

HUMANE

White paper

Roadmap for human-machine networks in eHealth

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Abstract	This white paper presents a roadmap for human-machine networks (HMNs) in eHealth. Considering eHealth services as HMNs allows us to discuss these services from the perspective of the involved actors and the relations between these. In particular, we discuss the need for addressing motivation and behaviour change, as well as the potential benefit of the efficient integration of personalized eHealth systems, devices and applications in human life and societies. 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. The roadmap is based on an online survey with more than 35 participants, a focus groups and interview study involving 10 service owners, researchers, and policy maker representatives, as well as on a desk research.
Key-words	Human-machine networks, eHealth, roadmap.

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This white paper has been created on the basis of official reports created in the EC H2020 HUMANE project on the development of the HUMANE typology and method. However, it does not represent views or statements from the European Commission. This document is distributed under the Creative Commons License Attribution 4.0 International (CC BY 4.0).



Introduction

The HUMANE roadmap on eHealth focuses on networks and applications for physiological monitoring of patients with smart mobile and wearable devices, which are currently 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 such systems, 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, as well as the trends towards early detection of diseases, healthier lifestyles and improving the overall quality of life make such personalized eHealth systems 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.

In the course of the HUMANE project, we considered personalized eHealth systems as networks of interactions of both humans and machines (collectively termed “eHealth HMNs”), and followed the HUMANE method to study the implications of parameters such as trust, motivation and network size. In the eHealth HMN roadmap, we provide an overview of the ensuing challenges and envisaged actions at European level for the efficient integration of eHealth HMNs in human life and societies.

About the study

We have combined desk research with feedback received from stakeholders through user surveys, focus groups and interviews, which helped to arrive at a consensus view of the roadmap. More specifically we received more than 35 responses on the online survey (<https://humane2020.eu/2017/06/12/understanding-human-machine-networks-through-a-survey/>) and conducted focus groups and interviews with 10 stakeholders (5 policy makers’ representatives, 3 researchers interested in the field and 2 service providers).

As a theoretical basis for the study, we have applied the framework for analysing human-machine networks developed in the HUMANE project, which studies dimensions such as human and machine agency, and the strength of ties in human-to-human (H2H) and human-to-machine (H2M) interactions.

The eHealth market

The global eHealth market is expected to reach US\$308 billion by 2022, 24% of which is attributed to the eHealth market.¹ The rising use of mobile technologies and Internet along with increasing adoption for home care by patients is expected to propel market growth. In Europe, the current revenue (2017) in the eHealth market amounts to US\$2.78 billion, and is expected to show an annual growth rate (CAGR 2017-2020) of 17.2 % resulting in a market volume of US\$4.47 billion in 2020.²

¹ <http://www.grandviewresearch.com/press-release/global-e-health-market>

² <https://www.statista.com/outlook/312/102/ehealth/europe#>



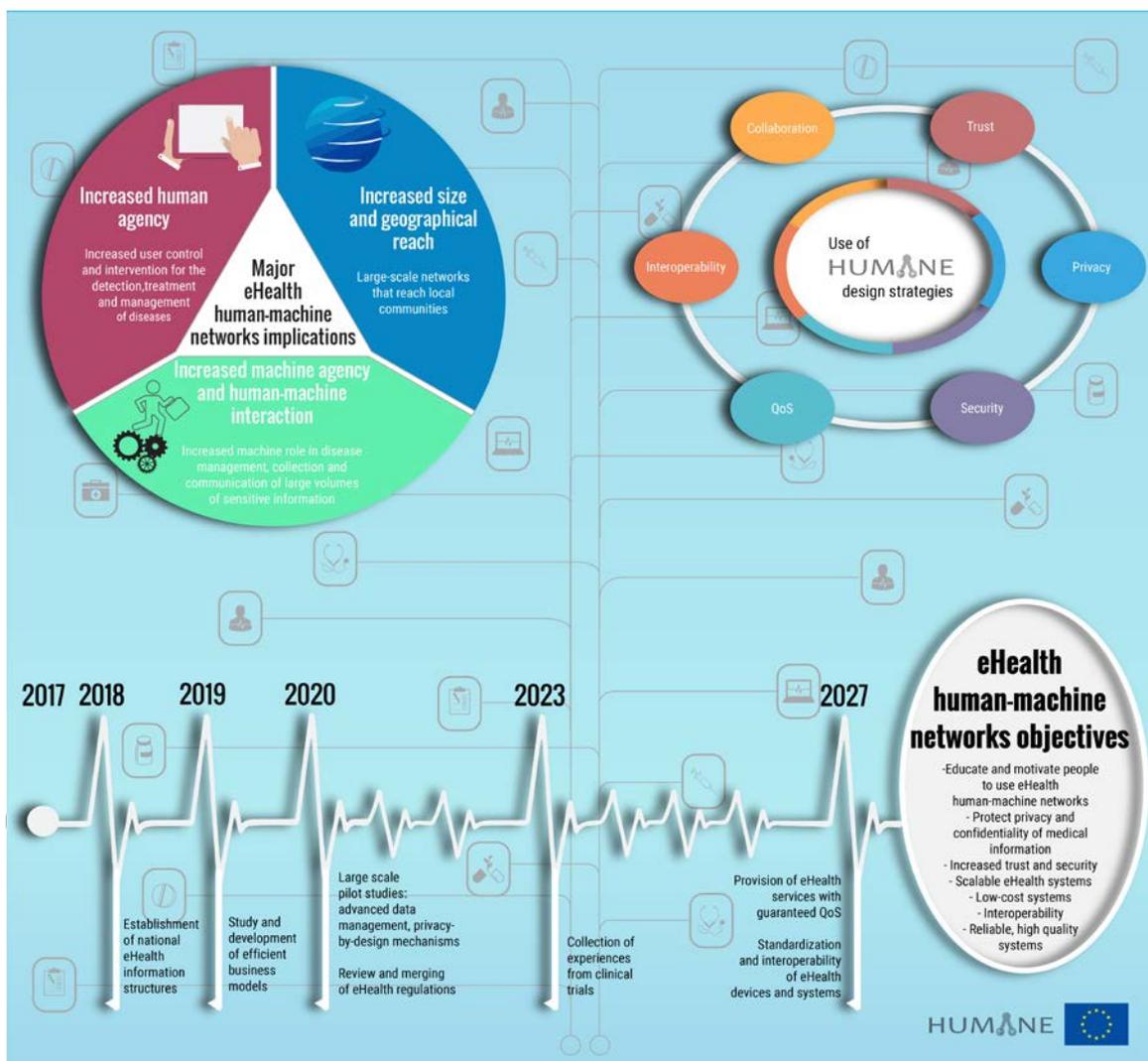
Roadmap objectives

The objectives we have set for this roadmap are to:

- Educate and motivate people to use eHealth HMNs
- Protect privacy and confidentiality of medical information
- Increase human trust in eHealth HMNs
- Increase security of eHealth HMNs
- Provide scalable eHealth systems
- Provide eHealth HMNs at reasonable cost
- Ensure the availability of critical health services
- Create standardized and interoperable eHealth devices and data

Roadmap overview

The roadmap was based on the implications of eHealth HMNs from different perspectives: human agency, the social tie strength of H2H interaction (usually between doctors and patients) and the relationship strength of H2M interaction (between a patient and the monitoring application). Additionally, we studied the implications incurred by the increasing size and geographical expansion of such systems.



Increased human agency

Personalized eHealth systems, devices and applications imply **increased control and intervention by users and 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 is now required for other conditions where self-management was usually not applied, like heart problems. In addition, it is required for the monitoring of vital signs and the uptake of a healthier lifestyle, in order to prevent diseases. Therefore, eHealth HMNs need to be designed so as to educate people for the handling of more complex health conditions, and to motivate otherwise healthy individuals to monitor their health conditions. At the same time, user engagement is also encouraged by having secure, privacy-protecting systems, which is another major goal of the HUMANE roadmap.

Roadmap actions

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.

HUMANE design patterns

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Higher machine agency and human-machine relationship strength

Higher machine agency creates a need for **security** and for the **protection of privacy 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). The protection of privacy and confidentiality mainly concerns the use of information by their intended recipients only for the intended purpose of use, and by any third parties in a way that preserves anonymity.

Data protection rules are expected to tackle another challenge, that of **increasing trust** and mitigating resistance from the patients and healthcare providers in using such products. A user of an eHealth device or application should be aware of 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. Design solutions should increase information towards users, so that they receive feedback on the actions performed, and are able 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.

Roadmap actions



In order to increase security, protect privacy and the confidentiality of medical information, and increase trust of human users in eHealth HMNs, we have proposed the application of privacy-by-design mechanisms in commercial eHealth HMNs, 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 can contribute to these objectives.

HUMANE design patterns

HUMANE design strategies for supporting and increasing trust, as well as for managing sensitive data with different levels of authorization support these actions.

Increased size and geographical reach

The **increased size and geographical reach** of eHealth systems call 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 for eHealth HMNs throughout the EU.

Roadmap actions

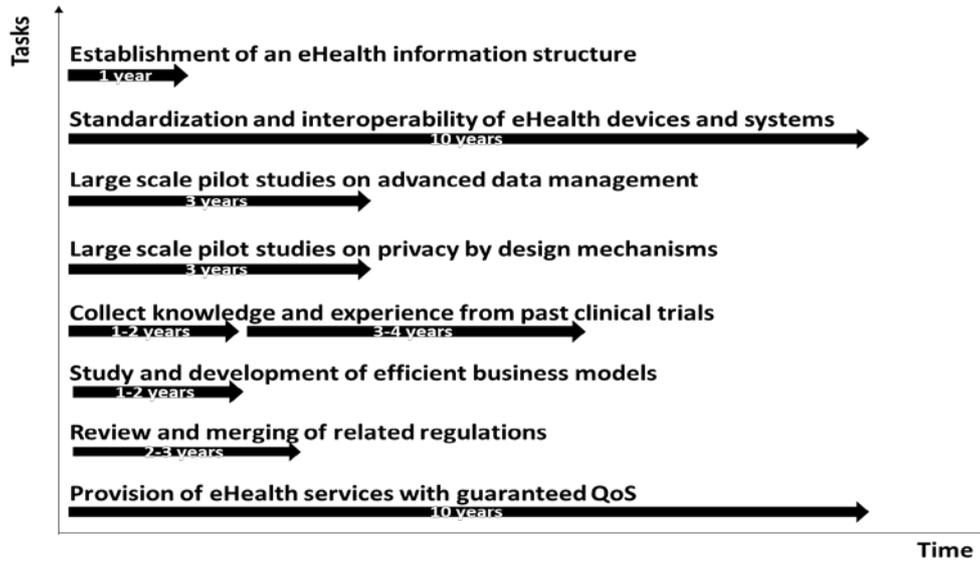
Design strategies for efficient data management and QoS are therefore also applicable here, and will contribute to scalability. However, one of the goals of the HUMANE roadmap is to successfully apply these practices at large scale, as pilot studies prior to their official adoption in the healthcare systems of EU countries. At the same time, the roadmap includes actions that exceed the design practices, and need a wider cooperation of stakeholders: the study of business models for eHealth monitoring, the review and merging of the different EU regulatory documents that relate to eHealth, and standardization of frequency bands, architectures and data.

HUMANE design patterns

Design patterns for efficient and scalable data management, guaranteed QoS.

Timeframe and prioritization

In the eHealth roadmap, we have set a timeframe of 10 years, however the majority of the actions is expected to be completed in the next 5 years. The standardization and interoperability of eHealth devices, as well as the provision of eHealth services with guaranteed QoS are the most demanding tasks, while the remaining tasks require varying degrees of effort.



Acknowledgement

The presented work is drawn from the HUMANE project deliverable Final Roadmap of Human-Machine Networks (HUMANE, D4.4). This deliverable is made public on the HUMANE website <https://humane2020.eu/>.