Social Machines

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INTRODUCTION

A key trend in the recent technological evolution of the Web has been the development of applications and services that support greater levels of user participation in the generation and management of online content. The Web has now emerged as a platform in which user communities play a key role in terms of what appears online, and the sole purpose of many sites on the Web is to support users in generating, editing and organizing online content. With the transition to greater levels of user participation, we have witnessed the rise of what has been referred to as the 'Social Web': a suite of applications, services, technologies, formats, protocols and other resources, all united in their attempt to both foster and support social interaction. Social media sites (e.g., YouTube), social networking systems (e.g., Facebook), and microblogging services (e.g., Twitter) all form part of this Social Web, and they have arguably transformed our traditional notions of what the Web can be used for. Far from being a mechanism to simply support the online publication and dissemination of information content, there is a growing sense that the Web can play an important role in a broad range of social processes. These range from simple forms of social interaction through to the coordination of large-scale collaborative efforts. They include various forms of socially-distributed problem-solving, various aspects of social relationship management (including the formation, maintenance and dissolution of both professional and personal relationships), and various aspects of social cognition or social sensemaking (for example, person perception). To an ever-greater extent, the Web is serving as a platform on which a variety of social process are implemented. Some of these are familiar processes; others are not. All of them, however, are shaped by the properties of the Web.

In response to the growth of the Social Web, a panoply of new terms has arisen to refer to various parts of the emerging conceptual landscape. We thus have terms such as crowdsourcing (Doan, Ramakrishnan, & Halevy, 2011), human computation (Quinn & Bederson, 2011), collective intelligence (Malone, Laubacher, & Dellarocas, 2010), social computing (Parameswaran & Whinston, 2007), the social operating system (Rainie & Wellman, 2012), and social machines (Hendler & Berners-Lee, 2010). This latter term, which is the focus of the current chapter, was first used in a Web context by Berners-Lee and Fischetti (1999), and it has since grown in popularity to the point where it is now the focus of large-scale research programs, such as the EPSRC's SOCIAM initiative[i], and the subject of a multitude of academic publications (e.g., Hendler & Berners-Lee, 2010; Shadbolt et al., 2013; Smart, Simperl, & Shadbolt, in press). The term is typically used in relation to systems such as Wikipedia, Facebook and Twitter, which are among some of the most popular sites on the Web today. In addition, the Web itself has been presented as a social machine (Hall & Tiropanis, 2012). This highlights the potential significance of the term to the Web and Internet Science community. By identifying a set of mechanisms and processes that are at the core of the Social Web, the notion of social machines serves as a conceptual anchor for research efforts associated with the nascent discipline of Web Science (Berners-Lee et al., 2006). In addition, by focusing attention on Web-based systems that are involved in the mediation or material realization of social processes, the notion of social machines serves to emphasize the *socio-technical* nature of the Web, and it provides the basis for multidisciplinary collaboration with the social scientific community. Such collaboration is of vital importance given the increasingly significant role the Web plays in the functioning of contemporary society.

The current chapter aims to provide a brief overview of social machines and associated research efforts. We start by focusing on what is meant by the term 'social machines'. Although social machines are the focus of current research, there is no consensus, at the present time, as to what the term 'social machine' actually means. This is unfortunate because without an ability to say what social machines are it becomes difficult to know where to focus research and development efforts. In addition, an understanding of the social machine concept is crucial if we are to answer questions concerning the relationship between social machines and ostensibly similar concepts, such as those associated with social computing, crowdsourcing, human computation and collective intelligence systems. One of the main aims of this chapter, therefore, is to critically evaluate the initial characterization of social machines, as made by Berners-Lee and Fischetti (1999), and propose a working definition of the social machine concept. A second aim of this chapter is to examine the variety of social machines that are available. Thirdly, we will look at some of the issues that form the basis for future research efforts into social machines.

BACKGROUND

What are Social Machines?

The topic of social machines has been the focus of increasing interest within the Web and Internet Science community in recent years. A multitude of research papers attests to this growing interest, as does the funding of large-scale research programs designed to investigate the capabilities and characteristics of social machines. In spite of this interest, however, there is still considerable confusion as to what the term 'social machine' actually means. The term is clearly used to draw attention to Web-based systems that feature some degree of active human participation, and it is this notion of active human participation that seems to be critically important to what makes something a social machine – systems in which humans merely browse or consume content without contributing anything in return do not seem to be regarded as social machines. But beyond this rather vague notion of active human participation there does not seem to be any consensus on what it is that makes something a genuine member of the class of social machines. This is not to say that people have been reticent in terms of pointing out specific examples of social machines. FaceBook, mySpace, Twitter, Ushahidi, Galaxy Zoo, reCAPTCHA, and Wikipedia have all been cited as examples of social machines. It thus seems relatively easy for people to point to specific examples of social machines, but it seems far less easy to identify what it is that enables us to treat these exemplars as a conceptually unified bunch. It is possible, of course, that the extension of the concept 'social machine' is something that can only be fixed by ostension. However, even in this case, it seems important to understand what it is that actually underlies the ostension: what are the features of certain kinds of Web-based system that appeal to our intuitions as to when we confront a genuine member of the class of social machines?

Perhaps the most popular characterization of what constitutes a social machine is provided by Berners-Lee and Fischetti (1999) in their book 'Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web': "Real life is and must be full of all kinds of social constraint – the very processes from which society arises. Computers can help if we use them to create abstract social machines on the Web: *processes in which the people do the creative work and the machine does the administration*" [our emphasis] (p. 172).

According to this characterization, we confront a social machine whenever we encounter a process in which there is a division of labor between the human users of a Web-based system and the technological elements that actually realize the processes implemented by the system. In particular, the contributions of the human end users should consist in some form of creative work, while the contributions of the machine components should consist in some form of administrative activity. Setting aside the (not unproblematic) notion that social machines should be equated with some form of process, the key features of this kind of characterization are 1) that multiple individuals are engaged in a process, 2) that the processes engaged in by the individuals are actually part of a larger joint process that is (perhaps essentially) bio-

technologically hybrid in nature (i.e., it requires the contribution of both human and machine elements), and 3) there is a commitment to the idea of human and technological elements fulfilling particular kinds of roles, roles that are (perhaps broadly) construed as either creative or administrative in nature.

One immediate problem with Berners-Lee and Fischetti's (1999) characterization concerns the precise meaning of the term 'creative work' and the extent to which it is just the human agent that can be said to perform it. The problem exists because it is not always clear that human creativity is something that can (easily) be accomplished in the absence of some form of bio-technological or bio-artifactual entanglement. Many cases of human creativity could be said to be ones in which extra-organismic resources are playing some form of representationally and/or computationally significant role. In the process of writing an academic paper, for example, we often witness a rich series of brain-body-world interactions that serve to productively constrain the nature of what gets written (Clark, 1997, p. 207). Inasmuch as human creative accomplishments are the product of processing loops that (at least occasionally) incorporate bio-external resources (see Clark, 2008), then it seems important to avoid a perspective that limits the kinds of roles that can be performed by human and machine elements, and which additionally seeks to impose a strict (and rather artificial) boundary on where particular processes need to take place.

Of course, it is possible that the notion of 'creative work' referred to by Berners-Lee and Fischetti (1999) is not so much about the generation of new artefacts or ideas as the generation of online content. Thus, when we look at purported examples of social machines, such as Wikipedia, what we encounter are situations in which humans are playing an important and perhaps indispensable role with respect to the creation of certain kinds of content. The human agents are 'creative', in this sense, simply because they are generating content that might otherwise be difficult or impossible for a machine to generate by itself. What we end up with, therefore, is the sense of humans playing a role in terms of the generation of *certain kinds of content*, content that the machine components (by themselves) would be unable to generate. According to the rest of Berners-Lee and Fischetti's claim, we can see the role played by the machine elements as largely 'administrative' in nature; i.e., as ones in which the function of the machine elements is to support humans with respect to the generation of content that they (humans) are best placed to provide.

Although Berners-Lee and Fischetti's (1999) characterization of social machines has been useful in terms of focusing attention on what it is that makes something a social machine, we suggest that the emphasis placed on the specific roles performed by human and machine components (creative, administrative, or otherwise) is overly restrictive and unnecessary. We suggest that social machines are best understood as systems in which human and machine components make complementary contributions with respect to the performance of some larger joint process. The nature of these contributions is obviously related to the kinds of capabilities possessed by human agents and conventional computing systems, and these may, at least in some cases, make the technological elements of a social machine best placed to play an administrative role while the human agents engage in more creative activity. However, there is no reason why human and machine elements *must* fulfill these roles. What matters most is that social machines are able to draw on a complementary range of representational and computational resources and exploit these to achieve forms of processing that would otherwise be difficult or impossible to realize. This is highlighted by one popular example of a social machine, namely Galaxy Zoo[ii]. Galaxy Zoo is a system whose most salient feature is that it engages in a particular task, namely galaxy classification. In performing this task, Galaxy Zoo relies on a set of representational and computational resources that are firmly embedded in the technological fabric of the Web. By themselves, however, these resources are not sufficient to realize the specific task that it is Galaxy Zoo's job to perform. It is only by factoring in the contributions of the human community that the larger system is able to achieve its information processing objectives, and this makes the human agents an important (and perhaps indispensable) part of the machinery that realizes the relevant target property (the performance of the galaxy classification task) of

the larger bio-technological ensemble. Both human and machine elements emerge, in this case, as forms of 'participant machinery' (see Clark, 2008, p. 207) relative to the information processing economy of the larger system (the social machine) in which they are situated.

In view of this discussion, we suggest that social machines can be defined as *Web-based socio-technical systems in which the human and technological elements play the role of participant machinery with respect to the mechanistic realization of system-level processes*. Although this definition is somewhat provisional, it captures, we suggest, the essential nature of social machines on the Web. A few features that are either explicit or implied by this definition are worth elaborating on here:

- Firstly, it should be noted that **social machines are *social* machines**, that is they feature the involvement of *multiple* human individuals. Because of this, many social machines will be involved in the realization of what may be called 'social processes' (i.e., processes that concern the interaction, communication and relationships between human individuals).
- Secondly, **social machines are systems that draw on the complementary contributions of both human and machine elements**. Human agents are the locus of particular kinds of capability that subtend the epistemic, cognitive, perceptual, behavioural, social, moral, emotional, affective and aesthetic domains. Computing technologies, in contrast, are renowned for their speed of processing, their ability to engage in repetitive symbolic manipulation, their capacity for digital data storage, and so on. By drawing on these diverse capabilities, social machines are poised to extend the reach of *both* human and machine intelligence, perhaps realizing at least some of the capabilities (e.g., curing a disease, solving world hunger, or deriving solution strategies to mitigate the effects of climate change) that have been mooted as the targets of the next generation of social machine systems (see Hendler & Berners-Lee, 2010).
- Thirdly, **social machines are forms of bio-technologically hybrid systems**. Bio-technological hybridization is an *essential* feature of social machine systems. Absent the human participation and the social machine ceases to be; shut down the machine components and the social machine is unable to function. It is, in fact, entirely possible that the kinds of processes realized by social machines are ones that *necessarily* depend on the specific form of bio-technological coupling that social machines make available. It may be that there is simply no other way in which the same process could be realized without resorting to some form of bio-technological hybridization.
- Fourthly, some of the most interesting extant **social machines are Web-based systems**. It is the socially-embedded nature of the Web – the fact that the Web is increasingly involved in every aspect of our lives – that makes Web-based social machines capable of supporting processes that would be difficult to realize in other social (or socio-technical) contexts. This makes social machines a compelling focus of scientific and social interest and a particular point of interest for those working in the Web Science community.
- Finally, **social machines may function as social systems**. Certain kinds of social machine may (on occasion) resemble miniature social systems, complete with their own norms, roles, practices, values, incentives, rewards, sanctions, and so on. Echoes of this sort of view can be found in the literature on social machines. Hendler and Berners-Lee (2010), for example, talk of the "social system" that has evolved in Wikipedia to control the quality of online content, with some users assuming the role of superuser to 'lock down' wiki pages that are controversial or out of control. McBride (2011) also seems to countenance this view of social machines when he states that social machines are a "combination of technology, rules, policies and organizational structures which drive or manage a social system".

Varieties of Social Machines

Social machines come in all shapes and sizes. Based on a list available from the SOCIAM project website[iii], social machines include systems such as Digg, Reddit, Facebook, Galaxy Zoo, LinkedIn, Wikipedia, and Ushahidi. As is evidenced by this partial list of social machines, social machines seem to be something of a motley bunch when it comes to their features, functions and user bases. This heterogeneity underscores the current interest in identifying the various types of social machines that exist, and it motivates the effort to develop a taxonomic framework for social machines (Smart et al., in press).

Based on the set of social machines that have been discussed in the literature, and which are the focus of ongoing research efforts, we can identify a number of different types of social machines:

- One important class of systems seems to be involved in processes associated with the formation and management of social relationships. These relationships can be of a variety of kinds. They could, for example, be familial and friendship relationships in the case of systems such as Facebook, professional relationships in the case of systems such as LinkedIn, or romantic relationships in the case of systems such as Match.com (i.e., online dating sites).
- Another class of systems seems to be concerned with the pooling, organization and distribution of certain kinds of resources. Some kinds of image and video hosting sites, such as Flickr.com may fall into this category. Interestingly, many of the systems that do fall within this category tend to conform to the original characterization of social machines as provided by Berners-Lee and Fischetti (1999). Take, for example, a highly popular range of websites that have been largely ignored by the Web Science community: sites with pornographic content. The most popular of these sites are all ones that rely on the user community to upload videos that are then shared for free with other users (Wondracek, Holz, Platzer, Kirda, & Kruegel, 2010). As in other domains, this model – where the host provides the infrastructure to support content creation and sharing, while the user community provides the actual content – has proven to be tremendously successful, both in terms of the scale and scope of available content, as well as the actual number of visitors the sites manage to attract. Inasmuch as we regard social machines as systems in which "people do the creative work and the machine does the administration", then it is probably acceptable to view many of the most popular online pornographic sites as social machine exemplars. As with many other kinds of social machines, the sites that host these systems are among the most popular on the Web today.
- A variety of social machines seem to be concerned with the provision of social support, advice, information and guidance. Sometimes this function can be served by social networking systems, such as Facebook; however, more often than not, people will turn to specialized discussion groups or Internet forums in order to seek advice on specific issues (e.g., medical or dietary advice).
- Systems such as Wikipedia epitomize an important class of systems that support the process of collaborative creation and editing.
- Some systems can be seen as supporting the coordination of collective action, often at large scale. Systems such as Ushahidi, for example, have served as a platform for social activism and the coordination of humanitarian relief efforts (as in the aftermath of the 2010 Haitian earthquake).
- Finally, we can discern a class of systems that seem to be involved in forms of socially-distributed problem-solving. The Zoouniverse collection of projects, for example, all provide opportunities for community involvement in the process of scientific analysis (e.g., galaxyzoo.org) and discovery (e.g., planethunters.org).

This way of categorizing social machines is only one that could have been undertaken. In distinguishing between the aforementioned types of systems, we have chosen to emphasize the (typical) function of the

social machine; i.e., the kind of thing the social machine does. Clearly, this is only one way of discriminating between distinct classes of social machines. Other typologies could focus on (e.g.) the nature of the processes that are being realized by the system, the role played by human and machine components in the larger information processing ensemble, or the features of the user base associated with the social machine.

FURTHER RESEARCH DIRECTIONS

In addition to an ongoing effort to characterize, classify and describe social machines, a broad range of issues are the focus of current research efforts. The following are just some of the research questions being addressed by social machine researchers:

- How does a greater emphasis on the social environment impact our contemporary approach to software development? The advent of social machines introduces us to the notions of the 'social computer' (Robertson & Giunchiglia, 2013) and the 'social operating system' (Rainie & Wellman, 2012). The claim here is that such systems cannot be programmed in traditional ways, and thus new methods, techniques and perspectives are required (see Robertson & Giunchiglia, 2013).
- What are the mechanisms that motivate individuals to participate in a social machine, and what kinds of mechanisms ensure their continued participation? What can be done to dissuade participation in socially-undesirable systems, such as carding forums?
- What are the social impacts of social machines? By supporting the emergence of new forms of social interaction, organization and coordination, social machines are progressively altering the way a broad array of social activities are performed, ranging from the way we communicate and transmit knowledge, establish romantic partnerships, generate ideas, produce goods and maintain friendships. Social machines may also precipitate more profound forms of social change, fundamentally transforming the organization and dynamics of the societies in which we live.
- How can we monitor the activity of social machines and collect sufficient data to drive future analytic efforts? The work that is being undertaken as part of the Web Science Observatory initiative (Tiropanis et al., 2013) is of crucial importance here.
- What are the psychological impacts of social machines? There has long been a concern that Web-based forms of social interaction constitute an impoverished form of social exchange – one that inevitably leads to negative outcomes (such as loneliness and depression) for its users (Turkle, 2011). Are such views relevant to the forms of social interaction and engagement that are enabled by contemporary social machines? What about individuals who choose not to engage with such systems? If social machines emerge as one of the primary means by which social relationships are formed, maintained and managed, does a failure to participate in social machines result in isolation and marginalization? Should equal attention be devoted to understanding the potential psychological consequences of a *failure* to engage with social machines as part of the future network society?
- How can we engineer social machines to meet a broad range of functional and non-functional criteria? We want social machines to satisfy a range of performance criteria; for example, we want them to efficiently realize their intended processing objectives. However, a range of other issues are also at stake. As social machines become increasingly embedded in the fabric of our society, issues of privacy, trust and security become of increasing significance.
- How can we adaptively configure social machines in order to ensure their proper functioning? A subset of social machines may be cast as distributed cognitive systems in which the objective is to perform some form of socially-distributed cognitive processing; for example, collective sensemaking. In order for such systems to function effectively, it may be necessary to modify the flow of information and influence within such systems at specific junctures in the problem-solving process.

CONCLUSION

The notion of social machines identifies an important part of the emerging conceptual landscape associated with the Social Web. We suggest that social machines can be defined as *Web-based socio-technical systems in which the human and technological elements play the role of participant machinery with respect to the mechanistic realization of system-level processes.* This definition serves to focus attention on the way in which Web-based technologies serve to control, constrain, coordinate or otherwise influence an increasing number of social processes. Purported examples of social machines include Facebook, Twitter, Wikipedia, Reddit, and (perhaps) a number of adult content websites. These systems are among some of the most popular on the Web today, and this underscores the importance of studying them within the context of the nascent discipline of Web Science. The notion of social machines also serves as a conceptual anchor for a variety of otherwise disparate research and development efforts. In addition to an ongoing need to catalogue social machines and understand their mode of operation, there is also a pressing need to understand their social impacts. Given that society is, at least in part, constituted by social processes, it should be clear that social machines – in virtue of being involved in the material realization of such processes – are well-placed to serve as the engines and social change and transformation. This makes the study of social machines of crucial importance, not just for those concerned with the development of popular Web-based systems, but also for those who are concerned about the power and potential of certain forms of socially-directed technological scaffolding to exert broader effects on the structure and organization of social life.

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KEY TERMS AND DEFINITIONS

Social Computing: Social computing is a general term for an area of computer science that is concerned with the intersection of social behavior and computational systems.

Social Machine: Social machines are Web-based socio-technical systems in which the human and technological elements play the role of participant machinery with respect to the mechanistic realization of system-level processes.

Social Networking System: A social networking system is a platform to build social networks or social relations among people who, for example, share interests, activities, backgrounds, or real-life connections.

Social Web: The Social Web is a set of social relations that link people through the World Wide Web. The Social Web encompasses how Websites and software are designed and developed in order to support and foster social interaction.

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[i] See http://www.sociam.org/.

[ii] See http://www.galaxyzoo.org/.

[iii] See http://www.sociam.org/social-machines.