GNFUV: Glasgow Network Functions for Unmanned Vehicles {EXP-SCI}

Dr Christos Anagnostopoulos
School of Computing Science

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Hypothesis (Plan)

- **Identify** & **Investigate** the opportunities of the Network Edge by experimenting with our lightweight, container-based NFV platform: **Glasgow Network Functions (GNF)**[1,2]

- **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[3], e.g., outliers detection and predictive regression.

[1] R. Cziva et al. Roaming Edge vNFs using Glasgow Network Functions: ACM SIGCOMM 2016, pp. 601–602.
[2] R. Cziva et al. Container network functions: bringing NFV to the network edge: IEEE Communications Magazine 24-31 2017
[3] C. Anagnostopoulos. Query-Driven Learning for Predictive Analytics of Data Subspace Cardinality: ACM TKDD 11(4): 47 2017

Experimentation Objectives

- **Virtualized Network Management Context**
    - **Vision:** virtualized management of Uxv by remotely allocating virtualized Functions.
    - **Idea:** Topology-driven network management methodology for the RAWFIE/UxV network

- **Virtualized Distributed Inferential Analytics Context (Application)**
    - **Exploitation: GNF for UxVs** for distributed & constrained-based inferential analytics

- **Derived Data & Knowledge will thus be produced in two directions:**
    - Manage virtualized constrained UvX Networks
    - Execute constrained-based distributed analytics over the GNF-RAWFIE Framework

Experimentation on Virtualized Network Management

- **Goal:** Network Management of UxVs
- **Hierarchical UxV Network Management Topology: Swarm with Leaders & Members**
  - **Management**: <u>monitor</u>, <u>report,</u> and <u>infer</u> the **state** of managed UxVs (**L**eaders) and their spatial neighbouring UxVs (**M**embers)

  - **UxV states**: remaining energy (trigger for swarm suspension), **L-M** connectivity (trigger for L replacement)

  - **Reflection**: An **aggregation** of layered vNFs.

Experimentation on Virtualized Distributed Analytics

- **Goal: Analysing** the expected behaviour of distributed processing **given** an UxV-managed topology.

- **On-line Local & Global Models** derived from the **Swarm** of Leaders & Members
  - **Local Predictive Models**, e.g., outlier detection/dependent statistics derived **locally** from **Member** UxVs.
  - **Global Predictive Models** derived from **Leader** UxVs:
  - Either by **aggregation** of Local Models
  - Or by **ensemble pruning** of the <u>most relevant</u> Local Models

- **Behaviour:** simple aggregation of Local Models (naïve solution)
- **Behaviour:** selectivity of the <u>most relevant</u> Local Models w.r.t. accuracy
- **Determine:** <u>when to update</u> the Local Models.

Experimentation Indicators

- **Assess** the **expected behaviour** of UxVs based on the **indicators**:
    - **vNF chain delay**: <u>quantify</u> to what granularity the infrastructure **can be virtualised** and shared between different experiments and testbeds.

    - **Memory requirements**: Since we are designing **vNFs for UxV devices** with limited memory, it is essential to <u>compare</u> memory requirements of containers with other vNF technologies.

    - **Performance** of inferential analytics of Global Models and Local Models
        - Impact of **simple aggregation** on accuracy and
        - Impact of **ensemble pruning** on accuracy

    - **Communication overhead & accuracy** <u>trade-off</u> departing from Global to Local Analytics.

Resources for Experimentations

- **Swarm of UxVs**: Assigning roles for **Leaders** and **Members**
- **Requirement for GNF:** Linux OS, e.g., Raspbian, Ubuntu, (or OpenWRT)
- **Indicatively**: PlaDyFeet USVs, VENAC UAVs, and FLEXUS USVs

- **Focus on Testbeds:**
    - **HMOD** (USV/outdoor), **HAI** (UAV/outdoor)
    - **Virtual Aeroloop:** UAV simulator (especially at the first phase!)

Our Experience on Experimentation Platforms

- **FRuIT: The Federated Raspberry Pi Micro-Infrastructure Testbed** – UK EPSRC Project: 2016–2019.

- **Instrumentation, Measurement and Control for the Cloud** – UK EPSRC Project: 2013-2015

- **Network Measurement as a Service (NMaaS)** – UK EPSRC Project: 2016-2019

- **Forecasting and Visualising Safety and Security Concerns as a Consequence of System Changes in Air-Traffic Management Networks** – Office of Naval Research (ONR): 2015–2017

- **Resilient Communication Services Protecting end-user Applications from Disaster-based Failures** - EU CA COST Action: 2015-2020

Thank you

NETLAB: https://netlab.dcs.gla.ac.uk/

Email: christos.anagnostopoulos@glasgow.ac.uk

Email: dimitrios.pezaros@glasgow.ac.uk

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