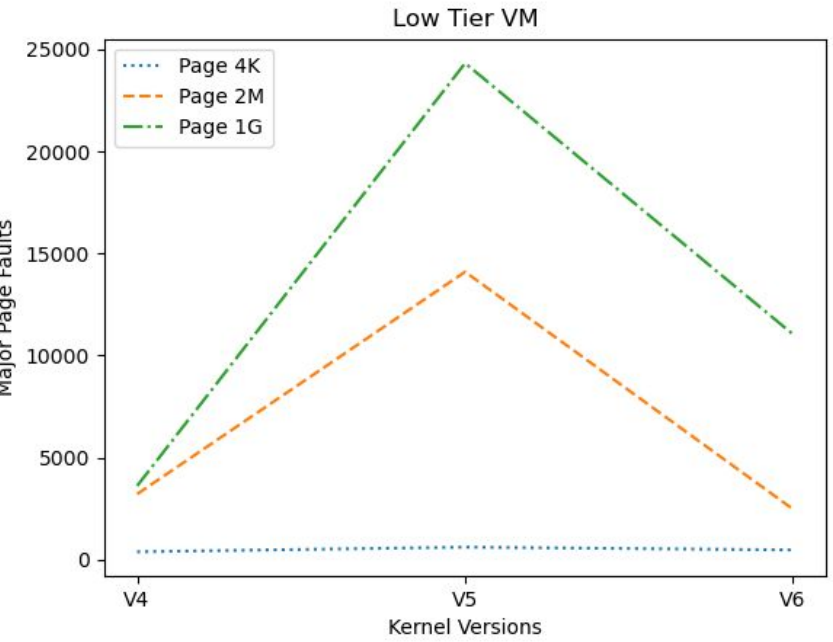
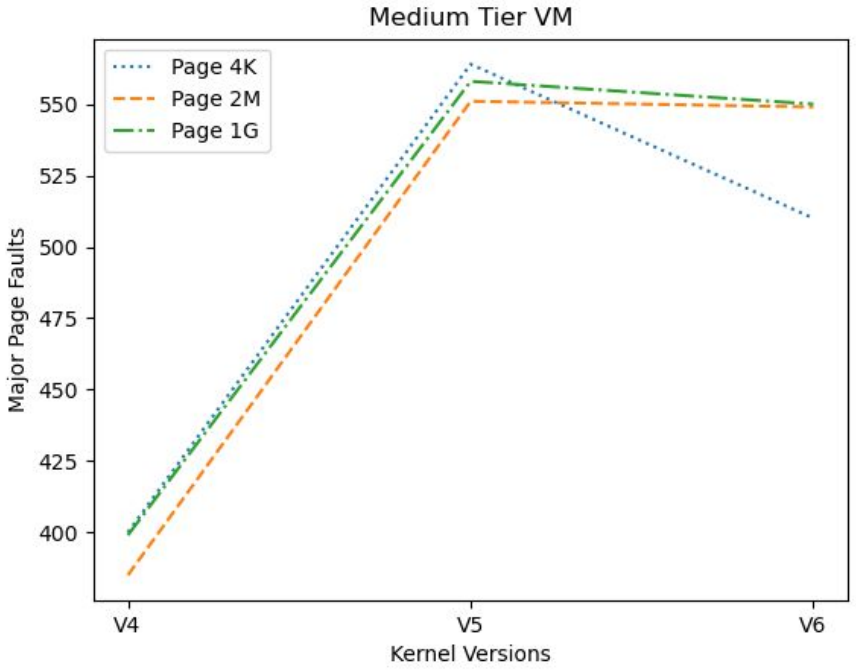
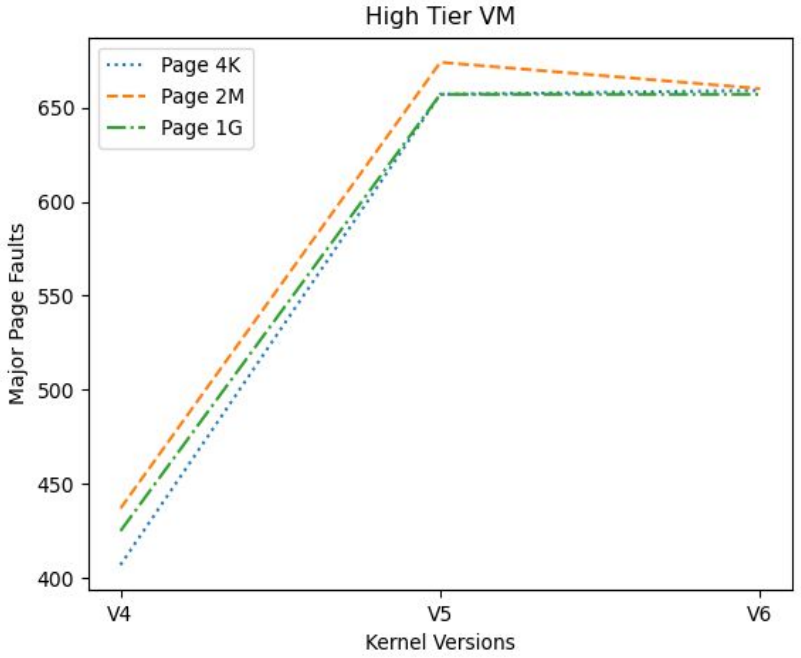
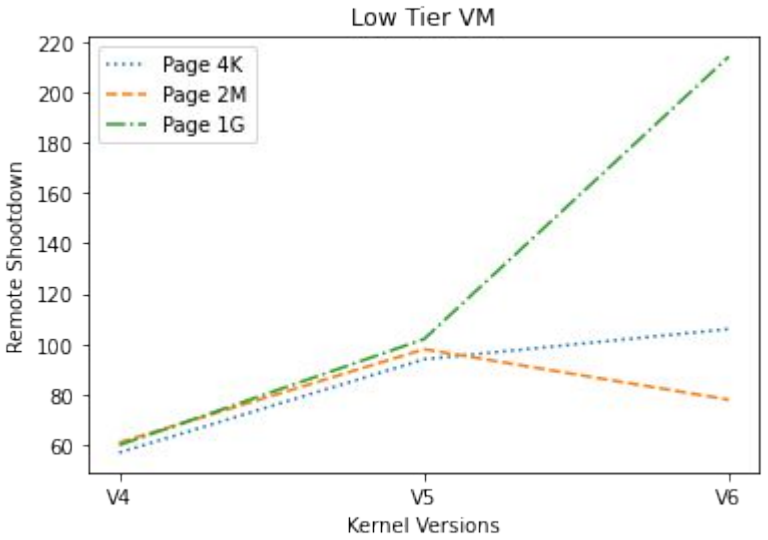

Low Tier VM
Page 4K
Page 2M
Page 1G
Major Page Faults
25000
20000
15000
10000
5000
0
V4
V5
V6
Kernel Versions

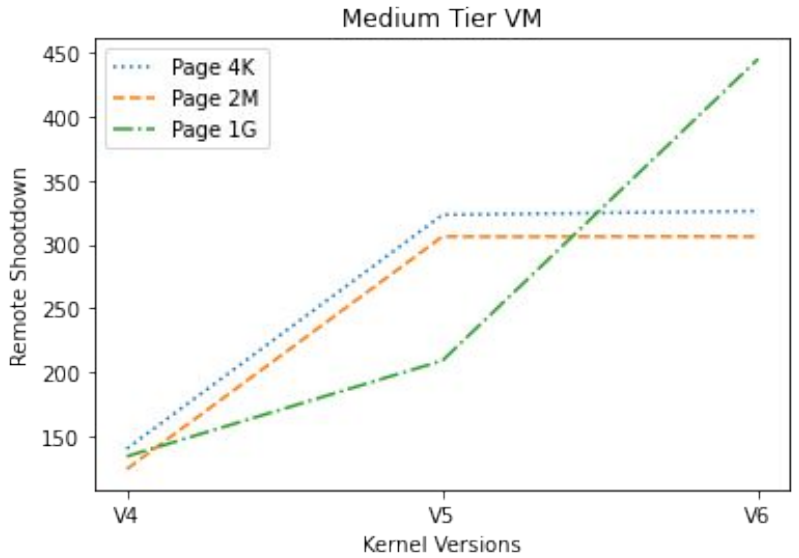

Medium Tier VM
Page 4K
Page 2M
Page 1G
Major Page Faults
550
525
500
475
450
425
400
V4
V5
V6
Kernel Versions

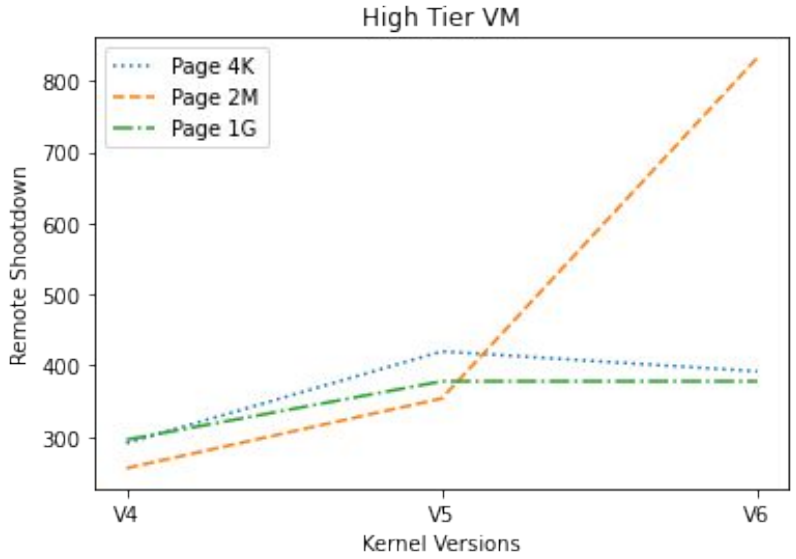

High Tier VM
Page 4K
Page 2M
Page 1G
Major Page Faults
650
600
550
500
450
400
V4
V5
V6
Kernel Versions

TLB Shootdowns

Geekbench







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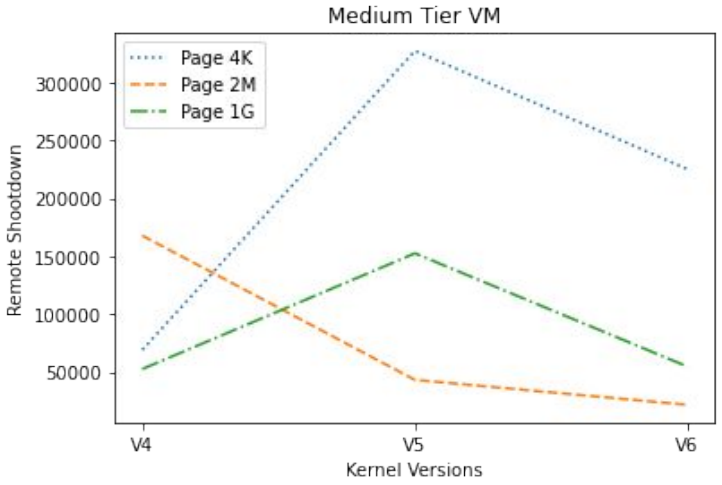

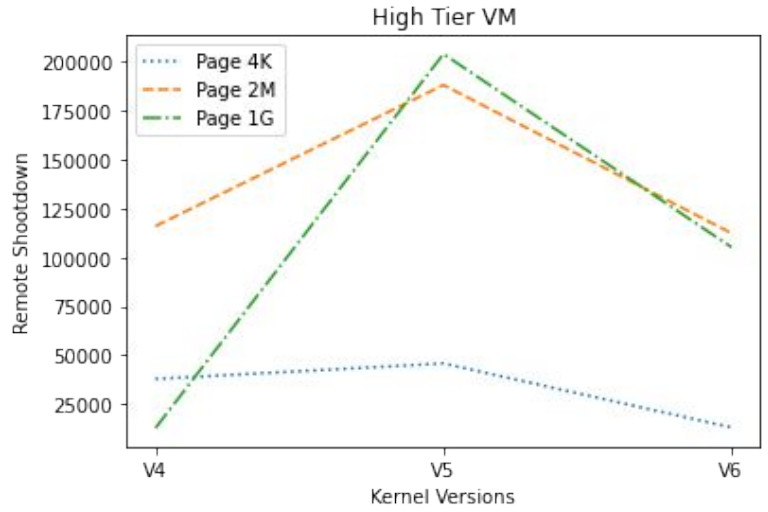

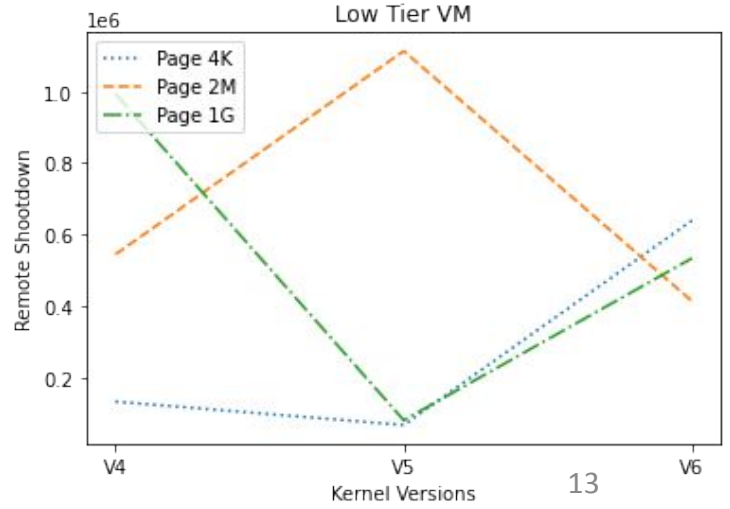

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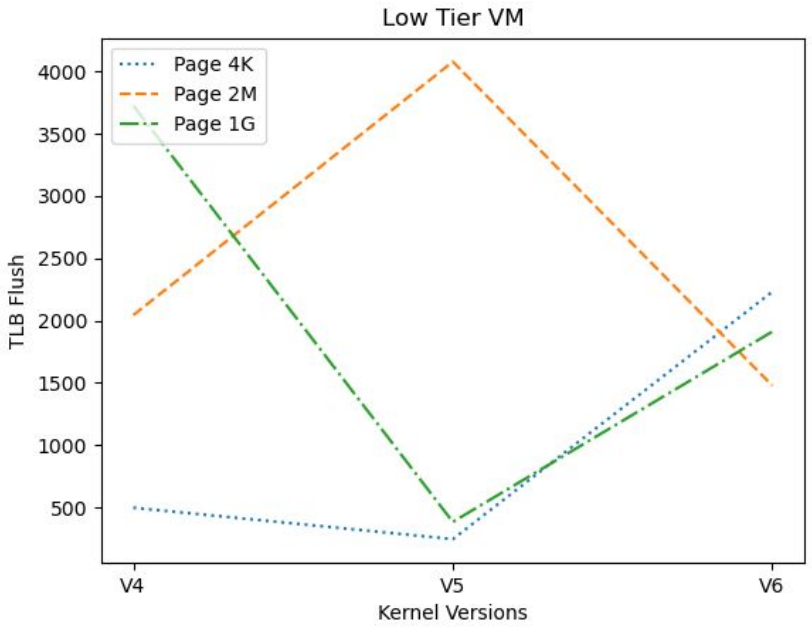
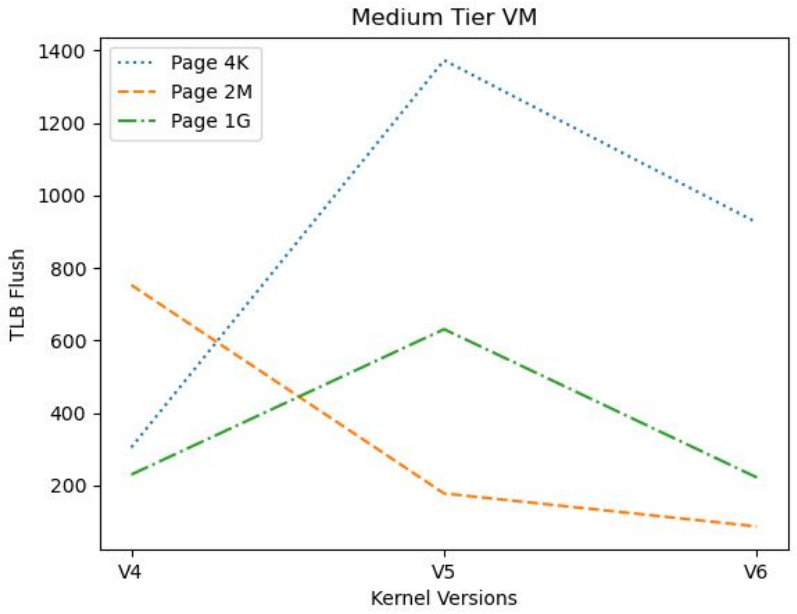
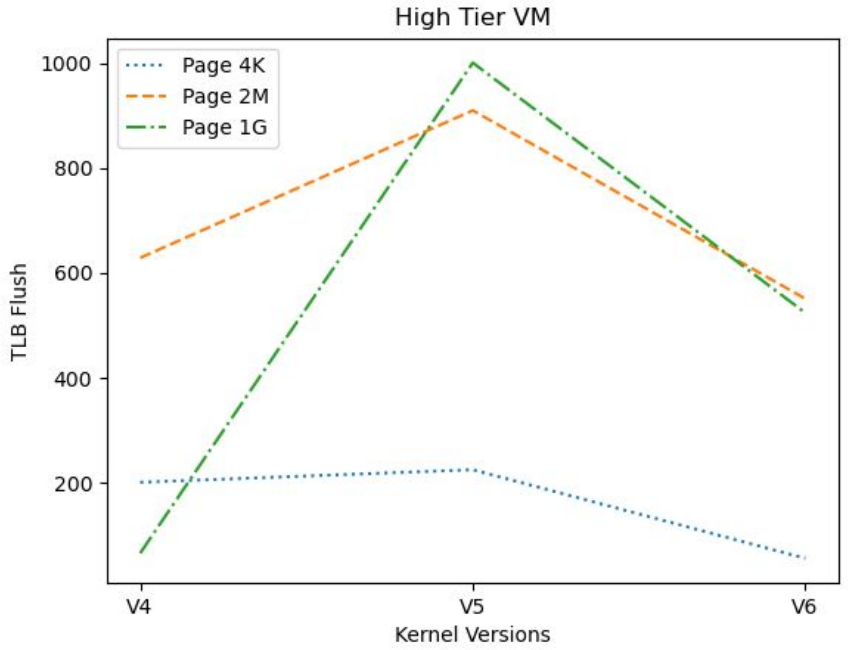
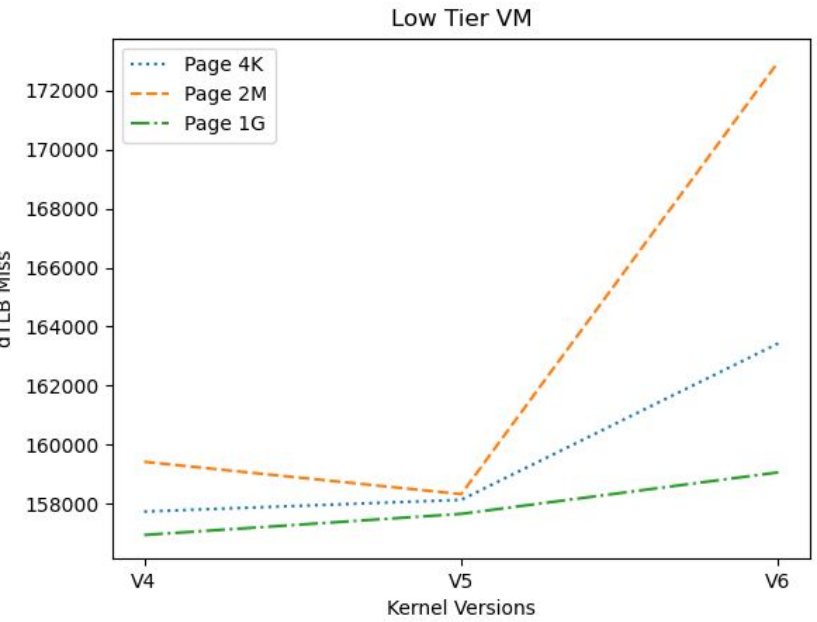
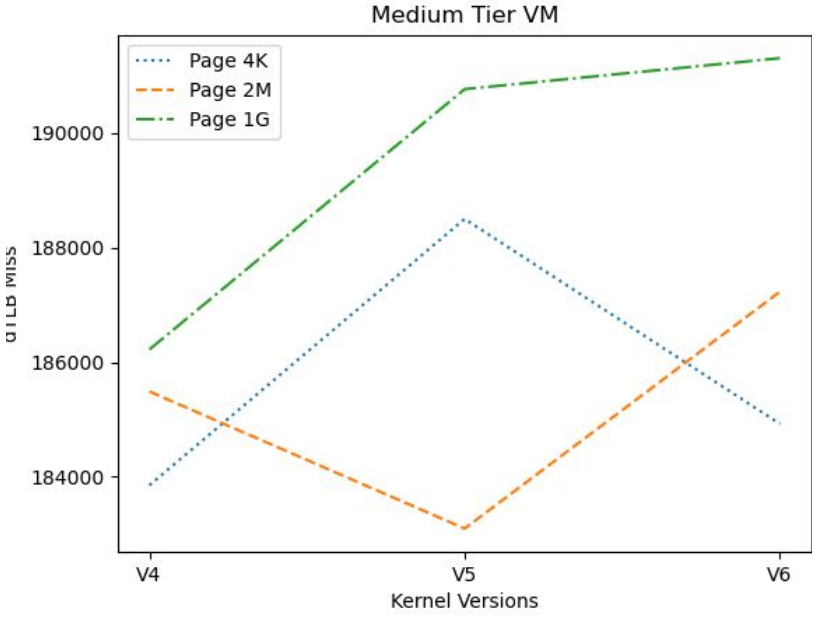

Low Tier VM
Page 4K
Page 2M
Page 1G
TLB Flush
4000
3500
3000
2500
2000
1500
1000
500
V4
V5
V6
Kernel Versions


Medium Tier VM
Page 4K
Page 2M
Page 1G
TLB Flush
1400
1200
1000
800
600
400
200
V4
V5
V6
Kernel Versions


High Tier VM
Page 4K
Page 2M
Page 1G
TLB Flush
1000
800
600
400
200
V4
V5
V6
Kernel Versions

Keras


Low Tier VM
Page 4K
Page 2M
Page 1G
172000
170000
168000
166000
164000
162000
160000
158000
V4
V5
V6
Kernel Versions


Medium Tier VM
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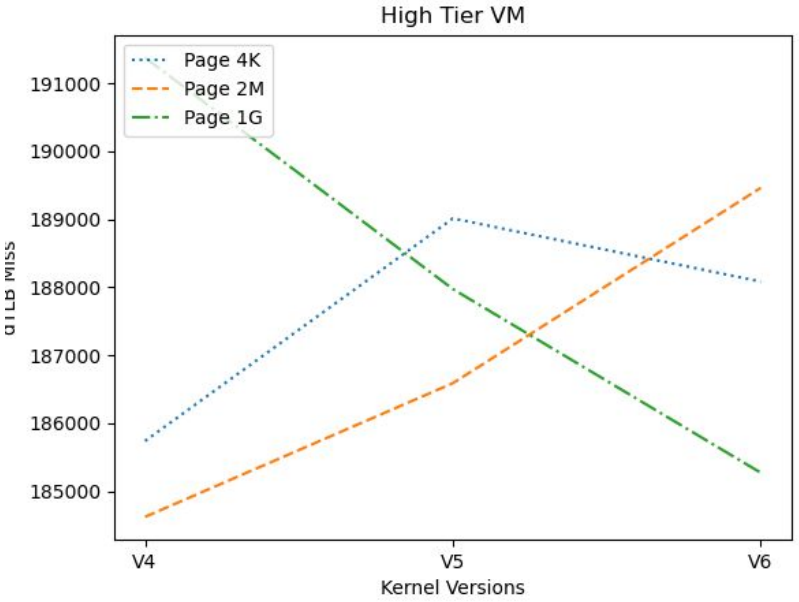
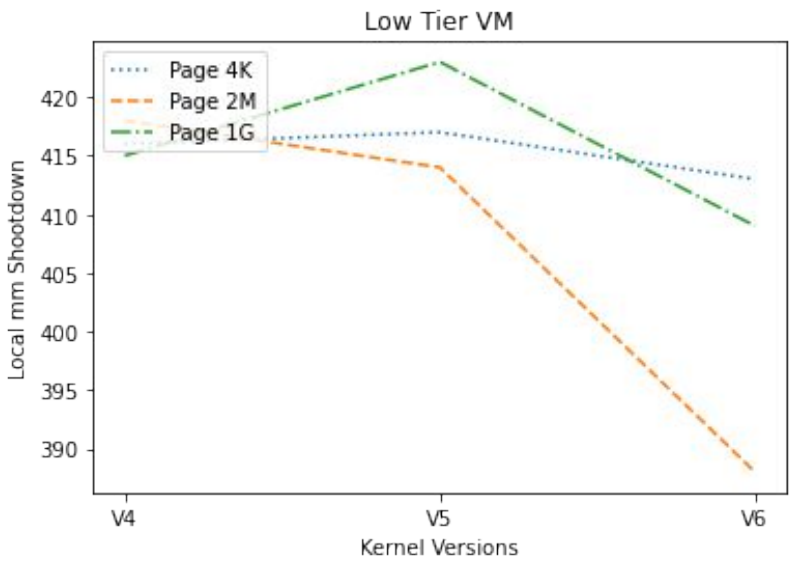
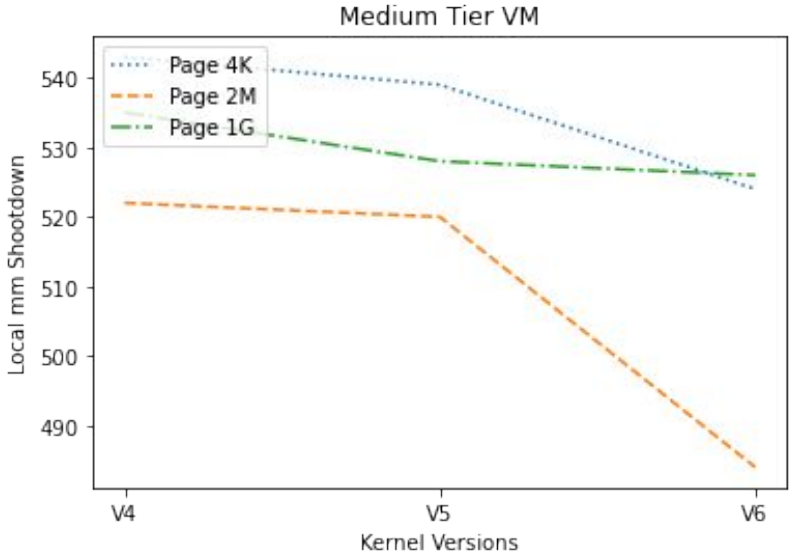
Page 2M
Page 1G
190000
188000
186000
184000
V4
V5
V6
Kernel Versions

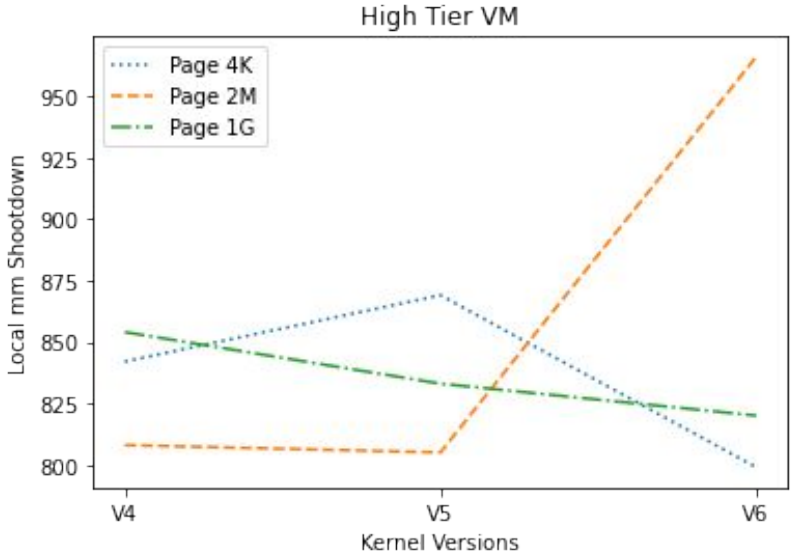

High Tier VM
Page 4K
Page 2M
Page 1G
191000
190000
189000
188000
187000
186000
185000
V4
V5
V6
Kernel Versions

TLB Shootdowns

Geekbench







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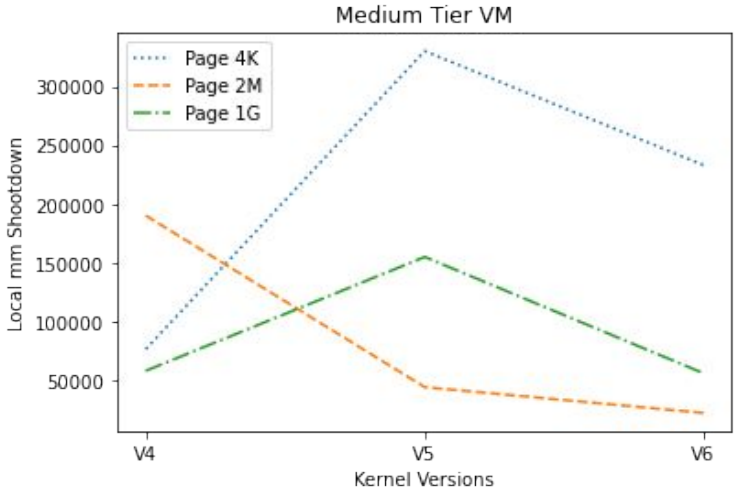
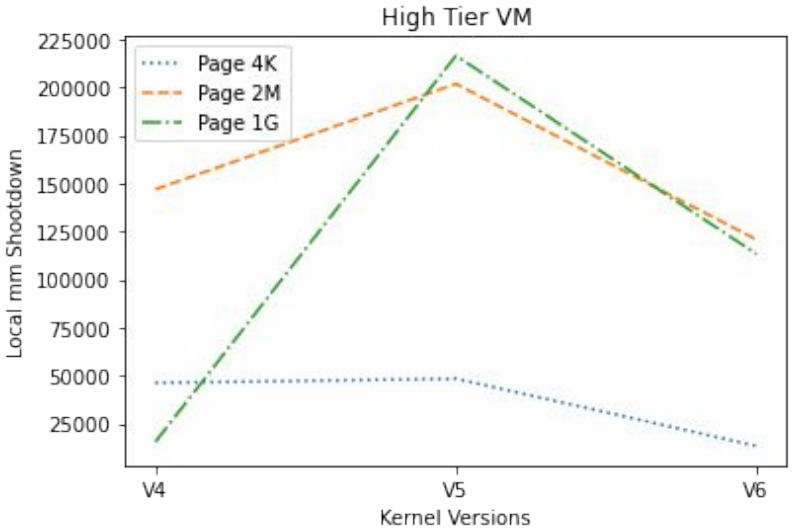
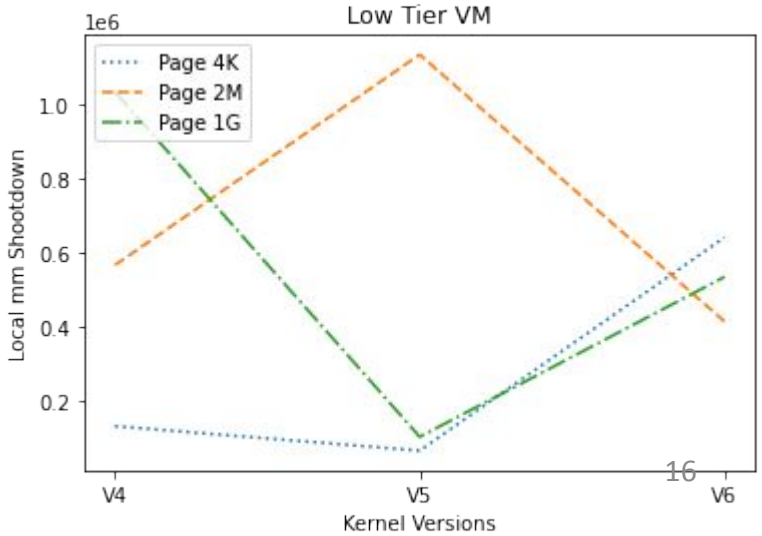
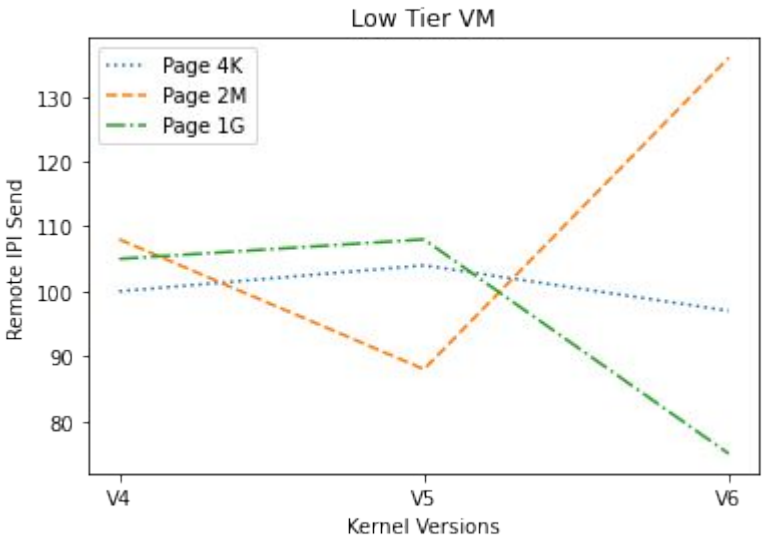


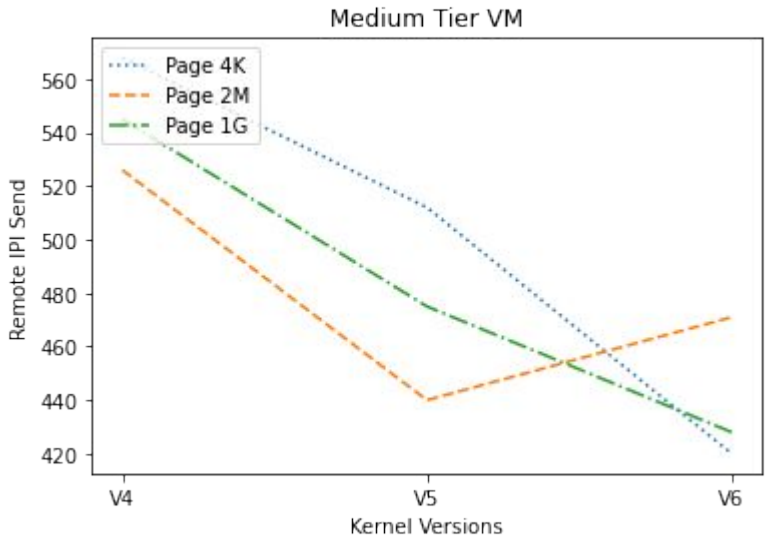


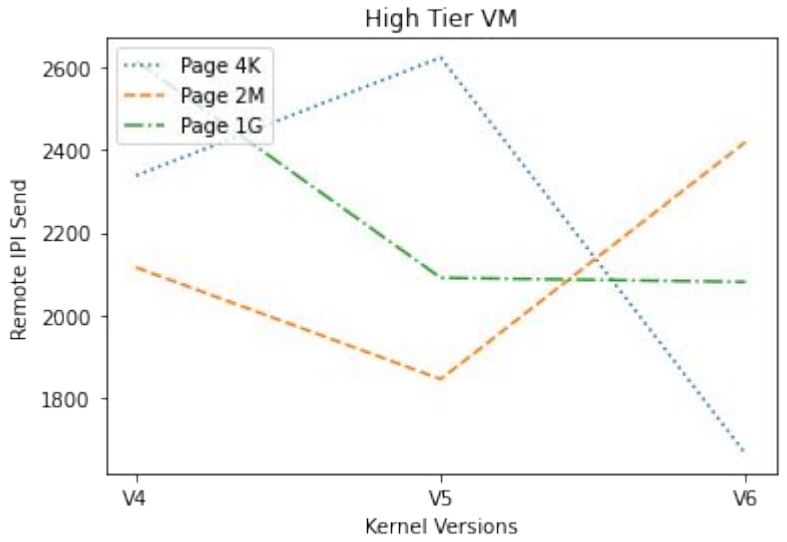


TLB Shootdowns

Geekbench







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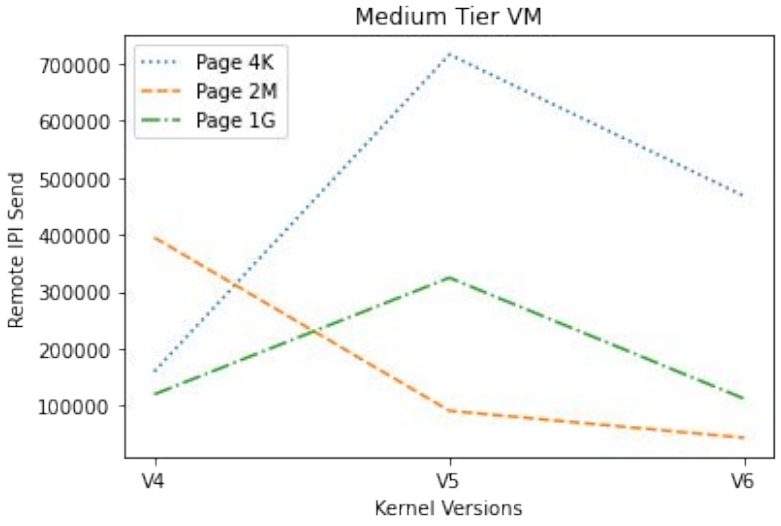

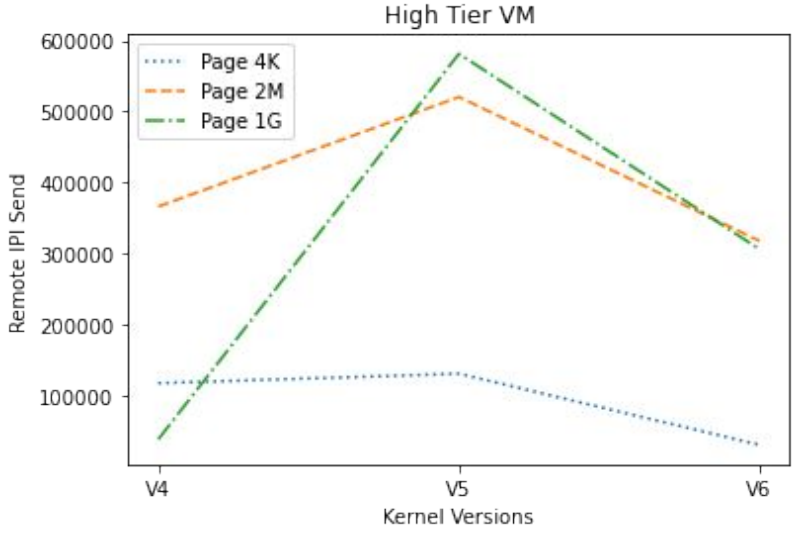

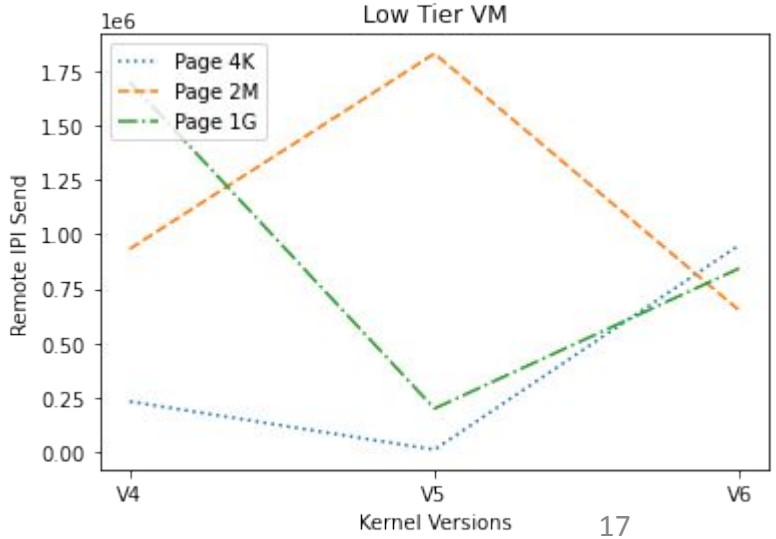

Thank You

Any Questions?