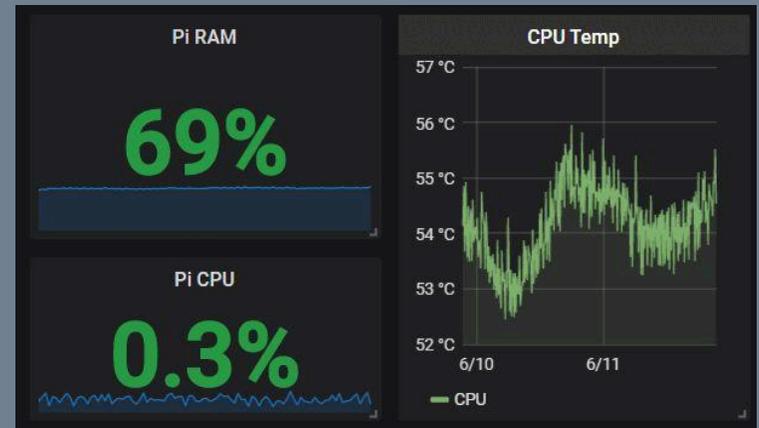


Resources & Monitoring



Overview

Raspberry Pis are small portable devices, that as you can imagine have resource limits.

- CPU
- Memory
- Storage
- Network
- Prometheus/Grafana

We are focusing mainly on what is relevant to the Raspberry Pis that we use in this club, and will not be going over examples in different operating systems (e.g. Windows/Mac), and we are not going over GPUs as a part of this talk.

Raspberry Pi 4

- Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.8GHz
- 1GB, 2GB, 4GB or 8GB LPDDR4-3200 SDRAM
- Micro-SD card slot
- 2.4 GHz and 5.0 GHz IEEE 802.11ac wireless, Bluetooth 5.0, BLE Gigabit Ethernet

But what does any of that mean?

[0] <https://www.raspberrypi.com/products/raspberry-pi-4-model-b/specifications/>

CPU

(C)entral (P)rocessing (U)nit -> carries out instructions

Components within a CPU:

- **Control Unit**: coordinates what happens and when, manages the CPU by sending signals (e.g. clock, hold, reset) to its parts to complete tasks
 - **Clock / clock speed**: timing signal that synchronizes all CPU operations and the resulting speed at which the CPU operates, measured in hertz (Hz) (specifically gigahertz (GHz) for modern processors)
- **Arithmetic and Logic Unit (ALU)**: performs arithmetic tasks and logical operations
- **Memory Unit**: small, fast memory inside the CPU (avoid waiting on slower system memory)
 - **Cache**: high-speed memory which stores frequently accessed instructions and data
 - **Registers**: very fast storage for data, instructions, and memory addresses used when instructions are running

Cores vs Threads:

- **Cores**: independent physical processing unit within a CPU, multiple cores = can handle multiple tasks simultaneously (juggle one or more threads)
- **Threads**: virtual sequence of instructions that cores can process (simultaneous multithreading (SMT), juggle multiple threads at once)

[0] <https://www.ibm.com/think/topics/central-processing-unit>

Further suggested topics: x86-x64 vs ARM. Raspberry Pi 4s have an ARM CPU.

CPU (Raspberry Pi 4)

- Broadcom BCM2711, Quad core Cortex-A72 (ARM v8) 64-bit SoC @ 1.8GHz
 - **Quad core** (no multithreading)
 - **1.8GHz** clock speed
 - Caches: 32 kB data + 48 kB instruction L1 cache per core. 1 MB L2 cache.

[0] <https://www.raspberrypi.com/products/raspberry-pi-4-model-b/specifications/>

[1] <https://www.raspberrypi.com/documentation/computers/processors.html>

CPU (command line)

top

h: show help

c: toggle showing full command

```
top - 15:06:13 up 6 min, 3 users, load average: 0.98, 0.61, 0.29
Tasks: 211 total, 2 running, 209 sleeping, 0 stopped, 0 zombie
%Cpu(s): 25.0 us, 0.0 sy, 0.0 ni, 74.0 id, 0.9 wa, 0.0 hi, 0.0 si, 0.0 st
MiB Mem : 7820.7 total, 6635.0 free, 573.1 used, 786.0 buff/cache
MiB Swap: 2048.0 total, 2048.0 free, 0.0 used, 7247.6 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
1869	labclub	20	0	16540	8388	5396	R	100.0	0.1	1:40.58	python3 -c while True: pass
997	labclub	20	0	556652	131436	101868	S	0.3	1.6	0:02.18	/usr/bin/labwc -m
1878	labclub	20	0	10276	5424	3252	R	0.3	0.1	0:00.07	top
1	root	20	0	25128	14348	10184	S	0.0	0.2	0:02.01	/sbin/init splash
2	root	20	0	0	0	0	S	0.0	0.0	0:00.01	[kthreadd]
3	root	20	0	0	0	0	S	0.0	0.0	0:00.00	[pool_workqueue_release]
4	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	[kworker/R-kvfree_rcu_reclaim]
5	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	[kworker/R-rcu_gp]
6	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	[kworker/R-sync_wq]
7	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	[kworker/R-slub_flushwq]
8	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	[kworker/R-netns]
9	root	20	0	0	0	0	I	0.0	0.0	0:00.04	[kworker/0:0-events]
13	root	0	-20	0	0	0	I	0.0	0.0	0:00.00	[kworker/R-mm_percpu_wq]
14	root	20	0	0	0	0	I	0.0	0.0	0:00.00	[rcu_tasks_kthread]
15	root	20	0	0	0	0	I	0.0	0.0	0:00.00	[rcu_tasks_rude_kthread]
16	root	20	0	0	0	0	I	0.0	0.0	0:00.00	[rcu_tasks_trace_kthread]
17	root	20	0	0	0	0	S	0.0	0.0	0:00.02	[ksoftirqd/0]

Memory

Information actively being used

- **Memory controller**: orchestrates communication between memory and CPU
- **System Bus**: main channel for communication between memory and CPU
 - **Data bus**: transfers data
 - **Address bus**: carries the memory address that specifies where data should be read from or written to
 - **Control bus**: sends signals that coordinate and control the activity (e.g. indicates read or write)
- **Volatile memory**: lost once power is lost
- **Non-volatile memory (NVM)**: data retained when power is lost
- **RAM (Random Access Memory)**: volatile memory (based on power supply), actively running programs / active data
- **Swap memory**: When main memory is exhausted, inactive memory contents are "swapped" to the slower disk space which can be restored later

Memory (Raspberry Pi 4)

- 1GB, 2GB, 4GB or 8GB LPDDR4-3200 SDRAM

[0] <https://www.raspberrypi.com/products/raspberry-pi-4-model-b/specifications/>

Memory (command line)

free & free -h

```
labclub@monk:~ $ free -h
```

	total	used	free	shared	buff/cache	available
Mem:	7.6Gi	558Mi	6.5Gi	87Mi	798Mi	7.1Gi
Swap:	2.0Gi	0B	2.0Gi			

```
labclub@monk:~ $ █
```

Storage

Persistent storage (persists after power loss, data that needs to survive a reboot)

Limited I/O (input/output) operations per second

- Reading: fetching existing data
- Writing: saving new data (slower)

Examples:

- Hard drives
- Solid state drives (SSDs) / Non-volatile memory express (NVMe)
- SD Cards
- Optical drives
- etc.

Storage (Raspberry Pi 4)

- Micro-SD card slot
 - Dependent on what Micro-SD card you use

Storage (command line)

df & df -h

```
labclub@monk:~ $ df -h
Filesystem      Size  Used Avail Use% Mounted on
udev            3.6G   0    3.6G   0% /dev
tmpfs           1.6G  11M   1.6G   1% /run
/dev/mmcblk0p2  117G  6.8G  106G   7% /
tmpfs           3.9G  280K   3.9G   1% /dev/shm
tmpfs           5.0M   16K   5.0M   1% /run/lock
tmpfs           1.0M    0    1.0M   0% /run/credentials/systemd-journald.service
tmpfs           3.9G    0    3.9G   0% /tmp
/dev/mmcblk0p1  510M   87M  424M  17% /boot/firmware
tmpfs           783M   72K   782M   1% /run/user/1000
tmpfs           1.0M    0    1.0M   0% /run/credentials/getty@tty1.service
tmpfs           1.0M    0    1.0M   0% /run/credentials/serial-getty@ttyS0.service
labclub@monk:~ $ █
```

Storage (command line)

lsblk

```
labclub@monk:~ $ lsblk
NAME                MAJ:MIN RM   SIZE RO TYPE MOUNTPOINTS
loop0                7:0    0    2G   0 loop
mmcblk0             179:0    0 119.1G  0 disk
├─mmcblk0p1         179:1    0   512M  0 part /boot/firmware
└─mmcblk0p2         179:2    0 118.6G  0 part /
zram0               254:0    0    2G   0 disk [SWAP]
labclub@monk:~ $
```

Storage (command line)

iostat

```
labclub@monk:~ $ iostat
Linux 6.12.47+rpt-rpi-v8 (monk)          02/03/26          _aarch64_          (4 CPU)

avg-cpu:  %user   %nice %system %iowait  %steal   %idle
           23.56    0.00    0.23    0.27    0.00   75.94

Device            tps    kB_read/s    kB_wrtn/s    kB_dscd/s    kB_read    kB_wrtn    kB_dscd
loop0              0.01         0.13         0.00         0.00         652         0         0
mmcblk0            5.57        107.47        447.30        22915.78     542122     2256370     115596130
zram0              0.02         0.28         0.00         0.00         1432         4         0
```

Network

Communication between machines

- Bandwidth: how much data can move at once
- Latency: how long it takes to arrive

Network

```
cat /sys/class/net/<interface>/speed  
ip addr
```

```
labclub@monk:~ $ ip addr  
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group default qlen 1000  
   link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00  
   inet 127.0.0.1/8 scope host lo  
       valid_lft forever preferred_lft forever  
   inet6 ::1/128 scope host noprefixroute  
       valid_lft forever preferred_lft forever  
2: eth0: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group default qlen 1000  
   link/ether d8:3a:dd:f8:f2:cf brd ff:ff:ff:ff:ff:ff  
   inet 10.70.57.92/24 brd 10.70.57.255 scope global dynamic noprefixroute eth0  
       valid_lft 16002sec preferred_lft 16002sec  
   inet6 fe80::c804:6e6e:6fca:101c/64 scope link noprefixroute  
       valid_lft forever preferred_lft forever  
3: wlan0: <BROADCAST,MULTICAST> mtu 1500 qdisc noop state DOWN group default qlen 1000  
   link/ether d8:3a:dd:f8:f2:d1 brd ff:ff:ff:ff:ff:ff  
labclub@monk:~ $ cat /sys/class/net/eth0/speed  
1000  
labclub@monk:~ $
```

Network

ping

```
labclub@monk:~ $ ping google.com -c 4
PING google.com (172.253.63.113) 56(84) bytes of data.
64 bytes from bi-in-f113.1e100.net (172.253.63.113): icmp_seq=1 ttl=99 time=4.65 ms
64 bytes from bi-in-f113.1e100.net (172.253.63.113): icmp_seq=2 ttl=99 time=4.62 ms
64 bytes from bi-in-f113.1e100.net (172.253.63.113): icmp_seq=3 ttl=99 time=4.49 ms
64 bytes from bi-in-f113.1e100.net (172.253.63.113): icmp_seq=4 ttl=99 time=4.39 ms

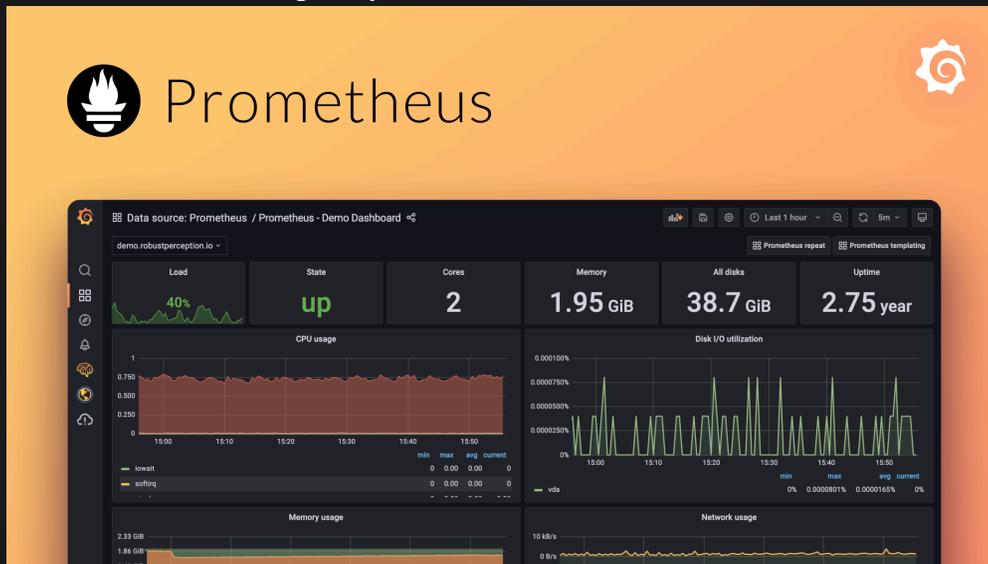
--- google.com ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 3005ms
rtt min/avg/max/mdev = 4.386/4.536/4.651/0.105 ms
labclub@monk:~ $
```

Why Monitor?

- Why is my Pi (or service running on my Pi) slow?
- Are there certain triggers over time causing slowdowns?
- What is the bottleneck in my Pi's performance?
- Checking once tells you what is happening at the moment you check, monitoring tells you what has been happening over time

Node exporter / Prometheus & Grafana

- Node exporter / Prometheus: data collection
 - gathers metrics
 - time-series data
- Grafana
 - visualize metrics
 - graphical dashboards



[0] <https://grafana.com/docs/grafana/latest/fundamentals/getting-started/first-dashboards/get-started-grafana-prometheus/>

