Honours Year Project Report

The Impact of Team Roles on Software Development

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Abstract

Software development projects have often been plagued with failures in the form of cost, schedule overruns and reduced functionalities. To increase the success rates of software projects, one of the salient factors identified is to build the right team. While it is popularly believed that capable programmers would ensure the success of software projects, researchers have suggested otherwise. Previous research suggests that the greatest potential for improving the success rate is to examine the team roles adopted. With the above motivation, this study uses Belbin's team role theory to evaluate the impact of team roles on team performance in different phases of the software development. Further, team role balance is expected to increase team performance. Apart from collocated teams, global virtual teams (GVTs) for software development are increasingly common. In GVTs, the challenge is to overcome possible negative impacts of spatial and temporal dispersion on performance. Therefore, this study will investigate the impact of team roles on GVTs' performance. The findings from this study show that different team roles cause better team performance in different phases of software development. Also, team role balance contributes to better team performance and the positive impact of people-oriented roles on GVTs' performance will be reduced by spatial and temporal dispersion.

Subject Descriptors:

D.2.9 Management
H.1.2 User/Machine Systems
K.4.3 Organizational Impacts
K.6.1 Project and People Management
K.6.3 Software Management

Keywords:

Team Role, team role balance, global virtual teams, team performance, software development.

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I would also like to show appreciation for Prof. Irene Woon's invaluable pointers for the study. Without her advice, it would be difficult to provide practical implications that relate to practices of software development in organizations without ample working experience.

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Chapter 1 Introduction

Software development projects are often plagued with failures in the form of cost, schedule overruns and reduced functionalities. Although the Standish Group's "CHAOS" report has shown improvements in failure rates, cost and time overruns, the average percentage of cost overrun and time overrun in 2004 is still considered high with 56% and 84% respectively above their original estimates (Hartmann, 2006). Such failures or abandoned projects cost the U.S. economy billions of dollars a year (Ewusi-Mensah, 2003). One of the critical success factors identified for the success of software projects is to build the right team (Reel, 1999).

Team composition plays an important role as the costs of poor team members' selection decisions may exceed the time and expense required to develop a systematic team selection process (Blackburn, Furst and Rosen, 2003). It appears intuitive to think that capable programmers for a software project would ensure the success of the software project. However, studies have shown that having a team of capable software developers may not be sufficient to guarantee high-quality work products (Beranek, Zuser and Grechenig, 2005; Faraj and Sproull, 2000). Belbin (1981) observed the Apollo Syndrome, whereby extremely gifted subjects grouped into a "super-team" under-perform teams comprised of average subjects. This means that intelligence and talent are not the only factors underlying a team's ability to be effective and successful. Thus the reason for poor team performance may not be due to a lack of ability or lack of sets of skills that the individual members might possess, but instead be largely due to personality issues. Having teams that are composed of exceptional individual programmers but coupled with personality conflicts or deficiencies would make the team unable to perform (Rajendran, 2005). Other researchers have also suggested that the greatest potential for improving software quality and process lies in personnel issues, rather than in technological or methodological concepts (Kellner, Curtis, Demarco, Kishida, Schlumberger and Tully, 1991). In this study, team role theories will be applied to propose team compositions that may positively impact software development team performance.

The composition of gobal virtual teams (GVTs) may also affect the performance of global virtual teams working on software development projects. GVTs are increasingly popular, particularly in the area of software development (Carmel, 1999, Koch 2004). Software development is no longer restricted to the traditional co-located development model. To attain cost savings, many companies in America and Europe have selectively outsourced their software development to countries such as India and China. Another attraction of having geographically distributed teams is an almost 24-hour software development cycle, thereby cutting down the duration of a project (Carmel, 1999). However, challenges have arisen from possible negative impacts of spatial and temporal dispersion of GVTs. One of the challenges is to create opportunities for team members to have the dialogue necessary to create a shared understanding of their work (Holton, 2001). Opportunities are difficult to create due to differences in working hours and inability to communicate face-to-face. GVT researchers have found that stronger team member relationships lead to higher team performance (Warkentin and Beranek, 1999). Effective communication is considered the key to successful global virtual teams (Haywood, 2000) and one of the keys to effective communication is how well team members are able to build and maintain their relationships in teams (Pauleen and Yoong, 2001) despite differences in working hours and locations of team members. In this paper, an attempt will be made to identify the type of team roles that will result in better GVT performance and also overcome possible negative impacts of spatial and temporal dispersion.

1.1 Research Motivations

Studies have been done to evaluate the relationship between role theories and team performance in software development (Sallie and Todd, 1999; Beranek et al., 2005). However, none has examined the impact of team roles in specific phases of software development. Hence, this knowledge will be useful for staffing decisions made on a phase basis rather than on the basis of the entire project. Team roles that will contribute most to team performance in different phases of software development will be proposed and investigated. Many team role theories have also advocated the balance of different team roles for better team performance (Belbin, 1993; Davis, Millburn, Murphy and

Woodhouse, 1992; Margerison and McCann, 1989). However, there is a lack of studies that have empirically validated the relationship of team role balance and team performance in software development.

GVTs are playing an increasingly important role in organizational life (Moshowitz, 1997) and will form the nuclei of twenty-first century organizations (Grenier and Metes, 1995). Although several studies (De Dreu and Weingart, 2003; Jehn, Chadwick and Thatcher, 1997) have shown the positive impact of strong team member relationships on team performance, there is a lack of research that have empirically validated the relationship of team roles and team performance and to also take into consideration the effects of spatial and temporal dispersion. Armed with quantitative measurements of spatial and temporal dispersion developed by O'Leary and Cummings (2004), this study will investigate the type of roles that reduce possible negative effects caused by spatial and temporal dispersion, resulting in increased team performance.

1.2 Research Objectives

With the above motivations in mind, the objectives of this research are:

(1) To identify desirable team roles that will improve the performance of software development team in different phases of software development
(2) To devise measurements for different categories of team roles so as to assess impact of team roles on team performance
(3) To investigate the relationship between team role balance and team performance in software development
(4) To propose and test desirable team roles that will facilitate GVT team performance with the consideration of spatial and temporal effects

1.3 Expected Contributions

This paper aims to serve as a guideline for managers of software development teams during team formation decisions in different phases of software development, by highlighting important roles that may affect the outcome of software projects. It could assist managers to form teams based on who can work effectively together. Moreover,

with such knowledge, managers can evaluate a team by identifying the lacking attributes within the team and resolve the problem by promoting desirable roles. For role theory researchers, this study aims to verify previous research findings as well as advance the literature by identifying some directions for future research. The results will also be of interest to IS and role theory researchers by providing a model and evidence of how team roles will affect the performance of software development teams and also add to the growing research on GVTs.

1.4 Structure of Report

After reviewing existing literature, the hypotheses will be formulated and a model will be developed. Next, the survey research methodology used and operationalization will be described. Conceptual validations of the survey instrument will then be performed. Descriptive statistics of data collected will be provided and the reliability and validity of data will be examined. The results of hypothesis testing will then be discussed. Implications of the results for managers will be provided. Lastly, the paper will conclude with a summary of findings, limitations, future research opportunities and contributions of this study.

Chapter 2 Literature Review

Relevant literatures will first be reviewed in order to accomplish the following:

(1) To identify metrics for team performance
(2) To identify the different phases of software development
(3) To examine various team role classifications and derive the most suitable team role classifications for our study
(4) To review previous research done using the team role classifications selected
(5) To derive the relationship between spatial and temporal dispersion, intra-team member relationships and team performance in GVTs based on existing literature

2.1 Team Performance

In order to measure the impact of team roles on team performance, team performance will have to be defined. According to Faraj and Sproull (2000), there are two dimensions

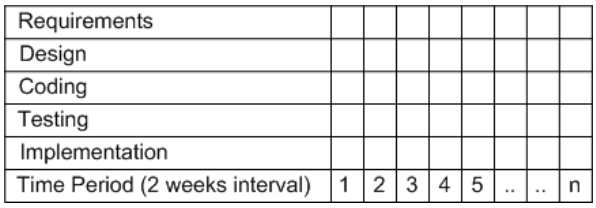
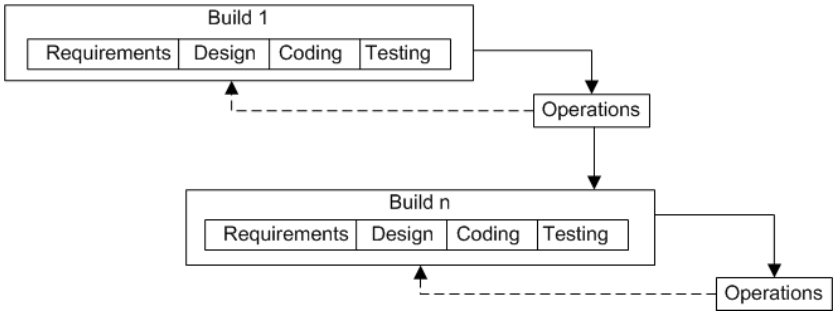
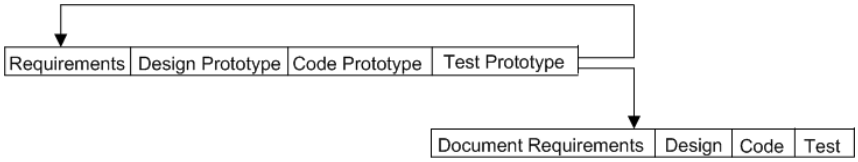
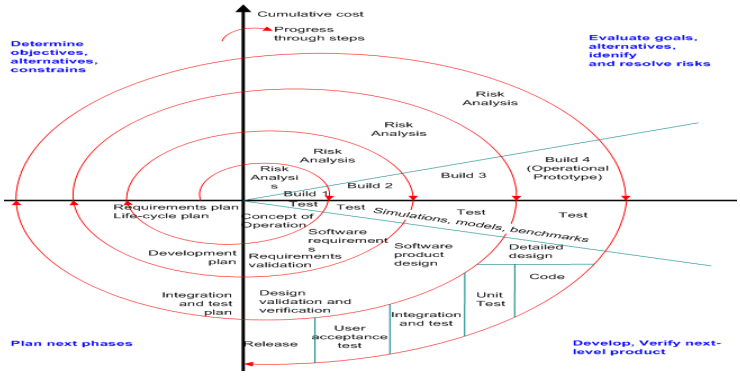
of team performance: team effectiveness and efficiency. Team effectiveness is based on the assessment of how well the project team has performed; on dimensions such as quality of work, ability to meet project goals and the extent of meeting objectives. Efficiency is based on the measures of the adherence to budget and schedules. Faraj and Sproull (2000) have argued that using performance measurement, in terms lines of code per person per month, may be problematic due to the following reasons:

- Statistics on the output of each software developer are often unavailable
- It may not reflect actual team performance as certain lines of codes may not fulfill product specifications or may even create bugs
- It does not show differences between projects or other constraints

These two dimensions of team performance i.e., team effectiveness and efficiency, are often used in organizations. Earned value management (EVM) that integrates the measurement of adherence to time and budget with the amount of work done, is a project performance measurement technique often used by software project managers (Peters, 2004; Schwalbe, 2005).

2.2 Phases of software development

In this study, the impact of team roles on team performance in various phases of software development will be analyzed. Therefore, it will be useful to understand the common phases in the Software Development Life Cycle (SDLC). Different SDLC models have been proposed and are summarized in Table 1.

SDLC Model	Description and Diagram
Agile (Peters, 2004)	 To minimize risk, software is developed in short iterations which typically last one to four weeks. Each iteration is similar to a software project and includes all the tasks such as requirements analysis, design, coding and testing.
Evolutionary or Incremental (Dorfman, 1990; Peters, 2004)	 This model is built upon the concept of "build a little, test a little, repeat."
Prototyping (Dorfman, 1990; Phillips, 1998)	 Prototyping is used as a means to develop specifications. Thus, the prototyping may be considered as a way to support requirement analysis.
Spiral (Boehm 1988, Phillips, 1998)	 Each cycle involves a progression from one phase to another that addresses the same sequence of steps. The spiral process provides ample opportunity for the developers and users to learn about the

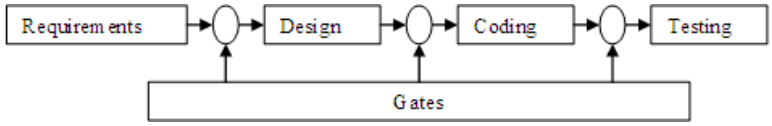
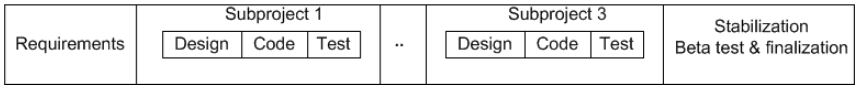
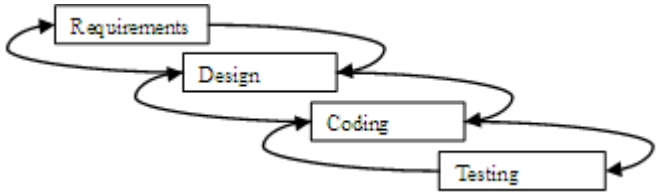
	product and reduce uncertainty of risk.
Stage Gating (Peters, 2004)	 Before a project can proceed to the next stage, gates are positioned at critical points in the life cycle to examine and evaluate against standards established for the project.
Synchronization and Stablization (Cusumano & Selby, 1997; Peters, 2004)	 This approach is similar to the incremental approach. Starting with requirements, a set of specifications and priorities are generated. The project is divided into a few major builds. Major builds correspond to the subprojects (Subproject 1, Subproject 2, and Subproject 3) shown. Subproject 1 is the first major build and represents the point in the development cycle with the widest range of possible changes in code. The most serious and even minor bugs are absent by the time Subproject 3 is established.
Waterfall (Peters, 2004)	 Traditional software development life cycle model with working results occurring near the end of the process.

Table 1 Summaries of SDLC Models

Based on Table 1, the common phases in the different SDLC models are: requirement analysis, design, coding, and testing. Requirement analysis is the activity of determining what functions the software will perform and documenting those functions along with other requirements in a software requirement specification (Thayer and Royce, 1990). The design phase or "the how phase" describes the implementation that will meet the requirements (Dorfman, 1990). During requirement analysis, it is frequently inevitable that design considerations be discussed as it is impossible not to at least consider solutions while learning about a problem (Phillips, 1998). Therefore, to avoid difficulties

in determining the exact phase where requirement analysis and design may occur simultaneously, we will combine these two phases into one and examine it as a phase, terming it as ***Phase 1***. Coding is the implementation of a software design in executable machine instructions. Unit testing or component testing is normally done by the programmer of the unit immediately after it is coded in order to expose errors (Bennatan 2000; Thayer and Royce, 1990). Therefore, we will term Coding and Unit Testing as ***Phase 2***. Since unit testing is normally done in the coding phase, the focus of the testing phase is on software integration testing and user acceptance testing. Software integration is the act of merging a software component or components with another software component (Thayer and Royce, 1990). User acceptance tests should show the software's capability, stability, resistance to failure, compatibility with systems and performance, as well as its stress points and structure (Phillips, 1998). Hence, Software Integration testing and User Acceptance testing will be grouped as ***Phase 3***. Therefore, the phases examined in this study are:

Phase 1: Requirement Analysis and design

Phase 2: Coding and Unit Testing

Phase 3: System Integration Testing and User Acceptance Testing

2.3 Team Roles

2.3.1 Team Role Categorization

The composition of software development teams have mostly been determined by matching tasks with either skills or status considerations in order to ensure the right level of expertise and experience. However, this approach fails to consider individual personalities, behaviours and relationships that will affect the team.

Previous research (Beranek et al., 2005; Sallie and Todd, 1999) suggests that the key element in building and leading successful software engineering teams is to understand the role distribution within the team. Role distribution consists of two aspects. The first being the formal role distribution, which is defined by project management, and second, the informal role distribution which grows within a team by the natural interactions between the team members and is based to some extent upon their individual

characteristics (Beranek et al., 2005). Belbin (1993) had a similar description, stating that people at work possess two roles: functional role and team role. Functional role is related to the function of the job and based on experience and expertise, whereas team role is the person's tendency to behave, contribute and inter-relate with others in a particular way. This paper will focus on the team roles present in software development teams that may affect the team's performance instead of looking at the functional roles which have been well studied. Table 2 shows the description and categorization of team roles proposed by past researchers arranged alphabetically. A detailed description of each role is available in Appendix A.

Authors (year)	**Categorizations of Team Roles *(Definition)* &** Specific Team Roles
Benne and Sheats (1948)	**Group Task Roles** ***(****Roles that help a group develop and accomplish goals, such as proposing new ideas or new ways to accomplish goals or expediting group movement by performing routine tasks)* Include Proceduralist, Recorder, Evaluator, Explainer, Idea Generator, Information/Opinion seeker, Information/Opinion giver
	Group Building and Maintenance Roles ***(****Roles that do not directly address a task itself but help foster group unity, positive interpersonal relations and development of the members' ability to work effectively together)* Include Follower, Motivator, Gate-keeper, Mediator, Tension-Releaser, Standard Setter
	Individual Roles ***(****Roles that are related to the personal needs of group members and may often negatively influence the effectiveness of a group)* Include Aggressor, Blocker, Recognition-seeker, Self-confessor, Playboy, Dominator, Help-seeker, Special interest pleader, Deserter
Belbin (1981, 1993)	**Action-Oriented Roles** *(Roles that take responsibility for tasks and accomplish them)* Include Shaper, Completer Finisher, Implementer
	People-oriented Roles *(Roles that relate well to other people within the team, help foster group unity, positive interpersonal relations and development of the members' ability to work effectively together)* Include Co-ordinator, Teamworker, Resource Investigator
	Idea / Cerebral-oriented Roles *(Roles that think creatively and analytically or contribute ideas)* Include Plant, Monitor Evaluator, Specialist
Davis et al. (1992)	**Planner** *(Estimates needs, plans strategies and schedules)*

	Include Strategist, Estimator, Scheduler
	Controller *(Records, audits and evaluates progress)* Include Monitor, Auditor, Evaluator
	Enabler *(Manages resources, promotes ideas and negotiates)* Include Resource Manager, Promoter, Negotiator
	Exec *(Coordinates and maintains the team)* Include Producer, Coordinator, Maintainer
	Driver *(Develops ideas, directs and innovates)* Include Developer, Director, Innovator
Margerison & McCann (1989)	Thruster-organizers, Concluder-producer, Controller-inspector, Assessor-Developer, Upholder-maintainer, Explorer-Promoter, Creator-Innovator, Reporter-Adviser
Myers (2002)	Crusader, Sculptor, Curator, Conductor, Coach, Explorer, Conductor, Curator, Innovator, Scientist
Parker (1994, 1998)	Contributor, Communicator, Collaborator, Challenger

Table 2: Team Roles and Categorization

From Table 2, it appears that while some researchers like Benne and Sheats (1948), Davis et al. (1992) and Belbin (1981, 1993) propose macroscopic categorization of team roles, other researchers like Margerison and McCann (1989), Myers (2002), and Parker (1994, 1998) propose microscopic categorization of team roles. In this study, we will attempt to study the macroscopic view of team roles because of the following reasons:

- A microscopic approach of individual team roles is too detailed as there are numerous team roles which may be difficult to keep track of by managers. Moreover, to utilize specific roles proposed in each theory can be time-consuming as most software developers are assembled in teams for projects that span over a short period of time and most teams are disbanded and reformed with other members in other software development projects.
- Comparisons between teams will be difficult for analysis as not all team roles are present in all teams to make a fair comparison. There may be overlap of individual team roles if we take the microscopic approach which will further complicate the analysis.

- Taking a macroscopic approach will also enable us to adopt a common methodology advocated by various studies.
- To utilize specific roles proposed in each theory can be expensive as they require tests to be administered for each team member in the team to identify their specific roles.

Therefore, in this study, we will use the macroscopic categorization of team roles. Table 3 shows the mapping between existing categorizations and our proposed categorization of roles in a team. Categorization of team roles by previous researchers are in **bold** whereas suggested categorizations of team roles are in ***bold and italics***.

Authors (year)	**Type of Team Roles** *(Definition)*					
Benne and Sheats (1948)	**Group Task Roles**		**Group Building and Maintenance Roles**		**Individual Roles**	
Belbin (1981, 1993, 1997)	**Action-Oriented Roles**		**People-oriented Roles**			**Idea / Cerebral-oriented Roles**
Davis et al. (1992)	***Action-Oriented Roles***		***Action- and People-Oriented Roles***			***Action-Oriented and Idea -oriented Roles***
	Planner	**Controller**	**Enabler**	**Exec**		**Driver**
Margerison & McCann (1989)	***Action-Oriented Roles***		***People-oriented Roles***			***Idea / Cerebral-oriented Roles***
Myers (2002)	***Action-Oriented Roles***		***People-oriented Roles***			***Idea / Cerebral-oriented Roles***
Parker (1994, 1998)	***Action-Oriented Roles***		***People-oriented Roles***			

Table 3: Existing and Proposed Categorizations of Team Roles

There are two common macroscopic categorizations of team roles by past researchers: 1) action-oriented roles that focus on completing tasks and 2) people-oriented roles that help foster group unity. Bales (1950) is one of the earliest researchers to propose these two main groups of roles. Task-oriented roles focus on completing the tasks whereas people-oriented roles foster group unity. These two main categorizations of roles have been consistently identified in most studies of team roles (Benne and Sheats, 1948, Belbin, 1993).

Other macroscopic groups of roles identified are (Berlin 1981, 1993) idea-oriented roles that provide ideas and solutions to problems. Prichard and Stanton (1999) commented that although never directly referenced, the research of Benne and Sheats (1948) appears to have inspired Belbin's (1981, 1993) team role theory. In particular, according to Belbin (1981, 1993), action-, people-, and idea-oriented roles could potentially be individual roles if their existence in a particular teamwork is not desirable.

According to Fisher, Hunter and Macrosson (1998a), although there are many team roles theories available, Belbin's Team Role Model appears to have the greatest impact by its widespread use. Belbin's Team Role Model is claimed to be used by over 40 percent of the top 100 companies in the UK, the United Nations, the World Bank and thousands of organizations throughout the world to enhance individual and team performance (Belbin 2006). Although Belbin's team role theory originally described in his book was developed from his work among managers and formulated with their activities and needs in mind, Fisher, Hunter and Macrosson (2002) have shown that Belbin's team role categorization can be used for non-managerial teams as well, such as software development teams (Sallie and Todd, 1999; Thomsett, 1990).

2.3.2 Desirable Team Roles in Different Key Stages of Team Activity

According to Belbin (1993), some team roles contribute more to team performance than others in a particular key stage of team building. Table 4 shows Belbin's categorization of key stages of team work and essential team roles required for each stage (Park and Bang 2002; Belbin, 1993).

Key Stages of Team Activity	Team Roles Relevant to Particular Stages
1. Identifying needs	Some projects fail because the wrong targets are set. Key figures at this stage are individuals with strong goal awareness. ***Shapers*** and ***Coordinators*** make their mark strongly in this area.
2. Finding ideas	It is often easier to formulate an objective than to decide how that objective can be achieved. Nothing begins to happen until someone has some ideas on how to proceed. Here ***Plants*** and ***Resource Investigators*** have a crucial role to play.
3. Formulating plans	Thinking about how it is all going to happen involves two prime activities. One entails setting out and weighing up the options, and providing pointers to the right decision. The second demands making good use of all relevant experience and knowledge so that any plans developed have the stamp of professionalism upon them. ***Monitor Evaluators*** make especially good long-term planners and ***Specialists*** also have a key role to play at this stage.
4. Making contacts	No plan is ever accepted unless people are persuaded that an improvement is in prospect. Ideas and plans need to be championed by cheer leaders who can drive home their value and win over the doubters. This is an activity in which ***Resource Investigators*** are in their element. But whipping up enthusiasm is not enough. Each new practice conflicts with an old one. Some disturbed group will need to be appeased. The best appeasers are ***Team Workers***.
5. Establishing the organization	One can never be sure that anything is going to happen until plans are turned into procedures, methods and working practices so that they may become routines. Here ***Implementers*** are in their element. These routines, however, need people to make them work. Getting the people to fit the system is what ***Coordinators*** are good at.
6. Following through	Robbie Burns reminds us that "the best laid plans of mice and men gang aft awry." Too many assumptions are made that all will work out well in the end. Good follow-through benefits from the attentions of concerned people. This is where ***Completer Finishers*** make their mark. ***Implementers***, too, pull their weight in this area, for they pride themselves on being efficient in anything they undertake.

Table 4: Key stages of team activity and required team roles

Table 5 shows a summary of the studies that utilized Belbin's team role categorization to investigate on certain roles that contribute more to team performance.

Authors (Year)	Type and Purpose of Study	Sample and Result
Senior (1997)	• Qualitative • To evaluate Belbin's team role theories in the context of a range of teams working within the public and private sectors	• 11 management teams of between four and nine members completed Belbin's Self Perception Inventory, participated in interviews to collect data on certain characteristics of their teams, the stage of team activity and their teams' performance. • The 11 teams were distributed amongst public and private sectors as follows: social services, borough councils, hospital trusts, benefit agency, financial institution and brewery. • Found some support for the hypothesis: Certain team roles contribute more to team performance in particular stages of activity.
Partington and Harris (1999)	• Quantitative • Examine relationship between team role and team performance	• 271 MBA students in 43 teams participated in a team-based management simulation. • Found support for "Some team roles contributing more to team performance than others for a given task" • Negative impact of Co-ordinator, Teamworkers and Plants • Positive impact of Shapers and Implementers
Park and Bang (2002)	• Quantitative • Examine performance with role balance and roles required for certain key stage	• 52 work teams with 316 employees from 6 companies participated in surveys which included Belbin's Self-Perception Inventory and Observers' Assessment. • The 6 companies are Hyundai Heavy Industries, Hyundai Motor Company,

		Hyundai Marine and Fire Insurance, Keum Kang Development Industrial, Hyundai Engineering and Construction, and Hunydai Human Resource Development Center) of the Hyundai Group in South Korea. • Performance of a team that has team roles required for certain key stage of the team will be better than those that do not have the required roles.
Rajendr an (2005)	• Qualitative • To present a team effectiveness analysis of software development teams by forming teams based on who can work effectively together	• 3 teams participated in surveys which included Belbin's Self-Perception Inventory and team leaders are interviewed. • The 3 teams consist of: 1. a four-person team from a major industry leader in telecommunications 2. a nine-person team from a small regional company focusing on software development and 3. a five-person team from a year long symposium on proper software development techniques that produces a viable product. • For the telecommunications team, innovation is needed for their project. Teams with a strong set of plants perform well where innovation is required. This is true for the telecommunication team which consists of all Plants and has performed well from all indications during the interview. • For the regional team, the team members' functions are strongly associated with the code on which they work. The team leader is expected to interact with people outside of the team. Resource investigators can address the needs of external interactions but the team leader is not a

		resource investigator. Hence, the team has indications of problems handling external contacts. • A major deficiency of the symposium team is in the testing area. This can by interpreted as a lack of completeness or attention to detail, which can be explained by the dearth of completer-finishers in the team.

Table 5: Summary of studies that show certain team roles contributing more to team performance

2.3.3 Desirable Team Characteristics in Different Phases of Software Development

Desirable team characteristics for each phase of the SDLC are listed in Table 6 (Peters, 2004).

Software Development Life Cycle (SDLC) Phase	**Desired Characteristic(s), Needed Skills**
Requirements	• Ability to listen, be non-judgmental, compassionate, gather facts • Ask questions only for clarification and not for assessment of the skill or fitness to job of the person being interviewed
Design	• Able to create multiple, alternative solutions, withholding selection of one or more as prime candidates for implementation until reviewed by others and evaluation criteria developed.
Code	• Work (largely) independently, interfacing primarily with a computer, work logically holding ego in check • Able to work within the constraints of the development environment and overcome other constraints, rules and issues not of their own making.
Test	• Strict, disciplined application of principles, processes, practices – logical, objective – strictly focused on being the messenger, not the message,

	dispassionate regarding results

Table 6: Desirable characteristics in the SDLC

2.3.4 Team Role Balance

One of the principles underlying Belbin's Team Role Model is that a team can deploy its technical resources to its best advantage only when it has the requisite range of team roles to ensure sufficient teamwork. This principle is known as "Team Role Balance" principle. Table 7 summarizes past studies of team role balance.

Authors (Year)	Type and Purpose of Study	Sample and Result
Senior (1997)	• Qualitative • To evaluate Belbin's team role theories in the context of a range of teams working within the public and private sectors	• 11 management teams of between four and nine members completed Belbin's Self Perception Inventory, participated in interviews to collect data on certain characteristics of their teams, the stage of team activity and their teams' performance. • The 11 teams were distributed amongst public and private sectors as follows: social services, borough councils, hospital trusts, benefit agency, financial institution and brewery. • Found some support for the hypothesis: A team should be balanced in terms of members' team roles in order for the team to be effective and high performing.
Partington and Harris (1999)	• Quantitative • Examine relationship between team role and team performance	• 271 MBA students in 43 teams participated in a team-based management simulation. • There is no significant correlation between team balance and team performance.
Prichard and Stanton	• Quantitative • To determine if	• 48 unpaid volunteers attending a management recruitment assessment day completed both Belbin's Self-Perception

(1999)	differences in team-role composition effected team performance at a management game in consensus decision making	Inventory and the Critical Reasoning Verbal Evaluation. • The participants are University graduates, whose ages ranged from 23 years to 45 years. • Supports Belbin's "role-balance" hypothesis: teams balance with respect to the team role composition of its members are more consistently successful than teams in which this balance is absent.
Park and Bang (2002)	• Quantitative • Examine performance with role balance and roles required for certain key stage	• 52 work teams with 316 employees from 6 companies participated in surveys which included Belbin's Self-Perception Inventory and Observers' Assessment. • The 6 companies are Hyundai Heavy Industries, Hyundai Motor Company, Hyundai Marine and Fire Insurance, Keum Kang Development Industrial, Hyundai Engineering and Construction, and Hunydai Human Resource Development Center) of the Hyundai Group in South Korea. • As the number of team roles represented in a team at a 90-score criterion is increased, performance of a team will be increased too. This provided some support for team role balance.
Higgs, Plewnia and Ploch (2005)	• Quantitative • Investigates the effect of team composition of teams in a real world setting and task complexity was also measured and compared to team performances	• 28 teams with over 270 employees at Ford Motor Company in the Body Construction Shop (Manufacturing) in Cologne and in Diesel Engineering Product Development in Dunton participated in questionnaires. The respondents are from collocated teams. • Team performance is positively influenced by high team role balance.

Table 7: Summary of studies on Team Role Balance

2.4 Impact of Team Roles on GVT's Performance

Factors caused by space-time dispersion such as time zone differences and communication delays have been commonly blamed for hindering the development of positive intra-team member relationships (Mannix, Griffith and Neale, 2002; Duarte and Snyder, 1999) and thus resulting in poor team performance (Kankanhalli, Tan and Wei, forthcoming; Lurey and Raisinghani, 1999; Warkentin and Beranek, 1999). Space-time dispersion in GVT has been linked to relationship conflicts that occur between interdependent individuals when they experience negative emotional reactions to perceived disagreements. Studies have related such conflicts with decreased team performance (Kankanhalli et al., forthcoming; De Dreu and Weingart, 2003; Jehn, Chadwick and Thatcher, 1997). Several studies have looked at the effects of distance on team work and found that conflict will be more extreme with geographically distributed teams as compared to collocated teams (Hinds and Mortensen, 2005; Hinds and Bailey 2003; Mannix et. al. 2002). Studies on distributed software teams also link geographic dispersion with increased failure to communicate, misunderstandings and increased coordination overhead (Carmel, 1999; Herbsleb, Mockus, Finholt and Grinter, 2000; Olson and Olson, 2000; Armstrong and Cole, 2002). People-oriented roles help foster group unity and positive interpersonal relations, thus reducing relationship conflicts and increase team performance.

Several studies have examined how virtual team facilitators utilize virtual team communications to alleviate the GVT problems mentioned above. Warkentin and Beranek (1999) found that virtual team communications will lead to improved perceptions of the interaction process over time, specifically with regard to trust, commitment and frank expression between members. Virtual team communications will also increase the exchange of socio-emotional information that helps teams develop relationships and result in improved performance (Warkentin and Beranek, 1999). Pauleen and Yoong (2001) has also looked at how virtual team facilitators build and manage relationships with their team members and found that distance and time affect the strategies used by restricting the kinds of communication channels available. Virtual team facilitators are similar to people-oriented roles and people-oriented roles will help to

increase virtual team communications. Virtual team facilitators are similar to the functions performed by people-oriented roles.

Chapter 3 Research Model and Hypotheses

The three phases of software development being looked into in this study are:

Phase 1: Requirement analysis and Design

Phase 2: Coding and Unit testing

Phase 3: System integration testing and User Acceptance testing

Belbin's team role theory is adopted and a macroscopic approach is taken to analyze the impact of team roles on team performance. The three categories of roles common across different team role theories are (1) Action-oriented roles, (2) People-oriented roles and (3) Idea-oriented roles.

3.1 Desirable Categories of Team Roles in the Different Phases of SDLC

Based on Table 4, Belbin (1993) has identified different roles for different key stages of team work. In the context of this study, it seems that in a particular phase(s) of software development, a particular group(s) of roles will contribute most to team performance. The summaries of studies in Table 5 further supports that certain roles contribute more to team performance. Based on the desirable characteristics identified in each phase in Table 6, hypothesis will be formulated to identify desirable categories of team roles in the three phases of software development identified.

Software engineers contribute ideas during requirement analysis and design in order to decide how best to implement the requirements by providing various alternative solutions, before evaluating each solution and deciding on the best implementation. Moreover, in Table 4, Belbin believed that plants and resource investigators have a key role to play in finding ideas, and that monitor evaluators and specialists have a crucial role in formulating plans. Finding ideas and formulating plans correspond to the activities performed in Phase 1. Plants, monitor evaluators and specialists are idea-oriented roles. Although resource investigators are not idea-oriented roles, they are adept at exploring

new opportunities, picking up other people's ideas and developing them. Such characteristics are also found in idea-oriented roles. Hence, in this phase, it is believed that idea-oriented roles will contribute most to team performance. Therefore, we hypothesize:

H1: In Phase 1, idea-oriented roles will contribute the most to team performance.

In the coding phase, the software developers will have to implement the decided design and complete the work according to plans, testing their own separate parts and ensuring it performs according to specifications. This phase is similar to the activity of "Following through" in Table 3. Belbin believes that completer finishers and implementers are important for this phase. Both completer finishers and implementers are action-oriented roles. Hence, we hypothesize:

H2: In Phase 2, action-oriented roles will contribute the most to team performance.

In the testing phase, system integration and user acceptance testing will be carried out. During system integration, as software developers integrate the different parts and test to see if it works. At the same time, they will compare the results to the specifications to check if they have completed the requirements. This is similar to the unit testing phase in Phase 2 which requires action-oriented roles. For user acceptance testing, demonstration of software before the user is required. Therefore, people-oriented roles are believed to play an important part. Therefore, we hypothesize:

H3: In Phase 3 action- and people-oriented roles will contribute the most to team performance.

3.2 Team Role Balance

The team role balance theory has not been tested before in the software development team context. A team will become unbalanced if all team members have similar team roles. This is because if team members have similar styles of behaviour or team roles, team members will not co-operate to complete the tasks but tend to compete for the tasks that best suit their natural styles. On the other hand, if all roles are represented, each member will complement each others' strengths and curtail their weaknesses (Fisher,

Hunter and Macrosson 1998b). Belbin asserted that the more a team displays "a spread of personal attributes, laying the foundation for different team role capabilities," the greater the probability for it to be high performing (Belbin, 1993). Researchers also claimed that when the team roles are fully represented among team members, the team's performance is improved (Park and Bang, 2002). There will be team balance when each role is represented in at least a team member's profile as a high-scoring role. Hence, we hypothesize:

H4: "Balanced" teams (those with a spread of action-oriented roles, people-oriented roles, and idea-oriented roles) will perform better than "unbalanced" teams (those with relatively more categories of team roles i.e. action-oriented roles, people-oriented roles or idea-oriented roles unrepresented).

3.3 Team Roles to Mediate Team Members' Relationships and Increase GVT's Performance

Research on GVTs is burgeoning, yet our understanding of the impact of team roles on the dynamics in distributed teams remains vague (Sutanto, Phang, Kuan, Kankanhalli and Tan, 2005). We set out to investigate the impact of team roles on intra-team member relationship and team performance as studies have often relate poor relationships between members with decreased team performance (De Dreu and Weingart, 2003; Jehn et al., 1997). We attempt to find team roles that will improve intra-team member relationship and thus increase team performance. Since studies on distributed software teams also generally link geographic dispersion with increased failure to communicate, misunderstandings and increased coordination overhead (Carmel, 1999; Herbsleb, Mockus, Finholt and Grinter, 2000; Olson and Olson, 2000; Armstrong and Cole, 2002), we seek to investigate the roles to mediate such problems in global virtual teams.

Based on the definition of people-oriented roles, it is believed that with a higher representation of people-oriented roles, intra-team relations will be improved. Hence, we expect that people-oriented roles may help to improve team performance. Moreover, Sutanto et al. (2005) observed that people-oriented roles helped a team to maintain group

cohesion. Therefore, we deduce that having a higher representation of people-oriented roles will increase team performance with increased geographical dispersion. However, we should not only focus on geographical dispersion and ignore the effects of time. O'Leary and Cummings (2004) point out that spanning time zones adds complexity to the coordination and communication in a team and is likely to amplify spatial separations and make events like conference calls difficult to schedule. Therefore, we assume that with less overlapping working hours, there will be fewer interactions among the distributed team, increasing the importance of people-oriented roles to foster group unity and positive interpersonal relations, thereby enabling members to work well together. Hence, we hypothesize:

H5: As the team is more dispersed across space and time, an increased representation of people-oriented roles will increase team performance.

A summary of the five hypotheses are presented in Figure 1.

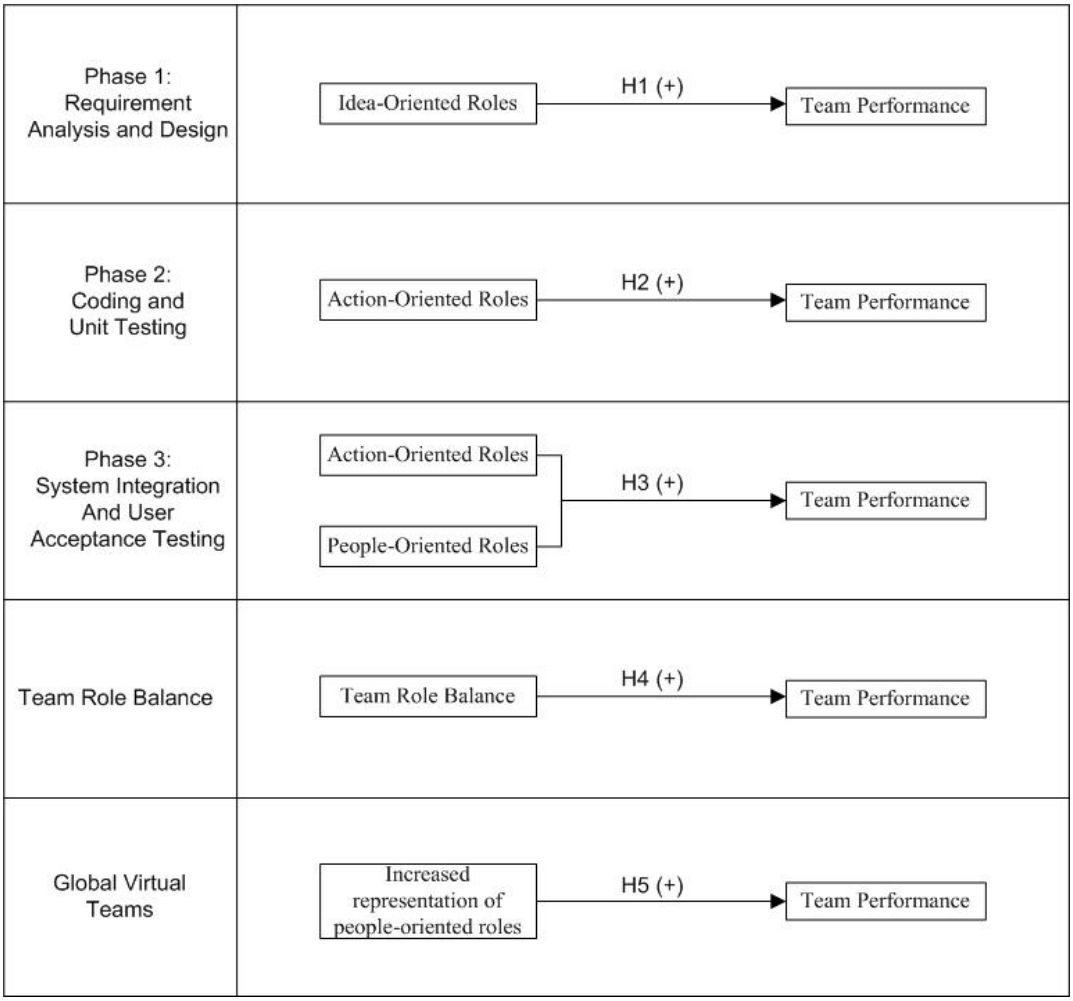


Figure 1: Summary of five hypotheses

Chapter 4 Research Methodology

This chapter presents the methodology used in this study. We will begin with the justifications to adopt the survey methodology and then go on to the operationalization and validation process of the survey instrument. Finally, we will look at the administration of the survey.

4.1 Justifications for Survey Methodology

A survey is a way of going from observations to theory validations (Newsted, Munro, Huff and Schwarz, 1998). IS researchers usually use surveys to determine the relationship of the constructs as a way of making sense of behaviour surrounding and involving IS (Newsted et al., 1998). Surveys are particularly useful in determining the actual values of variables under study, and the strength of relationships among them in positivist research (Newsted, Chin, Ngwenyama and Lee, 1996). Survey forms will be given to respondents that have some experiences with software development in a team, so as to determine the relations of variables and constructs identified in the hypotheses and ensure that the results can be generalized to other members of the population studied, or even similar populations (Newsted et al, 1998).

Since most of the items in the study are adopted from existing literature or newly developed, it will be necessary to go through a systematic procedure to ensure the validity of the survey items. If validated measures are lacking, the findings in this study will not be reliable. Moreover, attention given to instrumentation issues will bring clarity to the formulation and interpretation of the research issues (Straub, 1989). Churchill (1979) developed a framework to generate better measures for constructs. Moore and Benbasat (1991) provided a detailed procedure for conceptual validation of constructs. Based on their work, the instrument validation framework of this study is sketched in Figure 2.

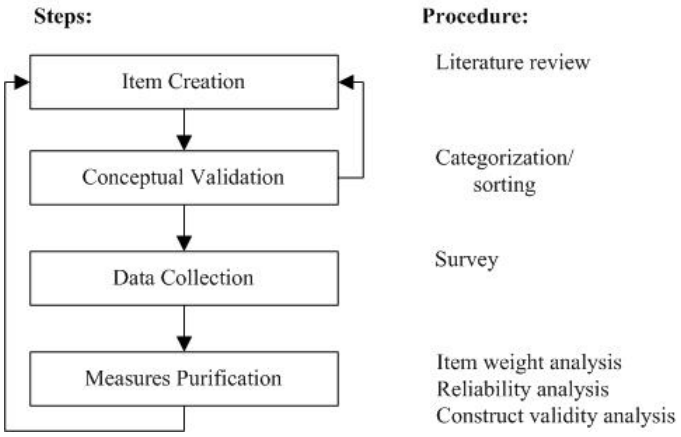


Figure 2: Instrument Development Framework (Adapted from Churchill, 1979)

4.2 Operationalization

4.2.1 Team Performance Metrics

In this study, we will measure the team performance based on the respondents' assessment of the team performance as compared to other software projects of similar size/complexity that respondents were involved in. Team performance is assessed through six questions using a seven-point Likert scale (1 being extremely low to 7 extremely high) based on the following attributes in Table 8:

Performance Items	Attribute
PERF1	The efficiency of the team operations
PERF2	The team's adherence to schedules
PERF3	The team's adherence to budget
PERF4	The quality of work the team produces
PERF5	The quality of the team's deliverables
PERF6	The team's ability to meet the goals of the Phase

Table 8: Performance Items and attributes

4.2.2 Measurements of Team Roles

To measure each category of team roles quantitatively, items are developed using the most applicable words pertaining to each category of team roles based on the description provided. Belbin has devised two instruments to measure and determine each team role. These two instruments are Self-Perception Inventory (SPI) and Observers' Assessment (OA). SPI are given to individuals to determine the subject's 'natural' team role whereas OA are given to peers to evaluate the subject's role and are generally completed by a

close colleague of the subject. The words used to measure each category of team roles are chosen from Belbin's Self-Perception Inventory (SPI) and Observers' Assessment (OA). A six-point scale was provided to determine whether the attribute is present in the team. The higher the score for an attribute, the higher the representation of the group of roles present. The usage of six-point scales is used to determine the attributes present in the team during the phases are acceptable as providing an adequate range (Hair, Anderson, Tatham and Black, 1995). Moreover, a six-point scale forces evaluation above or below the mid-point (Hair et al., 1995). The six-point scale also caters for attributes that are not present at all in the teams during the phases. Senior (1997) noted that in groups of executives and senior managers, there was a significant degree of agreement between self-perception and observant's perception, and between the observers themselves. Therefore, items measuring each macroscopic category of team roles studied are chosen from Belbin's two instruments that best represent the role and shown in 9.

Team Roles	**Item**	**Survey Items (adapted from Belbin's SPI and OA, 1997)**
Action-oriented roles	A1	Disciplined
	A2	Good at following through
	A3	Observant
	A4	Persistent
People-oriented roles	P1	Calm and confident
	P2	Encourage others
	P3	Outgoing
	P4	Diplomatic
Idea-oriented roles	I1	Imaginative
	I2	Innovative
	I3	Original
	I4	Unorthodox

Table 9: Measurements of Categories of Team Roles

4.2.3 Measurements of Team Role Balance

Although Belbin (1993) asserted that the most effective teams comprise a spread of all team roles identified in the Belbin Team Role model, the model provided little guidance on how to calculate balance. This study will make use of two team balance indexes (labeled TBI1 and TBI2) which were used by Partington and Harris (1999).

TBI1 is calculated on the premise that the aggregate score from each team will be evenly spread across three categories of team roles. On this basis, in a perfectly balanced team (TBI1=100 percent), the total score of each role category will be 20. The higher the aggregate of absolute deviations from 20, the lower the team role balance index. TBI2 is calculated from the premise that a balanced team would have at least indications of high or very high scores derived from data collected, in as many as possible of the three groups of roles. Each team will be awarded *1 point* for each group of roles that has a high or very high score and *2 points* for each group of roles that has a low or average score. A perfectly balanced team with all groups of roles represented will have a TBI2 of 100 percent. Examples of the calculations of TBI1 and TBI2 of Team A are presented in Table 10 and Table 11 respectively.

Team A	**Total score**	**Deviation from 20**
Action-oriented roles	18	2
Idea-oriented roles	12	8
People-oriented roles	17	3
	Total	13
Notes: TBI1 = 3 ÷ (13 + 3) × 100 = 18.75		

Table 10: Example calculation of TBI1

Team A	**Indications**	**Points**
Action-oriented roles	High	1
Idea-oriented roles	Very High	1
People-oriented roles	Low	2
	Total	4
Notes: TBI2 = (3 ÷ 4) × 100 = 75		

Table 11: Example calculation of TBI2

4.2.4 Measurements of Team Dispersion

To measure spatial and temporal dispersion, the respondents are asked to indicate the number of team members working during the phase, and the locations of the team members, the number of team members in each location and the working hours of team members. These data are collected to calculate both spatial and temporal dispersion.

To calculate spatial dispersion, the mileage index developed by O'Leary and Cummings (2004) was used. The mileage index is weighted by the number of members at each site, based on a matrix of all possible, non-redundant, member-to-member connections (O'Leary and Cummings, 2004). The higher the mileage index, the more dispersed the team. For a hypothetical team of 8 members dispersed across three sites (K, L, M) with distance (in miles) among sites are as follows: D_{KL}=1000 miles, D_{KM}=2000 miles, D_{LM}=3000 miles and with n_K=3, n_L=2 and n_M=3 members per site, the mileage index for this hypothetical team would be calculated as follows:

$$\text{Mileage Index}_{KLM} = [(D_{KL} * n_K * n_L) + (D_{KM} * n_K * n_M) + (D_{LM} * n_L * n_M)]/[(n^2-n)/2]$$

where n_i is the number of members at site I and n is the total number of members on the team (O'Leary and Cummings, 2004). Thus for this team, the Mileage index = $[(1000*3*2)+(2000*3*3)+(3000*2*3)]/[(8^2-8)/2] = 1500$. An expanded calculation can be used for teams with more sites, with distances and weights being added for each new member-to-member connection. To calculate mileage index, we refer to http://www.webflyer.com/travel/milemarker/ for the distance between two sites. After this, the mileage index is calculated based on the distances between the sites and the number of people at each site according to the formula above.

The Time Zone Index (O'Leary and Cummings, 2004) was used to capture the extent to which team members have common work hours during which they could communicate synchronously. Calculations of the Time Zone Index parallel that of the Mileage Index, in that it builds on a matrix of all possible member-to-member connections and the time zone of each site. To calculate Time Zone Index, we referred to http://www.timeanddate.com/worldclock/meeting.html for the difference in time zones between two countries. After this, the time zone index was calculated based on the

differences in time zones between the sites and the number of people at each site according to the Mileage Index formula above.

4.2.5 Control Variables

Three variables will be used as control variables in this study to check if they have any impact on team performance. These 3 variables are: (1) Task Novelty (2) Task Analyzability and (3) Task Variability. The items for each control variable are presented in Table 12.

Task Novelty Items	**Attribute**
TNOV1	The technology used in The Phase is new to the team.
TNOV2	All team members have never used the technology before.
Task Analyzability Items	**Attribute**
TAYL1	A clearly known way to do the work in The Phase
TAYL2	A clearly defined body of knowledge that can guide the work
TAYL3	An understandable sequence of steps that can be followed
TAYL4	Established practices to do the work in The Phase
Task Variability Items	**Attribute**
TVAR1	The actual work in The Phase fluctuated from what was planned.
TVAR2	The actual work in The Phase turned out different than planned.
TVAR3	The actual work in The Phase varied from what was planned.

Table 12: Control Variables and Attributes

4.3 Conceptual Validation

The conceptual validation procedure in this study is adopted from Moore and Benbasat (1991). The card-sorting methodology developed by Moore and Benbasat (1991) requires 4 judges to sort items into constructs categories. The sorting methodology adopted in this study is a slightly modified version of the Moore and Benbasat method as the first phase of the sorting process, whereby judges are asked to provide labels for the construct, is eliminated since the constructs are well defined. Moreover, as the judges had experience with sorting, the trial sort was eliminated too. Hence, only the structured sorting in the second round was administered.

Four postgraduate students were selected from the Information Systems department of the National University of Singapore as judges. Judges were provided with an overview of Belbin's team roles and were told to assume the role of an observer in the Observers' Assessment. A definition for team role which was the construct of interest was also provided. A category labeled as "Does Not Fit" was provided so as to avoid forcing an item into a given category. The conceptual validity of the items was measured by the level of agreement among the judges and the overall hit rate, which is the placement ratio of the items put into the correct targeted constructs. The level of agreement was measured by computing Cohen's Kappa scores (Cohen, 1960) across all pairs of judges. Table 13 shows the sorting results.

Judges	Raw Agreement	Cohen's Kappa
1 and 2	91.7%	87.4%
1 and 3	91.7%	87.4%
1 and 4	83.3%	74.5%
2 and 3	100%	100%
2 and 4	91.7%	87.4%
3 and 4	91.7%	87.4%
Average	91.7%	87.4%

Table 13: Raw Agreement and Cohen's Kappa Scores for sorting

The average Kappa score is 87.4%, which is above 0.65, a score that are considered acceptable (Jarvenpaa, 1989). Moreover, the average agreement between judges is 91.7% which was greater than the recommend level of 70% (Miles and Huberman, 1994). Based on the sorting comments, we discovered that item *A3* was somewhat ambiguous and was therefore reworded from "Observant" to "Attentive to details". The refined item lists used in the survey is as shown in Table 14.

Group of Roles	Item	Attribute
Action-oriented roles	A1	Disciplined
	A2	Good at following through
	A3	Attentive to details
	A4	Persistent
People-oriented roles	P1	Calm and confident
	P2	Encourage others
	P3	Outgoing

	P4	Diplomatic
Idea-oriented roles	I1	Imaginative
	I2	Innovative
	I3	Original
	I4	Unorthodox

Table 14: Final Survey Items

4.4 Survey Administration

The survey questionnaires were distributed to software professionals. Respondents are asked to answer the survey with respect to a particular phase of the software development process they were involved in. They are also asked to choose an experience of being involved in working in a global virtual team. All the participants in the survey were voluntary and they were paid SGD $10 after they completed the survey. A total of 123 software developers participated in the survey.

4.5 Descriptive Analysis

Out of 123 respondents, 57.8% have less than 3 years of working experience in their current organization and the majority of the respondents are employed in the computer industry (50.0%). Most of their organizations have between 1000-2499 employees (15.7%) or less than 50 employees (15.7%). Details of the characteristics of the respondents, their organizations and projects are shown in Table 15 and Table 16 respectively.

	Frequency	Percentage (%)
Working Experience in Current Company		
0 -< 3	59	57.8
3 -< 6	21	20.6
6 - <9	18	17.6
>=9	4	4
Total Working Experience		
0 -< 3	26	25.5
3 -< 6	27	26.5
6 - <9	25	24.5
>=9	24	23.6

Table 15: Characteristics of Respondents

	Frequency	Percentage (%)
Phase		
Requirement Analysis and Design	29	28.4
Coding and Unit Testing	40	39.2
System Integration and User Acceptance Testing	33	32.3

Team Type		
Global Virtual Teams	52	42.3
Co-located Teams	71	57.7
Type of Industry		
Manufacturing	9	8.8
Finance: Banking/Insurance	8	7.8
Trade: Wholesale/Retail	2	2
Computer Industry: Software Services/Consultants/Vendors	51	50
Transportation Services	3	2.9
Utilities and Communication	2	2.0
Education	10	9.8
Medical and Legal Services	1	1
Entertainment	1	1
Others	15	14.7
Type of Department		
Finance	2	2
Product Development	14	13.7
Operations	9	8.8
Information Technology	53	52
Research and Development	18	17.6
Others	6	5.9
Number of Employees		
Fewer than 50	16	15.7
50-249	19	18.7
250-499	13	12.7
500-999	10	9.8
1000-4999	29	28.4
5000 or more	15	14.7

Table 16: Characteristics of Organizations and Projects

Chapter 5 Data Analysis

5.1 Data Analysis Strategy

In this study, attempts are made to develop reliable and valid measures for the constructs. To ensure the reliability and validity of the items in the measurement model, a principal-component analysis was run for each hypothesis and the factor loadings and Cronbach's Alpha for constructs were looked at. Subsequently, hypothesis testing was performed using multiple regression. Principal components factor analysis with varimax rotation was used to summarize data relating to each variable. The principal components method was selected because it assumes that variables are linear combinations of factors, enabling underlying constructs identified by the analysis to be more concise. Factor analysis is used to identify items, which should be included in a consistent measuring instrument (Muttar, 1985). Given that one of the objectives of this study is to develop measures to identify different categories of roles so as to assess the impact of team roles

on team performance, factor analysis is chosen to evaluate construct validity (Nunnally, 1978; Badri and Davis, 1995). Varimax rotation was chosen because it further refines the underlying constructs by maximizing loadings on a single factor and minimized conflicting loadings on other factors.

Items for each factor have to load well on their respective constructs with a minimal standard of 0.45 suggested by Hair et al. (1995). A new variable for each factor was obtained using Anderson-Rubin scores for items that loaded together to ensure the orthogonality of the factors. Reliability analysis was conducted and the Cronbach's Alpha was examined. Cronbach's Alpha greater and equal to 0.65 was accepted and considered good (Stern, Mullennix and Yaroslavsky, 2006).

Multiple regression was used to account for the variance in performance, based on linear combinations of the different groups of roles for hypothesis 1, 2, 3 and 5. Multiple regression can establish that the different groups of roles explain a proportion of the variance in performance at a significant level (through significance test and R^2) and can establish the relative predictive importance of the independent variables (groups of roles). Prior to performing multiple regression, descriptive statistics are obtained to ensure that variables are normally distributed. Multicollinearity is assessed by inspecting the tolerance and variance-inflaction factor (VIF) in the collinearity statistics section. For testing of hypothesis 4, pearson product moment correlations are obtained in order to examine the relationship between team balance and team performance. Pearson product moment correlations were chosen because they were used in a similar study (Partington and Harris, 1999) and also measure linear associations between the two variables i.e. team balance and team performance. Control variables are accounted for in all hypotheses and did not have any effect on team performance.

Data was analyzed by using SPSS 14.0 for Windows. The instrument validity and the results of testing the respective hypotheses will be presented.

5.2 Instrument validation results

We will look at each hypothesis respectively and evaluate the constructs.

5.2.1 Phase 1

Out of a total of 123 survey respondents, 102 survey respondents chose one phase whereas the rest answered with respect to a few phases. Of these 102 respondents, 29 respondents answered with respect to requirement analysis and design (Phase 1). A principal-components analysis was run on the 27 survey items to examine the structure of participants' perception of the performance and the attributes found in the team. A seven-factor solution was obtained, and factor loadings after varimax rotation showed that six items (Efficiency of team operations, Adherence to schedules, Adherence to budget, Quality of work team produces, Quality of Team's Deliverables, Ability to meet the goals) loaded on the first factor (>.60), which was labeled Performance. Four other items (Disciplined, Good at following through, Attentive to details, Persistent) loaded on a second factor (>.63) which was labeled Action-Oriented. Four other items (Calm and confident, Encourage others, Outgoing, Diplomatic) loaded on a third factor (>.58) which was labeled People-Oriented. Three other items (Imaginative, Innovative, Original) loaded on a fourth factor (>.65) which was labeled Idea-Oriented. The last item *I4*, (Unorthodox) was dropped as it loaded with attributes that measure people-oriented roles. The items, TNOV1 and TNOV2 loaded on a fifth factor (>.76) which was labeled Task Novelty. The items, TAYL1, TAYL2, TAYL3 and TAYL4 loaded on a sixth factor (>.77) which was labeled Task Analyzability. The items TVAR1, TVAR2, TVAR3 loaded a seventh factor (>.61) which was labeled Task Variability. Table 17 shows the factor loadings for the items.

	Component						
	1	2	3	4	5	6	7
PERF1	.385	.793	-.028	.318	.018	-.043	.029
PERF2	.589	.593	.142	.038	.005	.080	.216
PERF3	-.083	.792	-.003	.024	.068	-.004	.303
PERF4	.384	.709	-.001	.098	.320	.206	-.190
PERF5	.280	.679	-.037	.242	.288	-.052	-.339
PERF6	-.042	.692	-.049	.382	.107	-.180	-.327

A1	.593	.248	.018	.625	-.081	.068	-.130
A2	.339	.283	.172	.631	.418	.112	.025
A3	.039	.097	.034	.789	.184	-.053	.049
A4	.232	.206	.269	.807	-.049	-.022	.167
P1	.299	.128	.842	-.024	.104	-.131	-.069
P2	.072	-.057	.768	.072	.121	-.221	.199
P3	-.222	-.038	.774	.037	.038	.146	.229
P4	-.348	.232	.581	.210	-.303	-.016	-.097
I1	.063	.146	.491	.178	.647	-.285	.067
I2	.060	.090	.617	-.046	.704	-.115	-.050
I3	.199	.237	.037	.344	.709	.107	.011
I4	-.194	-.256	.719	.185	.113	-.018	-.011
TNOV1	.152	-.066	.145	-.081	-.178	.149	.867
TNOV2	-.138	.071	.077	.289	.225	-.068	.760
TAYL1	.771	-.284	.180	.049	.197	-.128	-.022
TAYL2	.792	.179	-.151	.269	.260	-.052	-.100
TAYL3	.810	.320	-.215	.130	.218	-.102	-.017
TAYL4	.836	.320	-.094	.134	-.215	-.010	.110
TVAR1	.076	.228	-.221	-.087	.463	.609	-.067
TVAR2	.013	-.027	-.211	.003	-.187	.833	.238
TVAR3	-.183	-.088	.062	.027	.000	.896	-.061

Table 17: Rotated Component Matrix for Phase 1 Sample

The reliability was good for the seven factors (≥0.72) and the Cronbach's α for each construct is summarized in Table 18.

Construct	No. of Items	Items	Cronbach's Alpha
Performance	6	PERF1, PERF2, PERF3, PERF4, PERF5, PERF6	0.884
Action-Oriented	4	A1, A2, A3, A4	0.855
People-Oriented	4	P1, P2, P3, P4	0.766
Idea-Oriented	3	I1, I2, I3	0.829
Task Novelty	2	TNOV1, TNOV2	0.719
Task Analyzability	4	TAYL1, TAYL2, TAYL3, TAYL4	0.885
Task Variability	3	TVAR1, TVAR2, TVAR3	0.738

Table 18: Reliability Analysis for Phase 1 Sample

5.2.2 Phase 2

Out of a total of 123 survey respondents, 102 survey respondents chose one phase whereas the rest answered with respect to a few phases. Of these 102 survey respondents, 40 respondents answered with respect to coding and unit testing (Phase 2). A principal-components analysis was run on the 27 items to examine the structure of participants' perception of the performance and the attributes found in the team. A seven-factor solution was obtained and factor loadings after varimax rotation showed that six items (Efficiency of team operations, Adherence to schedules, Adherence to budget, Quality of work team produces, Quality of Team's Deliverables, Ability to meet the goals) loaded on the first factor (>.63), which was labeled Performance. Three other items (Disciplined, Attentive to details, Persistent) loaded on a second factor (>.50) which was labeled Action-Oriented. One item *A2* (Good at following through) was dropped as it loaded with attributes that measure performance. Three other items (Calm and confident, Encourage others, Outgoing) loaded on a third factor (>.65) which was labeled People-Oriented. One item *P4* (Diplomatic) was dropped as it loaded with attributes that were used to measure idea-oriented roles. Four other items (Imaginative, Innovative, Original, Unorthodox) loaded on a fourth factor (>.53) which was labeled Idea-Oriented. The items, TNOV1 and TNOV2 loaded on a fifth factor (>.89) which was labeled Task Novelty. The items, TAYL1, TAYL2, TAYL3 and TAYL4 loaded on a sixth factor (>.65) which was labeled Task Analyzability. The items TVAR1, TVAR2, TVAR3 loaded a seventh factor (>.77) which was labeled Task Variability. Table 19 shows the factor loadings for the items.

	Component						
	1	2	3	4	5	6	7
PERF1	.820	.071	.036	-.004	-.012	.064	-.097
PERF2	.700	.215	.230	-.193	.065	.246	-.016
PERF3	.655	.331	.142	.124	.202	.280	-.098
PERF4	.631	.352	-.021	-.185	.411	.228	-.081
PERF5	.748	.291	.060	-.124	.369	.103	-.054
PERF6	.672	.439	.197	-.230	.300	.126	-.007
A1	.342	.052	.140	-.156	.563	.027	.127
A2	.614	-.202	.161	.280	.383	.077	.150
A3	.166	.106	.263	.102	.605	.545	-.047
A4	.224	.138	.058	.021	.816	.079	.050
P1	.365	-.007	.142	-.161	.351	.654	-.037

P2	.320	.084	.096	-.128	.320	.675	-.235
P3	.146	.031	.391	-.035	-.253	.738	.226
P4	.300	-.048	.758	.045	-.064	.178	.119
I1	.064	-.106	.822	-.081	.077	.021	.113
I2	-.067	.420	.527	.006	.412	.228	-.192
I3	.479	.025	.623	-.189	.173	.021	-.043
I4	-.094	.101	.681	.111	.220	.294	.150
TNOV1	-.106	-.033	.177	-.142	.049	-.016	.891
TNOV2	.011	-.080	.059	-.036	.046	-.014	.913
TAYL1	.520	.689	-.200	-.040	-.031	-.005	.116
TAYL2	.226	.645	-.092	-.164	.028	-.057	-.379
TAYL3	.118	.857	-.017	-.114	.088	.151	.174
TAYL4	.159	.887	.148	-.008	.152	-.023	-.216
TVAR1	.112	-.050	.054	.771	-.126	-.337	-.064
TVAR2	-.169	-.193	.042	.909	-.018	.010	-.065
TVAR3	-.119	-.007	-.144	.929	.053	.078	-.052

Table 19: Rotated Component Matrix for Phase 2 Sample

The reliability was good for the seven factors (≥0.72) and the Cronbach's α for each construct is summarized in Table 20.

Construct	No. of Items	Items	Cronbach's Alpha
Performance	6	PERF1, PERF2, PERF3, PERF4, PERF5, PERF6	0.922
Action-Oriented	3	A1, A3, A4	0.724
People-Oriented	3	P1, P2, P3	0.758
Idea-Oriented	4	I1, I2, I3, I4	0.725
Task Novelty	2	TNOV1, TNOV2	0.880
Task Analyzability	4	TAYL1, TAYL2, TAYL3, TAYL4	0.855
Task Variability	3	TVAR1, TVAR2, TVAR3	0.875

Table 20: Reliability Analysis for Phase 2 Sample

5.2.3 Phase 3

Out of a total of 123 survey respondents, 102 survey respondents chose one phase whereas the rest answered with respect to a few phases. Of these 102 respondents, 33 respondents answered with respect to system integration testing and user acceptance testing (Phase 3). A principal-components analysis was run on the 27 items to examine the structure of participants' perception of the performance and the attributes found in the team. A seven-factor solution was obtained and factor loadings after varimax rotation

showed that six items (Efficiency of team operations, Adherence to schedules, Adherence to budget, Quality of work team produces, Quality of Team's Deliverables, Ability to meet the goals) loaded on the first factor (>.59), which was labeled Performance. Three other items (Disciplined, Good at following through, Persistent) loaded on a second factor (>.68) which was labeled Action-Oriented. One item, *A3* (Attentive to details) was dropped as it loaded with attributes that measure performance. Two other items (Calm and confident, Encourage others) loaded on a third factor (>.65) which was labeled People-Oriented. Two items, *P3* and *P4* (Outgoing, Diplomatic) was dropped as it loaded with attributes that measure action-oriented roles. Four other items (Imaginative, Innovative, Original, Unorthodox) loaded on a fourth factor (>.56) which was labeled Idea-Oriented. The items, TNOV1 and TNOV2 loaded on a fifth factor (>.89) which was labeled Task Novelty. The items, TAYL1, TAYL2, TAYL3 and TAYL4 loaded on a sixth factor (>.49) which was labeled Task Analyzability. The items TVAR1, TVAR2, TVAR3 loaded a seventh factor (>.54) which was labeled Task Variability. Table 21 shows the factor loadings for the items.

	Component						
	1	2	3	4	5	6	7
PERF1	.779	.204	-.017	.056	-.038	.026	.363
PERF2	.818	.180	-.188	.028	.170	.163	.059
PERF3	.729	.112	-.237	.424	.242	-.012	-.207
PERF4	.861	.072	.182	.010	-.168	.177	.198
PERF5	.908	.014	.129	-.004	-.175	.052	.151
PERF6	.587	.395	-.245	.038	-.298	.169	-.007
A1	.307	.765	.175	.199	.038	-.077	.245
A2	.350	.744	-.045	.153	.104	.232	.140
A3	.597	.517	.269	-.248	-.026	.124	.070
A4	.581	.681	-.079	-.116	.176	-.009	.148
P1	.280	.276	-.134	.050	.114	.128	.781
P2	.429	.255	.203	-.002	.030	.181	.648
P3	-.008	.813	.244	-.100	.063	.055	-.016
P4	-.052	.610	-.072	.051	-.439	.051	.409
I1	.246	-.015	.094	.080	.021	.831	.336
I2	.333	.241	-.042	-.065	-.050	.717	.150
I3	.356	.434	-.117	-.299	.023	.564	.071
I4	-.193	-.079	.182	.033	.178	.572	-.222
TNOV1	-.077	.034	.913	-.039	.063	.139	-.026
TNOV2	.089	.082	.892	-.119	.087	-.032	.119

TAYL1	.014	-.210	-.533	.537	-.160	-.053	.235
TAYL2	.030	-.336	-.562	.488	-.334	-.047	.350
TAYL3	.038	-.035	-.110	.813	-.387	-.069	-.103
TAYL4	.106	.189	-.121	.911	-.124	.032	.037
TVAR1	.175	.048	-.087	-.440	.536	-.081	-.236
TVAR2	-.087	.091	.056	-.165	.874	.071	.098
TVAR3	-.121	-.002	.295	-.225	.807	.125	.088

Table 21: Rotated Component Matrix for Phase 3 Sample

The reliability was good for the seven factors (≥0.70) and the Cronbach's α for each construct is summarized in Table 22.

Construct	No. of Items	Items	Cronbach's Alpha
Performance	6	PERF1, PERF2, PERF3, PERF4, PERF5, PERF6	0.902
Action-Oriented	3	A1, A2, A4	0.860
People-Oriented	2	P1, P2	0.731
Idea-Oriented	4	I1, I2, I3, I4	0.697
Task Novelty	2	TNOV1, TNOV2	0.910
Task Analyzability	4	TAYL1, TAYL2, TAYL3, TAYL4	0.854
Task Variability	3	TVAR1, TVAR2, TVAR3	0.780

Table 22: Reliability Analysis for Phase 3 Sample

5.2.4 Team Role Balance (All Phases)

For investigating the team role balance, all 123 respondents were used. A principal-components analysis was run on the 27 items to examine the structure of participants' perception of the performance and the attributes found in the team. A seven-factor solution was obtained and factor loadings after varimax rotation showed that six items (Efficiency of team operations, Adherence to schedules, Adherence to budget, Quality of work team produces, Quality of Team's Deliverables, Ability to meet the goals) loaded on the first factor (>.71), which was labeled Performance. Four other items (Disciplined, Good at following through, Attentive to details, Persistent) loaded on a second factor (>.55) which was labeled Action-Oriented. Four other items (Calm and confident, Encourage others, Outgoing, Diplomatic) loaded on a third factor (>.52) which was labeled People-Oriented. Three other items (Imaginative, Innovative, Original) loaded on a fourth factor (>.66) which was labeled Idea-Oriented. The last item *I4* (Unorthodox) was dropped as it loaded with attributes that measure people-oriented roles. The items,

TNOV1 and TNOV2 loaded on a fifth factor (>.91) which was labeled Task Novelty. The items, TAYL1, TAYL2, TAYL3 and TAYL4 loaded on a sixth factor (>.80) which was labeled Task Analyzability. The items TVAR1, TVAR2, TVAR3 loaded a seventh factor (>.74) which was labeled Task Variability. Table 23 shows the factor loadings for the items.

	Component						
	1	2	3	4	5	6	7
PERF1	.765	.158	.281	-.018	.085	.025	-.082
PERF2	.753	.171	.118	-.007	.213	.081	-.038
PERF3	.714	.190	.105	.100	.071	.045	.064
PERF4	.833	.133	.155	-.074	.016	.208	-.021
PERF5	.863	.102	.153	-.080	-.011	.172	-.050
PERF6	.737	.145	.214	-.140	.047	.154	-.070
A1	.202	.282	.782	-.095	.117	.034	.061
A2	.341	.128	.678	.200	.159	.241	.065
A3	.445	-.098	.546	.041	.220	.234	.035
A4	.416	-.034	.706	.047	.163	.083	.003
P1	.293	.128	.258	-.129	.634	.203	-.143
P2	.309	-.004	.283	-.106	.595	.170	-.174
P3	.075	-.013	.062	.007	.764	.021	.324
P4	.032	-.022	.354	-.057	.521	.107	-.016
I1	.165	.005	.091	-.061	.248	.834	.031
I2	.200	.106	.079	-.021	.248	.795	.024
I3	.300	.000	.379	.023	.033	.662	.017
I4	-.086	-.037	-.110	.063	.556	.342	.082
TNOV1	-.088	-.069	.032	-.052	.080	.045	.910
TNOV2	-.016	-.110	.048	.005	.023	.024	.929
TAYL1	.113	.804	-.043	-.121	.041	.034	.005
TAYL2	.179	.804	.011	-.123	-.028	.005	-.258
TAYL3	.181	.856	.090	-.136	-.045	.047	.065
TAYL4	.206	.809	.195	-.028	.037	.017	-.086
TVAR1	.036	-.085	.086	.741	-.224	.047	-.016
TVAR2	-.081	-.109	-.011	.900	.042	-.049	-.006
TVAR3	-.069	-.168	-.021	.886	.057	-.046	-.019

Table 23: Rotated Component Matrix for total sample

The reliability was good for the seven factors (≥0.71) and the Cronbach's α for each construct is summarized in Table 24.

Construct	No. of Items	Items	Cronbach's Alpha
Performance	6	PERF1, PERF2, PERF3, PERF4,PERF5,PERF6	0.906

Action-Oriented	4	A1, A2, A3, A4	0.836
People-Oriented	4	P1, P2, P3, P4	0.710
Idea-Oriented	3	I1, I2, I3	0.803
Task Novelty	2	TNOV1, TNOV2	0.883
Task Analyzability	4	TAYL1, TAYL2, TAYL3, TAYL4	0.872
Task Variability	3	TVAR1, TVAR2, TVAR3	0.826

Table 24: Reliability Analysis for total sample

5.2.5 GVTs

There were 52 respondents that answered the survey with respect to their experience with a global virtual team. A principal-components analysis was run the 19 items to examine the structure of participants' perception of the performance and the attributes found in the team. A five-factor solution was obtained and factor loadings after varimax rotation showed that six items (Efficiency of team operations, Adherence to schedules, Adherence to budget, Quality of work team produces, Quality of Team's Deliverables, Ability to meet the goals) loaded on the first factor (>.80), which was labeled Performance. Four other items (Calm and confident, Encourage others, Outgoing, Diplomatic) loaded on the second factor (>.63) which was labeled People-Oriented. The items, TNOV1 and TNOV2 loaded on a third factor (>.87) which was labeled Task Novelty. The items, TAYL1, TAYL2, TAYL3 and TAYL4 loaded on a fourth factor (>.64) which was labeled Task Analyzability. The items TVAR1, TVAR2, TVAR3 loaded a fifth factor (>.66) which was labeled Task Variability. Table 25 shows the factor loadings for the items.

	Component				
	1	2	3	4	5
PERF1	.808	.216	-.066	.059	.087
PERF2	.795	.146	-.208	.192	-.075
PERF3	.815	.163	-.020	.100	.126
PERF4	.897	.043	-.008	.062	-.066
PERF5	.902	.031	-.091	.073	-.056
PERF6	.863	.142	.068	.152	-.014
P1	.153	.114	-.178	.740	-.293
P2	.342	-.186	-.238	.630	-.294
P3	.073	-.063	-.038	.692	.331
P4	.115	-.057	.108	.743	.045
TNOV1	-.010	-.229	-.065	-.100	.872
TNOV2	.089	-.228	-.004	.059	.900
TAYL1	.053	.840	-.086	.128	-.098

TAYL2	.153	.750	-.042	-.142	-.395
TAYL3	.247	.821	-.103	-.154	-.041
TAYL4	.419	.638	.013	-.022	-.378
TVAR1	.123	-.129	.662	-.335	-.072
TVAR2	-.142	-.114	.912	-.012	-.071
TVAR3	-.151	.022	.898	.090	.072

Table 25: Rotated Component Matrix for GVT sample

The reliability was good for the following five factors (≥0.72) and the Cronbach's α for each construct is summarized in Table 26.

Construct	No. of Items	Items	Cronbach's Alpha
Performance	6	PERF1, PERF2, PERF3, PERF4,PERF5,PERF6	0.934
People-oriented	4	P1, P2, P3, P4	0.716
Task Novelty	2	TNOV1, TNOV2	0.898
Task Analyzability	4	TAYL1, TAYL2, TAYL3, TAYL4	0.852
Task Variability	3	TVAR1, TVAR2, TVAR3	0.800

Table 26: Reliability Analysis for GVT sample

5.3 Hypotheses Testing

Results for each hypothesis will be presented below.

5.3.1 Results for Hypothesis 1

H1: In Phase 1, idea-oriented roles will contribute the most to team performance.

No multicollinearity problems are observed for performing regression. The explanatory power and predictive validity of the structural model can be assessed by looking at the R^2 value of the dependant variable (Falk and Miller, 1992). The dependant variable is team performance. The R^2 Value of team performance is 0.409. Falk and Miller (1992) suggested 10% ($R^2 = 0.1$) as a minimum value to indicate substantive explanatory power. Thus, the R^2 value suggests significantly high predictive validity of the models. To determine whether a hypothesis is supported, the significance and the beta of the standardized coefficients are examined. With a significance level of 0.099, action-oriented roles exhibited the highest beta of 0.357. Therefore, ***H1 is not supported*** as action-oriented roles contribute most to team performance instead of the hypothesized idea-oriented roles which shows no significant relationship with team performance. (See Table C.1.3-4 in Appendix C)

5.3.2 Results for Hypothesis 2

H2: In Phase 2, action-oriented roles will contribute the most to team performance.

In this sample also, no multicollinearity problems are observed. The R^2 Value of team performance was 0.556. H2 ***is supported*** as action-oriented roles do contribute the most to team performance in Phase 2 with a significance of 0.072 and a beta of 0.357. However, we also found people-oriented roles to be significant to team performance in Phase 2 but with less significance (0.098) and lower beta (0.251) than the action-oriented roles. (See Table C.2.3-4 in Appendix C)

5.3.3 Results for Hypothesis 3

H3: In Phase 3, action- and people-oriented roles will contribute the most to team performance.

In this sample also, no multicollinearity problems are observed. The R^2 Value of team performance is 0.507. ***H3 is not supported*** as only action-oriented roles is shown to be significant (0.026) and contribute the most to team performance at a beta of (0.453) instead of the hypothesized action- and people-oriented roles. (See Table C.3.3-4 in Appendix C)

5.3.4 Results for Hypothesis 4

H4: "Balanced" teams (those with a spread of action-oriented roles, idea-oriented roles, people-oriented roles) will perform better than "unbalanced" teams (those with relatively more team roles unrepresented).

Based on the data collected, we produced Table 27 a table of "norms" to determine the category the range of scores fall in. TBI2 is then calculated from the premise that a balanced team would have at least indications of high or very high scores found in Table 27.

	Action-Oriented	**People-Oriented**	**Idea-Oriented**
Low (0-33%)	0-10	0-10	0-6
Average (33-66%)	11-14	11-14	7-10
High (66-85%)	15-18	15-17	11-13
Very high (85-100%)	19-20	18-20	14-20

Table 27: Table of "norms" in this study derived from data

The Pearson product moment coefficient of correlation between performance and team balance index of the 123 respondents and each of the correlation coefficient for the two measures of team balance are significantly greater than would be from random data (Table 28). Therefore, ***H4 is supported***. (See Table C.4.1-2 in Appendix C)

Team balance measure	Correlation coefficient
TBI1	0.534
TBI2	0.519

Table 28: Correlation between team performance and team balance

5.3.5 Results for Hypothesis 5

H5: As the team is more dispersed across space and time, an increased representation of people-oriented roles will increase team performance.

Regression was performed to find the relationship between spatial dispersion, temporal dispersion, team performance and the representation of people-oriented roles. For the regression analysis performed on spatial dispersion, team performance and people-oriented roles, the R^2 Value of team performance is 0.365. The findings show that people-oriented roles contribute to better team performance (beta of .713 and a significance level of 0.002), however the effects of spatial dispersion reduce the impact of people-oriented roles on team performance (beta of -0.471 and a significance level of 0.034). To investigate the relationship of temporal dispersion, people-oriented roles and team performance, regression is performed again and the R^2 Value of team performance is 0.403. The findings show that people-oriented roles contribute to better team performance (beta of .814 and a significance level of 0.000), however the effects of temporal dispersion reduce the impact of people-oriented roles on team performance (beta of -0.622 and a significance level of 0.004). This ***rejects H5*** that more representations of people-oriented roles will increase team performance as the team is more dispersed across space and time. (See Table C.5.3-4 and C.5.7-8 in Appendix C) A summary of the results are presented in Figure 3.

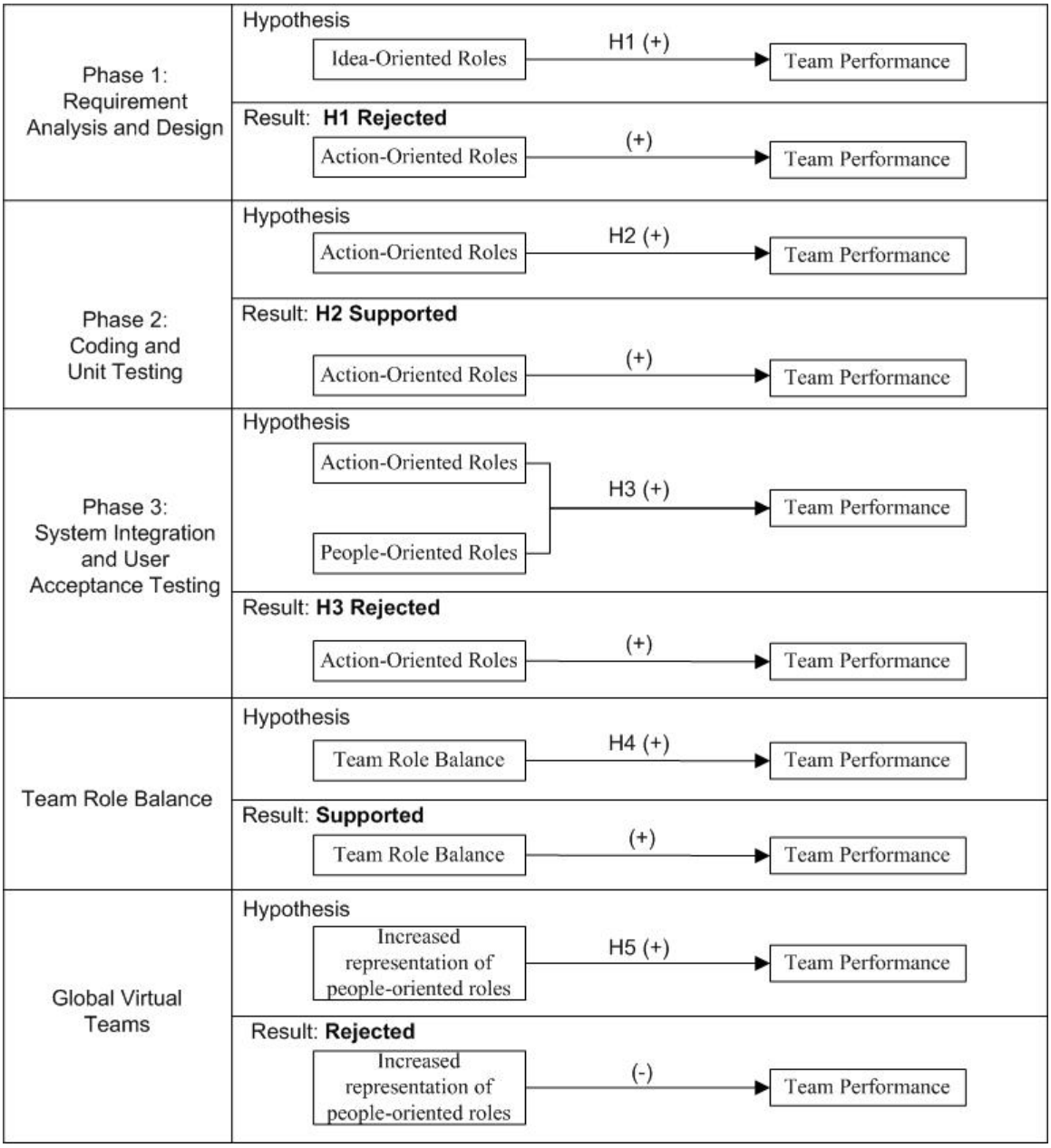


Figure 3: Summaries of Results

Chapter 6 Discussions and Implications

6.1 Discussion of Findings

The results of each hypothesis testing are discussed and the implications for managers are presented in this section.

6.1.1 Hypothesis 1

In Phase 1, action-oriented roles contribute most to team performance instead of the hypothesized idea-oriented roles. A possible reason is that the planning and conceptualization of the software to be developed has been performed before requirement analysis and design, i.e. during the presale of the software to internal or external users. After a successful presale, generation of ideas may no longer be important. In analyzing users' requirements and designing the software based on users' requirements, it is perhaps more important for the team to carefully follow through what the users want instead of attempting to suggest new ideas to the users. Consequently, action-oriented roles may become more important than idea-oriented roles in Phase 1. This may be an interesting avenue to be explored by future research.

6.1.2 Hypothesis 2

Hypothesis stating that action-oriented roles contribute most to team performance in Phase 2 is supported. Although action-oriented roles contribute most to team performance, analysis has shown that people-oriented roles are also significant to team performance. A possible reason that people-oriented roles are significant during Phase 2 is likely due to the level of modules coupling. In tightly-coupled modules, coders may need to work with common interfaces (i.e. shared data file accesses and function calls). Consequently, to be able to work productively, coders need to actively interact and communicate with each other (Andres and Zmud's 2001/2002). In this situation, people-oriented roles are needed to mediate possible relationship conflicts. Thus future research should not only examine the Coding and Unit testing phase as it is, but also pay attention to the level of modules coupling. Action-oriented roles may be the only important roles in the coding phase of loosely-coupled software; whereas in the coding phase of tightly-coupled software,

although action-oriented roles are still the most important roles, people-oriented roles may also be important in terms of team performance.

6.1.3 Hypothesis 3

For hypothesis 3, it is not supported as only action-oriented roles are shown to be significant (at a significance level of 0.005 and a beta of 0.593) instead of both action-oriented and people-oriented roles being significant. A possible explanation may be that we assume active interactions between developers throughout the System Integration Testing, and active interactions between developers and users during the User Acceptance Testing phase, which in turn require people-oriented roles to mediate the relationship among the software developers and between software developers and users. While the argument may always be valid for System Integration Testing, the same may not be always true in User Acceptance Testing. Some organizations do not allow interactions between software developers and users, requiring the project manager or sales representative to represent the whole team and to present the applications to the user during User Acceptance Testing. Thus future research should separate the two types of testing for studying role effects on testing performance.

6.1.4 Hypothesis 4

Hypothesis 4 stating that having team role balance will improve team performance, is supported as the Pearson product moment coefficient of correlation between performance and two team balance indexes of the 123 respondents are significant (0.534 and 0.519 for Team Balance Index 1 and 2 respectively). Therefore, this shows that the team role balance advocated by Belbin is applicable in the field of software development. Having a "balanced" team with various representations of team roles will result in better team performance.

6.1.5 Hypothesis 5

More people-oriented roles do increase team performance, however the impact of people-oriented roles on team performance is reduced as the team is dispersed across time and space. A possible reason is that that the measurements measuring people-oriented roles

only take into account the team building aspect instead of the coordination aspect with respect to GVTs. Thus, future research should investigate possible measures to measure the coordination aspect of people-oriented roles on team performance.

6.2 Implications for Managers

The findings of this study suggest some ways that managers can adopt to improve the performance of the software development team formed:

- Besides considering the technical capabilities of software developers during the formation of a team, the managers should consider the team roles required for the type of tasks assigned to the team.
- Action-oriented roles seem to enhance the performance of software development teams during Requirements Analysis and Design phase. This implies that managers should encourage action-oriented roles during this phase. However this finding should be exercised with caution because performance could be affected by possibly established ways of designs before the Requirements Analysis and Design phase.
- Action-oriented roles are shown to impact positively on team performance during Coding and Unit Testing. People-oriented roles are also found to impact positively on team performance. This implies that managers should encourage both types of roles.
- Only action-oriented roles seem to improve team performance during System Integration Testing and User Acceptance Testing. Although people-oriented roles do not seem to improve team performance, this may be due to a lack of active interactions between developers and users. Therefore, managers should encourage action-oriented roles and determine if people-oriented roles are required.
- Managers should ensure that different kinds of roles are represented as team role balance is shown to have positive impact on team performance. However, managers should note that different tasks require different types of roles to be dominant in order to have better team performance. Therefore, during different activities, more responsibilities can be placed upon the developers who have adopted the team roles required. This would aid in increasing the influence of the required team roles during the process of completing the tasks and increase team performance. Managers can also encourage needed traits of the required team roles during the execution of tasks.

Chapter 7 Conclusion

7.1 Summary of findings

This study has tested Belbin's team role theory in the area of software development and global virtual teams. The findings of this study are summarized as follows:

- Action-oriented roles contribute the most to team performance in all phases. However, this finding should be exercised with extra care and require more research to verify the findings because findings may vary according to the task characteristics and the required interactions among software developers.
- Although idea-oriented roles do not contribute the most to team performance during Requirement Analysis and Design in this study, the findings could be affected by possibly established ways of designs before Requirement Analysis and Design.
- People-oriented roles are found to be significant to team performance during Coding and Unit Testing. This may be due to the need for software developers to work closely with tightly-coupled modules, requiring people-oriented roles to mediate possible relationship conflicts.
- People-oriented roles are not significant to team performance during System Integration Testing and User Acceptance Testing despite the need to interface with both internal (developers) and external people (users). However, there may be cases where developers need not interact with users during User Acceptance Testing as some organizations require the project manager or sales representative to represent the whole team and to present the applications to the user during User Acceptance Testing. Thus, this may be why people-oriented roles are not significant to team performance.
- Team role balance impacts team performance positively and this relationship is not only applicable to other areas in previous research, but also in software development.
- People-oriented roles increase the team performance of global virtual teams but the positive impact of people-oriented roles on team performance is reduced with spatial and temporal dispersion.

7.2 Limitations

The first limitation is the potential limited, bias insight in survey responses. As the data is based on an individual's perspective of the project, the response may be subjective and limited, with possibilities of the individual not including self-evaluation, therefore resulting in problematic identification of attributes of the team. Moreover, the dependent variable, team performance, is measured through a cognitive process that could have been contaminated with unexpected effects. The major reason why such an evaluation of team performance is used lies upon the difficulty of measuring objective team performance. As comparisons between projects such as the differences in size and scope of each project are also unknown, it was practically impossible to draw a set of common criteria other than the one based on the team member's own evaluation. Thirdly, the characteristics of people at each site are also unknown to evaluate the influence of the different groups of roles present in each location. Lastly, the number of samples for each phase of the software development life cycle is also small, so it was difficult to control external factors.

7.3 Future Work

This is an empirical study in support of early stages of theory development. Further research is needed to enhance and confirm the findings. The finding that action-oriented roles instead of idea-oriented roles contribute to team performance in Phase 1 needs empirical justifications. Our arguments that in analyzing users' requirements and designing the software based on users' requirements, it is more important for the team to carefully follow through what the users want instead of attempting to suggest new ideas to the users need to be empirically tested. Although action-oriented roles seem to contribute most to team performance in all three phases, further research is required to understand reasons why people-oriented roles are significant in Phase 2 and not in Phase 3. It would be useful to investigate the impacts of other factors such as modules coupling, interactions among team members, and interactions between team members and users towards the importance of people-oriented roles in the team.

Although people-oriented roles do improve team performance in GVTs, the positive effects of people-oriented roles on team performance are reduced with spatial and temporal dispersion. Our arguments that measurements of the coordination aspect of people-oriented roles were not included should be verified. Future research should investigate possible measures to measure the coordination aspect of people-oriented roles and validate the impact of people-oriented roles on team performance.

After understanding the macroscopic perspective of group of team roles that will impact team performance positively, a microscopic perspective can be used to identify specific roles that will have the most positive impact on team performance. The configurational dimension aspect - the arrangement of different team roles across sites should also be considered.

7.4 Contributions

To our knowledge, this study is the first to examine the impact of categories of team roles on team performance in actual software development projects. In addition, the proposed type of group roles that mediate the effects of geographical and temporal distance was also explored. We hope that our findings contribute to further theoretical development of team role theory and to a more comprehensive model of the relationship between team roles and team performance in software development. The findings have several implications for forming and managing software development teams at different phases of the software development life cycle and global virtual software development teams. The findings of this study could also provide some hints to managers on how to manage their teams effectively to produce better team performance and it could also provide some guide to future research for researchers.

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Appendix A - List of Team Roles Proposed by various Researchers

Name	Description
Group Task Roles	
Proceduralist (Procedure person, moderator, agenda-keeper)	Expedites group movement by performing routine tasks.
Recorder (Record-keeper)	Keeps notes on the group's progress.
Evaluator (Devil's advocate, critic)	Evaluates the group's ideas etc.
Explainer (Coordinator, elaborator/clarifier, orienter, summarizer/integrator,	Clarifies the relationships among information, opinions, and ideas or suggests an integration of the information, opinions and ideas of subgroups; Spells out suggestions in terms of examples, furthers development of a discussion point, offers rationale or suggestions previously made, or tries to deduce how an idea or suggestion would work out if adopted; Defines the position of the group with respect to its goals and points to departures from agreed-upon directions or goals. This person often raises questions about the direction the group discussion is taking; Shows or clarifies the relationships among various ideas and suggestions, tries to pull ideas and suggestions together, or tries to coordinate the activities of various members of subgroups.
Idea Generator (Initiator/Contributor)	Suggests or proposes new ideas or new ways of regarding the group problems or goals.
Information/Opinion seeker	May ask for clarification of suggestions, information and facts; Asks primarily for the opinions of other group members or for clarification of opinions already stated.
Information/Opinion giver	Offers facts or generalizations that are "authoritarian". He or she may relate his or her own pertinent, personal experience; States his or her beliefs or opinions.
Group Maintenance Roles	
Follower	Goes along with the movement of the group passively, accepting the ideas of others sometimes serving as an audience.
Motivator (Encourager)	Praises, agrees with and accepts the contributions of others.
Gate-keeper (Expediter)	Attempt to keep communication channels open by encouraging or facilitating participation of others.
Mediator (Harmonizer)	Reconciles disagreements; mediates differences; reduces tensions by giving group members a chance to explore their differences
Tension-Releaser (Jokester)	Jokes or in some other way reduces the formality of the situation; relaxes the group members
Standard setter	Expresses standards for the group to attempt to achieve.
Individual Roles	
Aggressor	May work in many ways: Deflating others; expressing disapproval of the values, requests or feelings of others; attacking the group or its problems; joking aggressively; taking credit for the group's successes.
Blocker	Tends to have negative reactions and is stubbornly resistant, disagreeing and opposing beyond reason. Tries to maintain or resurrect an issue after the group has finished with it.
Recognition-seeker	Works in various ways to call attention to him or herself, by boasting, acting in unusual ways, trying to prevent being placed in less important roles, etc.
Self-confessor	Uses the group setting to express personal and non-group-related feelings, insights or ideologies.

Playboy/girl	Makes a display of his or her lack of involvement. This may take the form of cynicism, nonchalance, horseplay, and other forms of negative behaviour.
Dominator	Tries to assert authority or superiority. She or he works at manipulating the group or individuals. This may take the form of flattery, superiority, ordering others around, or interrupting others' contributions.
Help-seeker	Tries to get "sympathy" from others or from the whole group by expression of insecurity, personal confusion, or depreciation of him or herself beyond reason.
Special interest pleader	Speaks for a specific group or view, usually cloaking biases in the stereotype that best fits the particular need.
Deserter	Withdraws in some way; remains indifferent, aloof and sometimes formal; daydreams; wanders from the subject; engages in irrelevant side conversations

Table A.1: Benne and Sheats (1948) Team Roles

Name	Description	Allowable weakness	Not Allowable weakness
Action-oriented Roles			
Shaper	Challenging, dynamic, thrives on pressure. The drive and courage to overcome obstacles.	Prone to provocation. Offends people's feelings.	Inability to recover situation with good humour or apology
Completer Finisher	Painstaking, conscientious, anxious. Searches out errors and omissions. Delivers on time.	Inclined to worry unduly. Reluctant to delegate.	Obsessional behaviour.
Implementer	Disciplined, reliable, conservative and efficient. Turns ideas into practical actions.	Somewhat inflexible. Slow to respond to new possibilities.	Obstructing change.
People-oriented Roles			
Co-ordinator	Mature, confident, a good chairperson. Clarifies goals, promotes decision-making, delegates well	Can be seen as manipulative. Offloads personal work.	Taking credit for the effort of a team.
Teamworker	Co-operative, mild, perceptive and diplomatic. Listens, builds, averts friction	Indecisive in crunch situations.	Avoiding situations that may entail pressure
Resource Investigator	Extrovert, enthusiastic, communicative. Explores opportunities. Develops contacts	Over-optimistic. Loses interest once initial enthusiasm has passed.	Letting clients down by neglecting to make follow-up arrangements
Idea-oriented Roles			
Plant	Creative, Imaginative, unorthodox. Solves difficult problems	Ignores incidentals. Too pre-occupied to communicate effectively	Strong 'ownership' of idea when co-operation with others would yield better results
Monitor Evaluator	Sober, strategic and discerning. Sees all options. Judges accurately	Lacks drive and ability to inspire others.	Cynicism without logic
Specialist	Single-minded, self-starting, dedicated. Provides knowledge and skills in rare	Contributes on only a narrow front. Dwells on technicalities.	Ignoring factors outside own area of competence

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Table A.2: Belbin (1981, 1993) Team Roles

Name	**Description**
Driver *(Develops ideas, directs and innovates)*	
Developer	The Developer identifies directions for the team. They clarify the opportunities; describe their vision of the future and the strategy for getting there. The Developer ensures that the team grows along lines that best suit the chosen direction.
Director	Directors see improvement as a challenge and change as normal. The Director gets things done usually by others. They originate action and transform the working of the team. They will demand, instruct, urge, coerce and challenge in order to get what they want done.
Innovator	Innovators are imaginative and ingenious, and dedicated to discovering ways of making the team more effective, in all that it does. The Innovator is a catalyst for the team: sets the team's sights on new opportunities, introduces new methods and provides impetus to get going. The Innovator produces the original solutions to the team's problems that make these improvements possible. Innovators speed the process of change.
Planner *(Estimates needs, plans strategies and schedules)*	
Strategist	Strategists visualize the organization needed to achieve the aim, how to build it and the effect it will have on the people involved. They are able to link what has gone before with what the future may hold, so they are able to see what might go wrong. Seeing the threats that lie in wait, they design the appropriate defences. The Strategist draws up the actions the team must take to achieve its aims.
Estimator	The Estimator examines in detail the way the team currently operates. In this way, the Estimator assesses how much work the team is capable of doing and, by interpreting the strategy, the capacity likely to be required. The Estimator analyses the strategic goals to determine what resources the team will need, whether they are already available, or whether the team will need to acquire additional resources.
Scheduler	Schedulers analyze the tasks to be performed by the team to achieve their strategic aim. They will work out which tasks are best suited to each role and which activities must be combined and allocated as a single job function. The Scheduler will identify which tasks must be performed in sequence and when tasks can be performed in parallel. The Scheduler will tell you when team members should work together, determine what resources are needed and identify when and where they will be required. The Scheduler creates the timetable for tasks to be performed and plans the acquisition and use of resources.
Enabler *(Manages resources, promotes ideas and negotiates)*	
Resource Manager	Resource Managers understand the nature of the resources needed by the team, how they are used and how they are controlled. They are best at identifying and acquiring those resources (material, equipment, space, sponsorship and so on) the team will need for future activities. They will be the one who notes any problems in getting the resources the team needs and updates the Planner. Resource Managers recognize the sort of team they are trying to build. They create job specifications from the Planner's output and highlight the personnel needs that result. They consider the personal development of team members required by the team's plans, and identify the appropriate sources of training and skills development.
Promoter	Promoters publicize the team's successes both to the team, and to those outside it.
Negotiator	The Negotiator gives the team a realistic view of the outside world. They are best at forming a clear picture of the people with whom the team must negotiate; who may help and who could block the team's progress. The Negotiator identifies what people expect from expect from the team, and how satisfied they are with what they get. The Negotiator makes proposals for improvements to the team's output to satisfy external needs.

Exec *(Co-ordinates and maintains the team)*	
Producer	Producers turn plans and instructions into actions. Producers are goal-setters and goal achievers, but they are realists. They will not try to achieve the impossible. Producers need a system to operate or a procedure to follow. Producers participate in job design and organizing work flow and develop the technical skills, the flexibility and the resilience to do the jobs the team is given.
Coordinator	Coordinators are best at balancing the varied and often conflicting demands placed on the team by different parts of the organization. The Coordinator makes sure that each team member has a fair share of the day-to-day work and that individual tasks are aimed at achieving the same goals. Coordinators develop and regulate the team's standards of behaviour. They organize the individuals and fuse team members into a working team.
Maintainer	Maintainers hold the team together. They are the natural counselors of the team. Maintainers spot conflict early in its development and help those involved to clarify and resolve the issues. The Maintainer helps people to recognize the nature of their problems and gives insight into the ways they may solve them. Maintainers give continual support, as team members attempt to resolve their conflicts, solve their problems and talk over their progress and results.
Controller *(Records, audits and evaluates progress)*	
Monitor	Monitor produces the team's formal records. They observe the team operation, both in the work it does and as a group of people working together. Monitors check if the team is following its procedures, and record the results for feedback to the Planner. The Monitor watches over the actions critical to the team's success and records what is effective and what causes problems for feedback to the Developer and the Exec.
Auditor	Auditors analyze the team's activities in considerable detail. The Auditor will check that the resources (material, information, equipment) are of adequate quality to match the activity to be performed. Auditors will also check for errors and, if any are found, will identify cause and responsibility. Auditors will use their experience to give advice on how the problems might be solved, but are unlikely to take responsibility for solving them.
Evaluator	The Evaluator is the team's judge, at least the internal one. The Evaluator assesses in detail the costs incurred by the team's operation and the benefits achieved by it. The Evaluator will report whether the team has provided what was asked for, when it was needed, to the right standard, at a cost within the budget. The Evaluator provides the feedback that will show whether the team's choices were wise and their efforts truly successful.

Table A.3: Davis et al. (1992) Team Roles

Name	**Description**
Action-Oriented Roles	
Thruster-organizers	• Make things happen, produce action out of ideas, discussion and experiments • Enjoy organization, outputs and decisions – to get ideas into practice • Sometimes prone to impatience – may rush into uninformed action
Concluder-producer	• Take pride in producing products or services to a standard on a regular basis • Feel fulfilled if plans and schedules are met • Like working to procedures and routines/regularity; completing things on time, on budget and to specification • Likes using well-developed skills • Good at methodical, careful work
Controller-inspector	• Enjoy detailed work and information, i.e. facts and figures are correct • Careful and meticulous, concentrating for long periods of time on a task • Wish for depth and ensuring that work is done to accurately and to plan
People-Oriented Roles	

Assessor-Developer	• Likes organizing new activities/challenges • Willing to push ideas forward and organize workable schemes • Likes experimenting with new ideas • Good at evaluating different options.
Upholder-maintainer	• Take pride in maintaining the physical and social sides • Good at ensuring that the team is sound operationally • Can become the team's emotional strength providing support/help to team members • Can have strong views (convictions/beliefs) how the team should be run • If upset can become rather obstinate • When they believe in the project – a great source of strength/energy
Explorer-Promoter	• Good at taking up an idea and generating others enthusiasm for it • Enjoy exploring what people outside the organization are up to • Like to compare any new ideas with what others are doing • Good at making contacts and finding information and resources to help the team or project • Not always good at controlling details, but good at seeing the overview and developing others' enthusiasm for innovation • Capable of pushing an idea but may not be the best to organize and control it • Can be influential, public speakers and generating options and ideas
Idea-Oriented Roles	
Creator-Innovator	• Have ideas which may contradict and upset existing ways • Not afraid to challenge norms • Independent/wish to experiment and develop ideas regardless of present systems • Need freedom to work until their approaches are proven • A research and development culture allows such people to bring ideas to fruition • To develop ideas they need opportunity to talk through their views, even though this may challenge existing ways of operating • Good at starting new things
Reporter-Adviser	• Good at generating information and gathering it together so that it can be understood • Patient, prepared to hold decisions until the situation is understood • Often knowledgeable and well-liked • Likes to help others • Prefers to be slow and fully right rather than quick and mostly right

Table A.4: Margerison & McCann (1989) Team Roles

Name	**Description**
Action-Oriented Roles	
Crusader	Crusaders give importance to particular thoughts, ideas, or beliefs. They are value driven, and in a team discussion they often bring a sense of priority that is derived from their strong convictions. They seize upon and emphasise ideas or thoughts that have the greatest import, bringing them to the fore and stressing their significance. They assess the inherent value or importance of new ideas, focusing on those about which they feel most strongly.
Sculptor	Sculptors bring things to fruition by getting things done, and getting them done now! They are very action-oriented, dealing with whatever tasks the current situation presents, and spurring others into action as well. They make use of their experience and utilise tools or processes of which they already have knowledge. They try to have an immediate impact on things, injecting a sense of urgency, and aiming to achieve clear goals and tangible results.
Curator	Curators bring clarity to the inner world of information, ideas and understanding. They listen, ask questions and absorb information, so that in their mind's eye they

	can achieve as clear a picture or understanding as is possible. They expand their knowledge and collection of experiences, and also look to the future by envisaging clear goals and clear pathways to achievement of those goals. The focus on clarity also brings greater attention to detail.
Conductor	Conductors introduce organisation and a logical structure into the way things are done. They organise and systematise the world around them, establishing appropriate plans, identifying and implementing the correct procedures, and then endeavouring to make sure they are followed. They try to ensure that roles and responsibilities are properly defined and that appropriate resources or skills are available to undertake the work assigned.
People-Oriented Roles	
Coach	Coaches try to create harmony in the world around them, by building rapport with people, creating a positive team atmosphere, looking after people's welfare, motivating people and/or providing a service to the satisfaction of others. They value people's contributions, seek to develop the role that others play, and invest a lot of effort in building positive relationships. They try to overcome differences of opinion and find ways in which the team can agree.
Explorer	Explorers promote exploration of new and better ways of doing things, to uncover hidden potential in people, things or situations. They break new ground, and are often looking one step beyond the current situation to pursue unexplored avenues, until all the possibilities have been exhausted. Explorers often challenge the status quo and experiment with the introduction of change, to see if the situation can be improved or new potential uncovered.
Conductor	Conductors introduce organisation and a logical structure into the way things are done. They organise and systematise the world around them, establishing appropriate plans, identifying and implementing the correct procedures, and then endeavouring to make sure they are followed. They try to ensure that roles and responsibilities are properly defined and that appropriate resources or skills are available to undertake the work assigned.
Idea-Oriented Roles	
Curator	Curators bring clarity to the inner world of information, ideas and understanding. They listen, ask questions and absorb information, so that in their mind's eye they can achieve as clear a picture or understanding as is possible. They expand their knowledge and collection of experiences, and also look to the future by envisaging clear goals and clear pathways to achievement of those goals. The focus on clarity also brings greater attention to detail.
Innovator	Innovators use their imagination to create new and different ideas and perspectives. They observe the world around them, then use their imaginations to consider what they have observed from a number of different perspectives, and dream up new ideas and insights. Innovators often produce radical solutions to problems, develop long-term vision and demonstrate an apparent understanding of what cannot be clearly known.
Scientist	Scientists provide explanation of how and why things happen. They bring structure and organisation into the inner world of ideas and understanding. They analyse things, formulating hypotheses and explanations of how they function, and gather evidence to assess how true those explanations are. They produce mental models that replicate how particular aspects of the world works, and they try to understand the full complexity of any situation.

Table A.5: Myers (2002) MTR-i Team Roles

Name	**Description**
Action-Oriented Roles	
Contributor	A task-oriented team member, who provides the team with information, does her homework and pushes the team to set high performance standards and to use

	resources widely.
Challenger	A member who questions the goals, methods and actions of the team and is willing to disagree with the leader and management but who also encourages the team to take well-conceived risks.
People-Oriented Roles	
Communicator	A process-oriented person who is an effective listener, a facilitator of involvement, conflict resolution, consensus building and the creation of an informal, relaxed environment.
Collaborator	A goal-directed member who sees the vision and goal of the team as paramount, but is open to new ideas and is willing to pitch in and help in order to help the team reach its goal.

Table A.6: Parker (1994, 1998) Team Roles

Appendix B – Item Placement Rate

Target Category	Actual Category (by sorter 1)				Items	Hit Rate (%)
	Action-oriented roles	People-oriented roles	Idea-oriented roles	DNF		
Action-oriented roles	**A1 A2 A4**	A3			4	75.0%
People-oriented roles		**P1 P2 P3 P4**			4	100.0%
Idea-oriented roles			**I1 I2 I3 I4**		4	100.0%
Overall					**12**	**91.7%**

Table B.1: Placement rate of items for Sorter 1

Target Category	Actual Category (by sorter 2)				Items	Hit Rate (%)
	Action-oriented roles	People-oriented roles	Idea-oriented roles	DNF		
Action-oriented roles	**A1 A2 A4**		A3		4	75.0%
People-oriented roles		**P1 P2 P3 P4**			4	100.0%
Idea-oriented roles			**I1 I2 I3 I4**		4	100.0%
Overall					**12**	**91.7%**

Table B.2: Placement rate of items for Sorter 2

Target Category	Actual Category (by sorter 3)				Items	Hit Rate (%)
	Action-oriented roles	People-oriented roles	Idea-oriented roles	DNF		
Action-oriented roles	**A1 A2 A4**	A3			4	75.0%
People-oriented roles		**P1 P2 P3 P4**			4	100.0%
Idea-oriented roles			**I1 I2 I3 I4**		4	100.0%
Overall					**12**	**91.7%**

Table B.3: Placement rate of items for Sorter 3

Target Category	Actual Category (by sorter 4)				Items	Hit Rate (%)
	Action-oriented roles	People-oriented roles	Idea-oriented roles	DNF		
Action-oriented roles	**A1 A2 A4**	A3			4	75.0%
People-oriented roles		**P2 P3 P4**	P1		4	75.0%
Idea-oriented roles			**I1 I2 I3 I4**		4	100.0%
Overall					**12**	**83.3%**

Table B.4: Placement rate of items for Sorter 4

Target Category	Actual Category (by All sorters)				Items	Hit Rate (%)
	Action-oriented roles	People-oriented roles	Idea-oriented roles	DNF		
Action-oriented roles	**12**	3	1		16	75.0%
People-oriented roles		**15**	1		16	75.0%
Idea-oriented roles			**16**		16	100.0%
Overall					**48**	**89.6%**

Table B.5: Placement rate of items for all sorters

Appendix C - Data Analysis

C.1 Data Analysis for Hypothesis 1

H1: In Phase 1, the idea-oriented roles will contribute most to team performance.

	Mean	Std. Deviation	N
Performance	.0000000	1.00000000	29
Action-Oriented	.0000000	1.00000000	29
People-Oriented	.0000000	1.00000000	29
Idea-Oriented	.0000000	1.00000000	29
Task Novelty	.0000000	1.00000000	29
Task Analyzability	.0000000	1.00000000	29
Task Variability	.0000000	1.00000000	29

Table C.1.1: Descriptive Statistics for Hypothesis 1

Pearson Correlation	Performance	Action-Oriented	Idea-Oriented	People-Oriented	Task Novelty	Task Analyzability	Task Variability
Performance	1.000	**	-	*	-	-	-
Action-Oriented	.554	1.000	-	**	-	-	-
People-Oriented	.054	.226	1.000	**	-	-	-
Idea-Oriented	.344	.414	.481	1.000	-	-	-
Task Novelty	-.019	.122	.202	.073	1.000	-	-
Task Analyzability	.519	.503	-.074	.242	.018	1.000	-
Task Variability	.009	-.010	-.192	-.133	.082	-.090	1.000

Table C.1.2: Correlation for Hypothesis 1

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	Df2	Sig. F Change
1	.640(a)	.409	.248	.86730819	.409	2.537	6	22	.051

Table C.1.3: Model Summary for Hypothesis 1

Model		Standardized Coefficients	Sig.
		Beta	
1	(Constant)		1.000
	Action-Oriented	.357	.099
	People-Oriented	-.058	.776
	Idea-Oriented	.164	.428
	Task Novelty	-.073	.672
	Task Analyzability	.301	.144
	Task Variability	.056	.746

Table C.1.4: Coefficients for Hypothesis 2

C.2 Data Analysis for Hypothesis 2

H2: In Phase 2, the action-oriented roles will contribute most to team performance.

	Mean	Std. Deviation	N
Performance	.0000000	1.00000000	40
Action-Oriented	.0000000	1.00000000	40
People-Oriented	.0000000	1.00000000	40
Idea-Oriented	.0000000	1.00000000	40
Task Novelty	.0000000	1.00000000	40
Task Analyzability	.0000000	1.00000000	40
Task Variability	.0000000	1.00000000	40

Table C.2.1: Descriptive Statistics for Hypothesis 2

Pearson Correlation	Performance	Action-Oriented	Idea-Oriented	People-Oriented	Task Novelty	Task Analyzability	Task Variability
Performance	1.000	***	***	**	-	-	-
Action-Oriented	.553	1.000	***	**	-	*	-
People-Oriented	.533	.552	1.000	**	-	-	-
Idea-Oriented	.396	.494	.474	1.000	-	-	-
Task Novelty	-.080	.056	.012	.135	1.000	-	-
Task Analyzability	.559	.288	.208	.147	-.150	1.000	-
Task Variability	-.243	-.098	-.203	-.109	-.133	-.198	1.000

Table C.2.2: Correlation for Hypothesis 2

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.746(a)	.556	.475	.72433962	.556	6.889	6	33	.000

Table C.2.3: Model Summary for Hypothesis 2

Model		Standardized Coefficients	Sig.
		Beta	
1	(Constant)		1.000
	Action-Oriented	.357	.072
	People-Oriented	.251	.098
	Idea-Oriented	.094	.507
	Task Novelty	-.062	.611
	Task Analyzability	.395	.344
	Task Variability	-.088	.477

Table C.2.4: Coefficients for Hypothesis 2

C.3 Data Analysis for Hypothesis 3

H3: In Phase 3, the action- and people-oriented roles will contribute most to team performance.

	Mean	Std. Deviation	N
Performance	.0000000	1.00000000	33
Action-Oriented	.0000000	1.00000000	33
Idea-Oriented	.0000000	1.00000000	33
People-Oriented	.0000000	1.00000000	33
Action- and People-Oriented	.0000000	1.00000000	33
Task Novelty	.0000000	1.00000000	33
Task Analyzability	.0000000	1.00000000	33
Task Variability	.0000000	1.00000000	33

Table C.3.1: Descriptive Statistics for Hypothesis 3

Pearson Correlation	Performance	Action-Oriented	Idea-Oriented	People-Oriented	Action- and People-Oriented	Task Novelty	Task Analyzability	Task Variability
Performance	1.000	***	**	**	-	-	-	-
Action-Oriented	.628	1.000	***	**	-	-	-	-
Idea-Oriented	.539	.598	1.000	**	-	-	-	-
People-Oriented	.460	.416	.473	1.000	-	-	-	-
Action- and People-Oriented	-.136	-.286	-.039	-.102	1.000	-	-	-
Task Novelty	-.047	.089	.084	.107	-.289	1.000	**	-
Task Analyzability	.166	-.021	.055	-.090	.224	-.428	1.000	***
Task Variability	-.097	.111	.029	.102	.074	.249	-.549	1.000

Table C.3.2: Correlation for Hypothesis 3

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.712(a)	.507	.368	.79472718	.507	3.667	7	25	.007

Table C.3.3: Model Summary for Hypothesis 3

Model		Standardized Coefficients	Sig.
		Beta	
1	Performance		1.000
	Action-Oriented	.453	.026
	Idea-Oriented	.166	.389
	People-Oriented	.218	.194
	Action- and People-Oriented	-.012	.944
	Task Novelty	-.056	.730
	Task Analyzability	.110	.565
	Task Variability	-.100	.580

Table C.3.4: Model Summary for Hypothesis 3

C.4 Data Analysis for Hypothesis 4

H4: "Balanced" teams (those with a spread of action-oriented roles, idea-oriented roles, people-oriented roles) will perform better than "unbalanced" teams (those with relatively more team roles unrepresented).

Pearson Correlation	Performance	TBI1	Task Novelty	Task Analyzability	Task Variability
Performance	1	**	-	-	-
TBI1	.534	1	-	-	-
Task Novelty	-.092	.080	1	-	-
Task Analyzability	.386	.213	-.170	1	-
Task Variability	-.121	-.038	-.013	-.261	1

Table C.4.1: Coefficients for Hypothesis 4 Team Balance Index 1

Pearson Correlation	Performance	TBI2	Task Novelty	Task Analyzability	Task Variability
Performance	1	**	-	-	-
TB2	.519	1	-	-	-
Task Novelty	-.092	.065	1	-	-
Task Analyzability	.386	.201	-.170	1	-
Task Variability	-.121	-.003	-.013	-.261	1

Table C.4.2: Coefficients for Hypothesis 4 Team Balance Index 2

C.5 Data Analysis for Hypothesis 5

H5: As the team is more dispersed across space and time, more people-oriented roles will increase team performance.

Regression Analysis with Spatial Dispersion

	Mean	Std. Deviation	N
Performance	.0000000	1.00000000	52
People-Oriented	.0000000	1.00000000	52
Spatial dispersion	.0000000	1.00000000	52
People-Oriented and Spatial dispersion	.0000000	1.00000000	52
Task Novelty	.0000000	1.00000000	52
Task Analyzability	.0000000	1.00000000	52
Task Variability	.0000000	1.00000000	52

Table C.5.1: Descriptive Statistics for Hypothesis 5

Pearson Correlation	Performance	People-Oriented	Spatial dispersion	People-Oriented and Spatial dispersion	Task Novelty	Task Analyzability	Task Variability
Performance	1.000	**	-	-	-	-	-
People-Oriented	.330	1.000	-	***	-	-	-
Spatial dispersion	.169	.025	1.000	-	-	-	-
People-Oriented and Spatial dispersion	.072	.815	.080	1.000	-	-	-
Task Novelty	-.010	-.057	.136	-.003	1.000	-	-
Task Analyzability	.371	.009	.020	-.144	-.439	1.000	-
Task Variability	-.163	-.203	.051	-.093	-.019	-.139	1.000

Table C.5.2: Correlation for Hypothesis 5

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.604(a)	.365	.280	.84850919	.365	4.306	6	45	.002

Table C.5.3: Model Summary for Hypothesis 5

Model		Standardized Coefficients	Sig.
		Beta	
1	(Constant)		1.000
	People-Oriented	.713	.002
	Spatial dispersion	.160	.196
	People-Oriented and Spatial dispersion	-.471	.034
	Task Novelty	.167	.224
	Task Analyzability	.365	.212
	Task Variability	-.016	.898

Table C.5.4: Coefficients for Hypothesis 5

Regression Analysis with Temporal Dispersion

	Mean	Std. Deviation	N
Performance	.0000000	1.00000000	52
People-Oriented	.0000000	1.00000000	52
Temporal dispersion	.0000000	1.00000000	52
People-Oriented and Temporal dispersion	.0000000	1.00000000	52
Task Novelty	.0000000	1.00000000	52
Task Analyzability	.0000000	1.00000000	52
Task Variability	.0000000	1.00000000	52

Table C.5.5: Descriptive Statistics for Hypothesis 5

Pearson Correlation	Performance	People-Oriented	Temporal dispersion	People-Oriented and Temporal dispersion	Task Novelty	Task Analyzability	Task Variability
Performance	1.000	**	-	-	-	-	-
People-Oriented	.330	1.000	-	***	-	-	-
Temporal dispersion	.016	-.145	1.000	*	-	-	-
People-Oriented and Temporal dispersion	-.011	.784	-.313	1.000	-	-	-
Task Novelty	-.010	-.057	.046	-.007	1.000	-	-
Task Analyzability	.371	.009	.118	-.164	-.439	1.000	-
Task Variability	-.163	-.203	.068	-.067	-.019	-.139	1.000

Table C.5.6: Correlation for Hypothesis 5

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.635(a)	.403	.324	.82230105	.403	5.071	6	45	.000

Table C.5.7: Model Summary for Hypothesis 5

Model		Standardized Coefficients	Sig.
		Beta	
1	(Constant)		1.000
	People-Oriented	.814	.000
	Temporal dispersion	-.114	.363
	People-Oriented and Temporal dispersion	-.622	.004
	Task Novelty	.198	.135
	Task Analyzability	.366	.210
	Task Variability	.023	.847

Table C.5.8: Coefficients for Hypothesis 5