Towards a Model for Work Distribution to Overcome Communication Barrier in Global software development

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Abstract

According to competitive and complex market situations, the companies must provide more functionality and higher quality software faster to fulfill customer needs. Companies should be used existing resources as efficiently as possible, and they also need to utilize resources on a global scale from different sites within the company and associate companies throughout the world. All these provide in GSD increase the functionality and quality of software. The main problem that GSD team face are communication, coordination and work distribution. A proper mechanism for work distribution and communication has overcome the challenges that affect the project goal. To solve the GSD issues. We proposed a model that helps to mitigate these problems. We use the site/work dependency and work/site characteristics criteria for the work distribution model. We also implement a phased base configuration and work distribution model that helps in the work distribution mechanism. Furthermore, use NEOStation software to overcome the barriers of communication, coordination, and project management. The model has been developed to provide reliable communication between team members and provide an approach to the distribution of work as support for managers.

Keywords: Task Distribution, Task Allocation, Coordination; Communication; Project Planning, Global Software Development.

Introduction

Global software development (GSD) can be defined as "any aspect of software engineering that involves the combined efforts of software professionals in different locations separated by significant distances" [1]. Market motivated to start global software development due to lack of local software developers, inadequate resources, fixed budget and time. Nowadays internet is a significant source to share information with everyone around the world. There is limited information about GSD success and failure factors that impact project goals.

According to the literature, global software development becomes the latest and overall development in software engineering, brings new opportunities to get resources mobility, market speeding time, obtain additional information, and increase operational efficiency. In GSD, several resources are used to develop software that improves the quality of software development.

Software teams mutually develop a software project in different places. Due to the difference in time zone, teamwork on 24 Hours constantly that growth the efficiency rate of GSD. A skilled and qualified developer is hired from all over the world, increasing the success rate of software projects. The primary purpose of developing software is to increase the market value and decrease development cost, hiring skilled and professional developers of a diverse background.

However, there is limited information about the success and failure factors of GSD [2]. According to the study, many organizations fail to generate financial benefits [3]. The challenges that the GSD team faces are related to work distribution among different sites, face-to-face communication between teams, project planning, and project management.

The task distribution between different sites has a strong positive impact on effort and helps overcome the communication barrier. In the work distribution mechanism, tasks are assigned to different sites/teams according to their characteristics to develop quality software. Different tools and software are used for communication, coordination and project planning.

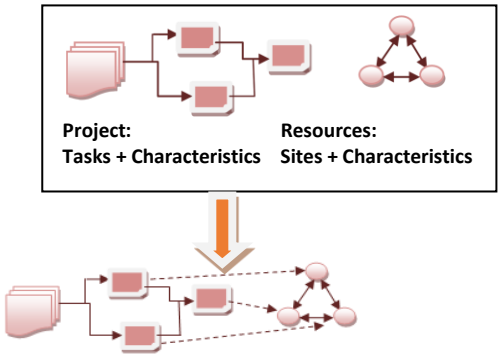

Figure 1: GSD work Allocation

In this paper, we try to solve different issues in the next section, which the GSD team faces mainly. A proper mechanism for work distribution and communication has overcome the challenges that affect the project goal. To solve the GSD issues. We proposed a model that helps to mitigate these problems. We use the site/work dependency and work/site characteristics criteria for the work distribution model. Use software for communication and project management and phase base configuration for work distribution.

Why we use phase base configuration?

In a phase-based configuration, work allocate at the early stage of the SDLC. Large projects are more frequently distributing work among locations/teams by phase than along the specific functionality lines [4]. Figure 2 illustrates suitable stages where different configuration methods can be adopted in the offshoring life cycle. In this paper, we use the phase base configuration of work distribution. Over the last few years, GSD is the latest topic in research initiatives. However, there has no adequately systematic review related to work distribution in GSD. In the primary phase, follow the guidelines by Richard Lai [2] that helped us find the GSD team's problem and provide a work distribution technique.

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The guidelines by Aliya et al. [3] helped to mitigate the problem of communication and coordination issues in GSD.

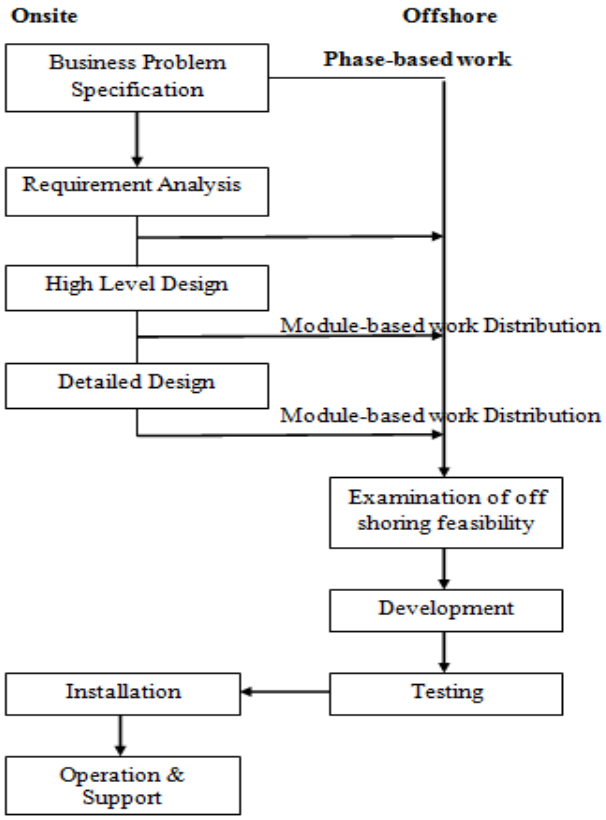

Figure. 2: A generalized offshoring life cycle model

Related Work

After work distribution analysis of different domains, the Bukhari algorithm is no information as to introduce as a promising model, but whether it will solve the GSD distribution problems. Abufardeh [5] perceptive the cultural impact on the GSD team. Mockus and Herbsleb [6] and Clerc, et al. [7] discuss issues and their solutions that the GSD team face in their work. They describe the critical issues between project process interdependencies, communication problems, lack of trust, and communication motivation.

Lamersdorf, et al. [8], was conducted qualitative study to identify the criteria for distribution that used in practice. They applied some criteria on sourcing strategy, and the result shows that the developed software has a significant effect on applied criteria. However, this study only analyzed the existing pattern of work distribution and there is no evidence to support this decision.

For suitable GSD architecture, the Global Architect framework is proposed to help in designing the architect. The base of the framework is meta-model and questioners. The questionable framework design of the GSD system that's based on predefined questions related to the abstract design rule. The tool selects the answers and instantiates the rules that create the GSD architecture. For industrial Cyber sift project, to design an architecture, Global Architect has been applied [9].

The problems of communication, gender issue and team setting challenges are examined. The two main areas used for research: first, it examines USA, Poland and Kuwait collaboration; and then investigates the cultural perspective proposed topics [10].

Software teams use many communication mediums like video, audio, email for communication. A survey was conducted on GSD process tools that can be used for each software development life cycle, but there is a lack of association between their tools. Research tools are developed for project management activities that overcome the GSD-related problems [11].

The research shows no models fully provide an approach for work distribution, communication, and project management. Our main focus to provide an approach that tackles work distribution, communication, project management, and coordination problems.

PROPOSED WORK

In our model use NEOStation software for coordination and communication and use different criteria for work distribution. According to the literature, GSD different configuration modes are follow-the-sun, phase-based and module-based. The follow-the-sun model aims to decrease the total development time by working 24 hours due to the different time zone [12].

For the use of the phase-based configuration, work allocate at the early stage of the SDLC. We also use the work distribution model to identify the risk and then allocate it to a particular site that fulfills the task's requirement. Our model has four major modules: coordination module, communication module, work distribution module, and project management module. Also, use virtual office software named NEOSTATION for face-to-face communication, coordination and project management.

The Approach:

At the client-side, "Site A, " the requirement engineer finalizes the user requirement and sends these requirements to the project manager. The site manager of "Site A" identifies the characteristics of the task and different Sites. Furthermore, send all this information to the Project manager at " Site B." Project manager distributes these tasks with the help work distribution model.

Find the most appropriate site for the given task is the major challenge of GSD. A major factor important to GSD in work Distribution is **work *and site dependency*** [2].

Using work-dependent characteristics (specific skill, rough estimate time, the complexity of the task, order of execution,) and site dependent characteristics (culture differences, language differences, resources, etc.), work can be easily distributed among different sites. Use phase-based configuration to distribute our work according to site dependency. In the phase-based configuration, distribute work on the early stage of the SDLC [2]. Through phase-based configuration, a large project is more easily distributing their work among different teams

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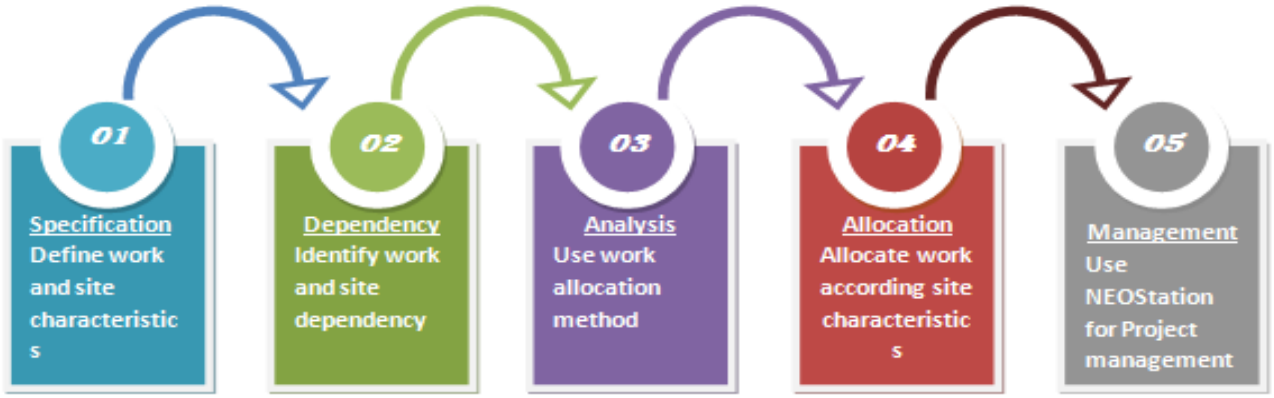

Figure. 3: Work Flow

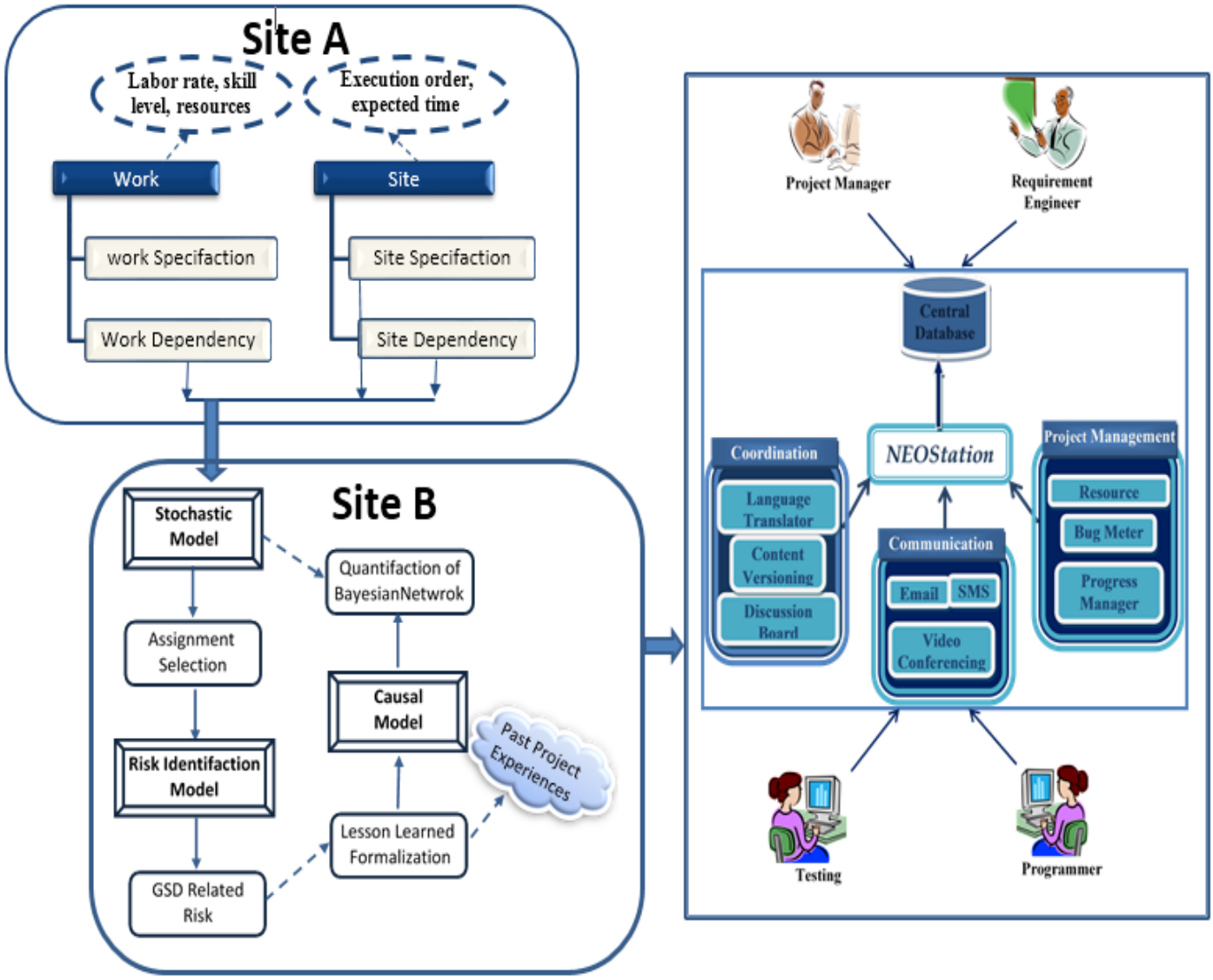

Figure. 4: work distribution and communication Model

We can also use a work distribution model to identify the risk and then allocate a different task among different sites. In this model, the first task and available sites are defined and check each site's resources. We can identify work and site dependency in the stochastic model. Through this model, a list of assignment suggestions is given with Bayesian networks' help [13]. The assignment list transfer to the risk identification model identifies a risk affecting the project goal [14]. Project goal and relevant influencing factors are identified in the causal model [15]. After this, a suitable task is allocated to a specific site to reduce the possible risk related to GSD work distribution.

Through proper work distribution between sites can reduce the communication expenses and the total effort is minimized. After work distribution, work allocates to the different sites according to site specification and site dependency. Every site has communication, coordination and project management module or NEOStation software teams. In this way, work distribution can affect in fewer communication expenses and the total effort is minimized.

Use virtual office software named Neostation for face-to-face communication, coordination and project management. In the project management module, a team leader manages the recourses, maintains the track of task, and uses Bug Meter to complete the missing task. NEOSTation solves the problem of communication, coordination and project management issues. It also maintains team members' records, no need for separate software for communication or coordination, or project management. It solved all the problems that the GSD team face.

Proposed Model:

Work distribution:

In work distribution, use different criteria for work distribution in different sites. With the help of a site specification, identification of work, work and site dependency, distribute our work on different sites using the Work distribution Model.

There are the following steps to work distribution process:

1. Identify work characteristics
2. Identify works dependency
3. Identify Site characteristics
4. Identify Site dependency
5. Analysis of these four steps
6. Allocate work to suitable sites

SITE A:

Work Identification:

The Factors involved in work identification are the rough estimated time for the task, compilation, specific skill, and work complexity that presented as a qualitative attribute (low(L), medium(M) & high(H)). In this step, identify work characteristics and formulate a work matrix. Work specific matrix presented in Table 1.

Tabel. 1 Work matrix

	RA	SD	D	T
Estimated time	2month	2month	7month	3month
Specific skill				
Execution order	1	1,2	2,3	3,4
Complexity	M	H	H	M

RA: Requirement Analysis, SD: Software design, D: Development, T: Testing

Work Dependency:

Based on software process models that define relationships between different phases. Development activities are managed in a specific order with the software process model's help [16]. At the beginning of software engineering, software process models have been planned that described by attributes such as: sequential vs. Incremental, linear vs. Iterative, plan-driven vs. Agile development, model-driven vs. Evolutionary development.

To minimize software projects' communication and coordination complexity, perform proper categorization that considers the software project model. The number of groups will be judged based on the number of distributed locations.

In this module, identify the task requirements and dependency, which help allocate work in different sites.

Site Dependency:

In site, dependency includes cultural diversity, the physical distance between different sites, time and language difference. Collaborative development helped to identify the distance between two sites that work together. All these factors can be used to determine how well-suited the two sites are.

Table 2 quantifies compatible sites (locations). The highest value can be used to identify which two sites are more compatible.

TD: Time Difference, LD: language difference, PR: Political Relationship, PD: Physical Difference, CD: Culture Difference, CM: Collaboration Maturity.

Table.2 Site Dependency characteristics

	LD	PR	PD	CD	CM	TD
High	0	1	0	0	1	0
Medium	0.5	0.5	0.5	0.5	0.5	0.5
Low	1	0	1	1	0	1

Suppose three different sites are located in Pakistan (P), China (C), Australia (A). Now we find the site

dependency between these locations using table 1 and the value shown in table 3.

Table. 3 Level of Site dependency

	LD	PR	PD	CD	CM	TD	Total
P-C	0	1	0.5	1	0	1	3.5
P-A	0.5	0	1	0.5	0.5	0	2.5
C-A	0.5	0.5	0	0.5	1	1	3.5

In table 2, the highest value shows the site is more compatible and the lowest value shows the sites are less compatible.

Site Specification:

According to the literature, site-specific parameters are labor cost [16], skill level, the accessibility of the site, financial and political stability. Minor dependency includes economic stability, political stability and significant dependency include labor rate, skill level, and accessibility of resources. With the help of these dependencies, site specifications are measured. After analyzing the work and site specification and dependency, that will help assign tasks to different sites. Table 4 shows the site specification of the different locations previously mentioned.

Table. 4 Site Speciation Matrix

	Pakistan	China	Australia
Economic Stability	M	M	H
Political Stability	L	M	M
Labor Rate	H	M	H
Skill Level	M	H	M

SITE B:

Causal Model:

The causal model store the relevant influencing factor and their impact on the project goal. Project goal (cost and quality) and influencing factors (time and culture) are determined.

In an informal network, these factors act as nodes are connected via a relationship with other nodes. The casual relationship may be positive or negative. For example, language difference has a strong positive impact and process maturity has a medium negative impact on communication problems.

Figure 5 shows the simple casual model in an industrial context. Pervious GSD project experiences stored in a casual model with influencing factors and their relationships.

Stochastic Model:

The Stochastic model determines the work allocation, distribution using matrices (work and site specification, work and site dependency) [2]. Use these matrices. It can identify the list of assignment suggestions based on a casual model. Different steps perform in the stochastic model.

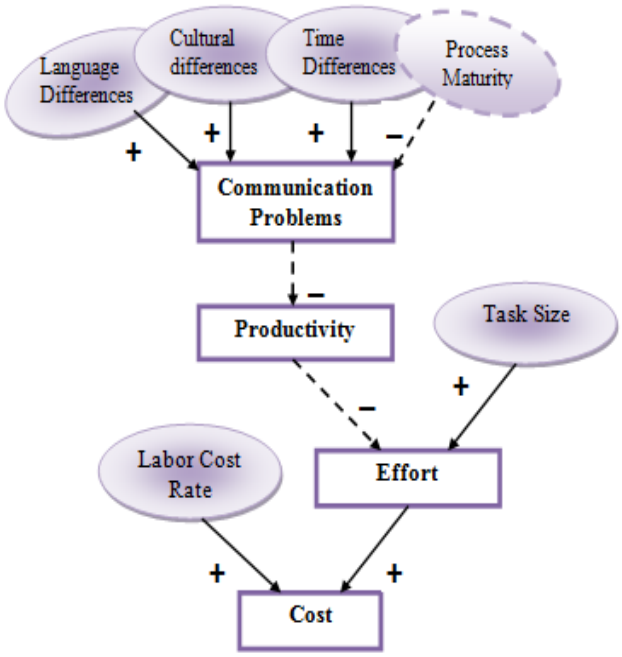

Figure 5: Simple Casual Model

The first step, the casual model that previously creates, is transformed into the Bayesian network. In the 2nd step, using project and resource properties, the impact of the possible assignment of the project goals is speculation on the Bayesian network. The project's impact was based on the total weight and stored a cost function used in the task allocation algorithm. In the third step, cost functions are based on probabilistic distribution and execute allocation algorithm.

Moreover, in the last step, each run is stored back-optimal assignment. The number of assignments and appearance orders all returned. In the end, the weighted list of assignment suggestions is presented. Furthermore, this weighted list sends to the Risk Identification model.

Risk Identification Model:

In this model, predict GSD-related risk for a given project and work distribution. Therefore, it can be used to identify risk and comparing the different assignment suggestions. In this model, every rule describes the factor that causes the GSD problem. A rule is formulated as "cause create a problem", the cause is the logical combination of influencing factors and problem that can negatively impact on GSD project.

Formalization of the rules, check the impact of influencing factors on risk. This can be done in two ways: the first combination of influencing factors may increase the possibility of risk and the other can decrease it. Such as, maybe according to a particular rule, "communication

problem increase because of cultural differences between different sites," that describes the one influence factor that has an impact on the risk. In another case, two influencing factors that have a specific value can impact the risk. For example, lack of trust increase because of no previous experience and cultural differences.

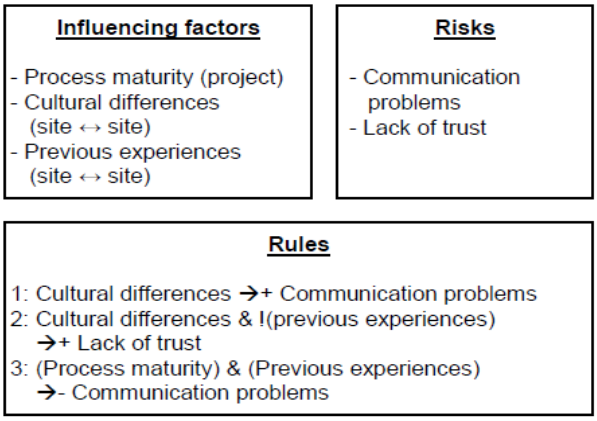

Figure. 6: Influencing factors using logical operators [14]

Figure 6 [14] show the influencing factors using logical operators AND (&), OR (|), NOT (!) in every rule.
All the given assignment suggestions that identify in the stochastic model, can be analyzed based on risk.

Work Allocation:

In this step, work distribution is performed in a way that supports the project objective. Time, cost and quality are the objectives of any project. The priority of these factors are varied in different projects. Based on project objectives, perform some changes in the mechanism of work distribution.
Our analysis of work distribution using work characteristics matrix and site characteristic matrix. Work distribution based on the suggestion that previously identifies in the risk identification model. A project's tasks distribute between different sites that use NEOStation software for coordination, communication, and project management.

Coordination Module:

In the coordination module, use
"**Content Version System"** facilitates data consistency and allows the team member to work on the same project.
Use "**Discussion Board and Language Translator"** for a conversation about the project, and language translator helps translate different languages in one predefined language.

Communication Module:

Communication Platform uses for communication, in which we use telephone calls for rapid/event-based communication and discussion forum for continuous communication. In communication, the module uses virtual office software named **NEOSTATION** for face-to-face communication. Short message service for emergency contact, emails for a formal discussion with a single click, and use telephone for audio conversion.

Project Management Module:
In the module, the project manager manages resources and handles all issues related to the project.
Resource management: In the resources management module, handle human resources (total number of team members, offline members, online members, their payments), software resources(platform, programming language, system requirement) and hardware resources (storage resources). All these resources easily handle through NEOStation Software.
Progress manger: In progress manager, maintain the track of task and show the task's position through progress meter.
Bug meter: In this tool, handle completed and incomplete tasks that help complete missing work in a project.
Activity analyzer: After a small interval of time, the activity analyzer takes a screen short of a team members' workspace that helps the manager keep track of the team members.

Result and Discussion

Through literature, find many problems that negatively impact GSD, like communication issues and work distribution issues. Many frameworks have proposed trying to solve communication or work distribution issues and overcome the barrier of GSD. In this paper, we proposed a model that helps overcome the GSD barrier and solve the GSD team's issues. The major problem that negatively impacts the GSD project is communication and work distribution issues. We use the work distribution model and NEOStation tool for project management and communication to mitigate these problems in the proposed model. A proposed model evaluate with the help that of GSD experts review and industrial experimentation. In the end, we compare our work with related ones.
This evaluation aims to obtain feedback about the proposed model and check whether it is capable of overcoming GSD problems or not and building confidence between team members to carry out effective communication with people of different cultures and languages.

Industrial Experimentation:

We validate our work through industrial experimentation. So we were defining Assessment factors (AF) to measure the satisfaction level of our proposed solution. These factors were Effective communication (AF-1), Resource management (AF-2), progress manager (AF-3), improve coordination (AF-4), identify work dependency (AF-5), identify site specification (AF-6), risk identification (AF-7).
In this experimentation, the total number of participants was Thirty (30). The risk involved in industrial experimentation was the selection of participants and poor domain knowledge about the GSD.

Table. 5 Questioners

Personal Detail	What is your name?
	What is the name of you company?
	What is your position in the company?
Development Methodology	Does your company dealing with global software development?
	Which work distribution methodology does your company use?
	How to communicate with your development team?
Proposed Model Evaluation	Do the suggestions made by the model match the actual work distribution in an industrial project?
	Do the suggestions made by the model match the retrospective view of experienced project managers?
	Do the experienced managers consider the suggestions made by the model to be reasonable and helpful?
	Is this Framework to help participants to develop the necessary skills to potential GSD?
	Does this Framework is to provide effective communication between team members?
	This framework is capable to increase product quality and save efforts?

Table. 6 Evaluation Result based on Assessment factors

Assessment Factor	Agree	Strongly Agree	Satisfactory	Disagree	Strongly Disagree	Satisfaction %
Effective Communication(AF-1)	11	7	8	3	1	86.6 %
Resource Management(AF-2)	10	6	7	4	3	76.6 %
Progress Manager (AF-3)	12	5	8	3	2	83.3 %
Improve Coordination(AF-4)	11	7	5	4	3	76.6 %
Identify Work dependency(AF-5)	11	5	6	5	3	73.3 %
Identify Site Specification(AF-6)	13	5	6	3	3	80.0 %
Risk Identification (AF-7)	12	8	7	2	1	90.0%

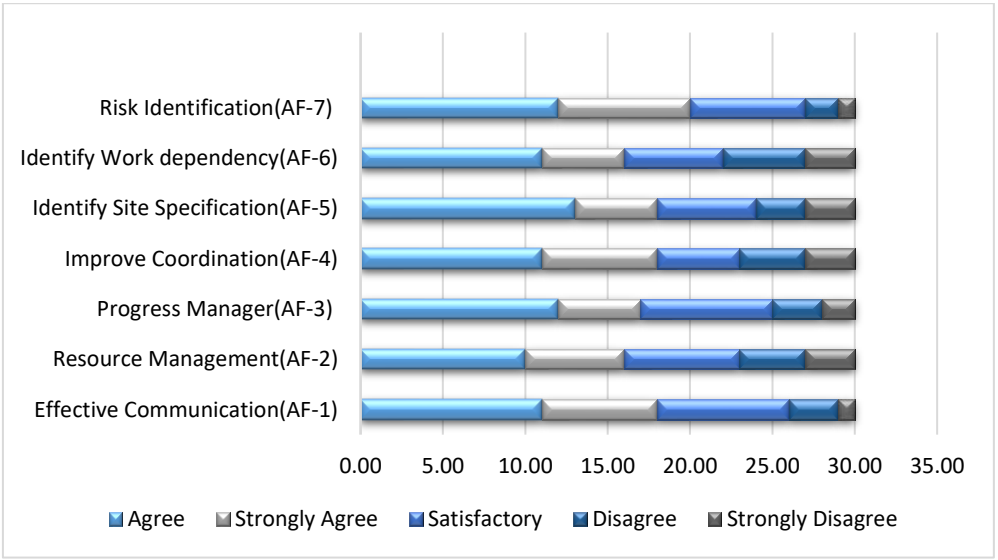

Figure 7: Trends of Satisfaction level

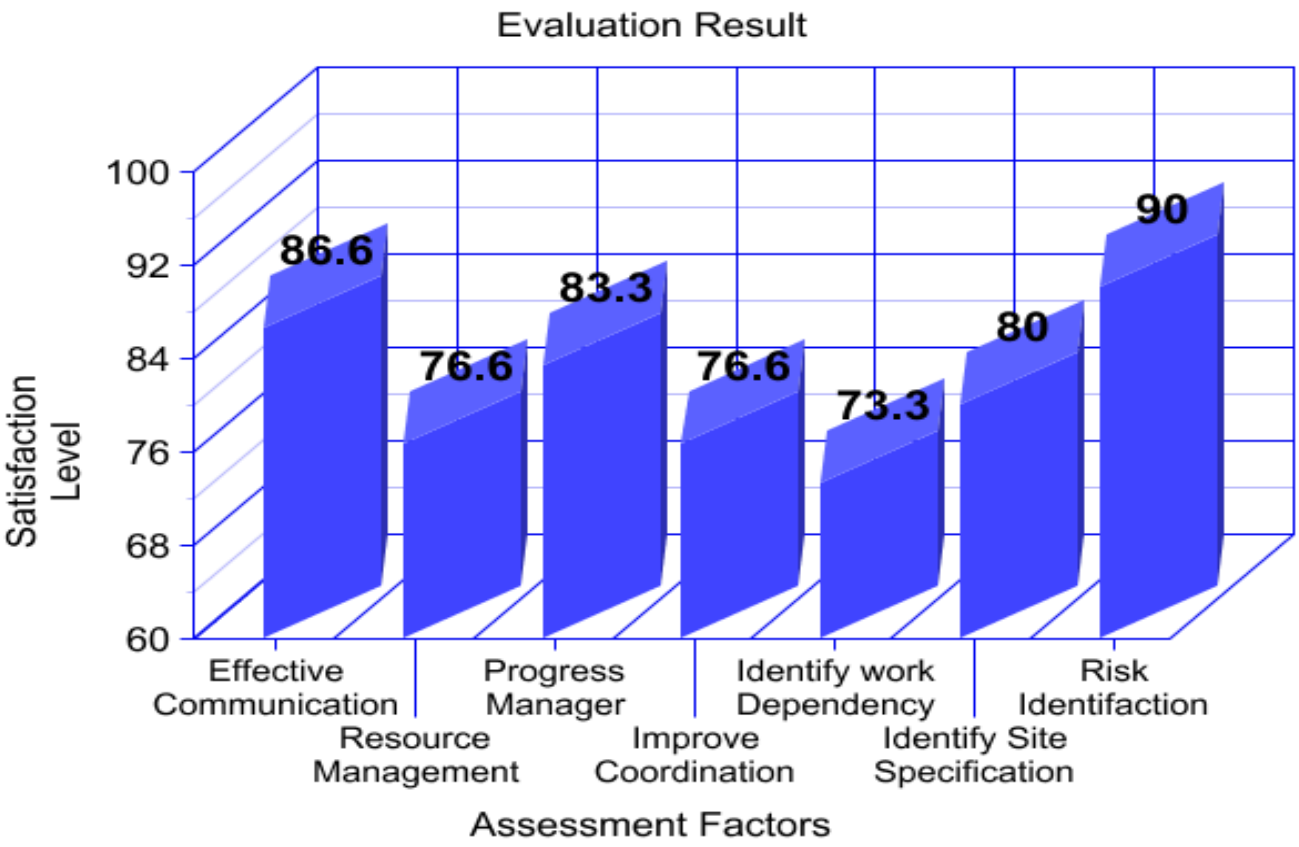

Figure 8: Satisfaction level

Table. 7 Comparison

✓ = exists × = does not exists **P** = partially exists

Contribution	Proposed Model	Existing Work				
	Communication barrier and Work Distribution	Study 1 [2]	Study 2 [3]	Study 3 [4]	Study 4 [13]	Study 5 [7]
Task Specification	✓	✓	×	P	×	✓
Site Specification	✓	✓	×	✓	✓	P
Risk Identification	✓	×	×	×	✓	×
Communication	✓	×	✓	×	×	✓
Coordination	✓	×	✓	×	×	×
Project Management	✓	×	✓	×	×	×

To avoid this type of risk, we select participants with appropriate domain knowledge with a questionnaire that divides into two sections shown in table 5. The first section of the questioner questions GSD experts' personal information and experience in GSD. The Second section, questions related to the proposed model after using it. The questionnaire comprised yes/no closed questions.

GSD experts answer all the research questions. They give feedback after the use of the proposed solution. The evaluation result based on assessment factors is shown in Table 6. All participants evaluate the proposed model under given assessment factors. Furthermore, the satisfaction level shows how many participants were satisfied.

The result shows that many participants were satisfied with the proposed solution's assessment factors, and few disagreed. Figure 7,8 shows the result in graphical form and proves that participants have shown their confidence in the proposed solution.

Comparison with existing model:

We compare our work with related ones in table 5. Richard et al. proposed a framework that handles the work distribution among different sites. They use phase-based configuration for the work distribution method. Risk is involved in work distribution because every site has different characteristics. A framework proposed by Richard et al. ignores this risk and tries to solve the work distribution issue based on work and site Specification [2].

Aliya et al. presented a framework to reduce communication, coordination, project planning, and GSD management issues. The framework facilitates all team members involved in the project to reduce the failure rate of the GSD project. They perform a survey and literature review to collect technological issues and proposed a framework. But they ignore the impact of cultural and political issues [3].

Another framework proposed by A.lamers drops that resolving work distribution issue. This framework just focuses on task distribution and ignores the risk involved during task distribution [8].

Norman et al. presented a causal model using Bayesian Network (BN) that helps as a decision support tool. In this paper, the causal model for resource estimation has six subnets. However, they provide the detail of two subnets that is people quality and functionality delivered. Moreover, show the causal relationship between variables and subnets. They use BN to identify resource prediction and budget/ time constraints [13].

(Mockus and Herbsleb and Clerc, et al.)[6] Discusses issues and their solutions that the GSD team faces in their work. They describe the critical issues between project process interdependencies, communication problems, lack of trust, and communication motivation.

The research shows no models provide an approach for work distribution, coordination, and project management entirely. However, the proposed model tackled all issues related to work distribution, communication and project management.

In our proposed work, we distribute our work on work and site characteristics and handle risk related to work distribution. We use a casual risk model for stored project experiences and influencing factors. The Stochastic model generates assignment suggestion based on the causal model and sends to risk identification model. Moreover, through the work allocation model, we assign work among different sites. Each site uses NEOStation software that helps in communication, coordination and project management.

Conclusion

This paper proposed a model that distributes a task among particular sites, involved the entire team member in the project, and allows the facility to coordinate with the project manager easily. This can facilitate to reduce the failure rate of GSD project. Many issues resolve through this model, especially project management, communication, coordination and work distribution in detail. Use phased base configuration and work distribution model that helps in the work distribution mechanism. And use Neostation software to overcome the barriers of communication, coordination and project management. Use multiple criteria for selecting the method and preference given to each criterion depends on the project's purpose. The model has been developed to provide reliable communication between team members and project provide an approach to the distribution of work as support for managers. In contrast, the proposed method is mainly for work distribution models and phase-based configuration. Moreover, the logic behind the work distribution method, coordination and communication tools can help the industry, which involves global.

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