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FAST FORWARD 2021

ATLANTA, GA
OCTOBER 11-14

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UNLEASH THE POWER OF LIMITLESS CONNECTIVITY

2021 Fall Technical Forum
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Wireless Access Network

Network In A Box

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Introduction

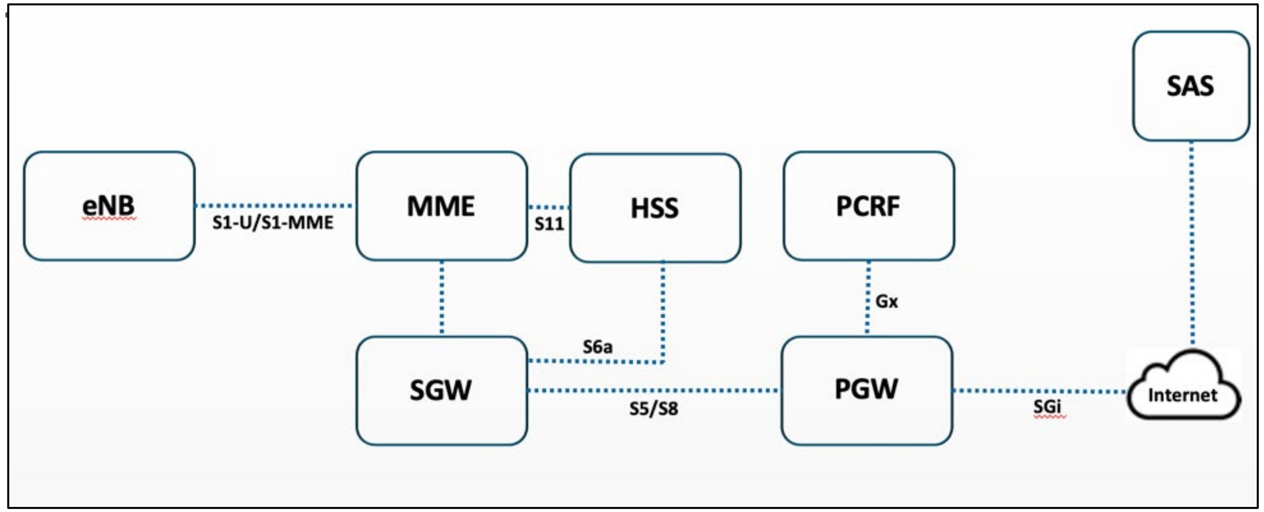
The Network In A Box (NIB) definition started with a 4G network that is operating the core network and base-station in a single box that is portable and self-organizing, which provides seamless connectivity to a group of mobile users, offering services such as internet connectivity and closed group communication (Push To Talk/Video/Text).

It expands cellular network coverage in various environments and different use cases, such as terrestrial disaster relief, private networks in-flight, at sea and in other scenarios and environments where an ad-hoc cellular network is required.

The NIB concept is a miniature evolution of the traditional cell on the wheel (COW) concept that has been widely used for cellular mobile voice communication.

Architecture

The network architecture shows the traditional 4G network architecture with a CBRS environment. The RAN (Radio Access Network) and CN (Core Network) architecture in the NIB setup is very much like the traditional LTE network in commercial solutions; main difference is the small-scale nature of the setup. Since the use of the frequency band B48 (3550 MHz – 3700 MHz) is ideal for the NIB approach – shared spectrum/no spectrum needs to be owned – the connectivity of the NIB setup to a SAS (Spectrum Access System) is mandatory.



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'Off the shelf eNodeB

LTE eNB Equipment Specifications

Specification	Value
Product	LTE Pico eNB
Band Support	B48 (3.55 – 3.7 GHz)
Carrier Aggregation	Up to 3 CA (only 1 Carrier used in NIB setup)
MIMO	2x2
Frame Configuration	TDD Frame Configuration 2 Special Sub Frame 7
IBW/OBW	150 MHz / 60 MHz
Output Power	2 x 250 mW (max), actual 2 x 25 mW
Antenna	Built-in average 0 dBi
Modulation QAM DL/UL	256 / 64
BF Capability	No
CBRS Classification	CBSD CAT A

- A commercial small cell Pico eNB is used
- Solution implementation proven working with multiple RAN vendor solutions
- The output power was limited to 14 dBm/25mW per antenna port but can be increased to 24 dBm/250mW if required for respective use case
- To be able to achieve ease of deployment, the eNB was put in 'free running' mode for synchronization

Open Source Core Network

The Core Network functions are established by utilizing an open-source application suite running on a bare-metal industrial small scale PC with a Linux-based operating system.

There are nowadays many options of open-source EPC/HSS solutions, see below for a list (not conclusive) of most popular open source core network:

- Open5Gs - Formerly NextEPC
- OpenAI Core Network - Related to / branched from OMEC
- Magma - Based on OMEC, with a focus on Fixed Wireless more than mobile
- OMEC – Open Evolved Mobile Core
- OpenMME – MME
- OpenCORD
- srsEPC

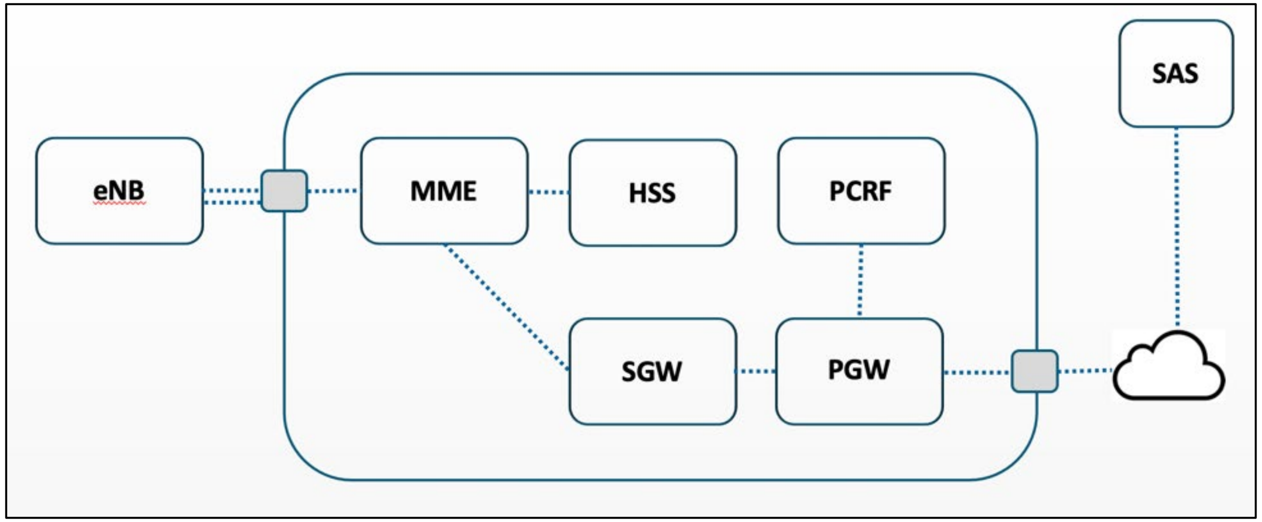
Network In A Box

To be able to easily deploy the NIB, all the components are installed in a Pelican case for easy transportation.

Additionally an embedded screen and wireless keyboard/mouse are included in the setup.

Showing the industrial type PC, running the EPC/HSS and O&M functionalities, on the left side in the case. The right component in the case is the commercial Pico eNB.

Connectivity Interfaces



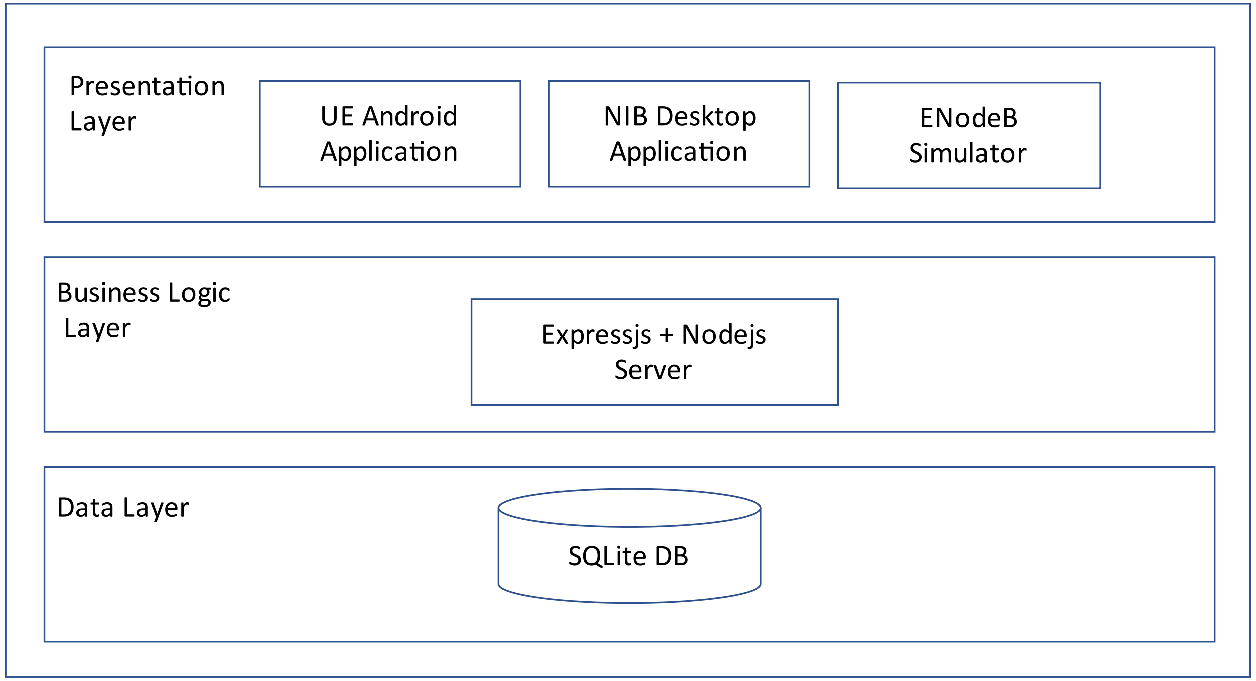
- eNodeB is physically interconnected to the industrial PC via 2 * RJ45 Ethernet cables => S1 & O&M
- The O&M link is utilized to automatically control the bring-up and maintain the system.
- A third Ethernet interface on the industrial PC is for the Backhaul connectivity to the Internet (user traffic and SAS connectivity). The same function can also be established via an internal WiFi or (Commercial) Cellular module.

System bring-up and device monitoring – “Zero Touch”

For the purpose of a ‘zero touch’ and controlled system boot-up, a software application suite was developed to overcome any possible grace conditions and system malfunctions while the NIB setup is coming in service. The application starts automatically after power-up of the NIB and observing the physical and functional status of all components. If a delay or intervention during the boot-up process is necessary, the application will do so. Once the system in completely in service and the Radio is On-Air, the user will be notified and the power-on of the end-user devices can begin.

The requirement was to automate all manual processes to start the private wireless network, known as Network in a Box. Therefore, the start mechanism has to follow the new concept of Zero Touch.

Three Tier SW Solution



- The presentation tier, or user interface
- The application tier, where data is processed
- The data tier, where the data associated with the application is stored and managed, is a well-established software application architecture that organizes applications into three logical and physical computing tiers.

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Presentation Layer

- Two applications: (1) one is a desktop application, (2) the second one is an android application.
- The desktop application runs on a ubuntu server:
  - Starts automatically when powered up.
  - Starts the private LTE components (MME, SGW, PGW, PCRF, and HSS).
  - Checks the log file for all of these components to ensure that each component starts correctly. It displays a block diagram to represent the elements of the network and it uses the color scheme to represent the status of each element as shown in the screenshots below.

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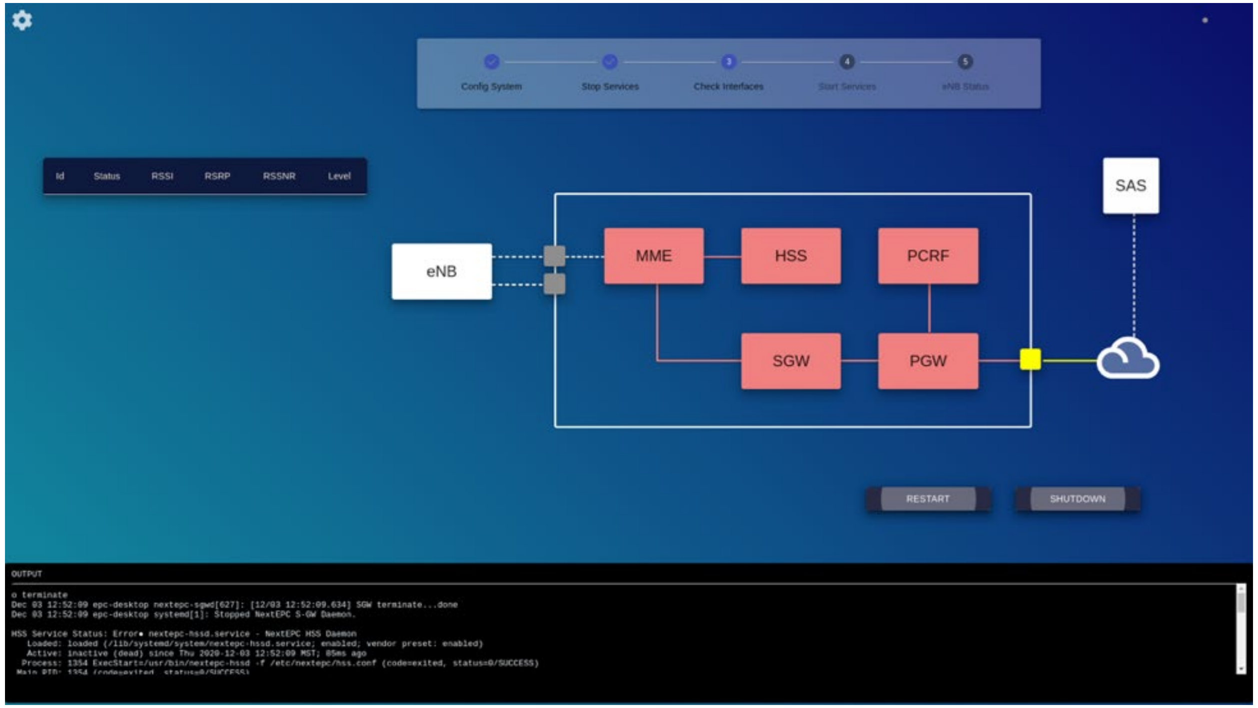
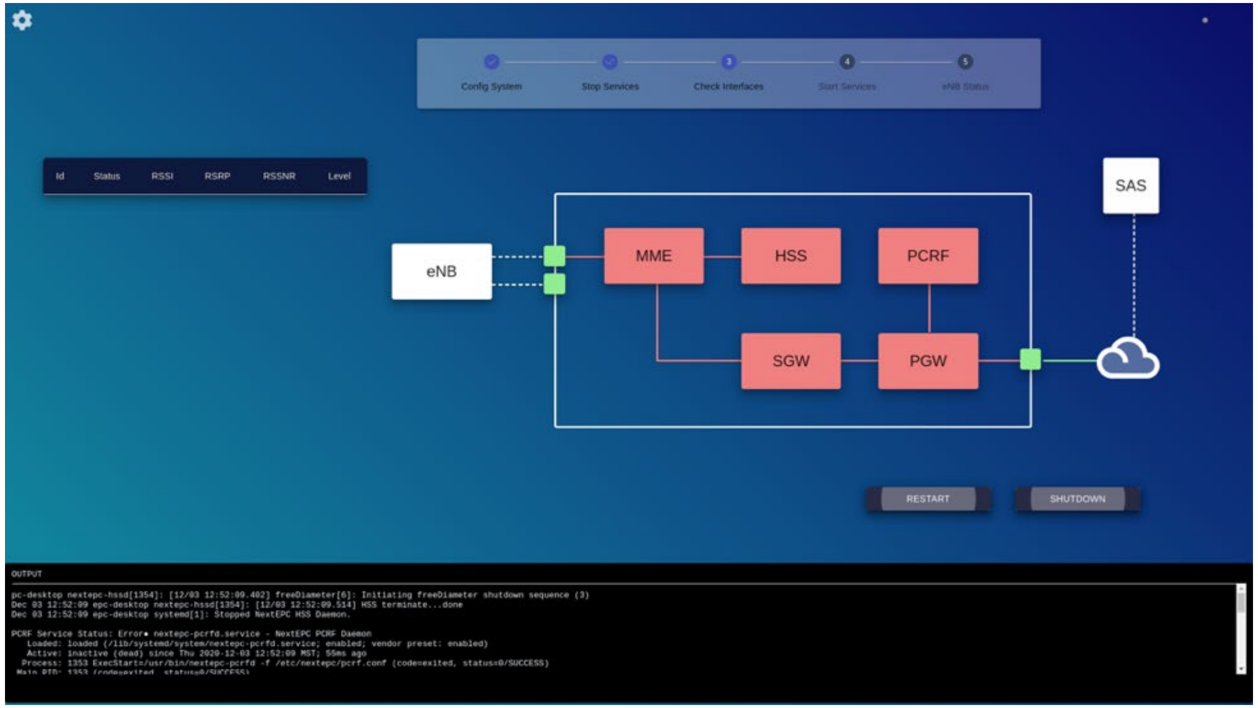
Power-Up



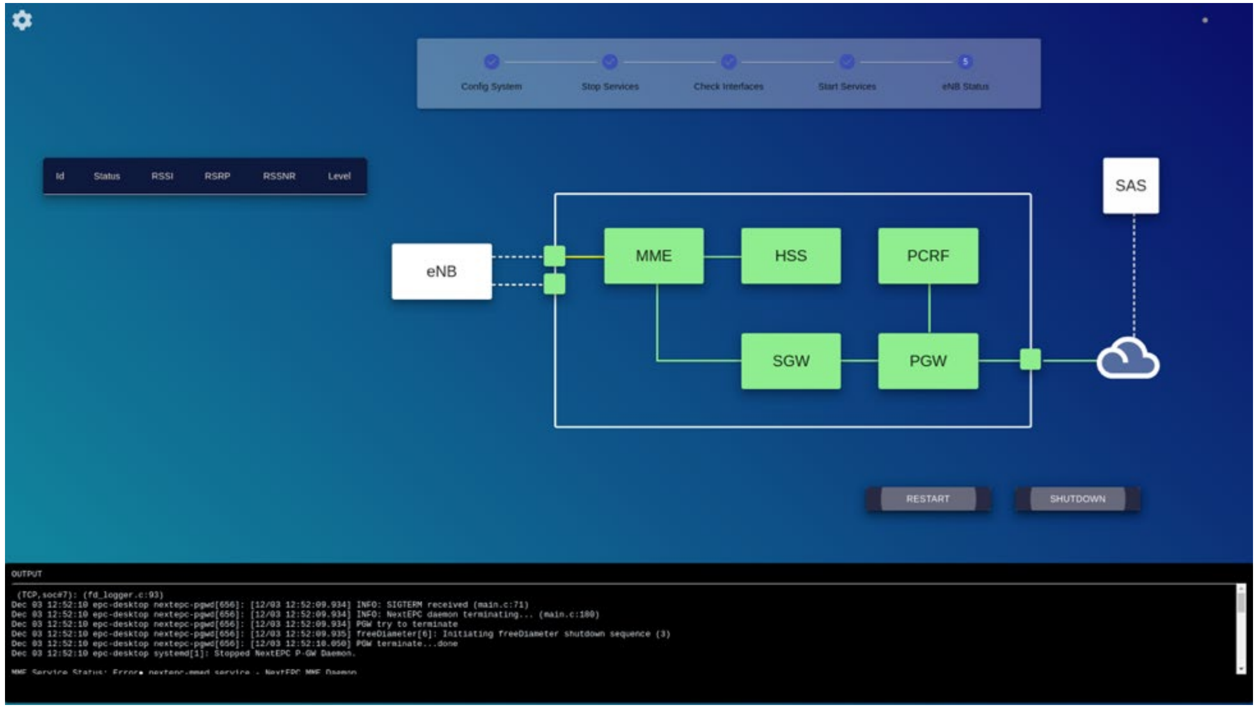
- Initial status after power-up
- Next step wait for physical interfaces to come in service

Interfaces In Service



- All Ethernet interfaces are in service
- Next step start of EPC/HSS services

Starting EPC/HSS



- EPC/HSS services started
- Next step activation of S1 link

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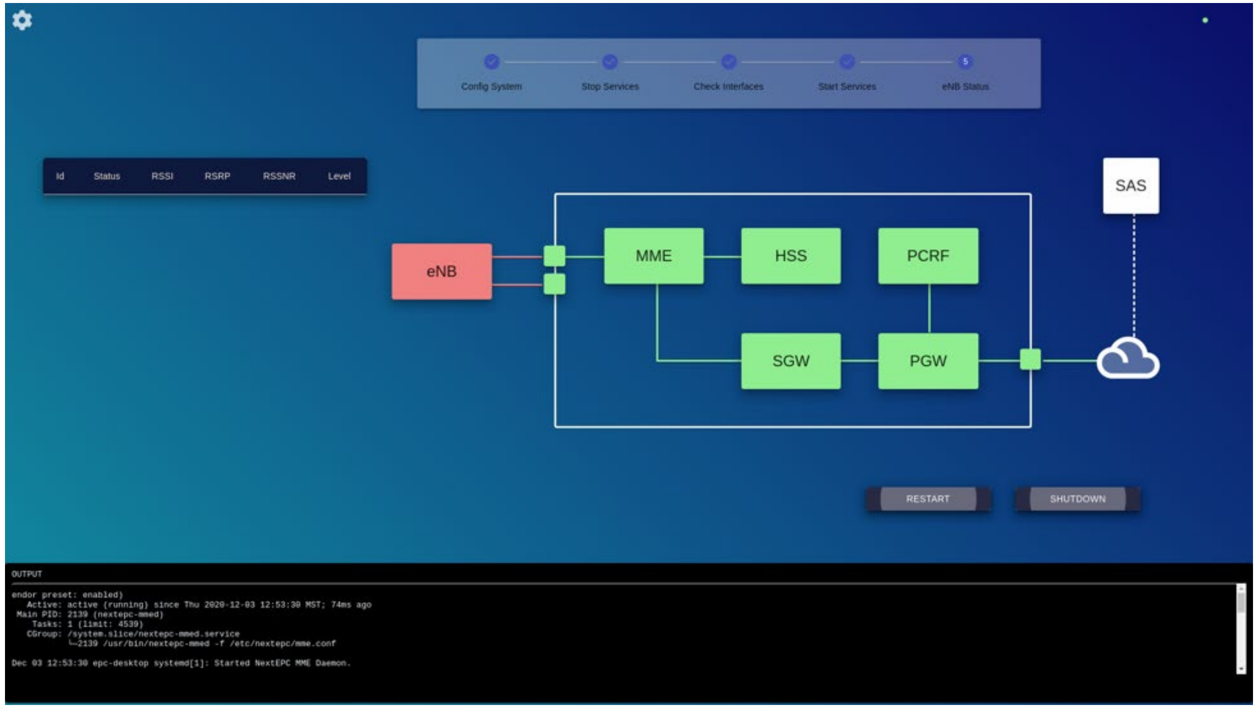
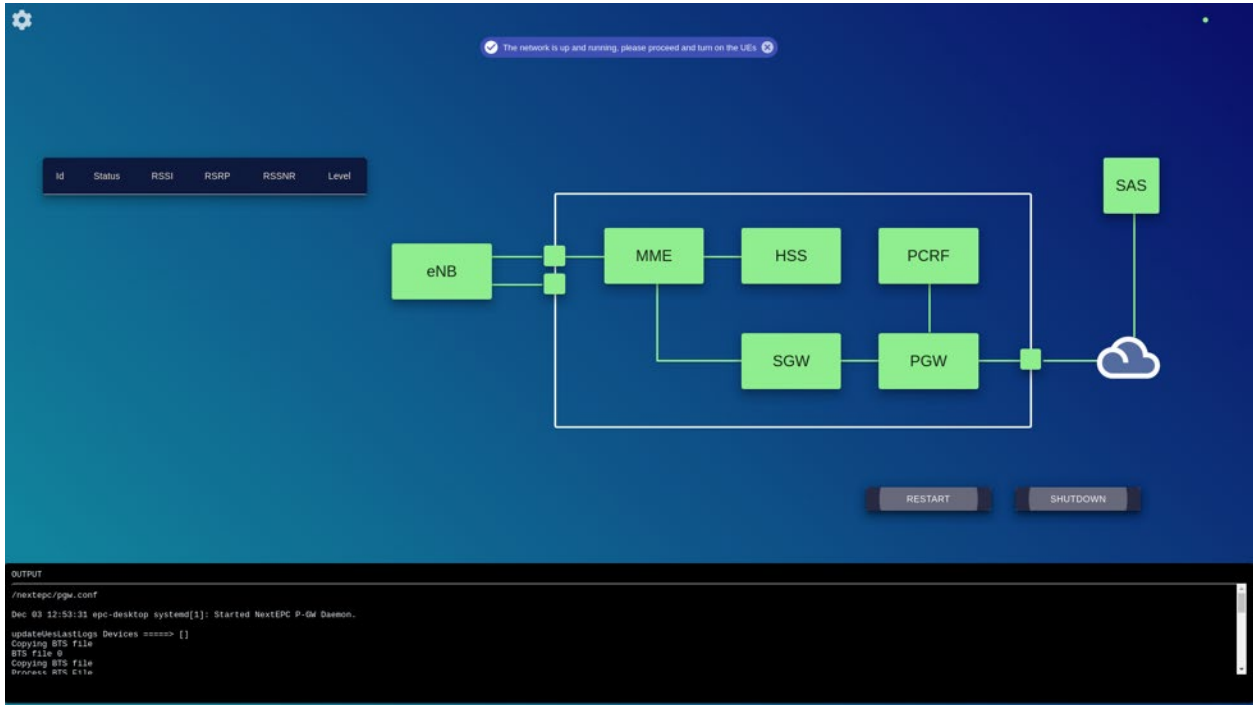
S1 link active



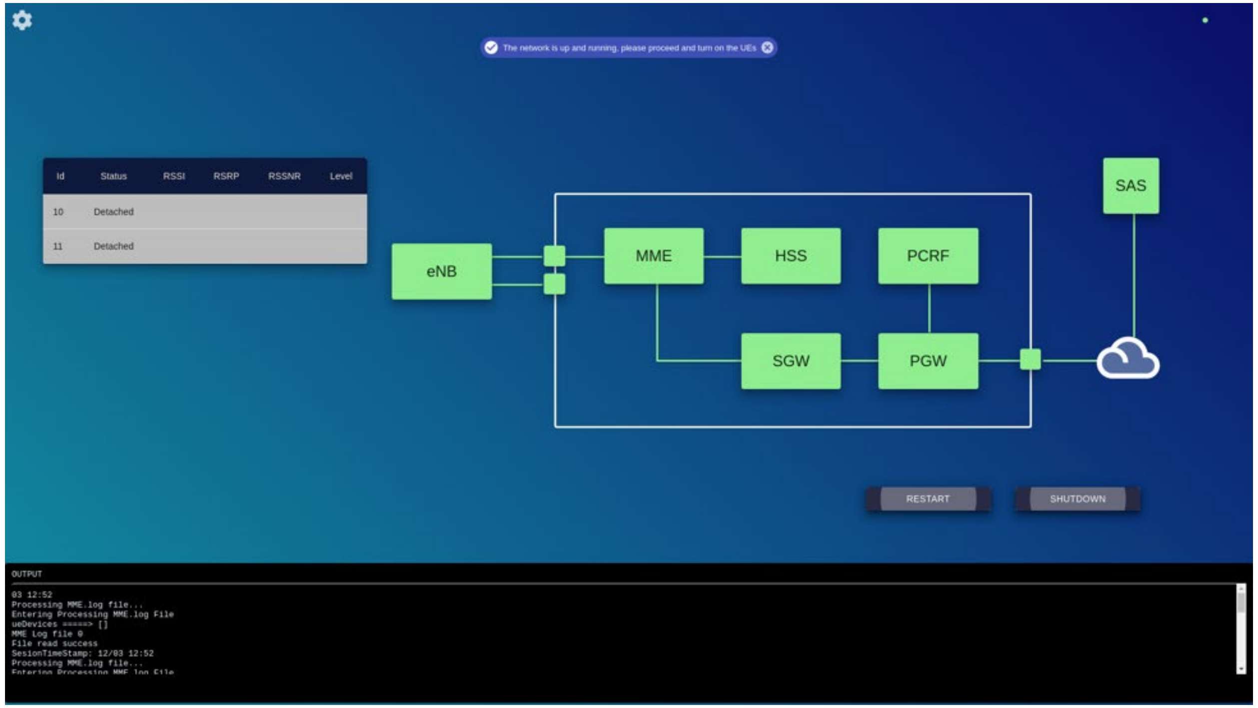
- S1 link is activated
- Next step wait for positive SAS communication and eNB to come On-Air

System in service



- System is fully in service and eNB On-Air
- User is notified that devices can be powered-on

UE/Device activation



After devices are powered-on, the device table is activated and device status monitored

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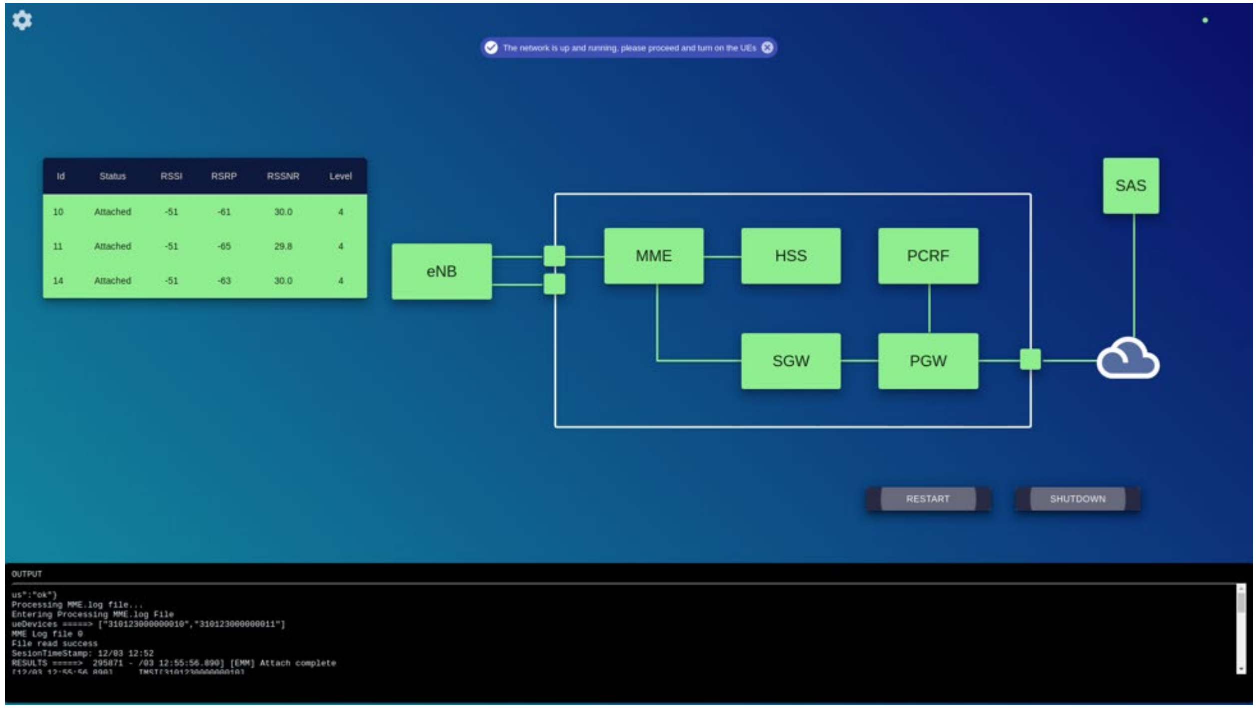
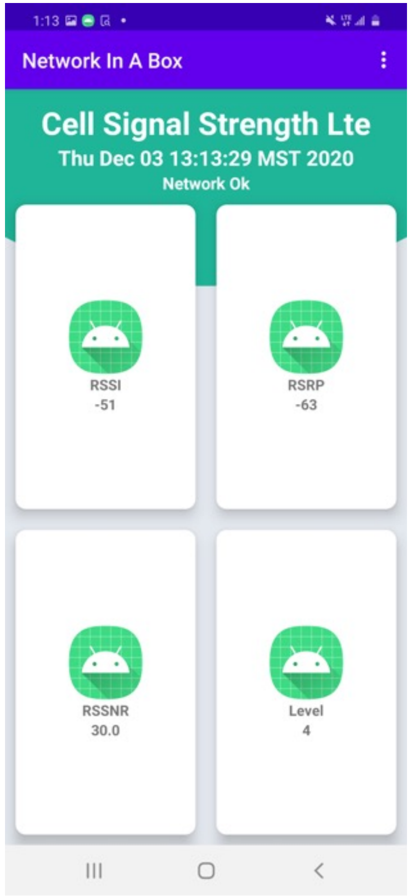
UE/Device attached and reporting



Devices are successfully attached to the NIB network and the RF conditions reported and presented in the NIB portal

Client application



Corresponding device NIB application

Business Logic Layer

- Three software components had to be used in this layer: ExpressJS, NodeJS and Puppeteer
  - Express is a Node.js web application framework that offers a comprehensive range of functionality for both web and mobile apps. Express adds a thin layer of basic web application functionality without obscuring the Node.js capabilities users already know and appreciate.
  - Node.js is a scalable network application builder that uses an asynchronous event-driven JavaScript engine. Many connections can be handled at the same time in the "hello world" example below. The callback is invoked with each connection, but if there is no work to be done, Node.js will sleep.
  - Puppeteer is a Node library that provides a high-level API to control headless Chrome or Chromium over the DevTools Protocol. It can also be configured to use full (non-headless) Chrome or Chromium.

Data Layer

The following information is stored in the database:

- UeID: User Entity Identification
- RSSI: Received Signal Strength Indicator
- RSRP: Reference Signal Received Power
- RSSNR: Reference Signal Signal to Noise Ratio
- CQI: Channel Quality Indicator
- level: Battery Level
- timeStamp: Time Stamp

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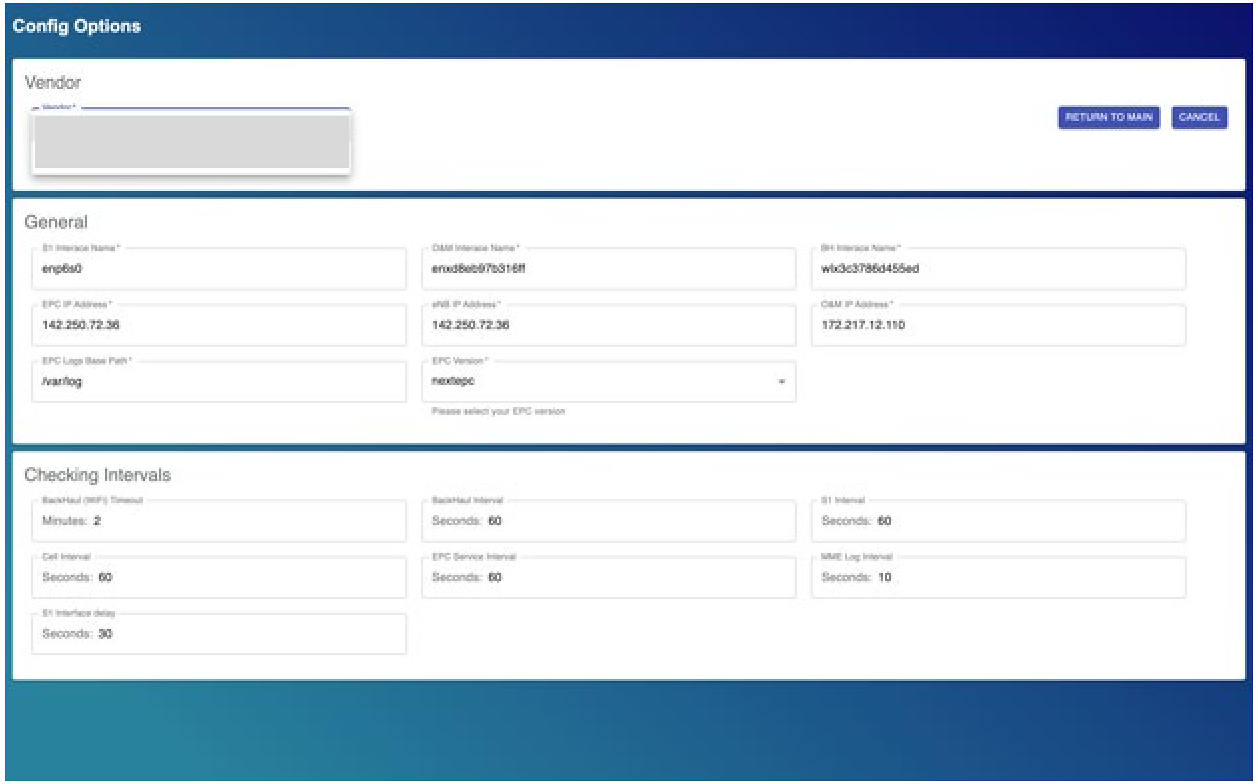
Configuration Management



A Configuration menu had to be added for the user to be able to choose between which ENodeB is connected to the PLTE Core Network

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Mobile Edge Compute Use Case Examples

Beside generic end-user internet access, different options for MEC-based use cases were explored. The following lists two examples:

<u>Closed Group Communication</u>

Closed Group Communication aka 'Push To Talk/Video/Text' is an ideal communication method in an enterprise private wireless environment, e.g. factory, hotel etc… End users can be easily communicating with their respective groups (all or some at once or one-to-one), or a local PTx network dispatcher, by a push of a button. In our NIB solution, we installed a demo version the PTx server and dispatch applications in the MEC and respective PTx client application on the end-user devices.

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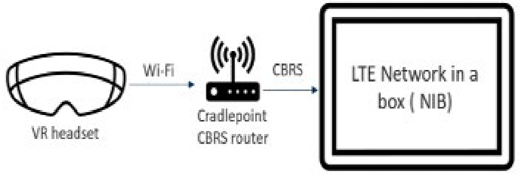
VR (Virtual Reality) low latency applications

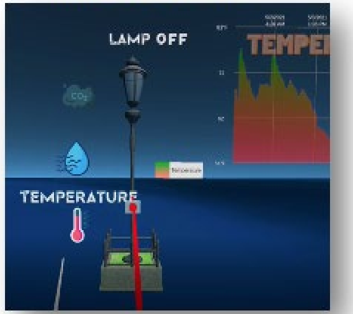
Overview



Oculus VR headset

VR workplace

VR smart light control



- VR Workplace: Teleport to virtual office floor, Interact virtually with lab – machines and sensors
- VR smart light control: Able the city workers to access Smart light for control and data retrieval using VR
- VR Healthcare: Control instruments remotely, read patient charts
- VR Industrial: Troubleshoot and analyze machine performance

Conclusions

Network In A Box has a well-deserved reputation in the cellular industry. With the addition of 'zero touch' control and MEC in the same compute platform, the use for any users and many applications domains is opened up.

Research and further development of NIB will continue which includes:

- Evolve to a 5G system, e.g. 5G n48 Pico eNB and a 5G SA Core Network
- Expand on the list of supported RAN vendors in the NIB 'zero touch' portal
- Migrate the CN to a virtualized/containerized implementation

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Thank You!

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