Software Testing and Global Industry

Software Testing and Global Industry: Future Paradigms

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This book is dedicated to my wife Gloria without whose love,
encouragement and continuous support this project
could not have been carried out.

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PREFACE

The advent of low-cost telecommunications coupled with the availability of well-educated low-cost labour in developing countries has made the implementation of a Global Software Development strategy popular with many software development companies in recent years. While the argument for doing this is often financial, other benefits include access to a technical labour force, proximity to a customer market and the possibility of setting-up 24-hour development cycles around the world. Although more and more companies implement Global Software Development, oftentimes, from a variety of perspectives, the strategy is not fully thought through. In fact, where companies implement Global Software Development solely from a financial perspective, they can be surprised at the 'real' implementation costs. Furthermore, while such a strategy may be to the benefit of a company, it may not be of benefit to the individual employees. They often have to cope with changing working conditions and possibly job losses in the longer term.

The discussion in this book focuses on a U.S. multi-national company who outsourced testing from its subsidiary in Ireland using virtual teams and the circumstances surrounding the implementation of the teams. The techniques used to collect the data include 5-months participant-observation followed by interviews with the software engineers who were based in Ireland. Analysis of this data resulted in the presentation of factors which managers should consider when implementing a Global Software Development strategy if it is to be successful.

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CHAPTER ONE

GLOBAL SOFTWARE DEVELOPMENT

1. Globalisation

The last two decades have witnessed an escalating trend toward the globalisation of business. This has led to the advent of a radically different global economic environment and new methods of operation. As a result, organisations are now operating in a truly global environment. Doing business in this environment is increasingly challenging. While there are more business opportunities than ever before, there is also much more competition.[1] This competition is coming from low-cost production centres with skilled workforces producing quality products. Until recently, the West's strategic economic advantage lay in its use of technology and its effective production methods. These factors were capitalised upon by a well-educated work force which could utilise these factors to maximise the competitive advantage they offered.

The advent of globalisation has meant that the old methods of achieving and maintaining competitive advantage are no longer as effective as they once were.[2] Goods can now be produced to the same level of quality and at a much cheaper price in more low-cost economies. To survive in this increasingly competitive economic environment companies are adapting their products and manufacturing locations to compete and capitalise on the opportunities which the global market provides. This has led to the

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[1] Turban, E., R.K. Rainer, Jr., and E.R. Potter, Introduction to Information Technology. Second ed. 2003: John Wiley & Sons, Inc.

[2] Grenier, R. and G. Metes, Going Virtual: Moving Your Organization in to the 21st Century. 1995, Upper Saddle River, NJ: Prentice Hall; Yager, S.E., Everything's Coming Up Virtual. Crossroads: Special issue on interdisciplinary computer science, 1997. 4(1): p. 20 - 24.; Davidow, W.H. and M.S. Malone, The Virtual Corporation. 1992, New York: Edward Brulingame Books/Harper Business.

relocation of manufacturing operations to countries such as Mexico, and other locations in Latin America, Eastern Europe and the Far East.[3]

A positive aspect of this development has been the expansion of world markets. As less-developed countries have benefited from increased economic prosperity, sections of their population have also been able to enhance their purchasing power. This has resulted in increased international demand for products and services. Those countries who have reaped the economic benefits of globalisation have also invested in their internal infrastructure and their education systems in order to support, maintain and expand their economic growth.[4]

One of the major outcomes of globalisation has been the loss of low-skilled manufacturing jobs in Western economies. On the positive side, these jobs have been replaced by more value-added type positions which utilise the advantages that high skill levels and location can provide. Furthermore, the loss of large numbers of low-skilled type positions as provided an incentive for students in these countries to attain higher academic and technical qualifications, thereby gaining additional value-added skills.[5]

1.1 Software Globalisation

The advent of the Internet, e-mail, intranets, extranets and improved low-cost international telecommunications has facilitated the development of virtual work groups and virtual companies.[6] These developments in communication have had a particular impact in the software industry. Such factors have been instrumental in instigating the migration of software development and maintenance operations to more geographically-

[3] Miller, D.S., S.E. Catt, and J.R. Carlson, Fundamentals of Management: A Framework for Excellence. 1996, St Paul, MN: West Publishing Company.
[4] Lipnack, J. and J. Stamp, Virtual Teams: Reaching Across Space, Time And Originating With Technology. 1997: John Wiley and Sons.
[5] Gopal, A., T. Mukhopadhyay, and M.S. Krishnan, The Role of Software Process and Communication in Offshore Software Development. Communicatications of the ACM, 2002. 45(4): p. 193-200.
[6] Crow, G. and B. Muthuswamy, International Outsourcing in the Information Technology Industry: Trends and Implications. Communications of the International Information Management Association, 2003 3(1): p. 25 - 34.

distributed locations.[7] In some cases, applications development and maintenance has been completely outsourced to remote third-party organisations. In other cases, multinational organisations have set up subsidiaries in low-cost economies. In the software sector, such approaches are known as Distributed Software Development, (DSD), Global Distribution of Software (GDS) or Global Software Development (GSD). The utilisation of such approaches has increased in popularity and has become an important strategy for the software industry generally.

Initially, the trend was for organisations to outsource basic software application development and maintenance activities to third parties or subsidiaries based in countries such as Ireland and India. In the beginning, these included projects such as Y2K and other projects incorporating straightforward development and maintenance. As a result of the success which this approach achieved, the level of confidence in this strategy has increased and organisations are now off-shoring or outsourcing more complex and mission-critical development projects. All of these factors have led to the situation today whereby software development has become a globally-sourced commodity

The dynamic nature of GSD is highlighted by the fact that the focus for off-shoring and outsourcing activities has shifted away from Ireland over the last few years. Nowadays many Irish-based multinationals and indigenous organisations are outsourcing and off-shoring their software development. This strategic change can be directly attributed to the country's economic success which has resulted in increased development costs.[8] Having achieved considerable success in the IT sector, the focus of the software industry in Ireland is now moving towards value-added (niche) and research-and- development-centric strategies. However, outsourcing and off-shoring sectors continue to expand in Eastern Europe, India and other locations in the Far East.

The general view is that organisations which implement a globally distributed software development strategy are increasingly seeking to gain

[7] Hayes, I.S., Ready or Not: Global Sourcing Is in Your IT Future. Cutter IT Journal, 2002. 15(11): p. 5 - 11.

[8] Cusumano, M.A., Software in Ireland: a balance of entrepreneurship and…lifestyle management? Communications of the ACM, 2005. 48 (10): p. 25 - 27.

a competitive advantage.[9] This development is attributed to labour arbitrage which is facilitated by the availability of large numbers of well-educated and technically competent software engineers in Eastern Europe, India and the Far East.[10] It is also believed that this can provide the opportunity for a shorter development cycle due to the leveraging of the temporal differences between the local site and the offshored or outsourced locations. The adoption of this approach facilitates the implementation of what has been termed a '*follow the sun'* development strategy.[11]

In these circumstances, the prospects for the availability of a large low-cost labour pool with the required skill-set is very attractive.[12] Coupled with the opportunity for round-the-clock development, these factors are all strong driving forces for the adoption of a GSD strategy[13]. In the majority of situations where GSD is implemented, the motivation is to leverage these various potential advantages so as to be the first to market and/or become a competitive player. The overall objective is to enable organisations to gain, maintain or increase their market share in what has become an increasingly volatile and dynamic global business environment.[14]

Given the potential economic benefits afforded by implementing this approach, the current trend to globalise software development is set to continue for the foreseeable future. This trend is further illustrated by the fact that Indian software companies are now outsourcing projects to China, Vietnam, and the Philippines. The number of organisations globalising

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[9] Prikladnicki, R., J.L.N. Audy, and R. Evaristo, Global software development in practice lessons learned Software Process Improvement and Practice 2003. 8(4): p. 267 - 279.

[10] Toaff, S.S., Don't Play with "Mouths of Fire," and Other Lessons of Global Software Development. Cutter IT Journal, 2002. 15(11): p. 23 - 28.

[11] Carmel, E., Global Software Teams: Collaboration Across Borders and Time Zones. 1999, Saddle River, NJ: Prentice Hall.

[12] Carmel, E. and R. Agarwal, Tactical Approaches for Alleviating Distance in Global Software Development. IEEE Software, 2001. 1(2): p. 22 - 29; Ebert, C. and P. De Neve, Surviving Global Software Development. IEEE Software, 2001. 18(2): p. 62 - 69.

[13] Edwards, H.K. and V. Sridhar. Analysis of the effectiveness of global virtual teams in software engineering projects. in The 36th Hawaii International Conference on System Sciences. 2003. Hawaii.

[14] Lipnack, J. and J. Stamp, Virtual Teams: People Working Across Boundaries with Technology. 2nd ed. 2000, New York: John Wiley & Sons. Inc.

their software development continues to rise. Ultimately, this means that globally distributed software development is set to have a significant ongoing impact on the software industry and the world economy as a whole.

1.1.1 Manufacturing versus Global Software Development

While global manufacturing has been a very successful phenomenon, the experience gained in other distributed development environments does not easily transfer to the software industry. This can be attributed to the levels of complexity involved in software development[15] including such issues as the problem of understanding requirements and integration. These difficulties are further compounded by cultural, linguistic and temporal differences, a lack of communication, manufacturer-customer distance and diverse process-maturity levels, testing tools, standards, technical ability and experience. These all have a strong impact particularly given that software development is a people-centric rather than a machine-centric activity. It is therefore vital that those involved in global software development have a good awareness of the organisational, motivational, cultural and communication-related issues that arise throughout the software life cycle.

1.2 Software Project Management

An essential element for the successful development of software is effective project management[16]. Software project management has been defined in the following terms:

> "Software project management today is an art. The skillful integration of software technology, economics and human relations in the specific context of a software project is not an easy task. The software project is a highly people-intensive effort that spans a very lengthy period, with fundamental implications on the work and performance of many different classes of people".[17]

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[15] Brooks, F.P., No Silver Bullet: Essence and Accidents of Software Engineering Computer, 1987. 20(4): p. 10 -19.

[16] Van Vliet, H., Software Engineering : Principles and Practice. 2nd ed. 2000, Chichester, U.K.: Wiley.

[17] Boehm, B.W. and R. Ross, Theory-W Software Project Management Principles And Examples. IEEE Transactions on Engineering Management, 1989. 15(7): p. 902 – 916.

The role of the software Project Manager can be compared to that of a juggler.[18] There is the need to be an arbitrator between diverse stakeholders with different expectations and agendas. There is also the requirement to manage the operation of the team effectively within the constraints of available resources, both financial and technological. The latter has to be achieved utilising the personnel and technical capabilities that are then available. The responsibility of the software Project Manager is to determine these various objectives. It is also the Project Manager's responsibility to define, create, evaluate and select alternatives in order to achieve these objectives and to control their implementation.[19] This is accomplished through planning, organising, staffing, leading, controlling and coordinating the project in an effective manner[20].

This range of characteristics is not adequate on its own, however. They also need to be coupled with the ability to plan, estimate, monitor and control the project effectively. The Project Manager needs to have the ability to arbitrate, appease, admonish, praise, inspire and motivate those whom they manage, often across a range of globally-distributed team-based projects. To summarise the software project management role: it requires effective people management, business management, risk management, and expectation management. Operating in a globally distributed environment, project management becomes a more complex task to undertake than in a collocated project.[21]

Therefore, it is no surprise that, in addition to the necessity for the effective organisation and management of collocated teams and projects, there are additional issues which require consideration in relation to the operation of geographically-distributed teams and their related projects.

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[18] Wiegers, K.E., 21 Project Management Success Tips, in Software Management D.J. Reifer, Editor. 2002, IEEE Computer Society: Los Alamitos, Calif. USA. p. 171 - 181.

[19] Gilb, T. and S. Finz, Principles of Software Engineering Management 1988, Wokingham, U.K.: Addison-Wesley.

[20] Weihrich, H., Management: Science, Thoery and Practice in Software Engineering Project Management, R.H. Thayer, Editor. 2000, IEEE Computer Society Press,: Los Alamitos, Ca. USA. p. 4 – 13; Reifer, D.J., Traditional Software Management Approaches, in Software Management, D.J. Reifer, Editor. 2002, IEEE Computer Society: Los Alamitos, Calif. USA. p. 137 – 148; Summerville, I., Software Engineering, ed. t. Edition. 2001, Harlow UK: Pearson Education Ltd.

[21] Karolak, D.W., Global Software Development: Managing Virtual Teams and Environments. 1999, Los Alamitos, CA, USA IEEE Computer Society Press.

> "The complex, usually uncertain, and highly interdependent nature of project tasks, together with geographical, temporal, structural and cultural gaps fundamental to distributed teams, make management of virtual projects a relatively complex undertaking".[22]

All these different factors, issues and variables need to be specifically addressed in a globally distributed team environment.

Effective communication and project management skills are essential in large collocated software development projects.[23] There are more important issues still for the operation of globally distributed software development.[24] The negative impact of distance on communication and coordination is well-documented.[25] Research has shown that cross-site communication and coordination negatively impacts on the speed of distributed software development.[26] The importance of good communication[27] and effective project management[28] cannot be

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[22] Paré, G. and L. Dubé. Virtual teams: an exploratory study of key challenges and strategies in Proceeding of the 20th the International Conference on Information Systems 1999 Charlotte, North Carolina, United States: Association for Information Systems.

[23] Curtis, B., H. Krasner, and N. Iscoe, A Field Study Of The Software Design Process For Large Systems. Communications of the ACM, 1988 31(11): p. 1268 – 1287.

[24] Battin, R.D., et al., Leveraging Resources in Global Software Development. IEEE Software, 2001. 1(2): p. 70 – 77; Rutkowski, A.F., et al., E-collaboration: The Reality of Virtuality. IEEE Transactions on Professional Communication, 2002. 45 (4): p. 219 – 230; Beise, C.M. IT Project Management And Virtual Teams. in Proceedings of the 2004 SIGMIS conference on Computer personnel research: Careers, culture, and ethics in a networked environment 2004. Tucson, AZ, USA ACM Press.

[25] Herbsleb, J.D., et al. An Empirical Study of Global Software Development: Distance and Speed. in Proceedings of the 23rd International Conference on Software Engineering, 2001. ICSE 2001. 2001 Toronto, Canada; Ebert, C., et al. Improving validation activities in a global software development in Proceedings of the 23rd International Conference on Software Engineering 2001 Toronto, Ontario, Canada IEEE Computer Society.

[26] Herbsleb, J.D., et al. Distance, Dependencies and Delay in Global Collaboration. in Proceedings of the 2000 ACM conference on Computer supported cooperative work 2000. Philadelphia, Pennsylvania, USA ACM Press.

[27] Suchan, J. and G. Hayzak, The communication characteristics of virtual teams: A case study. IEEE Transactions on Professional Communication,, 2001. 44(3): p. 174-186.

[28] Nidiffer, K.E. and D. Dolan, Evolving distributed project management. IEEE Software 2005. 22(5): p. 63 – 72.

underestimated in the context of effective globally distributed team operation.

1.2.1 Project Management in The GSD Environment

The impact of a distributed environment on the project management of GSD teams is considerable. The essence of effective management is coordination and control. Distance introduces complexity which directly impacts on both coordination and control and the facilitation of communication.[29] It is also affected by the level of project visibility which can be negatively impacted by distance. This range of variables is also influenced by language, culture and work processes. The need for effective collaboration and visibility between locations is essential.

All of these factors have a direct influence on the level of cooperation which can be achieved. An overview of the distance issue and its impact on the operation of globally distributed teams is presented in Figure 1.1.

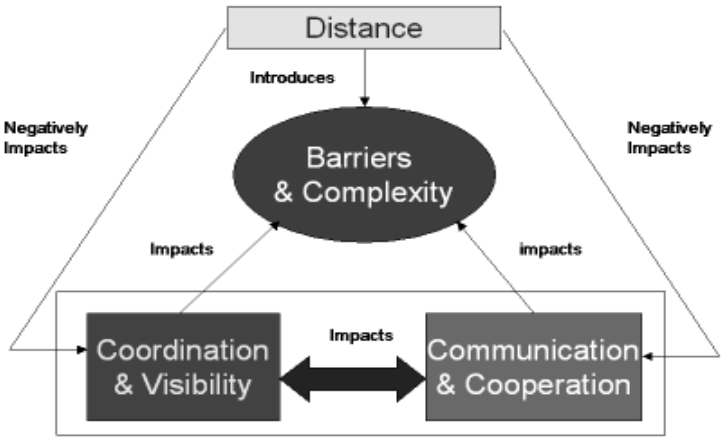

Figure 1.1: The Impact Of Distance On The Operation of Globally Distributed Teams

[29] Herbsleb, J.D. and A. Mockus, An Empirical Study of Speed and Communication in Globally Distributed Software Development IEEE Transactions on Software Engineering, 2003. 29(6): p. 481-494; Damian, D.E. and D. Zowghi. An insight into the interplay between culture, conflict and distance in globally distributed requirements negotiations. in Proceedings of the 36th International Conference on Systems Sciences (HICSS'03). IEEE. 2002. 2003. Hawaii.

This makes managing a global software team very difficult. Carmel (1999) paraphrased the particular difficulties faced by a software manager when he stated that *"no one in their right mind would do this"*. However, globally distributed software projects have to be managed effectively. Carmel (1999) identifies coordination breakdown as one of the five centrifugal forces which negatively impacts on the effective operation of globally distributed teams. His other four forces are loss of team-work, cultural difference, geographical dispersion and loss of communication richness. Carmel has also outlined six centripetal forces which can be utilised to counterbalance these issues. They are managerial techniques, team building, product architecture, telecoms infrastructure, collaborative technology and development methodology. The causes of the various problems experienced in effectively managing a globally disturbed team have been identified as follows:

> "Notably, globally distributed teams must contend with difficulties in communication and coordination that arise from differences in time zones, geographical location, and culture".[30]

1.3 Team Motivation And Trust

Effective planning, coordination, control and communication are essential aspects of effective project management for collocated and globally distributed software developments. To undertake these activities successfully, due consideration needs to be given to people management. Motivation and the development of trust are essential for effective people management[31] particularly in a GSD team environment.[32] In this context, it was considered of value to consider the literature on motivation.

1.3.1 Motivation

[30] Davidson, E.J. and A.S.M. Tay. Studying Teamwork in Global IT Support in In the Proceedings of the 36th Hawaii International Conference on Systems Science. 2003. Kona-Kailua, HI.

[31] Dawson, S., Analysing Organisations. 1992, London, UK: The Macmillan Press Ltd.; Handy, C.B., Understating Organizations. 1985, London, UK: Penguin Books.

[32] Casey, V. and I. Richardson. Practical Experience of Virtual Team Software Development. in Euro SPI 2004 European Software Process Improvement. 2004. Trondheim, Norway.

In his seminal works "*A Theory of Human Motivation*"[33] and "*Motivation and Personality*"[34], Abraham Maslow presented what has become known as Maslow's Hierarchy of Needs (see Figure 1.2). He proposed that humans have five types of needs, as organised in a hierarchical format. This group is further divided into what are termed lower-level '*deficiency*' needs, (or basic needs) and the higher-level '*being*' needs (or growth needs).

The deficiency needs are defined as:

- **Physiological needs**. Which Maslow refers to as homeostasis. These are the basic requirements for survival. These needs are the functioning of the body, the consumption of food, water, air etc. The greatest desire is to satisfy these needs and they take priority over all others until they are satisfied.

- **Safety needs.** When the physiological needs are met the individual has the desire to feel safe and secure.

- **Social needs**. When the physiological and safety needs are addressed the individual's desire is for social relationships. Humans have a need to be loved, to be accepted and to be a part of a group.

[33] Maslow, A.H., A Theory Of Human Motivation. Psychological Review, 1943. 50: p. 370 - 396.
[34] Maslow, A.H., Motivation and Personality 2nd ed. 1970, New York, USA: Harper and Row.

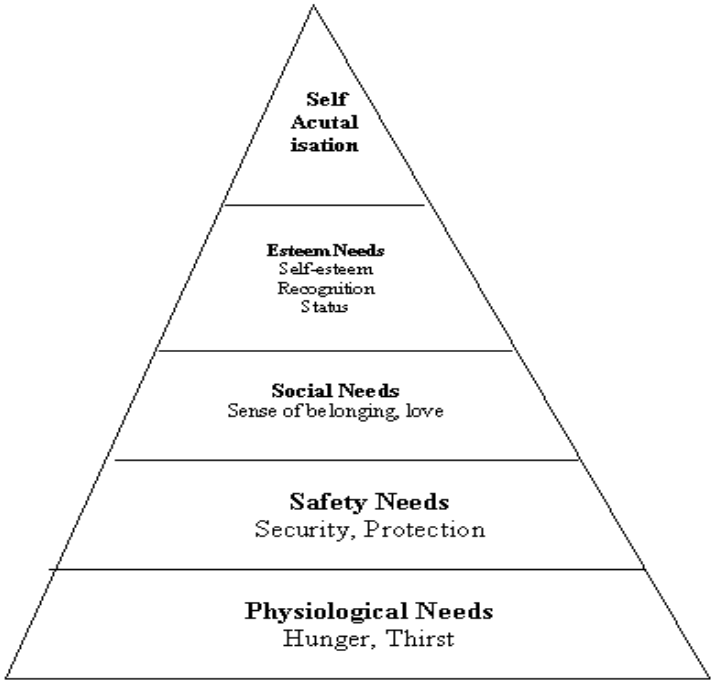

Figure 1.2

The term 'deficiency needs' is derived from the view that, if an individual is deficient in the areas of basic physiological, safety and social needs, they will fail to develop into a healthy person, both physically and psychologically. Maslow's view is that the individual is motivated to fulfil these primary needs in the order they are presented. This must take place prior to fulfilling what are termed the higher order 'being' needs.

The 'being' needs are defined as:

- **Esteem needs**. All individuals have a desire for self respect or, as Maslow calls it - *self-esteem* and the respect of others.

- **Self-actualisation**. Once the esteem needs are met, the individual has the desire for self-fulfilment. Maslow defines self actualisation as *"The tendency might be phrased as the desire to become more*

> *and more what one is, to become everything that one is capable of becoming*".

The 'being' needs (or growth needs) allow the individual to grow and achieve their full potential.

Based on the five needs or goals outlined, the individual is motivated to achieve or maintain their level of satisfaction in order to address these needs. Maslow has defined these as the key human motivating factors and in his view the individual is constantly striving to satisfy these goals. Given the hierarchical order of these needs, the individual is centrally focused on the achievement of each level sequentially. This is to the exclusion of those needs placed above those currently desired. Once the individual's current needs are met, the higher needs are then focused on, the premise being that once the needs at one level are satisfied that they are no longer motivators. The value of such a hierarchy of needs is that, if a person's location can be determined on the scale, the effective motivating factors can also be identified.

While Maslow's work was the basis for much subsequent further research, it is not without its critics. "*There is very little empirical support for his view of a universal hierarchy*". There is also the view that there very limited evidence exists that needs are activated in the order which Maslow postulates.[35] Additional research has been carried out by Clayton Alderfer, research which goes some way towards addressing these issues. Alderfer has developed what is call based on Maslow's Hierarchy of Needs, ed ERG theory[36], where he outlines three types of human needs:

- **E**xistence
- **R**elatedness
- **G**rowth

The term *Existence* equates with Maslow's physiological and safety needs. *Relatedness* links to the individual's requirement for social relationships while *Growth* relates to the human need for esteem and self-actualisation. These three concepts encompass Maslow's five areas of needs.

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[35] Furnham, A., The Psychology of Behaviour at Work: The individual in the organisation. 1997, Hove, East Sussex, UK: Psychology Press.

[36] Alderfer, C.P., Existence Relatedness and Growth: Human Needs in Organizational Settings. 1972, New York: Free Press.

Where Alderfer differs from Maslow is in his view that these needs do not need satisfying in any particular order and that more than one single set of needs may be influential at any particular time. He suggests that if a high-level need cannot be satisfied, the individual's desire to address a lower level need is increased as a consequence. This he identifies as the "*frustration and shy aggression dimension*". A constituent element of this approach is the organisational setting wherein an employee can have multiple needs to satisfy simultaneously.

1.3.2 Motivation: Theory X And Theory Y

Given the importance of motivation, it should be considered when selecting an effective management strategy. Douglas McGregor in his Theory X and Theory Y outlined two opposing views of management's approach to motivation. His work was based on Maslow's hierarchy of needs and he separates the lower-order needs into what he terms Theory X and the higher-order needs into Theory Y. A key element of McGregor's approach is *"Behind every managerial decision or action are assumptions about human nature and human behaviour*".[37] This statement is a key element in his Theory X and Theory Y approach to management.

Theory X: the traditional view of direction and control, as McGregor defines it, is based on three managerial assumptions with regard to workers and how they operate:

1. The normal worker dislikes work and will avoid it if he can.
2. Workers must be coerced, controlled, threatened and directed to put forth the required effort to achieve the organisation's objectives.
3. The normal worker wishes to be directed, likes to avoid responsibility, wants security and has little ambition.

The negative assumptions regarding the characteristics of employees as outlined in the Theory X style of management ensures that motivation is authoritarian and is supported by the threat of punishment for non-compliance. McGregor locates the roots of Theory X in the biblical view of Adam and the Fall whereby mankind was forced '*to earn his bread by the sweat of his brow'*. McGregor sums this up as follows: "*Theory X*

[37] McGregor, D., The Human Side of Enterprise 1960 New York, Toronto, London.: McGraw-Hill Book Company, Inc.

explains the consequences of a particular management strategy: it neither explains nor describes human nature although it purports to".[38]

In contrast, Theory Y - the integration of individual and organisational goals - is based on six managerial assumptions regarding workers:

1. Individuals do not dislike work and it is as natural to them as play or rest.
2. People are not lazy. Control and the threat of punishment are not the only methods that can be used to motivate staff and to achieve organisational goals. When an individual is committed to the achievement of an objective they will exercise self-direction and self-control to achieve that end.
3. Commitment to objectives is a function of the reward associated with their achievement. Self-actualisation can be a direct result of the effort expended in achieving organisational objectives.
4. Individuals working under proper conditions not only learn to accept responsibility but also come to welcome it. The desire to avoid responsibility, a lack of ambition and a focus on security are not inherited human characteristics, but factors which are learned over time.
5. Large numbers of people can exercise a level of imagination, creativity and ingenuity in their approach to solving organisational problems.
6. In industry, only part of the intellectual potential of the individual is utilised.

The Theory Y style of management assumes that individuals enjoy work, are self-motivated and self-controlled. They welcome responsibility and can be creative and imaginative in their approach to problem solving. There is also a pool of unutilised potential which can be harnessed for greater productivity, if employees are given the opportunity to excel. The satisfaction of doing a good job is an effective motivator rather than the "*carrot and stick approach*". The focus of a Theory Y manager is to remove the barriers which may prevent their staff from achieving their full potential.

[38] McGregor, D., The Human Side of Enterprise 1960 New York, Toronto, London.: McGraw-Hill Book Company, Inc.