The HTP Model: Understanding the Development of Social Machines

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ABSTRACT

The Web represents a collection of socio-technical activities inter-operating using a set of common protocols and standards. Online banking, web TV, internet shopping, e-government and social networking are all different kinds of human interaction that have recently leveraged the capabilities of the Web architecture. Activities that have human and computer components are referred to as social machines. This paper introduces HTP, a socio-technical model to understand, describe and analyze the formation and development of social machines and other web activities. HTP comprises three components: *heterogeneous networks* of actors involved in a social machine; the iterative *process of translation* of the actors' activities into a temporarily stable and sustainable social machine; and the *different phases* of this machine's adaptation from one stable state to another as the surrounding networks restructure and global agendas ebb and flow. The HTP components are drawn from an interdisciplinary range of theoretical positions and concepts. HTP provides an analytical framework to explain why different Web activities remain stable and functional, whilst others fail. We illustrate the use of HTP by examining the formation of a classic social machine (Wikipedia), and the stabilization points corresponding to its different phases of development.

Categories & Subject Descriptors

H.1.2 [Information Systems]: User/Machine Systems

Keywords

Web Engineering, Social Machines, Web Science

1. INTRODUCTION

The Web is not just one monolithic thing, but many: it is the product of a mix of technologies, documents, information, human activities, governing standards, and cultural practices, that act to reify the abstract "information space" that W3C formally identifies as the Web [11]. The co-constructive relationship between humans and technologies has enabled these activities to emerge and grow; and offers new ways for individuals (both humans and machines) to connect with each other, communicate, share information, and disseminate knowledge [4]. Indeed, established 'social systems' or 'fields' [3] such as news, music and video broadcasting are changing, shifting from traditional systems such as Television networks, to alternative platforms using distributed methods, including social media, Web TV, and similar socially interactive Web activities [7].

The Web, like society, is diverse in content, use and purpose, and also in terms of the technology that underpins it; it uses different protocols, programming languages, services, hardware stacks, and indeed, is accessible via different Web browsers or even native mobile applications. The development of the Web is improving the rate at which information and news can be disseminated and obtained [10], which itself has an impact both on the physical infrastructure of the Web – traffic, server loading, bandwidth – and on society and individuals – information integrity, validity and digital literacy.

As a result of this, capturing, or even conceptualizing how the Web operates and develops is a challenging task. Not only are the interactions between humans and technologies occurring within the online environment, but also across the blurred boundaries of the online and offline. One could examine the Web in order simply to re-engineering aspects that are sub-optimal; alternatively one could enquire why is it operating in a particular way, what this means, and how can we learn from it. Such a perspective appreciates the delicate socio-technical relationship between humans and technologies, and takes into consideration the impact of *interpretive flexibility* [2,5] on the Web's development. Simply, the development pathway of a technology is influenced by both the capabilities of the technology and the acceptance and use of it by humans and society. This makes the former (re-engineering) approach ineffective – we need to understand the co-constructed Web that has emerged.

Researchers are searching for methods to understand the rapid growth of the Web and its integration into society. In comparison, the development of our research methods have not been as fast, and as a consequence, we are without tools or models to offer an explanation or analysis of the socio-technical relationship between the humans and technologies. Aware that the Web does not operate solely as a technology – even the most sophisticated, autonomous machine or automated process requires at some point the involvement of humans – we are faced with a problem; as Tim Berners-Lee appropriately commented, the Web is a "*social machine*" [1], and Web activities such as social networking, online shopping etc., are *social machines* as well. They rely on the interactions between humans and technologies to function and grow; therefore, we need models and theoretical perspectives to start to understand this.

This paper introduces a novel model to understand the growth and structure of Web activities. HTP, which uses 3 concepts to understand the evolution of social machines, captures the co-constructive relationship between humans and machines; and is grounded by an interdisciplinary approach drawing upon sociological, philosophical, and computational concepts. We use HTP to construct an understanding of the Web that reflects its distributed, large-scale, emergent properties. We consider the Web as a network of networks, and provide a model to explain how

these networks – constructed themselves of networks of actors – function, at the micro and macro.

2. THE HTP MODEL

According to the W3C, the Web as an "*abstract information space*" [11] that relies on the development and use of technologies to make that space tangible – as a repository of linked documents, or a network of social interactions, or a mesh of linked devices, or a gallery of cultural artifacts. Drawing from mix of theoretical perspectives [8], we propose a conceptualization of this process as follows:

(1) The Web is developed by networks of actors that are **heterogeneous** (both human and machine) in structure, formed and driven around an agenda like Open Data or Citizen Science or Free Educational Content.

(2) Each network gains actors and become stable enough to make progress on its agenda and achieve its agreed outcomes. This is a **translation** of an initially unorganized set of network participants into a mobilized network of activities.

(3) The success of a network triggers changes in the surrounding networks (who share participants and goals), which in time causes a restructuring of the original agenda, changing the network and causes new **phases** of activity.

The following sections describe, in abstract, the individual components that form this 3-part "HTP" model. Section 3 applies this model to describe the development of the Wikipedia social machine.

2.1 Heterogeneous Networks (H)

The first component is based upon the concept of heterogeneous networks, which suggests a network is made up of both human actors and technological actants associated together by common interests; these associations are fluid, transient, and constantly reshaping [9]. In this account there is no methodological distinction between the humans and technologies, and as a consequence of their interactions the network exists, takes shape and produces outcomes. Individually, actors (and actants) have interests and goals, which in turn are shaped by the network that they belong to. There is a reflective relationship between the interests of the actors, and the shaping and outcomes of the network.

As a consequence of the dynamic nature of heterogeneous networks, they cannot be represented by a static illustration, and cannot be captured in the same perspective that we are familiar with in computer science or network science. They represent a dynamic network of associations and interactions between human and technologies. These associations might – but more often than not – represent the exchange in physical artifacts, or forms of communications and interaction, but these associations only exist at the time they occur, dynamically changing with the actions of other actors.

The heterogeneous networks are a product of the associations and interactions between actors and remain in a state of operation – stability – as long as the actors involved are committed to the shared agenda of the network; and over time this agenda may change due to the inclusion or loss of new and existing actors. Heterogeneous networks exist both at the micro and macro, and offer a way to capture the varying scale of emerging networks. Synonymous to the Web, heterogeneous networks are fractal in their structure: actors within a network also represents a heterogeneous network of actors, offering a way zoom in or
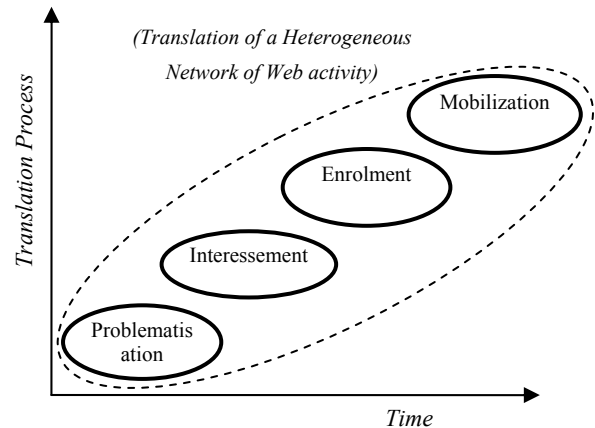

(Translation of a Heterogeneous Network of Web activity)

Figure 1. Illustrating the second perspective of the conceptualization of the Web, using the concepts of Heterogeneous networks and Translation

abstract away from the details. This therefore provides a way to explore the interaction between different Web activities that are interacting with each other via some shared entity. Actors may be part of multiple networks, and it is their interests – along with the other actors in a network – that defines and shapes the networks that they are in [5].

What advantage does deconstructing the Web in terms of the components and concepts associated with heterogeneous networks provide, and how does it help us form a theoretical position that enables us to conceptualize the Web? The answer lies within the deconstructive process; we no longer assume that the Web exists, we do not start with the entity that we recognize as the Web, but instead, the association between actors and the eventual outcomes of their interactions forms the different activities that we collectively label: 'The Web'.

2.2 Translation (T)

In the previous subsection we described the Web as a collection of heterogeneous networks, working in alignment or competition with each other via shared actors (or actants). However, this offers little to no detail of how the Web activities reached the state being observed, relative to the changes over time: the associations between actors are only temporarily stable, actors join and leave, and as a result, the network and its agenda is constantly changing shape and moving between states of development.

In order to capture this, we draw upon the concept of *translation* [8], which provides us with an understanding of how a network develops over time. This, as Figure 1 shows, helps describe how an initial set of actors led by a focal actor, gains the co-operation of new actors, in order to achieve the goals in response to the network agenda set out. Based on this '*network translation*', we can see how network outcomes are produced, and critically, how a network remains stable or fails. Translation is an iterative process, and depending on the size and commitment of the actors, happens at different rates of progress. For instance, a network may be achieving specific goals and operating in a stable state, but if the network incurs a disruption, the loss of an actor, or the threat of a competing network (e.g. Friendster against MySpace, or MySpace against Facebook), it may return back to the original state of translation – Figure 1, *Problematisation* – to re-define the goals that the network (or the original actors) can now realistically achieve. Therefore, progress is both a measure of time and state in translation.

We use the concept of translation to offer a finer level of granularity of how activity within a network occurs, and also as a way to discuss the actions of the actors and the 'progress' of the translation and the state that it is currently in. Using the concept of translation, it turns the seemingly flat heterogeneous networks into something that is undergoing a process of change; dynamic in terms of the actors involved, the goals of the network, and the outcomes being produced. The different stages of translational shown in Figure 1 is reflective of the number of actors involved, their commitment towards the goals of network, and the relevant outcomes that are being produced. These stages, which occur over time, are not necessarily uniform in duration or sequential in process, the dynamic nature of associations between actors lead to an iterative process; mobilization – the stage in which goals are achieved – is not necessarily the final state of a network.

2.3 Phases (P)

The final component in the HTP model is the concept of phases, which exposes the layers of heterogeneous networks that have led a Web activity to its current state. Being able to account for the layers in development provides a way to interpret the necessary – or even serendipitous - conditions that existed for an activity to grow.

The associations of the actors within a heterogeneous network extend beyond the boundaries of a Web activity, affecting other networks and their agendas. By tracing the activities of the actors involved offers a way to show translation in action, but more importantly, exposing the multiple layers of activity that are invisible if only considering a Web activity as a flat heterogeneous network. This is a critical component in HTP in order to conceptualize a Web activity, revealing the underlying processes that are hidden within.

To introduce this additional perspective of layers or *depth*, we first must comprehend how Web activities are within themselves made up of multiple networks of activity. As discussed, an actor can also represent a heterogeneous network, but is often black-boxed or *punctualised* [8] in order to reduce complexity. This simply means, rather than representing a network by all its actors and actants within it, the network can be considered as a single actor, as long as it remains functional. Although these black-boxed networks are individually undergoing their own process of translation, when collision between different heterogeneous networks via shared actors help form a new agenda - *re-problematised* – and re-aligned the interests of the actors into a newly forming network, and their actions help coordinate its translation towards a new set of common goals.

What has just occurred is an emergence of a *phase* (or layer), where different heterogeneous networks aligned their interests via the help and associations of shared actors. A new heterogeneous network has formed, consisting of all the original actors, yet simultaneously, the previous networks still exist – and must continue to remain – in order for the newly formed network to translate. As a result of the alignments, the newly formed network was able to produce network outcomes.

As a consequence of the interests and outputs of the newly formed network – phase 1 – other networks, which were previously unknown or disconnected to the activities of phase 1 now become visible to the newly formed network. The adoption of new agendas and the advances in the translation process captures the interests – via *re-problematisation* – of additional networks; and although not initially associated via shared actors, overtime these associations enable common interests to emerge and form.

2.4 HTP

We are now in the position to form a theoretical perspective on the Web and conceptualize it in terms of the three perspectives:

(1) The Web is made up of multiple heterogeneous networks that consist of both humans and technologies associated together via common interests and outputs. These networks represent different Web activities or *social machines*, which are collectively labeled as "The Web"

(2) The heterogeneous networks are all undergoing a process of translation, involving the continuous alignment of the actors already involved, and requiring the support and enrolment of new actors for its growth. The networks are dynamic and constantly changing shape as a result of the associations between actors. The stability (sustainability) of a social machine is dependent on the actors' commitment towards the network goals.

(3) A social machine is the product of a number of translating phases, which involves the alignment of different heterogeneous networks through the association of shared actors and interests. Within each of the phases, there exist numerous heterogeneous networks, which individually are translating, and must persist in a stabilized state in order for the subsequent phases to function.

Based upon the criteria explained above, we have now described the HTP model – Heterogeneous networks, Translation, Phases – which is framed around a socio-technical conceptualization of the Web. Individually, the three elements of HTP provide their own analytical insight into a social machines formation, development and structure, and by working with them in a single model, we are able to describe and explain the growth of 'The Web'.

Using the conceptualization that the HTP model offers, provides a way to examine different social machines, independent of context or domain; whether studying, Social Networking, Human Computation, or more generally, the Web as a network of 'Web activities'. Using HTP offers not only a way to describe how the activity formed and occurred, but also reveal the processes, layers, and structures that are hidden within.

3. APPLYING HTP TO WIKIPEDIA

In the following sections, we present an example case of exploring the formation of the heavyweight social machine [6], Wikipedia, and demonstrate how the HTP model provides a lens to unpack the various heterogeneous networks and multiple phases that led to its current state of stability. The data used for this example was sourced from Web archives[1] containing documentary evidence of the actions of the actors involved.

3.1 Nupedia: Phase 0

Prior to the formation of Wikipedia, or more specifically the ideas that led to the formation of Wikipedia, there were a number of actors and previous actor-networks already working with agendas that were involved with collaborative editing environments, where multiple users contributed to the creation and editing of articles. These agendas were also working with specific publishing policies and guidelines, such as the 'open content license', which enabled them to publish content which is publically accessible and free to reuse, redistribute, and even edit. As Figure 2 illustrates, a number of actors were present that were working towards this:

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[1]http://web.archive.org/web/20030905045141/http://www.nupedia.com/pipermail/nupedia-l/2001-January/000679.html (Accessed 20th January 2012)

Nupedia, an established actor-network, represented the activities of a collaborative encyclopedia where articles were written by topic experts, and subjected to an extensive peer-review process for validity, and accuracy. Nupedia were already using a Web platform named NupeCode, developers by actors enrolled in the network. Focal in this network was Jimmy Wales, who first problematised the agenda of a collaborative encyclopedia. This was supported by Larry Sanger, whose previous associations with Jimmy Wales led him to the role of Chief Editor. Another actor network involved, which we shall black-box was Bromis, a founding partner and investor for Nupedia, and also has a shared actor with Nupedia, Jimmy Wales.

Working towards similar a agenda, actors within a network we label the 'Free Software Foundation' were active in pursuing the goal of *Open Source* development and licensing, led by the focal actor, Richard Stallman. The GNU Free Documentation License was an artifact within this network, and was competing with the Open Content License online content. (The GNU license was competing with the open content license that Nupedia were using).

Although there already existed an online encyclopedia (Nupedia) supported by the open content license; the success was limited to the fact that it required experts to write the articles. Aware of this the Larry Sanger used his associations and role within the Nupedia network to problematise a new type of social system to be created, one where there was no peer-review system as such, as the articles could be written by anyone who wished to create, edit or comment on a page. This received support from members of the Nupedia mailing list, and also establishing Larry as the focal actor. The problematisation was aimed at gaining cooperation of a wider set of actors, and also the actors responsible for developing Nupedia's software platform, reassuring them that it would be "*very easy, […] done in literally ten minutes*".

These different requirements led to the formation of the Obligatory Passage Point (OPP) – a concept describing the agenda that actors must work towards in order to achieve network success [8]. Indeed, actors committed themselves to the agenda, and Wikipedia was established; a new phase of developed was reached.

3.2 Wikipedia: Phase 1

By gaining the interessement and enrolment of the actors within the previous stage, Wikipedia.com was established, which contained the inscriptions of all the different actors that were within the previous phase. Wikipedia.com represented a number of previous network agendas including:

- Larry Sanger's agenda to create an collaborative Web based encyclopedia without a peer-review system
- The software developed for Nupedia, inscribed by the Developers, establishing themselves within the network.
- Richard Stallman's agenda to use the GNU License for publishing articles, which would enable the articles and their content to be written under an Open License

However, what was not part the Wikipedia agenda was the actor-network, Bromis. Wikipedia was initially inscribed as a platform that would not enabling internet (Web) adverts; however, this did not align with the agenda of Bromis, who were the sole investors and financial support for Nupedia, and initially Wikipedia. As a result of this their relations were weakened and eventually lost. During this process, Bromis threatened the translation of the

Wikipedia network, trying to change the original agenda of no advertisements, however the strong relations between other actor-networks overcame this threat, and Wikipedia changed from a '.com' to '.org'. Subsequently, Nupedia lost funding, and the articles previously written were transferred over to the Wikipedia network. Effectively, Wikipedia subsumed Nupedia.

In addition to the translation of the Wikipedia network, there was also the change in the focal actor. Whilst the focal actor (Larry Sanger) during the initial phase helped problematise the actor-networks needed to establish Wikipedia, once the network has been established, the focal actor did appear to change due to the lack of activity (which is partly a consequence of the lack of funding from Bromis, causing financial problems). However, Jimmy Wales, the original focal actor which established the Nupedia network, set out to problematise the Wikipedia network in order to establish a number of goals for other actors to achieve, and by doing so, made him indispensable in the network. The previous agendas of Nupedia were used as incentive in the newly forming Wikipedia network, drawing upon the 'Neutral Point Of View' (NPOV) policy, which provided guidelines for how articles should be written. As Figure 3 illustrates, this then became an OPP, enabling Jimmy Wales become the focal actor

The developers were also active in updating the technologies that provided the software platform for Wikipedia to work. As a result of the continuous support of the Developers, a new software platform was created, MediaWiki, which offered features which were aligned with the agenda of Wikipedia, in terms of an openly collaborative environment.

Wikipedia's initial ties with the Nupedia network, which eventually became part of the Wikipedia network acted as a device of interessement, enrolling a growing contributor actor-network, which included actors that were not originally part of the Nupedia, reaching out beyond the experts that were previously creating the articles under a peer-reviewed system. The network of contributors grew substantially, and provided the necessary strengthening of ties to enable Wikipedia to translate towards a temporarily stabilized state. Wikipedia has now achieved the goals listed in the original agenda, the OPP has been passed through, and the new focal actor had established a new set of goals – specifically NPOV – to enable Wikipedia to remain stabilized.

3.3 Wikimedia: Phase 2

Due to the success and stabilization of the Wikipedia project and the increasing number of actors that are being enrolled into the
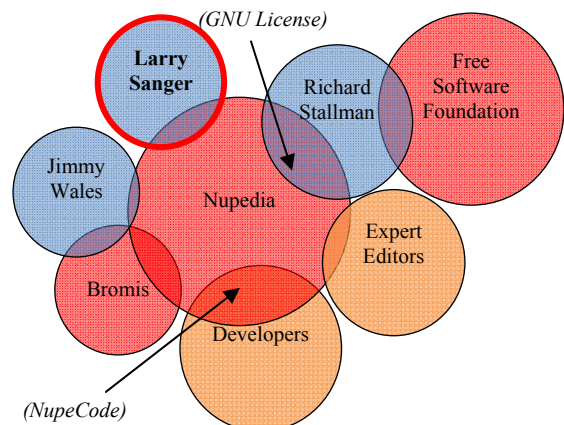

Figure 2. Phase 0 (enabling the formation of Wikipedia). *Focal Actor: Larry Sanger.* **The additional networks shared common interests to provide enough inertia for Wikipedia to form**

Article Editors network, other networks surrounding Wikipedia not only become interested in the agenda, but were affected by the Wikipedia artifacts. New interactions occurring with other Web activities; search engine such as Google enabled Wikipedia to gain more actors, strengthening network stability. Google's indexing of the articles provide visibility for Wikipedia across a wider set of actor-networks on the Web, and by doing so also affects other Web activities that previously had no similar agenda to Wikipedia.

By gaining interest from a number of new actor-networks involved in other Web activities, Jimmy Wales established himself once again as the focal actor within a broader collection of networks, enabling other kinds of activities to utilize the Wikipedia technologies in order to perform their tasks. As a result of the initial interests into Wikipedia, Jimmy Wales established an OPP where new activities could use the Wikipedia approach, but required the use of the MediaWiki technology.

As Figure 4 illustrates, Wikimedia was established, which was inscribed with the use of MediaWiki as the underlying piece of technology to enable other actor-networks to establish new forms of Wiki-style activities, such as online dictionaries travel facts, and even worldwide news portals. Wikipedia is now just another project within the Wikimedia projects, passing through the passage point that the focal actor set.

4. CONCLUDING REMARKS

In this paper we have introduced a new model to conceptualize the formation, growth and structure of social machines. HTP
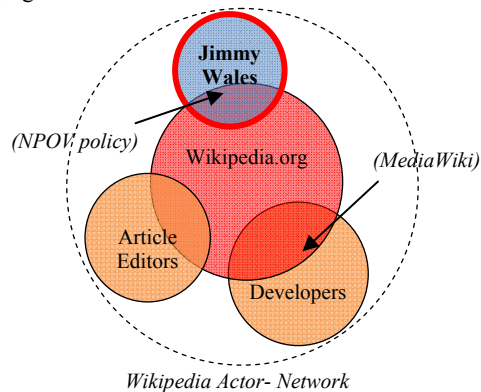
Figure 3. Phase 1 (The formation of Wikipedia). *Focal Actor: Jimmy Wales*, **who defines the OPP with the problematisation of the NPOV. Wikipedia.org represents a punctualised Actor-Network, incl. actors within the previous phase: Larry Sanger, The Expert Editors, Nupedia (articles), plus the GNU License as incentives to define how the articles need to be published. Jimmy Wales, the Developers and the Article Editors have shown to be external to the Wikipedia network, as they are all are affecting the overall translation of the Wikipedia actor-network.**
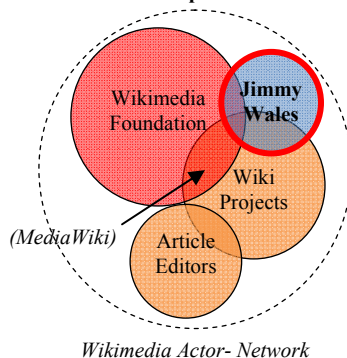
Figure 4. Phase 2 (Wikimedia established). *Focal Actor: Jimmy Wales*.

(Heterogeneous networks, Translation, Phases) builds on the observation that the Web is formed by diverse human and technical activities, and that those activities influence and reinforce each other.

By applying the concepts of HTP to examine the formation and growth of Wikipedia, we have revealed the phases that occurred in order for it to reach its current state of stability; and by doing so described the processes needed to achieve this.

In order to theorize and practice the engineering of social machines, it is necessary to describe and understand their existence. Wikipedia is more than just a standard website with a particular user interface; it is supported by an unusual content management technology that is the product of an exceptional knowledge sharing agenda that was itself developed over time and as the consequence of the interactions of a number of businesses and personal agendas. All users are expected to sign up to the current agenda, as well as signing on to the system.

HTP offers a way to describe and explain the growth and development of these kinds of Web activity, transforming the phenomena into a purposive network of structured activities, which are stabilized long enough for new social machines to emerge and grow.

ACKNOWLEDGEMENTS

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