

Benchmarking of Five Dutch Municipalities with Process Mining Techniques Reveals Opportunities for Improvement

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Abstract. This paper analyses the process of permit applications in five Dutch municipalities, using process mining techniques. This case study demonstrates a way to visually compare different processes in a process cube, by adding markers to data and using existing algorithms. The analysis reveals a number of leads for possible improvement in process flow and quality of the process, and identifies questions for further research on the compliance of processes. The analysis also reveals differences in the organizational structure of the municipalities and risks to the viability of the smaller offices.

Keywords: process mining, data mining, big data, organizational analysis, benchmarking, concept drift, markers, municipality, building permits, ProM, Disco, WEKA.

1 Introduction

1.1 Municipalities Issuing Environmental Permits

The Netherlands are a small and densely populated country. If a citizen or a company wants to do anything that changes the use of land or has an environmental or safety impact, he needs to apply for a permit. Most of these cases involve building related activities. In The Netherlands some 400 municipalities serve as the front desk for all government agencies involved in these permits.

A number of these municipalities participate in a project to improve their internal processes, using process mining techniques. This project is conducted with the Eindhoven University of Technology.

1.2 Business Process Intelligence Challenge 2015 with Public Data from Five Municipalities

As part of the annual conference in the field of Business Process Management, an International Workshop on Business Process Intelligence (BPI'15) is organized. The organizers of this workshop also organize an international contest: the Business Process Intelligence Challenge 2015 [1]. For the 2015-edition of this contest, the case of the environmental permits processes in Dutch municipalities is offered to contestants. The analysis in this paper was based on the data of five municipalities that was provided for this contest. All activities in the municipality offices are logged by the computer system. This log data was made publicly available for the contest [2].

1.3 This Paper Identifies Improvements and Addresses Process Mining Challenges

This paper aims to identify the possibilities for improvement with regard to the permit application process, that may be distilled from a process log and answer the questions of the municipalities. The municipalities want to know [1]:

1. What are the roles of the people involved in the various stages of the process and how do these roles differ across municipalities?
2. What are the possible points for improvement on the organizational structure for each of the municipalities?
3. The employees of two of the five municipalities have physically moved into the same location recently. Did this lead to a change in the processes and if so, what is different?
4. Some of the procedures will be outsourced from 2018, i.e. they will be removed from the process and the applicant needs to have these activities performed by an external party before submitting the application. What will be the effect of this on the organizational structures in the five municipalities?
5. Where are differences in throughput times between the municipalities and how can these be explained?
6. What are the differences in control flow between the municipalities?

This paper also addresses four of the challenges that were defined in the Process Mining Manifesto [16]: challenge 4 dealing with concept drift, challenge 7 cross-organizational mining, challenge 10 improving usability for non-experts and challenge 11 improving understandability for non-experts.

The approach for dealing with concept drift and cross-organizational mining, is explained in chapter 4. Usability and understandability for non-experts are pursued by choosing user friendly tools that produce results that are easy to understand, and by explaining all results in an organizational context envisioning a target audience of management of the municipalities rather than academics in the field of process mining.

1.4 Approach Designed to Work from Understanding of the Processes to the Quantitative Analysis.

In process mining literature [3] it is recommended to structure a process mining project, beginning with “understanding of the domain” and “understanding of the data”. This reflects the fact that the goal of process mining should not be to build the best number cruncher, but to make the best recommendations for processes in organizations.

So, rather than blindly attacking the data logs, we will first research the organizational context in chapter 2 and provide more contextual information in other chapters where useful for understanding data or results. Chapter 3 describes the available dataset and chapter 4 describes the methods and tools that were used for the analysis. In chapter 5 a brief framework is proposed to judge the performance of the five municipalities. In chapter 6 the differences in performance are presented, showing several impressive differences between municipalities. Further explanation of these differences follow from the description of the process flow in chapter 7 and the organizational differences described in chapter 8. Chapter 9 resumes conclusions and recommendations regarding the differences in the five municipalities. Chapter 10 finally evaluates the case study from a methodological point of view.

1.5 For Contest Purposes Only

This paper serves only as a contribution to the Business Process Intelligence Challenge 2015. No formal relationship exists between the author or his company and the municipalities in this case study. The analysis provided in this paper may therefore not formally be regarded as an advice or consult.

The type of numeric analysis presented in this paper, can only be the starting point of further investigation and is not meant to reach final conclusions. A proper analysis of the processes does require further interpretation of the results with the members of the organizations involved.

2 Permit Applications at the Dutch Municipalities

This chapter describes the context of the processes that are to be analyzed. In The Netherlands a citizen or an enterprise needs a permit or other approval for a variety of activities that may have an impact on the environment or the use of land, e.g.:

- a new building.
- demolishing a building.
- fire safety measures in a building.
- cutting a tree.
- environmental pollution by an enterprise.
- placing advertisements on a building.
- temporary placement of an object on a public road.
- any combination of these activities.

The municipalities are the government agency where these permits can be applied for. The procedure that the municipality needs to follow, is prescribed by the central government.

2.1 Process Is Complex by Design

A great number of permits and regulations were replaced by the introduction of the new law WABO (Law on general environmental regulations) in 2010. The objective of this law was to simplify the procedures for citizens and enterprises.

The government aimed to introduce one law and one desk for citizens, replacing 25 different regulations with sometimes contradicting demands [4], [5]. This law was effective as of October 1, 2010. This is the starting point of the data log that was provided for this analysis.

We should not be surprised about the great number of different traces that we see in the files, because the processes used to be divided over different institutions and cover very different subjects.

Moreover, the process of the permit applications is complex by design. When the central government published the new procedure for the 2010 law, it needed a one meter wide wall poster, with 78 blocks in 7 different colors and 5 different shapes, to explain the new process to professionals in the building sector and the general public [6]. The 78 blocks were implemented in the computer system of the municipalities, resulting in some 400 different activities in the log file. The activities that are combined in this process serve a number of goals that are as diverse as:

- promoting esthetics in architecture and city planning.
- enforcing fire safety.
- prevention of pollution.
- protection of monumental buildings.
- reduction of energy consumption in buildings.
- prevention of money laundering.
- protection of nature.
- prevention of the use of real estate for criminal purposes.

Given this diversity, it is only logical that a great number of different activities result in the process.

2.2 Government Aims for a Further Simplification of the Law

At this moment (June 2015) the government wants a further simplification of regulations and proposes a new law, to be effective as of 2018 [7], [8]. The design and implementation of the new law, is labeled as “the biggest legislation project since the writing of the constitution.” [15] This illustrates the complexity of the all the processes that are to be regulated in the new law. The main goal of these changes is to speed up the process and simplify the process for the applicants, since the complexity is regarded to be a barrier for investments. The government wants to lower these barriers in order to stimulate the economy.

3 Data Was Provided for the Analysis by the Municipalities

Every activity in the process of the environmental permits, is logged by the computer systems of the five municipalities. The five log files were anonymized and provided for analysis [2]. In this paper the five municipalities will be referred to as:

- MuniA (file: BPIC15-1.xes).
- MuniB (file: BPIC15-2.xes).
- MuniC (file: BPIC15-3.xes).
- MuniD (file: BPIC15-4.xes).
- MuniE (file: BPIC15-5.xes).

The combined log contains a table of 263.000 rows and 26 columns with for every activity executed in the process, values for 26 dimensions (case number, action, timestamp, employee number, type of permit, etc.) that were recorded. An overview of these dimensions is presented in appendix 1.

The logs show a great number of different starting points and endpoints for the processes. This raises the suspicion of incomplete logs, or cases that have not been completed within the timeframe of the log file, but there may also be several valid start and endpoints because of the nature of the process:

- a permit may be applied for through the Internet desk or in the office with a form and file on paper.
- an application that is disputed in court may have a different endpoint than a permit that is granted without any problems.

Unfortunately the case description does not give us any information to solve this problem. This leaves us with the choice to either use the whole log and deal with different start/endpoints or arbitrarily guesstimate a starting point and an endpoint. From the log we see that the field “case status” is usually “closed (G)” and yet cases have very different endpoints with descriptions that are plausible for the end of a process. This is consistent with the designed process as appeared from the contextual information. Therefore the whole log was used. Moreover, given the large number of cases, incomplete cases will not have a major influence on most statistics. When comparing municipalities the influence of incomplete cases will reduce if all municipalities have a similar distribution of cases. In the interpretation of results, the possible influence of incomplete cases will be discussed when necessary.

When useful, artificial start and endpoints were added to the log with ProM, in order to facilitate the mining algorithms that produce better results with a single starting point and a single endpoint. For some analyses a part of the process was selected with a uniform start and end event.

4 Methodology and Tools from Data Analysis, Process Mining and Data Mining Were Used to Discover Patterns and Relations in the Data

The data from 263.000 log entries and a total of 6,8 million data fields, can obviously not be judged at a glance. Different tools and methods were used.

4.1 Standard Software is Available for Analysis of Big Datasets

The data was processed using the process mining software ProM and Disco. The WEKA-package was used for data mining. To preprocess the data, prepare for the process mining and data mining and for slicing and dicing the information cube, the SQL-server tools that are provided by MS Powerpivot were used. PowerPoint and Excel were used to produce several graphs. MS Word was used to prepare the data for analysis in WEKA, in order to solve issues with incompatible file formats that needed to be solved on a text level.

4.2 Challenge to Visualize and Compare Processes within Process Cubes

The processes will probably be different for the five municipalities, for different types of permits, possibly for different employees, and the processes will also change over time because of improvements and changes in regulations (in scientific literature referred to as “concept drift”). All these dimensions can be combined to a multidimensional conceptual cube, where each cell has its own process [9]. To compare different processes in different cells of the cube, we can use a method that doctors use when they want to visualize flows in the human body. The doctor simply adds a marker to the process flow: the patient is asked to swallow a marker if the process flow in the intestines needs to be studied, or a marker fluid is injected in the veins if the circulation of the blood needs to be analyzed.

Using this method, we can get the processes from different cells on one screen, with their performance metrics and we can even simultaneously animate a simulation of the processes in different cells.

5 Performance Indicators Serve as a Framework to Judge Differences between Municipalities

Comparing the differences in the process flow and organization of the five municipalities, only makes sense as far as these differences have some relation to the performance of the municipality. Otherwise we end up comparing futile aspects of the organization, just for the sake of knowing that they are different.

We therefore need to establish relevant performance indicators that can be linked to the information in the data log. There are several performance indicators that can be linked to the available data logs and that will be analyzed and discussed:

- speed of service.
- compliance to the laws and regulations.
- quality of the processes.

These indicators will be used to discuss the differences between municipalities. It is not possible to use cost as a performance indicator, since there is no reliable information on the number of hours worked and the permit fee only represents the cost for the citizen, which may differ from the true internal cost.¹

6 Overall Score on Performance Indicators Shows High Performance of MuniC and Low Performance of MuniB

6.1 MuniB and MuniD are Consistently Slower

From the log we can calculate the average time to completion for each case. **Table 1** shows the time that is needed for the completion of a case.

Table 1. Average time to completion (all cases) is relatively high in MuniB and MuniD

	MuniA	MuniB	MuniC	MuniD	MuniE
average time (days)	115	188	77	132	108

MuniC is the best in class and MuniB is the worst in class on the overall average time needed. We know however that there is a huge variety in the permits that are applied for. A complicated case will cost more time than a simple case. A building permit is not the same as a permit for a billboard. We therefore need to compare similar types of permits.

In **Fig. 1** we see a graph with a line for each of the most popular types of permit that can be applied for. The time needed for each type of permit is represented by a line and on the horizontal axis the five municipalities are plotted. Although there are some slight variations, the pattern of the lines is consistent for most types of permits. MuniC is faster than MuniB and MuniD. MuniA and MuniE are somewhat slower

¹ There is no clear pattern in the fees, but MuniB and MuniD are cheaper for several permits.

than MuniC. The big question is: “Why?” We will look into the reasons for these differences in the next paragraphs.

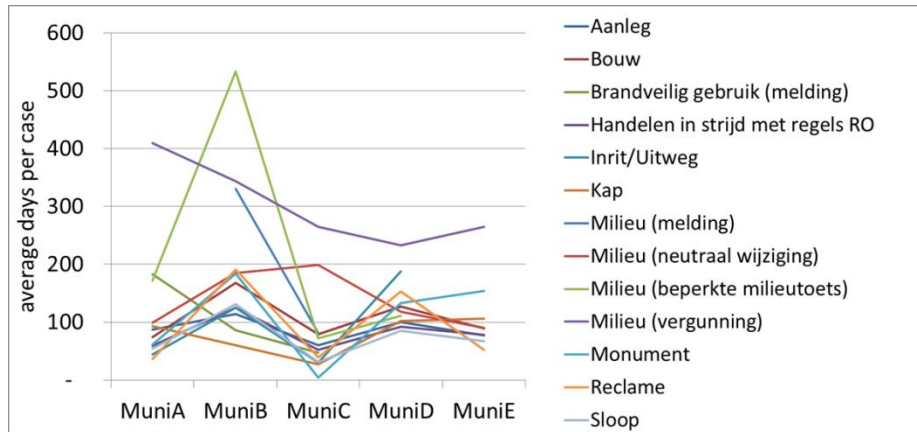


Fig. 1. A consistent pattern for the differences in time needed for different types of permits. Even if it is hard to distinguish the individual lines it is clear from the pattern that MuniB and MuniD need more time to complete a permit process. (only closed, single permit cases).

MuniD Has Improved Speed of Service In 2014 MuniD seems to have improved more in throughput time than others. For this analysis only building permits were selected. Half of all applications concern a building permit only, and building activities are also present in many combined applications. Building permits show the same pattern as described in **Fig. 1**, so they make a good and uniform subset for research. For all cases activity 01_HOOFD_010 was used as the start of the case. Cases were then sorted by startyear. **Table 2** presents the average number of days to completion. The last 2 years comprise incomplete cases and suffer from a bias because long running cases may not be finished yet, so absolute time is not relevant. MuniD has however improved far more than the other municipalities.

Table 2. Time for building permits has improved in MuniD in 2014. Average number of days, from activity 01_HOOFD_010, with a bias for shorter cases in the last 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

Batch Processing in MuniD and MuniB is one Cause of Delays. In Disco we can produce a graph with the number of cases that are being processed at any moment in time. If we do this for the five municipalities, we can observe different patterns. In MuniD there are many cases where the last steps are processed in a batch, causing a sharp drop in the number of cases. (Fig. 2). Before the batch is processed, many cases are waiting, causing process time to go up. A dotted chart analysis reveals that the batch processing in MuniD was also used for previous steps in the process. The waiting time has been reduced in the last year, by processing the batches more often.



Fig. 2. Batch processing in the last steps, causes sharp rises and drops in the number of cases in MuniD. Number of active cases at any moment in time.

In MuniC we see a more gradual development in the number of cases. (Fig. 3). MuniA has a pattern similar to MuniC, while MuniB shows several batches in the final step and many batches in previous steps. MuniE has had two occasions in the first half of the log period when suddenly a large batch of cases were finalized, but developed a more gradual pattern afterwards.

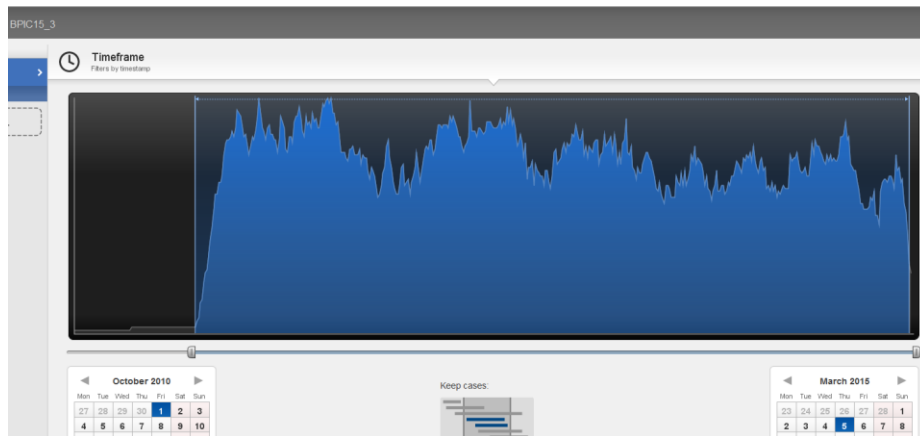


Fig. 3. More continuous number of cases in MuniC, without batch processing. Number of active cases at any moment in time.

Reasons for Batch Processing are Unclear. It would make sense analyzing the reasons for the batch processing in MuniD. It is hard to establish the cause from the log. For some reason the cases are left idle after most of the steps have been completed. When an objection is lodged, then suddenly the last steps are completed within a minute. If we analyze the cases that were finished in a burst at 17-4-2013, we see that the majority of the last steps was done by a single resource (560752). From the log it cannot be made clear if the involvement of this person is part of the solution or part of the problem. Apparently he does a lot of work, but the organization does have to wait for it.

Investigation on the shop floor is recommended. It may be that an external process is waited for, for instance a council decision or a decision from another government agency (province?). If MuniC is located in another province, that might cause the difference in speed of service in some steps.

Reworks Are a Minor Problem. The process maps show many back loops. However if we count the number of reworks (activities that have to be done more than once in a case) this seems to be a minor problem. For building permits, on average 2% of the activities need to be done more than once. Table 3 shows the percentage of activities that have to be done more than once.

Table 3. Reworks should be avoided, but do not explain the difference in time. % of total activities that need to be done more than once.

	MuniA	MuniB	MuniC	MuniD	MuniE
reworks	1,8%	2,0%	2,7%	1,6%	1,6%

6.2 Further Investigation Needed to Establish if the Use of the “By Law Procedure” is Compliant with Regulations

Government Regulations Prescribe a Quick Handling of all Permit Applications [6]. The regulations distinguish two possible procedures:

1. regular procedure (Dutch: reguliere procedure)
2. extensive procedure (Dutch: uitgebreide procedure)

The procedure must be finished within a number of weeks and the applicant must be informed about the decision of the municipality on his application. The terms for these procedures are (Table 4):

Table 4. The municipality is obliged to finish all procedures within a number of weeks

	max # of weeks	extension for advisors	max total
regular procedure	8	6	14
extensive procedure	26	6	32

If the complexity of a case requires the use of external advisors, the municipality is allowed an extra period of 6 weeks to finish the application process.

The fact that for a great number of cases, the indicator for regular or extensive procedure is missing in the log, raises the question whether the municipalities are “in control.” A further investigation is recommended, to see why this indicator is missing and how the municipalities manage to control their processes to be on time.

If Time Limits are Exceeded a Permit is Automatically Granted “By Law”. If in a “regular” procedure, a municipality does not take a timely decision, the citizen will automatically be granted a permit. (This is called “Omgevingsvergunning van rechtswege” in the log registered as 01_HOOFD_480 “by law”) We can see this in the process map from the ministry [6]. It is obvious that there is a suspicion of poor quality of the process when this would happen very often. Moreover all the work that has been done so far for this application, is in vain since the municipality might as well have issued the permit without looking into it at all. When a permit is granted in this procedure, the municipality may not ask a bigger fee (leges) than originally asked for, causing financial losses as well.

Procedure “By Law” is Used Very Often. The code 01_HOOFD_480 appears in more than 4000 cases. (see **Table 5**). Given the huge number of cases it is very likely that a plausible explanation will exist, but there are some concerns that might justify further investigation.

Procedure “By Law” Is Even Used when Time Limits Have Not Been Exceeded and in Extensive Procedures. The granting of permits “by law” can only be done in regular procedures [10] but all 5 municipalities have these cases logged in their extensive procedure. It might be wise to investigate if these cases are compliant with rules and regulations. This is especially important since for so many cases the procedure field is left empty and no compliance check is possible.

Table 5. The activity “by law” is logged in many cases, also in cases that do not follow the regular procedure.

action_code	activity	Muni	procedure			
			empty	regular	extensive	total
01_HOOFD_480	By law	MuniA	829	16	5	850
01_HOOFD_480	By law	MuniB	530	40	7	577
01_HOOFD_480	By law	MuniC	1029	26	4	1059
01_HOOFD_480	By law	MuniD	785	3	9	797
01_HOOFD_480	By law	MuniE	888	8	3	899
Total		Total	4061	93	28	4182

Analysis of the cases that end up in a by-law-permit in Disco, might suggest that the process takes a long time because of complicating factors like procedure changes, article 34 WABO, and subcases complicating the timely handling of the application. However, from analysis of the log data we see that the granting of permits by law is not only done for complex cases requiring multiple permits, but also for many cases where only one permit is applied for. These concern mainly building permits. In the log of MuniD there are a substantial number of permits for the cutting of trees that are issued “by law.”

Even more questions arise when we look into the time that was used in the process. In many cases the time that the law allows for the procedure, is not exceeded, and yet the procedure “by law” is followed, as if the municipality was too late (**Table 6**). In some of the cases the permit is issued “by law” on the very same day as the reception of application is confirmed. An example is case 3754056 in MuniA. This involves a permit for cutting trees. Within 2 minutes, 36 steps in the process are executed, resulting in a permit “by law.”

Table 6. A great number of cases are granted a permit “by law” (code 01_HOOFD_480) before the applicable terms have been exceeded. 3520 of these permits were granted before the end of a period of 8 weeks.

weeks	8	14	26	32	
days to 01_HOOFD_480	<56	<98	<182	<224	>224
# cases	3520	4012	4127	4144	35

Further Investigation Recommended. The figures in the activity log lead me to recommend discussing with the municipalities the cases with the use of the code 01_HOOFD_480 (by law).

At the introduction of the WABO, the Ministry was very clear on the intention of the procedure “by law”: it is meant for cases where the municipality does not decide in time [11]. The fact that a great number of employees (resources) use this procedure for other purposes, suggests that it is common practice to do so. Perhaps there was a change in regulations. It is also very well possible that the code “01_HOOFD_480 – by law” is used as a workaround, because the computer system does not have other possibilities to swiftly issue a permit. This might be for permits that are always granted, unless a third party objects.

In that case the municipalities might consider adapting the computer system, to properly facilitate the civil servants in their work. This would increase the possibilities to monitor compliance and reduce the vulnerability for abuse or fraud.

6.3 Quality of Logging or Quality of Work?

In the logs appear many cases with activities that follow each other within a few seconds. This raises doubts about the quality of logging: are the logs fabricated afterwards, perhaps by ticking the boxes in a final checklist rather than registering the completion of each activity? If not, then management should ask itself if sufficient quality of work can be achieved with this kind of work pace. In recent years many activities are logged without a timestamp (only a date). It should be considered to activate this function in the software.

6.4 MuniB is Often Forced to Revise its Decisions, Indicating a Lack of Quality

Appeals as an Indicator of Quality. Once the Municipality has decided, and the applicant is not happy with the decision (usually refusal of the permit), the applicant can fight the decision of the municipality. It is also possible that a third party disputes the decision of the municipality or the judge. Decisions of the municipality can be fought in two ways:

- cases with a normal procedure can be disputed within the municipality itself: this procedure is called “objection” (Dutch: “bezwaar”)
- cases in the extensive procedure can be disputed in court in an appeal case. The judge will then decide. Results of the “objection-”procedure can also be disputed in court. Court decisions can be disputed in the supreme court (department ABRvS).

Of course there will always be cases where citizens have conflicting interests and they will fight each other over the outcome of procedures. However, it is also clear that bad decisions and badly motivated decisions will result in more appeals. We will therefore use the percentage of appeals as a tell tail. A large number of appeals should result in further investigation of the quality of decisions. A large number of lost cases in court (resulting in revision of the permit), would give a clear signal that there may be a quality issue in the procedure.

MuniB Experienced many Problems. If we take the activity “register submission date request” as the starting point of every case and take the number of these activities as 100%, we can compare for how many cases objections, appeals and affected decisions are logged. **Fig. 4** shows the number of cases and the percentage of objections, appeals and affected decisions. The differences between the municipalities are huge. MuniB, MuniD and MuniE have some 60% objections logged, while MuniA and MuniC receive far less objections. In MuniB many cases go to court, and in a worrying number of these cases, decisions are affected (suggesting the municipality has lost). In MuniE for many of the cases that go to court, decisions are affected.

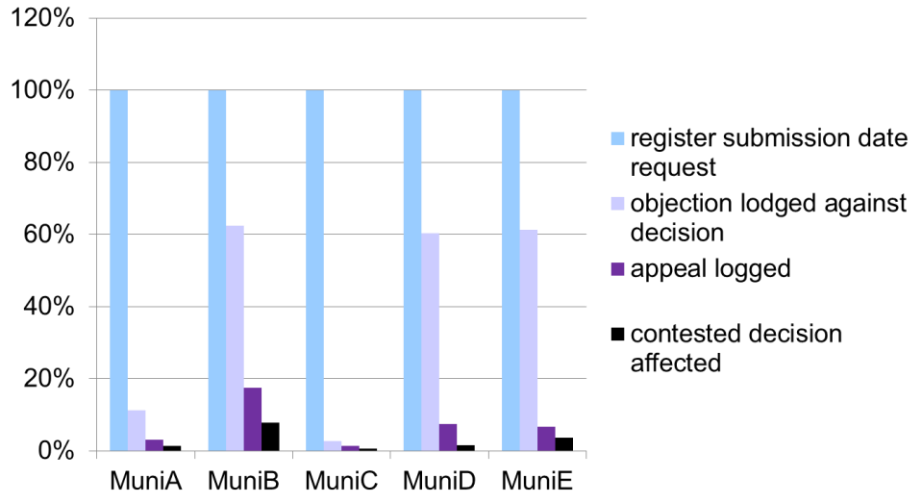


Fig. 4. Huge differences in objections and appeals: MuniB has a very high percentage of appeals and lost appeals. MuniE and MuniD do slightly better.

Analysis of building permits in MuniD with WEKA (J48-algorithm) reveals that the occurrence of objections, appeals or affected decisions cannot be satisfactory linked to a particular resource, activity or combination of both. We can therefore not pinpoint someone doing a bad job. CaseID is the best indicator of problems: old cases have problems, recent cases not. It is not clear if this is caused by a change in way of working or regulations, or that problems are yet to come for the younger cases.

In MuniB on the contrary, the objections, appeals and affected activities also appear in more recent cases. Objections and appeals are a stronger predictor of “affected” than resources and activities. Like in MuniD we cannot explain objections or appeals by resources and activities. In MuniE, the cases that ended up “affected” were old cases that could be explained (100% - JRIP algorithm) by the existence of both objections and appeals. Appeals are present in younger cases too, but not in recent ones. Objections were massive in the early years, but have since then improved but not completely disappeared.

Court cases are likely to cost a lot of money and time. Lost cases may even bring the risks of liabilities. It would be worthwhile to investigate why so many cases end in the BB-phases and what could be done to avoid this. This cannot be done from a log file. Qualitative research is needed. In MuniB there is a big potential for improvement. MuniD and MuniE might profit too, if they can avoid the large number of cases going to the objection- and appeal-phases.

7 Control Flow Changes over Time and Differs across Municipalities Despite Uniform Legislation.

7.1 Many Variants in the Process Flow

From the analysis of the logs, it appears that there is in every municipality a huge variety in the route permit applications follow through the process. As we saw in the contextual information, this was to be expected. However it is hard to imagine that there are hardly any cases that could follow the same flow through the process. The log of MuniE has 1156 cases in 1003 variants. Maximum 14 cases follow the same variant! It would be worthwhile to investigate if the number of variants in the process flow can be reduced.

7.2 Differences in Performance Show in Control Flow Municipalities

Although the processes are centrally designed, several differences are visible that make the difference in speed and objections very clear. We will focus on MuniC versus MuniB and MuniD, because the difference in performance is most obvious. **Fig. 5** shows the control flow for the three municipalities in Disco.

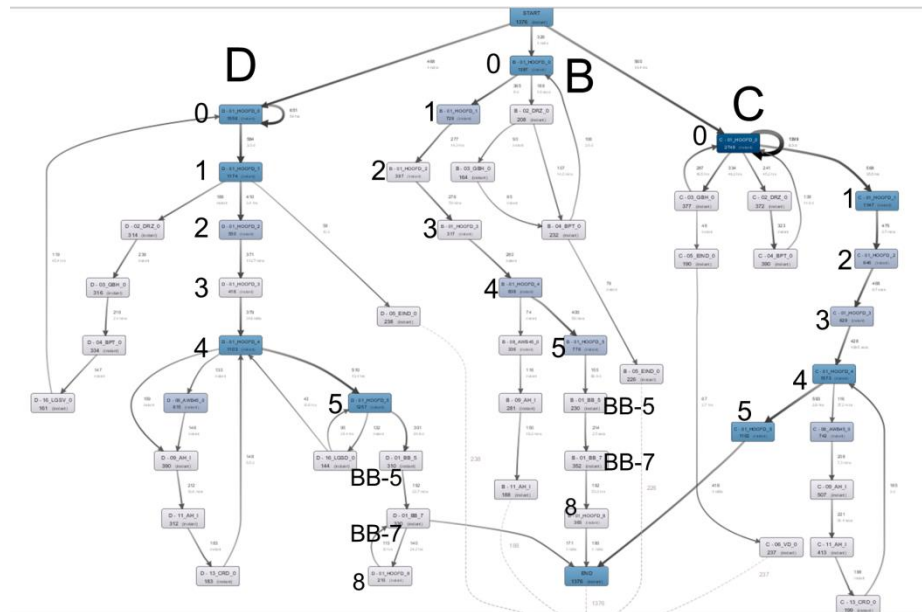


Fig. 5. Control flow for MuniD, MuniB and MuniC, shows the extra steps for objections and appeals (BB5/BB7).

Only building permits have been selected, as to avoid differences in flow and performance caused by a different mix/complexity of permits. All activities have been combined in phases according to their activity code. Markers were added to the activities to distinguish the municipalities.

The main phases 01_HOOFD_0 to 01_HOOFD_8 are indicated with the figures 0 to 8. The right flow from MuniC, shows a direct flow of cases from 5 to End. The middle flow from MuniB, adds the activity phases BB_5, BB_7 (objections and appeals) and HOOFD_8. These activities take extra time. MuniD on the left has a similar problem. MuniC has a loop in HOOFD_0 but is faster in most steps 0-5 than MuniB, well compensating the lost time in the loop. There are some slight differences in the loop from HOOFD_0 via 02_DRZ_0, 03_GBH_0 and 04_BPT_0, where MuniC is somewhat slower.

The still from the animation (Fig. 6) shows not only the bottleneck before BB_5 in MuniB and MuniD, but also the more regular distributed cases over the rest of the steps in MuniC.

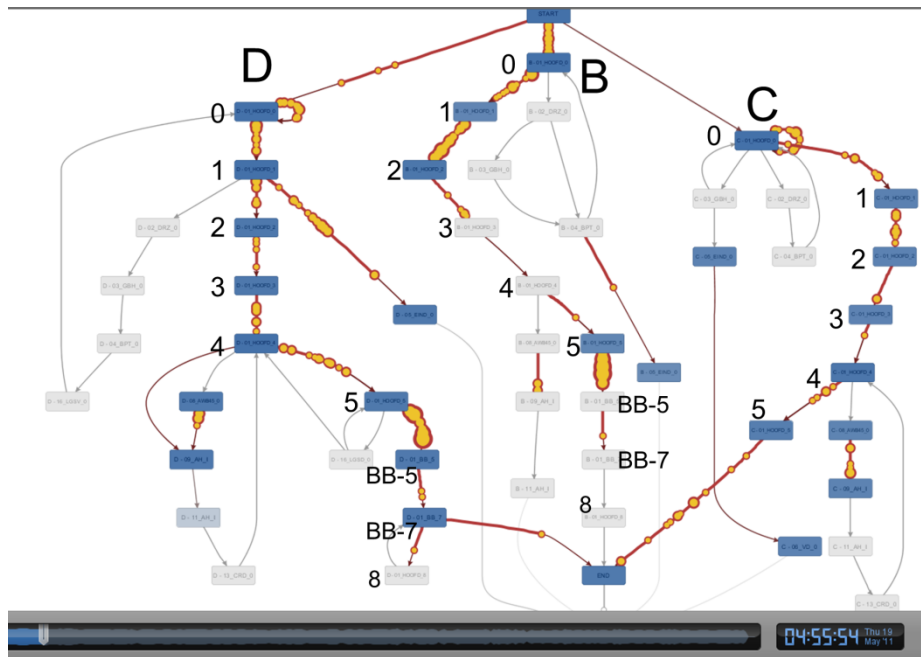


Fig. 6. Still from the animation of the flow of cases through the process, shows that cases in MuniC are more evenly distributed.

MuniA and MuniE are not included in the picture because of the limitations of detail in print. On the computer screen it can be seen that MuniA has a frequent backloops from HOOFD_5 to HOOFD_1 via 05_EIND and 06_VD. MuniE has a problem with the BB phases similar to MuniB.

Combining the throughput time for the phases in **Fig. 7** shows the different approach of municipalities: MuniA is slower in the first phases, but avoids the BB-phases (objection/appeal), while MuniE handles the first phases in a split second and then loses time from HOOFD_5 to BB_5. MuniB combines worst of both worlds.

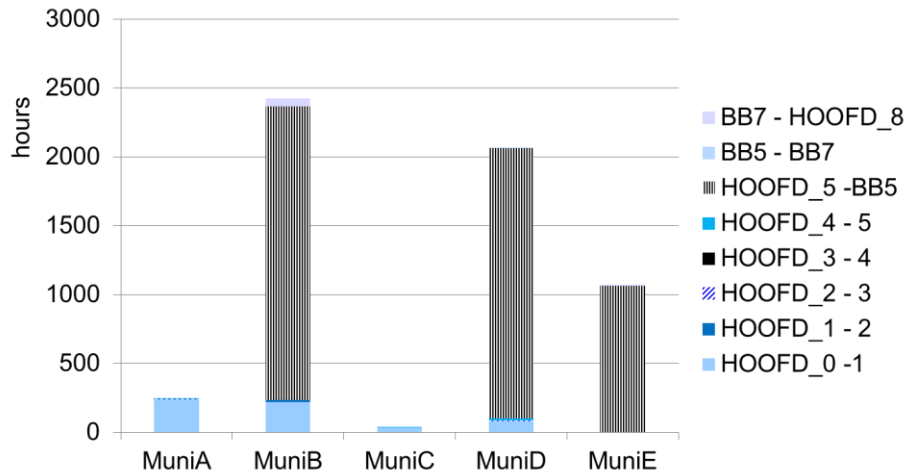


Fig. 7. Different approach: MuniA is slow in HOOFD_0 to HOOFD_5, but avoids BB-phases, while MuniE rushes through the HOOFD-phases and loses time from HOOFD_5 to BB_5. Average throughput times for main phases (including time between activities) in the process, as calculated in Disco: infrequent activities are filtered out. Building permits only, averages not weighted for the number of cases.

7.3 Major Changes in the Procedures

The municipalities wanted to know if the merger of two offices had caused a change in the processes. A change in processes can be identified with an algorithm for concept drift [12]. This algorithm basically calculates how many changes there are in the subsequent activities in a process when comparing cases that follow closely in time. This results in an indicator (the p-value) that equals 1 for a period without change, while a lower value signifies a bigger change. This is illustrated in **Fig. 8**.

Continuous Changes plus a Major Change in May 2012. If two cases with a completely different character, that require different procedures, follow each other, then the p-value will also drop, while the procedures have not fundamentally changed. It is therefore important to apply the algorithm to similar cases. Therefore first a subset of cases has been selected, with applications that require only a building permit.

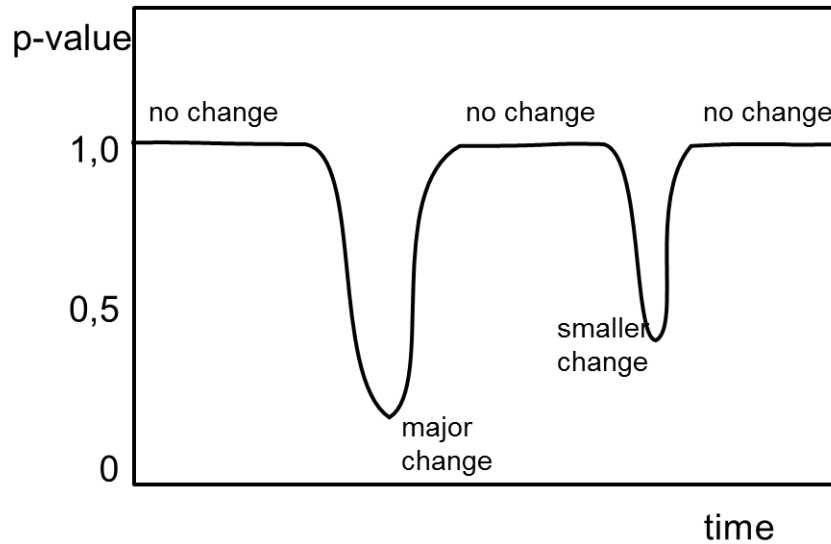


Fig. 8. The concept drift algorithm identifies periods of change in processes.

If we analyze these cases with the concept drift algorithm in the ProM software package we get the graph represented in **Fig. 9**. In this graph the five municipalities have been plotted on the same timescale and the baselines for the five municipalities have been drawn apart to clearly see the differences. Each line starts and ends at p-value = 1. Vertical lines connect the changes that more or less coincide.

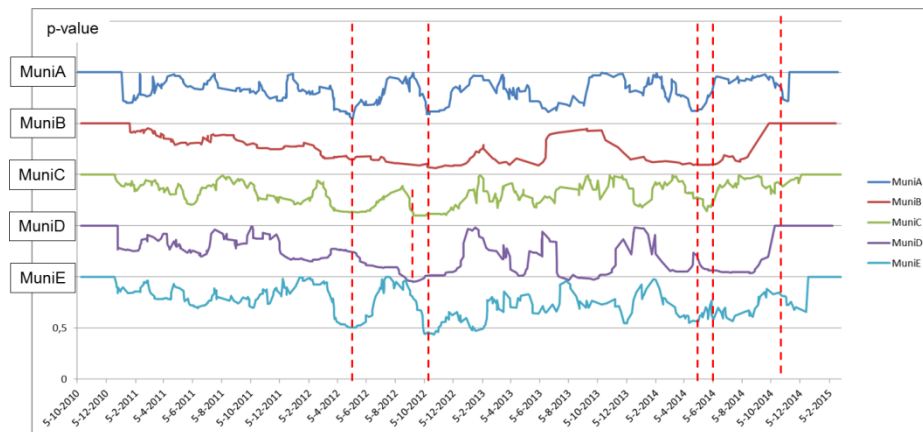


Fig. 9. Major changes in the processes in five municipalities for building permits. Possible moments in time identified using the concept drift algorithm in ProM. Drops in the line represent changes in the process.

The lines in **Fig. 9** are very different from the idealized line in **Fig. 8** in the sense that in the practice of the five municipalities the lines keep going down and up and do not very often go back to the level of $p\text{-value}=1$. This pattern is suggesting a period of continuous change. This raises the question what is the nature of the changes.

Between 1-10-2010 and 1-4-2015 there were 17 changes in the WABO-law [13] that may or may not, have influenced the procedures in the offices of the municipalities. That is an average of one change of law per quarter. It is a miracle that (/if?) the municipalities manage to distinguish for every permit application which version of the law applies. The log does not provide any information on the applicable version of the law, so we cannot see how cases and processes are affected.

The changes (drops in the line) do not occur 100% simultaneously in the five municipalities, which may be due to the fact that cases have different starting dates (possibly requiring different procedures) and different throughput times. There may also be some freedom for the municipality in the date of implementation of new rules.

Analyzing the process flow, before and after several possible changes, reveals a major change in all five municipalities in May 2012. Some activities disappeared from the log and a lot of new activities appeared in the log. Appendix 2 presents an overview of activities that do not appear after this date and activities that start appearing in the log from this date.

There are also some changes in the control flow when comparing the building applications before and after May 2012. Comparing process maps from before and after May 2012 shows for instance that the process starts in both pictures with the phase 01_HOOFD_0, but before May 2012 03_GBH_0 is one of the steps between 01_HOOFD_0 and 01_HOOFD_1, while after May 2012 this step is more frequent a side step from 01_HOOFD_0.

Many of the fluctuations in the p -value are influenced by noise that is caused by infrequent activities that are only occasionally executed, or possibly even by sudden changes in the number of cases that require this activity. Some cases do require additional steps, causing a change in the process flow compared to previous cases. This could be consistent with a more complex (and infrequent) type of building project that must be judged. There are also a number of small changes in the process flow.

7.4 Indication, but no proof, for a Change in Process Flow Because of the Merger of Two Offices

One question of the municipalities was if the process flow changed after the relocation of the office of two municipalities. One would hope to see a simultaneous dip in the lines of two municipalities in **Fig. 9**. Due to the continuous changes, this dip may be found in hindsight when the two organizations have been identified, but the graph will not tell us if and where the relocation led to changes. If we play the 5 municipalities on the animation that is shown in **Fig. 6**, we see that in MuniD the activities BB are disappearing in October 2014 (even when they remain in MuniB and in MuniE), that might be caused by the relocation but there is no proof for the cause.

8 Organizational Analysis Reveals Different Management Styles and Risks to the Viability of the Smaller Offices

In this chapter we will look into the organizational aspects of the permit application process. The municipalities want to know how the different roles of people appear from the log, if there are points for improvement and what possible consequences are from the law change in 2018.

8.1 Roles in Hierarchy Suggest Different Management Style

The log shows three kinds of roles in the organization, implying some kind of hierarchy or coordination:

- responsible resource
- monitoring resource
- resource

In organization theory it is currently fashionable to argue that a structure with less hierarchy, where responsibilities are brought to a lower level in the organization, perform better. Delaying (implying a greater span of control) would be an answer to the fact that “hierarchy as a coordinating mechanism has become too expensive and too slow” [14].

A quick glance at the numbers of the five municipalities seems to reveal a contradiction of this idea. **Table 7** shows the number of different persons in different roles for each municipality in the log. If a “responsible resource” is some kind of boss, then the log of MuniC shows more different bosses than people actually handling the permit applications. Yet we know that MuniC performs faster and with less problems than MuniB and MuniD. In MuniA the situation is hardly different from MuniC. Do we need to revise this part of organization theory?

Table 7. More chiefs than indians in MuniC?

# different persons	MuniA	MuniB	MuniC	MuniD	MuniE
responsible	21	7	20	9	8
monitoring	26	9	22	12	16
handling the applications (resource)	23	11	14	10	22

It is not clear what determines the roles for each case. From the data log appears no formal hierarchy with a division of labor over departments with heads of department:

- all cases have only one responsible actor, indicating that this is some kind of case manager.
- the relationship between resource and monitoring resource can be turned around in other cases, indicating that this relationship is no boss vs. worker relationship.

- a case may have up to 5 monitoring resources. The monitoring resource is not linked to a specific activity or specific case parts. The monitoring resource is therefore not likely to be head of a department or functional expertise.
- for many cases, the resource = responsible actor.
- for many cases, resource = monitoring resource.
- for many cases, responsible actor = monitoring resource.
- resources had up to 15 responsible actors to deal with (resource 560872 in 2011). For specific types of permits (case parts), this number is often restricted to 2 or 3.

There is however a remarkable difference between the municipalities. MuniB and MuniD (and to some extent MuniE) have a lower number of responsible actors and a lower number of monitoring resources, even compared to the size of their organization. It seems therefore that the municipalities have organized supervision differently.

Table 8. In MuniA the responsible actor is usually not the one who is doing the work

# activity	MuniA	MuniB	MuniC	MuniD	MuniE
not executed by responsible	92%	58%	58%	67%	48%
executed by responsible	8%	42%	42%	33%	52%

In MuniA there seems to be a greater separation between case responsibility and execution of activities. For only 8% of the activities (see **Table 8**) the responsible actor is executing the activity. In MuniE this is 52%. For 93% of the activities in MuniE the monitoring resource is also the responsible actor.

If we look at the different activities, we can see that a responsible actor in MuniA has no particular activities to perform himself. In MuniB on the contrary, the responsible actor is heavily involved in the BB-activities. In MuniE the responsible actor is (more than in other municipalities) involved in the execution of 01_HOOFD_450 to 01_HOOFD_490. In MuniB, MuniC and MuniD this involvement is more concentrated in the most important steps of the process.

Responsible actors do have a certain degree of specialization. In a table crossing responsible actors versus case parts, we can see that:

- many responsible actors were responsible for less than 5 cases. In MuniC only 10 out of 20 responsible actors were responsible for more than 5 cases.
- most responsible actors have one or two focusarea's (types of permits).
- the municipalities have the responsibility for a certain type of case part spread over several people, usually 3 to 5.

An analysis in WEKA with a decision tree (J48-algorithm) showed that the variables case part (first mentioned) and leges (as an indication of complexity) could predict up to 68% of the case responsables. (see **Table 9**) The results indicate a more specialized organization of responsibilities in MuniD compared to the equal size organization of MuniB. (The larger organizations will have multiple specialists which lowers the percentage of correct prediction).

Table 9. Case responsible explained by J48 based on case parts and leges, indicates more specialization in MuniD

	MuniA	MuniB	MuniC	MuniD	MuniE
% correct	45%	48%	54%	68%	53%

The monitoring of activities is rather differently organized in different municipalities. There is no information on the exact role of the monitor, but the faster municipalities have more monitoring resources per case (**Table 10**). Only qualitative research can reveal how this affects performance.

Table 10. The fastest municipalities have more different monitoring resources per case, who are more often doing the work themselves

	MuniA	MuniB	MuniC	MuniD	MuniE
average monitoring per case (persons)	2,74	1,47	2,44	1,66	1,80
resource = monitoring (% of activities)	52%	44%	49%	35%	55%

Altogether a different philosophy seems to be predominant in different municipalities. In MuniA there is a separation between execution of work and responsibility. The persons who are responsible often do not handle the applications themselves and those handling most of the activities are often not responsible for many cases. In the large team in MuniC there are only 5 people who are responsible for the major part of the cases. These people carry out a half of the work, but are assisted by colleagues who have hardly or no responsibilities. MuniD also has a small team but has a division of labor that resembles MuniA. In MuniE the responsible actors carry out about half of the work in cases that they are responsible for and another 25% in cases of their fellow responsible actors. 23% of the work is done by people who are never responsible for a case. MuniB has only a small team where the one who is responsible, gets to do the work for the most important steps in the process (objections and appeals). Responsible actors also do a lot of work for the other projects. In their team they have one resource who has little responsibility, but carries out a lot of work. Management theory apparently does not need to be revised, since the factual number of responsibles in MuniC is much lower than initially suggested and they are heavily involved in the execution as well.

8.2 Most Cases Require a Very Limited Number of Resources

Despite the huge number of different activities, the majority of cases are handled by two or three different resources (per case). For MuniB and MuniC the 50-percentile is two resources, and for the other municipalities three resources. Since there are so little people involved, no massive problems with the handover of work should be expected, but in MuniB a handover often coincides with a period of

inactivity followed by a batch of work. It is not clear if it is the handover that causes the delay or that the procedure requires additional time. The batch-processing does cause delays. MuniB has a major handover at 01_HOOFD_100, while the faster MuniC has a handover at an earlier activity (after 01_HOOFD_030).

8.3 No Strict Specialization on Phases in the Process

For every phase the municipalities have multiple resources available. For 2014 the number of resources for each phase is presented in appendix 3.

If only one or two resources are used, then this is usually for the rarest activities. Most resources work in multiple phases. Only 10716070 (MuniA) and 560594 (MuniE) concentrate on one phase only.

8.4 No Synergies Yet from Relocation of the Office or other Sharing of Resources

The Sharing of Resources between the Municipalities is Very Rare. Only five resources did substantial work for more than one municipality. This started in 2012 when 560752 worked for both MuniD and MuniE. The log data suggest that his (/her) work schedule was, that on the mornings of Wednesdays and Fridays he worked mainly for MuniD. The other days of the week were more evenly divided between MuniD and MuniE. His work for MuniE stopped altogether after Q1 of 2013.

In 2014, 560530 and 560849 worked for two municipalities. 560530 seems to have transferred from MuniB to MuniE, in May 2014 and did not work for two municipalities at the same time. 560598 originally worked only for MuniE, but during 2013 also worked for MuniB.

The sharing of resources would be a good way to increase the experience and knowledge of specialists. This only makes sense, when these specialists are effectively used for more complicated cases. However, if we look at the Case Parts (indicating the type of project for which a permit is applied for) we do not see a very strong specialization of the few resources that work for two municipalities. 560530 and 560752 were mainly occupied with bread and butter work, like building permits en tree permits.

Specialist knowledge of these resources may be used in cases of breaking the rules (Dutch: Handelen in strijd met regels RO), and for environmental permits (Dutch: milieu). If we consider the average fee (SumLeges) there is no indication of particular complex or large projects that the shared resources handle. Most fees in the projects of shared resources are below average.

560849 worked for MuniB, and started to work for MuniE as well, as of December 4, 2013. The connections between B and E could be an engagement prior to the future wedding of their offices.

Advantages of the Merger of Two Offices, Are not (yet) Being Harvested. We know from the information that was supplied with the caselogs, that two organizations have been moved to the same building. The rationale for the merger of the two organizations should be in sharing of resources and their knowledge, because hardly any advantages can be gained from sharing the coffee machine and some backoffice support.

We have seen from the contextual information that many goals are combined within one procedure. The complexity of the procedure requires more specialist knowledge than a small municipality can develop. However we see from the analysis that this has not (yet) led to the sharing of resources on a significant scale. The two organizations seem to stick to the work for their own municipality.

A reorganization of specialist work should be considered, to take full advantage of the possibilities of the merger of the two offices. Otherwise the municipalities do carry the cost of the relocation, but do not profit from the improved quality of the work.

8.5 Outsourcing of Work will Further Reduce the Workload with Risks for the Viability of MuniB and MuniD Departments

It is quite obvious that outsourcing of activities in 2018, will lead to a reduction of the workload (*ceteris paribus*). It may even reduce the need for specialist knowledge, allowing people to work on more different types of cases. The big challenge will then be to have the knowledge to judge the work of a third party that is hired by the applicant and will first of all try to serve the interest of its client.

More information is needed on the type of work that will be outsourced, to calculate the effects on the type and amount of work. It is very well possible that the municipalities have not received this information yet.

For the smaller organizations MuniB and MuniD, a reduction of the staff may reduce the scale to a level that is no longer viable. This can only be judged when it is clear what type of work will remain, which capabilities are needed and which (fluctuations in the) workload need to be absorbed. This must be seen in the light of a reducing workload during the period in the log. In 2011 a total of 1562 new cases were logged versus 1127 in 2014. This pattern was observed in all municipalities, apart from MuniD, that stayed roughly the same level.

9 Conclusions and Recommendations

As a rule, it is not possible or appropriate to draw final conclusions from a set of data, without verifying the sources of the data and discussing the meaning of the data with the organizations of the municipalities. Especially when it comes to compliance issues, no final conclusions should be drawn before further investigation. All results in this paper therefore have a preliminary status and should only be the starting point of further research into the qualitative aspects of the processes involved.

9.1 Conclusions

The main results from the analysis of the logs of the environmental permit processes of the five municipalities are:

- MuniB and MuniD were consistently slower than the other municipalities, due to batch processing, more time needed for individual phases and a great number of cases that end in the objection and appeal activities. MuniD seems to have improved recently.
- despite the fact that the process was designed by the central government, and then implemented by the different municipalities, we do see differences in the way the permit-processes are executed. In particular the way of working that leads to objections and appeals, causes a lot of extra throughput time and probably a lot of work (MuniB, MuniD, and MuniE).
- the relatively large number of cases that go to court and that require revision are a concern for MuniB and to a lesser extend for MuniE.
- reworks are a relatively small problem, but may present a small opportunity to improve.
- MuniA and MuniC seem to be citizens paradises, where permits are issued swiftly and no one fights a decision of the municipality, but the permits are not cheap.
- the involvement and number of responsible actors suggest different styles of management, with an impact on performance.
- the scale of the two smallest offices may become too small to keep the necessary expertise when work will be outsourced.
- the procedure “by law” is even used when time limits have not been exceeded and in extensive procedures, which does not comply with the procedure that was originally designed by the ministry.

9.2 Recommendations

From the analysis in this paper it is recommended to the management of the municipalities:

- to investigate the reasons for batch processing and discuss with the other municipalities how to avoid batches.
- to investigate why the procedure of permits issued “by law” (Dutch: “Omgevingsvergunning van rechtswege”) that was meant for cases where a municipality does not work fast enough and a permit is issued automatically, was invoked over 4000 times in these 5 municipalities, even while the time stamps suggest that in most cases time limits have not been exceeded.
- to investigate if the indicator for the type of procedure should be used.
- to qualitatively compare the roles of monitoring resource and case responsible and relate these to the apparent differences in performance.
- to see if the number of changes in the process can be reduced. The municipalities seem to be forced to change procedures very often to adapt to new regulations. It would be favorable if this frequency could be lowered, perhaps through their lobby association VNG.
- to swiftly implement possible synergies that could be gained after relocation of the two municipalities. Other municipalities might consider sharing specialists. Nowadays that does not necessarily require relocation.
- to investigate if the number of variants in the process flow can be reduced.
- to review if it is possible to judge all necessary aspects of an application within several minutes, as suggested by the log of several cases and/ or if the logs are fabricated afterwards.
- to consider to use the indicator for regular or extensive procedure, in the registration, to be able to monitor the proper and timely handling of the application.
- to organize a cleanup of all the codes and descriptions that are used in the log. There are currently several codes with identical descriptions, e.g. 01_HOOFD_ + 790/800/820 all refer to “close case/zaak afsluiten”.

10 Methodological observations

For the interested reader, some experiences are evaluated in the context of the challenges from the process mining manifesto [16].

10.1 Inserting Markers Helps to Get a Clear Picture, But Some Problems Must Be Dealt with

The experiences in this case study, show that the trick to visualize different flows using markers, appears to have several advantages in the way that it helps improving usability and understandability for non-experts (challenges 10, 11 from the process mining manifesto):

- comparing two processes from different organizations (challenge 7) can be done much faster than by replaying the data of one process on the petrinet of the other process, especially in a complex process (like this case) when the variety in the process causes many bypasses in the petrinet.
- using markers one can use a fast and easy to use software package like Disco, rather than the complicated and slow ProM-software.
- a process flow with activities and resources as building blocks gives far more insight than the abstraction of a handover-of-work network or subcontracting network, both with respect to control flow as well as performance metrics.

There are also some problems, that must be dealt with:

- a problem may arise when the different cells that are compared, contain a very different number of cases. The paths in the cell with more cases can become dominant and the level of detail in the representation of the other cell will go down. This problem can be solved by random oversampling of the cases: randomly duplicating cases in order to get the same number of cases in each cell. With a powerful computer one could even duplicate the whole log several times to get to roughly the same number of cases in each cell. That should be neutral to the controlflow and performance indicators, but the animation would have to be played with the original dataset, to avoid visual traffic jams that do not exist in reality.
- concept drift over time (challenge 4) produces a problems when two time periods are compared and cases run from the first to the second period. This can be dealt with by using two periods that are well separated in time, and taking out the longest cases. Two periods can be animated simultaneously by subtracting a fixed amount of time from all timestamps in the second cell. The algorithm for concept drift in ProM is very useful for identifying the moments of sudden changes in a process. It is hard to establish these moments using only different process maps.

10.2 Contextual Information Helps to Identify those Parts of the Process that Really Matter to the Success of the Organization

Process mining is a discipline with huge potential. The power of the mining analysis can be leveraged by the extensive use of contextual information to judge the relevance and impact of processed data. The contextual information adds a weight to figures that would otherwise remain very abstract and meaningless.

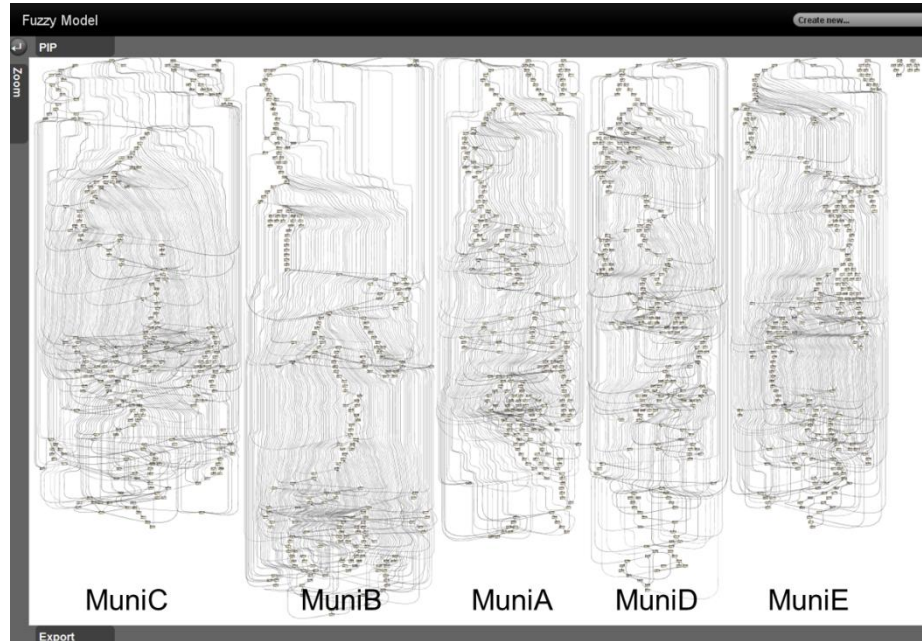


Fig. 10. “When we understand that slide, we’ll have won the war.”²
Process compared for 5 municipalities (building permits only). Contextual information is essential to select the right details.

Process mining (cl)aims to show what is really going on in an organization. In a process that is complex by design and nature, that results in a dilemma of either losing detail and not see what is really going on or getting a very complex process map as in **Fig. 10**.

Only by adding meaning from contextual information, it is possible to zoom in on the right part of the process and keep the desired level of detail.

² Quote from General Stanley McChrystal, NATO Commander in Afghanistan, after he got presented a slide of even lower complexity analyzing the situation in Afghanistan [17].

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Appendix 1: Variables in the log

variable	description
Case ID	a unique case number,
Activity	a short description in English
Resource	a number representing an employee; 72 different persons
Complete Timestamp	a date, and sometimes a time of completion of this activity
(case) IDofConceptCase	often empty
(case) Includes_subCases	yes/no, often empty
(case) Responsible_actor	a number representing an employee; 64 different persons
(case) SUMleges	the amount of money paid for the permitapplication, often empty
(case) caseProcedure	normal or extended, often empty
(case) caseStatus	Open (O) or Closed (G)
(case) case_type	a number that is the same for all activities in the log
(case) landRegisterID	a number, often empty
(case) last_phase	the last activity in the log for the case
(case) parts	a short description of the type of permit (building, demolishing, advertising,etc)
(case) requestComplete	true or false
(case) termName	not explained, often empty
action_code	a code for the type of activity, indicating position of the activity in the order of the process, eg 01_HOOFD_250_1
activityNameNL	a short description of the activity in Dutch
concept:name	not explained
dateFinished	a date, and sometimes a time of completion of the last activity for this case
dateStop	not explained, usually empty
dueDate	not explained, usually empty
lifecycle:transition	technical formality, Complete, to relate timestamp to the end of the activity
monitoringResource	a number representing an employee; 79 different persons
planned	a date/time, not explained, often empty
question	not explained, usually empty

Appendix 2: Activities that Do Not Appear after May 2012 and Activities that Start Appearing in the Log from May 2012.

ending activities		new activities	
01_HOOFD_060	regular procedure without MER	01_HOOFD_061	start WABOprocedure
		01_HOOFD_110_1	treat subcases completeness
		01_HOOFD_110_2	subcases completeness completed
		01_HOOFD_190_1	regular procedure applies
		01_HOOFD_190_2	enter senddate procedure confirmation
		01_HOOFD_196	procedure change after completeness
		01_HOOFD_250_1	treat subcases content
01_HOOFD_260	completed subcases content	01_HOOFD_250_2	completed subcases content
01_HOOFD_490_2	decision date prior to decision	01_HOOFD_490_2	generating decision environmental permit
		01_HOOFD_492_0	create subcases present decision
		01_HOOFD_492_1	treat subcases present decision
		01_HOOFD_492_2	subcases completed present decision
		01_HOOFD_493	enrich decision
		01_HOOFD_494a	phase decision ready
		01_HOOFD_510_3	enter senddate decision environmental permit
		01_HOOFD_510_4	enter senddate decision
		01_HOOFD_515	phase decision sent
		01_HOOFD_516	date decision for inspection
		01_HOOFD_814	phase archived case
01_OLO_120	send message OLO-status in progress	01_HOOFD_815	phase case handled
01_OLO_140	message request advice	08_AWB45_025	phase asked additional information
01_OLO_160	message change status	08_AWB45_045	phase additional information received
01_OLO_180	message change status	08_AWB45_050	send confirmation receipt additional data
01_OLO_190	message change status	16_LGSD_010	calculate final charges
01_OLO_240	message change status	16_LGSV_010	calculate provisional charges

Appendix 3: Resources Working per Phase

phase	MuniA	MuniB	MuniC	MuniD	MuniE
01_BB_5	5	3	1	1	7
01_BB_6	6	3	3	2	6
01_BB_7	5	5	4	2	9
01_HOOFD_0	9	8	7	5	13
01_HOOFD_1	12	8	8	6	11
01_HOOFD_2	11	7	7	5	10
01_HOOFD_3	11	7	7	4	9
01_HOOFD_4	10	8	8	5	12
01_HOOFD_5	8	7	6	4	10
01_HOOFD_8	7	7	6	6	11
01_OLO_1					1
02_DRZ_0	7	7	7	4	9
03_GBH_0	1	3	5	3	3
03_VD_0	3	2	3	2	3
04_BPT_0	9	8	7	4	12
05_EIND_0	1	4	3	2	5
06_VD_0	3	2	4	2	3
07_OPS_0	3		3	1	1
08_AWB45_0	12	8	8	6	10
08_AWB45_1	1	4	1	4	5
08_OLO_1				1	
09_AH_I	10	7	7	4	9
10_UOV_0	6	7	6	5	7
10_UOV_1	2	3	1	2	4
10_UOV_2		2		1	
11_AH_I	10	8	7	5	10
11_OLO_1					1
12_AP_0	5	2	4	2	4
12_AP_U	2	1	1	2	4
13_CRD_0	10	8	7	5	10
14_VRIJ_0	2			1	11
14_VRIJ_1		1			2
16_LGSD_0		4		2	6
16_LGSV_0		4		3	3
99_NOCODE_0		4		3	4