Discovery and analysis of the Dutch permitting process

BPI Challenge 2015

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Abstract. The BPI Challenge is an annual process mining competition, in which the participants are provided a real-life event log. This year's event log includes all events related to the permitting process of five Dutch municipalities, over a period of approximately four years. The municipalities would like to gain insights in their organizational structures and process-oriented differences. Therefore, we analyzed the event logs using a combination of process mining techniques and tools, including MS Excel, PowerPivot, PowerQuery, Disco and ProM.

Keyword: BPI Challenge, Process Mining, Event logs, Permitting process

1. Introduction

A major task Dutch municipalities face is public housing. Municipalities construction permits do not only ensure that construction activities take place in the right places and in accordance with zoning plans, but also that the houses built meet the strict safety standards such as those for fire safety and avoidance of noise pollution. [1]

The challenge for the municipalities is to deliver construction permits in a more transparent, easier, faster, safer, and cheaper way. In this context, five municipalities have asked to help them give insight in their organizational structure and process flow. [2] In order to answer the process owner's question we used the following approach:

In our first step we gained an understanding of the permitting process, the dataset as well as the problem statement. This understanding forms the basis for our further analysis and interpretations. Next, we did some data exploration in order to get a first insight in the dataset whereafter we started with the analysis. Our analysis is structured in line with the questions of the process owner and our conclusion can be found in the management summary.

We made use of a combination of process mining tools and BI tools, Disco (Fluxicon) and ProM respectively Excel PowerPivot and PowerQuery. We used Disco for process discovery purposes and ProM for social network analysis. PowerPivot and PowerQuery were mainly used for data exploration and visualization.

2. Management summary

Based on our analysis, we made several observations that could give the process owner further insight in the permitting process. We identified differences between the five municipalities which may the basis for improvement via the help of standardization, simplification, harmonization and automation.

In the main process flows of the municipalities, we noted that they are mostly performing the same activities, though it is in a different sequence. Especially in municipality 5 we found differences. This municipality performs activities like “procedure suspension” and “requests of additional information” in the main process flow, which are inefficiencies that could be removed by looking at the best practices of the other municipalities. We identified municipality 3 as the most efficient one, and therefore recommend to further analyze its process in order to see to what extent the best practices of this municipalities can be adopted by the other ones.

In line with this observation and following our results, we believe municipalities 2 and 3 have moved to the same physical location which had a positive impact on municipality 2. The average case duration in the municipality shows a decreasing trend after the adoption of municipality 3’s process. Continuing on the performance of the process flows, we noted no clear bottlenecks except for the lodging of objections which mainly occurs in municipalities 2 and 5. Depending on the municipalities, different paths take more time than other. Our results can be found in Appendix A and used for

further analysis. Important to note is that a lot of activities are performed instantly which may indicate the administrative actions are not properly recorded by the resources but that they perform a bulk update of the system status.

On the organizational level, we noted a signifcant number of isolated resources. If these resources only bring limited value to the process, we recommend to analyze the possibility to reassign them. Furthermore, the social network analysis showed that no clear roles can be assigned to the resources. Therefore, we also recommend to define clear roles and responsibilities in order to avoid that cases get stuck at resources that do not know which activities need to be performed. Also in the context of outsourcing, the reassignment of resources may be an important topic.

In conclusion, we can say that there are a number of possible improvement points both on process level and organizational level. However, cooperation with the process owner is necessary to verify the results and identify concrete actions that can be taken.

3. Our understanding

From the information provided by the BPI Challenge 2015 (BPIC'15), we understand that five Dutch municipalities would like to gain fact-based insight in their permitting process. They want to evaluate to what extent improvements and alignment between municipalities are possible.

In order to help the municipalities realizing this goal, we first needed to gain an insight in the different aspects of the optimisation exercise: the process, the problem and the data.

2.1 Process understanding

The framework for building rules and standards in The Netherlands is provided by the Housing Act. Under the Housing Act, municipalities issue building permits, supervise construction work and check permit applications for new developments against the Building Decree.

The building permit application, submitted to the municipality, must be accompanied with the necessary fees and documentation, including design plans, photos and pertinent reports. Processing time for building permits is regulated; by law, if the assessment is not processed within a fixed period, the permit must be approved. However, the responsible authority has the right to extend assessment time.

There are two types of permitting procedures:

- The regular procedure (i.e. reguliere procedure) for minor construction work like affixing of publicity, chopping trees, …
- The extensive procedure (i.e. uitgebreide procedure) for more complex construction, including environmental licensing activities.

Fig. 1 illustrates the process following DCMR, the environmental protection agency of local regional authorities in the Rijnmond region.

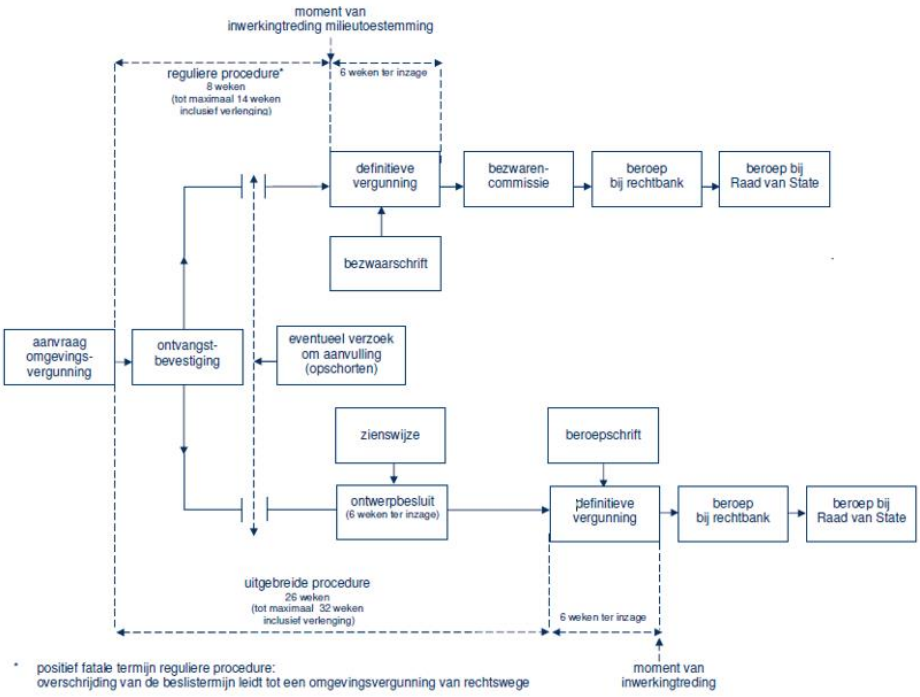


Figure 1. Process map of the Dutch permitting process (http://www.dcmr.nl)

2.2 Problem understanding

The building regulations are developed and streamlined at national level. Therefore, the processes in the five municipalities should be identical. However, it is possible that they differ because of changes to procedures, rules or regulations that were pushed to the municipalities at a different time.

In order to identify best practices and align their activities as much as possible, the municipalities raised a number of questions related to the process flow and to their organizational structure.

The following questions were raised:

- Process flow
  - Where are differences in throughput times between the municipalities and how can these be explained?
  - What are the differences in control flow between the municipalities?

- Organizational structure
  - What are the roles of the people involved in the various stages of the process and how do these roles differ across municipalities?
  - What are the possible points for improvement on the organizational structure for each of the municipalities?
  - 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?
  - 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?

2.3 Data understanding

Five event logs are provided, one for each participating municipality:

- **Municipality 1** - Log 1: 1199 cases, 52217 events, 398 event classes, 10.4121/uuid:a0addfda-2044-4541-a450-fdcc9fe16d17.
- **Municipality 2** - Log 2: 832 cases, 44354 events, 410 event classes, 10.4121/uuid:63a8435a-077d-4ece-97cd-2c76d394d99c.

- **Municipality 3** - Log 3: 1409 cases, 59681 events, 383 event classes, 10.4121/uuid:ed445cdd-27d5-4d77-a1f7-59fe7360cfbe.
- **Municipality 4** - Log 4: 1053 cases, 47293 events, 356 event classes, 10.4121/uuid:679b11cf-47cd-459e-a6de-9ca614e25985.
- **Municipality 5** - Log 5: 1156 cases, 59083 events, 398 event classes, 10.4121/uuid:b32c6fe5-f212-4286-9774-58dd53511cf8.

All log files have the same format. Each row in the log files represents a particular step or event in the permitting process. An example of such an event is “Register submission date request”. For each of these events several data attributes are available, like the employee ID of the resource who performed the event, the type of permit, etc. In Table 1. we give a full overview of the provided data attributes including our understanding based on the provided information by the BPIC’15 and further research on the internet.

Table 1. An overview of the available data attributes.

Event log permitting process	
Field	**Our understanding**
Case ID	The identifier of the permit application. The case identifier is necessary to distinguish different executions of the process.
Activity	The activity is a combination of the action code and the status of the activity: action code\\status. For example, 01_HOOFD_375\\complete.
Resource	The employee number of the person who executed the activity. If the employee number is the same in different event logs, we can assume it concerns the same person.
Complete Timestamp	The time at which the activity is completed. The timestamp is needed to bring the events in the right order.
case IDofConceptCase	Data attribute unclear.
case Includes_subCases	Indication whether the case contains subcases or not. If there are subcases, the value is equal to "J" (i.e. Yes). If not, the value is "N" (i.e. No).
case Responsible_actor	Data attribute unclear.
case SUMleges	Cost of the application.

case caseProcedure	Type of procedure. There are two types of procedures (see 2.1). If the case went through the regular procedure, the value is "Regulier". If the case went through the extensive procedure, "Uitgebreid".
case caseStatus	Data attribute unclear. *Three possible values: G, O and T.*
case case_type	Data attribute unclear.
case landRegisterID	The land registry code is the cadastral identifier of the land.
case last_phase	The status of the process. Possible values are "Aanvraag ontvangen" (Request received), "Beschikking verzonden" (Decision sent), etc.
case parts	Type of permit. Possible values are "Bouw" (Building permit), "Inrit/Uitweg" (Entrence/Exit), "Kap" (Felling permit), etc.
case requestComplete	Indication whether the application is complete (i.e. all necessary information available). If all information is available, the value is "TRUE". If extra information is needed, the value is "FALSE".
case termName	The category of term within which the activity falls. Possible values are "Termijn bezwaar en beroep" (Objections and Complaints), "Termijn tot besluit verlengd" (Decision deadline extended), etc.
action_code	The code of the activity. Each activity code consists of three parts: two digits, a variable number of characters, and then three digits. The first two digits and the characters indicate the subprocess the activity belongs to. The last three digits hint on the order in which activities are executed, where the first digit often indicates a phase within a process.
activityNameEN	The name of the activity in English.
activityNameNL	The name of the activity in Dutch.
conceptname	Data attribute unclear.
dateFinished	See Complete Timestamp. Note however that there are small differences between these timestamps.
dateStop	Data attribute unclear.

dueDate	The deadline for the municipality to announce and notify the requestor of the permit decision.
lifecycletransition	The status of the activity. The event log only contains activities that are completed.
monitoringResource	The name of the supervisor of the permit application. The person responsible for follow-up of the progress and compliance of the permit application.
planned	The time by which the municipality has planned to announce its decision and communicate to the requestor.
question	Indication whether a question has been asked/ communicated to the requestor. Possible values are the timestamp of communication or the comment itself.

The data contains all building permit applications over a period of approximately four years. Depending from municipality, the event log starts in 2009 or 2010 and ends in 2015. From the data attributes, we derived that the event logs contain both running and completed cases. Because we are focusing on discovery and enhancement of the process, we evaluated that only historical data and thus, completed cases are relevant to us.

4. Analysis of the process

As outlined in our approach, we first did some data exploration in order to get a general insight in the data. We uploaded the .csv files as provided by Fluxicon into PowerPivot with the help of PowerQuery. PowerQuery allowed us to append the files so that we could easily compare data from different municipalities. Furthermore, we loaded the files into Disco in order to discover the process flows.

After our data exploration, we performed some more in depth data analysis. We made a distinction between the analysis of the process flow and the analysis of the organizational structure. Per question of the process owner we provide an overview of our analysis and results.

3.1 Data exploration

As explained in the previous section, we decided to only take into account the completed cases. Therefore, we first set an attribute filter on *case last_phase*. We assumed that the following statusses are end statusses:

- Beschikking gereed, i.e. Decision ready
- Beschikking verzonden, i.e. Decision sent
- Besluit genomen, i.e. Decision taken
- Besluit onherroepelijk, i.e. Irrevocable decision
- Besluit vernietigd, i.e. Decision annulled
- Vergunning geweigerd, i.e. Permit refused
- Vergunning onherroepelijk, i.e. Irrevocable permit
- Vergunning verleend, i.e. Permit granted
- Vergunning vernietigd, i.e. Permit annulled
- Zaak afgehandeld, i.e. Case finished
- Zaak archiveren, i.e. Case archived

Table 2. Basic facts about the BPIC'15 dataset (only completed cases).

Fact	Municipality 1	Municipality 2	Municipality 3	Municipality 4	Municipality 5
% Completed cases	78%	82%	72%	80%	86%
% Events	88%	91%	81%	88%	92%
Number of events	46.336	40.474	48.377	42.070	54.479
Number of cases	943	690	1.020	850	998
Number of variants	888	630	884	731	866
Number of activities	280	274	264	226	276
Median case duration	9 weeks	16,6 weeks	5,7 weeks	15,6 weeks	11,2 weeks
Mean case duration	14,3 weeks	23,6 weeks	9,1 weeks	18 weeks	13,9 weeks
Start eventlog	6/10/2010	8/10/2010	1/01/2010	18/11/2009	23/11/2009
End eventlog	9/03/2015	4/03/2015	5/03/2015	4/03/2015	3/03/2015
Number of resources	21	11	11	10	19

Based on the statistics from Table 2, we could calculate the average number of events per case. Comparing the five municipalities, we noted no significant differences. The average number of events per case lies between 47 and 55. In the median case duration, however, there are significant differences with a range between 40 days and 16,6 weeks (i.e. 116 days). We noted that these values are moderately correlated (r = 0,67), meaning that the case duration is likely to increase/decrease when the number of events increases/decreases.

When looking at the average number of events per month, we noted that it is the highest in the municipalities with the most resources, i.e. municipalities 1

and 5. This is also evident from the correlation coëfficient between those measures. The number of resources available and the number of events per month are highly correlated (r = 0,88). However, this does not mean that municipalities with more resources are more efficient. For example municipalities 2 and 4 have approximately the same amount of resources available (11 and 10) and median case duration (16,6 weeks and 15,6 weeks), yet municipality 2 executes on average 10 events more per case. Another notable observation is that municipality 3 processes as much cases as municipality 5 with only half the number of the resources.

We also compared the main process flows of the different municipalities, which we generated in Disco. Figure 2 shows that the process maps are equally complex and going through a lot of activities (around 40). At first glance, the processes seem similar as expected by the process owner. Furthermore, we noted in Table 2 that almost all cases follow a unique path. For almost every case there is a unique variant. For example in municipality 1 there are 943 cases and 888 variants.

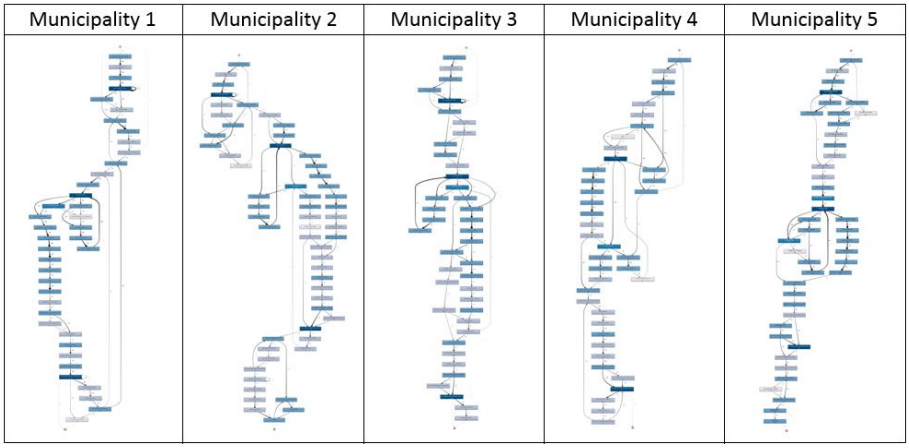
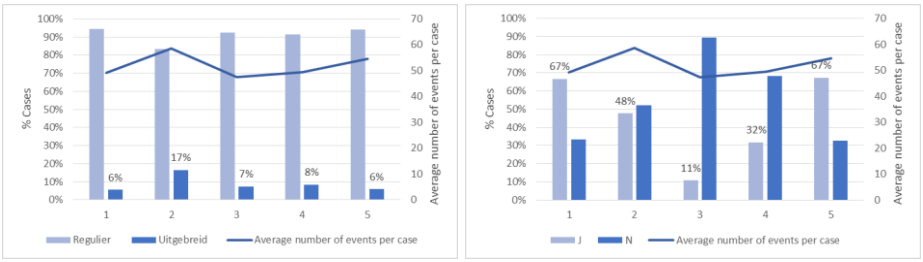


Figure 2. Visualization of the main process flows of the municipalities. The process maps are generated in Disco by moving the 'activities' and 'path' slider all the way down to 0%.

Based on our understanding of the process, we would expect that the average number of events per case is higher for municipalities with more extensive cases. In order to further explore this, we loaded the csv. files as provided by Fluxicon into PowerPivot and appended them via PowerQuery. This way we could generate a graph showing the percentage of cases per type of procedure

per municipality (Fig. 3). However, we noted that in 90% of the case the related field *case caseProcedure* was blank, which indicates a low level of data quality. Nevertheless, in order to get a meaningful graph, we assumed that the procedure followed is regular if the field *case caseProcedure* is blank. As can be seen, the graph does not confirm our expection unambiguously. In municipality 2, the amount of extensive cases is indeed notably higher than in the other municipalities. However, in municipality 5 the amount of extensive cases is rather low while the average number of events per case is also higher.



a. Type of procedure b. Includes subcases

Figure 3. a. Percentage of cases per type of procedure and b. percentage of cases with (J) and without (N) subcases per municipality compared to the average number of events per case.

Another possible reason for a higher number of events per case may be the existance of subcases or not. We generated the same type of graph, but now based on the field *case Includes_subCases*. This field as well has a notable number of blank values (21%). Here we assumed that there are no subcases if the value is blank. Also from this graph, we cannot draw an unambiguous impact pattern.

In summary, we made the following observations:

- Almost all cases follow a unique process path.
- The number of resources available has a high impact on the number of events that can be performed in a certain timeframe.
- There is no clear link between the complexity of cases and the complexity of the process flow followed.

3.2 Data analysis: Process flow

What are the differences in control flow between the municipalities? In our data exploration, we had a first look at the process maps of the five municipalities (Figure 2). These process maps as well as the main activities were further analyzed in order to answer the first question of the process owner: *What are the differences in control flow between the municipalities?*

As expected by the process owner, the main process flow is slightly identical in the five municipalities. From our analysis, we derived that the process goes through a number of phases. We identified the following three main phases:

1 Municipality receives permit application
2 Municipality performs a number of checks on the request requirements (information completeness) and determines procedure applicable
3 Competent authority evaluates permit application and decides on permit

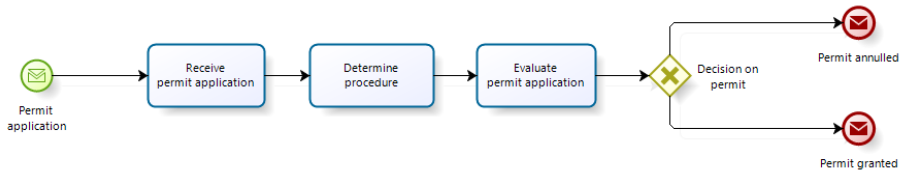


Figure 4. High level process flow of the permitting process. Process map created in Bizagi based on our observations from the process maps.

To answer the question, we will further elaborate on the differences per phase. In the first phase, we noted no differences. In order to receive an application, all municipalities perform the same 5 activities:

1 Register submission date request
2 OLO messaging active
3 Phase application received
4 Send confirmation receipt
5 Enter senddate acknowledgement

Also in the second phase, we noted few differences. We noted that in all municipalities the WABO (Wet Algemene Bepalingen Omgevingsrecht) procedure is followed, which allows that multiple permits related to one project are bundled into one environmental permit. The application is sent to the competent authority, who determines whether the regular or extensive procedure needs to be followed. The competent authority evaluates both the

completeness and content of all subcases of the permit application. Once all subcases are handled and the applicable procedure is confirmed, the evaluation phase can start.

The main difference we noted in this phase, is that municipality 5 sometimes need to request further information to complete the request which is not the case in the main processes of the other municipalities.

In the last phase, the process flow is also relatively similar across the municipalities. However, on subprocess level, we noted an important difference. When the permit decision is taken and communicated to the stakeholders, they can log an objection against it. In 2 municipalities (i.e., 2 & 5), we noted that this objection process is included in the main process flow indicating that it occurs relatively more often than in the other municipalities. This may have several reasons:

- More complex regulations;
- Less competent resources;
- More assertive applicants;
- …

To summarize, we have the following findings:

- The permitting process in the different municipalities is relatively identical;
- The main process flow activities – subprocesses not taken into account – are largely identical;
- Municipality 5 executes an extra (hidden) activity in comparison with the other municipalities: request further information;
- In municipalities 2 and 5, the main process flow includes the 'appeals and objections' process.

The impact of these findings on the performance of the process will be further analyzed in the following subsection.

Where are differences in throughput times between the municipalities and how can these be explained?

We started from the same process maps as in the previous section with that difference that we changed the values from frequency values to performance values. We decided to use the median duration as performance measure because this measure is less influenced by outlying measurements than the mean duration.

We approached this analysis in the same way as for the differences in the control flow. We valuated the performance per phase in the process. For the first phase, we noted no differences in the control flow. However, this is not the case for the duration. The duration ranges between 1,4 days and 5 days. This is fully determined by the path between *register submission date request* and *OLO messaging active*. All the other paths executed in the first phase are completed instantly as can be seen from Figure 5.

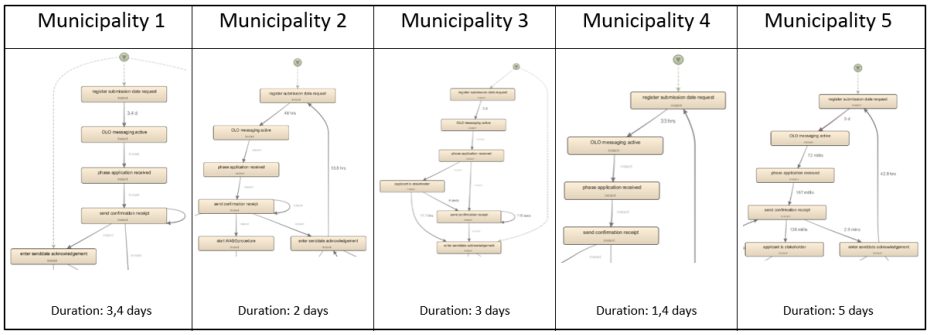


Figure 5. Process maps of the first phase in the permitting process, shown in mean duration.

In municipalities 5 it takes the longest to effectively receive an application, despite that it is one of the municipalities with the most resources. We noted no clear indication to why the duration varies.

As can be seen, the main process flow includes activity *"OLO messaging active"*. OLO is the online platform for submitting applications and therefore, cases submitted through OLO are considered more efficient. However, looking at the facts, there appears to be a positive instead of a negative correlation (r = 0,94) between the mean duration of the receival and the percentage of cases received through OLO (i.e., going through activity "received through OLO").

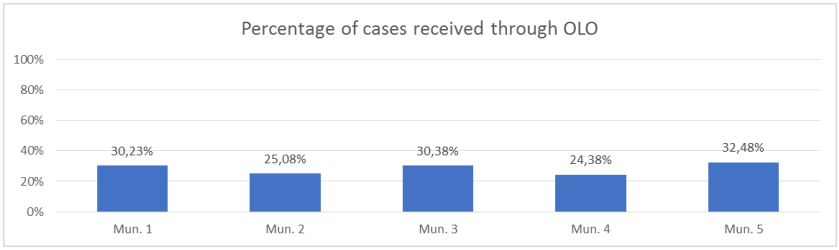
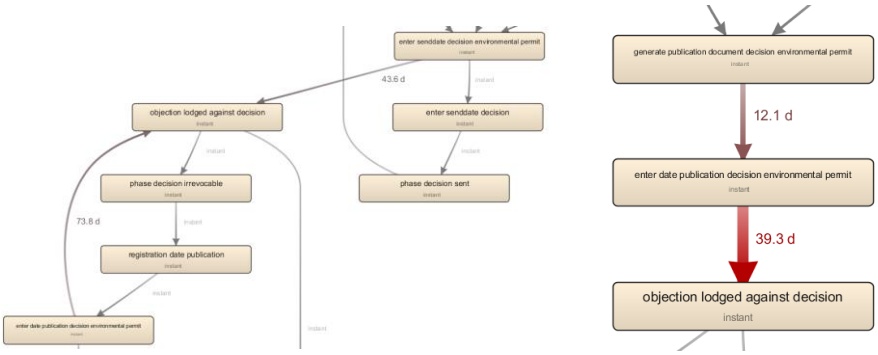


Figure 6. Overview of the percentage of cases received through OLO per municipality. The percentage is calculated based on the total number of cases for which OLO messaging was active.

Just like in the first phase, there are no clear bottlenecks (thick red arrows) in the second phase of the process. We assume the second phase starts after the activity *"Phase application received*" and ends with the activity *"Request complete".* We had a closer look at the paths in this second phase in order to determine whether there are any significant differences between the municipalities.

We noted that in municipality 5 the time spend across the paths is more equally spread than in the other municipalities. In the other municipalities, there is always one path that takes significantly more time than the others. For example, in muncipality 1 the time to complete activity *"treat subcases completeness"* takes 22,1 days while the other activities are executed instantly. A full overview of performance differences can be found in Appendix A.

In the third phase we noted a significant difference in the control flow, which is also reflected in the performance. In municipalities 2 and 5, the lodging of objections is included in the main process flow, which has an average impact on the median duration of 59 days respectively 39 days. In municipality 5 the process map clearly shows this is a bottleneck, as the path is presented as a thick red arrow. In municipality 2 it is considered less as a bottleneck, as there are more paths that take lots of time. For example, the activity to *"treat subcases completeness"* has a median duration of 34 days.



a. Muncipality 2 **b**. Municipality 5

Figure 7. Extract of the objection lodging path from the process maps of municipality 2 (a) and 5 (b).

3.3 Data anlaysis: Organizational structure

For the analysis of the organizational structure we made use of ProM 5.2.1. We converted the Disco file as provided by Fluxicon into MXML files. Just like in our previous anlaysis, we only looked at the completed cases. We made use of the social networking plug-ins, among which the Social Network Miner, Organizational Miner and SNA analysis techniques.

3.3.1 What are the roles of the people involved in the various stages of the process and how do these roles differ across municipalities?

We used the DST (Doing Similar Task) Miner in order to identify the roles of the resources. However, for all municipalities there was only one group identified (minedGroup0). Figure 8 shows the organizational model of municipality 1. This indicates that there are no clear roles assigned to the resources. The same model applies for the other municipalities.

Figure 8. The organizational model of municipality 1 mined through the DST (Doing Similar Task) miner in ProM 5.2.1.

Another approach we used to identify possible roles in the municipalities, is the Advanced Dotted Chart Analysis. Note that we used all cases, also the

running cases, to perform this analysis. From the Log Summary, we derived that in each municipality more than 200 different activities are performed. This high number of different activities makes the Dotted Chart Analysis diffucult to interpret. Therefore, we bundled the activities per phase and (sub)process. As indicated in Section 2.3, the action code contains information on the (sub)process and phase within the (sub)process. For municipality 1 this reduces the number of activities from 289 to 38, which makes the graph more clear.

The resources and timeline are mapped on the x-axis, respectively the y-axis. A dot on the chart represents an activity and each activity has a dedicated color. Activity 01_HOOFD_1 is red for example. Based on the color mapping it can be identified which resources perform similar tasks. The Dotted Chart for municipality 1 is shown in Figure 9.

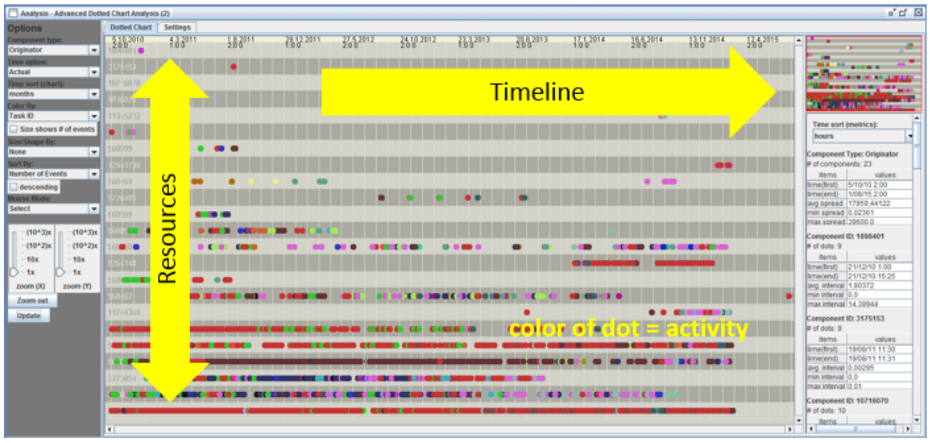


Figure 9. Dotted Chart Analysis of municipality 1 generated via ProM 5.2.1

In contrast to the organizational model, this graph does show similarities between resources. We noted that there are different groups of resources that perform similar activities. An overview of these groups is given in Table 3.

Table 3. Overview of resource groups identified with the help of the Dotted Chart Analysis in Figure 9.

Group	Resource	Main activity	# Activities	Time (first)	Time (end)	Avg. interval (days)	Min. Interval (days)	Max. interval (days)
1	9264148	01_HOOFD_0	973	23/01/2014	13/01/2015	0,4	0	57
	560925	01_HOOFD_0	1782	6/10/2010	24/03/2014	0,7	0	98
	560912	01_HOOFD_0	5346	13/10/2010	5/03/2015	0,3	0	41,5
	560872	01_HOOFD_0	12117	5/10/2010	9/03/2015	0,1	0	20
2	560890	01_HOOFD_5	7399	19/10/2010	27/02/2015	0,2	0	36
3	3273854	01_HOOFD_4 08_AWB45_0 08_AWB45_1	9075	5/01/2011	29/10/2013	0,1	0	28
	2670601	01_HOOFD_4 08_AWB45_0 08_AWB45_1	9886	7/10/2010	14/10/2014	0,1	0	32,3

In order to get a better insight in the roles, we then had a further look at the activities under the main activity. Under 01_HOOFD_0 for example, the following activities are performed: register submission date request, send confirmation receipt, forward to competent authority, etc. Based on this information, we identified the following roles:

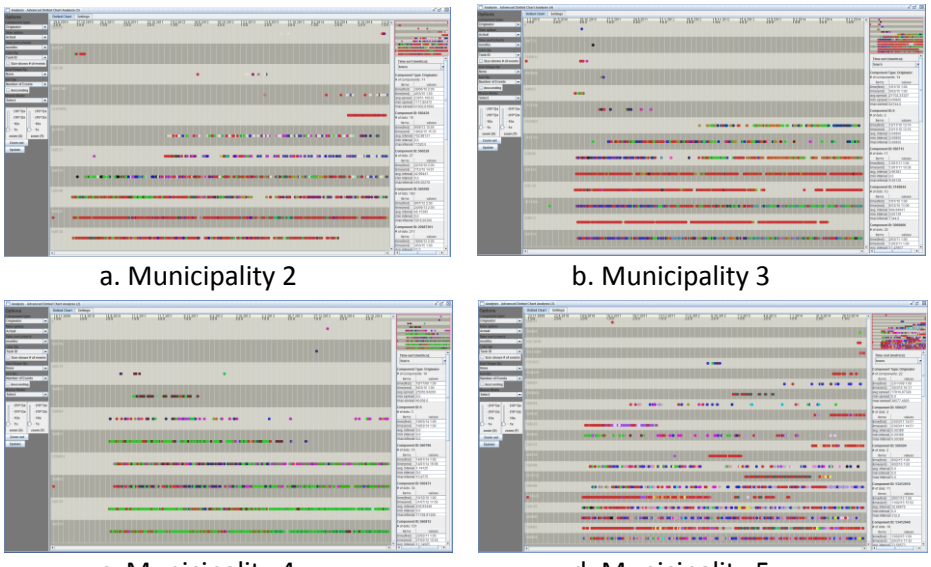
- **Role 1**: resources responsible for receiving permit applications, i.e., town clerks (administrative activities)
- **Role 2**: resources responsible for the communication and publication of the decision, i.e., correspondent
- **Role 3**: resources responsible for making the environmental permit decision, i.e., expert (content-related activities)

Looking at the Dotted Charts of the other municipalities, shown in Figure 10, the trend is relatively the same. In each of the graphs there is at least one resource that is dominated by one color and thus, performs a certain main activity. We assume that these resources represent the town clercks. In municipality 5, the town clercks are more difficult to identify, because his/her activities (predominantly red) are more interrupted. When applying a different sorting setting, we also note that municipality 5 operates in a significant different manner than the other municipalities. Over time, we noted much more resource rotation as can be seen from Figure 11.

In none of the municipalities, there is a clear correspondent like in municipality 1. From this, we can conclude that there are 2 main roles: the town clerck who performs the administrative tasks and the expert who performs the content-related activities.

Other observations that can be made from the Dotted Chart are:

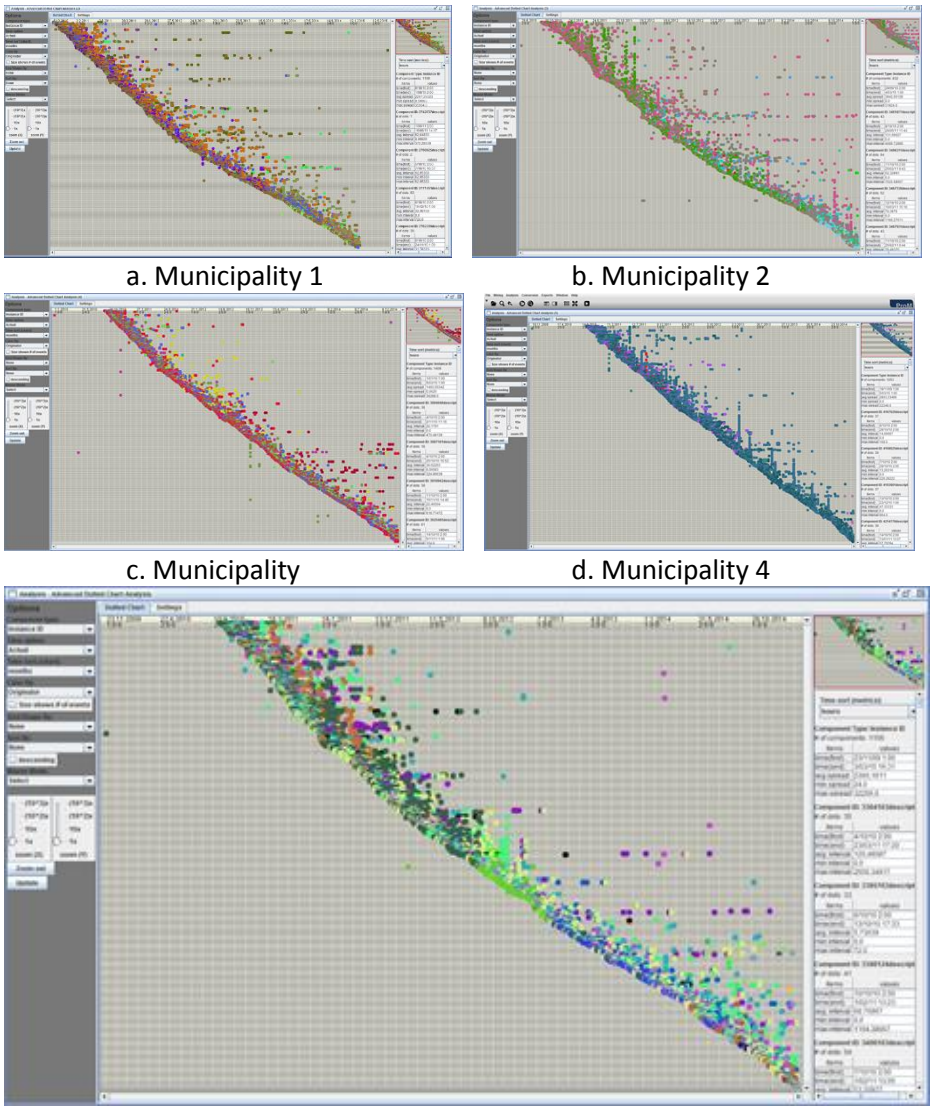
- Some resources perform different kind of activities over time. In municipality 3 for example, resource 560696 performed blue-coloured activities in the beginning of the period and started to perform more green and orange-coloured activities in the middle of the period. We did not further specify these activities.
- Some resources started later than others. In municipality 2 for example, resources 4634935 and 560521 started only at the beginning of February 2012 while most of the others started one year earlier.
- Some resources only perform a limited number of activities, widely spread over the period. In municipality 4 for example, resource 560431 performed 2 activities almost 1,5 years apart from each other.



a. Municipality 2 b. Municipality 3

c. Municipality 4 d. Municipality 5

Figure 10. Extract of the Dotted Chart Analysis for (a) municipality 2, (b) municipality 3, (c) municipality 4 and (d) municipality 5.



a. Municipality 1

b. Municipality 2

c. Municipality

d. Municipality 4

e. Muncipality 5

Figure 11. Extract of the Dotted Chart Analysis of the different municipalities with on the x-as the actual timeline, on the y-as the cases and with the color of the dot being the resource.

3.3.2 What are the possible points for improvement on the organizational structure for each of the municipalities?

In order to identify improvement points in the organizational structure, we used the Social Network Miner. This plug-in allowed us to determine how individual cases are routed between resources. We used the following 3 techniques [7, 8]:

- **Subcontracting**: This technique determines which resources subcontract other resources. It is assumed that individual i subcontracts individual j, when inbetween two activities executed by individual i there is an activity executed by individual j.
- **Handover of work**: This technique determines who passes work to whom. The technique is similar to subcontracting. However, in subcontracting the relationship between the resources is bidirectional and in handover of work it is unidirectional. There is handover of work when the first activity is completed by one individual and the second one is completed by another individual.
- **Working together:** Two individuals work together if they perform activities in the same case of an event log. This technique only counts how frequently individuals work in the same case.

The mined social networks are shown in Figure 12. We then also calculated a number of centrality metrics [8] in order to determine which resources are advantaged in the network. In Table 4 the centrality metrics for municipality 1 are given.

Following the degree centrality metrics, the most powerful resources in the network are 560872, 560890 and 560912. Following the betweenness centrality metrics, the most powerful resource is 2670601. We identified the first three resources as town clercks, which confirms the general insight that highly connected people often are assistants because they are responsible for both the preparation and completion of documents, in this case permit applications. The betweenness centrality is a different kind of power. Resources with betweenness centrality can influence contacts among other resources, for example isolate resources or prevent certain contacts.

Table 4. Overview of the centrality metrics of municipality 1 per type of social network analysis.

	Subcontracting			Handover of work			Working together		
Node Name	In Degree	Out Degree	Betweenness	In Degree	Out Degree	Betweenness	In Degree	Out Degree	Betweenness
6	0	0	0	0	0	0	0,0952381	0,0952381	0
560462	0,04761905	0,0952381	8	0,23809524	0,23809524	0,4	0,52380955	0,52380955	5,004761905
560464	0,04761905	0	0	0,14285715	0,1904762	0,2	0,3809524	0,3809524	14,66666667
560589	0,04761905	0	0	0,14285715	0,1904762	0	0,2857143	0,2857143	0
560872	0,2857143	0,2857143	61,5	0,61904764	0,61904764	5,621111111	0,7619048	0,7619048	3,280952381
560881	0,04761905	0	0	0,23809524	0,2857143	10,33333333	0,52380955	0,52380955	4,576190476
560890	0,1904762	0,14285715	23,5	0,5714286	0,47619048	1,8233333	0,8095238	0,8095238	5,047619048
560894	0,04761905	0,04761905	0	0,2857143	0,1904762	0,45	0,42857143	0,42857143	1
560912	0,14285715	0,0952381	10	0,52380955	0,47619048	4,376666667	0,8095238	0,8095238	6,824285714
560925	0,14285715	0,1904762	20,5	0,23809524	0,42857143	3,166666667	0,6666667	0,6666667	4,777619048
560950	0,04761905	0,04761905	0	0,23809524	0,0952381	0	0,42857143	0,42857143	4,2
1898401	0	0	0	0	0	0	0,23809524	0,23809524	0
2670601	0,14285715	0,23809524	30	0,5714286	0,5714286	41,599999	0,7619048	0,7619048	38,47619048
3175153	0	0	0	0	0	0	0,04761905	0,04761905	0
3273854	0,04761905	0,14285715	5	0,33333334	0,3809524	6,133333333	0,47619048	0,47619048	4,571428571
4936828	0	0	0	0,04761905	0,04761905	0	0,23809524	0,23809524	0
5726485	0	0	0	0,04761905	0	0	0,1904762	0,1904762	0
9264148	0,04761905	0	0	0,14285715	0,2857143	0,4	0,33333334	0,33333334	10,66666667
10716070	0	0	0	0,04761905	0	0	0,04761905	0,04761905	0
11345232	0	0	0	0	0,04761905	0	0,14285715	0,14285715	0
11744364	0,04761905	0,04761905	0,5	0,2857143	0,1904762	1	0,2857143	0,2857143	0,333333333

We calculated the same metrics for the other 4 municipalities. Just like the Dotted Chart Analysis, the Social Network Analyses indicate the same trend across the municipalities. However, there is no significant difference between the metrics of the town clercks and the experts. The only clear observation we can make is that there are a number of resources with centrality metrics equal to zero, which means that they do not have links with any other resources. This is also clearly shown by the isolated nodes in the social network models. Furthermore, it can be seen in the Dotted Chart Analysis that these isolated nodes match with the resources who perform a limited number of activities.

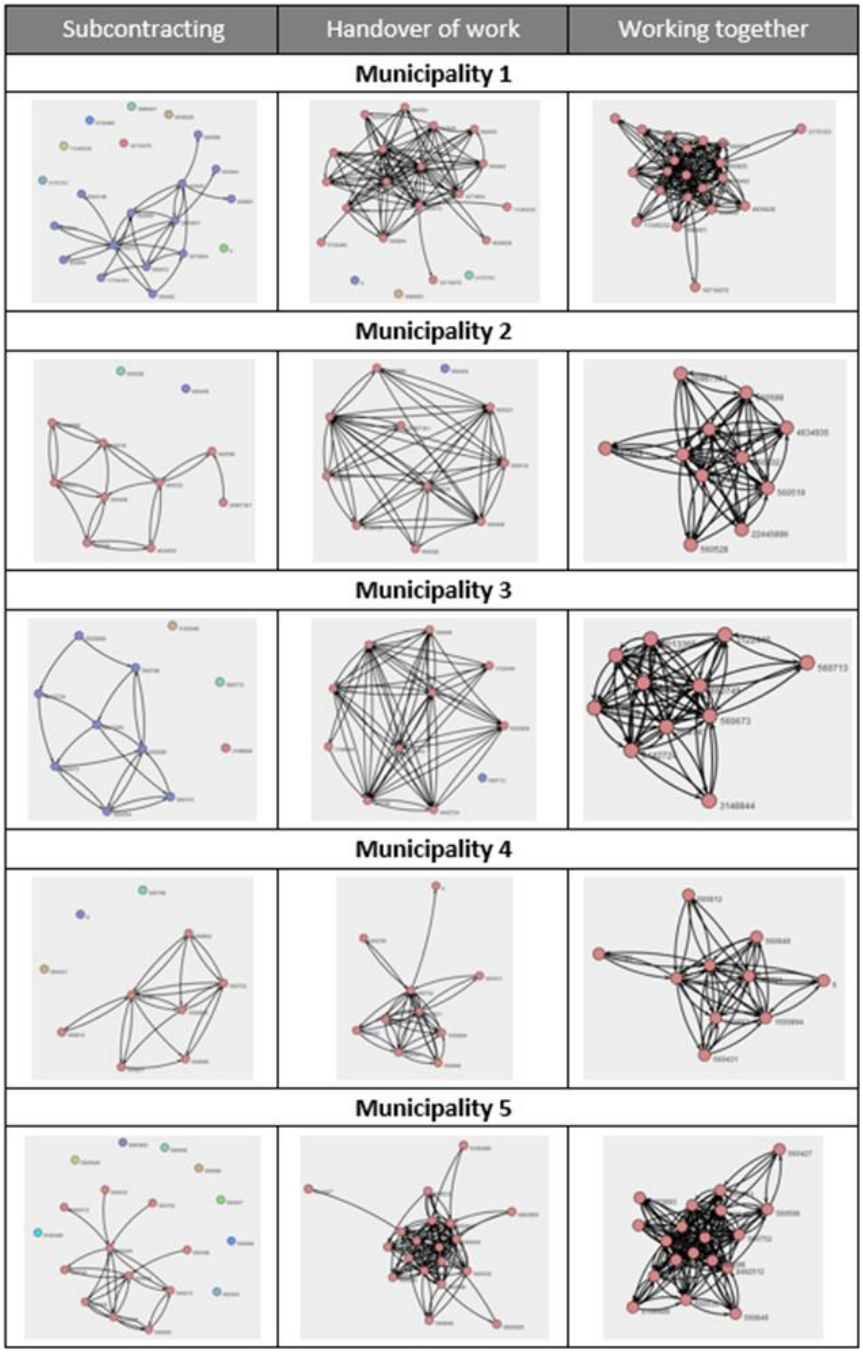


Figure 12. Overview of the Social Network Models generated with the use of the Social Netwerk Miner in ProM 5.2.1.

The existence of isolated nodes is not necessarily an issue, but might indicate that there are resources that bring limited value to the network. We investigated whether these isolated resources perform very specific activities, but this was not the case. We noted that the activities they performed are activities that are also performed by other resources. Especially in the subcontracting model, isolated nodes are significantly present. The isolated resources in the subcontracting models are shown in Table 5.

Table 5. Overview of isolated resources per municipality.

	Isolated resources
Municipality 1	3175153, 11345232, 5726485, 1898401, 10716070, 4936828, 6
Municipality 2	560528, 5560429
Municipality 3	3122446, 560713, 3148844
Municipality 4	560431, 6, 560796
Municipality 5	9106499, 6925826, 6993893, 560608, 560596, 560427, 560849, 560594

Based on our observations we believe improvement is possible in the following areas:

- Assignment of cases to dedicated resources. We noted that several town clercks work on the same cases. It might be interesting to assign ownership of a case to one town clerck.
- Reassignment of resources. We identified a number of isolated resources, who possibly add limited value to the process. It might be interesting to assign those isolated resources to a different role or different department in order to increase there value-adding.

3.3.3 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?

The question suggest that the move took place not long ago. We assumed that it took place not longer than 6 months ago. With the help of the Timeframe filter in Disco, we were able to compare the process flows of the municipalities over time. When selecting the timeframe between 01/01/2015 and the end of the period in scope, we noted that the process flows of municipalities 2 and 3 were almost completely identical. The process maps are available in Appendix B.

We mapped the two process flows next to each other in order to compare them in dept. The layout of the process flows for cases started since 01/01/2015 is exactly the same. Furthermore, both process flows contain the same number of activities (i.e., 40 activities). Of these 40 activities, 39 are the same and 1 differs. In municipality 2, activity "*Create monitoring case oversight*" is performed while in municipality 3, activity "*Enter senddate acknowledgement*" is performed.

Concerning the sequence in which the activities are executed, there are more differences. Different blocks of activities could be identified, which are listed in Table 6.

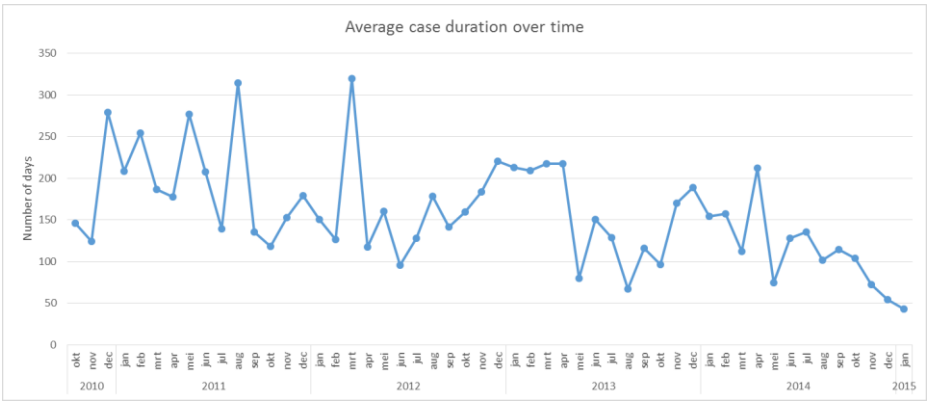
Table 6. Overview of activity blocks identified in the process maps of municipalities 2 and 3.

Block	Color (in Appendix)	Activities
1	Yellow	1 Request complete 2 Article 34 WABO applies 3 Suspension ground applicable 4 Coordination of application
2	Green	1 Set decision status 2 Decision date prior to decision 3 Generating decision environmental permit
3	Light blue	1 Submit decision 2 Phase decision ready

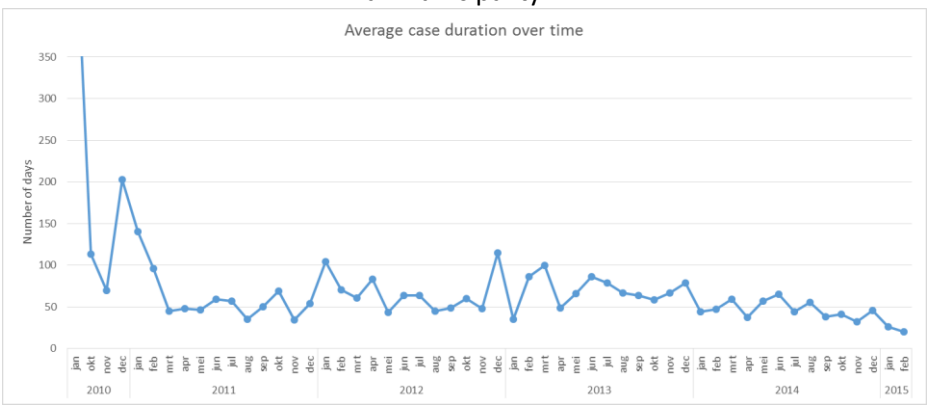
Within the same block, the activities are always performed in the same sequence. However, the blocks as a whole are performed in a different sequence. In municipality 2 they follow sequence 2-3-1, while municipality 3 performs the blocks in sequence 1-2-3.

Most of the activities from Table 6 are performed instantly. Except the time to go from activity "*Coordination of application*" to the next activity is significantly higher in both process flows (approximately 5 days). Because of these similarities, we consider that the activities are relatively interchangeable and that the process followed is identical. Thus, we derived that municipalities 2 and 3 adopted the same process flow since 01/01/2015. This may indicate that they moved to the same physical location at that time.

In our data exploration, we noted that municipality 3 is the most efficient municipality in that sense that it has the lowest median case duration. Furthermore, we noted that municipality 3 is able to handle as much cases as municipality 5 with almost half the number of resources. Based on this observation, we would expect that municipality 2's performance increases by adopting the same process flow as municipality 3. In order to verify this expection, we compared the average case duration over time, as shown in Figure 13.



a. Municipality 2



b. Municipality 3

Figure 13. Average case duration over time in (a) municipality 2 and (b) municipality 3.

From the graphs in Figure 13, we see that the average case duration of municipality 3 is more stable. In municipality 2 there is a clear decreasing trend at the end of the period in scope, which is in line with our expectation. The

decreasing trend starts around September – October 2014, during which the preparation phase of the merge may have started.

3.3.4 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?

Lastly, the process owner wants to know the impact of outsourcing on the current organizational structures. We understand that the outsourced activities should be performed before submitting the application to the town clerck. This means that the resources will not have new interactions with external parties. There will only be an impact on the internal connections.

The administrative tasks of receiving the application and publishing the decision will still have to be performed by the town clerck. We therefore assume that the outsourced activities concern content-related activities related to evaluation of the application (completeness and content of the subcases). The experts will have to perform less activities in that case, which will have an impact on their interactions within the organizational structure.

Outsourcing of activities may also lead to reassignment of resources or in other words, resources leaving the social network. We assume that there are 3 types of resources [6]:

- **Leader**: If the this resource is a leader, i.e., it has a high degree centrality, then its connections to other resources are also deleted but a network should exhibit at least one leader.
- **Mediator**: If the resource is a mediator between resources, i.e., it has a high betweenness centrality, then its existing connections are also deleted but they should in some way persist through a new selected mediator.
- **Other**: If the resource has no role, i.e., it is neither a leader nor a mediator, then its connections are also deleted but no substitute is needed because the resource is not enough important to identify a substitute.

As outlined in Section 3.3.2 there are no clear leaders and mediators, as both the town clercks and experts have high degree centrality and betweenness centrality. Whether a town clerck or expert leaves the social network, both should be replaced. In case one of the isolated resources, which can be

categorised as resources of type Other, leaves the network the impact is much less as it does not need to be substituted.

In Figure 14 an overview is given of possible situations that may happen when a resource is removed from the network. An existing leader/mediator may take over the role of the leader/mediator that left, one of the other resources may become the new leader or there may emerge new interactions.

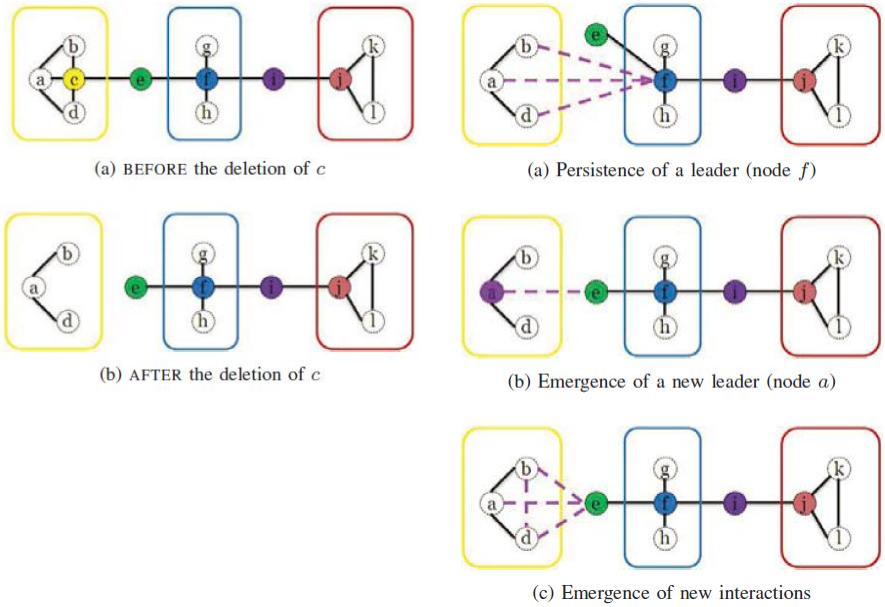


Figure 14. Overview of possible situations if a resource leaves a social network.

Except for the isolated resources, all the resources have connections with each other. We therefore assume that the most likely situation is that an existing resource is taken up by an existing resource. In the Dotted Chart Analysis we could see that this should not be an issue, as there are in all municipalities at least two resources performing the same type of activities who can probably act as each others substitutes.

5. Bibliography

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6. Appendices

Appendix A. Performance analysis

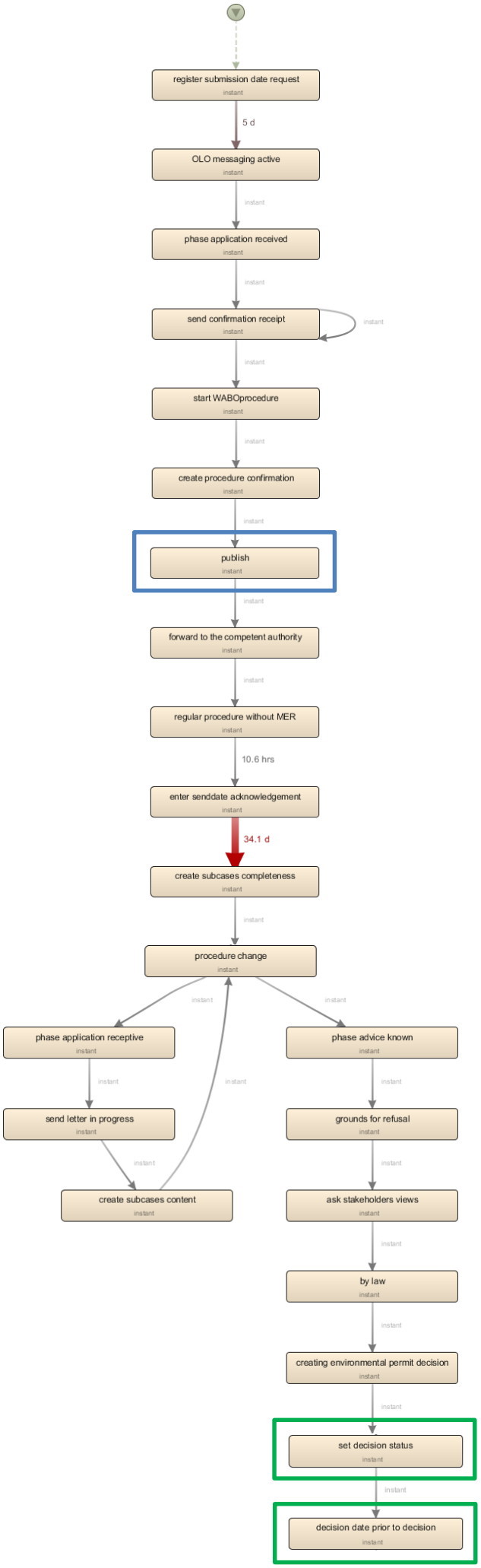
Action code	Activity	1	2	3	4	5
01_HOOFD_010	register submission date request	Start	Start/13,8 hours	Start	Start	Start
01_HOOFD_011	OLO messaging active	3,4 days	2 days	3 days	1,4 days	5,3 days
01_HOOFD_015	phase application received	instant	instant	instant	instant	instant
01_HOOFD_020	send confirmation receipt	9 sec	instant	40 sec	instant	30 sec
01_HOOFD_030_	enter senddate acknowledgement	instant	6,15 hours	Start/5,6 hours		instant
01_HOOFD_050	applicant is stakeholder		instant	instant		instant
01_HOOFD_050	inform BAG administrator					3 sec
01_HOOFD_061	start WABO procedure	3 sec	instant	8,5 days	instant	
01_HOOFD_065_	create procedure confirmation		instant	instant	instant	
01_HOOFD_040	forward to the competent authority	1,333 sec	1 sec	5,1 days	2 sec	2 sec
01_HOOFD_060	regular procedure without MER	instant	1 sec	instant	3 sec	instant
01_HOOFD_065_	send procedure confirmation	2 sec			instant	17 sec
01_HOOFD_065_	enter senddate procedure confirmation	Start/instant			5,2 hours	instant
01_HOOFD_090	publish				instant	
01_HOOFD_101	registration date publication	11 sec				3 sec
05_EIND_010	terminate on request		instant			
16_LGSV_010	calculate provisional charges		instant			
06_VD_010	extend procedure term					1 sec
01_HOOFD_540	suspend term					instant
01_HOOFD_110_	create subcases completeness		34,4 days	4 days	instant	
01_HOOFD_110	treat subcases completeness	22,1 days	instant		instant	2 sec
01_HOOFD_110_	subcases completeness completed	2 sec	1 sec			1 sec
01_HOOFD_180	procedure change	1,5 sec	instant	2 sec	instant	instant
15_NGV_010	request further information					instant
01_HOOFD_195	phase application receptive	1 sec	instant	instant	5,3 days	instant
01_HOOFD_196	procedure change after completeness	1,5 sec				

Action code	Activity	1	2	3	4	5
01_HOOFD_200	send letter in progress	0,5 sec	instant	instant	instant	instant
01_HOOFD_250_	create subcases content		instant		instant	
01_HOOFD_250	treat subcases content	1 sec		1 sec		1,5 sec
01_HOOFD_250_	completed subcases content	1 sec	instant	1 sec		1 sec
01_HOOFD_190	request complete	3 sec	1,5 sec	3 sec	2 sec	1,5 sec
09_AH_I_010	article 34 WABO applies	1 sec	instant	1,5 sec	instant	instant
01_HOOFD_370	assessment of content completed	1 sec	instant	1 sec		instant
01_HOOFD_265	phase advise known	instant	instant	instant	instant	instant
01_HOOFD_380	grounds for refusal	1 sec	instant	2,5 sec	instant	instant
01_HOOFD_430	ask stakeholders view	1 sec	instant	2 sec	instant	instant
01_HOOFD_470	suspension ground applicable	2 sec	instant	2 sec	instant	instant
13_CRD_010	coordination of application		instant	instant	instant	
16_LGSD_010	calculate final changes		instant			
01_HOOFD_480	by law	1 sec	instant	1 sec	instant	instant
01_HOOFD_490_	creating environmental permit decision	instant	instant	instant	instant	instant
01_HOOFD_440_	set decision status		instant	instant	instant	
01_HOOFD_490_	decision date prior to decision	3 secs	instant	instant	instant	
01_HOOFD_490_	generating decision environmental permit	instant	instant	instant	2,5 days	3,3 min
01_HOOFD_490_	record date of decision environmental permit	5 sec	instant	24 hours	9,6 hours	
01_HOOFD_490_	set decision phase decision permitting decided			instant	instant	
01_HOOFD_491	submit decision	instant	instant	instant	instant	
01_HOOFD_490_	register date environmental permit decision					2,5 days
01_HOOFD_494a	phase decision ready		instant	instant	instant	
01_HOOFD_495	phase decision taken	6 sec	instant	instant	instant	10,1 hours

Action code	Activity	1	2	3	4	5
01_HOOFD_500	register objection and appeals periods	instant	instant	instant	instant	
01_HOOFD_510_	creating cover letter decision		instant	instant	instant	
01_HOOFD_510_	transcript decision environmental permit to stakeholders	51,5 sec	instant	instant	instant	2 sec
01_HOOFD_510_	start decision phase decision permitting sent		instant	instant	instant	
01_HOOFD_510_	enter senddate decision environmental permit	2 sec/End	1,5 min	instant/End	7,1 days/End	instant
01_HOOFD_510_	enter senddate decision	instant	instant	instant	instant	
01_HOOFD_515	phase decision sent	instant	instant	instant/End	instant	
01_BB_540	objection logged against decision		58,7 days			34,7 days
01_BB_765	set phase decision revoked					6 sec
01_BB_770	set phase: phase permitting irrevocable		5,9 hours			instant/End
01_BB_775	phase decision irrevocable		instant			
01_HOOFD_790	register deadline		4 sec			instant
01_HOOFD_101	registration date publication		instant			
01_HOOFD_520	generate publication document decision environmental permit					5 sec
01_HOOFD_099	create publication document	4 sec				
01_HOOFD_530	enter date publication document decision environmental permit		instant			12,6 days
01_HOOFD_809	read publication date field		instant			
01_HOOFD_516	date decision for inspection	7,6 days/End				
01_HOOFD_811	stop all running subcases 2b		instant			
01_HOOFD_814	phase archived case		instant			
01_HOOFD_815	phase case handled		instant			
01_HOOFD_790	close case		1,5 sec/End			3 sec/End

Appendix B: Process flows of municipality 2, respectively 3 based on cases started after 01/01/2015

(see next pages)


register submission date request
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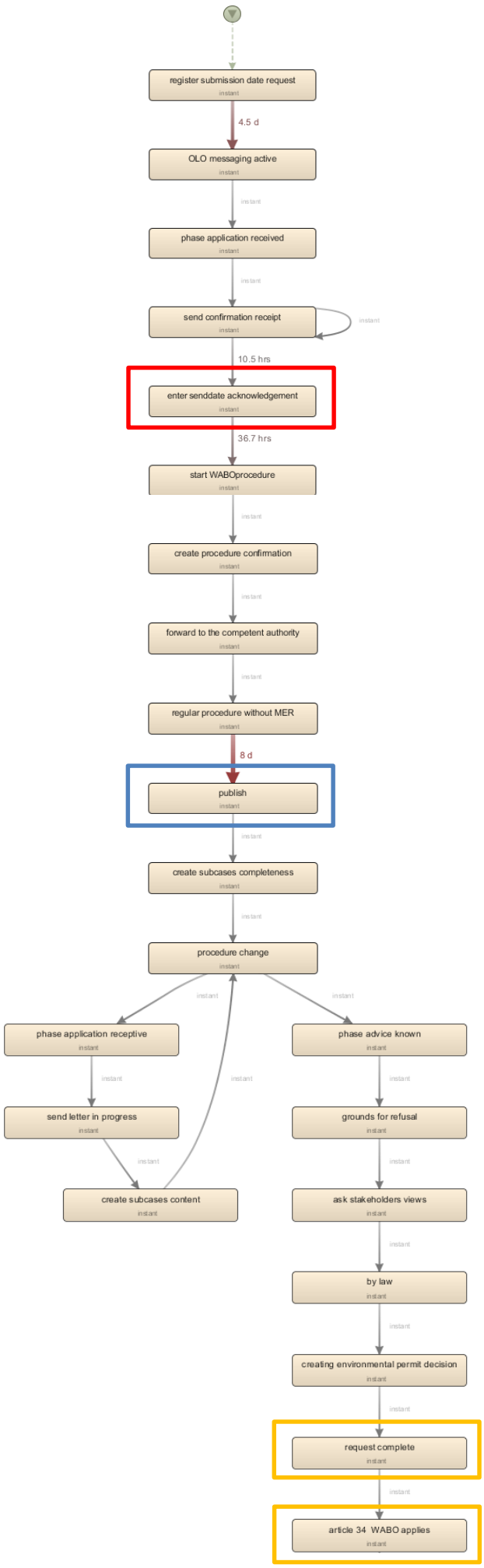
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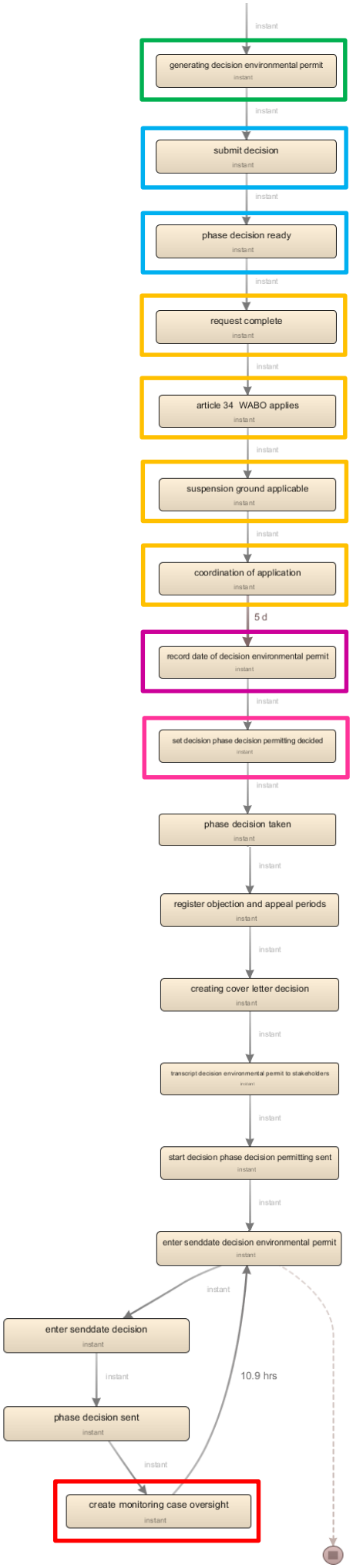
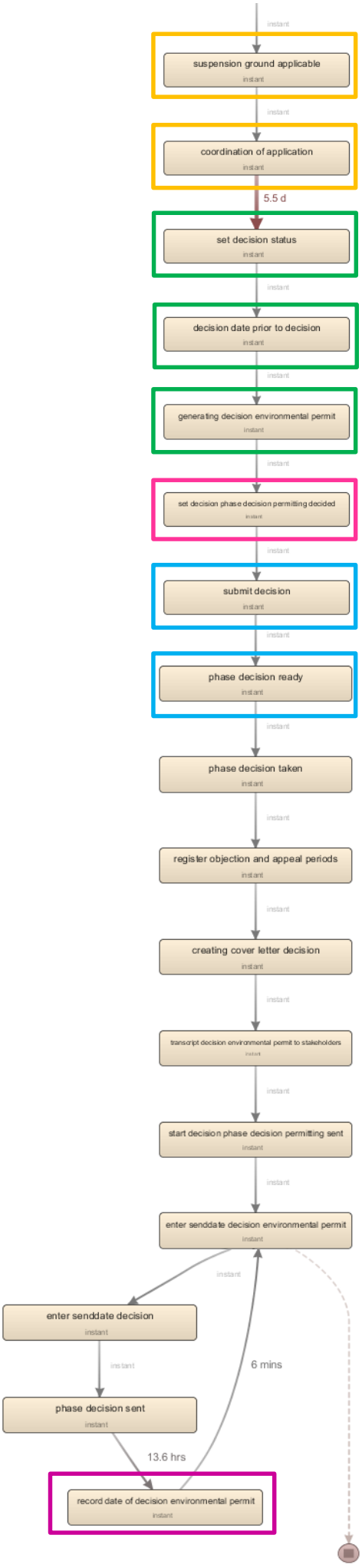

instant
generating decision environmental permit
instant
submit decision
phase decision ready
request complete
article 34 WABO applies
suspension ground applicable
coordination of application
5 d
record date of decision environmental permit
set decision phase decision permitting decided
phase decision taken
register objection and appeal periods
creating cover letter decision
transcript decision environmental permit to stakeholders
start decision phase decision permitting sent
enter senddate decision environmental permit
enter senddate decision
phase decision sent
10.9 hrs
create monitoring case oversight


instant
suspension ground applicable
coordination of application
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set decision status
decision date prior to decision
generating decision environmental permit
set decision phase decision permitting decided
submit decision
phase decision ready
phase decision taken
register objection and appeal periods
creating cover letter decision
transcript decision environmental permit to stakeholders
start decision phase decision permitting sent
enter senddate decision environmental permit
enter senddate decision
phase decision sent
6 mins
13.6 hrs
record date of decision environmental permit