



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

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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:** monitor, report, and infer the **state** of managed UxVs (**Leaders**) and their spatial neighbouring UxVs (**Members**)
 - **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 most relevant Local Models
- **Behaviour:** simple aggregation of Local Models (naïve solution)
- **Behaviour:** selectivity of the most relevant Local Models w.r.t. accuracy
- **Determine:** when to update the Local Models.



Experimentation Indicators

- **Assess** the **expected behaviour** of UxVs based on the **indicators**:
 - **vNF chain delay**: quantify 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 compare 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** trade-off 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



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Thank you

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