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Process Improvement for Error Records in a Financial Institution with the Analysis of Simulation on Using Value Stream Mapping

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Research Article

Abstract − Value stream mapping is an important tool used in process improvement in many industries. In this study, the error records opened by the end-users to the developers who developed the screens over the software development process in the Information Technologies (IT) group of a financial institution operating in the field of participation banking were examined. This paper has been addressed in order to reduce the operational risks that may arise during the resolution of the error records encountered during the use of the software. In financial institutions, customer satisfaction is closely related to the continuity of operational processes in financial transactions. First, the authors draw the current value stream map base on the approval and solution process adventure of these error records were handled in the processing logic, analyzed and a value stream map was drawn for the current situation. Then, based on the information obtained from the current situation, approval flow of the error records is simulated with the Arena simulation program. The obtained simulation results were discussed with the stakeholders of the error resolution process. Bottleneck activities have been identified through the current situation simulation outputs. A new value stream map has been prepared, based on the seven wasteful milestones defined in the lean production philosophy. Finally, the working style of the new situation developed was adapted to the process, remodeled on the Arena software and the new model was analyzed. The simulation results showed that the error/help call records decreased by 79.8% in the in-process return volume.

Keywords − *Arena simulation model, cycle time, error records, financial institution, value stream mapping*

1. Introduction

In the competitive environment, a company should determine the activities that do not add value and eliminate wastes to reduce production costs. The basic principle of Lean Manufacturing (LM) is the elimination of the wastes that do not add value in the production process (Womack & Jones, 1990). The fundamentals of LM are based on applications made by Taichi Ohno in Japan within the Toyota production system. In the Toyota production system, all activities are evaluated according to whether they add value to the product or service. Activities that do not add value are considered as wastage. To the application of the just-in-time production in the companies, the waste should be eliminated or minimized. Value Stream Mapping (VSM) is an LM technique that is widely used to eliminate waste. In the VSM technique, all activities in the product or service production processes are examined in detail. Each activity is evaluated from the customer perspective. Any process step that customers do not want to pay value is considered as a waste. At first, the process steps which do not add value are eliminated or minimized. VSM is an effective method used to eliminate wastes and improve processes in many areas such as the construction industry, transportation, product development, mining, health sector, public services nowadays.

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The recent studies on VSM are summarized as follows. Efe and Engin (2012) presented a map of the current state of the VSM technique at the emergency department of a training and research hospital. They analyzed the current situation, in line with the principles of LM and created a future map of the situation, and identified the improvements that can be made in the emergency service process. Andreadis, Garza-Reyes, and Kumar (2017) made a survey with 138 production companies worldwide to analyze the effectiveness of VSM. The authors examined with the five hypotheses and three complementary research questions that organizations using LM use VSM as a basic tool for eliminating wastage, the role of VSM in LM, the simplicity and challenges of VSM, and they tried to determine the critical success factors and obstacles for the implementation of VSM. Jia et al. (2017) proposed a new method of embedded-VSM in the optimization of cutting parameters to increase energy efficiency in machining. They showed that the consumed energy and the time efficiency increased. De Souza Pinto, Schuwarten, de Oliveira Júnior, and Novaski (2017) proposed the application of Define, Measure, Analyze, Improve and Control (DMAIC) tools, contained in the context of the six sigma, and VSM under the lean philosophy perspective to identify the focus of waste. Gören (2017) presented an industrial case example combining VSM and simulation in the furniture industry. The author described current and future state maps. Also developed a simulation model to show the before and after scenarios in detail. Heravi and Firoozi (2017) presented VSM in the production phase of prefabricated steel frames in a case study. Their study includes construction of three 16-story residential buildings made of prefabricated steel frames with bolt and nut connections in Iran. Zeeshan, Rana Muhammad, and Sahawneh (2017) investigated the integration of discrete-event simulation and VSM to enhance the productivity of road surfacing operations by achieving high production rates and minimum road closure times. Stadnicka and Ratnayake (2017) investigated the potential of lean concept implementation in a service-providing organization. The authors presented a case study based on value stream mapping in the telecommunication industry. Romero and Arce (2017) analyzed literature, published in refereed journals application of the VSM in the context of the manufacturing sector. Ellingsen (2017) discussed the study of a multinational organization's commercialization process of two large and complex projects and their research and technology/development and new product introduction processes. The author conducted a two-day VSM workshop for each of the projects. Behnam, Ayough, and Mirghaderi (2018) proposed a VSM approach and analytical network process to identify and prioritize the production system's Mudas. The authors presented a case study in the natural fiber clothing manufacturing company. Purba and Aisyah (2018) used VSM and storage design to increase productivity in the process of picking orders through a reduction of processing time. The authors presented a case study in the automotive part center. Kumar, Dhingra, and Singh (2018) presented an implementation of the Lean-Kaizen concept in a small and medium-scale enterprise in a non-capital region in India. The authors prepared the current state map, calculated the takt time, and identified bottlenecks. Finally, they developed a future state map. Deshkar, Kamle, Giri, and Korde (2018) developed an LM framework using VSM for a plastic bags manufacturing unit. Andreas, Aglaya, and Herwig (2018) presented an empirical survey with 170 participants from different branches was conducted. They searched the lean management, VSM, Industry 4.0, and the integration of both approaches with the web-based questionnaire. Ali-Asghar and Changiz (2018) investigated the effect of VSM on operational losses and analyzes the process. They presented a case study in an Iranian gas-ball-valve producing company. Also in another study, Dadashnejad and Valmohammadi (2019) searched the effect of improvements identified through VSM on the overall equipment effectiveness metric. They designed a structured questionnaire and employed it. Trebuna, Pekarcikova, and Edl (2019) proposed a method for optimizing material and information flows in a production company. They presented a case study focused on digital VSM in the environment of the simulation software TX Plant Simulation. Knoll, Reinhart, and Prüglmeier (2019) developed a methodology to apply process mining to internal logistics for a mixed-model assembly line. Their proposed methodology combines multidimensional process mining with proven principles of lean production and VSM. They presented a case study at a German automotive manufacturer. Guo, Jiang, Xu, and Peng (2019) developed a model for concurrent Lean-Kaizen based on Lean production thinking. The authors integrated VSM-DMAIC by adopting their advantages and avoiding their disadvantages. They applied this model on a production line. Stadnicka and Litwin (2019) integrated VSM and system dynamics for manufacturing line modeling. They presented a case study in the automotive industry. Carvalho, Carvalho, and Silva (2019) combined VSM with Kanban for the cost reduction in the finished goods inventory. They presented a case study at a textile company.

This study was carried out on the observation that the resolution times of error records opened by end-users in an information technology group in a financial institution. The main purpose of addressing this issue in

this study is the need to manage operational risks such as workload loss that may occur as a result of the disruption of operational processes during the software usage period. In financial institutions, it is very important to ensure that operational processes are not disrupted and to provide continuous service in financial transactions. Issues such as the interruption of financial transactions can reach levels that damage the reputation of institutions by making the agenda for end users who frequently use social media, especially during the pandemic period. So, it was decided to analyze the solution process over the VSM model to minimize the labor loss experienced by the end-users due to the long resolution times of the error records. Because it is thought that the resolution times of the error records are relatively long. First, the current situation was captured with VSM. Then, a simulation model was established in Arena software over the existing VSM model. Waste and bottleneck activities were determined through the simulation outputs. The aspect that expresses the originality of this study is that software error records made in a financial institution are determined on TO-BE based on VSM and AS-IS modeling, and time analyzes of the developments are made with simulation results.

This paper is organized as follows: Chapter 2 explains the materials and methods. Chapter 3, shows the analysis results of error records in the financial institution along with the current and new VSM and simulation analysis. Conclusion part presents the key results and discussions obtained from the study.

2. Materials and Methods

2.1. Value Stream Mapping

VSM is a lean production technique used to increase the effectiveness of organizations. VSM is a tool used to define the all flow from raw material and information to the finished product or service. According to Rother and Shook (2003), VSM refers to all the activities that are required, which add value and do not add value, as the design of all information and material flows from raw material to customer, product, or service. VSM provides a map of current material and information flow. Current VSM includes wastes and bottlenecks in the process. For the current VSM, analysis is done with the simulation model. Then, in the process, the future VSM is drawn by eliminating the wastes and bottlenecks. The future VSM is analyzed by the simulation model. The simulation results are compared with previously available results to evaluate cycle, delivery, and TAKT times, and inventory improvements. VSM is a graphical tool of lean manufacturing. VSM does not contain detailed information about the product or service. VSM provides information about the cycle, delivery, and TAKT times.

The stages of VSM are summarized below. (Deshkar et al., 2018; Rother & Shook, 2003).

1. *Selecting a product or service group:* To draw the VSM of all processes is not suitable for determining wastes and bottlenecks in the process. A specific product or service group should be selected for VSM. This product or service group is performed by the same machine family or with the same process steps.

2. *Drawing a value stream map for the current situation:* After determining the appropriate product or service group, an existing value stream map should be drawn for this product or service group. The current value stream map can be drawn using A3 paper. The following information should be collected before removing the current value stream map. These are given below.
   - Cycle time,
   - Operation time,
   - Inventory level,
   - Customer needs,
   - Delivery schedule,
   - Operation sequence,
   - Number of employees required for each operation,
   - Working hours,
   - Several shifts and breaks.

3. *Analyzing the value stream map for the current situation:* It should be analyzed according to the current value stream map, wastes, bottleneck processes, and process steps that are blocked. These analyzes

should be carried out according to seven types of waste accepted in lean production. These seven types of wastes are given below.

- Overproduction,
- Motion,
- Transport,
- Inventory,
- Waiting,
- Over Processing,
- Defects.

4. *Elimination of waste and future state value stream map:* At first, the wastes detected in the current value stream map should be eliminated or minimized. The flow should be made continuous and any waiting should be eliminated. The pulling system should be preferred instead of the pushing system. After the waste is eliminated, a future state value stream map is drawn.
5. *Simulation of the future state value stream map:* Future state value stream maps should be analyzed according to simulation software. The simulation model is performed for different repetitions of the future value stream map. The most suitable scenarios for the application are selected.
6. *Application:* According to the simulation model, the future situation is tested for different scenarios, and the results obtained by applying the value stream map are observed.

In this study, objects in the "Value Stream Map Shapes" object palette, which were added as ready templates in Visio Professional 2019 software for VSM, were used. Below are the descriptions of the relevant objects in items.

-  Customer/Supplier: This object is used when representing suppliers and/or customers.
-  Process: This object is used to represent an activity with a meaningful duration.
-  Electronic Information: This object is used when representing the electronic information flow.
-  Inventory: This object is used to represent the waiting area (if any) prior to the process.
- Timeline Segment: It is the object used to separate the waiting and processing times in the activities carried out in the process.

2.2. Introduction of Financial Institution

The financial institution, from which error records are obtained, operates according to the principles of participation banking and has branches in many provinces and districts. The VSM was created by examining the error records process that was somehow assigned to an organization of the IT group in that institution. The activities carried out in this group can be summarized as in-house software needs, requirements analysis, code development, and testing activities. In this study, the flow of error records opened by end-users was analyzed by the VSM method. Inspected error records are actual records approved by the administrator of the user who started the error confirmation flow. In addition, they are the error records assigned to the people in charge of IT organizations, for which time was spent to resolve.

2.3. Process Flow

Error records opened by end-users were analyzed in detail in terms of time and number. The defined process starts with the evaluation of the administrator of the user who opened the request. If the administrator approves the error record then it is assigned to the call center manager. The call center manager can resolve the error record himself or forward the error to different people in different organizations. If the Call Center manager thinks that the call is related to IT, he or she can direct the error to the IT person. The first candidate

for this routing action is the analyst position responsible for the screen where the error occurred. The analyst can reassign the error record to the call center administrator, review, resolve the record, or forward it to another user. Analysts can refer the software engineer to resolve the error log. Or, as a last resort, it can be assigned to the person who expresses different end-user roles and is responsible for the screen where the error occurs. This circular content referral sequence is carried out similarly in the software engineer review step and the responsible business unit review step.

2.4. Object Descriptions Used in Arena 14 Model

The main objects in the basic models in the arena simulation program are used in this study. Brief descriptions of the objects are given below. These explanations were obtained from the user quid and explanation pop-up screens included in the software.

- Create: This object assigns the type by generating the incoming mobile units for simulation according to certain distributions.
- Assign: An additional feature is the object used when assigning a variable to incoming mobile units.
- Process: t is the object where the duration information about the resources' execution of the relevant job can be entered through the Seize, delay, and release properties.
- Decide: It is the object definition in which the incoming mobile units can be directed by using 2-way, multi-directional or formula in the flow.
- Record: It is the object where temporal data or entity statistics are recorded on the basis of previously assigned properties or variables related to incoming mobile units.
- Dispose: It is the object that releases the incoming mobile units from the model and keeps the entity statistics in general.

2.5. Data Analyze Details for Current Situation

Error records are divided into different categories from the moment they are created and saved in the system. There are 846 different category breakdowns registered in total. For 846 different categories to have a multi-part structure in terms of numbers and for the analysis to be meaningful, 42 of the categories representing 80% of the error numbers in the categories were chosen as examples. 80% of a total of 8177 error records belonging to the first 6 months of 2018 were examined. The analysis focused especially on identifying the cycles in the process and the approval steps with a low rejection rate. The information about the decision points regarding the flow process and the directions in the flow are summarized as percentages in the From-To logic. While obtaining the following values, the percentage values of the directions in the from-to logic of each role were obtained from the meta data over their numbers. Assignments from each role to the other role and resolution in the last step were analyzed and calculated one by one.

1. End users who have problems with the system or think they are having problems, open the error log for the solution of the problem. After the error record is opened, the approval flow is approved or rejected by the administrator of the person who opened the error record. Information on the waiting, processing times, and rejection rate for this step are given below.
   - The refusal rate for manager approval: 0.3%.
   - The average standby time: 4.16 hours.
   - Approximate processing time: 3 minutes.

2. After the first step is approved, the error records are assigned to the target states based on the percentages shown below;
   - Percentage of error records forwarded to Call Center Supervisor Review: 77%
   - Percentage of error records forwarded to analyst review: 14%
   - Percentage of error records that are forwarded to a software developer review: 9%.

3. Error records assigned to the Call Center will hereinafter be referred to as "CC Review". The values of the time and referral percentages of the CC Review step are below.
   - The average standby time: 1.13 hours.

- Each error record is subject to a 10 minute review period. This stage is marked as non-value-added time.
- All error records to CC Review status are reviewed or forwarded with the following percentages and values;
  - Percentage of directly terminated error records: 28%
    - 30-minute examination and resolution time are spent for error records that are terminated directly. This period is defined as value-added time.
  - Percentage of error records forwarded to Analyst Review: 37%
  - Percentage of error records that are forwarded to a Software Developer Review: 15%
  - Percentage of error records forwarded to the Business Unit Review: 20%.

4. The error records assigned to the analysts are named as "Analyst Review" step. Time and flow forwarding information analyzed for this step are given below.
   - The average standby time: 1.03 hours.
   - Each error record is subject to a 10 minute review period. This stage is marked as non-value-added time.
   - All error records assigned to the Analyst Review status are processed at the following percentages and values.
     - Percentage of directly terminated error records: 14%
       - In this step, for the error records that are solved directly, 40 minutes of value-added activity is endured.
     - Percentage of error records that are forwarded to a Software Developer Review: 9%
     - Percentage of error records forwarded to the Business Unit Review: 3%
     - Percentage of error records forwarded to the CC Review: 74%.

5. The error records assigned to software developer roles are in "Software Developer Review" status. The time and routing details of this step are given below.
   - The average standby time: 1.78 hours.
   - Each error record is subject to a 10 minute review period. This stage is marked as non-value-added time.
   - In the Software Developer Review stage, all error records to the status are examined or forwarded on the following percentages and values.
     - Percentage of directly terminated error records: 9%
       - 75 minutes of value-added time is performed for direct-ended error records.
     - Percentage of error records that are forwarded to an Analyst Review: 24%
     - Percentage of error records forwarded to the Business Unit Review: 5%
     - Percentage of error records forwarded to the CC Review: 62%.

6. Error records arriving at the Business Unit stage are assigned as "Business Unit Review". Information about this step is given below.
   - The average Standby Time is about: 0.24 hours.
   - Each error record is subject to a 10 minute review period. This stage represents non-value-added time.
   - In Business Unit Review phase, all error records to the status are reviewed or forwarded on the following percentages and values.
     - Percentage of directly terminated error records: 3%
       - 20 minutes of value-added time is performed for direct-ended error records.
     - Percentage of error records that are forwarded to an Analyst Review: 10%
     - Percentage of error records that are forwarded to a Software Developer Review: 5%
     - Percentage of error records forwarded to the CC Review: 82%.

7. The grouped values of the error records of the average time spent in the system are given in Table 1. After all the inspection and processing time endured for the resolution of the error logs, sometimes high processing time is spent to eliminate the error, and deployment can be made to the main environment used by the end-users.

Table 1

Approximate average time spent in the system

Percentage %	Approximate Average Time (Hours)
05	36
20	24
20	3
30	2
25	1

Considering the redirection rates in terms of the return of the error records flow, high rate in the CC Review status draws attention at the whole process. VSM created by analyzing the current flow of error records is presented in Figure 1. Arena - V.14 software was used for simulation according to the current VSM diagram and detailed results were obtained.

3. Results and Discussion

3.1. Arena Simulation Model for the Current Situation

The simulation model derived from Figure 1 was run with Arena - V.14 software based on the process times and routing percentages extracted from the current error records flow. The flow of the existing error records was repeated 12 times in 30 days, thus reaching the data presenting the 1-year average information.

Arena - V.14, software, for the current situation, Windows 7 Home Basic operating system, Intel Core i5-3210M CPU 2.50Ghz - 6 GB RAM - 64-bit features were run on the computer. The simulation was completed in 65.6 seconds.

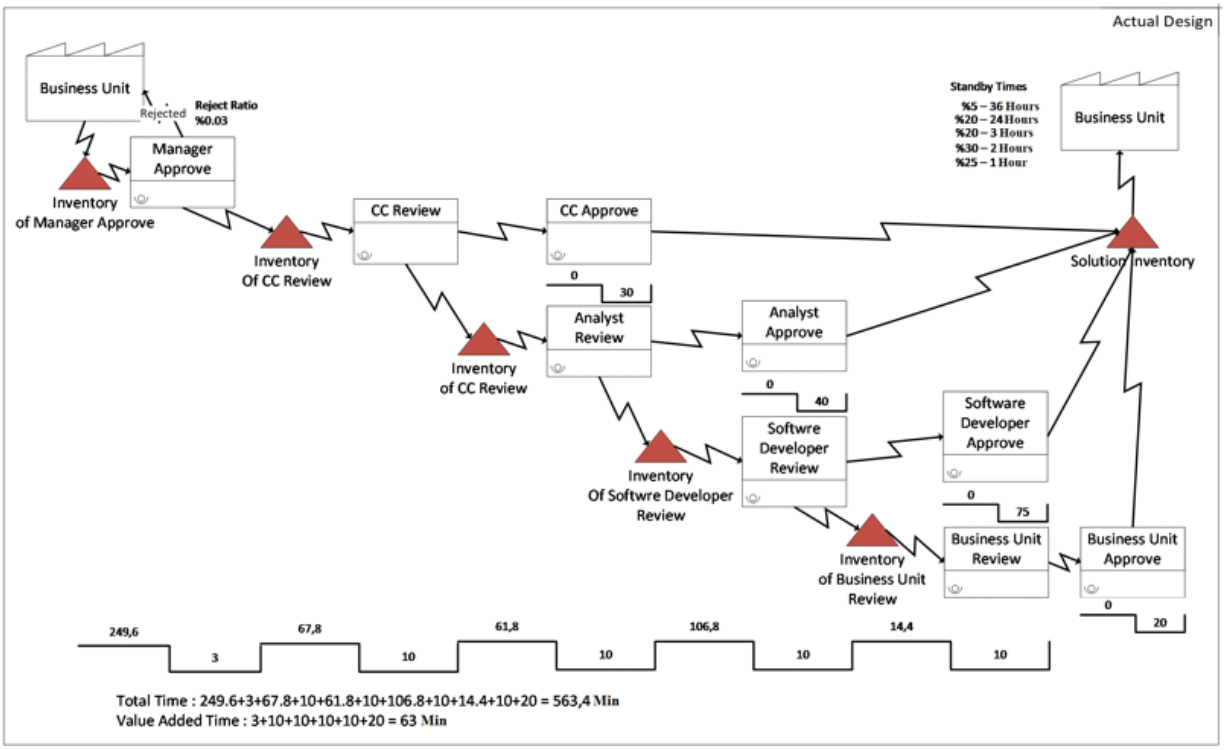

Figure 1. Current situation VSM model

In Figure 1 is to be explained, the flow begins with the step of converting the errors encountered by the business units during the use of the software screens into error records. Subsequently, this flow error record can be approved or rejected by the administrator of the user who first created records in the system. Error records are reviewed for the first time by employees in the CC role. As a result of the review, the assignments to the relevant roles (especially the analyst role) are made by the personnel in the CC role. Analysts can resolve error records as a result of their reviews or assign them to software developers. Software developers, on the other hand, can forward the records they examine to the business unit or close the error records directly. Records assigned to business units can also be forwarded directly to closing. This modeled design is illustrated independently of the so-called happy path. Reviews for each role have a dependent flow, looping through each other. In short, each role can forward the error records to the previous or next role.

By running the Arena simulation model designed by the process represented in Figure 1, 1081 average error records were generated monthly. According to the simulation of the current situation, the total number of closed error records at the end of the month is calculated as 853. These calculations mean that the input and output values are compatible with the current system monthly. This information is summarized in Table 2.

Table 2

Error numbers obtained from the current situation's simulation results

Unit type	Average	Minimum average	Maximum average
Opened error / assistance calls	1081	1081	1081
Closed error / assistance calls	853	834	874

3.1.1. Cycle Time

Cycle time is monitored as a key performance indicator in the relevant IT organizations and is paid attention to by all IT employees. A summary of the averages for the cycle time is given in Table 3.

Table 3

Cycle time results of current situation simulation

Cycle time results of error records	Average cycle time(Hrs)
Value-added activities	0.5751
Non-value added activities	0.8170
Standby time	78.5198
Total time	79.9119

When Table 3 is examined, it is seen that the share of average standby time in the total cycle is very high. As mentioned in the previous section, this high cycle time is thought to be due to the high rate of waiting and looping the error records in the CC Review step.

3.1.2. Queue Analysis

The queue data of the simulation results of the current system show the weakest steps among the confirmation steps over the time and number of error records. In Table 4, this information is given on average values. Table 4 clearly shows that the steps with the largest number of queues in terms of waiting times in the system are the CC Review and CC Approval steps. Among the other flow steps, these two steps stand out due to their high values.

Table 4

Standby time and average number results derived from simulation results

Steps	Average time (Hrs)	Average number
Analyst review	0.1231	0.2102
Analyst approval	0.1203	0.0285
CC review	22.361	79.203
CC approval	22.453	20.790
Business unit review	0.0049	0.0038
Business unit approval	0.0169	0.0004
Software developer review	0.0851	0.0690
Software developer approval	0.0478	0.0036
Manager approval	0.0000	0.0000

As a result of the case study of the current situation with the stakeholders, it was agreed that the main reason for these high values may be that the employees in this role do not have the opportunity to examine the error records promptly and accurately due to their workload intensity.

3.1.3. Resource Analysis

Based on the information we obtained in the previous titles, the most waits were experienced in the CC Review and CC Approval steps. Similarly, the fact that the steps with the highest redirect rates in the flow are CC Review steps indicates which approval flow steps are to be considered in resource analysis.

Summary information on resource usage of the roles involved in the current approval flow is given in Table 5. The numbers based on the resource utilization rate and the error records assigned to the resources are summarized in Table 5 over the averages taken from 12 30-day simulation repetitions.

Table 5

Current situation Resource Utilization Rate (RUR) and Numerical Distribution (ND) of error records Arena simulation results

Roles	Average RUR	Average ND
Analyst	0.4394	1393.25
CC responsible	0.9864	3013.50
Business unit	0.1358	569.33
Software developer	0.2263	635.67
Manager	0.0745	1074.00

Table 5 contains very striking findings. Based on this information, it is seen that employees in the role of analysts spend about 44% of their working time solving the error or examining whether the error is a real error, although their main task is not solving or examining the error records.

Analysts often tend to fix the error records themselves before passing them on to the software developer role, so as not to disrupt business development activities. For this reason, the solution time of the software developer in the total effort of possible errors is around 22%.

On the other hand, it is seen that the CC Responsible role, which is seen as the source of the problem in the above titles, devotes time to the calls at the highest rate. The main task of the CC Responsible role is to deal with the error records.

3.2. In-Process Assignment

While the current error record flow is simulated, due to the high rate of redirects obtained from real data, the redirects are specially processed and a simulation model has been created that can be analyzed numerically.

Through the design of the simulation model, which represents the current situation, it was determined how many records in the flow were assigned in normal or redirect type. This information is included in Table 6, based on roles. The expression CC in the table represents the role CC Responsible.

Table 6

Current situation flow type and number results

From- To Types	Number	Flow Type
From analyst to CC	910.92	Redirect
From analyst to the end	168.33	Normal
From analyst to business unit	36.33	Redirect
From analyst to software developer	109.00	Normal
From CC to analyst	877.00	Normal
From CC to the end	623.67	Normal
From CC to business unit	489.00	Redirect
From CC to software developer	355.58	Redirect
From business unit to analyst	56.25	Redirect
From business unit to the end	17.50	Normal
From business unit to CC	450.08	Redirect
From business unit to software developer	28.00	Redirect
From software developer to analyst	142.92	Redirect
From software developer to CC	360.58	Redirect
From software developer to the end	52.66	Normal
From software developer to business unit	26.58	Redirect

As expressed in the analysis of the real data, when the numbers in the role and flow type based assignments, which are of the type of redirect in Table 6 are examined carefully, it is seen that there is too much return to the CC Responsible.

3.3. Elimination of Waste and Future Situation Value Stream Map

The simulation data of the error records of the current situation clearly show some points of suggestions with a meaningful improvement. The effects of the desired system by eliminating some of the approval steps and reducing the redirections that can be avoided in the process are explained in the 3.4 section. This topic contains summary descriptions of improvement points.

The fact that the manager approval step in Figure 1 is rejected at a rate of 0.3% after examining the actual data in the current system brings with it the assumption that the time lost in this step is higher than the control efficiency. Therefore, the first suggestion of improvement would be to remove the manager approval step from the error record flow.

The second improvement suggestion is to mark the error records that are resolved in the removed manager approval step to the CC Review step and transfer them directly to the CC Responsible role. Infrastructural

requirements are provided for this improvement. The percentage of direct redirection of error records to the CC Responsible role for the improved model is found as follows.

- "Percentage of Direct Assignment to CC Review via Manager Approval" * "Percentage of CC Review First Time Solution"
  - o 21.5% = (77% * 28%),
- In this way, from the CC Review step, the required routing time to other flow steps and the CC Responsible role's error record review time will be decreased. Also, the redirection counts will be significantly reduced by not making unnecessary redirects.

As a third step, 78.5% (100% - 21.5%) of the error records that are assigned to the CC responsible role but should not be assigned after the error records are opened can be directly assigned to the analyst role. As the analyst role has clearer information about the solution addresses of the error records coming from their area of responsibility, it can make a more effective decision about forwarding the error records to the relevant person. Implementation of three improvement steps to the VSM diagram is presented in Figure 2.

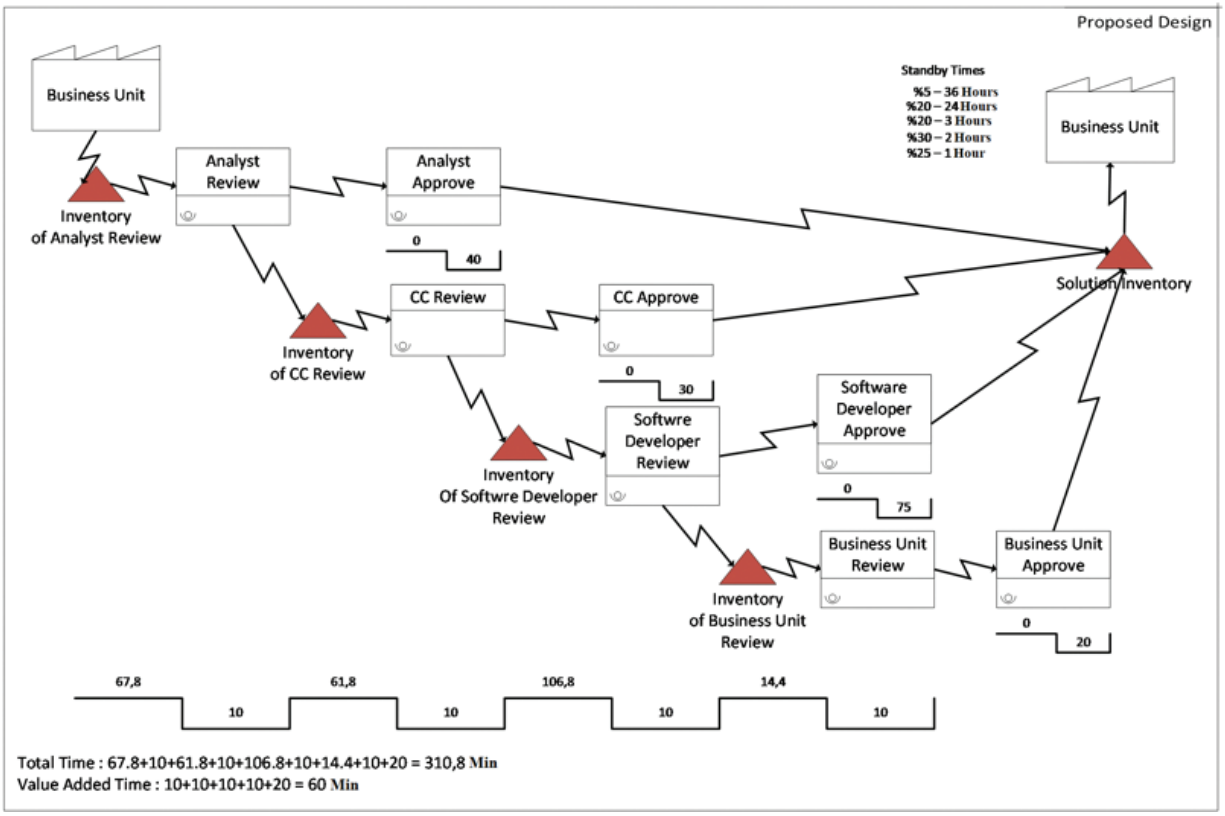

Figure 2. The proposed design of the VSM diagram

The proposed design, unlike the current situation, does not include the manager approval step. Thus, the non-value-added time value decreased from 563.4 minutes to 310.8 minutes. Value-added time has been reduced from 63 minutes to 60 minutes. However, the invisible part of this model, which is the main reason for the redirections in the process, is the effects of the prediction of being able to assign the right role the first time. It has been simulated how the process will be affected when the records are forwarded to the analyst instead of the CC role, except for the percentage of error records that the person in the CC role solves directly. These results are detailed under the following headings.

3.4. Simulation Model of Proposed Design

Under this title, the integration of three suggested improvement steps into the simulation model is briefly explained. As the first step of the proposed design, the approval of the manager was removed from the

simulation model and a 21.5% error record count was assigned to the CC Review step to meet the second recommendation.

Also, 72% of the distribution node of the number of error records transferred from CC Review to other steps was reset after the "CC Review" step, which is the highest redirection source. Because the main assumption is that the person in the CC responsible role solves the error records that are solely his responsibility and the other error records are distributed to other flow steps through the Analyst role (third improvement proposal).

Arena - V.14, software for the recommended situation, Windows 7 Home Basic operating system, Intel Core i5-3210M CPU 2.50Ghz - 6 GB RAM - 64-bit features were run on the computer. The simulation result was completed in 22.61 seconds. The simulation results of the proposed situation are given in Table 7.

Table 7

Simulation results of the proposed design

Unit type	Average	Minimum average	Maximum average
Opened error records	1081.00	1081.00	1081.00
Closed error records	1063.00	1058.00	1067.00

The average number of opened error records per month is 1081. The simulation model starting rules have not been changed and the monthly average number of error records kept constant to 1081 as the current situation simulation results. The total number of error records closed in the simulation results of the proposed design model was calculated as an average of 1063 at the end of each month. When the current situation simulation results (Table 2) are compared with the simulation results of the proposed design, it is seen that an improvement rate of 24.6% was achieved in terms of closing the number of error records within a month.

3.4.1. Cycle Time

The cycle time results of the proposed design are presented in Table 8. The active use of total cycle time in IT organizations as a key performance indicator further increases the importance of improvement rate in this criterion.

Table 8

The cycle time results of the proposed design simulation

Cycle time results	Average (Proposed)	Average (Current)	Improvement ratio (%)
Value added activity	0.5223	0.5751	9.2
Non value added activity	0.2978	0.8170	63.5
Standby time	10.53	78.5198	86.6
Total time	11.35	79.9119	85.8

The output of the proposed model in terms of cycle time is surprising but not unpredictable. The proposed model eliminates unnecessary redirections and ensures that directly redirected the error records to the correct role at the right time.

3.4.2. Queue Analysis

The queue analysis results regarding the new situation are presented in Table 9. Also in this table, the values for the waiting times based on the flow step are compared with the current simulation values.

Table 9

Proposed design simulation results based queue analyze

Queue standby time results	Average (Proposed)	Average (Current)	Improvement ratio (%)
Analyst review	0.0228	0.1231	81.5
Analyst approval	0.0018	0.1203	98.5
CC review	0.3141	22.361	99.9
CC approval	0.2709	22.453	99.9
Business unit review	0.0000	0.0049	100.0
Business unit approval	0.0000	0.0169	100.0
Software developer review	0.0049	0.0851	94.2
Software developer approval	0.0000	0.0478	100.0

Table 9 shows that CC Review and CC Approval steps as the highest step in terms of the maximum queue waiting time in the system. In the other steps of the stream, there is no noteworthy queuing time.

When we compare the current situation with the proposed design, it is seen that the waiting time in the CC Review step is significantly reduced at a rate of 99.9% and that means a significant improvement in the waiting times in the whole process. It can be stated that the main reason for the total cycle time improvement ratio in Table 8 is the improvement rate calculated in the waiting times in the CC Review and CC Approval steps.

3.4.3. Resource Analysis

The reflection of the proposed VSM model in terms of simulation results in terms of resource utilization rates and the number of error records that the resources are interested in has also been remarkable. These results are summarized in Table 10 and Table 11.

Table 10

Proposed design resource utilization rate (RUR) simulation results

Roles	Average RUR (Proposed)	Average RUR (Current)	Improvement ratio (%)
Analyst	0.3079	0.4394	29.9
CC responsible	0.8812	0.9864	10.7
Business unit	0.0076	0.1358	94.4
Software developer	0.0293	0.2263	87.1

Table 11

Proposed design numerical distribution (ND) simulation results

Roles	Average ND (Proposed)	Average ND (Current)	Improvement ratio(%)
Analyst	979.33	1393.25	29.7
CC responsible	1904.67	3013.50	36.8
Business unit	31.83	569.33	94.4
Software developer	86.00	635.67	86.5

In resource utilization, the resource usage percentages obtained from the simulation results of the proposed design were quite effective compared with the current situation. As can be seen in Table 10 and Table 11, assigning the error records directly to the responsible role will provide the solution of errors, resulting from the reduction of the queue of the CC Review step.

When Table 10 and Table 11 are examined by role, those in analyst roles are 29.9% less interested in error records. This means analysts now could spend their working time more on their main tasks. The CC Responsible role continues to be concerned with error records closely because this role's core mission is this. Also, end-user satisfaction will be increased, cause of reducing the number of unnecessary assignments at a rate of 94.4%. Similarly, the software developer role's dealing with error records has decreased by 87.1% based on RUR. Software developers will be able to devote more time to code development, which is their main job, by reviewing only the records that need to be assigned to them with the correct guidance of the analyst role. In short, the improvements of the proposed design model in terms of role-based number and effort usage are consistent.

3.4.4. In-Process Assignment

Another remarkable output of the Arena simulation model is that it provides the relationship between the number of error records that need to flow in the normal flow during the process and the number of returning flows in the process.

The Arena process assignments of the proposed VSM are presented in Table 12.

Table 12

Proposed design assignments and flow type

Status	Number (Proposed)	Number (Current)	Improvement ratio (%)	Flow type
From analyst to CC	639.42	910.92	29.8	Redirect
From analyst to the end	116.92	168.33	30.5	Normal
From analyst to business unit	27.41	36.33	24.6	Redirect
From analyst to software developer	78.33	109.00	28.1	Normal
From CC to analyst	0.00	877.00	100.0	Normal
From CC to the end	951.33	623.67	-52.5	Normal
From CC to business unit	0.00	489.00	100.0	Redirect
From CC to software developer	0.00	355.58	100.0	Redirect
From business unit to analyst	3.08	56.25	94.5	Redirect
From business unit to the end	1.00	17,50	94.3	Normal
From business unit to CC	25.16	450.08	94.4	Redirect
From business unit to software developer	1.58	28.00	94.4	Redirect
From software developer to analyst	17.33	142,92	87.9	Redirect
From software developer to CC	52.50	360,58	85.4	Redirect
From software developer to the end	6.25	52.66	88.1	Normal
From software developer to business unit	3.50	26.58	86.8	Redirect

In the process of examining and resolving the error records, it was determined that the errors were assigned to the wrong roles as the main problem, and the rate of redirection was high in the assignment to the main responsible role. The proposed three steps to solve this problem are included in the VSM model and then the new model is simulated. The returns and improvement rates of the simulation results based on the numbers of the proposed design model based on redirections are summarized in Table 12.

When the simulation results are analyzed based on redirections according to the flow type parameter and averaged on the role, the error records redirection volume decreased by 79.8%.

The number of error records resolved on average by the CC Responsible role, whose main task is to resolve error records, increased by 52.5% on average. Despite this increase, the personnel in the CC Responsible role, freed from the burden of reviewing the error records and dealing with unnecessary assignments, also found the opportunity to work more efficiently by focusing on their main duties.

In addition, when Table 12 is analyzed through numbers, it reveals the high number of unnecessary assignments to the role of CC Review by personnel in other roles due to the lack of some infrastructure developments. The results of the proposed design model provide information about the new process that can be achieved by getting rid of the meaningless workload in the queue and the improvement in the number and percentage of redirection to the CC Review step. Thus, unnecessary waiting times and time spent on non-value-added reviews are eliminated.

4. Conclusion

Value stream mapping (VSM) is a lean manufacturing technique used in recording activities in the production of products and services, identifying-eliminating bottlenecks, creating and implementing an action plan. In this study, the comparison of the current VSM model with the proposed VSM model was made by analyzing the simulation results. , This is the first study in participation banking based on error record analysis. The main advantages of the proposed flow structure can be summarized as follows; the average number of closed error records during the month increased by 24.6%. In addition, the cycle time of error records in the system has been reduced by 85.8%, above the average values. In the role-based resource analysis, more effective effort percentages were reached for each role. Thus, an indirect productivity increase has been achieved by focusing on the main task areas of roles whose main task is not to solve errors. Finally, it is assumed that internal customer satisfaction will increase as the number of error records incorrectly assigned to internal customers is reduced. Considering the results from a different point of view, possible improvement steps can be carried out on the simulation model, and the effects of changes in business processes on the current process can be analyzed more harmlessly. In addition, by evaluating the activities related to commercial loans in financial institutions with value stream mapping and simulation techniques in future studies, possible bottlenecks can be eliminated and a significant reduction in costs due to non-value-added activities can be achieved.

Author's Contributions

İbrahim Yel: Methodology, Data curation, Writing-original draft, Visualization, Investigation

Orhan Engin: Supervision, Methodology, Validation, Writing-original draft, Investigation, Conceptualization.

Conflicts of Interest

The authors declare no conflict of interest.

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