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A typology, method and roadmap for human-machine networks

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The HUMANE typology and method

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Abstract	In this deliverable we present the final HUMANE typology and method, intended to support the analysis and design for human-machine networks (HMN). The typology serves to characterize HMNs on dimensions pertaining to the actors of the network, the relations between the actors, network extent and network structure. The method supports profiling HMNs along these dimensions, to analyse implications of the network characteristics, identify similar networks, and enable the transfer of design knowledge and experience in the form of design patterns. The application of the typology and method is exemplified through summary presentations of three of the HUMANE case executions. Furthermore, an online tool to support HMN profiling and sharing of design knowledge is presented.
Key-words	Human-machine networks, typology, method, design patterns

Versioning and contribution history

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Definitions and abbreviations

Abbreviation	Definition
HCD	Human-centred design
HMN	Human-machine network
ICT	Information and communication technology

Executive summary

Human-machine networks (HMN) are understood as assemblages of humans and machines whose interactions have synergistic effects. That is, networks where the capabilities of humans and machines complement each other in ways that enable output which could not have been achieved by networks of humans or networks of machinery.

HMNs permeate nearly all aspects of society. The productivity and value creation in European industry and public sector depend on their ability to successfully design for, engage in, and realize the synergistic effects of the interactions within networks of humans and machines. To benefit from efficacious HMNs, there is a need to understand the key characteristics of HMNs, and how these characteristics affect peoples' experience and behaviour within the network as well as the networks capacity for innovation and improvement.

As a step towards providing the needed understanding of HMNs, we in the HUMANE project have developed a typology for HMNs and an associated method to apply the typology in analysis and design for HMNs. In this deliverable we present the final version of this typology and method.

In the typology, HMNs are characterized on eight dimensions addressing the actors of the network, their relations, the network extent, and its structure. The typology is based on a review of the literature on human-machine networks. The typology dimensions address the level of agency in the two actor categories of HUMANE: humans and machines (Dimension 1 and 2). Furthermore, it address the strength of the relations between the human actors of the HMN, as well as the strength of human-machine relations (Dimension 3 and 4). The extent of the network concerns the size and geographical reach of the network (Dimension 5 and 6). Network structure concerns the level of coordination required between network actors as well as the networks character of top-down vs. bottom-up organization (Dimensions 7 and 8).

To make the typology actionable, we have developed a method for applying the typology to the analysis of, and design for HMNs. Here, an existing or envisioned HMN is profiled according to the typology dimensions, that is, the HMN is considered and given a score for each dimension. The network profile in turn is applied to identify HMNs with similar characteristics, conduct an implication analysis, and support the transfer of design knowledge from the existing literature or from successful HMNs with similar characteristics.

An implication analysis concerns the detailing of potential consequences that the characteristics of an HMN may have for how users experience, behave, or collaborate within the network. In HUMANE we are in particular concerned with implications reflecting potential challenges that needs to be addressed in the design for the HMN.

To support the transfer of design knowledge from existing literature or HMNs with similar characteristics, a design pattern approach is applied. On the basis of the case work preceding this deliverable, about 40 design considerations for HMNs have been described in a design pattern format.

The HUMANE method is developed to complement a process for Human-Centred Design (HCD), and is supported by an online tool for HMN profiling and transfer of design knowledge. In this tool, HMNs

can be profiled according to the HUMANE typology dimensions, to review similar HMNs and to identify relevant design considerations associated with other HMNs. The tool, while presented in this deliverable, is also available at https://networkprofiler.humane2020.eu.

The development of the typology and method has involved in total eight cases for validation across two project iterations. The cases represent a broad range of HMNs as exemplified through three cases summarized in this deliverable: A decision support system, a platform for collaborative content verification, and a co-production platform (Wikipedia). For each of these cases, we provide an overview of how the typology and method have been applied and the outcomes of this. Specifically, we exemplify the application of the network profiling, the implication analysis, and the identification of design considerations through a design pattern approach.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

1.1 Motivation

In the networked society, the people and the machines we rely on for our working and civic lives are moving rapidly towards a pattern of always on, always connected. Our activities at work, as well as in our private lives increasingly depend on the networks of humans and machines in which these are embedded. Hence, the successful outcome of highly diverse activities such as industrial innovation processes, sharing economy transactions, citizen science, and news verification practices, to an increasing degree depend on human-machine networks (HMN).

Human-machine networks permeate nearly all aspects of society. The workplace sees the inclusion of ever new technology intended to strengthen effectiveness and efficiency, requiring adaptation of work tasks and representing opportunities for reshaping work as more strategic and knowledge intensive. The uptake of networked technology in social and civic life, opens up new opportunities for networking and socializing, participation, and value creation. As argued in the strategy Digital Single Market[1], the economy and society of Europe needs to prioritize digital growth. Productivity and value creation in European companies and organizations depend on these being able to successfully design for, engage in, and realize the potential of HMNs.

For European industry and public sector to benefit from efficacious HMNs, we need to thoroughly understand the key characteristics of such networks, and how these characteristics affect people's experience and trust in the networks, how they affect the way people behave and collaborate, and how they affect the networks' capacities for innovation and improvement. For example, how does the increasing reliance on machine intelligence in HMNs affect privacy and trust perceptions? How does the centralized organization of platforms for open innovation or citizen science affect motivation to contribute? How to ensure constructive collaboration between humans and bots in collaborative platforms such as Wikipedia? Answering questions like these require a conceptual framework for characterising and analysing HMNs.

We also need new approaches to design for HMNs. Through traditions such as socio-technical systems design (Mumford, 2006) and human-centred design (Maguire, 2001) we are provided frameworks needed to analyse the context of technology design, and processes for involving users and stakeholders in the design process to ensure effective and efficient work support. However, designing for networks of humans and machines remains challenging. Examples studied by HUMANE researchers include online innovation platforms that fail to strengthen innovation capabilities (Lüders, 2016), how procedures for including and excluding people in online collaboration may work against their intentions (Rudas, Surányi, Yasseri, & Török, 2016), and how the excessive use of bots in a network for collaboration may change or, at worst, challenge collaborative culture (Tsvetkova, García-Gavilanes, & Yasseri, 2016b). Failing to design for purposeful participation and interaction within HMNs may threaten both the value of investment in a design, but also potentially represent lost opportunities to

[1] European Commission: Digital Single Market - https://ec.europa.eu/digital-single-market/

improve on the quality and competitiveness of European society (Guerrieri & Bentivegna, 2011). Furthermore, design for HMNs needs to take into account the flexibility needed in networks to adequately respond in cases of unforeseen emergent behaviour within the network.

A key assumption in HUMANE, is that the purposeful design for HMNs will benefit from understanding the characteristics of the HMN in which it is to support. Complementing socio technical systems design and human-centred design, we seek to understand HMNs not only as particular and contextually embedded, but as holding a set of generic characteristics which may apply to HMNs across application areas and domains. These characteristics, and how they may be applied to support analysis and design for HMNS, are formulated as a typology and an associated method – the HUMANE approach. In this report, we present the final version of this typology and method.

1.2 The HUMANE approach

To support the analysis and design for HMNs, we have established a typology where HMNs may be characterised on dimensions pertaining to its actors (human or machine), the relations between these actors, as well as then overall network structure and extent. Characterising a HMN on the basis of these dimensions are intended to drive strategic reflection, for example during the early phases of a human-centred design process.

In HUMANE, the characterisation and analysis of the HMN, as well as the transfer of design knowledge and experience, is conducted in a stepwise process referred to as the HUMANE method. We detail this method in Section 5. As a summary overview, the method steps are:

1. **Context and scoping**: Explicate the purpose and objectives of the HMN.
2. **Network characterisation**: Establish the HMN profile through the typology dimensions and identify similar HMNs.
3. **Implication analysis**: Analyse key implications of the HMN profile in terms of user experience and motivation, behaviour and collaboration, innovation and improvement and/or privacy and trust.
4. **Design considerations**: Cross-domain identification and utilization of design knowledge and experience through a design pattern approach. Design knowledge is shared through what we refer to as *design considerations.*
5. **Evaluation:** Assess and refine current design proposals on the basis of the input from the HUMANE approach.

The typology and method is intended as a supplement to the human-centred design process (ISO, 2010), supporting analysis, requirements, design, and evaluation. Specifically, the typology and method is intended to support initial strategic reflections and considerations at the outset of the design process.

As the analysis is on the level of the network of humans and machines, rather than e.g. specific interactive devices, the design suggestions returned from using the method is at the level of the general network, rather than at the implementation of specific network components. As such, the

typology and method serves to strengthen human-centred design on the level of the actor network for which the design is ultimately intended.

1.3 Target audience

The target audience for the HUMANE typology and method include practitioners within ICT development and design, as well as researchers within fields approaching the phenomenon of human-machine networks.

Among practitioners within ICT development and design, the typology and method in particular target those working on a strategic level, such as project leaders and system architects, or those working to develop early-phase concepts or prototypes for innovative ICT systems or services. The typology and method is set out as a complement to the human-centred design process, and hence will have more appeal to practitioners concerned with how ICT should support the social or organisational context for which it is intended.

Among researchers, the HUMANE typology and method should be relevant to those conducting research within the fields on which the typology is based, such as socio-technical systems design or human-centred design, or fields addressing resembling topics of interest, such as those of social machine and social network analysis.

While the HUMANE project also address future thinking and policymaking of relevance to HMNs, the typology and method as presented in this deliverable only indirectly supports this. Rather, technology strategists and policy makers are addressed through the project work on roadmapping presented in forthcoming HUMANE deliverables (D4.2 and D4.4)[2].

1.4 The HUMANE project context

The final version of the HUMANE typology and method, presented in this report, is based on an iterative process within the HUMANE project. The development process is described in more detail in Section 3.3. Here we provide a brief overview of the general HUMANE project context.

The typology is grounded in a comprehensive literature review, surveying key literature pertaining to a wide range of HMNs (Tsvetkova et al., 2015). The typology and method has then been developed through two previous iterations (Følstad et al., 2015, 2016), where each version has been the subject of extensive case trials (D3.2 and D3.3[3]).

[2] D4.2 and D4.4 are the HUMANE project deliverables on the first and second version of the HUMANE roadmaps for human-machine networks.

[3] D3.2, Report on the First Set of Case Studies, and D3.3, Report on the Second Set of Case Studies, are confidential deliverables. Key findings from D3.2, motivating the updates of the typology presented in the second version, is presented in the second version of the typology (Følstad et al., 2016). Key findings from D3.3 are presented in the background section of this deliverable.

During the development of the typology and method, as well as in the associated case trials, key results and learnings have been extracted and represented in an online tool for HMN profiling (http://networkprofiler.humane2020.eu).

The development of the typology and method has also informed the HUMANE work on future thinking and roadmapping for HMNs. Here, the typology has been used as a framework to analyse trends, developments, and make policy recommendations for HMNs within domains that embrace technological applications, which promise to bring great benefits to the economy and society, such as the sharing economy, eHealth and citizen participation.

1.5 Structure of the report

In this report, we present the final version of the HUMANE typology and method. In Section 2 we present relevant background, including key outcomes of the work leading up to this version and theoretical underpinning of the implication groups of particular interest in the HUMANE method.

Following the background presentation, we then provide an overview of the final HUMANE typology for general strategic considerations and design support (Section 3), and an overview of relevant theoretical background to support implication analysis on the basis of the HUMANE typology dimensions (Section 4).

The HUMANE method is presented in Section 5. In Section 6 we then exemplify the use of the method with presentation of three of the previous HUMANE case studies in which the method has been used. In Section 7 we present the exploratory work on how general types of HMNs may be drawn on the basis of profiling a large number of HMNs. In Section 8, we present the online tool developed to support the HUMANE method. Finally, we present conclusions and future work in Section 9.

2 Background

2.1 Defining HMNs

In networked society, value creation typically happen in networks of humans and machines, where the capabilities of humans and machines complement each other in ways that enable output which could not have been achieved by networks of humans or networks of machinery. To capture this key characteristic we define HMNs as "assemblages of humans and machines whose interactions have synergistic effects" (Tsvetkova et al., 2017).

The Oxford Dictionary define *synergy* as interaction or cooperation of two or more entities "to produce a combined effect greater than the sum of their separate effects". A similar notion of synergistic effects is reflected in Actor-Network Theory (Latour, 2005), where a network of human and machine components takes on characteristics other than those held by the individual actors. Likewise, in the theory of double dance of agency (Rose & Jones, 2005), building on Actor-Network Theory, the emergent properties of the interplay between human and machine actors are accentuated.

Building on the theoretical foundations of socio-technical systems (Baxter & Sommerville, 2011; Mumford, 2006), machine components are seen as embedded in a context of systems of social and technological entities. The synergistic effect achieved in HMNs are achieved by combining human strengths, such as our capacity for creativity and interpretative meaning-making, and machine strengths, such as their endurance, accuracy, and computational power, to reach goals in response to a particular context.

Whereas any constellation of humans and machines may be said to have synergistic effects of some kind, networks of greater interest in HUMANE are those where the synergistic effects are immediately evident; as they are, for instance, in systems for mass-collaboration. In the HUMANE project, we have studied eight cases, including the online collaborative encyclopaedia Wikipedia[4], the citizen science platform Zooniverse[5], and the evacuation support system eVACUATE[6] - all of which are good examples of HMNs in which the interplay of human and machine actors enable synergy. For example, in the case of Wikipedia synergistic effects are apparent both as the technology platforms facilitates human collaborators to expand and refine on each others' contributions, and also in terms of the interaction between machine actors (bots) and human actors in maintaining and improving Wikipedia content where, for instance, machine actors may flag the need to expand on a Wikipedia article whereas the human actors collaborate on making the actual expansion. In Section 6 three of the HUMANE case studies are presented in more detail.

While such synergistic effects indeed are powerful when they are realized, as in the HUMANE cases of Wikipedia or Zooniverse, all too often the desired synergistic effect is not achieved. This may be seen, for example, in social intranets that fail to facilitate the intended company internal sharing and

[4] https://en.wikipedia.org
[5] https://www.zooniverse.org/
[6] http://www.evacuate.eu/

collaboration (Lüders, 2013), or in online innovation platforms for which the potential for the open involvement of customers and external experts is not realized (Lüders, 2016). A key aim of HUMANE is to improve our understanding of how synergistic effects are realized in HMNs, and how to design for this.

2.2 Classification, implication analysis, and transfer of design knowledge

To understand HMNs, and how to realize the synergistic effects of the networked interaction of humans and machines, we need a conceptual framework for characterizing variations in HMNs. A key assumption in HUMANE, is that the classification of HMNs along a relatively small number of generic dimensions will provide the basis for such a framework. Specifically, as this may enable us to compare and contrast different types of HMNs.

For this purpose, we have developed a typology for the classification of HMNs with respect to eight dimensions, structured in four analytical layers. This work is based on Bailey's (1994) general understanding of typologies as multidimensional classification systems, and the work of Collier et al. (2012) on typology development. The analytical layers, addressing the actors of the network and their relations, as well as the network structure and extent, are based on the cross-disciplinary literature review (Tsvetkova et al., 2015) conducted at the outset of HUMANE. The set of dimensions have been refined through the course of two project iterations, converging on the eight dimensions presented in Section 3.1; dimensions which reflect "salient elements of variation" (Collier et al., 2012, p. 233) in the overarching concept of HMNs.

To make the HUMANE typology actionable, we have developed a method for applying the typology to the analysis of, and design for HMNs. Three key steps of this method are: (a) profile the HMN according to the typology dimensions, (b) conduct an implication analysis based on the HMN profile, and (c) transfer design knowledge from the existing literature or from successful HMNs with similar characteristics.

The *profiling* of the HMN involves the systematic consideration of an existing or an envisioned HMN in terms of the HUMANE typology dimensions. For this purpose, each dimension is broken down into a small number of aspects, and each aspect is scored independently. The resulting profile may be used to identify other HMNs with similar profile, support implication analysis, and transfer design knowledge.

An *implication analysis* concerns the detailing of potential consequences that the characteristics of an HMN may have for how users experience or behave within the network. The implication analysis in the HUMANE method is inspired by how personas are used in human-centred design. Personas are representations of prototypical users embodying the characteristics of the intended user groups, used by a development team to infer implications of design decisions (Pruitt & Adlin, 2010). In HUMANE we are in particular concerned with implications reflecting potential challenges that need to be addressed in the design for the HMN. Background on the groups of implications considered in the HUMANE implication analysis is provided in Section 4 below.

As shown in previous HUMANE publications (Eide et al., 2016; Tsvetkova et al., 2017), when the typological characteristics of an HMN is known we can draw on the existing literature and experiences

from successful HMNs to increase our understanding about such implications. The HUMANE case examples presented in this deliverable, include implications drawn from the literature which concern, for example, how the organization of the network may affect innovation capacity (Section 6.1.3), how low levels of human agency may affect motivation (Section 6.2.3), and how trust may be affected by social tie strength (Section 6.3.3).

A *design pattern approach* is applied to extract and transfer design knowledge needed to address the challenges identified in the implication analysis. While this approach originates within the field of architecture (Alexander, Ishikawa, & Silverstein, 1977), the design pattern approach has been taken up as an approach within human-centred design to transfer design knowledge in a structured and accessible format (Seffah, 2015). A design pattern typically takes as its starting point a specific challenge or problem, and then present relevant background, including an overview of the factors affecting the problem, a possible solution, and real-world examples (Borchers, 2001; Seffah, 2015). Design patterns documenting solutions to a number of design problems may be systematized in design pattern libraries to serve as reference for future design (Borchers, 2001; Seffah, 2015; van Duyne, Landay, & Hong, 2002).

In the context of HUMANE we support the design for future HMNs at a strategic level, rather than specific implementation, and thus in this final version of the typology we refer to *design considerations* (and not *design patterns* as referred in previous deliverables). These considerations are derived through a design pattern approach and have more the character of needed strategic considerations rather than detailed solutions, whereas the term *design patterns* often is associated with design advice on a lower, implementational level.

2.3 Complementing the Human-Centred Design process

When designing technology to be applied in networks of humans and machines, a human-centred design (HCD) process provides support for involving users and enabling the outcome of the process to adhere to users' needs and requirements. A much cited version of the HCD process is the ISO standardised methodology on HCD for interactive systems (ISO, 2010), depicted in Figure 1. This methodology aims at including a human-centric perspective into the software development process, comprising the phases of context analysis, user requirements, design, and evaluation – seen as repeated iteratively throughout the design process. A range of methods have been proposed to support the individual phases of the HCD process (Maguire, 2001). However, methods to address the overall analysis and design for networks of human and machine actors is missing.

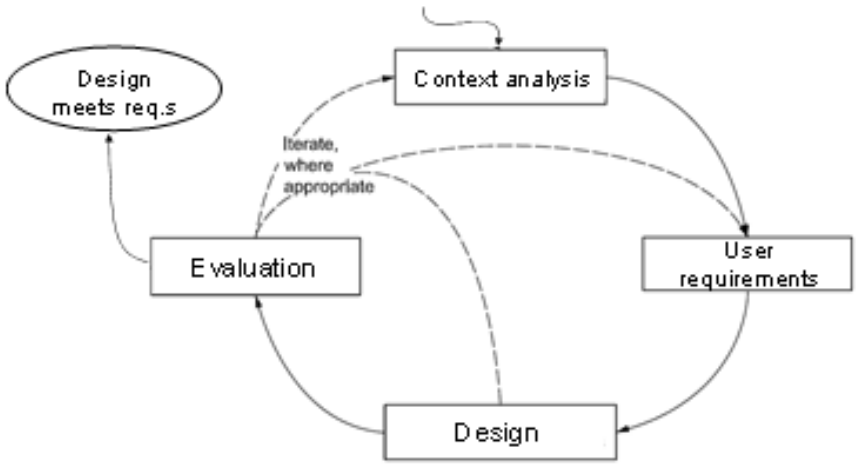


Figure 1: Human-centred design process.

A HCD process does not replace software development methodologies, but complements them in order to better take into account the user's perspective. Similarly, the HUMANE method is intended to complement the HCD methodology.

Specifically, the scoping and characterising of the HMN conducted in the first two steps of the HUMANE method complements the context analysis and user requirements phases of the HCD process. Furthermore, the implication analysis of the HUMANE method supports context analysis, user requirements elicitation, and early design. The design pattern approach in the fourth step of the HUMANE method supports the design phase of HCD. Also evaluation may be supported through contrasting implications and design suggestions identified through the HUMANE method with the current or proposed design.

2.4 Recommendations and updates of the typology and method based on HUMANE case trials

The HUMANE typology and method has been developed in an iterative process, involving two sets of case trials. On the basis of these, a number of updates and refinements have been made to improve the typology and method in response to the case feedback.

Updates and refinements motivated by feedback from the first set of case trials have previously been summarised and addressed when presenting the interim version of the typology and method (Følstad et al., 2016). Below, we present some of the main updates and refinements new to this final version of the typology and method, together with the feedback from the second set of trials on the basis of which the updates were motivated.

In Appendix 2, we provide a full overview of all recommendations from the second set of case trials and the corresponding changes in the typology and method.

2.4.1 Increased precision on purpose and target audience

From the second set of case trials, it was suggested that the purpose of the typology should be made more precise. Specifically, it was suggested that the typology and method should be presented as a means to support HCD on a strategic level rather than for technical implementation.

For this purpose, the target audience of the typology and method now has been clearly defined (Section 1.3). Furthermore, typology and method presentations have been reworked so as to more clearly show that it is intended to support the early, strategic part of the HCD process.

2.4.2 Strengthen ease of understanding and use

The second set of case trials indicated that the typology and the profiling process may be difficult to understand and apply, due to a lack of intuitive terminology and challenges in interpreting some of the scales used for profiling.

For this purpose, the terminology of the typology have been reworked to provide more intuitive terms for those of the eight dimensions (*social tie strength*, *human-machine relationship strength*, and *geographical reach*) and corresponding analytical layers (*relations*, *network extent*, and *network structure*) for which interpretation was seen as challenging. Furthermore, the aspects associated with one of the dimensions (*network size*) have been reworked to allow for more intuitive scales.

2.4.3 Represent variation and change

Participants in the second set of case trials suggested that it would be useful to introduce a means in the typology for representing change in the HMN across time. The second set of case trials also suggested the need for a mechanism to reflect underlying variation in the dimensions, for example in situations where different groups of actors in the network hold different levels of agency.

In order to meaningfully represent change by way of the typology, in the final version of the typology we have described how alternative profiles may be used specifically for assessing the difference between an envisioned future HMN and the current HMN. This should be particularly useful to support early-phase design decisions. See Section 3.2.2 for details.

2.4.4 Understanding HMN types

Our previous experience with profiling different HMNs suggested that there are certain types of networks that show similarity when their profiles are considered. This has led us to plan extracting types of networks based on profiling of a large number of networks and using clustering algorithms to classify profiles into types of networks. HMNs will then be considered as belonging to the same network type on the basis of similarities in their profiles.

To do so, we have profiled 200 HMNs and then analysed the values for each dimension (see Section3.1). In particular this analysis has helped us respond to key recommendations made on the basis of the second set of HUMANE case trials (D3.3). In particular, the exercise of profiling a large number of networks and analysis on the interrelation between dimensions and extracting the types

will help analysts and designers of a particular HMN identify other HMN profiles from the same type, and to more easily see the relation between domains and implications (e.g., if certain implications are specific to a certain domain, or are more general and applicable to multiple domains). Furthermore, it will allow us better understand the interrelationship between dimensions.

2.4.5 Overview of HUMANE cases for easy reference

For easy reference, throughout the remainder of this report, we provide an overview of the HUMANE case trials in the table below.

Table 1: Overview of the HUMANE cases

Case	Description	First case trials	Second case trials
1: Open innovation platform	Online platform intended to support crowd-sourced idea-gathering as well as the innovation process beyond	X	
2: Mobile reselling platform	Online platform for consumer-to-consumer reselling and redistribution of goods, resembling platforms such as eBay and Craigslist, but developed mainly for use on mobile devices	X	
3: eVACUATE	Intelligent system and sensor network to support emergency evacuation of crowds	X	X
4: REVEAL	Collaborative platform for journalistic curation and verification of social media content.	X	X
6: Wikipedia	Collaborative online encyclopaedia.	X	
6: Zooniverse	Platform for citizen science projects, where users from the general public participate in analysis of large volumes of qualitative data.	X	X
7: Emergency management system	Emergency management system for shared situational awareness and decision support, used by public and private organizations.		X
8: Decision support system	Decision support system supporting collaboration between human operators and intelligent agents in complex, time-critical contexts such as air traffic management		X

3 Typology

In this section we first present the HUMANE typology, and its analytical layers and dimensions. We then detail how the typology may be applied to characterize change in a HMN, before providing an overview of how the typology has evolved in the course of the project.

3.1 Typology dimensions

The aim of the HUMANE typology is to characterise HMNs in order to better understand how their properties affect the interactions of humans and machines within them, and to support the purposeful design for such networks.

HMNs may be characterised on the basis of a range of properties, many of these with important implications for the operations and outcomes of an HMN. It is important to gain insight into the actors of the network and their relations. Who are part of the network, and what is the character of their connection? Furthermore, we need to know the extent of the network, as well as its organization and how it operates.

For this purpose, based on the analysis of the HUMANE literature review (Tsvetkova et al., 2015), we distinguish between four analytical layers in the HUMANE typology: actors, relations, network extent, and network structure.

For each of these layers, we specifically address two distinct dimensions. These dimensions, eight in total, constitute the core of our framework for characterising HMNs. The analytical layers and associated dimensions are presented in Table 2.

Table 2: HUMANE typology – analytical layers and dimensions

Layer	Dimension	Description
Actors	1. Human agency	The degree to which human actors may have impact or cause change through open and diverse activities. *High levels of human agency mean:* People in the HMN typically can engage in many open and diverse activities towards self-decided goals, possibly aiming to influence others.
	2. Machine agency	The degree to which machine actors may have impact or cause change through open and diverse activities, as well as the extent they enable agency in human actors. *High levels of machine agency mean:* The networked machines typically can perform many open and diverse tasks, aiming to influence other actors in the network, possibly appearing human-like, and allowing human actors to do things they otherwise could not.
Relations	3. Social tie strength	The strength of typical relations between the human actors as nodes in the network. *High levels of social ties strength mean:* The social relations in the network typically hold characteristics of closeness such as intimacy, extended duration, and reciprocity.
	4. Human-machine relationship strength	The strength of the relation between humans and machines as nodes in the network *High levels of human-machine relationship strength mean:* The human actors in the network typically are trusting, dependent, and reliant on the machine actors.
Network extent	5. Network size	The number of actors as nodes in the network. *High network size mean:* The network has a large number of members and a dominant position in its market segment. A broad uptake of the network is required for intended network effects to be realized.
	6. Geo-graphical reach	The geographical extension of the network. *High levels of geographical reach mean:* The network covers large geographical areas, and in consequence typically have a character of transnationality and cultural diversity.
Network structure	7. Workflow inter-dependence	The levels of coordination and interaction required between the actors of the network. *High levels of workflow interdependence mean:* The desired results of the activities within the network typically require substantial interaction, coordination, and possibly also collaboration between its actors.
	8. Network organisation	The character of the network organisation with implications for predictability and emergence; specifically contrasting top-down vs. bottom-up organisation *High levels of network organisation mean:* The network is characterized by a top-down organisation, often with a hierarchical structure and centralized control. In contrast, low levels of network organisation indicate a flat organisational structure and substantial self-organisation

Any HMN may be characterized according to the eight dimensions of the HUMANE typology, as a basis for analysis of implications and identification of the design knowledge required.

Example: Within HUMANE WP4 (Implications for future thinking and policy making), we develop a roadmap for HMNs within the sharing economy. Here, an envisioned HMN may be characterized as shown in Figure 2. Human agency is low to strengthen process and quality control in the HMN, whereas intelligent matching of supply and demand is supported by high levels of machine agency. Social tie strength is low, as mainly strangers are matched in the HMN, and only for the duration of a specific transaction, whereas the relation to the technology and service platform is strong. Network extent (size and reach) is typically important in sharing economy HMNs to benefit from network effects and achieve sustainability. Finally, while the overhead associated with coordination and communication between actors (workflow interdependence) should be as low as possible, a relatively centralized and policy-driven network organisation is required to obtain predictability and trust for users.

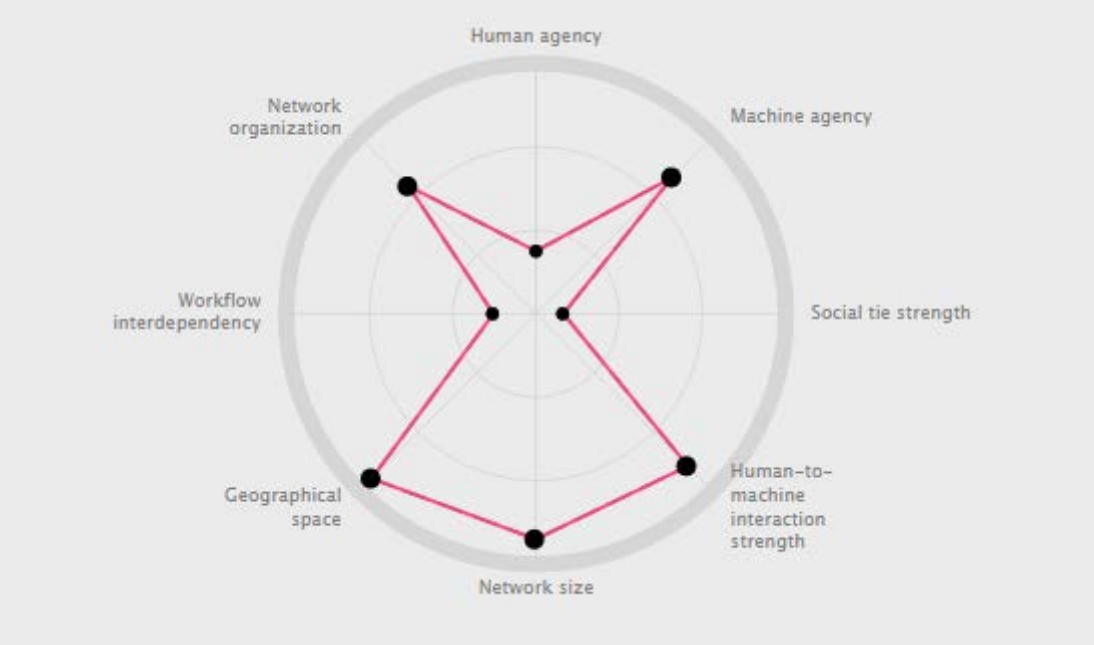


Figure 2: Example profile - envisioned sharing economy HMN.

More detail on the analytical levels and typology dimensions is provided below.

3.1.1 Actors

The two main HUMANE categories of actors are humans and machines. Drawing on Actor-Network Theory (Latour, 2005; Law, 1992), the HUMANE typology aims to conceptualise human and machine actors in terms of similar characteristics, such as the ability to modify a state of affairs to make a difference. While machines cannot be deemed to have intentionality in the same way as humans, advances in digital technology allow machines to behave in ways that to the casual observer may be perceived as intentional or human-like manner – be it the intelligent filtering and recommendation algorithms of a social network, the navigational and negotiating capabilities of the self-driving car or the human-like interaction of a social robot.

Our key interest in the actors of a HMN resides in characterising their *agency*. There are different definitions of agency, which was originally only attributed to human beings. For example, in structuration theory agency is defined as *"the capability to make a difference"* (Giddens, 1984), and in social cognitive theory *"agency refers to acts done intentionally"* (Bandura, 2001). The latter is a key differentiator for definitions of agency, as it implies that agency cannot be attributed to machine actors as their actions cannot be characterised as intentional (Friedman, Khan Jr, & Howe, 2000; Rose & Jones, 2005; Rose, Jones, & Truex, 2003). Nevertheless, theoretical positions in the literature have been proposed that attribute agency to machines as well (Engen, Pickering, & Walland, 2016; Latour, 2005; J. Law, 1992; Rose & Jones, 2005; Rose et al., 2003), on the basis that they are increasingly active and visible participants with the capability to make a difference and influence the outcomes of social systems or reach decisions in complex ways, not entirely transparent to other actors (Hildebrandt, 2015, 2016).

In HUMANE, we have adopted this broader definition on the basis of previous research, attributing agency to both humans and machines, suitable for the analysis and design of HMNs. We understand the agency of an actor, whether human or machine, as the capacity for performing activities and actions in a particular environment in line with a set of goals/objectives that influence their participation (Engen et al., 2016).

While machines do not have intentionality, they may operate on the basis of concrete goals or objectives, encoded by the intentions of human beings (Fogg, 2003). Further, we do reflect humans' tendency towards anthropomorphism (Nass, Lombard, Henriksen, & Steuer, 1995) as *perceived* agency, attributing human-like characteristics to co-operative machines (Applin & Fischer, 2015).

According to the above definition, we capture the degree to which the agents may assert influence on others in the network. In the theory on *double dance of agency*, Rose and Jones (2005) lay out how human and machine agency is enabled and constrained by the networked processes and context in which it takes place. In HUMANE, we consider more particularly the variety and character of the tasks made available to the actors of the network: what the actors might potentially do. For example, limiting the type of tasks that the actors may engage in, or limiting the degree to which the actors can determine how to execute these tasks, lowers agency. Lowering of agency may be beneficial, for example, for imposing adherence to quality standards within the network as seen in a highly predetermined workflow. Strengthening agency may be beneficial, for example, for more flexible problem solving and support for achieving goals requiring in-depth analysis or (human) creativity.

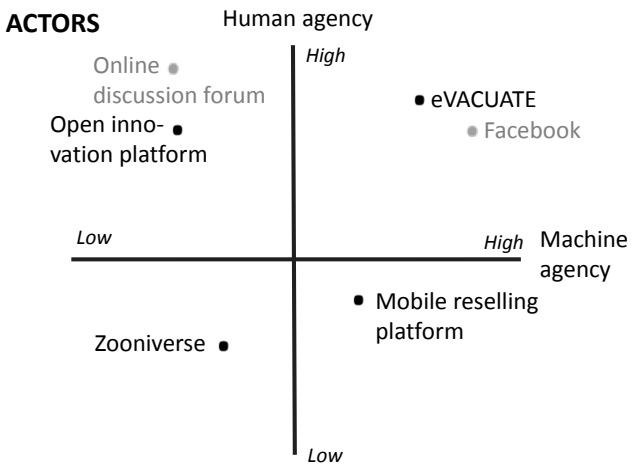
In a recent trust-model proposed by Pickering et al. (2017), we observe and hypothesise that human agency is related to self-efficacy, that is an individual's belief in their ability to be able to achieve a given objective (Bandura, 1977, 1982, 2012). Further, regulation is seen as a key influence on both human and machine agency, in particular how machine agency is seen as being negatively correlated with regulation, which we touched on above in the context of limiting the types of tasks actors may engage in.

D1 - Human agency. High level characterized by:

- **D1.1 - Diverse activities:** People can perform a diverse range of activities in the HMN.
- **D1.2 - Influence:** People are able to interact freely and influence other participants in the HMN, whether human or machine.
- **D1.3 - Open activities:** The activities people can perform allow them to express their personalities, behave diversely, freely, creatively and even use the HMN unpredictably.
- **D1.4 - Self-decided goals:** People can use the HMN to help them achieve goals (set by themselves) that they may otherwise not be able to achieve, e.g., via other people or technology in the HMN.

D2 - Machine agency. High level characterized by:

- **D2.1 - Diverse activities:** Machines (technological actors/agents) in the HMN can perform a diverse range of activities.
- **D2.2 - Influence:** Machines can interact freely with - and may influence other participants in the HMN, whether human or machine.
- **D2-3 - Open activities:** The activities the machine agents can perform are open, giving opportunity for dynamic and perhaps unpredictable behaviour.
- **D2.4 - Human-like:** The behaviour of the machines in the HMN can be seen as intelligent and autonomous, with human-like appearance or behaviour.



Characterising and reflecting on the level and interplay of human and machine agency to design for in HMNs may provide insight into a range of relevant implications (Pickering et al., 2017). Consider, for example, how the evacuation support concept developed in eVACUATE, may strengthen trust in evacuation situations by strengthened machine agency on the basis of advanced sensors and intelligent systems (Eide et al., 2016). Følstad et al. (2017) also discuss how the strengthening machine agency in decision support systems may pave the way for human actors to refocus work on a more tactical or strategic level. Another example, is the mobile platform for reselling second-hand goods studied in another HUMANE case, where the case owner seeks to strengthen user motivation by lowering the requirements for human agency, through intelligent support for entering ads and matching sellers and buyers (Eide et al., 2016).

3.1.2 Relations

The characteristics of the relations between the actors of a network are important to classify a HMN. By *relations* we refer to the links or edges between the actors of the network. In HUMANE we are particularly concerned with the human-human and the human-machine relations of the network. We acknowledge the importance of the characteristics of the links between machine actors of a HMN. However, the HUMANE analysis is scoped so that linked machine components which for human actors behave like a single entity are seen as a single entity.

Drawing on sociological theory, we characterize the human-human relations in the network in terms of *social tie strength* (Granovetter, 1973, 1983). *Strong ties* tend to be structurally embedded, and are characterized by high intensity, high intimacy, high reciprocation, and long duration (Granovetter, 1973), facilitating trust, improving solidarity and cohesion in the network, and decreasing conflict (Krackhardt, 1992; Nelson, 1989). Strong ties and strongly bonded networks, also are seen as facilitating collaboration (Lüders, 2016). *Weak ties* occur between individuals who interact less frequently and who often have few connections in common, and have important bridging functions, facilitating the transmission of information (Watts & Strogatz, 1998), establishing contacts (Granovetter, 1973), or creativity (Burt, 2004). *No ties,* characterize HMNs which do not provide conditions for social interactions at all, and participants remain mainly unaware of other participants' numbers and actions except on an aggregate level, such as for search engines.

The human-machine relations are mainly characterized with a basis in trust theory (Mayer, Davis, & Schoorman, 1995). Human actors within an HMN need to consider whether or not machine nodes are capable of performing the service or function desired. Only then are they prepared to exercise reliance and adopt the technology (Chuttur, 2009; McKnight, Carter, Thatcher, & Clay, 2011; Thatcher, McKnight, Baker, Arsal, & Roberts, 2011a; Venkatesh, 2000). We refer to this trust relationship between human and machine actors in an HMN as *human-machine relationship strength*. As discussed by Engen et al., (2016), establishing the trust relation required between humans and machines in the HMN may depend on a well-functioning interplay between human and machine agency and human agency.

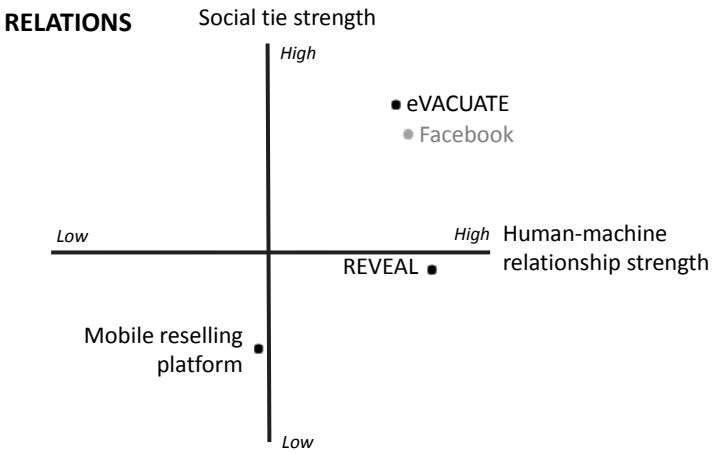
D3 - Social tie strength. High level characterized by:

- **D3.1 - Intimacy:** People in the network are typically connected to one another by friendship or other close affiliation
- **D3.2 - Duration:** Relationships between people in the HMN typically last a long time
- **D3.3 - Reciprocation:** People in the HMN are typically mutually supportive

D4 - Human-machine relationship strength. High level characterized by:

- **D4.1 - Trust**: People strongly trust the machines in the HMN
- **D4.2 - Reliance:** People tend to accept what the machines of the HMN do and would only rarely intervene
- **D4.3 - Dependency:** People depend on the machines in the HMN to achieve their goals

Rather than seeing different levels of *social tie strength* and *human-machine relationship strength* as strictly divided in types, we see these dimensions as continuums from low (no social ties / no trust in machine actors) to high (strong social ties / strong trust in machine actors), thereby allowing for more nuanced characterizations.



Characterizing a HMN on its relations dimensions, may open up for relevant implications. For example, in the HUMANE work on sharing economy HMNs (Jaho et al., 2017), such as the case of a mobile reselling platform (Følstad et al., 2016) we see that these are often characterized by high human-machine relationship strength, whereas the social tie strength between participants typically are low. This reflects Botsman's notion of layered trust in sharing economy services, where trust in the individual depends on trust in the platform (Mittendorf, 2017). In consequence, sharing economy service owners may prioritize human-machine relationship strength to social tie strength when designing for their HMNs (Jaho et al., 2017).

3.1.3 Network extent

The extent of the HMN may be important for its sustainability. In particular as the network effects (Katz & Shapiro, 1994) due to increased network size and reach lead to increased value for its actors. However, increased network extent may be also be associated with important challenges, such as the need to adhere to varying legislations and cultural norms as geographical reach extends across borders (Gomez-Herrera, Martens, & Turlea, 2014; Pickering & Boniface, 2012; Stylianou, 2008).

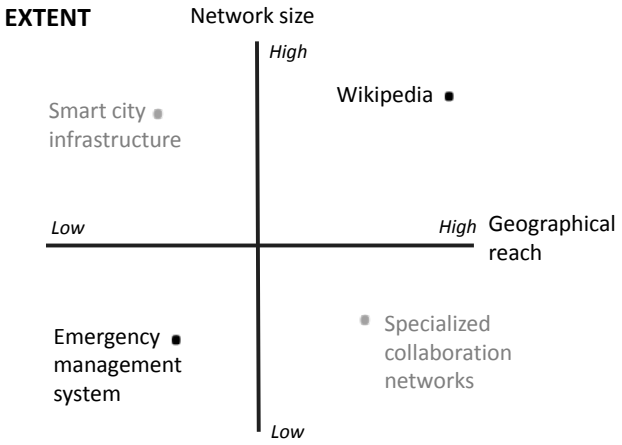
In HUMANE, we address network extent in terms of *network size* and *geographical reach*. Growth in terms of size and reach are today seen as key objectives for many HMNs, seen particularly for social networks such as Facebook and Twitter that rely on network effects both for functional and commercial reasons. Furthermore, network size and geographical reach may have important effects on other dimensions of the network, such as the need for increased machine agency and decreasing of social tie strength with increasing network size (Eide et al., 2016).

D5 – Network size. High level characterized by:

- **D5.1 Network effects**: Broad uptake is required for the intended network effects of the network to be realized.
- **D5.2 - Number of users:** The HMN includes a large number of users
- **D5.3 - Dominant positon:** The network has a dominant position in its target market segments.

D6 – Geographical reach. High level characterized by:

- **D6.1 Transnationality:** The HMN includes members and sites in several countries or states
- **D6.2 Cultural diversity:** The HMN includes members or sites across different cultural groups
- **D6.3 Geographical reach:** The HMN spans large geographical areas



For novel HMNs, high network size may be one of the critical characteristics to achieve for intended network effects to be realized. For example, within the sharing economy domain service owners accentuate the need for large size to network sustainability and adequate matching of supply and demand (Jaho et al., 2017). However, in initial phases, the network also needs to provide value even when size is low (Porter, 2010), something which represents a substantial design challenge. When the required network size is achieved, other challenges emerge such as that of information overload which may require increased machine agency for intelligent filtering and recommendations (Følstad et al., 2016).

While large network size often implies substantial geographical reach, high levels of geographical reach may also be found in HMNs with modest network size – such as in specialized decision support systems or collaborative networks. Low levels of geographical reach and high levels of network size may be found in smart city infrastructures. High levels of geographical reach may imply challenges resulting from the need for compliance with diverse legal systems and cultures, but also challenges of an even more practical nature such as collaboration challenges. For example, in the HUMANE case study, Zooniverse (Følstad et al., 2016), as well as in studies of Wikipedia (Yasseri et al., 2012) time similarities in contribution patterns tends to occur across time zones, limiting the opportunity for synchronous collaboration across the entire network. In consequence, local chapters may be needed for particular collaboration activities.

3.1.4 Network structure

The overall structure of the HMN may be characterized by the level of interdependence between its actors, and the general network organisation. Both dimensions concern the networks' capacity for emergent change. *Workflow interdependence* concerns the degree to which the actions of the actors in the network are dependent on and need to be synchronized with the actions of others. *Network organisation* concerns the degree of bottom-up vs. top-down organisation of the network.

The dimension of *Workflow interdependence* is loosely based on the concept of workflow (or task) interdependence from organisation theory (Collins-Thompson, Bennett, White, de la Chica, & Sontag, 2011; Van de Ven, Delbecq, & Koenig Jr, 1976). Here, patterns of workflow with increasing levels of interdependence starting with *pooled workflows* where the network actors contribute independently of each other, and culminating with simultaneous and multi-directional *team workflows*.

Network organisation has been a key area of interest from the early beginnings of social network studies (Borgatti, Mehra, Brass, & Labianca, 2009). Theorists of online social networks (Leadbeater, 2007; Shirky, 2008) have accentuated the capacity of these such networks for self-organisation and associated adaptability to local context, flexibility in problem solving, and innovative outcomes (Juris, 2012). The benefits of low levels of network organisation, and associated capacity for self-organisation, is also seen in other HMNs such as in the self-governance of knowledge commons such as Wikipedia (Forte & Bruckman, 2013).

However, HMNs in general, and online social networks in particular, may also benefit from being organized in a predefined, top-down fashion, in particular in order to improve network efficiency and effectiveness, as well as to strengthen predictability and quality control in the network. For example, in crowdsourcing networks, a top-down organisation imposed in terms of how contributions are aggregated and how remuneration is managed may strengthen network effectiveness and efficiency and thereby sustainability (Geiger, Seedorf, Schulze, Nickerson, & Schader, 2011).

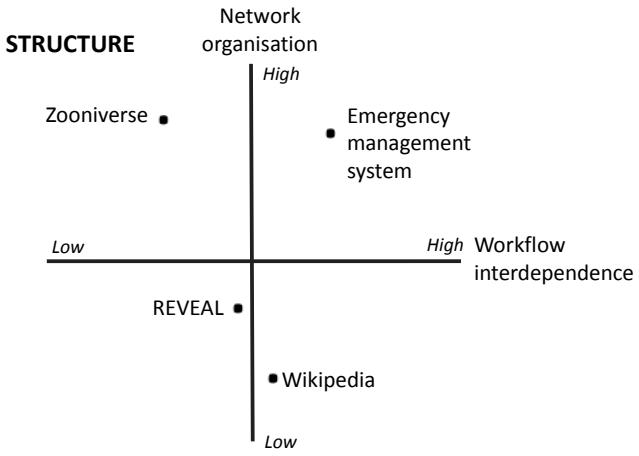
D7 – Workflow interdependence. High level characterized by:

- **D7.1 - Coordination:** Activity in the HMN require that people interact in a highly coordinated manner
- **D7.2 - Interdependence between actors:** The actions and communication between people in the HMN very much depend on the actions and communications of others
- **D7.3 - Collaboration:** There is extensive collaboration between the people in the HMN

D8 – Network organization. High level characterized by:

- **D8.1 - Top-down organisation:** The organisation of the HMN is highly centralized or predetermined.
- **D8.2 - Stability:** The HMN has a stable organisation that does not easily adapt to different conditions.
- **D8.3 - Regulation:** The HMN is regulated by thorough and detailed policies.

Emergent change may be more prevalent in networks characterized as bottom-up, where initiatives may spread from the grassroots. While efficient spread and refinement of emerging practices may require a certain level of interdependence between the network actors. HMNs characterized by high levels of network organisation and low levels of workflow interdependence may struggle to adapt through innovation and improvement in response to changes in the network context (Følstad et al., 2016).



At the same time, networks that emerge as grassroots or bottom-up initiatives may over time define structures to manage the growing organisation while at the same time keeping much of their self-organized character. Butler, Joyce, and Pike (2008) describe how such development and imposition of policies and guidelines have served to provide structure to the Wikipedia organisation. Likewise, for example, sharing economy networks, while often set out as allowing for a certain amount of self-organisation, benefit from increasing levels of network organisation in terms of efficiency and effectiveness in transactions (Jaho et al., 2017).

3.2 Addressing change when analysing and designing for HMNs

The synergetic effects of human-machine interplay in effective HMNs, changes in the HMN contexts, as well as fast-paced technology developments, make change a key characteristic of HMNs.

In consequence, HMNs may over time change in how they are characterized on the HUMANE typology. To some degree, human-machine networks are intended to change, but the change can be more or less predictable. In the HUMANE case eVACUATE, concerning a system for supporting crowd evacuation in an emergency situation, the HMN can be in different recurring states. This type of variation is largely predictable. Those designing and operating such HMNs can be expected to understand that different operational states will be required. A much more complex, and less predictable, network profile evolution may occur almost serendipitously as users take over a HMN for their own purposes. Twitter, for instance, is no longer merely a means to exchange personal and social updates to be shared with friends, families, and 'anyone else who knows me'. Instead, it is becoming increasingly politicised (Jungherr, 2014), and also becoming an arena for interactions between human users and automated accounts (Bessi & Ferrara, 2016). Emergent behaviours that were not initially predicted will exercise the typology in different ways. Users will and do exploit the full capabilities of a network for their own ends regardless of the originally targeted application.

In this section we will first take a look at key drivers of change in HMNs, before going into how such change may be analysed in terms of the HUMANE typology.

3.2.1 Drivers of change in HMNs

Emergent change, driven by the synergetic effects of the interplay between human and machine actors, may be seen as an inherent characteristic in HMNs. Such emergent change is, for example, seen in social networks and sharing economy services. Consider the development of the social network Facebook: starting out as a social network for connecting people at Harvard university campus, then extending to connecting across higher education institutions before opening up to become a global social network encompassing individuals, organisations, marketing communication, and civic initiatives alike. In organisational theory, it is argued that an organisation's capability for capitalizing on emergent change within and outside the organisation is key to sustaining competitive advantage (Teece, 2007). Likewise, analysis and design for HMNs needs to be sensitive to how to facilitate and capitalize on emergent change in the network.

Within the network, key drivers of change in a HMN may be characterized with reference to the HUMANE typology dimensions. We have above also discussed how the character of HMN actors, relations, extension, and structure affects its capabilities for innovation and improvement. For example, higher levels of agency in the network actors may motivate the diversity and creativity in activities required for innovation and improvement. Drawing on the theoretical position of social construction of technology, SCOT (Bijker et al., 1987), the evolving meaning making in variation in practice and interpretation of technology across social groups may lead to innovative uses which in turn drives technology innovation. Likewise, facilitating lower levels of network structure in the form or bottom-up organisation may serve to drive beneficial change.

Changes in the network context and technology may also drive change in the HMN. The profound impact of the spread and uptake of internet and mobile internet is well known[7], for example in terms of electronic commerce and the emerging platform economy, digital government, online citizen participation, online news distribution, and access to research and education. In coming years it is expected that emerging technologies within artificial intelligence (AI), machine learning, and smart things will significantly impact how humans and machines interact[8]. One example of such expected change may be the increasing influence of automated agents in online social networks. Studies from the 2016 US presidential election indicate that more than one fifth of the tweets that included the main election hashtags were generated by machine agents, potentially affecting the outcome of the election (Bessi & Ferrara, 2016). Driven by developments within AI and machine learning, in 2016 leading technology companies such as Google, Facebook, and Amazon, targeted conversational agents a highly influential emergent field of technology development (Dale, 2016), potentially profoundly changing how humans and machines interact in HMNs.

[7] Eurostat: Digital economy and society statistics - households and individuals. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Digital_economy_and_society_statistics_-_households_and_individuals

[8] Gartner's Top 10 Strategic Technology Trends for 2017. Available at http://www.gartner.com/smarterwithgartner/gartners-top-10-technology-trends-2017/

3.2.2 Addressing change in the HUMANE typology

Addressing how HMNs are expected to change may be used strategically for purposes of analysis and design for HMNs. However, while change in HMNs seem inevitable, understanding and addressing such change may be highly complex. As discussed above, change in HMNs may be the result of a broad range of drivers, in part external to the network itself. An assessment of such drivers, as well as any predictions associated with these imply substantial uncertainty.

While acknowledging the complexity in HMN change, we aim for the HUMANE typology to be useful for addressing aspects of such change. Specifically, change that affects a network's profile on the typology dimensions. In the following, we outline two forms of HMN change that may be addressed through the typology: Change towards an envisioned future HMN and recurrent change between different HMN states.

3.2.2.1 Change towards an envisioned future HMN

The first form of HMN change that may be addressed within the HUMANE typology, is change towards an envisioned future state "to be", that is, change towards a desired state that is not yet realized. The design and development work needed to realize an envisioned future state may be guided by a human-centred design (HCD) process.

To support a HCD the strategic design work needed to realize an envisioned future HMN, the HUMNE typology may be used to analyse the gap between the current HMN and the envisioned future HMN.

Example: Above (Figure 2), we presented the example profile of an envisioned sharing economy HMN. By contrasting this profile of an ideal future network with the profile of a current sharing economy HMN (Figure 3), we get an overview of HMN characteristics which would need to change in order to approach this envisioned HMN is accentuated. Lowering human agency implies reduction of the number of available tasks and increased standardization. An increase in machine agency is required to strengthen the intelligent matching of supply and demand, for example through filtering of content. Human-machine relationship strength needs to be increased, reflecting the need to strengthen user trust and loyalty in the platform. Network extent (size and reach) needs to be increased to obtain network effects and strengthen platform sustainability. Workflow interdependence should be reduced as well to avoid inefficient exchange e.g. between human actors in the HMN.

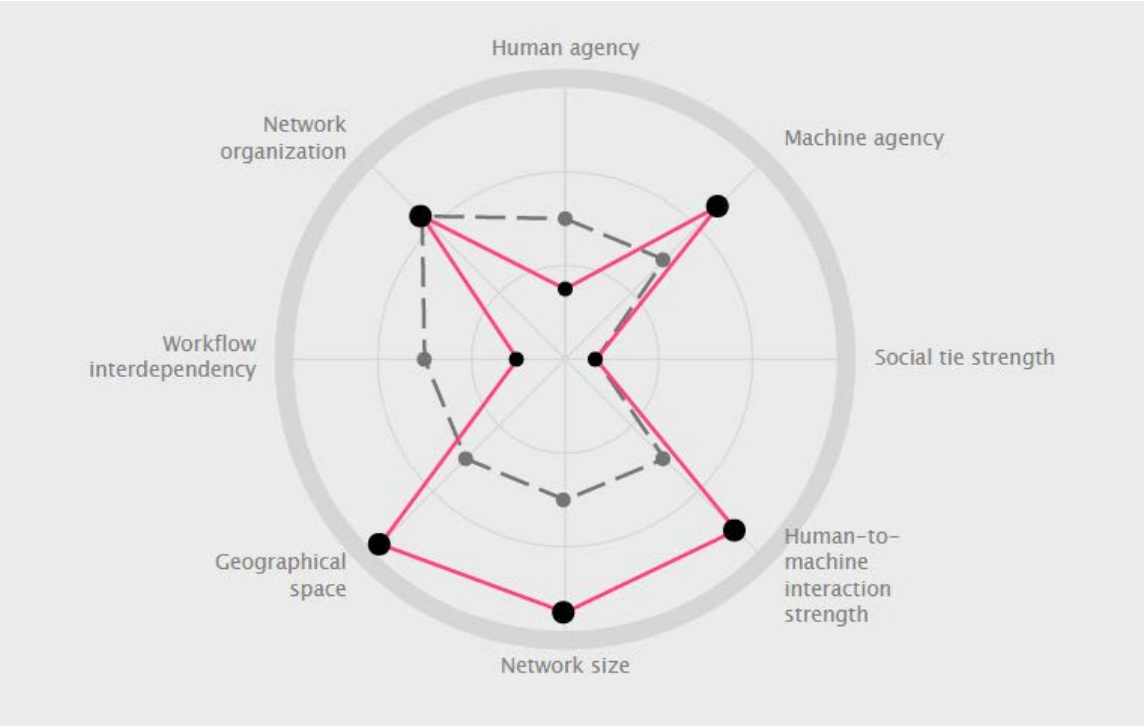


Figure 3: Example profile – envisioned sharing economy HMN (whole line) contrasted with current HMN (dotted line).

Hence, while a large number of drivers may affect change in HMNs, in HUMANE in particular we consider the change needed to move from the current situation to the envisioned HMN by seeing these as two different states. This extends the typology approach to HMN states as presented in previous versions of the typology (e.g. Følstad et al., 2015).

3.2.2.2 Change between alternating HMN states

The second form of change that may be addressed through the HUMANE typology, is recurrent change between different HMN states. This form of change is between known states of the HMN that may be readily investigated through real world examples. For example, in the HUMANE case eVACUATE which is a system for emergency evacuation of crowds, the HMN has two distinct states: that of monitoring and that of evacuation.

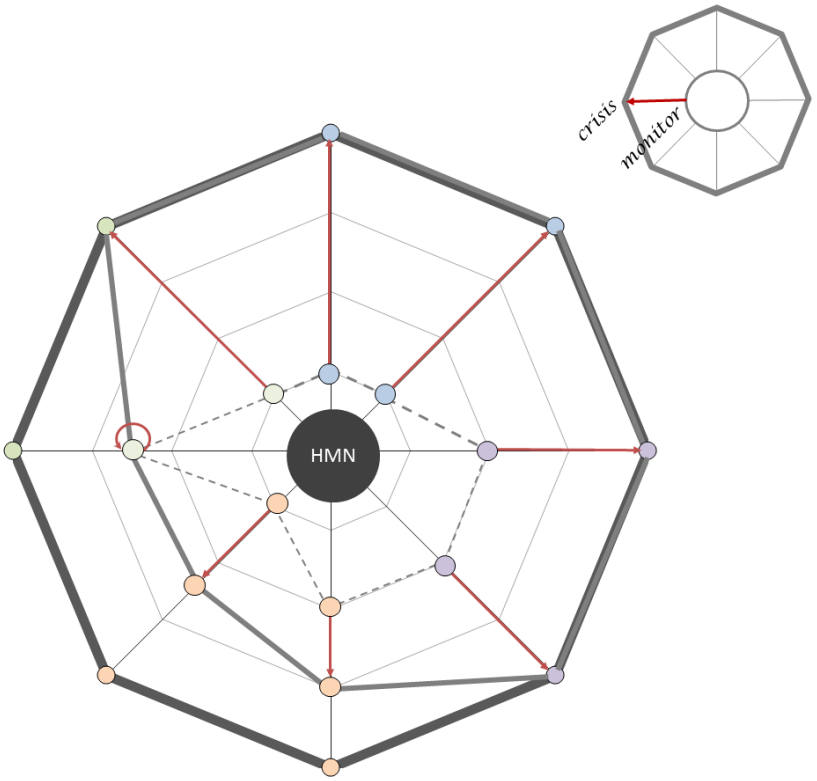


Figure 4: Looking at variation between HMN states

To analyse the difference between two HMN states, it is useful to visualize these. Figure 4 summarises one possible solution which we are evaluating with some of our original validation participants. As well as the profile diagrams originally shown in D2.1 (Følstad et al., 2015) for the HUMANE case eVACUATE, we have added additional information. First, the dynamic change in the network profile is shown with a set of arrows making explicit the direction of the variation. In this case, all but one dimensions (*Workflow Interdependence*) move to more extreme values as the HMN shifts from purely monitoring the situation to full blown crisis management: the safe evacuation of all involved. Add to this, however, further detail on the dimension change may provide a valuable insight for HMN design.

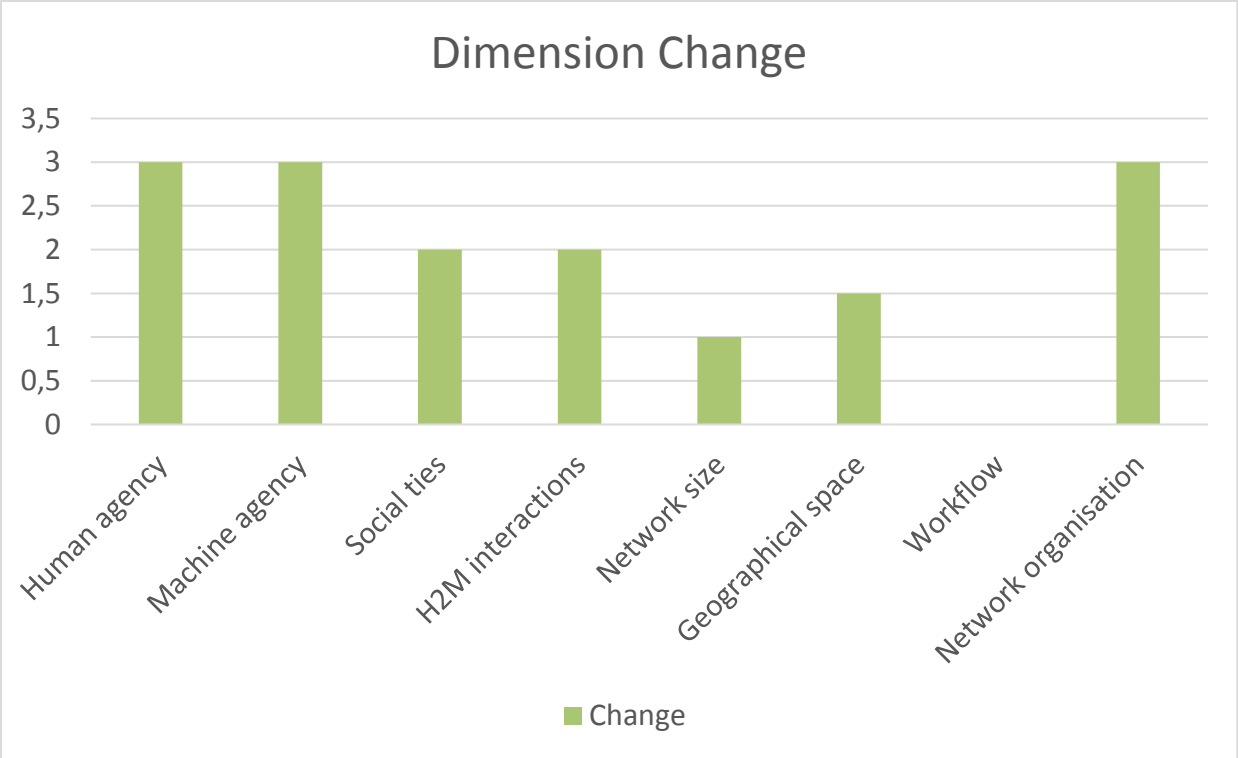


Figure 5: How individual dimensions change over time

Figure 5 summarises these changes. It is immediately apparent that the greatest changes occur in agency and *Network organisation*. Network organisation is often an engineering issue: network interfaces must be flexible and allow the dynamic inclusion of other resource as required. What's more important here, though, are the changes to *Human* and *Machine agency*. As we have discussed elsewhere, increasing *Machine agency* through automation can support increased *Human agency*, so long as task allocation and responsibilities are shared appropriately (Følstad, Engen, Haugstveit, & Pickering, 2017). Even more significant perhaps concerns the interplay of *Human* and *Machine agency* themselves which introduce issues of regulation, privacy and trust (Pickering et al., 2017).

In allowing temporal, activity-based variation to be represented explicitly on the profile will therefore enable other insights into the design implications for a given network. Reviewing other HMNs with similar change patterns as highlighted in Figure 5 may also provide a useful index into wider implications and the identification of relevant design solutions.

3.3 The evolving typology

The current version of the typology presented in this deliverable, is the result of an iterative process where earlier typology versions have been applied in case trials for feedback and refinement. The process of development and associated deliverables are presented in Figure 6

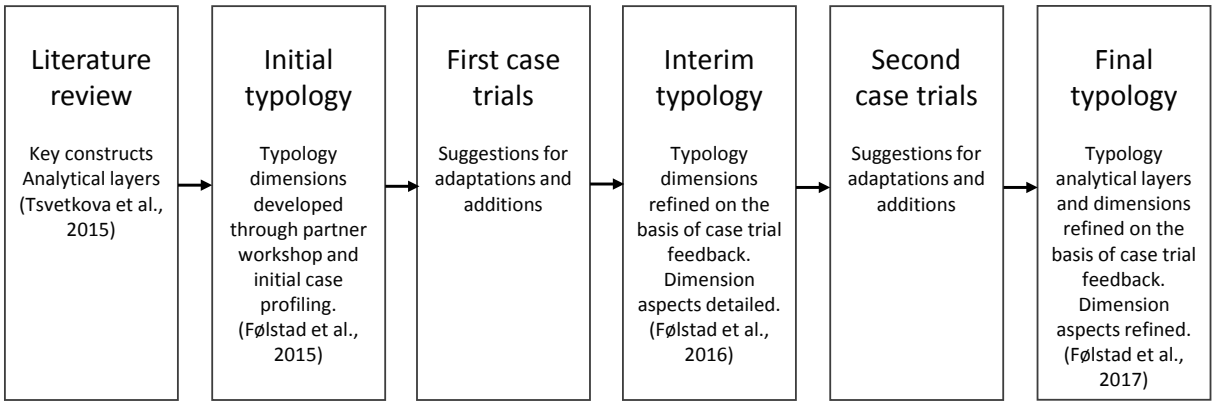


Figure 6: Process for HUMANE typology development

During the development process, it has become clear that one of the major benefits of the typology may not be in a direct aid for detailed network design. Rather, a benefit of the typology is to provide a relatively simple and accessible way to characterise and visualise a given HMN. Hence, the typology supports multi-disciplinary discussion and exploration of the network to identify issues and challenges, and to motivate design considerations. This was an unexpected outcome from the various validation engagements with our use cases, but represents a significant benefit: in supporting cross-discipline discussion, the typology offers multiple stakeholders a common basis to be able to explore the potential of the network.

In the following we summarize the main changes concerning the objective of the typology and its analytical layers and dimensions.

Changing objective: Throughout the project, the aim of the typology has been to provide support for the analysis and design for HMNs. The case studies indicated that this objective needed to be made more precise, as the typology was found to better support the initial strategic phases of the design process rather than implementation. As outlined above, this change to the original objective has revealed unexpected benefits in opening up multi-stakeholder discussion.

Refining content: The initial version of the typology was the result of extensive revision of a larger initial set of proposed typology dimensions. In the second version of the typology, the eight initial dimensions were kept with some minor revisions. Also, the dimensions were formulated in a more precise manner, by detailing a small number of key aspects for each dimension. In the final version of the typology, given the feedback from the second case trials that some of the typology analytical layers and dimensions were difficult to understand, we have reworked the typology terminology to better reflect the underlying conceptual understanding of each layer and dimension. In consequence, we have also provided greater emphasis in the preceding sections on what the consequences would be of instance of extreme values for a given dimension.

For future use of the typology, we recommend applying the typology layers and dimensions as presented in this deliverable.

4 Implications of the characteristics of an HMN

The HMN typology is intended as a means to characterise and classify HMNs, to support analysis and design. In particular, it is assumed that variation in the levels of the HUMANE typology dimensions may have a broad range of implications for how the humans in the network experience and behave as well as the underlying technical infrastructure.

For example, as is discussed above in Section 3.1.1, different levels of human or machine agency may hold implications for e.g. motivation or trust. Or, as discussed above in Section 3.1.4, different levels of network organization may hold implications for innovation and improvement as emergent change may be more prevalent in networks with low-levels of network structure.

In HUMANE we are in particular concerned with five groups of implications:

- User experience and motivation
- User behaviour and collaboration
- Innovation and improvement
- Privacy and trust
- Underlying technical infrastructure

In this section we provide a theoretical basis for each of the groups of implications. Then, we will in the subsequent method description (Section 5) detail how these implication groups are addressed within the HUMANE approach.

4.1 Implications for experience and motivation

The characteristics of HMNs potentially have important implications for how users experience the network, and how they are motivated to take part.

User experience of interactive systems has been much studied within human-centred design. User experience is understood as "a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service" (ISO, 2010), and concerns both cognitive and affective aspects. Cognitive aspects may concern aspects such as the perceived usefulness and ease of use in the interaction (Davis, 1989), where the user experience depends on the reaching of clear goals. Affective aspects concern experiences which hold an emotional valence, where the interaction may be seen as enjoyable or pleasurable in its own right (Hassenzahl & Tractinsky, 2006). Whereas HMNs characterized by a hierarchical or centralized network organisation and low levels of human agency may serve as an adequate environment for attaining the reaching of explicit goals in an effective and efficient manner, the fuzzy goal of having an affectively satisfactory experience may depend on the HMN holding different characteristics, such as an option to attain higher levels of agency and a more flexible network organisation.

User experience has been shown to depend strongly on the context in which system interaction takes place (Vermeeren et al., 2010), and to evolve across time as the user becomes more familiar with the interactive system (Kujala, Roto, Väänänen-Vainio-Mattila, Karapanos, & Sinnelä, 2011). Hence, while

a HMN may facilitate a desired user experience, the experience cannot be designed as such. We can design for a particular user experience, but the experience as such is created as the human actors engage in the network (E. Law, Roto, Vermeeren, Kort, & Hassenzahl, 2008).

User experience is closely related to user motivation. Drawing on theory from psychology and educational studies, it is useful do distinguish between intrinsic and extrinsic sources of motivation (Ryan & Deci, 2000) for participating in HMNs. *Intrinsic motivation* concerns when an activity or engagement is seen as inherently interesting or enjoyable, such as in Csikszentmihalyi's (1992) notion of *flow* - the pleasurable state of complete absorption or concentration in a task or activity. Also social interaction in HMNs may be a source of intrinsic motivation. In a study of user motivations for social network sites (Brandtzaeg, 2012), key motivators included socializing with new relations and socializing with friends, information gathering, and debating. HMN characteristics of human agency and social tie strength may greatly affect the degree to which intrinsic motivators may be supported. For example, low levels of human agency, through highly structured processes and limited task types available to users, may suggest that intrinsic motivation may be challenging as with respect to users ability to engage with others for informal socializing.

For HMNs which characteristics do not lend itself to intrinsic motivation, such as low levels of human agency or low levels of human-machine tie strength (where the relation between humans and machines is characterized by low levels of dependency and reliance), it will be critical to design the HMN with regards to providing adequate *extrinsic motivation*, where the users activity leads to a desirable outcome that is separate to the task itself, such as a reward or the absence of punishment. Extrinsic motivation may depend on the HMN helping users to reach goals that hold value to them, as in a way that is seen as useful and efficient. Venkatesh et al. (2000), on the basis of the technology acceptance model, show how perceptions of usefulness and ease of use affect motivation and behavioural intent.

Gamification is one much researched approach for strengthening extrinsic motivation in HMNs, through the setting of goals relative to features such as points, leaderboards, badges, and achievement levels. Hamari et al. (2014), in a review of existing research on gamification, show how gamification may positively affect both psychological and behavioural outcomes.

4.2 Implications for behaviour and collaboration

When considering implications for behaviour and collaboration in HMNs, a number of areas are relevant. In the following, we will provide an overview of literature specifically addressing behaviour change and social interaction.

Designing for HMNs often entails identifying and implementing means to drive behaviour change. For example, in terms of the human network actors taking up new tools or processes to improve work performance or in terms of changing human behaviour towards desirable new behaviour patterns. An example of the latter is the intended behaviour change towards sustainability implied in sharing economy networks. In the emerging field of social physics, Pentland (2014) discusses how behaviour change can be predicted and directed within social networks. Exposure to people holding alternative

attitudes and social motivation are shown to be critical drivers of behavioural change. In particular, weak ties are important to the diffusion of attitudes, as well as ideas (Granovetter, 1973), and may hence be instrumental also in behaviour change. Hence, network characteristics such as social tie strength and network size may hold important implications for behaviour change in the network.

The link between expectation and attitudes and behaviour change have been investigated, not only in the field of social physics, but from a broad range of theoretical perspectives such as the theory of planned behaviour (Ajzen, 2011) from the field of psychology, and the technology acceptance model (Davis, 1989) from the field of information systems. This close link is noteworthy, as network characteristics that affect experience and motivation, discussed above, ultimately also may hold implications also for behaviour and behaviour change.

Social interaction and collaboration are relevant topics of a HMN implication analysis, as the synergetic process in a network strongly benefit from high levels of interaction within the HMN. However, users are often not interacting as much as desirable (Lüders, 2016). Furthermore, social interaction between users in the network may be fragmented across multiple channels such as an online social platform, sms, phone, email, and face-to-face meetings (Haugstveit, Halvorsrud, & Karahasanovic, 2016). The long term benefit of strengthening collaboration and social interaction in a HMN, may hence be compromised by the conflicting short-term goals of the users. The social interaction and collaboration patterns are impacted by a number of HMN characteristics, such as the network organization, the level of human agency in the network, and the strength of the relations between users in the network as well as the human-machine relations.

The example of Wikipedia illustrate how social interaction and collaboration may be affected by the network characteristics. While the relatively weak social ties among editors are instrumental in the spread and uptake of Wikipedia editing, these may also affect collaboration negatively. Previous research suggests that edits and in particular, reverts of other editors' contributions, can be used to wage wars around controversial articles (Brandes, Kenis, & Lerner, 2009; Sumi, Yasseri, Rung, Kornai, & Kertész, 2011). Negative social interactions such as revenge and serial attacks may indeed occur on Wikipedia and are often associated with how senior the involved editors are (Tsvetkova et al., 2016b). In a sense, project contributions can be used strategically in social interaction and thus, social processes can affect collaboration.

Our research on Wikipedia (Tsvetkova, García-Gavilanes, & Yasseri, 2016a) also suggest the emerging need to consider human-machine and machine-machine collaboration in HMNs. Although bots constitute a tiny proportion of the total number of Wikipedia editors, they do a disproportionately large number of article edits. Importantly, bots often undo each other's edits and these "fights" may sometimes continue for years. In other words, our findings suggest that bots on Wikipedia are not designed for interaction and appear to be badly coordinated.

4.3 Implications for innovation and improvement

In recent innovation theory, such as theory of open innovation (Chesbrough, 2006) and theory of user innovation (Von Hippel, 2005), connecting with actors outside the established structure of an organisation is seen as beneficial for innovation. The theorists of these positions argue for the benefit of opening up existing intra-organisational structures for innovation, to benefit from competency and expertise outside the formal structures of the organisation. Similarly, the organisational theorist Teece (2007) argue that an organisation's capabilities for sensing emerging opportunities through a continuous scanning of the environment is critical for innovation and improvement.

The need for breaking up established structures and processes as part of innovation is also seen in the tradition of design thinking (Brown, 2009). Here, the highly structured innovation processes, driven by requirements and specification, is challenged by arguing that break-through innovation may require a more open process where designers challenge assumptions, seek qualitative insight and inspiration through familiarizing themselves with the domain, and move rapidly through possible concepts and prototypes.

In terms of the HUMANE typology, the recommendation to open up organisational structures, and challenging highly structured processes may be seen as a lowering of network organisation, moving from a top-down towards a bottom-up approach to innovation, and motivating self-organisation rather than centralized control.

At the same time, as shown by Van Aken and Weggeman (2000) there may be a need to balance the benefit of informal networking with some level of management and structure, to avoid an under-exploitation of the networks innovation potential. That is, while too high levels of organisational structure may be counter-productive to creativity and innovation, too low levels of structure may fail to realize the potential innovation capacity in emerging networks.

This need for balancing between a top-down and bottom-up approach to innovation, is seen in current open-innovation platforms following the model of Dell's Idea Storm (Bayus, 2013). Here, users and stakeholders are invited to contribute to the innovation processes of a brand or company, in particular in the ideation phase. Here, the aim is to bring together resources with weak or no social ties to contribute to a common innovation process. Informal networking between the external participants are typically encouraged. Nevertheless these platforms often have a fairly centralized and top-down organisation to fit the external input into the innovation processes of the company.

Innovation is not only the result of planned innovation processes, but may also be the outcome of novel products or services being disseminated and taken up in different user groups. Following the perspective of social construction of technology (SCOT) (Bijker, Hughes, & Pinch, 1987), the meaning making associated with the uptake of new technology may drive innovation. Here, the character of the social ties of the networks are important, as weak social ties are seen as important for the spread of ideas – serving as bridges between closely knit social groups (Granovetter, 1983).

A HMNs capability for innovation and improvement may also be affected by the level of agency bestowed on the network actors. Følstad et al. (Følstad et al., 2017) suggest that increasing machine

agency, for example through automation of routine processes in HMNs characterized by relatively low levels of human agency, may strengthen human actors' capacity for strategic and tactical work potentially facilitating innovation and improvement.

4.4 Implications for privacy and trust

The relationship between privacy and trust in HMNs might intuitively seem straight forward: if regulation can assure appropriate controls which guarantee privacy then this will lead to increasing levels of trust. However, this is not necessarily the case. For one of the most influential models, trust is defined as

> "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer, Davis, & Schoorman, 1995, p712)

This suggests at least that trustors engage in some sort of risk assessment to determine whether or not they are prepared to make themselves vulnerable (Shin, 2010). Indeed, in their later revision to the model, Mayer and his colleagues discuss how trust once compromised may yet be rebuilt (Schoorman, Mayer, & Davis, 2007). Further, as we have argued elsewhere, privacy regulation may not always be enforceable[9] or indeed protect the potential victim[10]. Privacy regulation may instead affect perceptions of risk and agency (what is permitted) in a network which may in turn mediate effects on trust (Pickering et al., 2017).

Trust remains an organising principle (McEvily, Perrone, & Zaheer, 2003), however, affecting many different aspects of interaction (Rousseau, Sitkin, Burt, & Camerer, 1998). Within the ICT environment, the assumption has been that person-to-person and / or person-to-organisation trust may directly transfer to and inform trust in technology (Thatcher, Zimmer, Gundlach, & McKnight, 2008). Certainly, more recent extensions to the technology acceptance model (TAM) (Chuttur, 2009; Thatcher, McKnight, Baker, Arsal, & Roberts, 2011b; Venkatesh et al., 2000) as well as online commercial transactions (Egger, 2000; Featherman, Miyazaki, & Sprott, 2010) have been based on just such an assumption. For networks, though, personal contact and social interaction seem to dictate how trust is developed and maintained (Li, Rong, & Thatcher, 2012), to the extent that virtual SNS-based engagement even develops similar characteristics, both positive (Ellison, Heino, & Gibbs, 2006; Marwick & Boyd, 2011) and negative (Slonje, Smith, & Frisén, 2013; Wigderson & Lynch, 2013), to the real world.

Privacy, in terms of the ability to be able to control information disclosure (Shin, 2010), turns out to be increasingly problematic. On the one hand, users may simply not be in a position to exploit all privacy features of a given service (Strater & Lipford, 2008). Irrespective of the amount of regulation ostensibly providing assurances of security, users simply don't understand what the implications are of their privacy decisions (Acquisti, Brandimarte, & Loewenstein, 2015; Strater & Lipford, 2008). The focus

[9] https://humane2020.eu/2016/12/15/gdpr-the-right-to-be-forgotten/
[10] https://humane2020.eu/2017/01/24/cyberbullying-no-place-to-hide/

should not be empowerment by regulators, but on supporting context-dependent user expectation and understanding (Acquisti et al., 2015). Ultimately, users seem to base decisions not on objective criteria, but in connection with a complex cost-benefit analysis [Acquisti, 2012] based on affective as well as cognitive responses (Shin, 2010) to any contention between a need for public presence versus a desire for privacy (Acquisti, 2009; Miltgen & Smith, 2015).

Privacy and trust are therefore related constructs, though interact to influence networked behaviours. As automation increases (Følstad et al., 2017), it is not necessarily clear how this interaction will develop. The dangers of misunderstanding the impacts of disclosure in an assumed private environment have been well-documented (Ronson, 2015). What is only recently becoming more apparent, though, is that regulation cannot keep up with the increasing sophistication of machine agency on the one hand and commercial but also social pressures, on the other. Privacy has become an economic asset; and is compromised at the same time by opaque inference engines and procedures (Hildebrandt, 2016). It has been clear for some time that e-Services that are easy to use and offered by credible providers mitigate perceived risk and are likely to lead to adoption (Featherman et al., 2010).

For the ongoing survival of any given HMN where privacy and trust are concerned, design must take into account both users and their expectations whilst being realistic about where responsibility lies for privacy and information propagation. It is not enough to create an attractive environment and claim compliance to appropriate standards and regulation. Instead, continued motivation and participation are predicated on a dynamic conversation between users and providers and an understanding that social norms and affect influence users while they do not necessarily appreciate the full implications of increasing agency or of their privacy choices.

4.5 Implications for the underlying technical infrastructure

The way in which we refer to the technical infrastructure here should not be confused with our use of the term ‘machine’ in the HUMANE typology. Machines are agents that depend on a technical infrastructure in a HMN (as do human agents, for that matter). The infrastructure involves both the processing (computing), storage and networking architecture that supports the functions of the HMN. An example distinction can be seen in a Service-Oriented Architecture (SOA) (Perrey & Lycett, 2003), which allows multiple services to be deployed within a network using a particular protocol of communication like SOAP (W3C, 2007) or REST (W3C, 2011). In this case, the services can be machine agents, which reside on a compute resource connected via a physical or wireless network that we can refer to as the underlying technical infrastructure.

There is a significant relationship between both the machine and human agents and the underlying technical infrastructure, in terms of their agency and the relationships they have potential to form. For example, different types of architectures may allow different level of autonomy, which would affect the agency. Also, architectures such as Peer-to-Peer (P2P) (Subramanian & Goodman, 2004) allows for a bottom-up (de-centralised) network structure, allowing self-organisation and emergent behaviour, which may have opportunities for flexibility, robustness and sustainability (Juris, 2012).

There is also a significant relationship to the other groups of implication. Privacy and trust requirements may, for example, have implications for the underlying technical infrastructure in terms of how data is transferred and stored. One noteworthy example is health-care HMNs needing to handle personal and sensitive information. As such, regulations (laws/legislations and standards) may have direct implications on the underlying technical infrastructure. Further, as proposed in a recent trust model by Pickering et al. (2017), regulation is seen to affect both human and machine agency, as well as the perception of risk; all of which may affect the behaviour of people in HMNs. To continue with a health-care HMN example, implementing standards such as HL7 may reduce the perception of risk by people who may use the HMN, encouraging their participation in the HMN. However, Pickering et al. (2017) also hypothesise that machine agency is negatively correlated with regulation. That is, regulations may constrain the functionality and behaviour of machines in a HMN.

Related to experience and motivation, as discussed above, we also see a significant link with the underlying technical architecture. For example, as SOA, GRID and Cloud Computing architectures emerged, Service Level Agreements (SLAs) come hand-in-hand in order to provide customers with assurances of the Quality of Service (QoS) that they could expect (Stantchev & Schröpfer, 2009). This notion, therefore, brings typical non-functional requirements such as availability, reliability and performance to end-users of services. This is not merely about a financial agreement, establishing the terms of trade with potential penalties if the service provider cannot fulfil the SLAs; it is also about the Quality of Experience (QoE) from the users' perspective (Moller, Engelbrecht, Kuhnel, Wechsung, & Weiss, 2009). The latter is about the satisfaction that end-users experience when using the services according to their expectations. If the services offered by the HMN does not fulfil the expectations from the users, they may simply use an alternative. As such, despite technological advances, system response time remains a key property of the technical infrastructure directly linked to user satisfaction (Hoxmeier & DiCesare, 2000).

One of the key selling points of Cloud Computing is scalability and elasticity; you only pay for the resources you need, and can scale up dynamically, adding infrastructure resources like compute nodes and storage should demand rise (Armbrust et al., 2010). If a HMN can expect significant changes, whether regularly or ad hoc, this is an architecture that should be considered. One example where this model is used is the HMRC in the UK, who have a very low load most days of the year, except for the period of the annual tax return (Britten, 2015). Another case is where a network may have different states in which the properties of the network pertaining to agency, interaction and structure may change, as in the eVACUATE network, which is discussed in Section 6.3. Interested readers are referred to an example of implications for eVACUATE with respect to state changes presented in the interim version of the HUMAN typology and method (Følstad et al., 2016).

5 Method

The HUMANE method comprises five steps (see Figure 7). Each step depends on the former, similarly to the phases of the HCD methodology (see Section 2.3). The figure below also shows what phase(s) of the HCD methodology each step targets.

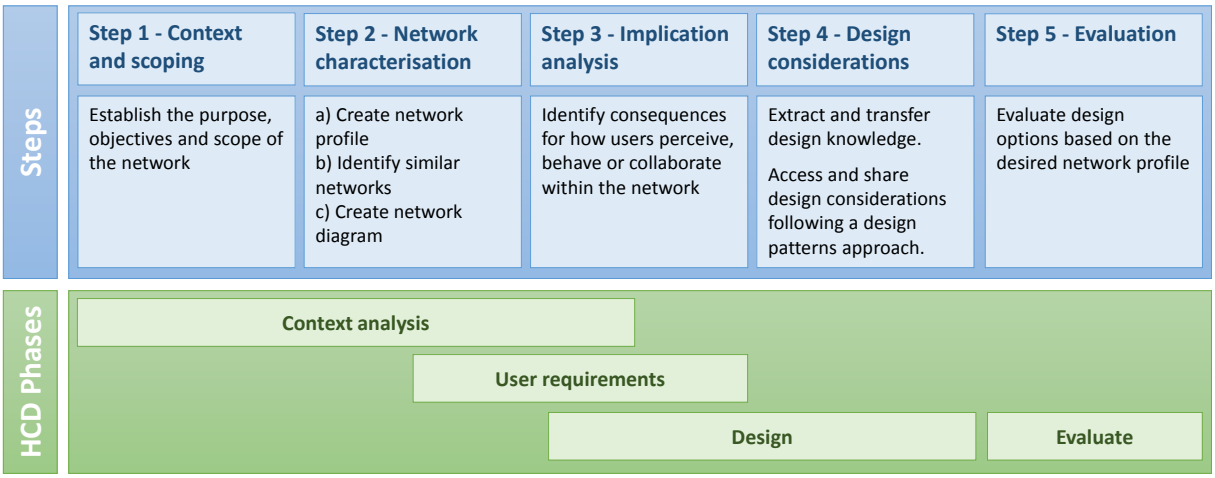


Figure 7: The HUMANE method mapped to HCD methodology.

Step 1 – context and scoping: Identify and describe the purpose of the HMN, broken down into objectives that can be used when assessing implications of design options, as well as evaluating the design(s) against. This step also includes a scoping exercise, to be clear about who the actors are who are considered to be a part of the HMN. This can be particularly important for HMNs that link with other networks, so as to not confuse the target network with other related networks in the subsequent method steps. The step overlaps in part the first step of the HCD process.

Step 2 – network characterisation: Characterising the HMN, primarily by creating a network profile using the HUMANE typology, potentially via the HUMANE profiling tool (see Section 8). By help of the tool, this is also the step in which other HMNs with similar profiles may be identified. Such identification can be valuable for comparison and for transfer of design experience. Finally, in this step, a more structural view of the network can also be created, by producing an initial network diagram depicting the known agents and how they are connected to form the HMN. The step overlaps in part the two first phases of the HCD process.

Step 3 – implication analysis: Based on the HMN profile and network diagram from Step 2, key implications with consequences for the design of the network may be identified. We in particular consider five implication groups: motivation and experience; user behaviour and collaboration; innovation and improvement; privacy and trust; and underlying technical infrastructure. The step overlaps in part the three first phases of the HCD process.

Step 4 – design considerations: Design knowledge and experience may be derived from the existing literature or from other successful HMNs. Having found HMNs with similar profiles in Step 2, those that successfully achieve objectives which are desirable for the HMN under design (or re-design) is

analysed with the aim of transfer of experience and knowledge. The step overlaps in part the third phase of the HCD process.

Step 5: Based on the desired network profile, this can be used as a benchmark for evaluating the design options. The step overlaps the fourth phase of the HCD process.

The steps are seen as supporting a creative or exploratory design process, and cannot be expected to be applied mechanically to achieve the desired results. Rather the steps facilitate discussion and reflection pertaining to e.g. implications of the HMN and transfer of knowledge and experience from successful HMNs. This is discussed further below.

5.1 Step 1: Context and scoping

In this step, the purpose and objectives of the HMN should be identified. The objectives are used directly in the latter steps of the HUMANE method, for interpreting implications and evaluating designs against.

To clarify the distinction between these two, you can, for example, define the purpose by answering ***why*** the network exists (or should exist, if it is a new network being designed). The key means of achieving (i.e., ***how***) the purpose can thereafter be broken down into objectives. The objectives are typically more tangible and should ideally be measurable. Moreover, the purpose of a network is likely to remain the same over time, while the objectives, business models and the HMN itself are likely to change.

If we take Wikipedia as an example, we could, for example, define the following purpose: *providing a free-access, free-content, Internet encyclopaedia*. In order to achieve that, we can, for example, define the following objectives:

- Facilitating cross-cultural synergy towards collaborative work.
- Advocating the free sharing culture.
- Developing infrastructure for fostering large-scale collaborative work.

A second activity that should be performed in this step is to scope the HMN. Minimally, this involves identifying the type of actors, both human and machine, and establishing their functions and capabilities in the network. Results from the HUMANE case studies (as summarised above in Section 2.4) demonstrated that people are prone to have different scopes of their respective network in mind, leading to inconsistencies when performing the profiling exercise part of Step 2. Depending on the nature of the HMN, the scoping should clarify boundaries of the network, especially if it interconnects with other networks (e.g., social media platforms or other Internet services). For example, although a particular HMN connects with Twitter users, it would be inappropriate to extrapolate the HMN to include Twitter in its entirety.

5.2 Step 2: HMN characterisation

Characterising a HMN is done through a profiling of the envisioned HMN, an analysis of the change involved in obtaining this profile, and an identification of similar HMNs. In addition, an optional network diagram may be drawn to further support the analysis.

5.2.1 Profiling

When the scope of the HMN is clarified, the HMN is to be characterized on the typology dimensions. We refer to this characterising process as **profiling**. The profiling represents an opportunity for strategic consideration and reflection on the key characteristics of the HMN to be analysed or designed for. Within human—centred design there is an established tradition for characterizing user groups in terms of prototypical characters, so called personas (Cooper, 1999). The HUMANE profiling may be seen as a similar exercise, but on the level of the entire HMN. Characterising the envisioned HMN should provide a target for guiding later design and development decisions.

The profiling follows the overall structure of the HUMANE analytical layers. First, typical human and machine actors of the envisioned HMN are considered in terms of the intended agency. Second, the strength of the relations between these actors are characterized. Thirdly, the envisioned extent of the network in terms of size and geographical reach. Finally, the overall structure of the network – both in terms of the intended interdependence between actors and the overall network organisation. An example profile is presented in Figure 2 above.

The profiling of a relatively homogeneous HMN is relatively straight forward. More challenging is the profiling of HMNs with great variations in their actor groups and how these different actors relate to each other. Whereas for homogeneous HMNs, it may be appropriate to make aggregations across the different agents in the system. However, in NMS characterised by substantial variety in actors and relations, it may be necessary to reflect this by creating multiple profiles for the different key stakeholders that should be analysed. Also, as shown for one of the case examples below (Section 6.2), as some HMNs important variations in state, this may also need to be reflected in multiple profiles.

The profiling process is supported in the HUMANE online profiling tool (http://networkprofiling.humane2020.eu). Here, the detailing of each dimension is supported by a set of questions concerning the key aspects of the dimension.

For example, *D3 – social tie strength* is broken down in the following aspects, where high agreement with each aspect translates into a high level on the dimension in question.

- D3.1 – Intimacy: People in the network are typically connected to one another by friendship or other close affiliation
- D3.2 – Duration: Relationships between people in the HMN typically last a long time
- D3.3 – Reciprocation: People in the HMN are typically mutually supportive

The full set of aspects detailing the typology dimensions are provided in the Appendix.

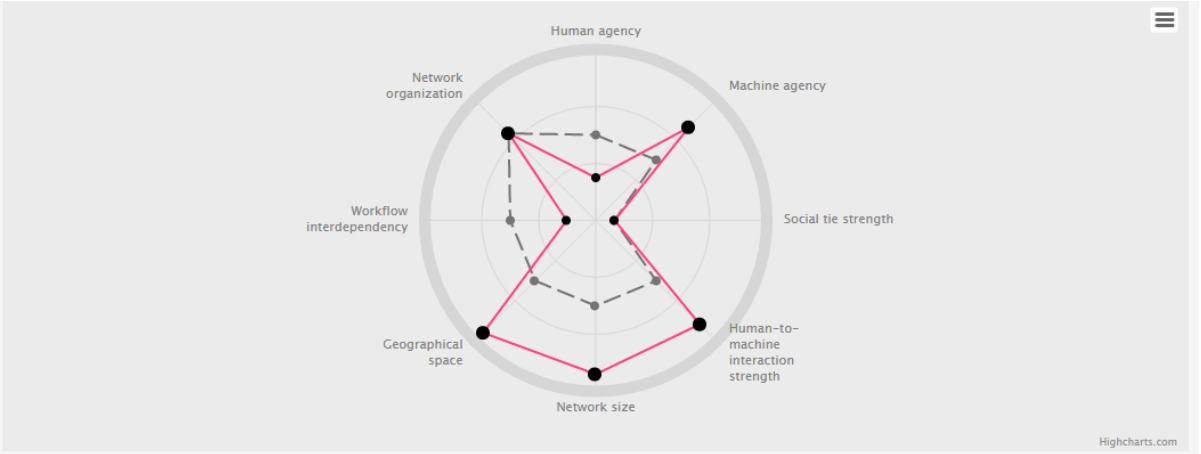
While profiling a HMN on the HUMANE typology dimensions is relatively straight forward, in particular if supported through the online profiling tool (https://networkprofiler.humane2020.eu), the utilization of the profiling for purposes of strategic reflection and design support may require an in-depth understanding of the typology and method. Previous case studies in which the typology have been applied for profiling purposes suggest that the process will benefit from being led by an analyst with in-depth knowledge of the typology.

5.2.2 Analysing required change

With a starting point in the profile of the envisioned HMN, the design team may analyse the current situation and what it requires to move from this to the envisioned end-point. The analysis of the current situation involves an assessment of the HMN as it is at the starting point of the design and development process. Each of the typology dimensions are considered, and dimensions for which change is needed are identified.

As support for the analysis of needed change, the online profiling tool provides a feature for setting up alternate scores for each of the typology dimensions. The HMN profile then highlight the dimensions where change is required (see Figure 8). How to achieve the required change is made subject of the subsequent implication analysis and the extraction and transfer of design knowledge.

Note, however, that depending on the perspective of the analysis, the alternative dimension scores may hold different connotations. If the analysis mainly consider an existing HMN, then the alternative scores could instead show the desired or expected future levels for the dimensions. Or, as we shall see below, if the analysis considers an HMN with two different recurring states, the alternative scores could represent one of these states.



The figure above visualizes the network profile of the HMN. In the table, the results for each dimension along with a more extensive description of the dimension is provided.

Dimension	Score	Description	Alt. score
Human agency	Low	The activities typical users can engage in are highly limited and predefined. There is typically not much interaction between the users.	Intermediate
Machine agency	High	The activities of the machine components of the network are open and varied, possibly human-line, often aimed at influencing others.	Intermediate
Social tie strength	Low	The users of the network typically do not have pre-existing social ties.	-
H2M interaction strength	High	The users of the network strongly depend and rely on the machine components of the network.	Intermediate
Network size	High	The network has a large or massive number of users, with high levels of diversity in the user groups. The network has seen large growth.	Intermediate
Geographical space	High	The network has wide geographical reach, spanning multiple jurisdictions and cultural groups.	Intermediate
Workflow interdependence	Low	The activity of the users of the network are only to a little degree depending on the actions of others. Little coordination is required.	Intermediate
Network organization	High	The network is largely centrally controlled, with little or no self-organization. Policies are detailed comprehensive. A lack in adaptability or flexibility may be a challenge in changing conditions.	-

Figure 8: Analysing required change in the profiling tool.

5.2.3 Identifying similar networks

A basic assumption in HUMANE is that analysis and design for HMNs may be supported by transferring design experience and knowledge from successful HMNs. For this purpose, it is useful not only to profile the HMN but also to use this profile to identify other HMNs with similar characteristics.

When considering similarities in HMNs, the HUMANE typology and method open up for two approaches:

- **Similarity in purpose**: This is typically found for HMNs within the similar domain. Typically, development teams are well aware of other HMNs with a similar purpose, for example, from competitor analyses. Learning from HMNs with a similar purpose is critical for owners of

HMNs in competitive markets. At the same time, such learning typically will only imply innovation that is new to the specific service or network but not new to the market.

- **Similarity in profile**: This may be found for HMNs belonging to different domains, and may provide a gateway to insight and design knowledge not immediately associated with the envisioned HMN. Learning from HMNs with similarity in profile is assumed to support transfer of design knowledge across domains, potentially leading to design suggestions potentially new to the domain of the envisioned HMN.

The basis for identifying similar networks in terms of the HUMANE typology, is the HMN profile. Here, the profile scores may be used to identify other HMNs with similar profiles; that is HMNs belonging to the same type of HMNs. In the online profiling tool, each HMN profile is associated with the most resembling HMNs already profiled, as shown in Figure 9.

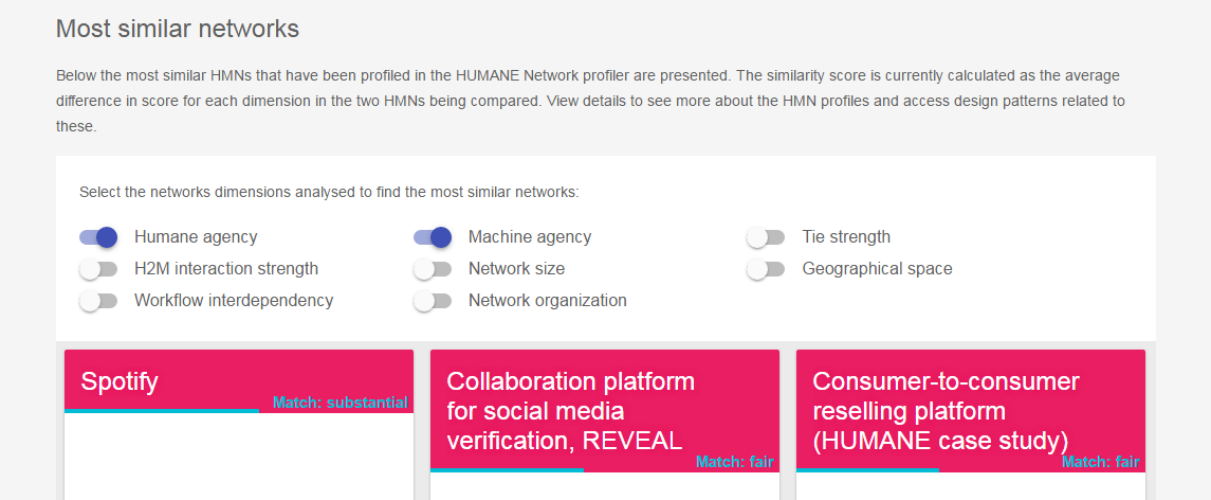


Figure 9: List of similar HMNs in the HUMANE online profiling tool

5.2.4 Characterising the detailed network organisation

For some cases, it may be beneficial to provide a detailed characterisation of the network organisation. In particular for HMNs consisting of a wide range of actors which may serve different purposes, as the HMN here may be insufficiently diagrammed elsewhere. In particular, this step is necessary for designers wishing to explore a modelling and simulation approach to evaluating design options, as discussed by Engen et al. (Engen, Papay, Jaho, Rapanakis, & Sarris, 2017).

Such a detail characterization may be provided through the drawing of a network diagram for the HMN, comprising the different agents (both human and machine) and depicting how they are connected. In the HUMANE literature review (Tsvetkova et al., 2015), a set of primitives were identified which can be used for such diagramming. An example diagram for the eVACUATE case study is provided in Figure 10, below. However, also an informal approach may work well, especially as it may be more intuitive for different stakeholders involved in the design process who are non-technical. See an example of this in Figure 11, which we will build upon in the following steps.

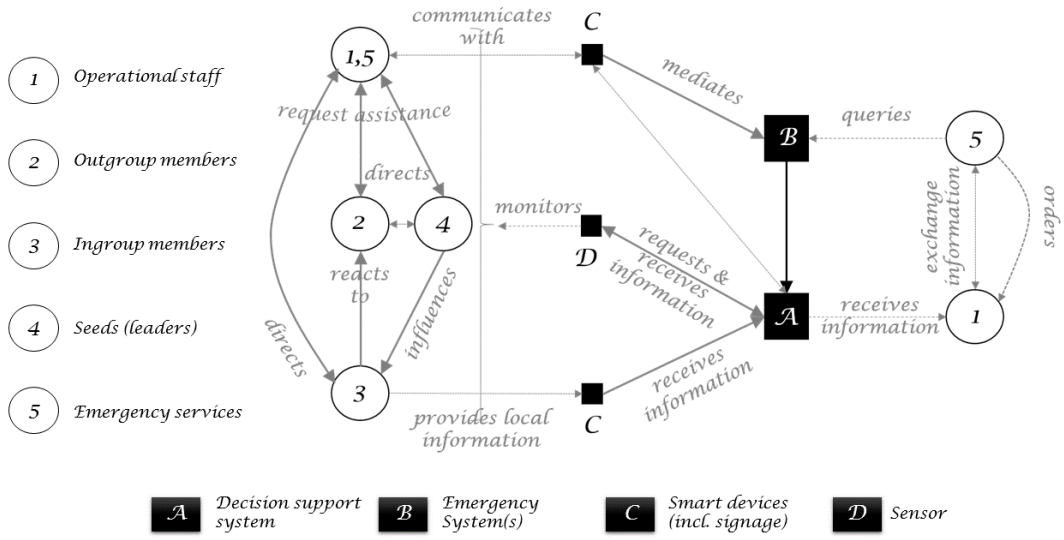


Figure 10: eVACUATE network diagram for context analysis using D1.1 primitives.

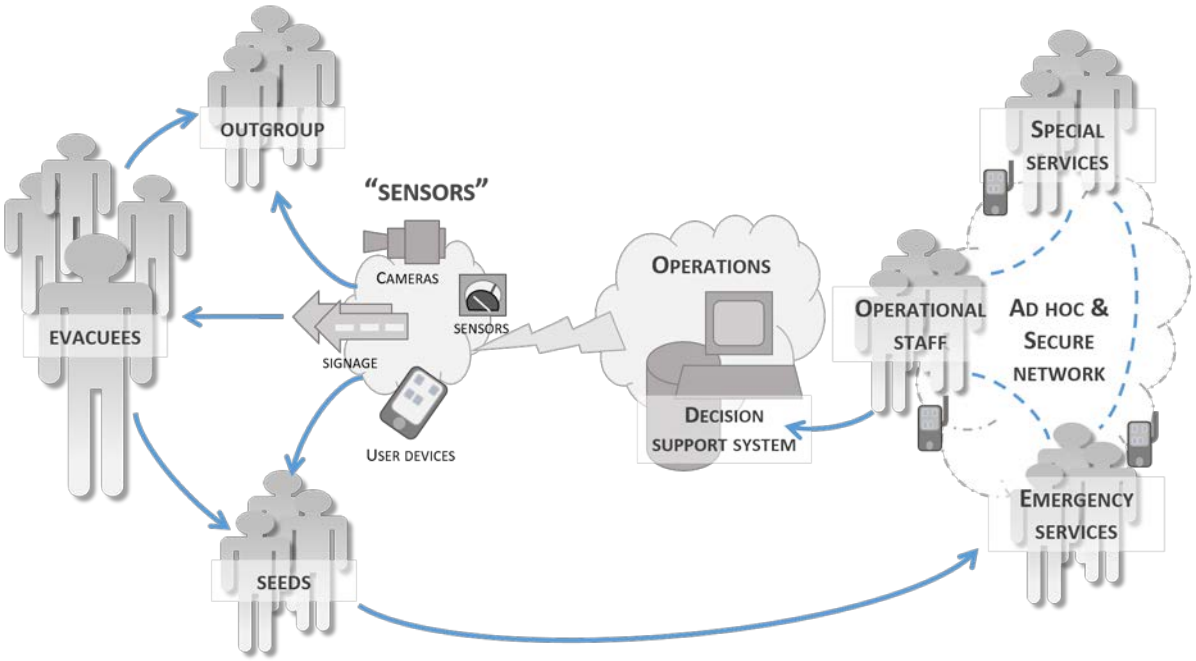


Figure 11: eVACUATE network diagram for context analysis using informal approach.

5.3 Step 3: Implication analysis

As discussed above in Section 4, we have identified 5 groups of implications in the HUMANE project. When applying the HUMANE method, we assume that implications within these groups may be identified and analysed on the basis of the HMN profile and network diagram established in Step 2. The role of the implication analysis is to identify and discuss consequences of the network characteristics that are of particular concern for a successful implementation of the HMN (i.e., having a positive impact on the objectives defined in Step 1). Solutions to potential challenges that are identified may then be sought through a design pattern approach in the subsequent method step (Step 4).

5.3.1 Implication analysis from HMN profiles

Using the HMN profiles to identify and analyse network implications may be done through a process of reflecting on the dimensions from the perspective of relevant implication groups. For the different groups described in Section 4, we have provided information to help perform the implication analysis. However, we do note that this exercise would benefit from people with specialised expertise and a mixture of technical and non-technical participants. Further, in order to focus the analysis, it may be scoped to a smaller subset of implications that are considered particularly relevant for the respective HMN.

The implication analysis can be scoped in terms of the dimensions considered. For networks that have different states, the analysis can be focused on the dimensions that change, rather than assessing all. Similarly, for existing networks are updated, a profile of the desired HMN characteristics may be defined in Step 2. In this case, the analysis can be focused on the dimensions that need to change in order to achieve the desired profile. See Figure 8 above for an example of a network profile with a desired profile change.

On the basis of the HMN profile established in Step 2, the development team reviews the dimensions or sets of dimensions that are assessed to be of particular interest for the implication analysis. This may be supported by the identification of other HMNs with similar profiles or similar scores on profile dimensions of particular interest.

Following this, each dimension is considered sequentially from the perspective of one or several of the implication groups. For each dimension, the initial identification of implications could take the form of a brainstorm, where the team members identify what they see as key implications of the particular dimension score. Implications are then prioritised and high-priority implications are analysed in detail.

It should be noted that while the implication analysis aims to support the discovery and analysis of implications that may otherwise not have been covered, the implication analysis is not assumed to provide a comprehensive identification of all potentially relevant implications. However, if well conducted, the implication analysis should enable a design or development team to systematically consider important implication groups in light of the HMN profile.

In principle, all groups of implications may be relevant for any of the dimensions or their combination. However, the case experiences with implications analyses within the HUMANE project suggest some implications to be particularly relevant for some dimensions, which is depicted below in Figure 12. Here, the associated coloured implication groups are highlighted for those dimensions for which more than 1/3 of the implications for a particular implication group has been identified across the HUMANE cases.

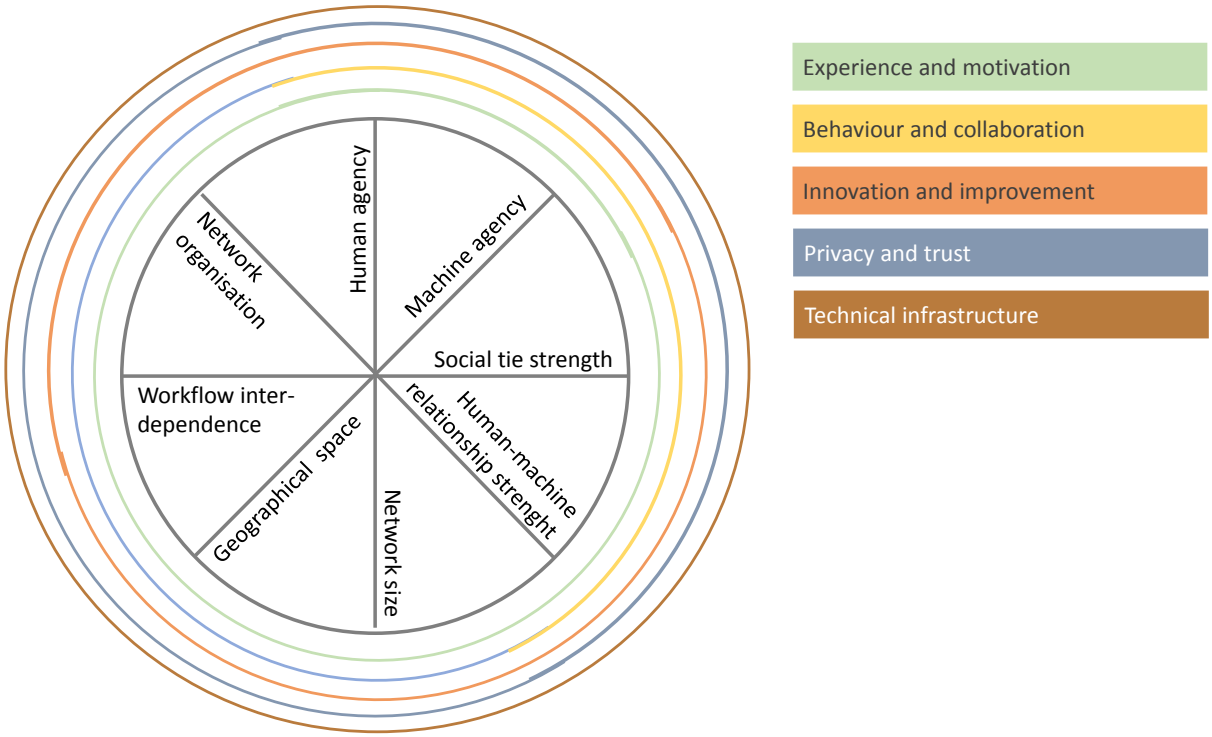


Figure 12: Typology dimensions and frequently associated implication groups in the HUMANE cases.

For example, in a HMN characterized by high human agency and social ties, it would be relevant to brainstorm these characteristics from the perspective of user behaviour and collaboration, and for privacy and trust. For further detail on implications associated with the HUMANE typology dimensions, please refer to Section 4.

5.3.2 Implication analysis from network diagrams

Having drawn a network diagram in Step 2, this can facilitate a more specific analysis of both technical and non-technical implications for the connections (relationships) between the agents. One of the benefits of discussing specific connections in this manner is that the context of the entire HMN is retained, as wider considerations will then be more obvious, unlike the isolated approach to use case analysis in UML (for each stakeholder), for example.

At this stage, it should also be possible to assert some key information pertaining to each connection. As illustrated in Figure 13, for the eVACUATE HMN, we have noted things like operational staff being suspicious of the decision support system and the strength of the ties between the evacuees. This information should be clearer after profiling the HMN, as discussed above.

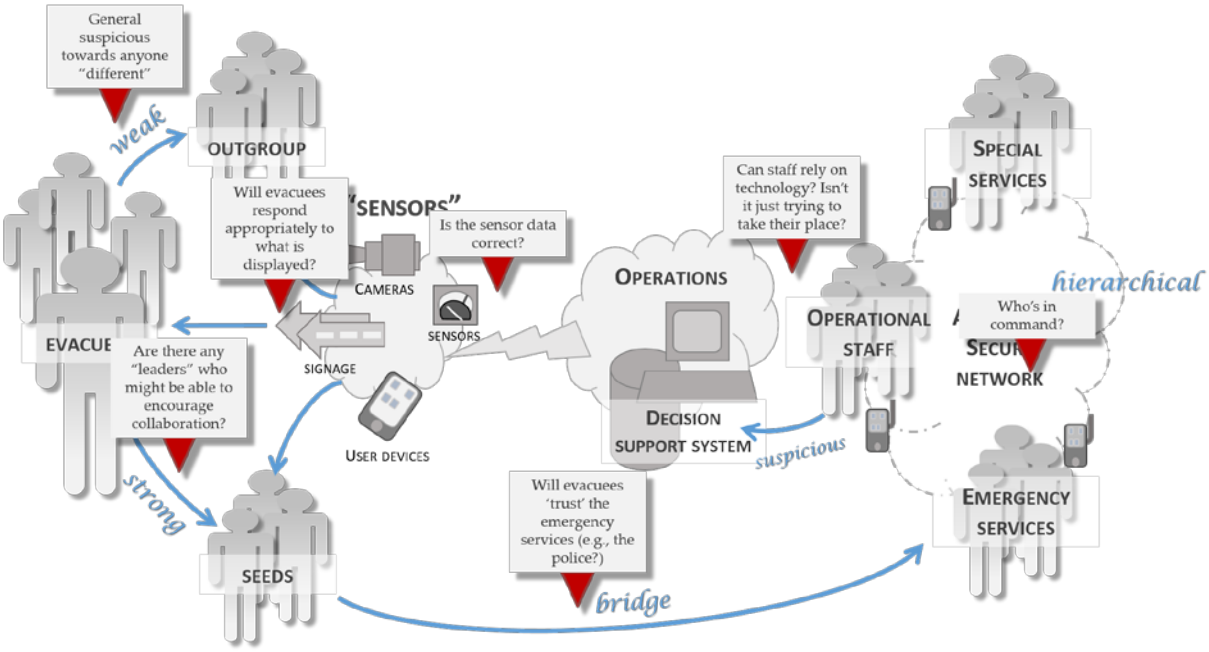


Figure 13: eVACUATE network for design implications.

For each implication group (see Section 4), each connection between agents in the HMN should be assessed. Figure 13 provides an example of an analysis of the trust implications in the network. Potential implications can be phrased as questions, for which possible design solutions may be sought. For example, can the operational staff rely on the decision support system? It has been identified that they are suspicious of the technology, governed by fears that it may replace their job. The designs should consider these aspects, as it will influence the uptake and use of the system.

5.4 Step 4: Design considerations

The HUMANE typology and method is intended to support the extraction and transfer of design knowledge from other successful HMNs and from the state-of-the-art on which these are based. This is to be conducted on the basis of characteristics of the HMN (identified in the profiling of Step 2), and in response to challenges identified in the implication analysis (Step 3).

The implication analysis should have sensitised the analyst to particular issues or challenges for which strategic design advice is needed. However, whereas the implication analyses serve to identify issues of particular relevance or concern, this analysis may not provide insight into how to resolve or mitigate these. For example, for a HMN with high levels of network organization the implication analysis may suggest that this is likely to be associated with challenges related to the networks capacity for innovation and improvement. However, the implication analysis does not in itself suggest how as to mitigate this challenge.

5.4.1 Design considerations through a design pattern approach

To make it possible to act in response to identified implications, the HUMANE method suggests a design pattern approach to the transfer of design knowledge and experience. The basic assumption of a design pattern approach it that solutions to a design problems have often already been solved elsewhere; what one needs to do is to identify the solution from analysing successful examples. Hence, the design pattern approach concerns the documentation of generic solutions to design problems at an appropriate level of abstraction, on the basis of experiences with existing successful designs.

Design patterns have been defined as:

> "[describing] a problem which occurs over and over again in our environment, and then […] the core of the solution to that problem, in such a way that you use this solution a million times over, without ever doing it the same way twice" (Alexander, Ishikawa, & Silverstein, 1977).

In HUMANE, the design patterns are seen as a format for transferring design knowledge and experience from successful HMNs.

While following a design pattern approach, we refer to the resulting patterns as *design considerations.* This to avoid confusion with regard to the kind of design knowledge reflected in these patterns, which is intended to support strategic considerations and decision making rather than practical implementation. This, in contrast to the more implementation-oriented design patterns found in software engineering.

Following the implication analysis in Step 3, key implications are prioritized for being followed up in a design pattern approach. Here, solutions for the implications are sought in HMNs sharing similar profiles. The solutions may already be explicated as design patterns. If not, new design patterns need to be established.

5.4.2 Exploring existing design considerations

The benefit of a design pattern approach, is the opportunity to access design knowledge and experience extracted by others (Seffah, 2015). Ideally, when having identified a challenge through an implication analysis, a design suggestion should be available from the work of others. In HUMANE, we have extracted design considerations from the case trials involved in the project work. This set of >40 consideration form the basis of a library of design considerations which is provided in the project's online profiling tool.

As a first step in the extraction and transfer of design knowledge, the analyst hence may explore the suggestions already available. The relevance of the suggestion will depend on the profile of the envisioned HMN. Hence, design considerations are suggested on the basis of these already being associated with HMN profiles that share the characteristics of the HMN in question.

For simplified exploring of design considerations, existing suggestions are characterized in terms of the group of implications they address (user experience and motivation, behaviour and collaboration, innovation and improvement, privacy and trust, and underlying infrastructure). This grouping allows for filtering according to the implication of interest. Furthermore, the individual design considerations are presented both in terms of the problem these address, as well as the suggested solution.

As an example, existing design considerations filtered on the implication group *Innovation and improvement* are listed in Figure 14.

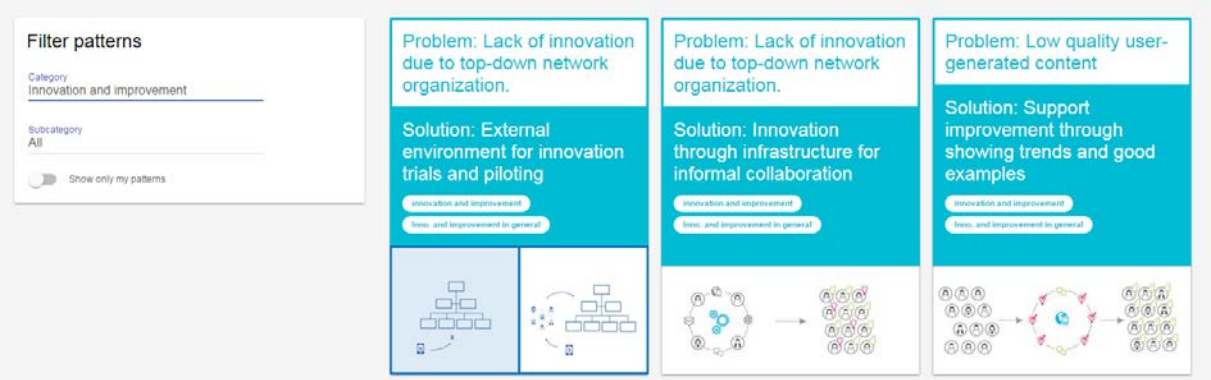


Figure 14: Example listing of design considerations

When identifying relevant design considerations, the analyst may associate these with the HMN profile, allowing for easy reference and also for improving the recommendation of design considerations for other HMN profiles.

5.4.3 Detailing new design considerations

When a relevant design suggestion cannot be found in the list of existing design considerations, the analyst may detail a new consideration. This is more demanding on the analyst, but some support is provided in the method.

First, the analyst may take as a starting point the list of similar HMNs identified on the basis of the HMN profile. This list may help to point out successful HMNs which may have solved the challenge in question.

The list of similar HMNs may also serve to identify domains in which resembling HMNs may be found, which may also help the analyst towards identifying relevant research and practitioner literature in which the challenge is addressed and design suggestions presented.

When this is said, the extraction of new design suggestions will involve exploratory work for the analyst which may not easily be described in a method description. However, if the analyst when identifying new design suggestions enter these in the set of existing suggestions, this set will increase in value for future analyses.

Using the online tool for including new design considerations for a HMN is simple, as soon as these are identified. The template for the content in a design suggestion is presented in Figure 15.

<Descriptive title> Implication: *<the implication group associated with the pattern>*
Problem: a brief description of the issue which the pattern is intended to resolve **Background:** a detailed narrative about a typical situation in which the problem might occur and therefore when the pattern might be appropriate. **Solution:** a brief overview of the proposed pattern **Illustration**: a visualisation representing the pattern-based solution. The illustrations are not intended as detailed descriptions of the solutions, but rather reflecting its overall approach. **When to use:** typically the development or deployment stage when the pattern might be used **Sources:** if appropriate, where the pattern was derived from or what it is related to

Figure 15: Template for HUMANE design considerations.

5.5 Step 5: Evaluate

Evaluation is a key phase in HCD. The HUMANE method may support such evaluation through a process of reflecting on the HMN profile as well as relevant implications and design suggestions for a given HMN. The use of the output of the previous steps of the HUMANE method for evaluation purposes, will need to be adapted for the specific case context.

In the following we suggest three approaches that may be considered. It should be noted that the suggested evaluation approaches have not been verified in HUMANE case trials. We expect the approaches to correspond to relevant potential uses of the output of the HUMANE method, but its verification will need to be considered future work.

Reflecting on the HMN profile: When analysing or considering possible overall designs for an HMN, the envision future HMN may be characterised in a HMN profile. The profile may then be augmented with the characteristics of the current state of the HMN, as described for Step 2. The divergences between the current and envisioned future HMN profile may constitute areas of particular interest when evaluating designs throughout the HCD process. In particular, considering how suggested designs may affect the overall HMN profile and whether the suggested design may contribute to narrowing the gap between the profile of the current HMN and the envisioned future HMN.

Reflecting on implications: The implications identified in Step 3 can be used as topics for evaluation work. During the implication analysis, key challenges for the envisioned HMN are identified. These challenges may in turn be used to guide evaluation efforts, serving to validate the identified challenges are relevant for the envisioned HMN and serving as guidance on evaluation topics.

Reflecting on design considerations: The design considerations identified through the design pattern approach in Step 4, may be used to guide evaluations in a similar vein as for identified implications. The relevance of design suggestions for the envisioned HMN may be validated through evaluation. Furthermore, the topic of the design considerations may guide evaluation effort. It should also be noted that the format of the design considerations is set up so as to facilitate analytical evaluation or critical discussion of suggested HMN design. For each design consideration, a possible solution is contrasted to a background situation illustrating a potential counterproductive situation. Hence, the design suggestion may also motivate reflection on design alternatives, and the degree to which these serve to address the counterproductive situation accentuated in the design suggestion.

6 Case examples

In this section, we present three cases in which we have applied the HUMANE typology and method for illustration purposes as well as to exemplify the value the application of the typology and method may have. The cases are as follows:

- Case 8 – a decision support system
- Case 6 – Zooniverse, a citizen science platform
- Case 3 – eVACUATE, a system for crowd evacuation support during emergency

All cases have been presented in detail elsewhere. Hence, the following presentations are summaries intended to illustrate applications of the HUMANE approach.

6.1 Case 8 – Applying the typology and method to discuss automation in decision support systems

In Case 8, the HUMANE typology and method was used to analyse and advise a research project on automation in decision support systems. The application of the typology and method was conducted by one of the HUMANE researchers, involving four of the project researchers through interview and the project team in a subsequent plenary session. The case has been presented in more detail in the HUMANE deliverable which report on the second set of HUMANE case trials, D3.3 (restricted access).

6.1.1 Step 1 - context and scoping (Case 8)

The context of the case-study was a research project on how to strengthening the collaboration between humans and decision support systems in complex, time-critical contexts. The potential scope of the intended HMN was wide, as the research project held a general aimed at increasing performance through increasing automation while keeping competent human operators in the loop as active decision makers. The decision support system was intended to supporting collaboration in networks of humans and software-based tools to reach improved decisions in (close to) real time contexts.

To make a useful analysis, adequate scoping was seen as essential. We scoped the analysis so as to concern an envisioned HMN where the decision support system under development was taken up by operators in air traffic management so as to increase performance through increased automation. This scoping was chosen as it was the most prevalent use-case of the research project, and also was relevant to HUMANE as it entailed the use of decision support in teams of operators rather than single operators' individual use of such support.

The purpose of applying the HUMANE typology and method was to (a) enable novel understanding of the characteristics of the HMN for which the decision support system is envisioned, (b) serve to identify potential challenging or beneficial implications on the basis of the HMN profiling, and (c) support the transfer of design knowledge from successful HMNs through a design pattern approach.

6.1.2 Step 2 – network characterisation (Case 8)

The characterization of the HMN started out with individual interviews with four project participants. Here, the participants were invited to reflect on the envisioned decision support system with regard to the eight typology dimensions. This reflection process started out with the dimensions pertaining to actors and their relations, then the network extent and the network structure. Then, in a subsequent analysis process, the HUMANE researcher collated the findings and established a consolidated profile used for implication analysis. The consolidated profile was presented at the subsequent workshop with the case representatives.

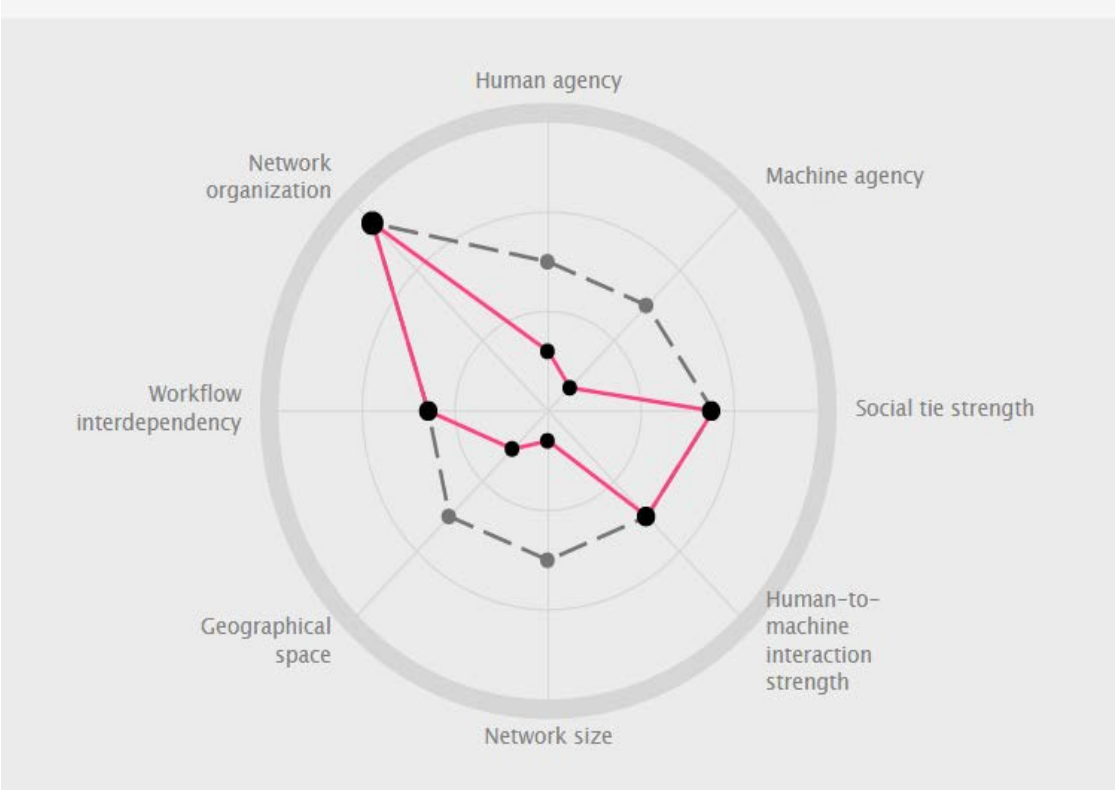


Figure 16 Case 8 - Decision Support System – HMN profile, current (solid lines) and envisioned (dotted lines).

To exemplify the level of detail in the analysis, we present excerpts from the analysis pertaining to the layer of actors. Similar analyses were also conducted also for the other dimensions, but are left out of this case example due to space limitations.

Excerpt from profiling – the analytical layer of actors

Human agency *(current - low; envisioned - intermediate):* Due to the complexity and safety requirements in air traffic management, human agency is largely determined by procedures and rules of thumb. The operators' main objective is to schedule and oversee the safe arrival and departure of the airplanes at the airport, and may have limited capacity and incitement for optimizing this schedule according to global performance criteria for the entire network.

A reported ambition for the new decision support system, was to increase the level of human agency so that operators can go beyond a mere procedural approach to scheduling to actively considering a larger set of scheduling options with respect to other KPIs. In particular, a reported aim was to allow the operators to work more on a tactical level, considering how to efficiently schedule arrivals and departures according to global performance indicators, rather than working towards only the local unit goal.

Machine agency *(current – low; envisioned - intermediate/high)***:** The current level of machine agency in air traffic management was described as low. The operators have ICT support for scheduling and monitoring of arrivals and departures, but while providing situational awareness this ICT support does not provide decision support.

The participants reported that the aim of the project is to increase machine agency to a level where the system can influence the operator by suggesting optimal scheduling alternatives and display the effects of these alternatives on global performance indicators. While micro-level decision making may be highly automatized, for higher-level tactical decision making the system support will more support information acquisition, analysis, and decision support – rather than implementation.

Hence, the participants reported that increasing machine agency this way could increase human agency, as it may enable the operators to work more on a tactical level rather than mainly following procedures for complying the requirements of their local context.

The excerpt shows how the current HMN was systematically contrasted with the envisioned HMN, to identify and explain desired change in the HMN. In the excerpt, we in particular see how the envisioned increase in machine agency, through increased automation, was seen as enabling an increase in human agency to support increased tactical and strategic on the side of the operators.

As may be seen in Figure 16, a similar contrasting of the current and envisioned future HMN was conducted also for network size and geographical reach. Here, increasing automation was seen as a potential means to increase the extent of the network for which the decision support system would be used – strengthening scheduling optimization across local units.

6.1.3 Step 3 - implication analysis (Case 8)

On the basis of the interview input, the consolidated profile, the HUMANE researcher conducted an implication analysis. Guided by the input from the participants, the implication analysis mainly concerned user motivation, behaviour and collaboration, trust, and innovation. During the analysis, the researcher explored and reviewed possible implications within these groups on the basis of the interview data, background literature, and implications identified for similar HMNs.

During the implication analysis, the HUMANE typology and method provided a supporting framework for identifying and structuring implications. At the same time, it should be noted that the method has an exploratory character requiring the analyst to bring relevant background in to the process. For this, existing design knowledge provided in the online HMN profiling tool may be useful. But the analyst may also need to identify implications not already identified by others.

In this case, seven new implications were suggested. The implications all had the character of challenges resulting from the characteristics of the HMN. For purposes of illustration, two of these are presented below.

Implications for innovation

Relevant dimensions: Network organization (high). Human agency (low -> intermediate)

Decision support within operational air traffic management is typically characterized by low human agency. Furthermore, the network organization is highly hierarchical and centralized, in response to the complexity of the management process and the safety-critical character of the domain.

Improvement and innovation is typically slow in organizations characterized by such a hierarchical structure, due to values associated with efficiency, timeliness, and consistency necessarily held in these organizations (Cameron & Quinn, 2006). Within this organizational context, innovation that radically breaks with existing procedures and ways of work will be hard to get approved. At the same time, benefitting from new technology in human-machine networks may require fundamental shifts in procedure and policy. Hence, there is a fundamental challenge pertaining to the introduction of beneficial innovation in such organizations.

This implication motivated the design consideration: "Establish environment for innovation trials and piloting."

Implications for motivation

Relevant dimensions: Human agency (low -> intermediate)

Decision support within operational air traffic management is typically characterized by low human agency. Due to the safety-critical character of the domain, users are engaged in highly procedural tasks when scheduling and monitoring arrivals and departures, relying on guidelines and rules of thumb acquired through training. Exploration through questioning assumptions or trying out new ways of work may not be encouraged. Rather, successful ways of work tend to be conserved as a gold standard way of work.

A key challenge in decision support systems, hence, is that they may not be sufficiently taken up among target users. This is particularly so for decision support in safety-critical domains, as is seen e.g. for clinical decision support systems (Shibl et al., 2013).

A reason for the lack of uptake may be a lack in user motivation. Given that the current way of work provides outputs that are acceptable with respect to commonly agreed on performance indicators, there is little incitement to motivate new ways of work. In particular, there is little incitement to improve on aspects of the work for which there are no explicit performance indicators.

6.1.4 Design considerations (Case 8)

Each of the seven challenges identified through the implication analysis motivated design considerations concerning how the challenges may be solved or addressed. Following from the design pattern approach applied in HUMANE, the design considerations were structured in a format addressing the problem, background, solution, and sources, as well as an illustration and advice on when to use the suggestion.

The design suggestions identified in this case were mainly drawn from the literature rather than specific HMNs. This indicates the usefulness in exploring and reviewing multiple sources of potential design knowledge as part of the HUMANE method, in particular as long as the number of profiled HMNs are relatively low making the available set of profiled HMNs for comparison relatively small.

Two example suggestions are presented below, corresponding to the example implications presented in the previous subsection.

A: Establish environment for innovation trials and piloting
HMN type: Network organization high. Human agency low -> intermediate.
Implications: Innovation

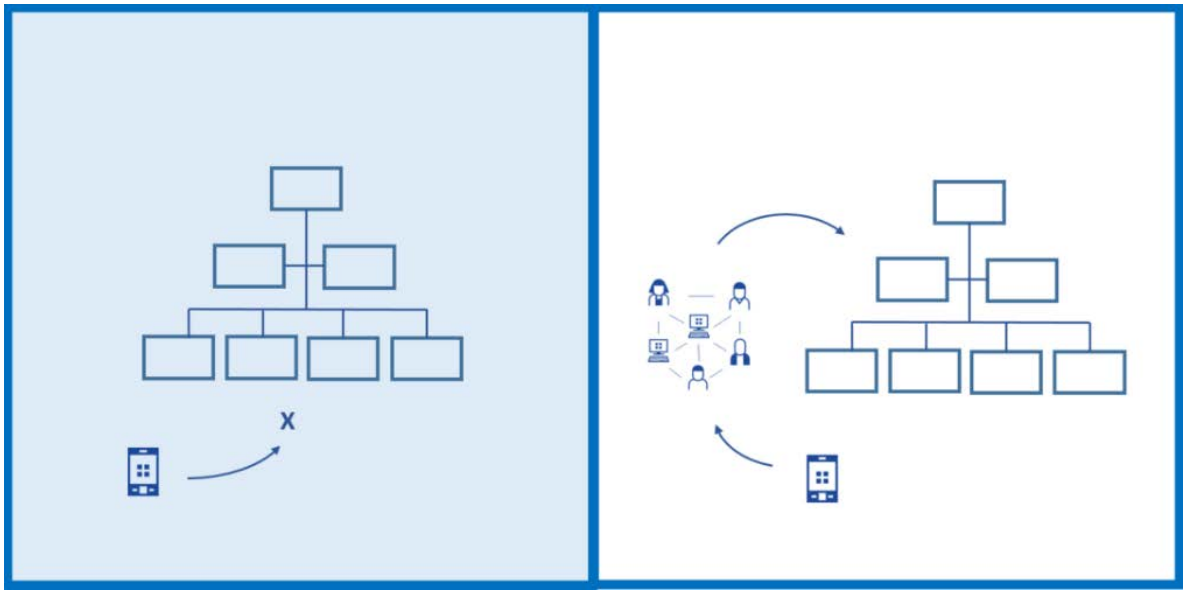
Problem: Innovation representing radical changes to established procedures and way of work may be hard to foster and implement in hierarchical human-machine networks.

Background: While new technology open new opportunities for innovation in human-machine networks, the values and policies governing hierarchical organizations may prevent innovation that require major shifts in existing procedure and organization. Hence, promising technology may risk not being developed further, not being implemented, or not being taken up.

Solution: To strengthen innovation capabilities, and avoid the inertia of hierarchical organizations to hamper innovation, some organizations establish centres or labs for innovation in which new technology can be taken up in near real life contexts for trials and refinement.

One form of such labs are so called living labs (Følstad, 2008) in which new technology is tried out in realistic or semi-realistic contexts, to strengthen innovation capabilities in clusters of collaborating actors.
Such labs or innovation initiatives may potentially be strengthened by including competitions or challenges, where new technology or different teams applying new technology is pitted against each other, possibly in a game-like fashion (Bullinger et al., 2010).

Illustration



When to use: Implemented as a strategic approach to innovation in an organization.

Sources

Bullinger, A. C., Neyer, A. K., Rass, M., & Moeslein, K. M. (2010). Community-based innovation contests: where competition meets cooperation. Creativity and innovation management, 19(3), 290-303.
Følstad, A. (2008). Living Labs for innovation and development of information and communication technology: A literature review. eJOV: The Electronic Journal for Virtual Organization & Networks, 10.

B: Optimize key performance indicators.

HMN type: Human agency low -> intermediate. Implications: Motivation

Problem: ICT systems are not taken up as expected in human-machine networks due to lack in user motivation or incentive.

Background: Lack of uptake of work support systems is a challenge in many domains. In particular in procedural work contexts, where users' mainly follow established routine, users may lack motivation to take up new work support. In the field of information systems, technology acceptance is regarded as key to the uptake of work support systems. Here, perceived usefulness is a decisive factor (Legris et al., 2003). Unless users perceive how new work support improve performance, motivation for uptake may be low.

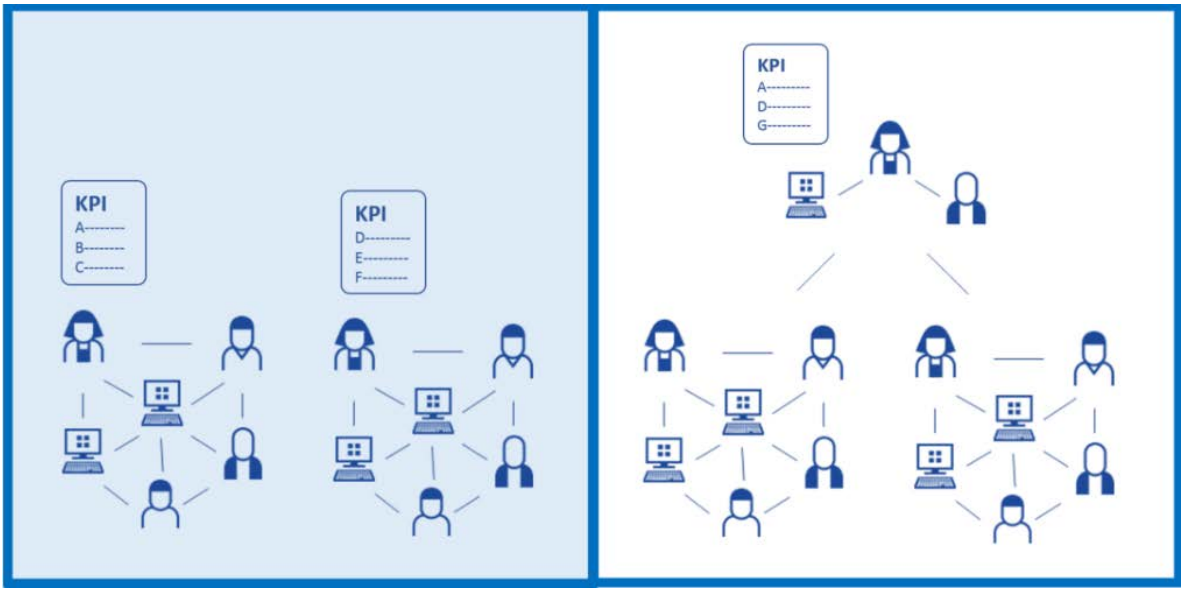
Solution: Optimize key performance indicators.

Key performance indicators (KPI) are quantifiable measures of an organizations achievement of its key objectives. The perceived usefulness of work support systems will depend, at least in part, on whether it helps the user in meeting the KPIs. However, KPIs may concern conflicting areas of interest (e.g. cost and quality) or may concern different organizational levels. By revising KPIs according to how well they measure achievement of key organizational objectives, and propagating these throughout the organization, the motivation for change, for example in the form of adopting new work support, may be strengthened.

In the field of marketing, KPIs such as customer satisfaction, and customer recommendation, are systematically assessed for their ability to predict customer loyalty. KPIs are propagated throughout the organization.

In the field of supply chain management, Cai et al. (2008) has suggested an approach to optimize KPIs with respect to analyses of their interdependent relations.

Illustration



When to use: To be used on a strategic level. Continuous revision of KPIs is important to motivate quality and improvement, and may precedes the successful introduction of work support.

Sources

Cai, J., Liu, X., Xiao, Z., & Liu, J. (2009). Improving supply chain performance management: A systematic approach to analyzing iterative KPI accomplishment. Decision Support Systems, 46(2), 512-521.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. Information & management, 40(3), 191-204.

6.1.5 Key learnings (Case 8)

The case provided a number of key learnings of relevance for the subsequent development of the typology and method. The participants reported the overall application of the HUMANE typology and method to provide useful input for the case, in particular to support reflection on the envisioned HMN and to identify useful design suggestions.

At the same time, the participants pointed out challenges and suggestions for improvement to the HUMANE typology and method. For example, they found the typology difficult to comprehend, suggesting the need for in-depth knowledge of the typology and method prior to analysis. They also reported it to be difficult to see how to draw actionable insight from the HMN profiles, and the potential technology-dependency of identified implications and design patterns.

In the final version of the typology and method, presented in this deliverable, changes concerning the typology terminology and the profiling process have been made to mitigate these challenges.

6.2 Case 6: Applying the typology to the analysis of a citizen science platform

In Case 6, the HUMANE typology and method was used to analyse the HMN of a major citizen science platform, Zooniverse. The application of the typology and method was conducted with one of the HUMANE researchers in collaboration with representatives of the Zooniverse team. The case has been involved in both sets of HUMANE case trials, and have presented in more detail in the HUMANE deliverables D2.2 and D3.3 (restricted access).

6.2.1 Step 1 - context and scoping (Case 6)

The citizen science platform of Zooniverse is a HMN in which citizen scientist, that are the general members of the public, help the scientist to achieve their goals through large scale data analysis that cannot be done by machines on their own. The basic assumption of citizen science is that the cognition power of humans combined with learning abilities of machine can solve scientifically challenging problems that could not be solved only by humans or only by machines. This makes citizen science platforms a perfect example of a HMN.

In a citizen science project the main actors are the human contributors who will classify objects, perform qualitative or quantitative micro-tasks, or evaluate other contributors' performances.

Accuracy and speed of the tasks, user retention and community building, and finally knowledge transfer through contribution are the main goals of citizen science projects.

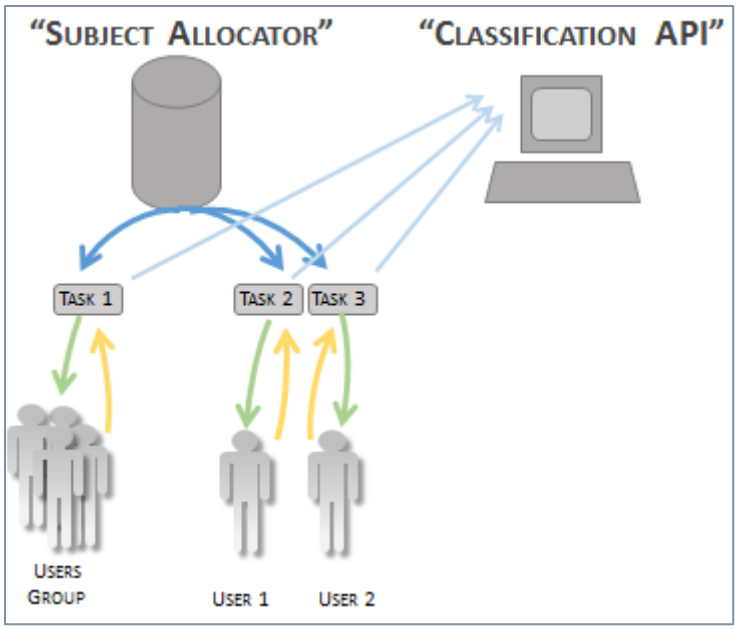


Figure 17: schematic diagram of a Zooniverse project

6.2.2 Step 2 - network characterisation (Case 6)

When profiling the platform following the HUMANE approach, we get a HMN profile as presented in Figure 18.

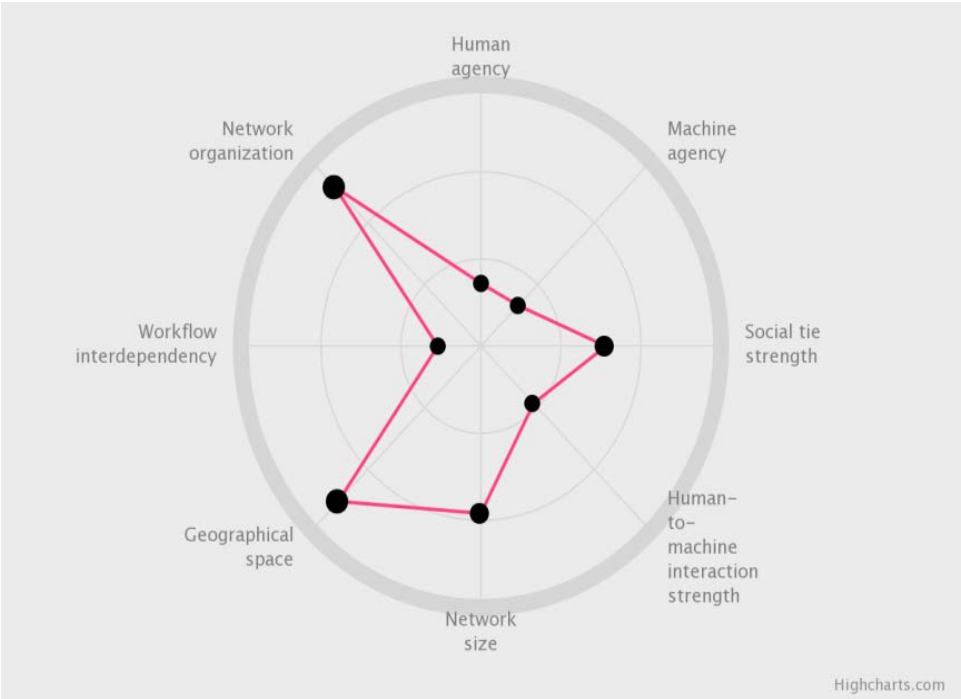


Figure 18 Case 6 - Zooniverse – initial profile

Human agency - low: Zooniverse has the so-called push-oriented labour market, where managers directly allocate appropriate tasks to workers as they arrive. Participants can rarely freely choose what and how to contribute. They have to follow a set of activities already planned for them.

Machine agency - low: Machine nodes in Zooniverse currently have low agency although they may in the future focus on task routing. At the moment, we are not aware if any task routing routines are implemented in the system.

***Social tie strength – intermediate*:** In Zooniverse, the interaction among volunteers, although important to some good extent, is characterised by weak ties. Volunteers can interact with others on discussion boards. Nevertheless, the interactions are still limited if compared to other popular social networks.

H2M interaction strength - low: Machine nodes distribute and gather contributions and are hence necessary. However, human actors are not reliant on these services to participate in the community.

Network size – high: Zooniverse faces an ever-growing network because new volunteers join every day. As of 2015, Zooniverse has 1.3M registered volunteers.

Geographical space- high: Zooniverse is open to volunteers from all around the world.

Workflow interdependence - low: Zooniverse projects combine contributions from many individual volunteers, relying on a version of the 'wisdom of crowds' to produce reliable and accurate data. These contributions are done independently of others.

Network organization – high: The organization is top-down. A project is first built and uploaded on the Zooniverse site, with predefined tasks, and then volunteers are assigned the corresponding tasks needed to achieve the objectives of the project.

6.2.3 Step 3 - implication analysis (Case 6)

The main implications of the Zooniverse HMN profile were identified as related to motivation, collaboration, and innovation.

Implications for Motivation: Volunteers on Zooniverse can freely choose which science project to participate in but within project, they are quite restricted as to the kind of tasks they can execute. In addition, most tasks are done independently and do not interact in any way with input by others. What is more, the tasks are by definition redundant, since crowdsourcing crucially relies on input by multiple independent actors.

These HMN features can undermine users' motivation. If users are not able to exercise agency in the HMN through goal-setting and creativity and do not receive feedback and share knowledge through collaboration with others, they are likely to perceive their own contribution as less meaningful (Kittur et al., 2013). As a result, they may choose not to participate at all.

A potential design challenge hence may be to strengthen *extrinsic motivation* (Ryan & Deci, 2000) for participation, for example in terms of making the participation attractive in terms of contributing to a greater good or in terms of tangible incentives.

Implications for Collaboration: Zooniverse is open to volunteers from all around the world. Regardless of their location, however, users exhibit similar time patterns in terms of when they make contributions. For example, most of activity happens in the late evening hours, between 19:00 and 23:00, which is time typically associated with leisure. This implies that collaboration is less likely to occur among individuals from different time zones. This could be undesirable, particularly if the tasks are short-lived or benefit from diverse language knowledge or different cultural perspectives.

Implications for Innovation: Zooniverse is organized top-down, meaning that volunteers can rarely have input into what projects should be pursued and how projects should be organized. This is common for most crowdsourcing systems. Such top-down organization may stifle creativity and innovation in the HMN. Through spending hours pouring over the data or the tasks, users could observe patterns that the scientists or the employers did not foresee. If the project is not designed to record such observations, this knowledge will be lost. Due to extensive experience, users are also likely to have a better idea how to design a project in order to attract and sustain high-levels of participation and high quality of contributions. If users are not allowed and encouraged to experiment with designing their own projects, learning will occur much more slowly.

6.2.4 Step 4 - design considerations (case 6)

On the basis of the implications identified in Step 3, a number of design considerations were extracted. Here we present two example of design considerations in relation to the implications that we discussed above.

The first design consideration is in relation to motivation and user retention.

The second example of a design consideration for collaboration and innovation is presented here, the main element of the suggested solution is gamification:

6.2.4.1 Campaigns, not routine, for attention in small-scale HMNs

HMN type: *Network-size low*. Implication: *Attention* Design Pattern Group(s): *H2M, M2H*

Problem

How to sustain participant attention in small-scale HMNs depending on content contribution and sharing

This problem is critical to resolve in HMNs depending on UGC

Background

For HMNs depending on content contribution and sharing, a key challenge is to have sufficient attention in the user base. This, in particular, holds for small-size HMNs. Here, the activity over time in the network will remain limited, with the risk of reduced attention due to limited activity, which in turn limits activity even more; a vicious circle.

Solution

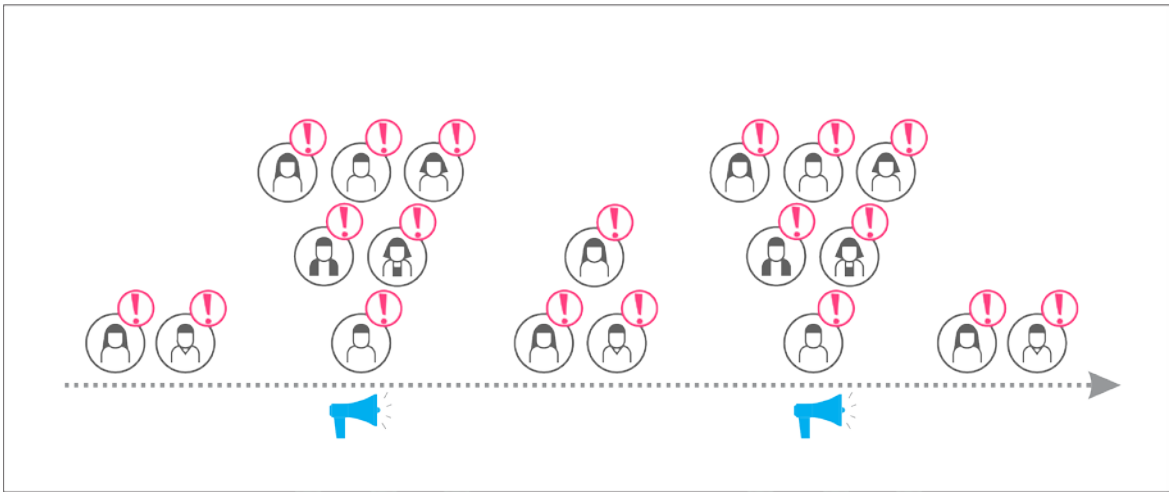
Campaigns, not routine, for attention in small-scale HMNs

Platforms for content production and sharing are often implemented to run indefinitely. However, for small-scale HMNs, this approach may defy its purpose as there is a risk over time of losing attention. To mitigate this risk, small-scale HMNs for content production and sharing may instead consider implementation for campaigns rather than routine availability.

The technical infrastructure may well be implemented on a permanent basis (possibly as a cloud service), but the actual instantiation of the HMN rather could be implemented as a series of short periods of high levels of attention, separated by longer periods of rest.

A campaign-oriented approach to HMNs for content sharing and production is beneficial both from the perspective of the platform host, who may direct full attention to the HMN during campaign periods, and the contributors, who may be more motivated to contribute as there is a short period of heightened attention among all potential contributors.

Illustration



When to use

Use in the processing of planning for a small-scale HMN for content creation or sharing. The pattern should be used during the early design phases, to make sure that the design of the recruitment process supports that contributors are nurtured through a process of consumption.

Sources

HMNs adhering to this pattern are networks for survey questioning, such as representative panels of volunteers that are invited to questionnaire studies a few times a year. Another platform that is successfully utilizing a campaign approach is Kahoot (https://getkahoot.com/), an eLearning solution where students are tried through short-term gamified quizzes.

6.2.4.2 Collaboration through gamified engagement

HMN type: *Social ties low, H2M interaction low, Workflow Interdependence low/intermediate*. Implication: *Collaboration;* Design Pattern Group(s): *H2H, M2H*

Problem

How to strengthen collaboration in HMNs were interaction among human actors is optional

Background

In HMNs, establishing vibrant collaboration is often challenging. For example, open innovation platforms which would benefit on collaboration between external contributors often see only parallel contributions with little or no interaction. Hence, opportunities for collaborative refinement of content or actions, as well as engagement among contributors is lost.

Solution

Collaboration through gamified engagement

Gamified engagement is an approach typically seen in online games, but also in social networks. Here, anyone typically is allowed to sign up and also contribute content. However, in order to progress the HMN members need to generate engagement in others. In online games, such as Clash of Clans, substantial progress is only possible through engaging with other players either as battle opponents or as clan collaborators. In social networks, such as Facebook, the level of engagement generated through your posts decided the reach of your future posts. Also, some open innovation platforms have taken on gamified engagement. For example Lego Idea allows anyone to post ideas, but only ideas that receive a predefined level of attention (upvotes and comments) are selected for review by the company.

Illustration

When to use

The pattern should be used during the early design phases, to make sure that the HMN will be helpful for users to access and engage with desired content and resources. Use in the process of planning the platform intended to serve the HMN.

Sources

Online games, e.g. Clash of clans, social networks, e.g. Facebook, and some open innovation platforms, e.g. Lego Idea reflect how gamified engagement may be applied to strengthen collaboration.

6.2.5 Key learnings

Citizen science is a rather new concept in the field of crowdsourcing and mass collaboration. The incentives are different to the paid micro-work platforms such as Amazon Mechanical Turk, and the type of tasks and the scale of the project are dissimilar to Wikipedia, hence the lack of theoretical framework to conceptualize citizen science projects appropriately.

The feedback we received was mainly related to this point. The analysis will provide the network owners with the framework to think about the project in a more abstract and less goal oriented way, as well as the possibility to compare the case with similar or related HMNs such as the ones mentioned above. In particular, issues in relation to motivation, collaboration and innovation can be considered and coped with using the HUMANE methods and in comparison to similar networks.

6.3 Case 3: Applying the typology and method to improve evacuation systems

Case 3 is based on an EC FP7 project called eVACUATE[11], which is about getting people out of dangerous situations. We will describe the network further below as part of the context and scoping step.

6.3.1 Step 1 - context and scoping (Case 3)

In the description of the eVACUATE network, above, we have already made a note of the purpose of the network as being about getting people out of dangerous situations. In other words, the purpose of the network is to keep people safe and facilitate large-scale evacuations should dangerous situations occur.

The context of the network in the case of eVACUATE is confined to a particular venue in a geographical sense. In eVACUATE, there are four different venues: an airport, a cruise ship, a metro station and a football stadium. Although each venue may have variation in objectives and network set-ups, we focus on the generic and common aspects here. Example objectives include:

- Monitor and detecting dangerous situations as soon as they unfold.
- Real-time analysis of monitoring data.
- Adapt evacuation plans dynamically to current conditions.
- To provide clear, easy to use, set of safe evacuation instructions.
- To support civil protection authorities in the formation and validation of safety procedures.
- To comply with regulations.

In terms of scoping the network according to its actors, we note that the main participants of the eVACUATE evacuation scenarios are: operational staff who are responsible for making sure people get out safely; the people to be evacuated; and the emergency services who are quasi autonomous but responsible for the safe evacuation of the site(s). There are two different types of machine “actors”: 1) the site itself, which is often equipped with various sensors (especially the cruise ship and airport cases), characterised by equipment with no particular autonomy in terms of execution, and 2) a

[11] http://www.evacuate.eu/

Decision Support System (DSS) developed in the eVACUATE project to assist the operational staff, which by contrast to (1) supports the operation of software components which act on and interpret the information coming from the non-autonomous equipment. Thus, we see this is a HMN where the 'machine' actors are both active and passive elements.

The eVACUATE HMN is used under two main circumstances: (i) during monitoring (normal operation) where the emphasis is on periodic checking by operational staff based on default input from sensors, that individuals act appropriately and safely; and (ii) during evacuation, where the HMN changes to accommodate tighter interaction with sensors, even the recruitment of additional sensors, and the possible involvement of emergency services such as paramedics, the police, or special forces.

6.3.2 Step 2 – network characterisation (Case 3)

The HUMANE consortium created the profile of the eVACUATE HMN, which was which was presented to and validated by members of the eVACUATE project (Lüders et al., 2016). Using the HUMANE tool (discussed below in Section 8), the profile is depicted below in Figure 19, representing the two states of operation: grey dotted line for monitoring; pink solid line for evacuation.

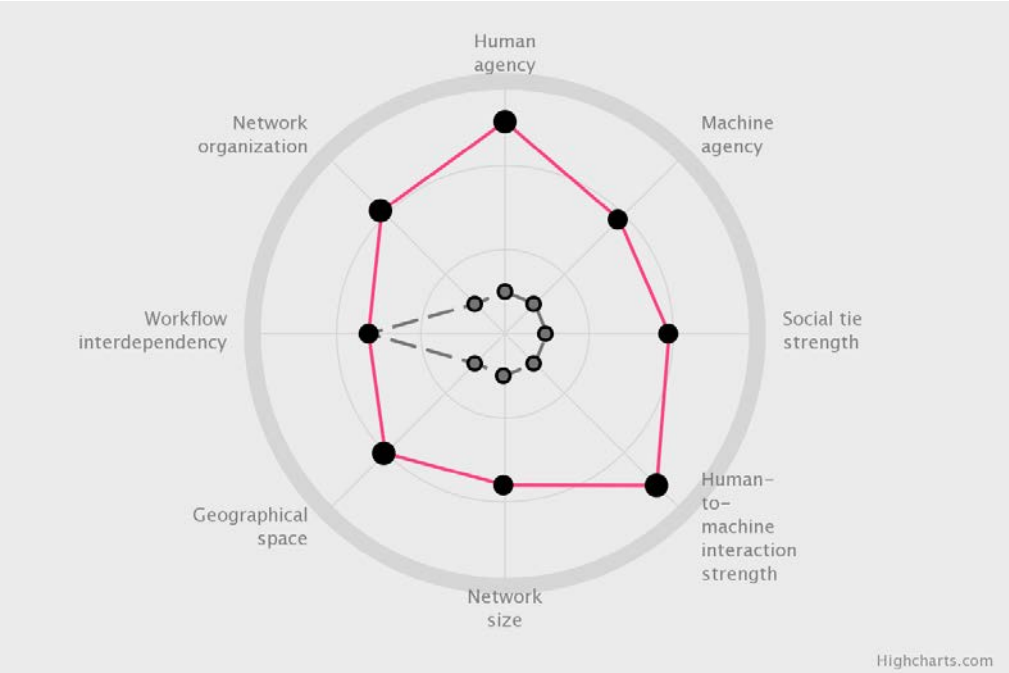


Figure 19: eVACUATE profile. Dotted line = monitoring; solid line = evacuation.

There are a number of general features and characteristics which are worth picking up on in the eVACUATE profiling. As previously stated, the eVACUATE case does not simply refer to a single situation. Instead, there is a default network, involved in the day-to-day monitoring of the specific venue(s). This is not a particularly complex network of humans and machines, interacting to check output or, in the case of potential evacuees, as passive subjects being monitored. With the exception of *workflow interdependence*, the associated HMN occupies the space towards the centre of the spider chart. However, the moment an evacuation is required for whatever reason, values become more

extreme approaching, if not attaining, the outer edges of the chart; again *workflow interdependence* is the exception. This is now effectively a short-lived, bespoke configuration in response to the specific requirements of the evacuation.

The significant changes in the profile of the two states raises several interesting questions that could be explored in the consecutive steps of applying the HUMANE method. For example, what transformations does the network have to go through to switch from one state to the other? Is the transformation uniform across all dimensions? Or are there one or more dimensions which may dictate where the others lie? Clearly, some dimensions such as *geographical size* are subject to other, external, factors and we could here expect variation between the four different venues considered in the eVACUATE project (airport, cruise ship, metro station and football stadium).

At this stage, what the spider graph indicates at this stage is a need to 'design for flexibility' (Clark, Wroclawski, Sollins, & Braden, 2002). The changes around *network size* and *geographical size* are externally dictated, and are really just a matter of scalability or elasticity. However, any dependencies such as between *human agency* and *network organisation* would need to be called out to the architect, along with any other consequences for *workflow interdependence* and *social tie strength* for instance. For the sake of brevity, we provide an example analysis of two of the eight dimensions below.

Social tie strength *(Monitoring: low. Evacuation: intermediate)*: There are significant differences in the relative strength and relationship of interactions between individuals. Further, there will be different levels of interdependency depending on participant role: they may be citizens / potential evacuees, operational staff, or members of the emergency services. Their relationships will change as situations change; further the social tie strength is not necessarily bidirectional.

During monitoring: Social tie strength will tend to be latent during normal operations: although being monitored by operational staff, neither group is particularly concerned with or dependent on the other. There may be strict guidelines and hierarchical dependencies between them as the situation changes, of course.

During an emergency: Social tie strength will increase during evacuation not least as dependencies increase: natural groupings are likely to form between evacuees with a view to mutual support if possible, and involvement of emergency services may introduce other relational dynamics between those responsible for the safe evacuation of participants. *Note* that in Figure 19 the value indicated represents an aggregate across all human participant types.

H2M interaction strength (*Monitoring: low. Evacuation: high*): H2M interactions will remain fairly low-key, with low levels of reliance and dependency on machines for citizens / potential evacuees and for operational staff. However, we do note that operational staff do have a greater reliance on machines to perform monitoring activities. This will change, though, as different situations arise, with occasional override by operational staff if they decide to check or have checked specific details and issues.

During monitoring: The overall strength of H2M interactions is relatively low, though the operational staff will tend to relinquish responsibility for monitoring to automated processes using data provided from sensors.

During an emergency: During evacuation or other emergencies, however, dependence on machine processing will to some extent reduce: potential evacuees, operational staff, and if involved, emergency staff may well make extensive use of the outputs of sensors and warnings and alerts from any decision support platforms, but they will typically retain overall responsibility for the synthesis of immediate and historical facts.

6.3.3 Step 3 - implication analysis (Case 3)

Following the previous step, we can make certain observations pertaining to implications when the network changes state. For example, we observe that agency increases differentially with greater real-time processing and two-way sensor control as well as increasing human decision making. As noted before, this has implications for the architecture, requiring flexibility and scalability.

We can also observe implications that lead to the desire to control certain dimensions, such as human and machine agency, both of which we see increase in the previous step. For example, the introduction of the DSS has implications pertaining to trust and reliability as the staff need to rely on the information for their decision making that they are ultimately responsible and accountable for. Hence, for safety reasons, the staff seek to control the agency of evacuees so that they follow instructions in order to safely evacuate; and for ethical reasons, the agency of machines so that their processes are transparent and decisions are left with operational staff rather than being fully automated.

In a focus group with five participants, discussing potential opportunities and implications for the eVACUATE network (Pickering et al., 2016). At a higher level, in terms of the objectives of the HMN, the increased agency introduced by the DSS (in particular), can increase safety levels while keeping the same number of staff. However, the participants also noted that the HMN owners may alternatively chose to save costs while maintaining the same safety levels.

In the aforementioned focus group, trust implications were explored. It was established that the trust relationship between the DSS and operational staff is important, as the staff need to rely on the information for their decision making that they are ultimately responsible and accountable for, as noted above. As such, using a network diagram approach (as discussed in Section 5.2.4 – see Figure 13

on page 53), we summarise the following implications and potential mechanisms for maintaining or building trust that were identified by the participants:

- ***Trust:*** transparent reporting of history and state might engender trust; i.e., the system should provide evidence about the recommendations it makes.
- ***Reliability:*** continuous service and fault tolerance essential as operational staff become reliant on the DSS and may be concerned with how the system's performance may impact on their job performance.
- ***Report state:*** the current state of the system should be made available to support the perception of reliability as well as trust.

6.3.4 Step 4 - design considerations (Case 3)

On the basis of the implications discussed above, existing design solutions identified in HUMANE apply, e.g., "increasing trust of users through transparent algorithms"[12], though not necessarily for all actors in the network. To build trust in the operational staff, the participants considered information transparency to be important. However, for the evacuees, different strategies were considered more appropriate, e.g.:

- ***Schema patterns:*** lighting used in support of information presented on signage, e.g., by turning off lights in hallways for paths evacuees should not follow.
- ***Informative displays:*** adding too much detail could potentially delay the processing of information and, therefore, an evacuation.

Put more generally, any information presented to users should be appropriately structured in order to ensure that they can understand and process the information fully under the circumstances where it will be used.

Specific to the DSS capabilities in the eVACUATE network, a design solution was proposed to retain browsable records of historical performance (correct as well as incorrect decisions made). In a similar vein, a possible design solution is to provide regular reports highlighting the accuracy of the system's performance. Both of these relate to the design solution noted above, about increasing transparency in order to maintain trust.

6.3.5 Key learnings (Case 3)

Within the HUMANE project, two eVACUATE focus groups were held. Both led to a number of insights of benefit to both the participants and the HUMANE consortium. In the first focus group (Lüders et al., 2016), the key benefit of the HUMANE approach was seen as facilitating cross-disciplinary communication. The participants stated that this was a common challenge for them, working with a range of technical and non-technical people. Even within groups of technical people, describing a system using formal methods like UML was not considered commonly understood. In comparison, the

[12] https://networkprofiler.humane2020.eu/patterns/aztzZQQtyKmRoY2Wi

approach in HUMANE allowed them to quickly gleam insights (implications) of the relationships between actors, for example.

Both focus groups (Lüders et al., 2016; Pickering et al., 2016) addressed a similar feedback with respect to the HMN profiling. They could see the benefit in the initial stages of a design process and for facilitating a means of knowledge sharing. However, they did feel it was too high level to be used for implementation. As such, they would then move on to using formal methods tailored for architectural design, for example. As such, the HUMANE approach has been focused on the higher, strategic, level.

In terms of conducting the profiling, the approach taken with the HUMANE tool was well received, reducing the entry requirements by the participants for being able to use the HUMANE method. They did, however, comment on possible improvements to make the statements posed by the tool simpler and include examples to help reliably interpret the dimensions of the typology. Further, they also missed a way in which they could address an issue with conflating information within a single dimension, such as the varying levels of agency that may be exhibited by different actors. As above, the HUMANE typology and tool has been updated according to this feedback, as discussed in Section 2.4.

7 Types from profiles

The HUMANE typology supports the characterisation and comparison of HMNs on a small set of dimensions. In the above, we have presented how the typology can be applied as part of the HUMANE method, to support analysis and design of individual HMNs.

However, the typology holds the promise also to support the identification of generic HMN types on the basis of similarities in HMN profiles. The identification of such HMN types would be useful both to explore the assumption of cross-domain similarities in HMN characteristics, to strengthen the basis for reflection on HMN similarities, and also to strengthen the support for implication analysis and transfer of design experience in the HUMANE method.

The identification of generic HMN types, however are challenging. In the HUMANE case trials (D3.2 and D3.3), we have found that the profiling of a HMN inevitably has an element of subjectivity associated with it. This may be seen as a strength in the typology and method, as it may be used to facilitate strategic discussion within a design team. At the same time, this element of subjectivity imposes some limitations on the identification of generic types from a large number of profiles.

In this section, we present our explorations into the extraction of main HMN types on the basis of individual HMN profiles. For this purpose, we have analysed a large number (200) of HMNs, and then applied clustering algorithms to identify nine specific HMN archetypes.

Given the subjectivity involved, the outcome of this analysis should be considered only as one possible interpretation of such HMN archetypes. Nevertheless, the analysis provides an interesting and engaging glimpse into the potential of HMN types as a means of supporting HMN analysis.

7.1 Research design

A list of HMN's was compiled based on, but not limited to, the HUMANE literature review (Tsvetkova et al., 2015). 200 different HMNs have been selected ranging a wide set of application areas.

The HMNs were profiled based on a refinement of the second version of the typology and method (Følstad et al., 2016). The profiling of each HMN was conducted by assessing the HMN on three aspects for each typology dimension. Each aspect was assessed through a single question, with a total of 24 such questions across the eight typology dimensions. The responses to the questions were rated on a four point Likert scale with the average of the three questions being the value for each dimension.

All 200 HMNs were profiled by a single coder. A random sample of 96 cases were profiled independently by a second coder to validate and assess reliability (see below).

7.2 Results

In this results section, we first present how we moved from scores on the questions reflecting dimension aspects to the typology dimension scores. Then we present some observations on the distribution of the dimension, as well as our analysis of the correlation between dimensions. Finally we present the cluster analysis and the emerging HMN types, before reviewing the limitations of this approach.

7.2.1 From questions to typology dimension scores

A HMN profile consists of the scores for the eight typology dimensions. Scores for each of the typology dimensions were obtained by averaging the scores for the three questions associated with that dimension. To assess whether such averaging was justified, we investigated the inter-item reliability of the items for each typology dimension.

Inter-item reliability concerns the degree of covariation between the items measuring the same dimension. Inter-item reliability of Cronbach's alpha >0,7 is considered satisfactory as a general rule of thumb. Across the 200 profiled cases, inter-item reliability for D1-D7 were all above 0,8. Inter-item reliability for D8 was 0,6.

Hence, inter-item reliability was established for D1-D7. For D8, Q3 (low level of regulation) was found to significantly reduce inter-item reliability.

7.2.2 Distribution of the dimensions

Based on the whole population of all the profiles, the distribution of the values of each dimension was determined. Visualizing the distribution of values for each typology dimension, as in Figure 20, allowed for an examination of trends in of each the dimension.

High levels of human-machine relationship strength, high network size, and large geographic spread were typical features across most HMN profiles. Human agency, machine agency, workflow interdependence, and network organization in the HMN profiles were somewhat more towards an intermediate level. Social tie strength typically was assessed as low.

At the same time, all dimensions show a certain distribution of values across the profiled HMNs. The distributions of dimension scores, hence, illustrate that relevance of differentiating between HMNs on the basis of their profiles, and also indicates that clustering of HMNs based on profile differences is feasible.

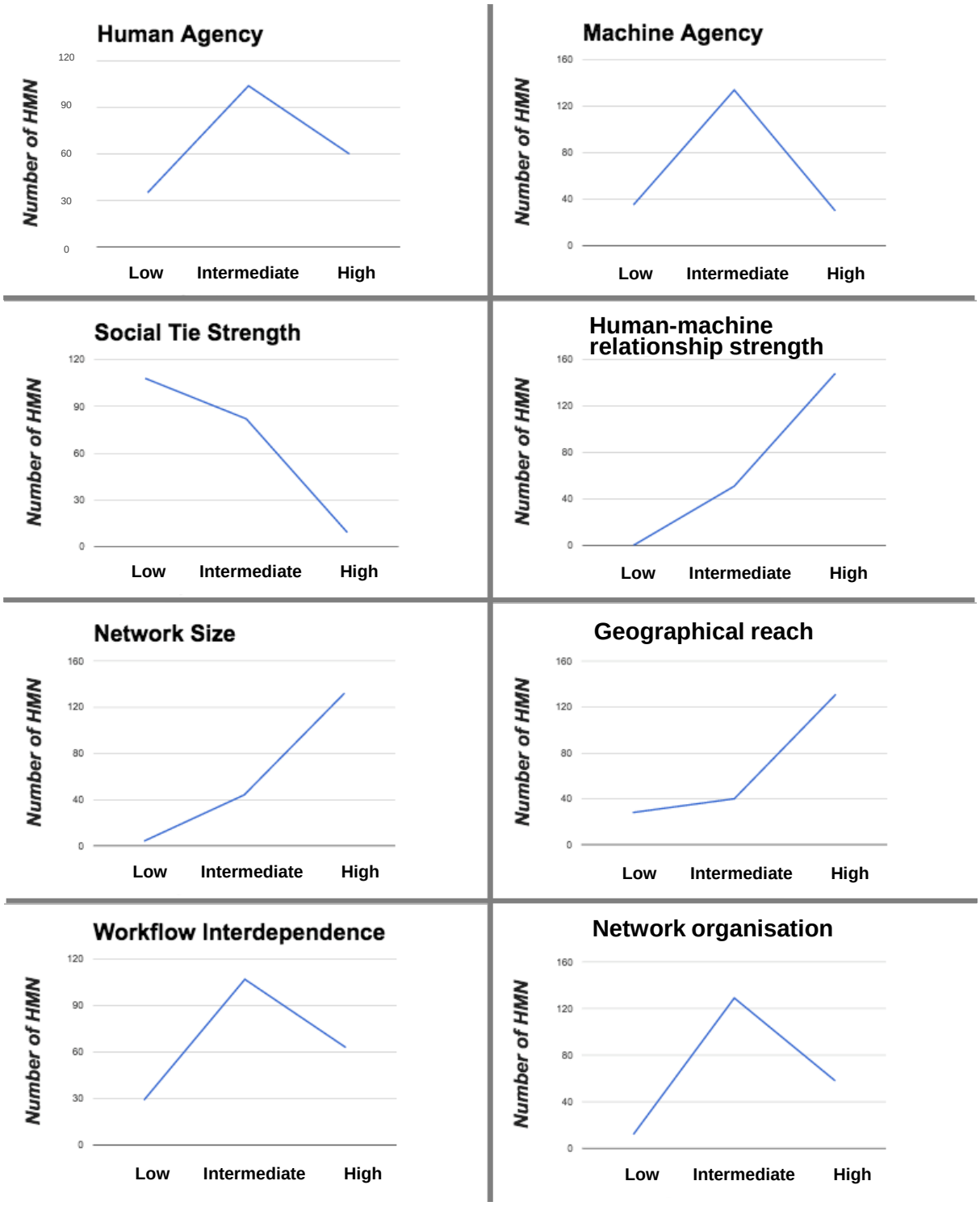


Figure 20: The distribution of values for each dimension for 200 profiled HMNs.

7.2.3 Correlation of dimensions

Upon having established the dimension scores for the different HMNs, the task was to identify different types of HMN's based on these scores. First we investigated the correlations between the values obtained for each dimension (Table 3).

Some interesting observations was made already at this point. The highest correlations were found between D1 (human agency) and D3 (social tie strength), as well as D7 (workflow interdependence) and D8 (network organization). Thus, in general higher human agency co-occurs with high social tie strength and larger network size corresponds to wider geographical reach. The correlation between human agency and social tie strength may for example point to the possibility that the levels of agency required in such networks depends on or is facilitated by high levels of social tie strength, while at the same time possibly the motivation required for high levels of human agency may be derived from stronger social ties. The correlation between size and reach may not be surprising, as larger networks also typically have an international character. However, it should be remembered that range of HMNs also exist which has high geographical reach and relatively small size such as may be the case of networks of collaborating researchers and research infrastructure.

The strongest negative correlation is observed between D6 and D8; centralized control of the network is associated with weaker geographical reach. This may possibly reflect the challenge in upholding a highly centralized HMN across diverse cultures and regions.

Table 3: Correlation matrix of the values for each typology dimension.

	D1 Human agency	**D2** Machine agency	**D3** Social tie strength	**D4** Human-machine rel. str.	**D5** Network size	**D6** Geogr. reach	**D7** Workfl. Interdep.	**D8** Network org.
D1	1.00	0.18	0.44	-0.15	0.09	0.10	0.13	-0.19
D2		1.00	-0.08	0.03	-0.15	-0.09	-0.03	-0.02
D3			1.00	0.05	0.08	-0.08	0.29	-0.02
D4				1.00	-0.03	-0.09	0.13	0.32
D5					1.00	0.43	-0.16	-0.03
D6						1.00	-0.14	-0.27
D7							1.00	0.09
D8								1.00

In order to examine the necessity of having 8 different dimensions, a Principal Component Analysis was run. The obtained latent values as a function of the number of dimensions considered is shown in Figure 21. The results do not suggest a dimension reduction, as all dimensions provided substantial explaination of the variance in the data. The latent does not reach 95% at any point before including all 8 dimensions.

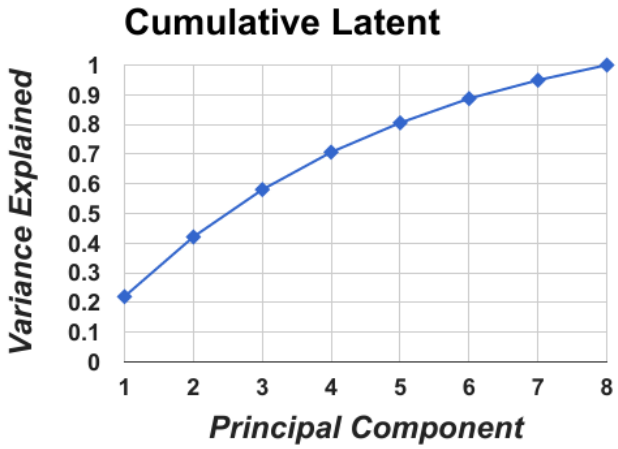


Figure 21: The latent values of Principal Component Analysis for the 8 dimensions of HUMANE typology

7.2.4 Cluster analysis

A cluster analysis was conducted to investigate which groups of HMN profiles that are sufficiently similar so as to form what we may interpret as HMN types.

A k-means clustering algorithm was run over the values for the 8 dimensions to identify different types of HMN. In k-means clustering, the number of clusters is a free input parameter. Different numbers of clusters were tested to optimize for the best ratio of within/cross cluster distance.

Nine was determined to be the preferable number of clusters. The identified clusters (types) and the average value of each dimension is reported in Table 4.

Table 4: The average values for each dimension reported for the identified types.

Cluster	D1: Human agency	D2: Machine agency	D3: Social tie strength	D4: Human-machine relationship strength	D5: Network size	D6: Geograph-ical reach	D7: Workflow interdep-endence	D8: Network organi-sation
1	2,2	2	2,2	3,6	3,2	1,6	3,6	3,1
2	3,3	2,5	1,5	3	3,7	4	2,3	2,1
3	2,1	1,9	1,6	3,5	3,7	3,8	2,9	2,7
4	1,8	2,4	1,3	3,2	3,4	2,1	1,9	3
5	3,3	2,5	2,4	3,7	3,8	3,6	1,9	2,9
6	1,6	3,4	1,1	3,5	2,1	2	2,1	3,1
7	1,8	2,5	1,1	3,7	3,7	3,9	1,9	3
8	3,6	3,1	2,2	3,5	3	2	3	2,8
9	3,2	2,7	2,3	3,5	3,7	3,8	3,4	2,7

The corresponding profiles for the emerged types are shown in Figure 22. There is less variation in some of the variables among all the types. This corresponds to what we have already seen above

(Section 7.2.2) that D3 (social tie strength) is generally low while D4 (human-machine relationship strength), D5 (network size), and D6 (geographical reach) are generally high among the considered HMNs.

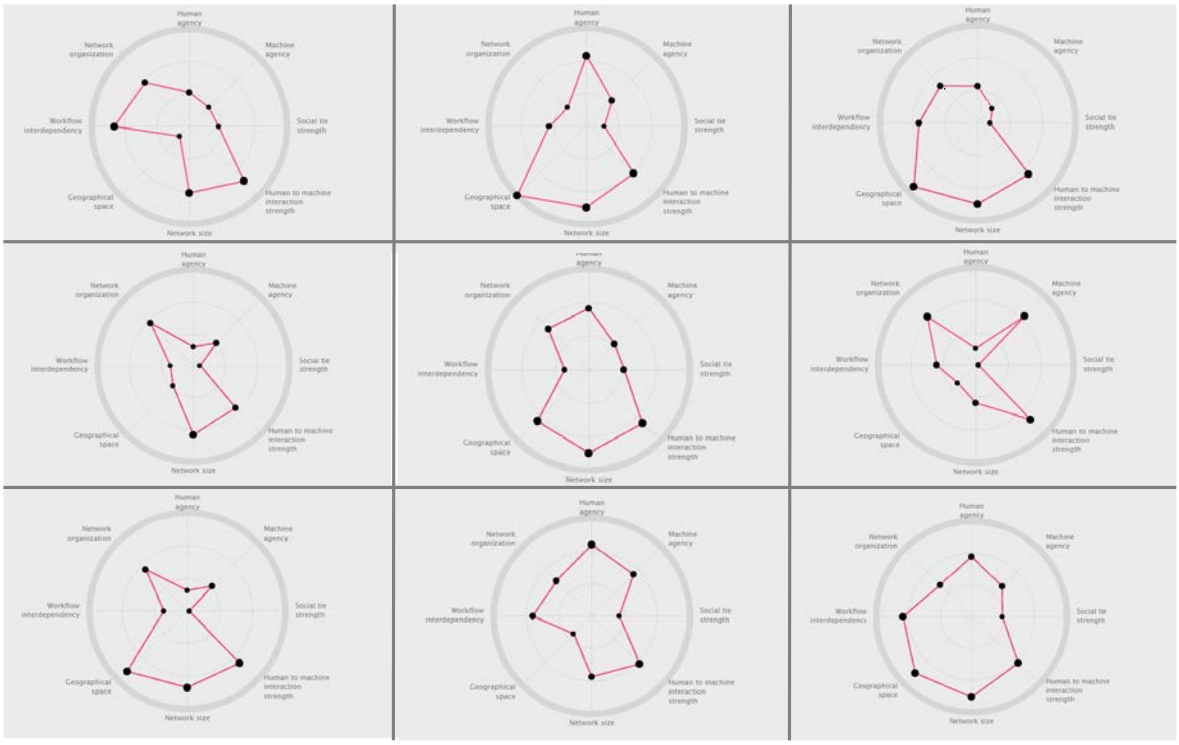


Figure 22: The profiles of the nine identified HMN types.

7.2.5 Reviewing the emerging HMN types

For each of the nine types as identified above, associated illustrative HMN profiles are shown in Figure 22 above. Since the dimensions for the archetypal profiles are based on the average values as shown in Table 4, the profile of individual HMNs belonging to a particular cluster may not look exactly like their type. This should not be surprising given the methodology and implications of averaging.

What is more striking perhaps is that networks with very different aims (for instance, *TripAdvisor* and *World of Warcraft* in Type 1) nonetheless cluster together. We see this as an interesting opportunity for cross-domain reflection on implications and transfer of design knowledge. While belonging to widely different domains, HMNs may share characteristics which make it meaningful to consider these as part of an implication analysis and as a source of design considerations.

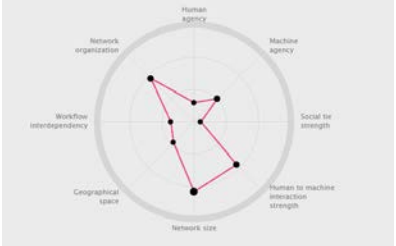
In the following we will exemplify this by reviewing some of the HMNs that cluster together.

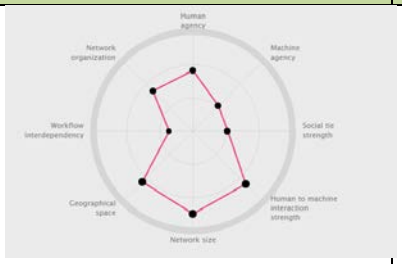
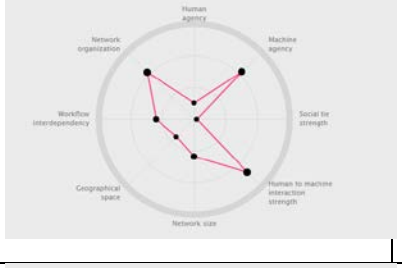
One example is the case of HMNs assigned to Type 2, which are characterized by low network organization (substantial self-organization) and low levels of workflow interdependence. While these HMNs can grow fast and wide quickly, the content control is a big challenge. Youtube, Reddit, Craigslist, Twitter, etc. all suffer from low credibility, misinformation, and hateful content.

Another example, are the HMNs assigned to Type 6. Here we find HMNs such as Amazon Alexa, Tesla Autopilot, Climateprediction, and Jukedeck. All of these are systems with high levels of automation or applications of artificial intelligence, as seen in the high level of machine agency, while the expected input from humans is relatively restricted, as seen in low levels of human agency. It is interesting to note that these HMNs also display relatively high levels of human-machine relationship strength and network organization, which arguably are required to facilitate the high levels of machine agency.

More generally, we believe that such clustering can help us to transfer knowledge within and cross types and network developers and designers can learn a great deal by comparing their networks to other examples in the same type or other types.

Table 5: Assignment of HMN's to the identified clusters.

	HMN type profile	Assigned HMNs
T1		Breakthrough, CreekWatch, Epic, Freecycle, Funding Circle, GoFundMe, Grubhub, Honor, Instacart, Lending Club, LendInvest, Lyft, Prosper, Shift, Shyp, SnapMD, Tettra
T2		Bitcoin, BitTorrent, Blogspot, Craigslist, Foursquare, Houzz, Imgur, InMobi, Pinterest, Pirate Bay, Reddit, Second Life, Skout, Sprinklr, Strava, Swarm, Tumblr, Twitch, Twitter, Vimeo, Weebly, Wikia, Wix, WordPress, Yelp, YouTube
T3		Adbrain, Airbnb, Aria Oncology, arXiv, BlaBlaCar, Booking.com, CareKit, CiteUlike, ConstantContact, Delivery Hero, DocuSign, eBay, Eventbrite, Glassdoor, Gumtree, Indeed, Kickstarter, Kiva, MailChimp, Monster, Quickbooks, Snapsale, Stack Overflow, StubHub, Tinder, Transferwise, Trello, TripAdvisor, Uber, Udacity, Udemy, Ushahidi, Venmo, Wikipedia, Zendesk, Zomato
T4		Amazon Go, Baidu, Betterment, Checkr, Credit Karma, Digg, FoldIt, Olio, Square, WayUp, Wealthfront, Yandex, Yikyak

	HMN type profile	Assigned HMNs
T5		Box, Confide, Dubsmash, EyeEm, Facebook, Flickr, Giphy, Goodreads, Google Docs, Google Trips, Hootsuite, Instagram, OpenTable, Pandora, Periscope, Research Gate, Scoop it, SHAREit, Sharing Academy, Shutterstock, Sina Weibo, Snapchat, SoundCloud, Untappd, Whatsapp
T6		Amazon Alexa, Climateprediction.net, Jukedeck, LHC@home, Nericell, Otto, Tesla Autopilot
T7		Babble, Bing, Bitly, Dataminr, DraftKings, Dropbox, DuckDuckGo, Duolingo, GoEuro, Google, Google, Flights, lynda.com, Napster, Netflix, PayPal, Pokemon Go, Publish or Perish, reCAPTCHA, SeatGeek, Shazam, Spotify, Stripe, WorldRemit, Yahoo, Zotero, Zwift
T8		After School, BURP, DonorsChoose, EatStreet, Gigster, LifeDojo, Magic Leap, MapMyRun, Myfreeimplants, Navdy, Okta, Qualtrics Surveys, Renren, Reveal, Wreckamovie, Youku, Zenefits, Zillow, Zocdoc
T9		Amazon Mechanical Turk, Couchsurfing, Coursera, CrowdFlower, edX, Etsy, Fiverr, Github, Google Allo, Grindr, Groupon, Hinge, Indigogo, Kaggle, LinkdIn, match.com, Messenger, OkCupid, OpenStreetMap, Quora, ResearchKit, Salesforce, Siri, Skype, Slack, Upwork, Waze, World of Warcraft, YouNow, Zooniverse

7.2.5 The subjectivity in profiling

As mentioned initially in this section, the profiling of HMNs likely imply a substantial element of subjectivity. Even though we have worked towards increasing the robustness through iterations over different versions of the questions and providing detailed explanations to the coders, HMN may still be profiled differently by different users. For instance, when we consider the case of Wikipedia and

the dimensions pertaining to network structure (workflow independence and network organization), one perspective might consider the network extremely organized with well documented conventions and policies, on the other hand the fact that all these norms are developed and institutionalized by users and within a bottom-up framework might suggest a lack of organization, at least in the original meaning of the concept.

The profiling hence, to some extent is expected to depend on the interpretation of the profiler. This does not imply that such profiling cannot be used as basis for a cluster analysis, but rather that the output of the analysis should be seen as one possible set of clusters which may be used to drive explorations into potential implications and design considerations rather than seeing the output as an exact detailing of a definitive set of clusters.

To investigate the degree of subjectivity interpretation in the profiling included in this analysis, we assessed inter-rater reliability of profile scores from individual profilers. Inter-rater reliability concerns the degree to which two raters reach similar profiles when independently assessing the same HMN. Since the dimensions are assessed on interval scales, inter-rater reliability may be investigated through Pearson correlation (*r)*.

Inter-rater reliability was investigated through having two independent raters assess the profiles of 96 of the HMNs included in the profiling study. Inter-rater reliability was somewhat low for dimensions D4 and D5, and to some extent also for D3, suggesting substantial subjective interpretation in the coding process for these dimensions. See Table 6. This subjectivity indicates that when exploring HMN profiles through clustering, it will be beneficial to use the same coder throughout the entire profiling.

Table 6: Inter-rater agreement for the eight typology dimensions

Dimension	**Inter-rater agreement (*r*)**
D1 (human agency)	0.41
D2 (machine agency)	0.49
D3 (social tie strength)	0.38
D4 (human-machine relationship strength)	0.15
D5 (network size)	0.27
D6 (geographical strength)	0.46
D7 (workflow interdependence)	0.42
D8 (network organization)	0.45

7.2.6 Future improvements

Apart from potential subjectivity in the profiling process, one has to bear in mind that the clustering approach involves a significant simplification. Reducing a phase-space of 6561 different configurations (3 values for each dimension, independent from each other) to 9 types unavoidably leads to imperfection of assignments of individual profiles. Hence one has to consider this exercise a method to find "related" rather than "similar" profiles. The mismatch between individual profiles and the average profile of the type that they are assigned to, should not be seen as an error, but an intrinsic feature of this approach.

The provided analysis can be improved in two different ways. First, the profiling used here is perfumed by a single coder and might be biased. A more consistent profiling scheme with high reliability is ongoing that will lead to a more robust clustering as well.

The clustering algorithm used here (k-means clustering) is sensitive to parameters and number of iteration. A more sophisticated algorithm may be applied to increase the consistency and robustness of the results.

8 The HUMANE tool

To make it easy to use the HUMANE typology and method in design and development projects, we have developed an interactive tool to support HMN profiling and transfer of design knowledge and experience in a design pattern format.

The tool, while not initially planned as part of the project, was developed in response to experiences from the HUMANE case trials (Lüders et al., 2016), that designers and developers would need tool support to profile HMN fast and easy. Furthermore, to identify similar HMNs and benefit from design patterns extracted by other researchers or practitioners adequate tool support is needed.

The tool has been developed to a fully functional prototype version and is available at https://networkprofiler.humane2020.eu).

A first version of the tool was presented in the previous version of the HUMANE typology and method (Følstad et al., 2016). This second version of the tool has been developed in response to feedback from the second set of case trials (Yasseri et al., 2016) as well as evaluation sessions with individual users.

8.1 Tool – overview

The tool, called HUMANE Network Profiler, is an interactive website with an introduction to HMN profiling and features for HMN profiling, sharing and reflecting on design knowledge in the form of design patterns, and browsing of existing HMN profiles and design patterns.

The user interface of the tool applies Google Material Design[13]. This is a design framework with an associated library of components, facilitating consistent design and good user experience across varying devices. The tool is implemented in Meteor 1.4[14], a javascript platform for web and app development.

The tool includes the following main parts:

- **Getting started:** An introductory page presenting the concept of HMN as well as the HUMANE typology and method.
- **Profile a network:** A page for profiling a particular HMN. The profiling is conducted as a stepwise process where the user score the HMN on the eight typology dimensions.
- **Browse networks:** Here all HMNs that are profiled in the HUMANE Network Profiler and set as publically available are listed. Each HMN profile is immediately presented in the list view. HMNs may also be filtered according to scores on one or more of the HUMANE dimensions.
- **Browse patterns:** Here all design considerations that are made available in the HUMANE Network profiler are listed. To see design considerations of particular relevance for a particular HMN, the list may be filtered on the basis of scores on one or more of the HUMANE dimensions.

[13] https://material.google.com/
[14] https://www.meteor.com/

- **View individual HMN profiles:** The details of all HMN profiles that are set as publically available may be viewed by all users. The HMN profile contains details on the profile, an overview of related design patterns, and an overview of the most similar HMN profiles.
- **View individual design patterns:** The details of all design considerations presented in the tool may be viewed by all users. The design considerations presents the problem, background and a solution. Each design consideration includes a comment facility where users can comment on, or suggest changes to the described consideration.

The "Getting started" page is presented in Figure 23. The features for entering, browsing, and discussing HMN profiles and design patterns are presented in the following subsections. One subsection also details the user access to the tool.

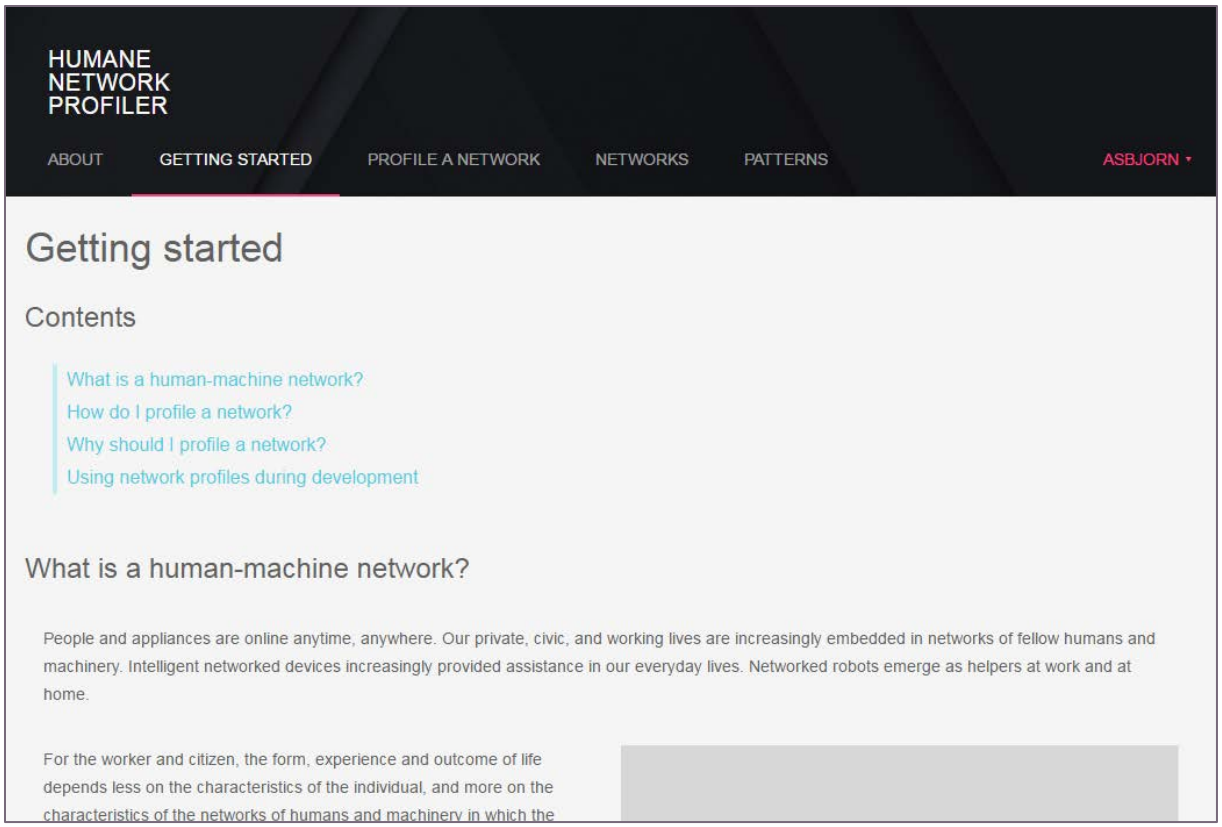


Figure 23: HUMANE Network Profiler - Getting started (screen dump).

8.2 Profiling a HMN in the tool

The profiling process of the tool aims to make the typology (Section 3) more easily available to designers and developers, and supports profiling a particular HMN in six simple steps.

In the first step, the HMN is given a name and brief description. For additional personalization, an optional HMN logo may be added as well as an optional link to an external website providing more details on the HMN.

In the next four steps, the profile is built through responding to questions for each dimension (see Annex 1 for an overview of the questions). Each question reflects one of the defining aspects of the dimension, and responses are given in percentage agreement. Each of the four steps corresponds to a HUMANE analytical layer. Hence one step concerns actors (human agency and machine agency), one concerns relations (social tie strength and human-machine relationship strength), one concerns network extent (network size and geographical reach), and one concerns network structure (workflow interdependence and network organization). In the final step, the profile is consolidated by visualizing the average scores of the questions belonging to each dimension as a spider diagram (See Figure 24).

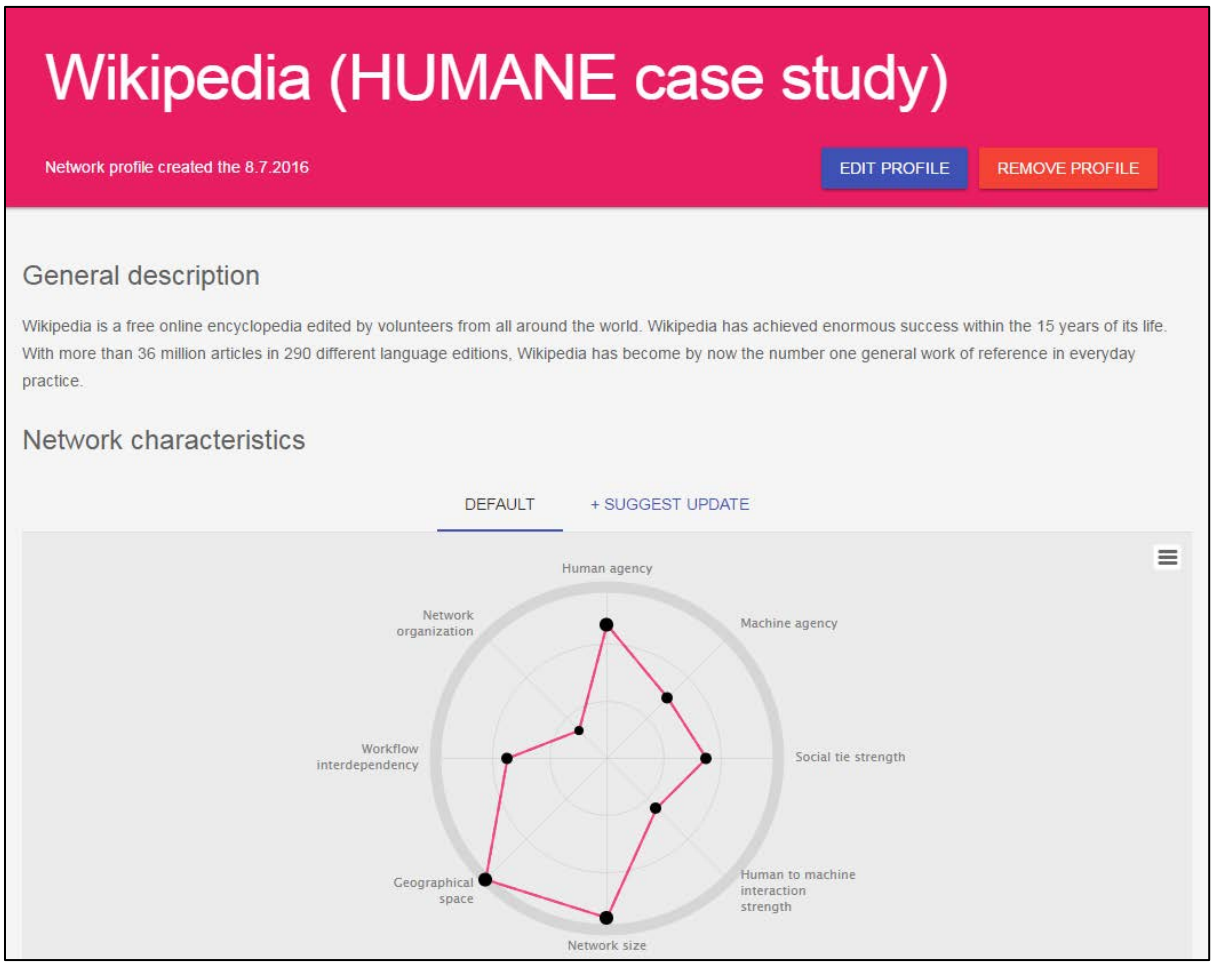


Figure 24: HUMANE Network Profiler – Consolidated network profile (screen dump)

When the profile is stored, it is made available for browsing by other users. Each HMN profile may be reviewed in a separate page. Such a page contains the spider diagram visualization of the HMN profile, a table overview of the eight typology dimensions and the associated profile scores, a listing of relevant design patterns, and a listing of the most similar HMN profiles already registered in the tool.

Address change through including alternative profile scores: In the diagram on the HMN profile page, the owner of the profile page may include alternative profile scores to (a) illustrate change across time towards an envisioned HMN or (b) change between two recurring states of a HMN (see Section 3.2.2

and Figure 8 above). This visualization supports a gap analysis, to enable reflection for example on the changes needed to reach an envisioned future HMN.

Suggesting profile updates: The diagram on the HMN profile page also supports other users to suggest profile updates. As shown in previous case trials, the HMN profiling implies an element of subjective assessment. Hence, a facility for suggesting updates to a HMN profile is useful. Here, the user wanting to suggest an update walks through the profiling process entering new score suggestions.

The suggested update to the profile is made available together with the original default profile, so that the owner of the HMN profile may review suggested changes and make needed updates (see Figure 25).

The user that suggest an update may describe the rationale for the update and include this with the suggested update. Suggested profiles may be made either anonymously or associated with a user name.

The suggested update is not shown by default, but may be accessed by clicking a link immediately above the original default profile.

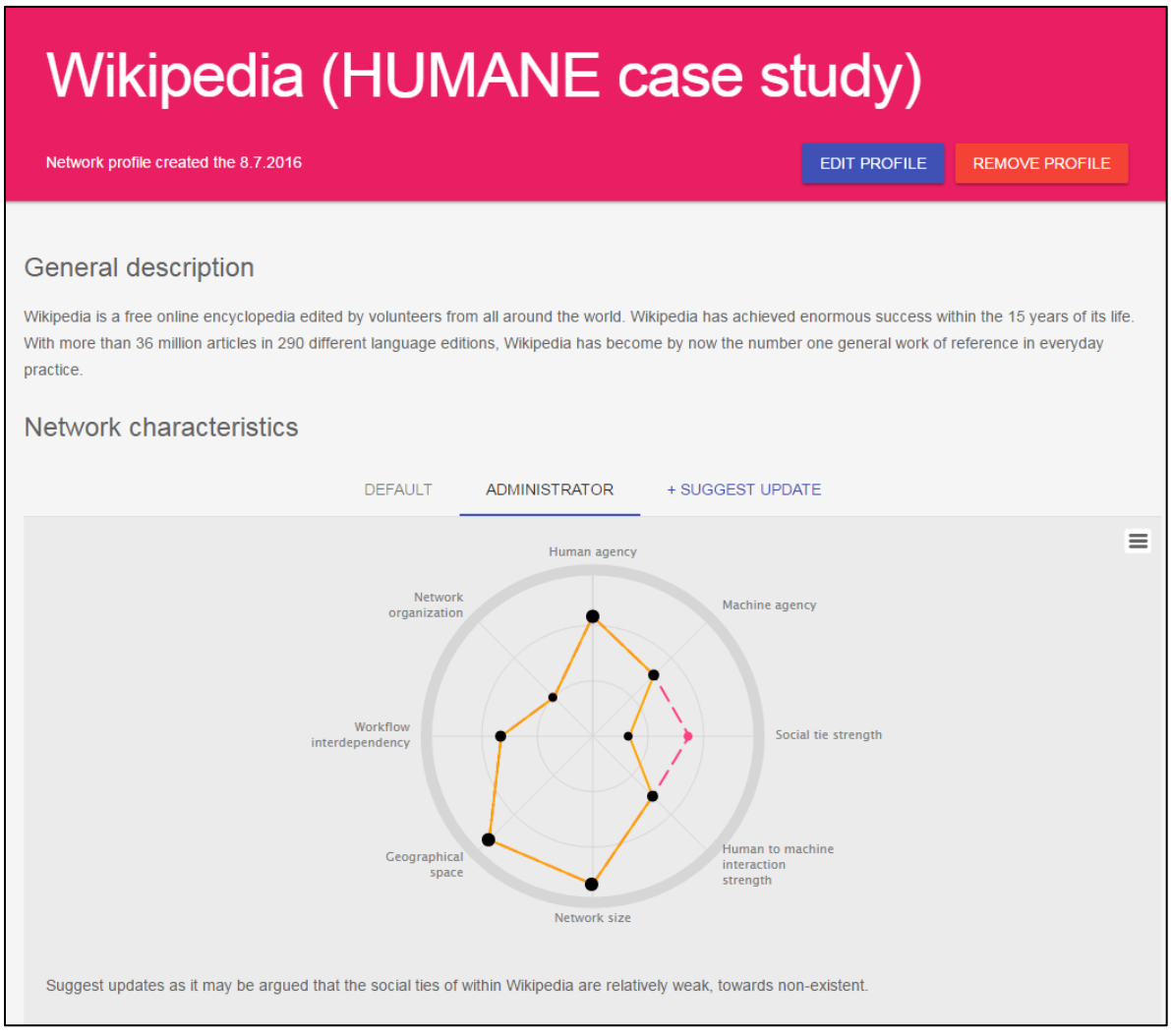


Figure 25: Suggested profile update (made by the user ADMINISTRATOR). Note the gap between the current default profile (pink) and the suggested profile (orange) (screen dump)

Entering additional content or suggestions: All HMN profile pages includes discussion module (http://disqus.com). Users are encouraged to enter comments for example on suggested profile updates as well as needed design patterns.

8.3 Reviewing similar HMNs in the tool

The HMN profile is the basis for identifying HMN that share similar characteristics as the profiled HMN. As part of the HMN profile, other HMNs are listed on the basis of their similarity with the HMN profile in question (see Figure 26).

The listing is done on the basis of a similarity score calculated as the degree of match between the dimension scores for the HMN in question and the matching HMN. A 100% match indicated absolute similarity on the considered dimension scores. A 0% match indicates maximum theoretical difference on all dimension scores. To be included in the list, the threshold similarity value is set to 60%.

HMN profile similarity is categorized as Strong (90-100%), Substantial (80-90%), Fair (70-80%), Weak (60-70%), and below threshold (<60%).

The list of similar HMN profiles may be filtered according to some or all of the typology dimensions. For example, to identify HMNs with similar profiles only in terms of Human agency and Machine agency as shown in Figure 26.

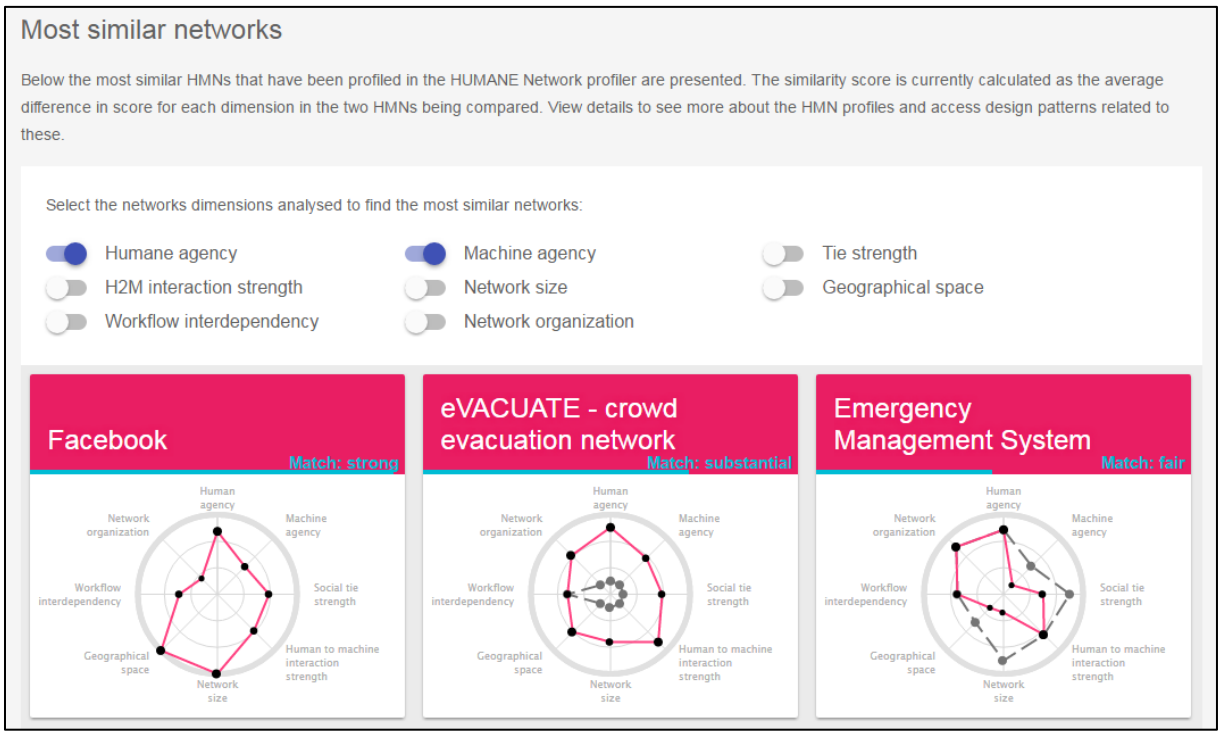


Figure 26: HUMANE Network Profiler – list of similar profiles in the HMN profile page (screen dump).

8.4 Identifying and sharing design considerations in the tool

The HMN profile is the basis for identifying relevant design considerations. Furthermore, the profile is the basis for sharing design knowledge and experience in the form of such considerations. An example design consideration is presented in Figure 27.

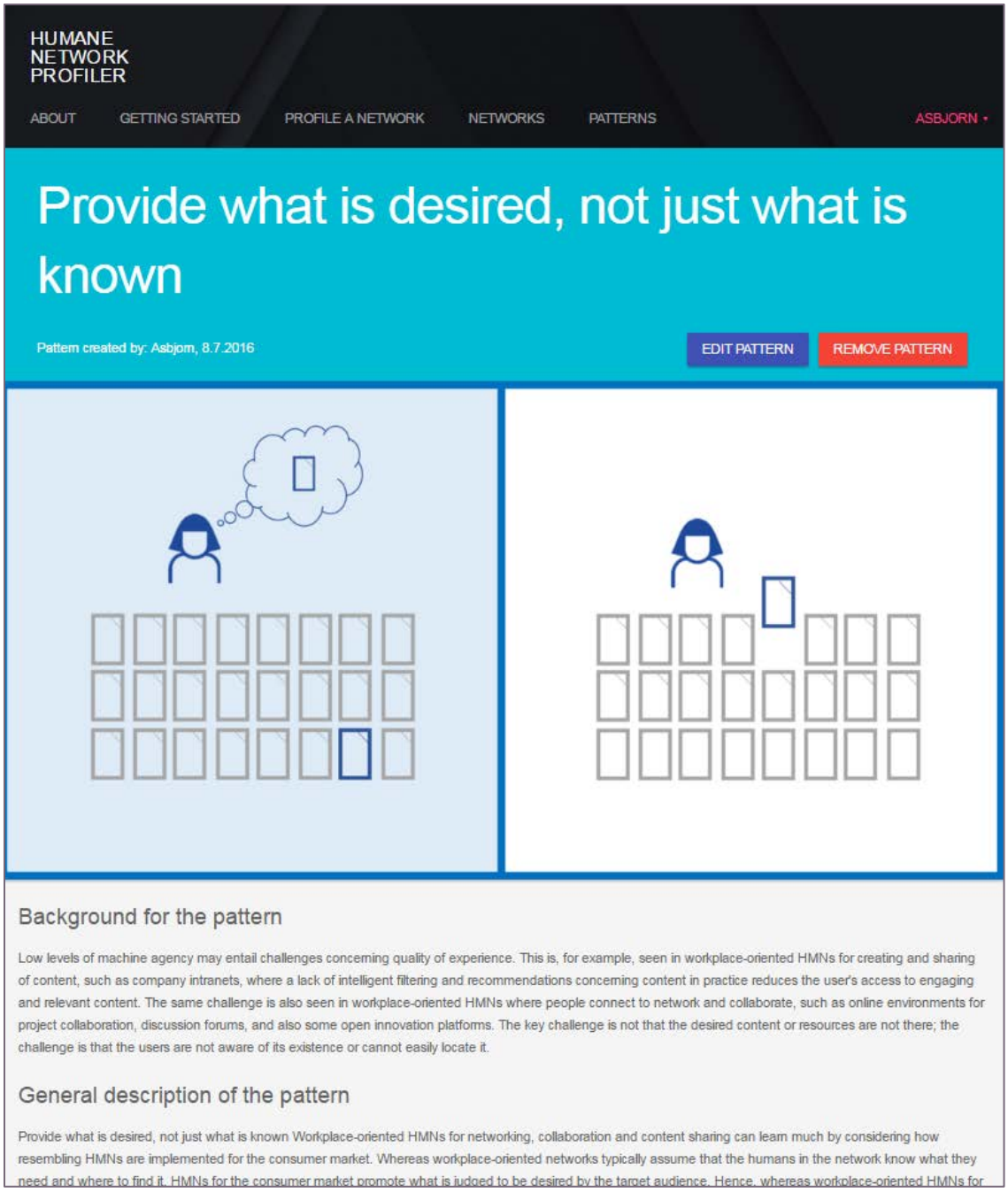


Figure 27: HUMANE Network Profiler – example design pattern[15] (screen dump)

[15] At the time of submitting this deliverable, the tool was not yet updated with respect to referring to "design patterns" as "design considerations". Hence, when referring to specifically to the labels in the tools concerning design considerations, we use the term "design patterns".

Entering additional content or suggestions: In all pages presenting design considerations, a Disqus discussion module is included to facilitate reflections on the design pattern and sharing of experience. This may allow a community of users to support each other in the evolving of entered design considerations.

Identifying relevant design considerations

Relevant design considerations can be associated with HMN profile pages. To populate the section with relevant design considerations from other HMN profiles, the HCD designer access all available design considerations by clicking "Add design pattern" in the HMN profile page. From here, it is possible to browse either all available considerations, or only "suggested patterns" (see Figure 28). Design considerations are suggested on the basis of profile similarity to the HMN profiles with the design consideration added.

Design considerations identified as relevant can be added to the HMN profile. These considerations then will populate the list of relevant design patterns in the HMN profile. Listed design considerations can be filtered according to the implication group they represent (experience and motivation, behaviour and collaboration, innovation and improvement, privacy and trust, or technical infrastructure). See Figure 28.

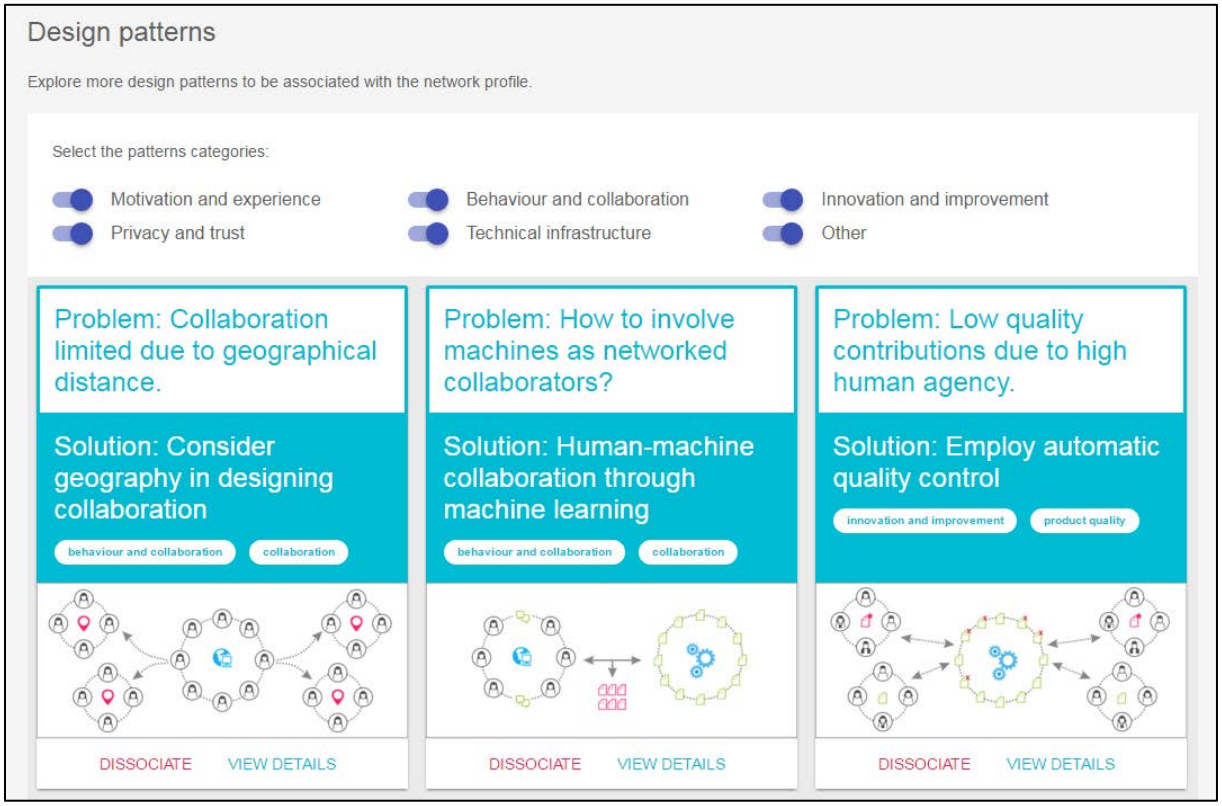


Figure 28: HUMANE Network Profiler - Adding suggested design patterns in example HMN profile page (screen dump).

Adding needed design considerations

Based on the HMN profile, it is also possible to add needed design considerations that are not already available in the HUMANE Network Profiler. Adding new design considerations is done by selecting "Add new pattern" next to the listing of available design considerations.

Adding a new design consideration is done by entering a pattern title, background, problem, solution, and instructions on how to use. The design considerations are also classified as addressing a specific implication category and subcategory. The main categories are User experience and motivation, Behaviour and collaboration, Innovation and improvement, Privacy and trust, as well as Technical infrastructure. An optional image may also be added.

8.5 Browsing HMN profiles and design considerations in the tool

All HMN profiles and design considerations that have been entered in the HUMANE Network Profiler is readily available for browsing through the menu options "Networks" and "Design patterns".

Browse HMN profiles

When entering the page for browsing HMN profiles, all profiles are listed in the order of which they were entered. The HMN profiles are visualized in the listing for all HMNs, to make it easy to compare HMNs through visual inspection.

To facilitate browsing, profiles can be filtered on the basis of the scores on one or more of the profile dimensions (see Figure 29).

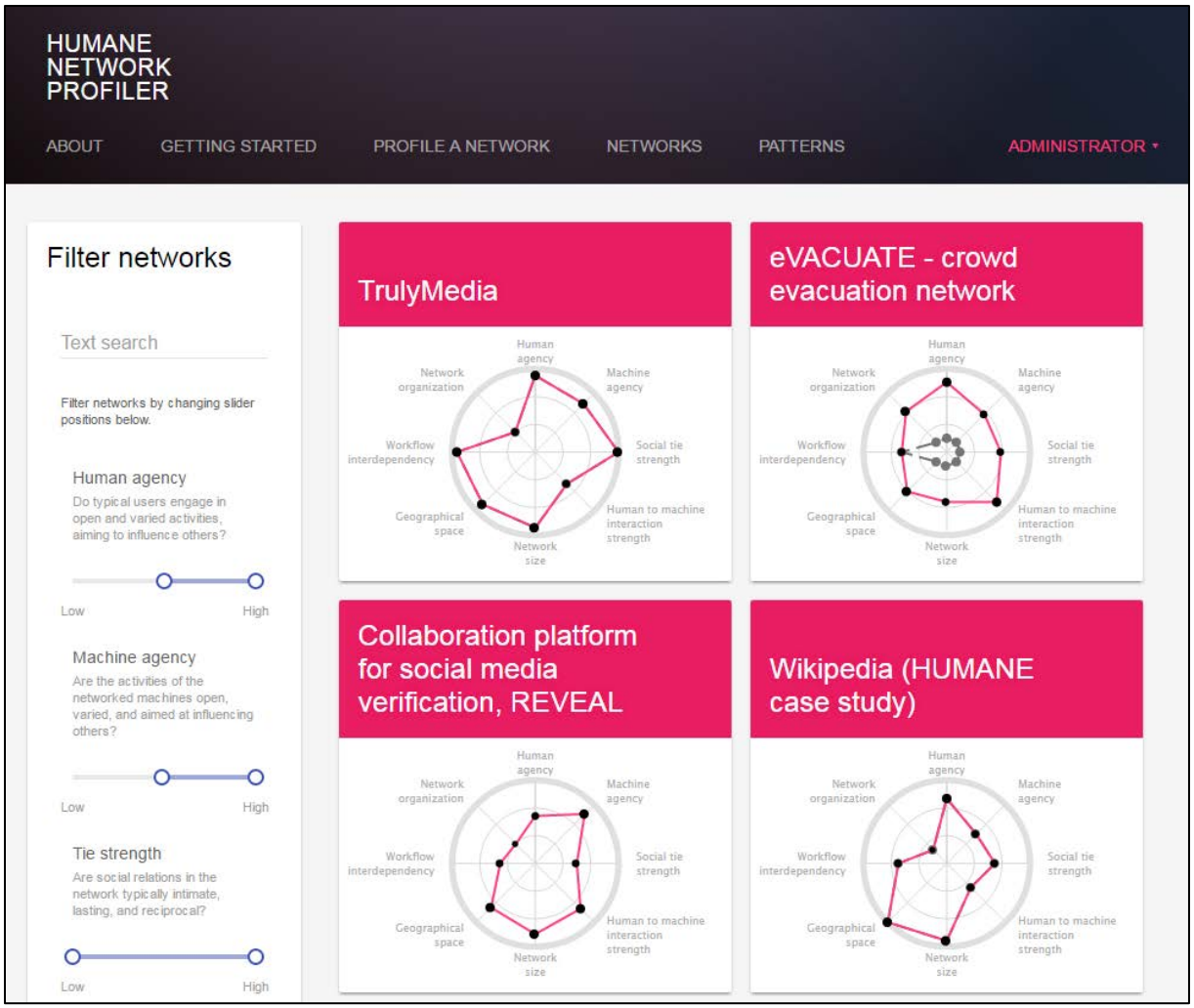


Figure 29: HUMAN Network Profiler - Browse HMN profiles. In this example view, the filter in the left pane is set to display only HMN profiles with high Human and Machine agency (screen dump).

Browse all design considerations

The page for browsing design considerations lists all considerations that have been entered in the online tool. In the listing, the problem addressed as well as the suggested solution is presented together with the optional illustration.

When entered, all design considerations are categorized as belonging to a specific implication group and subgroup. This categorization is used for filtering the design considerations, as exemplified in Figure 30.

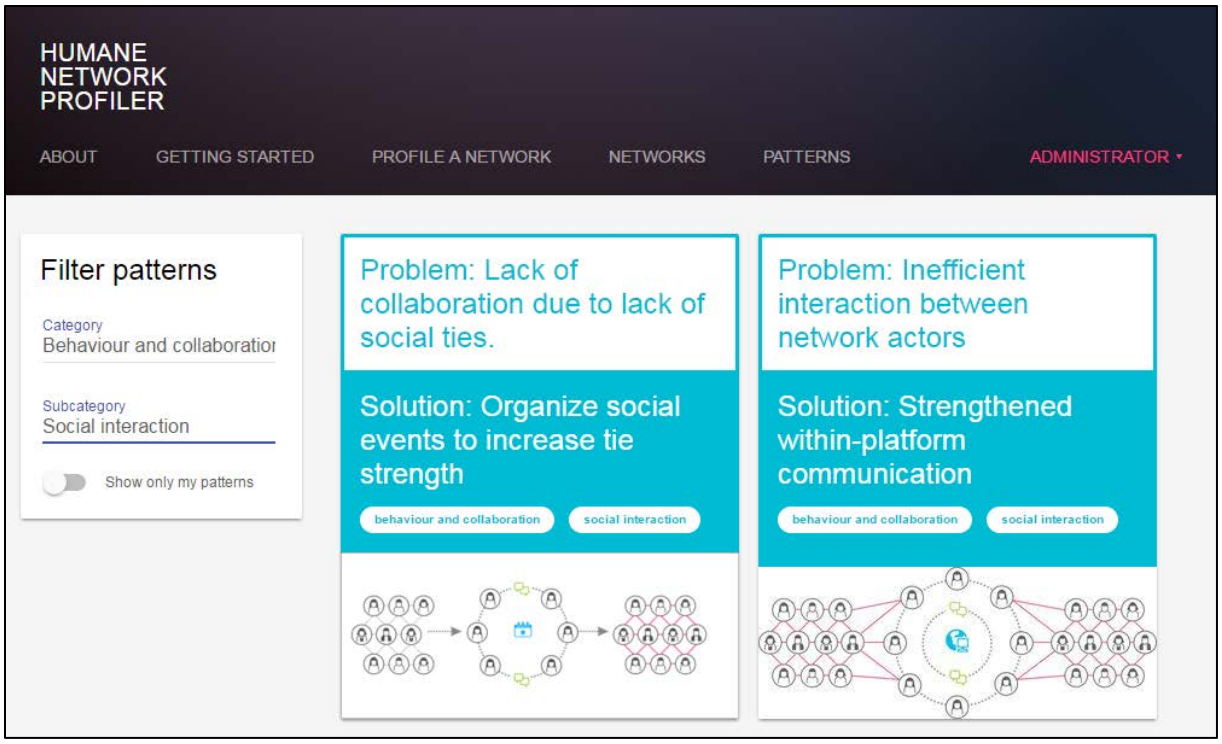


Figure 30: HUMANE Network Profiler - Browse design patterns. In this example view, the filter in the left pane is set to display only design patterns addressing the main category Behaviour and collaboration and the subcategory Social interaction (screen dump).

8.6 Access rights

The HUMANE Network Profiler distinguishes between three levels of access: Not logged in, logged in as regular user, and logged in as administrator.

- **Not logged in.** All content of the HUMANE Network Profiler is openly available to all users, whether logged in or not. The exception to this is HMN profiles that are not yet made public by their owners. Users not logged in can also enter HMN profiles and design patterns, but not make edits or deletions. These patterns and profiles are then marked as "anonymous". Participation in the discussion threads associated with each HMN profile and each design pattern is open to anyone with a Disqus user profile, but does not require to be logged in with a user in the HUMANE Network Profiler.
- **Logged in as regular user.** Any visitor to the HUMANE Network Profiler can register a user. Users can enter new HMN profiles and add design patterns to these, either from the list of existing design patterns or as a new design pattern. Logged in users can also remove or edit HMN profiles or design patterns that they have established themselves.
- **Logged in as administrator.** Administrators have the same access rights as regular users, but may in addition edit or delete HMN profiles or design patterns entered by others.

8.7 Application of the tool as part of the HUMANE method

The tool is designed to support the HUMANE method as described in Section 5. In particular, the tool supports Step 2, 3, and 4.

- **Step 2 – network characterisation.** The tool supports thoroughly the profiling of the HMN. The user is led through the profiling process in a series of steps corresponding to the HUMANE dimensions. The output of the process is a consolidated HMN profile, and support the user in identifying HMNs with similar profiles.
- **Step 3 - implication analysis.** The tool support the user in identifying relevant potential implications through the listing of design patterns. Relevant implication are formulated as a problem statement in the heading of each listed design pattern. The listing may be sorted according to implication group.
- **Step 4 - design considerations.** The tool supports identification and sharing of design knowledge and experience through design patterns. The design patterns are listed in a separate overview, where they may be filtered on implication group. Design patterns are also suggested for each individual HMN profile on the basis of the HMN profile scores.
- **Step 5 - evaluation.** The tool support evaluation by facilitating a gap analysis between a current HMN and an envisioned HMN to be. The profile of the current and envisioned HMN may be visualized for each HMN profile.

8.8 Feedback from evaluations of the tool conducted after the second case trials

Initial feedback on the online tool was provided through the second set of HUMANE case trials (presented in the deliverable D3.3). To get feedback on the online tool also after the improvements made towards this final deliverable, we have conducted a series of evaluations with individual users.

In total six users have been involved in such individual tool evaluations. The involved users are all experts in development and design of information systems, and are all working in research projects designing for human-machine networks. The users had no previous practical experience with the online tool.

8.8.1 Evaluation method

The evaluations were conducted as walkthroughs with individual users. Here, key tool functionality were presented to the participants and the participants were asked for feedback on what they liked, potential issues or problems, as well as change suggestions. Data were collected through note-taking during the walkthrough, and a brief report was summarize for each individual participants.

The detail steps of the evaluation procedure were as follows:

- **Introduction:** Briefly present HUMANE and the HUMANE typology and method. Explain that a prototype tool has been made to support this method, and that feedback is needed on the tool. Explain that the participant will be walked through the tool and encourage feedback on what the participant likes, problems the participant sees, and suggestions the participant has.

- **Profiling:** Walk through the profiling task by showing the steps needed to profile a HMN. One of the existing profiles may be used as an example.
- **Review HMN profiles.** Review the list of similar HMNs on the profile page of the example HMN, as well as the list of all HMN profiles on the page "Networks" with the option to filter networks on profiles.
- **Review design patterns.** Review the list of suggested design patterns associated with an HMN profile. Also show the opportunity to associate other relevant patterns to the profile, and how to add new design patterns. Open and read 2-4 example patterns. Also show list of all design patterns on the page "Patterns" with the option to filter patterns on implication group.
- **Positive things:** Ask for what the participants like. Prompt the participants by asking for things in particular for each of the steps
- **Problems:** Ask for problems. Prompt the participants by asking for things in particular for each of the steps
- **Suggestions**: Ask for suggestions. Prompt the participants by asking for things in particular for each of the steps

8.8.2 Evaluation findings

The participants were in general positive to the tool. The tool was typically considered to have a good presentation and layout. The diagram presentation of the HMN profiles was in general seen as useful and intuitive. Also the notion of design patterns or design considerations was seen as useful.

All however had input for improvement or change, which is a very useful basis for the future development of the tool. In the following we summarize some key identified problems and suggestions. Summaries for individual participants are provided in Appendix 3.

#	Topic	Issues and suggestions	Response
1	The introduction pages	The introduction pages should be even more precise and to the point, and to provide a more immediate overview of the typology, method, and the benefits of using the tool.	Will be given priority in future updates of the tool.
2	The profiling process	To some participants, the terminology of the dimensions and questions is not immediately intuitive.	The envisioned update on the introduction pages (#1 above), should also address this issue
3	The profiling process	Some of the participants suggested changes in the structuring of the profiling questions.	In the most recent tool update, the questions is more clearly structured.
4	The profiling process	Two of the participants suggested example scores from well known HMNs to be included in the question scales, serving as benchmarks when assessing a particular HMN.	Will be considered in future updates of the tool.

#	Topic	Issues and suggestions	Response
5	The individual HMN profiles	Some of the participants expressed the need to get a more immediate presentation of the benefit of the HMN profile, that is, to use the profile for identifying similar HMNs and relevant design considerations.	In the most recent tool update, we have restructured the profile page, to make the design considerations more prominent.
6	The individual HMN profiles	Some of the participants did not immediately understand why design considerations were recommended for a given HMN profile.	Will be given priority in future updates to the tool, e.g. by including lead texts.
7	The individual HMN profiles	Some of the participants expressed the need to have more explanation concerning the alt-scores for the profiles. This could be made more clear, e.g. through lead texts.	Will be given priority in future updates to the tool, e.g. by including lead texts.
8	The individual HMN profiles	Some of the participants saw it as problematic to present a too broad set of similar HMN profiles, and it was suggested not to show weak matching HMN profiles, as these were seen as too diverging from the target HMN profile.	Will be given priority in future updates to the tool.
9	The list of HMN profiles	Some of the evaluations were conducted prior to presenting HMN profile visualizations as part of the HMN profile lists. Here, such visualizations were asked for.	These visualizations have now been included in the tool.
10	The list of design considerations	The participants reported that some of the design consideration may need some reworking, e.g. some of the considerations may be context dependent and this needs to be more clearly reflected in the consideration.	Will be given priority in future updates to the tool.
11	The list of design considerations	The evaluations were conducted at a point where the design considerations were still labelled design patterns in the tool. Some of the participants were confused by this term, as they considered design patterns to be descriptions that may be immediately implementable rather than supporting considerations in the strategic phases of the design process.	This term has been changed to design considerations in the method description to this deliverable, and the tool will be updated accordingly.

9 Conclusion and future work

In this deliverable we have presented the final version of the HUMANE typology and method. We have also provided an overview of three example cases for which the typology and method have been applied, as well as an overview of the online profiling tool and our exploratory work on identifying HMN types on the basis of HMN profiles.

As the typology and method have been refined on the basis of two sets of case trials, we hold that it now can be applied also to benefit also other HMN analysis and design processes. In particular, the typology and method will be beneficial for supporting the initial strategic phases of the design process.

At the same time, opportunities for improvement and future research remain. In the conclusion of this deliverable, we summarize what we see as the main future opportunities.

First, the tool may be further updated on the basis of input from the individual evaluations conducted as part of this deliverable. Some highly relevant opportunities for improvement are provided in Section 8.8, such as providing an even more concise introduction and to be more restrictive in which HMN profiles that are presented as similar to a given HMN. Furthermore, the tool while strongly supporting Step 2 and 4 of the HUMANE method (profiling and design considerations), the implication analysis is not as clearly supported. For example, it could be useful in the tool to include facilities for identifying a problem without already having available a solution, and then ask other users of the tool for suggestions in terms of solutions.

Second, the exploratory work going from HMN profiles to HMN types could be strengthened. For example, it would be interesting to conduct in-depth case trials where such archetypical HMN types were used to guide implication analysis and design considerations.

Third, the theoretical positioning of the typology could be further elaborated, to establish a more complete theoretical framework for understanding HMNs. Furthermore, it will be interesting to apply the typology and method to an even broader set of HMNs to further challenge and potentially also rework the typology.

In conclusion, this final version of the HUMANEY typology and method provides a useful support for strategic design for HMNs. At the same time, it provides the basis for a broad range of exciting future research opportunities. Such future research is important, given the prominent role of HMNs in today's hyper-connected society.

10 References

Acquisti, A. (2009). Nudging Privacy: The Behavioral Economics of Personal Information. *IEEE Security & Privacy Magazine*, *7*(6), 82–85. http://doi.org/10.1109/MSP.2009.163

Acquisti, A., Brandimarte, L., & Loewenstein, G. (2015). Privacy and human behavior in the age of information. *Science*, *347*(6221), 509–514. http://doi.org/10.1126/science.aaa1465

Ajzen, I. (2011). Ajzen, I. (2011). Theory of planned behavior. In *Handbook of Theories of Social Psychology: Vol One* (pp. 438–459).

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A Pattern Language: Towns, Buildings, Construction*. New York, New York, USA: Oxford University Press.

Applin, S., & Fischer, M. (2015). Cooperation between humans and robots: applied agency in autonomous processes'. In *10th ACM/IEEE International Conference on Human/Robot Interaction, The Emerging Policy and Ethics of Human Robot Interaction workshop, Portland, OR*.

Armbrust, M., Stoica, I., Zaharia, M., Fox, A., Griffith, R., Joseph, A. D., … Rabkin, A. (2010). A view of cloud computing. *Communications of the ACM*, *53*(4), 50. http://doi.org/10.1145/1721654.1721672

Bailey, K. D. (1994). *Typologies and taxonomies: an introduction to classification techniques*. Thousand Oaks, CA: SAGE Publications.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84*(2), 191. http://doi.org/10.1037/0003-066X.37.2.122

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist*, *37*(2), 122. http://doi.org/10.1037/0003-066X.37.2.122

Bandura, A. (2001). Social Cognitive Theory: An Agentic Perspective. *Annual Review of Psychology*, *52*(1), 1–26. http://doi.org/10.1146/annurev.psych.52.1.1

Bandura, A. (2012). On the functional properties of perceived self-efficacy revisited. *Journal of Management*, *38*(1), 9–44. http://doi.org/10.1177/0149206311410606

Baxter, G., & Sommerville, I. (2011). Socio-technical systems: From design methods to systems engineering. *Interacting with Computers*, *23*(1), 4–17. http://doi.org/10.1016/j.intcom.2010.07.003

Bayus, B. L. (2013). Crowdsourcing New Product Ideas over Time: An Analysis of the Dell IdeaStorm Community. *Management Science*, *59*(1), 226–244. http://doi.org/10.1287/mnsc.1120.1599

Bessi, A., & Ferrara, E. (2016). Social bots distort the 2016 US Presidential election online discussion. *First Monday*, *21*(11).

Bijker, W. E., Hughes, T. P., & Pinch, T. J. (1987). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Boston, MA: MIT Press.

Borchers, J. O. (2001). A pattern approach to interaction design. *AI & Society*, *15*(4), 359–376. http://doi.org/10.1007/BF01206115

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network Analysis in the Social Sciences. *Science*, *323*(5916), 892–895. http://doi.org/10.1126/science.1165821

Brandes, U., Kenis, P., & Lerner, J. (2009). Network analysis of collaboration structure in Wikipedia. *Proceedings of the 18th International Conference on World Wide Web - WWW '09*, 731–740. Retrieved from http://dl.acm.org/citation.cfm?id=1526808

Brandtzaeg, P. B. (2012). Social networking sites: Their users and social implications—A longitudinal study. *Journal of Computer-Mediated Communication*, *17*(4), 467–488.

Britten, T. (2015). Peaks and clouds: improving how we work. Retrieved February 28, 2017, from https://hmrcdigital.blog.gov.uk/2015/08/14/peaks-and-clouds-improving-how-we-work/

Brown, T. (2009). *Change by design*. New York, NY: HarperCollins.

Burt, R. S. (2004). Structural holes and good ideas. *American Journal of Sociology*, *110*(2), 349–399.

Butler, B., Joyce, E., & Pike, J. (2008). Don't look now, but we've created a bureaucracy. In *Proceeding*

of the twenty-sixth annual CHI conference on Human factors in computing systems - CHI '08 (p. 1101). New York, New York, USA: ACM Press. http://doi.org/10.1145/1357054.1357227

Chesbrough, H. W. (2006). *Open innovation: The new imperative for creating and profiting from technology*. Boston, MA: Harvard Business Press.

Chuttur, M. (2009). Working Papers on Information Systems Overview of the Technology Acceptance Model : Origins , Developments and Future Directions. *Sprouts*, *9*(37), 1–21.

Clark, D. D., Wroclawski, J., Sollins, K. R., & Braden, R. (2002). Tussle in cyberspace. *ACM SIGCOMM Computer Communication Review*, *32*(4), 347. http://doi.org/10.1145/964725.633059

Collier, D., LaPorte, J., & Seawright, J. (2012). Putting Typologies to Work: Concept Formation, Measurement, and Analytic Rigor. *Political Research Quarterly*, *65*(1), 217– 232.

Collins-Thompson, K., Bennett, P. N., White, R. W., de la Chica, S., & Sontag, D. (2011). Personalizing web search results by reading level. In *Proceedings of the 20th ACM international conference on Information and knowledge management - CIKM '11* (p. 403). New York, New York, USA: ACM Press. http://doi.org/10.1145/2063576.2063639

Cooper, A. (1999). *The inmates are running the asylum: Why high-tech products drive us crazy and how to restore the sanity*. Indianapolis, IN: Sams.

Csikszentmihalyi, M. (1992). *Flow. The psychology of happiness*. London: Rider.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 319–340.

Egger, F. N. (2000). "Trust me, I'm an online vendor." In *CHI '00 extended abstracts on Human factors in computing systems - CHI '00* (p. 101). New York, New York, USA: ACM Press. http://doi.org/10.1145/633292.633352

Eide, A. W., Pickering, J. B., Yasseri, T., Bravos, G., Følstad, A., Engen, V., … Tsvetkova, M. (2016). Human-Machine Networks: Towards a Typology and Profiling Framework. In *HCI International*. Toronto, Canada: Springer.

Ellison, N., Heino, R., & Gibbs, J. (2006). Managing Impressions Online: Self-Presentation Processes in the Online Dating Environment. *Journal of Computer-Mediated Communication*, *11*(2), 415–441. http://doi.org/10.1111/j.1083-6101.2006.00020.x

Engen, V., Papay, J., Jaho, E., Rapanakis, S., & Sarris, N. (2017). *D3.4 Typology-driven modelling and validation of design options*.

Engen, V., Pickering, J. B., & Walland, P. (2016). Machine Agency in Human-Machine Networks; Impacts and Trust Implications. In *HCI International*. Toronto, Canada: Springer.

Featherman, M. S., Miyazaki, A. D., & Sprott, D. E. (2010). Reducing online privacy risk to facilitate e-service adoption: the influence of perceived ease of use and corporate credibility. *Journal of Services Marketing*, *24*(3), 219–229. http://doi.org/10.1108/08876041011040622

Fogg, B. (2003). *Persuasive Technology: Using Computers to Change What We Think and Do*. (Y. Kort, W. IJsselsteijn, C. Midden, B. Eggen, & B. J. Fogg, Eds.)*Persuasive Technology Using Computers to Change What We Think and Do* (Vol. 5). Morgan Kaufmann. http://doi.org/10.4017/gt.2006.05.01.009.00

Forte, A., & Bruckman, A. (2013). Scaling consensus: Increasing decentralization in Wikipedia governance. In *Proceedings of the 41st Annual Hawaii International Conference on System Sciences - HICSS* (pp. 157–166). IEEE Computer Society.

Friedman, B., Khan Jr, P. H., & Howe, D. C. (2000). Trust online. *Communications of the ACM*, *43*(12), 34–40. http://doi.org/10.1145/355112.355120

Følstad, A., Eide, A. W., Pickering, J. B., Tsvetkova, M., Gavilanes, R. G., Yasseri, T., & Engen, V. (2015). *D2.1 Typology and Method v1*.

Følstad, A., Engen, V., Haugstveit, I. M., & Pickering, J. B. (2017). Automation in Human-Machine Networks: How Increasing Machine Agency Affects Human Agency. In *International Conference on Man-Machine Interactions [submitted]*.

Følstad, A., Engen, V., Yasseri, T., Gavilanes, R. G., Tsvetkova, M., Jaho, E., … Pultier, A. (2016). *D2.2 Typology and Method v2*.

Geiger, D., Seedorf, S., Schulze, T., Nickerson, R. C., & Schader, M. (2011). Managing the Crowd: Towards a Taxonomy of Crowdsourcing Processes. *AMCIS 2011 Proceedings - All Submissions*. Retrieved from http://aisel.aisnet.org/amcis2011_submissions/430

Giddens, A. (1984). The Constitution of Society: Outline of the Theory of Structuration. *Contemporary Sociology*. http://doi.org/10.2307/2069992

Gomez-Herrera, E., Martens, B., & Turlea, G. (2014). The drivers and impediments for cross-border e-commerce in the EU. *Information Economics and Policy*, *28*, 83–96. http://doi.org/10.1016/j.infoecopol.2014.05.002

Granovetter, M. S. (1973). The Strength of Weak Ties. *The American Journal of Sociology*, *78*(6), 1360–1380. Retrieved from http://www.jstor.org/view/00029602/dm992612/99p02603/0

Granovetter, M. S. (1983). The strength of weak ties: A network theory revisited. *Sociological Theory*. Retrieved from http://www.soc.ucsb.edu/faculty/friedkin/Syllabi/Soc148/Granovetter 1983.pdf

Guerrieri, P., & Bentivegna, S. (Eds.). (2011). *The economic impact of digital technologies: Measuring inclusion and diffusion in Europe*. Edward Elgar Publishing.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work?--a literature review of empirical studies on gamification. In *Proceedings of the Hawaii International Conference on System Sciences (HICSS)* (pp. 3025–3034). IEEE.

Hassenzahl, M., & Tractinsky, N. (2006). User experience-a research agenda. *Behaviour & Information Technology*, *25*(2), 91–97.

Haugstveit, I. M., Halvorsrud, R., & Karahasanovic, A. (2016). Supporting Redesign of C2C Services through Customer Journey Mapping. In *Proceedings of the ServDes2016 Conference* (pp. 215–227). Linköping University Electronic Press.

Hildebrandt, M. (2015). *Smart Technologies and the End of Law: Novel Entanglements of Law and Technology*. Cheltenham, UK: Edward Elgar Publishing Ltd.

Hildebrandt, M. (2016). Promiscuous Data-Sharing in times of Data-driven Animism. *Ethics Symposium*. Taylor Wessing, London.

Hoxmeier, J. A., & DiCesare, C. (2000). System response time and user satisfaction: An experimental study of browser-based applications. In *AMCIS 2000 Proceedings*.

ISO. (2010). *Ergonomics of human–system interaction — Part 210: Human-centred design for interactive systems*. Geneva, Switzerland: International Organization for Standardization.

Jaho, E., Klitsi, M., Følstad, A., Lech, T. C., Walland, P., Pickering, J. B., & Meyer, E. T. (2017). *D4.2 Roadmap of future human-machine networks*.

Jungherr, A. (2014). Twitter in Politics: A Comprehensive Literature Review. *SSRN Electronic Journal*. http://doi.org/10.2139/ssrn.2402443

Juris, J. S. (2012). Reflections on# Occupy Everywhere: Social media, public space, and emerging logics of aggregation. *American Ethnologist*, *39*(2), 259–279.

Katz, M. L., & Shapiro, C. (1994). Systems competition and network effects. *The Journal of Economic Perspectives*, *8*(2), 93–115.

Kittur, A., Nickerson, J. V., Bernstein, M., Gerber, E., Shaw, A., Zimmerman, J., … Horton, J. (2013). The future of crowd work. In *Proceedings of the 2013 conference on Computer supported cooperative work - CSCW '13* (p. 1301). New York, New York, USA: ACM Press. http://doi.org/10.1145/2441776.2441923

Krackhardt, D. (1992). The strength of strong ties: The importance of philos in organizations. *Networks and Organizations: Structure, …*. Retrieved from https://bdpems.wiwi.hu-berlin.de/portal/sites/default/files/Session 2_Krackhardt.pdf

Kujala, S., Roto, V., Väänänen-Vainio-Mattila, K., Karapanos, E., & Sinnelä, A. (2011). UX Curve: A method for evaluating long-term user experience. *Interacting with Computers*, *23*(5), 473–483.

Latour, B. (2005). *Reassembling the Social-An Introduction to Actor-Network-Theory*. Oxford, UK: Oxford University Press. Retrieved from http://adsabs.harvard.edu/abs/2005reso.book.....L  Ü

Law, E., Roto, V., Vermeeren, A. P., Kort, J., & Hassenzahl, M. (2008). Towards a shared definition of user experience. In *CHI'08 extended abstracts on Human factors in computing systems* (pp. 2395–2398). New York, NY: ACM Press.

Law, J. (1992). Notes on the Theory of the Actor-Network: Ordering, Strategy, and Heterogeneity. *Systems Practice*, *5*(4), 379–393.

Leadbeater, C. (2007). *We-Think*. London, UK: Profile Books.

Li, X., Rong, G., & Thatcher, J. B. (2012). Does Technology Trust Substitute Interpersonal Trust? *Journal of Organizational and End User Computing*, *24*(2), 18–38. http://doi.org/10.4018/joeuc.2012040102

Lüders, M. (2016). Innovating with users online? How network-characteristics affect collaboration for innovation. *Journal of Media Innovations*, *3*(1), 4–22.

Lüders, M., Pickering, J. B., Engen, V., Bravos, G., Yasseri, T., & Tsvetkova, M. (2016). *D3.2 Report of first set of case-studies*.

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human-Computer Studies*, *55*(4), 587–634.

Marwick, A. E., & Boyd, D. (2011). I tweet honestly, I tweet passionately: Twitter users, context collapse, and the imagined audience. *New Media & Society*, *13*(1), 114–133. http://doi.org/10.1177/1461444810365313

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of Management Review*, *20*(3), 709–734. http://doi.org/10.5465/AMR.1995.9508080335

McEvily, B., Perrone, V., & Zaheer, A. (2003). Trust as an organizing principle. *Organization Science*, *14*(1), 91–103. http://doi.org/10.1287/orsc.14.1.91.12814

McKnight, D. H., Carter, M., Thatcher, J. B., & Clay, P. F. (2011). Trust in a specific technology: An

investigation of its components and measures. *ACM Transactions on Management Information Systems (TMIS)*, *2*(2), 12. http://doi.org/10.1145/1985347.1985353

Miltgen, C. L., & Smith, H. J. (2015). Exploring information privacy regulation, risks, trust, and behavior. *Information and Management*, *52*(6), 741–759.

Mittendorf, C. (2017). The Implications of Trust in the Sharing Economy – An Empirical Analysis of Uber. In *Proceedings of the 50th Hawaii International Conference on System Sciences - HICCS 2017* (pp. 5837–5846). IEEE.

Moller, S., Engelbrecht, K.-P., Kuhnel, C., Wechsung, I., & Weiss, B. (2009). A taxonomy of quality of service and quality of experience of multimodal human-machine interaction. In *International Workshop on Quality of Multimedia Experience*.

Mumford, E. (2006). The story of socio-technical design: reflections on its successes, failures and potential. *Information Systems Journal*, *16*(4), 317–342. http://doi.org/10.1111/j.1365-2575.2006.00221.x

Nass, C. I., Lombard, M., Henriksen, L., & Steuer, J. (1995). Anthropocentrism and computers. *Behaviour & Information Technology*, *14*(4), 229–238. http://doi.org/10.1080/01449299508914636

Nelson, R. E. (1989). The strength of strong ties: Social networks and intergroup conflict in organizations. *Academy of Management Journal*, *32*(2), 377–401. http://doi.org/10.2307/256367

Pentland, A. (2014). *Social physics: How good ideas spread-the lessons from a new science*. Penguin.

Perrey, R., & Lycett, M. (2003). Service-oriented architecture. *Applications and the Internet Workshops,*. Retrieved from http://ieeexplore.ieee.org/abstract/document/1210138/

Pickering, J. B., & Boniface, M. (2012). *Digital Agenda for Europe: Annual Progress Report 2011*. Retrieved from https://www.scribd.com/document/82171993/Digital-Agenda-for-Europe-2011v01

Pickering, J. B., Engen, V., Jaho, E., Sarris, N., Yasseri, T., Tsvetkova, M., … Følstad, A. (2016). *D3.3 Report on second set of case-studies*.

Pickering, J. B., Engen, V., & Walland, P. (2017). The Interplay Between Human and Machine Agency. In *HCI International*.

Pruitt, J., & Adlin, T. (2010). *The persona lifecycle: keeping people in mind throughout product design.* Morgan Kaufmann.

Ronson, J. (2015). *So You've Publically Shamed*. Oxford, England: Picador.

Rose, J., & Jones, M. (2005). The Double Dance of Agency: A Socio-Theoretic Account of How Machines and Humans Interact. *Systems, Signs & Actions*, *1*(1), 19–37.

Rose, J., Jones, M., & Truex, D. (2003). The Problem of Agency: How Humans Act, How Machines Act. In *International workshop on Action in Language, Organisations and Information Systems (ALOIS-2003)*.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., & Camerer, C. (1998). Not So Different After All: A Cross-Discipline View Of Trust. *Academy of Management Review*, *23*(3), 393–404. http://doi.org/10.5465/AMR.1998.926617

Rudas, C., Surányi, O., Yasseri, T., & Török, J. (2016). *Understanding and coping with extremism in an online collaborative environment* (No. 1607.08127). *arXiv*.

Schoorman, F. D., Mayer, R. C., & Davis, J. H. (2007). An Integrative Model of Organizational Trust: Past, Present, and Future. *Academy of Management Review*, *32*(2), 344–354. http://doi.org/10.5465/AMR.2007.24348410

Seffah, A. (2015). *The Patterns of HCI Design: Origin, Perceptions, and Misconceptions*. Springer International Publishing.

Shin, D.-H. (2010). The effects of trust, security and privacy in social networking: A security-based approach to understand the pattern of adoption. *Interacting with Computers*, *22*(5), 428–438. http://doi.org/10.1016/j.intcom.2010.05.001

Shirky, C. (2008). *Here Comes Everybody: The Power of Organizing without Organizations*. London, UK: Penguin.

Slonje, R., Smith, P. K., & Frisén, A. (2013). The nature of cyberbullying, and strategies for prevention. *Computers in Human Behavior*, *29*(1), 26–32. http://doi.org/10.1016/j.chb.2012.05.024

Stantchev, V., & Schröpfer, C. (2009). Negotiating and Enforcing QoS and SLAs in Grid and Cloud Computing. In *International Conference on Grid and Pervasive Computing* (pp. 25–35).

Strater, K., & Lipford, H. R. (2008). Strategies and struggles with privacy in an online social networking community. In *Proceedings of the 22nd British HCI Group Annual Conference on People and Computers: Culture, Creativity, Interaction-Volume 1* (pp. 111–119). British Computer Society.

Stylianou, P. (2008). Online dispute resolution: the case for a treaty between the United States and the European Union in resolving cross-border e-commerce disputes. *Syracuse Journal of Internal Law and Commerce*, *36*. Retrieved from http://heinonline.org/HOL/Page?handle=hein.journals/sjilc36&div=7&g_sent=1&collection=journals

Subramanian, R., & Goodman, B. D. (2004). *Peer to Peer Computing: The Evolution of a Disruptive Technology*. IGI Global.

Sumi, R., Yasseri, T., Rung, A., Kornai, A., & Kertész, J. (2011). Characterization and prediction of Wikipedia edit wars. In *Proceedings of the ACM WebSci '11* (pp. 1–3). Koblenz, Germany. Retrieved from http://journal.webscience.org/523/

Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319–1350.

Thatcher, J. B., McKnight, D. H., Baker, E. W., Arsal, R. E., & Roberts, N. H. (2011a). The Role of Trust in Postadoption IT Exploration: An Empirical Examination of Knowledge Management Systems. *IEEE Transactions on Engineering Management*, *58*(1), 56–70. http://doi.org/10.1109/TEM.2009.2028320

Thatcher, J. B., McKnight, D. H., Baker, E. W., Arsal, R. E., & Roberts, N. H. (2011b). The Role of Trust in Postadoption IT Exploration: An Empirical Examination of Knowledge Management Systems. *IEEE Transactions on Engineering Management*, *58*(1), 56–70. http://doi.org/10.1109/TEM.2009.2028320

Thatcher, J. B., Zimmer, J. C., Gundlach, M. J., & McKnight, D. H. (2008). Internal and external dimensions of computer self-efficacy: An empirical examination. *Engineering Management, IEEE Transactions on*, *55*(4), 628–644. http://doi.org/10.1109/TEM.2008.927825

Tsvetkova, M., García-Gavilanes, R., & Yasseri, T. (2016a). *Clash of Bots*.

Tsvetkova, M., García-Gavilanes, R., & Yasseri, T. (2016b). Dynamics of Disagreement: Large-Scale

Temporal Network Analysis Reveals Negative Interactions in Online Collaboration. Computers and Society; Physics and Society. Retrieved from http://arxiv.org/abs/1602.01652

Tsvetkova, M., Pickering, B., Yasseri, T., Walland, P., Lüders, M., & Engen, V. (2015). *D1.1 Systematic Literature Review*.

Tsvetkova, M., Yasseri, T., Meyer, E. T., Pickering, J. B., Engen, V., Walland, P., … Bravos, G. (2017). Understanding Human-Machine Networks: A Cross-Disciplinary Survey. *arXiv Preprint*.

Van de Ven, A., Delbecq, A., & Koenig Jr, R. (1976). Determinants of coordination modes within organizations. *American Sociological Review*. Retrieved from http://www.jstor.org/stable/2094477

van Duyne, D. K., Landay, J., & Hong, J. I. (2002). *The design of sites: patterns, principles, and processes for crafting a customer-centered Web experience*. Boston, MA: Addison-Wesley Longman Publishing.

Van Aken, J. E., & Weggeman, M. P. (2000). Managing learning in informal innovation networks: overcoming the Daphne-dilemma. *R&D Management*, *30*(2), 139–150.

Venkatesh, V. (2000). Determinants of perceived ease of use: integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research*, *11*(4), 342–365. http://doi.org/10.1287/isre.11.4.342.11872

Venkatesh, V., Davis, F. D., & College, S. M. W. (2000). Theoretical Acceptance Extension Model : Field Four Studies of the Technology Longitudinal. *Management Science*, *46*(2), 186–204. http://doi.org/10.1287/mnsc.46.2.186.11926

Vermeeren, A. P., Law, E. L. C., Roto, V., Obrist, M., Hoonhout, J., & Väänänen-Vainio-Mattila, K. (2010). User experience evaluation methods: current state and development needs. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries* (pp. 521–530). New York, NY: ACM Press.

Von Hippel, E. (2005). *Democratizing Innovation*. Boston, MA: MIT Press.

Watts, D. J., & Strogatz, S. H. (1998). Collective dynamics of “small-world” networks. *Nature*, *393*(6684), 440–2. http://doi.org/10.1038/30918

Wigderson, S., & Lynch, M. (2013). Cyber- and traditional peer victimization: Unique relationships with adolescent well-being. *Psychology of Violence*, *3*(4), 297–309. http://doi.org/10.1037/a0033657

Appendix 1 – typology dimensions and aspects

Each of the dimensions of the HUMANE typology are detailed in the form of a small set of key aspects. In Table 7 below, all aspects are presented. The aspect descriptions are formulated so as to reflect a high level of the dimension in question.

Table 7: Typology dimensions refined through characterizing dimension aspects

DIMENSION/ASPECT	DESCRIPTION
D1. Human agency	**The degree to which human actors may have impact or cause change through open and diverse activities.**
D1.1 Varied activities	People can perform a diverse range of activities in the HMN
D1.2 Influence	People are able to interact freely and influence other participants in the HMN, whether human or machine
D1.3 Open activities	The activities people can perform allow them to express their personalities, behave diversely, freely, creatively and even use the HMN unpredictably
D1.4 Self-decided goals	People can use the HMN to help them achieve goals (set by themselves) that they may otherwise not be able to achieve, e.g., via other people or technology in the HMN
2. Machine agency	**The degree to which machine actors may have impact or cause change through open and diverse activities, as well as the extent they enable agency in human actors.**
D2.1 Varied activities	Machines (technological actors/agents) in the HMN can perform a diverse range of activities
D2.2 Influence	Machines can interact freely with - and may influence other participants in the HMN, and may help human agents achieving goals they cannot achieve on their own
D2.3 Open activities	The activities the machine agents can perform are open, giving opportunity for dynamic and perhaps unpredictable behaviour
D2.4 Human-like	The behaviour of the machines in the HMN can be seen as intelligent and autonomous, with human-like appearance or behaviour
3. Social tie strength	**The strength of typical relations between the human actors as nodes in the network.**
D3.1 Intimacy	People in the network are typically connected to one another by friendship or other close affiliation
D3.2 Duration	Relationships between people in the HMN typically last a long time
D3.3 Reciprocation	People in the HMN are typically mutually supportive

4. Human-machine relationship strength	**The strength of the relation between humans and machines as nodes in the network.**
D4.1 Trust	People strongly trust the machines in the HMN
D4.2 Reliance	People tend to accept what the machines of the HMN do and would only rarely intervene
D4.3 Dependency	People depend on the machines in the HMN to achieve their goals
5. Network size	**The number of actors as nodes in the network.**
D5.1 Uptake	The HMN includes a broad range of users
D5.2 Number of users	The HMN includes a large number of users
D5.3 Growth rate	The HMN has grown, or is expected to grow very rapidly
6. Geographical space	**The geographical extension of the network.**
D6.1 Transnationality	The HMN includes members and sites in many countries or states
D6.2 Cultural diversity	The HMN includes members or sites across different cultural groups
D6.3 Geographical reach	The HMN spans large geographical areas
7. Workflow interdependence	**The levels of coordination and interaction required between the actors of the network.**
D7.1 Coordination	Activity in the HMN require that people interact in a highly coordinated manner
D7.2 Interdependence between actors	The actions and communication between people in the HMN very much depend on the actions and communications of others
D7.3 Collaboration	There is extensive collaboration between the people in the HMN
8. Network organisation	**The character of the network organisation with implications for predictability and emergence; specifically contrasting top-down vs. bottom-up organisation.**
D8.1 Top-down organisation	The organisation of the HMN is highly centralized or predetermined
D8.2 Stability	The HMN has a stable organisation that does not easily adapt to different conditions
D8.3 Regulation	The HMN is regulated by thorough and detailed policies

Appendix 2 – recommendations and responses

Overview of recommendations from the second iteration HUMANE case trials, and the associated responses made for the final version of the typology and method, as well as the online tool.

Ref.	Recommendation	Response in this deliverable	Relevant sections
Typology			
TYP 1	Be more specific on the purpose of the typology as a means to support human centred design on a strategic level	The target audience of the typology and method now has been clearly defined. Typology and method presentations have been reworked so as to more clearly show that it is intended to support the early, strategic part of the HCD process.	1.3, 3, 4
TYP 2	Consider the development of a more detailed typology for supporting implementation purposes.	Although a recommendation coming out of the case studies, this forms part of future work as it is a substantial work that devi-ates from the key focus of the HUMANE typology as it has evolved over the three iterations within the project.	NA
TYP 3	Explore the typology as a mechanism to understand potential challenges and issues	To highlight how the typology is used to understand challenges and issues, the design patterns presented in the online tool now also provide immediate overview of problems identified in the implication analysis as well as implication category.	8.5
TYP 4	Introduce means of representing change across time.	We describe how alternative profiles may be used specifically for assessing the difference between an envisioned future HMN and the current HMN. This should be particularly useful to support early-phase design decisions.	3.2.2
TYP 5	Consider how best the typology might be targeted to the needs of different stakeholders as a means for helping them understand current issues and challenges in an existing network.	The stakeholders have been clearly identified and described in Section 1.3. We have also elaborated on the background needed for the implication analysis, which is key to this recommendation, in Section 4.	1.3, 4

Ref.	Recommendation	Response in this deliverable	Relevant sections
Profiling approach			
PRO1	Review terminology and the layout of visualizations with the aim of making this more intuitive.	The terminology of typology dimensions (*human-machine relationship strength*, *geographical reach*, and *workflow interdependence*) and analytical layers (*relations*, *network extent*, and *network structure*) have been updated.	3.1
PRO2	Review the scales for some dimensions, with the aim of making these more easily applicable.	The aspects associated with one of the dimensions (*network size*) have been reworked to allow for more intuitive scales.	3.1.3
PRO3	Consider whether the profiling process can realistically be applied in-depth without initial knowledge, or whether the typology should primarily support practitioners that have the opportunity to spend some resource on familiarizing themselves with the typology and method prior to using it.	Considerations on the need for in-depth knowledge of the typology and method have been included in the profiling description.	5.2
PRO4	Strengthen method support for analysing clusters of dimensions.	The analysis on extracting HMN types from HMN profiles, presented in Section Types from profiles, will allow us to better understand the interrelationships between dimensions. By analysing the correlation between values assigned to each dimension for numerous profiled networks, one can see how in practice different dimensions are related. Furthermore, visual inspection of potential covariation in dimensions is now supported in the tool by allowing the user to filter HMN profiles according to the scores on one or	7, 8.5

Ref.	Recommendation	Response in this deliverable	Relevant sections
		more dimensions. Furthermore visual comparison of HMN profiles is facilitated by displaying the visualization of the HMN profile as part of the listing of these profiles.	
PRO5	Provide strengthened support in the design patterns in the tool, to indicate which specific dimensions that the design pattern addresses.	With a starting-point in this recommendation, it was found valuable to filter design patterns in the tool not mainly on HMN dimensions but on implication category. This is now implemented as a filtering mechanism for the design pattern lists ion the tool.	8.5
PRO6	The initial step of the HUMANE method should include a section on scoping of the HMN, so as to establish a common understanding of the boundaries of the HMN prior to profiling.	Step 1 of the HUMANE method is now updated so as to include scoping as a key activity prior to profiling.	5.1
PRO7	The profiling process needs a mechanism to reflect underlying variation in the dimensions.	With a starting-point in this recommendation, it was found valuable to strengthen the support for addressing recurring change between HMN states in the typology. This is now addressed in the typology presentation and in the method description.	3.2.2, 5.2.2
PRO8	Multiple profiles from different stakeholder perspectives would provide useful additional information in helping those stakeholders appreciate the interests and understanding of network participants	In the online tool, multiple users may suggest changes and updates to a specific HMN profile. This feature may potentially be used to include different stakeholder perspectives.	8.2

Ref.	Recommendation	Response in this deliverable	Relevant sections
Implication analysis			
IMP1	Consider whether additional information could be usefully stored	All HMN profile pages and design pattern pages include discussion modules where users can enter and reply to comments. The lead texts associated with these facilities now inform users that additional information or content may be offered as comments in the discussion threads.	8.2, 8.4
IMP2	Investigate how lessons learned might be collected as well as stored	The discussion facilitates addressing IMP 1 may also support the initial steps and communication needed for collecting lessons learnt. Full coverage of this recommendation needs to be seen as future work.	8.2, 8.4
IMP3	Review the assumption of cross-domain transfer of design knowledge, and – if relevant – indicate knowledge areas where such cross-domain transfer may be challenging.	The work on extracting HMN types from HMN profiles through a clustering approach, helps to identify similarity between networks from different domains and that facilitates cross-domain knowledge transfer. Network developers can learn from same-type networks in other domains.	0
IMP4	Consider to distinguish between domain-specific and domain independent implications in analysis.	By extracting the HMN types from HMN profiles, and connecting the implications to specific types, one can see the relation between domains and implications, and if certain implications are specific to a certain domain or are more general and applicable to multiple domain.	0
Design pattern approach			
DES1	Consider how best to present design patterns in the context of specific issues which relate to existing experience, rather than with implication analysis	All design considerations are now categorized according to their implication group (user experience and motivation, behaviour and collaboration, innovation and improvement, privacy and trust, and infrastructure issues). This allows for tagging	8.5

Ref.	Recommendation	Response in this deliverable	Relevant sections
		and filtering of patterns according to particular issues of need.	
DES2	Supplement the design patterns with known experience	The discussion facilitates addressing IMP 1 and IMP 2 may also support the initial suggesting and supplementing of known experience for individual design considerations.	8.4
Online tool			
TOOL1	Maintain information about the quality or usefulness of a given profile	Suggested updates to HMN profiles are now supported, so that any user may contribute a suggested update and an explanation for the suggestion. All suggested updates are stored and may be accessed from the current default profile.	8.2
TOOL2	Investigate interrelationships between dimensions	Visual inspection of interrelationships between dimensions for different HMN profiles are now supported, as all profile visualizations are made immediately available in HMN profile listings. Furthermore, the HMN profiles may be filtered according to the scores on one or more typology dimensions.	8.5
TOOL3	Present additional information as well as implications and designs	The discussion facilitates addressing IMP 1 and IMP 2 may also support the initial suggesting and supplementing of additional information, implications and designs. Furthermore, additional design knowledge in the form of design patterns may be suggested by any user.	8.4

Appendix 3 – HUMANE tool feedback – individual summaries

As part of conducting the final iteration tool development, evaluations with individual tool users were conducted. Summaries of the individual evaluations are presented below. An overall summary of the evaluations is provided in Section 8.8.

Participant E.1

Regarding the profiling, they felt the interpretation of the statements to be a challenge, though the approach using the statements help. They felt some examples would help in this regard, though with the amount of statements, they didn't think it would make sense to include examples for all. However, some examples to help people understand the approach to answering, using a common and understandable HMN would be valuable. Further, they felt they'd rather have more questions/statements if they were very quick and simple, although there are 26 already. A final suggestion was to consider some training questions/statements before conducting the real profiling.

Regarding the profile itself, they liked the spider diagram as a visualisation. However, they would like to be able to see more profiles to better judge if the profile was accurate and to see how expressive the spider diagram is. They felt the granularity on the spider diagram was appropriate. It was not obvious what the Alt. Score was without having it demonstrated and explained to them. They were wondering if there are obvious correlations between the dimensions, whether they could be re-arranged on the spider diagram for intuitive insights. For example, if two dimensions are generally positively correlated, they could be placed opposite to each other on the spider diagram as symmetrical relationships would be more obvious.

Regarding networks, it would be very useful to see the profile of the networks on the overview. This would better support comparisons of profiles in line with an earlier comment, as noted above.

Regarding design patterns, they felt the term was not appropriate. They were informed of potential renaming of this term, e.g., to design solutions, which they thought was better, but it still implied to them initially that there would only be one solution for the entire network, so the concept of applying multiple design patters/solutions was not obvious. As a general usability comment, they felt you'd need a lot of profiles for the tool to really give value, along with a committed user base. They thought it could be of significant value internally for a company, as part of knowledge sharing akin to how one might walk around asking people for what they did in previous work that might be related.

Participant E.2

As a general comment, they felt the approach and tool support was sensible and could see themselves benefitting. In particular for initial stages of HMN development, to facilitate knowledge transfer from previous work/existing networks. However, would not see it as being used as the development would progress towards implementation. In order to increase the benefits at the initial stages of HMN design planning, lessons learnt would be very valuable to capture.

Regarding the profiling, they felt the approach with scoring statements was good. They thought the terminology would benefit from being addressed in order to make some statements easier to understand and to avoid misinterpretations. One example given was questioning what a long time means in the following statement: “Duration: Relationships between people in the HMN typically last a long time”. Examples would also help resolve such issues.

Regarding the profile itself, they considered themselves a very visual person and felt the spider diagram was a great way to visualise the profile. They could gleam a lot from it very quickly, in contrast to the table. However, noting that others probably would feel the opposite. Currently, it was possible to add alternative scores to networks for a second profile state, but they were wondering how you would support networks with more than 2 states.

Regarding networks, this was also seen as a useful implementation, both for the related networks on a profile and being able to browse and filter all networks. For the related networks, they were wondering if the weak matches couldn’t just be removed when there were quite a lot of fair matches.

Regarding design patterns, one suggestion was offered about generating HMN specific instances of the more generic patterns. That is, to make terminology specific to properties of the network, as terminology seen in the existing patterns could mean quite different things in different contexts.

Participant E.3

As a general comment on being presented with the tool as a new user, they felt the UI was nice and clear and that it was easy to see what was going on. They felt the tool would benefit from some short and clear statements of the benefits of the tool on the welcoming page.

Regarding the profiling process, they felt there were quite a lot of questions, which could be experienced as disheartening when you see a long list of them. Therefore, they suggested an alternative approach would be a wizard-like box of statements, showing your progress graphically (a progress bar, for example). It was not clear to them if they could save a profile before completing all the questions, to be able to return to complete it at a later stage. Regarding the statements themselves, they found an issue with ambiguity and single statements including multiple, different, things, each of which might be rated differently. One example was the 'open activities' for human agency, in which they would agree with some, but not others for the network they had in mind. Therefore, to get more focused responses, simpler statements would be better, although that would increase the number of questions. Participant E.1 (above) made a similar suggestion, but commented specifically that they wouldn't mind an increase in questions if it would be quick to answer.

Regarding the profile itself, it was not clear how it would help them. How they could use the information. They commented that it was good to see a table of the definition of the dimensions. However, they were wondering if it would be possible to interact with the spider diagram, to see suggested changes if they alter one of the dimensions. Specifically, they also asked if they could draw their network, with specific types of actors and their relationships. They could imagine adding values to the nodes in that network pertaining to the dimensions of the typology, making it clear that some

have higher agency than others, for example. A graphical modelling tool could incorporate the questions, combining the profiling approach with network diagramming.

Regarding networks, the main comment was that the colouring of the boxes was not ideal as it was difficult to read. They actually did not see clearly the matching, and asked questions about how the related networks had been selected. They also expressed a potential issue with showing too many networks. This relates to a comment regarding the design patterns - see below.

Regarding the design patterns, they thought the concept could indeed be useful. However, in line with the final comment in the above paragraph, they felt there was quite a lot on the page although nicely presented. On the profile page, they suggested that an overview would be really helpful, essentially a compact version of the networks and design patterns showed lower on the page. And for this compact summary to include relevant links to networks and design patterns. Otherwise, there are so many large boxes to manoeuvre.

Participant E4

The participant found the tool to be orderly and aesthetically appealing. The participant was also positive to the overall approach represented by the tool, but had a number of suggestions for improvement

On the top menu, it was suggested that the name HUMANE network profiler may be difficult to understand, and the name "Human-machine network profiler" was suggested. It was also suggested to rename some of the menu items (e.g. Make New Profile | Profile gallery | Pattern library)

On the about / getting started pages, it was suggested the need to rework the wording in the presentation to make it accessible for a broader audience. Avoid unnecessary technical terms, and immediately explain the concepts of "HMN", "profiles", and "patterns".

On the page for new network profiles, if was suggested to clarify how the current dimension(s) are related to the others. E.g. by visualizing the two dimensions of current attention in each step. It was also suggested the need to refine wording for some of the questions and to have visible some example HMNs associated with the scales to make it more intuitive how the scales should be interpreted.

On the page for the consolidated network profile, it was suggested that the diagram could benefit from colour coding, and that it would be useful to make it more evident why suggested design patterns are suggested.

On the pattern list page, it was suggested that all five implication groups should be visible in the left hand panel, for easy filtering. Also, it was suggested the need for a lead text to explain the implication groups and to avoid that these are confused with the dimensions.

Participant E5

The overall impression was that the tool was sound and solid, but the language sometimes was too academic or abstract. Regarding the design patterns, the participant found this section to be detached

from the rest. The illustrations of profiles on the index page are appealing, but also somewhat confusing as they reflect a scale of four levels in each of the eight dimensions, and do not match the "high – medium – low"-scale of the profiling. In addition, the participant mentioned that the filtering functionality seemed to reflect a continuous scale rather than discrete. When browsing the collection of networks, the participant appreciated well-known networks like Facebook, and commented that this helps to understand the typology.

Profiling a network: The participant found some of the attributes of the dimensions difficult to grasp. The term "agency" was confusing, and wondered whether "machine agency" is about how the machines behave, or our *perception* of their behaviour. The question about self-decided goals (D1.4) were unclear difficult to address, the same with the attribute reciprocation (D3.3). It was commented that trust (D4.1) is an individual issue, and reliance (D4.2) was unclear. For the network behaviour, Collaboration (D7.3) was unclear and superfluous. For network organization it was suggested to replace Stability with Rigidity (D8.2). Also, it was mentioned that the term uptake (5.1) did not reflect the question, perhaps rather use "diversity". When viewing a given profile, it seems that the more filters you put does not reduce the number of "most similar networks".

Design patterns: Upon the first inspection of the site, the participant interpreted the design patterns as "typical networks" or "network archetype". (The profile called "Sharing economy service" is an example of this: a typical network profile for sharing platforms, rather than a specific profile for Uber or AirBnb). When revisiting the design patterns in the end of the session, the participant found the design patterns to be more detached from the rest. The participant could not see the immediate connection or relevance between the profiles and the design patterns.

The categories of the design patterns were found somewhat confusing, and the participant searched for a logic connection between a profile and a pattern. The filtering mechanisms for the patterns were difficult to discover, and the functionality somewhat hidden. When inspecting a specific pattern, networks using the pattern are listed below the pattern description. But the link is missing on how the pattern is associated with the networks. E.g. the Loyalty ladder is associated with the C2C reselling platform but there is no description or connection to a loyalty ladder in that network's profile.

Participant E6

The participant read the introductory text about the tool on the front page, and missed a richer description of the typology to learn more about the details. It would be useful with links on the index page directly to the next menu item.

When inspecting the dimensions, the participant found the first six dimensions intuitive, and the two last ones more fuzzy. The dimension Workflow interdependence was seen as unclear compared to the other dimensions. The participant also provided detail comments on the different questions.

The participant appreciated the ability to compare profiles, and suggested to include statistics on a portfolio level, e.g. average values, for the collection of profiles.

Design patterns. When introduced to design patterns the participant interpreted it as shapes of the spider diagram, i.e. patterns in the profiles. Upon reviewing two example patterns, the text was found satisfactory but the illustrations would need a legend to be helpful.

Overall, the profiles per se was seen as a valuable source for insights, and more emphasis should be put on the profiles, e.g. through including analytics on a collection of profiles by using overlays, colours etc.

Participant E7

After introducing the profiling tool, the participant read the introductory text and missed an explanation of how the existing profiles may guide the design of new HMNs, and who the target group of the tool is. It was commented that the *typology* in this project is used in a different way than normally, as the typology concerns the attributes of HMNs, rather than HMNs per se.

The participant characterized the overall design and layout as very appealing. In the section called "What is a HMN", the definition should come first, then the discussion of the topic. The text explaining the Humane approach was found very clear and helpful. The participant suggested to provide more explanations when introducing the eight dimensions, for example the sub-topics that defines each dimension.

Specific comments on the dimensions: Concerning Human agency it was unclear what "a diverse range of activities" means in this context. The sub-question concerning "open activities" was found overlapping with "varied activities". Concerning Machine agency it was commented that none existing HMN that the participant could imagine would fit with the characteristics of "open activities". An example here could be helpful. The dimension Human-to-machine interaction strength was found very difficult to address. A scale or reference level would make it easier. The same comment with Workflow interdependence. A context is needed to address the questions. For Network organization, there is a bias towards top-down organisation in the way the questions are presented. For the topic Network size, it should be relatively easy to provide guidelines for "broad range" and "large number". The instruction text discuss "network effect" and the participant miss an explanation of what this means.

When browsing network profiles in the collection, the participant would like to see how the different values were obtained. For example "Decision support", what makes the dimension machine agency low? And is this for a specific decision support system or is it a common attribute for all such systems? One suggestion was to exemplify all the sub-questions with common examples, and the participant argues that this would increase reliability among different individuals using the profiling tool. It was also suggested to let ten different analysts use the tool to profile a commonly known HMN to check for consistency in the results obtained.

Design patterns: The participant reacted to the fact that three different patterns have the same problem. For many patterns there are references to articles that are not immediately available. In the tradition of patterns the solution should be specific, and references should be provided for validation and further reading, while the substantial part of the solution would be provided upfront. The participant found the content of the pattern to support for evaluating a solution, rather than a

solution per se. In general the patterns inspected represented discussions rather than solutions. Below each patterns the tool links to profiles "using this pattern". This should be changed to reflect that these are HMS where this problem is relevant.