GENDER COMPOSITION FRAMEWORK FOR SOFTWARE PROJECT SUCCESS

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Abstract

The role of software in modern society is essential, influencing nearly all aspects of human activities. This importance drives continuous research into developing high-quality, efficient software solutions. As software costs increase, effective project management becomes critical. Despite various efforts, many organizations still struggle to produce high-quality software. Research indicates that human resources are more pivotal in software development than technical aspects. Numerous studies have investigated human resource management, focusing on role assignments based on individual characteristics and capabilities. However, these studies often yield conflicting results and face validity issues. Notably, the impact of gender on team composition and resource assignment has been largely neglected. This research addresses this oversight by proposing a framework to optimize team selection based on gender. The framework includes eight procedures aimed at improving collaboration among all genders, enhancing individual and collective performance, and efficiently assigning resources in software development.

Keywords: Composition Framework, Task Analysis, Team Selection, Gender Framework.

Introduction

Software development is crucial for organizations aiming to innovate and grow. Numerous studies have highlighted the failure rates in software projects, often linked to organizational challenges (Phan, 1988; Linberg, 1999; Gilal et al., 2016). Despite the demand for high-quality software that is cost-effective, meets performance criteria, and is delivered on time, achieving these goals remains challenging. Currently, only about 6% of software products under development meet these criteria on time and within budget (Gilal et al., 2016). Phan (1988) and Linberg (1999) reported that approximately 16% of software projects are both timely and within budget. The inefficiencies in team composition and task assignments are now seen as major contributors to these failures (Gilal et al., 2017).

To address these challenges, various models and strategies have been proposed, aiming to identify the most effective ways to enhance software project success (SPS). Some researchers have identified critical activities and strategies necessary for success, including team formation, composition and staffing, task scheduling, personal resources management, project selection, resource allocation, gender composition, and role assignments (Baykasoglu et al., 2007; Wei et al., 2009; Gayna, 2014; Egwali and Otokiti, 2019). Key factors such as technical and human aspects, psychology, product-related traits, process, and development environment have been explored (Acuna et al., 2006; Gilal et al., 2017).

Ensuring the success of software projects remains a significant concern for professionals. A lack of diversity in team composition can hinder production efficiency. Diversity within software development teams is essential for enhanced problem-solving, creativity, and excellence (Gayna, 2014). To improve SPS, it is necessary to expand current research to include team formation, gender composition, and gender-specific traits. Several schools of thought exist regarding the significance of integrating GPP, personality traits, or gender traits into software development processes (SDP).

Some researchers argue that human resources and their roles are more crucial to software development than technical factors, given the strong correlation between human factors and software quality, which influences project success (Chi & Cheng, 2009; Egwali & Otokiti, 2019). Additionally, when personality is viewed as a trait without considering gender differences in terms of GPP and other traits, some emerging issues have been observed (Stake & Eisele, 2010). Gender diversity in software engineering has predominantly been considered from a binary perspective, which can impact productivity levels.

In open-source communities, women tend to engage for more extended periods than men, often resulting in more questions asked but unanswered, leading to a less healthy community. Gender differences in GPP play a significant role in professional environments; for example, women often receive better performance evaluations and have a higher chance of promotion (Catolino et al., 2018; Vasilescu et al., 2015; Augustine et al., 2005). Women also face unique barriers in online communities compared to men (Tamburri et al., 2016). Blincoe et al. (2019) noted that diverse teams often have a more pleasant and social atmosphere, but women face more harsh treatment in terms of inappropriate jokes and social isolation. James *et al.* (2017) further explored the differences in recognition and opportunities based on accomplishments.

Recent research indicates that diverse gender traits within groups contribute positively to outcomes in innovative, knowledge-driven, and tech-focused disciplines. Gender diversity balances traits and skills, enhancing team performance (Capretz & Ahmed, 2010). This perspective suggests that addressing GPP and gender differences can contribute to software project success (SPS) by integrating a gender mainstreaming perspective.

James *et al.* (2017) conducted a systematic literature review on software engineers' personality traits, considering gender diversity and its impact on team climate and performance. Their study found that diverse software development teams tend to be more productive than homogenous ones, benefiting from increased gender diversity (Gilal et al., 2017). To support individual professionals, supervisors need to understand how gender class and personality traits affect performance.

In psychology, discussions around personality-based research in software development have highlighted gender's role (Trauth, 2009). The omission of gender considerations is seen as a major limitation in personality research. Studies spanning over fifty years have linked personality to various team aspects, such as effective team structures (Yilmaz et al., 2012b). Additionally, software developers' personalities have been associated with engineers' attitudes (Smite et al., 2012b).

An essential aspect of human resources management is the proper assignment of personnel to development roles, which significantly impacts how engineers work together. Previous studies have explored various factors related to human resources assignment management. Successful software project development hinges on well-defined project planning stages, including selection, composition, and assignment processes. Research has indicated that different team role formation and assignment models often yield inconsistent results, face validity issues, and lack clear guidance for selecting software development personnel.

Our objective is to generate broadly applicable results that contribute to stable and enduring theoretical advancements through a representative sample study. Additionally, these stable and long-term contributions to understanding the studied phenomena are fundamental characteristics of personality trait research. This principle applies not only to the general population, as noted by Cobb and Schurer, but also to software engineering professionals, making it relevant in software engineering research (Iyer et al., 2019).

Literature Review

Several research works and models have been implemented, attempting to find out the major keys to successful software production and to address challenging issues.

Conceptual Review

In the ever-evolving world of software production, achieving successful project outcomes hinges on a delicate balance of various factors. This conceptual review delves into the multifaceted approaches and models employed by researchers to optimize software development. The core focus lies in identifying and understanding the key elements that contribute to a project's positive trajectory.

One crucial area of exploration is team building, encompassing the entire lifecycle of a software development team. Researchers have delved into methods for assembling high-performing teams (Ikram et al., 2013; Yilmaz et al., 2012a). This includes not only the initial formation of the team but also strategies for effective staffing and ongoing management throughout the project. Studies have explored techniques for accurately determining the specific staffing needs of a project, ensuring the right people with the necessary skillsets are brought on board (Antoniol et al., 2004; Chien & Chen, 2008). Additionally, research has focused on optimizing resource allocation, ensuring that personnel and other project resources are distributed effectively to maximize efficiency and productivity (Gutjahr et al., 2010; Yoshimura et al., 2006).

The importance of establishing formalized processes within software development projects cannot be overemphasizd. Acuña and Juristo (2004) emphasized the positive impact of well-defined processes on project outcomes. Beyond team building and resource management, researchers have explored innovative techniques to further enhance software development success. Studies have investigated the use of analytical tools, such as the Analytic Hierarchy Process (AHP), to support human resource decisions, allowing for a more systematic approach to resource allocation and team composition (Tsai, 2003). Furthermore, the integration of psychological assessments into team management practices has shown promise. Acuña *et al.* (2015) explored the use of personality tests like the NEO Personality Inventory and MBTI to gain insights into individual team members' traits. This information can be used to optimize team dynamics and role assignment for improved overall performance.

The realm of artificial intelligence and data analysis has also made its mark on software development. Techniques like fuzzy logic and data mining have been explored to optimize team selection and recruitment processes (Baykasoglu et al., 2007; Chien & Chen, 2008). Fuzzy logic allows for the incorporation of uncertainty and subjectivity into decision-making, while data mining techniques leverage historical data to identify patterns and trends that can inform recruitment decisions.

Despite the significant advancements made in software development practices, there's still room for further exploration, particularly regarding the impact of human factors on team dynamics. A gap exists in our understanding of how gender and personality traits influence team interactions and the most effective allocation of roles within a team. The proposed model aims to bridge this gap by integrating these crucial considerations into the team formation process. By taking a holistic approach that considers both established practices and emerging human factor research, the model strives to enhance team formation and ultimately contribute to greater success in software development projects.

Theoretical Review and Framework

This review delves into a rich tapestry of theoretical models and frameworks that illuminate the critical factors for successful software production. These factors encompass the intricate processes of team formation, strategic staffing decisions, meticulous task scheduling, calculated resource allocation, the establishment of well-defined processes, and the crucial task of project selection.

A significant focus is placed on the realm of human resources. One model prioritizes resource replacements by meticulously evaluating strengths and weaknesses, ensuring a seamless transition within the development team (Tsai, 2003). Another approach sheds light on staffing needs specifically for software maintenance, ensuring a well-oiled machine for ongoing updates and bug fixes (Antoniol et al., 2004). Yet another model ventures beyond technical skills, delving into the fascinating world of psychology to create a perfect match between individual psychological traits and suitable software development roles. This ensures that team members not only possess the technical know-how, but also the temperament and approach that fosters a cohesive and productive unit (Acuna & Juristo, 2004; Acuña et al., 2015).

The realm of team building and project selection is further enriched by the introduction of advanced techniques. One approach leverages the power of fuzzy logic, a mathematical tool adept at handling uncertainties, to meticulously assess the capabilities of potential team members and efficiently match them with the specific skill requirements of a project (Baykasoglu et al., 2007). Another technique harnesses the power of data mining, decision trees, and association rules to create a data-driven framework for recruitment, ensuring that the most qualified and compatible personnel are selected for each project (Chien & Chen, 2008). Mathematical optimization comes into play with a model that utilizes mixed integer non-linear programming to elevate staff competence by strategically assigning projects that provide valuable experience and enhance skillsets (Gutjahr et al., 2010).

Frameworks for roles and team building offer valuable guidance for project managers. One framework emphasizes the importance of customizing roles to perfectly align with the specific needs and objectives of each project, ensuring that team members are operating at peak efficiency (Yilmaz et al., 2012a). Another framework acknowledges the inherent complexity of team selection by incorporating multiple criteria and utilizing a combination of prioritization techniques and historical project data to assemble high-performing teams (Ikram et al., 2013).

The review astutely identifies a critical gap in our current theoretical understanding: the interplay between gender, personality traits, and role assignment, and how these factors influence the ultimate success of software development projects. While previous studies have explored these elements individually, a comprehensive model that integrates them all remains elusive. The proposed team formation and role assignment model has the potential to bridge this gap, paving the way for a more robust and holistic theoretical framework for software development.

By integrating valuable insights gleaned from the field of psychology with the power of quantitative methods, these diverse approaches provide a strong foundation for effective software project management. Future research holds immense promise as we delve deeper to fully understand the intricate dynamics between gender, personality traits, and the overall effectiveness of software development teams. This exploration has the potential to unlock new avenues for optimizing team composition and ensuring the continued success of software production.

Empirical review

In this review, researchers delve into the intricate world of software development, specifically focusing on the factors that contribute to building successful teams. The analysis meticulously dissects various aspects of team formation, including how to strategically select members, assign roles that leverage their strengths, and meticulously allocate resources for optimal project execution. The review brings to light several compelling studies: Tsai (2003) unveils a practical model to aid decision-makers in navigating the often-challenging task of replacing human resources within a project. This approach injects a much-needed dose of consistency into the decision-making process by employing a quantifiable method. By implementing queuing theory, they create a model of maintenance processes, shedding light on efficient task assignment strategies. However, this approach

does not take into account the diverse programming skillsets that team members might possess. Acuna and Juristo (2004) embark on a fascinating exploration of how a person's inherent psychological traits can influence their effectiveness in various software development roles. Their research yields intriguing insights, suggesting a potential link between specific personality characteristics and an individual's performance within a particular role. Building upon this foundation, Acuña *et al.* (2015) went a step further by testing a method specifically designed for software development teams in small and medium-sized businesses. This method leverages personality assessments to create a meticulously crafted alignment between individual traits and suitable roles within the team. The review then ventures into a captivating exploration of additional studies that investigate various techniques for team formation and resource allocation. For instance, Baykasoglu *et al.* (2007) introduce a method that utilizes fuzzy logic to evaluate employee capabilities, while Chien and Chen (2008) delve into the potential of data mining for recruitment purposes. Despite the wealth of knowledge gleaned from these studies, the review identifies a critical gap in research, that is, the combined effects of gender, personality, and role assignment on the ultimate success of software development projects. To bridge this gap, the authors propose a groundbreaking new model and passionately advocate for further exploration in this area. Ultimately, the review underscores the paramount importance of considering both human factors, like personality, and quantitative methods, such as data mining, to achieve effective software project management. By strategically integrating these elements, software development teams can embark on a path towards achieving remarkable success.

Our review highlights current research efforts on forming effective software development teams and explores various methodologies for team composition, role assignment, and alignment with project requirements. We also highlighted a gap in current knowledge regarding the specific impact of gender and personality on team formation and software development success. This underscores the need for further research in this area hence our eventual model.

Gender Composition Framework

To optimize the selection of gender teams respectively, collaborate Males, Females and 'OTHERS' teams based on individual and collaborative performance and assign resources, the following gender composition framework is proposed with the following procedures:

Procedure 1: Collecting Criteria Corpus: The initial phase of our methodology involves gathering a comprehensive set of individual criteria. This will be done by combining the 16 criteria from the 16PF, the five criteria from the NEO Personality Inventory (Costa and McCrae, 1992), and relevant criteria from existing literature. The 16PF (Russell & Karol, 1994) will be used to examine personality structures in detail, identifying its key components and predicting behavior in various scenarios. This will help in aligning personality traits that affect specific capabilities. The NEO Personality Inventory-Revised addresses the Big Five personality factors: extraversion, agreeableness, conscientiousness, emotional stability, and openness to experience.

Procedure 2: Criteria Set Prioritization: The AHP method, which is applied when multiple criteria need to be considered in decision-making, will be employed to:

1. Identify the main hard and soft criteria.

2. Determine the priority weights of the evaluation criteria.

Procedure 3: Prioritizing Criteria Against Capabilities: To enhance the standard capabilities criteria for the software development field, data collected from software managers during interviews will be used to select key capabilities from the standard lists for software development. The resulting list will serve as a starting point for identifying the most suitable resources for software roles.

Subsequently, the personality traits that influence a specific capability will be established (i.e., relating the 16PF personality traits to the capabilities).

Procedure 4: Collation of Resource data derived from questionnaires

Procedure 5: Resource Performance Assessment: the next step is to use the additive weighting method to determine the value of individual performance of Resources P_i.

Let $D = [d_{ig}]_{nx1}$ be the decision matrix on resource performance, where d_{ig} is the consequence with a numerical value of resource P_i with respect to criterion I_g. Since the criterion I_g is subjective, then the corresponding criterion value will be obtained by experts' assessment using scores from 1 to 10 (1: very bad, 10: very good). To ensure commensurability between various criteria, the normalization of criterion values will be used. Every element in matrix $D = [d_{ig}]_{nx1}$ will be normalized into a corresponding element in matrix $D^l = [d^l]_{nx1}$ using the following formulas:

$$d_{ig}^{l} = \frac{d_{ig} - d_g^{min}}{d_g^{max} - d_g^{min}}, i = 1,2,\dots,n;\ g = 1,2,\dots,l, \qquad (1)$$

$$d_{ig}^{l} = \frac{d_g^{max} - d_{ig}}{d_g^{max} - d_g^{min}}, \qquad i = 1,2,\dots,n; \ (2)$$

$$where\ d_g^{max} = \max\{d_{ig} | i = 1,2,\dots,n\},\ \ d_g^{min} = \min\{d_{ig} | i = 1,2,\dots,n\}, g = 1,2,\dots,l.$$

Experts will give criterion weights v_g, g = 1; 2;. . . ; l, by direct assignment or using AHP (Saaty, 1980). To highlight the sub-objective, the utility values of the criteria will be synthesized based on multiple criterion decision making and multi-criteria utility theory (MCUT). In MCDM theory, if the criteria are independent and additive, then the overall utility value of each resource candidate will be obtained through weighted aggregation of criterion values. By simple additive weighting, the overall value of individual performance of resource P_i will be obtained using equation 3. At the stage we derive the universal set of resources n.

$$\varphi = \sum_{g=1}^{i} v_g d^I{}_{ig} i = 1,2,\dots,n. \qquad (3)$$

Step 6: Resource Gender Category Team Formation: According to the overall values of resource performance, $\varphi_1, \varphi_2, \dots, \varphi_n$, the following optimization model will be built to select the most preferred q members from n resource candidates in h(males, females, others) gender domain respectively only considering individual performance (see figure 1-3).

$$\text{Maximixe } Z_1 = \sum_{i=1}^{n} \varphi_i x_i$$

$$\text{Subject to} \sum_{i \in N_j} x_i = q_j, j = 1,\dots,h$$

$$x_i = 1 \text{ or } 0, i = 1,2,\dots,n$$

Where

n total number of candidates

P_i candidatei; I = 1, 2, . . . , n

q total number of desired resource members to form a gender team

q_j total number of desired resource members from gender specific domain j ,$\sum_{j=1}^{h} q_j = q$

v_g weight of criterion lg, $\sum_{g}^{l} v_g = 1, 0 \leq v_g \leq 1 \; and g = 1, 2, \ldots, l$

l total number of criteria for measuring resource performance

l_g criteria g for measuring resource performance $g = 1, 2, \ldots, l$

h total number of gender category domain (i.e. males and females)

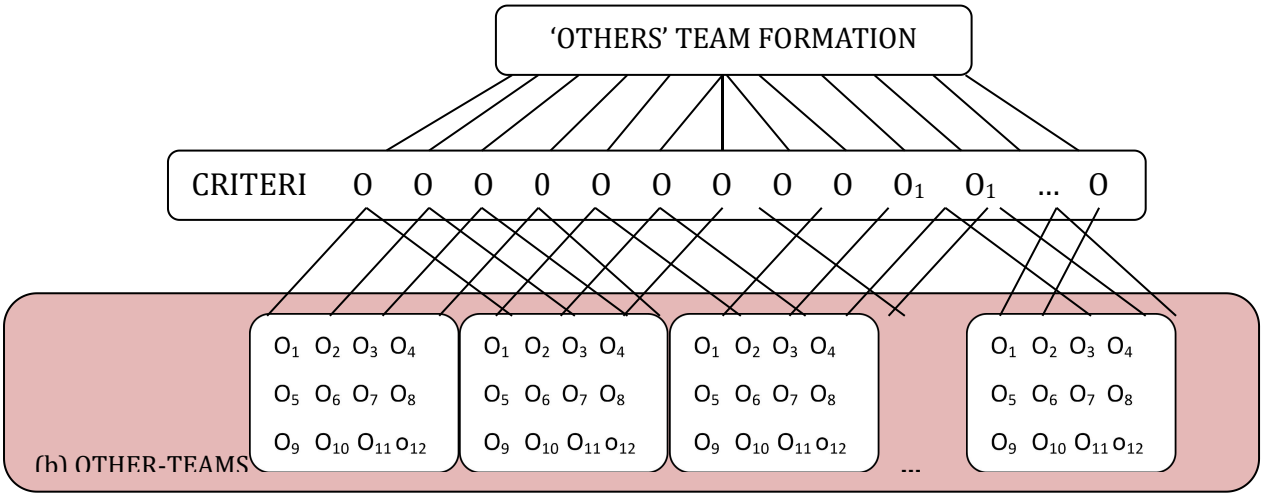

Figure 1: Structure for 'OTHERS' Team Formation

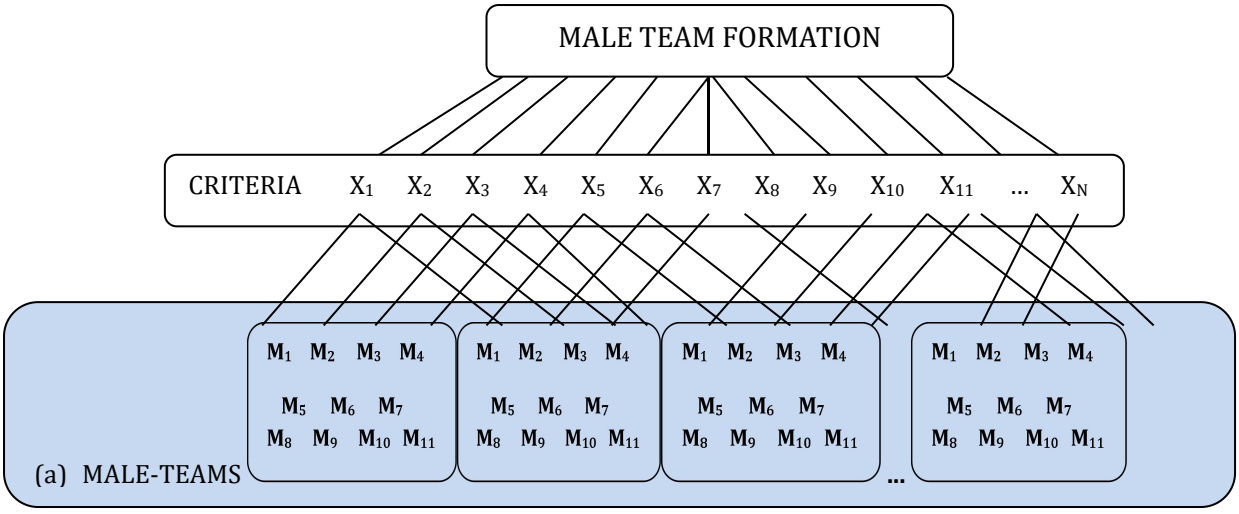

Figure 2: Structure for Male Team Formation

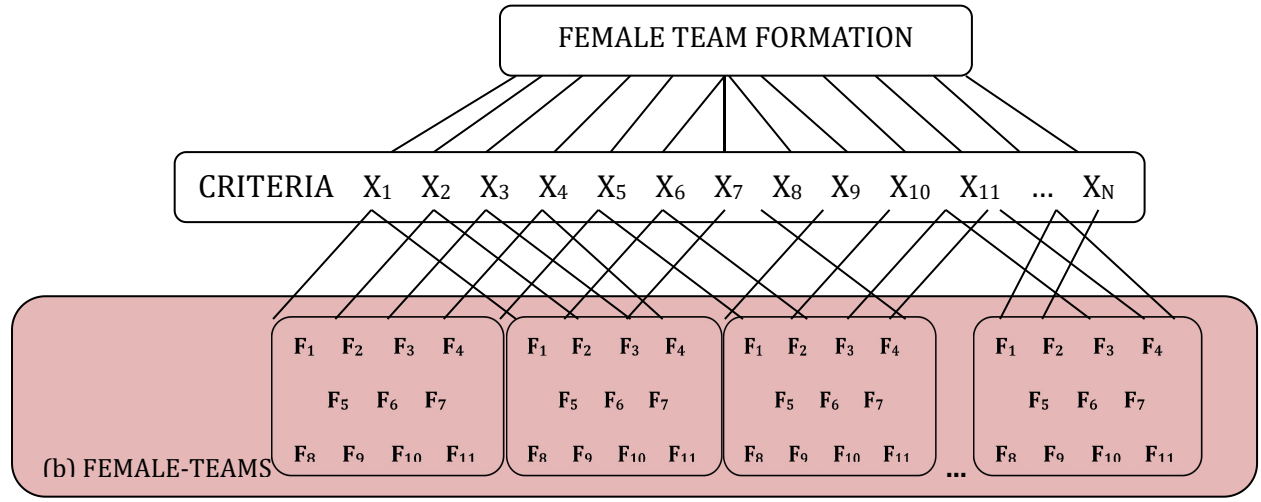

Figure 3: Structure for Female Team Formation

Procedure 7: Construction of the Conceptualized of the Proposed Model: G-TEAM

After the best q members from n resource candidates among the male, female and 'others' teams are obtained respectively, the male, female and 'others' individual performance as a single resource and the collaborative performance as a pair of resources will be considered to select members to form the proposed model, G-TEAM.

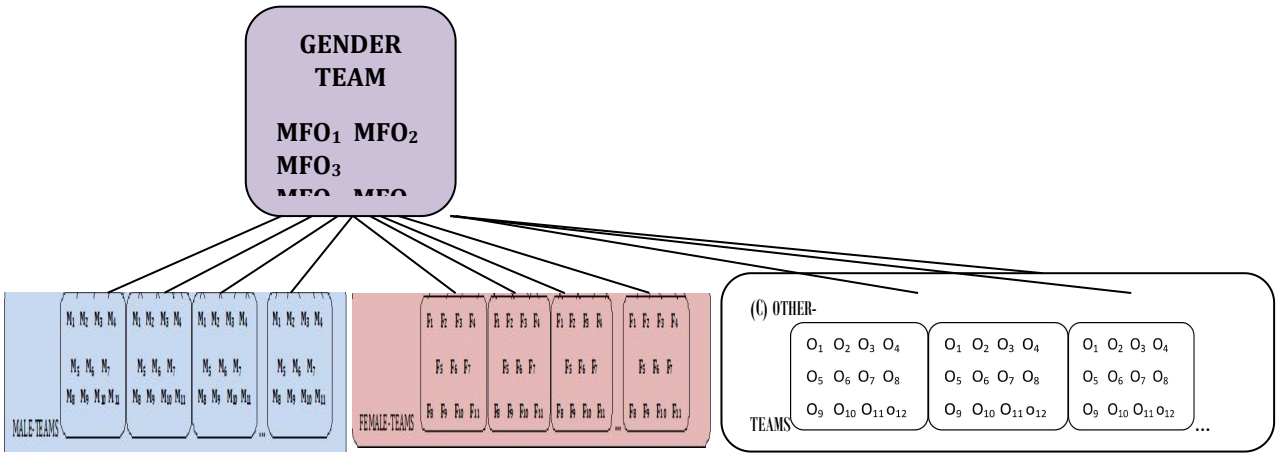

Figure 4: G-TEAM Formation

Procedure 8: Assign G-TEAM members to Roles

The capabilities-based assignment method proposed in G-TEAM will use the ratio of necessary capabilities each respondent satisfies to capabilities required to determine which resource best fit each role. The greater this ratio, the better suited a resource is to play a role. Measuring standard will depend on the management's opinion, available resources, and the resource's career goals.

Conclusion

This paper exposes the fact that the software development industry has experienced crisis overtime, even though a couple of research has been conducted towards software development success. It established GPP, personality traits and gender traits as key human factors of software development that has not been given the required attention it deserves and thus stands as a major limitation of current approaches. It has also highlighted the usefulness of GPP, personality traits and gender traits, team formation and role assignment in software development. With these in focus, a Team Formation and Role Assignment Model that incorporates GPP, personality traits and gender traits are proposed. In addition to some other required key factors, this model should be able to satisfactorily assign the

right resources to the right role at both individual and team levels in a view to contributing to a successful software development. We propose that future research efforts could look at conducting controlled experiments within software development teams to validate the effectiveness of our proposed model and also to establish a research framework for ongoing evaluation and refinement of the model proposed.

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