Toward a Future-Proof Global 6G: Business, Regulation, and Technology Perspectives

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Abstract— Sixth generation (6G) mobile communications are envisioned to be a comprehensive connectivity platform for unification between the human, digital, and physical worlds through the convergence of diverse enabling technologies across many disciplines. A plethora of competing 6G vision documents have been distributed with the intention of shaping the world's IMT strategy for 2030 or later in ITU-R and have largely continued the technology-centric paradigm that characterized previous mobile generations in the sense of foregrounding enabling technologies, use scenarios and performance metrics. Consequently, current ideologies have all led to a complex and partially overlapping landscape, lacking a coherent and holistic view and a common terminology required to harmonize a truly global 6G vision and thus hindering successful development and commercialization. While recognition of sustainability and human centric-ness is increasingly recognized as a major driving force, current visions often do not incorporate these dimensions through a multidisciplinary and multi-stakeholder approach. To fill this gap, a human-centric and sustainability-focused framework for the definition and development of 6G is proposed in the present paper in the form of a series of connected questions about the purpose of 6G; its intended beneficiaries, the stakeholders involved, envisaged use cases and modes of utilization, implementation mechanisms and metrics for success. The applicability of the framework is illustrated by the selected prospective 6G use scenarios and thus contributes to the establishment of a base for collaborative, future-proof, global 6G visioning.

Keywords: 6G vision, future mobile communications, human-centric design, sustainability, global IMT, multidisciplinary framework, usage scenarios

Introduction

The global vision of IMT up to 2030 and beyond, known as 6G, is expected to be decided in 2023 in the International Telecommunication Union Radiocommunication Sector (ITU- R). As the ITU-R vision deadline gets nearer and nearer, the need for competitiveness in the 6G dawn is not only urgent but also critical. Present 6G visions, which are promulgated by prominent research institutions and industrial stakeholders from different countries, provide complementary but partially divergent views on the definition of 6G and what it must include. These elements have to do with enabling technologies, use cases, and performance capabilities. Numerous vision

documents such as the white papers mentioned in [1] mainly follow the technology-centric approach provided in the IMT-2020 (5G) vision [2].

The actual commercialization of 6G, being a new class of technology of a general-purpose [3] nature, on top of an already deep technological undertaking, it poses a basis challenge of the remaining business model paradigm. Prior to the introduction of the 4G, connectivity business models showed relative stasis, hence allowing mobile network operators (MNOs) to sustain the dominance present in the market, while faced with mounting challenges emanating from content proprietors and cloud-based over-the-top (OTT) Internet entities. The IMT-2020 vision for 5G [2] defined three main technical use cases, i.e., enhanced mobile broadband (eMBB), ultra-reliable and low-latency communications (URLLC), massive machine type communications (mMTC) in a service-centric framework. These scenarios provided opportunities for breaking conventional connectivity-centric business models with the provision of integrated content /or context-based offerings and extensions to network as a service (NaaS) model. Moreover, 5G enabled the growth of the number of locally deployed, often private networks, operated by stakeholders other than MNOs and enabled organizations to deploy and run their own network infrastructure.

For 6G, upsets to current business models are expected to be even deeper. The first 6G white paper describes the technology as pervasive wireless intelligence [4], referring to integration of connectivity and artificial intelligence (AI) to enable new services to both humans and machines, and looking forward to the development of a complex 6G ecosystem. A complementary view comes from the European Hexa - X project20, which conceptualizes the definition of 6G as an intelligent fabric of technological enablers at the interface between human, physical and digital domains, which extends the definition towards user experience and societal results. Emerging paradigms such as holographic communications and transhumanism, assisted by advanced human-machine interaction modalities, such as haptic and empathic communications to access the Metaverse have expanded the scope imagined for 6G to cover almost all aspects of human and machine life. Accordingly, a purely technology-centric approach will be insufficient to reach the point where a globally adopted, sustainable, enduring and adaptable, i.e., future-proof, 6G deployment is reached. These elevated expectations will directly figure in the definition, design, deployment, evolution, and particularly a commercialization of 6G through novel business models.

Technology foresight and futures studies have been able to add a substantial contribution to the comprehension of the prospective emergence of 6G, considering the expected configurations of the technology itself and its implications for users, enterprises, institutions, sustainability, societies, and even geopolitical dynamics [6]. However, current 6G vision efforts have resulted in a patchwork of partially overlapping and, in some instances, competing components, as well as parallel cases scenarios that target dissimilar contexts, objectives and stakeholder groups. For example, service-oriented and collaborative robotic technologies are expected to be relevant to almost every scenario outlined in both Next G Alliance [7] and Hexa-X [5] vision documents. Overall, the major publicized 6G vision artefacts demonstrate an absence of a shared and systematic framework and a common terminology that will impede the achievement of a truly

future proof 6G architecture. To date, 6G visioning has largely relied on forward-looking techno-economic analyses that combine heterogeneous approaches and contextual assumptions to envision 6G development without taking the full multi-perspective, multi-level and multi-stakeholder development approach. Business and regulatory considerations, such as sustainability and human-centeredness, are not yet sufficiently integrated into (primarily) technology-driven visions.

To address the identified deficiencies, in this paper the following research questions are addressed: (i) What are the perspectives essential to visioning a future proof 6G and (ii) How can a future proof 6G vision be defined and developed. The objective of this report is to employ qualitative thematic analysis and methodologies linked to technology foresight to synthesize and build upon the insights established from existing 6G vision documents and white papers. It incorporates expert input, acquired from more than ten 6G white paper workshops involving over 70 external experts commissioned by the Finnish 6G Flagship programmer and the own experiential knowledge gained by the authors through the global 6G vision work. The contributions of this study are at three levels. First, an overall synthesis of business, technology, and regulatory perspectives is created among multiple stakeholders, which is based on a conceptual base, which is rooted in the business model theory. Second, a new type of framework that is novel, holistic and systematic, including essential elements and terminologies for future proof and 6G definition/communication, is proposed. Third, an agenda for the continued development of future - proof 6G is presented. The remainder of this paper is organized as follows: Chapter II discusses the perspectives needed for the definition of 6G; Chapter III details the level of analysis and fundamental principles that govern 6G definition; Chapter IV presents the proposed visioning framework along with some illustrative examples of its application; and Chapter V gives some concluding remarks.

Perspectives Needed in the Definition of 6G

Defining a global vision for 6G requires the fusion of a few interrelated perspectives, namely the economic and market dimensions, technological developments and regulatory policy frameworks. The process of creating a cohesive 6G framework needs systematic consideration of emerging, enabling, and embedded trajectories of novel technologies [9]. A future proof general purpose 6G ecosystem requires a holistic approach to commercial viability and sustainability. This involves complex integration of technical advances with market locality and regulation. Within the scope of the business, technology, and regulatory segments, creating universal approaches and policies offer great challenges when there is no common denominator, uniform terminology, or common vision. Without such cohesion, cross sector collaboration and interoperability is hindered. To supplement the prevalent technology-centric paradigm of 6G definition, this study proposes enlarging the boundaries of 6G to explicitly include business/market dimensions as well as regulatory/policy dimensions (see Fig. 1) for a sustainable, human-centric and future-proof 6G vision to be developed. Figure Paula Silva and Wojciech Chatrchyan IWT 2019, "6G Objectives

and Challenges," in 10.611.16, September 2019 Figure 1 gives an idea of the direct link between these views and the overarching 6G system objectives [10],[5],[11].

Programmable network infrastructure hardware that is agnostic to both on-premises and cloud environments must meet the varied requirements of a wide range of applications as well as meet the expectations of developers. The implementation of a high degree of flexibility and a high degree of specialization is indispensable for facilitating deployments on heterogeneous environments, consisting of very large wide solutions, but also very deep locally toed community,

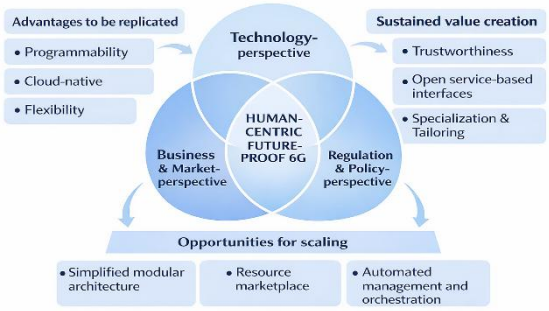

Figure 1 Perspectives for defining a future-proof 6G

on Premises and personal Area Networks. Consequently, extreme tailoring and agile service deployment have become vital to achieving the goal of uniquely optimizing each zone, sub-network and network instance and its specific use cases and business objectives. Fully cloud native 6G network functions and services need to be flexibly instantly with heterogeneity distributed in public and private cloud platforms to fulfill diverse key performance indicators (KPIs) and K-value indicators (KVIs).

The requirements for scalability in telecommunications infrastructures of the future require a marketplace-oriented orchestration of heterogenous infrastructure, capabilities and services (including programmatic network functions, storage, computing, artificial intelligence/machine learning, extended reality and metaverse-related offers). The factor of domesticating the digital twin, which is defined as the virtual replica of network entities, is one of the prerequisites for improving efficiency and productivity while enabling dynamic adaptive application-aware networking and bridging the gap between application-level goals and network requirements. Open, service-oriented application programming interfaces for both users and developers are a prerequisite for discoverability and accessibility of resources to support the composition and integration of functions and services from diverse resources for specific use cases, business imperatives and operational constraints. In addition, robust orchestration and automation across multiple network and administrative domains, stakeholders, and multilayer, multiple platforms is also critical for achieving scale. Trustworthiness - including comprehensive coverage, robust multi-connexon and the creation of trust zones - appears to be the main value proposition for sixth generations (6G) systems. To meet the requirements of the emerging 6G services, both the radio access and core network architectures must significantly increase their flexibility, scalability, and

programmability, which in turn makes it necessary to simplify the system architectures by having a minimum set of core functions and protocols.

A) How it is Seen from a Business and Market Perspective

From a business, market and techno-economic perspective, the realization of 6G innovation can provide substantial benefits only through a consistent approach of the 6G vision that enables both business and societal benefits to be systematically addressed, mechanisms for value creation and capture to be established, as well as identifying sources of competitive advantage for realizing the 6G vision to create the prerequisites for economic viability and successful commercialization in an increasingly digitalized business ecosystem [3]. To support commercialization, these outcomes of the framework must also support expected 6G outcomes, the scalability and replicability of solutions across use cases, domains, verticals and global markets, as well as sustainability and resilience, both in terms of continuity, complementarity and extendibility, of the solution lifecycles [12]. The triple-insider construct of sustainability, ensuring that the actions taken today do not compromise the economic, social, and environmental opportunities of the future, should be used to guide 6G research and development efforts. Addressing basic challenges to sustainability via ICT based solutions is a significant business opportunity for 6G, but at the same time it requests 6G technologies to comply with evolving sustainability requirements. An ecosystem level approach that involves the users of 6G actively is therefore essential to avoid the dominance of individual stakeholders and impediments to the success and long term viability of the wider 6G ecosystem.

B) Technical View ox IT Per spective

The thrust to 6G is enabled by innovations from a wide coalition of stakeholders across the lifecycle which spans multiple areas of technology from the domains of artificial intelligence, converged communications, localization, imaging, and sensing. This heterogeneity promises large potential variation and competition between potential commercialization solutions. 6G is envisioned to be an innovative, general purpose connectivity platform that will link the human, physical and digital worlds, convergence of data and platform capabilities across multiple application domains and industry verticals. The enabling trajectory requires a growing supply of complementing assets, which could be more expensive to supply due to their domain-specific nature. Consequently, business models for 6G commercialization must include activities at the firm, as well as at the ecosystem level; that is, they must support an embedding trajectory through which sustainable value creation and capture can be realized. The overlapping emergence, enabling and embedding trajectories in 6G development are highlighting the need for an integrated framework that enables definition development and deployment policy making for 6G.

C) Regulation and Policy Perspective

Regulation and policies play a decisive role in shaping the development of mobile communication markets14 Smith, F. From the perspective of environmental, societal and economic sustainability,

regulatory schemes impose requirements in several dimensions, including explicit requirements relating to environmental performance. Consequently, in developing 6G technology, a range of regulatory regimes must be accommodated, including spectrum allocation, market dominance, data access, ownership and utilization, as well as mandates dealing with platforms, digital markets, services, and artificial intelligence. A paradigm shift that can be clearly seen in the 5G transition is the growing presence of local mobile networks by actors other than traditional mobile network operators (non-MNOs). This shift is guided profoundly by regulatory determinations of the availability of spectrum and high-level policy. Further regulatory pressures are expected to come from environmental responsibilities; carbon offset mechanisms and another source of regulations linked to industry vertical-specific (tied to national sovereignty imperatives). Recent regulatory deliberations highlight the need to modernize, historically static regulatory frameworks by baking in the objectives of sustainable development in order to accommodate the timely and adaptive deployment of emerging technologies, innovative business models and the delivery of public welfare.

Collectively the business, market, technological, and regulatory - policy lenses provide a holistic view of 6G. Operationally, 6G represents the interconnecting, harmonizing, and redistribution of the resources/assets between different service providers and complementing entities to serve the evolving needs of users and other players that are part of the forthcoming 6G ecosystem. Figure 2 shows the development of a multilateral market with its representative elements.

Defining an 6G That Is the Future: An in-depth look Over educational

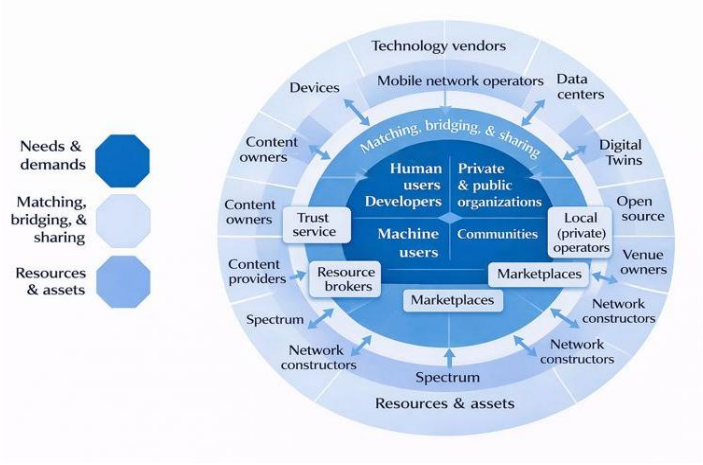

Figure 2 Resource configurations for 6G

Contemporary propositions of sixth generation (6G) wireless communication higher the human-centric orientation and inclusivity side-by-side with environmental and societal sustainability imperatives. These formulations also highlight trustworthiness, especially about privacy, security and safety and they require resilience and foster digital sovereignty. Nevertheless, existing 6G conceptions are not without controversies as they represent conflicting values and objectives. The resulting tensions are born of the fact that all at once arise tight requirements for social governance,

world commercial and industrial desires fueled by the ever-deeper technological race, efforts to harmonize and regulate, fears for national sovereignty, and military interests. Against this complex backdrop, an increased need is felt to define the characteristics that will define a future-proof 6G paradigm.

A. Levels of Analysis of a Futuristically Resilient 6G Architecture

The necessary themes that are required for the realization of globally viable 6G system were reconciled in [1] using causal layered analysis. At a superficial level 6G is envisaged as a general-purpose technology characterized by globally harmonized standards, mutually agreed intellectual property licensing regimes, innovative spectrum sharing mechanisms, and sustainability-driven KPIs and KVIs. An end-to-end set of standards which is industrial- and geographical-neutral is expected to ensure consistency, extensibility, complementarity and economies of scale in deploying 6G networks.

To realize this vision will require concerted research efforts, demonstration implementations and large-scale experimental campaigns, regardless of existing geopolitical tensions, sovereignty questions, or domestic policy requirements relating to innovation, implementation and regulation. Concurrently, policymakers must provide sufficient support to emerging technology innovators to support value capture. The increase in the use of 6G technology in new fields of application combined with the new generation of licensees and players who will emerge will significantly raise the intrinsic complexity of the licensing landscape with respect to standard essential patents (SEPs). As a result of this evolution [3], more precise interpretations and enforcement of fair, reasonable and non-discriminatory (FRAND) licensing principles are mandated.

Empirical observations from the 5G generation, in particular the system disaggregation, softwarization and cloudification, already made clear that there are ambiguities within the definition of FRAND and fair and reasonable licensing fees in standardization bodies. Within the context of the 6G ecosystem, there is a possibility that the value extraction of complementary assets will be further compromised due to the standard essential patents, which have furthered the power of the functionality of the platforms and technologies. Concurrently, business models are for mobile communications experiencing a transition towards network-as-a-service from all sectors of telecommunications, internet services, enterprises, and industries, with software-driven value creation and cloud delivery. Beyond traditional mobile network operators (MNOs), 6G networks will be designed, deployed, managed and commercialized by new actors such as local network operators, cloud service providers and resource brokers.

In terms of systems, the prospective development of 6G has to be consistent with the triple bottom line of sustainability, which is economic, environmental and social, all at the same time, while providing the reliability of the technology and creating strong regulatory frameworks for the use of artificial intelligence (AI) and machine learning (ML). This goal requires forward-thinking that will lead to the combination of open innovation and ensuring compliance with sustainable practices. At a more profound level of worldview, 6G can emphasize the legitimacy of ecological

systems by empowering human agents and enabling citizen-driven services to make embedded in the culture values of other living systems such as harmonious coexistence, well-being, and long-term progress.

B. Basic Requirements of the Definition of a Future-Proof 6G

Historically, it has been common practice for companies researching human-centricity in the mobile communications field to consider primarily such metrics as quality of service (QoS) or quality of experience (QoE). Several 6G paradigms predict immersive experiences with a foundation based on virtual, augmented and extended reality (VR/AR/XR) technologies, including haptic and empathic communication modalities. Nonetheless, human-centricity should be recognized as a design principle that serves as the starting point, which is aimed at enhancing and protecting human ability and rights, especially by incorporating artificial intelligence, unlike the idea of 6G that seeks to create something new from it.

Moreover, the concept of human centredness should go beyond end users, to include developers, regulators and public authorities. Figure in this Sector: "6G in this Sector: A New Challenge" Figure 3 illustrates the main drivers in the path towards a sustainable, human-centered and future-proof 6G.

Figure 3 Forces driving toward sustainable human-centric 6G

In order to complement human-centricity, planning of 6G systems needs to offer appreciable space for trustworthiness over the individual, machine and societal dimensions, instead of limiting trust issues to a pure technical dimension. Conforming to harmonised regulatory frameworks and ethical guidelines governing artificial intelligence, a value-based policy for trustworthy 6G can be thought of. This policy would be based on foundational principles that would include transparency, fairness, accountability, robustness, safety, human agency and oversight, privacy, and data governance.

In order to make 6G truly user- and developer-friendly, the technical processes and decision-making mechanisms concerning the 6G must be transparent and explainable to every relevant

stakeholder. This includes standardized documentation of data sets and AI/Ml based decisions to ensure traceability and auditability. Moreover, governance frameworks should also be geared toward human management, while users and developers need the requisite knowledge and tools to comprehend, interact and affect system behavior. Although privacy, security, and safety are not only necessary on an individual level, they also have implications on the societal level through inclusive access and the ability to opt out of communications when a user wants.

Sustainability within the domain of mobile communications has traditionally been focused on optimization of energy efficient network architecture; however, the latest discussions show that the need to reduce harmful exposure to electromagnetic field (EMF) radiation is now added to the dominant role of connectivity across a range of sectors. While industry initiatives are being undertaken to improve energy efficiency, the accelerated spread of demand for end-user data - and the escalating energy utilization which has correspondingly - runs the risk of negating these gains by overconsumption. Accordingly, the upcoming 6G paradigm will have to reconcile the triple bottom line of sustainability at the same time, hence combining societal, environmental, and economic considerations [12]. To this end, developmental priorities should be on meeting the sustainable end-user requirements and not the amplification of consuming mobile data.

Environmental sustainability cannot be allowed to undermine economic viability, in terms of investment viability and revenue generation, nor can it be allowed to stand in the path of society's progress as determined by the United Nations Sustainable Development Goals (UN SDGs). Societal values must be properly balanced so that they do not endanger economic or environmental sustainability. Economic sustainability, in turn, should be encouraged in a way as to have no adverse effects on society or environment. This integrated approach to the triple bottom line is indispensable therefore, to achieve system and societal resilience, especially when it comes to critical infrastructures.

The cumulative impacts of human centricity, trustworthiness, and sustainability have great implications for upcoming innovation policies and regulatory frameworks. Economically, such principles have added increased importance for entities seeking to commercialize 6G as a multi-sided platform, in addition to achieving a network-of-networks paradigm and extending the ecosystem to include novel and heterogeneous stakeholders.

A Proposed Framework for 6G Visioning

Next, we propose a novel framework and agenda for action with the aim of formulating a shared vision for 6G. The impetus to promote this visioning framework stems from the imperative that it is with the stakeholders in the emerging 6G mobile communications ecosystem to fathomably articulate and inclusively communicate their needs, objectives and visions. The main objective of the framework is to support the successful innovation and commercialization of 6G, while at the same time promoting a human centric, environmentally, socially and economically sustainable digital world. Accordingly, a top-down visioning framework aimed at providing a common framework for developing a future-proof 6G is outlined in Figure 4.

A. The Visioning Framework: Underpinnings, Methods & Uses

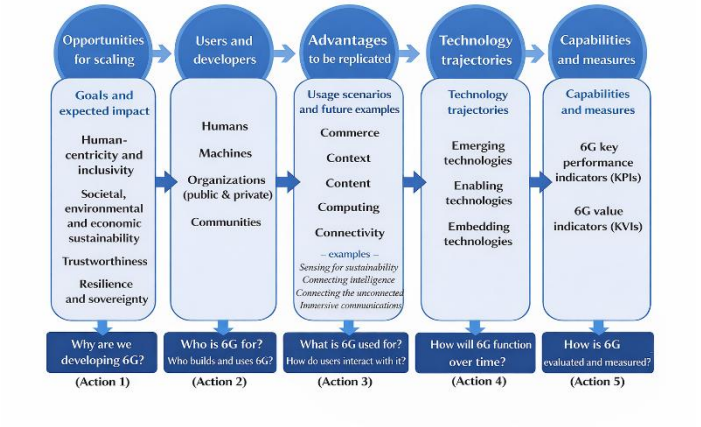

Figure 4 The proposed 6G visioning framework

To date, the cornerstone of a future-proof vision of 6G is mainly that of the delicate definition of its goals and expected societal consequences (Action 1). Current 6G vision concepts mainly cover:

a) Anthropocentrism and inclusivity, and
b) Societal, environmental and economical sustainability,
c) Trustworthiness when it comes to privacy, security and safety, and
d) Resilience, also at the level of societies and systems, including sovereignty aspects.

Although these visions give different priorities and interpretations to the objectives to be reached, they do converge on a clear purpose for 6G providing a solution to the basic question about the motivations behind 6G development.

Second, following the established articulated goals and the anticipated impacts, it is necessary to identify the users and developers of prospective 6G systems (Action 2). This cohort includes humans, machines, communities and a range of organizations. By outlining who 6G is being designed for and who will ultimately use and build it, we are providing the basis to design for a specific target. Distinct user and developer archetypes will perceive, deploy, and construct 6G in heterogeneous manners, and thus manifest divergent communication necessities and utilization patterns. Consequently, their systematic inclusion is critical to the development of a resilient and

future-proof 6G paradigm. In the absence of a thorough understanding of objectives, impacts and roles and responsibilities of stakeholders, scaling potential 6G-enabled solutions and services may not materialize.

Third, the proposed framework requires the definition of the desired end user's purpose for 6G and the models by which it will be used (Action 3). Such clarification allows us to appreciate the useful identification of use cases and prospective applications of the 6G. The overall objective is to identify the unique benefits 6G should offer to end-users while meeting overall societal goals and finding solutions that are both reproducible and practical in nature. Although 5G - Advanced is expected to enable experimentation with new use cases (at least initially during deployment, XR, VR or AI/ML driven network optimization are expected) The introduction of 6G is expected to take a more considered approach to combat the current shortcomings and to improve end -user experience. Even though an extensive and ever evolving catalogue of use cases exists, the framework presented is a guiding mechanism in Innovations towards solutions that can be deployed and indeed made commercially viable. A critical part of this step is to understand an interplay between multiple layers of a business (namely connectivity, computing, content, context, and commerce) and different combinations thereof.

Fourth, the formulation of resilient 6G architecture calls for identification of its technology trajectories (Action 4), that is defining the functional modalities of 6G as well as the technological enablers that will change over time. This step emphasizes the ability of 6G to enable the creation of value for the end user and society in general over a long period of time. The proposed technological pillars include AI - native communication frameworks, integrated sensing - communication systems, computing and communication infrastructure convergence, device-to-device communication paradigms, spectrum utilization efficiency and increased energy efficiency. These technological strands are anticipated to change in an iterative manner driven by open innovation mechanisms of the amplified mobile communications ecosystem.

Finally, in line with current technological trends, the technical abilities and performance characteristics of 6G must be defined (Action 5), and consequently the methodology of 6G performance evaluation. Existing scholarship focuses mainly on traditional key performance indicators (KPIs) and sustainability-inspired key value indicators (KVIs) that are linked to technical capabilities in a variety of usage scenarios. Nevertheless, a consensus on a comprehensive and unified collection of indicators for 6G is not yet available.

In summary, the proposed visioning framework is the result of their interrelated elements and activities, which represents the holistic and systematic mechanism aimed at facilitating communication among different and diverse ecosystem participants, namely developers, users, and regulators. Goals, impacts, and stakeholder definitions drive the usage scenarios and the examples of the future, and technology trajectories, capabilities, and metrics are based on these scenarios. The framework aims to provide a foundation for successful innovation and commercialization of 6G, and through its efforts to promote the human centric and sustainable digital transformation.

Crucially, this approach turns the conventional, technology-based reasoning on its head in that it starts, not from technological features as the only real determinant, but from user experience or sustainability and resilience. As represented in [15], new technologies result from combination, recursion and convergence. Within this framework, 6G has the potential to bind disparate technologies together and thus create a multifaceted marketplace with stakeholders simultaneously acting in competitive and cooperative dynamics.

B. Preliminary Scenarios for the Deployment of 6G

Numerous and illustrative examples help to explain the prospective applications of the sixth-generation wireless communication technology.

Sensing for sustainability:

To address the sustainability issues, Sixth Generation (6G) technology has the potential to be used as an advanced platform for sensing and measurement. Its adaptive sensing capabilities support acquiring context-specific data and sustainability indicators about different sectors, including public organizations, on top of appropriate Key Value Indicators (KVIs).

Integrative Study of Intelligence:

Second, the architecture of 6G will be intrinsically based on artificial intelligence (AI) and machine learning (ML) because it will enable the integration of sources of distributed intelligence like the computational agents used in the application of digital twins. By means of large-scale incorporation of sensing, AI and ML, 6G will attract synchronous physical and virtual domain alignment in real-time. Digital twins will enable users to observe, analyze, simulate and predict real life conditions that can support informed decision making and the implementation of timely interventions.

Connecting the unconnected:

Third, with an estimated 2.9billion people, still not having connectivity, the expansion of access remains a dual imperative, both for the commercial enterprise and public policy. The imminent arrival of 6G brings new deployment alternatives and operator paradigms and thus allows communities to build and manage autonomous networks in areas that are underserved and pose operational challenges.

Immersive communications:

Fourth, communication, an important building block of human interaction, will be transformative with the application of advanced XR technologies. By adding other forms of sensation such as haptic interaction and feeling, immersive communication systems are expected to reshape work processes and thereby add extra organizational agility and efficiency.

In all these examples, the pervasiveness of digitalization and software-driven innovation are apparent, and they make developer capacity a more important commodity. Cloud-natives have

made a fundamental change in software procurement and utilization thus empowering developers to impact key technological determinations. Successful life within this milieu often depends on development of a vibrant developer ecosystem. Therefore, there are countless organizations which are shifting from a top, traditional hierarchical market strategy to a bottom-up strategy-one which empowers users to try out and then adopt and incrementally scale solutions. Identifying the right issues to be addressed and matching them to the appropriate business and platform models is still a challenging but indispensable endeavor for 6G to succeed.

Conclusions

Current visions for 6G are not yet aligned as more organic competition in technology policy continues to impact consensus. This reality highlights the need for a holistic and integrated approach to the building of a common 6G vision. As 6G evolves, it will face significant problems related to the birth and growth of attractive uses, the implementation of cost-efficient solutions, and the creation of sustainable business models. Consequently, business and market views must blur with regulatory and policy views, linking with the usually technology-centric and techno-economic views that have dominated the development of mobile communications so far.

Envisioned to be a general-purpose technology, i.e., a platform of platforms or networks in 6G has the potential that can influence the global economy in a meaningful way, and also it has the potential to restructure society, economic and institutional structures in a fundamental caregiving fashion. In view of the urgent need for realizing economic, social and environmental sustainability, as well as systemic resilience, it is critical to define 6G, and implement and communicate about 6G, in a way that is human-centric, sustainable and future-proof.

The conception of 6G as an AI-enabled system that radically reshapes the way data is acquired, disseminated, analyzed and used, while at the same time fusing together human, physical and digital realms, is set for being a veritable enabler of scalable opportunities, replicable advantages and long-term value creation. This transformative shift is expected to create new actors and enable the creation of more stakeholders within the mobile communications ecosystem. Concurrently, 6G can be expected to shift toward modular architecture, which allows component development in isolation of each other with different design objectives. Although this modularity strengthens flexibility and triggers innovation, it might also lead to inter-module conflict and recursive interaction that might have a negative impact on the user experience or raise ethical and privacy issues, especially when it comes to data sources, processing, usage and storage.

Furthermore, emergent phenomena-there may be the proliferation of local networks managed by different stakeholders and with heterogeneous business models that may precipitate challenges to legitimacy. For the successful implementation of sixth generation (6G) technologies, solutions and associated business models, there is a need for them to win the approval of the wider mobile communications ecosystem, including end-users, software developers, private and public sector organizations, regulatory authorities, policy makers as well as community based institutions including standardization bodies.

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