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PRODUCTIVITY IN SOFTWARE MAINTENANCE MULTICULTURAL TEAMS

Literature review

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Abstract

Software maintenance has been and remains a significant part of the information technology business, no matter if you we are referring to legacy software, SAP, cloud or mobile applications. In the latest ten years we have witnessed a massive move of IT jobs into countries like India, Philippines, Brazil and Romania which generated a high degree of multicultural diversity. In this context it could have an impact on team overall productivity.

A significant part of the software lifecycle budget varying from 50% to 80% is spent in the maintenance phase, from where there is a high interest in continuous increase of productivity both from the client and the supplier.

Through this paper we are proposing to analyze previous written literature on this topic and use the experience in multicultural IT environment, as well as providing a fresh view of the factors contributing to higher level of performance.

Introduction

Software applications have become in the last 20-30 years an important part of our professional and personal life. Numerous studies (Schach, 1999; Lientz& Swanson, 1980) have showed that a significant part of the software lifecycle costs are in the maintenance phase.

Maintenance covers any modification to the software and it's documentation after the software has been delivered, covering evolutive, preventive, corrective and adaptive activities (IEEE Computer Society, 2005).

Combining the importance of the software maintenance and its costs, shouldn't be a surprise that there has been a lot of emphasize on how to improve productivity of the maintenance teams during the 80s, -90s.

In the latest ten years we have witnessed a massive move of IT jobs into countries like India, Philippines, Brazil and Romania which generated a high degree of multicultural diversity. In this context it is becoming important to understand if this is having an impact on the team overall productivity.

Through this paper we are proposing to analyze previous written literature on this topic and use the experience in a multinational multicultural IT environment,

Software maintenance productivity

There hasn't been agreed a solely way of measuring productivity for maintenance activities. In economic terms:

$$Productivity = \frac{Outputs}{Inputs}$$

The inputs for the software maintenance service: money, developer's time measured in man hours or man days, often mentioned as effort, requests received from the users or clients. The outputs of this process is a software performing at the right level of performance, user requests resolved or new functionality implemented.

While in the manufacturing environment productivity measuring it is well understood and visible by most of the people, when we are referring to services in general, and to software maintenance, in particular, the things are getting suddenly not so obvious.

Measuring software maintenance productivity has been under debate for more than 30 years. Previous researchers have been focused on measuring productivity in Function Points and Lines of Code, even though this has been showed as being paradoxical (Jones, 1978) since it measured the size of the code and not the efficiency. Our proposal is to look more simplistic at the maintenance service productivity as being calculated as following:

$$Productivity = \frac{Number\ of\ requests\ solved}{Period\ of\ time}$$

This approach is not singular, for example Sneed (1997) states that one of the key metrics a maintenance department should measure is the time required to accomplish the maintenance tasks.

To ensure that the bias due to requests complexity is reduced to a minimum, a suggested approach is to normalize the requests in several categories based on the effort required to solve the issue Appendix A (table N 1).

One simple implication of normalizing the effort by looking at the difficulty is that with the same effort required to solve a medium difficult request could have been solved 4 easy requests.

Looking through the eyes of the software end user, we might say that a highly productive team is the one who is solving requests very fast. Turnaround time of the request is critical to keep clients satisfied and we consider it to be a characteristic of an efficient team.

No matter how we are looking at productivity, the maintenance personnel

often suggest that these measurements of productivity are ambiguous and not reflecting reality.
One of the arguments is that the work being performed is creative and creativity cannot be measured. Another answer could be the complexity given by a multi-location and multicultural teams.

Factors impacting productivity

Many studies on factors impacting productivity have been conducted in the 80s-90s, while after year 2000 the researches on the topic are rare. Some of the findings we'll present here.
The amount of input (e.g. labor hours) required by a software development project depends on the size and complexity of the resulting product and the effects of a number of environmental complexity factors, such as the response time of the development hardware (Kemerer, 1988).
Making measurement an integral part of all software projects and capturing the knowledge gained via measurement from each project in a corporate database will enable a systematic improvement from project to project(Rombach&Ulery, 1989).
Short response times, programmer's skills, and program complexity have an impact on programmer productivity (Scacchi, 1989).
Maintainability is the quality factor with the most influence in the maintenance stage (Granja-Alvarez and Barranco-Garcia, 1997).
System age and deterioration were found as having an impact on productivity, as well as application familiarity (Chan, 2000).
Banker et al. (1991), are studying numerous variables impacting productivity like: having a good documentation, capability, application experience, and data processing experience, schedule constraints, staff loading, travel requirements, and project communication, high user-required reliability, requirements volatility, modern programming practices, use of software tools, response time, choice of language and hardware/ software volatility. Conclusions of their study: volatility is only marginal important, good documentation is not significant on the short term, loading measured as the total number of work-months divided by the total project duration in calendar months it has a negative impact, deadline pressure has a significant impact, especially on short term.
Regarding having a good documentation, Banker&Datar (1987), have clarified in another study that documentation has a negative impact on short term due to the effort required, however on long term the benefits will show, when new enhancements or repairs are required. In this initial study the factors under study were environmental factors like: ability, previous experience of the personnel, hardware and software tools, and attention spent on system quality.
Chapin (1991) sees 6 categories of factors: software factors, personnel factors, system factors, management factors, organizational factors, customer factors.
Prodan (2013) identifies that significant factors for a maintenance process are the number of interruptions, communication between Front Office and Back Office, problem description quality and the time required for understanding the requirements.

Multicultural dimension

Culture is "The collective programming of the mind that distinguishes the members of one group or category of people from others"(Hofstede, Hofstede, & Minkov, 2010). Some studies have been conducted in the last years on the multicultural dimension of the teams.
Borchers (2003) presented the main factors that impact multicultural software teams, based on Hofstede theory:

- Power Distance (PDI)-there are cultures with high PDI where authority is recognized by software teams and low PDI where authority is not recognized;
- Uncertainty Avoidance (UAI)-the resistance to change it is widely known but high cultures have reduced degree of UAI;
- Individualism (IDV)-the way people work, act together.

Alkandari et al., (2012) in his studies showed that miscommunication is amplified by cultural diversity. Key factors are attitude towards work, organizational culture, roles held, how time is understood by the team members, language (Appendix B, Table 2).

Some of the effects of miscommunication are rework, delays and conflicts which will lower productivity and increase costs.

(Congdon & Gall, 2013) brought a new perspective for culture diversity impact on performance and productivity, there are six dimensions that must be defined and followed for multicultural teams:

- autocratic-consultative
- individualist
- masculine-feminine,
- tolerant of uncertainty-security oriented,
- short term-long term, and
- low context-high context

Diversity can be for a maintenance team a constructive element if the broader experience-base from different cultures is exploited, but in the same time if the cultural diversity is not managed properly could bring the clash. A multicultural maintenance successful team is composed from well organized, experienced resources willing to work closely and able to produce and collect their own productivity data.(Alkandari et al., 2012). When understanding the impact of multiculturalism, is essential to take into account the cultural diversity of all parties involved in the process.(e.g. client, teams, partners, subcontractors, leaders) (Rahman, 2013).

Besides being a standalone factor, cultural diversity may have a significant impact on other factors, which have been identified by other researchers.

System complexity and size of the application (Kemerer,1988) are technical variables on which cultural diversity could have a limited impact. However, there are instances (e.g. maintenance process split between several teams spread in several location) when these two factors make service delivery even more difficult, generating a lower number of requests solved in a given period of time. Response time of hardware (Kemerer, 1988;Sccachi, 1989)is not being affected by cultural dimension, being a characteristic of the IT environment.

Skills (Sccachi, 1989; Chan, 2000) is one area where multicultural has a positive impact, an organization with a large diversity will be able to find experienced resources.

Measurement system and Capture knowledge in databases(Rombach&Ulery, 1989) are impacted by the three factors from Hofstede, PDI, UAI and IDV, the influence could be both positive and negative.

Maintainability (Granja-Alvarez& Barranco- Garcia, 1997) is impacted by the organizational way of working.

System age and deterioration (Chan, 2000) are not having a direct link with multicultural teams. Application familiarity(Chan, 2000) could suffer when outsourcing or offshoring the maintenance service, unless a strong knowledge transfer process is in place.

Requirements volatility (Banker et al., 1991)is related with service beneficiary's environment and organizational way of planning and executing.

Good documentation (Banker et al., 1991)it's good to have on the long term to avoid losing knowledge when maintenance personnel is changing (e.g. different role, attrition). It is one of the "must have" when we consider outsourcing maintenance. A common language, agreed

with the client, standardization and a common place to store the documentation are important elements.
Another factor is deadline pressure (Banker et al.,1991),a key short term factor, affected by the way various team members perceive the upcoming due date of a specific activity. This is a component of the organizational factor.
Last, the factors identified by Prodan (2013) through experiments: number of interruptions, communication between Front Office and Back Office, problem description quality. Communication has been shown to be affected by cultural diversity, and also that is impacting productivity. Number of interruptions describes level of discipline and attitude towards work of the Back office team, while problem description quality can be seen either a process problem or attitude towards work of the front office team and end users.

Conclusions

Due to globalization and the need to stay competitive in the market, many companies developed capabilities in many locations across the globe. In the latest years we are assisting to true multi country teams, as well as being difficult to see the end to end process, therefore difficult to see the output and measure productivity.
Gupta & Fernandez (2011) states that "While advanced collaboration tools are available in the market, feedback from organizations suggests a suboptimal use and insufficient value leveraged from these tools. Collaboration between team members in software projects is essential for ensuring the team meets all its goals."
Process itself is being affected by service provided from multiple locations, very often multi countries, same official language but spoken at different levels, multiple time zones. A fragmented process (steps of the process are performed by many different actors) can work well only if the communication between the spread teams includes the multicultural component.
Multicultural side has impact also on many of the "traditional" factors. Besides having a major impact on communication inside and outside of the team, it has a potential impact on other factors impacting productivity.
According with our simple way of calculating the productivity, in order to have a positive impact, a team needs to either increase the number of requests in a given period of time(reduce time required by one request) or increase the "available" time, meaning eliminate non value added activities.
Our study is based on previous research and literature and on authors experience and observations in the software maintenance field. A theory needs to be validated in real life in order to be accepted. Future research would need to be focused on creating various models of factors and test them in "real life".

Reference list:

Journal article

[1] Banker R.D., Datar S.M. (1987). Factors affecting software maintenance productivity: An exploratory study. *Proceedings of the 8th International Conference on Information Systems Pittsburgh*, 160-175
[2] Banker R.D., Datar S.M. &Kemerer C.F. (1991). A model to evaluate variables impacting the productivity of software maintenance projects. *Management Science*, Vol 37, No 1, 1-18
[3] Borchers, G. (2003). The Software Engineering Impacts of Cultural Factors on Multi-cultural Software Development Teams *Software Engineering, 2003. Proceedings. 25th International Conference*, 540-545
[4]Chan T. (2000). Beyond productivity in software maintenance: factors affecting lead time in servicing users' requests Software Maintenance. *Proceedings on International Conference on Software Maintenance.* 228-235
[5] Chapin N. (1981). Productivity in software maintenance.*AFIPS '81: Proceedings of the National Computer Conference*, 349-352
[6] Congdon, C., & Gall, C. (2013). *Vision Statement: How Culture Shapes the Office.*USA. Harvard Business School Publishing Corporation
[7]Granja-Alvarez J.C. &Barranco-Garcia M.J. (1997). A Method for Estimating Maintenance Cost in a Software Project: A Case Study. *Software*

Maintenance: Research and Practice, Vol. 9, 161–175

[8] Gupta, M.& Fernandez, J. (2011).How Globally Distributed Software Teams Can Improve Their Collaboration Effectiveness? *Global Software Engineering (ICGSE), 6th IEEE International Conference*, 185-189

[9] Jones, T.C. (1978), Measuring Programming Quality and Productivity. *IBM Systems Journal,Issue 1, Volume 17*, 39-63.

[10]Kemerer, C.F. (1988). Production process modeling of software maintenance productivity. *Proceedings of the Conference on Software Maintenance*, 1988.

[11] Prodan M. (2013) Case study of improving software applications maintenance service using Lean Six Sigma methodology *Proceedings of ICMIE 2013*

[12] Rombach H. D. &Ulery B. (1989) Improving Software Maintenance through Measurement.*Proceedings of the IEEE, Vol. 77, No. 4*,581-595

[13] Scacchi, W. (1989)Understanding Software Productivity: A Comparative Empirical Review. *Proceedings of the Twenty-Second Annual Hawaii International Conference,vol 2*, 969-977

[14] Sneed, H.M (1997). Measuring the Performance of a Software Maintenance Department Software Maintenance and Reengineering. EUROMICRO 97., First Euromicro Conference, 119-127

Book

[1] Alkandari, M., Bohner, S., Edwards, S., Cao, Y., Gracanin, D., & Wallace, L. (2012). *A Model of Multicultural Software Project Team Management applied in Requirements Engineering*. Blacksburg, Virginia.

[2] Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). *Cultures and Organizations Software of the Mind Intercultural Cooperation and Its Importance for Survival*. USA: McGrawHill.

[3] IEEE Computer Society. *Guide to the Software Engineering Body of Knowledge*. USA. IEEE Computer Society Press

[4] Lientz, B., Swanson, E.B.(1980).*Software Maintenance Management*. USA. Addison-Wesley

[5] Rahman, A. (2013). *How to Increase Performance and Productivity in a Multicultural Environment?* Retrieved from http://atiquemr9.hubpages.com/hub/performance_productivity

[6] Schach S. (1999) *Software Engineering*. Fourth Edition. USA. McGraw-Hill

Appendices

Appendix A
Table No. 1
Normalizing effort for request based on difficulty

Difficulty of the request	Effort for solving the request [man hours]
Easy	1
Medium	4
Difficult	7

Table No. 1
Normalizing effort for request based on difficulty

Appendix B
Table No.2
Cultural factors that conduce to miscommunication

No.	**Factors**	**Percentage**	**Occurrence**
1.	Attitudes	86%	often to sometimes
2.	Organizational policy, procedures, culture	83%	often to sometimes
3.	Time	78%	often to sometimes
4.	Roles	73%	often to sometimes
5.	Language	68%	often to sometimes

Note: Table adapted from (Alkandari et al., 2012)

Appendix B
Table No.2
Effects of miscommunication that impacts productivity

No.	**Effects**	**Percentage**	**Occurrence**
1.	Miscommunication produces conflicts that conduct to rework	79%	often to sometimes
2.	Miscommunication produces conflicts which increase the amount of delays	70%	often to sometimes
3.	Miscommunication increases the amount of errors/defects, that conduct to rework and delay	63%	often to sometimes
4.	Miscommunication, increases the risk of not delivering in time and budgeted costs	58%	often to sometimes
5.	Miscommunication, affect the overall project productivity	66%	often to sometimes

Note: Table adapted from (Alkandari et al., 2012)