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A typology, method and roadmap for HUman-MAchine NEtworks

Deliverable D4.2

Roadmap of future human-machine networks

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Abstract	A key outcome of the HUMANE project is a series of policy roadmaps which show a clear path for improving Human-Machine Networks (HMNs) in different social domains. In order to achieve this, we need to examine the broader impact and implications of HMNs in these social domains, the technical and regulatory challenges, and policy interventions that can help to overcome these challenges and accomplish the desired design goals. In this deliverable, we present the process for developing these roadmaps (roadmapping process) and a first version of roadmaps for three selected social domains: the sharing economy, eHealth, and citizen participation; all of these domains embrace exciting technological applications that promise to give great societal benefits. The roadmaps provide steps toward understanding the short- and long-term higher level goals for HMNs in these domains, and aid stakeholders in recognizing shared goals and their roles in reaching them. Despite focusing on these three domains, the presented roadmapping process is general and can also serve as a model or guidelines for roadmap creation in other domains.

Key-words	Human-machine networks, roadmapping process, roadmaps, sharing economy, eHealth, citizen participation, stakeholders, future-thinking

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Definitions and abbreviations

Abbreviation	Definition
CC	Collaborative Consumption
DSCP	Differentiated Services Code Point
ECG	Electrocardiography
EHR	Electronic Health Records
EU	European Commission
HMN	Human Machine Network
H2H	Human to Human
H2M	Human to Machine
ICT	Information and Communications Technology
IPTV	Internet Protocol Television
ISPs	Internet Service Providers
IT	Information Technology
MPLS	Multi-Protocol Label Switching
NGOs	Non-Governmental Organisations
QoS	Quality of Service
SWHS	Smart Wearable Health Systems and Applications
S&T	Science and Technology
VLAN	Virtual Local Area Network
WHO	World Health Organization

Executive summary

In the emerging hyper-connected era, work, private life, civic engagement, creativity and innovation are increasingly conducted in communication networks consisting of humans and machines. Machines interact with humans in increasingly important ways, in almost every aspect of human life and society: economy, health, work, governance, as well as human relationships. This has been the motivation for defining and analysing Human-Machine Networks (HMNs). In the course of the HUMANE project, we provide a framework and method for classifying and analysing the characteristics of such networks, and study how we can inform design and policy making so that we maximize societal benefits.

In previous work of the HUMANE project, we have examined the broader impact and implications of HMNs in social domains, the technical and regulatory challenges that we encounter, and reported on policy interventions that can help to overcome these challenges and accomplish the desired design goals (D4.1). In doing so, we have improved our understanding of the characteristics and implications of HMNs, the roles of humans and machines and their interactions. Building on this work, we in this deliverable develop roadmaps for future HMNs in different social domains (selected out of D4.1), focusing on the goals to reach in each domain and the steps to achieve these goals.

The chosen domains that we focus in this deliverable are: the sharing economy, eHealth and citizen participation. These are domains embracing exciting technological applications, which promise to bring great benefits to the economy and society. We present a roadmapping process adapted to the context of future thinking and policy making for HMNs. This process is applied to develop roadmaps for the three domains selected, but is general and can serve as a model or guidelines for roadmap creation in other domains. The roadmaps can be seen as a step toward understanding the short- and long-term higher level goals for HMNs in various domains, and thus aid stakeholders in recognizing shared goals and their roles in reaching them. This is the goal to reach within the upcoming work in HUMANE (in the context of D4.4).

The sharing economy roadmap highlights an area that has seen rapid economic growth in recent years and has expanded into new sectors (such as transportation, goods, hospitality, and media) and new markets around the world. The roadmap for eHealth focuses on personalized eHealth systems which allow for monitoring the physical states and activities of humans using mobile or wearable technologies. The citizen participation roadmap focuses on how social media can be used to enable members of the public to engage with elected representatives and participate directly in the democratic process. All the three roadmaps highlight interesting challenges and opportunities for policy making that account for structures of both humans and machines.

For this version of the deliverable, we present the process based on which the roadmaps are developed (roadmapping process), and a first version of the roadmaps. The roadmaps follow the common structure that is defined in the roadmapping process, but have been developed independently by different consortium partners. As a result, they are currently at different development stages. We provide a detailed description of the work so far, and the remaining work to finalise the roadmaps (D4.4).

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1 Introduction

The Internet is currently undergoing a major transformation: from a network of interconnected computers that simply allowed access to each other's information, to an "Internet of services" (Cardoso, Voigt, & Winkler, 2008) and an "Internet of Things". It is driven by the advanced possibilities brought by web technologies for service provisioning, and the ability to interconnect objects and machines that collect information from the environment and interact with humans and the physical world (Gubbi, Buyya, Marusic, & Palaniswami, 2013). This transformation is expected to have a tremendous impact in almost every domain of human life and activity. Applications in healthcare, home entertainment and security, road traffic management and logistics, emergency services, environmental remote monitoring, utilities and infrastructure, are already being used worldwide, with users spanning from individuals to governments and organisations at national and international level.

This technological evolution also brings changes in social structure. Machines are becoming active participants in business and social processes, indispensable tools for the provisioning of public and private services, can react autonomously to physical world events, and can trigger actions by humans, that in turn impact other humans or machines. A network of communications and interactions is thus formed, composed of both humans and machines. This will inevitably impact human relationships as we know them; machines were initially seen as tools to facilitate human work, while Internet and web applications were a transparent medium to connect people and facilitate communication. However, machines acting as autonomous agents claim a new status in human social structures: analogously to what happens for human beings, socialization among connected objects is envisaged, in which trust and reputation play a major role (Atzori, Iera, & Morabito, 2011).

Exploiting this radical technological evolution to create a smart interconnected society poses a tremendous challenge to policy makers. It calls for a human-centred design that finds a balance among appropriate regulation, industry dynamics, and market receptiveness (Shin, 2014). There exists well-known research on measuring Human-Computer Interaction (Preece & Rombach, 1994), modelling trust between humans and machines (Muir, 1987), for considering what types and levels of automation should be implemented in a particular system (Parasuraman, Sheridan, & Wickens, 2000), and on human-machine cooperation (Hoc, 2000). Within HUMANE, we aim to provide decision tools to support the design and modelling of the interactions between humans and machines. The HUMANE project bases its research on the theoretical and empirical knowledge of social network theory, socio-technical systems, actor-network theory, socio-economics of trust and simulation of human-machine networks.

Within the HUMANE project, we have defined networks composed of humans and machines that interact to produce synergistic effects as Human-Machine Networks (HMNs), and developed a typology[1] of such networks as a basis for supporting future thinking and policy making. Furthermore, we developed and categorized design strategies, and studied key implications of such strategies in terms of experience, motivation, collaboration, innovation, improvement, trust and privacy, which are cornerstones for the organization of social structures. We also plan to develop modelling and

[1] Deliverable D2.2: "Typology and method". Humane Project (2016)

simulation tools for policy modelling and evaluation, which can help assess the efficacy of policies before they are implemented.

Furthermore, in previous work[2] we performed an in-depth study of innovative applications in social domains where HMN applications have a great potential for social change and identified challenges in HMN design, as well as policy interventions that can help to overcome these challenges. In doing so, we have improved our understanding of the characteristics and implications of HMNs, the roles of humans and machines and their interactions. The chosen domains were: the sharing economy, eHealth, citizen participation, workplace robotics, telework, and decision support systems for crowd management. All these domains embrace technological applications, which promise to bring great benefits to the economy and society. They present diverse HMN characteristics, such as the levels of human and machine agency, the human-to-human and human-to-machine ties and interaction strength, or the network size and coverage. By choosing this diverse set of domains, we aimed to explore the major transformations induced by digitalisation in human relations, governance, the economy, the organisation of work, as well as the production of knowledge and social capital.

HUMANE aims to help in the future developments of HMNs by supporting the process of creating roadmaps for domains such as those listed above. We focus on creating roadmaps to guide the policy making process, but they are equally of interest and importance to other stakeholders such as IT experts and domain professionals. In this deliverable, we present a generic roadmapping process, which is broken down into seven clearly defined steps. We also include roadmaps that are under development to help serve as examples for the application of this process. The roadmaps are for three of the aforementioned domains, namely the sharing economy, eHealth and citizen participation. Each roadmap focuses on specific HMN applications relevant to the respective domains, set specific objectives and detail the roles of stakeholders, and finally derive a time plan for accomplishing the objectives.

The structure of this deliverable is as follows: In Section 2 we provide background for this work, including a description of several human-machine networks in different domains in the context of HUMANE. We also provide an introduction to the different types of roadmaps, describe the characteristics of the HUMANE roadmaps and discuss the need for implementing roadmaps of future HMNs. In Section 3 we describe the HUMANE roadmapping process and the steps that the relevant stakeholders need to follow in the form of actions for the roadmap implementation. We also outline the importance of the HUMANE method and tools (developed in D2.2) in designing the roadmaps, as they can readily provide design strategies (i.e., design patterns on a strategic level, not tied to detail implementation but to strategic choices) based on the characteristics of the respective HMNs and provide examples of similar networks in order to choose the most efficient technology solutions. We then briefly present the social domains of the sharing economy, eHealth and citizen participation for which we create roadmaps, and explain the reasons for focusing on these domains. Sections 4, 5 and 6 are the main sections of the deliverable: for each domain we describe the HMN that we focus on, the policy background and regulatory context, the goals and the expected outputs of the roadmap,

[2] Deliverable D4.1: "Report on implications of future thinking". Humane Project (2016)

and the needed design strategies. We also present a detailed outline of required actions by stakeholders, their complementary roles in implementing the roadmap, along with the priorities and timeline for implementation. Section 7 summarizes the findings regarding the HUMANE roadmaps and reports on their status. Finally, in conclusion (Section 8), we summarize the work in this report and discuss the next steps for finalizing the roadmaps.

2 Background

2.1 Human-machine networks

HMNs are networks composed of humans and machines that interact to produce synergistic effects. They have been conceptualized due to the increasingly important role of machines with processing and communication capabilities in modern society; when viewed as agents or nodes in a network, such machines mediate or effect many human actions and exercise significant influence. For example, modern initiatives to address environmental problems are executed in networks involving government, private firms and citizens, but also smart devices and sensor networks. Systems for emergency response and rescue involve complex interactions between sensors, smart machines, and emergency response teams. Education and work is increasingly conducted from a distance using collaborative software.[3]

An individual that lives in such an environment does not only need to learn how to interact with other people, but also how to use or interact with the machines in his environment. The outcome of a human action may in part be determined by the capabilities or constraints of a machine. The study of HMNs is important in order to better design machines so that they fulfill human and societal needs (human-centered design), but also in order to help human societies adjust to the new human-machine environment and maximize positive synergistic effects.

Of primary importance for HMNs is the notion of agency, defined as the capacity of an actor (a human or machine) to perform activities that influence others in the network. In addition, trust development between human and machine actors is very important to be able to seize the full potential of future technology. In previous work, we discussed and demonstrated the impact and trust implications for machine actors in human-machine networks for emergency decision support, healthcare and future smart homes.[4] Other research in HMNs has been done on the modeling and prediction of HMN properties, focusing on robotic systems (Sycara et al., 2013), and participatory aspects of HMNs, by studying the requirements for collaborative environments that engage citizens and companies in finding solutions, activating business markets, and addressing important societal challenges (Boniface, Calisti, & Serrano, 2016).

[3] Understanding Human-Machine Networks: A Cross-Disciplinary Survey. Tsvetkova, Milena, et al. (2015) Available on line: https://arxiv.org/abs/1511.05324

[4] Engen, Vegard, J. Brian Pickering, and Paul Walland. "Machine Agency in Human-Machine Networks; Impacts and Trust Implications." arXiv preprint arXiv:1602.08237 (2016).

2.2 The HUMANE typology and method

Within the HUMANE project we have developed a framework (D2.2) for studying HMNs that consists of a typology of HMNs and a method for creating HMN profiles that can support the analysis, requirements collection, design, and evaluation of such networks. The typology consists of different dimensions, such as human and machine agency, tie and interaction strength, network size and geographical expansion, workflow interdependence and network organization. These are organized into abstract layers of actors, interactions, and layers of network and behavior characteristics. The abstraction helps to identify similarities and differences between HMNs, and understand implications of HMNs (i.e. effects on motivation, trust, shared responsibility, privacy, etc.) that can help to guide the design process. Case trials for the use of the HUMANE typology and framework for the purpose of profiling HMNs have been shown for a crisis management system and a peer-to-peer reselling network (Eide et al., 2016).

The typology also serves as guidance for examining social domains we study in this deliverable. In each social domain, we try to characterize the different HMN dimensions and describe implications of different design practices.

2.3 Roadmaps and roadmapping processes

A roadmap is a comprehensive work plan to meet desired goals in a certain domain. It consists of short- or long-term goals (or both), and specific solutions to meet these goals. A roadmap acts as a reference on which to base a collaborative effort for a complex task, such as the one needed for finding and implementing efficient policies for HMNs. It helps all the involved parties recognize the goals and the steps needed for their achievement, and to better understand their roles and interrelations.

Roadmaps were initially conceived as a decision aid to policy makers on technology issues, and as a support for the management of the increasingly complex science and technology issues (Kostoff & Schaller, 2001). Thus roadmaps are inherently about technological issues. However, there are numerous roadmap applications depending on the type of goals one is trying to achieve and the type of stakeholders who are mainly involved in the implementation. In a published taxonomy of roadmaps (Albright & Schaller, 1998), there was a distinction between the objective of the roadmap (research/understanding, technology development, or administration) and the domain or level of application (product or project level, firm or organization level, industry level, or national/cross industry level).

Another basic distinction can be made between policy roadmaps, business roadmaps and technology roadmaps. In a policy roadmap, we usually have higher-level goals more closely related to desired societal benefits. The main implementers are public administration bodies and policy makers, but there are usually stakeholders from different fields, including technical, legal and economical. In a business roadmap, the goals are usually related to company goals, such as company growth, or the successful launch of a new product. The company personnel is mainly responsible for the implementation, although it may depend on third parties, such as external technology providers, and external factors such as the regulatory framework and the overall financial situation in the country

where it is to be implemented. In a technology roadmap, the goals are usually limited in scope (although they may exceed the technological scope) and specific technological solutions help meet these goals. The main implementers are technology creators and providers, although other third parties and external factors can also play an important role.

Sometimes the lines between the roadmaps are very thin. For example, policy and business roadmaps most often use technology solutions, but also a business or technology roadmap can sometimes use policy means (e.g., a change in a regulation) to accomplish the goals. However, the distinction exists and knowing what kind of roadmap is being developed helps increase awareness between the involved parties.

Furthermore, despite their differences, all roadmaps usually share some common structure:[5] A roadmap usually begins with a description of the status quo and needs in the domain or topic of interest. Then one or more goals are set that should be reached at the end of the road. Usually, a thorough gap analysis is needed in order to derive these goals. Specific actions are then discovered that help meet these goals; specifying actions also implies identifying the responsible stakeholders, as well as synergies between the stakeholders. The sequence and an estimated outline of the actions is then derived based on the importance, complexity, and logical predecessor-successor relations. In addition, the roadmapping process includes the selection of strategic alternatives that can be used to achieve a desired S&T objective (Kostoff & Schaller, 2001). Finally, the last step of the roadmaps is the publication and dissemination to the intended recipients, i.e. at least the roadmap implementers, but possibly also to the involved stakeholders.

There are two fundamental roadmapping approaches: expert-based and computer-based (Kostoff & Schaller, 2001). In the expert-based approach, a team (or teams) of experts is convened to identify and develop attributes for the roadmap objects. Usually, the team of experts involves a mixture of representatives from industry, government, and academia to ensure a balance of expertise and views. The appropriate expertise is often fully developed after a complete roadmap has been constructed, hence this roadmap development process is usually iterative and involves many consultation cycles, which may even last for years. In the computer-based approach, large textual databases that describe science, technology, engineering, and end products are subject to computer analyses. These databases could include published papers, reports, memoranda, letters, etc. Through the use of generic computerized methodologies, including computational linguistics and citation analyses, research, technology, engineering, and product areas are identified; their relative importance is estimated and quantified and their relationships and linkages to other areas are identified and quantified. Once all these node and link attributes have been specified, the network is then constructed. Compared to the expert-based approach, the computer-based approach has more objectivity. However, it is still in its infancy because of the advanced computer analysis that is required. Hybrid approaches are also possible, involving both human and computer input.

The HUMANE roadmaps that we present here are policy, or administration roadmaps. Therefore they have higher-level policy goals, and are intended to be implemented by administration bodies and

[5] https://pragmaticarchitect.wordpress.com/2013/05/14/how-to-build-a-roadmap-define-end-state/

policy makers. The structure of the roadmaps - which we elaborate later in Section 3.1 - follows the standard steps mentioned above. The roadmapping process is expert-based, involving representatives from all stakeholders identified in each social domain. Because of the roadmap acting as a reference for a collaborative effort, it is necessary to reach a consensus about the set of goals that we are trying to describe, the steps to achieve them, and the roles of the involved parties. This is why stakeholders will be involved in the roadmap construction process, especially in the critical tasks of setting the goals and describing the necessary actions.

2.4 The need for roadmaps of future HMNs

In the course of the HUMANE project we examined important social domains, where human-machine interaction is expected to be significant in the future, and studied in more detail the type of interactions, the roles of humans and machines, and the challenges that must be addressed to ensure the successful integration of machines in a way that is beneficial for society. More specifically, in D4.1 we studied the domains of the sharing economy, eHealth, citizen participation, telework, workplace robotics, and decision support for crowd management. All these social domains present innovative applications in the digital society with significant implications for future thinking.

We found challenges such as data security, the need for scalability as the volume of data and the number of nodes increases, and the need for synchronization and decision support systems in collaboration environments. Additionally, we found several gaps in legislation, such as the lack of legal clarity for the operation and marketing of eHealth applications, or the fragmentation of legislation in both the domains of the eHealth and the sharing economy. Furthermore, many products and innovations regarding HMNs are being developed by private firms, but in order to provide critical social services at low cost, without creating a technological divide between classes of people, it is necessary to provide business models that show the sustainability of providing low-cost services. Finally, we identified many ethical challenges, such as the need to protect privacy and human values, and avoid the use of HMNs to manipulate people.

Different categories of key stakeholders are involved in HMNs that are relevant to roadmapping: policy makers, domain professionals, user groups, IT experts and researchers. A concerted effort from a number of different stakeholders is necessary to overcome the challenges of efficient HMN design in different social domains. For example, it is often necessary to conduct realistic large scale trials or pilot studies in order to examine the efficacy of a HMN in a real life situation. These trials need the cooperation of IT experts, researchers and professionals, but also need to be facilitated by policy makers and officials guiding the necessary funds. Further, when policy makers create a new law to address an identified gap due to the emergence of a new technology, the cooperation of domain professionals and IT experts is not only necessary to identify the gap, but also to fix it, otherwise the implementation of the new law may face significant difficulties. Finally, in many cases it becomes clear that technological solutions alone cannot overcome these challenges. A typical example of this is in the design of interoperable systems. In many cases there are legislation differences between different countries, which need to be smoothed by policy makers to achieve interoperability.

Thus, the need for a collaborative effort between different stakeholders in order to overcome the challenges of HMNs creates the need for roadmaps in the domains where they are applied. Objectives must be set and milestones that can clearly demark the progress for achieving a specified higher-level goal. There must also be a consensus on the best strategy to achieve for reaching the goals, so that the stakeholders are engaged in this process.

3 The HUMANE roadmapping process

3.1 The process

The development of the HUMANE roadmaps will be based on the general process described in Section 2.3. It aims at presenting the roadmapping process for a general HMN and domain of interest and consists of the following steps, as illustrated in Figure 1.

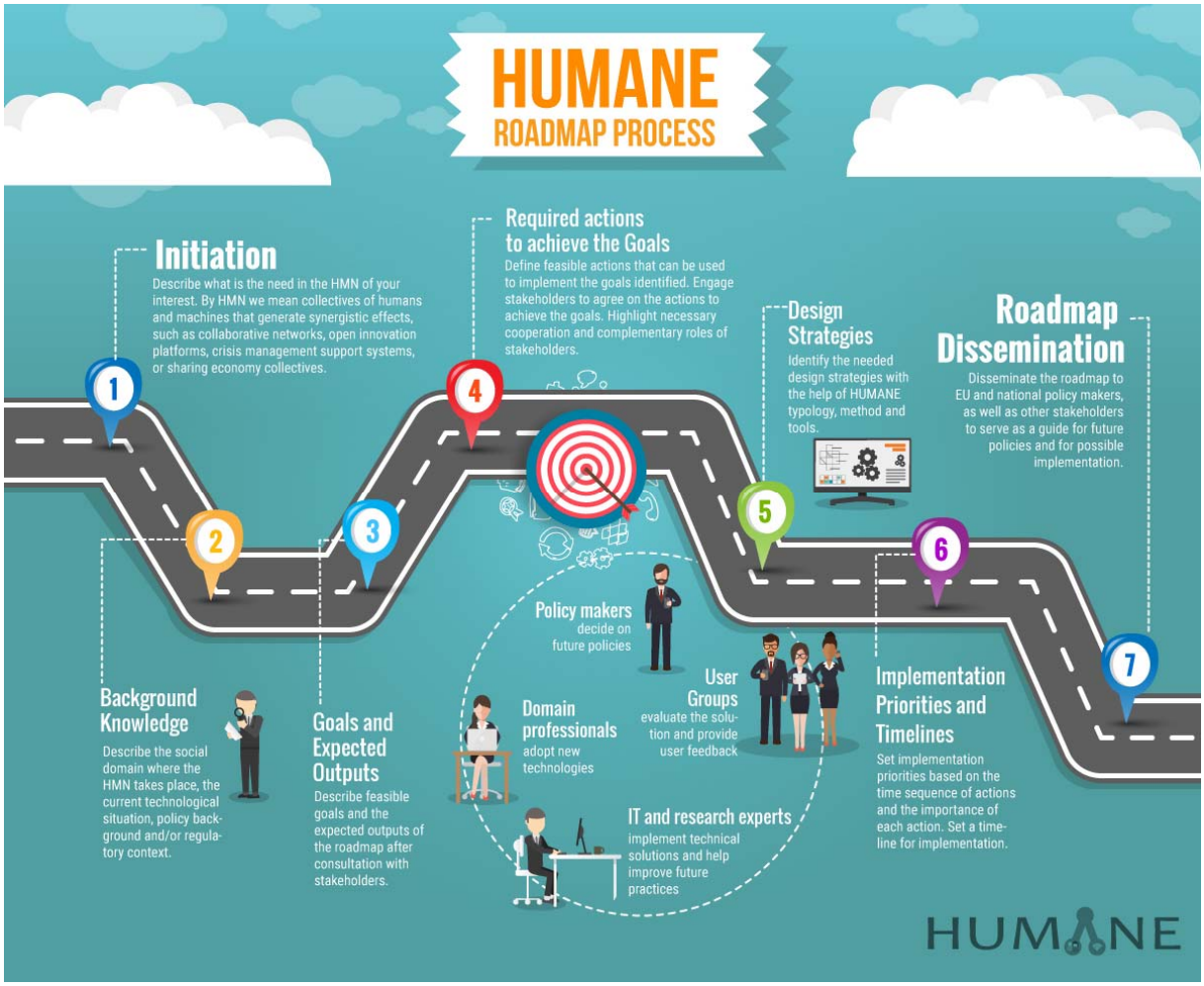

Figure 1: HUMANE roadmapping process

1. ***Initiation:*** In this first step, we describe what we want to achieve and the need to design or improve the HMN in the social domain of interest. The need should be documented by shortcomings of current HMN designs in key HUMANE implication areas (user experience and

motivation, behavior and collaboration, innovation and improvement, privacy and trust), and by emerging and future trends in the domain of interest.

2. ***Background knowledge***: Here we describe the current technological situation, policy background and regulatory context. This background knowledge will help to identify the gaps between the current state of affairs and where we want to arrive at, and will serve as a reference for the future work and proposed policy actions.
3. ***Goals and expected output***: This step is carried out in cooperation with stakeholders with a view to describe the goals that are feasible to implement in a relatively short timeframe, and to describe the actual outputs of the roadmap. An output could be a new regulation or code of practice, a newly provided service, a report on case studies, etc. Together with the current situation described in step 2, it is used to make a gap analysis between the current and the desired HMNs we want to have in the future.
4. ***Required actions to achieve the goals***: This is also a collaborative step with stakeholders. The objective is to describe the stakeholder roles, comprising the actions that are necessary to achieve the goals in the previous step. Emphasis is given to highlighting the complementary roles of different stakeholders in achieving the goals, and the synergistic effects of their actions.
5. ***Design strategies***: This is a crucial step in the HUMANE roadmap process, as it will help to identify the necessary design strategies based on the characteristics of humans and machine in the social domain of interest and will apply the HUMANE topology, method and tools to find appropriate design strategies. These design strategies can be selected among the initial design strategies developed in D2.2, but if necessary new design strategies can be created to address specific needs of an examined HMN.
6. ***Implementation priorities and timeline***: In the last step of the roadmap construction, implementation priorities for the different tasks will be determined, based on the dependencies between action, but also the importance of each action. The degree to which current challenges are addressed, as well as the complexity of the tasks will be taken into account in order to set a timeline for implementation. In addition, the output from the gap analysis will help to estimate the investment of time, money and human resources required to achieve the desired outcomes.
7. ***Roadmap dissemination:*** The HUMANE roadmaps can be disseminated to policy makers, ICT designers, as well as other stakeholders to serve as a guide for future policies and for possible implementation.

The HUMANE method and tools (D2.2) will have a central role in designing the roadmaps, as they can readily provide design strategies based on the characteristics of the HMNs and provide examples of similar networks, in order to choose the most efficient technology solutions.

The flowchart (Figure 2) describes the process for choosing design strategies. Our view is that this flowchart would be carried out as an intermediate step in the roadmap implementation.

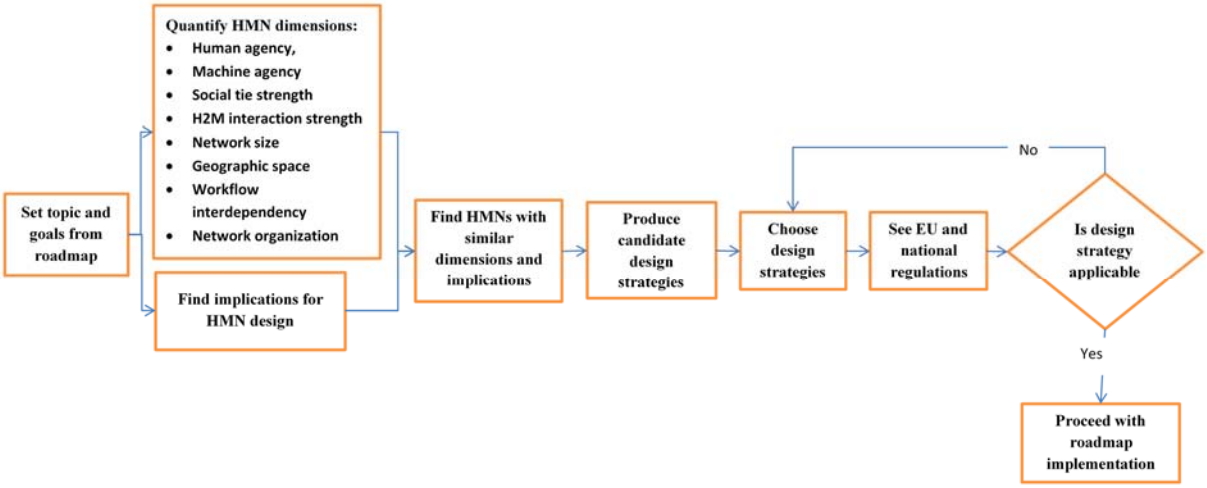

Figure 2: Process for choosing design strategies

First, based on the topic (social domain and application) we quantify the HMN according to the 8 dimensions in the HUMANE topology: the human and machine agency, tie strength, H2M interaction strength, network size and geographical space, workflow interdependence and network organization. These dimensions help to create a network profile, and to find implications for HMN design. Based on the derived profile, we find HMNs with similar dimensions and implications, and produce a set of candidate design strategies. The chosen design strategies will be produced from a synthesis of the candidate design strategies (from WP2), by removing overlaps, assessing the technical feasibility, and the sufficiency or compatibility with the current regulatory framework (e.g. a policy maker could see that a regulation should be improved or changed in order for a design strategy to be implemented).

The HUMANE tools can also assist the design process: the HUMANE profiling tool can help to automatically generate a profile for a HMN. Further, the HUMANE simulation modelling can help to simulate the HMN operation, so that designers can assess the efficacy of each design strategy before actually implementing it.

3.2 The selected social domains

For the HUMANE projects, the steps in the roadmapping process will be followed to develop the roadmaps for each social domain, but can be also taken as guidelines by policy designers to develop HMN roadmaps for other domains. For the specific domains studied here it will be based on input from D4.1, where preliminary challenges, high-level objectives and opportunities for policy interventions in each domain have been identified. In D4.1 we also identified the stakeholders in each domain, as well as their roles and interests. We classified stakeholders in 5 categories, which are common for all social domains: policy makers, domain professionals, user groups, IT experts, researchers, who will have a central role in the development of roadmaps for HMNs in different social domains. During roadmap development, stakeholders will be consulted to discuss the current state of challenges, to further

analyse and validate the roadmap goals, and produce a list of actions for the roadmap implementation. The roadmap development will be a living process where stakeholders from the different domains will be consulted to further analyse and agree on the roadmap goals, the process to achieve the goals, concrete actions and their expected outcomes.

We create roadmaps that can help guide future policies for selected social domains. The following social domains have been chosen, out of the ones which were studied in D4.1: the sharing economy, eHealth and citizen participation. These domains share commonalities, but also different HMN characteristics, so together they can cover a broad range of issues pertaining to HMNs and policy making.

More specifically, the sharing economy (also called "collaborative economy") consists of the ecosystem of online collaboration, sharing, and collaborative consumption (CC). CC sites are alternative forms of online marketplaces where users can engage in peer-to-peer activities of obtaining, giving, or sharing the access to goods and services, coordinated through community-based online services. Similar to online marketplaces, people can provide information on their shared goods or provided services and the system can allow comparisons of prices and services, provide recommendations and reputation information. More generally, the various instances of the sharing economy also share the characteristics of online collaboration, online sharing, social commerce, and some form of underlying ideology, such as collective purpose or a common good (Hamari, Sjöklint, & Ukkonen, 2016). These platforms are in many ways a natural outgrowth of social media which bring together people with common interests to share not only ideas and information but also goods and services. The importance of the sharing economy lies in its ability to alleviate societal problems such as hyper-consumption, pollution, and poverty by lowering the cost of economic coordination within communities. The collaborative economy is small but growing rapidly, gaining important market shares in some sectors. Some experts estimate that the collaborative economy could add EUR 160-572 billion to the EU economy.[6] The recently published European Agenda for the collaborative economy[7] highlights this importance and presents key issues and challenges for a balanced provision of such services.

We also study eHealth systems, a domain of great social importance where consistent rules must be set-up in the EU. eHealth services can benefit society by improving access to care, improving the quality of care and by making the health sector more efficient. eHealth includes information and data sharing between patients and health service providers, hospitals, health professionals and health information networks, electronic health records, telemedicine services, portable patient-monitoring devices, operating room scheduling software, robotized surgery and blue-sky research on the virtual physiological human. It is important to identify challenges and barriers against the efficient management of eHealth systems, as well as opportunities and future policies that could support HMNs in this domain (see D4.1). In this deliverable we focus on networks for physiological monitoring of patients with smart mobile or wearable devices, as one of the most innovative and rapidly evolving

[6] A European agenda for the collaborative economy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Brussels, 2-6-2016

[7] http://ec.europa.eu/growth/single-market/strategy/collaborative-economy_en

technologies worldwide that can benefit society by improving access to care and improving the quality of care while at the same time lowering hospitalization expenses and making the health sector more efficient.

Another domain of interest we focus on, is citizen participation. Citizen participation systems are an extension of e-government systems whereby citizens perform the role of partner rather than customer in the delivery of public services, and change the traditional way that the public and the government interact. This can have tremendous benefits for improving democratic operation, building social cohesion and collective social capital. Yet individuals and citizen groups have a small part in decision making. Apart from voting for elections or referendums, citizen involvement in decision making is usually restricted to commenting in public consultations. In D4.1 we have investigated the role of HMNs in building efficient citizen participation systems, leveraging on social media, collaborative tools and decision support systems.

The above domains were selected by the consortium partners as the most relevant to the scope of HUMANE, the consortium partners' expertise and the background work on the methodology and tools. The consortium partners have significant expertise in data collection, content aggregation and recommendation systems, social media and participation systems. In D2.2, many design strategies have been identified that can improve the operation of such systems. To name a few, patterns for attracting and motivating users in content aggregation, curation and recommendation systems, for making behavioural change, encouraging shared responsibility HMNs, enhancing privacy and security and supporting trust, etc. During roadmap construction, we show how these strategies can be used to provide for a more efficient design and where additional improvements are necessary.

Furthermore, all the above domains and HMNs have attracted the interest of policy makers and have a central role in the Digital Single Market Strategy as a driver for growth, but also as a means to create an inclusive economy and increase social cohesion. The sharing – or collaborative – economy is recognized as having the potential for an important contribution to jobs and growth in the EU, for contributing to the EU's sustainability agenda and to the transition to the circular economy.[8] By promoting the usage of eHealth monitoring devices and applications, the DSM strategy aims at a better quality of life for European citizens, innovation and growth for a competitive EU industry and more sustainable healthcare systems for society.[9] Finally, the DSM strategy aims to empower citizens to play a full part in the single market, and to mobilise them to act as co-legislators at key initiatives.[10]

Despite the fact that HMNs in different domains may share some common challenges and objectives, we will design separate roadmaps for each domain, in order to manage and evaluate them more efficiently. We will also focus on short-term goals, which could be implemented in a relatively short time.

[8] http://ec.europa.eu/DocsRoom/documents/16881/attachments/2/translations/en/renditions/native
[9] https://ec.europa.eu/digital-single-market/en/ehealth-and-ageing
[10] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:2020:FIN:EN:PDF

4 Roadmap for human-machine networks in the sharing economy

4.1 HMNs in the sharing economy: Current technological situation, emerging and future trends

Sharing behaviour and collaborative consumption have existed as long as humans have (Belk, 2014). However, with the developments and uptake of the internet and mobile ICT, the *sharing economy* has emerged as a new way of accessing goods and services.

Key to the sharing economy are (a) models that facilitate access to goods and services, rather than ownership, and (b) the reliance on the internet as a means of connecting the owners and users of these goods and services (Belk, 2014). Belk (2014) defines collaborative consumption as "people coordinating the acquisition and distribution of a resource for a fee or other compensation". Others, such as Botsman and Rogers (Botsman & Rogers, 2010) have a broader understanding of what is included in the sharing economy, such as giving away surplus goods or services (Botsman & Rogers, 2010).

The term sharing economy refers to a broad set of services and practices, analysed in different ways. In their report on the sharing economy, PwC (Lieberman, 2015) discuss four sharing economy areas: automotive and transportation, retail and consumer goods, hospitality and dining, and media and entertainment. Others also discuss sharing of competency and work capacity as part of the sharing economy (e.g., (Malhotra & Van Alstyne, 2014)). Well-known brands typically mentioned as part of the sharing economy are AirBnB and Uber, but a large number of smaller companies and services are emerging within all service areas identified by PwC.

The sharing economy is by some seen as representing a fundamentally new approach to service provision, where the service platforms do not need to hold a large inventory, but rather serve as matchmaking middlemen connecting existing supply with demand (Arun Sundararajan, 2013).

Theorists have explored how business models as well as consumer attitudes and behaviour change as a consequence of the emerging sharing economy. For example, Cannon and Summers (Cannon & Summers, 2013) discuss sharing economy and regulation. Belk (2014) discuss business implications of the sharing economy. Malhotra and Van Alstyne (2014) discuss how sharing economy services should create consumer value. However, the underlying interplay between technology and consumers, and how to design for supporting this interplay, has not been given the same attention. In particular, we do not have sufficient knowledge on how the design of sharing economy platforms and services affect user experience or behaviour, the services' capacity for innovation and improvement, and issues such as privacy and trust.

This gap in the literature is critical, as it is difficult for policymakers and service developers to respond adequately to future developments in the sharing economy without sufficient insight into how sharing economy services, as well as their underlying technological and societal context, should be shaped in order to exploit their industrial and societal potential.

As a first step towards closing this gap, we will in this section present an initial analysis of human-machine networks in the sharing economy. By *human-machine networks*, we mean assemblies of users and networked technology in which synergistic effects are made possible; as they are in sharing economy networks. The analysis will, in particular, address the human-machine networks of the sharing economy in terms of the involved actors, their relations, as well as the extent and the organization of the networks. The analysis will in turn serve as basis for developing a roadmap for human-machine networks in the sharing economy.

The initial analysis is based on 11 interviews with six representatives of sharing economy services, referred to below as *service owners*, as well as five experts and policymaker representatives within the public sector, NGOs and research, referred to below as *experts and policymakers*. In addition to these interviews, we draw on the current academic and practitioner literature. The involved service owners, represented companies all the sharing economy areas discussed by PwC (Lieberman, 2015) except media and entertainment. All interviews were conducted with Norwegian participants. Hence the findings will reflect the Norwegian context. This may limit the generality of the findings. At the same time, the orientation towards the Norwegian context is useful as this is a context characterized by a relatively small and homogenous market which makes it easy to get an overview of the current landscape.

In the analysis, we will consider current challenges in designing well-functioning human-machine networks for collaborative consumption. We will describe stakeholders' goals for sharing economy services, the gaps that need to be closed to attain these, as well as the potential means to close these gaps. Taken together, these forms the basis for a roadmap for future human-machine networks for the sharing economy. The roadmap will be further developed and finalized in the subsequent HUMANE deliverable, D4.4.

The intended audience for the roadmap is sharing economy platform developers and owners, as well as policy makers oriented towards technology and societal issues.

4.2 Policy background and regulatory context

As a basis for our presentation of stakeholders' perceptions of challenges, goals and potential means to reach the goals for human-machine networks in the sharing economy, in this section we provide background on the policy and regulatory context of sharing economy HMNs.

4.2.1 Policies and regulations for the sharing economy?

In the aftermath of the recent financial crisis in Europe, European policy has to a large extent focused on innovation and economic growth. The Europe 2020 strategy for smart, sustainable and inclusive growth (2010) is the main driver of the Union towards creating more jobs and better lives[11]. Meanwhile, the uprising sharing economy introducing new business models driven by an increased

[11] European Commission (2010) Europe 2020 - A European strategy for smart, sustainable and inclusive growth. Available at: http://ec.europa.eu/eu2020/pdf/COMPLET%20EN%20BARROSO%20%20%20007%20-%20Europe%202020%20-%20EN%20version.pdf

demand for sustainable consumption was eagerly embraced by European and national policymakers in order to achieve the goals of smart and sustainable growth.

However, as often the case, policy making has not kept pace with technological developments, leaving the sharing economy in a regulatory grey zone, in terms of market access requirements, a delayed data protection regulation, taxation and consumer or employee rights. This has been acknowledged on European level and was addressed in the European Agenda for the collaborative economy[12].

Sharing economy services have been seen as a challenge to current regulation and policy. Koopman et al. (Koopman, Mitchell, & Thierer, 2015) argue that current regulations and policies may not serve consumers best interest. In particular, current regulations may provide an undesirable disadvantage to sharing economy innovators as opposed to established services providers.

4.2.2 Policymaker expectations for the future development

Among the interviewed experts and policymakers, three expectations about the future development for HMNs in the sharing economy were prevalent.

a) Convergence of sharing economy and traditional service provision

On the one hand side, there is a convergence of the sharing economy and "regular" eCommerce services in the on-demand, or platform driven economy. This is exemplified by Uber, which operates in the grey zone between a ride sharing service (which would belong to the sharing economy) and a commercial on-demand transportation service.

b) Awareness of sharing economy services among traditional service providers

Furthermore, among the established commercial players, we observe a growing awareness of the competition they are facing from services in the sharing economy, exemplified by the recent €64m take-over of the British start-up *Onfinestay* by the global hotel chain Accor[13], or the acquisition of the ride sharing services *Hailo* and *MyTaxi* by the car manufacturer Daimler Benz[14].

c) Consolidation within certain areas

Another, expectation is that we will observe a consolidation of certain areas of the sharing economy, where domains like mobility or accommodation will be dominated by few large players. This development might be reinforced by the complex regulation landscape imposing compliance challenges that can be hard to overcome by start-ups.

Traditionally, such consolidation can either lead to closed, exclusive ecosystems, where the main players use their power to introduce high market entry barriers for newcomers, or open platforms that

[12] European Commission (2016). A European agenda for the collaborative economy. Available at: http://ec.europa.eu/DocsRoom/documents/16881

[13] https://www.bloomberg.com/news/articles/2016-04-05/accor-buys-onefinestay-to-grow-in-luxury-serviced-homes-market

[14] https://techcrunch.com/2016/07/26/confirmed-hailo-sells-60-of-company-to-daimler-as-it-merges-with-mytaxi/

again allow for a growth market of add-on services, such as Lotel, a start-up that provides advertising, cleaning and insurance services for users that rent out rooms or apartments through AirBnB[15].

A goal for decision makers should be to avoid creating additional barriers for start-ups, as such emerging new players are likely to be valuable for the development of the sharing economy as a viable market area. A way to reduce barriers may be, for example, to make it easy to comply with regulation.

4.2.3 A transfer from human agency to intelligent digital platforms

Human-machine-networks in the sharing economy need to be seen in the wider context of *on-demand* (or *access*) *economy* (digital, primarily mobile, marketplaces that offer convenient access to goods and services) and the platform economy that allow for a plethora of services and business models to connect to and build upon). While the former contributes to reducing friction in business models and transactions, e.g. replacing the *man-in-the-middle* by pervasive and ubiquitous digital platforms, the latter opens up for efficient implementation, testing and roll-out of new businesses. As such, these concepts are highly technology-driven, building upon the ever growing market penetration of smartphones and other connected devices as well as social networks.

In the context of HMNs in the sharing economy, this means that we observe a transfer of human agency to digital platforms. While finding a person to borrow a reliable car from could be a tedious task, involving inquiries to friends, relatives and friends of friends, this time-consuming activity has been obsoleted by mobile services such as Zipcar (http://zipcar.com) or the Norwegian Nabobil (http://nabobil.no) matching supply and demand at the users' fingertips. Or, to put it another way, while the traditional view on digitalisation entails the transformation of analogue processes into digital ones, the access and platform economy introduces well-known processes from the digital world into peoples' physical, day-to-day lives.

The frictionless access to a new and desirable set of resources, enabled by technology, is key to human-machine networks. At the same time, the rise of the sharing economy is not purely technology-driven. (Botsman & Rogers, 2010) argue that the experiential aspects of a growing awareness for sustainability among consumers has paved the way and accelerated the uptake of collaborative consumption. Yet others, such as (Hamari et al., 2016) point also to the experiential aspects of sharing economy services.

4.2.4 Utilizing sharing economy platforms as basis for regulatory compliance

Interestingly, while the regulatory aspects of sharing economy services have been much debated (Cannon & Summers, 2013), (Koopman et al., 2015), less attention have been given to how the digital platforms of the sharing economy may, in principle, provide improved support for regulatory compliance.

Within some of more mature sharing economy platforms, rich data on financial transactions are registered and stored within a single framework. Potentially, this could be exploited by policymakers

[15] www.lotel.no

and regulatory bodies. However, this does not seem to have been a key point in the debate on regulation.

4.3 Key goals for HMN in the sharing economy

Through the interviews with service owners, experts and policy maker representatives, a number of challenges and goals for HMNs in the sharing economy were identified. The interviews were structured according to the HUMANE typology and method, as introduced in Section 2.2.

In this section, we present the identified challenges and goals for each of the four analytical layers and underlying dimensions. This way, we are able to address challenges and goals of relevance for multiple aspects or perspectives on HMNs in sharing economy. Given the complexity and emerging character of the sharing economy field, not all goals may apply equally well to all sharing economy HMNs. Nevertheless, we find the identified challenges and goals to have a sufficiently broad relevance to be a useful starting point for the HUMANE roadmapping activity.

4.3.1 The actors of sharing economy HMNs

The sharing economy is characterized by collaborative consumption between non-professional users, facilitated by specific sharing economy services. The services typically are embodied as platforms for sharing and collaboration; platforms that are constituted by online facilities for matching people and supporting transactions.

Main actors of the sharing economy, hence, are non-professional consumers on the one hand, and service owners represented through technology platforms on the other. We discuss challenges and goals concerning each of these below, in terms of human agency and machine agency.

4.3.1.1 Human agency –empower consumers

Through sharing economy services, consumers are empowered to access a new range of goods and services, offering the potential for bargains, new experiences, and more sustainable consumption. Consumers are also empowered as potential providers of goods and services, that is, to contribute to the supply-side of consumption.

This empowerment of consumers entails a range of challenges and goals for sharing economy HMNs. In particular, our participants reported on the following:

Motivating consumers

While sharing economy HMNs represents vast opportunities for empowering consumers, not all consumers are equally eager to participate. In a Norwegian survey on peer-to-peer online second-hand markets, conducted by two HUMANE researchers in the project Conserve & Consume (Lüders, M., & Følstad, 2015), it was found that while about half the Norwegian population have sold or bought items on such markets the last year, only about 15% are heavy users. Hence, a key challenge for sharing economy HMNs is to motivate users to join in - both at the supply and demand side.

Previous research (Hamari et al., 2016) has pointed out a number of motivational factors for consumers in sharing economy services. In particular, financial gains, experiential aspects, and a perceived sustainability benefit. Hamari et al. suggest that the potential financial gains are the most important, while the perceived sustainability benefit is relevant mostly for consumers that already hold positive attitudes for collaborative consumption. Möhlmann (2015), in a survey study of users of sharing economy services for transportation and hospitality found, that the users' likelihood of returning to the services is explained mainly by self-benefit. Perceptions of environmental impact were found to have no impact.

In line with (Hamari et al., 2016) and (Möhlmann, 2015), most of the participating service owners argue that the financial and practical aspect of sharing economy services are important to users. Sharing economy HMNs need to be financially alluring or convenient to reach high market uptake. At the same time, both the experiential and sustainability aspects are accentuated by all service owners. In particular, most of the service owners seem to place more weight on sustainability as a key selling point than what the findings of Hamari et al. and Möhlmann suggest.

Change consumer behaviour

Hand-in-hand with the goal of motivating users, is the goal of changing consumer behaviour. Sharing economy services implies a fundamental shift in consumer behaviour, moving from buying new to buying second-hand, moving to individual ownership to shared ownership. Changing behaviour is difficult as it concerns the discontinuity of habit. Discussing sustainable consumption, Verplanken & Roy (2015) suggest that the habit discontinuation is more likely in contexts of contextually dependent discontinuities. For example, for commuters it is more likely to establish a habit of car-sharing in a period of strike in collective transportation services. Without such "naturally" occurring discontinuities, behavioural change is less likely.

The services owners typically reported it challenging to change consumer habits, particularly because consumers need to change their views on service acquisition. One of the service owners suggested that millennials may represent a tipping point for sharing economy services, which is in line with Verplanken and Roy's (2015) argument that consumers in contexts of discontinuity, as youth and young adults are exposed to, are more likely to take on new habits.

Among the policymaker representatives, there was little if any attention towards the challenge of behavioural change. Rather, these were concerned with policy-making targeting the formalization of sharing economy services rather than exploring policies leading more directly to change in consumer behaviour.

Provide quality control

Malhotra and Van Alstyne (2014) point out low quality as a potential challenge in sharing economy services. For example, low quality content in ad listings. Similarly, a lack in quality control may make it challenging for consumers to know what to expect as the demand side in a sharing economy relationship, in terms of the quality of shared or used goods, or the timeliness and standardization of the service.

While the service owners involved in our study all noted the importance to leave the users in control of some aspects of the sharing or reselling processes, they all see the need of streamlining the process to reduce frictions between suppliers and consumers. The platform and the encounters with other consumers need to be seen as convenient and frictionless, while at the same time the platforms should allow the transaction to remain its characteristic as a process between two non-professional users. That is, the HMN needs to reduce friction while keeping a human face.

Leverage role diversity

Users take on different roles in sharing economy HMNs. For example, while it is common to have tried selling or buying through online second-hand markets, only a few use these a lot and the frequent sellers may not be frequent buyers and vice versa (Lüders, M., & Følstad, 2015).

This role diversity in sharing economy HMNs is acknowledged by service owners, experts, and policymakers. Some of the service owners note that, in particular, on the supply side there may be high levels of specialization where suppliers in e.g. online second-hand markets or transportation take on volumes resembling professionals.

Some of the service owners also noted that role diversity may be driven by life-situation factors. For example, young adults may be more likely to serve as demand side in consumer goods services, whereas older people may be more likely to be on the supply side. This role diversity is argued to be potentially beneficial, as it may help balance supply and demand. At the same time, it indicates the importance of engaging a broad range of users in HMNs to fit all the roles needed.

4.3.1.2 Machine agency – predictions and match-making

In HMNs for the sharing economy, technology platforms are taking the role as the man in the middle, providing intelligent and personalized matching of supply and demand. This match-making character of sharing economy services is so characteristic to the degree that the US Department of Commerce has defined sharing economy services as digital matchmaking firms.[16]

Strengthen prediction capabilities

Key to the success of sharing economy HMNs is the predictive ability of the platform. While the internet and mobile ICT have been seen as initial key enablers of the sharing economy (Belk, 2014), the developments in artificial intelligence and machine learning may be just as important for its future development. This, however, is not unique to the sharing economy. As the involved experts and policymaker representatives noted, artificial intelligence and machine learning will likely be transformational for almost any sector.

The participating service owners, experts and policymaker representatives all report on the importance of advanced prediction capabilities for a successful sharing economy service. The

[16] Telles, R. (2016). Digital Matching Firms: A New Definition in the "Sharing economy" Space. ESA Issue Brief. U.S. Department of Commerce. Available online: http://www.esa.gov/sites/default/files/digital-matching-firms-new-definition-sharing-economy-space.pdf

mentioned areas where predictions are important include matching supply and demand, suggesting alternative goods or services, supporting fair pricing, and identifying illicit behaviour such as fraud.

The participants argue that good prediction capabilities are important to reduce noise and increase conversions. Furthermore, they argue that good prediction capabilities may strengthen trust in the platform, as well as between the participating individuals.

Platforms that allow predictions

The participating service owners explained how the technology platforms of sharing economy services are key to gathering the data needed to build prediction capabilities. For platforms where both the matching of supply and demand, as well as the subsequent transaction, is supported, a wealth of data may be obtained – in turn leading to improved predictions. Given a sufficiently large volume of data, and detailed knowledge of transactions, it is possible to measure effects in detail and use these for prediction making.

At the same time, as noted by some of the participating service owners, the benefit of large volumes of data highlight a potential challenge for newcomers, as the established actors will have an advantage in data quality and quantity. One of the participants discussed that to be able to make valid predictions, large data volumes are needed. This may make it challenging to start-ups. In fact, the importance of predictive analytics was pointed out by another one of the service owners who had established a business model on selling specialised analytics services to other reselling platforms inside and outside of the sharing economy, thus filling a thereto undiscovered blank spot in the ecosystem.

Hence, most of the service owners, reported that the technology supporting the sharing platform was equally as important as the marketplace. That is, the two are in a symbiotic relations where the marketplace depends on the technology platform for matchmaking, whereas the technology platform depends on the marketplace for data.

4.3.2 The relations of sharing economy HMNs

Following the analysis of the actors of the HMN, we study the relations between them. In particular, we consider the relations between human actors, in the form of *social ties*, and the relations between human and the technology platform, in the form of *human-to-machine interaction strength*. Both these dimensions support insight into challenges and goals of sharing economy HMNs.

4.3.2.1 Social ties – the good meeting of strangers

Keep the human aspect

Peers are key to sharing economy HMNs. In the literature, it is noted how consumers' use of sharing economy services may be linked to feelings of social relatedness and intrinsic motivation, which in turn may be a source to enjoyment (Hamari et al., 2016).

For most of the service owners, the social meeting between people is reported to be an important part of the service experience. As one of the participants expressed it: "*users come for the price and stay for the experience*". Hence, service owners reported as an important goal to facilitate meetings

between humans, so as to keep the human aspect. Some of the service owners also accentuate the importance of human encounters in order to establish trust and reduce undesirable incidents.

Matching strangers rather than group formation

While most of service owners accentuate the importance of keeping the human aspect of sharing economy services, they do not report to be particularly concerned about facilitating strong social ties between users. Some of the service owners have set up follower functions, but have not made it a main priority to use these for establishing closer personal links, subgroups or communities within the service. The reasons for this, as reported by most of the service owners, is that such group formation is not seen as critical for the value of the platform as a sharing economy facilitator. For the service owners it is more important that the users tie to the platform rather than that they tie to a particular subgroup of users within the platform.

Hence, the service owners reported as a main priority to strengthen the loyalty between the users and the platforms, rather than encouraging strong ties between individual users. That users gather in groups is seen as something that may happen, but not something that is particularly encouraged. However, one of the service owners take a different viewpoint of this and see group formation and leveraging existing social groups as desirable.

The concern for loyalty also entail cross-platform issues. Some of the service owners argue that users may benefit from using different channels or interfaces for different purposes. For example, to provide all details needed as a supplier, a desktop interface may be preferable, whereas for rapid browsing of potential matches a mobile application may be preferable. Hence, loyalty needs to be established across channels, that is, loyalty needs to be established for the brand rather than for a specific online environment.

4.3.2.2 Human-to-machine interaction strength – develop loyalty to the platform

The participating service owners argue that the main relations in sharing economy HMNs will be between users and the digital platforms, rather than between users. Though services and transactions are conducted between users, the main tie should be to the platform. This entails two challenges and goals: An awareness challenge and a trust challenge.

Strengthen awareness of the service

The participating service owners report that in spite of the current interest the sharing economy and its most well-known services, such as AirBnB and Uber, still experience an awareness challenge. That is, their potential users are not sufficiently aware neither of them as specific services and of their niche within the sharing economy.

The service owners typically want their brand to immediately come to mind whenever potential users experience a particular need, as for example transportation or specific types of goods, and aim to increase the engagement of users and build a loyal relationship. They acknowledge the hard competition that has appeared within many of the sharing economy service areas, but argue that currently the main competitors are not other sharing economy companies but rather the established

traditional service providers. Increased competition between sharing economy companies is argued even to be beneficial as it serves to increase attention for sharing economy services at large.

Develop trusting relations

Trust has thoroughly been discussed as critical for sharing economy services. (Botsman, 2016) discusses three layers of trust: Trust in the idea of collaborative consumption, trust in the platform, and trust in the individual. Trust in the individual may be affected by the design of the platform, such as the opportunity to provide personal photos (Ert, Fleischer, & Magen, 2016). At the same time, trust-increasing features such as personal presentations and review systems may be manipulated or biased; users may manipulate their own reputation by biased positive reviews or descriptions, or users may manipulate others reputation by biased negative reviews (Malhotra & Van Alstyne, 2014).

The service owners all report that establishing trust is an important goal. Following the reasoning of Botsman, they work with trust aspects of the meeting between the consumer and the service platform and trust aspects pertaining to the encounters between individuals using the platform.

Some of the service owners report on the importance of personal interaction and encounters between individuals as important to create trust. Others discuss the importance of rating systems, and the necessity to have some level of policing of the user activity on the site; for example to detect fraud.

4.3.3 The extent of sharing economy HMNs

Human-machine networks may differ widely in size and geographical reach, which in turn has important implications for how the networks are perceived and used, as well as how they evolve. In this section, we consider the goals for sharing economy HMNs pertaining to the extent of the networks.

4.3.3.1 Network size – the need for large scale

All being startups, the sharing economy services involved in the study are typically relatively small compared to the most well-known services such as Uber and AirBnB. Nevertheless, all participating service owners report on a strategy for growth. From a service owner perspective, each individual transaction in the sharing economy platform is of relatively small value. Hence, they see the need for the platforms to facilitate large volumes of transactions to be economically sustainable, something that indicate the need for large-scale networks. Several of the service owners reported on ambitions to become national leaders in their field, and several had international aims.

Network size is also discussed by most of the service owners as important for the HMN to have the potential to provide good matches to a specific supply or need. Furthermore, a large number of transactions are needed to make valid matching or predictions. Newcomers to the market will be challenged in terms of poorer matchmaking ability, both with regard to actual suppliers and seekers, and in terms of prediction capabilities based on artificial intelligence and machine learning.

The need for large size, to support a sustainable business and to meet matchmaking demands, indicates a potential winner-takes all market where there is only room for one or a few actors within

a sharing economy market area. Potentially, newcomers in a few years from now will be even more challenged than current service providers.

4.3.3.2 Geographical reach – keep local relevance while scaling

Local relevance in trans-local service provision

All service owners report large-scale ambitions; indicating the need to provide services of a broad geographical reach. At the same time, the service owners acknowledge the highly local character of many sharing economy services. For example, sharing of work and competency may in many cases require physical proximity, similar to the sharing of transportation or goods. Furthermore, sensitivity to the local context may be important to best adapt the service. And a local orientation may strengthen trust and reduce the risk for fraud.

Services that scale

At the same time, some of the service owners report on the need to develop their platforms and services to scale across local contexts. That is, platforms and services needs to be developed in a way that they can be implemented in different local contexts with a minimum of contextual tailoring. This is seen as important both to be easily recognized for users that use the service across local contexts, and to be able to scale up the service at a low cost. The HMN must, hence, facilitate the establishment of local ecosystems for sharing while supporting a trans-local presence.

4.3.4 The structure (workflow interdependence and organization) of sharing economy HMNs

In the HUMANE typology, the structure of HMNs is considered in terms of *workflow interdependence*, that is, the dependencies between the actions of the actors in the network, and *network organization*, that is, the degree of hierarchical or centralized organization in the network. These dimensions are seen as having particular impact on the network capability for change in response to contextual developments.

4.3.4.1 Workflow interdependence – support efficient interaction

The workflow interdependence in sharing economy services concerns the interaction between the actors involved in a given transaction. Typically this will be a supplier, a customer, and the platform. An efficient transaction thus depends on the responsiveness and accuracy of the service provision. This, clearly, does not always happen. There may be issues both in response times, in clarity, and in keeping deals and agreements. We can call this a dialogue challenge. Also, the need to match supply and demand in a market with a broad variety in offerings and less predictability than traditional commercial markets, may imply planning challenges.

The dialogue challenge

Most of the service owners report that they see it as beneficial to allow users a certain flexibility in their interaction with others. At the same time, the service owners acknowledge that this flexibility

may introduce friction in the interaction and report on a need to further reduce such friction. For example, users may need guidance on reaching agreements fast to avoid too many messages back and forth, and there may be a need for sanctioning mechanisms for users that do not adhere to accepted agreements.

However, since much of the interaction takes place not with the service owner but with another individual user, the service owners explain that it may be difficult for the service owners to get insight into all the details concerning the customer experience. Hence, it may be difficult to monitor and manage the quality in the dialogue and interaction. Also, as argued by several of the service owners, the interaction between the users may not benefit by being fully streamlined as this flexibility serves to maintain a level of human touch in the service provision.

Reduce the need for planning

Due to the broad variation in offerings in sharing economy services, some of the service owners report that using sharing economy services may require some more planning by the individual consumer than using regular commercial services. For example, whereas a traveller typically may book a room at his favourite hotel at short notice, he may need to plan more in advance to book a particular apartment through a sharing economy platform. This need for planning may represent a threshold that is difficult to surpass for some potential users. Reducing the need for planning is seen as potentially beneficial, as reported by some of the service owners. Strengthening the supply side of the sharing economy HMNs is reported as a possible way to reduce the need for planning, as users in demand of goods or services would then have greater chances of finding a match at short notice.

4.3.4.2 Organization – predictable services

Network organization concerns its degree of hierarchical or centralized structure, which in turn hold implications for the network's capacity for dynamic adaptation and change. This capacity may be limited in networks characterized as highly hierarchical or centralized, whereas a larger degree of self-organization may entail strengthening of this capacity.

The platform as the central node

As the growth of the sharing economy is enabled by the technological developments of the internet, it may be tempting to assume that sharing economy services have substantial self-organization. However, the participating service owners rather argued for a centralized structure as beneficial. In particular, the platform is seen as the central node through which the interaction between users are conducted. Between service owners, differences exist in terms of how much of the interaction between users is actually conducted through the platform. Some, for example, do not provide means for financial transactions or transportation of resold goods. Others, support all transactions of the service process through the platform.

Some service owners also discuss whether the self-organizing ability of the network may change as matchmaking increasingly will rely on artificial intelligence. Here, matches between users will be determined by the platform and the user together, rather than by the user alone. Improved prediction abilities in the platform, may reduce the users' need to have an active role in the matchmaking.

The service owners also report that the need to ensure a certain level of quality, the need to remove friction in interaction between users, and the need to balance supply and demand also point towards a more centralized mode of service provision. For the latter, the service owners typically reported on a need to encourage an increase in the supply side of the sharing economy networks.

Risk management and security

A centralization of sharing economy services, using the platform as a central node for the transactions pertaining to a sharing economy relationship may also strengthen the need for risk management and security in the sharing economy HMNs.

Risks associated with sharing economy services has been a much debated issue. In particular for transportation services such as Uber (Malhotra & Van Alstyne, 2014). As noted by some of the service owners, risk management is critical to successful sharing economy services.

Some of the service owners also accentuated the challenge of fraud, in particular as geographical reach is increased. Hence, platform owners need to police the network to curb unethical or illegal behaviour.

Managing unintended implications – keeping a green perspective

Some of the service owners, as well as the participating experts, discussed how to deal with unintended implications of the sharing economy in general, as well as within particular sharing economy platforms. In particular, the participants discussed how to deal with potential implications that may affect the green character of the sharing economy.

Nearly all the service owners reported on ecological sustainability as being an important motivation for the service, though they did not expect it to be important for all their users. Some also argued for the need to have financial owners also seeing environmental sustainability as important.

However, concern was voiced by several of the participants that sharing economy services may well deviate from this green starting point. In particular, in cases where demand in the sharing platform outstrips supply and the low prices and easy access provided by the platform increases demand. Here, sharing economy services could actually drive increased production rather than merely utilizing surplus capacity.

4.4 Actions to achieve the goals

The participating service owners, experts and policymaker representatives discussed a number of possible actions to achieve the identified challenges and goals. In this section, we provide an overview of the potential actions that are discussed, as well as the goals for which no immediate actions were identified.

The overview is provided in the form of a table, where we list the identified goals and present discussed actions. The different possible actions discussed are reviewed below the table. Note, however, that at this point the actions are not clearly defined, but rather general proposals for improvement. For the final version of the roadmap (D4.4), the actions will need to be more precise.

Areas of interest	Challenges and goals	Possible actions discussed
1. Human agency: Guiding consumers	Motivate consumers Change consumer behaviour Provide quality control Leverage role diversity	Accentuate financial gains and convenience Leverage circumstantial causes for habit discontinuity Drive change through policy Explore existing niches of collaborative consumption Invest in customers Differentiated products
2. Machine agency: Matching and predictions	Strengthen prediction abilities Platforms that allow predictions	(Associated with the need to increase network size; row 5 below)
3. Social ties: The good meeting of strangers	Keep the human aspect Matching strangers rather than group formation	A different kind of communality?
4. H2M interaction strength: Loyalty to the platform	Strengthen awareness Develop trusting relations	
5. Network size: Increase network size	Increase network size	
6. Geo-graphical reach: Local relevance in trans-local services	Local relevance in trans-local services Services that scale	
7. Workflow interdependence: Efficient interactions	Efficient dialogue Reduce the need for planning	
8. Network organization: Predictable services	Strengthen the platform as a central node Strengthen risk management and security Keep a green perspective	(Associated with the need to increase loyalty to platform; row 4 above) Reduce risk through insurance Identify and counter unintended implications

Table 1: Overview of challenges, goals, and discussed possible actions

Accentuate financial gains and convenience

As indicated in the literature (Hamari et al., 2016), (Möhlmann, 2015), the promise of ecological sustainability may not be sufficient in itself to motivate consumers to use sharing economy services.

Rather, these authors highlight the need to accentuate financial gains and convenience, as well as experiential aspects.

Likewise, the service owners are clear on the need to provide value propositions that accentuate the financial aspects of sharing economy services. For example, that the services enable you as a supplier to make money on surplus resources in a convenient manner.

Leverage circumstantial causes for habit discontinuity

Changing consumer patterns of behaviour is hard. The service owners all agree on this challenge, and some indicate that life situation may determine whether consumers are willing and able to make the needed change. These participant reports are in alignment with research presented by Verplanken and Roy (2015). These argue that a transfer to sustainable consumption patterns need to leverage circumstantial causes for habit discontinuity. As examples of such circumstantial causes they list life-events (when moving, when becoming a student, when getting a family). Potentially, service owners could to a larger degree leverage circumstantial causes. For example by addressing users in changing life circumstances, or in non-everyday situations such as vacations.

Policy as a means to drive behaviour change

Surprisingly, none of the participating stakeholder representatives discuss policy as a means to change consumer behaviour towards using sharing economy services. Rather, potential policy changes that are discussed concern adapting existing regulations also to sharing economy services.

However, some of the service owners discussed policy change as a means to drive behaviour change. For example, changing regulation or taxing of transportation could increase consumers' likelihood to try out sustainable sharing alternatives. This is in line with Verplanken and Roy (2015) who discuss behavioural change through upstream interventions (macro-level policy, as for example in tax reform, infrastructure changes, restriction of alternatives, or directly regulate behaviour).

Explore existing niches of collaborative consumption

For some users, collaborative consumption is already the norm and does not require a fundamental change in behaviour. For example, among farmers sharing of harvesting resources and equipment has been a norm for centuries. Within more recent communities, such as photographers and movie producers, sharing and peer-to-peer renting of specialized equipment is common practice also prior to the sharing economy. Some of the service owners discuss how such existing niches of sharing and collaboration can be leveraged to strengthen sharing economy services.

Invest in customers

Some of the service owners discuss individual support to their users as a way to strengthen quality in presentations and services. This may be resource demanding, but is seen as a long-term investment in increased quality. In the literature, it is also discussed how investment in customers may provide such an effect. Malhotra and Van Alstyne (2014) argue that sharing economy platforms would benefit from investing in their users so that these are able to create more value as for example AirBnB has done by investing in helping their supply side with improved quality in the prospects pictures and descriptions.

Differentiated products

Sharing economy platforms include different types of consumers holding different roles. Some lean towards being suppliers, others represent demand. Some want efficient and highly streamlined processes, others are more appreciative of the experiential aspects of the services.

Some of the service owners discussed the possibility to provide different types of products to accommodate different types of users. Such product differentiation is already seen in leading providers, such as the different Uber services (e.g. X, SUV, BLACK), or AirBnB regular booking and the book now option.

A different kind of communality?

The services owners see their platforms mainly as a good means for matching strangers. Hence, the communality between the users may not be that they already know each other, but that they share or complement each other on other characteristics. Sharing the same geographical location may be one such characteristic, but also other characteristics may apply such as common demography or common interests. The participating experts argued that service owners may benefit from exploring further how communalities between users may be explored as part of the service provision.

Reduce risk through insurance

Risks associated with sharing economy services has been a much debated issue. In particular for transportation services such as Uber. Malhotra and Van Alstyne (2014) argue that policies are needed to manage risk associated with sharing economy services, where the services or platforms take on a greater responsibility for risk management. The participating service owners discuss how provision of insurance as part of the service is instrumental in building trust and reducing the risk associated with collaborative consumption. Third party insurance providers may hence see sharing and collaborative consumption as a new market area.

Increase security through fraud detection

Fraud in sharing economy services has also been pointed out as an important challenge. Malhotra and Van Alstyne (2014) suggest that platform owners should take on responsibility to police their networks, as they are closer to the services and can be better at spotting illegal or unethical behaviour in their platforms than government law enforcement organizations can.

Identify and counter unintended implications

As sharing economy services are potentially disruptive, they may lead to changes that are not intended, and that are not seen as beneficial neither as seen from the consumer perspective or the perspective of the service owners. One example of this, is the potential drifting away from a green ambition due to lowered cost of consumption and a lack in surplus resources or capacity. Some of the service owners discussed the need for sharing economy companies to work strategically to mitigate such unintended implications. For example, by having investors or owners that share their perspective in green consumption.

4.5 Way forward

We have in this section presented our initial work towards a roadmap for sharing economy HMN. Specifically, we have presented our findings for the four first steps of the HUMANE roadmapping process.

As a conclusion from these first steps, we observe a strong interest for the sharing economy among relevant policy makers and NGOs on a national and European basis. While many of the interviewees appear optimistic about the opportunities of creating a thriving ecosystem of start-up companies, SMEs and innovation, the challenges and trends and recommended actions described in Sections 4.3 and 4.4 are not necessarily acknowledged sufficiently. In order to counteract detrimental developments of the market such as centralisation and monopolisation driven by (mostly) US actors, a more urgent engagement by relevant stakeholder groups in terms of reviewing and implementing regulations in order to support and secure the competitiveness of European companies, especially start-ups and SMEs, early on. This includes clear marked access regulations, clear and easily implementable guidelines for the handling of consumer and employee rights, as well as privacy and security regulations.

As a first supporting step in this process, we will in the next roadmapping deliverable (D4.4) use these findings as a basis to present design strategies, implementation priorities and timelines as well as the detailed roadmap.

As further basis for this work, we have in our work in the HUMANE typology and method identified implications and design strategies for peer-to-peer reselling services which are also relevant for this work (D2.2).

5 Roadmap for eHealth human-machine networks

HMNs in eHealth include networks for the management and dissemination of Electronic Health Records (EHRs), telemedicine networks and applications (including telesurgery) and networks for physiological monitoring of patients with smart mobile or wearable devices (Smart Wearable Health Systems and Applications - SWHS). ***The HUMANE roadmap focuses on the latter, which we call more generally as "personalized eHealth systems, devices and applications" or simply "eHealth HMNs"***, as the most typical example of HMNs in the eHealth domain and one of the most innovative and rapidly evolving technologies worldwide. The advancements in micro/nano, bio-technology and telecommunications have significantly extended the capabilities of eHealth HMNs, beyond the simple monitoring of vital signs. Today, there are devices and applications for the management of chronic diseases, back problems, biochemical indices, heart problems, and many other medical conditions. Such devices are intended for a large public, but are adapted to the specific needs of individual patients, and store or communicate personal information, so that they become "personalized".

The need to address the high economic burden of the healthcare sector and to provide for an ageing population, and the high interest of both consumers and professionals make eHealth HMNs a promising and challenging sector. However, policies to efficiently integrate such technology in medical

care and everyday life seem inadequate to match the pace at which such devices enter the market. As the analysis in D4.1 revealed, there are significant challenges regarding privacy and security, efficient information processing, and quality of service. The roadmap for eHealth HMNs aims to map the problems and propose efficient design strategies, as well as steps for their solution.

5.1 eHealth HMNs: Current technological situation, emerging and future trends

The use of HMNs in eHealth coincides with the trends observed in developed countries towards early detection of diseases, health status monitoring, healthy lifestyle, and improvement of the overall quality of life. This is also related to the higher life expectancy, population ageing, and the need for older people to be valuable economic and social resources.

According to evidence from the World Health Organization (WHO), life expectancy has increased globally in the last years, although great inequalities persist within and among countries. According to this year's "World Health Statistics: Monitoring Health for the SDGs" report, life expectancy increased by 5 years between 2000 and 2015, the fastest increase since the 1960s (World Health Organization, 2016). In a press release by the WHO in 2015 for the International Day of Older Persons[17], it was noted that the number of people over the age of 60 is expected to double by 2050, which will require radical change in order to ensure that these extra years are healthy, meaningful and dignified. However, as was noted in the WHO's "World report on ageing and health 2015"[18], there is very little evidence that the added years of life are being experienced in better health than was the case for previous generations at the same age. In other words, although more people live longer lives, their quality of life is generally not better than the one of people in previous decades that reached the same age. To achieve a good life quality, a radical society change will be needed, in the way society deals with health and ageing as a whole. Cited research suggests that the benefits to society would far outweigh any investments that might be needed to provide the health services, long-term care and social security that older populations require.

Technological advances can greatly help in this direction, by facilitating treatments and monitoring the physiological condition of a person not only in older age, but throughout a person's lifetime, so that more people are able to reach higher ages in good health.

eHealth HMNs can be seen as a subfield of telemedicine, which generally refers to the application of electronic communication for the provision of medical information. However, the field of eHealth HMNs has grown so much that it can be seen as a separate sub-category of HMNs. They include stand-alone devices for the measurement of vital signs like ECG (Electrocardiography), blood pressure, heart rate, respiratory rate and oxygen saturation, skin temperature, and posture (e.g. monitoring the body positions and movements for determining relationships to sleep apnea). New developments include sweat sensors, i.e. strips that analyze the metabolic substances in sweat and help consumers track their internal biochemistry (information on electrolyte balance, hydration level and muscle exertion),

[17] http://www.who.int/mediacentre/news/releases/2015/older-persons-day/en/
[18] WHO, "World report on ageing and health 2015", 2015. http://apps.who.int/iris/bitstream/10665/186463/1/9789240694811_eng.pdf?ua=1

devices for asthma management, management of lower back problems and quell relief, glucose sensors for the management of diabetes, and detection of cardiac problems like atrial fibrillation.[19,20] This also includes smartphones (where the relevant domain is often referred to as 'mHealth'), as they can also be turned into medical devices (e.g. with apps that allow the user to rest their finger on the case, which will then measure heart rate or alert the user if atrial fibrillation is detected). Furthermore, current research is moving towards monitoring of multiple vital signals, as well as towards their use in a networked online environment, where sensor results can be collected and transmitted to medical establishments in real time. There is an increasing number of eHealth software applications, both on mobile and desktop computers, that help people monitor and improve their health condition, with or without the use of specific devices (e.g. dietary advisors, fitness applications, applications for diagnosis of health status and diseases). Such solutions enable patients to live a more normal life, whilst facilitating efficient management of diseases and early diagnosis of symptoms from a distance. They also reduce the need for medical visits and save related expenses and time for both doctors and patients.

Personalized eHealth systems, devices and applications are also closely related to other HMNs in eHealth; obvious with other telemedicine applications (e.g. a doctor can interact remotely with a patient and read the measurements of an eHealth device), but also with EHRs. For example, telemedicine applications can benefit from having access to information in EHRs, while measurement results from remote monitoring devices can be aggregated and produce statistics which enrich a patient's EHR.

Personalized eHealth monitoring systems, devices and applications are also a cornerstone of the EU eHealth policy and research.[21] But, while such devices and applications are being used extensively by individuals, there is very small integration of such devices in every day clinical practice (Wicks, Stamford, Grootenhuis, Haverman, & Ahmed, 2014). This is complicated by the lack of legal clarity and certification of eHealth applications that are available for user devices. Relevant challenges were discussed in D4.1, and will be elaborated on here in order to help build the roadmap for the successful integration of such systems.

5.2 Policy background and regulatory context

The European Commission (EC) adopts its Digital Single Market strategy for Europe, which aims to make the EU's single market freedoms "go digital" and boost growth and jobs in the EU. The strategy is designed to prompt eHealth interoperability and standards in the EU, for the benefit of patients, health professionals, and health systems and industry.

The EC has adopted an action plan on eHealth for the period 2012-2020 (European Commission, 2012). According to this plan, one of the barriers to the development of eHealth is the lack of clarity on legal

[19] https://www.wearable-technologies.com/2015/04/wearables-in-healthcare/
[20] http://www.beckershospitalreview.com/healthcare-information-technology/5-digital-health-trends-for-the-new-year.html
[21] http://ec.europa.eu/information_society/doc/factsheets/009-ehealth-en.pdf

and other issues around mobile health ("mHealth") and "health & wellbeing applications" and about the role that network operators, equipment suppliers, software developers and healthcare professionals could play in the value chain for mHealth. In addition, following the adoption of the Directive on the application of patients' rights in cross-border healthcare, the EC established the eHealth network[22], a network of national responsible authorities on eHealth, in order to ensure the alignment of eHealth with health strategies and needs at the Union and national levels through the direct involvement of national health authorities.

In April 2014, the European Commission published a Green Paper on mHealth[23], which explored the potential of mHealth, and issues such as privacy, patient safety, legal frameworks and cost-effectiveness. Immediately after, a public consultation was launched, open until 10 July 2014, in which it invited stakeholders to provide their views on 11 identified barriers to the uptake of mHealth in the EU. It was targeted at several stakeholders, which are also considered by HUMANE: regional and national authorities, health professionals and practitioners, consumers, application developers, mobile manufacturers, but also insurance agencies and associations such as sports centres and health clubs. Based on the responses, it was concluded that privacy and security, patient safety, a clear legal framework and better evidence on cost-effectiveness are all required to help mobile Health care flourish in Europe.

Together with the Green Paper, the Commission also published a Staff Working Document on the existing EU legal framework applicable to lifestyle and wellbeing apps, providing legal guidance on EU legislation in the field to app developers, medical device manufacturers, digital distribution platforms, etc.[24] Following these works, the EC planned to establish an industry-led Code of Conduct for mobile health apps, which was recently released[28]. The objective of this code is to foster citizens' trust in mHealth apps, raise awareness and facilitate compliance with EU data protection rules for app developers. [25] Furthermore, in February 2016 the EC appointed a working group with the mission to draft mHealth assessment guidelines. The group includes representatives of patients, health professionals and providers, industry, academia and public authorities. The group will seek to provide common quality criteria and assessment methodologies that could help different stakeholders, in particular end-users, in assessing the validity and reliability of mobile health applications. The guidelines are expected to build on existing initiatives and best practices in Europe.

Finally, under the Horizon2020 programme, the EU plans to invest more than €2 Billion on projects related to Health, Demographic Change and Wellbeing. Amongst the goals of the programme are to improve our ability to monitor health and to prevent, detect, treat and manage disease, as well as test and demonstrate new models and tools for health and care delivery. The 2014-2015 period included calls for ICT solutions for assisted living environments, self-management of health and disease and

[22] http://ec.europa.eu/health/ehealth/policy/network/index_en.htm
[23] European Commission, "GREEN PAPER on mobile Health ("mHealth")". Brussels, 10.4.2014. Available online at: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=5147
[24] European Commission, "COMMISSION STAFF WORKING DOCUMENT on the existing EU legal framework applicable to lifestyle and well-being apps". Brussel, 10.4.2014. Available online at: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=5146
[25] https://ec.europa.eu/digital-single-market/en/news/mhealth-green-paper-next-steps

patient-empowerment through ICT, decision support systems for self-management, innovation in organizational and business models for service delivery, as well as standardization and interoperability of ICT platforms, methods and services for eHealth. For the 2015-2016 period, the above topics were also included; in addition there were specific calls for scaling up of ICT solutions for active and healthy ageing, as well as on Big Data methods supporting public health policies. Related calls should also address topics about ownership of data, data protection/privacy, liability and consumer protection.

5.3 Key goals for eHealth HMN

In D4.1, we presented an overview of challenges in the eHealth domain. Here we provide a summary of these challenges focusing on personalized eHealth systems, devices and applications, and suggest policy goals of the roadmap based on what has been accomplished so far and the feasibility of solutions.

The major policy goals of the HUMANE roadmap for eHealth, as identified in the opportunities for policy intervention in D4.1, are to efficiently manage and protect personal medical data, provide an up-to-date framework for regulating eHealth applications, provide sustainable business models for smart wearable health systems (SWHS), and rules for QoS-enabled medical services.

More specifically, technical challenges are to:

- **Ensure the efficient management of very large volumes of data** from monitoring devices. Besides efficient storage, categorization and search of eHealth data, the focus should be on real-time event detection for early avoidance of severe health episodes and provision of hospital-level care remotely. Efficient data management also includes mechanisms for **protecting personal data**. In D4.1 we noted that wearable devices that can transmit data continuously can exacerbate the uncertainty regarding the access to and sharing of medical data that occurs without knowledge of the patient. We highlighted the need for transparency regarding access to and use of such data, as well as for accountability in case of misuse. From the processing viewpoint, we highlighted the need for different levels of detail in data records, from the detailed history of treatment and results required by doctors, to anonymized statistics used to inform public policies.
- **Ensure the availability of systems and services**, especially those for critical diseases, such as remote heart monitors. Availability is required on the user side as long as the devices are used (a patient could decide to switch off the devices), and necessarily at the back end, where data from devices are processed. **Availability is related to QoS-enabled medical services and avoidance of congestion episodes, as well as security and protection from attacks** (DoS attacks, power drain attacks, etc.). In D4.1, we noted the need to provide QoS-enabled services for real-time monitoring operations, especially when large amounts of data have to be transferred. This is not always possible with best-effort Internet services that are vulnerable to congestion. We highlighted the difficult problem of providing QoS-enabled services, as envisaged by the Open Internet Regulation (EU) 2015/2120, while at the same time not undermining the general quality of the Internet access.
- **Provide for medical data security**. In D4.1, we highlighted the fact that many of the sensor networks applications in healthcare are heavily relied on technologies that can pose security

threats like eavesdropping and denial of service. The EC, in its 2014 Green paper on mHealth,[23] noted the risks for accidental exposure of medical data to unauthorized parties, and the risks from loss or theft of devices storing sensitive information. They concluded that mHealth solutions should contain specific and suitable security safeguards such as the encryption of patient data and appropriate patient authentication mechanisms to mitigate security risks.

- **Achieve interoperation between eHealth devices of different manufacturers**. This is related to global efforts for **standardization** of M2M communications. Currently, eHealth standardization is under active consideration in different standards fora such as ETSI TC M2M, ETSI TC e-Health, ITU-T Focus Group (FG) on M2M etc. Interoperability and standardization are also expected to create economies of scale that can provide more **cost-efficient systems and services**. There is a need for harmonizing the spectrum in which these devices operate across the whole of Europe and ideally, worldwide, as the Industrial Scientific and Medical (ISM) band seems to be overcrowded. Barriers to standardization include the existence of proprietary systems, the massive amounts of data being collected from these systems, the lack of standard content format and the lack of open freely available standards (Fan, Haines, & Kulkarni, 2014).

Non-technical challenges identified in D4.1 are to:

- **Provide eHealth HMN at reasonable cost**, so that they are widely adopted. This is related to the need to provide **business models to ensure the sustainability of the offered services**. In a 2010 report on business models for eHealth (Rand, 2010), the authors attested the need to evaluate different business models and share best practices for funding and financing individual eHealth systems, such as tax breaks, different reimbursement procedures or co-funding mechanisms. It is also known that the legal and social environment where eHealth services are provided plays a major role in the choice of business models (Kimble, 2015).
- **Provide a clear legal framework about the status of eHealth applications**, the norms that they should adhere to, and the responsibilities of manufacturers and developers towards the end-users. Such a framework can also help to **facilitate clinical trials**, as well as **increase consumer trust in such products**. In 2014, the EC published a report on the existing EU legal framework applicable to lifestyle and wellbeing apps.[26] Therein it was noted that there is still several room for interpretation regarding the applicability of existing legislation on the newly developed eHealth applications. The current legal framework is intertwining between the *Data Protection Directive*, the *e-Privacy Directive*, the *Consumer's Rights Directive*, the *eCommerce Directive*, and the *Unfair Commercial Practices Directive*.
- **Perform clinical validations of eHealth HMN**, which will attest the safety and efficacy of such systems. Clinical validation may include the combination of data from eHealth monitoring devices and data from traditional clinical procedures (Wicks et al., 2014). Validation of all systems of eHealth HMN is an impossible task, because of the sheer number and pace at which such systems enter the market, therefore this task should rather relate to **standardization**, and the need for

[26] European Commission. "COMMISSION STAFF WORKING DOCUMENT on the existing EU legal framework applicable to lifestyle and wellbeing apps", Brussels, 10.4.2014. Available online at: http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=5146

these systems to **follow certain norms and procedures**. The appropriateness and efficacy of the latter should be verified by clinical trials. Currently, the knowledge about the results of clinical trials on mHealth applications is fragmented within individual research projects, which included clinical trials for mHealth services.[27]

- **Protect the privacy of individuals and confidentiality of medical information**: this has to be ensured through **efficient data management** and **security mechanisms**, i.e. encryption and authentication mechanisms on all communicated data (sensor-to-sensor communication in a body area network or home network, or data communication from the home network to a hospital backend). Additionally, it is necessary to apply **consistent rules in the EU for the management of medical information**, including patient data. Data protection rules are expected to tackle another challenge, that of **increasing trust and mitigating resistance from the patients and healthcare providers in using such products**. As previously mentioned, the European Commission has facilitated the creation of a Privacy Code of Conduct on mobile health (mHealth) apps, which is expected to be applied into practice soon.[28]

An interesting observation in the analysis of these challenges is that they are to a high degree interrelated. Above we have highlighted these challenges, and how they relate to each other. For example, medical data security is closely related to privacy and confidentiality, which is in turn related to increasing consumer trust in such products. Or, standardization can facilitate clinical trials, which would ensure the appropriateness and efficacy of the products and again increase consumer trust. The following table (Table 2) shows the interrelation of challenges.

	Efficient data management	Availability	QoS-enabled medical	Security	Interoperability	Standardization	Cost-efficiency	Clear legal framework	Trust	Clinical validation	Privacy & confidentiality
Efficient data management											X
Availability			X	X							
QoS-enabled medical services		X									
Security		X							X		
Interoperability						X	X				
Standardization					X		X				
Cost-efficiency					X	X					
Clear legal framework									X	X	
Trust				X				X		X	X
Clinical validation								X	X		
Privacy & confidentiality	X			X				X	X		

Table 2: Interrelations of eHealth HMNs challenges (x signifies an interrelation)

[27] European Commission, "eHealth projects Research and Innovation in the field of ICT for Health and Wellbeing: an overview", June 2016. Available online at: http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=2852

[28] https://ec.europa.eu/digital-single-market/en/privacy-code-conduct-mobile-health-apps

The HUMANE approach can provide solutions that tackle these challenges from the initial design of such systems, and thus help promote eHealth HMN.

5.4 Actions to achieve the goals

In this section we propose detailed actions for achieving the goals set in the previous section.

In order **to ensure the efficient management and protection of medical data** stored and communicated by eHealth monitoring devices, we consider that realistic large scale studies are required, which will systematically examine the application of advanced data management by eHealth HMNs. Besides efficient storage, categorization and search of eHealth data, the focus should be on real-time event detection, for early avoidance of severe health episodes. Different levels of detail should be provided depending on the intended use (e.g. raw data for use by medical researchers or aggregated data for statistical reports) and the level of authorization of the persons accessing the data. In addition, techniques should be demonstrated that empower the users to take control of their personal data, and provide transparency with regard to their exploitation by the data collectors and any third parties. The demonstrated systems should also be robust to attacks and eavesdropping, and have advanced encryption and authentication mechanisms.

To ensure the availability of critical eHealth services offered by monitoring devices in the public Internet, it is necessary to develop eHealth services with guaranteed QoS. Providing QoS guarantees in the public Internet is a longstanding problem existing for about 35 years, and failures to do so are attributed to a mixture of technical, business, and political reasons (kc claffy & Clark, 2015). Currently, the penetration of Internet services in everyday life, including critical human and societal functions, has refurbished the interest in this topic. There is increasing talk about 'specialized' or 'managed' services, or services 'other than Internet access services', as is the terminology in the recent European Open Internet Regulation (EU) 2015/2120. We believe that a concerted effort of the involved parties (ISPs, content providers, and consumers) is required to provide such services in practice without undermining the general quality of the Internet, and jeopardizing the benefits that Internet freedom and equality has brought to the public.

To ensure the interoperability of eHealth devices and data from such devices, it is necessary to harmonize the frequency band for the operation of such devices, and to encourage the development of standard content formats for the exchange of generated medical information. Other functions for which standards should be developed are the networking architecture, as well as the configuration of devices and reading of measurement data (kc claffy & Clark, 2015).

Regarding the need **to provide such systems at reasonable cost**, it is necessary to harvest the experience by offering products with eHealth monitoring capabilities in recent years. A study of existing business models is required that compare different models and forms of state subsidies, and also examines regulatory differences in each country, as well as differentiations based on the social conditions and mean income.

Regarding the **legal framework**, it is necessary to review and merge the provisions of the different regulatory documents that relate to eHealth HMN: the Data Protection Directive, the e-Privacy

Directive, the Consumer's Rights Directive, the eCommerce Directive, and the Unfair Commercial Practices Directive. It should aim at removing redundancies and resolving ambiguities in the marketing and use of eHealth HMN.

Clinical validations should aim at deriving best practices and discovering the safest and most efficient monitoring systems, and at demonstrating the integration of eHealth HMN with current clinical practice procedures. Such practices could then become norms that such products should follow. To this end, there is also a need to collect the experience from clinical tests that have already been performed with eHealth monitoring devices.

Finally, there is a need **to apply privacy-by-design mechanisms** in commercial eHealth HMN. This is related to the empowerment of users to manage their personal information, and to control the level of confidentiality. Similarly to data management, we consider that large-scale pilot studies of such systems would be extremely helpful. In addition, we should examine the application of the forthcoming mHealth code of practice and assess its efficacy.

5.5 Design strategies and technology solutions

There are several dimensions of interest in eHealth HMNs. Because of the immediate concern for human life, more emphasis is placed on human-centred dimensions such as human agency, human-to-human (H2H) interaction (usually between doctors and patients) and human-to-machine (H2M) interaction (between a patient and the monitoring application). Nevertheless, dimensions such as the size and geographical expansion are also important for the design of such systems.

We may have different degrees of human agency and H2M interaction, depending on the type of medical condition the systems are supposed to manage and the degree of human intervention. For example, a device that only performs monitoring of vital signs and sends the measurements to a remote medical centre has a low level of human agency, whereas a system with glucose sensors for the management of diabetes has a high level of human agency, as it requires user intervention — which in its turn impacts the measurement results.

On the other side, machine agency is always high, because of the high dependency on machines to complete the tasks; even machines used for mere monitoring tasks mediate the results to patients, and potentially to medical establishments, and thus impact both the patients and doctors. Some of the devices are also used for therapeutic purposes (also known as "wearapeutics")[29], in which case their importance and agency greatly increases. For example, devices which deliver drug doses (such as insulin patches), or devices for quell relief. Services need to be accurate with limited or no errors (especially if they are also used for therapy). They need to analyse health data quickly, and need to be secured and transparent, and available anytime and anywhere.

The degree of H2H interactions usually varies based on the purpose for which they are used, and the severity of the medical condition. In eHealth systems such as fitness applications or dietary advisors

[29] https://www.flextronics.com/live-smarter/wearable-technology-wearables/wearable-medical-devices-wearapeutics

there is usually no or very little interaction between patients and doctors. However, in systems used for severe health conditions such as heart monitors day to day communication may be required. Other H2H interactions include interactions between the users and IT experts, or technology providers, to ensure the proper functioning of equipment, as well as mutual exchanges of experiences between users or between doctors; the latter often provide significant feedback for the system functionality.

The size of eHealth HMNs usually varies proportionally to the number of their users, and the number of vital signs they are supposed to monitor: from simple systems that monitor single vital signs, to more complex ones, such as body area networks, that monitor multiple vital signs. These systems may be enriched with location sensors, or sensors that measure environmental parameters (temperature, humidity, light, pollution), which can be combined for assessment by doctors or researchers (Milenković, Otto, & Jovanov, 2006). In view of the intended uptake of eHealth HMNs by large parts of the population, a single eHealth HMN could consist of thousands of users and should definitely be designed to manage very large volumes of data.

Finally, the geographical expansion of an eHealth HMN is more likely to be limited by the number and density of users, and the limitations in scalability. So if there is a dense set of users in a small area, an eHealth HMN connected to a medical establishment could be setup to serve the users in this area. In a rural area where there is lower system load, a large area could be covered. The geographical expansion also depends on movement limitations imposed by the monitoring system itself: in e-monitoring applications with non-wearable devices, the patient may only be free to move within a closed area where continuous connectivity can be provided easily. Wearable technologies, on the other hand, are designed to allow more movement, and combine different access technologies (Wi-Fi inside the home or cellular networks outside) along with data transmission techniques and synchronization methods that allow continuous monitoring even in cases of intermittent connectivity.

According to the above dimensions, we describe the design strategies from D2.2 which are considered more relevant, and explain their suitability for eHealth HMNs.

Behavioural change through social motivation[30]

Even though people are intrinsically motivated to look after their personal health and the health of other people in their environment, the widespread adoption of eHealth HMNs requires a break in a pattern of behaviour that exists for many decades. People are used to visit their physician even for simple incidents, and to think that disease monitoring and – much more – therapy can only be provided at medical establishments. The design strategy for *Behavioural change through social motivation* aims to attract a critical mass of first adopters, which can subsequently motivate other users to participate in the eHealth HMN. As described in D2.2, this can be facilitated by the creation and support of groups of users with common attributes.

[30] Code of design strategy from D2.2: 14.2.1.2

Making behavioural change a basic premise of the HMN[31]

HMNs that depend on behavioural change in their human actors should consider explicating benefits of HMNs, not just for the user himself, but for society as a whole. For example, devices and apps for training such as Fitbit[32] engage their users in a HMN where the aim is to get help to change behaviour, be nudged to reflect on own behaviour change, and get feedback on own progress.

Collaboration through gamified engagement[33]

Gamified engagement is an approach typically seen in online games, but also in social networks. Gamification is the use of game design elements in non-game contexts and offers great potential regarding the engagement and motivation of the elderly (Gerling & Masuch, 2011). Gamification in eHealth should not aim at merely adding visual components of games, such as points and rewards, but to achieve long-term motivation and adherence (de Vette, Tabak, & Vollenbroek-Hutten, 2015).

Supporting trust across HMN interactions[34]

This design strategy addresses the lack of user trust in relation to their data or their contribution(s), and is mostly related to the H2M interaction. In eHealth HMNs there is a need to increase the trust of patients in using eHealth HMNs. A user of an eHealth device or application may wonder what happens to the data that are recorded and communicated. In addition, a user should be able to authorise the parties which are using the data, and the ways in which they are used. Possible solutions, as described in D2.2, are to turn one-way interactions into multi-directional, so that the user receives feedback on the actions performed, and to track usage traces for the provided data. Additionally, a data management service could be offered that tracks data access attempts, as well as refuses data release without explicit consent and/or generic agreement.

Maximising the benefits of affordances[35]

This strategy addresses the problem of confused or inappropriate user response to signals and alerts. In eHealth HMNs it is important to increase the probability of correct response to signals or of appropriate input. It is important when the machine agency in these systems is high, such as in eHealth HMNs for monitoring critical diseases. It is important to accurately guide the users, and prevent panicking or leading the users to perform actions that would cause the eHealth HMN to malfunction. For implementing this design strategy, solutions should relieve user pressure, extend contextual awareness and shift to a mode of engagement with human agency that promotes either automatic responses (schema-based) or refocuses attention to re-evaluate a situation (cf. D2.2).

[31] Code of design strategy from D2.2: 14.2.1.1
[32] https://www.fitbit.com/
[33] Code of design strategy from D2.2: 14.2.2.1
[34] Code of design strategy from D2.2: 14.4.3.3
[35] Code of design strategy from D2.2: 14.1.1.2

Enhancing security in HMNs concerning data aggregation and content curation services[36]

This design strategy is meant to address the problem of unauthorized access to user information, or improper user of such information and also contributes to *supporting trust across HMN interactions*. It is particularly important in eHealth HMNs, because of the personal nature and sensitivity of health information. It is much more important when there is high H2M interaction and high machine agency, where a user does not control the information that is collected and possibly communicated. The solution is to apply enhanced security mechanisms in order to prevent attacks on the HMN. Apart from authentication mechanisms, there should be strict control on how aggregated data can be provided for third-party services, control for fake profiles and strict privacy and confidentiality agreements.

Securing HMNs[37]

This design strategy aims to address the burden incurred from separate authentication and authorization mechanisms in a network, when a large number of nodes exists. For example, it cannot be expected by a member of the medical staff to manage different authentication and authorization processes for each different individual of an eHealth HMN. At the same time, there is a need to protect individual user privacy. Therefore there is a need for a single 'authority' who would vouch for individual agents, humans or machines, to mediate their access to other services.

Managing privacy[38]

Having provided content, data or information to an eHealth HMN, the original user (data subject or source), in this case the patient, may lose control over who can access such data and what they do with it. It is important when machine agency is intermediate/high. This design strategy shares common features to the design strategies for supporting trust and enhancing security in HMNs. A solution proposed in D2.2 calls for a repository controlled by a trusted third party. Data subjects, content providers, and information sources would be able to specify who and under what circumstances the data or content can be released, even responding to ad hoc requests from unknown parties. In this way, first the data or content would be managed on behalf of the source; secondly, there would be an audit trail to the last authorised party should the data subject or owner suspect that it has been compromised.

Increasing trust of users through strict, clear privacy policies[39]

A common problem in HMNs is the increasing trust requirements for the handling of personal data and the confidentiality of information. Complex, obscure or insufficient rules for the protection of personal data are likely to deter users from submitting data or providing comments and opinions, or even from registering and participating in the HMN. Thus it is important to increase trust of patients with strict privacy policies for the use of their data. The user should know beforehand how his/her personal data are being used and who has the right to access them, if such data are shared with third parties and

[36] Code of design strategy from D2.2: 14.4.1.1
[37] Code of design strategy from D2.2: 14.4.2.1
[38] Code of design strategy from D2.2: 14.4.1.2
[39] Code of design strategy from D2.2: 14.4.3.5

under what conditions, and how this data can be deleted. Additionally, accountability mechanisms could be installed so that the user knows when personal information is accessed and by whom, and methods to detect and remove fake profiles.

Moreover, potential new design strategies for eHealth HMNs include:

Efficient management and protection of sensitive data through different levels of detail and authorization

HMN type: *Machine agency intermediate/high*. Implication: *Privacy;* Design Strategy Group(s): *M2H, M2M*

Problem

How to serve the needs of different parties accessing eHealth data at different levels of detail, while maintaining user privacy and transparency.

Background

The storage and retrieval of eHealth data collected from monitoring devices can facilitate a number of different tasks: from doctors performing disease diagnosis, to researchers performing clinical trials and third parties creating statistical reports. Each task requires a different level of detail: the highest level needed for disease diagnosis, and the lowest level for creating population statistics. At the same time, there is a need to minimize creating redundant copies or fragmenting the database, and to provide a high level of privacy and transparency regarding data management.

Solution

Different levels of details should be provided depending on the intended use (e.g. raw data for use by medical researchers or aggregated data for statistical reports) and the level of authorization of the persons accessing the data. An organization of data in the form of a hierarchical tree that has branching levels of data options with increasing specificity is envisaged, with possibility for separate authorization at each level.

Illustration

The rendering of data in different levels of details, from raw to aggregated data could follow methods similar to those of spatial statistics, where there are different aggregation layers, from coordinate-level to aggregation layers in different regions.

When to use

Use in the planning and design of a healthcare database for an intermediate to high machine agency in HMNs for physiological monitoring of patients with smart mobile or wearable devices. The pattern should be used during the early design phases, to make sure that the design of the transparency process supports that data are transparent with regard to their exploitation by other parties than patients and patients' health providers.

Sources

Gelfand, Alan E., et al., eds. Handbook of spatial statistics. CRC press, 2010.

See other strategies

Compare with 14.4.1.2 (reported in D2.2) which deals specifically with managing privacy.

QoS guarantees in critical eHealth services offered by monitoring devices in the public Internet

HMN type: *H2M interaction intermediate/high*. Implication: *User experience;* Design Strategy Group(s): *H2M, M2H*

Problem

Reduced availability of critical eHealth services due to lack of QoS guarantees.

Background

The current best-effort Internet services may not satisfy the stringent throughput and delay requirements of applications for eHealth HMNs, especially the ones that are critical for the life of the patient (e.g. heart monitors). At the same time, the cost to build private infrastructures that are unaffected by congestion problems in the public Internet is prohibiting the wide use of such practices. Hence there is a clear need to provide QoS-enabled services for medical applications at low cost, ensuring high availability and efficiency of critical applications.

Solution

QoS guarantees for eHealth services could be provided similar to 'specialized' or 'managed' services, like live IPTV, that are already provided by ISPs worldwide. This should be done in accordance with the recent European Open Internet Regulation (EU) 2015/2120. A concerted effort of the involved parties (ISPs, content providers, and consumers) is required to provide such services in practice without undermining the general quality of the Internet.

Illustration

Internet services with enhanced quality can be provided using various technologies, such as MPLS (Multi-Protocol Label Switching), VLAN separation, or DSCP (Differentiated Services Code Point) marking. Such technologies are already applied by network providers for prioritizing real time traffic or traffic from business customers.

When to use

The provision of a service with enhanced QoS can be done at the operation phase or rollout, as the load of the service increases.

Sources

Xiao, Xipeng. Providing quality of service in the Internet. Diss. Michigan State University. Dept. of Computer Science and Engineering, 2000.

Bohnert, Thomas Michael, et al. "Internet quality of service: a bigger picture." Proceedings of the First OpenNet QoS Workshop 'Service Quality and IP Network Business: Filling the Gap. 2007.

Claffy, K. C., and David D. Clark. "Adding Enhanced Services to the Internet: Lessons from History." Available at SSRN 2587262 (2015).

See other strategies

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Interoperability of eHealth devices and data from such devices

HMN type: *Machine agency intermediate/high*. Implication: *User experience;* Design Strategy Group(s): *M2M*

Problem

Reduced experience due to lack of interoperability between devices in such HMNs.

Background

Standardization and interoperation between different devices is necessary for widespread usage, within and across national boundaries. Interoperability and standardization play a large role in consumer trust, and are also expected to create economies of scale that can provide more cost-efficient systems and services

Solution

It is necessary to harmonize the frequency band for the operation of eHealth devices and data from such devices, and to encourage the development of standard content formats for the exchange of generated medical information. Other functions for which standards should be developed are the networking architecture, as well as the configuration of devices and reading of measurement data.

Illustration

An example is the X73PHD standard for personal health devices, which has been adopted by Continua Health Alliance as standard de factum for medical devices interoperability.

When to use

Interoperability of eHealth HMNs is achieved by following common or standardized design practices at the initial design of a system.

Sources

Martinez, I., et al. "Implementation experiences of ISO/IEEE11073 standard applied to new use cases for e-health environments." 2009 Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE, 2009.

Lymberis, Andreas. Wearable ehealth systems for personalised health management: state of the art and future challenges. Vol. 108. IOS press, 2004.

See other strategies

14.4.3.5. Increasing trust of users through strict, clear privacy policies (reported in D2.2)

5.6 Breakdown of the roles of stakeholders

In this section we list the actions described in Section 5.4 and outline the roles of stakeholders in implementing these actions. These roles will be further elaborated in D4.4 with the outputs from stakeholder meetings where the roadmap will be discussed.

- ***Conducting realistic large scale studies to examine the application of advanced data management by eHealth monitoring devices and systems, and the application of privacy-by-design mechanisms in commercial eHealth HMN***:
    - ***Role of stakeholders:*** EU and national authorities can direct research funds to encourage the conduction of such pilot studies. They should encourage all other stakeholders to participate, including health professionals so that they can be integrated in clinical trials.
- ***Developing eHealth services with guaranteed QoS***:
    - ***Role of stakeholders:*** This is a complex task that primarily involves researchers, ISPs and providers of eHealth monitoring devices and applications. Researchers and IT experts involved in standardization groups can provide recommendations on feasible and efficient systems on end-to-end service delivery with guaranteed QoS, something that has not been possible until today. Regulatory authorities and EU bodies can assist by laying rules and supervising the provision of so-called 'specialized' or 'managed' services. A valuable output of the roadmap would be a regulatory document elaborating on the provision of such services mentioned in Regulation (EU) 2015/2120, possibly (but not necessarily) focusing on eHealth services and applications.
- ***Providing interoperable eHealth devices and common data formats***:
    - ***Role of stakeholders:*** Standardization groups and organizations should continue the work to harmonize frequency bands, and provide recommendations for networking architecture, device configuration and data formats. A problem with standards is that they are often published without being adequately applied in practice over long periods of time. This requires the cooperation of national authorities and health professionals and is more time-demanding.
- ***Study of business models for eHealth monitoring in European countries***:
    - ***Role of stakeholders:*** The study should cover all applications of eHealth monitoring devices, from simple mHealth apps to more complex remote monitoring networks and cover different countries, with diverse economic levels and social environments. The study should be conducted by research experts and be facilitated by EU and national authorities.
- ***Review and merge the provisions of the different regulatory documents that relate to eHealth HMN***:
    - ***Role of stakeholders:*** This task is recommended to be undertaken by EU authorities, with the cooperation of the national authorities.
- ***Perform clinical validations for assessing the safety and efficiency of eHealth monitoring devices***:
    - ***Role of stakeholders:*** This task should be performed by medical research experts and health professionals, and be facilitated by EU/national authorities and eHealth device manufacturers.

5.7 Implementation efforts and timeline

In this section we assess the difficulty of the aforementioned stakeholder tasks and the amount and type of resources required, and finally provide a timeline for implementation, based on the logical sequence of tasks and the estimated time required for implementation.

We consider the standardization and interoperability of eHealth devices and systems as a basis for conducting large scale pilots studies and clinical trials, as well as for providing QoS-enabled services. An initial assessment of the timeline and effort can be made by reviewing the status of standardization activities in two large organizations, ETSI and ITU:

- The standardization activities of ETSI include personal wearable and portable communicable systems including those for medical implants, health portals, and many other ICT-based tools assisting disease prevention, diagnosis, treatment, health monitoring and lifestyle management. Vital aspects considered by the ETSI project (EP) eHealth are: Security of systems and data, Quality of services, Interoperability and validation by testing, Usability.[40] So far EP eHealth has developed an initial report in developing eHealth user service models, and examined the applicability of existing ETSI and ETSI/3GPP deliverables to eHealth. The models which have been developed address interoperable solutions for healthcare data collection, transmission, storage and interchange with the required security, privacy and reliability. According to their website, the next step of this work will be to develop requirements and service architecture to provide improved eHealth services involving the relevant stakeholders, including users, medical professionals, etc. At the end of 2016, ETSI had also early drafts on recommendations for short-range medical devices, while in 2017, they are expected to release recommendations on paging services and use cases for eHealth.[41]
- The ITU-T study group 16 is the lead ITU-T Study Group on e-health. It originally focused on the standardization of Multimedia Systems to support telemedicine applications, but has also recently produced recommendations for the interoperability design guidelines for personal health systems, and a suite of conformance testing specifications of personal health devices.[42] There are currently no other work items under development.

Therefore, we see that the currently the standardization effort has focused on general design guidelines and not at complete system specifications. It is likely that such specifications will emerge as de facto standards from large manufacturers who are able to dominate the market.

The design requirements of such systems are well known, both from the aforementioned recommendations and the eHealth literature. Hence we consider that large scale pilot studies that examine the application of advanced data management by eHealth monitoring devices and systems, and the application of privacy-by-design mechanisms in commercial eHealth HMN are a mature work-

[40] http://www.etsi.org/technologies-clusters/technologies/ehealth
[41] ETSI Work Programme (accessed 2-1-2017)
[42] http://www.itu.int/en/ITU-T/studygroups/2013-2016/16/Pages/ehealth.aspx

package that could be conducted by a coordinated stakeholder effort through EU-funded projects, typically for a 3-year duration.

On the other hand, a preparatory work may be required to study the aspects of eHealth HMNs that must be systematically studied in clinical trials, in order to have a concerted effort at EU level and avoid fragmentation. This preparatory phase should also collect the knowledge and experience from previous eHealth projects that included clinical trials.[43] We envisage 1-2 years for this preparatory phase, followed by clinical trials that last for 3-4 years.

The study and development of efficient business models is a stand-alone task that could be undertaken in 1-2 years. On the other hand, reviewing and merging the provisions of the different regulatory documents that relate to eHealth HMNs (the Data Protection Directive, the e-Privacy Directive, the Consumer's Rights Directive, the eCommerce Directive, and the Unfair Commercial Practices Directive) is a significant task, which may require 2-3 years, in view of the need to study the design requirements, conduct discussions in EU institutions and member states, as well as public consultations. This review can benefit from input of standardization efforts, as well as business model requirements.

Finally, we consider the development of eHealth services with guaranteed QoS as the most difficult task, which requires the concerted effort of the involved parties (ISPs, content providers, and consumers) because it disrupts the current best-effort nature of the Internet. It may also require the improvement of communications infrastructures, as well as the development of new QoS standards. We see this as a challenging task for the next decade, which may also be impacted by the evolutions for providing QoS for multimedia entertainment services such as IPTV, or for emergency preparedness services.

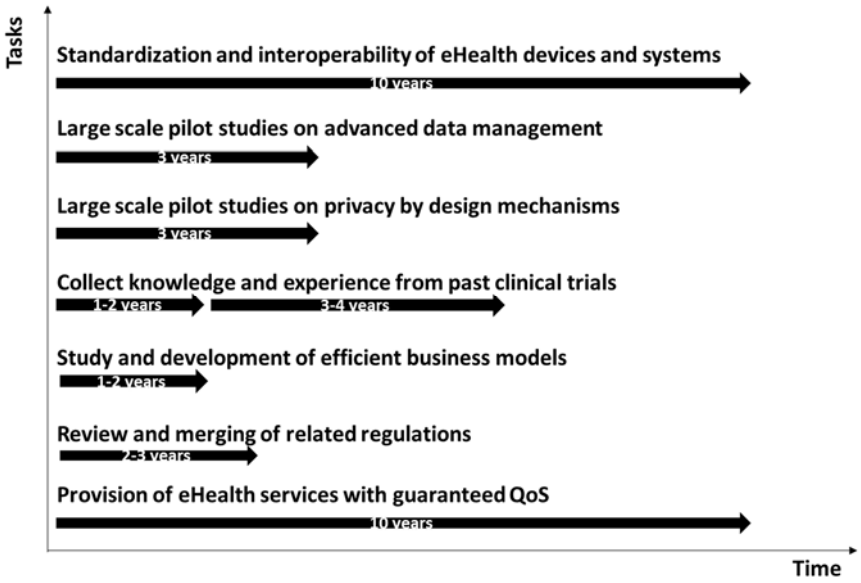

Figure 3: eHealth HMN timeline

[43] European Commission, "eHealth projects Research and Innovation in the field of ICT for Health and Wellbeing: an overview", June 2016. Available online at: http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=2852

The eHealth HMN timeline is shown in Figure 3. We show the timeline for a 10-year period. The standardization and interoperability of eHealth devices, as well as the provision of eHealth services with guaranteed QoS are considered as continuous tasks during the whole period. The periods for the remaining tasks have been estimated based on experience and the degree of difficulty of the tasks, as discussed here.

5.8 Way forward

In this deliverable we have presented the preliminary version of the eHealth roadmap, following the guidelines for roadmap development in Sections 2.3 and 3.1. The proposals in the roadmap were largely based on the challenges and opportunities for policy intervention identified in D4.1, which have been further elaborated in order to describe the current status of related work, the specific actions and tasks of stakeholders, and the dependencies between these tasks. A preliminary assessment of the complexity of the tasks and the time required for their completion has also been presented.

In order to complete the roadmap development, the feedback of stakeholders is crucial, particularly in determining in more detail the tasks that need to be performed, the timeline and resources. As emphasized in Section 2.3, a roadmap is a product of a collaborative process and it would be optimal to arrive at a consensus on all issues, or at least to represent and try to incorporate all different opinions. The stakeholders can also help to identify more detailed objectives, other appropriate design strategies or examples of design strategies that have already been applied in specific products or use cases.

We first plan to collect stakeholder feedback by disseminating an online questionnaire about eHealth HMN. We aim to collect feedback on the importance of the aforementioned challenges of eHealth HMNs, the tasks or specific actions to address these challenges, the current level of maturity of these tasks and actions, their level of difficulty and dependencies between them. The responses will be used to corroborate or challenge the roadmap proposals made in these deliverable, or to find new challenges and action directions.

In order to get more detailed feedback, we also plan to host dynamic discussions in focus groups (or interviews) composed of stakeholder representatives. Focus groups can help to quickly collect detailed feedback from all stakeholders and stimulate the exchange of opinions. More than one focus group may be setup, to gather complementary stakeholder feedback, e.g., a focus group composed of patients groups and medical professionals, or one composed of policy-makers, IT experts and researchers.

Finally, the last step in the roadmapping process is the dissemination of the roadmap to EU and national policy makers, and other eHealth stakeholders. Together with the last version of the roadmap, we will describe specific groups for dissemination, the dissemination material that will be prepared, as well as the dissemination means and/or channels.

6 Roadmap for citizen participation human-machine networks

During two recent events[44,45] hosted by the Hansard Society of London[46] under the auspices of the SENSE4US EC funded project[47], aspects of citizen engagement with government and the democratic process were discussed. The first event, held in Westminster, UK, took as its theme "Future Parliament, Hacking the legislative process" and involved panellists from the UK Parliament, from Government offices, from citizen representation groups and technologists. The second event, held in Brussels, looked more broadly at citizen engagement across Europe, and was entitled "Building Trust in the Policy-Making Process", and involved similar types of stakeholder, but drawn from across Europe, and was therefore wider in geographical scope than the UK event. The discussion topics have provided a rich source of comment and information for a first consideration of the views and concerns regarding the development of social media mediated citizen engagement, which can be drawn upon in the context of the questions which the HUMANE project is addressing in this area.

The key questions that have been identified to underlie semi-structured interviews in this area are those below – in the following sections information taken from the transcripts of the two events has been analysed for comments and contributions that are relevant to these questions, with attributions where possible. The discussions raised interesting, and often contradictory, observations about the social as well as technical implications of wider and more effective citizen participation in the process of policy definition and enactment.

The key questions analysed were these:

1. What are the concerns with the way social media is being used?
2. What are the positive aspects and benefits of social media [in citizen participation]?
3. Should there be guidance or management of the use of social media [for citizen participation]?
4. What should policy makers be doing to minimise the risks of social media [citizen] engagement?
5. How might citizen engagement over social media evolve in the future?

The answers, or contributions, to these questions gleaned from discussion have been used to inform the discussions presented in the following sections. In the final part of this section (section 6.7) the threads are drawn together to suggest what this insight offers to the future development of the roadmap.

6.1 Citizen Participation: Current technological situation, emerging and future trends

There is much discussion around citizen participation in policy making and governance, particularly in the light of recent uses of social media for political lobbying, electioneering, popular expressions of

[44] On the 14th November 2016 at Westminster, UK and 8th December 2016 in Brussel
[45] http://www.itpro.co.uk/government-it-strategy/27775/can-technology-improve-our-democracy
[46] https://www.youtube.com/playlist?list=PLchpIkwdUkzbN3Dm6wVmLxoNj5X-k3H-Q
[47] http://sense4us.eu/

disquiet and wide distribution of factual or false comments on political issues (see for example the discussions on the UK Brexit vote by European Law Monitor[48] and the list of social media impacts on the US election published by The Verge[49]). But social media covers more than just twitter and Facebook, the most-cited channels of popular discussion. Other channels are used, from mumsnet to fixmystreet or streetlife in the UK to StudyVZ or KWICK! in Germany[50] ordinary people are engaging in discussion amongst themselves online, and expressing and sharing opinions that in former times they may have discussed in small local social groups. The difference now is that on-line discussion has a much broader geographical reach, and can be used to influence broad public opinion in many ways, both positive and negative. Governments are becoming increasingly aware of the power of social media, but are failing to take advantage of its true power as a democratising force. There are many reasons for this – there is a fear of technology amongst some of the older generation of politicians, but there is also a sense of isolation. The kind of discussion that goes on at the level of social media is seen by many to be totally removed from the type of policy discussions that are essential at the level of governance. Social media is largely used as a broadcast and advertising medium by politicians and policy makers, tweeting about a proposal in order that the mainstream media will pick it up for newsprint publication is a typical example. There are politicians who recognise that social media can be used in a much more powerful way, enabling citizens to become more involved in the process and debate surrounding policy [as described by Stella Creasey MP at the Westminster event], but they recognise also that more fundamental changes in culture are needed before such engagement becomes practical. Technology may contribute to this process, but much of the technology for discussion and engagement is already in place. What is missing is the technology to manage the enormous amount of traffic and data that democratic representatives are exposed to. Stella Creasey MP referred to the many thousands of emails she receives on a daily basis, many of which she is unable to action, many of which are mass mailings from charities and lobbying organisations and all of which obscure the emails that she should be dealing with as a parliamentary representative. Technology needs to provide tools to enable representatives to manage this torrent of data, but whilst social media is seen simply as a way of informing, rather than debating, then these tools are not seen as a priority by any but the most social media savvy policy makers.

It seems, however, that the perspective of those who want to become more involved in the political process is somewhat different. The lobbying groups use mass emails from their supporters to target key politicians, distributing the text to their supporters via social media channels. Their intention is to show the politicians and policy makers the extent of public support for their campaign, in much the same way that on-line petitions are intended to show popular support. Social media connectivity is essential to distribute the message and to gather the popular response, whilst also bringing an issue to the attention of a wider audience. The ease with which blanket emails can be distributed and forwarded, and the simplicity of sharing across networks has made this a popular approach to

[48] http://www.europeanlawmonitor.org/eu-referendum-topics/the-eu-referendum-result-has-no-democratic-legitimacy-at-all.html

[49] http://www.theverge.com/2016/11/14/13626694/election-2016-trending-social-media-facebook-twitter-influence

[50] See for example http://www.extradigital.co.uk/articles/social-media/social-media-germany.html

attempting to influence politicians, but, as we have noted, since it leads to over-flowing inboxes for politicians who are time-poor, it may in reality be counter-productive.

The point was made many times during the SENSE4US workshop sessions that, for citizen participation in the policy process to be effective, the medium needs to be used for discussion, not for broadcasting information. The challenge which still exists, and which perhaps consideration of the networking will illuminate, is the extent of the cultural, social and technical changes that are needed in order for citizen participation in policy making to become a reality.

6.2 Policy background and regulatory context

There is at present no coherent government policy at national level aimed at creating true citizen participation anywhere.[51] This is inevitable, since national governments are well established on the principle of representative democracy, in which the people periodically elect a representative on the basis of a candidate's stated intentions, then the elected representative acts in parliament on behalf of their constituents, within the framework of their stated manifesto commitments (or that of their sponsoring party). There are mechanisms by which individual citizens can contact or lobby their representative, and the government uses a range of mechanisms, some traditional and some over social media, to communicate their activity and intentions. It is worth noting that the only country to have effectively crowd-sourced a new constitution has yet to ratify it in parliament. This was reported by Oktavia Jonsdottir, elected deputy MP of the Icelandic Pirate Party (IPP)[52]. Within the small but dispersed community in Iceland social media debate was used to discover the topics of real interest to Icelanders, leading to a revised constitution that was the subject of a referendum. With the IPP invited to form and lead a new government, this could lead to the first country where direct democracy is put on trial.

Although citizen participation is somewhat limited at national level, there is much more effective participation if we look at the local level. This is much more immediate and relevant to the citizens, and networks such as 'fixmystreet'[53] are popular routes for people to contact and influence their local government directly, without first contacting a local representative, and the results of successful intervention, such as mended potholes or replaced street lights are clear to see.

Without specific policy or regulation regarding citizen participation through social media, the principal instruments quoted are privacy, openness, transparency and access to data. The principle of privacy

[51] The Pirate Party, founded in Sweden as a response to copyright law in 2006, has led to the creation of political parties operating under the same name in other countries, but increasingly championing civil rights, direct democracy and participation in Government. This has led to the Icelandic Pirate Party leading the creation of a citizen-sourced revised national constitution, but this has yet to be ratified or implemented, leading to unrest and political pressure within the country, and the appointment of the first Pirate Party led government in the world As of today's date, the people's contribution has yet to be recognised by the more conservative elements of government, identifying Iceland as an ideal test-bed for the exploration of citizen participation, but not yet demonstrating a national governmental policy based on it. See https://en.wikipedia.org/wiki/Pirate_Party for more detail.

[52] See the Icelandic Pirate Party web site at http://piratar.is/en/

[53] https://www.fixmystreet.com/

can conflict with the need for verification of contributors, and there is an ongoing debate over whether anonymity should be respected since it permits more open comment, or whether it in fact encourages trolling and mis-direction. Since there is a low level of trust in governing institutions (reported by all contributors to the workshops) there may well be resistance on the part of the citizens themselves to reveal their identity. This suggests that identity preserving technology that allows verification may be necessary, although is not yet available.

Access to data is also carefully controlled. Many governments permit data to be available to all, but certain data is still held back for security or national interest reasons. Recent exposures have demonstrated the dark side of that regulation, but equally there are also valid reasons for managing some of that data. There is a question of who owns their data, and there is no clear or consistent understanding of data ownership, which will also need to be resolved before effective citizen participation and direct democracy can be established.

6.3 Stakeholders in Citizen Participation networks

Understandably, there are many stakeholder actors in citizen participation networks beyond the obvious targets of policy makers and the citizens themselves. At the policy maker level there are elected representatives, analysts, policy institutes, consultants and experts and IT professionals and designers. At the corporate level there are NGOs, lobby groups, charities, industry bodies, and at the citizen level there are action groups, clubs, topic groups, demographic groups and individuals. And there are organisations attempting to organise and lead citizen-initiated proposals to government, such as the Pirate Party and 38 degrees[54].

6.4 Machine Actors in Citizen Participation networks

The important machine actors in citizen participation networks are those non-human components that have an effect on human behaviour. We can therefore identify social media networks as actors, since aspects of the behaviour of those networks have an effect on their human users. This is most clearly seen in the way that 'like' buttons create 'bubbles' or 'echo chambers' of opinion, forming like-minded groups who, as we have seen earlier, can be influenced by false or mis-represented posts and comments. These social media networks do of course also serve the function of promoting information sharing, and the role of bots is therefore important when they are used to either propagate information, remove or modify comments or identify individuals for targeted information. The other available platforms should also be regarded as machine agents, such as government supported networks (e.g. gov.uk) or citizen networks (e.g. fixmystreet) within which active agents and bots discover, collate and report information to or from government. Increasingly, we also need to consider other emerging data collection networks, such as the pothole detection system being pioneered by Jaguar Land-Rover and Coventry City Council in the UK which automatically gathers the kind of

[54] https://home.38degrees.org.uk/

information that can be cross-correlated with citizen reports of road damage in order to inform local government of actions it needs to take[55].

6.5 Perceived risks and challenges

A number of perceived risks have been identified by various stakeholders in this area, which are summarised here. Each of the risks needs to be addressed in any effective citizen participation network:

1. ***Trust***
   People have always had very low levels of trust in their rulers, although it has been observed that the issue isn't one of trust so much as belief in what is stated. A group of politicians will, by definition, state opposing cases. Since they cannot all be right this means that what they say cannot be trusted, so the real issue is creating an understanding of what 'trust' means in this context, and what that trust is actually in. It is suggested that one reason people don't tend to get involved in eParticipation initiatives created by governments is a lack of trust, and a mistrust of motives and motivations is part of that concern, which is related to a lack of transparency around the sponsors of initiatives, such as large corporations or lobby groups.
2. ***Evolving constituencies***
   The on-line constituencies are evolving and no longer conform to the classes and sub-classes into which constituents have traditionally been organised. International groups of like-minded people are forming and geographical boundaries are breaking down.
3. ***Always-on culture***
   There is an expectation that digitisation creates a 24/7 'any time anywhere any device' access to politicians and process, to which current government structures are unable to respond.
4. ***Expectation of effect***
   With representational democracy there is the expectation that an elected representative will respond in some way to the individual. With direct democracy there is an expectation of action, and an expectation from participants that their voice is heard and somehow makes a noticeable difference. If they feel that their contribution has no effect then people will stop using social media for political engagement. There is also an expectation that informing a policy maker is the same as ensuring action – there needs to be a cultural shift towards putting responsibility for taking action back onto the person or group who wants the outcome.
5. ***Privacy and security***
   There is a need for policies that make it clear who owns data, and to what purposes it is put. This may mean that a fundamental change in ownership policy needs to be made, by which individuals maintain total ownership of all data referring to them, and have the technical tools available to track and manage it.

[55] http://www.landrover.com/experiences/news/pothole-detection.html

6. ***Skills gap in the use of technology***

   There is a skills gap amongst policy makers and their staff in the use of technology and social media which is holding some of them back from using or endorsing the use of social media.

7. ***Manipulation of collaborators***

   There is a concern that contributors to on-line discussions regarding policy can be manipulated by skilled practitioners and lobbyists by careful intervention to divert or derail discussion. This may work to their advantage in the short term, but would undermine trust in the process in the longer term.

8. ***Physical and technical limitations***

   There are limits to how much data and information an individual such as a member of parliament can cope with, and there are limits to the capacity of discussion forums, which can be overwhelmed when major issues erupt. Similarly, expectations of technology can be over-optimistic and idealised, meaning that users may expect the technology to manage and sort data to be available and perfectly reliable, when it may be neither.

9. ***Creation of Filter bubbles***

   As people form closed groups it is possible for them to create a 'filter bubble' within which they only hear views that align with their own (also known as 'echo chambers'). This in itself can stifle debate, but there is also a concern that these bubbles can be manipulated to exaggerate and amplify the views of people within the bubble, leading to a form of extremism.

10. ***Cutting through the noise***

    Any social media exchange contains a great deal of 'noise' – comments that are off-topic, derogatory, abusive or simply incomprehensible. There is a huge technical challenge to identify the noise or, conversely, to identify the valid and useful comment buried in the noise. Whilst the social media comments that policy makers are exposed to contain so much noise, there is the concern that they simply won't listen to it.

11. ***Limited acceptance by policy makers***

    There are a number of reasons why policy makers may not accept social media as a source of popular dialogue. If those posting the comments are not identified in terms of identity and demographic then there may be little point in listening to them. Similarly, the limited and self-selecting nature of those using the medium may be a disincentive to its use. There has also been an observation that, since high-profile individuals have recently damaged their careers through ill-considered comments on social media, this may represent a significant disincentive for many to use it.

12. ***Comprehension gap between technologists and policy makers***

    There is a lot of jargon used in the political sphere, and the process of government is arcane and complex. Similarly, technologists use their own jargon and do not understand the non-technical users. This creates a gap in comprehension that hinders dialogue and may prevent the creation of technology that delivers what the policy makers want.

13. ***Limited social media demographic***

    There is a belief that social media is only used by a very limited demographic, and that therefore other, less technically minded or interested demographics will be disenfranchised or ignored.

There is also the suggestion that young people are not followers of Twitter, so as a citizen engagement medium it won't meet the objective of engaging the young. It is also observed that many people may be on social media (for example, as reported by Oktavia Jonsdottir during the SENSE4US conference in Brussels, in Iceland 90% of the population are on Facebook) but that most of them only use it to listen, and not to contribute to the debate themselves.

14. ***Online bullying***

    Online bullying over social media is a serious problem, and can lead to individuals being vilified for making unpopular statements, which might be those that don't align with the views of their particular filter bubble. This reduces the effectiveness of citizen engagement, but any kind of censorship in order to control bullying would be an attack on freedom of expression. If freedom of expression is only permitted within certain boundaries, there remains the question of who sets those boundaries and how their motivations remain transparent.

6.6 Opportunities created

Despite the many concerns described in the previous section, many opportunities and benefits of social media based citizen engagement have been identified. These are summarised below:

1. ***Openness and Transparency***

    If citizen participation leads to improved relevance, accountability, influence, satisfaction and efficacy then it will bring value. This will lead towards good governance, open policy-making, open government and greater transparency of process. Transparency and accessibility are seen as very important aspects.

2. ***Access to open government data***

    Much data previously only accessible to government is being made available openly. This means that the public can make use of it, generally via specific apps that are created by companies both large and small. In combination with real-time sensors and data this will increasingly allow for dynamic response and engagement with citizens on evolving situations. Authenticated data increases the acceptance and trust in the information being propagated, leading to greater engagement in the process.

3. ***Improved timeliness of policy creation***

    Much policy is formulated and analysed before being opened to the public for discussion, by which time most people feel it is too late to change. More open engagement, such as advocated and demonstrated in Iceland, allows citizens to be involved in the policy making process at a much earlier point, meaning that the public are able to contribute their views at a time when they can make a difference to the policy formulation.

4. ***Creation of new markets and innovation mechanisms***

    The use and sharing of data and information within citizen participation networks provides much opportunity for new innovations in the use and presentation of data, and can lead to new market concepts built around the value of data as well as its tradability, perhaps building on the concepts of blockchain to ensure defined ownership and management.

5. ***Creation of a culture of engagement***

   Many people appear to believe that the process of governance is not something in which they are, or can be, actively involved. Similarly, there are politicians who may well believe that they are elected to run the country, not ask the electorate in a kind of crowd-sourced democracy. As citizen engagement develops it needs to drive a new culture and expectation of the workings of democracy, moving from a fully representative democracy towards a contributory democracy of engagement. This change in culture and perception is necessary for all stakeholders, not just for the citizens or the politicians, but it is a cultural change that should be initiated at the top level, in the anticipation that, as citizens become more engaged in all aspects of government and the infrastructure is developed to allow them to do so, so there will be initiated a domino effect by which the change in culture and behaviour will be effected.

6.7 Future development and way ahead

The feedback obtained from engagement with a range of policy makers on the topic of citizen engagement has highlighted many issues and opportunities. In terms of the future roadmapping exercise, it is clear that it is possible to deduce the goals of a citizen engagement network from what has been said by both politicians and citizen representatives, and that it is practical to glean network goals from other similar engagements, however, there are many obstacles to be overcome in order to reach those goals. The roadmapping needs, therefore, to frame the goals in terms that are susceptible to analysis and monitoring, and the roles and connectedness of the stakeholders defined for each type of citizen engagement that is envisaged. Further engagement with stakeholders to expand on the key issues and actions will inform this analysis, and ideally lead to proposals for structuring and analysing networks that lead towards their ambitions.

7 Summary of current status of the HUMANE roadmaps and common themes

This deliverable has been an attempt to create a series of focused policy roadmaps that are a step toward being able to guide the policy making process to help advance HMNs in a variety of sectors. These roadmaps are a step toward understanding the short- and long-term higher level goals for HMNs in various domains, and thus aid stakeholders in recognizing shared goals and their roles in reaching them. Here, we summarise the current status of the three HUMANE roadmaps and discuss common themes that can been extracted.

7.1 Status of the HUMANE roadmaps

As noted before, this is an interim version of the final roadmap deliverable in the project (which will be delivered at the end of the project in D4.4), so each of the cases presented here are currently at different stages of the roadmapping process. The sharing economy case has consulted with stakeholders while the eHealth case will be holding stakeholder meetings in the coming months. The citizen participation case has consulted with stakeholders via public meetings organized by a

collaborating project, but will also be holding structured stakeholder interviews before the completing the respective roadmap.

The ***sharing economy roadmap*** highlights an area that has seen rapid economic growth in recent years and has expanded into new sectors (such as transportation, goods and services, hospitality, and media) and new markets around the world. The roadmapping process is currently at stage 4 in the HUMANE process: working collaboratively with stakeholders to identify required actions to achieve implementable goals. The process thus far has highlighted not just the disruptive nature of the sharing economy touted by some of its more vocal proponents, but also the complex and nuanced relationship with traditional sectors of the economy. While early narratives about sharing economy platforms and tools focused on their novelty, it has become clearer that, as these platforms evolve and mature, they start to experience convergence with more traditional activities, as traditional service providers become aware of the new services. This in turn results in consolidation: new providers either grow to dominate a sector (such as Uber seems to be doing in ride sharing in many locations) or existing players acquire these new start-ups and then raise barriers to new entrants in the market so as to protect their own position and investments.

The roadmap so far also highlights the role that sharing economy platforms have played in introducing digital practices into the day-to-day life. For instance, while the growth of smartphone usage cannot be attributed to ride sharing, accommodation sharing, and the like, the ability of the machines in this network (which includes the smartphones but also the platforms and the communication networks and tools) to replace human intermediaries with fast, easy-to-use, reliable, and efficient machines reinforces and amplifies the desire of human actors to increase their reliance on these HMNs and to continue to invest their time and resources, which in turns keeps the HMN able to leverage the economies of scale they require to function.

The sharing economy roadmap also clearly shows that not all HMNs are designed to increase the formation of social groups (human-human connections). Instead, the sharing economy platforms are designed to strengthen the loyalty between human participants and the platforms (human-machine connections). This transfer of trust then can be leveraged to expedite short-term human-human interchanges (sharing a ride, sharing a room), which are fleeting and temporary by nature.

The ***roadmap for eHealth*** focuses on personalized eHealth systems which allow for monitoring the physical states and activities of humans using mobile or wearable technologies. A preliminary version (steps 1-6) of the roadmap is presented in this deliverable, while stakeholder consultations are being planned to finalize it. The eHealth domain highlights some issues in particular that are also present in other HMNs but are particularly acute when speaking about something as personal and important as our health. In particular, the role of the HMN in allowing for efficient management and protection of personal medical and health data is crucial, and this is then linked to a greater need for regulation (either top-down or emergent) because activities enabled by eHealth HMNs can literally affect life or death situations. This is also reflected in one of the key issues raised by the roadmap: the need for reliable Quality of Service (QoS) enabled medical services that go beyond 'best effort' services such as the Internet when the medical services affect quality of life and the length of life of patients.

The importance of good health at both the personal level and the societal level are also reflected in the main issues raised by the roadmap thus far. More than any of the other roadmap, the eHealth roadmap highlights the absolute need to focus on accountability and reliability as eHealth HMNs grow in importance. This takes a number of forms in the roadmap: the call for clinical validations of eHealth HMNs to attest to the safety and efficacy of the systems, the need for a clear legal framework that identifies what responsibilities manufacturers and developers have to human participants in the network, and the need to put in place consistent rules and regulations that protect people's privacy and the confidentiality of their medical information.

One contrasting challenge to those focusing on increasing regulation is that eHealth HMNs should be provided at reasonable cost, partly because of the need to increase adoption and partly as a recognition that many of these services are potentially of greatest use to vulnerable populations such as the ill and the elderly. This means that it might be necessary for new business models to emerge that are particularly suited to the eHealth domain and are not necessarily applicable in other sectors where the risk of exclusion and digital divides are real, but do not constitute a day-to-day risk to life.

Another potential of eHealth HMNs is to inspire behavioural change through social motivation, either by the design of the platform or by facilitating the formation of support groups that share common attributes. This might be enhanced with strategies learned in gaming applications ('gamification'), by enhancing feedback from the system to support desired behaviours and interactions, and by maximizing the abilities of affordances designed into the HMN to enhance human outcomes from engagement with and participation in the system.

The ***citizen participation roadmap*** focuses on how social media can be used to enable members of the public to engage with elected government representatives and participate directly in the democratic process. The roadmap is at stage 4 in the HUMANE roadmap process: some of the current evidence supporting the roadmap has been gathered from stakeholders in relevant workshops, but additional interviews are planned to expand the stakeholder engagement. The citizen participation roadmap brings to the fore a number of questions around current practices surrounding social media in civic engagement and evidence for ways forward in this sphere.

The citizen participation roadmap highlights an interesting counterpoint to the scale issues raised in the sharing economy roadmap. While facilitating citizen participation is a main goal, the lowered barrier to communication from constituents to democratic representatives can result in floods of communication, overwhelming the ability of representatives to respond to their constituents, and to detect the important signals from the noise of huge volumes of messages.

Another interesting element related to this has to do with the direction of information: social media has been largely used by politicians, policy makers, and political action groups as a broadcast and advertising medium to elicit support (or sometimes feedback) on policy proposals or political actions. There have been fewer attempts thus far to actually engage a broader range of people directly in democratic deliberation and debate.

The issues of scale and information direction come together in the changing political landscape within which citizen participation HMNs are operating today. Constituencies are evolving, as online

communities of interest do not necessarily conform to traditional geographic boundaries or pre-determined classes of people. Politicians engaged in action that gets global attention may find themselves part of a global around-the-clock debate, with pressures to satisfy the demands of a huge variety of people, many of who are not direct constituents of the politician or necessarily citizens of the same country or state. Skilled on-line contributors can use this to their advantage, swinging debate on an issue toward their point of view.

Even with these concerns, there is considerable potential for enhancing citizen participation through engagement with social media HMNs. Openness and transparency efforts are frequently underpinned by the accountability that can be demanded on the public square of social media, policies can be adjusted in a more responsive and timely fashion, new markets enabled by data can emerge, and generally a culture of engagement can be encouraged.

7.2 Common themes

In the three roadmaps discussed above, we have identified some commonalities, which we address as 9 'common themes' in respective sections below.

7.2.1 Personalization

In the sharing economy roadmap, the services described are essentially about matching people and supporting transactions in a way that allows their personal experience of the HMN to seem highly specific and personal even while the overall volume of activities are growing. For example, the specific Uber car which can be tracked on the Uber app as it comes to collect you and recognised when it arrives by the photos provided is a more personal experience than ringing a dispatcher and wondering when a taxi might arrive and if the taxi you see down the street is yours or not.

Personalization also is a key theme in the eHealth roadmap: while healthcare is a societal issue and the relevant cost amounts to a significant percentage of the GDP in most countries, our experience of health as humans is inevitable personal. Thus, any particular chronic disease might be on the rise in the population, but we understand the disease as intensely personal if it affects us or someone in our close personal circle. Thus, successful HMNs for eHealth must recognize and capitalise on this by making the experience of the HMN seem personal for the human participants.

7.2.2 Importance of peers

In the sharing economy roadmap, the importance of the social aspects of the platforms was highlighted as a key part of the human experience in the HMN. Beyond that, we have seen that both human and machine actors in the HMN can play different roles at different times within the HMN, but that certain actors may gravitate towards specific roles within the network, either by design or by predilection. This is true for the sharing economy (in which people might be providers and consumers of services in different contexts) and for citizen participation (when people will choose to engage in certain discussions and debates that are more important to them while skipping others entirely). The HMN can recognize that one's peers are not a static group of actors, but a shifting and re-forming landscape

of people and machines pairing and grouping together for varying lengths of time depending on the interests of each.

7.2.3 Prediction

Closely tied to personalization is *prediction*, or the ability of the HMN not only to respond to recent and current events, but to proactively reallocate network resources and actors by using past patterns to predict near-future events. As prediction abilities increase, the HMN can better respond to situations where supply and demand are likely to become wildly out of sync (using techniques such as surge pricing or instant discounts to encourage new entrants on the unbalanced side of the equation), to support fair practices and pricing, and to identify emerging illicit behaviour such as fraud more quickly.

In the eHealth domain, prediction can take the form of real-time event detection such as the identification of a health episode that requires a response either from the human participant themselves (e.g. self-administering medication or treatment) or from other participants in the HMN such as emergency response personnel.

Of course, the risk of prediction is also highlighted by the citizen participation roadmap: if people's activities can be accurately predicted, there is a risk that they can also be manipulated by skilled actors so as to shift the policy landscape and political outcomes.

7.2.4 Regulation

Regulation also appears in multiple roadmaps, and not just in the obvious sense of recognizing that emergent socio-technical systems inevitably require some sort of standards and responsible bodies if they are to function and grow in the long term. The sharing economy roadmap, for instance, highlights the ability of sharing economy platforms to enhance the ability of policymakers and regulatory bodies to do their jobs because of the rich financial and behavioural data that is being stored and could be analysed to better understand economic transactions, day-to-day activities, travel patterns, and many other questions for which aggregate data is often very slow to appear, or insufficiently detailed to allow for effective regulatory interventions in a short time (and not, as usual, until after problems have ballooned in size). This is particularly acute in the eHealth domain, when problems that emerge from the HMN can have serious health consequences.

7.2.5 Consistency

Consistency of outcome and of experience is another theme. For sharing economy participants, ride sharing only works as an HMN if the human riders are able to reliably get from point A to point B and if the human drivers are able to be reliably compensated for their participation in the HMN. For eHealth participants, they must be able to rely on the HMN to allow them to monitor and respond to changes in their health situation. At the moment, many of the standards which support consistency in the eHealth domain are emerging as de facto standards which rise out of the design decisions made by large manufacturers who are able to dominate a market; recognising this can be the basis for a broader

discussion of whether these de facto standards are sufficient or whether there is a need for a higher level of standardization. In the citizen participation domain, consistency refers less to consistency of outcome (since political processes often have outcomes that cannot be predicted at the outset) and more to the consistency of the experience and to the ability of actors to understand how the experience is being shaped by the HMN.

7.2.6 Quantity versus quality

As sharing economy platforms grow it may be difficult for platform operators to monitor and manage the quality of human-human interaction and dialogue enabled by the system. In the eHealth roadmap, the interoperability of eHealth devices and the data they generate is highlighted. If the number of devices proliferates but there are no standard content formats used, then the quality of experience for participants who use multiple devices (such as patients with comorbidities) or for those who deal with multiple data streams (such as health providers or general practitioners with many patients) would decline. Similarly, politicians who become overwhelmed with huge numbers of messages may mistakenly act based upon what appears to be a clamour of support but is actually a low quality source of evidence about public opinion due to skilful manipulation of the HMN by certain actors.

7.2.7 Trust

Of course, as with any emergent technological or social system, *trust* is a key theme: trust in the idea of the HMN, trust in the implantation of the platform or tools, and trust in the other actors (human and machine) in the network are all crucial. Patients and doctors in an eHealth HMN must be able to trust that the services provided are accurate and contain limited or no errors. Participants in the sharing economy must trust that the exchange of goods and services is done fairly and safely. And citizens must trust the outcomes of political processes (even if they don't trust individual politicians) if democracy is to succeed in the long term.

7.2.8 Risk management and security

Closely related to trust is *risk management and security* of the HMN. Fraud, unethical or illegal behaviour, and risk introduced by the HMN itself (e.g. due to a design that aims to facilitate user access and participation) are important considerations when designing HMNs that will be resilient to situations when participants in the HMN have malicious purposes. This risk might be mitigated by existing or new models of insurance, but also by increasing the ability of the HMN to autonomously intervene when the system detects a high network risk. The eHealth roadmap also highlighted the need for single authorities who can vouch for individual human and machine agents as a way of mediating their access to other parts of the network and other actions available within the HMN. This also applies in the political sphere: how can participants be sure of the security and credentials of those who are acting within the HMN.

7.2.9 Emergence

A final issue to highlight is the emergent nature of HMNs: all the planning in the world and all the roadmaps ever drawn up will inevitably fail to anticipate some of the emergent characteristics of HMNs that result from unexpected synergies, unanticipated sequences of events, and uncontrollable outside forces. For instance, in the sharing economy roadmap, we highlighted that while ecological factors were an important motivation for many service owners (e.g. tapping into surplus capacity as a way of reducing overall waste), the success of the platforms could instead drive increased production. And of course, in the political world, unexpected outcomes happen with regularity, including surprise election outcomes and unexpected changes in governments and policies.

8 Conclusion and further work

At the beginning of this report, we highlighted the range of possibilities for increasing the power of networks of humans and machines to solve real world problems in nearly all domains of human endeavour. However, we also highlighted that, they have also seen massive increases in their ability to actively respond to their environment without direct human intervention. This increasing autonomy of machine participants creates both huge potential as machines become embedded in social processes and business practices, but also serious risks when public policy and social practice are not designed to deal with the consequences of machine-led actions. The HUMANE project aims to support policy makers and other stakeholders craft policies and design systems that account for attributes of both humans and machines, and their interaction.

The main contributions of this deliverable are the detailed approach for producing the HUMANE roadmaps and the preliminary versions of the roadmap for each of the selected domains. Additionally, we have enriched the analysis of social domains that started in D4.1 with more challenges, opportunities and design strategies that can be applied for each of the domains.

In the next steps, the work remaining for each roadmap will be carried out. As emphasized in the previous section, the roadmaps are currently at different steps of the HUMANE roadmapping process. The remaining work concerns collecting feedback received from stakeholders through user surveys, focus groups or interviews. In the final version of the roadmaps, the HUMANE design strategies will be presented for all social domains. Moreover, the results from desk research (including scientific papers, technical reports, surveys, etc.) should also be combined with the up-to-date stakeholder feedback, to corroborate or challenge the findings of each, and arrive at a consensus view of the roadmap for each domain.

The roadmaps will be disseminated to policy makers, ICT designers, as well as other stakeholders to serve as a guide for future policies and for possible implementation. Appropriate information material will be prepared, such as roadmap summaries, presentations, or advertising material. The roadmaps will be presented in conferences or other events related to policy issues of emerging technologies in the sharing economy, eHealth and citizen participation. The partners responsible for each roadmap will be responsible for promoting and exploiting their roadmaps, and if necessary update the roadmaps to reflect future developments.

9 References

Albright, R., & Schaller, R. (1998). Taxonomy of roadmaps. In *Proceeding of technology roadmap workshop, Office of …*. Retrieved from https://scholar.google.com/scholar?q=R.+Albright%2C+R.+Schaller%2C+Taxonomy+of+roadmaps%2C+Proceeding+of+Technology+Roadmap+Workshop%2C+Office+of+Naval+Research%2C+Washington%2C+DC%2C+1998.&btnG=&hl=en&as_sdt=0%2C5#0

Arun Sundararajan. (2013). From Zipcar to the sharing economy. *Harvard Business Review*. Retrieved from https://hbr.org/2013/01/from-zipcar-to-the-sharing-eco

Atzori, L., Iera, A., & Morabito, G. (2011). SIoT: Giving a social structure to the internet of things. *IEEE Communications Letters*, *15*(11), 1193–1195. http://doi.org/10.1109/LCOMM.2011.090911.111340

Belk, R. (2014). You are what you can access: Sharing and collaborative consumption online. *Journal of Business Research*, *67*(8), 1595–1600. http://doi.org/10.1016/j.jbusres.2013.10.001

Boniface, M., Calisti, M., & Serrano, M. (Eds.). (2016). *Next generation internet experimentation: drivers transforming next generation internet research and experimentation*. Future Internet Research and Experimentation. Retrieved from http://eprints.soton.ac.uk/397641/

Botsman, R. (2016). New Trust Networks: Your Best Friend is a Stranger. *WIRED*, 89–90. Retrieved from http://rachelbotsman.com/wp/wp-content/uploads/2016/01/Rachel-Botsman-in-WW2016.pdf

Botsman, R., & Rogers, R. (2010). *What's Mine Is Yours - How Collaborative Consumption is Changing the Way we live*. *Business*. http://doi.org/10.1016/S0168-9525(00)00086-X

Cannon, S., & Summers, L. H. (2013). How Uber and the Sharing Economy Can Win Over Regulators. *Harvard Business Review*.

Cardoso, J., Voigt, K., & Winkler, M. (2008). Service engineering for the internet of services. *Enterprise Information Systems, Lecture Notes in Business Information Processing (LNBIP)*, 15–27. Retrieved from http://www.springerlink.com/index/k4g47766q0005496.pdf

de Vette, F., Tabak, M., & Vollenbroek-Hutten, M. (2015). Increasing motivation in eHealth through gamification. In *5th Dutch Conference on Bio-Mechanical Engineering*. Egmond aan Zee, The Netherlands: IEEE EMBS. Retrieved from http://doc.utwente.nl/95614/

Eide, A. W., Pickering, J. B., Yasseri, T., Bravos, G., Følstad, A., Engen, V., … Lüders, M. (2016). Human-machine networks: Towards a typology and profiling framework. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 9731, pp. 11–22). http://doi.org/10.1007/978-3-319-39510-4_2

Ert, E., Fleischer, A., & Magen, N. (2016). Trust and reputation in the sharing economy: The role of personal photos in Airbnb. *Tourism Management*, *55*, 62–73. http://doi.org/10.1016/j.tourman.2016.01.013

European Commission. (2012). *eHealth Action Plan 2012-2020 – Innovative healthcare for the 21st century*. *Dynamical systems with applications using MATLAB* (Vol. 53). http://doi.org/10.1017/CBO9781107415324.004

Fan, Z., Haines, R., & Kulkarni, P. (2014). M2M communications for E-health and smart grid: An industry and standard perspective. *IEEE Wireless Communications*, *21*(1), 62–69. http://doi.org/10.1109/MWC.2014.6757898

Gerling, K., & Masuch, M. (2011). Exploring the Potential of Gamification Among Frail Elderly Persons. In *Proceedings of CHI 2011 Workshop on Gamification*.

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, *29*(7), 1645–1660. http://doi.org/http://dx.doi.org/10.1016/j.future.2013.01.010

Hamari, J., Sjöklint, M., & Ukkonen, A. (2016). The sharing economy: Why people participate in collaborative consumption. *Journal of the Association for Information Science and Technology*, *67*(9), 2047–2059. http://doi.org/10.1002/asi.23552

Hoc, J. M. (2000). From human-machine interaction to human-machine cooperation. *Ergonomics*, *43*(7), 833–843. http://doi.org/10.1080/001401300409044

kc claffy, & Clark, D. D. (2015). Adding Enhanced Services to the Internet: Lessons from History. In *Proceedings of the 43rd Research Conference on Communication, Information and Internet Policy (TPRC'15)* (pp. 1–28). Retrieved from http://ssrn.com/abstract=2587262

Kimble, C. (2015). Business Models for E-Health: Evidence From Ten Case Studies. *Global Business and Organizational Excellence*, *34*(4), 18–30. http://doi.org/10.1002/joe.21611

Koopman, C., Mitchell, M. D., & Thierer, A. D. (2015). The Sharing Economy and Consumer Protection Regulation: The Case for Policy Change. *The Journal of Business, Entrepreneurship & the Law*, *8*(2), 529–545. http://doi.org/10.2139/ssrn.2535345

Kostoff, R. N., & Schaller, R. R. (2001). Science and technology roadmaps. *IEEE Transactions on Engineering Management*, *48*(2), 132–143. http://doi.org/10.1109/17.922473

Lieberman, M. (2015). Pwc-Consumer-Intelligence-Series-the-Sharing-Economy. *PWC Consumer Intelligence Series: The Sharing Economy*, 30.

Lüders, M., & Følstad, A. (2015). *Kunde-til-kunde gjenbrukstjenester i Norge – status og markedspotensial (C2C services for reuse – status and market potential)*.

Malhotra, A., & Van Alstyne, M. (2014). The dark side of the sharing economy … and how to lighten it. *Communications of the ACM*, *57*(11), 24–27. http://doi.org/10.1145/2668893

Milenković, A., Otto, C., & Jovanov, E. (2006). Wireless sensor networks for personal health monitoring: Issues and an implementation. *Computer Communications*, *29*(13–14), 2521–2533. http://doi.org/10.1016/j.comcom.2006.02.011

Möhlmann, M. (2015). Collaborative consumption: Determinants of satisfaction and the likelihood of using a sharing economy option again. *Journal of Consumer Behaviour*, *14*(3), 193–207. http://doi.org/10.1002/cb.1512

Muir, B. M. (1987). Trust between humans and machines, and the design of decision aids. *Int. J. Man-Machine Studies*, *27*, 527–539. http://doi.org/10.1016/S0020-7373(87)80013-5

Parasuraman, R., Sheridan, T. B., & Wickens, C. D. (2000). A model for types and levels of human interaction with automation. *IEEE Transactions on Systems, Man, and Cybernetics. Part A, Systems and Humans : A Publication of the IEEE Systems, Man, and Cybernetics Society*, *30*(3), 286–297. http://doi.org/10.1109/3468.844354

Preece, J., & Rombach, H. D. (1994). A taxonomy for combining software engineering and human-computer interaction measurement approaches: towards a common framework. *International Journal of Human-Computer Studies*. http://doi.org/10.1006/ijhc.1994.1073

Rand, L. V. (2010). Business Models for eHealth Final Report. *RAND Europe*, (February), 65.

Shin, D. (2014). A socio-technical framework for Internet-of-Things design: A human-centered design for the Internet of Things. *Telematics and Informatics*, *31*(4), 519–531. http://doi.org/10.1016/j.tele.2014.02.003

Sycara, K., Lebiere, C., Lewis, M., Cummings, M., How, J., Campbell, M., … Parasuraman, R. (2013). *Modeling Synergies in Large Human-Machine Networked Systems*.

Verplanken, B., & Roy, D. (2015). 15. Consumer habits and sustainable consumption. *Handbook of Research on Sustainable Consumption*, 243.

Wicks, P., Stamford, J., Grootenhuis, M. A., Haverman, L., & Ahmed, S. (2014). Innovations in e-health. *Quality of Life Research*. http://doi.org/10.1007/s11136-013-0458-x

World Health Organization. (2016). *WORLD HEALTH STATISTICS - MONITORING HEALTH FOR THE SDGs*. *World Health Organization*. http://doi.org/10.1017/CBO9781107415324.004