



And what would you do with ten thousand Raspberry Pis?

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University of Glasgow

UK Systems Research Workshop

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FRUIT

<https://fruit-testbed.org>
[@fruit_testbed](#)

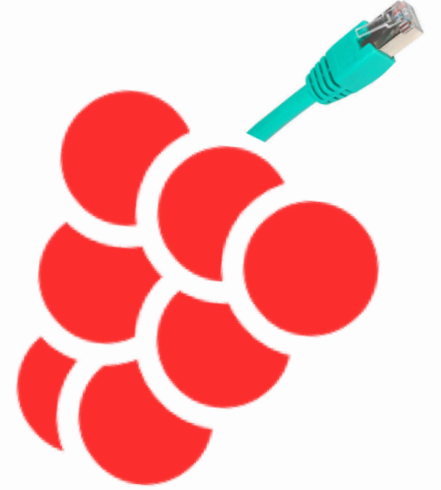
EPSRC

Federated

Raspberry

Unfrastructure

Testbed



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CAMBRIDGE



University
of Glasgow



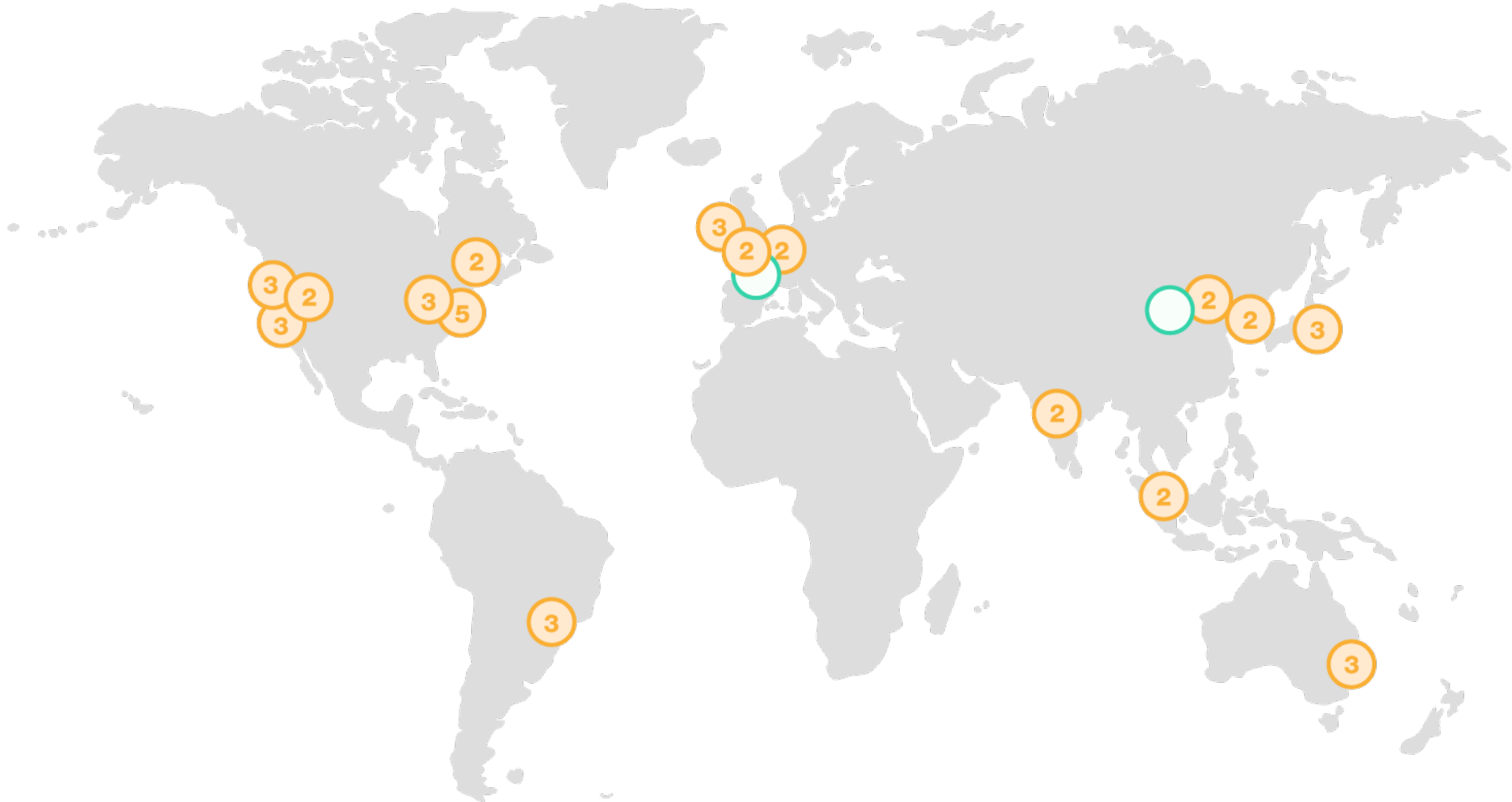
Loughborough
University

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



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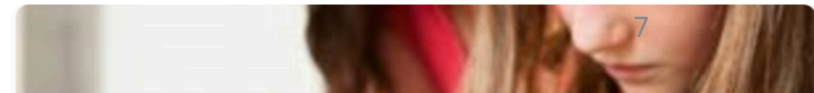
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Britain has 18 smart devices per household

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

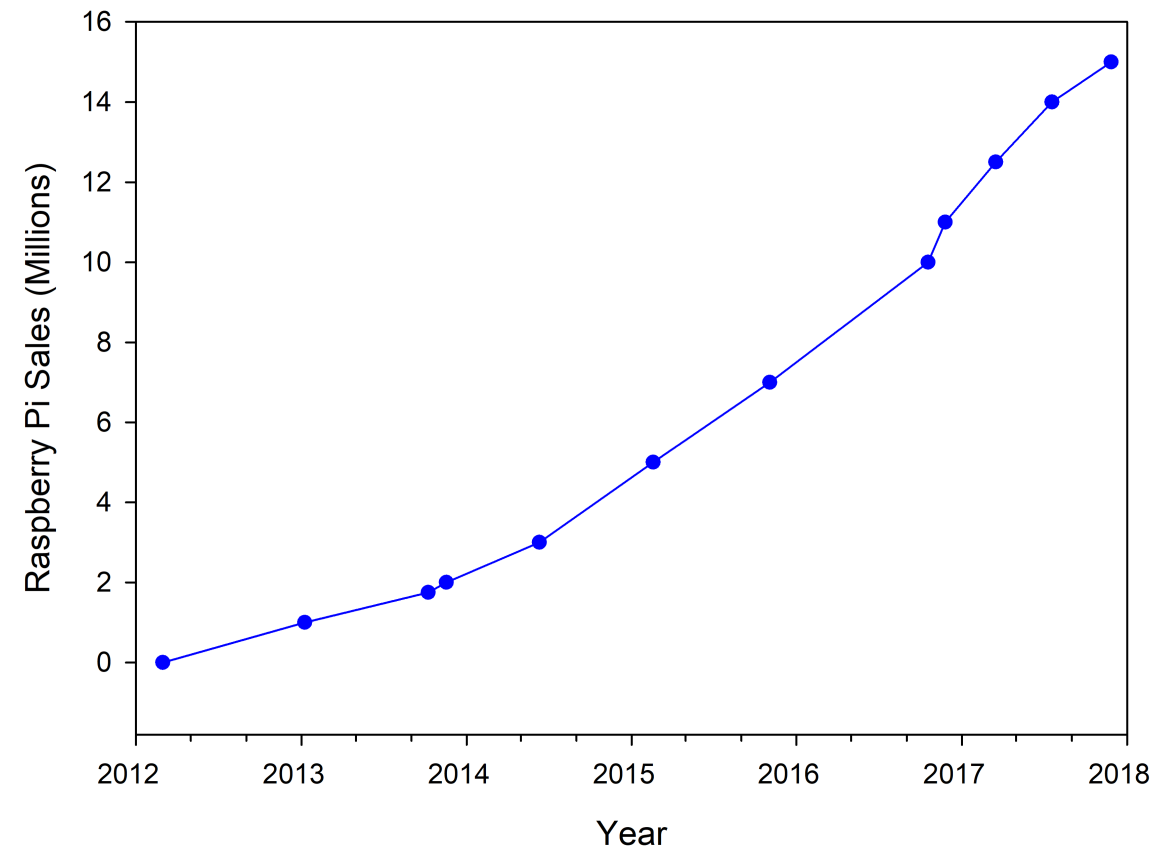
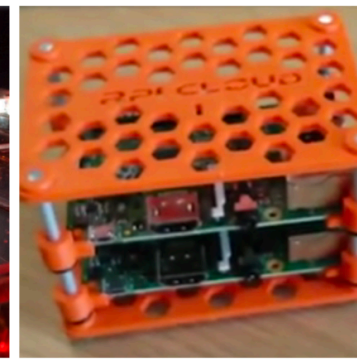
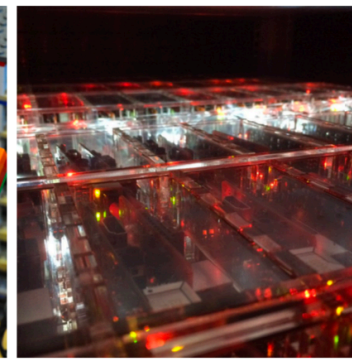
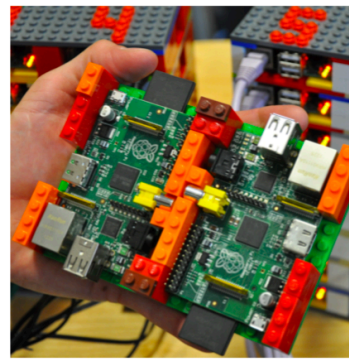


Table 4: Example Raspberry Pi Clusters

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

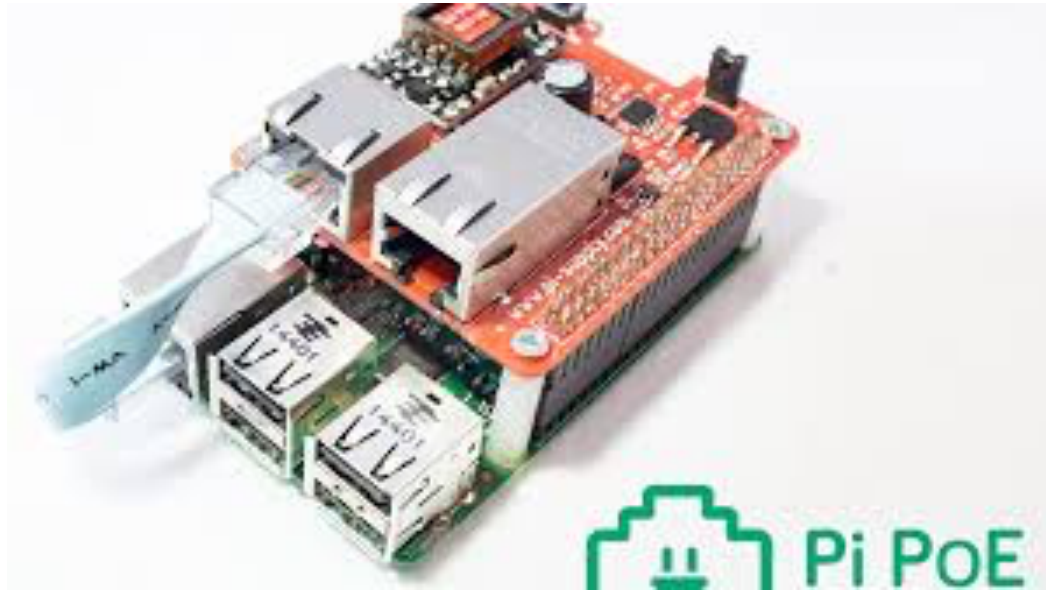


Challenges on Hardware

- 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-ethernet-for-raspberr>



<https://ebay.com>

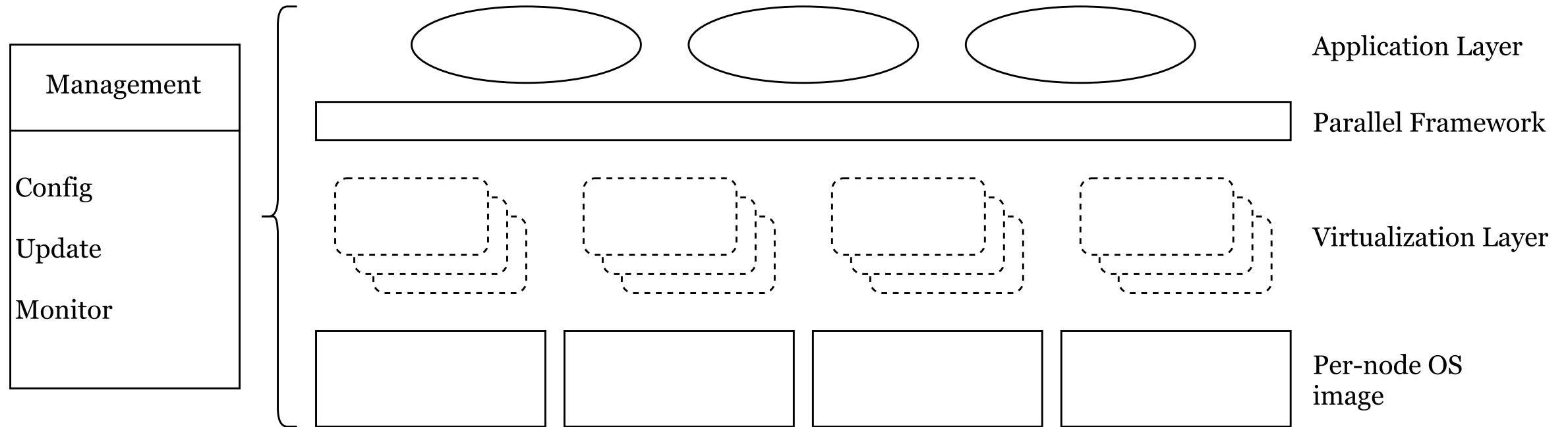


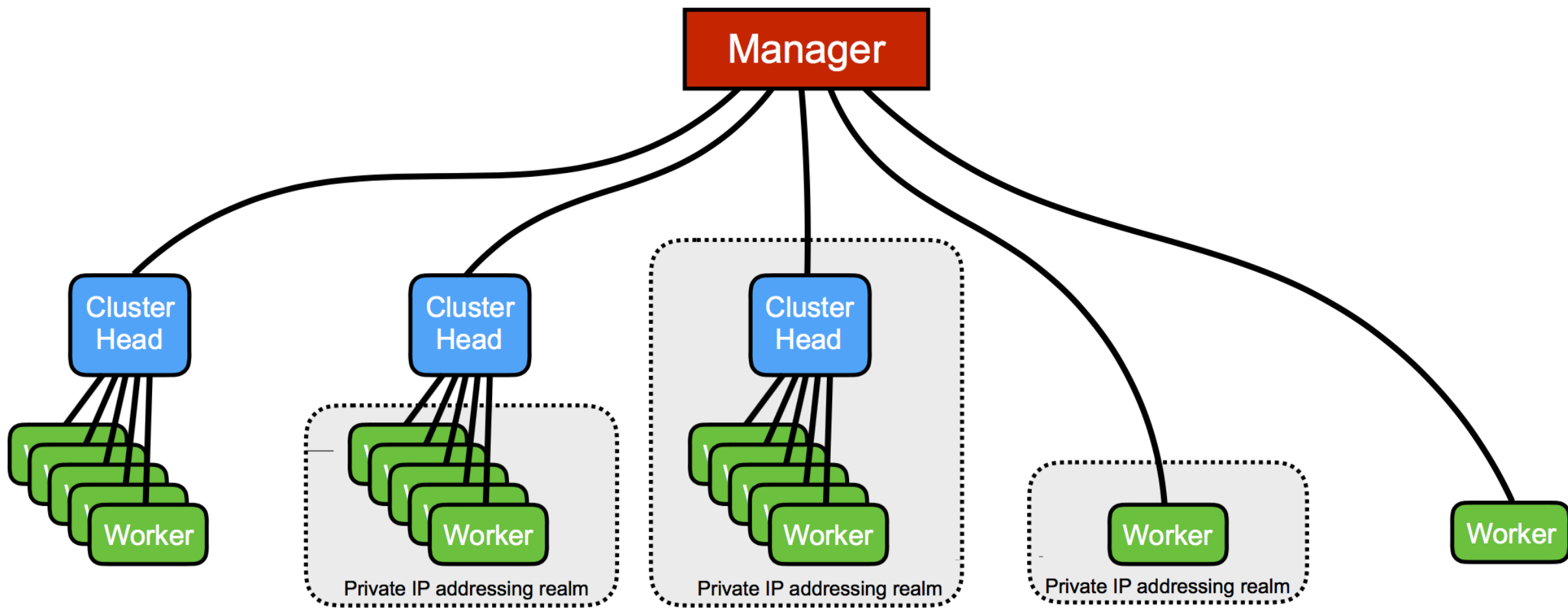
PiStack



- 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

Federated Management





Challenge: System Update

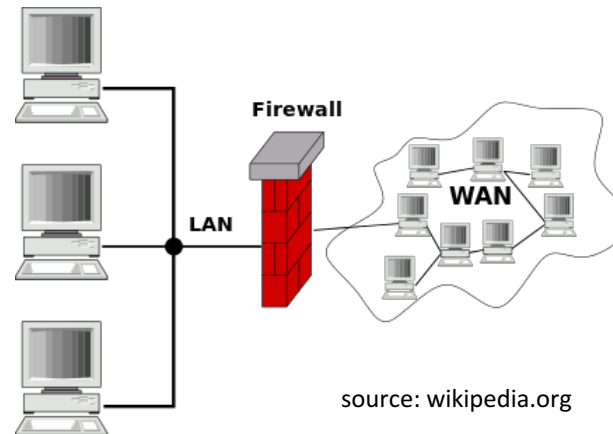
- Update system is critical
- Limited (or no) physical access
- Heterogeneous Network
 - Some nodes are behind NATs (e.g. residential) or Firewalls (e.g. university)
- Single-point of failure
- Scalability
 - Denial of Service attack on update server
- Existing tools
 - Requires direct SSH access
 -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



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



source: airpi.es

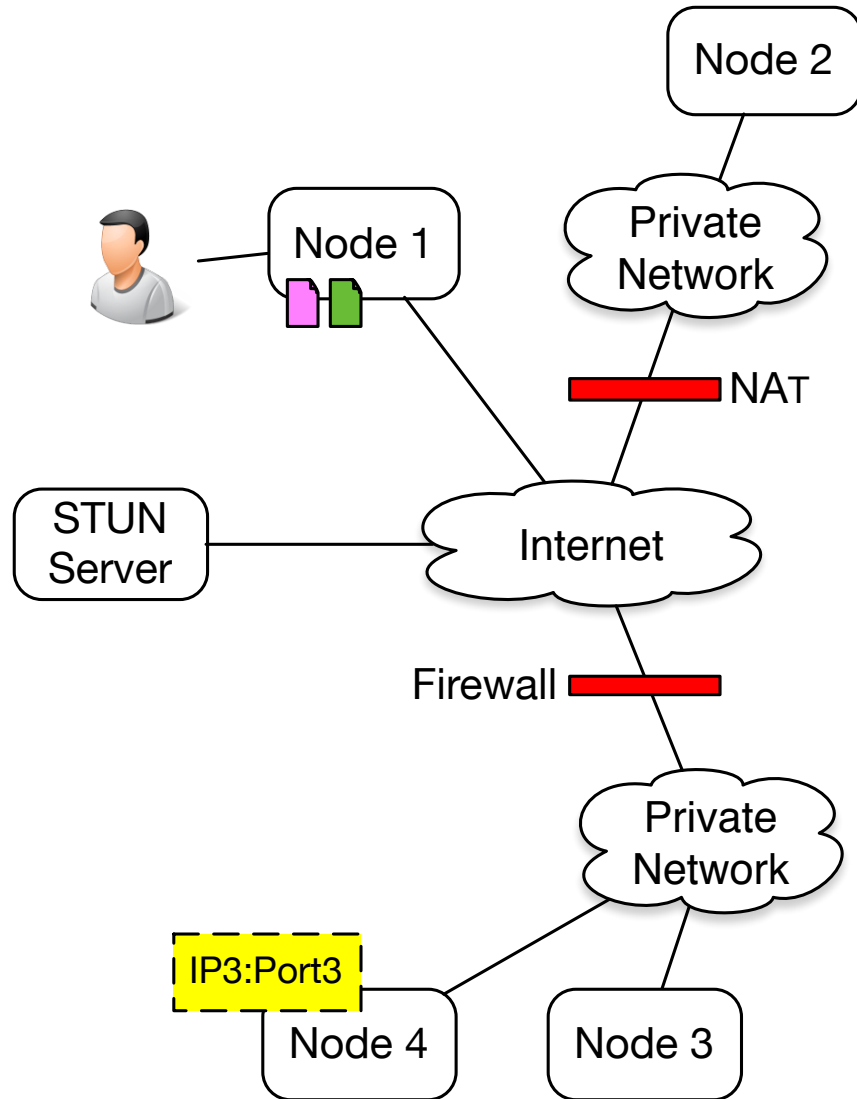


source: wikipedia.org

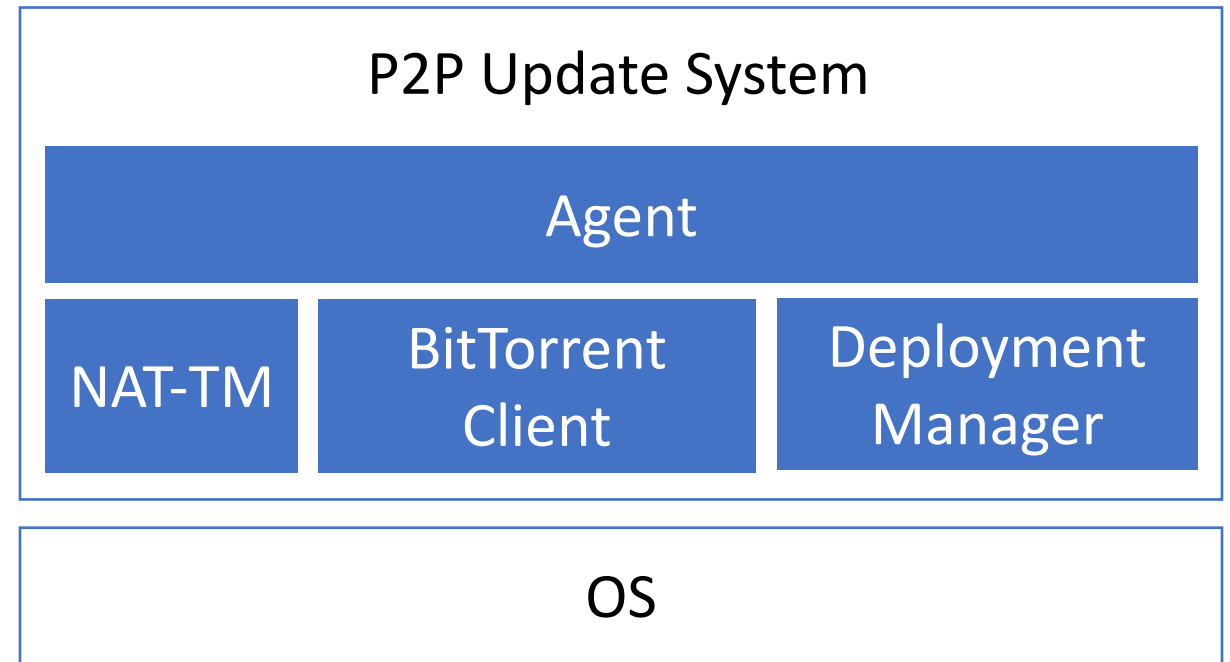


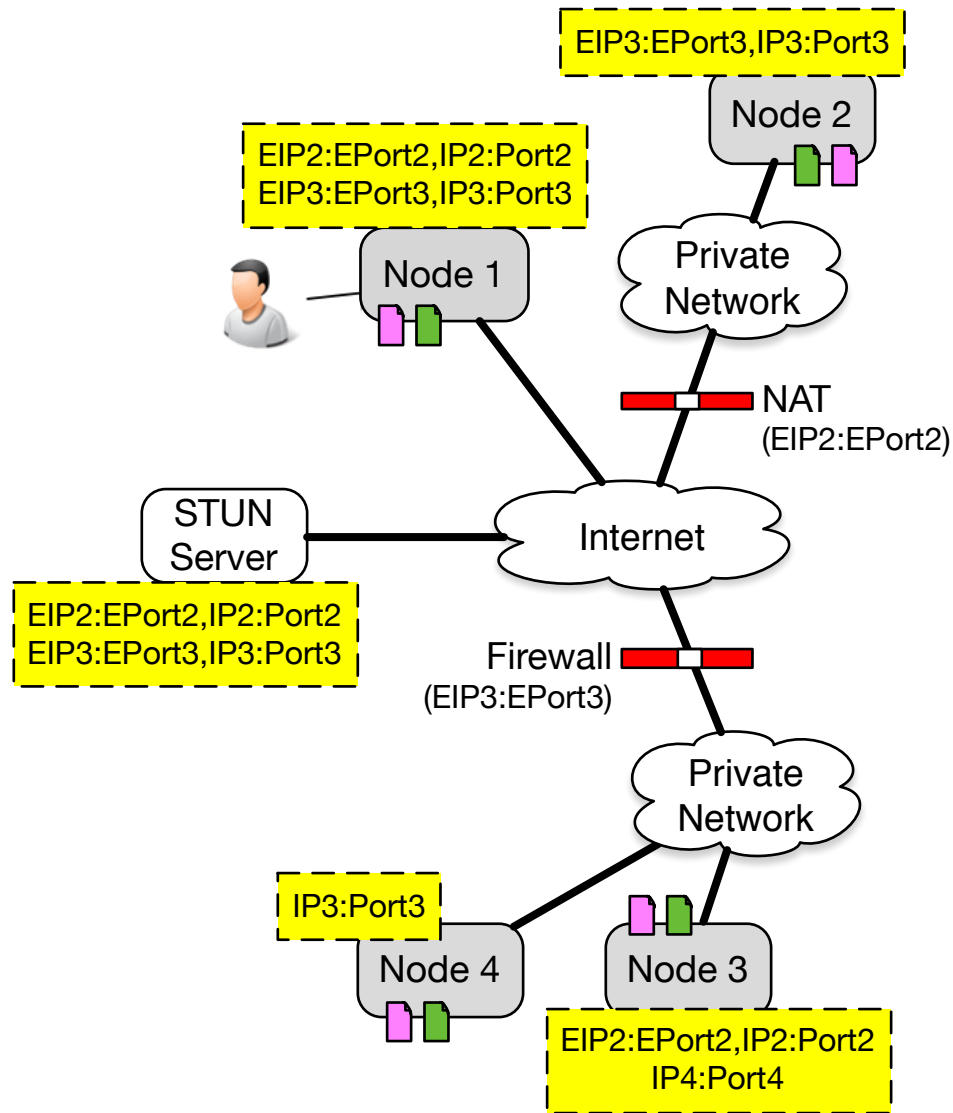
source: Geeky Gadgets
(<http://bit.ly/2BCQRUL>)

Peer-to-Peer Secure Update



○ node ○ updated-node 📄 torrent-file 📄 update-file





○ node ◐ updated-node 📄 torrent-file 📄 update-file

Torrent-file++

Torrent-file (Standard)

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

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

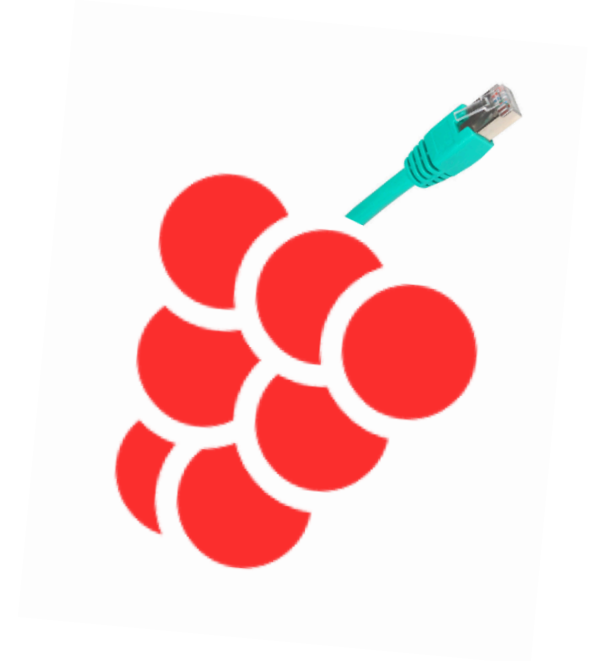
Show/Hide | List Operations | Expand Operations

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

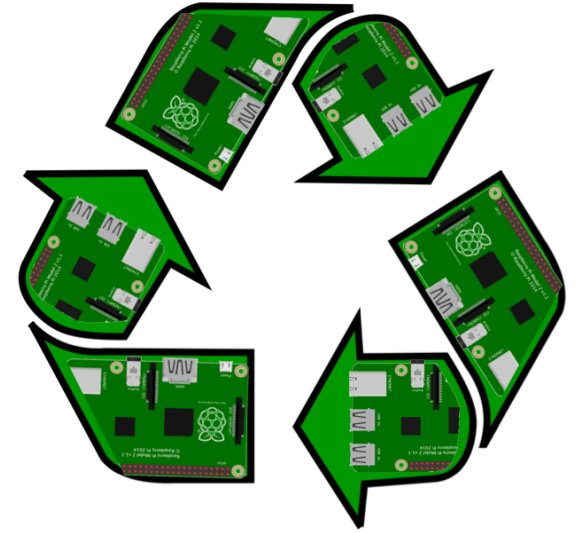


Others

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

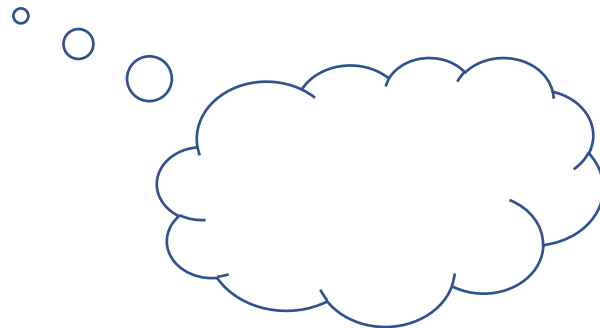
how can you help?

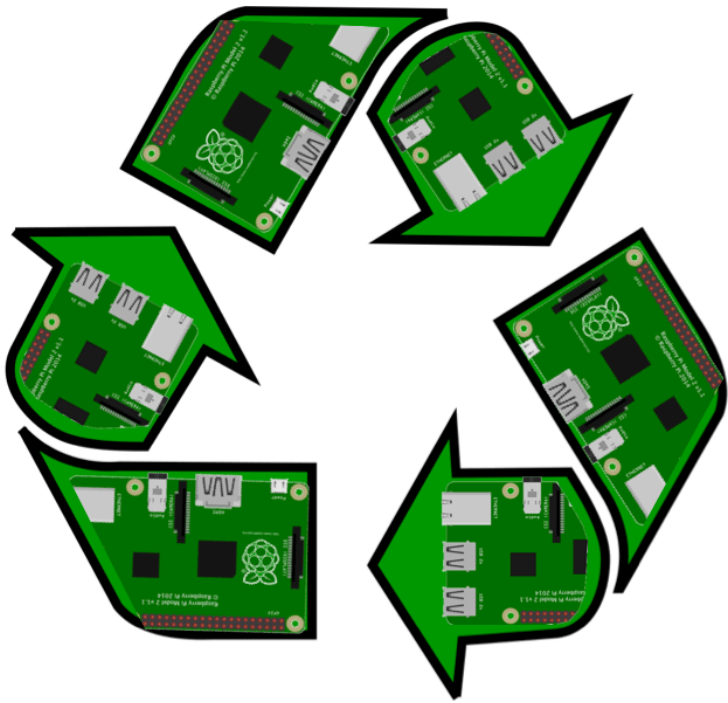
- Current: 500+ nodes across 4 sites
- donate your unwanted pi boards
 - see picycle.org



FREEPOST PICYCLE

- suggest use cases (workloads) for the platform





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!