

# A Situational Approach to Data-Driven Service Innovation

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**Abstract.** Though organizations are increasingly aware that the huge amounts of digital data that are being generated, both inside and outside the organization, offer many opportunities for service innovation, realizing the promise of big data is often not straightforward. Organizations are faced with many challenges, such as regulatory requirements, data collection issues, data analysis issues, and even ideation. In practice, many approaches can be used to develop new data-driven services. In this paper we present a first step in defining a process for assembling data-driven service development methods and techniques that are tuned to the context in which the service is developed. Our approach is based on the situational method engineering approach, tuning it to the context of data-driven service development.

**Keywords:** Method Engineering, Data-Driven Services, Service Innovation.

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## 1 Introduction

In many organizations the availability of data leads to the search for new opportunities to gain competitive advantage or to better service customers or clients. Data-driven services open the possibility of offering services that are more to-the-point, timely and accurate, and thus more appealing to consumers. Realizing the promise of big data is not straightforward, however. Issues that must be addressed concern how to collect data, analyze it and translate it into service, both from a technical point of view and a regulatory as well as ethical point of view. The latter is becoming increasingly important. In programs such as the Dutch National Science Agenda researchers are looking for ways to create value with data in a responsible manner. The question we address in this paper is how to make the results of such, and other, academic research broadly accessible and usable in the market, especially for small and medium-

sized organizations. In practice, the implementations of processes such as service innovation, portfolio management and product management vary across organizations. Small and medium-sized organizations may not possess a dedicated data-science unit, whereas large organizations often have such capabilities in house. Large organizations tend to make decisions in a more hierarchical manner than smaller organizations, with more involvement of specialized roles. In addition, organizations in specific sectors such as health and finance may have to meet special requirements and constraints when dealing with data. No single approach therefore is suitable for all organizations. Depending on their situation and context, the right techniques and approaches must be identified and combined into a data-driven service development process. In this paper we focus on how to describe available techniques and approaches to make them findable. Our approach is based on situational method engineering. The purpose of the present study is to design a metamodel for characterizing data-driven service development method fragments that enables the retrieval of suitable method fragments in a specific data-driven service innovation situation. We start with deriving a generic metamodel from the literature on situational method engineering. Next, we tune this metamodel to the domain of data-driven service innovation, based on specificities of this domain found in literature. To demonstrate its usefulness, we apply it to the development of a data-driven service in oral care. The ultimate goal of our research project is to build a method base with method fragments for data-driven service development, derived from either practice or academic research.

In the next section we provide the theoretical background to our research, situational method engineering and data-driven service innovation. In section 3 we combine the insights from situational method engineering and data-driven service innovation into a metamodel for defining method fragments. We illustrate and discuss the use of the metamodel in the context of preventive healthcare in section 4. Section 5 contains conclusions and further research.

## 2 Theoretical Background

We base our study on situational method engineering. Brinkkemper [1] introduces method engineering as a research framework for information systems development methods and defines method engineering as: “method engineering is the engineering discipline to design, construct and adapt methods, techniques and tools for the development of information systems”. A method is defined by Brinkkemper as “an approach to perform a systems development project, based on a specific way of thinking, consisting of directions and rules, structured in a systematic way in development activities with corresponding development products” (p.275-276).

In our case the information systems concerned are data-driven services. Situational method engineering is motivated by the conviction that the suitability of an IS development method depends on the situation and that there is no one-size-fits-all method that suits all situations. Therefore, the goal of situational method engineering is to

enable method engineers to build a method tailored to the situation based on reusable method fragments that are stored in a method base (Fig. 1).

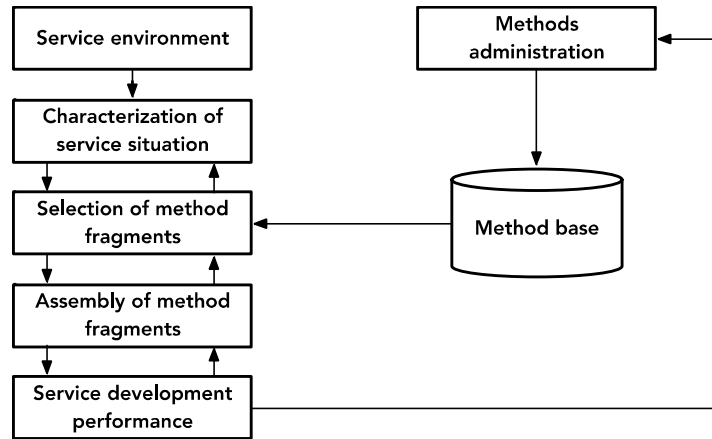


Fig. 1. Method Engineering (adapted from [1]).

The method engineering process contains three main steps: 1) characterize service situation, which leads to method requirements [2], 2) select method fragments, 3) assemble method fragments. In this paper we focus on how to describe method fragments in the method base in order to enable effective selection (step 2). We aim to identify the characteristics that can be used to select appropriate method fragments.

In [1] method fragments are defined as coherent pieces of IS development methods. A distinction is made between product fragments and process fragments. Other authors allow fragments that contain both product and process elements in the same fragment [3]. In [4] the concept of a method chunk is used to refer to method fragments consisting of one process fragment and one product fragment. Cossentino et al. [5] compare various method fragment metamodels and arrive at the general metamodel depicted in Fig.2.

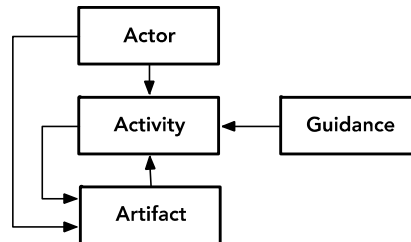


Fig. 2. General metamodel summarizing the fundamental elements of method fragment approaches (adapted from [5])

The metamodel of [5] is comparable to the metamodel for development methodologies defined in ISO/IEC 24744. This standard refers to both methodologies and their instances (in the form of endeavors), as well as to five aspects of the modeled method components [6]: Work Units (cf. Activity), Work Products (cf. Artifact), Producers (cf. Actor), Model Units (cf. Guidance) and Stages. The concept of stages is not present in Cossentino's metamodel. However, stage can be regarded as part of the context in which the fragment can be used, rather than of the fragment itself. Börner [7] refers to 'any reasonable combination of method elements representing a coherent part of a method' as a method fragment, where method elements are techniques, activities, roles and results. In Börner's definition a method fragment can contain any of these elements in any number, including nil. We will use Börner's definition of method fragment in this paper.

In addition to the content of the method fragment, for it to be reusable, information is needed about the context in which the fragment can be used. Mirbel and Ralyté [2] describe a method chunk as consisting of (1) a body, which contains a process part (process fragment) and a product part (product fragment), (2) an interface, containing the situation in which the method chunk can be used (i.e. precondition, usually containing obligatory input products, e.g. "problem statement") and the intention the method chunk can achieve (e.g. "to construct a use case model"), and (3) a descriptor providing the contextual information about the context in which the method chunk is applicable. The interface and body are used for method construction and evaluation. The descriptor is purely used to select method chunks from the method base [8]. It contains a reuse context describing criteria for use of the method chunk and a reuse intention describing the goal that can be achieved by the method chunk. The descriptor is the link to the situational context in which a method chunk can be used.

To achieve method fragment selection, the method fragment characteristics must be matched to the situational factors of the context. This means that the descriptor part of the fragment, consisting of the criteria for use (reuse context) and the goals that can be achieved (reuse intention) must be matched with situational factors. The values describing a method fragment must be chosen in such a way that they can be matched with specific context. Thus, it is useful to know by which situational factors a context can be defined (step 1: characterize service situation).

Mirbel and Ralyté [2] present categories of criteria for selecting method fragments: human, application domain, and organizational, subdividing the latter into system engineering activities, contingency factors and project management. Each of these categories of criteria is represented by a tree of criteria. The reuse context of a method fragment may refer to one or more trees and one or more criteria from the trees. At least some of these criteria seem to be very close to what might be regarded situational factors, e.g. project clarity & stability or high technology innovation level. Mirbel and Ralyté indicate that an organization must build its own reuse frame.

Other authors too, make a selection of criteria suited to their purposes [2] [7] [9] [10] [11] [12] [13]. Comparing the situational factors identified by these authors, we find that the diversity is large, as these seven authors together mention a total of 90 situational factors. It seems there is no common agreed upon set of relevant situation

factors. Thus, it does not provide us with a solid base for defining the values with which to populate the method fragment metamodel.

### 3 Data-driven service development method fragment model

To describe method fragments for data-driven service development, we combine the method chunk metamodel of [2] with the definition of method fragments used by [7], by allowing in the body part of the method fragment any combination of activities to be done, results produced, techniques used, and roles involved (Fig. 3).

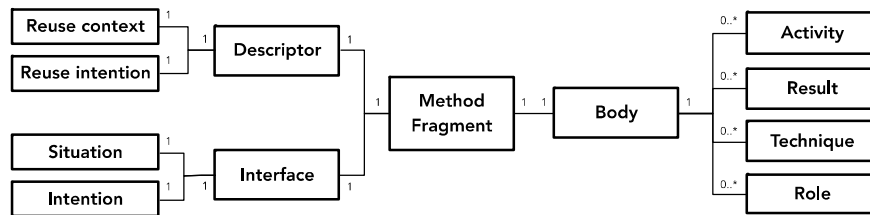


Fig. 3. Method fragment metamodel

Though in more recent studies, the distinction between descriptor and interface as described by [2] is not explicitly made [14] [15], we find the distinction useful to accommodate the difference between the specific goal that can be achieved with a method fragment from a method construction perspective (interface intention) and a more generic purpose a method fragment can contribute to (descriptor reuse intention). The interface intention is expressed from the perspective of the method fragment and what it can do, whereas the descriptor reuse intention is expressed from the perspective of possible contexts and what is needed. A descriptor reuse intention can be contributed to by different interface intentions, dependent on context and situation.

To further tune the metamodel to the domain of data-driven service development, we turned to the literature about data-driven services, using the metamodel as a lens. Based on literature on service innovation and information systems, Troilo et al. [16] provide a framework relating data-rich environments and service innovation. The framework distinguishes three intertwining key dimensions of service innovation: service concept, customer experience, and service process. Innovation can take place along each of these dimensions. Service concept innovation concerns offering a new solution to a need or problem. Customer experience innovation concerns the interaction between service provider and customer. Service process innovation concerns more efficient or effective delivery of services. Specific to data-driven service innovation is the concept of datafication [17] [18]. Datafication means that data are detached from the material world (dematerialization), manipulated, moved around and (un)bundled (liquidity), and again rematerialized by converging data in a particular context, time and place to create value (density). The latter, the data density process-

es, are the mechanism by which service innovation is realized. It makes the insights generated by data analytics actionable. Troilo et al. [16] further elaborate the data density processes into three types, i.e. pattern spotting, real-time decisioning and synergistic exploration. Pattern spotting analyzes past data to improve on service delivery. Its objective is explanation and its main aim is service process innovation. Real-time decisioning applies data-analytics to (near) real-time data to identify suitable responses to real-time events. It is primarily aimed at prediction to enable customer experience innovation. Synergistic exploration explores data from a great variety of sources to search for new service concepts. From a method fragment metamodel perspective the types of data density processes can be categorized as activities, their immediate objectives are examples of interface intentions and their ultimate aims can be categorized as descriptor reuse intentions.

Sivarajah et al. [19] perform a structured literature review on big data challenges and analytical methods. They classify big data analytical methods into descriptive analytics, inquisitive analytics, predictive analytics, prescriptive analytics and pre-emptive analytics. Descriptive analytics are aimed at describing a current situation. Inquisitive analytics, such as factor analysis, use data to confirm or reject propositions. Predictive analytics uses data to make predictions about the future. Prescriptive analytics turns data into improvement actions. And pre-emptive analytics use data to mitigate anticipated undesirable future events. In method fragment metamodel terms these types of analytics are techniques with associated interface intentions.

Gandomi and Haider [20] discuss the basic concepts relating to big data. They too mention various techniques available for big data analytics, but from the perspective of type of data being analyzed: text analytics, which can be used for information extraction, text summarization, question answering and sentiment analysis; audio analytics for large-vocabulary continuous speech recognition or a phonetic-based approach; video analytics in which they distinguish server-based architecture and edge-based architecture; social media analytics such as content-based analytics or structure-based analytics; and predictive analytics, for which new statistical techniques are needed because of the big data characteristics of heterogeneity, noise accumulation, spurious correlation and incidental endogeneity.

Maglio and Lim [21] present four archetypes for the design of smart service systems. They define a smart service system as a “configuration of people, information, organizations, and technologies that operate together for mutual benefit and is capable of learning, dynamic adaptation, and decision-making based upon data received, transmitted, and/or processed to improve its response to a future situation” [21] [22]. Maglio and Lim [21] use two dimensions to distinguish four ways of using big data in smart service systems: the source of data (mainly from people or mainly from objects) and the use of data (informing people or managing objects directly). ‘Smart operations management’ uses data from objects to manage objects. ‘Smart customization and prevention’ uses data from people to manage objects. ‘Smart coaching’ uses data from people to inform people. ‘Smart adaptation and risk management’ uses data from objects to inform people. The dimensions source of data and use of data may be relevant for the descriptor reuse context. For instance, because data sourced from people may have more privacy issues connected to it.

Lim et al. [23] use a framework for discussing cases that contains four generic service design process phases: preliminary investigation and opportunity identification, service idea generation and refinement, service concept and delivery process design, and validation and implementation issue identification. These four phases can be used as descriptor reuse contexts. They also identify 11 managerial issues that should be considered in using data to advance service. When fed with solutions, these issues might be considered examples of interface intentions. In addition, they argue that the application domain, such as the health sector, may pose requirements on data-driven services. This makes application domain a candidate for reuse context.

Table 1 maps the concepts from the literature discussed above to our metamodel of a data-driven service development method fragment. It illustrates the type of values that may be relevant to describe data-driven service development method fragments.

**Table 1.** Data-driven service metamodel values from literature.

<b>Metamodel concept</b>	<b>Possible values derived from literature</b>
Body – activity	<ul style="list-style-type: none"> <li>- This may be very diverse, including any activity that may be performed in any of the stages of the method outline depicted in Fig. 4. Examples are pattern spotting, real-time decisioning and synergistic exploration [16].</li> </ul>
Body – result	<ul style="list-style-type: none"> <li>- Interventions [16]</li> <li>- Decisions [21]</li> <li>- Predictions [19]</li> </ul>
Body – technique	<ul style="list-style-type: none"> <li>- Source-dependent Analytic techniques: Text analytics; Audio analytics; Video analytics; Social media analytics [20]</li> <li>- Purpose-dependent Analytic techniques: descriptive analytics, inquisitive analytics, predictive analytics, prescriptive analytics and pre-emptive analytics [19]</li> </ul>
Body - role	<ul style="list-style-type: none"> <li>- Besides the obvious role of data scientist, one can also think about domain experts (for instance medical doctors) supporting the analysis process and evaluating outcomes or legal experts consulting on data use limitation in industries handling sensitive data [23]</li> </ul>
Interface – situation	<ul style="list-style-type: none"> <li>- Actuality of data: past, present [16]</li> </ul>
Interface – intention	<ul style="list-style-type: none"> <li>- Explain, Optimize, Predict, Respond, Explore, Diversify [16]</li> <li>- Collecting data, Protecting Customer values, Integrating data sources [23]</li> </ul>
Descriptor – reuse context	<ul style="list-style-type: none"> <li>- Application domain: health, chemical industry, finance [23]</li> <li>- Type of data: people, objects [21]</li> <li>- Type of use: inform people, manage objects [21]</li> </ul>

	<ul style="list-style-type: none"> <li>- Dominant V of data: volume, velocity, variety [16]</li> <li>- Service development phase: preliminary investigation and opportunity identification; service idea generation and refinement; service concept and delivery process design; validation and implementation issue identification [23]</li> </ul>
Descriptor – reuse intention	<ul style="list-style-type: none"> <li>- Innovation type: Service process innovation; Customer experience innovation; Service concept innovation [16]</li> </ul>

Fig. 4 shows a preliminary population of the metamodel for data-driven services.

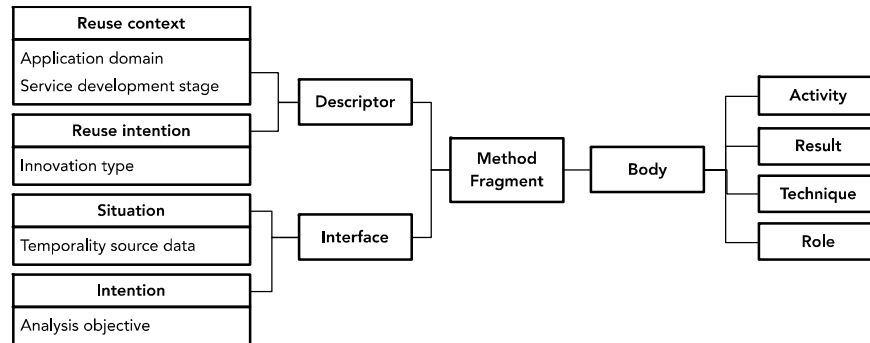


Fig. 4. Data-driven service development method fragment metamodel.

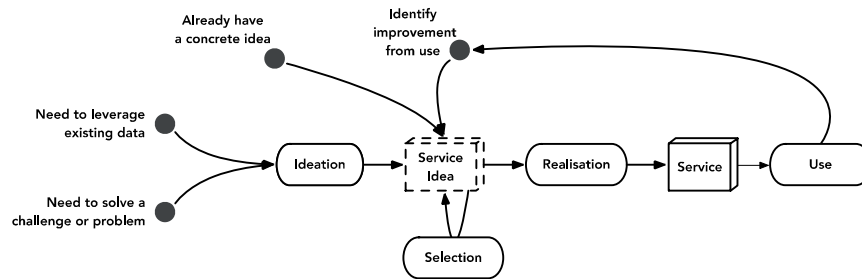
Application domain is the domain in which the method fragment is appropriate, for instance Health, Finance or Industry. Service development stage indicates in which phase of the development process a method fragment can be used: preliminary investigation and opportunity identification; service idea generation and refinement; service concept and delivery process design; validation and implementation issue identification. Innovation type refers to the distinction between service process innovation, customer experience innovation and service concept innovation. Temporality source data indicates whether the method fragment needs past or present data as input. And analysis objective distinguishes between method fragments used for explanation, optimization, prediction, responding, exploring or diversifying. The metamodel is to be further refined in case studies.

## 4 Demonstration

To conduct a preliminary test of the metamodel we applied it to the first phase of the design of a data-driven service in the context of preventive healthcare. A data-driven



service development process was initiated with the oral care unit of a health clinic, with the purpose of validating various research results from our research project. We defined a generic method outline, largely based on [23], to use as an initial framework (Fig. 5): the stages ideation, idea selection, realization and use in the method outline correspond to the four stages distinguished in [23].



**Fig. 5.** Method outline for data-driven service development

Our next step was to identify potential method fragments that might be used in the case study. A preliminary, non-exhaustive scan of existing method fragments from literature or practice by the researchers in the project, generated 22 method fragments that might potentially be used in a data-driven service development process, depending on the situation. An example is the real-time decisioning data density process discussed in [16]. Describing this process in terms of the metamodel results in Table 2.

**Table 2.** Real-time decisioning described as method fragment.

Metamodel concept	Possible values derived from literature
Body – activity	- Real-time decisioning
Body – result	- Intervention
Body – technique	- Prescriptive analytics
Body - role	- Provider
Interface – situation	- Actuality of data: present
Interface – intention	- Predict and Respond
Descriptor – reuse context	- Type of use: inform people - Service development phase: use
Descriptor – reuse intention	- Innovation type: Customer experience innovation

Next, in an interactive session the researchers in the project selected five method fragments to be used in the ideation phase of the oral care service to be developed: 1) long-term goal definition, 2) empathy map, 3) discovery of relevant values, 4) story board, and 5) operationalization of relevant values. Method fragments 1, 2 and 4 are well-known fragments from professional publications, fragments 3 and 5 are the re-

sult of research done by the project team. The selected fragments were elaborated with the aid of the metamodel. For illustration purposes we present the method fragments *empathy map* and *discovery of relevant values* in Tables 3 and 4.

The empathy map is an instrument for understanding audiences, including users, customers, and other players in any business ecosystem, originating from practice and developed by XPLANE [24]. It is a qualitative instrument aimed at understanding and categorizing the needs of a prospective service user. We used the empathy map to generate ideas for a data-driven service, but the fragment can also be used for services that are not data-driven, as can be deduced from the interface intention.

**Table 3.** Example method fragment from practice: empathy map

<b>Name fragment</b>	<b>Empathy Map</b>
Body – activity	<ol style="list-style-type: none"> <li>1. Roughly sketch a persona of the consumer.</li> <li>2. Each team member writes observations in the appropriate quadrant of the map.</li> <li>3. Identify unknowns for later inquiry or validation.</li> <li>4. Discuss observations and fill in gaps collaboratively.</li> </ol>
Body – result	A visualization of what is known about a consumer.
Body – technique	<p>An empathy maps is divided into 4 quadrants (Says, Thinks, Does, and Feels), with the consumer, user or persona in the middle.</p> <p>The <b>Says</b> quadrant contains quotes and defining words of the consumer.</p> <p>The <b>Thinks</b> quadrant captures what the consumer is thinking throughout the experience.</p> <p>The <b>Feels</b> quadrant is the consumer’s emotional state.</p> <p>The <b>Does</b> quadrant contains the actions of the consumer.</p>
Body – role	Marketeers, service designers and software developers
Interface – situation	<p>Optional: qualitative or quantitative inputs like interviews, field studies, consumer data, or qualitative surveys.</p> <p>Optional: the empathy map is ideally being used in conjunction with data discovery. There is a continuous interaction between requirement articulation and exploration of data.</p>
Interface – intention	Explore: creating user/customer/consumer insight by visualizing and categorizing the user's needs.
Descriptor – reuse context	Ideation stage.
Descriptor – reuse intention	Service concept innovation: externalizing knowledge and experience about consumers in order to create a shared understanding of consumer needs

The method fragment *discovery of relevant values* aims to identify the values of direct and indirect stakeholders that may be impacted by a data-driven service in the health

domain. This method fragment is aimed specifically at data-driven services, as can be deduced from the interface situation and the descriptor reuse intention.

**Table 4.** Example method fragment from research: discovery of relevant values

<b>Name fragment</b>	<b>The discovery of relevant values</b>
Body – activity	Answering 28 questions about how values may be impacted by the new service.
Body – result	List of relevant values that must be addressed in the design of the new service.
Body – technique	Moral dialogue.
Body – role	Designers and potential users.
Interface – situation	A concrete idea for a data-driven service.
Interface – intention	Explore: find the values that are relevant to, inspire, or inform the design project.
Descriptor – reuse context	Health domain. Ideation or Selection stage
Descriptor – reuse intention	Service concept innovation: Value Sensitive Design of a data-driven service.

Both fragments depicted in Tables 3 and 4 can be used in the ideation stage. Comparing the body result and the interface situation of both fragments, however, indicates that the method fragment *empathy map* should be applied before the method fragment *discovery of relevant values*: the result of *empathy map*, a visualization of what is known about the customer, is part of gaining a concrete idea of a service, which is a prerequisite for *discovery of relevant values*.

The two fragments are a preliminary result and discussed here primarily for illustrative purposes. More fragments will be collected, both from academics and from practice, in the context of the preventive health service, and used to test the metamodel and further populate it with optional or obligatory value ranges for the interface and descriptor parts of the model.

## 5 Conclusion

In this paper we present a metamodel to describe data-driven service development method fragments with the purpose of making method fragments from both academics and practice accessible to the market. Based on literature on situational method engineering and data-driven service innovation we defined a metamodel and made a first inventory of relevant values to populate the metamodel. We applied the metamodel to defining a development method for the ideation phase of a data-driven service development process in preventive healthcare.

The main contribution of this paper is the metamodel to describe data-driven service development method fragments. The metamodel is an essential part of a situational method engineering approach to data-driven service development. It is part of the method base architecture. Besides validating the metamodel in more depth, further

research will focus on the situational method engineering phases of characterization of the situation and selection of method fragments, i.e. matching situational characteristics with method fragment characteristics.

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