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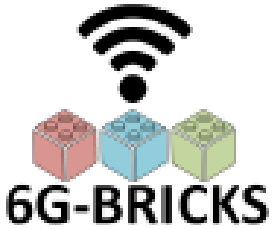

6G-BRICKS

Developing a Modern Experimentation Facility for Validation, Testing and Showcasing of 6G Technologies and Devices

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Introductory Framework

Introduction _(1)

- **Commercial deployments of 5G are now progressing worldwide, *delivering new capabilities, improved performance and new applications for customers.***
- **For Mobile Network Operators, a set of 5G-supported features –*including network slicing, disaggregation, and cloud-native design*– are enabling the use of new applications and new business models.**
- **The gradual shift to the full digitization of the real world shall create vast amounts of generated data and applications**, *like* ***immersive communication***, *and* ***holographic telepresence***.
  These emerging applications exceed the current and future capabilities of 5G networks, *in terms of* ***Key Performance Indicators (KPIs)*** *as well as in terms of their* ***requirements on an ultra-dense computational infrastructure***.
- **Both industry and academia have "shifted" their attention to the investigation of a new generation of Smart Networks, *capable of supporting such performance*.**
- *The first results of such efforts show that* ***6G networks will deliver efficiency clearly superior to 5G and satisfy evolving services and applications***, *making them* ***a "key enabler" for the intelligent digital society of 2030.***

Introduction _(2)

- **5G kick-started a trend towards software-defined infrastructures (SDI) and Software Networks that replace "black boxes"** (e.g., physical network functions, such as firewalls) **with their softwarized equivalents, *deployed at standards-based "Whitebox" Servers.***
- **This trend has gradually propagated to the RAN (Radio Access Network) via the O-RAN (Open-RAN) initiative** *that delivers software implementations of the CU (Centralized Unit) and DU (Distributed Unit) components, while Software-Defined Radios (SDRs) allow softwarization principles to reach down to the low-PHY (Physical layer).*
- **Where softwarization and open APIs have been adopted with the objective of promoting interoperability and reducing OPEX and CAPEX*, they have also revolutionized experimentation platforms and testbeds.***

- ***Open Source software stacks and Common Off-the-Shelf (COTS) hardware can be leveraged to build and scale-up testbeds,*** *allowing customization and experimentation on every aspect of 5G and Beyond (B5G) infrastructures.*
- ***The enormous complexity of the 5G standards and software stacks makes end-to-end (E2E) experimentation platforms extremely challenging to deploy, requiring interdisciplinary efforts and big investments in integration.***

Introduction _(3)

- **The 6G-BRICKS project will deliver this "vision"**, ***bringing together specialists that work on breakthrough 6G technologies from all architecture tiers,*** *namely:*
  - ***Cell-Free (CF) networking*** *and*
  - ***Reconfigurable Intelligent Surfaces (RIS).***

- ***These technologies will be integrated in reusable, self-contained testbed nodes, to be deployed at two E2E 6G testbed sites*** (*i.e.: Katholieke Universiteit Leuven (KU-L) in Belgium and Eurecom (EUR) / CEA-LETI in France*).
  These will be federated under a common set of Experimentation Tools, deployed under a common Cloud node, *offered by ATHENA/ISI in Greece*.

6G-BRICKS: Essential Scope

6G-BRICKS: Essential Scope _(1)

- ***6G-BRICKS will be the first open 6G platform that combines***
  - *Cell-Free,*
  - *Open Air Interface (OAI) and*
  - *RIS,*

  while adopting the proven principles of
  - *softwarization,*
  - *open Interfaces (O-RAN), and*
  - *Open Source software stacks,*

  thus "putting" future expansion and evolvability at its core.

- ***However, experience from past 5G-PPP efforts has shown that the enormous complexity of the standards and software stacks:***
  - ***makes evolvability and scaling-out efforts extremely challenging**, and;*
  - ***requires interdisciplinary efforts and big investments in integration** by the involved market "actors".*

6G-BRICKS: Essential Scope _(2)

- ***6G-BRICKS will deliver the first open and programmable O-RAN Radio Unit (RU) for 6G Networks*** *(termed as the OpenRU, based on an NI Universal Software Radio Peripheral (USRP) platform)*.
- ***6G-BRICKS aims to "integrate" the RIS concept into the OAI.***
- ***The scheduled effort will lead to breakthrough experimentation tools,***
  - ***going well beyond*** ***the current Testing as-a-Service (TaaS) capabilities of current initiatives, and;***
  - ***allowing experiments also on devices*** ***via O-RAN compliant xAPPs***.

- ***An xApp is a software tool*** *used by a* ***RAN Intelligent Controller (RIC)*** *to manage network functions in near-real time*.
- *The* ***xApps are part of a RIC****, which is a central software component of the Open RAN architecture, being responsible for controlling and optimizing RAN functions and resources.*
- *These applications –or services – include functions like radio resource management, mobility management and security.*

6G-BRICKS: Essential Scope _(3)

- ***6G-BRICKS aims to deliver a new 6G experimentation facility, building on the baseline of "mature" ICT-52 platforms, that bring breakthrough cell-free and RIS technologies, which have shown high opportunities for growth in beyond 5G networks.***
- *Moreover, **novel unified control paradigms based on Explainable AI (XAI) and Machine Reasoning are to be explored, in detail.***
- ***All corresponding enablers will be delivered in the form of reusable components with open APIs, termed as "bricks".***
- ***Initial integrations with O-RAN will also be performed, aiming for the future-proofing and interoperability of 6G-BRICKS outcomes.***

6G-BRICKS: Essential Scope _(4)

6G-BRICKS will offer a trusted, agile and evolvable 6G experimentation facility,

- **federating two experimentation platforms** *(one in Belgium and one in France) from previous 5G-PPP initiatives*
- **under a "Core Site"** *(in Greece) acting as the facility's "entry point" and offering Public Cloud and experimentation services.*

This 6G experimentation facility shall be accessible by:

- ***third-party consortia,***
- ***vertical application owners and***
- ***experimenters***

from the vertical and component industry.

The facility will showcase a disaggregated Management Plane and Operations Support System (OSS) to support extendibility, evolvability and multi-tenancy, beyond centralized Cross-Domain Service Orchestrators (CDSOs) and OSS / BSS systems (as in current 5G-PPP experimentation platforms).

6G-BRICKS: Core Objectives

6G-BRICKS: Core Objectives _(1)

- **Delivering an evolvable 6G experimentation facility that:**
  - ***will integrate breakthrough 6G technologies and***
  - ***will efficiently "federate" two well-established experimentation platforms-testbeds, under a common set of experimentation tools.***

*The **intended scope** is about:*

(i) ***Delivering an open Experimentation and Business Support layer*** *with DevOps-driven testing and Zero-Touch service management capabilities,* ***thus unlocking access to the facility for vertical owners and experimenters,*** *and;*

(ii) ***supporting a managed UE farm layer, thus "pushing" computation down to the device tier.***

6G-BRICKS: Core Objectives _(2)

- **Validate and showcase advanced use cases in holographic communication, metaverse and digital twinning, *showcasing the benefits of 6G breakthrough technologies and architectures*.**

Intended targeted actions:

(i) Demonstrating the technological feasibility of "better than 5G" KPIs, in terms of capacity, reliability, location accuracy and energy efficiency;

(ii) evaluating the effect of Network KPIs and Edge Continuum deployments on extreme 6G Service KPIs, thus identifying bottlenecks and trade-offs, and;

(iii) validating a set of Key Value Indicators (KVIs), jointly defined with four ongoing ICT-52 baseline projects (i.e.: MARSAL, REINDEER, RISE-6G and HEXA-X).

6G-BRICKS: Core Objectives _(3)

- **Support fully disaggregated and software-defined infrastructures (SDIs), *by adopting virtualization, Software-Defined Radio (SDR) and O-RAN interfaces to promote modularity and reusability of developed components.***

Intended targeted actions:

(i) ***Delivering open and reusable components ("bricks") for all involved technological domains;***

(ii) ***offering programmable infrastructures at the compute domain and at the network domain, where physical resources (e.g., UEs) and virtual resources (e.g., slices, etc.) can be shared by multiple tenants;***

(iii) ***hosting third party experiments and vertical applications from corresponding future Open Calls, and;***

(iv) ***supporting RAN slicing and RRM down to the RU level, allowing low-level control from experimenters via xAPPs.***

6G-BRICKS: Core Objectives _(4)

- **Offer a fully decentralized management plane, *supporting zero-touch orchestration of compute and communication resources based on Explainable AI (XAI).***

Intended targeted actions:

(i) ***Defining and delivering a scalable architecture of DMOs*** *(Domain Manager Orchestrators);*

(ii) ***implementing a Zero-touch policy engine that benefits from XAI and Machine Reasoning (MR) methods;***

(iii) ***defining a XAI and MR for root cause analysis at DMO level****, and;*

(iv) ***defining both XAI and MR to help experimenters to debug the tests run on 6G-BRICKS (including RAN and Cloud Edge Continuum platforms) and find solutions.***

6G-BRICKS: Core Objectives _(5)

- **Offer a Compute Continuum abstraction framework, *supporting a disaggregated wireless Xhaul.***

Intended targeted actions:

(i) Delivering an interoperable continuum of solutions, comprising of
- ***Cloud, Edge and Far Edge/IoT device levels, as well as***
- ***the disaggregated wireless Xhaul systems that link them*** *(Fronthaul, Midhaul, Backhaul);*

(ii) offering a PaaS abstraction framework, by
- *exposing infrastructure resources via common and open APIs, and;*
- *following the Composable Infrastructures paradigm;*

(iii) delivering Multi-agent Deep Reinforcement Learning (DRL) agents, driving automatic adaptations and joint optimizations to the E2E provisioning and connectivity layer to fluctuating user demand.

6G-BRICKS: Core Objectives _(6)

- ***Deliver breakthrough technologies towards a 6G RAN via Distributed Cell-Free and RIS.***

Intended targeted actions:

(i) ***Integrating for the first time RIS and gNB (mmWave) to demonstrate and experiment with RIS technology by using E2E service;***

(ii) ***devising and implementing a novel RIS controller to dynamically update RIS reflector configuration to support UE mobility;***

(iii) ***Devising and implementing novel ML-based RIS control algorithms, to predict user position and optimal RIS configuration;***

(iv) ***defining novel CF algorithms that distribute the computations in an optimal way (according to the respective use case);***

(v) ***implementing selected algorithms as software "Bricks";***

(vi) ***designing novel multi-band algorithms and implementing a selection of these as software "Bricks.***

6G-BRICKS: Core Objectives _(7)

- ***Provide a secure and trusted Experimentation Facility for multiple concurrent tenants and experimentation platforms.***

Intended targeted actions:

(i) Supporting zero-trust establishment via the Software Defined Perimeter (SDP) paradigm;

(ii) offering VPN as-a-Service,

- ***for simplifying the establishment towards cross-site VPN encrypted tunnels, and;***
- ***for ensuring future expansion towards experimentation sites outside the GEANT network.***

(i) Delivering a Security Orchestrator (SO), for the overall management of the security policies and configurations of the facility.

6G-BRICKS: Core Objectives _(8)

- **Maximise the impact expected to be created by the project to a great number of potential "actors"/recipients, *through wide means of:***
  - ***Dissemination activities,***
  - ***Communication activities,***
  - ***Standardisation activities and***
  - ***Exploitation activities.***

Overview – Concluding Remarks

Overview – Concluding Remarks _(1)

- **The 6G-BRICKS project**
  - ***brings together specialists on breakthrough 6G technologies, such as cell-free networking, distributed processing and RIS,***
  - ***as well as adopting principles of modularity and softwarisation***

  to deliver the first truly modular E2E 6G experimentation platform in Europe.

- **6G-BRICKS focuses upon structuring the various architecture tiers around the concept of "LEGO Bricks",** ***delivering self-contained testbed nodes that can be reused across testbed infrastructures.***
  - ***This significantly lowers the barrier of entry to an E2E experimentation platform for specialists,*** ***to bring their breakthrough technologies for validation and experimentation***

Overview – Concluding Remarks _(2)

- The 6G-BRICKS experimentation facility aims to serve a "dual role":
  - as a *"playground" for testing advanced vertical applications, and;*
  - *for validation testing and showcasing of the clear benefits and capabilities* of 6G breakthrough technologies and devices.

- The scope is about delivering and testing new architecture principles with,
  - *multi-tenancy;*
  - *disaggregated Operations Support Systems (OSS), and;*
  - *Deep Edge integration at the forefront.*

Thank you for your attention!

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