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A typology, method and roadmap for human-machine networks

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Typology and method v1

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Abstract	Design for human-machine networks is challenging. To improve our understanding of human-machine networks and strengthen the design of such networks and supporting technologies, a first version of the HUMANE typology and method has been developed. The typology is based on a systematic literature review (HUMANE D1.1), and is structured according to four analytical layers: Actors, interactions, networks, and behaviours; each including two dimensions. Profiling a human-machine network on the dimensions of the HUMANE typology is intended to facilitate access to relevant design knowledge and experience, following a design pattern approach. We provide a first version of a profiling framework and method, and outline associated implications. An early concept for a profiling tool is suggested. This initial version of the typology and method will be applied in the six HUMANE use cases. Experiences from these cases will be used to further refine and develop this approach.
Key-words	Human-machine networks, typology, method, design patterns

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Definitions and abbreviations

Abbreviation	Definition
H2M interaction strength	Human-to-machine interaction strength (see Section 4.4)
HCD	Human-centred design (see Section 2.3.1)
HMN	Human-machine networks (definition in Section 2.4)
ICT	Information and communication technology

Executive summary

Increasingly, work and leisure is conducted within the context of human-machine networks; that is collectives of humans and machines interacting to produce synergistic effects. However, as is seen from the frequent failure of intended human-machine networks, understanding and designing for such networks is challenging.

To improve our understanding of human-machine networks (HMN) and strengthen our capacity to design for such networks, a first version of the HUMANE typology and method has been developed. The typology is based on a systematic literature review (HUMANE D1.1); the method is outlined to be compliant with the international standard for human-centred design. The target audience for the typology and associated method are technology and service providers in general, and practitioners of human-centred design in particular.

In this deliverable we present the initial version of a profiling framework and method, and outline associated implications. The initial dimensions of the typology concerns key characteristics of human machine networks and has been established through a process of trial analysis and reflection using the six use-cases of HUMANE as test cases.

Profiling a human-machine network on the dimensions of the HUMANE typology is intended to facilitate access to relevant design knowledge and experience, following a design pattern approach. The underlying idea is that the profiling of an envisioned or existing human-machine network will both facilitate relevant design discussion and, more importantly, serve to identify the network type. Through the profile type, relevant technical, social and design implications can be drawn.

In this initial version of the HUMANE typology we have mainly concentrated on establishing the typology dimensions and profiling framework. Technical, social, and design implications of the profiling are outlined but not detailed. The HUMANE method is also outlined, and an early concept for a profiling tool is suggested.

This initial version of the typology and method will be applied in the six HUMANE use cases for purposes of context analysis (HUMANE D3.2). Experiences from these cases will be used to further refine and develop the typology and associated method in the next project iteration (HUMANE D2.2).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Introduction

In the emerging hyper-connected era, people and appliances are online all the time. Private life, civic engagement, creativity and innovation are increasingly conducted in networks comprising of humans and machines. Machines have for centuries had a transformative impact on human interaction. However, the hyper-connectedness of people and machines have strengthened this transformational capability to a point where any human or societal purpose may be reached through what may appear at first glance to be near infinite different configurations of networked humans and machines, although we will argue below that this apparent infinite complexity can be reduced into a simpler and conceptually coherent set of possible configurations. Readily available examples of the variety of instantiations of networks comprising both humans and machines may be found in media, commerce, and crisis management. Whereas media for decades was dominated by broadcasters and newspapers in a predictable relation with their consuming audience, in the hyper-connected era media content is produced, made available, and consumed in a wide range of rapidly evolving networks of service providers, technologies, producers, prosumers, and consumers. Likewise, in commerce, the stable and predictable relation of producers, retailers, and consumers is now replaced with various and rapidly changing constellations involving new actors such as online broker platforms, peer-to-peer reselling networks, and sharing economy services. Even in crisis management, the proliferation of personal sensors and mobile communication introduces opportunities for improving e.g. rescue and evacuation through various approaches to ad-hoc rescue networks including civilian non-professional resources.

The wide availability and evolving character of the human-machine network configurations that may be evoked to reach a human or social purpose, represent significant challenges to established technology and service providers. In particular, as technologies and solutions are used in interacting networks of humans and machines, rather than by individual customers or users, classical approaches to human-centred design is insufficient for providing a thorough understanding of the context of use and user requirements. For technology and service providers, a rapid innovation pace is critical given the increasing change rate both in technologies and customer needs (Chesbrough, 2006). Innovation prior to the hyper-connected era could target improvements in services or technologies that served a defined role in relatively stable and predictable purposeful types of human-machine networks. However, when pursuing innovation in the hyper-connected era, improvements in services or technologies needs to be based on an updated understanding of the envisioned human-machine networks of which the innovation will become a part. Innovation, hence, requires the capacity to identify the current and emerging characteristics of the human-machine network, as well as the associated actors, patterns of behaviours and interactions.

The overall objective of HUMANE is to understand and describe the human-machine networks that constitute the context or objective of service and technology innovation, and use this understanding as a basis to facilitate access to relevant innovation and design knowledge. Such an understanding is needed to support the design and improvement of public and private services. The importance of the HUMANE objective is seen in the all too common failures of services intended to establish or support purposeful human-machine networks: social network services all too often fail to establish vibrant online communities (Shneiderman, Plaisant, Cohen, & Jacobs, 2013); systems for networked collaboration during emergency response often fail to support emergency organizations in an efficient manner (Turkle, 2011); collaborative systems for knowledge workers are designed that are not taken up and used by the intended collaborators (Morozov, 2013); citizen-government collaboration systems are not taken up by the citizens to the degree expected (Tayebi, 2013). There is currently a lack in capabilities for planning and establishing solutions and services that support or serve to establish purposeful human-machine networks, because the conceptual frameworks and abilities needed to model such networks are missing.

Towards the overall HUMANE objective, we develop a typology of human-machine networks and rely on this typology to underpin appropriate associated methods. The typology aims at providing an overall understanding of key dimensions of human-machine networks and associated implications for innovation and design. In particular, the typology aims at facilitating the systematization and access to knowledge and experiences from relevant disciplines and application areas. The support for associated methods then facilitates the application of the HUMANE typology in specific cases of service or technology innovation and design. As such, the typology is intended to support human-centred design (HCD) for human-machine networks. The target audience for the typology and associated method are technology and service providers in general, and practitioners of human-centred design in particular.

The typology and method should also support the development of a roadmap to help the public and private sectors gain a better general understanding of how the field of human-machine networks is evolving, as well as key challenges and possible solutions within this field. That understanding, in turn, will improve the odds of both sectors successfully navigating human-machine networks as a context for future pursuit of innovation.

This deliverable represents our first attempt at developing a typology of human-machine networks, henceforth a *HUMANE typology*. The work includes the initial:

- identification and validation of dimensions and types to be included in the typology
- method for using the typology for analysing human-machine networks
- implications of the dimensions and types
- outline of suggested tool-support

2 Background

The basis for the development of the typology is the HUMANE literature review in D1.1 (Tsvetkova, Pickering, Yasseri, Walland, & Lüders, 2015). In this background section we first provide an overview of human-machine networks. We then provide general background on typologies and how to support design in HCD. Finally, we summarise key concepts and definitions pertaining to human-machine networks.

2.1 Human-machine networks

Through the work in HUMANE, we aim to provide increased insight into the emerging field of human-machine networks. Below, we provide our starting point, explicating the scope and objective of this emerging field and its key analytical layers. Furthermore, we provide some detail on the concept of agency, to clarify our position on agency in humans and machines.

2.1.1 Scope: Networks with synergistic effects

In the HUMANE literature review (Tsvetkova et al., 2015), the concept of *human-machine networks* was delineated as *"networks of humans and machines whose interactions have synergistic effects"*. That is, in human-machine networks the interaction of human and machine actors allows for the setting and reaching of objectives that would not be feasible without such networked interaction. The concept of *human-machine networks* is to be understood as a perspective for analysis, that is, a way of addressing the phenomenon of humans and machines interacting in networks. The main concern of this perspective is to understand the synergistic effects in such networks and, as importantly, to support the design and prediction of such synergy.

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. For example, the synergistic effects of the interaction of humans and machines in Wikipedia is immediately evident, both in terms of the synergy between human collaborators, but also in terms of the interaction between machine actors (bots) and human actors in maintaining and improving Wikipedia content.

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. In such unsuccessful cases, the synergistic effects residing in the human and machine may be considered an unrealized potential.

2.1.2 Objective: Implications from types

The objective of establishing human-machine networks as a field of interest is to provide new knowledge and method support to facilitate the realization of synergistic effects in such networks. In particular, the knowledge and methods should support the gathering and making available of implications of relevance when designing for human-machine networks.

An important lesson learnt from the literature review is that identification of *types* of human-machine networks may serve to structure existing knowledge and experience of relevance to design. That is, when the type of network is known, we may draw on the existing literature and experiences from successful solutions to increase our understanding in regard to key concerns and issues pertaining to the specific type.

In the literature review, preliminary network types were identified, including *online markets* and *systems for mass-collaboration*. On the basis of existing literature, key implications were made available for each network type; implications that may serve as design support. For example, for systems for mass collaboration one implication pertained to the informal use of "joining scripts", that is, implicit constructs that determine the typical level and type of activity a newcomer needs to go through before becoming a contributor. The concept of joining scripts may be valuable for trust building in systems for mass collaboration, and should be easily accessible when designing for such HMNs. However, the same joining scripts will not necessarily be adequate in human-machine networks requiring less intensity in involvement, such as online markets. In online markets reputation systems may be a more adequate mechanism to facilitate trust between actors, and should be included as part of available design implications for this type of human-machine networks.

The idea of deducing implications from existing knowledge and experience on the basis of network type is central to the HUMANE typology. In line with the approach of the literature review, we assume that identification of network type will, in turn, allow us to identify relevant existing knowledge. Relevant knowledge or experience may be identified in the literature or in current examples of successful human-machine networks. Such identification and structuring of knowledge and experience will be valuable to practitioners of human-centred design, as it may support the design of novel solutions while benefiting from pervious experiences concerning efficient design.

2.1.3 Analytical layers

Our starting point for identifying HMN types are four analytical layers: Actors, interactions, networks, and behaviours. The analytical layers were identified in the literature review and are summarized in Table 1 on the following page.

Table 1: Analytical layers of HMNs.

Layer	Description
Actors	Actors are nodes in HMNs that are considered or treated as single nodes by the other actors in the network. A high-level distinction is made between human and machine actors. Human actors may be constituted e.g. as individuals, organizational roles, or entire organizations. Machine actors may be constituted e.g. as single devices or complex back-end systems behaving to the HMN of interest as a single node. Actors in HMNs may have different levels of agency, which we detail with regard to **human agency** and **machine agency** respectively.
Interactions	HMNs enable new interactions between humans, between machines and humans, and between machines. As discussed in the literature review, we in HUMANE in particular target (mediated) human-human interactions and human-machine interactions. A key concept with regard to human-human interactions in HMNs is **tie-strength**. The strength of an interpersonal tie is seen as "a combination of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (Granovetter, 1973). An equally established concept as that of tie-strength does not yet exist for describing the quality of the human-machine relation. For this purpose we aim to develop **human-machine interaction strength** as a dimension in the HUMANE typology**.**
Networks	Given the concern for synergy between human and machine actors in the human-machine perspective, the network layer is primarily focused on interactions between humans and machines. The network layer concern the integration of actors and interaction into larger compounds, and aims towards defining types of such sets of actors and interactions. In the HUMANE literature review (Tsvetkova et al., 2015), eight preliminary network types were identified based on configurations of human and machine agency, this idea of defining network types on the basis of the configuration of agents and interactions will be pursued in the typology. In addition, we will consider dimensions related to **geographical space**, that is, the geographical extension of the network, and **size,** that is the volume of nodes and interactions on the network.
Behaviours	The behaviour of actors and constellations of actors concerns the emergent qualities of HMNs. That is, the changing characteristics or roles of actors depending on network context, emergence of new patterns of interaction in the HMN, new applications of the network, and the overall evolution of the network. Given the complexity of HMNs, such emergent qualities are difficult to predict. Important frames for making such predictions may be the dimensions of **workflow interdependence**, that is, the degree of dependency between interactions in HMNs, and **network organization**, that is, the degree of top-down vs. bottom up organizational structure of the network.

2.1.4 Agency in human-machine networks

In our study of networks of human and machine actors, we need to make an early clarification concerning the construct of *agency*. This is a potentially complex construct, which is demonstrated by the diversity of definitions in the theoretical models proposed in the literature. We address key models here and propose our initial understanding of agency serving as basis for the HUMANE typology. This understanding is likely to evolve as the typology is developed further and applied in the project use cases.

In the literature, agency is explained and defined in various and, at times, contradictory ways. For example, in structuration theory agency is defined as *"the capability to make a difference"* (Giddens, 1984); 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 characterized as intentional (Friedman & Kahn, 1992; Rose, Jones, & Truex, 2003; Rose & Jones, 2005).

Nevertheless, theoretical positions in the have been proposed that attribute agency also to machines, such as actor-network theory (Latour, 2005; Law, 1992) and the double dance of agency model (Rose et al., 2003; Rose & Jones, 2005). The latter observes the intertwined nature of human and machine agency as an interactive process that creates emerging outcomes in a social system, though the contributions of humans are machines in this interaction process are not considered equal.

In HUMANE, we see it as beneficial to consider both human and machine action in terms of agency. We aim at a) identifying a shared understanding of both human and machine agency in HMNs, while b) delineating differences between the two as is seen, e.g., in the dimensions proposed in Sections 4.1 and 4.2. We note that machines can both enhance and restrain human agency (Rose et al., 2003), that is, a machine hold particular *affordances*, or actionable properties, in the human-machine relationship (D. A. Norman, 1999). Furthermore, machines can exhibit agency themselves (Deci & Ryan, 2000; Fogg, 1998; Rose et al., 2003; Rose & Jones, 2005), in terms of acting in line with a set of contextually dependent objectives. Broadly speaking, 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.

Considering machine action in terms of agency, however, does not imply that we assume that machines have the capacity for intent or motivation; neither does it imply that machines experience trust or reliance, and or behave altruistically or irrationally of their own volition (Jia, Wu, Jung, Shapiro, & Sundar, 2012; Rose, Jones, & Truex, 2005). Such aspects of agency are considered relevant only for human actors. In practice, some of what constitute apparent machine agency may rather be a transitive function, with the machine being the conduit for decisions made by human agents and enacted via code and algorithms. Nevertheless, it is practical for the purposes of characterising and understanding HMNs to refer to machine agency in the sense that they are assuming increasingly complex, sophisticated and prominent roles in modern systems, exerting influence over other actors in the HMN. Machine agency is further discussed in Section 4.2.

Actors may have different degrees of agency in the HMN. Their agency is typically constrained by the respective ICT system they form a part of and the interfaces they can use for interacting with the system and other actors. Moreover, the actors may have different levels of agency according (a) the activities the actor can perform, (b) the nature of the activities; and (c) the ability to interact with other actors.

The activities the actor can perform (a) typically differ between the actors of a HMN. For example, some may be restricted viewing content while others may be allowed to generate content, and moderators in online communities typically have higher levels of agency than other community members. In many HMNs, individual machine actors may have low agency as they may be focused on performing a limited number of fixed tasks, such as peripheral devices like sensors.

The nature of the activities (b) concerns actors to behave diversely, unpredictably, freely, and creatively in order to pursue their respective goals/objectives for participating in the HMN. We can distinguish whether the activities themselves are open or closed. A closed activity is one that is restricted or fixed and, hence, predictable with an expected pre-defined outcome. An open activity is one in which the actors are able to exercise a degree of freedom, leading to diversity in the HMN. Allowing actors to express themselves in free text allows creativity and unpredictability in their activities. Twitter is a good example of this; although actors are limited to 140 characters of free text, Twitter supports individuals and actors and organisations to socialise, perform marketing, customer relationship management, engage in political propaganda, etc. Moreover, Twitter is an example of machine actors effectively being able to do similar activities as human actors. While some machine actors are under direct control by human actors to schedule tweets, such as propagating news, other machine actors (bots) act and network so as to pose as humans (Boshmaf, Muslukhov, Beznosov, & Ripeanu, 2011; Chu, Gianvecchio, Wang, & Jajodia, 2010) and influence human actors, for example, by spreading misinformation and propaganda (Boshmaf et al., 2011).

The ability to interact with others (c) determines an actor's potential for influencing other actors or the HMN itself. The ability to interact with others depends on the degree to which the actors are able to communicate with each other and how open the form of communication is. One could argue that if actors cannot interact, they are not a part of a network. However, there are examples of HMNs where users may simply not be aware that they are in fact a part of a network, such as ReCAPTCHA. Nevertheless, they form part of a network of millions of users, mediated via a machine, though they are not visible to one another.

2.2 Typologies

On the basis of the HUMANE literature review, we aim to develop a typology of human-machine networks. In this section, we provide a basic introduction to typologies as a general approach to classification, to serve as background for the development of the HUMANE typology.

2.2.1 Typologies as multidimensional classifications

Understanding and relating to the world require us to classify events, objects, or relations. As argued by Bailey (1994), classification is a prerequisite of reasoning and basic to all conceptual work. When analysing, describing, or designing for a human-machine network, we inevitably engage in an extensive process of classification.

Classification is the process of grouping according to one or more dimensions (Bailey, 1994). An example dimension for classification could be *relationship strength*, including the classes *no relationship*, *weak ties,* and *strong ties* (following Granovetter, 1973). Adequate classification require the classes of a dimension to be collectively exhaustive and mutually exclusive; that is, the classes of the dimension should cover all possible cases (exhaustiveness) and each case should fall into only one of the dimensions classes (exclusiveness).

Typologies, the organized system of types (Collier, LaPorte, & Seawright, 2012), are a form of classification much used in the social sciences (Bailey, 1994). Typologies typically are multidimensional classifications used for conceptual purposes. That is, a typology typically details a basic concept according to two or more dimensions, where the dimensions serve to describe the concept by its key defining characteristics. When cross-tabulating the dimensions, each cell of the cross-tabulation constitute one of the types in the typology.

As an illustration of how a typology can be constituted by its underlying dimensions, consider the crowdsourcing typology presented by Prpić, Shukla, Kietzmann, and McCarthy (2015).

Table 2: Example typology - from Prpić et al. (2015): Crowdsourcing

		Contributions	
		Aggregated	Filtered
Content	Subjective	Crowd-voting (e.g., American Idol)	Idea crowdsourcing (e.g., Threadless)
	Objective	Micro-task crowdsourcing (e.g. ReCAPTCHA)	Solution crowdsourcing (e.g. Netflix Prize)

The crowdsourcing typology of Prpić et al. (2015) (Table 2) is a useful example typology as it shows how a concept is explained by two characterizing dimensions, and how the cross-tabulation of the dimensions define the types. Both dimensions are exhaustive, and the dimension categories are mutually exclusive, which in turn renders the set of types exhaustive and the types mutually exclusive.

2.2.2 Typologies and concept formation

Following Collier et al. (2012), typologies are fundamental to concept formation. Typologies help clarify the meaning of concepts, establish the connection between concepts, and organize concepts into hierarchies. The types of the typology constitute different kinds hierarchically nested in the overarching concept. Likewise, the underlying dimensions of the concept constitute the key defining attributes of the types.

Establishing a typology, hence, is to understand and detail a concept useful for a particular purpose. Such understanding and detailing is reached through describing the underlying dimensions of that concept and demonstrating how their combination serves to pinpoint types that are of particular relevance to the objective at hand.

2.2.3 Typology development

Collier et al. (2012) provided a basic template for typology development, concerning (a) overarching concept, (b) dimensions, and (c) cross-tabulation and type descriptions.

First, the overarching concept is to be outlined. This concept is what the typology is to describe or measure; the object of interest. In HUMANE, the overarching concept is *human-machine networks*, as described in Section 2.1.

Second, the key dimensions that characterize the overarching concept are to be identified. The dimensions should capture *"salient elements of variation in the concept"* (Collier et al., 2012, p. 223). Hence, the dimensions both need to be of high relevance to all kinds belonging to the concept while at the same time they need to discriminate between kinds. Identifying useful dimensions is described as a task that requires both creativity in terms of which dimensions to include, and rigor in organizing these dimensions in adequate kind hierarchies.

Third, the dimensions are cross-tabulated and the types are described. The usefulness of types can then be verified by putting them for use in analysis, or, in the case of HUMANE, in designing ICT systems.

2.2.4 Typologies - criticism

The dimensions of typologies typically are categorical variables, something that has resulted in typologies being criticised as a tool for social science research. In particular, the assumption that scale variables are more desirable than categorical variables for measurement purposes has motivated this criticism. Furthermore, it has been argued that typologies may mask multidimensionality in cases where the categories used for classification are too coarse to capture the many-faceted nature of the underlying dimensions. An example of a categorical delimitation that possibly may hide multidimensionality may be that of grouping ties as "strong, weak, or latent" as multiple dimensions may potentially underpin each of these categories; for example may the category "strong ties" include both relations characterized by mutual trust and by mutual affection.

Nevertheless, as argued by Collier et al. (2012), categorical variables underpin and to a large extent also are integrated in current statistical analysis methods. Also, the issue of masking multidimensionality may be countered through the thorough development of typologies including the key dimensions needed to describe the concept of interest.

2.2.5 Typologies in HUMANE

The purpose of the HUMANE typology is to inform ICT-development for HMNs. In particular, the typology should support the analysis, design and evaluation required to conduct such development according to a human-centred design process. Hence, when developing the typology, the key dimensions should be those that support critical design decisions. The dimensions of the HUMANE typology should be dimensions that ICT-developers typically need to consider in analysis, design, and evaluation. Furthermore, the dimensions should clearly discriminate between different human-machine networks of individual ICT projects.

2.3 Design support in human-centred design

2.3.1 Human-centred design and human-machine networks

The HUMANE typology is intended to support human-centred design and future thinking in ICT. Human-centred design (HCD) is structured iteratively in phases such as the one described in the international standard on HCD (ISO, 2010); illustrated below in Figure 1.

In HCD, much emphasis is put on the context analysis and requirements phases of development. In these phases, the system's context of use is studied, and requirements are identified on the basis of general knowledge of human-machine interaction. However, whereas user requirements in current standards for HCD typically concern the interactions between individual users and machine interfaces, design support for HMNs needs to identify and model the entire network as part of the analysis and requirements phases.

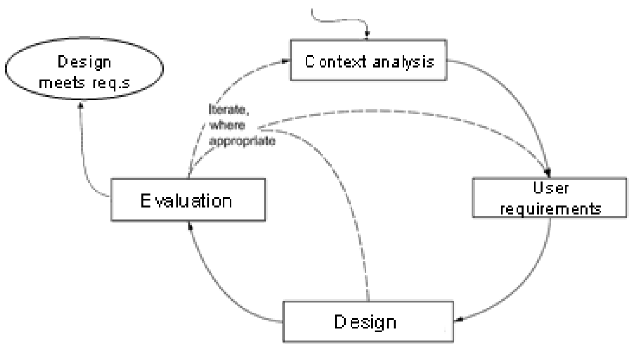

Figure 1: Human-centred design process (ISO, 2010)

Hence, we need design support that allows human-centred designers and future thinkers to benefit from existing knowledge and experience on the level of HMNs.

2.3.2 Design patterns as design support

One approach from the field of HCD that may be beneficial to support practitioners in the design for HMNs is that of design patterns. The notion of design patterns originates from the field of architecture (Alexander, Ishikawa, & Silverstein, 1977). The basic idea of design patterns is to analyse successful real-world solutions to design problems with the aim of identifying solutions that may be re-used in for similar design problems. Hence, the design pattern approach concerns to document solutions to specific design problems on the basis of experiences with existing successful designs. Seffah (2015) notes that design patterns are interesting, not because they provide new ideas or design solutions but because they package available design knowledge in an easy-to-use manner.

The notion of design patterns has been adopted in a number of fields, in particular that of software engineering, but also the field of interaction design and human-centred design. For example, the work of Van Duyne et al. (2002) documents solutions to webpage user interface design problems, such as navigation, sign-up processes, and interactive forms, on the basis of successful designs found online.

Design patterns typically include the following content (Borchers, 2001; Seffah, 2015):

- *Context:* A brief presentation of the context and background for the pattern is presented
- *Problem:* The problem to be solved is outlined.
- *Forces:* The different factors that affect the problem are discussed. Typically an optimal solution may require the balancing of forces.
- *Examples*: Successful real-world solutions are provided as examples.
- *Solution:* The solution is presented as a generic abstraction, drawing on lessons learned from the examples.

Design patterns documenting solutions to a number of design problems may be systematized in design pattern libraries. Such design pattern libraries serve as a hierarchical structuring of design patterns and should serve as reference for future design (Borchers, 2001; Seffah, 2015; van Duyne et al., 2002). Some have also succeeded in making design pattern libraries living entities, such as UI Patterns (http://ui-patterns.com). Some of these are set up for communities to collaborate on building pattern libraries, as in the pattern library solutions provided by Patternry (http://patternry.com). However, establishing such living community-based libraries is challenging, and it seems as if dedicated team efforts to provide design pattern libraries are more feasible, as in the cases of van Duyne et al. (2002). One proposed solution to gathering content for design pattern libraries is to conduct dedicated design pattern workshops (Iacob, 2011).

2.4 HUMANE concepts and definitions

To conclude the background section, we provide an overview of key human machine concepts and definitions.

Def 1.1: A human-machine network is a collective structure where humans and machines interact to produce synergistic effects.

A human-machine network is a set of humans and machines that interact to produce an effect that is greater than the sum of their individual efforts. This synergistic effect is produced by the combined interactions that occur between the humans and machines in the network.

Def 1.2: An *actor* in a human-machine network is a human or a machine node that interacts with at least one other node in the network.

When designing or modelling a human-machine network, we need to distinguish between human and machine actors in the network. Humans and machines have different properties, and thus (in most cases) may take on different roles and responsibilities in the network. Any actor, regardless of their nature, must interact with another actor in the network in order to be seen as part of the human-machine network.

Def 1.3: *Agency* in a human-machine network is defined as an actor's capacity for performing activities or actions in the network, in line with a set of objectives that influence their participation.

Actors' capacity for performing actions is strongly linked to their potential for interacting with and influencing other actors and the human-machine network itself. There are differences between humans and machines in terms of agency. However, both types of actor can influence other actors in the network and make perform activities or actions in line with a set of objectives that influence their participation.

Def 1.4: An *interaction* in a human-machine network is the process whereby the action of one actor in the network influences another actor.

The interactions between the actors in a human-machine network are essential to produce the synergistic effects that the network aims to produce. Interactions between humans are typically, but not necessarily mediated by machines. Interactions between humans and machines are typically facilitated by user interfaces. Interactions between machines are typically facilitated by network interfaces and computer networks.

Def 1.5: A synergistic effect of a human-machine network is an effect produced by the network which is greater than the sum of the effort produced by its nodes.

Following from definition 1.1 above, human-machine networks aim to produce synergistic effects. In general terms, this means that the network should produce effects that are greater than the sum of the effort of the individual actors involved. More specifically, it indicates that a human-machine network should serve some higher level purpose (general or specific) that could not have been achieved solely by combining the efforts of the individual actors. However, the synergistic effects in a network might also be regarded as the combination of human strengths and computer strengths (i.e. the effort of the human actors and the machine actors). For instance, this means that systems such as ReCAPTCHA, which combines human strengths (to digitize text) with machine strengths (to integrate human contributions), may be considered as enabling some synergistic effects; though the input from human actors are merely aggregated, the effect is brought about by combining human and machine strengths.

3 Approach to the typology development and validation

The HUMANE typology and associated method will be developed through an iterative approach. The first version of the typology and associated method, presented in this deliverable, is based on the HUMANE literature review and adjusted according to initial feedback from the project cases.

3.1 Developing the HUMANE typology and method v1

The first version of the typology and development was developed in an iterative process involving all HUMANE project partners. The development process is outlined in Figure 2 and detailed below.

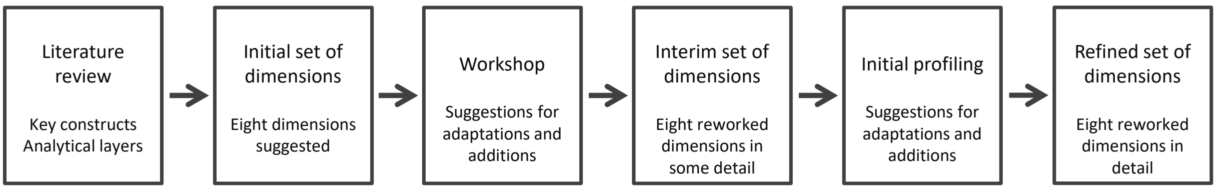

Figure 2: HUMANE typology development process.

The literature review in D1.1 (Tsvetkova et al., 2015) provided the set of key constructs and analytical layers as a basis for the typology. Furthermore, the findings of the literature review provided insight into relevant dimensions.

On the basis of the literature review, an initial set of eight dimensions was suggested by the partners. This initial set was presented to all project partners in a project workshop. Following the workshop, an adapted set of dimensions were provided and used for a preliminary profiling of the HMNs of the six HUMANE case projects. On the basis of this profiling, further suggestions for adaptations and additions were provided by all project partners. On the basis of the suggested adaptations and additions, a refined set of dimensions were suggested. An overview of the initial set of dimensions, the suggested additions and adaptations, and their mapping to the refined set of dimensions is provided in Appendix A. The refined dimensions are presented in Section 4.

3.2 Validating the HUMANE typology and method v1

The HUMANE typology and method will be validated in the first set of HUMANE case-studies (T3.2). In this validation we will target the usefulness of the typology, in particular for the purpose of understanding the human-machine systems context of use.

The validation in the case studies should address the themes as outlined in Table 3, below.

Table 3: HUMANE typology validation themes.

Validation theme	Description
Usefulness of profiling approach	The usefulness of the profiling approach depends on the benefit inherent in (a) analysing and discussing the case's HMN in terms of the suggested dimensions, and (b) getting design input on the basis of implications drawn from the profile. The validation should provide insight into the perceived usefulness of the profiling approach for the particular case, and (if any) suggestions for improvement.
Completeness and adequacy of suggested dimensions	The suggested dimensions are developed on the basis of the HUMANE literature review and a process involving all case partners. Nevertheless, the initial set of dimensions is assumed to be incomplete and in need of further refinement. The validation should provide input concerning other useful dimensions, opportunities for simplification in the dimension structure, or adaptations of individual dimensions.
Input from case studies concerning implications	The case profiling, and the analysis and discussions of dimensions, is assumed to provide insight on the basis of the current literature and real-world examples. However, the case analysis may also serve to identify and systematize implications already known from previous work in the analysed case, and that may be of relevance also for other cases. If so, it will be valuable to gather such implications as input from the case analysis.

4 The HUMANE typology - dimensions

In this section we describe the dimensions of the initial HUMANE typology. These dimensions are aimed at targeting key defining characteristics of HMNs. After this, in Section 5, we then describe a framework for profiling HMNs on the basis of these dimensions and identify HMN types on the basis of these profiles. The process leading up to the set of dimensions included in the initial HUMANE typology is described in Appendix A.

In this initial HUMANE typology, we target dimensions that concern the four analytical layers for HMNs identified in D1.1 (Tsvetkova et al., 2015): actors, interactions, networks, and behaviours. For each analytical layer, two key dimensions have been identified. An overview of the dimensions is provided in Table 4.

Table 4: Dimensions included in the initial typology.

Analytical layer	Dimension	Description
Actors	1. Human agency	The capacity of the human actors in terms of what they can do and achieve in the network. (Three point scale: none/low, intermediate and high.)
	2. Machine agency	The capacity of the machine actors in terms of what they can do in the network, as well as to what extent they enable agency in human actors. (Three point scale: none/low, intermediate and high.)
Interactions	3. Tie strength	The tie strength between human nodes in the network. (Scale: no ties, latent ties, weak ties, strong ties.)
	4. H2M interaction strength	The nature and strength of the interaction between humans and machines (H2M) in the network. (Scale: independent-optional, independent-necessary, reliant-optional, reliant-necessary.)
Network	5. Network size	The number of human nodes in the network. (Scale: small, large, massive.)
	6. Geographical space	The geographical extension of the network. (Scale: local, regional, global.)
Behaviours	7. Workflow inter-dependence	The level of interdependence between actors of in the network. (Scale: low, intermediate, high.)
	8. Network organization	Network organization with implications for predictability and emergence. (Scale: bottom-up, intermediate, top-down.)

Given its status as the first version of the typology, limitations to the current set of dimensions are to be expected. The current set of dimensions is kept small for the sake of simplicity. We aim to iterate on this set of dimensions in second version of the typology, and will use the HUMANE case trials for identifying other critical dimensions. During the work leading towards this first version of the typology, we also considered other dimensions; dimensions that have been suggested or identified as part of this work, but not included in the first version of the typology, are listed in Appendix A.

4.1 Dimension 1: Human agency

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 (See Section 2.1.4). Given this broad definition of agency in HMNs, we further discuss the specifics of *human* agency here.

In social cognitive theory, human agency is modelled as emergent interactive agency; as being affected by both internal and external influences (Bandura, 1989). Moreover, Bandura (1989) notes that human agents are seen as both producers and products of social systems. This is important, as it relates to the intertwined nature of human and machine agency that Rose et al. (2003; 2005) discuss; i.e., the machines affect human agency.

Core to the views of human agency is *intentionality*, which relates to the ability human actors have in choosing to behave in a certain way; in particular, with a future course of action in mind. Another aspect of human agency, discussed in social cognitive theory, is *forethought*, which is related to the temporal characteristics of intentionality in the sense that people set goals for themselves and will behave in a certain way in order to achieve desired outcomes and avoid undesired outcomes related to their goals (Bandura, 2001).

In terms of intentionality and forethought, we can extrapolate that human participants use HMNs in order to fulfil a set of goals, which may not be dependent on the network itself; that is, the HMN may be seen as a means to an end. Bandura (2001) outlines different modes of agency, one of which is of particular relevance here: *proxy agency*. This refers to socially mediated agency where people try to get those who have the needed or desired resources or expertise to act on their behalf to achieve goals they cannot achieve on their own. In this context, we note again the intertwined nature of human and machine agency. E.g., Rose et al. (2003) argue that humans exploit the agency of machines to serve themselves; that is, human beings may exercise proxy agency via machines such as when using social bots on Twitter for sharing information in a way that is not humanly possible (e.g., at a high frequency and around the clock) to effectively reach a global audience.

When assessing human agency, the dimension may be scaled with the following extremes:

- **No/low agency**: only able to perform a single homogeneous, closed, activity without the ability to interact directly with other participants in the HMN. Examples include Amazon Mechanical Turk and ReCAPTCHA. In the latter example, we can argue that human actors aren't able to exert *any* agency, in the sense that they are generally not aware they are a part of a HMN set up to help digitise books – they are merely using a website and need to get past a prompt to prove they are indeed human. While, in the former example, human participants are aware of the premise of the system and chose to participate, whether for altruistic reason or financial gain.

- **Intermediate agency**: able to perform multiple, heterogeneous activities, enabling a certain degree of creativity and unpredictability. Agency will still be limited, for example in the ability to communicate with other agents, e.g., being unable to form social groups or exercise proxy agency. An example is peer to peer redistribution markets, such as Craigslist, with limited community-features beyond contacting sellers by phone or e-mail.
- **High agency**: able to perform multiple, heterogeneous, open-ended and interconnected activities, while being able to interact with other actors in the HMN to exercise both individual and proxy agency. An example is online games and virtual worlds (as discussed in the literature review, Tsvetkova et al., 2015). Although such examples may be purely for entertainment, even online games can develop complex socio-economic structures that expand the game itself, e.g., via trading outside the game.

Human agency is an important dimension in terms of reflecting the ability of the human actors to be creative and use the HMN in unintended ways. It also links to the motivations of users to participate in the HMN. If they are not able to exercise agency in the HMNs, in terms of achieving the objectives that underpin their reasons for participating, they may choose not to participate.

4.2 Dimension 2: Machine agency

Machine agency is based on the same basic understanding of agency as described in Section 2.1.4, as is human agency; that is, the capacity for performing activities and actions in a particular environment, in line with a set of goals/objectives that influence their participation.

Machine agency is, however, not assumed to equal human agency. A key issue is the aspect of *intentionality* in human agency. In contrast to humans, machines do not have agency in the sense of being intentional or motivated, experiencing trust or reliance, or behaving altruistically or irrationally of their own volition (Friedman & Kahn, 1992; Jia et al., 2012; Rose et al., 2005). However, machines do act in line with goals and objectives within their environment, makes a difference, and influence the outcomes of social systems (Rose et al., 2003; Rose & Jones, 2005; Rose & Truex, 2000).

Following Rose and Truex (2000), it is also relevant to consider the *perceived agency* of machines; referring to humans attributing agency properties such as intentionality to machines. This is in line with Nass et al. (1995) argument concerning humans' tendency towards anthropomorphism.

While our definition of machine agency does not imply that machines have intentionality, it is useful in HMNs to refer to machine agency in terms of the intentions of their human designers. For example, in the field of captology, concerning computers as persuasive technologies (Fogg, 1998, 2003), it is discussed and demonstrated how interactive technology may be deployed to change human attitudes or behaviours (Fogg, 1998). Hence, persuasiveness may be highly relevant for machine agency in human machine networks.

In essence, machine agency reflects the degree to which machine actors may a) perform activities of a personal and creative nature (e.g., personalised health care), b) influence other actors in the HMN, c) enable human actors to exercise proxy agency via the machines, and d) the extent to which they are perceived as having agency by human actors. When assessing machine agency, the dimension may be scaled with the following extremes:

- **No/low agency**: a machine actor that passively participates in the network performing a single, homogeneous and closed activity. Human participants in the HMN may not even be aware of its presence or purpose. For example a sensor that passively performs monitoring.
- **Intermediate agency**: a machine actor that performs a single or small set of functions, participating in the network with direct interactions with other human actors, influencing their user experience. Alternatively, it could be a machine actor that performs multiple (open and/or heterogeneous) functions, but is limited in its interactions with human actors. For example Amazon's use of robots in their warehouses[1] (each robot limited in terms of activities, but interact with human workers and form complex communication networks with other machine actors), or the use social bots on platforms such as Twitter and Facebook (see Section 2.1.4).
- **High agency**: an anthropomorphic machine actor that can interact in an open manner with other participants in the HMN in multiple ways (digitally, verbally and physically), enabling proxy agency on behalf of human actors. An example is a personalised health-care system, such as that in the project PAL (http://pal4u.eu/), which includes a humanoid robot that interacts with patients in the hospital (and virtually when they are at home).

Higher levels of agency imply a need for considerations of the implications of the machines' role in the HMN. This relates to, e.g., the trust relationship between humans and machines, which is an aspect of dimension 4 'H2M interaction strength' (Section 4.4).

4.3 Dimension 3: Tie strength

This dimension measures the existence and typical intensity of social interactions among the human nodes in the network. Tie strength is an important social-scientific concept because different types of relations can affect both the individual's behaviour and the collective outcomes (Burt, 2009; Granovetter, 1983). Scholars have particularly focused on the distinction between weak and strong ties. Close friends and family are considered strong ties while acquaintances are weak ties.

Strong ties are characterized by high intensity, high intimacy, high reciprocation, and long duration (Granovetter, 1973). Strong ties tend to be structurally embedded in the sense that the two individuals tend to have multiple friends in common. They facilitate trust, improve solidarity and cohesion in the network, and decrease conflict (Krackhardt, 1992; Nelson, 1989).

Weak ties occur between individuals who interact less frequently and are less invested in the relationship. Weak ties often connect socially distant individuals who otherwise have few connections in common. While this may seem to imply that weak ties are less important, in practice they can be extremely important in the sense of being a conduit for novel information and connections that are otherwise difficult to find in a small, tightly connected, but homogenous

[1] http://time.com/3605924/amazon-robots/

networks. For instance, they facilitate the transmission of information (Watts & Strogatz, 1998) and can help one find a job (Granovetter, 1973) or generate creative ideas (Burt, 2004).

In HMNs, tie strength can vary from no ties to strong ties, with latent and weak ties in-between. Certain networks do not provide conditions for social interactions and participants remain unaware of other participants' numbers and actions. These networks are characterized by *no ties*. ReCAPTCHA, the embeddable Turing test that serves to digitize large volumes of old printed publications, exemplifies this case: participants make their contributions in isolation, without the ability to interact with others. Similarly, typical tasks on the crowdsourcing platform Amazon Mechanical Turk do not allow users to connect with each other.

Certain networks allow for *latent ties*. Networked technologies may open up opportunities to interact between individuals who would not otherwise connect, and 'latent ties' can accordingly be defined as connections that are 'technically possible but not yet activated socially' (Haythornthwaite, 2005). In HMNs where users gather without any prior relationship, connections can hence be said to be latent. Examples include the online market Craigslist and the content community Reddit. Users do not need to have any relations with other users in order to be a user or member of these networks, or in order to benefit and derive value from the HMN. If they contact a seller in Craigslist or comment or upvote a Reddit contribution, technically enabled latent ties *may* eventually turn into weak ties if repeated over time between the same users.

Next on the scale of tie strength are hence *weak ties*. In weak-tie networks, users interact with each other but their interactions are usually sporadic and cursory. Such interactions are often conducted publicly, for example, by ranking and commenting on another user's post or contribution. Weakly tied pairs may choose to connect for example in Twitter by following and replying to each other. As explained above, HMNs may also enable latent ties to become weak if people find reasons to interact more regularly.

Finally, in networks of *strong ties*, typical individuals' interactions are mutual, repeat over time, and involve a high throughput of information. Further, these interactions often occur along private channels, such as e-mail or instant messages. Facebook, the largest online social network, serves as a good example here, even though personal networks are typically characterized by strong and weak ties combined: peoples' friends-list include close friends as well as more distant contacts.

Tie strength is an important dimension for HMNs that aim to connect humans and/or benefit from the resources offered by social networks. Particular types of social ties can be strategically encouraged to improve participant motivation, affect individual behaviour, instigate collective action, or propagate important information.

4.4 Dimension 4: H2M interaction strength

This dimension highlights the degree to which human actors in an HMN have to trust the machine actors, whilst providing some level of flexibility in the dependence level of the relationship.

The nature of interactions between humans and machines depends on a number of factors. Consider the following scenarios:

- Warnings are often displayed or implied on websites, automatic tellers (ATMs) and the like to report anything suspicious or to double-check that the user wishes to proceed with a transaction, especially if it would lead to the disclosure of personal or sensitive data;
- In critical situations, reliance on a machine may be regarded as too risky: human actors may prefer to reassert control and dominance at such times;
- Equally, in dangerous or life-threatening contexts, there may be no alternative but to rely on machines to monitor or recover a given situation.

From the human perspective, this in general relates to trust, or a willingness to expose oneself to vulnerability, and trustworthiness, the attribute or characteristic of someone or something which encourages another to trust (R. C. Mayer, Davis, & Schoorman, 1995). Trust then becomes a characteristic of the human actor and trustworthiness of the machine(s). This dimension is affected by the trust and level of interaction between the human and machine nodes linked by their interaction. Mayer et al.'s original construct was based on three main trustworthiness factors (1995, p. 715, Figure 1): ability, benevolence, and integrity, each of which relates to the scenarios listed above. Human agents 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, 2011; Venkatesh, 2000). They may need to see the machine and what it does to be the product of design intended to support them in what they do (Colquitt, Scott, & LePine, 2007; Grimmelikhuijsen & Meijer, 2014; E. Montague & Asan, 2012): the machine is there to help them. Finally, they need to understand that what the machine does, it will do so without unfortunate side effects, such as injure them or allow their data to be lost (Cheshire, 2011; E. N. H. Montague, Kleiner, & Winchester, 2009).

Unlike machine-to-machine interactions though, there is a unique characteristic of human-machine interactions insofar as humans will accept machine malfunction, and develop compensatory behaviours (Lee & Moray, 1992; Lee & See, 2004). Indeed, with increasing familiarity with services or the environment in general, they will be quicker and more understanding of problems (Dutton & Shepherd, 2006; Onarlioglu, Yilmaz, Kirda, & Balzarotti, 2012) This does not, however, lead to unequivocal and appropriate use of technology (Dzindolet, Peterson, Pomranky, Pierce, & Beck, 2003). It may even be the case that trust is a solely human-to-human construct and reliance is more a commercial or pragmatic response (Mouzas, Henneberg, & Naudé, 2007)

Wiegmann and his colleagues maintain that trust and reliance are independent (Wiegmann, Rich, & Zhang, 2001). In disuse *versus* misuse decisions, the reliability of the technology itself is not the only mediator of adoption and trust. Extending the original model from Dzindolet and her colleagues

(Dzindolet, Pierce, Beck, Dawe, & Anderson, 2001), which identifies the influence of social, cognitive and motivational factors leading to a decision to *rely* on the technology, Wiegmann et al. refer to a notion of experience (a "perfect automation schema", *op.cit.,* p. 364), derived from other work by (Dzindolet, Pierce, Beck, & Dawe, 2002). Dzindolet et al. return to this problem, suggesting as (Dutton & Shepherd, 2006) found, that knowing why the technology makes errors seems to increase trust (Dzindolet et al., 2003). Lee and See (2004) tried to pull together the various aspects here, concluding that trust and reliance are related, not because of a 'perfect automation schema', but rather because humans react socially to machine (op.cit., 2004, p. 51, et passim).

Finally, there is the case of reliance on technology becoming indispensable: we need to use clinical monitoring equipment, for instance, because we cannot or cannot easily achieve the level of care or complexity any other way (Locsin, 1995), or because we allow ourselves to drawn to this dependence (Gzik, 2011; Hoffman, Novak, & Peralta, 1999). Overall, there is a degree both of dynamism and flexibility in human-to-machine directed interactions, whereby trust and reliance refer to different things; reliability does not necessarily mediate trust; and an increasing dependence on technology-based interactions and capabilities.

This would suggest an interrelationship between different factors in human-to-machine interactions: one the one hand, the level to which humans could work *independently* or have some degree on *reliance* in technology; but on the other, whether or not they are free to operate independently of technology (is it *optional* or *necessary*). The interaction between these factors generates a matrix of dimensionality as outlined in Table 5.

Table 5: Matrix of dimensionality for H2M interaction strength

	Optional	**Necessary**
Reliant	This is the second strongest interaction type. It occurs when under normal circumstances (such as monitoring) human actors will trust machines to control and manage situations. However, if need arises, humans may override and intervene to retake control. For example: an automatic pilot.	This is the strongest interaction, implying the human actor must trust the machine completely. For example: life support systems
Independent	This is the loosest interaction type, whereby the human actor does not need to trust the machine and may achieve the same goal independently but with more effort. For example, parking sensors.	This is a moderate interaction strength, when human agents can and do often operate independently but would normally rely on the machine. For instance, if a lift breaks or is disabled in emergency, human actors would need to use an evacuation slide or stairs, or even climb down a building.

In consequence, the dimension would go from low H2M interaction strength (Independent-optional), via intermediate interaction strength (independent-necessary, reliant-optional), to high (reliant-necessary).

H2M interaction strength represents an important dimension for HMNs where there is dynamic interplay between human and machine agents. The dimension helps to identify the flexibility of roles within a network, highlighting the potential for emergent behaviours in the network which may have different consequences from the confusing and frustrating (Whitten & Tygar, 1999) to the downright dangerous (C. Norman, n.d.; D. A. Norman, 2013). H2M interaction strength therefore is essential in HMN design to avoid potentially disastrous outcomes.

4.5 Dimension 5: Network size

Network size can be easily quantifiable and measured. By “network size” we define the number of nodes that are part of a human – machine network. The dimension’s scale though is not that easily defined. A ‘small’ network for one type of networks may have a number of nodes that would characterize another type of network as ‘big’. In addition to that, heterogeneity of the nodes is also an issue - a small, heterogeneous network may be more complex than a large homogeneous one. To that end, it should be clarified that the size is not always proportional to the network’s complexity. Further, the network size may change during a network’s operation (e.g. with nodes joining the network or leaving it) or be fixed, depending on the network type and the application.

The scale to be used in the network size dimension is set up to be simple and practically applicable, based on three levels: Small, Large and Massive. A *small* network consists of dyads or teams with up to a few hundreds of human nodes, a *large* network consists of constellations with some thousands of nodes to a few millions, and a *massive* network has many millions and above. As HMNs continuously grow and evolve, the dimension should reflect the size capacity of the network, rather than its actual size at the current moment of evaluation.

For instance, public-resource computing projects are distributed computing networks, where each processing unit is a voluntarily offered personal computer. Current implementations of public resource computing are limited to tasks with independent parallelism, meaning that participating machines are not required to communicate with each other (Anderson et al., 2002). Such networks may consist of 5-10 nodes (defining a small network) or hundreds or thousands of nodes, defining a large network. In such a case, a *small network* would be easier to manage, but less efficient in terms of actual information exchange. Newer public resource computing projects, however, take the form of peer-to-peer networks (Marozzo, Talia, & Trunfio, 2012; P. Mayer, Velasco, & Klarl, 2015). Such networks do not require a high-level management but rely on communication between the independent nodes. Such networks can grow to massive size.

Other examples related to the size of a network may include social media HMNs, such as Facebook and Twitter. These two networks consist of billions of nodes (both machines and humans), defining very good examples of massive networks.

4.6 Dimension 6: Geographical space

The 'geographical space' dimension focuses on the area that an HMN spans geographically. In addition to that, it is also important regarding this dimension's definition to include considerations on legal territory in this dimension. For example, it will be important to a HMN whether it is within or across legal jurisdictions (country, EU). To that end, the scale of this dimension varies from (i) local, to (ii) national / regional and finally to global /cross-border.

A crowdsourcing network such as Amazon Mechanical Turk and Zooniverse may span (essentially) the whole world, while a crowd sensing network, such as a traffic monitoring and environmental monitoring systems, usually spans only one specific city or country. Mass collaboration projects are frequently developed by geographically and organizationally dispersed contributors. Such networks are also expected to operate worldwide with respect to geographical space.

The geographical space of a HMN may affect its efficiency, as well as the extent to which its services are exploited. A *local network* is limited in terms of exploitation as well as in terms of efficiency: if we consider a network that investigates the trustworthiness of online sources, as the REVEAL case study (see Section 5.2.3), then such a local span would lead to insufficient data and questionable conclusions, while at the same time the number of people able to exploit the network's services would be limited.

On the other hand, *a global network* may be more efficient and useful in terms of exploitation, but it may introduce difficulties in regards to the overall management and organization of the network. For instance, Facebook faces many challenges in storing and processing the data of more than a billion of users across the planet. The challenges are faced mainly on three broad topics: small data, big data, and hardware trends. Small data refers to OLTP-like queries that process and retrieve a small amount of data, usually 1-1000 objects requested by their id. Indexes limit the amount of data accessed during a single query, regardless of the total volume of data. Big data refers to queries that process large amounts of data, usually for analysis: trouble-shooting, identifying trends, and making decisions. The total volume of data is massive for both small and big data, ranging from hundreds of terabytes in memory to hundreds of petabytes on disk[2]. Similar challenges are faced by other global networks as well.

4.7 Dimension 7: Workflow interdependence

Interdependence reflects the extent to which the human nodes' actions depend on each other; the higher the level of interdependence, the higher the need for coordination. This dimension is loosely based on the concept of workflow (or task) interdependence from organization theory (Thompson, 2011; Van de Ven, Delbecq, & Koenig Jr, 1976). According to this work, there are four patterns of workflow with increasing levels of interdependence: pooled, sequential, reciprocal, and team. Pooled interdependence describes independent contributions, sequential interdependence describes a one-directional workflow where one unit's outputs are another unit's inputs, reciprocal interdependence

[2] https://research.facebook.com/blog/1522692927972019/facebook-s-top-open-data-problems/

represents a similar pattern except that the interactions are bidirectional and repeated, and team interdependence describes simultaneous and multi-directional workflow.

While the sequential and reciprocal forms of interdependence may be common in formal organizations, they are rare in their pure form in less structured HMNs. Hence, we will use a continuous scale that goes from low to high interdependence; for practical purposes in the HMN profiling we apply a three step scale of *low*, *intermediate*, and *high* workflow interdependence.

In HMNs with *low interdependence*, human actors make their contributions independently. Hence, these systems require low levels of time coordination. For example, citizen science projects such as Galaxy Zoo collect classifications from multiple users. Any user can contribute regardless of how many others have contributed and when. The order in which the classifications arrive does not matter for the project. This is also the case for public-resource computing networks for tasks with independent parallelism, such as SETI@home.

In networks with *high interdependence*, users' contributions and experiences are contingent on other users' participation. Contributions need to be coordinated in time. Virtual worlds such as Second Life and multiplayer online games such as World of Warcraft exemplify this situation.

Networks with *intermediate levels of interdependence* allow for independent contributions but involve partial dependencies, even if they do not require synchronization. For example, coders who contribute to open-source software projects such as the Python programming language can each write their functions or libraries independently; however, they need to update them if other coders make significant changes to the code base.

An increasing level of interdependence in a HMN requires more sophisticated tools for real-time communication and coordination. Designing such tools involves dealing with the problem of latency, or long time delays between sending and receiving signals. This problem can be particularly challenging when the network in question is massive in size.

4.8 Dimension 8: Network organization

Network organization concerns the level of formal, predefined structure to the network. Network organization has been a key area of interest from the early beginnings of social network studies (e.g. Leavitt, 1951). For the purpose of the HUMANE typology, we may distinguish between *bottom-up* or self-organized network organizations on the one hand, and *top-down* network organizations on the other, with an *intermediate* position where both approaches to the organization is immediately apparent.

With the introduction of online social networks, new media theorists have, in particular, highlighted the capacity for self-organization in social networks (Leadbeater, 2007; Shirky, 2008). Self-organization in online social networks has been demonstrated in a range of case studies, in particular for cases of collective action and collaboration. Examples include the bottom-up gathering and organization of volunteers in crisis situations (Starbird & Palen, 2011), social protest movements

(Juris, 2012), and the self-governance of knowledge commons such as Wikipedia (Forte & Bruckman, 2013).

It is argued that a de-centralized, self-organizing structure in such movements for collective action represent opportunities for flexibility, robustness and sustainability (Juris, 2012). Self-organizing in online contexts follow design principles known also from off-line contexts, such as *congruence between rules and local conditions*, *collective choice arrangements*, *monitoring*, and *conflict-resolution mechanisms* (Forte & Bruckman, 2013). Self-organization may also be relevant between machine components, such as discussed in the field of autonomous computing where the machine components within a system are made responsible their own resources and operations (Steiner, 2008).

However, HMNs in general, and online social networks in particular, may also benefit from being organized in a predefined, top-down fashion. Examples of such top-down organization may be found e.g. in some types of crowdsourcing. For a crowdsourcing organization, it is argued that key design decisions concern aggregation of contributions (integrative or selective) and remuneration (Geiger et al., 2011).

HMNs may also display aspects of both top-down and bottom-up organization. Organizations that emerge as grassroots or bottom-up initiatives may over time define structures to manage the growing organization 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 organization. When profiling HMNs, we conceive of networks that display considerable top-down and bottom-up structure as having an *intermediate* network organization.

5 The HUMANE typology - Profiles and types

The set of dimensions constituting the v1 HUMANE typology is intended for profiling of HMNs. In this section we describe the profiling framework, present an initial profiling for the HMN of each project case, and discuss how we can derive key types of HMNs on the basis of the profiling.

5.1 Profiling framework

Based on the layers in the HUMANE typology, we have developed a framework for profiling of HMNs that can be used by designers and developers to help identify similar HMNs and relevant design implications. The term *profiling* in this context refers to the process of identifying and pinpointing the characteristics of any given HMN according to the four analytical layers in the HUMANE typology (i.e. actors, interactions, network, and behaviour). The output from the profiling process is a network profile that describes the characteristics and flexibility of the network. Once this profile has been defined, it can be used to identify similar networks, and eventually to help identify design implications and relevant design patterns for the network. This section provides guidance and materials to help facilitate and structure the profiling process.

5.1.1 The objective of HMN profiling

The overall objective of HMN profiling is to generate insights that help designers and developers make informed decisions about the design of any given HMN. The profiling process supports this (1) by helping designer and developer teams to reflect upon and reach consensus about the characteristics of the given network they are developing, (2) by producing a profile of the network that works as a documentation of its envisioned characteristics, and (3) by enabling designers and developers to identify similar networks that can be used to find relevant design implications and design patterns. Moreover, profiling is also important to derive key types of HMNs within the HUMANE project because it simplifies and facilitates the process of comparing different networks with each other by means of network profiles.

To some extent, profiling might also be used to identify deviations between the current implementation of a HMN and the planned, envisioned implementation (i.e. by profiling the current implementation of a network and comparing it with the envisioned profile). Such use is however not described in the current version of the profiling framework.

5.1.2 Incorporating profiling into the human-centred design process

The profiling framework is intended to be used as part of a human-centred design approach. Specifically, as the profile of a HMN should be used to inform the design of the network, it is important that the profiling work is initiated early on in the design process. At the same time, it is clear that the profiling itself cannot be conducted without first having a substantial overview of the context that the HMN is built to support. In relation to a typical human-centred design lifecycle, profiling should therefore take place immediately following the context analysis phase, after an initial understanding of the users, tasks, and environments has been established. Throughout the iterations of the human-centred design lifecycle, it might be necessary to update the profile as the understanding of the network context increases. Updating of the profile should only be done in agreement with all relevant actors, such as designers, developers and other stakeholders. Figure 3 illustrates how profiling can be incorporated into a typical human-centred design process.

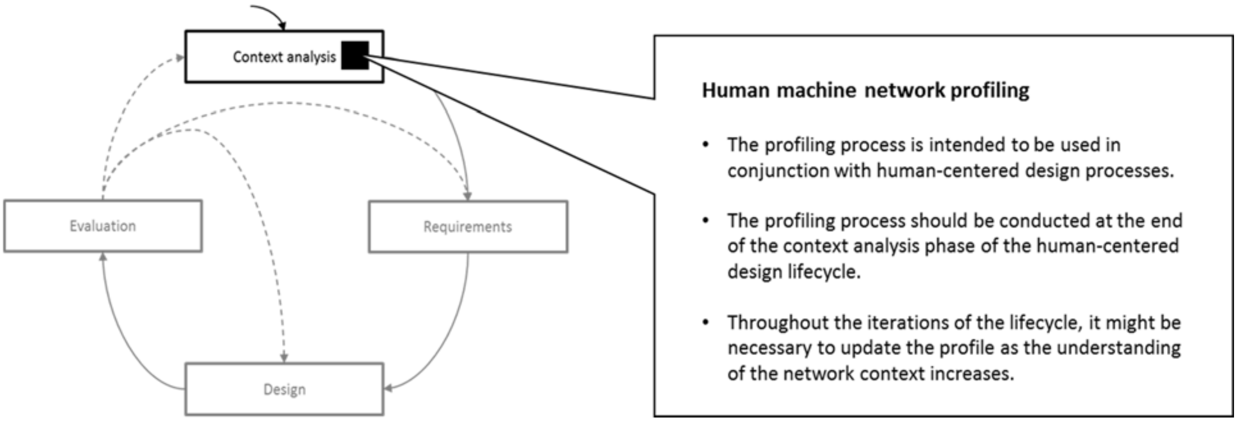

Figure 3: Incorporating HMN profiling into human-centered design processes

5.1.3 Procedure for profiling and identification of design principles

The procedure for HMN profiling and identification of relevant design principles consists of four main steps. These steps are not meant as strict rules that must be followed, but rather as a suggestion to how designers and developers can conduct profiling and identification of relevant design principles.

Step 1 involves the definition of network characteristics according to the four analytical layers in the HUMANE typology, and the dimensions within these layers. In this step, the involved participants together must describe the network by pinpointing where the network fits along the continuum of the eight dimensions in the typology. In cases where a network is flexible to support multiple levels along the dimension, the group should pinpoint the two extremes along the axis to capture the flexibility of the network.

Step 2 involves the creation of a joint profile for the HMN, based on the characteristics of the network that were defined in step 1. The joint profile consists of a visual representation of the network characteristics which makes it easier to compare the network to other networks, and a textual description for each of the eight dimensions that describes why the network has the given characteristics. A template is provided to facilitate the creation of the profile.

Step 3 is to identify similar HMNs based on the profile created in step 2. To a large extent, this is a reflective activity such as step 1, requiring the participants to brainstorm similar networks that they are aware of. However, this should also be facilitated by comparing the profile visualization diagram with the profile diagrams of other networks. The profile diagram of the network does not have to match the other diagrams completely to be regarded as similar. It is up to the participants to judge whether the other networks are to be regarded as relevant or not.

Step 4 is to extract relevant design implications and design patterns from the similar networks that were identified in step 3. This requires the participants to take a closer look at the similar networks, and identify relevant design principles that have been applied in these networks to make them support the characteristics as defined in their profile. In this step, the participants need to be careful only to adopt design principles that have proven useful in the similar networks, and that find highly relevant for the network under discussion.

The four steps described above are summarized in Figure 4.

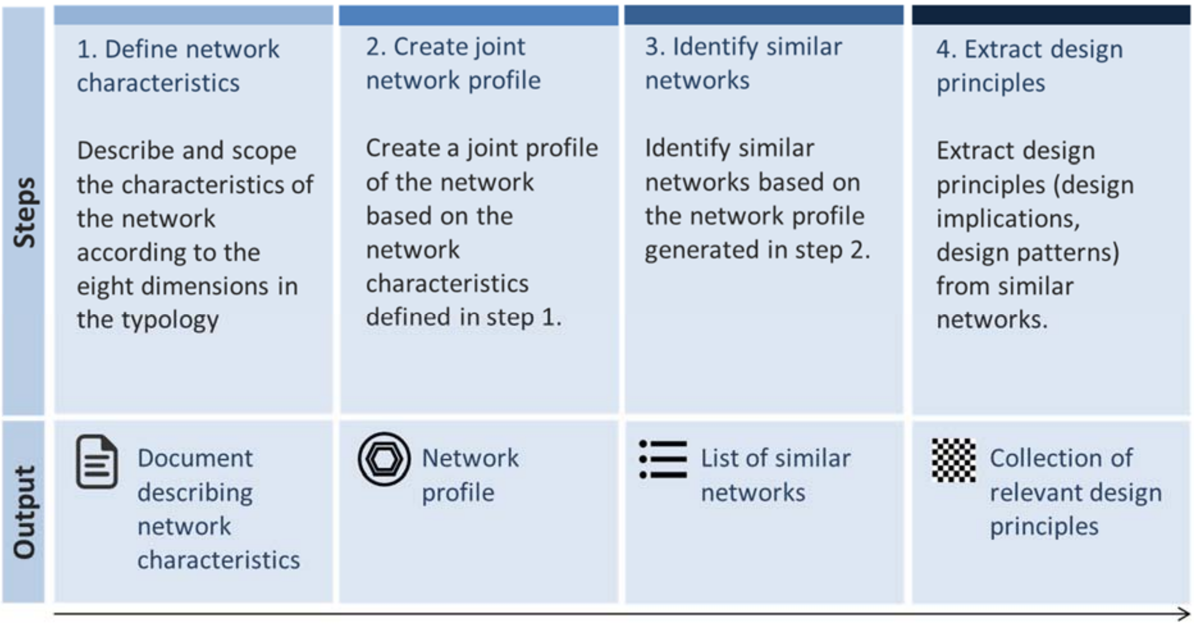

Figure 4: Procedure for HMN profiling

The process of profiling a HMN and identifying relevant design principles should preferably be conducted in an interactive group setting such as a workshop or focus group, where participants are free to discuss and reflect upon the characteristics of the network. Preferably, the group should consist of experts that are involved in the design or implementation of the network, such as designers, developers and other relevant stakeholders. We recommend that a whole day is set aside to complete the four steps in the profiling process. However, it should be emphasized that one might need to repeat the process during the network development process, when new knowledge about the network has been established. Such iterations of the process should always be based on the results from the previous iteration.

5.1.4 Materials to support the profiling process

To support the four steps in the profiling process, we have developed an Excel template that can be used to help document the output of each step. This template consists of five worksheets. The first worksheet (see Figure 5) gives general information about the template, and enables the user to add basic information about the network. The second worksheet (see Figure 6) enables the user to characterize the network according to the eight dimensions in the HUMANE typology, using sliders that make it easy to specify where the network is positioned along the dimension continuum. Because some networks are flexible and can fit under several points on the continuum, it is possible to specify a range in the sliders, by holding the *shift* key while dragging the slider. The third sheet (see Figure 7) creates a visual profile of the network based on the characteristics selected in the previous step. The profile shows how the network relates to the eight dimensions in the typology using a radar chart. In cases where the network is flexible to fit under several points along the continuum of one or more dimensions, there are two axis in the chart, one for the outermost profile (represented by a black line), and one for the innermost profile (represented by a dashed line). The fourth sheet (see Figure 8) provides a table for registering similar networks, while the last sheet (see Figure 9) provides a table for registering relevant design principles. The template is attached to the document, and can be found in Appendix B.

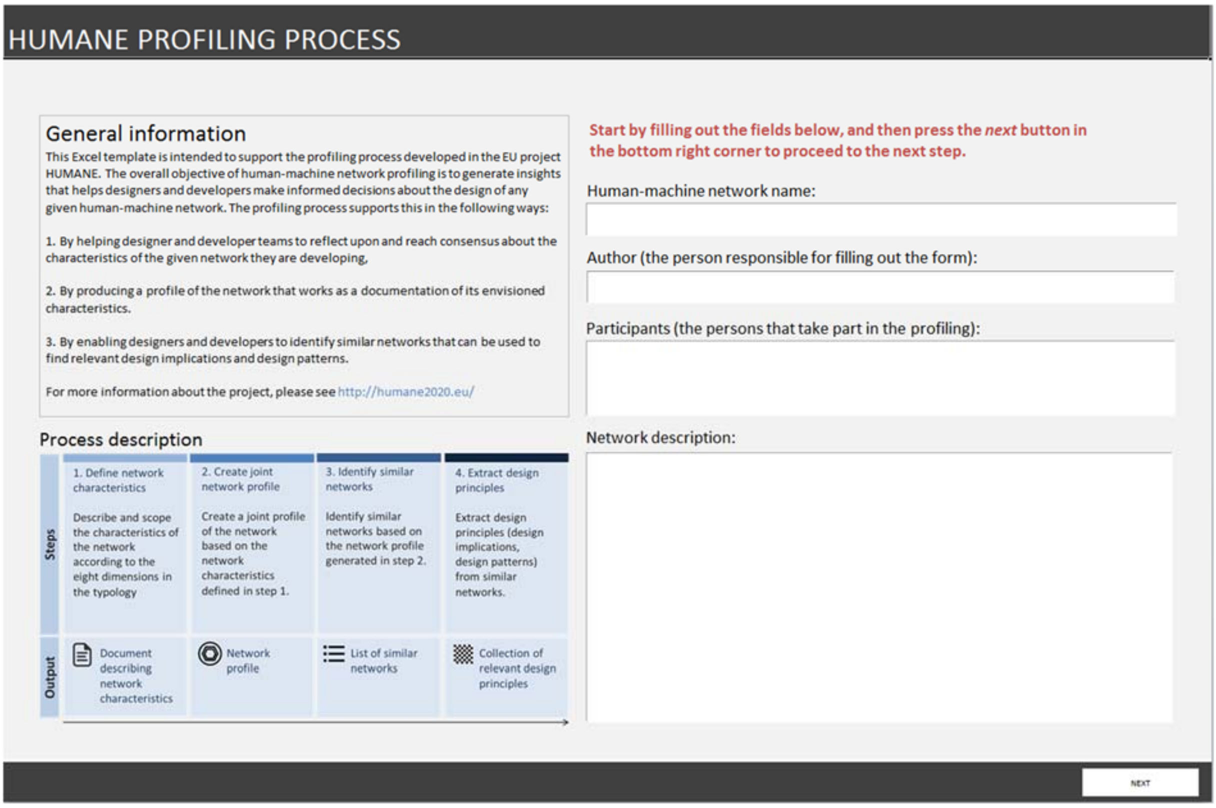

Figure 5: Profiling template: sheet 1

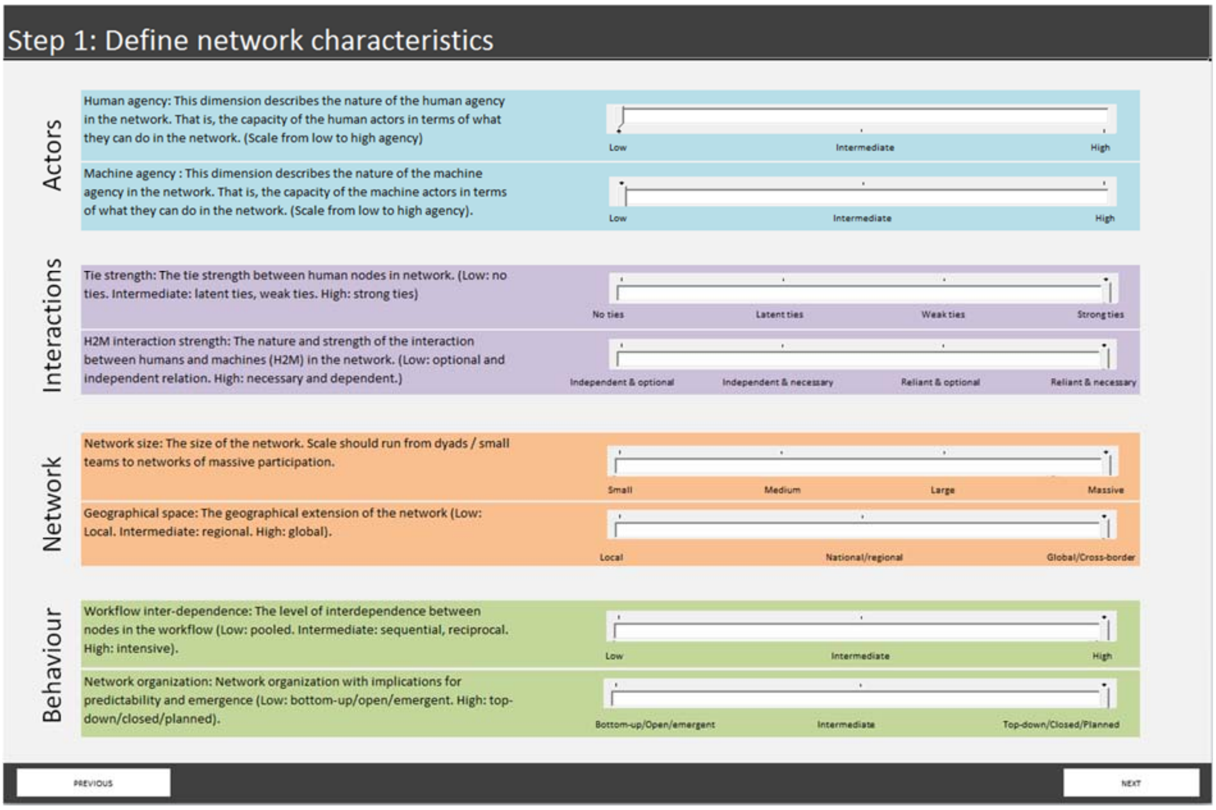

Figure 6: Profiling template: sheet 2

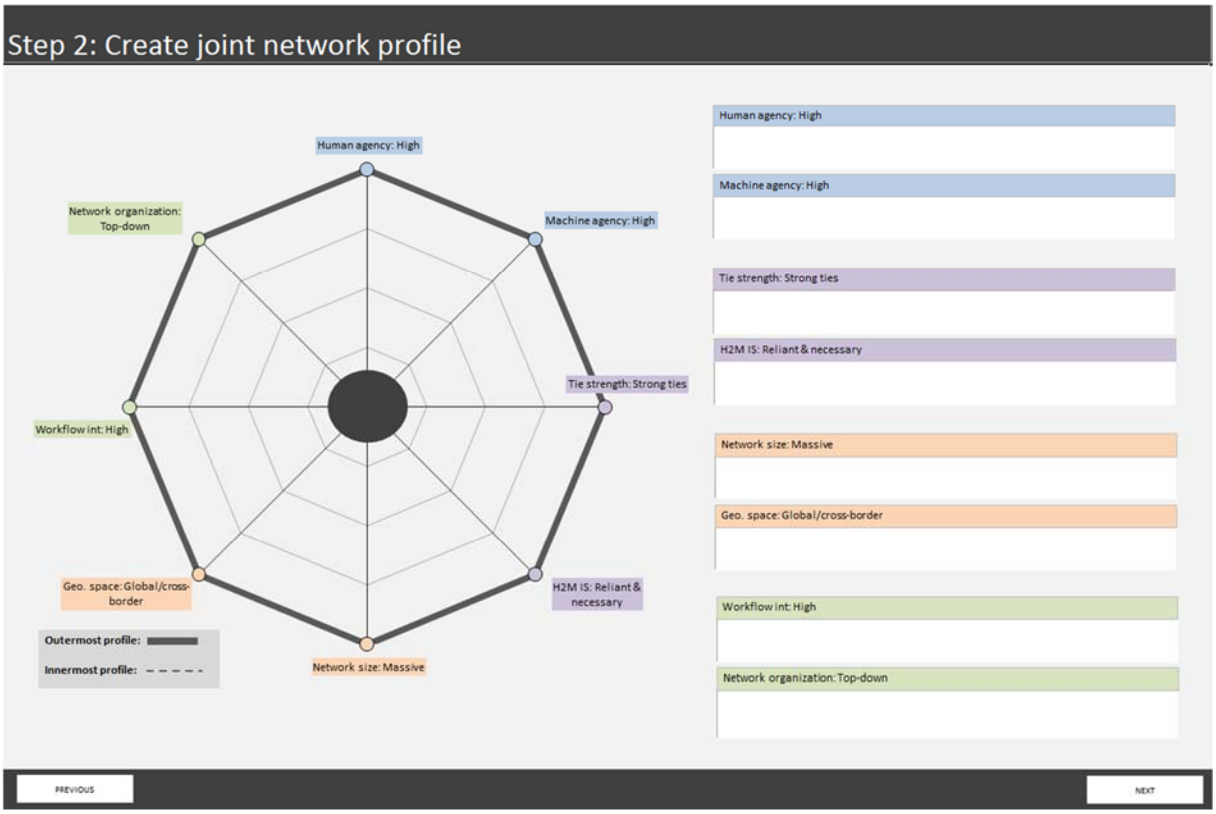

Figure 7: Profiling template: sheet 3

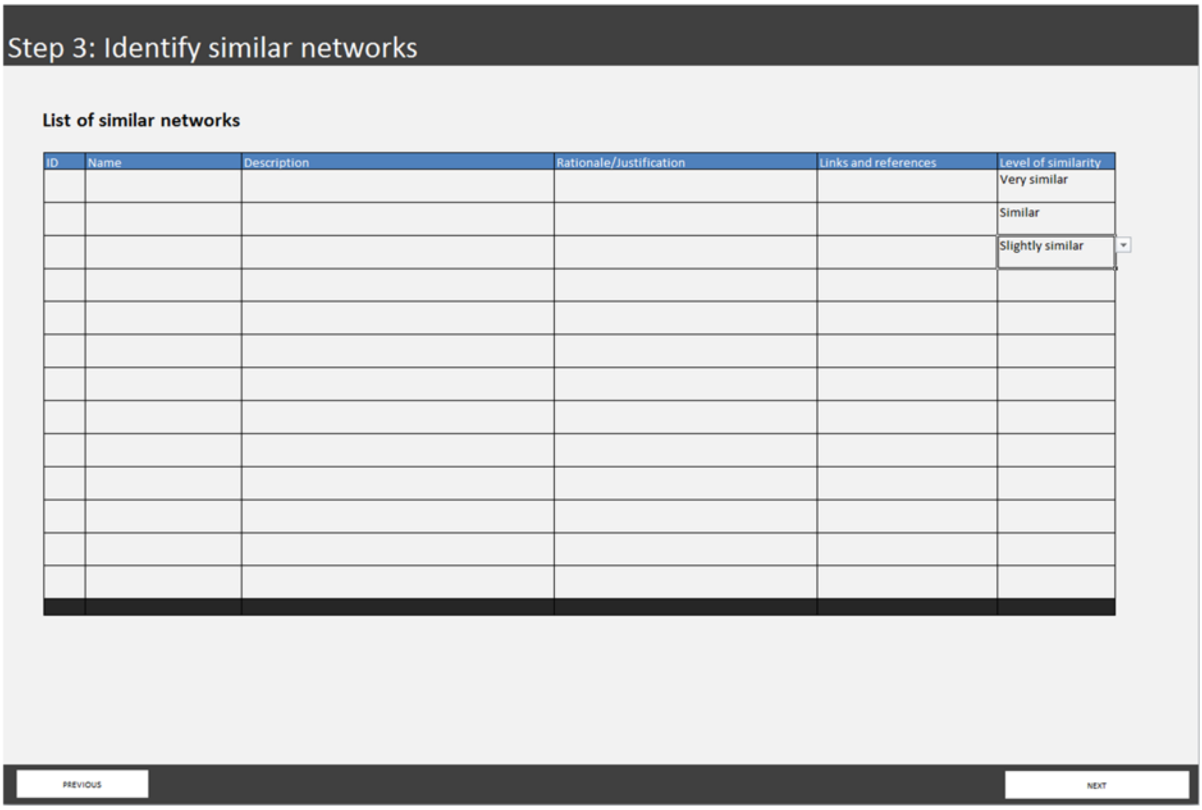

Figure 8: Profiling template: sheet 4

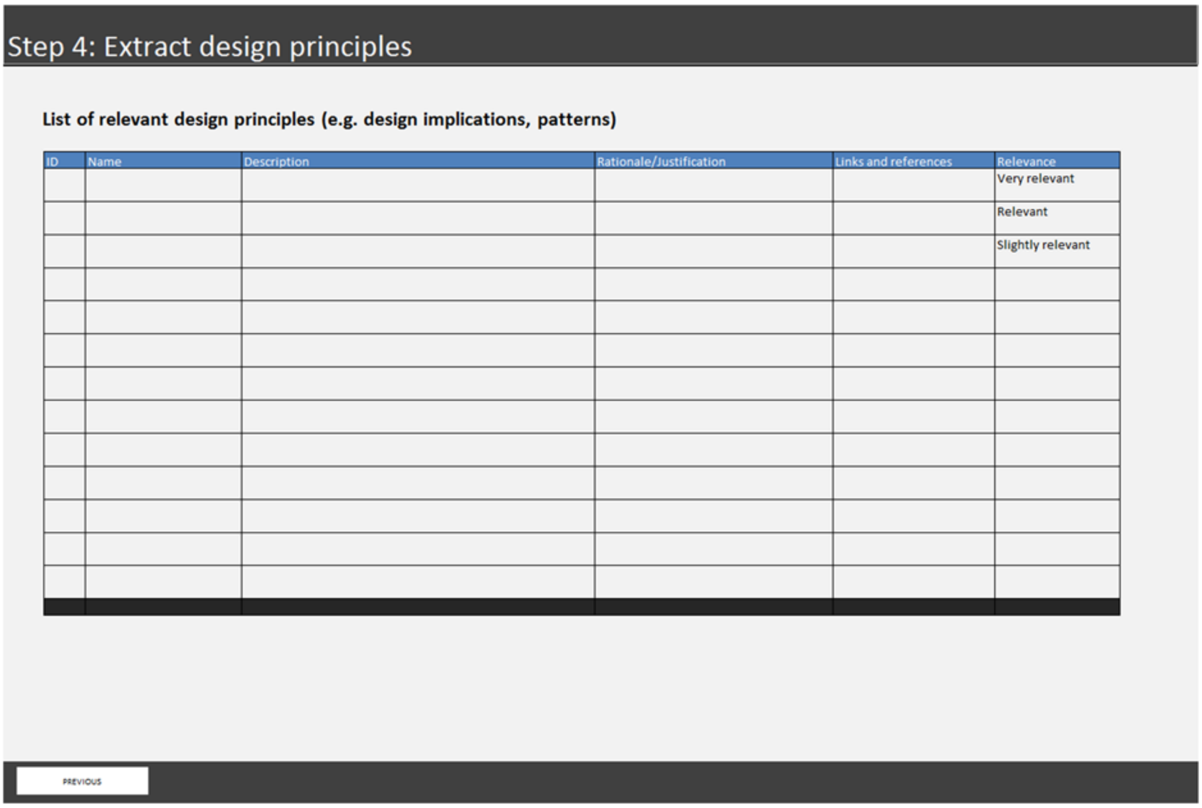

Figure 9: Profiling template: sheet 5

5.2 Initial profiles for each HUMANE case

In this section, we present tentative initial profiles for each of the six HUMANE cases. For each case, provide brief rationale for each dimension. The profiles are intended as vehicles for identifying types based in real-world example HMNs. Hence, a small number of real-world examples that share the profile with the presented cases are provided.

5.2.1 CSI Open innovation

Open innovation platforms are intended to support the innovation process also beyond the first stage of idea-gathering and ideation. By taking advantage of knowledge across networks, innovation processes are expected to speed up and improve, increasing the quality, efficiency and commercial success of service innovation projects. The Center for Service Innovation (CSI) is an open innovation network that aims to increase the quality, efficiency, and commercial success of innovation activities at leading Norwegian service providers and enhance the innovation capabilities of its business and academic partners. The network is organized as a virtual center encompassing four Norwegian research partners, two international research partners and 11 business partners.

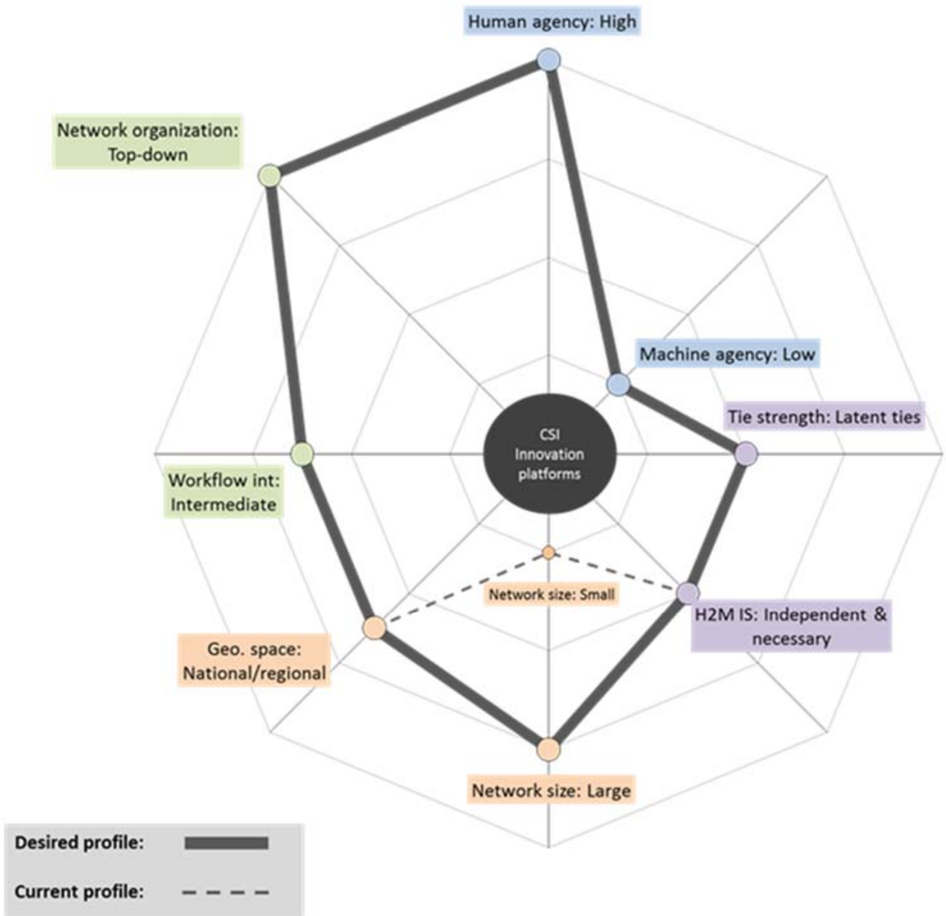

Figure 10: Initial case profiling - CSI open innovation

Human agency (high): In CSI open innovation platforms human actors are encouraged to provide ideas or proposals of a wide variety. Human actors may also read, rate, and add to others contributions. Contributions may be expected to have a specific format or be within a specific are of interest, but the human agents have high degrees of freedom in terms of content and creativity is encouraged.

Machine agency (low): The level of machine agency in CSI open innovation platforms is limited to providing structure for processing contributed ideas or suggestions. Such structure includes, e.g., to notify participants and stakeholders of new or particularly popular or controversial topics, and to submit requests for contributions at predefined times or intervals.

Tie strength (latent): Contributors to CSI open innovation platforms are not required to, and typically do not have existing social relations. The exception to this is when innovation platforms are implemented as inter-organizational tools for idea harvesting. However, contributors with promising ideas may be involved in the subsequent process to refine and develop ideas which may lead to moving beyond weak ties.

H2M interaction strength (fairly low; independent-necessary): Human actors can choose to trust the innovation platform with their ideas or contributions, and then use it as intended, or they can choose to make their contribution through other channels.

Network size (may in initial phases be small, desire large): For CSI innovation platforms to be effective, they require relatively large volumes of ideas and proposals, as well as contributors. Highly successful innovation platforms, with MyStarbucksIdea in a league by itself, may have millions of contributors. An important challenge for CSI open innovation platforms, however, is recruitment of contributors.

Geographical space (regional): CSI innovation platforms typically concern a regional geographical space. The platforms may e.g. be set up as an innovation platform for a national health region, a municipality or a geographically distributed enterprise.

Workflow interdependence (intermediate): Ideas or proposals typically are submitted to CSI innovation platforms in a pooled fashion. However, as soon as an idea or proposal is submitted, this moves into a sequential process for refinement and development including a number of predefined steps.

Network organization (top-down): Being a crowdsourcing solutions where ideas or proposals are submitted and pooled following a specific format, and then processed in a predefined process with explicated roles and responsibilities, the network organization is considered as fairly top-down, through the opportunity for commenting or discussing contributions also among external contributors may allow for some self-organizing.

There are several networks that have similar characteristics as the CSI Open Innovation case (i.e. that align to the eight dimensions in a similar manner as the CSI Innovation case). Below we provide a short description of some of these networks, and why they can be considered similar to this case.

- *Collective intelligence networks:* CSI Innovation platforms are designed to leverage the combined knowledge of multiple human actors to support innovation processes. There are several HMNs that share this quality, for instance by helping groups of humans reach consensus on specific topics by combining their shared effort or intelligence (e.g. Ushahidi, Lumenogic, Kaggle). As with the CSI Open Innovation case, these networks are often high in human agency, organized in a top-down fashion, and intermediate in terms of workflow inter-dependence. Moreover, the human actors in these networks typically hold latent ties.

- *Research and problem-solving networks:* To some extent, CSI Innovation platforms involve a form of collaborative problem solving. There are several HMNs that are designed specifically for this (e.g. Hypios, Innoget, One Billion Minds, and PRESANS), and many of them hold similar characteristics as the CSI case. The most prominent shared characteristics include high levels of human agency, latent ties, and intermediate workflow inter-dependencies. However, there are also some differences worth mentioning, such as network organization, and machine agency, which may vary somewhat from the CSI case.

5.2.2 Conserve and Consume peer-to-peer reselling

Conserve and Consume represents peer-to-peer reselling systems that make use of web-services and apps to enable consumers to bypass the commercial logic of hyperconsumption and instead prolong the lifetime of products by selling and buying previously owned goods online. The basic functions of the website or app in these networks is to serve as an interface and communication channel between sellers and buyers who, in most cases, will not know each other beforehand. The items for sale are the primary focal point, and in these networks the service intermediary should strive for an optimal matching of sellers and buyers based on their shared interest in the items listed for sale.

Human agency (relatively low, service owners want higher human agency): In Conserve and Consume (C2) solutions for peer-to-peer reselling, human actors contribute ads of goods or services for sale or to giveaway. The contributions follow a specific pattern, so though the text and images of the ad is personal, the contributions may be said to follow a pre-defined pattern with relatively little creativity involved. Service providers would, however, like to see more creative ads. In particular, the Norwegian provider Finn has encouraged creativity among its customers.

Machine agency (relatively low): The level of machine agency in C2 solutions is limited to filtering and presentation of contributions according to pre-set configurations.

Tie strength (latent): Contributors to C2 solutions are not required to, and typically do not have existing social relations. However, as users are allowed to follow other users' profiles, one can argue that the ties between human actors are latent, or even weak if interactions between users are repeated.

H2M interaction strength (fairly low; independent-necessary): The interaction strength is independent-necessary because human agents can buy/sell items independently from the network, and make purchases or sell items through other means. Typically however, human actors choose to trust the reselling platform to sell or buy items, and then use it as intended.

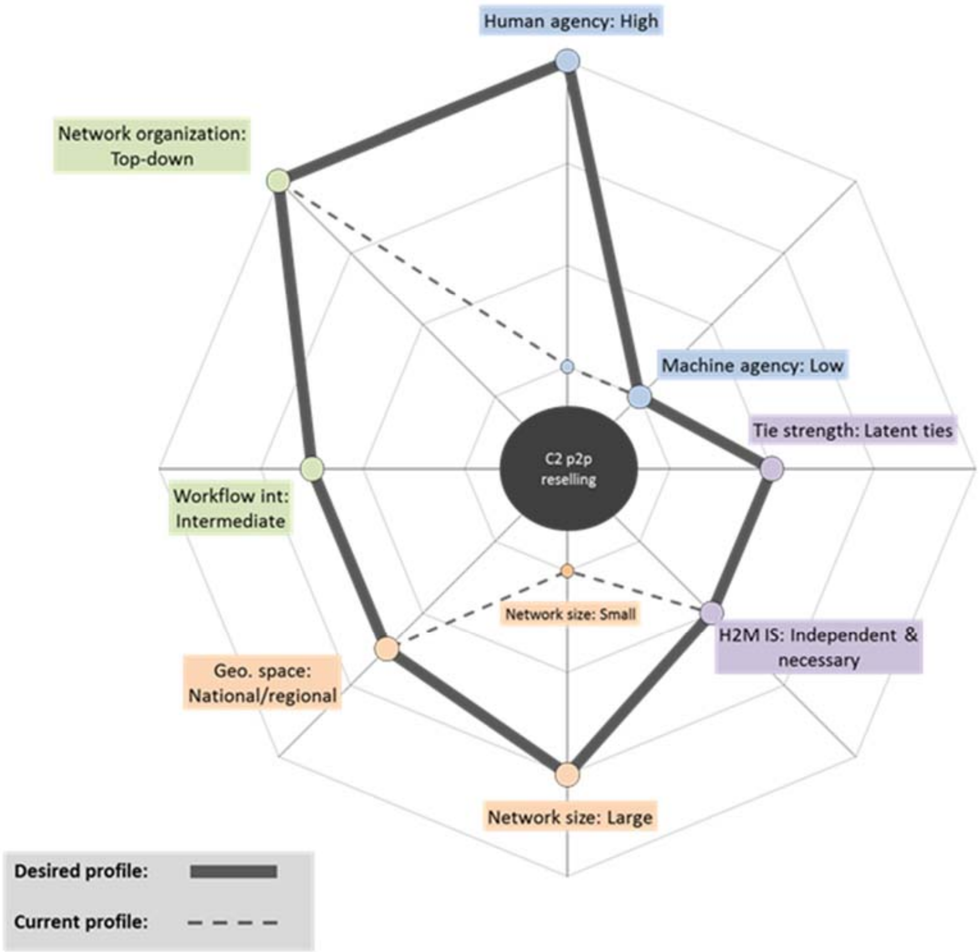

Figure 11: Initial case profiling - C2 peer-to-peer reselling

Network size (start-ups may be relatively small, but often desire to be relatively large): For C2 platforms to be effective in terms of selection and opportunities for sellers to meet buyers, they typically need relatively large volumes of users and ads (unless the purpose is high focused targeting a small by dedicated audience). Highly successful platforms, such as eBay, may have millions of users. An important challenge for new C2 platforms, however, is recruitment of users.

Geographical space (regional): C2 solutions may in principle be global, but most seem to have a national or regional orientation. National orientation may (at least for outside-EU services) be a consequence of customs regulations. Also, some local C2 markets are often seen as bottom-up initiatives at general social networking sites, such as reselling groups at Facebook.

Workflow interdependence (intermediate): Ads are provided independently and pooled. Some sequential process structure is involved in the process of buying and selling as the solutions may provide support for dialogue between users and also for money transfer from buyer to seller.

Network organization (top-down): The network has a high degree of predefined formal structure, where submitted ads need to be placed in predefined categories. Users are not allowed to change the structure of the page, or add new categories. There is therefore limited opportunity for self-organizing. However, there are functionalities for messaging and following user profiles.

There are several networks that have similar characteristics as the C2 peer-to-peer reselling case (i.e. that align to the eight dimensions in a similar manner as this C2 case). Below we provide a short description of some of these networks, and why they can be considered similar to this case.

- *Marketplace and reselling networks:* There are numerous HMNs that support humans in selling, buying or browsing personal artefacts or services (e.g. eBay, Craigslist, Finn). These networks are similar to the C2 peer-to-peer reselling case because they share similar goals, and because they enable individuals to commercially advertise items to other users of the network. The H2M interaction strength in these networks is typically quite low, because the users can choose to make sales or purchases through other means. The human actors in these networks typically hold latent ties because the users of the network are not required to, and typically do not have existing social relations.
- *Retail & e-shopping networks:* These are networks that sell consumer goods or services (e.g. clothes, technology, food, furniture) via online shopping portals (e.g. Amazon, WalMart, Target) typically supported by shopping cart systems. In similarity with the C2 peer-to-peer reselling network, these networks are organized in a top-down manner, and the ties between the human actors are latent or non-existing. Machine agency is typically very low, but the level of human agency might differ somewhat from the C2 case, by sometimes being quite low.
- *Online goods and services networks:* Apart from the above, there are also networks (e.g. Netflix, Adobe creative cloud, ITunes, Steam) that enable selling, buying and exchange of online goods and services (e.g. e-books, software, streaming media). These networks are similar to the C2 peer-to-peer reselling case because they enable human actors to browse and buy goods and services, but represent something different because they focus on intangible artefacts, such as experiences, software, or similar, rather than tangible objects.

5.2.3 REVEAL social media verification

REVEAL aims to advance the necessary technologies for making a higher level analysis of social media possible, thus enabling users to reveal hidden 'modalities' such as reputation, influence or credibility of information. REVEAL provides tools to support journalists in their verification of content and sources in social media. In the REVEAL case study, we will analyse how journalists interact with sources, the public and other journalists, and investigate how they use the tools provided by the project case study for revealing information with respect to social media contributors (source of the information), content (the information itself) and context. The aim is to help journalists make informed decisions with regard to a source trustworthiness and reputation.

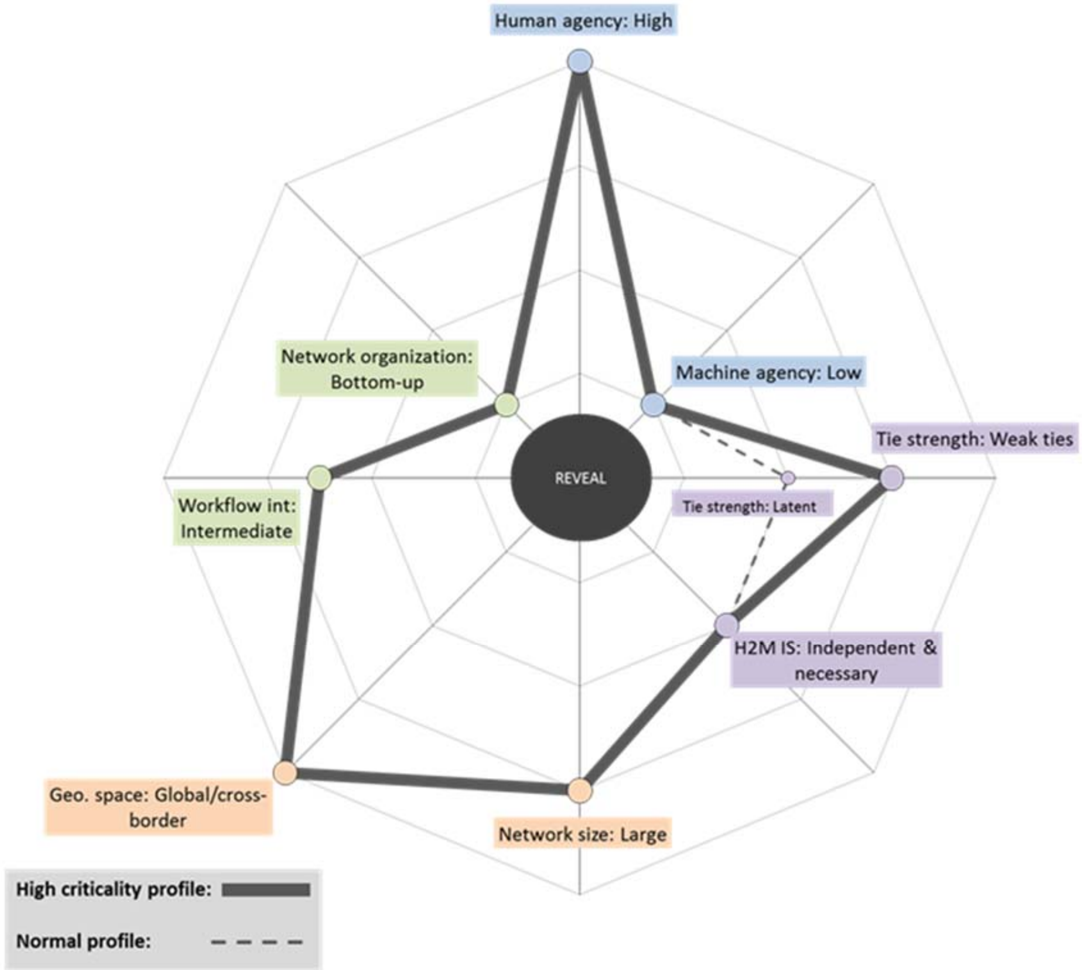

Figure 12: Initial case profiling – REVEAL

Human agency (high): With respect to the degree to which human participants actively engage with the network, in REVEAL we have a high level of engagement. Humans are the main actors responsible for creating sources for any incident, as well as for forming the final audience. In more detail, an incident may include any kind of progress / update in any field of everyday life, (e.g. politics, financial issues etc.) mentioned by any human within a social network. Moreover, the recipients of that information are also humans – any users with profiles in specific social media. Thus, human participants in REVEAL are highly engaged to the network.

Machine agency (relatively low): The degree to which machine elements are expected to be actively engaged to a REVEAL network is significantly lower than the one for human elements. As already stated, the key – actors in such a network are the human nodes. On the other hand, it has to be stated that machine nodes within the REVEAL HMN are responsible for the data aggregation and analysis, in order to reach decisions about the level of trustworthiness of each source. To that end, their role is still critical.

Tie strength (latent or weak): The tie strength between the network's nodes in the REVEAL use case is considered to be between latent or weak. More specifically, the intensity of social interactions among the human nodes in the REVEAL network is not expected to be high, and these interactions are not expected to be characterized by high reciprocation and long duration – on the contrary, these interactions are occasional, event – driven and are not expected to last long. Individuals in the REVEAL network interact less frequently and are less invested in the relationship – therefore the expected ties are weak. Weak ties often connect socially distant individuals who otherwise have few connections in common, and this is also the case in REVEAL. Nevertheless, depending on the criticality level of the incident, the required tie strength may vary.

H2M interaction strength (fairly low; independent-necessary): As already stated, this dimension highlights the degree to which human actors in an HMN have to trust the machine actors, whilst providing some level of flexibility in the dependence level of the relationship. While in the REVEAL use case the issue of trustworthiness is of great importance, nevertheless the trust issues are mainly evident between the human nodes of the network. As far as the human-to-machine interaction strength, human actors can choose to trust the REVEAL platform to verify content, but this is not obligatory in the framework of the network's operation. In other words, human actors may also choose to conduct their own verification in regards to the trustworthiness of a specific source.

Network size (large): The network size is related to the number of nodes comprising a network. In regards to the REVEAL HMN, the network can be characterized as massive. A *massive* network has many millions of nodes and potentially comprises the whole human population. In REVEAL, the sources as well as the end users of the network may consist of hundreds of thousands of people. On the other hand we have to point out that depending on the type of incident the network handles, the size of the network may significantly vary.

Geographical space (Global): A REVEAL network may deal with incidents that interest people all over the world. This means that people all over the world may provide contributions related to such an incident through social networks, comprising a set of contributors / human actors of the network that spans globally. To that end, and with respect to the geographical space, a REVEAL network may operate globally. Nevertheless it has to be taken into account that some parts of the world do not have the ability to be part of such a network.

Workflow interdependence (intermediate): Interdependence reflects the extent to which the human nodes' actions depend on each other; the higher the level of interdependence, the higher the need for coordination. Activities within the REVEAL network are reciprocal in most cases. Each incident triggers specific activities within the network, which lead to journalists taking decisions and evaluating the trustworthiness of each source. For example, a new comment or contribution related to an incident triggers a set of specific actions related to (i) the identification of the source of the contribution, (ii) the investigation of whether that source contributed before for the same incident, (iii) the examination of the current trustworthiness level of the source etc. In other words, the REVEAL network allows for independent contributions but involve partial dependencies, even if they do not require synchronization. To that end, the network is characterized by an *intermediate level of interdependence*.

Network organization (bottom-up): Network organization refers to the level of formal, predefined structure to the network. The REVEAL network is mainly based on a bottom–up approach with respect to its organization. This is justified as, based on what has already been stated regarding that dimension, such an approach corresponds to self-organizing structures which is exactly the case in a REVEAL HMN. The network's operation is triggered from the 'bottom', based on an incident that is published through a channel, and after that the network is organized dynamically according to additional contributions, people interested in the incident etc.

The characteristics presented for the REVEAL network are comparable to other HMNs, such as those presented below.

- *Peer-to-peer file sharing networks*: A network where a file / item is becoming available by a node or a number of nodes, and other nodes become interested in that file, resembles the REVEAL network structure. The size of such a network may be massive, the structure is bottom-up, and issues of trustworthiness also rise.
- *Smart transportation – traffic control*: Smart transportation systems are based on the identification of specific incidents within cities or large territories and data analysis in order to come up with the optimal decisions. The main similarities to the REVEAL network refer to the human and the machine agency, the network's size, as well as the H2M interaction strength.

5.2.4 eVACUATE - evacuation support systems

eVACUATE is an EC FP7 project, which is about getting people out of dangerous situations. 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 Decision Support System 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.

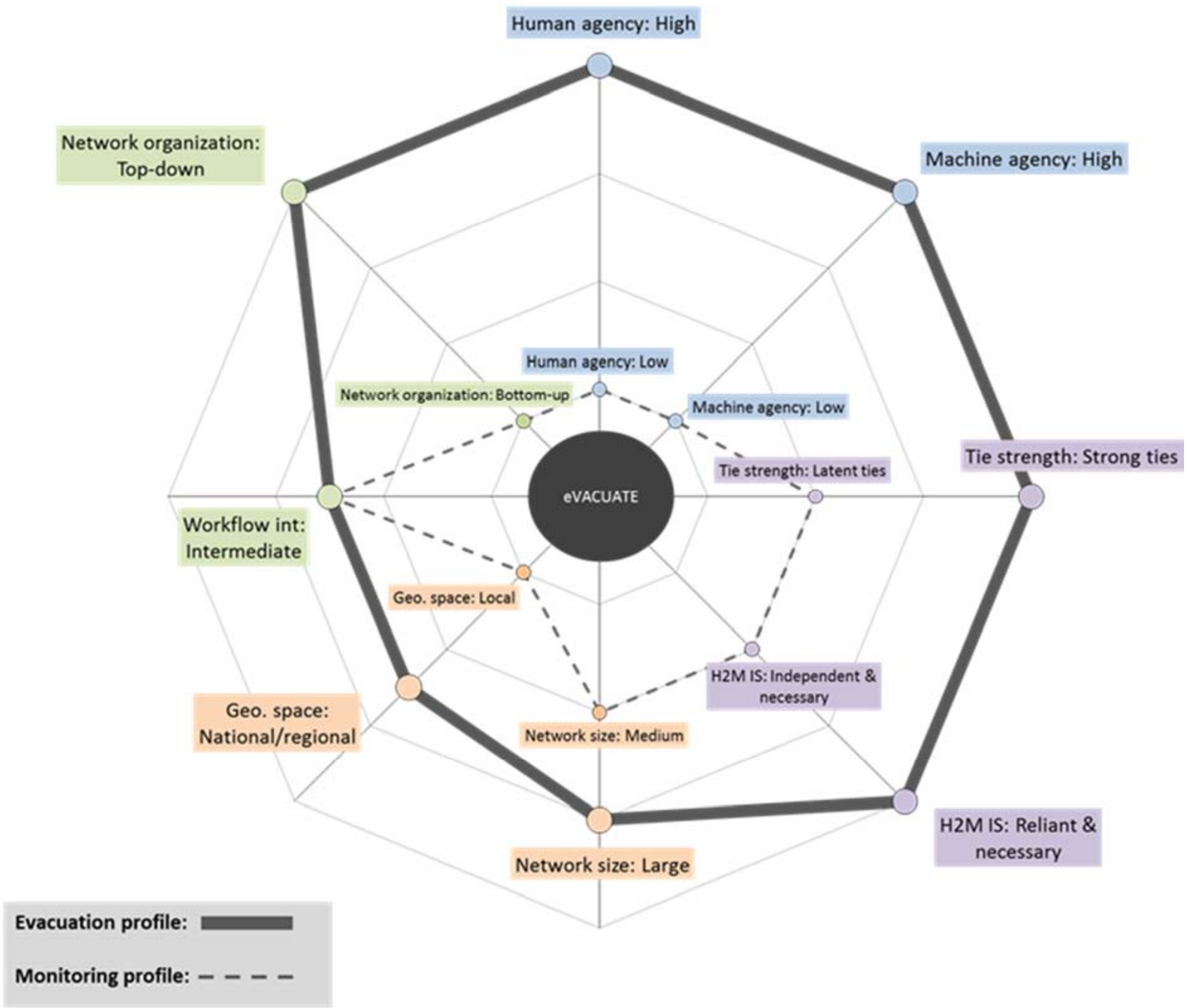

Figure 13: Initial case profiling - eVACUATE

Human agency (Monitoring: low. Evacuation: high): Applies in different ways to eVACUATE participants depending on their role, but also depending on the operational status. *During monitoring:* human agency is very low other than a final, confirmatory overview on operations from staff checking that automatic monitoring does not indicate the need for intervention. *During an emergency:* Human agency is a major factor in evacuation scenarios: operational staffs (and potentially emergency services) have a responsibility for the safe egress of all involved. In some situations (notably the cruise ship) operational staffs are also part of the evacuation itself.

Machine agency (Monitoring: relatively low. Evacuation: high): Ultimate responsibility lies with the operational staff and / or emergency services which restricts machine agency as such, although there is some difference between degrees of autonomy, as well as whether information is requested from or presented to, for instance, the sensors. *During monitoring: Machine agency* remains at a relatively low level during normal operations, with machines doing specific and pre-defined functions. Much of the operation is automated, following rigid procedures. *Machine agency* is probably a little higher than *human agency*, since they remain directly involved in monitoring and collating information. *During an emergency:* machine agency becomes much more significant during actual crises, with more interactive interchanges (asking for specific information, instead of just processing incoming feeds; sending settings and updating parameters; sending content for signage; and so forth. This has two significant outcomes: first, throughput between machines and devices increases along with an increase need for information, increasing load on the connections as well as requiring increased reliability; secondly, collaborative exchanges between the machines and devices will also increase as an attempt is made to validate assumptions made in the decision support system.

Tie strength (Monitoring: latent or weak. Evacuation: strengthening): 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 citizens / potential evacuees, operational staff, or members of the emergency services. Their relationships will change as situations change; further the tie strength is not necessarily bidirectional. *During monitoring:* 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:* 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 13 the value indicated represents an aggregate across all human participant types.

H2M interaction strength (*Monitoring: relatively low. Evacuation: high*): H2M interactions will remain fairly low-key, with *independent-optional* and *independent-reliant* levels for citizens / potential evacuees and for operational staff respectively. 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 high around *reliant-optional*, on the basis that human agents 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.

Network size (Monitoring: relatively small. Evacuation: larger.): This is a difficult dimension to apply specifically for eVACUATE where the human actors may be many thousands, each of whom individually is important to the network and to the overall goal of the network. In general terms, though, the networks tend to be fixed and of moderate size. *During monitoring: Network size* will tend to be finite and include machines and humans specifically tasked with monitoring and the ongoing operation of a given venue. It will also include a highly variable factor: the individuals being monitored. *During an emergency:* In evacuations, the network will remain relatively contained, although there may be some additional elements such as repurposing of sensors and recruitment of other resources (for instance, personal smart devices in a crowd-sourcing setting). Further, the network may become a hybrid with interconnection off to the specialised network(s) of the emergency services. The degree of integration, albeit temporary, would depend on need as well as security.

Geographical space (Monitoring: local. Evacuation: local to regional): The geographical distribution of the networks in eVACUATE tend to be constrained by the venue, though in some emergency cases there may be a temporary functional spillover into neighbouring spaces to manage the consequences of crowds leaving the venue. *During monitoring:* The *geographical space* occupied by the network would be very much constrained by the venue itself: sensors, operational facilities, and so forth will tend to be fixed and in fixed locations. *During an emergency:* in the case of emergency, the network may be extended first to include approaching or co-operating emergency services, but also to the immediate vicinity to ensure the continued safety of evacuees once out of the venue.

Workflow interdependence (Monitoring: sequential. Evacuation: reciprocal): There are some interdependencies between different work activities in the eVACUATE networks. However, the majority tend to be sequential interactions. *During monitoring:* Under normal operations, much of the workflow is sequential, with some interdependencies on data and data feeds for the standard, default decision-making required for monitoring. *During an emergency:* During evacuation, however, the complexity and therefore interdependence of the workflows increase: communication links become critical, confirmatory data may be sought, sensors across multiple areas may become dependent on one another for the information they need to gather.

Network organization (Monitoring: top-down. Evacuation: bottom-up): The complexity of the way that the network is organised will also change in accordance with the specific operation being run at any one time. *During monitoring:* The *organisation* is relatively simple and fixed during standard, monitoring operation. *During emergency:* With collaboration between operational staff, possibly the emergency services and any associated equipment / infrastructure they need, and evacuees themselves, the network will become increasing more disparate and complex in its organisation with both increased specialisation of new nodes, but also repurposing of existing ones.

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 *network lifecycle*, 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 *network lifecycle* is the exception. This is now effectively a short-lived, bespoke configuration in response to the specific requirements of the evacuation. It would be interesting to consider what transformations the network would have to go through to switch from one to the other. Is the transformation uniform across all dimensions? Or are there one or more dimensions which may dictate where the others lie? Further, as *human* and *machine agency* increase to the extreme, are changes in other dimensions, such as *network* *organisation*, *tie strength* and so forth dependent? Will they increase as a consequence or do they increase independently? Clearly, some dimensions such as *geographical size* are subject to other, external factors. Comparing the networks of Section 5.2, we should also consider what the scales associated with the dimensions actually mean: would an extreme value (on the outer edge) for one HMN mean the same as for another, for instance?

Having said all of that, what the spider graph may well show in terms of network design is how to 'design for flexibility' (Clark, Wroclawski, Sollins, & Braden, 2002): the changes in Figure 13 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 *tie strength* for instance. The design implications will be dealt with in more detail in Section 6.3 below.

The characteristics captured in Figure 13 may relate to a number of similar HMNs, and may therefore be considered as a representation of such networks.

- *Health and social care monitoring*: the switch between default operations monitoring activity or behaviour to a situation where intervention may be required may typically involve similar network profiles as those represented above. This would relate to in-house hospital monitoring in intensive care units, for instance, as well as ambient home living for vulnerable members of the population, such as the elderly.
- *Immigration*: border points would normally require only low-level monitoring as travellers and returning citizens pass in and out of the country. However, there may a need for increased vigilance as a result of significant numbers of refugees, or criminal activities.
- *Transport networks:* under normal circumstances, traffic will move steadily. Monitoring is essentially only to check that events are as expected. In case of any incident, such as an accident or other interruption to flow (a breakdown or shed load), or even some major incident (fire, flood etc.) then diversions may become necessary as well as managing any backlog of vehicles and passengers directly affected by any such incident, and the introduction of emergency services to handle and recover the situation.

Effectively, any monitoring system, but especially those involving an unpredictable human element, and waiting to identify any critical incident requiring direct intervention and management, often time constrained, would also match this overall profile.

5.2.5 Wikipedia

Wikipedia is a free online encyclopedia edited by volunteers from all around the world. Wikipedia has achieved enormous success within the 15 years of its life. With more than 36 million articles in 290 different language editions, Wikipedia has become by now the number one general work of reference in everyday practice. However, the phenomenon of collaborative work in Wikipedia is still a big puzzle: How can an encyclopedia be reliable if anyone can edit it? The bon mot of Wikipedians is not a satisfactory answer, namely that: "It works only in practice. In theory, it can never work."

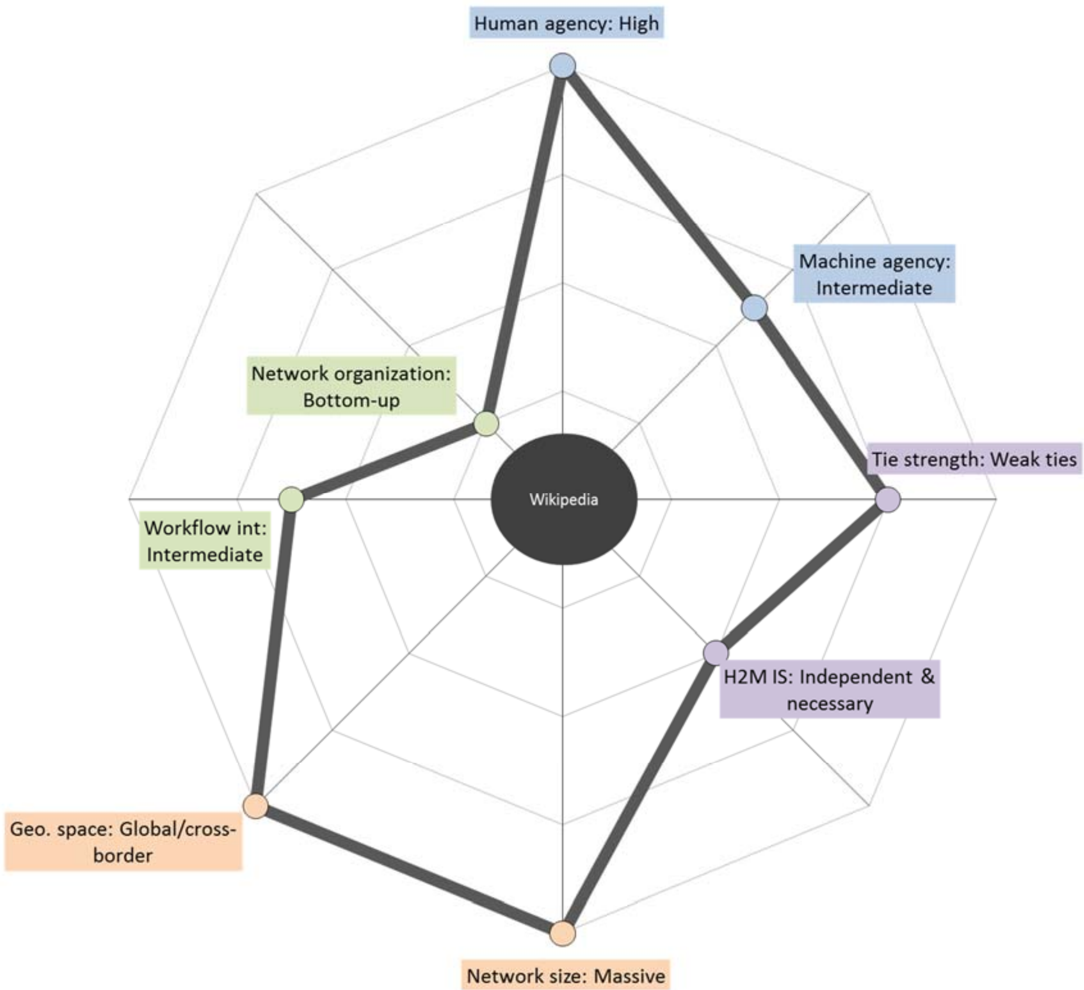

Figure 14: Initial case profiling – Wikipedia

Human agency (high): Wikipedia has a system relying on open contribution for human nodes, but these human actors take on a variety of different roles. Most users are able to perform different types of activities such as edits, reverts, multimedia upload, etc. More specifically, in a study carried out by Wikimedia foundation in 2011, fifteen types of editors' activities were identified. On top of that, a small proportion of Wikipedia's editors have also special permissions (up to 19 additional special permissions).[3] Furthermore, the activities of a given editor may vary and are not predictable.

Machine agency (fairly high): Machine nodes in Wikipedia can modify content. The content is restricted and controlled by autonomous computer programmes, called "bots". The bots are carefully programmed for a variety of different tasks, including writing articles (Nasaw, 2012), all of which aim to keep order within the online encyclopaedia.

Tie strength (weak ties): In Wikipedia, the interaction among editors, although important and essential to some extent, is characterised by weak ties. Editors have numerous ways of reaching

[3] https://en.wikipedia.org/wiki/Wikipedia:Wikipedians

other editors. The ease with which interactions occur is key to a better editing experience. In a study carried out by Wikimedia foundation in 2011 about its editors, fifteen different available interactions were identified.[4]

H2M interaction strength (fairly low; independent-necessary): Machine actors, such as bots, perform a useful function on Wikipedia by detecting vandalism, fixing grammar and spelling mistakes, cross-linking articles, and checking links, among others. Bots can make changes to the content but human actors can override them.

Network size (massive): Wikipedia's network of editors and bots is massive. Wikipedia faces an ever-growing network of editors. The number of active editors may vary with time but it is still significantly large. For example, in September 2015, the English Wikipedia has around 31K active users (users with >5 edits) and more than 26M total users[5]. Since we are not focusing on activity level, we classify the network size of Wikipedia as massive.

Geographical space (global): Wikipedia is definitely global although still very western-centric. As part of Wikipedia's efforts towards increasing its global footprint, there is a commitment to supporting less mature language projects and ensuring quality articles in native languages, especially in the Global South. Wikipedia is the most popular and premier destination for information and knowledge on the Web in over 250 languages.

Workflow interdependence (intermediate): Wikipedia editors can contribute independently, but *de facto* they collaborate with humans and machines to produce the content. Although reciprocal workflow is the general form of collaboration on Wikipedia, leadership and editors' interactions become critical for the effectiveness of the site. Controversial issues generally require more collaboration than do articles on neutral topics.

Network organization (bottom-up): Wikipedia has a bottom-up organization. Wikipedia is considered as an extreme form of a self-organized system. The contributions of many editors are linked, sometimes at many levels, until a complete top-level output (i.e., encyclopaedia) is formed. One could expect that this bottom-up approach, with the absence of top-down organisational control, would lead to a chaos, but this seems not to be the case (Spek, Postma, & Herik, 2006).

The above characteristics of the Wikipedia network are shared also by other HMNs. On the basis of such similarities, knowledge and experiences from Wikipedia may also be of relevance for these other HMNs and vice versa.

- *Co-design networks:* Wikipedia holds an inherent similarity to networks that supports co-design (e.g. OpenStreetMap, eYeka, 99Designs, and Guerra Creativa), because of its ability to support large-scale collaborative content creation, and consensus reaching. These networks typically are high in human agency, intermediate in machine agency, intermediate in workflow inter-dependence, and weak in terms of human tie strength.

[4] https://upload.wikimedia.org/wikipedia/commons/7/76/Editor_Survey_Report_-_April_2011.pdf
[5] http://stats.wikimedia.org/EN/ReportCardTopWikis.htm

- *Open-Source software*: Large-scale open-source software projects exhibit a similar profile as Wikipedia, with high human agency, intermediate workflow interdependence, weak ties, and bottom-up network organization. Prominent examples of open-source software projects include the Linux operating system, the Firefox web browser, and the Python programming language. Open Source repository hosting services such as GitHub is also relevant here, as a system that enables human actors to take part in open source development by supporting distributed revision control and source code management across a wide number of users.

5.2.6 Zooniverse

Zooniverse is a citizen science web portal owned and operated by the Citizen Science Alliance. Zooniverse projects involve volunteers from all around the world who help scientific projects by performing numerous simple tasks, mostly categorization. Zooniverse is known to be the Internet's largest citizen science project. The total value of contributions to the projects estimated in comparison with Amazon Mechanical Turk is $1.5 million (Sauermann & Franzoni, 2015). Some of the Zooniverse projects have led to ground-breaking scientific discoveries.

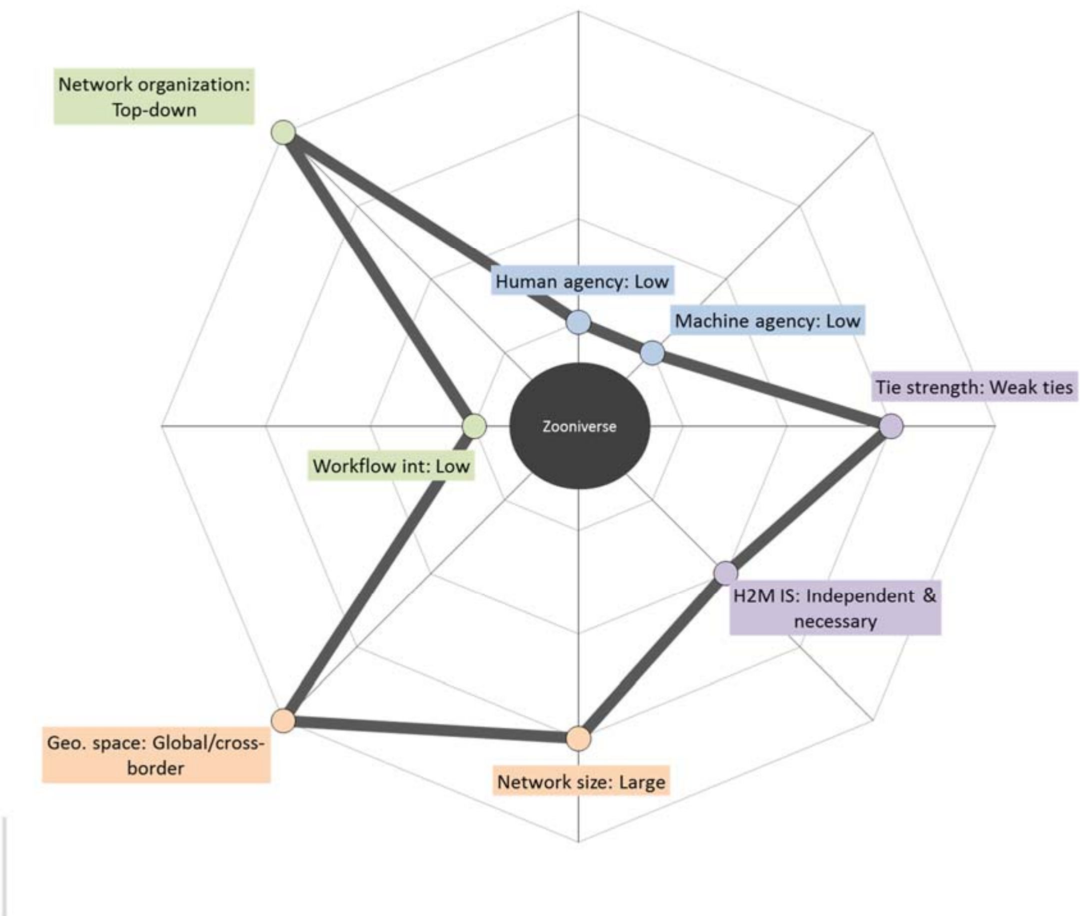

Figure 15: Initial case profiling – Zooniverse

Human agency (low): The human nodes in Zooniverse are known as citizen scientists or volunteers. The project managers predefine the contributions. On the one hand, Zooniverse lets everyone take part in the research projects from many fields across the sciences, humanities, and more. Most users are able to perform different types of activities on different research projects by answering the tasks given to them. On the other hand, 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. Once there is enough data about tasks and workers, the crowdsourcing system might give easy tasks to novice workers and route difficult problems to experts. At the moment, we are not aware if any task routing routines are implemented in the system.

Tie strength (weak ties): 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. For example, Talk, an online discussion tool used for all projects to provide a real-time interface for volunteers and coordinators, facilitates the rapid discovery of important features. Nevertheless, the interactions are still limited if compared to other popular social networks.

H2M interaction strength (fairly low; independent-necessary): 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 (large): Zooniverse has a large network size. Zooniverse faces an ever-growing network because new volunteers join every day. As of 2015, Zooniverse has 1.3M registered volunteers[6].

Geographical space (global): Global as Zooniverse is open to volunteers from all around the world.

Workflow interdependence (low): In Zooniverse, the workflow interdependence is 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 (top-down): 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.

The Zooniverse profile characteristics are shared also by other HMNs. On the basis of such similarities, knowledge and experiences from Zooniverse may also be of relevance for these other HMNs and vice versa.

- *Crowdsourcing networks:* Most crowdsourcing systems have similar profiles to Zooniverse. For example, the microwork platforms Amazon Mechanical Turk and CrowdFlower also rely on low human and machine agency, low workflow interdependence, and top-down network organization. However, these platforms do not usually allow for social ties (perhaps latent

[6] http://irevolution.net/2013/03/26/zooniverse-big-crisis-data/

social ties in some cases). In addition, they use monetary incentives to motivate participation, while Zooniverse relies on participants' intrinsic and social motivation.

- *Volunteer computing networks:* This is a type of distributed computing where computer owners donate their computing resources to one or more projects or similar. Such networks, (e.g. BOINC, Xgrid, Grid MP), though not crowdsourcing networks, do share some key characteristics with Zooniverse; in particular, in terms of their top-down organization, low degrees of workflow inter-dependence, and low levels of human- and machine agency.
- *Search engines:* Google and other search engines also share some similar profile characteristics with Zooniverse. In particular, they are organized in a top-down manner, provides limited agency for both humans and machines, have global coverage, and a massive amount of users. Such similarities may provide a basis for transfer of knowledge and experiences from the Zooniverse case to search engine HMNs and vice versa.

5.3 Types from profiles

HMNs encompass an ever-growing variety of systems. Some of these systems are designed for specific purposes, while others are more generic in their nature. Due to the vast variety of HMNs out there, and the fact that these networks often intertwine and interact with each other, it is a very challenging task to classify HMNs into logical categories or types. Moreover, due to the rapid developments in the area of ICT, it is likely that any form of high-granularity classification would be outdated very quickly, as new types of HMNs are introduced.

Profiling of HMNs may help support the definition of HMN types because it enables comparison of different networks in terms of how they are characterized along the eight dimensions in the HUMANE typology. For example, this can enable identification of similar networks by looking for patterns in their characteristics. Groups of similar networks can thereafter be formalized into HMN types. However, making efficient use of profiling to identify key HMN types requires access to a large number of HMN profiles, and, preferably, computerized support to identify patterns in the profiles.

In this section, we introduce an initial high-level classification of HMNs based on an informal analysis of the HMN profiles of the six case networks (see Section 5.2), and an additional 10 networks that were selected by the authors to demonstrate a range of variation. For each network, we created a HMN profile describing how the network aligns on the eight dimensions in the HUMANE typology (see Table 6). The profiles were generated based on our own understanding of the networks under discussions. Thereafter, we looked for differences and similarities in the characteristics of the 16 networks, trying to find groups of similar networks. A main criteria for regarding networks as similar were that their characteristics were the same for multiple dimensions in the typology. The overall purposes of the networks were also taken into account to help facilitate this process.

Based on this informal analysis, we identified four high-level HMN types, as listed below:

1. HMNs for content production and sharing
2. HMNs for problem-solving
3. HMNs for socially-oriented activities
4. HMNs for e-commerce and advertising

The identified key HMN types represent a very high level of abstraction, and might therefore be of limited usefulness for designers or developers of HMNs. Identification of more concrete HMN types with a higher level of granularity requires a larger and more varied set of HMN profiles. Moreover, it would require a more sophisticated analysis of network similarities using statistical models.

Based on our initial experiences with using HMN profiles to define HMN types, we find that some networks are difficult to place in one category only. This observation underlines the complex, dynamic and intertwined nature of many HMNs, and pinpoints the challenge of defining mutually exclusive HMN types, even when working on the level of abstract, general HMN types. Nevertheless, we see the four identified HMN types forms a good starting point for continuing the identification of key HMN types in the next version of the HUMANE typology.

In the following sections we describe each of the four HMN types in detail.

Table 6: Initial profiling and comparison of HMNs to extract HMN types

Network type	HMN	Human agency	Machine agency	Tie strength	H2M interaction strength	Network size	Geographical space	Workflow inter-dependence	Network organization
HMNs for content production and sharing	**YouTube**	High	Low	Latent	Independent/necessary	Massive	Global	Low	Bottom-up
	Wikipedia	High	Intermediate	Weak	Independent/necessary	Massive	Global	Intermediate	Bottom-up
	CSI Innovation platforms	High	Low	Latent	Independent/necessary	Large	Regional	Intermediate	Top-down
	GitHub	High	High	Weak	Independent/necessary	Massive	Global	Intermediate	Bottom-up
HMNs for problem-solving	**Zooniverse**	Low	Low	Weak	Independent/necessary	Large	Global	Low	Top-down
	REVEAL	High	Low	Weak	Independent/necessary	Large	Global	Intermediate	Bottom-up
	eVACUATE	High	High	Weak	Reliant/necessary	Medium	Regional	Intermediate	Bottom-up
	Stack Overflow	High	Low	Weak	Reliant/optional	Massive	Global	Intermediate	Bottom-up
HMNs for socially-oriented activities	**Facebook**	High	Low	Strong	Independent/optional	Massive	Global	High	Bottom-up
	Second life	Very high	Low	Strong	Independent/optional	Large	Cross-border	High	Bottom-up
	EVE Online	Very high	High	Strong	Independent/optional	Massive	Global	High	Bottom-up
	Tinder	High	Low	Weak	Independent/necessary	Massive	Global	Intermediate	Bottom-up
HMNs for e-commerce and advertising	**Craigslist**	Low	Low	Latent	Independent/necessary	Massive	Global	Intermediate	Top-down
	Conserve and consume	Low	Low	Latent	Independent/necessary	Medium	Regional	Intermediate	Top-down
	Amazon	Low	Low	No ties	Independent/optional	Massive	Global	Intermediate	Top-down
	Online banking	Low	Low	No ties	Reliant/optional	Large	Country	Intermediate	Top-down

5.3.1 HMNs for content production or sharing

Type 2 - HMNs for content production and sharing: *Any HMN that aims to help humans create, access, share or exchange content (e.g. articles, videos, images, software).*

Several HMNs are designed to facilitate creation or sharing of content, for example in the form of articles, software, ideas, art, and other media. Wikipedia and CSI Open Innovation are examples of such networks from the cases addressed in the project. Wikipedia is a free and open encyclopedia that relies on users from all over the world to contribute and edit content that is made freely available online. In the CSI open innovation network, human actors are encouraged to provide ideas or proposals of a wide variety. Human actors may also read, rate, and add to others contributions. Contributions may be expected to have a specific format or be within a specific are of interest, but the human agents have high degrees of freedom in terms of content and creativity is encouraged.

Examples of successful networks that support content creation or sharing include YouTube, Spotify, DeviantArt, online newspapers, BitTorrent, and GitHub. It is important to highlight that not all of these networks actively supports the creation of content. Often, the networks only enable the users to share content that they have already produced, or that they otherwise have access to. This is for example the case for YouTube, DeviantArt and BitTorrent. GitHub and Wikipedia however are examples of networks that facilitate both creation and sharing of content. In these networks, machines play an important role in the content creation process, either by merging content contributed by different users, or by validating the content produced by human actors.

Generally speaking, this type of network is characterized by being organized in a bottom-up fashion where the content and structure of the network is shaped by the individual contributions and actions of each user. Users are typically given a large degree of freedom to share content, rate and comment on the content of others, create new communities within the network, and so forth. Consequently, this network type is also characterized by providing its human actors with a high degree of agency, where users can freely interact with other actors in the HMN, form groups with other actors, communicate in heterogeneous and open ways, and exercise personal, proxy and collective agency. The agency of machine actors in this type of network is typically limited to detecting and correcting acts of vandalism performed by human actors. This can for instance be observed in Wikipedia, where artificial intelligence bots play a crucial role in repairing erroneous content.

In this type of network, users often make their contributions individually, without being contingent or dependent on other user's contributions. However, there are several cases of networks where multiple users collaborate to produce content. This can for instance be observed in collaborative authoring networks such as OpenStreetMap and Wikipedia. Due to this, it is difficult to characterize this type of network in terms of workflow interdependence.

Social interaction forms an inherent part of many networks for content production and sharing. However, the social aspect is typically implemented as a means to discuss or improve the content of the network. The ties between the human actors are usually latent or weak.

5.3.2 HMNs for problem-solving

Type 1 - HMNs for problem-solving: *Any HMN that aims to solve or help solve real-life problems or challenges (e.g. decision-support systems, optimization, Q&A systems).*

A large number of HMNs are built specifically to support problem-solving of some form. The common denominator for these systems is that they are built specifically for finding solutions to real-life problems or challenges. Examples of such networks from the case networks studied within the HUMANE project include eVACUATE, REVEAL, and Zooniverse. The eVACUATE network supports problem solving by helping humans make informed decisions during emergency situations. REVEAL helps journalists verify and determine the trustworthiness of social media. Zooniverse is designed to help solve research challenges by enabling anyone to participate in and contribute to the analysis of large data sets.

Other successful and well-known examples of networks that are designed to facilitate problem-solving include air traffic management systems, emergency management systems, public resource computing systems, Q&A platforms, and systems for organizing and allocating resources. These networks can range from only supporting solving of specific problems (e.g. scheduling of human resources via Doodle), to supporting solving of a broad spectrum of problems/challenges (e.g. Q&A in Stack overflow). The problem solving in these networks are sometimes handled mainly by the machine actors (e.g. public resource computing solving mathematical problems), sometimes by the humans (e.g. Stack overflow), and sometimes by a combined effort between the two (e.g. seen in information systems for crisis management).

HMNs for problem-solving are often organized in a bottom-up manner (although there are some exceptions e.g. Zooniverse). The problems that are going to be solved by the network are defined, structured and resolved in a collaborative effort by the actors participating in the network. Another shared characteristic is that the human actors in these networks are connected by weak ties. Usually, the actors can interact with each other but their interactions are often sporadic and cursory. Moreover, interactions are most often conducted publicly, for example, by ranking and commenting on another user's post or contribution.

The networks of this type may differ greatly when it comes to network size, geographical distribution, and the level of agency for both humans and machines. For instance, some networks such as Zooniverse allow people from all over the world to participate as users in the network, while other networks, such as local decision-support systems, often only involves users from a specific company, region or country. Similarly, some networks involves millions of users (e.g. Stack overflow), while others only involve a very limited amount of users (e.g. decision-support tools for routing of aircraft on an airport). As the networks differ with respect to whether it is the humans, the machines, or both that supports the actual solving of the problems, agency will vary greatly across networks.

Means for social interaction are provided in many of the networks within this category, but the interactions are mainly implemented as means to help solve the problems or challenges addressed by the network, and not specifically to facilitate social bonding and relationships.

5.3.3 HMNs for socially-oriented activities

Type 3 - HMNs for social networking: *Any HMN that aims to support social activities between human actors (e.g. friends, family, colleagues).*

There is a broad range of HMNs dedicated to supporting socially-oriented activities. A main quality of these networks is their ability to facilitate social interactions between human actors in the network. For instance there is a wide variety of HMNs for building social networks or social relations among human actors (i.e. persons, organizations) who share similar interests, activities, backgrounds or face-to-face connections. Albeit not represented specifically within the case networks in the HUMANE project, there are multiple well-known examples of such networks, such as Facebook, Twitter, Tinder, Snapchat, LinkedIn, and Instagram. Typically, these HMNs consist of a representation of each user (often a profile), his or her social links, and a variety of additional services/functionality to interact with other human actors in his or her network.

Virtual worlds and multiplayer games represent another form of socially-oriented HMNs. These HMNs consist of computer-based simulated environments populated by human actors using personal avatars, and (in some cases) machine actors represented by computer-generated avatars. The actors can simultaneously and independently explore the virtual environment and interact with each other. Examples of such networks include Second Life, World of Warcraft, and EVE online. The case HMNs in HUMANE do not include virtual worlds or multiplayer games.

The common denominator for networks of this type is the relatively strong ties between the human actors that participate in the network, and the high level of human agency. Typically, individuals' interactions in these networks are mutual, repeat over time, and involve a high throughput of information. Users are able to freely interact with other actors, form social groups with other actors, communicate in heterogeneous and open ways, and exercise personal, proxy and collective agency. Another common characteristic of such networks is that most of them are organized in a bottom-up manner, where the social relations are formed through dyadic ties between human actors that are established and controlled by the users themselves. Furthermore, these networks often allow, and are designed for near real-time interactions, thus making them high in workflow interdependence.

It should be noted that these networks may include different types of human and machine actors. For instance, there will be producers and consumers of content or output, customers and clients, service providers, lurkers, trolls, and many others. More than one type of human actor is therefore possible in any given socially-oriented network. Machine actors will tend to be confined to simple clients and servers, and bots that detect and corrects vandalism in the network. However, in certain virtual world HMNs, machines may also play an active social role in the network using computer-generated avatars.

5.3.4 HMNs for e-commerce and advertising

Type 4 - HMNs for e-commerce: *Any HMN that aims to facilitate trading of products, services, money or other artifacts, or advertising of products or services.*

The last type of HMNs that we have identified represents networks that facilitate trading in products, services, money, stocks, or advertising of products or services. There is a multitude of networks that are designed for this purpose, such as online banking systems, peer-to-peer reselling, online retail, pre-tail, marketplaces, and brokers. Electronic commerce draws on technologies such as mobile commerce, electronic funds transfer, supply chain management, Internet marketing, and online transaction processing.

Among the case networks studied in the project, Conserve and Consume represents an e-commerce network for peer-to-peer reselling. In this network, human actors contribute ads of goods or services for sale or give-away. Other successful and well-known examples of networks that reside in this category include Amazon, eBay, Taobao, StockTrader, and Craigslist. Although several of these networks support processing of financial transactions, this is not necessarily required to fit into this category. In fact, there are several networks that do not support such transactions, but merely provides functionality such as classified advertising. This is typical for open networks that enable anyone to advertise for products or services, such as Craigslist or Finn.no.

Typically, e-commerce HMNs are characterized by an intermediate workflow-interdependence between the actors in the network. This can for instance be observed in online markets where orders placed by a customer are processed through a number of actors, banking systems where transactions are verified and processed by other actors, and peer-to-peer reselling systems where the workflow will go back and forth between seller and buyer. Moreover, these networks are usually organized in a top-down manner, provide a low degree of machine agency, and low interaction strength (i.e. either independent-reliant or independent-necessary) between humans and machines (i.e. human actors can choose to trust the e-commerce platform to e.g. sell or buy items, or to make sales or purchase through other means). The human agency is in these networks is usually quite low (i.e. human actors are only able to perform few, homogeneous, closed, activities.

Ties between human actors in e-commerce networks are usually non-existent or latent. For example, the online market Craigslist allows individuals to post short advertisements. Apart from responding to particular advertisements, users cannot interact with others by commenting on their postings. Nevertheless, viewing others' contributions is a latent form of social interactions that affects one's experience and sense of community.

At the same time there are also several aspects that vary greatly across e-commerce networks. For instance, the networks differ when it comes to characteristics such as network size, and geographical space (i.e. there are several global retail networks (e.g. Amazon, eBay, StockTrader), while reselling networks are often restricted to specific countries (e.g. Craigslist, Finn.no).

6 Implications

In this section we discuss implications of the different dimensions and types of the typology. First we discuss the innovation implications, in particular risks and challenges. Second we discuss relational implications concerning e.g. trust, motivation, reputation, responsibility, attention, privacy and safety. Finally, we discuss design implications.

6.1 Technical implications

The identified dimensions and types imply certain technical risks and challenges that HMNs need to address.

Many HMNs need to grow to be large or even massive in order to provide good service and experience for the users. This is certainly the case for online network and content communities. To start a successful online community, one needs a critical mass of users to begin with. That critical mass is also needed to prevent an HMN from unravelling and dying out (Garcia, Mavrodiev, & Schweitzer, 2013). The online social networks Google Plus and Friendster failed because they could not address these challenges.

Networks with massive size and global geographical range face the challenge of scaling their operations without affecting the quality of service. As the number of humans in HMNs grows, machines need to connect, communicate, and compute in a more efficient way, including sometimes sophisticated routing and resource allocation management to ensure connection between the right users and the right machines (Cardellini, Colajanni, & Philip, 1999; Ugander & Backstrom, 2013). Also when the network grows massively in size crossing political and cultural boundaries, certain issues may arise from the clashes between socio-political values and norms. Cross-lingual editorial wars in Wikipedia are good examples of this kind of challenge.

Networks that rely on strong ties and high interdependence further face the problem of providing multiple communication channels with high throughput and low latency. For example, massive multiplayer online games such as World of Warcraft need to provide consistent service with fast response times for thousands of users simultaneously (Claypool & Claypool, 2006; Yahyavi & Kemme, 2013).

Networks with high levels of human agency are particulalrly vulnerable to security problems. The more infromation users can input and the more activities they can execute, the higher the risk of deliberate malevolence such as hacking, vandalism, and intentional abuse of algorithms. Vandalism on Wikipedia, whereby anonymous users can delete and alter whole articles, presents a good case in point.

In the other extreme, HMNs with low machine agency entail «quality of experience» problems for the users. Machine-controlled filtering or adaptation of the content that observers see and use is often necessary and beneficial. Without such filtering, the result may be information overload on the humans in the HMN. Further, from a machine network perspective, the size and amount of content to be delivered will impact network performance.

Human agency is also related to the problem of low-quality contributions. The relationship here is reversed: networks with low human agency are more at risk for contributions of low quality. This is particularly the case for crowdsourcing networks such as Amazon Mechanical Turk, where insufficiently motivated or outright malevalent contributors can submit sloppy work and introduce biases and errors to a project (Allahbakhsh et al., 2013; Quinn & Bederson, 2011).

6.2 Social implications

Particular dimensions and types are also related to problems with trust, motivation, privacy, social influence, and social organization.

For example, networks with high levels of machine agency and weak ties face more challenges related to trust than networks with low machine agency and strong ties. In networks where the machine can filter content, similarly to what the well-known Facebook news ranking algorithm does, users may struggle with a concern that the technology will undermine their own position, or be unwilling to rely entirely on the capabilities of the machines (Lee & Moray, 1992; Lee & See, 2004). In networks where users' interactions are occasional and semi-anonymous, as in peer-to-peer online markets such as Craigslist, users may be unwilling to interact with others unless they know more about their reputation.

Networks with low levels of human agency and no or latent ties have to deal with problems related to participant motivation. When users are involved in multiple tasks that allow for creativity, they are often intrisically motivated by the opportnity to gain or create knowledge, share knwoledge, or help others. When users interact with others intensely, they are often socially motivated by the opportinity to create, build and maintain reputation and social relations, or simply to participate in interesting conversations (Ardichvili, 2008; Chiu, Hsu, & Wang, 2006; Yee, 2006). Networks that do not foster creativity and social interaction, such as the crowdsourcing platform Amazon Mechanical Turk, can only rely on economic incentives by offering payments. Higher payments, however, do not necessarily imply better contributions (Mason & Watts, 2010).

Networks with high levels of human agency carry the risk of breached privacy (Dwyer, Hiltz, & Passerini, 2007; Krasnova, Spiekermann, Koroleva, & Hildebrand, 2010). When users reveal their true identity or input large amounts of personal information, they become vulnerable to identity fraud and theft. Other untrustworthy users, ill-intentioned third parties, as well as the service providers themselves could potentially exploit users' personal data. Protecting privacy is a particularly complex problem in social media applications, such as Facebook. Even if users keep their profiles private, their friendships and group affiliations sometimes remain visible. In addition, some of their friends may have public profiles. Previous research has shown that friendships, group memberships, and rating behaviour can be used to infer sensitive personal attributes and information (Kosinski, Stillwell, & Graepel, 2013; Zheleva & Getoor, 2009).

Networks with high levels of machine agency are susceptible to the perils (as well as boons) of social influence. Machine interventions to the content that observers see and use can lead to undesirable self-reinforcing feedback loops that can negatively impact the service rendered. For example, if the number of users who see a particular contribution increases the chance of others seeing it, the diversity of content can decrease. HMNs with high machine agency often employ “black-box” algorithms that can affect one’s behaviour and mood without the participant’s knowledge and explicit consent (Bond et al., 2012; Kramer, Guillory, & Hancock, 2014). These effects have been labelled “filter bubble” (Pariser, 2011).

Finally, networks with bottom-up organization face the challenge of social organization. In particular, mass collaboration platforms such as wikis and open-source software projects need to organize the leadership, coordination, and collaboration among their contributors (Crowston, Wei, Howison, & Wiggins, 2012). While some research suggests that more decentralized communication networks are beneficial to the growth of the HMN (Crowston & Howison, 2005), other studies correlate internal cohesion with success (Singh, Tan, & Mookerjee, 2008).

6.3 Design implications

The key objective of the HUMANE typology is to support human-centred design of ICT. In particular, the typology will be used to identify relevant design patterns, that is, solutions to design problems that are drawn from existing examples of successful solutions.

Concerns such as design for privacy (Bellotti & Sellen, 1993; Langheinrich, 2001), design for flexibility and modularity (Sullivan, Griswold, Cai, & Hallen, 2001), design for interaction (Borchers, 2001; Erickson, 2000; Iacob, 2011), reusable software components (Gamma, Helm, Johnson, & Vlissides, 1994) and embedded technologies (Sangiovanni-Vincentelli & Martin, 2001), as well as design for possible bandwidth contention (Yang & Kravets, 2005; Yao, Mukherjee, Yoo, & Dixit, 2003) or between stakeholders (Christin, Weigend, & Chuang, 2005; Clark, Wroclawski, Sollins, & Braden, 2005) has meant that significant effort and research has been devoted to the identification of common issues as well as potential solutions for them. On the basis of the profiling exercises in the previous sections, and in an attempt to identify common issues requiring the solutions of design patterns, the following table summarises some of the key factors which need to be considered in the search for and identification of known design patterns. A distinction is made between functional (including operational) and non-functional requirements (Chung & do Prado Leite, 2009; Glinz, 2007; Gross & Yu, 2001; see also Shah & Rogers, 1988): the former are within the control of the software or network engineer, but the latter usually relate to activities and procedures which should be followed around the base components.

Across all of these areas, the power of design patterns as a “structured description of an invariant solution to a recurrent problem” (Dearden & Finlay, 2006). After Alexander’s original call for pattern-based design (Alexander, Ishikawa, & Silverstein, 1977), he set out a basic approach in attempting to capture the value of the pattern:

- Identify the best pattern
- Identify patterns to support this pattern
- Identify patterns *supported by* this pattern
- Modify the pattern if required (Alexander, 1977).

In establishing the relationship between different patterns – or "spreading activation" in Alexander's terms – this may further place the profile in a broader design context.

Within HUMANE, the ultimate goal is as follows: not only to identify the specific patterns which would help solve the challenges and problems identified by the profiling of different HMNs (see Chapter 0), but also to relate this to associated patterns. One benefit of this work would be to provide a common language and representation which could be shared across social scientists, design and software engineers, as well as network designers, namely allowing all of the different areas outlined above to be able to review and benefit from the patterns we might identify (Borchers, 2001; Dearden & Finlay, 2006; Erickson, 2000). At the same time, though, it is important to contextualise both profiles and patterns (Kaplan, 2001; Stolterman, 2008). To this end, we begin in the next section here to consider the approach and illustrate on the basis of two of the profiles described above (Section 5.2).

6.3.1 HMN Examples

Taking Alexander's approach further (Alexander, 1977), for a given profile we should consider the following overall descriptive schema:

Examples	Application areas where the pattern is used
Context	When the pattern is currently used
Problem	That the pattern is intended to solve
Forces	Any constraints on the solution to the above problem
Solution	The pattern itself
Resulting context	Once deployed, what is the outcome; where should we look next?
Notes	Any related comments or information

Using this basic schema, we consider in the following sections two of the illustrative profiles based on the HUMANE use cases. In each case, we attempt to characterise the profile, as well as identify some of the fields in the descriptive schema.

6.3.1.1 Dimension-to-dimension implications

The Conserve and consumer peer-to-peer reselling network provides an example of a relative stable HMN, notwithstanding the occasional peak in human agency and network size as previously identified (see Section 5.2). This kind of profile is characterised by modest geographical space requirements, a top-down network organization, tie strength between human agents, human agency itself and H2M interaction strength. The remaining dimensions show low or equivalent values. In some, this is about computer-mediated interactions across a fairly local setting, with a reasonable amount of interaction between human participants.

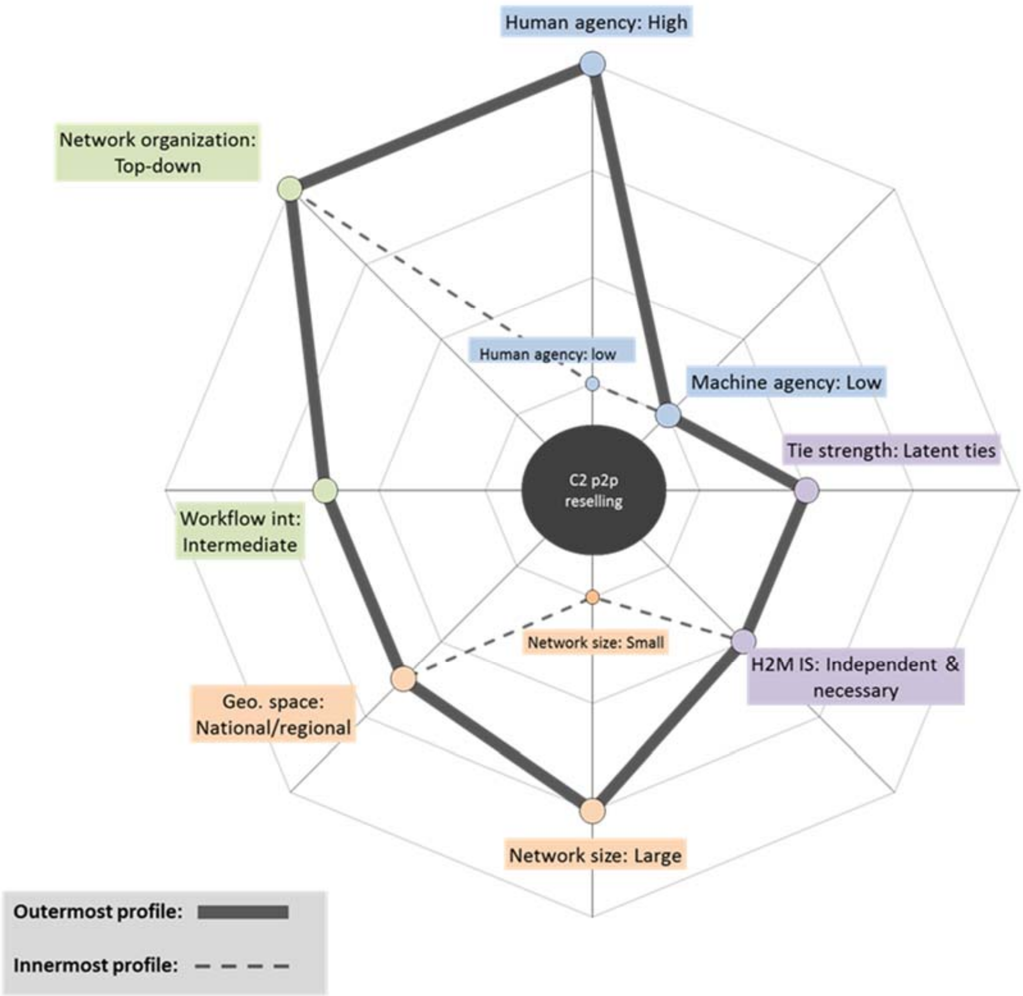

Figure 16: Initial case profiling - C2 peer-to-peer reselling (copy of Figure 11)

Looking back to the C2C peer-to-peer reselling case (see Section 5.2), and reviewing Alexander's approach (*op.cit.*), we may identify the following:

- The ***Problem*** we need to address therefore in design pattern terms relates to support for the collaboration of human agents in a local area.
- The ***Context*** where appropriate patterns may be found include HCI (to maintain consumer engagement) and online service design.
- The ***Forces*** associated with the search for appropriate patterns include a requirement for low machine autonomy (cf. the non-existent machine agency), low workflow and network complexity (the network organisation and workflow interdependence dimensions).

With this in mind, design patterns will need to be sought from

- ***Examples*** within HCI, online services and retail transaction handling.

The broader context for this type of HMN profile, however, needs to consider where online collaboration might lead. There will also need, therefore, to be a review of collaborative networks

(Dutton, 2008; Romero & Molina, 2011), and more especially the innovative, if superficially chaotic collaborations already witnessed elsewhere (Glasgow & Fink, 2013; Howard et al., 2011; Kreiner & Schultz, 1993).

6.3.1.2 Situation-to-situation implications

The eVACUATE case represents a different type of HMN, but more importantly is dependent upon design patterns which will support flexibility and almost limitless network complexity (cf. Babaoglu et al., 2006). The two states of the network may be characterised as follows:

> ***During monitoring****:* all network and distribution dimensions are fairly modest, including network size, geographical size, workflow interdependence, and network organisation, with little human agency. Human agency, tie strength and H2M tie strength are all at higher, though still modest levels: this is a network where there is limited intervention from human agents, but instead the machine nodes take the larger part of the burden to maintain the status quo.
>
> ***During an emergency:*** the complexity and size of the network and of the workflow running on it, but more importantly the level of human interaction all increase dramatically. At the same time, there is a slight reduction, and in fact reversal by comparison to the *monitoring* state, in H2M interaction strength. The human and machine agents now adopt more active and interdependent roles, even taking back some of the responsibility to the human agents from the machine nodes.

As such, design patterns must be found which can support both the dynamism of network needs, but also the changing roles and responsibilities that such changing needs require.

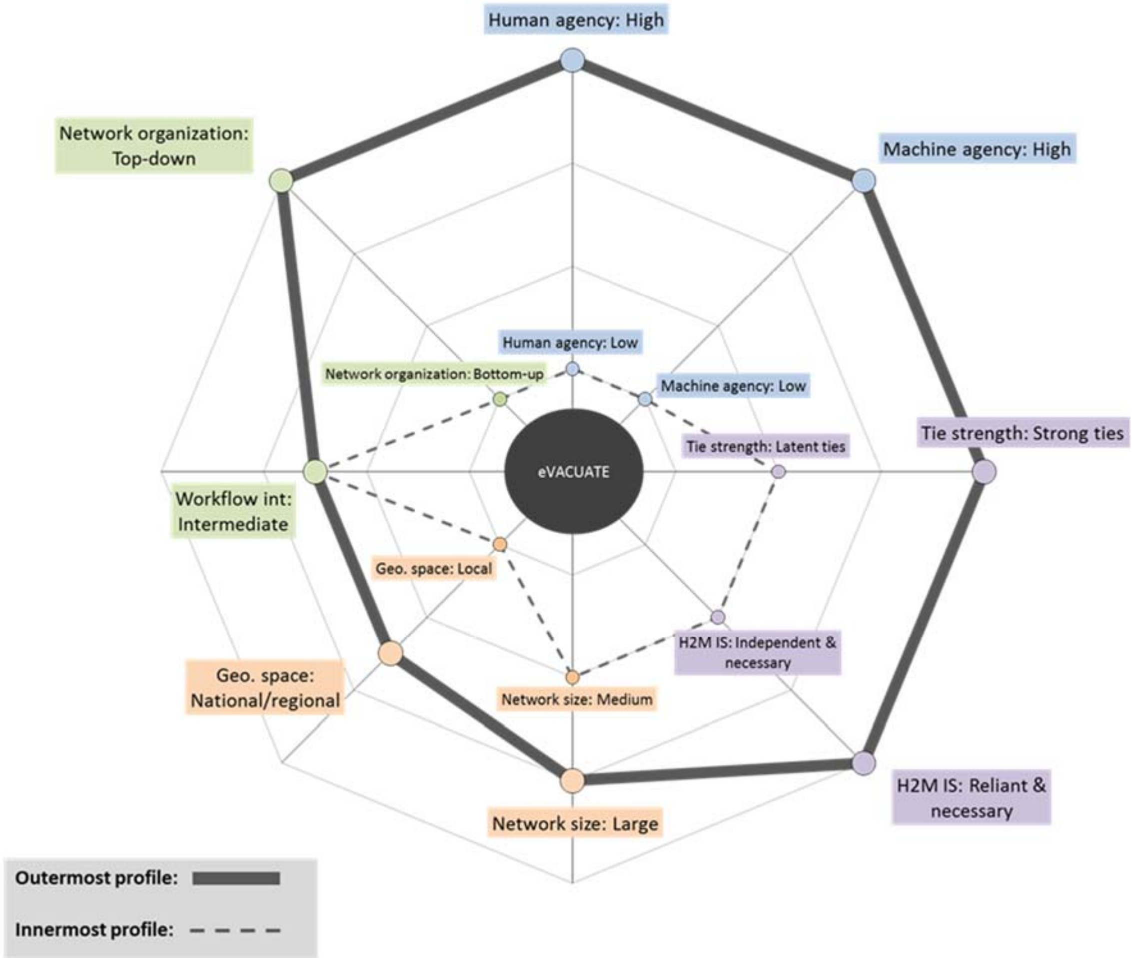

Figure 17: Initial profiling of the eVACUATE case (copy of Figure 13)

Once more looking at the different aspects of design for this case:

- For HMNs of this type, the ***Problem*** is multifaceted: there is a need for flexibility across the network and in all dimensions, including switching responsibilities, and catering for shifting geographical complexity and both human and machine agency; there is a need to cater for increased size; there is a need to support shifting strengths between human agents (tie strength) as well as humans and machines (H2M interaction strength).
- The ***Context*** is equally challenging: patterns need to be identified which will allow for dynamic changes in network size, but also in the relationships between and responsibilities associated with both human and machine agents.
- The ***Resulting context*** will by definition need to be responsive and robust (this is a mission critical HMN in the extreme). An additional dynamic will come out of the human-to-human interactions in the network, requiring a specifically social interactionist approach (Forlizzi, 2007; Kaplan, 2001).
- The ***Forces*** associated with this type of scenario are clearly bounded by the fact that this HMN is (i) **critical**: human lives literally depend on the correct and continued functioning of

the network; and (ii) inherently **unpredictable**: it is not clear, even during evacuation it is unclear which nodes will be involved, nor what their functional responsibility will be.

Providing ***Examples*** and ***Context*** for the relevant design patterns is both trivial and extremely problematic. On the one hand, the machine network itself would rely on patterns available from existing Internet of Things infrastructures, as well as mission-critical decision-support type operational platforms. A useful starting place would be the Future Internet Public Private Partnership (FI-PPP) catalogue of enablers for open-source, standards-based component descriptions. On the other hand, though, the dynamic and people-based interactions and changes in responsibility will need to review traditional group and interaction dynamics as well as trust and reliance on technology (see, for instance: McEvily, Perrone, & Zaheer, 2003; E. Montague & Asan, 2012).

6.3.2 Using design patterns

Design patterns based on this approach can be collected into a library to be associated directly with the different profile types. In the preceding sections, we have reviewed a design approach and the implications for two exemplars from the HUMANE use cases. We have identified typical contexts where appropriate design patterns should be sought, such as HCI (Crumlish & Malone, 2009; Granlund, Lafrenière, & Carr, 2001), online social (Burkhardt & Brass, 1990) and transactional networks, but also large distributed decision support systems based on common components (Arnott & Pervan, 2005; Shim et al., 2002) and the Internet of Things (Kortuem, Kawsar, Fitton, & Sundramoorthy, 2010). For each of the different profile types identified, this exercise is of value and will lead to a collection of design prototypes which are of relevance for the implementation of such an HMN.

This is not the whole story, though. In line with Alexander's spreading activation (*op.cit.*), there is a twofold benefit in identifying related, dependent or derivative, patterns. First, this ensures that profiles can be described not only in terms of the patterns needed to deliver them, but also in identifying related design areas and implementations which may inform the longer term view of where the HMN might lead. Secondly, though, this would position the profile within a broader context of network types (Milo et al., 2002). In this way, considering the profiles along with their associated design patterns allows the network to be situated within a broader context of complex networks (Newman, 2003; Newman & Park, 2003). Consequently, it will pave the way for an understanding of social interaction between the human and machine nodes within the network (Vinciarelli et al., 2012).

The intention behind Milo et al.'s work is to identify the fundamental building blocks which would help characterise complex networks (Milo et al., 2002). Leading on from this, any roadmap for HMNs will need to cover both the individual components, and relate them via spreading activation to related areas of technology, but also to look at usage and attempt to predict where the network will be taken as part of emergent behaviour. One way to begin with this exercise will be to compare the HMN typologies generated here, extended to include other relevant HMNs (see, for instance, discussion in D3.1), and establish how configurations of design patterns relate to actual instances of

HMNs. As Newman laments, such efforts have been frustrated by a lack of consistent tools and descriptions of the components associated with networks (Newman, 2003). In identifying patterns in this way, HUMANE is already contributing in this area. In the near and mid-term, it is hoped that profiling networks like this will help identify constraints on network topology and design.

Combining patterns would lead, of course, to a *quasi-infinite* set of configurations. Some of them may well be well-established and exemplars easy to find. Others may be a lot rarer, or simply unknown up to this time. Where potential, though undocumented, network topologies can be identified in this way, then the question is: why are they so rare? Answering that question would further contribute to our knowledge about HMNs which in turn may allow us to predict both possible as well as implausible HMN topologies. This kind of predictive power is something to be considered in subsequent deliverables.

7 Method

The HUMANE method describes the steps required to use the HUMANE typology for design support. It is intended to be utilised as part of human-centred design (see Section 2.3). In this deliverable, the focus is on giving an outline of the method, describing the scope and aims of the method, usage scenarios and notes on application of the method. This will be further developed and reported on in the following deliverables in this series, namely D2.2 and D2.3 due end of July ’16 and March ’17, respectively.

7.1 Scope and objectives

As discussed above in this document, primarily in Section 2.3, the HUMANE typology and method are intended to support human-centred design as described in the standard on human-centred design for interactive systems (ISO, 2010). The method is intended to be used by ICT developers practicing a human-centred approach to design for HMNs. The method is not intended to be limited to the design of new HMNs; but also for evaluating and re-designing existing systems. More discussion on usage scenarios is included below in Section 7.2.

A key overarching objective of the HUMANE method is to impact on the innovation capacity of ICT development companies, which will impact on competitiveness and the economic market. In turn this will impact on end-users who will benefit from improved systems that support their needs better.

Using the HUMANE typology and method, ICT developers will be able to plan and evaluate their design options in terms of better understanding the potentially complex interactions that may take place between the actors in the respective HMNs, in particularly in terms of emergent phenomena and unexpected behaviour. The HUMANE typology and method can be used to identify key aspects of the HMNs to focus on in terms of design and implementation options, e.g., by evaluating different design options in terms of ‘what-if’ scenarios. Moreover, the HUMANE method covers a profiling framework, discussed above in Section 5.1, which is intended to help identify design implications and design patterns for the HMN, leveraging information about existing HMNs with similar characteristics.

In terms of the HCD, the HUMANE method is intended to help in all four phases:

- **Context analysis:** Provide an iterative process for analysing the context of use in terms of the envisioned network. The starting point of the analysis will be to identify and model the type of network based on the network profiling framework. The analysis of such envisioned network will evolve as the HMN design project progresses.
- **User requirements:** Extend user requirements with characteristics and implications of the envisioned network, covering the different levels of interaction (human-human, human-machine, machine-human and machine-machine).
- **Design:** Support the design phase with design patterns for ICT solutions supporting successful HMNs of the same type as the envisioned network.
- **Evaluation:** Analytical evaluation and design critique through comparing the implications of the design with the needs and requirements of the envisioned network. Where divergences are found, case mitigating actions are needed. Simulation modelling is an added-value step in this phase, which will be introduced later in the HUMANE project. This is not only to capture emergent phenomena otherwise difficult to predict, but also to enable simulation of different design options and what-if scenarios otherwise not possible to test in the early stages of development of ICT solutions for HMNs.

7.2 HUMANE artefacts and usage scenarios

In summary, the HUMANE method comprises the following artefacts:

- The HUMANE typology, describing dimensions to characterise HMNs.
- HUMANE profiling framework:
  - Method for profiling, using the dimensions of the typology.
  - Design patterns.
- HUMANE simulation framework (do not exist at the time of writing, but is planned developed in a later HUMANE task (Task 3.4, deliverable planned for December,2016)

We also foresee the opportunity of providing tool support for the method (see Section 8).

Using the outputs of HUMANE, we can envisage three usage scenarios, each of which are described below:

- Designing new ICT systems for HMNs
- Evaluating existing ICT systems for HMNs
- Updating existing ICT systems for HMNs

7.2.1 Designing new ICT systems

Designing new ICT systems puts much emphasis on the context analysis and user requirements elicitation. The former is critical, as the context of use of a HMN is important to be able to establish aims and objectives in relation to assumptions about who will use it, where, when and how, etc. This typically informs the design of the system itself, in order to support any anticipated user behaviour in line with requirements that are captured.

Designing a new system is inevitably done based on a range of assumptions. The typology is designed to help in this kind of scenario in the sense of identifying desired and likely characteristics according to the various dimensions. Each dimension describes characteristics and their potential implications, which can be used to shape the design of the network in terms of the objectives of the HMN.

Key here is the use of design patterns related to different HMN characteristics and profiles from existing HMNs, which can greatly help in the development of new ICT systems. That is, instead of starting with a blank sheet of paper, the aim of the HUMANE method is to leverage existing knowledge encapsulated in existing HMNs in order to assist ICT system designers.

As the context analysis and user requirements phases of the HCD process is maturing and a system design is emerging, the simulation framework is of interest. Although calibration of simulations will be based on rough estimates at this stage, unless there is data available from similar, existing, HMNs the simulations can help give indications of the emergent behaviours of the actors in the HMN. What-if scenarios could be defined, in terms of exploring different design options for example.

7.2.2 Evaluating existing ICT systems

While the design of new ICT systems is largely guided by qualified assumptions, evaluating existing ICT systems has the benefit of availability of usage information and data. This is a scenario where owners of a HMN may wish to make improvements, either to address issues identified in the existing solution or to explore options for becoming more competitive compared with other HMNs.

Profiling of the HMN is key to such an evaluation process, using the HUMANE assets. Especially in terms of comparing with other existing HMNs that may be similar, but are seen to be more successful. For such an evaluation, it is also of interest to compare with HMNs that are different, but share similar objectives.

This usage scenario does not imply going through an entire HCD process; rather it may help shape business requirements motivating a change to the HMN and provides input to the first HCD process on context analysis.

7.2.3 Updating existing ICT systems

This usage scenario overlaps with the one above, evaluating existing ICT systems. However, while the above only feeds into the first phase of the HCD process, this usage scenario effectively issues the entire process in order to update an existing ICT system. Therefore, after having done an evaluation, proceed with the user requirements, design and evaluation phases as for designing a new ICT system.

While the usage scenario discussed above for designing a new ICT system included use of the simulation framework, the opportunity in this scenario is that actual usage data of the current HMN can be used to a) calibrate simulation models and b) form a baseline for evaluating different what-if scenarios. Therefore, the accuracy of the simulation results is likely to be significantly higher than when designing a new HMN.

7.3 Application of method

Different usage scenarios have been discussed above, which illustrates different ways in which the HUMANE assets can be used. Each of the three scenarios discussed require a variations of the same method. In this section we provide a summary of key aspects of the application of the HUMANE method that will be defined later in the project (D2.2 and D2.3, as noted above).

First, it is essential to define the objectives/aims of the HMN that is going to be designed or updated. This context is key to extrapolating technical, social and design implications as discussed above in Section 6. For example, at design time of a new HMN, the dimensions of the typology would initially be scored to form a profile of the desired system. Therefore, if the objective of the HMN is to stimulate knowledge sharing between human actors, then the implications of dimensions such as *tie strength* are important.

Second, it is necessary to determine if the system has got or will have different usage modes that should be analysed separately. An example of this is eVACUATE, as discussed above in Section 5.2.4. Each scenario may yield very different HMN profiles, which needs to be in response to the needs of the actors in the HMN in accordance with the objectives of the HMN itself. In the eVACUATE case, a key objective is to facilitate the safe, effective and efficient evacuation of people. When there is an evacuation taking place, the way in which human and machine actors need to behave to achieve that objective is different to the situation where there is no evacuation.

Third, since many of the dimensions of the typology aggregate and abstract some details, it is important to consider whether the abstraction is appropriate. For example, when analysing the HMN in terms of a dimension such as human or machine agency, there may be different key stakeholders that exhibit significantly different levels of agency. Aggregating across them may not be appropriate, and may need to be analysed individually.

As a consequence of the second and third points, above, a single HMN may have multiple profiles. Each profile may have its own design implications, which will form important input to all of the HCD phases.

8 Tool support

It may be beneficial to develop tool support for the HUMANE typology and method. Below we present some suggestions towards such possible tool-support, that is, a profiling support tool and a tool support for a design pattern library. We also relate to the tool support to be developed in HUMANE Task 3.4.

8.1 Profiling support tool

A profiling support tool can be based on an application that will enable designers and developers to (i) visualize the profiles of existing or envisioned HMNs, (ii) make comparisons in regards to different dimensions, (iii) categorize the HMNs with respect to several different attributes, and (iv) support the design and development of HMNs with similar profiles as existing ones.

The overall objective of HMN profiling is to generate insights that help designers and developers make informed decisions about the design of any given HMN. The profiling process supports this by (i) helping designer and developer teams to reflect upon and reach consensus about the characteristics of the given network they are developing, (ii) producing a profile of the network that works as a documentation of its envisioned characteristics and (iii) enabling designers and developers to identify similar networks that can be used to find relevant design implications and design patterns.

To that end, the user will be first prompted to define the network's name, the author of the submission, the participants that take part in the profiling as well as a short description of the network. When a new project is created, the user will be prompted to go to the 1st step of the process and fill in information regarding the 4 main layers already defined (i.e. actors, interactions, network and behaviour). For each layer the user will have a separate screen with two dimensions. In addition to that, the user will be able to see a short description / explanation of the dimension.

Through adjustable bars, the user interface will enable the user to provide values for each dimension as shown in the following Figure. Each dimension will have the appropriate scaling. For each dimension's scale examples of typical networks will be available.

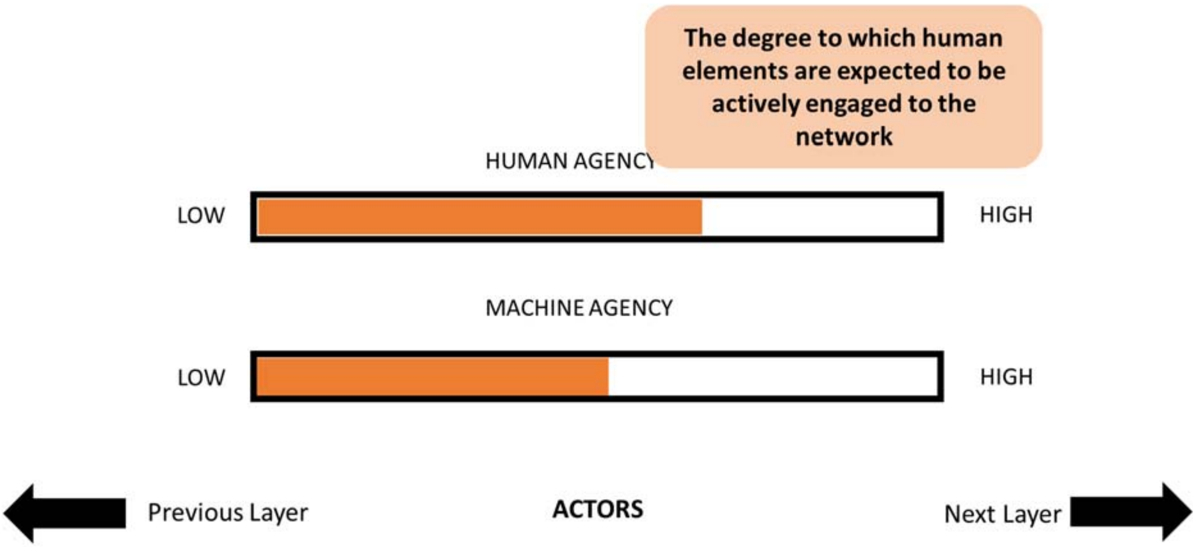

Figure 18: Sliders/bars for characterizing a network along dimensions

After all dimensions are filled in, the tool will provide to the user a visualization of the network's profile, similar to that provided in the current Excel templates (see Appendix B: Templates for profiling support). An example of this is given in Figure 19.

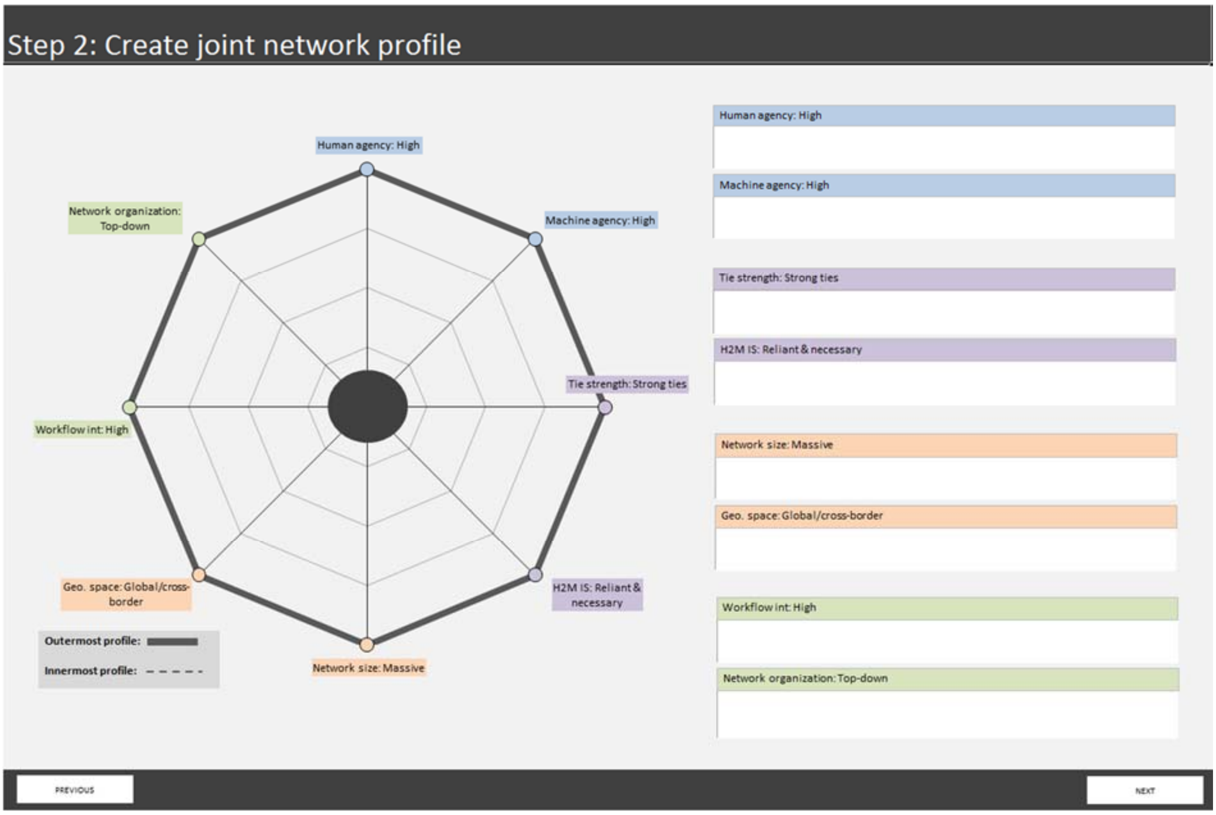

Figure 19: Example of profile visualization

8.2 Interactive tool for accessing the design pattern library

The tool will have some basic patterns that will be based on the four analytical layers: actors, interactions, network and behaviour. To that end, specific patterns will be designed for networks that focus mainly either on one of these analytical layers, or on any combination of 2 or 3 layers. In total 4 (combinations of 1) + 6 (combinations of 2) + 4 (combinations of 3) = 14 basic patters will be designed.

Apart from that, each project will be stored in pattern repository / library. Storing projects will form groups of networks with similar characteristics, e.g. networks that focus mainly in actors and interactions. When a new project is to be developed, the user may provide general information about the human – machine network under investigation, and get the profiles (patterns) of other networks that have similar characteristics.

In order to carry out the aforementioned processes, a profile analysis and pattern matching unit is required. Such a unit will be able (i) to identify the profiles designed through the basic profiling tool in order to store it to the pattern repository in the appropriate pattern / category and (ii) to analyse the available patterns in order to provide the necessary input to the profiling tool.

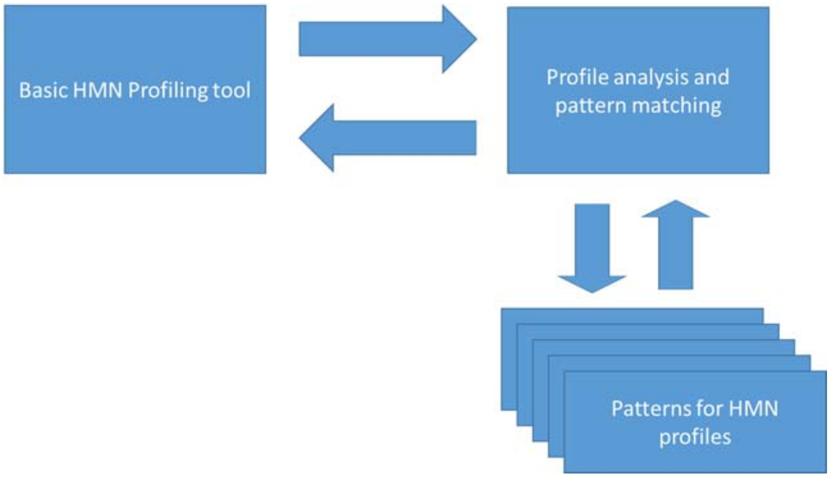

Figure 20: Basic architecture for analyzing profiles and identifying patterns

Based on that tool, the user will be able to access information regarding 2 additional issues: First, a list of similar networks will be available to the user, based on the profiles already stored in the repository. Second, a list of relevant design principles (design implications, patterns etc.) will also be created by the tool.

8.3 A software model of the typology and the simulation framework

Among the support tools to be designed and developed in HUMANE, a core model is also included, that aims to form the basis for specific models that will be run for the examined case studies in order to simulate and validate different design options. The purpose of this is to demonstrate how the developed typology can be exploited and utilized in the evaluation phase of human centric design at a stage before one would be conducting large-scale testing or doing alpha releases of software.

Such a tool will be exploited towards the validation of all design options developed in the framework of WP2. This validation will be carried out within WP3, and specifically in task 3.4. The validation carried out with the tool will be based on the internal and external use case executions of HUMANE, which also will take place in WP3 (tasks 3.2 and 3.3).

9 Conclusion and further work

In this deliverable we have presented the first version of the HUMANE typology and method. The target audience for the typology and associated method are technology and service providers in general, and practitioners of human-centred design in particular. The method is outlined to be compliant with the international standard for human-centred design.

The typology forms the basis for a profiling framework. Profiling a HMN on the dimensions of the HUMANE typology is intended to facilitate access to relevant design knowledge and experience, following a design pattern approach. The underlying idea is that the profiling of an envisioned or existing HMN will both facilitate relevant design discussion and, more importantly, serve to identify the HMN type. Through the profile type, relevant technical, social and design implications can be drawn.

In this initial version of the HMN we have mainly concentrated on establishing the typology dimensions and profiling framework. Technical, social, and design implications of the profiling have been outlined but not detailed. The HUMANE method is also outlined, and an early concept for a profiling tool has been suggested.

This initial version of the typology and method will be applied in the six HUMANE use cases for purposes of context analysis (HUMANE D3.2). Experiences from these cases will be used to further refine and develop the typology and associated method in the next project iteration (HUMANE D2.2).

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Appendix A: Other dimensions considered for v1

The set of dimensions included in the first version of the typology is the result of the initial detailing of dimensions based on the literature review and the feedback on the initial set of dimensions in a case-oriented workshop involving all project partners (and, hence, representatives of all HUMANE cases). For transparency of the process, an overview of dimensions assessed as part of this process is provided below. The process leading up to the dimensions included in the Typology v1 is described in Section 3.1.

Initial dimension	Source	Modification	v1 dimension
Workflow interdependence	From initial set of dimensions	Kept as is	Workflow interdependence
Network size	From initial set of dimensions	Need scale modification (workshop)	Network size
Nature of contributions (homogenous vs. heterogeneous)	From initial set of dimensions	Needed reworking (workshop)	Human Agency
Member roles (singular vs. multiple)	From initial set of dimensions	Needed reworking (workshop)	
Network lifecycle	From initial set of dimensions	Modified in workshop. Excluded following initial profiling.	
Effect production	From initial set of dimensions	Excluded during dimension refinement	
Node membership (static vs. variable)	From initial set of dimensions	Excluded during dimension refinement	
Network execution (distributed vs. real time)	From initial set of dimensions	Excluded during dimension refinement	
Hierarchy: Degree of hierarchy in network	From workshop	Merged during dimension refinement	Network organization
Level of coordination required	From workshop		
Top-down vs. bottom-up	From workshop		
Geographical space of network	From workshop	Kept as is	Geographical space of network
Machine agency	From workshop	Kept as is	Machine agency
Network dependent on the machine?	From workshop	Excluded during dimension refinement.	
Passive observers as part of network	From workshop	Incorporated in the dimension "Human agency"	
Tie strength	From workshop	Kept as is	Tie strength
H2M interaction strength	From initial case profiling	Kept as is	H2M interaction strength

During the work towards the initial case profiling, the result of which is presented in Section 4.3, potentially interesting dimensions were suggested that were not included in v1. In the following a brief overview of these is provided.

Suggested dimension (analytical layer)	**Description**
Member roles (actors)	Allowing individual actors (machines as well as humans) to be classified in accordance with the number of roles they can adopt may be useful for some of the cases. For instance, sensors will tend to be fixed function passive transmitters of data in normal operations; but can become active and collaborative components, operating in full duplex mode in an evacuation.
Interaction frequency (interactions)	Being able to specify the level of interactions in addition to any interdependence between interactions, as well as their respective strength, may be a useful independent characteristics.
Emergent production (networks)	Such a dimension does seem to be an important distinction between other dimensions such as size and complexity of a network *versus* any propensity for unpredicted patterns of behaviour to emerge.
Humans vs. machines (behaviours)	We have already included *Network organisation* and *Human/Machine agency*. But the balance of who is more responsible in the network, or more or less prominent, may be an important consideration.

Appendix B: Templates for profiling support

The template for profiling support is embedded into this word document, and can be opened by double clicking the Excel icon below.

HUMANE_Profiling_te
mplate_D2_1_Final.xl