Information & Management 63 (2026) 104390

Contents lists available at ScienceDirect

Information & Management

journal homepage: www.elsevier.com/locate/im

Smart services in B2B contexts: A taxonomy and archetypes☆

Daniel Heinz *, Marcel Fassnacht, Carina Benz, Philipp Luchner, Gerhard Satzger

Institute for Information Systems (WIN) at the Karlsruhe Institute of Technology (KIT), Kaiserstraße 12, 76131 Karlsruhe, Germany [1]

ARTICLE INFO

Keywords:
Service innovation
Digital transformation
B2B
Smart service
Taxonomy
Archetypes

ABSTRACT

Smart services – data-enabled services built on connected physical products – are increasingly central to digital transformation, yet organizations still struggle to systematically design and scale them in business-to-business (B2B) settings. Prior classifications predominantly reflect B2C assumptions or underrepresent B2B's multi-actor governance, risk/liability, and data sharing constraints. Drawing on literature and a corpus of 100 publicly described B2B smart service cases, we develop and iteratively evaluate a taxonomy that captures the B2B smart service design space. The resulting taxonomy comprises seven dimensions with 25 characteristics, spanning innovation type, smart service outcome, service provider, target user, analytic capabilities, acting features, and information provision. Building on the taxonomy, we identify five empirically grounded archetypes via hierarchical clustering and qualitative interpretation: (A) Enhanced operational productivity, (B) Retrofitting upgrade, (C) Strategic provider insights, (D) Integrated remote management, and (E) Intelligent autonomous operation. Together, the taxonomy and archetypes provide a shared language for cumulative research and offer practitioners a strategic tool to assess portfolios and plan capability-aligned evolution paths.

1. Introduction

Digital transformation is reshaping how organizations create and capture value through digitally enabled innovation and service delivery [1,2]. In this context, "smart services" use data-generating, connected products ("smart products") to provide insights and, in some cases, automated or autonomous responses [3–5]. Enabled by the Internet of Things (IoT), intelligent automation, and digital platforms [6,7], these services can improve efficiency and margins for providers and customers [3,8,9]. For example, Kimberly-Clark equips dispensers with sensors that trigger usage-based restocking alerts via a central platform [10]. By 2030, connected smart products are expected to reach 29.4 billion, further expanding the opportunity space for smart service innovation [11].

While smart services have gained attention, research and practice have predominantly focused on Business-to-Consumer (B2C) settings. Comparatively little is known about smart services in Business-to-Business (B2B) contexts, despite their growing importance and multi-actor complexity [12–14]. In B2B markets, introducing smart services requires aligning stakeholders, value propositions, and organizational routines; firms that fail to do so risk losing future market share [9,15]. Common barriers include unclear smart service strategies, limited innovation processes, and underdeveloped value propositions [14,16,17], often amplified by interdependencies among product, platform, and practice requirements [18,19].

Existing work has proposed taxonomies and frameworks for smart services [20–22], yet many focus on B2C or do not capture the multi-actor governance, risk-sensitive contracting, and heterogeneous installed bases that distinguish B2B environments. Previous classifications frequently assume static pricing models and limited service interactions [20,21], or emphasize value types (e.g., enjoyment-related or social value) that play a minor role in B2B relationships [23]. Moreover, a generalizable, well-grounded typology of B2B smart services remains unavailable. Existing archetypes often focus on specific application domains, such as smart living [24], connected cars [25], or singular aspects of the business model [26], without reflecting the broader complexity of B2B contexts. These gaps warrant a fresh examination of how B2B firms can put digital transformation and innovation management to work in designing effective smart services, weighing what emerging technologies make possible against what established practices require [27].

We address two questions that follow directly from these gaps.

RQ 1: *What dimensions and characteristics can be used to analyze the similarities and differences among smart services in B2B contexts?*

☆ This article is part of a Special issue entitled: 'IS Methods' published in Information & Management.

* Correspondence to: Kaiserstraße 12, 76131 Karlsruhe, Germany.
E-mail address: daniel.heinz@kit.edu (D. Heinz).

[1] https://win.kit.edu/

https://doi.org/10.1016/j.im.2026.104390
Received 21 April 2024; Received in revised form 29 May 2026; Accepted 22 June 2026
Available online 27 June 2026

This question responds to limitations in existing classifications that are predominantly B2C or do not reflect multi-actor settings, do not distinguish between acting with information provision, and treat service outcomes as mutually exclusive [20–22]. We therefore seek a B2B-appropriate, multi-actor taxonomy that allows co-occurring outcomes and separates role allocations from capability and action features.

RQ 2: *What are archetypes of smart services in B2B contexts?*

This question addresses the absence of cross-industry, empirically grounded archetypes: prior work typically offers domain-specific patterns (e.g., smart living, connected cars) or focuses on single business-model facets, which limits generalizability to B2B settings with heterogeneous installed bases and governance regimes [24–26].

To answer these questions, we adopt a two-phase research design. First, we develop a taxonomy of B2B smart services using established methodology guidelines [28,29]. Second, we identify archetypal patterns through cluster analysis and interpretation [30]. Our data sources include a systematic literature review (SLR) of 31 articles and an examination of 100 publicly available B2B smart service descriptions.

This study makes three contributions. First, we develop a B2B smart service taxonomy (Section 4) as a Type I "theory for analyzing" [31] tailored to multi-actor, risk-sensitive contexts. Relative to prior classifications, it decouples *service provider* and *target user*, distinguishes *acting features* from *information provision*, models outcomes (transparency, optimization, remote control, autonomy) as non-exclusive and linked to analytics, and makes governance/liability constraints explicit. Second, we identify five cross-industry archetypes (Section 5) via Ward clustering and cross-table comparison, revealing recurring bundles of analytics, information and acting features, and role allocations; we further validate them against two out-of-sample provider portfolios. Third, we translate the taxonomy and archetypes into diagnostic guidance for mapping portfolios, surfacing capability and governance gaps, and selecting feasible adjacent moves (e.g., toward remote control or autonomy).

Together, these contributions specify *who* makes which decisions, *with what analytics and information*, and *through what acting features*, and show how connected products reallocate decision rights, risk, and value capture across the actors involved [1,2].

The article is structured as follows: Section 2 reviews relevant literature. Section 3 explains the methodology for developing the taxonomy and identifying archetypes. Sections 4 and 5 detail the final taxonomy and archetypes. Finally, Section 6 discusses the relationships among the archetypes, implications, and limitations, and the concluding section summarizes our work.

2. Foundations and related work

2.1. Smart services

Equipping physical objects with sensors, connectivity, and data-processing capabilities has fueled the IoT, initially framed as an architecture for tracking and identifying objects [32,33]. Today, it denotes an ecosystem of sensor-, actuator-, and processor-equipped objects that connect to the Internet and one another [8]. Resulting "smart products" vary in autonomy, adaptability, and inter-device cooperation [3,34], and not all incorporate every component [4]. For instance, Kimberly-Clark's dispensers provide basic monitoring and connectivity [10], whereas autonomous electric vehicle chargers enable more advanced remote or autonomous operation [35].

Smart products serve as boundary objects that support co-creation of value between a provider and user, forming what scholars term "smart service" [4,32]. Forwarding data or triggering remote actions, the smart product mediates interactions and shapes the roles each actor can perform. This interplay becomes especially significant in *smart service systems*, where data-intensive exchanges enable service providers to offer remote optimization or automation features and, simultaneously, glean insights for continuous improvement [3,4]. Value creation in such systems hinges on the degree to which co-produced outcomes – for example, operational efficiency, reduced downtime – benefit both the service provider and the user [9,36].

Most early studies on smart services examine consumer-oriented use cases, but B2B settings differ in concrete ways: multi-actor coordination, contractual liability, and audit-trail requirements that consumer offerings rarely face [12,37]. B2B smart services typically operate under stricter reliability, security, and intellectual property (IP) constraints [38,39], while also requiring long-term trust-based relationships [40]. Consequently, organizations pursuing B2B smart services often favor incremental over disruptive innovation to accommodate existing operational practices and ensure system stability [41]. Machine-to-machine interactions further intensify the need for robust cybersecurity and data privacy measures, as sensitive operational or production data must be protected [19,42].

B2B smart services increasingly unfold in broader socio-technical ecosystems, where institutional arrangements and regulatory demands shape service design and delivery [43,44]. As offerings expand, data governance, IP rights, and compliance become more pronounced [45]. Firms thus need to address not only technological requirements but also organizational and regulatory concerns, balancing the affordances of connected products against the constraints of specialized usage contexts [43]. In particular, designing secure communication protocols, aligning with data privacy regulations, and maintaining reliable integration with partners' systems are vital considerations for B2B providers aiming to deploy smart services at scale [46].

To meet these challenges, many B2B companies take a product-centric approach by integrating incremental sensor-based services – such as remote monitoring and predictive analytics – before moving to more advanced, autonomous capabilities [40,47]. Others build upon digital platforms to coordinate third-party services and develop integrated solutions [48,49]. In both cases, an important differentiator is the level of customization and multi-actor coordination, which often exceeds the complexity seen in B2C contexts [18]. Accordingly, some firms begin by offering basic monitoring services (e.g., real-time machine data) while gradually extending to multi-source data fusion or predictive maintenance, reflecting both technological maturity and socio-technical constraints [50–52]. In this study, we examine how these interlinked factors shape the design, provision, and adoption of B2B smart services.

2.2. Existing taxonomies and archetypes of smart services

Gregor [31] suggests that "theories for analyzing" form the basis for other types of theories that provide explanations, predictions, or prescriptions. Theories for analyzing "say what is" by studying a particular subject and providing some form of classification that can refer to both the organization of knowledge and the organization of instances of the subject [53,54]. In this vein, taxonomies – created empirically using observations and exemplary objects [55] or conceptually using existing theories [28] – offer a powerful means for systematically classifying a subject along multiple dimensions and characteristics [31,56].

Several taxonomies aim to classify smart services, but many are calibrated to consumer contexts. Paukstadt et al. [20], for instance, emphasize service concept, delivery, and monetization, including hedonic and social value propositions [57] that are typically secondary in B2B settings [23]. Domain-focused work includes Azkan et al. [22] on manufacturing (e.g., main value, data sources, aggregation levels). From a value co-creation perspective, Brogt and Strobel [21] adapt Paukstadt et al. [20]'s value proposition dimension by substituting social with financial value and further differentiate value-in-use versus value-in-exchange and context (participant, social, technology).

However, applying the adapted value proposition dimension to cases of B2B smart services suggests that the characteristics of functional and financial value overlap strongly, as efficiency gains and

Table 1
B2B challenges, implications for smart services, and how the taxonomy addresses them.

Key B2B challenge	Implication for smart services	How our taxonomy addresses it
Multi-actor governance and role ambiguity (provider ≠ manufacturer; partners, operators)	Role allocation must be explicit; service logic depends on who provides and who benefits.	Separates *Service provider* from *Target user*, allowing multi-actor configurations.
Contract-bound relationships, liability, service-level agreements	Cautious escalation from information to action; need auditability and human-in-the-loop.	Treats *Smart service outcomes* as non-exclusive; decouples *Information provision* from *Acting features*; *Innovation type* captures risk-sensitive incrementalism.
Heterogeneous installed base and legacy constraints	Retrofitting/interface heterogeneity shapes feasible capability levels and delivery options.	Admits non-OEM provision (retrofit supplier); stages feasibility via *Analytic capabilities* and *Acting features*.
Data access/ownership and IP regimes	Data-sharing scope conditions provider- vs. user-facing services; consent/logging needs shape delivery.	*Target user* distinguishes provider-facing vs. user-facing; *Information provision* models push/pull/none; *Outcomes* capture transparency vs. optimization choices.
Security and safety-critical operations	Remote action/autonomy restricted; intermediate forms (e.g., triggers) favored; staged progression required.	*Acting features* separate process triggering, digital, and physical action; paired with *Analytic capabilities* and *Outcomes*.
Regulatory compliance and auditability	Preference for explainable information, logging, access control; external reporting.	*Information provision* accommodates auditable push/pull; role dimensions capture internal vs. external recipients; outcome mix reflects compliance constraints.
Long life cycles and total cost of ownership focus	Value via incremental improvements and provider learning; remote management valued over disruptive change.	*Innovation type* distinguishes incremental/additional vs. radical; *Outcomes* emphasize transparency/optimization; *Target user* (provider) supports Strategic provider insights.

Representative sources for each challenge (full discussion in Section 2): (1) [4,47]; (2) [38,58]; (3) [18,19]; (4) [43,45]; (5) [38,42]; (6) [43,46]; (7) [14,41].

increased transparency – common examples of the functional value of B2B smart services [3,9] – directly manifest themselves in the form of financial value through reduced labor, material, and maintenance costs. Brogt and Strobel's [21] taxonomy further considers the level of automation in smart service systems as either semi-automated or automated. However, many B2B smart services, such as monitoring services for machines, require a significant degree of human interaction and have very limited autonomy due to their high-risk environment [58,59].

Despite these important contributions, existing classifications do not fully address the unique complexities of B2B smart services. Many assume single-stakeholder contexts, static pricing models, or high levels of autonomy, yet real-world B2B use cases often involve a broader set of dimensions and interactions. For instance, the level of risk, the need for trust-based partnerships, or the deployment of machine-to-machine interaction can challenge or even contradict dimensions proposed in consumer-oriented classifications [4,38]. Furthermore, extant work frequently focuses on a single stage of the smart service lifecycle – such as data collection or service deployment – without capturing the potential evolutionary trajectory that B2B smart services often follow [52,58].

To make explicit which recurring B2B boundary conditions a taxonomy must accommodate, Table 1 synthesizes key challenges and links each to the corresponding taxonomic design choices. Illustratively, contract- and liability-sensitive settings such as pay-per-part arrangements (e.g., TRUMPF; C054) motivate separating information provision from acting features, heterogeneous installed-base scenarios (e.g., Bosch lift monitoring; C055) foreground non-OEM provision and feasibility constraints, and regulated/auditability-focused offerings (e.g., 3M tamper-proof pharmaceutical label; C059) highlight traceable information provision and recipient roles (see Appendix C).

Archetype-based research on smart services, meanwhile, remains relatively sparse. Studies that propose archetypes tend to examine a single facet (e.g., revenue models, application domains), making it difficult to capture the multi-actor, multi-technology nature of B2B scenarios. For example, Koldewey et al. [26] present archetypes centered on particular business model innovations, Fischer et al. [24] offer archetypes for "smart living" solutions or Sterk et al. [25] for connected car business models, both largely consumer-focused domains. These valuable insights nonetheless leave open questions about the variety and structure of B2B-specific smart services, where solutions often integrate advanced data processing, remote or autonomous functionality, and inter-organizational collaboration.

2.3. Theoretical relevance of taxonomies and archetypes

We position the taxonomy and archetypes (Sections 4 and 5) as a *Type I "theory for analyzing"* [31]: a structured classification of B2B smart services that clarifies constructs and admissible combinations rather than asserting explanatory or predictive mechanisms. We treat the taxonomy as *taxonomic theory* when it is transparent in development and useful in application [60], and follow established IS guidance for taxonomy design, reporting, and evaluation [28,29]. Archetypes complement the taxonomy as representative instantiations of recurring configurations, showing how dimension bundles co-occur in practice.

This contribution applies to smart services that (1) are grounded in connected physical products (industrial IoT), (2) involve inter-organizational coordination typical of B2B exchanges, and (3) entail non-trivial data governance and operational risk. The taxonomy is not intended to classify purely virtual services detached from smart products or primarily B2C offerings emphasizing hedonic value. We return to the theoretical implications of this positioning, including how the design space can scaffold subsequent theorizing, in Section 6.2.

3. Research design

Our research design comprises two sequential phases, adopting the structure of previous studies [e.g., 25,61]. In the first phase, we design and evaluate the taxonomy using Nickerson et al.'s [28] taxonomy development method and supplementary evaluation guidelines [29].

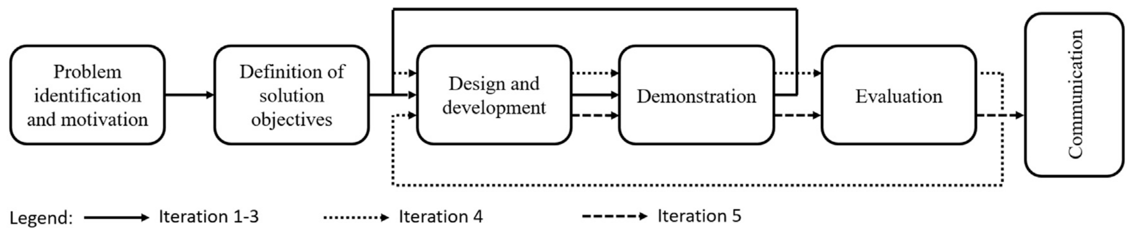

Fig. 1. Extended taxonomy design process based on Kundisch et al. [29].

In the second phase, we build on the results of the first phase to identify archetypes through cluster analysis and interpretation [30,52] and interpret the results.

3.1. Taxonomy development

Our first research phase develops and evaluates the taxonomy using established guidelines [28,29]. We follow Nickerson et al.'s method [28] and the Extended Taxonomy Design Process (ETDP) extension [29], which structures taxonomy design and evaluation into six steps with iterative loops. Fig. 1 summarizes our process; we briefly explain each step in more detail below, with a particular focus on the design and development of the taxonomy (Section 3.1.1) and its evaluation (Section 3.1.2), before communicating the resulting final taxonomy in Section 4.

In the problem identification and motivation step, we introduce our subject of research – B2B smart services – and explain why a taxonomy of such services is useful for our primary target audience of scholars who seek to explain or predict phenomena related to these offerings (e.g., What are the success factors of profitable B2B smart services?, How should organizations adapt to become a smart service provider?) [62]. Accordingly, our goal is to propose a parsimonious description of B2B smart services by identifying their constituent characteristics and organizing them into coherent dimensions.

Next, we define solution objectives by specifying which characteristics the taxonomy should capture. Our meta-characteristic is: "Key characteristics of B2B smart services that describe how the service is perceived and delivered". We scope the taxonomy at the *offering level* and therefore do not model contextual conditions (e.g., firm size, industry setting, installed base, regional market structures, or digital maturity) as taxonomy dimensions. Such conditions may shape scaling, and evolution of smart service configurations, but they do not constitute the configuration itself. Accordingly, we assembled a corpus with breadth across contexts without stratifying on any single contextual variable; contextual factors are treated as boundary conditions for subsequent explanatory work building on the taxonomy.

Afterwards, we define ending conditions for the taxonomy development process and specify evaluation criteria. We adopt the objective ending conditions (E1–E8, see Fig. 2) and subjective ending conditions (conciseness, robustness, comprehensiveness, extendible, explanatory) suggested by Nickerson et al. [28]. In addition, we select ex-post evaluation criteria – completeness, simplicity, understandability, fidelity with the real world – based on the taxonomy's purpose and target audience.

3.1.1. Iterations of taxonomy design and development

We design and develop the taxonomy by iterating between two design approaches: The first approach, conceptual-to-empirical (C2E), uses existing knowledge about the topic [28], including literature reviews or researchers' experience and judgment [29]. The second approach, empirical-to-conceptual (E2C), involves examining real objects of the studied topic to identify common characteristics and form a conceptual understanding.

Table 2
Systematic literature review search terms.

Topic	Search terms
A	service*
B	''smart servi*'' OR smart OR cyberniz* OR IoT OR ''Internet of Thing*'' OR ''internet-of-thing*'' OR IIoT
C	characteristic* OR classification OR conceptualiz* OR taxonomy OR taxonomies OR archetype* OR typology OR typologies OR ''maturity model*'' OR morphology OR morphologies OR morphological OR cluster* OR survey*

In our taxonomy development process, we first derived a seed codebook conceptually (C2E) from 12 smart service taxonomies and refined it with 19 additional articles, yielding preliminary dimensions, characteristics, and decision rules. We then applied this codebook empirically (E2C) to 100 publicly disclosed cases. Coding was led by one primary author to ensure consistency; we used an insider–outsider review in regular author meetings within and after each iteration to challenge boundary decisions and adjust operational definitions. In case of uncertainty, this also involved independently coding a low number of cases for particular dimensions under question; discrepancies were discussed and the decision rules refined until substantial agreement was reached. In total, we conducted six design and development iterations, which are summarized in Fig. 2 and described in more detail below.

Iteration 1. For the first iteration, due to the diversity of the empirical objects, we apply the C2E approach by starting with a comprehensive SLR following the methodological guidelines of vom Brocke et al. [63] to obtain an overview of the existing knowledge base [64]. To construct our search string, we identified three relevant subtopics (Table 2): Topic A includes the primary subject of "service", while Topic B includes synonyms for "smart", and Topic C captures research findings and methods that might reveal characteristics of the subject. We created the search string by linking Topics A, B, and C with an AND operator.

Following the approach suggested by Webster and Watson [64], we searched for articles in IS journals and conference proceedings, as well as journal articles in related fields (i.e., management, production, organization). To ensure the quality of the articles, we applied several criteria, such as the articles being peer-reviewed and following established scientific rankings of journals and conference proceedings. The Scopus and Web of Science databases were used to identify 157 articles, which were then independently assessed by two authors for relevance to the subject, reducing the literature sample to 24 articles. Forward and backward searches allowed the literature sample to be expanded to a total of 31 articles. Fig. 3 provides an overview of the search and filtering process.

For the analysis of the articles, we divided the literature sample into two groups. We examined 12 taxonomy-related articles in the first iteration, leaving the remaining 19 articles for iteration 2. The articles were analyzed inductively by extracting potential dimensions

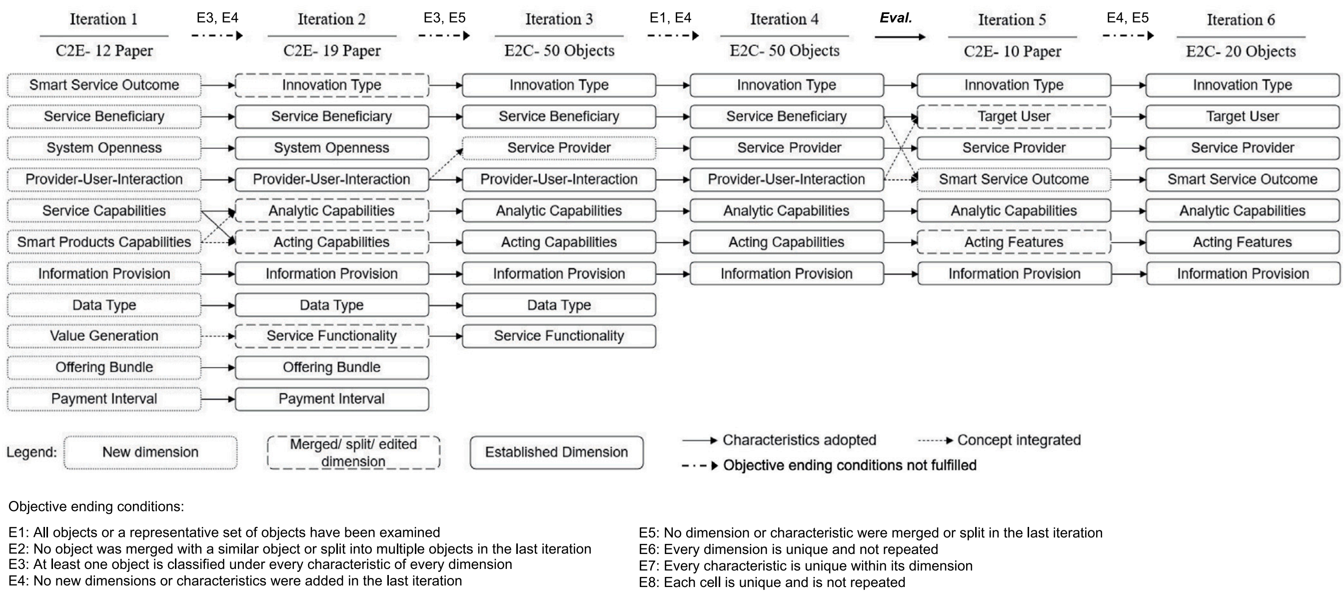

Fig. 2. Overview of iterative taxonomy design and development.

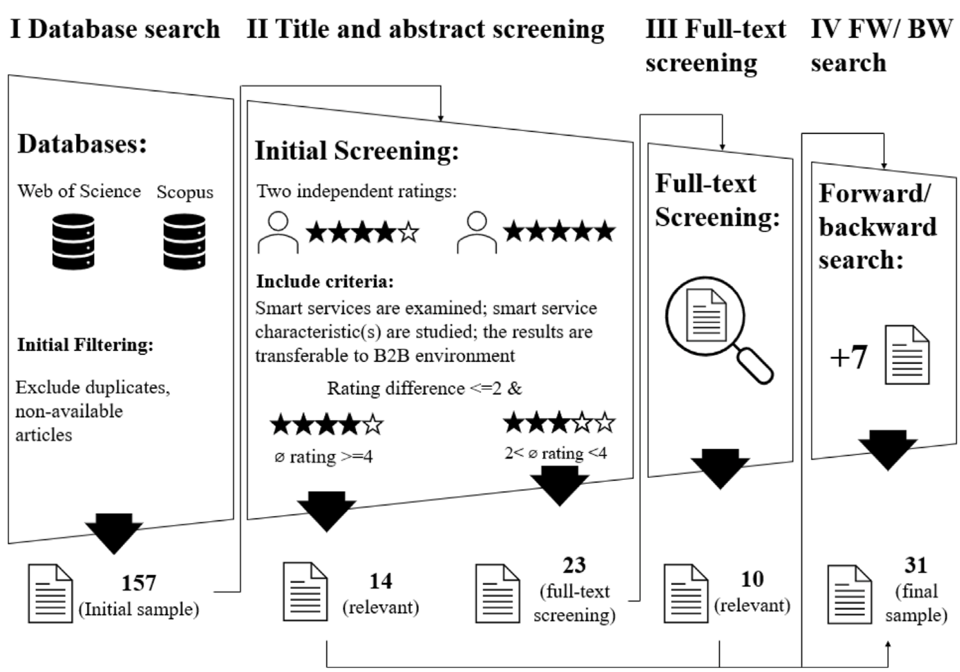

Fig. 3. Search and filtering process of systematic literature review.

and characteristics into a concept matrix [64]. The resulting dimensions after this iteration are shown in Fig. 2. Since no object had been classified under any characteristic (E3), and all dimensions were newly created (E4), we performed another iteration.

Iteration 2. Next, we used the remaining 19 articles to perform another iteration using the C2E approach to reinforce the soundness of the existing dimensions and characteristics. Consequently, we mapped the concepts to the existing dimensions and characteristics. As a result, several changes were made, such as renaming the "smart service outcome" dimension to "innovation type" and removing characteristics that were not directly related (e.g., business insights and efficiency gains). The "service capabilities" and "smart product capabilities" dimensions were merged and split based on the type of capability addressed ("analytic capabilities" or "acting capabilities"), while the "service functionality" dimension was developed by editing the "value generation" dimension. Reviewing the objective ending conditions, again, no real objects were studied (E3), and the taxonomy was modified (E5).

Iteration 3. In this iteration, we used the E2C approach based on publicly available use case descriptions of smart services. We collected 100 cases (Appendix C) from publicly available sources such as IT vendor success stories (n = 51), consulting reports (n = 11), interview transcripts from previous research (n = 10), scientific literature (n = 6), and an Internet search for use cases in domains that were rarely represented in the rest of the data (n = 22). To ensure the quality of the identified cases and to assess their suitability, we defined and applied a set of six criteria: (1) written in English or German, (2) describes a smart service in the B2B domain with a smart product as the boundary object, (3) has a clearly defined value proposition for the customer and potential secondary beneficiaries, (4) provides a comprehensible description of how the service is delivered, (5) is implemented and tested in a real-world scenario, and (6) is scalable across customers with only minor manual adjustments. The final sample of cases is spread across a wide range of industries: manufacturing (25%), utilities and infrastructure (15%), healthcare (13%), transportation (12%), agriculture and food processing (12%), construction and property management (11%), and other (12%).

Because many public sources are marketing-oriented, our sample likely overrepresents externally publicized successes and underrepresents failed trials, internal pilots, or routine services. We therefore treat the 100 objects as a *purposive, non-probability sample of publicly disclosed implementations* – a constructed corpus suited for pattern discovery rather than prevalence estimation [e.g., 65,66]. Mitigations applied include diversifying source types and industries, applying uniform "implemented" inclusion criteria, and independent coding with reconciliation prior to analysis. Inference is by *analytic generalization* to configurations, not to population frequencies [67].

We used 50 cases of the final sample in this iteration to reduce the taxonomy to its most useful dimensions for describing our sample. For example, we found that "offering bundle" and "payment interval" did not represent a constituent factor of B2B smart services due to their inflexible nature and dynamic and complex value capture configurations in cases involving multiple actors. Instead, we added the "service provider" dimension to the taxonomy to capture the provider perspective of the provider-user interaction and to reveal the types of actors involved. However, because not all objects were considered and a dimension was added, two of the objective ending conditions were violated (E1, E4).

Iteration 4. With the remaining 50 objects, we again follow the E2C approach. During this process, we deleted the dimension "data type" because most B2B smart services use a wide range of data types, making it difficult to identify a concise set of meaningful characteristics that match the use cases. Further, we found that the dimension service functionality overlapped with the innovation type and analytics capability dimensions, which led us to remove it from the taxonomy. After this iteration, all objective ending conditions were met, and we discussed the subjective ending conditions among the authors. We considered the taxonomy to be concise, as it included the most important characteristics identified in the four iterations. The number of dimensions was within the size interval recommended by Nickerson et al. [28]. The robustness and comprehensiveness of the taxonomy were confirmed by re-evaluating the objects of this iteration. Since the dimensions and characteristics were generally independent, the taxonomy was also assessed as extendible and explanatory. Thus, all subjective ending conditions were considered to be met.

To evaluate the taxonomy, we recruited six scientists with a background in smart service research and conducted a focus group. We explained the taxonomy and presented the participants with two use cases that they were asked to code using our taxonomy as a codebook. Then, each participant independently rated the taxonomy based on the pre-defined evaluation criteria (completeness, simplicity, understandability, and fidelity with the real world), and the participants could provide additional verbal feedback. Overall, the evaluation showed an insufficient fulfillment of the criteria, with a hit ratio of only 60–70% for the respective dimensions. Therefore, we decided to reiterate the preliminary findings and address the following overarching suggestions made by the focus group: (1) The target user and purpose of the taxonomy should be addressed more specifically in the taxonomy. (2) The dimensions "service beneficiary" and "provider-user interaction" neglect the widely accepted understanding of value co-creation in service systems [68]. (3) The labels and descriptions of the characteristics should be simplified and made more concise.

Table 3
Results of the second evaluation episode.

Dimension	Hit ratio (%)
Innovation type	64.9
Smart service outcome	84.8
Service provider	82.4
Target user	85.3
Analytic capabilities	70.3
Acting features	77.0
Information provision	87.9
Average	**78.9**

Iteration 5. We then supplement our data with additional literature specific to the dimensions to be reconstructed (C2E). Based on the feedback, we added the "target user" dimension, which combines concepts from the service beneficiary and provider-user interaction dimensions. In addition, we reintroduced the smart service outcome dimension instead of describing the provider-user interaction. To better reflect the characteristics of the dimension, we renamed "acting capabilities" to "acting features" and further split its characteristics for a more precise characterization. These changes resulted in the non-fulfillment of the two objective ending conditions (E4, E5).

Iteration 6. Finally, we re-examined 20 randomly selected use cases from iterations 3 and 4 by applying the current taxonomy (E2C) to check if the dimensions matched the cases and if any characteristics or dimensions were missing. The taxonomy was not changed, so all objective ending conditions were met. We also reviewed the subjective ending conditions and concluded that the two additional iterations, guided by the focus group feedback, improved the level of fulfillment of the criteria assessed in iteration 4. Consequently, all subjective ending conditions were met and we could proceed with another evaluation episode.

3.1.2. Evaluation of the final taxonomy

After the sixth iteration, we conducted an ex-post evaluation by presenting ten B2B smart service cases purposefully sampled from our dataset to 13 researchers with medium to high experience in smart services. The participants were asked to use the taxonomy to code the cases based on the case descriptions. Additionally, we shared a summary of the smart service, including its value proposition, the user and provider of the smart product, and the user and provider of the smart service. To reach an agreement on the "ground truth" coding, the authors independently coded the taxonomy, with discrepancies being mutually resolved through discussion. We then used hit ratios to assess the inter-coder reliability [69] by calculating each participant's hit ratio for each characteristic and averaging the results to obtain dimension-specific hit ratios, as shown in Table 3.[2]

The survey group achieved an average dimension-specific hit ratio of 78.9%, with the hit ratios ranging from 64.9% (innovation type) and 87.9% (information provision). Four dimensions had a hit ratio of > 80% and two dimensions > 70%. Overall, the results indicate

[2] In exclusive dimensions (innovation type and analytic capabilities), selecting one characteristic inherently precludes agreement on alternatives, increasing the likelihood of disagreement and lowering the hit ratio.

the validity of the taxonomy, with six dimensions having more than 70% of correct placements and strong overall reliability [69,70], supporting the credibility of the designed taxonomy and confirming its applicability. However, the evaluation also highlighted the innovation type dimension – which is commonly used in existing smart service taxonomies [20,22] – as a weak point of the taxonomy; we return to the likely reasons and to directions for future work in Section 6.4.

After the final taxonomy was successfully evaluated, we re-coded all of the 100 cases using the dimensions and characteristics presented in Section 4 for further analysis. A compact crosswalk illustrating how cases map to the final dimensions is provided in Appendix A. Appendix B provides the final codebook including decision rules for handling ambiguity and missing detail; the anonymized object×characteristic matrix for the 100 cases can be made available upon request.

3.2. Archetype identification

In the second phase of our research, we identify a set of archetypes that are salient configurations of real-world smart services represented through our taxonomy elements. We performed two primary research activities – a quantitative cluster analysis [30] to identify clusters of similar real-world objects, and a qualitative cross-table analysis of the clustering solution [71] to derive meaningful archetype labels and descriptions from the clusters. Finally, we validated our results by examining the portfolios of major smart service providers to test the applicability of our findings.

As a first step, we performed a cluster analysis, with the goal of categorizing objects according to their similarity by aiming to minimize the distance of the objects in the same cluster while maximizing the distance between clusters [72]. This technique allowed for clustering the cases according to their similarities and differences in characterizations along the taxonomy. For the cluster analysis, the statistical computing language R was used. We again used the sample of 100 smart service cases collected during the taxonomy development process as real-world objects for the cluster analysis. Given the purposive, non-probability nature of this publicly disclosed corpus, we interpret cluster memberships and sizes as analytic descriptions of configuration space rather than population incidence. We refrain from prevalence claims and focus on whether stable, interpretable configurations emerge [67]. Based on these cases, we created a dataset for the quantitative analysis using dichotomous variables for the characteristics within each dimension of the smart service taxonomy. Here, each row represents an object (i.e., a smart service use case) and the columns correspond to a characteristic of the taxonomy for which we applied a binary system (1 for presence and 0 for absence of the characteristic).

Since the ideal number of clusters is unknown ex ante, we adopted agglomerative hierarchical clustering [72], which incrementally merges clusters from individual objects into a unified cluster [73]. This coefficient ranges from 0 to 1 and serves as an indicator for the balance as well as the robustness of a clustering structure [30]. Researchers must then validate these clustering options and determine an optimal number of clusters.

We computed the agglomerative coefficient [74] for single, complete, average, McQuitty, and Ward linkages and selected Ward's method [75] because it achieved the highest coefficient on the 100-case dataset ($c \approx 0.93$), indicating the most robust clustering structure (Table 4). Ward iteratively merges clusters to minimize the increase in total within–cluster sum of squares (WSS); the increase from merging clusters A and B is $\Delta\text{WSS} = \frac{n_A n_B}{n_A + n_B}\|\mu_A - \mu_B\|_2^2$ (Ward, 1963).[3] Ward's method is widely used in IS clustering studies (e.g., Fischer et al. [24], Hunke et al. [52]) and well suited to inductive analyses with many variables [73]. We used Euclidean distance, which corresponds well to Ward's method [72].

[3] Toy example: three points (0, 0), (0, 1), (3, 0) give ΔWSS = 0.5 when merging the first two points versus 4.5 and 5.0 for the alternatives, hence Ward merges the closest pair first.

Table 4
Agglomerative coefficient by linkage method (100 cases; Euclidean).

Linkage method	Agglomerative coefficient
Ward	0.925
Complete	0.753
Average (UPGMA)	0.662
Weighted (McQuitty/WPGMA)	0.655
Single	0.547

Notes: Computed on the 100 common cases × 25 features; Euclidean distance; no standardization; values rounded to three decimals.

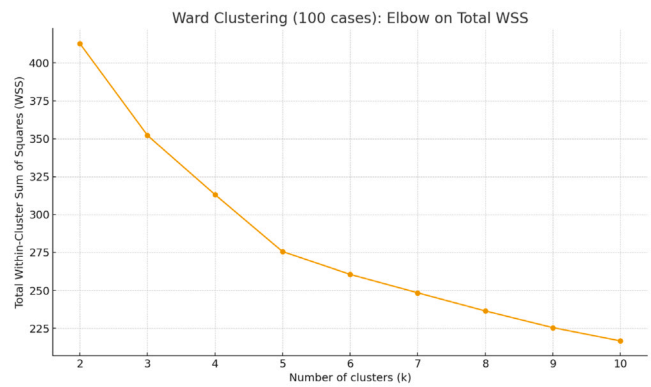

Fig. 4. Ward clustering elbow on the 100-case dataset: total within–cluster sum of squares (WSS) for $k = 2 \ldots 10$ (Euclidean, all binary features, no standardization). The elbow occurs at $k = 5$; we triangulated this with silhouette and interpretability.

The lack of established guidelines for choosing an ideal cluster count [76] prompted us to triangulate different quantitative techniques to find a cluster count that is robust to changes in intra-cluster distances [77]. The elbow on the Ward WSS curve (Fig. 4) indicated $k = 5$ for our data [55,72]; the $\sqrt{n/2}$ rule of thumb suggested $k = 7$ [72]. We also inspected the Ward dendrogram to assess stability with respect to changes in intra-cluster distances. Because silhouette can favor very small k in high-dimensional binary data, we used it as a secondary diagnostic (local high at $k = 5$ (0.230), global maximum at $k = 2$ (0.254)) and prioritized interpretability. This triangulation led us to a consensus on five distinct clusters that crystallize into coherent, robust, and interpretable archetypes; neighboring solutions ($k = 4$ and $k =$ 6–8) either merged conceptually distinct configurations or produced small, unstable clusters. Fig. 5 depicts the dendrogram, illustrating the potential cluster configurations and the merging process.

After clustering, the next phase was to identify archetypes, as ideal smart service types representing salient outcome configurations of smart service innovation processes, still using our smart service dataset [56,78]. Archetypes, by their nature, should be relatively consistent; minor variations in characteristics should not change the cluster affiliation of a related real-world object [79]. We therefore combined a within-cluster examination of the available case data with a cross-table analysis (Fig. 7). The cross-table analysis was performed to calculate the frequency distribution of each characteristic per cluster. It highlighted the most salient features for each cluster, marked their importance, and underscored the differences between clusters [56,71]. These distinctions were instrumental in outlining cluster boundaries and defining archetypes using our domain expertise [56]. For each archetype, we identified one or two representative cases, which were then incorporated into the archetype descriptions. This analysis culminated in the labeling of the five clusters as (A) Enhanced operational

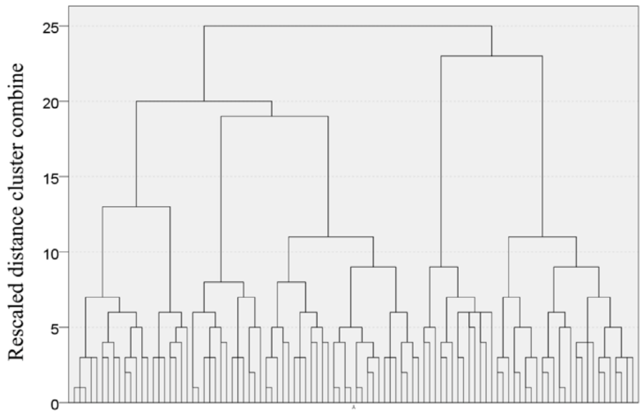

Fig. 5. Dendrogram plot of the hierarchical clustering analysis using Ward.D2 clustering.

productivity, (B) Retrofitting upgrade, (C) Strategic provider insights, (D) Integrated remote management, and (E) Intelligent autonomous operation.

To validate the usefulness of our findings, we assessed the applicability of the five archetypes to larger portfolios of smart services offered by major B2B vendors. To do so, we revisited case study data, including 13 interview transcripts and miscellaneous archival data from two companies, previously conducted as part of another research project. We found that the taxonomy-based archetypes served well to distinguish different efforts to innovate through smart services (e.g., operational support tools, pay-per-use business models, remote support capabilities, remote machine control). While real-world objects are messier than the ideal configurations represented in our set of archetypes, the archetypes helped to more clearly delineate the primary motivation of the smart service provider to develop and deploy the service. These proprietary materials were not used to construct the taxonomy or the clustering dataset and therefore serve as an out-of-sample check that reduces, though cannot eliminate, concerns about publicity/survivorship bias in the public corpus.

4. A taxonomy of smart services in B2B contexts

This section presents the final taxonomy of B2B smart services (Fig. 6), which consists of seven dimensions and corresponding characteristics. The last column indicates whether each dimension is exclusive (E), with a single applicable characteristic, or non-exclusive (N), with the potential for multiple characteristics to be applicable. In parentheses, we indicate the number of occurrences of each characteristic in the sample of 100 use cases. For non-exclusive dimensions, the total number of occurrences may exceed the number of cases.

Innovation type. This dimension captures the novelty of the smart service's value proposition to the user, which shapes the user's incentive to participate in the smart service system [80]. If the original focal value proposition of the service system remains the same but is enhanced by cost reduction, time savings, or increased flexibility [62], we classify the services as *incremental improvements* [81,82]. For example, Siemens uses data collected on a soldering line to predict the likelihood of a non-functioning solder joint, reducing the number of parts that need to be X-rayed and ultimately shortening lead times [83]. Smart services that give rise to new, complementary value propositions are referred to as *added functionality* [84]. For example, FedEx introduced online package tracking [85], which provides users additional value beyond the delivery of a package, as package tracking enables advanced planning for the customer. Finally, *radical new offering* refers to smart services that change the primary value proposition perceived by the business user [20,82,86]. This type includes innovative services, such as augmented guidance through Google Glasses [87]. The primary value proposition of such glasses differs significantly from normal glasses with clear lenses that can be used to protect the eyes, as they allow customers in the logistics sector to augment the fastest routes into the field of vision of their employees, reducing picking times while keeping their hands free.

Smart service outcome. By providing information about their environment, status, and usage to their users or external parties [3,88], smart products can increase *transparency* and provide a better understanding of usage patterns, related processes, or the customers themselves [44]. This information can be further processed to derive actionable insights [88]. *Optimization* refers to smart services that inherently contain actionable insights to improve the product's value-in-use [44]. This includes data-driven recommendations for smart product configuration parameters or usage behavior adjustments [22,88]. Other actors in the smart service system can also optimize their value, for example, by improving their interaction with the product, related processes, customer contact, or product design [4]. *Remote control* of the smart product allows actors to send information and commands to the smart product remotely, increasing its value-in-use for onsite users [4,88]. More advanced smart products can make adjustments *autonomously* without human interaction [88,89], reducing the workload of the actors and responding to changes in the environment in real time [4].

Service provider. This dimension explores the different roles that the actor providing the smart service can play in the smart service system. We group the roles into four categories: The *smart product manufacturer* can provide additional smart services to complement its products and increase the overall value proposition [3,47]. A *retrofit supplier* can provide the technical infrastructure, such as sensors and communication technology, to increase the smartness of a product [47]. The *system operator,* who is responsible for operating the smart product in the field [47], can, for example, provide services related to personnel, maintenance, or consumables. Finally, *external partners* are actors outside the core provider–user–manufacturer triad, such as third-party application developers, integration consultancies, or physical service providers. Companies can play several roles at once, such as a tool manufacturer that provides a service to track the performance of its products (smart product manufacturer) while also allowing third-party products to be integrated into the tracking system (retrofit supplier). Manufacturers can also choose to enhance the smartness of purchased products and create smart services for their own use, acting simultaneously as system operators and retrofit suppliers.

Target user. Similarly, several actors in the overall service system can fill the role of the target user as the primary beneficiary of the smart service exchange. *Smart product users* improve the use of their product through the smart service and derive improved or new value in use. *Smart product providers* can use smart services to optimize their products or their interactions, for example, by using field data to improve simulation models of the product's behavior. Finally, *external actors* can benefit from smart services, which are typically located in the environment of the smart product and interact with it only indirectly [88]. These external actors can be, for example, component suppliers, downstream processes such as recyclers, or regulatory authorities.

Analytic capabilities. Smart services rely on data analytics to derive valuable information from data [90]. *Descriptive analytics* involves preparing, aggregating, and visualizing past or present data to identify what has happened or is happening [24,91,92]. Basic analytical models, such as thresholds or if-else rules, can be applied to extract and communicate more useful results to a human operator or a machine [90]. *Diagnostic analytics* go beyond descriptive capabilities and explain drifts or emerging patterns in the data [24,92]. As a result, they require more advanced methods, skills, and product capabilities [84,90]. *Predictive analytics* use past and current data to forecast future developments based on patterns in the existing data [92,93]. Complex machine learning techniques are typically used to make these predictions [22,91].

Dimension	Characteristics				E/N
Innovation Type	Incremental Improvements (58)	Added Functionality (34)	Radical New Offering (8)		E
Smart Service Outcome	Transparency (83)	Optimization (51)	Remote Control (13)	Autonomy (16)	N
Service Provider	Smart Product Manufacturer (54)	Retrofit Supplier (35)	Smart Product Operator (17)	External Partner (8)	N
Target User	Smart Product User (71)	Smart Product Provider (21)	External Actor (11)		N
Analytic Capabilities	Descriptive (35)	Diagnostic (38)	Predictive (15)	Prescriptive (12)	E
Acting Features	Physical (16)	Digital (7)	Process Triggering (10)	None (67)	N
Information Provision	Push (20)	Pull (75)	None (14)		N

Fig. 6. Taxonomy of smart services in B2B contexts.

Based on these predictive insights, *prescriptive analytics* can provide recommendations for actions to achieve desired outcomes [91,93] by simulating possible actions and evaluating their impact on future developments [24,92]. We consider services to be prescriptive only if the recommendations provided are not obvious from the predictive analysis. The analytic capabilities each build on the preceding ones, with prescriptive as the most advanced capability encompassing all other capabilities [91].

Acting features. Different forms of acting features are another building block for the achievement of desired smart service outcomes. Smart services cross the boundary between the digital and physical worlds through actuators and use them to *physically act* and influence the product and its environment [82,93]. For example, a modern harvesting machine's route and mode of operation can be automatically adjusted based on weather data. *Digital actions* can include updating a car's software over the air [58] or displaying personalized advertisements on a smart monitor. These actions go beyond simply displaying monitored data or recommendations and directly affect the environment of the smart product user [4]. *Process triggering* describes a digital trigger of an action not performed by the smart product or a human operator as part of the inherent smart service. For example, a smart Kanban container could use a camera or scale and machine learning to assess the level of available parts and trigger an ordering process when the filling level is running low.

Information provision. Displaying information about the smart product or its environment is typically one of the key features of a smart service [3]. The smart service itself can trigger the provision of information (*push*), for example, via notifications on a smartphone, tablet, or email when a particular threshold is exceeded [58]. Alternatively, the user of a smart service can initiate the provision of information themselves, which we refer to as *pull* information. For example, information may be accessed through a continuously available dashboard, a web service, or a retrievable report. Some smart services may *not provide information* to the user as part of the offering, such as automation services or certain control services that provide limited or no information about what happens to or with the smart product during its usage.

5. Archetypes of smart services in B2B contexts

This section presents five archetypes of smart services that manifest as distinctive configurations that reflect real-world smart services, with each archetype representing one of the five clusters that summarize 13–28 cases discovered based on the taxonomy and our case base. The cross-table (Fig. 7) shows an overview of the frequency distribution of the taxonomy characteristics for each archetype, resulting from the cluster analysis. After evaluating the use cases within the five cluster groups, paired with cross-table analysis, we conceived the following interpretive labels for the archetypes: (A) Enhanced operational productivity (n = 28), (B) Retrofitting upgrade (n = 25), (C) Strategic provider insights (n = 13), (D) Integrated remote management (n = 21), and (E) Intelligent autonomous operation (n = 13). Table 5 presents the essence of these five archetypes and highlights their unique characteristics regarding the original taxonomy characteristics while providing sample applications. In the following, this section offers a more thorough description of the archetypes and illustrates them using real-world examples from our dataset.

5.1. Archetype descriptions

Archetype A: Enhanced operational productivity. The first archetype, labeled as *Enhanced operational productivity*, describes smart services that enhance the core value proposition of existing physical product offerings. It is primarily offered by the original smart product manufacturers (96%), which ensures deep integration and understanding of the product's capabilities and limitations, and lets them use their product knowledge and established marketing channels to reach the smart product's customers (89%). Services in this archetype focus on incremental enhancements (75%) that directly impact the operational efficiency of the product. Easier portfolio integration for the vendor and a familiar value logic for the user help explain why this is the most common archetype in our sample. The service mainly involves providing information for the purpose of transparency (79%) and optimization (82%). This is achieved through a range of analytic capabilities, the most common of which is diagnostic (54%), which allows monitoring, analysis, and prediction of product performance issues. Most smart services do not take immediate action (82%), and most information is provided as pull information (89%), with some information also provided as push notifications (25%).

As an example of this archetype, water purification equipment provider Evoqua Water Technologies pulls data from its customers' equipment to gain insight into its performance, compares the performance of each customer's equipment to that of the larger group, and provides insights and recommendations to customers [94]. For

Dimension	Characteristic	Cluster A	Cluster B	Cluster C	Cluster D	Cluster E
Innovation type	Incremental improvements	75%	76%	38%	29%	54%
	Additional functionality	21%	16%	62%	48%	46%
	Radical new offering	4%	8%	0%	24%	0%
Smart service outcome	Transparency	79%	96%	100%	95%	31%
	Optimization	82%	44%	54%	10%	62%
	Autonomy	11%	0%	0%	10%	85%
	Remote control	4%	0%	0%	29%	46%
Service provider	Smart product manufacturer	96%	0%	31%	95%	23%
	Retrofit supplier	7%	92%	8%	10%	54%
	Smart product operator	4%	24%	38%	5%	31%
	External partner	7%	0%	31%	0%	15%
Target user	Smart product user	89%	96%	0%	67%	62%
	Smart product provider	0%	4%	100%	14%	31%
	External partner	11%	0%	0%	29%	15%
Analytic capabilities	Descriptive	11%	32%	23%	95%	8%
	Diagnostic	54%	40%	54%	5%	38%
	Predictive	21%	16%	15%	0%	23%
	Prescriptive	14%	12%	8%	0%	31%
Acting features	Physical	7%	0%	8%	33%	46%
	Digital	4%	4%	0%	10%	23%
	Process triggering	7%	12%	8%	0%	31%
	None	82%	84%	85%	57%	0%
Information provision	Push	25%	36%	23%	5%	0%
	Pull	89%	68%	85%	95%	15%
	None	4%	0%	8%	5%	85%

Legend:	0% - 25%	26% - 50%	51% - 75%	76% - 100%

Fig. 7. Frequency distributions of taxonomy characteristics for each archetype.

Table 5
Overview of the identified archetypes of smart services in B2B contexts.

Archetype	Separating characteristics	Typical applications
A. Enhanced operational productivity	• Incremental enhancements to product features. • Transparency and optimization via diagnostic analytics. • Offered by original equipment manufacturers (OEMs) with native integration.	• OEE dashboards. • Real-time monitoring for process improvement. • Predictive maintenance based on product usage patterns.
B. Retrofitting upgrade	• Services offered by retrofit suppliers to enhance capabilities of non-smart products. • Increased transparency allowing for significant optimization targeting the user of the smart product. • Utilization of a broad range of analytics capabilities.	• Retrofitting for legacy products to enable smart capabilities. • Custom analytics for user decision-making. • Interface systems for detailed control and insights.
C. Strategic provider insights	• Tailored for product providers to gain actionable insights into product usage and behavior. • Universal transparency with optimization suggestions. • Diverse providers and a broad mix of analytic capabilities depending on information needs.	• Internal tools for R&D and performance optimization. • Data aggregation for strategic decisions. • System diagnostics for preventive maintenance and assurance.
D. Integrated remote management	• Innovative offerings, often radical deviation from existing solutions. • Often strengthening or exploiting remote control capabilities for products. • Wide user base, including external partners and platform business models for novel value creation.	• Advanced data visualization for pattern discovery beyond the product. • Remote operation platforms for off-site control and management. • Integrated systems for real-time data and control, e.g., to support usage-based pricing models.
E. Intelligent autonomous operation	• Self-directed service execution of autonomous physical and digital actions. • Broad range of autonomous features, from simple process triggering to complex physical actions. • Rendered by varied providers for a diverse user base.	• Hands-free autonomous systems for operation and optimization. • Intelligent process automation replacing or augmenting human tasks. • Self-regulating systems for real-time adjustments without human intervention.

example, it can see if a filter is purifying water at the right rate, if there is a leak, or if a part is underperforming. Evoqua also provides customers with reports on how much water they purified before and after installing Evoqua equipment and suggests changes to the purification process to maximize output. Another exemplary smart service in this cluster is the service provided by a packaging machine manufacturer, which offers their customers a dashboard that tracks errors and groups them into categories to provide greater visibility into its processes and identify problems faster.

Archetype B: Retrofitting upgrade. Smart services within the *Retrofitting upgrade* cluster are provided by a retrofit supplier (92%) and offer transparency (96%) and optimization (44%). This archetype is closely related to archetype A and differs mainly in the service provider not being the smart product manufacturer (0%), but a dedicated retrofit supplier (92%) and/or the smart product operator (24%), which provides the service itself. It focuses on extending the capabilities of non-smart products to enable the delivery of smart services, which is particularly important where legacy systems are prevalent and a complete overhaul is neither feasible nor economically viable. As with Archetype A, smart services are mostly incremental improvements (76%), with additional functionality (16%) and radical new offerings (8%) being scarce. Almost all smart services in this cluster provide transparency (96%) to their users, with optimization about half as common (44%) as in Archetype A. The target user is again the smart product user (96%). The analytic capabilities required focus mainly on basic descriptive and diagnostic capabilities: descriptive 32%, diagnostic 40%, predictive 16%, and prescriptive 12%.

An example of a smart service with low analytic capabilities is the elevator retrofit solution from Bosch [95]. They offer a monitoring hardware box that can be retrofitted to elevators from different vendors. The box collects data (e.g., position, acceleration, distance traveled, door openings) and transmits it to the cloud. There, data is analyzed and checked against predefined maintenance settings, such as a specified travel distance. The user can monitor the data in a dashboard to schedule a service if required, allowing them to respond more quickly to outages and schedule maintenance. An example with prescriptive capabilities is the Greenkeeping App Dashboard, a collaboration between FC Bayern Munich, Siemens, and the Technical University of Munich [96]. The app uses data on light, temperature, humidity, turf salinity, wind, and the chlorophyll content of the grass to provide greenkeepers with recommendations on how long and intensively to light, water, and heat the turf.

Archetype C: Strategic provider insights. This archetype includes services that provide transparency (100%) and optimization suggestions (54%) to the *provider* of the smart product itself (100%). These services provide additional functionality (62%) or incremental improvements (38%) tailored for the product provider to gain a deep understanding of product usage, behavior, and performance. The insights gained from this data can then be used to inform a wide range of strategic decisions, such as design improvements and new feature development, targeted maintenance schedules, and customer training programs. They are the most diverse type of service provider (i.e., smart product manufacturers (31%) and smart product operators (38%)). Analytic capabilities are similar to Archetype A, with 54% of services having diagnostic, 23% descriptive, 15% predictive, and 8% prescriptive capabilities. Action capabilities are typically limited, with only 8% of the services in our sample offering physical action and 8% offering process initiation. The information provided is mostly accessed by the smart product provider actively pulling required information (85%).

For example, Sunwest Bank uses a smart money bag counting service [97]. The smart bags are originally used by the bank's customers to track their movements, so they have advanced security. However, Sunwest recognized the opportunity to provide a smart service to themselves that helps increase their immediate value. By monitoring the number of bags deposited, they can determine how much time will be spent collecting and counting the money each morning. This allows bank managers to allocate a sufficient number of employees to the task, ultimately increasing process efficiency. Similarly, the city of Cleveland provides its residents with smart trash carts [98]. The carts detect whether residents roll carts to the curb for collection regularly and report that information to the city council. As a result, garbage collectors are alerted to residents who are not using their recycling bins and can further detect improper waste separation. Ultimately, this encourages environmentally responsible waste disposal and saves the garbage collector from unnecessary searches.

Archetype D: Integrated remote management. The fourth archetype, *Integrated remote management*, includes more innovative smart services that either provide data unrelated to traditional processes or allow remote control of the smart product. It represents the cluster with the highest frequency of radically new offerings (24%). While nearly all services in this cluster provide minimally processed descriptive information (95%) through pull mechanisms (95%) to increase transparency (95%), about one-third also allow remote control (29%) and physical acting features (33%). The typical provider of such services is again the smart product manufacturer (95%), while the typical user is more split between the smart product user (67%), smart product provider (14%), and external partners (29%). Comparing the cases included in this cluster and analyzing the dendrogram, two subtypes can be identified within this cluster, one that provides transparency only and one that also provides remote control of the product.

One example of a transparency service is provided by Michelin: They use RFID tags attached to their tires so that dealers can easily check the quantity delivered and recyclers can get information about the rubber compound, allowing for better quality recycled products [99]. Both of these services go beyond the typical application of the product, targeting non-traditional actors, and therefore require more innovative thinking than the services of archetype A. As another example, SICK offers a remote connection to its sensors [100]. When users discover a problem with one of their products, SICK's service support staff can remotely access the device to read errors and, if possible, change parameters directly or make an initial assessment and plan the necessary on-site actions. This saves time for both the customer and SICK. Smart payment services combine innovative data and control services, representing another archetypal example of this cluster.

Archetype E: Intelligent autonomous operation. The *Intelligent autonomous operation* archetype represents the highest level of smart service innovation. Smart services in this cluster are characterized by their ability to perform physical actions (46%), digital actions (23%), or trigger processes (31%). They typically complement and extend traditional value propositions, providing incremental improvements (54%) and additional functionality (46%). Consistent with their ability to act by themselves, they are able to make decisions autonomously (85%) and provide transparency (31%), optimization (62%), and remote control (46%). The provider of such services can be a variety of actors: retrofit supplier 54%, smart product operator 31%, smart product manufacturer 23%, or external partners 15%. The same corresponds to the target user, which is split between the smart product user (62%), its provider (31%), and external partners (15%). Since autonomy is at the core of the service, only 15% of the services in this cluster return information to the user.

The previously introduced smart service case of Clever's electric vehicle charger [35], which automatically charges the car when there is enough sustainable energy in the power mix, fits into this cluster and is an illustrative example of this archetype. As another example, a packaging machine manufacturer in our sample provides an autonomous setup service for their machines. The packaging machine needs to be configured for each new product that is used, in terms of for example the temperature of the sealing process or the tension of the film. Since many companies do not have a dedicated machine for each product, this process may be performed several times per day by machine operators with different skill levels. To reduce the complexity of the task, the company offers a smart service that requires the dimensions of the product to be packaged and the film to be used, and automatically configures the machine based on previous experience.

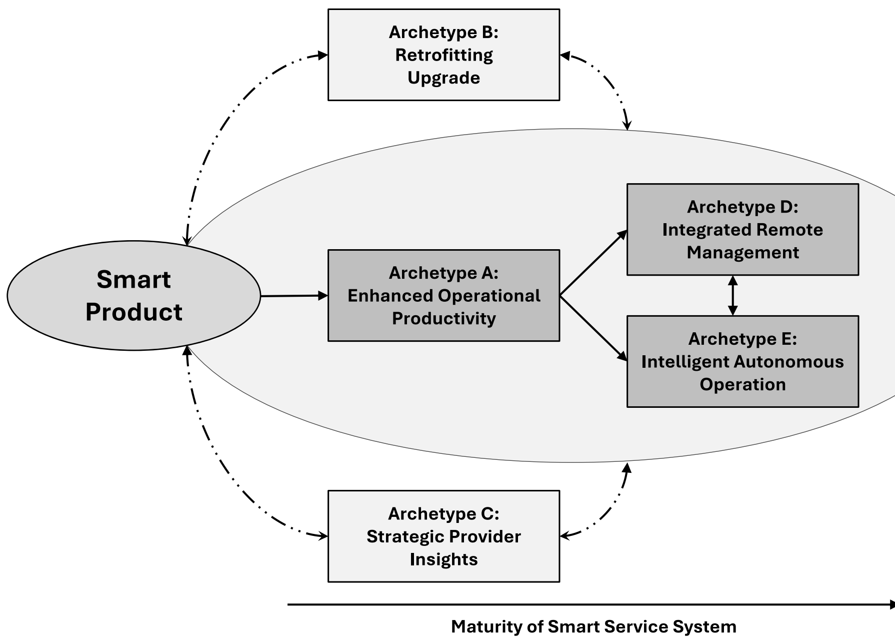

Fig. 8. Overview of smart service archetypes and their relationships.

5.2. *Toward unfolding relationships between the archetypes*

Rather than independent end-states, the archetypes populate a maturation space anchored by the smart product, in which capability build-up and governance maturity together gate transitions among configurations. While a longitudinal study of portfolio evolution lies beyond the scope of this paper, applying the archetypes to cases from our corpus and to portfolios of major B2B vendors lets us hypothesize how these relationships are organized. Fig. 8 summarizes the result: The five archetypes span the B2B smart service solution space and trace a plausible maturation path as technology-enabled capabilities expand.

In this framework, Archetype A (Enhanced operational productivity) is the typical entry point: it innovates around the smart product's core value proposition for the existing user base. Archetypes D (Integrated remote management) and E (Intelligent autonomous operation) represent more advanced configurations that often build on A and require greater investment in embedded technology and governance (e.g., secure remote operation for D; actuators and cyber–physical safeguards for E). We view D and E as complementary paths rather than mutually exclusive endpoints, reflecting different escalation logics from information to remote control and autonomy [27,101]. Archetypes B (Retrofitting upgrade) and C (Strategic provider insights) operate as complementary routes that (B) increase installed-base instrumentability and (C) accumulate provider-side learning, both of which can enable subsequent moves across the space.

To make the archetypes actionable, we propose four alignment cues as *diagnostic heuristics*:

1. *Capability thresholds.* Each archetype presupposes minimum analytics and acting-feature levels (e.g., A → D requires secure remote-control processes and operator training; A → E presupposes prescriptive analytics and safety/liability arrangements).
2. *Installed-base feasibility.* Sensor and actuator penetration in the installed base shape whether *Retrofitting upgrade* is a pragmatic step or whether embedded control (D/E) is the more realistic move.
3. *Data access and regulatory intensity.* Data-access rights, liability, and regulatory regimes condition the viability of remote control and autonomy (D/E) relative to transparency and optimization (A/C).
4. *Role allocations.* Provider–user–partner role allocations indicate whether provider-facing learning (C) or user-facing services (A/D/E) are the near-adjacent move.

6. Discussion

Having presented the taxonomy and the five archetypes, we now relate the result to prior classifications (Section 6.1), develop its theoretical implications for digital servitization research (Section 6.2) and its managerial implications for portfolio and platform decisions (Section 6.3), and discuss limitations and avenues for future research (Section 6.4).

6.1. *Relating key results to existing research*

We contribute descriptive knowledge of B2B smart services by offering a taxonomy with seven dimensions and associated characteristics that provide a common ground for cumulative research [31]. Several dimensions build on prior classifications but are adapted to the distinguishing features of multi-actor, risk-sensitive B2B contexts.

First, with the *innovation type*, we explain the degree to which a service is perceived as new by its user, drawing on incremental, modular, architectural, and radical patterns [81,82,102]. While Paukstadt et al. [20] and Azkan et al. [22] cover related notions, they do not foreground how perceived newness conditions adoption in B2B markets – where offerings often remain low or medium innovation due to risk and legacy constraints [14,103]. We extend this lens to capture such constraints.

Second, building on smart product capability thinking [3], our *smart service outcome* dimension allows for outcomes ranging from transparency to autonomy. In contrast to previous work [e.g., 20,21], we do not see these outcomes as mutually exclusive, as our evidence shows that B2B firms sometimes blend stages (e.g., combining transparency with optimization in archetype A) or skip providing intermediate outcomes (e.g., autonomous process triggering in external systems without full transparency into the underlying data flows in archetype E).

Third, our taxonomy decouples the *service provider* and the *target user* roles to reflect that B2B smart services need not be offered by the OEM. This extends prior work that implicitly assumes manufacturer provision [e.g., 20,22] by admitting third parties like retrofit suppliers, platform operators, or solution integrators [47]. Distinguishing these actors opens new avenues for researching how different organizational roles influence the innovation process and resulting service designs.

Fourth, we incorporate *analytic capabilities* as a distinct dimension, recognizing that B2B smart services can vary widely in the sophistication of data processing [52,92]. Adding to existing research, we show that services can be primarily descriptive, predictive, or geared toward more autonomous decision-making, each configuration involving different technological and organizational dependencies.

Fifth, our taxonomy differentiates *information provision* from *acting features*, aligning with calls to treat remote control, autonomy, and data sharing as independent yet interrelated features [58]. This reveals intermediate forms such as "process-triggering" services that automate tasks without direct physical actuation and that earlier taxonomies may not capture [21,22].

Finally, the five archetypes we derive (A–E) show how these dimensions combine in practice and connect to earlier archetype/role ideas. For example, Allmendinger and Lombreglia [9] propose provider roles like the "embedded innovator" or "aggregator", aligning with our Archetypes A and E, yet they largely assume that the product manufacturer delivers the service. Our findings reveal that multiple actors may assume these roles – sometimes retrofit suppliers or specialized solution integrators – leading to more varied patterns of autonomy, revenue models, and user involvement than previously documented [24,26]. Thus, while our archetypes build on established concepts, they more explicitly capture multi-actor environments and mixed innovation types that characterize B2B scenarios.

Together, these refinements clarify the B2B design space and its boundary conditions, and set up the theoretical implications we develop next.

6.2. Theoretical implications

Situated as a *Type I "theory for analyzing",* [31] the taxonomy clarifies the construct space, admissible value combinations, and boundary conditions of B2B smart services (see Section 4). The archetypes (A–E; Section 5) serve as representative instantiations that anchor this analysis in practice without claiming explanatory or predictive status. In line with Muntermann et al. [60], we regard this clarified design space as *taxonomic theory* (Type I) that scaffolds cumulative theorizing.

By decoupling *service provider* from *target user* and separating *information provision* from *acting features*, the taxonomy makes explicit B2B boundary conditions – multi-actor governance, risk/liability allocation, and data sharing regimes – that shape feasible configurations of analytics, action, and outcomes. Elevating these conditions to first-class constructs improves analytic precision and supports comparability across digital servitization studies.

The taxonomy further offers a configuration-centric lens on smart service design by articulating how *analytic capabilities*, *information provision*, and *acting features* cohere into distinct service logics observed empirically (e.g., monitoring-centric vs. remote management configurations). Although descriptive, this lens sensitizes researchers to configuration-level regularities and to design trade-offs, such as the need to align escalations in acting features with maturing analytics capabilities and governance arrangements.

Evidence from the archetypes indicates that capability build-up in B2B does not necessarily follow the linear stage models advanced in the digital-servitization literature [9,47,50]. Firms may blend or skip steps – for example, triggering processes in external systems without full transparency – as installed-base data accumulates and governance matures. Rather than asserting mechanisms, we delineate a *trajectory space* for longitudinal inquiry into digital transformation pathways in which firms transition among configurations over time.

Admitting retrofitters, platform operators, and solution integrators as legitimate *service providers* foregrounds role permutations that redistribute decision rights, data access, and accountability. This extends servitization theorizing beyond manufacturer-centric assumptions toward ecosystem-level analyses of value capture and risk sharing in networked settings.

Finally, distinguishing *information provision* from *acting features* – rather than collapsing "functionality" into a single dimension – demonstrates how fine-grained separations improve domain coverage and usefulness, informing ongoing debates on taxonomy scope, conciseness, and evaluation in IS [28,29]. We report development steps and evaluation evidence in Section 4, Appendix B, and Appendix C to support transparency and reuse. Consistent with Gregor [31] and Muntermann et al. [60], a Type I taxonomy can enable, without over-extending its claims, subsequent theory types. Future research may use the clarified design space to specify and test mechanisms linking configuration bundles to outcomes (Type II), examine regularities in trajectories among configurations as learning, technology, and governance mature (Type III/IV), and translate recurring configurations into evaluated design knowledge for organizational decision making (Type V).

6.3. Managerial implications

Our taxonomy and archetypes offer managers a practical diagnostic lens. Organizations can first locate existing and proposed services within the seven taxonomy dimensions and, by extension, within one of the five archetypes. This mapping surfaces configuration gaps between the current portfolio and a plausible adjacent configuration. In practice, most portfolios anchor in Enhanced operational productivity and evolve by adding either remote control (toward Integrated remote management) or autonomous features (toward Intelligent autonomous operation), while Retrofitting upgrade and Strategic provider insights operate as complementary routes to extend legacy assets and accumulate provider-side learning. The diagnostic value lies in making explicit where the offering stands on, for example, analytic capabilities, acting features, and information provision, and which governance conditions – data access, liability, and control rights – would need to mature for the next step.

For CIOs and heads of digital, the taxonomy translates into a capability roadmap within the scope of larger digital transformation aspirations [104]. Services positioned in monitoring and optimization depend primarily on descriptive and diagnostic analytics and reliable data pipelines; progression to remote control requires secure command channels, robust identity and access management, change-control processes, and incident response across organizational boundaries. Movement toward autonomy presupposes prescriptive analytics and safety cases that link technical safeguards to contractual liability and auditability. The taxonomy thus helps sequence platform investments – streaming and storage first, device and API governance next, and only then actuation and autonomy – so that ambition is aligned with the underlying data and control fabric.

For service and product managers, the archetypes support portfolio design and migration choices. When the installed base is heterogeneous and only partially instrumented, Retrofitting upgrade is often the least disruptive path to generate transparency and user-facing value while creating the data foundation for subsequent optimization and provider insights. Where customers already depend on remote support workflows, Integrated remote management becomes the natural adjacent move, provided escalation, service levels, and operator training are formalized. Pursuing autonomy is advisable only once recommendations are demonstrably effective in use and the surrounding processes (e.g., fallbacks, overrides, and audit logs) are in place. In each case, the taxonomy clarifies whether the next value step is best realized by deepening analytics, by introducing acting features, or by adjusting the allocation of provider–user–partner roles.

For platform and ecosystem designers, the dimensions foreground multi-actor considerations that are often implicit in technical roadmaps. Remote control and autonomy shift decision rights and risk; successful configurations therefore hinge on data-sharing arrangements, permissioning, and provenance that are credible to customers and regulators. Strategic provider insights can proceed with narrower data scopes and internal users, while user-facing services will require clearer consent, benefit sharing, and dispute mechanisms. The taxonomy helps determine where to keep interfaces closed for safety and liability reasons and where to open them to third parties to stimulate complementary offerings without undermining control of critical functions.

Reading Fig. 7 as a portfolio map also surfaces configuration-dependent execution risk for these managerial roles. Three dependencies recur across our cases and the B2B boundary conditions in Table 1: (1) escalations in *acting features* (none, remote control, autonomy) require commensurate governance – change control, identity and access management, audit logs, and liability coverage; (2) broadening the *target user* beyond the smart product user raises consent, access, and auditability demands; and (3) moving from descriptive toward prescriptive *analytic capabilities* increases model validation, monitoring, and fallback requirements. Practitioners can annotate their own configuration maps with these dependencies to plan adjacent moves prudently.

These role-specific uses share a common logic: map the current configuration, identify the smallest adjacent move that creates additional value, and address the most salient mismatches before scaling [105]. Typical mismatches include aspirations for autonomy without prescriptive analytics, remote intervention without change-control and liability coverage, or platform openness that outpaces data governance maturity. By making these dependencies explicit, the taxonomy supports staged investment, reduces rework, and improves the odds that new services are technically feasible, governable, and acceptable to customers [106]. While our contribution does not claim causal mechanisms, it offers a structured vocabulary and configuration logic that managers can use to organize portfolios, prioritize capability builds, and negotiate the organizational agreements required for more advanced forms of smart service.

6.4. Limitations and future research

Three limitations bound the claims we can make from the present study and shape the agenda for future work.

First, our 100-case corpus is largely drawn from publicly available descriptions, which are prone to publicity and survivorship biases – successful, externally communicable offerings are likely overrepresented, whereas abandoned pilots, internal-only services, or routine maintenance offerings are likely underrepresented. We therefore position the five archetypes as analytically generalizable configurations distilled from a purposive, non-probability sample of publicly disclosed implementations, not as estimates of population prevalence [67]. Our mitigation steps – diversifying source types and industries, enforcing "implemented" inclusion criteria, independent coding with reconciliation, and an out-of-sample check against two proprietary portfolios – mitigate but do not remove this limitation [e.g., 65,66]. Future work should deliberately add negative cases and firm-internal portfolios to probe whether additional configurations appear or relative frequencies change.

Second, we acknowledge the interdependence of certain characteristics of the dimensions we have identified – namely, smart service outcomes, analytic capabilities, and acting features. While our analysis confirms the importance of each dimension in characterizing B2B smart services and suggests that none can be disregarded, the complexity of their interrelationships invites further investigation. In particular, the innovation type dimension, which had the lowest hit ratio at 64.9%, warrants additional investigation to determine its effectiveness in its current form or to identify necessary adjustments. This relatively low agreement likely reflects three factors intrinsic to the construct: perceived "newness" is reference-frame dependent (industry, prior portfolio, installed base) and public case descriptions rarely make this anchoring explicit; public sources are typically marketing-oriented and seldom disclose the design rationale, so coders must infer the magnitude of change; and our categories (incremental improvement, added functionality, radical new offering) demarcate a continuum rather than discrete kinds, so cases near a boundary are coded differently by reasonable raters. Future studies could mitigate these challenges by triangulating provider self-reports, longitudinal portfolio observation, or expert panels with explicit domain anchoring.

Third, smart services and the technologies behind them evolve quickly, and parts of the taxonomy may need revision as new acting features, governance regimes, or analytics capabilities emerge. Our corpus is also public-record only: it admits replication and extension, but proprietary portfolios are likely to surface additional configurations, particularly at the frontier of autonomy and platform-mediated services. We see periodic re-coding against a refreshed corpus, ideally including proprietary cases, as the most direct way to keep the taxonomy current.

Given these limitations, several avenues for future research emerge. In line with calls to connect digital innovation to organizational reconfiguration, a promising lens is to treat the taxonomy and archetypes as a *state space* for studying digital transformation as movement among recurring smart-service configurations. From this view, portfolio evolution reflects how firms build and reconfigure capabilities (e.g., data, analytics, and governance) to scale more advanced service logics over time [107], and how such evolution is enabled or constrained by digital platform architectures and ecosystem boundary resources (interfaces, standards, access rules) in multi-actor settings [108].

Empirically, extending the corpus to proprietary portfolios and still-developing services could surface nascent innovations and, importantly, stalled or abandoned initiatives that are largely invisible in public descriptions. Further work on the interdependencies among dimensions could improve our understanding of how they jointly shape smart service configurations, and the innovation type dimension (lowest hit ratio) warrants reexamination as markets and perceived newness evolve.

Against this backdrop, future work can tighten the link between archetype transitions and digital transformation processes by examining how capability maturation and ecosystem governance co-evolve. Building on our Type I contribution, we see three tractable next steps that convert the agenda above into testable questions: (1) *Portfolio trajectories:* Which transitions among archetypes (e.g., A → D vs. A → E) occur across industries, and how are they associated with installed-base maturity, data-access rights, and liability regimes? (2) *Role allocations and outcomes:* How does separating *service provider* from *target user* (OEM vs. retrofitter vs. operator) influence adoption, value capture, and risk allocation for otherwise comparable configurations? (3) *Information provision, auditability, and trust:* How do *push/pull/none* modalities and audit trails shape trust and acceptance in triadic ecosystems (provider–user–partner) across archetypes?

Methodologically, these questions lend themselves to longitudinal portfolio studies (event-history/sequence analysis), matched case comparisons, and field or online experiments to isolate governance and information-sharing effects.

7. Conclusion

Our study provides a domain-independent taxonomy that clarifies the B2B smart service design space and its boundary conditions; a set of empirically grounded archetypes that capture how analytics, information provision, acting features, and role allocations co-occur in practice; and diagnostic guidance that helps managers locate current offerings, identify adjacent configurations, and sequence capability and governance investments. These contributions extend prior work that is predominantly B2C or domain-specific by making multi-actor dependencies explicit, separating action from information, and demonstrating cross-industry configurations. While we deliberately refrain from causal claims, the clarified construct space and recurring configurations create a foundation for future explanatory and predictive studies on portfolio evolution, capability build-up, and performance outcomes.

In contrast to prior taxonomies that are calibrated to consumer settings or restricted to a single domain – for example, Paukstadt et al. [20]'s emphasis on hedonic value, Azkan et al. [22]'s focus on manufacturing, or Brogt and Strobel [21]'s binary view of automation – our seven-dimension framework jointly captures the multi-actor governance, contract-bound liability, heterogeneous installed bases, and data-sharing regimes that distinguish B2B smart services. Likewise, where extant archetype studies have examined a single facet such as business-model archetypes [26] or consumer-leaning domains like "smart living" [24] and connected cars [25], our five archetypes are derived inductively from 100 publicly disclosed cases spanning seven industries and validated against major B2B vendor portfolios, evidencing structural patterns that hold *across*, rather than *within*, particular domains. The taxonomy thereby offers a shared vocabulary for cumulative cross-industry research, while the archetypes provide a strategic frame – grounded in real configurations rather than stylized ideal types – against which managers can locate, benchmark, and evolve their own offerings.

CRediT authorship contribution statement

Daniel Heinz: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Marcel Fassnacht:** Conceptualization, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Carina Benz:** Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Validation, Writing – review & editing. **Philipp Luchner:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Visualization, Writing – original draft. **Gerhard Satzger:** Funding acquisition, Methodology, Supervision, Validation, Writing – review & editing.

Declaration of Use of Generative AI and AI-assisted Technologies in the Writing Process

During the preparation of this work, the authors used DeepL Write, OpenAI ChatGPT, and Anthropic Claude to produce draft text and revise wording. Multiple versions of ChatGPT over different time periods were used, with all versions based on the underlying GPT-4 or GPT-5 large language model; the Claude assistant used during the final revision rounds was based on the Claude Opus 4 large language model. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Funding

This work was supported by the German Federal Ministry of Education and Research through the research projects "bi.smart" (grant no. 02J19B041) and "DL2030" (grant no. 02K18D200).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Dimension	Characteristics				E/N
Innovation type	**Incremental improvements**	Added functionality	Radical new offering		E
Smart service outcome	**Transparency**	**Optimization**	Remote control	Autonomy	N
Service provider	**Smart product manufacturer**	Retrofit supplier	Smart product operator	External partner	N
Target user	Smart product user	**Smart product provider**	External actor		N
Analytic capabilities	**Descriptive**	Diagnostic	Predictive	Prescriptive	E
Acting features	Physical	Digital	Process triggering	**None**	N
Information provision	**Push**	Pull	None		N

Fig. 9. Kimberly-Clark's monitoring of bathroom consumables (Case C096).

Dimension	Characteristics				E/N
Innovation type	Incremental improvements	**Added functionality**	Radical new offering		E
Smart service outcome	Transparency	Optimization	**Remote control**	**Autonomy**	N
Service provider	Smart product manufacturer	**Retrofit supplier**	Smart product operator	External partner	N
Target user	**Smart product user**	Smart product provider	External actor		N
Analytic capabilities	Descriptive	**Diagnostic**	Predictive	Prescriptive	E
Acting features	**Physical**	Digital	Process triggering	None	N
Information provision	Push	Pull	**None**		N

Fig. 10. ITI Sistemi's autonomous HVAC control (Case C061).

Acknowledgments

The authors would like to thank all parties involved in the evaluative research episodes for their generous support.

Appendix A. Taxonomy illustration

To further test the taxonomy and demonstrate its usefulness for our subject, we show the application of our taxonomy in three exemplary use cases from our data set.

The first case of a smart soap dispenser was briefly discussed in the introduction of this article. Kimberly-Clark, a global provider of public restroom equipment, serves B2B customers, primarily facility managers responsible for maintaining clean and functional restrooms (C096; Fig. 9) [10]. To provide smart services to its customers, Kimberly-Clark has integrated sensors and communication technology into its equipment to monitor the filling level of physical products (service provider: smart product manufacturer). The soap dispenser can send information about the remaining soap back to Kimberly-Clark, which uses this information to notify the customer (push) when the soap level falls below a predetermined threshold (descriptive) and needs to be refilled. This service provides transparency to the facility manager and enables optimization of the cleaning and replenishment schedule based on actual restroom usage. This is most useful in office environments, for example, where usage varies significantly with occupancy, making it difficult to predict using traditional metrics and leading to unnecessary site visits. The facility manager receives push notifications and presents himself as the provider of the smart product (i.e., the soap dispenser) to his customers while being the target user of the smart service. The smart service is an incremental improvement because the main value proposition for the facility manager (the ability to provide clean restrooms with enough soap and paper towels to keep the restroom's users satisfied) remains the same but is enhanced by the improved scheduling possibilities. The service has no acting features other than informing the facility manager.

In the second case (C061; Fig. 10), an Italian government agency partnered with systems integrator ITI Sistemi (a retrofit supplier) to optimize the use of workplace resources and develop smart services

Dimension	Characteristics				E/N
Innovation type	Incremental improvements	Added functionality	**Radical new offering**		E
Smart service outcome	**Transparency**	**Optimization**	Remote control	Autonomy	N
Service provider	Smart product manufacturer	**Retrofit supplier**	Smart product operator	External partner	N
Target user	**Smart product user**	Smart product provider	External actor		N
Analytic capabilities	Descriptive	**Diagnostic**	Predictive	Prescriptive	E
Acting features	Physical	**Digital**	Process triggering	None	N
Information provision	Push	**Pull**	None		N

Fig. 11. Accenture's assembly assistance through smart glasses (Case C012).

for its offices [35], specifically to control the heating, ventilation, and air conditioning (HVAC) of the agency's meeting rooms. The solution developed by ITI Sistemi uses several sensors in the meeting room to assess its occupancy (diagnostic). When the rooms are unoccupied, and no meeting is scheduled, the HVAC system is autonomously turned off to reduce energy waste (autonomy and remote control). The agency and its staff are not involved in this process, which means that the service does not provide transparency or optimization by our definition (both would require a human to use the information provided to make improvements). Therefore, we consider this service an added functionality rather than an incremental improvement since the automation is a major change to the overall system and usage processes. On the other hand, it is not a radically new offering because the primary value proposition – room temperature control – remains the same, and energy savings is a secondary concern.

In the third case (C012; Fig. 11), Airbus partnered with Accenture, a consulting firm that acts as the service provider and retrofit supplier, to use augmented reality glasses to simplify its assembly processes [109]. These glasses act as smart products that augment information in the worker's field of vision to analyze their view and mark the aircraft's floor for seat installation. The glasses also provide additional information about the assembly process in real time, with diagnostic capabilities that identify points of interest and take digital actions to mark those areas in the worker's field of view. In addition, workers can select the assembly step they are working on using voice commands or barcode scans to pull the information they need. The service outcome is advanced transparency into the assembly process and optimization through continuous training, which reduces error rates and improves productivity by up to 500%. This smart service functionality goes beyond simple safety or prescription glasses. It is considered a radical new offering for Airbus, which uses the glasses specifically to take advantage of the augmented reality-based smart service.

Appendix B. Codebook for coding B2B smart service cases

This codebook specifies operational definitions and decision rules for assigning each empirical object (a publicly described B2B smart service case) to the taxonomy's characteristics.

Unit of analysis ("object"): One distinct smart service offering or use case that:

- is grounded in a connected physical product (smart product as boundary object),
- operates in a B2B setting (organizational use context), and
- contains a described value proposition and delivery logic (how data and/or actions create value).

General coding instructions and principles:

- Read for the service logic, not the tech stack. Code what the service does for whom (roles, outcomes, information/action), not which technologies are named.
- Prefer the "offering view". Code the service as presented to the target user, not what could theoretically be possible with the underlying product.
- Code conservatively: assign a characteristic only when supported by the case description (explicit statement or unambiguous implication); otherwise, leave it uncoded.
- Resolve overlaps via dimension-specific decision rules. If two labels seem plausible, apply the tie-breaker for that dimension.
- Record a brief justification (1–2 sentences) for any borderline assignment.

(1) Innovation type (Exclusive)

Goal: Capture the novelty of the smart service's value proposition as perceived by the target user relative to the non-digital/prior baseline.

Characteristics:

- *Incremental improvement* – Enhances an existing value proposition (same "job to be done"), e.g., faster, cheaper, more reliable, more convenient.
- *Added functionality* – Adds a new complementary value proposition on top of the existing one (new capability/service value), without redefining the primary offering category.
- *Radical new offering* – Substantially changes the primary value proposition (new dominant logic of use; step-change for the user).

Decision rule:

- Identify the user's baseline primary value proposition; then classify: same value proposition but better → Incremental improvement; extended with a new complementary value stream → Added functionality; fundamentally changed primary value proposition → Radical new offering.

(2) Smart service outcome (Non-exclusive)

Goal: Capture what the service enables or achieves in terms of transparency, optimization, remote control, and autonomy. Outcomes may co-occur.

Characteristics:

- *Transparency* – Provides understanding of status/usage/environment (visibility).
- *Optimization* – Provides actionable insights/recommendations to improve value-in-use or process performance.
- *Remote control* – Enables sending commands/changes to the smart product remotely.
- *Autonomy* – System makes and executes decisions without human interaction (within predefined boundaries).

Decision rules:

- Transparency: monitoring/visibility outputs (dashboards, reports, status, alerts).
- Optimization: actionable recommendations or parameter suggestions (beyond "here is the status").
- Remote control: remote parameter changes, remote configuration, remote operation, or command execution.
- Autonomy: system triggers/executes changes automatically without a human decision at the time of action.
- Tie-breaker: human triggers remote actions → Remote control; system triggers actions → Autonomy. Pure anomaly detection that only flags issues → Transparency unless it includes recommended actions or parameter changes.

(3) Service provider (Non-exclusive)

Goal: Identify which actor(s) provide the smart service offering (i.e., deliver, operate, and commercialize/offer it).

Characteristics:

- *Smart product manufacturer* – Original manufacturer of the focal smart product provides the service.
- *Retrofit supplier* – Third party adds sensors/connectivity/analytics to existing non-smart products and provides the service.
- *Smart product operator* – Actor operating the product in the field provides the service (e.g., facility operator, fleet operator).
- *External partner* – Other provider role (consulting/integrator/platform developer/third-party service provider) not covered above.

Decision rules:

- Code the provider as the party delivering the service offering (contractually and operationally), not necessarily who built every component.
- If multiple parties jointly deliver, code all applicable roles.
- Tie-breaker: branded/run by OEM → include Smart product manufacturer even if partners contributed; core value is enabling connectivity for legacy equipment → include Retrofit supplier; operator offers monitoring/optimization mainly for its own operated assets or customers → include Smart product operator.

(4) Target user (Non-exclusive)

Goal: Identify the primary beneficiary(ies)/intended user(s) of the smart service.

Characteristics:

- *Smart product user* – Organization/person operating/using the product in its work process.
- *Smart product provider* – Provider (e.g., OEM) uses the service for provider-side learning, R&D, service operations, or portfolio decisions.
- *External actor* – Actor in the product's ecosystem not directly operating/providing the product (e.g., recycler, dealer, regulator, insurer, downstream process partner).

Decision rules:

- Identify the service's "who is it for?" from the case description.
- Explicitly internal-facing for provider improvement → Smart product provider.
- Enables actors like recyclers/dealers/regulators to act on product-related information → External actor (in addition to others if applicable).
- Facility/fleet/plant operator managing the asset → typically Smart product user.

(5) Analytic capabilities (Exclusive)

Goal: Capture the sophistication of analytics required by the service. Code only the highest level clearly evidenced.

Characteristics:

- *Descriptive* – Summarization/visualization, thresholds, "what is/was happening".
- *Diagnostic* – Explanation/attribution of patterns, root-cause style analysis ("why").
- *Predictive* – Forecasts/failure likelihood/remaining useful life ("what will happen").
- *Prescriptive* – Optimized recommendations or decision support that evaluates alternatives ("what should we do").

Decision rules:

- Assign the highest level with evidence (start at Prescriptive and work downward).
- Prescriptive requires non-trivial recommendation logic that proposes/optimizes choices (e.g., parameter tuning, scheduling alternatives, optimization under constraints).
- Predictive if it forecasts failures/events/time-to-failure.
- Diagnostic if it explains reasons for anomalies or deviations.
- Descriptive if it only reports status/alerts with rules.
- Tie-breaker: trivial recommendations that are direct consequences of prediction (e.g., "failure likely → schedule maintenance") can still be Predictive.

(6) Acting features (Non-exclusive)

Goal: Capture whether and how the service acts beyond providing information. Multiple acting features may co-occur. If none are present, explicitly code "None".

Characteristics:

- *Physical action* – Actuates physical behavior in the product/environment.
- *Digital action* – Performs digital changes (e.g., OTA updates, software configuration changes, digital environment modifications).
- *Process triggering* – Triggers an external process (e.g., ordering, ticket, dispatch) not executed by the smart product itself.
- *None* – No acting beyond information provision.

Decision rules:

- Information only (even with strong analytics) → None.
- Launches a workflow in another system (order, service dispatch, ticket) → Process triggering.
- Modifies software/configuration/content digitally → Digital action.
- Moves/controls physical actuators or operation modes → Physical action.
- Tie-breaker: a human receiving an alert and then calling someone is not Process triggering unless the system triggers the process itself.

(7) Information provision (Non-exclusive)

Goal: Capture how information is provided to users (push, pull, none). Push and pull can co-exist.

Characteristics:

- *Push* – System sends notifications proactively (alerts, emails, messages) based on conditions/events.
- *Pull* – User retrieves information on demand (dashboard, portal, report access).
- *None* – Service does not provide information as part of the offering (often automation/autonomy focused).

Decision rules:

- Push: proactive alerts/notifications based on conditions/events.
- Pull: on-demand access via dashboard/portal/reporting interface.
- None: case description implies information is not provided as part of the offering (or the service is purely autonomous and users are not informed).
- If both are described and clearly part of the offering, code both.

Appendix C. Overview of cases included

See Table 6.

Table 6
Overview of the empirical data sources.

Case ID	Case name	Cluster	Reference link	Last accessed
C001	SICK - Picture deviation detection	A	https://www.sick.com/ch/de/sick-appspace/sick-appspace-artificial-intelligence/deep-learning/c/g547657	16.12.2024
C002	SICK - Remote Service	D	https://www.sick.com/cl/en/catalog/products/digital-services-and-software/sick-sensorapps/remote-service-connect/c/g515551	16.12.2024
C003	Deloitte - Elevator monitoring	B	https://www2.deloitte.com/de/de/blog/internet-of-things-blog/2020/artificial-intelligence-of-things.html	30.06.2022
C004	Deloitte - Piston monitoring	B	https://www2.deloitte.com/de/de/blog/internet-of-things-blog/2020/artificial-intelligence-of-things.html	30.06.2022
C005	Deloitte - Cellar humidity regulation	E	https://www2.deloitte.com/de/de/blog/internet-of-things-blog/2020/artificial-intelligence-of-things.html	30.06.2022
C006	Google - Shortest route in glasses	A	https://www.wsj.com/articles/dhl-unit-plans-google-glass-experiment-in-us-warehouses-1439568950	16.12.2024
C007	Daimler - Truck quality problem prediction	C	https://www2.deloitte.com/content/dam/Deloitte/us/Documents/about-deloitte/us-about-deloitte-daimler-truck-manufacturing-case-study.pdf	16.12.2024
C008	Texmark - Chemical pumps predictive maintenance	B	https://www2.deloitte.com/content/dam/Deloitte/us/Documents/strategy/us-stratops-texmark-refinery-of-the-future.pdf	16.12.2024
C009	Spirit - Dispatch jobs on material tracking	B	https://www2.deloitte.com/content/dam/Deloitte/us/Documents/process-and-operations/us-dynamic-scheduling-takes-flight.pdf	16.12.2024
C010	DaVinci - Minimal invasive surgery	D	https://www.davincisurgery.com/da-vinci-systems/about-da-vinci-systems	16.12.2024
C011	DaVinci - Visual guidance and information during surgery	A	https://www.intuitive.com/en-us/products-and-services/da-vinci/software	16.12.2024
C012	Airbus - Augmented reality assisted assembly	B	https://www.accenture.com/us-en/case-studies/aerospace-defense/airbus-wearable-technology	16.12.2024
C013	Google - Read barcodes handfree with glasses	E	https://www.wsj.com/articles/dhl-unit-plans-google-glass-experiment-in-us-warehouses-1439568950	16.12.2024
C014	Anonymized - Integrated measuring in clamping device	D	Case from Interviews	30.06.2022
C015	Anonymized - Predictive maintenance machine filters	A	Case from Interviews	30.06.2022
C016	Anonymized - Air quality check	A	Case from Interviews	30.06.2022
C017	Anonymized - Machine performance optimization	A	Case from Interviews	30.06.2022
C018	Anonymized - Tooling performance tracking	B	Case from Interviews	30.06.2022
C019	Anonymized - Automatic configuration of packaging machine	E	Case from Interviews	30.06.2022
C020	Anonymized - Production KPI	B	Case from Interviews	30.06.2022
C021	Anonymized - Machine error analysis	A	Case from Interviews	30.06.2022
C022	Anonymized - Running time overview of chainsaws	D	Case from Interviews	30.06.2022
C023	Anonymized - Process anomaly detection	A	Case from Interviews	30.06.2022
C024	Fraunhofer - Harvest yield influencing factors comparison	B	https://www.iese.fraunhofer.de/blog/big-data-landwirtschaft/	16.12.2024
C025	Omron - Blood pressure measuring watch	D	https://www.smartwatch.de/news/blutdruck-smartwatch-von-omron-erhaelt-die-zulassung/	16.12.2024
C026	Philips - X-ray quality improvement	A	https://www.documents.philips.com/doclib/enc/fetch/2000/4504/577242/577261/577262/3923070/452296228811_stentboost_LR.pdf	16.12.2024
C027	Philips - Memory function operating table	D	https://www.documents.philips.com/assets/20200403/23fe7d73f44243eb8e33ab9200bd9d82.pdf	16.12.2024
C028	Philips - Medical device tracking	B	https://www.philips.de/healthcare/produkte-loesungen/referenzprojekte/olvg	16.12.2024
C029	Philips - Medical device theft detection	B	https://www.philips.de/healthcare/produkte-loesungen/referenzprojekte/olvg	16.12.2024
C030	Philips - Patient deterioration risk score	A	https://www.philips.de/healthcare/produkte-loesungen/referenzprojekte/sana-klinikum-berlin-lichtenberg	16.12.2024
C031	Johnson & Johnson - Orthopedic instrument supply based on image-identified needs	A	https://www.jnj.com/innovation/how-johnson-johnsons-innovative-supply-chain-technology-is-helping-transform-how-we-work-and-live	16.12.2024

(*continued on next page*)

Table 6 (*continued*).

Case ID	Case name	Cluster	Reference link	Last accessed
C032	Roche - Blood glucose dashboard	A	https://www.rochediabetes.com/de-de/accu-chek-smart-pix-software	16.12.2024
C033	RAM - Pasta defect identification	B	https://siemens.mindsphere.io/content/dam/mindsphere/success-stories/ram-elettronica/RAM%20Elettronica_Digitalization%20comes%20to%20pasta%20making.pdf	30.06.2022
C034	Hamburger Containerboard - Machine optimization recommendations	B	https://new.siemens.com/global/en/company/stories/industry/2021/yorkshirewater-water-ai-iot-uk.html	16.12.2024
C035	SKF - Bearing as a Service (financial efficiency)	A	https://www.siemens.com/global/en/company/stories/industry/2021/rotatingequipment-outcomebasedcontracts-outcomebasedservices-xaas-cloud-skf.html	16.12.2024
C036	SKF - Bearing as a Service (operational efficiency)	A	https://www.siemens.com/global/en/company/stories/industry/2021/rotatingequipment-outcomebasedcontracts-outcomebasedservices-xaas-cloud-skf.html	16.12.2024
C037	Siemens - Predictive quality assessment	E	https://siemens.mindsphere.io/en/solutions/customer-success-story/siemens-relieving-a-quality-assurance	16.12.2024
C038	Yorkshire - Waterpipe blockage prediction	B	https://new.siemens.com/global/en/company/stories/industry/2021/yorkshirewater-water-ai-iot-uk.html	16.12.2024
C039	Digitread - Automatic operation of floating docks	E	https://new.siemens.com/global/en/company/stories/industry/cloud-marine-digitread.html	30.06.2022
C040	FC Bayern - Grass maintenance recommendations	B	https://new.siemens.com/global/en/company/stories/industry/the-turf-whisperer-communicating-with-grass.html	30.06.2022
C041	Siemens - Electric load prediction	C	https://siemens.mindsphere.io/en/solutions/partner-use-cases/advanta-electric-vehicle-charging	16.12.2024
C042	Evoqua - Product development based on analysis of failures and unused features	C	https://customers.microsoft.com/en-us/story/evoqua-water-technologies	30.06.2022
C043	Evoqua - Equipment recommendation	A	https://customers.microsoft.com/en-us/story/evoqua-water-technologies	30.06.2022
C044	ATF - Security surveillance	B	https://customers.microsoft.com/en-us/story/atf-services	30.06.2022
C045	DWTC - Asset tracking of rental equipment	C	https://customers.microsoft.com/en-us/story/dubaiworldtradecentre	30.06.2022
C046	Bosch Rexroth - Remote configuration	D	https://apps.boschrexroth.com/rexroth/de/connected-hydraulics/produkte/obed/	16.12.2024
C047	Eaton - Energy waste discovery	A	https://www.eaton.com/content/dam/eaton/markets/machinebuilding/designing-more-energy-efficient-machines/documents/documents-german-language/WP040005de_fin_apr2016.pdf	16.12.2024
C048	Michelin - Inventory management (Speed of delivery control)	D	https://news.michelin.de/articles/michelin-vernetzt-pkw-reifen	16.12.2024
C049	Michelin - Inventory management (Product recycling quality)	D	https://news.michelin.de/articles/michelin-vernetzt-pkw-reifen	16.12.2024
C050	RENK - Condition monitoring of boat engines	A	https://www.renk-group.com/de/produkte-service/produkte/condition-monitoring/	16.12.2024
C051	Schaeffler - Condition monitoring of bearings	A	https://www.schaeffler.de/de/produkte-und-loesungen/industrie/produktportfolio/digitale_services/conditionanalyzer/index.jsp	16.12.2024
C052	Heidelberger Druck - Pay per output	A	https://www.heidelberg.com/global/de/services_and_consumables/print_site_contracts_1/subscription_agreements/subscription_1.jsp	16.12.2024
C053	MAN - Remote maintenance	D	https://www.engines.man.eu/global/de/marine/yachtmotoren/isea/ihr-plus/Ihr-Plus.html	16.12.2024
C054	Trumpf - Pay per part laser cutting	D	https://relayr.io/de/pay-per-part-trumpf-und-munich-re-planen-neues-geschaeftsmodell-fuer-die-produzierende-industrie/	16.12.2024
C055	Bosch - Lift monitoring	B	https://www.bosch-elevatorcloud.com/de/aufzug-monitoring/	16.12.2024
C056	Bosch - Asset tracking	B	https://bosch.io/de/use-cases/industrie-logistik/container-und-asset-tracking/	16.12.2024
C057	Scanalytics - Customer movement and conversion rate detection	C	https://www.scanalyticsinc.com/retail	16.12.2024
C058	E-Zpass - Automated toll collection	E	https://www.e-zpassiag.com/	16.12.2024
C059	3M - Tamper proof pharmaceutical label	D	https://customers.microsoft.com/en-us/story/blockchain-3m	30.06.2022
C060	Tagdat - Virtual geofencing	B	https://customers.microsoft.com/en-us/story/737504-tagdat-smart-spaces-azure-uk	30.06.2022
C061	INAIL - HVAC control based on room occupancy	E	https://customers.microsoft.com/en-us/story/724174-inail-national-government-azure	30.06.2022

(*continued on next page*)

Table 6 (*continued*).

Case ID	Case name	Cluster	Reference link	Last accessed
C062	INAIL - Credential control meeting room	E	https://customers.microsoft.com/en-us/story/724174-inail-national-government-azure	30.06.2022
C063	Bell - Helicopter predictive maintenance	A	https://www.ibm.com/case-studies/bell-flight-predictive-maintenance	30.06.2022
C064	Urbano Agroindustrial - Executive production dashboard	B	https://www.ibm.com/case-studies/urbano-agroindustrial	30.06.2022
C065	Urbano Agroindustrial - Check silo level	B	https://www.ibm.com/case-studies/urbano-agroindustrial	30.06.2022
C066	Mitsufuji - Health monitoring via Shirts	D	https://www.ibm.com/case-studies/mitsufuji-watson-iot-maximo-worker-insights	30.06.2022
C067	Flight Safety - Flight simulator training insights	A	https://www.ibm.com/case-studies/flightsafety/	30.06.2022
C068	Flight Safety - Customized flight simulator training	A	https://www.ibm.com/case-studies/flightsafety/	30.06.2022
C069	SilverHook - Race boat distance monitoring	A	https://www.ibm.com/case-studies/silverhook-powerboats	30.06.2022
C070	SilverHook - Race boat engine monitoring	A	https://www.ibm.com/case-studies/silverhook-powerboats	30.06.2022
C071	IntelliStreets - Count pedestrians and direction	C	https://www.intellistreets.com/	16.12.2024
C072	All Traffic Solutions - Road speeding overview	D	https://www.alltrafficsolutions.com/products/shield-radar-speed-displays/	16.12.2024
C073	Xerox - Pay as you print service	D	https://www.xerox.com/downloads/usa/en/gdo/casestudies/gdo_casestudy_city_of_new_york.pdf	16.12.2024
C074	City of Cleveland - Recycling bin usage tracking	C	https://www.cleveland.com/metro/2010/08/city_of_cleveland_to_use_high-.html	16.12.2024
C075	iFarming - Watering management	A	https://www.ibm.com/case-studies/ifarming-watson-cloud	16.12.2024
C076	Teijin - Tracking of used medical items	D	https://customers.microsoft.com/en-us/story/775244-teijin-chemicals-azure-japan	30.06.2022
C077	Sunwest Bank - Cash drop tracking	B	https://customers.microsoft.com/en-us/story/761419-sunwest-bank-banking-capital-markets-azure	30.06.2022
C078	Sunwest Bank - Fast count of work	C	https://customers.microsoft.com/en-us/story/761419-sunwest-bank-banking-capital-markets-azure	30.06.2022
C079	Takasago - Efficient building heating strategy	E	https://customers.microsoft.com/en-us/story/779169-takasago-thermal-engineering-azure-japan	30.06.2022
C080	Draeger - Automated information provision of gas clearing	A	https://customers.microsoft.com/en-us/story/781719-draeger-azure-discrete-manufacturing-en	30.06.2022
C081	Celli - Drink demand forecast	D	https://customers.microsoft.com/en-us/story/792978-celli-group-manufacturing-azure-iot	30.06.2022
C082	Celli - Drink quality monitoring	C	https://customers.microsoft.com/en-us/story/792978-celli-group-manufacturing-azure-iot	30.06.2022
C083	CarePod - Covid testcenter queue management	C	https://customers.microsoft.com/en-us/story/830377-citizen-care-pod-health-provider-azure-canada	30.06.2022
C084	Witte - Car lock access management	D	https://customers.microsoft.com/en-us/story/833882-witte-digital-azure-active-directory-api-sql-app-iot-mobile-german-germany	30.06.2022
C085	Witte - Car telemetry data	B	https://customers.microsoft.com/en-us/story/833882-witte-digital-azure-active-directory-api-sql-app-iot-mobile-german-germany	30.06.2022
C086	Axilion - Traffic management recommendation	C	https://customers.microsoft.com/en-us/story/820930-axilion-smart-spaces-azure	30.06.2022
C087	Axilion - Autonomous traffic management	E	https://customers.microsoft.com/en-us/story/820930-axilion-smart-spaces-azure	30.06.2022
C088	AdMov - Personalized ads in taxis	E	https://customers.microsoft.com/en-us/story/836838-admov-professional-services-azure-en-philippines	30.06.2022
C089	Seraku - Agriculture abnormalities detection	B	https://customers.microsoft.com/en-us/story/844625-seraku-professional-services-azure-en-japan	30.06.2022
C090	Seraku - Agriculture growth monitoring	B	https://customers.microsoft.com/en-us/story/844625-seraku-professional-services-azure-en-japan	30.06.2022
C091	Nexans - Tracking of cable drums	D	https://customers.microsoft.com/en-us/story/854108-nexans-discrete-manufacturing-azure-en-united-states	30.06.2022
C092	3am - Firefighter communication	A	https://customers.microsoft.com/en-us/story/862084-3am-innovations-partner-professional-services-azure-cognitive-services	30.06.2022
C093	3am - Firefighter tracking	D	https://customers.microsoft.com/en-us/story/862084-3am-innovations-partner-professional-services-azure-cognitive-services	30.06.2022

(*continued on next page*)

Table 6 (*continued*).

Case ID	Case name	Cluster	Reference link	Last accessed
C094	BIC - Use-driven razor development	C	https://customers.microsoft.com/en-us/story/1397444480270094354-bic-consumer-goods-azure-en-greece	16.12.2024
C095	MacDonald-Miller - HVAC predictive maintenance	B	https://customers.microsoft.com/en-us/story/713846-macdonald-miller-professional-services-dynamics-365-azure-powerbi	30.06.2022
C096	Kimberly-Clark - Soap Dispenser consumption monitoring	C	https://customers.microsoft.com/en-us/story/1389274803812164767-kimberly-clark-professional-onvation-smart-spaces-azure-en-united-states	16.12.2024
C097	Clever - Energy grid load balancing with EVs	E	https://customers.microsoft.com/en-us/story/1396259073599324009-clever-azure-sustainability-automotive-energy	30.06.2022
C098	Eneco - Intelligent energy distribution	E	https://customers.microsoft.com/en-us/story/1409247707847710655-eneco-energy-microsoft-365-en-netherlands	16.12.2024
C099	Upepo - Smart meter for water distribution (leakage detection)	A	https://customers.microsoft.com/en-us/story/1388233226031180940-upepo-technology-professional-services-azure-en-kenya	16.12.2024
C100	Upepo - Smart meter for water distribution (contactless meter reading)	D	https://customers.microsoft.com/en-us/story/1388233226031180940-upepo-technology-professional-services-azure-en-keny	16.12.2024

References

[1] S. Nambisan, K. Lyytinen, A. Majchrzak, M. Song, Digital innovation management: Reinventing innovation management research in a digital world, MIS Q. 41 (1) (2017) 223–238, http://dx.doi.org/10.25300/misq/2017/41:1.03.

[2] L. Wessel, A. Baiyere, R. Ologeanu-Taddei, J. Cha, T.B. Jensen, Unpacking the difference between digital transformation and IT-enabled organizational transformation, J. Assoc. Inf. Syst. 22 (1) (2021) 102–129.

[3] M.E. Porter, J.E. Heppelmann, How smart, connected products are transforming competition, Harv. Bus. Rev. 92 (11) (2014) 64–88.

[4] D. Beverungen, O. Müller, M. Matzner, J. Mendling, J. vom Brocke, Conceptualizing smart service systems, Electron. Mark. 29 (1) (2019) 7–18, http://dx.doi.org/10.1007/s12525-017-0270-5.

[5] J. Effah, F. Amankwah-Sarfo, R. Boateng, Affordances and constraints processes of smart service systems: Insights from the case of seaport security in Ghana, Int. J. Inf. Manage. 58 (2021) 102204, http://dx.doi.org/10.1016/j.ijinfomgt.2020.102204.

[6] C. Kowalkowski, J. Wirtz, M. Ehret, Digital service innovation in b2b markets, J. Serv. Manag. 35 (2) (2024) 280–305.

[7] Y.C. Yang, H. Ying, Y. Jin, H.K. Cheng, T.-P. Liang, Special issue editorial: Information systems research in the age of smart services, J. Assoc. Inf. Syst. 22 (3) (2021) 579–590.

[8] P. Zheng, Y. Lin, C.H. Chen, X. Xu, Smart, connected open architecture product: An it-driven co-creation paradigm with lifecycle personalization concerns, Int. J. Prod. Res. 57 (8) (2019) 2571–2584, http://dx.doi.org/10.1080/00207543.2018.1530475.

[9] G. Allmendinger, R. Lombreglia, Four strategies for the age of smart services, Harv. Bus. Rev. 83 (10) (2005) 131–145.

[10] Microsoft, Kimberly-Clark: Professional champions innovative IoT restroom servicing solution on microsoft azure, 2021, URL: https://www.microsoft.com/en/customers/story/1389274803812164767-kimberly-clark-professional-onvation-smart-spaces-azure-en-united-states.

[11] Transforma Insights, Global IoT connections to hit 29.4 billion in 2030, 2022, URL: https://transformainsights.com/news/global-iot-connections-294.

[12] N.V. Wünderlich, K. Heinonen, A.L. Ostrom, L. Patricio, R. Sousa, C. Voss, J.G.A.M. Lemmink, 'Futurizing' smart service: Implications for service researchers and managers, J. Serv. Mark. 29 (6/7) (2015) 442–447, http://dx.doi.org/10.1108/jsm-01-2015-0040.

[13] F. Kaltenbach, P. Marber, C. Gosemann, T. Bölts, A. Kühn, Smart services maturity level in Germany, in: Proceedings of the IEEE International Conference on Engineering, Technology and Innovation, ICE/ITMC 2018, 2018.

[14] M.M. Klein, S.S. Biehl, T. Friedli, Barriers to smart services for manufacturing companies—an exploratory study in the capital goods industry, J. Bus. Ind. Mark. 33 (6) (2018) 846–856, http://dx.doi.org/10.1108/jbim-10-2015-0204.

[15] D. Heinz, H.-R. Park, C. Benz, G. Satzger, Innovating smart product-service systems in manufacturing SMEs: Current practices, affordances, and constraints, in: Proceedings of the 24th IEEE Conference on Business Informatics, CBI 2022, 2022.

[16] T. Grubic, J. Peppard, Servitized manufacturing firms competing through remote monitoring technology: An exploratory study, J. Manuf. Technol. Manag. 27 (2) (2016) 154–184, http://dx.doi.org/10.1108/jmtm-05-2014-0061.

[17] J. Kurtz, C. Zinke-Wehlmann, N. Lugmair, M. Schymanietz, A. Roth, Characterising smart service systems—revealing the smart value, J. Serv. Manag. Res. 7 (2) (2023) 112–128, http://dx.doi.org/10.5771/2511-8676-2023-2-112.

[18] R.N. Stott, M. Stone, J. Fae, Business models in the business-to-business and business-to-consumer worlds—what can each world learn from the other? J. Bus. Ind. Mark. 31 (8) (2016) 943–954.

[19] S. Leminen, M. Rajahonka, R. Wendelin, M. Westerlund, Industrial internet of things business models in the machine-to-machine context, Ind. Mark. Manag. 84 (2020) 298–311.

[20] U. Paukstadt, G. Strobel, S. Eicker, Understanding services in the era of the internet of things: A smart service taxonomy, in: Proceedings of the 27th European Conference on Information Systems, ECIS 2019, 2019.

[21] T. Brogt, G. Strobel, Service systems in the era of the internet of things: A smart service system taxonomy, in: Proceedings of the 28th European Conference on Information Systems, ECIS 2020, 2020.

[22] C. Azkan, L. Iggena, F. Möller, I. Gür, B. Otto, A taxonomy for data-driven services in manufacturing industries, in: Proceedings of the 24th Pacific Asia Conference on Information Systems, PACIS 2020, 2020.

[23] A. Menon, C. Homburg, N. Beutin, Understanding customer value in business-to-business relationships, J. Business-To-Business Mark. 12 (2) (2005) 1–38, http://dx.doi.org/10.1300/j033v12n02_01.

[24] M. Fischer, D. Heim, A. Hofmann, C. Janiesch, C. Klima, A. Winkelmann, A taxonomy and archetypes of smart services for smart living, Electron. Mark. 30 (1) (2020) 131–149, http://dx.doi.org/10.1007/s12525-019-00384-5.

[25] F. Sterk, A. Stocker, D. Heinz, C. Weinhardt, Unlocking the value from car data: A taxonomy and archetypes of connected car business models, Electron. Mark. 34 (2024).

[26] C. Koldewey, J. Echterfeld, J. Gausemeier, M. Reilender, Business model portfolio planning for smart services, in: ISPIM Innovation Symposium Proceedings, 2018.

[27] L. Wessel, J. Sundermeier, H. Rothe, S. Hanke, A. Baiyere, F. Rappert, M. Gersch, Designing as trading-off: a practice-based view on smart service systems, Eur. J. Inf. Syst. 34 (2) (2024) 181–206.

[28] R.C. Nickerson, U. Varshney, J. Muntermann, A method for taxonomy development and its application in information systems, Eur. J. Inf. Syst. 22 (3) (2013) 336–359.

[29] D. Kundisch, J. Muntermann, A.M. Oberländer, D. Rau, T. Schoormann M. Röglinger, D. Szopinski, An update for taxonomy designers: Methodological guidance from information systems research, Bus. Inf. Syst. Eng. 64 (4) (2022) 421–439.

[30] L. Kaufman, P.J. Rousseeuw, Finding Groups in Data: An Introduction to Cluster Analysis, John Wiley & Sons, 1990.

[31] S. Gregor, The nature of theory in information systems, MIS Q. 30 (3) (2006) 611–642, http://dx.doi.org/10.2307/25148742.

[32] L. Atzori, A. Iera, G. Morabito, The internet of things: A survey, Comput. Netw. 54 (15) (2010) 2787–2805.

[33] M. Papert, A. Pflaum, Development of an ecosystem model for the realization of internet of things (IoT) services in supply chain management, Electron. Mark. 27 (2) (2017) 175–189, http://dx.doi.org/10.1007/s12525-017-0251-8.

[34] A. Valencia, R. Mugge, J.P.L. Schoormans, H.N.J. Schifferstein, The design of smart product–service systems (psss): An exploration of design characteristics, Int. J. Des. 9 (1) (2015) 13–28.

[35] Microsoft, Clever accelerates business growth with sustainable mobility, 2021, URL: https://customers.microsoft.com/en-us/story/1396259073599324009-clever-azure-sustainability-automotive-energy.

[36] P.P. Maglio, S.L. Vargo, N. Caswell, J. Spohrer, The service system is the basic abstraction of service science, Inf. Syst. e-Business Manag. 7 (4) (2009) 395–406, http://dx.doi.org/10.1007/s10257-008-0105-1.

[37] S. Hagen, O. Thomas, Expectations versus reality—benefits of smart services in the field of tension between industry and science, in: Proceedings of the 14th International Conference on Wirtschaftsinformatik, WI 2019, 2019.

[38] M.R. Palattella, M. Dohler, A. Grieco, G. Rizzo, J. Torsner, T. Engel, L. Ladid, Internet of things in the 5 g era: Enablers, architecture, and business models, IEEE J. Sel. Areas Commun. 34 (3) (2016) 510–527.

[39] P. zur Heiden, J. Priefer, D. Beverungen, Predictive maintenance on the energy distribution grid—design and evaluation of a digital industrial platform in the context of a smart service system, IEEE Trans. Eng. Manage. (2024) 3641–3655.
[40] M. Classen, T. Friedli, 'It's not like we can charge for everything': Revenue models to capture value from smart services in pacific asia, Asia Pac. Bus. Rev. 27 (3) (2021) 405–430.
[41] O. Troisi, A. Visvizi, M. Grimaldi, The different shades of innovation emergence in smart service systems: The case of Italian cluster for aerospace technology, J. Bus. Ind. Mark. (2021).
[42] H. Boyes, B. Hallaq, J. Cunningham, T. Watson, The industrial internet of things (IIoT): An analysis framework, Comput. Ind. 101 (2018) 1–12.
[43] M.M. Herterich, C. Dremel, J. Wulf, J. vom Brocke, The emergence of smart service ecosystems—the role of socio-technical antecedents and affordances, Inf. Syst. J. 33 (3) (2023) 524–566, http://dx.doi.org/10.1111/isj.12412.
[44] D. Heinz, C. Benz, J. Bode, F. Hunke, G. Satzger, Exploring the potential of smart service systems: A multi-actor view on affordances and their actualization, J. Serv. Manag. Res. 6 (2) (2022) 132–146, http://dx.doi.org/10.5771/2511-8676-2022-2-132.
[45] M. Fassnacht, J. Leimstoll, C. Benz, D. Heinz, G. Satzger, Data sharing practices: The interplay of data, organizational structures, and network dynamics, Electron. Mark. 34 (1) (2024) 47.
[46] J. Pöppelbuß, M. Ebel, J. Anke, Iterative uncertainty reduction in multi-actor smart service innovation, Electron. Mark. 32 (2) (2022) 599–627, http://dx.doi.org/10.1007/s12525-021-00500-4.
[47] J. Anke, J. Pöppelbuß, R. Alt, It takes more than two to tango: Identifying roles and patterns in multi-actor smart service innovation, Schmalenbach Bus. Rev. (2020) 599–634, http://dx.doi.org/10.1007/s41464-020-00101-2.
[48] D. Beverungen, D. Kundisch, N.V. Wünderlich, Transforming into a platform provider: Strategic options for industrial smart service providers, J. Serv. Manag. 32 (4) (2021) 507–532, http://dx.doi.org/10.1108/josm-03-2020-0066.
[49] F. Sterk, D. Dann, C. Weinhardt, Monetizing car data: A literature review on data-driven business models in the connected car domain, in: Proceedings of the 55th Hawaii International Conference on System Sciences, HICSS 2022, 2022, pp. 1975–1984.
[50] A. Kampker, V. Stich, P. Jussen, B. Moser, J. Kuntz, Business models for industrial smart services—the example of a digital twin for a product-service-system for potato harvesting, Procedia CIRP 83 (2019) 534–540.
[51] D. Martin, N. Kühl, G. Satzger, Virtual sensors, Bus. Inf. Syst. Eng. 63 (3) (2021) 315–323, http://dx.doi.org/10.1007/s12599-021-00689-w.
[52] F. Hunke, D. Heinz, G. Satzger, Creating customer value from data: foundations and archetypes of analytics-based services, Electron. Mark. 32 (2) (2022) 503–521, http://dx.doi.org/10.1007/s12525-021-00506-y.
[53] R. Hirschheim, H.K. Klein, K. Lyytinen, Information Systems Development and Data Modeling: Conceptual and Philosophical Foundations, Cambridge University Press, 1995.
[54] G.C. Bowker, S.L. Star, Sorting Things Out: Classification and Its Consequences, MIT Press, 2000.
[55] R.R. Sokal, The principles and practice of numerical taxonomy, Taxon 12 (5) (1963) 190–199.
[56] D.H. Doty, W.H. Glick, Typologies as a unique form of theory building: Toward improved understanding and modeling, Acad. Manag. Rev. 19 (2) (1994) 230–251, http://dx.doi.org/10.5465/amr.1994.9410210748.
[57] T. Rintamäki, H. Kuusela, L. Mitronen, Identifying competitive customer value propositions in retailing, Manag. Serv. Qual.: Int. J. 17 (6) (2007) 621–634.
[58] M. Mikusz, Channel multiplicity in digitized, connected products, in: Proceedings of the 39th International Conference on Information Systems, ICIS 2018, 2018.
[59] S. Berger, M. Bogenreuther, B. Häckel, O. Niesel, Modelling availability risks of IT threats in smart factory networks - a modular petri net approach, in: Proceedings of the 27th European Conference on Information Systems, ECIS 2019, 2019.
[60] J. Muntermann, R. Nickerson, U. Varshney, Towards the development of a taxonomic theory, in: Proceedings of the 21st Americas Conference on Information Systems, 2015.
[61] J. Weking, M. Mandalenakis, A. Hein, S. Hermes, M. Böhm, H. Krcmar, The impact of blockchain technology on business models—a taxonomy and archetypal patterns, Electron. Mark. 30 (2) (2020) 285–305.
[62] F.v. Wangenheim N.V. Wünderlich, M.J. Bitner, High tech and high touch: A framework for understanding user attitudes and behaviors related to smart interactive services, J. Serv. Res. 16 (1) (2013) 3–20, http://dx.doi.org/10.1177/1094670512448413.
[63] J. vom Brocke, A. Simons, B. Niehaves, K. Reimer, R. Plattfaut, A. Cleven, Reconstructing the giant: On the importance of rigour in documenting the literature search process, in: Proceedings of the 17th European Conference on Information Systems, ECIS 2009, 2009.
[64] J. Webster, R.T. Watson, Analyzing the past to prepare for the future: Writing a literature review, MIS Q. 26 (2) (2002) xiii–xxiii.
[65] M.Q. Patton, Qualitative Research & Evaluation Methods: Integrating Theory and Practice, Sage publications, 2014.
[66] M.B. Miles, A.M. Huberman, J. Saldaña, Qualitative Data Analysis: A Methods Sourcebook, fourth ed., SAGE Publications, 2018.
[67] R.K. Yin, Case Study Research and Applications, Sixth ed., SAGE Publications, 2018.
[68] S.L. Vargo, P.P. Maglio, M.A. Akaka, On value and value co-creation: A service systems and service logic perspective, Eur. Manag. J. 26 (3) (2008) 145–152.
[69] G.C. Moore, I. Benbasat, Development of an instrument to measure the perceptions of adopting an information technology innovation, Inf. Syst. Res. 2 (3) (1991) 192–222.
[70] C.M. Jonas, K. Schmitt A.M. Oberländer, S. Wethmar, Demystifying industrial internet of things start-ups: A multilayer taxonomy, in: Proceedings of the 17th International Conference on Wirtschaftsinformatik, WI 2022, 2022.
[71] D.C. Hambrick, Taxonomic approaches to studying strategy: Some conceptual and methodological issues, J. Manag. 10 (1) (1984) 27–41, http://dx.doi.org/10.1177/014920638401000104.
[72] J. Han, M. Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, University of Illinois, 2006.
[73] F. Murtagh, P. Contreras, Algorithms for hierarchical clustering: An overview, WIREs Data Min. Knowl. Discov. 2 (1) (2012) 86–97.
[74] P.J. Rousseeuw, A Visual Display for Hierarchical Classification, in: E. Diday, Y. Escoufier, L. Lebart, J. Pages, Y. Schektman, R. Tomassone (Eds.), Data Analysis and Informatics, vol. 4, North-Holland, Amsterdam, 1986, pp. 743–748.
[75] J.H. Ward, Hierarchical Grouping to Optimize an Objective Function, J. Amer. Statist. Assoc. 58 (301) (1963) 236–244.
[76] J. Wu, Advances in K-Means Clustering: A Data Mining Thinking, Springer, Berlin/Heidelberg, 2012.
[77] F. Nielsen. Hierarchical clustering, Introduction to HPC with MPI for Data Science, Springer International Publishing, 2016, pp. 195–211.
[78] J.C. McKinney, Constructive Typology and Social Theory, Ardent Media, 1966.
[79] K.D. Bailey, Typologies and Taxonomies: An Introduction to Classification Techniques, SAGE Publications, 1994.
[80] J.P. Wisdom, K.H.B. Chor, K.E. Hoagwood, S.M. Horwitz, Innovation adoption: A review of theories and constructs, Adm. Policy Ment. Health Ment. Health Serv. Res. 41 (4) (2014) 480–502.
[81] A. Oke, Innovation types and innovation management practices in service companies, Int. J. Oper. Prod. Manage. 27 (6) (2007) 564–588.
[82] M.R. Basirati, J. Weking, S. Hermes, M. Böhm, H. Krcmar, Exploring opportunities of IoT for product-service system conceptualization and implementation, Asia Pac. J. Inf. Syst. 29 (3) (2019) 524–546, http://dx.doi.org/10.14329/apjis.2019.29.3.524.
[83] Siemens MindSphere, Releasing a quality-assurance bottleneck with the power of AI, 2022, URL: https://siemens.mindsphere.io/en/solutions/customer-success-story/siemens-relieving-a-quality-assurance.
[84] L. Püschel, H. Schlott, M. Röglinger, What's in a smart thing? Development of a multi-layer taxonomy, in: Proceedings of the 37th International Conference on Information Systems, ICIS 2016, 2016.
[85] B.H. Wixom, J.W. Ross, How to monetize your data, MIT Sloan Manag. Rev. 58 (3) (2017).
[86] H. Snyder, L. Witell, A. Gustafsson, P. Fombelle, P. Kristensson, Identifying categories of service innovation: A review and synthesis of the literature, J. Bus. Res. 69 (7) (2016) 2401–2408.
[87] R. Whelan, Dhl unit plans google glass experiment in u.s. warehouses, 2015, URL: https://www.wsj.com/articles/dhl-unit-plans-google-glass-experiment-in-us-warehouses-1439568950.
[88] M. Heuchert, Y. Verhoeven, A. Cordes, J. Becker, Smart service systems in manufacturing: An investigation of theory and practice, in: Proceedings of the 53rd Hawaii International Conference on System Sciences, HICSS 2020, 2020.
[89] S. Alter, Making sense of smartness in the context of smart devices and smart systems, Inf. Syst. Front. 22 (2) (2020) 381–393.
[90] D. Rau, L.-H. Perlitt, A. Wenninger, M. Röglinger, Pushing the frontiers of service research—a taxonomy of proactive services, in: Proceedings of the 41st International Conference on Information Systems, ICIS 2020, 2020.
[91] H.J. Watson, Tutorial: Big data analytics: Concepts, technologies, and applications, Commun. Assoc. Inf. Syst. 34 (2014) 1247–1268.
[92] F. Hunke, C. Engel, R. Schüritz, P. Ebel, Understanding the anatomy of analytics-based services—a taxonomy to conceptualize the use of data and analytics in services, in: Proceedings of the 27th European Conference on Information Systems, ECIS 2019, 2019.
[93] P. Scharfe, M. Wiener, A taxonomy of smart machines in the mechanical engineering industry: Toward structuring the design solution space, in: Proceedings of the 41st International Conference on Information Systems, ICIS 2020, 2020.
[94] Microsoft, Evoqua water technologies: The secret life of water, 2017, URL: https://customers.microsoft.com/en-us/story/evoquawater-technologies.
[95] Bosch, Aufzug-monitoring – intelligentes zusammenspiel von sensoren, software und service, 2022, URL: https://www.bosch-elevatorcloud.com/de/aufzug-monitoring/.
[96] Siemens, Iot in the soccer arena: The turf whisperer, 2022, URL: https://new.siemens.com/global/en/company/stories/industry/the-turf-whisperercommunicating-with-grass.html.

[97] Microsoft, Sunwest bank improves cash deposit security and differentiates service with azure IoT solution, 2020, URL: https://customers.microsoft.com/en-us/story/761419-sunwestbank-banking-capital-markets-azure.

[98] Cleveland, High-tech carts will tell on cleveland residents who don't recycle, 2010, URL: https://blog.cleveland.com/metro/2010/08/city_of_cleveland_to_use_high-.html.

[99] Michelin, Michelin vernetzt bis 2024 alle seine pkw-reifen, 2020, URL: https://news.michelin.de/articles/michelin-vernetzt-pkw-reifen.

[100] SICK, Sick appspace sensorapps – remote service connect, 2022, URL: https://www.sick.com/cl/en/sick-appspace/sick-appspacesensorapps/remote-serviceconnect/c/g515551.

[101] W. Ketter, K. Schroer, K. Valogianni, Information systems research for smart sustainable mobility: A framework and call for action, Inf. Syst. Res. 34 (3) (2022) 1045–1065.

[102] R.M. Henderson, K.B. Clark, Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms, 1990, pp. 9–30,

[103] H. Demirkan, J.C. Spohrer, R. Badinelli, Introduction to the smart service systems: Analytics, cognition and innovation minitrack, in: Proceedings of the 49th Hawaii International Conference on System Sciences, HICSS 2016, 2016, pp. 1652–1652.

[104] N. Bilstein, C. Stummer, Editorial–special issue: managing smart services and smart service systems, J. Serv. Manag. Res. 7 (1) (2023) 2–6.

[105] D. Heinz, J. Anke, Empowering practitioners: A conceptual framework for value co-creation through smart service innovation methodologies, in: Proceedings of the 31st European Conference on Information Systems, ECIS 2023, 2023.

[106] N. Bilstein, A.P.P. Henkel, K. Heinonen, Research horizons of smart service technologies–special section editorial, J. Serv. Theory Pr. 34 (2) (2024) 157–162.

[107] D.J. Teece, Business models and dynamic capabilities, Long Range Plan. 51 (1) (2018) 40–49.

[108] Y. Yoo, O. Henfridsson, K. Lyytinen, Research commentary—the new organizing logic of digital innovation: An agenda for information systems research, Inf. Syst. Res. 21 (4) (2010) 724–735.

[109] Accenture, Airbus soars with wearables, 2022, URL: https://www.accenture.com/us-en/case-studies/aerospace-defense/airbus-wearable-technology.

Daniel Heinz is a postdoctoral researcher at the Institute for Information Systems (WIN) at the Karlsruhe Institute of Technology (KIT), Kaiserstraße 12, 76131 Karlsruhe, Germany, E-Mail: daniel.heinz@kit.edu.

Marcel Fassnacht is a researcher at the Institute for Information Systems (WIN) at the Karlsruhe Institute of Technology (KIT), Kaiserstraße 12, 76131 Karlsruhe, Germany, E-Mail: marcel.fassnacht@kit.edu.

Carina Benz is a researcher at the Institute for Information Systems (WIN) at the Karlsruhe Institute of Technology (KIT), Kaiserstraße 12, 76131 Karlsruhe, Germany, E-Mail: carina.benz@kit.edu.

Philipp Luchner contributed to this research as a master's student at the Karlsruhe Institute of Technology (KIT). He is now a Product Manager at Siemens Energy, Karlsruhe, Germany. E-Mail: philipp.luchner@alumni.kit.edu.

Gerhard Satzger is a Professor at the Institute for Information Systems (WIN) at the Karlsruhe Institute of Technology (KIT), Kaiserstraße 12, 76131 Karlsruhe, Germany, E-Mail: gerhard.satzger@kit.edu.