TAMPERE UNIVERSITY OF TECHNOLOGY

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COORDINATION OF VIRTUAL TEAMS IN MULTI-SITE PROJECTS

Master of Science Thesis

Examiner: Prof. Miia Martinsuo
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ABSTRACT

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Virtual teams consist of individuals who work across time, space and organizational boundaries to achieve their goals while utilizing computer mediated communication technologies. Virtual teams offer benefits such as tapping into high quality workforce, flexibility in the team structure, and reduced costs etc. which have contributed to the increase in the number of virtual teams around the world. Due to lack of face-to-face interaction and cultural differences, virtual teams are susceptible to conflicts, misunderstandings and communication breakdowns.

The objective of this thesis work is to study the functioning and operations of virtual teams in a multi-site setup and devise a criteria to gauge the performance of such teams. To achieve these objectives a detailed study of existing literature is conducted and a framework focusing on different phases in the lifecycle of virtual teams is developed. The framework takes into account the elements critical to the smooth operation of virtual teams such as team selection, communication tools etc., and the disruptive factors which can negatively impact their functioning e.g. lack of cohesiveness between team members.

The proposed framework is then used to study the working of a high-tech organization operating in virtual setup. Online survey and interviews are conducted in the target organization to assess its functioning. Based on the study recommendations are made to the organization management about the steps needed to further enhance its effectiveness. The recommendations mainly focus on reducing the number of tools and processes in the organization and utilizing them more efficiently, improving multi-site collaboration, and enhancing knowledge creation. To improve the multi-site collaboration the organization needs to invest in cultural awareness trainings and promote direct communication between the team members. Knowledge creation is one of the key benefits of virtual teams and can be enhanced by having a harmonized and well defined document creation, sharing, and storing mechanism between the sites.

PREFACE

I have worked in multi-national companies for more than 12 years. Most of the projects that I have been involved in were completed in a virtual setup where teams were dispersed across multiple sites and relied on computer mediated communication technologies for sharing the information and synchronizing the tasks. I have experienced first-hand the benefits and drawbacks associated with working in virtual setup. Virtual teams on one hand provide the flexibility in team setup and access to desired resources but at the same time pose some challenges to manage the cultural diversity and maintain a smooth information flow. The benefits associated with virtual teams can be lost very quickly if the teams are not managed properly. I choose this topic for my master's thesis to enhance my understanding of the operations of virtual teams.

First and foremost I am very thankful to Professor Miia Martinsuo for providing me the guidance and support during the course of my thesis work. I would like to thank the management of the case organization for giving me the opportunity to work on this thesis topic and conduct research in the organization. I would also like to thank my parents for their prayers, and my family for their support during the course of my studies.

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Muhammad Imran Anwar

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ABBREVIATIONS AND NOTATION

CMC	Computer mediated communication
DGIn	Dynamic group interaction model
F2F	Face-to-Face
FEO	Formation, execution, output analysis framework
ICT	Information and communications technology
IPO	Input, process, output model
R&D	Research and development
SoC	System on chip
TPP	Technology, people and process model

1. INTRODUCTION

1.1. Background

Teams are the foundation of an organization. Team work allows businesses to achieve their goals by optimal utilization of skills, creativity and diversity of its team members. The proliferation of modern virtual technologies have allowed the teams to expand geographically and take advantage of human resource available around the globe. Now-a-days, teams that are not using virtual technologies are almost non-existent in the high-tech industry. In the past teams used to be collocated in the same geographical location. This was required to align the interdependent tasks needed for the operation of these team as a single unit. This has changed with the advent of modern computer mediated communication (CMC) technologies. Organizations these days are creating teams spread over a wide geographical area, dispersed with respect to time zones, and containing members from multiple organizations. These teams synchronize their work using modern communication technologies. This approach for creating teams is giving rise to globalization of companies, and the number of multi-site, multi-cultural and multi-national companies is increasing rapidly (Lipnack & Stamps, 1997). According to Gould (2006) virtual teams can be represented by the following equation.

$$\textit{Virtual teams} = \textit{teams} + \textit{electronic links} + \textit{groupware}$$

In this equation, electronic links refer to the modern communication technologies and groupware points to software and hardware platforms used by virtual teams to share information and collaborate with other team members. It's quite apparent from this equation that the structure of virtual teams is very different as compared traditional collocated teams. Thus these teams needs a different set of tools, processes and mind-set to function efficiently.

Advancement in communication technology is the main enabler for the establishment of virtual teams. The existence of virtual teams around the globe started increasing due to the benefits offered by these teams such as tapping into high quality work force, diversity of the team, location of the team members close to the customers etc. (Tribe and Allen, 2003). These benefits are not the only factors promoting the companies to go global. Another strong driver for the popularity of virtual teams is the establishment of business networks. Businesses are establishing long term strategic relationships with their suppliers and customers, and are sharing their R&D resources to improve their competitiveness. These goal-oriented strategic alliances provide benefits for both partners

and results in formulation of business networks and extend the existence of virtual teams (Bal and Gundry, 1999)

Since members of virtual teams are dispersed across time and space, there are number of challenges associated with the working of virtual teams. Lack of face-to-face communication and physical interaction reduces the level of trust and cohesiveness in the teams (Cascio, 2000). Cultural diversity, and language barriers can impact the team members' understanding of goals, tasks and responsibilities (Holmstrom et al., 2006). Complete reliance on computer mediated communication technologies for synchronizing the interdependent tasks can cause misunderstandings (Kimball, 1997). Therefore, virtual teams are particularly prone to communication break downs, conflicts, and lack of trust (Rosen et al 2007). To leverage the benefits offered by virtual teams and to reduce the impact of drawback associated with reliance on modern communication technologies, virtual teams require careful management to reach their full potential.

The research work will target a high-tech R&D organization in a multi-national company working in the domain of system on chip (SoC) design. The organization is spread across multiple sites located in different countries. Virtual teams are used in the organization for cross functional collaboration and execution of projects. The organization has been able to leverage the benefits associated with virtual teams to build a very competitive team. At the same time the organization has faced some pitfalls associated with multi-site projects e.g. difficulty in synchronization of tasks and poor quality of communication. This study will evaluate the performance and effectiveness of virtual teams in the focus organization. The results of the study will be used to come up with some concreate steps that can assist the organization in improving the efficiency of multi-site projects.

1.2. Objectives of the study

The purpose of this thesis work is to examine the functioning of virtual teams in a multi-site R&D organization and define some action points to improve the efficiency of these teams. To achieve this purpose benefits, challenges, structure and characteristics of virtual teams are studied in detailed. A criteria for assessing virtual team performance is devised and a new framework focusing on different phases in the lifecycle of virtual teams is developed. The framework is extended from existing literature on virtual teams and is tailored for virtual teams working in the high-tech domain. It takes into account both the lifecycle phases of projects and elements critical for the smooth operation of virtual teams at each phase. The framework provides the ability to assess the operations of virtual teams from technology, people and process perspective and also highlight the disruptive factors which can negatively impact the virtual team functioning. Thus the overall objective of this thesis can be summarized as:

-"... to build a framework to systematically analyse the functioning and performance of high-tech virtual teams in multi-site projects ."

The framework will assist us in answering the following research questions:

Q1. What criteria should an organization use to analyse the performance of virtual teams?

Q2. How should an organization structure the virtual teams in high-tech multi-site projects?

Q3. What steps should an organization take to minimize disruptive factors associated with virtual teams?

Q4. How should an organization utilize technology, processes and human resources in multi-site projects for enriched communication and motivated workforce?

In this thesis we used the qualitative method to gather the data to analyse the workings of virtual teams. The research involved extensive study of existing material on the topic of virtual teams. Utilizing this study a framework is built to identify the elements critical to the efficient functioning of virtual teams. Based on the framework a questionnaire survey is conducted inside a high-tech virtual organization. After the survey qualitative interviews were arranged with a selected group of employees working in the organization. The author of this research has been working in virtual teams for many years and therefore author's observations also contributed to the research outcomes.

1.3. Structure of the Thesis

This thesis report is divided into 6 chapters. Chapter 1 provides the introduction to the topic, and briefly explains the objectives of the research work. It also gives an insight into the research methodology used in this thesis work. Chapter 2 builds the theoretical foundation needed to explore the virtual teams in detail. It gives the definition of virtual teams from different perspectives, and points out multiple classification from research literature to measure the level of virtuality in a team. The factors contributing to the prevalence of virtual teams and different types of virtual teams are discussed in detail in this chapter. It also highlights the benefits and drawback associated with virtual teams, and defines the criteria to measure the performance of such teams.

Chapter 3 provides the framework foundation for this research work. This chapter explores four different frameworks from the research literature to analyse and evaluate the working of virtual teams. One of these frameworks is based on life cycle model, two frameworks are based on input, process, output (IPO) model and one framework evaluates the working of virtual teams from technology, people and process perspective. This chapter also presents our "Formation, Execution and Output Analysis" (FEO) framework

to analyse the working of virtual teams. The elements identified in our FEO framework impacting the operation of virtual teams in different phases are also discussed in detail in this chapter.

Chapter 4 provide details about the structure of the high-tech organization that is focused in this thesis work. It also gives a brief history of the organization and presents the flow of research work to gather data from the organization. Chapter 5 discusses the results of survey and interviews conducted for the purpose of this research work. Chapter 6 presents the conclusions drawn from our research work.

2. THEORETICAL FOUNDATION

2.1. Definition of virtual teams

Virtual teams comprise of group of individuals working across time, space and organizational boundaries and taking advantage of modern communication technologies to achieve their goals (e.g. Gilson et al., 2014). Earlier research on virtual teams focused on differentiating virtual teams from collocated (traditional or conventional) teams (Archer 1990; Hollingshead et al., 1993; Warkentin et al., 1997) and provided the basic definition of virtual teams centered on time, space, and organizational boundaries. This approach of defining virtual teams can be termed as "dichotomy approach" (Hosseini, 2015).

Traditional or conventional teams where all the team member are collocated are getting rare. Even in the collocated teams the reliance on technology has increased tremendously (Kirkman & Mathieu 2005). Many characterizations of virtual teams such as use of communication technology to cooperate within a team, cultural differences, common goal setting and mutual accountability are now-a-days also valid for face-to-face teams and thus further categorization of virtual teams is required (Schweitzer and Duxbury, 2010). Latest research is focusing more on the degree of virtualness in the teams based on the use of communication technology, diversity, autonomy etc. This approach of defining virtual teams can be termed as "degree of virtuality approach" (Hosseini, 2015).

In our research we will explore the definition of virtual teams utilizing both approaches, i.e. binary approach and virtual approach, to get deeper insight into the concept of virtual teams.

2.1.1. Dichotomy approach to virtual teams

Advancement in communication technology has allowed the organization to get the best talent available around the globe and create virtual teams with people located in wide ranging geographical location (Prien et al., 2012). Some of the definitions of virtual teams used in research literature based on binary approach are listed in the Table 1 below.

Table 1: Definitions of Virtual Teams

Author	Definition
Townsend et al., 1998; Bell & Kozlowski, 2002	*"Groups of geographically and/or organizationally dispersed coworkers that are assembled using a combination of*

Author	Definition
	telecommunications and information technologies to accomplish an organizational task."
Lipnack & Stamps, 1997; De-Guinea, 2012	*"Virtual teams are teams with geographically distributed members, cross-time and organization boundaries, are culturally diverse, utilize computer mediated communication to perform non-routine but interrelated tasks and are united around a common goal."*
Ebrahim, 2015	*"Virtual groups exist when several teleworkers are combined and each member reports to the same manager. In contrast, a virtual team exists when the members of a virtual group interact with each other in order to accomplish common goals."*
Gassmann et al., 2003; Peters, 2003	*"A group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies. Virtual teams can exist for a short period of time, or be continuous."*
Zenun et al., 2007	*"A small number of people with complementary skills who are equally committed to a common purpose, goals, and working approach for which they hold themselves mutually accountable"*
Anderson et al., 2007	*"The term virtual team is used to cover a wide range of activities and forms of technology-supported working"*
Hertel et al., 2005	*"Virtual teams, are distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.)"*
Leenders et al., 2003	*"Virtual teams are groups of individuals collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organization."*

Some researchers add global component to the virtual teams when the team members are working in different countries. These teams are categorized as global virtual teams (Maznevski & Chudoba, 2000). One more factor highlighted by some authors is the temporal and goal oriented nature of the virtual teams. These authors suggest that the virtual teams are formulated to achieve a specific goal for a limited amount of time and disintegrate once the goal is achieved (e.g. Bal & Teo 2001; Paul et al 2004). Powell et al. (2004) define virtual teams as "*groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks"*. Some authors emphasize less on the temporary aspects of virtual team and use the term "may be temporary" to describe the temporal nature of the team (Gassmann, 2003).

2.1.2. Degree of virtuality approach

The term "virtual" has multiple context depending on team or organization being analyzed (Chudoba et al., 2005). Many researchers consider the 'binary approach' of categorizing the teams as either face-to-face or virtual as obsolete and outdated (Hosseini, 2015). Teams that are relying more on communication technologies in their daily work such as email, chat messenger, teleconferencing, phone, electronic databases etc. are more virtual in nature than the teams having more face-to-face interaction. The complexity and the nature of work done by both the teams can be same but the level of virtuality is different (Gibson et al. 2014). The level of virtualness is determined by the extent to which team utilizes communication technology in their daily work rather than face-to-face communication (Berry 2011). Highest degree of virtualness is achieved when all member of the team are located in different area, communicate only via communication technologies and are located in different time zones (Kirkman et al 2002).

Level of virtuality in the team greatly impact the working model, effectiveness and performance of the teams. Just like collocated teams virtual teams need to collaborate and communicate efficiently to deliver the products and services. Shared and clear understanding of the project targets, complexity of the tasks, work-split and team goals is an important factor dictating the success of virtual teams. Depending upon the nature, type and virtuality of the team an efficient and effective communication technology, which allows the team member to interact successfully, must be in place to get optimal performance from the team (Arling 2011). Hosseini (2015) sub categorized the *Virtual approach* used in literature into three subcategories i.e. discrete levels, constructs of virtuality and discontinuities.

Discrete level approach to define virtuality focus on defining discrete steps in which virtuality can be categorized. For example, Niedeman and Beise (1999) defined four categories of virtual classification i.e.

- Inactive: Low level of face-to-face communication and low usage of information technology communication.
- Traditional: High level of face-to-face communication and low usage of information technology communication.
- Highly Virtual: Low level of face-to-face interaction and high usage of information technology communication.
- Fully supported: High level of face-to-face interaction and high usage of information communication technologies.

Constructs of virtuality approach classify teams as a measure along a continuum. This approach includes factors which shifts the team structure from highly virtual to conventional collocated teams depending on the prevalence of each factor in the team arrangement. For example Kirkman et al. (2002) proposed to assess virtuality based on the proportion of time allocated by team members to work virtually. Gibson and Gibbs (2006), on the other hand used multidimensional factor to categorize team virtualness. These factors included spatial distance i.e. geographical dispersion, dynamic structure i.e. flexibility in allocated team resources, diversity of team members' i.e. nationalities part of the team, and dependency on computer mediated communication. O'Leary and Cummings (2007) measured the level of dispersion in the team as a set of five indices which are:

- Mileage index: Average distance among team members.
- Time zone index: Average number of time zones separating the members
- Site index: Number of sites representing the team.
- Isolation index: Team members working alone on their site.
- Imbalance index: Dispersion of membership across sites. (Cummings, 2007)

Discontinuities approach to define virtual teams focus on the factors which can cause disruptions in team work and negatively impact the performance of team. For example Watson-Manheim, Chudoba, and Crowston (2002) classified team virtualness based on following disruption factors: temporal, cultural, spatial, organizational, work group, and relationship. Similarly Rosen et al. (2007) in his research identifies that virtual teams are vulnerable to mistrust, communication break downs, conflicts, and power struggles.

This thesis will focus on the factors that impact the efficiency of the teams working in virtual environment. The factors highlighted in the discontinuities approach are most critical to the operations of virtual teams as they can impact the efficiency of virtual teams negatively if not managed properly. Based on the discussion above to define the virtual teams we can devise following criteria for the definition of virtual teams (Table 2):

Table 2: Common criteria for virtual teams (Adapted from Ebrahim et al., 2009)

Characteristics of virtual team.	Description	Reference
Basic Approach	Geographically dispersed (over different time zones)	Townsend et al., 1998.
	Driven by common purpose	Hertel et al., 2005.
	Enabled by communication technologies	Peters, 2003
	Involved in cross-boundary collaboration	Gassmann et al., 2003.
	It is not a permanent team	Paul et al., 2004.
	Small team size	Bal & Teo, 2001.
	Team member are knowledge workers	Kirkman et al., 2004
	Team members may belong to different companies	e.g. Leenders et al., 2003
Virtual Approach	Degree of virtuality is impacted by following factors: temporal, cultural, spatial, organizational, work group, and relationship.	Chudoba & Crowston, 2002
	Vulnerable to disruptions such as mistrust, communication break downs, conflicts, and power struggles	Rosen et al., 2007

Based on the discussion above we will define virtual teams as:

> *"... small temporary group of knowledge workers dispersed in terms of time, space, and geographical boundaries, who rely on communication technology to synchronize everyday tasks and to focus their energies to accomplish a common goal. The degree of virtuality in the team impacts its efficiency and depend on factors such as team dispersion in respect of time, space and organization, cultural diversity and relationships among team members."*

2.2. Types of virtual teams

Virtual teams can be categorized into several types. In the book "Mastering virtual teams: strategies, tools and techniques that succeed", Duarte and Snyder (1999) identify six types of teams that exist most commonly. This categorization is done based on the team structure, functions and challenges faced by the team member in day-to-day activities. These teams are:

1. Networked teams
2. Parallel teams
3. Project development teams
4. Work, production or functional teams
5. Service teams
6. Offshore ISD teams

Networked teams are geographical dispersed and can contain members from different organizations. These teams are usually formed to bring together the experts from different organizations to discuss a specific topic. These experts share their thought to find the solution for the problem on hand and reach a consensus. These teams usually last for a limited time span and the life cycle of the team depends upon how quickly the issue is resolved. This type of teams are commonly found in high-tech organizations and consulting firms (Duarte & Snyder, 1999).

Parallel teams are composed of specialists to accomplish a specific task. The requirement for these teams is usually for a very short time span. These teams are goal oriented and can contain members from the same organization as well as different organizations. These teams are usually geographically dispersed (Duarte & Snyder, 1999).

Project development teams are involved in the development of new products and services. These teams are composed of specialists, architects, developers and mangers. Project development teams can be geographically dispersed, and make high use of communication technology for communication during the course of the project. These teams last longer than parallel teams as the time span of full project is usually longer than individual tasks. New members can be added and removed from the project development teams at any time as per the resource requirement of the project (Duarte & Snyder, 1999).

Work, production or functional teams are focused on a specific function e.g. finance, research, human resource management, procurement, training etc. These teams are geographically dispersed and implement the regular tasks (Duarte & Snyder, 1999).

Service teams are assigned with the task of maintaining the infrastructure of the company and providing support to the customers. These teams are focused on a particular service e.g. network maintenance, data management, customer support etc. These teams are

geographical dispersed and are normally located in different time zones to provide their services 24 hours a day (Duarte & Snyder, 1999).

Offshore ISD outsourcing teams are independent service provider teams. There is a growing trend that companies focus on their core capabilities and outsource part of the work to offshore teams. These teams operate in close cooperating with onshore teams. The tasks outsourced to offshore companies can contain network maintenance, software development, R&D activities, customer support etc. (Duarte & Snyder, 1999).

Fisher & Fisher (2001) identified six type of virtual teams by mapping three variables i.e. time, space and culture in three dimensions as shown in Table 3. The traditional definition of virtual teams is focused around time, space and organizational boundaries, but Fisher & Fisher (2001) replaced the third variable with cultural dimension. This model enable us to have an in-depth analysis of challenges associated with cultural diversity. Time and space variables are part of same continuum. A team widely dispersed in time due to its location around the globe will also share widely dispersed space. Cultural dimension also has a relationship with space-time continuum, as a widely dispersed team in space and time dimension is very likely to include multiple nationalities, high diversity and dispersed cultures.

By mapping time, space and culture continuum in a 3D chart we get eight different kind of team. The teams which share the same time and space, even if they have different cultures, are not considered by Fisher & Fisher (2001) as virtual teams. All team types identified by Fisher and Fisher (2001) are summarized in Table 3 along with their complexity level categorization and some examples of such teams.

Table 3: Type of virtual teams and their management complexity (Fisher & Fisher, 2001.

Type	Time	Space	Culture	Example	Management complexity
1	Different	Same	Different	Manufacturing operations, Warehouse activities, customer services	Medium-low
2	Different	Different	Different	High-tech R&D activities, Software development, large organization in multi-national companies, global project teams,	High

Type	Time	Space	Culture	Example	Management complexity
				international product development teams	
3	Same	Different	Different	Regional services	Medium
4	Different	Same	Same	Same as for type 1 teams	Low
5	Different	Different	Same	Same as for type 2 teams	High-Medium
6	Same	Different	Same	Same as for type 3 teams	Medium-low
7	Same	Same	Same	Not a virtual team	
8	Same	Same	Different	Not a virtual team	

Since type 2 and 5 teams' do not share time and space and thus they are most complicated to manage. Type 3 and 6 teams share the same time and thus it's relatively easy to manage the ongoing activities owing to interactive communication technologies. Type 1 and 4 teams are easiest to manage among the virtual teams as they share the same location and communication requirement are also very limited. Type 4, 5, & 6 teams have the added advantage of homogeneous culture, which make them comparatively less trivial as compared to teams of types 1, 2, & 3 respectively which share the same characteristics of time and space (Fisher & Fisher, 2001). Cultural diversity is considered as one of the advantaged of virtual teams because different cultures come with different approaches to solve the problem and lead to multiple and innovative solutions (Kayworth & Leidner, 2000). If not managed correctly cultural differences can easily lead to conflict, lack of trust and misunderstanding among the team members. This could adversely affect the overall performance of the team (Piggott et al., 2015).

2.3. Benefits of virtual teams

We have already touched upon some of the benefits offered by the virtual teams in the previous subsections. In this subsection we will look in detail all the positive factors offered by the formation of virtual teams. Organizations are creating virtual teams because they provide economic value, business opportunities, competitive advantage, flexibility and help in providing innovative solutions for the companies to achieve their goals and solve problems. At the same time virtual teams empower the members of the team and provide them flexibility which results in job satisfaction and improved

performance. Improved efficiency and economic value offered by virtual teams is promoting many organization to go virtual. Boiny (2001) estimated that over 2/3 of fortune 1000 utilize virtual teams in their operations. Cascio (2000) highlighter following benefits of using virtual teams:

- Reduction in real estate expenses
- Increase in productivity
- High profit levels
- Improvement in customer service
- Access to global markets
- Environmental benefits (Cascio, 2000)

Virtual teams offer economic value by drastically reducing costs related to relocation time and travelling (Bergiel et al., 2008). Virtual teams use CMC technology to coordinate their interdependent tasks and thus costs related to accommodation, daily allowance and travelling can be decreased. Virtual teams, once fully functional have been found to be more efficient and thus results in shorter time to market (Lipnack & Stamps, 2000). Shorter development time has a direct correlation with cost and improved productivity and therefore impacts the economic performance of the companies (Chen, 2008).

Virtual teams provide competitive advantage to the organization, as it enable them to respond quickly to the changing business environment (Bergiel et al., 2008). Virtual teams are very flexible and thus new members can be added and old member can be removed as per the requirement of the project. In addition a new team can be assembled very quickly with all the required resources to cater for the challenging business needs. Decision making in the virtual teams is much faster and more accurate as the management can get quick feedback from the experts even if they located in different countries before drawing any conclusion (Chen, 2008).

Another great benefit offered by the virtual teams is the improved quality of research & development (R&D) activities. Virtual teams bring innovation to the organization and improve its problem solving skills by bringing together experts in highly specialized fields and working at great distance from each other (Merali & Davies, 2001). R&D project which require cross functional and cross boundary skills benefit greatly by the creation of virtual teams as it is normally difficult to have all resource required for such projects located at same place (Lee-Kelley & Sankey, 2008). Virtual teams allows the organization to hire the best talent available in the market regardless of their location.

Virtual team allow an organization to have a global reach. Having the team member located close to the customers and suppliers improve customer service and supply chain management respectively. Virtual teams offer greater degree of freedom to its employees, as it allows them to work more flexibly and at the same time be more accountable.

Compute-mediated-communication (CMC) technology offer the possibility to all the employees to selectivity access the ongoing activities in other teams and organizations and enhance their knowledge. Employees can be assigned to multiple teams, move from one project to another more flexibly and manage both personal and professional lives in a better way (Cascio, 2000)

Virtual teams greatly rely on CMC technology for communication in their daily work. The interaction between team members based on communication technology is very different as compared to face-to-face communication. Weisband & Atwater (1999) found that in face-to-face communication, liking between group member is based on non-rational and non-task based factors. In virtual teams liking between group member is more related to the contribution to team performance. McKenna (2008) pointed out that in highly functional CMC team following relation attributes are established:

- Greater liking for and acceptance by other group members
- Negating the effects of social anxiety
- Decreased feelings of isolation and loneliness
- Increasing one's social network
- Coming together and feeling part of the group (McKenna, 2008)

Ebrahim et al. (2009), in their literature review compiled a list of advantages associated with the creation of such teams. Similarly Nydeggar & Nydeggar (2010) formulated a list of major benefits offered by virtual teams. Based on the work of these authors and other researchers we have categorized the benefits offered by virtual teams into five domains i.e. economic value, competitive advantage, R&D efficiency and innovation, employee empowerment and flexibility. The results of our finding are summarized in theTable 4 below.

Table 4: Benefits of virtual teams.

Benefit	Description
Economic Value	• Reduce infrastructure costs, travel costs and relocation time cost (Rice et al., 2007). • Travel, lodging, parking, and leasing/owning building space are expenses that can be eliminated or minimized (Nydeggar & Nydeggar, 2010).
Competitive Advantage	• Reduce time-to-market (May and Carter, 2001). • Can manage the development and commercialization tasks quite well (Chesbrough and Teece, 2002). • Enable organizations to respond faster to increased competition (Hunsaker & Hunsaker, 2008).

Benefit	Description
	• Greater productivity, shorter development times (Mulebeke and Zheng, 2006). • Greater client satisfaction (Jain & Sobek, 2006)
R&D Efficiency and innovation	• Easier access to experts and other sources of information (Nydeggar & Nydeggar, 2010). • Useful for projects that require cross-functional or cross boundary skilled inputs (Lee-Kelley and Sankey, 2008). • More effective R&D and fast decision making (Cummings and Teng, 2003). • Optimize the contributions of individual members toward the completion of business tasks and organizational goal (Samarah et al., 2007).
Flexibility	• Greater degree of freedom to individuals involved with the development project (Ojasalo, 2008). • Provide flexible hours for the employees, and give more sense of responsibility (Precup et al., 2006). • Employees can be assigned to multiple, concurrent teams; dynamic team membership allows people to move from one project to another (Cascio, 2000). • Perform their work without concern of space or time constraints (Lurey and Raisinghani, 2001).
Knowledge Creation	• Sharing knowledge, experiences; Facilitate knowledge capture (Merali and Davies, 2001). • Provide a vehicle for global collaboration and coordination of R&D-related activities (Paul et al., 2005). • Improve the detail and precision of design activities (Vaccaro et al., 2008).
Employee Satisfaction	• Better team outcomes in terms of quality, productivity, and satisfaction (Gaudes et al., 2007). • Employees can more easily accommodate both personal and professional lives (Cascio, 2000).

2.4. Drawback of virtual teams

Virtual teams offer many advantages and benefits but there are also some disadvantages and drawback linked with virtual teams. Virtual teams are particularly prone to mistrust, conflicts, and power struggles (Rosen et al., 2007). Virtual teams allow member of team to collaborate from a distance but face to face discussion, both formal and informal (e.g. chat with a trusted colleague at a coffee corner), are still considered more effective and reliable (Gassmann & Von Zedtwitz, 2003a). Opinion and perception related to problems faced by the virtual teams some time makes it very difficult to find the root cause. For example, the blame of failing to meet the established goals in virtual teams is often put on technology, but it could be some other social factors or individuals causing this below-par performance. Performance related issues in virtual team are frequently caused by poor sharing of information, over ambitious goal settings, and unclear or lack of accountability (Kimball, 1997).

Virtual teams are commonly associated with cost reduction but that is not always the case. For example, in some small organizations and companies the cost of setting up and maintaining the hardware and software required to support the virtual teams might not be feasible. Creation of virtual teams might require time consuming trainings and some senior and mature employees in the company might not be comfortable with the concept of using computer mediated communication. Thus cost/benefit analysis, organizational culture, financial constraints, technological requirement and human resource capabilities need to be carefully considered by an organization before taking the decision to go virtual (Nydeggar & Nydeggar, 2010)..

Trust plays a very important role in the success of any virtual team. Due to the lack of face-to-face communication the distant members will not be able to read the facial expressions and other non-verbal cues during communication with the team members. Establishment of trust is closely related with exchange of information in virtual teams (Jarvenpaa & Leidner, 1998). Trust is positively linked to the performance of team and a lack of trust among the team members badly effects the efficiency, creativity and the quality of output of the team. To maintain a high level of trust in the virtual teams, the team leaders must invest in communication technologies to find the most suitable means of communication which meets the requirement of the team tasks. Trust becomes even a bigger issue when the things are not going well, e.g. when the project is behind schedule, some unforeseen issues are seen in the project execution, the quality of the product does not meet the requirements etc. Distant team member have the tendency to lay the blame on others or develop a perception that the problems exists due to other team members which can easily lead to conflicts in the virtual teams (Jarvenpaa & Leidner, 1998).

Team cohesiveness or the lack of it is another factor which impacts the virtual teams. Team cohesiveness is the extent to which the members trust each other and feel

connected. Due to CMC, member of virtual teams do not show the same level of team cohesiveness as in the case of conventional collocated teams (Lea & Spears, 1991). The member of virtual teams feel more loosely connected as compared to the collocated teams and the level of cohesiveness is determined by the amount, type and quality of communication that exists in the organization (Nyddegar & Nyddegar, 2008).

The cultural diversity in the virtual team is regarded as one of the factor contributing to innovative solutions. Culture has a strong influence on the how individuals understand information, act on it, and relate to other individuals (Holmstrom et al., 2006). Cultural diversity couple which language differences can sometimes lead to misinterpretation and misunderstanding among the team members. For geographically dispersed virtual teams comprising of multiple nationalities, culturally diverse team members have the tendency to interpret the information via cultural filters. This can distort the information provided and the team member will not be fully aligned about what has been communicated. Therefore cultural differences can impact the ability of the teams to share ideas and coordinate project tasks. Different cultures have their own attitude to time which can negatively impact the project execution and schedule (Kayworth & Leidner 2000). Similarly language differences can lead to the misinterpretation of information. Multinational companies often use English language as a medium of communication between geographically dispersed teams with multiple nationalities. With English not the first language of the team members some part of the information exchanged can be "lost in translation". For example if team is geographically dispersed between Asia and Europe then verbal communication can be more challenging due to different accents. With linguistic barriers, written communication e.g. via email, is preferred to avoid misinterpretations (Adaba et al., 2015). Cultural barrier in virtual teams can be depicted as shown in Figure 1.

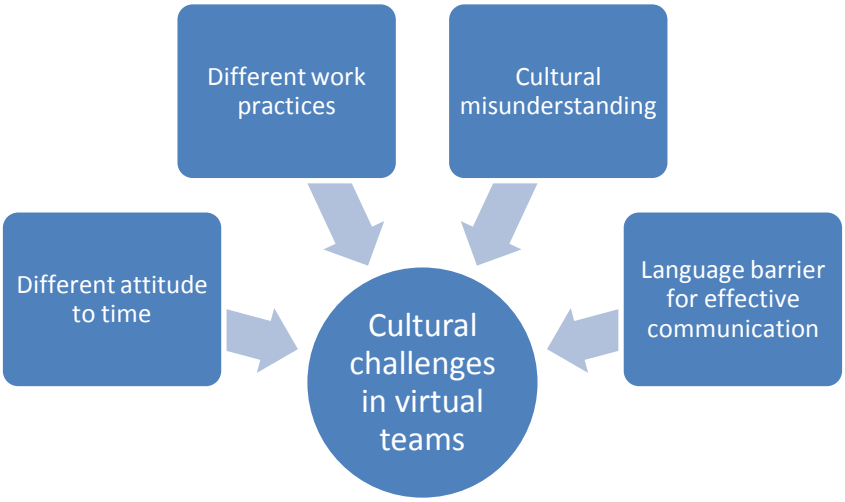

Figure 1: A Model of Cultural Barriers to Virtual Team (Adapted from Adaba et al., 2015)

The main disadvantages of virtual teams can be summarized as:

- Lack of trust as compared to conventional teams.
- Loss of team cohesiveness caused by lack of face-to-face communication.
- Cultural diversity in virtual teams lead to difference in how individuals understand information and act on it.
- Language differences can sometimes result in misunderstanding.
- Team members need special training and encouragement (Ryssen and Godar, 2000).
- Lack of Face-to-Face collaboration (FFC). FFC is need to develop a better conceptual understanding of a problem (Cascio, 2000).
- Complex technological applications are some time needed. (Bergiel et al., 2008).
- For small teams and companies the setup cost for maintaining tools required to support the virtual teams can be too high.
- The virtual structure might not fit the operations of the company. Highly sequential or integrated work can create problems for virtual teams.

The team leaders and team members work in different roles in virtual teams. Thus the challenges faced by both groups in virtual teams are of different nature. Team leader needs to ensure that a process is in place to coordinate the activities of the team, process and workflows are aligned, and there are no conflicts building up in the team. In addition team leader need to have a mechanism to provide feedback to the team members about their performance. The team members on the other hand are concerned that the manager will not be able to assess correctly the complexity of their tasks. If the team members are located in a different location from the rest of the team then they are worried that they are missing out on important informal information that is delivered to the collocated team members.

2.5. Performance evaluation of virtual teams

Evaluating the performance of virtual teams is one of the objectives of this thesis. In this sub-sections we will devise a criteria for measuring the performance of such teams. The performance can simply be defined as the ability of a team to solve problems and reach its objectives in the specified amount of time. Some to the major contributors to virtual team performance are trust, team structure, team cohesion, team empowerment, task interdependence, group interdependence, and task coordination (St-Amant et al., 2015). St-Amant et al. (2015), in their literature review on the topic of performance measurement in virtual teams, found that researchers have used three approaches to evaluate performance in virtual setup i.e.:

- Output grading
- Quantifying results
- Self-assessment.

In the first approach, i.e. output grading, the quality of the work completed by the virtual teams is evaluated or graded by independent experts against the established or expected outcome. This approach is most suitable when the duration of the project is very short. For example, grading approach has been used in educational/research setups to evaluate the performance of virtual student teams created to study the aspects of cultural diversity, cohesion and performance in virtual setups (St-Amant et al., 2015).

In quantifying results approach, researchers quantify different output variables to evaluate team performance. This approach is most suitable for longer projects, or study the effectiveness of teams which are in operation for long time. Quantification of results can be done in terms of project duration, project cost and project quality or any other parameter which is more suitable for the project being investigated e.g. customer satisfaction for customer support team (St-Amant et al., 2015).

The third approach uses self-assessment as a measure to evaluate team performance. This approach is suitable for both short term and long term projects. The belief of the group members about their team performance is a strong predictor of the effectiveness of virtual teams. Self-assessment approach can be used to gauge both team performance and individual performance. This approach can be used just to get a pulse of team effectiveness and is not fully reliable (St-Amant et al., 2015).

There has been lots of research done in the area of improving performance and effectiveness of traditional and virtual teams. For example, Chaudron (1995), while focusing on the effectiveness of traditional collocated teams highlighted the following factors to setup an efficient team:

1. Select the team members carefully.
2. The team should be clear about its purpose and goal.
3. Everyone should understand the functioning of the team clearly.
4. Team building measures and trainings should be given to enhance team cohesiveness.
5. The results of team effort should be clearly noticeable to boost the morale of the team. (Choudron, 1995)

All the factors associated with the performance of collocated teams are also applicable for virtual teams. These performance factors normally cater for R&D efficiency, productivity, time-to-market, product or service quality, on-time delivery, and cost control (Samarah et al., 2007). Virtual teams rely on communication between distant

member and experts using CMC technologies. Due to the nature of these teams all the processes, interactions, flows and technical aspects of tasks on-hand need to be well documented. This provide virtual teams an enormous potential to create and share knowledge (Vaccaro et al., 2008). Thus knowledge creation can be used as an additional factor for measuring the virtual team performance. Employee motivation and job satisfaction is also an important factor in the effectiveness of virtual teams. Virtual team members tend to work in dispersed time and space boundaries and thus employee satisfaction is another factor used by researchers to measure the effectiveness of virtual teams (Prasad & Akhilesh, 2002). Thus performance of virtual teams can be gauged using parameters defined in Table 5.

Table 5: Performance measurement in virtual teams.

Virtual teams performance criteria	
1.	Traditional measures e.g. • Quality of products and services. • Ability to solve problems. • On-time completion of project milestones • Cost Management. • R&D efficiency and innovation
2.	Knowledge creation
3.	Employee Satisfaction

The performance measurement criteria identified in Table 5 will be used in next chapters to build the framework for monitoring the functioning and efficiency of virtual teams.

3. FUNCTIONING OF VIRTUAL TEAMS

In the last chapter we explored the concept of virtual teams in detail and focused on the types of virtual teams, prevalence of such teams in today's business environment, various benefits and drawback associated with the virtual teams, and criterion used to evaluate the effectiveness and performance of virtual teams. In this chapter we will discuss the various frameworks and methods used to evaluate the structure and optimize the performance of virtual team in distributed organizational network.

3.1. Virtual team life cycle model

Tuckman (1965), proposed a group development model to analyse different stages in the lifecycle of a team working on any project. The stages are forming, storming, norming and performing. These stages of group development are also applicable for virtual teams. As discussed in previous chapters, the virtual teams are particularly prone to conflicts and communication breakdown caused by lack of trust, lack of face-to-face communication and cultural differences. Johnson et al. (2002) added and additional stage i.e. conflict resolution to study the virtual teams model as shown in Figure 2.

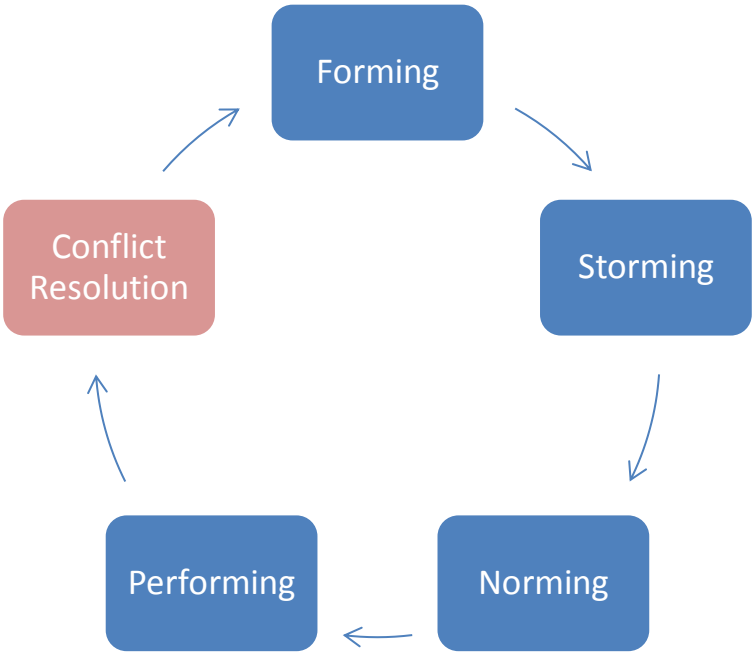

Figure 2: Stages of virtual teams (Adapted from Johnson et al., 2002, Tuckman, 1965)

In the team forming stage for virtual teams, objectives of the project are defined and tasks are split into identifiable blocks. Resources needed for the execution of projects in terms of manpower and technology etc. are allocated for the team. At this point, it is evaluated

how dispersed is human resource in terms of time and space, and if the right kind of communication technology mechanism is in place to effectively share the information and support communication between the team members (Tuckman, 1965).

In the next stage i.e. storming the team members allocated for the project are taken on board. At this stage the schedule of the project and interdependence of the tasks is established. The member of the team get themselves acquainted with the project and the different tasks that they have to work-on. The objectives and goals are clarified for the whole teams and rules and mechanism for inter-teams and intra-team communications are also laid out (Tuckman, 1965). For virtual teams whose members are dispersed geographically it is good to have some face-to-face interaction at this stage. Face-to-face interaction at the start of the project allows distant team members to know each other better and promotes better communication using CMC technology during the course of the project. The roles of the team members e.g. developer, architect, project manager etc. are also clarified at this stage (Johnson et al., 2002).

The first few day or weeks after the start of the project, depending upon the project scope and project size, can be categorized as norming stage. In this stage "norms" are developed to facilitate the team perform better (Tuckman, 1965). For example at this stage the teams decide how many formal meeting they are going to have every week to synchronize the tasks, how to share knowledge and information within and across the team, and familiarize themselves with the new tools and technology that will be used during the course of the project.

Performing stage is normally the longest in terms of time among all the stages associated with project life cycle. The execution of most of the tasks associated with a project takes place in this stage. Performance management is an important aspects of this stage for timely execution of the project and its milestones (Tuckman, 1965).. All the benefits and drawbacks linked to the virtual teams should be accounted for during this stage to get the maximum output from the team. Factors like team motivation, job satisfaction, knowledge sharing, effective communication, quality management and leadership etc. all play their role in this stage to build trust among the team member and build a cohesive team unit (Johnson et al., 2002).

Though "conflict resolution" is shown as the next stage after "performing" in the model depicted in Figure 2, but in practice the performing and conflict management stages overlap. The managers should keep an eye on any conflicts arising in the team due to cultural differences, lack of trust, distant communication or some unforeseen circumstances arising during the execution of the project. Most conflicts in virtual teams arise due to lack of planning, over optimistic project schedules, unclear project guidelines and ambiguous task divisions with members working at different location. These conflicts especially become visible when the project is lagging behind in terms of schedule and

quality and failing to meet the milestones set at the start of project. The social issues in the team adversely effects the team motivation and badly impact the project schedule. Thus it critical to evaluate the tasks and schedule in detail during the forming and norming stages of the project for smooth execution of the project (Johnson et al., 2002).

3.2. Technology, people and process model

Bal & Gundary (1999), studied the supply chain network in automotive industry and devised a model for the study of virtual teams from the perspective of technology, people, and process (TPP). They observed the interaction between employees, organization processes, and technology and identified twelve element for effective virtual team working as shown in Figure 3.

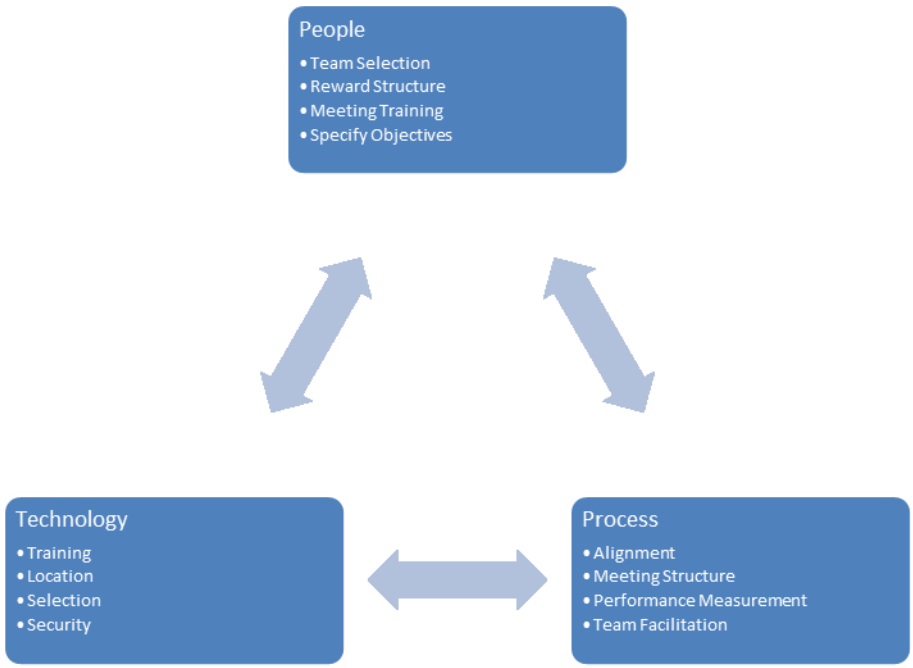

Figure 3: Model for Effective virtual team working (Adapted from Bal and Gundary, 1999)

Virtual team working: Technology perspective

From the technology point of view there are four elements highlighted in the model i.e. selection, location, security and training. Technology selection is very important for enriched communication between the team members for the success of virtual teams. Simple flow of information from one point to another is not sufficient for the needs of virtual teams. Team leader and team members should invest some time to select the most appropriate technology for the project while keeping in mind the cost/benefit analysis (Ebrahim et al., 2012). Some examples of technologies in use in virtual teams include instant message services (e.g. skype), database repositories (e.g. sharenet),file transfer, virtual private network (VPN) access, email and telephone. Information can be transferred using multiple tools but if will not have the same level of richness. For example a file

shared with the whole team using email will not have the same richness level as if the same file is uploaded to shared database repository and information is send to the whole team about its existence using email. File share via email is not versioned control and could easily get buried under the weight of all the emails received and difficult to find when needed. On the other hand team members knowing the location of documents repository can simply go to the place and can access the latest version of the file without any hassle. Similarly email is a more appropriate tool to send small amount of information when immediate response is not required. Messenger on the other hand is useful tool for less intensive interactive communication. Thus technology selection should be done keeping in mind the project needs and the effectiveness of technology for the communication purpose (Thissen et al., 2007).

The location element in the model refers to the fact that technology should be able to support the geographically dispersed individuals to work together as a team. The member of the team should be provided needed training to utilize the technology and tools in optimal way. At the same time, the technology should be secure as the virtual team members are involved in the sharing of sensitive and critical information over the communication network. It is the responsibility of team leader to identify the special technological and security level needs for virtual team operations. (Hunsaker and Hunsaker, 2008).

Virtual team working: People perspective

From the people perspective, the model has identified four elements i.e. team selection, reward structure, meeting training and specify objectives. The selection of the team is the most critical item out of these four and could be the difference between the success and failure. The team leaders should make an effort to include the people most suitable for the project from the resource pool available in the organization (Hunsaker and Hunsaker, 2008). This could be at times a bit tricky as some of the experts might already be involved in some other projects and do not have the bandwidth to contribute to a new project. Non-the-less, project leaders should make an effort to pick the best available resources for the team. Another issues faced during the selection of team member for the virtual teams is the geographical dispersion involved (Bal and Gundry, 1999). The compute mediated communication technology, if carefully selected, can enhance the richness of communication mechanism, but it cannot fully compensate the advantages associated with face-to-face communication and collocation of team members. Depending upon the size and complication of the project at times it is more suitable to split the project into multiple interdependent big blocks and allocate it for team members collocated at one particular site. In this scenario the complexity of synching the tasks in virtual teams decreases tremendously. Thus for team selection the team leader has to consider the expertise as well as location of the members.

The performance of the virtual team member must be recognized and rewarded fairly. A just reward systems at the start of the project for the work being performed adds to the motivation of the team members (Bal and Teo, 2001a). Similarly, simply recognizing the good work done by the team also tends to improve the spirit of the team. The training requirements for the members of virtual teams are different from ordinary teams. For example, to work efficiently some of the training requirements for virtual teams are self-managing skills, communication and meeting training, project management skills, technology training, etc. (Bal and Teo, 2001b). Due to the nature of structure of virtual teams, i.e. team members are dispersed across time, space and organizational boundaries, the team members might be managed more effectively by empowering them to make some decision related to their tasks. By empowering the team and delegating some managerial roles to the team members they become more accountable for the tasks being implemented (Hertel et al., 2005). To make this empowerment happen, the tasks and objectives of team members should be clearly definable and accountable. Empowerment of the team members also increases the motivation in the team and as a result the team becomes more efficient.

Virtual team working: Process perspective

The four elements identified from the process perspective by Bal & Gundary (1999) in their virtual team working model include alignment, meeting structure, performance measurement, and team facilitation. Alignment refers to the fact that just having the processes to share the information and knowledge in the team is not sufficient, but the team members should have the know-how about the utilization of the processes and tools, and they should be willing to use these processes effectively to share the information and disperse the knowledge (Rosen et al., 2007). At the start of the project the processes and tools should be re-aligned in accordance with the team capabilities and projected needs. One of the advantages of the creation of virtual teams is that all the processes and work done is documented to keep the team members in-sync, and this in turns create knowledge. To take advantage of this knowledge creation, alignment of the processes in-line with the team capabilities and project requirements is mandatory.

For the virtual teams that are highly distributed having a well-defined meeting structure is required to keep the activities aligned. The lack of face-to-face communication and physical interaction reduces the cohesiveness of virtual teams (Massey et al., 2003). Having less physical interaction with the team leader contributes to decrease of extrinsic motivation factor (Kayworth and Leidner, 2002). Thus in such circumstances it is required to have a meeting structure in place to discuss the progress of the team and resolve the issues.

The performance measurement of the virtual teams is some-what different as compared to collocated conventional teams. Traditional parameters for measuring the performance

of co-located teams include time-to-market, R&D efficiency, meeting the project goals, cost management and quality of products and services etc. Virtual teams create knowledge during their interaction and employee empowerment/satisfaction is one of the key contributors in the improvement of performance of virtual teams as discussed in chapter 2.5. Thus the performance of virtual teams is measured using the traditional parameters, and the additional factors taken into account to measure the performance include knowledge creation and job satisfaction of the team (Prasad & Akhilesh, 2002). Team facilitation is the final element identified in this model for impacting the working of the virtual teams from process perspective. To facilitate the team members to carry out their work smoothly there should be well defined rules and responsibilities. If the rules and responsibilities are ambiguous then the team members feel less accountable for the outcome and it results in the loss of productivity. Therefore in a virtual setup rules and responsibilities should be set in place to facilitate the team to work efficiently.

3.3. Input, process, output model

Another popular method to evaluate the structure and effectiveness of virtual team is input, process, and output (IPO) model. This model is usually employed to study the system level flow in software products, but it also provides the framework needed for the evaluation of virtual teams (e.g. Brown, 1996). Powell et al. (2004) used the IPO model to assess the different factors impacting the performance of virtual teams over their life cycle. They identified four general categories of variables i.e. inputs, socio-emotional processes, task processes, and outputs as shown in Figure 4. Under each category they defined the factors which impact the working of virtual teams during the life cycle of project. These factors have already been discussed in detail in previous sections in this report. Thus we will briefly look into the main categories and these factors to grasp the flow of this framework.

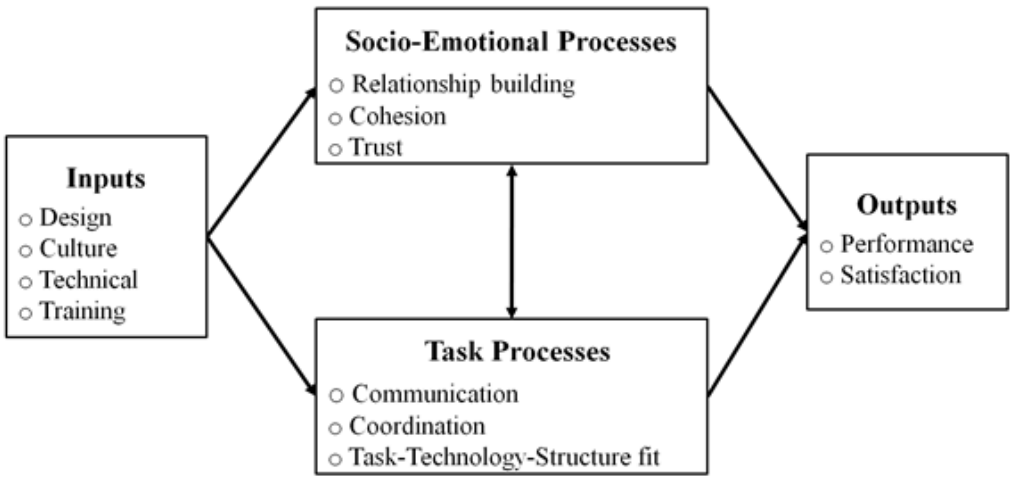

Figure 4: Virtual team research areas (Powell et al., 2004)

Inputs represent the characteristics of virtual teams at the time of its formation. This include the resources allocated for the team and the skills and abilities of the team members. Powell et al. (2004), splits the inputs for virtual teams into fours sub-categories i.e. design, culture, technical and training. Design emphasize the structure of virtual teams e.g. physical dispersion, level of face-to-face interaction, goal settings, communication media, values and norms. Technical aspect takes into account the technical expertise of the members of the team to complete the project goals. Cultural differences among the team members tends to bring innovation. The cultural differences can also lead to conflict and communication difficulties among the members of the team. Training at the start of the project to make the employees familiar with the tools and processes needed for the project tend to enhance the overall efficiency of the team (Powell et al., 2004).

The model splits the process part of IPO model into two main categories i.e. socio-emotional process and task process. Socio-emotional process deals with the social dimension of the interaction between team members. The lack of face-to-face contact among the members of virtual teams results in lack of cohesiveness among the team members. Trust is also impacted due to cultural differences and lack of physical interactions (Powell et al., 2004). Relationship among the team members is also affected because the distant members of the distant members of the team pre-dominantly rely on computer-mediated-communication during their daily work. A kick-off meeting at the start of the project where the members of the team gather at one location and get a chance to meet other members in person positively impacts the relationship among distant members of team.

Task process category focuses on processes which occur when the members of virtual teams work together. This category includes communication, co-ordination, and task-technology-structure fit as its sub-categories (Powell et al., 2004). Communication is one of the main issues in virtual teams and discussed in detail in previous sections. Coordination is related to the synchronization of interdependent tasks between the members of virtual team. According to Cheng (1983), "*coordination represents the degree of functional articulation and unity of effort between different organizational parts and the extent to which the work activities of team members are logically consistent and coherent*". Coordination is especially a challenge in virtual teams because difference in time zone, culture and distant communication. More complex and interdependent the tasks are in a virtual project, more difficult it becomes to co-ordinate between the members of virtual team. For this reason, when face-to-face meetings are not feasible a well-defined meeting structure assist greatly in coordination and collaboration between the team members (Tan et al., 2000). In big organizations another approach used during project planning to reduce the level of coordination is to execute the complicated parts of projects in collocated members of virtual teams. Task-technology-structural fit highlights that the technology selected for the execution of project should be aligned with the

requirements for enriched communication between the team members and information exchange requirements of the team.

The output category in this model includes performance and satisfaction. Section 2.5 of this report focuses on the measurement of performance in virtual teams and highlights the fact that team satisfaction is also a performance measuring criteria for virtual teams since it directly impacts the efficiency of such teams.

3.4. Dynamic group interaction model

This model brings together the elements of several theories related to communication, performance and group dynamics to create a holistic model for group interaction. The model highlights the interaction between group processes, resource characteristics, and performance parameters over the life cycle of a project/team, while keeping in view both individual and group perspective, organizational settings, and changing competitive environment to create a framework for studying group interactions, as show in Figure 5.

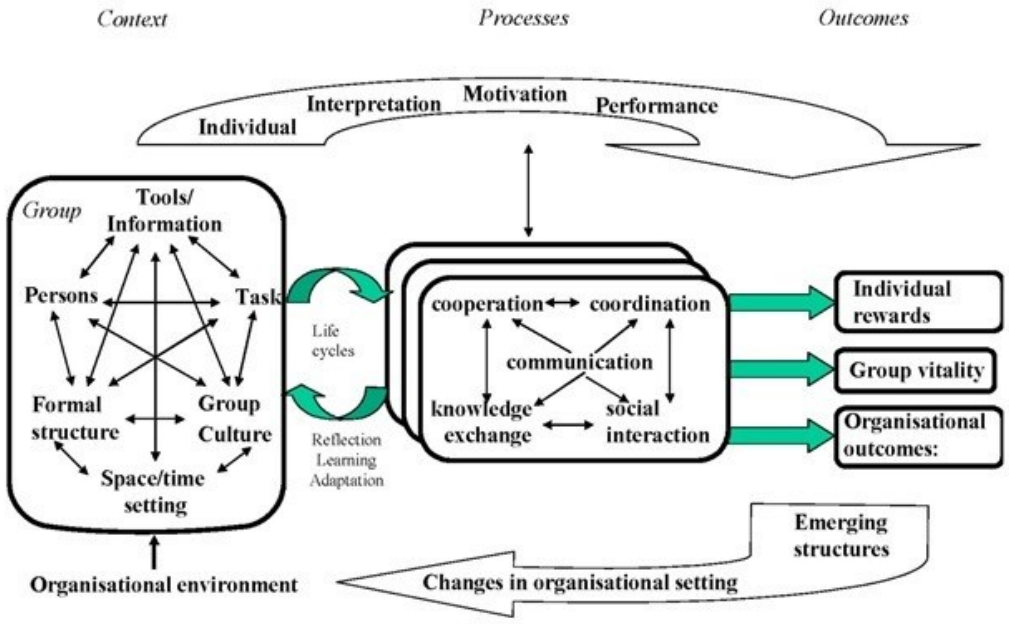

Figure 5: Dynamic Group Interaction Model (DGIn) (Andriessen, 2002).

On a higher level the model creates a distinction between input characteristics, processes and outcomes, just as in case of IPO model. The output of the group/team is a function of group processes used to share information in the team, and the group processes are determined by the characteristics of input parameters. The group processes and group characteristics are interlinked in this model and evolve with time to stay effective and keep up with the competitive environment. The group processes may impact the characteristics of the input, and similarly group processes may change during group life cycles. For optimal performance the characteristics of the inputs need to be balanced in

terms of size, tasks, group culture, group composition, formal structure, space/time dispersion etc. (Andriessen, 2002).

The model identifies five group processes i.e. communication, cooperation, coordination, social interaction and knowledge exchange. Communication is different from other group processes as it is a vital ingredient for other group processes to work. Cooperation, coordination and knowledge sharing are task oriented processes. Cooperation refers to working together and using ones skillset to achieve the goal, coordination is alignment of interdependent tasks to work efficiently, and knowledge exchange occurs as part of sharing information. Social interaction assists in developing trust and cohesion in the team and contributes to team building (Andriessen, 2002).

3.5. Comparison of virtual team models

We have presented four frameworks from research literature to analyse the working and efficiency of virtual teams. One of the frameworks is based on the concept of life cycle of virtual teams i.e. five stage model (forming-storming-norming-performing-conflict resolution). Second framework we presented focus on the working of virtual teams from the perspective of technology, people, and processes, and identifies four elements in each category which impact the performance of virtual teams. Then we discussed the framework presented by Powell et al. (2004), which is based on the input-process-output model. Dynamic group interaction model presented in the end is also bases on input-process-output model but it also includes some theories from the domain of communication and group interaction.

The technology, people and process model is very detailed as it extracts the 12 elements which impact the performance of the team. The IPO framework from Powell et al. (2004) can include all elements listed in technology, people and process framework. In addition it puts a special focus on socio-economic processes (i.e. relationship building, cohesion, & trust) which are vital components for the success of any virtual team. These socio-economic factors if not handled correctly can cause conflicts and power struggle in the team and adversely effects it performance. Similarly the DGIn model lays a specific focus on the enrichment of communication. It identifies co-ordination, cooperation, communication, knowledge sharing, and social interaction as separate interlinked processes impacting team performance.

3.6. Framework for functioning of high-tech virtual teams

In the last sub-chapters we discussed some of the existing frameworks that can be used for the evaluation of functioning of virtual teams. We would like to focus on the functioning and performance of virtual team in high-tech organizations part of multi-national companies. Thus we will take into account all factors critical to smooth operation

of virtual teams in high-tech multi-site setup. In this section we will present a new framework that is extended from existing models discussed in previous chapters. Our framework is based on technology, people, and process model by Bal and Gundary (1999) and IPO model by Powell et al. (2004). We also included the communication processes highlighted in DGIn model (Andriessen, 2002) and some other important elements we discovered during our research on virtual teams in our extended framework. Our model has three distinguishable phase i.e. *formation phase* – feasibility study, resource analysis, competitive environment analysis etc., *execution phase* – team formation, project implementation, information sharing etc., and *output analysis phase* – results, achievements, lessons learnt etc., and thus it is named as Formation, Execution & Output analysis (FEO) framework for the evaluation of virtual teams. This framework is directed towards research and development organization in technology centric companies. The FEO framework is presented in Figure 6 and its phases are discussed in detail in the following subsections.

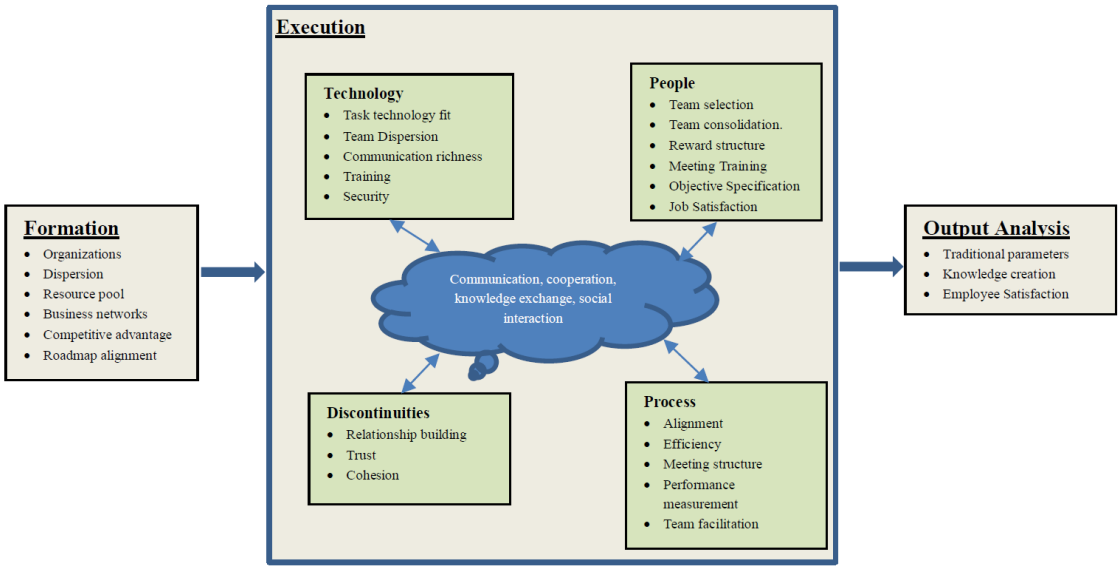

Figure 6: Formation, Execution & Output Analysis (FEO) Framework for the evaluation of Virtual Teams.

3.6.1. Formation phase of high-tech virtual team framework

The first phase in the FEO model is the formation phase. In this phase a higher level concept of the project is drawn and feasibility study of the project is done in terms of resource availability and market competitiveness. Critical technologies, skills and competencies to meet future market demands are identified. Team leaders and architects dig out the details of cross-functional collaboration needed between different organizations for the project to meet its target. The geographical and organizational dispersion of critical resources is assessed.

Companies are establishing long term strategic partnerships with their suppliers to enhance their competitiveness. This allows the organization to keep their focus on their core competences and leverage the R&D expertise and innovation of their business network to gain competitive advantage. This phase evaluates value addition offered by its strategic partners and business network, and the competitive standing of the product when it will hit the market.

FEO framework is targeted for organization operating in high-tech domain. These organization usually have a roadmap showing the upcoming projects against a timeline. The roadmap is aligned with the activities of the strategic partners to ensure that the components and IPs needed from the collaborating partners are available in time for the successful completion of the project. The strategic partners can also contribute technical and human resources to the project. The roadmap is shared with all the members of the organization. This provide visibility to the employees about the organization long term goals and how they are contributing to achieve those target. This in turn motivate the employee and bring efficiency to the organization. The alignment of the deliverables from the strategic partners, third party component providers, and project internal milestones is also done at the formation phase. According to Bernal et al. (2009), "*roadmaps are part of a methodology that guarantees the alignment of investments in technology and the new development of capabilities, so that they are able to make capital out of future market needs"*.

The formation phase in our model covers a wide scope to analyse the things in a bigger picture. Usually in the high-tech organizations the internal resources allocated for one project are reserved for the upcoming projects in the roadmap. The formation phase not necessarily points to immediate launch of a new project, but it ensures that technical and human resources will be available, along with required intellectual resources when the project is schedule to be launched. The key points of the formation phase are summarized in Table 6.

Table 6: Formation Phase in FEO framework for virtual teams working.

Formation Phase	Key Points
Organization	• Identify cross-functional collaboration needed between different organizations with in the company. • Identify collaboration needed with external organization in business network.
Dispersion	• Asses the dispersion of teams and organizations in terms of location and time zone difference.

Formation Phase	Key Points
Resource pool	• Estimate the availability of resources when project is scheduled to start. • Check if all desired skills, resources, tools and technologies are available.
Business Network	• Identify the contributions required from the strategic partners to accomplish the project. • Confirm the status of deliverables from partner companies and third party supplier.
Competitive Advantage	• Asses the deliverables of the project against the market competition expected at the time of completion of project. • Evaluate the competitive advantage gain expected from the project.
Roadmap update	• Align the roadmap with the collaborating partner companies.

3.6.2. Execution phase of high-tech virtual team framework

The execution phase in our model is adapted from the technology, people and process (TPP) model by Bal and Gundary (1999). We have added some additional elements for the technology, people and process perspectives, and changed the name of few elements and redefined their scope. In addition we introduced a new perspective to assess the virtual team working i.e. “discontinuities”. The term discontinuities originates from Hosseini et al. (2015) classification of different approaches to define virtual teams discussed in section 2.1.2. The discontinuities approach of defining the virtual teams’ focuses on elements which can negatively impacts the performance of the team, and if not managed correctly can cause disruptions in the team operation. Thus in our model the execution phase has four different perspectives i.e. technology (5 elements), people (6 elements), process (5 elements), and discontinuities (3 elements), linked together using a fabric of enriched communication, cooperation, coordination, knowledge sharing and social interaction.

Technology perspective in the execution phase of FEO model focuses on the selection of suitable communication medium to share the information effectively between the members of the virtual team. The technology should be able to handle the dispersion of the team members in terms of time and space by taking into account the requirements of the project. As compared to TPP model we have made special emphasis on having multiple mediums of communication to enrich the shared information in virtual

environment. For example information can be shared between the team members via phone call, chat, email, database repository etc. but the nature of information exchange determines the best medium for the job. Similarly trainings for efficient usage of the tools and processes, and security of the information exchanged are essential in high-tech R&D organizations for smooth working of the teams. Key points of technology perspective in the execution phase of FEO model are summarized Table 7.

Table 7: Execution Phase (Technology Perspective) in FEO framework for virtual teams working

Execution Phase Elements	**Key Points (Technology Perspective)**
Task technology fit	• Technology should be able to provide suitable communication medium for the project. • Cost/benefit analysis for the selection of technology.
Team Dispersion	• Technology should be able to address the geographical and temporal dispersion in the team. • Technology should also cover the dispersion due to collaboration with strategic partners.
Communication richness	• Multiple communication channels should be made available suitable for different kind of communication, and information sharing needs as per project requirement e.g. email, chat messenger, FTP, database repository etc.
Training	• Team members should familiar with the technological tools and communication processes. • Trainings should be identified for new tools and new processes to get the team up-to-speed quickly.
Security	• Communication, data sharing, and information sharing between team members is secure.

People perspective in the execution phase of FEO model focuses on selection of virtual team members with required skills and expertise needed for the project to meet its goals. We have added a new element i.e. team consolidation in our model as compared to TPP model for the people perspective. Virtual teams offer many advantages but they are also coupled with some draw backs. Geographical dispersion of team members can create some serious problems in the synchronization of task, especially if the tasks are complex in nature and highly interdependent. Thus selecting a virtual team while keeping in mind

to reduce the geographical dispersion of the team members, or reserving the complex and highly interdependent tasks for collocated team members can positively impact the efficiency of the virtual team. Thus a careful analysis of geographical dispersion of the team members is also required when selecting the virtual team. In our model we have linked the reward structure to individual performance, team performance, and organizational performance. Reward structures should be such that it promotes cooperation and coordination among the members of virtual team. Virtual team members should be trained to communicate effectively using the available tool and processes. Virtual team members should have well defined and accountable objectives to reduce the ambiguity created due to lack of F2F communication. This allows the team members to focus on their tasks without getting distracted. Job satisfaction is another key factor impacting the performance of virtual teams. The members of virtual teams needs to be self-motivated and well organized due to lack of physical interaction with the team leaders. Job satisfaction plays a pivotal role in keeping the members motivated and focused on their tasks. Key points of people perspective in the execution phase of FEO model are summarized in Table 8.

Table 8: Execution Phase (People Perspective) in FEO framework for virtual teams working

Execution Phase Elements	**Key Points (People Perspective)**
Team selection	• Suitable resources in terms of skills, expertise, and experience should be included in the team. • Size of team should match the project size and project schedule.
Team consolidation.	• Geographical location should be considers during the selection of the team. • Task split should be made in a way to centralize the complex and big tasks to collocated team members, if possible. • The number of sites or geographically dispersed group of people working in the team should be manageable.
Reward structure	• Transparent and fair reward structure to motivate the team. • Reward structure should be based on accountable individual goals, team targets, organizational level targets and companies overall performance.

Execution Phase Elements	Key Points (People Perspective)
	• Reward structure should promote cooperation and coordination among members of the virtual team.
Communication Training	• Training to share information effectively. Use the right communication technology to share information.
Objective Specification	• Accountable, definable and clear objectives. • Well defined responsibilities and facilitation in achieving the objectives.
Job Satisfaction	• Steps to provide higher level of job satisfaction e.g. job rotation, recognition of achievements, on-job trainings etc.

Process perspective in the execution phase of FEO model focuses on availability of efficient tools and processes to facilitate the working of virtual teams. In the process perspective we have one additional element as compared to TPP model i.e. "efficiency". The organizations should make an effort to limit the number of different processes in use. Having too many processes can overwhelm the employees and resultantly tend to lose their effectiveness. In addition the processes should be comprehensible, not overly complex, and should limit the amount of bureaucracy involved. The other elements from process perspective in our model i.e. alignment of the processes across the organization, well defined meeting structure, processes to provide continuous feedback, and processes to facilitate the team in carrying out its day to day activities are same as defined in TPP model. Key points of process perspective in the execution phase of FEO model are summarized in Table 9.

Table 9: Execution Phase (Process Perspective) in FEO framework for virtual teams working

Execution Phase Elements	Key Points (Process Perspective)
Alignment	• Same processes and tools used by the members of team. • Team members should be willing to use the process and communication technology to share information.
Efficiency	• Select the processes and tools that positively impact efficient of team.

Execution Phase Elements	Key Points (Process Perspective)
	• Too many processes in an organization adds to complexity and reduce the efficiency of the process.
Meeting structure	• Well defined meeting structure to synchronize the activities of the team members, e.g. weekly meetings to discuss the progress.
Performance measurement	• Provide continuous feedback to the team members regarding their performance as a unit using predefined and transparent processes which include e.g. milestone achievements, knowledge creation etc.
Team facilitation	• Well defined rules and responsibilities to help the team focus on ongoing tasks.

Discontinuities perspective in our FEO framework is added to reduce the impact of factors that can cause disruptions in the working of virtual teams. There are many elements which can negatively impact the performance of virtual teams, e.g. geographical dispersion, cultural diversity, lack of trust, language barriers, lack of team cohesion, communication break down due to misunderstanding etc. Most of these factors are already covered by the elements identified for technology, people and process perspective. Three elements most critical to the working of teams in virtual environment are trust, cohesion and relationship building via effective communication. These elements have also been highlighted by Powell et al. (2004) in their IPO model as "socio-economic processes" impacting the working of virtual teams. For the discontinuities perspective we have added these three elements in our model to emphasize their importance in the smooth operation of virtual teams. Trust and team cohesiveness is built through effective communication, coordination and cooperation. Meyerson et al (1996) defined trust as "*willingness of a party to be vulnerable to the actions of another party, based on the expectation that the other will perform a particular action important to the person in whom trust is placed, irrespective of the ability to monitor or control that other party*". In virtual teams lack of F2F communication and physical interaction negatively impact the trust. To overcome this hurdle the importance of enriched communication increase further. A F2F team even at the start of the project with all the team members present at same location promotes trust in the team. Team cohesiveness is the ability of the virtual team to work as a unit and is dependent on degree of trust between the virtual team members. Thus relation-ship building in the virtual team via formal and informal

interaction, and effective communication mechanism plays a role in building trust, enhancing team cohesiveness and improving performance. Key points of discontinuities perspective in the execution phase of FEO model are summarized in Table 10.

Table 10: Execution Phase (Discontinuities Perspective) in FEO framework for virtual teams working.

Execution Phase Elements	**Key Points (Discontinuities Perspective)**
Relationship Building	• Team building events to give a chance to employees to interact in informal settings. • Communication mediums where employees can interact in informal way e.g. (chat messenger)
Trust	• Perception about the competences of team members, and formal and informal contact impact the level of trust in the team.
Cohesion	• Team cohesiveness is the ability of the team to work as a unit and depends on the degree of trust among the members of the team.

3.6.3. Output analysis phase of high-tech virtual team framework

The output analysis phase measures the efficiency and effectiveness of virtual teams as a unit. The criteria for measuring the performance of virtual teams is discussed in detail in section 2.5 of this thesis report. The performance of the virtual teams can be measures by using the traditional parameters for measuring the effectiveness of collocated team e.g. time to market, cost management, meeting the schedules etc. In addition the performance of virtual teams is calibrated based on the amount of knowledge creation and job satisfaction of employees. Knowledge creation is used as a parameter because virtual team need to document all the flows, processes, technologies and design aspects of the project. This in turns generate knowledge which is used to measure the efficiency of virtual teams. Similarly virtual team member are more empowered as compared to collocated team members due to their dispersion in terms of geographical location and time zones. Lack of F2F discussions with distant team member and distant team leaders put more responsibility on virtual team members to synchronize their task and sort the issues. Thus the member of virtual teams need to be self-motivation and should take more responsibility to contribute effectively to the team targets. This is only possible when the employee are satisfied with their work environment. Therefore employee satisfaction is used as a factor to measure team performance as shown in Table 11.

Table 11: Output Analysis Phase in FEO framework for virtual teams working.

Output Analysis Phase	Key Points
Traditional measures	• Quality of products and services. • Ability to solve problems. • On-time completion of project milestones • Cost Management. • R&D efficiency and innovation
Knowledge creation	• Knowledge created in the virtual team by sharing of information via formal channels and documents.
Employee Satisfaction	• Satisfied employees contribute more effectively to virtual teams due to the structure of such teams. For example they are more empowered, share more responsibilities and thus need to be more organized and self-motivated.

4. RESEARCH METHODS

4.1. The case organization

The case organization we will focus for the purpose of this research work is part of a high-tech company operating in the field of network technology. The members of the organization are working in the domain of System on Chip (SoC) design. They are geographically dispersed and are assembled in multiple organizational teams to better manage the human resources. The focus area of each organizational team is defined e.g. design, verification and architecture, but the member of these organizational teams do not necessarily work on the same project. The project teams are created using the resource pool available in these organizational teams. The high-level structure of the organization is depicted in Figure 7.

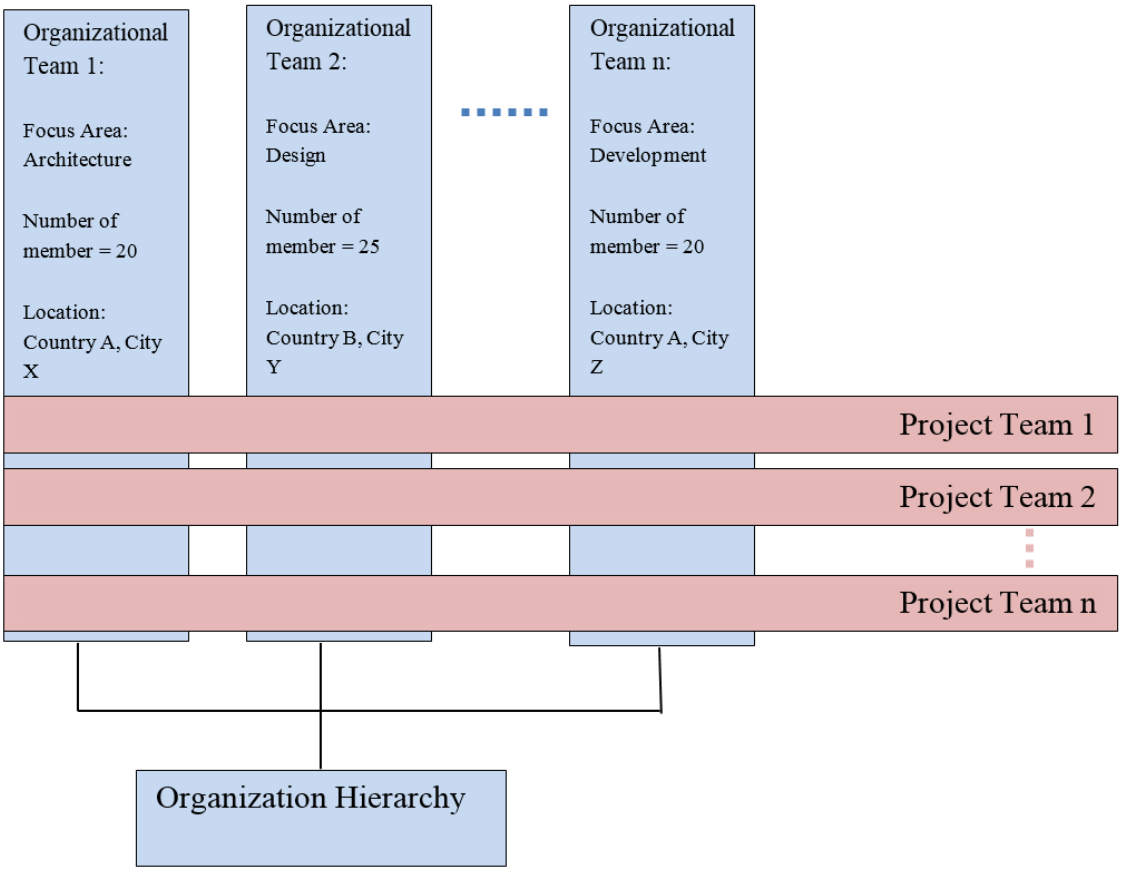

Figure 7: Parent organization structure

For clarification purpose we will use following terminologies in this case study to refer to the teams, organizations and the company:

- Organizational Team: Teams to manage human resources in the organization.
- Project Teams: Teams created from resource pool available in organizational teams to work on a particular project.

Using the classification done by Duarte & Snyder (1999) for the types of virtual teams (discussed in section 2.2 of this thesis report) the project teams working in the parent organization can be classified into following three types of virtual teams.

1. Networked teams
2. Parallel teams
3. Project development teams

Networked teams are short lived and contains experts from different specializations or different organizations to discuss a specific topic. Parallel teams are also short lived. These teams are required to accomplish some task needing wide range of specializations. Expertise can be sort from within the organization and also from other organizations. Project development teams, as the name suggests, are involved in the research and development activities to accomplish the project goals. These teams contain specialists, architects, developers and mangers.

Similarly, based on categorization done by Niedeman and Beise (1999), working of these project teams can be categorized as “highly virtual” (i.e. Low face-to-face interaction and high usage of ICT technology) and “Fully Supported” (High face-to-face interaction and high usage of ICT technology).

4.2. Organization background

The parent organization was created approximately four years ago due to a shift in parent company’s strategy to bring some offshore development to in-house development. Some of the members of this organization share a history of working together for over fifteen years. The member of the organization have been involved in business transfer deals, mergers, acquisitions and joint-venture formations. Owing to highly complex and competitive nature of the technical domain, the project teams have always worked in a virtual environment involving collaboration with strategic partners. The parent organization thus offers rich grounds to study the workings of virtual teams and evaluate the factors impacting their performance.

- The members of organization have first-hand experience of working in virtual environment.
- The members of organization have used different tools and communication technologies to accomplish their tasks.

- The organization members have been involved in collaborating with strategic partners to boost up the research and development activities.
- The members have vast experience of working in culturally diverse environment.
- The members have experienced the impact of merging of two different company cultures, as it happens during the formation of joint-ventures and acquisition.
- The organization members have dealt with the conflicts, power struggles, and communication related issues arising due to cultural diversity in virtual teams.

4.3. Research flow

In our research we have used the elements identified in the FEO framework to gather data and information on the working of virtual teams. We have analysed the challenges associated with the working in virtual environment from two different perspectives i.e.

- Leader's perspective.
- Team member's perspective.

The leader's perspective incorporates the views of managers in the organization, team leaders and architects. These people have to interact more frequently with dispersed team members located in different sites to synchronize and align the ongoing tasks in the project. The team member's perspective focuses on the remaining team members whose tasks have relatively smaller scope. Our approach to gather data from the organization members include:

- Questionnaire survey
- Interviews

The first step to gather information is to map the factors highlighted in the FEO framework for the working of virtual teams to a set of questions to be asked from the organization members. This step requires some deliberation and thoughtful process to come up with a correct set of question that extracts the right information from the organization members on the challenges faced while working in virtual environment. The survey should include questions that should address the challenges and advantages associated with working of virtual teams from team leader and team member's viewpoint.

The next step is to select a focus group comprising of virtual team leaders and virtual team members to send the survey questions. The focus group should not be restricted to one country or one site. Rather it should include members geographically dispersed around the globe and working in different virtual teams. The diversity in the selection of focus group includes point of view of people working in different cultures and different environments and thus makes the response more thorough and detailed.

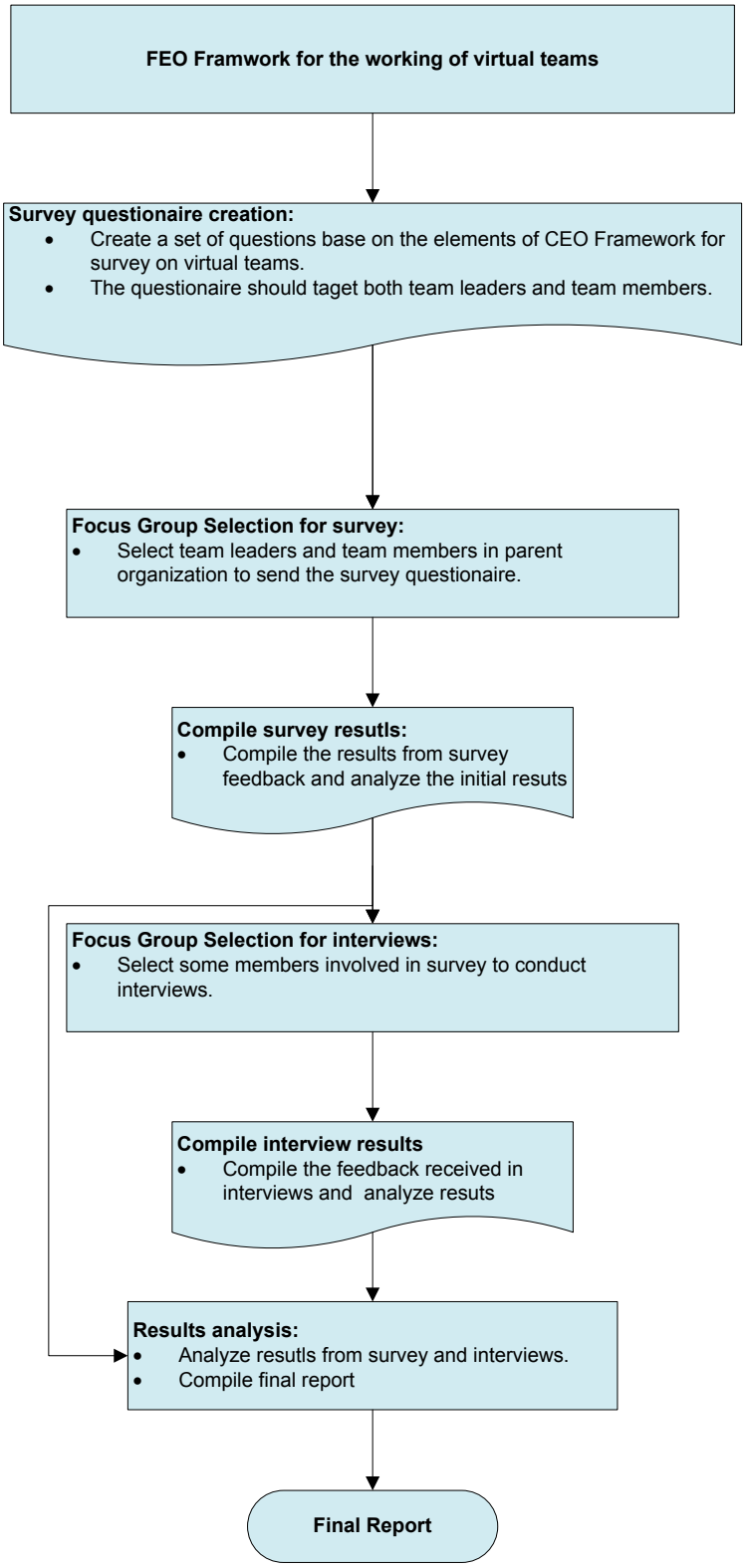

Figure 8: Research methodology flow.

The response received from the organization members is then compiled and analysed to extract some important factors critical to the working of the virtual teams. The next step is to select some members from within the focus group to conduct interviews. The

interviews focus on getting more detailed feedback about the various critical factors identified for working in virtual environment. The response from the survey and interviews is then compiled into a final report. The flow of research methodology is summarized in the Figure 8.

4.4. Survey and interview content

The survey to assess the working in the virtual teams was conducted using google forms. Google forms provide a free platform to collect and organize information from multiple users into google sheets [Google forms, Accessed October 22, 2016]. The data can then be analysed to extract useful information. The survey is deliberately kept anonymous so that the respondents can provide their feedback more openly. The survey was split into six section. The first section gathered details about the respondents in terms of their location, position and experience. The second section focused on the project formation phase in the FEO model. The third, fourth, fifth and sixth sections focused on four different perspective highlighted in the execution phase of FEO model i.e. technology perspective, people perspective, processes perspective and dispersion perspective respectively. The output analysis phase of FEO model focuses on knowledge creation and team satisfaction in addition to traditional measures (e.g. Quality, time to market etc.) for evaluating the team performance. A separate section for this phase was not created and it was covered in section four, five and six of the survey i.e. people perspective, process perspective and dispersion perspective.

The questions in the survey were intentionally kept short and focused on a specific point. Most of the questions in the survey required the respondents to provide their input on a scale of 1 to 5. In some questions the respondents were asked to select one or more option from available choices. At the end of each section the respondent was provided a free text box to provide additional comments. The survey questionnaire is available in the Appendix 1.

Respondent information:

The respondents for the survey were carefully selected to get the point of view of people working in different roles in the organization. Though the survey was kept anonymous, the respondents were required to provide some information about their location (country and site), current position, years of work experience and nationality (optional) to better organize and analyse the data gathered.

Formation phase survey questions:

The project formation phase is related to the conception of the project, feasibility study, resource availability analysis, and assessment of collaborating partner in the project in terms of capabilities and road map alignment. This section of the survey thus prompted

the respondents to evaluate the importance of some factors at the start of the project. These factors included appraisal of cross-functional collaboration needed within and outside the organization, determination of team dispersion in terms of time, space and organizational boundaries, and estimation of resource availability. The respondents also provided their feedback about assessment of contributions from strategic partners and study of competitive advantage gain before the start of project.

Execution phase (technology perspective) questions:

Technology perspective section focused on optimal usage of communication technology to synchronize the tasks between the members of virtual team. This part of the survey concentrated on getting the user feedback about the communication tools they deemed most effective in terms of project execution. The respondents of the survey provided their input on the optimal number of tools to be used in the project, evaluated the quality and efficiency of the communication tools in use in their organization, and assessed their familiarity with the tools. They also evaluated the quality of trainings available in their organization to familiarize them with the tools.

Execution phase (process perspective) questions:

Process perspective section evaluates the processes in use in virtual teams to facilitate the team work as a single unit and execute the project efficiently. The survey respondents were asked to evaluate the various process in use in their organization e.g. to track project milestones and provide continuous performance feedback. They also provided their grading for the processes in term of creating knowledge, and provided their feedback for total number of processes used in their organization.

Execution phase (people perspective) questions:

The people perspective of the survey deals with the impact of team dispersion on the execution of project. This section focused on factors influencing job satisfaction and views of the team members about the fairness of reward system. This part of the survey also gauged the opinion of team members about the work load, work-life balance and their assessment about the capabilities of their team.

Execution phase (dispersion perspective) questions:

The dispersion perspective analyze the factors which if not managed properly can cause disruptions in the working of the teams. These factors include job satisfaction, team cohesiveness, communication and responsibility allocation. Most of these factors are already catered for in the earlier sections and therefore this section mainly focused on the job satisfaction and team cohesiveness.

Interview Content:

Interviews were conducted after the survey. For the interviews three team members and three members working in the leadership role were selected. The results of the survey were shared with the interviewees beforehand. The interview was conducted in an informal manner without having a set of specific questions. The interviewees were asked to give their thoughts about the workings of virtual teams and highlight some factors which impacts the working of such teams positively and negatively. They were also asked to share their experience of some projects where virtual environment facilitated the execution of project and also some projects where virtual team did not function smoothly.

4.5. Respondent selection

The respondents for the survey were selected from three different countries i.e. Finland, China and Poland. The total number of sites involved in the survey was four i.e. two from Finland (Oulu and Tampere), one from China (Hangzhou), and one from Poland (Wroclaw). The respondents were further scrutinized for their role in the organization (i.e. manager, team leader, architect, team member) and years of work experience (less than 3 years, between 3 and 8 years, between 8 and 15 years, more than 15 years). The survey link was sent to 90 potential respondents out of which 58 provided feedback for the survey. Thus the response rate for the survey was approximately 65 percent. The factors contributing to the dispersion of survey respondents are summarized in Table 12.

Table 12: Selection of survey respondents

Factor	Dispersion
County	Finland, China, Poland
Sites	Tampere, Oulu, Hangzhou, Wroclaw
Time dispersion	• China: GMT + 8 hours • Finland: GMT + 2 hours (Daylight saving +1 hour) • Poland: GMT + 1 hours (Daylight saving +1 hour)
Position in Organization	Manager, Team Leader, Architect, Team member
Years of work experience	• Less than 3. • Between 3 and 8 years • Between 8 and 15 years • More than 15 years
Nationality (Optional)	Approximately people from 7 different nationalities were involved in the survey.
Response Rate	65 percent. Survey request sent to 90 potential respondents. Feedback received from 58 respondents.

The respondent dispersion is summarized in the Figure 9. Approximately 89% of the respondents were from Finland (Tampere 72%, Oulu 17%), 9 percent from China (Hangzhou), and 2 percent from Poland (Wroclaw). Among the respondents 60 percent categorized themselves as team members, and remaining 40 percent categorized themselves in a leadership role (19 percent as managers, 12 percent as team leads and 9 percent as architects). Most of the members of the SoC organization have worked in the semiconductor industry for many years. In our respondent group 79% possessed more than 8 years of work experience (44% more than 15 years; 35% between 8 and 15 years). 21% of the respondents have less than 8 years of experience (10.5% between 3 and 8 years; 10.5 % less than 3 years). The respondent group contained approximately 7 different nationalities i.e. Finnish, Iranian, French, Chinese, Pakistani, Polish, and Indian. The nationality field was optional in our survey and therefore many respondents left this field empty.

The respondent group provide good diversity to thoroughly analyse the virtual team working environment in the target organization. Utilizing the diversity information we have created sub-groups to gauge the opinion of the people based on years of work experience, role in the organization and location. We have identified seven different categories to explore the result i.e.:

- All respondents.
- Respondents having leadership role (managers, team leaders, architects).
- Respondents working as team members.
- Respondents having more than 8 years of experience.
- Respondents having less than 8 years of experience.
- Respondents from Finland.
- Respondents from other countries.

There were only six responses from countries other than Finland (5 from China, and 1 from Poland). Due to very small sample size these results are not very reliable. We will present the results from other countries for reference in the compiled tables but will not discuss them in detail. The results of the survey are presented and discussed in the following subsections.

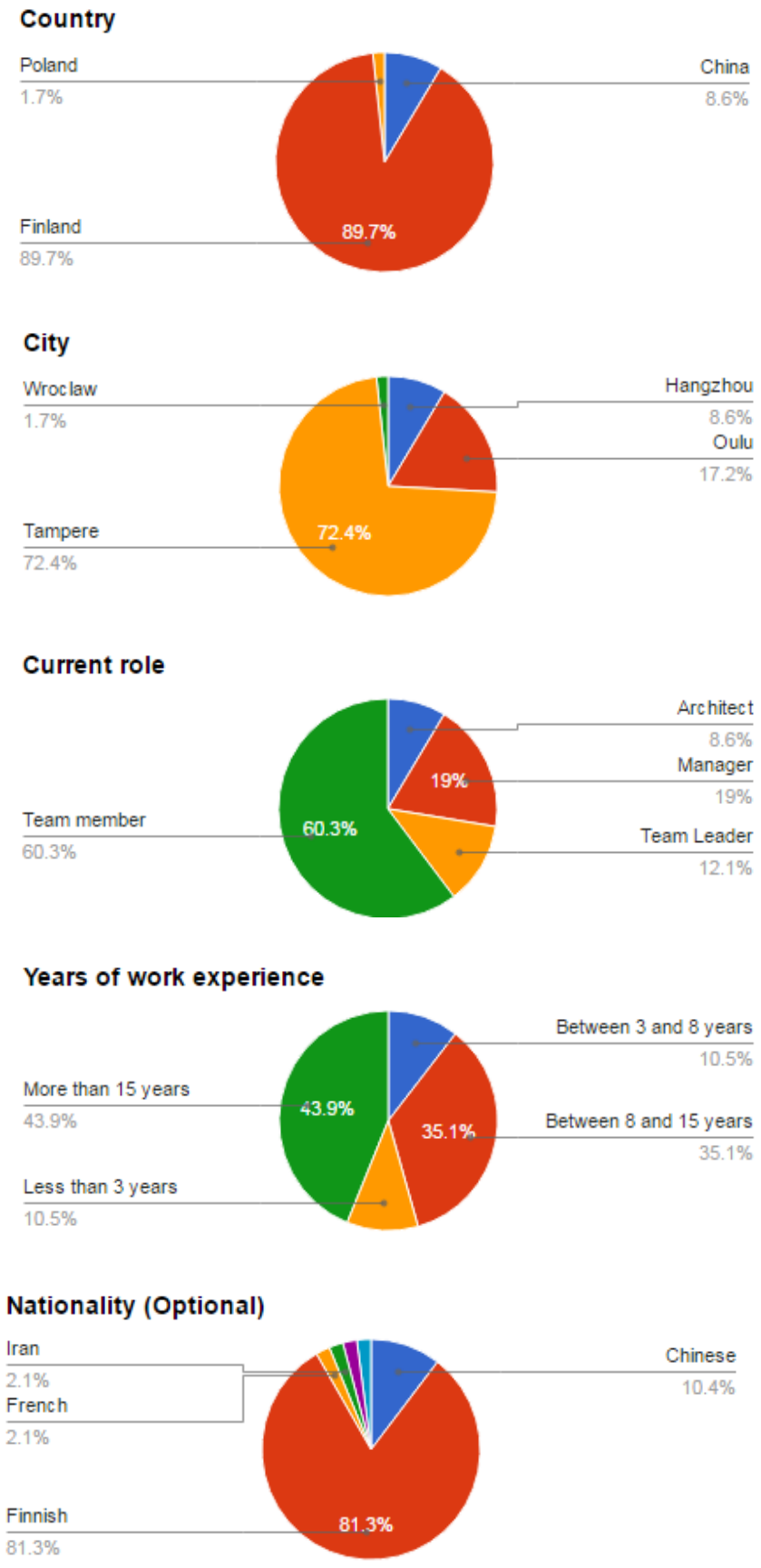

Figure 9: Respondent dispersion for virtual team survey (58 responses received)

4.6. Data analysis approach

As discussed earlier, for the purpose of this research work data is gathered from the respondents using a questioner survey and interviews. In order to come up with an effective approach to analyse this data we need to first consider the type of data generated. Our generated dataset has following main features:

- Feedback on a scale of 1 to 5.
- Multiple choice answers.
- Feedback in free text box.
- Interview feedback on survey contents and results.

Most of the questions in the survey required the respondents to provide their feedback on a scale of one to five. To analyze the data of this nature two important aspects are the spread of the data and the average value of the dataset.

The mean or average of the dataset provide an indication about the convergence point of the respondent opinion. To make the analysis more meaningful we have calculated the mean value for the seven groups identified in the last section. With this approach we can measure how the opinion of different groups compare with each other and to the mean value for all respondents.

The mean value only tells about the central tendency of dataset but does not provide information about the dispersion of data. Dispersion is critical to analyze the data of this nature as it indicates how much the opinions differ in the team on the same topic. The amount of variation or dispersion in the dataset can be measured using standard deviation. A small standard deviation indicates that values in the data set are close to the mean. Similarly a high value of standard deviation indicated that data is spread out over a wide range of values. [Standard deviation, Accessed November 9, 2017]

Therefore for the feedback received on the scale of 1 to 5 our approach to analyze the data can be defined as:

- Calculate mean and compare different groups.
- Calculate standard deviation to measure dispersion.

Multiple choice questions in the survey focused on the selection of tools, processes etc. This data is thus analyzed by calculating mean and comparing different groups. Feedback received from the interviews and survey via free text box is analyzed in the context of results from survey in the discussion section.

5. RESULTS AND DISCUSSION

5.1. Project formation phase

The project formation phase deals with the feasibility study and conception of the project. The survey results for this section are summarized in Table 13. All the elements we identified for the project formation phase have been rated by the respondents as very critical (approx. level 4, maximum standard deviation 0.8). The results between different sub-groups are more or less in harmony. The respondents working in the leadership role have rated the cross-functional collaboration needed between different organization within and outside the organization slightly more important as compared to other sub-groups. Similarly, the alignment of roadmap with collaborating partners and competitive advantage gained from the project was assessed slightly less important by them as compared to other sub-groups. These points were also discussed during the interviews. The people in the leadership role were of the view that there should be more than one strategic partners who can offer similar services to drive competition among the suppliers. Too much reliance on one strategic partner create monopoly and reduces the leverage of the organization on resources external to the company. Road map alignment and competitive advantage is important but too much focus on these factors can result in ignoring some critical areas all together. Cross functional collaboration is linked to the cost and thus, it is very critical to be analyzed at the start of the project.

Table 13: Project information phase survey results.

Survey Questions	Overall (n=58)	Standard Deviation (n=58)	Managers, team leaders and Architects (n=23)	Team members (n=35)	Less than 8 years' experience (n=14)	More than 8 years' experience (n=44)	Finland (n=52)	Other countries (n=6)
Rate cross-functional collaboration needed between different organizations?	4.2	0.68	4.4	4.1	4.0	4.3	4.2	4.0
Rate collaboration needed with external organizations outside the company?	4.2	0.74	4.3	4.1	3.8	4.2	4.2	4.0

Survey Questions	Overall (n=58)	Standard Deviation (n=58)	Managers, team leaders and Architects (n=23)	Team members (n=35)	Less than 8 years' experience (n=14)	More than 8 years' experience (n=44)	Finland (n=52)	Other countries (n=6)
Assess the dispersion of teams and organizations in terms of location and time zone difference?	3.9	0.77	4.0	3.9	3.8	4.0	3.9	4.3
Assess resource availability, skill set availability during the conception phase of project?	4.4	0.64	4.4	4.3	4.4	4.4	4.4	4.0
Assess contributions required from the strategic partners (e.g. external IP's providers)?	4.2	0.66	4.3	4.1	4.2	4.2	4.2	4.0
Align the roadmap with the collaborating partner companies?	3.9	0.75	3.7	4.0	3.8	3.9	3.9	3.8
Assess the competitive advantage gain expected from the project	3.9	0.8	3.7	3.9	3.7	3.9	3.8	4.0

Text Feedback (Selected Comments):

- Project planning is the most important phase of the project life cycle, so all the information required to complete the project work should be taken into account in this phase.
- Estimation for the competitive advantage gain is quite important, but if this has too big weight there is a risk that important project could be missed due to wrong estimation.
- Careful planning ensures sufficient resourcing, fluent communication between multi-site teams, effort split and allocation, and of course business case evaluation will be the driver always.
- External collaboration in practice means capital expenses and need to be budgeted very early for OPEX planning. SoW with external collaborator is also key items there. So all external collaborators need to be clearly identified very early in the planning

Overall, the respondents rated the assessment of resource availability as most critical followed by cross-functional collaboration, team dispersion and competitive advantage.

5.2. Project execution phase

5.2.1. Technology perspective

This section of the survey analyzed the usage of communication tools inside the SoC organization. Most of the respondents thought that the optimal number of tools to be used for communication in the organization should be between 3 and 4 as shown in Figure 10. The respondents were then asked to select the three most significant tools for sharing information. The four most popular tools were email (53 responses), audio web conference (38 responses), document repository (34 responses) and chat messenger (29 responses). A sizeable number of respondents also voted for error tracking tools (19 responses) and internal wiki pages (11 responses) for sharing information. Majority of the people who voted for error tracking tool and internal wiki pages are working in the leadership role. Web based tools (e.g. yammer and confluence) and specification capture tools (e.g. DOORS) got the least number of votes from the survey respondents.

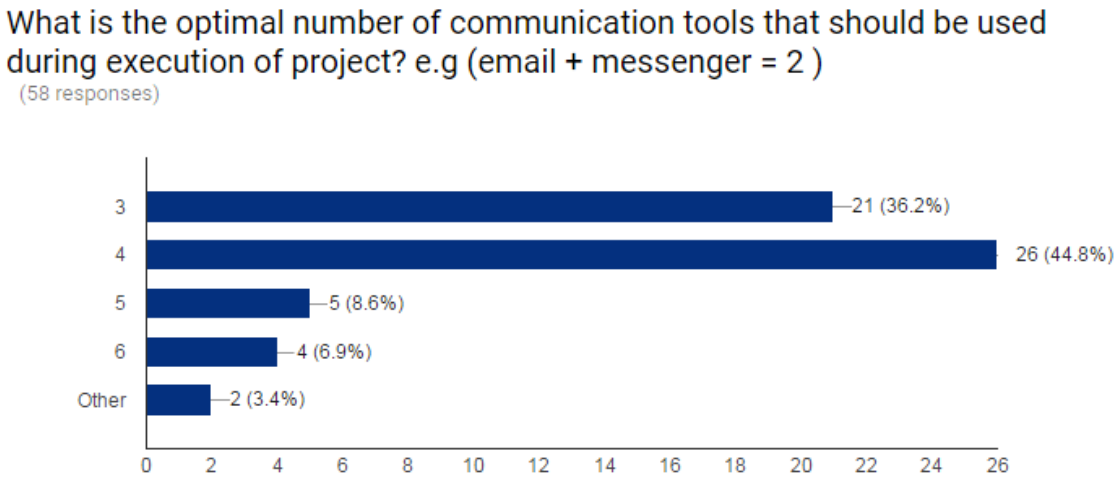

Figure 10: Optimal number of tools for communication.

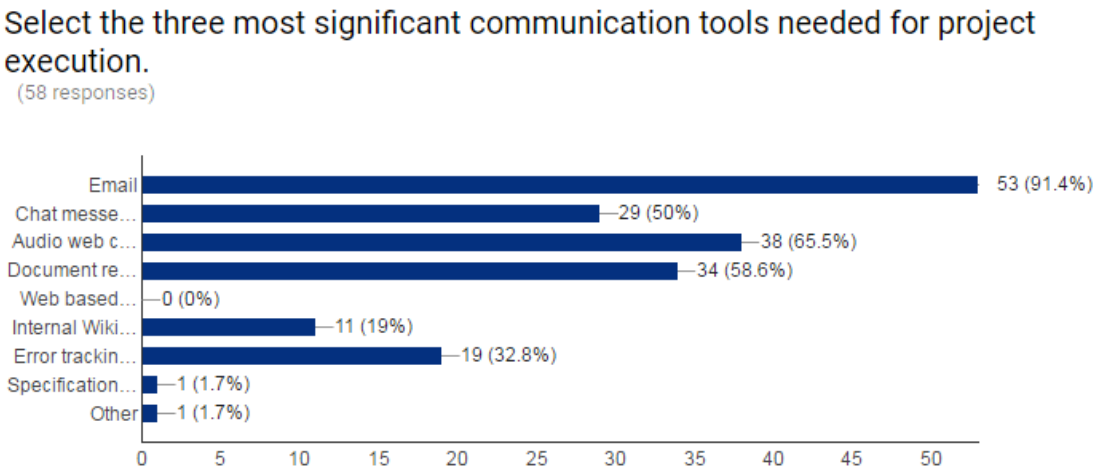

Figure 11: Most important tools for communication

The number of communication tools used in the organization and their efficiency was also discussed during interview session. Though people would like to limit the number of tools to around four but this is not always possible. Some tools are more critical for a particular role as compared to others. For example managers rely more on error tracking tools to check the progress of projects and assign tasks. On the other hand team members are more inclined towards chat messenger as it provides a very efficient communication medium to synchronize ongoing tasks with their distant colleagues. This notion was also captured in one of the textual comment in the survey.

> *"Different tools for different purposes. Phone, email and chat for everyday communication, confluence/wiki for task lists, sharenet for specs, JIRA for bug reporting."*

There was consensus among the interviewees that multiple tools should not be used in the organization for the same purpose. The tools should be thoroughly investigated to evaluate their usefulness, ease of use and efficiency. Once the tool has passed the selection criteria it should be rolled out in the whole organization. A focused effort should be made to align the usage of tools between different sites as well. This area is especially critical as people working in different sites tend to develop their own preferred ways for storage and communication of information. In a multi-site project having multiple communication mediums in use for the same purpose negatively impacts the efficiency of the team. All documents and information related to a project should be located in a single place in a well-structured format. The same information should not be replicated in multiple documents and tools as it becomes difficult to keep all the information in sync and can lead to spreading wrong information in the organization.

> *"All of the documents related to a project should be found in one single place. Hiding for example design specifications under one tool and requirements under another tool is just asking for trouble."*

The response from all the subgroups about other questions in this section ranged between 3 and 4 (i.e. between neutral and good) with maximum standard deviation of 0.85. Thus, there is some room for improvement in the organization in terms of quality and efficiency of communication tools. The respondents in the leadership role rated their familiarity with the communication tools highest i.e. 3.9. Since these people are using the communication tools more often in their daily tasks e.g. reviewing the specs, following the progress in error tracking tool etc. and thus they are more at ease with different tools used in the organization.

Table 14: Technology perspective survey results

Survey Questions	Overall (n=58)	Standard Deviation (n=58)	Manager, team leaders and Architect (n=23)	Team members (n=35)	Less than 8 years' experience (n=14)	More than 8 years' experience (n=44)	Finland (n=52)	Other countries (n=6)
Evaluate the quality of communication tools available for multi-site project execution?	3.6	0.75	3.5	3.7	3.6	3.7	3.6	3.3
How efficiently the communication tools are utilized during the execution of projects?	3.4	0.80	3.4	3.5	3.6	3.3	3.4	3.7
How do you rate your familiarity with the communication tools and processes?	3.7	0.71	3.9	3.5	3.8	3.7	3.7	3.7
How do you assess the trainings available to familiarize the team with new tools?	2.9	0.85	2.8	3.0	2.6	3.0	2.9	3.2
	Text Feeback (Selected Comments): - No team/project level trainings and discussions held about usage of tools and common practices. - There are really not a lot of trainings for communication tools, but if a tool is too convoluted to use upon first glance, it's a bad tool.							

	- Biggest source for problems, especially in multi-site projects, is that the information is scattered. There should be only one central hub through which all the information can be found. And the tool should be intuitive and easy to use. - Tools are what they are but usually we only use part of their feature set. So if a tool is acceptable usually its usage can be quite poor or we would need an excellent tool in order to reach adequate utilization. - Interaction could happen by several means (e.g. phone calls, email, chat) but project should avoid multiple parallel places for information storage (e.g. sharenet, community pages, confluence) because information gets easily outdated.

Another key finding of the technology survey is that the number and quality of tools related training can be improved. The responses received on the number of tool related training has the maximum standard deviation i.e. 0.85 in technology related questions. People with less than 8 years of experience rated the availability and quality of training at 2.6 (i.e. between not good and neutral). One of the interviewee pointed out that some tools have been assigned for use in a project without any formal training. Though people learned to use the tool by themselves by reading the user guide of the tool, but it took much more time for the team to use those tools efficiently. People developed their own flow and practices for using the tools and thus common methodology for tools usage is lacking.

Respondents were also provided a text box to provide their recommendation for the tools to be used in the organization. There are many comments received about new tools to be taken into use and some tools that should be discarded. This input will be explored more to improve the quality and efficiency of the tools used in the organization. Some of the major findings of surveys technology section and discussion with interviewees is can be summarized as:

- People would like to use a limited number of tools for information sharing and communication. The tools should be easy to use and have good quality and efficiency.
- Some tools are more critical in a particular role to share information. Therefore it is not always possible to restrict the total number of tools below a certain threshold. None-the-less there should be only one tool in the organization to serve a particular purpose e.g. error tracking.
- The quality, timing and number of trainings available in the organization to familiarize people with communication tools needs to be improved.

5.2.2. Process perspective

This section of the survey focused on the processes employed in the SoC organizations to facilitate day to day activities of team members and follow the project progress. The section covered the processes specific to SoC organization e.g. project milestones tracking, and companywide processes for travelling, performance evaluation etc. The responses received for this section have the greatest dispersion with standard deviation ranging between 0.82 and 1.06. By comparing the average of sub-group responses there is an agreement among the survey respondents that overall there are too many processes used in the company. It is quite cumbersome to find the right process to fill in the details of even a very simple operation e.g. travelling. Overall 64% of the people were of the view that there are too many process in the company as shown in Figure 12.

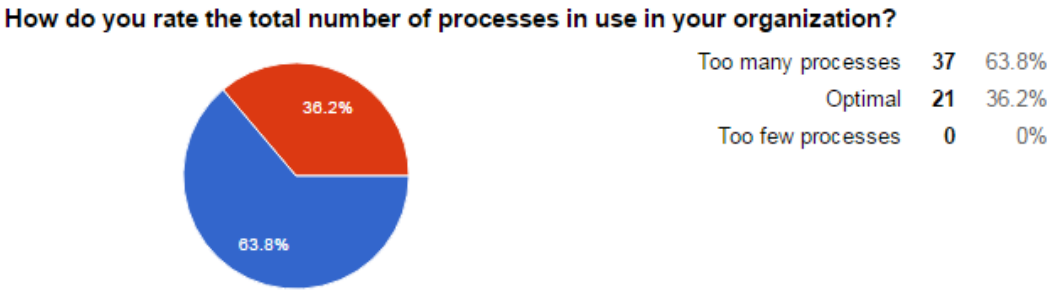

Figure 12: Total number of processes used in the organization.

In terms of quality and efficiency of the processes used in the organization for project management, people management, performance feedback and meeting structure the respondents from all subgroups rated those around neutral mark i.e. level 3 (standard deviation 0.85) as shown in Table 15. This points to the fact that the processes were able to get the job done but there is still room for improvement. Some of the improvement ideas gathered from interviewees and free text comments are:

- Anonymous feedback should be gathered from the team members about their colleagues on regular basis.
- Information about all the required processes should be made available in a common place. Information is available in the intranet but is dispersed and difficult to find.
- More efforts should be made to follow the processes strictly. Having lots of exceptions reduces the effectiveness of the processes.
- Projects have the flexibility to define their work flow but there should be some broader guidelines to organize the projects better.

Table 15: Process perspective survey results.

Survey Questions	Overall (n=58)	Standard Deviation (n=58)	Manager, team leaders and Architect (n=23)	Team members (n=35)	Less than 8 years´ experience (n=14)	More than 8 years´ experience (n=44)	Finland (n=52)	Other countries (n=6)
Grade the processes used in your organization to track project milestones?	3.2	0.82	3.4	3.1	3.2	3.2	3.1	4.0
How do you evaluate the other processes in use in your organization e.g. performance evaluation, travelling, personal development?	3.0	0.85	2.8	3.1	3.1	2.9	2.9	4.0
How well the processes in use in your organization provide continuous feedback in terms of your performance?	3.2	1.06	3.1	3.3	3.4	3.2	3.1	4.2
How satisfied you are with the meeting/reporting structure put in place in your project to track and synchronize the project progress?	3.4	0.89	3.3	3.4	3.7	3.2	3.3	3.7
Rate the processes in use in your organization in terms of creating and sharing knowledge?	2.9	0.83	2.8	3.0	2.9	2.8	2.8	3.5

One important area for improvement has been identified as the ability of the processes to share and create knowledge. This could be achieved by utilizing a well-defined structure of documents and well-defined hierarchy to locate the documents related to the tools and projects. One of the comments received in the free text box suggested taking Agile methodology [Agile Methodology] into use in SoC organization to improve processes and practices.

"We are applying Agile methods in SoC development without taking the whole Agile flow into use. We need to align our process with this fact and apply some of the Agile principle: continuous integration, prioritize working (RTL) code to documentation, get organized as vertical team (multi-functional) working in sprint, time boxed mode etc."

Agile methodology is developed to cater for the needs of software projects and software organization. The methodology fits to SoC development flow quite well. It could address some of the short comings highlighted in the survey such as knowledge creation, process harmonization etc. Interviewees in the leadership roles and team member roles agreed that it should be investigated further to be taken into use at organizational level.

5.2.3. People perspective

The people perspective of the survey gathered the view of the respondents about team skillset, resource availability, efficiency and the fairness of reward system. All the respondent subgroups rated the skillset availability in their teams as good. The respondents in leadership role were a bit more skeptical about resource availability to execute the project as compared to team members with less than 8 years of experience (3.1 vs 3.6, standard deviation 0.96) as show in Table 16. This is attributed to the fact that members with less experience are normally assigned on a specific tasks. On the other hand, team leaders have to view the resource availability on a broader perspective.

The efficiency of multi-site teams located in the same country is rated below neutral (overall average 2.8, standard deviation 0.88) by all sub-groups. When it comes to efficiency of multi-site teams located in different countries the rating falls below satisfactory level (overall average 1.9, standard deviation 0.83). This topic was specifically discussed with interviewees to gain insight how the efficiency of multiple site teams can be improved. Some of the points highlighted during the discussions are:

- Having weekly meetings with lots of participants do not allow the team members to focus on the topic they are working on with their distant colleagues.
- In bigger meeting mostly managers provide a higher level status of the ongoing tasks without digging into details. Team member's point of view is thus missed or they are hesitant to bring it up in a wider audience.
- Having met the distant colleague at least once breaks the ice and assists in reaching out to team member located on other sites to discuss the details.
- For multi-site projects tasks and their ownerships should be well defined. Team members should be clear about their roles and expected deliverables from them.
- For multi-site project communication works best in pairs or small group of employees working on a specific task. How well this communication is handled depends greatly on the team members involved. Team leader's role is to provide

the contact information of relevant team members located at distant sites. Managers and team leaders should monitor the effectiveness of communication between the team members. If they pick up some communication gap then they need to take appropriate steps e.g. setting up some dedicated meetings between the members, or ask to be looped in the email discussion etc.

- The best tools for communication between multi-site team members are chat messenger, email and audio conference with sharing facility.
- If team members are located in different continents then team members might face difficulty in audio communication due to different accents. In such scenario, chat messenger and emails are best source of communication.
- For cross continental communication, cultural aspects should also be taken into account. Team members should have some training or info sessions to be aware about these cultural differences.
- For multi-site project execution, the site where largest number of employees are located should take a dominant role in terms of defining the processes and project execution practices. The smaller sites should act in a supporting role.
- The team leaders at each site managing the resources, human resources, and processes should be selected carefully. Technical expertise should not be the main criteria for selection of team leaders in multi-site projects. Flexibility, openness to new ideas, methodologies and processes, good communication skills and technical expertise should all be considered when selected team leaders.
- For multi-site projects where sites are located in different countries, placement of people across sites in expat roles assist in building trust and improving communication between the sites.

Table 16: People perspective survey results

Survey Questions	Overall (n=58)	Standard Deviation (n=58)	Manager, team leaders and Architect (n=23)	Team members (n=35)	Less than 8 years' experience (n=14)	More than 8 years' experience (n=44)	Finland (n=52)	Other countries (n=6)
Rate the skills, expertise and experience of the team to execute the most recent project you have worked on?	4.0	0.67	4.0	4.1	4.0	4.0	4.0	4.0

Survey Questions	Overall (n=58)	Standard Deviation (n=58)	Manager, team leaders and Architect (n=23)	Team members (n=35)	Less than 8 years´ experience (n=14)	More than 8 years´ experience (n=44)	Finland (n=52)	Other countries (n=6)
How well the size of the team aligned with project size and project schedule in your most recent project?	3.3	0.96	3.1	3.4	3.6	3.2	3.3	3.3
How do you evaluate the efficiency of multi-site team (same country e.g. Tampere and Oulu) vs. same site collocated team?	2.8	0.88	2.7	2.8	2.5	2.7	2.8	2.3
How do you rate the efficiency of multi-site team (different countries e.g. Finland and China) vs. same site collocated team?	1.9	0.83	2.0	1.9	2.1	1.8	1.9	2.0
How do you grade the fairness of reward structure in use in your organization?	3.2	0.87	3.3	3.1	2.7	3.2	3.2	3.5
How well your reward structure incorporates accountable, definable and clear objectives?	3.1	0.81	3.0	3.1	2.8	3.2	3.0	3.7
	Free Text (Selected Comments) - Face to face meetings are extremely important in virtual teams, people need to meet each other face to face, at least once. And this is especially important for designer level, it is not enough that managers meet rather designer level face to face sessions are must.							

In the reward category, most of the subgroups rated their organization around the neutral mark (i.e. 3.2, standard deviation 0.87). Only the team members with less than 8 years of experience rated the fairness of reward system, and incorporation of accountable, definable and clear objectives in the reward system below the neutral mark. Overall in terms of job satisfaction the respondents rated "achievement" as the most important factor. It was followed by flexibility, recognition and reward (monetary benefits) as shown in Figure 13. This probably highlights the fact that in the beginning of their career people are more ambitious and gradually the priorities change in life.

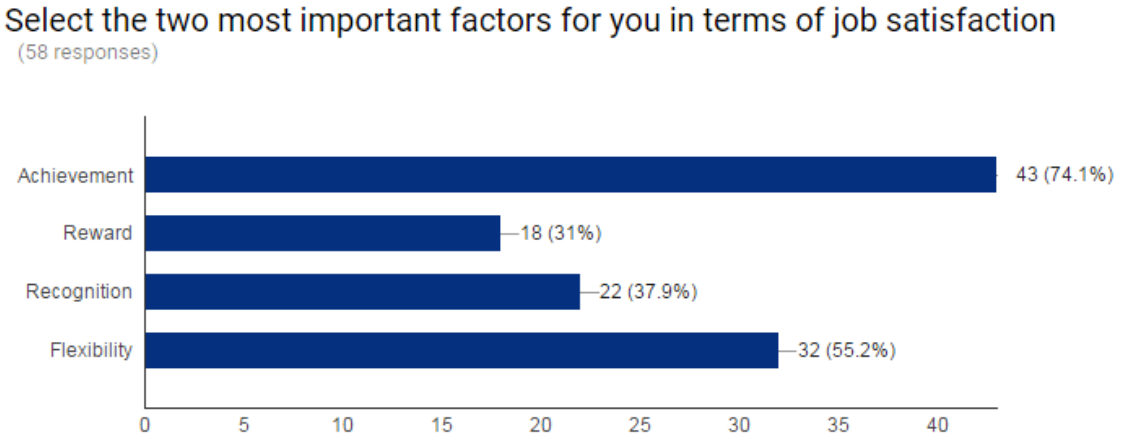

Figure 13: Most important factors in terms of job satisfaction.

5.2.4. Dispersion perspective

The dispersion perspective in the survey focused on team cohesiveness and steps taken by the organization to build trust in the team. As per survey results, the level of trust among the team members located at the same site is very good i.e. rated around 4.0 mark with standard deviation of 0.79. For multi-site project the level of trust among team members located in different sites is above neutral level (overall average 3.2). This is still very good considering that face-to-face interaction between members located at distant locations is quite limited. Respondents are satisfied with the steps taken by the organization to provide job satisfaction e.g. Job rotation opportunities and recognizing achievements. The bonus structure in the organization incorporates personal objectives, team achievements and company goals. The respondents rated the reward structure in the organization as neutral (overall average 3.1, standard deviation 0.9) in terms of promoting team cohesiveness. The only factor which is rated below neutral (overall average 2.8, standard deviation 0.99) by the respondents is the amount of events held in the organization to support team building. The organization should allocate more budget to organize team events and provide more opportunities to team members to interact

socially. This will enhance the level of trust in the team. The survey results for dispersion perspective are summarized in Table 17.

Table 17: Dispersion perspective survey results

Survey Questions	Overall (n=58)	Standard Deviation (n=58)	Manager, team leaders and Architect (n=23)	Team members (n=35)	Less than 8 years´ experience (n=14)	More than 8 years´ experience (n=44)	Finland (n=52)	Other countries (n=6)
Grade the steps taken in your organization to promote team cohesiveness (e.g. team events)?	2.8	0.99	2.6	2.9	2.7	2.8	2.7	3.7
How will you evaluate the level of trust and cohesiveness in your team/organization (multiple sites e.g. Tampere and Oulu)?	3.2	0.85	3.0	3.3	3.3	3.2	3.2	2.8
How will you evaluate the level of trust and cohesiveness in your team/organization (same site)?	3.9	0.79	3.9	4.0	4.1	3.8	3.9	4.0
How will you rate the steps taken in your organization to provide higher level job satisfaction (e.g. job rotation, recognition of achievements, on-job trainings etc.)?	3.2	0.95	3.2	3.2	3.2	3.2	3.1	3.8
How would you evaluate the reward structure in terms of promoting co-operation and coordination among team members (Individual targets, team targets, organization targets and company target)?	3.1	0.90	3.2	3.0	2.9	3.1	3.0	4.0

5.3. Action points for the case organization

From the survey results and interviews some action points were extracted which can improve the functioning and operation of the case organization in a virtual setup. The action points fell in to four main domains i.e. tools, processes, people and multi-site collaboration. These action points are summarized below:

Tools:

- Limit the number of tools used for communication. Avoid using multiple tools for the same purpose.
- Tools usage methodologies between different sites harmonized. i.e., align the usage of tools between different sites.
- All documents related to a project must be stored at same location using single tool (e.g. sharenet). Avoid using multiple tools (e.g. confluence and sharenet) for sharing documents.
- Involve team members in the process of selection of the tools.
- Increase the number of trainings offered for tool usage and make necessary efforts to improve the quality of trainings.
- Available tools are not utilized efficiently for cross-site communication. Some trainings in this domain will improve the quality of communication in multi-site project.

Processes:

- Too many processes are in use in SoC organization for performance evaluation, personal development, travelling etc. The number of process and tools for people management needs to be decreased.
- Generally people are satisfied with 1-in-90 process to provide continuous feedback but it lacks the feedback from team members. A process is needed to collect feedback from team about individual members of the team.
- In terms of creating and sharing knowledge (e.g. promoting best practices; good quality documentation) the processes need to be improved.
- Agile based flow should be investigated to be taken into use in SoC organization. It will assist in improving the quality of processes and improve communication between multi-site teams.

People:

- At least one face-to-face meeting between people working at different sites must be arranged. This could easily be achieved for sites located in same country. Management level face-to-face interaction between different sites is not sufficient.

- Two main factors contributing to job satisfaction are achievement and flexibility followed by recognition and reward. People are quite satisfied with the opportunities provided for personal development (e.g. job rotation). The organization need to continue these practices.
- The level of trust and cohesiveness between members of SoC organization is very good especially in the same site and same country. The number of team building events are very limited and should be increased.

Multi-site collaboration:

Multi-site project execution has been highlighted in the survey as week point in the SoC organization. Some recommendations to improve the collaboration in multi-site projects are given below:

- Promote direct communication between team members located at distant sites. Team leader level communication are not very helpful for team members working together at distant sites.
- Limit the number of meeting with too many participants.
- Cultural awareness, especially when teams are located in different continents, helps to improve communication. Some training in this regard can be very useful.
- For multi-site projects tasks and their ownerships should be well defined. Team members should be clear about their responsibilities and expected deliverables from them.
- Sites need to be aware about their role in multi-site projects. One site should be in dominant role while other sites should be in supporting role. This is a critical factor to avoid conflicts between the sites. The site in dominant role should define the methodologies and processes in collaboration with supporting sites.
- Team leaders at each sites must be selected carefully. In addition to technical expertise some other key aspects to be considered while selecting team leaders include openness to new ideas, methodologies and processes. Good communication skills and good networking skills are also critical to successfully lead multi-site projects.
- Placement of expats needs to be considered in multi-site projects to improve the communication and collaboration between sites.

These action points were passed on to higher management for further analysis, examination and implementation.

6. CONCLUSIONS

Existence of virtual teams have increase many fold in the last two decades. Modern communication technologies have allowed the teams to work across time, space and organizational boundaries. These teams rely on computer mediated communication (CMC) technologies to exchange information and synchronize the ongoing tasks.

Organizations are creating virtual teams because they provide economic value, business opportunities, competitive advantage, flexibility and help in providing innovative solutions for the companies to achieve their goals and solve problems. Virtual teams empower the members of the team and provide them flexibility which results in job satisfaction and improved performance. At the same time there are some negative factors associated with virtual teams which adversely impact their performance. Geographical dispersion, cultural diversity and language barrier can result in trust deficiency, lack of team cohesion and communication break down due to misunderstanding.

6.1. Academic Contributions

The topic for this thesis work was selected with the intent to evaluate the functioning of high-tech virtual teams involved in multi-site projects and devise a criteria to measure their performance. To achieve this target in a systematic way we conducted a detailed study of existing literature and frameworks on virtual teams. We created a framework extended from existing models that is focused on high-tech multi-site virtual teams in an international setup. Our framework has three distinguishable phases i.e. ***formation phase*** – feasibility study, resource analysis, competitive environment analysis etc., ***execution phase*** – team formation, project technology selection, information sharing etc., and ***output analysis phase*** – results, achievements, knowledge creation, employee satisfaction etc. Our framework is therefore named as Formation, Execution & Output analysis (FEO) framework for the evaluation of virtual teams and discussed in detail in chapter 3.6.

FEO framework is different from the existing frameworks as it lays a specific focus on the disruption factors (Discontinuities in FEO framework) which negatively impacts the efficiency of virtual teams. In addition FEO model includes a performance criteria (Output analysis in FEO model) which can be used to evaluate the performance of teams in a virtual setup.

Virtual teams performance criteria:

From our research we concluded that the knowledge creation and employee satisfaction are two addition measures that can be used to evaluate the performance of virtual teams

as compared to traditional teams. Performance of traditional teams is measured via R&D efficiency, productivity, time-to-market, quality, and cost control etc. Virtual teams rely on communication between distant member and experts using CMC technologies. Due to the nature of these teams all the processes, interactions, flows and technical aspects of tasks on-hand need to be well documented. This provide virtual teams an enormous potential to create and share knowledge. Thus knowledge creation can be used as an additional factor for measuring the virtual team performance. Employee motivation and job satisfaction is also an important factor in the effectiveness of virtual teams. Virtual team members tend to work in dispersed time and space boundaries and thus employee satisfaction is another factor that can be used to measure the effectiveness of virtual teams.

Virtual teams structure and catering disruptive factors:

Virtual teams should be structured while keeping in mind cross-functional collaboration needs, dispersion between team members and suitability of team members in terms of skills, expertise, and experience. Selecting the appropriate technology and processes to provide communication richness and smooth flow of information is a pre-requisite for getting good performance from the virtual teams. These factors have been discussed extensively in existing literature. In our framework we have also highlighted the factors that can negatively impact the performance of virtual teams and cause disruptions ("Discontinuities"). Team cohesion, trust between team members and relationship building via effective communication are critical for the efficient working of virtual teams. Over reliance on computer mediated communication and lack of physical interaction negatively impact the trust and cohesiveness in virtual teams. To overcome this hurdle the importance of appropriate technologies and process for information sharing and enriched communication increase further. Relation-ship building in the virtual team via formal and informal interaction, and effective communication mechanism plays a role in building trust, enhancing team cohesiveness and reducing the impact of disruptive factors.

6.2. Recommendations for target organization

Using our FEO framework a detailed online anonymous survey and interviews were conducted in a selected organization. The target organization is part of a multi-national company and its employees are dispersed across multiple sites. Based on the study recommendations were made to the target organization for improvement in multi-site collaboration and for better selection of tools and processes. The key findings of the survey are:

- Communication and knowledge sharing:
    - Usage of multiple information sharing and communication tools reduces their effectiveness.

    - The optimal number of tools to be used for information sharing is 4 (Email, chat messenger / web call, document repository, issue tracking).
    - Knowledge sharing is hindered by storing documents using different tools at multiple locations.
    - Productivity can be improved by harmonizing tools usage between different sites and more tool related trainings.
- People Management:
    - Large number of processes and tools for people and performance managements make the flow difficult to understand.
- Multi-site collaboration:
    - Promote direct communication between team members located at distant sites.
    - More cultural awareness trainings to better understand the cultural differences.
    - Well structure and organized multi-site meeting with limited number of attendees to promote better interaction and communication.
    - Placement of expats in multi-site projects to improve communication.

6.3. Future study

This study has been conducted on one organization with a limited scope. The organization has two sites in Finland, one in Poland and one in China. Approximately 89% of the total of 58 survey respondents are from Finland and all the 6 interviewees are from Finnish sites. For future study the sample size of the survey and interviews should be increased and an effort should be made to improve the response from sites not located in Finland.

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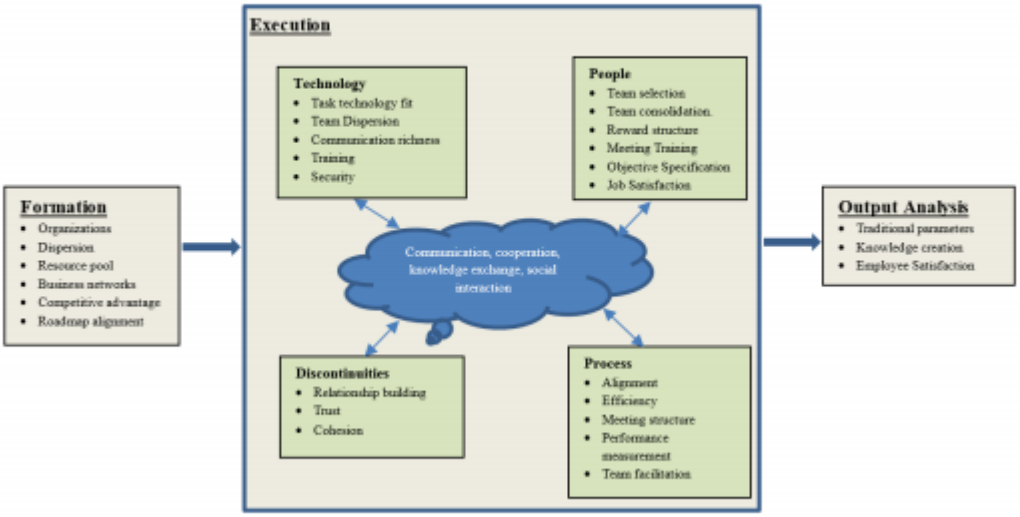
Appendix 1: Survey on functioning of virtual teams

Formation, Execution & Output Analysis (FEO) Framework



1. **Country** *
Mark only one oval.

- ◯ Finland
- ◯ China
- ◯ Poland
- ◯ Other: .....

2. **City** *
Mark only one oval.

- ◯ Tampere
- ◯ Oulu
- ◯ Espoo
- ◯ Hangzhou
- ◯ Wroclaw
- ◯ Other: .....

3. **Current role** *
Mark only one oval.

- ◯ Manager
- ◯ Team Leader
- ◯ Team member
- ◯ Architect

4. **Years of work experience** *
Mark only one oval.

- ◯ Less than 3 years
- ◯ Between 3 and 8 years
- ◯ Between 8 and 15 years
- ◯ More than 15 years

5. **Nationality (Optional)**

.....

Project Planning Phase

6. **How critical it is to identify cross-functional collaboration needed between different organizations within the company before project start?** *
Mark only one oval.

	1	2	3	4	5	
Not critical	◯	◯	◯	◯	◯	Extremely critical

7. **How important it is to identify collaboration needed with external organizations outside the company before the project start?** *
Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Extremely important

8. **How significant it is to assess the dispersion of teams and organizations in terms of location and time zone difference before the start of project?** *
Mark only one oval.

	1	2	3	4	5	
Not significant	◯	◯	◯	◯	◯	Extremely significant

9. **How critical it is to assess resource availability, skill set availability during the conception phase of the project?** *
Mark only one oval.

	1	2	3	4	5	
Not critical	◯	◯	◯	◯	◯	Extremely critical

10. **How necessary it is to assess contributions required from the strategic partners (e.g. external IP's) during conception phase of the project?** *
Mark only one oval.

	1	2	3	4	5	
Not necessary	◯	◯	◯	◯	◯	Extremely necessary

11. **How essential it is to align the roadmap with the collaborating partner companies?** *
Mark only one oval.

	1	2	3	4	5	
Not essential	◯	◯	◯	◯	◯	Extremely essential

12. **How crucial it is to assess the competitive advantage gain expected from the project at the conception phase of project?** *
Mark only one oval.

	1	2	3	4	5	
Not critical	◯	◯	◯	◯	◯	Extremely critical

13. **Any other feedback?**

.....

.....

.....

Project Execution (Communication Technology Perspective)

14. **Select the three most significant communication tools needed for project execution.** *
Check all that apply.

- ☐ Email
- ☐ Chat messenger
- ☐ Audio web conference
- ☐ Document repository e.g. Sharenet
- ☐ Web based social tools e.g. yammer
- ☐ Internal Wiki pages
- ☐ Error tracking tools e.g. Jira
- ☐ Specification capture tools e.g. Doors
- ☐ Other:

15. **What is the optimal number of communication tools that should be used during execution of project? e.g (email + messenger = 2)** *
Check all that apply.

- [ ] 3
- [ ] 4
- [ ] 5
- [ ] 6
- [ ] Other: .....

16. **How do you evaluate the quality of communication tools available to you for multi-site project execution?** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

17. **How efficiently the communication tools are utilized during the execution of projects?** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

18. **How do you rate your familiarity with the communication tools and processes?** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

19. **How do you assess the training available to familiarize the team with new tools?** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

20. **Any other comments?**

.....

.....

21. **Any other recommendation for tools used in the team?**

.....

.....

Project Execution (Process Perspective)

22. **How do you grade the processes used in your organization to track project milestones (ICM/IPM etc)** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

23. **How do you evaluate the other processes in use in your organization e.g. performance evaluation, travelling, personal development etc.** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

24. **How do you rate the total number of processes in use in your organization?** *
Mark only one oval.

- ◯ Too many processes
- ◯ Optimal
- ◯ Too few processes

25. **How well the processes in use in your organization provide continuous feedback in terms of your performance ? (e.g 1 in 90)** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

26. **How satisfied you are with the meeting/reporting structure put in place in your project to track and synchronize the project progress?** *
Mark only one oval.

	1	2	3	4	5	
Bad	◯	◯	◯	◯	◯	Excellent

27. **How do you rate the processes in use in your organization in terms of creating and sharing knowledge (e.g. promoting best practices; good quality documentation etc)** *
Mark only one oval.

	1	2	3	4	5	
Bad	◯	◯	◯	◯	◯	Excellent

28. **Any additional comments?**

.....

Project Execution (People Perspective)

29. **How do you rate the skills, expertise and experience of the team to execute the most recent project you have worked on?** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

30. **How well the size of the team aligned with project size and project schedule in your most recent project?** *
Mark only one oval.

	1	2	3	4	5	
Poor	◯	◯	◯	◯	◯	Excellent

31. **How do you evaluate the efficiency of multi-site team (same country e.g. Tampere and Oulu) vs. same site collocated team?** *
Mark only one oval.

	1	2	3	4	5	
Multi site team has much low efficiency	◯	◯	◯	◯	◯	Multi-site team has much higher efficiency

32. **How do you rate the efficiency of multi-site team (different countries e.g. Finland and China) vs. same site collocated team?** *
Mark only one oval.

	1	2	3	4	5	
Multi site team has much lower efficiency	◯	◯	◯	◯	◯	Multi-site team has much higher efficiency

33. **How do you grade the fairness of reward structure in use in your organization?** *
Mark only one oval.

	1	2	3	4	5	
Low	◯	◯	◯	◯	◯	High

34. **How well your reward structure incorporates accountable, definable and clear objectives?** *
Mark only one oval.

	1	2	3	4	5	
Bad	◯	◯	◯	◯	◯	Very well

36. **Any other points you want to highlight?**

.....

Project execution (Dispersion perspective)

37. **How will you grade the steps taken in your organization to promote team cohesiveness (e.g. team events)** *
Mark only one oval.

	1	2	3	4	5	
Bad	◯	◯	◯	◯	◯	Excellent

38. **How will you evaluate the level of trust and cohesiveness in your team/organization (multiple sites e.g. Tampere and Oulu)?** *
Mark only one oval.

	1	2	3	4	5	
Bad	◯	◯	◯	◯	◯	Excellent

39. **How will you evaluate the level of trust and cohesiveness in your team/organization (same site)?** *
Mark only one oval.

	1	2	3	4	5	
Bad	◯	◯	◯	◯	◯	Excellent

40. **How will you rate the steps taken in your organization to provide higher level job satisfaction (e.g. job rotation, recognition of achievements, on-job trainings etc.)** *
Mark only one oval.

	1	2	3	4	5	
Bad	◯	◯	◯	◯	◯	Excellent

41. **How would you evaluate the reward structure in terms of promoting co-operation and coordination among team members (Individual targets, team targets, organization targets and company target)** *
Mark only one oval.

	1	2	3	4	5	
Bad	◯	◯	◯	◯	◯	Excellent

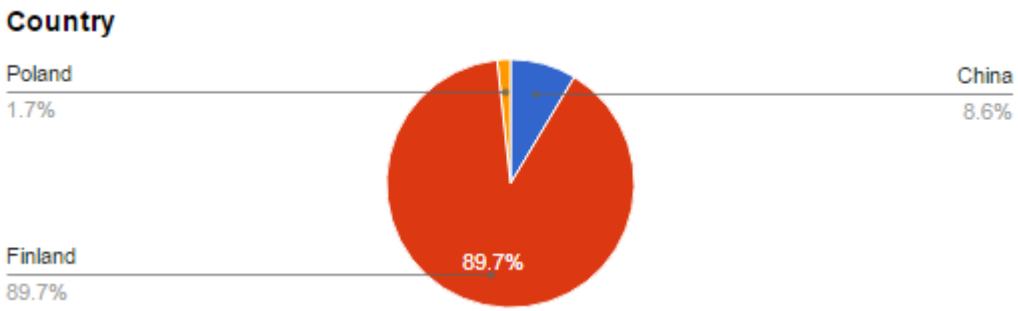
42. **Any other items?**

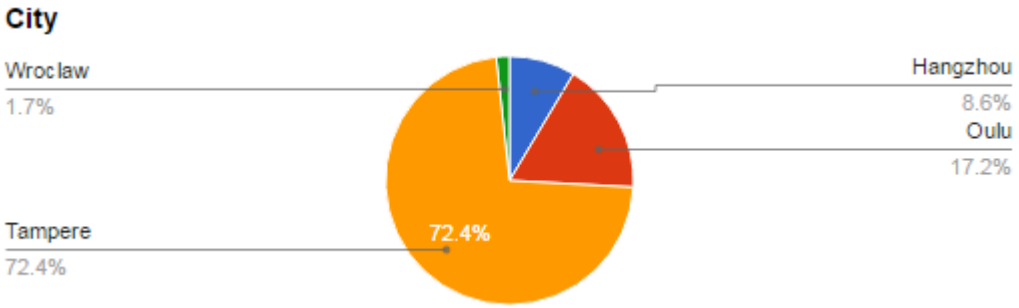
.....

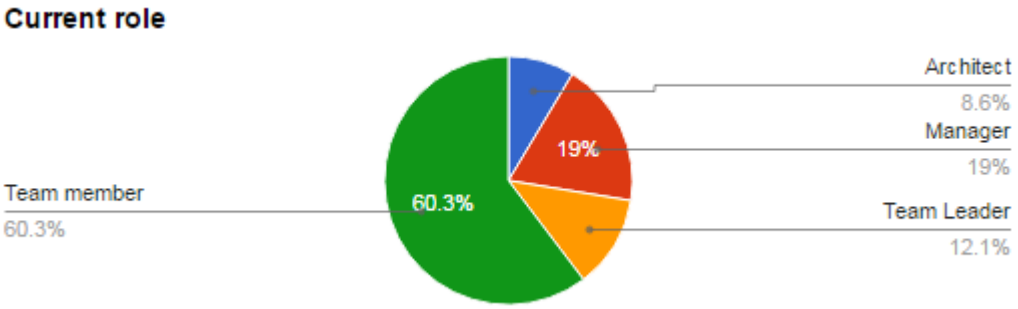
.....

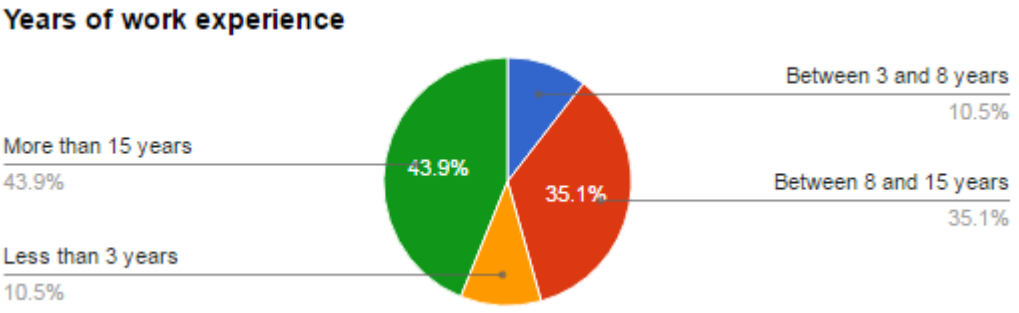
Appendix 2: Virtual team survey results

Total number of respondents = 58

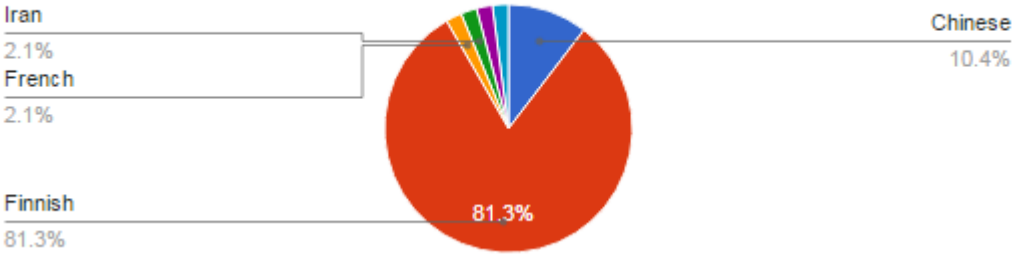






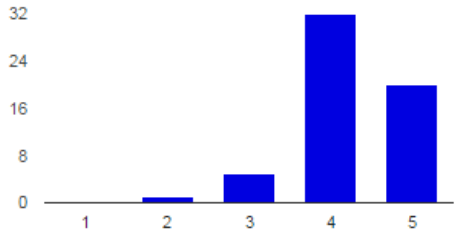


Nationality (Optional)



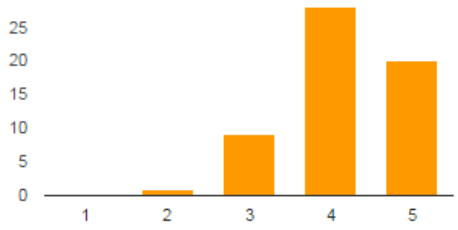
Project Planning Phase

How critical it is to identify cross-functional collaboration needed between different organizations within the company before project start?



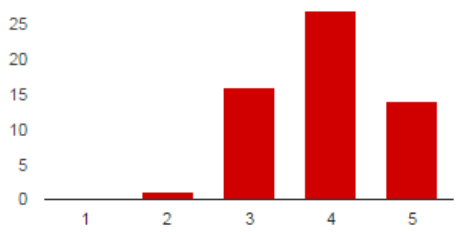
Not critical: 1	**0**	0%
2	**1**	1.7%
3	**5**	8.6%
4	**32**	55.2%
Extremely critical: 5	**20**	34.5%

How important it is to identify collaboration needed with external organizations outside the company before the project start?



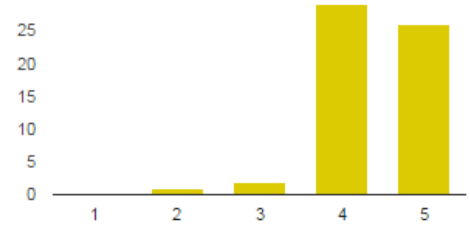
Not important: 1	**0**	0%
2	**1**	1.7%
3	**9**	15.5%
4	**28**	48.3%
Extremely important: 5	**20**	34.5%

How significant it is to assess the dispersion of teams and organizations in terms of location and time zone difference before the start of project?



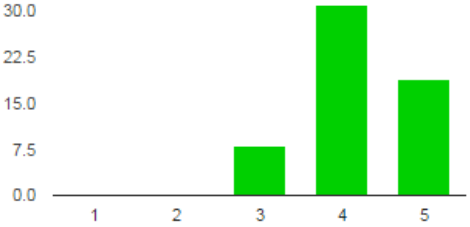
Not significant: 1	**0**	0%
2	**1**	1.7%
3	**16**	27.6%
4	**27**	46.6%
Extremely significant: 5	**14**	24.1%

How critical it is to assess resource availability, skill set availability during the conception phase of the project?



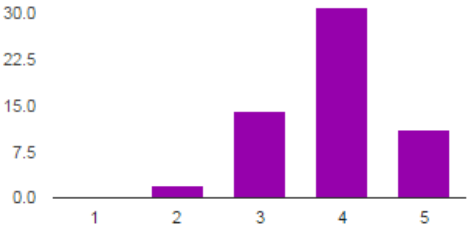
Not critical:	1	**0**	0%
	2	**1**	1.7%
	3	**2**	3.4%
	4	**29**	50%
Extremely critical:	5	**26**	44.8%

How necessary it is to assess contributions required from the strategic partners (e.g. external IP's) during conception phase of the project?



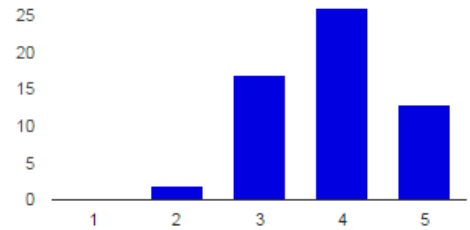
Not necessary:	1	**0**	0%
	2	**0**	0%
	3	**8**	13.8%
	4	**31**	53.4%
Extremely necessary:	5	**19**	32.8%

How essential it is to align the roadmap with the collaborating partner companies?



Not essential:	1	**0**	0%
	2	**2**	3.4%
	3	**14**	24.1%
	4	**31**	53.4%
Extremely essential:	5	**11**	19%

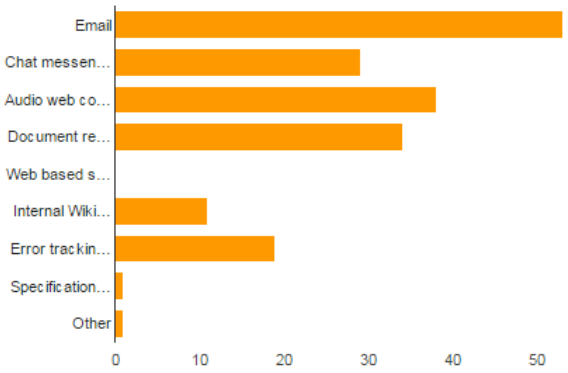
How crucial it is to assess the competitive advantage gain expected from the project at the conception phase of project?



Not critical:	1	**0**	0%
	2	**2**	3.4%
	3	**17**	29.3%
	4	**26**	44.8%
Extremely critical:	5	**13**	22.4%

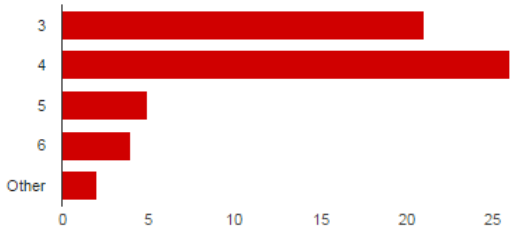
Project Execution (Communication Technology Perspective)

Select the three most significant communication tools needed for project execution.



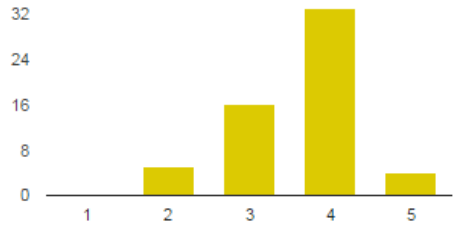
Email	53	91.4%
Chat messenger	29	50%
Audio web conference	38	65.5%
Document repository e.g. Sharenet	34	58.6%
Web based social tools e.g. yammer	0	0%
Internal Wiki pages	11	19%
Error tracking tools e.g. Jira	19	32.8%
Specification capture tools e.g. Doors	1	1.7%
Other	1	1.7%

What is the optimal number of communication tools that should be used during execution of project? e.g (email + messenger = 2)



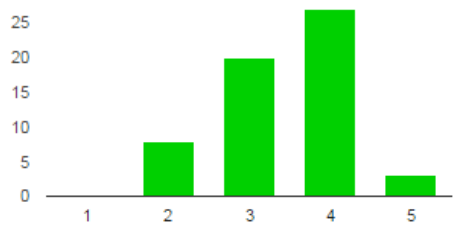
3	21	36.2%
4	26	44.8%
5	5	8.6%
6	4	6.9%
Other	2	3.4%

How do you evaluate the quality of communication tools available to you for multi-site project execution?



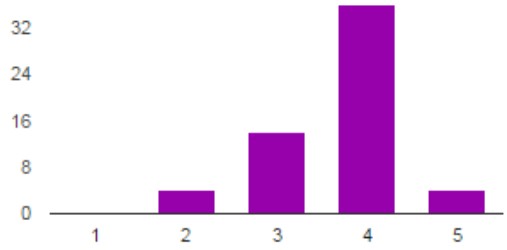
Poor: 1	0	0%
2	5	8.6%
3	16	27.6%
4	33	56.9%
Excellent: 5	4	6.9%

How efficiently the communication tools are utilized during the execution of projects?



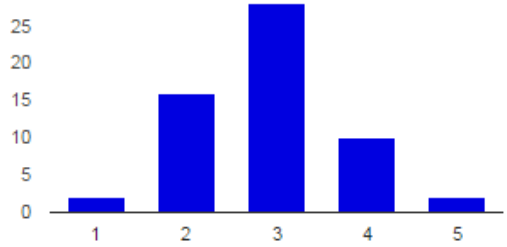
Poor: 1	0	0%
2	8	13.8%
3	20	34.5%
4	27	46.6%
Excellent: 5	3	5.2%

How do you rate your familiarity with the communication tools and processes?



Poor: 1	**0**	0%
2	**4**	6.9%
3	**14**	24.1%
4	**36**	62.1%
Excellent: 5	**4**	6.9%

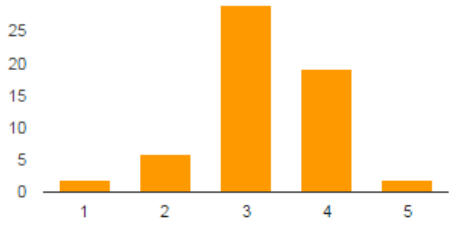
How do you assess the training available to familiarize the team with new tools?



Poor: 1	**2**	3.4%
2	**16**	27.6%
3	**28**	48.3%
4	**10**	17.2%
Excellent: 5	**2**	3.4%

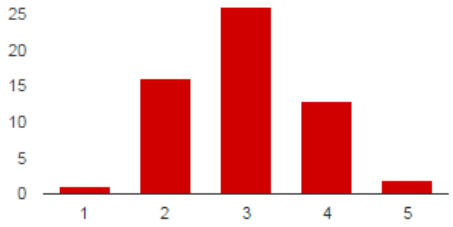
Project Execution (Process Perspective)

How do you grade the processes used in your organization to track project milestones (ICM/IPM etc)



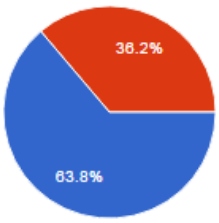
Poor: 1	**2**	3.4%
2	**6**	10.3%
3	**29**	50%
4	**19**	32.8%
Excellent: 5	**2**	3.4%

How do you evaluate the other processes in use in your organization e.g. performance evaluation, travelling, personal development etc.



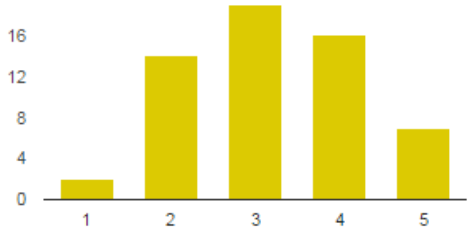
Poor: 1	**1**	1.7%
2	**16**	27.6%
3	**26**	44.8%
4	**13**	22.4%
Excellent: 5	**2**	3.4%

How do you rate the total number of processes in use in your organization?



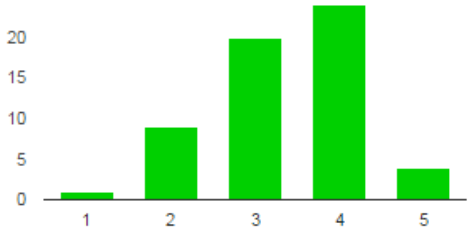
Too many processes	**37**	63.8%
Optimal	**21**	36.2%
Too few processes	**0**	0%

How well the processes in use in your organization provide continuous feedback in terms of your performance ? (e.g 1 in 90)



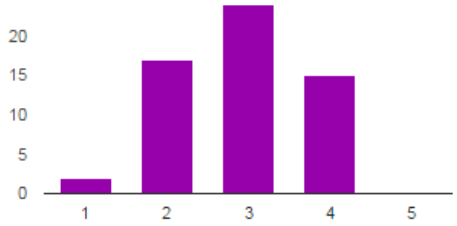
Poor: 1	**2**	3.4%
2	**14**	24.1%
3	**19**	32.8%
4	**16**	27.6%
Excellent: 5	**7**	12.1%

How satisfied you are with the meeting/reporting structure put in place in your project to track and synchronize the project progress?



Bad: 1	**1**	1.7%
2	**9**	15.5%
3	**20**	34.5%
4	**24**	41.4%
Excellent: 5	**4**	6.9%

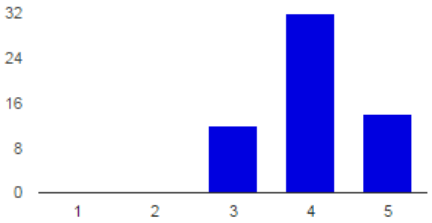
How do you rate the processes in use in your organization in terms of creating and sharing knowledge (e.g. promoting best practices; good quality documentation etc)



Bad: 1	**2**	3.4%
2	**17**	29.3%
3	**24**	41.4%
4	**15**	25.9%
Excellent: 5	**0**	0%

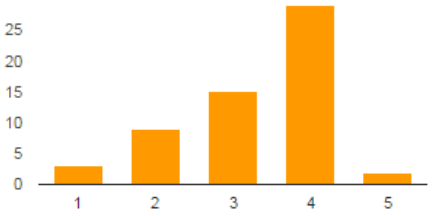
Project Execution (People Perspective)

How do you rate the skills, expertise and experience of the team to execute the most recent project you have worked on?



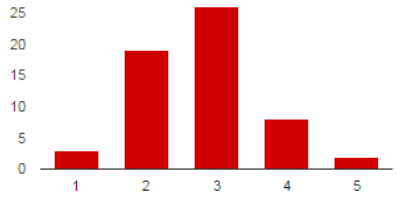
Poor:	1	0	0%
	2	0	0%
	3	12	20.7%
	4	32	55.2%
Excellent:	5	14	24.1%

How well the size of the team aligned with project size and project schedule in your most recent project?



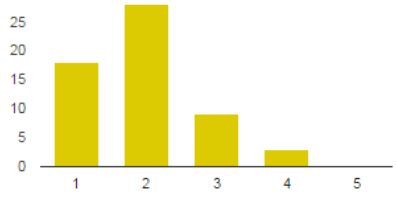
Poor:	1	3	5.2%
	2	9	15.5%
	3	15	25.9%
	4	29	50%
Excellent:	5	2	3.4%

How do you evaluate the efficiency of multi-site team (same country e.g. Tampere and Oulu) vs. same site collocated team?



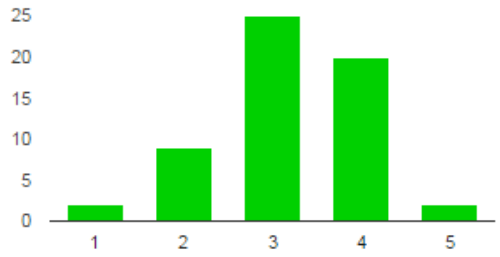
Multi site team has much low efficiency:	1	3	5.2%
	2	19	32.8%
	3	26	44.8%
	4	8	13.8%
Multi-site team has much higher efficiency:	5	2	3.4%

How do you rate the efficiency of multi-site team (different countries e.g. Finland and China) vs. same site collocated team?



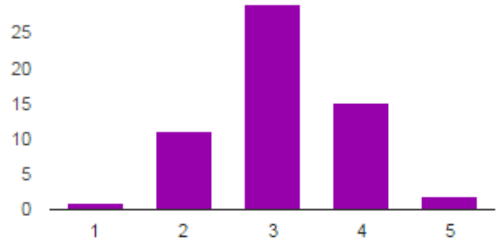
Multi site team has much lower efficiency:	1	18	31%
	2	28	48.3%
	3	9	15.5%
	4	3	5.2%
Multi-site team has much higher efficiency:	5	0	0%

How do you grade the fairness of reward structure in use in your organization?



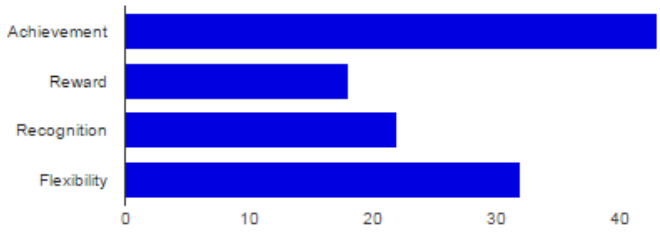
Low: 1	**2**	3.4%
2	**9**	15.5%
3	**25**	43.1%
4	**20**	34.5%
High: 5	**2**	3.4%

How well your reward structure incorporates accountable, definable and clear objectives?



Bad: 1	**1**	1.7%
2	**11**	19%
3	**29**	50%
4	**15**	25.9%
Very well: 5	**2**	3.4%

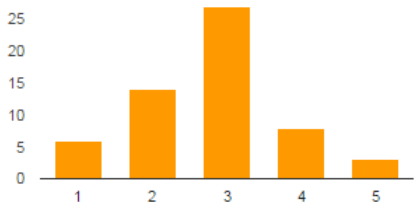
Select the two most important factors for you in terms of job satisfaction



Achievement	**43**	74.1%
Reward	**18**	31%
Recognition	**22**	37.9%
Flexibility	**32**	55.2%

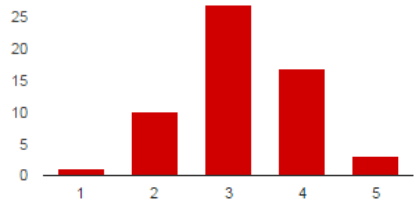
Project execution (Dispersion perspective)

How will you grade the steps taken in your organization to promote team cohesiveness (e.g. team events)



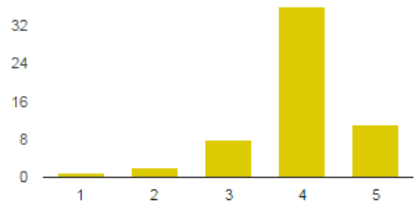
Bad: 1	**6**	10.3%
2	**14**	24.1%
3	**27**	46.6%
4	**8**	13.8%
Excellent: 5	**3**	5.2%

How will you evaluate the level of trust and cohesiveness in your team/organization (multiple sites e.g. Tampere and Oulu)?



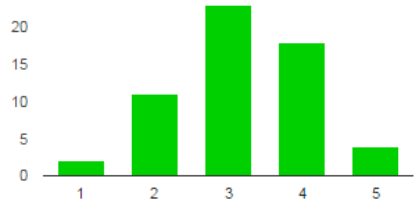
Bad: 1	**1**	1.7%
2	**10**	17.2%
3	**27**	46.6%
4	**17**	29.3%
Excellent: 5	**3**	5.2%

How will you evaluate the level of trust and cohesiveness in your team/organization (same site)?



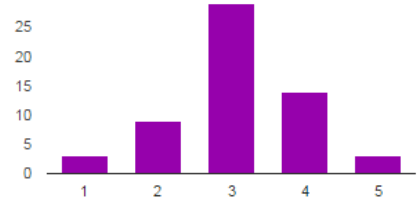
Bad: 1	**1**	1.7%
2	**2**	3.4%
3	**8**	13.8%
4	**36**	62.1%
Excellent: 5	**11**	19%

How will you rate the steps taken in your organization to provide higher level job satisfaction (e.g. job rotation, recognition of achievements, on-job trainings etc.)



Bad: 1	**2**	3.4%
2	**11**	19%
3	**23**	39.7%
4	**18**	31%
Excellent: 5	**4**	6.9%

How would you evaluate the reward structure in terms of promoting co-operation and coordination among team members (Individual targets, team targets, organization targets and company target)



Bad: 1	**3**	5.2%
2	**9**	15.5%
3	**29**	50%
4	**14**	24.1%
Excellent: 5	**3**	5.2%

Timestamp