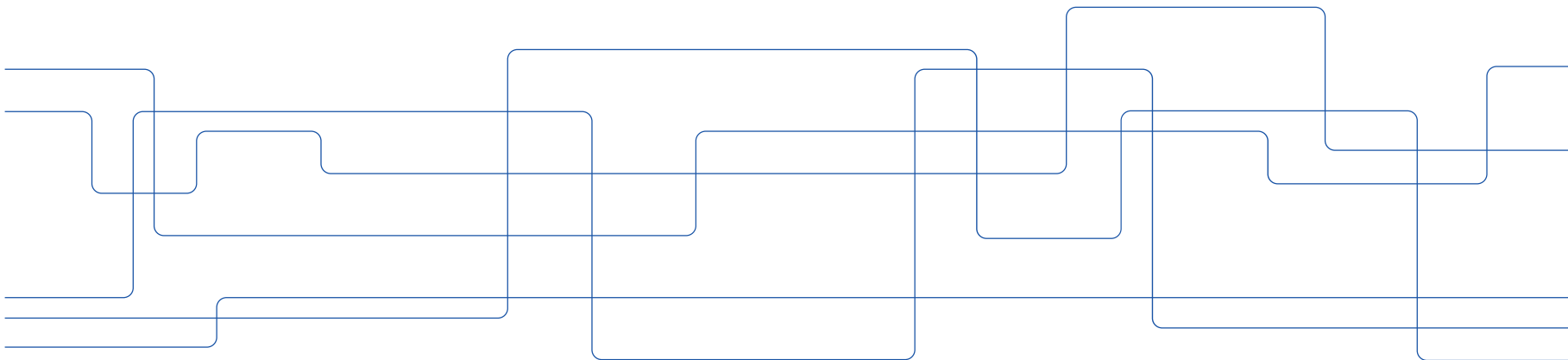




ExPECA Testbed

Overview and Configuration





Agenda

09:00 Overview of the testbed

- What and where is ExPECA?
- Hardware
- Software
- Observability / Monitoring
- GPS/GNSS synchronization
- Software-Defined Radio (SDR)

09:30 5G / Openairinterface

- Main components in OAI 5G
- Main 5G services in OAI

10:00 Configuration of the testbed

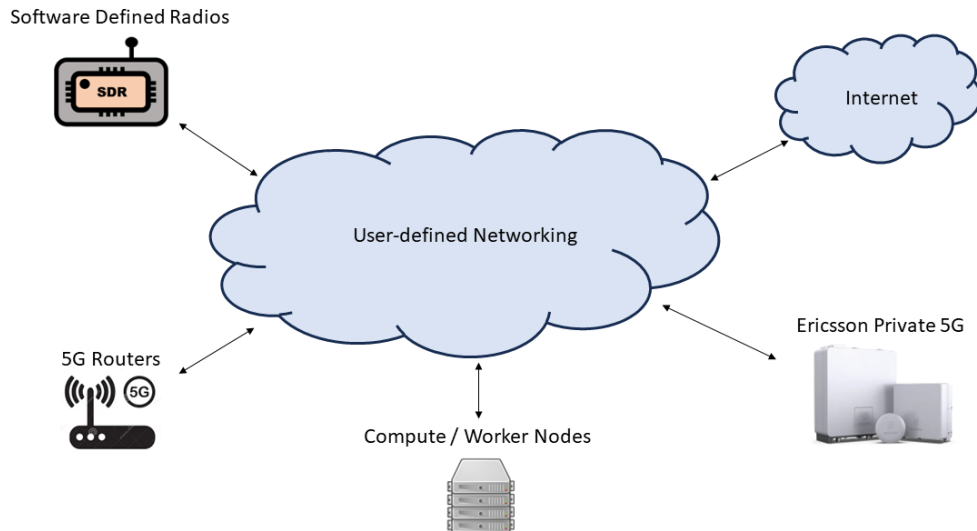
- ExPECA Experimental Workflow
- Experimental Scenarios
- Configuration with GUI

10:30 Group assignment

- Configuration with Python Notebook
- 5G Core setup
- GNodeB setup
- Verification
- Research example: EDAF

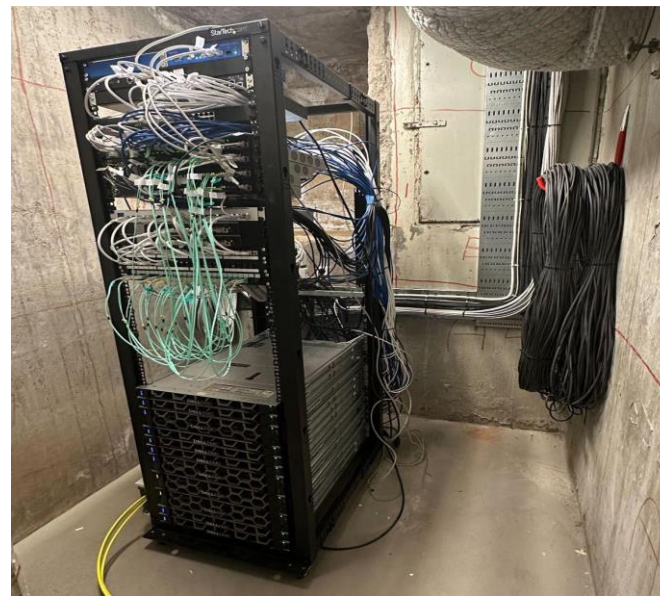
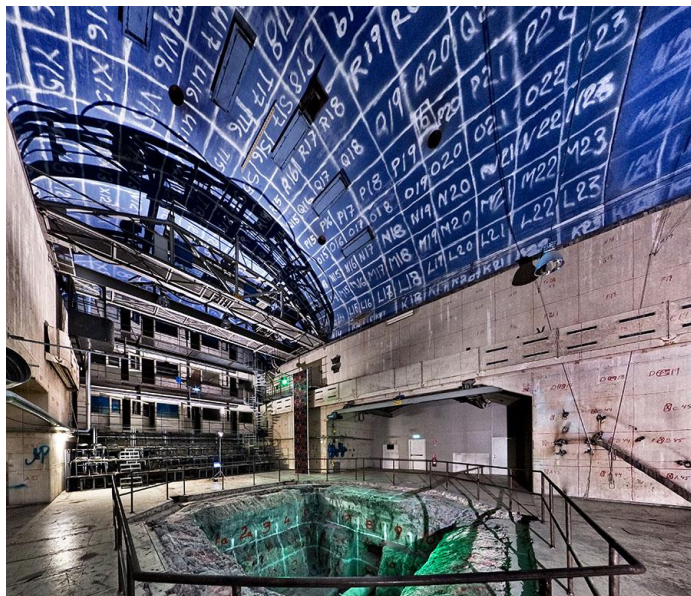
What is ExPECA?

- An Experimental Platform for Edge Computing Applications
- Connects wireless devices, SDRs, and an Ericsson Private 5G system with networking and compute resources, to form a highly configurable research environment



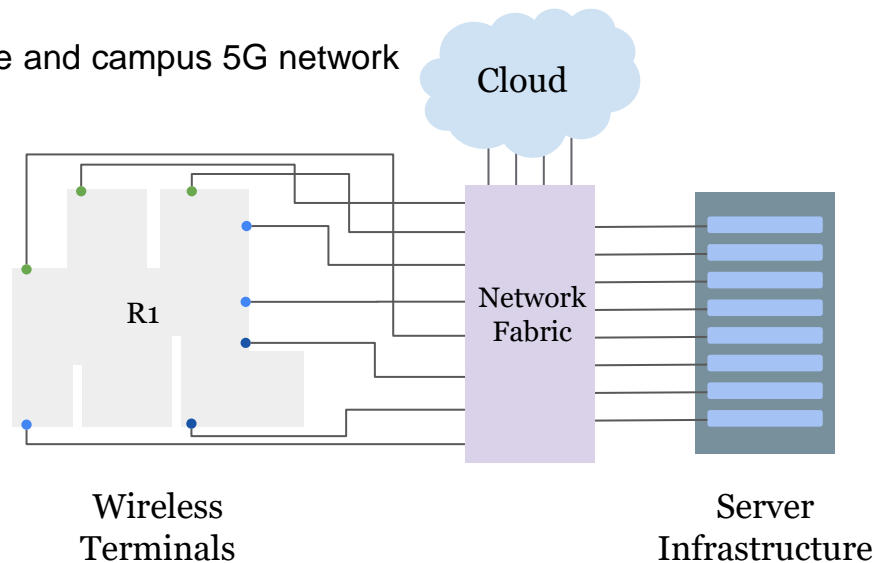
Where is ExPECA?

- Located in R1, the old reactor hall on KTH campus
- Provides a disturbance-free environment for wireless experimentation
- Provides a large area for distribution of wireless equipment

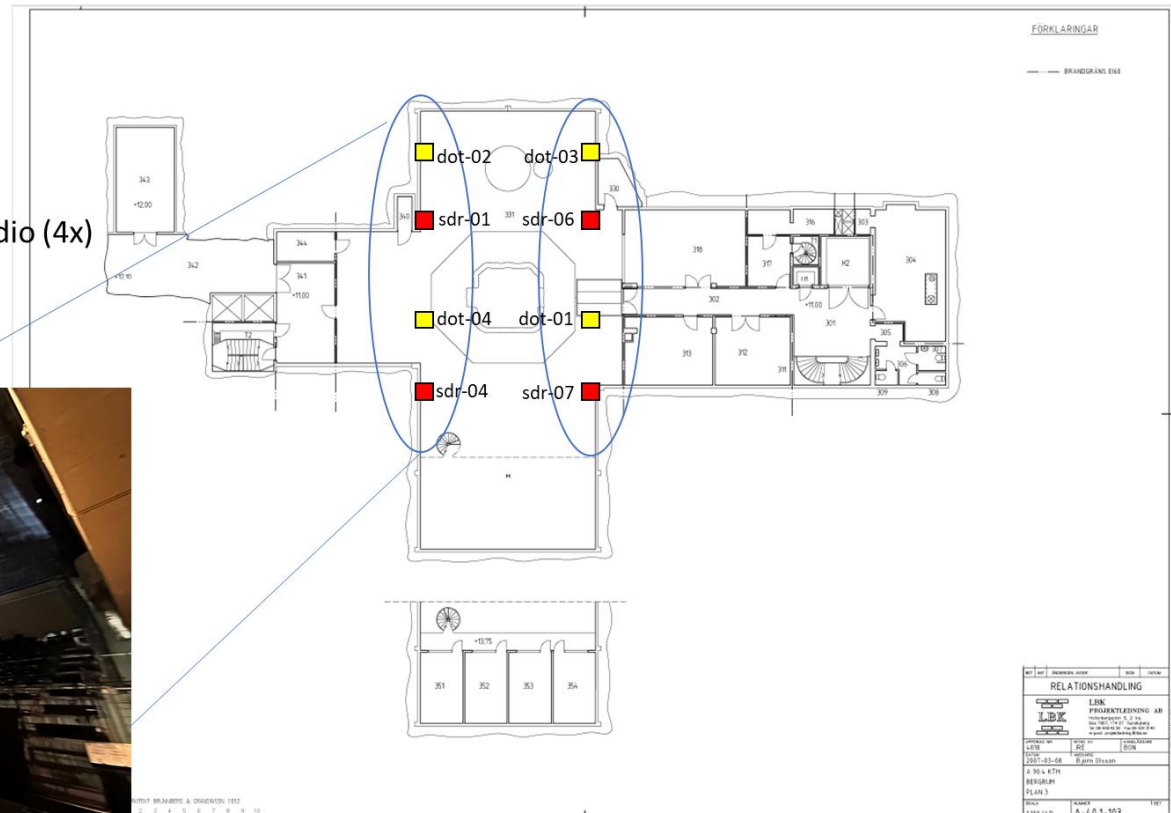
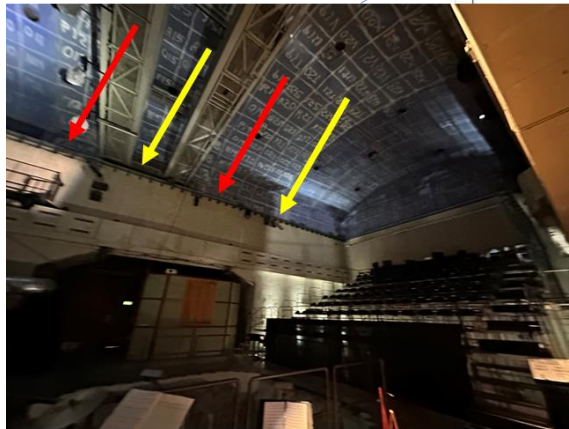


Hardware

- 10 SDRs, 8 5G COTS UEs, 4 Ericsson Private 5G Radio Dots
- 1 Controller server, 10 Worker servers, Ericsson Private 5G servers
- GPS sync system, including antenna, cables, and 1 PTP Grandmaster clock
- Networked by routers and switches
- Public internet address and connection
- Fiber connection to Telenor Edge infrastructure and campus 5G network



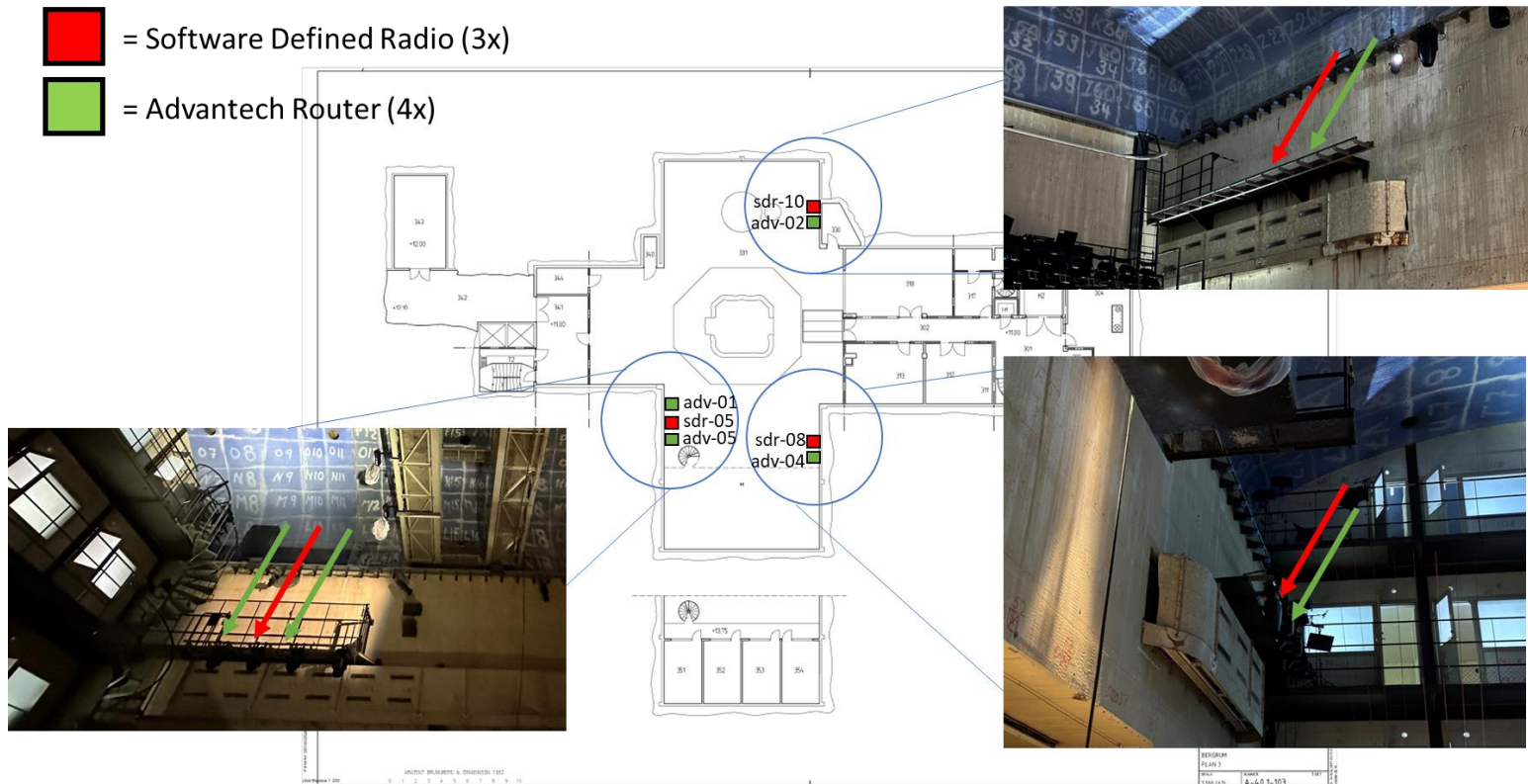
 = Software Defined Radio (4x)

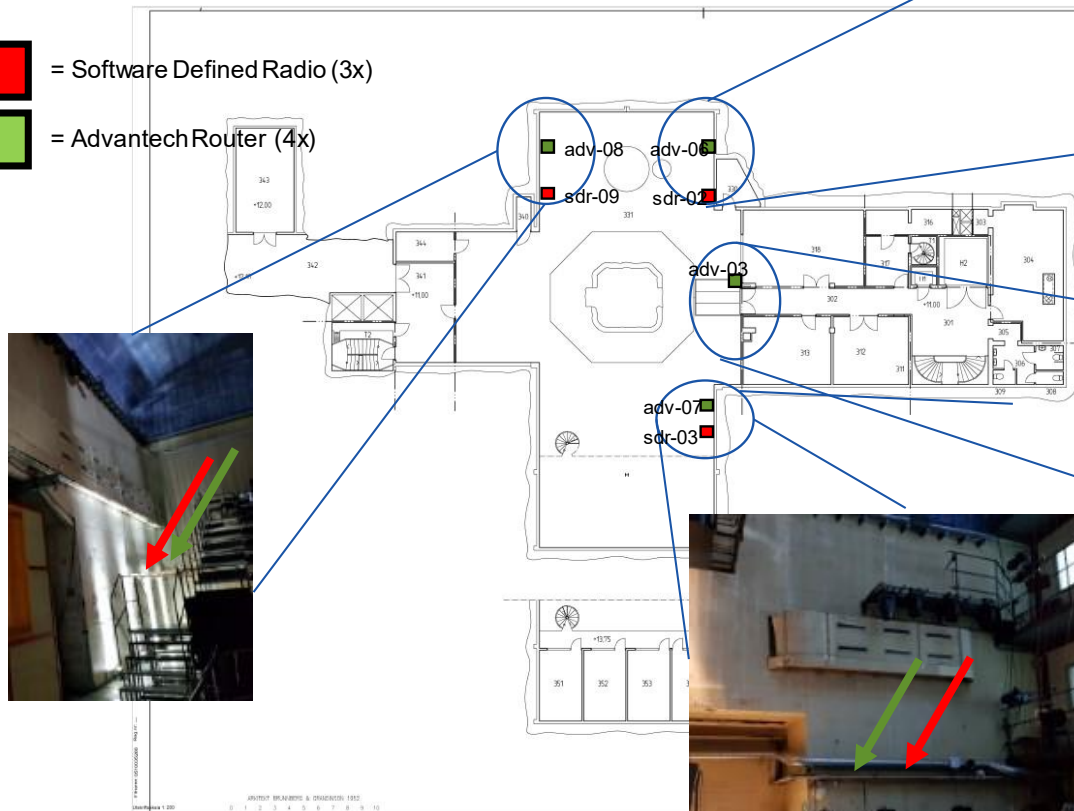
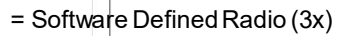


Medium Location Nodes (6m height)

 = Software Defined Radio (3x)

 = Advantech Router (4x)





REF	DISPOSITION ACTION	BOOK	DATE
RELATIONSHANDLING			
		LBK PROJEKTLÆSNING AR Høstvejsgade 5, 3 DK-2800, Vir Øst Tel: 045 92 12 12 Fax: 045 92 12 40 e-mail: projektl@lbk.dk	
UPTAGET DEN 4-078 2007-03-08	HØRTE AF JANE Søren Jørgen	ANMÆLSELSEN DON	
A 90 A KTH BEGRUND PLAN 3			
STATUS	NUMMER	TITEL	
	100 462		

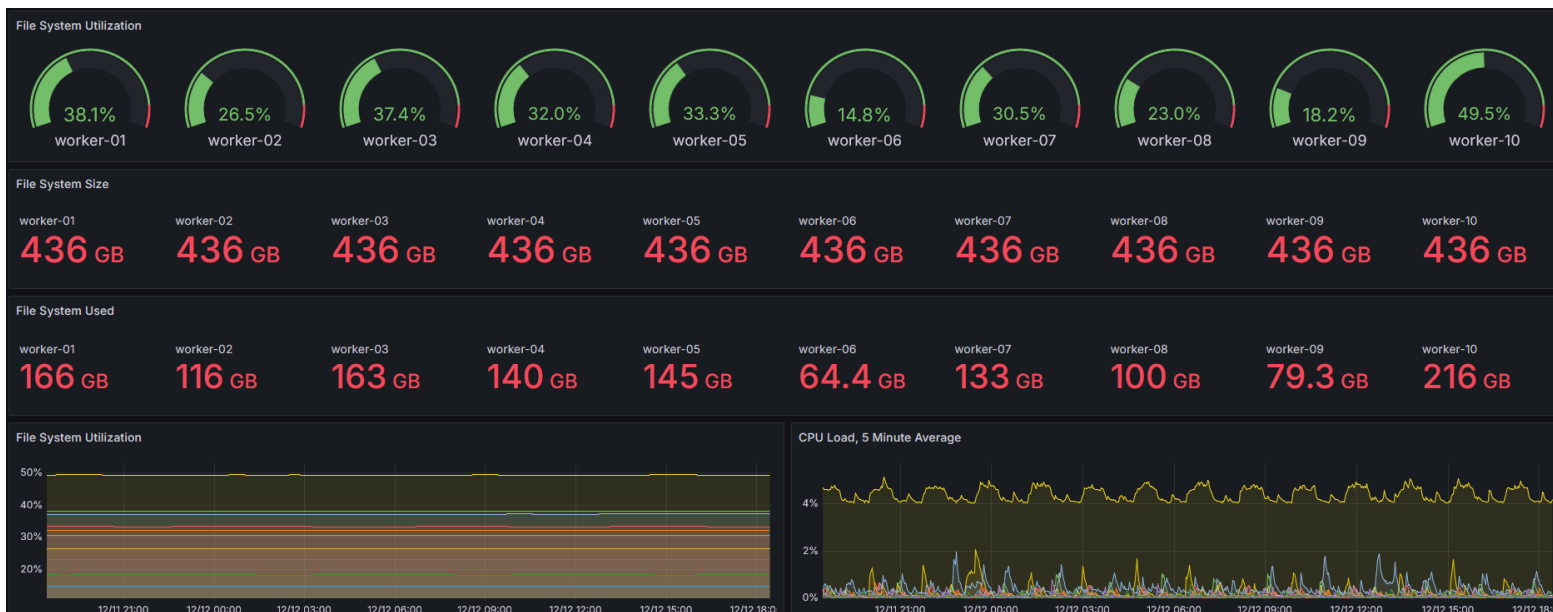
Software

- Orchestration adapted from Chameleon testbed, using Openstack
- Applications packaged as Docker images, distributed by Kubernetes



Observability / Monitoring

- Collects performance / status data from various parts of the testbed
- Displays them via Grafana dashboard for easy monitoring



Observability / Monitoring, continued

- Data for the Advantech 5G routers

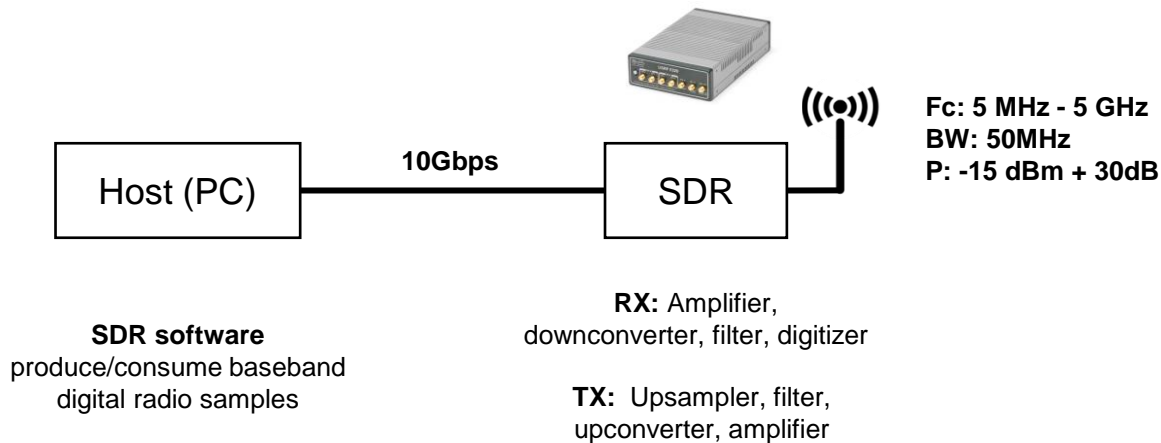
Router	advantech-03	▼
Advantech Router Data		
Label 1	Label 2	Value
1 - Active Connection	Cell	N/A
1 - Active Connection	Channel	N/A
1 - Active Connection	LAC	N/A
1 - Active Connection	Operator	N/A
1 - Active Connection	PLMN	N/A
1 - Active Connection	Registration	N/A
1 - Active Connection	Signal Strength	N/A

GPS / GNSS Synchronization

- Use GPS / GNSS signal to time sync our servers and devices
- Better than μs precision
- Enables research that requires high precision time stamping
- Necessary for Ericsson Private 5G



Software-Defined Radio (SDR)



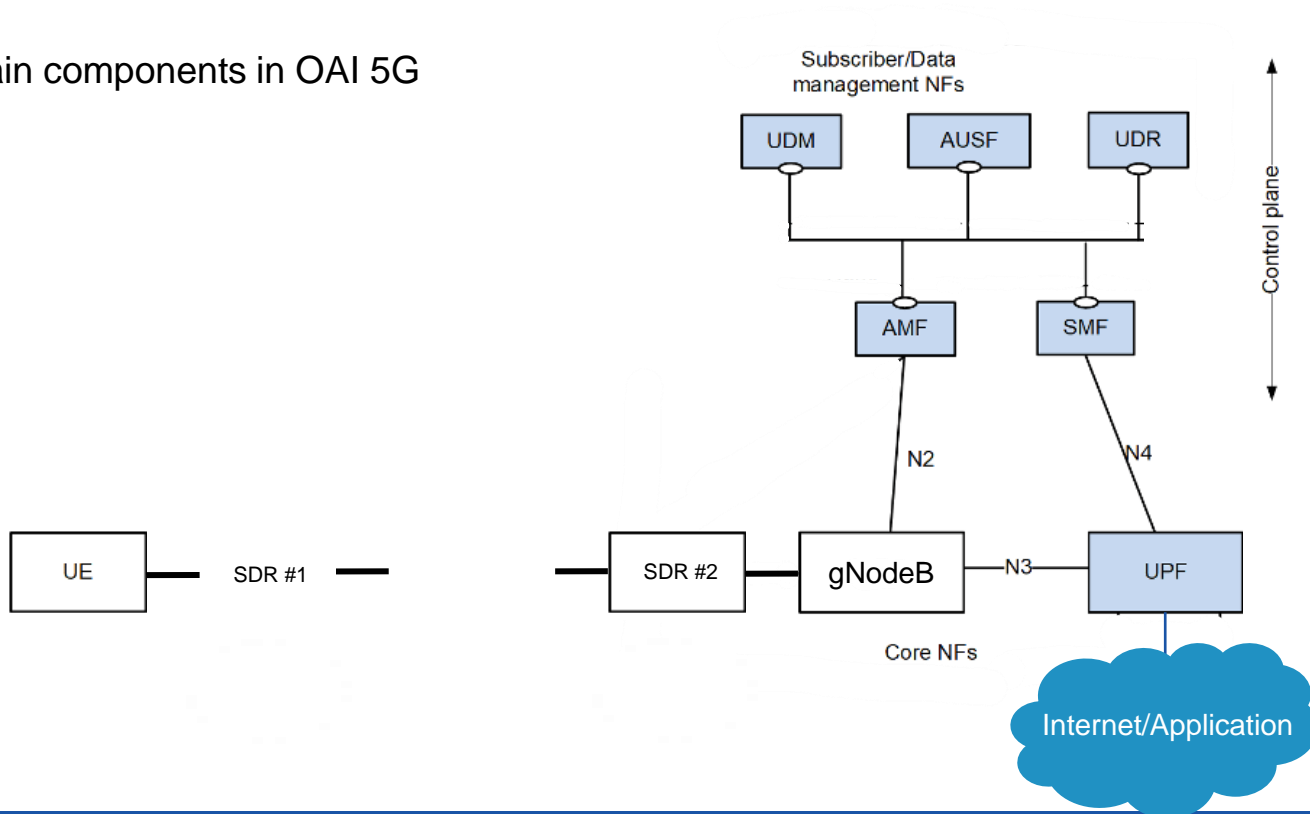
SDR hardware: *USRP E320*

SDR software:

- Openairinterface 5G/LTE, Mangocomm WiFi
- SRS 5G/LTE
- GNU Radio, etc

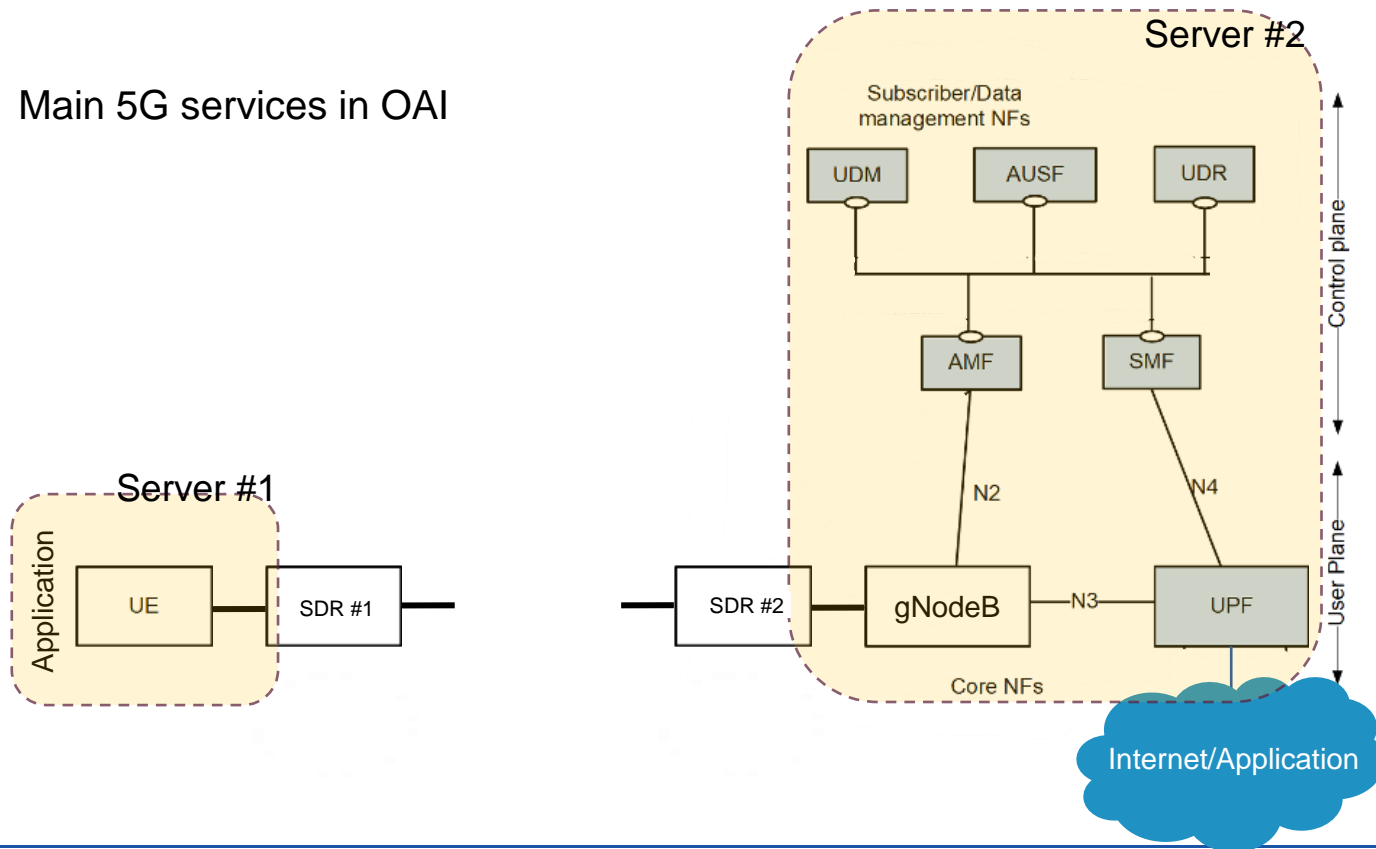
5G / Openairinterface

- Main components in OAI 5G



5G / Openairinterface, continued

- Main 5G services in OAI



ExPECA Experimental Workflow

Reservation

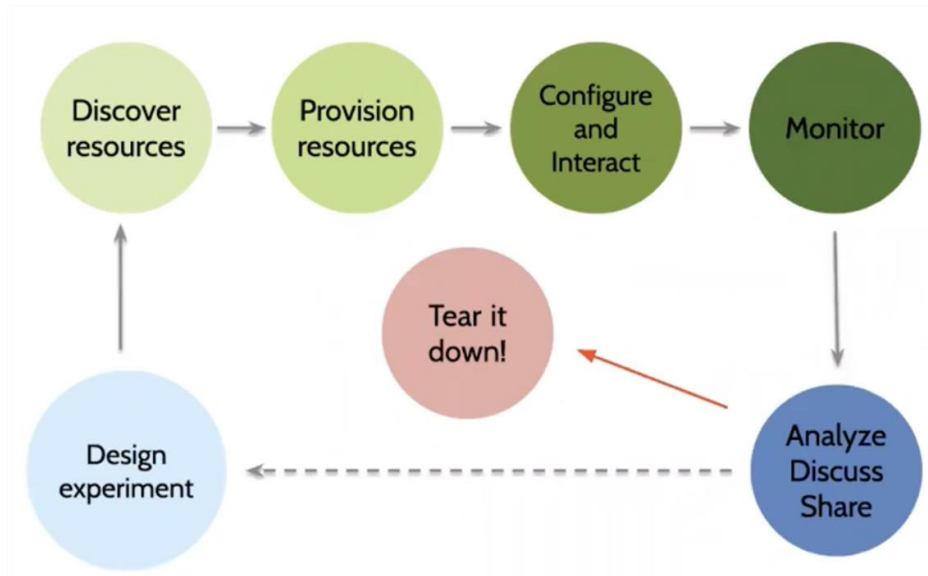
- Reserve workers
- Reserve radios
- Reserve storage

Configuration

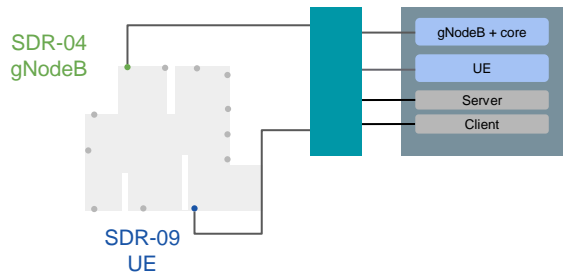
- Provision the network
- Run applications as containers

Extract the results

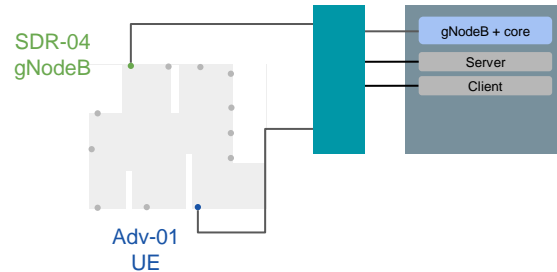
- Object and block storage



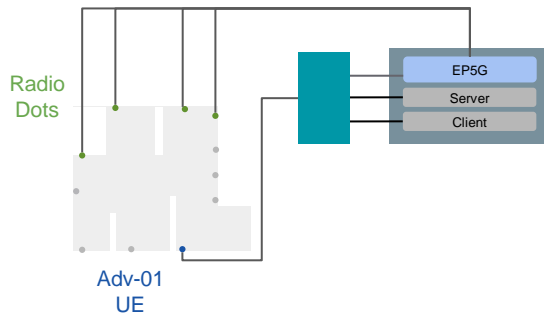
Experimental Scenarios



1) SDR-SDR 5G



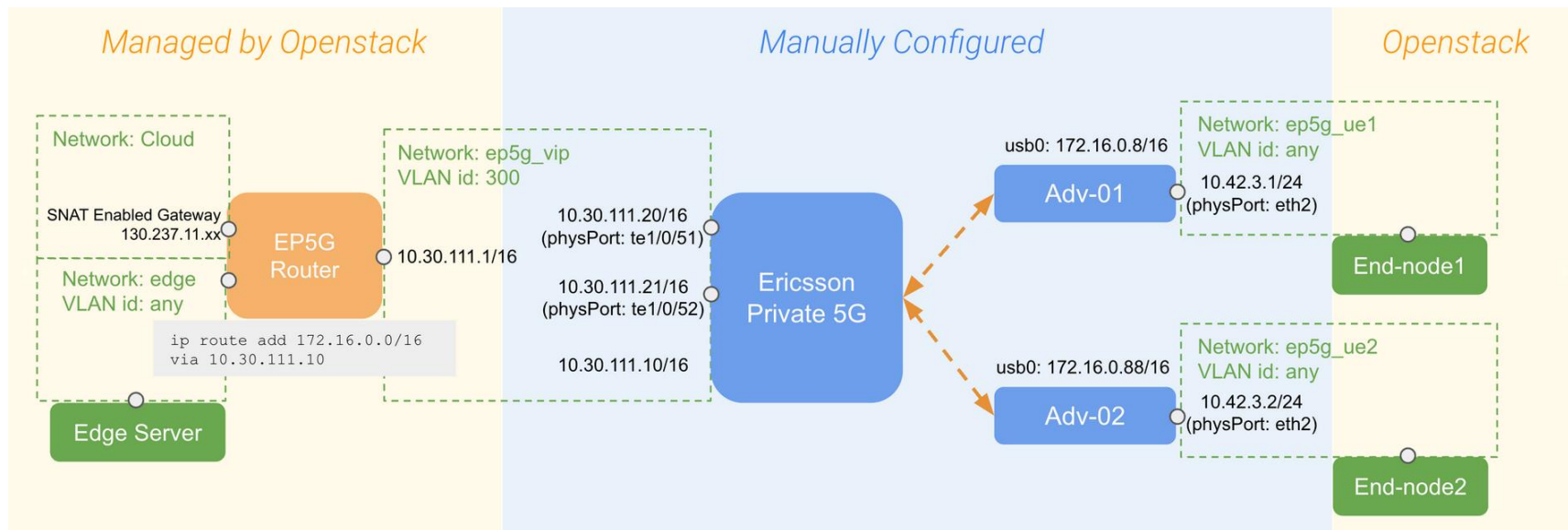
2) SDR-COTS 5G



3) EP5G-COTS 5G

Configuration with GUI

- Plan your setup
- In this case: EP5G + Adv. router + Container at edge server



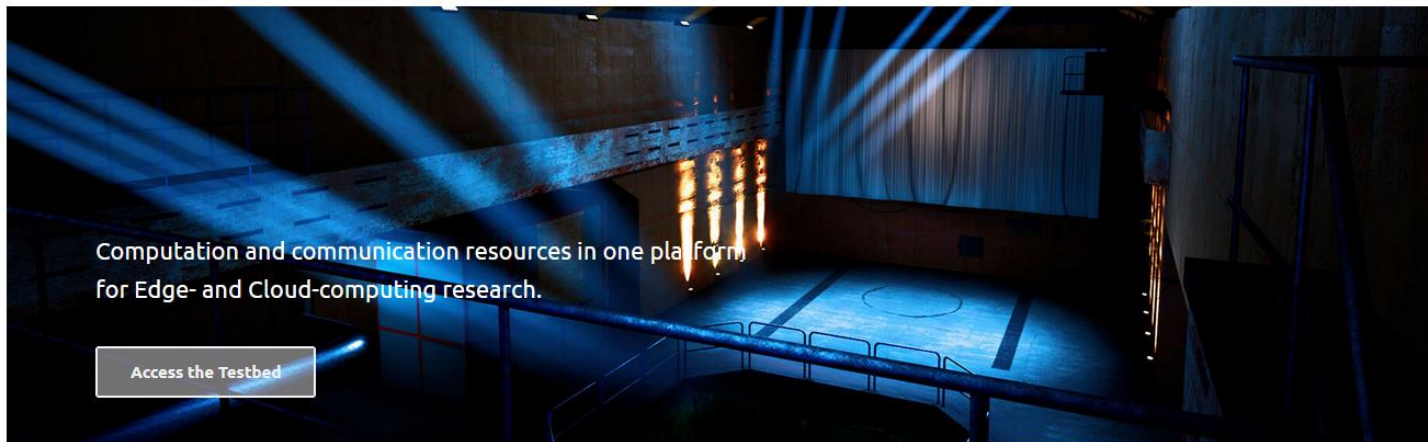


ExPECA Home Page

- <https://expeca.proj.kth.se/>

To Hardware Discovery

To testbed GUI





Hardware Discovery

Hardware discovery

SDRs

sdr-01
sdr-02
sdr-03
sdr-04
sdr-05
sdr-06
sdr-07
sdr-08
sdr-09
sdr-10

Adv Routers

adv-01
adv-02
adv-03
adv-04
adv-05
adv-06
adv-07
adv-08

Worker Nodes

worker-01
worker-02
worker-03
worker-04

adv-03

ID	MODEL	LOCATION	SIMCARD1 IMSI	SIMCARD2 IMSI	EP5G IP Address
advantech-03	ICR-4453 5G Router	?	999080000000099	001010000000011	172.16.0.40

INTERFACE	INTERFACE NAME	IP	INTERFACE SPEED	INTERFACE MTU	SEGMENT ID	TYPE
SFP	eth2	10.42.3.1/24	10Gbps	9000	133	sfp

Remember for lease creation

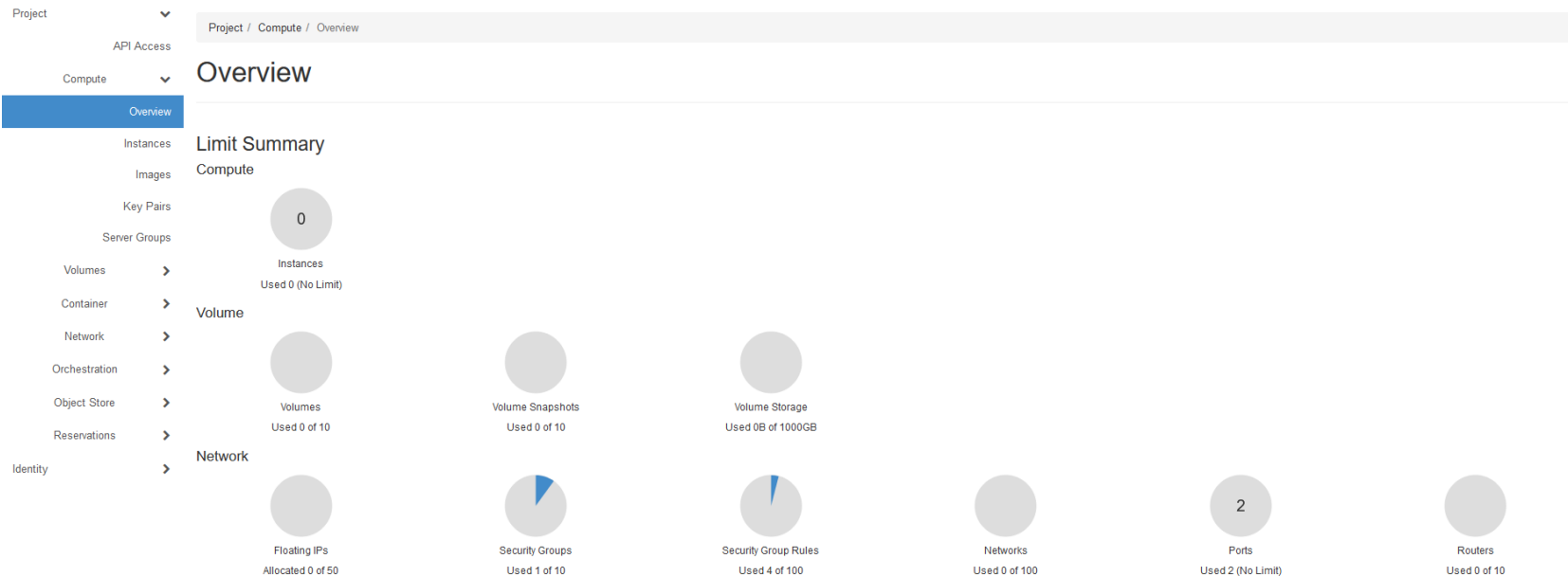
adv-04

ID	MODEL	LOCATION	SIMCARD1 IMSI	SIMCARD2 IMSI	EP5G IP Address
advantech-04	ICR-4453 5G Router	?	999080000000010	001010000000010	172.16.0.96

INTERFACE	INTERFACE NAME	IP	INTERFACE SPEED	INTERFACE MTU	SEGMENT ID	TYPE
SFP	eth2	10.42.3.1/24	10Gbps	9000	134	sfp



GUI Overview / Starting Point



Step 1: Reservation / Lease Creation

Create Lease

General

Hosts

Networks

Devices

Lease Name

worker-02-lease

Start Date

2024-12-13

Start Time

Now

Lease Length (days)

1

Ends

2024-12-14

End Time

Same time as now

Cancel

« Back

Next »

Always pick

Your timezone is currently configured as UTC. If you need to update your timezone please go to your [User Settings](#).

Please be courteous to other users of the testbed and make sure your lease represents a responsible use of Chameleon resources and complies with our [best practices](#). Chameleon operators reserve the right to terminate leases judged to be abusive.

For leases shorter than 24 hours, use a lease length of zero days.



Create Lease

General

Hosts

Networks

Devices

☒ Reserve Devices

Minimum Number of Devices

1

Maximum Number of Devices

1

Resource Properties

machine_name

=

worker-02

X

Add Filter

Cancel

« Back

Create

Step 1: Reservation / Lease Creation, continued

Create Lease

General *

Hosts

Networks

Devices

Lease Name *

ep5g-lease

Your timezone is currently configured as UTC. If you need to update your timezone please go to your [User Settings](#).

Start Date ?

2024-12-13

Start Time ?

Now

Please be courteous to other users of the testbed and make sure your lease represents a responsible use of Chameleon resources and complies with our [best practices](#). Chameleon operators reserve the right to terminate leases judged to be abusive.

Lease Length (days) ?

1

For leases shorter than 24 hours, use a lease length of zero days.

Ends ?

2024-12-14

End Time ?

Same time as now

Cancel

« Back

Next »



Create Lease

General *

Hosts

Networks

Devices

☒ Reserve Network

Network name is required when reserving a network.

Network Name ?

ep5g-vip

Network Description ?

Network reservations are required for some advanced networking features, like stitching and the filesystem. It is possible to create a private layer 2 VLAN without a network reservation. [Learn more](#).

Resource Properties ?

vlan_id = 100

Add Filter

☐ Reserve Floating IPs

Number of Floating IP Addresses Needed ?

0

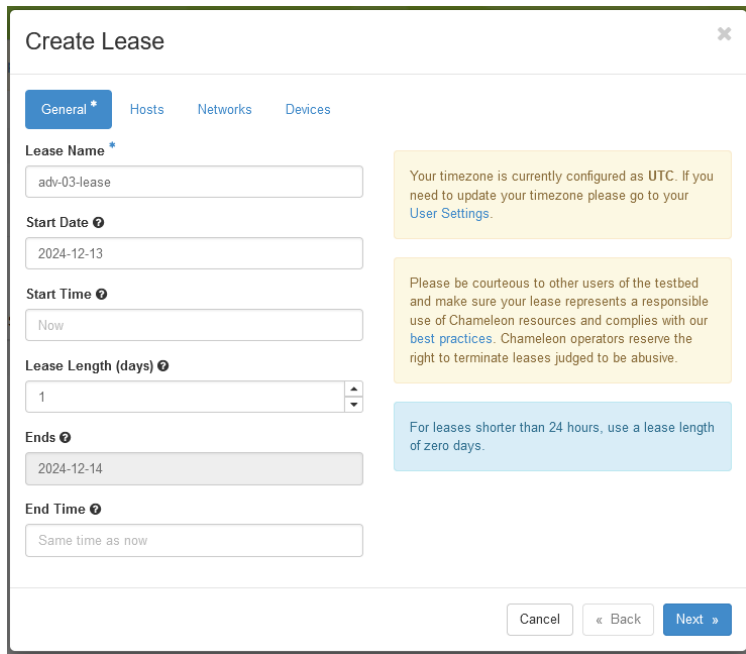
Cancel

« Back

Next »

For EP5G, use 100

Step 1: Reservation / Lease Creation, continued



Create Lease

General * Hosts Networks Devices

Lease Name *
adv-03-lease

Start Date ⓘ
2024-12-13

Start Time ⓘ
Now

Lease Length (days) ⓘ
1

Ends ⓘ
2024-12-14

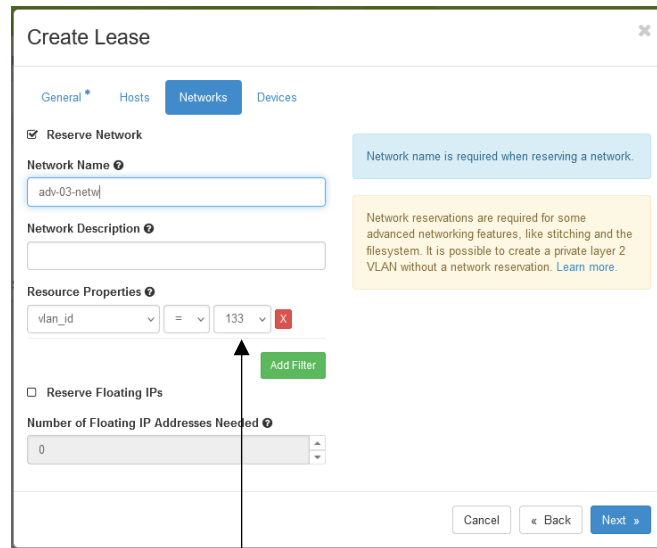
End Time ⓘ
Same time as now

Your timezone is currently configured as UTC. If you need to update your timezone please go to your [User Settings](#).

Please be courteous to other users of the testbed and make sure your lease represents a responsible use of Chameleon resources and complies with our [best practices](#). Chameleon operators reserve the right to terminate leases judged to be abusive.

For leases shorter than 24 hours, use a lease length of zero days.

Cancel « Back Next »



Create Lease

General * Hosts Networks Devices

☒ Reserve Network

Network Name ⓘ
adv-03-netw

Network Description ⓘ

Resource Properties ⓘ
vlan_id = 133

☐ Reserve Floating IPs

Number of Floating IP Addresses Needed ⓘ
0

Network name is required when reserving a network.

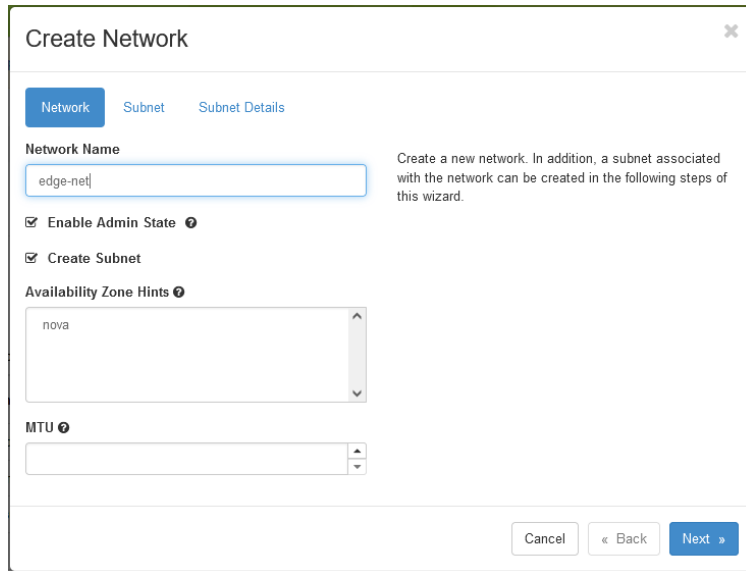
Network reservations are required for some advanced networking features, like stitching and the filesystem. It is possible to create a private layer 2 VLAN without a network reservation. [Learn more](#).

Add Filter

Cancel « Back Next »

From ExPECA home page,
hardware discovery (segment ID)

Step 2: Network Creation



Create Network

Network Subnet Subnet Details

Network Name
edge-net

Create a new network. In addition, a subnet associated with the network can be created in the following steps of this wizard.

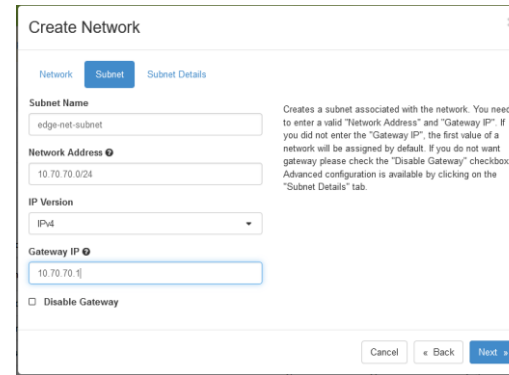
☒ Enable Admin State ⓘ

☒ Create Subnet

Availability Zone Hints ⓘ
nova

MTU ⓘ
[]

Cancel « Back Next »



Create Network

Network Subnet Subnet Details

Subnet Name
edge-net-subnet

Network Address ⓘ
10.70.70.0/24

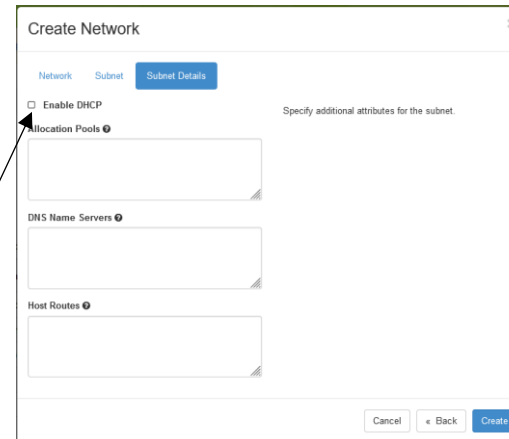
IP Version
IPv4

Gateway IP ⓘ
10.70.70.1

☐ Disable Gateway

Creates a subnet associated with the network. You need to enter a valid "Network Address" and "Gateway IP". If you did not enter the "Gateway IP", the first value of a network will be assigned by default. If you do not want gateway please check the "Disable Gateway" checkbox. Advanced configuration is available by clicking on the "Subnet Details" tab.

Cancel « Back Next »



Create Network

Network Subnet Subnet Details

☐ Enable DHCP

Allocation Pools ⓘ
[]

DNS Name Servers ⓘ
[]

Host Routes ⓘ
[]

Specify additional attributes for the subnet.

Cancel « Back Create

Uncheck box



Step 3: Router Creation

Create Router

Router Name

Description:

Creates a router with specified parameters.

☒ Enable Admin State ?

External Network

public

Availability Zone Hints ?

nova

Cancel

Create Router

Step 4: Router Interfaces

Add Interface

Subnet *

ep5g-vip: 10.30.0.0/16 (blazar_subnet)

IP Address (optional) ?

10.30.111.1

Description:

You can connect a specified subnet to the router.

If you don't specify an IP address here, the gateway's IP address of the selected subnet will be used as the IP address of the newly created interface of the router. If the gateway's IP address is in use, you must use a different address which belongs to the selected subnet.

Cancel

Submit

Add Interface

Subnet *

edge-net: 10.70.70.0/24 (edge-net-subnet)

IP Address (optional) ?

10.70.70.1

Description:

You can connect a specified subnet to the router.

If you don't specify an IP address here, the gateway's IP address of the selected subnet will be used as the IP address of the newly created interface of the router. If the gateway's IP address is in use, you must use a different address which belongs to the selected subnet.

Cancel

Submit

Step 5: Router Static Route

Add Static Route ✕

Destination CIDR *

Next Hop *

Description:

Add static route to the router.
Next Hop IP must be a part of one of the subnets to which the router interfaces are connected.

Cancel

Submit



Step 6: Running a Container

Project

API Access

Compute

Volumes

Container

Network

Orchestration

Object Store

Reservations

Leases

Identity

Project / Reservations / Leases /

Lease Detail

Lease

Name

Id

Project Id

Start date

End date

Status

Degraded

worker-02-lease

1d454b09-39b5-41da-bd62-01c191dc8549

86f53dca1b154aa0a5deca6a10afc0eb

2024-12-28 09:42 UTC

2025-01-04 09:41 UTC

ACTIVE

No

Events

before_end_lease

end_lease

start_lease

• Status: Undone

• Time: 2025-01-02 09:41 UTC

• Status: Undone

• Time: 2025-01-04 09:41 UTC

• Status: Done

• Time: 2024-12-28 09:42 UTC

Reservations

id

status

resource type

missing resources

resources changed

resource_properties

before_end

min

max

91d4593e-77a4-4558-bef9-02b57da3889d

active

device

No

No

["==","\$machine_name","worker-02"]

default

1

1

Copy reservation ID

Step 6: Running a Container, continued

Create Container

Info

Spec

Volumes

Networks

Ports

Security Groups

Miscellaneous

Labels

Scheduler Hints

Name

multitool

Image *

pragma/network-multitool

Image Driver

Docker Hub

Image Pull Policy

Select policy.

Command

A command that will be sent to the container.

☒ Start container after creation

✕ Cancel

< Back

Next >

✓ Create

Step 6: Running a Container, continued

Create Container

Info

Spec

Volumes

Networks

Ports

Security Groups

Miscellaneous

Labels

Scheduler Hints

Networks provide the communication channels for containers in the cloud.

▼ Allocated 1

Select networks from those listed below.

Network	Subnets Associated	Shared	Admin State	Status
1 > edge-net	edge-net-subnet	No	Up	Active

▼ Available 4

Select one

Q

Click here for filters or full text search.

×

Network	Subnets Associated	Shared	Admin State	Status
> ep5g-vip	blazar_subnet	No	Up	Active
> telenor-shared-net	telenor-shared-subnet	Yes	Up	Active
> caliconet	caliconet-subnet	Yes	Up	Active
> serverpublic	serverpublic-subnet	Yes	Up	Active

✕ Cancel

< Back

Next >

✓ Create

Step 6: Running a Container, continued

Create Container

Info

Spec

Volumes

Networks

Ports

Security Groups

Miscellaneous

Labels

Scheduler Hints

Labels

networks.1.interface=ens1f1,networks.1.ip=10.70.70.200/24,networks.1.routes=172.16.0.0/16-10.70.70.1

✕ Cancel

< Back

Next >

✓ Create

Step 6: Running a Container, continued

Create Container

Info

Spec

Volumes

Networks

Ports

Security Groups

Miscellaneous

Labels

Scheduler Hints

This step allows you to add scheduler hints to your container.

You can specify scheduler hints by moving items from the left column to the right column. Use the "Custom" option to add scheduler hints with the key of your choice.

Available Scheduler Hints

Filter

Custom reservation

No available scheduler hints

Existing Scheduler Hints

Filter

No existing scheduler hints

Click each item to get its description here.

Cancel

Back

Next

Create



Create Container

Info

Spec

Volumes

Networks

Ports

Security Groups

Miscellaneous

Labels

Scheduler Hints

This step allows you to add scheduler hints to your container.

You can specify scheduler hints by moving items from the left column to the right column. Use the "Custom" option to add scheduler hints with the key of your choice.

Available Scheduler Hints

Filter

Custom

No available scheduler hints

Existing Scheduler Hints

Filter

reservation -02b57da3889d

reservation (reservation)

Cancel

Back

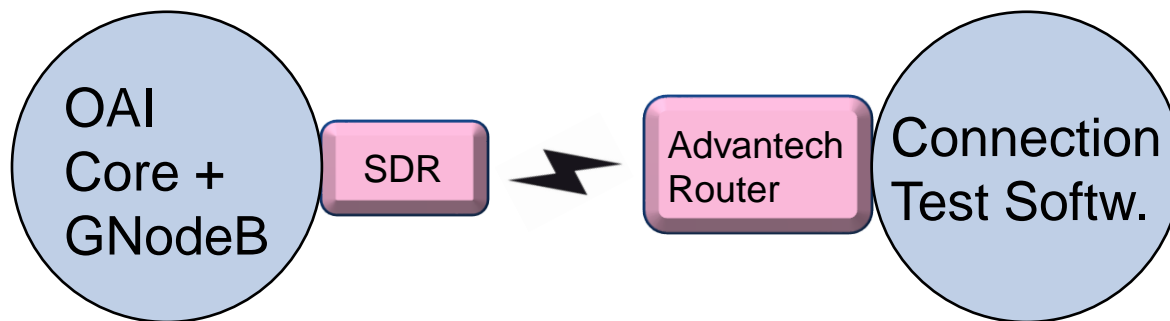
Next

Create



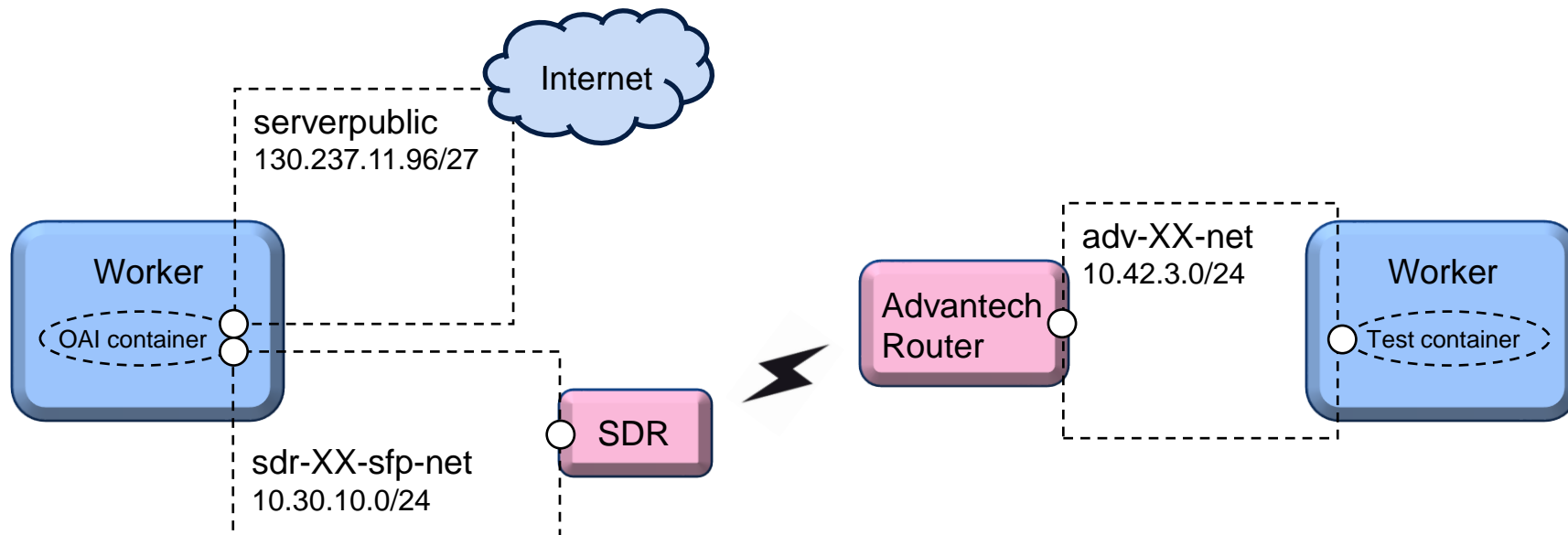
Group Assignment

- Openairinterface 5G network (Core Network + GNodeB) + 5G Router UE
- Configuration with Python Notebook
- https://github.com/KTH-EXPECA/examples/blob/main/workshop/workshop_setup.ipynb



Group Assignment, continued

- Testbed configuration plan





Group Assignment, continued

- Prerequisite: Google account, login on browser
- Prerequisite: SSH client on computer
- Python notebook: Configure ExPECA testbed via Python interface
- Colab: Google execution environment for Python notebook
- Python notebook uses API towards the testbed, via function calls



Group Assignment, continued

- Configure OAI Core + GNodeB in container via SSH
- Test 5G connection from container associated with 5G router
- https://github.com/KTH-EXPECA/examples/blob/main/workshop/workshop_gnbcoreinone.md
- For SSH to Core/GNodeB container, 2 SSH terminals will be used
- `ssh root@<Public IP>`
- Communication with Advantech router container will be via GUI container log + console



Group Data

Group	User	SDR	Adv Router	Worker	Band
1	workshop01	sdr-04	adv-08	worker-01	41
2	workshop02	sdr-09	adv-06	worker-02	48
3	workshop03	sdr-05	adv-07	worker-03	77
4	workshop04	sdr-02	adv-02	worker-04	78
5	workshop05	sdr-03	adv-04	worker-06	79