Bring the human to the network: 5G and beyond

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***Abstract*—Communication networks beyond 5G will bring about a human existence that is ever more virtual. Allowing new communication services with virtual existence and involvement everywhere is likely to redefine and place new demands on how humans can and wish (or do not wish) to engage with the connected network. The ubiquitous nature of the 6G network evolution enables increased involvement and affords more power to networks and machines (and those designing them) versus humans. This paper advocates that human-centric 6G networks should put humans' interests and potential first and foremost, in a holistic manner. There is a need to critically monitor, (r)evaluate, and adjust the above power implications. Human-centric design perspectives applied to future network technologies incorporate the human element more broadly. Thus, meaningful user control, empowerment, and agency should be key features of future network technologies beyond 5G and 6G. The network system's ability to protect human potential and humanity first, to serve multiple normative standards, while balancing the interests of all parties, can become a catalyst for stimulating better governing practices and for managing consensus building between individuals, communities, governments, and networked machines embedded with human-like capabilities. However, realising this vision and potential requires a thorough alignment with the human- and humanity-centric paradigm and a renewal of its operationalisation and implementation. This paper overviews a set of human-centric design interpretations and discusses the next challenges and implications in a beyond 5G and 6G context.**

***Index Terms*—human-centric theory, democratization, power, user involvement**

I. Introduction

Human-centric communication technology will be critical for successfully developing and deploying future network capabilities beyond 5G [1]. The next 6G technologies are expected to extend to hundreds of billions of connected machines embedded with identification, sensing, or actuation capabilities [2] and offer the ambitious potential to augment and transform existing human-technology experiences by connecting previously un- and under-connected worlds [3]. At this technological juncture, "intelligent" will be the inherent feature of new network technology; AI and automation will be embedded in all connected devices, their related services, and the overall management of the integrated system [4]. The intelligence embedded in each machine, will be subordinated to the system as a whole to allow for seamless communication and the integration of computing resources [5]. Connected machines will be the dominant users, acting on behalf of humans, when setting requirements for 6G technologies, services, and applications [5].

The 6G technology vision is explicitly marketed as human-centric, suggesting that human-centric network technology, services, and applications will reinvent the next-generation communication networks [1], [6]. As part of the overall vision of building in the human element, personalised, yet anonymised mechanisms are envisioned for ensuring high Quality of Service (QoS) and Quality of Experience (QoE) [7] of new 6G services [5]. Via observation, interpretation and actuating features, the 6G network will be able to develop deep intelligence for improving QoE and system performance [4], while concurrently committing to protecting the privacy of every individual [8]. Further, the rationale for ensuring a human-centric design approach to 6G network technologies stems from the high impact of sensor actuating networks' influence on everyday activities affecting human behaviour and lives. It will here be suggested that human-centered approaches to network design and development should make it possible to not only tackle human needs and aspirations at the individual, micro-level, but also at the macro-level, to create sustainable and liveable connected ecosystems in society [9].

In this context, the focus on humans, their needs and requirements, and the appropriate usability knowledge and techniques supports the shaping of a value-centric, human and inclusive network technology [6], [9]. However, the very requirements of increased intelligence of the network as a means to make the network more human- and humanity-centric, may paradoxically undermine the values at the core of the human-centric notion. Hence, closer integration of human-centric theory and practice into next-generation networking may close the gap between visions and actual implementation.

Building upon the above vision and its potential implications and challenges, this position paper concentrates on the relevance of human-centric design perspectives in designing and deploying 5G and beyond technologies. It is written from an inherently human-centered theoretical lens and driven by the conviction that to realise the human-centric visions, more systematic involvement of fields and research traditions that consider humans as an essential part of the system may be beneficial. We discuss interpretations stemming from inherently human-centered (as opposed to technology-centered) research traditions that can bring promise to requirements for broader human involvement in network technologies beyond 5G.

This paper is organised as follows: Section II briefly sketches the broader context in which this work should be situated. Next, in Section III, existing theoretical frameworks and relevant human-centric design interpretations are introduced. Thereupon, based on a focused and selective review of human-centric approaches and themes, as put forward in the literature on the 5G and beyond era, we use the above lens to critically discuss - from a human-centric disciplinary perspective - potential implications of and challenges related to the envisioned embedding of human-centric network technologies with new advanced methods for autonomous and perceptive network control functionalities and implications. In Section V, we share some thoughts on concepts and topics that - from a human-centric point of view - may need to be put more prominently on the agenda. Lastly, we suggest recommendations for future research towards a human-centric 6G that serves a genuinely empowered and democratic society by responding to people's fundamental needs for empowerment and agency. Finally, the paper is concluded in Section VI. Our broader aim is to contribute to understanding what a human-centric network beyond 5G should be to serve individual well-being and the public good.

II. Context

5G as a human-centric service, inherits the foundations from previous network evolutions, where network technology development is largely driven by the service-provider's perspective of human/user-centric. 5G aims to connect humans and things to ensure efficient, reliable and trustworthy communications services [10]. The priority is performance of network delivery via enhanced mobile broadband, ultra-reliable low-latency communication (URLLC), and massive machine-to-machine communication providing a platform for internet-of-things [1], [10]. 5G mechanisms that accommodate human-centric network outcomes relate to the service-provider perspective of what network users' need, do and expect, in order to be connected in a trustworthy, secure and private manner.

Over the past years, research under the umbrella of Quality of Experience [7] - as a bridge towards users - has sought to diversify and enrich this understanding from a perceptual point of view. While it has triggered novel QoE-based network- and application management approaches, human users are still ascribed a predominantly passive role and dynamic human influence factors (e.g., intent, affective state [11]) are not or only to a limited extent taken into account [12].

Building upon existing principles, mechanisms and their shortcomings, a number of researchers have begun developing human-centric visions for 6G, along with communication scenarios that propose human-centric services, applications and enabling technologies for 6G. Various human-centric design interpretations are applied to different network architecture designs [8], applications and interfaces, with the suitable usability methods, mechanisms, and associated goals and outcomes [13]. However, several of these (e.g., the QoE concept) have their roots in techno-centric and techno-economic views of human-centric network technology and the role users therein.

A key aspect fueling the more recent increased emphasis on human-centric approaches and visions is that the human role in 6G is likely to undergo a massive transformation [9]. Machines will become the dominant users of 6G communications, with enhanced abilities to perceive, interpret, and actuate on behalf of humans [5]. Reinforced with these capabilities, machines will contribute to most human decisions. This network development can reduce the human role to a sensed system in the service of other computer systems, without any active human involvement [9].

It can be argued that this significant transformation of the human role is the critical difference between the existing data-gathering 5G network and the subsequent sensing and actuating 6G network system [2]. This transformation is lead by enhanced automation in network technology which is a key component of future networks. While it - as already indicated - comes with a set of potentials and opportunities, this transformation also entails a set of threats and explicit as well as subtle high impact implications that need to be addressed.

Building upon the grand 5G and beyond visions, a ubiquitous virtual human existence should aim to genuinely empower each human to live free to know, observe and decide on outcomes [6], [14]. Furthermore, to establish human potential and well-being for multiple communities' benefit [15], factors that bring emancipation are essential [16]. Emancipation can take form via mechanisms that promote inclusion, empowerment, active participation, and meaningful user control and agency [1], [17]. Prior research has in this case, already argued for higher degrees of human involvement in the future sixth-generation network, where the "human is kept in the loop" and can control decisions and actions [8], [18]. Further essential requirements and features include trustworthiness, privacy and security [5]. The latter is also a particular concern among European policymakers, namely to ensure that citizens' agency is preserved in the future human-centric network technologies [6].

With the above context and its potential implications in mind, there is a need to critically reflect on and evaluate which 6G design principles, requirements, affordances, and outcomes have the potential to be genuinely human-centric. Before turning to a more in-depth discussion of how human-centric themes and mechanisms are approached in the 5G and beyond landscape, we briefly discuss a number of influential human-centric design traditions that can serve as guiding paradigms in this respect.

III. Potential human-centric design interpretations

The relevant theoretical frameworks that incorporate broader human involvement in system technology design are plentiful and varied. Our goal is not to provide an exhaustive and detailed overview of the various interpretations and approaches but to highlight the most important ones and their origins. They help to understand what is at their core. The most relevant paradigms that have brought forward a more human-centric, trustworthy, and inclusive system technology design, where networks are an essential part, prior are;

- The user-centered design tradition

- The Scandinavian/socio-technical design tradition, including participatory design
- The humane technology design tradition for citizen empowerment

A. The man-machine fit

The field of human factor engineering emerged along with industrial engineering, with a focus to improve the "man-machine" fit [19]. The dominant system design principles in industrial engineering were under the spell of "scientific management" and Taylor's logic of business performance efficiency. Highly specialized technology experts were firmly in the grasp of technological determinism, driven by the logic of efficiency in industrial system design management. The resulting user-design was meant to make a person fit the machine, not vice versa [19]. Human workers' tasks were reduced and controlled by developing reliable, dependable systems with maximum profitable output. The logic of technological determinism prescribed a system design framework where those with power overruled involvement in decision-making by workers and communities whenever they felt threatened by the outcome of the involvement [20].

B. Systematic process, easy to use and understand

At the turn of the last century, the need for a more human-centric approach to technology system design started as a reaction to the techno-deterministic design approaches that resulted in deskilling workers and reduced quality of working life [21]. The early incarnations of human-centric design placed user experience as a critical concern for the design process. At IBM's Watson's research center in 1983, Gould and Boise's introduced a three-step principled design approach for creating easier to learn and more usable systems. According to Gould and Boise, the critical steps; early involvement and considerations of users' characteristics and needs, empirical and experimental validation, and an iterative process served as a systematic and structured process for system design with an increased focus on user involvement [22]

Norman and Draper [23] used this systematic process to develop a philosophy of *user-centred system design* that was grounded in the interests and needs of the user while making products easy to use and understandable. Prior to these early incarnations, system design principles were driven by either technology capabilities or the designers' intuition relying on the creators' instincts and talents [22].

C. Socio-technical design traditions

In the socio-technical view of human-centredness, the focus on humans' involvement with technology is broader than the simple fit between human and machine [19]. The socio-technical design goal is to balance the requirements between the social system of human activities, interactions, understanding of the environment, and the technical approach of rule-based, codified procedures managed by technical measures and performance indicators [21]. The term "human-centric" rather than "user-centric" refers to the impact in a broader group of participants instead of those typically considered users. Although both terms are in practise used as synonyms [24].

In the socio-technical tradition, human-centric technology's design processes enter a more challenging territory that gives primacy to human actors, their values, and activities versus the technical tools and environments that shape everyday lives [19]. This view of human-centric becomes richer and offers more potential to protect the interests of multiple stakeholders, humans, and society. At the same time, it is harder to engineer and pin down technically [25].

D. Human interests and potential first

Gill's [25] interpretation places human potential at the center of the technological systems' activities, which requires a cutting loose from external system guidelines and agendas. This perspective brings in the emancipatory notion of human-centric design, providing conditions necessary for social, emotional, and intellectual growth, enabling a free democracy and society that stimulates human potential [15]. In practise, this means that the technology system is designed to empower and provide individuals with the ability to decide and act based on their senses, experiences, and decisions.

E. Civic and humane design frameworks

Recently, perspectives of civic and humane design frameworks have moved into focus. The definition of civic technology as the *"the use of technology for the public good"* envisions the system to respond to *"a plurative of normative standards"* [26]. The government institutions serving the public need and the bureaucrats serving them must be sensitive to such standards, which will only occur if the physical and virtual environments reflect that pluralism (p.13) [27]. Not maintaining a diverse environment or keeping in mind the needs of a variety of stakeholders leads to a *"normative world"* taking *"systematic precedence"* [27]. In delivering civic technology in service of the public good, the design principle is to stimulate better governing practises, and manage conflicts by building consensus between individuals, communities, and governments.

A more holistic approach to capturing human-centredness in the system design understands what is valued by a system's stakeholders and supports them in delivering this value. The design solution's intended and actual outcome is evaluated according to the overall value representation, the target, and measured achievement. The human-centric methods and mechanisms function as facilitation between the stakeholders to bring a valuable outcome with all parties' interest in mind [28]. Then, to enable human potential, the design principle needs to make room for negotiation of outcomes and confront unbalanced power structures between stakeholders.

IV. Human-centric in the 5G and beyond landscape and its implications

Turning back now to the beyond 5G and 6G vision, it has been argued that this is enabled by human-centric mechanisms and methods that can capture the all-encompassing knowledge of users' intent and environmental conditions [29]; [30]. Further, the next communication technology generation of human-centric networks will become holistic AI systems, fueled by automation and intelligence, to realize more efficient, more reliable, and low-cost communication systems [1], [5], [31].

To illustrate how human-centric design interpretations take form in the context of 5G and beyond, we have selected to focus on network technology capabilities that acquire more knowledge about humans, their environmental context, and the critical parameters proposed. Different human-centric design interpretations relate to the mechanisms and methods chosen to bring humans closer to the network design and experience. In theory, such capabilities and mechanisms may allow a closer alignment with and embedding of situated human needs as in the user-centred system design tradition [23]. However, to create more awareness about the broader potential implications of embedding new advanced methods for (autonomous and perceptive) network control functionalities and applications into human-centric network technologies, we discuss them by means of the human-centric theoretical lens introduced above.

A. Human-centric capabilities - what brings the human closer to the network?

Firstly, autonomous and perceptive network capabilities will allow future networks to obtain human-like qualities to self-manage and adapt according to changing user expectations [8]; [30]. The autonomous characteristics of the 6G network arise, e.g., when deploying Intent-Based Networking (IBN) functionality to the 6G network [32]. Intelligence applied to networks replaces the traditional network policy configurations with the expert user's or businesses' needs and performance goals, represented as intent [30], [33]. The definition of intent in this context is *"a set of specific policy types written in high level operational and business objectives"* [34] and the intent input comes from humans (either written, spoken, observed, or collected), with the high-level goal of meeting system requirements without detailing how to achieve these objectives [34]. Intent-based networking therefore defines the software or APIs that enable network control in the form of policies, expressing what and how to plan, design, and implement/operate networks in a way that can improve network availability and adaptability [35]. The result is a high intelligence 6G network built to capture human intent, translate the expression into configurations that automate the deployment throughout the network infrastructure to assure that the desired intent is executed [32], and more broadly, that can perceive, control, and act on behalf of humans [36]. With this mechanism, human needs and wants will be translated into configurations the network understands.

Adaptive/perceptive network functionalities, on the other hand, also referred to as *a tactful network*, are/is defined as *"a network that considers human behavioral characteristics (i) to foresee user needs and actions; (ii) to self-adapt to the inherent heterogeneity and uncertainty of individuals; (iii) while offering a better quality of experience and improving system efficiency"* [8]. The goal of adding such adaptive/perceptive capabilities to the network is also referred to as *experiential network intelligence (ENI)*, assigning it with human-like capabilities of observation, interpretation, and reaction to changes in user needs/expectations, environmental conditions, and business goals [8], [29], [35]. To be considered human-centric, the system thus provides proactive accommodation of human behavior, which refers to the anticipation of users' intent and behaviors, allowing the services and the communication systems to adapt to it proactively [8], [29], [30]. However, this perspective introduces a set of challenges.

B. Complex human contexts

To create a self-managing network that is user- and context-aware is hard as it relies on each specific use case, user preference, and environment [33]. Moreover, autonomous networks will interact with users in a social and physical environment, and their context of use will have few boundaries or change rapidly [24]. The network functionality becomes more sensitive to the details of specific settings of use [29]. From the explicitly defined human-centric 6G requirements, the network will tailor the system's behavior or its response to patterns of human behavior and use by passively interpreting the context. The system developers conceptualise the notion of context from the perspective of capturing human action and the relationship with the computational system [37]. The methods of translating human activities' and the contextual system requirements into the technical molding of user patterns and experience depend on the underlying human-centric design interpretation. For instance, the expectation that rules can be applied to interactive systems to make them intuitive, easy to use, error-free, and unnoticeable, labeled as guidelines, is a remnant of Gould and Boise's early system design principles [28]. In the future scenario of human-centric networks, a diverse set of user scenarios and the associated context will need to be adapted for [38]. To capture the understanding of the various contextual and social settings of which the action unfolds, the idea of *"a situated action"*, does not require the user to follow a predefined script [39]. The context of use is then interpreted as forms of engagements or practises with the prescribed technical settings instead of predefined configurations. The central point is the meaning behind the human action that evolves into user-generated practise [37]. This perspective disentangles the design from the easy fit between the human and the machine to a system that would effectively assist in shaping the user's action based on the ways users' determine the meaning of use and incorporated practise [37], [39].

C. The empowerment gap

To obtain the most cost-effective and optimal network service and management, the most accurate user data/information is required [33]. 6G will impact the intelligence process of communication technologies by gathering deep and ubiquitous knowledge of everyday users' lives [36]. The accuracy of users' intent, behavior, or environmental context will therefore demand increased intrusion into more spaces where humans spend their everyday lives, where the demand for free spaces will increase [26]. As a consequence, the gap between the creation of networking protocols and services (e.g., usually limited to service providers' needs or types of application) and the everyday user behavior or needs will worsen [8].

An important aspect to consider is who is in control and what mechanisms allow control to be exercised. In the example of autonomous and adaptive 6G networks, the capture of intent would configure the upper-level network configurations, with input from expert users [30]; [32]. This abstract expression of what a network should do provides the expert user with *"power to"* direct the intent [17], where the business imperatives are the overarching guiding policy principles [32]. The expert user has the potential to act and decide on *what* a system should achieve, but not the *how* [35]. The experts decide by communicating the top-level business intents to the automated network. However, little involvement is required to execute network operations and management [29]. The experts, both commercial and technical, are the ones who see, know, and decide on behalf of the end-users.

What follows is the lower-level configurations of the envisioned cognitive network infrastructure that is fully automated, without human involvement, using artificial intelligence and context-aware policies to adjust service delivery [29], [30]. The broader automated functionality considers humans' ability to control, or choose how the network is serviced, to be outside the remit of a technical network operation. However, a question that arises is whether the envisioned human-centric network design principles are purely driven by technology capabilities [22], when the prioritisation of network flows are set and guarded by the control functionality of the network operations? The instinct of the system designer and the automated configurations guiding the system will direct the prioritisation of access, which will not always benefit the end-user [22], [23]. The system designers' value system will be incorporated into the network intelligence build with or without consideration for the users and stakeholder groups' interests and desire to decide [28]. With the assistance of automated network intelligence, the priorities set by the design team's decisions will direct the network service choices experienced by the end-users.

D. Create a balanced power structure

As stated in Section III, the term "human-centric" (as opposed to "user-centric") refers to the technology system's impact on a broader and more diverse group of users [24]. In ENI (Experiential Network Intelligence) systems, various actors such as expert users, business entities, corporate actors, and end-users will have varying degrees of priority in how the network allocates resources to applications [33]. However, a key question is whether the network can optimise and negotiate service outcomes that facilitate the interest and potential of all humans? A fair resource allocation between various groups becomes critical when network flows are optimised based on each user's expectations and environmental conditions automatically. When offering a differentiated (personalised) and optimised service with AI, operators/service providers can introduce 'reasonable' discrimination using tiers based on, for example, Quality of Experience or traffic band-with [5] [38]. Therefore, a key question is how the next-generation networks will classify, negotiate, and decide on the subjective interpretations of human experience? While the QoE concept has been pushed forward in this respect, a significant challenge will be to adapt QoE measurements towards more proactive approaches and away from the more passive role ascribed to end-users.

When approaching the understanding of a human-centric 6G from a socio-technical tradition, what needs to be considered is *whose needs and potential* are we talking about in the system design [24]? That is, who will benefit from the impact of interacting with ubiquitous networks that recognize and incorporate new and changed knowledge to directly or indirectly influence outcomes? The socio-technical factors that influence a design response can range from personal, community, business, organization, and governmental needs, as well as from technological innovation [40]. The various stakeholders' actual roles and how they play out in everyday life when interacting with network services are essential. The degree of impact on everyday life, therefore, needs to be assessed. Consequently, there is a need to map which individuals, communities, businesses, organisations, and governments will know more, who decides, and who is in control? At what level in the technology system structure do the various stakeholders have a say? The designed roles among all stakeholders, actual or intentional, are they active or passive, or indirectly or directly involved?

Human-centric methods and mechanisms can facilitate negotiation between the stakeholders currently engaged in envisioning the next-generation networks, such as research communities, policy, private corporations, end-users and communities [26]. Nevertheless, to bring forward outcomes with all parties' interests in mind, the 5G and beyond network design principles should consider the inclusion of proactive involvement mechanisms, with room for negotiation of outcomes [26], [28].

E. From observed to empowered

Finally, we reflect on the question: Should 6G network systems deliver human-centric services that allow for active human involvement? If we were to align the 5G and beyond human-centric vision with the design perspectives that incorporate the human element more actively into the system design, higher degrees of human involvement in the network loop [6] require that the human presence moves from a passive external factor in the system design to an integral component of the networked system [18] [25]. More specifically, this will entail a human-centric design that provides extended functionalities that bring humans' agency into the network loop [18]. Humans should be able to accept, change, or reject the solutions provided by the system, express their preferences related to a specific service, indicate what are their satisfaction/dissatisfaction levels regarding the provided solutions, inform about their habits and goals and specify new services that cover new needs or existing ones [41], [42].

Further, the network design team's human-centric mindset influences the way the system design considers human potential. For example, the network system designers' thinking, values, and principles are likely reflected in the degrees of user/human involvement incorporated in the architecture. With the growing hyper-connectivity and advanced intelligence comes intrusiveness to personal lives and freedom. In Intent-based networks (IBN) and tactful networks, humans are often referred to as another node in the network or as a source for gathering as much behavioral information and artificial intelligence as possible. Of course, not without meeting the most critical requirements of security and trust [32]. Even so, an expert mindset among the network design visions prevails [17]. The validity of providing a *human-centric* network technology that contributes to humans having the ability to act on its potential and to improve opportunities of human life [5], can be questioned when those with power are in full control [16], [25]. We need to vary in prescribing a network design framework that allows specific groups or individuals with *"power over"* other groups to carry out their will despite their resistance [17], [20]. The design logic driven by the interest of a few, with the ability to overrule the decision-making of many passive users/participants, will therefore not serve a genuinely empowered and democratic society [20].

V. Recommendations for future research

To facilitate alignment in what constitutes a "human-centric" network in 5G/6G, and based on more continuous and systematic involvement of human-centered research fields, we propose specific recommendations for future research.

A. Reflect on the underlying power imbalance in future network design

We have put forward essential questions that should inspire a new understanding of the underlying meaning of "human-centric" in the context of network technology. The existing 6G network vision represents the "human" in the form of a system engineer or business manager working towards achieving corporate goals or imperatives or as a passive node on par with connected machines.

Can future network services and software take into account and negotiate between human users vs. other community groups or between humans' and machines' interests? Understanding each stakeholder, the role they play, who else is involved and has control will be required to learn how the networked intelligent system can negotiate between various interests. The appropriate human-centric methods and mechanisms can function as facilitation between the stakeholders to bring a valuable outcome with all parties' interest in mind [28].

B. Consider human-centric network design mechanisms that lead to empowerment

Among most human-centric 6G visions, the design decisions are based on adjusting and accommodating user behaviour to the network product. What factors keep the network evolution to apply the passive collection and intelligence to humans consistently? QoE as a measure assumes the desired intent of the user passively. Future research needs to address how the 6G network vision can move toward involving end-users in a less passive and more participatory, and meaningful way.

As such, the next 6G network systems need to deliver human-centric services that allow for active human involvement, where active involvement refers to an ability to know, decide and act based on humans' agency and free will. How can the cognitive network architecture recognise the user as an intelligent human who can create information and invent goals instead of another object/signal/node connected to the sensor network [9]? The network will need to see the user as a self-directing agent with the power to decide and act.

C. Investigate technical feasibility and scalability constraints

The requirements for future network solutions are also framed towards passive human involvement when it comes to influence or impact on how the network behaves. In our understanding, designing for active human involvement only happens at the service level, and everything that happens in the network is informed by passive knowledge of human behaviour. Designing for active involvement is cumbersome and potentially impossible to implement due to, for instance, the hard separation between the network's control plane and data plane. Consequently, the proposed network capabilities are as "human-centric" as the technical constraints allow. Therefore, more attention is needed on whether and how the technical constraints in the network architecture block the possibility of unlocking human potential and empowerment in network development.

VI. Conclusion

This paper has sought to highlight the implications of human-centric design interpretations on the proposed mechanisms and methods used to develop a more human-centric network technology beyond 5G from a human-centered theoretical lens. While there are significant technical capability challenges in achieving the proposed human-centric 6G visions, they bring a wealth of implications when considering paradigms for network design that serves a genuinely empowered and democratic society. Among the most significant challenges is the trade-off between capturing more precise measures for human behaviour and the control of network behavior, allocation of resources, and service experience. The future network generation is currently predominantly envisioned from a technologically deterministic perspective, based on the assumption that human-centric 5G and beyond networks will serve users, individual humans, and society as a whole. Here, the human-centric perspective implies knowing as much as possible about human behaviour to facilitate optimal service delivery and experience. From a genuinely human-centred design perspective, however, understanding of humans and their needs would improve the network, not the other way around.

We argue that to achieve a future network beyond 5G that is in the service of a democratic and free society, the power balance obtained from the converged network intelligence will need to shift more towards human users, which include expert users, but also end-users and their communities. The concentrated power of system engineers, business managers, and the automated functionality of networks can lead to discrepancies in power, with the potential to dis-empower less visible end-users/participants or communities. A critical evaluation and rethink of the incentives behind the configuration of network goals, the purpose of the application of advanced human-centric methods, and improved mechanisms that truly bring humans closer to the network is therefore required. Follow-up research can shed light on which human-centric approach will lead to more humane outcomes in the interest of all citizens. Furthermore, future work on contrasting, realistic scenarios can better inform the human-centric design application to human-centric network development and the operation of network slicing. A move towards human-centric design principles that are humane and more value-driven, in addition to technical -and business-driven metrics, may guide a successful network product delivery that factors in human empowerment, well-being, and human potential when developing and deploying next-generation network technology beyond 5G.

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