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Experimenting During Lockdown: The Importance of Remote Testbeds in a Post COVID-19 World

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Scope of Disclosure	Whom it may concern
Head of Information Owner Section	**Mahesh Sooriyabandara (mahesh@toshiba-trel.com)**

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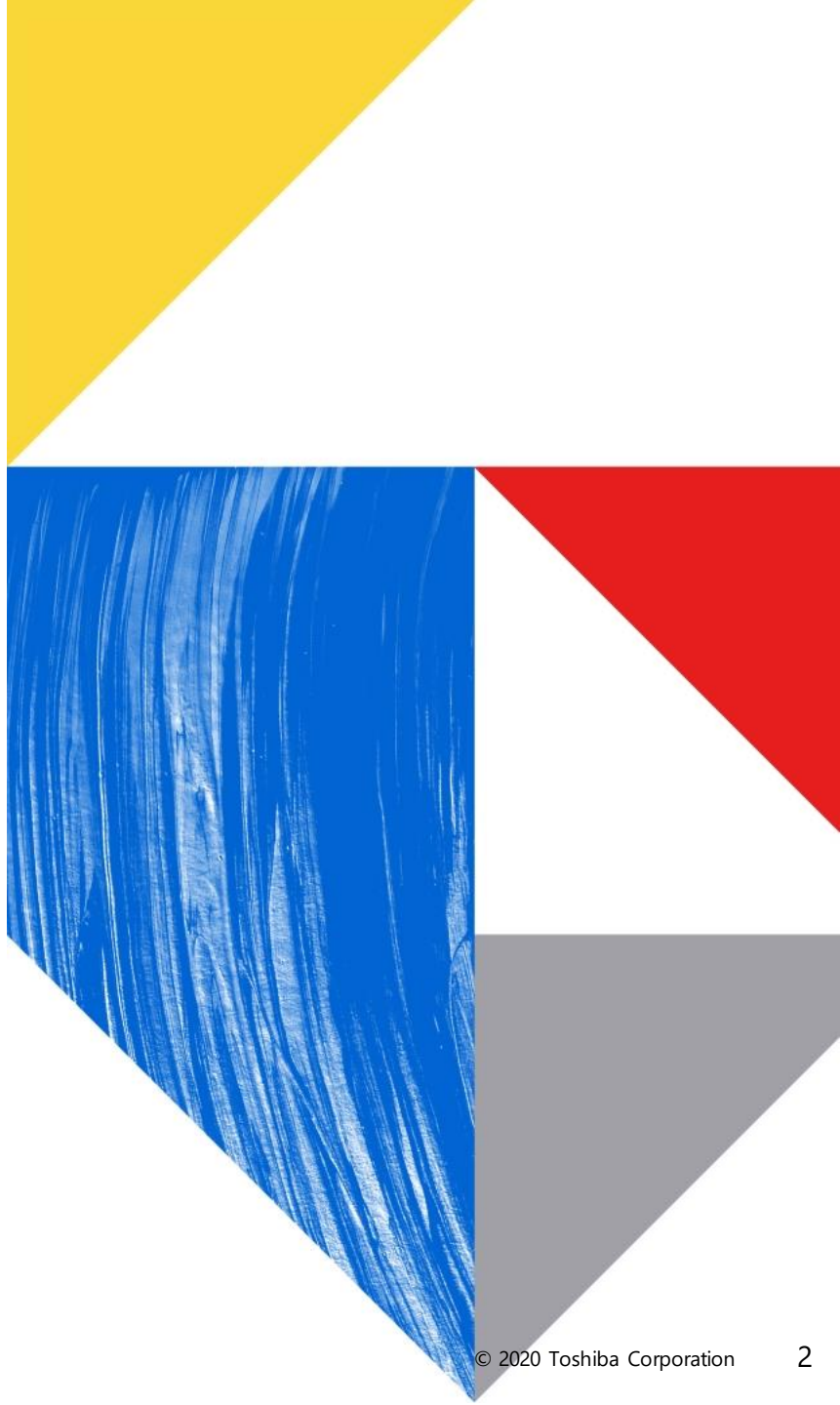
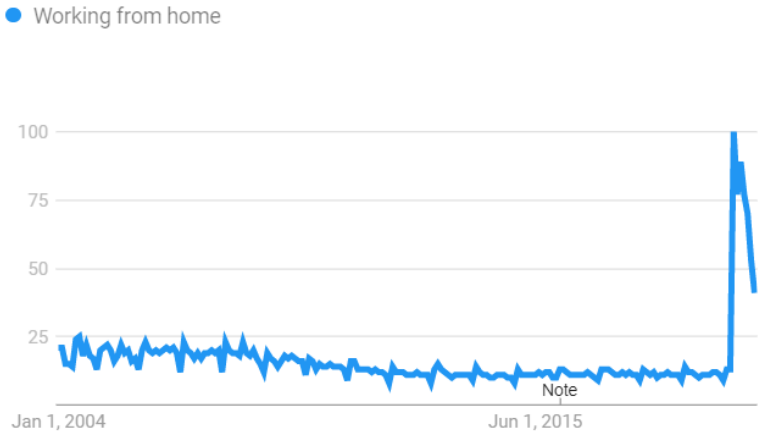
COVID-19 and the “New Normal”



From the Office to Working-From-Home

Much of society has still not returned to the office.

- Social distancing restrictions due to COVID.
- Many just don't want to!
  - Essentially a pay rise.
  - Flexibility + work/life balance.
- Particularly pronounced in Anglo-Saxon countries.
  - Historically liberal market economies have less of a balance than coordinated market economies.



[1]

[1]

1	United Kingdom	100
2	Ireland	69
3	Australia	61
4	South Africa	48
5	New Zealand	45

1. https://trends.google.com/trends/explore?date=all&geo=US&q=working%20from%20home

From the Office to Working-From-Home

While WFH is great for some, it's a mixed bag for others.

- Certain jobs just can't be done remotely.
- Strain on close relationships.
- The home **isn't** the office!

Social distancing at universities is forcing remote teaching.

- Does this reduce the quality of education?
- Does this reduce the value of a degree?

…What does this mean for us as researchers?

Lockdown Lessons in Testbed Management

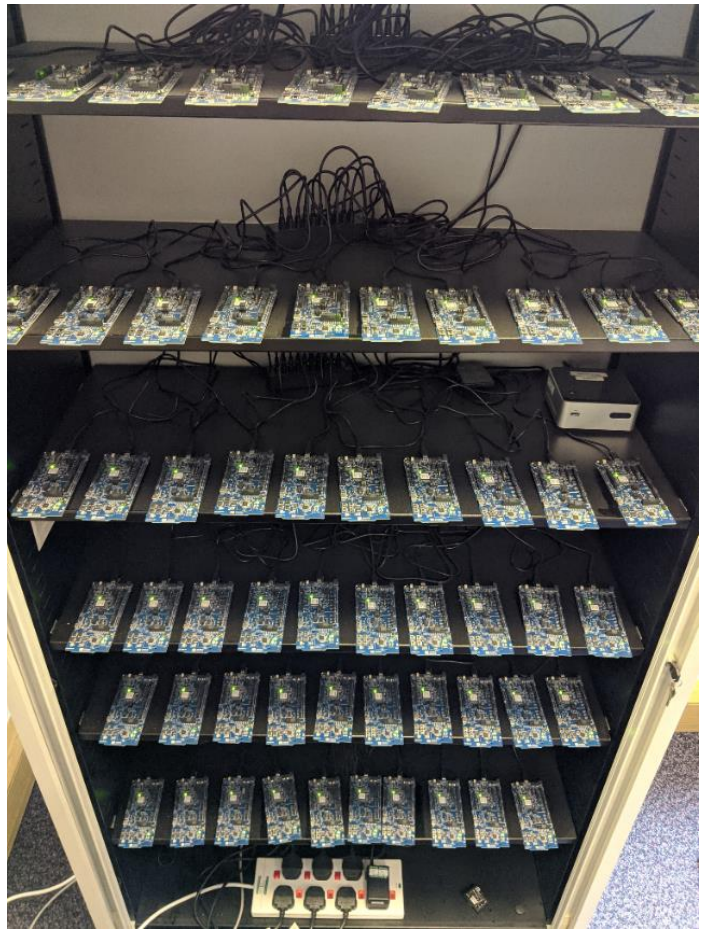
As researchers, we can't take everything home…

A testbed setup can be incredibly complex and consist of many devices (see right). When lockdown happened luckily we had already set up…

- Remote services to use our internal testbeds.
- Remote tools to maintain our internal testbeds.

At first…

Later…



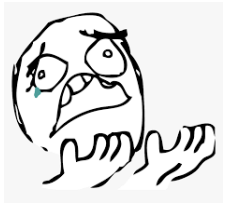
Toshiba BRIL Internal Testbed

March: Before Lockdown…
Nodes: 21

Toshiba BRIL Internal Testbed

June: MSc students arrive…
Nodes: 11

Toshiba BRIL Internal Testbed



August: Redecorating…
Nodes: 9

What Have We Learned?

Students are **THE WORST**.

With no one around to maintain it, 12 nodes were cannibalized for other projects. Testbeds require…

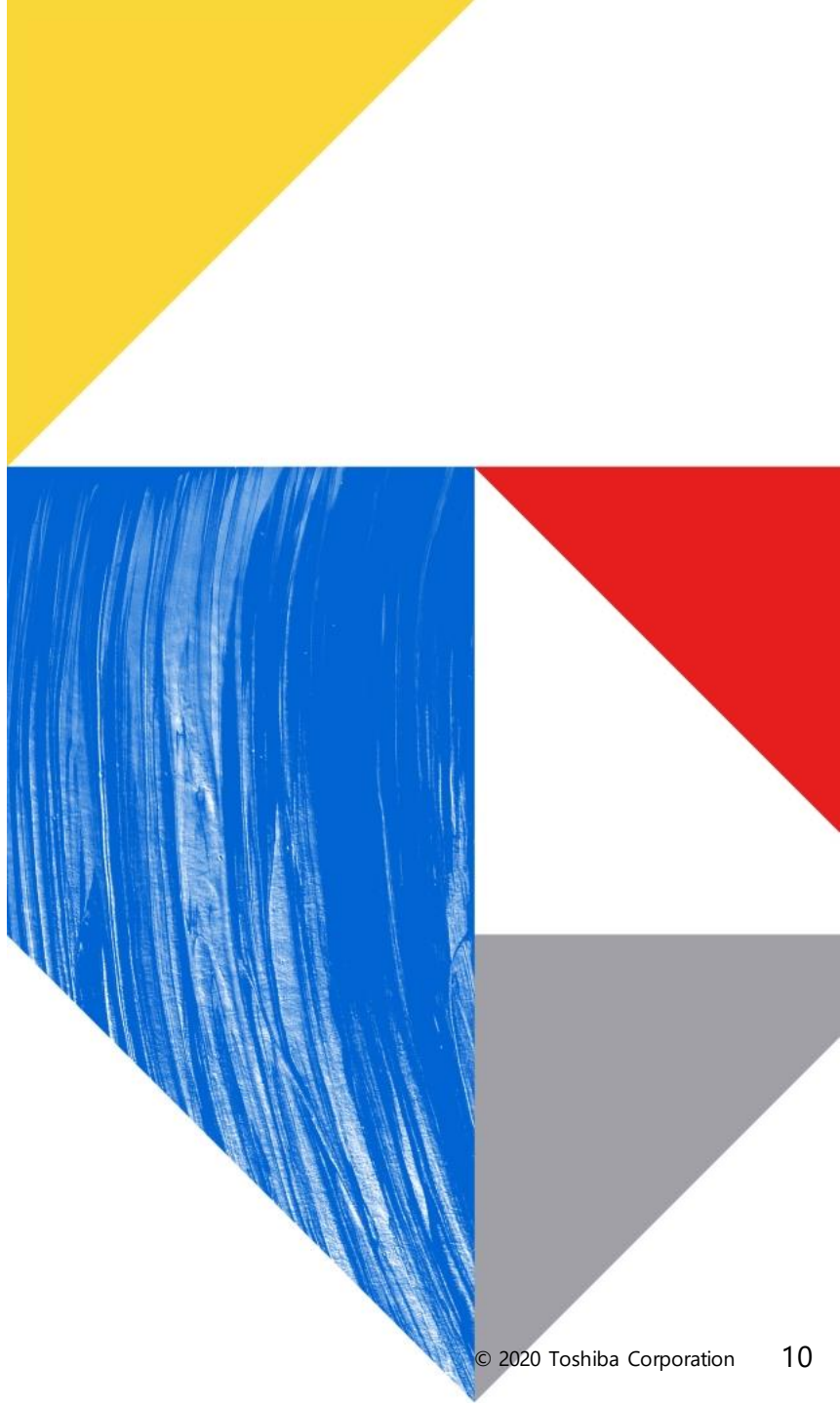
- Time.
- Effort.
- Constant maintenance and monitoring.

At the start however…

- Easier to perform experiments.
- Easier to log and anlyise data.
- It can be done from ANYWHERE

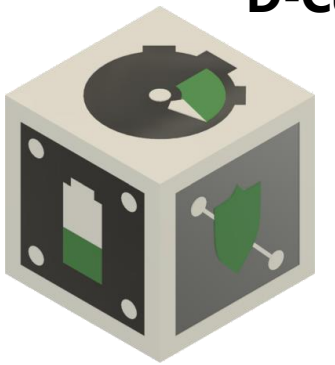
02

Remote Testbeds in the Low-Power Wireless Community



Popular Open Testbeds in the Low-Power Wireless Community

D-Cube[1]



TU Graz
Graz University of Technology

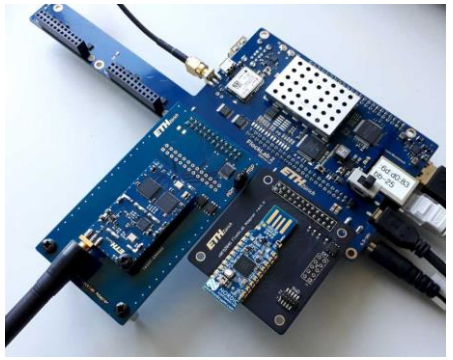
FIT-IoT[2]

FIT IOT-LAB

Indriya2[3]

NUS
National University of Singapore

FlockLab2[4]

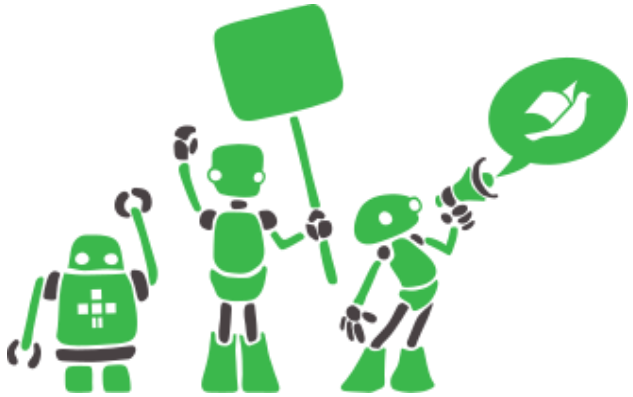


ETH zürich

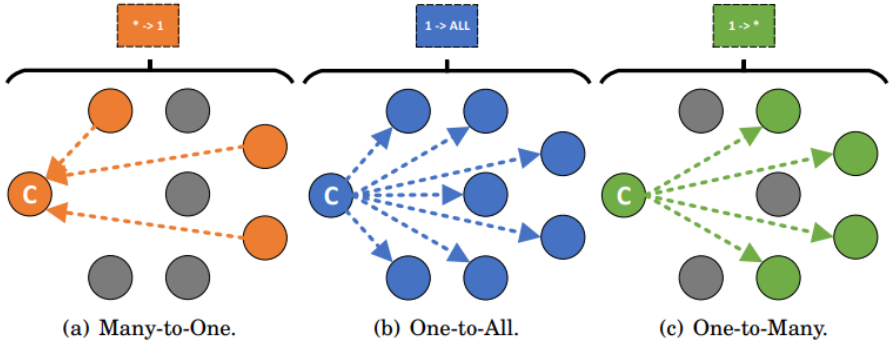
1. https://iti-testbed.tugraz.at/wiki/index.php/Main_Page
2. https://www.iot-lab.info/
3. https://indriya.comp.nus.edu.sg/
4. https://tec.ee.ethz.ch/research/networked-embedded-systems/flocklab.html

Common Features / What Makes a Good Remote Testbed?

Open Access + Open Tools

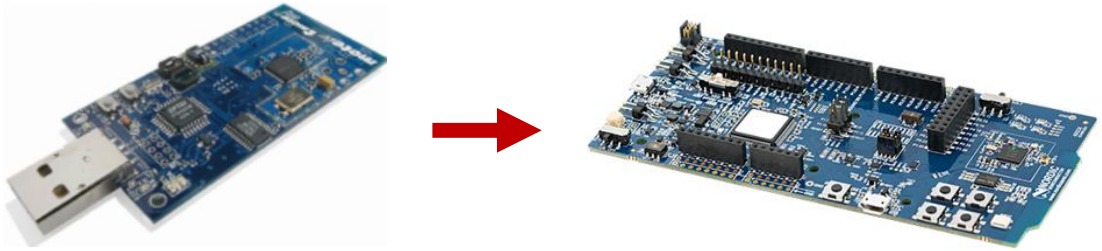


Standard Use-Cases/Scenarios

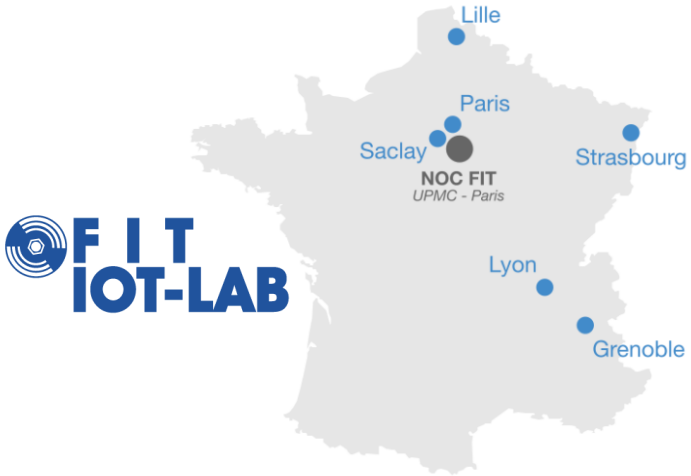


(a) Many-to-One. (b) One-to-All. (c) One-to-Many.

Support for Modern Devices…



Maintenance and Scalability…



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UMBRELLA Multi-Radio IoT Testbed

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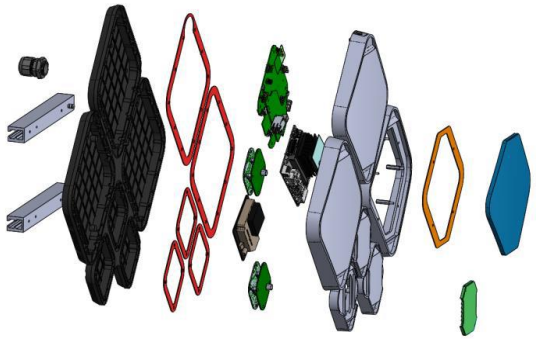
South Gloucestershire Council

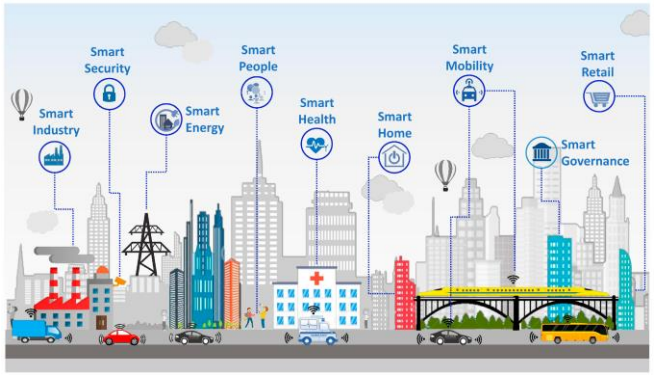


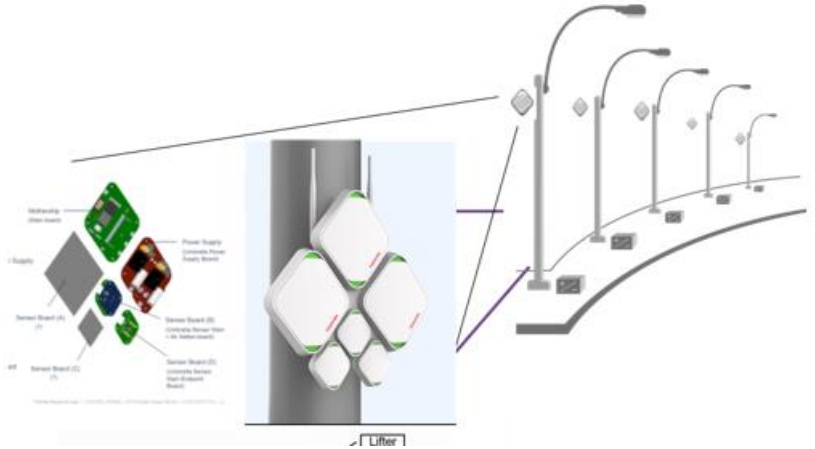
UMBRELLA: What is it?

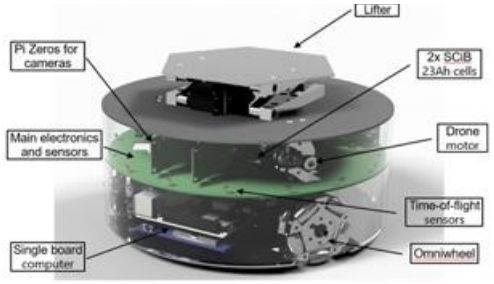
Open City Sensing

Wireless Testbed

Warehouse Robotics







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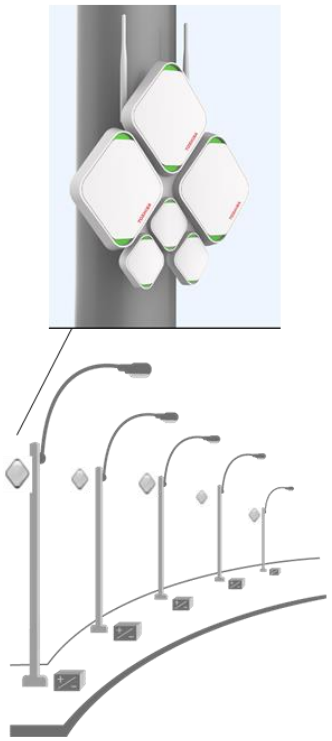
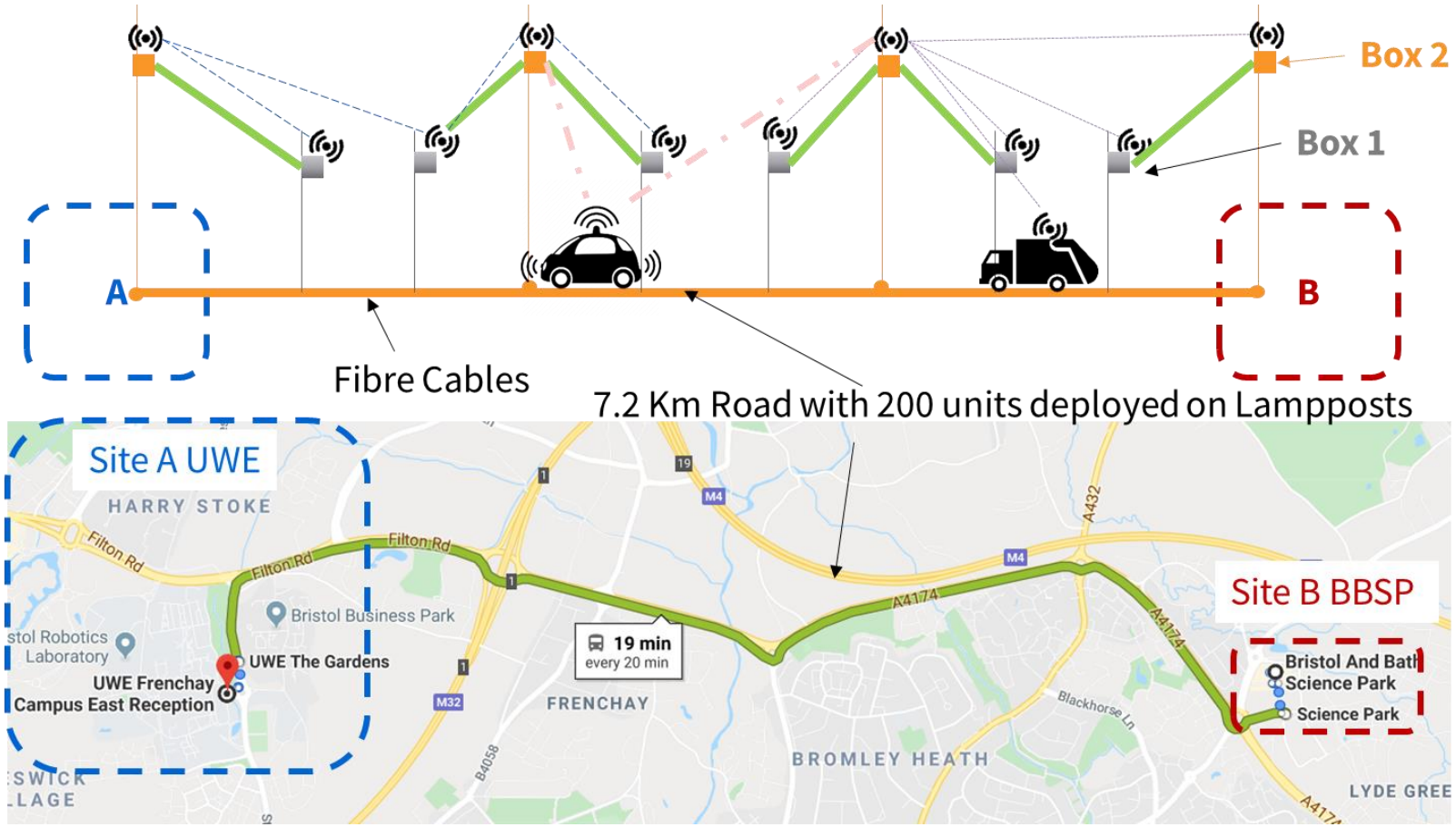
A Single Unified Platform

UMBRELLA: Where is it?





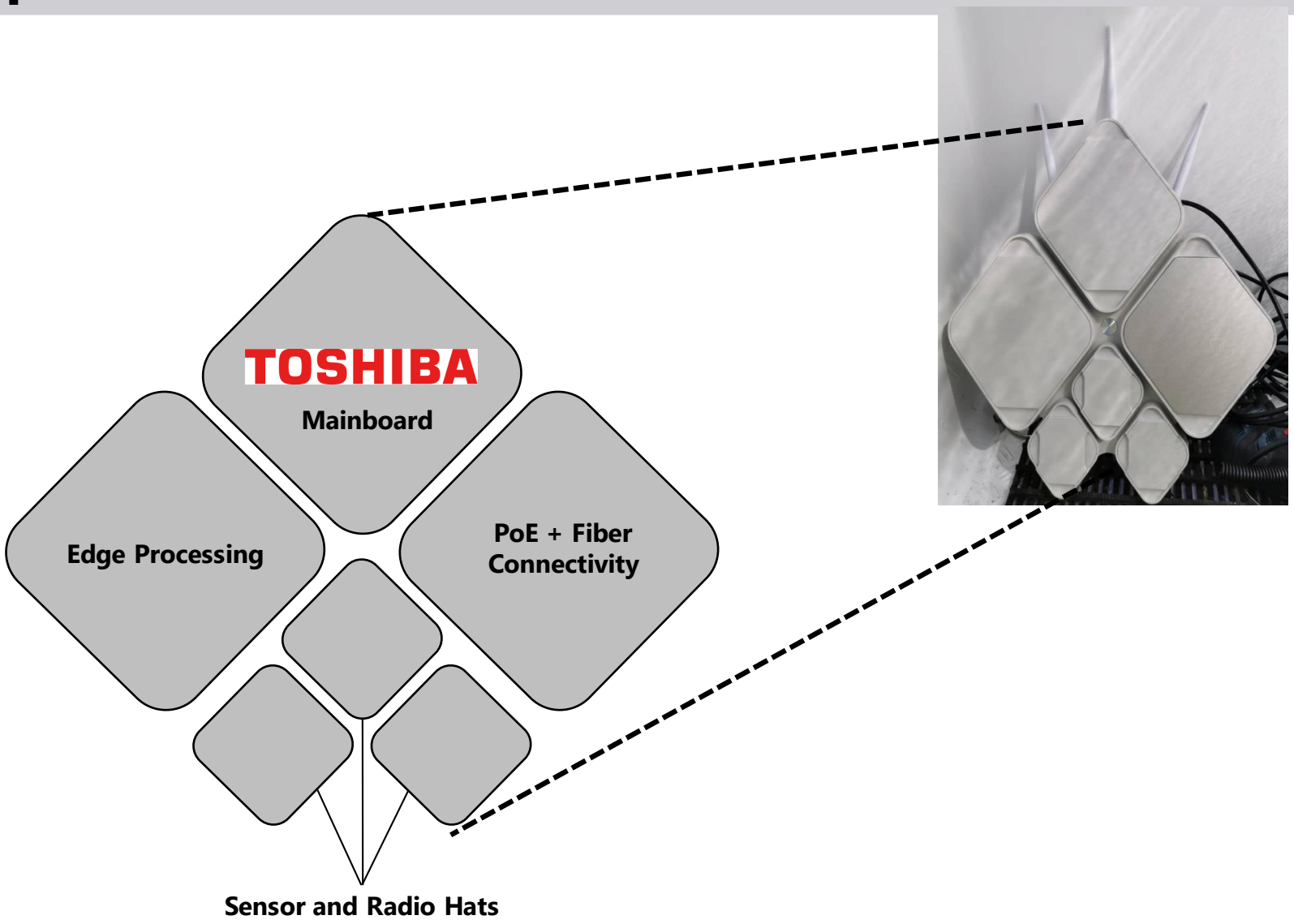
UMBRELLA: An Example Node

A Node for All Use-Cases

Modular Hardware
- One node, many hats

Experimental Radios
- IEEE 802.15.4 (2.4 GHz)
- IEEE 802.15.4 (Sub-GHz)
- LoRa
- LoRa 2.4 GHz
- BLE 1M/2M/500K/125K

Sensors
- Many!

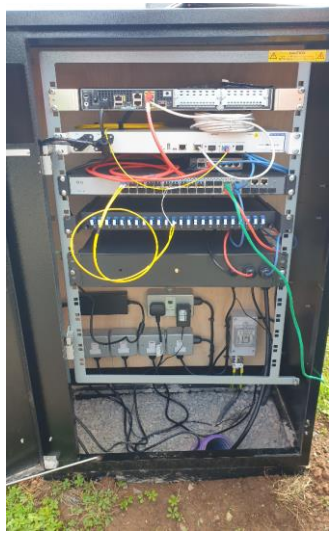


UMBRELLA: Backend System

Challenge: How do you make a testbed "indestructible"?

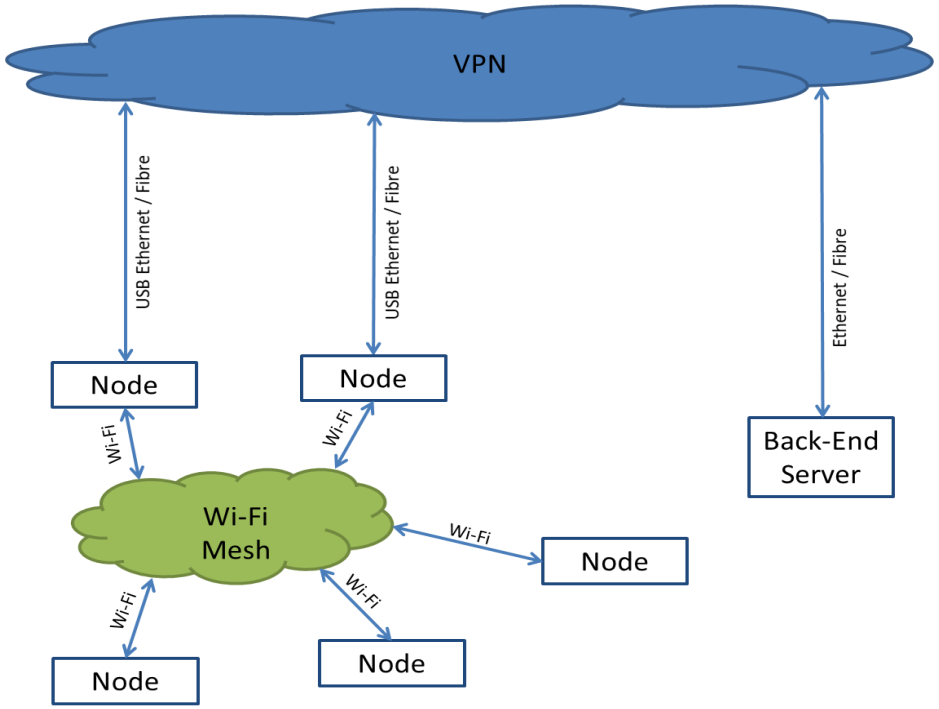
...backups, backups, backups!

Fiber



WiFi Mesh

Cellular



UMBRELLA: Initial Deployment

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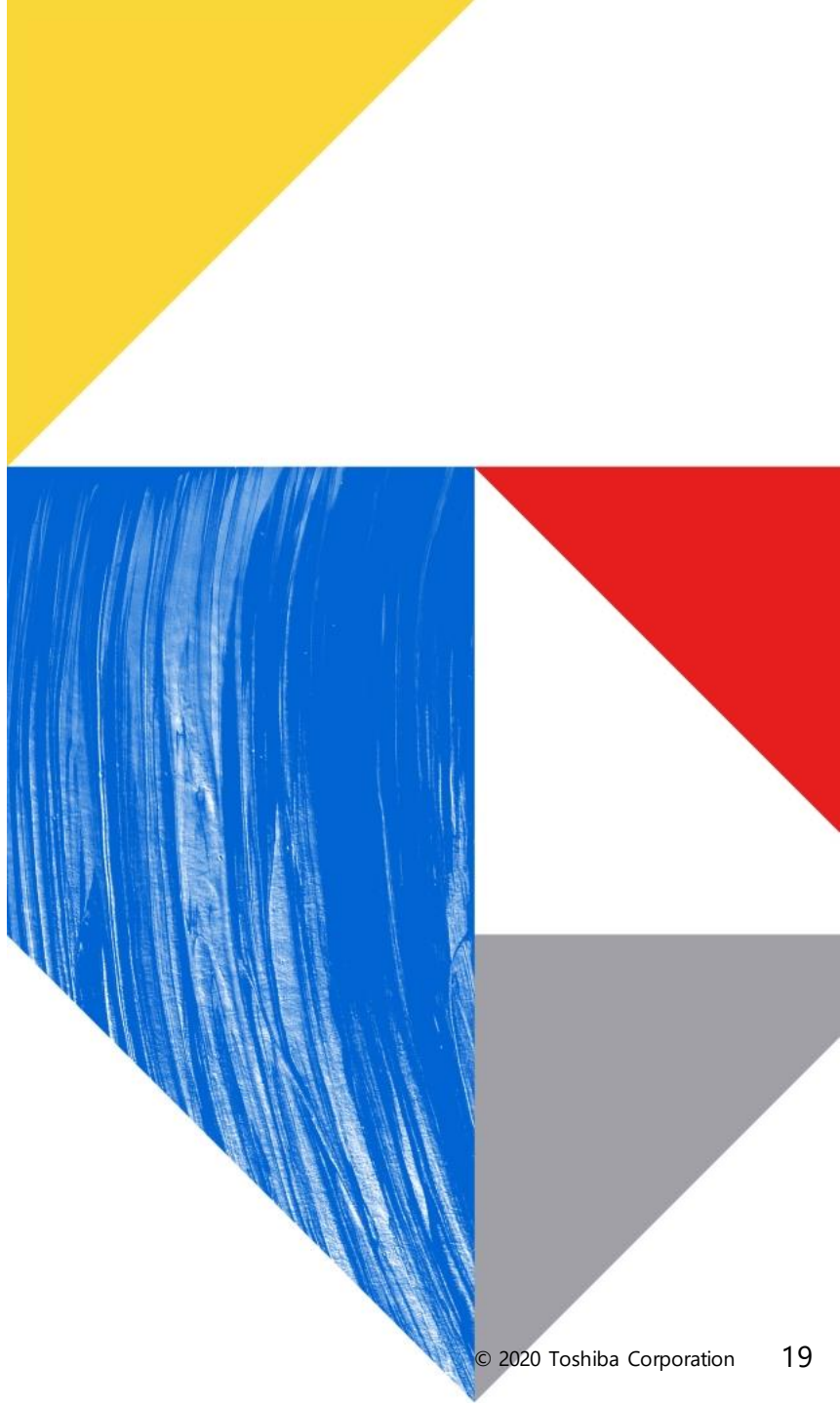
Post-COVID: Challenges and Opportunities for Remote Experimentation



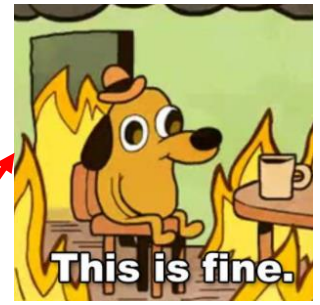
Post-COVID: Challenges

Building a remote testbed already faces significant challenges/hurdles

Including but not limited to…

- Planning permission.
- Safely deploying equipment.
- The "Tin Foil Hat Brigade"
- Temperature / Precipitation
- Tampering
- **Actual** Bugs

… and many more.



Post COVID: Challenges

COVID restrictions add to these challenges…

- Social distancing delays deployment.
- Orders and purchases are delayed.
- Decisions need to be made virtually

Some things remain the same…

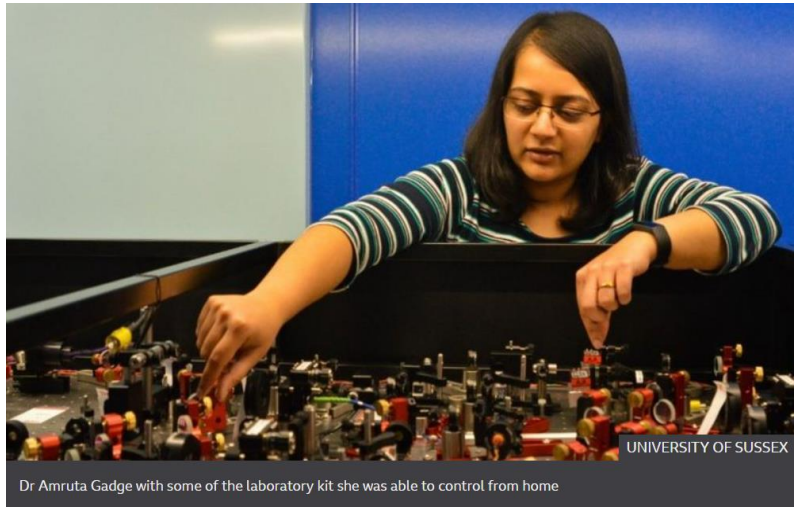
- It's not always sunny In Bristol ☹

Post-COVID: Opportunities

Open access and collaboration is not a bonus, but a necessity in a Post-COVID world…

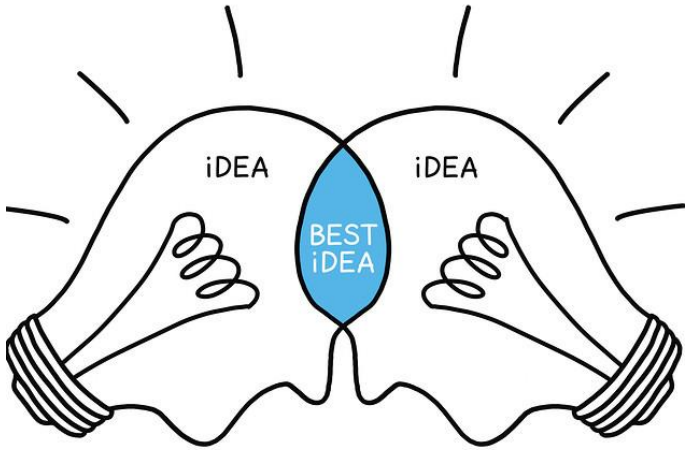
- Overcome social restrictions.
- Adapt to the changes in how we work and teach.
- Innovation in the **types** of Remote Testbeds
- Fosters collaboration and allows resources to be pooled.
- It's makes life **easier!**

Remote Laser Testbed (University of Sussex) [2]



Dr Amruta Gadge with some of the laboratory kit she was able to control from home

 [1]



1. Justin Metz
2. https://www.bbc.co.uk/news/technology-54028720

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