# Elapsed Times in Criminal Justice Systems

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## ABSTRACT

An important determinant for the well-functioning of a criminal justice system is elapsed times. The elapsed time of a case is the period that is required to handle a case that pertains to a suspect or convict. Long elapsed times may be interpreted as delays in a criminal justice system, which in turn may lead to "justice delayed, justice denied". Such a development may undermine the public trust in the government. Therefore insight in elapsed time is of crucial importance for policy-makers to define a sound and healthy justice policy. To gain this insight, we propose a model to measure the elapsed time of criminal cases.

The task of measuring elapsed times in the justice domain is not straightforward. Some challenges have to be taken into account before elapsed time can be measured. These include the type of case that is being processed, choosing the starting and finishing point of a criminal case, and integrating data pertaining to a criminal case from different sources. We propose a pragmatic approach to measuring elapsed times, which takes these challenges into account. As an example, we show how the elapsed times of criminal cases in the execution phase of the justice system can be calculated. This example also illustrates the effect of two different calculation methods on the measured elapsed times.

## Categories and Subject Descriptors

C.4 [**Computer Systems Organization**]: Performance of systems – *Measurement techniques.*

## General Terms

Algorithms, Design and Theory, Management, Measurement, Performance

## Keywords

Criminal Justice System; Elapsed Time; Heterogeneous Data Sources; Chain Management

## 1. INTRODUCTION

The Dutch criminal justice system operates as a chain of interdependent organizations, where each organization within the chain is responsible for carrying out certain tasks regarding the different stages in this system: investigation, prosecution, trial and execution. For example the police, who are at the beginning of the chain, are responsible for upholding law and order, investigating criminal cases and arresting people who break the law. The Public Prosecution Service is responsible for prosecuting the suspects brought in by the police, while the courts may convict or acquit a suspect and impose sanctions. The sanctions are carried out by prison facilities, fine agencies or probation services.

To gain insight into the functioning of the justice system, the performance of the organizations in the chain and the whole system should be measured. Common performance measurements are for example, the output (e.g. the number of criminal cases processed in a certain period) or the average elapsed time to process criminal cases in an organization.

Elapsed times relate to one of the key objectives for the justice system: to be effective and efficient. To achieve a well-functioning criminal justice system all the primary work processes in the system have to be timely, smooth, and reliable. In practice, this is not always the case. Often long elapsed times are involved. For example, when someone is arrested and taken into custody by the police, it takes time to investigate the crime and to gather evidence before the suspect can be brought before court. The court usually holds several hearings for complex cases before giving the verdict and these hearings may be days, weeks or even months apart depending on the complexity of the case and the available capacity. Also, in a chain of organizations it is important to have agreements on working and transfer times that are honoured by all parties. Otherwise, when an organization fails to adhere to these agreements this immediately delays the work process, and consequently affects the performance, of the next organization in the chain.

Long elapsed times may be interpreted as delays in a criminal justice system, which in turn may lead to "justice delayed, justice denied". The elapsed time of a case is built up from several time-components, such as waiting, transfer and working times. Especially, long waiting times are an unwanted phenomenon. While it may not be possible to avoid them all together, since a process must follow a certain course through the system, it may be possible to reduce them. Measuring elapsed times is desirable from the viewpoint of multiple stakeholders: the suspect and the victims (if any), the justice organizations involved and the government. In Section 2 we elaborate on the relevance for several stakeholders.

Measuring the elapsed times of criminal cases is not a straightforward task, because there is much variation in the course that a criminal case or suspect can take through the system. For example, not all cases that enter the public prosecution service are sent in by the police or are brought to court. It is therefore often difficult to determine how long it takes from the moment a case or suspect enters till it leaves the system. Additionally, measuring the elapsed time of a case involves data on events that reside in the different information systems of each partner [11]. These data have to be integrated. This will be explained further in Section 4.



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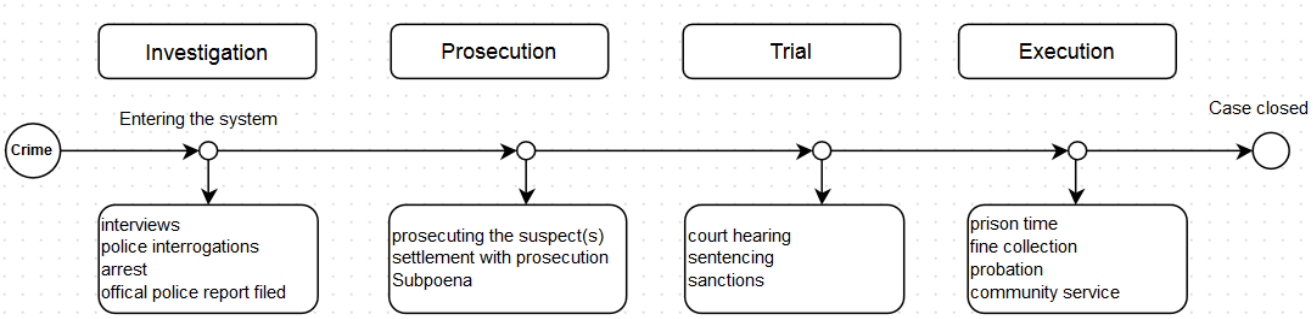


**Figure 1** ***Stages in the criminal justice chain***

Our goal is to design a model to measure elapsed times for the criminal justice system. This gives policy-makers and organizations insight into the elapsed times of suspects or cases and helps them to reduce any delays where possible. A model is a mapping of reality. To estimate a model, reliable and good quality data are required. Since, these data are not always available, we present a pragmatic approach. As an example we measure the elapsed times of cases in the execution stage of the system. Through this example we show how to apply two different methods to compute the elapsed times of multiple criminal cases and compare the results of these two methods.

Various studies show that the mean elapsed time of processing cases in certain stages of the justice system have a continuing long-term trend towards increased duration, see, for example, [1]. A large part of the elapsed time of criminal cases is waiting time [10, 12]. Only a small part of this waiting time results from legal procedures. A study on the length of court proceedings in the E.U. member states addressed some reasons for delays [4]. The study argues that the causes of delay in the justice system, and thus long elapsed times of criminal cases, are structural problems relating to the organization of the Public Prosecution Service, decisions to join or not to join criminal cases in court, failure of witnesses to attend hearings and the dependence of civil proceedings on the outcome of criminal proceedings.

These studies show the importance of gaining insight into the elapsed times of criminal cases. Methods to gain this insight have been applied in the context of scheduling entities (e.g., judges, defendants, and court rooms) involved in the various stages of the criminal justice system [13]. In this approach the focus is on the future state of the criminal case, since elapsed times of cases are predicted. In contrast, our approach measures the real elapsed times based on data registrations for different types of cases or suspects that pass through the individual organizations and the whole system. Thus, we are able to get a quick insight into the elapsed times, using a method that acquires less information and computational efforts than other methods.

The remainder of this paper is organized as follows: Section 2 describes the relevance of measuring elapsed times for the justice domain and gives an example of how it is used in practice by stakeholders. Section 3 addresses the challenges encountered when elapsed times in the criminal justice system are measured. In Section 4 we describe our model for determining elapsed time, while in Section 5 we explain our pragmatic approach to calculating elapsed times using two different calculation methods. Finally, Section 6 concludes the paper and proposes further work.

## 2. RELEVANCE OF ELAPSED TIMES

The key objectives of any criminal justice system is to create a more effective and efficient system with increased public safety, decreased recidivism, reduced costs, fair justice, and an efficient administration. Delays in the justice system undermine one of the central ideals of the justice system: the promise of a speedy trial. Reduction of delays in the process is therefore an important aspect in achieving an efficient and effective justice system. Elapsed time is a meaningful variable for stakeholders, as it can give insight into the delays or bottlenecks of the system. It provides vital information of the various steps in the process of handling criminal cases and, consequently, constitutes an important basis for improving and speeding up processes.

Delays in the criminal justice system are built up from several time components. Some relate to (static) waiting times due to fixed legal procedures, others to (variable) waiting times in work processes depending on the context of the criminal case being processed. To reduce delays, insight is needed into these types of waiting times, which can be addressed with measuring the elapsed times. The static waiting times are difficult to shorten, since they are based on legislation. The variable waiting times usually provide options for time reduction.

The reduction of delays in the justice process is desirable from the viewpoint of all stakeholders: suspects, victims, organizations in the justice system and the government. For the suspect it is desirable, because there is less waiting and the suspect knows more quickly where he/she stands in terms of the outcome of the justice process, for example knowing whether he/she is being prosecuted, or the outcome of the trial. Less waiting time is also desirable for victims of a committed crime, who have to wait before the trial finishes to know whether justice has been served. For a partner in the chain, insight into the time spent in processing a case and the waiting time might be helpful in optimizing its business processes or policy. This may result in a higher efficiency for the organization and the justice chain as a whole.

From the perspective of the government responsible for the well-functioning of the justice system, it is desirable to have a good and reliable understanding of the flows within as well as between the organizations [7, 8]. Policy-makers can use the computed elapsed times as a tool to detect unwanted effects and implement policies to reduce any unnecessary delays. An example of the latter is the Program Execution of Criminal Convictions (USB) of the Dutch Ministry of Security and Justice, which is responsible for exercising control on the work processes of the execution chain and the chain as a whole. Several key-performance indicators, such as the timely start of the execution of sanctions [3], were agreed upon with the organizations in the chain. Elapsed times of

criminal cases in the execution chain are measured periodically to determine whether cases start in time. Subsequently, policy makers of the USB program (in accordance with the chain organizations) define norms with regard to percentages of criminal cases that have to start within a certain time. These norms then force the organizations in the chain to collaborate better and to speed up their work processes to reduce delays. In the next section we will describe all the challenges that are involved when measuring the elapsed times in the justice domain.

# 3. PROBLEM SETTING

Measuring elapsed times in the criminal justice system is not a straightforward task. In the beginning of a case (e.g. when it is taken on by the prosecution), there is a large number of unknowns, and many exceptions occur during the whole process. To understand the reason of delays in the Dutch criminal justice system, one must have a clear picture of the whole process and the possible bottlenecks in it. In the next subsections we will elaborate more on these issues.

## 3.1 The Dutch Criminal Justice System

This subsection describes the complexity of the Dutch criminal justice system. We address the structure of the system in Section 3.1.1 and the distinction between standard and complex criminal cases in Section 3.1.2. Both aspects influence the measurement of elapsed times, as will be described in Section 3.2.

### *3.1.1 Structure of the Justice System*

The Dutch criminal justice system is a linear chain that consists of the following stages:

- investigation,
- prosecution,
- trial, and
- execution.

It is linear in the sense that a stage must be concluded before the next stage may begin. However, as a whole it is not strictly linear, as some organizations, like the probation service or Dutch Institute for Forensic Psychiatry and Psychology can work on a criminal case in parallel with the police and the Public Prosecution Service. Also, during the execution stage there are parallel processes, for example, when a court sentence contains multiple sanctions to be executed. In Figure 1 we depict the different stages of the chain from left to right. The boxes at the bottom of the figure describe some activities within these different stages of the chain.

Each stage involves several partners that may work in parallel. The main partners in the justice system are the police, the Public Prosecution Service (PP), the courts, the Central Fine Collection Agency (CFCA), the Agency of Correctional Institutions (prisons) and the probation service (PS). Beside these main partners, there are other partners involved in the justice system, such as, for example, the Netherlands Forensic Institute (NFI), Legal Aid Board, Advocacy and the Council for the Administration of Criminal Justice and Protection of Juveniles. In the remainder of this paper we focus on the elapse times with regard to the main partners.

### *3.1.2 Standard Versus Complex Cases*

The justice system processes different types of cases with various degrees of complexity: some cases are rather simple, while others are complex. Complex cases usually take much longer to process than standard cases, for example, when a case is being lodged at a higher court, it will take much longer until the final verdict is reached. Therefore, when the average elapsed times of criminal cases are calculated, it makes sense to distinguish between standard and complex cases. This also makes it possible to compare them with other benchmarks. More fine-grained classifications of types of cases are possible (e.g., misdemeanor, felony, capital crime), however, this will make determining elapsed time more difficult.

A group of experts involved in the Dutch criminal justice chain formulated specific requirements to define categories of criminal cases [14]. Standard cases are defined as the bulk of the criminal cases that handle common crimes and offenses. Specific requirements of these cases are:

- the suspect is not a repeat-offender,
- no pre-trial investigation has taken place during the criminal investigation, the case has been concluded by the police, the public prosecutor (PP), a sub-district court judge or a police magistrate, and
- no appeal has been lodged to a higher court.

Complex cases in the Dutch criminal justice system are consequently defined as criminal cases that not meet the above criteria. These are criminal cases that are handled by a trail, consisting of three judges that have to deal with severe or complex cases. Included in this category are also cases where a juvenile suspect is on trial according to the adult criminal law, and cases that were handled by the police, PP, a district judge, in which the suspect was a repeat-offender, a pre-trial investigation has taken place and/or appeal to a higher court has been lodged.

## 3.2 Challenges

In this section we elaborate more on the challenges faced when one wants to calculate the elapsed time of criminal cases.

### *3.2.1 Definition of Elapsed Time*

In the criminal justice system, there is no widely accepted definition of elapsed time as it depends on the context. For example, the police may define this as the number of days from the moment a crime is reported till the moment the case is transferred to the public prosecutor or till the case is dropped. For a prison, this may be the number of days from the moment a convict enters the prison till he/she is released (unless the sentence was for life, in which case the definition loses its purpose).

Outside the field of justice, elapsed time may be defined more exactly. For example, a manufacturer may define it as a the number of hours from the moment the production of one (batch of) goods starts till it leaves the compound, ready to be shipped. In such context, it will be known beforehand what the elapsed time will be, including an error margin, and the following processes can be scheduled accordingly. In the criminal justice domain, there is a large number of different paths a case can take, and many exceptions that can occur during the whole process.

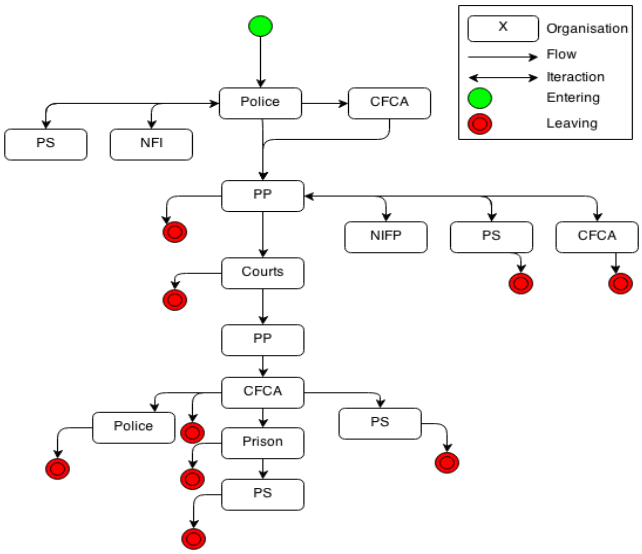


**Figure 2** ***Schematic overview of start- and finishing point for a criminal case in the criminal justice system.***

| Partner | Begin/Inflow date | End/Exit date |
|---|---|---|
| Police | crime report | dismissal or |
| | | out-of-court settlement or |
| | | sending the police report to the CFCA or the PP |
| PP | inflow from the police | dismissal or |
| | | out-of-court settlement or |
| | | sending to court |
| | inflow from the CFCA | dismissal or |
| | | out-of-court settlement |
| | | sending to court |
| Courts | inflow from the PP | verdict in the first instance (discharge or verdict of guilty) |
| Prisons | prison sentence | end of prison sentence and/or |
| | | sending to after-care services |
| CFCA | inflow from the police | exiting the system or sending to the PP |
| | inflow from PP | leaving the system or sending back to the PP |
| | inflow from the courts | leaving the system or sending to the PP or to prison or |
| | | to the police (fugitive suspect) or to the probation service |
| PS | inflow from the police | exiting the system |
| | inflow from PP | exiting the system |
| | inflow from the prisons | exiting the system |
| | inflow from the CFCA | exiting the system or sending back to the CFCA |

**Figure 3** ***Start and finish dates in the criminal justice system for standard cases.***

The elapsed time for each partner in the chain depends on the various steps to be taken in the process (i.e. is a case referred to the central fine collection agency, does the public prosecutor decide to settle the matter out-of-court or to issue a punishment order, or does the suspect get subpoenaed?), some of these steps may overlap. This makes it impossible to give a general impression of the average working time of each partner individually in the chain, but it is very well possible to determine when a suspect or case enters and leaves an individual partner in the process. As an example, consider the flow of a standard adult criminal case through the system depicted in Figure 2. Cases can enter (light grey bullets) and exit (dark grey bullets) the system in multiple ways. As cases flow through the system, they enter and exit various organizations as they are sent from one organization to the next. Figure 3 lists examples of dates that correspond to these entry and exit dates. This figure shows that, for example, the starting date for the PP is the date on which the police report or the case from the CFCA is received. The finishing date for the same case at the PP can either be the data of the dismissal, the out-of-court settlement, or the subpoena. These dates can be used to compute elapsed times.

After all, intuitively to compute the elapsed time, a so-called "starting" and "finishing" point is required. The starting point is the point in time at which a case or person enters the system and the finishing point is the time that the person or case leaves the system. The elapsed time is the difference between these two moments. In Figure 2 the criminal case enters the system at the police and when it flows through the justice system it can exit the system at many different stages and at many different partners in the chain. When the court dismisses the criminal case brought forward by the PP it leaves the justice system after the trial at the court partner. The elapsed time is then the difference between those two dates. Although the conceptual definition of elapsed time is quite intuitive, the operationalization of the definition in the context of the criminal justice chains entails two challenges.

The first challenge is to choose a starting point and finishing point, as this is not always straightforward. Suppose that we want to compute the time that was required to solve a murder. Should we take the date on which the murder was committed, the date that the murder was reported to the police, or the date that the police charged the murder as the starting point? Also, not all cases originate from the police when they enter the Public Prosecution Service, so those will have a different starting point. A similar challenge holds for the finishing point. Should we take the date that suspect was convicted for a crime or the date that the convict completed all his punishments?

Second, once we agree upon the dates for computing the elapsed time, a challenge is to collect these dates since they are scattered among several databases. These databases are owned and maintained by the different organizations involved in the chain of the criminal justice system. In practice it appears a tough task to combine these databases, even if they share some unique attributes. In Section 3.2.2 we elaborate upon both issues.

### *3.2.2 Semantic Interoperability*

In order to measure elapsed times in the justice domain, data attributes on suspects or cases from different information systems have to be collected and integrated. Based on the chain structure of the justice system one would expect that relating the data of a criminal case from one system to the next is simple. Thus, making it easy to follow a particular criminal case or suspect through the system. However, this is not always the case, as in the justice domain there is no strict 'one-on-one' relation between the data exchanged between organizations [5, 6]. An example of this can be found in the relation between the police and PP. One would expect the input of the prosecution to be equal to the output of the police. However, in reality this is not the case. This is due to the fact that the police and the prosecution use different definitions of the entity "case". For the police a case corresponds to one criminal offence which can have multiple suspects. A case at the PP is unique to one person, but may contain multiple crimes. Thus, one case with multiple suspects registered by the police, results in two cases for the prosecution, while two cases with the same suspect may result in one case for the prosecution. Consequently, it may be hard to relate the entities registered by the police to the entities registered by the prosecution.

Related to this problem is the question of which entity to follow through the system: suspects or criminal cases. Sometimes this choice is guided by privacy regulations, which makes it impossible to use privacy-sensitive attributes related to a suspect. Also, partners register their data at different entity levels: the

police and the organizations involved in the execution of sanctions are individual-oriented, while the Public Prosecution Service (PP) and the courts are more case-oriented. As a result, tracking and coupling data of a unique person becomes more difficult.

Following suspects or cases affects the measured elapsed times. For example, when a case is executed this does not always mean that the person also leaves the system. A person can be convicted for two criminal cases, which both have to be to be executed before the person leaves the system. Thus, the elapsed time of the first case is shorter than the elapsed time of the person. Similarly, the elapsed time of the second case is prolonged by the execution of the first case. For example, a convict cannot execute a community service while he is in prison. For a proper measurement of the elapsed time of the second case, the time the convict is kept in prison for the first case has to be taken into account. Therefore, even when measuring elapsed times on a case level, one cannot completely ignore the person level.

In the justice domain there are other data issues that affect the measurement of elapsed time. These have to do with the quality of the data, redundancy and inconsistencies, as some attributes may reoccur in multiple sources. This entails three issues that will be explained below.

First, for example, the courts register the date of the verdict, which is often also registered by the partners in the execution stage. One expects these dates to be the same, but this is not always the case. When calculating elapsed times, one of the conflicting dates has to be chosen. This is not straightforward, because it is hard to determine which date is correct from registration data alone. In order to do so one would need to retrieve the original case documents.

Second, one partner might have a registration of an event concerning a case that is not found in the system of the other partner. For example, when the Probation Service (PS) has a registration on the execution of a criminal case with a community service, we expect to find this same criminal case in the system of the courts where the community service sanction was imposed. When only a PS registration is available, we may miss some of the events necessary to measure the elapsed time. If this occurs frequently, we need to take alternative starting and finishing points into consideration.

Third, partners may use their own definition for seemingly similar data. An example of this is the CFCA that coordinates the execution of community services and sends cases to the PS. Both the CFCA and the PS register a start date of the community service, as the CFCA receives this date from the PS. At first these dates seem equal or similar, but in reality they are different. The date registered by the CFCA is a system date returned by the information system of the PS about the start of the community service. This date is different from the actual start date, the day the convict started with the first hours of the community service, which was registered by the PS employee. Using one of these dates as a starting or finishing point obviously affects the measured elapsed time.

# 4. APPROACH

In this section we propose a model to calculate the elapsed times of criminal cases. The model itself is described in subsection 4.1. Subsequently, in subsections 4.2 we elaborate on the design of a system that integrates the heterogeneous data of the different partners to make measuring elapsed times possible.

## 4.1 A Model for Determining Elapsed Time in the Justice System

In principle we distinguish two approaches to determine the elapsed time of a (linear) chain. In the first approach the elapsed time of a chain is based on the elapsed time of each partner involved in the chain. The elapsed time is the sum of the elapsed time of each partner plus the time that is required to transfer the output of this chain to the next partner. In the second approach, the elapsed time is based on the partner at the beginning of a chain and the partner that ends the chain. The role of all intermediate partners is neglected in this approach. Both approaches have their advantages and disadvantages. While the first approach provides insight in how the elapsed time of a chain is built up, in the second approach the elapsed time can be computed with less information and computational efforts. To utilize the best of both approaches we propose a third approach, which is a hybrid form of approach one and two. In subsection 4.1.1 and 4.1.2 we will describe the first approach and the second approach respectively, while in subsection 4.1.3 the hybrid approach is explained.

### *4.1.1 The Sum of Elapsed Times per Stage*

The total time T for a system with n linear stages $s_1, \ldots, s_n$ can be expressed as:

$$T = \sum_{i=1}^{n} T(s_i)$$

In terms of *"working time"* W and *"waiting time"* Q, this becomes

$T(s_1) = W(s_1) + Q(s_1)$

$T(s_2) = W(s_2) + Q(s_2) + (t_{in}(s_2) - t_{out}(s_1))$

…. = …

$T(s_n) = W(s_n) + Q(s_n) + (t_{in}(s_n) - t_{out}(s_{n-1}))$;

where $t_{in}$ is the moment in time the suspect/case enters the stage and $t_{out}$ is the moment it leaves the stage. Delays due to transfers between stages are also taken into account. Note that $t_{in}(s_n) - t_{out}(s_{n-1})$ is the transfer time from $s_{n-1}$ to $s_n$.

The working and waiting times depend on the partners involved in a certain stage. Since some stages take longer than others, $W_i$ and $Q_i$ may also differ depending on the stage. For example, the trial stage tends to take more time than the prosecution stage. This is inherent in the way the justice system works. The waiting time for a certain stage may be divided into two components: the variable waiting time, which is, depending on the crime, and the static waiting time, the amount of time required by law to wait before a verdict may be passed or executed or a protest can be made against a verdict. For a stage $s_i$, this can be expressed as:

$$Q(s_i) = Q_{var}(s_i) + Q_{stat}(s_i)$$

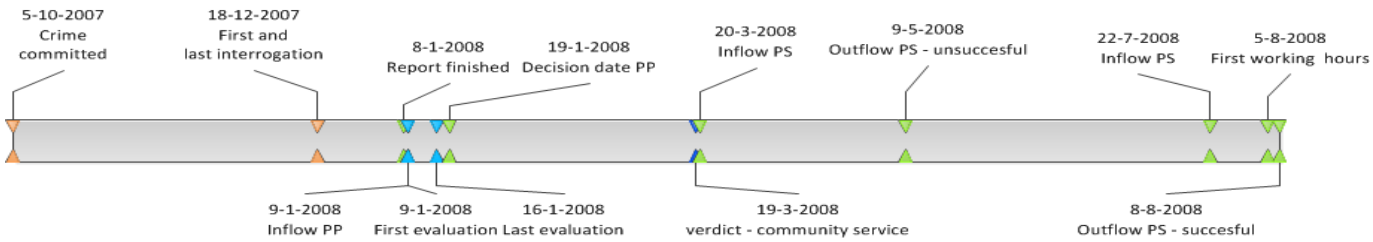


**Figure 4** ***Timeline view of a criminal case with dates from different sources***

The static waiting times enforced by law are usually the maximum amount of time for a given circumstance, and need not be used up. For example, a citizen does not need to wait till the end of the period allowed by law before entering a protest. This amounts to:

$$Qstat(s_i) = \min [Q_{stat};\max(s_i);Q_{stat};actual(s_i)].$$

There are also delays due to transfers between the partners in a certain stage, besides the ones between the stages, as mentioned above. These will be a part of the variable waiting time per stage. For a stage $s_i$ with n partners $p_1$, …, $p_n$ working in parallel, this is given by $Q_{var}(s_i)$

$$= \max[(t_{in}(p_2) - t_{out}(p_1)),(t_{in}(p_3) - t_{out}(p_2)),\ldots,(t_{in}(p_n) - t_{out}(p_{n-1}))]$$

This formal model describes how the elapsed times in the criminal justice system can be calculated. However, information on the specific waiting and working times is not available in most cases. Additionally, because there are many paths, with several side tracks, a case may take through the system, it would be difficult to take them all into account separately. Therefore, a more pragmatic solution for measuring the elapsed time of a suspect or criminal case is required, which will be explained in the next subsections.

### *4.1.2 Backtracking*

Backtracking cases is an approach that requires less information and computational effort than the first approach. We start where a case leaves the system and backtrack this path in time to the beginning of the process. This works as follows: the elapsed time of a criminal case from the moment the police arrested a suspect until someone ends up in prison, can be defined as: the date on which the convicted person is put into prison *minus* the date on which the criminal report has been filed.

Thus, for a chain that is linear in stages, the total elapsed time T' can be defined as:

$$T' = t_{out} - t_{in}$$

where $t_{in}$ is the moment in time the suspect/case enters the system and $t_{out}$ is the moment it leaves the system. This approach simplifies the elapsed time calculation, since all intermediate partners of the chain are neglected in this approach.

### *4.1.3 Hybrid Approach*

The first approach is complex in nature and infeasible due to a lack of data. The second is simple and fast, but does not cover all paths a case can follow through the system. Therefore, we propose a third approach. This approach also backtracks cases, but includes domain information to determine the specific path through the system. In this hybrid approach we capture a traversed path of a case through the system. To measure the elapsed times of this case we use the context of the case to determine a starting and finishing point.

In Figure 2 we showed that a case can enter and leave the system in multiple ways. Not all cases leave the system at the end of the chain. For instance, a case can leave the system at the PP, without entering one of the partners in the execution phase. To determine whether or not a case leaves at the PP we need to know the final case decision of the PP. If they dismiss the case, then it leaves the system at the PP. One of the other possible decisions of the PP is to send the case to court. If one wants to determine the elapsed time for a part of the chain, let's say from the police till the PP, then the PP is considered the last partner. The same holds for the starting point, since not all cases enter the system at the police.

For a chain that is linear in stages, the total elapsed time T'' can be defined as:

$$T'' = t'_{out} - t'_{in}$$

where $t'_{in}$ is the chosen starting point of the suspect/case and $t'_{out}$ is the determined finishing point. Depending on the context of the case $t'_{out}$ and $t'_{in}$ can be chosen from different partners, as explained above. These starting points can be at the same or different partners, which depends on the case context.

In order to determine T'', we construct a timeline for each case by finding the date that a case enters a partner and the date that the same case leaves the partner. Such a timeline is obtained by performing a set of joins [9] on the databases of various partners and transforming the result into a sequence of events in the course of time [2]. In Figure 4, an example of a timeline is depicted. This timeline was obtained by joining a set of records coming from the police, PP, courts, and PS (see Figure 5). This timeline shows the relevant events of the case that took place on different dates. For example, the time line starts with a crime that was committed on October 5, 2007. In this example the police had two suspects of a crime that were passed on to the PP. The PP pursued one of the two cases and brought that case to court. The suspect is found guilty by the court and as punishment the convict had to perform a community service. The PS received this case for execution, but fails to execute the sanction the first time, because there was no contact possible with the client. The second time the PS was successful and the case left the system at the PS. This crime was committed and registered on date October 5, 2007. The case left the execution partner PS on August 8, 2008. The total elapsed time for this case is thus 305 days. Using this time line, also other elapsed times can be calculated, for example, the time between the subpoena by the PP (on January 9, 2008) and the verdict by the court (on March 19, 2008).

As shown above, for this approach, data from different organizations need to be collected and coupled. In the next section, we will explain how the underlying data from different sources within the justice system are collected and integrated.

## 4.2 Data Collection and Integration

Information about suspects, convicts and their criminal cases are currently distributed among the legacy systems (i.e. database management systems) of the organizations in the chain. Each organization registers data about their organizational processes

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| POLICE | Suspect ID | Report ID | Crime committed | First Interrogation | Last interrogation | Report Finished | |
| | 1122 | 22-1234-33 | 5-10-2007 | 18-12-2007 | 18-12-2007 | 8-1-2008 | |
| | 1124 | 22-1234-33 | 5-10-2007 | 22-12-2007 | 22-12-2007 | 8-1-2008 | |
| | | | | | | | |
| PP | Case nr. | Report ID | Inflow date | First evaluation | Last evaluation | Case decision | Decision date |
| | 23333 | 22-1234-33 | 9-1-2008 | 9-1-2008 | 16-1-2008 | Subpoena | 17-1-2008 |
| | | | | | | | |
| Courts | Case nr. | Report ID | Trail | Verdict | Punishment | Verdict | |
| | 23333 | 22-1234-33 | 19-3-2008 | Guilty | Community service | 19-3-2008 | |
| | | | | | | | |
| PS | Person ID | Case nr | Date inflow | First working hours | Product | Date outflow | Result |
| | 997788 | 22-1234-33 | 20-3-2008 | | Community service | 9-5-2008 | No contact with client |
| | 997788 | 22-1234-33 | 22-7-2008 | 5-8-2008 | Community service | 8-8-2008 | Finished community service |

**Figure 5 Data records of an executed community service per partner**

that fall into the scope of their responsibilities. Bringing this information together is necessary to measure the elapsed times throughout the whole chain. In order to do so, discrete events (dates) and characteristics (types or actions) of the criminal cases need to be extracted from these legacy systems.

In Section 3.2 we discussed the most important issues when selecting data from these sources to measure elapsed times. These issues related to data quality, redundancy of data (choosing between attributes that reoccur in multiple sources and resolving inconsistencies), and data context (attribute semantics). To operationalize the elapsed times of cases or suspects we first define the starting and finishing points we need for each partner and then search in the systems of the partners for their availability. In addition, we recognize relations between data attributes from multiple sources and make them explicit. This is important in order to being able to relate these distributed attributes (e.g. events) to a specific case or suspect. Since partners in the chain sometimes register different or similar dates in their systems, we select the best starting and finishing points per partner in consultation with the stakeholders. Hence, collecting and combining data from the different management information systems is not straightforward.

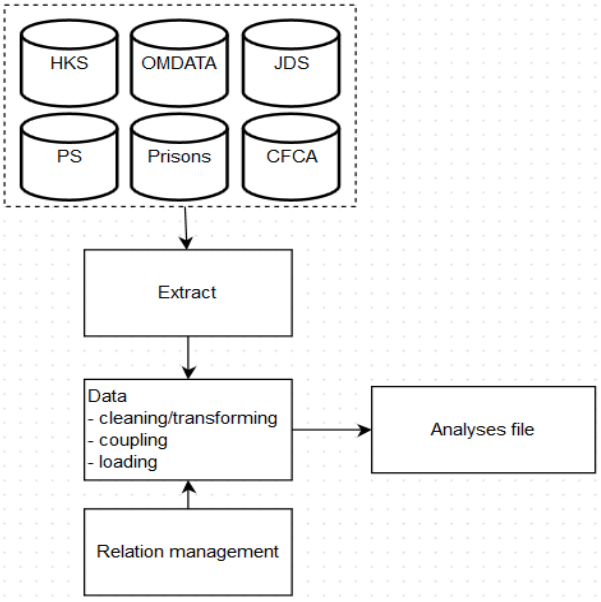


**Figure 6 Schematics of an approach to determine elapsed times.**

Figure 6 depicts a schematic overview of our approach to collect and integrate data. This figure shows that first from a set of data sources the necessary attributes are extracted. These data elements are then cleaned, transformed, and coupled. In the latter step, domain information is used to relate data elements from different sources. In the final step the relevant data is loaded into the analysis file from which the elapsed times of cases or suspects are calculated.

To obtain such an analysis file, a case, this case must be recognisable (i.e. identifiable) throughout the whole criminal justice system. Therefore, a unique identifying key that is present in all database systems is required. If such a key, is not available or not desired because of privacy-regulations, then combining can be performed using a set of common characteristics [5]. Based on this key, or the set of common attributes, events regarding a suspect or case from different sources are combined. The first important step of the data integration process is extracting of the same conceptual data from the different database systems. In general this would be so-called "micro data" on the level of a case or person. Figure 6 shows that data of the Dutch criminal justice system are extracted from the sources HKS (police registrations), OMDATA (the registration system of the Public Prosecution Service), and JDS (a central Dutch documentary system of all past criminal records). Additionally, information from registration systems of other important organizations in the chain, for instance, the organizations that are involved with the execution of sanctions (PS, prisons and CFCA), is used. Figure 5 shows an example of data attributes that are extracted and loaded.

The relation management module is used to clean (remove records with known wrong registrations from the source files) and combine the data (relate all available events to a unique case or suspect). The relation management module can also be used to deal with missing data. If the value of an attribute is (temporarily) unavailable, for example due to technical problems, it may be replaced with the value of a similar attribute that is measured at a slightly earlier or later point in time, but more or less covers the same notion. This is called imputation. The imputed value may come from either the same or a different source. For instance, when the information system OMDATA of the PP has no explicit date registered for their *final case decision*, then the most similar attribute, in this case the *final evaluation date*, can be used instead. The relation module is also used to relate cases to unique suspects/convicts. This is necessary to determine whether the processing of cases that relate to the same suspect will have an effect on each other. For example, a convict's detention has to be finished before he or she can perform the community service.

The analysis file contains all necessary date events of a suspect/ case throughout the justice chain. Subsequently, elapsed times can be calculated from this analysis information. In the next section we will show an example case for measuring elapsed times and key-performance indicators with regard to the execution of sanctions.


**Figure 7 KPI - timely start for an imposed community service sanction**

# 5. MEASURING ELAPSED TIMES: AN EXAMPLE IN PRACTICE

In this section we describe how to measure the elapsed times of criminal cases that are in the execution phase. In Section 5.1 we describe our approach and the choices made for possible starting and finishing points. In Section 5.2 we describe two different methods to calculate elapsed times.

## 5.1 Operationalization and Data Integration

In the execution phase there are many paths (i.e. scenarios) a criminal case can take, especially when multiple sanctions are imposed. In that case different partners in the execution stage are involved, either in parallel or in succession. A parallel process, for instance, occurs when a prison sentence and a fine have to be executed. The process is serial when, for example, an unconditional prison sentence and a community service sentence are imposed. In that case the prison sentence has be executed first and only when the detention is finished, the community service can start. These different scenarios have to be taken into account when measuring elapsed times. The examples described in this section are limited to standard cases in the sense that cases in which an appeal is lodged are not taken into account.

As the execution stage also involves different organizations, cases have to be followed from one database system to the other, preferably using a unique key. Such a key allows us to combine data from various sources easily and reliably. In the execution phase the unique case number registered by the Public Prosecution Service can be used, as it is available in most registration systems of the partners involved. All relevant events are integrated and related to the unique case number. This results in a timeline per imposed sanction, so when there are more sanctions in a case there will be more than one timeline. The timeline events are stored in an event database.

Based on these timelines we are able to measure elapsed times for each executed sanction. In order to do so, first the starting and finishing points have to be selected. The starting point of the execution chain is typically either a court verdict by a judge or a decision made by the Public Prosecution Service. The finishing point is the moment the imposed sanction is executed.

In Section 2 we mentioned the key-performance indictor (KPI) that gives insight into the timely start of the execution of sanctions. This relates to the elapsed time between the sentence and the start of the execution. In Figure 7 we show how this time is measured for a criminal case with an imposed community service sanction. The starting point in this case is the date of the verdict by the court and the finishing point is the date of the *'first working hours*' registered by the probation service (PS). The elapsed time is the date of the *'first working hours*' minus the date of the verdict. To check if a case had a timely start, the elapsed time is compared with a certain predefined observation period (e.g. 30 days), which depends on agreements between the partners and policy makers. When the measured elapsed time is shorter than the observation period the case is considered as 'started' in time. When there is no date registered for the first working hours or the elapsed time is larger than de observation period the case is categorized as 'not started'. In this approach different subscenarios can be applied to further specify the 'started' or 'not started' categories. For example, we can distinguish cases that did not start because they were not sent to the CFCA or the PS.

As explained in section 3.2.2, since in this approach cases are followed, information about the convict has to be taken into account while the elapsed time for each imposed sanction in each separate criminal case is measured. For instance, when two sanctions need to be executed in succession, for example, first a prison sentence and afterwards a community service, then the elapsed time of the community service is negatively affected. In this case, the detention period is also part of the measured elapsed time of the community service. Otherwise, it might not be useful to include the detention period, when insight in the speed of the system is required, since it does not tell us anything about the speed. The elapsed time between the verdict and the start date of the community service does not represent the actual execution time, because one has to wait until the detention period is over. Therefore, the detention period(s) between the verdict and start of the community service, or the end of the observation period, need to be subtracted from the measured time. This correction should be done for sanctions that need to be executed in succession. This can either be because two sanctions were imposed for the same criminal case or in two different cases that belong to the same person. For the latter, additional information is needed that relates case numbers to unique individuals.

In the next section we show the effect on the elapsed time results of two different calculation methods.

## 5.2 Methods to Calculate Elapsed Times

To compute elapsed times two methods can be used: the backward or forward view method. In this section we explain both methods. In the next section, we examine their effects on the calculated results.

### *5.2.1 Backward View Method*

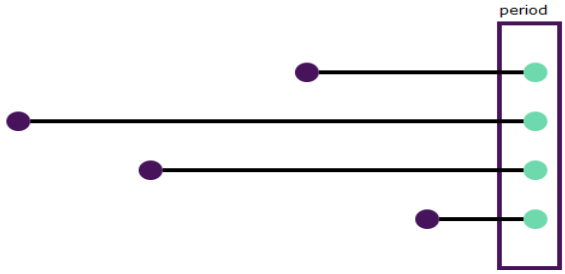


**Figure 8 Backward view method**

In Figure 8 we show the backward view method. This method looks at a set of criminal cases that ended (have their finishing point) in the same reference period (e.g. quarter), and measures the elapsed time from a certain starting point. The average elapsed

time is then calculated by averaging over all elapsed times of all cases that ended in the chosen period.

### *5.2.2 Forward View Method*

The forward view method, shown in Figure 9 selects all criminal cases starting (have their starting point) in a particular period (the "cohort"). These cases are followed for a certain predefined time period (the "observation period"). During this observation period a finishing point may or may not occur. For cases with a finishing point, the elapsed time between the starting point and the finishing point is measured. Similar to the backward view method, the average elapsed time can be calculated by averaging all elapsed times of all cases in the cohort. However, a choice have to be made about what to do with cases that have no finishing within the observation period. This will be explained in the next section.

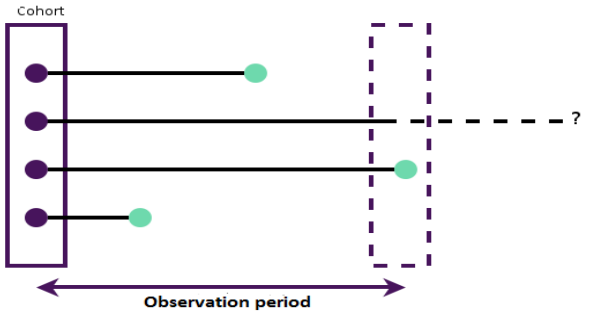


**Figure 9 Forward view method**

A benefit of this approach for measuring the elapsed times in the justice domain is that a set of criminal cases that originate from the same period (e.g. have a verdict date in the same quarter) are usually based on the same legislation. In the backward view this is not always the case, as the starting and finishing point can be far apart in time.

## 5.3 Results and Effects of the Method Used

We will illustrate both methods with our example of the KPI 'timely start'. We will do this for two types of sanctions: community services and fines. In the first case, the elapsed time is defined as the time between the verdict of the court and the first working hours by the convict registered by the Probation Service (PS). For the second case, the elapsed time is the time between the verdict and the first payment made by the convict (registered by the CFCA). Table 1 shows the average elapsed times, measured in weeks, for community services and fines which are calculated using both methods. For the backward view method the reference period is set to the second quarter of 2011, for the forward view method all cases sentenced in the fourth quarter of 2009 are used with an observation period of 12 months.

**Table 1** ***Elapsed times of backward vs. forward view method***

| | Community service | | Fine | |
|---|---|---|---|---|
| ***Backward view method*** | **No. of cases** | **Mean** | **No. of cases** | **Mean** |
| Outliers included | 5.541 | 33 | 27.187 | 55 |
| Outliers excluded (max set to 3 years) | 5.541 | 32 | 27.187 | 50 |
| ***Forward view method*** | **No. of cases** | **Mean** | **No. of cases** | **Mean** |
| Cases without finishing date excluded | 5.778 | 22 | 19.514 | 18 |
| Cases without finishing date included | 8.405 | 25 | 39.340 | 35 |

When these results are compared, we see that the results obtained with the two methods are different. The reported average of the backward view method is considerably higher, because also criminal cases with an extremely long processing time may be included in the calculations. To reduce the effects of these outliers, the average may be cut off, for example by maximizing the processing time to three years for cases with a longer processing time. As a result, the average is lower, but it is still higher than for the forward view method. For some sanctions this difference can be rather big. This is, for example, the case for fines, where the average becomes 50 instead of 55 weeks.

**Table 2** ***Mean results when cases without finishing dates are in- or excluded***

| *Exclusion* | **Community service** | | **Fine** | |
|---|---|---|---|---|
| **Observation period** | **No. of cases** | **Mean** | **No. of cases** | **Mean** |
| 3 months | 1140 | 10 | 9268 | 9 |
| 6 months | 3925 | 16 | 15009 | 12 |
| 12 months | 5778 | 22 | 19514 | 18 |
| 18 months | 6179 | 25 | 22417 | 24 |
| 24 months | 6345 | 27 | 24246 | 29 |
| *Inclusion* | **Community service** | | **Fine** | |
| **Observation period** | **No. of cases** | **Mean** | **No. of cases** | **Mean** |
| 3 months | 8405 | 6 | 39.340 | 17 |
| 6 months | 8405 | 15 | 39.340 | 20 |
| 12 months | 8405 | 25 | 39.340 | 35 |
| 18 months | 8405 | 32 | 39.340 | 47 |
| 24 months | 8405 | 39 | 39.340 | 58 |

The forward view method is considered to be more reliable as it is less sensitive to outliers (all cases, by definition, have an elapsed time that lies within the scope of the chosen observation period). However, the forward view method also has an important restriction, as not all criminal cases may have a finishing point within the observation period. This is possible, because not all convicts may perform their community service or pay their fine immediately. Including or excluding such cases presents an essential difference in the results. When the cases without finishing date are excluded, the average is low, as only the relatively quickly started cases are included in the calculations. The results from this scenario are considered to be too optimistic, because slower cases are disregarded. As an alternative, the cases without a finishing date can be included by setting their elapsed time to the length of the observation period (in the example: 12 months). For both the community services as the fines, this results in a higher average (25 instead of 22 weeks and 35 instead of 18 weeks).

Another important choice related to the forward view method is related to the length of the observation period. A longer observation period will generally yield a higher mean. Table 2 shows how altering this length (between 3 and 24 months) affects the average elapsed time for both the scenario in which the cases without a finishing date are excluded as the scenario in which they are included. For the exclusion-scenario, the number of cases considered changes when the observation period varies. With a short observation period, only a few cases are used in calculating the elapsed time, as a lot of cases do not yet have a finishing date. The inclusion-scenario has the advantage that, while all cases from a certain cohort are considered, the number of cases remains the same, regardless of the observation period. This provides us with an addition reason why the inclusion-scenario is preferred over the exclusion-scenario. However, for this inclusion-scenario the average shows a larger range (for the community services between 6 and 39 weeks and for the fines between 17 and 58). Therefore, other measures for elapsed time are considered.

***Table 3 Cases without finishing date included***

| *Inclusion scenario* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Observation period** | **No. of cases** | **Mean** | **P10** | **P20** | **P30** | **P40** | **P50** | **P60** | **P70** | **P80** | **P90** |
| 3 months | 8405 | 6 | 12 | | | | | | | | |
| 6 months | 8405 | 15 | 12 | 15 | 18 | 22 | | | | | |
| 12 months | 8405 | 25 | 12 | 15 | 18 | 22 | 28 | 36 | | | |
| 18 months | 8405 | 32 | 12 | 15 | 18 | 22 | 28 | 36 | 55 | | |
| 24 months | 8405 | 39 | 12 | 15 | 18 | 22 | 28 | 36 | 55 | | |

An alternative approach to measuring elapsed times for a set of cases is percentiles. A percentile indicates the value below which a given percentage of observations in a group of observations falls. For example, the 30th percentile (P30) denotes the elapsed time of 30% of the cases. Table 3 shows the percentiles for the finishing date inclusion-scenario for the community services. This table, for instance, shows that 50% of the cases have an elapsed time of 28 weeks or lower. Thus, the median elapsed time is 28 weeks. In contrast with the average, the results obtained are stable over time.

# 6. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

In this paper we argued that, in order to gain insight into delays in the criminal justice system, elapsed times should be measured. The challenges involved with measuring elapsed times in this domain were described and we presented a method to determine elapsed times of cases. We explained that measuring elapsed time in principle entails two approaches. One approach tries to sum the elapsed time of each partner which includes working and waiting times. In the second more pragmatic approach, the elapsed time is based on backtracking cases. While the first approach provides more insight into how the elapsed time of a chain is built up, in the second approach the elapsed time can be computed with less information and computational efforts. However, the second approach does not cover the exact paths a case can follow. Therefore, we proposed a hybrid approach that creates a timeline of events for each case to determine a starting and finishing point and measure the elapsed time between them. This allows us to follow the processing steps of a case in detail, like in the first approach, with acceptable computational effort.

A topic for further research is the evaluation of our model. Through an evaluation of the results of the model we want to gain insight into how useful the elapsed times are in defining justice policy. Currently, policy-makers of the justice department use the model to detect unwanted effects in processing times of criminal cases. Next we will investigate how these results are utilized in practice. In addition, we will zoom in on the processing steps within individual partner or between two partners to gain more specific insight into that particular elapsed time in order to expose possible bottlenecks. These bottlenecks may give rise to define improvements of some steps involved a judicial process.

The presented method for measuring elapsed times is not limited to the Dutch justice domain. It applies to most criminal justice systems and also to other domains similarly structured like a chain of organizations, such as the health-care domain.

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