Using Mixed Methods to Track the Growth of the Web: Tracing Open Government Data Initiatives

Ramine Tinati, Susan Halford, Leslie Carr, Catherine Pope
University of Southampton,
Southampton, United Kingdom
rt506@ecs.soton.ac.uk

1. INTRODUCTION

In recent years, there have been a rising number of Open Government Data (OGD) initiatives; a political, social and technical movement armed with a common goal of publishing government data in open, re-usable formats in order to improve citizen-to-government transparency, efficiency, and democracy [1]. As a sign of commitment, the Open Government Partnership was formed, comprising of a collection of countries striving to achieve OGD [2]. Since its initial launch, the number of countries committed to adopting an Open Government Data agenda has grown to more than 50; including countries from South America to the Far East.

The process of adopting an OGD initiative is faced with political, economic, social and technological challenges, requiring the support of civil servants and citizens, plus the input from developers, engineers, and grassroots movements, and even with this support, success is not guaranteed [3]. Publishing government data requires the development of legal frameworks, policies and technologies able to handle various types of data which are currently hidden away by non-proprietary formats, copyrights, closed social practices, and privacy concerns. The activities of OGD are inherently socio-technical, and the Web plays a critical role in its development. Technologies developed must reflect the practices and social factors that are embedded within government, and similarly, government must adapt to new organizational changes that affect their day-to-day practices.

The activities of Open Government Data initiatives – which occur in society and on the Web – are at the very heart of the Web Science agenda; a multidisciplinary research area which aims to understand how the Web and society influence and develop each other [4]. The relationship between society and the Web is complex and mutually shaping, and requires research to draw upon a variety of disciplinary techniques and analytical approaches if an informed understanding is to be achieved [5]. As Web Science is a relatively new field, current approaches to understanding the Web are still being developed. Methodologies grounded in multidisciplinarity are still yet to be achieved; typically, research follows a social or technological approach underpinned by quantitative or qualitative methods, and rarely combining the two into a single analytical framework [6]. In recent times, there has been an increasing demand for combining quantitative and qualitative approaches to enable a mixed method analysis, but underlying epistemological and ontological differences raise questions about their compatibility [7]. Qualitative and quantitative approaches ask different questions about the same phenomena, and use different methods to address them: quantitative approaches provide an understanding via mathematical and statistical rigor, whereas qualitative methods use exploratory techniques to examine the context and content that underpins such findings [8] [9]. However, the demand to use mixed methods has been amplified by the rising interest in social network analysis [10], arguing that using both quantitative and qualitative approaches complement each other's analytical capabilities [11] [12].

In this paper, a mixed methods approach will be introduced, which uses qualitative data underpinned by sociological theory to complement a quantitative analysis using computer science techniques. This method aims to provide an alternative approach to understanding the socio-technical activities of the Web. To demonstrate this, the activities of the UK Open Government Data initiative will be explored using a range of quantitative and qualitative data, examining the activities of the community, to provide a rich analysis of the formation and development of the UK OGD community.

2. A MIXED METHODS FRAMEWORK

The framework introduced in this paper uses social theory and computer science techniques to provide a mixed methods approach to understand the socio-technical activities that occur as a result of the interaction of society and the Web. The framework draws upon two distinct disciplines: (1) sociology, specifically theories associated with Science and Technology Studies (STS), and (2) computer science, specifically analytical techniques involving network analysis and graph theory.

Science and Technology Studies is a well-established research field within sociology, established back in the 1970's, where early studies examined the practices of science and technology in laboratory environments [13]. Concerned with the relationship between society and technology, STS has offered a number of perspectives over the past decades, from technological deterministic, to socially constructed views of the world [14]. Aimed at providing a non-deterministic view, Actor network Theory

(ANT) places emphasis on both the social and the technical components of a network [15]. Humans and technologies are part of a network of interactions, who's actions determine the outcomes and eventual success of the network [16]. ANT offers a number of theoretical concepts which enables a detailed and insightful analysis of the relationship between humans and technologies, thus being a theoretical framework for a number of Web related studies such as the analysis Web Services [17], Web 2.0 [18], the role of DNS on Web development [19], and also the practices of online banking [20], [21]. Drawing upon concepts from ANT, the methodology in this paper uses the *process of translation* – an analytical framework to break down and understand the way heterogeneous network of actors interact with each other to produce outcomes [22].

Typically, sociological studies use qualitative sources of evidence, enabling a descriptive dialog and analysis [23]. These are performed at small scale, often restricted by time, location, and practicality. The underpinning qualitative approach within ANT suggests researchers 'follow the actors' via observations and interviews, providing an interpretive account of the activities of the network. We argue that to capture activities of the Web to the fullest, our framework must draw upon both qualitative and quantitative data for analysis. One of the fundamental differences between quantitative rich studies such as those typically used within the computational sciences and the qualitative studies often underpinning sociological studies are the epistemological and ontological position taken; quantitative is positivistic, whereas qualitative is inherently interpretivist or constructionist [7]. As a result of this the construction of reality and what is true are completely different. Positivism is backed by empirical research, and phenomena can be reduced to empirical indicators; there is only one truth and that exists independent of the researcher [7]. Alternatively, qualitative research is based on interpretivism or constructionism, leading to multiple realities and truths based on the researchers construction of reality [24]. Undoubtedly, this presents a challenge during the analytical process, but it enables multiple perspectives of the phenomena observed to be achieved [7]. Rather than using the different approaches to cover up the others weaknesses, by using them to complement each other provides far richer analytical capabilities [7].

The global scale of the Web means that small scale studies do not permit all the actions of the humans and technologies to be understood; in order to adequately trace the activities of the actors on the Web at a global scale, a methodology needs to adopt data collection and analytical techniques which are used within computer and network science. These focus much more on large amounts quantitative data sources [23], and rely on mathematical or scientific processes for analysis. Furthermore, there are also techniques, which are not specific to the computational sciences that enable large amounts of data collection and analysis to be made possible. Techniques such as data mining' or 'Web crawling' offer a way of trace actions of actors, both humans and technologies (tracing data sources).

Exploring the computational science literature, there exists a whole range of research that explores the Web: examining network properties of the Web [25], the dynamics of networks [26], and also how the behavior and structure of the Web affect each other, forming adaptive networks [27]. Examining the Web at a small scale, there are studies which examine the structure of Web communities and their changes in network topology [28], the cascade of information through traditional social networks [29] and micro-blogging social networks such as Twitter [30]. In recent times, this area of research grown, examining how innovation occurs and is distilled on the Web [31], and how information is passed and socially filtered within social networks [30], [32–34]. Such research often use graph theory in combination with a collection of large datasets to make sense of the patterns and behavior that is observed. Qualitative methods, such as interviews and observations are used [35], however this is far less common [23]. These studies provide a method to map and explain the structure and patterns observed within a network, perfectly suited for quantitative based studies. However, we argue that for a Web Science methodology, this is not enough. We need to look beyond just network structure, we also need to understand the context that underpins the 'social relations' in these networks [10]. Complementing these techniques with sociological theory will provide an understanding of the socio-technical activities that occur on and off the Web.

By paring the quantitative computational techniques and the qualitative sociological techniques, a mixed-method, mixed-discipline methodological approach can be achieved. By complementing the quantitative- with the qualitative-approaches, the activities and interactions of the actors in the online and offline world can be followed.

3. ACTIVITIES OF THE UK OPEN GOVERNMENT DATA INITATIVE

To demonstrate a mixed methods framework, the following analysis will examine the activities of the UK OGD during 2010, which includes the deployment of data.gov.uk. A number of quantitative and qualitative data sources will be examined and used to trace the activities of the human and technological actors, aimed at providing an insight into the mutually shaped relationship between the Web and society.

The UK Open Government Data initiative consists of various sub-communities of actors. These extend across different sectors of society, including government, academia, non-profit organizations, industry, developers, and citizens. The UK was one of the first countries to take up the calls for an Open Government initiative; resulting in the development of policy and technologies that enabled government data to be published in open and reusable

formats, within a searchable, single point of access – data.gov.uk [36].

3.1 Data Collection and Quantitative Analysis

The initial step of the analysis is to examine the quantitative data sources, which have been obtained using data scraping and web crawling techniques. The data can then be analyzed via statistical methods and graph theory techniques to produce a comprehensible and meaningful version of the data. Within this study, data sources include: social network data (Twitter), Google Groups data, and Government Data deposit records, shown in Figures 1, 2 and 3 and Table 1 and 2.

The Twitter dataset collected contains any tweet that mentioned the hashtag #datagovuk (and also #data.gov.uk) during 2010. The dataset comprises of 1866 tweets, and 1010 unique Twitter users. Figure 1 illustrates the daily frequency of tweets during January and December 2010. In early 2010, there was a low activity level compared to the activity during September 2010 and onwards. A preliminary analysis of this would suggest that this may be due to the increased publicity and awareness of the OGD initiative, which is supported by the growth in users tweeting during 2010. From January to July 2010, there were only 247 users active on the Twitter community, compared to 1010 by the end of December 2010 – a 400% increase. In addition to this, the number of tweets can be examined in more detail, calculating the number of retweets (tweets rebroadcasted by a Twitter user with a reference to the original user) provides an additional metric to assess the actors online activities. Not only do retweets provide a way to track message flow (tracing interactions between users), but also provide a metric to judge a user's influence within the network [37]. The dataset consisted of 1255 retweets, which is 67% of the total tweets made during 2010. Based on this list of users can be generated, ordered by the number of their tweets retweeted. Table 1 shows the top 5 retweeted users, based on a threshold or 20 retweets or more. These top 5 users accounted for 25% of the total number of retweets made during 2010 - an indication of their relevance and influential within the community.

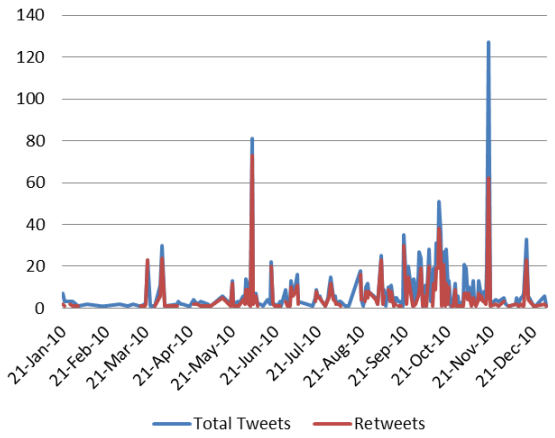

Figure 1 #data.gov.uk Twitter Tweet and Retweet Freq.

Table 1 Top retweeted users in Twitter dataset (Anonymised)

Twitter User	Num. of Retweets
R*****	119
D*****	85
L*****	40
N*****	37
J******	22

Table 2 #datagovuk Retweet Network Graph Metrics

Graph Metrics	#datagovuk
Max. in-Degree	84
Mean. in-Degree	1.3
Max out-Degree	25
Mean out-Degree	1.3
Mean Closeness Centrality	0.165

To further explore the networks structure, the #datagovuk dataset can also be analyzed using graph theory techniques, which will help unpack the unequal distribution of retweets identified. As the initial analysis has already discussed, there exists a number of users who have been highly retweeted, however the mean in-degree indicates that most of the users have less than 2 retweets, suggesting that the highly retweeted users are potentially well connected individuals in the network, which may be a result of their role within the UK OGD community. Furthermore, the mean-out degree suggests that a single user does not interact with many users, on average retweeting less than 2 unique users. Both these values reflect the low value of closeness centrality, an indicator that the #datagovuk network is not strongly connected.

The *UK Government Data Developers Google group*, an online discussion space for developers and interested parties in Government Data, provides another source of analysis. Using Web crawling techniques, 1846 messages posted where collected, along with the corresponding metadata of 360 users. Shown in Figure 2 is the daily frequency of user posts during January and December 2010. An initial analysis suggests that the sudden increase of activity during January 2010 corresponds to the public launch of data.gov.uk. A more detailed examination of the posts indicates that there is standard deviation (SD) of 11 in regards to the number of user posts, with the mean number of posts being 5. In contrast to this, the most active user accounted for 149 of the total posts; and 32% of the total posts were from the top 10 posters. This large SD suggests that there exists a core group of users posting, forming the majority of the conversation. The observed drop in activity after March 2010 may be a result of these users becoming less active, and the smaller number of daily posts reflects the typical activity level of users.

As a method to track the activities of the technologies and data in the OGD community, the published data available at data.gov.uk was harvested. Figure 3 illustrates the number

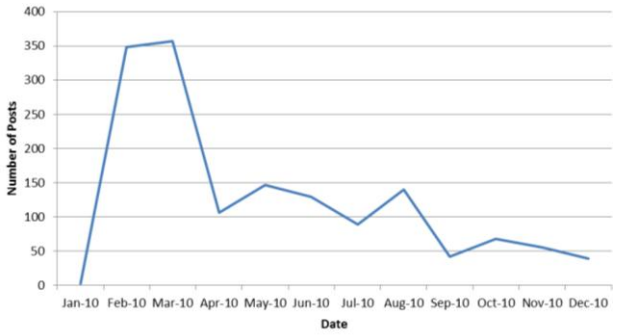

Figure 2 Freq. of Posts – UK Gov. Data Developers Group

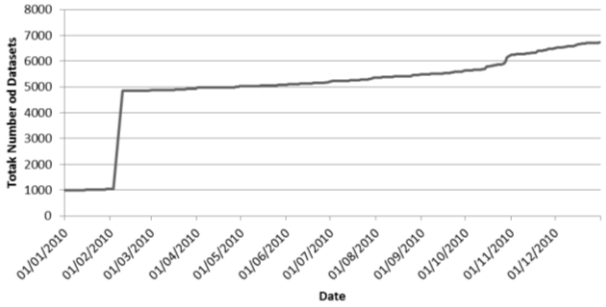

Figure 3 Total Number of Datasets in data.gov.uk

of published datasets available during 2010. An initial analysis suggests the growth in deposits following the large deposit of data (corresponding to the public launch date of data.gov.uk) indicates that there is continuous activity and commitment to publishing data, with frequent deposits, often containing 10 or more datasets within a single deposit. The initial quantitative analysis has provided findings which indicate that during 2010 there has been increasing levels of Web activity within the UK OGD initiative, thus presumably growing interest in the offline community as well. The analysis will now call upon a qualitative approach to provide context to understand what these activities are.

Based on the collected Twitter data, the most active users identified by their tweet and retweet count provide a list of individuals that are potentially influential in both the online and offline world. The UK Government Data Developers Google group also provides another source of identification of users, based upon their post count during 2010.

As a means to obtain a more informed understanding of the activities and interactions of the community; semi-structured interviews were conducted with a number of the identified individuals. Questions were asked regarding their role in the community, their opinions on how the community has grown and how the Web activities reflect the real-world practices.

In order to structure the qualitative data collected, concepts borrowed from social theory concerned with the formation of socio-technical networks [15] was used a framework for analysis. By combining this with the quantitative analysis and with a timeline of events and activities of the UK OGD initiative [38], an analytical description will be produced, exposing a number of unexplored analytical paths which provide an in-depth understanding towards the socio-technical relationship that underpins the UK OGD initiative.

3.2 Analysis of UK OGD Community Activities

The following analysis is an extract of the activities of UK OGD community which focuses on a segment during 2010. The analysis begins at a stage where a number of actors, including civil servants, and members of organizations involved with Open Data, have already established common goals for the community, and by doing so, they promote themselves as focal actors, making them a crucial and integral part in the initiatives success. These common goals which include providing a single point of reference for publishing OGD were formed as a result of interactions between actors earlier in the network's formation. This initial stage is required for a network to gain momentum, and identify barrier, drivers, and suitable actors.

At the start of 2010, data.gov.uk was ready to be publically launched. Although it had been unofficially released in September 2009 for developers to test, it was held back due to the lack of activity during the Christmas holidays. Although not reflected in the Twitter community, the public launch was well received, it's launch was a "major milestone", acting as a catalyst for growth in the online and offline world. Interestingly, a few weeks before data.gov.uk's release, the London Datastore was announced, along with the announcement of a large set of 'Transport for London' data – campaigned for by activists and developers for a long time. It appeared that this activity was overshadowed by the presence of data.gov.uk, potentially down to a number of reasons. (1) The technology that underpinned the London Datastore was not the same as data.gov.uk, which was using CKAN (Comprehensive Knowledge Archive Network) which was a result of previous negotiations, and decisions based on the government's Open Source policy, its reliability, the projects short turnaround time, and also the strong ties that existed with the developers of CKAN. (2) It would appear that the release of the London Datastore was supported by actors from other OGD networks based in other countries, potentially seen as a threat or distraction to the achievements of the goals originally set out earlier in the networks formation.

Subsequent to the release of data.gov.uk came the major publication of government datasets, as reflected in Figure 3, which was excellent source of publicity for data.gov.uk. The large number of published datasets was used to promote the success of the UK OGD initiative during a number of interviews and presentations, thus strengthening the ties between actors already involved in the network, and also gaining the interest of others.

Interestingly, the increased activity levels of the UK Government Data Developers Group during January 2010 did not reflect the context of offline activities. Untold to the public and other interested parties, the political decision to

"get everything out there and worry about it next year" presented a number of issues, many which were raised in the Developers group. The decision to release the large amount of data was may have also been a response to the "healthy competition" with other competing OGD initiatives. Other competing networks, in this case, other countries with OGD communities, potentially had an effect on the speed to which the UK OGD community mobilized, including the launch of data,go.uk. Competition had both a positive and negative affect: spurring on the development of data.gov.uk, but rushing the decision process of data publication.

The public launch of data.gov.uk and the subsequent publication of data had a multi-translational effect on the OGD community; it strengthened ties with already existing actors, both the humans and technologies (CKAN), and also established links with new and potentially useful actors needed to push the network further – reflected by the growth of users participating in the #datagovuk Twitter conversations. Irrespective of "inconsistent and incomplete" published data within data.gov.uk, support from developers and interested parties remained strong, and Web applications using the published data were produced and released, and positive press coverage of OGD continued.

The strong social ties, which were a result of the close set of actors, including, civil servants, academics, developers and activists, helped translate the network from being weakly connected to a network which demonstrates properties of a enrolled network – where actors work together towards a number of common goals original, formed during the earlier stages of the networks development. Interestingly, the strongly connected network of real-world activity is not reflected in the findings of analyzed Twitter network.

The difference between the findings of the Twitter #datagovuk structure compared to the real-world structure of interaction between actors can be explored even further by examining the diverse set of views regarding the influential actors of the network Some express a view – which are reflected by press releases – that the OGD initiative was instigated and driven by a top-down approach, and held together by a few high profile actors. In contrast to this, some suggest that without the grassroots movements, i.e. the activist groups and developers, the initiative would not have gain momentum. The former opinion of a top-down approach shows similarities with the findings of the quantitative analysis. Based on the online activities, both the UK developers group and the Twitter dataset suggest that the community has a top-down structure, with a few distinct individuals being highly active and well connected. However, as the qualitative analysis suggests, this is not to disregard the less active individuals, with their efforts of every member of the community – at all levels, in the online and offline world – the community would have not developed. The quantitative data provides a 'snapshot' of the activities of the community, but the qualitative data provides a dynamic understanding of the processes that led to the community's current state.

Structurally, it is more appropriate to consider the community as not only "top-down and bottom-up, but also middle-out". Underpinning this are the activities that occur both on the Web and in society; the high-level meetings helped set out an agenda, strengthening government ties to the idea of OGD, the middle men, building ties with the developers and activists, who in turn used published government data to develop OGD tools and applications; and enabling this to happen was the communications that propagated across the online and offline world.

In this short analytical passage, a number of key components to the activities of the UK OGD initiative have been unpacked, including how data.gov.uk was not a means to an end, but was actually the product of something much more complex and ongoing. Also, the driving forces responsible for the speed of development within the UK OGD initiative are a result of a top-down, middle-out, and bottom-up approach that has enabled the network to transition between stages of development in a short period of time.

4. CONCLUDING REMARKS

The analysis conducted in this paper highlights the strength of using a mixture of data sources to examine the activities of a Web based community. The technical analysis of the Twitter data provided a method of identifying network structures and key actors within the OGD community, and also provides direction for collecting the qualitative data via interviews. The qualitative data provided a detailed and informed understanding of the underlying social processes that occurred during the development of the UK OGD community.

The mixed methods presented in this paper aims to provide Web Science with the appropriate tools and theory to appreciate the scale of the Web at both micro and the macro level. By appreciating the underlying differences between quantitative and qualitative approaches and combining techniques from the computational sciences and analytical perspectives from social theories in sociology, the socio-technical activities that drive the Web can be explored.

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