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An information strategy for the traffic control chain

P. Seignette*
Utrecht University, Department of Information and Computing Sciences
P.O. Box 80115, 3508 TC Utrecht, The Netherlands
E-mail: p.seignette@students.uu.nl
* Corresponding author

J.J. Dijkman
Vellekoop & Meesters BV
P.O. Box 95, 3970 CB Hoevelaken
E-mail: j.j.dijkman@vm-advies.nl

J.H.A.M. Grijpink
Utrecht University, Department of Information and Computing Sciences
P.O. Box 80115, 3508 TC Utrecht, The Netherlands
E-mail: grijpink@cs.uu.nl

M.G.A. Plomp
Utrecht University, Department of Information and Computing Sciences
P.O. Box 80115, 3508 TC Utrecht, The Netherlands
E-mail: plomp@cs.uu.nl

Abstract: This article presents the results of the chain analysis of the traffic control chain according to the method of Chain-computerisation.[1] The traffic control chain co-operation aims at maintaining car mobility with minimal delay. Car mobility is threatened by disruptions of traffic flows that are caused by incidents on the road. A chain information system could possibly be a solution to ensure car mobility with minimal delay.

A chain analysis assesses beforehand the chance of success of a chain information system. A theoretical and practical introduction to this chain analysis methodology can be found in the founding article in this journal (Grijpink, 2010). This chain analysis is part of the Chain Landscape Research Programme at the Department of Information and Computing Sciences of Utrecht University.

According to this chain analysis, a chain information system is necessary but not feasible for the traffic control chain because of the low degree of organisation. Therefore, the information strategy advice is that the chain should focus on public-private co-operation. This co-operation is essential to pave the way for a more integrated and effective approach to traffic congestion.

Keywords: chain-computerisation, traffic control, information strategy, chain analysis

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[1] We thank P.-J.F. Kleevens, G. Hoogeboom, Y. van Dijke and W. Koopmans for their contribution.

1 Introduction

This article describes the results of the chain analysis of the traffic control chain. This chain analysis is done as a part of the Chain Landscape Research Programme of Utrecht University. The goal of this research programme is to explain the (frequent) failure of a chain project, and to prevent failure by assessing beforehand a project's chance of success. At the same time, this research programme provides a continuous empirical validation of the theoretical framework of Chain-computerisation (Plomp & Grijpink, 2009).

For years, the congestion problem in the Netherlands has been causing public outrage and the problem only seems to be getting worse. For example, the number of traffic jams has increased in 2010 compared to 2009 (De Pers, 27 December 2010). Daily commuters are in the same traffic jam at the same place every day. But there are also many disruptions of the traffic which are not caused by rush hours and road maintainance, but by unpredictable traffic impediments such as accidents or weather conditions.

In order to optimise car mobility and minimize the traffic delay, traffic disruptions should be prevented as much as possible and - if this fails - handled effectively. A chain information system could be a solution if it is both necessary and feasible for this traffic control chain. The goal of this article is to assess this necessity and feasibility. The central question of this article is, therefore:

> *Is a chain information system necessary for the traffic control chain, and to what degree is this chain information system feasible in this chain?*

To answer this question, Chapter 2 describes the current infrastructure of the traffic control chain (computerisation, ICT and co-operation). Chapter 3 presents the results of the chain analysis regarding the necessity and the feasibility of a chain information system. By comparing the results of the chain analysis with the current situation, in Chapter 4 we formulate an information strategy for the traffic control chain. Finally, this information strategy is evaluated with regard to other relevant current ICT projects.

2 The current infrastructure of the traffic control chain

2.1 Chain challenge: car mobility with minimal delay

The traffic control chain focuses on maintaining car mobility and minimising traffic delay. Car mobility can be compromised by predictable congestions -- because for example, of commuting traffic, vacation traffic, events or maintenance -- but also because of unpredictable traffic impediments such as accidents or bad weather conditions. By guiding the traffic, for example by providing traffic information, placing traffic information displays alongside the road and providing information about detours, the traffic control chain tries to maintain car mobility as much as possible by optimally utilising the road network's capacity.

The traffic control chain does not focus on the predictable daily congestion, but will come into action when there is a traffic jam caused by an unpredicted incident, where intervention is important to prevent severe disruption of traffic flows.

2.2 Current infrastructure: many public and private parties participating, different systems in use

Public as well as private parties participate in the traffic control chain. Public parties are, for instance, road managers (Rijkswaterstaat [Ministry of Public Works and Water Management], provinces and municipalities) who are responsible for measuring instruments (such as sensors) in and on the roads. Private parties are, for instance, organisations offering navigation systems for cars. They also collect information about the occupancy rate of the road network, for example using mobile phone signals.[2] This information is used to guide traffic flows to the most suitable roads. A number of chain partners use different methods to do this: private parties act as service providers and offer travel advice and information services to individual cars. Road managers use traffic information displays above and alongside roads to give advice on speed and current traffic jams.

When an incident causes a traffic jam, several chain partners will come into action. With the road measurement results, a picture of the (approaching) traffic is created. Based on this information, road managers can intervene and, for example, open another lane to limit the delay of the traffic. By using traffic information displays, upcoming traffic flows can be guided around the impediment or accident.

Information collected by road managers about the current traffic on the roads is stored in the National Traffic Information Database [Nationale Databank Wegverkeersgegevens (NDW)], which is managed by an executive organisation in which several chain partners co-operate. The measurement information provided by a number of road managers is stored in the database. This information can, in turn, be used by other chain partners to guide the traffic.

2.3 The current infrastructure is not sufficient to achieve car mobility with minimal delay

Without adequate interventions by the chain parties involved, the traffic flows will be disrupted, thus seriously affecting car mobility. The current infrastructure, however, gives no possibility to share information chain-wide and to coordinate the measures to be taken at the moment there is road incident. Private parties are, for example, not represented in the NDW, although they do serve a large percentage of car drivers.

3 A chain information system is necessary to prevent disruptions, but is not feasible due to the current low level of chain co-operation

The previous chapter concluded that the current chain co-operation and IT infrastructure are not sufficient for effective traffic control. A chain information system could provide a solution to effectively maintaining car mobility without unnecesary delay. Therefore, this chapter presents the chain analysis results with regard to the necessity and feasibility of a chain information system for the traffic control chain.

3.1 Methodology

To assess whether or not a chain information system is necessary and feasible for maintaining car mobility with minimal delay during disruptions of traffic flows, a chain analysis has been done following the Chain-computerisation method. The

[2] An example of this is the (Dutch) website www.geenfile.nl.

founding article of this journal (Grijpink, 2010) provides a theoretical and practical introduction to the chain analysis methodology used here.

The theoretical framework of Chain-computerisation contains four normative profiles in order to assess (1) whether a chain information system is truly necessary and (2) whether a chain information system is feasible:

- The **mission profile** gives a description of the chain. Based on this, the necessity of the chain information system can be assessed at the level of the goal of the chain;
- The **coordination profile** enables assessment at the level of the chain process concerning whether or not a chain information system is necessary for the chain-wide coordination of the efforts to tackle the dominant chain problem;
- The **information profile** allows us to assess the necessity for a chain information system at the level of the information exchange;
- The **co-operation profile** shows the chain's degree of organisation and the degree to which the chain parties are used in certain modes of co-operation. Effectively using a chain information system requires certain facilitating modes of chain-wide co-operation. The co-operation profile shows whether or not these are currently present in this chain.

The chain analysis based on these four profiles is included in the appendix of this article. Note that it is only the co-operation profile assessment results that depend on the scale of analysis. The degree of co-operation at a regional level can differ from the degree of co-operation at a national level, leading to different assessment results.

Research material for carrying out this chain analysis is collected by conducting interviews at the NDW, the province of Utrecht, the municipality of Utrecht and with an external expert not associated with any of the chain partners. A brief document study was also done.

3.2 Chain analysis conclusion: a chain information system is necessary but not feasible at the national level

To maintain car mobility with minimal delay and to prevent disruptions of traffic flows during incidents on the road, a chain information system with the following critical details is necessary:

a. location of the traffic impediment;
b. estimated time of removal of the traffic impediment;
c. expected average delay.

If this information is shared chain-wide, then chain parties can intervene during incidents and prevent the traffic being disrupted. However, based on the current degree of co-operation in this chain, a chain information system is not feasible.

This overall conclusion is derived from the subconclusions of the four profiles which will be described below.

3.2.1 Mission profile: a chain information system is necessary to tackle the dominant chain problem

The traffic control chain focuses on car mobility with the least possible delay. The chain partners in this chain are forced to co-operate in order to guide traffic flows throughout the road network effectively, because disruptions of traffic flows are unpredictable. The dominant chain problem is indeed "disruptions of traffic flows, because of the unpredictability of impediments (incidents, accidents or bad weather conditions)." The critical details essential for dealing with this dominant chain problem are: location of the traffic impediment, estimated time of removal of the

traffic impediment and expected average delay. Once this data is shared throughout the chain, it will be possible to guide traffic during incidents without unnecessary delay. According to the mission profile, a chain information system with these critical data is essential to effectively guide traffic flows.

3.2.2 Coordination profile: a chain information system is necessary for the chain-wide coordination

A chain information system is necessary for the chain-wide coordination in order to be able to tackle the dominant chain problem: “disruptions of traffic flows, because of the unpredictability of impediments (incidents, accidents or bad weather conditions).” For simple linear chains without feedback loops in the chain process, standardisation of working methods is sufficient as the most advanced coordination mechanism at the chain level. Only complex chains cannot function properly without feedback loops in the chain process, thus necessitating a common chain information system and mutual (informal) adjustment at chain level. Currently, the traffic control chain has standardisation of working methods as the most advanced coordination mechanism, but appears to be a complex chain for several reasons. Because traffic flows are exceedingly dynamic and cannot easily be delineated, there is a constant need for feedback in the chain process. There is also the possibility of a domino effect when an incident causes peristalsis in traffic flows: every traffic intervention in turn demands adjustment of traffic flows elsewhere in the road network. This means that, according to the coordination profile for the traffic control chain, a chain information system is essential for the chain-wide coordination with regard to to the dominant chain problem “disruptions of traffic flows, because of the unpredictability of impediments (incidents, accidents or bad weather conditions).”

3.2.3 Information profile: a chain information system is necessary in order to bridge fault lines at the information level

In principle, at the information level a chain information system is necessary in order to bridge fault lines in the chain information infrastructure causing structural communication problems. For each step in the chain process, a core concept is defined that characterises the focus of the chain partners in that particular process step in the chain. Thus, in the process step ‘measuring,’ the focus is on incidents and in the process step ‘intervening’ on interventions and locations. These widely divergent focuses demarcate ‘linguistic areas in a chain that are independent of each other, causing structural communication problems that cannot be prevented by better organisation or good intentions because the causes are inherent in the process. However, disrupting consequences can be prevented as much as possible with a chain information system.

The information profile of the traffic control chain shows a fault line between the process steps ‘measuring’ and ‘intervening.’ This means that there is a structural communication problem concerning the use of traffic measurement information for intervention after an incident. In order to bridge this fault line and to prevent its most disrupting consequences, a chain information system is necessary.

3.2.4 Co-operation profile: a chain information system is not feasible at the national level

In this chain analysis, the degree of organisation has been studied at the national level. The national situation in the traffic control chain can be described as follows. At the support level, the most advanced co-operation mode is ‘joint decision making.’ In the ‘front runner consultation [koplopersoverleg]’ of the NDW, the chain partners jointly decide which traffic information is to be shared and how. At the level of the primary process, the chain partners confer with each other about events and road maintenance projects that might impede traffic. Formal

consultation about predictable impediments, therefore, is the most advanced mode of co-operation, as it is at the policy level, where chain partners formally confer with each other about their strategy concerning traffic information and traffic management in the Stategic Traffic information and Traffic Management Summit [Strategisch Beraad Verkeersinformatie en Verkeersmanagement (SBVV)]. This rather limited degree of chain co-operation implies that a chain information system at the national level is not feasible at the moment.

4 Information strategy for the traffic control chain

The chain analysis indicates that a chain information system is necessary for the traffic control chain, but that such a chain-wide traffic information system is not feasible because the degree of organisation in the chain at the national level is too low. Therefore, the chain should – on the one hand – focus on other ways of computerisation in order to tackle the dominant chain problem, and – on the other hand – try to further increase its degree of organisation.

Thus, there are two possible solutions which can be aimed for simultaneously: boosting public-private co-operation and improving the degree of organisation (in two different ways). These solutions will be discussed below. Finally section 4.2 will discuss what this information strategy implies for some current ICT projects.

4.1 Intensify the public-private co-operation and improve the degree of organisation

The first possible solution in tackling the dominant chain problem consists of an integration of the perspectives and the information systems of both public and private parties. It is important that chain partners receive a complete picture of the situation on the road. Partners in the public sector, such as road managers, can share their data about traffic flows in the NDW. However, due to the content of the measurement information, they can only provide traffic guidance based on generic information about traffic flows; customised guidance requires access to the individual car.
Private sector chain partners (for example suppliers of navigation systems) do have access to the individual car equipped with their systems. This way, they can obtain information about individual cars and offer customised travel advice. An important constraint is that this information cannot be traced back to the person. So, this can be regarded as non-personal customisation of travel advice which public chain parties cannot produce without sharing information and communication channels with their private chain partners.

The second possible solution concerns the improvement of the degree of organisation of the chain. A higher degree of organisation allows for the development of a more integrated traffic picture and a more integrated method of traffic guidance, thus preventing various chain partners from influencing traffic differently or even giving conflicting travel advice. This requires a good adjustment among the various channels.

The chain can improve the degree of organisation in two ways, which are not mutually exclusive:
(1) the chain could focus on achieving joint decision-making at the level of the primary process. This means that, during incidents, public and private chain partners together decide about which traffic flow should be guided towards which part of the road network and which traffic information facilities and communication channels should be used. This can be done, for example, by sharing information about disruptions and deciding together about the travel advice to be given.

(2) although a national approach is, in principle, desirable in this chain, pilots could focus on specific regions or specific road sections (for example, Utrecht). On this smaller scale, chain partners can share information about (potential) disruptions more easily. In this way, the chain can benefit from the fact that the degree of chain co-operation is often higher at the regional level than at the national level. In these pilots, chain partners can also get a better idea of which modes of co-operation and which methods of information exchange are most effective. In this chain, small-scale projects seem feasible.

4.2 Test for current ICT-projects: reaching all car drivers using multi-channel solutions

To which conclusions does this chain analysis lead us when looking at current relevant IT projects? During the interviews two developments were mentioned: one is at the level of the road network and the other is at the level of the individual car. Both developments together can, in the future, lead to a more integrated traffic picture so that unnecessary traffic jams can be avoided. However, at the moment, the two are running separately. No single chain partner can reach every car using only his own communication channel(s).

- Road managers collect information at the level of the road network. The information from various road managers is collected in the NDW. Minute by minute, this information – e.g. from sensors in the road - is sent to this database. After editing, this information can be used to guide traffic.
- In the private sector, providers of navigation systems collect information about individual cars; by measuring the density of the mobile phone network occupancy, the rate of occupancy of the road network can be calculated. (TomTom 2009). Their rerouting advice can be based on this information.

Public and private partners complement each other in the traffic control chain. It is only by merging the two (independent) information facilities into a multi-channel solution that all individual cars can be reached. This would be especially effective if, in the future, the chain parties could together create a more integrated traffic picture. It is only when public and private chain partners work together mutually adjusting their guidance and developing a multi-channel solution that the dominant chain problem can be more effectively tackled.

Biographical notes: P. (Peter) Seignette (1987) has a BSc in Information Science from Utrecht University and is currently working on his master thesis for the master Content and Knowledge engineering. His master thesis deals with (semantic) errors in conversations.

J. (Jesse) J. Dijkman has a BSc in Computer Science and a MSc in Information Science from Utrecht University. He is currently employed at Vellekoop & Meesters B.V. There he works as an organization advisor on projects concerning the internal organization of companies and governments and on several chain projects.

Prof. dr. *mr.* J. (Jan) H.A.M. Grijpink (1946) studied Economics (1969) and Law (1971) at Groningen University. He obtained his PhD. in 1997 at the Technical University Eindhoven for his thesis Chain-computerisation. He is Principal Advisor at the Strategy Development Department of the Dutch Ministry of Justice and Professor of Information Science (Chain-computerisation) at Utrecht University.

M. (Marijn) G.A. Plomp (1984) has an MSc in Information Science from Utrecht University and is currently employed there as a PhD Researcher. His research focuses on the technological and organisational determinants of chain digitisation. He also has a position as researcher/consultant at Dialogic innovation & interaction in Utrecht, The Netherlands.

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Appendix: Chain analysis of the traffic control chain 2010

General information	
Source	Chain Landscape Research Programme (Utrecht University)
Date	May 2010
Scale	National
Number of cases	138.9 billion car kilometres in 2007 (Mobiliteitsbalans 2009, Kennisinstituut voor Mobiliteitsbeleid)

Mission profile	
Social chain product	Welfare
Chain challenge	Car mobility with minimal delay
Dominant chain problem	Disruptions of traffic flows, due to the unpredictability of impediments (incidents, accidents or bad weather conditions)
Target group	Traffic flows
Chain partners	National Database Traffic information [Nationale Databank Wegverkeersgegevens (NDW)], provinces, regions, cities, urban regions, public and private sector traffic and travel information providers, car drivers, transportation sector, Ministry of Transport, Public Works and Water Management [Ministerie van Verkeer en Waterstaat (V&W)], Rijkswaterstaat, traffic control centers, Traffic Control Center the Netherlands [Verkeerscentrum Nederland (VCNL)], Traffic Information Service [VerkeersInformatie Dienst (VID)], Royal Dutch Tourists Federation [Koninlijke Nederlandse Toeristenbond (ANWB)], Connekt, police
Process steps at operational level (links in the chain)	1. Expecting: assess the expected traffic flows based on, for example, events, maintenance and past information. 2. Measuring: measure the road network at a specific moment using, for example, loops in the road. 3. Intervening: directly influencing of the traffic, such as opening rush hour lanes. 4. Guiding: indirectly influencing (guide) of the traffic using traffic information provisions, such as navigation systems and delay alerts.
Intermediary product(s) of each link	Prediction of traffic flows (1), occupancy of the road network (2), intervention (3), travel advice (4)
Critical details	Location of the traffic impediment, estimated time of removal of the traffic impediment, expected average delay
Important points of contact	Measurements on the roads, traffic information facilities
Criterion for the chain	(Potential) congestion
Conclusion	A chain information system with the above critical data is essential for dealing with the dominant chain problem.

Coordination profile	
Coordination mode	Standardisation of working methods
Reasoning	In the chain, there are fixed procedures for using traffic information and traffic signs and displays.
Process structure	Complex
Reasoning	The chain object, traffic flows, is extremely dynamic and difficult to delimit. There is also the possibility of domino-effects: every guiding of traffic therefore needs additional adjustment somewhere else in the road network.
Conclusion	A chain information system is essential.

Information profile				
	Key concepts			
Process steps	Location	Incident	Intervention	
Expecting	X	X		
Measuring		X		
Intervening	X		X	
Guiding	X		X	
Reasoning	There is a fault line between measuring and intervening.			
Conclusion	A chain information system is essential.			

Co-operation profile					
	Mode of co-operation				
Level of the chain process	**Informal consul-tation**	**Formal consul-tation**	**Joint decision making**	**Chain project**	**Joint chain body**
Support	X	X	X		
Primary process	X	X			
Policy	X	X			
Reasoning	The chain partners jointly decide in the 'leaders' consultation' [koplopersoverleg) how to share traffic information. At the level of the primary process, the chain partners consult on event and road maintenance which might impede traffic. At the policy level the Stategic Traffic information and Traffic Management Summit [Strategisch Beraad Verkeersinformatie en Verkeersmanage-ment (SBVV)], chain partners formally consult on their strategy concerning traffic information and traffic management.				
Conclusion	A chain information system is not feasible at the national level.				

Registers	
National registers	Standard Map of the Netherlands [Standaard Basiskaart Nederland (GBKN)]
Source registers	National Database Traffic Information [Nationale Databank Wegverkeersgegevens (NDW)]