Designing Business Models in the Era of Internet of Things*

Towards a Reference Framework

Stefanie Turber[1], Jan vom Brocke[2], Oliver Gassmann[3], and Elgar Fleisch[4]

[1] Chair of Innovation Management, University of St Gallen, Switzerland
stefanie.turber@unisg.ch
[2] Hilti Chair of Business Process Mgt., University of Liechtenstein, Liechtenstein
jan.vom.brocke@uni.li
[3] Chair of Innovation Management, University of St Gallen, Switzerland
oliver.gassmann@unisg.ch
[4] Chair of Information Management, ETH Zurich, Switzerland
efleisch@ethz.ch

Abstract. The increasing pervasiveness of digital technologies, also refered to as "Internet of Things" (IoT), offers a wealth of business model opportunities, which often involve an ecosystem of partners. In this context, companies are required to look at business models beyond a firm-centric lens and respond to changed dynamics. However, extant literature has not yet provided actionable approaches for business models for IoT-driven environments. Our research therefore addresses the need for a business model framework that captures the specifics of IoT-driven ecosystems. Applying an iterative design science research approach, the present paper describes (a) the methodology, (b) the requirements, (c) the design and (d) the evaluation of a business model framework that enables researchers and practitioners to visualize, analyze and design business models in the IoT context in a structured and actionable way. The identified dimensions in the framework include the value network of collaborating partners (who); sources of value creation (where); benefits from collaboration (why). Evidence from action research and multiple case studies indicates that the framework is able to depict business models in IoT.

Keywords: Internet of Things, business model, value networks, digitization, service-dominant logic, collaboration, digital ecosystem, architecture.

1 Introduction

Today companies are exposed to highly dynamic business environments, driven by rapid developments and ever-increasing pervasiveness of digital technologies.

* An earlier version of this manuscript appeared in the Proceedings of the 22nd European Conference on Information Systems as “A Business Model Type for the Internet of Things", Research in progress, S. Turber and C. Smiela.

M.C. Tremblay et al. (Eds.): DESRIST 2014, LNCS 8463, pp. 17–31, 2014.

A driving force is that digital technology gets increasingly weaved in previously non-digital products, such as bikes, clothes and everyday household appliances. This phenomenon, referred to as "Internet of Things" (IoT) [1], is expected to have a major influence on the nature of products and services, and in consequence on overarching business models (BM) [2, 3], i.e. the overarching logic of how businesses work [4].

The "Nest", a digitized thermostat for private homes, is a popular, recent example to demonstrate how IoT is changing market dynamics: Equipped with sensors and connected to the internet, the "Nest" can be controlled remotely via a mobile app and can track the energy use of a household over time. These features open up numerous opportunities for novel services and business models within an emerging ecosystem of new collaborators. A current campaign for example includes energy providers as partners to reward users, when they let their "Nest" switch off the HVAC[1] during peak times[2]. From this lens "Nest" itself serves as platform, which brings multiple partners together to (co-) create and exchange valuable services (conf. [5]).

IoT in general inspires a wealth of new business models, which frequently involve diverse partners of thereby arising cross-industry ecosystems [6, 2]. This fact requires companies to rethink their firm-centered lenses in order to stay ahead in IoT driven market environments [5]. However, many companies have difficulties to capture and tap into the unprecedented ecosystem complexity around products and services in a structured way. Burkhardt [6] generally identifies the "absence of formalized means of representations (..) to allow a structured visualization of business model" as a major research gap. We applied existing methods for business modeling in workshops with companies, and found that the important characteristics of IoT ecosystems cannot sufficiently be addressed by these methods. Such characteristics, for instance, include multi-partner collaborations on digital platforms or the customers' enhanced role as value co-creator by providing user data [7, 8].

Our research addresses the need for a business model framework in IoT-driven market environments, which recognizes the specific impact of above-mentioned digitization. We chose a design science research (DSR) approach for our study to design a "framework for IoT business models" as the intended artifact. The artifact's design requirements build upon sources of justificatory knowledge across different domains: Marketing, strategic management and information systems.

The overarching research process is guided by the method described by Peffers et al [9]. All in all, the business model framework shall provide researchers with a framework to readily analyze business models in complex, IoT driven ecosystems. Practitioners are provided with an understandable and consistent framework to depict their organization's current and envisioned business models within complex IoT ecosystems.

In the following section we begin by outlining the method and procedure of our study in more details. We then set out related work and the requirements for the intended artifact. In section 4 we explicate the design of our business model framework by describing each dimension, including a brief rationale and an illustrative real-

[1] HVAC: Heating, ventilating, air conditioning.

[2] `https://nest.com/thermostat/life-with-nest-thermostat/`

world instantiation. The next section describes aspects of the evaluation to test and improve the design, as well as insights on the performance of the proposed artifact. We conclude by outlining key features and limitations of the artifact, as well as implications and an outlook on future research.

2 Research Design

As our primary goal is to create a new artifact, we chose a design science research approach. In this paper, the artifact, which we describe as business model framework for the Internet of Things, is an approach for visualizing, envisioning and analyzing complex business models in digital market environments. Our study mostly applies the method suggested by Peffers [9] and includes six iterative activities. Table 1 provides an overview of how we applied the method in our research. The first column outlines each activity A_1 to A_6. The second column provides details about applied methods and evaluation per activity. The last column includes outcome and status.

Important is that each activity is linked with an appropriate evaluation method to reach at the intended outcome, and less visible, that activity $A_{1\text{-}6}$ rather iterative than strictly subsequent. So we iterated in particular the prototyping and evaluation activities (A_3) - the core activities of DSR - several times to continuously determine and improve the performance of the progressing artifact [10]. After several completed iterations we are approaching at the end of A_3 to continue with a cross-industry business model workshop as final proof-of-concept demonstration in A_4. At this point we see the artifact advanced to a level to share it with the wider scientific community. The present paper describes the artifact prototype prior to the proof-of-concept activity (A_4) of the research process.

3 Background

Applying a DSR approach, we build our artifact upon relevant, extant work [11], which we find in three domains:

- Information Systems (IS) research provides us with essential insights regarding the nature of digital technology and digitized objects (3.1).
- Service-dominant (S-D) logic as part of recent marketing research provides a valuable extract about new market dynamics in the light of increasing digitization (3.2).
- Business Model (BM) research provides insights into useful building blocks by a large number of previous modeling approaches for different purposes [6] (3.3).

We proceed with a compact outline of each knowledge source and extract the relevant "bites" to inform the design of our business model artifact.

Table 1. Application of DSR for developing the IoT business model artifact [9]

Activity	Method & Evaluation	Outcome
A 1 Outlining the problem situation	Method/Stimulus: Real-world BM workshops with companies revealed the difficulty to visualize, develop and analyze business models in IoT driven business environments with extant BM approaches. Evaluation: • BM workshops in various industries, e. g. heating (5/13), home security (6/13), smart lighting (6/13), mobility (8/13), industry 4.0 (8/13), smart city (11/13) etc. • Literature review, review with researchers (IS, Management sciences), interview with practictioners (strategy, C-level)	• Clear design objective: A "BM for IoT context" • Justified research gap of high relevance • Preliminary assumptions on artifact requirements Status: done (see: 1 Intro)
A 2 Analyzing extant research for ideas and definition of solution requirements	Method: • Review of extant research at the intersection of management sciences, marketing and information systems research • Review of extant business model approaches • Derivation of requirements from theory Evaluation: Cross-check w. experts and practictioners, test w. simple real-world IoT-business model instances (Nest)	• Relevant research streams identified, i.e. (1) IS: Digitized objects research; (2) BM research; (3) S-D logic • Justified artifact requirements Status: done (see: 3 Background)
A 3 Prototyping solutions & testing in practice	Method: • Prototyping by employing design principles [12] as interdisciplinary research team (IS, Strategy Management et al) • Several times: Testing and revisiting prototypes of the new artifact through 1. multiple case studies (cases: BM of startups and incumbents in the IoT context, in the smart home and smart city context specifically. 2. Action research: Business model workshops in IoT context (smart city) Evaluation: As part of each testing. Evaluation criteria equals the criteria in A5	• Validated artifact instances, in particular in smart home and smart city context Status: done (see: 4 Artifact)
A 4 Proof-of-concept demonstration of the applicability of the proposed framework	Method: • Action research: Cross-industry BM workshop with several companies, which are ecosystem partners, i.e. startups and incumbents in the overarching IoT context. Ideal: Wide range of industries represented Evaluation: • Equals evaluation in A5 • By expert and practictioners	• Validated artifact instance in the overall IoT context Status: ☐ planned in 2014
A 5 Summary evaluation	Method: • Semi-structured interviews with BM workshop participants after cross-industry workshop (A 4). • Review with experts from research and practice • Analysing Evaluation: Structured evaluation according to following sets of criteria • Set 1: to evaluate DSR process by Hevner's Guidelines • Set 2: to evaluate DSR output (artifact)	• Field tested, actionable and justified artifact, ready to use for and researchers and practicioners. Status: ☐ planned in 2014
A 6 Communication	Method: Four levels of communication • Academic conference / journal contributions (IS, Strat. Mgt) • Articles in practictioners outlet • Workshop concept to operationalize & apply the BM artifact in firms Evaluation: • Feedback of wider IS research and BM community • Feedback by practice partners	• Peer reviewed publications Status: ongoing

3.1 IS: The Nature of Digitized Objects as Nucleus of Business Models in IoT

The Internet of Things, as stated, includes the universe of products and services, which are enabled by digital technology. They are internet-connected and able to directly communicate with each other [12]. According to Yoo et al [2] the incorporation of digital material causes physical objects to adopt all characteristics of digital technology, i.e. e. they become programmable, addressable, sensible, communicable, memorable, traceable, and associable. Yoo et al [3] further theorize that all digitized objects feature a layered architecture, which includes four layers (Fig. 1): The device layer comprises hardware, which can be any kind of devices, and an operating system to control the hardware; the network layer involves both the logical transmission plus network standards, and the physical transport; the service layer features direct interaction with the users through application programs, e.g. as the user create or consume content; the content layer hosts the data, such as texts, images or meta-data like geo-time stamps.

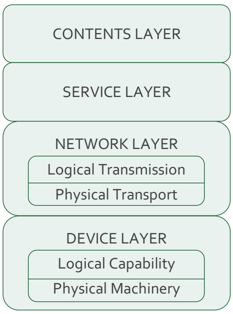

Fig. 1. The modular layered architecture of digital technology [5]

A key feature in the context of IoT business models is, that these four modular layers of digitized objects can be de-coupled. This way the digitized object represents a combination of elements across these layers, which are solely loosely interconnected through specified interfaces. "De-couplebility" of content, devices and information infrastructures allows multiple stakeholders to contribute across the four layers in an unforeseen way - interoperability provided [13, 14]. In the final analysis, the layers can be regarded as sources of value creation by multiple ecosystem partners [15, 16] and lay the foundation of business models, which distributively exist in multiple sites. For our artifact we adopt the four layers to naturally structure and organize value creation across multiple partners in digital ecosystems. We regard this as the nucleus of our business model framework in IoT.

3.2 Service-Dominant Logic Translates into Key Artifact Requirements

The increasing pervasiveness of digital technology is closely linked with the increasing ability to separate service and information from physical goods [3]. This special affordance of digital technology is a major reason for the emergence of new market dynamics and complex webs of activities between market partners. In this line, the S-D logic has evolved, as a new marketing paradigm seeking to describe the principles of these transformations [8]. As the S-D logic describes a type of market environments, which we envision our business model framework to operate, the S-D logic provides us with valuable input to define our artifact's requirements[3].

A first important cornerstone of S-D logic is the network-centric view. The focus is put on relationships between market partners and customers, which together build "value creation networks". The single firm appears, in the first place, as "organizer of value creation" [18]. In this light a firm's collaborative competence becomes a core premise for competitive advantage [19]. For our artifact we state the first requirement:

R_1: Provide a network-centric view to reflect multi-partner collaborations

Another distinctive aspect is the assumed **role of the customer**. While traditional value creation models regard firms as the only value creators due to their production and distribution activities, S-D logic ties in with the opposing literature stream, which conceives the customer as an indispensible part in the value creation process: The customer as co-creator and co-producer of value [20]. The traditional producer/consumer divide becomes consequently obsolete [21]. The reason for customers – and entities in general - to contribute to the value creation process differ [22]. For the purpose of this study we classify the reasons as monetary and non-monetary benefits and derive further requirements:

R_2: Reflect customer's role as co-producer in the value network
R_3: Reflect monetary as well as non-monetary reasons to collaborate

The concept of customer as co-creator leads also to a revised notion of offerings in S-D logic, by which offerings are no longer conceived as output of a manufacturing process. Instead, offerings are seen as input feeding into the value co-creation process, or what Normann calls "artifacts designed to more effectively enable and organize value co-production" [20]. Offerings can be composed of a variety of artifacts, such as services or goods. In abstract terms, these artifacts represent "carriers" of certain competences [20], and ideally serve all as "a service platform that enables service exchange and value co-creation" [21]. In this light, physical products are conceived as medium to provide service. The traditional distinction between goods and services is finally transcended [21].

This view on artifacts features an important parallel with Yoo et al's layer model of digital innovation (2.1): In S-D logic the "artifacts" serve as platform to create value upon, which perfectly corresponds to the layer model, by which each single layer serves as platform on which other actors can build modules in other layers [23] and with each layer can be seen as source of value creation [conf. 15].

R_4: Reflect layer architecture to structure sources of value creation

---

[3] Normann's approach is here framed as part of the S-D logic stream for proven similarities [20]

The S-D logic offers a fresh view on resources: The fact that firms always co-create value with the external environment implies that not only internal resources shall be regarded as relevant – as the prevalent resource-based view suggests [24] - yet also external resources that the firm can draw upon. Instead of an internal/external categorization, S-D logic therefore classifies resources as "operant" or "operand". The primacy is put on operant resources. They are dynamic and able to cause effects, such as knowledge, skills and technologies, and usually intangible. Operant resources are employed to act on other resources, while operand resources are acted on [21]. The latter are static and tangible, and include raw materials and goods. [7, 21]. Finally, in S-D logic a firm's external environment, its "ecosystem" of co-creating actors, is therefore seen as operant resource and important source of competitive advantage. It delivers the last requirement:

R_5: Reflect ecosystem and value network partner as operant resource

To summarize: There is a need for a business model framework featuring five solution requirements $R_{1\text{-}5}$, which can be derived from S-D logic (Table 2). These requirements guide the building process of the artifact in A_3. For the evaluation activities, the requirement serve as criteria the artifact has to meet.

Table 2. S-D logic translated into requirements for the business model artifact

S-D Logic (extract)	Requirements (R) for the artifact:
• Collaboration is essential	**R_1**: Network-centric, rather than firm-centric
• Customer and partners are operant resource and co-producer of value	**R_2**: Reflects customer as co-producer, rather than solely receiver
• Incentives to participate in the ecosystem can be monetary and non-monetary	**R_3**: Take monetary and non-monetary benefit from collaborating into account
• Artifacts (=Yoo's "layers") are source of value creation	**R_4:** Reflect four layers of digital innovation as source of value creation
• Ecosystem is operant resource	**R_5**: Explicates all (potential) IoT ecosystem participants of the external environment

3.3 Business Model Research Delivers the Main Building Blocks

So far literature does not provide a commonly acknowledged definition of "business model" and what elements it consists of [2, 28]. In general terms, as stated, the concept refers to the overarching logic of how a business works [4], or put differently, represents "a holistic picture of the business by combining factors located inside and outside the firm" [26]. A review of the extant literature by Mason [27] moreover has yet revealed a shift over time: Initially, the business models were intended to describe the roles of various network actors, especially in the narrow context of early internet and e-commerce businesses. Among them, Timmers' approach might be the most popular example [28]. As the business model concept became more widely applied beyond the context of digital businesses, the network-centric perspective has largely given way to a firm-centric view conceiving business models as undivided "property of the firm" [27]. Today, as digitization reaches all kinds of business and industries - vividly illustrated by the "Nest" example (section 1), we intend to revitalize the network centric view and tie in with early business model research [27, 28]. Not least this parallels with the first solution requirement R_1.

Moreover, we analyzed the extant business model approaches as of 1996 against the identified set of solution requirements $R_{1\text{-}5}$ as outlined in section 3.2. Our conclusion is that none of the prior studies found met all criteria for mainly two reasons: The approaches conceive business models as concept at firm level rather than network level, or are meant to explicate business models on a generic level and so are not supportive in capturing specifics of IoT ecosystems. As an exception can be seen the approach by El Sawy et al [2], emphasizing the evolutionary dimension of digital business models.

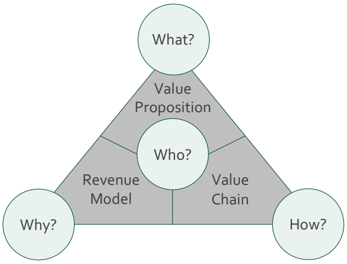

Fig. 2. Archetypal Business Model [32]

Despite the variety of business model approaches, it is noticeable that some continually recurring components exist although named differently [4, 26]: These essential elements can be summarized by the following dimensions (Fig. 2): *"Who"* defines the target customer to be addressed, *"What"* refers to the value proposition towards the customer, *"How"* addresses the value chain needed to deliver the value proposition. *"Why"* finally describes the underlying economic model to capture value. This basic approach traces back to Peter Drucker [4] and builds the foundation of business model research to this day [20]. For its archetypal character we elected this conceptualization as starting point to build a specialized business model artifact upon.

4 Artifact

In this section, we describe our artifact, a business model framework for IoT contexts, which we reached at after several iterations along the path of six activities as outlined in section 2. In general our research has led to a network-centric, 3-D framework consisting of three dimensions:

- Who: Collaborating partners who build the value network
- Where: Sources of value co-creation rooted in the layer model of digitized objects
- Why: Benefits for partners from collaborating within the value network

We explicate each dimension of the artifact including a short rationale and by referring to the requirements. We illustrate the dimension by the "Nest" case, as introduced in section 1, which also serves as instantiation in the evaluation section.

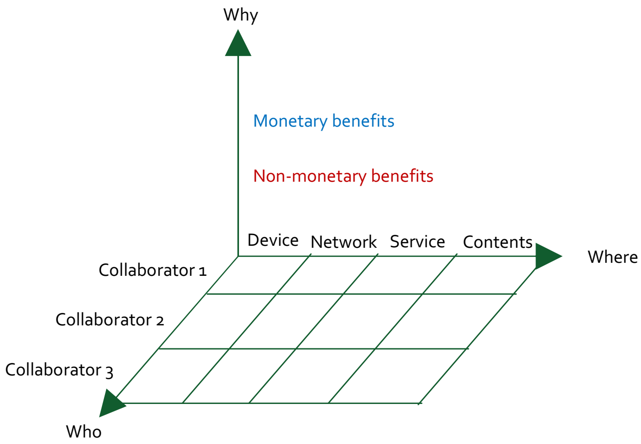

Fig. 3. Artifact: Framework design for a business model framework in the IoT context

4.1 Dimension "Who": Value Network of Collaborators

The first dimension "Who" encompasses all participants of an IoT ecosystem circling around digitized products. This includes partners, customers and all remaining stakeholders, which we refer to as "collaborators" in a wider sense and which are listed one by one. They can be specified at the intended level of abstraction.

Rationale: The explicit itemizing of all participants reflects the service-dominant logic's view that a company's external environment represents an "operant resource" offering the inherent opportunity for each participant to co-create value with other external participants as collaborators [19]. Moreover, customers are listed together with other collaborators on a single dimension, which conveys the philosophy, that value is always co-created with the customer, often even co-produced, especially in the digital context [7]. A distinction between partners and customers reflected by different dimensions was therefore redundant. *Requirements considered:* R_1, R_2, R_5.

Instantiation "Nest": In the "Nest" case the collaborating partners, i.e. value creators, are the following: (1) Nest Labs, a company which provides home owners with the "Nest", i.e. a learning thermostat plus an app, to remotely control the device (2) The "Nest" user, who contributes first in a monetary way by purchasing the "Nest" and later by using it as "Nest" feedbacks real-time data about the user's heating habits to Nest Labs (data layer). Nest Labs processes the data to customize the "Nest", i.e. adjusts it to the user's habits, to increase the overall user experience. So far (1) and (2) build a bilateral relationship. As Nest “owns” valuable data due to this relationship, also other partners are interested to collaborate and enhance the value-creation network: (3) Energy providers, who reward Nest users based on individual consumption data (data layer). E.g. if users run their “Nest” in the "rush hour reward" mode, so that the HVAC gets switched off during peak times. (4) Finally Google, who has recently joined the ecosystem by acquiring Nest Labs. Google’s contribution is not clear at this point. It is assumed they are enabled to offer new services by access to behavioral data beyond the Web. In our artifact, all four collaborators are listed one by one on the dimension "Who". Depending on the desired level of abstraction the collaborators can be displayed abstract as "Nest users in California” and "Energy companies" or more precisely, such as “Green Mountain Energy Ltd" and "Nest users in San Francisco, CA 94104”[4]

4.2 Dimension "Where": Sources of Value Creation

The dimension "Where" features the four-layered modular architecture of digitized products, which includes the device, connectivity, services and contents layer (3.1). Each layer represents a distinct source of opportunities for collaborators to contribute to the value creation process [15, 16].

Rationale: We exposed the four-layer architecture in the artifact by an extra dimension, as the nucleus of business models in the IoT context (3.1). The layers naturally structure the collaborators according to their kind of contribution in the value creating process. Another benefit is, that the four layers are able to depict "co-opetition" aspects within the ecosystem landscape: Two players can be partners at one layer and compete on another layer in the same ecosystem [5]. *Requirements considered:* R4

Instantiation "Nest": Along the four-layered structure, Nest Labs contributes on the device layer with the "Nest" thermostat, on the service layer by providing the app as interface to the "Nest" thermostat, and finally on the data layer by providing valuable user data. The user contributes on the device layer by purchasing the "Nest", the content layer by feedbacking real time data. Concerning co-opetition: Playing on different layers, Nest Labs and the energy provider are complimentary in the described scenario. Would the energy provider come up with an own internet-connected thermostat, they may still partner on the service layer, yet compete on the device layer.

4.3 Dimension "Why": Benefit for Collaborators

The dimension "Why" outlines each collaborator's "reason" to participate in the ecosystem. It is meant to depict all monetary as well as non-monetary benefits, which attracts collaborators to participate in the ecosystem [19].

Rationale: We find it essential to not only depict one company's revenue model, which "Why" is usually meant for (3.2), yet to consider all collaborators' benefits in a wider sense from their participation in the ecosystem. The reason is, that the collaborators

---

[4] In compliance with the prevailing privacy code of conduct.

in sum build the external ecosystem, i.e. e. an essential "operant resource" [7]. In consequence a healthy ecosystem features a competitive advantage, whose overall stability depends on each collaborator's satisfaction. Moreover, as the customer is likewise regarded as collaborator, it is no longer necessary to feature a customer-specific value proposition (in the traditional BM: "What", see 3.2), yet can be covered by the same dimension, "Why", which outlines all benefits occurring in the ecosystem. These can be monetary as well as non-monetary (fun, ethic reasons etc.) [19]. *Requirements considered:* R_1, R_3

Instantiation "Nest": Nest Labs derives first of all monetary benefits from being part of the ecosystem, i.e. e. revenues by selling the "Nest" device and by selling meaningful data. The "Nest" user's benefits from using "Nest" in the ecosystem context are varied, and may include haptic benefits (pleasant temperature), ethical benefits (saving energy), economic benefits (saving money, getting rewarded) or psychic benefits (benefits). The energy providers are attracted by the possibility to reduce the risk of energy shortage by influencing customers' behavior by monetary incentives. Google may benefit from new insights into consumers' behavior beyond the Web to leverage its data analytics competences into the internet of things[5].

5 Evaluation

In the first place, the new artifact should be useful and an effective solution to the problem of depicting IoT-driven business models (cf. "goal" in table 3). To assess whether we have reached at an artifact, which is equally rigor and relevant, we conducted evaluations at two levels: We evaluated (a) the artifact as research output and (b) the underlying research process. For the latter, we compared our overall DSR study with Hevner et al's suggested guidelines for building and evaluating design science research [29]. The following section outlines (a) the output evaluation, with regard to the overall evaluation scheme applied as well as major findings.

As performance is closely related to the intended use, we specifically compared the progressing artifact prototype with the initial goal, i.e. the effective depiction of IoT business models. We operationalized our goal by two sets of criteria: Criteria set 1 analysis whether and to what extent the artifact features good model properties, inspired by March et al [10]. Criteria set 2 examines whether and how well the solution requirements, we derived from S-D logic (section 3) are incorporated in the artifact.

To use appropriate methods for the evaluation of our framework artifact, we consulted prior DSR work specifying the evaluation of models and frameworks [10, 29–31]. We finally gathered a wealth of insights and evidence especially by using case studies and action research, enriched by expert and practitioner evaluations operationalized by questionnaires. Table 3 summarizes the applied evaluation scheme. In the following, we use first and foremost the "Nest" example (detailed in section 4) as instantiation to representatively indicate evidence in a concise way.

[5] http://www.wired.com/business/2014/01/googles-3-billion-nest-buy-finally-make-internet-things-real-us/

Table 3. Criteria and methods to evaluate the artifact's performance

Goal of our DSR study	Criteria sets based on goal	Methods for gathering evidence
An effective solution...	**Set 1 Good model properties** M_1: Fidelity with the real world M_2: Completeness (=R_1-R_6) M_3: Level of detail M_4: Robustness	Interviews / expert evaluation multiple case studies, action research, instantiation
...which is able to depict business models in IoT environments	**Set 2 Justified solution requirements** R_1: Network-centric view R_2: Customer as co-producer R_3: (Non-) monetary reasons to participate R_4: Value creation across four layers R_5: Ecosystem as operant resource	

Concerning criteria set 2 we may refer to the elaboration on the dimensions including the "Nest" case, which demonstrated that all solution requirements R_{1-5} are incorporated in the artifact. Concerning set 1: The criteria *"Fidelity with the real world"* is seen reflected as the framework is able to describe the partner constellations and the value creation logic of "Nest" and other analyzed ecosystems, despite its strong simplification. The criteria *"completeness"* is inherent to the artifact by transitive relation: The requirements R_{1-5}, which are built in the artifact, reflect the central concepts of the S-D logic. The S-D logic itself is recognized to comprehensively depict digital market dynamics. Hence, we may argue R_{1-5} justifies completeness. Regarding the criteria *"level of detail"* evaluation reveals that overall the artifact's dimension help to depict the core of an IoT ecosystem without getting lost in details. Except for dimension "Why", which carries the benefits for each partner from participating: Here the classification of "monetary" and "non-monetary" benefits helps to clarify on a generic level why partner collaborate. A more fine-grained dimension involving metrics could reveal further useful insights, such as the degree of partner's satisfaction and insights on the ecosystem' overall stability. The artifact's *"robustness"* we see reflected by the flexibility to work smoothly from several angles, e. g. in the Nest case, it is irrespective whether one looks at it from the energy provider's or Nest Labs' perspective. Moreover, the framework is evaluated applicable across different IoT themes and industries, e.g. to smart home, smart city and to any other IoT-driven context. In addition, what we learned as side effect from business model workshops with practitioners is that a method or instruction is desirable to complement the artifact and facilitate using it. A final proof of the value of the artifact is provided by a cross-industry business model workshop and summary evaluation, which are both still to come.

6 Conclusion

Although many business model approaches exist, there is no actionable business model framework to effectively depict business models in IoT ecosystems. We see this gap in sharp contrast to the overall importance and omnipresence of the topic[6]

[6] http://www.weforum.org/sessions/summary/new-digital-context

and in essence, our research approach attempts to address this need. This section is meant to summarize core features of the artifact and how it contributes to research and practice. We outline limitations and give an outlook on future research.

The specific features of our business model framework can be seen in three differentiating elements incorporated in the artifact: (a) IoT-driven market principles are recognized by applying solution requirements rooted in S-D logic, (b) the sources of value creation in IoT environments are recognized by applying the four layer model. (c) the relevance of the external environment is recognized by strictly applying a network-centric view. Another benefit can be seen in the applied design science research method [9] ensuring that the artifact is closely linked with theory and practice.

Our project is currently approaching at the proof of concept demonstration in A_4. Several "prototype and test" iterations in A_3 along defined criteria enabled us to determine whether both good model properties and solution requirements are represented in the artifact, and to refine accordingly. In a nutshell, we find the artifact as is well performing in both regards for IoT business models across industries. However, we see some limitations concerning the criteria "level of detail": In the present state the dimension "Why" allows only for a rough picture on each collaborators benefit, which restricts the artifact to solely manual use. To serve as basis for a business model software solution, as requested [6], the dimension needs to be further enhanced e.g. by an underlying metric. Moreover, the artifact works well as tool to depict business models in IoT, yet would benefit from a complementary method to facilitate its application. Furthermore, we tested the artifact so far in ecosystems involving IoT. We yet assume the artifact likewise applicable to digital ecosystems in general, which is another area of future research.

Our DSR study at its completion represents a business model framework, which contributes to both theory and practice: For theory, our work adds to the current business model research in the emerging context of Internet of Things by providing a both theoretically founded and field-tested business model framework. In this way researchers can readily use the framework to for example analyze IoT business model patterns in an efficient and structured way. Our paper also demonstrates, how DSR can be applied for developing a framework at the interface of three different domains: Strategic management, marketing and information systems. So far DSR has been commonly employed in IS research [11], yet is rarely used in management sciences.

For practitioners the artifact serves as tool for depicting, analyzing and envisioning business models in IoT. By making recent IoT-driven market dynamics and specifics of digitized goods explicit, the artifact is able to decidedly support business model development in complex IoT ecosystems. This is relevant, as without a clear view on market dynamics and collaborative value creation logic, it is hard to create sustainable IoT ecosystems and be a competitive part of it, which is the situation today for many companies, with roots in manufacturing in particular. Not least, resulting instance business models, specific to a certain IoT ecosystem, can be seen as mean of communication between current and future ecosystem partners.

Acknowledgements. The present work is supported by the Bosch IoT Lab at St Gallen University, Switzerland. An earlier version of this manuscript appeared in the Proceedings of the 22nd European Conference on Information Systems. The authors are grateful to the anonymous reviewers for thoughtful comments and helpful suggestions.

References

1. Atzori, L., Iera, A., Morabito, G.: The Internet of Things: A survey. Comput. Networks 54, 2787–2805 (2010)
2. El Sawy, O.A., Pereira, F.: Business Modelling in the Dynamic Digital Space. Springer, Heidelberg (2013)
3. Yoo, Y., Lyytinen, K., Boland, R., Berente, N., Gaskin, J., Schutz, D.: The Next Wave of Digital Innovation: Opportunities and Challenges. In: Research Workshop: Digital Challenges in Innovation Research, pp. 1–37 (2010)
4. Magretta, J.: Why business models matter. Harv. Bus. Rev. 80, 86–92 (2002)
5. Yoo, Y., Henfridsson, O., Lyytinen, K.: Research Commentary —The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. Inf. Syst. Res. 21, 724–735 (2010)
6. Burkhart, T., Krumeich, J., Werth, D., Loos, P.: Analysing the business model concept - A comprehensive classification of literature. In: International Conference on Information Science, pp. 1–19 (2011)
7. Vargo, S.L., Lusch, R.F.: Evolving to a New Dominant Logic for Marketing. J. Mark. 68, 1–17 (2004)
8. Yoo, Y., Boland, R.J., Lyytinen, K., Majchrzak, A.: Organizing for Innovation in the Digitized World. Organ. Sci. 23, 1398–1408 (2012)
9. Peffers, K., Tuunanen, T., Rothenberger, M.A., Chatterjee, S.: A Design Science Research Methodology for Information Systems Research. J. Manag. Inf. Syst. 24, 45–77 (2007)
10. March, S.T., Smith, G.F.: Design and natural science research on information technology. Decis. Support Syst. 15, 251–266 (1995)
11. Gregor, S., Hevner, A.R.A.: Positioning Design Science Research for Maximum Impact. Manag. Inf. Syst. Q. 37, 337–355 (2013)
12. Kominers, P.: Interoperability Case Study Internet of Things (IoT). Berkman Cent. Res. Publ. 7641 (2012)
13. Palfrey, J., Gasser, U.: Mashups Interoperability and eInnovation. Berkman Publ. Ser (2007)
14. Eaton, B., Elaluf-Calderwood, S., Sørensen, C., Yoo, Y.: Dynamic structures of control and generativity in digital ecosystem service innovation: the cases of the Apple and Google mobile app stores, LSE Working paper series 183. London (2011)
15. Mejtoft, T.: Internet of Things and Co-creation of Value. In: 2011 Int. Conf. Internet Things 4th Int. Conf. Cyber, Phys. Soc. Comput., pp. 672–677 (2011)
16. Yoo, Y., Henfridsson, O., Lyytinen, K.: Research Commentary—The New Organizing Logic of Digital Innovation: An Agenda for Information System. Inf. Syst. Res. (2010)
17. Vargo, S.L., Lusch, R.F.: Service-dominant logic: continuing the evolution. J. Acad. Mark. Sci. 36, 1–10 (2007)
18. Michel, S., Vargo, S.L., Lusch, R.F.: Reconfiguration of the conceptual landscape: A tribute to the service logic of Richard Normann. J. Acad. Mark. Sci. 36, 152–155 (2007)

19. Lusch, R.F., Vargo, S.L., O'Brien, M.: Competing through service: Insights from service-dominant logic. J. Retail. 83, 5–18 (2007)
20. Normann, R.: Reframing Business: When the Map Changes the Landscape. Wiley (2001)
21. Lusch, R.F., Nambisan, S.: Service Innovation, A Service-Dominant (S-D) Logic Perspective, MIS Q (forthcoming).
22. Lusch, R.F., Brown, S.W., Brunswick, G.J.: A general framework for explaining internal vs. external exchange. J. Acad. Mark. Sci. 20, 119–134 (1992)
23. Tiwana, A., Konsynski, B., Bush, A.A.: Research Commentary —Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics. Inf. Syst. Res. 21, 675–687 (2010)
24. Penrose, E.T.: The Theory of the Growth of the Firm, vol. 1, pp. 1–23. John Wiley & Sons Inc., New York (1959)
25. Zott, C., Amit, R., Massa, L.: The Business Model: Recent Developments and Future Research. J. Manage. 37, 1019–1042 (2011)
26. Gassmann, O., Frankenberger, K., Csik, M., Weiblen, T.: The 4I - framework of business model innovation: a structured view on process phases and challenges. Int. J. Prod. Dev. 18 (2013)
27. Mason, K., Spring, M.: The sites and practices of business models. Ind. Mark. Manag. 40, 1032–1041 (2011)
28. Timmers, P.: Business Models for Electronic Markets. Electronic Markets 8, 3–8 (1998)
29. Hevner, A.R., March, S.T., Park, J., Ram, S.: Design Research in Information Systems. MIS Q. 28, 75–105 (2004)
30. Osterwalder, A.: The Business Model Ontology: a proposition in a design science approach. Inst. d'Informatique Organ. Lausanne, Switzerland, Univ. Lausanne, Ec. des Hautes Etudes Commer. HEC. 173 (2004)
31. Peffers, K., Rothenberger, M., Tuunanen, T., Vaezi, R.: Design Science Research Evaluation. In: Peffers, K., Rothenberger, M., Kuechler, B. (eds.) DESRIST 2012. LNCS, vol. 7286, pp. 398–410. Springer, Heidelberg (2012)
32. Gassmann, O., Frankenberger, K., Csik, M.: Revolutionizing the Business Model. In: Management of the Fuzzy Front End of Innovation, pp. 89–98. Springer International Publishing, Cham (2014)