View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by Elsevier - Publisher Connector

Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 91 (2016) 734 – 743

Procedia Computer Science

Information Technology and Quantitative Management (ITQM 2016)

A Study of Process Mining-based Business Process Innovation

Sungbum Park[a], Young Sik Kang[b]*

[a]20, Hoeo-ro 79 beon-gil, Baebang-eup, Asan-si, Chungcheongnam-do, Republic of Korea 31499
[b]*34 Geobukgol-ro, Seodaemun-gu, Seoul, 120-728, Republic of Korea*

Abstract

Businesses have adopted diverse process management approaches such as business process re-engineering (BPR) and Six Sigma for their survival and growth. Even though these approaches have partially made a contribution to the improvement of organizational performances such as cost reduction and value innovation, they have a high possibility of failure. In particular, the failure probability of BPR and process innovation (PI) is as high as 60-70%. Most process management approaches include traditional interviews and observation-dependent business process analysis (BPA). This conventional BPA requires a lot of time. However, it derives subjective and incomplete analysis results and has no tool to measure improvement effects. As a way to overcome this kind of limitation of conventional BPA, this study introduces a process mining technique through the analysis and utilization of a huge amount of process data kept almost unused in domestic information systems. Processing mining is a process management technique which helps users figure out business processes in a fast and objective manner by analyzing these data and automatically visualizing actual process flows. In particular, this study derives a process improvement plan and offers academic and practical implications through analysis on municipality data in the Netherlands.

© 2016 Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the Organizing Committee of ITQM 2016
Keywords: Process mining, Big data, Business process reengineering, Process innovation

1. Introduction

In the 1980s, organizations started to aggressively display their interest in processes (Rummler and Brache, 1995). Even though it's been over 3 decades, however, the problems of conventional BPA aren't solved yet. Furthermore, the success probability of BPR or PI still shows no sign of increase. Package software (e.g., SAP ERP), BPMS and internally developed information system automate business processes or at least support manual operations. In addition, the records (i.e., big process data) stored in the package software or internal information system have become the important sources of big data (Kang Yeong-sik et al., 2015). These data

* Corresponding author. Tel.: +82-2-300-0776; fax: +82-2-300-0776
E-mail address: yskang@mju.ac.kr

1877-0509 © 2016 Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of the Organizing Committee of ITQM 2016
doi:10.1016/j.procs.2016.07.066

include event logs which could be utilized in process mining. An event log includes specific records on when and by whom the business activities which support the information system were performed (Kang Yeong-sik et al., 2013).

Process mining is a process management technique which helps users figure out business processes in a fast and objective manner by analyzing business data which include event logs and automatically visualizing actual process flows. Therefore, this technology can considerably reduce the time and costs needed to understand current processes. The process participants are able to gather and concentrate on why the target processes are handled the way they are. In addition, the same analysis can be repeated anytime almost without additional costs. Therefore, improvement based on continued assessment on the effects of changes can be repeated. This kind of competency of process mining can make a contribution to solving the problems of conventional BPA. In fact, hundreds of organizations around the globe have experienced diverse effects such as cost reduction and value innovation through process mining (Kang Yeong-sik et al., 2015; van der Aalst, 2011).

Figure 1. Five Sources of Big Data

2. Concept and Value of Process Mining

2.1. Current position and goals

The goal of process mining analysis is to improve processes, not to analyze data regarding the execution of processes (event log). As shown in Figure below, the improvement of processes can be divided into two perspectives: performance perspective and compliance perspective (van der Aalst, 2011). In general, when a process mining project is started, performance and compliance-centered questions or problems which should be answered through process mining analysis are derived. Then, process mining analysis is performed to find an answer these questions or problems (Mans et al., 2015). Meanwhile, process mining is situated in a position to fill a gap between the analysis techniques (e.g., simulation) focusing on a process model without considering real event data and classical data-centric analyses (e.g., data mining) which do not consider processes (van der Aalst, 2011).

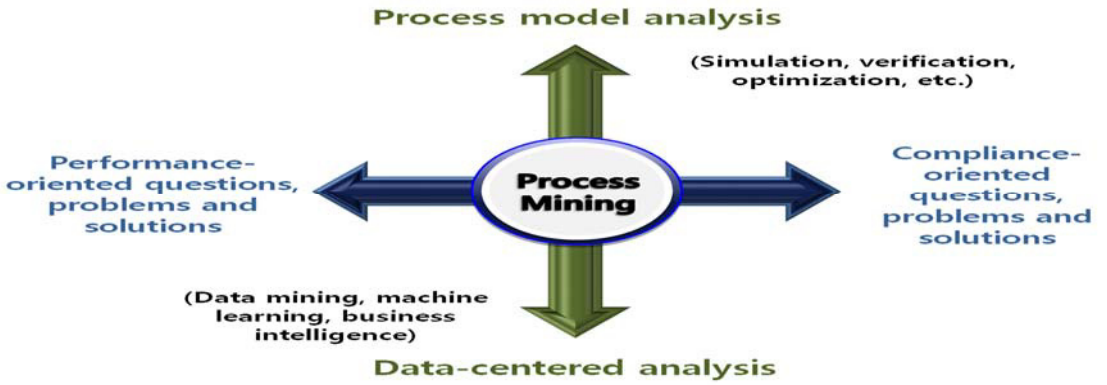


Figure 2. Current Position and Goals of Process Mining

2.2. 3 different types of process mining: Process discovery, conformance checking and enhancement of business processes

Depending on how a process model is related with event logs which can be viewed with a set of cases (process instances), process mining analysis can be divided into three types: Process discovery, conformance checking and enhancement of business processes (Kang Yeong-sik, 2014; van der Aalst, 2011).

(1) Process discovery

First, 'process discovery' is the most typical technique of process mining. In 'process discovery,' a process model which represents the execution of actual processes in log data even without knowledge on the process model can be automatically derived (see Figure 3). Through the process discovery technique, a process analyzer is able to get an insight on how the process is actually carried out and on the interactions among the resources relating to business operation (Kang Yeong-sik et al., 2013).

(2) Conformance checking

Second, conformance checking is to compare and analyze differences between a pre-defined process model and process behavior recorded in the information system in an event log form (Roziant and van der Aalst, 2008) through these comparison and analysis, it is able to find the cases which are executed different from an ideal process model that reflects standards, guidelines and project policy or discover deviation parts. In addition, this technique is able to measure the severity of this difference (van der Aalst, 2011).

(3) Enhancement of business processes

Lastly, it is the 'enhancement of business processes.' This analysis type is to enhance the process model discovered through process mining or conventional process model from diverse viewpoints (van der Aalst, 2011). For example, using the time information relating to business operation in the event log, it is able to analyze process performances from the perspective of time or discover a bottleneck point. In addition, it would be possible to analyze the effects on certain elements in a decision-making point on the decision of execution paths through analysis on previous cases. With this kind of analysis, traditional data mining techniques such as a decision-making tree can be utilized as well (Kang Yeong-sik et al., 2013).

Based on these three characteristics of process mining, this study suggests importance cases and implications which allow process mining to be applied to the improvement of general business processes by presenting the cases applied to the analysis of application for construction permit in municipality in the Netherlands.

3. Application of process mining through a case study on log analysis of municipality tasks in the Netherlands

3.1. Case study

The Netherlands has a country with a small territory, whose population density is higher than other European countries. If a citizen or company wants to change the use of land, and this change has influence on safety, it is required to get an environment (mostly construction)-related permit. About 400 local authorities in the Netherlands play a part of a front desk's role for the said permit-related government agencies (van der Aalst, 2011).

This study aims to verify the value of process mining in the advancement of government administration and goal achievement through analysis on process data relating to the application for construction permit in five municipalities of the Netherlands.

When the Dutch government announced a new construction permit handling procedure under the law which was put into effect in 2010, it needed a 1m-long wallpaper having 78 blocks to explain a new construction permit application process to the general public. The 78 blocks were implemented in the e-government system, and about 400 diverse activities were recorded in a log file. In other words, the construction permit application process is very complicated. In the BPR/ISP Project,' in general, it is almost impossible to individually analyze these complicated construction permit application processes which have been handled by five public agencies, using a traditional process.

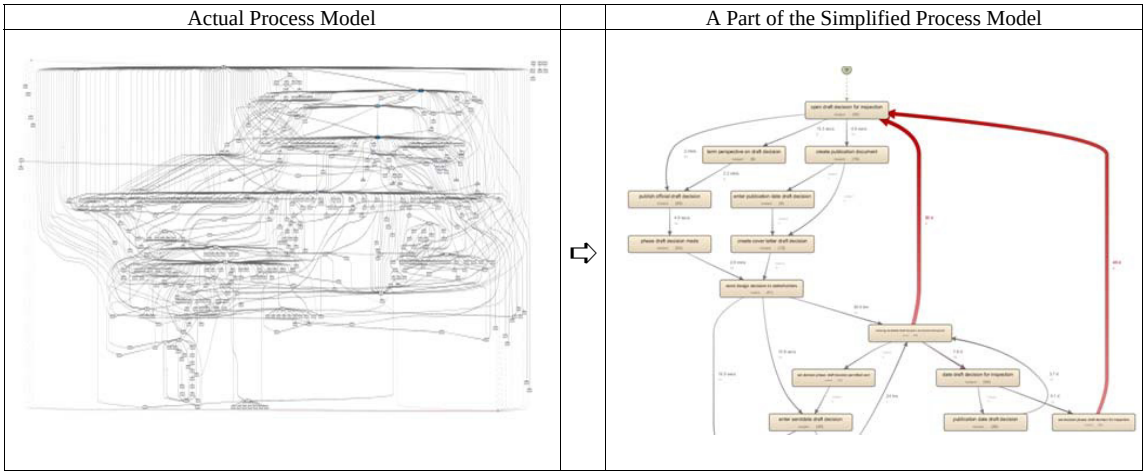


Figure 3. The Process Model and Simplified Process Model Used by Five Municipalities for Handling Application for Building Permit

3.2. Understanding of analysis data

The analyzed actual event log data include the records of all activities relating to construction permit application process which has been handled by five municipalities for the past four years (DOI: 10.4121/uuid:31a308ef-c844-48da-948c-305d167a0ec1).

Table 1. Summary of Important Attributes

Category	Five Municipalities				
	Muni A	Muni B	Muni C	Muni D	Muni E
No. of Cases	1,199	832	1,409	1,053	1,156
No. of Events	52,217	44,354	59,681	47,293	59,083
No. of Activities	289	304	277	272	285
No. of Resources (Performers)	23	11	14	10	22
Timestamp (Initial Date – Final Date)	Oct. 5, 2010 – Aug. 1, 2015	Jun. 29, 2010 – Mar. 4, 2015	Jan. 1, 2010 – Mar. 5, 2015	Nov. 18, 2009 – Mar. 5, 2015	Nov. 23, 2009 – Mar. 3, 2015

3.3. Process innovation and improvement through case studies

3.3.1. Rationality of process mining in analysis procedures

(1) Reduction of time and costs

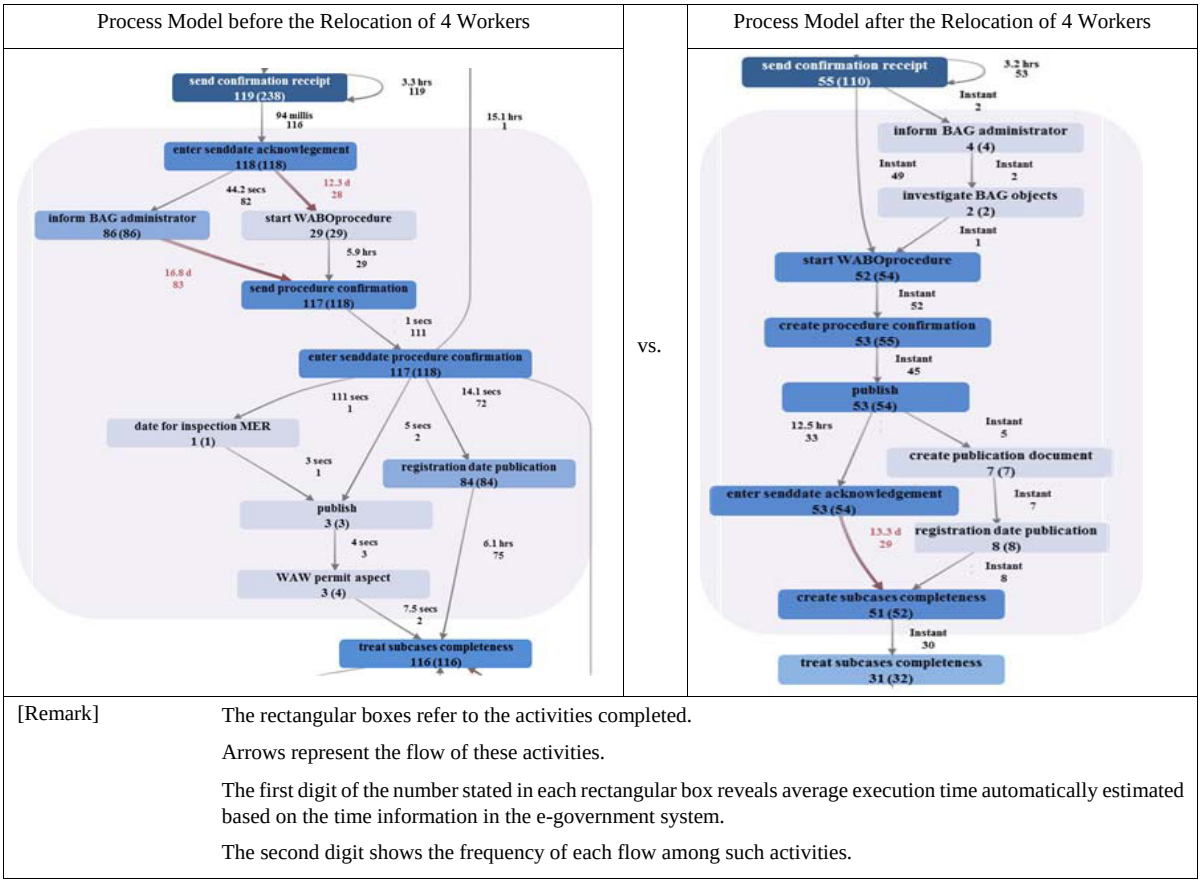
The process mining technique can be helpful in handling the constraints of ‘BPR/ISP Project’ (short project period; unable to find out how businesses are actually performed).

In process mining analysis as well, there should be time for data extraction and pre-processing. Compared to a traditional method, however, it can considerably save time (Rozinat and Günther, 2014; van Gefen and Niks, 2013). If process mining is utilized, diverse process models can be automatically derived depending on the type of the attributes recorded in the information system. In other words, consultants are able to automatically derive the process models performed by municipality during a certain period of time.

For example, if there is an attribute to classify a type of construction permit, the process models by the type of construction permit are acquired. In addition, simplified process models which include the activities frequently executed in the complicated process models only are automatically derived as well.

With these advantages, compared to the conventional BPR/ISP method in which consultants consume a lot of time in analyzing current status including interview and process mapping at the introduction of process mining, this new technique allows them to concentrate on analyzing the causes of change and deriving an improvement plan based on objective analysis results.

Furthermore, consultants are able to be free from a risk of deriving subjective and incomplete analysis results because they don't have to get involved in the unproductive workshop or interview.



[Remark]

The rectangular boxes refer to the activities completed.

Arrows represent the flow of these activities.

The first digit of the number stated in each rectangular box reveals average execution time automatically estimated based on the time information in the e-government system.

The second digit shows the frequency of each flow among such activities.

Figure 4. Comparison of Task Changes in Mini E after the Relocation of 4 Workers

(2) Evidence-based management information

Through analysis on the provided data, it was confirmed that 2 out of 4 government employees were relocated from MuniB and MuniD to MuniE. In addition, there was analysis on the effects of the relocation of four employees on construction permit application process in MuniE. In a traditional BPR/ISP method, consultants have to perform an interview with 18 government employees (22-4 = 18) who participated in the MuniE's construction permit application process before the four employees were relocated in order to answer such questions (Kang Yeong-sik et al., 2014; Rebuge and Ferreira, 2012). Furthermore, consultants had to carry out an in-depth interview with these four employees who were relocated to MuniE. Using process mining instead of manual analysis, Analysis Team is able to analyze the performances of the four employees and changes before and after they were sent to MuniE in objective fashion (see Figure 4).

According to the analysis, among the activities which were performed before the relocation of the four employees, five activities haven't been left unexecuted after they were sent to MuniE. In addition, change in the

order of executing the activities has been found. If process mining is used, it is able to utilize time information on all cases (permit applications) which refer to population. In other words, time information is utilized in a way that the average or total execution time on business flow on a certain activity of between activities is automatically calculated. The competence of this process mining can make a contribution to the supply of evidence-based management information.

3.3.2 Improvement of actual processes according to analysis results

(1) Performance comparison among the five Dutch municipalities.

In terms of 'service speed (processing time),' the causes of difference among local authorities were analyzed. First, the factors which cause comparison and difference in terms of service speed were derived. The average time ('service speed') required to complete each case in the event log data was calculated. In terms of average time, MuniC was the best while MuniB was the worst.

Table 2. Average Processing Time To Wrap Up Cases by Municipality (Service Speed, Unit: Days)

	MuniA	MuniB	MuniC	MuniD	MuniE
Service speed: Average processing time	115	188	77	132	108

The service speed can greatly differ depending on a type of the permit application so that the permit applications by the similar type were compared. Even though there was a slight difference, MuniC was the fastest in handling the cases while MuniB and MuniD were relatively slow. In Table 3, the reason of short average processing time in all municipalities in 2014 was because incomplete cases were included. In general, incomplete cases are excluded from analysis. Because there were little grounds to conclude that the cases were incomplete, however, all cases were used for analysis. The 2014 statistics may differ from actual average processing time. In overall, however, the average processing time of MuniD whose service speed is slow significantly improved in 2014.

Table 3. Each Municipality's Average Processing Time by Year (Unit: Days)

Year	MuniA	MuniB	MuniC	MuniD	MuniE
2010	78	211	61	281	108
2011	79	172	54	116	104
2012	72	123	67	127	91
2013	93	148	80	139	70
2014	67	104	61	58	63

[Remark] Arranged according to each case's initial point

(2) Analysis of the root causes of differences in service speed among five municipalities

[Cause I]: In MuniB and MuniD, objections and appeals have been found in many cases. Even though the target process was designed by the central government, a clear difference in process flow was found among the

local authorities. In fact, this difference has a significant effect on differences in average processing time. Therefore, the analysis concentrated on MuniC vs. MuniB and MuniD in which the difference of average processing time was obvious. Since it is inefficient to compare complicated process flows including all 400 activities, all activities were combined by certain upper-level phases according to the ‘action_code’ attribute included in the log data. In Figure 5, the ‘action_code' attribute refers to a code (e.g., 01_HOOFD_250_1) which presents the types of activities. It includes the values which represents an order of the execution of particular activities. For simplification, key steps (HOOFD_0 thru HOOFD_8) were marked in numbers (0-8) in Figures 3-3 and 3-4. For classification of MuniB, MuniC and MuniD, a marker was added to the target activities in log data. If assumed that there was a 3D process tube which takes each process flow of MuniB, MuniC and MuniD as a single cell, a method which is used for a doctor to visualize a flow in a human body can be adopted to see and compare the process flows in each cell in a single screen. For example, if needed to examine process flows in intestines, doctors may ask a patient to swallow a marker. If they want to analyze blood circulation, in addition, market fluids can be injected to the vein. In addition, a marker (MuniB, MuniC, MuniD activity) can be marked on the log data which recoded the activities which were performed in a similar pattern.

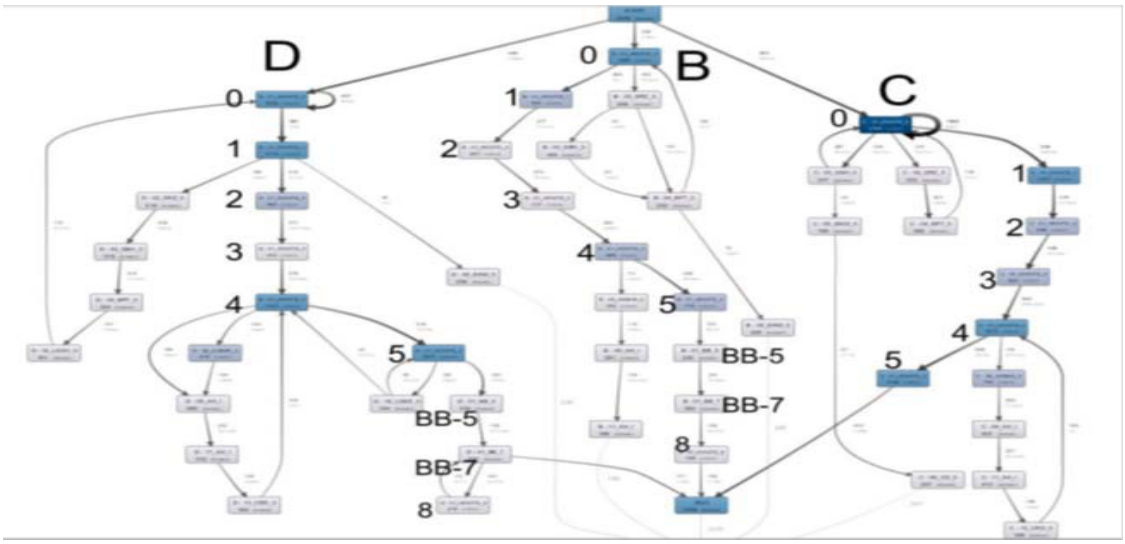


Figure 5. Comparison of Process Flows (4MuniB, MuniC and MuniD)

In Figure 5 above, BB_5 and BB_7 refer to the stages relating to objection and appeal respectively. In general, the municipality’s decision on the application for permit can be objected in a local authority or appealed to the court. In particular, the cases appealed to the court cause a lot of time and costs. As shown on the right side in Figure 5, the MuniC’s cases are immediately completed in HOOFD_5 without going through BB_5 and BB_7. In contrast, the cases of MuniB and MuniD wasted time by going through BB_5, BB_7 and HOOFD_8 additionally. In MuniC, HOOFD_0 thru HOOFD_5 stages sere handled faster than other stages despite a loop at the HOOFD_0 stage. Therefore, it was able to make up for the time wasted during the loop. According to an animation (see Figure 6) provided by the process mining tool DISCO, a bottleneck was found right before the BB_5 step in case of MuniB and MuniD. A partial bottleneck was observed in HOOFD_0 thru 2 stages as well.

In MuniC, on the contrary, most cases were handled equally. The target processes were very complicated, and the process standardization was very low.

For example, MuniE's log data had 1,003 variants against 1,156 cases. One process variant refers to a flow of particular activities throughout the process (Hallerbach et al., 2012). A total of 14 cases are only performed according to the same variant. Therefore, it is needed to find a way to reduce the number of variants for the improvement of process standardization.

[Cause II]: A batching process in MuniB and MuniD was one of the causes of delay. Disco is able to provide a graph which reveals the number of cases that are processed at a certain point of time. When this kind of graph was derived from the five municipalities, there were many cases in which the last stage is handled as a batch in MuniD as shown in Figure 3-5. Since many cases are waiting prior to batching process, process time increases. In 2014, it was able to reduce MuniD's delay time by performing batching process more frequently. In MuniB as well, several batches are handled at the last stage. In MuniC, however, many cases were gradually processed by minimizing batch processes.

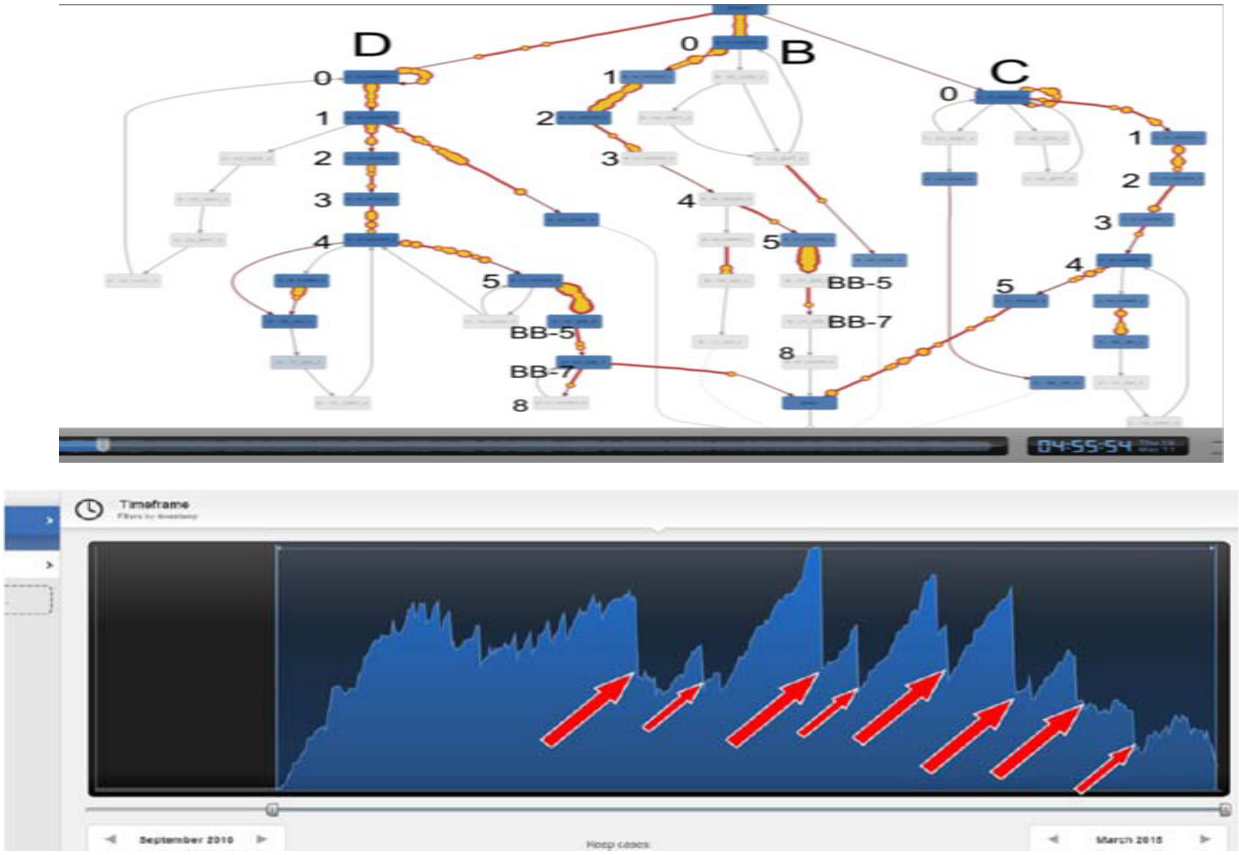


Figure 6. Comparison of Process Animation among MuniB, MuniC and MuniD

4. Conclusion

Even though MuniD has improved recently, MuniB and MuniD have still been behind other municipalities in terms of service speed because of a lot of batch processes, time requested at each stage and many cases which cause objection and appeal. The municipalities have handled the same process designed by the central government differently. In particular, objection and appeal in MuniB and MuniD caused a great amount of time and workload additionally. As shown in analysis on the municipalities of the Netherlands in this study, the problems detected in process mining analysis were easily improved (e.g., prevention of information omission through the improvement of website). In many cases, however, additional improvements such as job redesign, advancement of information system, readjustment of performance indicators and establishment of management system are required. Process mining is a field of study, which keeps growing and developing. It continues searching for new fields of application. The domestic organizations which adopts and utilizes process mining would be able to find a new possibility as well as the benefits stated in this study.

References

[1] Kang Yeong-sik, Park Seung-beom, Lee Bo-gyeong, Kang Sung-koo (2015), “A Study of Linkage between SAP ERP Process Mining and Process Monitoring in the Era of Big Data,” e-Business Studies, 16(4), 265-288.

[2] Kang Yeong-sik, Kang Chang-jae, Lee Eun-sang, Shin Chul-gyu (2013), “A Study of Application of Process MInining Audit in Big Data Environment,” Jounrnal of Auditing, 20, 5-35.

[3] Hallerbach, A., Bauer, T., & Reichert, M. (2012), “Configuration and management of process variants,” In: J. vom Brocke, M. Rosemann (Eds.), Handbook on Business Process Management 1: Introduction, Methods, and Information Systems. Springer, 237-256.

[4] van der Aalst, W. M. P. (2011), “Process Mining: Discovery, Conformance and Enhancement of Business Processes,” Springer.

[5] Mans, R., van der Aalst, W. M. P., & Vanwersch, R. J. B. (2015), “Process Mining in Healthcare: Evaluating and Exploiting Operational Healthcare Processes,” Springer.

[6] Rozinat, A., & van der Aalst, W. M. P. (2008), “Conformance checking of processes based on monitoring real behavior,” Information Systems, 33(1), 64-95.

[7] van Geffen, F., & Niks, R. (2013), “Accelerate DMAIC using process mining,” CEUR Workshop Proceedings.

[8] Rummler, G. A., & Brache, A. P. (1995), “Improving Performance: How to Manage the White Space in the Organization Chart, 2nd Ed.,” John Wiley & Sons.

[9] Rebuge, Á., & Ferreira, D. R. (2012), “Business process analysis in healthcare environments: A methodology based on process mining,” Information Systems, 37(2), 99-116.