A SEARCH ENGINE BASED ON KNOWLEDGE

A material object analysis of Google's search engine to identify the actors in an actor-network that cause a paradigm shift to semantic search

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Abstract

Searching the Web for information has become an essential part of our online habits. By using search engines like Google we are requesting information and expect an overview of the best information available. However, the presentation of search results is particularly based on algorithms that include mathematical calculations, which constitutes a hierarchical overview from relatively unstructured information. In order to improve the quality and relevance of these results a new development is emerging: semantic search. By investigating in online search and semantic search I will argue that semantic search lies at the basis of a new search engine paradigm. I will show historical paradigm shifts in online search and argue that a new paradigm is emerging. On the basis of a material object analysis of Google's search engine I will reveal actors that maintain or transform the actor-network in a search engine paradigm. By conducting this analysis I will show what the characteristics, implications, and interrelations are for the actors involved in the network of online search.

Keywords: search engine, online search, semantic search, material object analysis, actor-network theory, paradigm shift, Google

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Introduction

Every time I enter the World Wide Web through my browser I am confronted with my home page: Google Search. I have been using Google Search as my home page for years now. With its clean design and structure it is the perfect portal to the rest of the Internet for me. The importance of search engines is increasing, because 'parallel to the growth of the Internet and the Web, there is an ever growing need for effective mediation between information sources and audiences' (Van Hoboken 2009, 86).

In my recent experience and work about Search Engine Optimisation (SEO) I have encountered different ways of influencing the search results as presented by Google's search engine. From On-Page SEO and link building to the use of social media platforms in order to try to get or maintain the highest possible rank for the most relevant search query. SEO techniques are practiced to influence the search results presented by Google. In an earlier research about the role of SEO techniques I argued that there is a mutual state of interaction between SEO and Google's search engine that helps in getting a better user experience for online search (Van den Broek 2014, 8).[1] In this research I want to look further than the impact of this mutual state of interaction for user experience and will take a look at a new *search engine paradigm*.

I will employ terminology derived from the Actor-Network Theory (ANT) as described by Michel Callon and Bruno Latour in order to describe an actor-network that maintains or transforms a search engine paradigm. An *actor*, in this sense, is a subject or object engaging in affordance, design, and appropriation (Schäfer 2011, 19), as I will show in this research. By employing terms from ANT I will analyse the actors in the network of online search and show their characteristics. Online search is changing in representation and technology what causes a shift in the way online search works and is perceived. During my research I will show what the implications are for the actors involved in the network of online search and subsequently the changes in representation and technology by investigating in Google's search engine. This analysis includes historical paradigm shifts, business model, design, and affordances of the search engine. Because I do not want to focus on the user experience I will not include the concept of appropriation in this research.

I will address a new direction in online search, which is the basis of a new search engine paradigm: *semantic search*. Although *vertical search* and *mobile search* are also

[1] When referring to "online search" in this research, I am referring to text-based search, unless stated otherwise.

important new directions in online search I will not focus on these concepts because of the scope of this research. Semantic search claims taking the ambiguity out of search results and providing search results that are based on the intent and contextual meaning of the search query. It is a development that encourages the use of knowledge as coherent information in search results. The term 'knowledge' derived from Google's *Knowledge Graph*, which is part of semantic search. The Knowledge Graph is a technology that: 'enables the user to search for things, people or places that Google knows about—landmarks, celebrities, cities, sports teams, buildings, geographical features, movies, celestial objects, works of art and more—and instantly get information that's relevant to your query' (Singhal 2012). In short: knowledge refers to the way Google presents information through the Knowledge Graph: as clustered information.

British computer scientist, best known as the inventor of the World Wide Web, Tim Berners-Lee wrote in an article in *Scientific American* in 2001 about the *Semantic Web* and how search can be improved by this concept: 'The search program can look for only those pages that refer to a precise concept instead of all the ones using ambiguous keywords' (Berners-Lee, Hendler, & Lassila 2001). In this research I will analyse the features, structure, and name of semantic search and Google's Knowledge Graph.

The following questions are the focus of my research: What are the characteristics of new search engine paradigms? What are the implications of the development of these paradigms for the heterogeneous actors, which maintain or transform the actor-network of a search engine paradigm? My research is based on the hypothesis that the shift to a new search engine paradigm has implications for the actors involved in the network of online search. This hypothesis is mainly based on the impact of new developments in the field of online search, such as PageRank (Brin & Page 1998; Pasquinelli 2009, 153) and personalised search (Horling & Bryant 2009; Stalder & Mayer 2009).

Methodology

In order to answer my research questions I will conduct a material object analysis of Google's search engine and the development of semantic search in terms of representation and technology. The method of object analysis regarding new media studies is a method in development. While textual analysis (Gillespie & Toynbee 2006) and discourse analysis (Jorgensen & Phillips 2002) are common methods, object analysis is relatively new in new media studies. However, with the emergence of media objects as technological artifacts, like websites (Wikipedia), platforms, (Twitter, Facebook), applications (WhatsApp, Snapchat), and web services (SaaS solutions like

Dropbox and Salesforce), a method for object analysis becomes necessary. By analysing media objects as hybrid assemblages of both hardware and software we are able to make them subject to research in new media studies. Examples of analysing media objects can be seen in research about retweets (Starbird & Palen 2010), hashtags (Glasgow & Fink 2013), and hyperlinks (Helmond 2013). Starbird and Palen are analysing the use and role of retweets on Twitter's platform during two mass emergency situations in 2009 (Starbird & Palen 2010). Glasgow and Fink conduct a similar research by focusing on the use and role of hashtags on Twitter's platform during the London riots in 2011 and how they generate a network of communication with multiple actors involved (Glasgow & Fink 2013). New media researcher Anne Helmond is analysing the technical reconfiguration of the hyperlink and argues it changed from a navigational device into an analytical device (Helmond 2013, 1). In her analysis she describes the hyperlink since its inception and how it evolved over time. To make her argument about the hyperlink being an analytical device she describes how the hyperlink is pre-configured through Web 2.0 applications and websites (*ibid*, 4). Furthermore, she uses a case study of a *short URL* shared on Twitter to examine, what she calls, the 'algorithmization of the hyperlink' (*ibid,* 8).[2] By conducting this material object analysis she is able to reveal the actors that have contributed to the role of the hyperlink. She analyses the representation of the hyperlink (the use of short URLs), the technology of the hyperlink (how it changed from a navigational device to an analytical device), and the affordance of the hyperlink (the case study shows how short URLs are used).

A benefit of the material object analysis is the specification of analysing a media object as opposed to textual or discourse analysis. The elucidation of dissecting a media object helps in understanding and distinguishing the technology, representation, and affordance of this media object. The dissection of a media object is also a limitation of this research method, because it can turn into a full-fledged research itself. The challenge lies in specifying the object and boundaries of the analysis.

In this research, I am using Google's search engine and semantic search as my primary objects of investigation and will analyse them on two basic levels: representation and technology. The presentation of search results will be an analysis of the user interface regarding its affordances through design. The technology will be analysed by showing how Google collects, stores, processes, adjusts, and returns information from the Web. My analysis will give insight in Google's search engine as a

[2] A *short URL* is a URL shortened by a URL Shortening Service (USS) to save characters by shortening links.

collection of algorithms, a collection of information, a web interface, and a business model. On the basis of this analysis I will show the coherence between Google's search engine and earlier search engine paradigms. The ideas and concepts of these earlier paradigms are: 1. File search. This paradigm is based on searching for filenames. 2. Full-text search. This paradigm is based on searching through the content (full-text) of documents and webpages. The use of meta tags and keywords is important during this paradigm. 3. Linked network search. This paradigm is based on networked documents through links. The PageRank algorithm (Brin & Page 1998; Hillis, Petit, & Jarret 2013, 18) is a key development in this paradigm, because it classifies webpages based on links and backlinks. 4. Universal search (Mayer 2007; Sullivan 2007a). This paradigm is based on the idea to show, in addition to web results, also news, images, and grouping results on the page. 5. Personal search (Pariser 2011, 10). This paradigm is based on the idea of using specific variables of the user in order to determine relevant search results for each specific user. I will give a more elaborate analysis and time period of the paradigms mentioned above in section 1.1. I will argue that a new search engine paradigm, based on the concept of semantic search, is emerging and that this development has implications for the actors that are engaging in representation and technology.

In my object analysis of Google's search engine and semantic search I will amplify the emergence of a new search engine paradigm by employing terms of the Actor-Network Theory (ANT). I will analyse the infrastructure of the actor-network of online search and reveal its actors, which maintain or transform a search engine paradigm. The interrelated actors will highlight anomalies that constitute a crisis, which leads to a paradigm shift.

ANT is based on the principle that after analysing a phenomenon, artefact, or process it appears as a network of heterogeneous actors. A network, on the other hand, can appear as one actor. Originally created by French scholars Bruno Latour and Michel Callon, ANT is an attempt to understand processes of innovation and knowledge-creation in science and technology and is therefore suitable for employing within the field of new media studies. The earlier mentioned article about *The Algorithmization of the Hyperlink* also describes the use of actors in the object analysis, as derived from ANT (Helmond 2013, 13). Furthermore, media researcher Theo Röhle employs terms from ANT in his research about Google and power relations, where he argues that search engines have a position 'as intermediaries between content and users' (Röhle 2009, 120).

ANT does not typically aim at explaining why a network exists; it is rather interested in the infrastructure of actor-networks. In this research I describe Google's

search engine as a technological innovation that I will analyse by conducting a material object analysis. Through this analysis I will reveal the actors involved in the actor-network of online search and show the characteristics of a search engine paradigm. As a conceptual framework ANT helps to understand the process of the technological innovation of Google's search engine and explains the infrastructure of the actor-network. By describing how the infrastructure of the actor-network of online search is formed and changing I will show how a paradigm shift occurs. A shift in search engine paradigm is happening when an actor-network is falling apart and re-forming again.

While ANT also describes users as actors in the actor-network it goes beyond the scope of this research to investigate user practices. The user can be described as an actor that is engaged in a process of relying and building on other actors within the actor-network, but is here taken as a black box. In fact, because I am not focusing on field research, I am conducting a kind of semi-ANT analysis. Field research in user practices and experiences can be conducted in a follow-up study in order to give a more detailed insight in user practices and behaviour.

A limitation of the ANT framework is that it does not have specific borders. An actor-network formed by actors can, as a whole, also be described as one actor in an actor-network on another level. In this sense, ANT has no specific borders and can be an on-going process of analysing actor-networks and its actors. Professor Simon Cooper argues that 'in its essentialization of hybridity, and in its hostility towards larger contextual categories such as capitalism, social form, race and culture, Actor Network Theory has gone beyond microanalysis to construct itself as a master discourse, one which demands to be engaged with as such' (Cooper 2008, 308). Professor of sociology John Law shares this concern about ANT and asks how it is possible to 'talk about something […] without reducing it to the fixity of singularity' (Law & Hassard 1999, 11). However, despite ANT as a method is black-boxed, it 'challenges some common epistemological convictions by rejecting essential subject/object, culture/nature, or society/technology distinctions' (Williams-Jones & Graham 2003, 272). Entities that appear in the actor-network, both human and non-human, do not have significance in themselves, but rather achieve significance through relations with other entities: 'If differences exist it is because they are generated in the relations that produce them' (Law 2006, 4). In this research I use Google's search engine as the starting point of my actor-network analysis and will focus on the actors that are present within this actor-network.

As described by Law, ANT is a 'disparate family of material-semiotic tools, sensibilities and methods of analysis that treat everything in the social and natural

worlds as a continuously generated effect of the webs of relations within which they are located. It assumes that nothing has reality or form outside the enactment of those relations' (Law 2008, 141). It describes actors as a collective noun for subjects and objects. These actors can consist of 'objects, subjects, human beings, machines, animals, 'nature', ideas, organisations, inequalities, scale and sizes, and geographical arrangements' (*ibid.*). The meaning and state of actors in relation to others is changing when they react on, associate with, negotiate with, mobilize, enrol, inscribe, persuade, adjust, comply with, transform, rule out, take over, or subordinate with other actors. This is why actors are changing and adapting continuously. When this happens the network, as a whole, is changing as well. An actor-network is therefore not a static network, but a set of transformations (Latour 1999a, 15). Various actors are trying to create alliances in order to form and develop the network (Callon 1986a; Law & Callon 1992).

ANT assumes that every actor should be integrated into the same conceptual framework, which is called the principle of *generalised symmetry* (Callon 1986a, 199). All actors are analysed using the same repertoire, which allows the network to generate the differences between actors in the network of relations (*ibid.*). Latour describes that an actor-network consists of *intermediaries* and *mediators* (Latour 2005, 38).

An intermediary is 'what transports meaning or force without transformations: defining its inputs is enough to define its outputs' (*ibid,* 39). Intermediaries are passive, predictable, and exist of one entity, even if it is internally made of many parts. An intermediary can be taken as a black box (Latour 1999b, 304), which describes a complex system that is simplified to an individual node interacting with other nodes within its network. When the simplified black box is "opened" to analyse the system new actors will be revealed (Callon 1986b, 29).

In contrast to an intermediary a mediator cannot be counted as just one entity. Mediators 'might count for one, for nothing, for several, or for infinity. Their input is never a good predictor of their output; their specificity has to be taken into account every time. Mediators transform, translate, distort, and modify the meaning or the elements they are supposed to carry' (Latour 2005, 39). A mediator is dynamic, unpredictable, and an entity with a multidirectional conduit of influence.

In my analysis of Google's search engine, the actors in the actor-network can maintain or transform a paradigm. I will argue that the mediators that will be revealed through my analysis are the entities that can achieve a paradigm shift, since they can transform the meaning or the elements they are supposed to carry. The process of actors that are transforming each other is called *translation* (Law 1992*,* 5; Callon

1986a). In his article about the way scientists study scallops in St. Brieuc Bay Callon refers to the *sociology of translation*, which he describes as a method that includes four "moments" of translation: problematisation, interessement, enrolment, and mobilisation (Callon 1986a, 196). While this concept of translation is not a universal method of researching transforming actors, it helps understanding the process of translation by describing these four moments.

The first moment of translation is problematisation, which is about framing the problem and identifying the relevant actors. By framing the problem an Obligatory Passage Point (OPP) can be posed. An OPP can be seen as the narrow end of a funnel that forces the involved actors to converge (*ibid*, 202). Röhle describes that Google established itself as an OPP, because 'both webmasters and users need to pass this point if they want to continue moving on their program of action' (Röhle 2009, 120).

The second moment of translation is interessement, which is the process of negotiation in which the actors identified during the problematisation are persuaded to identify with their assigned roles. The researcher analyses the relative positions of the different actors (Callon 1986a, 203). An example can be the identification of the actors that are present when a user enters a search query in a search engine.

The third moment of translation is enrolment, which identifies the process of negotiation in which the actors are persuaded to act out their roles. The researcher 'sought to define and interrelate the various roles they had allocated to others' (*ibid*, 196). This moment can be characterised by the accepted roles of Google and users. Google is successful in this process because 'its clean interface and comparatively spam-free results effectively re-installed the illusion of control for the users' (Röhle 2009, 120). This idea is reinforced because 'most users are ignorant about how ranking operates and often consider it as the true response to their queries and an "objective" vision of the world' (Lobet-Maris 2009, 79).

The fourth, and last, moment of translation is mobilisation. Mobilisation is the process whereby the actors are justified as representing their constituents. It consists of a set of methods used by the researcher to ensure the identified actors indeed represent where they stand for (Callon 1986a, 207). The actors involved in the process of entering a search query in a search engine will represent their own stakeholder(s) and will see whether the search results meet their expectations.

A successful translation signifies the process that allows the actor-network to be represented by a single actor. The interrelated domains of an actor-network are connected and work together in order to create a forum, a central network in which all the actors agree that the network is worth building and defending. When the translation

is successful the actors work together in order to transform the actor-network in one actor. In this research this process will identify a search engine paradigm.

I will start this research by delineating the concepts: search engine paradigm, semantic search, and (Google's) business model. I will then analyse both Google's search engine and semantic search on the levels of representation and technology. These analyses are my material object analyses. The concepts from the earlier mentioned paradigms will be related to the emerging new search engine paradigm.

1. The field of online search

By delineating and giving a brief description of the concepts search engine paradigm, semantic search, and (Google's) business model, I will show how these phenomena are embedded in this research.

1.1 Search engine paradigm

American philosopher of science Thomas Kuhn introduced the term *paradigm* in *The Structure of Scientific Revolutions* as 'universally recognized scientific achievements that, for a time, provide model problems and solutions for a community of practitioners' (1962, 10). It can be seen as a complex set of ideas, methods, and questions that the scientific community of a certain period provides an idea of questions that are important and how they should be solved. Research questions, available methodologies, and shared assumptions within the scientific community lead to the accumulation of science under specific paradigms. Kuhn argues that the view of science is not stable and linear. When the role of science is redefined, new questions, perceptions, and tools are adopted. This is a *paradigm shift* (Szulecka 2011, 2).

Kuhn did not consider the concept of paradigm appropriate for the social sciences. While writing his book Kuhn spend time in a community that was predominantly composed of social scientists. He observed them and noted that they had unanticipated problems, which was completely different in the community of natural scientists where Kuhn had been trained: 'I was struck by the number and extent of the overt disagreements between social scientists about the nature of legitimate scientific problems and methods' (Kuhn 1962, x). Due to this observation Kuhn coined the concept in order to distinguish the natural sciences from the social sciences: 'Attempting to discover the source of that difference [between natural science and social science] led me to recognize the role in scientific research of what I have since called "paradigms"' (*ibid.*).

Examples of paradigm shifts are described surrounding several topics, which include a paradigm shift in solar energetic particles (Reames 1995), brain research (Carlsson 2001), and in globalisation (Oprescu 2011). For new media studies, which deals with the content, history and effects of media, we can also identify paradigm shifts. Regarding Kuhn's concept we can say that the view of new media studies and the development of new media is also not stable and linear. Concepts and theories of new media are developing, which raises new questions, perceptions, and tools that are

adopted. In general, when looking at new media, we can say that there has been a media revolution from classic media to new media with the arrival of the digital age (Rogers & Balle 1985). This is a revolution from a traditional analogue media environment to an environment with new communication dynamics based on interactivity and multimedia, also referred to as *participatory culture* (Jenkins et al. 2009). In this participatory culture there is an advent of convergent new media, which blurred the lines between producer and consumer (Jenkins 2006; Miller 2011, 87). Spanish professor José Luis Orihuela studies the impact of technology for communication and describes ten paradigm shifts that lie on the basis of this media revolution, which includes a shift from audience to user (and producer), from periodicity to real time, and from linear content to hypertext (Orihuela 2003). More paradigm shifts regarding new media studies are described about advertising (Perez-Latre 2007) and the rise of social media for marketing industries (Mangold & Faulds 2009; Page 2011; Guneysel 2014). These paradigms regarding new media studies describe communication dynamics that serve as a media standard. In this research I will argue we can identify a *search engine paradigm* and historical shifts in this paradigm.

I define a search engine paradigm as a coherent system of models, theories, and technologies that forms a conceptual framework surrounding online search. The purpose of this paradigm serves a similar one to the paradigm as described by Kuhn, namely to serve as a set of assumptions, concepts, values, and practices that influence several things, which include the perception, research, agenda-setting, and technology of online search. Shifts in this paradigm can occur when a fundamental change in, particularly, technology is developing. Kuhn describes the process of a paradigm shift that begins with anomalies that are encountered and cannot be explained by the universally accepted paradigm of a certain period (Kuhn 1962, 65). During any paradigm there are anomalies that are ignored or seen as acceptable errors. However, when enough significant anomalies are encountered a state of crisis is reached (*ibid*, 66). This crisis paves way for new ideas that are tried. On the basis of the new ideas a new paradigm will be formed. This change in paradigm is called a paradigm shift. Kuhn continues to describe his idea of *incommensurability* as a universal property that defines the relationship between successive paradigms (*ibid*, 112). In this research this refers to the relation between the new search engine paradigm and its predecessors.

The historical search engine paradigms that we identify are based on the following ideas and concepts: file search, full-text search, linked network search, universal search, and personal search. There are some developments that are not

specifically mentioned in these paradigms, such as "reverse image search".[3] Although such a development is a change for online search, I do not consider this as a paradigm shift like the other mentioned historical search engine paradigms, because they do not ensure a fundamental change in the representation or technology of online search. I will briefly describe each of the search engine paradigms to show the impact of these shifts on online search.

The first paradigm is based on searching for filenames and existed from 1990 until 1994. Before the World Wide Web emerged the first search engine was introduced by Alan Emtage in 1990: Archie (Wall n.d.). Documents were manually assigned with filenames created by its producers. Using Archie, users were able to type in a filename and see where the file was available on the Net (Gaffin & Heitkötter 1994). In order to use this application it was a prerequisite for the user to know the filename in order to find it. While the Web grew and HTML became the standard for webpages it became almost impossible to search for only filenames to find relevant documents. This expansion of the Web and the emergence of HTML induce the prerequisite of having to know a filename as an anomaly that leads to a crisis and a paradigm shift.

The second paradigm is based on full-text search and existed from 1994 until 1998 (Wall n.d.). While the previous paradigm was based on searching for filenames, this paradigm introduced searching for words that are "on the page" in the content of documents and webpages (Goldman 2005, 529). If you search for [dogs] you will get search results of pages that have the word "dogs" on their page. A page that mentions this word 150 times will rank higher than a page that mentions this word 100 times. Relevance was based on the amount and the location of these keywords. Keywords on the top of the page will count for a bit more than the keywords down below on the page. Meta tags are also considered in this ranking system. Meta tags are elements in the *head* section of a webpage that can be used to specify additional information about the webpage, such as: description, keywords, and author. The content, keywords, and meta tags of webpages are entered by the producer of the webpage. These elements became used and misused by webpage producers. By deliberately selecting, repeating, and placing keywords with no relevance to the content of the webpage, producers tried to get more attention than the webpage should deserve (*ibid*, 531). We can identify this as an anomaly that led to a crisis and subsequently to a new search engine paradigm.

The third paradigm is based on linked network search and existed from 1998 until 2007 (Wall n.d.). As an answer to the problem with content on the page, as described in the previous paradigm, now elements "off the page" became important.

[3] Google introduced reverse image search in June 2011 (Wright 2011).

This paradigm is based on link analysis. An important development is the PageRank algorithm (Brin & Page 1998). Search engine Google launched in 1998 based on the PageRank algorithm, which Google used to look at the "recommendations" of webpages by measuring the amount and value of links to webpages (*ibid.*). Media researcher Matteo Pasquinelli describes that 'the ranking of a web page can be quite intuitively understood: its rank value is determined by the number and quality of incoming links. Particularly, a link coming from a node with a high rank has more value than a link coming from a node with a low rank' (Pasquinelli 2009, 153). Google 'considers links to be like votes' (Sullivan 2007b). Based on the amount and value of these votes the PageRank algorithm gives a value to each webpage. While the algorithms used by Google to rank webpages on their Search Engine Results Pages (SERP) mainly used the PageRank value, they now rely on more than 200 unique signals to rank webpages (Google, 'Algorithms' n.d.). Google frequently updated their algorithms to improve search results in several ways, such as speed and quality (Moz n.d.). I do not consider each algorithm update as a paradigm shift, because the core of this paradigm is still based on linked network search. However, anomalies were encountered since the emergence of blogs, online newspapers, and content like images and videos that were, until then, not indexed and blended with the search results. The emergence of websites with dynamic content, like blogs, is in particular the reason that led to a crisis. Blogs introduced the use of a new type of link, the *permalink*: 'Permalinks gave each blog entry a permanent location –a distinct URL– at which it could be referenced' (Blood 2004, 54). Based on the permalink, blogs are semi-automatic linked through trackback and pingback to other blogs: 'These automatic link notification systems […] created reciprocal links between blogs, making the link openly visible on both blogs. Trackbacks and pingbacks […] are automated linking mechanisms making previously invisible links on the receiving end visible by displaying them underneath the blog post, usually within the comment space' (Helmond 2013, 4). This crisis resulted in a paradigm shift.

The fourth paradigm is based on universal search and existed from 2007 until 2009 (Mayer 2007; Sullivan 2007a). This paradigm shift occurred on the occasion of the lack of specific results in the form of online newspapers, images, and the development of websites with dynamic content, like blogs. In addition to static web results, content from images, videos, maps, books, blogs, and online newspapers is now blended and grouped into the search results (Mayer 2007). With the emergence of *Web 2.0* (O'Reilly 2005), which describes a set of web technologies that facilitated easy publishing and content sharing and the establishment of social networks, anomalies were encountered. The advent of Web 2.0 made it clear that 'users are not just knowledge-seeking individuals,

but also social beings intensely connected to each other online and offline' (Stalder & Mayer 2009, 103). The anomalies are characterised by the technology of social platforms, like Twitter and Facebook. Sharing, liking, and tweeting content on these platforms generate links, which count as 'votes' for the content the user is linking to. This led to another paradigm shift. The fifth paradigm is based on personal search and exists from 2009 until now (Horling & Bryant 2009). Google introduced Social Search in 2009 to increase the personal search experience by presenting 'relevant web content from your friends and online contact' (Heymans 2010). While there is discussion about the impact of social networks on search results (Fishkin 2011) Google's head of the webspam team Matt Cutts said in 2014 that pages from social networks Facebook and Twitter are not used as signals in their ranking algorithms (Google Webmasters 2014). However, we can see that votes generated through other platforms, like Google+, are used in presenting search results (Sterling 2012). The ratings and reviews for a restaurant, for example, can be seen in the search results on the basis of users that vote or recommend a restaurant on Yelp or Google+. Furthermore, personal search is using specific variables of Google users in order to determine which search results are relevant for each specific user (Stalder & Mayer 2009). These variables include, for example, the user's search history on Google, clicked results, IP address, and type and language of the used browser (Google, 'Search History' n.d.). These variables are 'connected in different ways in order to create a model of the individual user's preferences, which can be employed to re-rank results (Röhle 2009, 124). While personalised search was already introduced in 2005 for users that were signed in to Google (Kamvar 2005), it became available for everyone in 2009 (Horling & Bryant 2009). With this concept Google is able to 'customize search results for you based upon 180 days of search activity linked to an anonymous cookie in your browser' (*ibid.*).

By giving a historical overview of paradigm shifts in online search I have shown how they are all encouraged by insoluble problems and new technologies or technologies developed in order to solve the problems and anomalies. In order to analyse what I conceive as the latest shift to a search engine paradigm based on semantic search, I will address the concept of semantic search in the next section.

1.2 Semantic search

Semantics is a word derived from the Ancient Greek word *semantikos*, meaning *significant*. Semantics is the study of meaning, focusing on the relations between *signifiers*, like words, phrases, signs, and symbols. The *Semantic Web* is a collaborative movement led by international standards introduced by the World Wide Web

Consortium (W3C). The W3C argues that the Semantic Web 'provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries' (W3C, 'Semantic Web Activity' n.d.). While the Web contains linked webpages, the content on each specific webpage consists of unstructured and semi-structured data. British computer scientist Tim Berners-Lee coined the term Semantic Web and argues that it 'isn't just about putting data on the web. It is about making links, so that a person or machine can explore the web of data. With linked data, when you have some of it, you can find other, related, data' (Berners-Lee 2009). Instead of a Web based on hypertext, the Semantic Web links between structured data, information, what constitutes a form of knowledge.[4] Knowledge refers here to a cluster of related meanings and concepts. Instead of information that is available through hypertext, this knowledge is available as clustered information.

If we relate this concept to online search we can identify a paradigm shift due to anomalies that are characterised by the structure of semantic content on the Web, as opposed to a Web based on hypertext. Berners-Lee argues that 'the search program can look for only those pages that refer to a precise concept instead of all the ones using ambiguous keywords. More advanced applications will use ontologies to relate the information on a page to the associated knowledge structures and inference rules' (Berners-Lee, Hendler, & Lassila 2001). An ontology is a system of clearly defined relations between clearly defined concepts. They are a representation of a specific domain of knowledge.

S*emantic search* can be described as 'search for information based on the intent of the user and contextual meaning of the search terms, instead of depending on the dictionary meaning of the individual words in the search query' (John 2012). The search engine understands the search query entered by the user and subsequently takes the ambiguity out of the search results.

In section 1.1 I described how a paradigm shift occurred from important elements on the page to important elements off the page. With semantic search, information is directly presented at the interface (SERP), instead of clicking on a search result to see this information: a shift to no page at all. By providing information directly at the SERP Google takes away the step to click on a search result and go to an external webpage. This concept of semantic search is based on *entities*, which can include 'things, people or places that Google knows about—landmarks, celebrities, cities, sports teams, buildings, geographical features, movies, celestial objects, works of art and more'

[4] As from 11 December 2013 the Semantic Web is part of a larger scope: *The W3C Data Activity.* This concept merges and builds upon the Semantic Web (W3C, 'Data Activity' n.d.).

(Singhal 2012). These entities have values. When searching on Google for [Paul McCartney] the search engine returns a summary of who he is plus associated values, like: age, height, and spouses (see figure 1). This specific way of showing information is part of Google's Knowledge Graph, which I will further describe in the third section of this research. Google shows information for an entity with the associated values at the right side of the page, next to the usual search results.

Figure 1. Semantic search information for [Paul McCartney].

The Semantic Web is also described as a metadata initiative (Marshall & Shipman 2003, 62). Meta tags in online content generate different clusters of information within specific domains. The use of meta tags here is not the same as I described in the earlier, second, paradigm where meta tags are added by the producers of a webpage in order to specify additional information about the webpage. Here, meta tags are associated values of entities, like we can see in figure 1. Google's search engine implements meta tags through the Knowledge Graph by using semantic information deriving from public sources such as Freebase, Wikipedia and the CIA World Factbook (Singhal 2012). The presented information is furthermore tuned on the search queries of users (*ibid.*).

Although there is some criticism about the Semantic Web and the use of ontologies (Marshall 2004; Shirky 2005) it is a development that encourages the use of knowledge as coherent information in online search, which encourages a paradigm shift.

1.3 Business model

Business models are for themselves already complex concepts that can be studied through multiple disciplinary and subject-mattered lenses (Zott, Amit, & Massa 2010, 1). A business model is a framework that helps us understand how different entities of a business blend to create value for their operators. These entities can include: production, finance, marketing, sales, and engineering. By describing Google's business model and strategy we can understand how their operators create value.

Google offers a wide range of products and services for both business and home use, which include Google Maps, Gmail, and Google Docs.[5] While most services and products are free for home use Google also offers business plans. Although these business plans create revenue for Google, their main revenue is gained through selling advertising space.

In October 2000 Google launched Google Adwords, a: 'Self-service ad program [that] promises online activation with a credit card, keyword targeting and performance feedback' (Google, 'Our history in depth' n.d.). By selling advertising space Google is creating value and revenue. When you buy advertising space your '*ad* appears beside relevant search results' (Google, 'AdWords' n.d.). In this way Google offers *contextual advertising*, since advertisers can place bids for certain keywords (Röhle 2009, 125). Contextual advertising facilitates 'real-time translation of information needs into consumption needs. This translation is possible because search queries are reasonably good representations of information needs' (*ibid.*).

Later, in 2003, Google also launched Google AdSense (Google, 'Our history in depth' n.d.). While Google AdWords enables advertisers to show advertisements on relevant SERPs, Google AdSense brings these advertisements to websites outside Google through their Display Network.[6] Google partners with websites through the AdSense programme, which allows advertisers to relate their advertisements to the content of the website.[7] This advertising model is Google's main source of income by generating

[5] A list of products and services can be found here:
<http://www.google.co.uk/intl/en/about/products>.
[6] More information about Google's Display Network can be found here:
<http://www.google.com/ads/displaynetwork>.
[7] More information about Google's AdWords and AdSense programmes can be found here:
<http://www.google.com/intl/en/ads>.

more than 50 billion dollar of advertising revenue in 2013 (Google, 'Financial Tables' n.d.). From this perspective, we can argue that the actual customers of the search engine are not their users, but their advertisers (Stalder & Mayer 2009, 98). Google wants to 'deliver relevant search results to the users, and to deliver relevant users to advertisers (*ibid,* 99).

The advertising model is effective during all paradigms described in section 1.1. However, by analysing a paradigm shift based on semantic I argue this advertising business model is subject to change. While selling advertising space will still be the main source of Google's income I will show that the developments of a new search engine paradigm will have an impact on business models for search engines.

2. Search engine analysis

Online search is a complex synthesis that can be described as two basic levels of materiality: representation and technology. I will use Google's search engine as a starting point in this analysis and will focus on the actors that are present in this actor-network. By conducting this analysis the roles of heterogeneous actors as intermediaries and mediators will become clear.

2.1 Representation

The representation of Google's search engine is shaped by its user interface. The interface of Google's homepage consists of the following elements: the Google logo, a search bar, two search buttons, links to services in the top right corner, and informational links in the footer, see figure 2.[8] While the technology of Google remains hidden for the user, the interface is the part of the search engine for the user to interact with.

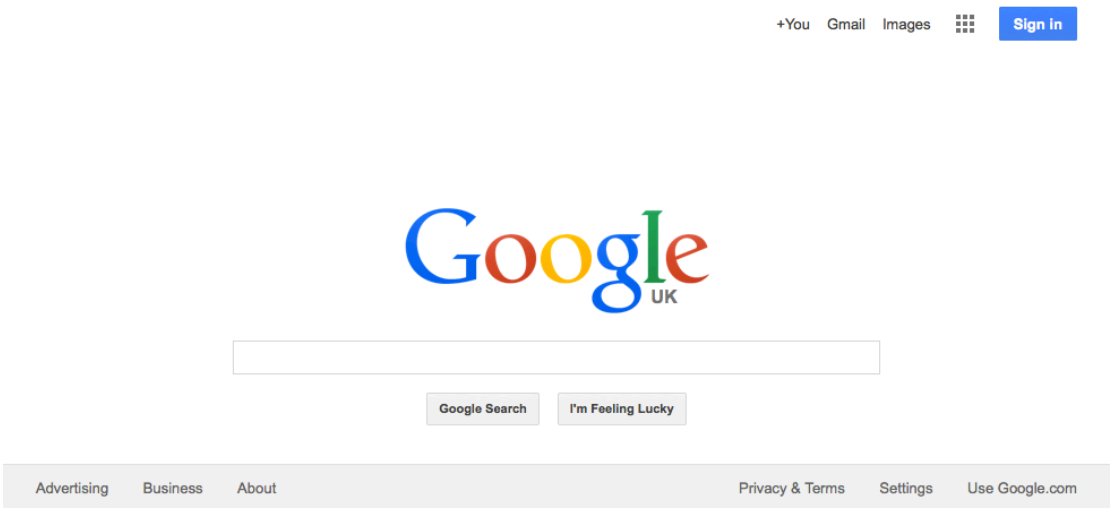

Figure 2. User interface of Google's homepage.

The elements on the homepage are identified as actors of the interface. Because the logo, search bar, and links on the top and bottom of the page are passive actors, they are identified as intermediaries; they do not transform any meaning.[9]

[8] Sometimes, depending on current events, Google's logo is changed in a *Doodle* (Google, 'Doodles' n.d.).

[9] When Google's logo is changed in a Doodle one could argue that the logo does transform meaning, because the logo becomes clickable and links to a SERP, based on the current event. However, this does not affect my analysis of the actors on Google's homepage, because entering an equal search query will result in the same SERP.

Through a process of translation actors of the representation of the search engine are transforming each other. When a user enters a search query and clicks on the "Google Search" button a process of sending the search query to the technology of the search engine starts, which results in an overview of *organic* search results presented as a hierarchical list on the Search Engine Results Page (SERP). Organic search results are results that are generated through ranking algorithms and are presented based on their relevance regarding the contemporary search engine paradigm. The "I'm Feeling Lucky" button used to skip the SERP and send the user directly to the first webpage from the organic results. However, this feature changed in 2012 by letting the button link to the Google Doodles gallery or other Google services, depending on your settings (Paul 2012; Google, 'I'm Feeling Lucky' n.d.). While the "I'm Feeling Lucky" button used to act as a mediator, it is now identified as an intermediary, because it does not transform any meaning. The "Google Search" button is identified as a mediator, because it transforms the search query to a SERP.

Next to the organic results the search engine also presents non-organic search results: advertisements, see figure 3. On the top of the page and on the right side of the page are non-organic search results presented, which are characterised by an "Ad" label. In the example of figure 3 I searched for [swim shorts]. The advertisements that are presented are based on the relevance to this search query in combination with the variables from the personal search engine paradigm, which include my search history on Google, clicked results, IP address, and type and language of the used browser (Google, 'Search History' n.d.). These personal variables are 'connected in different ways in order to create a model of the individual user's preferences, which can be employed to re-rank results' (Röhle 2009, 124). Just as the organic search results the advertisements are retrieved from an index. Another ranking algorithm will determine which advertisement will be presented on which spot. I will not further describe this index and algorithm, because I want to focus on the organic search results.

I will describe the SERP on the basis of its *affordances.* Affordance is a term introduced by researcher in cognitive science Donald Norman. It describes the specificity of technology and refers to the 'fundamental properties that determine just how the thing could possibly be used' (Norman 1998, 9). Affordance describes two characteristics, the specificity of the object and the affordance imposed on it through its design (Schäfer 2011, 19).

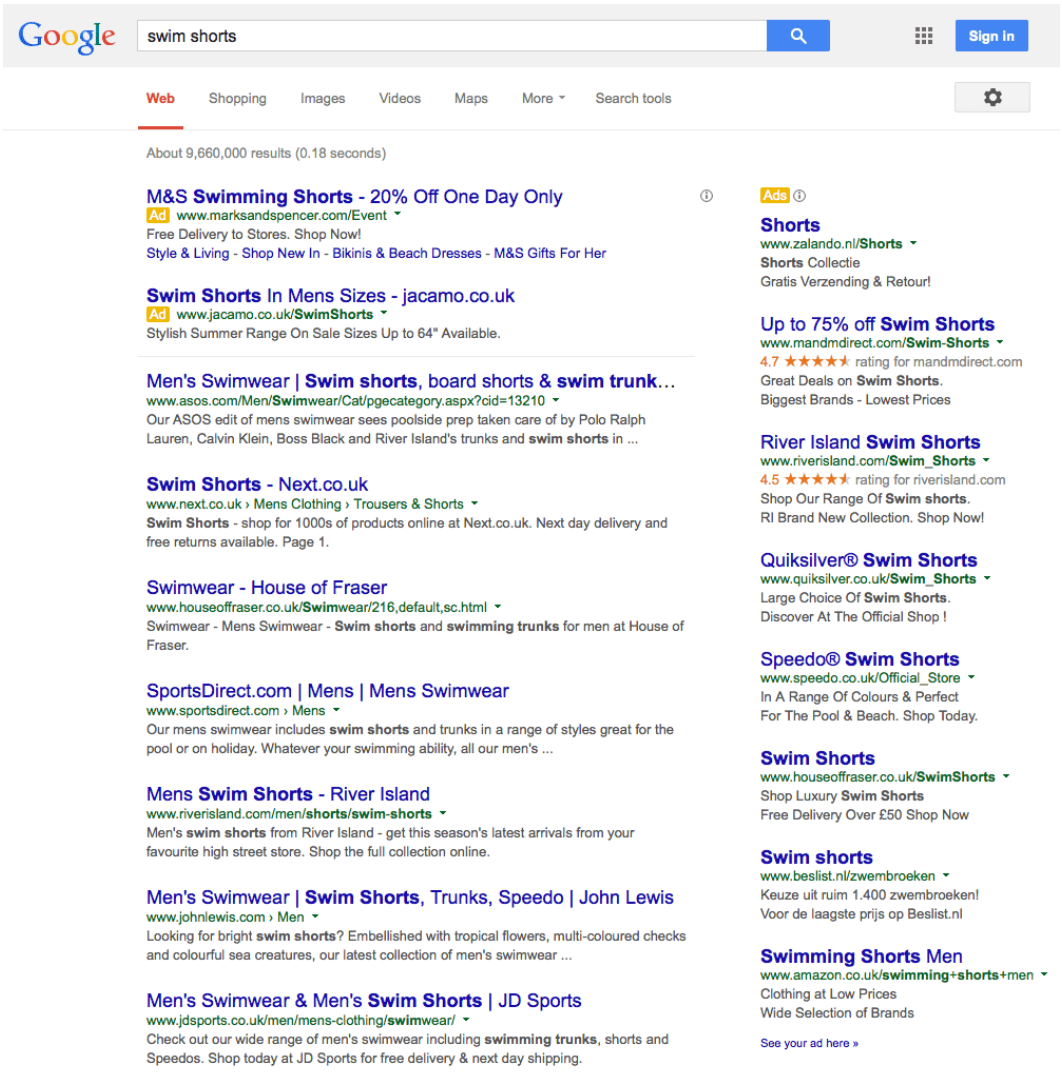

Figure 3. Organic and non-organic search results.

When analysing my SERP from figure 3 we can see that the advertisements have the same design as the organic search results, which is a little trick to ensure that they are completely integrated in the SERP. The intention of this trick is to let users click on the *paid results*. The paid results are part of Google's AdWords tool and business model. However, research shows that just 6% of users click on the paid results and 94% on organic results (Neo Mammalian Studios 2012), which has implications for Google's business model. The user and advertisements are interrelated actors through the enrolment of the users that subsequently has implications for Google's business model. By showing a yellow "Ad" label at the paid results Google shows the affordance by defining the fundamental property that determine how the search result can be used. Norman uses the term *signifier*: '[An] indicator, some signal in the physical or social world that can be interpreted meaningfully' (Norman 2008). While Norman refers to the

physical or social world, I argue this also applies for the digital world. The yellow label acts here as a signifier and gives meaning to the search result.

Google uses default settings for presenting search results, which include the amount of organic results that are presented. The default number of organic results is 10, but can be set up to 100 results on each SERP. However, research shows that webpages listed on the first SERP generate 92% of all traffic from an average search (Chitika 2013, 7). Furthermore, the top listing in Google's organic search results receives 33% of traffic, compared to 18% for the second position, degrading until 2% for the tenth position (*ibid*, 6). In the top right corner on the SERP, as seen in figure 3, under the "settings icon" the user can change the amount of results presented by clicking on "Search settings". In addition to this affordance, Google has two more affordances to specify the search results presented. The first affordance to specify search results is by filtering search results with the options that are available after clicking on "Search tools" at the top of the SERP.[10] Filters that are available include searching for publish date, nearby results, and reading level.[11] The second affordance to specify search results is by using Boolean search. Boolean searches are carried out by using search *operators*, which include symbols and words like: OR, a dash (-), and an asterisk (*).[12] Google also offers an *advanced search* page to create similar searches without entering search operators manually, but by entering the specific properties in search boxes.[13] The user can narrow the search results down by, for example, searching for an exact word or phrase, exclude a word, or search within a site or domain.

I have shown the elements in the actor-network of the representation of Google's search engine, which is subsequently identified as a black box that, when opened, consists of intermediaries and mediators. As described by Theo Röhle, Google 'established itself as an obligatory passage point' (Röhle 2009, 120), because the user has to pass the SERP to continue to the webpage with the information needed. A search query has to be entered and the "Google Search" button has to be clicked by users to reach the SERP. I argue that the user, by entering a search query, can be identified as a non-human intermediary. While the interaction of the user with the SERP is identified as signals/input for the search engine, the search query entered is just a piece of code. From the perspective of the actor-network of Google's representation the user is a mere

[10] Not all search tools are available in every language or only shown if you're signed in to your Google Account (Google, 'Filter Your Search Results' n.d.). Furthermore, different filters are available for different types of results, like Web or Images.
[11] For a full list of search filters visit <https://support.google.com/websearch/answer/142143>.
[12] For a full list of search operators and their functionalities visit <https://support.google.com/websearch/answer/136861>.
[13] Google Advanced Search <http://www.google.co.uk/advanced_search>.

collection of code. The affordances, as functionalities of the search engine, are identified as mediators, because they transform, translate, and modify the meaning of the search results. However, this translation only happens when there is an interrelation with the user. The actor-network, as a black box, falls apart and re-forms again after the translation. The actors in the actor-network of Google's interface mobilise each other, create alliances, and become one actor: the representation. From now I will refer to online search, as just described, as *classic search*.

2.2 Technology

Google's search engine technology is a complex system that consists of the following elements: a web crawler, an index algorithm, an index, a computer network, a retrieval algorithm, and a ranking algorithm. While the technology contains more specific elements I will focus, because of the scope of this research, on the most important elements mentioned above.[14] These elements are identified as the actors in the actor-network of Google's search engine technology. I will analyse this technology as described by its founders Larry Page and Sergey Brin on the basis of the identified actors (Brin & Page 1998). By analysing these actors I will show how they are transforming each other through a process of translation, as described by Callon (1986a, 196).

The first actor we identify is the web crawler that retrieves information. Google's web crawler is called Googlebot (Google, 'Googlebot' n.d.). Googlebot is a piece of software, written in programming language Python (Brin & Page 1998), which uses an algorithmic process to crawl webpages from a URLserver that sends lists of URLs to be fetched by the crawler (*ibid.*; Google, 'Googlebot' n.d.).[15] A URL (Universal Resource Locator) is the web address of a webpage we typically use when surfing the Web.[16] These URLs can be identified as intermediaries. They are passive entities that transport meaning without transformations. The crawler itself transports the fetched webpages in a repository. In this process the crawler takes snapshots of each page and adds the current date as a backup in case the current page is not available (Google, 'Cached Link' n.d.). For this reason, the crawler can be identified as a mediator.

[14] See Brin & Page's paper for a more detailed description of Google's technology (Brin & Page 1998).
[15] Brin and Page describe that Google, in the beginning, typically ran about 3 web crawlers (Brin & Page 1998). Now Google uses several crawlers to gather more content, which include news, images, and videos (Google, 'Google's website crawlers' n.d.).
[16] A URL is particularly used with HTTP (Hypertext Transfer Protocol). HTTP is the foundation of data communication for the World Wide Web.

The next step is to sort the repository. This is carried out by the next actor: the index algorithm, or *indexer*. The indexer reads, uncompresses, and parses the repository of webpages. The repository itself is identified as an intermediary, because it only serves as passive storage space. The indexer, however, is a mediator that transports the meaning of the webpages with transformations by a process of conversion. As Brin & Page describe: 'Each document is converted into a set of word occurrences called hits. The hits record a word, position in document, an approximation of font size, and capitalization. The indexer distributes these hits into a set of "barrels", creating a partially sorted forward index' (Brin & Page 1998). Another function of the indexer is to parse all the links in every webpage and store the important information in anchor files. A URLresolver reads these anchor files and 'converts relative URLs into absolute URLs and in turn into docIDs. It puts the anchor text into the forward index, associated with the docID that the anchor points to. It also generates a database of links which are pairs of docIDs. The links database is used to compute PageRanks for all the documents' (*ibid.*).

After the indexer sorted the repository, another sorter resorts the set of barrels by wordID to generate the *inverted index* (*ibid.*). This database is also an actor that represents the index that will be used and consulted when a user enters a search query in Google's search engine.

When a user enters a search query three actors enter the actor-network: the retrieval algorithm, the ranking algorithm, and the user. The user determines which information the search engine has to gather from its index and starts the process of the retrieval and ranking algorithm. The retrieval algorithm will gather and collect matching information from the index. This algorithm parses the user's search query and converts these words into wordIDs to search through the index for matching words (*ibid.*). After this, the ranking algorithm will rank all returned webpages as a list of search results to the user. At the time in 1998 Google had a new and unique formula with their PageRank algorithm: 'The apparently flat data ocean of the Internet was shaped by Google in dynamic hierarchies according to each website's visibility and importance' (Pasquinelli 2009 ,153). This algorithm measures, next to the keywords and content on a page, the links from and backlinks to a webpage (Brin & Page 1998). Based on this link structure PageRank calculates a ranking for each webpage. Search results are subsequently presented to the user ranked on signals, which include the relevance of content, keywords, and PageRank (*ibid.*). Today the index is ranked on more than 200 unique signals, which include the freshness of content and the region of the user (Google, 'Algorithms' n.d.). As described in the previous section about the representation of the

search engine, the user is a mere collection of code and thus an intermediary. The retrieval and ranking algorithm are mediators. They transform the gathered information from webpages to a list of search results ranked on their relevance, motivated by PageRank.

To get this whole operation up and running the actors, in terms of software, have to be running and saved somewhere in order to operate. This is established through a network of computers. This computer network represents the next actor. While the software ensures the process of retrieving, parsing, and indexing webpages, the hardware ensures that this software is able to operate properly.[17] The hardware is a passive actor and thus identified as an intermediary that constitutes the ability for the software to operate.[18]

I have identified the actors and shown how they are interrelated and acting out their roles. The interrelation between, particularly, the Googlebot, indexer, index, user, retrieval algorithm, and ranking algorithm identifies how they enrol each other. This also identifies the actors as intermediaries and mediators. It begins with information retrieved by Googlebot, followed by the indexer, which stores everything in the index. Subsequently, a user enters a search query and the retrieval algorithm and ranking algorithm will act out their roles. This is a set of transformations where the actors create alliances in order to re-form the actor-network that falls apart into multiple actors. The actors involved in this process consist of algorithms and pieces of code and are thus identified as non-human actors.[19]

The technology of Google's search engine is identified as a black box, containing both hardware and software (Latour 1999b, 304). However, when opening this black box the actors just described appear as elements that are identified as mediators and intermediaries that mobilise each other.

The translation of the technology results in a list of webpages that are ranked by the variables of the contemporary search engine paradigm. These are the variables described in section 1.1, which include filenames, content on the page, content off the page, universal content, and personal content. The variables of the ranking algorithm

[17] What first started with 'just' a network of computers now works with massive data centers that have key values of efficiency and using renewable energy (Google, 'Data Centers' n.d.). Furthermore, by operating its own facilities Google is more flexible and scalable in its design (Google, 'Cloud Platform' n.d.; Google, 'Efficiency: How we do it' n.d.).

[18] The network of computers as an intermediary can also be described as a black box that consists of new actors. This can be another starting point for an actor-network, based on the network of computers.

[19] Next to the non-human actors, it is well known that Google also uses humans to test proposed changes in organic search algorithms (Miller 2012). However, they do not have a direct influence on search engine rankings (Google Webmasters 2012).

clarify the algorithm as a mediator, which can cause a paradigm shift. In this sense, the PageRank algorithm 'introduced a revolutionary change in Information Retrieval technologies and in the search engine panorama of the late 90s' (Pasquinelli 2009, 153).

The search results that are presented by the ranking algorithm are identified as the organic results. The organic results are based on mathematical calculations, such as PageRank, which is 'in practice a highly complex construct intelligible only to professional mathematicians' (*ibid.*). The whole ranking system is based on algorithms, which makes it an 'elusive, complicated machinery of magic which structures our encounters with information on the Web' (Metahaven 2009, 185). The algorithms rely and are restricted to the content, keywords, and links from webpages. The problem with 'web search relevance ranking is to estimate relevance of a page to a query' (Zaragoza & Najork 2009, 1). This problem lies at the basis of a paradigm shift towards semantic search where 'pages not only store content as a set of unrelated words in a document, but also code their meaning and structure' (Benjamins et al. 2002, 2). We can identify anomalies, which are characterised by unstructured search results, in terms of meaning and ontology, and by the disability of interpreting ambiguous search queries. Researcher in information science Bernhard Rieder argues that 'framing the Web purely in terms of topological (a network of documents and links), syntactical (documents as containers of markup language), and statistical (word occurrences) structure radically departs from our human habit of ordering information into subject matters, areas of activity, context, and so on' (Rieder 2009, 136). These anomalies lead to a crisis and subsequently to a new search engine paradigm. I will continue in the next section by analysing this new search engine paradigm, which is based on semantic search.

3. Semantic search analysis

In the previous section I argued that a problem of unstructured search results, in terms of meaning and ontology, and the disability of interpreting ambiguous search queries lies at the basis of a new search engine paradigm. Search engine Google is based on searching for webpages using signals from earlier paradigms, which include: filenames, content on the page, content off the page, universal content, and personal content. By using algorithms these signals are translated through mathematical calculations to a list of search results based on the relevance of a webpage to a search query. I will now analyse semantic search in order to develop my argument about a new search engine paradigm that will take the ambiguity out of search results and provide search results that are based on the intent and contextual meaning of the search query.

3.1 Representation

Semantic search presents search results by making use of Google's *Knowledge Graph* (Google, 'Knowledge Graph' n.d.). By analysing the interface of the SERP based on semantic search technology I will show changes in affordance, compared to the interface of classic search.

Amit Singhal, senior vice president and software engineer at Google, describes in his blog post that Google's Knowledge Graph 'enables you to search for things, people or places that Google knows about—landmarks, celebrities, cities, sports teams, buildings, geographical features, movies, celestial objects, works of art and more—and instantly get information that's relevant to your query' (Singhal 2012).[20] Singhal argues that the Knowledge Graph changes the design of search results in three main ways.

The first way is about finding the right thing that you are looking for. By narrowing down the search results and offering results for ambiguous search queries the search engine optimises the chance for finding the right information. The second way is characterised by summarising relevant content around the topic that the user is searching for. The third way is presenting, next to the summary, additional information based on metadata and linked entities (*ibid.*). By looking at examples of Google's Knowledge Graph I will describe the affordances of the semantic search interface.

In figure 4 we see the SERP for [Old Trafford], the stadium of football club Manchester United. At the top of the search results we see a separate box with

[20] As described by Singhal, the Knowledge Graph works particularly for these search queries. Other search queries will not benefit from all the features of the Knowledge Graph.

information about their spot in the English Premier League, their last result, and the first upcoming game.[21] In classic search I have to click on one of the search results and go to an external webpage in order to gather this information, while semantic search provides the affordance of presenting this information directly at the interface: a shift to no page at all.

In classic search, the right side is mainly used for advertising. In figure 4 we can see that semantic search consists of a right side with another box of additional information (metadata) about Old Trafford.[22] Old Trafford is here the entity, or node, as I will further describe in the next section about the technology of semantic search. An affordance of the Knowledge Graph is that it shows when the stadium was opened, what the capacity is, and who the architect is. Furthermore, it shows a user rating of the location, upcoming events, and at the bottom of the box a list of other suggestions titled with "People also search for". In this section the Knowledge Graph shows links (edges) to other webpages (nodes), which are here represented by football stadiums to present information that the user might be interested in. In the next section I will describe the technology behind these links to other webpages and how they represent a network of nodes and edges.

Another example is shown in figure 5 where I searched for music duo [Daft Punk]. The image shows the right side of the SERP and includes, next to metadata, separate songs and albums of Daft Punk and related artists. By clicking on one of the albums a horizontal list of Daft Punk albums is presented at the top of the page, see figure 6.[23] This horizontal list is a carousel that is part of the Knowledge Graph (Google, 'Knowledge Graph' n.d.). The user can click on any album and see the search results for that specific album. On the SERP of the album the right side now contains metadata of the album plus a list of the songs on the album. By clicking on any of the songs the user will be directed to the page shown in figure 7. The tracklist of the album is presented with the search results for the chosen song. Furthermore, the first result includes a video of the song, which will direct the user to Google's video platform YouTube.

[21] If you click on this box it will expand and will show an even more extended overview of last games played and upcoming games.
[22] This will have implications for Google's Business Model, because the advertisements are now replaced.
[23] The albums can be ordered by release date and popularity by clicking on the dropdown in the top right corner of the carousel.

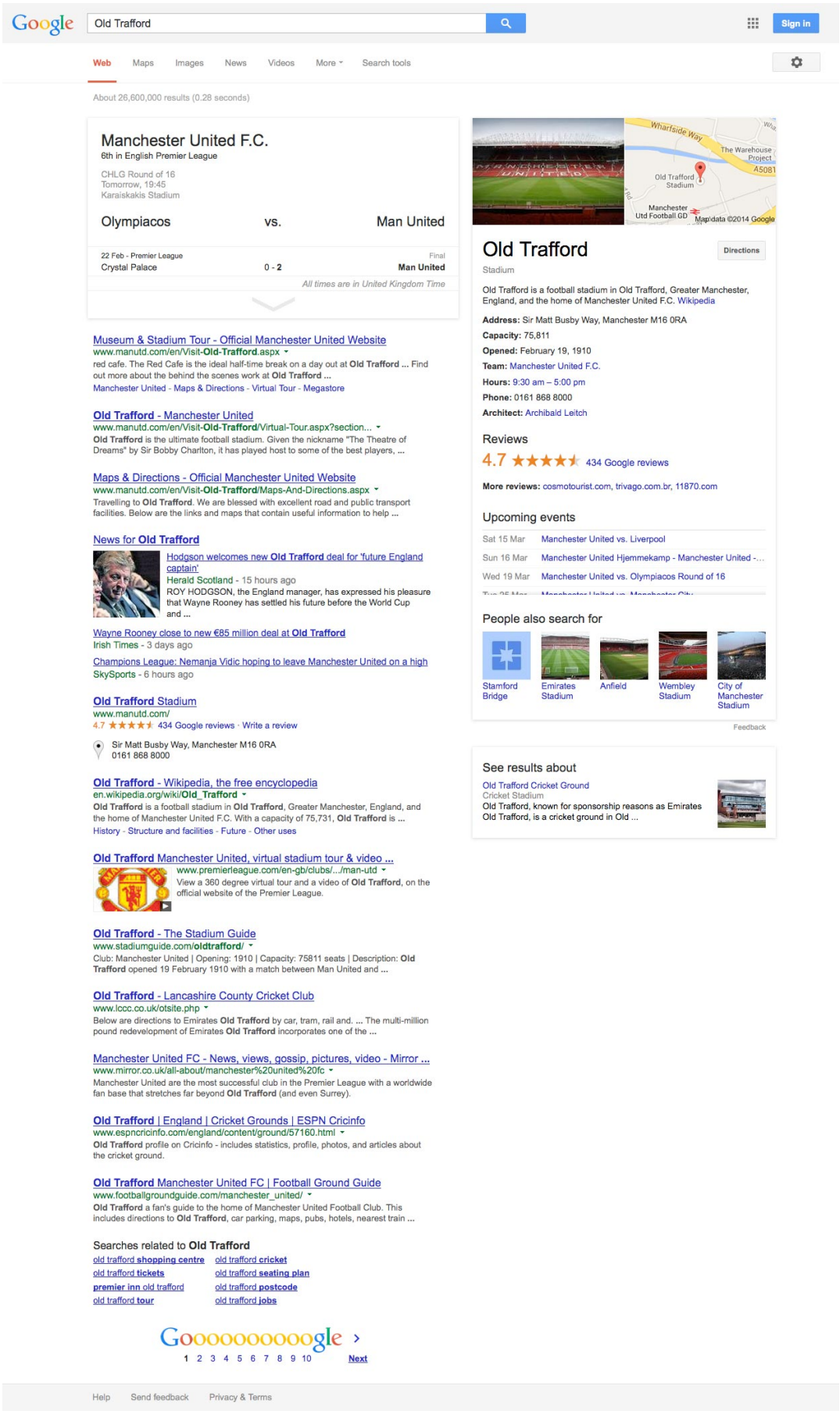

Figure 4. Google SERP for [Old Trafford].

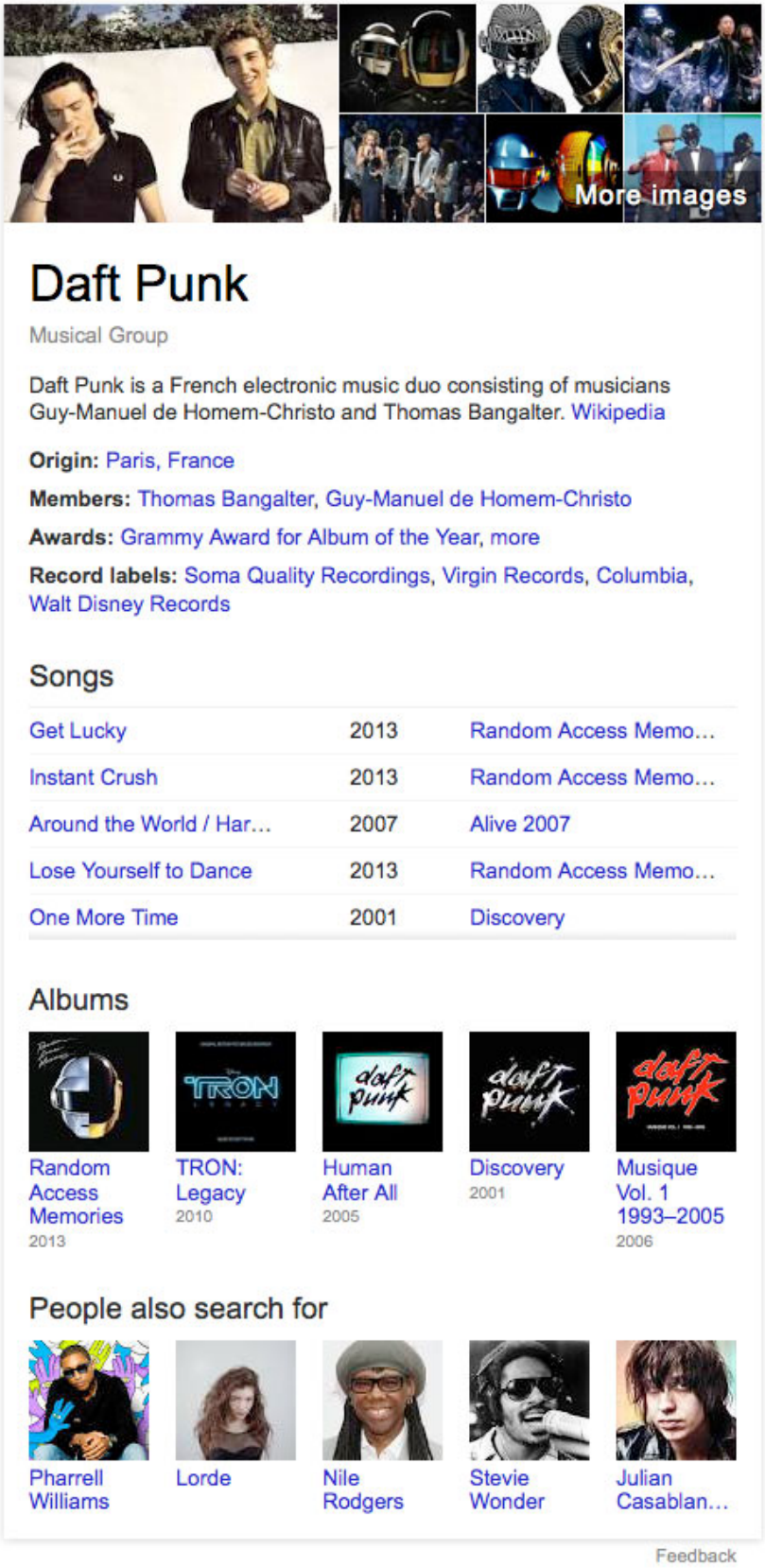

Figure 5. Right side of SERP for search query [Daft Punk].

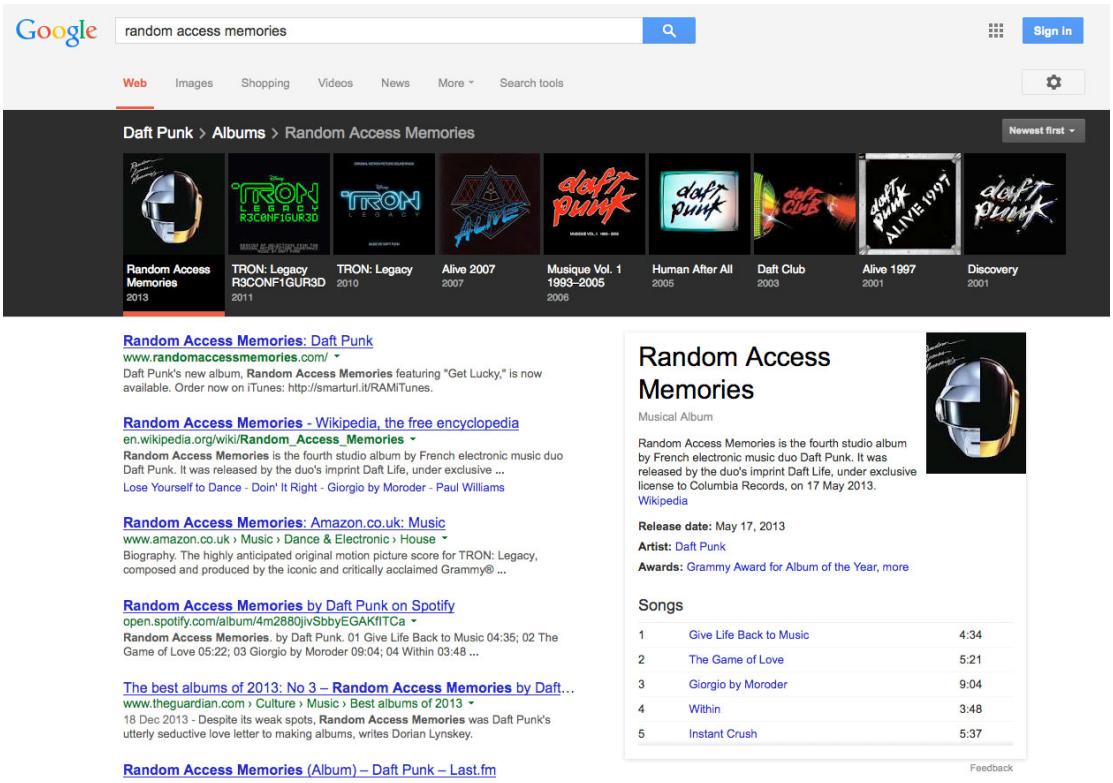

Figure 6. All Daft Punk albums presented in Google's carousel.

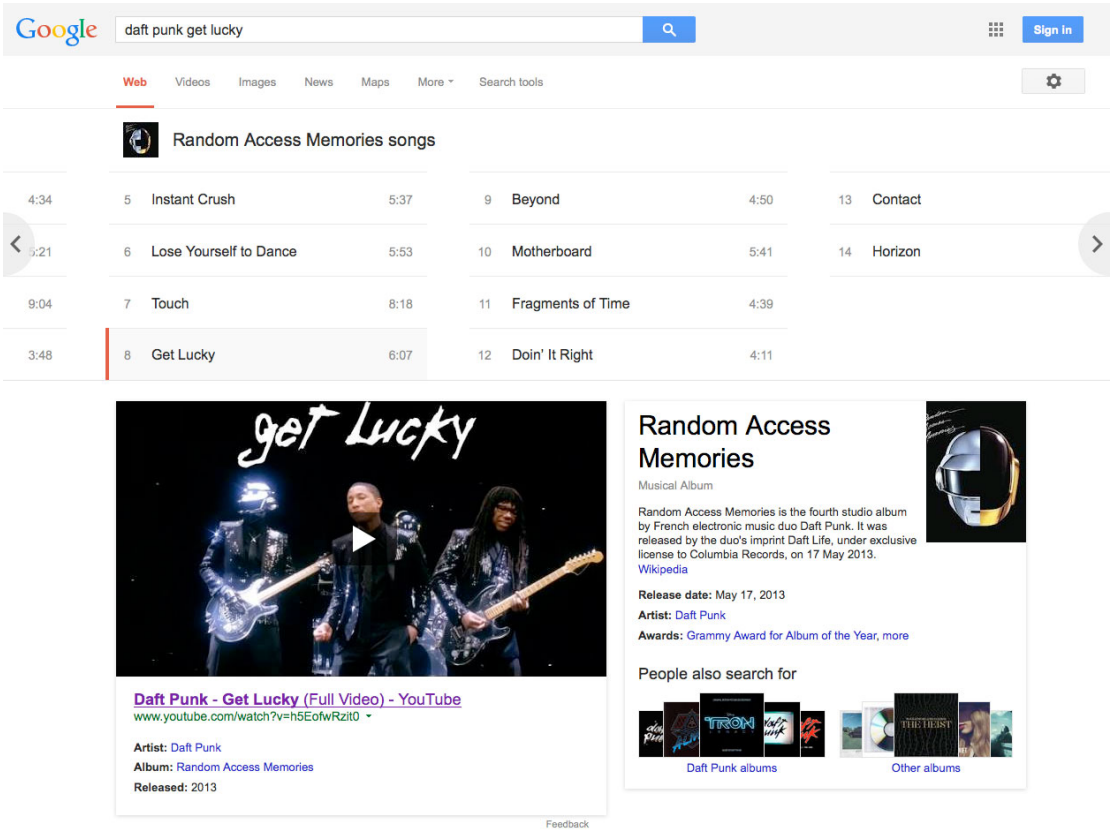

Figure 7. Tracklist of the *Random Access Memories* album.

The examples of Old Trafford and Daft Punk illustrate the affordances of semantic search. When users are searching for 'things, people or places that Google knows about—landmarks, celebrities, cities, sports teams, buildings, geographical features, movies, celestial objects, works of art and more' (Singhal 2012), they get instantly information, which is directly presented at the interface of the SERP.

The changes in the interface, based on semantic search, are on the basis of a shift in affordance for the representation of search results. The user is offered a multi-linear experience by providing more specific information about the search query directly at the SERP. Entities are connected to other related entities what constitutes a graph of connected entities in combination with their individual information in the form of metadata. In this sense, Google's search engine is no longer presenting unstructured and ambiguous search results, but is, by connecting entities, presenting information based on predefined relations and context. With the emergence of semantic search the problem of ambiguity, in the paradigm of classic search, is taken out by giving 'outright answers and pages that are directly associated with the question we have typed in search' (Amerland 2014, 7). "Answers", in this sense, are identified as the clustered information about entities that we see in the elements of the Knowledge Graph.

The representation of semantic search is identified as a black box that consists of actors that create, through a set of transformations, alliances in order to become one actor. The affordances of the representation of semantic search can be identified as mediators, because they change the meaning of the SERP through a process of translation, based on the search query of the user. The SERP suggests that this is the right thing that you are looking for, summarises relevant content around the search query, and presents additional information based on metadata and linked entities. In short, the SERP no longer presents unstructured search results, but takes the ambiguity out of search results and presents clustered information through the Knowledge Graph.

3.2 Technology

Just like my analysis of classic search, semantic search technology involves multiple elements that represent the actors in the actor-network of semantic search: a web crawler, a Universal Resource Identifier (URI), a Resource Description Framework (RDF), and an ontology library. I will show how these elements are interrelated and subsequently how they form an actor-network and are transforming each other.

Semantic search starts with a web crawler. As described in the previous section, web crawlers fetch webpages and store them in a repository. The repository consists of raw data that needs to be classified. From this raw set of data the URI is needed. A URI is

a sequence of characters used to identify a webpage, which can consist a Uniform Resource Locator (URL) and a Universal Resource Name (URN) (Amerland 2014, 11). The URN defines an item's name, or identity, while the URL provides a method for finding it, the location. An example is the Internet Movie Database (IMDb), which has a large database of movies.[24] Each movie has an identifier (URI) to identify the movie as an entity. The movie *Inception* has a URN: tt1375666 and a URL: http://www.imdb.com/title/tt1375666/. Together they represent the URI of the movie.

The next step is to refine the URI through the RDF. The RDF is a general method for conceptual description or modelling of information using a variety of syntax notations and data serialisation formats. It is a 'data model for annotations in the Semantic Web' (Pan 2009, 73). In other words, it makes use of an algorithm that specifically places the URI to matching data in its framework. This framework 'enables the encoding, exchange and reuse of structured metadata' (Miller 1998). To illustrate this, let's take a look again at my example of the movie *Inception* from IMDb. When the URI processes through the RDF it matches with metadata like *Christoper Nolan* (director), *Leonardo DiCaprio* (actor), and *adventure* (genre).

When the URI is processed through the RDF it will be connected through an algorithm to the relations within its specific domain of knowledge deriving from the ontology library. As described in section 1.2 an ontology is a system of clearly defined relations between clearly defined concepts. Ontologies are a representation of a specific domain of knowledge. The power of associating information with contextually related information can be seen in figure 8 where I searched for [movies of dicaprio]. The algorithm understands that "dicaprio" refers to actor Leonardo DiCaprio and that I am looking for movies where he played in. The horizontal list of movies that are presented at the top of the page is a similar carousel to the one with Daft Punk albums. On the right side we see another part of the Knowledge Graph, which consists of additional information (metadata) about Leonardo DiCaprio, including his full name, day and place of birth, height, awards, nominations, and the names of his parents. A list of suggested people is also presented under the header "people also search for". This SERP is created by cross-reference information based on mathematical rules and calculations from the crawled data, identified with the URI that is processed through the RDF and connected to an ontology library.

[24] The Internet Movie Database <http://www.imdb.com>.

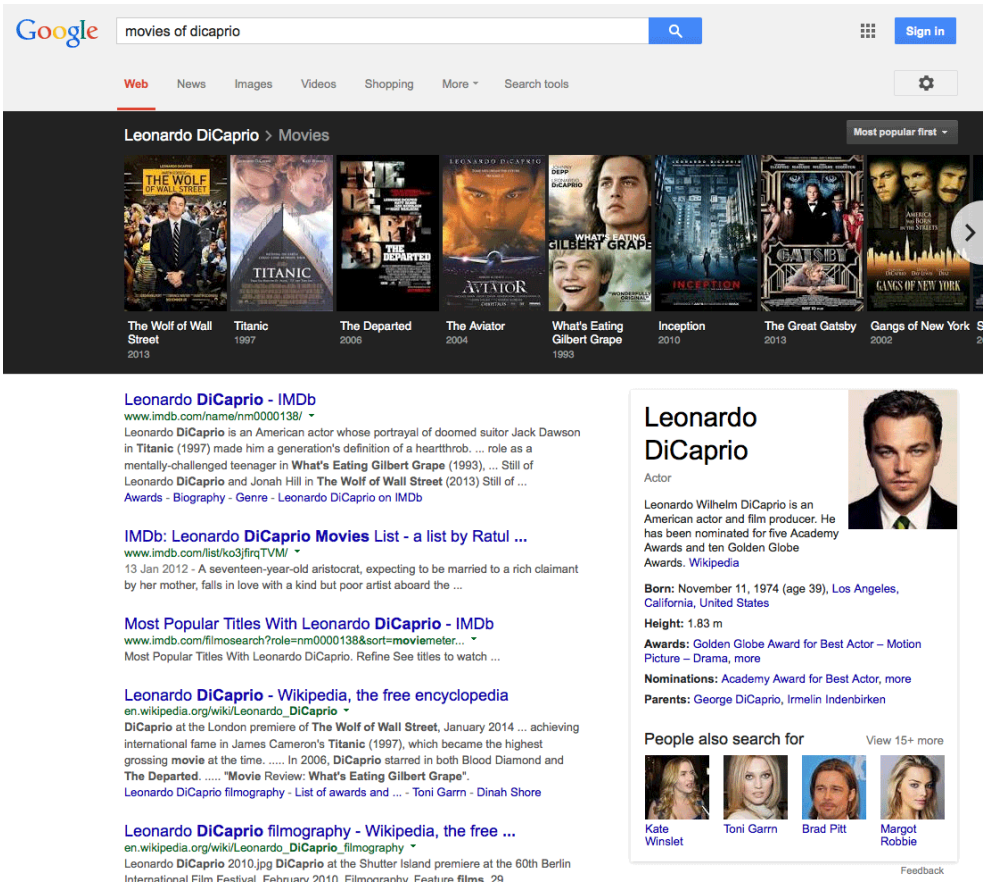

Figure 8. Search results for [movies of dicaprio].

Google introduced the Knowledge Graph in 2012 as a new way of presenting search results that understands 'real-world entities and their relationships to one another: things, not strings' (Singhal 2012). A graph model consists of nodes and edges. Figure 9 shows on the left side a visualisation of random nodes and on the right side how these nodes are connected to each other with edges. The concept of the Knowledge Graph is about searching through the nodes and edges that represent the webpages and links from Google's technology. When I searched for [movies of dicaprio] the engine has to understand that "dicaprio" are not just letters on a webpage, but that I am looking for an entity, a person: Leonardo DiCaprio. This entity represents a node (webpage) that is connected through edges (links) to other nodes. In this case these nodes represent movies of Leonardo DiCaprio and other actors and actresses. Furthermore, the node that represents Leonardo DiCaprio is connected to metadata, which includes: occupation, day and place of birth, age, height, awards, nominations, and parents names.

Figure 9. A basic visualisation of a graph.

Through my analysis of the technology of semantic search I identified the elements URI, RDF, and ontology library as mediators. They transform and modify the meaning of the raw data that is indexed by the web crawler by creating nodes and edges, which represent entities and their values. The role of the crawler can be compared to its role in classic search, as a mediator. The repository is identified as an intermediary, since it is a passive entity that does not transform the stored webpages. After the process of translation the actor-network becomes one actor: the technology.

In semantic search, as opposed to classic search, Google is not established as a real OPP for the user to go through, because the integration of semantic content on the SERP takes away the step to go to an external webpage. However, Google tries to create (preferred) passage points by navigating users to the first search result(s), the results from the Knowledge Graph, and other Google services, which include Google Maps, Google Books, and Google Fights.

By presenting search results that not only 'store content as a set of unrelated words in a document, but also code their meaning and structure' (Benjamins et al. 2002, 2), semantic search is a fundamental change in search engine technology that lies at the basis of a new search engine paradigm. From the earlier described paradigms based on filenames, content on the page, content off the page, universal search, and personal search, to "no page at all"; a paradigm shift based on semantic search.

My analysis has shown that in this new paradigm search results are based on graphs, predefined ontologies, and clustered information. The search engine codes the meaning and structure and takes out the ambiguity of the search results, based on the search query. This process of translation is mainly carried out by a new set of algorithms. The user is, just as in classic search, a mere collection of code and not transforming any meaning in the search process and thus identified as an intermediary.

Semantic search, as a technology that causes a paradigm shift, is through the analysis of an actor-network mainly based on new algorithms, which include the identified elements in the actor-network of the technology of semantic search that represent and maintain this new search engine paradigm. In this sense, the actor-network of the technology of Google's search engine, as described in section 2.2, falls apart and re-forms again in the actor-network of the technology of semantic search.

Conclusion

In this research I started by identifying paradigm shifts and their anomalies. By conducting a material object analysis I have shown how Google's search engine, in classic search and semantic search, operates. Furthermore, my material object analysis shows how the anomaly of unstructured search results in terms of meaning and ontology and the disability of interpreting ambiguous search queries have led to a new search engine paradigm based on semantic search.

My material object analysis has revealed the actors involved in the process of online search, in terms of representation and technology, and also identified them as mediators and intermediaries. The actors involved in the actor-network mobilise each other in order to maintain this emerging new paradigm. I have shown the implications for the heterogeneous actors regarding this new paradigm by identifying the user as an intermediary. From both the perspectives of the representation and the technology of online search, the user is seen as a mere collection of code and is not transforming any meaning. The actors that transform meaning are represented by the new collection of algorithms and elements, as described in the technology of semantic search. These elements lie on the basis of the new search engine paradigm and are the mediators that matter and cause a paradigm shift. In the new search engine paradigm the technology of Google's search engine adds an intelligence that is based on clustered information and relies on, particularly, the mediators URI, RDF, and ontology library. Together with the set of transformations in the interface of the search engine I can conclude that the development of a paradigm shift constitute changes in the heterogeneous actors that are revealed in the representation and technology of semantic search.

I have shown whether the material object analysis starts by analysing the actor-network of the representation, the technology, or the business model of Google's search engine, the role of the actors as mediators and intermediaries are the same. It is not the user that influences the search results, but the collection of new algorithms that lie on the basis of a paradigm shift. This shows how Google, as a combination of its representation and technology, lies on the basis of a new search engine paradigm based on semantic search.

Discussion

In my attempt to explain the emergence of a new search engine paradigm based on semantic search I have analysed Google's search engine in terms of representation and technology and related these concepts to the business model, design, and affordances of the search engine. However, I did not investigate in the implications for Search Engine Optimisation (SEO) regarding the new search engine paradigm. It is worth investigating how SEO techniques are present in a search engine paradigm and how the role of the user differs from my analysis. SEO techniques are trying to create Obligatory Passage Points in order to present users specific search results. These OPPs are created by influencing the search results through SEO techniques. Together with the appropriation by users, regarding the new search engine paradigm, this can be part of a follow-up study. By tracking down the translations between SEO, users (appropriation), and the search engine the roles of each of these actors will be revealed.

One last note that I want to mention here is the analysis of vertical search and mobile search, which I did not include in this research. These developments can also be considered as new directions in online search and can also be analysed in terms of a material object analysis to show the transformations in the actor-network and possible implications for the search engine paradigm.

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