Full stack DevOps toolchains accelerating ideas from the desktop to city testbeds

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FLAME’s DevOps Pipeline

• Verification, validation and evaluation of novel full stack 5G systems with users is challenging
  • infrastructure, platform, services have complex interdependencies
  • all require significant resources to be fully operational
  • trials with users have specific non-technical requirements (logistics, GDPR)
• FLAME provides a set of connected DevOps environments that are designed to:
  • address specific test objectives related to the level of resources available
  • control costs by incrementally increasing levels of realism at each stage
  • allow developers to seamlessly (as possible) transition between environments through platform portability and consistent APIs
Platform Engineering
Platform Integration Pipeline

**SIMULATION**
- **Project:** FLIPS Component
  - Build
  - Unit Tests
  - Integration

**EMULATION**
- **Project:** Platform
  - Build
  - Integration Tests

**EXPERIMENTATION**
- **Bristol Deployment Pipeline**
- **Barcelona Deployment Pipeline**
- **Southampton Deployment Pipeline**

**Artefacts**
- Code & Commit

**Platform Integration Policy**

**Product Release Policy**

**Product releases**

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ARDENT: Objectives & Challenges

- Automated platform DEployment Toolchain (ARDENT)
- Automate platform deployment into infrastructure slice
  - Focus on OpenStack
  - Sanity checks (networks, subnets, port security, security groups)
  - Resource quota calculation and configuration
  - Creating NVF resources preparing for platform deployment
  - Deployment of platform using platform descriptor (HEAT)
- Preserve/respect tenancy relationship with infra provider
Infrastructures

Integration
- Infrastructure Product - Commodity
  - Media Service Sandboxing Infrastructure
  - Functional Integration Infrastructure

Replication
- Infrastructure Product - Bristol
  - Bristol Staging Infrastructure
  - Bristol Production Infrastructure

- Infrastructure Product – i2CAT
  - Barcelona Staging Infrastructure
  - Barcelona Production Infrastructure

- Infrastructure Product – Replicator
  - Another Staging Infrastructure
  - Another Production Infrastructure

Legend
- Control plane
- Wireless data plane
- Wired data plane

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Media Service Development
DevOps Pipeline

Increasing complexity, realism and cost

<table>
<thead>
<tr>
<th>Development</th>
<th>Integration</th>
<th>Integration &amp; Experimentation</th>
<th>Testing &amp; Experimentation</th>
<th>Trials</th>
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</thead>
<tbody>
<tr>
<td>Tasks</td>
<td>Components:</td>
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<td>Remote testing</td>
<td>Small trials:</td>
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<tr>
<td>SF development</td>
<td>FLIPS</td>
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<td>On-site testing:</td>
<td>10 people</td>
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<td>1-2 people</td>
<td>1-5 hours</td>
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<td>Telegraf integration</td>
<td>SF packaging</td>
<td>FMS</td>
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Experimentation Workflow

Validate Components

5

Technology demonstration
 Barcelona
 Bristol

Validate components in Simulated or Realspace Environment

4

FLAME-in-a-Box

3

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Iteration / Non-linear
DevOps Pipeline

Increasing complexity, realism and cost

Development
- Developer machine

Integration
- FLAME-in-a-Box
  - Components: FLIPS
  - Tasks: SF packaging, TOSCA validation, SFC testing (1 cluster)

Integration & Experimentation
- Sandpit
  - Components: FLIPS, CLMC, FMS
  - Tasks: Tutorial, SFC testing (4 clusters), Data exploration, Adaptation

Testing & Experimentation
- Replica
  - Remote testing
  - On-site testing:
    - 1-2 people

Trials
- Replica with people
  - Small trials:
    - 10 people
    - 1.5 hours
  - Large trials:
    - 20 people
    - 1-2 days
FLAME-In-A-Box

• FLAME-in-a-Box is a virtual appliance that fits on an ordinary modern office laptop
• FLAME-in-a-Box is a VirtualBox-base mini-FLAME platform which allows for testing of:
  • SFC orchestration templates
  • SF provisioning
  • Basic communication tests of deployed SFEs
• All instances that come as a single OVA and can run on a normal laptop 4 cores and 8GB of RAM.
FLAME-In-A-Box – Topology

- a UE (user equipment node) for the test or client software;
- a “cluster” where packaged service functions are deployed;
- the “sr-ue” which is a service router connecting the ue, cluster and pce-sfemc;
- the “pce-sfemc” node (path computation element and service function endpoint management and control services) which also includes the FLAME orchestrator;
- another service router (“sr-ps”); and
- a “ps” instance for platform services such as DHCP, IP gateway and DNS.
DevOps Pipeline

Increasing complexity, realism and cost

**Development**
- Developer machine

**Integration**
- FLAME-in-a-Box

**Integration & Experimentation**
- Sandpit

**Testing & Experimentation**
- Replica

**Trials**
- Replica with people

### Tasks
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**Remote testing**
- Small trials:
  - 10 people
  - 1-5 hours
  - Large trials:
    - 20 people
    - 1-2 days

**On-site testing:**
- 1-2 people
FLAME Sandpit

• The Sandpit supports integration testing, functional testing and experimentation of control scenarios

• Uses a combination of containers and virtual machines to emulate a deployment of the FLAME platform in a physical infrastructure

• In contrast to FLAME-in-a-Box
  • provides FLAME’s cross-layer management and control (CLMC)
  • provides sufficient resources for service functions to execute and tested

• Includes “emulated UE” nodes which allow experimenters to install their test clients on the user-equipment (UE) nodes
FLAME Sandpit Architecture

- The physical infrastructure is a single machine with 72 cores and 8TB of disk.
- OpenStack and Floodlight provide management of virtual compute and the SDN fabric
- OpenStack is deployed within LXD/LXC containers
  - the topology of the compute infrastructure and the capacity constraints of each compute to be flexibly configure
- No physical SDN fabric beyond OVS switches deployed as part of the FLAME platform itself
FLAME Sandpit Topology

- The data plane topology of the sandpit with clusters (green), emulated UE (red) and SDN switches (blue)
- Design supports a hierarchical topology of edge and metro data centres with different capacity constraints
- Configuration offers a practical baseline for testing scenarios
  - switches allows different SF routes to be explored including cases of routing loops.
  - The heterogeneity in DC and Edge resources allows SF endpoint management policies to be explored under different resourcing constraints
  - The distribution of UEs allows for demand to be generated from different parts of the network
Sandpit Tutorial Demonstration
DevOps Pipeline

Increasing complexity, realism and cost

Developer machine
FLAME-in-a-Box
Sandpit
Replica
Replica with people

Development
Integration
Integration & Experimentation
Testing & Experimentation
Trials

Tasks
SF development
HTTP services
Telegraf integration
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SF testing

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Remote testing
On-site testing:
1-2 people

Small trials:
10 people
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Bristol Replicator Infrastructure

- The purpose of the replicator infrastructures is to support experiments and user trials to explore the acceptance, viability and performance

- Deployed at UoB 5GUK Test Network Infrastructure

- Locations of MEC in the four towers, WiFi technology, and actual physical deployment location of the Millennium Square in Bristol
Bristol Replicator – Logical Topology
## Bristol Replicator Capacity

<table>
<thead>
<tr>
<th>Resource</th>
<th>Capacity</th>
<th>Availability Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compute</td>
<td>4 x OpenStack Compute Node with 15 core available.</td>
<td>These resources are dedicated to FLAME.</td>
</tr>
<tr>
<td>Storage</td>
<td>4 storage nodes with 900GB</td>
<td>These resources are dedicated to FLAME.</td>
</tr>
<tr>
<td>Networking</td>
<td>4x EdgeCore SDN switches, 4 x Ruckus WiFi access points</td>
<td>These resources are shared across projects.</td>
</tr>
</tbody>
</table>
Workflow Stage Checklist

Develop SF
[Unit] test SF
Integrate with CLMC monitoring
Integrate with WHOAMI
Test integration

Package SF

Write TOSCA spec
Validate TOSCA spec
Define triggers

Define objectives
Define test scenario
Define metrics of interest

Agree schedule
Agree support

1. Southampton Sandpit
Execute integration tests
Explore monitoring and alerts
Examine data in Chronograf

2. Experiment
Adjust TOSCA spec
Define triggers

Define objectives
Define test scenario
Define metrics of interest

Agree schedule
Agree support

Urban Hacking

3. Small trial
Execute trial
Observe and record
Debrief in person
Examine data
Disseminate

Obtain ethical approval (local / EIB)
Register with DPA
Sign data sharing agreement
Prepare participant info sheet
Prepare consent form
Engage participants
Obtain consent
Write data management plan

Prepare mobile devices
Adjust TOSCA spec
Define triggers

Define objectives
Define test scenario
Define metrics of interest

Agree schedule
Agree support

4. Large trial
Execute trial
Observe and record
Debrief online
Examine data
Disseminate

Anticipate issues with longer schedule
Prepare for BYOD

Publicity
Engage more participants
Obtain consent

Define triggers

Define objectives
Define test scenario
Define metrics of interest

Agree schedule
Agree support

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Dev-Ops Pipeline

Increasing complexity, realism and cost

Development
- Tasks:
  - SF development
  - HTTP services
  - Telegraf integration
  - Unit testing
  - SF testing

Integration
- Components: FLIPS, Tasks: SF packaging, TOSCA validation, SFC testing (1 cluster)

Integration & Experimentation
- Components: FLIPS, CMLC, FMS
  - Tasks:
    - Tutorial
    - SFC testing (4 clusters)
    - Data exploration
    - Adaptation

Testing & Experimentation
- Remote testing
- On-site testing:
  - 1-2 people

Replica with people
- Small trials:
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## Experimentation Scale and Cost

<table>
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<tr>
<th>Evaluation Approach</th>
<th>Maturity Levels</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology selection sub-set; some experimental; lower levels of automation.</td>
<td>Proven technology set, mostly automated and managed at a medium scale.</td>
<td>Full technology set, full automation, at urban scale.</td>
</tr>
<tr>
<td>First assessment of value &amp; impact for stakeholders; rich-picture evidence of use in the small scale.</td>
<td>Revised scenarios and impact assessment; complete technology set deployed; more focused, quantitative evidence to support value propositions. Ecosystem replication proven.</td>
<td>Full scale urban deployment using replication; large data sets with evidence for demand, acceptance, usage and impact.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scaling</th>
<th>10-50 Users</th>
<th>50+ Users</th>
<th>1000+ Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phases</td>
<td>Phase 1</td>
<td>Phase 2</td>
<td>Phase 3</td>
</tr>
</tbody>
</table>
GDPR

- Unifies data protection regulations across the EU
  - and in Switzerland
  - and in post-Brexit UK
  - and in countries dealing with EU data
- Comes into effect 25 May 2018
- Fines of up to 4% of annual worldwide turnover or €20m, whichever is greater, may be levied on both controllers and processors who are in breach of GDPR
Rights & Responsibilities Summary (1)

- FLAME will collect personal data from which sensitive data may sometimes be inferred
- Personal data:
  - will only be collected and processed when justified
  - will be pseudonymised as soon as possible
- Each trial will:
  - complete a data protection impact assessment
  - provide a participant information sheet
  - ask for explicit, informed consent for data collection
Rights & Responsibilities Summary (2)

• The platform and media services are:
  • being architected to enable Data Subject’s rights
    • such as the right to have data deleted
  • using data protection by design and default principles

• Data Controllers and Processors will:
  • sign a standard contract to govern the data processing
  • keep detailed documentation on data control and processing activities
  • will each appoint a Data Protection Officer and will inform them of the project
The diagram illustrates the flow of personal data and activity data through various entities and processes. It includes:

- **Trial participant (Data subject)**: Can withdraw consent at any time and request that all their personal data be removed.

- **Consent form**: Signs, permits lawful processing of personal data.

- **Trial leader (Data controller)**: Owns, controls, permits processing of personal data.

- **Controller / Processor Contract**: Describes and constrains the purpose of the processing.

- **Mobile app & media service processes**: Creates, owns, processes, creates pseudonymised participant activity data.

- **Pseudonymised participant activity data**: Observes, uses, adds to aggregate data.

- **Media service activity data**: Uses, observes, adds to aggregate data.

- **Aggregate activity database**: Processes, added to CLMC service process.

- **Infrastructure slice**: Processes, creates, observes, aggregate data, added to traffic data.

- **Traffic data**: Aggregate data, added to CLMC knowledgebase.

- **Platform service activity data**: Added to CLMC service process.

- **Platform service activity data**: Processes, updated by CLMC knowledgebase.

- **Platform operator (Data processor)**: Owns, controls traffic data, processes participant activity data. Cannot process data for any purpose other than in the contract.

- **CLMC service process**: Hosts, creates, processes, updates CLMC knowledgebase.

- **CLMC service process**: Adds to CLMC knowledgebase.

- **Digital signature**: Signs, permits lawful processing.

- **Data controller (Trial participant)**: Signs, permits lawful processing of personal data.
Conclusions

• Verification, validation and evaluation of novel full stack 5G systems with users is complex

• FLAME provides a set of connected DevOps environments that are designed to:
  • address specific test objectives related to the level of resources available
  • control costs by incrementally increasing levels of realism at each stage
  • allow developers to seamlessly (as possible) transition between environments

• During the hackathon you’ll experience the sandpit and replicator
This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731677

THANKS!

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