A Digital Interaction Framework for Managing Knowledge Intensive Business Processes

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Abstract. Many business processes present in modern enterprises are loosely defined, highly interactive, involve frequent human interventions and coupled with a multitude of abstract entities defined within an enterprise architecture. Further, they demand agility and responsiveness to address the frequently changing business requirements. Traditional business process modelling and knowledge management technologies are not adequate to represent and support those processes. In this paper, we propose a framework for modelling such processes in a service-oriented fashion, extending an ontology-based enterprise architecture modelling platform. Finally, we discuss how our solution can be used as a stepping stone to cater for the management and execution of knowledge-intensive business processes in a broader context.

Keywords: Knowledge intensive business processes
Semantic modelling · Agile · Business process
Service oriented architecture

1 Introduction

During the last decade, we have seen a growing success of applications that support Business Process Management (BPM) practices. These achievements are mostly associated with operational business processes which can be defined as routine, repetitive, standardized and high-volume transactional processes. The intrinsic nature of operational business processes has enabled organisations to define their models using the state of the art modelling notations such as BPMN[1], execute these models on service oriented architectures[2], collect data in traditional database management systems and analyze the results using traditional

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[1] http://www.bpmn.org.

[2] http://www.opengroup.org/soa/source-book/soa/p1.htm.

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statistical techniques. Although these achievements are extraordinary, they have not scaled up to address the requirements of non-traditional business processes such as Knowledge Intensive Business Processes (KIBPs) [17]. Organisations might be spending most of their resources for operational processes but the competitive advantages are frequently created by KIBPs [17] which are regarded as "people-driven processes" that by nature involve less scripted and even ad-hoc process flows, composed with less structured "smart" decision-making tasks completed by knowledge workers [16].

To address the ad-hoc nature and frequent changing nature of KIBPs, related techniques and tools should support process agility. One obstacle in supporting agile process re-engineering is the gap between organizational level process models and the models built for execution [11,13]. The models built for execution capture the current state of the organizational goals, strategies, and structures, but do not explicitly define them and create the associations between high-level concepts and the execution models. As a result, once the high-level concepts such as strategies and goals change the mapping exercise corresponding to the whole process should be repeated.

The existing technologies discussed in Sect. 2 does not have sufficient capability to capture business or domain knowledge and link them with process models. Further, those modeling approaches are not flexible or malleable to support frequently changing loosely-defined KIBPs.

Baghdadi [3], in his work of modelling business processes for agile enterprises, defines a business process as an artefact that defines a dynamic composition of concrete activities and data, provided as services that add value to customers. We extend that definition with a "Digital Interaction" (DI) construct, which is defined as part of an enterprise architecture model and enables concurrent definition of process and data models. The proposed framework enables the dynamic composition of concrete services, user interactions and underlying knowledge and information concepts and delivers value to the customer. This composition can capture complex interactions involving humans, events or programming entities such as web services.

Following are the main contributions of this paper.

- DI meta-model: An ontology-based knowledge repository to capture elements of a KIBP, integrating domain knowledge, operational artifacts and human interactions.
- DI framework that embeds the propose meta model into an architectural framework, facilitating organizations to manage associations between high-level and execution-level concepts with less effort, re-engineer and deploy them rapidly in response to business changes

We discuss the background of knowledge modelling approaches and business process modelling in Sect. 2. Section 3 presents CAPSICUM framework and its proposed extension to cater for the Digital Interaction construct. Section 4 presents a case study. The paper concludes in Sect. 5 with an discussion of the future work and limitations of the proposed framework.

2 Related Work

2.1 Business Process Modelling

There are two main approaches for business process modelling [3] - graphical modes and rule specifications popular in workflow coordinations. These modeling approaches limit their focus to a specific feature or capability [15]. Yet the dynamic nature of unconventional business processes is not sufficiently addressed in these approaches [3]. Integrating service-oriented architecture provides a certain flexibility for business process modelling and links the execution model to the business level process model. Yet research efforts that focus on the composition of business processes with services such as Cauvet et. al [7] and Stein [23] are limited in their contribution to a static description of an executable business process.

There are studies that address challenges related to non-traditional business processes such as SmartPM [18] which offers a certain flexibility via run-time adaptation of processes with BPMN 2.0 based modeling schema. ArtiFact-GSM [8] proposes an event-driven, declarative and data-centric approach for business process modelling and highlights the importance of information models as business artefacts to address change management. Baghadadi [3] proposes a more agile business process modelling approach where the business process is a state representing its life cycle, with a set of specialized services that will interface business objects.

The main limitation of this line of research is the inadequacy in associating domain knowledge in a flexible manner and the inability to model complex interactions such as event-based and human interactions together with other business artefacts such as services and strategies.

2.2 Knowledge Modelling

We look beyond traditional information modelling techniques and focus on advanced knowledge representation techniques based on semantic modelling and ontologies. The main role of an ontology is to capture the domain knowledge, to evaluate constraints over domain data, to prove the consistency of domain data and to guide solution engineering while developing domain models [2]. It is a powerful tool for modelling and reasoning [1]. A recent study [5] of how semantic models are used for modelling and realizing data analytics processes stands as an evidence of the potential of knowledge modelling for KIBPs.

There are vocabularies such as Semantic Annotations for REST (SA-REST) [22] notation and Web Service Modelling Ontology [12] that capture semantic representations for service implementations and service related knowledge around a business process. Ontologies are proposed for business process management in different research works such as Hepp and Roman [14], and Weber et. al. [24]. Approaches such as PROMPTUM [10] aim to integrate domain ontologies with business processes to provide semantic quality and traceability between domain knowledge and process models. Rao et. al. [20] propose to use ontology-based knowledge maps for process reengineering, demonstrating the level of traceability achieved by an ontology.

Yet they provide limited support for KIBP management, and need to have formalized knowledge representation around KIBPs. Further, existing modeling approaches have limited ability in linking accumulated knowledge with execution-level process model.

2.3 Research Contribution

Literature suggests that existing process modeling approaches do not leverage domain knowledge sufficiently and do not support complex interactions associated with KIBPs. Knowledge modeling is a possible solution for that. Yet the existing technologies lack formal knowledge representation and management strategies to accumulate knowledge and link it with execution-level processes.

According to our experience in studying data analytic process engineering [4,5,19], BPM Ontology integration [9,10] and backed by different literature discussed, we identify a need for new frameworks that could be used by an enterprise to support flexible business processes, with adequate knowledge representation and agility in an integrated way. Instead of developing a framework from scratch, we advocate in this paper an extension of the CAPSICUM enterprise architecture modeling framework [21]. Details for the proposed framework are discussed in the Sect. 3.

3 Proposed Framework

The contribution of this paper is the Digital Interaction framework, based on a semantic meta-model, defined as a dynamic composition of concrete services, set of interactions and underlying information concepts which can be easily converted into execution level code. This is designed as an extension for the CAPSICUM architecture modeling framework and implemented using the Capsifi Jalapeno tool.

This section starts with a motivation scenario to demonstrate the behavior and challenges associated with KIBPs. Then introduction to the CAPSICUM framework is presented, followed by DI meta-model. How it is supported by Jalapeno tool is described in Sect. 3.4.

3.1 Motivation Scenario

We consider a large scale organization that conducts data analytics to support the day-to-day decision making based on information repositories. Each data analytics process can be observed as a KIBP, designed by data scientist to conduct particular objective and repeatedly executed by different users in different contexts. For example, one KIBP will be designed to predict sales of the next quarter, and it will be executed independently in each sales center located in different suburbs.

As Fig. 1 illustrates, information repositories related to this scenario fall into 3 categories: domain-specific knowledge, analytics models and data obtained from different sources. This information changes frequently in response to changes in the external environment and needs to be frequently updated.

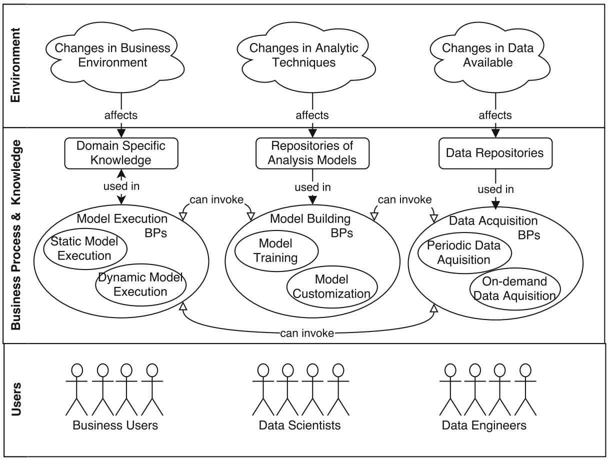

Fig. 1. Overview of case study

As an example KIPB, we are presenting the process of conduction predictive in such environment. Data scientist can import different datasets, apply predefined prediction models for a specific time period and generate a report. This is realized using three services (REST APIs) that import datasets from given data sources, execute a predictive model and export results. The process and related knowledge are presented in Fig. 2.

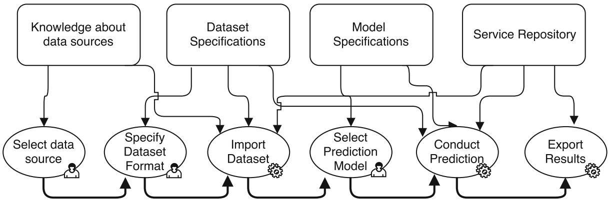

Fig. 2. Example digital interaction 1

To model similar KIBPs in a flexible manner, preserving the knowledge through an information model is the objective of the proposed framework. Web services, user interactions and information models are represented and linked together and when a change occurs in any one part of the model, it should be reflected in other related parts. Finally, our solution should provides the capability to convert the abstract process model into execution-level model.

3.2 CAPSICUM Framework

The CAPSICUM[3] framework proposes an integrated, semantic meta-model for an executable business architecture [21]. Based on an ontological definition, it decomposes various actors and artefacts of the business into a dynamic, canonical model which articulates how constructs such as strategies, goals, business processes, roles and rules interact with and relate to each other. The framework provides a meta model which details what these fundamental constructs are, how they are defined and how they relate to each other. For each organisation, the meta model and the concepts can be instantiated and relevant links can be defined to provide an accurate and dynamic representation of the organisation's business architecture.

The main constructs in the CAPSICUM Framework are encapsulated in logical cells and arranged in four abstraction layers as shown in Fig. 3. The layers are:

- Strategic Purpose (SP) is where high-level concepts of a strategic plan such as strategies, goals, policies, requirements and capabilities are defined and relationships between them are established;
- Business View (BV) represents elements of the architecture and operation of a business such as business processes, roles, rules, conceptual data models and common terms and definitions;
- Technical View (TV) defines platform-independent constructs of technical system designs such as APIs and data types;
- Platform View (PV) documents the implementation details of the technical designs in specific technology platforms.

This layered approach enables organisations to document their business assets at different abstraction levels enabling business architects to focus on the business model of the organisation without getting into the implementation details and the specifics of relevant business processes. The high-level business assets can then be reconciled with the details of technical implementations, supporting systems and applications, underlying data models and APIs. The interconnection between concepts in the CAPSICUM Framework provides great traceability, consistency and transparency across the organisation and enables maintaining the alignment between implemented systems with high-level strategic goals and requirements.

The CAPSICUM framework is the foundation of Capsifi Jalapeno platform[4], a cloud-based enterprise architecture modelling platform backed by a multi-model triple store as the database. Jalapeno provides a dynamic way to define,

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[3] Stands for Coordinating, Access, Processes, Services and Information in a Common Unified Model.

[4] https://www.capsifi.com.

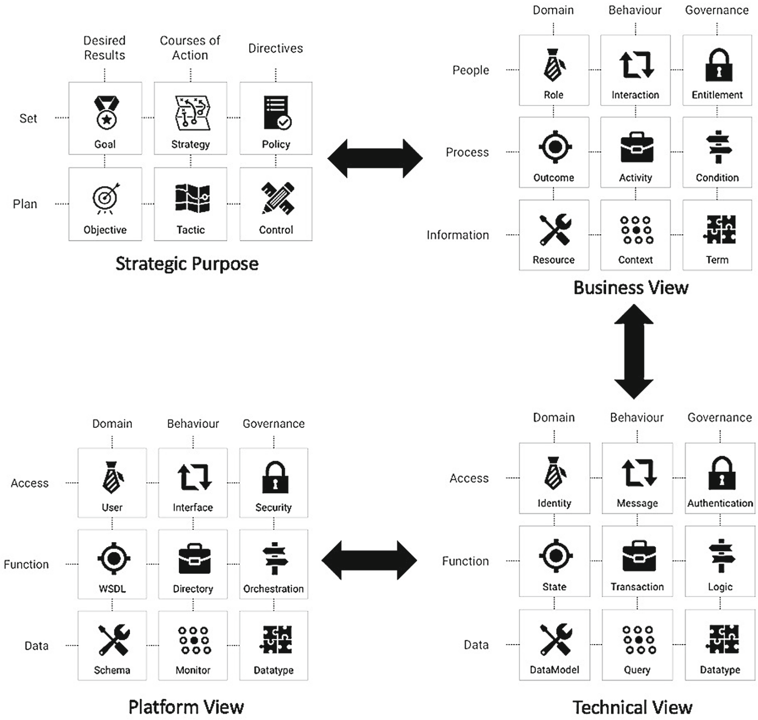

Fig. 3. The four layers of CAPSICUM framework and the cells in each layer (extracted from the Capsifi Jalapeno platform)

analyse and maintain comprehensive business models based on the framework. It offers a variety of views to explore and trace the models from various perspectives as well as ways to export the models in machine-readable formats (RDF, OWL, XSD, JSON).

Validity of the CAPSICUM framework as an effective tool for enterprise architecture modelling is visible through the customers such as Australian regulatory financial supervision authority (APRA), Service NSW and Australian Taxation Office (ATO) as well as many more in the US and Europe who use the platform to catalogue, manage and transform their enterprise business architecture.

Thanks to the underlying semantic technologies (e.g. RDF, OWL, SPARQL) and semantic inferencing capabilities, both the CAPSICUM Framework and the Capsifi Jalapeno platform provide great extensibility. They can be extended with new concepts and relationships and customised to satisfy the specific needs of organisations and to evolve in response to ever-changing business environments. In the following section, we will explain how the CAPSICUM Framework is extended with a meta model for Digital Interaction.

3.3 Digital Interaction Meta-Model

As we are proposing a process model with execution level artefacts, CAPSICUM framework's ontologies at technical view layer were extended to represent Digital Interactions composed of services models, information models, and interaction models. Some concepts from business view layer were also extended to capture the links of execution level and the business level.

Namespaces used for ontology definitions

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rdfs: <http://www.w3.org/2000/01/rdf-schema#>
rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
owl: <https://www.w3.org/OWL/>
capsi-bv: <http://capsi.com.au/core/CAPSICUM-BV#>
capsi-tv: <http://capsi.com.au/core/CAPSICUM-tv#>
sarest: <http://www.knoesis.org/research/srl/standards/sa-rest/#>
di: <http://adage.unsw.edu.au/DigitalInteraction/#>
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RDF[5], RDFS[6] and OWL[7] are the building blocks of ontologies, given in prefixes rdf, rdfs, and owl respectively. We reuse two ontologies from CAPSICUM framework related to business view (prefix: capsi-bv) and technical view (prefix: capsi-tv). Concepts from SA-REST (prefix: sarest) are used for service model definition and represented with prefix sarest. The prefix di represents concepts specific to the proposed Digital Interaction framework.

Information Model. The objective of the information models is facilitating organizations to represent their business objects. As defined by OMG's Business Object Management Special Interest Group, a business object is a representation of a thing active in the business domain, including at least its business name and definition, attributes, behavior, relationships, and constraints. It may contain resources, records, domain knowledge, people or product information related to an organization.

We extend capsi-bv ontology by defining di:Information as a subclass of capsi-bv:Concept. Any information concept related to an organization can be modelled as a subclass of capsi-bv:Concept and extended with related properties.

Service Model. Service is the main building block which links the user-defined interactions and information into actual execution. Our service model extends capsi-tv:Service in CAPSICUM technical layer to define di:Service. Components of the di:Service are defined using the SA-REST vocabulary [22] as shown in Fig. 4. For example di:Service has a parameter di:ServiceField of type sarest:Parameter and a method sarest:HTTPMethod. Other than the classes and properties defined in Fig. 4, di:Service consists of a set of attributes that define their access endpoints, versions etc. A service model has to be self-contained so we can create an executable workflow based on it.

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[5] https://www.w3.org/RDF/.

[6] https://www.w3.org/TR/rdf-schema/.

[7] https://www.w3.org/OWL/.

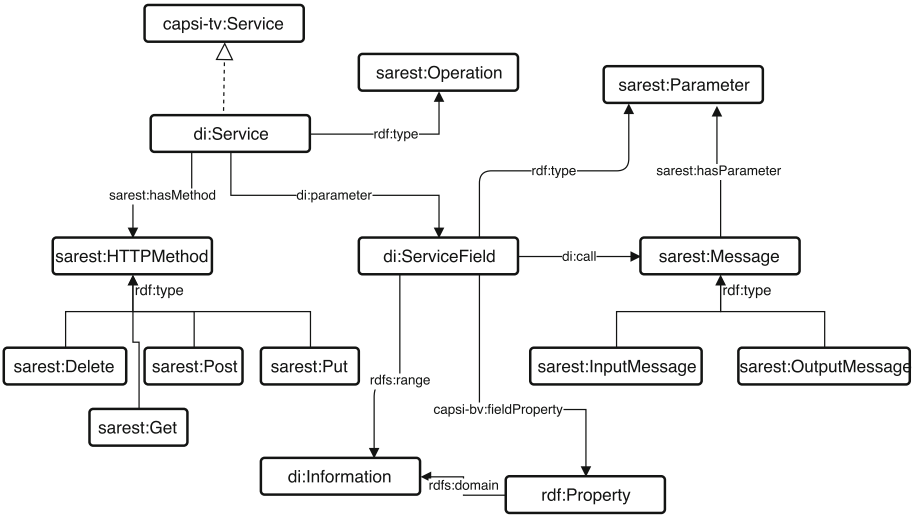

Fig. 4. Main components of the proposed service ontology

In Fig. 4 we also illustrate the relationship between di:ServiceField and di:Information model: A parameter to the service can be a di:Information or the parameter could be a property of di:Information.

We limit the scope of our prototype to REST-based services. But the core concepts of service ontology can be extended to cater different services required by an organization. The validity of this service model was tested by importing independent third-party service schemas and related information objects (e.g.-Xero APIs[8]) directly into this meta-model.

Interaction Model. An interaction is defined a mechanism in which inputs or outputs are exchanged between different entities. Some example interactions are messages or events passed within a computer system or human providing inputs through a user interface such as filling a form. Particularly human interactions are frequent and crucial to drive KIBPs. By modelling these an interaction, we make them flexible, malleable and interpretable.

The Interaction meta-model circled in Fig. 5 shows the di:Interaction concept as a subclass of capsi-bv:Interaction. Interaction is extended to three subclasses: form-based, message-based and event-based. Organizations can extend this further to incorporate other interaction types. Interactions contain di:InteractionField, which represents different components of the interaction. For example, in a form-based interaction di:InteractionField defines the various fields a user fills within the form. di:InteractionField is linked to information meta-model allowing to define the range of di:InteractionField as an information model or to map a property in the information model directly to di:InteractionField.

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[8] https://github.com/XeroAPI/xero-schemas.

This way the semantics of the di:InteractionField such as its related domain, range, data type etc. are automatically accessible at execution.

Digital Interaction. The concept di:DigitalInteraction defined as a combination of Interaction and Service concepts, linked together via di:FlowLogic and di:ServiceInteraction-FieldMapping is shown in Fig. 5. The concept di:ServiceInteractionFieldMapping is used to map inputs from interactions to the service parameters so that a service can be invoked automatically followed by interactions.

The concept di:FlowLogic defines the control flow between different components of the Digital Interaction. di:FlowLogic is authorized by a service or an interaction which initiates a flow. It contains a set of rules which evaluate a set of InteractionFields or ServiceFields and if they match expected values defined through the information model, respective service, interaction or Digital Interaction is triggered. For example, we can define a Boolean interaction field and create a di:FlowLogic to trigger two services depending on whether the value of interaction field is true or false.

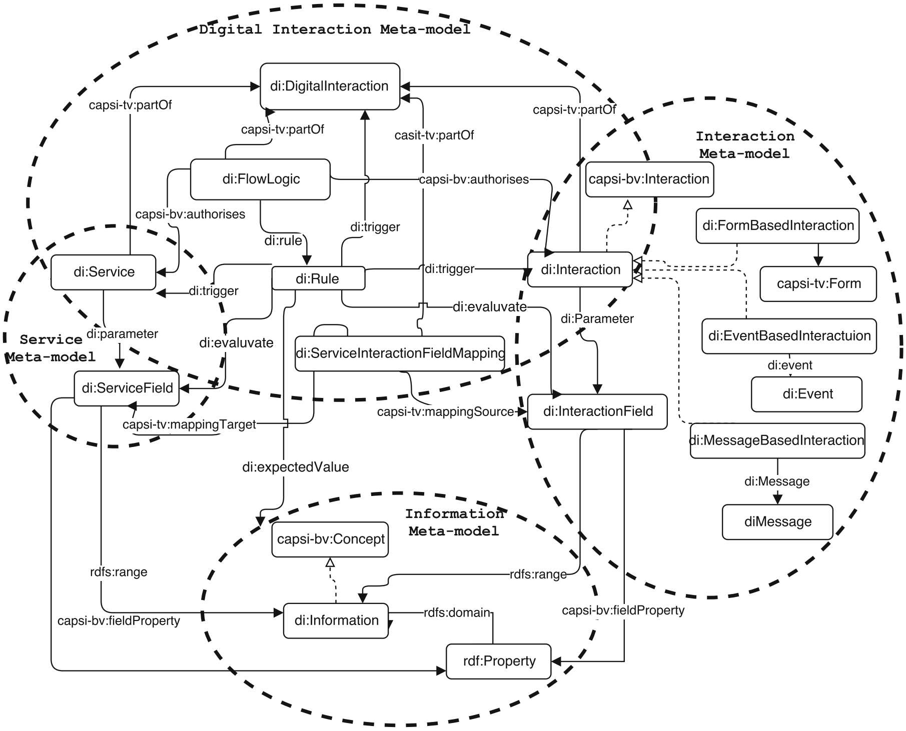

Fig. 5. Main components of the Digital Interaction meta-model with related Information, Service and Interaction model components

3.4 Tool Support

We extended the Capsifi Jalapeno platform and developed a prototype of the Digital Interaction Framework.

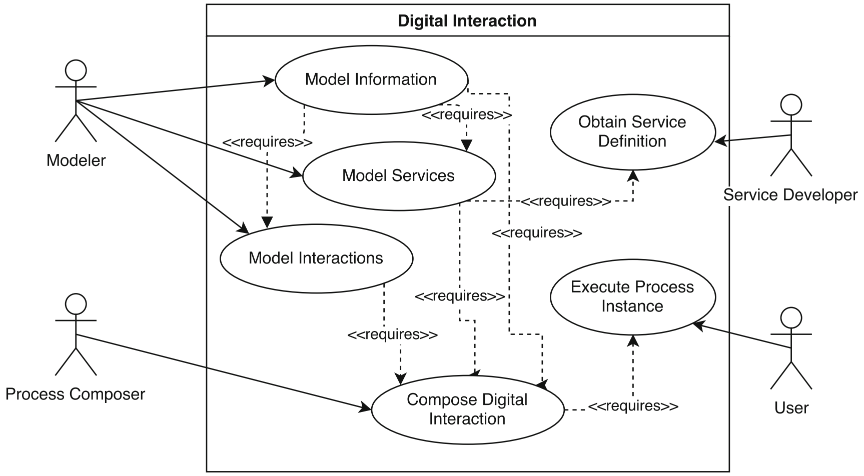

Fig. 6. Use case diagram for Jalapeno-DI extension

Figure 6 shows the use cases that are supported in Jalapeno-DI extension. It is expected that the modelling of information, services, and interactions takes place first before the composition of Digital Interactions can be conducted. Each operation is described below.

- **Model Information**: This use case is inbuilt to Capsifi Jalapeno platform. We can define any semantic concept, its attributes, and relations.
- **Model Services** - We extended the Capsifi Jalapeno platform with a new user interface to model existing or desired services, backed by the service ontology we designed. Further, we implemented a feature to import service models from existing OpenAPI standard service definitions, to reduce modelling effort for organizations that already have their services cataloged
- **Model Interactions** - Capsifi Jalapeno platform provides a user interface to model interactions and their corresponding fields. This interface has an advanced feature for Form-based interaction modelling by creating Pages and Forms by drag-and-drop different components such as text fields, drop-down, radio-buttons etc. Further, we can link interaction fields to information models via this interface, so at the execution level, the user inputs can be mapped automatically to information models.
- **Compose Digital Interaction** - Once the information, service and interaction models are created, we can use them to define Digital Interactions. We extended Capsifi Jalapeno platform's "Form-Flow" feature to

compose Digital Interactions. It provides a canvas to drag-and-drop predefined interactions and services and links them using di:FlowLogic and di:ServiceInteractionFieldMappings concepts.
- **Execute Process Instances** - Once a Digital Interaction is modelled, it can be exported in a machine-readable format and executed. Execution environment should support service invocation as well as inference of the semantic models.
- **Obtain Service Definitions** - Service developers can obtain and use service definitions, automatically exported as an OpenAPI standard documentation from service models. They act as requirement specifications for service developers, provided by modelers when a need for new service is identified.

4 Case Study

To demonstrate the capability of the proposed framework we modeled the example KIBP provided in Sect. 3.1 through Jalapeno-DI extension.

- **Model Information** We identified four high-level information concepts: Data Source, Dataset Format, Dataset and Prediction Model and their associated properties. Together they can capture domain knowledge and information sufficient to conduct an analysis.
- **Model Services** Our example leverages three services, modeled within Jalapeno-DI extension. They are 1. Import Dataset 2. Conduct Prediction 3. Export Result.
- **Model Interactions** We defined 5 interactions: Select data source, Specify dataset format, Import Dataset, Select Prediction Model, Conduct Prediction. Import Dataset and Conduct Prediction interactions provide parameters necessary for respective service executions, while other three aid in the decision making. All interactions are backed by information models to provide suggestions for decision making and to identify parameters user should provide.
- **Compose Digital Interaction** We model the Digital Interactions that starts with Select data source interaction, followed by Specify dataset format and Import Dataset. Import Dataset interaction triggers the Import Dataset service. Then Select Prediction Model interaction and Conduct Prediction service are linked respectively. Dataset returned from the Import Dataset service is mapped to Execute Model service. Export Results service is triggered immediately after the completion of the Execute Model service to generate a report for the user.

  Each link between two components of a DI is captured through di:FlowLogic. To link fields of Interactions with Services, di:ServiceInteractionFieldMapping concept is used. For example, Data Source returned by Import Dataset service is mapped as the input for Conduct Prediction service.

Once this DI is designed, an execution engine is necessary to create graphical user interfaces from interactions and handle different service calls. Different users can use this DI to conduct individual prediction tasks. Detailed evaluation of the capabilities and limitations of the Digital Interactions framework can be found in our work published in Bandara et. al. [6].

5 Conclusion and Future Work

In the paper, we proposed a new ontology-based framework called Digital Interaction to support knowledge-intensive business processes management by providing agility and better domain knowledge representation.

By implementing Digital Interaction meta-model on top of CAPSICUM framework we enabled the linking of service concepts, interactions and Digital Interactions into the holistic enterprise architecture. We can define Digital Interaction as a part of a high-level business process or model how different organizational value streams and strategies are linked to these processes. It provides context and traceability for the services, information, and interactions we define. Hence we get one step closer to better alignment between business and IT architecture of the organization.

Marjanovic in her recent work [17] proposes a new theoretical model for ongoing improvements of KIBPs that support business intelligence and analysis. It composes of three phases: 1. Availability of latest technology infrastructure, 2. Tool support for individual decision makers to gain insights 3. Ability to share insights among decision makers across different instances of the same KIBP. From the experience we had in implementing the predictive analytic case study through Digital Interaction, we believe the proposed Digital Interaction framework can act as a stepping stone for realizing this theoretical model.

When considering phase 1, as the computations of DI are purely service based that are not coupled to particular technology or platform, enabling a rapid shift of technology infrastructure to reflect latest technologies available. To realize phase 2, semantic meta-model that contains organization information can be used to support and guide individual decision makers. As the semantic models are based on open world assumption, they can be frequently updated to reflect new information without changing other related artefacts.

To realize the phase three of Marjanovic's model we need to extend the information models to capture user insights, opinions and learn from previous Digital Interaction instances. Then a user can use that accumulated knowledge in future DI design and execution.

One limitation of our study is the restrictions imposed by extending the CAPSICUM framework. We lose certain level of flexibility, specially when designing flow logic, as we are building on top of CAPSICUM ontologies. It is a trade-off we made as we believe the value of Digital Interaction framework is enhanced by extending a framework that is already accepted and used by large scale organizations such as Australian Taxation Office and Australian Broadcasting Corporation.

Further, to harness the full potential of Digital Interactions we need a good execution platform that can access semantic models and drive different interactions dynamically.

The main challenge in adapting Digital Interactions framework for an organization is designing a good information model that reflect business objects. This model is unique to an organization and developing it from scratch can be challenging. Our framework is designed to link existing information models (e.g.- RDF Cube to model Dataset used in the case study) easily. Hence designing a repository of abstract information models and guidelines for specific KIBP domains such as data analytics, finance or marketing can lift the burden of information modelling and encourage many organizations to adapt Digital Interaction framework.

We consider this work as a foundation for a new approach to solve challenges related to KIBP management and execution. As future goals to achieve that objective, we propose to extend Digital Interaction to contain a knowledge layer that can enable knowledge workers to share their insights and experience, which can supports others in conducting similar KIBPs and decision making.

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References

1. Abelló, A., et al.: Using semantic web technologies for exploratory OLAP: a survey. IEEE Trans. Knowl. Data Eng. **27**(2), 571–588 (2015)
2. Baader, F.: The Description Logic Handbook: Theory, Implementation and Applications. Cambridge University Press, Cambridge (2003)
3. Baghdadi, Y.: Modelling business process with services: towards agile enterprises. Int. J. Bus. Inf. Syst. **15**(4), 410–433 (2014)
4. Bandara, M., Behnaz, A., Rabhi, F.A., Demirors, O.: From requirements to data analytics process: an ontology-based approach. In: Daniel, F., Sheng, Q.Z., Motahari, H. (eds.) BPM 2018. LNBIP, vol. 342, pp. 543–552. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-11641-5_43
5. Bandara, M., Rabhi, F.A.: Semantic modeling for engineering data analytic solutions. Semant. Web J. (under review)
6. Bandara, M., Rabhi, F.A., Meymandpour, R.: Semantic model based approach for knowledge intensive processes. In: Stamelos, I., O'Connor, R.V., Rout, T., Dorling, A. (eds.) SPICE 2018. CCIS, vol. 918, pp. 215–229. Springer, Cham (2018). https://doi.org/10.1007/978-3-030-00623-5_15
7. Cauvet, C., Guzelian, G.: Business process modeling: a service-oriented approach. In: Hawaii International Conference on System Sciences, Proceedings of the 41st Annual, pp. 98–98. IEEE (2008)
8. Cohn, D., Hull, R.: Business artifacts: a data-centric approach to modeling business operations and processes. IEEE Data Eng. Bull. **32**(3), 3–9 (2009)
9. Coskuncay, A., Gurbuz, O., Demirors, O.: Transformation from business process models to process ontology: a case study. In: MCIS 2017 Proceedings, p. 40 (2017)

10. Coşkunçay, A., Gürbüz, Ö., Demirörs, O., Ekinci, E.E.: PROMPTUM toolset: tool support for integrated ontologies and process models. In: Dumas, M., Fantinato, M. (eds.) BPM 2016. LNBIP, vol. 281, pp. 93–105. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-58457-7_7
11. Demirors, O., Celik, F.: Process modeling methodologies for improvement and automation. In: 2011 IEEE International Conference on Quaity and Reliability (ICQR), pp. 312–316. IEEE (2011)
12. Domingue, J., Roman, D., Stollberg, M.: Web service modeling ontology (WSMO)-an ontology for semantic web services (2005)
13. Filiz, C.Y., Demirors, O.: Utilizing process definitions for process automation: a comparative study. In: 2010 BPM and Workflow Handbook, Spotlight on Business Intelligence (2010)
14. Hepp, M., Roman, D.: An ontology framework for semantic business process management. In: Wirtschaftinformatik Proceedings, vol. 27 (2007)
15. Kumaran, S., Liu, R., Wu, F.Y.: On the duality of information-centric and activity-centric models of business processes. In: Bellahsène, Z., Léonard, M. (eds.) CAiSE 2008. LNCS, vol. 5074, pp. 32–47. Springer, Heidelberg (2008). https://doi.org/10.1007/978-3-540-69534-9_3
16. Le Clair, C., Moore, C.: Dynamic case management? An old idea catches new fire. Forrester Research (2009)
17. Marjanovic, O.: Improvement of knowledge-intensive business processes through analytics and knowledge sharing. In:International Conference on Information Systems, pp. 2820–2838 (2016)
18. Marrella, A., Mecella, M., Sardina, S.: Smartpm: an adaptive process management system through situation calculus, indigolog, and classical planning. In: KR (2014)
19. Rabhi, F., Bandara, M., Namvar, A., Demirors, O.: Big data analytics has little to do with analytics. In: Beheshti, A., Hashmi, M., Dong, H., Zhang, W.E. (eds.) ASSRI 2015/2017. LNBIP, vol. 234, pp. 3–17. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-76587-7_1
20. Rao, L., Mansingh, G., Osei-Bryson, K.M.: Building ontology based knowledge maps to assist business process re-engineering. Decis. Support Syst. **52**(3), 577–589 (2012)
21. Roach, T.: CAPSICUM - a semantic framework for strategically aligned business architecture. Ph.D. thesis, University of New South Wales (2011)
22. Sheth, A.P., Gomadam, K., Lathem, J.: SA-REST: semantically interoperable and easier-to-use services and mashups. IEEE Internet Comput. **11**(6), 91–94 (2007)
23. Stein, S.: Modelling method extension for service-oriented business process management. Ph.D. thesis, Christian-Albrechts Universität Kiel (2009)
24. Weber, I., Hoffmann, J., Mendling, J., Nitzsche, J.: Towards a methodology for semantic business process modeling and configuration. In: Di Nitto, E., Ripeanu, M. (eds.) ICSOC 2007. LNCS, vol. 4907, pp. 176–187. Springer, Heidelberg (2009). https://doi.org/10.1007/978-3-540-93851-4_18