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Chain Analysis for Large-scale Communication Systems: A Methodology for Information Exchange in Chains

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Abstract: The chain concept is introduced to explain how large-scale information infrastructures so often fail and sometimes even backfire. Next, the assessment framework of the doctrine of Chain-computerisation and its chain analysis procedure are outlined. In this procedure chain description precedes assessing the necessity and the feasibility of large-scale chain communication systems. The nature of the assessment tools is explained as well as the way they can be used. With the results of a chain analysis a chain information strategy can be defined focused on the development and maintainability of chain information systems. An organisation strategy can be derived from the chain analysis results, as well. Some interesting results are presented based on the comparison of twenty case studies in the context of the chain research project at Utrecht University. Finally, conclusions are drawn and some major challenges identified.
Notice that this founding article is meant as a guide to future case studies. A vocabulary of the relevant terms and concepts of Chain-computerisation in relation to chain analysis is added to this article.

Samenvatting: Dit artikel behandelt het onderdeel ketenanalyse van het leerstuk Keteninformatisering. Het begrip 'keten' wordt gebruikt om uit te leggen waarom grootschalige communicatiestelsels zo vaak teleur stellen of mislukken. Vervolgens wordt de procedure van een ketenanalyse beschreven. Hierin gaat beschrijving van de keten vooraf aan toetsing van de noodzaak en haalbaarheid van keteninformatiesystemen die de kern vormen van een ketencommunicatiestelsel. De aard van de hiervoor gebruikte toetsingsprofielen wordt toegelicht, alsmede de verschillende manieren waarop deze kunnen worden gebruikt. Op basis van de resultaten van een ketenanalyse kan ook een keteninformatiestrategie worden geformuleerd met het oog op het tot standbrengen van een ketencommunicatiestelsel. Vervolgens worden enkele interessante resultaten gepresenteerd van het meerjarige onderzoek naar het Ketenlandschap van Nederland dat wordt verricht aan de Universiteit Utrecht. Ten slotte worden conclusies getrokken en uitdagingen geformuleerd voor de verdere ontwikkeling van het vakgebied Keteninformatisering.
Dit artikel is tevens bedoeld als toelichting en achtergrondinformatie voor toekomstige ketenanalyses. Aan het artikel is een lijst toegevoegd met voor het onderdeel ketenanalyse belangrijke kernwoorden zoals gedefinieerd in het kader van het leerstuk Keteninformatisering.

Keywords: chain, value chain, chain computerisation, interorganisational, information systems, coordination, co-operation, network, information technology, The Netherlands, collaboration, dominant chain problem

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Justice and Professor of Information Science (Chain-computerisation) at Utrecht University.

1. Introduction

1.1 Chain issues

Barely a day goes by without chain issues making the news. Today's headlines are about terrorists' attacks and football hooliganism, tomorrow's about juvenile delinquency and medical errors due to faulty data transfer. We are thus confronted with many large-scale chain issues that are difficult to resolve. These issues always involve the large-scale exchange of information among huge numbers of more or less autonomous organisations and professionals. No single chain partner has the power to compel other chain partners to co-operate effectively. Moreover, they are often confronted with sloppy compliance or sometimes even with direct hostility or opposition by the persons involved: e.g. a forgetful patient, an angry citizen or a suspect. If something goes systematically wrong with the communication in a chain, so many wrong decisions are made that the chain becomes disrupted and discredited.

1.2 Concepts of 'chain', 'dominant chain problem' and 'chain level'

'Chain' does not mean logistics (the process of handling goods) that we so often come across in the business community, nor an information chain (closely linked information systems) nor a chain of transactions (subsequent transactions within a process). The chain concept here refers explicitly to social chains, large-scale inter-organisational processes that yield a social product such as income support, safety or survival. (See figure 1). In a social chain, thousands of organisations and professionals work together without a clear relationship of authority, in ever-changing combinations depending upon the actual case. However, co-operating with other organisations and professionals takes a great deal of effort, time and money. There must be a cast-iron reason for doing so. One important element of the chain concept introduced here is, therefore, that chain partners only co-operate if they are forced to do so by a dominant chain problem. A dominant chain problem is one that none of the partners can solve on his own. If only one organisation inadvertently accepts a deliberately mistaken identity, the identity fraudster can use it anywhere else without arousing suspicion. It is only by effectively co-operating that chain partners can prevent the systematic failure of their own organisation and the entire chain.

The doctrine of Chain-computerisation has as its working hypothesis that every dominant chain problem causes its own chain co-operation pattern and needs a specific tailor-made communication system. So far, this hypothesis has not been falsified. Chains or chain co-operation patterns are abstract constructions in our mind, although we tend to see them as physical objects. Thus, the chain analysis methodology described here must not be considered as a means to uncover the absolute truth about the real chain co-operation world, but as a scientifically based instrument to identify potentially unsuccessful large-scale chain communication systems and projects (Grijpink, 1997; Grijpink, 1999; Grijpink, 2000a; Grijpink, 2000b; Grijpink, 2002; Grijpink, 2009a).

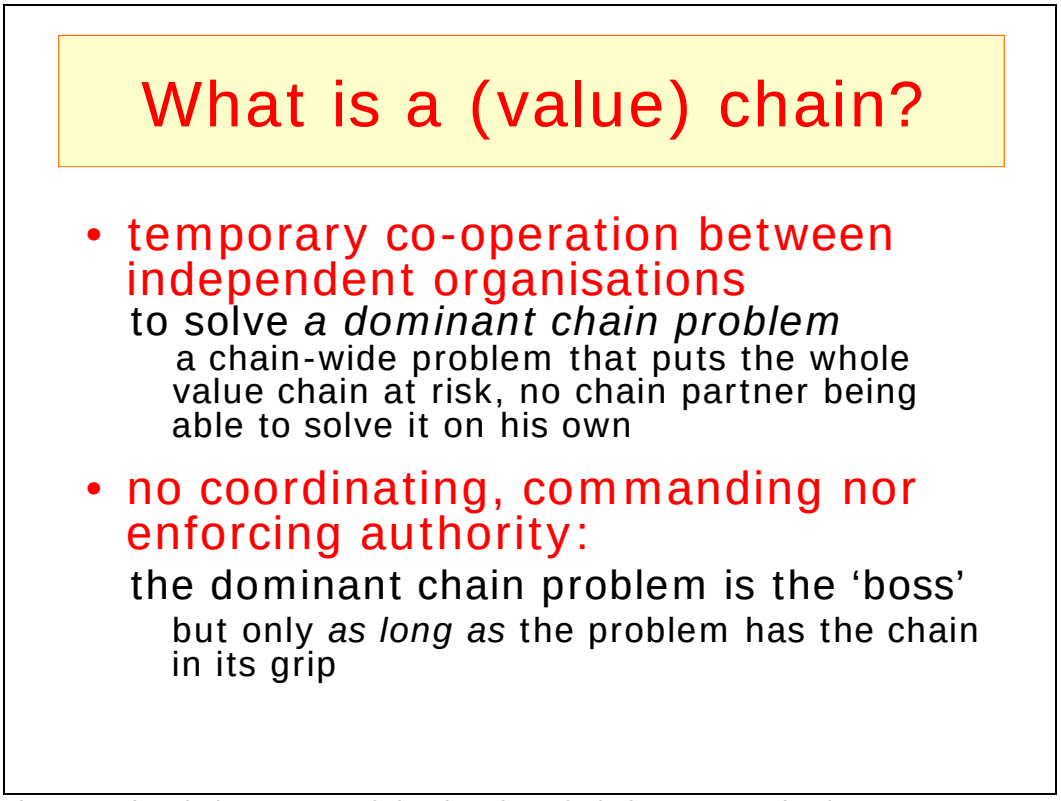

Figure 1 The chain concept of the doctrine of Chain-computerisation

1.3 Chain thinking

Chain thinking is gaining importance. Advancing specialisation and mounting social requirements make private and public organisations and professionals increasingly more dependent on each other. However, chain co-operation proves to be anything but easy. Because common interests are less pronounced than people usually think – and are also often unclear – the badly needed cohesion can only be provided by a pressing dominant chain problem. Only then is there sufficient support for the large-scale exchange of information.

Because overall leadership or authority is absent, the chain is a difficult administrative domain in which decision-making and information exchange proceed differently than *within* organisations. Rationality and efficiency are often hard to find at the collective chain level and, as a consequence, unpredictability and lack of control are the order of the day (Cohen, March & Olsen, 1972; March & Olsen, 1976; Moch & Pondy, 1977; Padgett, 1980; March, 1994; Miller, Hickson & Wilson, 1996). Put simply, chains form a bleak working environment. However, that is nonetheless where the computerisation of society is – to a significant extent – taking place, thus determining the quality of life in the future information society.

1.4 The scientific relevance of the chain concept: fallacy of the wrong level

Information science derives its core concepts and theories from several disciplines and sub-disciplines. We are familiar with the idea that knowledge is only valid within the boundaries of the theoretical framework from which it has been gained. Combining concepts from different theoretical frameworks is an additional challenge. Even when applying insights from one discipline to the real world, we are confronted with

validity errors. But rarely in daily practice do we realise that the validity of knowledge is also limited to the level or scale at which it is gained (see figure 2). In information science – as well as in organisation science and management – we usually derive insights from small-scale situations such as an information system, a small group experiment or a local pilot. Thus, we have gained insights into the power of recording data and in management tools, such as time schedules and budgets. If we transpose such insights to large-scale situations without checking (at that level) the validity of underlying assumptions, we often make a 'fallacy of the wrong level.' This might partly explain why so many policy measures and large-scale systems unexpectedly produce poor results – or may even backfire (Grijpink, 2005; Grijpink, 2006).

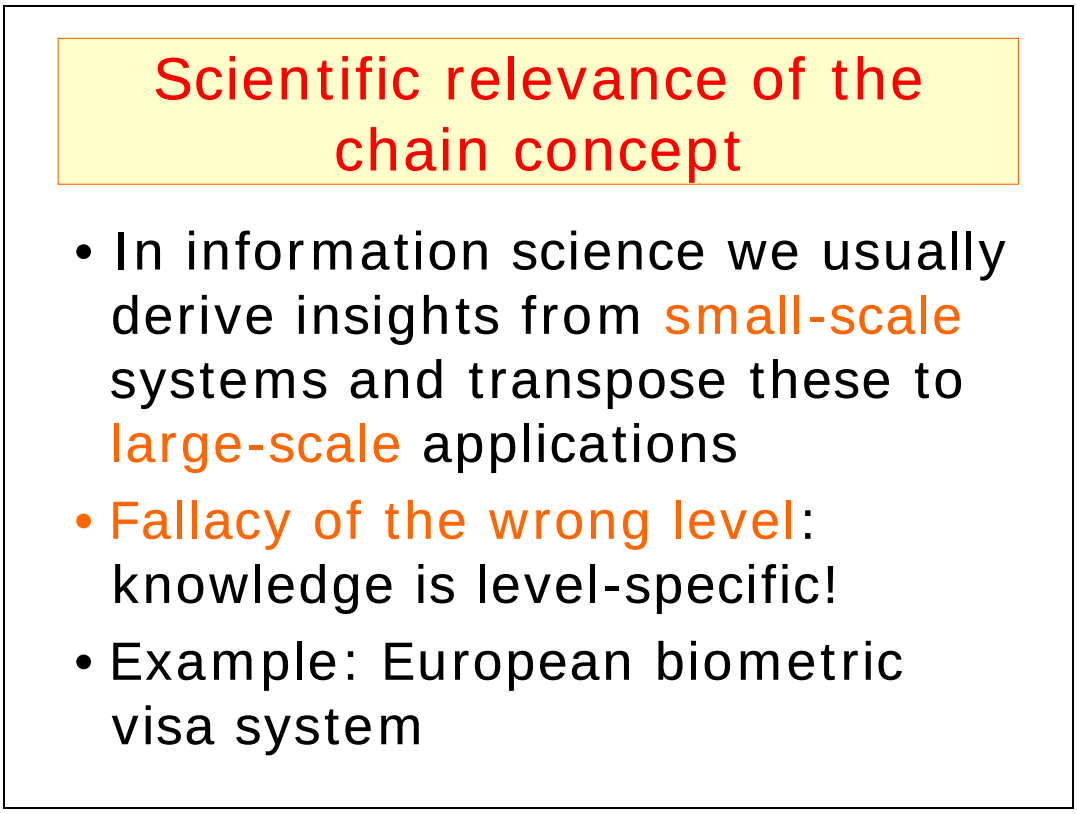

Figure 2 The chain concept safeguarding against fallacies of the wrong level

Example: The European Union's biometric visa system

Recently, biometrics has been added to the EU visa system to prevent unwanted foreigners from coming to the European Union. The term biometrics refers to the recognition of a person by a physical characteristic such as a fingerprint or the pattern of an iris. Information technology makes it possible to quickly digitise a live physical characteristic and to compare it, on the fly, with a previously stored specimen. Biometrics is regarded as a more precise way of recognising individuals than using only administrative details that are not physically linked to the person involved. Thus, the Dutch embassy in the foreign country takes the traveller's fingerprints which are then sent to The Netherlands. If those fingerprints correspond – in the European database – to the fingerprints of unwanted foreigners, then the visa is refused.

On a small-scale, biometrics is considered as an effective instrument for accomplishing this recognition. But will biometrics prove to be as effective when used

on a global scale? Consider this contrasting scenario: a criminal network needs to send someone to The Netherlands. Suppose that the visa is refused because his fingerprints are in the EU-database of unwanted foreigners. Because of this refusal of the visa, the network knows that it has to send someone else or choose a route where traffic control is weak. This means that, instead of the expected greater control of incoming passenger traffic, the arrival of unwanted foreigners will now go largely unnoticed. Thus, the overall result of the biometric visa system is that we put an unnecessary burden on welcome visitors and lose sight of the unwanted foreigners who were the prime target of the system! In this scenario, biometrics applied on a global scale in a visa system is counterproductive.

This example demonstrates how easily a fallacy of the wrong level is made, unless we take into account plausible counter-scenarios when designing or building large-scale systems. The larger the scale of a system, the more sophisticated and numerous the checks and balances should be and the smaller the steps to be taken in the process of implementing it to be able to timely counter-balance negative side-effects as soon as they emerge or have been uncovered. Only a gradual approach, a modest policy measure or a very selective information exchange has any chance of success in a large-scale environment without coordinating authority.

1.5 Chain analysis: assessment of chain information systems

Many large-scale IT-projects fail or backfire. Chain analysis takes as its aim to prevent this by prior assessment of a chain communication system's chances of success by assessing the necessity and feasibility of the composing chain information systems. The key tenet of the theory of Chain-computerisation is that chain co-operation centers on a concerted approach to its dominant chain problem. So, derivation of the chain communication system needed for a concerted approach of a particular dominant chain problem is the first of the two components of a chain analysis according to the methodology of Chain-computerisation. Only after this chain communication system has been derived from the characteristics of the dominant chain problem, its composing chain information systems can be analysed. So, the second component of the chain analysis is the assessment of the necessity and the feasibility of every chain information system making up the chain communication system needed to combat the dominant chain problem. Not all chain partners participate in every case, the actual parties involved depending on the case at hand. Given the large-scale and varying patterns of chain co-operation, critical data that can trigger the co-operation in the chain must be communicated using a common chain information-infrastructure. The core of this information infrastructure is a chain communication system based on one or several chain information systems such as a number system, a reference index or a database containing a few critical (meta-)data.

Figure 3 presents an example of such a chain communication system, to clarify the relation between the chain communication system and its components, chain information systems. The red arrows represent the core of the chain communication required in this chain: the essential questions and answers needed to tackle the dominant chain problem of the drug addicts' health care chain. If the wrong patient is given the drug or the drug replacing medicine it can be sold in the black market or lead to health risk. For this chain communication an information-infrastructure is needed consisting of some chain information systems, a personal number system (LCMR number), a reference index pointing towards this patient's coordinating doctor and the moment of the last delivery – to prevent shopping behavior. Moreover, this chain communication system makes use of data on an additional part of the chain's information-infrastructure: the addict's LCMR-chipcard (card number, LCMR-number and biometric details). Chain information systems and card systems are part

of the chain's information-infrastructure at chain level. The doctors' or pharmacists' patient files are part of the chain's information-infrastructure at the base level of the chain.

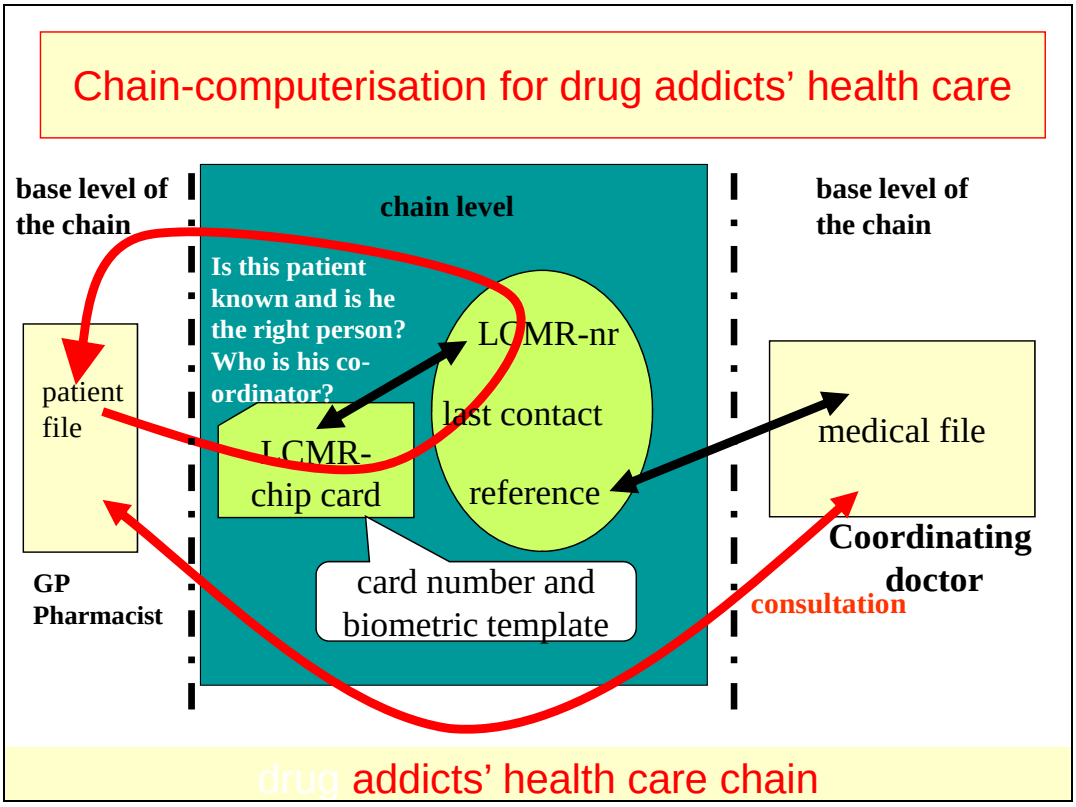

Figure 3 A chain communication system for addicts' health care

The assessment framework of Chain-computerisation consists of four assessment profiles that together enable to accurately differentiate between promising and less promising chain information systems. A promising chain information system must be:

1. indispensable to solving the dominant chain problem in that chain (to be established with the *mission profile*);
2. indispensable for the necessary coordination of the process within that chain (to be established with the *coordination profile*);
3. indispensable to bridge fault lines in the information structure of that chain (to be established with the *information profile*);
4. feasible in the current developmental stage of the co-operation in that chain (to be established with the *co-operation profile*).

The first three profiles (mission profile, coordination profile and information profile) assess whether a proposed chain information system is really necessary. According to the theory, a chain information system that is not needed at one or more of these three levels (mission, process and information) will be difficult to put in place. In that case, developing that chain information system should not be undertaken. The fact that a chain information system is necessary is not to say that it is feasible. Therefore, the fourth assessment profile (co-operation profile) is used to ascertain whether in this particular chain a chain information system is feasible given its interorganisational cohesion. If that is not the case according to the co-operation profile, it will not be possible to develop and install that chain information system, even if the other assessment profiles cast no doubt on the necessity of it.

This does not mean that improving chain co-operation in other ways than by installing a chain information system is impossible. One could work towards a small-scale implementation of information exchange between a few partners who recognise that exchange as being in their own best interest. This information exchange is not chain-wide nor positioned at chain level. Focusing on chain co-operation itself one could experiment with more advanced procedures and mechanisms that pave the way to better conditions for jointly managed chain information systems.

Practical notes concerning the assessment framework

1. The four profiles of the assessment framework can be used both to describe an existing chain and to assess a chain information system. Both description and assessment must relate to the chain as a whole. Especially for descriptive use it is important to bear in mind that the described characteristics, phenomena or objects should be chain-wide. For example, a specific coordination mechanism can be found in *any* link of the chain, but that does not justify the conclusion that the entire chain is coordinated in that way unless it is explicitly established that *every* link of the chain participates in this coordination mechanism.
2. The indispensability and feasibility of each proposed chain information system must be separately assessed in the light of the dominant chain problem. The assessment framework should not be applied spontaneously to an information infrastructure as a whole.
3. Chain analysis aims at preventing IT-projects to produce poor results or fail. The assessment framework, therefore, is meant to uncover specific risks. This implies that one has to be careful to overestimate the chain data gathered during field study. Conservative guesses are better because they sometimes result in unexpected advantages.

2. Step-by-step chain analysis plan

Figure 4 shows the 9 steps of a chain analysis according to the theory of Chain-computerisation. The arrows show the work direction and any necessary repeat steps. The steps 1-5 cover the derivation of the chain communications system; the steps 6-9 produce the assessment of its composing chain information systems.

Deriving the chain communication system and the description of the chain

The first step in a chain analysis is to identify the dominant chain problem forcing the chain partners to co-operate. A dominant chain problem must be able to provoke the breakdown of the chain co-operation in case of repeated failure. Many chain problems fail to withstand this test. That does not say anything about the inconvenience of those insufficiently serious chain problems, but simply that the interplay of forces is not sufficient to develop or maintain a chain information system.

In practice it is sometimes necessary to explore several dominant chain problems or several variants of one dominant chain problem. Thus, the first stage of a chain analysis, steps 1-3, must be repeated until a dominant chain problem that is sufficiently intrusive, recognisable and plausible has been identified. Only then is it worthwhile to describe the chain process in logically consecutive steps representing the links of a particular chain. One should continue only after the dominant chain problem and the chain itself have been sufficiently sharply defined.

The second stage of the derivation of the chain communication system needed for dealing with the dominant chain problem comprises steps 4-5 in the step-by-step plan. Step 4 involves ascertaining which information is vital to solving that dominant chain problem. In this step of the chain analysis we look for one or more

(meta-)details that strongly prompt all of the chain partners to adopt a decisive approach to the dominant chain problem. The analysis then establishes which chain partners need the information and who possesses it (step 5). These steps provide for the building blocks of a chain description. This is treated in section 3.

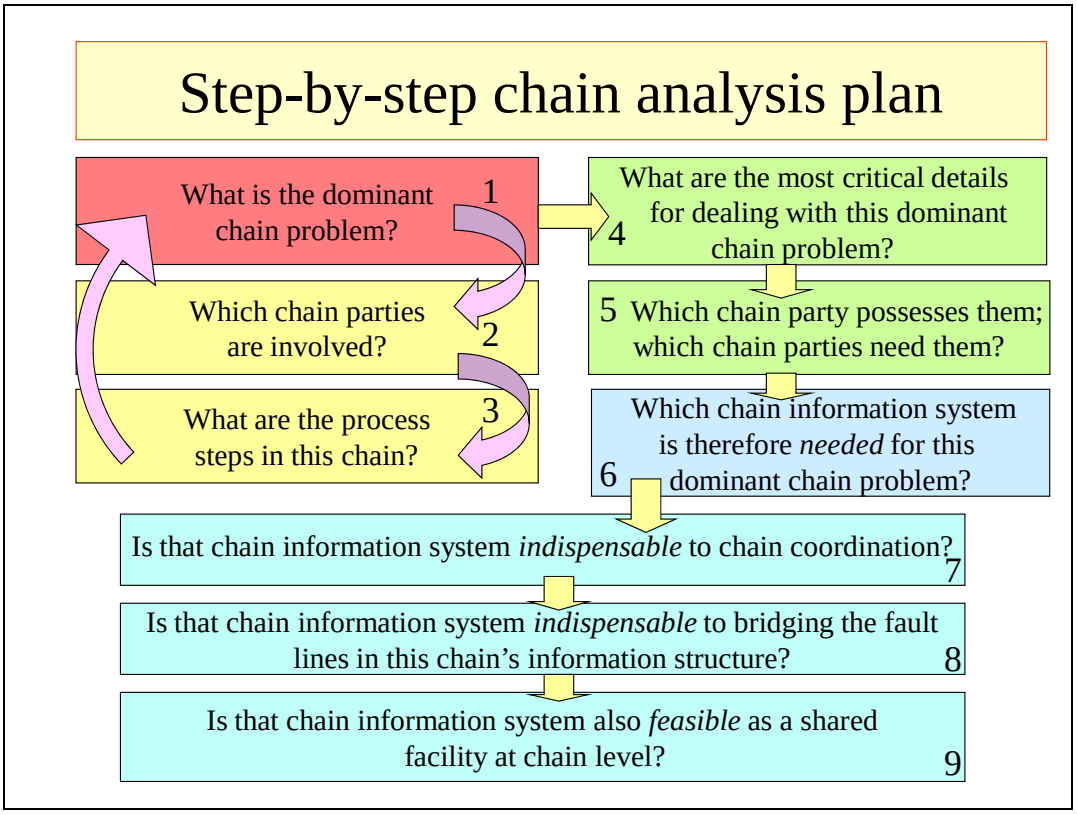

Figure 4 The chain analysis procedure of Chain-computerisation

Assessing chain information systems
As soon as a chain information system needed for a dominant chain problem has taken shape (step 6) it can be assessed in terms of its indispensability and feasibility (steps 6-9). That is the subject of sections 4 and 5.

Formulation of chain information and organisation strategies
From the results of the steps 6-9 of the chain analysis the information and organisation strategies can be derived. This is explained in section 6.

Practical note concerning the step-by-step chain analysis plan
In the development of the assessment profiles of the doctrine of Chain-computerisation (Grijpink, 1997) use has been made of many tried and tested insights drawn from organisation and administrative sciences and management, taking account of the validity of those insights at chain level. That makes it possible to assign a normative value to the assessment results (see sections 4 and 5). That is less true if the assessment profiles are used as descriptive or inspirational tools (see sections 3 and 6).

3. Description of the chain

Steps 1-5 of the chain analysis can now be summarised in the mission profile chart (see table 1). Note that we use the mission profile here to *describe* the *chain*, not

to *assess* a *chain information system*. We use the questions in table 1 to build up a systematic description of a chain which at least provides a clear understanding of the dominant chain problem and the critical details prompting the chain co-operation needed to tackle it.
In section 4 we use the mission profile again, but this time to assess the necessity of a proposed chain information system containing the critical details needed to tackle the dominant chain problem in a particular chain. There, the example – illustrating the assessment use of the mission profile – is taken from the chain analysis of the Dutch medication chain (Grijpink & Plomp, 2009). See table 2.

- The *social chain product* indicates what society can and should expect from a particular chain co-operation, which basic social value is being contributed to by this chain co-operation (e.g. safety, health, well-being, prosperity, etc.).
- The *chain challenge* is the concrete objective aimed at in order to substantiate the (contribution towards the) social chain product.
- This is not the same as the *dominant chain problem*, which refers to the operational problem that prevents the chain partners from meeting the chain's challenge.

Elements	**Explanation (underlying questions)**
Social chain product	What is the purpose of this chain in our society? Which basic social value is achieved through the chain co-operation?
Chain challenge	Which concrete objective is being worked towards to contribute to the social chain product?
Dominant chain problem	Which chain problem that none of the chain partners is able to solve on its own is causing the chain partners such difficulty that it could result in the entire chain being discredited?
Target group	On what (object) or who (subject) does the chain focus? Which role do they play (risk location; victim, applicant) and what position do they take: are objects private property (building) or is the object a moving phenomenon (traffic congestion); are the subjects co-operating (e.g. a patient) or non-co-operating (e.g. a crime suspect)?
Chain partners	Which chain partners contribute to the social chain product by jointly tackling the dominant chain problem while trying to meet the chain's challenge?
Process steps at operational level (links in the chain)	In which logically consecutive process steps (links in the chain) is the social chain product brought about?
Intermediary product(s) of each link	With which intermediary products – used to pass on the result of the work from one link to another – is the social chain product brought about?
Critical details	Which essential details (usually 2-3) can prevent incorrect decisions and trigger the right action in the chain? What information do you *need* to know?
Important points of contact	Where or on which occasions do chain partners usually meet the target group?
Criterion for the chain	What determines the chain's boundary? Which cases belong to the chain, and which do not?

Table 1 The mission profile with explanatory questions

- To gain an impression of the *target group* we need to consider persons (stakeholders or clients), but the chain process can also focus on objects, such as cars or buildings. Which role is played by objects belonging to the target group? A building has a fixed location, but the risks involved may change over time. Traffic congestion is an object that moves and varies at the same time. Which role is played by people belonging to the target group? Are they applicants or victims? Is their involvement in the chain voluntary or involuntary? Is it to their benefit or their detriment? The capacity in which a person or an object takes part in the chain has a serious effect on the chain. For example, it determines whether people co-operate or not (consider the difference between the health care sector and the criminal law chain in this context). If the target group consists of objects, similar questions can be formulated about various aspects that determine the object's role in the chain such as location, immovability, value, interested parties, etc. to gain a better understanding what that chain co-operation is about.
- The *chain partners* need to solve that dominant chain problem together in every forthcoming case in order to prevent the chain from being discredited. If one of the partners in the chain drops the ball, the whole chain is discredited. None of the partners holds the solution: they are dependent on each other for their approach to the problem. Are there big differences in their contributions?
- In which – logically consecutive – *process steps at operational level* is the envisaged social chain product produced given the chain's dominant chain problem?
- With which *intermediary products* is the social chain product brought about? *Intermediary products* transfer the results of the work from one link in the chain to another and are often handed to the target group. Examples include a passport, a residence permit, a treatment, a sum of money or a criminal sentence.
- Next, we are to answer the question: which *critical details* can prevent incorrect decisions from being made in the chain that could result in the chain being discredited? Critical details are needed in the chain communication to set the chain co-operation in motion in an actual case. If a critical detail is incorrect, wrong decisions will be made, actions will be wrongly omitted or intermediary products will fall into the wrong hands.
- To get a better idea of the chain context we now are asked about the most *important points of contact* between chain partners and their clients/chain objects. In which situations (where and when) can stakeholders or clients come into contact with chain partners? The concept of a 'point of contact' is a broad one and refers to the place and circumstances in which chain partners meet their clients. The municipal citizens' desk or a hotel desk are points of contact, but so is catching a burglar red-handed in the criminal law chain.
- Finally, the *criterion for the chain* is needed to sharpen the definition of a chain's boundary by indicating which cases are or are not covered by the chain. Mostly, the criterion limits or refines the relevant part of the target group. Examples of criteria refining target groups of persons are age, nationality, residency or a particular medical diagnosis.

Practical notes concerning the mission profile as a descriptive instrument

1. The description must remain at chain level and address the chain as a whole. In practice, however, people often lose sight of the chain as matters proceed.
2. Chain partners look at chain issues only from the viewpoint of their own organisation, interests and priorities. In our chain research at Utrecht University, we were confronted with the problem that, as a result, dominant chain problems cannot be found by interviewing chain partners and

merely adding the responses. We had to perform disciplined analysis to discover a chain problem, if any, and to then assess its dominant character. The good news is that, once it has been defined, chain partners generally recognise the dominant chain problem as the major common problem.

3. The first steps in the chain analysis (see figure 1) will generally have to be taken several times. In practice, matters are often clarified by exploring two dominant chain problems and comparing the two chain-specific information infrastructures. If they closely resemble each other, the dominant chain problem can be formulated more generally, otherwise that is precisely the opposite of what should be done. In that case there are two separate patterns of chain co-operation, each with its own chain communication system and information infrastructure.
4. In practice the chain challenge can be more effectively identified by positively formulating it with a concrete objective ('above the age of 18, back to work within six months'), while the dominant chain problem with a negative formulation is easier to find: '... must not be allowed to happen', or '... must be avoided at all costs').
5. In the third step of the chain analysis in which the logically consecutive process steps of the chain are identified, the dominant chain problem is the determining factor. At the start of the chain analysis the process steps generally form a short, logistical chain without much of a social problem related to the process. Then, it is barely possible to indicate where the dominant chain problem spoils the process. Process steps have to be added to the chain at least until the entire approach to the dominant chain problem fits within the chain (from prevention to repression and aftercare). It is also important to make sure that the entire life cycle of the dominant chain problem, from inception to solution, fits within the chain confines.

4. Assessing the need for a chain information system

The indispensability of a chain information system in a chain can be established using three assessment profiles consecutively: the mission profile, the coordination profile and the information profile. A chain information system is only necessary if all three assessments have a positive outcome. If not, the chain information system is not necessary and should not be developed. Note that the necessity of a chain information system does not depend on the scale of the chain co-operation which can vary from local to international.

4.1 Assessment with the mission profile

The mission profile provides a picture of the chain based on some characteristic features and indicates which chain communication system is needed to tackle the dominant chain problem. The mission profile – set out in section 3 as a descriptive instrument – is now re-used for assessment purposes. The mission profile of the Dutch medication chain (Grijpink & Plomp, 2009) is our example here. See table 2.

We use the mission profile to critically consider whether – at the level of the purpose of the chain co-operation – a chain information system containing the indicated critical (meta-)data is actually needed to effectively tackle the dominant chain problem by inducing the chain partners to co-operate in a concrete case. If that is the case, a chain information system with those critical details is indispensable in that chain. This assessment is shown as step 6 in the step-by-step chain analysis plan.

To test the necessity of a chain information system, therefore, relates to whether the indicated critical details are essential to the approach to the dominant chain problem.

Elements	Notes
Social chain product	Health
Chain challenge	Prevention of damage to health being caused by medicines
Dominant chain problem	Prescription for medicines that are dangerous to the patient owing to a lack of information about medicine usage and personal risk factors.
Target group	Patients
Chain partners	Researchers, pharmaceutical industry, European Medicines Agency (EMEA), pharmaceutical wholesale sector, pharmacies, Royal Dutch Society for the Advancement of Pharmacy (KNMP), general practitioners, specialists, dentists, obstetricians, doctors' associations, patient associations, Ministry of Health, Welfare and Sport
Process steps at operational level (links in the chain)	Inform, Diagnose, Prescribe medicines, Issue medicines, Monitor the medication, Intervene
Intermediary product(s) of each link	Information, Diagnosis, Prescription, Issued medicine, Knowledge, Action
Critical details	Health care identification number (Citizen Service Number), Current use of high-risk medicines, ID number of the doctor, Personal risk factors related to the patient
Important points of contact	Consultation with doctor, visit to the pharmacy, admission in the hospital, scientific research
Criterion for the chain	Conflicting medicines and/or personal risk factors

Table 2 The mission profile for the medicine chain (see explanatory questions in table 1)

Practical note concerning the mission profile as an assessment tool
The mission profile establishes whether a chain information system is needed at the level of the purpose of a specific chain co-operation. It does not establish whether the particular chain co-operation is needed or whether the dominant chain problem really exists!

4.2 Assessment with the coordination profile

The coordination profile (see table 3) is used to ascertain whether a chain information system is needed for the chain-wide coordination of the approach to the dominant chain problem in question. This necessity test relates to the level of the chain process. The coordination profile reflects a number of concepts and theories that are broadly accepted in organisation and administrative sciences and management (Taylor, 1911; Woodward, 1965; Thompson, 1967; Lawrence & Lorsch, 1967a; Lawrence & Lorsch, 1967b; Lawrence & Lorsch, 1969; Galbraith, 1973; Van de Ven, Delbecq & Koenig, 1976; Van de Ven & Delbecq, 1976; Mintzberg, 1979; Kumar & Van Dissel, 1996; Grijpink, 1997, pp. 67-75; Grijpink, 1999; Grijpink, 2002; Grijpink, 2009b, pp. 57-60).

The theory of Chain-computerisation is based on the notion that a chain information system can only be successfully developed and maintained if it is indispensable for the chain-wide coordination. This is the case, if the chain's process structure is complex, meaning that tackling the dominant chain problem in every individual case requires feedback as well as feed forward between mutually dependent links of the chain. That leads to nodes or loops in the treatment process of a concrete case. Keep in mind that this test is only one out of three; this one relates to the process level of the chain.

Type of process structure at chain level	**Coordination mechanisms at chain level**					
	general production rules	standard-isation of the product	standard-isation of expertise	standard-isation of working methods	common chain informa-tion sys-tem	mutual (informal) adjustment
simple chain structure (lin-ear structure)	X	X	X	X		
complex chain structure (node struc-ture)	X	X	X	X	X	X

Legend: X = applicable; the two shadings indicate two different types of coordination systems.
Table 3 Coordination profile of a chain

Table 3 shows how the coordination mechanisms necessary in a chain depend on the type of process structure. The coordination needs of a complex chain can only be met with chain information systems owing to the dominant chain problem requiring feed forward and feedback. Keep in mind that it is the dominant chain problem, too, that determines what type of chain information system is needed and which critical details it has to contain.

The vertical dimension of the coordination profile comprises two types of process structure: simple or complex. The essence of a simple chain structure is a serial dependence of the links of the chain, with feed forward only for the coordination in the chain. The simple chain structure can be characterised by a purely linear structure or by a linear structure that initially consists of a number of converging chain parts (a convergent linear structure) or a linear structure that fans out at the end into a number of linear chain parts (a divergent linear structure). In the complex chain structure 'everything depends on everything', which calls for a lot of information exchange and mutual adjustment (often in person) requiring feedback as well as feed forward for the necessary coordination.

The horizontal dimension of the coordination profile features a typology of coordination mechanisms at chain level, i.e. for the chain as a whole, in ascending order of complexity, from left to right. More complex coordination mechanisms presuppose the less complex ones.
The simplest coordination mechanisms at chain level are formed by *general production rules and product standardisation*. For example: a standard content of a bottle enables people to know what the bottled output will be of a previous link in the chain. But when product properties are less concrete, these two forms of coordination do not give us enough to go on. In those cases it may be necessary to standardise the necessary expertise, as is the case in health care chains, for instance in

relation to nursing. Nurses' training gives them standardised knowledge and skills. If *standardisation of expertise* is not yet sufficient to coordinate the chain as a whole, consideration is also given to *standardising working methods*. The checklist for a major service for a car is an example of this type of coordination. The next coordination mechanism at chain level consists of common *chain information systems*. An even more complex coordination mechanism is *mutual (personal) adjustment* in which the interpretation of common details is compared in relation to the features of a given case.

If a chain features a linear process structure, a chain information system is not needed for the chain-wide coordination when it comes to tackling the dominant chain problem. Feed forward mechanisms will provide enough coordination at chain level. Trying to develop a chain information system will not be successful according to the theory. Only complex chain process structures require a common chain information system and mutual adjustment.

Note that – with the coordination profile – it is the type of chain process structure that determines the assessment result given the chain's dominant chain problem. It is, therefore, important to find out why feedback mechanisms are essential for tackling the dominant chain problem. A complex chain structure comes about, for example, when the object of chain care (suspect, patient) can occur at the same time in several places in the chain, possibly in various links. Identity fraud, for example, can arise or become visible in all sorts of places and for that reason requires feedback. A chain is also complex if the correct route through the chain or the right type of treatment can only be derived from critical data that are spread throughout the chain or are changing over time. This is all the more so if that feedback also affects the interpretation and significance of the critical detail. In the criminal law chain, for example, a recidivist can come up at the same time in a large number of crimes among a large number of judicial bodies in all sorts of different phases in the chain process, spread throughout the entire chain. Recidivism calls for an approach of its own, and it must be possible to take all judicially relevant situations into account. For that reason, the criminal law chain can be regarded as a complex chain. Conversely, the asylum chain features a linear process structure, for an asylum seeker can only go through the asylum chain once with the same identity. Ultimately, he or she is permitted or not to remain in The Netherlands. The simple chain structure becomes complex when people can easily assume various identities and simultaneously occur at various points in the chain, with a different identity on each occasion. The dominant chain problem of identity fraud in that asylum chain causes the asylum chain to become a complex chain. In that case a chain information system featuring biometrics is needed to detect the multiple identities in the asylum chain.

Practical note concerning the coordination profile as an assessment tool

1. The structure of a chain process is a crucial aspect of the chain analysis. It is, therefore, necessary to critically consider whether the dominant chain problem requires feedback from later links in the chain concerning the object of chain care. That could be the case if the chain object can occur at the same time at more than one point in the chain and so give rise to a situation to which the dominant chain problem refers. That is often the case concerning behaviour or situations such as (chronic) sickness or recidivism.
2. The number of chain partners (organisations or professionals with discretionary powers) is not determinative to establishing whether a chain has

a simple or more complex structure. Decisive is the need for feedback in the chain's operational process required by the dominant chain problem.

3. In common with a simple linear chain, a complex chain features a number of logically consecutive process links. The need for feedback in the chain is independent of this logical sequence of links in the chain.

The adage 'the chain is of the simple type, unless the nodes and loops can be convincingly explained' is a good starting point. Only then can we avoid a situation where weak chain projects are undertaken on a structural basis.

4.3 Assessment with the information profile

The information profile (see table 4) makes it possible to assess a proposed chain information system at information exchange level by exposing the structural causes of recurring problems in the mutual exchange of information in a chain. That is because co-operating organisations have to talk about 'the same things'. The information profile uses the term 'key concept' to typify the focus of a link in a chain and of the organisations and professionals in that link (Grijpink, 1997; Grijpink, 1999; Grijpink, 2002; Grijpink et al., 2007; Grijpink & Plomp, 2009).

	Key concepts		
Process steps	offence	case	person
Detect offenses	X		
Investigate offenses	X		
Elicit a decision		X	
Give legal advice		X	
Decide		X	
Execute a decision			X
Rehabilitate			X

Legend: X means applicable. ——— *Fault line between two linguistic areas*

Table 4 The information profile of the criminal law chain

Thus, a key concept indicates what an organisation 'talks about', which object or aspect is so central to the work that the organisation strives on that point as strongly as possible to make its information complete, accessible and up-to-date. An organisation is usually able to focus on no more than one or two key concepts at the same time. Errors often occur if that organisation needs information from a chain partner that focuses on a different key concept, because the content, topicality or quality of the detail is sufficient for the one organisation but not for the other. The pattern of key concepts in a chain reveals the underlying structure of 'linguistic areas'. Structural communication problems occur where a fault line between two linguistic areas in the chain's information structure appears. Since such a fault line is deeply rooted in the work and the division of work in a chain, it cannot simply be eliminated by means of organisational measures, for example. However, a fault line can be bridged with a chain information system but that will only help if this chain information system is tailored to that chain's dominant chain problem. Thus, a chain information system is only truly required if it helps to bridge a fault line in that chain's information structure by providing the critical details needed to tackle that dominant chain problem. The identified key concepts indicate what the critical details must relate to.

In table 4, presenting the information profile of the criminal law enforcement chain, we see that investigative bodies in the first two links of the criminal law chain focus on detecting and investigating criminal offences for which the legislator has set serious criminal sanctions. So, the key concept for co-operating organisations in the first two links of the criminal law chain is 'offence'. When a crime is detected the

details are registered in such a way that the criminal offence is documented as completely, relevantly and clearly as possible. The following links in the criminal law enforcement chain focus on the key concept ‘case’: details about a criminal offence and the people involved in it are collected for each case as completely, relevantly and clearly as possible. At these stages it is no longer about investigating the criminal offence but about the charge and the sentence, taking the circumstances of the crime and personal factors into account. This often concerns several people in mutual relation, each with their own criminal actions and their own personal backgrounds. A case is referred to the court with a summons, unless the Public Prosecution Service effects a settlement or decides not to prosecute. In the last two links, details about the convicted person are laid down as completely, relevantly and clearly as possible. In the criminal law enforcement chain a ‘person’ refers to a natural or legal person.

The information profile of the criminal law enforcement chain thus shows three separate linguistic areas, with two fault lines (see table 4). The exchange of information in each concrete case that goes through the criminal law enforcement chain must always go past these two fault lines, with all the communication problems that entails. The presence of a fault line in the information profile implies that a chain information system is necessary to ensure that the exchange of information in the chain proceeds smoothly.

The information profile of the criminal law enforcement chain indicates that a chain information system with a personal number system and a reference index for persons referring to the chain partners involved in the particular case, can build a bridge between the *person* orientation at the end of the chain and the *criminal offence* or *case* orientation in the previous links of the criminal law enforcement chain. If a new criminal offence comes to light concerning a suspect who has already been imprisoned for another offence, this chain communication system can faultlessly direct a summons and a judgment to the right prison for service in person, so that the judgment can then be executed straight away. Without this system, which was put in place in 1995, a new judgment often arrived too late, after the convicted person had just been released and could no longer be found.

To identify the desired content of a chain information system to bridge a fault line, it is best to start by considering the key concept of the last link in the chain (i.e. at the bottom right of the information profile). This critical detail is the first to come into the picture for being made available throughout the chain with a chain information system. From the information profile of the criminal law chain we can thus establish that we first have to include the critical detail that uniquely identifies the person in the chain information system. For that reason, since 1993 there has been a national criminal chain number operational with a reference to all judicial bodies currently involved with the person concerned. That makes it possible to provide an integral judicial image of a person to all partners in the chain. Table 4 shows that the second fault line can be bridged with a detail indicating the particular case. That is done by stating the relevant case number in the reference to the relevant judicial body.

If there is no fault line in the information profile, no chain information system is required. An (imaginary) information profile of this nature is shown in table 5. There are no fault lines identifiable between the process steps ‘investigate’ and ‘decide’ and between ‘handle’ and ‘provide aftercare’ because a solid connection can be made between any two key concepts, usually even within each of the cooperating organisations.

Process steps	Key concepts		
	A	B	C
-	X		
-	X		
-	X	X	
Investigate	X	X	
Decide		X	
Handle		X	X
Provide aftercare			X

Legend: X means applicable.

Table 5 Example of an imaginary information profile *without* fault lines

Practical notes concerning the information profile as an assessment tool

1. The following procedure is used to clearly map out the fault lines in a chain's information structure.
   a. The process steps are taken from the mission profile and are placed in the first column from top to bottom in the same (logical) sequence shown in the mission profile.
   b. The next step is to indicate, from top to bottom for each process step, the main information entity in that link of the chain. These key concepts are placed at the top of the information profile in their order of appearance, from left to right. The best picture of the information structure is created if only one but no more than two key concepts are allowed in each process step. After all, this profile is not intended to be a complete description of the information structure of the chain, but an analytical instrument to assess the need of a chain information system by uncovering the fault lines.
   c. The pattern of crosses should be a(n almost) diagonal one, from the top left to the bottom right. There is no fixed sequence in the horizontal series of key concepts, so the columns must be shifted until the crosses show the best possible diagonal pattern from the top left to the bottom right.
   d. A fault line is then identified by a white box underneath a vertical column of consecutive crosses, while in the next column on the white box's row there is a cross without a cross above it. See the two fault lines in table 4.
2. If there are consecutive crosses vertically or horizontally, there is no fault line. See table 5 and compare with table 4.
3. To identify the necessary content of a chain information system to bridge a fault line, it is best to start by considering the key concept of the last link in the chain (i.e. at the bottom right of the information profile). This critical detail is the first to come into the picture for being made available throughout the chain.

5. Assessing the feasibility of a chain information system

The fact that a chain information system is necessary is not to say that it is feasible. Many chains are less cohesive than the chain partners want us to believe. That poses a serious threat to a chain-computerisation project because its chance of success can easily be overestimated. Failed projects remain in the collective memory for lengthy periods and block new initiatives for a long time. Therefore, the chain co-operation profile makes it possible to assess the feasibility of a chain in-

formation system by providing a clear picture of the chain-wide forms of co-operation that are familiar in a chain. These set limits to the feasibility of a chain information system. There can be big differences between chains regarding the level of interorganisational cohesion. In the one chain, chain partners make daily agreements about the joint approach to a given case, while in another chain even informal contact will be treated with suspicion.

The co-operation profile relates the forms in which organisations structurally work together at chain level to the system level of the chain process at which that takes place:

1. The horizontal axis of the co-operation profile shows five forms of co-operation that from left to right follow on logically from each other. The forms of co-operation farther to the right cannot exist without the preceding ones. Formal consultation, for instance, calls for stronger mutual ties than informal consultation because it implies an obligation to participate and a degree of planning. Common secretarial support for formal consultation does not necessarily imply that a chain is already able to make joint decisions in individual cases or to take on a common computerisation project. If a chain has common facilities (projects or bodies) there are even stronger ties, since each chain partner depends on the facility without being able to directly and individually exert influence on its quality and availability. Apparently, there is sufficient confidence that the interests of an individual chain partner will not easily be damaged and if this happens, there are procedures to satisfactorily resolve any disputes that arise.
2. The vertical axis of the co-operation profile shows the three system levels at which co-operation can take place: support, execution of the primary process and policy making. Co-operation at the level of common support – e.g. a common computer centre or a common training course – features a lower threshold in a chain than co-operation at the execution level of the primary process. The threshold for joint action in the primary process is usually high because the increasing mutual dependence affects the chain partners' operational autonomy and more joint support is required. Co-operation at policy level in all five separate forms features the highest threshold because it is often feared that this could adversely affect the institutional autonomy of a participating organisation.
3. The organisational level of the chain is indicated with the pattern of shaded blocks that represents the chain-wide practiced forms of co-operation at the indicated system level. If in the field research particular forms of co-operation are not being found, the relevant blocks stay white.

The development of the chain co-operation over time does not, of course, have to keep to the logical phasing indicated on the horizontal dimension of the chain co-operation profile. Incidents or new developments can elicit reversion to a previous level, and sometimes there is rapid development.

Level of the chain process	**Form of co-operation**				
	Informal consultation	Formal consultation	Joint decision making	Chain project	Joint chain body
Support					
Primary process					
Policy					

Legend: shading indicates that the form of co-operation is currently chain-wide at that level.

Table 6 The co-operation profile showing the level of interorganisational cohesion

The co-operation profile reflects a number of concepts and theories that are broadly accepted in organisation and administrative science and management (DeVries, 1978; Tichy & Fombrun, 1979; Können, 1984; Grijpink, 1997, pp. 56-63; Grijpink, 2000a; Grijpink et al., 2007; Grijpink & Plomp, 2009, pp. 64-68).

The idea underlying the co-operation profile is that a chain system or project has little chance of success if it does not fit in a current familiar form of co-operation in that chain. But feasibility is a matter of degree. Table 7 shows four different chain projects (A, B, C and D) with different degrees of feasibility according to the co-operation profile as indicated by the shaded boxes.

Level of the chain process	**Form of co-operation**				
	Informal consulta-tion	Formal consulta-tion	Joint decision making	Chain project	Joint chain body
Support			A	B	C
Primary process					
Policy					D

Legend: shading indicates that the form of co-operation is currently chain-wide at that level.

Table 7 Four chain projects, A, B, C and D with different degrees of feasibility

An imaginary chain project A represents a joint training plan for a specific expertise that is important to the chain's primary process at execution level. The chain partners therefore want to make a joint decision about the training programme, which can be regarded as a support facility in relation to the chain's process at execution level. An example that illustrates D is the creation of a collective body that sets policy principles for all chain partners for the implementation of the chain's primary process. The content of those policy principles depends on the specific chain and the powers of that collective, coordinating body. Chain project A has a good chance of success because it is in keeping with what people are accustomed to doing together in this chain. Project D has white boxes all around it. According to the co-operation profile, project D does not have the faintest chance of success.

If a chain information system is not sufficiently feasible at chain level, it is possible in some cases to develop a solution at the base level of the chain. That solution will not be chain-wide, but could none the less have a sufficiently favourable effect on a number of chain partners. But from the perspective of the chain co-operation concerning a specific dominant chain problem, it remains makeshift. For that reason we discuss the alternative of an organisational development strategy at chain level in section 6.

Practical notes concerning the co-operation profile as an assessment tool

1. The method used to ascertain a chain's level of interorganisational cohesion is of course vital to judging the feasibility of a chain information system. It is important to avoid taking an overly rosy view of the feasibility aspect. If the co-operation profile is also used for the chain's organisational development, it is possible that if a pessimistic assessment has been made the conditions will turn out more favourable than expected. That can be responded to more quickly than setbacks.
2. To accurately characterise a chain's level of interorganisational cohesion it is important to state what is regarded as the execution level of the

primary process, e.g. the treatment given to a patient or the handling of a disaster. Then, the two other process levels (support and policy) fall into place. Support relates to what is needed for the treatment or handling, policy is about the conditions and rules to be met.

3. The second step is to shade the boxes representing familiar chain-wide forms of co-operation in the chain. A box should only be shaded if the form of co-operation can truly be regarded as in chain-wide practice. To limit the amount of field work required one could start the research looking for joint decision making at support level, proceeding to the right in the chain co-operation profile if this particular form of chain co-operation does exist and to the left if it does not. Next, proceeding to the execution level starting with the highest form of co-operation established at the support level. And so on.
4. The third step involves placing the project or the envisaged system in the correct box. If the intended result of the project does not form an element of the execution of the primary process itself, it is usually of a support nature. So: 'support, unless…'.

6. Organisational strategy for chain co-operation

There is no need to stop the process of chain computerisation once a feasibility assessment has been made on the basis of the co-operation profile indicating that a chain information system is not feasible. There are many other ways of improving chain co-operation. For instance, by organisational development – chain-wide or less – to improve the feasibility conditions for chain information systems in the future. This organisation strategy can be derived from the co-operation profile, as well. When using the co-operation profile in this way it is important to bear in mind that the suggestions put forward by the co-operation profile do not have the normative significance of the feasibility assessment. It should also be borne in mind that the development of the co-operation in time does not of course have to keep to the logical sequence from a lower to a higher organisational level. Incidents or new initiatives or developments can create zigzag movements in time. These can elicit a reversion to a previous level, but could equally give rise to an unexpected surge that suddenly renders a chain information system feasible.

How do we go about deriving an interorganisational development strategy from the feasibility assessment of project C representing a joint chain body that independently manages a chain information system (see table 7)? This chain project C is not feasible given the current level of interorganisational cohesion of this chain, but according to the chart the chances for that project would increase if joint ad hoc action at support level was already being regularly practiced in the chain. That could be initiated or promoted by chain project B, because it borders on a box with a co-operation form that is in keeping with current practice in the chain and that – being positioned at support level – will arouse little resistance. In due course project B could pave the way towards project C, a jointly managed chain information system. A chain project B is usually worthwhile because the scope and coverage of alternatives in the form of minor solutions at the chain's base level are generally too modest and take up too much time in relation to the benefits for the chain as a whole.

7. Results of the chain research programme at the University of Utrecht

During the past five years, more than twenty-five Dutch large-scale chain co-operation cases have been studied at the Institute of Information and Computing

Sciences of Utrecht University, using the guidelines and the chain analysis tools provided by the doctrine of Chain-computerisation. This has led to some valuable insights and breaking views.

1. Large-scale systems cannot do without a suitable chain approach
Large-scale systems must inevitably be implemented without overall authority and adequate management support during development and exploitation. If there is no overall coordinating authority, management tools and rational models are often not – or only partially – valid. Moreover, many chains produce collective values regarding subjects that do not (fully) collaborate. A chain approach that takes this rough and chaotic working environment into full account is indispensable, with at least the following features:

a. Above all, that approach should warn against fallacies of the wrong level. The validity of insights is restricted to the level from which they have been gained. If transposed to higher or lower level, these insights and underlying assumptions are often not valid. In information practice, fallacies of the wrong level abound, causing robust systems to be rare and many large-scale systems to carry more weaknesses and risks than people think. This can only be counterbalanced with a gradual approach in the development and implementation of large-scale communication systems.
b. Next, a chain has to be seen as a multi-level phenomenon. There are still too many people, for instance, who believe it is necessary and feasible to stuff all of the content information of a chain into a single chain database. At this enormous scale, that yields little more than a concentration of management activities, not communication. Information must stay within reach of its source and be managed there, too. Thus, chain communication must be separated from data collection and storage. Hence, communication at chain level and data gathering at the base level of the chain. Keep in mind that this is an analytical distinction, not a two-floor-building.
c. The core of the chain approach should be a dominant chain problem prompting interplay of forces strong enough to make large-scale chain communication possible.

This chain approach focusing on communication that prevents the dominant chain problem from ruining individual cases, must lead to lean and flexible chain information infrastructures to cope with resistance and lacking support and to adapt to unforseen changes. Moreover, many large-scale systems lack adequate checks and balances within the system itself, as well as tools and procedures protecting it against large-scale risks. More risk analyses and more chain analyses should therefore be undertaken, preventing naïve solutions. Risks associated with the dominant chain problem are the most significant ones and should also be monitored during the development and exploitation phases of large-scale systems.

In information science – as well as in management – we usually derive insights from small-scale situations such as a local information system, a small group experiment or a regional pilot. Thus, we have gained insights into the power of recording data and in management tools, such as time schedules and budgets. If we transpose such insights to large-scale situations without checking (at that level) the validity of underlying assumptions, we often make a ‘fallacy of the wrong level.’

2. The vigorous impact of a dominant chain problem
A dominant chain problem creates the necessary interplay of forces that triggers large-scale chain co-operation. There is a wide variety of dominant chain problems, each provoking a different intensity of co-operation and requiring a different and customised chain communication system – including a method for signals and alerts

– so that all chain partners can gain access to the essential information, when necessary. For someone who has had a heart attack, it is important that a small number of details are immediately available to the consulting physician so that he can effectively intervene when necessary. The chain will therefore have to be able to supply those details as quickly as possible. This communication system is completely different from that for diabetics, for instance, which is focused on monitoring the patient's condition and depends upon his own lifestyle and self-discipline.

3. Chain partners have only a limited view of the dominant chain problem
Chain partners look at chains only from the viewpoint of their own organisation, interests and priorities. Thus, they overestimate chances and opportunities and underestimate risks and difficulties. This might be the principal reason why big projects and systems fail or disappoint. In our chain research, we were confronted with the problem that, as a result, dominant chain problems are usually hidden and cannot be found by interviewing chain partners and adding the responses. We had to perform disciplined analysis to discover a chain problem, if any, and to then assess its dominant character. The good news is that, once it has been defined, chain partners generally recognise the dominant chain problem as the major common problem.

4. Often, large-scale communication systems are not feasible
Two other major causes of failing large-scale projects and systems have surfaced in our chain research. The first relates to the complexity of the chain process, the second to low levels of interorganisational cohesion in a chain.

a. It is only complex chains requiring feed forward and feedback mechanisms for adequate case handling in the chain that cannot do without a chain information system for information exchange and mutual adjustment. In chains with a dominant chain problem that can be tackled within sequential dependency of the chain partners involved, feed forward mechanisms alone will suffice. In these cases a chain information system is not necessary, implying that a large-scale implementation of a chain information system will not be possible.
b. The second cause lies in a lack of interorganisational cohesion. The chain partners should be familiar with co-operation mechanisms that can cope with large-scale feedback and interdependency. If not, implementing a chain information system will not be feasible.

Most of the complex chains studied so far in our chain research programme have a low level of organisation, causing national projects to abort or fail. However, sometimes a regional approach, nevertheless, is promising, but politics, public administration and information professionals have a strong preference for big, nationwide and ambitious projects.

5. Identity problems are on the rise
Identity fraud/theft is easy and profitable and our large-scale social systems are generally not designed to prevent or detect identity fraud or identity theft. Moreover, in our legal culture identity checking is considered to be an invasion of privacy requiring regulation and transparency. Procedures can be observed and predicted, so identity fraudsters can be well prepared. Most of the chains studied in our chain research programme are struggling with identity problems but in different ways depending on the dominant chain problem involved. Identity management and checking should take into account that they should be chain-specific to be able to cope with the particular dominant chain problem. Moreover, in some chains, identity fraud is at the core of the dominant chain problem creating an interplay of forces that increases the chain's organisation enormously and intensifies the need of chain-specific ID solutions. Governments, unfortunately, show a preference for general ID-instruments.

8. Conclusions and challenges

Finally, some conclusions can be drawn:

1. Because overall leadership or authority is absent, the chain is a difficult administrative domain in which decision-making and information exchange proceed differently than within organisations. Rationality and efficiency are often hard to find at the collective chain level and, as a consequence, unpredictability and lack of control are the order of the day. Put simply, chains form a bleak working environment. However, that is nonetheless where the computerisation of society is – to a significant extent – taking place, thus determining the quality of life in the future information society.
2. Advancing specialisation and mounting social requirements make private and public organisations and professionals increasingly more dependent on each other. However, chain co-operation proves to be anything but easy, in practice. Because common interests are less pronounced than people usually think – and are also often unclear – the badly needed cohesion can only be provided by a pressing dominant chain problem. Only then is there sufficient support for the large-scale exchange of information.
3. A realistic view of the difficult interorganisational world combined with a robust chain analysis methodology may lead to better large-scale chain communication systems and more effective information strategies for large-scale chain co-operation. The doctrine of Chain-computerisation provides both. This chain analysis methodology must not be considered as a means to uncover the absolute truth of the chain co-operation world but as a scientifically based instrument to identify potentially unsuccessful large-scale systems and projects.
4. The doctrine of Chain-computerisation has as working hypothesis that every dominant chain problem causes its own chain co-operation pattern requiring a chain-specific tailor-made communication system. So far, this hypothesis has not been falsified.
5. Many large-scale systems lack adequate checks and balances within the system itself, as well as tools and procedures protecting it against large-scale risks. More risk analyses and more chain analyses should, therefore, be undertaken to prevent naïve solutions. Risks associated with the dominant chain problem are the most significant ones and should also be monitored during the development and exploitation phases of large-scale systems.

The theory and methodology needs further refining and its application can be improved to ensure controllability and reproducibility of the chain analysis' results. This brings us to some major future challenges for information science and professionals. We need:

a. better methodologies to uncover dominant chain problems and find out about their dynamics and impact on large-scale chain co-operation;
b. better risk analysis and monitoring methodologies for large-scale social systems (criminal records, patient files, identity records), before, during and after development;
c. better methodologies to develop suitable checks & balances within large-scale social systems that can effectively prevent or cope with threats and risks;
d. better methodologies to gradually develop and exploit large-scale communication systems;
e. new methods and business models of identity fraud prevention in large-scale systems.

If at least a few of these challenges could be adequately solved in the next decennium, our information society will be a better place to live.

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Appendix: Vocabulary of Chain-computerisation

Italicised terms refer to other items on the list

Assessment profiles (four)	Analysis tools of the doctrine of *Chain-computerisation* for the assessment of the necessity (mission profile, co-ordination profile, information profile) and the feasibility (co-operation profile) of a *chain information system*.
Base level of a chain	*Level of analysis* that separates the coordination of chain activities from the chain activities themselves, thus enabling visualisation and analysis of a chain partner's own *source register* and its functioning within a large-scale *chain communication system*.
Chain	'Chain' does not mean a logistics chain (the process of handling of goods) that we so often come across in the business community, nor an information chain (closely linked information systems) nor a transactions chain (subsequent transactions within a process). The chain concept is used here explicitly to refer to social chains: large-scale interorganisational processes that yield a social product such as well-being, security or health. In a social chain, hundreds of organisations and professionals work together without a clear relationship of authority, in ever-changing combinations depending on the actual case. But co-operating with other organisations and professionals takes a lot of effort, time and money. There must, therefore, be a cast-iron reason for doing it. An important element of the chain concept introduced here is, therefore, that chain partners only co-operate if they are forced to do so by a *dominant chain problem*.
Chain analysis framework	Part of the doctrine of *Chain-computerisation* that consists of four *assessment profiles* to test the necessity and feasibility of *chain information systems* and *chain projects*. Together they enable to accurately differentiate between promising and less promising chain information systems. A promising chain information system must be: 1. indispensable to solving the *dominant chain problem* in that *chain* (to be established with the mission profile); 2. indispensable for the necessary coordination of the process within that chain (to be established with the coordination profile); 3. indispensable to bridge *fault lines* in the *information structure* of that chain (to be established with the information profile); 4. feasible in the current developmental stage of the co-operation in that chain (to be established with the co-operation profile). The first three profiles (mission profile, coordination profile and information profile) determine whether a chain information system is really necessary. According to the theory, a chain information system that is not needed at (any) one of these three levels (mission, process or information) will be difficult to put in place. Nevertheless, chain information

	systems that are indispensable are not always feasible. Therefore, the fourth assessment profile (the co-operation profile) is used to ascertain whether in a particular chain a chain information system is feasible.
Chain analysis procedure	The chain analysis procedure of the doctrine of *Chain-computerisation* is a structured approach to the assessment of the necessity and feasibility of a *chain information system* in a particular *chain* using the four *assessment profiles*.
Chain communication (system)	Large-scale and chain-wide (system of) information exchange using *chain information systems* that signal critical *meta-data* throughout the *chain* to prevent wrong decisions disrupting and discrediting the chain and its chain partners.
Chain-computerisation (the doctrine of)	A body of theoretical and practical knowledge and tools focused on large-scale communication systems in social chains. Chain-computerisation consists of: • a *chain perspective*, with concepts and theories to prevent so-called *fallacies of the wrong level*; • an assessment framework for *chain projects* and *chain information systems* with four *assessment profiles*; • an intervention framework for better *chain interventions* with three intervention models. The doctrine does not limit itself to chain information systems at *chain level*, although the assessment framework is especially focused on chain information systems.
Chain co-operation	Structural co-operation of autonomous organisations and professionals that together bring about a certain social product such as security, health, asylum or well-being. Moreover, this chain co-operation is a temporary phenomenon because *Chain-computerisation* sees it as based on a joint approach to a *dominant chain problem* that can be overruled by another in the course of time.
Chain coordination	The various ways in which chain partners collectively limit the room for individual autonomous policy making or action with regard to their joint approach to the *dominant chain problem*.
Chain information infrastructure (lean)	By information infrastructure is meant the general, permanently available basic facilities for the processing, storage and transportation of data that are used collectively between organisations in a *chain*: • collective technical facilities and standard software (computers, networks and database management systems); • collective data and knowledge (data with rules about the connection between those data); • collective administrative organisations, procedures and standards. These facilities can be used for a variety of different purposes. In practice, information infrastructures can be recognised by joint, collective management, which is in-

	dependent of the management of the specific applications that use them.
Chain information structure	A picture of the 'linguistic areas' within a *chain* by relating the process steps of a chain (links) to the key concepts one 'talks about' in that link of the chain indicating which object or aspect is so central to the work that the organisation strives as strongly as possible to make its information complete, accessible and up-to-date. Structural communication problems occur where a *fault line* between two linguistic areas in the chain's information structure appears. Since such a fault line is deeply rooted in the work and the division of work in a chain, it cannot simply be eliminated by means of organisational measures, for example. However, a fault line can be bridged by a *chain information system*.
Chain information system	A jointly managed information system – available for every *chain* partner – containing critical *meta-data* about the chain's target group (persons or objects). Which meta-data need to be included in the chain information systems depends on the *dominant chain problem*.
Chain intervention (framework)	A chain intervention means how an individual chain partner can influence processes in a *chain*. For this purpose *Chain-computerisation* provides three models making up its chain intervention framework consisting of three intervention models to develop effective chain interventions. The three intervention models cover decision making, strategic positioning and choosing stable long term objectives.
Chain level	*Level of analysis* that separates the coordination of chain activities from the chain activities themselves, thus enabling visualisation and analysis of a *chain information system* and its functioning within a large-scale *chain communication system*.
Chain object	Target of *chain* care and *chain co-operation*. This can be a natural or legal person, an object or an event.
Chain perspective	This perspective characterises the way *Chain-computerisation* looks at *chains* and chain issues. It consists of three components: (1) a decision making model based on *irrationality* at *chain level*; (2) the major impact of the *dominant chain problem*; (3) an analytical distinction between a chain level and a *base level of a chain*.
Chain project	A joint organised effort to bring about a certain chain-wide facility either at the *base level of a chain* or at *chain level* within a definite period of time.
Chain signalling	See *Chain communication (system)*.
Dominant chain problem	A dominant chain problem is one that none of the chain partners can solve on his own. It is only by effectively co-operating that chain partners can prevent the systematic failure of their own organisation and the entire

	chain. The doctrine of *Chain-computerisation* has as its working hypothesis that every dominant chain problem causes its own *chain co-operation* pattern requiring a chain-specific tailor-made *chain communication system*.
Fallacy of the wrong level	The validity of knowledge is limited to the level or scale at which it is gained. If insights gained in small-scale situations are transposed to large-scale situations without checking (at that level) the validity of underlying assumptions, we often overestimate our chances and underestimate risks and problems because of invalid assumptions and expectations.
Fault line	The pattern of key concepts in a *chain* revealing its information structure by showing the composing 'linguistic areas'. Structural communication problems occur where a fault line between two linguistic areas in the *chain's information structure* appears. Since such a fault line is deeply rooted in the work and the division of work in a chain, it cannot simply be eliminated by means of organisational measures but it can be bridged by a *chain information system*.
Identifying personal details	Unchanging details uniquely identifying a person (surname, first name, gender, date of birth, place of birth).
Identity fraud	Identity fraud – using or stealing somebody else's identity with malicious intent – can take place anywhere and in many ways and is not restricted to specific situations, procedures or ID-documents. Even photos, actions or events can be used because they all feature an identity suggestion from which people draw conclusions about whom they are dealing with. The real problem is that if an identity fraud succeeds, all clues and traces lead to the victim instead of the culprit. This victim subsequently has much difficulty proving his innocence.
Information infrastructure	See *Chain information infrastructure (lean)*.
Irrationality	See *Rationality / irrationality*.
Level of analysis	System level to enable making analytic distinctions, e.g. between the communication about or the coordination of *chain* activities and the chain activities themselves. The *chain perspective* of *Chain-computerisation* is based on at least two such levels of analysis, the *chain level* and the *base level of the chain*.
Meta-data	Data indicating non-content aspects of an entity such as its location or the number under which it is filed. Content aspects, on the contrary, indicate inherent characteristics of the entity (person, object or event) involved such as a classification as a criminal or an indication of the specific risk inherent in a building, event or person.
Person-identifying detail	See *Identifying personal details*.
Rationality / irrationality	Rationality implies having a set of traditional assumptions

	in mind that characterises western logic based on causality and hierarchy. Problem and solution have a clear relation based on a chain of cause and effect. Irrationality means that these assumptions are being loosened if: - objectives are unclear or contradictory; - it is unclear which parties are involved; - there is a difference of opinion about the approach to a problem or solution. According to the doctrine of *Chain-computerisation*, this condition often holds in situations of large-scale *chain cooperation*.
Source register	Information system within a *chain* partner's own organisation that is used for the management of the full content information needed for that organisation's workprocesses. Within a *chain information infrastructure*, source registers can be connected with a *chain information system* facilitating the exchange of critical information needed for a correct decision, at the right moment and place.