Revisiting the Three Rs of Social Machines: Reflexivity, Recognition and Responsivity

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ABSTRACT

This paper sets out an approach to Social Machines (SMs), their description and analysis, based on a development of social constructionist theoretical principles adapted for Web Science. We argue that currently the search for the primitives of SMs, or appropriate units of analysis to describe them, tends to favour either the technology or sociality. We suggest an approach that favours distributed agency whether it is machinic or human or both. We argue that current thinking (e.g. Actor Network Theory) is unsuited to SMs. Instead we describe an alternative which prioritizes a view of socio-technical activity as forming 'reflexive project structures'. We show that reflexivity in social systems can be further usefully divided into more fundamental elements (Recognition and Responsivity). This process enables us to capture more of the variation in SMs and to distinguish them from non-Web based socio-technical systems. We illustrate the approach by looking at different kinds of SMs showing how they relate to contemporary social theory.

Keywords

Social Machines, Socio-technical Systems, Agency, Reflexivity, Social Theory

1. INTRODUCTION

Current work engaged in developing an understanding of Social Machines (SMs) has prioritized the search for the fundamental principles of their operation, organization and/or activity in one of three ways: (i) a computer science oriented search for an exhaustive taxonomy of the fundamental properties of SMs (e.g. [16]); (ii) a classificatory schema established by exploring the distinctions and intersections of SMs with social computation, crowd-sourcing and knowledge acquisition systems [2]; and (iii) an approach seeking to balance the emphasis on the technical with a focus on 'the social' (e.g. [17]) which, by focusing on the universal cognitive capacity for stories, prioritizes the 'sense-making' activities of human agents participating in SMs.

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Each of these types of approach has been productive in the investigation of some aspects of SMs, and each represents a partially valid line of inquiry into some of the characteristics and nature of SMs. However, our view is that the range and diversity of current examples of SMs have complex features not adequately described by recent attempts to build a comprehensive classification system. We suggest that the introduction of 'social primitives', derived from social theoretical concepts, should help build a richer conceptualization of SMs. Nevertheless, we remain mindful of over-prioritizing sociality at the expense of obscuring the role of technical innovations in the constitution of SMs.

What is required is the specification of an approach that respects both sides of socio-technical phenomena. In the present paper we argue (i) briefly why this has been difficult to achieve with approaches such as ANT; and (ii) how Tarte et al's approach can be better reconciled with a search for 'socio-technical primitives' based on social theoretical 'units of analysis' which have a long pedigree in social theory and which can be adapted for Web Science.

We argue here that the attempt re-balance the approach towards sociality though a theorization of SMs, by virtue of their 'storying capacities' [17], can lead us to a position where we are able to grasp the natures of diverse Social Machines. However, to do this entails that we subsume 'story capacity' under a more generic set of 'social theoretical primitives' or units of social analysis: reflexivity and 'project structures'. As has been argued elsewhere, agent reflexivity is a social behavioural ordering mechanism that has consequences for large systems at societal scale [5, 1]. Yet, reflexivity also has implications for individual human agents and their sense-making, and self-organizing activities at local level through the human agent's powers of 'narration' but also in the forms of co-operative 'project structures' that agents engage in.

2. IN SEARCH OF 'SOCIAL PRIMITIVES'

2.1 The Shortcomings of ANT for Analysing Social Machines

Social Machines are socio-technical phenomena but not all approaches to understanding such phenomena are concerned to establish an analytical language that would help us make judgements about any qualitative differences between different machines and their social transformational effects both at the granular level and also at scale. Yet, these are the questions currently confronting the field of digital sociology [12]. To make judgements about the differential

characteristics of social machines, and their social dynamics from a change impact perspective requires social theoretical approaches geared for making such judgements. Here we highlight two otherwise productive approaches which fall short when applied to the problem of examining qualitative changes to sociality.

Actor Network Theory (ANT) [7] has developed a vocabulary for mapping human-technology complexes. The vocabulary is unique in treating humans and things as equal agents that form networks with regard to specific events or activities such as the complex of economic, technical and social phenomena that, say, constitute mussel farming in a French fishing town [8]. We highlight here two major problems with this. Firstly, the networks evinced by ANT in such instances have an ethnographic richness which provide a detailed research platform for further inquiry. However, if one were to focus on, say, a *dynamic* issue related to mapping historical change in that network one would have to produce another, different network whose focus was not the constitution of mussel farming, but the key moments that stabilized yet another network focused on some political event, say, that threatened changes to the local economy [19]. Secondly, ANT's understanding of 'the technical' in socio-technical is convergent with the anthropological concept of material culture [10]. In itself this is no bad thing, but it offers no analytical distinctions between the material things and technologies of any era and WWW. If we are interested in mapping the unique qualities of the Web in the context of a narrative about impact and social change then ANT is somewhat moribund. It suffers a 'situated overspecificity' and can be made to fit any situation: its focus being not on the processes which predicate social action, but on the static relationships between actants.

A more historically dynamic approach is provided by Tarte et al [17]. The 'story' approach to social machines was developed as a balance to other approaches to social machines that focus less on sociality than the technology in ascertaining the principles of social machines. Tarte et al discuss a basic capacity human agents have universally to represent themselves and their worlds through a process of storying. Actors, human or machine, become 'characters' with converging 'plot lines' and following these through we can see dynamic social processes at work in social machines. From this account, we can grasp elements of how social machines emerge, sustain themselves and pass away. Thus, it has a built in grasp of social change. However, while this approach has historical sensitivity it seems to lose 'technological sensitivity'. The story approach could be applied, much like ANT, to particular historical human-technology complexes. For example, we could apply both ANT or the story approach to produce an account of the Library of Alexandria. The Library, whose heyday pre-dates the Web by 2000 years, has many features reminiscent of the Web, but with quite different technologies. To use the categories of the story approach, the library was a kind of Social Machine that enrolled participants and established them in a new form of scholarship sociality and methods of scientific practice long before the model of universities [9]. People were recruited and aligned their own career trajectories with the 'plot lines' offered by this emergent institution. The technologies invented concerned archiving and knowledge storage on scrolls such that they "gather under one roof all the world's knowledge". It became a knowledge generating machine: "Euclid worked out the elements of geometry, Eratosthenes determined the circumference of the earth. Courtesied designed a water-clock and built the first keyboard instrument. Archimedes refined his theory that explained the weight and displacement of liquids and gases, Calligraphers, poet and librarian, catalogued the huge collection of scrolls" [6].

The central thesis of the library and the stories about the prominence of the library attracted new contributors, whilst the narratives within the library and the accumulation of knowledge perpetuated a life-cycle of idea generation, cataloguing and reflection. As well a social collective that facilitated the advancement of thought across a vast array of disciplines [9].

If we apply Tarte et al's criteria to "diagnose the health" of a SM [17] to the Ancient Library of Alexandria we see high concordance with its classification as a SM, namely that it includes the 'ingredients' of a good story - that there are compelling characters, settings, conflicts and resolutions. Further, that there are stories both about and within the SM, that the machine emerged and has a finite life-cycle, or is demonstratively sustainable. The success of the Tarte et al model here is also its problem. Like ANT, we have to ask if we can re-contextualise the approach so that we can see if different technologies make any qualitative difference to the human-technology complex under review. The story model, because it applies equally well to social machines and the library suggests that it might struggle to identify what was unique about Web based social machines.

It is for the reasons given above that we sidestep ANT, and choose to concentrate on the social theory frameworks that underlie Tarte et al's more potentially productive 'storytelling' conception, and discuss how considering these gives a richer approach to understand processes within social machines.

2.2 Proposed model: socio-technical systems and Social Machines as 'reflexive project structures'

The task is to be able to identify the features of socio-technical phenomena, such as social machines, in a way that (i) enables us distinguish their characteristics from other similar and dissimilar phenomena with respect to the socio-technical interface and (ii) enables us to map and understand if, and how, social machines change the character of sociality.

The central features of Tarte et al's model are pre-figured in established social theoretical models of agency but ones which generate a broader scope than that adopted through a focus on stories alone. Broadly speaking within social theory the umbrella term social constructionism points to a number of parallel schools of thought about the formation, maintenance and decline of types of sociality within a diverse set of social and cultural ecologies. The concepts of social constructionism, its claims about agency, the relation between agents and technology and the relation of agents to group formation etc. are universal. At the same time these concepts account for the anthropological diversity and relativity of human social strategies in cognitive work such as problem-solving and creativity deployed in the course of sustaining everyday life. These concepts need to be re-developed in the light of how we now understand agency in the context of the Web. Social theory works with a series of models of human agency, each of which prioritises different aspects of

at the social contexts in which agency occurs. Some of these models focus on how human action is oriented towards pre-specified goals, how it uses resources to achieve ends what motivates it and so on. However, the debate about agency in social theory also examines what happens in social contexts where the goals of activity are not yet formulated, where they have to be negotiated, how actors are re-positioned relative to each other in some emergent enterprise and so on. Agency is associated with 'actor choice' and meaning, and social contexts are examined from the point of view of the 'social structural limits' or constraints contexts impose on such choices. While these models of agency are contested within social theory they offer more scope to Web Science than the model of agency that tends to dominate Computer Science which is based on AI implementations of the rational actor oriented toward pre-defined goals. This is only one model of agency within social theory among others that have more success across different forms of sociality. Although beyond the scope of the present paper, Web Science needs to develop a model of agency that captures the diversity of contexts found in the social world. For present purposes we adopt a revised structuration theory approach [5] which is also gaining ground in Information Science (e.g. [13]. The key advantages of structuration theory are that it provides a framework that links the level of the individual and their sense-making activities as outlined by Tarte et al, with large scale social phenomena and events spread over time and space (the focus of [16]). Structuration typically shows how large scale social changes impact at the level of individual experience, as well showing how new sense-making frames impact on the infrastructures of large scale events.

To pursue this for current purposes we outline here some generic concepts at the level of agency from our own revisions to structuration theory [19, 20] Agency presupposes ways in which the distribution of activities as events in time can be ordered and monitored. Making a cup of tea or solving the DARPA Balloon Challenge involve the ordering of sequences of activities/events in time and space. In humans this is achieved through the routine exercise of 'reflexive monitoring capacities', and in machines through feedback/feed-forward loops embedded in algorithms. Both forms require knowledge handling capabilities and knowledge acquisition (cf. [15]) processes. The structuration approach links knowledge acquisition to the 'storage capacity' of socio-technical systems at scale [5], but also with the organization of human activities at local level. We are concerned to develop a Web Science conceptualization of this here.

In our revised structurational model we argue that key to understanding socio-technical relations in the context of Social Machines requires an understanding of sociality as an arrangement of 'reflexive project structures'. This is a development of a key contribution to structuration theory [14] in which people are understood to co-ordinate their activities, carry out the cognitive work of developing goals, formulating negotiable images of goals and monitoring progress towards them through the medium of 'projects'. Projects depend on people's powers of 'narration' in that, as Tarte et al rightly point out, the story form universally enables the production of virtual representations of events. Indeed, stories that become very useful to societies are given space within media offered by their particular forms of 'storage capacity'. However, there are further properties of reflexive project structures which, if we disassemble them further, provide us with concepts that begin to show differences between socio-technical systems where types of sociality and the types of technical infrastructure can vary.

Clearly, 'projects' can take many forms and can be of different sizes - making a cup of tea, merging two corporate business organizations or carrying out web-based crowdsourced science through GalaxyZoo involve varying socialities and deployment of technical resources. In what follows we isolate features of reflexive project structures that are common to all such forms but which highlight variation between types.

2.2.1 *Analysing Reflexive Project Structures: Resources, Recognition and Responsivity*

Projects can be chronically sustained large institutions that persist over time and extend over space, that recruit and acculturate personnel or can be short time frame tasks. Social Machines can also have extensive time-space dimensions or be relatively transient. Time variation then is unlikely to be of much analytic use in understanding differences between SMs. Instead, we might look at how reflexivity, goal formation and goal orientation can be re-developed. Reflexivity is a complex cognitive process which relies on a capacity for agents to self-monitor and co-ordinate their activities in relation to each other and project goals. Projects are best conceived as 'action ecologies' that provide for the linguistic, cognitive and technological resources to generate goal images, orient participants to them and co-ordinate efforts over time. 'Resource' is here conceptualised differently to standard structuration theory. We define resources as the material that any human or machine agency utilizes (knowledge, language, cognition or technology) in the context of a project structure.

We are aware that different SMs will involve different levels and qualities of human engagement and interactivity (cf. [4]). But key to this variation, from a project structure perspective, is how reflexivity is utilised and how humans, technology and resources are re-configured with respect to one another. Furthermore, we are interested in how these configurations evolve and how reflexivity is involved in this.

Following Vass [19] we focus here on further analysing reflexivity and the monitoring process. Cognitive science has long established the importance of feedback and feed-forward monitoring of task outcomes in intelligent systems. The same models applied to machines are traditionally applied to humans. Social theory, by contrast, has developed a discourse that privileges the socially and linguistically maintained practice by human agents of 'reflexivity'. The latter enables humans in groups to co-ordinate their activities in time and space through a project structure, and 'position' each other with respect to the project in hand. Reflexivity, as a concept, provides for the manner in which human agents monitor antecedent conditions of action, draw legitimately on available resources and elaborate appropriate behaviours under the auspices of a project. Within social theory reflexivity is not generally further analysed. However, There are good theoretical reasons to create further analytical distinctions here. Vass argued that reflexivity is central to how people establish a coherent sense of self, role, identity and social position within the flux that typifies the events that make up social interactions. However, reflexivity is not just a 'feedback process'. It is made up of two mutually configuring dimensions: Recognition and Responsivity. Recogni-

Table 1: Responsivity and Recognition within SMs

		Responsivity	
		High	**Low**
Recognition	**High**	Power sharing - machines are mutually and equally constituted by all agents such that each has an equal opportunity to determine goal orientation	Power imbalance - one agent (or collection of agents) constitutes the remaining agents such that the latter has little agency to change their role/orientation
	Low	Projection - one agent (or collection of agents) provides a narrative and enacts agency on behalf of a 'silent' or identity-poor agent	Data objects - agents perform data exchange with little attempt to re-orient goals

tion refers to the way in which project structures provide for the fact that participants need to establish or maintain their 'social positions', and how this positionality is acknowledged and made available as a resource for other participants. Responsivity refers to the quality and speed of reaction to the efferent activity of participant humans and technologies, but also the levels of Recognition given in responses to participants. Approaching project-monitoring and reflexivity in this way enables us to dimensionalise reflexivity into a matrix of correlated variables: high/low Recognition and high/low Responsivity (see Table 1). This distinction is based on a set of arguments [19] that remind us that although socialites vary in their characteristics and all humans organise their activities by reflexively monitoring them, we need to be aware that humans adopt different strategies in the monitoring process that enables them to establish how they are situated with respect to each other and with respect to the nature of the project tasks. Indeed, it has been shown [18] that even in the group problem-solving of mathematical problems understanding one's social position through the Recognition of others can be used as a 'resource' to further elaborate problems to the solution of the task.

In the following section we look at some examples of SMs and provide a preliminary analysis based on the features of reflexive project structures outlined above. In particular we are keen to see if profiling SMs according to the dimensions associated with these features enables us to evince qualitative differences between types of SM.

2.3 Case Studies

2.3.1 CAPTCHA

CAPTCHA is an example of a SM with dual goal structure - an explicit goal (a user wants to gain access to a site, and the site owner wants to protect the site from malicious non-human web-crawlers; and a concealed goal - CAPTCHA images typically consist of a 'known' element (which the site uses to verify that the users are human and an 'unknown' fragment, which the user labels with a semantically accurate description of the image (albeit generally unwittingly).

The opportunity for (alternative) goal formation is limited - Durkheim [3] might reflect that users are recruited much as factory workers were in the industrial era - they are cogs in a larger machine, but have little ability to sculpt their surroundings or work conditions such that they exhibit low levels of agency. In this sense, whilst the human participants receive high Recognition for their ability to recognise the 'semantics' of a given image much more efficiently than any machine learning algorithm is currently capable of, they are recruited much like a machine, to perform an algorithmic process with low levels of Recognition and Responsivity.

2.3.2 DARPA Balloon Challenge

In the DARPA Balloon Challenge, the primary goal was prescribed, namely, the first team to accurately relay the location of 10 red weather balloons would win $40,000 [11]. The approach implemented by the winning team from MIT involved the recruiting the lay public with financial incentivisation and recommender strategies - thus outsourcing further recruitment to already recruited participants in a pyramid like structure of diminishing returns. MIT's approach provided high Recognition in the assignation of roles to human and non-human actants in the search for balloons, but little opportunity for recruits to re-shape the approach. The challenge was not without subversion attempts, whereby users formed 'devious' goals via the misreporting of the position of balloons (by error or malice) [11], but MIT's verification processes resulted in the most time efficient SM that took up the challenge.

In contrast, the team ranked 10^{th} formulated a different sort of social machine that relied in part on a strategy that (if it were the sole strategy) was by definition, never going to win, but that interacted with other SMs. Their strategy was to use web-based technologies to crawl the social networking sites employed by other teams to 'scrape' the location of balloons found by rival agents. This form of SM clearly shows a power imbalance and almost 'parasitic' re-purposing of the knowledge of others (low Recognition) in near real-time.The immediacy of connectivity afforded by social media streams ultimately facilitated both teams allow teams in their approaches, such that the winning team was able to locate all 10 balloons in under 9 hours, a feat inconceivable without the web.

2.3.3 Retro Computing Website

The site is a focus for a community repairing and maintaining 8 bit computers over 30 years old. Enthusiasts develop new hardware, software and interface projects so that old 8 bit technology works with new technologies. The website is a focus for formulating new projects. Distributing new hardware and software, repairing machines and has an extensive forum. The forum acts as a community knowledge repository and a resource for creative problem-solving online as issues are resolved and new hardware problems are adapted to modern electronic resources.

In a typical forum post, goal formation is initially the domain of the Original Poster (OP), who poses a question for which they need the help/opinions of others. It may thus initially appear as if the OP holds total agency in the formation of the social machine's goals, and the respondents are merely recruited to perform the role of responding to the query. However, in reality, the respondents are often

Table 2: Agency and Reflexivity Profiles of Case Study SMs

	Agency			Reflexivity	
	Human	Non-human		Recognition	Responsivity
	Symmetry	Embedded	Architecture Afforded		
CAPTCHA	Asymmetric	High	Volume ✓ Response Speed Storage & Retrieval	Low	Low
DARPA (MIT)	Asymmetric	Low	Volume ✓ Response Speed ✓ Storage & Retrieval	High	Low
DARPA (10^{th})	Asymmetric	High	Volume Response Speed Storage & Retrieval ✓	Low	Low
Retro Computing Website	Symmetric	Low	Volume Response Speed Storage & Retrieval ✓	High	High
Ubertee	Asymmetric	High	Volume ✓ Response Speed ✓ Storage & Retrieval	High	Low
Sikh EDL	Symmetric	Low	Volume ✓ Response Speed Storage & Retrieval ✓	High	High

involved in collaboratively re-formulating goals and in extending the enquiry into interesting asides. Often the OP will (in their ignorance) not ask the 'right' question, and a negotiation between OP and respondents about the nature of problem they are trying to solve involves relatively high agency on all sides in the formulation and completion of the project.

The maintenance of the forum SM relies on the Responsivity and intersubjectivity of the respondents and OP. An OP who receives no responses, or wholly negative comments is incentivized to not post again. Recognition, both of the OP and of the respondents who provide useful information is also key to the project of the forum. One prominent feature of fora is that whilst the role of the OP and the handful of respondent agents is obvious, the post itself becomes a resource for thousands of future users who search and model their activities around the archive of relevant posts, thus shaping the formation of goals and perpetuity of the forum as an SM.

Whilst the analogous term 'forum' indicates that this sharing of knowledge and debate is not unique to the web, it is poignant to note that the retrieval of this information (and thus the speed and breadth of the dissemination of this acquired knowledge is greatly facilitated by the architecture of the web. Where previously, there may have been no resources available to the web using community at large about the problem of interfacing a retro device with modern equipment (the problem is a novel one), the power of search engines allow the fruits of this SM to permeate the web.

Furthermore, some fora harness the desires of their users to develop products, e.g. adapters that will allow users to interface retro computers with modern devices. In this sense, the social machine can be seen to contribute to a fundamental shift in the market research of tangible goods.

2.3.4 Übertee

Übertee is a further example of how (online) SMs can be seen to alter the demand structure and manufacturing processes of tangible (offline) goods. Übertee's model is based on the contributions of three forms of human actor - the designer, the voter and the consumer; a non-human actor in the form of web technologies and Übertee itself, an organizational collextive. The goals of each are distinct, but highly interdependent, demanding the Responsivity of one another to fuel the SM.

- The *designer* is an actor who uploads a t-shirt design, which they hope will be chosen to be printed, and receives commission for t-shirts sold.
- The *voter* is a user (usually also a designer, consumer or both) who peruses t-shirt designs and votes on which designs they would like to become available to buy.
- The *consumer* is a user who purchases one of the t-shirts of the day.

The business model limits the choice of t-shirts to a handful per day, which have count down clocks permitting orders only in a 24 hour window, thus channeling consumers to purchase a design for which the crowd has shown preference, greatly reducing manufacturing costs, virtually eliminating overstock and giving consumers a sense of owning a 'limited edition' product.

Übertee therfore shows how an SM comprising five fundamental actors can effect a very efficient manufacturing process such that the balance of power is shifted from consumer to producer. Übertee is facilitated by the ubiquity and speed of communication and hinges on the successful recruitment of the designer, voter and consumer actants, but also avoids the intial investment and reflexivity required in marketing products in tranditional market places.

2.3.5 Sikh EDL

With the advent of the Sikh EDL, an ethnic minority wing within the broadly anti-Muslim English Defence League (EDL), prominent on sites such as Facebook, we see an emergent SM

that must grapple with two seemingly opposing characteristics in the formation of their identity as a group. We are currently witnessing the relationship between two reflexive project structures (Sikh and mainstream EDL). One of the emergent outcomes are new forms of identity based on high Recognition work where members of both project structures promote and sustain the social positions of the membership. On the one hand, Sikhs are a historically immigrant population apparently coming into alignment with a group who traditionally would be antagonistic, on the other, they are English and have a shared goal with the traditional EDL to eradicate the perceived 'Islamification' of England.

Sikh's engagement with social networks allows them significant agency in contemporaneously exploring and expressing their Sikh, English and EDL-sympathetic identites, allowing a reconciliation of these conflicting statuses that would be difficult to accomplish without web-mediation as a member of an immigrant or mixed community.

2.4 Summary of Case Study SMs

A summary of the 'agency' and 'reflexivity' (Recogntion and Responsivity) profiles of each of the case studies discussed is shown in Table 2. Here, the human agency is the capacity of human actors to constitute the functionality of the machine (as outlined in Table 1). This is represented in terms of 'symmetry', where a highly symmetric SM would facilitate all human agents equal power in the constution of the machine; and a highly assymetric SM describes a machine where a small minority of human actors have all the power in shaping the lifestory of the SM. Non-human agency is split into: *Embedded* - the capacity of non-human actors to constitute the functionality of the machine; and *Architecture Afforded* - prominent features of Web technologies that facilitate the SM, and are specific to the domain on the Web.

Three examples of such affordances are described in the table with a check mark indicating particular importance of this factor for the given machine. The exemplar factors are:

- Volume - the machine is made possible by the volume of agents brought together, or in the case of Sikh EDL, by the volume of a specific type of agent that may not congregate offline for practical or cultural reasons.
- Response Speed - the machine benefits from the speed of communication afforded by Web technologies.
- Storage & Retrieval - the machine is aided by the Web's capacities as a data storage silo and the efficacy of search engines to index and retrieve information.

3. CONCLUSIONS

These examples highlight the enormous variation in the form, domain, purpose and distribution of agency within social machines. The identication of a robust taxonomy to describe and explain these phenomena is not trivial. By examining the mechanisms of goal formation and project structuring of social machines we are beginning to see variation along the axes discussed in this paper. We suggest this is a productive path to follow as the universality of reflexive project structures suggest that, although developed in the context of Web Science has much to offer an understanding of the social world within an emerging digital sociology.

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