(Re)Integrating the Web: Beyond 'Socio-Technical'

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1. INTRODUCTION
The World Wide Web transcends linguistic, geographic, social, cultural, and political borders, and despite being underpinned by common technological principles and standard protocols, its applications are not prescribed. The Web is a ubiquitous technology; it may be accessed via a desktop computer, a smart phone, or embedded into personal and household appliances. Along with being technologically platform independent, it is unrestricted in terms of purpose and use: it is used for scientific research and innovation, for entertainment and business, in support of charitable causes, political revolutions and criminal activities. Many societies, in the West and beyond, are now permeated with digital technology [6]. At the same time, human interactions are disrupting and redefining the functionality and capabilities of the Web; how it is used, modified, adopted, or dismissed, in turn shaping its evolution. The Web has become not one thing, but many. From this perspective, the W3C definition of the Web as 'an information space' of identifiers (URIs), interactions (HTTP) and formats (HTML) [9] is profoundly inadequate, failing to capture the complex, co-constructed and dynamic emergence of the Web over the past 25 years.

The Web is more than just a space of information; it is a space of socio-technical activity in which practices and their outcomes are both unpredictable and highly significant to economics, societies and individuals. To conceptualise the Web in this way is to understand the Web as situated within a highly intricate network of technological developments while at the same time part of a larger network of social change. The Web has not developed in isolation from other technologies and scientific innovations. As a 'social machine' [2][5], it has developed as part of the changes in society. From one perspective, the Web can be considered as the reflection of human creativity and change. From another perspective, the Web can be considered as a technical network of electronic devices communicating and sharing bits of digital data. Whilst both perspectives for describing the Web are correct, individually they do not explain the mutual shaping of the Web [3].

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However, whilst there is increasing recognition of the Web as socio-technical, in principle [1,4] there have been no in-depth studies tracing how the Web has grown from this perspective, and those that have studied the evolution of the Web have been drawn into tracing its expansion in quantifiable terms network measurements and metrics.

This paper redresses this and readjusts the lens to examine the socio-technical growth of the Web. We present the findings of a three year study of an emergent area of Web activity, focussing on the UK Open Government Data (OGD) community, a leading field of Web development. OGD is an emergent Web activity that is driving both social and technological change on the Web. Its growth is not only having an effect on national and international policies and governance, but it is also helping shape the landscape of Linked Data and Semantic Web technologies and standards. The Web activity of UK Open Government Data was examined by using sociological theory [8] to reveal a complex actor-network comprising of humans and technologies producing socio-technical artefacts. By de-punctualising the Web activity, it was possible to see stabilised layers (phases) in this activity, and how new layers of activity emerged from the formation of network outcomes and the development of an agenda.

2. A SOCIO-TECHNICAL WEB
Whilst the current understanding of the Web tends to consider it as a quantifiable entity, with its growth being understood ultimately as a quantifiable set of metrics relating to the number of Web pages and the hyperlinks connecting them together. However, underpinning the Web's network structure is a complex and dynamic network of human and technological interactions. The Web graph's collection of nodes, edges, hubs and authorities are underpinned by socio-technical interactions between networks of actors who are themselves creating and promoting new kinds of processes, agendas, services and data within a new sphere of Web activity. Through a socio-technical lens, the formation of these networks can be likened to the vapour trails or exhaust of the digital traces of actors, and by the time observations are made, they have changed shape, and reconfigured [7].

By considering the Web as a network of different Web activities and applying a conceptualisation of the Web's growth based upon these analytical findings, what emerges is a Web which has evolved via the stabilisation and interaction of diverse socio-technical Web activities. In one sense, the Web is an abstract concept, which develops as a result of the continuous stability of previous Web activities, and its structure is the consequence of the associations of actor-networks. The interactions of actor-networks create network artefacts, represented by websites, Web pages, Web content, and Web data. But these networks represent much more than this; the growth of these networks are the result of humans and technologies associated via common interest and goals, which manifests overtime to translate into different Web activities.

The Web does not just 'support' these independent human activities, but the Web's technical capabilities and integration into sociality are extended by humans who are trying to achieve their interests and goals using the Web. For instance, individuals do not just 'do shopping' using a platform called the Web, rather, the Web starts to become an integral part of the way that people shop, the Web adopts new capabilities (*e.g.* authentication and security protocols and online payment technologies, and design principles such as the 'shopping basket') that enable people to shop. Consequently, the Web challenges previously established 'offline' shopping facilities, which themselves react and re-configure. The growth of the Web is a dynamic process that is adopted and adapted by humans to do the activities they want to do and in the process it changes and grows along with the individuals using it.

New Web activities try to establish themselves as part of 'the Web' and in the process of doing so, interact, affect, and re-configure other 'established' Web activities. However this is a dynamic and temporary stabilised process, Web activities emerge, grow and remain operational as long as humans and technologies stay committed, and these activities are likely to change once new Web activities are introduced and established. The `Web' is defined by the Web activities that become and are becoming temporary stabilised, and as new activities emerge and establish themselves, the Web becomes and is defined by these activities as well.

3. A MODEL OF WEB ACTIVITY

Based on the empirical findings of the UK OGD analysis and the theoretical position driven by the lens of Actor-Network Theory, we describe a theoretical model to understand the growth of the Web, synthesising the findings into a number of core principles, which are:

1. Web activities develop by multiple networks of actors that are **heterogeneous** (both human and machine) in structure, formed and driven around an agenda such as Open Data. These actors introduce multiple agendas, and by negotiations and cooperation between actors translate towards a common set of goals.
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. During the translation process, negotiations and conflict occur, which either lead to network stability or failure, depending on the cohesion and agreement between actors.
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. These phases of activity provide the foundations for new networks (and Web activities) to form, and by doing do, re-configure existing networks.

These principles, collectively known as the HTP model help describe how a Web activity emerges and grows, HTP offer a re-configuration of the boundaries between the micro and the macro. Unlike traditional engineering perspectives of iterative design lifecycles which consider development as 'inside' and 'outside' the lab, the model described in this paper provides an understanding of Web growth beyond an iterative, micro-to-macro development process. As the emergence of OGD illustrates, a Web (activity) grows via a collection of stabilised and operational actor-networks, which are heterogeneous in structure. As illustrated in Figure 1, the stability of these networks not only provides new networks with a stabilised layer to build upon, but as a consequence of their construction, they re-configure surrounding networks of activity and practice, thus re-configuring 'the Web'.

This paradigm has implications for the way the boundaries between the micro and the macro are defined. As the growth of the OGD Web activity has shown, there is no clear distinction between 'engineering' and 'deployment', these are processes which happen as part of multiple complex socio-technical processes rather the iterative cycle once conceived is no longer applicable. The development of a technology is as much a social process as it is technical; it is the arrangement and re-configuration of network of actors around different agendas and interests. Adopting this perspective has implications beyond just re-conceptualising the Web, it raises questions towards how Web development is performed.

4. CONCLUDING REMARKS

This paper has introduced a new perspective to understanding the evolution of Web development lifecycle in contrast to the traditional perspective associated with the engineering and computer science paradigm. What has been shown is that development is only one process within a set of activities required to achieve a successful Web outcome. Essentially, the development of a Web activity occurs through the translation of multiple agendas and goals, and includes a variety of socio-technical processes.

Future work will attempt to harness the abstract concepts of the HTP model finding utility in the principles learnt for development methodologies and design practices which complement traditional software engineering approaches, and offer developers, designers, engineers and participants in the Web, an integrated socio-technical tool for supporting the creation of Web activities.

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