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Towards a Reference Process for Developing Cognitive Service Systems

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ABSTRACT

In recent years, digital technologies such as artificial intelligence found their way into existing services, while at the same time providing the basis for entirely new possibilities. However, our understanding of the development of services based on these technologies is still limited. Due to the high complexity, they can rarely be developed within the boundaries of a single company or on the basis of knowledge from a single discipline. Building on the relevant literature, we derive a sound understanding of cognitive service systems from existing perspectives. Following an iterative process, we conducted several interdisciplinary workshops and analysed existing development approaches, which were adapted and recombined into a process model for cognitive service development. Our work contributes to a common understanding of cognitive service systems. By introducing a reference model that addresses the specific requirements for the successful development of cognitive services, we take a first step towards a systematic and holistic development of cognitive service systems that supports companies in this complex task.

Keywords: AI, Artificial intelligence, Service science, Service development, Service engineering, Service systems

INTRODUCTION

The increasing complexity of competitive environments, the emergence of artificial intelligence (AI) and the transformation from product-based to service-based business models present companies with numerous challenges. At the same time, these developments come with a wide range of opportunities to exploit new business areas, enter new markets or satisfy existing customer needs more effectively and efficiently. For companies, the development of so-called "cognitive services" offers a promising way to exploit these opportunities. These highly automated and intelligent services can either be stand-alone services or complement existing offerings. Depending on the area of application, they help to make internal value creation processes more efficient or offer a new value proposition for external customers.

However, the development of cognitive services also presents companies with certain challenges. Due to their intensive use of data and technology, as well as the automated adaptation of processes and value propositions, development requires knowledge and methods from more than one development discipline, e.g., service engineering, data science and IT infrastructure management (Ahner et al. 2021). Moreover, these complex services can rarely be developed and operated within the boundaries of one company, due to lacking resources (e.g., access to data, need for IT-infrastructure), knowledge and technical infrastructure available (Neuhüttler et al. 2020a). This also leads to an increasing relevance of joint development with external stakeholders and a more system-oriented development process. Although the concept of cognitive service systems is not new, there is still no integrated approach that takes a holistic view of their development and that of the required subcomponents.

In order to support companies with the complex task of developing cognitive services systematically, the aim of our paper is (1) to contribute to a common understanding of the phenomenon of cognitive service systems, (2) to introduce a reference model that addresses the specific requirements for a successful development of cognitive services by recombining approaches from neighbouring disciplines and (3) show how the reference model can be applied in specific development projects.

UNDERSTANDING COGNITIVE SERVICE SYSTEMS

Since there are a variety of existing perspectives and adjacent or partially overlapping concepts of cognitive service systems, this chapter first presents our understanding from a developmental perspective. Smart service systems represent the overarching concept for this, which is why they are considered below.

Smart services are characterized by their ability to adapt to a specific context (Neuhüttler et al. 2019) and can be defined as databased, individually configurable bundles of intelligent products, digital services, and personally delivered services that are organized and performed via integrated service platforms. Adaptivity can either be supported by the use of artificial intelligence and in particular machine learning methods, or by using classical rule-based algorithms. Emerging from the fields of service science and service engineering, the phenomenon of smart services is researched in several domains (e.g. marketing, management, and information systems) and from different perspectives (e.g., customer perspective, company perspective) (Korper et al. 2020).

The terms system and **ecosystem** are used at different levels in the service-related literature. As services and their associated value are created by a combination of resources accessed in an exchange with other resources, both internal and available through other exchanges (Lusch and Vargo 2006), services have a certain system character by nature. According to the service-dominant logic, in the process of value co-creation, actors integrate resources in service systems that are configured by institutional arrangements through which service ecosystems emerge endogenously (Blaschke et al. 2018; Vargo and Lusch 2016a). The concept of service systems is also often used to integrate service-related aspects across organizational boundaries (Spohrer et al. 2008). As the ever-increasing complexity in technology and markets necessitates the inter-organisational combination of resources, digital ecosystems are another phenomenon that has significantly gained in relevance, both in research and business. Along with this, new configurations for firms to collaborate and combine resources have become an important part of value creation (Jacobides 2022).

Linking the characteristics of smart services to the ecosystem perspective, **smart service systems** include the capability of self-adaption and the requirement of technology incorporation. Therefore, smart services are understood as systems, in which data contributes significantly to the creation of value (Brogt and Strobel 2020; Lim and Maglio 2018). Furthermore, smart service systems are able to self-improve continuously (Demirkan et al. 2019). Spohrer et al. 2017 extend the concept of smart service systems by linking it to the human side of service engineering, adding connections to human values and ethical questions. As technical capabilities increase, so do the demands for responsibility. The authors argue that there is a need for better rule systems and conflict-resolution methods (Spohrer et al. 2017).

Cognitive services can be described as a subset of smart services. Smart services use data to provide situation-specific, individualized added value in an automated manner. This also applies to cognitive services, although they represent the most automated to autonomous offerings in the range of different smart services. This is made possible by the use of cognitive technologies. In general, they rely on computational components that deliver cognition as a service, augmenting human intelligence and capabilities across the spectra of sensory perception, deduction, reasoning, learning, and knowledge (Spohrer & Banavar, 2015; Mele et al. 2021). Cognitive systems therefore can be described as highly automated to autonomous systems that perceive the environment, learn from experience, anticipate the outcome of events, act to pursue goals, and adapt to changing circumstances (Vernon 2021). Machine learning algorithms and AI applications, such as speech, image or face recognition, predictive inference and decision making as well as generative AI, therefore build the technical core of such cognitive services (Neuhüttler et al. 2020b). According to Demirkan et al. 2019 an increasing relevance of cognitive assistants in the field of smart service systems can be observed. Cognitive services as a sub-category of smart services, with focus on a highly automated to autonomous acquisition and processing of data and the execution of actions with the help of artificial intelligence.

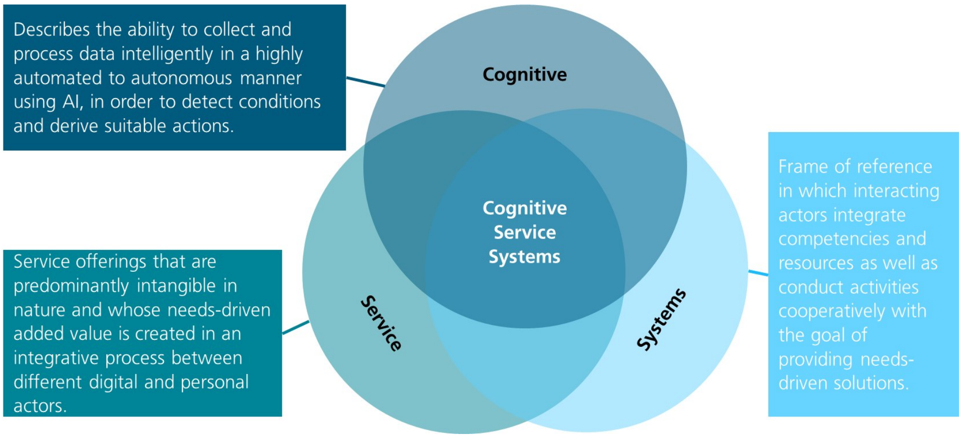

Figure 1: Definition of cognitive service systems.

For the purposes of the following work, we understand **cognitive services** as interactively provided services that enable an automated adaptation of service processes and outcomes to specific needs through the use of AI. Figure 1 shows the central fields of action and development of cognitive service systems.

TOWARDS A REFERENCE PROCESS FOR DEVELOPING COGNITIVE SERVICE SYSTEMS

Requirements of Reference Processes

The overall goal of our contribution is to develop a reference process for the holistic development of cognitive services. Reference models constitute a generic representation of a specific topic that can be adapted to a specific use case (Rosing et al. 2015). They serve to collect and structure knowledge on this topic and can thus be used for knowledge exchange between different users and application areas. The recurring application generates empirical knowledge and enables a low-effort implementation (Frank et al. 2020). However, in order to do so, Frank et al. 2020 summarize the following requirements that they need to meet. First, a reference process strives for completeness it should comprehensively represent the phenomenon to be described. As a second requirement, a reference process needs to be of a universal nature, it must be suitable for different applications and fields of use. Furthermore, reference processes must be both adaptable and reusable (Schlagheck 2000). Finally, a reference process has a recommendatory character (Rosemann 2003).

Since the development of cognitive services is a multidisciplinary task in a dynamic and complex environment, we assume that an appropriate reference model contributes to a reduction in complexity. As there is a need for knowledge and methods from several disciplines at the same time, existing, discipline-specific reference processes are reaching their limits. In other words: Since each of these disciplines has its own specific theoretical foundations, methods and principles, a reference process for the development of cognitive services can only fulfil the requirement for completeness if it makes use of all relevant disciplines.

Method and Approach

To achieve the goal, a multi-level approach was taken with several interdisciplinary workshops, with researchers from the disciplines of service science, innovation management, embedded information systems, data science and engineering. The first step was to establish a common understanding of cognitive service by conducting an initial literature review, the results of which were discussed among the participants. This was followed by an intra-disciplinary analysis of existing approaches in each of the relevant development disciplines. The identified models were compared with each other and the fit towards cognitive services as well as their adaptability were evaluated. Table 1 provides examples of the development disciplines and approaches examined.

Table 1. Overview of analysed reference models.

Discipline	Reference process	Process steps and activities
Service Science/ Service Engineering	Task-based reference model of Smart Service Engineering (according to Meiren/Neuhüttler 2019)	1. Ideation 2. Requirement analysis 3. Conception 4. Test 5. Implementation 6. Launch
	Development Approach for Smart Service Engineering (according to Jussen et al. 2019)	1. Strategy development 2. Prototyping 3. Market development
	Development of digital service systems (according to Post et al. 2019)	1. Analysis 2. Design 3. Implementation
Information Systems	Crisp-DM (*Cross-industry standard process for data mining)* (according to Wirth et al. 2000)	1. Business understanding 2. Data understanding 3. Data preparation 4. Modeling 5. Evaluation 6. Development
	ITIL (*Information Technology Infrastructure Library)* (according to Axelos 2013)	1. Service Design 2. Service Transition 3. Service Operation
Ecosystem perspective	Ecosystem development Framework (according to Jacobides 2022)	1. Potential Scope of play and target choice 2. Competitive landscape & anchor analysis 3. Role of the firm & strategic approach 4. Ecosystem double value proposition 5. Partnership strategy 6. Governance and engagement 7. Metrics of success and next steps

Subsequently, tasks that are relevant to the development of cognitive services were extracted from all considered disciplines. This step was followed by clustering and merging the identified tasks.

By following the method described above, a first version of a reference process consisting of 3 dimensions and 6 phases is developed (cf. Figure 2). As it is designed in a task-based manner, it explicitly does not specify a fixed order for the execution of phases or development tasks. The 3 dimensions are derived from the definition stated in Figure 1 and provide the basic structure into which the identified development steps and tasks of cognitive service systems can be integrated. The division into 3 dimensions, namely cognitive, service

	Problem analysis	Ideation	Conception	Design	Evaluation	Roll-out
Cognitive (addresses data acquisition and processing)	PC Analyzing existing infrastructures and data resources	IC Exploring data and assess data potential	CC Technical architecture and data acquisition	DC Training models and developing algorithms	EC Validation and verification of models and components	RC Implement prototypes
Service (addresses service offerings)	PS Analyzing needs of relevant actor groups	IS Co-Creative idea generation and prioritizing	CS Design of service concept (resources, activities & outcomes)	DS Establishing service prototype(s)	ES Validation of service prototype(s)	RS Determine marketing concepts
System (addresses business ecosystem)	PSys Under-standing ecosystem and define influencing factors	ISys Identifying cooperation potentials	CSys Analysis of potential partners and value contributions	DSys Planning the value configuration	ESys Evaluate the gains from collaboration and stability	RSys Establish collaborations

Figure 2: Reference process for developing cognitive service systems.

and system, ensures that it is still possible to assign the relevant tasks and activities to the original disciplines which they each represent. The chosen subdivision into the six phases - (1) problem analysis, (2) ideation, (3) conception, (4) design, (5) evaluation, (6) roll-out - was achieved by abstracting and consolidating the reference models shown in Table 1. This segmentation allows the parallelisation and coordination of the relevant steps of all considered disciplines. The vertical and horizontal subdivisions give rise to a total of 18 development tasks.

The 18 development tasks come with a description along the components of objectives, activities, methods, tools and results. In addition, they can be supplemented by corresponding role models and a meta-model, which concretise the process and reduce interdisciplinary complexity. For example, existing methods that are suitable for implementation can also be assigned. One example is the method for testing perceived quality by Neuhüttler et al. 2022, which can be assigned to the activity "ES". The individual tasks are described in a non-overlapping and coherent manner, and interfaces with the other tasks are specified. This has the advantage that they can be arranged and executed in different order depending on the needs of a development project. This fundamental principle is demonstrated in the following section.

POSSIBLE APPLICATION OF THE REFERENCE PROCESS

To consider both adaptability and generality as two important features of reference models, the individual activities can be arranged in different ways. This is also to ensure that the approach can be adapted to the specific needs and circumstances of different development projects and contexts. Figure 3 shows the adaptability of our approach by presenting three exemplary project approaches with different focus in terms of objectives and scope. Moreover, the modularity allows both linear and iterative structures to be represented.

Example 1 describes a needs-driven development project that is to be implemented within a company. The development project starts with the analysis of existing problems, be they on the level of cognitive technology (PC), the needs of potential customers (PS) or in an ecosystem (PSys). After

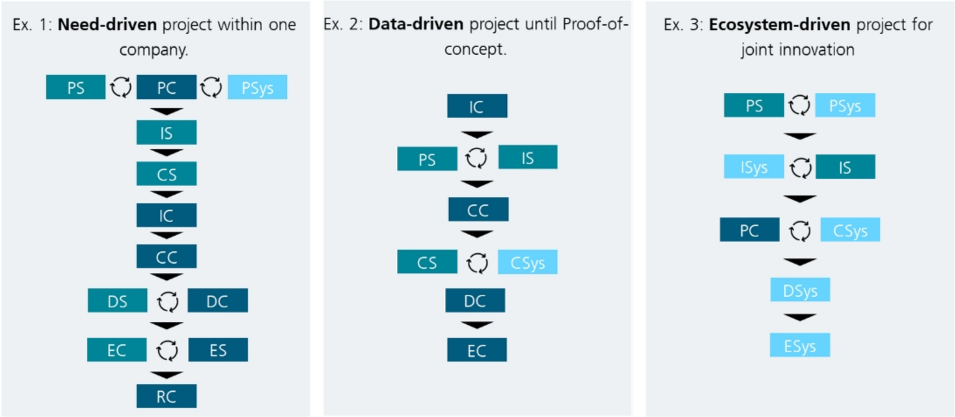

Figure 3: Demonstration of process adaptability with three exemplary project types.

the analysis, a co-creative ideation follows to find and evaluate ideas for a new cognitive service (IS). Selected ideas are described by a service concept (CS), whose feasibility is completed by an exploration of data (IC) as well as a technical conception (CC). Finally, the evaluation and roll-out of the implemented concepts follow.

A data-driven development project, as illustrated in example 2, could start with an in-depth exploration of existing data to identify existing needs (IC). The identified needs must be compared with an analysis of the problems of potential customers (PS) and combined into a concrete idea (IS). Based on this, the technical and service concept (CS) can first be planned with the participation of various actors outside the company (CSys). This is followed by the development of a technical prototype (DC) and its verification and validation (EC).

Example 3 describes an ecosystem-driven development project, such as might be implemented by partners on an innovation campus or as part of a governmental, overarching initiative. First, potential problems of end customers (PS) and of the actors in an ecosystem (PSys) are analyzed in order to evaluate ideas for a service concept (IS) and the possible potential for cooperation (ISys). In a subsequent step, the existing technical infrastructures and data pools of the partners are examined (PC) and possible value contributions to the implementation of the service idea are examined (CSys). After that, the value configuration within the ecosystem is planned (DSys) and validated (ESys).

CONCLUSION AND OUTLOOK

As a result of this paper, we propose a first version of a task-based reference process for the development of cognitive service systems, based on established processes in literature, which we recombine and develop specifically for cognitive service systems. The model focuses on six main activities: problem understanding, ideation, conception, design, evaluation and roll-out. As our model is of an interdisciplinary character, every task is described for a data, service and system-related dimension. Striving for completeness as a characteristic of reference processes, we combine the three relevant sub-disciplines in one model. To ensure that our model is up to the manifold challenges and requirements of different complex projects in the field of cognitive service development, we follow a modular approach. This means that the procedure can also be adapted to the specific requirements of individual projects within its basic structure. Our work can be understood as a first step in a systematic and holistic development of cognitive service systems that supports companies in this complex task.

In order to meet the overarching objective, further research will be needed. First of all, the content of the 18 development activities must be designed and backed up with appropriate methods and tools to enable their application in practice. Although the reference process was designed by a group of researchers that possess practical experiences from development projects in all relevant disciplines, practical applicability and completeness must be demonstrated in different cognitive services development projects. Moreover, there is a need to evaluate the models' comprehensibility and adaptability.

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