Towards a Big Data-based Technical Customer Service Management

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Abstract: The increasing use of Information Systems (IS) in diverse business sectors and the growing degree of mobility has changed the traditional use of Information Technologies (IT) in the economy. While Big Data is a current issue in the telecommunication and trade sector, high data intensity is also in the service sector given. Especially in the Technical Customer Service (TCS) area, a large variety of information and data exist that are needed for a service process or that result from them. In this paper, a conceptual framework for Big Data-based Service Management of the TCS is presented revealing opportunities and improvements for both product and service development. These opportunities lead to generating value from the use of large datasets and applying advanced analytical methods to increase efficiency and service quality. Finally, with the help of the framework an optimized Product-Service-Lifecylce Management is envisioned.

1 Introduction

The machinery and plant engineering encompasses more than 6.000 companies and approximately 978.000 employees which makes it to the largest industrial employers in the German industry. The increase of the mechanical engineering production by 24 percent in the past 3 years clarifies the importance of this sector [Vdma13]. In addition to industrially manufactured products, industrial services are also of great importance. A majority of these services are inputs for the manufacturing sector, with the manufacturing sector as one of the largest buyers of business services [Edle13]. This results from the fact that in recent years suppliers of machines and plants have emerged from a mere producer to service providing producer, because customers are increasingly demanding integrated solutions to meet their individual needs [ThWL08a]. In this way, conventional products turn into customer-focused solutions that provide plant and machinery installers the opportunity for competitive differentiation [BhVF93]. The interface of the industrial service to the customer is provided by the Technical Customer Service (TCS). The TCS takes an active part in the utilization phase of a physical product and serves the purpose to maintain the performance of the property during the life cycle continuously. In addition, the TCS ensures that the investment of the users will pay off in the long term [Harm99]. The traditional functions of the service technician include repair, inspection as well as maintenance activities that are performed on a service object at customers' site [Walt10a]. Due to the product-related operations with technical consumer goods, the TCS has become an essential part of the so-called Product-Service Systems (PSS) and requires intelligent support in its knowledge-intensive activity [ThWL08b].

A large number of systems exist aiming at supporting the service technician, e.g. diagnosis system, condition-monitoring, maintenance system and various teleservice system solutions. Besides, mobile assistance systems are increasingly used for processing service orders [MFÖK13]. The integration of mobile solutions into business processes owns a lot of potentials to revolutionize the service delivery at the "point of service" admittedly, but to date there is still no structured development of integrated systems that aim at real-time analysis of relevant service data and their communication and evaluation in an adequate way before, during and after a service process. In addition, appropriately processed data and thus important requirements from the customer's perspective do not or insufficient flow back to the research and development and into the product planning phases of the manufacturer. This is somewhat surprising regarding the already identified growing importance of service and support as a Big Data field of application [Bitk12]. In fact, it is challenging for traditional data analysis to cope with emerging requirements, imposed by the growing data volumes, the increasing number of data users, the growing number of data sources and the demand for real-time analysis [ZiLa13]. The challenge is even amplified by current surveys showing that in future the number of intelligent networked products and services will continue to multiply exponentially in all industries [Deut14]. To meet these challenges, an effective data preparation and use is required, which provides the integration, processing and deployment of service relevant data along the value creation process of the Product-Service System and including the value added partners with the aim to optimize the data usage so that these information can be integrated into new products and services. For this reason, an appropriate Big Data-based infrastructure is necessary to meet the demands of the growing data of the TCS.

In this paper, we investigate Big Data issues in the field of the Technical Customer Service and provide a conceptual Big Data-based Service Management framework for the TCS. Section 2 introduces to Service Management in the area of the TCS by providing fundamental knowledge about TCS processes and pointing out information needs as well as data occurrences within these service processes. In section 3, we categorize the Big Data topics and transfer them to the TCS domain. Further, Big Data analytic tools are presented. In section 4 a conceptual framework of Big Data leverage is described including potencials for the TCS. Section 5 reveals challenges of Big Data in the service sector and section 6 concludes our approach and gives an outlook to further research.

2 Service Management and the Technical Customer Service

2.1 Technical Customer Service Processes

The service process involves activities undertaken to realize and deliver the service [BoYa05]. A service process of the TCS consists of various functions and sub-processes, which may occure in different manifestations depending on the company. The master and transaction data serve as a base that enrich the functions and processes (Figure 1).

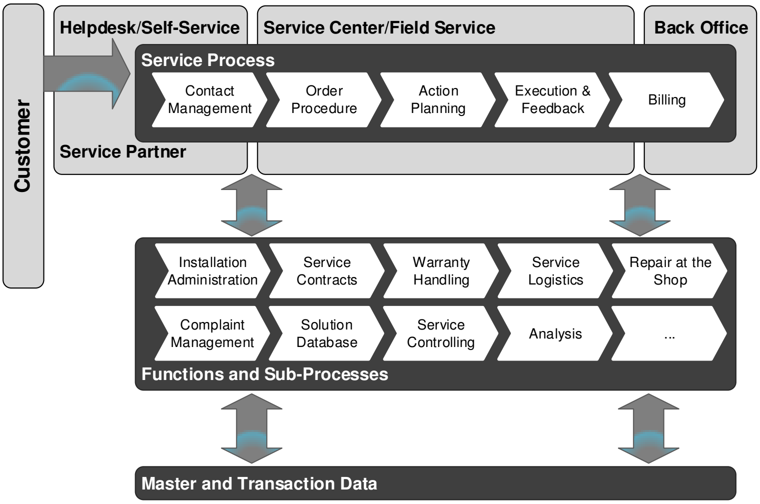

Figure 1: Functions, data and actors of a service process (referring to [Vdma08])

The customer initiates the service process by contacting the TCS so that the contact management takes place. After the contact management occurred the service process passes the stages order procedure, action planning, execution and feedback ending with the billing of the service order. The service process can pass through different departments that operate on the service process. Each department may require a slightly different view of the service processes where different requirements for the Service Management solution emerge. Stakeholders of those departments can be, for example, employees of the helpdesk, customer service employees, service field workers, accountants and logistics experts. Within the service process functions and sub-processes arise, e.g. installation administration, complaint management, which can vary depending on the service order. The execution of these functions and sub-processes needs access on master and transaction data and transmitts in turn data back after processing [Vdma08]. A wide variety of IT resources and capabilities are relevant to provide the transaction and master data required for the execution of the customer service process [RaMB05]. The integration of mobile IT improves the service process and supports the service technician at multiple levels by providing required information in real-time [ÖFMD13][BrTW08]. The service technician needs the relevant information about the state of the system and the documentation and order data either for remote operation or when he is at the customer’s site in a timely manner. [BNST08][Walt09]. The integration of mobile devices introduces higher levels of flexibility and personalization of the service technician and presents organizations opportunities to integrate new or enhanced business processes that would result in greater productivity, efficiency and effectiveness [CoHH08]. Information needs of the TCS causes that there is the necessity to integrate appropriate IS to support the operation and the staff efficiently. For ensuring the competitiveness and quality of the service, it is important to structure and process the information needs and existing data of the service phases and sub-processes with analytical methods that meet the demands of the growing (big) data.

2.2 Information Needs and Data Occurrence in Service Processes

Information can be declared as a fundamental component for the performance of a service process. For this reason, the usage of IS is a critical success factor to provide the TCS employees the needed information for a qualitative service delivery [RaMB05]. The activities of employees require in-depth knowledge, skills and sufficient trained IT support to cope with the wide range of tasks. Thus not only information about the service itself, but also information about the considered products are required [Stil03] which are likewise important for the entire value chain [Walt10b][ÖsSe06]. The information base must also include customer data due to the customer proximity of the service technician [DeWB09]. In all phases of the service process including the functions and sub-processes, the documentation of information occurs [Stil03]. Documents that are stored as data with IS, provide information that can be recycled [WaPK95]. The documented facts are also fundamental part in the subsequent assessment phase of service provision, since this information is used for after-sales purposes and conveys retroactively information by explicit analysis of the service provision [Harm99] [PoMi85]. While traditional Knowledge Management encompasses the activities of maintaining, structuring, representing and sharing of knowledge within an organization [ScLe02][Sofi14], requirements for Knowledge Management changed through the growing amount of large data sets caused by multiple systems and actors in the value creation process [KaWa14]. These generated or received data during a service process can be of structured, semi-structured or unstructured nature (Figure 2). Examples for structured data are customer master data that reside in fixed fields, like columns or rows [MCBB11]. Placed in a relational database the fields and their relations to one another are clearly defined [Cóte14]. Semi-structured data are also structured to a certain grade but they also own an unstructured part (e.g. e-mails in which the head of the mail follows a clear structure but the body can be of unstructured nature comprising contents and attachments of any type or XML and RSS-feeds). Unstructured data comprise data that do not reside in fixed fields and include free-form text or human language, e.g. articles, talks, untagged audio [Russ11]. Within a service process, the involved actors generate unstructured data by people to people communication in virtual communities, social networks or web logs. Also a communication between people and applications or machines exist like data resulting from e-commerce or data generated by using specific mobiles. Machine to machine communication includes data from sensors, GPS data or images and videos from cameras [KlTH13]. Embedded systems are now integrated into a variety of objects and thus endow them with intelligence. Equipped with sensors, intelligent objects capture data from their environment and react upon them [Deut14] which occasions increasing data traffic without human interaction.

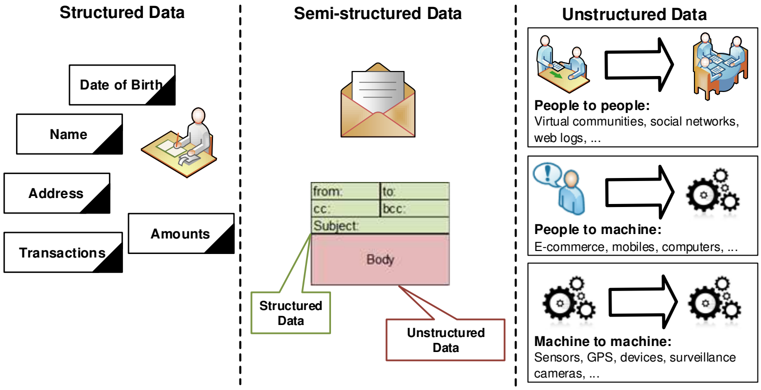

Figure 2: Data structures of a service process (referring to [KlTH13])

These different types of data are generated in the multimedia-based and knowledge-intense environment [Kant11] and need data-mining methods to handle them and make them analyzable.

3 Big Data

3.1 Big Data Topics and their Pertinence to the TCS

In recent years, Big Data has become a new ubiquitous term [BRMH13] but however no consistent definition exists [KlTH13]. Chen et al. (2012) see Big Data Analytics as a related field of Business Intelligence (BI). The term comprises large and complex data sets that require advanced IT for data storage, analysis and visualization [ChCS12]. Initial situation that triggers Big Data, includes data collection from enterprises of various department sections and even data beyond their own company, like data of customers and business partners [BrCM11]. Elementary components of the Big Data topic are four basic properties, namely volume, velocity, variety and veracity [BRMH13]. While the property volume relates to the amount of data, variety refers to its heterogenity. In the range of velocity measures and techniques need to be integrated to optimize the speed of data processing [Lyce13]. Veracity concerns data regarding their quality. Transferring the Big Data topics to the TCS we ascertained the following findings.

Variety. The traditional functions of the service technician comprise the tasks of maintenance, which include the maintenance, inspection and improvement [Din12]. They are mainly carried out at the customers' site on a service object. A challenge in the performance of maintenance tasks consists of the large number of manufacturers whose service objects underly various maintenance requests, so that the service technician needs to be available of a wide range of subject-specific knowledge at the right ”point of service“. Effective data preparation and data use allow the automation of routine service and analysis of service cases, so that the service engineer can focus on the difficult cases [Bitk12]. Despite these efforts, the engineers are increasingly overtaxed without a comprehensive preparation and provision of diverse data on mobile assistance systems as a consequence of the enormous product variety and complexity of the complicated maintenance tasks [MFÖK13].

Velocity. The increasing interconnection of physical objects with information-processing components (also known as cyber-physical systems [GeBr12]), e.g. sensors, generates data which require a fast transfer. The continuous monitoring of sensor data enables predictive handling of technical problems and avoidance of far-reaching damages. For example, a trouble-free maintenance of an air conditioning, which is used for cooling server rooms, has to be guaranteed. If a fault is transmitted via sensors, the responsible object manager needs to be informed. Such errors, error messages and other information about the state of the plant have to be used to prevent impairments of the machinery. However, sensor data need to be transferred in real-time to the appropriate positions in order to avoid such downtime.

Volume. To facilitate analysis and conclusions in terms of product development, the collection, analysis and correct interpretation of all relevant data from the environment of the service object is required. Also data in form of huge amounts of unstructured text from service reports or product forums of the social web need to be used to draw conclusions on problems or opportunities for product and service improvement [MCBB11].

Veracity. Information generated by sensors but also additional information, such as customer feedback data may include noise, errors and distortions but information need to be accurate and reliable for decision making. Incompleteness and errors must be managed during data analysis but doing this correctly is a challenge [ABBD11].

As the previous sections have revealed, the problems that are at the heart of Big Data and that are characterized by the four “V”s also increasingly gain importance in the context of the TCS. Hence, Big Data analytic tools can be leveraged to tackle these challenges in the TCS associated to the four “V”s.

3.2 Big Data Analytic Tools

The analysis and mining of Big Data is challenging. In order to make use of Big Data deep analysis, instead of just generating simple report forms, is needed [CCDL13]. Data warehouse is a relational database system used for storing, analyzing and reporting functions of structured data employing Standard Query Language (SQL). Unstructured data are of a more complex nature what makes tradtitional methods of storing and managing impractical [Baks12]. “Not only SQL” (NoSQL) database management systems are designed for large-scale data storage of a huge quantity of data especially when the data’s nature does not require a relational model [Hoss13]. The MapReduce algorithm was developed to process large data collections and builds the foundation for

Apache Hadoop which is a distributed file system modeled on Google File Systems (GFS) and a distributed processing framework, using both MapReduce concepts and a distributed database called HBase [BoCL12]. Hadoop also includes a cluster file system that scales to store massive amounts of data, also called Hadoop Distributed File System (HDFS). The MapReduce algorithm is dived into two phases. In the map-phase input data is subdivided into smaller workloads and are assigned to a map-task that processes each block of data. The result is a sorted list that is spread in the reduce-phase. Out of the preliminary result from the map-phase, the final output is produced and written to the HDFS [Baks12][KlTH13]. Since Big Data become present, different storage systems have been developed [RSJG12]. However, in consideration of the developments, new IT infrastructure opportunities build the starting point towards the intelligent management of data and their usage, especially in the field of the TCS.

4 A Conceptual Big Data-based Service Management Framework

Much of the value that Big Data can create in the TCS sector requires the access and varied use of data from multiple sources across the extended enterprise [MCBB11]. Figure 3 shows the crucial partners participating in the general extended value-adding chain.

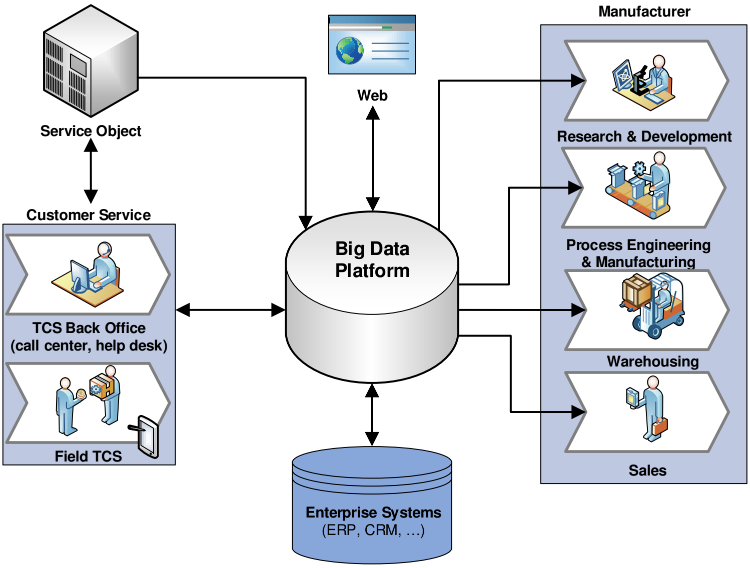

Figure 3: Big Data-platform for the TCS

The partners contribute to the product-supporting service provision and are differentiated into the work areas research and development, process engineering and manufacturing, warehousing and sales [FHBT11]. The manufacturer in total creates necessary data that are relevant for the service provision of the TCS (e.g. product data, manual or service handbook). However, the heterogeneous amount of data the TCS needs to be available of and which is generated by the plurality of machines and equipment is difficult to control because the service objects underly different maintenance requests, e.g. operating instructions. In addition to the data and information provided by the work areas of the manufacturer the TCS itself generates also information about the service object, service order or customer within the back office or in the field. These can be structured or unstructured data comprising service reports, protocols, lack messages, bills or simple comments about the service order. Due to the increasing interconnectedness of physical objects with information-processing components, data of the service object itself are transmitted to the TCS and their devices. Sensor data must be integrated into the service process and transmit in real-time to relevant authorities. At the same time a further channel, the web, is claimed by the increased cross-linking and presence of producers and service providers on the internet. Here, information is shared among customers and also partly employees of the company. The bidirectional arrow directions indicate the data and information exchange between the actors and objects.

Hitherto, regarding the information flow between the partners of the value chain, research has focused on the integration of information across the value chain with the aim to provide improved (mobile) access to information that are stored in an integrated information system [TWLN07][BlNü10]. Taking these underlying conditions into account, an appropriate Big Data-based processing is needed to allow an exploratory, retrospective and prospective analysis of data in order to support the Service Management of the TCS. The proposed Big Data-platform should contain a generic collection of methods, algorithms and use case descriptions intended to facilitate and guide implementation of Big Data systems in the TCS domain. The data reflow from the platform constitutes the supply of information. The leverage of Big Data in the domain of the TCS is the use of customer-related data to provide insights for the benefit of all partners in the value chain. Data- and text-mining algorithms used for unstructured data allow their editing and reflow to relevant actors of the value-chain. Especially for research and development departments great opportunities are offered to accelerate product development, product improvements and service-efficient product development that minimize production costs and harness consumer insights [MCBB11]. Analyzing service-relevant data in real-time at the mobile point of service enables a preventive maintenance of the TCS by direct information evaluation and provision, e.g. through fault hypotheses and user-driven data analysis using “one click mining”-concepts [BMKT13]. Preventive actions improve customer satisfaction and provide for a more efficient warehousing [KuWD09]. Thus, the user is able to benefit from the analysis algorithms in the context of their daily work without requiring help of experts. This helps to improve the autonomy of the TCS and allows the automation of other service instances. The real-time processing of both structured and unstructured data plays especially for ensuring the operability of the systems an important role since it affects performance-critical product-related services. Also errors can be spotted in early development phases, since the cost for errors increase considerably in each stage of the product lifecycle [ABBD11]. A holistic optimization of the service lifecycle can be realized because manufacturers have tremendous potential to generate value from the use of large datasets, integrating data across the extended value chain and applying advanced analytical techniques to raise their productivity both by increasing efficiency and improving the quality of their products [MCBB11].

5 Challenges of Applying Big Data in the TCS Domain

Gathering and analyzing large amounts of data for both gaining real-time insight into the operation of the TCS and to inform other departments such as warehousing and sales has not been proposed to date. However, the core idea of controlling the growing mass of information and data through innovative solutions is associated with challenges. Data analysis, organization, retrieval and modelling of different structures and created by different departments of the value chain are foundational challenges. Furthermore, the interconnection of machines to other computer systems and the growing importance of the web afford additional data that may also possible sources of error: computer systems can have bugs or results can be based on erroneous data [ABBD11]. Moreover semantic challenges exist which makes it difficult to extract only those information that are relevant for the value-added content of a company out of an unstructured mass [ZaPG13]. In human collaboration, which is given in the TCS domain, the extra challenge is the uncertainty of the data collection devices. Smart devices used for Big Data analytics and even the so-called “Bring Your Own Device”-trend (BYOD) are critical regarding data privacy and can be seen as a further driver for data growth. Traditional instruments of the data protection law are barely to deploy although the Federal Data Protection Act commands that data which is gathered for different purposes need to be processed isolated (separation rule). Gathered data can only be processed and used for purposes that are compatible with the purpose of the collection (purpose limitation) but Big Data requires the decoupling of data from their purpose. Even with BYOD there is a risk, that data may be alienated [Conr13]. Further, attempts in mobile web attacks have increased, along with the growth of mobile device users. Especially mobile web services are affected by this because service methods of many businesses have changed to web-based services, and their dependence on web system has also increased with the rapid increase in mobile web applications [HaLe14]. As we can see a wide range of challenges exist affecting different scopes. Big Data users need to be aware of these challenges to work efficiently with Big Data solutions and to avoid adverse consequences.

6 Conclusion and Outlook

While the relevance of Big Data is widely discussed in the fields of social media, e-commerce [BRMH13] and healthcare [Cóte14], it is not prevalent in the machinery and plant engineering and it’s accompanying TCS yet. Especially social media is seen as a showpiece for Big Data due to the variety of user data and the need to calculate and analyze them to control offers in real time and provide an optimized referral marketing. The service sector is equally affected by Big Data problems through the necessity of information and the increasing use of mobile IS which also cause a wide variety of data in structured, semi-structured or unstructured form. Expecially product-related services of the TCS require analytical tools that enable the effective and efficient processing of data before, during and afterwards the service process. For ensuring the competitiveness and quality of the service delivery it is important to structure and process the existing data. Big Data analytic tools support the return of processed data back from service delivery into the planning phase of product development. This enables a holistic optimized product-service lifecycle management by submitting current issues, problems and suggestions to each actor of the extended value chain. This paper provides a conceptual framework for a Big Data-based Service Management of the TCS. Opportunities are revealed and challenges described that occure as side-effects of Big Data technologies. In a next step, it is planned to gather existing applications and required interfaces in the field of the TCS to specifiy appropriate Big Data-based analytic algorithms to enable the demand-actuated recall of integrated and rehashed service data.

References

[ABBD11] Agrawal, D.; Bernstein, P.; Bertino, E.; Davidson, S.; Dayal, U.: Challenges and Opportunities with Big Data 2011-1. Cyber Center Technical Reports, Purdue University, 2011.

[Baks12] Bakshi, K.: Considerations for Big Data: Architecture and Approach. In: 2012 IEEE Aerospace Conference (Mar. 2012), pp. 1–7.

[BhVF93] Bharadwaj, S.G.; Varadarajan, P.R.; Fahy, J.: Competitive Advantage in Service Industries: A Conceptual Model. In: Journal of Marketing 57 (1993) 4, pp. 83–99.

[Bitk12] BITKOM: Big Data im Praxiseinsatz – Szenarien, Beispiele, Effekte. Berlin 2012.

[BlNü10] Blinn, N.; Nüttgens, M.: Empowering Technical Customer Services with Intelligent Mobile Applications: A Contingency Theory-Based Approach. In: Proceedings of the IFIP, Working Papers on Information Systems, 10 (107), 2010.

[BMKT13] Boley, M.; Mampaey, M.; Kang, B.; Tokmakov, P.; Wrobel, S.: One Click Mining – Interactive Local Pattern Discovery through Implicit Preference and Performance Learning. In: IDEA'13, 2013, pp. 27–35.

[BNST08] Blinn, N.; Nüttgens, M.; Schlicker, M.; Thomas, O.; Walter, P.: Lebenszyklusmodelle hybrider Wertschöpfung: Modellimplikationen und Fallstudie an einem Beispiel des Maschinen- und Anlagenbaus. In: Multikonferenz Wirtschaftsinformatik 2008, pp. 711–722.

[BoCL12] Borkar, V.; Carey, M.J.; Li, C.: Inside "Big Data Management": Ogres, Onions, or Parfaits? In: EDBT/ICDT 2012, 2012, pp. 3–14.

[BoYa05] Boughnim, N.; Yannou, B.: Using Blueprinting Method for Developing Product-Service Systems. In: International Conference on Engineering Design, 2005, pp. 1–16.

[BrCM11] Brown, B.; Chui, M.; Manyika, J.: Are you ready for the era of "big data"? In: McKinsey Quarterly (2011), pp. 1–12.

[BRMH13] Buhl, H.U.; Röglinger, M.; Moser, F.; Heidemann, J.: Big Data – A Fashionable Topic with(out) Sustainable Relevance for Research and Practice? In: Business & Information Systems Engineering 5 (Feb. 2013) 2, pp. 65–69.

[BrTW08] Brocke, J.; Thurnher, B.; Winkler, D.: Improving IT-Service Business Processes by Integrating Mobility: The Role of User Participation – Results from Five Case Studies. In: Proceedings of the International Conference on e-Learning, e-Business, Enterprise Information Systems, and e-Government (EEE'08), 2008.

[CCDL13] Chen, J.; Chen, Y.; Du, X.; Li, C.; Lu, J.; Zhao, S.; Zhou, X.: Big data challenge: a data management perspective. In: Frontiers of Computer Science 7 (Apr. 2013) 2, pp. 157–164.

[ChCS12] Chen, H.; Chiang, R.H.L.; Storey, V.C.: Business Intelligence and Analytics: From Big Data to Big Impact. In: MIS Quarterly 36 (2012) 4, pp. 1165–1188.

[CoHH08] Coursaris, C.; Hassanein, K.; Head, M.: Mobile technology and the value chain: Participants, activities and value creation. In: International Journal of Business Science and Applied Management 3 (2008) 3, pp. 14–30.

[Conr13] Conrad, I.: Big Data und ByoD – Datenschatz und Datenschutz. In: Informatik-Spektrum 36 (Jun. 2013) 4, pp. 407–408.

[Cóte14] Cóte, M: Data Motility – The Materiality of Big Social Data. In: Cultural Studies Review 20 (2014) 1, pp. 121–149.

[Deut14] Deutsche Akademie der Technikwissenschaft (acatech): Smart Service Welt – Umsetzungsempfehlungen für das Zukunftsprojekt Internetbasierte Dienste für die Wirtschaft. 2014.

[DeWB09] Deuse, J.; Wischniewski, S.; Birkmann, S.: Knowledgebase für die kontinuierliche Innovationsarbeit im Technischen Kundendienst. In (Herrmann, T.A.; Kleinbeck, U.; Ritterskamp C. eds.): Innovationen an der Schnittstelle zwischen technischer Dienstleistung und Kunde. Physica, Heidelberg 2009, pp. 155–176.

[Din12] DIN: Grundlagen der Instandhaltung 31051. Beuth Verlag, Berlin 2012.

[Edle13] Edler, D.: Die Industrie – ein wichtiger Treiber der Nachfrage nach Dienstleistungen. In: DIW Wochenbericht (2013) 34, pp. 16–24.

[FHBT11] Fellmann, M.; Hucke, S.; Breitschwerdt, R.; Thomas, O.; Blinn, N.: Informationssystemarchitekturen zur Unterstützung technischer Kundendienst-leistungen. In: Wirtschaftsinformatik Proceedings 2011, pp. 252–261.

[GeBr12] Geisberger, E.; Broy, M.: Integrierte Forschungsagenda Cyber-Physical Systems – acatech STUDIE. München 2012.

[HaLe14] Ham, Y.J.; Lee, H.W.: Big Data Preprocessing Mechanism for Analytics of Mobile Web Log. In: International Journal of Advance Softwared Computing 6 (2014) 1, pp. 1–18.

[Harm99] Harms, V.: Kundendienstmanagement. Dienstleistung, Kundendienst, Service-strukturen und Serviceprodukte; Aufgabenbereiche und Organisation des technischen Kundendienstes. Neue Wirtschaftsbriefe, Herne 1999.

[Hoss13] Hossain, S.A.: NoSQL Database: New Era of Databases for Big data Analytics – Classification, Characteristics and Comparison. In: International Journal of Database Theory and Application 6 (2013) 4, pp. 1–14.

[Kant11] Kantardzic, M.: Data Mining: Concepts, Models, Methods, and Algorithms. Wiley & Sons, 2011.

[KaWa14] Kandalkar, N.A.; Wadhe, A.: Extracting Large Data using Big Data Mining. In: International Journal of Engineering Trends and Technology (IJETT) 9 (2014) 11, pp. 576–582.

[KlTH13] Klein, D.; Tran-Gia, P.; Hartmann, M.: Big Data. In: Informatik-Spektrum 36 (Apr. 2013) 3, pp. 319–323.

[KuWD09] Kuo, Y.F.; Wu, C.M.; Deng, W.J: The relationship among service quality, perceived value, customer satisfaction, and post-purchase intention in mobile value-added services. In: Computers in Human Behaviour 25 (2009) 4, pp. 887–896.

[Lyce13] Lycett, M.: "Datafication": making sense of (big) data in a complex world. In: European Journal of Information Systems 22 (2013), pp. 381–386.

[MCBB11] Manyika, J.; Chui, M.; Brown, B.; Bughin, J.; Dobbs, R.; Roxburgh, C.; Byers, A. H.: Big data: The next frontier for innovation, competition, and productivity, 2011.

[MFÖK13] Matijacic, M.; Fellmann, M.; Özcan, D.; Kammler, F.; Nüttgens, M.; Thomas, O.: Elicitation and Consolidation of Requirements for Mobile Technical Customer Services Support Systems – A Multi-Method Approach. In: Proceedings of the International Conference on Information Systems (ICIS) 2013, 2013.

[ÖFMD13] Özcan, D.; Fellmann, M.; Matijacic, M.; Däuble, G.; Nüttgens, M.; Thomas, O.: Use Case based description of IT-supported customer service processes. In: Proceedings of XXII. International RESER Conference, 2013.

[ÖsSe06] Österle, H.; Senger, E.: Innovative Geschäftskonzepte im After Sales Service. Erfolgreich mit After Sales Services. Springer, Berlin 2006, pp. 37–54.

[PoMi85] Porter, M.E.; Millar, V.E.: How information gives you competitive advantage. In: Harvard Business Review July-Augus (1985).

[RaMB05] Ray, G.; Muhanna, W.A.; Barney, J.B.: Information Technology and the Performance of the Customer Service Process: A Resource-Based Analysis. In: MIS Quarterly 29 (2005) 4, pp. 625–652.

[RSJG12] Rabl, T.; Sadoghi, M.; Jacobsen, H.A.; Gómez-Villamor, S.; Muntés-Mulero, V.; Mankovskii, S.: Solving Big Data Challenges for Enterprise Application Performance Management. In: Proceedings of the VLDB Endowment, Vol. 5, No. 2, 2012, pp. 1724–1735.

[Russ11] Russom, P.: Big Data Analytics, TDWI Best Practices Report. Renton 2011.

[ScLe02] Schultze, U.; Leidner, D.E.: Studying Knowledge Management in Information Systems Research: Discourses and Theoretical Assumptions. In: MIS Quarterly 26 (2002) 3, pp. 213–242.

[Sofi14] Sofianti, T.D.: Framework for Measuring Knowledge Management for Service Development in Industrial Distributor. In: Proceedings of the International MultiConference of Engineers and Computer Scientists (IMECS), 2014, vol. II.

[Stil03] Stille, F.: Produktbegleitende Dienstleistungen gewinnen weiter an Bedeutung. In: Wochenbericht des DIW 21 (2003), pp. 336–344.

[ThWL08a] Thomas, O.; Walter, P.; Loos, P.: Product-Service Systems: Konstruktion und Anwendung einer Entwicklungsmethodik. In: Wirtschaftsinformatik 50 (Jul. 2008) 3, pp. 208–219.

[ThWL08b] Thomas, O.; Walter, P.; Loos, P.: Design and usage of an engineering methodology for product-service systems. In: Journal of Design Research 7 (2008) 2, pp. 177–195.

[TWLN07] Thomas, O.; Walter, P.; Loos, P.; Nüttgens, M.; Schlicker, M.: Mobile Technologies for Efficient Service Processes: A Case Study in the German Machine and Plant Construction Industry. In: Proceedings of the Americas Conference on Information Systems (AMCIS 2007), August 9–12, Keystone, USA, 2007, p. 49.

[Vdma08] VDMA: Entscheidungshilfe zur Einführung von Servicemanagementsystemen. VDMA Verlag, Frankfurt am Main 2008.

[Vdma13] VDMA: Maschinenbau in Zahl und Bild 2013. VDMA Verlag, Frankfurt am Main 2013.

[Walt09] Walter, P.: Modellierung technischer Kundendienstprozesse des Maschinen- und Anlagenbaus als Bestandteil hybrider Produkte. In (Thomas O.; Nüttgens M. eds.): Dienstleistungsmodellierung: Methoden, Werkzeuge und Branchenlösungen. Physica, Heidelberg 2009, pp. 129–145.

[Walt10a] Walter, P.: Technische Kundendienstleistungen: Einordnung, Charakterisierung und Klassifikation. In (Thomas, O.; Loos, P.; Nüttgens M. eds.): Hybride Wertschöpfung. Springer, Berlin 2010, pp. 24–41.

[Walt10b] Walter, P.: Hybride Wertschöpfung durch IT-basierte Integration: Am Beispiel des Technischen Kundendienstes im Bereich komplexer technischer Gebrauchsgüter. Logos, Berlin 2010.

[WaPK95] Watson, R.T.; Pitt, Leyland F.; Kavan, B.C.: Service Quality: A Measure of Information Systems Effectiveness. In: MIS Quarterly 19 (1995) 2, pp. 173–187.

[ZaPG10] Zaslavsky, A.; Perera, C.; Georgakopoulos, D.: Sensing as a Service and Big Data. In: Proceedings of the International Conference on Advances in Cloud Computing (ACC 2012), Bangalore, India.

[ZiLa13] Zilch, A.; Landrock, H.: Big Data – kein neuer Hype, aber eine neue Dimension, Experton-Group, Ismaning, 2013. URL: http://www.experton-group.de/research/ict-news-dach/news/article/big-data-kein-neuer-hype-aber-eine-neue-dimension.html (25. April 2013).