Taxonomy for real-time digital data initiatives

A taxonomy for real-time digital data initiatives in the age of Big Data: An affordance perspective

Abstract
Real-time digital data are becoming important assets in a growing number of organizations. Accordingly, this paper, applying the affordance theory, describes the development of a taxonomy for achieving an understanding of real-time digital data initiatives taken by firms. The proposed approach is based on relevant techniques for developing a taxonomy in the Information Systems (IS) literature. The method applied considers 177 real-time digital data initiatives for which we identified categories and their relative dimensions of the developed taxonomy. Specifically, applying the affordance theory, the proposed taxonomy is composed by two categories, the technological affordance and the affordance actualization, being composed respectively of four and five dimensions. Specifically, the technological affordances of the real-time digital initiatives are named real-time sensing, real-time mass visibility, real-time experimentation and real-time coordination, while the affordance actualizations are named service, efficiency, analytics, aggregation and generation. We finally discuss the developed taxonomy's implications for companies.
Keywords: Big Data; real-time digital data; technological affordances; affordance actualization.

1. Introduction

A Digital Data Stream (DDS) is the continuous real-time digital encoding and transmission of data describing a related class of events. Examples abound: every day, people generate digital data through tweets, clicks, videos and the plethora of sensors embedded in their devices. Beside humans, instruments and machines such as smart meters, manufacturing sensors, equipment logs, and vehicle tracking systems, automatically and continuously, generate digital data. As firms increasingly rely on data to face market variability, changing in data availability and timing directly affect firms' ability to create value in the form of new products, services, or processes. Uber is an emblematic case of this new breed of services. Worth 50 billion dollar, the largest "taxy" company in the world owns no vehicles, but harnesses the DDS of its drivers' cars and matches them with the real-time demand for rides.

These DDSs refer to the Velocity dimension of the 'big data' initiatives (Add McAfee, A., Brynjolfsson, E., Davenport, T. H., Patil, D. J., & Barton, D. (2012). Big data. The management revolution. Harvard Bus Rev, 90(10), 61-67). In established companies, DDS and 'big data' initiatives attracted increasing investments for exploring their potential (Chen, Chiang, & Storey, 2012), driving digital business strategy (Bharadwaj, El Sawy, Pavlou, & Venkatraman, 2013) and improving decision making (Eastburn & Boland, 2015), and successes were reported across a wide range of industries (McAfee & Brynjolfsson, 2012).

As with any major disruption, opportunities for value creation abound and research must contribute to our understanding of the phenomenon. In fact, even if emblematic success cases (e.g., LaValle *et al.*, 2013; McAfee *et al.*, 2012) were explored and researched, little attention was devoted to the analysis of the ways through which firms profited from DDS to create value. What did enable these initiatives? Which forms or value propositions did firms configure to create value? To explore these questions, we develop a research framework rooted in the theory of technology affordances. Technology Affordances are possibilities for goal-oriented action, emerging relationally from the intersection of IT and organizational systems (Zammuto et al. 2007). Being just potentials for actions Technology Affordances need to be actualized to produce outcomes. Technology Affordance actualization is then the series of actions organizations perform as they take advantage of the Technology Affordances to achieve organizational goals.

Therefore, in our study we identify the emerging DDS affordances - the opportunities organizations perceive – and identify the value propositions resulting from their actualization. In this sense, firms' DDS initiatives (Pigni et al. 2016) generate value propositions as outcome of DDS affordances actualization – the organizational goal oriented actions.

To identify both DDS affordances and DDS actualization outcomes, we develop a taxonomy of DDS initiatives. A taxonomy is a form of classification that can be derived conceptually, empirically or through a mixed approach (Nickerson, 2013). While taxonomies are common through Information Systems (IS) literature only recently a comprehensive methodology was suggested for their development (Nickerson, 2013).

At a conceptual level, we identify and classify DDS value creation opportunities as Technology Affordances and the outcomes of the actualization actions as value propositions. Empirically, we derive the classification dimensions from the analysis of real cases. A taxonomy of value creation opportunities (i.e. Technology Affordances) and value propositions (i.e. Affordance Actualizations) is a useful tool for both theorists and practitioners for distinguishing the characteristics and dimensions of an emerging phenomena - like DDS - and to found the development of frameworks and tools to support the design of new Information Technology (IT) enabled strategic initiatives (Piccoli and Ives 2005).

The rest of the paper is organized as follows. First, we detail the theoretical background of the study and then, we discuss the methodology used to generate the taxonomy. We conclude the paper with an extended discussion, summary of our results, and practical implications for companies.

2. Theoretical background

2.1 Technology Affordance

The concept of affordance (as it has been used in recent literature, such as Zammuto, 2007; Markus and Silver, 2008; Yoo et al., 2012; Majchrak and Markus, 2012; Volkoff and Strong, 2013; Leonardi, 2013; and Seidel et al., 2013) originated with Gibson (1986) in ecological psychology as the interaction between an actor with the environment, defined as the surroundings of the actor. The conditions that enable the interaction include both the properties of the actor and of the environment (Gibson, 1986). Affordances are preconditions for an activity, but do not imply that the specific activity will occur (Greeno, 1994).

Hutchby (2001) is the first author to extend the original concept of affordance to the IT domain. He considered the functional and relational aspects of affordance as possibilities for action and acknowledged the potential of this approach for studying the complex relationship between technologies and the actors. Social actors are not just individuals, but also organizational systems such as groups of people, teams and business units. Indeed, in the IS field, affordances are considered possibilities for goal-oriented action emerging from the relation between an IT and organization systems (Strong *et al.*, 2014), and afforded to specified groups of actors by technical objects (Markus & Silver, 2008). As affordances are just potentials for action, affordances need to be triggered (Volkoff and Strong, 2013) or actualized (Strong et al., 2013) by a goal-oriented actor to produce an outcome.

In organizations, affordances are the result of the intertwining of the capabilities of IT and the actions performed by organizational systems (Majchrzak, 2011). Organizational systems can originate, perceive, and enact the affordance with the intention to support organizational goals. In this term, the potential for coordinated action by a group of actors can be thought as an organizational affordance (Zammuto *et al.*, 2007; Volkoff & Strong, 2013; Strong *et al.*, 2014).

As a consequence, Affordance Theory allows to overcome some of limitations of current management theories (Majchrzak & Markus, 2012) that ignore the possibility that humans using technology can enact new practices or outcomes by focusing only on psychological or social behavior, and that technology can produce and have unintended uses, thus overcome simplistic or deterministic assumptions about the effects of technology on human and organizational outcomes.

2.2 Affordance Actualization

Consistently, Affordance Actualization is defined as the action taken by actors to achieve outcomes in support of organizational goals, as they take advantage of one or more affordances through their use of technology (Strong *et al.*, 2014). Actualization is a goal-oriented and iterative process (Strong *et al.*, 2014; Leonardi, 2011; Leonardi, 2013).

While traditionally neglected, the actualization process is recently receiving higher interest from scholars (Strong *et al.*, 2014; Leonardi, 2013; Volkoff & Strong, 2013; Bernhard *et al.*, 2013). For many years, both ecological psychologists (Gibson, 1986; Greeno, 1994) and scholars that applied affordance theory to IT systems (Hutchby, 2001; Zammuto *et al.*, 2007) disregarded how the affordance potential could be realized through goal-directed behaviour. Furthermore, actualization was presented as an individual journey or individual-level process differently experienced by each single actor taking goal-oriented actions (Strong *et al.*, 2014; Leonardi, 2013; Volkoff & Strong, 2013). The concept of actualization at the organizational level was introduced only recently (Strong *et al.*, 2014) and founded on collective constructs literature. Organizational level actuation was then defined as the collective construct emerging from the aggregation of the many actors' actualization processes and outcomes of the individual-level. In other words, actualization as an organizational journey emerged as the collective accomplishment of the many individual actor level journeys. To actuate affordances at an organizational level, Leonardi (2013) introduced the concept of shared affordance, that is, an affordance shared by all members of a group in which all actors manifest similar use of technology features. In essence, when actors agree on the usage of a similar sequence of technology features, the affordance created by the interaction with a specific technology can be actualized at an organizational level. When an IT affordance is actuated at organizational level, its outcome is an intended IT enabled initiative for realizing organizational goals.

Our challenge is to decline this principles to the DDS and hence to identify the possibilities DDS afforded to organizations and the actualizations resulting in specific value propositions. In other words, we seek to identify the potentials of DDS from the outcomes of the actualization activities.

3. Research methodology

To identify the potentials of DDS from the outcomes of the actualization activities, we employed an inductive multiple case study approach. This research approach is suitable for examining "a contemporary phenomenon in its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2003). Our objects of analysis were the DDS initiatives and we looked at the Technology Affordances and the Affordance Actualizations. Then we classified the Technology Affordances and the Affordance Actualizations in a taxonomy, following the Nickerson *et a*l. (2013) methodology. This methodology is iterative and requires to fix objective and subjective ending conditions. Our objective ending condition asks that: "*All objects or a representative sample of objects have been examined*", while our subjective ending condition requires that our taxonomy is concise, robust, comprehensive, extendible, and explanatory.

In order to achieve our ending conditions, we conducted three iterations. The first iteration took place in 2012, when we formally launched this study. For this first iteration we analyzed the 12 DDS initiatives we were already aware of. The second iteration took place between 2012 and 2014. We gathered data about 58 DDS initiatives from multiple publicly available sources: prospectuses, annual reports, academic and professional articles, company web sites, press releases, initiative descriptions, white papers, web search engines. We analysed both start-ups as well as established large corporations, spanning a number of countries in our sampling of initiatives. The third iteration took place at the end of the 2014. We downloaded all the articles published on Factiva[1] from the first of January 2011 to the end of November 2014, containing as keyword "real-time data" in order to identify additional DDS initiatives to analyse. Overall we downloaded and read 1,839 articles and among these articles, we identified 101 DDS initiatives.

Every iteration was characterized by three steps. In the first step, we identified the initiatives to consider in order to define the new dimensions to include in the taxonomy. In the second step, we defined the dimensions to add in the taxonomy. In the third step, we verified whether our ending conditions were achieved (Figure 1).

Complementary to the creation of the taxonomy, we illustrate the application of taxonomy with five DDS initiatives (see Appendix A - Table A1 for the taxonomy application to all the real-time initiatives considered in this study).

[1] Factiva is a business information and research tool owned by Dow Jones & Company, which aggregates content from both licensed and free sources.

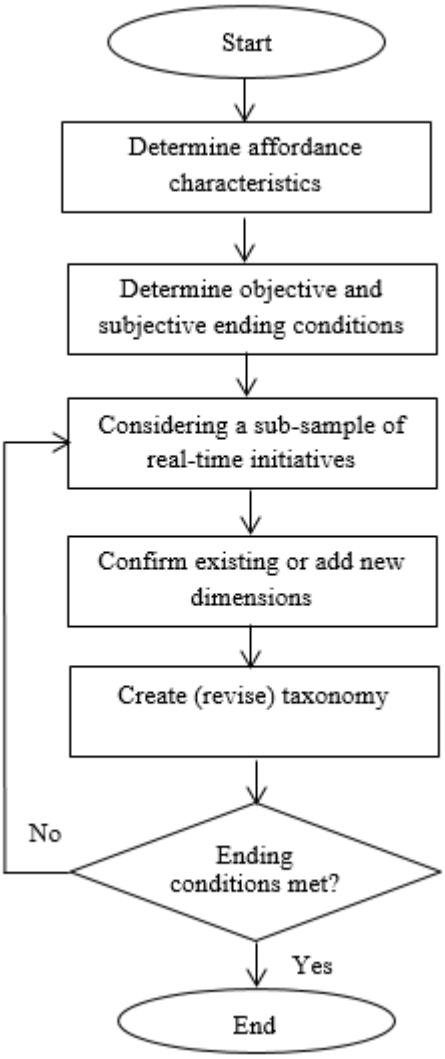

Figure 1 Process followed in taxonomy development

4. Results

4.1 Sample composition

Overall, 177 initiatives were analyzed (Table 1). The majority of the DDS initiatives in the sample are composed by initiatives that refer to solutions sold by professional vendors for their clients. In terms of the industrial sectors where the DDS initiatives are found, the Information Technology is the sector that includes the highest percentage of DDS initiatives of the total sample. The second most representative sector is the transportation, followed by the healthcare, while the less representative sectors are the aerospace, agriculture, construction and gaming.

Industrial Sector	Vendor	Number	Percentage	Total in the sample	Percentage
Information Technology	Yes	75	42.37%	80	45.20%
	No	5	2.82%		
Transportation	Yes	13	7.34%	26	14.69%
	No	13	7.34%		
Healthcare	Yes	14	7.91%	15	8.47%
	No	1	0.56%		
Manufacturing	Yes	11	6.21%	14	7.91%
	No	3	1.69%		
Energy	Yes	9	5.08%	10	5.65%
	No	1	0.56%		
Commerce	Yes	1	0.56%	4	2.26%
	No	3	1.69%		
Finance	Yes	4	2.26%	9	5.08%
	No	5	2.82%		
Tourism	Yes	0	0.00%	7	3.95%
	No	7	3.95%		
Other*	Yes	7	3.95%	12	6.78%
	No	5	2.82%		
Vendor all sample					
Yes				134	75.71%
No				43	24.29%
Total				177	100.00%

*Aerospace, agriculture, construction, gaming.

Table 1 Sample composition

4.2 Taxonomy development

The 177 DDS initiatives were analysed over three iterations that are described in the following paragraphs.

4.2.1 First iteration

In the first iteration, we gathered the first 12 DDS initiatives. The first DDS initiative (I1) is called Social Media Monitoring by BrandWatch company and we associated it to the "*real-time sensing*" (RTS) Technology Affordance and the "*analytics*" (AN) Affordance Actualization (Table 2). Specifically, we define RTS as the Technology Affordance gained by detecting in real-time the current state of a single given entity (human, object, event...). Examples are the location of a single airplane, the speed of a specific car, or the mood of an individual person. By one hand, Web 2.0 and social networks have allowed the creation of new ways for people to interact in real time. On the other hand, RTS is also emerging from machine-to-machine (M2M) data streams as electronic devices have an unprecedented ability to automatically and continuously sense the environment, and automatically react to the incoming flow of data. Examples are the automatic alerting system at an air traffic control center in case of specific flight path deviation or the automatic cruise control of the speed of a car. The IT capabilities that support RTS include the diffusion of electronic identifiers (RFID chips, flash-tag…) and relative readers (smart phones, RFID readers, cameras…), the technologies providing the possibility to communicate a status update, and the processing capability to analyze the characteristics of the single entity in near real-time. These characteristics can be brought along by the entity it-self or remotely stored elsewhere and accessed at the moment of the individual identification. The sensing intent is related to the social actors' intention to exceed current bounded perception related to their own sphere of experience. By tapping into a wider characterization of digitally represented entities cognition is extended beyond traditional physical barriers.

Complementary, we define AN the Affordance Actualization dimension related to the processing of DDS information to produce analyses or to improve visualizations with the objective of enabling better decision making and producing superior insight or knowledge. To create value from DDS, companies leverage the increased streamability of events by innovating on their interpretability. This dimension of technological actualization focuses on the analysis end of assimilate-to-analyse to create value. It merges DDS to create the breadth of information necessary for supporting high-level value creation opportunities and thus reduce innovation risk. It typically has a higher value impact than the other technological actualization dimensions because it can have implications for a larger number of products or customers.

With the initiative I2, called Netflix prize by Netflix, we identify a new Technology Affordance which we called "*real-time mass visibility*" (RTMV), and a new Affordance Actualization called "*service*" (SE). Specifically, we define RTMV as the Technology Affordance based on identifying the state of multiple entities in real time, altogether, contextualized by their relationships. RTMV is a second-order affordance based on the, hence, first-order RTS Technology Affordance. For example, if RTS makes possible to locate a single vehicle, this RTMV second-order Technology Affordance makes possible to sense all the cars on a road and new variables, like traffic congestion, could be detected. The IT capabilities related to RTMV are the development of rule-based and filtering functionalities and of complex event processing engines. The joint effect of the IT capability to filter relevant information and to process them provides the opportunity to "sense" and evaluate multiple and meaningful concurrent events. Through these IT capabilities, each entity of a given population is uniquely identifiable and distinguishable. The availability online of massive information concerning products, services or user behaviors effectively determines the potential for comparing and choosing based on data available for the entire population. The sensing intent is related to the social actors' intention to track and trace entire entity populations both in time and space. In business this intent is pursued with the aim of optimizing business processes and streamline activities, and of exerting market power. This intent typically resulted in specific strategic initiatives deployed to increase the control of product and services along supply chains or in retail surfaces or for monitoring resources and capacities (empty seats for airliners, number of passengers, flow of people, products on the shelves, etc.).

Furthermore, we define SE as an Affordance Actualization that implies the merging and manipulation of DDS to provide new services or to improve existing ones. For instance, managers of entertainment parks can provide RFID cards to guest enabling them to check guest entrances to each attraction, and their purchases of food and merchandise during their stay, from simple RFID readings.

The next 4 DDS initiatives, from initiative I3 to initiative I6, did not reveal any new dimension, while the seventh initiative (I7), called Netvibes monitoring solution by Netvibes corporation, requires the creation of a new Affordance Actualization that we called "*aggregation*" (AG). Specifically, we define AG as the Affordance Actualization that refers to the way firms focus on collecting, and aggregating DDS in order to repurpose them and make them available to customers. While some degree of aggregation of data is a prerequisite for all DDS initiatives, the AG Affordance Actualization implies that the combination of this collection, aggregation and repurpose of DDS represents is the core value proposition for those organizations. Indeed, these organizations create platforms providing access to DDS generated by other companies, thus exploiting the recognized value in the streamability of certain specific events with widespread value creation potential. A key value proposition of aggregators is to link the disparate DDS, in order to make them useful to customers seeking. In these cases, the customers of the aggregator's service will extract additional value from these repurposed DDS.

The following five DDS initiatives did not revealed the need for new Technology Affordances nor Affordance Actualizations. Nevertheless, when we verified the ending conditions we concluded that the taxonomy was not yet comprehensive and that new objects would probably extend this preliminary taxonomy. Hence we launched our second iteration to examine more real-time initiatives.

ID initiative	DDS initiative name	Company name	Technology Affordance		Affordance Actualization		
			RTS	RTMV	AN	SE	AG
I1	Social media monitoring	BrandWatch	X		X		
I2	Netflix prize	Netflix	X	X		X	
I7	Netvibes monitoring solution	Netvibes	X				X

Table 2 The first DDS initiatives and their respective company, revealing a new Technology Affordance or a new Affordance Actualization of the first iteration

4.2.2 Second iteration

We gathered other 58 DDS initiatives for the second iteration. We associated the fourteenth initiative (I14), called LiveServices by TomTom company, to a new Affordance Actualization that we labeled

"*generation*" (GE) (**Errore. L'origine riferimento non è stata trovata.**). Specifically, we define GE as an Affordance Actualization related to the creation of value in originating the DDS by the organization it-self. This Affordance Actualization is developed by organizations that recognize (or stumble upon) events with high streamability. These events may have been streaming in the past, but their value went unrecognized or, more often, their streamability has increased recently due to some technology advances. The stream could arise as a by-product of some business operations (e.g., a sale) or as a deliberate action to capture data (e.g., RFID tags in gambling chips to track a player's bets). Firms that embrace GE realize (or think) that the capturing of these highly streamable events unlocks previously inaccessible value and they aim at directly applying process-to-actuate for creating value. They take a potential data source, such as a sensor reading or a click on a web site, and convert it into a data stream element. Hence, GE creates a resource that can be considered pre-strategic until applied to a critical problem. This resource can eventually be made accessible to external partners or used exclusively internally.

Going on with the gathered DDS initiatives, we identified in the eighteenth initiative (I18), called Groupon deals by Groupon, a new Technology Affordance we called "*real-time coordination*" (RTC). Specifically, we define RTC the Technology Affordance gained by adjusting a behavior based on fast cycle feedback regarding the current state of other entities. RTC is a third-order Technology Affordance based on the second-order RTMV Technology Affordance. The IT capabilities that support this Technology Affordance include the diffusion of electronic communication devices (mobile phones, computers…) and the telecommunication infrastructure (Internet network, GSM network…) making the information exchange between these devices possible. Moreover, the availability of virtual networks - both social and M2M networks - provides the logical infrastructure for the exchange and the digital coordination to emerge. The social actors' intents that support this affordance are related to the willingness to coordinate with the other social actors as well as with the other artifacts. This peer-to-peer approach spreads out together with the principle of human equality and mutual aid in order to achieve objectives beyond the capability of the single individual. The combination of these IT capabilities and human intents allows the emergence of the RTC.

Continuing our examination of the DDS initiatives, we associated the twenty-sixth initiative (I26), called Takadu solution by Takadu company, to a new Technology Affordance that we called "*real-time experimentation*" (RTE), and a new Affordance Actualization that we called "*efficiency*" (EF). By one hand, we define RTE as the Technology Affordance gained by fast cycling data generation and streaming on the entity with actions on this measured entity or its environment. RTE is another second-order affordance based on the first-order RTS. RTE makes possible to test and have immediate feedback on business decisions, from the change of a webpage layout, such as A/B tests, to more complex information and massive experimentation. The IT capabilities that support this Technology Affordance include the actuators (software as well as hardware: thermostats, motors, electro-active polymers…) located in the sensed environment, in addition to the IT capabilities required for the first-order RTS (electronic identifiers, readers, processing capability). The social actors' intents that support this affordance are related to the wish to understand the material reality. This wish to understand takes the specific form of the empirical method that arbitrates between competing theories, models and hypotheses through experimental science. The combination of these IT capabilities and human intents allows the emergence of RTE.

On the other hand, we define "*efficiency*" (EF) as the Affordance Actualization that leverages external or internal DDS in order to optimize internal company operations. These organizations already recognize the value that is intrinsic in the streamability of events within or outside their organizational boundaries. The EF applies assimilate-to-analyse, but the goal in this case is to harvest efficiency gains. Higher performance, lower prices and risks and cost savings are typical examples of how greater organizational efficiency translates into customer value.

The following 43 DDS initiatives did not revealed the need for new Technology Affordances nor Affordance Actualizations. We started thinking that maybe we satisfied our ending conditions. Nevertheless we decided to run a third iteration to extend even more our sample and to increase our confidence in the comprehensiveness of the taxonomy.

ID initiative	DDS initiative name	Company name	Technology Affordance				Affordance Actualization				
			RTS	RTMV	RTC	RTE	AN	SE	AG	GE	EF
I1	Social media monitoring	BrandWatch	X				X				
I2	Netflix prize	Netflix	X	X				X			
I7	Netvibes monitoring solution	Netvibes	X						X		
I14	LiveServices	TomTom	X	X				X		X	
I18	Groupon deals	Groupon	X		X			X		X	
I26	Takadu solution	Takadu	X			X	X				X

Table 3 The first DDS initiatives and their respective company, revealing a new Technology Affordance or a new Affordance Actualization of the first and second iterations

4.2.3 Third iteration

The third iteration considered the set of 101 DDS initiatives gathered from Factiva. No more dimensions, neither Technology Affordances nor Affordance Actualizations, were added. We definitively concluded that our objective and subjective ending conditions were met, judging our taxonomy concise, extendible, robust and explanatory.

Thus, our final taxonomy of DDS initiatives was composed by four Technology Affordances and by five Affordance Actualization (Table 4). Considering the orders of the Technology Affordances, RTS emerges as the unique first-order Technology Affordance. RTMV, RTC and RTE Technology Affordances are built on RTS and hence they are second-order Technology Affordances. On the opposite, we do not identify any differences in orders for the Affordance Actualizations: all the five Affordance Actualizations, SE, EF, AN, AG and GE are all first-order Affordance Actualizations.

Object	Order level	Acronym	Name	Definition of the dimension	Number of cases
Technology affordance	First-order	RTS	Real-time sensing	Detecting in real-time the current state of a single given entity (human, object, event).	177
	Second-order	RTMV	Real-time mass visibility	Identifying the state of multiple entities in real-time.	78
		RTE	Real-time experimentation	Fast cycling data generation and streaming on an entity with actions on this measured entity or its environment.	8
	Third-order	RTC	Real-time coordination	Adjusting a behaviour based on fast cycle feedback regarding the current state of other entities.	1
Affordance Actualization		SE	Service	A firm uses DDS to provide services to consumers or to improve service quality.	51
		EF	Efficiency	A firm uses DDS to optimize internal operations.	37
		AN	Analytics	A firm uses DDS to produce analyses or improved visualizations to enable better decision making and to produce superior insight or knowledge.	62
		AG	Aggregation	A firm collects, aggregates and uses DDS to repurpose them and make them available to customers.	17
		GE	Generation	A firms originates DDS itself, either knowingly or as a by-product.	10

Table 4 Summary of the taxonomy of the Technology Affordances and of the Affordance Actualizations

Additionally, Table 5 provides an overview of the number of initiatives of our sample combining the dimensions related to the value creation opportunities that can be exploited from the real-time digital data.

Affordance actualization (how) Technological affordance (what)	Service	Efficiency	Analytics	Aggregation	Generation
Real-time sensing	51	37	62	17	10
Real-time mass visibility	29	14	27	5	4
Real-time experimentation	1	1	7	1	0
Real-time coordination	1	0	0	0	0

Table 5 Detailed combinations of the taxonomy development dimensions

4.3 Taxonomy application

In this section, we briefly apply our taxonomy on companies to further illustrate its usefulness to study real-time initiatives.

4.2.2 Initiative 1: Scada Application Software of Chemtrols Industries Ltd company

Chemtrols Industries Ltd offers a SCADA Application Software which is based on the combination of telemetry and data acquisition. A SCADA system consists of master station collecting the data in real-time via a communication system from remote terminal units which in turn are collecting data from the field, making real-time sensing and mass visibility (Table 6). The operator can perform remote control tasks since the master station displays the acquired data. The company offers CT Meerkat, complete SCADA master station application software for real-time monitoring and control of substation equipment. CT Meerkat provides all user-friendly tools to efficiently monitor, safely operate, accurately analyse data and maintain the power system, by leveraging on the analytics affordance actualization. CT Meerkat's powerful visualisation system presents reliable and real-time data using various colours and animation. The mimics are highly customisable as per the end user's standards and suitability (source: Factiva, 2014).

Affordance	Taxonomy dimension acronym	Taxonomy dimension	Scada Application Software by Chemtrols Industries Ltd
Technological affordance	RTS	Real-time sensing	A terminal unit collects data from the field.
	RTMV	Real-time mass visibility	Master station collect the data in real-time via a communication system from remote terminal units.
	RTE	Real-time experimentation	None
	RTC	Real-time coordination	None
Affordance actualization	SE	Service	None
	EF	Efficiency	None
	AN	Analytics	CT Meerkat accurately analyse real-time data.
	AG	Aggregation	None
	GE	Generation	None

Table 6 Taxonomy application to the Scada Application Software initiative of Chemtrols Industries Ltd

4.2.3 Initiative 2: Acsis ProducTrak of Acsis company

Acsis sells of Acsis ProducTrak, a suite of data collection and task management software that adds functionality to major ERP systems including SAP, Oracle, and J. D. Edwards. According to a release, Acsis ProducTrak brings real-time connectivity to every point in the supply chain, from incoming materials, through manufacturing, warehousing and distribution, making real-time sensing and real-time mass visibility (Table 7). With Acsis ProducTrak, the enterprise gets the real-time data it needs for effective management achieving efficiency goals. This system tells the what, when and where a product was sent, omitting the guesswork and reporting inaccuracies in the process. This consistent, granular data is the key to providing a true picture of product movement throughout the extended supply network and is the basis for the ProducTrak solution suite (Factiva, 2014).

Affordance	Taxonomy dimension acronym	Taxonomy dimension	Acsis ProducTrak of Acsis
Technological affordance	RTS	Real-time sensing	Acsis ProducTrak brings real-time connectivity to every point in the supply chain.
	RTMV	Real-time mass visibility	Acsis ProducTrak brings real-time connectivity to every point in the supply chain.
	RTE	Real-time experimentation	None
	RTC	Real-time coordination	None
Affordance actualization	SE	Service	None
	EF	Efficiency	With Acsis ProducTrak, the enterprise gets the real-time data it needs for effective management achieving efficiency goals.
	AN	Analytics	None
	AG	Aggregation	None
	GE	Generation	None

Table 7 Taxonomy application to the Acsis ProducTrak of Acsis

4.4.3 Initiative 3: DatSift platform of DataSift company

DataSift sells a real-time social media data-filtering platform. Through this solution companies access to real-time intelligence that is impactful to their business - allowing them to easily and quickly detect

and respond to major trending events, social behaviors, customer preferences from social media that produces millions of data streams every day - and ultimately, avert any impending crises. Specifically, DataSift filters and aggregate social media data in real-time by making real-time sensing and real-time mass visibility (Table 8) to help users unlock the power of data for brand monitoring and other applications. The DataSift platform sorts user conversations from sources like Twitter to find granular and relevant insight from the hundreds of millions of social media posts per day. The platform is able to filter social media data for demographic information, online influence and sentiment. DataSift does not limit searches based on keywords and allows companies to define extremely complex filters, including location, gender, sentiment, and language, to provide quick and very specific insight and analysis. DataSift' s technology can also apply the data filtering process to any content that is represented as a link within the post itself, providing companies with an accurate, holistic picture, by aggregating all necessary information (Factiva, 2014).

Affordance	Taxonomy dimension acronym	Taxonomy dimension	DatSift platform of DataSift
Technological affordance	RTS	Real-time sensing	Information is gathered from social media.
	RTMV	Real-time mass visibility	Companies access to real-time intelligence that is impactful to their business.
	RTE	Real-time experimentation	None
	RTC	Real-time coordination	None
Affordance actualization	SE	Service	None
	EF	Efficiency	None
	AN	Analytics	None
	AG	Aggregation	DataSift filters and aggregate social media data in real-time.
	GE	Generation	None

Table 8 Taxonomy application to the DatSift platform of DataSift

4.4.4 Initiative 4: BMW Routes Portal of BMW ConnectedDrive company

BMW ConnectedDrive offers innovative services and features for establishing intelligent networks between the driver, the vehicle and the world at large, enabling BMW customers to enjoy unparalleled comfort, Infotainment and safety while on the road. BMW was the first manufacturer worldwide to introduce the wide range of unique features and functions that are available with BMW ConnectedDrive. The company continues to lead the competition by leveraging its pioneering know-how to launch exclusive new features and technologies for BMW owners. The latest innovation is an enhancement for users of the BMW Routes Portal: Customers who have subscribed to the BMW Assist and BMW Online features offered in BMW ConnectedDrive now have access to the latest traffic reports via Real-Time Traffic Information (RTTI) from the Web portal with any Internet-enabled device. Previously users could only access this service while in the vehicle. RTTI is a reliable and precise solution that transmits traffic information in real time for planning travel routes and avoiding congested areas or unfavourable conditions in advance. The programme uses local traffic data and tracks the anonymous movement profiles of mobile communication devices in dynamic networks, thus creating a precise overview of the current traffic situation by determining the number, speed and positions of vehicles currently on the road, making possible real-time sensing, real-time mass visibility and real-time coordination (Table 9). RTTI is able to monitor real-time data from taxis or fleet vehicles having navigation systems that communicate with central dispatchers - this adds to the speed and accuracy of information that points to traffic problems. In addition to motorways and expressways, RTTI also covers secondary roads, city streets and interurban connections. BMW ConnectedDrive customers can enter their destination online at anytime and easily plan their next route. They can also access traffic information about incidents or traffic flow, in addition to defining route criteria and requesting alternative routes from the system. Based on the current traffic situation, the route planner can also calculate the exact time of arrival. And if traffic conditions should change or worsen once a route has been planned, the route planner can send the driver an e-mail well in advance and suggest an earlier departure time. This allows the driver to continue working at the office or take part in a meeting without worrying about when to get behind the wheel - the route planner will indicate the precise time to leave for the next appointment. That saves time and reduces stress (Factiva, 2014).

Affordance	Taxonomy dimension acronym	Taxonomy dimension	BMW Routes Portal of BMW ConnectedDrive
Technological affordance	RTS	Real-time sensing	The solution is able to understand the position of each vehicle.
	RTMV	Real-time mass visibility	The solution creates a precise overview of the current traffic situation.
	RTE	Real-time experimentation	None
	RTC	Real-time coordination	The solution enables the coordination of all cars.
Affordance actualization	SE	Service	BMW offers a new service to drivers since the route planner can send the driver an e-mail well in advance and suggest an earlier departure time in case of traffic.
	EF	Efficiency	None
	AN	Analytics	None
	AG	Aggregation	None
	GE	Generation	None

Table 9 Taxonomy application to the BMW Routes Portal of BMW ConnectedDrive

4.4.5 Initiative 5: Engagement A/B Reporting of FetchBack Inc. company

FetchBack Inc. uses Engagement A/B Reporting, a new analytics tool that shows and experiments how the company's retargeting campaigns motivate consumers to engage deeper with brands, leading to longer-term conversion success. As marketers aim to measure campaign effectiveness, FetchBack's new Engagement A/B Reporting demonstrates that other factors besides "clicks" can significantly influence consumer behaviour, making real-time sensing (Table 10). The Engagement A/B Reporting tool is part of FetchBack's proprietary analytics platform, FIDO, which displays real-time, deep analytics of a client's retargeting campaign. Beta tests of the Engagement A/B Reporting tool showed that consumers who received FetchBack's retargeted ads will return to the clients' websites sooner, more frequently, and will engage more with the website than those that did not receive the retargeted ads. These clients are running tests as often as every month and results continue to support the increase in brand engagement (Factiva, 2014).

Affordance	Taxonomy dimension acronym	Taxonomy dimension	Engagement A/B Reporting of FetchBack Inc.
Technological affordance	RTS	Real-time sensing	The solution is based on the idea that other factors besides "clicks" can significantly influence consumer behaviour.
	RTMV	Real-time mass visibility	None
	RTE	Real-time experimentation	Engagement A/B Reporting is a new analytics tool that shows and experiments how the company's retargeting campaigns motivate consumers to engage deeper with brands, leading to longer-term conversion success.
	RTC	Real-time coordination	None
Affordance actualization	SE	Service	None
	EF	Efficiency	None
	AN	Analytics	The real-time initiative is part of FetchBack's proprietary analytics platform, FIDO, which displays real-time, deep analytics of a client's retargeting campaign.
	AG	Aggregation	None
	GE	Generation	None

Table 10 Taxonomy application to the Engagement A/B Reporting of FetchBack Inc.

5. Discussions and conclusions

Recent research explored the value creation opportunity of DDS (e.g., LaValle *et al.*, 2013; McAfee *et al.*, 2012), but little attention was devoted to the analysis of the ways through which firms leverage DDS to create value. What did enable these DDS initiatives? Which forms or value propositions firms configured to create value from DDS initiatives?

This paper has proposed the development of a taxonomy for DDS initiatives by an affordance perspective. In so doing, we considered the method proposed by a recent IS scholar (Nickerson *et al.*, 2013) who provided guidance for developing a taxonomy by evaluating a set of necessary conditions for usefulness.

By considering 177 DDS initiatives, we came up with a taxonomy composed by two dimensions and characterized by four and five instances respectively. The category Technology Affordance replies to the "What did enable these DDS initiatives?" research question and we identified four instances: real-time sensing, real-time mass visibility, real-time experimentation and real-time coordination. The category Affordance Actualization replies to the "Which forms or value propositions firms configured to create value from DDS initiatives?" research question and we discovered five instances: service, efficiency, analytics, aggregation and generation.

In terms of managerial contribution, this taxonomy could be a useful tool for managers. This taxonomy could help companies considering peculiarities of the DDS initiatives they want to incur in and take the relative investments and actions accordingly. This taxonomy should give a more structure breadth to the evaluation of value creation opportunities that might be considered when a DDS initiative is undertaken. For example, companies that want to leverage DDS for efficiency purposes should know whether a similar DDS initiative already exists. If a similar DDS initiative exists, the company should understand how to implement and gather value from DDS by looking at successful prior implementations. Hence, this taxonomy makes acknowledgeable the companies about the possibilities that DDS can provide, what can enable the implementation of DDS initiatives, and the actions to take for achieving outcomes according to their organizational goals.

Looking at a temporal perspective, this study provides an image of the taxonomy of the DDS initiatives, with the existing dimensions and instances. Overtime, new instances could appear in the future and new dimensions could become relevant to be included. On the opposite, we can assist the disappearance of some instances because not able to create value over longer periods of time. Hence a monitoring of DDS initiatives could provide evidences of this potential evolution of the DDS initiatives. Moreover, this study insisted on a wide overview of the DDS initiatives, hence limiting the possibility to have an in depth look at the internal processes linking a Technology Affordance to its Affordance Actualization, down to the impact on the financial performance or other economic advantages for companies.

Appendix A: Taxonomy application to all DDS initiatives considered in this study

			Technological affordance				Affordance actuation				
ID initiative	**DDS initiative name**	**Company name**	**RTS**	**RTMV**	**RTE**	**RTC**	**SE**	**EF**	**AN**	**AG**	**GE**
I1	Social Media Monitoring	BrandWatch	x						x		
I2	Netflix prize	Netflix	x	x			x				
I3	Tripit Pro	Tripit	x				x				
I4	MyCityWay solution	MyCityWay	x				x				
I5	Reputation Manager	ActValue	x						x		
I6	NetSeven	NetSeven	x						x		
I7	Netvibes monitoring solution	Netvibes	x							x	
I8	Pachube	Pachube	x							x	
I9	Mint financial solution	Mint	x	x					x		
I10	Predictive analytics software	New Brand Analytics	x	x					x		
I11a	Inforchimps Platform	Inforchimps	x							x	
I11b	Inforchimps Data Marketplace	Inforchimps	x						x		
I12	Adara Media Platform	Adaramedia	x	x					x		
I13	401k	Brigthscope	x	x			x				
I14	LiveServices	Tom Tom	x	x			x				
I15	Advisors	Brigthscope	x	x					x		
I16	Influence Explorer	Influence Explorer	x							x	
I17	Online Energy Management Tools	Opower	x	x					x		
I18a	Groupon API	Groupon	x								x
I18b	Groupon deals	Groupon	x				x				
I19	Groupon now!	Groupon	x				x				
I20	Knoema	Knoema	x						x		
I21	Google Trends	Google	x	x					x		
I22	Public Data	Google	x						x		
I23	Factual	Factual	x							x	
I24	Liveplasma	Liveplasma	x	x					x		
I25	TuneGlue	TuneGlue	x	x					x		
I26	Takadu solution	Takadu	x		x				x		
I27	Taxy call management	MyTaxy.net	x	x				x			
I28	Datamarket	Datamarket	x						x		
I29	Spookeo	Spookeo	x							x	
I30	Eureka	Canal+	x	x			x				
I31	Peekyou	Peekyou	x							x	
I32	Smart metering	Iren	x								x
I33	Taxy call	MyTaxy.net	x				x				
I34	MobiHealth Mobile	MobyHealth	x								x
I35	OneBusAway	MTA Bus Time	x								x
I36	MBTA real-time Website	Massachusetts Bay Transit Authority	x				x				
I36	MBTA real-time API	Massachusetts Bay Transit Authority	x								x
I37	Service-oriented Data-Driven Organisation With	InterContinental Hotel Group	x						x		

	Big Data										
I38	Revenue Management	Marriott	x		x				x		
I39	Big Data To Deliver Excellent Customer Service	Southwest Airlines	x						x		
I40	Know Me program	British Airways	x						x		
I41	Airport Collaborative Decision Making	Heathrow Airport Holdings	x	x				x			
I42	Big Data Analysis With HP Vertica	BlaBlacar	x						x		
I43	Uber	Uber	x	x			x				
I44	Tripadvisor	Tripadvisor	x	x			x				
I45	Hipmunk Flight Ranking	Hipmunk	x	x			x				
I46a	Kayak A/B Testing	Kayak	x		x			x			
I46b	Kayak Price Forecast	Kayak	x	x			x				
I47	Reputation Manager	Reputation Manager	x	x			x				
I48	TrustYou	TrustYou	x	x						x	
I49a	Optimizely Testing	Optimizely	x		x				x		
I49b	Optimizely Personalization	Optimizely	x	x			x				
I50	Datameer	Datameer	x						x		
I51	Amadeus	Amadeus	x							x	
I52	Facebook	Facebook	x	x			x				
I53	Digital cow	J.R. Simplot company	x	x					x		
I54	Nike+ shoes	Nike	x				x				
I55	Zynga	Zynga	x	x			x				
I56	People You May Know	LinkedIn	x		x		x				
I57	High-performance-analytics	Macy's	x						x		
I58	Natural language processing solution	United Healthcare	x						x		
I59	Big Data at Bank of America	Bank of America	x						x		
I60	Data as a service solution	Sears Holdings	x						x		
I61	ORION	UPS	x	x				x			
I62	Total Rewards loyalty program, web clickstreams, and real-time play in slot machines	Caesar	x		x				x		
I63	Tesla logs	Tesla Motors	x	x							x
I64	Anvita Insight analysis	Anvita health	x						x		
I65	Talend Real-Time Big Data Platform	Talend	x						x		
I66	ParStream's Analytics Platform	ParStream	x						x		
I67	RMG's Visual Supply Chain solutions	RMG Networks	x	x				x			
I68	BigMemoryMAX	Software AG	x					x			
I69	Druid	Metamarkets	x				x				
I70	Real Time Data	London Stock Exchange	x				x				
I71	Digital Suites for Oil and Gas	Honeywell Process Solutions	x					x			

I72	Salesforce Lighting Connect	Salesforce.com	x	x						x	
I73	Aisys CS2 anaesthesia platform	GE Healthcare	x				x				
I74	the ParStream Analytics Platform	ParStream	x						x		
I75	PubMatic Analytics	PubMatic	x						x		
I76	ANPM product	Optus	x				x				
I77	MOM application	GMT	x	x				x			
I78	NOVOsphere	NOVOTM	x					x			
I79	Predictive Analytics Solution	AudaExplore	x	x				x			
I80	TIBCO Engage	TIBCO Software Inc	x		x				x		
I81	Biometric-based time and attendance system	UGO Foods	x					x			
I82	GE Monitor Asset Tracking	GE Capital Fleet Services	x	x				x			
I83	iCommand	Overwatch Intelligence Solutions	x	x					x		
I84	Drive Safe Systems	Con-way Freight	x					x			
I85	Patient Classification Clinical Information Interface software solution	API Healthcare	x					x			
I86	Sensorium software	2BM	x					x			
I87	AdMall PRO's Digital Audit	AdMall Pro	x							x	
I88	ExASolution	ExASOL AG	x						x		
I89	Preclarus	Pharmaceutical Product Development	x	x					x		
I90	AQUARIUS Forecast	Aquatic Informatics Inc	x				x				
I91	SolarSNAP	Shoals Technologies Group and Synapse Wireless	x					x			
I92	Brand LIVE Pulse	NetBase	x	x					x		
I93	Bloe washroom service and Tork EasyCube	Svenska Cellulosa	x				x				
I94	StoryTeller Inrix Traffic App	AccuWeather	x	x			x				
I95	Hyundai Dealer Portal	Dealertrack Canada	x	x			x				
I96	Plexus	PROFILE Software	x	x				x			
I97	Shiraz	W&H Systems Inc	x					x			
I98	RFRTDTemp2000A	MadgeTech Inc	x	x							x
I99	AquaView	Select Energy Services	x					x			
I100	NC-1 non-contact in-line system	Konica Minolta Sensing Americas Inc	x					x			
I101	NASDAQ Last Sale	SINA Corporation	x							x	
I102	Simplify Commerce	SumAll	x						x		
I103	Metronome device	MetroMile	x				x				
I104	VeriWise	Asset Intelligence	x					x			
I105	OmniWell	Weatherford International Ltd	x	x					x		
I106	Orion	United Parcel Service Inc	x	x				x			

I107	INRIx real-time traffic information	INRIx	x	x			x				
I108	Graco InSite	Graco Inc	x	x							x
I109	Jibe Recruiting Analytics	Jibe Inc	x	x					x		
I110	TDSR	Talksum Inc	x	x						x	
I111	First Derivatives	NYSE	x	x			x				
I112	Elektron Real-time	Thomson Reuters	x	x						x	
I113	DEC	Thismoment	x	x					x		
I114	Product Link	Caterpillar	x	x			x				
I115	RTSM	Perceptive Informatics	x	x				x			
I116	Faronics LabPro	Faronics	x	x			x				
I117	TASS	Verint(R) Systems Inc	x	x					x		
I118	FleetLocate	Spireon, Inc.,	x	x			x				
I119	Parker	Bellis	x	x			x				
I120	Customer Conversation Hub	Message Systems	x	x			x				
I121	DMFusion 2.0	Luxoft	x					x			
I122	ProFicient 5	InfinityQS International Inc	x					x			
I123	ION Mustering	Apprion	x	x				x			
I124	TrackWise Analytics	Sparta Systems Inc	x					x			
I125	WebTrak	Finavia	x	x							x
I126	PPD InVision	Pharmaceutical Product Development, LLC (PPD)	x	x			x				
I127	ParkSight Portal	Streetline Inc	x	x			x				
I128	Publishflow	Sargas Capital	x	x					x		
I129	ProRAE Guardian System	RAE Systems	x				x				
I130	Intel AIM Suite	Broadcast International (BCST.OB)	x	x					x		
I131	SCADA Application Software	Chemtrols Industries Ltd	x	x					x		
I132	Aegis Pi	Aegis	x	x					x		
I133	Imagine	Ingenious Med	x	x					x		
I134	HPM solution	Cognizant	x	x					x		
I135	Bi3 SaaS applications	Bi3 Solutions Inc	x	x					x		
I136	Acsis ProducTrak	Acsis	x	x				x			
I137	ProRAE Guardian CloudServer	RAE Systems Inc	x				x				
I138	SYNC Destinations	Ford Motor	x				x				
I139	WV511	Open Roads Consulting	x	x			x				
I140	AutoVault	Talyst	x	x				x			
I141	LP Marketer	LivePerson, Inc.	x						x		
I142	OneViewPOV	Verizon Wireless and Pedigree Technologies	x					x			
I143	DataSift platform	DataSift	x	x						x	
I144	Timecard GPS	Econz	x	x			x				
I145	REFLExx	Digitexx Data Systems Inc	x	x					x		
I146	Trimble(R) RTx	Trimble	x				x				

	technology										
I147	SiRFstarV	Cambridge Silicon Radio	x				x				
I148	InCrowd platform	InCrowd	x	x			x				
I149	SonicWALL Global Management System (GMS) 7.0	SonicWALL Inc	x	x					x		
I150	Oracle Health Sciences Pharmacovigilance Operational Analytics	Oracle	x	x					x		
I151	Google Analytics Real-Time	Google	x						x		
I152	BioClinica Express EDC	BioClinica Inc	x					x			
I153a	Blackbay's enterprise mobility solution	DPD Ireland	x	x			x				
I153b	Blackbay's customer feedback	DPD Ireland	x								x
I154	BMW Routes Portal	BMW ConnectedDrive	x	x		x	x				
I155	MEDHOST HD	MEDHOST	x					x			
I156	SD Card Real-Time Data Logging Instruments	General Tools & Instruments	x				x				
I157	ODBC	Attunity Ltd	x							x	
I158	WaferSense	CyberOptics Semiconductor	x					x			
I159	Fleet Director 8.2	Teletrac	x	x					x		
I160	Trac Tag	Libramation	x					x			
I161	EffiMax 3000 Boiler Efficiency Monitoring Packages	Forbes Marshall	x					x			
I162	LiveInsights	InsightExpress	x						x		
I163	4SIGHT solution	4SIGHT	x	x				x			
I164	FireScope Analytics	FireScope Inc	x						x		
I165	GRRM platform	MConcierge Systems Inc	x				x				
I166	PI for StreamInsight	OSIsoft, LLC	x						x		
I167	GreenGlobe Data Visualizer	NEC Corporation	x							x	
I168	Web-based Check-Net data management platform	Checkpoint Systems	x					x			
I169	Excalibur-Litho	Magma Design Automation Inc	x						x		
I170	Engagement A/B Reporting	FetchBack Inc	x		x				x		
I171	GO 2505 M LIVE	TomTom	x	x			x				

Table A1 Taxonomy application to all DDS initiatives

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