xApp DevOps Evolution and Observable OAM in Open RAN Ecosystem

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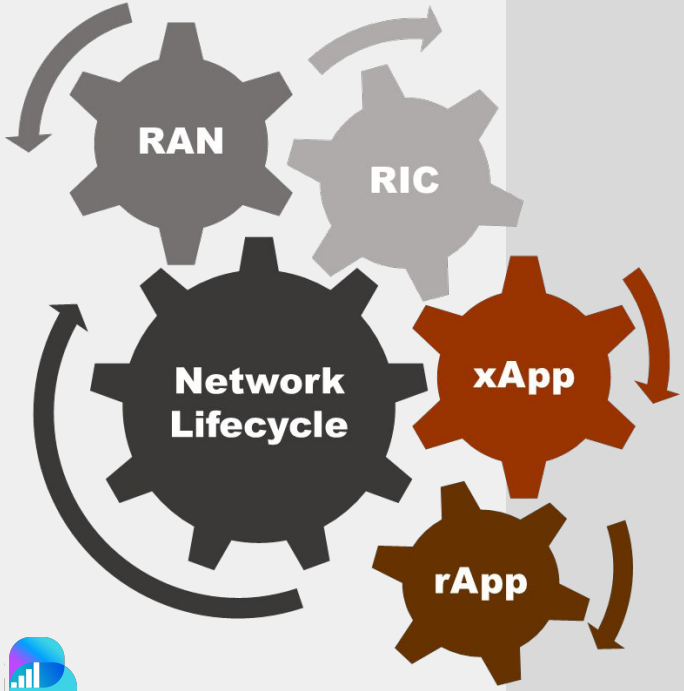
Independent xApp Lifecycle



- Accelerating innovative xApp development
- Operating xApp dynamically through SMO
- Leading the way of xApp evolution in O-RAN ecosystem
- Bridging xApp and rApp seamlessly
- Enabling a smooth transition from RAN to data

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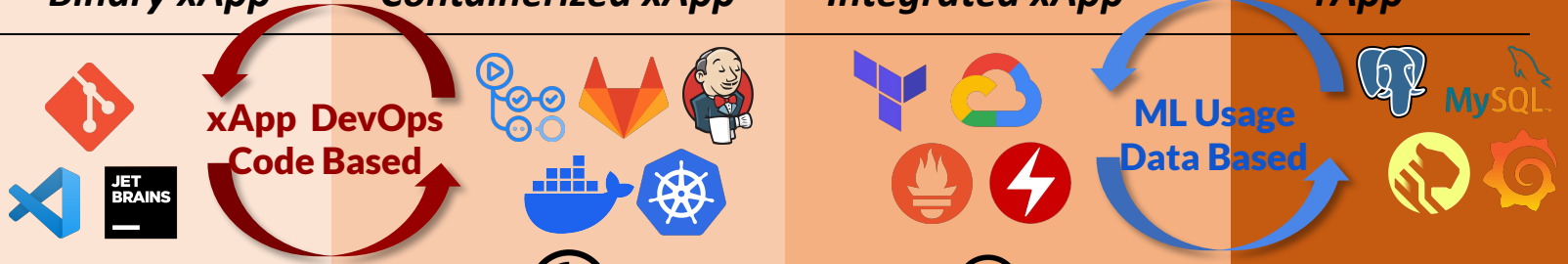
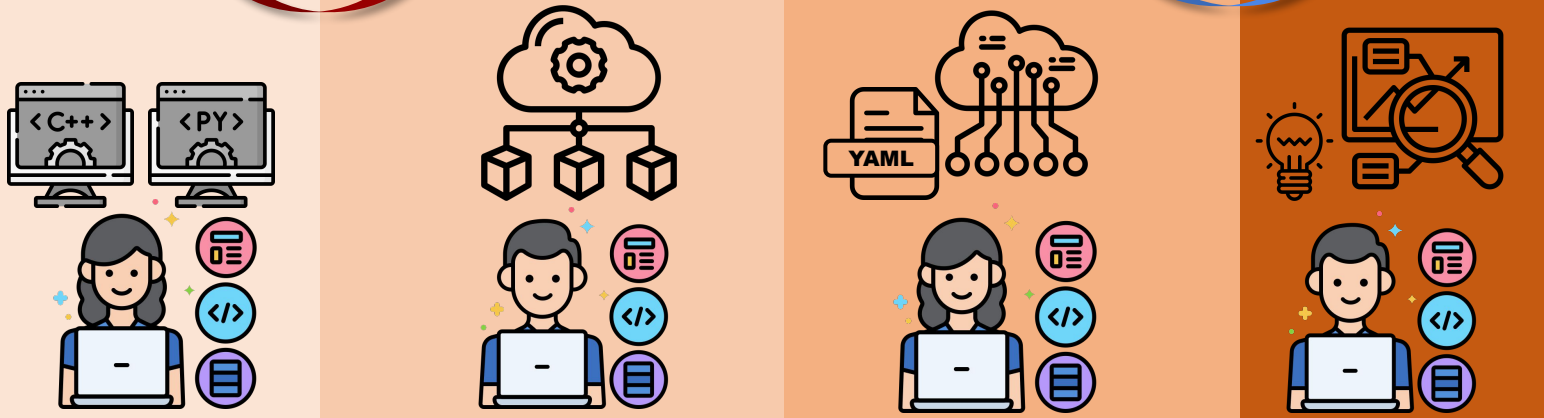
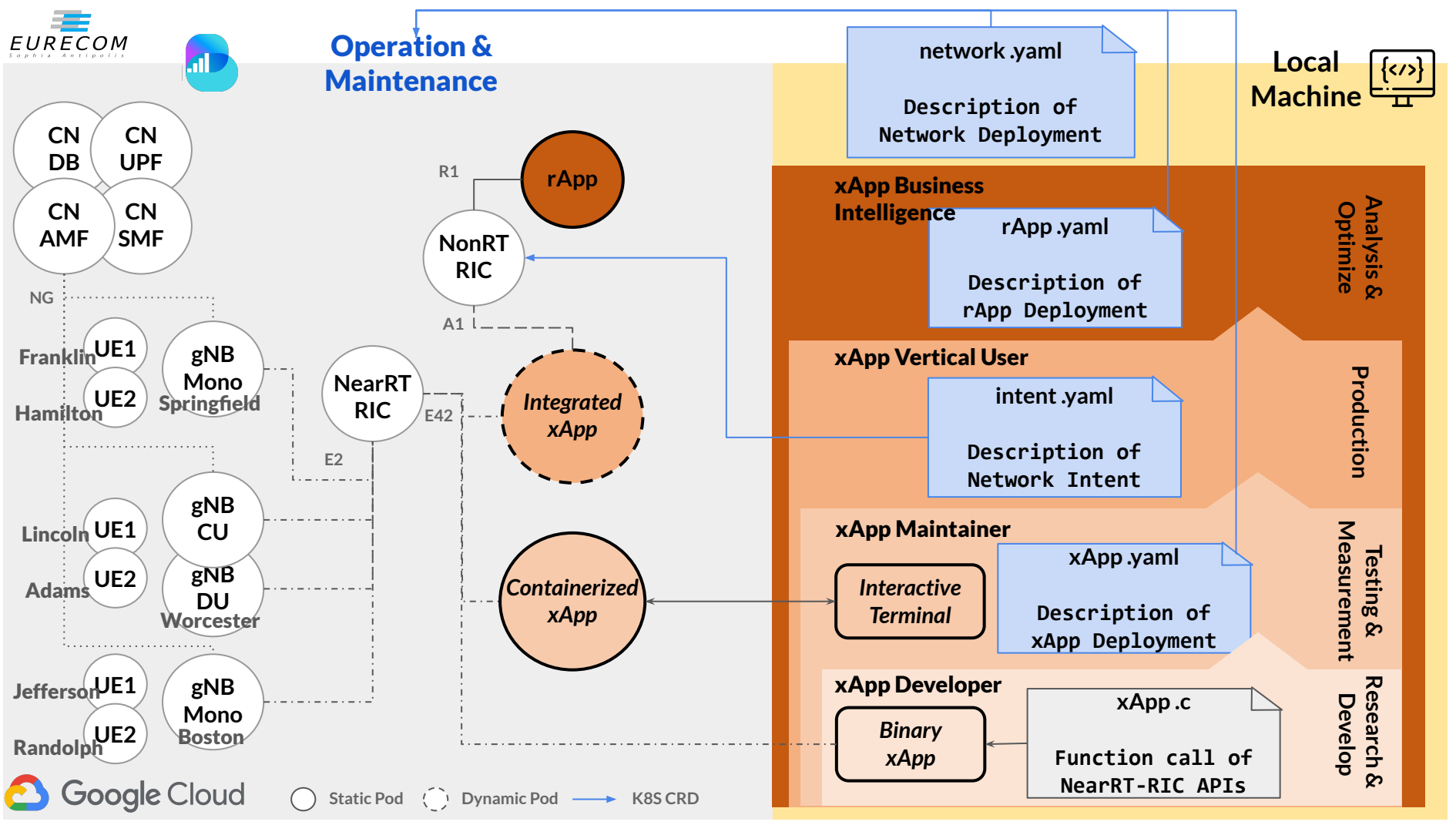
Independent xApp Lifecycle

Binary xApp | *Containerized xApp* | *Integrated xApp* | *rApp*





xApp Developer | xApp Maintainer | xApp Vertical User | xApp BI


EURECOM
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Operation & Maintenance
CN DB
CN UPF
CN AMF
CN SMF
NG
Franklin
UE1
UE2
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gNB Mono Springfield
Lincoln
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R1
rApp
NonRT RIC
A1
NearRT RIC
E42
E2
Integrated xApp
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network .yaml
Description of Network Deployment
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xApp Business Intelligence
rApp .yaml
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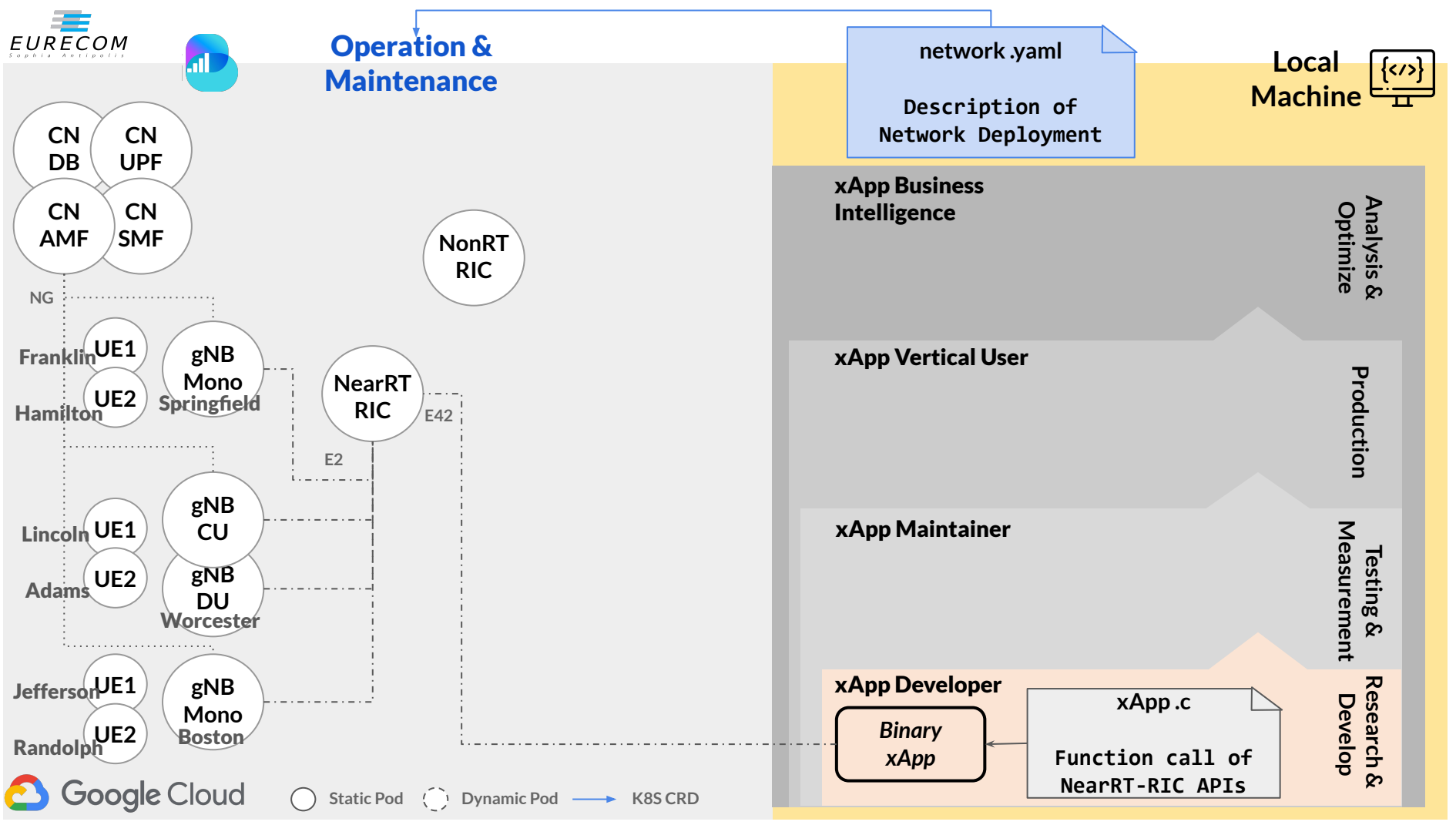
xApp .c
Function call of NearRT-RIC APIs
Research & Develop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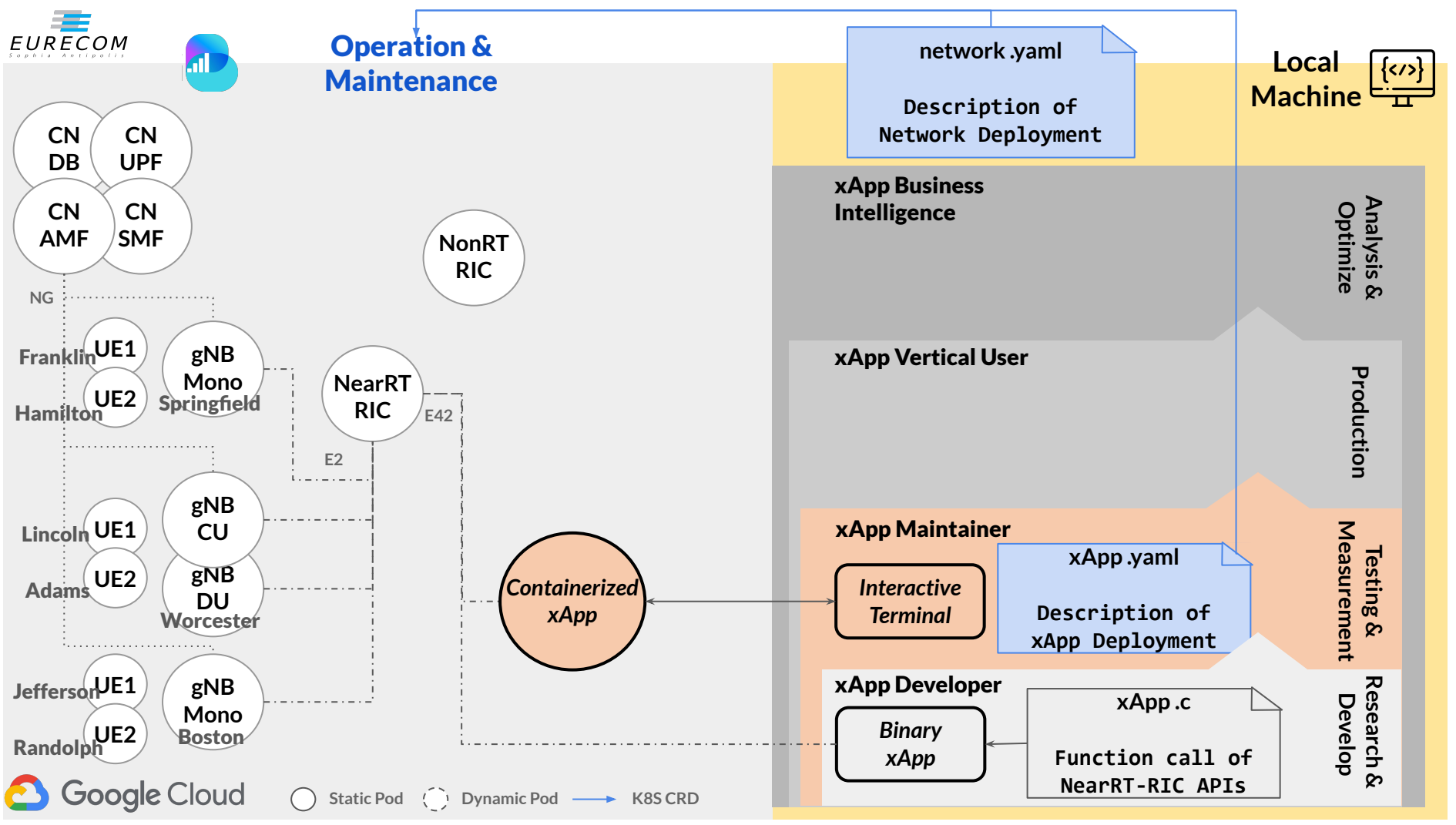
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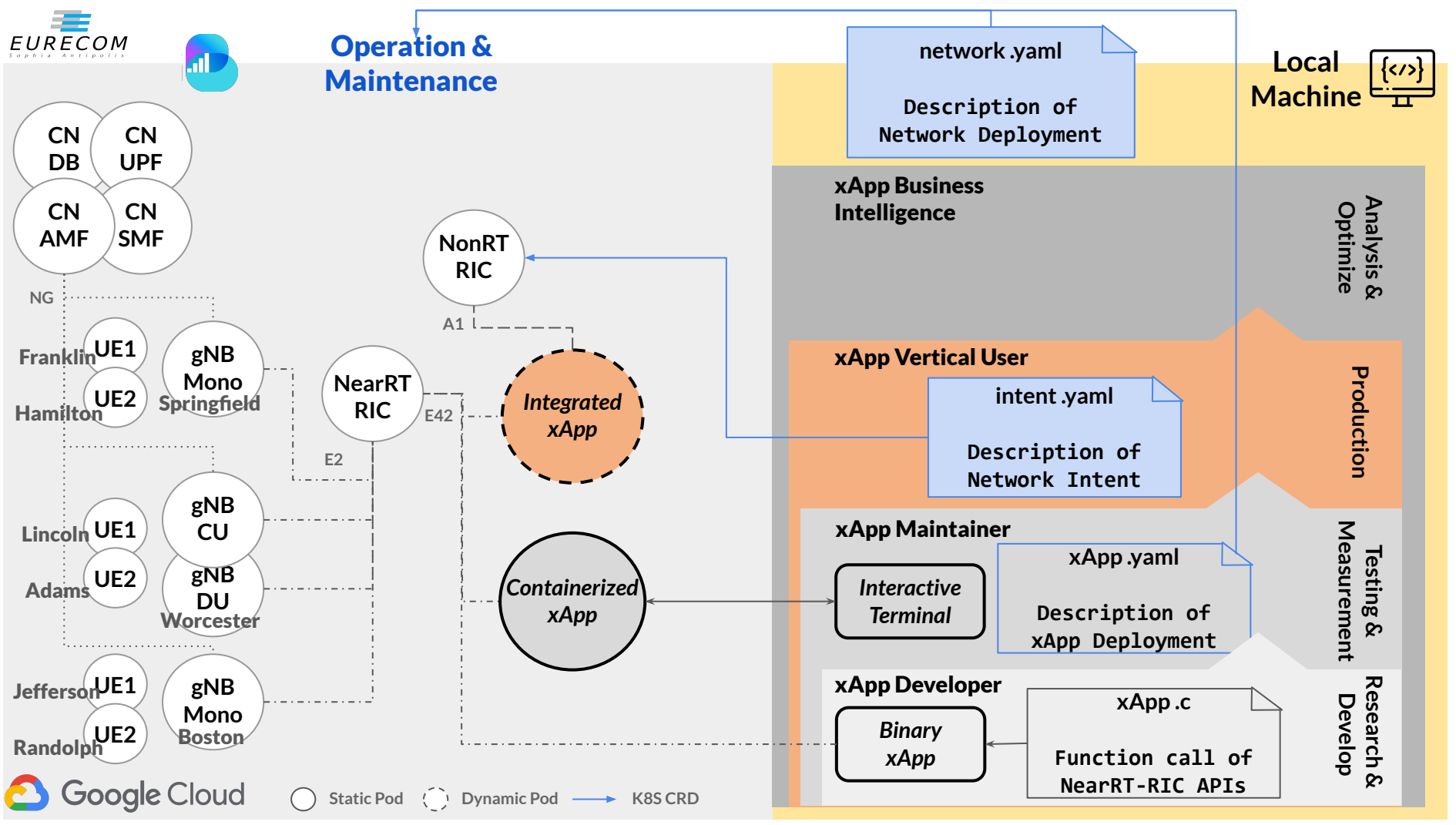
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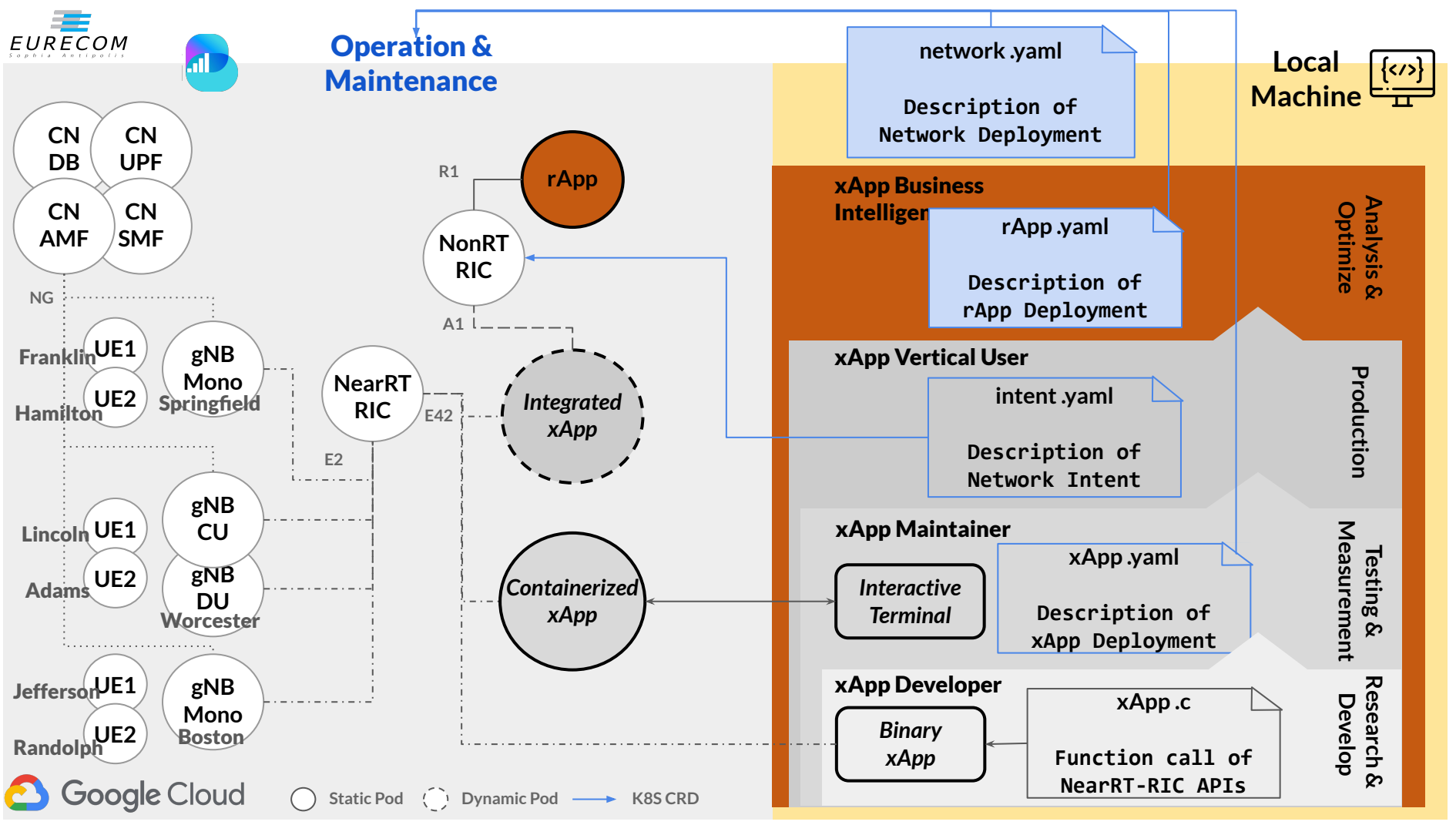
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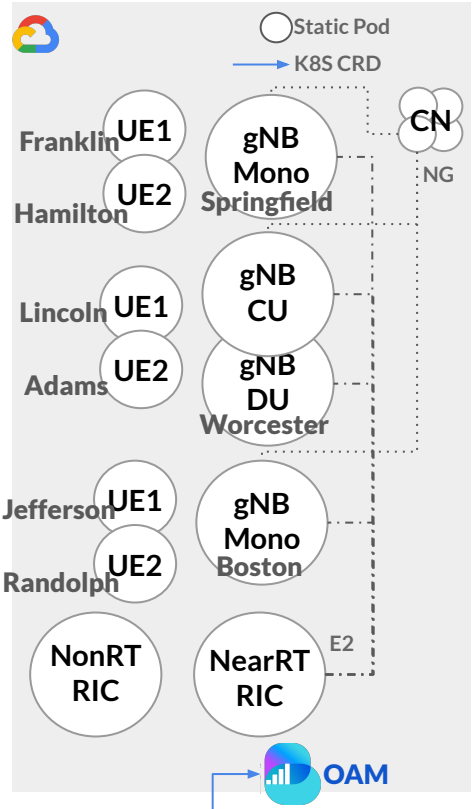
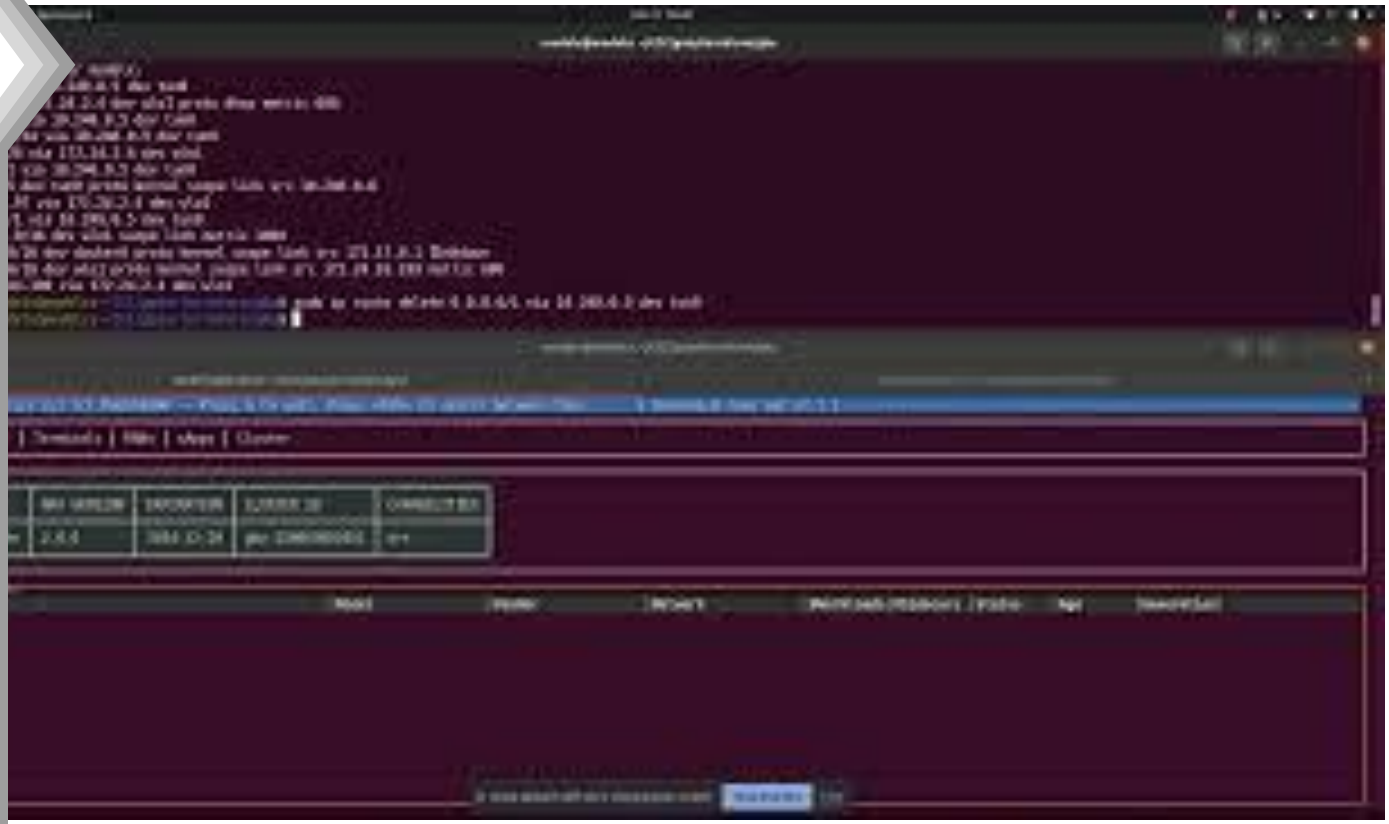
Network Deployment



network .yaml

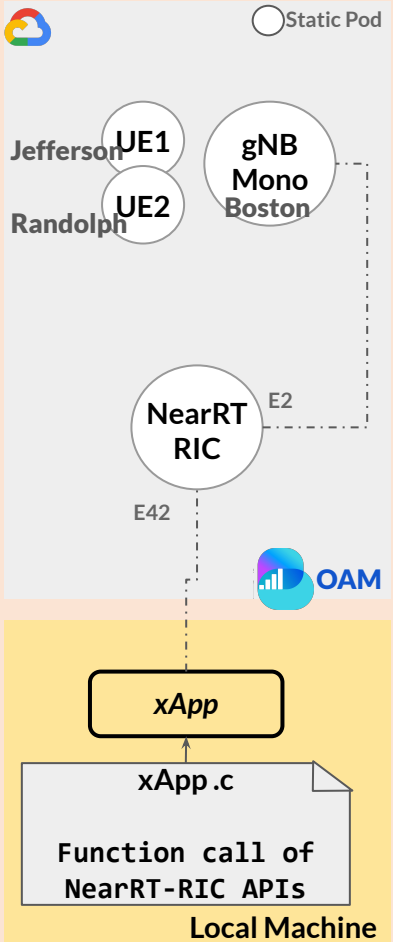
`Description of Network Deployment`

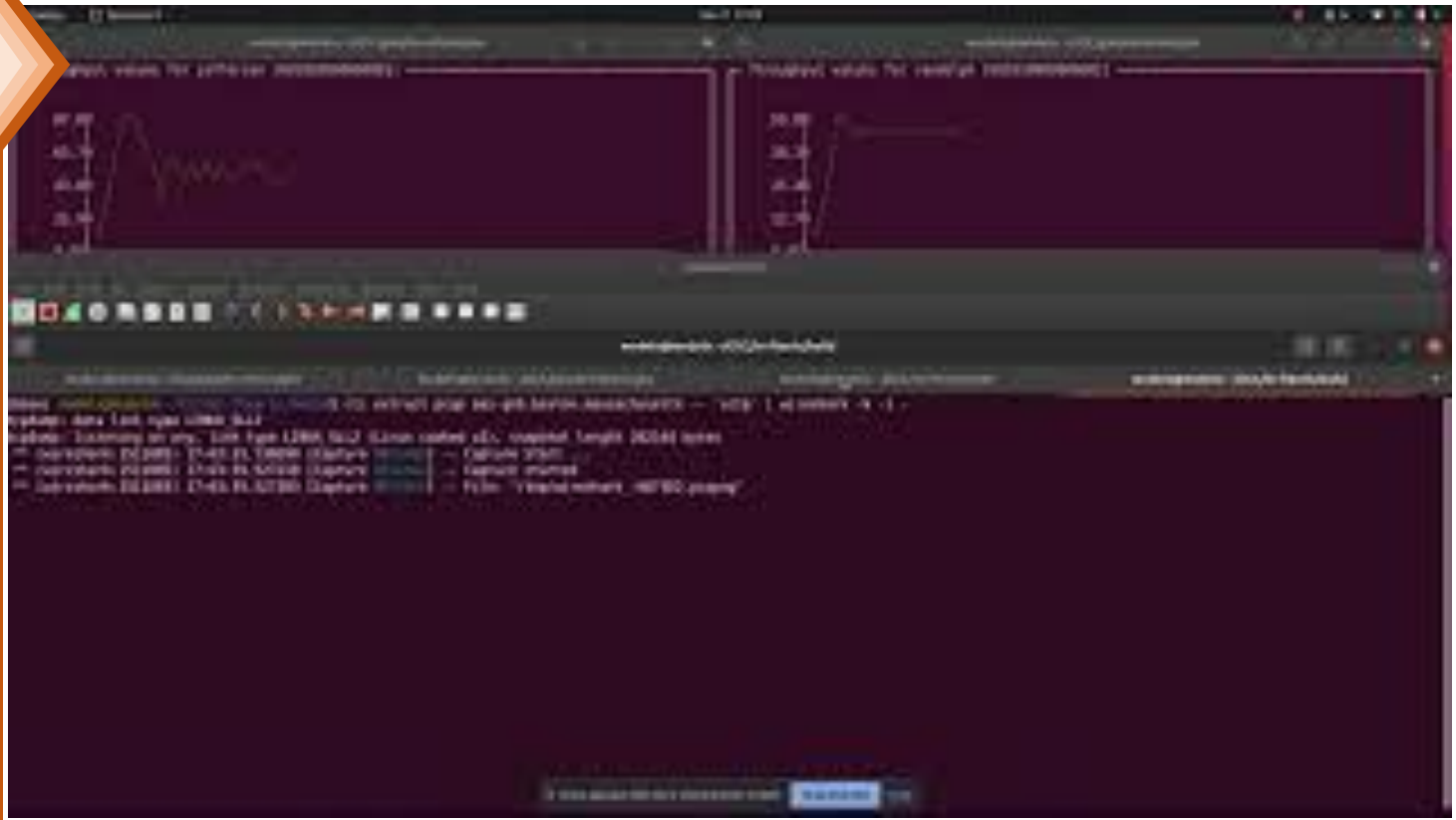
Local Machine



Video link: https://youtu.be/CnxVsEjntWM

Binary xApp
> xApp Developer
> Develop & Research



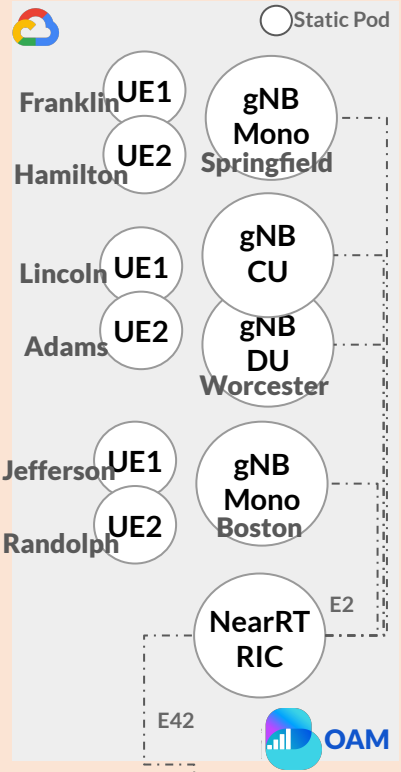


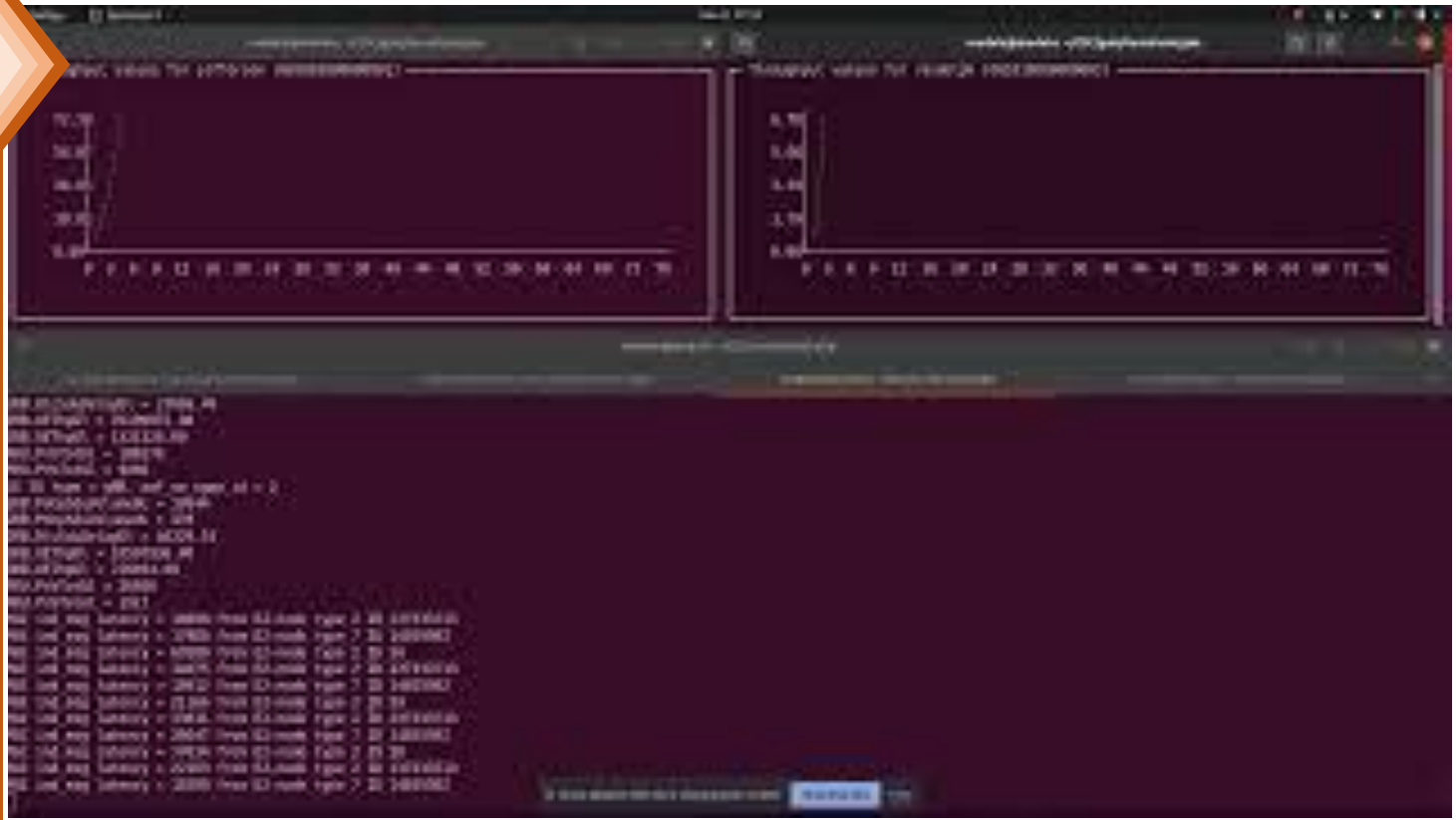
Video link: https://youtu.be/eZBAVBZNrEw

Binary xApp

> xApp Developer

> Develop & Research





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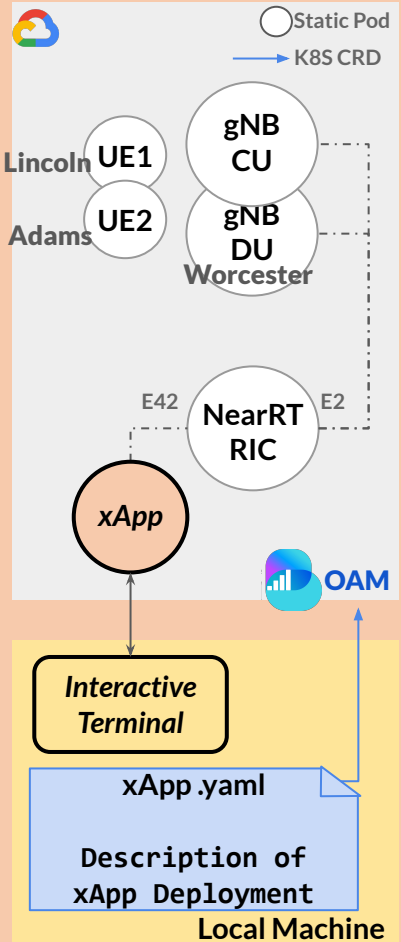
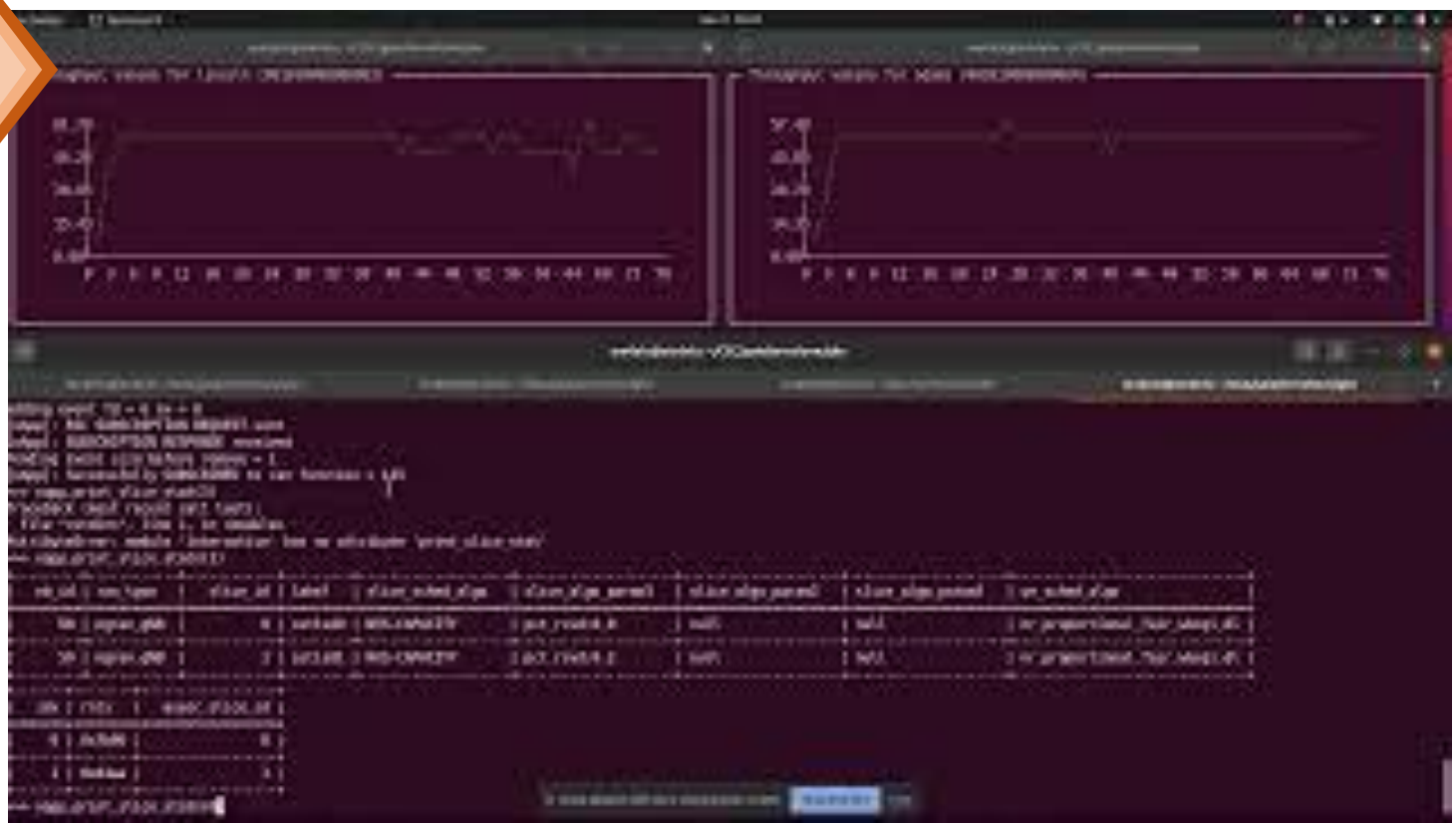
Containerized xApp

> *xApp Maintainer*
> *Testing & Measurement*



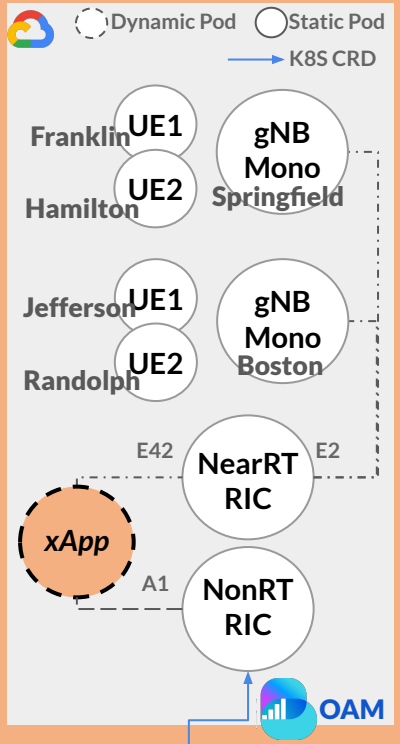


Video link: https://youtu.be/kbh31hSxVFI

Integrated xApp

> xApp Vertical User

> Production



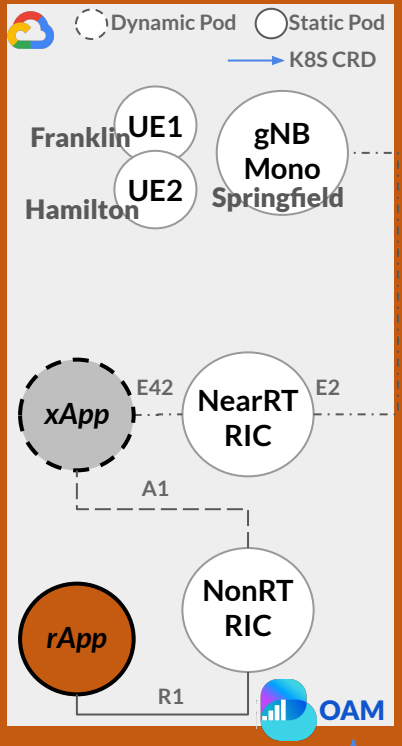
intent .yaml

```
Description of
Network Intent
```

Local Machine

Video link: https://youtu.be/3oHtkL39eo0

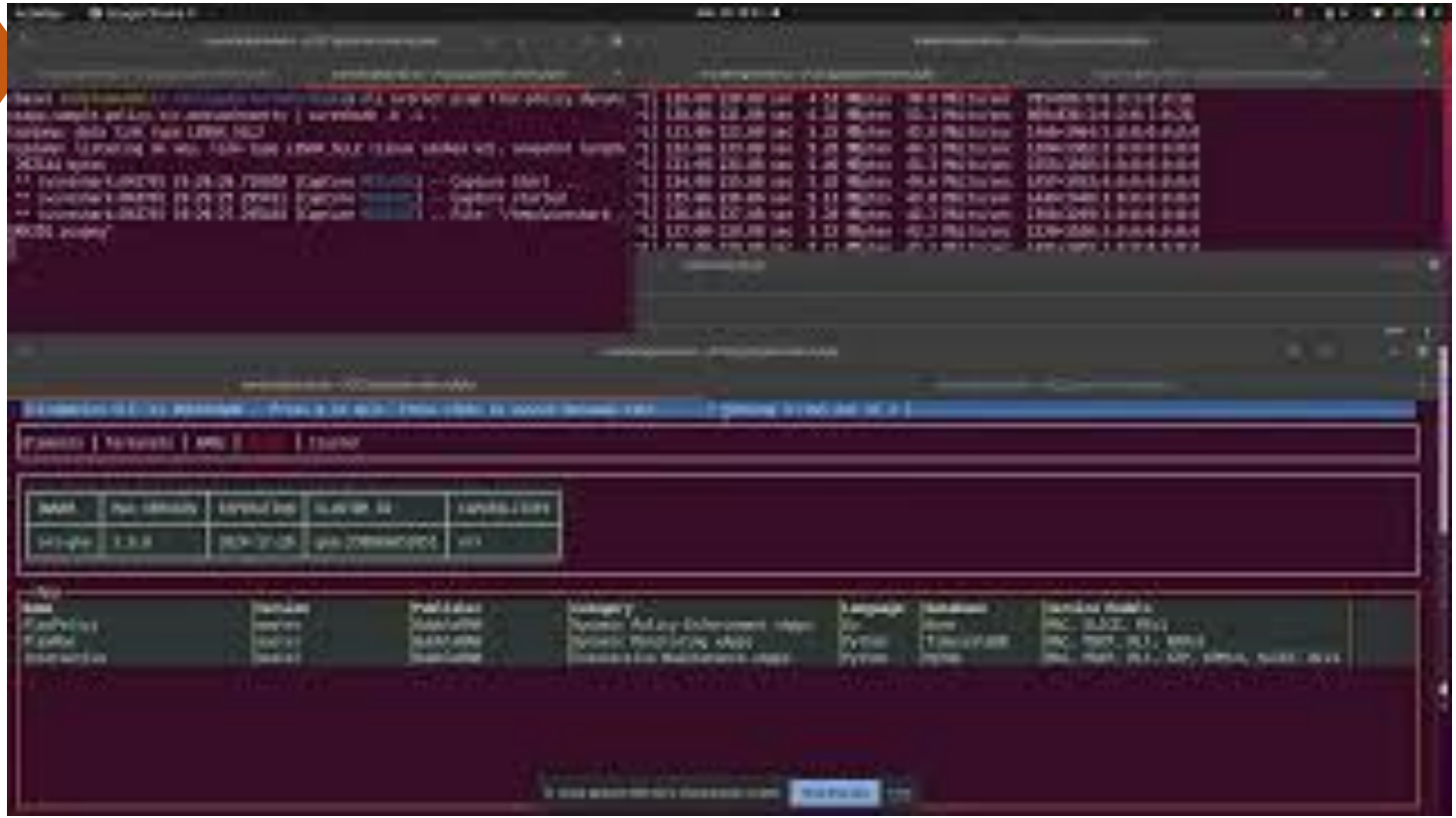
rApp
> xApp Business Intelligent
> Analysis & Optimize



rApp .yaml

Description of
rApp Deployment

Local Machine



Video link: https://youtu.be/Qfz_tzZ0Q94

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xApp DevOps

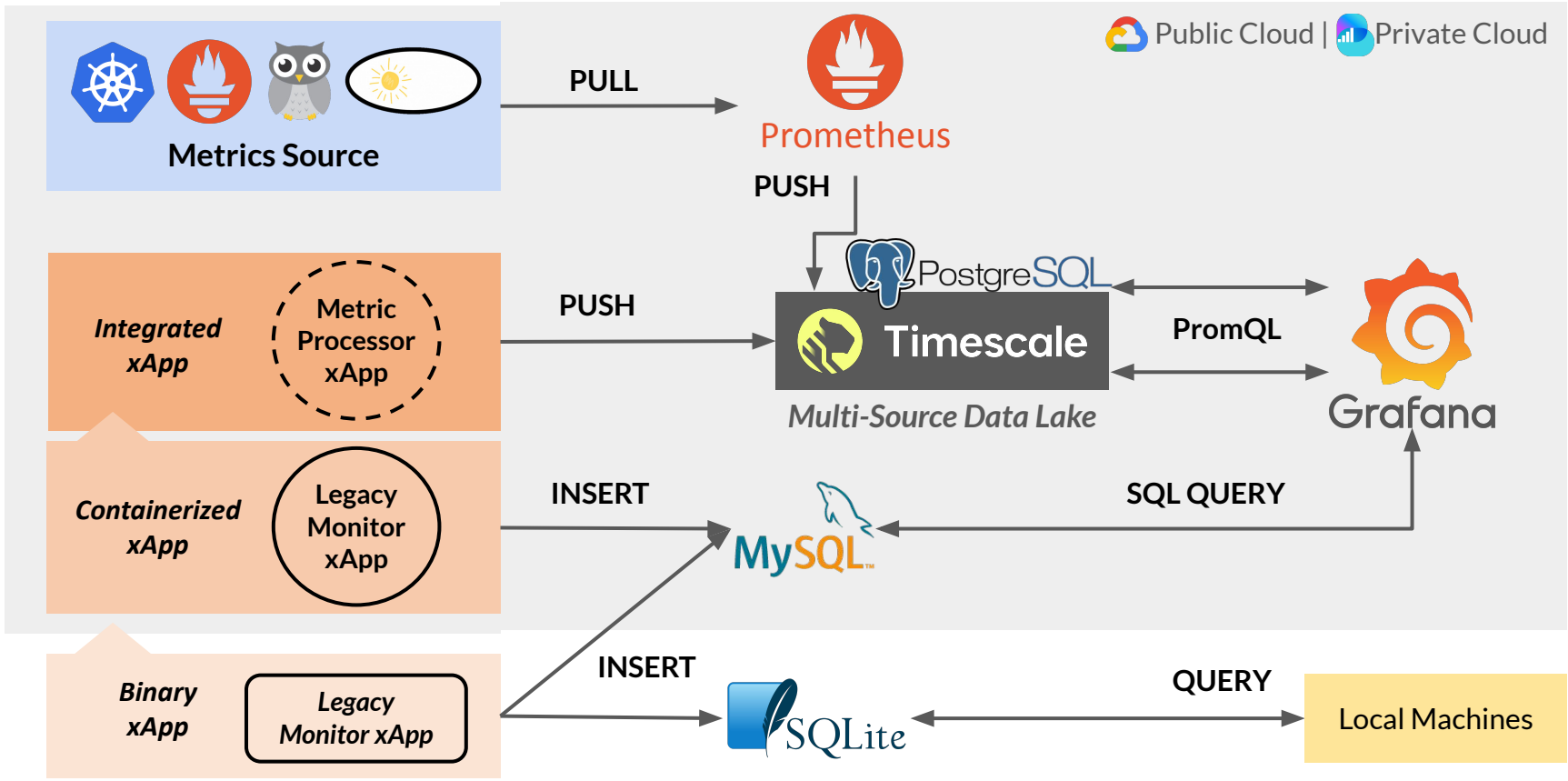
Data & ML

Open RAN Ecosystem	*Binary xApp*	*Containerized xApp*	*Integrated xApp*	*rApp*
Roles	**Developer**	**Maintainer**	**Vertical User**	**Business Intelligent & Data Analyst**
Participants	**Vendor**	**Operator**	**Application Provider**	**Stakeholder**
Usage Scenario	**Research & Develop**	**Testing & Measurement**	**Production**	**Analysis & Optimize**
Knowledge of NearRT-RIC APIs	**Proficient**	**Moderate**	**Basic**	**None**
Knowledge of SMO APIs	**None**	**Basic**	**Moderate**	**Proficient**
Actions	**Develop New Functionalities**	**Interact with Network**	**Apply & Enforce Policy**	**Define Network Intent & Create Policy**
Programming Languages	C/C++, Python, Go	Python, Go	Python, Go	Any
Network Configuration	Manual	Automatic	Automatic	Automatic
Network Deployment	Static	Static	Dynamic	Dynamic
Demo Example	C xApp with Control & Monitor service	Python & Go xApp with Interactive Module	Go xApp with A1 APIs & Programmable Python xApp	Go rApp with Cell Management

xApp DevOps Code Based

ML Usage Data Based

Multi-Source Dataflow Architecture



BubbleRAN Open RAN Landscape

MX Products	Descriptions
ORS: Open RAN Studio SW	E2E Cloud-Native Open RAN
PDK: Open RAN Infra SDR, HW + SW	Cloud-Native Multi-Vendor Network Featuring Open RAN
Extension → **UE** HW + SW	Multi-Vendor Soft UE in a Box
PRO: Plug & Play Private 5G RU, HW + SW	Industrial-Grade Cloud-Native Network Optionally with Open RAN & DevOps Platform
Extension → **HUB** HW + SW	LAN in a Box with Backhaul & Edge Service

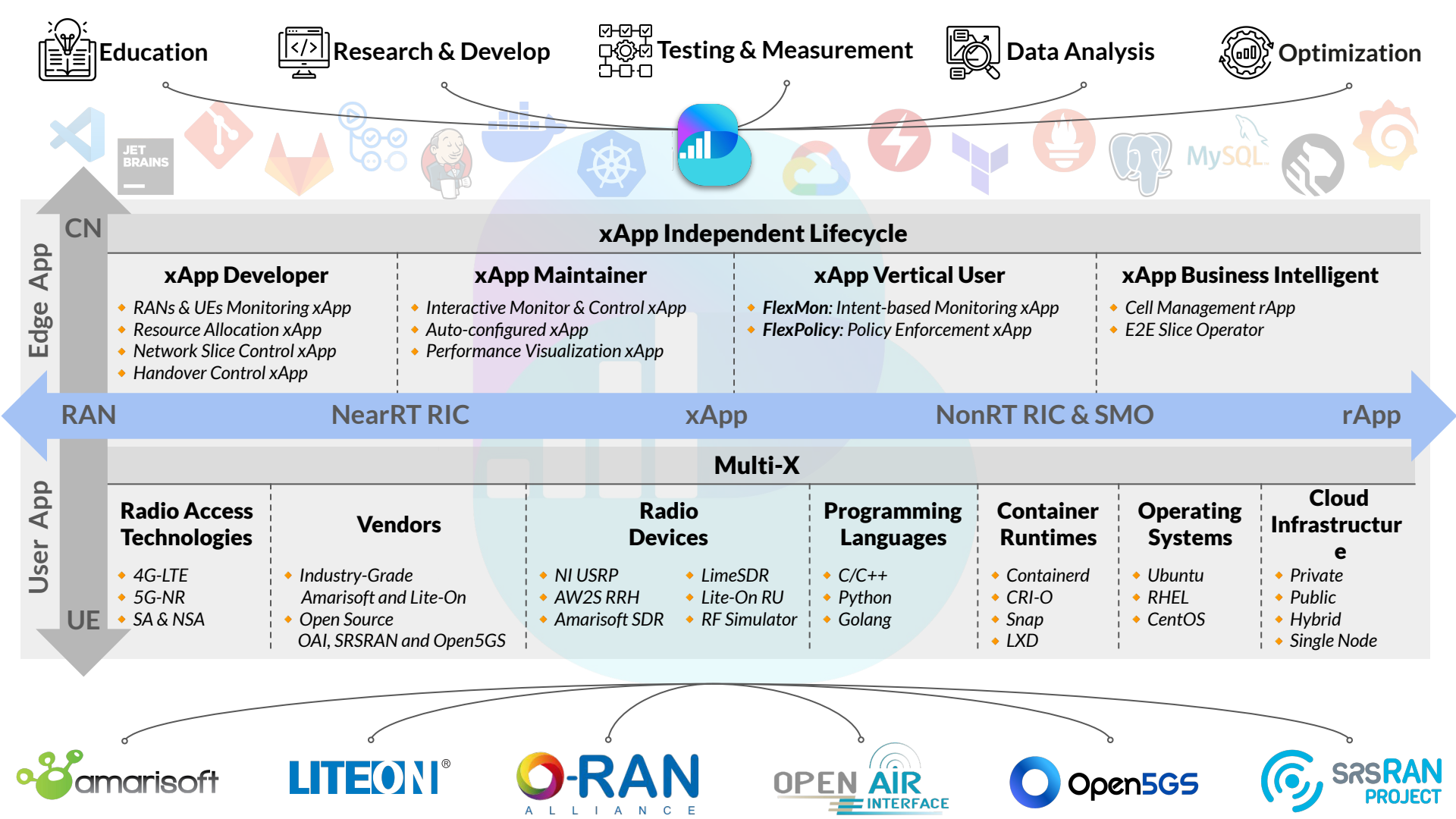
Deployment & Optimization — *PoC/MVP* — *Upgrade*

xApp Features

Language	O-RAN SMs			Customized SMs					
	KPM		RC	MAC	RLC	PDCP	GTP	SLICE	TC
	v2	v3	v1						
C	v	v	v	v	v	v	v	v	v
Python	v	v	24'Q2	v	v	v	v	v	TBD
Go	v	v	24'Q2	v	v	v	v	v	TBD
Database									
SQLite3	v	v	24'Q2	v	v	v	v	v	N/A
MySQL	v	v	24'Q2	v	v	v	v	v	N/A
TimescaleDB	v	v	TBD	v	v	v	TBD	TBD	N/A

BR-T9S Command Line Interface

Commands	Descriptions	
`observe`	Open up the observation toolbox	
`cic`	CLI in CLI	
`install`	Install a component on Trirematics	
	`Ex: cli install operator/model/network`	
`extract`	Extract contents from the containers	
	`config`	Get decoded configurations out of an Element
	`logs`	Get logs from a specific Element
	`graph`	Get the network graph
	`pcap`	Get PCAP from the network interfaces of the Workload
	`infra`	Get infrastructure data
	`port`	Get particular port number and IP address from a specific Element
`test`	Perform an evaluation	
	`rtt`	Measure the round-trip time
	`throughput`	Measure the network throughput
`remove`	Remove a component on Trirematics	
	`Ex: cli remove operator/model/network`	
`completion`	Generate the auto-completion script for the specified shell	
	`Ex: cli completion bash/powershell/fish/zsh`	
`login`	Authenticate to Harbor for the current namespace	
`list`	List all the operators, models, or networks	
`diag`	Perform diagnostics against the cluster	
`help`	Help about any command	
`run`	Run an arbitrary command list	


Education
Research & Develop
Testing & Measurement
Data Analysis
Optimization
JET BRAINS
MySQL
Edge App
CN
xApp Independent Lifecycle
xApp Developer
RANs & UEs Monitoring xApp
Resource Allocation xApp
Network Slice Control xApp
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Open Source
OAI, SRSRAN and Open5GS
Radio Devices
NI USRP
AW2S RRH
Amarisoft SDR
LimeSDR
Lite-On RU
RF Simulator
Programming Languages
C/C++
Python
Golang
Container Runtimes
Containerd
CRI-O
Snap
LXD
Operating Systems
Ubuntu
RHEL
CentOS
Cloud Infrastructure
Private
Public
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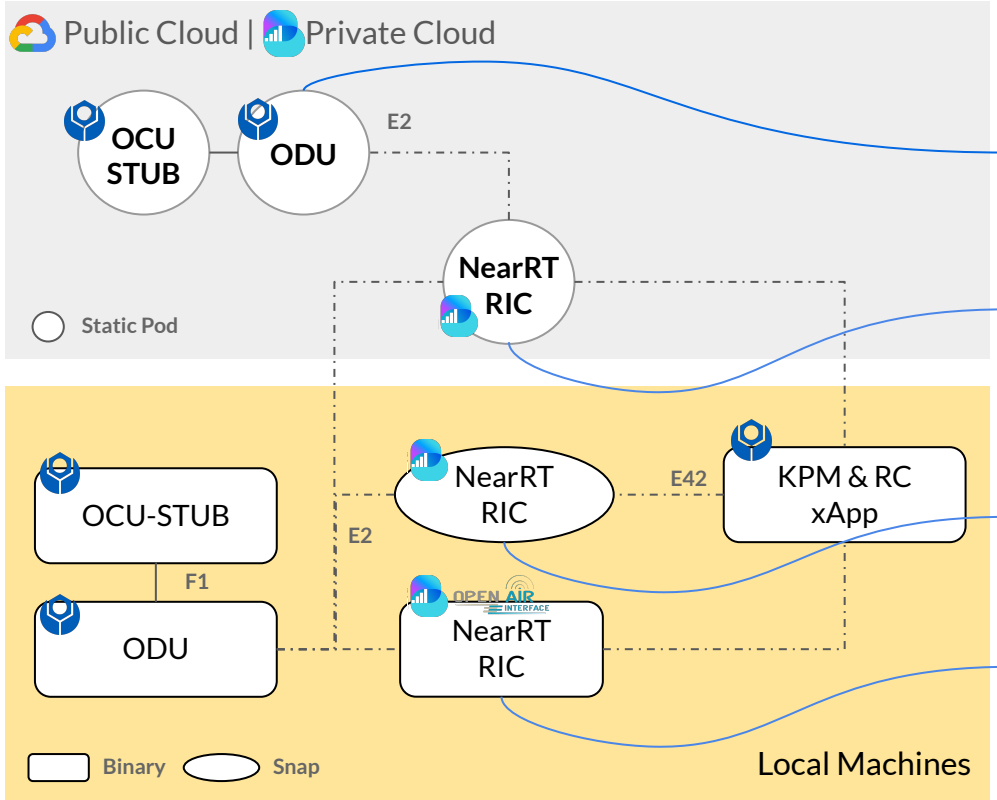
Single Node
amarisoft
LITEON
O-RAN ALLIANCE
OPEN AIR INTERFACE
Open5GS
SRSRAN PROJECT

Interoperability Testing



Stage 4
On-Boarding ODU and OCU STUB

Stage 3 - Pod
On-Boarding new version NearRT RIC

Stage 2 - Snap
Testing & Measurement

Stage 1 - Source Code
Merge Request and Integration

DevOps