Internet of Things–Related Business Change: A Qualitative Meta-Analysis

Masterarbeit

zur Erlangung des Grades eines Master of Science
im Studiengang Wirtschaftsinformatik

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Abstract

The Internet of Things (IoT) recently developed from the far-away vision of ubiquitous computing into very tangible endeavors in politics and economy, implemented in expensive preparedness programs. Experts predict considerable changes in business models that need to be addressed by organizations in order to respond to competition. Although there is a need to develop strategies for upcoming transformations, organizational change literature did not turn to the specific change related to the new technology yet.

This work aims at investigating IoT-related organizational change by identifying and classifying different change types. It therefore combines the methodological approach of grounded theory with a discussion and classification of identified change informed by a structured literature review of organizational change literature. This includes a meta-analysis of case studies using a qualitative, exploratory coding approach to identify categories of organizational change related to the introduction of IoT. Furthermore a comparison of the identified categories to former technology-related change is provided using the example of Electronic Business (e-business), Enterprise Resource Planning (ERP) systems, and Customer Relationship Management (CRM) systems.

As a main result, this work develops a comprehensive model of IoT-related business change. The model presents two main themes of change indicating that personal smart things will transform businesses by means of using more personal devices, suggesting and scheduling actions of their users, and trying to avoid hazards. At the same time, the availability of information in organizations will further increase to a state where information is available ubiquitously. This will ultimately enable accessing real time information about objects and persons anytime and from any place. As a secondary result, this work gives an overview on concepts of technology-related organizational change in academic literature.

Kurzfassung

Das Internet der Dinge – Internet of Things (IoT) – ist kürzlich der entfernten Vision des Ubiquitous Computing entwachsen und findet nunmehr konkret Eingang in Politik und Wirtschaft, welches sich in aufwendigen Förderprogrammen äußert. Unternehmen sehen sich mit dem von Experten vorhergesagten, gravierenden Wandel von Geschäftsmodellen konfrontiert und müssen darauf reagieren, um im Wettbewerb bestehen zu können. Obgleich daher ein Bedarf zur Strategieentwicklung bezüglich der kommenden Veränderungen in Unternehmen besteht, ist das Thema des organisationsbezogenen Wandels in Hinblick auf die neue Technologie in der akademischen Diskussion derzeit noch wenig präsent.

Die vorliegende Arbeit erforscht IoT-verknüpften Wandel in Unternehmen, indem sie unterschiedliche Arten des Wandels identifiziert und klassifiziert. Sie kombiniert zu diesem Zweck den methodischen Ansatz der gegenstandsbezogenen Theoriebildung (Grounded Theory) mit einer Diskussion und Klassifikation von identifizierten Veränderungen vor dem Hintergrund eines strukturierten Literaturüberblicks im Bereich des Wandels in Organisationen. Diesbezüglich erfolgt eine Meta-Analyse von Fallstudien mittels einer qualitativ-explorativen Kodierungs-Methode zur Identifizierung von Kategorien des organisationsbezogenen Wandels, welcher mit der Einführung von IoT in Verbindung steht. Darüber hinaus wird eine Gegenüberstellung der identifizierten Kategorien mit vorherigem technologie-verknüpftem Wandel am Beispiel von Electronic Business (e-business), Enterprise Resource Planning (ERP)-Systemen und Customer Relationship Management (CRM)-Systemen durchgeführt.

Den Hauptbeitrag dieser Arbeit stellt die Entwicklung eines umfassenden Modells von organisationsbezogenem Wandel bezüglich IoT dar. Das Modell präsentiert zwei Hauptthemen des Wandels, welche nahe legen, dass persönliche, intelligente Objekte Unternehmen dadurch verändern werden, dass vermehrt personen-gebundene, mobile Geräte zum Einsatz kommen. Objekte schlagen ihren Nutzern Tätigkeiten oder den gesamten Arbeitsablauf vor und versuchen gefährliche Situationen zu vermeiden. Gleichzeitig wird die Verfügbarkeit von Informationen im Unternehmen bis zur ubiquitären Präsenz steigen. Dies wird es letztlich ermöglichen, Informationen bezüglich Objekten und Personen jederzeit und an jedem Ort zu nutzen. Als Nebenergebnis gibt die vorliegende Arbeit einen Überblick über Konzepte der wissenschaftlichen Literatur im Bereich technologie-verknüpften Wandels in Organisationen.

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Glossary

BPR	Business Process Redesign
CRM	Customer Relationship Management
e-business	Electronic Business
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
GPS	Global Positioning System
IoT	Internet of Things
IS	Information Systems
IT	Information Technology
RFID	Radio-Frequency Identification
RO	Research Objective
ROs	Research Objectives
RQ	Research Question
RQs	Research Questions

1 Introduction

This first chapter presents the status quo of the topic area, a problem statement, and the motivation for this research. It outlines how the research process itself as well as this work is structured and finally gives an overview over the content of this work.

1.1 Problem Statement

The Internet of Things (IoT) is promoting the seamless integration of physical objects into information networks (Haller et al. 2009). It gained popularity in academic research as well as in practice during the last decade (Fleisch et al. 2009), resulting in over a hundred publications on the topic (Whitmore et al. 2015). Very recently, IoT developed from the far-away vision of finally realizing the *ubiquitous computing* concept of Weiser (1991) into very tangible endeavors. Significant political actors like the United States, Korea or the European Union now are investing large amounts into research and the promotion of IoT in order to maintain their "preparedness for IoT" in the international race (Muralidharan et al. 2016). At the same time, "IoT technologies are at their infant stages" (Li et al. 2015, p. 243) and cannot be considered to be commercial off-the-shelf products yet.

In this unsteady, evolving situation organizations are trying to evaluate the adoption of the new technology. For instance, every second German company is already claiming to use IoT technology to some extend (BMWi 2016, p. 77). This implies that a great amount of companies is currently figuring out how to take advantage of IoT. Following the argumentation of Fleisch (2010), organizations that are confronted with new technology first need to ask themselves, whether the new tool is useful to them and where the organization could utilize it. They need to find out which kind of problems can be addresses by the usage of the new technology in their organization, their products, and their services. Furthermore academic publications are predicting considerable changes in companies' business models (Fleisch et al. 2015). These changes need to be addressed by traditional companies in order to respond to competition in the near future. Therefore companies need to engage in investigating how the IoT will change their company, i.e. find out which changes are inevitable and which changes can be steered.

In an analysis of recent IoT development initiatives in Korea, Shin (2014) advocates that more attention should be payed to socio-technical inquiries regarding IoT, i.e. reflecting on the technology on a conceptual level rather than merely focusing on building a smart environment. He argues that "building the IoT" is a misleading term used in the public discussion, as it implies that an infrastructure could be built in a controlled and fully directed manner. In his opinion, this assumption cannot be proven from a historic review. Shin (2014) states that there are still socio-technical challenges to overcome in order to enable the further development of the IoT on a national basis. He recommends that future research should try to "explain technological change, that is, how technological change occurs, and how a new technology is evolved" (Shin 2014, p. 529). The author is embedding this recommendation into a call for an integrated research perspective on IoT, i.e. one that is paying regard to the interactions of the different socio-technical components.

Implicitly, this suggestion is drawing on a branch of Information Systems (IS) research that is concerned with investigating the interrelation of organizational change and technological change. Research has been conducted in that subject area for at least sixty years now (Markus and Robey 1988). Starting from researching the organizational effects related to the company-wide usage of Information Technology (IT) in general (Leavitt and Whisler 1958), the field evolved further. The introduction of new technology to organizations also resulted in new, specific research on the topic. Often, in a two-sided approach, publications like the work of Ash and Burn (2003) are giving implications for practitioners, i.e. companies, as well as for research.

This kind of research is still missing for IoT technology as of now. Current academic publications on IoT are heavily focused on the technology itself (Whitmore et al. 2015). They deal with hardware, software, and architectural issues, applications of IoT, or challenges like privacy. Still, they do not take a comprehensive, integral view on the interrelation of technological and organizational change as required by Shin (2014). Notable exceptions are rare, like the work of Bremer (2015) on the changes that IoT brings about in logistics regarding man-machine interaction.

The early state of the IoT technology poses a strong challenge on research in this area. As companies are still figuring out, how to adopt IoT technology in their organization, examples of companies that are productively using the technology might be hard to find. Still, Shin (2014) advises that technology should not be analyzed as a black box as this approach omits to investigate the interrelation of socio-technical components. Therefore he suggests to base research on examples from case studies on the development and use of IoT solutions "to illustrate the conceptualization of the IoT" (Shin 2014, p. 530).

This work aims at filling the gap in research literature that exists regarding the organizational implications of IoT. It is focusing on organizational change that happens in relation to IoT technology and proposes to give insights on the interrelation of technological characteristics and organizational change. The work combines the methodological approach of grounded theory with a structured literature research on organizational change literature. In doing so, it takes up the idea of Shin (2014) to explain technological change by means of analyzing empirical case studies. In order to be useful to practitioners as well as researchers it aims at deriving a classification of organizational change related to IoT. Providing this analytical tool shall serve the purpose of fostering further academic discussion on the topic as well as give hints to organizations and society on what change to expect from IoT. The intended classification is therefore also a first step in systematically establishing the preparedness for IoT that political actors are trying to achieve.

1.2 Research Aim, Objectives, and Questions

The aim of this research is to investigate IoT-related organizational change by identifying and classifying different change types. This research aim can be split up into three major research steps, which are reflected in three Research Objectives (ROs) that have been formulated accordingly. The objectives have been furthermore split up into Research Questions (RQs) to structure the research process. The three objectives of this research are to identify concepts of business change in general, to investigate how businesses change when IoT is introduced, and to visualize business change that has been found during this work. An illustration of the objectives, data sources, and expected research outcomes is depicted in figure 1.1 and will be explained in the following. A description of the overall research design including the research methods used to achieve the ROs will be presented in chapter 2.

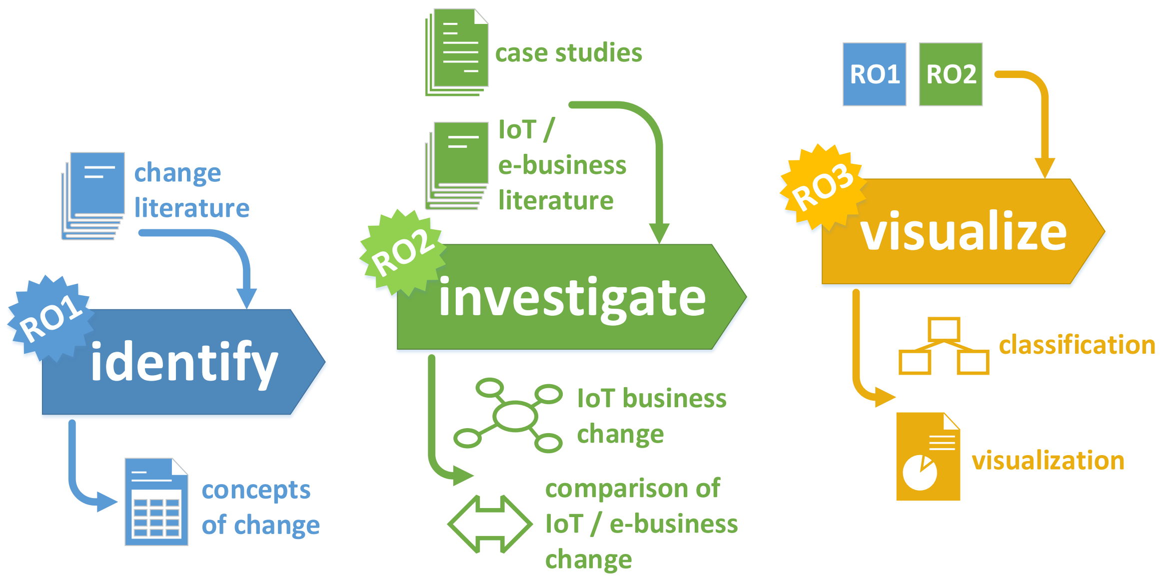

Figure 1.1 Visualization of research objectives, data sources, and research outcomes (own illustration)

As mentioned in the problem statement of chapter 1.1, research on the interrelation of IS and organizations has been going on for some decades already. A body of academic theories pertaining organizational change and technology has been published. Therefore it seems reasonable to profit from this collection of research outcomes while researching current change in the field of IoT. The first Research Objective (RO) aims at creating a collection of theoretical concepts to inform the further research process and for later reference in the course of this work. It will be specifically helpful to interpret the phenomena discovered during the investigation of IoT-related changes in a historical context. In doing so it will enable comparisons between current and past changes and furthermore provide this work with the research background of the topic area of organizational change and technology research.

Research Objective

RO1 Identify concepts of technology-related change in business context.

In order to reach this objective, organizational change literature needs to be reviewed for concepts of technology-related change. A collection of such concepts should be produced as an outcome of this research step. The first Research Question (RQ) accordingly leads to a respective literature review which summarizes the concepts found.

Research Question

RQ1 What concepts of change do exist regarding the introduction of new technology in business context?

The main matter of this work is to identify what change types the introduction of IoT might cause in a business context. To shift the focus of research in the direction of transformations happening in practice, another data source is added in this second research step through the analysis of case studies. Although the collection of concepts gained during RO1 might help with establishing a terminology to describe the phenomena discovered, keeping an unbiased view as far as possible is essential for two reasons. First, it is important to discover transformations that have not been happening before and are therefore not reflected within the research literature so far. In order to achieve this goal, an exploratory research design will be used as opposed to a pre-defined analytical scheme as will be explained in chapter 2. Furthermore conceptions from theory and real-world examples from practice should be equally considered in order to identify IoT-related characteristics in change observed. Abstract terms from literature might be described more specifically in the real-world case studies. In order to contribute to the overall aim of this research, identified changes should be linked to IoT capabilities as well as findings of research on previous technology waves, e.g. the introduction of e-business. That way similarities and differences can be identified. Furthermore changes can be evaluated in the sense of whether they are specific to IoT or just generally valid for any kind of technology introduction. An in-depth investigation of change happening is the subject of research for the second RO.

Research Objective

RO2 Investigate how businesses change when IoT is introduced.

In a first exploratory step, changes need to be identified based on observations regarding IoT solutions that are used or could be used in a business environment. RQ2a is focusing on this intention. Case studies will be used as a data source to shift the focus from merely theoretical suggestions to observations from practice.

Research Question

RQ2a What types of business change can be observed when IoT is introduced?

In order to identify what contribution the use of IoT makes regarding the observed changes, those changes should be put in relation to key characteristics of the technology. This might give an insight into the degree that these changes can be attributed to the newly introduced technology. RQ2b leads to such considerations.

Research Question

RQ2b How does this business change relate to key characteristics of IoT?

Another question while investigating technology-enabled change is the one of novelty. It should be argued whether the observed changes are a new phenomenon or if they have been present already during former technology introductions. RQ2c therefore implies a comparison with former technologies, e.g. e-business, for which academic research on change has already been conducted.

Research Question

RQ2c How is change related to IoT different from former technology-related changes?

After investigating change related to the introduction of IoT, it should be sorted into a comprehensive model, which should also be represented graphically. This serves the purpose of reducing the observations made to the main aspects in order to make them more accessible to researchers and practitioners alike, e.g. highlight the key themes that organizations should pay attention to in their IoT-based transformation projects. Furthermore this summarizing step is also necessary to gain a whole picture out of the different partial phenomena observed. Both steps are contained in the third RO, which will conclude this work.

Research Objective

RO3 Develop a model to visualize business change related to the introduction of IoT.

RQ3a and RQ3b accordingly focus on achieving this main goal of a visualization based on a classification of change. The classification step might employ ideas from the collection of theoretical concepts created during RO1 as an inspiration.

Research Question

RQ3a How can business change related to IoT be classified?

Research Question

RQ3b How can business change related to IoT be visualized?

1.3 Outline

This work is divided into seven chapters, following the conceptual and chronological structure of the research work. They are presented in the following, along with a short summary of the topics covered by the respective chapter. Chapter 1 at first introduces the topic area of IoT to the reader and presents a problem statement. Subsequently, it displays the research aim, objectives and questions of this work and – in this section – gives an outline of the work's structure. Chapter 2 gives insights into the research methodology and research methods of this work. It furthermore provides the reader with a statement on the scope and basic theory of the work, followed by a description of the sources and collection methods of data used. Chapter 3 compares three different approaches to define the term Internet of Things (IoT) and synthesizes an own collection of IoT characteristics, which is used within this research work. Chapter 4 identifies concepts of technology-related change in business context by means of a literature review of publications from organizational change literature. It presents an overview on the concepts along with a summary of the historical development of this stream of academic literature. Finally, it presents organizational change related to e-business, Enterprise Resource Planning (ERP) systems, and Customer Relationship Management (CRM) systems as an example of technology-related change. Chapter 5 investigates business change related to IoT by means of a case study meta-analysis. After presenting a strategy for search and selection of case studies, the method of analysis is explained in detail. Subsequently, the results of the analysis are presented in the form of categories of identified changes. In the last section of the chapter the identified change categories are discussed regarding their relation to IoT characteristics and former technology-related change. In chapter 6 a classification and a visualization of the investigated IoT-related business change is developed. The classification picks up on the change categories identified in the chapter before and generalizes them to more abstract themes of change. The subsequent visualization presents a comprehensive model of the main findings of the work. Chapter 7 finally provides the reader with a summary of the overall research work, the research findings, limitations, and gives an outlook on future research.

2 Research Design

This chapter gives an overview on the research design which supports achieving the research aim and objectives formulated during chapter 1.2. At first, *grounded theory* is introduced as the research methodology which is used as a foundation of this work. Following this, the analytical research methods that will be applied on the data are presented. Afterwards the scope of this work and the utilization of a basic theory will be explained. A section on the sources, methods and timing of data collection concludes this chapter.

2.1 Research Methodology

«Grounded theory serves as a way to learn about the worlds we study and a method for developing theories to understand them.»
— Charmaz (2006, p. 10)

After formulating the research aims and objectives of this work, the research methodology should be defined, i.e. "the strategy, plan of action, process or design lying behind the choice and use of particular methods" (Crotty 1998, p. 3). During the preliminary considerations it soon became apparent that the research method of *qualitative coding* can be used to explore and analyze case study data for changes brought about by the introduction of IoT technology. Qualitative coding allows for searching for patterns in narrative, possibly unstructured data (Saldaña 2009, p. 8) like interviews or – in this case – case study data. This research method will be presented in more detail during the course of the next section 2.2. For this work, the coding approach will be used to develop a theory regarding organizational change by analyzing case study data. While thinking about which methodology would fit the process of coding, employing strategies from *grounded theory* seemed natural. For one thing, qualitative coding is a research method typically used in grounded theory research (Charmaz 2006, p. 3). More importantly, the methodology fits the research aim as it enables learning about a certain topic which is possibly unknown to the researcher before – in this case the organizational change of IoT – and likewise the development of a theory, which would be the emerging classification of change.

The methodology is rather explorative as it is "developing theories from research grounded in data" (Charmaz 2006, p. 4) as opposed to methodologies that are deducing new insights from existing theories. This seemed appropriate for the research endeavor of this work as little is known so far about the organizational effects and consequences of IoT introduction. In exploring the data, this work will follow an inductive approach from the tangible to the more theoretical. It will start with simple, isolated observations on IoT usage in practice and proceed by weaving these pieces to a more comprehensive picture of change.

There is however not only one single way of conducting grounded theory research, rather researchers can chose from a set of strategies, which they may use to their own discretion. This flexible approach has already been propagated by the original authors of the method, Barney G. Glaser and Anselm L. Strauss (Charmaz 2006, p. 9). Researchers may as well "only [acknowledge] specific aspects of the approach" (Charmaz 2006, p. 9) and still produce qualitative studies. The classical grounded theory approach is performed circularly which involves reexamination of earlier data or obtaining of new data at certain times during the analysis in order to fill gaps or refine emerging theory (Charmaz 2006, p. 12). Such a typical research process is depicted in figure 2.1. Starting from a research problem and research questions, phases of coding and memo writing are passed. There are typically two coding phases used in grounded theory research, one of *initial coding* and one of *focused coding* – two different coding methods which are described in more detail in the next section 2.2. Right from the beginning and also during the whole process the observations and thoughts of the researcher are written down in so-called *analytic memos*. These memos are used to foster understanding of the data in a kind of conversation of the researcher with him- or herself. As the analysis progresses, the codes develop from simple first thoughts to tentative categories, conceptual categories, and theoretical concepts. This process is supported and documented by writing analytic memos. Later on, the memos are integrated and presented visually. The first draft of the final document is constructed from the stack of memos and diagrams produced. Also this stage of writing is still part of the circle. That way the whole process of theorizing and constant data analysis "extends into the writing and rewriting stages" (Charmaz 2006, p. 154).

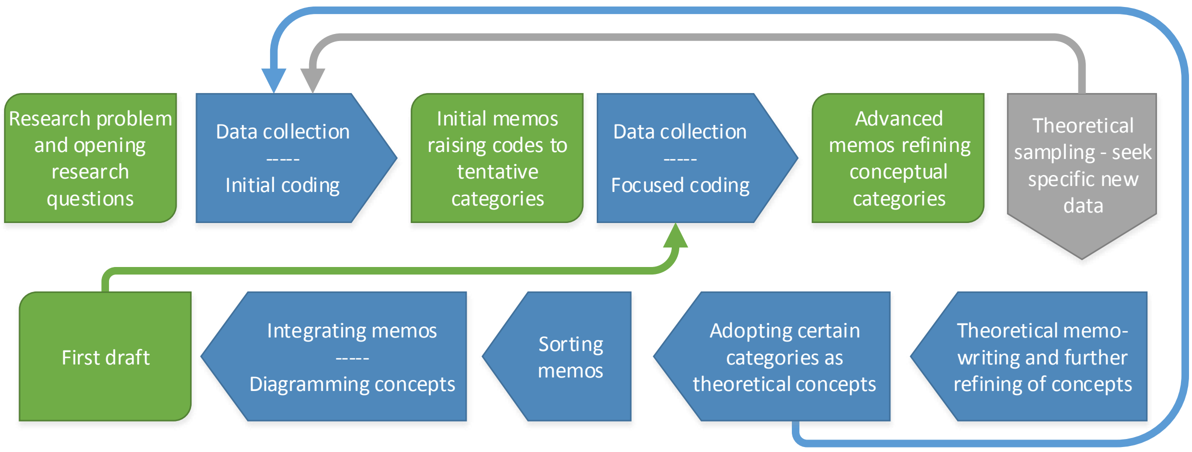

Figure 2.1 Typical grounded theory research process (adapted from Charmaz (2006, p. 11))

The arrows in the figure show that at certain points in the process earlier data will be reexamined in order to gain new insights or refine emerging categories. Although this work will follow the circular approach in analysis, it is not possible to obtain new research data at all times during the research process due to limitations in the data collection process. This limitation will be addressed in more detail in section 2.4. One process step, depicted in gray in the figure, is therefore omitted within this work: The theoretical sampling of new data based on the conceptual categories developed so far.

The usage of grounded theory within this work is guided through literature, still "the finished work is a construction" (Charmaz 2006, p. xi) based on the data gained, but processed and interpreted in a subjective way. This research employs ideas from Charmaz (2006) who assumes that theory is constructed through all the involvement and interactions the researcher has experienced so far with people, their perspectives and the practice of research. It is only naturally that other researchers might come to different conclusions based on their interpretation of the same data. The result is an "interpretive portrayal of the studied world, not an exact picture of it" (Charmaz 2006, p. 10). Additionally the theory constructed might be challenged by new insights derived from different data. In order to make the research process transparent to the reader, this work is reporting about analytical decisions during the process when possible, e.g. about decisions made while coding the case studies in chapter 5.2.

It is disputed among grounded theorists when to perform a literature review of other researchers' publications (Charmaz 2006, p. 165). The original methodology of Glaser and Strauss suggests to postpone the literature review until the own analysis of data has been completed in order to avoid "[forcing] data in pre-existing categories" (Charmaz 2006, p. 165). Their approach has been both rejected as naive and adopted as visionary within the research community. Charmaz (2006) suggests to treat existing theory as somewhat problematic and work critically with earlier research. Still she acknowledges "that researchers hold prior ideas and skills" (Charmaz 2006, p. 48). This kind of critical appraisal for former theory will also be used in the course of this work. A literature review will be performed upfront to achieve RO1. RO2 and RO3 will then follow the grounded theory process described above. In this step it is crucial to pay attention to phenomena that have not been covered yet in literature or that do not fit existing theory. As there is no possibility to start with a completely unbiased mind, it should be "acknowledge[d] that preexisting theories [might] drive the entire research enterprise" (Saldaña 2009, p. 12). Nevertheless, no explicit basic theory will be chosen for data analysis as will also be explained below in section 2.3. Instead the analysis will be performed open-ended. This kind of separation is also recommended by Charmaz (2006) as "preconceived theoretical concepts may provide starting points for looking at [...] data, but they do not offer automatic codes for analyzing these data" (Charmaz 2006, p. 68). Insights from RO1 will later be weaved into the analysis done during the grounded theory process to compare change related to the introduction of IoT and by other technologies and to develop a classification of change.

2.2 Research Methods

One popular method to study data in grounded theory is the one of qualitative coding. It is the act of attaching a summative attribute, often a word or phrase, to a portion of data in order to depict what the segment is about (Charmaz 2006; Saldaña 2009). This summative attribute is called a *code*. The codes can be attached to single words, whole sentences, or complete paragraphs, depending on the coding approach of the researcher. Coding serves multiple purposes (Charmaz 2006, p. 3). It reduces and summarizes data in terms of amount and also structures and sorts it through building categories. It furthermore enables comparisons of different segments of data.

The following excerpt from a case study of Lee et al. (2016) describes the situation of commonly used laundry machines in place at a dormitory before the introduction of an IoT solution and that way implicitly gives insights on what improvements will be made through the new technology. The coded excerpt is an example for the coding approach used within this work. The codes on the right margin reflect the possible improvements as an indicator of change that has happened through IoT introduction.

As examples of [1]inefficient waiting time, [2]a current active user (a user in use) who was waiting the completion of his/her laundry showed frequent movements between his/her room to	[1]USING MORE EFFICIENTLY [2]REDUCING HUMAN MOVEMENT
the laundry machine to [3]check the completion or spent meaningless time near the machine because	[3]SAVING TIME
[4]there is not a substantial way to monitor current status of washing or drying from the machine in own room. Other users who are waiting his/her turn for use of the machine also had to frequently check the completion of current use by physical movements between rooms.	[4]RETRIEVING STATUS INFORMATION REMOTELY

There are several coding methods, e.g. Saldaña (2009) lists over twenty methods. They mostly differ in what gets coded and how codes are constructed. One characteristic of grounded theory coding, and as well of qualitative coding in the sense of Saldaña (2009) in general, is that categories or codes are not defined upfront but are created during the analysis of the data (Charmaz 2006, p. 46). Two coding methods are especially prominent in grounded theory building: *initial coding*, sometimes also referred to as *open coding*, and *focused coding*.

Initial coding is done to get a first grasp of the themes and structure of the data. It is usually performed in a detailed way "naming each word, line, or segment of data" (Charmaz 2006, p. 46). In grounded theory research, initial coding forms the starting point of the analysis. Its purpose is to identify ideas that should be investigated in more detail during later analytical research steps. The researcher at this stage should be open to whatever theoretical direction might emerge from the data and to follow up on these emerging ideas. Charmaz (2006, p. 47) suggests to use codes to focus on identifying actions that can be seen in the data rather than trying to match preexisting categories with the data. This can be e.g. enforced through the use of gerunds as codes instead of nouns.

Focused coding is done after an initial overview of the data has been achieved. It is then used for reexamining "the most significant or frequent initial codes to sort, synthesize, integrate, and organize large amount of data" (Charmaz 2006, p. 46). In doing so, focused coding represents the beginning of theoretical integration that goes on in further steps reducing data to increasingly abstract categories and theory. In grounded theory coding however this process is not linear but rather cyclic as mentioned in the grounded theory process depicted in section 2.1 above.

Another important method in grounded theory research besides coding is writing analytic memos. It is "the pivotal intermediate step" (Charmaz 2006, p. 72) that links data collection through coding and academic writing. Memo-writing means stopping the coding process and thinking about codes, elaborating ideas that are evolving, and writing them down in the form of "conversing with yourself" (Charmaz 2006, p. 72). They employ an "informal, unofficial language for personal use" (Charmaz 2006, p. 80) which is usually not intended for being published but rather to involve analytical thinking early in the process and increases the level of abstraction (Charmaz 2006, p. 72). In doing so, memos often do not capture the exact meaning at the first try as they result from a spontaneous action. This is intended and part of the cyclic process in which memos can be revised several times and rewritten later (Charmaz 2006, p. 80). Memos can also give hints on which directions to pursue next while collecting and analyzing data (Charmaz 2006, p. 72). This could lead the researcher to further data collection or revision of preliminary results. Advanced memos might discuss formerly found (sub-)categories in relation to each other, e.g. make comparisons or ask "where does it fit into the course of [the category]" (Charmaz 2006, p. 81).

The example below shows a short analytic memo which has been written by the author of this work during the initial coding phase of the case studies. As such it is rather brief and does not elaborate on advanced categories. It however depicts how already in this early phase of data collection preliminary analytical ideas evolve that can be grasped in a memo for later reexamination. In this case the two initial codes MONITORING and REDUCING HUMAN MOVEMENT are linked with each other and an outlook on some emerging idea is given.

Topic: MONITORING and REDUCING HUMAN MOVEMENT

In the laundry case a MONITORING system is used in order to REDUCE unnecessary and annoying HUMAN MOVEMENT for CHECKING the STATUS of a device, in this case a SHARED DEVICE. This seems to be typical for scenarios like these and fits my theory that IoT is often used as a prolonged nervous system to ENHANCE HUMAN PERCEPTION in order to SENSE their ENVIRONMENT.

2.3 Scope and Basic Theory

To achieve the aim of this work an explorative, qualitative meta-analysis of case studies is to be conducted. It will employ methods of qualitative coding to construct categories of change based on the data displayed in the studies and then elaborate them as far as possible to develop a classification of change. The meta-analysis will be preceded by a literature review of organizational change literature, which will focus on identifying existing concepts of change regarding technology introduction to organizations.

The upfront choice of a basic theory has been omitted for two reasons: Firstly, the grounded theory methodology strongly advises against basing one's research on an already established theory as its primary goal is to generate new theory that is only grounded within the data. Secondly, a review of existing theory about the topic of organizational change that is enabled by technology is performed in the first research step of this work to fulfill RO1. This review is however conducted open-ended and as neutral as possible, so no single theory could have been chosen as a basic theory for this work upfront. The literature review presented in chapter 4 might still inform the further research process as "lines often blur between a literature review and a theoretical framework" (Charmaz 2006, p. 163). In order to avoid overly biased interpretation of the data so it would match the basic theory, non of the theories presented during the review is elected as a basic theory for this work.

2.4 Data Sources and Data Collection

As grounded theory is built up most entirely from the data being used, the selection of high-quality data is a crucial step in the research process. Often grounded theorists would collect their data themselves and that way be able to influence data quality. However, collecting own case study data from a reasonable number of settings would not have been possible for the author of this work. For once, performing such endeavors might take years for data collection alone. Furthermore the IoT community is scattered around the globe which would have also required a significant amount of traveling to reach spots where organizational transformations are taking place right now.

In order to still conduct research that addresses the aim of this thesis, secondary case study data will be used. There are several thousands of case studies available for free on the web[1] as well as some academic case studies. One limitation resulting from the use of these sources is the lack of control on data quality that will arise by using other authors' work. The case studies might not focus on the same questions and will present different granularity in answering those questions. Furthermore especially case studies that are available for free from companies are not peer-reviewed in an academic sense and might rather serve the purpose of advertisement for commercial products. The differing foci do not have a great effect on the qualitative and exploratory research process of this work. As the data analysis is done in a qualitative way, not all studies have to report about the same aspects. A single occurrence of an aspect might be as valuable as one that is occurring several times. On the contrary the exploratory analysis may profit from differing perspectives on the object of study in order to create a rich picture of the heterogeneous sites that research has been conducted on.

As a means to maintain a certain data quality and as a means to also gain reliable research results, a list of criteria has been formulated. Selected case studies should provide a specific business scenario and not only be built up on a pure technical description of an IoT solution. Furthermore they should describe the scenario in more detail and not only name it. The original criteria list is depicted in section 5.1. Only case studies that fulfill these criteria have been used for analysis within this work. A similar approach has been used to select the publications used for the literature review that is part of RO1. The search and selection procedure for the literature used for RO1 is presented in section 4.1. The selected publications form the research data for the literature review presented in chapter 4.

As a consequence of the data collection method for case study data, no follow-up questions could be posed to the interviewees and no follow-up research could be done on the sites that were used by the original authors to conduct their research. This limitation pertains the gathering of new data based on earlier analytical results that is usually propagated by the original grounded theory process as presented above in section 2.1. With this in mind the results of this research work can only be a first step into understanding IoT-related changes within organizations and will need follow-up research to either confirm or correct the discoveries made within this work.

[1] e.g. a web search on Bing (`http://www.bing.com`) for the keyword "internet of things case study" on September 4th, 2017 listed 490.000 results

3 The Internet of Things

The term IoT comprises the vision of physical objects being connected to a virtual world (Mattern and Floerkemeier 2010). These objects are also called *smart things* (Fleisch 2010) or *smart objects* (Kortuem et al. 2010) due to the fact that they can act in a smarter way than usual objects. Acting smarter means that they enable interaction with other objects, users of the object, or its surroundings by embedding additional capabilities like means for identification, sensing, or networking into the object. This includes the capabilities to remotely control these objects and vice versa for objects to access information from the virtual world (Mattern and Floerkemeier 2010). The idea is closely related to the concept of *ubiquitous computing*, which has been introduced by Weiser (1991). It comprises that rather than simulating a virtual reality, the real world should be invisibly enhanced by technology. Users should be freed from thinking about technology while using it and that way being able to focus on new goals. The concept of the IoT is still blurry when it comes to how to achieve the vision in general (Kortuem et al. 2010), e.g. it is not agreed upon whether computing capabilities need to be an essential part of every smart thing (Fleisch 2010). As a consequence several research publications deal with defining more precise definitions of the topic area.

Mattern and Floerkemeier (2010) name two distinctive features of IoT, namely *digitally upgrading* conventional objects, which means adding digital capabilities, and *collecting up-to-date information*, which means that the state of objects can be observed remotely. Furthermore, the authors mention that the contribution of IoT is not established by a single technology. Instead it is the combination of several capabilities which defines IoT from a technical perspective. These capabilities are (Mattern and Floerkemeier 2010, p. 244):

- **Communication and cooperation** through wireless technology
- **Addressability** to remotely interrogate or configure objects
- **Identification** that is unique for every object
- **Sensing** of surroundings through sensors
- **Actuation** to manipulate the environment
- **Embedded information processing** using processors or microcontrollers
- **Localization** to make objects aware of their physical position
- **User interfaces** of objects to communicate with humans

The authors state that most applications would only implement a subset of these capabilities, due to cost limitations and needed effort for implementation. Therefore they do not define an exact definition of what IoT is and what it is not. Their perspective on the topic features a rather incremental approach: Surely objects that become smarter through imprinted barcodes or Radio-Frequency Identification (RFID) tags are not participating in a network of smart objects themselves. Still Mattern and Floerkemeier (2010) interpret these solutions as the first step in an evolution of smart objects.

According to Kortuem et al. (2010) the goal of the IoT development should be things that are "autonomous physical/digital objects augmented with sensing, processing, and network capabilities" (Kortuem et al. 2010, p. 30). In order to rate the progress in achieving this goal, the authors introduce a three-step typology for smart objects:

- **Activity-aware objects** are the basic category of the typology and can detect use and handling of themselves. They do not interact with other objects, but rather just record or aggregate information over time. An example would be pay-per-use objects that record their usage for later billing.
- **Policy-aware objects** are the next step in the typology and feature the additional capability to process sensed data, e.g. matching it with sets of rules that have been stored on the object. It may interact with humans or other objects to provide context-sensitive information. An example would be warnings for users if the object is used in an non-intended manner.
- **Process-aware objects** add the capability of process understanding to the former capabilities. The object can give suggestions about work activities to users based on a process model that allows for such inference.

Atzori et al. (2010) hold the view that there is no single vision of IoT and attribute the blurriness of the IoT field to that fact. Instead the authors distinguish three different perspectives that feature specific aspects of the whole. They state that none of these perspectives alone can define the term, rather "the IoT paradigm shall be the result of the convergence of the three main visions addressed" (Atzori et al. 2010, p. 2788):

- The **Things-oriented perspective** focuses on the objects that are part of the IoT. It comprises traditionally mostly simple items, e.g. RFID tags. The goal of these solutions has been to improve object visibility, i.e. knowing the status of the object, its location and the ability to constantly record this information. From the authors' examples it becomes clear that there is a focus on hardware technology within this perspective.
- The **Internet-oriented perspective** focuses on the networking aspect, i.e. by which means the objects participating in the IoT should be enabled to communicate. According to the authors, the most discussions within this perspective deal with networking protocols and networking standards.
- The **Semantic-oriented perspective** assumes that due to a large number of devices, information processing will become very challenging. This perspective accordingly focuses on representation, storage, interconnection, search, and organization of information within the IoT utilizing semantic technologies.

In comparison it becomes clear that the approach of Atzori et al. (2010) is the most extensive one among the three presented. The works of Kortuem et al. (2010) and Mattern and Floerkemeier (2010) are examples for publications that employ partial visions of the IoT, which is visualized in figure 3.1. Both feature rather things-oriented perspectives enhanced with parts of networking and semantic aspects.

The approach of Atzori et al. (2010) seems to be most comprehensive as it is able to classify parts of more narrow definitions. It is depicted in the center of the figure in blue color. The approach does not only include characteristics of smart objects like the approaches of Kortuem et al. (2010) or Mattern and Floerkemeier (2010) but also includes the whole ecosystem of IoT like external storage of information generated by things or networking with the smart environment.

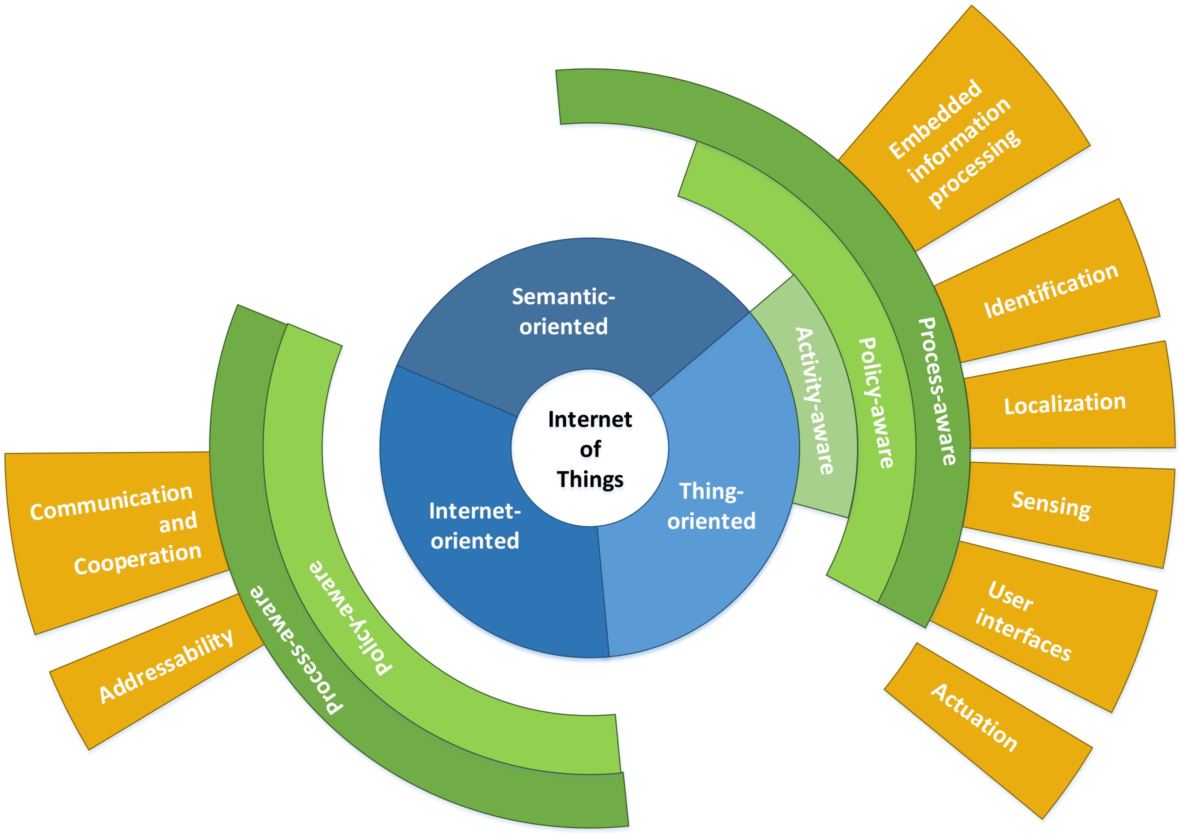

Figure 3.1 Visual comparison of IoT definitions (own illustration)

The approach of Kortuem et al. (2010) is presenting three stages of smart object development. It is depicted in the second level of the figure in green color. The overlap of circles roughly represents the overlap of definitions. For instance, the activity-aware object definition comprises parts of the thing-oriented vision. Furthermore it comprises parts of the IoT capabilities definitions of Mattern and Floerkemeier (2010), namely parts of embedded information processing, identification, localization, and sensing. It is specifically remarkable that none of the definitions of Kortuem et al. (2010) includes the idea of actuation at all in their typology of smart objects.

The capabilities list of Mattern and Floerkemeier (2010) is defining detailed features of IoT objects. The single items of the list are depicted in the outermost ring of the figure in yellow color. It is however also lacking precision especially in the semantic perspective as it comprises mostly things-oriented capabilities. Still, the capability of embedded information processing is overlapping with the semantic-oriented vision. Furthermore, the capabilities of addressability and communication and cooperation can be located in the internet-oriented vision.

In order to work on the topic of IoT for this research it is necessary to decide upon which vision of the term should be used to define IoT. Furthermore the characteristics of IoT will be later used in chapter 5.4 to relate them to change identified in the IoT case studies. As a basis for this work, the three perspectives on IoT visions of Atzori et al. (2010) will be used. This more general definition of IoT will allow for covering narrow definitions that focus only on specific aspects of IoT. Compared to the capabilities list of Mattern and Floerkemeier (2010), the three perspectives lack precision when it comes to characteristics of IoT. In order to preserve gain more precision in this work, the capabilities list will be used in combination with the three perspectives to define characteristics of IoT.

4 Concepts of Technology-Related Change in Business Context

Since the introduction of computer technology to businesses, researchers address the impact that technology has on organizations. As IoT is one very recent wave of technology introduction to businesses, prior theoretical models of technology-related change may form a basis for the analysis of currently happening change in businesses. Prior models will also support the comparison of changes caused by former technology waves and the ones caused by IoT. This chapter summarizes the main concepts of organizational change caused by technology introduction in section 4.2. Afterwards a short overview of the historical development of the topic area is given in section 4.3. In order to gain these results, publications from two online databases have been selected by keyword search and abstract. Theoretical concepts have been identified and grouped during a subsequent literature review. Section 4.1 contains a detailed description of this work.

4.1 Search and Selection of Publications

In order to give a comprehensive overview regarding concepts of organizational change and technology introduction, a structured literature search has been performed in January 2017. The publication databases Springer Link[1] and Google Scholar[2] have been searched for the keywords "business change technology" and the local university library of Koblenz for the German equivalent "unternehmen wandel technologie". Another search term – "change role of technology" – emerged from Galliers and Baets (1998) and has also been used for searching both online publication databases. For the online publication databases, the first 20 to 40 search results have been considered for each search term. The library database contained only 20 matches with the search term, all of which have been considered. In sum, out of the 150 search results, 19 have been selected by abstract. The respective publications would have been selected if the abstract had indicated that the article would deal with the relation of organizational change and technology. Six additional publications have been selected by backward citation search (Hammer 1990; Drucker 1988; Kraut et al. 1989; Turner 1984; Orlikowski and Iacono 2001; Leavitt and Whisler 1958) because they have been found relevant to the research question during analysis of the publications referring to them. Six publications have been rejected during analysis because they did not match the research question which has not been clear from their abstract before. As a result, a total of 19 publications have been reviewed for concepts of organizational change when introducing technology. An overview of the search terms and respective results can also be found in table 4.1. During analysis of the publications, "organizational change and technology" emerged as the central term for the topic area.

[1]Springer Link: `http://link.springer.com/`
[2]Google Scholar: `https://scholar.google.com/`

Table 4.1 Search Terms and Results of Literature Search

Search Term	Database	Results Considered	Selected
business change technology	Google Scholar	30	4
	Springer Link	40	5
unternehmen wandel technologie	university library	20	2
change role of technology	Google Scholar	20	5
	Springer Link	40	3

4.2 Identified Concepts

Twenty-four concepts of technology-related change in organizations could be identified analyzing the literature. Often multiple authors would describe the same phenomenon or idea in a slightly different manner. Whenever possible these concepts have been grouped in order to enhance the reader's overview on the whole topic of technology-related change. Still, the grouping of concepts presented below and the association of works to these groups are subject to the author's own thinking and will sometimes blur or overlap. An overview of the identified concepts and respective publications that deal with it is depicted in the cohesive tables 4.2 and 4.3. Whenever a concept appeared during the analysis of the respective publication it has been marked in the table. If the concept did not exist in the table yet, a new column has been added to it for the concept.

4.2.1 Intentionality of Changes

Kraut et al. (1989) distinguish between two kinds of organizational changes: intentional and unintentional. The authors report on the introduction of a new information system in a company and the reaction of the employees. They state that some of the changes that could be observed were intended by the IS designers, like jobs' most common parts becoming quicker and easier to do, reducing job pressure, and increased happiness and mental health of the employees. Other effects that were degrading jobs were made unintentionally. These changes were e.g. making jobs less satisfying, making them less complex, interesting, or challenging. Through the introduction of the new IS skills of workers became less relevant and workers' satisfaction and involvement with colleagues was decreased. Most publications reviewed only deal with intentional change efforts. Only some discuss changes that are caused unintentionally (Turner 1984; Kraut et al. 1989; Brynjolfsson and Hitt 2000; Cabrera et al. 2001; Linde and Linderoth 2008; Leonardi and Barley 2008).

4.2.2 Reasons for Change

Drucker (1988) names four reasons, why organizations need to transform their businesses: First, companies need to react to changing demographics like age distribution. Second, the command-

Table 4.2 Identified concepts of technology-related change in business context (own illustration)

	Intended change	Unintended change	Reasons for change	Environmental change	Technological imperative	Organizational imperative	Emergent perspective	Enabling role of technology	IT to speed up status quo	Radical change	Incremental change	Process characteristics	Prognosis of change
Leonardi and Barley (2008)	•	•			•								
Linde and Linderoth (2008)	•	•			•								
Overby et al. (2006)	•			•	•			•					
Dodgson et al. (2006)	•						•				•		
Ash and Burn (2003)	•						•						
Cabrera et al. (2001)	•	•				•		•					
Orlikowski and Iacono (2001)	•						•						
Brynjolfsson and Hitt (2000)	•	•	•		•			•		•			
Galliers and Baets (1998)	•					•				•	•		
Watad and Ospina (1996)	•						•	•					
Sroka and Stanek (1996)	•					•							
Lyons (1995)	•				•					•			
Davenport and Short (1990)	•		•		•				•	•		•	
Hammer (1990)	•		•		•			•	•	•			•
Kraut et al. (1989)	•	•					•						
Drucker (1988)	•		•	•	•			•	•				
Markus and Robey (1988)	•						•					•	
Turner (1984)	•	•			•								
Leavitt and Whisler (1958)	•		•		•			•	•				•

and-control model, that has been prevalent for a long time, is not suited anymore for knowledge workers capable of making their own decisions. The two main reasons however are changes in the economic environment that organizations need to react to and increased usage of IT. Organizations need to "innovate and be entrepreneurs" (Drucker 1988, p. 3) to keep up with economic development. Davenport and Short (1990) support these assumptions by highlighting that there has been a stagnation in productivity since 1973. To increase productivity again, organizations need to reach out for organizational change (Hammer 1990). Additionally the authors stress that organizations need to be more flexible because business environments are not stable anymore (Davenport and Short 1990). These environmental changes consist of multiple factors (Overby et al. 2006): competitors are taking actions that organizations need to react to, consumers preferences are changing, regulations or laws change, economies are shifting, and technologies are constantly advancing. The practical application of new knowledge is happening faster than before (Leavitt and Whisler 1958). Increased usage of IT in work practices forces companies to strengthen their analytic capabilities, otherwise they will be "swamped by the data" (Drucker 1988, p. 4). Furthermore computerization causes a different structure of communication because costs for communication are decreasing (Brynjolfsson and Hitt 2000). All of this increases pressure on organizations to keep up with development (Leavitt and Whisler 1958) and to constantly renew their organizational structure and ways of working.

4.2.3 Causal Agency

Markus and Robey (1988) identified three types of causes for change during their study: change originating from organization, from technology, or from a combination of both. They call this concept *causal agency*. The authors argue that changes could be either seen as caused by external forces – called the *technological imperative* – or by people purposefully trying to achieve them – called the *organizational imperative*. The technological imperative view describes technology as an "exogenous force which determines or strongly constrains the behavior of individuals and organizations" (Markus and Robey 1988, p. 585).

The organizational imperative view to the contrary implies that the impulse for change lies within the organization. System designers are purposefully developing solutions to fit organizational needs for information, while having "almost unlimited choice over technological options and control over the consequences" (Markus and Robey 1988, p. 587). The authors argue that this view typically includes the assumption that system designers have control over the impacts of information systems if they attend to both the technical and the social aspects of the introduction.

A third view of causal agency is characterized by "refusing to acknowledge a dominant cause of change" (Markus and Robey 1988, p. 589). The authors call it the *emergent perspective*. According to this view, the "use and consequences of information technology emerge unpredictably from complex social interactions" (Markus and Robey 1988, p. 588) of actors, context, and technology.

Kraut et al. (1989) suggest that the changes of technology and organization are bidirectional, i.e. "any technological configuration is itself a historical product of social, economic, and political decisions that shape it" (Kraut et al. 1989, p. 236).

Leonardi and Barley (2008) state that the separation of material and social aspects of technology-enabled effects in organizations is not as clear as it seems to be. Still they conclude that most researchers eventually favor either technological or organizational factors in order to explain their findings. Indeed most publications analyzed for this work could be assigned either to the technological imperative (Leavitt and Whisler 1958; Turner 1984; Drucker 1988; Hammer 1990; Davenport and Short 1990; Lyons 1995; Brynjolfsson and Hitt 2000; Linde and Linderoth 2008; Leonardi and Barley 2008) or the organizational imperative (Sroka and Stanek 1996; Cabrera et al. 2001), whereas only Watad and Ospina (1996) explicitly employ the emergent perspective in their research, while Dodgson et al. (2006), Ash and Burn (2003), and Kraut et al. (1989) present a similar approach.

4.2.4 Enabling Role of Technology

Already Leavitt and Whisler (1958) state that IT will "challenge many long-established practices and doctrines" (Leavitt and Whisler 1958, p. 48). Hammer (1990) still holds the view that information technology has the power to enable new processes, that would not have been possible before. He bases that view on the assumption that former processes have not been designed at all or been designed for information poverty, i.e. people could not be aware of all the information available throughout the whole company while working at a certain issue. As IT possibly enables this information availability at every single workplace of an organization, technology can be seen as an enabler of change. This is one example of the technological imperative view that has been described above in section 4.2.3. Other authors have also seized the idea that technology either determines or strongly constrains what ways of working are possible within an organization. Drucker (1988) for instance implies that computer technology is an enabler of new work practices as it makes data-intensive analyses available for every-day use. That way e.g. alternative strategies can be easily tested before acting, which would have taken a long time for calculation before. Technology in this case produces information out of data, as it is "endowed with relevance and purpose" (Drucker 1988, p. 4).

In a similar way, Overby et al. (2006) state that information technology is one specific enabler of agility, because it enables both sensing the environmental change and responding to it readily. Both factors are considered to be substantial for agility, they argue: If organizations posses an adequate level of IT capabilities, they can sense upcoming changes that will be happening due to advances in technology. As a direct effect this enables the organizations to respond to respective opportunities too. As an indirect effect, IT contributes to performance in business processes and provides digital options, like making knowledge more accessible.

Cabrera et al. (2001) highlight that technology is influencing the nature of work because a new behavior might be necessary to use new technology. The authors claim that companies can not only adopt a new technology, but rather need to adapt the whole structure and human resources architecture, so employees are in the right position to gain benefits from the technological advantages. Technological changes that way also cause changes in other parts of the organization like procedures, decision making, jobs and job assignments.

To Brynjolfsson and Hitt (2000), IT is a general purpose technology. It can be used to achieve multiple goals and therefore possibly facilitates other innovations. These can be technological, but also organizational innovations. The authors summarize the value of IT as "its ability to enable complementary organizational investments such as business processes and work practice". These investments in turn would lead to increased productivity like cost reduction or increased output quality. Watad and Ospina (1996) add the important distinction that change is enabled by technology, but "technology does not automatically determine the desired consequences in a change process" (Watad and Ospina 1996, p. 203).

Despite all these advantages, technology might also hinder organizations: Overby et al. (2006) give the example of a monolithic IT architecture that will limit the range of agile responses for an organization. Furthermore IT might as well limit information visibility as it often just offers certain ways to retrieve or interpret information to the user. Incompatible systems might finally put a heavy burden on planned extensions of process reach, e.g. incorporating processes and data of suppliers.

4.2.5 IT to Speed up Status Quo

In his vision on the information-based organization of the future, Drucker (1988) remarks that so far people "use the new technology only to do faster what they have always done before" (Drucker 1988, p. 4). Other authors agree that heavy investments in IT have been disappointing in terms of results because companies are mechanizing old ways of working, just speeding them up with technology (Hammer 1990). The full potential of technology is not used because it "has been used in most cases to hasten office work rather than to transform it" (Davenport and Short 1990, p. 12). Leavitt and Whisler (1958) were recognizing this still in a positive way as IT might "allow fewer people to do more work" (Leavitt and Whisler 1958, p. 43).

4.2.6 Radical vs. Incremental Change

One main theme of organizational change research is the one of radical versus incremental change approaches. Both center around the idea of intentional changes that organizations like to perform for various reasons, as described in sections 4.2.2 and 4.2.1. The approaches however differ regarding one main question: Should organizational changes be introduced radically, i.e. completely changing the organization to the desired state at once, or incrementally, i.e. introduced step-by-step? Two publications that are closely related to this discussion are the ones by Davenport and Short (1990) and Hammer (1990). What they suggest is to "use the power of modern IT to radically redesign our business processes" (Hammer 1990, p. 104). Information technology should "fundamentally reshape the way business is done" (Davenport and Short 1990, p. 12).

Davenport and Short (1990) claim that traditionally IT has been used in offices to hasten work, which means that no transformation of practices took place. A stagnation of productivity has been the result. The main idea of Business Process Redesign (BPR) is explained by the authors as follow: Business activities are broken down into processes, that can be designed for maximum effectiveness. The desired huge increase of performance results from the fact that current processes stem from former ad-hoc decisions that did not pay much attention to effectiveness. In contrast, current redesign should happen with a specific business vision and with specific objectives in mind, e.g. cost or time reduction within the process. Known past problems may influence this design process. The most important suggestion made by the authors however is that process designers should start "with a clean slate" (Davenport and Short 1990, p. 16), not building on top of existing work practices. According to Lyons (1995), BPR propagates a fundamental departure from current ways of working. It is a holistic intervention, radical in nature, that pertains all enterprise components, although it is centered on work processes and IT.

A similar idea is suggested by Hammer (1990): Reengineering tries to break away from unarticulated rules shaping the organizations daily work in order to "achieve quantum leaps in performance" (Hammer 1990, p. 105). In a similar manner, work practices are completely redesigned instead of speeding up existing ones through technology. Therefore fundamental processes are analyzed from a cross-functional perspective instead of focusing on single departments. It is a main goal to change old organizational hierarchies and job descriptions.

The later work of Lyons (1995) reports that "BRP has created a religious zeal among business managers world wide" (Lyons 1995, p. 43). The managers' need to derive return from investment in IT has been a main motivation to look out for such optimizations. Accordingly Galliers and Baets (1998) criticize that BPR is solely centered around profit maximizing and does not pay attention to other aspects or outcomes of organizational change. Galliers and Baets (1998) also highlight that there is no such contrasted situation of radical and incremental change. To the contrary, radical improvements may be based on former incremental changes of information systems already in place. The case study of Dodgson et al. (2006) supports the observation that technology-related organizational changes do not "happen overnight". In addition technology has not been able to replace existing work practices of employees in their case.

The required transition from established work processes to newly designed ones creates own difficulties. These might be as large that for some companies it seemed easier to start "afresh on green field sites with totally new processes, people, structures and systems" (Lyons 1995, p. 43)

– an approach which has also been observed in practice by Brynjolfsson and Hitt (2000). Practitioners report low success rates of about thirty percent for reengineering endeavors (Galliers and Baets 1998) and further difficulties caused by radical approaches like "getting the information systems and technology infrastructure in place" and "dealing with fear and anxiety throughout the organisation" (Lyons 1995, p. 44).

Lyons (1995) considers IT to be a bottleneck to enactment of new processes, and therefore the "single greatest impediment" (Lyons 1995, p. 49) to success. This is e.g. due to the fact that legacy systems need to be maintained in parallel because they carry "hidden intelligence" that has been collected over the years. Still, the author concludes that BPR can improve operational performance if the enactment of redesigned processes in IT is successfully performed. Brynjolfsson and Hitt (2000) state that especially these difficult technology investments may be outweighed completely if they are not well-aligned with organizational practices already in place. An incremental approach in this case "can create significant productivity losses" (Brynjolfsson and Hitt 2000, p. 25) because newly introduced procedures or systems are slowed down by old ones still in place.

Despite their radical approach to process redesign, Davenport and Short (1990) also propose to stabilize processes before analysis and improvement. They furthermore suggest a practice of stabilizing, assessing and improving processes to become an institutionalized part of the organization. In response to the catastrophic results produced by the early BPR and Reengineering wave, Galliers and Baets (1998) propose what they call a "socio-technical approach to BPR", where "IT can be a catalyst in [the] process" (Galliers and Baets 1998, p. 240), but is just one factor of many. They conclude that the discontinuous thinking propagated e.g. by Hammer (1990) does not necessarily lead to a radical change approach. It might as well be reasonable to implement changes incrementally, depending on the individual case. They argue against too rigid applications of change methods as "each situation is unique and should be treated as such" (Galliers and Baets 1998, p. 227).

4.2.7 Process Characteristics

Davenport and Short (1990) define three process characteristic dimensions in order to classify processes. The authors claim that change and management activities have to be adapted to the type of the process pertained. One characteristic of processes is their reach, i.e. the organizational entities between which they take place. *Interorganizational processes* cross the boundaries of business organizations, e.g. two or more companies. *Interfunctional processes* take place within an organization between functional or divisional entities, e.g. business units. *Interpersonal processes* limit their scope to small work groups, e.g. self-managing teams. A similar distinction is presented by Markus and Robey (1988), called *level of analysis*. The authors state that theories contain assumptions about either individuals, collectives, or whole societies.

Processes can also be distinguished according to the objects involved. In manufacturing for instance, *physical objects* are typically part of the main processes. *Informational objects* on the other hand are rather used e.g. in management activities or services. Of course some processes involve both of these objects, e.g. packet tracking consisting of the real packet and the information object in an information system representing its properties.

Finally processes include different types of tasks and can be classified accordingly. *Operational activities* are performed on a day-to-day basis to support the main business purpose. In order to "control, plan, or provide resources" (Davenport and Short 1990, p. 20) to these tasks, additional *managerial activities* are needed.

4.2.8 Prognosis of Change

Two of the reviewed publications suggested which changes could follow in the next decades from the introduction of information technology. Whereas Hammer (1990) presents these changes in a more prescriptive manner, Leavitt and Whisler (1958) call their much earlier assumptions rightly "prognostications". Leavitt and Whisler (1958) predict that information technology will impact middle and top management. Planning tasks should be done more and more by specialists, which decide how everyday work is going to be performed by everyone else in the company. The authors call this highly structured performance of work *programming*. They assume that all workers and even middle management will follow these programmed routines. As a consequence, organizations will re-centralize and more creative tasks will be done by specialists in the top management.

In his work on reengineering, Hammer (1990) gives specific hints on how to improve work processes, especially supported by the introduction of IT: Generally speaking, the focus of organizations should shift from cost, growth, and control towards quality, innovation, and service. Splitting of work should be avoided, as it has been only a means of controlling uneducated workers. Nowadays, skilled workers could take more responsibility for their actions and make processes more centralized at one point and therefore more efficient.

The author suggests as further principles for reengineering (Hammer 1990, p. 108 et seqq.):

- A process should possibly be performed by those who use the output of it.
- Information-processing should be integrated into the work that produces the information.
- Geographically dispersed resources should be treated as though they were centralized.
- Parallel activities should be linked, e.g. through communication, instead of integrating their results at the end only.

Table 4.3 Identified concepts of technology-related change in business context (cont'd) (own illustration)

	Facilitators of change	Organizational culture	Innovation on deployment	Quality of work lives	Tool view	Proxy view	Ensemble view	Determinism	Voluntarism	Materialism	Idealism
Leonardi and Barley (2008)			•				•			•	
Linde and Linderoth (2008)	•		•				•			•	
Overby et al. (2006)					•			•		•	
Dodgson et al. (2006)					•						•
Ash and Burn (2003)	•						•			•	•
Cabrera et al. (2001)		•					•				•
Orlikowski and Iacono (2001)							•		•	•	
Brynjolfsson and Hitt (2000)					•						
Galliers and Baets (1998)					•			•			
Watad and Ospina (1996)							•			•	
Sroka and Stanek (1996)							•				•
Lyons (1995)					•					•	
Davenport and Short (1990)					•			•		•	
Hammer (1990)					•			•		•	
Kraut et al. (1989)			•	•			•	•			
Drucker (1988)					•			•			
Markus and Robey (1988)					•		•	•		•	•
Turner (1984)				•		•		•			
Leavitt and Whisler (1958)		•		•	•			•		•	

- Decisions should be made on-site, where work is performed. Control of decisions should be realized through the process.
- Information should be captured once and at the source.

To some extend, the predictions of both publications are similar, especially in the case of decisive power: Both hold the view that some kind of "programming" (Leavitt and Whisler 1958) or "process" (Hammer 1990) is controlling everyday work and decisions within the organization. It is set up by specialists or the top management and enabled by information technology. That way the organization can act more centrally and with less or even no middle management needed.

4.2.9 Facilitators of Change

Ash and Burn (2003) found that successful change projects introducing electronic enterprise resource planning systems had facilitators in technological as well as in organizational aspects.

These could either be information systems already in place, as well as work practices or cultural aspects supporting change. Another organizational aspect of change is presented by Linde and Linderoth (2008) who suggest that alliances need to be formed between actor groups, e.g. between certain managers and users, in order for organizational change to be successful.

4.2.10 Organizational Culture

Cabrera et al. (2001) claim that IT-projects often fail due to inadequate management of non-technical factors. The authors conclude that changes in technology also imply changes in other organizational subsystems, as technology is one company subsystem of many. Accordingly they state that success is also a matter of aligning technology and culture. Their intended goal is that an introduction of new technology should "minimize the human costs of the transition while maximizing the benefits obtained from the technology" (Cabrera et al. 2001, p. 246). In particular the authors highlight organizational culture as a medium to assess and manage change. It can help detect potential resistance to change and identify organizational strengths already in place. This approach of reducing resistance to change has also been presented earlier by Leavitt and Whisler (1958).

Cabrera et al. (2001) suggest the six dimensions of cross-organizational variability by Hofstede to characterize a company's culture. *Process- vs. results-orientation* distinguishes whether an organization focuses on the way a result is achieved, i.e. the procedures of work, or just cares about the results no matter how they are achieved. Organizations might also differ in whether they are *employee- or job-oriented*, i.e. rather care about the well-being of their staff or if the job is done. They can foster a *parochial or professional identity* depending on whether employees identify themselves rather with their organization or with their profession in general. If information can flow easily through the organization, it might have an *open* communication climate, other organizational cultures might be *closed*. Management can put *loose or tight control* on individuals and their respective preferences. The last dimension pertains *normative vs. pragmatic mentality*, which means if the organization is following a fixed set of rules or acting market-driven.

In order to support the organization's goals, culture needs to fit the strategic perspective of the organization. Cabrera et al. (2001) distinguish three types of strategies. *Defenders* want to decrease costs, while increasing efficiency. *Prospectors* focus on new products and therefore want to keep flexibility. *Analyzers* care most about the "efficient adoption, implementation and marketing of innovations that have proven valuable elsewhere" (Cabrera et al. 2001, p. 255).

4.2.11 Innovation on Deployment

Kraut et al. (1989) describe how employees were using a newly introduced computer system in a way that allowed them to carry out their old work practices although the new system did not explicitly support them. This had not only been unplanned by the company's management, but even undesired and caused the management to forbid this kind of usage. The authors report that some of the work practices – although forbidden – were still performed by users as it was not possible to track users' behavior. Similar phenomena have also been observed by other authors: Leonardi and Barley (2008) mention the idea that users might especially adapt technology if its functionality does not fit their needs. Linde and Linderoth (2008) assume that information and communication technology features inscribed programs of actions, i.e. several possibilities that are delegated to the socio-technical network of users by the system designers. These programs might give space to innovation as well as restrict it. Both can be a benefit or drawback depending on the use case. Apart from technology itself, supervisors' behavior and training has also been found to influence the extend of user innovation (Kraut et al. 1989).

4.2.12 Quality of Work Lives

Leavitt and Whisler (1958) predict that the depersonalization of relationships by use of IT will lead to psychological problems. In their opinion, it should be expected that workers will try to resist changes in their work that will reduce autonomy, like programmed, highly structured ways of working enforced by technology. Turner (1984) found that the quality of work lives of employees is influenced by the form of an application system. As opposed to his former hypothesis, a better performance of an information system's interface did not improve the task environment of employees. To the contrary, apparently a faster system was leading to a poorer work environment and well-being of staff. Turner (1984) concludes that the restructuring of work permitted by the new technology did have a greater impact on employees than the technology itself. Therefore he suggests that the whole job must be considered if new technology shall be introduced. Furthermore he concludes that productivity and work-life quality compete. This should be kept in mind when introducing new technology. Kraut et al. (1989) argue in a similar way that job effectiveness and employment quality can be altered already by computerization of small components. Furthermore the authors remark that unless quality of work life is explicitly addressed, it will usually decrease when new technology is introduced.

4.2.13 Conceptualization of the IT Artifact

When researching technology-related change, it is also necessary to discuss different approaches to how technology is seen, i.e. what concept of technology itself is prevalent within an organization. Orlikowski and Iacono (2001) conducted a meta-study during which they identified 14 specific conceptualizations of IT by means of a literature analysis on research publications. The authors clustered the conceptualizations into five meta-categories, either been seen as a tool, proxy, ensemble, computational power, or absent.

During the review of other publications for this work, it became apparent that the respective authors often employ concepts of technology close to the conceptualizations of Orlikowski and

Iacono (2001). These views influence how the role of technology in a change process is being seen. For each publication an approximation of which conceptualization it might employ – may it be on purpose or unwittingly – has been done. It can be derived from the overview in table 4.3. Three of the meta-categories could also be identified in publications reviewed: the tool view, the proxy view, and the ensemble view.

The *tool view* meta-category comprises conceptualizations that deal with the being and meaning of technology. It assumes that technology does "what its designers intend it to do" (Orlikowski and Iacono 2001, p.123) and focuses on technical matters. Technology in this view is seen to replace human workers, augment labor, or alter information processing and social relations. An example for this category of conceptualizations can be found in the works of Davenport and Short (1990) and the ones of Hammer (1990). Like other authors that employ this conceptualization they share the optimism and confidence that technology will enable the intended organizational changes the way they planned them as a "straightforward activity" (Davenport and Short 1990, p. 13). The result will be that "now it's fast and efficient" as Hammer (1990, p. 107) puts it. For these authors technology is the most important aspect in organizational transformation – a tool for change. In this point the category overlaps with the technological imperative view of Markus and Robey (1988) which has been discussed before in the sections 4.2.3 and 4.2.4. It is also quite deterministic as will be shown in section 4.2.14.

The *proxy view* meta-category assumes that aspects of IT are best captured through some kind of measures. This could be users' perception of technology, figures of diffusion, or costs associated with the purchase or usage of technology. Turner (1984) for instance aims at investigating the interplay of workers and IT applications by conducting questionnaire research and observation of the workplace. The author's argumentation is strongly based on the figures he gains from the quantitative analysis of the questionnaires. Change here means predominantly choosing the right measures and performing the right actions to optimize the measured results. In the case of Turner (1984) this view is as well stressing the technological imperative and deterministic thoughts like the examples of the tool view discussed above.

The *ensemble view* meta-category focuses on the interaction of social and technical aspects in a system, especially human-machine interaction. This could be the processes during development, the state of development of a technology within a certain industry or society, the social influences on technology, or the dependencies between technology and usage conditions. Markus and Robey (1988) already present such a view in their concept of the emergent perspective discussed in section 4.2.3 and all the publications relating to it share this conceptualization too. For these authors change is a complex phenomenon that can not be assigned to a single cause but to an ensemble of several change factors.

Two categories of conceptualizations have not been found in the publications reviewed for RQ1. The *computational view* meta-category centers around technologies' capabilities to process information, e.g. in terms of algorithmic issues, or data modeling and simulation. The *nominal view* meta-category comprises publications that do not explicitly deal with a concept of technology. In these cases, technology is named, but no description or theory of IT artifacts is presented.

4.2.14 Philosophic Stances in IS Research

A philosophical approach to IS research is presented by Leonardi and Barley (2008). The authors state that researchers might follow a more or less specific stance of philosophy approaching information systems studies. They give four examples of these stances: determinism, voluntarism, materialism, and idealism. Like in section 4.2.13 above for each publication an approximation of which stance it might employ has been done. It is likewise depicted in the overview in table 4.3.

In *determinism*, human actions are thought to be caused by external forces like technology or culture. They are seen to be prior to and independent of humans behavior. Most of the older publications in this review employ this philosophical stance, which will be discussed in section 4.3. All the publications that imply a strong cause-and-effect relationship between some actions or new tools and resulting change employ some kind of determinism. Examples are both the technological imperative and the organizational imperative presented in section 4.2.3. Also the publications in this review that employ the tool view or the proxy view presented in section 4.2.13 share these thoughts.

Determinism is sometimes linked to *materialism* which implies that human action "stems from physical causes and contexts" (Leonardi and Barley 2008, p. 160) like – again – technology. Again, Davenport and Short (1990) and as well Hammer (1990) are good examples for this combination. What makes their determinism tilt towards materialism is the fact that they assume that given the right processes and the right tools employees will just perform their work in a perfect way. They do not pay attention to the fact that "users' practices, beliefs and agendas significantly shape how information technologies affect organizing" (Leonardi and Barley 2008, p. 160).

Voluntarism to the contrary suggests the free will of human actors, which Leonardi and Barley (2008) call "agency". This stance is somewhat problematic for organizational change research as it ultimately implies that managerial actions might completely fail to have the intended effects. For instance Galliers and Baets (1998) encounter deterministic ideas insofar as they refuse to highlight a single dominant factor for achieving change. However like every publication that advises managers to follow a step-by-step approach to a certain result it is somewhat deterministic as well. From this point of view the emergent perspective presented in section 4.2.3 features some notion of voluntarism but also of determinism.

Idealism finally holds that social aspects like ideas or norms shape human actors' behavior. Such cultural discussions can be e.g. found in the works of Cabrera et al. (2001), which have been presented in section 4.2.10. They consider e.g. learning processes to be the crucial factor in achieving organizational change. Whether or not this learning is actually taking place in the employees' minds is depending on an well-elaborated organizational transition plan that considers organizational culture as well as technology.

Markus and Robey (1988) discuss the idea of determinism within a concept they call *logical structure*. One type of structure, which they call *variance theory*, assumes that once sufficient preconditions are given, a defined outcome will invariably occur. This is clearly a deterministic approach. The other type of structure, called *process theory*, assumes that chance and random effects might intervene all the time. That way outcomes might not occur, even when preconditions are met. One possible explanation given by the ensemble view concept discussed in section 4.2.13 could be that the phenomenon has been too complex to be grasped by the preconditions identified, which also relates to the emergent perspective presented in section 4.2.3.

4.3 Historical Development

A citation analysis of the literature reviewed is depicted in figure 4.1. It shows which publications cite and discuss prior publications and that way gives an insight to the historical development of the academic debate. In order to reduce complexity, citations in a row have been joined – such as A citing B and C, and B citing C – is now depicted as A citing B, and B citing C.

According to the approach of Leonardi and Barley (2008), every concept of technology-related organizational change can also be associated more or less precisely with one or more philosophic stances. In a historical course of investigation the authors state that the predominant stance in information systems research has changed over time. They claim that early research up to the 1970's favored a deterministic materialism, which means that changes observed in organizations were attributed to physical causes. In this case they were most likely attributed to newly introduced technology. The authors state that later research during the 2000's was coping with the legacy of this early philosophical stance and instead promoting more idealistic and voluntaristic ideas.

Indeed this hypothesis of dominating determinism can be verified to some extend by the publications analyzed. Deterministic views of technology are dominant until the year 1990, which is depicted in table 4.3. Apart from that however no such clear distinction in terms of historical development can be made: All of the concepts seem to be constantly debated within fifty years of research. That way ideas reoccur again in a slightly different context years after their first publication, e.g. the idea of highly structured work which is presented independently by Leavitt and Whisler (1958) and Hammer (1990).

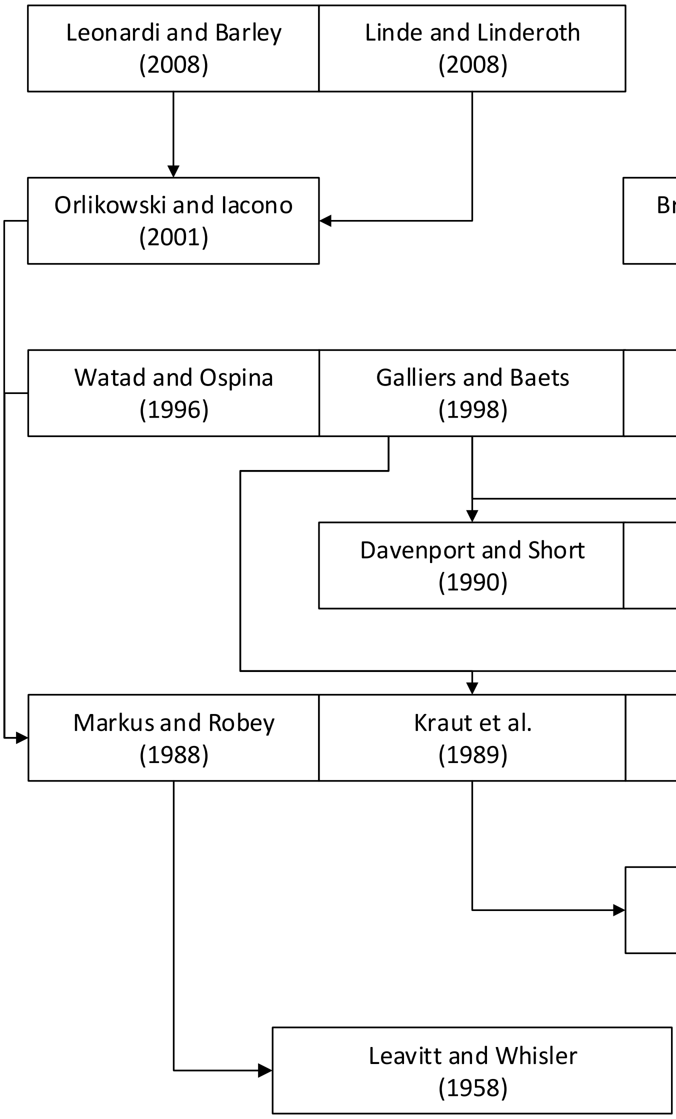

Figure 4.1 Citation analysis for technology-related change literature (own illustration)

4.4 E-Business and ERP/ CRM - an Example of Technology-Related Change

As presented in chapter 1.2, one objective of this work is to compare the current change in organizations that is related to IoT with change that happened in the past related to former technology. When Fleisch et al. (2009) are arguing that IoT is the "logical next wave of IS integration after the introduction of ERP systems and the Internet" (Fleisch et al. 2009, p. 100), what they imply is that the last big organizational change has been related to the introduction of company software like Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP) systems and the concept of Electronic Business (e-business). These three technologies are not the same, however the practical consequences of usage are often interlinked. For instance, the case studies of Schubert and Williams (2010) show some cases where the goal of the ERP implementation has been the "seamless exchange of electronic business documents between the involved business partners" (Schubert and Williams 2010, p. 473), which is a topic also included in e-business. Consequently, a short summary of e-business change will be presented in the following along with a presentation of change resulting from the use of CRM and ERP systems. Both will serve as a basis for comparing identified changes related to IoT with the changes that this former technology wave brought about. This comparison will be presented in chapter 5.4.

4.4.1 E-Business-Related Change

According to the original definition of IBM, e-business means "the transformation of key business processes through the use of Internet technologies" (Schneider 2011, p. 4). This comprises processes where businesses are trading with customers, other businesses, and the internal procedures that support related activities. However, the term e-business refers to more than just selling products on the Internet, it means "moving processes and communications online" (Amor 2002, p. 17). Change in business that companies experience can be derived from the characteristics of the Internet as the underlying infrastructure enabling e-business (Amor 2002, p. 16).

First of all, the Internet makes information globally available which enables expanding market reach beyond the company's geographic location (Amor 2002). Even for small companies it is therefore possible to address new customer segments scattered around the globe (Schneider 2011). The global accessibility of information also increases purchasing opportunities for the buyer as it enables efficiently obtaining information about price and delivery terms (Schneider 2011, p. 18). Always available product information on the Internet replaces mailed catalogs or printed product specification sheets (Schneider 2011, p. 18).

As a consequence of the globalized and more transparent market, the competition becomes harder for the companies. For instance, pricing becomes less relevant "as all prices drop to the lowest possible level" (Amor 2002, p. 16). In order to be able to distinguish their products from competitors' products companies need to e.g. add services that increase the value of the product without additional cost for the customers. As a further step, companies might want to create virtual communities, i.e. constitute pools of people with shared interests online. Once established, virtual communities may "become ideal target markets for specific types of products or services" (Schneider 2011, p. 17). Easier access to information and a never-closing site however also contribute to an improved customer loyalty (Amor 2002, p. 17).

When businesses decide to link their information system through the Internet they grow closer relationships (Amor 2002). The fully digital business processes increase speed and accuracy of information exchange between companies (Schneider 2011, p. 18). Furthermore, businesses may use electronic commerce "to identify new suppliers and business partners" (Schneider 2011, p. 18) and that way grow their digital network of business partners.

Increasing their profits might be one mayor goal for most companies. From a broad view, e-business change might be seen as simply increasing sales and decreasing costs (Schneider 2011,

p. 17). When looking at it more closely e-business is changing the structure of companies e.g. through reducing the number of employees needed in call centers. This is possible as customers are also able to find answers to common questions online. As another example, by means of the Internet the delivery of some goods, e.g. software, can be optimized. The distribution of online-only products over the Internet can be realized almost free of charge (Amor 2002, p. 17). Customers may order and download the product at any time they want, which can in turn also increase sales (Amor 2002, p. 18). This reduces the time that the customer needs to spend after buying before starting to use the product.

Amor (2002) claims that companies are spending much working time in transferring information from one medium to another, e.g. entering the information contained in a fax into a database. The author calls this process, where an information does not change but needs to be transferred to a new medium, a media break. According to him, one major achievement of e-business is the reduction of media breaks through central digital platforms that enables sharing of information "by all the participant in the business process without the risk of losing parts of the information" (Amor 2002, p. 18).

In general, e-business is speeding up processes of companies: It is enabling shorter time to market and faster response time to changing market demands (Amor 2002, p. 17). Due to more timely communication with suppliers it enables just-in-time inventory, i.e. the suppliers are integrated into the digital ordering process and can deliver needed products more timely (Amor 2002, p. 24). That way the inventory can be cut down to reduce the cost of storage.

4.4.2 ERP- and CRM-Related Change

Schubert and Williams (2010) identified and classified typical benefits that have been realized through the usage of ERP and CRM systems in business context. They grouped the benefits gained from the analysis of case studies into four categories, namely strategy and processes, resources, functional areas of the company, and technology components. Although the authors specifically focused their research on benefits, most of the identified features have been reflected also in general organizational change literature presented above in section 4.2. For instance, strengthening analytical capabilities of companies and general increases of productivity have been discussed in section 4.2.2. Therefore the results of their research seemed suitable to compare it with e-business change literature and is included into the comparison of changes.

Regarding strategic decisions it was shown that companies benefited from quick adaptability of their ERP system to changing conditions. In some cases, the software was used especially to realize elements of the business models, e.g. just-in-time delivery. Furthermore companies experienced an acceleration of their processes and increased transparency. As a result the authors summarize that "both the control and the rapid execution of processes are important benefits arising from the use of ERP and CRM systems" (Schubert and Williams 2010, p. 476). In terms of resources the authors identified improved availability of information as a benefit, often enabled through a central repository. This non-redundant use of data also provided an additional increase of information quality. Further benefits in the resources area of the companies have been lower costs and decreased capital lockup. The increase in efficiency also lead to higher satisfaction and motivation of employees.

Benefits regarding the functional areas of the companies comprised the possibility to generate analyses and reports timely from the data stored in the system. The sales and delivery department has been the one realizing the most improvements regarding the companies in the study. An increased degree of automation realized through implemented workflows has been another benefit in the functional areas. Faster order processing also lead to increased customer satisfaction. Regarding technological components the most important theme mentioned was integration, i.e. "the unification of different functional areas in a single database and an integrated software solution" (Schubert and Williams 2010, p. 478). Integration also lead to improved cooperation with partners as integration interfaces between the companies enabled process improvements. Some companies benefited from outsourcing of IT services.

4.4.3 Summary

When comparing the identified changes regarding e-business and ERP and CRM systems, it becomes clear that they share a common set of features. Table 4.4, which summarizes the respective changes, has been sorted into topic groups accordingly to make the common features transparent. Both technology waves increased availability of information within and outside the company. They enabled closer integration of business partner into the company's own processes. This has been a necessary precondition to establish more timely business models like just-in-time delivery. Manual work has been reduced through increased automation of business processes which made these processes faster and cheaper.

Amor (2002) divides the Internet presence of companies into six phases. Starting from a simple web without the possibility to interact with the company, the Internet presence develops further. More structure and more possibilities for communication are added, then the intranet databases of the company are connected to the website in order to to provide timely information to customers or other businesses. The fifth phase is described as "pervasive e-business" by the author, being the next goal to reach within five years after publication, i.e. in the year 2007. Pervasive e-business means that all computational devices, i.e. the ones containing a chip, can be used to participate in e-business. The possibility to take participate in business processes should become completely independent of the user's location. As the remote vision and last phase, Amor (2002) presents the phrase "one world, one computer" which he describes in the following quote.

> "All chip-based devices are interconnected and create one huge information resource. The devices are able to interchange any type of information on an object-oriented level. Applications are transparent to these devices. Users won't know where the answer to their problems came from" (Amor 2002, p. xxxvi).

Although the author presents this vision as the ultimate goal of the e-business technology wave, he already anticipates change that IoT is about to bring. The general concept of IoT has been presented in chapter 3, change in businesses related to IoT will be presented in the next chapter 5.

Table 4.4 Comparison of E-Business-related and ERP- and CRM-related change (own illustration)

E-Business-Related Change	ERP- and CRM-Related Change
Availability of information	
• global availability of information (e.g. product information)	• improved availability of information
Globalization of markets	
• globalized and more transparent market	
Business integration	
• closer integration of partners into own business processes • more timely communication with partners (e.g. just-in-time inventory)	• increased integration (e.g. with partners) • realizing new business models (e.g. just-in-time delivery)
Efficiency	
• faster and cheaper processes through less manual work (e.g. reducing media breaks)	• acceleration of processes and increased transparency • increased degree of automation • faster order processing • increase of efficiency • lower costs
Timeliness & Quality	
	• quick adaptability to changing conditions • timely reporting and analyses • increase of information quality

5 How Businesses Change When IoT Is Introduced

In order to investigate how businesses change when IoT is introduced, a case study analysis has been done using a qualitative and exploratory coding approach. The theoretical foundations of this approach have been described in more detail in chapter 2.2. This chapter presents the results of the case study search and selection as well as the results of the subsequent analysis. The last part of the chapter discusses how the observed changes in businesses are related to characteristics of IoT, and if and how they are different from former technology-related changes.

5.1 Case Study Search and Selection

Early reviews of case studies published by companies online revealed varying scopes and poor methodology of the studies while offering only shallow information on practical implications of the presented IoT scenarios. Therefore, only academic publications were included as data sources for this work subsequently. The publication databases Springer Link[1] and Google Scholar[2] have been searched for case studies using the keyword *internet of things case study* in May 2017. The first 50 documents within the search results of both databases have been read briefly in order to examine if they matched the research purpose. Three criteria have been defined for selecting case studies:

1. The case study should describe an IoT application that could possibly also be used in a business scenario. Therefore pure technical presentations that do not display a business use case have been excluded. Examples for such excluded case studies are e.g. Zorzi et al. (2010) and Klauck and Kirsche (2012).

2. In order to identify business changes happening, only publications that describe specific application scenarios were included. The description should at least span some sentences and should not only name scenarios, but describe them in more detail instead. Atzori et al. (2010) for instance name a lot of possible IoT use cases, but omit further descriptions.

3. Due to the early stage of most IoT projects, reports on prototypes in business and research have also been included as long as they provide a clear use case.

By means of the criteria list thirteen publications have been selected for further analysis. Table 5.1 lists the selected studies in order of publication date. It features a short scenario description and whether the studies involve a prototypical IoT solution or a finished product. Most of the studies report on projects in a prototypical state of development, which might also be related to the academic nature of the publications, focusing on research rather than on production.

[1]Springer Link: `http://link.springer.com/`
[2]Google Scholar: `https://scholar.google.com/`

Table 5.1 Case studies selected for analysis (sorted by year)

Author (Year)	Type	Scenario
Valsamakis and Savidis (2017)	Prototype	Ambient assisted living
Ramirez et al. (2017)	Prototype	Smart long cane
Piccialli and Chianese (2017)	Production	Smart museum
Nobre and Tavares (2017)	Production	Smart shoe / Smart lighting
Lee et al. (2016)	Prototype	Smart washing machine
Fernandes and Lucena (2015)	Prototype	Patient monitoring
Chen et al. (2014)	Prototype	Pallet inventory / Pallet monitoring / Container tracking
Hu et al. (2011)	Prototype	Smart doormat / Energy consumption visualization
Kranz et al. (2010)	Prototype	Smart kitchen / Room management
Kortuem et al. (2010)	Prototype	Smart storage of chemicals / Smart construction tools
Michael (2007)	Prototype	Journal life cycle management
Efstratiou et al. (2007)	Prototype	Smart construction tools
Strohbach et al. (2004)	Prototype	Smart storage of chemicals

In the case of Kortuem et al. (2010) it became apparent that two original case studies have been summarized for this publication. In order to gain more information about the case study scenarios, the two original case studies of Efstratiou et al. (2007) and Strohbach et al. (2004) have also been included in the analysis. The studies did also match the criteria list.

5.2 Case Study Analysis

Most of the publications analyzed are not pure case studies, rather they contain case studies embedded into a presentation of the development of an IoT solution. In these cases only the parts where the solution is described either in practical or theoretical use have been coded. Technically detailed descriptions have not been coded if they did not contain information about the usage scenario. Likewise, summaries of general theory have not been coded either.

The case studies have been analyzed using a qualitative and exploratory coding approach. The analysis has been performed in two interlinked phases, following the suggestions of Charmaz (2006) and Saldaña (2009). In a bottom-up manner the studies have been coded very detailed at first in order to later focus on a reduced number of codes in a second step. This reexamination of codes included renaming and removing unnecessary or imprecise codes and forming tentative categories of codes.

For the first cycle, the method of *Initial Coding* also referred to as *Open Coding* has been used. This first step in the analytical process should "stick closely to the data" (Charmaz 2006, p. 47). Gerunds have been used to describe actions whenever possible. This is derived from the approach of *Process Coding* (Saldaña 2009, p. 77). It is suggested in order to "gain a strong sense of action and sequence" (Charmaz 2006, p. 49), which seemed appropriate for constructing a theory that investigates how influences of IoT are interlinked and how they interact with the organization. The resulting codes have been revised in a second round in order to reduce duplicates or split up too general codes comprising more than one meaning. For the second cycle, the method of *Focused Coding* has been used in order to raise the most significant codes to tentative categories. The approach of using gerunds has been maintained also for the category names following the examples of Charmaz (2006) and Saldaña (2009).

The overall coding process of this work is depicted in figure 5.1. The initial coding cycle as well as the focused coding cycle have been conducted several times each in order to investigate IoT-related change in the case studies. In the first round of initial coding, a large number of codes emerged that were describing actions of smart objects in general. These codes were often not precise enough to grasp what IoT specifically contributes in the respective case. However they already marked the spots in the case studies where further attention should be payed to. A list of codes resulting from the first round of this cycle can be found in Appendix A. One example for such too general codes is the code *interacting with user*. It marks the spots in the case studies where IoT objects are interacting with a user, however it does not give any hint on specific types of interactions. In subsequent coding cycles too general codes have been re-coded and replaced by more specific phrases that are better describing what IoT is specifically contributing in the described situation. This has however not been a straightforward process, rather the re-coding took place while reviewing codes during memo writing and led to further analytical memos. The phases of coding and memo writing were alternately interrupting each other. As a further result not all of the codes have been reviewed as can be seen from the final code list in Appendix B. Codes that were not included in analytic memos, e.g. because there were only used once without further relation to other codes, would just stay in the code list until the end of the analysis without being revised.

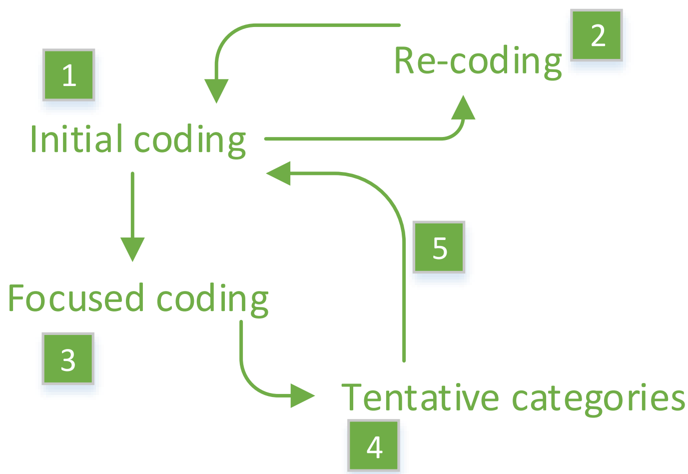

Figure 5.1 Coding cycles in chronological order (own illustration)

In the third step of the coding process the most significant codes have been selected to elaborate them as tentative categories, which is depicted as the fourth step. Codes that turned out to be not precise enough during the development of the tentative categories needed to be reexamined in the second initial coding round, which is depicted as the fifth step of the coding process. Afterwards the process has been followed again through focused coding and development of tentative categories. One indicator that has been used to determine whether a code was precise enough is the "touch test" presented by Saldaña (2009, p. 187). It is a strategy to develop codes from the real to the more abstract. The general rule behind the test is that if you can physically touch the item that the code refers to, it is not abstract enough. Consequently, the respective code should be reworded in order to grasp the abstract meaning behind the physical object. For instance, the code list after the first cycle of coding included codes like *user interfaces* that were reworded or omitted after applying the test on them.

5.3 Identified Changes

After several cycles of coding and memo writing ten most frequent codes in the analysis have been identified. These were in descending order of frequency:

1. using personal devices
2. suggesting actions
3. building chains of information flow
4. storing status information remotely
5. retrieving status information remotely
6. accessing real time information
7. cooperating with other objects
8. avoiding hazards
9. attaching status information to objects
10. scheduling actions of users

The ten codes were used as candidates to form tentative categories of change. Some codes that were interrelated closely have been joined in one tentative category. Each of the categories will be discussed in the following providing a short definition, an explication of the properties through examples from case studies, and their relation to other codes and categories. In the end, an overview of all the categories will be provided in section 5.3.8.

5.3.1 Using Personal Devices

The IoT needs endpoints to communicate with the user. Where Weiser (1991) was suggesting to use pads, i.e. portable "scrap computers" that can be used by any user to run any application and are not bound to a specific user, the IoT case studies often suggest to use smart devices, e.g. a smart phone. These are usually only used by a single person but for multiple applications and therefore can be considered to be rather *personal devices*. These devices are the main interface between the user and the surrounding smart environment. In the following the codes associated with this category will be discussed. Their interrelations are also visualized in figure 5.2. Categories are depicted in bold lettering in the figure; other categories than the current one are depicted in blue color.

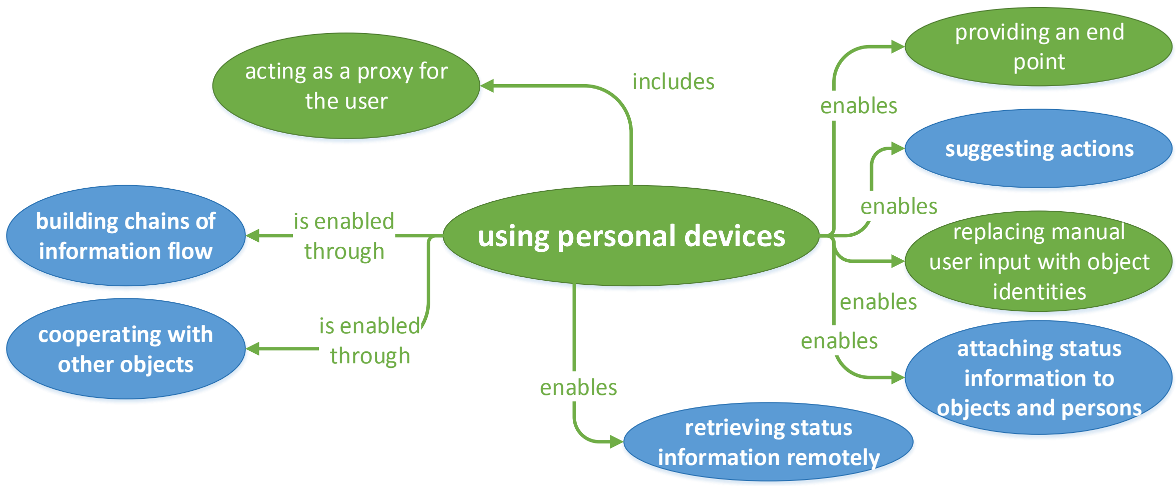

Figure 5.2 Codes relating to the category *using personal devices* (own illustration)

The personal device can be "the end-point of the entire context-aware solution" as Piccialli and Chianese (2017, p. 339) put it in their smart museum case study. It can be the one central point where interaction of machines with the user is taking place. The device can also be the main machine that is coordinating and linking other devices as "the core of this new concept" (Ramirez et al. 2017, p. 114). For instance the smart city environment and a smart long cane that a visually impaired user is utilizing are both connected to the smart device of the user. The device is in turn providing awareness of the environment to the user combining all the information available.

There is a range within this category between very rich, full-featured personal devices like in the museum case and very simple personal devices like in the smart construction tool case. In the case of the smart museum "the service delivery to the visitor is fully enabled by the [...] mobile application" (Piccialli and Chianese 2017, p. 339). It is only utilizing some wireless beacons that enable the personal device to identify cultural items or places that are close by. The greater part of the service however is performed on the smart device of the user. In the smart construction tool case (Efstratiou et al. 2007) the personal device is much simpler and merely a portable display for information. It is only one part of the infrastructure and delivering the service together with a sensor node in the tool, an on-site information hub in a vehicle, and a back-end database at the company's office. Another difference is the flexibility of attribution regarding the personal device and the user. In the smart construction tool case a device is assigned to a worker at the beginning of the shift and can easily be reassigned to another worker afterwards. In the case of the smart museum the user is bringing his or her own device and therefore the attribution of device and user is rather fixed.

In the smart construction tool case of Efstratiou et al. (2007) the personal device also serves as a representation of the user in the virtual world. It associates the pure sensor measurement data with the specific user and that way enables a semantic link of attribution for this data. It is a common pattern in all of the case studies that IoT enables *attaching status information*. This category will be presented in more detail in section 5.3.7. An exemplary case of the category is the use of patient bracelets in patient monitoring (Fernandes and Lucena 2015): Every patient is wearing a bracelet that is first read by a health professional and then triggers the automatic attribution of measured health data with the patient's electronic health record. Without the association of data through the bracelet the health professional would need to perform the association of data and patient manually.

This concept of an identification device that is attached to the user has already been propagated in the prototypical ubiquitous computing solutions of Weiser (1991) who was attaching "wearable badges" to employees so that automatic doors and computing devices could identify the users close to them. The system could then decide whether the user is authorized to enter the room or to access certain data through the computing device. The usage of personal devices, tags, or bracelets as identifiers enables *replacing manual user input with object identities*, which means that instead of manually linking data to virtual representations of objects or persons this linking is now done casually by means of the identifier. This saves time in the process because it replaces lengthy retrieval of the right digital records. Furthermore it avoids misentries resulting from accidental association of new data to the wrong record.

The personal device also enables to access the virtual overlay that is created by attaching digital information to an object or person, e.g. a "mobile RFID reader displays the information" (Michael 2007, p. 88) about a journal to the user when it is close to the object. A novelty is given by the fact that in more advanced scenarios the physical identifier does not have to be within the reach of the personal device to obtain the status information about the object or person. Because the information can be forwarded through wireless interfaces it is possible to *retrieve status information remotely*, i.e. without the necessity of the physical presence of the user or object. This category is discussed in section 5.3.4.

Exceeding the functionality of an identifier and information portal, the personal device is sometimes *acting as a proxy for the user*. It is bridging actions of the real and the virtual world because it is enabling the user to control the invisible network that all the machines surrounding him or her create. Some authors envision that "every human user has [an] own mobile device to communicate between agents such as human users or the machine" (Lee et al. 2016, p. 368). This means that the personal device is not only identifying the user or displaying information, but also representing him or her as an actor because it is performing representative action at the user's discretion. As an example the user could "use [an] own personal device (e.g., smartphone) to access the main device (e.g., laundry machine)" (Lee et al. 2016, p. 368) and perform some action remotely. Before, it would have been necessary to be physically present at the machine in order to perform the action.

In order to realize all this functionality the personal device is *cooperating with other objects*. There is no need for a separate desktop computer and in some cases not even for a centralized back-end server. The objects are forwarding the local information they gained through sensors or user input to other objects. Either on request of the user or completely autonomously they are *building chains of information flow*. The category comprising these two codes will be discussed in more detail in section 5.3.3.

As the personal device is aware of the surroundings of the user, either by use of own sensor data or through forwarded information from other objects, it is able to *suggest actions* to the user. It could be e.g. "providing just-in-time information about required work activities" (Kortuem et al. 2010, p. 35) on a construction site. This category of codes is presented below in section 5.3.2.

5.3.2 Suggesting/ Scheduling Actions

The category *Suggesting/ Scheduling Actions* comprises codes that deal with targeted influences on users' daily activities by means of IoT. Both influences on private as well as on work life could be observed during the analysis of the case studies. A common theme within these cases is that IoT objects are using their capabilities to get aware of a situation present in the surroundings of the user. Subsequently they use pre-defined rule sets to determine useful or necessary actions that the user could or should perform in the situation. In more sophisticated applications the smart objects are even able to match their suggestions with a comprehensive process allowing for advanced suggestions to the user. The codes associated with this category are visualized in figure 5.3 and will be discussed in the following.

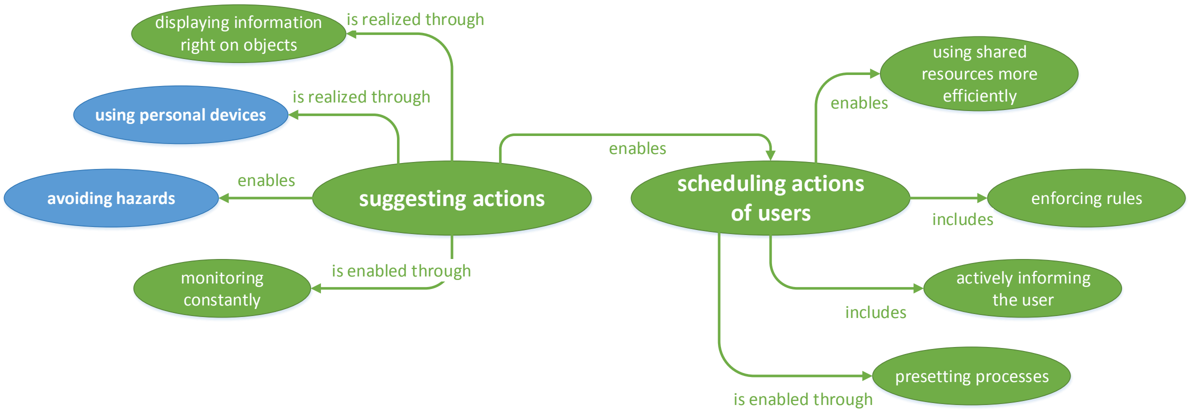

Figure 5.3 Codes relating to the category *suggesting/ scheduling actions* (own illustration)

The heart of the category is formed by the code *suggesting actions*. It means that objects suggest to the user what actions he or she should or could perform based on the data that the objects collected before. One example would be the smart shoe in the case study of Nobre and Tavares (2017) that is able to identify when the shoe is in the condition to be replaced. In this case it is left open by the authors of the study how the user will be informed about the suggested action of replacing the shoe by a new one. The presentation of suggested actions is often realized through the *usage of personal devices* that has been discussed in section 5.3.1. In the case of the smart museum (Piccialli and Chianese 2017) the personal device of the user is used to present the suggestions in a companion application. The museum application on the personal device of the visitor is "suggesting cultural items and fruition[s] tours" (Piccialli and Chianese 2017, p. 339). It is also able to offer alternatives if the currently approached museum room is too crowded to continue the tour. The system is guiding the user in his or her decisions through offering alternatives to the current action. An alternative method to suggest actions to the user is to *display the information right on objects*. In the case of the smart chemical storage (Kortuem et al. 2010; Strohbach et al. 2004), the containers themselves signal through status lights if the current storage situation is acceptable or if it should be rearranged in order to meet the requirements. A mixed approach is taken by the smart doormat (Hu et al. 2011) that displays short symbolic information to the user right on the surface of the doormat. If the user wants to have a more detailed explanation of the symbol he or she can use the personal device to obtain it.

Suggesting actions implies *scheduling actions of users* which means that not only the next action of the user is derived from the current situation but the IoT object is even aware of the whole process that this action is part of. The processes that the machine is utilizing to suggest actions to the user are also called workflows, routines, or programs. The machine is again guiding the user in making a decision but this time the user is lead through a chronological order of actions. This scheduling of users' actions could be observed in different scenarios: One would be to *use shared resources more efficiently* through scheduling the "messed order of the machine use among multiple users" (Lee et al. 2016, p. 366), e.g. in the case of a washing machine. This may also imply *enforcing rules*, e.g. when the machine uses authentication mechanisms to "check the present user at his/her reserved time" (Lee et al. 2016, p. 370) before allowing usage. Another example are smart construction tools that can determine "how workers are supposed to use [them] in each context and which activities ought to be done next" (Kortuem et al. 2010, p. 35). These tools are able to present the whole workflow to the user and let him or her navigate through the process steps to see past and future process steps along with the currently performed activity.

The IoT-equipped solution consisting e.g. of a washing machine and the user's personal device is aware of the steps in the process and can lead the user in following that process, e.g. reserving a washing machine, starting the washing process and collecting the laundry after the machine is done. During the process it can *actively inform the user* about the status, i.e. it is alerting the user when the status changes or further actions are required to proceed with the process. The user does not have to check regularly whether the status of the machine has changed, because the machine is notifying the user about incidents that pertain the process. The process may also be performed according to external constraints, e.g. to "alert [the user] to do this task at a specific time daily" (Valsamakis and Savidis 2017, p. 163) like measuring health data. In order to inform the user timely about suggested actions the respective IoT object needs to *constantly monitor* the status of other objects, sensors, or timers. In the patient monitoring case a central object "constantly monitors the collected patient data through agents that should react in case of anomalies detection" (Fernandes and Lucena 2015, p. 659). Often the object communicating the suggested action to the user is not the object that initially collected the status information. Personal devices and other objects that present suggestions to the user need to *cooperate with other objects* to enable the whole concept of supporting the user in the situation. The codes relating to this category will be discussed in section 5.3.3.

Most of the studies assume that the manufacturer of the IoT solution is *presetting processes* on the objects that can then be utilized by the users. The machine-readable definition of processes is a precondition for the scheduling of actions. The codes relating to this sub-category will be explained in the following and are depicted in figure 5.4. In the ambient assisted living case (Valsamakis and Savidis 2017) the authors of the case study present some important ideas about presetting: In their case the system is able to *adjust programmed routines to context*, e.g. maintaining different versions of a process depending on the day of the week. Some versions would then include a specific task but others would not. Furthermore the user can also create complete processes with the aid of simple tools, e.g. *programming routines visually* through a symbolic programming language. This approach allows for combining preset process blocks instead of using a complete process that has been predetermined by the manufacturer. If the IoT solution allows for it, the user may also *integrate objects into own processes* and that way start *building chains of information flow*. This code means that the information is passed from one object to another without the interference of the user. It will be further discussed in section 5.3.3 below. As the target user group of ambient assisted living may also include users that are not able to program their objects themselves due to disabilities, the authors also thought about enabling *programming routines remotely*. This could be done by e.g. a relative of the user or a health professional depending on the type of process that needs to be adjusted.

The suggestions mentioned so far are mainly proposals that the user may follow arbitrarily. They may enhance the experience of the user, but do not imply severe consequences if not followed. Suggesting actions however also enables *avoiding hazards*, i.e. the smart object is taking action to prevent the user from hazards. The codes relating to this category will be discussed in section 5.3.6.

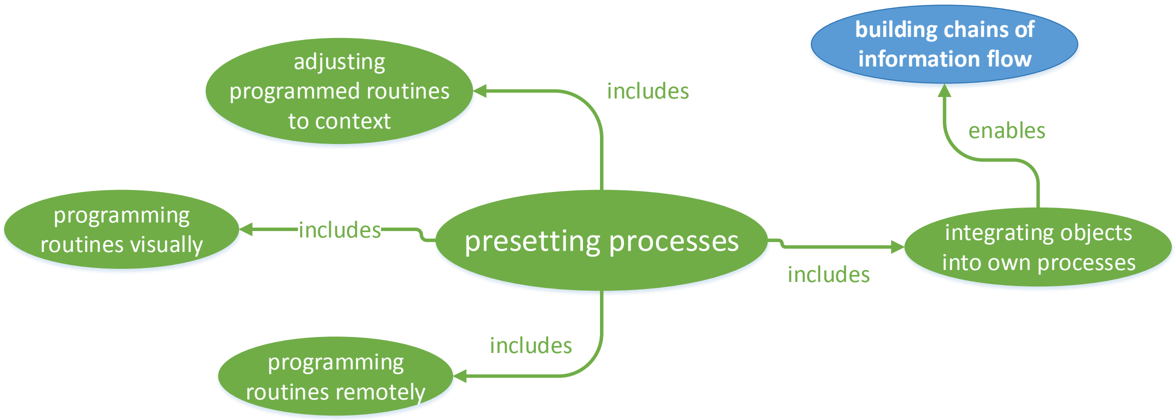

Figure 5.4 Codes relating to the sub-category *presetting tasks* (own illustration)

5.3.3 Building Chains/ Cooperating

The two codes *building chains of information flow* and *cooperating with other objects* have occurred in close proximity in the analyzed case studies. The distinction of their individual meaning is difficult as they seem to be close but not the same. They are discussed in the following together with other codes and categories relating to this category, which are also depicted in figure 5.5.

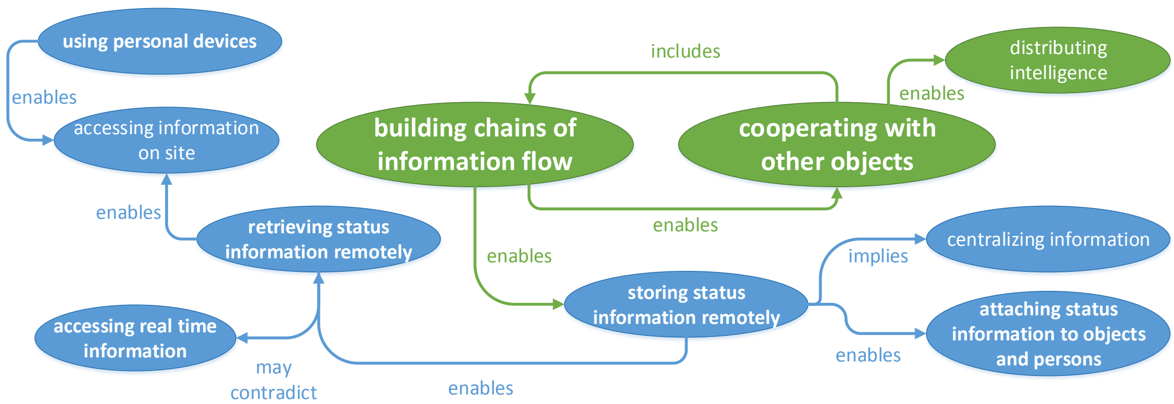

Figure 5.5 Codes relating to the category *building chains/ cooperating* (own illustration)

Building chains of information flow describes the abstract overall concept of passing information from one object to another. The individual object might only be aware of its immediate neighbors, still they form a chain starting from some information producing object, e.g. a sensor object, and ending at some information receiving unit, e.g. a user or a database. In the case study of Efstratiou et al. (2007) about smart construction tools the personal device of the construction workers is communicating with the construction tool as well as with some relay station in the construction site vehicle that is in the end forwarding information to some central database. They build a chain of information flow from the sensor in the construction tool to the user and the database that are both receiving the information forwarded.

Cooperating with other objects in turn is a more general code when it comes to the purpose of interaction among the objects involved. The purpose of chains of information flow is to forward information from one point to another. The purpose of a cooperation of objects could also be to create an aggregation of their individual capabilities. In the smart storage of chemicals case the "detection of [dangerous] situations requires reasoning across all artefacts present in a particular situation" (Strohbach et al. 2004, p. 3). Every single chemical container would not be able to assess whether a storage situation is dangerous or not due to its limited knowledge, i.e. it only knows its own content. However through cooperation with the surrounding containers it is able to detect a dangerous situation. This decision process is based on facts in a knowledge base about which chemicals can be stored next to each other that is present in each of the smart chemical containers. However to come to a decision this general facts need to be combined with information about the surrounding containers' content that is transmitted through forwarding of information. That way the codes are interlinked.

The cooperation of objects enables *distributing intelligence* among them. Every single object is then adding its own knowledge to an overall result or makes decisions individually on the basis of information forwarded by other objects. In both cases there is no central authority that assumes the responsibility for decisions. Ramirez et al. (2017) even argue that their is a "paradigm in IoT of having distributed intelligence between the different devices" (Ramirez et al. 2017, p. 114). In the chemical storage case the containers "act as a collective system" although the "reasoning process 'jumps' from one smart object to the next" (Kortuem et al. 2010, p. 35).

In a more classical scenario building chains of information flow enables *storing status information remotely*. A client object could forward information that it either gained from own sensing or that it was reading from e.g. an object to some kind of server for the purpose of permanent storage of the information. The codes relating to this category will be discussed further in section 5.3.4. Remote storage of information can possibly lead to *centralizing information*, which means that information pertaining objects or persons is stored at one central place within the network. Other objects can read or update this information through their network interfaces. The idea of centralization is to some extend contrary to the idea of distributing intelligence presented above. Both approaches have been identified in the case studies and both serve the goal of making information available within a group of objects. As the information stored remotely is often pertaining objects or persons this is referring to the category *attaching status information* that will be discussed in section 5.3.7.

The client object, possibly a *personal device*, could vice versa also ask about the status of an object, device, or person. If the status information can then be obtained without the physical presence of the respective object or person, the client object is *retrieving the status information remotely*. The possibility to retrieve information through a network connection together with the use of portable objects enables *accessing information on site*, wherever the user may be without leaving the current context. In the case of the smart doormat (Hu et al. 2011) the user is able to retrieve simple information about other objects in the house right before leaving it, e.g. whether the light is still on in another room. Optionally the doormat can also forward more detailed information to the user's personal device. Codes relating to the category of *using personal devices* have already been discussed above in section 5.3.1, the ones relating to the category of *retrieving information remotely* will be discussed in section 5.3.4. It should be remarked that the remote storage and retrieval of information by means of a central storage object may be contradicting the idea of *accessing real time information*, because it might cause delays in information forwarding and allows for spreading outdated status information. This is however depending on the exact definition of "real time" in the respective case. Codes belonging to that category will be discussed in section 5.3.5.

5.3.4 Storing/ Retrieving Status Remotely

The two codes *storing status information remotely* and *retrieving status information remotely* both deal with information that represent the status of an object or person. This information is communicated through networking interfaces, often by means of wireless networks. This enables the physical separation of the communicating objects; the status information is available remotely. Codes and other categories relating to this category are discussed in the following and are also depicted in figure 5.6.

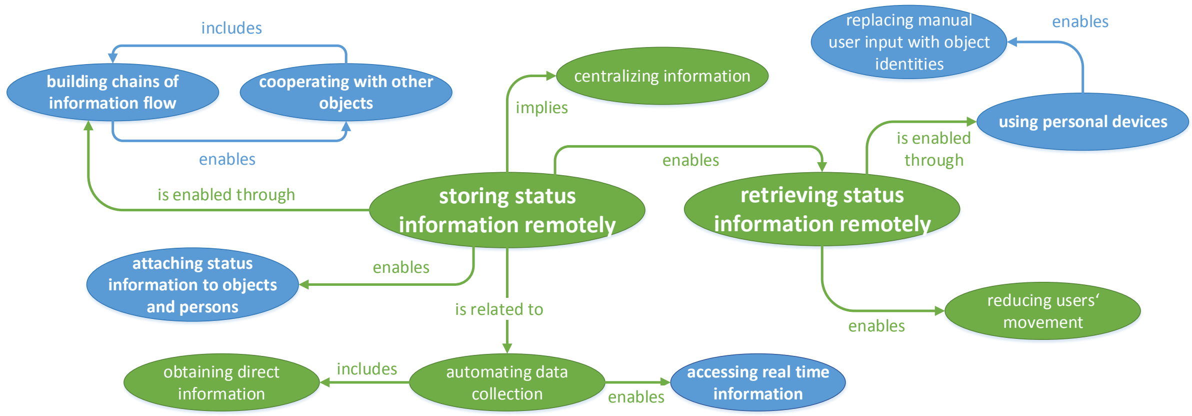

Figure 5.6 Codes relating to the category *storing/ retrieving status remotely* (own illustration)

When a object is *storing status information remotely* it is first obtaining the information from a source. This could be own sensor data as in the room management case study (Kranz et al. 2010): A smart magnetic board at a room's door is used to stick a status token to a predefined position on the board. Every position on the board represents a status of the respective room, e.g. "occupied" or "empty". In order to make this status available to other objects, "the device can detect the magnet's position and then wirelessly transmit the state to [a] component connected to a central database" (Kranz et al. 2010, p. 50). Another option would be that the object is obtaining status information from an external source, e.g. an external sensor that is sending sensor information to the object. In the construction tools case study "the sensor node sends the total amount of drilling time to the operative's personal device over the wireless interface" (Efstratiou et al. 2007, p. 131) each time the user interrupts usage of the drilling tool. In both cases however the object that obtained the status is *cooperating with other objects*. It is *building chains of information flow* in order to forward the information to other objects. Codes belonging to this category have been discussed above in section 5.3.3.

Vice versa an IoT object is able to *retrieve status information remotely*. It can either obtain that information immediately from the object that collected it, or it can obtain information that has been forwarded and potentially also has been stored by an intermediary object. In the smart laundry case (Lee et al. 2016) the user's personal device is obtaining status information immediately from the washing machine without the use of an intermediary. However in the patient management case (Fernandes and Lucena 2015) the patient's health data is stored in a central database. Other objects that want to obtain health information about the patient are retrieving it from that database. In such cases the central storage object implies *centralizing information* as has been mentioned already in section 5.3.3. Any kind of "cloud database service" (Fernandes and Lucena 2015, p. 659), "central database" (Kranz et al. 2010, p. 50), or "back-end database" (Efstratiou et al. 2007, p. 128) used for storage is having that impact.

Related to the remote storage of information is the idea of *automating data collection*. It comprises that data is now digitally available from the object that measured it. Health data, like blood glucose levels in the ambient assisted living case (Valsamakis and Savidis 2017) for instance, are immediately forwarded from the measuring object to the object that stores them for later reference. This *obtaining of direct information* is superseding manual user input that has been used before to transfer measurement data from the measuring object to a computerized record system. When using manual input records "must be estimated by operatives, most often hours after work has been completed" (Efstratiou et al. 2007, p. 128). In many cases this error-prone method of gathering data "raises serious concerns with respect to completeness, accuracy and consistency of captured data" (Efstratiou et al. 2007, p. 128). As a result, automating data collection and obtaining direct measurement data from objects is also increasing precision and reliability of captured data. The automated data collection may additionally allow for *accessing real time information*, which will be discussed in section 5.3.5.

Another improvement that the remote retrieval of information is enabling is *reducing users' movement*. Usually users would need to be physically present at objects in order to obtain information about their status. In the washing machine case (Lee et al. 2016) this means that users would need to check regularly whether the machine has finished their laundry and therefore also walk to the machine. This regular checks can be replaced when it is possible to retrieve the status of the machine remotely. Then the user's personal device might also alert him or her whenever the status of the machine changes, as has been discussed before in section 5.3.2.

Information that is stored remotely is usually linked to an object or person through an identifier that enables retrieving it later. The identifier is used to *attach the status information to the object or person*, a category that will be discussed in section 5.3.7 below. As mentioned before in section 5.3.1, *using personal devices* for data collection is very common in the case studies. They can be e.g. used as intermediary objects that receive data from a measuring object and add the attribution to a certain object or person to the data set before forwarding it to a storage object. This workflow is performed in both the smart construction tool case (Efstratiou et al. 2007) and the ambient assisted living In the patient management case (Fernandes and Lucena 2015) the personal device is at least used for retrieving the patient's health information after scanning the patient's bracelet. This wearable identifier is *replacing manual input with object identities*, as discussed before.

5.3.5 Accessing Real Time Information

In the smart long cane case the authors are sketching the vision that "each user, by means of his or her mobile devices [...] would have access to real time information about their environment" (Ramirez et al. 2017). Publishing information in real-time means that IoT objects are collecting data with sensors and subsequently sharing it with other objects without further delay. *Accessing real time information* means that IoT objects can become aware of their surroundings on a timely basis. The information they retrieve is up-to-date. Codes and other categories relating to this category are discussed in the following and are also depicted in figure 5.7.

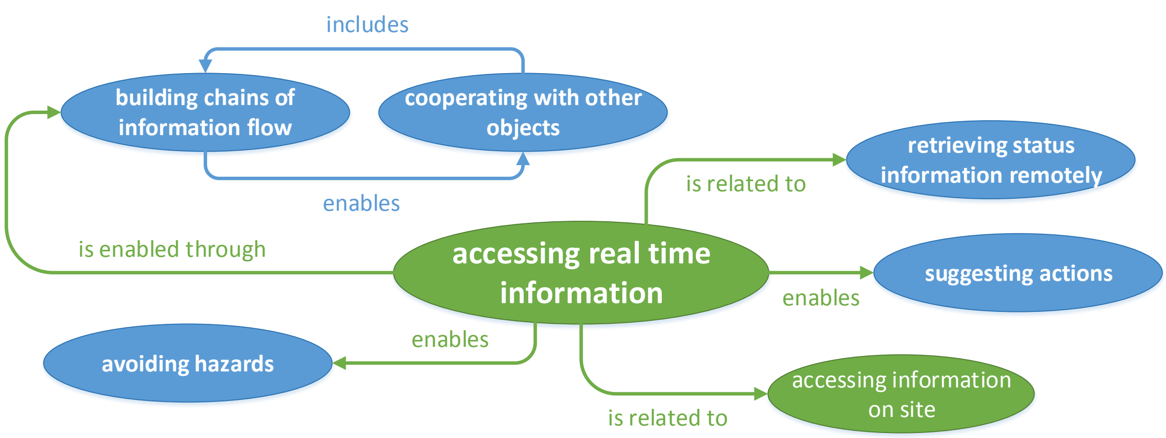

Figure 5.7 Codes relating to the category *accessing real time information* (own illustration)

Often the information that the objects are accessing might be pertaining the status of some object or device. For instance in the smart lighting case "lightning needs can be controlled and monitored online and real time" (Nobre and Tavares 2017, p. 466). This is relating to *retrieving status information remotely*, which has been discussed in section 5.3.4.

In the smart construction tool case study the authors are criticizing that "current solutions are tailored for off-line processing of data in the back office, ignoring the potential benefits for real-time information in the field" (Efstratiou et al. 2007, p. 128). Indeed, *accessing information on site*, i.e. "in the field", could be observed in combination with using real time information in the case studies. Apart from the construction tool case already mentioned, the smart doormat (Hu et al. 2011) allows the user to check the status of other objects in his or her home at that moment. The doormat is also *suggesting actions* to the user, e.g. to turn off a certain object when leaving the house. In order to do so the doormat is relying on real time information pertaining the other objects in the building.

An enabling factor of real time information forwarding are objects that are *building chains of information flow*. This can include forwarding the data to several objects like in the smart construction tool case (Efstratiou et al. 2007) where the sensing object is forwarding the important vibration data to the personal device of the worker for immediate display and alerts. At the same time this data is also forwarded by the personal device to a central database for storage and later processing. This category has already been discussed in section 5.3.3.

Real time information can help *avoiding hazards* as "hazardous situations are defined by a combination of pre-defined domain knowledge [...] and real-time observations" (Strohbach et al. 2004, p. 3). This category is going to be discussed in section 5.3.6 below.

5.3.6 Avoiding Hazards

Avoiding hazards means that IoT objects are trying to prevent their users from situations that could harm their physical integrity. In the analyzed case studies this is often done through *indicating hazardous situation*, which means that objects detect a potentially hazardous situation and communicate it to the user through some kind of interface right on the object or personal device. The user is e.g. advised to leave the situation or take appropriate action to defuse the situation. If the user is not following these advices it might have negative consequences, e.g. for the health of the user. One main motivation of the smart construction tool case (Kortuem et al. 2010) is to avoid painful diseases that result from overuse of the tools. The smart storage case (Strohbach et al. 2004) tries to prevent user from dangerous storage situations of chemicals. The authors claim that there were reasonable rules regarding the storage of chemicals already in place, however "manual processes are not always foolproof, which can lead to accidents, sometimes of disastrous proportions" (Strohbach et al. 2004, p. 2). Codes and other categories relating to this category are discussed in the following and are also depicted in figure 5.8.

In order to be able to prevent them, objects first need to *recognize hazardous situations*. They may use their sensing capabilities, e.g. measuring influences to the user's body in the case of the smart construction tool, and then use *embedded rules* to assess the situation. This means that a knowledge base is available to the object that enables it to assess whether a certain situation represented by certain input data is hazardous or not. For instance, the personal device in the smart construction tool case knows which dosage of vibration is the maximum permissible per

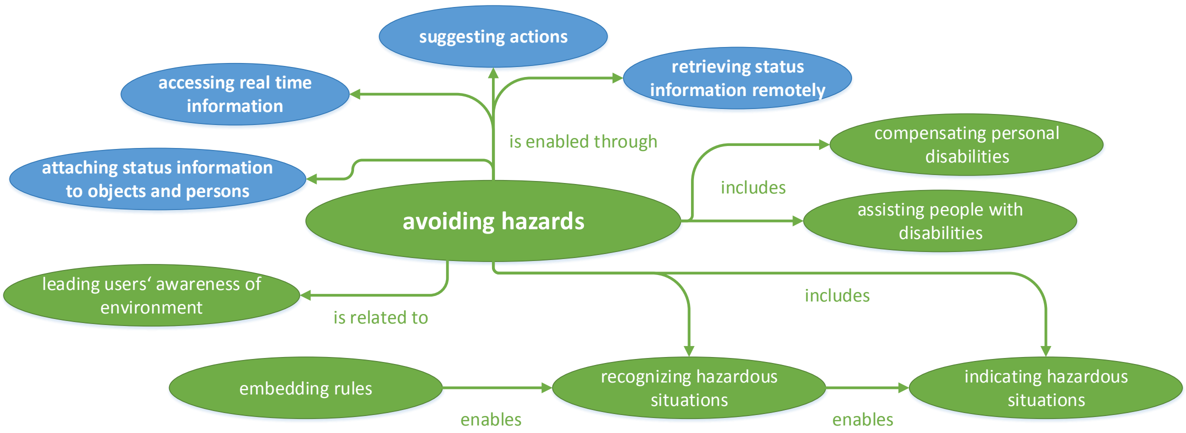

Figure 5.8 Codes relating to the category *avoiding hazards* (own illustration)

day. As mentioned before in section 5.3.5 *accessing real time information* is required to assess the situation that the user is exposed to. Only through gaining timely information about the surroundings of the user, the device is able to make a reasonable assessment of the situation he or she is in. In order to prevent dangerous situations related to other objects, e.g. in the household, the device may also *retrieve status information remotely*. For instance, in the ambient assisted living case "automated checks are made for possibly forgotten electric devices which have not been turned off (e.g. oven)" (Valsamakis and Savidis 2017, p. 166). Finally, *attaching status information* is enabling objects to link abstract information like the physical position of an object to a certain situation that the user is in. In the smart long cane case (Ramirez et al. 2017) the user's personal device is using database information about objects in the surroundings of the user additionally to the sensor data of the long cane. That way it is able to warn the user about obstacles long before they can be detected by the object itself.

In preventing hazardous situations, smart objects are often *compensating personal disabilities* to full extend or at least *assisting people with disabilities* to make their extend less severe. An example would be the smart long cane (Ramirez et al. 2017) that warns blind users about obstacles long before they could even recognize them with their regular long cane. It is also able to recognize obstacles above the waistline that the user would not be able to detect with traditional aids. It becomes clear from the chemical storage case (Strohbach et al. 2004) however that the compensated disabilities might not necessarily be permanent or even physical ones. The user could just be absent-minded in an important situation and cause a hazardous situation on accident. The smart object can cope with this negligence through *leading users' awareness of the environment*. The result of the situation assessment needs to be communicated to the user. It can be enriched with more or less specific *suggested actions* that the user should perform to cope with the situation. In the smart construction tool case (Efstratiou et al. 2007) the worker is alerted when the maximum exposure level of vibration is exceeded. The implicit suggestion to the user is that he or she should not expose themselves to more vibration that day. The smart storage solution for chemicals indicates dangerous storage situations with an "LED to visually alert users of potential safety hazards" (Strohbach et al. 2004, p. 8). That way the user is informed that the storage situation needs to be changed as soon as possible in order to comply with the regulations.

5.3.7 Attaching Status Information

One central code regarding IoT cases is pertaining *attaching status information to objects and persons*. It means that a fact regarding the status of an object or person is attached to it in form of a virtual overlay. The information can be retrieved by anyone who knows the identifier that represents the information and can access the storage object. Codes and other categories relating to this category are discussed in the following and are also depicted in figure 5.9.

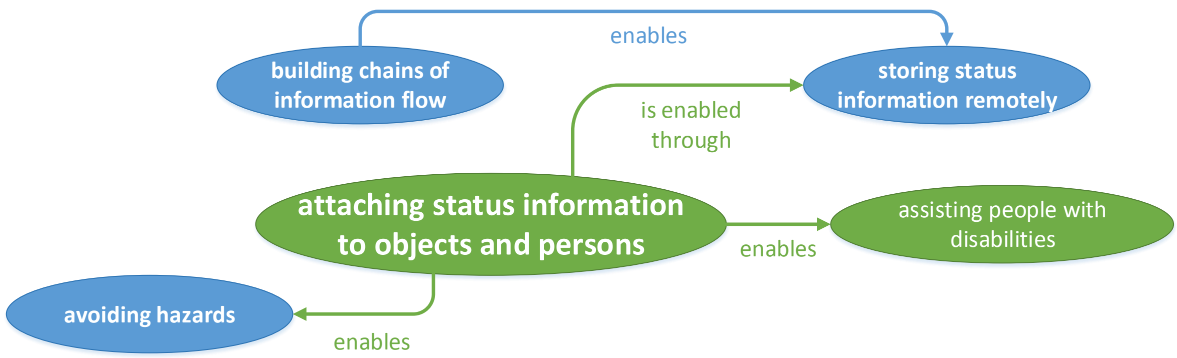

Figure 5.9 Codes relating to the category *attaching status information* (own illustration)

The storage object can be the object itself or physically attached to it, or it can be a remote storage as well. In most of the case studies analyzed, the attaching information is realized using a local identifier on the object or person and a remote storage object where the actual status information is located. In the pallet inventory case (Chen et al. 2014) the pallet is uniquely identified using an RFID tag, however the position of the pallet can be tracked in an online system which implies that the position is stored on a central object, e.g. a database. This idea of *storing status information remotely* has already been discussed in section 5.6. In order to communicate the information between the object reading the tag in the local situation and the remote storage *building chains of information flow* is necessary which has been discussed in section 5.3.3.

As discussed in section 5.3.6 above, attached status information enable *avoiding hazards* as well as *assisting people with disabilities*, which becomes especially clear in the smart long cane case (Fernandes and Lucena 2015) and the ambient assisted living case (Valsamakis and Savidis 2017).

5.3.8 Overview of the Categories

Starting from the ten most frequent codes, tentative categories of change have been compiled and presented above. Six of the initial codes have been joined pair-wise into categories. These were the pairs of *suggesting actions* and *scheduling actions of users*, *building chains of information* *flow* and *cooperating with other objects*, and *storing status information remotely* and *retrieving status information remotely*. As a result, seven tentative categories of change have been identified:

- Using personal devices
- Suggesting/ Scheduling actions
- Building chains/ Cooperating
- Storing/ Retrieving status remotely
- Accessing real time information
- Avoiding hazards
- Attaching status information

The main codes of the respective categories and their most important relations are displayed in figure 5.10. A notable aspect is the degree of interrelation among the codes and – as a result – their categories. Apart from *avoiding hazards* and *scheduling actions of users*, every code is linking to at least one other major code. However there is no recognizable hierarchy within this relations, which could point to the fact that all codes and categories are equally important for describing IoT-related business change.

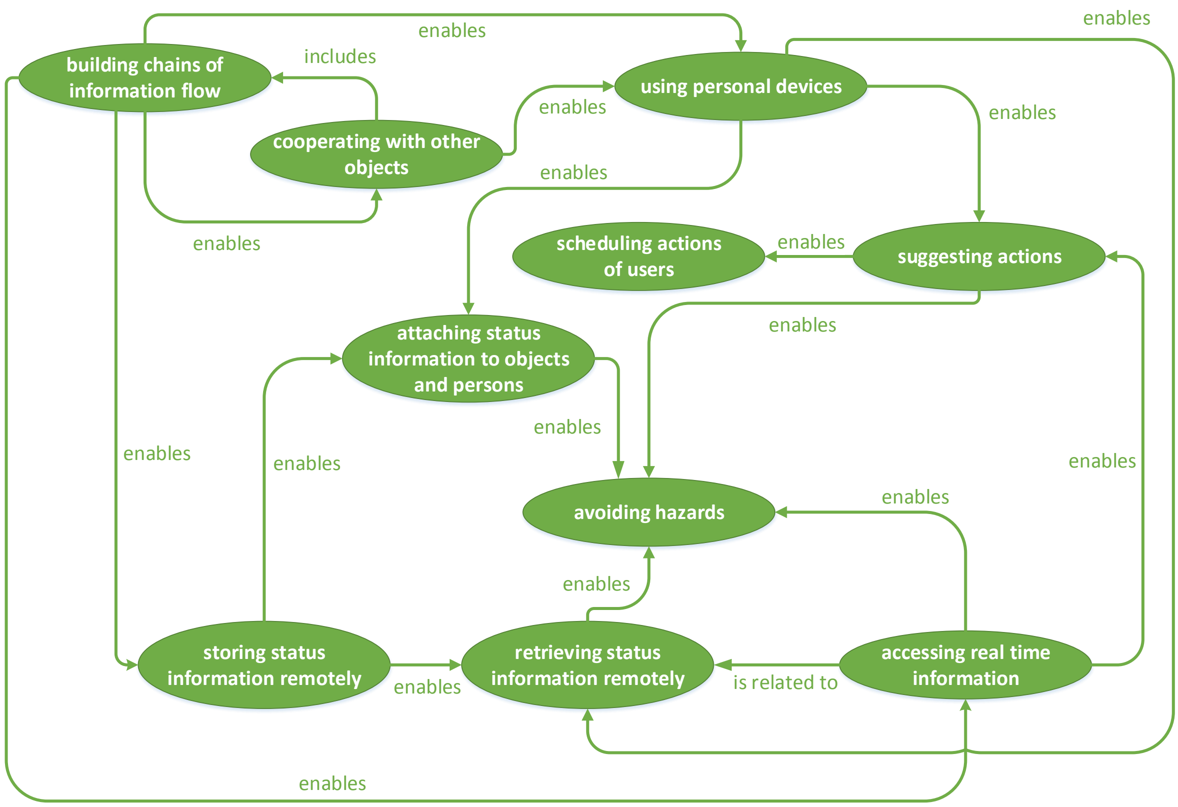

Figure 5.10 Overview of the identified categories of change (own illustration)

5.4 Discussion of Identified Changes

In the previous section the most frequent codes have been presented in the context of the analyzed case studies. Furthermore seven categories of IoT-related change have been compiled. In the following the business change displayed in the identified categories will be discussed regarding its relation to key characteristics of IoT. This will be done by means of the three perspectives of Atzori et al. (2010) and the IoT capabilities list of Mattern and Floerkemeier (2010) that have both been presented in chapter 3. Furthermore it will be argued to what extent IoT-related change differs from former technology-related change, especially the one of e-business and ERP/CRM which has been presented in chapter 4.4.

5.4.1 Relation to Key Characteristics of IoT

Table 5.2 depicts the identified categories of change in relation to the IoT characteristics that have been acquired in chapter 3. The respective relation will be discussed in the following. The columns of the semantic-oriented and the Internet-oriented perspective also feature a characteristic named *Other*. It is used to depict that further characteristics than the ones originally contained in the three perspectives model have been identified for the respective category of change. The specific characteristics are then presented in the discussion below. In the comparison of IoT definitions in chapter 3 the thing-oriented perspective has been the most nuanced one, while the semantic-oriented perspective was still missing precision in terms of specific capabilities. Such being the case, it is not surprising that most additional characteristics were found for the semantic-oriented perspective. At the same time, no further characteristics have been found for the thing-oriented perspective.

Identification. A unique identification of objects is needed for attaching status information to objects and persons. Is is also needed to access these information in real time and store and retrieve status information remotely. When a personal device is the main point of interaction of the user with other machines they need to be uniquely identifiable. Chains of information flow can also run somewhat anonymous, although it might be useful to determine who was the originator of a forwarded information or which object did ask for a cooperation. Technically speaking this could however be done with temporary identities, that do not have to be unique over time. As avoiding hazards can be done locally the category does not necessarily need identification features of IoT.

Sensing. The sensing of surroundings through sensors is needed to avoid hazards. Objects might either perform sensing themselves or rely on information sensed by other objects. In order to suggest actions objects need to be aware of the situation the user is in. The functionality of an end point that personal devices deliver could however also be achieved without sensed information. In the strict sense, objects could just forward their own status and omit sensing

Table 5.2 Relation of change categories and IoT characteristics (own illustration)

	Thing-oriented					Semantic-oriented		Internet-oriented		
	Identification	Sensing	Actuation	Localization	User interfaces	Embedded information processing	Other	Communication and cooperation	Addressability	Other
Using personal devices	•				•	•	•	•	•	•
Suggesting/ scheduling actions		•			•	•	•			
Building chains/ cooperating						•	•	•	•	
Storing/ retrieving status remotely	•					•	•	•	•	•
Accessing real time information	•				•	•	•	•	•	
Avoiding hazards		•			•	•	•			
Attaching status information	•					•	•			•

their surroundings. This would enable all kind of information attaching, forwarding, storing, and retrieving even without further sensing capabilities.

Actuation. The capability to manipulate the environment, also called actuation, is no essential requirement of the seven identified categories of change. Still, there have been three small hints on remote actuation in the case studies. They were centered around controlling light in a factory centrally (Nobre and Tavares 2017), setting the status of a magnetic board remotely (Kranz et al. 2010), and switching off home appliances from the front door when leaving the house (Hu et al. 2011). Apart from that, there have been no significant codes relating to actuation which is the reason why it has not been further developed as a category.

Localization. The capability of localization comprises that objects are aware of their own physical position. None of the identified categories necessarily requires this capability. However there are specific cases which relate to it. For instance, the smart museum case (Piccialli and Chianese 2017) relies on the position of the personal device in order to give the visitor information on nearby objects. In this case the physical location of the personal device is estimated depending on the proximity of wireless beacons. Technically speaking the personal device itself is not able to detect its physical location on its own. Location tracking assisted by Global Positioning System (GPS) has been part of the pallet tracking case (Chen et al. 2014). The related codes were not significant enough to form an own category, i.e. they did only occur in this one case and did not show interrelations to other codes.

User interfaces. In order to communicate with users, objects need the capability of user interfaces. Consequently all categories that rely on the exchange of information with users require this capability: Personal devices can only realize their functionality as an end point if they are able to communicate their results through a user interface. The same is true for suggesting or scheduling of actions and accessing real time information. Furthermore, user interfaces are a necessity to make the user aware of hazards in order to avoid them. Categories that rather comprise machine to machine communication like cooperation of objects do not necessarily require a user interface to perform their actions.

Embedded information processing. Basically all the categories rely on embedded information processing, which is realized through processors or microcontrollers. Personal devices need the information processing capabilities to fulfill their functionality as end points. They are also needed for suggesting and scheduling of actions, as well as for information forwarding and cooperation with other objects. In order to store, retrieve, attach, and access information remotely, objects need to be able to handle the information and process it further. Lastly, in order to avoid hazards objects need to be able to evaluate the information they gain using predefined rule sets.

Other semantic-oriented characteristics. Personal devices show coordinating and linking characteristics not only on a networking, but also on a semantic level. They play the role of a mediator between different IoT objects from simple sensors to complex machines. In this role, the personal devices need to be able to combine information from different sources. This is probably what (Atzori et al. 2010) mean when they attribute characteristics like interconnection or organization of information to the semantic perspective. Regarding the category *suggesting/ scheduling actions* it already has been mentioned that the respective objects may be be process-aware, i.e. be aware of the steps of a work process and be able to identify which of the steps is currently performed. In order to achieve this feature, the objects need to be able to represent the process semantically and also draw logical conclusions from it. As avoiding hazards is enabled through suggesting actions, the same characteristics are related to it on a semantic level. The reasoning that a smart object is performing may also be realized as a shared task that is carried out with support of other objects. Therefore the characteristic of reasoning is also related to the category of building chains of information flow and cooperating with other objects. When forwarding information from one object to another, IoT capabilities regarding the storage or representation of information will be needed. This is the reason why all the categories including attaching, forwarding, storing, or retrieving of status information relate to this characteristic.

Communication and cooperation. Personal devices are the main interface between the user and the smart environment. As such they rely heavily on the communication and cooperation with other objects around them. Suggesting and scheduling of actions might be realized by objects even without communicating or cooperating with other objects if one single object itself is collecting all the necessary information for a suggestion. In the case studies however most solutions offering suggestions to users relied on forwarded information from other objects. Such chains of information flow and cooperation with other objects require communication and cooperation capabilities of all involved objects. By definition, storing/ retrieving status remotely also requires communication capabilities. Accessing real time information can be realized locally in the same way mentioned for suggesting of actions. However, the original code that formed the category refers to the usage in the smart long cane case (Ramirez et al. 2017). There, the smart environment can be monitored in real time, which requires communication capabilities with this environment. The category *avoiding hazards* does not necessarily imply communication with other objects as long as all the relevant information can be obtained by the object itself as presented above for suggesting actions. Attaching status information can per se be realized locally if the object that is attaching the information to an object is also the one retrieving it later. An example would be an RFID reader device that is only storing information locally.

Addressability. When a personal device is acting as a proxy for the user it needs to interrogate objects remotely and therefore makes use of the addressability capability of IoT. This is not necessarily required for suggesting or scheduling of actions. To the contrary, in order to build chains of information flow it is necessary to remotely interrogate objects. In oder to realize a cooperation of objects it might be even necessary to configure other objects remotely. The same is true for storing and retrieving status information, as well as for accessing information in real time. The categories *avoiding hazards* and *attaching status information remotely* do not necessarily relate to addressability characteristics for the same reasons mentioned above for the capability of communication and cooperation.

Other Internet-oriented characteristics. Apart from the mentioned internet-oriented characteristics of IoT, one further characteristic was sticking out: Personal device do not always need a preconfigured network interface in order to connect to other objects. The capability of ad-hoc networking realizes instant connections to other objects, e.g. an RFID reader does not need to be preconfigured to read a tag, the user simply holds the tag close to the device. This capability is also related to the categories *storing/ retrieving status remotely* and *attaching status information*.

In summary, it can be stated that the semantic capabilities form the characteristical core when put in relation to the identified change categories of IoT. All change categories relate to multiple capabilities of this perspective. The second-most frequent relation can be seen regarding the internet-oriented perspective, especially communication, cooperation, and addressability. In the thing-oriented perspective, the relation of change categories to capabilities varies. This has already been assumed by Mattern and Floerkemeier (2010), as they state that usually only a subset of capabilities would be used due to cost and time limitations in development. The high degree of correlation between the proposed change categories and the IoT characteristics can be interpreted as an indication that the respective change may be attributed to IoT. Still it is remarkable that none of the change categories relates to the capabilities of actuation and localization. One possible explanation would be that actuation and localization are falsely included in the IoT capabilities list and do not actually relate to the IoT vision of developers. Another explanation would be that, given the relatively small number of case studies analyzed, the absence of this one specific capability is just an unfortunate coincidence.

Table 5.3 Relation of IoT change categories and former technology-related change (own illustration)

Topic	Former change	IoT change category
Closing the gaps in information flow	Enabling Role of Technology Radical vs. Incremental Change Process Characteristics E-Business / ERP / CRM	Using personal devices Suggesting/ scheduling actions Building chains/ cooperating
Increasing timeliness and information quality	E-Business / ERP / CRM	Accessing real time information Storing/ retrieving status remotely
Reducing manual work, increasing automation	Radical vs. Incremental Change IT to Speed up Status Quo E-Business / ERP / CRM	All change categories
Programming of workflows	Prognosis of Change Innovation on Deployment Quality of Work Lives	Suggesting/ scheduling actions
Integration on an object level	Process Characteristics E-Business / ERP / CRM	Storing/ retrieving status remotely Accessing real time information
Increasing on-site presence of IS	Prognosis of Change	Building chains/ cooperating Attaching status information Storing/ retrieving status remotely Accessing real time information Suggesting/ scheduling actions

5.4.2 Comparison to Former Technology-Related Changes

In the following, the identified categories of change for IoT will be discussed in relation to former technology-related change. This includes concepts of technology-related change that have been presented in chapter 4.2 as well as the specific change that is related to the last technology wave of e-business and ERP/CRM which has been presented in chapter 4.4. The comparison is summarized in table 5.3. In order to increase overview, the comparison has been sorted according to topics that relate to both identified concepts and former change.

Closing the gaps in information flow. To increase the availability of information has been a goal of IS research for a long time, which has been presented in chapter 4.2.4. Technology has been discussed as an enabler of change in organizations, e.g. to establish new work practices. Through the introduction of IoT, the reach, i.e. the range of influence, of technology is further increased. IT can get closer to both the user and the environment. The use of personal devices enables an almost permanent access to an IS during the whole everyday life of a person. Before, the user could not obtain information from the computer or an attached network whenever he or she was not close to a personal computer. This resulted in the user being isolated from the global network of information for a certain time of the day. The spatial boundedness of the stationary computing device could not be overcome just with the interconnection of computer systems in the e-business era. There still was a gap between the real world and its virtual representation.

In everyday work this gap was most significant, when the work activity was not performed at a desk anyway. For instance, in logistics workers are moving through their warehouse and need to specifically return to a computer terminal to look up information. Likewise, construction workers are typically far away from a desktop computer while they are carrying out their work. In addition, even a worker close to a computer terminal needs to interrupt current work to look up information. As has been shown in section 5.3.2, IoT enables reducing these interruptions through displaying information right on objects. While personal devices can be carried around and are in the situation with the user, displaying information on the object that is currently used by a person avoids additional breaks in the workflow caused by switching to another object. As a result, through taking relevant information right where the work activity is taking place the ubiquity of digital information is increased. This change can be interpreted as the successor of the global availability of information that the e-business and ERP / CRM technology wave brought about. It is rather an incremental change, as discussed in chapter 4.2.6, because it is maintaining the basic idea of the previous change related to e-business.

The presented change is also pertaining the collection of information. In a former technology wave, e-business reduced the number of media breaks, i.e. how often an information that has already been gathered in a systematic way needs to be captured again by a human actor and transfered to a different system. IoT is closing the gaps in the chain, i.e. it has the potential to replace remaining steps of human action within the information forwarding process by machines. The chain of digital information flow is prolonged as additionally to IS, now objects can be added to the chain. For instance, sensor information can be forwarded without an employee that needs to read it from a measurement instrument and manually enter it into a computer system. Rather the sensor itself can communicate the already digital information to the next participant in the chain of information flow. This current change as well as the former change of e-business can be related to the prognosis presented in chapter 4.2.7. Hammer (1990) envisioned that information ideally would be captured "once and at the source". This has been partially enabled by e-business, that avoided media breaks, and can finally be completely realized through IoT, that is providing the last link.

Increasing timeliness and information quality. The ERP- and CRM-related benefits presented in chapter 4.4.2 identified timely availability of reports and analyses and the increase of information quality as positive changes related to the technology use. Both can be considered true for IoT as well: Accessing real time information enables to report on object activities and status changes immediately. Retrieving those status information remotely makes them available in the company worldwide at the same time. As these information are gathered automatically without the interference of error-prone manual transfers of information, information quality will probably increase.

Reducing manual work, increasing automation. Apart from the special case of avoiding hazards, the combination of the identified IoT change categories is enabling new possibilities to replace manual work through automated processes. For instance, communication with the customer can be altered in a way that machines are taking over jobs that were originally done by an employee. Though this phenomenon is by no means a new one, the extent is of new quality. In the case study of Piccialli and Chianese (2017) a smart museum is relying on a combination of smart personal device and technically prepared rooms in order to offer many of the museum's services without further employees involved, e.g. ticketing, guided tours, or information of the visitors that the museum is closing soon. As a result, processes can be accelerated and costs can be reduced, which has already been a topic of e-business, ERP / CRM, and of the reengineering presented in chapter 4.2.5 and 4.2.6. As an example, fully automatized data collection as discussed above is cheaper and faster than manual data collection, because it makes data availably without delay and usually works without the intervention of employees.

Increased automation through IoT however also pertains the customer's side of the processes. For instance, retrieving real time status information remotely enables customers to reduce their own manual work as presented in the laundry case (Lee et al. 2016). Instead of checking the status of the washing machine themselves, they are informed by their personal device when the laundry is done. Although not explicitly stated in the change literature relating to former technology, it seems reasonable to assume that every technology implies changes for companies and their customers alike. When customers want to profit, e.g. from e-business, they need to take part in the change that it is implying.

Programming of workflows. The suggestions and scheduling of actions implies that possible actions are known to the smart object. As a result, the user can only chose actions from a set of predefined activities. This predetermines certain routines that can be carried out in work or life activities, a concept that has already been presented in chapter 4.2.8. Leavitt and Whisler (1958) predicted this limitation of creativity in business they called *programming*. The original concept of programming defines two roles of actors: specialists and regular users. The specialists are able to plan the tasks and decide upon which actions can be performed by the regular users. The regular users can only draw on the actions that have been defined by a specialist. Company-wide, standardized workflows that are implemented into IS realized this vision long before IoT, as has been presented in chapter 4.2.11 and 4.2.12. Still, IoT enables to enforce this workflows on an object level, which results in an extend of control or at least influence that has not been possible before. While analyzing the case studies it became apparent that no common idea on the distribution of power exists among the authors of the studies. For instance, (Valsamakis and Savidis 2017) argue the programming of objects by the users. They debate how users could be supported in programming own routines, e.g. through visual programming techniques. In contrast, the washing machine in the case study of (Lee et al. 2016) can only be operated in the exactly the way that the system designers intended. The works of (Linde and Linderoth 2008) discussed in chapter 4.2.11 refer to this as *programs of actions* that designers can delegate to the user or predefine themselves. It will be up to the companies implementing and adopting IoT technology to decide upon who should have the power to define or redefine work routines.

Integration on an object level. In the e-business and ERP / CRM era, more timely communication with partners and formalized, IS-supported business processes enabled closer integration of partners into the company. However, companies were mainly exchanging standardized business documents over the Internet. This was decreasing costs, but technically speaking did not introduce a new way of integrating business partners. Basically the Internet was offering a less costly way to engage in Electronic Data Interchange (EDI) (Schneider 2011, p. 9), although this decrease in costs can be seen as an important enabling factor for mass adoption of the technology. A different kind of integration is presented in the IoT case of smart lighting at the facilities of an automotive company (Nobre and Tavares 2017). The manufacturer of the light system installed in the factory is managing all the installations remotely by means of a "light as a service" model. This is enabled by the fact that the lightning needs of the facility as well as direct information from each of the 1200 fixtures can be monitored remotely. The technical solution changes the communication between the manufacturer and its client. The manufacturer can obtain unaltered information without delay, but potentially also without the control of the client.

In the case of smart construction tool of Kortuem et al. (2010) these tools are part of inter-organizational processes according to Davenport and Short (1990), as presented in chapter 4.2.7. The processes and therefore also the tools are crossing boundaries of organizations. This has been happening before in e-business, still it has a new quality as the organization might get infiltrated by objects that are potentially not in the exclusive control of their owners, i.e. the companies using them. The potential influence of manufacturers now reaches deep into the everyday processes of organizations. External partners do not just feed electronic documents into the processes of the company, they potentially influence the way objects like industrial machines work. This poses severe questions of authority and control regarding the organization's processes. If a product only tracks the usage like the smart shoe in the case study of Nobre and Tavares (2017), it is merely an issue of classical data privacy. It might be aggravated by the fact that data collection is now more ubiquitous and harder to inhibit by the customer. IoT solutions that allow for more interaction or even act by themselves however might be completely altered by a software update of the manufacturer without the customer's consent being necessary. As Amor (2002) was predicting in his vision of e-business development, the interchange is now happening on an object level. The consequences he mentioned are now becoming true for IoT: Applications are transparent, i.e. users do not know "where the answer to their problems came from" (Amor 2002, p. xxxvi).

Increasing on-site presence of IS. Along with closing the gaps in information flow through IoT come changes that pertain the presence of IS in work activities. The fact that IS can be accessed even without switching to a fixed, dedicated computing device enables a new way of involving retrieval and gathering of data into work practices. As presented in chapter 4.2.8, (Hammer 1990) suggests principles of reengineering business processes. Interestingly enough, all of them relate to identified IoT change categories.

In general, the author advises that splitting of work should be avoided. Particularly information-processing should not be performed by another person, but integrated into the work that actually produces the new information. Furthermore, decision should be made on-site where work is performed, instead of being passed along in the hierarchy. IoT is enabling this integrated information processing through building chains of information flow and attaching status information to objects and persons. Objects themselves can forward relevant information that should be processed further, which frees the user from leaving the current work activity just to document relevant information. Furthermore the information can be immediately linked to the right object or person which means that information processing is performed in the situation without further delay. IoT enables that all information needed to make a decision are available on-site, e.g. by means of retrieving status information remotely. That way, decisions can be made right in the work situation as suggested by Hammer (1990).

The author is also suggesting to treat resources as though they were centralized even when they are actually geographically dispersed. This implies that resources can be made available just-in-time with the help of careful planning, e.g. supported by an ERP system. Accessing real time information as well as storing and retrieving status information remotely allows for using information about objects as if they were actually present, no matter where the user currently is located. The change category of cooperating with objects even allows for performing actions with objects. The user may just instruct the remote object to perform an action in place of him or her. That way, IoT is contributing to the on-site presence of dispersed resources. Another suggestion regarding dispersed actors is that parallel activities should be linked, e.g. through communication, instead of waiting until the end to integrate the work results. The same change categories that enable the work with dispersed resources also supports the work with dispersed actors. As a last point, Hammer (1990) suggested that control of employees' decisions should be realized through the work process. This was intended to reduce the need for supervising employees that are just checking that other employees are doing their work right. The suggestion and scheduling of actions realizes the control that the author was imagining by means of smart objects.

In summary, the identified change categories of IoT can be related to several concepts of technology-related organizational change. Furthermore they can be related to a great majority of the changes related to the e-business and ERP / CRM technology wave. Still, in none of the cases IoT is just reproducing the same change that former technology brought about. Rather it is either fulfilling the original idea to a greater extend or integrating it further into the work practice of the user. The change category *avoiding hazards* could not be related to any former concept of change. A possible explanation would be that it is too specific to be considered on the abstract level of organizational change literature. Another explanation would be that avoiding hazards in everyday work has not been possible for IS before the introduction of IoT because they were lacking the necessary physical components to engage in users' routines.

6 A Model to Visualize Business Change Related to IoT

The previous chapter identified business change related to the introduction of IoT. It ended with a preliminary categorization of IoT-related change, that has been discussed regarding the relation to key characteristics of IoT. Furthermore the change categories have been compared to topics from organizational change theory and to former technology-related change. In the following, a classification of change is elaborated on the basis of the identified change categories. Subsequently, the classification will be visualized in a comprehensive model of IoT-related business change.

6.1 Classification of IoT-Related Business Change

In order to highlight the key themes of business change related to IoT and make the insights of the analysis more accessible, a classification of change is presented in the following. It is gained by relating the change categories identified in chapter 5 to classification criteria from organizational change literature presented in chapter 4.2 and IoT characteristics presented in chapter 3.

Intentionality of changes. The application of technology in organizational context might cause unwanted side effects apart from its intended purpose, which has been discussed in chapter 4.2.1. All of the identified change categories relate to intended changes, which might be caused by the fact that the authors of the analyzed studies are often also the developers of the IoT applications under study. Therefore they might have a biased view on the implications of their own applications. Furthermore they might mainly highlight the positive aspects of change related to their new invention. A notable exception is the case study of Efstratiou et al. (2007) that is reporting also on negative experiences with their prototypes in great detail. Construction site workers using smart tools in the study complained that certain form factors of vibration sensors that were mounted around their wrist "gave them a feeling that they are being monitored on whatever they do" (Efstratiou et al. 2007, p. 137). The researchers put effort in reducing this feeling of employees by using more convenient and unobtrusive form factors for their personal sensing devices so they could "relate better with the particular device" (Efstratiou et al. 2007, p. 137). Still, the user evaluation points to the general topic of privacy problems raised by increased data collection. The users had the feeling of being subject to a "special purpose surveillance system" (Efstratiou et al. 2007, p. 137) of their employer. As all of the change categories share the same intentionality of changes, this feature can not be used for deriving a more elaborated classification.

Process reach and involved objects. As presented in chapter 4.2.7, processes can be classified according to their reach and the objects involved in the process. Figure 6.1 illustrates the relation of the identified change categories to the reach of the process underlying the change category and the relation to the objects involved. Most of the categories relate to both informational and physical objects. This could imply that a change related to IoT can be expected in processes involving either kind of objects. Furthermore it refers to a characteristical feature of IoT to closely combine physical objects with informational objects, as reflected especially in the category *attaching status information*. However, some categories tend to focus more on a certain objects: *Accessing real time information* is almost completely pertaining informational objects. The respective information might be related to some physical object, however the category itself is more general and therefore has been positioned at the very top of the figure. In contrast, *using personal devices* is already focus on physical objects in its title. The fact, that users are interacting with a physical object are essential for the category. That is the reason why it has been positioned at the bottom of the figure.

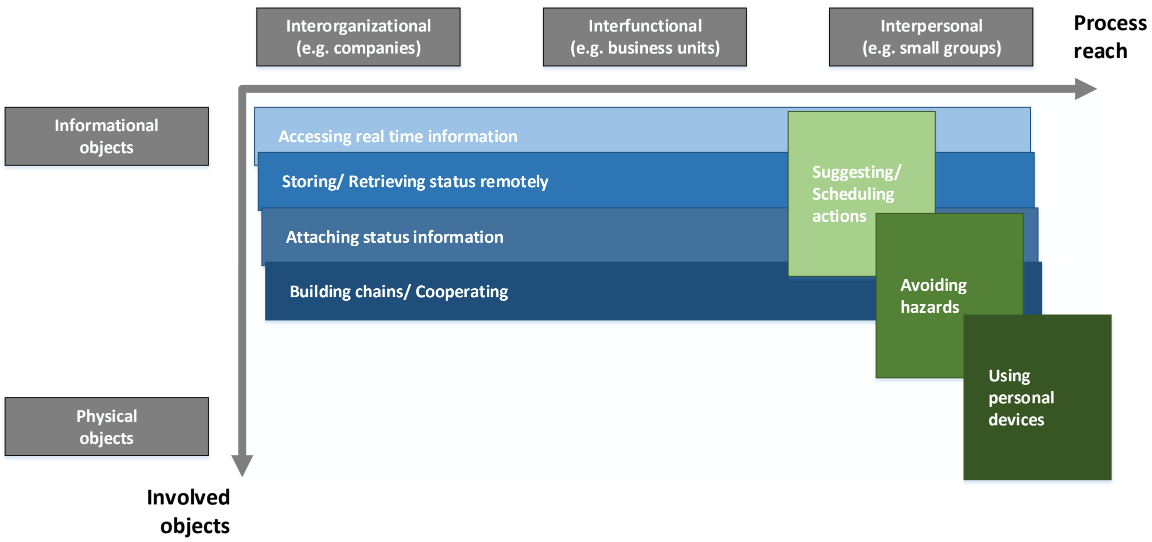

Figure 6.1 Relation of process reach, involved objects, and change categories (own illustration)

The process reach describes between which organizational entities the process takes place, respectively it describes the extent of the process's scope. As can be inferred from the figure, four of the identified change categories depicted in blue are pertaining interorganizational as well as interpersonal processes. The change they are describing is relating to processes within small groups, e.g. a member of a working group is attaching status information to an object that other members can retrieve later. Still, the change is also relating to processes among companies, e.g. one company is attaching information to an object that is transported to another company which is retrieving the information later. Three of the identified change categories depicted in green do only relate to interpersonal processes. For instance, suggesting and scheduling of actions is usually only pertaining processes that an employee is performing immediately within his or her work area.

As a result, two groups of change categories can be identified: The first group is consisting of the categories *Accessing real time information*, *Storing/ Retrieving status remotely*, *Attaching status* *information*, and *Building chains/ Cooperating*. It is the one that is pertaining all kinds of processes, but does focus predominantly on the informational aspect of objects involved in the process. The second group is consisting of the categories *Suggesting/ Scheduling actions*, *Avoiding hazards*, and *Using personal devices*. Categories of that group pertain only interpersonal processes. Their involvement with objects spreads from informational to physical objects.

IoT Characteristics. The preliminary categories of IoT-related change have been related to characteristics of IoT in chapter 5.4. When comparing the two groups of change categories regarding their relation to the characteristics, it becomes apparent that each group as a whole slightly tends to either thing-oriented or Internet-oriented characteristics of IoT, while at the same time sharing the semantic-oriented characteristics. Interestingly, the blue group which is relating to the wider scope of processes and the informational aspect of objects, is more relating to the Internet-oriented characteristics. The green group that has been more focused on interpersonal processes and both aspects of objects, is relating more to the thing-oriented characteristics. It should be noted however that the figure also shows two special cases: The categories *using personal devices* and *accessing real time information* relate to all of the characteristics.

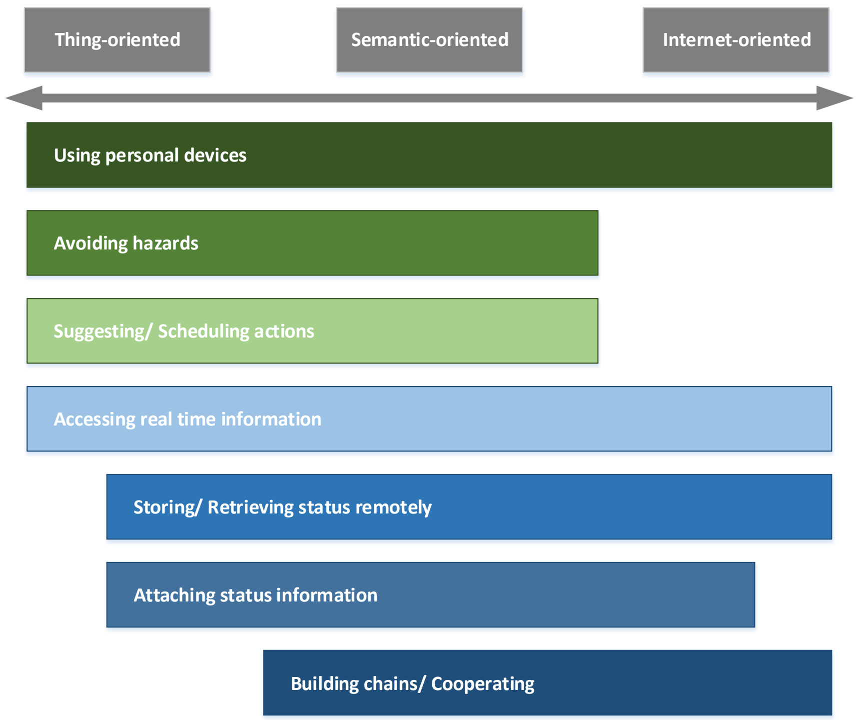

Figure 6.2 Relation of IoT characteristics and change categories (own illustration)

In summary, it can be stated that the identified categories of IoT-related business change can be classified into two major groups according to their predominant characteristics. Following the codes-to-theory model for qualitative inquiry of Saldaña (2009, p. 11f.) the groups will be called *themes* as they generalize several categories each. The two overarching themes of change result from the interpretative act of the author of this work to identify common features within the categories. The first theme is named *Ubiquitous Information*. The included categories have been classified as pertaining all kinds of processes from interpersonal to interorganizational. Furthermore the focus of the theme lies on informational objects. Regarding IoT characteristics, the categories of the first theme relate more to the Internet-oriented side of the spectrum. This focus on communication of information across all borders of companies, business units, or working groups establishes the name of the theme.

Theme 1: Ubiquitous Information

- Accessing real time information
- Storing/ Retrieving status remotely
- Attaching status information
- Building chains/ Cooperating

The second theme is named *Personal Smart Things*. The included categories have been classified as pertaining only interpersonal processes. The focus of the theme lies on informational as well as physical objects. When comparing the second theme with the first one, the categories of the second theme relate more to the thing-oriented side of the IoT characteristics. Again, the name is derived from the focus on interpersonal processes and things, that combine informational and physical aspects – smart things, that have been presented in chapter 3.

Theme 2: Personal Smart Things

- Suggesting/ Scheduling actions
- Avoiding hazards
- Using personal devices

6.2 Visualization of IoT-Related Business Change

After presenting a thematic classification of the identified change categories in the previous section, the main findings of this work are now integrated into a comprehensive model in the following. This models serves the purpose of visualizing and reducing the observations made to the main aspects. It aims at making the key themes more accessible to researchers and practitioners alike. In doing so it also summarizes the main findings contributing to the overall research aim of this work. The final model, which is depicted in figure 6.3, includes four main aspects discussed within this work so far: IoT characteristics, IoT business change themes, IoT business change categories, and involved objects. In the following, the model is explained in more detail by reference to these four aspects.

IoT Characteristics. The second row from the top of the model is displaying three characteristics of IoT. In the course of this work, typical IoT characteristics have been presented first in chapter 3, based on the works of Atzori et al. (2010) and Mattern and Floerkemeier (2010). It was shown that the capabilities list of Mattern and Floerkemeier (2010) could be integrated with the three perspectives of Atzori et al. (2010). This condensed tool has then been used to analyze identified categories of IoT-related business change in chapter 5.4.1. As stated in the former section 6.1, the three perspectives proved to be useful in deriving a classification into themes from the analysis of change categories. Therefore the three perspectives have been included into the model serving as top characteristics. It should be kept in mind though that these top characteristics are representing the more detailed characteristics, that were first derived from the capabilities list of Mattern and Floerkemeier (2010) and later on extended by own observations in chapter 5.4.1.

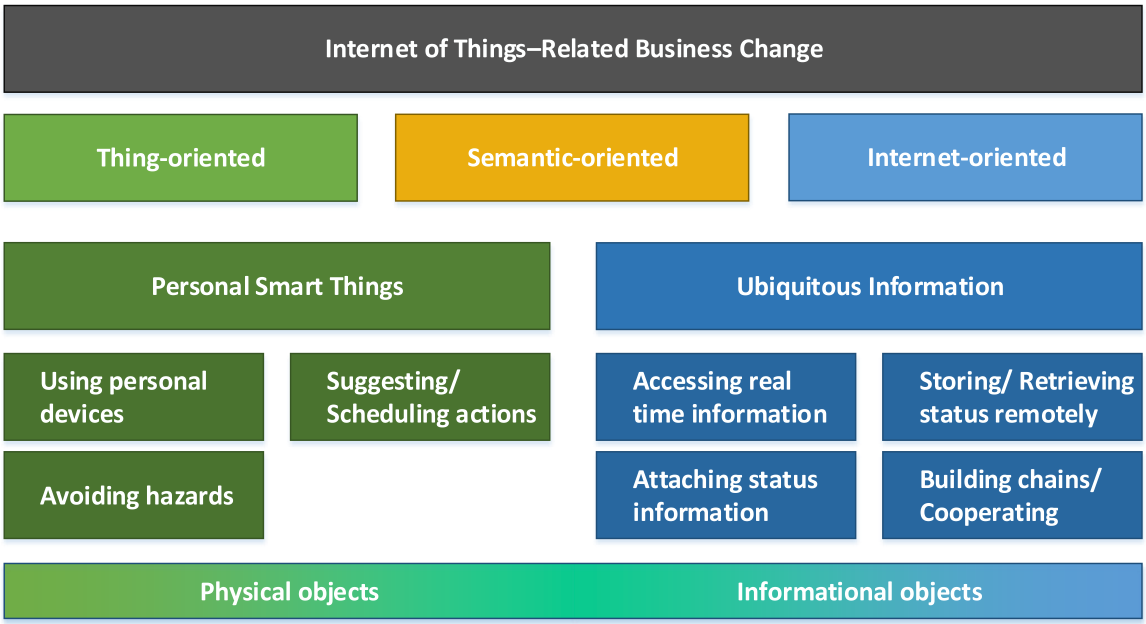

Figure 6.3 Comprehensive model of IoT-related business change (own illustration)

IoT Business Change Themes. In the third row of the model, the two themes of IoT-related business change are presented. They have been gained during the course of the previous section 6.1 by relating the seven categories of change identified within chapter 5 to classification criteria from organizational change literature and characteristics of IoT. In the model, the themes serve the purpose of clustering the seven change categories into two groups. For that reason, they are depicted like headlines of the subjacent categories. As presented in the previous section, the categories belonging to one theme tend to relate to either thing-oriented characteristics or Internet-oriented characteristics for the greater part. The themes have been colored accordingly to match the color of one of these two top characteristics. As has been already stated in chapter 5.4.1 and in the previous section, this does explicitly not exclude their relation to the semantic-oriented characteristics. Quite the opposite, both themes and all of their associated categories relate to them. Consequently, the semantic-oriented characteristics have been arranged centrally to emphasize their major role in the model.

IoT Business Change Categories. The largest part of the model is assigned to the depiction of the categories of IoT-related change. The categories have been elaborated from codes used during the case study analysis conducted in chapter 5. As the change categories form the basis of the subsequent analysis presented in the chapters 5.4 and 6.1, they are positioned on the bottom of the model. They are each presented in the color of their higher level theme, which is referring to the IoT characteristics they are most relating to – either thing-oriented or Internet-oriented characteristics. Again, this does not exclude the semantics-oriented characteristics in their relation to the change categories. Rather every category relates to semantic-oriented characteristics of IoT as has been discussed in chapter 5.4.1.

Involved Objects. On the bottom of the model, the range of objects involved in IoT-related business change is presented. As has been argued in the previous section 6.1 on classification, the categories of the two themes differ regarding the objects they are relating to. While the categories of *Personal Smart Things* relate to informational and physical objects alike, the categories associated to *Ubiquitous Information* tend to relate more to informational objects. This is depicted symbolically in the model, which aligns the physical objects on the side of *Personal Smart Things* and the informational objects on the side of *Ubiquitous Information*. The color gradient connecting both types of objects represents the fact that still there is no exact correlation between categories and objects; in terms of IoT the objects form a continuum.

Altogether, the model summarizes the main findings of the former chapters in one visualization. It is intended to reduce the complexity of the findings while giving an overview of topics covered within this work. Each part of the model and each item included in these parts refers to more detailed findings as has been presented above. Therefore the parts of the model can be mainly considered to be references and the model as a whole to be a mnemonic device. The presentation of the comprehensive model of IoT-related business change concludes this work.

7 Conclusion

The aim of this research has been to investigate IoT-related change by identifying and classifying different change types. In the beginning of this work, the research aim has been split up into three major research steps, which are reflected in the three ROs presented in chapter 1.2. All three objectives have been achieved during the course of this work. In the following, the research findings of every research step are summarized. Subsequently, limitations of this research work are discussed. The chapter concludes with a short argument on the implications that the findings of this work have for research and practice.

7.1 Research Findings

First, the work identified concepts of technology-related change in business context by means of a literature review. This research step has been presented in detail in chapter 4. A total number of 19 publications out of 150 search results have been selected for that purpose. The selected publications have been reviewed for concepts of organizational change related to the introduction of technology, resulting in an overview of 24 concepts. The concepts have been discussed regarding the different views expressed by the authors of the publications reviewed. It has been stated that the philosophic stances associated with organizational change research slightly changed over time. One notable finding is the remarkable dominance of determinism until the year 1990. Apart from that however all of the concepts seemed to be constantly involved in the academic debate within the fifty years of research that has been reviewed. In order to be able to compare IoT-related change with former technology-related change, the chapter concluded with a summary of organizational change related to ERP, CRM, and e-business. It was stated that the main topics of this era have been global availability of information, increased integration of partners into own business processes, and efficiency-related topics, e.g. reduced manual work and an increased degree of automation.

In the second research step, this work investigated how businesses change when IoT is introduced by means of a meta-analysis of case studies. This research step has been presented in detail in chapter 5. In order to identify types of business change related to an introduction of IoT, thirteen academic case studies have been analyzed. The case studies have been selected out of one hundred academic publications using a common set of criteria. They have been analyzed using a qualitative and exploratory coding approach embedded into a grounded theory methodology. In a cyclic process of coding and academic memo writing, ten most frequent codes have been identified. These codes have been elaborated into seven categories of IoT-related change in business context while defining the main codes of every category and their relation to other codes and categories. It was shown that the identified categories are interlinked and as a result it was argued that all of the categories and associated codes are equally important for describing business change related to IoT.

Subsequently, the identified categories of change have been discussed regarding two aspects: their relation to key characteristics of IoT and their relation to former technology-related change. As presented in chapter 3, an own set of IoT characteristics has been compiled on the basis of the works of Atzori et al. (2010) and Mattern and Floerkemeier (2010). It was shown, that the semantic characteristics form the core of IoT as they are related to all of the identified change categories. The second-most frequent relation has been identified regarding the Internet-oriented characteristics. It has been argued that the varying relation to thing-oriented characteristics could be a result of differing application scenarios. The high degree of correlation that has been identified between IoT and the categories of change has been interpreted as an indication that the proposed change categories are fitting IoT-related business change and are typical for this technology.

Regarding the relation to former technology-related change, it was noted that the identified change categories take up a great majority of the ideas that have been already present in the e-business and ERP / CRM technology wave. Common topics that have been recognized include closing gaps in businesses' information flow, increasing timeliness and information quality, reducing manual work through increased automation, programming of workflows, integration with business partners on an object level, and increasing on-site presence of IS. All of these topics are however not only repeated by IoT in the same manner as before. Rather IoT is developing and extending these topics by adding new aspects to the topic while maintaining the direction of change. Almost all of the seven change categories have been involved in multiple topics, which might indicate that IoT-related business change can not be easily divided into completely independent parts. The change category *avoiding hazards* has been identified as the only category that did not correspond to former technology-related change and could therefore be considered an indicator for a completely new type of change.

Finally, the work developed a model to visualize business change related to the introduction of IoT. In order to do so, a classification of IoT-related change has been developed based on the seven categories of change previously identified. The change categories have been classified into two major themes according to their predominant characteristics: The theme *Ubiquitous Information* focuses on communication of information across all borders of companies, business units, or working groups. Accordingly, it is related to all kinds of processes from interpersonal to interorganizational. It involves mainly informational objects and relates more to the Internet-oriented characteristics of IoT. The theme *Personal Smart Things* focuses on interpersonal processes that involve smart objects combining informational and physical aspects. It relates more to the thing-oriented characteristics of IoT.

As a last step, a comprehensive model of IoT-related business change has been developed in order to summarize the main findings of the work in one visualization. The model reduces the complexity of the findings while it aims at giving an overview of this work. It is referencing four main aspects of the findings in displaying the seven categories of change identified along with the corresponding two change themes. Furthermore it relates themes and categories to characteristics of IoT and the involved informational and physical objects.

7.2 Limitations

When interpreting the findings of this work, some limitations should be considered. As has already been stated in chapter 2.4, the grounded theory approach is to a great extend dependent on quality and range of the original data. Everything that is not covered in the data can not be included into the further analytic process, unless it is possible to gather specific information later in the research process. As this work is based on secondary data collected by other authors, it has not been possible to revisit sites and interviewees for follow-up research. Consequently, in comparison to criteria for grounded theory studies it is mainly the data-related aspects of this work that should be evaluated critically. Charmaz (2006, p. 182f.) presents such criteria grouped into four categories, namely credibility, originality, resonance, and usefulness. In the following, possible impacts on the findings of this work will be discussed on the basis of these criteria.

In terms of credibility the "range, number, and depth of observations contained in the data" (Charmaz 2006, p. 182) could not be influenced by the author of this work. The claims made during the analysis have been associated with the case study data that they originated from, which allows the reader to independently assess the statements. Still, it is possible that a wider range of empirical observations would have resulted in a different analysis. This work can be considered original because it is among the first research works exploring organizational change related to IoT. The analysis "provides a new conceptual rendering" (Charmaz 2006, p. 182) of the case study data and extends organizational change research in the direction of new technology.

Regarding the resonance of this work, it should be noted that there are strong hints that the categories do not reflect the full range of IoT introduction in business context. As mentioned during the relation of IoT characteristics to the identified categories of change in chapter 5.4.1, it is remarkable that none of the change categories relates to the capabilities *actuation* and *localization*. Further research of empirical cases that involve these capabilities might have resulted in further categories of change or might as well have altered existing ones. For reasons stated above, it was not possible to involve participants of the case studies into the analytic process. Therefore it can not be determined whether the developed categories and themes make sense to them or offer them deeper insights. The analysis can be considered useful as it suggests generic categories of change that transcend the specific case studies. It contributes to practical understanding of IoT change in organizations and may be used as a basis for further research.

7.3 Implications for Research

The qualitative, exploratory approach used within this work generally produces an interpretation of the real world phenomenon, not an exact reflection of it (Charmaz 2006, p. 10). As mentioned in the research design in chapter 2.4, this work should be seen as a first step into understanding organizational change related to IoT. With this in mind, at least two implications for research follow from the results of this work immediately: First, testing or verifying of the produced theory could be done subsequently, e.g. using a quantitative research design (Creswell 2008, p. 16). The suggested themes and categories of change could be tested regarding their usefulness, applicability to more IoT cases, or completeness in different business scenarios. More important however, as mentioned in the previous section, there is some evidence that points to the possible incompleteness of the categorization. Assuming that the categories are not reflecting the whole variety of change in real-world IoT business scenarios, it seems advisable to further investigate business change especially in scenarios that were missing in this work.

As a secondary result of this work, definitions of IoT characteristics have been tested regarding their practicability. The definitions were needed in order to compare the identified categories of change with characteristical features of IoT. The three perspectives on IoT visions of Atzori et al. (2010) provided a useful, abstract frame to classify characteristics in a broad sense. In order to increase precision however, verifiable characteristics were needed. For that reason, the three perspectives have been extended by the items of the capabilities list of Mattern and Floerkemeier (2010). As has been shown during chapter 5.4, the capabilities list falls short especially regarding capabilities of the semantic perspective on IoT. In order to improve future comparisons or even establish a common way to classify IoT scenarios, more effort should be put into developing a comprehensive collection of IoT characteristics.

Another gap in research has been identified as a secondary result of this work: During the classification of categories in chapter 6.1 it became apparent that current academic case studies focus mainly on positive, intentional aspects of change related to IoT. It was assumed that this fact could correlate with the circumstance that most of the authors were reporting on an IoT application that they developed themselves. This could have resulted in a biased view on organizational change that has been reported in the case studies. Future research work should aim at achieving a more neutral impression of business change related to IoT that explicitly addresses negative, unintentional aspects of change as well. This would fit the tradition of organizational change research that remarks already in early works how small technological changes "can have profound effects on job effectiveness and employment quality" (Kraut et al. 1989, p. 236).

7.4 Implications for Practice

In the beginning of this work, identifying practical implications of IoT has been stated as a main motivation to start research in the area of organizational change. Following the argumentation of Shin (2014) that a socio-technical perspective on IoT is needed in order to develop it in a way that is beneficiary to society as a whole, this work aimed at giving first insights into the change that organizations might undergo soon.

From a societal standpoint, this work can only provide a first part of the picture as has been stated in the section on limitations above. More research will be necessary to understand IoT-related change. Although the classification of change might be incomplete as of now, it still gives first hints on organizational change that can be expected. The two themes identified indicate that personal smart things will transform businesses by means of using more personal devices, suggesting and scheduling actions of their users, and trying to avoid hazards. At the same time, the availability of information in organizations will further increase to a state where information is available ubiquitously. This will ultimately enable accessing real time information about objects and persons from any place and with any object. It remains still unclear what these changes mean for every single organization, but it clearly indicated that organizational change has been transcending the cost and speed-up notion that stuck on early computerization of businesses.

Finally, it is debatable if the currently observed changes are inevitable. When following the argumentation of the emergent perspective (Markus and Robey 1988) or newer works on materiality and change (Leonardi and Barley 2008), technology and organization influence each other, which implies that technology and organizations might change each other vice versa. It is about time for organizations and society to engage in this kind of thoughts. Political as well as economic actors should participate in shaping the change companies and society will undergo. Bremer (2015) identified two possible outcomes of business change: IoT could either assist employees in carrying out their autonomous work or restrict their work by giving instructions and setting tight limits to employees' autonomy. The author states that there is no unambiguous trend yet regarding these two scenarios, although the more restrictive scenario has been favored by the research institutes in her study. At this point, organizations should reconsider the consequences of such technological interventions. They should be well-aware of the implications for their employees and customers when introducing IoT solutions in their organizations and act accordingly.

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Appendix

In the following all appendices of the work are listed in alphabetical order.

Appendix A: First Code List

access over ownership

accessing on site

accessing real time information

acting

acting as intermediary

acting remotely

alerting user

analyzing impacts

analyzing information

annoying experts

assisting

associating users with devices

augmenting reality

authenticating

automating

automating data collection

automating: different versions

avoiding hazards

centralizing information

changing environments

checking availability

checking status

communicating: among users

communicating: with other devices

communicating: with user

computing

controlling

converting usage to costs

cooperating: with devices

customizing

decentralizing

decentralizing access

decentralizing manufacturing

delivering just-in-time

detecting accidents

detecting anomalies

displaying information

distributing

distributing intelligence

ease of use

embedded electronic

embedding rules

empowering decisions

enforcing policies

enhancing artifacts

enhancing human perception

ensuring data recording

equipping with sensors

estimating

everyday objects

explaining

extending capabilities

familiarizing

forwarding information

gamify

gathering complex information

generating savings

guiding user

haptic technology

improving life

improving safety

increasing precision

increasing privacy

individualize

individualize access

integrating within work processes

interacting naturally

interacting: audio

interacting: virtual reality

interacting: with devices

interacting: with user

lacking restrictions

linking information

locating objects

lower costs

making decisions

making processes transparent

managing lifecycle

memorizing

minimize waste

minimizing effort

minimizing obstruction

mobile application

modular approach

monitoring

negotiating resources

networking

networking: ad-hoc

notify

obtaining critical information

obtaining direct information

obtaining information in advance

offering information

offering multimedia

operating autonomously

optimizing design processes

optimizing energy consumption

optional usage

ordering

personal assistant

pre-fabricating components

processing information

reacting to environment

reacting: to change

reasoning

reasoning: actions

reasoning: context

recording usage

recycling

reducing human movement

reducing uncertainty

refinding objects

relocating competences

reminding

reporting

reporting violations

representing reality

saving energy

saving environment

saving materials

saving resources

saving time

sensing

sensing: distance

sensing: environment

sensing: hazards

sensing: location

sensing: misuse

sensing: other devices

sensing: product condition

sensing: proximity

sensing: state

sensing: surroundings

sensing: use

sensing: user

sensing: vibration

sensing: weight

sharing devices

sharing economy

shifting ownership

simulating impacts

specifying tasks

staying in the background

storing information

suggesting actions

supporting human activities

supporting learning

supporting maintenance

supporting performance

tracking

tracking: consumption

tracking: health

tracking: time

user-interface

using familiar form factors

using individual devices

using more efficiently

virtual reality

visualizing information

wearable user devices

withstanding rough conditions

working out problems

Appendix B: Final Code List

access over ownership

accessing information on site

accessing real time information

acting as a proxy for the user

acting automatically according to users' location

acting remotely

activating appropriate services

actively informing the user

adapting functionality to the user

adapting interface to user

adjusting programmed routines to context

analyzing information

annoying experts

assisting

assisting people with disabilities

attaching status information to objects and persons

automating data collection

automating reporting of violations

avoiding hazards

building chains of information flow

causing privacy concerns

centralizing information

checking availability

communicating: among users

compensating personal disabilities

converting usage to costs

cooperating with other devices

crossing boundaries between organizations

decentralizing manufacturing

delivering services to the user

detecting accidents

detecting anomalies

devices acting automatically

displaying information right on objects

distributing intelligence

ease of use

embedded electronic

embedding rules

empowering decisions

enabling decisions on site

enabling statistics of usage through activity tracking

enforcing policies

enforcing rules

ensuring data recording

equipping with sensors

estimating: remaining time

everyday objects

explaining

extending capabilities

extending interaction to multiple devices

familiarizing

gamify

generating complete reports immediately

generating data casually through actions

generating savings

guiding user

improving life

increasing precision

increasing privacy

indicating hazardous situations

integrating devices into own processes

integrating within work processes

interacting naturally

interacting: audio

interacting: virtual reality

lacking restrictions

leading users' awareness of environment

locating objects

lower costs

making decisions

making devices aware of users' presence

making processes transparent

measuring influences to users' body

measuring users' physical parameters

modular approach

monitoring compliance

monitoring constantly

negotiating resources

networking: ad-hoc

obtaining critical information

obtaining direct information

offering multimedia

operating autonomously

optimizing energy consumption

optional usage

pre-fabricating components

pre-processing information for user

presetting processes

processing information on site

programming routines remotely

programming routines visually

providing an end-point

providing immediate feedback to work actions

reacting to environment

reasoning

reasoning: actions

reasoning: context

recognizing hazardous situations

recording usage

recycling

reducing users' movement

refinding objects

replacing manual user input with object identities

restructuring communication

retrieving status information remotely

ruggedizing user input devices

saving energy

saving environment

saving materials

saving resources

saving time

scheduling actions of users

sensing status information from environment

sensing: distance

sensing: location

sensing: misuse

sensing: product condition

sensing: proximity

sensing: state

sensing: surroundings

sensing: use

sensing: vibration

sensing: weight

sharing devices

sharing economy

shifting ownership

specifying tasks

staying in the background

storing information locally

storing status information remotely

suggesting actions

supporting human activities

supporting individual learning

tracking: consumption

tracking: time

using familiar form factors

using personal devices

using shared resources more efficiently

visualizing abstract information tangibly

wearable user devices

withstanding rough conditions

