

Conceptual Framework for Flexible Workflow Generation in Federated ERP Systems Mediated by a FERP Mall

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Abstract. This paper proposes a conceptual framework outlining two scenarios for flexible workflow generation in Federated ERP (FERP) systems mediated through a FERP mall. However, the lack of technical framework details, empirical analysis, and implementation testing implies the practical utility and effectiveness remain hypothetical. Significant additional research involving algorithm design, simulations, and real-world validation across diverse organizations is needed to substantiate the feasibility of the proposed scenarios. While presenting a preliminary foundation, the conceptual nature and limitations temper the conclusions and practical impact claimed. Focused improvements in framework design and rigorous evaluation can help fulfill the potential.

Keywords: FERP system, web services, workflow, FERP Mall, conceptual framework

1. Introduction

Service Oriented Architecture (SOA) has provided new concepts for enveloping and delivering the software's applications as a service by using web-based standard techniques (Josuttis, 2007; Niknejad et al, 2020; Rotem-Gal-Oz, 2012). Heutschi defined SOA as the following, SOA is a multi-layered, distributed Information System (IS) architecture that encapsulates parts of applications for simplified process integration as business-oriented services while considering specific design principles. A service represents an abstract software element or an interface that offers other applications standardized access to application functions over a network, (Heutschi, 2007). The new settings of this architecture has been widely used from many vendors of application information system to meet the needs of user enterprises especially Small and Medium sized enterprises (SMEs) which are not able to allocate huge budget for obtaining integrated systems like ERP systems. The majority of SMEs rely on a variety of information systems to meet their operational needs. This approach often results in challenges related to data integration and redundancy. Simultaneously, when SMEs opt for integrated ERP systems, they encounter distinct issues, including inefficiency due to unnecessary components, High costs associated with licensing, administration, and maintenance, Complexity and a steep learning curve, given the overload of features and functions in typical ERP systems., Demands for high-end hardware and the lack of IT expertise (Abels et al, 2006; Brehm & Marx Gomez, 2010; Kiran, 2019 and Chatti, 2021). In light of these challenges and on the basis of SOA, the concept of a Federated ERP (FERP) system has emerged in recent years as business application software as a service for the benefit of SMEs.

A Federated ERP system (FERP system) represents an innovative iteration of the traditional ERP system. It comprises ERP components distributed as Web Services across a computer network. The functionalities of this system are delivered through a collaborative network of functions, seamlessly integrated to present themselves as a unified ERP system to the user enterprise. Various components of the ERP system can be developed by different vendors, as illustrated in Figure 1 (Abels et al, 2006; Brehm & Marx Gomez, 2010 and Brehm et al, 2007) .

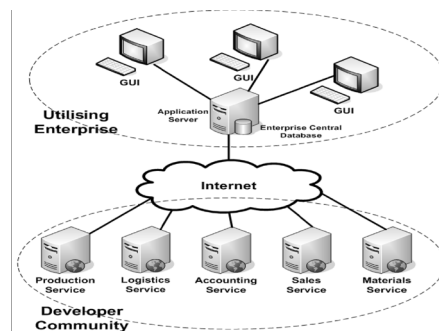


Fig 1: Architecture of Federated ERP system

The FERP (Federated Enterprise Resource Planning) system aims to achieve combined standardization of functions and data within the operational environment and can be implemented in companies of any size. This can be accomplished by consolidating the specifications of all operational core functions within companies, referring to a defined data model. The structure of the set of ERP providers and user companies resembles the principle of federalism. This structure is based on an organized need for standardization and a strong correlation between a centrally controlled standardization effort and the possibility for independent configuration of ERP systems. The service oriented concept of ERP system raised central problem related to how the quality assurance of the provided workflow which integrates various web services offered from independent providers.

This paper introduces novel conceptual Framework for flexible workflow scenarios as the

intermediary role of the FERP Mall, thereby bridging the gap between web service providers and user enterprises. The structure of this work will be continued as the following: exploration and discussion of relevant literature in section 2, section 3 will include the core conceptual framework with the explanation of proposed workflow scenarios, and section 4 will discuss the evaluation process, while the summative conclusion will be encapsulated within the purview of section 5.

Literature Review

A workflow, in its essence, embodies a structured sequence of actions executed either sequentially or in parallel, akin to a choreographed series of activities. These activities are meticulously designed to either produce or utilize business outcomes (Brehm & Gómez, 2007; Hanabaratti, 2021; Ramon-Cortes et al 2020). The convergence of a business process, harmoniously supported by a spectrum of web services (WSs), necessitates the division of this orchestration into distinct architectural components. This intricate process unfolds across three hierarchical levels, namely the process definition, orchestration, and composition levels (Erl, 2005):

In the initial stage, the process definition phase, the blueprint of a business process's graphical structure takes shape. This is accomplished by leveraging the Business Process Modelling Language (such as BPMN), a well-established industry standard (Group, 2005).

The second stage, orchestration, breathes life into the business process structure outlined in the initial step. It involves the implementation of the graphical structure through executable components, often realized using the Business Process Execution Language (e.g., BPEL) or other relevant languages. The culmination occurs at the composition level, where the actual process is executed by invoking selected web services through tailored SOAP messages. Extensive research efforts have been directed towards enhancing the quality of web services (WSs) integration from a technical perspective, giving due consideration to factors such as service quality, efficiency, and compositional flexibility, as evidenced by numerous studies (Freudenstein et al, 2007; Alrifai, 2012; Ardagna & Pernici, 2007 and Dahan, 2017).

In the realm of conventional ERP systems, the scenario contrasts with that of web services integration. Here, the workflow is typically implicit and deeply intertwined with the underlying functions within the processing layer, forming an inseparable unity. This intrinsic workflow component varies between ERP solutions, as illustrated in Figure 2, which delineates four distinct layers:

- The Standardization-layer champions the initiative for the standardization of FERP Web Services (WSs). The Development-layer is inhabited by web services developers tasked with encapsulating business functionalities within web services. Additionally, a workflow designer is entrusted with specifying the intricacies of the business logic.
- The Marketing-layer serves as a marketplace, showcasing a plethora of FERP workflow definitions and web services.
- The Utilization-layer is characterized by the standard software system employed by enterprises. It comprises a graphical user interface, a database, and a workflow management system, all working in harmony to facilitate efficient business operations

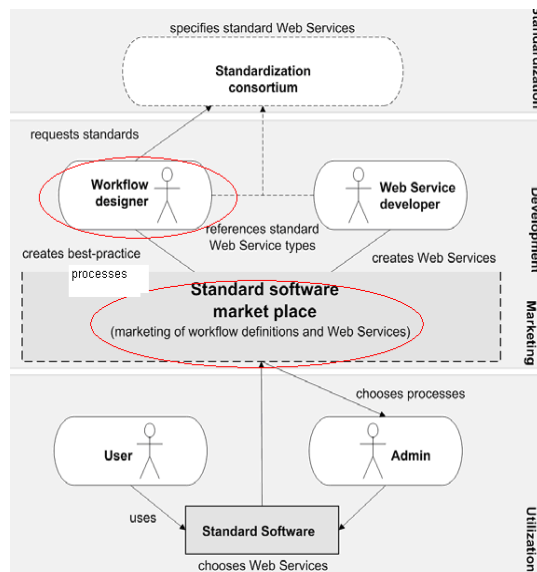


Fig 2. Marketing model for best-practice processes based on Web Services (Brehm & Gómez, 2007).

The ERP workflow within the context of FERP systems has been changed from implicit in the traditional ERP to explicit to be a marketable product in case of Federated ERP system. This product can be independently managed and offered, either by the mediator, or can even be custom-crafted by user enterprise itself. The forthcoming section of this discussion delves into this intricate dynamic, exploring the various possibilities and scenarios within the framework that will be presented.

Numerous prior research studies, including the work of Asfoura and others, have comprehensively characterized and outlined the concept that an FERP Mall, acting as an intermediary, represents the most suitable business model (Asfoura & Abdel Haq, 2015; Zh, Youfu Li, 2015 and Asfoura et al, 2018). This mall functions as a hub for FERP Web services, accessible via an online directory, and operates as an integrator for FERP Web Services (WSs) within FERP processes through a workflow reference model. This reference model encompasses all potential business scenarios within an enterprise. The integrator's role is twofold: it not only meets the required FERP functionality but also assumes responsibility for ensuring the quality of ERP processes for user companies.

Within the FERP Mall, all FERP shops present themselves as a unified entity to customer companies, facilitating all phases of transactions. However, it's essential to note that the direct execution of WS functionality occurs exclusively between the FERP WS providers and the end-users. Additionally, the FERP Mall provides services as service providers, primarily aimed at facilitating the marketing of FERP Web Services. These services may be housed in separate establishments within the mall, as shown in figure 3. Importantly, all the shops within the FERP Mall operate under a unified shopping and payment system.

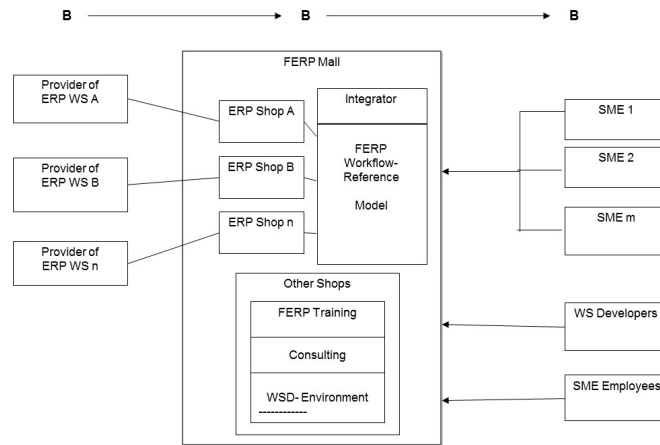


Fig 3: The character-concept of FERP Mall

Subsequently, the articulation of workflow definitions stands as a pivotal outcome furnished by the FERP Mall, serving as the cohesive link that amalgamates diverse ERP web services aimed at encompassing the requisite functionalities demanded by user enterprises. Consequently,

As extending the role of the described intermediary model in term of the integration of web services in suitable workflow with considering the flexibility against the end user enterprises. For this objective the next section will provide a conceptual framework describing two different scenarios for generating ERP workflow to meet the requirements of the user enterprises.

2. Research Methods

The methodology used in this paper is basically based on the design science research (DSR) in information systems. As a result, to conduct the DSR process, propose the new artifact and add new knowledge to the research to solve the research problem presented in this work, a Design Science Research Methodology (DSRM) process that is proposed by Offermann et al. (2009) will be followed. Therefore, the methodology can be divided into three main phases which are: "Problem identification," "Solution design," and "Evaluation" (Offermann et al., 2009). In this paper, a literature review is conducted to define the scientific gap and requirements, followed by designing the conceptual framework in the "Solution design" phase, and finally the conceptual framework is evaluated by both qualitative and quantitative methods in the "Evaluation" phase.

This research provides conceptual framework as artifact for extending the role of FERP mall as intermediary business model for managing the workflow felinely for different enterprises. The framework delineates two distinct scenarios, user-side workflow and FERP mall-side scenario, each of them includes a series of interaction steps between the user enterprise (often an SME) and the web service providers, all orchestrated under the guiding hand of the FERP Mall. These scenarios aim to develop the most suitable business process for the SME. The steps of the different scenarios will be discussed in details within the next two subsections

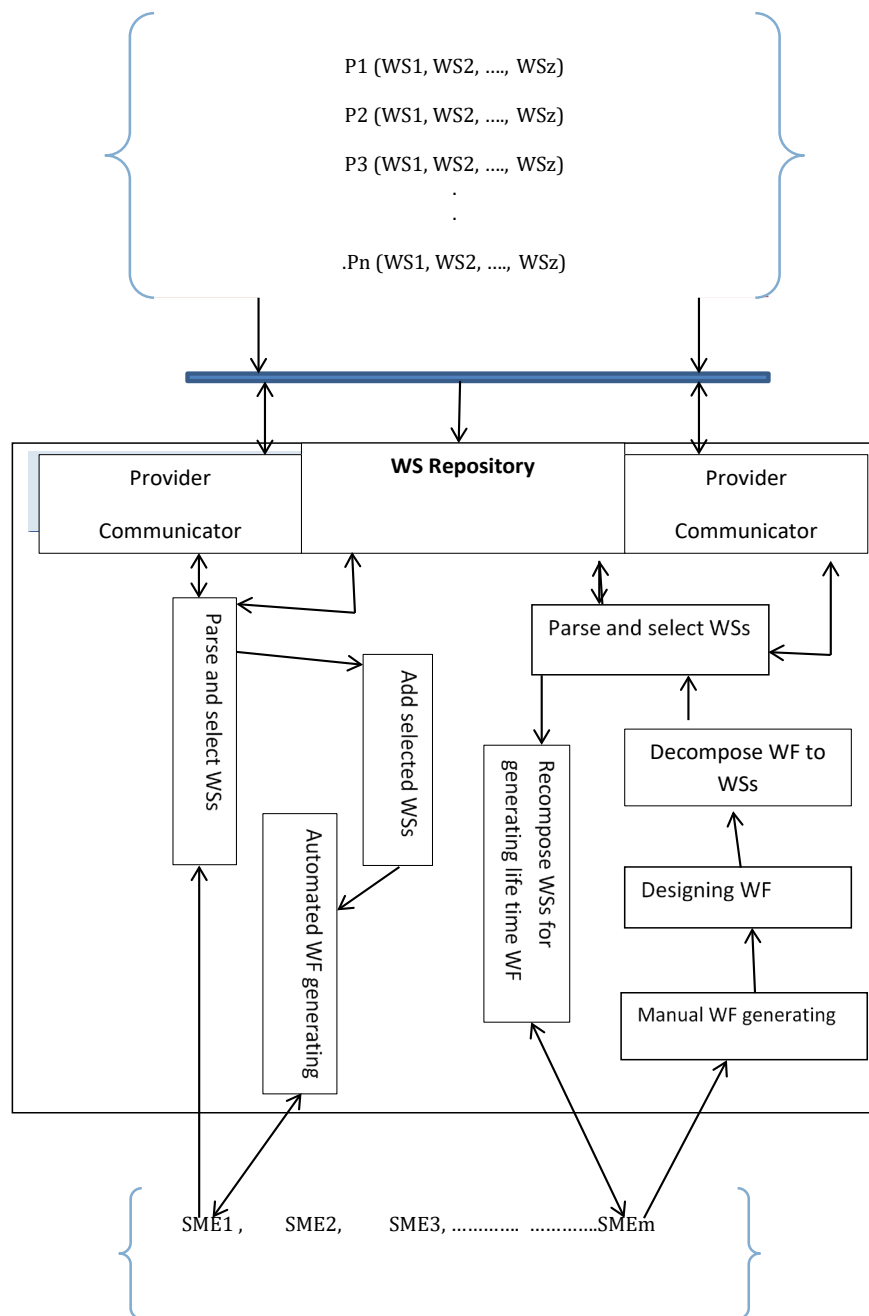


Fig. 4: Conceptual framework for SME workflow scenarios in case of FERP Mall

3.1. User-side scenario

This Scenario is suitable when the SME have the capacity to manually design its own workflow, utilizing the Workflow platform provided as a service by the FERP Mall as shown in figure 5.

The publication of offers commences when the service provider transmits service details to the FERP mall operators, continuing until the contract is formally signed. These service details comprehensively outline both static and dynamic attributes of each service operation. (It's important to note that a web service may encompass multiple operations.) They also articulate the anticipated benchmarks for dynamic attributes, serving as service-level indicators.

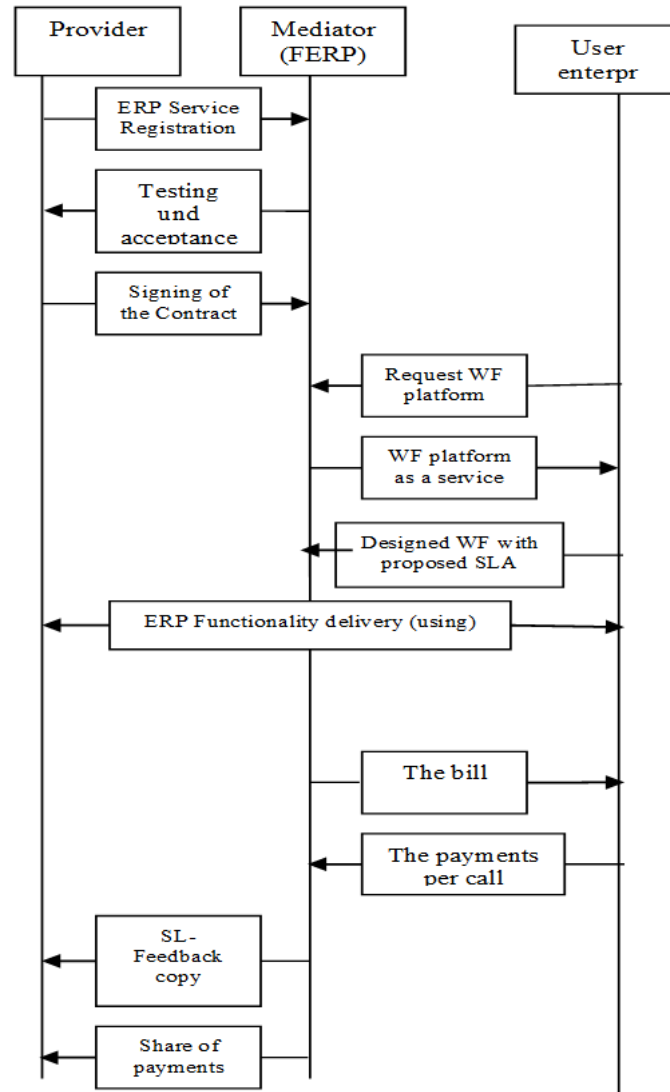


Fig 5: the role of FERP mall in case of user enterprise -side workflow scenario

The FERP Mall functions as the representative of the provider vis-à-vis the end-customer enterprise. During this phase, the intermediary possesses the capability to test the offers using suitable methods. The SME meticulously outlines the desired process levels, encompassing both functional and non-functional specifications (Asfoura, 2010). Subsequently, the mediator (FERP Mall) dissects the workflow, identifying the requisite web services (WSs), and traverses the WSs repository (UDDI) to locate WSs with compatible functional and non-functional attributes. After using the integrated ERP functionality, the user enterprise should pay to the FERP mall as central representative for the called web services.

3. 2. FERP mall-side scenario

In the Second Scenario the intermediary (FERP Mall) will play the same role presented in previous scenario in terms of the contracting with web service providers. But the main difference in this scenario is that the SME directly will contact the mediator and presents an informal description of its business process, with the intent of generating the necessary workflow. The SME peruses the mediator's repository, wherein various providers publish their WSs, to pinpoint WSs exhibiting the

necessary functional and non-functional attributes. The mediator, in turn, undertakes the automatic integration of these services to be integrated through the requisite workflow. The user enterprise should pay in this case for both the called ERP web services as well as for the workflow designing as additional services provided by the FERP mall (see figure 6).

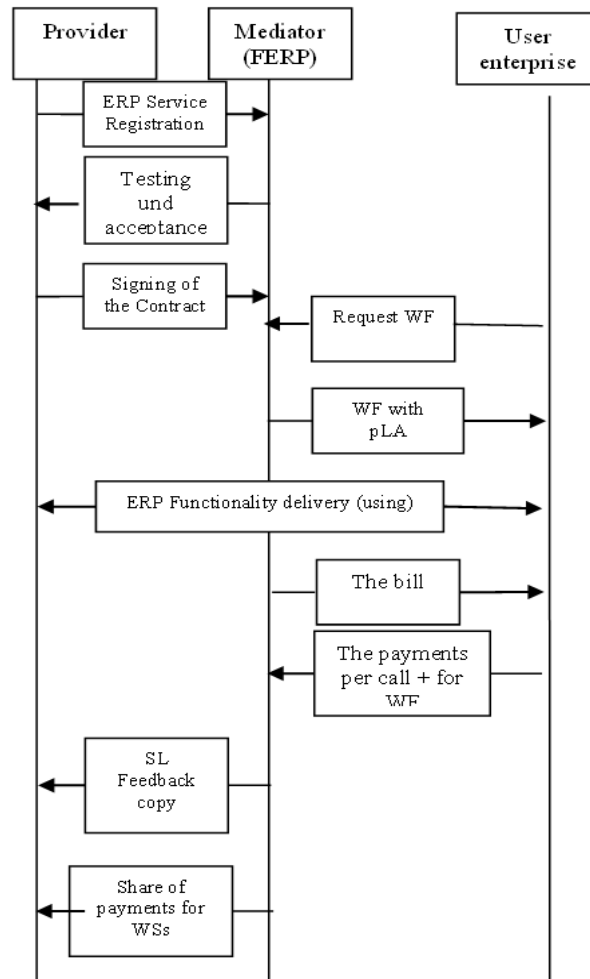


Fig 6: the role of FERP mall in case of FERP Mall-side workflow scenario

The two scenarios proposed in the conceptual framework above encompass a spectrum of flexible options that empower SMEs to craft their ERP business processes through the mediator. Notably, the mediator plays a crucial role in ensuring the quality of these processes, recognizing the paramount importance of both the business process and its quality within the domain of FERP systems. The next section will offer a detailed evaluation, encompassing both qualitative and quantitative.

3. Result evaluation and discussion

This section will comprehensively assess the suggested workflow scenarios through both qualitative and quantitative perspectives. Qualitative evaluation will involve an in-depth exploration of the pros and cons of the two scenarios, focusing on their impact on both the mediator and the SMEs (user enterprises):

Table 1: qualitative evaluation of proposed framework scenarios

First workflow scenario			
Mediator (FERP Mall)		SMEs (user Enterprise)	
Advantages	Disadvantages	Advantages	Disadvantages
Reduced accountability for the quality of the business process	Less revenue because business process is designed by SME	Less cost and less dependency on mediator	SME will be responsible for the quality of business process
Receiving revenue through providing platform as services for supporting SME by designing workflow and through intermediation of WSs	the mediator should decompose manually the business process and find understand clearly the needed functionality and WSs	The business process will be more suitable for SME functionality because the user know more than the other parties about what he need	Less business process guaranty from the mediator side
Second workflow scenario			
Mediator (FERP Mall)		SMEs (user Enterprise)	
Advantages	Disadvantages	Advantages	Disadvantages
More revenue through designing workflow and intermediation of WSs	Higher responsibility for the quality of business process	Using experience of mediator by creating business process	More cost
Mediator will generate business process automatically	Mediator will be responsible for business process reengineering when user enterprise ask	More guaranty from the mediator for the quality of business process	More dependency mediator

Quantitative Assessment: In this section, we will present the findings related to the workflow, which are based on the data illustrated in Figure 7. This data originates from an extensive survey conducted among 120 small and medium-sized enterprises (SMEs) situated in the Saxony region of Germany. The primary aim of this survey was to gauge the level of acceptance and adoption of the FERP System and the concept of the FERP Mall as a viable solution to meet the ERP functionality requirements of these companies.

The survey was distributed through both fax and email, including an informative summary of the FERP System and FERP Mall concepts in the invitation package. Out of the total number of companies invited, 33 elected to participate in the survey. Interaction with these surveyed companies took place through two main channels: 73% of the communications were carried out in person, while the remaining 27% occurred electronically via email correspondence

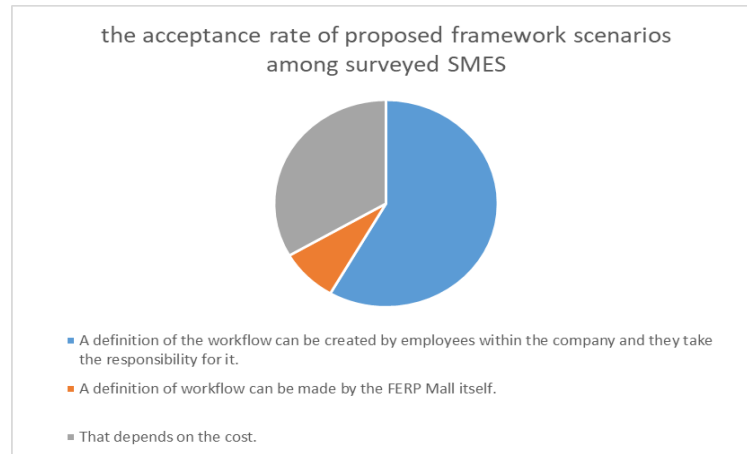


Fig 7: the acceptance rate of proposed framework scenarios among surveyed SMES

Figure 7 displays the results concerning responses to the workflow scenarios. Out of the surveyed SMEs, 63.6% showed a preference for the first workflow scenario, while only 9.1% accepted the second scenario. Approximately 36.4% of the surveyed SMEs indicated that their choice of scenario would be based on production costs. This suggests that both scenarios have potential market shares.

The framework proposed in this paper focuses on managing an appropriate workflow at the end-user enterprise level, mediated by the FERP Mall business model, to enhance flexibility for these user enterprises. Prior research in this field primarily concentrated on methods to increase the flexibility and scalability of workflows for cloud computing, such as (Zhao et al, 2014; Bala and &Chana, 2012; Hoenisch et al, 2013; Nai-zhong, 2013), and other studies explored the control model for service level agreements (SLA) in cloud-based workflows, as seen in (Sun et al, 2013; Badidi, 2016). In the context of SLA, this work introduces a management approach for both SLA and PLA (Process Level Agreement) within the context of FERP, as discussed in (Asfoura et al, 2009) and (Asfoura et al, 2011). All of these related works can be considered as complementary technical foundations for the framework proposed in this paper, which aims to offer flexible scenarios for workflow generation within user enterprises while extending the role of the mediator (FERP Mall) between various ERP WS providers and user enterprises for mutual benefit."

4. Conclusion and Limitation

In conclusion, this paper proposed a conceptual framework delineating flexible workflow generation scenarios for Federated ERP systems mediated through a FERP mall. However, the lack of specific technical details on underlying algorithms, assumptions, and empirical analysis implies practical applications remain largely hypothetical. Substantial additional research is imperative through methods like framework implementation, simulations, and validation across diverse organizations to realize and substantiate the framework's purported benefits. While serving as an early conceptual foundation, the limitations in concrete design specifications, evaluation methodology, and testing significantly restrict the conclusions and practical contributions claimed. Concentrated efforts to address these limitations can help translate the conceptual visions outlined here into impactful real-world solution.

This work present conceptual framework for identifying the role of FERP Mall as proposed business model for successful implementation while the implementation has been considered as future work and need huge project which also is subject for time and resources. Therefore the evaluation of the proposed framework focused only on the qualitative and quantitative theoretical analysis.

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References

- Abels, S., Brehm, N., Hahn, A., & Gomez, J. M. (2006). Change management issues in Federated ERP systems: an approach for identifying requirements and possible solutions. *International Journal of Information Systems and Change Management*, 1(3), 318-335.
- Ardagna, D., & Pernici, B. (2007). Adaptive service composition in flexible processes. *IEEE Transactions on software engineering*, 33(6), 369-384.
- Alrifai, M., Risse, T., & Nejdl, W. (2012). A hybrid approach for efficient Web service composition with end-to-end QoS constraints. *ACM Transactions on the Web (TWEB)*, 6(2), 1-31.
- Asfoura, E., Kassem, G., & Dumke, R. (2009). Kombination von service, process level agreement und zahlungsverhalten für sichere FERP malls. In *Workshop Bewertungsaspekte serviceorientierter Architekturen. BSOA 2009*;(Darmstadt-Germany 18.11. 2009).
- Asfoura, E., Jamous, N., Kassem, G., & Dumke, R. (2011). Extending the role of FERP mall for more flexible softy for satisfying the end-user-enterprise. the *International Journal for Digital Society (IJDS)*, 2(1), 397-405.
- Asfoura, E., & Abdel Haq, M. S. (2015). Adapting a business model for marketing of distributed ERP components. *International Journal of Computer and Information Technology*, 4(6), 895-900.
- Asfoura, E., Kassem, G., Georgieva, K., & Dumke, R. (2011). Developing Approach for Conception of Appropriate Business Model for Federated ERP Systems. In *Proceedings of the International Conference on e-Learning, e-Business, Enterprise Information Systems, and e-Government (EEE)* (p. 1). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp).
- Asfoura, E., Abdel-Haq, M. S., & Chatti, H. (2018). Three-Phase approach for developing suitable business models for exchanging federated ERP components as web services. *International Journal of Advanced Computer Science and Applications*, 9(11).
- Asfoura, E., Abdel-Haq, M. S., Chatti, H., & Radouche, T. (2018). Classification of business models with focusing on characterizing “as a service” offers. *International Journal of Advanced and Applied Sciences*, 5(11), 16-23.
- Asfoura, E., Jamous, N., Kassem, G., & Dumke, R. (2010, June). FERP mall role in FERP Web Services marketing. In *2010 International Conference on Information Society* (pp. 143-148). IEEE.
- Bala, A., & Chana, I. (2012). Design and deployment of workflows in cloud environment. *International Journal of Computer Applications*, 51(11).
- Badidi, E. (2016). A broker-based framework for integrated sla-aware saas provisioning. *arXiv preprint arXiv:1605.02432*.
- Brehm, N., & Marx Gomez, J. (2010). Federated ERP-Systems on the basis of Web Services and P2P networks. *International Journal of Information Technology and Management*, 9(1), 75-89.
- Brehm, N., Gómez, J. M., Pietsch, T., & Lang, C. V. (2007). Web service-basierte referenzarchitektur für föderierte ERP-systeme. *Ressourcenmanagement*. Erich Schmidt Verlag, Berlin, 125-142.

- Brehm, N., & Marx Gomez, J. (2010). Federated ERP-Systems on the basis of Web Services and P2P networks. *International Journal of Information Technology and Management*, 9(1), 75-89.
- Brehm, N., & Gómez, J. M. (2007). Service-oriented development of federated ERP systems. *Software Engineering Methods for Service-Oriented Architecture 2007 (SEMSEA 2007)*, 76.
- Chatti, H., Radouche, T., & Asfoura, E. (2021). Framework for the evaluation of the ERP implementation success: case study in SMEs. *Journal of Management Information and Decision Sciences*, 24(4), 1-25
- Dahan, F., El Hindi, K., & Ghoneim, A. (2017). An adapted ant-inspired algorithm for enhancing Web service composition. *International Journal on Semantic Web and Information Systems (IJSWIS)*, 13(4), 181-197.
- Erl, T. (2005). *Service-oriented architecture: concepts, technology, and design*. Pearson Education India.
- Freudenstein, P., Buck, J., Nussbaumer, M., & Gaedke, M. (2007, July). Model-driven Construction of Workflow-based Web Applications with Domain-specific Languages. In *MDWE*.
- Group, O. M. (2005): *Business process Modeling Notation (BPMN)*. Object management Group.
- Hoenisch, P., Schulte, S., & Dustdar, S. (2013, December). Workflow scheduling and resource allocation for cloud-based execution of elastic processes. In *2013 IEEE 6th international conference on service-oriented computing and applications* (pp. 1-8). IEEE.
- Hanabaratti, K. D. (2021). Web service composition for executing workflows: open issues, challenges, survey and future directions. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, 12(9), 2599-2608.
- Heutschi, R. (2007): *Service-orientierte Architektur : Architekturprinzipien und Umsetzung in die Praxis*. Springer-Verlag Berlin Heidelberg (Business Engineering).-229 S.- ISBN 978-3-540-72357-8.
- Josuttis, N. M. (2007). *SOA in practice: the art of distributed system design*. " O'Reilly Media, Inc."
- Kiran, T., & Reddy, A. (2019). Critical success factors of ERP implementation in SMEs. *Journal of Project Management*, 4(4), 267-280.
- Nai-zhong, W. U. (2013). Dynamic composition of web service based on cloud computing. *International Journal of Hybrid Information Technology*, 6(6), 389-398.
- Niknejad, N., Ismail, W., Ghani, I., Nazari, B., & Bahari, M. (2020). Understanding Service-Oriented Architecture (SOA): A systematic literature review and directions for further investigation. *Information Systems*, 91, 101491.
- Offermann, P., Levina, O., Schönherr, M., & Bub, U. (2009, May). Outline of a design science research process. In *Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology* (pp. 1-11).
- Ramon-Cortes, C., Lordan, F., Ejarque, J., & Badia, R. M. (2020). A Programming Model for Hybrid Workflows: combining Task-based Workflows and Dataflows all-in-one. *Future Generation Computer Systems*, 113, 281-297.
- Rotem-Gal-Oz, A. (2012). *SOA patterns*. Simon and Schuster.
- Sun, Y., Tan, W., Li, L., Lu, G., & Tang, A. (2013, June). SLA detective control model for workflow composition of cloud services. In *Proceedings of the 2013 IEEE 17th International Conference on Computer Supported Cooperative Work in Design (CSCWD)* (pp. 165-171). IEEE.

Zhao, Y., Li, Y., Raicu, I., Lu, S., Tian, W., & Liu, H. (2015). Enabling scalable scientific workflow management in the Cloud. *Future Generation Computer Systems*, 46, 3-16.