# Toward the EthicNet: Challenges and Enablers for Ethics-Aware Networks

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The authors introduce the Value of Service framework which integrates KVIs and KPIs to extend concepts like Quality of Service and Quality of Experience. They propose EthicNet, a high-level architecture for a network centered on the VoS concept, and describe its founding enabling technologies.

## Abstract

Recently, the awareness is gaining ground that technology, at large, should participate in the sustainable and inclusive development of society. In such a context, the concept of Key Value Indicators (KVIs) as complements of the widely used Key Performance Indicators (KPIs) has been introduced and is obtaining the increasing interest of scientists in most research fields. Computer networking is not an exception and in the last few years research activities and results on the subject are being published. In this perspective, contributions of this article are manifold and can be summarized as follows. First, the Value of Service (VoS) framework is introduced which integrates KVIs and KPIs to extend concepts like Quality of Service (QoS) and Quality of Experience (QoE). Then, a high-level architecture for a network centered on the VoS concept, which we name EthicNet, is proposed and described and its founding enabling technologies identified. Finally, the most compelling and urgent open research issues are discussed.

## Introduction

In an ever increasing number of countries, local and national governments are identifying specific Key Value Indicators (KVIs) for the development of the society, usually defined in terms of significant ethical principles, such as: open collaboration, fairness, security, privacy, trust and sustainability. As one of the neuralgic infrastructures for the realization of most of the human activities, data networks should support the satisfaction of the KVIs that are selected when deploying and managing the services.

Emerging visions in the sixth generation (6G) research arena have begun to consider KVIs, capturing trustworthiness, inclusiveness and sustainability [1–3]. Indeed, 6G is expected to be a key enabler to achieve sustainability along the economic, societal and environmental perspectives [4]. For instance, digital twins and ultra-reliable low-latency communication solutions can contribute to promptly and securely accessing health services; ubiquitous coverage can promote digital inclusion by providing access to information everywhere; green networking aims at selecting energy-efficient networking technologies and products to promote sustainability in resource usage. However, up to the fifth generation (5G), design objectives of data networks have always been stated in terms of precise low-level deterministic Key Performance Indicators (KPIs) univocally defined such as loss probability, data rate, delay, jitter, skew, which are very far from the high-level societal focused objectives. Therefore, current approaches to network management are unable to consider KVIs, making it difficult, if not impossible, to control and assess the impact of an important societal asset in terms of these KVIs. We believe that this requires *a shift in the procedure for defining the operational objectives of future networks*, which implies the introduction of a *set of rules for defining the high-level requirements of all the stakeholders involved* (e.g., end-users, network and application service providers) in terms of KVIs and their mapping onto low-level objectives to drive network operating modes.

Following this vision, we introduce an *innovative network paradigm, that of the Ethics-aware Network* (EthicNet in short). It uses KVIs capturing sustainability goals to define precise policies to be inserted into the network and to automatically configure and manage the network to support services while meeting a new class of ethical requirements.

For example, an end user (EU) must be enabled to express a KVI, relating to environmental sustainability, which reflects her willingness to access a service, for example a huge download of content, delivered with a minimal $CO_2$ footprint from a chain of hardware components produced and manufactured with the highest amount of recycled materials. Then, the network operator should be able to understand such demands and translate them into the proper network configurations: selection of network nodes powered by green energy sources and of the download timeframe when excess energy is available. After network configuration, suitable monitoring routines should be put in place to ensure that the provided service meets the EU's requests.

The overall envisioned workflow entails to deeply revise the network procedures, well-beyond what even current 6G visions offer. In this context, the main original contributions of this article are the following:

- Discussing the path from KPIs to KVIs and providing a concept of KVI which grounds on the current vision of sustainable development objective
- Defining the disruptive EthicNet vision by pinpointing the main candidate enabling technologies and identifying the open research challenges

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- Analyzing a representative use-case where the use of KVIs is expected to have a key impact and make a disruptive change in network behaviors.

## From KPIs to KVIs

A KPI is a critical quantifiable indicator of progress toward an intended operational result; thus, it provides the analytical basis for decision making. In the context of communication networks the typical KPIs participate in the definition of the Quality of Service (QoS).

The recent efforts toward the Quality of Experience (QoE) concept and Key Quality Indicators (KQI) to measure it [5] are the evidence that in communication networks there has long been the awareness of the inadequacy of traditional KPIs and QoS concepts to take into account all the aspects that contribute to a satisfactory user experience. Other than system aspects, KQIs also include human and context influence factors that affect user's perception [6].

Nevertheless, so far the research conducted has focused on the experience of the user as an isolated individual. On the contrary, humans live in complex environments as components of highly interconnected societies and their well-being is strictly related to the status of the surrounding environment.

The awareness of this is gaining ground in several domains and many organizations are broadening their focus to include KVIs besides KPIs in the planning and implementation of their strategies [5]. Similarly to KPIs and KQIs, KVIs can be defined as *critical quantifiable indicators of progress toward the achievement of a societal goal* and complement them to account for aspects determining the success of a project, solution, or service from the overall society point of view.

Therefore, KVIs are the indicators needed to define what we call Sustainability of Service (SoS), where sustainability is intended in agreement with the well-known triple bottom line of economic sustainability, societal sustainability and environmental sustainability. The defined SoS participates together with the QoE in determining what we call the Value of Service (VoS), as shown in Fig. 1. VoS defines the value brought by a service directly to the user (or group of users) exploiting the service and indirectly to the society as a whole; not having a single recipient in the service delivery chain, its estimation is inevitably obtained via a combination of KQIs and KVIs measurements.

One may object that there is empirical evidence that sustainability is not irrelevant for the QoE, as user experience depends on perceived service sustainability. However, prominent features differentiate the concept of KVIs and thus, of the SoS, from that of KPIs and QoE:

- QoE is usually individual and an improvement of the QoE of a user (or a group of users) requires resources for which there is competition, whereas SoS is cooperative by its nature.
- Traditional QoE dimensions are related to perception and instantaneous enjoyment of the product/service whereas fulfillment stemming from SoS has a longer lifetime and relevant KVIs look at the future (e.g., saving energy grants users a better future, eventually)
- QoE is strongly rooted in human perception and natural interaction patterns, whereas SoS dominant components are cultural (e.g., individuals grown in different societies might not agree on the importance of certain values).

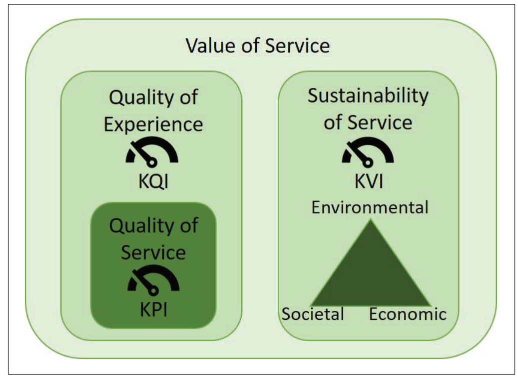


**FIGURE 1.** The VoS framework.

One may object that there is empirical evidence that sustainability is not irrelevant for the QoE, as user experience depends on perceived service sustainability.

The first step toward the definition of a framework for the SoS is the identification of KVIs, for which the United Nations (UN) Sustainable Development Goals (SDGs) 17 high-level goals are a good basis. The focus shift toward KVIs is happening in all ICT contexts, including communication networks. For example, the European 6G Smart Networks & Services (SNS) work programme deems KVIs and the technological alignment with the UN SDG crucial for 6G in Europe.

However, current network technologies are unable to support KVIs. For instance, taking urgent action to combat climate change and its impacts by introducing sustainable consumption and production patterns (as per SDG 13), which is key to sustain the livelihoods of current and future generations, can be considered a KVI. How to evaluate the extent to which currently implemented network services meet this important goal? And how to enforce its fulfillment if necessary?

Very recently, several disruptive initiatives are being carried out that try to address the above issues (see the Hexa-X [1] project, for example). However, these initiatives consider KVIs as high-level objectives immediately translated into KPIs without dedicated procedures. What is missing is a *conceptual framework for the direct measurement of KVIs and a methodology for their translation into network policies and behaviors* for its actual fulfillment. This is a totally new problem, not addressed so far. The most notable exception [7] is a taxonomy effort that classifies KVIs in two groups, "Growth" and "Efficiency & Sustainability," but does not provide formal procedures for their evaluation.

## Toward EthicNet

### The Vision

To support the envisioned VoS framework, a new type of network is needed, which we call EthicNet.

In EthicNet, novel workarounds are introduced for:

- The definition of the VoS objectives in the network management.
- The setting/selection of the KVIs from all the involved stakeholders.
- Their translation into KPIs to feed the lower level operational systems.

First of all, a set of common and globally applicable KVIs need to be standardized to be applied

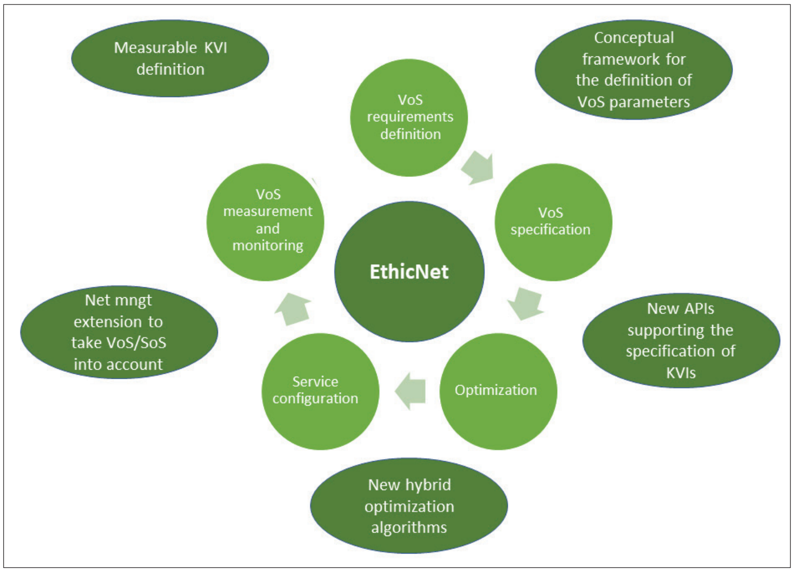


FIGURE 2. EthicNet operations and required innovations.

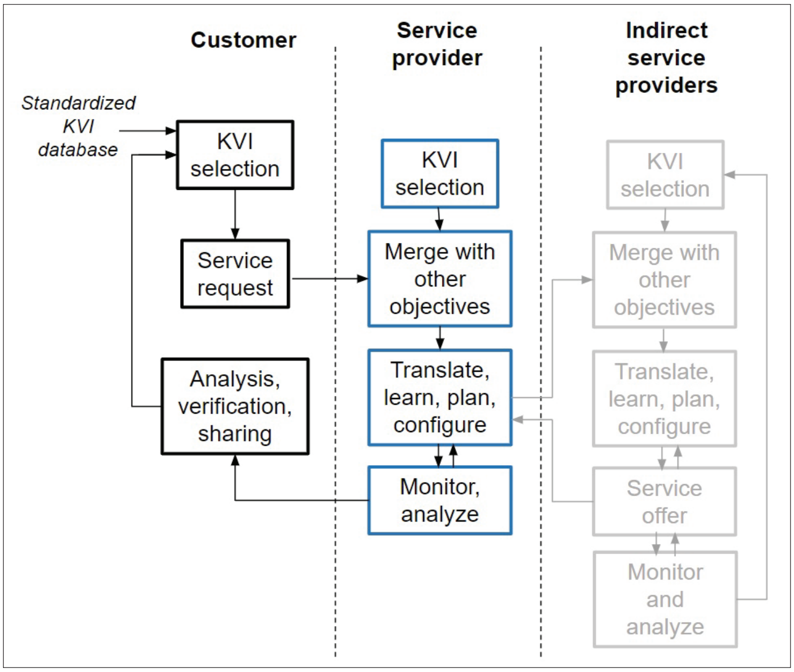


FIGURE 3. Workflow of KVI management in EthicNet.

also in multi-tenant scenarios. We believe that KVIs can be univocally defined by proper organizations, such as the International Telecommunication Union (ITU), to reflect some of the societal development goals well captured by the 17 UN SDG. They can be both qualitative (e.g., capturing whether the energy required for network operations is sourced from renewable resources) and quantitative (e.g., accounting for the minimum proportion of used renewable sources in an offered service).

EthicNet requires *automated procedures for the identification of the requirements regarding the KVIs for a given service offered to a given user.* Requirements shall be given as input to the network management functions through *novel Application Programming Interfaces (APIs) that enable the specification of KVIs besides traditional KPIs.* Network management functions will derive the configuration of the service chain implementing the desired service while satisfying the requirements on KPIs and KVIs.

Additionally, *a conceptual framework is needed for the quantitative evaluation of the KVIs offered end-to-end by the network to a given application.* Specifically, methods are needed to evaluate end-to-end KVIs by starting from KVIs of each individual service in a service chain, as usually done for KPIs (e.g., end-to-end delay is the sum of the delays introduced by the chained services). *Novel optimization algorithms are needed to identify the appropriate overall ethical service deployment configurations* depending on the characteristics of the involved deployment scenario. Once the requirements on KVIs are known and the conceptual framework for their evaluation is available, *tools are needed for verifiable measurement, monitoring, and assessment of the offered KVIs.* The overall process is represented in Fig. 2. We explicitly observe that the assessment of KVIs is not obvious and we believe it will need a thorough discussion in the community. Nevertheless, we anticipate that sovereign quality standardization bodies will play a key role. For example, the International Standardization Organization (ISO) has identified a set of standards for each of the UN SDGs, as reported in [8]. Therefore, we believe that a network service supports a set of KVIs to the extent to which the involved functions/processes and pieces of equipment are realized in compliance with the relevant quality standards. In this way, assessment can be performed by the accreditation and inspection bodies such as those participating in the *International Accreditation Forum.*

## Workflow

Figure 3, instead, shows the overall workflow implemented by the EthicNet vision. First, the customer expresses the requirements in terms of KVI(s) of her interest by selecting them, from a predefined list, either autonomously, if presented in user-friendly manner, for example, from very low to very high, or in automated manner, otherwise. This selection from a proposer database of standardized KVIs can be done for each single service, for a category of services, or for all the services and can be repeated at different instants of the service lifetime.

Whenever a service is selected by the customer, the related request is sent together with the selected KVIs to the Service Provider (SP), which can either be the Application Service Provider or the Network Service Provider, a.k.a. the Network Operator (NO). The customer, in its turn, can either be an end user, or a virtual operator (Tenant).

Similarly to the customer, the SP selects the KVIs, which typically are not defined on a service basis but for the whole set of provided services or for each class of services/customers. At this point, the final (combination of) KVI(s) is decided according to the weights given by the SP to the internal and external (customer) values.

The next step consists in translating the service request into a set of actions (i.e., orchestration of internal and external micro-services) that optimize network operations considering also the feedback and observations from the network itself. The translation relies on the evaluation of the whole set of possible implementation alternatives that also rely on services and products provided by third parties (indirect SPs). The latter are suppliers of ancillary services to the SP through specif-

| Enabling technology | Potential role in EthicNet | Required enhancements/customization |
|---|---|---|
| IBN | Support for KVI-based intents fulfillment and assurance and automated network management | • Ethical intent definition and mapping<br>• Game theory-based ethical intent resolution<br>• New performance metrics to enforce ethical intent assurance |
| NDTs | Emulation of the KVI-driven network operations and their optimization | Collaboration among DTs of different stakeholders |
| UDTs | To support the end-user for the definition of KVI-based intents and their mapping | Social-aided KVIs definition and mapping |
| Network slicing | Intelligent management of different multi-tenant slices | • Interfaces to expose KVI-driven capabilities of network/service components<br>• Optimization algorithms targeting KVIs in slice configuration |

**TABLE 1.** Enablers for EthicNet.

Network slicing has been proposed in 5G to enable the coexistence of different verticals with different demands, served by multiple logically-isolated network slices over the same physical infrastructure.

ic business-to-business agreements; for instance, these could be those providing security control or network maintenance services to the NO.

The SP informs the indirect SPs of the requested KVIs; these are then merged with its own KVIs according to the internal policies; the indirect SP is also requested to provide information to the SP of the contribution to each KVI for each available service. This information is needed by the SP to make a decision on which external service to select. Depending on the decision of the SP, the indirect SP may decide to change the weights given to internal and external values.

The reached level of service will be monitored and analyzed by the SP to identify possible causes of poor performance. For some KVIs the resulting level may change from one service to another (e.g., the percentage of renewable energy used). For others, the resulting level remains the same for all the services and cannot be measured automatically, as human assessments are needed (e.g., quality of working conditions). After their verification and analysis, the customer is expected to socially share the resulting values given their important social relevance.

## EthicNet Deployment: Enablers and Guidelines

The full support into 5G/6G networks of the VoS framework presented earlier requires groundbreaking concepts and technologies, better described in the following and summarized in Table 1. However, we believe that there are consolidated technologies giving foundations of upcoming 6G systems which can enable early implementation of what was presented above. These technologies are presented in in the following sub-section. Following that, we discuss the open research issues to be addressed to achieve a full implementation of the EthicNet.

### Enabling Technologies

**Intent-Based Networking (IBN):** The focus on KVIs has an impact on network management. In this context, inputs can be defined in terms of intents implemented by an Intent-Based System (IBS) [9]. The intent allows NOs to focus on what are the desired outcomes (even expressed in natural language) without focusing on the details of the underlying hardware and software that are handled by the IBN and IBS. In IBN, intents are ingested by interacting with the user. Then, appropriate functions translate them into actions and requests that can be consumed by network management entities. The Intent Fulfillment functions are complemented by the Intent Assurance functions, necessary to ensure that the network complies with the desired intent [9]. Consequently, IBN is a first class candidate to support EthicNet as intents could have an ethical nature (ethical intents).

**Network Digital Twins (NDTs):** Standardization bodies, such as IETF and ITU, are defining the NDT as a new generation of network modeling tools leveraging Machine Learning (ML) techniques to build an accurate data-driven digital network representation. A NDT implements a model that mimics the physical network, taking as input a network state description. Starting from it and via proper prediction routines, the NDT can estimate network performance implementing a (cyclic) optimization process and therefore, addressing tasks, such as, traffic engineering, network planning, network function placement. An innovative aspect of the EthicNet's way of using NDTs is that by injecting the outputs into the real network, the KVIs expressed by the involved users can drive all network operations.

**User Digital Twins (UDTs):** Allowing EUs and other stakeholders to provide their KVIs for a given service may entail the usage of proper interfaces. By tracking and learning user preferences, also through ML techniques, a UDT may help to refine and preliminarily translate the KVIs declared by the EUs.

**Network Slicing:** Network slicing has been proposed in 5G to enable the coexistence of different verticals with different demands, served by multiple logically-isolated network slices over the same physical infrastructure. In 6G networks, NDT can improve network slicing effectiveness: before its actual instantiation, a slice can first be verified in an NDT by simulating the effects of devices, traffic conditions, and network functionalities to unveil potential issues. EthicNet can benefit from such a synergy to effectively satisfy the (ethical) demands of EUs and SPs.

### Open Research Issues

Based on the enabling technologies above, achieving a full implementation of EthicNet requires addressing several open research problems. Below is a list of those we consider important.

**(Inclusive) Interfaces for KVI Setting/Selection:** Novel solutions are needed to enable the EUs and other stakeholders to provide their KVIs. Most users do not have the competences and the time to manage formulas that specify their ethical

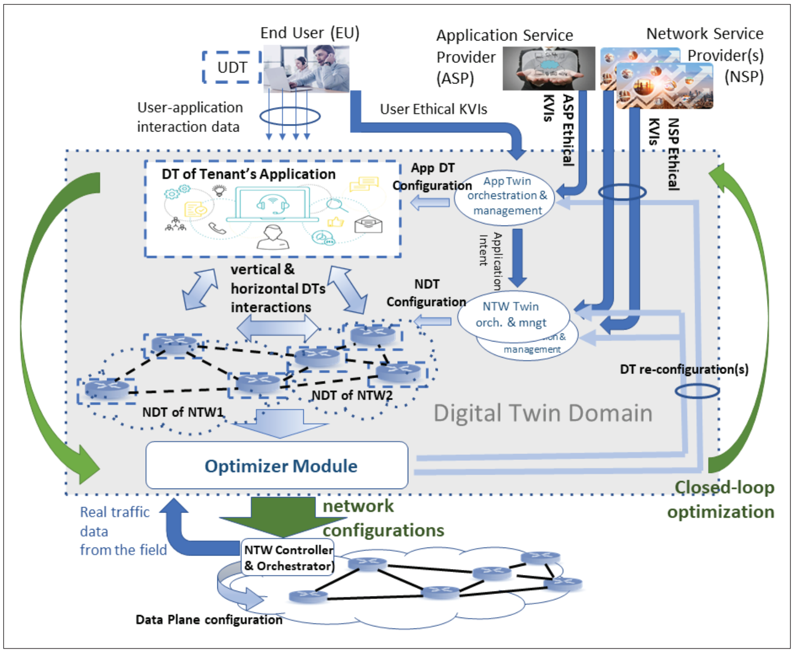


FIGURE 4. Closed-loop optimization in EthicNet through DTs.

priorities in a precise and unambiguous manner. The UDTs can be leveraged to understand and model the user preferences in terms of KVIs so that they can properly interact with SPs on their behalf. Alternatively, several basic pre-configurations of the same service, for example with user-friendly sustainability labels attached, matching different KVIs can be presented by the SP to the EU, which can make a more informed service request.

**(Social) DT-Aided KVIs Mapping and Resolution:** Once such KVIs are ingested, they must be properly mapped onto network/service configurations and potential conflicts among different players resolved. For example, the KVIs expressed by an EU sensitive to environmental sustainability may conflict with the profit requirements of the SP. The DTs must be able to dynamically intercept the KVIs expressed by the various players and configure the network behavior accordingly. Cooperation among different NDTs and UDTs should be envisioned, to foster a collective intelligent behavior. For example, to better meet an end-to-end requirement for a given service, groups of NDTs may cooperate more effectively if they have a history of success stories for the same service (and environment), tracked by a trustworthiness relationship. Furthermore, social relationships between EUs can be exploited, so that KVIs can be suggested via UDTs to EUs based on previously expressed preferences for similar services by "friends" sharing similar ethical values and priorities.

**KVI-Driven Service Provisioning and Assurance Functions:** To enforce KVI-compliant network/service behavior, EthicNet should:
- Monitor the operating conditions of the various segments according to new metrics
- Enforce KVI-driven configurations and manage their adaptation based on the ethical requirements
- Discover adequate DTs with which to cooperate in achieving objectives of ethical networking
- Train NDTs to be able to predict the impact of each available network option in terms of KVIs.

The EthicNet control units (orchestration and management and optimizer modules in Fig. 4) may leverage, for example, game theory to decide network operating points that are satisfactory for everyone. Moreover, optimization may be enforced through a closed-loop process between physical network entities and relevant NDTs, re-iterated until a configuration properly combining the ethical KVIs of EUs and SPs is found and set into the network. Whenever sufficient data is not available, different domains managed by different providers may share learned practices by NDTs, for example, through transfer learning techniques. In such a context, optimization objectives will significantly depart from the conventional ones, as they may capture sustainability perspectives (e.g., $CO_2$ footprint reduction, inclusiveness guarantees).

An ethical network slice configuration may require orchestrating computing and communication resources that dynamically and on-demand shall allocate and migrate network functions, resources, and chains of EthicNet services. This must be supported by new mechanisms, for example federation and sharing of resources between SP and EU devices according to sharing economic principles, to allow the reuse of software and devices themselves in carrying out complex tasks, with a view to reducing energy consumption. The sharing of resources already present in an EthicNet ecosystem will also enable ethical principles such as the ability to provide services at costs that are more affordable for everyone (ethical applications' market).

Evaluating performance to understand if it matches the KVIs requirements needs new metrics, possibly measured and updated in a smooth and dynamic way, involving the EU through subjective methods. A way to proceed by successive and continuous network adaptation steps must therefore be found, interspersed and guided by updates of the input data to the implemented functions with data relating to the user's behavior in consuming a specific service in a specific context.

**KVI-Driven Network/Service Exposure:** The most suited network/service configuration of a given ethical network slice matching the expressed KVIs can be identified if proper interfaces expose the capabilities of the different hardware/software components involved in the end-to-end service provisioning, also encompassing their overall lifecycle (e.g., manufacturing, disposal, utilization, recycling). For instance, network devices should be able to transparently expose whether the company providing them (and those providing their pieces) complies (comply) with greenhouse gas emissions standards, like ISO-14064-2 and ITU-L.1420. These capabilities should be made quantifiable in the same way as computing capabilities of a node and latency of a link. Information exposure of systematic energy consumption/carbon footprint of offered services to vertical customers should be also enabled, as advocated by 3GPP TR 22.882.

**KVI-Driven Networking Functions:** In EthicNet there is the need to radically rethink consolidated protocols at different layers. When selecting the sub-networks to cross, routing algorithms should consider their levels of ethical value (defined through the KVIs measured and certified by third parties), besides conventional, mainly, distance-based cost metrics. The same applies to congestion control algorithms which must decide the admission of a new connection based on the impact that it will have on the KVIs of interest (for example, the overall energy impact of the new connections admitted) other than on the overall service KPIs. Security mechanisms by design exploiting the physical properties of the channel to secure information must be conceived. These participate in the improvement of trustworthiness on network technologies and services as well as technology acceptance and privacy control. Furthermore, at the physical layer it will be possible to conceive mechanisms of semantic communications, that is, transmit source semantic information based on the environment knowledge in wireless networks, such that the efficiency in the usage of radio resources increases significantly (this being particularly useful for new services related to ML, Virtual/Augmented Reality (VR/AR), autonomous driving, etc.) and therefore, contribute to the ethical objectives of environmental sustainability.

## Use Case Analysis

**Context:** To better highlight some future challenges, we now apply the EthicNet vision to the compelling use case of *immersive multimedia communications*, Fig. 5, fostering new scientific and business opportunities.

**KVIs Selection and Assessment:** Energy consumption in multimedia communications is expected to be further exacerbated due to an increased number of information flows, data rates, and required processing capabilities. This greatly increases the importance of environmental sustainability KVIs, given their direct impact on SDGs 7, 12, 13. These KVIs attract the attention of key stakeholders, among which are EUs with environment-friendly attitudes (exemplary case in Fig. 5), national and local governments, and SPs targeting $CO_2$ neutrality in the near future [10]. Carbon footprint related metrics (e.g., percentage reduction of emitted $CO_2$ per user) could be used as KVIs, that may consider the number of streaming hours per user, of flows, and of used devices, and the quality of data, among others. They can be assessed periodically or predicted by applying a statistical model.

**KVIs Fulfillment Strategies:** Different strategies could be implemented to target the fulfillment of the mentioned KVIs:

- Shifting energy-hungry operations (e.g., ML training procedures aiding AR services) in hours of the day when renewable energy is available
- Reducing the wireless transmission power according to the number of active users (e.g., during the night)
- Attracting the interest of non-environmentally friendly users on the adoption of a sustainable usage of the Internet services, by also offering them incentives
- Preferably use hardware/software components developed by vendors satisfying sustainability standards
- Introducing a controlled quality-aware degradation of the provided services (e.g., reducing the resolution of video streaming services, increasing the content compression ratio, leveraging multicast transmissions).

The above is a (not exhaustive) list of numerous, sometimes complex, strategies to be all considered to address the target KVIs and that require the collaboration of different SPs at different levels: content delivery network providers should provide information on their sustainability index certified by third parties; content providers should cooperate in the content distribution process; EUs should be keen on partially reducing the QoE to increase environmental sustainability. Additionally, the different strategies should consider the different service configuration settings, which depend mainly on the number of users, number of used devices, combination of VR/AR flows, which may change over time, even during the same session.

An ethical network slice configuration may require orchestrating computing and communication resources that dynamically and on-demand shall allocate and migrate network functions, resources, and chains of EthicNet services.

**EthicNet in Action:** In the process of selecting the right strategy to implement, UDTs and NDTs turn to be very useful. The mentioned dynamic nature of the service configuration requires a quasi-continue emulation of the service deployment chain to predict the expected service mash-up behavior which however can be done per bundle of services instead of per individual instance. In view of this, each UDT will have to monitor its associated user's behavior and infer both her attitude in terms of energy consumption and her degree of sensitivity to different KVIs. Alternatively is the EU that could directly express her KVIs-related requirements. Practically, the result of this action can be, for example, a vector of length $N$, where each element is a parameter representing the requirement for each of the $N$ KVIs. Based on the nature of the KVI, some of these may represent the weight that the EU gives to a KVI (with 1 being the highest value and 0 the lowest), other may just be a boolean value indicating whether a given KVI is of interest or not.

On its turn, the NDT should monitor used services, current energy consumption (and their sources), predicted user behaviors (by interacting with UDTs), and requested service configurations.

A further task of the NDT is to start from such data and (interacting with other NDTs, if necessary) carry out a cyclical optimization that aims to meet the needs of the various players involved (EUs and SPs) using the players' declared KVIs as constraints, and considering the possible evolutions in the behavior of all users consuming the same service.

The process becomes more complex when the SP has one or more KVI-related requirements contrasting with the ones of the EU. The former might also focus, for example, on the KVI of "stimulating better working conditions," contrasting ICT products and services produced by companies that do not guarantee the minimum acceptable levels of working conditions. This implies that EthicNet will have to offer services by monitoring and relying only on certified companies providing/producing any piece of software and service [11] (this is the case, for instance, of the ISO 45001 standard). However, it may happen that this KPI contrasts with the previous one when the companies that do not meet the ISO 45001 requirements are those that use less energy than others or allow for a reduction in the content transmission energy because they belong to the closest SPs to EUs. Besides, it can even happen that EU's KVI requirements conflict with those of the provider or with those of other EUs willing to use, at the same time, the same service. Game theory techniques can help to come up with configurations that can

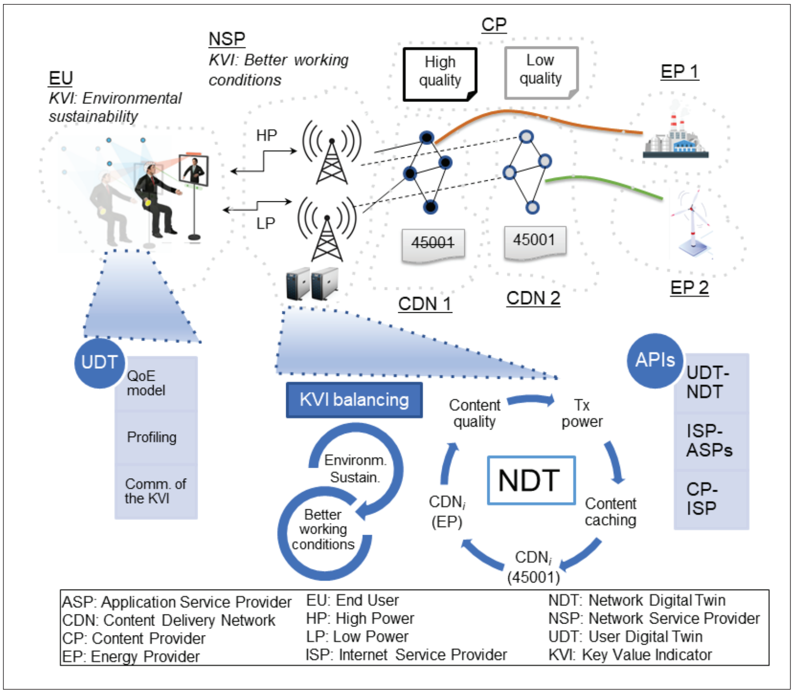


FIGURE 5. EthicNet for immersive multimedia communications.

guarantee stable coalitions and that maximize the utility of all players or minimize their costs (i.e., the distance from the declared values of interest in the various KVIs).

Thanks to the presence of an ecosystem of NDTs, all processing can be done without affecting network operations, until a stable configuration is found. This latter can then be mapped by each NDT onto the network/device/subnet it represents and the service can be delivered by best meeting the requirements expressed in terms of KVIs by involved players. For instance, the NDT may implement the following tasks:

- Estimate the willingness of users to slightly sacrifice QoE for a reduction in power consumption (this can be done either by the UDT or NDT). Analyzing the streaming requests and consumption at varying quality levels might serve the purpose
- Instruct the user terminal and/or home devices to cache contents in order to reduce the energy load when the same content is predicted to be consumed again at a later time
- Trigger to decrease the quality of the streamed content, in controlled manner, w.r.t. what the network would allow to improve energy efficiency.

Data may be then collected also during/after the service provisioning about the actual user satisfaction and (network/energy) resources consumption, by the UDTs and NDTs, respectively, to further update their knowledge base driving subsequent behaviors and exposed capabilities.

## Conclusions

In this article we have introduced the novel concept of EthicNet, that is, a network which provides the interfaces and tools to specify, support, and verify the satisfaction of the ethical requirements of all involved stakeholders in terms of KVIs besides KPIs. A high-level EthicNet architecture has been proposed and the underlying technological pillars presented along with relevant open research issues.

## Acknowledgment

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