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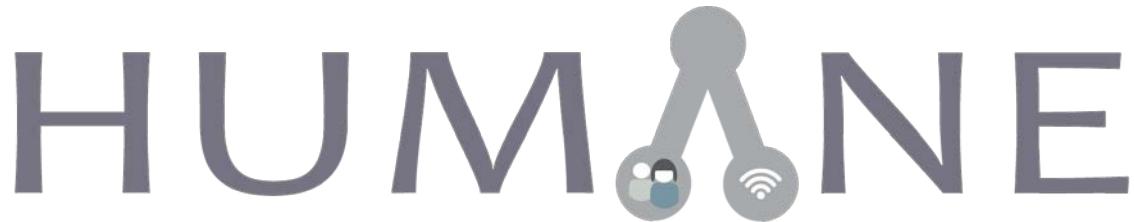
A typology, method and roadmap for HUman-MAchine NEtworks

Deliverable D4.4

Final 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 provide guidance for improving Human-Machine Networks (HMNs) in different social domains. In order to achieve this, we need to foresee future trends in these social domains, examine the broader impact and implications of HMNs, the technical and regulatory challenges, and set the desired goals at the end of each roadmap. We then need to propose concrete actions or steps that should be taken to achieve these goals. The contribution of this deliverable is two-fold: First, a roadmapping process addressing HMNs in specific social domains. Second, the roadmaps for three such domains: the sharing economy, eHealth, and citizen participation. These domains all embrace exciting technological applications that promise to give great societal benefits. The roadmapping process has been construed to take into account implications of HMNs, e.g. with regard to notions of trust or motivation. The presented roadmapping process is general and, hence, serves as a model or guidelines for roadmap creation in other domains. The roadmaps themselves 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.
Key-words	Human-machine networks, roadmapping process, roadmaps, sharing economy, eHealth, citizens' participation, stakeholders, future-thinking

Versioning and contribution history

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Definitions and abbreviations

Abbreviation	Definition
CC	Collaborative Consumption
DSCP	Differentiated Services Code Point
DSM	Digital Single Market
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 the societal benefits they can bring.

In previous work of the HUMANE project (Jaho et al., 2016), we have examined the broader impact and implications of HMNs in several 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. 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, in this deliverable, we build roadmaps for future HMNs in different social domains (selected out of (Jaho et al., 2016)), focusing on the goals to reach in each domain and the steps to achieve these goals.

The selected domains are the sharing economy, eHealth and citizens' participation. All these domains embrace exciting technological applications, which promise to bring great benefits to the economy and society. We present a general process to develop roadmaps, adapted to the context of future thinking and policy making for HMNs, which also serves as a model or guidelines for roadmap creation in other domains.

For the three roadmaps we provide three different short documents in order to be more accessible by the relevant stakeholders. The documents also contain short summaries, graphical illustrations and tables of the roadmaps, which will help to create promotional and dissemination material (leaflets, fact sheets, posters), and maximize dissemination efficiency. In the roadmaps, we describe what we want to achieve and the need to improve HMNs in the domain of interest, the current technological situation, policy background and regulatory context, the goals and the actual outputs of the roadmap, and the required actions to achieve the goals. For each roadmap, we explain the HUMANE design strategies, which are suitable to address design goals of the HMNs. We also provide prioritizations for the required actions, if appropriate, and give a timeframe for their implementation. Notions of trust, motivation, and network size, which are predominant in HMNs, are examined extensively in the roadmap, and solutions are proposed to address their implications.

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 corresponding markets around the world. Sharing economy services need to motivate consumers, leveraging both economical and convenience motivators. Trust in sharing economy platforms is a major prerequisite for the success of these services, which can be assisted by the use of advanced algorithms for more accurate predictions (matchmaking, recommendations). In the roadmap, we also

foresee that sharing economy services need to grow to survive, which typically implies scaling on an international level, but without losing relevance to the local context. As part of growing, sharing economy services will need to be in control of larger parts of the transaction process in which the customers are involved. Finally, we point at several societal aspects of the services.as the boundaries between sharing economy and traditional services are blurred, and discuss changes in policies and regulations.

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. Such systems imply a need for increased control and intervention by users and patients for the detection, treatment and management of diseases. To address this implication, we have proposed the establishment of a permanent information structure, which provides continuous support to patients for the use of eHealth HMNs, but also informs health professionals about latest developments. This information should be coordinated at national level, but also reach the level of local communities, where services are offered. In addition, we call for the improvement of application design, with emphasis on user engagement and behavioural change. HUMANE design strategies for behavioural change, collaboration and user guidance can greatly contribute to this end. Additionally, the increased use of machines creates a need for security, for the protection of privacy and confidentiality of medical information. To accomplish these, we have proposed the application of privacy-by-design mechanisms in commercial eHealth HMN, the efficient management and protection of medical data, the development of reliable services with guaranteed QoS, and the conduction of clinical trials, which can assert efficiency and inspire trust. HUMANE design strategies for supporting and increasing trust, as well as for managing sensitive data with different levels of authorization are relevant to these objectives. Finally, eHealth HMNs are also expected to increase, both in number of users and geographical scope. One of the goals of the HUMANE roadmap is to successfully apply efficient design practices at large scale, as pilot studies prior to their official adoption in the healthcare systems of EU countries. At the same time, the roadmap includes actions for standardization and interoperability, as well the economic sustainability of the services.

The citizen's 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. In developing this roadmap, it has become clear that a citizens' participation platform should function as a collaborative entity and not in serving an individual within the network. Trust needs to be in the network rather than individual interests or goals; similarly, motivation must be based on contribution to the successful operation of the HMN rather than for individual outcomes or expected results. In addition, a key challenge in the coming years relates to compromises to HMN security, or "Cyberattacks". This covers several different contemporary phenomena though. On the one hand, there is the traditional attack aimed at compromising data integrity or privacy. But more recently, there are the deliberate attempts by internal or foreign political agencies to compromise information dissemination and election outcomes.

Additionally, mechanisms for gathering all different views, and assisting in conflict resolution between entities participating in the democratic process should be established.

All roadmaps follow the common structure that is defined in the roadmapping process, but have been developed independently by different consortium partners. The last step in the roadmapping process is the dissemination of the roadmaps to policy makers, ICT designers, as well as other stakeholders to serve as a guide for future policies and for possible implementation.

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1   Introduction

The Internet has been 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 having an 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 and indispensable tools for the provisioning of public and private services. They can react autonomously to physical world events, and can trigger actions by humans, which 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, and socio-economics of trust.

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 (Følstad et al., 2016, 2017) 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.

Furthermore, in previous work (Jaho et al., 2016), 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, citizens' 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 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 citizens' 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. The HUMANE method and tools (Følstad et al., 2016, 2017) are also being used in designing the roadmaps: based on the characteristics of the respective HMNs they readily provide design strategies and point to 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 citizens' participation for which we create roadmaps, and explain the reasons for focusing on these domains. Sections 4, 5 and 6 are describing the application of the roadmapping process to each of the chosen. 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. For each roadmap, we also describe the dissemination actions that have so far been performed. Summaries of all roadmaps are presented in Section 7, along with a discussion of the common themes in the roadmaps. We conclude the deliverable in Section 8, by summarizing the work in the whole report and pointing at further dissemination actions.

2   Background

2.1   Human-machine networks

HMNs are networks composed of humans and machines that interact to produce synergistic effects (Tsvetkova et al., 2017). 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 affect 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 (Tsvetkova et al., 2017).

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 their 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 fulfil 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 (Følstad et al., 2016, 2017).

Of primary importance for HMNs is the notion of agency, which we understand as the capacity of an actor (a human or machine) to perform activities, in line with a set of objectives, that influence and shape the extent and nature of the participation (Engen, Pickering, & Walland, 2016). The degree of agency critically affects the influence that an actor exercises on others in the network. Key implication areas in HUMANE are user experience and motivation, behavior and collaboration, innovation and improvement, privacy and trust. For example, trust development between human and machine actors is very important. In previous work, the impact and trust implications for machine actors in human-machine networks for emergency decision support, healthcare and future smart homes has been discussed and demonstrated (Engen et al., 2016). 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).

2.2   The HUMANE typology and method

Within the HUMANE project we have developed a framework (Følstad et al., 2016, 2017) 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: human and machine agency, social tie strength and human-machine relationship strength, network size and geographical reach, workflow interdependence and network organization. These are organized into abstract layers of actors, interactions, network extent, and

network structure. 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. 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 different types of roadmaps 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 and business roadmaps. In a policy roadmap, we usually have higher-level goals more closely related to desired societal benefits. It is used by public administration bodies and policy makers who create, enforce and monitor the policies, 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. Sometimes the lines between the roadmaps are very thin. For example, a business 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: [1] 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 science and technology objective (Kostoff & Schaller, 2001). Finally, the last step of the roadmaps is the publication and dissemination to the intended recipients, i.e., at least to the roadmap implementers, but possibly also to all of 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, a network is then constructed, showing relationships between different areas. The policy analyst can then develop a deeper understanding of the evolution in the field, and can recommend new directions for policy actions. 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 roadmaps. Therefore, they have higher-level policy goals, and are intended to be implemented by administration bodies and policy makers. The structure of the roadmaps - which we describe 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 the roadmap acts 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.

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

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 (Jaho et al., 2016) we studied the domains of the sharing economy, eHealth, citizens' 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 process for developing the HUMANE roadmaps consists of the following steps, as illustrated in Figure 1.
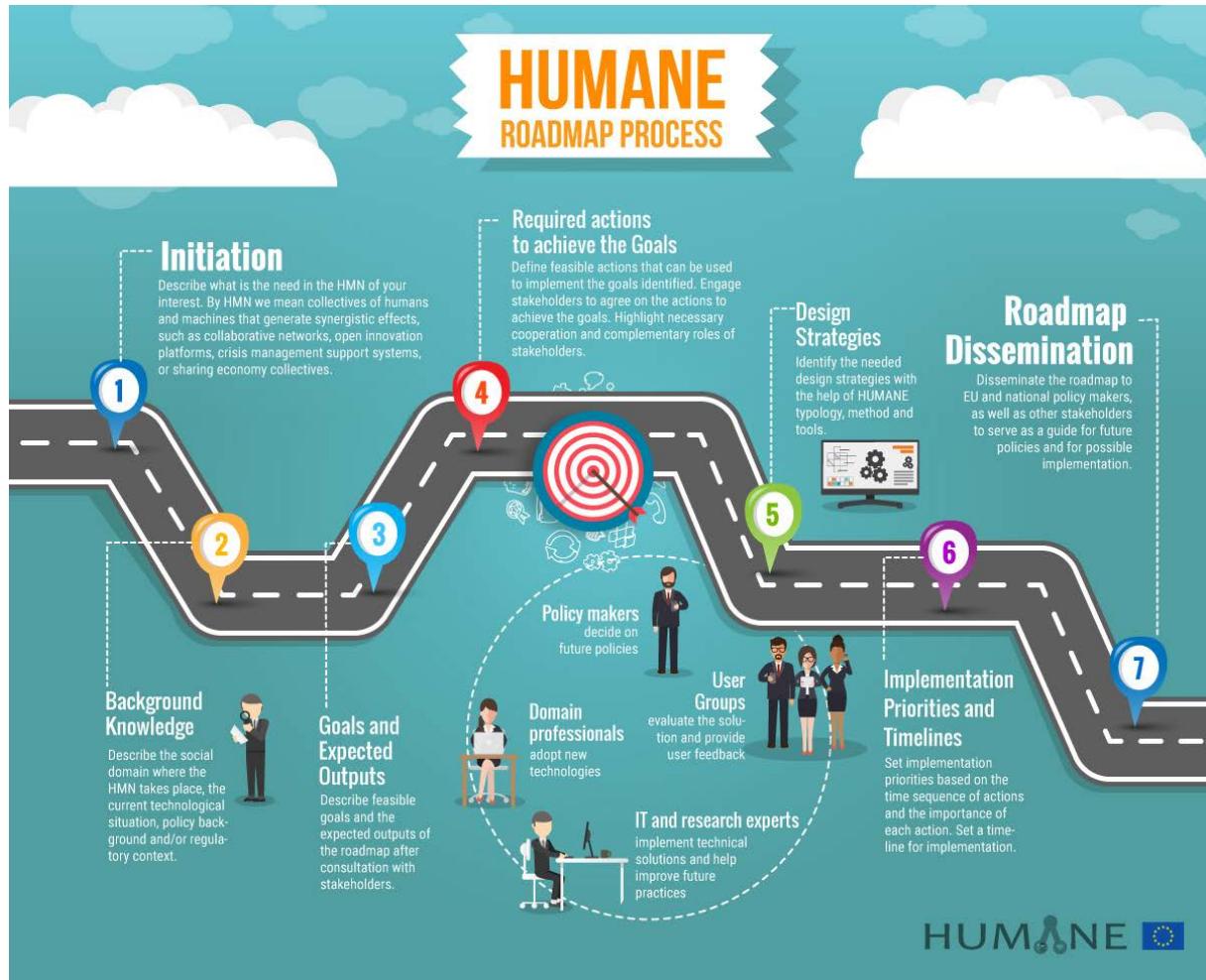
Figure 1: HUMANE roadmapping process

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 typology, method and tools to find appropriate design strategies. These design strategies can be selected among the initial design strategies developed in (Følstad et al., 2016, 2017), 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 actions, 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 (Følstad et al., 2016, 2017) 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 below in Figure 2 describes the process for choosing design strategies, which would be carried out as an intermediate step in the roadmap implementation.

First, based on the topic (social domain and application) we quantify the HMN according to the 8 dimensions in the HUMANE typology: the human and machine agency, social tie strength and human-machine relationship strength, network size and geographical reach, workflow interdependence and network organization. These dimensions help to create a network profile (the HUMANE profiling tool can also be used here to generate a profile for a HMN), 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, 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).
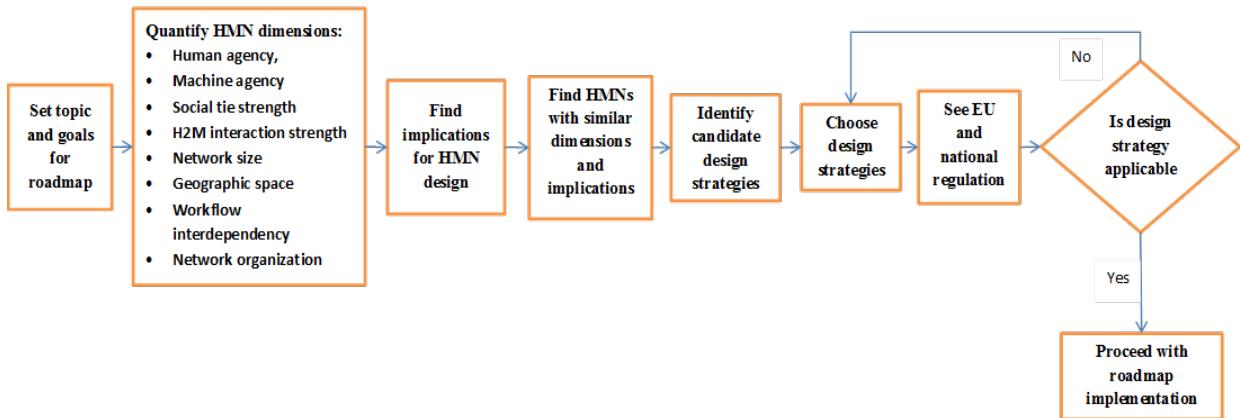
Figure 2: Process for choosing design strategies

3.2   The selected social domains

We have applied the roadmapping process to the three social domains discussed previously in this deliverable, which can be taken as guidelines by policy makers to develop HMN roadmaps for other domains. For the specific domains studied here it will be based on input from (Jaho et al., 2016), where preliminary challenges, high-level objectives and opportunities for policy interventions in each domain have been identified. In (Jaho et al., 2016) we also identified the stakeholders in each domain, as well as their roles and interests. We classified stakeholders in five categories, which are common for all social domains: policy makers, domain professionals, user groups, IT experts and researchers. During roadmap development, stakeholders will be consulted to discuss the current state of the 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 (Jaho et al., 2016): the sharing economy, eHealth and citizens' participation. These domains share commonalities, but also different HMN characteristics, so together they cover a wide range of issues pertaining to HMNs and policy making across the three different domains.

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 to the traditional retail paradigm of local shops, 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 the shared goods or services they offer, 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.[2] The recently published European Agenda for the collaborative economy[3] 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. 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 (Jaho et al., 2016). 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 technologies worldwide. Such HMNs can greatly 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.

The third domain of interest we focus on is citizens' participation. Here too, this could be said to be a natural progression from social media, an environment already understood by private individuals for popular interaction and communication. Citizens' participation systems are an extension of e-government systems whereby citizens adopt the role of partner rather than consumer in the delivery of public services, and change the traditional way that public and government interact. Currently, individuals and citizen groups have only a small part in decision making. Apart from voting in elections or referenda, citizen involvement in decision making is usually restricted to commenting on public consultations. In (Jaho et al., 2016) we have investigated the role of HMNs in building efficient citizens' participation systems, leveraging on social media, collaborative tools and decision support systems. Building such HMNs can have tremendous benefits for improving democratic operation, building social cohesion and collective social capital.

The above domains were selected by consortium partners as both relevant to the scope of HUMANE, consortium partner expertise and diversity. Because they are different as outlined above, they provide an opportunity to exercise the HUMANE methodology and tools to further test the benefit of project outcomes. The consortium partners have significant expertise in data collection, content aggregation and recommendation systems, social media and participation systems. In (Følstad et al., 2016, 2017), many design strategies were identified intended to improve the design and operation of such systems. To name just a few, patterns for attracting and motivating users in content aggregation, curation and recommendation systems, for making behavioural change, encouraging shared responsibility HMNs,

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[2] 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

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

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, as well as where additional improvements might be 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 (DSM) 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 a circular economy. [4] 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.[5] 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.[6]

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. With this in mind, and responding to the differences in the three domains discussed, the following sections (Sections 4, 5 and 6) are structured around the major issues and concerns associated with each of the individual domains. A common thread for all three, though, is the application of HUMANE methodology and tools as they inform the development of the separate roadmaps. We will also focus on short-term goals, which could be implemented in a relatively short time.

4   Developing roadmaps across different domains

Having described how the roadmaps can be created, we now turn to the application of that process to three illustrative domains. In the following three subsections, each of the domains selected – *Sharing economy, eHealth* and *Citizen participation* – are dealt with in turn, leading to the creation of three roadmaps using the approach described above. Each subsection describes the roadmap development from a common set of perspectives:

- **Current technological situation, emerging and future trends**: which sets out the technical context in which the HMN operates;
- **Policy background and regulatory context**: by contrast, describes the legal background of those HMNs;
- **Key challenges and goals**: the issues which face HMN stakeholders;
- **Suggested strategies and actions**: how to resolve those issues;
- **Overview of the roadmap**: what the resulting roadmap looks like;
- **Timeframe and prioritisation**: when and how the roadmap 'destination' may be reached; and
- **Roadmap dissemination**: how the roadmap is shared with the wider community.

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

Using this common structure, domain-specific differences can be identified quickly and easily. In this way, it is apparent not only the complexity of HMNs but more importantly the generic applicability and value of the HUMANE methodology in identifying possible solutions to help both developers and operators at design time as well as during operation.

4.1 Developing the sharing economy HMNs Roadmap

4.1.1 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. While the sharing economy is still in its early years, the EC considers it as implying "a significant potential to contribute to competitiveness and growth" (EC, 2016, p. 2). It is predicted that the value of sharing economy transactions in Europe will increase substantially the coming years, from 8 billion Euro in 2015 to an estimated 570 billion Euro in 2025 (PwC, 2016).

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 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. Botsman and Rogers (2010) distinguish three main areas of collaborative consumption, including *collaborative lifestyles*, leveraging sharing of non-tangible assets such as skills and competencies, *product-service systems,* concerning the sharing of tangible assets such as consumer goods, and *redistribution markets*, addressing peer-to-peer distribution of used goods.

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. In a more recent study, PwC (2016) has adapted these areas to include sharing of competency and work capacity, which is in line with e.g. Malhotra and Van Alstyne (2014).

Currently, the landscape of sharing economy services is constituted by a (a) small number of large, transnational service providers such as AirBnB and Uber, (b) a modest number of established providers that dominate particular countries or regions, and (c) an extensive set of start-up service providers that aim to take markets shares from the established service providers and target new markets.

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 discuss sharing economy and regulation (Cannon & Summers, 2013). 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 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 analysis is based on 19 interviews; nine with representatives of sharing economy services, referred to below as *service owners*, six researchers who study the sharing economy, referred to as *experts*, and four policymaker representatives within the public sector and NGOs, referred to as *policymaker representatives*. In addition to these interviews, we draw on the current academic and practitioner literature. The involved service owners, represented companies of four key sharing economy areas: hospitality, transportation, consumer goods, and sharing of work capacity. All interviews were conducted with Norwegian participants. Hence the findings will reflect the Norwegian context. This may limit the wider applicability 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. Furthermore, as Norway has a comparatively high penetration of mobile Internet, a key enabler of sharing economy services, findings from this country are likely also indicative for the near future situation in countries with lower current mobile Internet penetration.

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. This forms the basis for a roadmap for future human-machine networks for the sharing economy. In this section we present the analysis serving as the basis for the roadmap. Then, the roadmap itself is presented in Section 7.1.

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

4.1.2   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.

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[7]. Meanwhile, the uprising sharing economy introducing new business models driven by an increased 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 is often the case, policy making has not kept pace with technological developments. This has left the sharing economy in a regulatory grey zone in terms of market access requirements, data protection regulation, taxation, and consumer or employee rights. These issues are acknowledged on European level and was addressed in the European Agenda for the collaborative economy[8].

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.

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.

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[7] 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

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

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 *Onefinestay* by the global hotel chain Accor[9], or the acquisition of the ride sharing services *Hailo* and *MyTaxi* by the car manufacturer Daimler Benz[10].

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 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[11].

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.

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

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

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

[11] www.lotel.no

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.

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

4.1.3 Key challenges and goals

Through the interviews with service owners, researchers 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. Specifically, the interviews addressed the four analytical layers of the typology; the actors, relations, network extent and network structure of the sharing economy HMNs.

In this section, we present the identified challenges and goals for each of these 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 challenges and 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.

4.1.3.1 The actors of sharing economy HMNs – challenges and goals

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.

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:

Motivate 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. The need for providing convenient and frictionless services in the sharing economy was also addressed by most of the researchers. The researchers, however, to a somewhat greater extent than the service owners accentuated the value of leaving users of sharing economy in control, that is, to allow for relative high levels of human agency. Finding the right balance between the need for standardisation, to strengthen quality control, and the need to allow users flexibility and freedom to shape the services they way they want.

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, researchers, and policymaker representatives. 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.

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.[12]

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 researchers and policymaker representatives noted, artificial intelligence and machine learning will likely be transformational for almost any sector.

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

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[12] 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

marketplace depends on the technology platform for matchmaking, whereas the technology platform depends on the marketplace for data.

4.1.3.2 The relations of sharing economy HMNs – challenges and goals

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 of these dimensions support insight into challenges and goals of sharing economy HMNs.

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.

However, the importance of the human aspect in sharing economy services may vary between service contexts. This was suggested by both service owners, researchers, and policy makers. There may be individual differences in the degree to which users want or desire social interaction as part of the service experience, where may also be differences depending on the context (e.g. business-oriented vs. leisure-oriented), and also between sharing economy market niches.

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.

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. For the platform to take on this role, it will be critical for the platform to develop trusting relations with its users.

Develop trusting relations: *T*rust 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 development of trusting relations is also seen as closely associated with how sharing economy services handle risk. Hence, risks associated with sharing economy services has been a much debated issue. In particular for transportation services such as Uber (Malhotra & Van Alstyne, 2014).

Most of the service owners report that establishing a trusting relation with their users 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. Likewise, some of the researchers and policy maker representatives accentuate the need to establish such trust.

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 social recommendation systems, and the necessity to have some level of policing of the user activity on the site; for example to detect fraud. Also, the researchers and policymaker representatives see social recommendations within the sharing economy services for establishing and keeping trust to the platform and, in turn, between the users.

The service owners, as well as some of the researchers and policy maker representatives also accentuate that risk management is critical to successful sharing economy services. For example through the establishment of good insurance options, so that the sharing economy service can help users manage risk in sharing transactions.

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.

4.1.3.3 The extent of sharing economy HMNs – challenges and goals

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.

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, is suggested by the researchers and policy-makers to 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. Some argued for the need to make sure that policies and regulation on sharing economy services helps alleviated this tendency, so as to make it possible for innovative newcomer services to be established.

Geographical reach – keep local relevance while scaling

Local relevance in trans-local service provision: All service owners report ambitions of becoming large-scale services; 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. Also some of the researchers addressed the need for local relevance, in the sense that sharing economy services need to be developed with a sensitivity to the local context.

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.

Balancing the need for adapting to local context with an ability to efficiently scale across local contexts is assumed to be critical for sharing economy services.

4.1.3.4 The structure (workflow interdependence and organization) of sharing economy HMNs – challenges and goals

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.

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.

Also the interviewed researchers discussed the dialogue challenge for sharing economy services. Here, this challenge was seen as closely tied to the possible need to standardise or streamline services. That is, to mitigate the dialogue challenge by way of reducing human agency. At the same time, the researchers did not see reducing human agency as a straight-forward solution, as for many contexts they also considered high levels of human agency to be valuable to the service users.

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. Also, planning needs may be reduced also by strengthening the prediction capabilities in the sharing economy platforms. Hence, this challenge is closely tied also to the question of increased machine agency in the networks.

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.

Service delivery networks: Within the field of service research, it is noted an emerging trend of services being provided in networks of interrelated service providers, so called service delivery networks (Tax, McCutcheon, & Wilkinson, 2013). Within the sharing economy, such sharing economy networks are commonplace. For example, redistribution platforms may depend on third party services for payment

and transportation, in addition to utilizing social media channels to promote both the service and second-hand goods sold there.

Some of the service owners, as well as the researchers and policy maker representatives, reflected on such service delivery networks in the context of the sharing economy. Third party services which were discussed included insurance companies for risk management in the context of rentals, marketing services for promoting content on sharing economy platforms, transportation services for transfer of goods bought through online redistribution platforms, payment services such as solutions for mobile payment, or platform-providers for startup sharing economy services.

An important challenge in such service delivery networks may be that the individual user may need to serve as a service integrator, tying together the services needed for completing a sharing economy transaction. This may be seen as beneficial, as it allows for greater flexibility, but it may also be seen as complex and confusing as the users are exposed to a range of providers which they may or may not be familiar with. Some of the sharing service owners accentuate the benefit of flexibility, also as it reduces the responsibility for the sharing economy platform. For example, if the users of the platform needs to figure out themselves how to transfer money for the shared goods this reduces the burden on the platform. At the same time, it may increase the workload on the users. Hence, other service owners argue for the possible need to integrate such service delivery networks within the sharing platform so that the sharing economy platform and not the user is the service integrator.

4.1.3.5 Societal aspects of sharing economy services -challenges and goals

In addition to the challenges and goals identified for the HUMANE analytical layers and dimensions, the participating service owners, researchers and policy maker representatives pointed out a number of challenges, goals, or topics of interest of relevance to sharing economy services. In this subsection we report on four of these

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.

Policy and regulations

As the sharing economy matures, there will be an increasing need for adapting policies and regulations to facilitate the development of innovative and sustainable services. At the same time, policies and regulations are needed to ensure that the evolving sharing economy is in line with societal expectations concerning, for example, taxation, workplace standards, and consumer rights. The European Commission (2016) accentuates the need to avoid a regulatory context where there is uncertainty regarding the rights and obligations of those participating in the sharing economy.

Service owners, researchers and policymaker representatives pointed to the need for policies and regulations that motivated to sustainable and transparent services. While policy making and regulation was often discussed from the perspective of the need not to hamper growth in sharing economy services, some also pointed to the current opportunity for government policy makers to positively guide or direct sharing economy services owners and users. In particular, some pointed out the current opportunity for government policy makers for requesting transparency in sharing economy platform, potentially strengthening adherence e.g. to tax regulation. Others pointed out the opportunity to motivate consumers to increase their use of sharing economy services, for example by providing financial incentives for sharing of resources such as cars.

Blurring boundaries

The researchers and policymaker representatives, more so than the service owners, discussed and challenged the boundaries of the sharing economy. For example, by pointing out the lack of a commonly taken up definition of sharing economy and that sharing is a form of social behaviour that has existed as long as mankind. Furthermore, the range of services categorized as within the sharing economy makes it challenging to identify a set of strict common criteria for these services.

The blurring of boundaries between sharing economy companies and traditional services and goods providers was mentioned as interesting by some of the policy maker representatives and researchers. Here, it was discussed how traditional providers take up practices which also characterize the sharing economy, such as for example social recommendation systems or by expanding on sharing-like offerings such as leasing.

Managing unintended implications – keeping a green perspective

Some of the service owners, as well as the participating researchers and policy makers, discussed how to deal with unintended implications of the sharing economy in general, as well as within particular sharing economy platforms. The main example of such discussions was 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.

4.1.4 Suggested strategies and actions

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

The overview is summarized in Table 1, where we list the identified challenges and goals and present actions and strategies discussed by the participants. The different possible actions and strategies are reviewed in more detail below the table.

Layer	Area of interest	Challenges and goals	Possible actions and strategies
Actors	1. Human agency: Guiding consumers	Motivation and behaviour change: Motivate consumers and drive behaviour change	Accentuate financial gains and convenience Leverage circumstantial causes for habit discontinuity Explore existing niches of collaborative consumption
		Standardisation: Provide quality control and leverage role diversity	Standardised processes Invest in customer culture and provide differentiated products
	2. Machine agency: Match and predict	AI-driven predictions: Strengthen prediction abilities through intelligent platforms	Prioritize prediction capabilities Access to large volume user data
Relations	3. Social tie strength: The good meeting of strangers	Experiential aspects: Keep the human aspect	Human meeting value adding Social interaction as a feature
		Brief social encounters: Matching strangers rather than group formation	Matching strangers default approach for sharing economy services – also in the future
	4. Human-machine relationship strength: Loyalty to the platform	Trust in the platform: Develop trusting relations	The platform as the basis for trust Mechanisms to strengthen trust in the platform
Network extent	5. Network size: Increase network size	Growth and consolidation: Increase network size	Prepare for consolidation and winner-takes-all markets

Layer	Area of interest	Challenges and goals	Possible actions and strategies
	6. Geographical reach: Local relevance in trans-local services	Local and global: Local relevance in trans-local services. Services that scale	Address the local-global challenge
Network structure	7. Workflow interdependence: Efficient interactions	Efficient dialogue and reduce the need for planning	Standardised processes (see "Actors" above) Invest in customer culture and provide differentiated products (see "Actors" above)
	8. Network organization: Predictable services	Centralised organisation: Strengthen the platform as a central node	Develop the relation to the platform as the main relation
		Service provider networks	Sharing economy services as resource integrators
Societal aspects		Strengthen awareness	First mover curse or first mover advantage?
		Policy and regulations	Allow innovation and growth in the evolving sharing economy Direction through policy
		Blurring boundaries	Uptake and adaptation of sharing economy practices
		Managing unintended effects	Identify and counter unintended implications

Table 1: Overview of potential actions and strategies for sharing economy HMN

In the following, we provide more detail on the suggested actions and strategies. Where relevant, we also point out related design considerations identified through previous work in HUMANE (Følstad et al., 2016, 2017).

4.1.4.1 Actors: Key actions and strategies

From the analysis of human and machine actors in sharing economy HMN, three main challenges and goals have emerged as particularly relevant. In the following we discuss actions and strategies of relevance for these.

Motivation and behaviour change

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.

The interviewed service owners are clear on the need to provide value propositions that accentuate the financial aspects of sharing economy services. This position is also reverberated by some of the researchers and policy maker representatives. For example, that the services enable you as a supplier to make money on surplus resources in a convenient manner. Also, experiential motivations, in the meeting between private persons as part of the sharing transaction or in the finding of "treasures" when buying used goods through online redistribution platforms, and also sustainability motivations, such as the desire to avoid waste, are argued as important motivators. However, financial gains and convenience are more important still.

In consequence, sharing economy services will need to accentuate potential financial gains and convenience as part of the provided service. Policy makers, likewise, may potentially support such motivation of users through financial incentives for using sharing economy services.

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. Also, the participating researchers and policy maker representatives acknowledge this challenge.

Some of the service owners argued that changing life-events for consumers may represent a golden opportunity for behaviour change. 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. This strategy for behaviour change is in alignment with research on habit discontinuity presented by Verplanken and Roy (2015).

Hence, targeting groups that are in a life situation where habit discontinuity is likely, may be particularly relevant to achieve the needed behaviour change. For example, targeting a younger demographic may be one way to exploit changing life situations for habit discontinuity.

Explore existing niches of collaborative consumption: Some of the service owners and researchers also pointed out existing niches of collaborative consumption as a potential means to drive a broader uptake of sharing economy services through behaviour change. In such niches, 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.

Potentially, such niches of collaborative consumption may be used to drive behaviour change also for other market areas. In particular for services or platforms which provide a wide range of sharing options. Such niche sharing may also serve to strengthen general public awareness of sharing economy services.

Relevant HUMANE design considerations: Previously in the HUMANE project, a range of design considerations for HMNs have been described. Some of these may also be relevant for motivation and behaviour in sharing economy services:

- **Behaviour change through KPI feedback loops**[13]: On how behaviour indicators and feedback mechanisms may be applied to drive behaviour change
- **Behaviour change through social motivation**[14]: On how the behavioural patterns in a social group may drive individual behaviour change

Standardisation

Standardised processes: Most of the service owners, and also some of the interviewed researchers and policy maker representatives, argued for the need increasingly streamline or standardise the sharing processes conducted within their platforms. While acknowledging the need to be flexible and allow for as much agency in their users as possible, most of the involved service owners acknowledged that a lack of process support where the users are free to figure out how to do the sharing themselves may be counterproductive.

Standardising processes typically implies making the sharing economy services more closely resembling the processes of eCommerce services, with detailed support for all phases of the transaction. However, typically depending on two-sided markets where the users represent both the supply and demand side, sharing economy services typically may not achieve the same level of standardisation and quality control as may be expected in a regular eCommerce transaction.

Invest in customer culture: One response to the non-feasibility of entirely standardising typical sharing economy processes, some of the service owners discuss means of investing in customer culture and helping users to become better sharers. Providing guidance materials was suggested as one approach to this.

Investing in customer culture may also entail individual support to 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 will 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.

Provide 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.

Currently, most sharing economy platforms arguably provide the same value offering to all its users. Indeed, individual configuration is often possible, but the way the sharing transactions are conducted often are expected to be similar for all users.

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

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[13] https://networkprofiler.humane2020.eu/patterns/seFBmgey4nBqCgoLk
[14] https://networkprofiler.humane2020.eu/patterns/YYLCgG59SFdSSky3F

providers, such as the different Uber services (e.g. X, SUV, BLACK), or AirBnB regular booking and the book now option.

The option of providing differentiated products may represent a means of balancing the need for standardisation and the need for allowing for as much agency in the human users as practically feasible. In the future, it will likely be important for sharing economy service providers to provide more clear differentiation between different service options.

Relevant HUMANE design considerations: To build a positive customer culture, as discussed above, some of the design considerations previously identified in the HUMANE project may be relevant:

- **Support improvement through showing trends and good examples**[15]: On how to users may be led to improve their communication through being shown successful examples from others.
- **Protect new users from bouncing**[16]: On how a human-machine network may encourage experienced users to take responsibility for and support newcomers.

AI-driven predictions

Prioritize prediction capabilities: Most of the service owners accentuated prediction capabilities as a competitive advantage for sharing economy services, and a need for prioritizing the strengthening of such capabilities in the sharing economy platforms. Prediction capabilities are critical for enabling good matching between users with goods or services available and users in need for such services, simplifying the process of entering ads or Examples of how such prediction capabilities can be utilized are, for example, seen in recent applications for redistribution markets, such as American LetGo[17] or Norwegian Snapsale[18] where ease and convenience is strengthened through, e.g. automatic image recognition so that sellers get automatic support in categorising and writing their ads, and prediction capabilities to provide relevant suggestions to potential buyers.

Some of the service owners also noted other areas where strengthened prediction capabilities may be critical such as in fraud detection, in adapting the service to the changing context of the users, and in providing lifecycle services for products or services targeting users on the basis of their prior consumption patterns.

Some of the service owners, as well as the researchers and policy maker representatives, however noted that prediction capabilities needs to be designed and implemented with care. In particular, it was argued to be important that the prediction capabilities were perceived as helpful and beneficial by the users. Hence, a user-centred design of prediction capabilities, where these are designed and validated mindful of users' needs and how they are perceived by users, is important. In particular, it was advised that users should be given the opportunity to override automatic suggestions when needed. In part, such overriding of automatic suggestions may be handled by introducing

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[15] https://networkprofiler.humane2020.eu/patterns/8BcHkWuL3rWktmNkZ
[16] https://networkprofiler.humane2020.eu/patterns/CYjHiYMuuvYjdwrfN
[17] LetGo - https://letgo.com
[18] Snapsale - http://www.snapsale.com/

differentiated products, as discussed above, with varying levels of automatic prediction and matchmaking.

Access to large volume user data: When discussing prediction capabilities, some of the service owners made particular note of that prediction capabilities in the sharing economy platforms require access to large volumes of user data. This includes data on user profiles, but also data on transactions and their outcomes to enable prediction of successful matching and recommendations. For sharing economy services, access to large volumes of data may be critical, something that may favour large, established service providers. Hence, for start-up companies access to user data may need to be resolved through other means. Possibly, through links to third party service providers, such as providers of social media services, though this was not specifically mentioned by any of the service providers.

At the same time, the need for large volumes of user data will require sharing economy platforms to be particularly mindful of privacy and data protection regulations. Hence, while strengthening their access to user data, and improving prediction capabilities, sharing economy services will benefit from prioritizing to establish and maintain comprehensive quality processes for data management.

Relevant HUMANE design considerations: The issue of privacy in human-machine network has been targeted in design considerations previously identified in the HUMANE project. This may be relevant in relation to the need for accessing large volumes of user data in sharing economy services.

- **Managing privacy through trusted third party**[19]**:** On how to mitigate privacy issues in a HMN by applying intermediary repository controlled by a trusted third party.

4.1.4.2 Relations: Key actions and strategies

From the analysis of the human-human, as well as the human-machine relations in sharing economy HMN, three main challenges and goals have emerged as particularly relevant. In the following we discuss actions and strategies of relevance for these.

Trust in the platform

Trust is accentuated as a key issue in sharing economy services, by service owners, researchers and policy maker representatives alike. In particular, they see it as necessary to strengthen the relationship between the users and the sharing economy service. In the terminology of HUMANE, they see the need to strengthen human-machine relationship strength. As pointed out by some of the participants, sharing behaviour has always depended on trust. However, in pre-Internet times, sharing behaviour has been dependent on trust between individuals or smaller social groups. In the sharing economy, trust do not primarily depend on the relations between individuals but on the relation between the individual and the sharing economy platform.

Hence, building trust in the platform is seen as critical. As actions and strategies towards this goals, the service owners, as well as the researchers and policy maker representatives, pointed out a number of

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[19] https://networkprofiler.humane2020.eu/patterns/sEXgJwLYEcbRL5KCg

possible actions to strengthen trust in sharing economy platforms. Specifically, a number of mechanisms for strengthening trust was discussed, many of which are applied in current sharing economy services:

- **Build trust through social recommendation:** Most participants discussed social recommendation and rating as a critical means of building trust in the platform. In particular as the platform mainly aim to match strangers. Sharing economy services typically have such recommendation systems available, but their design and implementation differ. Providing effective and efficient social recommendation may represent a competitive advantage in terms of trust building.

- **Reduce risk through insurance:** Provision of insurance as part of the service may be instrumental in building trust and reducing the risk associated with sharing practices. In particular for market niches where current insurances may not cover liability sufficiently during sharing, such as for car sharing. One consequence of this is that third party insurance providers may hence see sharing and collaborative consumption as a new market area. Provision of effective and efficient sharing economy insurance may represent a strategic advantage both for sharing economy service providers and insurance providers.

- **Trust through traceability in transactions:** Some of the policy maker representatives discussed the traceability in transactions provided by sharing economy services as a potential trust enhancing mechanism. This was exemplified with the traceability provided by Uber, contrasted with the traceability in a regular taxi. As such, the traceability in transactions may represent safety-enhancing surveillance.

- **Thrust through privacy policies.** While traceability in transactions represent a strengthening of trust through surveillance, some of the researchers and policy makers also accentuated the need to build trust through beneficial and easy to understand privacy policies. Balancing the potential for traceability in sharing economy services with privacy requirements may be critical for building trust in sharing economy platforms.

The success of sharing economy services is seen as depending on the degree to which the platforms are trusted by the users to provide adequate recommendations and matches, and the degree to which they help users to reduce risk. To build trust in the platforms, emerging sharing economy service may in the future be prepared to take responsibility for more of the risk associated with sharing than what may be the case for some of these today.

Relevant HUMANE design considerations: Trust in human-machine networks has been targeted in design considerations identified in the HUMANE project. The following may be relevant for sharing economy HMN:

- **Strengthen trust through rich profiles and recommendations[20]:** On how social profiles and recommendations may strengthen trust in human-machine networks.

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[20] https://networkprofiler.humane2020.eu/patterns/RYGpEua6mNTTWiJzq

- **Enhancing security in data aggregation services**[21]: On how human-machine networks may strengthen trust through restricting third party access to user data.
- **Increasing user trust through transparent algorithms**[22]: On how trust may be affected by the level of transparency in the algorithms used e.g. for recommendation in HMN

Brief social encounters

When discussing social tie strength in the context of sharing economy services, nearly all service owners accentuated that the default mode of operation, also in the foreseeable future, was to match strangers rather than build closely knit subgroups. Indeed, some of the services include social functions such as following, and nearly all include social recommendations. Nevertheless the service owners typically reported not to see any incentive to strengthen social ties between their users. Some also noted that strong social ties may work counter to effective social recommendation systems, as friends may be prone to assess each other less critically than would strangers.

Given that social encounters are to be kept brief in the sharing economy services, it may be strategically relevant to identify other means of building community than through social ties. Some of the researchers discussed how user commonalities could be exploited for building a sense of community in a human-machine network of strangers. Examples of such commonalities are social demographics, such as age, gender and geographical location. Also common interests may strengthen commonality in the HMN.

A strategically important action for sharing economy services may, hence, be to identify how commonalities in user groups may be applied to guild a sense of community in a HMNs where the default mode of matching is the brief social encounter between strangers.

Experiential aspects

While the service owners saw the default mode of operation for sharing economy services to be the matching of strangers, nearly all also accentuated the experiential value of the positive meeting between strangers in the context of the sharing economy. This meeting between humans was reported to be value adding, and something that increase loyalty in the service. Furthermore, the meeting between humans was reported to potentially reduce risk as this was seen as strengthening the involved users' sensitivity towards each others' needs and inducing borrowers to be more careful with the borrowed goods.

Hence, for sharing economy services it may be important to facilitate such beneficial meetings. In consequence, some redesigns of a sharing economy service to improve efficiency, such as the pick-up of keys for shared cars in third party locations, should only be implemented with sensitivity to the potential cost in terms of reduced personal meetings between those involved in the sharing transaction.

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[21] https://networkprofiler.humane2020.eu/patterns/FtHXQ2TYzqAcgWsCF
[22] https://networkprofiler.humane2020.eu/patterns/aztzZQQtyKmRoY2Wi

However, as reported by some of the service owners, researchers, and policy maker representatives, not all users desire the meeting with strangers as part of a sharing economy transaction. This may be due to individual differences between users, differences in context, and differences between market niches. Hence, some of the service owners suggested the positive meeting between strangers to be designed as an opt-in/opt-out feature, where the users may choose between a sharing mode with or without a personal meeting with the other user involved in the sharing transaction.

4.1.4.3 Network extent: Key actions and strategies

From the analysis of the extent of the sharing economy HMNs, in terms of network size and geographical reach, two key challenges and goals emerged as relevant. In the following we discuss actions and strategies for these.

Growth and consolidation

Sharing economy services typically strive for international reach and massive market shares. In the interviews, nearly all the stakeholders reported on intentions of massive growth and increased geographical reach. Likewise, the researchers and policy maker representatives made note of this trend and reflected on the implications of such growth.

As may be self-evident, such ambitions for growth imply that much of the start-up sharing economy services of today will not be able to stay competitive over time. Indeed, the sharing economy market is projected to have exponential growth the coming years (PwC, 2016), but the market likely still will not be sufficiently large for all current services to prevail. On the contrary, some of the researchers and policy maker representatives predicted substantial consolidation within sharing economy services, potentially towards a winner-takes-all market for each sharing economy market area such as hospitality, transportation, and consumer goods.

For sharing economy services providers it will be critical to consider how to stay competitive in a market characterized by few, large players. For example by targeting particular niche markets, or by working towards market leadership in limited geographical regions.

For policy makers it may be important to consider how the active use of policy and regulation could mitigate a situation where a single actor becomes too powerful in a given market, to keep up competitiveness.

Local and global

While service owners typically accentuate the need to extend global reach for their particular service, they also highlight the importance of local relevance. In the service owner interviews, the potential tension between local relevance and trans-local (or possibly global) reach was thoroughly discussed. Local relevance was seen as important both in terms of building trust and loyalty, in terms of becoming a market leader in a given geography, and in terms of sharing typically being locally embedded.

Service owners hence need to work strategically towards leadership in any local region in which they aim to develop. For this purpose, as discussed by some of the service owners, local adaptations may be tempting, and given that the local region is sufficiently large, may also be a feasible option. For

example may a sharing economy service to some extent be efficiently adapted to a national or regional context. At the same time, the local adaptation should not be allowed to become so extensive so as to hamper extending geographical reach.

In the future, most sharing economy services will depend on growth, which in turn will imply scaling across geographies – possibly on an international level. Successful services will be those who are able to balance the strategic aim for local relevance with the strategic aim for ease of scaling across local contexts.

Relevant HUMANE design considerations: Previously in the HUMANE project, a range of design considerations for HMNs have been described. Some of these may also be relevant for the growth and consolidation of sharing economy HMNs:

- **Consider geography in designing collaboration** [23]: On how collaboration may depend on geographical location and how to acknowledge this in design.
- **Apply a loyalty ladder** [24]: On how to drive growth through segmented customer relationship management.

4.1.4.4 Network structure: Key actions and strategies

The final analytical layer in the HUMANE framework is the structure of the network. Here, through considerations of the organization, as well as the workflows in the sharing economy HMN, two key challenges and goals emerged. In the following we discuss actions and strategies of relevance for these

The platform as the central node

While emerging phenomena on the Internet often are characterized by being bottom-up or self-organized, sharing economy service often are characterized by high levels of centralisation. In particular, as single sharing platforms serve as the connecting node for the sharing activity and that only to a limited extent subgroups are formed. This tendency towards establishing the sharing economy platform as the central node in a sharing economy HMNs, was also accentuated by the interviewed service owners. As discussed above, the service owners argue for limiting human agency in the networks to improve quality control, and not to work towards the forming of strong social ties between service users but to strengthen the ties between the individual user and the platform.

This has important strategic implications for sharing economy services. In particular, it will be imperative to serve the users from the platforms and strengthen user loyalty by broadening and improving service offerings. Rather than depending on third party providers independent of the sharing platform to complement the service offering, for example for transportation, payment, insurance, maturing sharing economy services may need to increasingly provide this as part of the service. At the same time, as we shall see below, may it be challenging for newcomer sharing economy services to provide a sufficiently comprehensive service offering.

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[23] https://networkprofiler.humane2020.eu/patterns/cJrQ3RuG6ENKj2R9N
[24] https://networkprofiler.humane2020.eu/patterns/tFcPEK9nXQQk29upk

Service delivery networks

Sharing economy services often has the character of service delivery networks, where multiple providers are involved as part of the users service processes. For example by providing options for payment, marketing and communication, transportation of sold goods, insurance and similar.

In the interviews, some of the service owners accentuated the benefit of being only a part of such service delivery networks also as seen from the perspective of the users. For example, some reported to see themselves as a mere matchmaker but that the users would need to figure out some of the practicalities involved in the sharing transaction themselves, such as how to conduct the payment. From the service provider point of view, this was reported to be necessary to make it feasible to start up the service, and also potentially beneficial in terms of making clear to the users that the responsibility of the sharing economy service is limited to the matchmaking.

Other service owners, however, argued that sharing economy services need to mature into providing more comprehensive service offerings, to make sharing processes more predictable and convenient for the users and to serve as a trusted platform. This requires the service platform to be set up as a hub through which a comprehensive set of offerings are provided. These more mature sharing economy platforms will still be part of sharing delivery networks, however, the platform takes on more responsibility as an integrator of the needed service providers.

For sharing economy services to grow into becoming the default option for consumers in a ten year perspective, it seems likely that the services need to follow the example of leading providers such as AirBnB and strive for providing comprehensive service offerings.

Relevant HUMANE design considerations: Previously in the HUMANE project, a range of design considerations for HMNs have been described. Some of these may also be relevant for the organization of sharing economy HMNs:

- **Catering for network evolution**[25]: On network design to allow for dynamic growth and reduce need for adaptations.
- **Managing privacy through trusted third party** [26]: On how to provide effective and efficient privacy management of relevance for service delivery networks.

4.1.4.5 Societal aspects: Key actions and strategies

Through the interviews with the service owners, researchers and policy maker representatives, four goals and challenges concerning societal aspects were identified which do not easily map on the HUMANE framework. In the following, we address actions and strategies of relevance for these.

Strengthen awareness

For the sharing economy to grow as envisioned in the coming 10 period, awareness among consumers is required. Some of the interviewed service owners point out that their current greatest competitors

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[25] https://networkprofiler.humane2020.eu/patterns/E2z4Do68yarsQ95PE
[26] https://networkprofiler.humane2020.eu/patterns/sEXgJwLYEcbRL5KCg

are not other sharing economy services but that consumer still tend to use providers from the traditional service or consumer goods sectors. Also, some of the researchers pointed out this need for strengthening awareness in the market.

Strategically, this may be challenging for sharing economy services. Whereas some areas of the sharing economy, such as redistribution platforms, are well established, other areas are less well known in the general public.

The challenge of strengthening awareness is closely tied to the challenge of motivation and behaviour change discussed above. In addition to strategies for this purpose, it may be beneficial for sharing economy services to collaborate in professional networks for competence sharing and for strengthening visibility.

Relevant HUMANE design considerations: Previously in the HUMANE project, a range of design considerations for HMNs have been described. Some of these may also be relevant for strengthening the awareness of sharing economy HMNs:

- **Design for consumer engagement** [27] : On how to design digital platforms to strengthen consumer engagement.
- **Campaigns, not routine, for attention in small-scale HMNs** [28]: On how to maximize attention-generating efforts.

Policies and regulations

As the sharing economy matures, policy and regulations need to follow suit. Policy change may be needed to facilitate the establishing of sharing economy services. Also, policies may serve to guide the evolving sharing economy market towards directions that are beneficial for society at large.

Among the interviewed participants a number of relevant policy areas were discussed. In line with the general EC policy on the sharing economy, the interviewed policy maker representatives see the sharing economy as holding substantial potential for innovation and growth, but that policy change is needed to avoid outdated policies to curb beneficial developments. Relevant areas for policy change to support innovation and growth are transportation and hospitality. We will not go into detail on this, as this has been thoroughly treated in existing policy documents (e.g. EC, 2016).

The participants also discussed policy needs to curb undesirable developments in the sharing economy, as well as policies potentially driving desirable change. Some of these are well known others less treated:

- **Transparency requirements:** As noted by some of the service owners and policy maker representatives, the sharing economy holds great potential for increased transparency in transactions. Something that may be beneficial, e.g., for tax reporting. For this potential to be realized, government policy makers and regulatory bodies may consider to strengthen requirements for reporting from sharing economy platforms. This suggestion is in line with the

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[27] https://networkprofiler.humane2020.eu/patterns/T4yn5buTktqB5Cw3W
[28] https://networkprofiler.humane2020.eu/patterns/EahzrXLPHromBnRya

official Norwegian report on the sharing economy of 2016[29], where it is recommended that digital sharing economy platforms in the future should be obliged to report on transactions through these platforms.

- **Policies on privacy in the sharing economy.** Because of the value of user data in sharing economy services, as well as the potential benefit of transparency in such services, such services may entail substantial privacy issues. Policies and regulations for privacy will, hence, be of critical importance in such services. Potentially, policy makers and regulatory bodies will need to specifically consider such services in future policy developments. Though not specifically discussed by the participants, sharing economy services may also be in particular need of support for a helpful implementation of the general data protection regulation (GDPR)[30].

- **Policies to maintain competition in the sharing economy market.** Given that the sharing economy is at risk for evolving into winner-takes-all markets, some participants discussed the need for policies maintaining such competition. This is, however, seen as potentially challenging given the international character of sharing economy services.

- **Policies to encourage sharing behaviour.** Some of the service owners discuss the potential opportunity of government policies to incentivise sharing behaviour. For example, to strengthen the incentives for redistribution of second-hand goods or for co-driving.

Blurring boundaries

As noted by some of the interviewed researchers and policy makers, the sharing economy represent a blurring of boundaries. Both between providers and consumers of goods and services, as well as between traditional service and goods providers and sharing economy providers. For example, it was discussed how useful practices from the sharing economy will likely be taken up by traditional service and goods providers.

In consequence, some of the policy makers and researchers predicted convergence between sharing economy services and traditional providers. Hence, in the future it may be even more challenging than it is today both to define the sharing economy and to specifically design or develop policies for sharing economy services.

Managing unintended effects

Being a disruptive approach to service provision, the sharing economy is bound to introduce unintended effects. As, for example, when sharing demand outweighs sharing supply, and the platforms for sharing no longer serves to facilitate the sharing of idling resources but rather drives demand for new resources – as is for example seen in the concern voiced for visitor takeover of popular tourist destination due to the efficient sharing of private homes (Slee, 2016).

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[29] NOU 2017:4. Delingsøkonomien – utfordringer og muligheter
https://www.regjeringen.no/no/dokumenter/nou-2017-4/id2537495/
[30] GDPR portal - http://www.eugdpr.org/

The service owners, as well as researchers and policy maker representatives, discussed such unintended effects. In particular, the potential drifting away from an ambition of sustainability in services or green consumption due to lowered cost of consumption and a lack in surplus resources or capacity. Some of the service owners accentuated the need to have owners or investors that also has sustainability or green consumption as an explicit priority.

4.1.5 Overview of the roadmap

In this section, we provide an overview of the sharing economy roadmap, consisting of the implications brought by sharing economy HMNs, the objectives and actions we have set in the roadmap in an effort to address these implications and challenges, and HUMANE design strategies that can assist in the realization of the actions.

Sharing economy HMN implications	Roadmap objectives	Actions to implement the objectives	Related HUMANE design strategies
The actors of sharing economy HMNs: Convenience through predictions and standardising processes	Motivation and behaviour change Strengthen quality control AI-driven predictions	Prioritize financial and convenience motivators Standardize service processes for improved service quality Prioritize data capture to support prediction capabilities	Behavioural change through social motivation Support improvement through showing trends and good examples
The relations of sharing economy HMNs: Matching strangers through trust in the platform	Trust in the platform Brief social encounters with strangers The experience in the meeting with strangers	Prioritize trust-building mechanisms, such as social recommendations, insurances, authentication systems, transaction traceability, and privacy policies. Provide the social experience as value-adding option (opt in / opt out)	Strengthen trust through rich profiles and recommendations Increasing user trust through transparent algorithms Enhancing security in data aggregation services
The extent of sharing economy HMNs: Growth towards a	Growth and consolidation Local and global	Envision a market characterized by few, large players	Consider geography in designing collaboration Apply a loyalty ladder

Sharing economy HMN implications	Roadmap objectives	Actions to implement the objectives	Related HUMANE design strategies
winner-takes-all market?		Work for leadership locally in targeted regions Develop networks that easily scale across local contexts	
The structure of sharing economy HMNs: Centralized networks for simplified workflows	The platform as the central node Incorporating service delivery networks	Support entire service process through the platforms. Third party providers as integrated offerings. Strengthen user loyalty by broadening and improving service offerings	Catering for network evolution Managing privacy through trusted third party
Societal implications: Awareness, policies, and change	Strengthen consumer awareness Update policies and regulations	Breadth in actors and services strengthen consumer awareness Consider policies on transparency, privacy, and to facilitate the establishment of sharing economy services.	Design for consumer engagement Campaigns, not routine, for attention in small-scale HMNs

4.1.6 Timeframe and prioritization

In the interviews with the service owners, researchers and policy maker representatives, the timeframe for how HMNs in the sharing economy may be expected to develop was discussed. For the service providers, we discussed their expected development in a time frame of up to 5 years.

However, given the rapid changes within the sharing economy in part due to a broad range of start-up and newcomer companies, it is difficult to make precise predictions in terms of the timeframe for developments within this field. Also, it is challenging to speculate on how to prioritize the actions and strategies discussed above, as this will depend on a range of uncertain factors.

A more constructive approach to the question of timeframe, may be to take for granted current predictions of growth in the sharing economy, from a 28 billion Euro value of sharing economy

transactions in Europe in 2015 to an estimated value of 570 billion Euro in 2025[31]. Such growth require that sharing has been taken up as a default approach to consumption by a substantial share of the European market. For this to happen, the key actions and strategies addressed above will be of high relevance.

A tentative, high-level ordering of when the different actions and strategies may be implemented may be that actions associated with the actors of the sharing economy networks will be highly prioritised. Specifically actions concerning consumer motivation and behaviour change will need to happen relatively early on for a broad uptake of sharing economy services. According to a Eurobarometer study[32] no more than one fifth of Europeans had used sharing economy services in 2016, and nearly half were unaware of such services. Hence, motivation and behaviour change is key – along with initiatives to strengthen awareness.

Through such motivational and behaviour change, actions and strategies concerning relations between the network actors becomes important. In particular, to establish the sharing economy platforms as a trusted basis for sharing economy transactions.

Actions and strategies pertaining to network extent and network structure may be somewhat slower to address, as these in part depend on actions and strategies concerning actors and relations. Also, societal aspects may be slower to address. This is not to be understood as actions and strategies concerning network extent and structure, as well as those concerning societal aspects are prioritized lower, but that it may take more time to realize these.

A visual indication of the timeframe for the different actions and strategies are suggested in the roadmap presented in Section 7.1.

4.1.7   Roadmap dissemination

A whitepaper presenting the roadmap on HMNs in the sharing economy has been developed, summarizing key takeaways from the roadmapping process presented above. This roadmap is intended to serve as a low-threshold overview of key challenges, goals, actions, and strategies of relevance for the development of future sharing economy services.

This version of the roadmap is published on the HUMANE project website and promoted through social media channels. Furthermore, on the basis of the presented work in this deliverable, a paper presenting the roadmapping work and outcome will be submitted to an academic journal supporting green or gold open access.

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[31] PWC (2016). Shared benefits: How the sharing economy is reshaping business across Europe. http://www.pwc.co.uk/issues/megatrends/collisions/sharingeconomy/future-of-the-sharing-economy-in-europe-2016.html

[32] TNS Political & Social (2016). Flash Eurobarometer 438 – the use of collaborative platforms. http://ec.europa.eu/COMMFrontOffice/publicopinion/index.cfm/Survey/getSurveyDetail/instruments/FLASH/surveyKy/2112

4.2   Developing the eHealth HMNs Roadmap

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 biochemical indices, heart problems, back pains, 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.

4.2.1   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[33], 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"[34], 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

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

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), 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.[35,36] 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.

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[35] https://www.wearable-technologies.com/2015/04/wearables-in-healthcare/
[36] http://www.beckershospitalreview.com/healthcare-information-technology/5-digital-health-trends-for-the-new-year.html

Personalized eHealth monitoring systems, devices and applications are also a cornerstone of the EU eHealth policy and research.[37] 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.

4.2.2   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 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[38], 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[39], 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,

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[37] http://ec.europa.eu/information_society/doc/factsheets/009-ehealth-en.pdf
[38] http://ec.europa.eu/health/ehealth/policy/network/index_en.htm
[39] 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

etc.[40] Following these works, the EC planned to establish an industry-led Code of Conduct for mobile health apps, which was recently released[44]. 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. [41] 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 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.

4.2.3   Key challenges and goals

Here we provide an overview of the challenges and goals, focusing on personalized eHealth systems, devices and applications. The main implications brought by eHealth HMNs are the increased control and intervention by users and patients for the detection, treatment and management of diseases, the higher machine agency, which creates a need for security, for the protection of privacy and confidentiality of medical information, and the establishment of trust, and the increased size and geographical expansion of eHealth systems, which calls for the efficient management of large volumes of data, high availability and QoS guarantees in service provisioning, standardization and interoperability, as well as the provision of economically sustainable eHealth services and of coherent rules throughout the EU.

More specifically, technical challenges and goals 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

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[40] 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
[41] https://ec.europa.eu/digital-single-market/en/news/mhealth-green-paper-next-steps

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,[39] 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 or policy goals are to:

- **Educate** people for the handling of more complex health conditions, and to **motivate** otherwise healthy individuals to monitor their health conditions. Personalized eHealth systems, devices and applications imply increased control and intervention by patients for the detection, treatment and management of diseases. While knowledge and activation on the part of patients used to be necessary for the management of chronic diseases such as diabetes and hypertension, patient

activation and knowledgeability, and generally **user engagement**, is now required for more sophisticated conditions, like heart problems, but predominantly for the monitoring of vital signs and the uptake of a healthier lifestyle, in order to prevent diseases.

- **Provide eHealth HMNs 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. [42] 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 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. [43]

- **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**

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[42] 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

[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

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.[44]

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 services	Security	Interoperability	Standardization	User engagement	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				X	X
Interoperability						X		X				
Standardization					X			X				
User engagement				X				X			X	X
Cost-efficiency					X	X	X					
Clear legal framework										X	X	X
Trust				X			X		X		X	X
Clinical validation									X	X		
Privacy & confidentiality	X			X			X		X	X		

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

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

4.2.4 Suggested strategies and actions

In this section we suggest design strategies, as well as detailed actions for achieving the goals set in the previous section.

Patient information is a key component of self-management and **user engagement**. Therefore, initiatives need to be undertaken by authoritative entities, such as ministries, health organizations and hospitals. These should not only be temporary information campaigns; we believe that a permanent information structure is required, which provides continuous support to patients and individuals for

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

the use of eHealth HMNS, so that people feel and understand that is an essential part of prevention and treatment. Usually, providing information on health advancements is a two-stage process: health professionals are first informed, which then communicate the information to their patients. However, the rate of advancements in eHealth and the use of web information channels often results in a horizontal process, where patients may even know first about new methods, devices, and uses. Therefore a mechanism for information dissemination needs to be setup that keeps abreast with the latest developments and coordinates the services that can be provided by healthcare professionals, with the provided information.

Moreover, for increasing **user engagement**, we need to design eHealth HMN systems that are simple and user-friendly, by employing relevant design strategies. Additionally, user engagement depends largely on establishing trust, which in turn depends on guaranteeing user privacy, confidentiality, as well as the integrity and security of medical devices and data, which are separate goals themselves.

In order **to ensure the security of systems and data, the protection of privacy, as well as the efficient management 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.

4.2.4.1 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, the social tie strength of human-to-human (H2H) interaction (usually between doctors and patients) and the human-machine relationship strength of 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 human-machine relationship strength, 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 high machine agency, but the corresponding human agency is usually low. Whereas a system with glucose sensors that notifies the human user of required insulin doses, prompts for a higher level of human agency, as it requires user intervention — which in its turn impacts the measurement results.

On the other side, human-to-machine interaction strength 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")[45], 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 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 reach 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 reach 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 (Følstad et al., 2016, 2017) which are considered more relevant, and explain their suitability for eHealth HMNs.

Behavioural change through social motivation[46]

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

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[45] https://www.flextronics.com/live-smarter/wearable-technology-wearables/wearable-medical-devices-wearapeutics
[46] Code of design strategy from (Følstad et al., 2016, 2017): 14.2.1.2

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 (Følstad et al., 2016, 2017), this can be facilitated by the creation and support of groups of users with common attributes.

Making behavioural change a basic premise of the HMN[47]

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[48] 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[49]

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[50]

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 (Følstad et al., 2016, 2017), 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[51]

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

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[47] Code of design strategy from (Følstad et al., 2016, 2017): 14.2.1.1
[48] https://www.fitbit.com/
[49] Code of design strategy from (Følstad et al., 2016, 2017): 14.2.2.1
[50] Code of design strategy from D2.2: 14.4.3.3
[51] Code of design strategy from D2.2: 14.1.1.2

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 (Følstad et al., 2016, 2017).

Enhancing security in HMNs concerning data aggregation and content curation services[52]

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[53]

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[54]

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 (Følstad et al., 2016, 2017) 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[55]

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

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[52] Code of design strategy from D2.2: 14.4.1.1
[53] Code of design strategy from D2.2: 14.4.2.1
[54] Code of design strategy from D2.2: 14.4.1.2
[55] Code of design strategy from D2.2: 14.4.3.5

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 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 are presented in Annex I.

4.2.4.2 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.

- *Establishment of a permanent structure for providing continuous support and information about the use of eHealth HMNs*
  - *Role of stakeholders:* The permanent structure should be part of the national healthcare system, and should be an authoritative entity for public health information programs. National healthcare administrators should lead the effort, supported by eHealth manufacturers and experts. The information program should include both healthcare professionals and the general public.
- *Conducting realistic large scale studies to examine the application of advanced data management by eHealth monitoring devices and systems, and the application of user-engaging and privacy-by-design mechanisms in commercial eHealth HMNs*:
  - *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 pilot studies are 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**:
  - o **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**:
  - o **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**:
  - o **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.

4.2.5 Overview of the roadmap

In this section, we provide an overview of the eHealth roadmap, consisting of the implications brought by eHealth HMNs, the objectives and actions we have set in the eHealth roadmap in an effort to address these implications and challenges, and the HUMANE design strategies that can assist in the realization of the actions.

eHealth HMN implications	Roadmap objectives	Actions to implement the objectives	Related HUMANE design strategies (Sect. 5.5)
Increased human agency (increased user control and intervention for the detection, treatment and management of diseases)	Educate and motivate people to use eHealth HMNs	- Establishment of a permanent information structure - Improvement of application design, with emphasis on user engagement and behavioural change	- Behavioural change through social motivation - Making behavioural change a basic premise of the HMN - Collaboration through gamified engagement - Maximising the benefits of affordances
Increased machine agency and H2M interaction (increased machine role in	Protection of privacy and confidentiality of medical information	Application of privacy-by-design mechanisms in commercial eHealth HMN	- Supporting trust across HMN interactions - Managing privacy - Increasing trust of users through strict, clear privacy policies

eHealth HMN implications	Roadmap objectives	Actions to implement the objectives	Related HUMANE design strategies (Sect. 5.5)
disease management, collection and communication of large volumes of sensitive information)			- Efficient management and protection of sensitive data through different levels of detail and authorization
	Increased human trust	- Developing reliable eHealth services with guaranteed QoS - Application of privacy-by-design mechanisms in commercial eHealth HMN - Clinical validations for assessing the safety and efficiency of eHealth monitoring devices	- Supporting trust across HMN interactions - Increasing trust of users through strict, clear privacy policies
	Increased security	- Efficient management and protection of medical data - Developing reliable eHealth services with guaranteed QoS	- Enhancing security in HMNs concerning data aggregation and content curation services - Securing HMNs

eHealth HMN implications	Roadmap objectives	Actions to implement the objectives	Related HUMANE design strategies (Sect. 5.5)
Increased size and geographical expansion	- Provide scalable eHealth systems - Provide eHealth HMN at reasonable cost - Availability of critical health services - Standardization and Interoperability of eHealth devices and data	- Efficient large-scale data management mechanisms - Harmonize frequency bands, provision of standards for networking architecture, device configuration and data formats - Review and merge the provisions of the different regulatory documents that relate to eHealth HMN - Study of business models for eHealth monitoring in European countries	- Efficient management and protection of sensitive data through different levels of detail and authorization - QoS guarantees in critical eHealth services offered by monitoring devices in the public Internet - Interoperability of eHealth devices and data from such devices

4.2.6 Timeframe and prioritization

In this section we provide a timeframe for implementation, based on the required implementation effort.

The establishment of an eHealth information structure is an administrative procedure, which consists of setting up the rules and procedures, establishing links with eHealth industry and communication channels, finding offices and recruiting personnel. A timeframe of 1 year is envisaged for setting up a basic structure.

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 on personal wearable and portable communicable systems include 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.[56] 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.[57]

- 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.[58] 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 user-engaging and privacy-by-design mechanisms in commercial eHealth HMN are a mature work-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.[59] 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,

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[56] http://www.etsi.org/technologies-clusters/technologies/ehealth
[57] ETSI Work Programme (accessed 2-1-2017)
[58] http://www.itu.int/en/ITU-T/studygroups/2013-2016/16/Pages/ehealth.aspx
[59] 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

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.

The eHealth HMN timeframe 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.


Figure 3: eHealth HMN timeframe

Among these actions, setting up a basic information structure and creating a modern and coherent regulatory framework can be considered as a priority, as they will help to exploit the eHealth HMNs that are already in operation, so they can bring their benefits to society. Overall however, a concerted effort on all aspects and all stakeholders in necessary to achieve the full potential.

4.2.7 Roadmap dissemination

We have prepared a short white paper (https://humane2020.eu/2017/05/15/a-roadmap-for-future-human-machine-networks-in-ehealth/) on the eHealth HMN roadmap, which is intended to provide a quick overview of the roadmap that is easy to read and understand, and will help to increase awareness among the target stakeholders. The paper starts with a brief introduction to eHealth HMNs, followed by a description of the policy background and regulatory context. We then proceed by explaining the implications of HMNs, such as the requirement for more engagement on the part of patients for self-management and prevention of diseases, the need to protect privacy and establish trust, and the large

size and geographical expansion of such networks. Finally, we describe the actions in the roadmap which help to address these implications.

The eHealth roadmap white paper is published on the project website, together with the roadmaps on other domains. In addition, it will be published on the project's Mendeley page (group: Humane), as well as on social media channels (Twitter).

In addition to the eHealth white paper, we have created a summary of eHealth HMN implications, objectives, actions and related Humane design strategies in table format, as well as a graphical illustration of the roadmap. These will help to create promotional and dissemination material (leaflets, fact sheets, posters) to be distributed to eHealth stakeholders.

4.3 Developing the citizen participation HMNs Roadmap
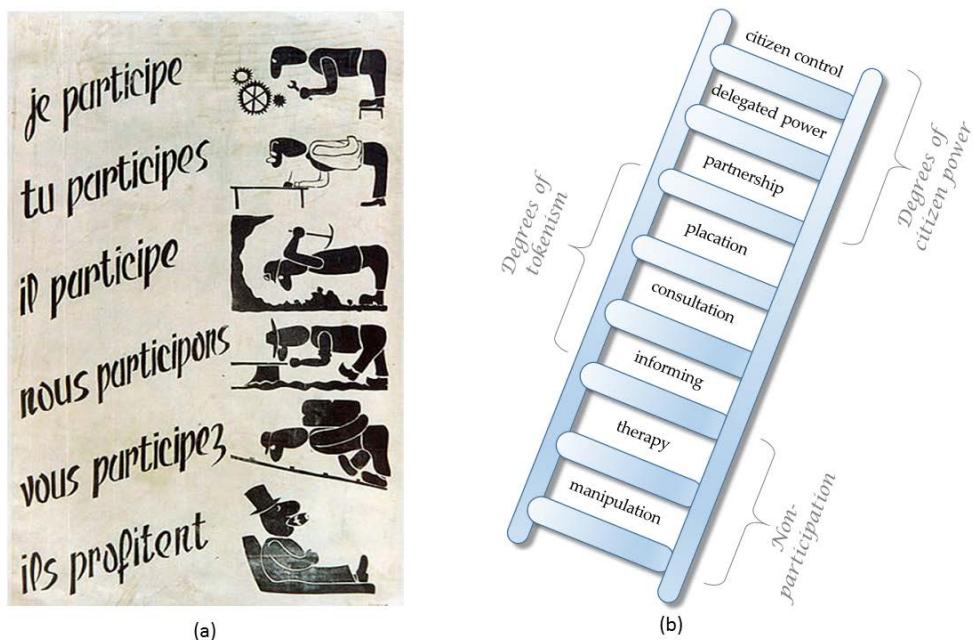
Figure 4: (a) the 1968 satirical representation of participation by the *Atelier populaire* (b) The Ladder of Citizen Participation (Arnstein, 1969)

The concept of *citizen participation* is not without controversy. As far back as Arnstein (1969), it was already well-established that there was something sinister and underhand about encouraging participation, summarised in a satirical poster from the *Atelier populaire de l'ex-École des beaux-arts*[60] (Figure 4 (a)). Arnstein elaborates by developing a ladder of participation running from non-participation associated with 'manipulation', through tokenism, to citizen power with 'partnership, delegated power and citizen control' (Figure 2 (b)). Her more nuanced interpretation has coloured much of the theoretical work in the area since, and at the very least provides a basis upon which to evaluate participatory networks.

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[60] ⊛ The accompanying image has been released into the Public Domain by the *Bibliothèque nationale de France*

Across the human-machine networks that we have reviewed and those we have studied in some detail, it is apparent that Arnstein has a point. Social networks, for instance, provide some form of 'therapeutic' outlet for many participants in developing and presenting a public persona to their would-be peers, whilst the more recent commercialisation of such networks may be said to 'manipulate' subscribers. Such manipulation includes recommender systems which seek to predict and influence potential future purchase decisions on the basis of what a consumer has already bought, and by highlighting what other, allegedly similar, consumers have purchased (Adomavicius & Tuzhilin, 2005). This manipulation may, however, be more insidious whereby search-engine results are filtered in accordance with monitored online activity (Fortunato, Flammini, Menczer, & Vespignani, 2006; Meiss, Menczer, Fortunato, Flammini, & Vespignani, 2008), thus presenting a consumer with only those results which they might have expected, or which align with a commercial or political agenda. These are at the level of *non-participation* according to Arnstein (*op.cit.*). Yet as the Arab Spring as well as the London riots in 2011 demonstrate, there is significantly more potential for open exchange and inter-citizen interaction within such networks, which would conform to some extent with Arnstein's first level of participation through partnership. We note, however, that as social machines supporting social networking attract marketing and retail activity, for example through advertising alongside popular YouTube videos or targeted advertising derived from automated analysis of FaceBook exchanges, so the networks start to take on the characteristics of more complex socio-technical systems or actor networks. Nonetheless, these networks cannot be considered to be more than participatory, in the sense that they do not allow the users to climb Arnstein's ladder to achieve any level of delegated power or control. Where eDemocracy has been lauded in community, local or national contexts, the reality has been merely at the level of participation, where websites have been hosted to gather comment, or opinion has been garnered and analysed for sentiment drawn from twitter or FaceBook discussion. Whilst these might create the opportunity for citizens to feel that they are communicating with those in government, the reality is that the input from citizens has little direct effect on government decision making or policy. Influence is at best indirect, through coordinated direct action, such as seen in the grass-roots exchanges in riots or revolution, or through the combined weight of negative opinion circulating on social media and often amplified by national and international media outlets. But even in this case, there is a case to be made that this is in fact manipulation through social media of the people subscribing to it, rather than the users of social media driving opinion for themselves. In order that citizen participation moves up Arnstein's ladder to the highest rungs of delegated power and ultimately control, it will be necessary for those that currently exercise power to permit its delegation to the crowd, and for the crowd to be sufficiently representative of the population as a whole. This will necessitate the inclusion of checks and controls on the networked behaviour, exercised through the existence of machine agents within the network implementing moderation in a non-partisan way, and controlling the natural desire of individuals to dominate and direct those around them. Thus it can be seen that for citizen participation through networks to escalate up Arnstein's ladder, then those networks need to exhibit all the characteristics of human-machine networks, in which both the human and machine actors exhibit agency.

There have been two major updates since we first outlined the plans for a citizens' participation roadmap (Jaho et al., 2016, 2017): a number of elections and referenda have taken place with increasing reliance and concern about online technologies (Section 6.1); data protection with the EU has now been formalised into a general regulatory framework. We should now consider each of these and their potential effects on the roadmapping exercise for citizens' participation (Section 6.2).

4.3.1 Citizen participation HMNs: Current technological situation, emerging and future trends

For some time, there has been concern over Internet-based elections for the actual voting itself (Phillips & von Spakovsky, 2001; Springall et al., 2014). More recently, though, there have been allegations of direct manipulation[61] or the threat of intervention[62]. This may have been manifest in the spreading of false information[63] as opposed to any direct vote rigging. But perhaps more worryingly are the indications of bot intervention during campaigns (Bessi & Ferrara, 2016; Chu, Gianvecchio, Wang, & Jajodia, 2010; Ford, Dubois, & Puschmann, 2016; Neff & Nagy, 2016). This could undermine participation and motivation, leaving the citizens' participation HMN with insufficient levels of engagement, or worse still, a one-sided and non-representative demographic, suspicious of the network itself and whether or not their views are being handled by an automated system or the democratically elected representative they are targeting as seen in other contexts (Barratt, Ferris, & Lenton, 2015).

As human and machine agency change in these networks, there is a need to think about what effects potential automation might have on user perspectives (Engen, Pickering, & Walland, 2016; Følstad, Engen, Haugstveit, & Pickering, 2017). At the same time, though, it's important to remember that individuals can and do adapt to online contexts. How their behaviours change may relate to role (Lai & Chen, 2014), or more subtle motivational and attitudinal factors (Grabner-Kräuter & Bitter, 2015). Being aware that information may be deliberately misleading is already the focus of research. It may, for instance, be possible to identify misinformation by appropriate technology (Conroy, Rubin, & Chen, 2015). More significantly, perhaps, it may equally come down to using social media – i.e., online communities themselves (Schifferes et al., 2014). The point is, networks need to be aware of and suitably handle the question of *provenance* and reliability. Communities themselves – that is HMNs – may prove adaptive here as well.

4.3.2 Policy background and regulatory context

In April, 2016, the General Data Protection Regulation (GDPR; European Commission, 2016) was published, and is set to replace the original 1995 Directive (European Commission, 1995) in May, 2018, across EU Member States. The regulation seeks to harmonise and simplify data protection

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[61] http://www.newyorker.com/magazine/2017/03/06/trump-putin-and-the-new-cold-war
[62] http://www.foxnews.com/world/2017/04/20/france-concerned-over-russian-interference-in-elections-amid-reports-hacking-fake-news.html
[63] https://www.theguardian.com/media/2016/dec/18/what-is-fake-news-pizzagate

requirements across Europe. For instance, there will only need to be a single Data Protection Authority (DPA) involved in any cross-border service or activity. Non-EU States, including Norway and Switzerland in Europe, possibly the UK at some later date, and the US, Canada and Japan, will all have to demonstrate compliance with the provisions of the regulation to be allowed to process and exchange personal data with EU Member States.

Of particular interest for citizens' participation is the right to be forgotten or the right to erasure[64] . This could help provide some protection for citizens who may not wish to be associated directly with the views they express. Providing a guarantee of anonymity in this way might encourage participation and motivate a more open and honest debate. This should be understood though in the context of Government control and alleged security [65] (see also European Commission, 2016; Recital (16); L119/3): if the Government decides that something is sensitive enough in terms of national security, then there is no protection for the individual. Regulation is therefore one-sided and does not encourage trust or shared responsibility for the network.

The other related concern, though, is that it is not always apparent who the other party is in a given interaction. This echoes what was highlighted in the previous section: how do I know if an interlocutor is a person, not a bot; and whether the information is real or 'fake news'? By contrast, there are times when individuals will use a cloak of anonymity for inappropriate purposes[66]; and individuals should surely have a right to make their own choices about who they share their information with across a shared community[67]. Empowerment and self-efficacy must be considered in balancing attempts at regulatory control (Pickering et al., 2017). Regulation is therefore only part of the story when it comes to managing participatory networks and designing for long term engagement and commitment.

4.3.3 Key challenges and goals

In the context of the updates in the previous sections, we should now revisit the original constraints and focus on items we identified for the original set of stakeholders we identified in (Jaho, Klitsi, Sarris, et al., 2017). The original characteristics we highlighted continue to be relevant and are reproduced in Table 3. However, and in light of the discussion above, we have added a new line: *provenance.*

	Local and National Government	Citizen Groups	NGOs	Industry	Security Services
Motivation	X	X			
Trust & Security	X	X	X	X	X

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[64] Although see also https://humane2020.eu/2016/12/15/gdpr-the-right-to-be-forgotten/
[65] https://www.theguardian.com/uk/2011/aug/11/cameron-call-social-media-clampdown
[66] https://humane2020.eu/2017/01/24/cyberbullying-no-place-to-hide/
[67] https://humane2020.eu/2016/12/20/sensitive-data-cognitive-resource-and-my-community-extending-the-tie-strength-dimension/

	Local and National Government	Citizen Groups	NGOs	Industry	Security Services
Control	X			X	
Accessibility	X	X			
Transparency	X	X	X	X	
Accountability	X			X	X
Regulation/legislation	X	X	X	X	X
Subversion	X	X		X	X
"Provenance"	X	X	X		X

Table 3: Constraints and issues for different stakeholders in citizens' participation

In addition to the provenance line which we return to in a moment, we have added Subversion as a factor for Citizen Groups themselves (see the highlighted cells in Table 3: the backgrounds are green; and the 'x' marks are in red). This reflects potential concerns that users may have that information is created and disseminated by bots. At the very least, this would distort perspectives. That aside, though clearly related to it, we identify provenance – where information or interactions originate from – as concerns for:

- *Local and national government*: if views do not reflect the citizens that the government agency seeks to represent, outcomes will not be representative or satisfactory to those citizens;
- *Citizen groups*: citizens may be influenced by incorrect or unrepresentative information; this could exacerbate any problems;
- *NGOs*: without assurance of where information comes from, NGOs cannot possibly represent suitable views; similarly, if it is unclear that interactions originate from actual citizens, this would cause the NGO to take action unnecessarily; and
- *Security services*: without knowing where information or interactions coming from, those responsible for security will not know whether a network is subject to attack or not, and whether corrective action needs to be taken.

All of this relates more specifically to behaviours and context around the HMN rather than any particular technical issues. Increasing machine agency will need to be managed sensitively, therefore, if the HMN is to evolve in ways that participants want.

4.3.4 Suggested strategies and actions

A number of specific conflicts have arisen as the roadmap has been developed. Such conflicts reflect issues related to stakeholder expectations and how these differ from stakeholder to stakeholder, to providing trust mechanisms, and to support motivation. To resolve these issues, the HUMANE typology and methodology provides a suitable set of design solutions which offer generic HMN-centric solutions

not necessarily specific to citizens' participation networks. These are summarised below; the order is as they appear in (Følstad, Yasseri, et al., 2016). The design solutions were separately validated and are grouped into specific areas: *Experience, Motivation, Reputation, Behavioural Change, Collaboration, Loyalty, Shared Responsibility, Social Interaction, Innovation and Improvement, Product Quality, Network Growth, Privacy* and *Trust,* shown in brackets along with the respective design solutions examined. The range of such categories reflects the fact that resolving potential conflict requires many different HMN-centric issues.

Provide what is desired, not just what is known (*Experience*)	This design solution is geared specifically towards ensuring that relevant information is provided and not just standard messages. As such, this would mean that participants would be given access to information related directed to any given interaction, i.e., the particular discussion that the individuals are engaged with. This might be expected to relate to **Trust** and **Motivation** as potential sources of conflict.
Motivating users to contribute content in HMNs (*Motivation*)	This solution is aimed at making it easy for users to contribute and engage. Of course, this may be different depending on user category – e.g., whether the user is a citizen or policy maker. This obviously relates to conflicts between **Stakeholder Expectation**s, and suggests that all expectations need to be considered and designed for. Clearly, this will also have relevance to **Motivation**.
Reward users to keep them motivated (*Motivation*)	Gamification, for example, is often used to encourage participation. However, motivation may not simply be a product of 'badges': prosocial behaviours for instance are not necessarily motivated this way. It is therefore important that the reward be associated with the goals and expectations of users. For example, for citizens' participation, this might be providing direct access to policy makers for a specific discussion. This relates specifically to **Motivation**. However, if the reward includes appropriate transparency and information about the network and how it functions, this level of openness may promote **Trust**.
Strengthen social ties to keep users motivated (*Motivation*)	This group of design solutions relate specifically to exploiting the social nature of online interaction (see, for instance, Kreiss, 2015). Clearly, much can be learned from understanding social forces, including social identity and intergroup factors. This clearly relates to **Motivation**; but as social engagement also includes factors of **Trust**.
Preserving reputation of an individual, company or organization in HMNs (*Reputation*)	
Behavioural change through social motivation (*Behavioural change*)	
Collaboration between machines and humans through machine learning (*Collaboration*)	This may seem a surprising design solution. However, allowing AI techniques to identify patterns of behaviours or activity would provide valuable information which could be used by all participants in the network to understand each other's motives and drivers. This would help support issues

	of understanding **Stakeholder expectation,** and might encourage **Trust** and **Motivation** in consequence.
Apply loyalty ladder to build and maintain a sustainable user base (*Loyalty*)	This design solution relates back to *reward systems* outlined above. As such, it may support **Motivation** and **Trust**.
Encouraging shared responsibility HMNs (*Shared Responsibility*)	If participants can be encouraged to take ownership for the HMN, then this may be expected to contribute to the success of the network. In so doing, this would help **Motivation** and **Trust**. It may also help participants understand **Stakeholder expectation**, and may lead to increased participation.
Supporting social interaction through strengthening within-platform communication (*Social Interaction*)	This design solution relates back to the *social forces* mentioned above.
Contributors learn to improve by being consumers first (*Innovation and Improvement*)	This design solution relates especially to **Stakeholder expectation**: allowing different participants to gain a perspective of other players in the network may encourage a better understanding and appreciation of those different players. As such, this may support **Trust** and **Motivation**.
Strengthen innovation through infrastructure for informal collaboration (*Innovation and Improvement*)	This design solution explicitly recognises that HMNs may develop in unexpected directions. However, designing for serendipitous interaction between participants at different times might encourage **Trust** at the very least, but also **Motivation**.
Employ automatic quality control (*Product quality*)	This relates back to machine learning and AI within the network. However, in respect to the quality of contributions (Loukis & Wimmer, 2012), having an automated system prompt participants to improve the quality of their input privately rather than publically across the network may encourage participation, i.e., relate to **Motivation**.
Protect new users for beginning (*Network growth*)	As above, allowing new users to find their own way, possibly even via making mistakes, then this may encourage **Motivation**, and possibly **Trust** in the network.
Managing privacy (*Privacy*)	This is an obvious design solution: participants need to know that their personal data *but also* their interactions are protected. This would support **Trust** as well as **Motivation**.
Strengthen trust through efficient handling at first point of contact (*Trust*)	Related to the *social forces* comments above, and obviously related to **Trust** and **Motivation**, these design solutions provide obvious support to the ongoing success of the HMN.
Strengthen interpersonal trust through rich profiles and recommendations (*Trust*)	
Supporting trust across HMN interactions (*Trust*)	

The HUMANE methodology offers helpful informative design solutions as described above. Derived from a set of HMN use cases which were not related to citizens' participation, this suggests that the design solutions are not specific to any particular type of HMN. Instead, they provide network-centric, rather than user-centric, solutions and patterns which resolve network level issues. In so doing, the HUMANE design solutions help finalise the roadmap creation as shown previously by providing solutions to possible conflicts which might otherwise mean that the challenges identified cannot be addressed.

4.3.5 Overview of the roadmap

In this section, we provide a high-level summary of the citizens' participation roadmap. The table highlights:

- **Implications associated with citizens' participation HMNs** (as identified in (Jaho et al., 2016))
- **Objectives of the roadmap**, as they relate to the overall goals outlined in Section 6.1 and then repeated in Section 7.3.2.
- **Actions needed to achieve those objectives** derived from the discussion above (and summarised under *Challenges* in Figure 8 and
- **Design strategies** which will be expanded in the later subsections of this section.

For simplicity, the third column ("Actions needed to achieve the objectives") lists the challenges that relate specifically to the implications which we had previously identified (Jaho et al., 2016), shown in the first column. These need to be understood by those wanting to offer or operate such an HMN. So, the third column extends the implications we identified as they relate specifically to the roadmapping process for Citizen Participation. In the fourth and final column, the design strategies.

Implications associated with citizens' participation HMNs	Roadmap objectives	Actions needed to achieve the objectives	Related HUMANE design strategies[68]
Increasing human agency: this is mainly an opportunity for the network. Empowering participants may increase participation, but also demonstrate at first hand the citizens'	Generate a culture of public engagement	**Understand the real role of technology, including regulation** **Manage motivation: how and why do people participate?** **Publicise outcomes: how to demonstrate that it's worth doing** **Manage trust: what encourages**	- Provide what is desired, not just what is known[69] - Strengthen social ties to keep users motivated[70] - Apply loyalty ladder to build and maintain a sustainable user base[71]

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[68] Note that section numbers refer to (Følstad et al., 2016).
[69] D2.2, 14.1.2.1
[70] D2.2, 14.1.4.4
[71] D2.2, 14.2.3.1

Implications associated with citizens' participation HMNs	Roadmap objectives	Actions needed to achieve the objectives	Related HUMANE design strategies[68]
participation HMN is worthwhile		**participations to trust others and the system** Addressing all of the challenges identified above will contribute to the promotion of a culture for public engagement. This is key to the ongoing success and sustainability of a citizens' participation HMN	• Encouraging shared responsibility in HMNs[72] • Supporting social interaction through strengthening within-platform communication[73] • Contributors learn to improve by being consumers first[74] • Strengthen innovation through infrastructure for informal collaboration[75]
	Deal with issues of trust	• **Understand the real role of technology, including regulation** • **Publicise outcomes: how to demonstrate that it's worth doing** • **Manage trust: what encourages participations to trust others and the system** Trust recurs as a challenge and must be addressed to facilitate take-up and motivation.	• Preserving reputation of an individual, company or organization in HMNs[76] • Protect new users from bouncing[77] • Managing privacy[78] • Strengthen trust through efficient handling at first point of contact[79] • Strengthen interpersonal trust through rich profiles and recommendations[80] • Supporting trust across HMN interactions[81]

[72] D2.2, 14.2.4.1
[73] D2.2, 14.2.5.1
[74] D2.2, 14.3.1.1
[75] D2.2, 14.3.1.3
[76] D2.2, 14.1.5.1
[77] D2.2, 14.3.3.1
[78] D2.2, 14.4.1.2
[79] D2.2, 14.4.3.1
[80] D2.2, 14.4.3.2
[81] D2.2, 14.4.3.3

Implications associated with citizens' participation HMNs	Roadmap objectives	Actions needed to achieve the objectives	Related HUMANE design strategies[68]
Increasing machine agency: this is both an opportunity (in that increasing the power and sophistication of machine components will enhance overall HMN efficiency) as well as a risk (increasing machine agency may provoke suspicion among users)	Deal with issues of trust	• **Understand the real role of technology, including regulation** • **Publicise outcomes: how to demonstrate that it's worth doing** • **Manage trust: what encourages participations to trust others and the system** See above	• Employ automatic quality control[82] • Managing privacy[Error! Bookmark not defined.] • Strengthen trust through efficient handling at first point of contact[Error! Bookmark not defined.] • Supporting trust across HMN interactions[Error! Bookmark not defined.]
	Foster accountability	• **Publicise outcomes: how to demonstrate that it's worth doing** • **Manage trust: what encourages participations to trust others and the system** Promoting transparency helps to encourage participation and ownership of the HMN. This will provide an impetus for the long term sustainability of the network.	• Provide what is desired, not just what is known[Error! Bookmark not defined.] • Collaboration between machines and humans through machine learning[83] • Encouraging shared responsibility in HMNs[Error! Bookmark not defined.] • Contributors learn to improve by being consumers first[Error! Bookmark not defined.]
Interactions: for citizens' participation to work effectively, interactions must be encouraged both in terms of how many interactions take place, but also with regard to the quality of those interactions	Create open and transparent debate	• **Manage motivation: how and why do people participate** • **Publicise outcomes: how to demonstrate that it's worth doing** • **Manage trust: what encourages participations to trust others and the system** See above. Once more promoting transparency	• Reward users to keep them motivated[84] • Strengthen social ties to keep users motivated[Error! Bookmark not defined.] • Preserving reputation of an individual, company or organization in HMNs[Error! Bookmark not defined.]

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[82] D2.2, 14.3.2.2
[83] D2.2, 14.2.2.4
[84] D2.2, 14.1.4.3

Implications associated with citizens' participation HMNs	Roadmap objectives	Actions needed to achieve the objectives	Related HUMANE design strategies[68]
		and openness would be expected to encourage participation and debate.	• Behavioural change through social motivation[85] • Encouraging shared responsibility in HMNs[Error! Bookmark not defined.] • Managing privacy[Error! Bookmark not defined.]
	Motivate engagement	• **Manage motivation: how and why do people participate** • **Publicise outcomes: how to demonstrate that it's worth doing** • **Manage trust: what encourages participations to trust others and the system** See above. Motivation to participate will be encouraged if participants see value to what they do whilst their concerns for, e.g., privacy are removed or contained.	• Motivating users to contribute content in HMNs[86] • Reward users to keep them motivated[Error! Bookmark not defined.] • Protect new users from bouncing[Error! Bookmark not defined.] • Supporting social interaction through strengthening within-platform communication[Error! Bookmark not defined.] • Employ automatic quality control[Error! Bookmark not defined.] • Protect new users from bouncing[Error! Bookmark not defined.] • Strengthen trust through efficient handling at the first point of contact[Error! Bookmark not defined.]
	Foster accountability	• **Publicise outcomes: how to demonstrate that it's worth doing** • **Manage trust: what encourages**	• Collaboration between machines and humans through machine learning[Error! Bookmark not defined.]

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[85] D2.2, 14.2.1.2
[86] D2.2, 14.1.4.1

Implications associated with citizens' participation HMNs	Roadmap objectives	Actions needed to achieve the objectives	Related HUMANE design strategies[68]
		participations to trust others and the system As well as encouraging responsibility (see above), trust may be increased along with transparency.	• Encouraging shared responsibility in HMNs**Error! Bookmark not defined.** • Contributors learn to improve by being consumers first**Error! Bookmark not defined.**
Network extent: on one level (digital literacy and reach) this is a significant factor which could increase participation and HMN effectiveness. However, as demonstrated recently with cyberattacks and accusations of inappropriate interventions in elections, there need to be safeguards in place to avoid a reduction in trust and engagement	Deal with issues of trust	• **Understand the real role of technology, including regulation** • **Publicise outcomes: how to demonstrate that it's worth doing** • **Manage trust: what encourages participations to trust others and the system** This is especially relevant given recent events in the online social and political world.	• Employ automatic quality control**Error! Bookmark not defined.** • Managing privacy**Error! Bookmark not defined.** • Strengthen trust through efficient handling at first point of contact**Error! Bookmark not defined.** • Supporting trust across HMN interactions**Error! Bookmark not defined.**

In the following subsections, we will expand on the challenges and possible solutions to those challenges as identified through other work in HUMANE.

4.3.6 Timeframe and prioritization

Unlike other roadmaps, there is something both unique and critically context-dependent about any timeline associated with citizens' participation. This is summarised in Figure 9 below.
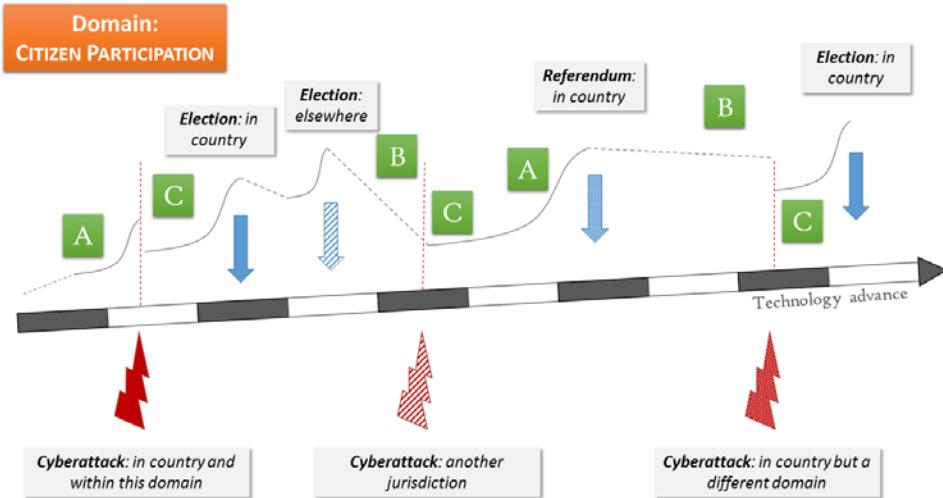
Figure 5: Context-dependent timeline for citizens' participation roadmapping

Although we would expect technology (and associated regulation) to improve and increase in power and complexity over time, there are different factors which will affect how citizens' participation develops over time. Not least given the update in Sections 6.2 above, we would expect technology adoption to be rather less linear. Especially in the run-up to an election of some sort (shown as "A" on the diagram), there may be expected *a priori* to be increased interest and participation. Note that elections may be in country (both local and national) and in which local citizens will be assumed to take part; or they may occur elsewhere, with citizens in one country interested (or affected by) the outcomes of elections in other countries. Elections may also be parliamentary or presidential, involving a potential change in legislature, or to gauge public opinion which may influence the legislature and / or the executive, such as opinion polls associated with elections or referenda. Between elections (or referenda etc.), there may be a decrease in interest and engagement (shown as "B" on the diagram). However, in response to a specific external event, there may also be a sudden resetting of the level of citizen engagement ("C"): i.e., citizen participation reduces as citizens lose confidence in the process or the level of security. In Figure 9 we have taken the example of a cyberattack, since these typically result in widespread media coverage. In practice, though, this may be any event which exposes a vulnerability in a network or computer-mediated system. For example, this may be as simple as a doctor or MP losing a laptop or other device holding personal information about others. Any such event may include a simple breach of security, or a more subtle manipulation of information which may affect future decisions or events. As with elections and referenda, these may take place in country or abroad.

The evolution over time and in response to technological improvement may involve increased citizens' participation. However, this will not be a straight-forward progression towards any specific goal. Instead, there is likely to be a *quasi*-cyclical development which will be facilitated by inclusion of the HUMANE design strategies we outline above which were selected to address the specific HMN challenges we had identified in the preceding steps described in this section.

4.3.7 Roadmap dissemination

To complement this deliverable, we have also prepared a short white paper on the roadmap for citizens' participation HMNs. The white paper is intended to provide a quick and accessible overview of the roadmap to increase awareness among the target stakeholders. It provides a summary of the complete roadmap generation process as described in this chapter and the following specific to citizens' participation. In so doing, the white paper on citizens' participation HMNs works through the survey reported in (Klitsi, Jaho, Pickering, & Walland, 2017) and modified to provide greater and detailed relevance to the community associated with citizens' participation. Having discussed the results, and as outlined below, we use the HUMANE methodology to identify design strategies appropriate to addressing the challenges identified and which stand in the way of attaining the overall goals derived from interaction and discussion with stakeholders. As highlighted in the preceding sections in this chapter, the main issues relate to different expectations expressed by different stakeholder categories as well as trust and motivation. The latter two issues are not unique to citizens' participation HMNs.

As with the other roadmaps discussed here, the citizens' participation roadmap white paper will be published via the project website, made available via the Mendeley HUMANE group and the HUMANE social media channels. In addition, we will share the roadmap with the community approached to encourage input for the surveys reported previously (Klitsi et al., 2017).

5 Summary of 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 represent progress 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 three HUMANE roadmaps and discuss common themes that are shared across the roadmaps. In so doing, we highlight the key messages which policy makers and other stakeholders should derive: each of the relevant sections (see Section 5.2: Key Messages for Policy Makers and Stakeholders) provides an easy-to-read summary before going into detail in the section text itself.

5.1 Summary of the HUMANE roadmaps

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 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 also highlights the role that sharing economy platforms have played in introducing digital practices into 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). The roadmap process focused on four analytical layers needed to understand sharing economy human-machine networks: networked actors, the relations between actors, the extent of sharing economy networks, and the structure of the networks. 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. The eHealth domain highlights some issues 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, as well as other serious risks such as identity theft, sensitive information falling into the wrong hands, discrimination against individuals based on health information, and many others. 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. 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 **citizens' 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 citizens' 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 citizens' participation roadmap highlights an interesting counterpoint to the scale issues raised in the sharing economy roadmap. While facilitating citizens' 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 citizens' 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 citizens' 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.

5.2 Key Messages for Policy Makers and Stakeholders

In the three roadmaps discussed above, we have identified some commonalities, which we address as ten 'common themes' in respective sections below. At the beginning of each section, we have provided a key 'take-away' to help summarise significant points for the reader.

*To encourage continued participation and ensure positive experience, HMNs should include customisation capabilities to ensure each participant enjoys personalised service. **Policy makers** must provide guidelines to help service providers customise user experience within the context of GDPR Article 22 (Automated individual decision-making, including profiling).*

5.2.1 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.

5.2.2 Importance of peers

HMNs are an essentially social environment. Service providers should facilitate interaction between participants. Ad hoc and dynamic groupings are to be expected, but may be no more than accidental or casual. As such, they should not be exploited to make decisions about individual participants or infer anything about their connections. **Policy makers** *may need to consider what regulatory measures should be in place to protect the privacy of individuals but also their inferred association with others in the network.*

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 citizens' 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.

5.2.3 Prediction

Predicting resource and outcomes could benefit would improve the efficiency of any given HHM, but also those dependent on the network for strategic planning. There is a risk though that prediction might constrain innovation at least, or more seriously reduce the autonomy of network users. **Policy makers** *should consider introducing guidelines for when and how prediction may be allowed in HMNs.*

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 participants 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 citizens' 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.

5.2.4 Consistency

*Although personalised experience is beneficial to network users (see above), there needs to be some level of uniformity of how a given HMN operates to provide "affordances" to users. This will allow increased digital engagement without the need for ad hoc training. **Policy makers** should initiate standards for service design to provide consistent coverage for common function.*

Consistency of outcome and of experience is another theme. This theme can sometimes run counter to the theme of *personalization* mentioned above, since the advantages of the Internet are often framed as relating to the strength of having unlimited choice and flexibility. 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 citizens' 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 process; the experience itself and the ability of actors to understand how the experience is being shaped by the HMN.

5.2.5 Regulation

*Activity within HMNs provides valuable sources of data ("administrative data") which can and should be used to provide more accurate information and statistics for local, regional, national and international planning purposes. However, its use needs careful management to avoid inadvertent disclosure or false conclusions being reached. **Policy makers** need to develop guidelines for the appropriate use of administrative data, including information on how to validate conclusions.*

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.

There is no doubt that the volume of data available today is unprecedented; and this trend is set to continue with no sign of slowing down. That being the case, applying standard analytical techniques and statistical approaches may be inadequate. For example, does *retweeting* really suggest complete agreement with an original view and therefore should be counted along with the original tweet. Further, tweet provenance (bots *vs* human agent) needs to be taken into account. **Policy makers**: Official government statistics must be based on appropriately pre-processed data to avoid potential and unintended bias.

5.2.6 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.

5.2.7 Motivation

Many emergent human-machine networks rely on people to change what they do, or how they do it. Change does not always come easily, so successful human-machine networks tap into existing motivations and behaviours that then allow change to occur by leveraging the right incentives. For instance, in the sharing economy roadmap, it was noted that young adults who have not previously owned a car are easier to engage in car sharing networks (by lowering the high start-up costs to driving) compared to trying to convince current car owners to give up their privately-owned vehicles.

Motivation also appeared prominently in the citizens' participation roadmap, since many of the applications in this domain cannot rely on instrumental motivations (such as the desire to move from point A to point B) but instead rely on convincing citizens of the value of participation as part of a healthy democracy. Unless citizens are motivated to engage with the process and believe that their

> Without continued engagement and participation, HMNs falter and are no longer used. Motivating continued use is therefore important. However, it is nuanced by specific domain (leisure *vs* citizen participation, for instance) as well as by user type or role. Motivational strategies should therefore take account of this complexity. ***Policy makers****: Regulation should allow some degree of profiling or typing of users in order to allow operators and designers to maximise the chance of HMN longevity.*

participation will cause governments to act on citizen contributions they are less likely to participate.

5.2.8 Trust

Trust is the basis and an organising principle of many activities in the real world, as well as in the virtual one. As such a major design and process issue has to consider how to enable and maintain trust. ***Policy makers****:* Policy which seeks to empower data subjects may have only limited effect. Instead, policy makers should understand the complex interplay of different factors in how trust develops and in turn affects behaviour.

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.

5.2.9 Risk management and security

With increasing technical capability – self-organising and self-healing systems, for instance – HMN developers and operators should include a more complex approach to risk management and security: the network should be allowed develop its own strategies to identify and mitigate risk. ***Policy makers****:* Legislation, such as data protection, needs to be understood within the broader context of what an HMN is capable and not seen as the standalone solution to 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 intentions. 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.

5.2.10 Emergence

> As a consequence of technological advances, but also increasing experience and sophistication in man-machine interaction, HMNs support the emergence of behaviours which may not have been anticipated. HMN design must allow for such emergence if the network is to succeed, even if that means the network will develop in directions previously unwanted (cf. *Twitter* in politics). ***Policy makers****:* there is a huge challenge to introduce appropriate safeguards whilst protecting freedom for emergent behaviour to develop.

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.

6   Conclusion

There exist large possibilities for increasing the power of networks of humans and machines to solve real world problems in nearly all domains of human endeavour. However, the 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 roadmaps for each of the selected domains. Additionally, we have enriched the analysis of social domains that started in (Jaho et al., 2016) with more challenges, opportunities and design strategies that can be applied for each of the domains.

To develop the roadmap, we have combined desk research with feedback received from stakeholders through user surveys, focus groups or interviews, which helped to 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

such as graphical illustrations and tables, along with roadmap summaries, will be used for posters, leaflets, presentations, blogposts, and other promotional material. The roadmaps will be presented in conferences or other events related to policy issues of emerging technologies in the sharing economy, eHealth and citizens' 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.

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8 Annex I: New design strategies for eHealth HMNs

Suggested new design strategies 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: *human-machine relationship strength 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)

9   Annex II: Updated online survey uptake and results

The information below is an update of the survey presented in (Klitsi et al., 2017). However, the major findings in the analysis have not changed from the previous survey.

9.1   Information about the respondents

Overall 85 people have participated in the online survey. The following figure presents the number of participants per domain. 31 participants indicated that eHealth is the domain that they are professionally engaged, while 24 participants indicated the Sharing economy domain and 30 the Citizen Participation domain.
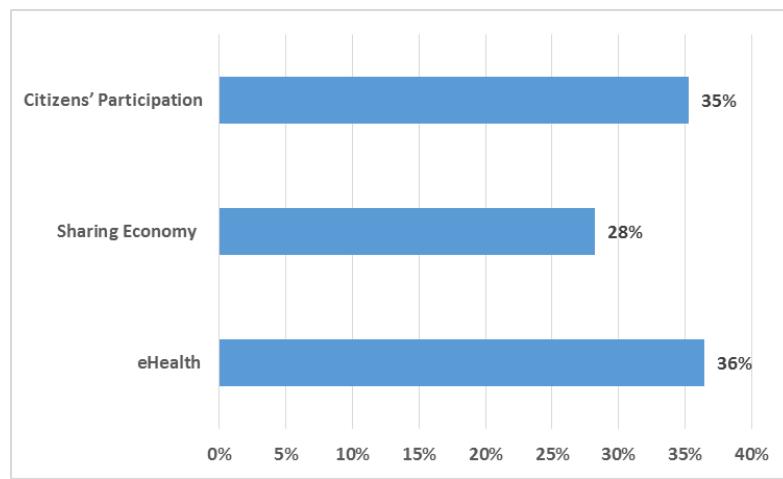
Figure 6: Number of participants per domain

The majority of respondents are working for an Academic Institution, followed by people working in the private sector. The number of participants from the public sector was relatively small; this is a drawback since the roadmaps are intended to be policy support tools, but we tried to have a more balanced representation of stakeholders in other feedback-collecting exercises, such as focus groups and interviews.
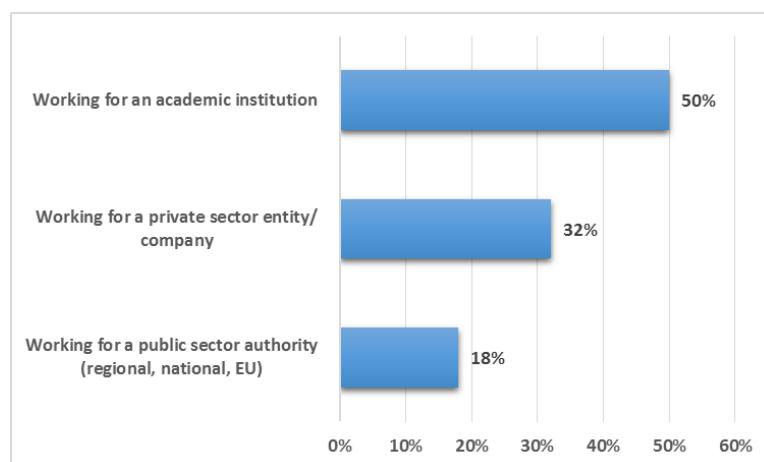
Figure 7: Employment status of the participants

9.2 Findings of relevance to the sharing economy domain

67% of the respondents addressing the sharing economy answered that their organisation is familiar with the concept of the sharing economy as depicted in the below figure.
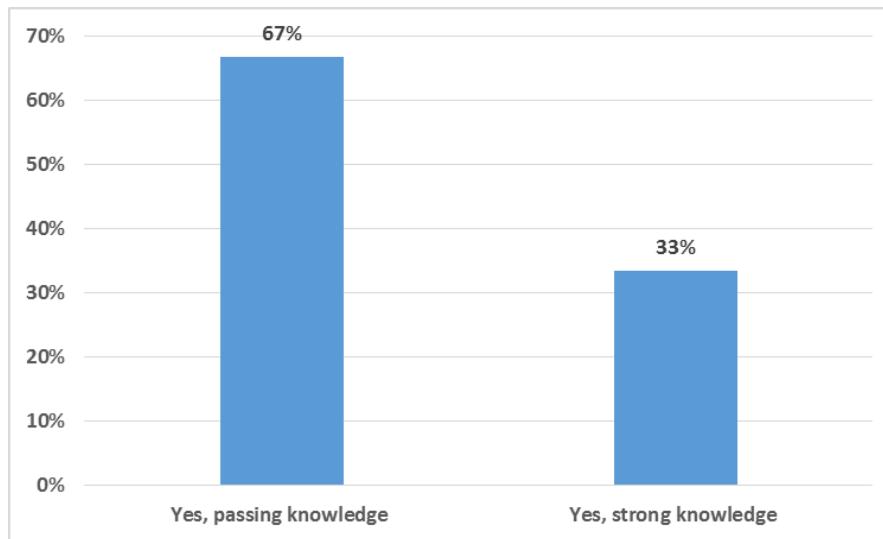
Figure 8: Level of familiarity of the respondents with the sharing economy domain

9.2.1 Expectations on user participation in the sharing economy

Sharing economy has emerged as a new way of accessing goods and services. 50% of the respondents consider that consumers' participation in the sharing economy in the next 12 months will increase strongly, 38% consider that it will increase somewhat, while 13% consider that it will stay the same.
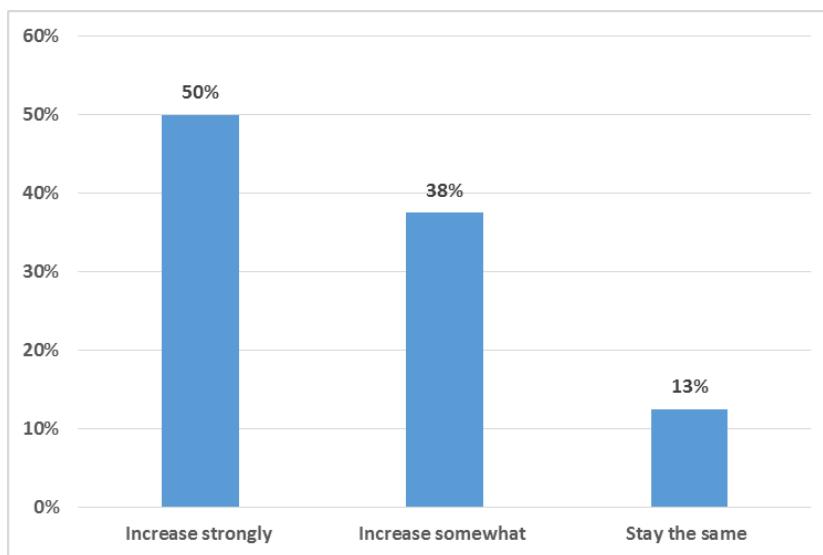
Figure 9: Consumers' participation in the Sharing economy

As illustrated in the Figure below most respondents indicated financial gains as well as ease of use as the main factors that influence consumers' participation in the sharing economy, while the social experience as well as the environmental/sustainability concerns are less important factors. At the

same time we witness a strong polarization of opinions for most of the factors: about the same numbers of people consider some factor influential and non-influential. This may be explained by the multitude of sharing economy services (some have more financial incentives, while others are focused on solidarity between people) and the different experiences that people have had, as well as the lack of common understanding about these services.
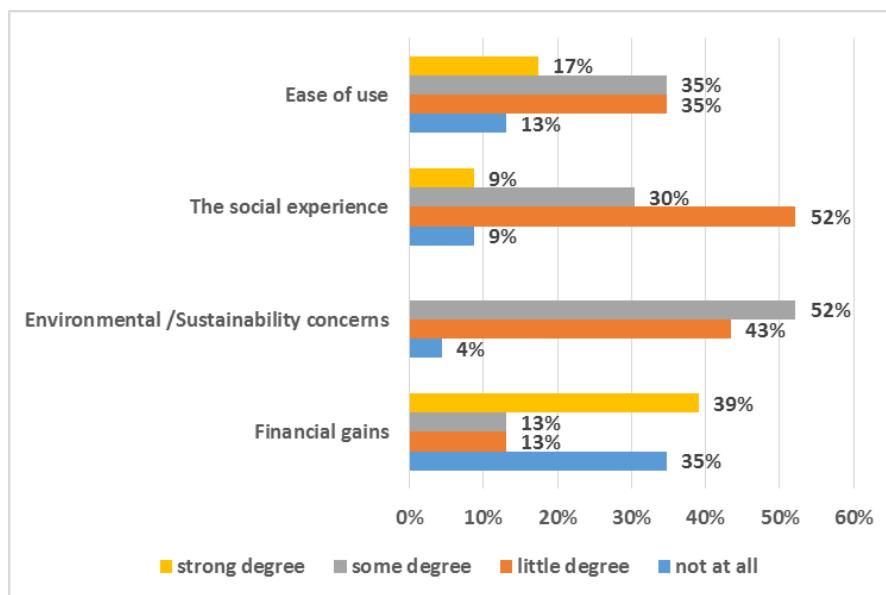
Figure 10: The factors that influence consumers' participation in the sharing economy

9.2.2 Expectations for sharing economy services

We have requested from the respondents to rate the following statements (as depicted in Figure 15) depending on their importance.

Statement 1 - In the near future there will be a need for substantial changes in public policy and regulation to accommodate sharing economy services: 29% of the respondents have indicated this statement as not so important, while the 24% of the respondents consider that this statement is very important.

Statement 2 - In the near future there will be substantial consolidation among sharing economy service providers: 29% of the respondents have indicated this statement as not so important, while the 19% of the respondents consider that this statement is very important.

Statement 3 - In the near future traditional service providers will face increasing competition from sharing economy services: 10% of the respondents have indicated this statement as important, while only the 5% of the respondents consider that this statement is not important at all.

Statement 4 - In the near future Sharing economy services and traditional service provision will converge: 34% of the respondents have indicated this statement as important, while the 24% of the respondents consider that this statement is not important.
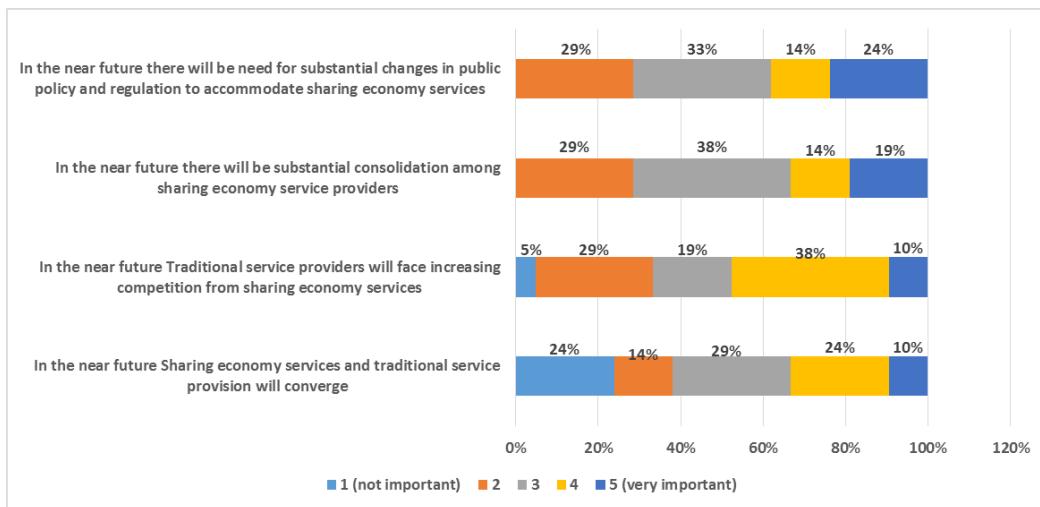
Figure 11: Sharing economy statements

9.2.3 Expected key stakeholder groups

As illustrated in the Figure 16 below, respondents have indicated Infrastructure & Technology providers as well as Government Policy makers as important groups in shaping sharing economy services in the future. Established traditional service providers along with existing and newcomer sharing economy service providers have been indicated as somewhat less important groups.
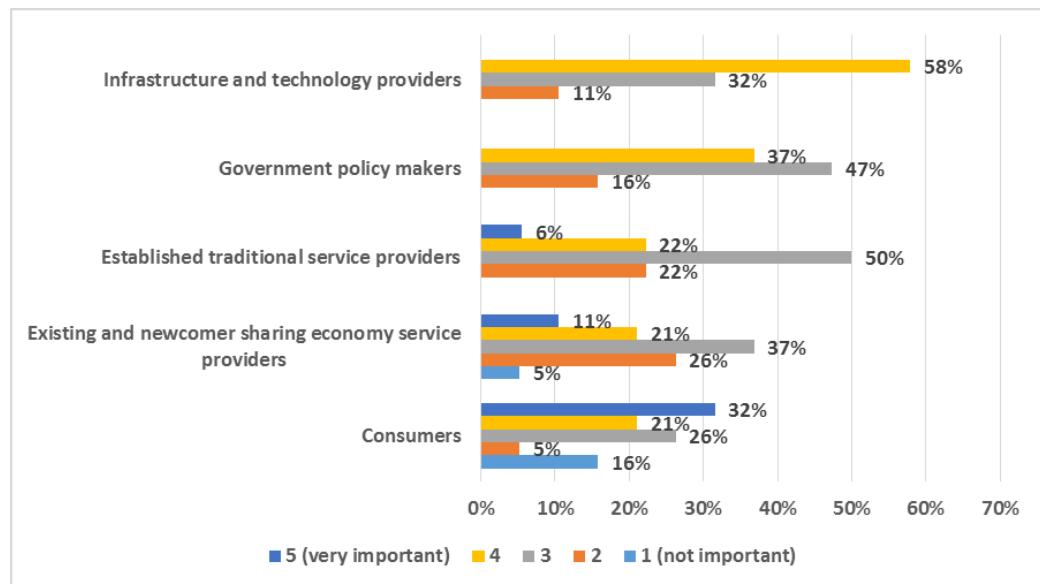
Figure 12: Groups in shaping sharing economy services

9.2.4 Expected challenges for sharing economy services

We have listed the key challenges for sharing economy service providers and we have requested from the respondents to rate these challenges depending on their importance. As illustrated in the Figure 17 below:

Challenge 1 - Strengthen security and privacy in sharing economy services: 32% of the respondents consider that this challenge is important while 21% of the respondents consider that this challenge is less important.

Challenge 2 - Develop sharing economy services as a green alternative: 32% of the respondents consider that this challenge is important while 26% of the respondents consider that this challenge is less important.

Challenge 3 - Develop trusting relations in sharing economy services: 26% of the respondents consider that this challenge is important while 37% of the respondents consider that this challenge is less important.

Challenge 4 - Provide efficient quality control of shared goods and services: 37% of the respondents consider that this challenge is important while the same percentage of respondents consider that this challenge is less important.

Challenge 5 - Make sharing economy services easy and engaging to use: 26% of the respondents consider that this challenge is important while 32% of the respondents consider that this challenge is less important.

Challenge 6 - Apply advances in artificial intelligence to match supply and demand in sharing economy services: 27% of the respondents consider that this challenge is important while 37% of the respondents consider that this challenge is less important.

Challenge 7 - Change consumer behaviour patterns towards sharing and collaborative consumption: 48% of the respondents consider that this challenge is important while 27% of the respondents consider that this challenge is less important.
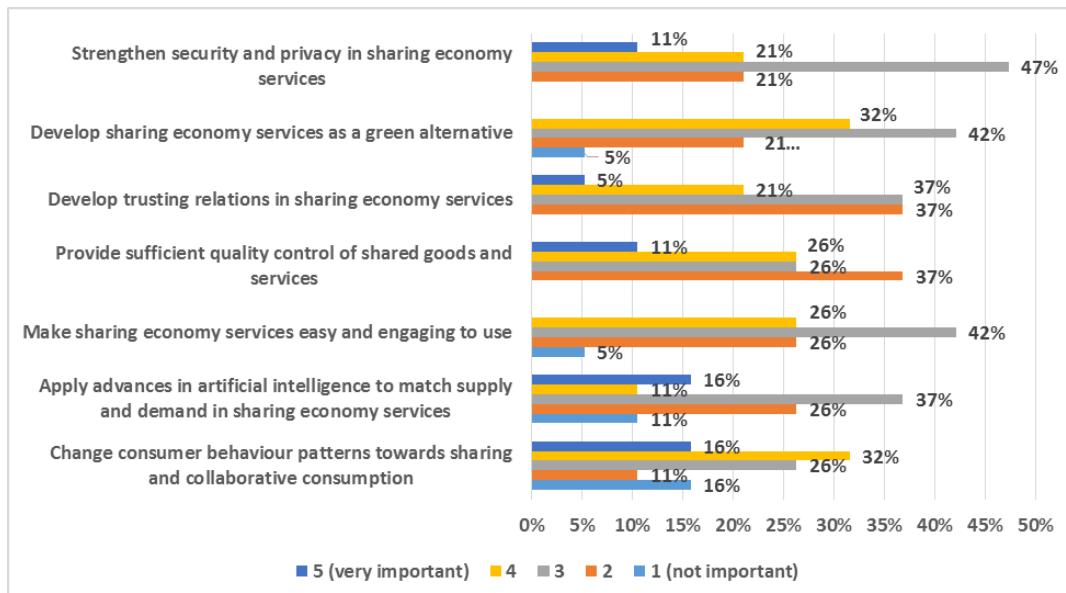
Figure 13: key challenges for sharing economy service providers

9.2.5 Key needs and requirements for sharing economy services

As illustrated in the figure below, respondents consider as important statement H (Allow for experimentation with wide ranges of services and business models) while statements B (Provide well

defined transaction processes with limited freedom to interact with the service in other ways) and D (Keep users mostly anonymous in order to comply with privacy) are somewhat less important.
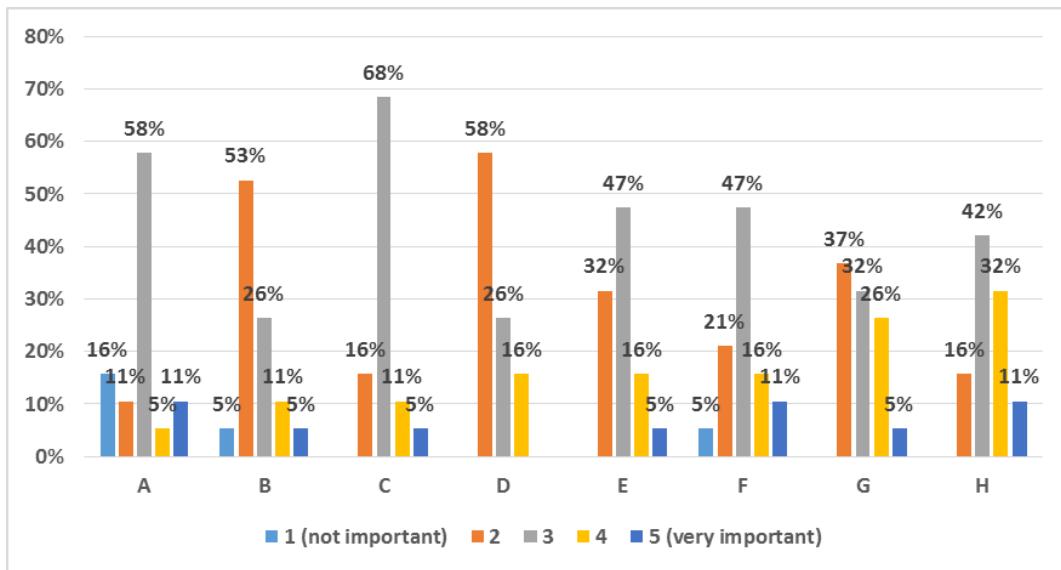
Figure 14: Sharing economy services

A   Be open platforms that allow users to act and interact in a wide range of ways

B   Provide well defined transaction processes with limited freedom to interact with the service in other ways

C   Allow for personal presentations of users in order to increase trust

D   Keep users mostly anonymous in order to comply with privacy

E   Connect users globally in order to offer a wide choice of goods and services

F   Keep a local flavour in order to develop communities

G   Be strongly regulated in order to ensure that services are in line with consumer and employee rights

H   Allow for experimentation with wide ranges of services and business models

9.3   Findings of relevance to the eHealth domain

9.3.1   Respondents perceived relevance of eHealth issues and systems

67% of the respondents addressing eHealth have indicated that eHealth is a topic that is addressed/discussed within their organization indicating Medical devices as the main issue addressed.
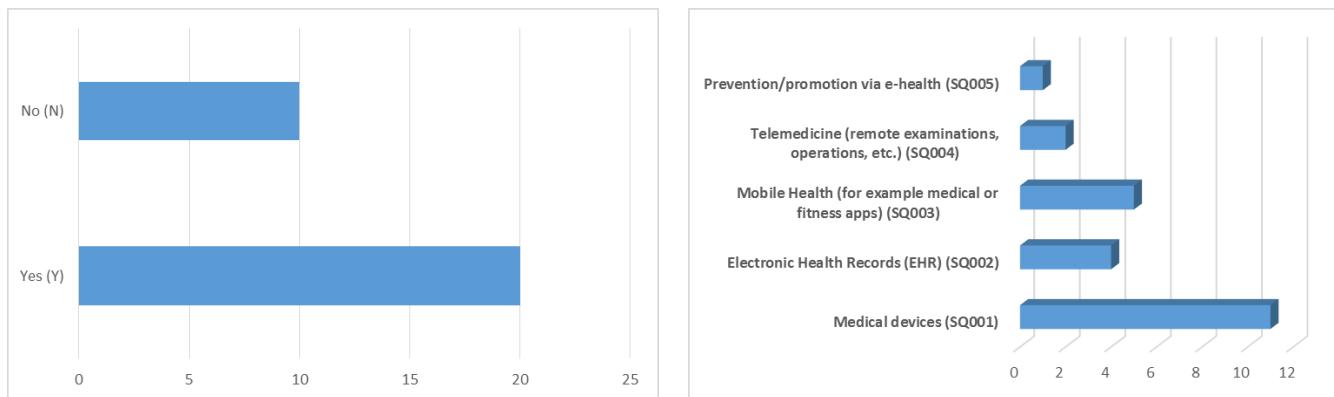
Figure 15: Main eHealth issues discussed/addressed

We have requested from the respondents to rate the eHealth systems/services, as presented in the Figure 20 below. As we see from the results, most of the participants consider mobile health apps and self-monitoring systems as most important, which is in line with the project's decision to focus on this domain for the roadmap.
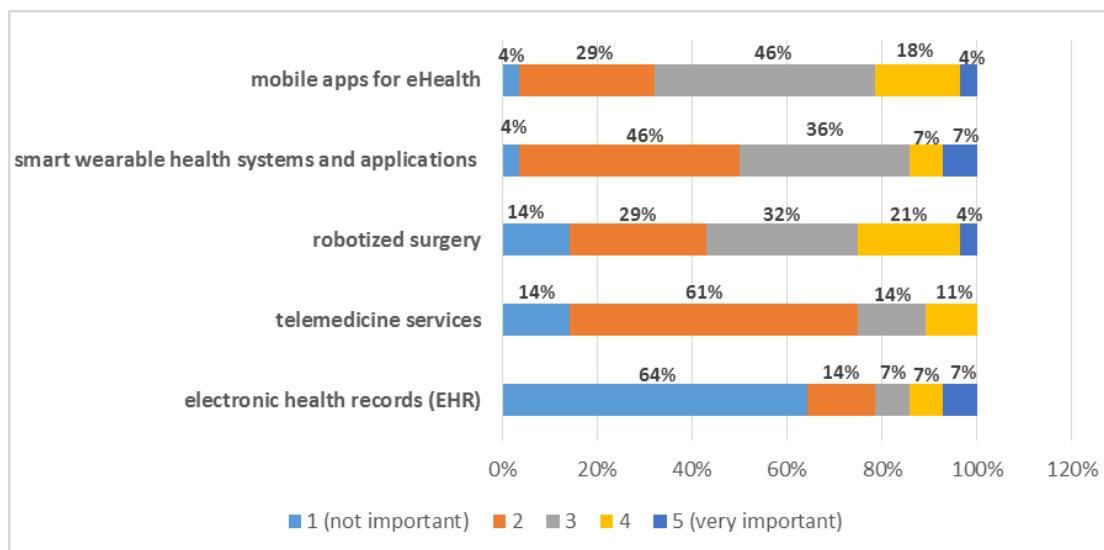
Figure 16: eHealth systems/services

9.3.2 Key challenges for personalized eHealth systems

In the HUMANE eHealth roadmap (D4.2), we present a summary of the challenges focusing on personalized eHealth systems, devices and applications. We have listed the identified challenges and we have requested from the respondents to rate them based on their importance, and the degree to which they think that they have been addressed so far. Based on the analysis of the responses, it seems that the most important challenge is the protection of individuals' privacy and the confidentiality of medical information. The second most important challenge is the safeguard of the availability of systems and services.
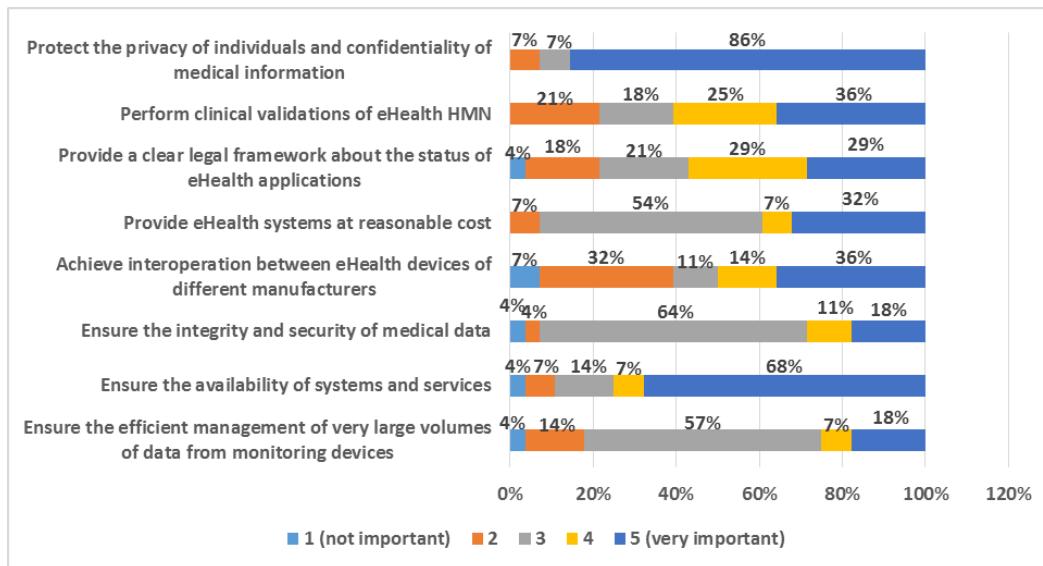
Figure 17: Challenges focusing on personalized eHealth systems

9.3.3 Key tasks/actions for personalized eHealth system developers

In the HUMANE roadmap for personalized eHealth systems, we have envisaged a list of tasks/actions (as presented below: A-G) to be implemented, as a means to address the aforementioned challenges. We have requested from the participants to indicate the level of difficulty and the estimated implementation period for each action. Based on the analysis of the responses it seems that actions E and G have been characterized by the respondents as difficult and extensive tasks while the majority of actions (A, B, C, D, F) have been identified as difficult tasks to be implemented. It may be noted that no additional action has been identified by the respondents.
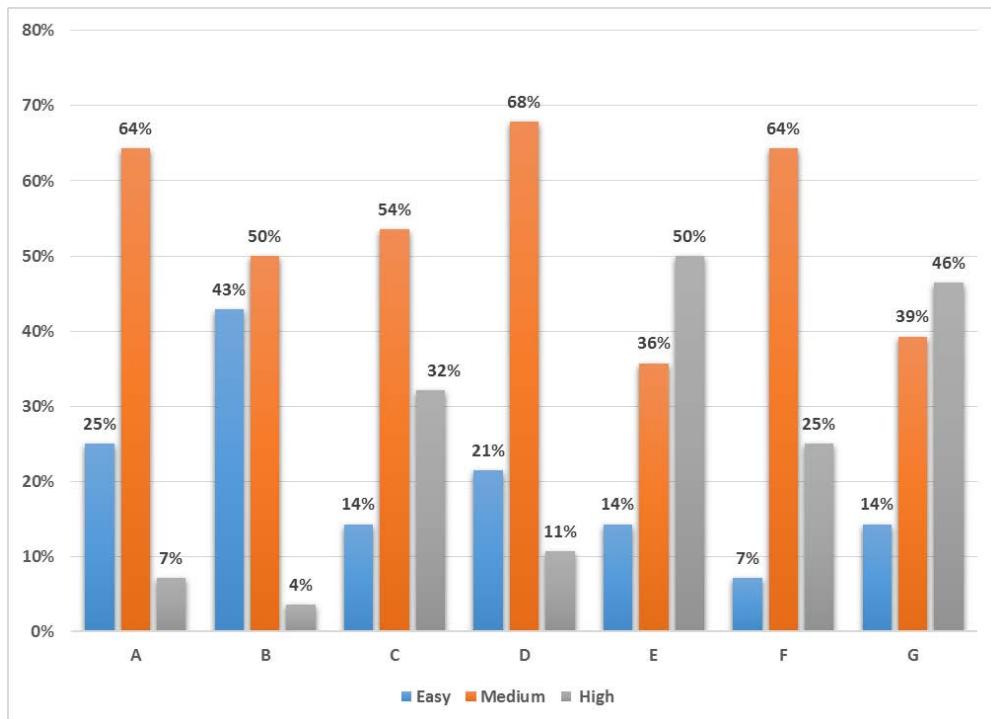
Figure 18: Level of difficulty per task/action

A   Develop eHealth services with guaranteed QoS (Quality of Service)
B   Provide interoperable eHealth devices and common data formats
C   Perform clinical validations for assessing the safety and efficiency of eHealth monitoring devices
D   Conduct realistic large scale studies to examine the application of advanced data management by eHealth monitoring devices and systems
E   Conduct realistic large scale studies to examine the application of privacy-by-design mechanisms in commercial eHealth HMN
F   Study of business models for eHealth monitoring in European countries
G   Review and merge the provisions of the different EU regulatory documents that relate to eHealth (e.g. Data Protection Directive, the e-Privacy Directive, the Consumer's Rights Directive, the eCommerce Directive, and the Unfair Commercial Practices Directive)

As far as concerns the estimated implementation period required for each action, the majority of respondents consider that most of the proposed actions can be implemented within a six months period. Action F needs relatively more time.

Figure 19: Estimated implementation period for each action

A   *Develop eHealth services with guaranteed QoS (Quality of Service)*

B   *Provide interoperable eHealth devices and common data formats*

C   *Perform clinical validations for assessing the safety and efficiency of eHealth monitoring devices*

D   *Conduct realistic large scale studies to examine the application of advanced data management by eHealth monitoring devices and systems*

E   *Conduct realistic large scale studies to examine the application of privacy-by-design mechanisms in commercial eHealth HMN*

F   *Study of business models for eHealth monitoring in European countries*

G   *Review and merge the provisions of the different EU regulatory documents that relate to eHealth (e.g. Data Protection Directive, the e-Privacy Directive, the Consumer's Rights Directive, the eCommerce Directive, and the Unfair Commercial Practices Directive)*

In eHealth roadmap, we discern stakeholders in the following categories/groups: a) EU and national authorities (policy makers/implementers), b) ICT experts, c) standardization groups and organizations, d) researchers, e) professionals (doctors, nursing or administrative personnel, insurance funds and companies, etc.), and f) users or patients. We have requested from the respondents to distinguish between the stakeholders that should be leading the proposed actions and those that should have a participant role.

Action A: 36% of the respondents consider that leading role to the implementation of this action should have the Standardization groups & organizations (Figure 24) while participating role (Figure 25) should have the professionals (doctors, nursing or administrative personnel, insurance funds and companies, etc.).

Action B: 36% of the respondents consider that leading role to the implementation of this action should have Researchers (Figure 24) while Standardization groups & organizations should have a participating role (Figure 25).

Action C: 61% of the respondents consider that leading role to the implementation of this action should have Researchers (Figure 24) while Standardization groups & organizations should have a participating role (Figure 25).

Action D: 29% of the respondents consider that leading role to the implementation of this action should have Researchers (Figure 24) while ICT experts should have a participating role (Figure 25).

Action E: 32% of the respondents consider that leading role to the implementation of this action should have Researchers (Figure 24) while ICT experts should have a participating role (Figure 25).

Action F: 43% of the respondents consider that leading role to the implementation of this action should have Researchers (Figure 24) while ICT experts should have a participating role (Figure 25).

Action G: 43% of the respondents consider that leading role to the implementation of this action should have EU & National Authorities (Figure 24) while Standardization groups & organizations should have a participating role (Figure 25).
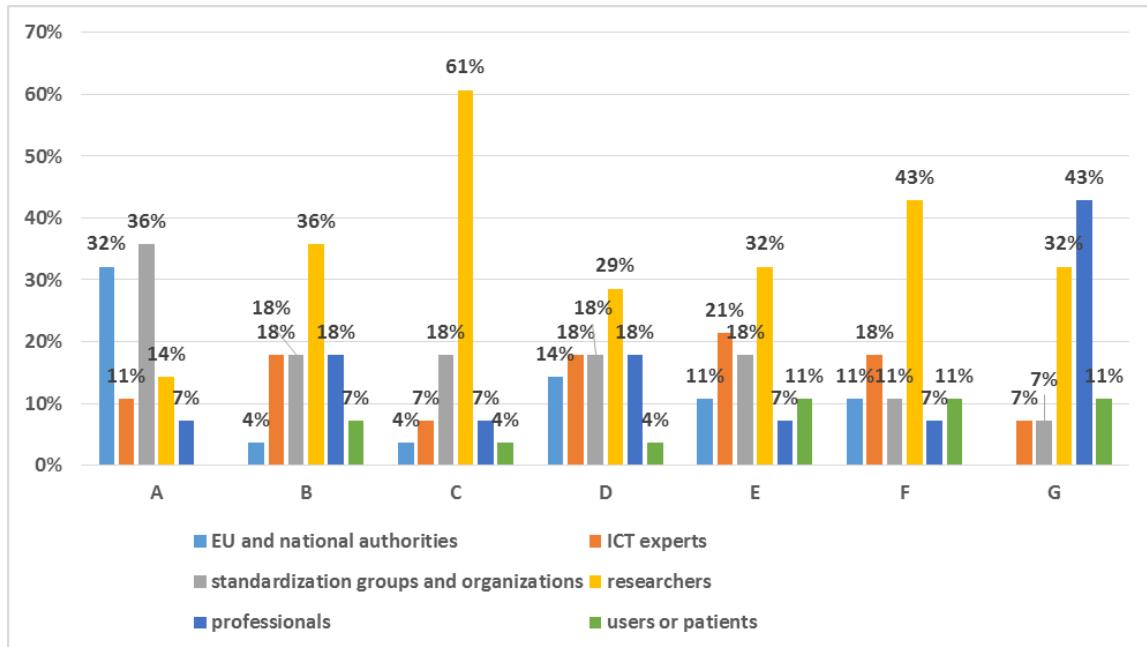
Figure 20: Leading actors

- A   *Develop eHealth services with guaranteed QoS (Quality of Service)*
- B   *Provide interoperable eHealth devices and common data formats*
- C   *Perform clinical validations for assessing the safety and efficiency of eHealth monitoring devices*
- D   *Conduct realistic large scale studies to examine the application of advanced data management by eHealth monitoring devices and systems*
- E   *Conduct realistic large scale studies to examine the application of privacy-by-design mechanisms in commercial eHealth HMN*
- F   *Study of business models for eHealth monitoring in European countries*
- G   *Review and merge the provisions of the different EU regulatory documents that relate to eHealth (e.g. Data Protection Directive, the e-Privacy Directive, the Consumer's Rights Directive, the eCommerce Directive, and the Unfair Commercial Practices Directive)*

Figure 21: Participating actors

A *Develop eHealth services with guaranteed QoS (Quality of Service)*

B *Provide interoperable eHealth devices and common data formats*

C *Perform clinical validations for assessing the safety and efficiency of eHealth monitoring devices*

D *Conduct realistic large scale studies to examine the application of advanced data management by eHealth monitoring devices and systems*

E *Conduct realistic large scale studies to examine the application of privacy-by-design mechanisms in commercial eHealth HMN*

F *Study of business models for eHealth monitoring in European countries*

G *Review and merge the provisions of the different EU regulatory documents that relate to eHealth (e.g. Data Protection Directive, the e-Privacy Directive, the Consumer's Rights Directive, the eCommerce Directive, and the Unfair Commercial Practices Directive)*

9.4 Findings of relevance to the Citizen Participation domain

9.4.1 Characteristics of the respondents on citizen participation

As illustrated in Figure 26, 50% of the respondents addressing citizen participation, participate rarely in a decision making process while the 43% have indicated that they often participate. A small percentage 13% have not participated but they would like to do it.
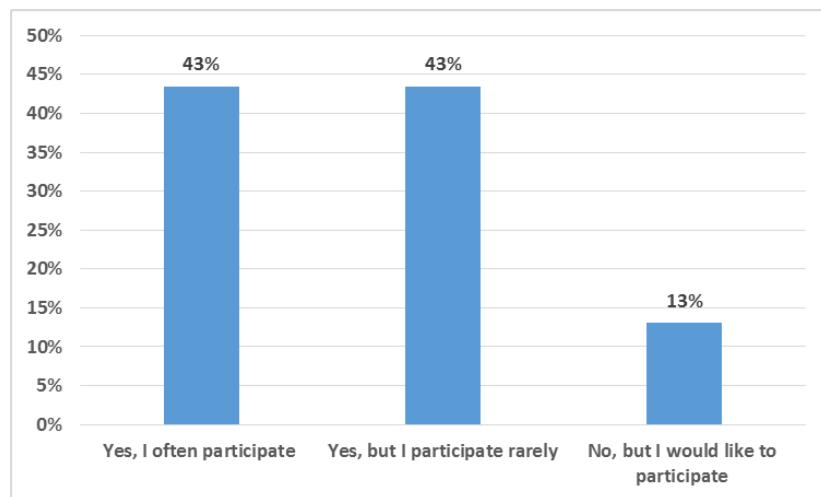
Figure 22: Citizen participation in a decision making process

As far as concerns the form of public participation that they have been involved in. Public Discussion is the form of participation mentioned by the largest proportion of respondents (Figure 27).
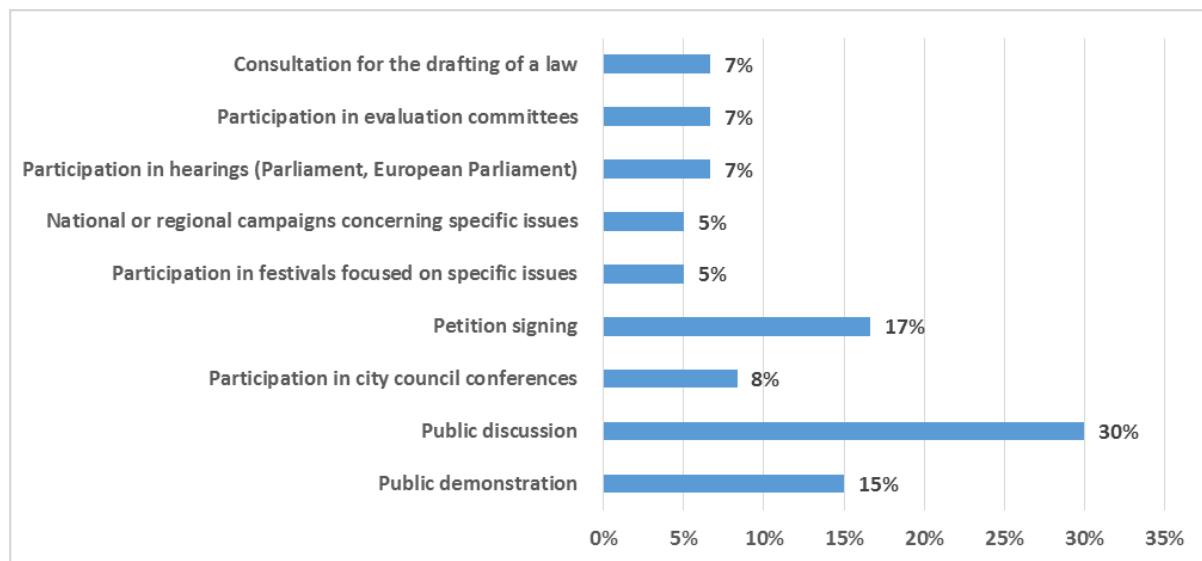
Figure 23: Forms of public participation

As seen from Figure 28, the majority of the respondents use Social media in order to discuss issues of public participation with other citizens.
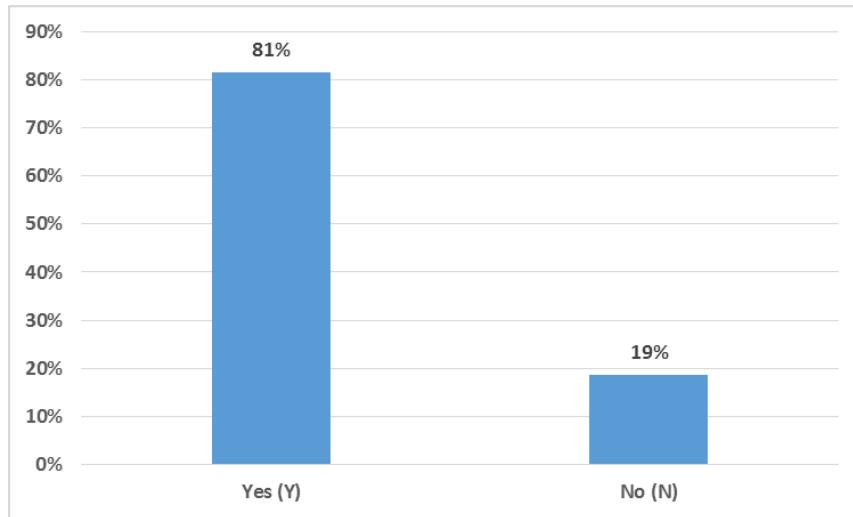
Figure 24: Use of social media

Social media are used by the majority of the respondents as illustrated in Figure 29 and the majority of respondents report to uses these frequently to discuss policy related issues (Figure 30). Furthermore, 81% of the respondents consider that the right time to involve citizens in policy making process is during idea formulation (Figure 31). This means that the public are able to contribute their views at a time when they can make a difference to the policy formulation.
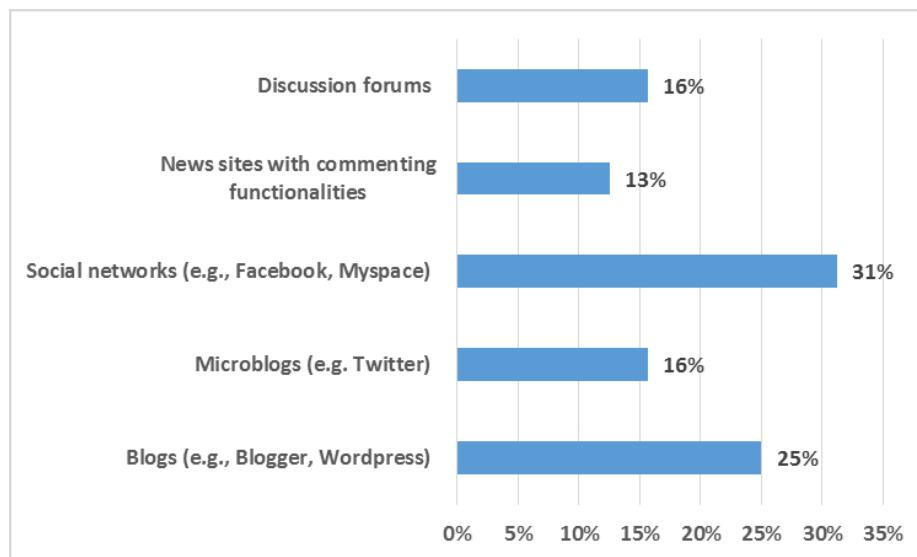
Figure 25: Social Media channels
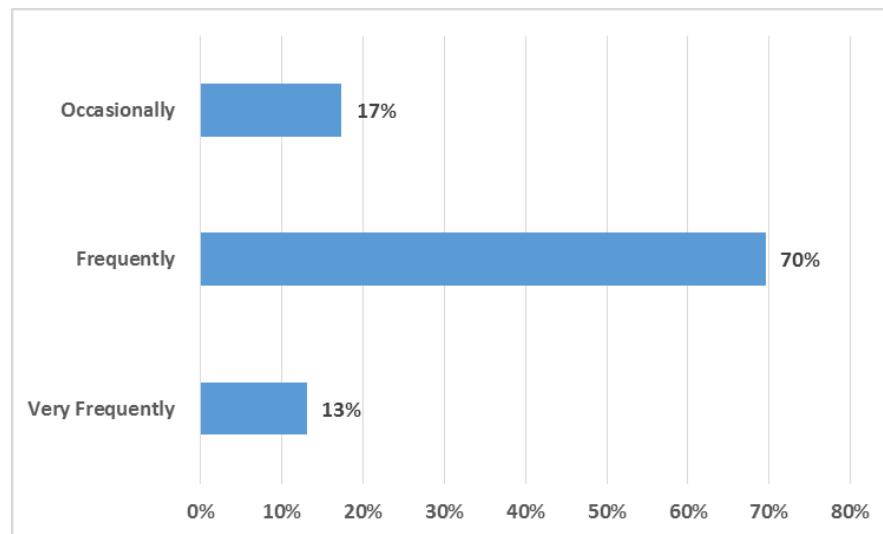
**Figure 26: Frequency of use**
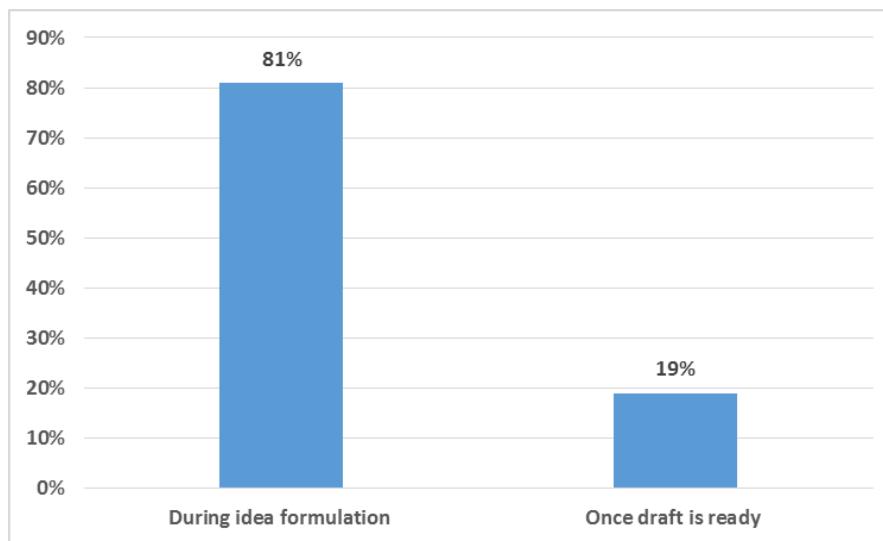
Figure 27: Citizens' involvement in the policy making process

9.4.2   Barriers and challenges to citizen participation

As far as concerns the barriers that respondents identify, towards a citizen participation network, it seems that the lack of interest from politicians and citizens about the process and the final results are the main barriers.
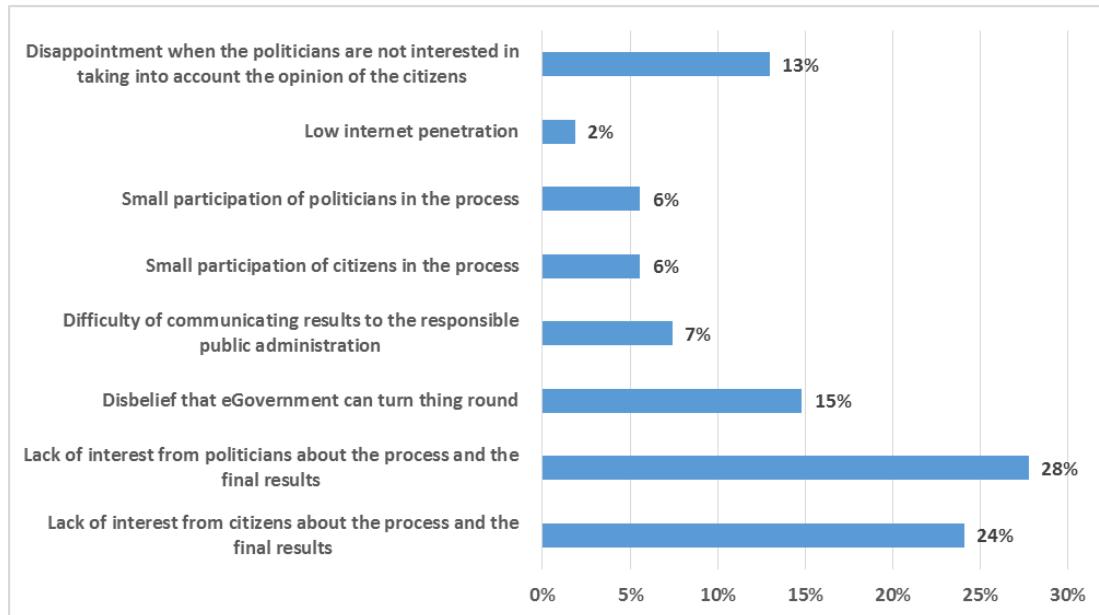

Figure 28: Barriers that citizens identify, towards a citizen participation network

In addition, 3 respondents have identified (through an open ended question) the following barriers:

- Incompatibility between their job and the liberty to express their opinion in public.
- Lack of adequate platforms of participation that render meaningful engagement with following tangible results for the public to see efforts of civic engagement.
- Lack of knowledge by citizens of how to get involved in shaping legislation and policy coupled with a lack of interest from politicians in increasing accountability.

9.4.3 Opportunities and benefits of citizen participation through social media

In citizen participation roadmap, a list of opportunities and benefits of social media based citizen engagement have been identified. We have requested from the respondents to rate these opportunities depending on their importance. As illustrated in the figure "Openness & Transparency" as well as "Culture engagement" are very important opportunities / benefits.
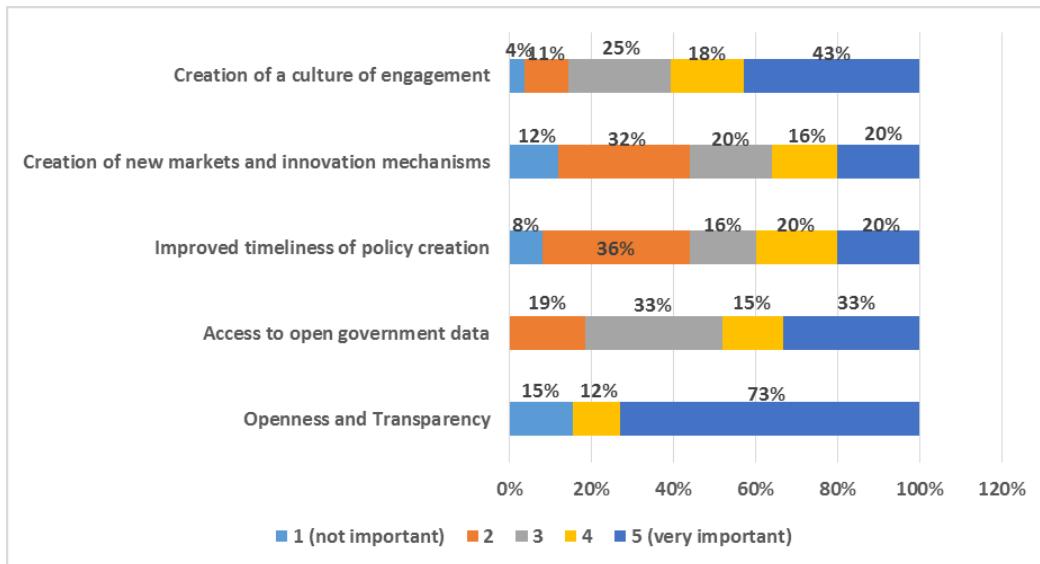

Figure 29: Opportunities & benefits

9.4.4 Challenges concerning citizen participation through social media

As illustrated in the figure below, "Trust" is considered to be the most important challenge for an effective citizen participation network. All the rest challenges are considered to some extent important as well.
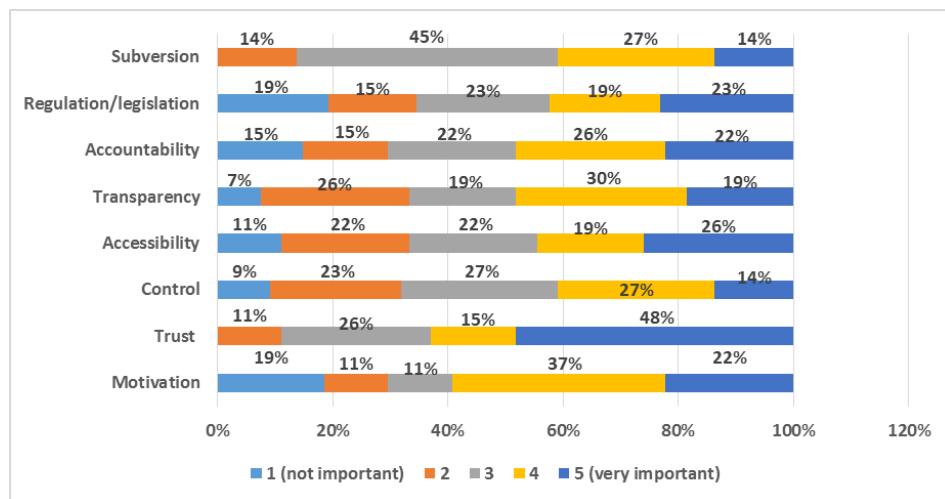

Figure 30: Challenges for an effective citizen participation network

9.4.5 Key stakeholders for shaping online citizen participation

As presented in the figure below, the respondents consider Citizens Groups, and to some extent also, NGO's as key to shaping participation services in the future. Government Policy makers and IT professionals and designers are considered somewhat less important groups.
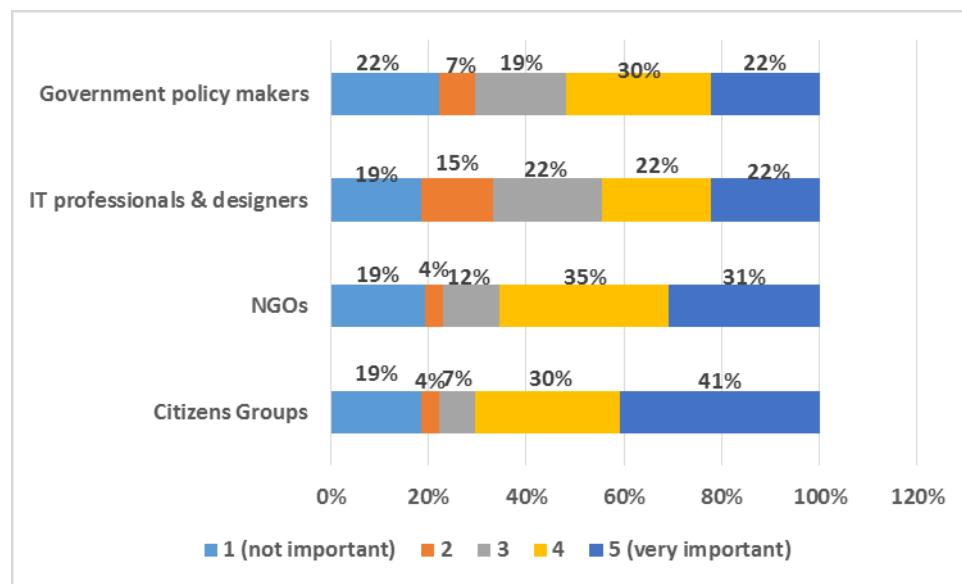

Figure 31: Key stakeholders for shaping citizen participation services