Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Developing appropriate pricing models for workflow and workflow reengineering in case of federated ERP system

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ARTICLE INFO

Article history:
Received 12 December 2019
Received in revised form
20 April 2020
Accepted 30 April 2020

Keywords:
ERP system
FERP system
FERP mall
Workflow
Workflow reengineering

ABSTRACT

The workflow in case of software as a service integrates various web services depending on the needs of the user. The same is in the case of the federated ERP (FERP) system, which its functionality is provided from independent providers as web services, which are integrated as a single system against the user enterprises. The composition of FERP web services is carried out by a mediator who is introduced and described as FERP Mall through many previous papers. A FERP Mall aims to cover the needs of small and medium enterprises (SMEs) to ERP functionality as integrated web services that are provided from various providers because the conventional ERP systems are mostly expensive for SMEs because of the related needs like high-end hardware, software, and customization. For the intermediation of FERP Web Services, the FERP Mall (as mediator) will provide the appropriate FERP Workflow (Wf). The relevant questions, in this case, are: How to find the appropriate price of each FERP workflow description as a marketable product? And how the mediator will logically determine the workflow reengineering price also when the user enterprise asks him for business process reengineering. Therefore, this paper aims to derive a mathematical model based on a logical analysis of the complexity of this product (Wf definition) because no like this model has been provided in the literature. In contrast, the previous researches focused on the workflow composition methods and technologies, and few of them provided some considered complexity issues. The targeted model can be considered for determining logical prices of workflow modeling and workflow reengineering in case of web services composition as a separate product.

1. Introduction

Cloud computing and, as a service, is one of the modern and fast-growing technology which has been applied in many fields usefully because its flexibility and scalability (Kulkarni et al., 2012; Cunha et al., 2017). One of the critical application of software as a service is the federated ERP (FERP) system for benefits of enterprises, especially for small and medium-sized enterprises (SMEs), as well as the software developers. An FERP system is a federated ERP system (FERP system) is an ERP system which consists of system components that are distributed within a computer network. The overall functionality is provided by an ensemble of allied network nodes that all together appear as a single ERP system to the user. Different ERP system components can be developed by different vendors. As shown in Fig. 1 (Abels et al., 2006; Brehm and Marx Gomez, 2010; Brehm et al., 2007; Asfoura and Abdel Haq, 2015).

A FERP system in addition to the low cost because of pay as you go system and the coemption among the different providers who can provide similar web services which distinguish this proposed system from the other types of as a service provided ERP software which depends on one vendor like SAP Business by design (for more information about it see (Mathur et al., 2013).

In the case of the FERP system, workflow which needed to integrate web services from different and independent providers can be offered as a separate product to the end-user enterprises. A workflow (Wf) is a plan of sequentially or in parallel chained functions as working Steps in the meaning of activities that lead to the creation or utilization of Business benefits (Brehm and Marx Gomez, 2010). This workflow as the product needs a logical base for

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pricing. Therefore, this work will focus on deriving a suitable model that can be considered as a logical base for determining suitable workflow and workflow reengineering prices. The structure for accomplishment the proposed models will include in addition to this introduction, a background which includes an overview of the related works, research methods as the core part, the evaluation through workflow samples which are chosen randomly, and the end will be with the conclusion of the work.

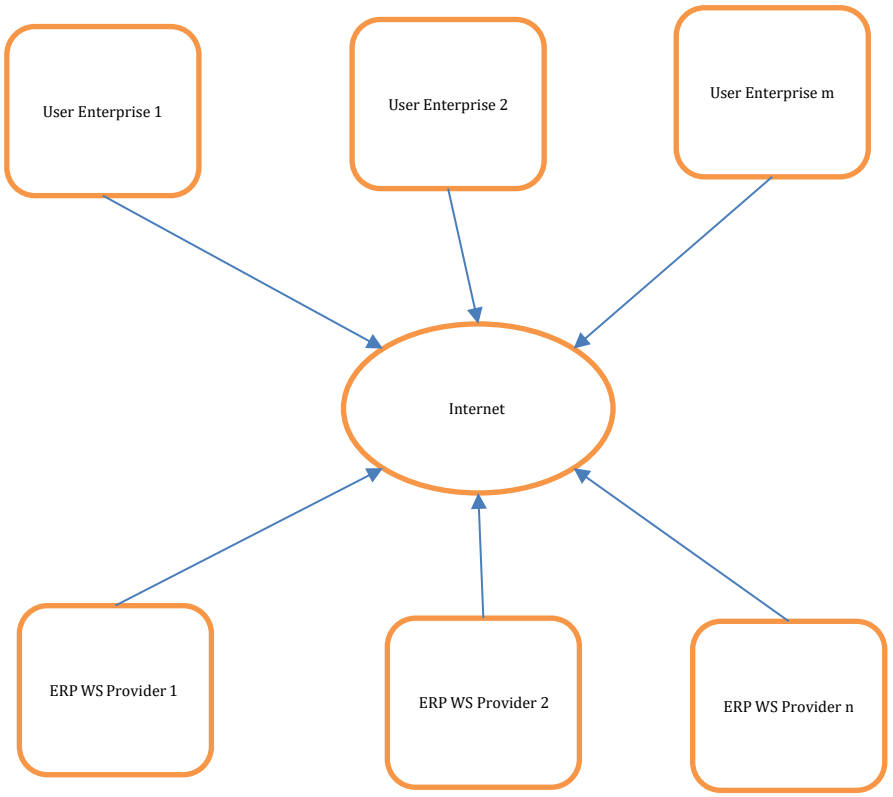

Fig. 1: Architecture of conventional ERP system

2. Background

The idea of the workflow as a new and separate product in the case of FERP is new, and no pricing model has been considered related to it. Therefore, this section will focus on the works that characterized the FERP system and its suitable business model.

In the case of FERP system, these layers are (Fig. 2):

- Standardization-layer represents initiative for the Standardisation of FERP Web Services (WS).
- Development-layer represents the Web services developers that encapsulate business functionality in Web services and workflow Designer, which is responsible for the specifications of the business logic.
- Marketing-layer represents the marketplace for the offering of FERP workflow definitions and Web services.
- Utilization-layer is represented by a standard software system for utilizing enterprises. This system consists of a graphical user interface, database, and workflow management system.

This work focus on the marketing of FERP workflow definitions. The first and most crucial step in this direction is the description of a suitable business model for the marketing of FERP systems. There are many definitions of the business model in literature like the definitions of Timmers (1998), Magretta (2010), Slávik (2011), Boons and Lüdeke-Freund (2013), Reim et al. (2015), but here the definition of Timmers (1998) will be presented in the following because it characterized the main components and architecture of the business model.

A business model includes Architecture for the flow of products, services, and information a description of the various actors and their roles, a description of the potential benefits for the individual actors, and a description of the revenues. In other words, the business model characterizes the actors, their roles, and the goods and cash flow between them.

In the FERP case, there are more than one customer and provider of the ERP components in this business model. Therefore, this business model serves as a commercial intermediary between providers and customers. This intermediary offers the ERP components of different providers and organizes a cross-vendor to satisfy the functionality demanded by the customers as well as manages and control the service level and process level agreements between them both (Asfoura et al., 2009a; 2011). An intermediary is an entity that stands among suppliers and customers and can act actively or passively. Besides the added value of the intermediary experience, the mediation between customers and providers is relevant because the

search process by such intermediary is cheaper than a direct single search process. That includes e-mall as well as e-auction (Bartelt and Lamersdorf, 2001).

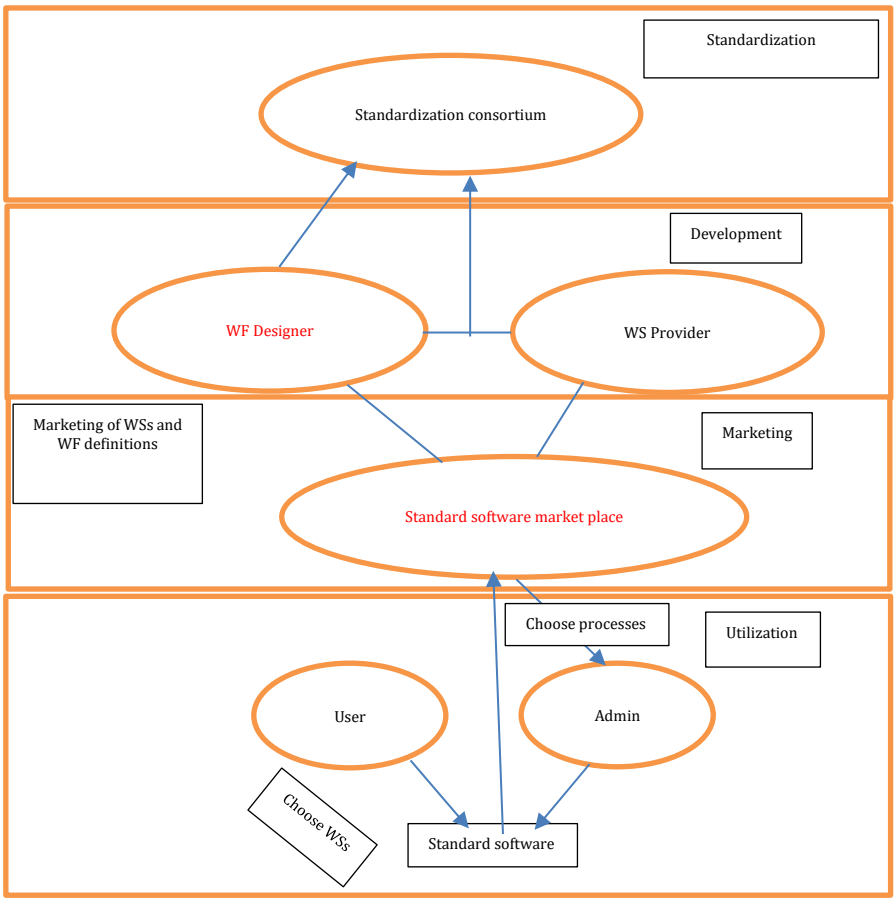

Fig. 2: Marketing model for best-practice processes based on web services (Brehm and Gómez, 2007)

In ERP auction, the customer (user or company) should sign several contracts if different ERP WS providers cover his/her requirements. That means that each provider is partially responsible to the user, and there is no single "one" responsible party which the customer could deal with in case of failure or any accident. As a result of this problem, besides the high prices of ERPs software, we consider this possibility practically inapplicable in this stage because it still in the conception and designing phase (Asfoura et al., 2018a).

As a result, a FERP E-mall as an intermediary business model between the providers and the end-customer is the reasonable and appropriate business model type, which can fulfill the needs of small and medium-sized enterprises (SMEs) through an appropriate adaptation (Brehm and Marx Gomez, 2010; Asfoura et al., 2009b; 2009a; 2018b).

This e-mall contains several professional ERP shops and offers support services in addition to the supplying role of FERP WS as other necessary shops, which are necessary for this mall as an integrator. The integrator provides the FERP-Reference workflow model, which represents all possible business scenarios of an enterprise (Fig. 3).

This intermediary integrates the business functions required by the user in an appropriate business process.

There are also many works related to workflow modeling and simulation like Bazoun et al. (2016), Ougaabal et al. (2019), and Chen et al. (2015), which can be considered as related to this paper. However, the main difference in this work is that this work relies on modeling and simulation as a base to determine the complexity of workflows as a variable that affects the suitable workflow modeling. This paper describes a logical analysis of this product (Wf-definitions) and finds out a suitable pricing-models, which can be considered for the determination of logical prices of these products and for workflow reengineering (reengineering) because the enterprises work in rapidly changing business environment, and they need allows business process reengineering.

3. Research method

This paper will use mathematical l methods with the theoretical analysis an investigation for the derivation of the proposed pricing models.

As shown in the previous section, FERP mall integrates FERP Web service inappropriate Workflows. Fig. 4 presents an example for manufacturing business process which includes three functions as for example (Material requirements planning, Purchase order and

Production scheduling) every one of these functions will be provided by the deferent provider.

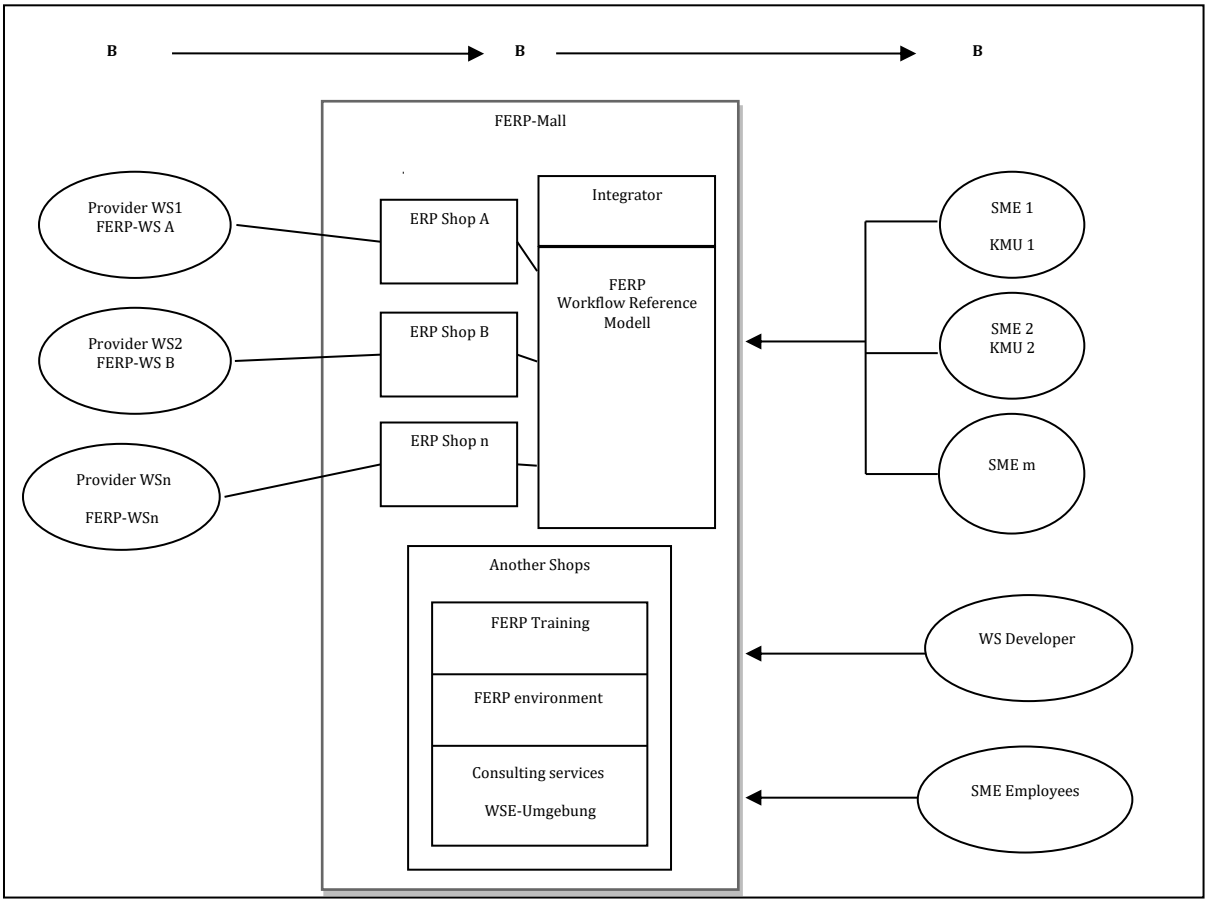

Fig. 3: ERP Mall for the marketing of FERP components as web services (Asfoura et al., 2018b)

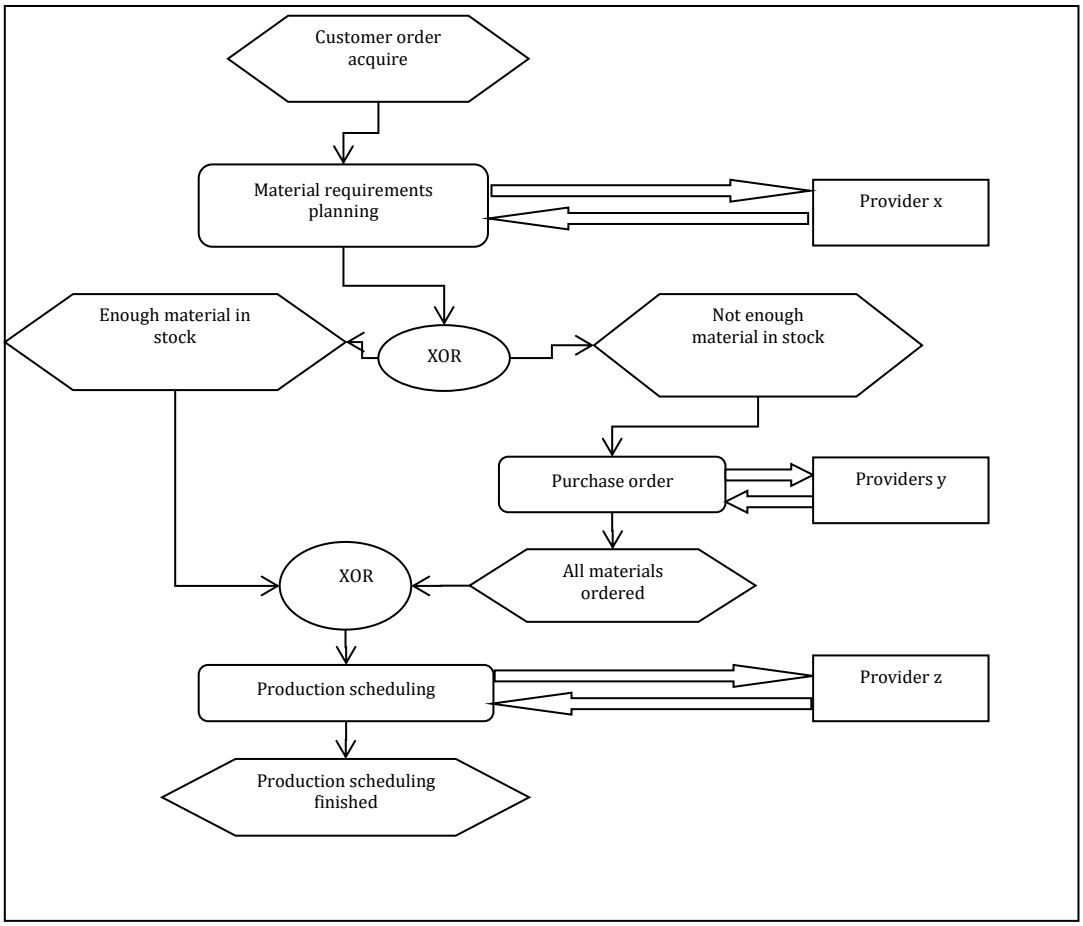

Fig. 4: Example manufacturing business process and outsourcing of ERP-functions

In our case, FERP mall works as FERP Workflow Designer against the end-user enterprises. As in the definition of workflow explained previously in the introduction, the main building block of a workflow is the activity (A), which is executed by the operation of a FERP WS.

From the designer perspective, the activities remain as black boxes, because those activities are executed by the providers themselves by FERP WS. Here comes the question: How can the designers determine the logical prices of the workflow descriptions (as a product) based on Wf-activity as a mean element in this product?

The price of each product is dependent on the total cost of this product, and the total cost of a workflow design is dependent on the designer's efforts. These efforts are dependent on the size and complexity of the workflow.

$$Workflow - size = Number\ of\ Activities\ (AN)$$

Workflow complexity is dependent on the Number of Arrows and the Number of Activities (A), joins (J), and Splits (S). That is not so far from the definition of the complexity of a system, which depends on the number of system elements and their relationships (Rautenstrauch and Schulze, 2003).

The logical representation of this complexity is done through the well-known coefficient of network complexity (Coefficient of Network Complexity, Short CNC) from the graph theory (Cardoso et al., 2006), and this is calculated as follows:

$$CNC = \frac{\text{Number of Arrows}}{\text{Number of Activities, Joins and Splits}}$$
$$CNC = \frac{(ArN)}{(A,J,S)N}$$

Joins and splits are the control-flow elements. The price per Activity (Ap) as a static value, which is determined by the designers through their practical experience.

And two variables: Workflow-size, which is the Number of Activities (AN), and Coefficient of Network Complexity (CNC).

According to this logical representation and explanation of the involved elements, we formulate a function which can be considered for the logical determination of Workflow prices (Wfp):

$$Wfp = Ap \times AN \times CNC$$
$$Wfp = Ap \times AN \times \frac{ArN}{(A,J,S)N}$$

Model 1: Wfp is Workflow- Price; Ap is Price per Activity; AN is Number of Activities; ArN is Number of Arrows; (A, J, S)N is Number of Activities, Joins und Splits.

But this pricing model is not enough to solve the workflow pricing related problem because the user enterprises work in a dynamic business environment with always growing functionality needs. Therefore, they will ask the mediator periodically to change the business processes. For this reason, this paper will present in addition to the previous workflow pricing model, another model which can be considered as a logical base for determining the appropriate price for Workflow reengineering (Wfreng) depending on the old or can be called as, the basic workflow.

This WfReng pricing model depends on the Wfp of the basic workflow, which the enterprise currently uses weighted with the change proportion.

We can be calculated using the previous model, and the change proportion is related will represent the proportion of new workflow elements (activities, and/or arrows, and/or split and join points) to the total number of the old workflow elements. Then the WfReng price (WfRengP) will be calculated as the following:

$$WfrengP = Wfp \times \frac{((nA,nAr,nJ,nS)N)}{(A,,ArJ,S)N}$$

WfrengP is the price of workflow reengineering; WfP is price of the basic (or old workflow) workflow; (nA, nAr, nJ, nS) N is Number of new (activities, arrows, split and join points); (A, Ar, J, S) N is a total number of (activities, arrows, split and join points) in the old workflow.

This model reflects the proportion of change in size and complexity in the updated workflow to the old version. For more explanation, we will present in the next section various examples to evaluate the validity of the previous models as a base for logical Wf pricing methods against the end-user enterprises.

4. Evaluation

The evaluation will include two parts; each part relates to one pricing model 1 and 2 by giving examples for validity evaluation.

4.1. Evaluation of workflow pricing model (model 1)

We give here three different examples of workflow from different sizes and complexity, which are designed by the UML Activity diagram. The price per activity is identified through the experience (for example) Ap=50 monetary units. The goal of these examples is the evidence of the practicability of our model by the logical comparison method. The practical evidence is not possible now, because FERP mall as an enterprise for the marketing of FERP Web services and FERP workflows is not available yet.

Fig. 5 represents a simple sequential workflow with (8) Activities and without splits and joins. Also, Fig. 6 and Fig. 7 shows Workflow 2 and Workflow 3, respectively.

$$AN = 8$$
$$ArN = 9$$
$$(A,J,S)N = 8$$

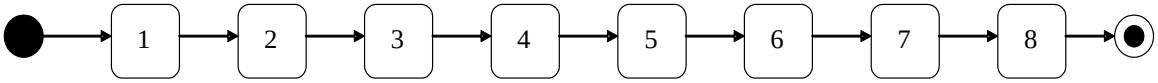

Fig. 5: Workflow 1

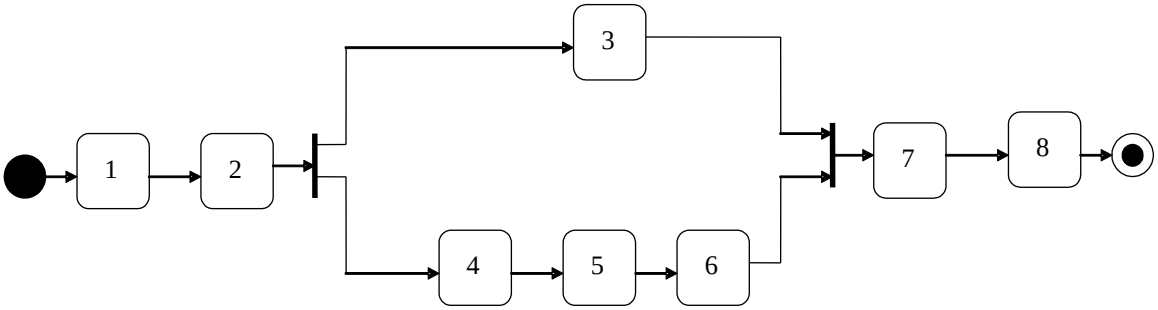

Fig. 6: Workflow 2

Workflow 2 has the same number of activities (same size) like Workflow 1, but in workflow 2, there are more relations (arrows) with split and join points. This means: Workflow 2 more complex and expensive than Workflow 1:

$AN = 8$
$ArN = 12$
$(A, J, S)N = 10$
$Wfp = 50 \times 8 \times \frac{12}{10}$
$Wfp = 480\ monetary\ unit$

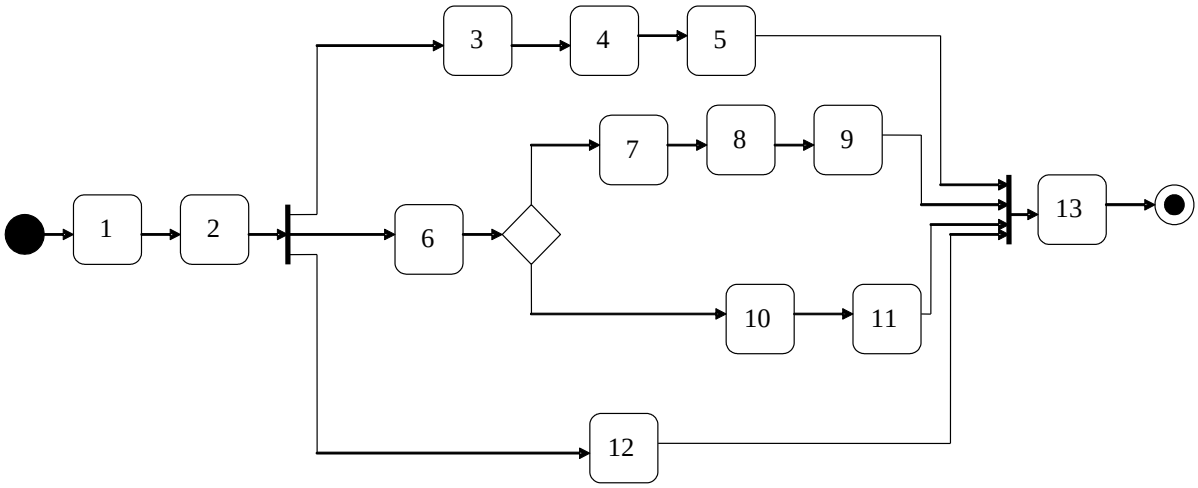

Fig. 7: Workflow 3

Workflow 3 is larger and more complex than workflow1 and 2, because it includes more Activities, relations, joins and splits. Therefore, this workflow is the most expensive between our examples:

$AN = 13$
$ArN = 20$
$(A, J, S)N = 16$
$Wfp = 50 \times 13 \times \frac{20}{16}$
$Wfp = 812.5\ monetary\ unit$

We will compare the workflow size, complexity, and prices in the following table. The relation between the variables and results in Table 1 are explained in two-dimensional graphics, which will be shown in Fig. 7 and 8.

Table 1: Comparing the workflow sizes, complexities, and prices

	AN	CNC	Wfp
Wf1	8	9/8=1.125	450
Wf2	8	12/10=1,2	480
Wf3	13	20/16=1.25	812.5

The relation between the variables and results in Table 1 is explained in two-dimensional graphics, which will be shown in Figs. 8, 9, and 10.

Table 1 and Figs. 8, 9 and 10 show the harmony and the relation between the Wf-prices, Wf-sizes, and Wf-complexity through our three examples: The most significant workflow with the highest complexity grad has the highest the price of the Wf-definition. That means number workflow activities and the complexity grad, which is determined in this work through (CNC) can be considered as the basic variables for determining the suitable workflow prices for various enterprises.

4.2. Evaluation of Workflow reengineering pricing model

If the user enterprise was using (for example) workflow 1 in Fig. 5 and asked the mediator to change this workflow to be like the workflow in Fig. 11. In this case, the logical price for this service can be determined as the following:

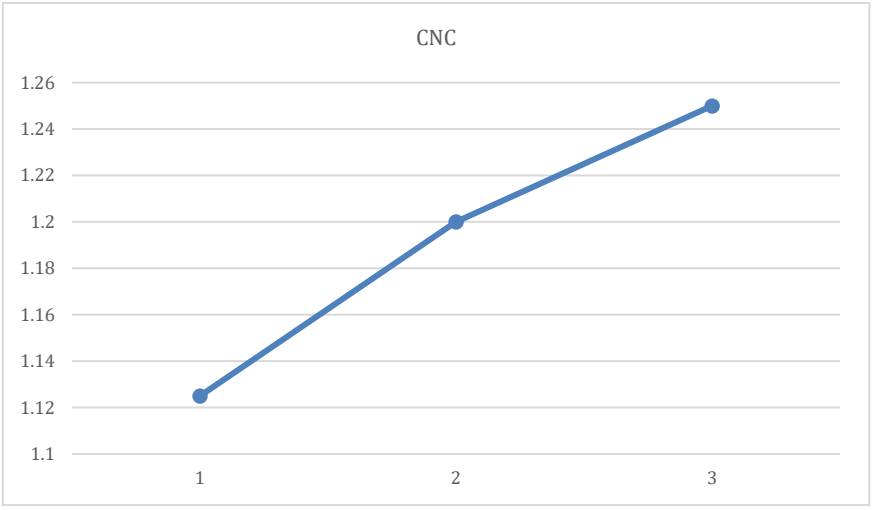

Fig. 8: Coefficients of Network Complexity for the three workflow samples

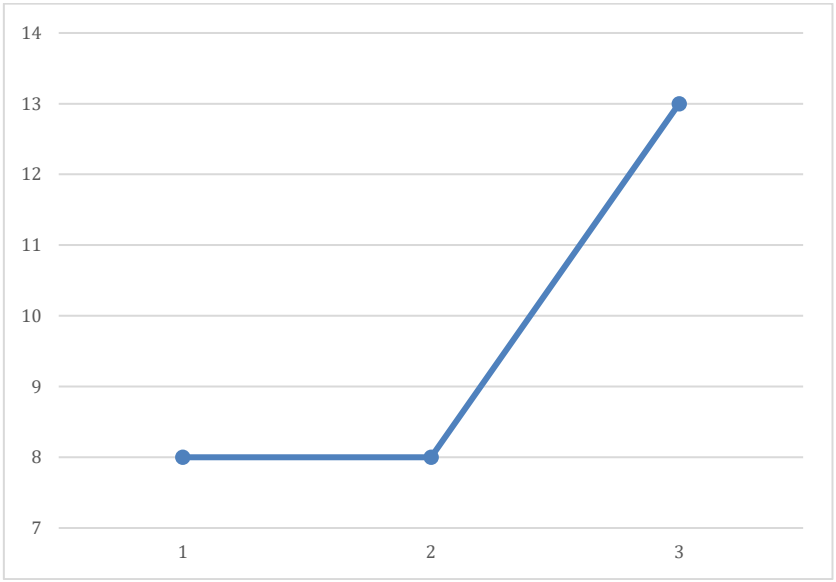

Fig. 9: sizes of the three workflow samples

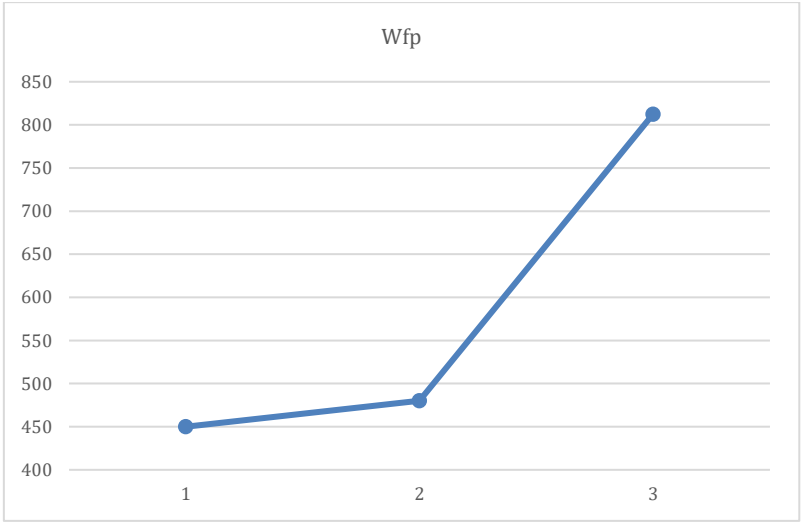

Fig. 10: Workflow prices (Wfp) of the three workflow samples

$$WfrengP = Wfp \times \frac{((nA,nAr,nJ,nS)N)}{(A,,ArJ,S)N}$$

$$WfrengP = 450 \times \frac{(0+3+2)}{(8+9+0\ )} = 132.3$$

If the user enterprise was using (for example) workflow 2 in Fig. 6 and asked the mediator to change this workflow to be like the workflow in Fig. 12. In this case, the logical price for this service can be determined as the following.

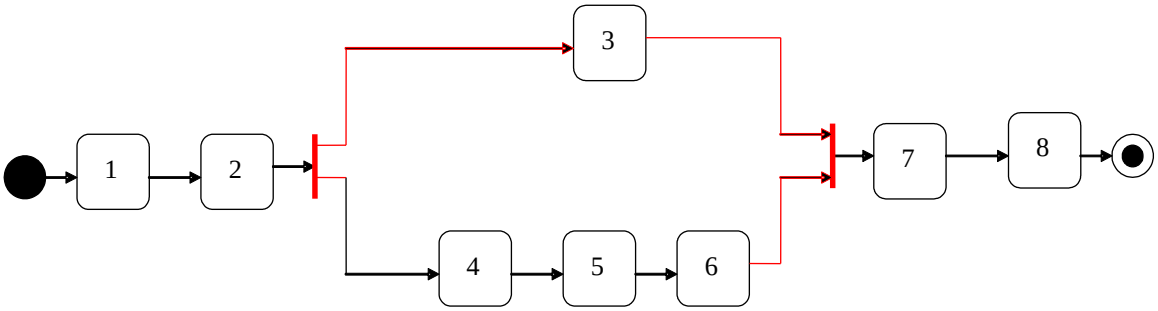

Fig. 11: Re-engineered version of workflow 1

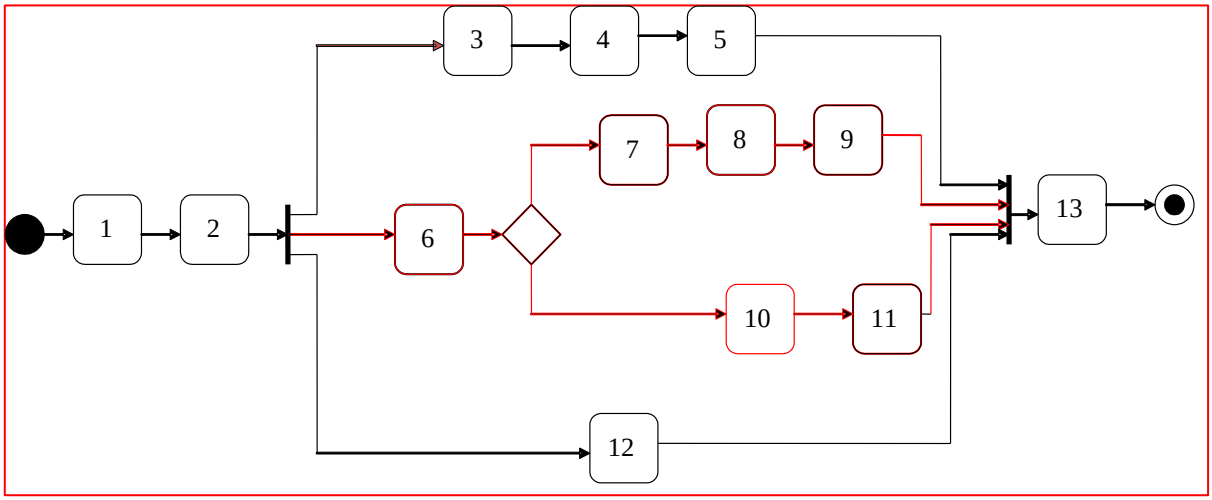

Fig. 12: Reengineered version of workflow 2

$$WfrengP = 480 * \frac{(6+8+1)}{(8+12+2)} = 327.3$$

Please note that we could not use;

$$WfrengP = new\ Wfp - old\ Wfp,$$

because the changes are not allowed through adding new elements, but rather, the changes may include the elimination of other elements that means sometimes the new Wfp will be equal old Wfp that leads to WfRengp=0.

5. Conclusion

In this paper, we have presented the FERP workflow as a new product. This product differs depending on user organization requirements, and at most, the end-user price will ask the workflow provider for business process reengineering. Therefore, this paper presented derived logical functions (models) that take the Wf size and the Wf complexities into account. Those models (Wfp and WfRengp) can be used as a logical base for the price-determination of the different workflow definitions and workflow reengineering. The validation and appropriateness of the proposed models have been explained through some examples of different Workflow sizes and complexities. The Wf activity in this work has been considered as a black box from the mediator point of view, because this activity is executed by the FERP WSs providers themselves separately, and the price per activity, in this case, is fixable from the mediator perspective. The future work in this subject will discuss the possible workflow scenarios that can be used from the mediator to increase the flexibility against the different needs and capabilities of the user enterprises.

Acknowledgment

This research has been supported by Dar Al Uloom University.

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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