



And what would you do with ten thousand Raspberry Pis?

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University of Glasgow
UK Systems Research Workshop
Newcastle, March 22nd 2018

In collaboration with:

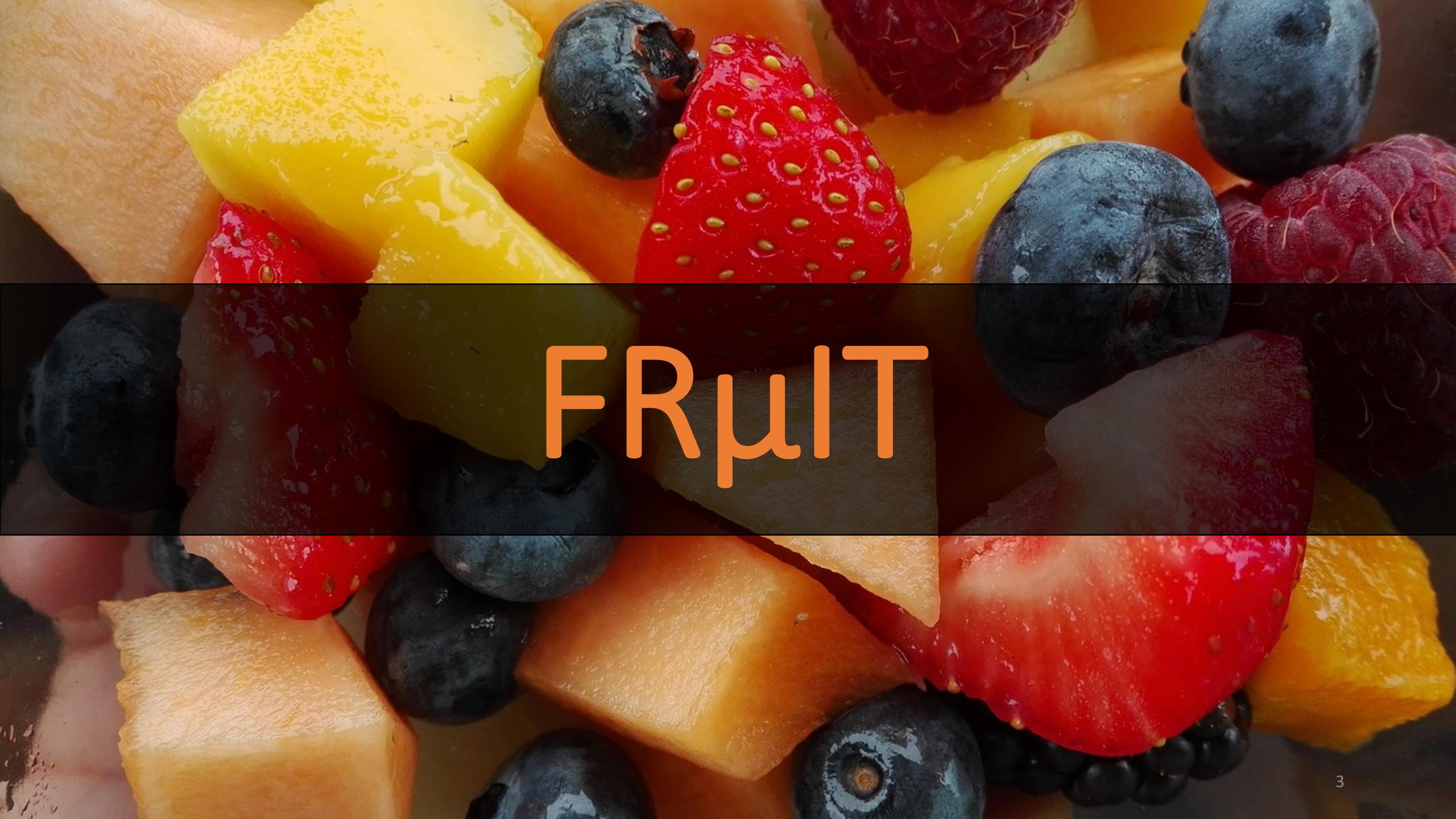
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FRUIT

<https://fruit-testbed.org>
@fruit_testbed

EPSRC

F ederated

RaspberryPi



UNIVERSITY OF
CAMBRIDGE

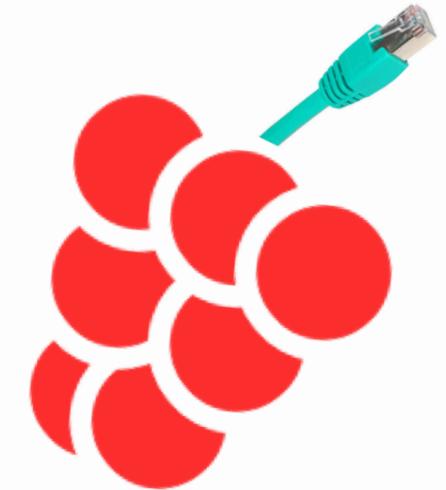


Loughborough
University

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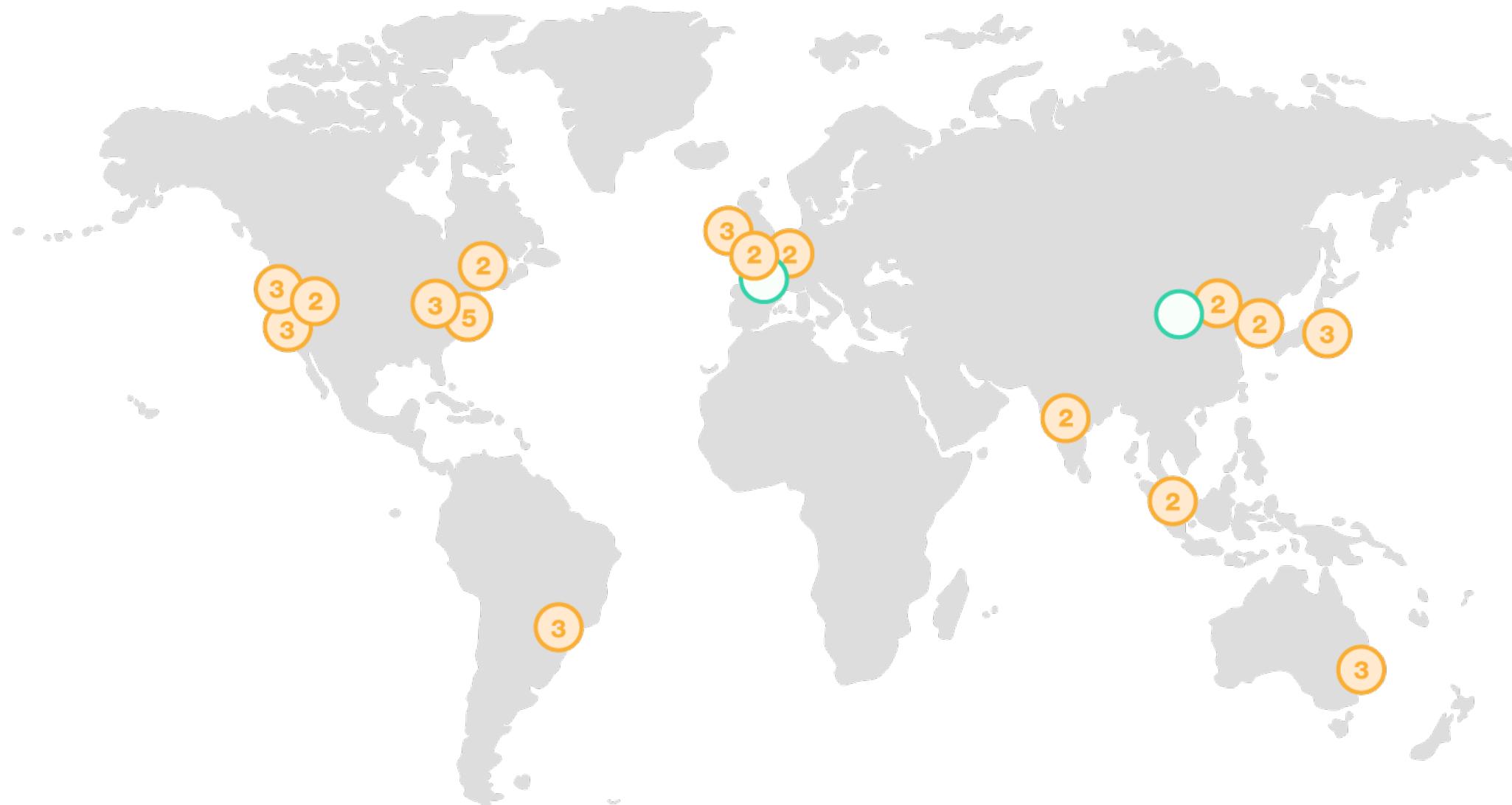
University
of Glasgow

UNIVERSITY OF
Southampton

Project Goal

Massive aggregation of low-cost, low-power, commodity infrastructure to form an efficient and effective compute fabric for key distributed applications

From dozens of million-node datacenters ...



<https://aws.amazon.com/about-aws/global-infrastructure/>

To millions of dozen-node datacenters

The digital publication for ambitious SMEs

home > tech

Smartphones

Online all
household

Smartphones are i
according to YouG

YOU ARE AT: Home

SALES &
MARKETING

broadbandchoices

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Home > News > Miscellaneous

Britain has 18 smart devices per household

Friday, July 3, 2015 By Kim Staples

When it comes to technology,
Brits are among the most

Applications

- Education
- Edge Compute
- Expendable Compute
- Resource Constrained Compute
- Next Generation Data Center
- Portable Clusters

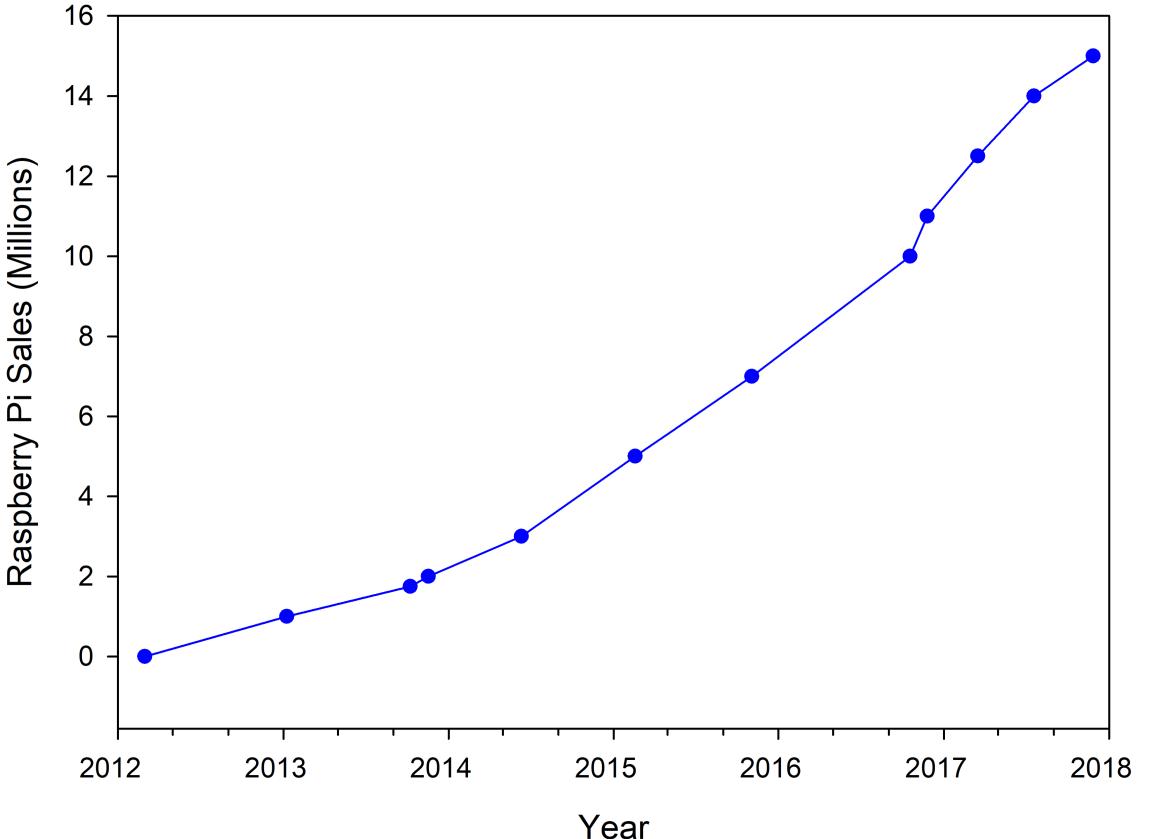
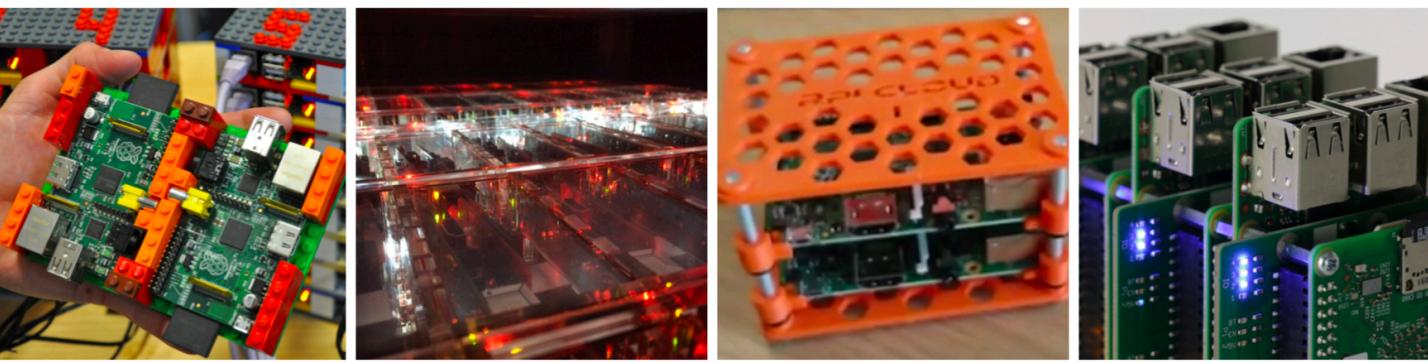
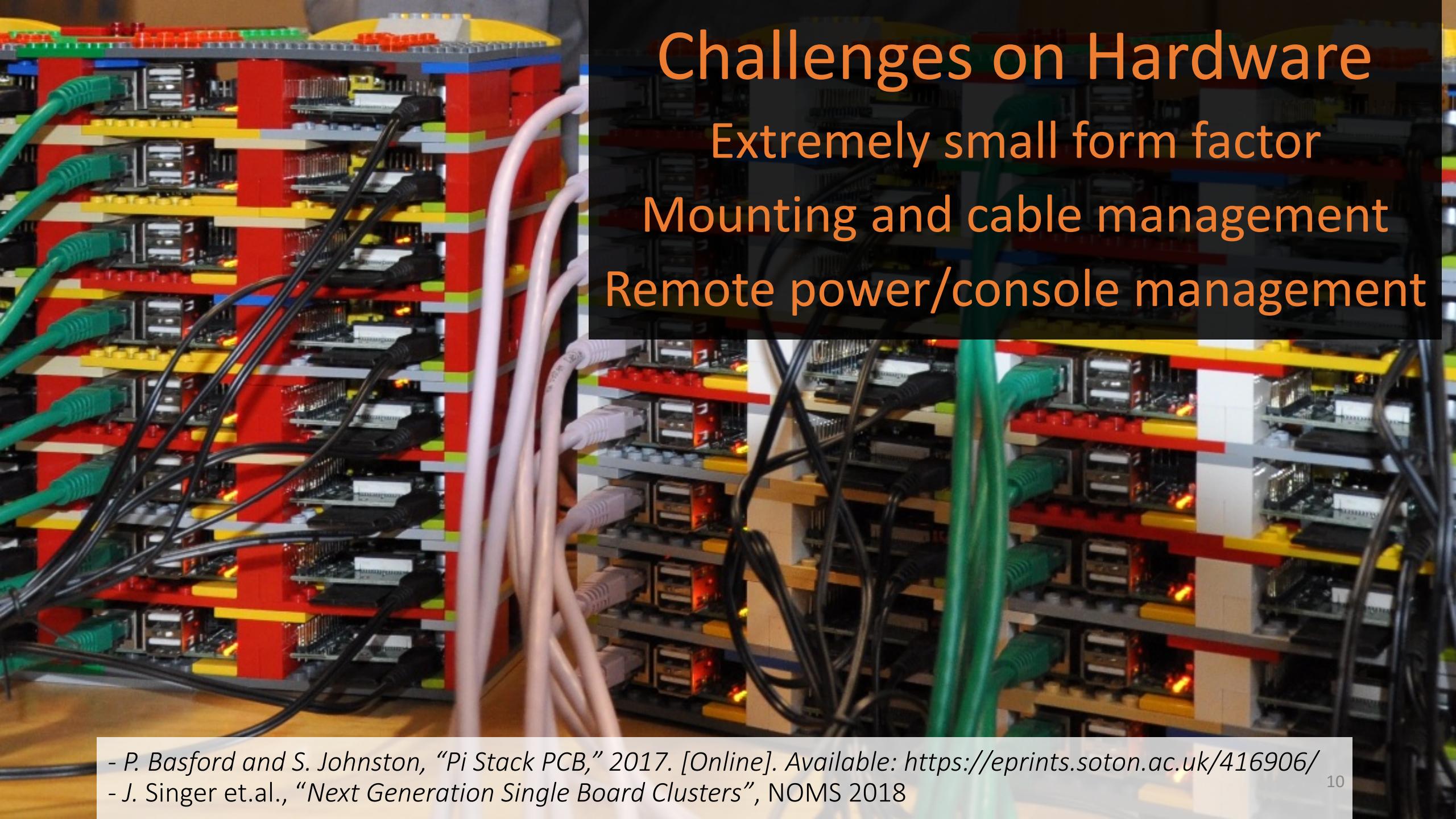


Table 4: Example Raspberry Pi Clusters

| Name | Year | Owner | Hardware | Use cases |
|--------------------------------------|------|----------------------------------|-------------------|---|
| Pi Co-location [14, 32] | 2013 | PC Extreme (NL) | 2500 Pi1 | Pi hosting provision |
| National Laboratory R&D Cluster [29] | 2017 | Los Alamos National Lab (USA) | 750 Pi 3 | R & D prior to running on main cluster |
| Bolzano Cloud Cluster [33] | 2013 | Free University of Bolzano (ITA) | 300 Pi1 | Education, research, & deployment in developing countries |
| SeeMore [6] | 2015 | Virginia Tech (USA) | 256 Pi2 | Art installation, education |
| The Beast [25] | 2014 | Resin.io (UK) | 120 Pi1 | Demonstrating/testing distributed applications |
| The Beast 2.0 [26] | 2017 | Resin.io (UK) | 144 Pi2 | Demonstrating/testing distributed applications |
| Pi Hosting [15, 19] | 2016 | Mythic Beasts (UK) | 108 Pi3 / 4U rack | Pi hosting provision |
| Raspberry Pi Cloud [4] | 2013 | University of Glasgow (UK) | 56 Pi1 & 14 Pi2 | Research and Teaching light-weight virtualisation |
| Bramble [34] | 2015 | GCHQ (UK) | 66 Pi1 | Internal teaching tool |
| Iridis-Pi [3] | 2013 | University of Southampton (UK) | 64 Pi1 | Education |
| Wee Archie Green [35, 36] | 2015 | University of Edinburgh (UK) | 19 Pi2 | Education Outreach |



Challenges on Hardware

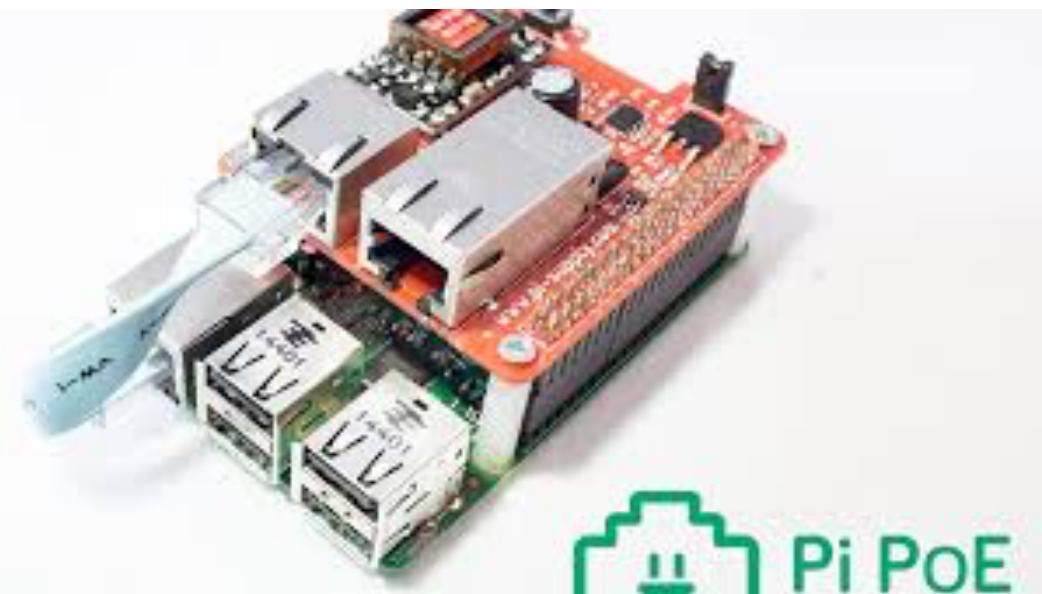
Extremely small form factor

Mounting and cable management

Remote power/console management

- P. Basford and S. Johnston, "Pi Stack PCB," 2017. [Online]. Available: <https://eprints.soton.ac.uk/416906/>
- J. Singer et.al., "Next Generation Single Board Clusters", NOMS 2018

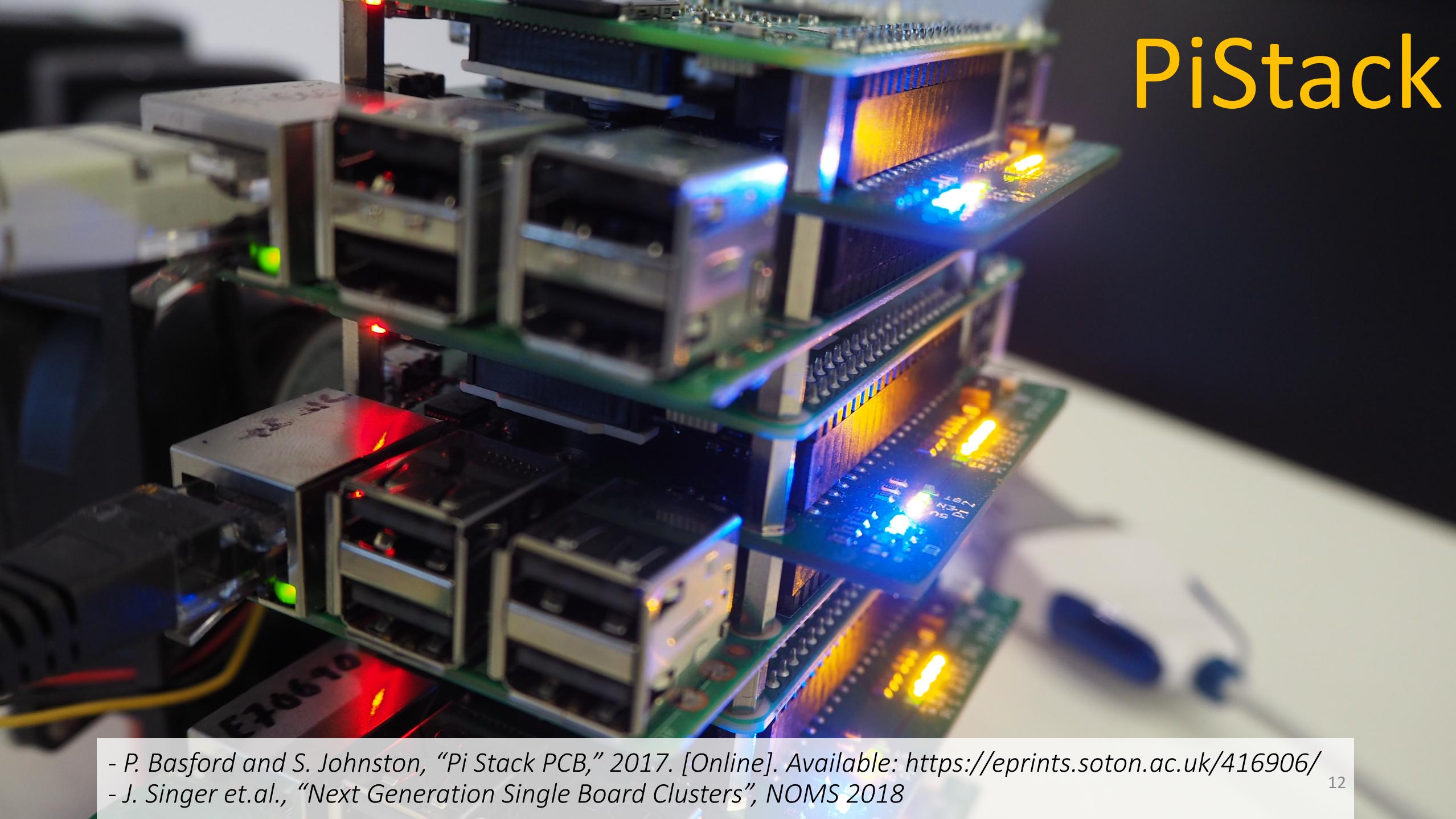
[https://www.kickstarter.com/projects/pisupply/pi-poe-switch-hat-power-over-ethereum-for-raspber](https://www.kickstarter.com/projects/pisupply/pi-poe-switch-hat-power-over-ethernet-for-raspber)



<https://ebay.com>

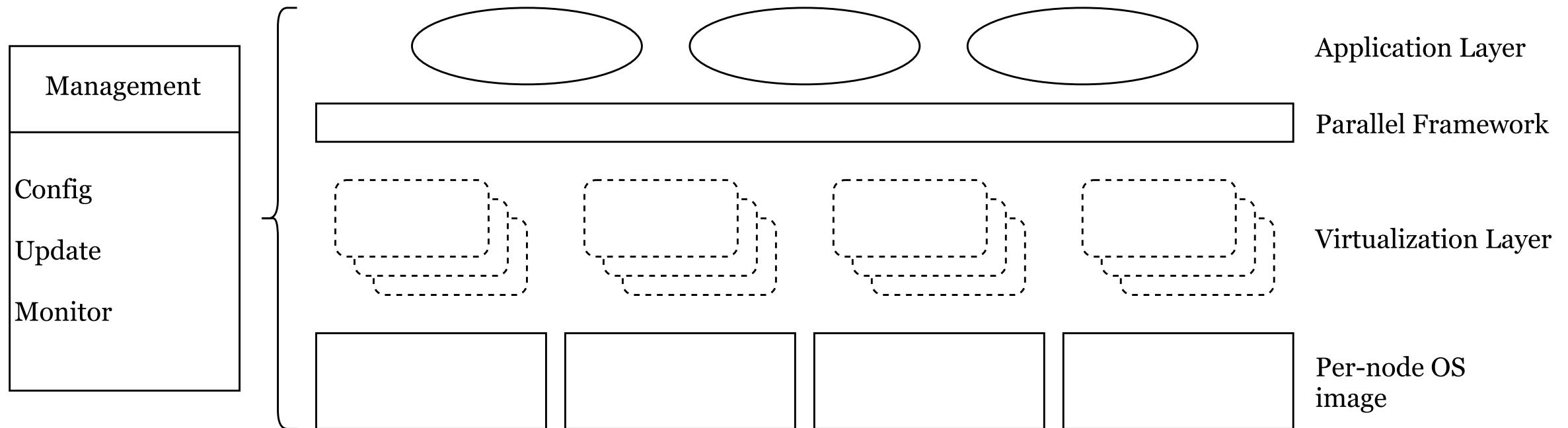


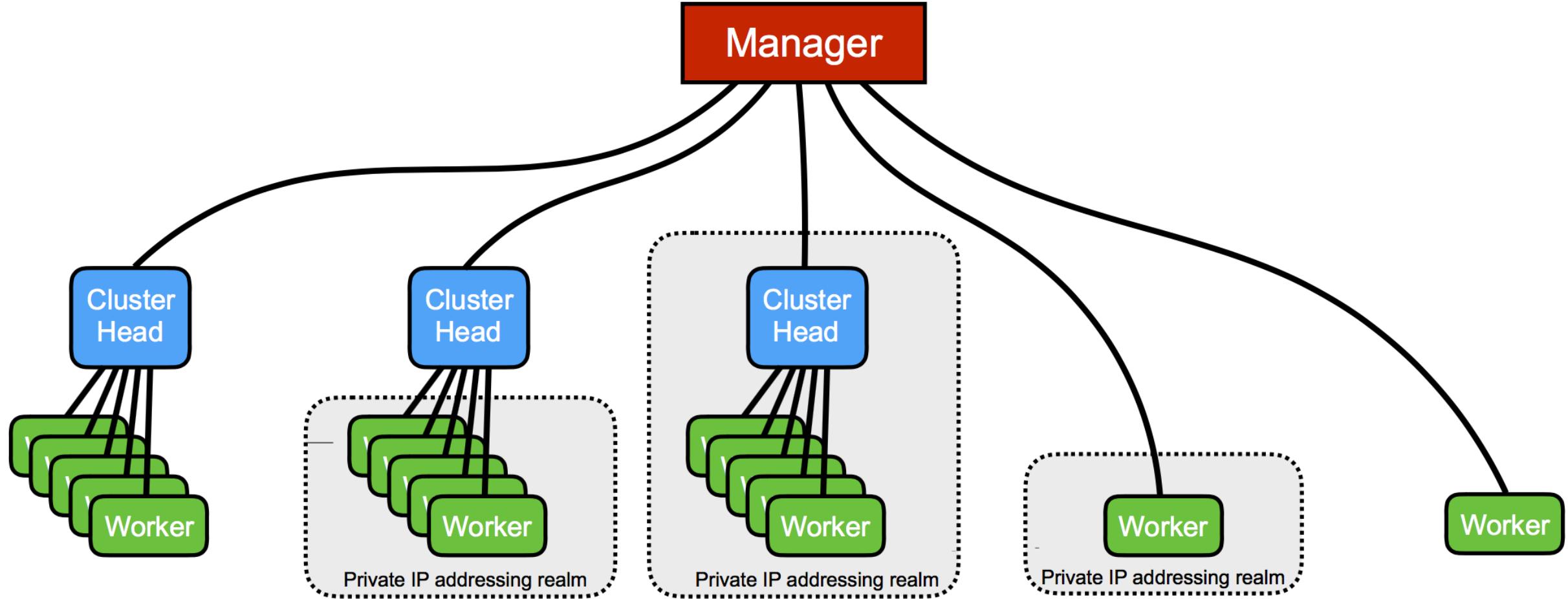
PiStack



- P. Basford and S. Johnston, "Pi Stack PCB," 2017. [Online]. Available: <https://eprints.soton.ac.uk/416906/>
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Federated Management



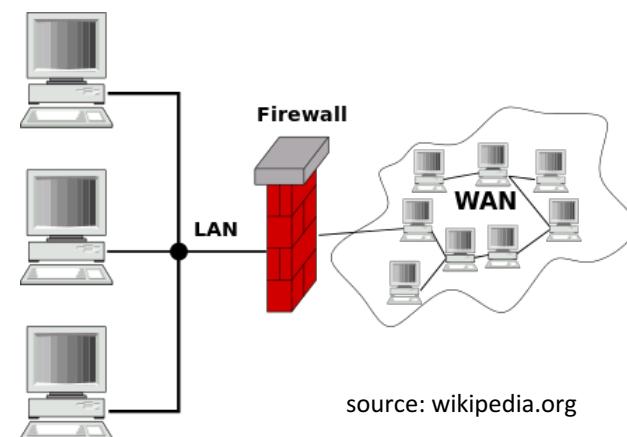


Challenge: System Update

- Update system is critical
- Limited (or no) physical access
- Heterogeneous Network
 - Some nodes are behind NATs (e.g. residential) or Firewalls (e.g. university)
- Single-point of failure
- Scalability
 - Denial of Service attack on update server
- Existing tools
 - Requires direct SSH access
 - Needs well-connected server



source: techadvisor.co.uk (<http://bit.ly/2FrBW22>)



source: wikipedia.org

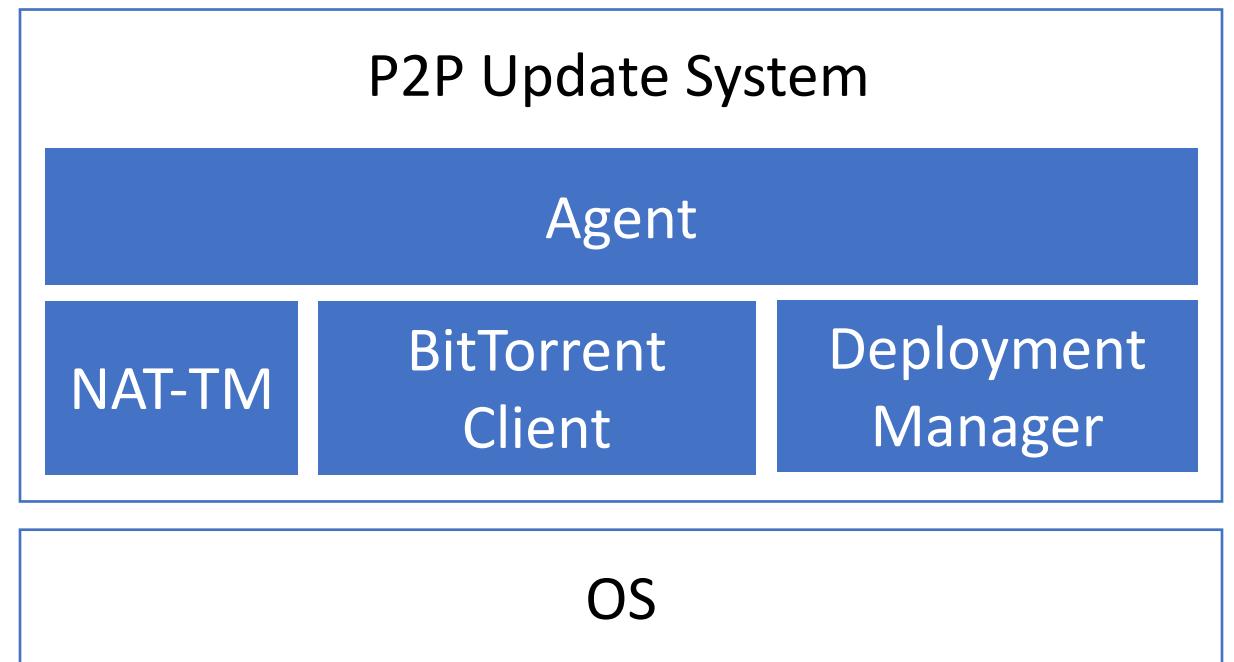
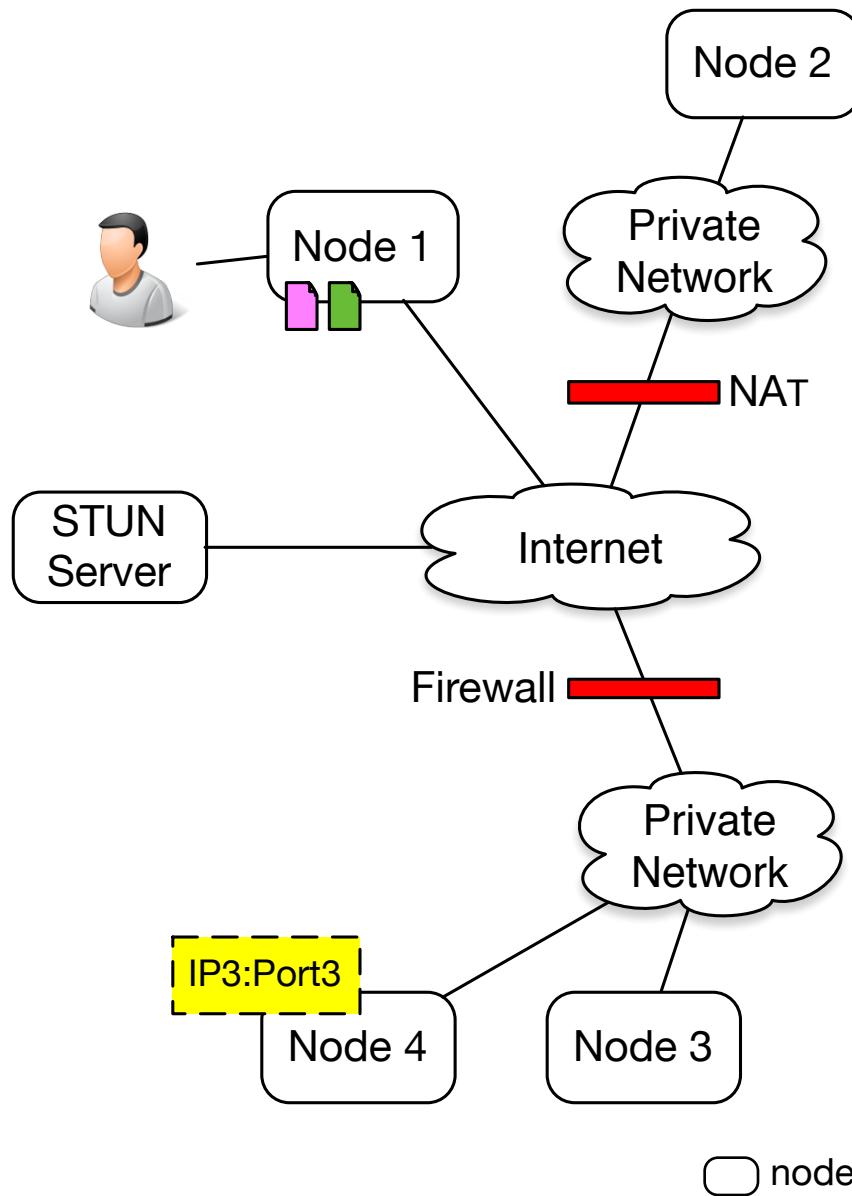


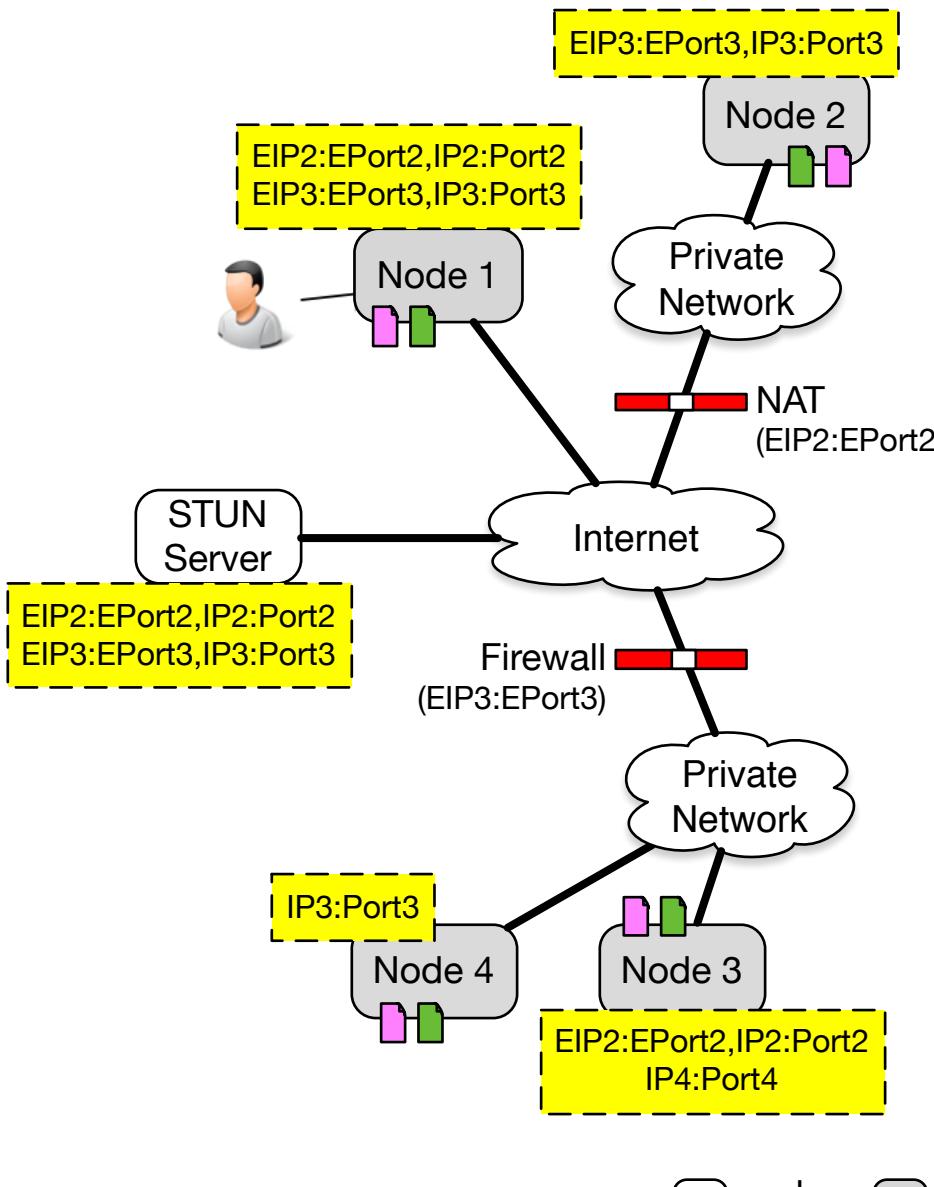
source: airpi.es



source: Geeky Gadgets¹⁵
(<http://bit.ly/2BCQRUL>)

Peer-to-Peer Secure Update





- Torrent-file (Standard)**
- Tracker/Nodes
 - File-name
 - File-length
 - Piece-length
 - Cryptographic-hashes of file pieces
 - **Target resource identifier (BEP0035)**
 - **Version**
 - **Digital signature**

 node
 updated-node
 torrent-file
 update-file

fruit-testbed / fruitos

Code

Issues 3

Pull requests 0

Projects 0



A lean Linux OS distribution for Raspberry Pi

raspberrypi

iot

alpine-linux

operating-system

linux

Manage topics

- ✓ A/B Root Partitions
- ✓ Over-the-Air, Peer-to-Peer Secure Update
- ✓ Remote Declarative Configuration Management
- ✓ Docker and Singularity Containers
- ✓ Support Raspberry Pi Zero, 1, 2, 3

FRUIT Management API

FRUIT Management API

[Contact the developer](#)

[Apache 2.0](#)

users : Operations available to regular users

Show/Hide | List Operations | Expand Operations

| | | |
|--------|--------------------|---|
| GET | /monitor | get the latest monitoring data of all nodes |
| GET | /monitor/{name} | get the latest node monitoring data |
| GET | /node | get list of node |
| DELETE | /node/{name} | delete node's data |
| GET | /node/{name} | get node's properties |
| GET | /user | get list of user |
| DELETE | /user/{email} | delete user |
| GET | /user/{email} | get user details |
| PUT | /user/{email} | add user |
| GET | /user/{email}/node | return a list of nodes owned by given user |

agents : Software agent running on nodes

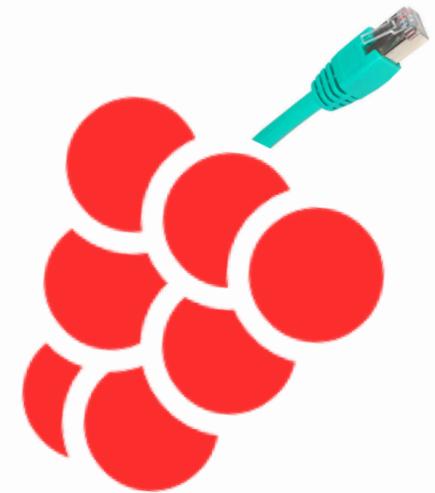
Show/Hide | List Operations | Expand Operations

| | | |
|------|----------------------|-----------------------------|
| POST | /monitor/{name} | submit node monitoring data |
| GET | /node/{name}/config | get node's fruit.json |
| GET | /node/{name}/openvpn | get OpenVPN config file |
| GET | /node/{name}/ssh_key | get ssh public key |

<https://fruit-testbed.org/os/edge/releases/armhf/>

Applications

- Sensor data processing and machine learning
- BOINC volunteer computing

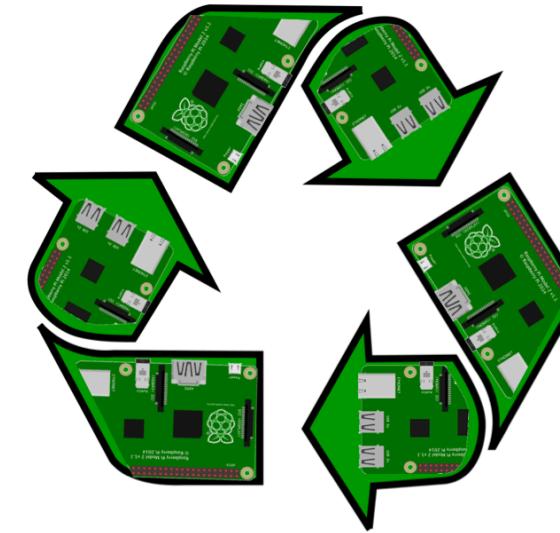
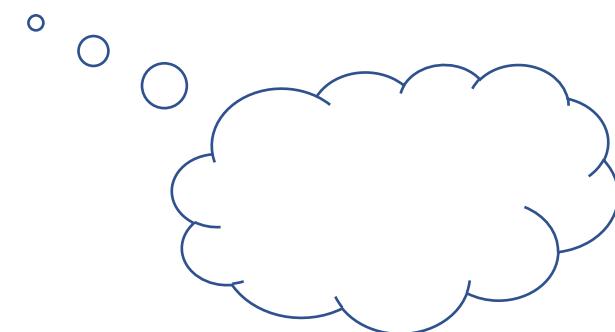


Others

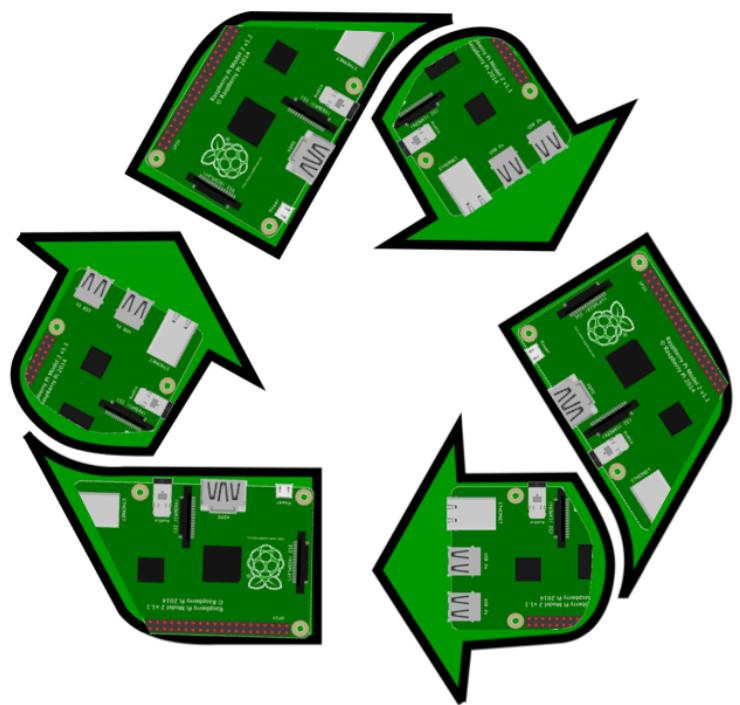
- Federated workload management
 - Federated Kubernetes
- Federated monitoring
 - Centralized vs Distributed

how can you help?

- Current: 500+ nodes across 4 sites
- donate your unwanted pi boards
 - see picycle.org
- suggest use cases (workloads) for the platform



FREEPOST PICYCLE



picycle.org

- (1) Put your Raspberry Pi back into its original box.
- (2) Put your packaged Pi into a Jiffy bag.
- (3) Address the parcel **FREEPOST PICYCLE**
- (PI) Optionally, include a note with:
 - your email address
 - your full name
- (4) Drop your parcel in a Royal Mail post box

EPSRC

Pioneering research
and skills

Thank you!