HUB4NGI

D1.1 NGI CLASSIFICATION AND ASSESSMENT METHODOLOGY

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Abstract	This deliverable presents the NGI Classification and Assessment Methodology as well as the KPI structure and metrics to be collected.
Keywords	Classification, KPIs, Benchmarking, Assessment, Monitoring

HUB4NGI

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EXECUTIVE SUMMARY

The Next Generation Internet (NGI) initiative, launched by the European Commission in autumn 2016, aims to shape the Future Internet as an interoperable platform ecosystem that embodies the European values of openness, inclusivity, transparency, privacy, cooperation, and protection of data. The NGI should ensure that the increased connectivity and the progressive adoption of advanced technologies drive transformation, while contributing to making the future internet more human-centric.

This ambitious vision relies upon the capability to embrace the best Internet research and innovation initiatives across Europe and beyond to address technological opportunities arising from cross-links and advances in various R&D fields ranging from network infrastructures to platforms, from application domains to social innovation.

The GUIDE Work Package has the objective of defining the set of methodologies that will be used in the project to collect and assess the information collected in the NGI domain. It will therefore 1) define the models and templates, as well as a database structure to collect data; and 2) collect, organize, and analyse information across the entire National and European range of NGI Initiatives. Additionally, it will detail procedures to analyse data as well as a KPI infrastructure to measure and assess projects and private intiatives in the domain.

The first goal of this document is to provide a mechanism to classify and categorize those initiatives that will come to life over the course of the NGI initiative and receive support from the European Commission or that are identified by the program support actions, including the HUB4NGI project, or related research and studies. The second objective of this document is to provide a framework for assessing how well any of the initiatives that are identified respond to the objectives of the NGI initiative as expressed by the European commission and the public consultation that will guide the program itself.

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1   INTRODUCTION

The primary objective of this document is to define a performance measurement framework to observe, quantify and describe progress of the Next Generation Internet (NGI) program[1] as it moves forward over the next several years. To do this, this document will initially provide a mechanism to classify and categorize initiatives that will come to life over the course of the NGI programme, including those initiatives that receive support from the European Commission, identified by the HUB4NGI research or highlighted by the general community. The second objective of this document is to provide a framework for assessing how well any of the identified initiatives respond to the objectives of the European commission and the public consultation performed to prepare the NGI programme[2].

To achieve these two goals, we have described the objectives of the NGI program and the principal technologies expected to be the focus of NGI intitiaves. We have provided a methodology to classify initiatives that fit into the program by outlining the technological areas they address. We have outlined the process to categorize, record and describe these initiatives using a common catalogue approach. Finally, we have described the process to measure the impact that the single initiatives have in furthering the goals of the NGI.

In particular, section 2 of this document sets the frame of reference and describes the process with which the NGI was founded including public consultation, expert advice and consultations with member states. This section also describes the objectives and the logic of the assessment itself. It describes the objective to provide a common classification so that initiatives can be compared and discussed. It describes the need to measure the performance of the initiatives using a recognized Key Performance Indicator monitoring process.

Section 3 of this document describes the HUB4NGI framework to classify any initiative and provide an unequivocal identification for that initiative. HUB4NGI proposes a three-faced approach to classification. Each initiative will be categorized according to the detailed technology used, the category of products or services involved, and the vertical market being addressed. To identify the technology involved, HUB4NGI will use the international Patent Office Classification Scheme, which is widely accepted and has proven effective for identification. To identify products and service categories, HUB4NGI will use the IDC Black Book Classification, updated annually and effectively used for generations in defining technology product categories. To identify vertical market sectors HUB4NGI will use the NACE 2.0 standard used commonly by Eurostat and public authorities to classify market and economic activity. Each initiative can be clearly identified using these three codes. In the future, any initiative can be compared to all of the other similar initiatives based on the area of discussion while any investigator can examine the HUB4NGI databases and quickly extract all of the initiatives responding to a particular characteristic needed for analysis.

Section 4 of this document details those technologies that are, and are not, in scope of the NGI program in order to focus the analysis and make findings more pertinent. To this end, this section provides a succinct overview of the main technological areas that the program will sponsor. It provides an overview of the technologies that will be employed in the monitored

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[1] The NGI initiative is a program promoted by the European Commission, Directorate-General for Communications Networks, Content and Technology, Directorate E: Future Networks, Unit E3: Next-Generation Internet. More information can be found at: https://ec.europa.eu/digital-single-market/en/policies/next-generation-Internet.

[2] Complete information regarding the open consultation held to define the NGI initiative can be found at: https://ec.europa.eu/digital-single-market/en/news/consultation-next-generation-Internet.

initiatives, and an indicative idea of where these technologies could be deployed. Each description also includes the types of measurable elements that NGI program planners or researchers can monitor to determine if the technologies are in fact maturing according to expectations.

The final chapter provides a mechanism to assess the relevance and impact of the initiatives sponsored under the NGI program and their relation to the requirements expressed during the public consultation. Individual researchers will benefit from understanding how they can measure the impact and performance of their initiatives. They will be interested in understanding how they compare to their peers in the NGI program and to industry in general. They will benefit by identifying the areas in which they should invest their resources to ensure increased impact. Program planners will benefit by understanding where their portfolio of projects covers the objectives they originally set for themselves. They will be facilitated in understanding which objectives should be the focus of future calls. Section 5 provides a framework for this investigation and provides a detailed set of Key Performance Indicators (KPIs) to monitor and assess implementation. This section describes the methodology and the approach to collecting the KPI information and then details the individual KPI categories which include Innovation, Economic Sustainability, Technological Maturity, Market Needs, Social Utility and User Centricity. Each of the Categories is described, detailing the logic behind investigating the particular category and its relation to overall NGI goals. Each of the sections details the questions that will generate the metrics for the KPIs. The manner the information will be presented is detailed for each category. In six cases a five-point scale is described where indicator scores are standardised. Two of the KPIs also provide an initiative footprint highlighting strong points and comparing to the community performance. As is industry practice, the KPI calculation method is dependent on the collection of real data and is not included at the onset. Once data is collected, KPI calculation and benchmarks will be established. One of the KPIs is based on a historical database and benchmarks are already known.

2   GOALS AND OBJECTIVES

2.1 GOALS OF THE NGI

The Next Generation Internet (NGI) initiative, launched by the European Commission in autumn 2016[3], aims to shape the future Internet as an interoperable platform and ecosystem that embodies the values of openness, inclusivity, transparency, privacy, cooperation, and protection of data.

The NGI should ensure that the increased connectivity and the progressive adoption of advanced concepts and methodologies (spanning across several domains such as artificial intelligence, Internet of Things, interactive technologies, etc.) drive this technological revolution, while contributing to making the future Internet more human-centric.

In particular, as recently presented by the European Commission at the Net Futures 2017 conference held in Brussels on the 28-29 June 2017[4], the main goals of the NGI initiative are to:

1. Defragment and connect:

   - Create and assist the creation of a pan-European ecosystem.

   - Ensure that such an ecosystem reaches beyond the ICT scene.

2. Engage new stakeholders, which might not have been necessarily involved in related EC initiatives, so as to ensure new ideas and "fresh blood" are injected into the overall ecosystem.

3. Link long-term research with applied research and innovation, with policy and societal expectations.

4. Promote new functionality, services, applications and technologies to support people's lives and global sustainability.

5. Reflect and promote the European core values: openness, security, privacy and participation, to create a level playing field for all business actors, open to innovation and preserving democracy.

6. A movement for a human Internet as a political objective that can be shared across Europe.

This ambitious vision requires the involvement of the best Internet researchers and innovators to address technological opportunities arising from cross-links and advances in various research fields ranging from network infrastructures to platforms, from application domains to social innovation.

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[3] See: https://ec.europa.eu/futurium/en/node/1460

[4] http://netfuturesconference.eu/

In this respect, in the last 8-10 months beginning in January of 2017, a number of activities have been promoted by several stakeholders within the future Internet scene in order to create increased awareness about the NGI initiative overall, promote its principles and ensure engagement of a broad set of target stakeholders, including researchers, SMEs / Start-up, industry players, policy makers and civil society actors. This includes:

➜ An open consultation that took place from 14 November 2016 until January 2017. A total of 449 people took part and answered questions about technologies and values that are relevant for the Internet of the future. The results of the consultation have been summarized in a report.

➜ The Futurium online platform (https://ec.europa.eu/futurium/en/next-generation-Internet) to engage with a broad audience where participants can access and comment on background documents and learn about relevant events. In this platform, additional discussions have been launched on the most relevant topics identified by the consultation.

➜ A call for support actions (objective ICT-41) in the Horizon 2020 work program 2017, to identify the specific research topics and to create an ecosystem of relevant stakeholders.

➜ Specific workshops to share expert insight and build content and credibility.

In this context, the HUB4NGI project plays a key role as a support and coordination action that started in January 2017 to provide help and contribute to the overall success of the NGI initiative in several ways. By creating an innovation "hub" for the NGI, the HUB4NGI aims indeed to:

➜ Contribute to **ground the NGI vision**, defining **research scope and priorities**, building the **community** and **engaging key players**.

➜ Facilitate **contributions to the NGI from technological opportunities** arising from cross-links and advances in various related RTD fields.

➜ Contribute to **the NGI roadmap definition** to help shaping and defining its future, including recommendations for WP 2018-2020 and FP9.

This has already led to several concrete outcomes and ongoing activities, such as the creation of the NGI Online Map, the HUB4NGI portal, the organisation of and participation in several NGI events, as well as the work described within this deliverable.

2.2 GOALS OF MONITORING AND ASSESSMENT

This section describes the goal describing the HUB4NGI classification mechanism to identify technologies used, establish the scope of the initiatives we are assessing, defining the technological field of application and developing a KPI framework to assess the initiatives which have been identified. The following figure illustrates the three steps.
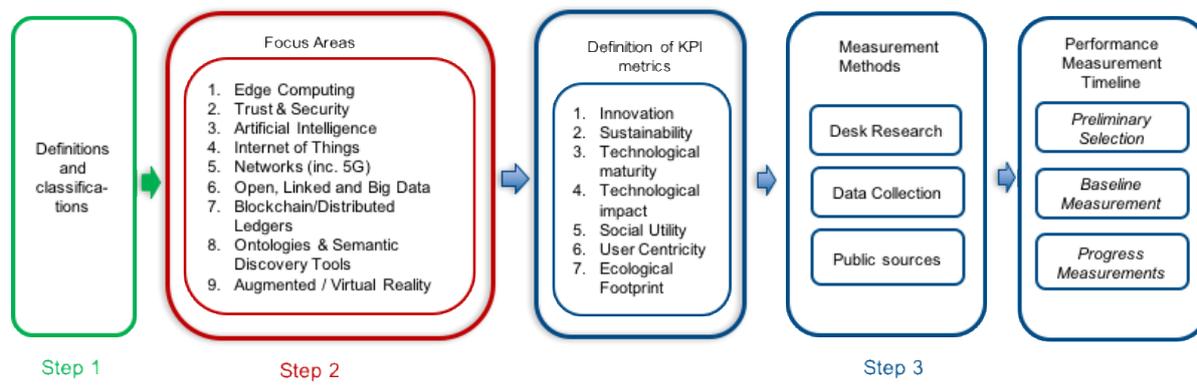
Assessment and Monitoring

FIGURE 1. STEPS IN THE ASSESSMENT AND MONITORING APPROACH

For the first step, we will use an IDC classification mechanism based on well-known international standards. The objective is to provide a system with which all program stakeholders can discuss initiatives and the utility of those initiatives in a standard format, using a standardised language independent taxonomy to classify the technological and business sectors in which initiatives are being developed. The HUB4NGI approach is based upon the International Patent Classification, IDC Black Book 2017 and Eurostat NACE rev.2.0 codification scheme.

The second step delimitates the scope of initiatives that will be assessed during the HUB4NGI project. The technologies that contribute to forming the Internet are extensive and we are obliged to focus our efforts on those areas that will be funded by the European Commission as part of the NGI Initiative. To do this we have taken the work done by the NGI public consultation described in paragraph 3.1 and distilled the top 9 technology areas that are expected to make up the core of NGI research and development before 2025. These are defined and described.

The third step introduces Key Performance Indicators (KPIs) based on observable metrics to measure the contribution of the initiatives to the objectives of the NGI initiative. KPIs are expected to be:

➔ able to measure the performance of initiatives to achieve the goals introduced in the previous section, at present and over time, furthering desired trends, in terms of main achievements and impacts on technology, social cohesion and the European economy;

➔ based on data generated from the initiatives themselves or from external sources and through desk research and surveys;

➔ suitable to provide realistic, actionable and feasible advice to the initiatives, NGI stakeholders and to the European Commission;

➔ able to feed into the assessment of the key success factors and barriers to the strategies put in place to achieve the objectives of the program.

The KPIs will be used as a supporting tool in the advisory activities of HUB4NGI in order to help assess current work programs and model future funding streams, plan similar initiatives and to assess achievement of goals and objectives. The KPIs will support the European commission providing objective evidence to assess the actual impacts of the initiatives implemented.

2.3 METHODOLOGY

The goals and objectives include creating a common classification mechanism for HUB4NGI, circumscribing the areas that will be in scope of our performance assessment and the focus of the project and measuring and assessing the contribution to the goals of the NGI program described in section 2.1. HUB4NGI is following a detailed approach to the objectives of these areas. The methodology we are employing is described in the following sections.

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3   IDENTIFICATION AND CLASSIFICATION

In a large program like the NGI it is essential to have a common understanding of the concepts and terminology that is being discussed and a common frame of reference to classify the initiatives. In order to record, catalogue and measure initiatives the community needs to create a common classification. Existing classification schemes all have a specific focused and alone are not entirely suited to describing the factors present in the initiatives that we expect to see in the next generation internet. As we see in Figure 2, the HUB4NGI classification is broken into three distinct areas: technology identification, potential ICT product and service categories, and identification of the vertical market where initiatives will operate.
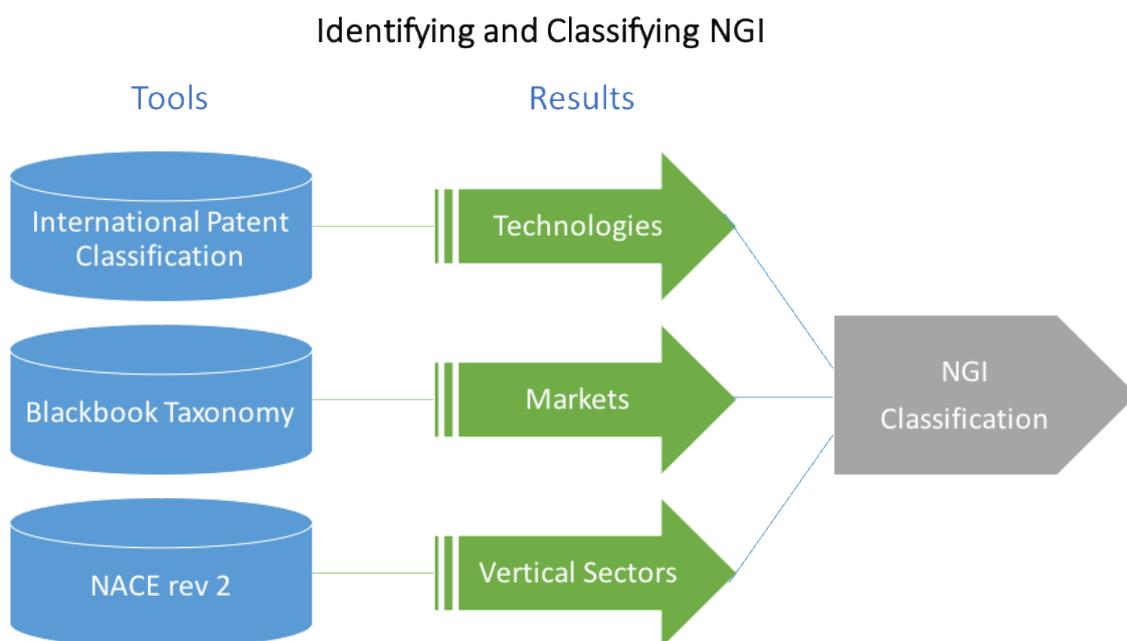
Identifying and Classifying NGI

FIGURE 2. NGI CLASSIFICATION

Identifying of Technologies in the NGI

The first challenge is to identify and classify the exact technology(ies) that an initiative is investigating. We expect to evaluate initiatives employing very subtle differences in technologies. Many initiatives are leveraging future and emerging technologies not currently used in the marketplace and for which there are no well-defined technological sectors. Currently if you make a technological discovery and should wish to protect your intellectual property or ascertain if others have made such a discovery, you perform a Freedom to Operate analysis5. Using the collection of all the patents currently deposited you can determine if and where the detailed technologies are employed in order to investigate any invention or discovery. Patents are organised according to the International Patent Classification (IPC), established by the Strasbourg Agreement6, which provides for a hierarchical system of language independent symbols for the classification of patents and utility models according to the different areas of technology to which they pertain. The IPC divides technology into eight sections with approximately 70,000 subdivisions. The practical level of detail is already used

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5 See e.g. http://www.ideaprotection.co.uk/freedom-to-operate-analysis/

6 www.uibm.gov.it/attachments/Accordo%20di%20Strasburgo.pdf

by those proposing patents and has demonstrated a very good description of the technical components of patent applications. Users can assign one or more codes that indisputably identify the technologies that are under consideration. This approach has been employed in a number of classification projects for computational sciences7. The codification scheme allows for new technologies to branch off the mother technologies. Where innovation occurs a Committee of Experts employs well defined process for introducing completely new technologies and applications. In the context of HUB4NGI it is not important that an initiative actually obtain or apply for a patent but that the initiative can identify and communicate the chapter and subchapter of the IPC so as to identify the technology they are intending to investigate.

Identifying Product and Service Markets

IDC has performed technology and market assessment for over 50 years regarding markets in over 100 countries around the globe in almost as many languages. Necessarily IDC has had to standardize the taxonomy it uses to describe technology markets and ICT spending. IDC analysts and the technology suppliers they assist use what is known as the Worldwide Black Book taxonomy to have an overview of the total ICT industry products and services and to understand where their own offerings are captured within IDC's view of the total market. The Black Book is used on a global basis, to provide cross-regional consistency in definitions, standards, and categorizations. The current 2018 versions of the Worldwide Black Book, starts from Worldwide Black Book Version 3.2 (December 2016). If any additional taxonomy changes are made during 2017, a new taxonomy document update will be published. In July of 2017, IDC introduced the current version of the Worldwide Black Book, the "3rd Platform edition." This new version has introduced new detail for technologies drawn mainly from innovation accelerator markets including IoT, cognitive computing, robotics, 3D printing, AR/VR, and next-gen security, cloud, mobile, Big Data, and social. As shown in Figure 3, IDC's standard Worldwide Black Book taxonomy is made up of five primary market segments: devices, infrastructure, software, IT services, and telecom services.

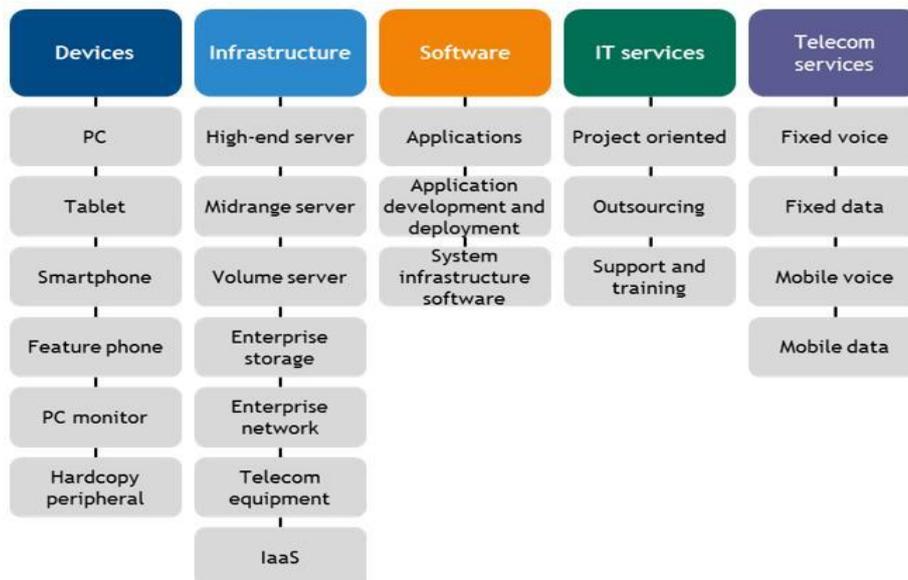| Devices	Infrastructure	Software	IT services	Telecom services
PC	High-end server	Applications	Project oriented	Fixed voice
Tablet	Midrange server	Application development and deployment	Outsourcing	Fixed data
Smartphone	Volume server	System infrastructure software	Support and training	Mobile voice
Feature phone	Enterprise storage			Mobile data
PC monitor	Enterprise network			
Hardcopy peripheral	Telecom equipment			
	IaaS			

FIGURE 3. WORLDWIDE BLACK BOOK TAXONOMY

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7 B. Murgante, O. Gervasi, Computational Science and Its Applications - ICCSA 2012

Each of the categories has several levels of detail for each of the market segment. HUB4NGI will attempt to map each of the initiatives highlighted to these market segments. In this way we can monitor the potential impact in terms of the economic dimension and the importance to the European economy. For each of the market segments a significant amount of market data exists to establish baselines and benchmarking of economic factors. This data will be used not only to classify initiatives but also to perform program wide analysis and market coverage.

Identifying Vertical Market Segments

Research and development in scientific areas is often best tailored to a well-defined vertical market segment. For example, an IT technology used for tracking and tracing perishable food expiry to reduce food waste will provide most benefits and impacts specifically in the retail foods segment. When cataloguing, monitoring and measuring aspects regarding an initiative, it will be imperative to capture this vertical market segment to highlight the market dimensions and potential economic impact. Again, IDC has a classification scheme for the vertical markets. This classification scheme is however tied to international classification schemes which are based on North American North American Industry Classification System (NAICS) in North America and on the Nomenclature statistique des activités économiques dans la Communauté européenne (NACE) in Europe. The two classifications are very similar but independent. NACE is a four-digit classification scheme providing the framework for collecting and presenting a large range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment and national accounts) and in other statistical domains developed within the European statistical system (ESS). It has a very widely used vertical sector division and captures the vertical segments commonly in use in the technology domains. In this project we are adhering to the NACE codification scheme as they are in use in Eurostat and we can correlate data. Various NACE versions have been developed since 1970, The current version of this classification is the NACE Rev. 2[8], which was adopted at the end of 2006.

3.1 TECHNOLOGICAL FOCUS AREAS

The technological areas which will play a part in the Internet in the future are vast. Most current or future IT technology will in some manner play a role in the development of NGI, but to be pragmatic we will focus our efforts on monitoring initiatives that will play a significant role in the development of the EC's NGI vision. The technological themes and focus areas have been determined through a significant effort carried out by the NGI unit and the stakeholders through a public consultation process to identify those technologies and themes that the community believes are most important As mentioned above, an open consultation for the NGI was held between 10th November 2016 and 9th January 2017[9]. 449 people took part and provided their views and considerations as input during this consultation. Participants were asked to rate and comment upon the importance of value statements and technology areas and encouraged to provide their views on how to support the NGI. Following this process internal discussion was carried out in the NGI unit. The most important technologies and themes were catalogued and the HUB4NGI consortium adopted the top nine topics for inclusion as Focus areas to monitor to select the technologies that would be monitored during and after the project. Expert opinion of consortium members and review of European Commission and Member State consultation was considered when selecting the most important themes. New themes that come up over

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[8] established by Regulation (EC) No 1893/2006

[9] David Overton, Next Generation Internet Initiative – Consultation - Final Report March 2017
https://ec.europa.eu/futurium/en/content/final-report-next-generation-Internet-consultation

the next several years will also be included in our framework. The focus areas which are roughly ranked according to importance indicated in the process include the following:

1. Edge Computing

2. Trust and Security

3. Artificial Intelligence

4. Internet of Things

5. Networks (including 5G)

6. Open, Linked and Big Data

7. Blockchain/Distributed Ledgers

8. Ontologies and Semantic Discovery Tools

9. Augmented/Virtual Reality

Initiatives examined will focus on one or more of these technology domains. They will be catalogued and monitored according to these focus areas. The single focus areas are described in the following paragraphs, which describe the technology being considered, give examples of where this technology is used and provide an idea of how they can be assessed in terms of contribution to the wider NGI goals described in Section 2.1.

3.1.1 Edge Computing

DESCRIPTION

"Edge computing" refers to a cloud computer system in which computing is carried out by devices at the edge of the network, as well as by the centralized computing resources. The edge devices may form groups which can distribute the computing load among themselves, either in a peer-to-peer fashion, or with some devices acting as computing resources to be shared by a group of others. In the latter case, the inter-communicating group of devices is often referred to as a "cloudlet".

Edge computing is analogous in concept to content distribution networks (CDNs), in which copies of popular and frequently accessed movies, music and other content types are stored (or "cached") at multiple locations around the network. Users requiring a piece of content access it from the server nearest to them, rather than having all users requiring that content access it from the same central store. Similarly, in an edge computing environment, devices that have data to process can interact with the computing resource nearest to them, rather than having to use the same central computing resources as all other devices.

The main benefits of edge computing are that:

➡ the amount of data traffic that the cloud system's communications links must carry is reduced, because edge devices can carry out some data processing for themselves and/or for each other, obviating the need to pass data to and from centralized data processing resources

➔ the network latency experienced by edge devices can be reduced, because the paths over which they send and receive data are shorter than in a pure cloud system, where all data must travel to and from the centralised computing resources

➔ the consequences of a computing device on the network failing are less severe as less data is compromised.

➔ scalability is improved, because of the ability to configure virtual computing resources as needed from a larger and more distributed set of processors

For service-provider networks, the European Telecommunications Standards Institute (ETSI) has developed a standard for edge computing known as MEC. Originally standing for Mobile Edge Computing, the acronym now stands for Multi-access Edge Computing, the change reflecting the fact that the standard is equally applicable to fixed-line and mobile access networks. MEC specifies a network architecture in which applications are run, control processing takes place and data is stored at the network edge. In the mobile network case, compute and storage resources are sited at the cellular base stations, enabling faster delivery of content to end users, and shorter paths between the network's data processing resources and the end points that use them. In addition to the benefits mentioned above, MEC-enabled base stations can also be made accessible to third-party developers via APIs.

Development of MEC has been led by Nokia Networks, which also holds the chair of the MEC working group in ETSI. In July 2017, Nokia and Amazon Web Services (AWS) announced a partnership which has the potential to help extend the role of MEC into the enterprise networking domain. AWS's Greengrass10 is an implementation of the edge computing concept in software, whose footprint is small enough to run on IoT device chipsets. Under their partnership, Nokia's MEC server and edge devices enabled with AWS's Greengrass are combined into an IoT platform with edge computing capability.

POTENTIAL USE CASES

➔ **Factory/site automation**

Industrial automation has been in progress for decades, but the machinery in which automation is implemented has been largely stationary. Now, there is a growing trend for industrial machines to be mobile, both on the ground and – increasingly – in the air, as industrial organisations start realizing the potential of drone technology. As more and more machines move around, it will be increasingly important for them to be aware of, interact with, and avoid colliding with each other. They will frequently be operating in indoor locations, where GPS location service is unavailable, so there will be a constant need for robots and drones to interact with local systems for detection and reporting of their own location, and to be informed of the location of others.

➔ **Remote command and control**

There are clear benefits for companies in sectors such as construction and mining to be able to remove personnel from operational sites. Costs can be saved by reducing headcount, but more importantly still, health and safety benefits can be realized from the ability to reduce the number of human workers that are needed to operate in conditions which are often highly hazardous. These benefits can be achieved by a combination of autonomous machines, as described above, and remote control of machines that must be operated by humans. Remote

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[10] for more information see: http://docs.aws.amazon.com/greengrass/latest/developerguide/what-is-gg.html

command and control requires a network with very low latency, so that an operator's action results instantly in the machine doing what is required.

➜ **Traffic control and automation**

There is a major trend in the automotive industry towards connected vehicles, enabling a broad set of applications ranging from in-vehicle infotainment, through vehicle performance monitoring, to partially and fully autonomous vehicles. For some of these applications, such as usage-based insurance, data processing and transmission can be carried out in batches, after the fact. Others, such as telemetry and predictive maintenance, could benefit from the real-time capability. Still others, such as vehicle autonomy, absolutely require not only real-time data processing but also very low latency, for communication from vehicle to vehicle, and between vehicles and road infrastructure. Both of these are enabled by applying edge computing to the road network's connectivity infrastructure.

➜ **Monitoring and analysis**

Business is increasingly being driven by intelligence gained from the collection and analysis of large data sets, colloquially referred to as big-data analytics. However, in some cases, the value of the intelligence thus gained is large but short-lived; and as the volume of data being generated for analysis burgeons, enterprises will find it increasingly difficult to carry out the analysis quickly enough if they rely solely on centralized data processing resources. By implementing edge computing, enterprises can ensure that there are local resources for carrying out analytics on data in the area where it is collected, reducing the potential or contention and delay associated with relying on centralized resources. The latency benefits of edge computing can also be important in cases where action on data analytics can be extremely time-sensitive, such as financial trading applications.

➜ **Telecoms cost automation**

For large enterprises, wide-area networking (WAN) links between its sites can be very costly to source and operate, especially internationally. By implementing edge computing, enterprises can reduce the amount of data that needs to be transmitted over the WAN, and thus reduce the amount of WAN capacity that needs to be paid for. In combination with software-defined (SD) networking, edge computing also has potential to enable a more variable and flexible approach to WAN sourcing, by constantly monitoring and predicting wide-area transmission, and adding or subtracting WAN capacity accordingly. There will be growing potential to do this in real time, as telecoms service providers increasingly offer SD-WAN connectivity products in place of more costly products such as IP VPNs and leased lines.

➜ **Real-time interactive multimedia**

Burgeoning capacity in both fixed-line and mobile access networks is enabling a richer set of multimedia services to be delivered over the Internet. Increasingly, such multimedia will involve a high degree of interactivity, in applications such as online multiplayer gaming and online virtual reality (VR). Such interactive multimedia services will require networks with very low latency, in order to be sufficiently responsive to users' actions. In an interactive game, when a player takes an action such as firing a missile at another player, the other player will need to be able to react immediately. When online VR users move their heads, the scene they are experiencing will need to change accordingly straight away, or the users will quickly develop motion sickness. It is clear, then, that as the level of interactivity in online multimedia grows, the low network latency enabled by edge computing will become increasingly important

WHAT WE SHOULD MONITOR

Edge computing is a paradigm for both cloud computing and IoT networking, so it is important to avoid measuring things which are part of those markets and not specific to edge computing. Things that are specific to edge computing include:

➡ Edge computing servers

➡ Edge computing device software

➡ Co-location sites and services

Potential market size and predictions

IDC forecasts that by 2019, as IoT adoption grows in major industry, government, and consumer sectors, at least 40% of IoT-created data will be stored, processed, analysed, and acted upon close to, or at the edge of, the network[11].

IDC reports that at the end of 2016, enterprises around the world owned and operated just over 40,000 datacentres of more than 2,000 sq. ft usable space. After eliminating the millions of server closets and rooms as well as smaller datacentres under 2,000 sq. ft that are owned/operated by small, independent businesses, a typical enterprise owns and operates over 97 edge IT facilities, with some owning and managing hundreds or thousands of such facilities.[12]

3.1.2 Trust And Security

DESCRIPTION

Trust and Security are vast subjects, which impact many aspects of life. According to the Oxford English Dictionary, "trust" is defined as:

"Firm belief in the reliability, truth, or ability of someone or something."[13]

Therefore, trust is a decision made by a person, and we can infer from the "belief" aspect of the definition that a trust decision usually involves some kind of explicit or implicit risk evaluation. Technologies can alleviate or can exacerbate the level of risk or perceived risk, and to reinforce a positive evaluation of risk, technologies need to give people information or confidence to enable them to make a trust decision.

The OED defines "security" thus:

"The state of being free from danger or threat."[14]

The specific case of security relevant to the NGI is cybersecurity, defined as:

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[11] http://www.idc.com/getdoc.jsp?containerId=US42779117&pageType=PRINTFRIENDLY

[12] http://www.idc.com/getdoc.jsp?containerId=US42762517

[13] https://en.oxforddictionaries.com/definition/trust

[14] https://en.oxforddictionaries.com/definition/security

"The state of being protected against the criminal or unauthorized use of electronic data, or the measures taken to achieve this."[15]

Cybersecurity is at heart a study of threats on the Internet caused by e.g. malicious behaviour such as cybercrime or inadvertent data leaks, and how to provide safeguards to protect from those threats. It is an ever-evolving field, because attackers and security technologies are continually making advances over each other – once one vulnerability is patched, a malicious hacker finds another and devises ways to exploit it.

Regarding technologies, the discipline of cybersecurity encompasses a series of technologies that provide safeguards to help bring about the protection referred to in the definition. Examples include cryptographic techniques that can encrypt data[16] and identify citizens[17]. If the user knows about the presence and effect of these technologies, this can help support their confidence in deciding whether to trust use a particular service, resource or protocol. A well-known example of security technology being advertised to increase the trust of the user is the "SSL padlock" that appears in web browsers, indicating that the connection between the browser and the server is encrypted, and that the server's identity is authenticated.

Citizens are becoming ever more aware of the dangers of the Internet due to highly publicised cases of cybercrime and cyberterrorism but are largely ignorant of many of the serious but subtle dangers they face. A case in point is illustrated in Hub4NGI D2.1 – NGI GUIDE V1, which consolidates a number of data sources that have surveyed experts and the general public: the experts most commonly-mentioned concern is the loss of citizen control over their personal data and what large corporations do with citizens' personal data[18], but experts have also mentioned that the general public are not aware of the cost they are paying when they submit their personal data to a website – they are more interested in the benefits the website can give them.

The EC's General Data Protection Regulation (GDPR)[19] is an attempt by the EC to provide greater protection to citizens' personal data than previously. It replaces the original Data Protection Directive (95/46/EC) with measures that apply Europe-wide, rather than the original directive, which was interpreted by each member state in its own legislation. The regulation also applies to countries outside the EU, if they trade within the EU or monitor EU subjects. The GDPR has the following major principles:

➔ Personal data can only be processed under certain specified conditions. This usually means that the subject of the data has given informed consent, but other conditions include compliance with a legal contract, or it is necessary to comply with a legal obligation such as national law.

➔ Data subjects must understand the consent they are giving, the consent must be freely given, and given before the processing. The processor must also retain demonstrable proof of the consent.

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[15] https://en.oxforddictionaries.com/definition/cybersecurity

[16] See e.g. https://en.wikipedia.org/wiki/Transport_Layer_Security

[17] See e.g. https://en.wikipedia.org/wiki/Public_key_certificate

[18] An illustrative example is given in https://www.theguardian.com/technology/2016/dec/12/facebook-2016-problems-fake-news-censorship

[19] http://www.eugdpr.org/

➔ Data subjects must be informed about the processing of their data.

➔ The GDPR provides the following rights for individuals[20]:

- The right to be informed

- The right of access

- The right to rectification

- The right to erasure

- The right to restrict processing

- The right to data portability

- The right to object

- Rights in relation to automated decision making and profiling.

The GDPR promises an advance in the protection of citizens' privacy, but there are concerns over the complexities introduced by its implementation[21].

POTENTIAL USES

The following potential uses are threats derived from the consultations and surveys that have been synthesized by the HUB4NGI Deliverable "D2.1 NGI GUIDE" and reflect currently-perceived trends regarding threats. Multiple disciplines, including technology, sociology, economics and legislation are needed working together to address these threats.

➔ The trend towards interconnectedness of people, devices and resources poses threats, and the increasing ease of connectivity is a threat to countries' national security.

➔ The increasing ubiquity of IoT devices is also a significant threat, often because they are a proliferation of devices from unknown origin or provenance with no indication of their resilience to hijacking or hacking. In addition to the above, the trend towards many "smart devices" of dubious security credibility being located within citizens' homes is cause for concern.

➔ Threats from cybercrime, e.g. identity theft or fraud and cyberterrorism, such as the recent worldwide ransomware attacks.

➔ There are threats to citizens' privacy, which is based on a perceived loss of control over that personal data – once the citizen has submitted it to a website, they do not know what happens to that data, and have no real control over it.

WHAT SHOULD WE MEASURE

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[20] From: https://ico.org.uk/for-organisations/data-protection-reform/overview-of-the-gdpr/individuals-rights/

[21] https://community.spiceworks.com/research/gdpr-impact-on-it

The measures listed here are aimed at providing an indication of the overall trend of trust of citizens in the Internet, and tracking trends regarding current threats and progress towards countermeasures to these threats.

➔ There should be an "Index of Trust" for the Internet. A 2016 article in the Washington Post[22] described a survey of Americans that indicated that significant numbers (in the order of 30%) were discouraged from doing things they wanted to on the Internet due to concerns about such as identity theft, fraud and collection / exploitation of their personal data by unauthorised parties. These concerns represent a loss of trust in the Internet, and trends concerning citizens' faith in the Internet should be monitored. The index of trust is difficult to compute, as it is a measure of peoples' belief that they will not come, and it is likely that it needs to be determined as part of ongoing surveys of the populace on their relationship with the Internet. There are more general-purpose trust indices, such as the Edelman Trust Barometer[23], which gauges trust in the domains of business, government, NGOs and media, but a more specific trust index for Internet activity would be additionally helpful.

➔ An oft-mentioned fear of using the Internet for citizens is the loss of control over their personal data. Technologies and regulation to address this have been proposed, e.g. the GDPR and privacy enhancing technologies, and their effectiveness needs to be measured, in terms of citizen satisfaction. It is recommended that as part of the above-mentioned trust index, citizens be surveyed as to their fears regarding loss of control of their personal data.

➔ The number, types and scale of cyberterrorism and cybercrime attacks should be observed, and trends measured over time. We need to understand which attack types are on the increase and which are on the decrease, as this shows us which measures are successful in counteracting them, and which attacks need to be worked on. Overall, we need to know how cybercrime is evolving and whether the cybersecurity research and development keeping pace. This can be broken down. Following is an exemplary list but should not be considered exhaustive as new types of attack emerge over time.

  ▪ Number of instances of identity theft[24]

  ▪ Number of instances and types of Internet fraud[25]

  ▪ Number of instances of ransomware attacks[26]

  ▪ Number of instances and types personal data misuse[27]

The number, types and scope of awareness-raising and education activities in the threats of cybercrime should be observed, as well as observing trends of cybercrime and cyberterrorism

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[22] https://www.washingtonpost.com/news/the-switch/wp/2016/05/13/new-government-data-shows-a-staggering-number-of-americans-have-stopped-basic-online-activities/?utm_term=.12bd8cb6ad2f

[23] http://www.edelman.com/trust2017/

[24] See e.g. http://www.identitytheft.org.uk/

[25] Examples are given in http://www.actionfraud.police.uk/fraud-az-online-fraud

[26] A case in point is the recent "wannacry" ransomware attacks. http://www.bbc.co.uk/news/technology-40416611

[27] Examples are given in https://www.observeit.com/blog/importance-data-misuse-prevention-and-detection/ and the EC's redress process is given in http://ec.europa.eu/justice/data-protection/individuals/misuse-personal-data/index_en.htm

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reporting in the mass media. A key weapon in counteracting these menaces is to educate the general public, so measures of the effectiveness of different education techniques should be considered.

It has been proposed that security-critical applications and IoT devices be certified as fit for purpose, (e.g. commitments to patch software to cover vulnerabilities), and that the certification is clear and obvious to non-experts[28]. Tracking trends of security certification and labelling to determine its effectiveness is considered useful.

3.1.3 Artificial Intelligence

DESCRIPTION

Artificial Intelligence (AI) has its origins in the 1950s – it is generally regarded that its birthplace and date was a conference at Dartmouth college in 1956[29], and has been a prominent research topic since then. It has gone through several hype cycles and has had major successes but also has often failed to live up to expectations. Its major characteristic is the simulation of human intelligence such as the acquisition, understanding and application of knowledge for useful purposes, or recognition, decision making and goal seeking in automated machines. AI includes a number of sub-disciplines, reflecting different aspects of human intelligence, including:

➜ Machine learning – algorithms that "learn from experience" – the more they are used, the better they get at their task.

➜ Planning and optimizing – automatic determination of a decision-making path to achieve an objective that achieves an optimum balance of multiple factors.

➜ Machine perception – identification and recognition of real-world artefacts and phenomena, e.g. machine vision or speech recognition.

➜ Natural Language Processing – parsing and analysis of prose text

➜ Agency – the ability to sense environmental conditions, make decisions and act to achieve a strategic goal

An AI trend that has appeared over time is that due to advances in it, what was once thought of as AI is now thought of as run of the mill computing. Speech recognition is an example. This field of work began in the AI sphere, and fits with the definition of AI as simulation of human intelligence but is now ubiquitous (e.g. in phones and cars), so it is regarded not as AI any more.

There are fears regarding AI. As with the trend towards automation, it is a common fear that AI will remove employment opportunities for people, resulting in mass redundancy. There are also fears that AI may eventually "take over", the subject of much science fiction, but eminent

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scientists and entrepreneurs such as Stephen Hawking[30] and Elon Musk[31] have warned about the dangers of AI. Musk calls for regulation of AI, and legislation for and regulation of AI are current topics of discussion, with different camps arguing for ethical design of AI and regulation of AI's applications. A key theme is the question of AI responsibility and regulation of AI and the identification of responsibility is needed, as AI is increasingly used in safety critical or high impact applications.

POTENTIAL USES

➜ **Transport**

Autonomous vehicles (also known as self-driving cars). This has been a strong research theme over the past few decades and shows no sign of slowing. Some technologies have already been included in production vehicles, e.g. parking assistance, and more advanced systems have been demonstrated.

➜ **Automated decision systems**

Automated decision systems, e.g. loan deciders, recruitment applicant filtering and insurance quotation systems. These remove the need for human intervention in tightly controlled decision making (with associated cost savings), and the intention is also that the decisions are consistent. There are however calls for transparency in the decision making.

➜ **Business Management**

Strategic planning and optimising. A famous example of this type of application is IBM's Deep Blue chess machine, which defeated Grand Master Garry Kasparov in 1997. This is an example of evaluation of multiple options, possibly looking many moves ahead and weighing all possible outcomes to determine the immediate course of action most likely to achieve the strategic goal (in this case winning the chess game).

➜ **Healthcare**

Medical diagnosis and prescription support. AI in healthcare is a growing field and provides benefits of consistent diagnosis and recommendations of treatment courses.

➜ **IT Management**

Fraud detection and spam filtering. These are instances of pattern recognition, e.g. detection of anomalies in normal behaviour for fraud detection or matching heuristic characteristics to determine whether an email is spam or not.

WHAT SHOULD WE MEASURE

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[30] "The development of full artificial intelligence could spell the end of the human race. Once humans develop artificial intelligence, it will take off on its own and redesign itself at an ever-increasing rate. Humans, who are limited by slow biological evolution, couldn't compete and would be superseded." Stephen Hawking, BBC News, 2 December 2014. http://www.bbc.co.uk/news/technology-30290540

[31] Elon Musk: artificial intelligence is our biggest existential threat. The Guardian, 27 October 2014. https://www.theguardian.com/technology/2014/oct/27/elon-musk-artificial-intelligence-ai-biggest-existential-threat

This describes what elements can be quantified in this technology and initiatives using this technology

The observable measures generally applicable for AI are listed as follows.

➜ Increases in efficiency brought about by the adoption of AI for an application. This could possibly be measured by staff saved or cost savings.

➜ Costs – what are the costs in adopting the AI? This could be measured as the financial costs of creating, installing or maintaining the AI system, or could measure the costs in terms of loss of peoples' livelihoods through automation. Another potential cost could be liability, in the case that an important decision that causes some injury or disadvantage is made by the AI system.

➜ Verifiability – the numbers of correct or incorrect decisions. There is a question of how to determine what a correct decision actually is – there may need to be evaluation criteria or control groups for example. For safety critical applications, detailed analysis of any incorrect decisions will clearly be required, especially if human lives are put at risk.

➜ Transparency – is the decision made by the AI system explainable? It is an increasing requirement that AI decisions are transparent because the perception of bias needs to be avoided.

➜ Responsibility – the degree of impact that the AI decisions affect people or society. This can be from low impact where if the AI gets the decision wrong, the consequences are not at all concerning, to safety critical or high impact, where a wrong decision could have catastrophic consequences or be life-threatening.

There may be other, more specialised measures targeted at applications of AI, but these are likely to be specific to the application itself rather than the AI that contributes to the application.

3.1.4 Internet of Things

DESCRIPTION

The Internet began and developed as a system for enabling people to get online access to documents, of an increasing variety of types. Later in its development, the Internet also evolved into a system for enabling people to communicate with, and share documents with, each other. In both cases, people are the common element.

However, more recently, a growing number of Internet applications have emerged in which the end-point devices are not used by people: rather, they are devices that interact with each other, detecting and measuring conditions around them, and carrying out actions in response to those conditions, or to remote commands. The range of device types involved in these applications is so large and so diverse that the IT industry has failed to come up with a more adequate catch-all noun than "things": and so, this new class of Internet applications has come to be known as the Internet of Things (IoT).

The Internet of Things (IoT) is an aggregation of endpoints that are uniquely identifiable; that carry out data capture, transport and analysis; and that communicate with each over a network without needing human interaction, using a combination of local and wide-area connectivity. People, applications, data, and devices converge in the IoT context to turn information into actions. IoT automates many manual processes making them more efficient and can support business transformation by enabling timelier and more accurate decision making.

IoT can be considered as an evolution of machine-to-machine (m2m) connectivity. Both involve connected objects interacting with each other. However, whereas m2m deployments are closed systems, IoT deployments can interconnect and interact with each other. This distinction makes the potential IoT market much bigger, and open to a wider range of players; however, it is also acting as a growth inhibitor in this early phase of the IoT market, because:

➔ The large number of contending players, each trying to establish market predominance for its technologies and offerings, has resulted in a very fragmented IoT market. Until winners emerge, enterprises will be inhibited from committing large investments to specific IoT platforms, for fear of backing the wrong horse

➔ Security and data privacy are immature and inadequate in many IoT products at present, as demonstrated by the recent DDoS attacks carried out by hackers enlisting insecure IoT devices into botnets. Enterprises are wary of exposing their systems to an IoT widely populated with insecure devices, limiting their willingness to exploit the interconnectedness of IoT systems to the full.

A key battleground that has emerged is the market for IoT platforms. An IoT platform is the middleware that connects endpoints to applications, enterprise back-end systems, and analytics tools. IoT platforms are central to monetizing the end-to-end IoT ecosystem, and no vendor currently provides the full stack in a coherent, integrated solution. Most IoT platform vendors focus on device and connectivity management and some form of analytics, leading to a fragmented and highly competitive market contended by players who are racing with each other to build the rest of the stack into their offerings.

POTENTIAL USE CASES

There are a wide range of IoT use cases already being deployed, and a huge number of potential further use cases. Accordingly, this section is far from exhaustive; we present here a small selection of important use cases, to a give a flavour of what is being carried out and planned in the area of IoT.

➔ **Freight monitoring**

By attaching small, cheap radio-frequency devices to items and packages, freight and logistics companies are able to track and monitor the location and status of shipments while they are in transit. They can also make that information available both to their customers and to their customers' customers, enabling both to track their own shipments directly. As well as being able to tell where the shipment is at any point in its journey, companies can also monitor the condition of the shipment where appropriate: for example, it can be verified that a cargo that needs to be refrigerated has been kept within the required temperature range throughout its journey.

➔ **Asset management**

By attaching small, cheap radio-frequency devices to individual assets, companies are able to track those assets' location and potentially other aspects of their condition. This can make it easier for companies to find those assets when needed, to audit them, and if necessary, to ensure that they do not stray outside a given area. A very wide range of assets can be managed in this way, ranging from power tools, to construction plant, to farm animals.

➔ **Smart grid**

By equipping meters and delivery infrastructure with connected sensors and actuators, utility companies can make improvements in the areas of customer service, efficiency and business

models. In customer service, these improvements include automated meter reading and analytics-based advice on how to use energy/water more economically. In efficiency, these improvements enable detection of leakages, and dynamic resource allocation in response to short-term changes in usage patterns. In business models, these improvements include the ability to arbitrage wholesale more dynamically, both as a supplier and as a customer; and to manage supplies from a large and diverse network of micro-producers, including individual customers.

➜ **Healthcare**

There is a very wide range of ways in which the connectivity of devices can make improvements in both the quality and the efficiency of healthcare. Examples include:

- Monitoring and automating the delivery of critical medications in the patient's home, such as insulin management for diabetics, and control/prevent medication for asthmatics

- Continuous monitoring in the home of patients' vital signs such as heart rate and blood pressure, with alerts as needed

- Movement sensors to monitor the impact of injuries and conditions such as arthritis on patients' behaviour, to optimize physiotherapy regimes and to remediate where necessary before further damage is done

➜ **Smart city**

Municipal applications comprise another wide and diverse set of IoT applications, collectively referred to as a "smart city". Early examples being developed and implemented in many cities at present include:

- Smart street lighting, optimizing energy efficiency by enabling street lighting to be switched on and off and adjusted in response to levels of ambient light, and variations in local conditions such as the approach of pedestrians

- Smart waste management, whereby waste bins in homes and businesses are fitted with sensors that detect and report how full they are, so that collection can be carried out on an as-needed basis

- Smart parking, in which parking spaces are equipped with sensors that report whether or not the spaces are occupied, so that drivers looking for parking spaces can be informed where they are available

➜ **Smart home**

By equipping home systems with connected sensors and actuators, householders are able to monitor and control those systems both when they are at home, and when they are away. Common examples of connected systems in smart-home applications are heating, lighting and security. Less common but emerging examples include connected locks and leak/smoke/CO detectors.

➜ **Connected vehicles**

As well as providing the Internet delivery of information and entertainment content, connectivity can be added to vehicles to provide functional improvements, new services and new ways of driving. Functional improvements include telemetry and analysis of engine performance data, to enable advance failure warnings and predictive maintenance. New services include usage-

based insurance, enabling policies and premiums to be tailored more closely to a customer's usage patterns and driving behaviour. New ways of driving include communications between commercial vehicles to enable "platooning", whereby trucks travel closely together so that they can use their slipstreams to reduce fuel consumption.

WHAT SHOULD WE MEASURE

IoT should can be observed as the number of times an IoT initiative employs an element in their IoT-specific items that can be counted include:

➜ chipsets/SoCs specific to IoT devices;

➜ number of connected devices themselves;

➜ number of suppliers of IoT devices;

➜ IoT platforms that manage an IoT installation;

➜ Network connectivity to run the IoT devices;

➜ Software used to manage, calibrate or maintain the IoT installation that is not part of the management platform;

➜ Implementation and operational services.

MARKET SIZE

By the end of 2017, IDC expects the annual IoT market in Western Europe to be worth around US$178bn, comprising 19% connectivity, 33% hardware, 25% services and 23% software.

By the end of 2020, IDC forecasts the annual IoT market in Western Europe to be worth around US$290bn, comprising 20% connectivity, 32% hardware, 23% services and 25% software.

3.1.5 Networks Including 5G

DESCRIPTION

Telecommunications (telecom) networks comprise the publicly accessible infrastructure enabling information to be exchanged between:

➜ individual devices

➜ private local-area networks in homes and businesses

➜ private wide-area networks in businesses.

Privatisation of the operation of telecom networks began in Europe during the mid-1980s, and since the late 1990s all telecom networks in EU countries have been operated by private or privatized companies. However, much of the physical plant that still comprises today's European telecom networks was built during the period when networks were owned and operated by state governments. This is one reason why the operation of telecom networks is a highly regulated activity, with especially demanding regulation governing the activities of the operators formed through privatization of the former state-owned telecom provider. (Such operators are often referred to as "incumbents".)

Telecom networks can be broadly divided into those accessed via:

➜ fixed-line infrastructure, mostly copper wires, coaxial cables or fibre-optic lines. Within the connected premises, access to the connection is often distributed with radio signals on frequencies in unlicensed spectrum bands, using the Wi-Fi (IEEE 802.11) set of standards

➜ mobility-enabled radio links, referred to as mobile networks. Unlike Wi-Fi in fixed-line networks, the radio link in a mobile network is not merely a means of distributing the connection; it is the connection itself. Mobility is enabled by using an architecture known as cellular radio, in which a geographical area is covered by multiple radio transmitter/receivers known as base stations. As a moving connected device moves out of base station A's range and into that of an adjacent base station B, the network connection is transferred from base station A to base station B without interrupting the session, a process known as "hand-off".

In addition to mobility, another clear distinction between Wi-Fi and mobile networks has been that the former operates in radio spectrum bands that are openly accessible, but the latter operates in radio spectrum that is licensed to mobile network operators, with each operator's network having exclusive use of the frequencies to which the operator holds licences. However, that distinction is starting to blur, several mobile operators having recently adopted technologies such as LAA (License-Assisted Access) which enable them to aggregate unlicensed spectrum with their licensed spectrum to increase the capacity of the radio links to their networks. This trend is likely to spread over the next few years. It is even being mooted that the use of unlicensed spectrum should be encompassed in the standards for the next generation of mobile networks (the fifth generation or 5G), although it remains to be seen whether that happens.

Mobile networks account for an increasing percentage of Internet usage, and that trend will continue for the foreseeable future, driven by factors including:

➜ the trend towards mobile devices, primarily smartphones and tablets, becoming people's primary Internet access devices

➜ the fact that the utility value of some Internet services increases when it is possible to use them away from the home or place of work

➜ the trend among enterprises to mobilise employees' access to IT systems

➜ rapid increases in the data capacity, performance and capabilities of mobile networks

➜ the ability to provision new network connectivity more economically by using radio links than fixed-line links

POTENTIAL USE CASES

➜ **Person-to-person communications**

Originally, both fixed-line and mobile telecoms networks were built primarily to enable person-to-person (P2P) communication, through telephony and other services such as telegraphy, telex, fax and SMS (short message service). P2P communication still constitutes an important use case for telecom networks, not only through these traditional operator-provided services, but also increasingly through Internet-based communications services offered by third-party service providers, using telecom networks for connectivity.

➜ **Data communications**

The transmission of computer data over telecom networks has been taking place since the 1940s, but for several decades it remained a small part of operators' total business, confined mostly to specialized services used by large enterprises. Since Internet usage became widespread in the mid-1990s, however, a fast-growing proportion of telecoms network traffic has been associated with data communications rather than P2P communications. In today's telecom networks, both fixed-line and mobile, the vast majority of traffic is associated with data communications.

➡ **Industrial applications**

As the capacity and latency of public telecoms networks continue to improve, it is becoming feasible to use them as the connectivity infrastructure for automated industrial systems. Robotics is emerging as major trend in the evolution of manufacturing, construction, warehousing and logistics. In many cases this new generation of industrial robots will be controlled, and will interact with each other, using public telecom network infrastructure.

➡ **The Internet of Things**

As detailed in the "Internet of Things (IoT)" section, a growing proportion of the devices connected to telecom networks are not used directly by people. Rather, they are sensors and actuators exchanging data with each other, and with control systems, in an increasingly diverse range of "smart" applications in homes, transport networks, urban infrastructure and utility grids. Telecoms networks are evolving in ways that enable them better to accommodate the needs of these IoT devices and systems. For example, upgrades are available for 4G mobile networks that reduce the power consumed by connected devices, so that they can stay in service for several years on a single battery charge. In the next generation of mobile networks, 5G, one of the design goals of the standards-making process is a much higher density of device connections than today's networks can support, with densities in the range of 1 million devices per square kilometre being widely mooted.

WHAT SHOULD WE MEASURE

Telecom networks both comprise and enable a large and diverse market, whose elements include:

➡ Physical network infrastructure, including cables, switches/routers, mobile base stations;

➡ IT systems and services associated with the construction and maintenance of telecom networks;

➡ IT systems and services for operating, managing and controlling telecoms networks;

➡ IT systems and services associated with telecoms operators' customer-facing functions such as provisioning, billing and support;

➡ Services provided by telecom network operators to their customers, either directly or through wholesale;

➡ Bandwidth available to commercial users in the last mile.

MARKET SIZE

The source for the following figures is IDC's Telecom Services Database.

In 2016, the revenues earned by telecom network operators from services provided to their customers amounted to US$ 222.1 billion. 51% of these revenues were earned by fixed-line network operators, and 49% by mobile network operators.

In 2021, IDC forecasts that the revenues earned by telecom network operators from services provided to their customers will amount to US$ 226.5 billion. 49% of these revenues will be earned by fixed-line network operators, and 51% by mobile network operators.

3.1.6 Open, Linked and Big Data

Linked Data (Berners-Lee, 2006) has established itself as the de facto means for the publication of structured data on the Web, enjoying amazing growth in terms of the number of organizations committing to use its core principles for exposing and interlinking data for seamless exchange, integration, and reuse (Bizer, Heath, & Berners-Lee, 2009). More recently, data explosion on the Web, fuelled by social networking, micro-blogging, as well as crowdsourcing, has led to the Big Data phenomenon (Manyika et al., 2011; McAfee & Brynjolfsson, 2012). This is characterised by increasing volumes of structured, semi-structured and unstructured data, originating from sources that generate them at an increasing rate. This wealth of data provides numerous new analytic and business intelligence opportunities to various industry sectors. Moving further away from the purely technical, organizations are more and more looking into novel ways to capitalize on the data they own and to generate added value from an increasing number of data sources openly available on the Web, a trend which has been coined as Open Data (Open Knowledge Foundation, 2012).

POTENTIAL USES

Big and (Linked) Open Data has the potential to revolutionize business, government, and society. Amongst the potential benefits are productivity increases in manufacturing and novel services resulting from increased business process efficiency; increased competitiveness resulting from lower barriers of entry for smaller businesses which can now use the hundreds of thousands of open data sets that have been released on the Web; and an improved allocation of production factors through improved decision making, as a result of a shift from instinct to data-informed processes in the way organisations are run and operate.

WHAT SHOULD WE MEASURE

➜ Growth rate of unstructured / structured / semi-structured data on the web

➜ Growth rate of unstructured / structured / semi-structured organisational data

➜ Growth rate of linked and open data initiatives[32]

3.1.7 Blockchain and Distributed Ledgers

DESCRIPTION

Sometimes the terms 'distributed ledgers' and 'blockchains' are used interchangeably when they are in fact not equivalent. Distributed ledgers are replicated, shared and synchronised digital data geographically dispersed over multiple sites possibly including multiple institutions.

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[32] http://lod-cloud.net

A peer-to-peer network is required for communication and a consensus algorithm to ensure replication and synchronisation across the multiple nodes.

It is important to emphasise the key differences between applications that run on standard platforms and those that run on top of distributed ledgers. Rather than connecting from a device (e.g. a mobile phone) to a central server, which holds all the required data (possibly including private customer data), every player or volunteer in the network gets a complete copy of all the data.

A blockchain is a specific type of distributed ledger where an ever-growing list of records, called blocks, are linked together to form a chain – hence the term 'blockchain'. The first blockchain was conceived by Satoshi Nakamoto[33] as the basis for Bitcoin the most famous blockchain based crypto-currency. The main idea behind Bitcoin was to create a currency specifically for the Internet rather than (as is the case in all fiat currencies) map an originally physical currency to the Internet.

The first issue that arises with Internet based currencies is what is called the 'double spend problem'.[34] This is the case when a digital 'coin' is spent, by an individual, for some service or good, and then the same coin is spent again by the same individual. For example, by copying or duplicating the relevant data. Blockchains address this problem by providing an immutable public ledger of all historical transactions. Once processed and stored within a block a transaction cannot be altered even by the transaction owners.

Immutability is provided through a number of related mechanisms:

➜ **Timestamp** – each block has a timestamp.

➜ **Cryptographic hash** - Each block is linked to the previous block through a cryptographic hash.[35] A cryptographic hash function is a hash function which takes an input (which can be of any size) and returns a fixed size string. Small changes in the input result in large changes in the output. It is this last feature which means that and changes to the input can be easily detected (as the hash function will no longer be verifiable). Additionally, it is not easy to regenerate the input from any given output. This aids in use cases which involve an element of privacy.

➜ **Cryptographic puzzle** – in order to gain the right to create the next block a participant (often called a 'miner') has to be the first to solve a cryptographic puzzle. This feature prevents a malicious attack aiming to re-write the history of a set of transactions since this would require many cryptographic puzzles to be solved (since the hash of each block had been altered).

➜ **Participant network** – since the data related to all the transactions are copied across all participants (miners) in the network, all are able to check if any protocols or rules have been violated.

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[33] https://en.wikipedia.org/wiki/Satoshi_Nakamoto

[34] https://en.wikipedia.org/wiki/Double-spending

[35] https://simple.wikipedia.org/wiki/Cryptographic_hash_function
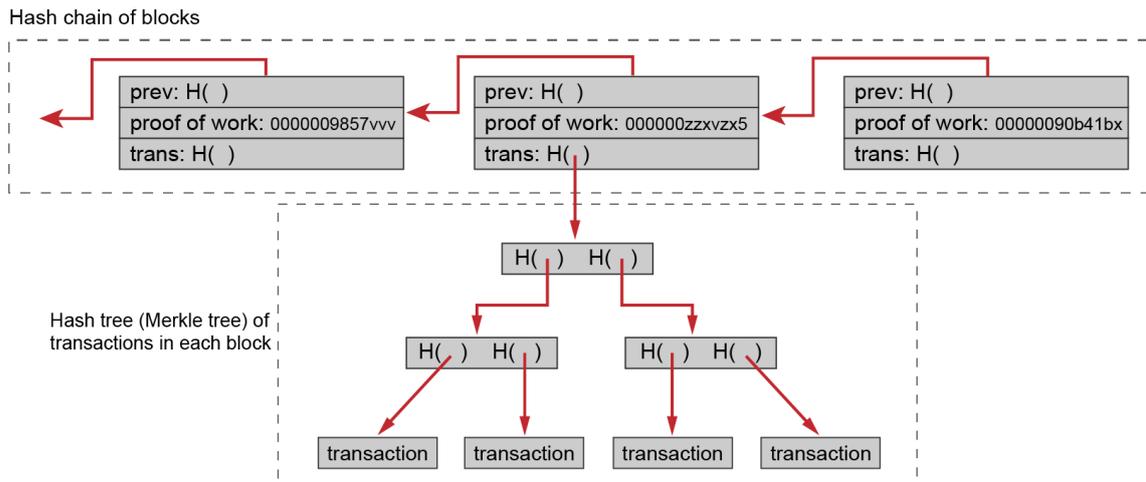
Hash chain of blocks

FIGURE 4. A BLOCKCHAIN WITH THREE BLOCKS.

Figure 4 shows a blockchain containing three blocks. Starting from the right, the newest block, each block points to its predecessor using a hash function. Each block contains the solution to the cryptographic puzzle, termed proof of work and a timestamp (left out of the figure for simplicity). Transactions are stored in a Merkle Tree - a tree of hashes where the leaf nodes contain the transactions. This ensures the veracity of the individual transactions in addition to the block – if a transaction is altered then the hash link will no longer be valid.

The proof of work consensus mechanism which involves solving the crypto-graphic puzzle before anyone else has led to the growth of computing power and associated electricity. Estimates are that by 2020 the Bitcoin network will consume as much electricity as Denmark.[36] This has led to several platforms exploring other consensus mechanisms such as:

➜ *Proof of stake*[37] – where the chances of being selected to produce the next block depend on the value of a 'stake' stored by a miner in a specific location. Variants of this take into account the 'age' of the stake.

➜ *Proof of capacity* – rather than the chances of being selected being related to the amount of CPU, as above, here the probability is related to the amount of storage a miner holds.

➜ *Proof of burn* – sending coins to an irretrievable address ('burn') gives one the right to be selected. The chances of being selected to mine the next block are related to the value of the burn.

➜ *Proof of elapsed time* – Intel has produced a special processor capability to implement this mechanism which relates elapsed time to the probability of being selected.[38]

ETHEREUM AND SMART CONTRACTS

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[36] https://motherboard.vice.com/en_us/article/aek3za/bitcoin-could-consume-as-much-electricity-as-denmark-by-2020

[37] https://en.wikipedia.org/wiki/Proof-of-stake

[38] http://www.coindesk.com/intel-winning-blockchain-critics-reimagining-bitcoins-dna/

After Bitcoin Ethereum[39] is the best known blockchain platform. Rather than serving as a platform for a cryptocurrency the underlying aim for Ethereum is to be an open blockchain platform to support the development and use of decentralised applications. Unlike Bitcoin Ethereum is Turing Complete so that general applications can be run on what the founders call a 'world computer'.

At the core of the Ethereum concept are two types of accounts:

➔ **Externally Owned Accounts (EOAs)** which are controlled by private keys. A private key is a cryptographic mechanism allowing for individuals to unlock data which has been secured by a corresponding public key. EOAs are controlled by individual users or organisations.

➔ **Contract Accounts**, also termed 'Smart Contracts' are controlled by contract code and are activated by EOAs.

When Ether, the currency used within Ethereum, is sent from an EOA to a Contract Account the contained program is executed. This can result in further transactions and payments and additional Smart Contracts being invoked. Smart Contracts form the basis of Ethereum applications which are called 'dApps' (for distributed applications).

It is Smart Contracts that have attracted a lot of attention in this platform. In principle Smart Contracts facilitate the removal of intermediaries such as banks and legal establishments within financial and legal processes. Ethereum is available as open source code.

POTENTIAL USES

Blockchain is a generic platform technology which implements consensual trust between parties in the same way that the Internet is a platform for connecting devices and the Web is a platform for connecting documents. As such its reach will cross many sectors. We outline a few prominent exemplars below.

➔ **Financial Services**

Blockchains will affect financial services in a number of ways:[40]

● **Asset Management** – the settlement of complex trade processes across borders and for non-standard investment products could be greatly simplified, sped up and costs reduced through the removal of intermediaries.

● **Insurance** – policies could be represented as smart contracts offering complete control, transparency and traceability for each claim. Pay-outs can be made automatically. The existence of a complete claim history would also allow for sector wide risk modelling breaking down existing silos.

● **Supply chains** – can have intermediary banks and clearing houses removed. Instead relying on the execution of Smart Contracts to transfer the titles of goods and funds. This

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[39] https://www.ethereum.org/

[40] https://www.finextra.com/blogposting/13068/5-ways-blockchain-will-transform-financial-services

removes the need for banks to provide products such as letters of credit. Within supply chains transparency will be increased for customers and auditors alike.

- *International payments* – are costly and can sometimes take days. In principle blockchains can reduce the costs by orders of magnitude and the time taken to minutes. In the late spring of 2016 Santander launched a trial blockchain based app for international transfers for between £10 and £10,000 with a transfer delay of only 24 hours.[41]

- *Compliance* – Blockchains can provide a single source for digital ID thus reducing the overhead of transferring these types of documents between banks and external agencies. This will dramatically lower the process costs associated with the Know Your Customer regulatory constraint.

➜ **Identity Management**

As mentioned just above the use of private/public keys blockchains support the linking of online identities to personal records or assets. ConsenSys (a well-known player in the Ethereum ecosystem) has produced a tool called uPort for managing personal identity ('Self Sovereign Identity') on Ethereum.[42] Below we describe Estonia's advances in this area.

➜ **Luxury Goods**

Everledger[43] is a company which uses the immutable ledger property of blockchains as a platform for tracking the sales of luxury goods such as diamonds. Simply put, the reason why a high financial value is placed on a luxury good is often based on its provenance. For example, a painting was not made yesterday in a garage but has a history of owners going back to the claimed possibly famous artist.

Everledger's platform tracks an asset's defining features including its ownership history as a hash. Currently, records relating to over one million diamonds sit within its blockchain infrastructure. The company contributes to the Hyperledger platform[44] an open source tool whose industrial members include IBM and Intel.

➜ **Energy**

Blockchains may well decentralise the energy grid. Rather than big power plants generating power and sending that over long distances local power producers, including homeowners, will generate power through solar panels and sell that directly to their fellow citizens.

A micro-grid project in Brooklyn,[45] a joint venture between Lo3 Energy and ConsenSys, aggregates the energy generated by the local community and uses the blockchain to record and distribute the generated funds.

➜ **IoT**

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[41] http://uk.businessinsider.com/santander-develops-blockchain-international-payment-app-with-ripple-2016-5

[42] https://www.uport.me/

[43] https://www.everledger.io/

[44] https://www.hyperledger.org

[45] http://brooklynmicrogrid.com/

IBM recently published a paper 'Device Democracy'[46] arguing that blockchains form the best way forward for an Internet of Things consisting of many billions of devices to succeed. As can be seen in Figure 2 there has been an evolution from closed centralised networks to today's position of managing IoT devices through a centralised cloud. Blockchains will allow devices to talk to each other directly with no central mediator thus removing a significant communications bottleneck.

FIGURE 5. DEVICE DEMOCRACY - SOURCE IBM[47]

In Autumn of 2015 Visa and DocuSign created a demo[48] where visa card payments for a car lease, insurance, parking could be made whilst in the car being purchased. In essence, through a blockchain, the car held all the card information to make any necessary payments.

A demo from IBM showcased a washing machine able to order its own washing powder through blockchain smart contracts. A future scenario which IBM envisage is the ability to turn any physical object to a searchable and rentable service on the Internet. Extensions of this would turn any physical object into its own trading company applying governance mechanisms explained below.

➜ **Land Registry**

A number of countries including: Georgia, Sweden, the Ukraine and the UK are moving towards using blockchains for land registry.[49] [50] As well as making the whole process more reliable, cheaper and more efficient blockchains are also more resilient. For example, there are still ongoing land ownership arguments in Haiti after all the paper records were destroyed in the recent disaster.

➜ **Education**

The main educational use cases for blockchain technology are in the areas of the verification of academic credentials including micro-credentials termed badges and the storage of student portfolios of work.

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[46] https://www-935.ibm.com/services/us/gbs/thoughtleadership/Internetofthings/

[47] http://www-935.ibm.com/services/multimedia/GBE03620USEN.pdf

[48] http://tinyurl.com/yaj3slex

[49] http://www.coindesk.com/blockchain-land-registry-solution-seeking-problem/

[50] https://www.cryptocoinsnews.com/u-k-land-registry-looks-register-property-blockchain/

In the summer of 2014, the University of Nicosia issued the first academic certificates whose authenticity can be verified through the Bitcoin blockchain to students who successfully participated in or completed a course.[51] This experience was also replicated by the Holberton school later in 2015.[52]

Sony have developed their own new educational infrastructure based on blockchains.[53] This infrastructure is currently being tested in the company's own programs and then be pushed for wider adoption. Although most of the idea still remains undisclosed, it seems that their goal will be to allow students to freely and securely share certain academic parameters (e.g., time taken to answer questions) with relevant parties.

The MIT Media Lab have created a startup Learning Machine[54] where accreditation, stored on the Bitcoin blockchain can be accessed through a smartphone app.
Rather than placing a hash of an accreditation onto the blockchain, researchers at the Open University[55] have developed a native Smart Contract representation for educational badges. Ongoing experiments continue in placing student work onto blockchains and investigating to what extent educational processes can be supported by this technology.

Governance

At the core of a blockchain is a consensus mechanism which ensures that the transactions held within blocks across a peer to peer network remain in sync. There is no central administrator, anyone is free to join, a 'one machine one vote' process facilitates overall governance. On top of this core in platforms such as Ethereum Smart Contracts enable computer code to represent replace financial and legal protocols and constraints. There are ongoing experiments in using these mechanisms for governance at organisational and regional levels.

A Decentralised Autonomous Organisation (DAO)[56] is an organisation that runs through Smart Contracts. The best-known example of a DAO was 'The DAO',[57] implemented on the Ethereum blockchain, for venture capital funding which was launched in 2016 and at its peak had attracting $160M of funding. The key features of The DAO were that it had no conventional management structure or board of directors – just a set of Smart Contracts which were open source. The DAO was stateless which generated a variety of issues.

Bitnation[58] allows anyone to create 'Embassies' to live and work in and 'Consulates' for shared working space. The openness of this platform allows refugees from Syria to gain land registry rights.[59]

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[51] http://digitalcurrency.unic.ac.cy/free-introductory-mooc/academic-certificates-on-the-blockchain/

[52] http://thenewstack.io/one-school-using-bitcoin-blockchain-authenticate-degrees/

[53] https://www.cryptocoinsnews.com/sony-blockchain-education-system/

[54] http://www.learningmachine.com/

[55] http://blockchain.open.ac.uk/

[56] https://en.wikipedia.org/wiki/Decentralized_autonomous_organization

[57] https://en.wikipedia.org/wiki/The_DAO_(organization)

[58] https://bitnation.co/

[59] https://bravenewcoin.com/news/blockchain-company-helping-syrian-refugees-delivering-on-the-united-nations-vision/

Estonia is playing a leading role in this space too through their own Estonia government developed KSI blockchain.[60] Since 2012, blockchains have been in operational use in Estonia in areas such as national health, judicial, legislative, security and commercial code systems, with plans to extend its use to other spheres such as personal medicine, cyber security and data embassies. They also allow anyone to apply for e-Residency of the country supported by their blockchain platform.[61]

WHAT SHOULD WE MEASURE

There are claims that the blockchain is the most disruptive invention since the Internet[62] or Web[63] - a generic platform for all transactions. Measuring take-up will take a broad variety of measures.
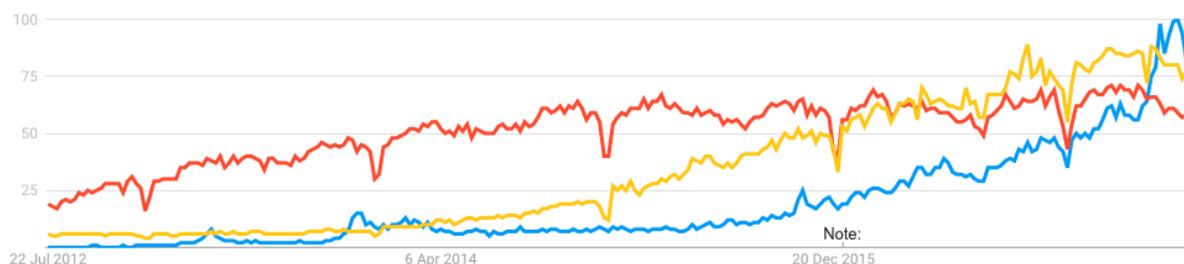

FIGURE 6. GOOGLE TRENDS 'BLOCKCHAIN', 'BIG DATA' AND 'IOT'

One easy way is to look at Google Trends. Figure 6. GOOGLE TRENDS 'BLOCKCHAIN', 'BIG DATA' AND 'IOT' above compares the number of searches for the term 'blockchain' to 'big data' and 'IoT' over the last 5 years.

FIGURE 7. THE VALUE OF ONE BITCOIN

Other ways of observing its impact include:

➔ ***The market value of main currencies such as Bitcoin and Ether*** – obviously, the currency value will reflect the value of the services associated with the platform. Figure 7above shows the value of Bitcoins compared to the Euro over the last 4 years.

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[60] https://e-estonia.com/solutions/security-and-safety/ksi-blockchain/

[61] https://blogs.thomsonreuters.com/answerson/e-estonia-power-potential-digital-identity/

[62] https://www.digitaldoughnut.com/articles/2016/april/blockchain-is-the-most-disruptive-invention-since

[63] https://www.forbes.com/sites/valleyvoices/2015/12/21/why-the-blockchain-is-the-new-website/

➜ ***Number and diversity of the sectors*** – how many and how many different types sectors have blockchains been applied to will indicate the strength of the technology.

➜ ***Number of startups*** – this area seems to be dominated by startups. The Ethereum events attract an audience of over 1,000 most of whom have their own startup. The website Angel Startups lists currently 748 blockchain startups.[64] Note that blockchain startups often work in a different way to standard startups with 'ICOs' (Initial Coin Offerings) allowing investors to buy a new currency associated with a potentially lucrative new service. In this way blockchains are disrupting the startup landscape. An ICO for Ethereum raised nearly $20M making it one of the largest crowdfunded projects ever.

➜ ***Value of the overall market*** – predictions vary but it is generally acknowledged that the overall blockchain market will be in the billions of dollars by the early 2020s.[65]

3.1.8 Ontologies and Semantic Discovery Tools

DESCRIPTION

An ontology is "a specific vocabulary used to describe [a part of] reality, plus a set of explicit assumptions regarding the intended meaning of that vocabulary"[66]. Classically, ontologies come from the metaphysics area of philosophy which deals with the nature of reality or of what exists. In computer science, an ontology is a recognised identification and naming of the types, properties, and relationships of the entities that exist for any particular domain. It is thus often a practical application of a naming mechanism using a taxonomy to identify elements. An ontology classifies variables needed for some set of computations and establishes the relationships between them.[67] In the fields of artificial intelligence, systems engineering, software engineering, biomedical informatics, information architecture ontologies are used to organize information and limit complexity by providing a shared meaning for constructs. An ontology can then be applied to shared understanding and problem solving.

The Semantic Web is one of the principal areas that uses ontologies. In the Semantic Web, content is expressed in machine-processable form using ontologies, so that software agents (Semantic Discovery Tools) can discover and maintain it, enhancing presentation, search precision and enabling logical reasoning. According to Berners-Lee, Hendler, and Lassila (2001),[68] the Semantic Web is about "giving information a well-defined meaning, better enabling computers and people to work in cooperation". Linked Data described above has several common features with the Semantic web and will closely be correlated.

POTENTIAL USES

Although the concept of Ontologies and the Semantic Web have been around for decades, they still hold potential value for the future of the Web,

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[64] https://angel.co/blockchains

[65] http://www.marketsandmarkets.com/PressReleases/blockchain-technology.asp

[66] iaoa.org/isc2012/docs/Guarino2009_What_is_an_Ontology.pdf

[67] Gruber, Thomas R. (June 1993). "A translation approach to portable ontology specifications"

[68] The Semantic Web. T. Berners-Lee, J. Hendler, and O. Lassila. Scientific American 284 (5): 34-43 (May 2001)

➜ **White good manufacturing**

In the IoT scenario, where everyday devices, such as cars, fridges and televisions are connected to each other and exchange data. In such a scenario, ontologies can be used to express this data in machine-understandable and interoperable formats for efficient communication between diverse devices. Semantic Discovery Tools can be used on top of this infrastructure in order to discover data, web services and devices that fulfil certain roles and requirements.

➜ **Personal Knowledge Management**

Semantic Web technologies are increasingly being used in personal data management software and social media applications to enhance information published on Intranets and Internet, but also to improve personal information management and direct exchanges between people be they in social contexts or workforces in professional contexts.

➜ **Data integration and Migration**

Given that much knowledge in organisations is stored in relational database management systems, another relevant area for Semantic technologies is to facilitate existing data integration with Semantic Web applications.

➜ **Healthcare**

Healthcare is a good example of where the portability of data can have a beneficial effect. Public data can be compared and shared to improve epidemiologic disease treatment and prevention. Research data can be shared to discover new relationships between existing illness and other medical knowledge. Personal data can be conveyed from one healthcare information management system to another allowing people to move between healthcare structures to improve the efficient use of medial resources, to ensure that the medical records follow them and to avoid unnecessary replication or precautionary treatment.

➜ **Transport and Supply Chain Management**

As merchandise moves around physical locations it also moves between physical information systems that manage related description of the merchandise and data about regarding its locations, physical properties, delivery commitments, customers and suppliers. Import, export and lading information is needed by commercial and public entities like customs other public authorities. Ontologies and Semantic web can help operators understand what information is coming moving system and what merchandise is represented.

OBSERVABLE MEASURES

- Number of ontologies developed per month/year

- Number of concepts and instances of each newly developed ontology

- Number of new concepts and instances added to existing ontologies per month/year

- Facts per entity in binary relationships added

- Number of semantic web services and semantic discovery tools developed per month/year

- Number of new smart devices added to the Semantic Web and the IoT per month/year

- Number and quality[69] of ontology engineering tools developed and commercialised

- Number and quality of ontology matching tools developed and commercialised

- Number and quality of reasoning systems developed and commercialised

- Number and quality of semantic search tools developed and commercialised

- Number and quality of Semantic web service tools developed and commercialised

3.1.9 Augmented AND Virtual Reality

DESCRIPTION

Virtual Reality (VR) and Augmented Reality (AR) describes those technologies that a technology that superimposes a computer-generated image on a device's vision of the real world, thus providing a merged image. They provide users with an enhanced or enriched experience by generating artificial surroundings and adding context-aware data to a real-world environment. Although the two concepts are often mentioned together due to the impact to the way how we may perceive the world that we see, hear and feel they are clearly different. VR immerses a human in a computer-generated 3D environment and allows to interact with it by simulating their physical presence. The recent advancements, already available headset products like Oculus Rift, HTC Vive, Sony's PlayStation VR or Samsung Gear VR, show that VR is becoming an important market driver for commercial and mobile devices and will continue to foster investment in research and drive business.

Virtual Reality has emerged as a new form of content and experience where the user is completely involved in the content and can interact with elements of a virtual world. VR has the potential to disrupt the entire media industry providing immersive and interactive experiences that are not possible with current content formats.

VR technologies are being driven initially by the videogame industry. Game consoles are being enhanced with VR capabilities, and VR applications and content are being produced by the game industry. As a result, VR devices are becoming popular and it is expected that they will have significant user penetration very soon. VR for the non-gaming industry (Video Entertainment, Cinema, TV, VoD, media art) appears as a completely new form of content, including a new form of storytelling. The Film and video industries are creating the first platforms and content packages and creating dedicated spaces for exhibiting VR and immersive media at film and media art festivals. Other forms of immersive media, such as dome projection are converging by using similar underlying technologies.

VR media is still in its early stages as many technical, and non-technical issues are not solved yet. The current generation of VR applications has several quality issues that are the result of the limited resolution, low frame rate, and limited Field-of-View (FoV) of the current devices. In addition, there are other unsolved issues such as limited user interfaces and limited interaction capabilities.

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[69] H. Al-Kilidar, K. Cox, and B. Kitchenham. The use and usefulness of the ISO/IEC 9126 quality standard. In 2005 International Symposium on Empirical Software Engineering, 2005, page 7. IEEE, 2005.

The second concept which is AR consists in enriching existing reality with computer-generated information. For example, an AR implementation may enhance camera view in a smartphone placing additional information layers. For 2017 the number of mobile phone users is forecast to reach 4.77 billion, so it is clear that value-added AR solutions will be most affordable and thus ubiquitous. To strengthen the message, it is worth to mention a report from research firm SuperData that by 2020, the virtual reality market will be worth 15 times what it was in 2016 ($28.3B to be precise).

In the next years several advances have to be developed in order to deliver the next generation of immersive media experiences. Technology improvements for better audio-visual experience include: ultra-high definition (UHD) video, support for higher quality image formats including High Dynamic Range (HDR) and Wide Colour Gamut (WCG), higher FoV, seamless interactive personalized media, immersive audio, etc.

POTENTIAL USES

The following paragraphs are areas where augmented and virtual reality can have a large impact:

➜ **Gaming and entertainment**

Virtual reality gaming is revolutionizing the gaming industry. In VR gaming a person can experience being in a multi-dimensional environment and interact with that environment during a game. An essential part of VR gaming is the detection of a person's presence in a game – bio-sensing. Bio-sensing is being realized with a set of small sensors attached to a digital glove, suit or a body to record the body's movement of the person in a 3D space. Additions of virtual elements to the real world in examples like Pokémon Go promise to revolutionize the gaming world.

➜ **Social networks**

Social networks can be summarized as Internet-based applications and services for end users to express opinions and present their perspectives. Current social media are dominated by big players, offering content-based services (e.g. YouTube, Instagram, etc.), social networking applications (e.g. Facebook) or collaborative spaces (e.g. Wikipedia).

Leading industry representatives in the field invest significant efforts in development of future social network use cases. For example, Facebook bought Oculus VR, the most famous virtual reality company in the world, for $2 billion back in 2014. With this investment Facebook attempted to combine the world's leading social networking company with the biggest VR company, and as a result, the users get a promise of a new type of experience, the way to enter the virtualized world via Facebook.

➜ **Healthcare**

Virtual Reality technologies already changed the healthcare experience in many fields. On the one hand, VR allows to present operations in real-time, which makes it open for a wide audience, not limited to those physically involved in the operation. On the other hand, existing VR technologies allow to help patients to release stress and reduce pain while they are in hospitals, or even at home, e.g. using specialized goggles. Moreover, the use of VR can limit the stress of small children who spend their time in hospitals, far away from home, their families and beloved toys. All these technologies yet introduced to the market as proof-of-concept products, have revolutionized the healthcare sector. However, the massive adoption and use of VR in hospitals or home treatment is far from its realization, therefore it can be considered as a key enabler for Next Generation Internet initiatives and projects.

➜ **Tourism**

Virtual Reality can transform the tourism industry. There are big opportunities and potential applications awaiting practical realization in real life-driven use cases in the tourism business. Advanced applications could help the users to make decisions about where to travel, taking advantages of virtual tours through several places considered as travel destinations, before booking their trip.

TECHNOLOGY DRIVEN USE CASES

➜ **Production workflows**

In order to produce high quality content for VR devices that is not CGI, real-life footage has to be obtained. This requires the use of special acquisition devices such as arrays of cameras for panoramic shooting in 2D and 3D formats. Several of those devices already exist on the market ranging from prosumer arrays of action cameras such as GoPro, to professional cinema cameras for panoramas such as the OmniCam.

➜ **Video Coding and Delivery**

Once the content has been produced and post-produced a delivery format has to be created to distribute it to its final users. Existing delivery mechanism such as VoD platforms cannot be used directly as they lack support for panoramic 2D/3D content. Some of them are starting to appear (such as JauntVR, with.in for VR Video/Cinema, and NextVR and VokeVR for live events, and Youtube and Facebook for 360 video). A key part of the delivery chain is video compression. The use of a particular video codec determines the compression performance and this in turns determines the maximum quality offered under some bitrate constraints.

➜ **VR Displaying**

When the content has been selected and received by the client device it has to be displayed appropriately on the VR device. The most important role of the display stage is to ensure that the content intent is preserved as much as possible from the original idea of the content creator. The display process includes decoding the compressed files, the entire restitution of the content from the panoramic planar format to the curved format required by the VR display, and the adaptation to the particular device.

WHAT SHOULD WE MEASURE

Proposed elements which can be quantified in this technology and initiatives using this technology:

- total headset device shipments per year

- cost reduction

- revenue

- number of applications using VR/AR technology available on the market and/or used by users

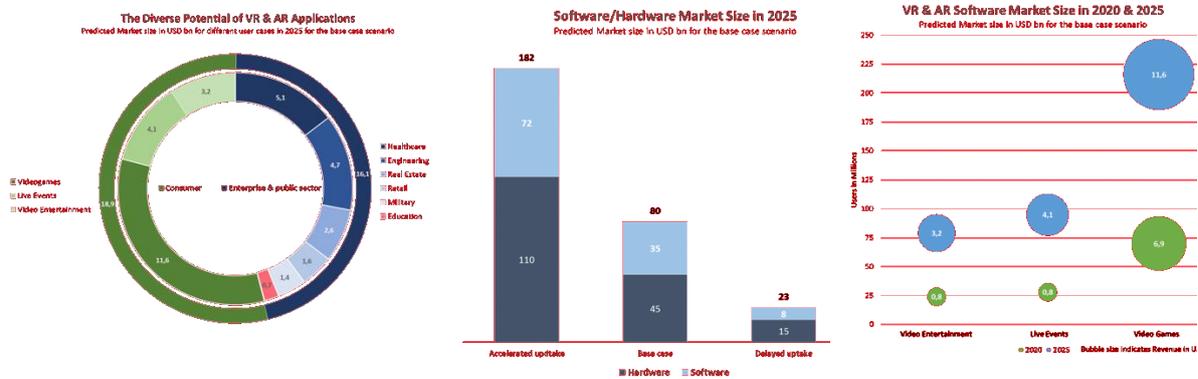- number of new functionalities/implementations/projects within VR/AR technology

POTENTIAL MARKET SIZE

VR and Augmented Reality (AR) have the potential to become the next big computing platform and has the potential to change business models and the ways in which we transact. VR immerses the user in a virtual world and AR overlays digital information onto the physical word. Both are a driving trend towards the adoption of HMDs. The enterprise was the driver of the PC and the consumer was the driver of the smartphone, both forces are at work to drive the VR/AR adoption, with consumer use cases driving the momentum in the beginning. Different market analysis[70,71,72,73] have shown the potential of the entire market and its growth rates:

According to recent industry analysis the worldwide revenues from AR and VR will grow from 5.2 USD billion in 2016 to more than 162 USD billion in 2020. The same analysis shows that the sales of software for AR/VR is growing more than 200% year over year. Similar predictions have been presented by other industry reports.

ABI Research anticipates more than 50 million mobile VR devices by 2020 with a CAGR of 84.5%. Other study forecasts a global user base of more than 275 million in 2025.

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4   INITIATIVE ASSESSMENT AND KEY PERFORMANCE INDICATORS

We intend to monitor the general range of technologies in the NGI and the previous section has given some indication of how we can classify and assess the progress of the most pertinent technologies. However, a key objective of HUB4NGI is to monitor and assess the single initiatives that are funded in the future by the NGI initiative or that are brought to our attention from commission services as well as those that are identified through events including conferences, workshops and literature review. This section describes the methodology we intend to follow for the Assessment of these initiatives identified in HUB4NGI. Initiatives will be monitored across 7 types of KPIs which emphasize how well the initiatives address the goals of the NGI. These types of KPIs are measured according to a number of metrics which contribute to make a KPI for each of the dimensions. As was the case for the focus areas, the KPIs were distilled from the discussion that occurred in the public consultation referred to in section 2.1. Input from the NGI unit and expert opinion of the consortium members was taken into consideration when selecting these dimensions. These initiatives will be assessed to understand how well they perform in the areas of:

1. Innovation

2. Economic Sustainability

3. Technological maturity

4. Market Needs

5. Social Utility

6. User Centricity

7. Ecological Footprint

Each of the managers of initiatives will receive a description of the benefits[74] of participation and will be expected to respond to a short survey in which they perform a self-assessment responding to a series of short closed questions. Each of the questions will provide a metric that will be used to compute a KPI for each of the categories shown above. The single KPIs will be compiled to provide an NGI performance footprint. The KPIs will be measured over time at the initiatives request, to demonstrate progress in their performance and can be adopted by the initiatives for planning and for their reporting processes. The information will be included in the NGI map[75] (a visual catalogue being prepared by the HUB4NGI consortium) and populated over the course of the HUB4NGI initiative.

4.1 METHODOLOGY

The consortium has already invested considerable effort to identify the process, metrics and the KPIs to be measured. This section describes the iterative process for the activities that will be performed during the project. There are seven steps in the HUB4NGI approach, which include:

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[74] Benefits described in section 1, may also include access to project resources, prizes and increased visibility.

[75] https://www.hub4ngi.eu/map/

1. Confirm Metrics - Publish and approve the metrics the KPIs and the process used to measure them with community;

2. Provide Guidelines - Provide rationale, instructions and indications regarding the timing and process;

3. Identify Users - Identify initiatives and enrol pertinent users;

4. Collect Data - Collect data using on-line forms in the HUB4NGI Website;

5. Create Database - Populate NGI database making it available to the consortium that will elaborate and analyse it;

6. Provide Reports - summaries and analyse performance footprints to Initiatives and to NGI policy makers who will use it to make operational and policy decisions;

7. Elaborate Use information to identify areas for improvement and identify potential success stories.

The steps that are depicted in the figure below will be the ongoing work to be performed in Work Package 1 over the course of the project. The activities that are expected are described in the following paragraphs.
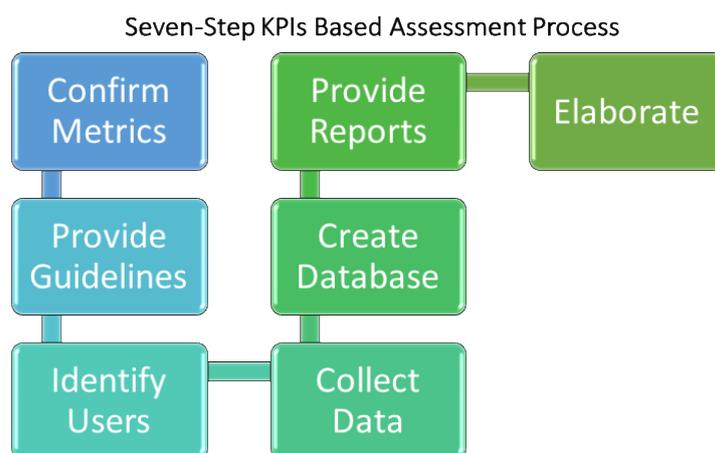
Seven-Step KPIs Based Assessment Process

FIGURE 8. KPI METHODOLOGY

STEP 1 CONFIRM METRICS: The metrics and KPIs proposed in this document are the result of expert opinion. The approach to decide what is important to measure is based on:

1. The objectives of the NGI program;

2. The specific measures that can potentially be measured in the Focus Area Technologies;

3. Measurable elements that would give the best evidence of performance in Initiatives;

4. The metrics that specify the operational details of the single initiatives.

The approach is based upon good industrial practice and has been discussed and agreed upon in the consortium, however it is important in any KPI process that the approach and measures be widely accepted by the community. Acceptance of the measurement criteria is the principle factor that will lead to participation. This deliverable (D1.1 NGI Classification and

Assessment Methodology) when circulated and commented by the community will achieve this goal.

STEP 2 PROVIDE GUIDELINES: This document provides the rationale and explanations of who is expected to perform activities in this process and the timing that they are expected to respect. More specific guidelines for the single data collection instances during the phase of surveying is made available in the web form complete by the single initiatives. Each form filled in will have a general instructions introduction and detailed descriptions of the information being collected, the calculation and the use of the metrics in generating the KPIs.

STEP 3 IDENTIFY USERS: The NGI community and the HUB4NGI consortium will be active in defining the stakeholders and a process to identifying initiatives that receive funding from the European commission. Each of the initiatives that receives funding from the European Commission will be contacted after they have received a contract and invited to complete the survey. Additional stakeholders from other programs and from industry will be identified through NGI events and related seminars workshops and conferences where HUB4NGI partners are present. These contacts will be catalogued, and invitations will be extended to these actors to complete the survey.

STEP 4 COLLECT DATA: Stakeholder initiatives will be contacted via email using HUB4NGI mailing lists and potential survey respondents will be requested to complete the survey. Respondents will be given a permalink to the data collection form. Questions will be concise, but descriptions will be included to avoid misinterpretation. The process of collecting performance data is critical to its integrity. To be sure that the data collected is "fit for purpose" the data for each of the surveys will be considered useful if at least 80% of the questions are answered. Incomplete (below 80%) surveys will generate a request for completion but after 10 days from the second reminder will be discarded.

STEP 5 FEED DATABASE: Data coming from the forms will be extracted into an excel format. Data will be normalized, and outlying data will be removed. Data cleaning will be limited through the use of closed question principally numerical responses. Excel tables will periodically be batch imported into the HUB4NGI database that has been prepared to receive this data. Access to the database by HUB4NGI analysts will be available for extraction and analysis according to the access policy of HUB4NGI.

STEP 6 PROVIDE REPORTS: After each initiative has performed the KPI Survey a report is provided immediately after completion showing the footprint of the respondent against the overall KPI assessment framework. This confidential report will show the respondents score on a standardised five-point scale in each of the KPI areas going from a low score 1 (lagging) to the maximum mark (excelling). The footprint will be detailed for each of the category and presented as single and cumulative radar graphs as seen in the example in Figure 9 serving as guidance for initiatives, depicting where progress can be made (comparison of own score with community averages and target scores) thus providing a roadmap for the initiative to plan where they could invest resources and where they could improve. The maximum score in each of the areas can be seen as a target for the initiatives and provide an idea of when the exercise should be repeated to assess progress.
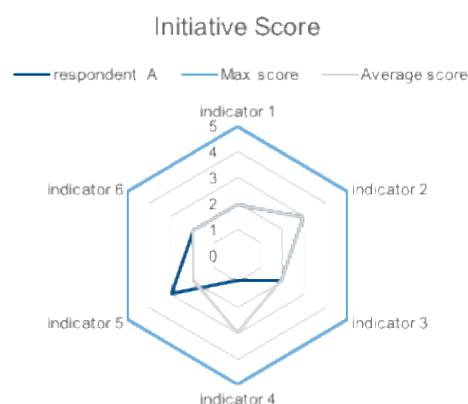

FIGURE 9. PROJECT SUMMARY SCORE REPORT EXAMPLE

Each of the individual reports will later be used to develop aggregate reports for all initiatives in each of the focus areas and across the KPI dimensions. They will have been stripped of any personal data regarding respondents or initiatives and automatically contribute to overall program performance developed on the portal without referring to the particular initiatives. The portal will offer an aggregated dashboard view as per the purely demonstrative example in Figure 10 below.
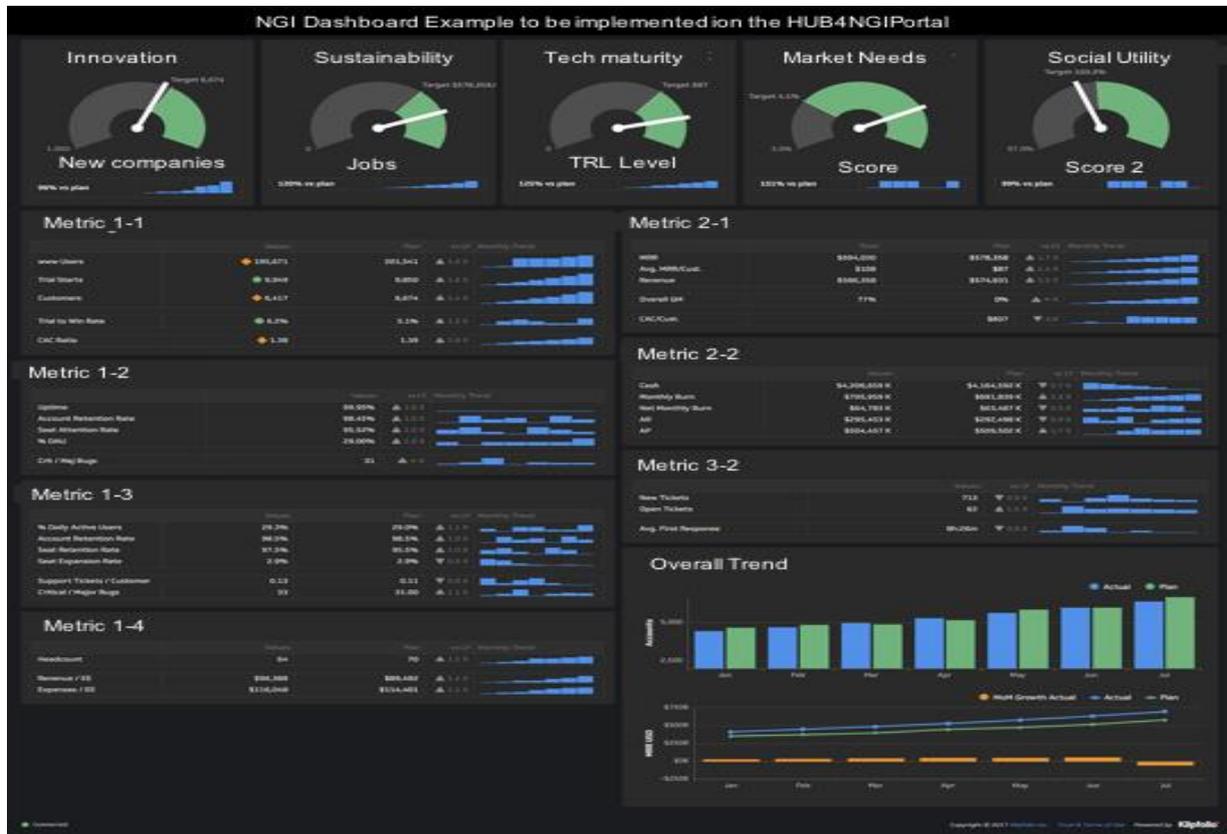

FIGURE 10. EXAMPLE NGI KPI DASHBOARD

4.1.1 KPIs: Main Principles

The performance measurement system is aligned with the best practice principles of Performance Assessment and Benchmarking, building on the extensive experience of the partners in the consortium.

To insure the efficiency and effectiveness of the KPIs the system was envisioned to have the following practical attributes, which are aligned to best practice Impact Assessment methods:

➜ **Comparability** between all NGI Initiatives;

➜ **Flexibility**, to adapt to the evolving context of NGI technologies (so that it can potentially remain usable also after the end of the HUB4NGI project);

➜ **Reliability**, both for the scientific quality of the methods used to calculate the indicators and for the quality of the data used to measure them;

➜ **Feasibility and sustainability**, with a reasonable balance between (repeated) data collection and elaboration costs and the value added guaranteed by the indicators;

➜ **Clarity and Transparency:** calculation methods are based on proven methodologies, clearly documented, and the meaning of the indicators is unambiguous.

➜ **Representativeness,** the data represent a balance of experiences across the measured initiatives, taking into account their differences and specificities.

4.2 KEY PERFORMANCE INDICATORS FOR INDIVIDUAL INITIATIVES

The KPIs that have been developed span the areas which were highlighted as important for the monitoring of the program. Initiatives that will be identified in the course of the HUB4NGI project and after the lifetime of the project in further program monitoring activities are expected to use the framework provided here. The following table provides an overview of the KPI categories used, how they will be measured and the type of output that will be provided for each of the initiatives:

TABLE 1. INDIVIDUAL INITIATIVE ASSESSMENT KPI OVERVIEW

KPI category	Measures	Type
Innovation	Innovation Pace Originality Sectorial Innovation Public Innovation Policy Level Strategic Innovation Organisational Support for Innovation	5-Point Scale
Economic Sustainability	Total Funding Needs Sources of Funding Adequacy of Planned Funding	Low to high continuum
Technological Maturity	Temporal Maturity Stability Stage of Adoption Development Pace Reliability	Adapted TRL Score

	Future Development and Support	
Market Needs	Satisfaction of Consumer Market Needs Satisfaction of Enterprise Market Needs	Raw Score Comparison to industry Benchmark
Social Utility	Health, demographic change and wellbeing Beneficial Impact on Environment Beneficial Impact on Energy Beneficial Impact on transport Environmental Efficiency Inclusiveness	Initiative Footprint 5-point Scale
User Centricity	Individual and Personal improvement User interaction User learning User satisfaction User costs Use of Personal Data	Initiative Footprint 5-point Scale

Each of the following sections describes a single KPIs. Each section includes the logic as to why they are included. Each of the chapters provides the questions that will solicited via survey to provide the metrics that will calculate the given KPI. Each of the chapters also describes how the KPI will be calculated and how the results will be represented.

4.2.1 Innovation

According to the Oxford Dictionary, Innovation is the process of "mak(ing) changes in something established …by introducing new methods, ideas, or products[76]. The Innovation

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[76] https://en.oxforddictionaries.com/definition/innovation

indicator expresses the level of originality introduced by the initiative as an idea or concept. The single measures are used to create an innovation indicator but are also correlated to the calculation of the Technological maturity and Market Needs Indicators.

DESCRIPTION

Alone the level of innovation in an initiative is neither essential nor irrelevant. When contextualized in a specific NGI Focus Area, adopting a particular technology, with a specific vertical sector orientation or adopting a particular business model, the value of innovation can be significantly important. For example, in a vertical market such as desktop operating systems where the market is very mature, there are few market players and there is very little yearly change in market share from one player to another. Substantial innovation in terms of either technology or value proposition will make the contribution to NGI goals more attractive. However, in a market like logistics applications with a large number of actors and substantial yearly change among market offerings, the suitability to existing customer needs and the identification of potential customers may outweigh the need for it to be considerably innovative. An innovative initiative can make a significant Impact on the NGI goals if it has a high technological maturity score (see Technological Maturity section on page 52) and is ready to be implemented in an NGI context, but could conceal substantial engineering, planning, development and testing risks if the initiative is still in the "back of napkin phase"[77]. Additionally, new product and service concepts can be concrete and realistic or conversely can be unrealistic. A lot of innovative product and service ideas have a technology horizon far beyond the proposed 2025 horizon to support NGI goals or potential needs. If the ideas being developed are shared among research groups and perhaps national or international technology development strategies funds and operational plans, the possibility of being "farfetched" and inapplicable to concrete NGI goals is reduced. Innovation can contribute to impact where it is realistic and part of a shared strategy but can add excessive risk where not clearly applicable to a community's paths and trends. When linked to the market needs KPI and the markets express a strong need for the technology there can on the other hand be great potential for disruption.

4.2.2 Measurement Approach

This section measures the applicability and innovation of the concept via six simple questions:

1. Does your initiative progress the underlying technology domain Incrementally or radically change existing technologies?

2. Has the application of the technology been described in scientific publications or been demonstrated in pilot applications?

3. Does the technology being developed exist but is now being applied to a vertical sector where no such application of the technology has previously been demonstrated?

4. Has piloting of the application of the technology been specifically referenced in National or International technology development strategy funds or operational plans?

5. Is the development of the technology stand-alone or is it addressing a gap in a larger organisational technology development roadmap?

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[77] Harvard Business Review, Steve Blank, May 2016

Co-funded by the Horizon 2020
Framework Programme of the European Union

6. Has the initiative been discussed and validated with a board of directors, strategy board, potential Investors or customers?

Each question has at least two possible answers. When answered, each response will contribute to provide an overall Innovation Score for the concept being assessed. Scores will be normalized to a 5-point scale. The score will be compared the corpus of initiatives in the HUB4NGI database and to benchmarks from literature and provide the user with his/her comparison to the average and the benchmark. The user will see his specific Innovation indicator expressed on a continuum from low to high represented on a 5-point scale. And receive a short description of the industry benchmark.

4.2.3 Economic Sustainability

DESCRIPTION

Moving from a research-oriented initiative and developing a market viable initiative requires a steady stream of funds, especially in the early phases of development. For initiatives that are substantial enough to have an impact on shaping the next generation Internet, funding will need to be available over a lengthy period. We use the term "economic sustainability" to refer to the availability of sufficient funds, for a sufficient length of time, for the initiative to remain in existence and to develop fully to fruition.

There are several possible sources of funding, ranging from public sector sources, through academic institutions, to revenues from paying customers. The purpose of this KPI assessment is to determine what sources an initiative is using to fund its activities, and how sustainable those sources are likely to be over the long term.

MEASUREMENT APPROACH

The following questions will be for gauging the economic maturity of the initiatives and technologies being used in these initiatives.

Master question: What are your main sources of funds for sustaining and developing your initiative? Please indicate an approximate percentage for each that applies.

I. Founders of/participants in the initiative

II. Private backers (such as individual investors and venture capital firms)

III. Investors via public stock markets (such as Nasdaq and AIM)

IV. Funding from government organizations or agencies

V. Funding from academic institutions

VI. Revenues from paying customers

VII. Other(s)

Additional questions applying to the numbered answers above:

I. (a) For how long do you expect the founders of/participants in the initiative to continue funding it?

II. (a) how many rounds of funding have you raised to date? (b) how much did each round raise? (c) what is your roadmap for further fundraising?

III. (a) When did the IPO(s) that form the basis of your public investment funding take place? (b) What percentage of equity was sold in the IPO(s)? (c) How much did the IPO(s) raise? (d) Are further IPOs expected?

IV. (a) Please state which organizations or agencies are funding your initiative (b) When did the funding program(s) commence, and for how long will they continue?

V. (a) Please state which institutions are funding your initiative (b) When did the funding program(s) commence, and for how long will they continue?

VI. (a) What has been your pattern of quarterly/annual growth in revenue relating specifically to the initiative? (b) What is your forecast for future revenue growth? (c) If applicable, what is the percentage breakdown in your revenues between one-off purchases/licenses and ongoing subscriptions?

VII. (a) please specify and briefly describe the other sources of funding for your initiative

Each master question will be answered with a percentage of total necessary funds or a "not applicable" answer. When all applicable choices are complete, each response will contribute to provide and secured funding assessment considering a five-year secured funding horizon benchmark ascertained from literature. Initiatives will be compared the rest of the collected initiatives in the HUB4NGI database and if possible to benchmarks coming from literature. Results will be provided to the user with his/her comparison to the average and to the benchmark. The user will see his specific Economic Sustainability indicator expressed on a continuum from low to high.

4.2.4 Technological Maturity

DESCRIPTION

Technological Maturity describes the status of the technology at the heart of the initiative being assessed in terms of its development, adoption and reliability.

Maturity in a technology is neither an unambiguous asset nor an unambiguous liability. It has both advantages and disadvantages. The balance between these will vary according to what the technology is being used for, and what expectations users have of it.

Positive aspects of maturity in a technology include:

➜ Stability. A mature technology provides a firm platform upon which to build an initiative. It will be known to work properly and reliably, and major faults will have been ironed out during earlier stages of its development.

➜ Widespread adoption. To survive long enough to reach maturity, a technology needs to have been adopted by enough of its target market to make it economically sustainable.

➜ Ecosystems. A mature technology with widespread adoption will attract a diverse range of companies wishing to use it in products and services, and to develop it in various directions in response to market needs.

➜ Risk management. Having become established as something that is widely adopted and that works well, a mature technology represents a relatively safe bet for investment from those looking to adopt it for use or development.

➔ Talent availability. The more mature a technology is, the more numerous – and therefore easier and cheaper to recruit – practitioners with relevant skills are likely to be.

Negative aspects of maturity in a technology include:

➔ Market homogeneity. It is harder to use a mature technology than an emerging technology as a basis for building sustainable differentiation against competitors

➔ More cumbersome development. As a technology becomes mature, the process of making changes to it involves an increasing number of interested parties, such as end users and companies that have built the technology into its products and services. The more interested parties there are, the harder it is for technology changes to satisfy them all, and thus the slower the process of making changes become.

➔ Vulnerability to being superseded. As the development of a mature technology gets more cumbersome, the likelier it becomes that a technology will emerge addressing the same needs in a better way – e.g. it may be easier to use, or cheaper to maintain.

➔ Less scope for a breakthrough. Development takes place along more predictable lines as technologies become more mature, reducing the likelihood of improvements that radically transform how effectively the technology satisfies market needs.

Although it is not necessary from the definitional aspect, maturity in a technology tends to be indicated by acquisition of the status of a standard in its area of application. This gives prospective buyers greater certainty about the soundness of their technology purchase, and developers greater prospect of a large addressable market for products and services built on the technology. A technology's status as a standard can either be:

➔ *De jure* – the technology is the result of, or has been adopted by, a recognised standards-making body, with development of the technology taking place through that body's processes and procedures. Examples of such bodies in the technology field include the Institute of Electrical and Electronic Engineers (IEEE), the Internet Engineering Task Force (IETF) and the European Telecommunications Standards Institute (ETSI)

➔ *De facto* – the technology has been adopted by a sufficiently large fraction of its target market to be considered a standard in practice. The fraction is debatable, but one-third is a reasonable rule of thumb. Examples of technologies that have acquired *de facto* standard status include Microsoft's Windows operating system for personal computers and Google's Internet search engine. It is important to note that *de facto* standard status can change quite quickly: for example, Microsoft's Internet Explorer was once the predominant web browser, but other browsers such as Google's Chrome and Apple's Safari now have larger shares of the market.

In assessing the maturity of the fundamental technologies in an initiative, we will consider several aspects of the technology's nature, including:

I. How long the technology has existed: the longer a technology has been in existence, the more mature it is likely to be;

II. What stages of adoption the technology has passed through? Is its use mainly confined to laboratory/experimental applications? Is it being used for prototyping? Is it being widely used as the basis for commercial products and services?

III. How quickly the technology has passed through the various stages of development. If a technology's performance and capabilities are improving less rapidly now than

they have previously done, that would indicate maturity. The answer will be months in last three TRL stages;

IV.   The reliability of the base technology will be assessed by determining the number of other initiatives, domains and vertical sectors where the technology is already being applied: technologies that are more widely adopted in other initiatives, applications and domains demonstrate maturity. Answers will be integers with one point for each external use of the technology at the heart of the initiative.

V.   Whether its future development is likely to be evolutionary or revolutionary in nature: the more mature a technology, the more likely that developments will be incremental in nature, rather than radical changes in the technology's capabilities and performance. Innovation question number one will automatically populate this field.

MEASUREMENT APPROACH

We propose the following questions for gauging the maturity of the technologies being used in initiatives.

I.   What are the main technologies that are being used in your initiative? The answers will be based on the classification mechanism described in section 3, and will be used to calculate the response to questions two and three of this section.

II.   For how long have these technologies been in existence? The answer distilled from literature, the IDC Black Book and the IPO classification and will be expressed in years.

III.   How many versions of those technologies have been released to date? The answer will be an integer.

IV.   For each of these technologies: is its development governed by one or more recognized standards-making bodies (e.g. IETF, IEEE, ETSI)? An on/off answer is expected.

V.   Are any of these technologies unavailable from commercial vendors? In cases where the answer is "yes", are these technologies sourced from outside your organisation, or did you develop them? This is a yes/no question where the positive answer will generate an additional sourced/developed response.

VI.   When you chose these technologies, were there any viable alternatives for the role that they play? In cases where the answer is "yes", how many others did you consider before selecting the one that was chosen? What were the main criteria that guided your choice?

This series of questions is essential for the cataloguing and statistical analysis of the initiatives according to the HUB4NGI classification methodology. In case of a lack of response or for control, the first question will be able to generate the following two. The last three questions will provide numerical answers and each response will contribute to provide the Technological Maturity assessment. Initiatives will be compared the collection of initiatives in the HUB4NGI database and to a benchmark derived from literature. The user will see his specific Technological Maturity indicator expressed on a range from low to high, represented as a TRL level taking into consideration factors including Temporal Maturity, Stability, Stage of Adoption, Development Pace, Reliability, and Future Development and Support.

4.2.5 Market Needs

DESCRIPTION

An initiative has the best chance of succeeding and growing if it does one or more of the following:

➜ Satisfies an existing market need that is currently unsatisfied

➜ Satisfies an existing market need more effectively than existing means

➜ Satisfies an existing market need more cheaply than other means

➜ Satisfies a market need that is expected to arise in the future

Market needs can arise from economic factors, such as changes in people's desires, behaviour or circumstances; or changes in the competitive environment of businesses. Needs can also arise from the actions of governments and regulators. Examples in the technology sector include:

➜ Restrictions on access to additional radio spectrum giving rise to the need for wireless connectivity technology that uses radio spectrum more efficiently

➜ More stringent requirements regarding the protection of people's personal information giving rise to the need for improved data security technology

MEASUREMENT APPROACH

This question is answered either for initiatives that cater to enterprise needs or those initiatives that cater to consumer or citizen's needs. Data will be imported from the first question in Technical Maturity and a qualifying question from the general classification based on IDC Black Book will ascertain the vertical sector most applicable to the imitative.

➜ **For initiatives addressing the enterprise market**

There is only one Master question which will assess the main expected needs the initiative will satisfy in its target market(s). When answering this question, respondents will self-assess how well their initiative responds or will respond to real needs coming from industry. The possibilities are included in IDC "Enterprise Needs Data" and include:

• Reducing operational costs (including energy efficiency)

• Improving sales performance

• Improving marketing effectiveness

• Enhancing customer/citizen/patient care

• Innovating the products/services sold/provided

• Strengthening multi-channel delivery strategy

• Simplifying regulatory tasks/compliance

• Improving data protection

- Increasing use and distribution of open data

- Improving scalability of existing tools

- For Initiatives addressing the consumer market

There is only one Master question which will assess the main expected needs the initiative will satisfy in its target market(s). When answering this question, respondents will self-assess how well their initiative responds or will respond to real needs coming from industry. The possibilities are included in IDC "Consumer Needs Data" and include:

- Enabling communication/collaboration

- Entertainment

- Improving quality of life

- Simplifying daily tasks

- Reducing/saving time

- Having easier and faster access to information/services

- Saving money

This question will compare responses to a database of similar responses and provide a numerical correspondence to expressed needs. Responses will provide the Market Needs assessment. Initiatives will be compared the corpus of initiatives in the HUB4NGI database and to a benchmark derived from IDC studies. The user will see his specific Market Needs indicator expressed on a range from low to high, represented on a 5-point scale.

4.2.6 Social Utility

DESCRIPTION

"Utility" is defined as: "The fact, character, or quality of being useful or serviceable; fitness for some desirable purpose or valuable end; usefulness, serviceableness."[78]

Its key element is thus usefulness. In most economic cases, utility is judged by the consumer of a good or a service, and can take many forms, for example different quantities of the same good for the same price may differentiate between two purchase options, or less tangible qualities such as enjoyment or happiness.

Social utility can be defined as utility (usefulness) applied to a community, as opposed to a single individual.

When evaluating an NGI initiative as to its social utility, we must therefore consider its benefits to the collective society, rather than on benefits to individual citizens or users. As with consumer utility, these benefits can take many forms, and it is impossible to list all of them here. Instead, here we discuss classifications of factors that may be used to evaluate an NGI

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[78] http://www.oed.com/view/Entry/220771

initiative and suggest examples of factors that may be members of a classification group, in the form of questions. The classification groups are influenced by the Horizon 2020 Societal Challenges79. These are below for reference, but the classification groups focus on social utility properties of the NGI specifically:

➜ Health, demographic change and wellbeing

➜ Food security, sustainable agriculture and forestry, marine and maritime and inland water research, and the Bioeconomy

➜ Secure, clean and efficient energy

➜ Smart, green and integrated transport

➜ Climate action, environment, resource efficiency and raw materials

➜ Europe in a changing world - inclusive, innovative and reflective societies

The key evaluation criterion for each classification group is the answer to the question: "how does the initiative contribute to the classification area?" The classification groups are described below, along with some exemplary questions. In many cases, not all questions will be applicable, and in some cases, whole classifications may not be applicable. This is acceptable, since there will be a multitude of NGI initiatives covering many different applications and benefits.

Health and wellbeing. The population's health and wellbeing are clearly of paramount importance, and the NGI initiative can contribute to these factors. This section pertains to the general health and wellbeing of society, as opposed to the health and wellbeing of individual citizens as this is covered in the User Centricity section. The key questions concern the overall health, fitness and family life of the population.

- Does the initiative support the overall fitness of the European citizens? How?

    ▪ Is there a differentiation between fitness as leisure activity, and as an activity to improve health, or both?

- Does the initiative improve the overall health of the European population? How?

    ▪ Is there a differentiation between medical approaches, and ways of changing the life-style of the European citizens, or both?

- Does the initiative support family life? How?

    ▪ What is its impact on families (from quality of life to single-parent households)?

Food Security. This is less relevant to the NGI than other classifications due to its focus on agriculture and the bio-economy, but the NGI may be able to contribute through areas such as supply chain optimisation and security, so the key question still applies:

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79 https://ec.europa.eu/programmes/horizon2020/en/h2020-section/societal-challenges

- Does the initiative support sustainable food supply and / or reduction of food waste? How?

Secure, clean and efficient energy. While the main aim of the classification concerns research and development into sustainable and clean energy, the NGI can contribute to this area indirectly, e.g. via smart energy management through IoT devices. The key question therefore remains:

- Does the initiative support clean, efficient, sustainable energy? How?

Transport. The NGI clearly has connections to transport applications, such as the use of AI in autonomous vehicles, and integrated traffic management in smart cities. Key questions include:

- Does the initiative contribute to smart vehicles? How?

- Does the initiative support greener transport? How?

- Does the initiative support greater integrated transport? How?

Environment & resource efficiency. This group concerns how the NGI can contribute to the protection of the environment and the efficient use of finite resources. The sustainable use of finite resources and reduction of waste is becoming ever more important as the population density increases unevenly. Key questions concern the initiative's contribution to different forms of sustainability and how the environment is protected:

- Does the initiative contribute to the reduction of waste of finite resources? How?

- Does the initiative contribute to the protection of the environment? How?

Inclusive, innovative and reflective societies. This group concerns how the NGI initiative supports communities on the Internet, how they can be created and sustained, and how the initiative can enhance and support real-world communities. People have ever more immediate access to many different kinds of communities, from local groups on Facebook, to special interest forums. Key questions regarding how the initiative can support communities include:

- Does the initiative utilise the ever-increasing speed of communication and the ubiquity of connection to positive effect? How?

- Does the initiative promote inclusion? How?

- Does the initiative support collaboration? How?

- Does the initiative enable discovery of new people and communities? How?

- Does the initiative differ from the social networks that already exist? How?

Safety & Security. This group concerns the specific protection of Internet users from its dangers, e.g. malicious attacks or data loss. Key questions concern how the NGI initiative protects users.

- Does the initiative contribute to the perceived security of communities, neighbourhoods, and housing? How?

- Does the initiative contribute to protection from attacks such as cyberterrorism, identity theft, fraud, cybercrime and cyberbullying? How?

In addition to the classifications above, other areas specific to the NGI are relevant. These are discussed next.

Knowledge & Learning. The Internet is a major source of information easily accessible to society. This has major potential for the benefit of society, but there are risks associated with verifiability of information. Some key questions for evaluation include the following.

- Does the initiative enable access to relevant information? How?

- Does the initiative address challenges of bias or information veracity? How?

- Does the initiative support Generativity? How?

- Does the initiative support e-learning? How?

MEASUREMENT APPROACH

Data collection will be performed by simply asking the respondent a series of yes/no questions to which either a 1 or a 0 will be allocated. The qualitative "how" responses are aimed at providing evidence to the overall determination of a score that assesses the initiative's contribution to the classification area.

The respondents' answers will not generate a score as in previous KPIs but rather provide a Social Utility footprint KPI showing on a radar diagram where they cover social questions, however a benchmark will be provided that compares the user results to the rest of the database respondents.

4.2.7 User Centricity

DESCRIPTION

User centricity describes how well a technology, product or service responds to the needs and aspirations of the users of that application or service. User centricity is specifically engineered at design time and is a critical element in the development of systems, specifically aiming to enhance user experience. Understanding the needs, wants and limitations of end users must be given extensive attention throughout the design process.

HUB4NGI specifically focuses on the utility, experience and costs of the NGI initiative from the perspective of the individual user, rather than from the overall community's perspective. The experience aspect cover's the user's perception of the initiative and the point of delivery, and costs cover anything that the user has to give up using the initiative. This KPI takes inspiration from the EXPERIMEDIA80 approach to user-centric design. The following criteria are aimed at capturing the user's experience of using an NGI initiative.

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[80] Serrano, Isaris, Schaffers, Domingue, Boniface, Korakis. "Building the Future Internet through FIRE." (2017).

Well-being and Quality of Life. The citizen's wellbeing may be positively affected by their use of the initiative.

- Does the initiative positively affect the user's health or fitness?

- Does initiative enable the user to engage with other people in ways that would not be possible without the application or the Internet?

Enjoyment and entertainment. One of the main uses of the Internet for citizens is for entertainment and enjoyment, whether this is through delivery of media content or social media, for example.

- Is the user expected to be entertained by the initiative?

- Does the user interact with others?

- Does the user play a game?

- Are leisure activities enhanced by the initiative?

Quality of experience. The International Standard Organisation81 (ISO 9241-210) defines User Experience as "a person's perceptions and responses that result from the use or anticipated use of a product, system or service", and the quality of experience is a key factor in user centricity as it reflects the user's perception and opinion of the initiative as delivered to them. At deployment time, polling users (or samples of users) is expected to be the key mechanism for assessing quality of experience. Satisfaction of the user - feedback about relative satisfaction with their experience covering aspects such as utility, emotional, subjective, economic, usability and usefulness - is obviously important but highly subjective and depends on the application and the experience expected.

- Is there a process to ascertain if users are satisfied in their experience with the initiative?

- Is there a process to ascertain if the user has the experience they expected, or if the experience was delivered better or worse than expected?

- Ease of use – is the initiative expected to be easy to use for the end users?

- Is there a process to ascertain the ease of use?

Learning. A key goal of many NGI initiatives is that the users emerge having acquired knowledge or achieved improvement of a skill or ability. Augmented and Virtual Reality tools are gaining in popularity for improving skills and e-learning applications aim to improving citizens' knowledge.

- Can the user learn a new skill?

- Can the user practice and improve a skill they already have?

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[81] ISO 9241-210:2010 Ergonomics of human-system interaction -- Part 210: Human-centred design for interactive systems -https://www.iso.org/standard/52075.html

- Does the user receive any official recognition for their learning achievements?

Personalization. The user might be able to tailor their experience to maximize their satisfaction. This can include inviting friends to participate in a group experience or customizing the experience to suit their preferences, for example.

- Is it possible for the user to customize their experience?

Community and Collaboration. The user-focused version of collaboration addresses the individual user's relationship to a group, in terms of interpersonal relationships, social interaction, group dynamics (e.g. questions in a group presentation), and group enhancement.

- Does the initiative support communal experiences for the users? (i.e. user can invite groups of users interact via the initiative)

- Does the initiative support collaboration between users, for example to achieve a common goal? How?

Context. The user's environment may be a contributory factor in their experience of the initiative.

- Is the initiative dependent on a certain user environment?

Costs to the user. The user may face costs to experience the initiative. These can range from financial costs, where they pay for a service, the opportunity costs of time and attention during an experience, or indirect costs in terms of loss of right to self-determination (i.e. privacy).

- Are there financial, lost opportunity or self-determination costs associated with the use of the technology, service or product?

Risks. The user may expose themselves to risks when using the initiative.

- Does the user face any risks when experiencing the initiative, over and above their normal use of the Internet?

MEASUREMENT APPROACH

Each of the areas described above will generate a "yes / no" response. As in the previous KPI the responses to the questions will generate a general footprint of the initiative, provided as a radar diagram, and compared to the other data in the database. A general score will be provided rating their performance to a benchmark based the community of respondents in the database and criteria from desk research as well as expert opinion.

4.3 INFORMATION COLLECTION

Initiatives will be identified in collaboration with European Commission services, from previous data collection initiatives from Horizon 2020 and from direct contacts at trade fairs, forums workshops and conferences. Each of the initiatives that are identified will be approached via email and requested to provide responses to a set of questions in the form of an on-line survey. They will be provided with a link with which they can enter information into the tool. The expected time to complete the survey is expected to be less than twenty minutes. Following an incomplete survey, a respondent will be able to access the previous version and complete the information required. When a respondent does not autonomously remember to complete the information a set of three reminders will be sent at three-day intervals.

4.4 TIMING

There are currently very few potential users coordinating initiatives to be contacted. Further information on the timing of the initiative selection and contact plans will be provided in the management report for the project after consultation with commission services. This will occur after this deliverable has been released.

5   CONCLUSIONS

The primary objective of this deliverable has been to create a classification scheme and a performance measurement framework to observe, quantify and describe progress of the NGI as it moves forward over the next several years. To do this we have described the objectives of the NGI program and depicted the focus areas that have come out of the public consultation and discussions with the European Commission as these are the areas we will be observing. This document has highlighted the technological focus areas and the classification mechanism we are using so that the technologies and vertical implementation domains of the initiatives can be compared. The deliverable has provided a performance assessment mechanism to assess the initiatives that will be funded by the European commission as well as initiatives that are harvested from the wider community.

The next step will be to actively search for initiatives and employ the methodology. We will first prepare a test survey and an interview guideline to test the types of data collection and classification mechanisms described in the document. The results will either confirm the classification scheme and questions in section 5 or will lead to slight adaptations. At this point an on-line survey will be prepared in the HUB4NGI portal.

NGI research initiatives are not yet started and it is premature to start collecting data, but it is correct to start at this early phase in the NGI program so that we will have time to perfect the data collection and classification scheme. Starting now, when the first initiatives are launched they will be able to be categorized, catalogues and assessed. In this way, the results generated in the program can be assessed in a transparent manner and the knowledge generated can be shared with the widest possible community.