Mediated behavioural change in human-machine networks: exploring network characteristics, trust and motivation

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Abstract. Human-machine networks pervade much of contemporary life. Network change is the product of structural modifications and not just participant relations. Taking citizen participation as an example, engagement with relevant stakeholders reveals trust and motivation to be the major objectives for the whole network. Using a typology to describe network state based on multiple characteristic or dimensions, we can predict possible behavioural outcomes in the network. However, this has to be mediated via attitude change rather than material or reputational reward predicted by social exchange models. Motivation for the citizen participation network can only increase in line with enhanced trust. The focus for changing network dynamics, therefore, shifts to the dimensional changes needed to encourage increased trust. It turns out that the coordinated manipulation of multiple dimensions is needed to bring about the desired shift in attitude.

Keywords: Humane-machine networks, Network dimensions, Typology, Trust, Motivation, Behavioural change, Modelling, Social exchange, Social networks, Virtual communities.

1 Introduction

Human-machine networks[1] (HMNs) pervade contemporary life from social and family interactions to retail, online learning and eDemocracy. These HMNs display varying characteristics, offering many different ways to interact and achieve whatever the goals of participants might be [1]. But these networks can and do change as users alter their behaviours [2]; and attempts to account for network evolution often fail to appreciate user expectation and creativity when they engage, especially when explanations of dynamic change are reduced to theoretical models [3] or social exchange [4]. A more pragmatic approach might be to weigh user expectations and actions when using the network as it was intended, and then monitor how it changes. In so doing, we necessarily need to consider both intrinsic and extrinsic motivation [5]: is it the individual or the group which encourages participation [6] or the value of contributions [7]? In this

[1] We use the terms human-machine network (HMN) and network interchangeably.

paper, we examine different aspects of behavioural change in networks: the design of the network itself and the interaction between external and internal motivators.

2 Citizen participation networks

Given the reach of the Internet [8], it is no surprise that human-machine networks are also present within democratic processes [9, 10]. However, it is not clear how social network activity leads to participation in democracy [11]. On- and offline democratic processes do differ [8]: social network discussions do not necessarily translate directly into participatory behaviour [12]. eDemocracy and eParticipation tend to complement rather than replace traditional processes [9] extending debate rather than improving it [13]. Online discussion leads to a more refined understanding of a single issue, rather than shaping political decision-making [14], and as an inherently social activity [14] is influenced by social forces [15, 16]. In consequence, HMNs supporting citizen participation have to integrate social, political and technical factors if they are to succeed [9, 17]. There is therefore an inherent challenge in striking a balance between stakeholder expectations on the one hand, and socio-technical issues such as acceptability, system adoption and willingness, on the other [17]. Modelling online behaviour solely in terms of social exchange [18] underplays trust in the HMN itself [19], and the recognition that motivation changes over time in response to the interplay between intrinsic, social and extrinsic factors [6, 20]. To understand such interplay, we must first characterise the network and then return to the exploration of motivation.

3 Profiling human-machine networks

Fig. 1 summarises a set of eight characteristics or dimensions grouped into four abstract layers [21][2]. These dimensions allow individual aspects of the network to be examined; further, the interplay between each pair of dimensions within an abstract layer allows network dynamics to be explored [22, 23]. How this dynamism affects the network offers the opportunity to control and manipulate the network. To maintain participation for instance [7, 19, 20, 24], we use these limited dimensions to modify the network and encourage behavioural change [25].

Within an Analytical Layer, such as *Actors*, individual dimensions may be more or less independent of one another. Manipulating these dimensions will change network characteristics, either opening up additional opportunities or restricting others. For instance, if increasing the capabilities of the machine components allows human agents to do more then *Human* and *Machine agency* increase in tandem [22]. Further, the coordinated increase in Human and Machine agency is likely to increase participants' perception of self-efficacy: they can do more and possibly achieve more. Similarly, reducing *Network organisation* together with *Workflow interdependence* would increase autonomy for HMN participants. However, there may be other implications. Increasing autonomy in this way may lead to confusion about what can and cannot be

[2] See https://humane2020.eu/

done in the network, and therefore, reduce self-efficacy compromising motivation to engage with the network.

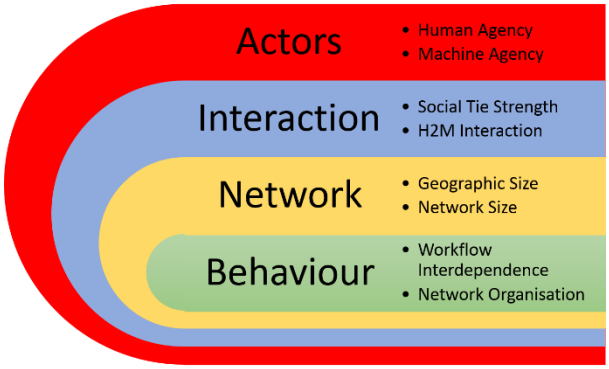

Fig. 1. Dimensions of a citizen participation human-machine network

So the limited set of dimensions from the typology not only changes the structure of the network but also affects how actors in the network achieve their ultimate goals. It becomes important therefore to consider how those dimensions might affect generic, cross-cutting concerns such as motivation, trust and participation. To identify these intangible issues, or *meta-dimensions*, we propose to consider more than the structure of the network and its characteristics. To clarify how network dimensions may be used as controls in modifying network outcomes, we must engage directly with participants to establish what they need and expect from their HMN.

4 Identifying stakeholder perspectives

Fig. 2 encapsulates a process for understanding the objectives of an HMN. Taking eParticipation as an illustrative example, stakeholders include policy makers, politicians, citizens and lobby groups each with their own priorities. From observation, discussion and questionnaire, we can surmise their respective goals[3]. Looking at the goals stakeholders aspire to, citizens want their voices to be heard; policy makers to understand what is important to the citizens and how they will respond to proposed legislation; and lobbyists to ensure that their point of view reaches the policy makers, and their objectives (and those of their members) met. At the same time, there are blockers or challenges to achieving those goals: citizens feel constrained to express what they truly feel, or lack trust that what they say will be taken into account; policy makers need to decide between opposing views and interests in formulating policy; and lobbyists need to demonstrate that they have faithfully represented those they serve *and* that there has been a positive effect [26].

[3] See https://humane2020.eu/2017/01/16/humane-roadmap-process/

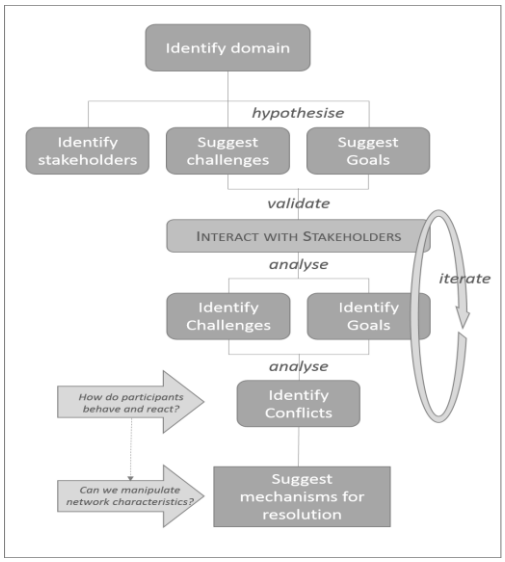

Fig. 2. Exploring participant perceptions

Validating these challenges and goals with the stakeholders allowed us to home in on how participants react. Monitoring their behaviours identifies what the relevant meta-dimensions for this network are. In a recent study, a small group of self-selecting actors involved in citizen participation [27] first ranked stakeholder roles in order of importance within the network: Citizen groups (most important), Non-Government Organisations (NGOs), Government, Policy makers, and IT Professionals and designers (least important). It is perhaps surprising to find Government and Policy makers ranked below Citizens themselves and NGOs. However, citizen engagement has been seen as more about debate and social interaction than necessarily establishing contact with Policy makers [13, 14, 17].

Turning to goals and challenges, the main goals of citizen participation networks turned out to be: (i) *Managing trust*; (ii) *Generating a culture of engagement*; (iii) *Encouraging open and transparent debate*; (iv) *Motivating participation from all parties*; and (v) *Accountability*. These relate particularly to **trust in the network** and **motivation**. Trust is affected by a number of different aspects of the network such as the technology involved and how competent individual users feel with the technology. Yet one of the challenges to network success is understanding the real role of technology. Further, looking at accountability and a call for open and transparent debate, trust is affected by perceptions of the process itself: does participation really make a difference, for example? Here again, one obstacle to achieving the overall network goals was the desire to see outcomes being publicised and made available to all actors in the network. Finally, trust will be affected by whatever safeguards are in place to ensure accountability and protect open discussion.

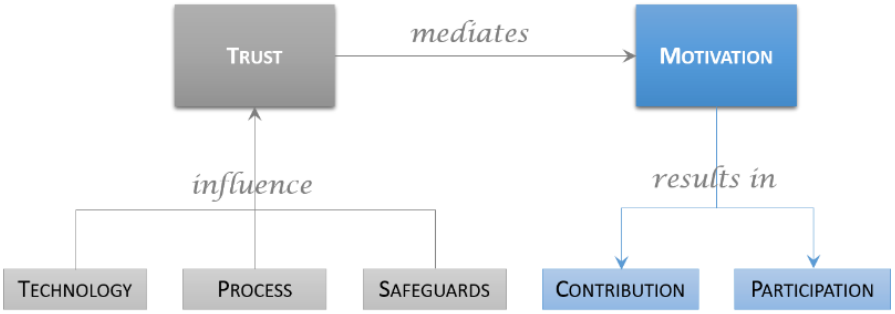

Fig. 3. A simple model of meta-dimensions in HMNs

Trust therefore is influenced by the factors summarised in **Fig. 3**. As an intrinsic factor, trust is not available for manipulation. However, it is possible to change network constructs like technology, process and safeguards. In this way, changes in trust as a consequence of manipulation of these factors will have an effect on motivation. Thus there is a mediating effect of trust: the underlying drivers of technology, process and safeguards encourage motivation. Stakeholders identified the need to generate a culture supportive of debate and to encourage participation and contributions from citizens. Motivation is precisely about driving active participation so that citizens and citizen groups provide input and contribute to the success of the network. So the way to facilitate these beneficial effects of motivation, we need to consider how we might affect the influencing factors which lead to changes in trust.

The two meta-dimensions, trust and motivation, are key components influencing behaviour and thereby the success of the network. In turn, they too are dependent on other constructs. For example, if trust is a willingness to expose oneself to vulnerability [28–30], then perceived risk and any regulation mitigating that risk will influence trust [23] and not the other way round [19]. Motivation on the other hand will relate to the willingness to participate driven externally by a social desire to engage [6, 14, 16], but equally there is an internal drive to demonstrate competence, affiliation and commitment [31, 32]. Importantly, though, how will the network dimensions engender trust and in turn motivation. We turn now to look at changes to individual dimensions and what effect this has on the meta-dimensions.

5 Manipulating networks through controlling network dimensions

Given the simple model of human-machine networks, encouraging trust in the HMN to influence and improve motivation is not straightforward. Since the network dimensions do not directly affect trust, they must be applied to components in the network (technology), its outcomes (process) and external influences (safeguards). Starting with *Actors*, increasing machine agency in support of human agency encourages self-efficacy and a sense of competence increasing motivation and thereby a willingness for participation. Increasing Social Tie Strength facilitates communication and promote

publication of outcomes and transparency as citizen participant stakeholders identified[4]. Raising H2M interaction strength improves self-efficacy via technical know-how. Using our example of eParticipation networks, as self-efficacy increases so trust in the overall process should improve. Geographic size is constrained to include only those geographically affected by outcomes of such participation (e.g. just within a national jurisdiction), whilst within that, as many individuals as possible should be enabled to participate. If the digital divide is an issue, then the technology must be implemented with ease of use and user experience as design principles. Workflow interdependence should attempt to lower perceived risk. This is where the interplay between different actors (e.g. policy makers and citizens) is most significant, and trust in the process is greatest, creating the system of government. Finally for Network organisation, a bottom-up evolution doesn't necessarily lead to participation in governance, as both *facebook* and *Twitter* have shown. Similarly, top-down creation of participation networks by government have also failed, since there is insufficient trust in the system [19], and poor communication of the objectives of the network [6]. Yet a purely bottom-up approach would lack the cohesion required to support constructive debate, and exposes the network to side-tracking by extremism. There is therefore a need to consider what the identification of an 'intermediate' organisation might be, and how a network that is neither bottom-up nor top-down might be created.

Since the analytical layers and network dimensions alter network characteristics, changing individual dimensions may bring about behavioural change. For, as the characteristics themselves are modified, so the behaviours associated with the network would be constrained or freed up to engage in different types of activity. If the model in **Fig. 3** is correct, this indirect outcome – by manipulating network dimensions, which change trust levels, and in turn mediates motivation, leading to greater participation and so forth – reveals a process for behavioural change in networks. What we need to do now, though, is go one step further and identify the effects of multiple dimension changes at the same time.

6 Trust and agency in human-machine networks

In a recent study on how trust, human agency and machine agency might affect behaviour, Pickering et al. [23] modified previous work by Thatcher, McKnight and their colleagues on trust in technology [33, 34]. **Fig. 4** shows the research model Pickering and his colleagues proposed (with individual constructs in black), centred on the relationship between trust and behaviour. Briefly, *regulation* controls what can and cannot be done in a network, directly affecting human and machine agency; similarly, regulation will provide input to the estimation of any *perceived risk.* Together, they act as safeguards associated with the network. Interestingly, as regulation is typically external (linked with legislation and similar controls), so perceived risk tends to be internal (the result of some form of cognitive algebra). Only this internal factor affects trust and network behaviours directly, not external regulation. *Machine agency* allows human

[4] See also [7]

agents to achieve more in the network, and thereby increases *self-efficacy*, which will in turn affect network behaviours, along with trust in the network and *social norms*. This model summarises the effects we propose by manipulation of the network dimensions as outlined. But the model also makes clear that increasing trust is not simply about the aggregated effect of changes in technology, process and safeguards.

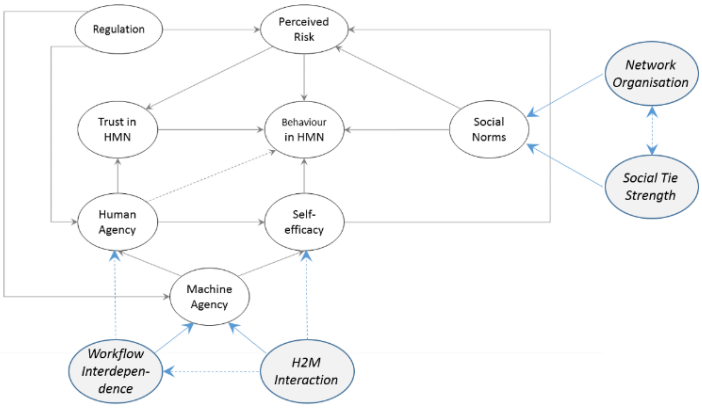

Fig. 4. Trust in Human-machine Networks

Taking this one stage further (the shaded constructs in **Fig. 4**), linking safeguards and agency with trust, self-efficacy and thereby network behaviours means that the model we propose may usefully be extended. The *interaction* and *behaviour* layers (see **Fig. 1**) affect different parts of the trust-behaviour model. To begin with, *Network organisation* can be expected to influence social norms: a bottom-up configuration would leave social cohesion outside the scope of the network, and therefore dependent solely on the individuals themselves. A top-down structure would impose uniformity on how human agents can interact and communicate with one another: the network would therefore constrain the possible effects of social norms. By contrast, *Workflow interdependence* will affect both *Human* and *Machine agency*: the more structured the workflow, the greater the machine agency, whilst human agency is constrained. With less structure, however, the opposite is not necessarily true.

Turning to the interaction layer, *Social tie strength* affects social norms*:* as individuals identify with other network participants, so social norms are determined by group identity. With weaker ties, social norms will be less influential since social identity among network users is less likely. At the same time, *H2M interaction* will influence *Self-efficacy*: as human network actors become more comfortable with what machine components do, so their perception of what they can achieve increases. First, for H2M interaction to have a significant, positive influence on Self-efficacy, Workflow interdependence would need to be less structured to enable greater Human agency and thereby increased Self-efficacy. Similarly, increased Social tie strength suggests less top-down Network organisation.

Coordinated network dimension change is needed if the goal is to increase trust for its mediating effect on behaviour in the HMN, or motivation for citizen participation.

Behavioural change in human-machine networks is therefore not a simple issue of providing incentives, but the more complex effects of changing network characteristics as they influence non-deterministic motivation [35] and the meta-dimensions we propose.

7 Concluding remarks

Trust is a socio-cognitive construct inaccessible to direct influence. Lack of trust is therefore a blocker to the future development and growth of a citizen participation HMN. In addition, trust is seen as a goal in itself: for the network to succeed and continue to be successful there has to be trust between participants and the associated process [6, 19, 34].To investigate whether this is indeed the case, we have used a network typology comprising a set of dimensions describing different network characteristics. Changing these dimensions is a novel approach to modify how the network operates. The focus for changing network dynamics is to encourage increased trust. Further, the coordinated manipulation of multiple dimensions is needed to bring about the desired shift in attitude. This is a different focus from previous models of participation [6, 19].

Extending this discussion, a typology to describe network state based on multiple network characteristics or dimensions makes it possible to predict behavioural outcomes in the network. Directly modifying network dimensions represents a top-down intervention, an intentional manipulation which paradoxically may well undermine any beneficial effects: if network participants are aware that there is an attempt to influence them, say by financial incentive, then they may well withdraw co-operation. Indeed, any such incentive fails to recognise that altruism, for instance, is not about external reward [20, 36, 37]. Similarly, though, acknowledging network participant objectives without modifying the HMN to be able to support those objectives – participant aspirations emerging bottom-up – may simply lead to frustration and reduce motivation. How to resolve the tension between the top-down and bottom-up aspects of HMN change is the challenge we are now looking to address.

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