MULTI-VENDOR SOFTWARE ECOSYSTEM: CHALLENGES FROM COMPANY' PERSPECTIVE

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Abstract. Software ecosystem is the term used for the distributed development of software when a company outsources a whole or a part of their product to single or multiple vendors. Along with the various benefits, outsourcing comes up with various challenges for companies as well as vendors. As there are many studies conducted to identify issues faced by vendors, this study intends to summarize the challenges faced by companies who outsource and then extends the challenges list by defining new challenges which can be observed in the multivendor ecosystem. Defined new challenges are preliminary in nature, thus open for discussion and validation through case studies or other means.

1   Introduction

Software ecosystem represents all the entities, businesses, organizations, and their interactions, which come together for the development of software of mutual interest [1]. Outsourcing software as a whole or its parts; brings advantages such as cost reduction, high availability of resources, less infrastructure cost etc. which is achieved by hiring vendors from different geographical locations; but it also brings challenges like management of complex interactions among different entities involved [2]. Iqbal et al. [3] reported that even though there are many success stories of outsourcing, there is a surprising number of outsourced projects which failed in the past decade. Khan et al. [4] further supported the argument that even though offshore outsourcing brings many opportunities for companies however most of the outsourced work tends to be of low value due to poor management.

The future of outsourcing is to create standard procedures to maintain client-vendor) relationships in software ecosystem sustainable (but competitive so that both parties can harness profits [5]. There are high chances of project failure if profit and advantages are not equally shared [6]. In long term, 78 percent of client-vendor relationships fail, and companies who outsource bear the loss [7]. To identify the reasons of outsourcing failure and challenges faced by different parties in outsourcing, many studies [9-20] have been conducted during last two decades. These studies have presented different aspects of outsourcing, some studies underlined the challenges faced by vendors, whereas others identified the challenges faced by companies [8]. For this study, we have focused on the company perspective to limit the scope of the paper. Our exploration of the semi structured literature review revealed that the challenges identified by different studies are scattered, and no study has put all challenges in one place. This study is effort to reduce that gap. Also, our compilation of current literature indicates that most of these studies are focused on single vendor ecosystem.

Sparrow [9] quoted that multi-sourcing is a new trend to diversify the risk of single vendor ecosystem, as outsourcing companies can replace vendors whose performances are not good in respect to company goals. Also, in single vendor ecosystem contracts are risky and lengthy at the same time, which leads to vendor lock-in [9]. Sharma and Loh et al. [10] stated that companies outsourcing projects can get more benefits by following the multi-sourcing strategy. In this regard, the challenge for the outsourcing companies is to align their strategic goals such that when much of the work is outsourced risks are manageable, especially in multi sourcing due to complex interactions and decisions involved. To the best knowledge of the authors of this study and according to the available literature it was found that no study has defined the challenges for companies functioning in a multi-vendor ecosystem. Therefore, to address the gap this study defines the new challenges which are an addon to the company opting for multi-sourcing. Following two research questions (RQ) have been framed for this study:

RQ 1: What are different challenges enlisted in the state of the art, faced by companies in a single vendor ecosystem?

RQ 2: Could there be different barriers/challenges faced by companies in addition when companies opt for outsourcing in the multi-vendor ecosystem?

Subsequent section describes the process followed to answer these research questions, thereafter sections answer the research questions. This paper is structured as follows: Section 2 describes research methodology, section 3 details challenges faced by companies in a single vendor software ecosystem, which answers the research question 1. Section 3 presents challenges that can potentially exist in a multivendor ecosystem followed which answers to research question 2. After that in section 4 conclusion and areas of future work follows.

2   Research Methodology

To conduct this study semi structured literature review is carried out. Figure 1 depicts the process followed to answer the research questions. The process of identifying new challenges starts with going through different studies and enlisting those challenges in different defined categories. We also extracted what research methodology has been used to conduct the study.
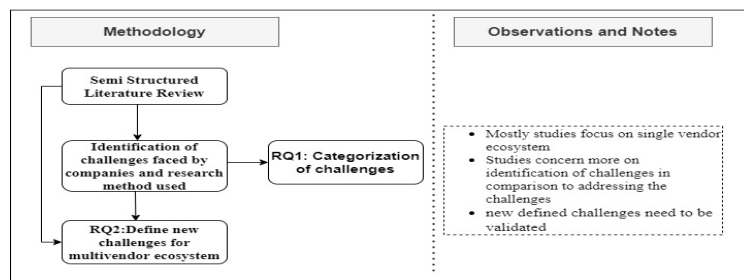

Figure 1:Methodology followed to answer research questions and observations made

Along with enlisting challenges various observations are made throughout the process, as shown in figure 1 by compiling the extracted data from literature. After that, based

on the observations, and understanding of authors, new challenges for multivendor eco-system have been defined.

3 Challenges in single vendor ecosystem

This section enlists all the challenges (faced by companies in a single vendor eco-system) identified in different studies so far and addresses the research question 1. To prepare the list of challenges faced by companies a semi structured literature search is conducted. Various categories have been defined to present the list of challenges effec-tively. Defined categories are inspired from the study conducted by Herath et al. [11]. Herath et al. [11] provided a long list of challenges faced by the companies and cate-gorized them in the four categories as shown in table 1. We further extended the table by mentioning how other studies carried so far have contributed towards each category of these challenges.

Table 1: Categories of challenges faced by outsourcing companies (adapted from [11] and modified)

Challenge Category (CC)	Challenge Category Name	Identified /addressed in	Explanation
CC_A	Strategic Deci-sion	[4] [11] [12] [13] [14] [14]	This category consists of all the challenges, which creates a hindrance to the companies while making a strategic decision about the vendor hiring and outsourcing
CC_B	Decision Process for Vendor Se-lection (Single)	[11] [15] [13] [16]	This category consists of those challenges which are a barrier to the vendor selection process and make the selection process com-plex
CC_C	Vendor interac-tion (single) management	[4] [11] [13] [14] [17] [18] [14] [19] [20]	This category enlists the challenges which are faced by the companies to have effective interaction with vendors, throughout the pro-ject development.
CC_D	Technology (Ar-chitecture)	[4] [11, 21] [15]	This category details those challenges which are faced by companies when supported technology does not benefit up to the expec-tations or needs of company personnel.

Table 2-5 enlist all the challenges found under different categories. The decision of putting different challenges in one category is made according to a) best knowledge of authors b) understanding of existing literature c) description of challenges given in re-spective studies. Tables brief that which study identified the challenge and using which research method. Also, tables report weather a particular challenge is identified only or addressed as well in the specified study. For the same abbreviation 'I' is used for iden-tified challenges, and 'A' is used for addressed challenges. If two or more studies have identified similar challenges through different case studies or other means, that has also been reported. For example, in table 2, 'Improper task allocation' is identified and ad-dressed in study conducted by Ruhman et al. [22] and was also addressed in study conducted by Akbar et al. [13].

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Table 2: Challenges faced by companies to make strategic decisions (CC$_A$)

Challenge name	Identified (I) / Addressed (A)	Method used by specific study
What to outsource	[11] (I and A)	literature survey and empirical study
What is the right proportion to out-source?	[11](I and A)	literature survey and empirical study
Improper task allocation	[14] (A) [22] (I and A)	State of the Art
To frame low cost and high-value contracts	[4] (I)	Case study of suppliers from India and customer firm from the UK
lack of psychological contract and poor contract management	[13] (I)	SLR
Budget constraints	[19] (A)	State of the Art
Internal readiness of the company	[12] (I and A)	Case study
Lack of coverage of GSD development processes.	[14] (I)	SLR

Khan et al. [4] suggested that the main challenge for companies is to identify and frame strategies that can give benefits of outsourcing to companies without the involvement of new risks. And these strategies should be framed for all different aspects enlisted in the table. Posten et al. [12] detailed the challenge category 'vendor selection' and 'vendor management' and defined the activities involved to address these challenges. Authors stressed on 'vendor information management' upfront for Vendor selection and the need for contract facilitation and relationship governance for vendor management. Pal et al. [15] presented a model named "trait-based approach" for vendor selection and then handle complex interactions involved throughout the project development. They applied a mathematical model to frame the approach where four criteria quality, cost, safety, and delivery were utilized to achieve the desired support.

Table 3: Challenges faced by companies during the vendor selection process (CC$_B$)

Challenge name	Identified (I) / Addressed (A)	Method used by specific study
Selecting an appropriate vendor	[11] (I and A)	Literature survey and empirical study
	[15] (A)	A vendor's trait-based approach is suggested
Vendor opportunism and low mutual trust	[13] (I)	SLR
Organizational Differences	[13] (I)	SLR
Difference in Maturity	[16] (I and A)	Analysis was done on CMMI 1.2 for each combination of maturity difference
Hidden cost and high anticipated switching	[13] (I)	SLR
Lack of support for collaboration and group decision making	[14] (I)	SLR
Vendors providing legacy technology	[11] (I and A)	Literature survey and empirical study

Ali et al. [13] went a step further and provided a mapping and interrelation theory for the identified challenges. The authors came up with 27 barriers using SLR and then

they surveyed 20 different countries involving 50 experts to compile the mapping between different challenges.

Table 4: Challenges faced by companies to have effective interaction with vendors (CC_C)

Challenge name	Identified (I) / Addressed (A)	Method used by specific study
Effective Knowledge transfer	[15] (I)	Case Study
The disparity between what is negotiated and what is delivered	[11] (I and A)	literature survey and empirical study
Communication	[18] (I and A)	SLR and interviews
Communication gap and poor client-vendor coordination	[13] (I)	SLR
Poor knowledge sharing management		
Lack of effective communication	[19] [14] (A)	State of the art
Cost escalation	[11] (I and A)	Literature survey and empirical study
Dynamicity of task allocation	[17] (I)	Web-based survey
Operational risks due to vendor locations Temporal differences	[11] (I and A)	Literature survey and empirical study
	[14] (A)	State of the art
Risks due to environmental, cultural, legal differences	[11] (I and A)	Literature survey and empirical study
Cultural differences	[14] (A), [14](I)	State of the art
Lack of motivational activities	[14] (A)	State of the art
Lack of management commitments	[14] (A)	State of the art
Relational risk and poor relationship management	[13] (I)	SLR
Poor quality of service and lack of co-monitoring by companies	[13] (I)	SLR
Lack of ability to track the progress of tasks assigned to team members in GSD projects	[14] (I)	SLR
Control	[18] (I)	SLR and interviews
Knowledge Management and sharing challenges	[15] (I)	Empirical study

Sundararajan et al. [21] highlighted and addressed the technological challenge by stating the unsuitability of 'Agile methods' in the case of outsourcing. Niazi et al. [20] identified the challenges that companies face concerning tools used in Global software development. Williams et al. [19] utilized knowledge-based theory to frame a model for effective knowledge transfer between the vendor and the client. They highlighted that effective knowledge transfer is the main challenge for outsourcing companies in process of vendor management.

Table 5: Challenges faced by companies due to technology issues (CC_D)

Challenge name	Identified (I) / Addressed (A)	Method used by specific study
To have enough control and understanding of the technologies used	[11] (I and A)	Literature survey and empirical study
Insufficient quality of technical capability of vendors	[13] (I)	SLR
Agile method suitability and related challenge to cope up	[21] (I and A)	Case Study

Lack of awareness of existing tools used in GSD projects.	[20] [14] (I)	SLR and survey
Inappropriate use of synchronous and asynchronous communication tools.	[14] (I)	SLR and survey
Difficulties in adapting and learning to use the existing tools for GSD projects.	[14] (I)	SLR and survey
Lack of data integration because of different collaboration tools used in GSD projects.	[14] (I)	SLR and survey
Lack of security and privacy in communication and collaboration tools.	[14] (I)	SLR and survey

Kasse et al. [16] reported that low maturity of vendors or difference in the maturity of vendor and client is the main challenge for companies to collaborate with vendors Imtiaz et al. [17] stated that task allocation is the main challenge for the companies outsourcing the projects whereas Ulziit et al. [18] enlisted three main challenges namely: communication, control, coordination from the software maintenance aspect in distributed software development. Further, Akbar et al. [14] identified the challenges related to requirement chain management in distributed development.

It has been observed that most of the identified challenges related to outsourcing are at the management side for a single vendor ecosystem and technological challenges are less reported. For example, how different parties agree on the underlying framework to be used, how do different entities involved agree on mutual architectural design? How different parts delivered from vendors are combined? Who is accountable for maintenance and what is the effective way to do so? Having noticed these research gaps, and after compilation and analysis of literature, new challenges which may persist in multivendor ecosystem are defined in the subsequent section.

4   Challenges faced by companies in a multi-vendor ecosystem

This section addresses the research question 2, the challenges which may persist in the multi-vendor ecosystem when multiple vendors are hired, in addition to the challenges faced by companies in a single vendor ecosystem. Exploration and analysis of existing literature is the basis to define these new challenges (figure 1).

Deciding on vendor composition: Companies hiring multiple vendors for a specific project go through rigorous practice of analyzation of vendor's capabilities and then finding out the set of vendors which fits well with each other and the company's architectural and strategical goals as well. This challenge can be termed as 'deciding on vendor composition'. The study presented by Lodha et al. [23] suggests an automatic process to handle multi aspects for a single vendor, this study can be extended for multiple vendor selections. On the same aspect, a multi-criteria decision-making machine learning technique has been proposed for vendors, utilizing which vendors can access and compare proposals from different companies [24]. A similar kind of technique can be developed for clients/customers to decide on multiple vendors. Study conducted by Rahman et al. [22] also suggested this challenge to be investigated as their future study.

Handling dynamicity of requirement: Companies collect requirements from different end users and clients which are mostly dynamic in nature. Handling dynamicity of those requirement and the passing on to the specific vendor who can handle it in an effective manner is challenging when companies function in multi-vendor ecosystem [17].

Handling dynamicity of requirement can be the biggest challenge for outsourcing companies [17]. As stated in the study conducted by Jung [25], dual sourcing (in-house development along with outsourcing) can suffer from the competition if task allocation and observance of the market are not done effectively. We further extend and raise the same concern in the context of a multi-vendor ecosystem, that it is complex and difficult for personnel of companies to allocate different tasks involved to multiple vendors, as here tasks will vary according to received dynamic requirement.

Quality and interoperability assurance: How shall companies ensure the quality of different parts delivered by different vendors? How and when the interoperability check should be scheduled and carried out when multiple vendors are involved? These all tasks can be troublesome and complex for the personnel of the companies which are outsourcing, this sort of challenges can be termed as 'Quality and interoperability assurance'. A similar concern was raised in studies conducted by Swetha and Thippeswamy [26] and Muntes et al. [27] for interoperability in multi-cloud environments. Authors of these studies concluded that checks on security and interoperability are the main challenges for multi-cloud service providers. The same challenge may persist in the companies working in multiple vendor ecosystems, irrespective of the development of software of any domain. As provided in study done by Wohlin et al. [28] "evidence-based software engineering" can help for various related decision making for composite software. Studies reflecting on COTS integration can also be extended in this particular aspect [29].

Dynamicity of the vendors and Control Assurance: Vendors join and leave due to non-reliability of contract and other uncertain reasons. To have control on vendor's functioning and activities remotely is challenging and can be termed as 'Dynamicity of the vendors and Control Assurance'.

Agile method is quite popular for in-house development. Sundararajan et al. [21] highlighted and addressed technological challenges for companies involved in offshore outsourcing, by stating the unsuitability of 'Agile methods' in case projects are outsourced. There are no supported studies found to address this challenge when multi-vendor or even single vendor ecosystem outsourcing is concerned. In the case of multi-vendor hiring, what can be an effective way of handling the dynamicity of vendors joining and leaving and, how companies/client hiring can have optimal control of work going on?

5   Conclusion and future work

Functioning in a software ecosystem brings various challenges for companies as well as for vendors. This paper reports challenges identified so far in the literature, from the company's perspective at different stages of the software development in a single vendor ecosystem. Although conducted literature search was semi structured. It is observed that identified challenges so far in the studies are result of previous literature surveys and very few challenges have been validated. Thus, there is a need to bring coherence between challenges enlisted in state of the art, and state of practice. Most of the identified challenges have not been addressed yet, allowing researchers to work on those. Also, challenges need to be categorized according to the different domains, as

for instance challenges would be different for the companies dealing in education center than the challenges faced by companies in energy sector.

Further, this study presented the preliminary set of challenges that can be observed in the multi-vendor ecosystem because of the understanding gained from the literature review in this context. This list of new challenges can be used as a basis for further advancements to extend the list, verify this list with the practitioners by conducting case studies/empirical studies and subsequently, new strategies can be proposed to address the enlisted/newly identified challenges. Also, it will be interesting to see what roles (personnel) of companies from different domain deal with these challenges, and at what level these challenges do exist in the practical scenarios. For example, challenges presented in section 3 are merely addressed and validated, as very few empirical studies have been conducted. And challenges enlisted in section 4 specially for multi-vendor ecosystem need to be validated.

Also, to cope up with requirement dynamicity, research communities need to come up with standard methods to allocate requirements and different tasks between multiple vendors while dealing with the dynamicity of requirements. The model presented by Pal and Kumar [15] is limited to the vendor's evaluation and sub-contract distribution in presence of dynamic technology. The presented model can be further extended for the multi-vendor system's parameters (after identification) to deal with the dynamicity of requirements for the project. Further, how clients should manage all these complex management activities, is still an open question for research communities. New standard procedures, artifacts should be developed in the support.

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