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IMPROVING IT PROCESS MANAGEMENT THROUGH VALUE STREAM MAPPING APPROACH: A CASE STUDY

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ABSTRACT

Value-Stream mapping (VSM) is a helpful tool to identify waste and improvement areas. It has emerged as a preferred way to support and implement the lean approach. While lean principles are well-established and have broad applicability in manufacturing, their extension to information technology is still limited. Based on a case study approach, this paper presents the implementation of VSM in an IT firm as a lean IT improvement initiative. It involves mapping the current activities of the firm and identifying opportunities for improvement. After several interviews with employees who are currently involved in the process, current state map is prepared to describe the existing problem areas. Future state map is prepared to show the proposed improvement action plans. The achievements of VSM implementation are reduction in lead time, cycle time and resources. Our finding indicates that, with the new process change, total lead time can be reduced from 20 days to 3 days – 92% reduction in overall lead time for database provisioning process.

Keywords: value stream mapping, VSM, lean principle, IT process management

1. INTRODUCTION

In today's highly competitive business environment, information technology (IT) plays a critical role in supporting business functions and satisfying business requirements. Effective and efficient IT management has the potential to transform business as well as positively impact on a company's performance (Iden, 2012). As business requirements constantly change, the business function expects IT to streamline IT service provision to improve time-to-market responsiveness. Furthermore, firms are performing continuous IT process re-engineering initiatives to reduce complexity and cost while providing high quality of services, control, and availability (Attaran, 2004).

Lean IT is an approach for creating cost-effective, agile and flexible IT process management (Bell and Orzen, 2010). Lean principles were originally developed to improve quality and reduce cost in manufacturing. Later, Lean tools were used to

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improve quality and reduce costs of services. In Lean IT, the thinking has evolved into a robust approach for optimizing IT service provisioning and IT-enabled business processes by improving quality, eliminating waste, shortening lead times and reducing cost. Lean IT principles have gained significant attention as a viable option to address the challenges of enabling and sustaining the continuous IT process improvement. According to McKinsey & Company, applying Lean IT principles can increase application development and maintenance productivity by as much as 40% while improving the quality and speed of execution (Kindler et al., 2007). Among various Lean IT tools, Value-Stream mapping (VSM) is a helpful tool to identify waste and improvement areas. VSM is a standardized way of documenting the process steps and flow of work items, and then applying a systematic way to analyze these processes in order to develop an improvement plan (Ali et al., 2016; Chen et al., 2012; Damelio, 1996; Tapping and Shuker, 2003). The visualization and quantification of the process flow makes it easier to identify waste and other constraints on value chain. VSM has emerged as a preferred way to support and implement the lean approach (Grewal, 2008; Serrano et al., 2008; Seth and Gupta, 2005; Tortorella et al., 2016; Tyagi et al., 2015).

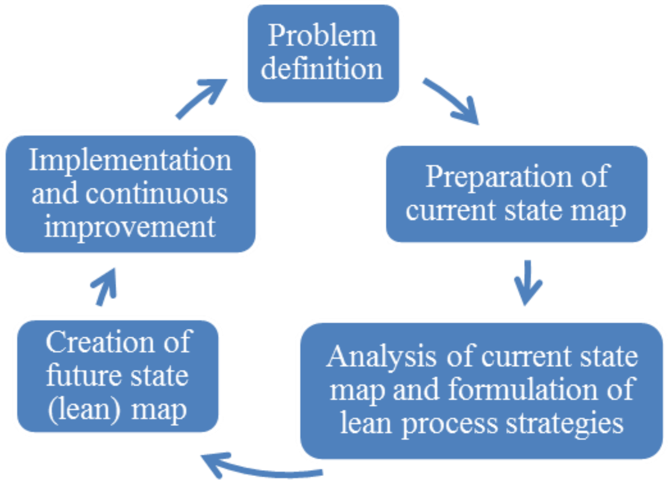
This paper describes the implementation of VSM in an IT firm as a lean IT improvement initiative. While VSM is well-established and has broad applicability in manufacturing, little consideration has been given in service areas such as healthcare and banking, least of all in information technology (Bonaccorsi et al., 2011; Machado and Leitner, 2010; Piercy and Rich, 2009; Snyder et al., 2005; Wang and Chen, 2010). We apply VSM for improving IT process management to achieve operational efficiency such as reducing project delivery time, time-to-market or eliminating non-value added steps. A case study conducted at ABC Company is presented. ABC is a leading firm in information technology services. However, the company faces several challenges in delivering IT services such as database provisioning. Due to process inefficiency, it creates a high number of project escalations which cause more costs to the company. We discuss the company's current process flows and identify bottlenecks. Based on the analysis, we also provide recommendations and present future state map (to-be-process).

2. VALUE-STREAM MAPPING: AN OVERVIEW

Value Stream Mapping (VSM) is a standardized way of documenting (mapping) processes and information/material flows as they are, and applying a systematic way to analyze these processes in order to identify various waste and target specific areas for improvement (Ciarapica et al., 2016; Damelio, 1996; Kuipera et al., 2016; Rother and Shook, 1998; Tapping and Shuker, 2003). This visual representation facilitates the process of lean implementation by identifying value-adding steps in a value stream and eliminating non-value-adding steps or waste (Grewal, 2008). VSM was originally developed to focus on the analysis and improvement of disconnected flow lines in manufacturing environments (Rother and Shook, 1998), but it has emerged as the preferred way to support and implement the lean approach for all industries. VSM enables a company to see the entire process in both its current and desired future (lean) state, and identify and eliminate waste, thereby streamlining work processes, cutting lead times, reducing costs and increasing quality (Abuthakeer et al., 2010; Ballard and Howel, 1994; Jasti et al., 2014; Rother and Shook, 1998; Tabanli and Ertay, 2013).

The first step to implement VSM is to draw a current state map. The value stream map of current process is created and identifies different kinds of value-added as well as non-value-added activities in this stage. The current state map is typically drawn by a cross-functional, multi-disciplined team to document how things actually operate ("as-is" process). The next step is to develop a future state map ("as should be"). In order to do so, the current state map should be analyzed first. The team needs to identify gaps or improvement areas (e.g. large inventories, long lead/cycle time), and provide rationale as to how and why these activities identified are non-value-added. Based on the gap areas found, the team proposes what must change in the process, methods, and organization. Then, the future state map is developed to design a lean process flow through the elimination of non-value-added activities and through process improvements. The last step is to analyze the results after implementing the proposed changes. This has to be quantified in terms of lead time reduction, cycle time reduction, inventory reduction, etc. In addition, the team needs to develop a change plan that provides action steps needed to support the proposed changes. The steps in the implementation of VSM are shown in Figure 1.

Figure 1. Steps in implementation of VSM



3. RESEARCH METHODOLOGY: CASE STUDY

Since the objective of this study is to describe how VSM can be implemented within a real-life context, a case study was used. According to Yin (2002), the case study method is well suited when a contemporary event is examined within its real-life context and when the researcher has little or no capability of manipulating the event. In addition, it is pertinent when research addresses a "how" question (McCutcheon and Meredith, 1993).

3.1 Case Description

ABC is a leading firm in information technology services. It had 315,000 employees and its revenue was approximately $138 billion in 2015. The company has comprehensive product portfolios which include hardware products, software solutions, and IT services to large enterprises, small and medium business and individual customers. The firm's business operations have been organized in seven different functions: Enterprise Services, Enterprise Storage and Servers, Personal System Groups, Software, Imaging and Printing Group, Financial services, and Technological Solution Group.

ABC has its own huge internal IT infrastructure setups and data centers to support

IT needs for different business units. They are managed by a large unit which is called "ABC IT". ABC IT consists of several departments. Some departments provide IT support and services to business units (e.g. enterprise system, personal system, technological solutions). Other departments are responsible for other IT functions such as storage support, network service or database support that provide services across all vertical business units.

3.2 Data Collection

Since this is a study of IT processes, unlike the manufacturing industry, we do not have any physical shop floors to walk through and do a visual study. For the data collection, engineers and IT managers across different geographical regions are involved. They work with each other in virtual environment and through virtual meetings. Only physical infrastructure which will get implemented is going to be located in one of the US data centers, and every involved team will be accessing remotely over the network. Below are the geographic locations from where teams of engineers and managers have been interviewed.

- United States
- Mexico
- Singapore
- Malaysia

We conducted multiple virtual interviews with the detailed demand review (DDR) team located only in United States. Also, database infrastructure build team, database operation team, database build engineers and database SMEs (subject matter experts) were interviewed from Singapore (on-site interview), Malaysia, Mexico and United States. A total of 22 employees were interviewed for this study. More specifically, they were asked to give a walkthrough, step by step process, and/or activities "what do they do during the database build activity?" A paper and pencil was used to make a rough map as the engineers are going through various activities. Collected information and rough process or activity steps recorded during the interviews were reviewed with other engineers and build managers using the virtual room sharing, and ensured the quality of the collected data.

This data collection process was repeated with some of the old build engineers who now has moved to different projects and with current build engineers. The current state of processes was also discussed with senior managers to gather their management view and requirements which helped us to finalize an "expected/ideal goal". Once all involved personnel was interviewed, we moved to the next stage where "current state" process map of various activities were created.

4. CASE STUDY: IMPROVING DATABASE PROVISIONING PROCESS TO MEET BUSINESS DEMANDS

4.1. Step 1: Problem definition

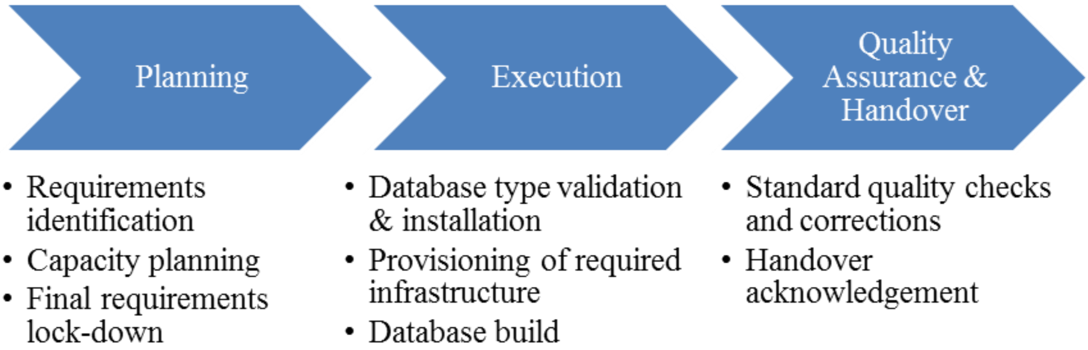
ABC IT faces several challenges in delivering IT services. One of the bottlenecks in delivery of IT services is the database support and service process in Global Database Administration (GDBA) department. GDBA department is responsible for delivering all kinds of back-end database infrastructure needs and maintaining database operations. As business demands have been constantly changing, the current database server provisioning process is no longer suitable to meet the level of requirements.

Furthermore, the process inefficiency has led to even higher number of project escalations, causing more costs to the company. Databases and servers are the backbone of application deployments or enterprise services, so timely delivery of these services plays an important role in business. It becomes necessary to review the current database provisioning processes and evaluate against new demands and forecasting.

4.2. Step 2: Preparation of Current State Map

Figure 2 illustrates the overall database build and delivery process. In three-phase process below, each phase also has its own set of sub-processes. We present more details of each phase in the following.

Figure 2. Overview of database building and delivery process

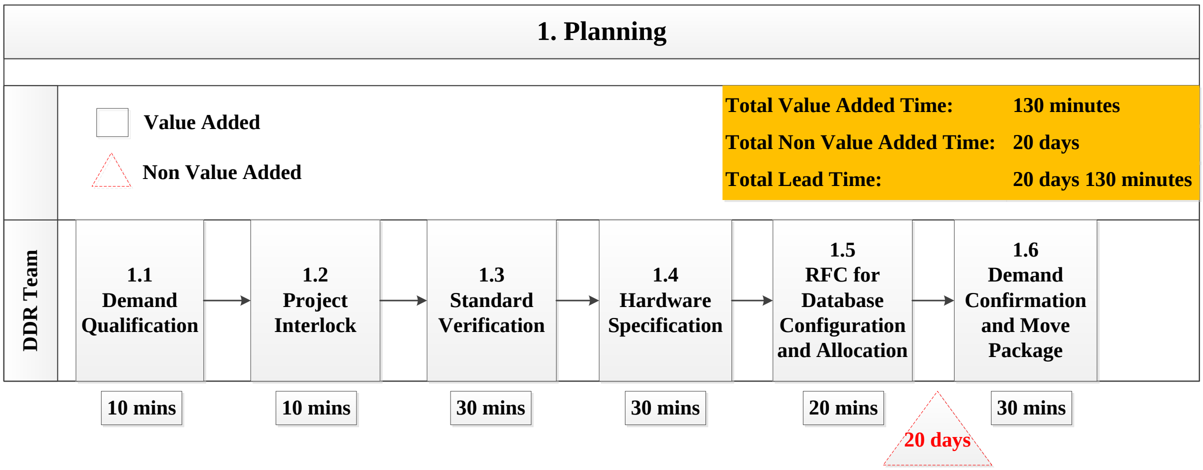


Phase 1 - Planning

Upon receiving a business request for database(s), GDBA Detail Demand Review (DDR) team meets with a business manager to identify database infrastructure requirements in details[1]. Planning process is mostly standardized in a way that DDR team manually goes through a set of pre-defined questionnaires to get requirements from the business manager. Various aspects of infrastructure requirement such as demand feasibility, availability of engineers, standard, hardware, and configuration are reviewed. Once DDR team and the business manager come to an agreement, the request for change (RFC) of database allocation and configuration is submitted. If the RFC is approved by different managers involved, final requirements are locked down and the work order is sent to the build team (however, if the request from business units is infeasible, it will go back to the business manager for repeated review). Figure 3 provides a detail view of planning phase and its value-added and non-value-added time for each activity. The completion time of each activity varies, so we used an average time based upon information collected during the interview process. In the planning phase, we estimated 130 minutes of value-added activity time and 20 days of non-value-added time.

[1] It takes an average of 15 days even for a business manager to schedule a meeting with DDR team. We decide not to include this non-value-added time in the analysis since it is not a part of database provisioning process, however, this should be noted as another major bottleneck.

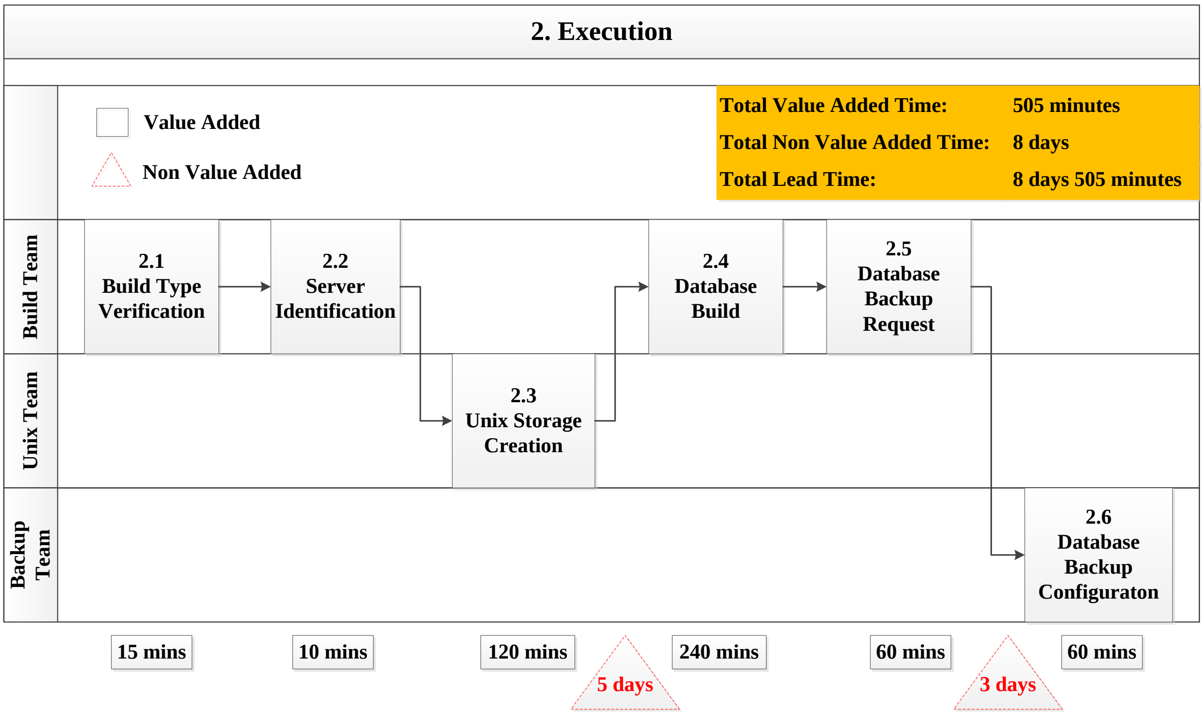
Figure 3. Sub-processes in planning phase



Phase 2 - Execution

This is the process which takes the inputs from approved work order for actual database implementation. The execution process is mainly related to technical work done by engineers. The assigned engineers verify the type of database needs to be created and identify the hardware for installation. Once the type of database and hardware is confirmed, UNIX team starts configuring the new hardware as per standard, and the build team works on software installation and database creation. Lastly, database backup request is submitted, and backup team sets up appropriate backup infrastructure and database backup. Figure 4 shows the detail activities involved in the execution process and their timelines. In the execution phase, we estimated 505 minutes of value-added activity time and 8 days of non-value-added time.

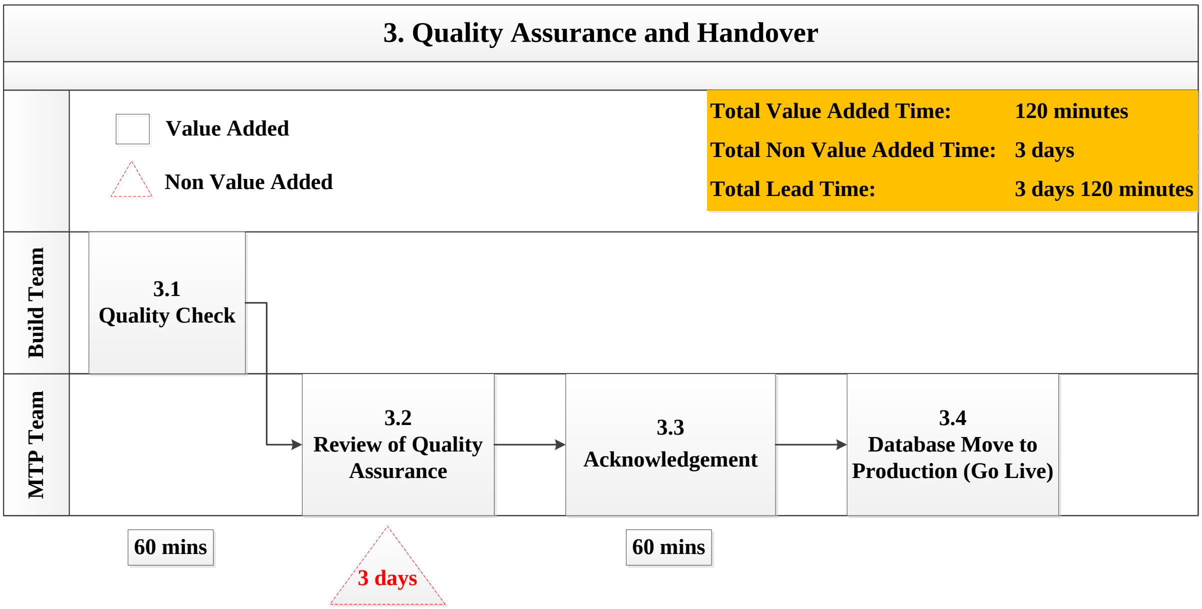
Figure 4. Sub-processes in execution phase



Phase 3 - Quality Assurance and Handover

Once the database creation is completed, a quality assurance and handover process will start. This process is iterative in nature and goes for several rounds of standard quality checks and corrections between databases engineers and MTP (Move-To-Production) team. This iteration is mainly because of differences in standard check parameters that each team has. Each team follows their own manual check list to ensure the quality of new database. Once this phase is cleared, the database will be handed over to MTP team and go live. Figure 5 illustrates the detail activities involved in the quality control and handover process and their timelines. In the quality control and handover phase, we estimated 120 minutes of value-added activity time and 3 days of non-value-added time.

Figure 5. Sub-processes in quality assurance and handover phase



4.3. Step 3: Analysis of current state map and formulation of lean process strategies

Table 1 provides a summary of value-added and non-value-added time. The analysis of current state map reveals that non-value-added time accounts for almost 97% of total database delivery time. While some delays may be inevitable, it is surprising that significant portion of delivery time is actually spent on waiting or non-value-added activities. A major bottleneck in the current process is the planning phase where its waiting time contribution is 64.5% of the total database delivery time.

Table 1. Summary of value-added and non-value-added time

Phase	Value-Added Time	Non-Value-Added Time
Planning	130 minutes	20 days
Execution	505 minutes	8 days
QA & Handover	120 minutes	3 days
Total	755 minutes (12.6 hours)	31 days

There are several problems identified in the planning phase. First of all, the planning phase is a purely manual process that DDR team manually goes through a set of pre-defined questionnaires to get requirements. Even after the final requirements are confirmed, it has to go through the manual RFC approval processes by different managers which take an average of 20 days. Figure 6 provides the detail work flow and problems in the planning phase. The problems during the execution phase are that any changes should have a minimum of 5 days of implementation window after RFC approval due to RFC process guideline. It means that there are 5 days of turnaround time before UNIX team can even start configuring a new hardware. We also find that the database backup configuration is an internal process of Backup team which has a lead time of 3 days. However, this can be automated and incorporated during the database build process to improve the current processing time. Lastly, the problem identified in quality assurance and handover process is that, due to the lack of quality check standard, each team has its own local checklist and they manually go through the lists. Another problem is while the build team conducts an initial quality check, MTP team also runs a separate quality check before the acknowledgement of quality assurance. This repeat verification and manual re-check process accounts non-value-added time of 3 days. Table 2 summarizes the non-value-added time in different phases.

We also calculated “TAKT” time. TAKT time is used to synchronize the pace of production with pace of sales. It is calculated by dividing net time available with total demand (Buzby et al., 2002; Grewal, 2008). Based on the company’s recent scorecard, we identified that the annual demand for database is approximately 1,030. And we calculated the net time available for build per year is 58,800 hours (considering 52 weeks per year * 5 working days per week * 24 hours * 10 engineers).

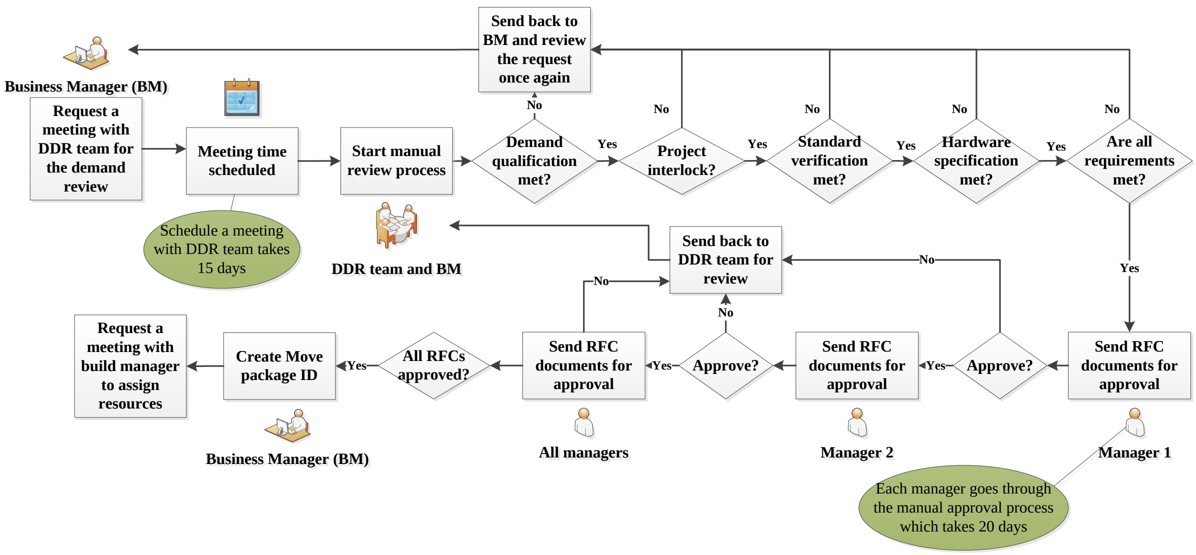
TAKT time = 58,800 / 1,030 = 57.1 per hour (2.4 days)

This number implies that GDBA team has to produce one completed database in every 2.4 days to meet the company’s annual database demand. However, with the current process, it takes almost 32 days to complete one work order which is a significant problem.

Table 2. Summary of non-value-added time

Phase	Activity	Non-Value-Added Time	Problem Identified
Planning	Request for change (RFC) for database configurations and allocation	20 days	• Planning phase is a purely manual process • Getting RFC approval from different stakeholders take a long time
Execution	Unix Storage Creation	5 days	• Due to RFC process guideline, any change should have minimum of 5 days of implementation window after RFC approval • 5 days of turnaround time before Unix team starts configuring the new hardware
Execution	Database Backup Request & Configuration	3 days	• Backup Team will setup the backup infrastructure for the database
Quality Assurance & Handover	Acknowledgement of Quality Assurance	3 days	• Repeat verification and manual re-check process

Figure 6. Current work flow and problems identified in planning phase



4.4. Step 4: Creation of future state (Lean) map

The analysis of current state map was shared with senior managers to obtain their views and suggestions. This helps us to identify requirements and finalize an expected (target) goal. Based on the gap areas identified, several changes were proposed.

- Automation of the planning phase including RFC approvals to minimize human resource dependencies (delays)
- Create an automated script for backup specification which can be incorporated in the execution process. This will benefit both teams by reducing the work in backup engineers and by reducing the waiting time for build team during the execution process
- Design a unified QA standard to streamline the quality check and handover process. Make the quality check results available on the internal IT website or SharePoint. At the same time improve the technical build scripts and processes as per the required standard to get the product right at first time only

Based upon the proposed changes, we prepared a future state (lean) map for each phase.

Phase 1 - Planning

As shown in Figure 7, we propose a new system that automates the entire planning process. Once the business manager fills out an online request form, the request notification is sent to DDR team, and the team verifies different demand review specifications without setting up a meeting. As mentioned earlier, it even takes 15 days for the business manager to schedule a meeting with DDR team. Another benefit of new system is that the business manager can submit multiple requests online, and these DDR requests flow in the system simultaneously.

After the demand specifications are reviewed by DDR team, RFC approval request mail will be sent to different managers involved. The system automatically obtains approvals by providing required information in a single mail or documents attached. This new process reduces the waiting time of planning phase significantly as “getting RFC approval and follow-up” takes the longest waiting time. Figure 8 illustrate the automation of planning phase as future state map. While the process itself does not change in this phase, we expect that the total lead time spent can be reduced from 20.09 days to 2.07 days by replacing the current manual process with the automated system.

Figure 7. Future state map in planning phase

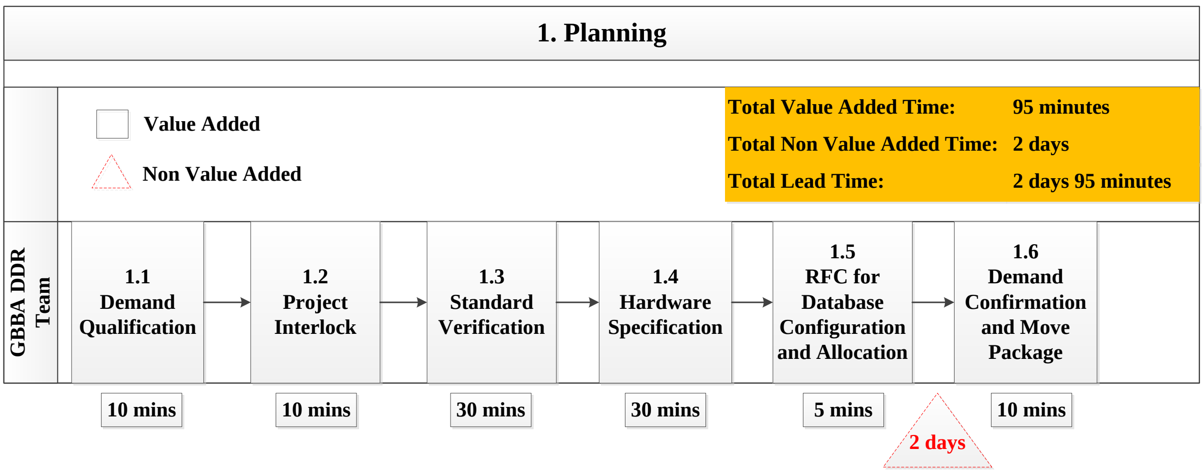
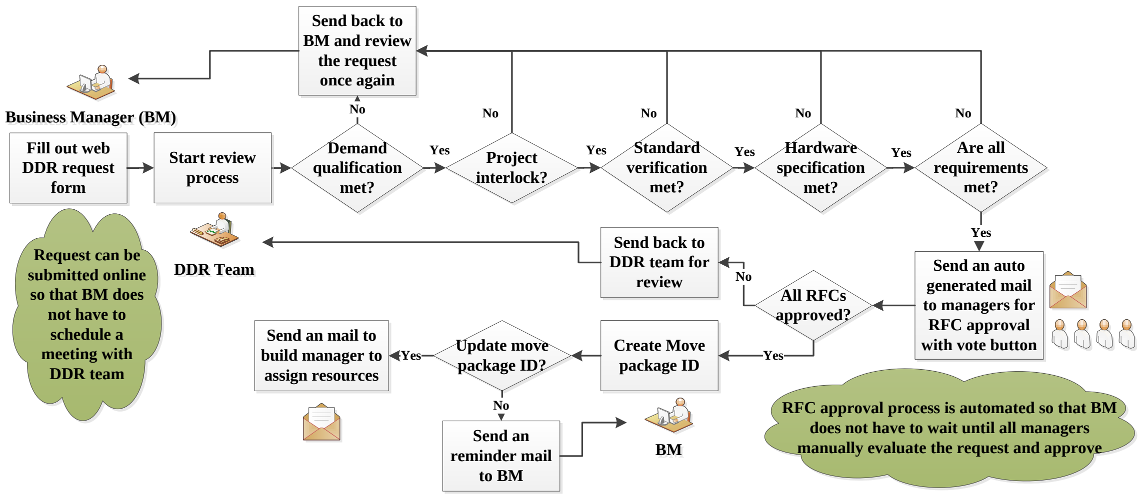


Figure 8. Future state map – Automation of Planning phase

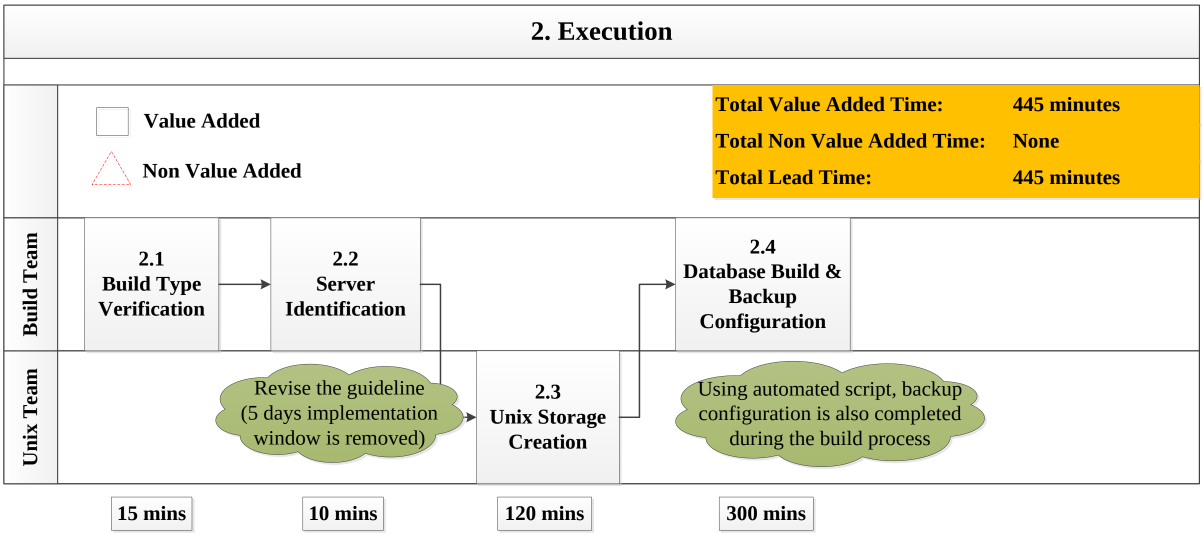


Phase 2 - Execution

During the interview process, we found that, due to RFC process guideline, any changes should have a minimum of 5 days implementation window after RFC approval. That's the reason why Unix team has 5 days of turnaround time before they starts configuring the new hardware. In the future state map, we reverse the current standard so that 5 days implementation window can be removed.

Another process change is to create an automated script for backup configuration. Database backup configuration is an internal process of Backup team which has a lead time of 3 days. However, this can be automated and incorporated during the database build process. This not only benefits backup engineers by reducing the workload, but also helps the build team to avoid the backup team dependency. With the proposed process changes in the execution phase, we expect that the total lead time can be reduced from 8.35 days to 7.4 hours (445 minutes).

Figure 9. Future state map in execution phase



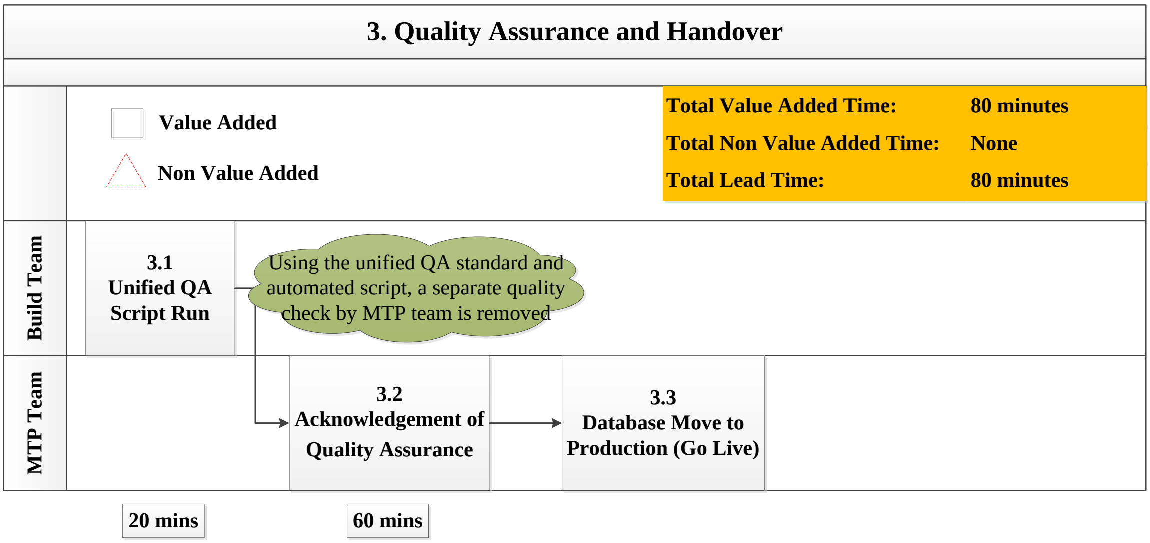
Phase 3 - Quality Assurance and Handover

The problem identified in quality assurance and handover process is that, due to the lack of quality check standard, each team has its own local checklist and they manually go through the lists. Another issue is while the build team conducts an initial quality check, MTP team also runs a separate quality check before the acknowledgement of quality assurance.

To improve the current process, we design a unified QA standard to streamline the quality check and handover process. We interviewed various teams to gather all checklist parameters that need to be evaluated during QA. We found that 99% of lists are technical issues, so it can be scripted and deployed with the build script. What it means that as soon as the build process is finished, it runs the quality check script and uploads the results to the common SharePoint and/or website for reference and review.

The unified QA standard has an additional benefit. Build engineers are the ones who run the build automation script to evaluate software installed and database creation. Since they know what quality check parameters are used during QA process, this will help engineers to build the right database at first place. With the proposed process changes in the QA and handover phase (shown in Figure 10), we expect that the total lead time can be reduced from 8.08 days to 1.3 hours (80 minutes).

Figure 10. Future state map in QA and handover phase



5. DISCUSSION AND CONCLUSION

One of the challenges that ABC faces is the database provisioning process. The analysis of current state map reveals that current database delivery lead time is almost 32 days, and 97% of total database delivery time is actually spent on waiting or non-value-added activities. We found that the current process must be improved so that GDBA team can produce one completed database within 3 days to meet the company's annual demand. Future state map was prepared after proposing several changes in the process to reduce different wastes. The planning phase including RFC approval process is automated to minimize human delays. The automated script for backup specification is built to reduce the workloads of backup engineers and the build team. And the unified QA standard is designed to streamline the quality check and handover process

With these new process changes, there is 89.7% reduction in lead time at planning phase, 96.2% reduction at execution phase, and almost 98% reduction at QA and handover process. Collectively, there is 92.2% reduction in overall lead time for GDBA database provision process (shown in table below). Using the lean system and techniques, GDBA department can meets its expected database delivery within 3 days. This provides a powerful base for the database demand management.

Table 3. Summary of benefits

Phase	Total lead time (Current State)	Total lead time (Future State)
Planning	20 days 130 minutes	2 days 95 minutes
Execution	8 days 505 minutes	445 minutes
QA & Handover	3 days 120 minutes	80 minutes
Total	31 days 755 minutes (31.5 days)	2 days 620 minutes (2.4 days)

This article presents a case study of IT process re-engineering initiative. The case study shows that Lean IT can be a useful approach for optimizing IT service provisioning and IT-enabled business processes by improving quality, eliminating waste, shortening lead times and reducing cost. In addition, the case study demonstrates that VSM is a useful lean IT tool to document current process flows in order to identify bottlenecks for improvement. We applied VSM for improving database provisioning process to reduce project delivery time. Based on the current flow analysis, we provided recommendations and presented future state map. Observations and findings from this study can be useful to practitioners for motivating their efforts to implement VSM and supporting the continuous improvement of IT processes.

For instance, one interesting observation during the interview process was that current state process map the build engineers constructed was quite different from the existing process architecture (determined by senior IT managers). While project demand and requirements constantly change, the build engineers were not allowed to modify/skip the existing processes. This, in fact, caused longer delivery time and required additional resources. The build team was always being in fire-fighting mode and under the pressure of meeting delivery deadline which also reduces the quality of project. This finding was presented to senior management, and we recommended that it does not have to follow the pre-defined process cycle, but needs to customize the process to achieve the faster delivery of project. This change would enable the build team to move away from the project-based delivery structure to more appropriate 'capability' based structure to collect the requirement and to deliver projects.

Our study has several limitations which creates scope for future research. In this paper, only one case study is considered in the single IT department. Further validation is therefore required across both multiple IT departments and also more broadly across different IT functions before we can fully support the lean approach in these contexts. This paper provides useful exploratory evidence on lean IT improvement initiative but further research is needed to support our findings. Furthermore, the interviews and documents have only involved staff who were actively involved in the process. No doubt there would be opposite views both from different IT staff and users. To extend this research and gain a broader view, interviews with a wider range of stakeholders can be conducted.

REFERENCES

Abuthakeer, S.S., P.V. Mohanram, and G.M. Kumar, 2010. Activity Based Costing Value Stream Mapping, *International Journal of Lean Thinking*. 1(2), pp. 51-64.

Ali, Nauman Bin, K. Petersen, and K. Schneider, 2016. FLOW-assisted value stream mapping in the early phases of large-scale software development. The Journal of Systems and Software, 111, pp. 213-227.

Attaran, M., 2004. Exploring the relationship between information technology and business process reengineering. *Information & Management*, 41(5), pp. 585-596.

Ballard, G., and G. Howell, 1994. Implementing lean construction: Stabilizing Work Flow, *Journal of Production and Inventory management*. pp. 37-48.

Bell, S., and M. Orzen, 2010. Lean IT, Enabling and Sustaining Your Lean Transformation. New York: Productivity Press.

Bonaccorsi, A., G. Carmignani, and F. Zammori, 2011. Service Value Stream

Management (SVSM): Developing Lean Thinking in the Service Industry. *Journal of Service Science and Management*, 4, pp. 428-439.

Buzby, C., A. Gerstenfield, L. Voss, and A. Zeng, 2002. Using lean principles to streamline the quotation process: a case study. *Industrial Management & Data Systems*, 102(9), pp. 513-520.

Chen, Joseph C., and R. Cox, 2012. Value Stream Management for Lean Office-A Case Study. *American Journal of Industrial and Business Management*, 2, pp. 17-29.

Ciarapica, Filippo Emanuele, M. Bevilacqua and G. Mazzuto, 2016. Performance analysis of new product development projects - An approach based on value stream mapping. International Journal of Productivity and Performance Management, 65(2), pp. 177-206.

Damelio, R., 1996. The Basics of Process Mapping. New York: Productivity Press.

Emiliani, M.L., and D.J. Stec, 2004. Using value-stream maps to improve leadership. *The Leadership & Organization Development Journal*, 25(8), pp. 622-645.

Grewal, C., 2008. An initiative to implement lean manufacturing using value stream mapping in a small company. *International Journal of Manufacturing Technology and Management*, 15(3), pp. 404-417.

Iden, J., 2012. Investigating process management in firms with quality systems: a multi-case study, *Business Process Management Journal*. 18(1), pp. 104-121.

Jasti, Naga Vamsi Krishna and A. Sharma, 2014. Lean manufacturing implementation using value stream mapping as a tool - A case study from auto components industry. International Journal of Lean Six Sigma, 5(1), pp. 89-116.

Kindler, N.B., V. Krishnakanthan, and R. Tinaikar, 2007. Applying Lean to Application Development and Maintenance. *The McKinsey Quarterly*, http://www.executivesondemand. net/managementsourcing/images/stories/artigos_pdf/produtividade/Applying_lean_to_application_development_and_maintenance.pdf.

Kuipera, Alex, R. Hoef, M. Wesseling, B. Lameijer, and R. Does, 2016. Quality quandaries: Improving a customer value stream at a financial service Provider. Quality Engineering, 28(1), pp. 155-163.

Machado, V.C., and U. Leitner, 2010. Lean tools and lean transformation process in health care. *International Journal of Management Science and Engineering Management*, 5(5), pp. 383-392.

McCutcheon, D. M., & Meredith, J. R., 1993. Conducting case study research in operations management. Journal of Operations Management, 11(3), 239-256.

Nepal, B. P., O.P. Yadav, and R. Solanki, 2011. Improving the NPD Process by Applying Lean Principles: A Case Study. *Engineering Management Journal*, 23(1), pp. 52-68.

Piercy, N., and N. Rich, 2009. Lean transformation in the pure service environment: the case of the call service centre. *International Journal of Operations & Production Management*, 29(1), pp. 54-76.

Rother, M., and J. Shook, 1998. Learning to See: Value Stream Mapping to Add Value and Eliminate Muda. Brookline: The Lean Enterprise Institute.

Serrano, I., C. Ochoa, and R.D. Castro, 2008. Evaluation of value stream mapping in manufacturing system redesign. *International Journal of Production Research*, 46(16), pp. 4409-4430.

Seth, D., and V. Gupta, 2005. Application of value stream mapping for lean operations and cycle time reduction: an Indian case study, *Production Planning and Control*. 16(1), pp. 44-59.

Snyder, K.D., P. Paulson, and P. McGrath, 2005. Improving processes in a small health-care network: A value-mapping case study, *Business Process Management Journal*. 11(1), pp. 87-99.

Tabanli, R. Murat and T. Ertay, 2013. Value stream mapping and benefit–cost analysis application for value visibility of a pilot project on RFID investment integrated to a manual production control system-a case study. *International Journal of Advanced Manufacturing Technology*, 66, pp. 987-1002.

Tapping, D., and T. Shuker, 2003. Value Stream Management for the Lean Office. New York: Productivity Press.

Tortorella, Guilherme Luz, F. Fogliatto, M. Anzanello, G. Marodin, M. Garcia and R. Esteves, 2016. Making the value flow: application of value stream mapping in a Brazilian public healthcare organization. Total Quality Management & Business Excellence, pp. 1-15.

Tyagi, Satish, A. Choudhary, X. Cai, and K.Yang, 2015. Value stream mapping to reduce the lead-time of a product development process. *International Journal of Production Economics*, 160, pp. 202-212.

Wang, F.K., and K. Chen, 2010. Applying Lean Six Sigma and TRIZ methodology in banking services. *Total Quality Management*, 21(3), pp. 301-315.

Ward, P., and H. Zhou, 2006. Impact of Information Technology Integration and Lean/Just-In-Time Practices on Lead-Time Performance. *Decision Sciences*, 37(2), pp. 177-203.

Yin, R. K. 2002. Case Study Research, Design and Methods. 3rd ed. Newbury Park, CA, Sage Publications.