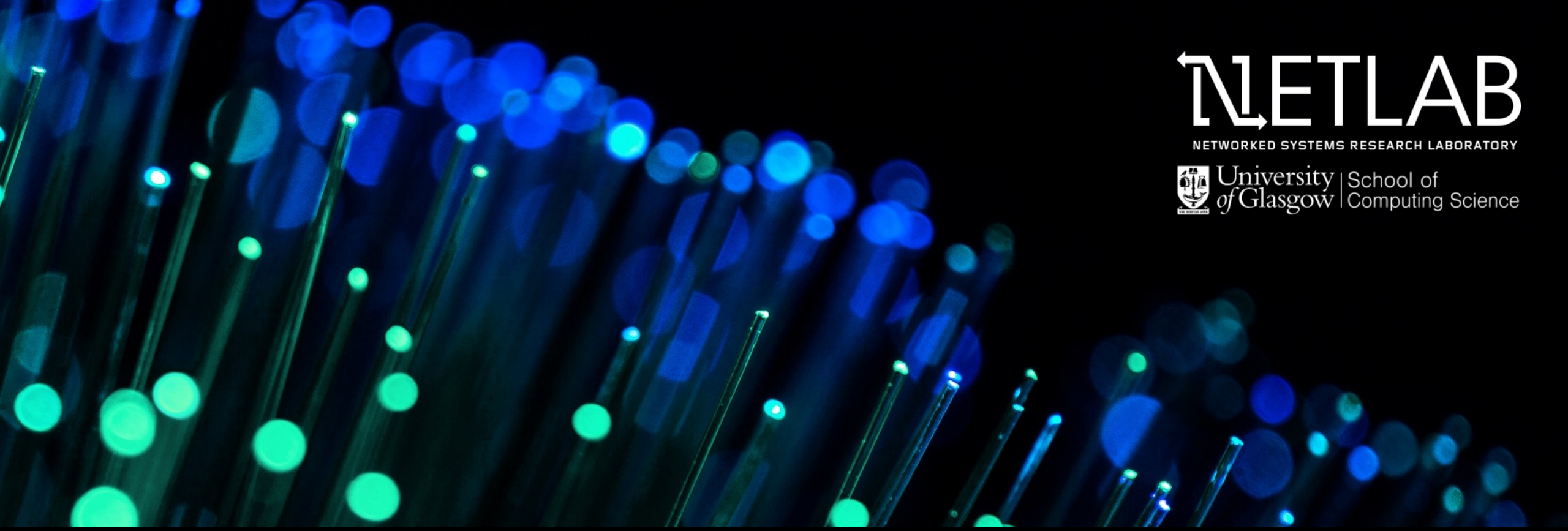

NETLAB
NETWORKED SYSTEMS RESEARCH LABORATORY
University of Glasgow | School of Computing Science

Glasgow Network Functions: From Data Centres to Unmanned Vehicles

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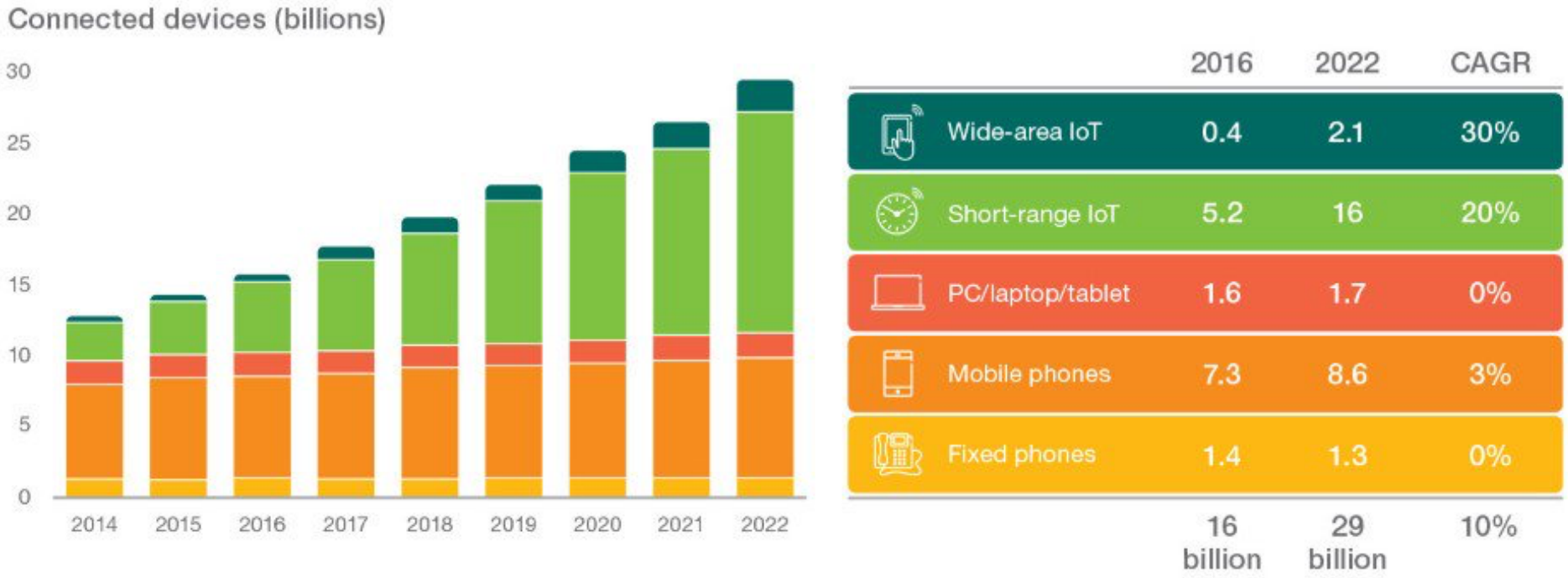
About Netlab, University of Glasgow

- University of Glasgow, United Kingdom
  - Fourth oldest university in the English-speaking world and one of Scotland's four ancient universities. Founded in 1451.
- Networked System Research Laboratory “Netlab”, School of Computing Science
  - Website: https://netlab.dcs.gla.ac.uk
  - Team: 3 academics, 4 researchers, 7 PhD students
  - Director: Dr. Dimitrios P Pezaros
- Research on SDN, NFV, mobile edge, network security and data plane programmability, resilient infrastructure …
- Project partners include: BT Google airbnb Microsoft ARM HUAWEI

Number of connected devices



Source: Ericsson IoT forecast
https://www.ericsson.com/en/mobility-report/internet-of-things-forecast

Increased expectations

- Future networks are expected to support
  - Context-aware
  - Ultra-reliable
  - User-specific network services
- Connected by
  - High-bandwidth and
  - **Low-latency** connections

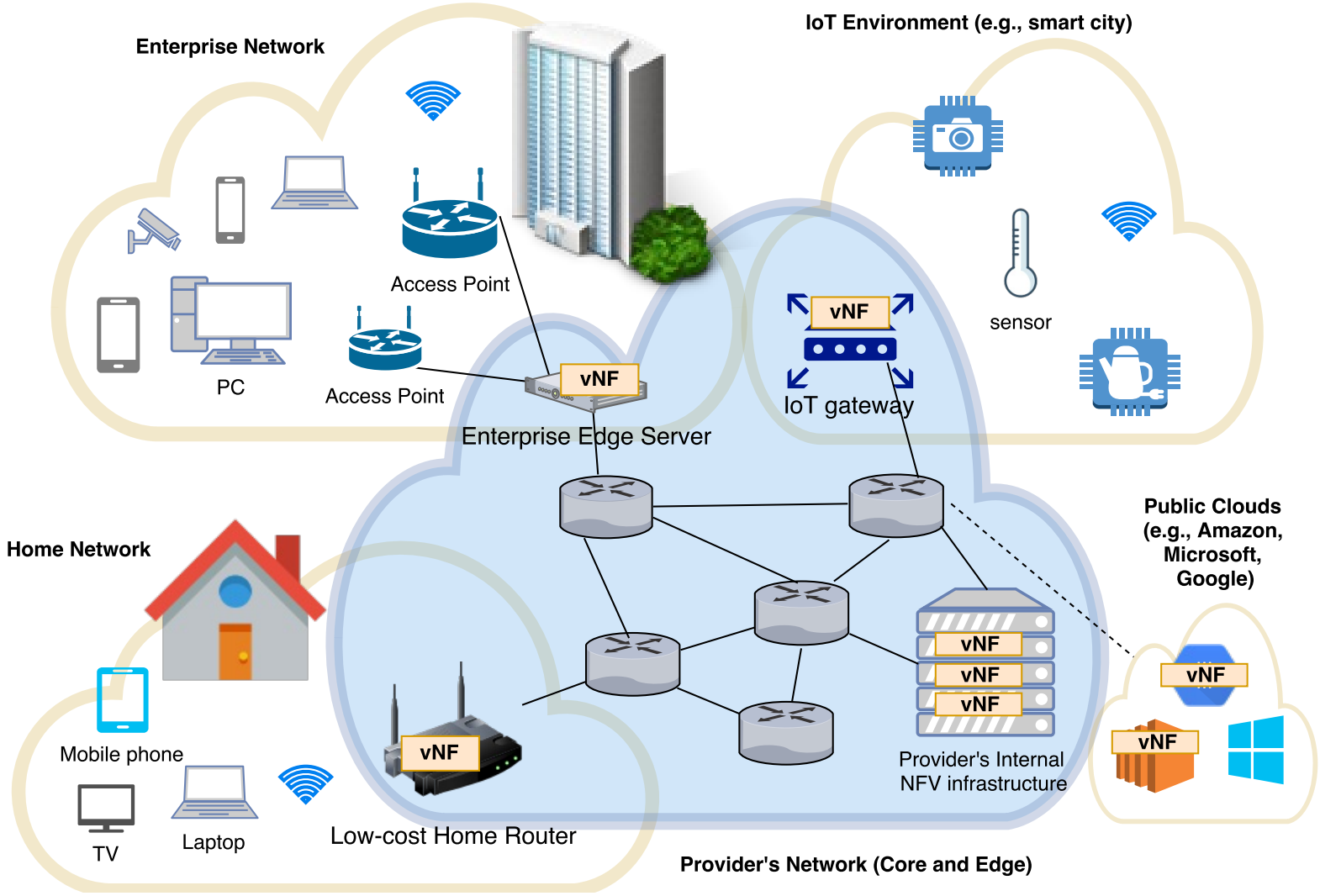
Example services: video content caches, user-specific firewalls, DDoS mitigation modules, etc.

Opportunities with Edge NFV

One way to solve these challenges is to
bring Network Function Virtualization to the Network Edge

- **Network Function Virtualization**
  - Decoupling network services from hardware and running them in software
  - Used in data centers, in the core of the network
  - *Lacks latency-optimal service orchestration*
- **Multi-Access Edge Computing**
  - Compute infrastructure at the edge of the network
  - Also known as “fog computing”
  - Close proximity to the user => low latency connectivity
  - Services at the edge save utilization for the core

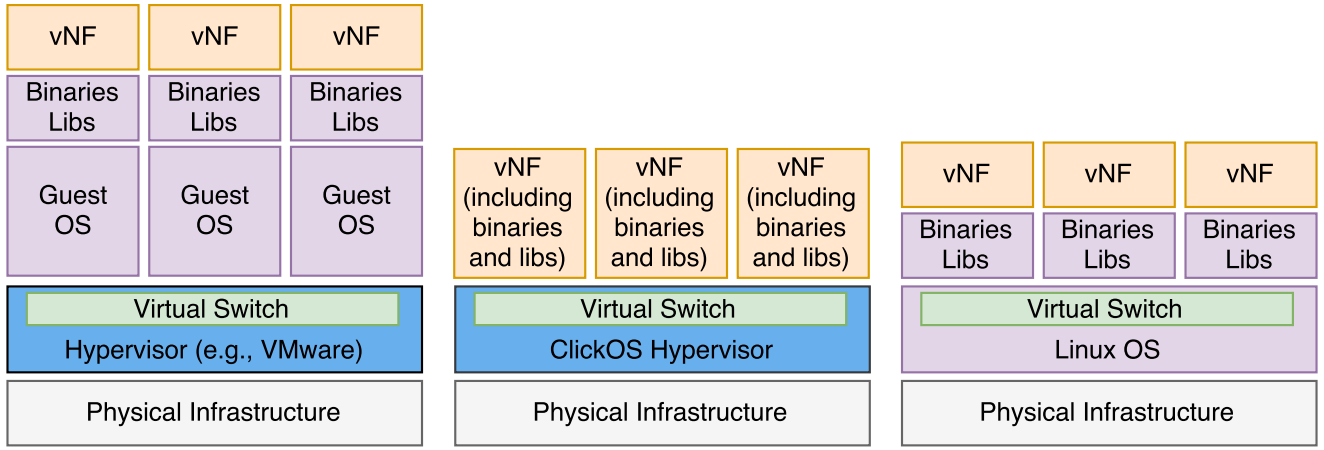
Edge NFV Architecture



Container vNFs

- Lightweight “virtualization”
- Fast create/start/stop/delete
- High performance: small delay, high throughput, low memory footprint

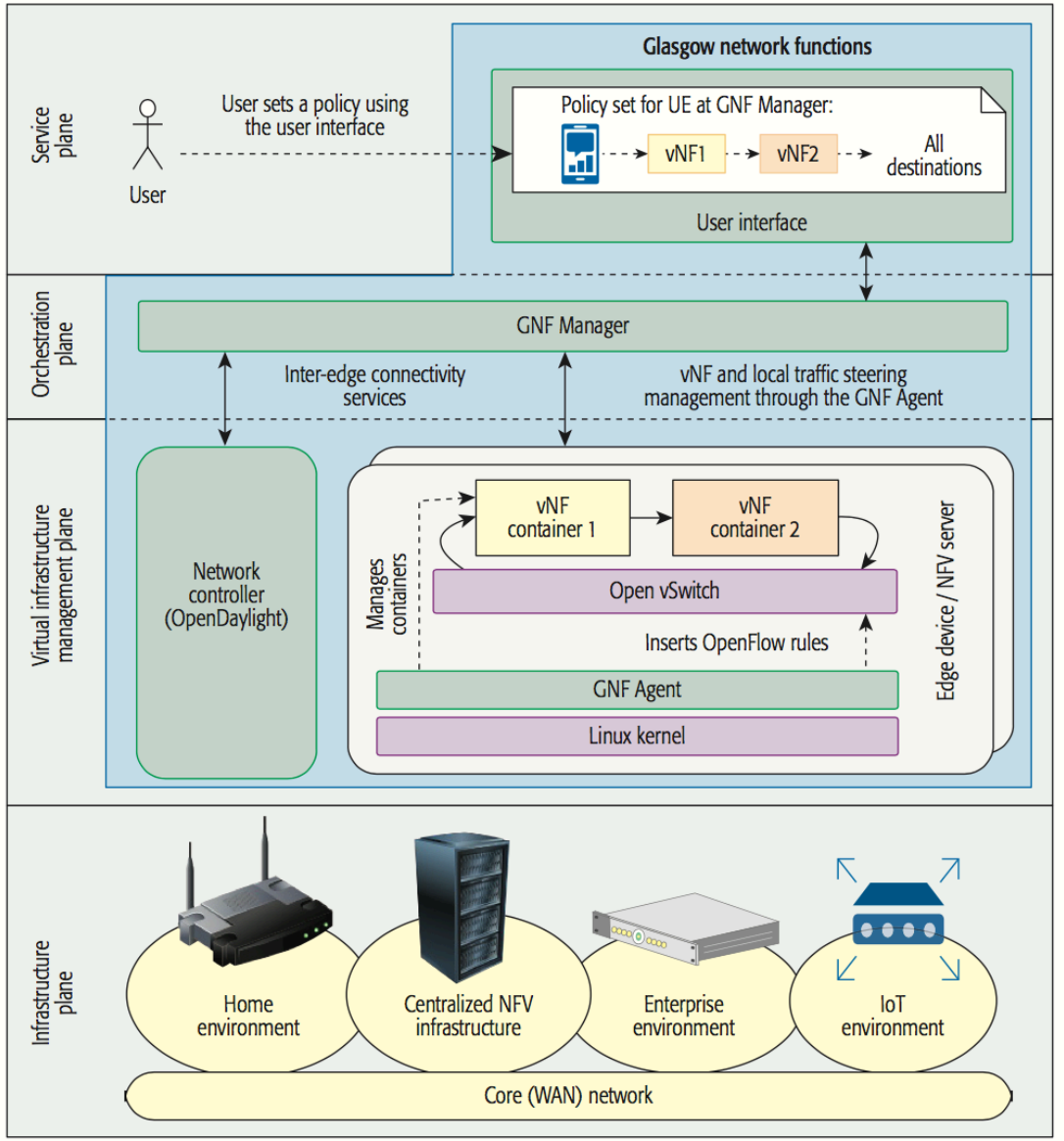
- Reusable / shareable
- Traditional software environment
- Micro-services architecture
- Runs (almost) anywhere!



Glasgow Network Functions (GNF)

Main characteristics:

1. Container-based
2. Minimal footprint
3. Support for vNF roaming
4. End-to-end, SDN-based transparent traffic steering



Source: **Container Network Functions: Bringing NFV to the Network Edge**
by *Richard Cziva* and *Dimitrios P Pezaros* (University of Glasgow), IEEE Communications Magazine, June 2017

Idea: vNFs on unmanned IoT infrastructures

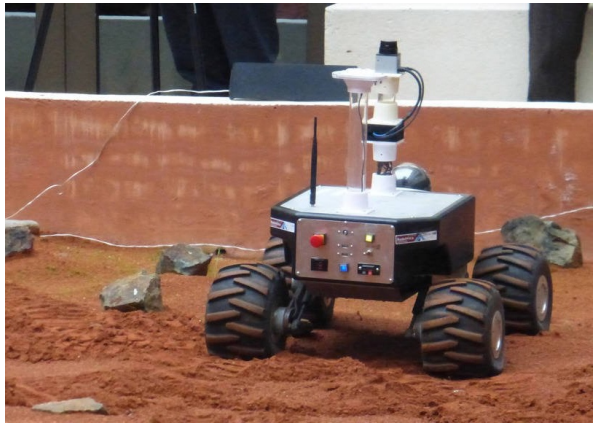
- Focus on: unmanned robots, moving vehicles, sensor nodes
  - Challenges
    - Securing data transmission, malicious activity, fault detection
    - Moving of devices increases complexity of management
    - Networking is hard with moving devices (radio or WiFi?)
  - Opportunities
    - Distributed, closed-loop, low-latency data processing
    - Privacy enhancement (data doesn't have to be transferred to the cloud)
    - Peer-to-peer, ad-hoc networking
    - Increased computational power in the devices (e.g., conventional CPUs, memories)

Source: https://www.sensorsexpo.com/iot-ecosystem

- RAWFIE (Road-, Air-, and Water- based Future Internet Experimentation) is a project funded by the European Commission (Horizon H2020 programme) under the Future Internet Research Experimentation (FIRE+) initiative that aims at providing **research facilities for Internet of Things (IoT) devices**.

RAWFIE resources: nodes that can run vNFs

PlaDyPos



Robotnik

Niriis

Base station

Flexus

Vamos

GNFUV: Glasgow Network Functions for Unmanned Vehicles

- **Identify & Investigate** the opportunities of the Network Edge by experimenting with our lightweight, container-based NFV platform: Glasgow Network Functions (GNF)

- **GNF** will be adopted to run and orchestrate virtual Network Functions (vNFs) in the form of container namespaces onto the RAWFIE constrained UxV network;

- **Showcase** the capabilities of different UxV Devices through GNF to support distributed edge-computing inferential analytics, e.g., outliers detection and predictive regression.

Use-Case: DDoS mitigation in sensor networks

- Imagine sensor nodes being compromised with e.g., Mirai malware, generating malicious traffic
- DDoS mitigation vNFs (e.g., firewall container vNFs) can be deployed in close proximity of these sensors (or on the sensors themselves)

Use-Case: Distributed information processing

- Data generated by various devices can be consumed, analysed, aggregated on nearby devices without transferring data to the cloud
- This saves battery, network utilisation and maintains a fast feedback loop
- vNF allocation can be managed to equalise battery levels

Experimentation has started

Publication (so far)

- Ali, A., Anagnostopoulos, C. and Pezaros, D. P. (2018) On the Optimality of Virtualized Security Function Placement in Multi-Tenant Data Centers. In: *IEEE International Conference on Communications* (ICC 2018), Kansas City, MO, USA, 20-24 May 2018,
- Cziva, R., Anagnostopoulos, C. and Pezaros, D. P. , (2018) Dynamic, Latency-Optimal vNF Placement at the Network Edge. *IEEE Conference on Computer Communications* (INFOCOM 2018), Honolulu, HI, USA
- Harth, N. and Anagnostopoulos, C. (2017) Quality-aware Aggregation & Predictive Analytics at the Edge. *IEEE International Conference on Big Data* (IEEE Big Data 2017), December 11-14, 2017, Boston, MA, USA.
- Harth, N., Pezaros, D. , Anagnostopoulos, C. (2017) Predictive intelligence to the edge: impact on edge analytics. *Evolving Systems*
- Harth, N., Delakouridis, K. Anagnostopoulos, C. (2017) Convey intelligence to edge aggregation analytics. In: Yager, R. R. and Pascual Espada, J. (eds.) *New Advances in the Internet of Things.* Series: Studies in computational intelligence (715). Springer, pp. 25-44.
- Cziva, R. Pezaros, D. P. (2017) Container network functions: bringing NFV to the network edge. *IEEE Communications Magazine*, 55(6), pp. 24-31.

Thank you for your attention!

http://netlab.dcs.gla.ac.uk

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