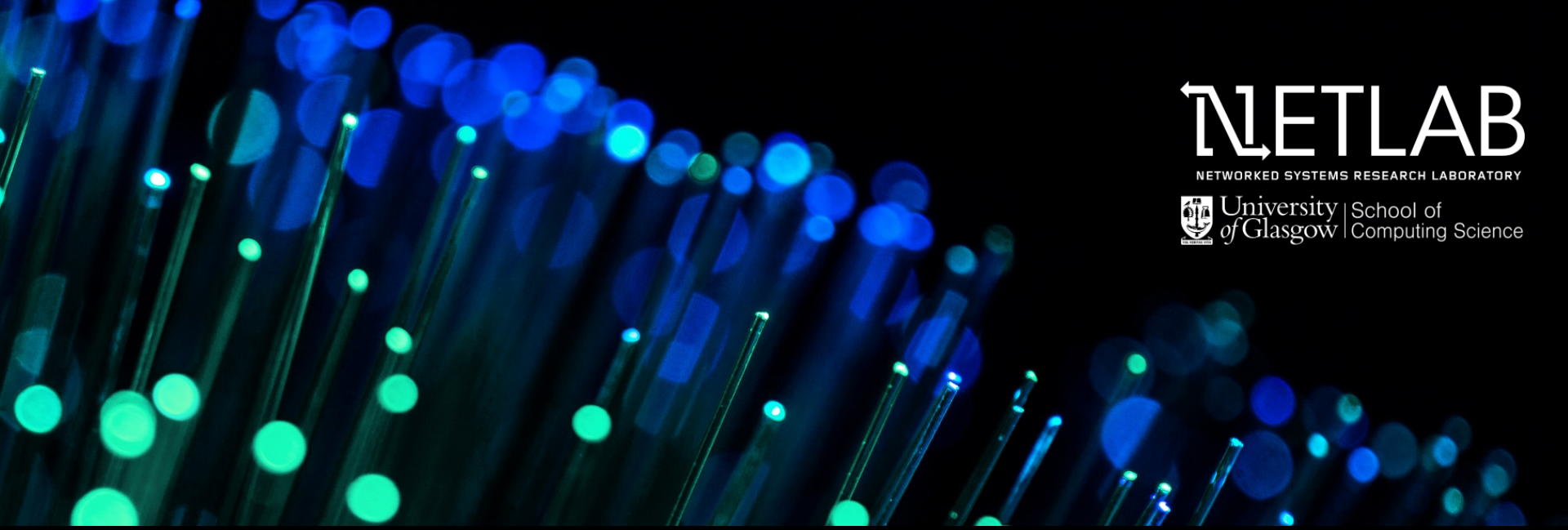


NETLAB
NETWORKED SYSTEMS RESEARCH LABORATORY
University of Glasgow | School of Computing Science

Container Network Functions: Bringing NFV to the Network Edge

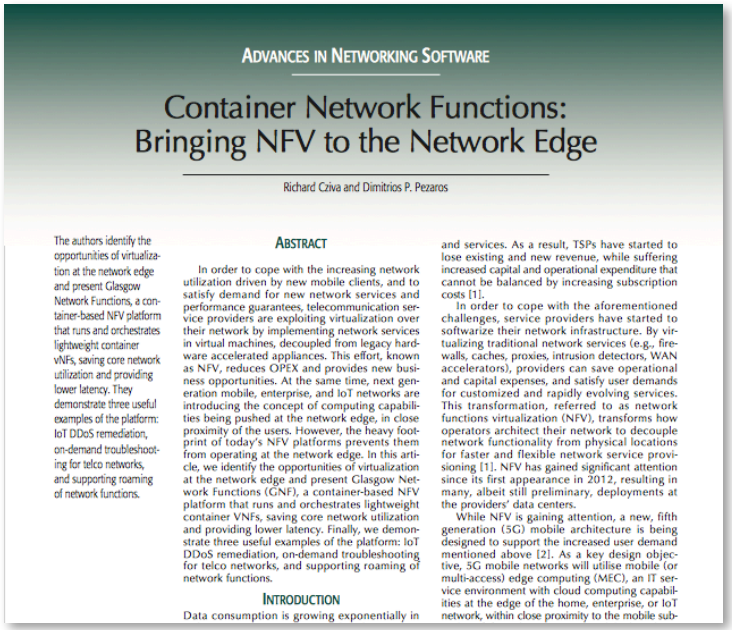
Richard Cziva | University of Glasgow | Richard.Cziva@glasgow.ac.uk | SDN / NFV WORLD CONGRESS 2017, The Hague, Netherlands

About Netlab

- 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 AIRBUS GROUP ARM

Today's talk is based on …

- **Container Network Functions: Bringing NFV to the Network Edge** by *Richard Cziva* and *Dimitrios P Pezaros* (University of Glasgow)
- Published in:
  IEEE Communications Magazine
  Issue: June 2017, Page: 24-31



ADVANCES IN NETWORKING SOFTWARE

Container Network Functions: Bringing NFV to the Network Edge

Richard Cziva and Dimitrios P. Pezaros

The authors identify the opportunities of virtualization at the network edge and present Glasgow Network Functions, a container-based NFV platform that runs and orchestrates lightweight container vNFs, saving core network utilization and providing lower latency. They demonstrate three useful examples of the platform: IoT DDoS remediation, on-demand troubleshooting for telco networks, and supporting roaming of network functions.

ABSTRACT

In order to cope with the increasing network utilization driven by new mobile clients, and to satisfy demand for new network services and performance guarantees, telecommunication service providers are exploiting virtualization over their network by implementing network services in virtual machines, decoupled from legacy hardware accelerated appliances. This effort, known as NFV, reduces OPEX and provides new business opportunities. At the same time, next generation mobile, enterprise, and IoT networks are introducing the concept of computing capabilities being pushed at the network edge, in close proximity of the users. However, the heavy footprint of today's NFV platforms prevents them from operating at the network edge. In this article, we identify the opportunities of virtualization at the network edge and present Glasgow Network Functions (GNF), a container-based NFV platform that runs and orchestrates lightweight container VNFs, saving core network utilization and providing lower latency. Finally, we demonstrate three useful examples of the platform: IoT DDoS remediation, on-demand troubleshooting for telco networks, and supporting roaming of network functions.

INTRODUCTION

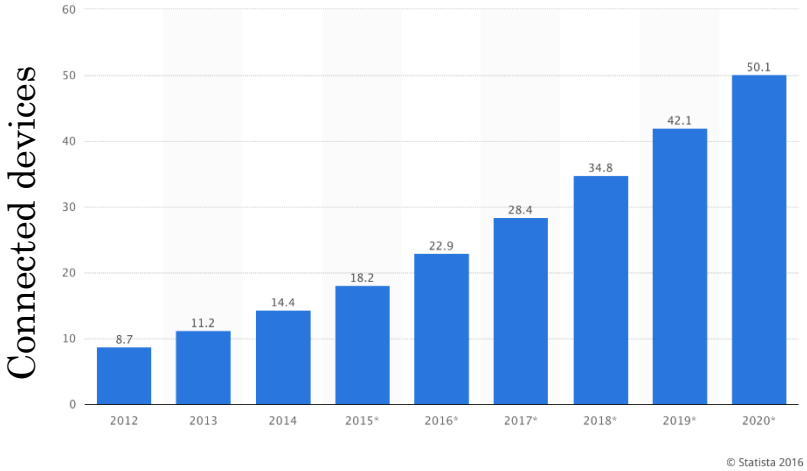
Data consumption is growing exponentially in and services. As a result, TSPs have started to lose existing and new revenue, while suffering increased capital and operational expenditure that cannot be balanced by increasing subscription costs [1].

In order to cope with the aforementioned challenges, service providers have started to softwarize their network infrastructure. By virtualizing traditional network services (e.g., firewalls, caches, proxies, intrusion detectors, WAN accelerators), providers can save operational and capital expenses, and satisfy user demands for customized and rapidly evolving services. This transformation, referred to as network functions virtualization (NFV), transforms how operators architect their network to decouple network functionality from physical locations for faster and flexible network service provisioning [1]. NFV has gained significant attention since its first appearance in 2012, resulting in many, albeit still preliminary, deployments at the providers' data centers.

While NFV is gaining attention, a new, fifth generation (5G) mobile architecture is being designed to support the increased user demand mentioned above [2]. As a key design objective, 5G mobile networks will utilise mobile (or multi-access) edge computing (MEC), an IT service environment with cloud computing capabilities at the edge of the home, enterprise, or IoT network, within close proximity to the mobile sub-

Motivation

- Operators see network utilization increasing
  - Driven by new mobile clients and media-intensive applications
  - 2020: “50 billion connected devices” ”1 billion terabytes traffic yearly” (Cisco / Ericsson / ABI)
- Customer expectations are also growing
  - Low latency, high throughput
  - Network support for new application (e.g., VR, tactile Internet)



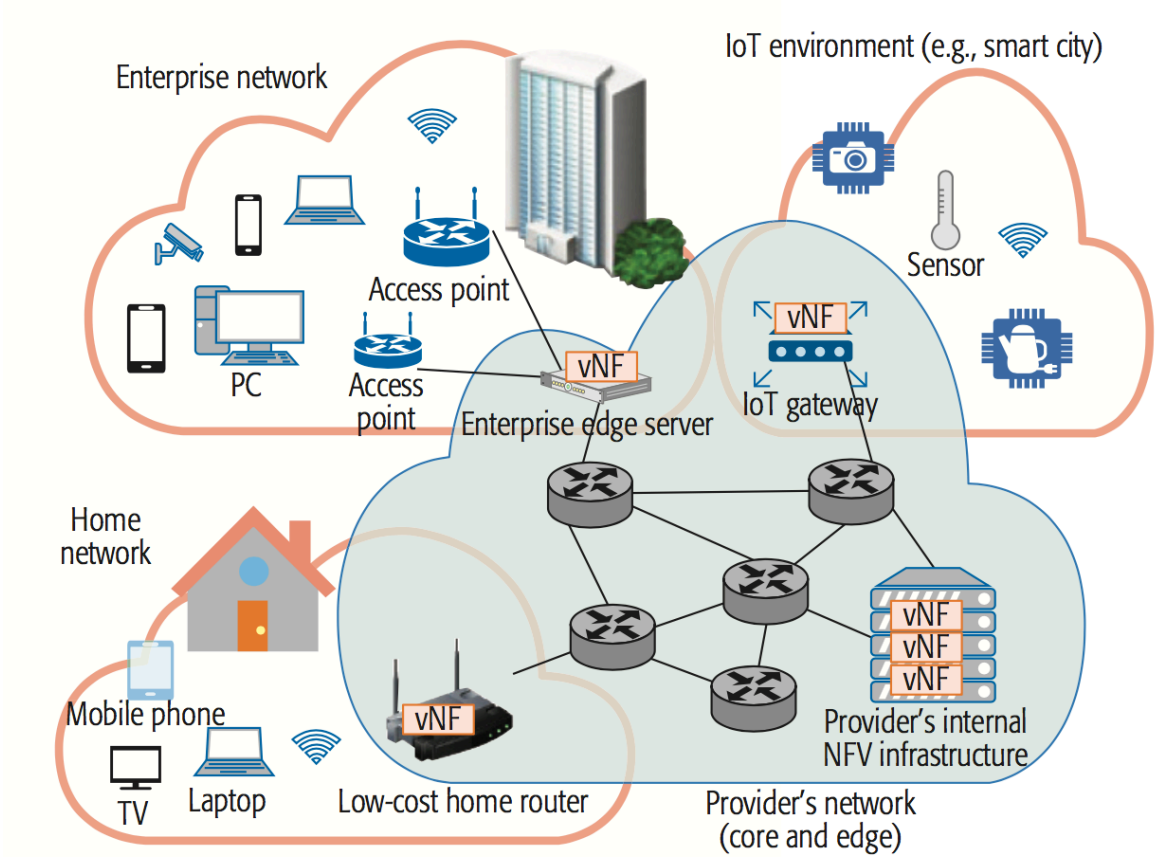
Network Function Virtualization

- NFV proposed to cope with increasing traffic and network expectations while keeping costs down
  - Provide an architecture for delivering virtual network services in the core network
- Current NFV platforms:
  - Utilize heavy-weight VMs that take few minutes to provision
  - Run on powerful servers
  - Designed to process high traffic volume in the core
  - Some example frameworks: OPNFV, UNIFY, T-NOVA, Cloud4NFV

Lightweight edge NFV

- Mobile / IoT applications have diverse network requirements
- Network service reconfiguration needs to be very fast (and frequent)
- New services need to be tailored to the user
- Network services should offer low latency and high reliability
- **Our solution: bring lightweight NFV to the Network Edge**

Opportunities at the Multi-Access Network Edge



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

Example Edge Devices

Customer device	Release	Architecture	CPU	Memory
Residential CPE home routers				
Virgin SuperHub 3 (Arris TG2492S)	2015	Intel Atom	2x1.4 GHz	2x256 MB
Google Fiber Network Box GFRG110	2012	ARM v5	1.6 GHz	Not known
Orange Livebox 4	2016	Cortex A9	1 GHz	1 Gb
Commodity wireless routers				
TP-LINK Archer C9 home router	2016	ARM v7	2x1 GHz	128 MB
Ubiquiti EdgeRouter Lite 3	2014	Cavium MIPS	2500 MHz	512 MB
Netgear R7500 Smart Wifi Router	2014	Qualcomm Atheros	2x1.4 GHz	384 MB
IoT edge gateways				
Dell Edge Gateway 5000	2016	Intel Atom	1.33 GHz	2GB
NEXCOM CPS 200 Insdustrial IoT Edge Gateway	2016	Intel Celeron	4x2.0 GHz	4GB
HPE Edgeline EL4000	2016	Intel Xeon	4x3.0 GHz	Up to 64 GB

Source: **Container Network Functions: Bringing NFV to the Network Edge**
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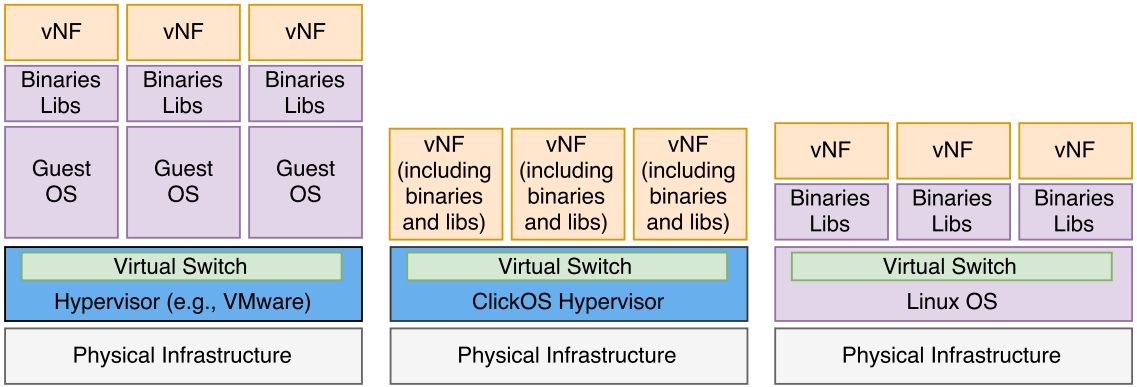
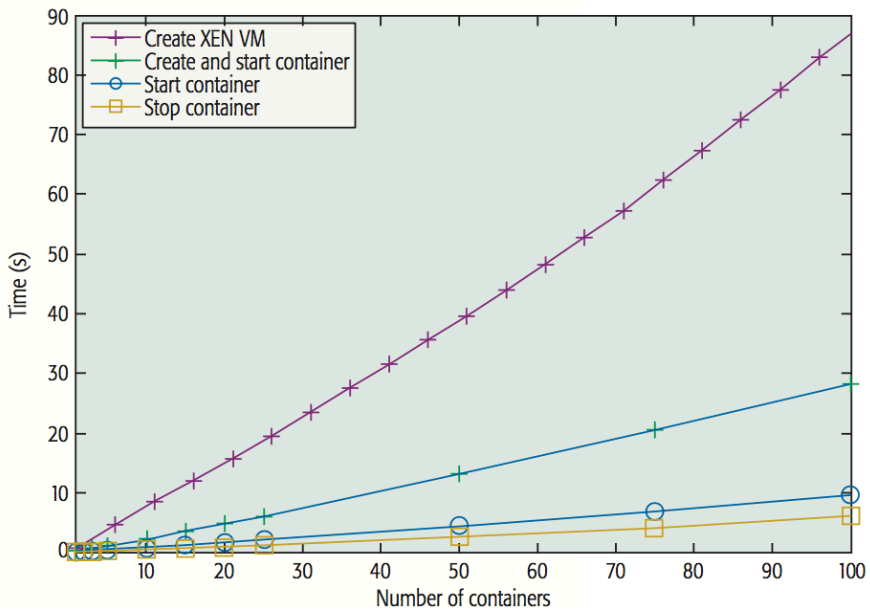
Container vNFs

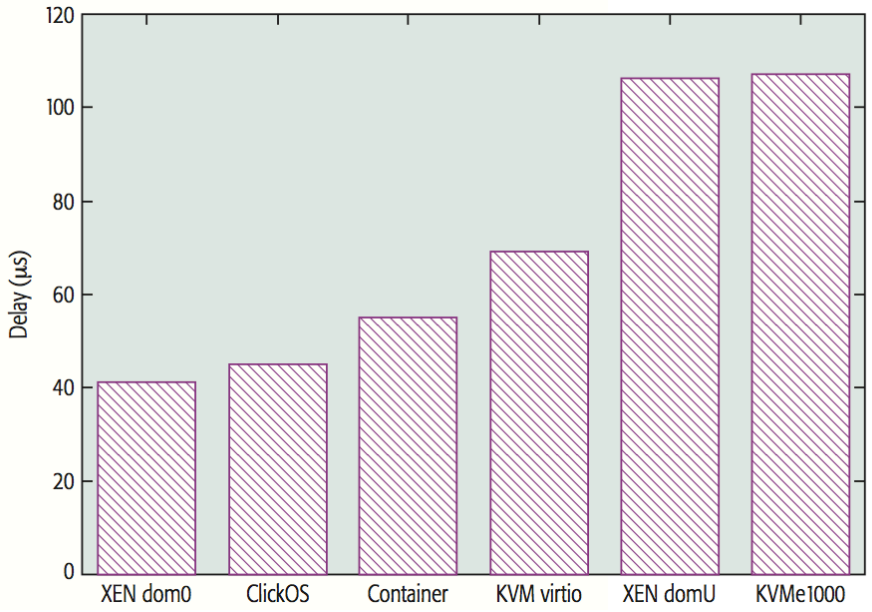
- Lightweight “virtualization”
- Fast create/start/stop/delete
- High performance: small delay, high throughput, low memory footprint
- Reusable / shareable
- Traditional software environment
- Micro-services architecture



Container vNFs - performance



Fast instantiation

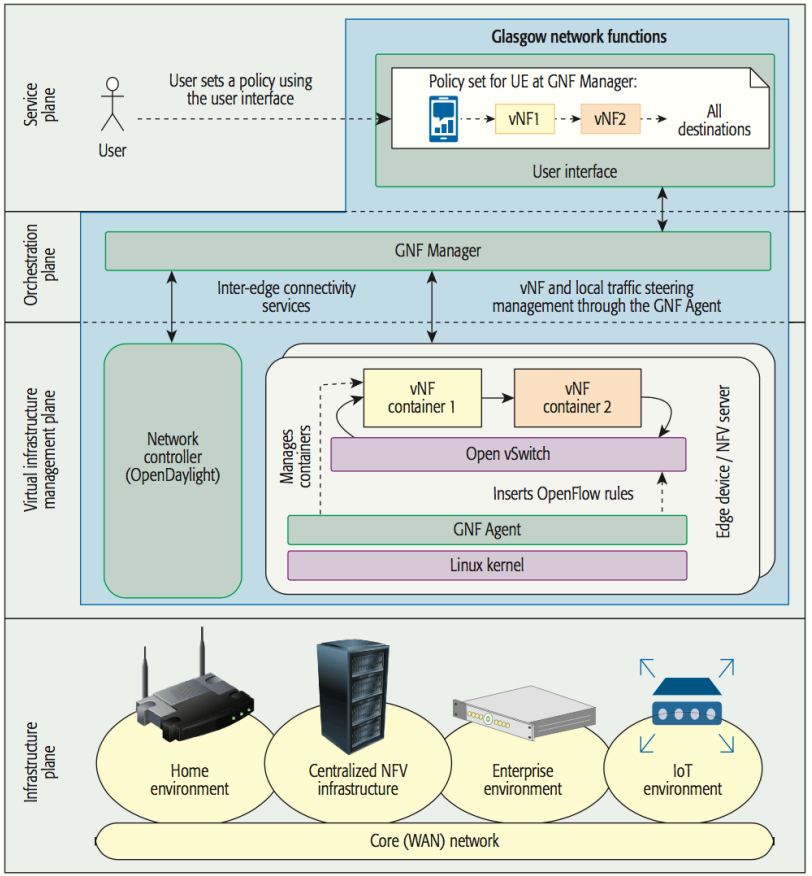


Idle ping delays

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



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Example container vNFs

- Firewall
- HTTP proxy
- Network measurement functions
- Rate limiter
- DNS load balancer
- SNORT

12 lines (9 sloc) | 261 Bytes

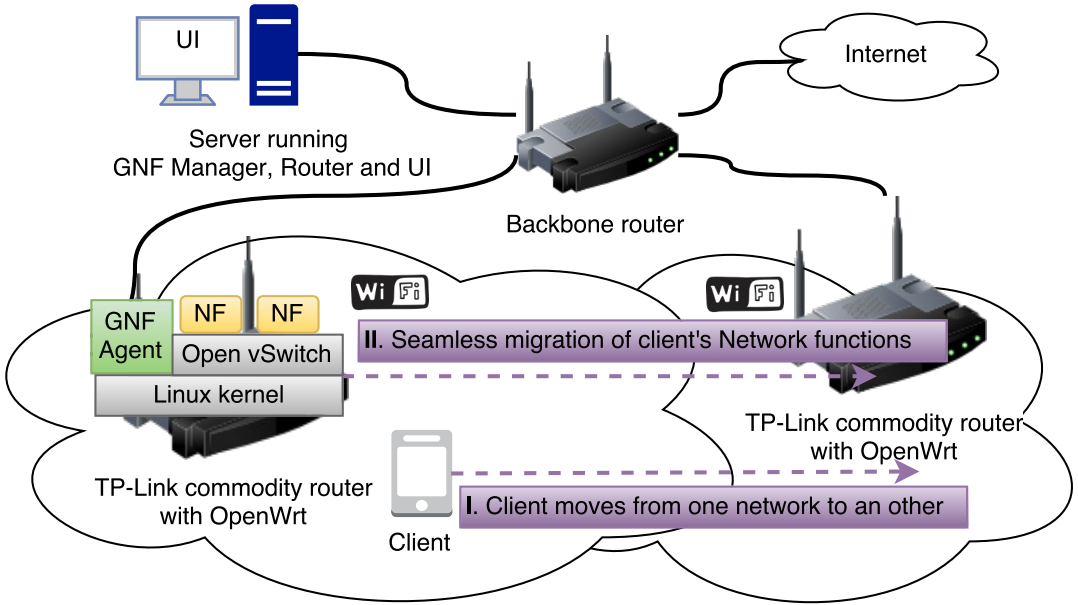
```
1  # Allow HTTP traffic only
2  # Firewall example for GLANF
3
4  FROM glanf/base
5  MAINTAINER Richard Cziva
6
7  ENTRYPOINT ifinit && \
8          brinit && \
9          iptables -A FORWARD -p tcp --dport 80 -j ACCEPT && \
10         iptables -A FORWARD -j DROP && \
11         /bin/bash
```

GNF firewall example

All of these (and even more): https://github.com/UofG-netlab/gnf-dockerfiles

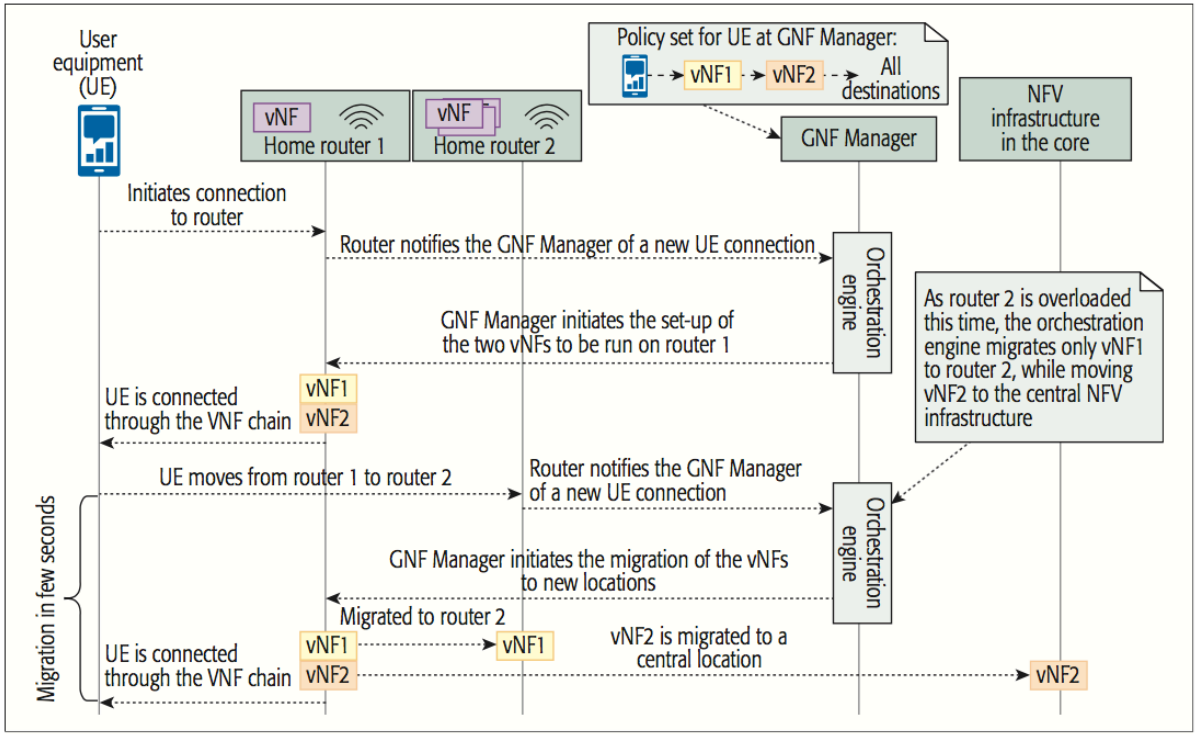
Use Case: Roaming vNFs

Let network functions follow end users while the roam between small cells.



More in: Roaming edge vNFs using Glasgow Network Functions.
Richard Cziva, Simon Jouet and Dimitrios P Pezaros, ACM SIGCOMM 2016, Florianopolis, Brazil

Use Case: Roaming vNFs



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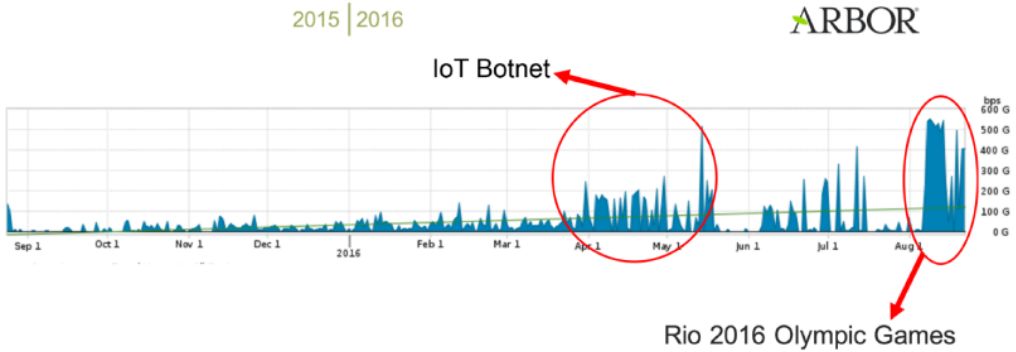
Use Case: Troubleshooting

- Providers spend manpower (and money) on network troubleshooting
  - Often a manual task
  - Visibility is low and troubleshooting actions on certain devices are limited
- Solutions: Container vNFs with simple troubleshooting modules can be launched at different points of the infrastructure
  - E.g., measurement vNF container can be set-up on customer's home gateway in a few seconds as opposed to manual troubleshooting
- Next step: operators could automate measurements to identify networking issues

Use Case: IoT DDoS mitigation

- Problem: DDoS attacks originating from infected IoT devices
  - E.g., “Mirai malware” – 665 Gbit/s unprecedented attack against Akamai hosted website
  - 21 October 2016: unseen DDoS attack targeting DNS servers

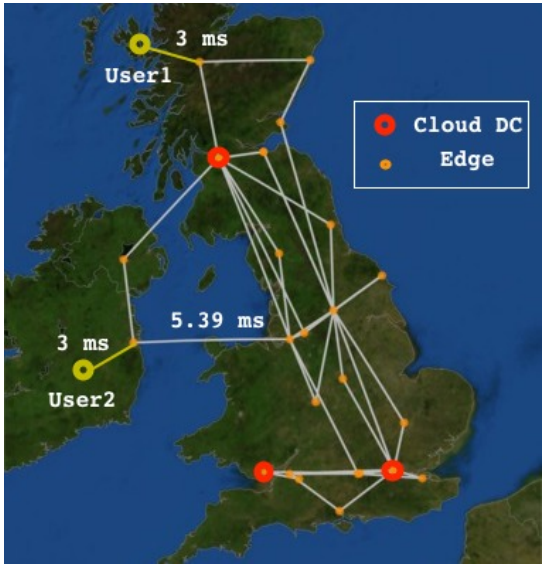


Source: https://www.arbornetworks.com

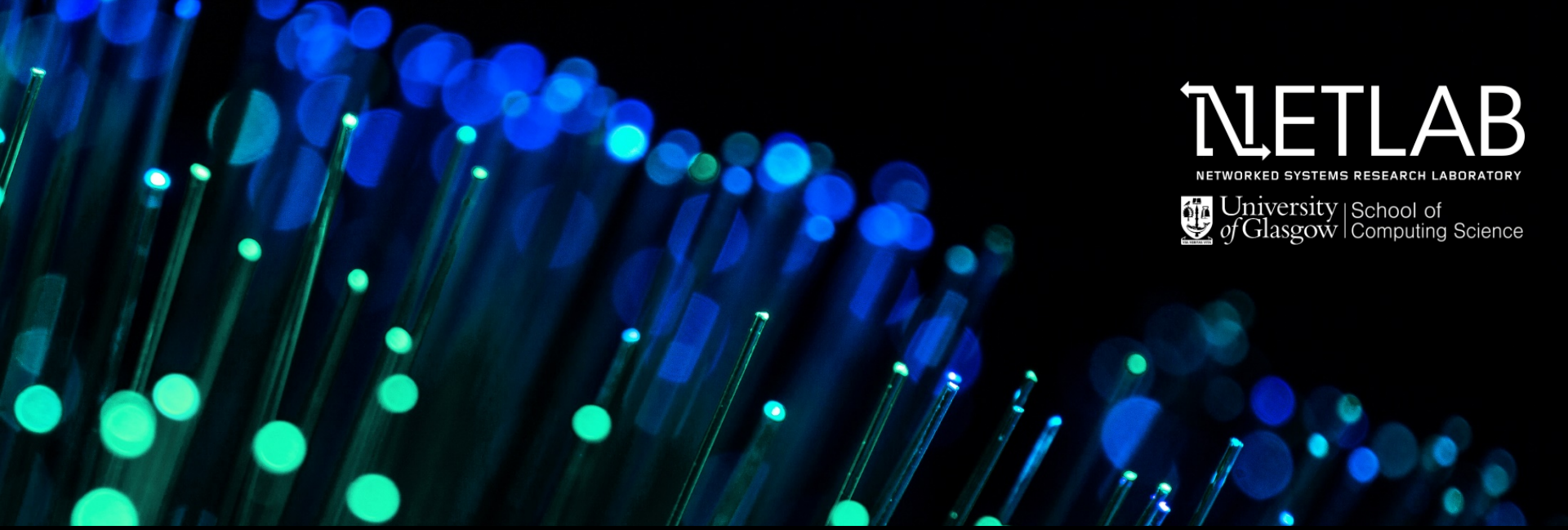
- Container vNFs at the edge can kill malicious traffic at the source efficiently – a small container firewall module is sufficient

Challenges and future work

- Security / isolation of containers
- MANO challenges: how do we manage the lifecycle of millions of container vNFS?
- What vNFs can actually run on low-cost edge devices?
- Dynamic placement and orchestration of edge vNFs
  - Where to place edge vNFs
  - When to re-arrange placement



Users move – vNFs should also move to keep low latency!
More in: Richard Cziva and Dimitrios P. Pezaros: On the Latency Benefits of Edge NFV ACM/IEEE Symposium on Architectures for Networking and Communications Systems (ANCS 2017) 105—106



Thank you for your attention!
Questions?

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GNF vs other NFV frameworks

	GNF	Cloud4NFV [5]	UNIFY [6]	T-NOVA [7]	OPNFV
Virtualization technology	Container	VM	VM	VM	VM
End-to-end service mgmt	Yes	Yes	Yes	Yes	Yes
Distributed infrastructure	Yes	Yes	Yes	Yes	Yes
Traffic steering	Yes	Yes	Yes	No	Yes
Runs on the network edge	Yes	No	No	No	No
SFC support	Yes	Yes	Yes	No	Yes
Roaming VNFs	Yes	No	No	No	No

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