# The Raspberry Pi Cloud

## Experience, Lessons & Opportunities

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# where do your music/videos/pictures live?


# in the cloud

# in the data centres - enormous & costly

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Facebook's Data Centre,
North Carolina
$606 million

# in the data centres - enormous & costly

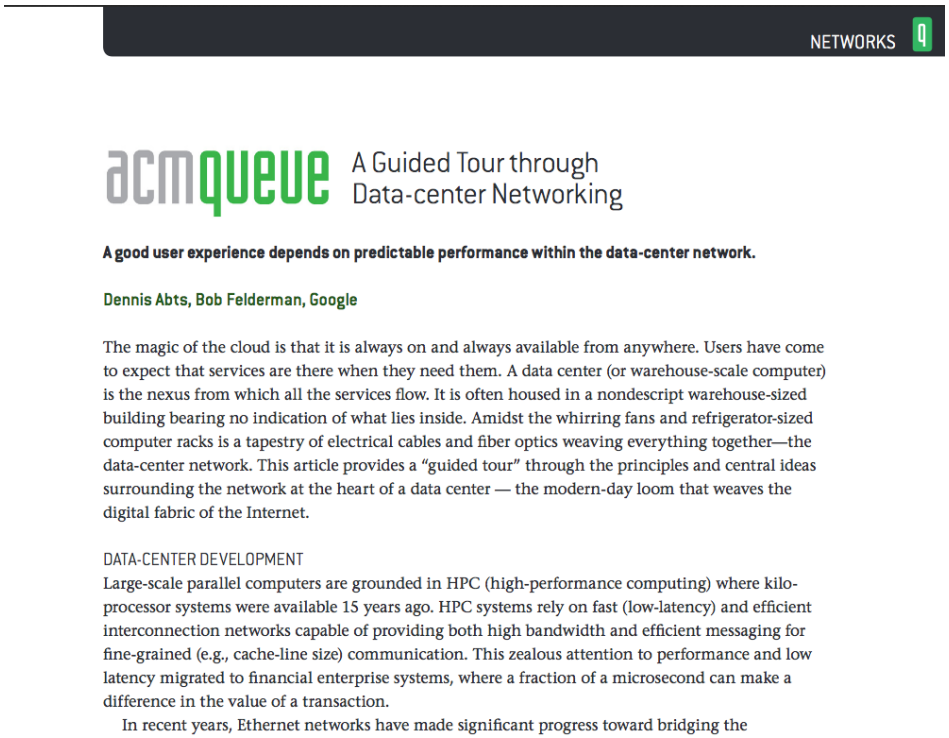
Apple's Data Centre,
Maiden
$1 billion

# on the inside - a closer look

# wait, authorised persons only!


can't get in, normally

# how to find out about it?



NETWORKS

acmqueue

## A Guided Tour through Data-center Networking

**A good user experience depends on predictable performance within the data-center network.**

Dennis Abts, Bob Felderman, Google

The magic of the cloud is that it is always on and always available from anywhere. Users have come to expect that services are there when they need them. A data center (or warehouse-scale computer) is the nexus from which all the services flow. It is often housed in a nondescript warehouse-sized building bearing no indication of what lies inside. Amidst the whirring fans and refrigerator-sized computer racks is a tapestry of electrical cables and fiber optics weaving everything together—the data-center network. This article provides a "guided tour" through the principles and central ideas surrounding the network at the heart of a data center — the modern-day loom that weaves the digital fabric of the Internet.

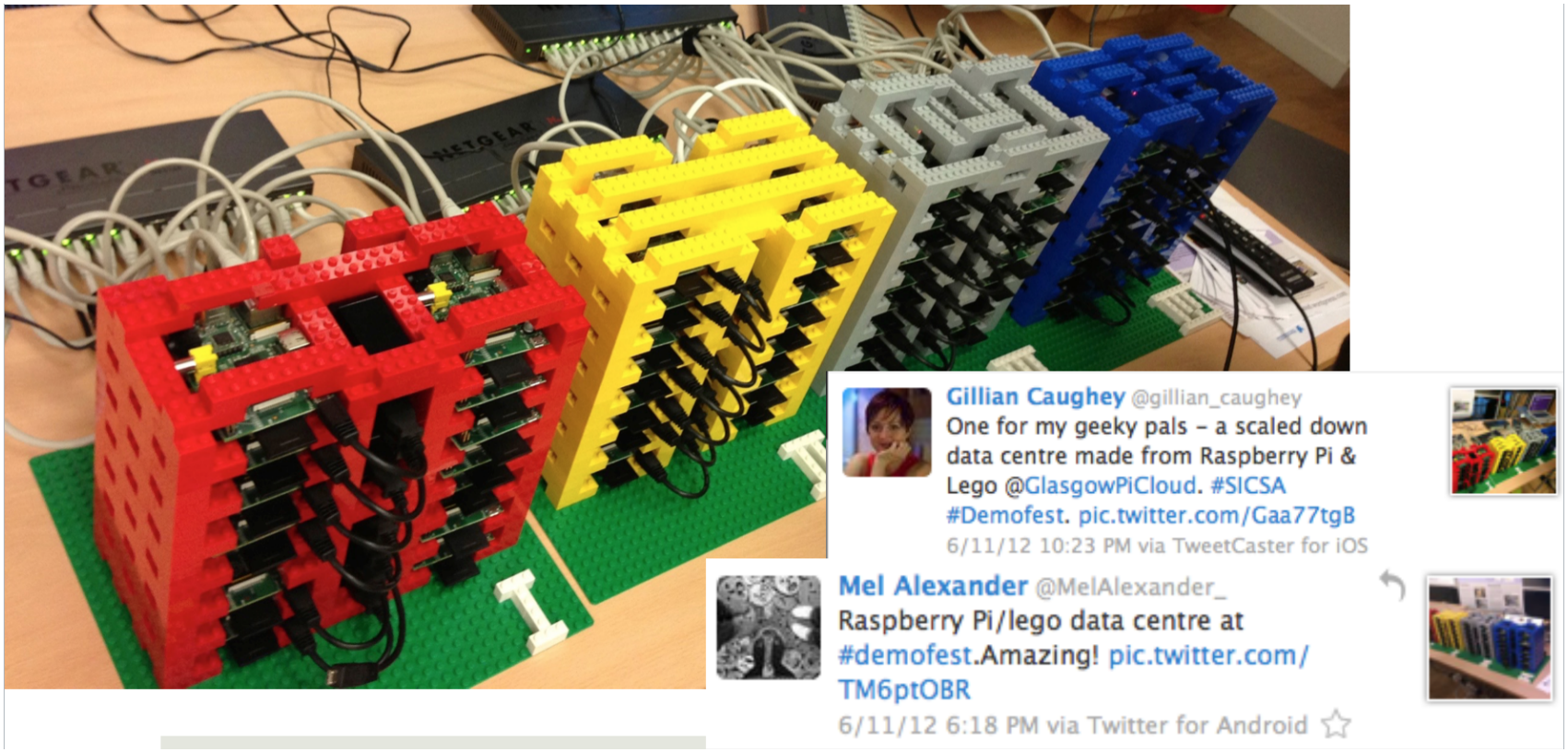
DATA-CENTER DEVELOPMENT

Large-scale parallel computers are grounded in HPC (high-performance computing) where kilo-processor systems were available 15 years ago. HPC systems rely on fast (low-latency) and efficient interconnection networks capable of providing both high bandwidth and efficient messaging for fine-grained (e.g., cache-line size) communication. This zealous attention to performance and low latency migrated to financial enterprise systems, where a fraction of a microsecond can make a difference in the value of a transaction.

In recent years, Ethernet networks have made significant progress toward bridging the

# build a scale model

# Raspberry Pi Cloud



# where to start?

- putting together hardware is an easy task.

# cost of labour: 5 quids worth of cookies

time spent: one afternoon

# where to start?

- putting together hardware is an easy task.
- today's cloud means virtualisation.
  - Options? - KVM, Xen, and LXC.
- we need cloud stack that could run on ARM platforms.
  - Options? - OpenStack, CloudStack ...

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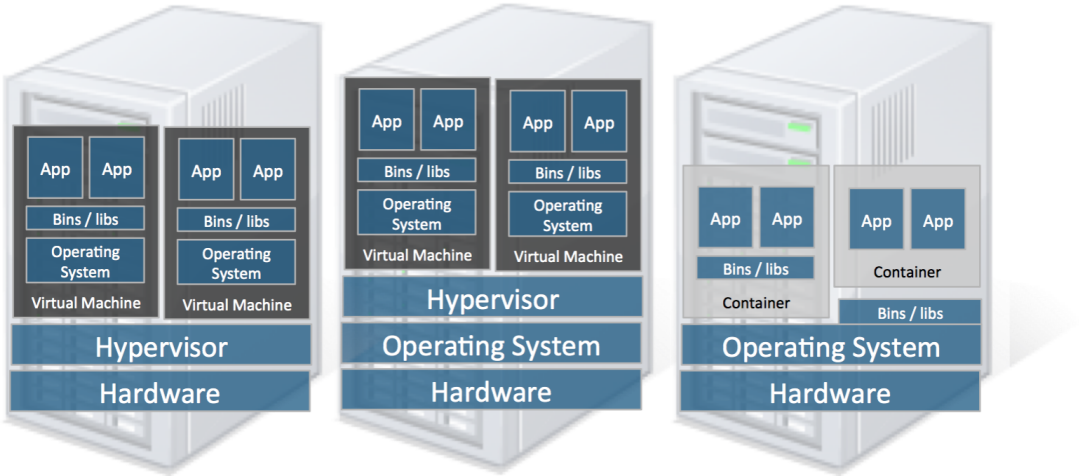
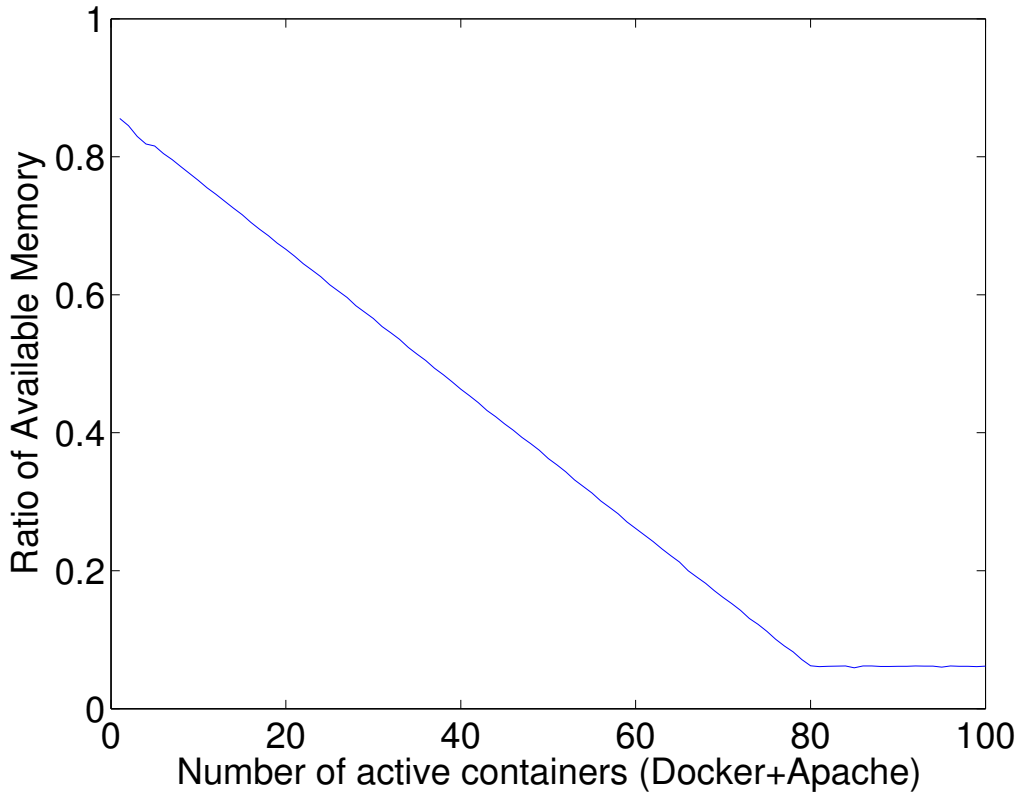
# Virtualisation - Hypervisor vs. Container




LXC - LinuX Container

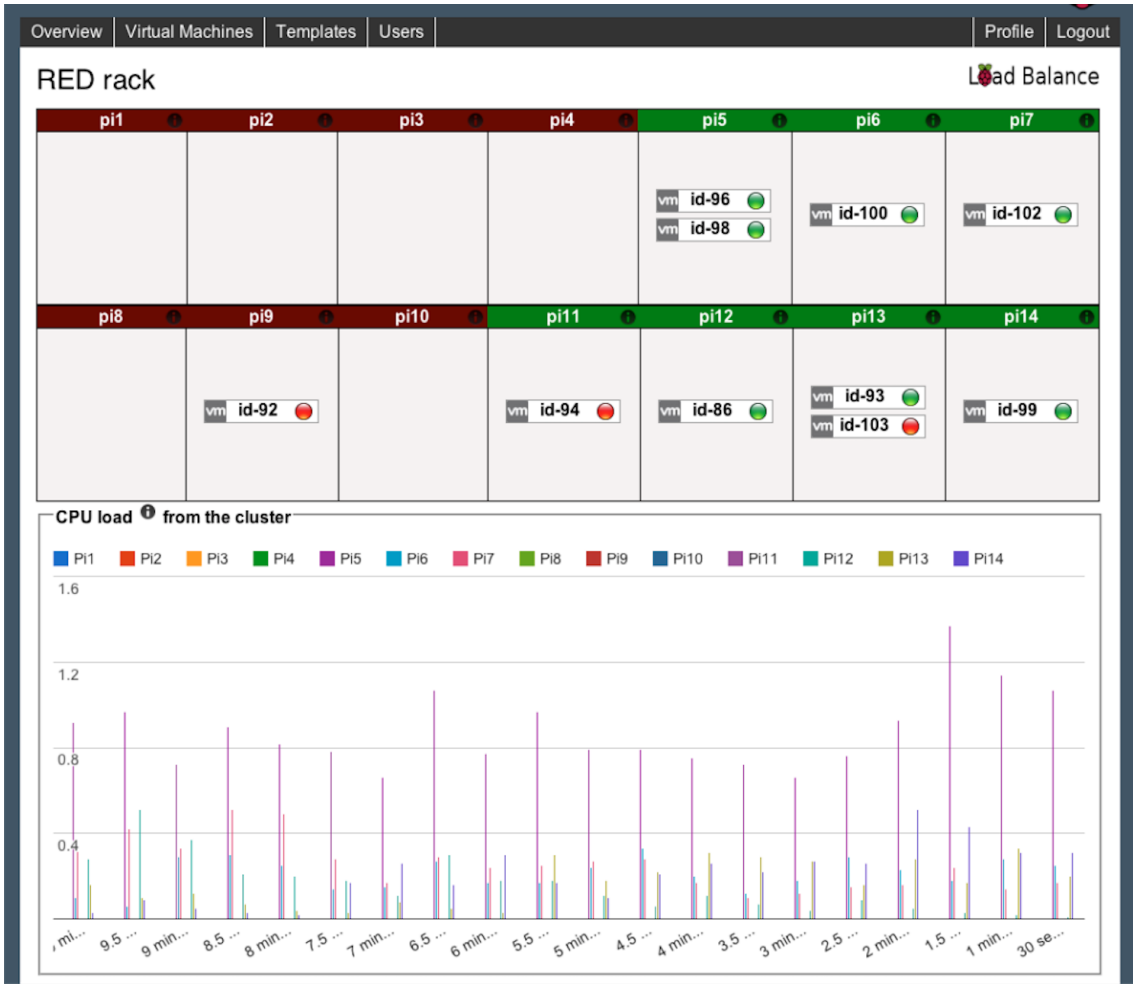
- OS level virtualisation.
- low overhead (?)
- enabled by modern kernel features.
- we use docker.

# low overhead virtualisation




RPi B+ can run 80 (idle) web servers in parallel.

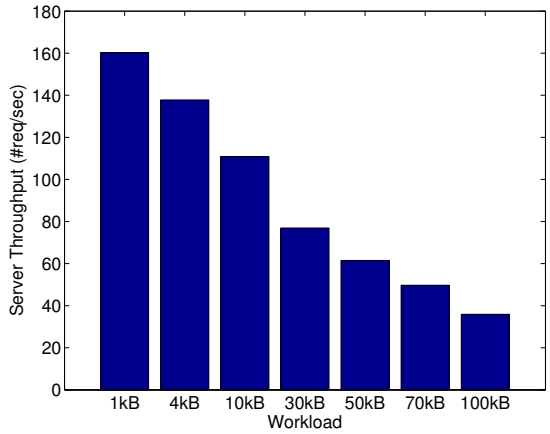
# lightweight management stack



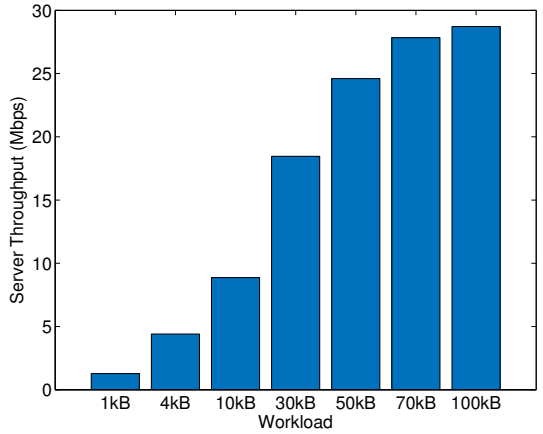

Web-based management (w/ libvirt and Django)

# what can a RPi (model B+) do?

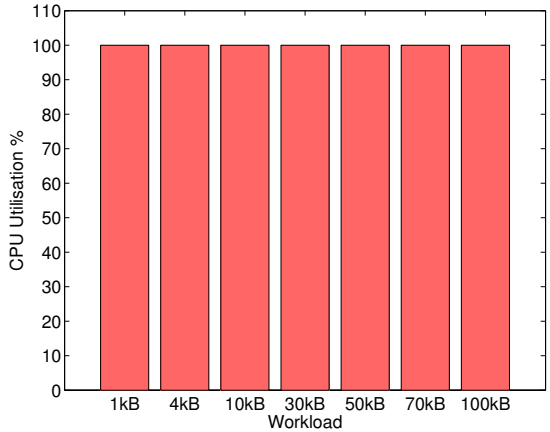
## -*httperf* performance benchmarking



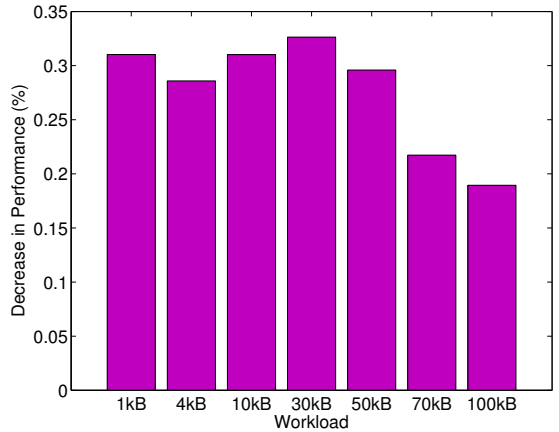

(d) Work Throughput




(e) Network Throughput




(f) CPU Utilisation




(g) Virtualisation Overhead

# a peek into Big Data (Hadoop)[1]

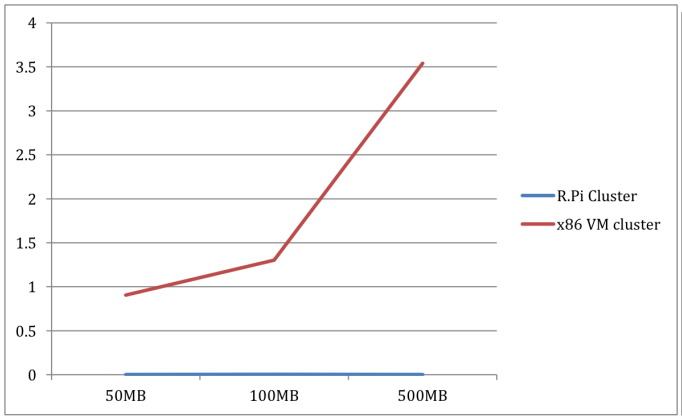
- we try to be more ambitious.

- 14 RPis vs. 3 x86 VMs (Core i5@2.6GHz, 1 core, 1GB RAM)
- Metric: data processed per second ($DPS = \frac{InputDataSize}{Executiontime}$)
- Scenarios: WordCount, Sort, TeraSort

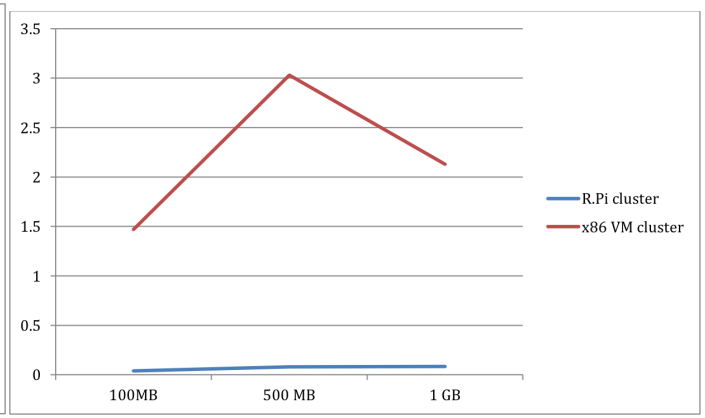
[1] *Big Data on Mini Computers*, Qibing Cheng, MSc thesis, University of Glasgow, 2014

# a peek into Big Data (Hadoop)[1]

- we are too ambitious.




(h) WordCount




(i) Sort

- Raspberry Pi Cloud spent hours to finish jobs - minutes for x86 testbed.
- on average, x86 is 100-250 times faster.
- lack of equipment to measure power consumption :(

[1] *Big Data on Mini Computers*, Qibing Cheng, MSc thesis, University of Glasgow, 2014

# we learned a lesson

We set our expectation too high - RPi is too limited.

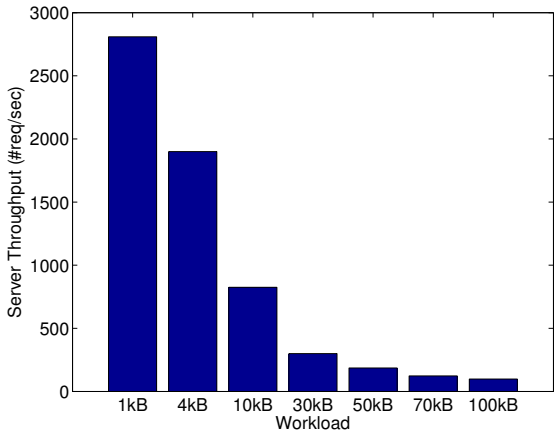
# Raspberry Pi Cloud Version 2

- a new Raspberry Pi Cloud comprised of RPi2s
- funded by TAE's Faculty Research Pump Priming, £10k

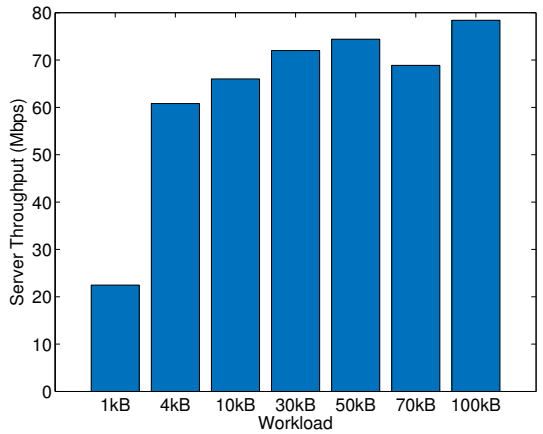
- the new Raspberry Pi 2 has a 900MHz quad-core ARM Cortex-A7 CPU.
- the CPU supports hypervisor-based virtualisation, e.g. KVM, and Xen.

# what can a RPi 2 do?

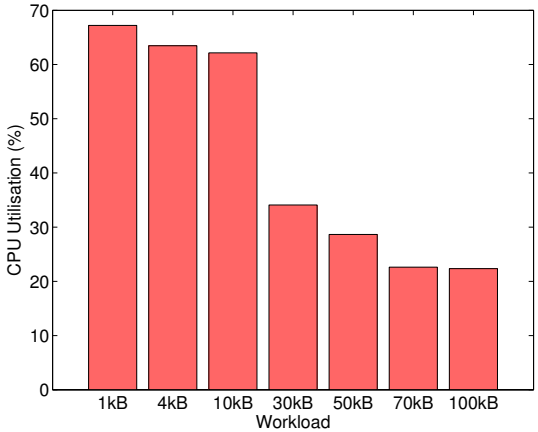
## - significant CPU and network bandwidth headroom



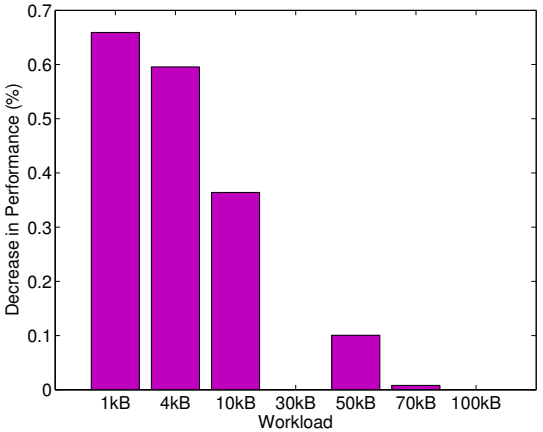

(j) Work Throughput




(k) Network Throughput

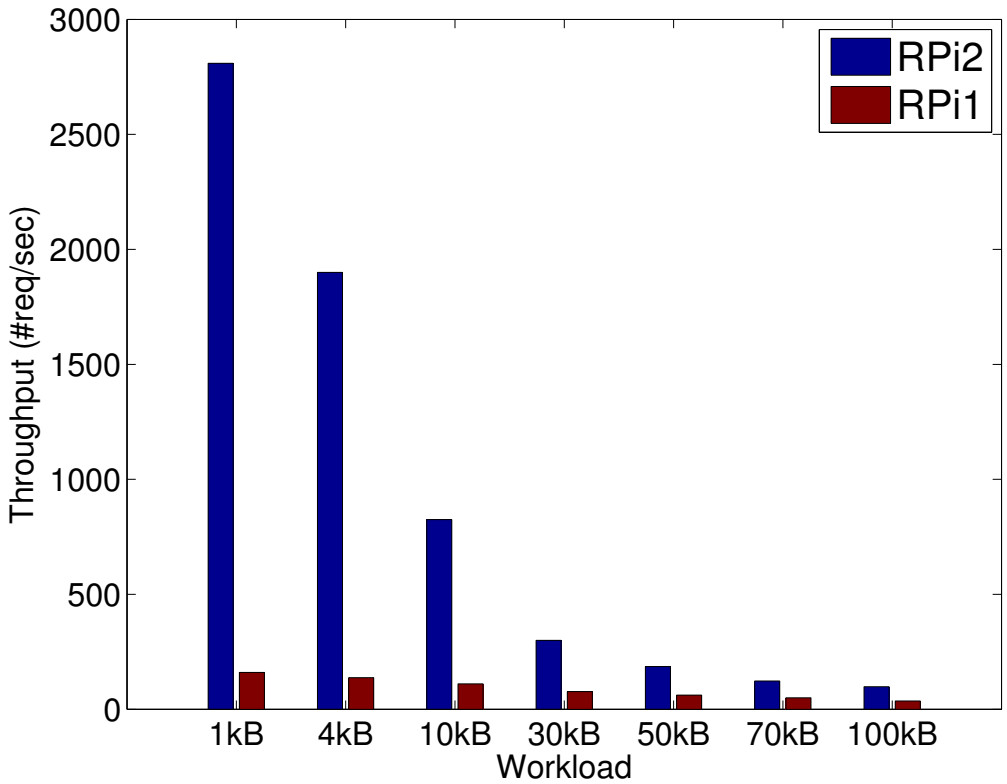



(l) CPU Utilisation




(m) Virtualisation Overhead

# RPi2 vs. RPi1




RPi2 is 3 to 18 times better than RPi1.

# what next?

## - and I need volunteers too

- KVM/Xen on RPi2 (we're close)
- "software defined" cloud.
- cloud federation - connecting to its sister project at the University of Glasgow.
- big data processing using ARM cores.
  - legacy tools are designed for x86.
- from "cloud" to "fog". E.g.:
  - real-time micro-data mining.
  - network function optimisation.

if you're interested in these projects, please get in touch.

# Thank You!

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