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SOFTWARE DEVELOPMENT TEAM COMPOSITION: PERSONALITY TYPES OF PROGRAMMER AND COMPLEX NETWORKS

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ABSTRACT. Several authors have identified the different personality types for software team composition. Effective personality types for software development roles is still a question. This study aims to measure the relationship between different personality types by using complex network approach for finding effective nodes of personality type for software programmer. In order to achieve the objective, the study was conducted on student population. Myer-Briggs Type Indicator (MBTI) personality assessment tool was used to obtain the personality types of participants. Furthermore, degree centrality, betweenness centrality, and closeness centrality measures were used on data. These measures were used to find the strongly liked personality types among team members, personality types that can create effective communication, and personality types which can work close with other personality types. Basically, two types of results were obtained from applied measures: personality types which are weighted and frequent and personality types which are weak and less frequent. For example, ISTJ, INFJ, ISTP, and INFP personality types were found very less lucrative in working close with other personality types. On the other hand, ISTJ has been found very effective personality type for programmer role in software development literature. The results suggest that each personality type has its own complex behavior which should be extracted for better outcomes. Deciding one particular personality type for programmer role would be an injustice with it. Therefore, this paper recommends to use complex network phenomenon to extract the hidden facts behind each personality types for software development roles.

Keywords: software development, programmer, personality type, complex networks

INTRODUCTION

Demand of software has been increased in last few decades but detrimental decrease is observed in delivering successful software from development houses (Gilal et al., 2016). Several past studies have attributed this decrease due to human factor issues (Capretz & Ahmed, 2010; Gilal et al., 2014). They have highlighted that a personality factor of human impacts the overall performance of team. As a result, number of frameworks and models have been proposed with different techniques and solutions for composing effective teams (Gilal,

Omar, & Sharif, 2014; Omar, Syed-Abdullah, & Hussin, 2011) Based on the best of authors' knowledge, personality based team composition by using complex network approaches is weakly explored. It should be considered that personality is an element of human behavior and composed complex in nature. According to González (González, 2006), "a system consisting of many interacting units whose collective behavior cannot be explained from the behavior of the individual units alone". Similarly, a software development team consists several members to behave like an individual unit. Hence, based on the complex network definition, it is a fact in human psychology that one cannot generalize the individual behavior of member for all. Keeping this in view, this study has set the objective to investigate the relationship between different personality types by using complex network measures for finding effective nodes of personality for software programmer. Logically, following questions were answered:

- Q1. Which personality type was strongly liked personality among team members?
- Q2. Which personality type that can create effective communication?
- Q3. and which personality which can work close with other personality types?

The novelty and contribution of this work, may be considered, is the new way of finding effective programmer based on personality types by using complex network approach. The following section has grounded the importance of the mentioned problem within the title "related work". The methodology section has summarized the data collection approach and it also elaborated the measures which were used to extract the information. Additionally, important outcomes are discussed in the results and discussion section after the methodology section. In the last section, the conclusions are made with future directions.

RELATED WORK

The past research on software development mentions that software development is a complex sociotechnical activity (Robey & Newman, 1996; Scacchi, 2005). The vast research stream mainly asserts that software development is not only to develop the technical product but it also includes the social process which involves several actors with different backgrounds working together to achieve the same goal (Robey, 1994; Sawyer, 2001). In the same vein, Curtis et al., (1988) maintained that the software development process should be treated as communication, negotiation, and learning activity. It is the main objective of this study to see the effective personality types which can ensure the communication, negotiation and learning processes effectively. Nowadays, several scholars have realized the importance of social structures. They believe that social structures can bring effectiveness in teamwork (Yang & Tang, 2004). This shows that social network concept is gaining its popularity in several disciplines. For example, association of network factor with perceptions of job related issues and performance (Lucius & Kuhnert, 1997), academic performance (Baldwin, Bedell, & Johnson, 1997), conflicts within groups (Labianca, Brass, & Gray, 1998), and individual performance. Apart from this, complex network approaches: centrality and two-mode networks are also being used in health department such as to identify the dengue epidemic (Malik, Mahesar, Abid, & Wahiddin, 2014).

Software development involves people in process. Issues related with human can never be ignored. Human factor is a foundation of software development because software is developed for people by people (Capretz, 2014; Gilal et al., 2015). It is a very important element of software development success. Technical skills alone cannot make sure the success of software development. Human factors or non-Technical skills (such as personality) have the similar importance in software development as the technical skills (Gorla & Lam, 2004). Several authors have contributed to find out the relationship between software development roles and personality types (Capretz & Ahmed, 2010). It is believed that software developer can work effectively within team if he is assigned a job aligned with his personality (Gilal, Omar, & Sharif, 2013; Martínez, Licea, Rodríguez-Díaz, & Castro, 2010).

For instance, a team leader job has a responsibility to collect information from higher management or clients and deliver it within team members. In this case, a leader with introvert personality will might not maintain the effectiveness. Thus, this study has used a complex network approach to find out the network between participants' personality types which highly centered or highly frequent.

METHODOLOGY

In order to achieve the main objective, this study has used controlled experimented data of student population. The data was collected during the PhD of the first author of this paper. The data collection experiments were conducted on Universiti Teknologi Petronas (UTP) students of software engineering course. It is worth noting here that two groups of teams were formed: controlled and experimental. The part of data used in this study was from experimental dataset set. Experimental group followed Role Assignment Methodology for software engineering teams (RAMSET) (Martínez et al., 2010). In the main study, during data collection process, the RAMSET method was used to measure the impact of role assignment methodology on the personality preferences of software developers based on role. The dataset used in this study had contained the information of 30 students. In the experiment, MBTI tool (Myers, McCaulley, Quenk, & Hammer, 1998) was used to extract the personality types of the participants. Moreover, during experimental group data collection, participants' consents were measured for to know: 1. who they wish to work in team and 2. with what confidence level. In other words, their consents were recorded based on their satisfaction to their favorable personality types. Therefore, this study arranged personality type as a node and confidence level as a weight in this network. Due to homogeneous node, this network could only be weighted one-mode network. Table 1 contains the personality types with the numbers which were used in network analysis.

Table 1. The 16 MBTI Personality Types.

ISTJ (1)	ISFJ (2)	INFJ (3)	INTJ (4)
ISTP (5)	ISFP (6)	INFP (7)	INTP (8)
ESTP (9)	ESFP (10)	ENFP (11)	ENTP (12)
ESTJ (13)	ESFJ (14)	ENFJ (15)	ENTJ (16)

For the network analysis, two broader types of measures were used: local and global. Opsahl's et al., (2010) metric of weighted degree centrality was used to measure the degree, strength and degree centrality. Tuning parameter (i.e., α) was used to control the equation outcomes. For example, if $\alpha=0$ then the metric will return the number of nodes connected with each nodes (i.e., node degree), or otherwise, it will return the weight of the links (i.e., strength) when α is set with 1. Last, it will use degree and weight both to measure the links (i.e., weighted degree centrality) if α is between 0 and 1. On the other hand, Betweenness and Closeness centrality global measures were applied to find the shortest path within the nodes. Furthermore, betweenness and closeness centralities were formalized based on Opsahl's et al., (2010) equations. In which, the equations calculated binary short distance only if the tuning parameter is set to 0 (i.e., $\alpha=0$). But, it was set to Dijkstra's algorithm if $\alpha=1$ otherwise the equation measures based on the both if $\alpha=0.5$. The following equations were used in the said experiments. Moreover, R-project tool was used to implement these equations to extract the results. The i-graph package within R-project was used to project the overall sight of connections.

Weighted degree centrality:

$$C_D^{W\alpha}(i) = deg_i \times \left(\frac{strength}{deg_i}\right)^\alpha \quad (1)$$

Betweenness centrality:

$$C_B^{W\alpha}(i) = \sum_J^N \sum_K^N \frac{g_{jk}^{W\alpha}(i)}{g_{jk}^{W\alpha}} \quad j \neq k \quad (2)$$

Closeness centrality:

$$C_C^{W\alpha}(i) = \left[\sum_J^N d^{W\alpha}(i, j) \right]^{-1} \quad (3)$$

RESULTS AND DISCUSSION

The first metric was used to find the strong node of personality based on degree and strength. The second metric was used to see which personality type can be the bridge between different members for effective communication. Because, in team environment, programmers are responsible for effective communication for better outcomes. Lastly, the third metric was kept to find the personality types that can work close within team. For example, in pair programming, programmers have to sit next to each other for effective results. Following Figure 1 presents the overall behavior of the network.

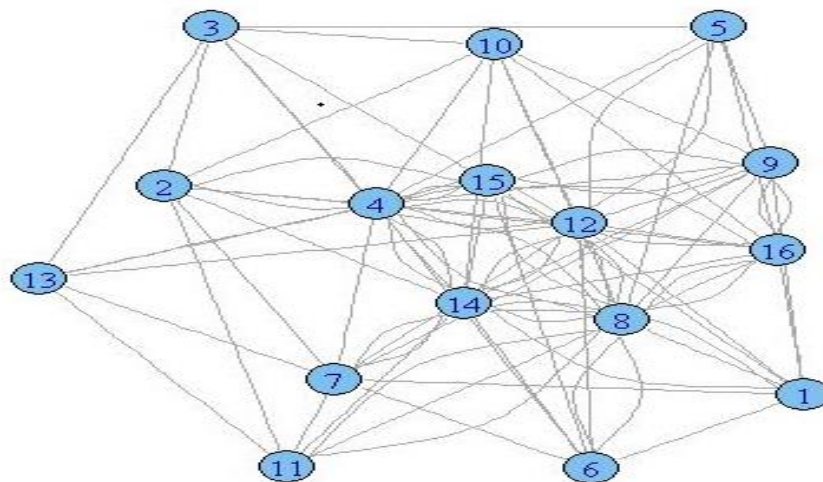


Figure 1. Projection of MBTI personality based network.

In general, it is not easy to summarize this network from its graph. This network could be more complex if the connections or number of participants are huge. Table 2 summaries the results of used measures.

Table 2. The summary of results

P.Type	Weighted Degree Centrality (Q1)			Betweenness Centrality (Q2)			Closeness Centrality (Q3)		
	$\alpha=0$	$\alpha=0.5$	$\alpha=1$	$\alpha=0$	$\alpha=0.5$	$\alpha=1$	$\alpha=0$	$\alpha=0.5$	$\alpha=1$
ISTJ	4	14.14	50	3	5	10	0.037	0.033	0.029
ISFJ	5	22.36	100	9	16	24	0.040	0.042	0.041
INFJ	4	14.14	50	4	1	0	0.038	0.035	0.033
INTJ	7	32.40	150	18	24	36	0.043	0.046	0.042
ISTP	3	12.25	50	1	6	10	0.032	0.035	0.034

ISFP	6	24.49	100	1	2	4	0.038	0.036	0.032
INFP	4	14.14	50	9	1	0	0.033	0.030	0.025
INTP	9	35.50	140	24	36	53	0.048	0.045	0.040
ESTP	9	42.43	200	6	4	0	0.045	0.044	0.042
ESFP	4	14.14	50	10	3	2	0.036	0.035	0.032
ENFP	4	14.14	50	6	8	7	0.038	0.035	0.032
ENTP	7	26.46	100	16	26	42	0.043	0.040	0.034
ESTJ	3	12.25	50	5	5	4	0.034	0.037	0.037
ESFJ	6	22.58	85	18	24	25	0.038	0.037	0.031
ENFJ	7	30.74	135	25	21	25	0.043	0.043	0.039
ENTJ	8	35.78	160	11	17	35	0.045	0.048	0.045

Based on the results obtained from the first metric, weighted degree centrality, it was found that personality types INTP and ESTP were most favorite among participants (based on connections or $\alpha=0$). Similarly, ISTP and ESTJ were found less demanded personality types for working within teams. But, whilst measuring based on degree and weight together ($\alpha=0.5$), ESTP and ENTJ personality types were most favorite and trusted. Although, ENTJ personality type had lesser degree than INTP but it was trusted more than INTP. It may be occurred because the introvert (I) personality type people are mostly reserved. Therefore, working with them, may be, a stronger choice but trusting them can be a weaker decision. But, on the other hand, as extrovert (E) you grow, it may also leave some reservations on your personality. Hence, ESFP, ENFP, and ESTJ were disconnected with many nodes. Besides, ESTP and ENTJ are extensively found in literature for programmer personality (Capretz, 2008).

In the communication fields, betweenness centrality is used to find the shortest path node that can behave as a bridge between two other nodes. In our case, we have also used to it see the most active node which can be considered bridge between different types of personality. Though, ENTP and ENTJ were found higher in degree frequency, but these personality types could not manage to come in-between for the best communication. Whereas, INTP personality type appeared highest in betweenness centrality among all sixteen personality types with 36 frequency. On the other hand, ENTP personality type did not obtain the high degree frequency but it appeared 26 times in betweenness centrality. Moreover, INFP, ISFP, and INFP were remained almost disappeared within team choice for maintaining the betweenness. It is, may be, because the feeling (F) and introvert (I) traits are sentimental and get hurt quickly. It might have dragged these personality types to not follow them in the teams as members. Additionally, it should be noted here that programmer has job to communicate frequently with team members. Therefore, finding betweenness centrality among team programmers can bring the lead programming skills visible which can help to let members communicate or work with each other.

The last results for this paper were on findings of closeness centrality. Basically, closeness centrality is also used to find the shortest path of nodes that can be suitable for any node to deliver message easily within network. In other words, closeness centrality helps to identify the node which can be deliver the information with short distance. In this study, it was tried to find the suitable personality based on the closeness centrality between different personalities that can allow easy understanding amongst programmers to work close to each other. Personality type ENTJ personality was seemed absolutely effective personality in closeness centrality results. Moreover, ENTJ personality type was also found comparatively effective in

degree centrality but not in betweenness centrality. In the same vein, it was also observed that INTJ was found second frequent close personality in the network. Although, INTJ personality type was not most frequent among team members but yet have received good strength in betweenness and closeness centralities. Additionally, ISTJ, INFJ, ISTP, and INFP were appeared negligible in closeness centrality. However, it should be noted that ISTJ personality (Cunha et al., 2007) has been observed most frequent in literature for programmer. Whereas, this paper results show that ISTJ personality does not create closeness with other personality types.

CONCLUSION

This study is an initial step to use complex network approach to find the effective personality types within programmer role. The results of the study are insufficient for generalization due to the limited data size but it can be concluded that it is not easy to decide a particular personality type for programmer role. For instance, some personality types are frequently demanded for teamwork (i.e., ESTP and ENTJ) but yet to be effective for communication. On the other hand, working in a team requires communication (i.e., INTP, ENTP) between other team members. Additionally, some personality types can work close to each other: ENTJ and INTJ, but some does not work. It is most important to measure the understanding of team members before composing team. Thus, complex networks can help to extract the hidden relationship between personality types and software development team composition. Moreover, future work can be carried out to find the relationships between gender and personality types of software programmer. It is already found that personality has certain relationship with gender. Therefore, one cannot generalize an identical type of personality for male and female programmers. Complex network approach can be used to identify the social network for better understanding of personality behavior among male and female programmers in teams.

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