Experiments Overview of the EU-Brazil FUTEBOL Project

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***Abstract*— The EU-Brazil co-funded project Federated Union of Telecommunications Research Facilities for an EU-Brazil Open Laboratory (FUTEBOL) composes a federation of research infrastructure in Europe and Brazil, develops a supporting control framework, and conducts experimentation based research in order to advance the state of telecommunications systems through the investigation of converged optical/wireless networks. This paper provides a description of the main experiments considered for the FUTEBOL project.**

Keywords*— *Experiments; Wireless/optical convergence

I. INTRODUCTION

Telecommunications research remains largely segregated between optical networks and wireless systems and rarely do researchers cross the boundary between the two. We argue that the needs of future telecommunication systems, be it for high data rate applications in smart mobile devices, the Internet of Things (IoT), or backhaul requirements brought about from cell densification, require the co-design of the wireless access and the optical backhaul and backbone. In this context, the EU-Brazil co-funded FUTEBOL project [1] aims at developing a converged control framework for experimentation on wireless and optical networks and to deploy this framework in federated research facilities in Europe and Brazil.

The focus of FUTEBOL is on converged wireless-optical experimentation. On the wireless side, new spectrum access modalities such as Licensed Shared Access (LSA) will soon open more spectrum for mobile broadband. The proliferation of small cells increases frequency reuse and is responsible for a major proportion of the gains in mobile network capacity. On the optical network side, network function virtualization (NFV) and the concept of software-defined networks (SDN) are revolutionizing the way that network resources are managed. We view virtualization on the optical side and densification and capacity increase on the wireless access as major game changers in future networks that will deliver the best benefits when co-designed and experimented together. FUTEBOL therefore creates the infrastructure that enables academic and industrial researchers in Europe and Brazil to experiment at the convergence points between wireless and optical networks.

Fig. 1 illustrates the layered nature of FUTEBOL: the end-user-driven advancement of telecommunications relies on the development of the FUTEBOL converged control framework, which, in turn, requires the composition of federated research infrastructure. Through this approach, FUTEBOL provides a research infrastructure tailored to the needs of experimenters throughout Brazil and Europe interested in issues that cross the boundary between wireless and optical networks.

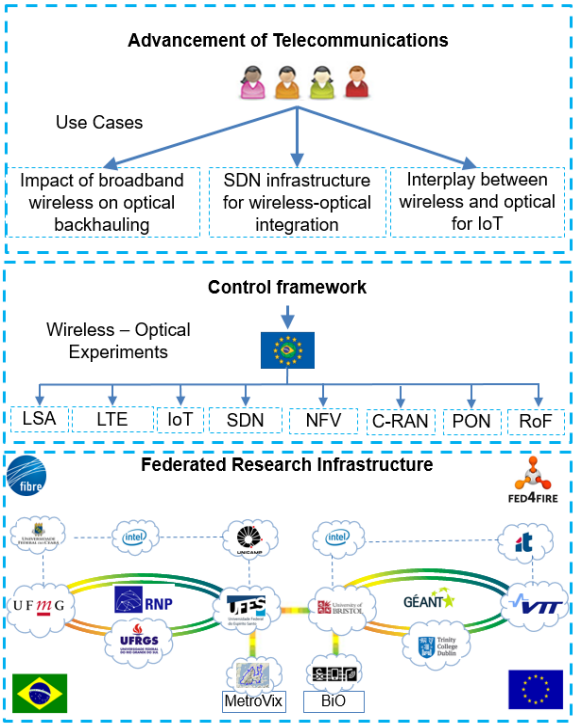

Fig. 1 FUTEBOL approach [1].

This paper introduces the five main experiments that will be conducted in FUTEBOL. They encompass the driving research areas within FUTEBOL and also present the wide range of capabilities available in FUTEBOL research testbed facilities for the use of partners and third party experimenters in converged wireless/optical networks.

II. Experiment I: Licensed Shared Access for extended LTE capacity with E2E QoE

Experimentation is very important to build up the trust in shared spectrum technologies, demonstrating no interference with incumbents and a tangible advantage for secondary users in terms of QoE. The main objective of this experiment is to use the FUTEBOL federation to test the protocols and interfaces defined by the standardization process of LSA in ETSI, and quantify their performance in terms of end-to-end (E2E) Quality-of-Experience (QoE), considering the wireless and the optical domains of the network infrastructure. This experiment will make use of the LTE LSA trial environment to demonstrate the viability of LSA as a way to increase capacity with limited investment in spectrum bands of common interest for Brazil and Europe. The results of the experiment will disseminated to the Brazilian regulator agency, Agência Nacional de Telecomunicações (ANATEL), in view of furthering the dialog about the potential for a more flexible spectrum management in Brazil.

III. Experiment II: Heterogeneous Wireless-Optical Network Management With SDN And Virtualization

The objective of this experiment is to show the dynamic adaptation of integrated optical wireless networks, considering three parts: wireless access, optical access, and metro/core. In the wireless part, virtual machines will be set up to perform processing in the backhaul and fronthaul using Software Defined Radio (SDR). The optical access will be implemented using a Passive Optical Network (PON), including the use of logical connections. Also, in the metro and core network parts, SDN and virtualization mechanisms are aimed at establishing wavelength paths. This experiment is comprised of three stages: 1) dynamic switching between backhaul and fronthaul, 2) migration of video servers closer to the wireless customers, and 3) Device-to-Device (D2D) with coded caching. Such stages represent steps in the implementation of logic parts of a unified view, requiring the integration of decisions induced by different network layers.

IV. Experiment III: Real-Time Remote Control of Robots Over a Wireless-Optical SDN-Enabled Infrastructure

The main objective of this experiment is to evaluate the impact of SDN and cloud computing technologies in systems running real-time applications with low E2E latency and high bandwidth requirements. We will demonstrate how communication infrastructure, including optical-wireless integration and datacenter networking, need to evolve to support future robotics as a service (e.g., rehabilitation therapies, robot localization and navigation, assistive robotics). Innovative solutions to reduce overall latency employing SDN to achieve complex coordinated architectures with dynamically controlled bitrates will be tested using the FUTEBOL testbed.

V. Experiment IV: Adaptive Cloud/Fog For IoT According to Network Capacity and Service Latency Requirements

In converged networks, cloud/fog computing becomes fundamental for mobile devices and IoT applications to meet Quality of Service (QoS) requirements, including low latency and response time. This experiment will validate the use of cloud/fog computing as part of future network infrastructures for IoT deployments in an optical/wireless environment. We will compare the processing in different network tiers (local, fog, cloud) assessing the gains of such approach for real-time applications in converged networks. In particular, the adaptive cloud/fog computing will be assessed through a real-time system designed for people with special needs using speech and sign languages.

VI. Experiment V: Radio-Over-Fiber For IoT Environment Monitoring

Radio-over-Fiber (RoF) technology has emerged as an important candidate for wireless access networks, due to advantages such as high transmission capacity and immunity to electromagnetic interference. Moreover it enables the processing of several radio frequency (RF) signals in a centralized entity. This experiment will develop an efficient RoF system to monitor the environment over a university campus (temperature, humidity, noise, etc.) using an optical infrastructure. Among other aspects we will evaluate the performance of different multi-hop protocols and the efficiency of RoF and D-RoF (Digitized Radio over Fiber) technologies.

VII. Conclusions and Future Work

FUTEBOL major goal is to allow the access to advanced experimental facilities in Europe and Brazil for research and education across the wireless and optical domains. To accomplish this goal, we are developing a converged control framework to support optical/wireless experimentation on the federated research infrastructure from all associated partners. Through the five experiments described in this paper, measurements and analysis will be carried out to demonstrate the benefits of the FUTEBOL research infrastructure in exploring the boundaries of wireless/optical networks.

Acknowledgment

FUTEBOL has received funding from the European Union's Horizon 2020 for research, technological development, and demonstration under grant agreement no. 688941 (FUTEBOL), as well from the Brazilian Ministry of Science, Technology and Innovation (MCTI) through RNP and CTIC.

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