Open Data Services: Research Agenda

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Abstract

Open data promises an increased availability of previously private, mostly governmental, datasets for service development. However, research on the topic is only starting to surface. In this article we propose a research agenda for open data service research. We review earlier relevant literature to extrapolate open data as a phenomenon from the perspective of the information systems field. Based on a classification of research challenges, we build a research agenda, and outline a set of research questions. We contribute to the discussion on future avenues for research on open data in IS.

1. Introduction

A vast array of previously private data is becoming available and new businesses are increasingly based on services that use and aggregate this data. One way of speeding up this development is to look at the services based on the open data. For instance, many public entities have large data sets, but do not have the funds and/or resources to develop services on this data. One way of addressing this issue would be to define service interfaces and then let third parties and users develop the needed services.

Computer science, and more specifically, research on semantic web [1, 2] has studied the technical side of opening datasets. To complement the more technical understanding of open data, we conceptualize the phenomenon from the perspective of service research and service dominant logic [3]. We suggest that open data provides a rich domain for research on Information Systems as well. Service provisioning and design as the practical uses of the data are among the most interesting research issues.

An example of possibilities of building services on open data sets is the use of weather data. Figure 1 shows a live map of hurricanes in the South Eastern region of USA. This map is made available through esri.com web site for those developing disaster mapping applications. The map is connected to live feeds from disaster areas and it supports the use of standard ArcGIS API (Application Programming Interface) for third parties to tap into the data and develop custom applications (http://www.arcgis.com/home/item.html?id=c74acddfcb1844eb90f8f9d40be2c823). The map itself is updated through social media services, such as, Twitter, YouTube and Flickr feeds by using location info and tags in those services. The result is a map augmented with end-user information and possible new third party services.

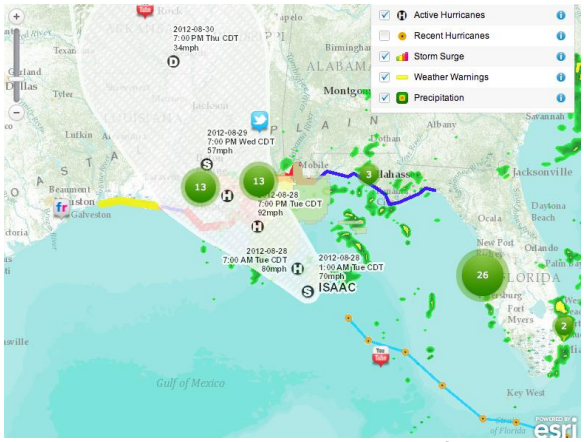

Figure 1 Live hurricane map from esri.com

The structure of this paper is as follows: First, we introduce the common definitions of open data and linked open data. We then discuss these definitions in light of earlier developments in the body of knowledge of Information Systems and service research. We review the key research streams that have addressed open data and open data services so far, and identify a research gap by pinpointing what has been understudied. As our main contribution, we outline a more holistic research agenda of open data services for the new set of research challenges that emerge when data is opened. Furthermore, we suggest possible research problem areas and derived research questions for the discipline of Information Systems to tackle the identified issues.

2. Definitions of Open Data and services

Any new organizational invention undergoes some renegotiation over its exact meaning when it is diffusing in an industry [4]. The term open data is no exception [5]. In the context of open data, this renegotiation has first taken place in policy discussions, public and professional press, and consultancy. The second arena of renegotiation is when organizations make sense of how to benefit from open data [5]. Thus our aim is not to provide the final word or an exact definition of open data. Rather, in what follows, we offer some initial remarks on the character of data as a digital object or artifact, and a brief excursion to the origins of the term.

2.1. Data as a Digital Object

Data is a term related to the storage and preservation of symbols and often is an end result of some kind of measurement. In itself, data does not have a meaning, but can become *information* when interpreted by an actor. We are mainly interested in digital forms of data and omit the discussion of the term "knowledge" from this paper.

Outside computer science, data is understood widely as information organized in some way to form a basis for decision-making or scientific inquiry. However, Computer science conceptualizes data and information in a bit different manner with a dichotomy of *data* and *application*, where data is used for storage and, the application is used for different operations based on data. Data is thus information suitable for processing, represented preferably and most often in quantitative format. The origins of viewing information in this technical way as a signal (storage and communication) can be tracked back to the work related to the Information theory by Shannon [6]. This understanding of information was contested already early on for example by MacKay's [7] critique that Shannon's theory views information as context-free. MacKay posited a different view of the amount interpretation required and the impact of competence, social context and situation. Information is thus a verb, not a noun. Another early critic was Bateson [8] who defined information as "the difference that makes the difference", in other words meaning makes the difference, also contrasting Shannon. In information systems field information is discussed and defined by McKinney and Yoos [9].

Data can be stored in different kinds of physical objects (storage media), such as, tapes, hard-drives, USB-sticks, books or letters. Although data could consist of different kinds of copyrighted works in digital format such as music, video, image, and statistics, it is most often used to refer to text and numbers in database tables. In this paper, we limit ourselves to text that can be stored in a digital archive.

Both storing and retrieving data require infrastructure, standards and interfaces that can be used to interpret, transfer and manipulate the data and together form an information infrastructure [10]. There are several epistemologically interesting sequential moments related to data in design of a service. The first moment is when a classification system is used to decide *what data to collect* and *how to store* it [11, 12]. The second interesting moment is when the meaning of the retrieved data is interpreted for a given purpose through individual and collective sensemaking. For example, performance data can be used to stage claims of authority [13]. These two moments are anticipated in the design of a service built on the data, when selections are made about what is relevant and what can be filtered out or forgotten [12] and not presented to the user.

Data can be conceptualized as a specific type of artifact or a digital object [14]. Generic attributes in the theory of digital objects [14] are editability, interactivity, openness and distributedness. According to the theory, openness means reprogrammability by other digital objects, such as, computer programs. This reprogrammability is one cornerstone in the creation of the interconnected set of different digital objects, where data and applications can operate on each other[14]**.** This interconnectivity raises issues in relation to preservation and authenticity as the identity of the digital objects (data) becomes more elusive[14]. To illustrate the problem, retrieving preserved data related to the WWW is difficult. Internet Archive (http://archive.org/) does preserve the static html-pages of text and pictures, but not the dynamic interactions with the users [12]. Hence, a snapshot of a WWW page is very different from what WWW is when used.

2.2. Open Data

Open data has connotations to a specific subset of all data – data that is "openly" made available. "Openly" should be understood here as a more of an umbrella term rather than the strict technical meaning of reprogrammability. Wikipedia (http://en.wikipedia.org/wiki/Open_data) describes open data as "*the idea that certain data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control"*. For example Open Knowledge Foundation embraces in the following a bit more technical definition (http://opendefinition.org/): *"A piece of content or data is open if anyone is free to*

use, reuse, and redistribute it — subject only, at most, to the requirement to attribute and/or share-alike."

The push for open data releases can be traced back to Berners-Lee [15], the inventor of WWW, who wrote a seminal paper on the topic of semantic web and linked open data. This paper has subsequently had considerable influence in policy discussion on increasing the number of open data initiatives of Open government in US (http://www.data.gov/), different national contexts in Europe (for example (http://data.gov.uk/), as well as the discussions around PSI (Public Service Information) in the European Union [16].

Open data as a movement has its intellectual roots in the Open Source movement [17], as well as in the literature on open innovation [18, 19] and open access [20]. The main difference between open source and open data is that of an application and data: open data is about the openness of data, not the applications and their source code.

2.3. Consumption of Open Data

Referring to the tension between public transparency and profit generation business, Gurstein [21] takes a somewhat more critical view on open data. He also notes the separation of supply and demand of open data. While the supply side makes the data available, the demand side builds something useful on the data. Conceptualized this way, access to open data is just the first building block of an infrastructure that allows end-users to consume open data services.

What kind of openness is then required of the data in order to build services on top of it? We address this question by drawing on discussion related to the term "open" taken from the context of open source ([22]; [23]) to identify the different issues that need to be addressed when building services on top of open data. These are technical openness, legal openness and commercial openness of data.

2.3.1 Technical openness. Technical openness means issues related to the interfaces and standards. Interface is the way an application communicates with the data, for example, instructions on where the application can get the data, if the required data is released over the internet. The format is the way the data is stored and thus how it can be retrieved. Obstacles to technical availability are normally handled when the data is initially made available (for example if there is an access control mechanism, such as a password). Application might need maintenance, if there are changes in the interfaces or formats. Common obstacles for data formats are related to metadata availability and the semantic richness of the available data [15]. For example, whether files uploaded to the internet in Microsoft Excel format (.xls and .xlsx) can be consider open data is debatable.

2.3.2 Legal openness. Legal openness is related to the question of whether the data is intended to be used for building services. Legal obstacles to data use can be, for instance, about contracts of the data use, copyright of the data, licenses, and privacy and data protection. Some kind of licensing fee for the service developers is in many cases seen as a way to find funding for the collection, publication and the maintenance of the open datasets.

2.3.3. Commercial openness. Commercial openness, in turn, usually means that open data is made available on the internet free of charge. Otherwise, the access to the data would be limited to only those who can and are willing to pay the requested fee. In some cases, however, data is not intended for commercial use at all. There is a lot of political discussion on this because, for example, the European Union [16] has suggested that the marginal (production) costs could be included in the price of open data. This debate echoes earlier, very similar concerns related to Open Source and Free software [17], see also (http://www.fsf.org/philosophy/free-software-for-freedom.html).

2.4. What are Open Data Services?

The nature of services (as a general term) has been described through the characteristics of the service act, type of customer relationship, customizability of the service, the nature of demand, delivery mechanism, and attributes of the service product [24]. Service-dominant logic, which has been recognized as the potential foundation for the emerging discipline of service science, is based on the premise that service as an application of competences for the benefit of another is the fundamental basis of exchange [25]. In the realm of service computing, Alter [26] defines services as acts performed by one entity for a different entity, the entities including human actors, organizations, as well as computerized services systems. Services can be described through its intrinsic attributes (the service itself), and extrinsic (the networks needed for service development, provisioning and consumption) [27].

Open data is just data. For the data to become valuable there need to be a chain of steps that either take the raw data, make it available to others as services, or further down the chain analyze, combine and present data in ways that make it useful for users to interpret as information.

Berners-Lee [15] addressed the issue from a technical point of view by deliberating how to convert the raw or source data into more enriched and abstract formats that would have semantic links. His key message was that the better the format of the initial publication of the data, the more useful the data set will be later on.

The level of structure and semantic richness of the data determines how difficult it is to scrape and use in the next step in the process leading to the service. Berners-Lee [15] suggested a five star classification scheme to measure how much effort it takes to convert the data set towards reusable formats.

Kuk and Davies [28] view open data as artifacts comprised of data, source code and service technology. They describe the artifact flow in steps where open data sets create public value. The artifact flow can be characterized by five stages/artifacts, which serve as arenas of interaction. The five sequential artifacts constituting the entire chain that needs to be designed in order to provide the data are 1) Cleaned data, 2) Linkable data, 3) Software source code, 4) Shared source code, 5) Service technology. Kuk and Davies [28] argue that the stages follow each other, and the choices in the different phases of the creation of the service – especially those related to the openness of the artifact – both constrain and enable different choices or design principles later in the design of the service.

Consequently, the data publication process can be divided into stages based on data richness. Latif et. al. [1] have provided a classification of the entities of the publishing process to help conceptualize the revenue opportunities of the different actors in the value chain. Building on the work of Latif et. al. [1], Tammisto and Lindman [29] developed a theoretical framework of actors (including individuals as well as different types of organizations) and their roles in open data business.

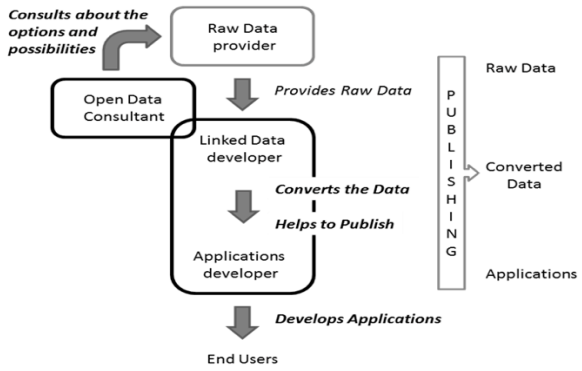

Figure 2. Roles in open data business (Adopted from [1]; [29])

Based on empirical evidence from the emerging Finnish Open data industry, Tammisto and Lindman [29] identified as the key actors open data consultants, raw data providers, linked data and application developers, and end users.

The raw data provider publishes raw data, the linked data producer utilizes the raw data to produce linked data, and finally the application provider utilizes the linked data to produce a valuable application for the end-user [1].

The open data consultant informs and advices raw data providers about the possibilities of developing and publishing their data, transforming the data into linked open data, and developing applications on top of the data. While performing these three activities of data development, data service providers also help data providers publish the data [29].

2.5. Research gap

Based on our review of the existing literature, we conclude that there is a clear gap in our understanding of open data services. In particular, it is entirely unclear how to build a sustainable open data market and establish the actors within it. Furthermore, it is of crucial importance to explore, from both theoretical and practical perspective, what are sustainable OD network structures and how sufficient revenue can be created. Only a better understanding of these challenges and opportunities can ultimately lead to more and better services for citizens, consumers, as well as organizational users.

3. Building a research agenda

In order to fill the research gap outlined in the previous section, we will next identify the most important areas for research and research problems related to the emerging phenomenon of open data services. Information Systems Science builds on a wide range of possible lines of enquiry and theories adopted from the disciplines of Marketing, Management and Economics, to name a few. Thus we will refrain from formulating the research issues in the light of any specific theory or approach, but rather provide topics.

There are two basic approaches for organizing the research issues according to the challenges that emerge when data is made available to the public, and further provided as services. These are: 1) an analysis of the life-cycle of the data and 2) an analysis of the levels of inquiry at which the open data phenomenon is studied.

Following the work systems framework of Alter [26] (see Figure 3), we first define the different levels as a stack starting from the most technical and moving

towards the more societal sets of issues. The stack that we propose to organize research on open data services is as follows:

1. Technologies
2. Information
3. Processes and activities
4. Products and Services
5. Participants (including developers, data owners, and service developers)
6. Customers
7. Environment

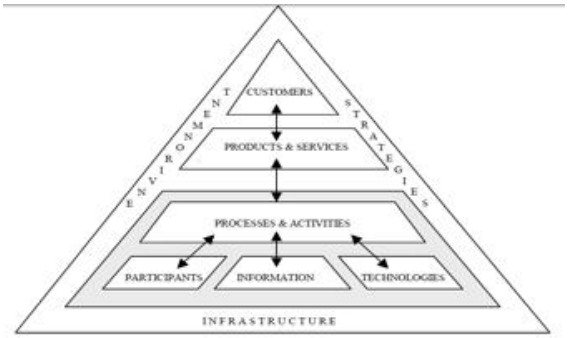

Figure 3. Work Systems [26]

Alter [26] emphasizes the idea of service systems, which extends the computing oriented view in the previous section. Details are important when open data services are viewed as service systems, but the key to service focused thinking is the view that the use of the data serves some purpose for someone. In other words, "customers and customer issues should be prominent throughout the analysis of systems" [26].

3.1.1 Technologies. As mentioned in section two, the key technological building blocks of open data are data storage systems and data storage and interface standards. Interesting research questions relevant from the service perspective arise from the availability and access to these building blocks, their interoperability, and the technical platforms they make up:

- How to ensure the availability of and access to as well as the interoperability of the needed technical components for developers willing to design and develop open data services?

- How to support the production of services for different technical user platforms?

From the users' perspective, the questions revolve around issues of compatibility of the services as well as access devices, as well as the actual usability of the available open data services:

- How to ensure technical compatibility of the open data services for users with heterogeneous access devices?

- What kind of user interface the users prefer for the open data services in different use contexts?

- How to support user upgrades to the services and facilitate users migrating from one technical platform to another

Furthermore, security and privacy issues need to be addressed, also from a technical perspective.

- What tools are needed to identify, address and manage security and privacy issues?

3.1.2 Information. Open data is created as raw data in different organizations and/or by devices and individuals collecting data. This raw data is not usually suitable for consumption by itself, but needs to be cleaned through the processes and activities of the production of the service.

Data format standards allow for the consistent interpretation of data. Berners-Lee's linked open data is an important building block here, but further domain specific and solution specific standards, such as XML based languages, are needed also. Interesting research questions arise from the need to understand the role of standards in services and their interoperability:

- What organizations and organizational processes are involved in standard setting or formation related open data availability, access and service development?

- How to categorize the various standards in a way that is useful for open data service developers?

3.1.3 Processes and activities. Raw data is usually not suitable for use without modifications and even in the most basic forms of screen scraping there is a need for processes of collecting the data from text files or html pages and then formatting it for further use. As the users get more sophisticated and data needs approach real time, there is a need for automatic processes for formatting data. From the services perspective, in

addition to the developers' processes, the most critical questions revolve around achieving sufficient timeliness of the data:

- What are the processes needed for accessing the raw data and, subsequently, transforming it into a usable format?
- What is the level of timeliness required (or acceptable) for the data used in open data services from the users perspective?

3.1.4 Products and Services. Assuming that the data is made available as linked open data at the previous level, it can be bundled and repackaged as ready-made products that are given or sold to customers (e.g. apps, such as public transportation timetables), or exposed as services to third party developers (e.g. utility metering data). Even more interesting phenomenon is, however, the servicization of the data. This means that instead of the low-level programming and data manipulation skills needed in the hacker culture of the "first generation" open data services, we are now moving into a phase, where service providers - often large software consultancies, but also smaller players - expose the linked, or even real-time data through service API's. This will offer the service developers a much more stable platform to develop new services on.

Even though empirical research and evidence is still scarce, we can expect that more large-scale processing services for historical data as well as data aggregation services will appear in the near future. These players will be able to bundle the data into products or services that can be made available or even sold on a continuous basis. An interesting example of this is a Finnish consumer credit rating agency Asiakastieto, that retrieves and bundles data from different public records and sells it then to companies that need to check the credit-worthiness of their customers. This example points out that open data services can also be business services, in addition to much more talked-about consumer or citizen services.

From the discussion above, we can derive (at least) the following research questions:

- How to define and conceptualize the servicization of open data services?
- What are the key drivers for business or private use of open data services?
- How to evaluate different open data service apps, in terms of their quality, and user value?
- What are the potential application areas for open data services and what are the dimensions most useful in categorizing them?

3.1.5 Data providers. In Alter's [26] model, data providers are grouped together with hackers and service developer companies as (non-customer) participants to value co-production. Open data providers include organizations such as public administration, traffic services, and weather services, to name a few. These data providers can have mixed motives for opening their data resources.

In the new public management [30] it was important to seek revenue from selling the data that public administration has collected. This can be an important revenue stream for agencies that invest resources in collecting the valuable information related to, for example, map services or traffic administration. Thus they are often reluctant to open their data without any financial compensation. Nevertheless, the initial experiences, for instance, from UK and Canada, seems to indicate that the benefits of open data services in terms of increased transparency; service innovations and efficiency gains in administration can be more significant than the loss of revenue. The research questions that are crucial to study in relation to data providers include the topics of motivation and business models:

- What are the motivations for data owners to agree or refuse to offer their data and provide APIs for open data services? What types of incentives are needed?
- What are the motivations and incentives needed for the data providers to maintain the data and ensure its continued accuracy?
- How to design sustainable business models for the data providers?
- How to support service innovation within the data provider organizations, as well in form of co-creation with citizens or consumers?

3.1.6 The developers. The developers, also participants in value-creation in Alter's model [26], face a number of challenges (some of which we have discussed in earlier sections of this paper), ranging from gaining access to the data needed and the actual development of the services to being able to raise the interest of potential users. Hence, focusing on the developers of open data services offers a multitude of interesting research avenues, from a number of different perspective:

- What are the motivations of developers to produce open data services? Are the incentives utilitarian, hedonic or social?
- How to convince data providers to open their data, if not already available? How to mitigate the information asymmetry rising from diverse and differing motivations?
- What are the skills and knowledge needed in developing high quality open data services?
- How to communicate the existence of the open data service to potential users?
- How to differentiate the service from other similar services?
- What are the possible business models for open data service developers?
- What are the motivations and incentives for developers to maintain their open data services?

3.1.7 Customers. Services can be developed in an amazingly short time frame through development competitions and the like [31], but as discussed above, for making open data services sustainable, there need to be customers; users who are willing to pay for the services or finance them through other means (e.g, donations, advertisement). In addition to those alluded to in the previous sections, there is, indeed, a whole range of questions pertinent to the customers, both in context of business users as well as consumer or citizen users:

- What impacts customers' willingness to pay for open data services?
- What are the users' attitudes towards advertisement in the context of open data services?
- How to support customer adoption of open data services?
- What is the role of network effects in the context of open data services that are consumed in two-sided or many-sided markets?

3.1.8 Environment. The most critical environmental factor from the perspective of open data services is society. Many recent public initiatives have pushed for the opening of public data in, for example, USA, UK, Canada and EU. Open data is seen by some almost as a panacea for moving towards more of a service and less of a product oriented society.

The potential of open data services for societies has been demonstrated for example in the above mentioned initiatives, but a host of questions and challenges remain:

- What are the legal issues involved in open data services? What kind of legal framework is needed to support the development and use of them? In particular, how to address the data security and privacy issues involved?
- What are the political and economical power issues that are related to development and use of open data services?
- What are the information asymmetries between policy makers and open data service developers and providers?
- What is the societal impact potential of different types of open data services, in terms of, for instance, democratization and entrepreneurial opportunities?
- How can public authorities facilitate service innovation in open data services?
- What are the issues related to the interplay between society and different open data service ecosystems?

4. Discussion

In this paper, we have presented a research agenda and a set of research questions for open data service research. We reviewed the relevant (but still scarce) extant literature to identify and classify the challenges related to open data services, and built a research agenda to support future research in this emerging area.

To this end, we provided a list of possible research questions connected to different aspects of open data services. Even though the list is quite extensive, we do not claim it covers all relevant questions. On the contrary, we believe that many more are needed, and from a multitude of perspectives, and will be addressed by researchers from different disciplines. However, we are certain that the research agenda presented in this

paper can serve as an inspirational starting point into an area that is likely to be important beyond our current comprehension.

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