Perspectives on 6G in Brazil: A SMARTNESS View

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***Abstract*—This work contributes with a glimpse of 6G initiatives in Brazil by presenting perspectives that range from 5G-centric initiatives to 6G-native research endeavors. An overview of the main funding forces and relevant active projects are followed by a closer look at the recently started 10-year SMARTNESS engineering research center. The vision and research strand approach of SMARTNESS are highlighted. To conclude, final remarks and future perspectives are provided.**

I. The Brazilian Path to 6G

In Brazil, research and funding efforts toward 6G technology are gaining momentum through some initiatives. As common in other regions and required by the multi-faceted evolution of 5G technologies, the Brazilian approach to contributing to 6G follows a strategy to foster collaboration between academia, industry, and governmental bodies.

Through targeted investments and strategic partnerships, Brazil aims to harness its collective expertise and infrastructure to address the complex challenges inherent in 6G development. These include technological enablers in wireless communications, wired networking, and computing, along with workforce development, i.e., the next generation of professionals who will engineer, operate, and develop solutions for 6G.

Current research and development efforts are mostly devoted to available 5G technologies, adoption, and evolution. There is a sense of priority in unlocking its full potential and mastering the 5G and edge technologies to deliver truly transformative applications and use cases. Another concern is finding sustainable and economically viable ways of bringing 5G to the large geography of Brazil, with a special interest in rural areas and a huge potential to improve productivity and efficiency through technological advances that demand proper connectivity and computing facilities.

One exemplar initiative of this 5G-centric investment that can be regarded as an "ecosystem pre-requisite" before being able to contribute to 6G effectively is Open5G@Campinas.[1] The main guiding principles include: (i) Focus on the demands of companies and society; (ii) Use of open architectures and components, favoring integration; (iii) Innovation openly and collaboratively to accelerate innovation; (iv) Global thinking, acting locally; (v) Promotion of technology-based entrepreneurship; and (vi) Strengthening the local ecosystem. In a nutshell, towards mastering 5G, key objectives include: (a) Sharing experiences and knowledge among participants; (b) Collaborating with other members of the initiative (industry, academia, government, or users); (c) Attracting new members who also believe in our vision; (d) Promoting developments and experiments with startups; (e) Attracting R&D investments in 5G applications (e.g., IoT, AR/VR, drones, and robotics).

By fostering innovation and fueling a conducive ecosystem for experimentation and deployment, Brazil aims to position itself to play a significant role in shaping the global trajectory of 6G technology. A relevant initiative based on testbed-based experimental research, education, and innovation is OpenRAN@Brasil.[2] The multi-year multi-phased project led by the Telecommunication Research and Development Center (CPQD) and the Brazilian Network for Education and Research (RNP), funded by the Ministry of Science, Technology and Science (MCTI), also embraces academic groups into the mission of developing a distributed OpenRAN-based testbed that spans multiple domains, namely wireless, optical, programmable networks, edge computing, and orchestration. The project is currently in phase two with the testbed being almost in operational mode to support several research targets by different research groups. Next, use case pilots and partnerships with start-ups and companies are expected in phase 3.

Brazil is poised to make significant contributions to shaping the future of 6G and unlocking its transformative potential for society and industry alike. To this end, we can highlight different funding trusts that are expected to deliver scientific and technological contributions en route to 6G.

Technology Competence Centers (Embrapii / MCTI). After a joint call of MCTI and EMBRAPII (Brazilian Company of Research and Industrial Innovation), three institutions were recently selected for the formation of three Embrapii Centers of Excellence in frontier technology areas:[3]

- CPQD. With a focus on OpenRAN, the aim is to develop open technologies for telecommunications network infrastructure. The center should streamline companies to specialize in the development of open software and hardware, enabling the emergence of new companies in the segment and increasing the supply of equipment and solutions to network operators.
- INATEL. The center will continue to develop 5G research to improve network quality and, in parallel, develop standards and norms for 6G, enabling applications that require high transfer rates and low latency, such as autonomous transportation, remote surgeries, wearable technologies, among others.

[1] https://www.cpqd.com.br/inovacao/open-5g/

[2] https://www.rnp.br/projetos/openranbrasil

[3] https://embrapii.org.br/mcti-embrapii-anunciam-180-milhoes-tres-centros-fronteiras-te

- CEIA-UFG. Focused on immersive technologies applied to virtual worlds, the center will research enabling technologies to simulate the physical world through virtual reality, generating a sense of immersion, stimulating the senses - vision, hearing, touch, smell, and taste, creating real sensations – a vision also referred to as The Internet of Senses.

Brazil 6G Project. Started in 2021 and funded by MCTI, the Brazil 6G Project is the first and currently main 6G-native initiative led by the National Institute of Telecommunications (INATEL) and RNP. The project will merge efforts with the above-mentioned competence center responsible for the development of 5G/6G led by INATEL. The project is about to inaugurate the program's third phase that brings together academic research on the topic. The project is divided into several research fronts, with collaboration from different educational institutions, such as the federal universities of Pará, Ceará, Goiás, Rio de Janeiro, Santa Catarina, University of Campinas (Unicamp), and CPQD.

In the first phase, studies and bibliographic surveys were conducted on existing knowledge about 6G worldwide. Architectures and enabling technologies were also identified. In the second phase, researchers focused on novel ideas and use case environments for 6G, ending up with a remarkable focus on the so-called "smart farm" as the main environment to exercise 6G advancements. In the upcoming third phase, the experimentation environment will be created, including the initial prototypes and proof-of-concepts, to be expanded to other regions of Brazil.

Sao Paulo Research Foundation (FAPESP) Grants. FAPESP is a major funding source of high-quality research in all areas of knowledge. In the scope of 5G/6G, multiple initiatives can be found in key areas such as ultra-reliable low-latency communication (URLLC), massive MIMO (Multiple-Input Multiple-Output), optical communications, Terahertz spectrum utilization, virtualization, among others. A quick and dirty search ("6G" AND "Telecommunications") on the database of research supported by FAPESP[4] unveils a non-exhaustive list of projects with the potential of contributing enablers for 6G:

- New strategies to confront with the threat of capacity exhaustion. Grant number: 15/24341-7 (Oct/2017 - Sep/2024). Principal Investigator: Helio Waldman.
- High-speed strategic internet technologies. Grant number: 21/06569-1 (Aug/2023 - Jul/2028). Principal Investigator: Evandro Conforti.
- PORVIR-5G: programability, orchestration and virtualization in 5G networks. Grant number: 20/05182-3 (Feb/2021 - Jan/2026). Principal Investigator: José Marcos Silva Nogueira.
- Quantum Rio network. Grant number: 21/06823-5 (Jul/2022 - Jun/2027). Principal Investigator: Antonio Zelaquett Khoury.
- Acquisition of Transmission and Characterization Equipment for Ultra-High-Speed Data Links. Grant number: 22/11596-0 (Aug/2023 - Jul/2030). Principal Investigator: Darli Augusto de Arruda Mello.

[4]https://bv.fapesp.br/pt/pesquisa/buscador/?

Two active grants stand out for their focus on 6G and the 2030 networking landscape:

- 6th generation wireless communication networks: new concepts, algorithms and applications. Grant number: 23/00579-0 (Aug/2023 - Jul/2028). Research Projects - Thematic Grants. Principal Investigator: Rodrigo C. de Lamare.
- SMART NEtworks and ServiceS for 2030 (SMARTNESS). Grant number: 21/00199-8 (Apr/2023 - Mar/2033). Research Grants - Research Centers in Engineering Program. Principal Investigator: Christian Rodolfo Esteve Rothenberg.

The FAPESP Engineering Research Center (ERC) program[5] is a noteworthy initiative that draws principles from the National Science Foundation (NSF) Engineering Research Centers,[6] as well as EU Public Private Partnerships (PPPs),[7] with the common denominator of seeking research environments that blend universities and/or research institutions with the broader society, so that undergraduates and graduates are better trained to cover up-to-date and future-looking themes of advanced research, relying on companies that partnering with academia push the limits of knowledge frontiers.

In sum, an ERC supported by FAPESP is expected to execute internationally competitive research following global excellence benchmarks, demonstrating (a) World-class research at the knowledge frontier, fundamental or application-oriented, in both cases actively exploring opportunities to contribute to problem-solving and to produce well-defined results with demonstrable potential to create a social impact and technological innovation; (b) Knowledge transfer to partner companies and society including the business sector, the non-governmental and/or the public sector; and (c) Interaction with the education system, especially primary and high schools.

II. The SMARTNESS 2030 Approach

Initially conceived in 2020 by Ericsson and UNICAMP, the SMARTNESS Engineering Research Center (ERC)[8] targets cutting-edge research in communication networks and applications in strategic areas where significant scientific and technological impacts can be achieved towards 2030 / 6G.[9]

As 5G releases roll-out and the vision on 6G is being developed, SMARTNESS's main challenge is how to engineer (i.e., design and operate) cloud computing and network infrastructures with adequate capabilities to empower next-generation Internet services and applications. The scope of end-to-end Internet-scale services is exceptionally broad and requires contributions from various disciplines along with large capital and human resource investments. However, the ongoing digital transformation in vertical industries and a shift towards open source network softwarization and disaggregation of infrastructures at multiple levels and protocol stack layers have

[5]https://fapesp.br/cpe/home

[6]https://www.nsf.gov/eng/eec/erc.jsp

[7]https://research-and-innovation.ec.europa.eu/research-area/transport/public-private-partnerships_en

[8]https://smartness2030.tech/

[9]As an anecdotal note, the "Smart Networks and Services" name overlap with EU SNS JU was an unforeseen coincidence in 2020.

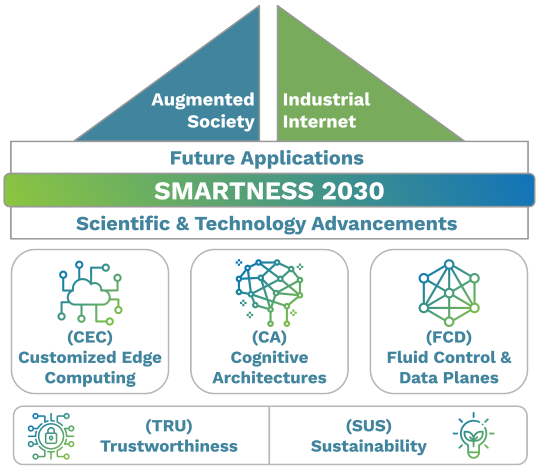

Fig. 1. SMARTNESS Scientific and Technological Advancements (STA).

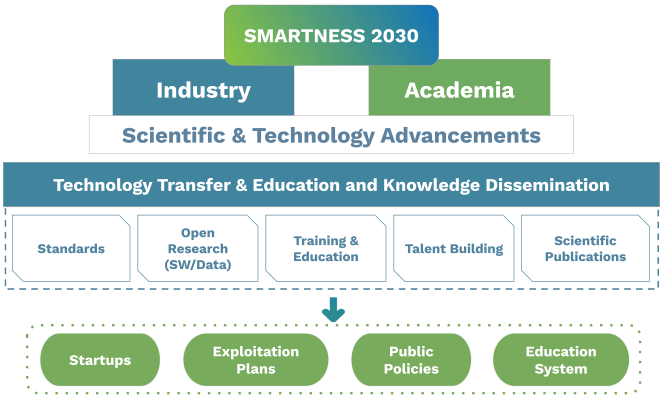

Fig. 2. SMARTNESS Impact Setting.

opened well-scoped opportunities for accelerated innovation at unprecedented entry barriers for research enterprises based on academic and industrial partnerships.

Cloud computing and network infrastructures are increasingly becoming more multidisciplinary, requiring system-oriented end-to-end views that leverage advances in Hardware (HW) for computing and networking, modern Software (SW) architectures, machine intelligence (AI/ML), user interfaces, "as a Service" consumption and new business models, among other engineering disciplines (e.g., energy efficiency and design for security). SMARTNESS aims to exploit well-thought-out opportunities through a proper methodology based on the confluence of parallel Research Strands (RS) tailored for successful impact research and innovation at world-class levels towards realizing challenging use cases in Internet scenarios for industry and society with a 2030 horizon view.

The SMARTNESS ERC has the ambition to go beyond the state-of-the-art of networked system disciplines that can be clustered into five major areas of Scientific and Technological Advancements (STA), namely, (i) Customized Edge Computing, (ii) Fluid Control Data Planes, (iii) Cognitive Architectures, (iv) Trustworthiness - Security, Privacy, Safety, Ethics, and (v) Sustainability. As shown in Figure 1, the scope of SMARTNESS includes STA, regarded as enablers of future applications relevant to society and industry in the horizon of 2030 and the 6G time frame. The vision of SMARTNESS is to structure STAs that gather specific, ambitious objectives within a common theme, acting as building blocks upon which Research Strands (RS) are defined and executed. Each RS encompasses a group of well-defined, timely STA research objectives described in Work Packages (WP) to carry out tasks towards the realization of exemplary use case applications.

SMARTNESS follows a push-pull model for academia-industry collaboration. Academic Research Push brings new research findings, ideas, trends, etc. from SMARTNESS to Ericsson Research and other stakeholders at national and international scope. In the other direction, Community / Ericsson Pull is exercised through the sharing of new research demands/opportunities from related research projects (e.g. EU SNS JU) and/or standardization efforts (e.g., O-RAN, 3GPP) brought to SMARTNESS to provoke relevant contributions after shaping ongoing Research Strand WPs and/or creating new ones. Both the Push and Pull thrusts are carefully curated by the EC plus, as needed, advised through interactions with the STA Board (STAB) and International Advisory Board (IAB).

SMARTNESS is poised to significantly influence both the Brazilian and global contexts. Figure 2 illustrates our impact-setting approach, encompassing a multifaceted strategy including public policy, startup ventures, and societal impact, all guided by tailored exploitation plans. As described in the Center proposal and detailed earlier in Section I.C on Expected Results, the impact endeavors are structured around a four-axis framework: (i) Science / Technology, (ii) Standardization, (iii) Training / Education, and (iv) Commercial.

III. Concluding Remarks

Through a series of investments and strategic research efforts, Brazil aims to harness its collective expertise and infrastructure to address the complex challenges inherent in 6G development. Meanwhile, fueling the adoption and evolution of 5G across a large country characterized by a diversified set of use case scenarios remains critical to effectively deliver value of 5G investments and impact 6G. Key tenets of 6G around (i) softwarization, (ii) disaggregation, and (iii) AI/ML, all areas where Brazil has proven competencies and/or credible capabilities,[10] speak in favor of matching the 6G standardization time frame with tangible presence.

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[10]In addition to driving forces from the Brazilian digital games industry (cf. https://www.gamesindustry.biz/brazilian-games-industry-grew-by-32-in-2023)