TOWARDS A META MODEL FOR DESCRIBING COMMUNICATION

How to address interoperability on a pragmatic level

Boriana Rukanova, Kees van Slooten, Robert A. Stegwee
School of Business, Public Administration and Technology, University of Twente, P.O.Box 217, 7500 AE Enschede, The Netherlands

Keywords: business information systems, interoperability, pragmatics, standard

Abstract: The developments in the ICT led companies to strive to make parts of the business transaction electronic and raised again the issue of interoperability. Although interoperability between computer systems has been widely addressed in literature, the concept of interoperability between organizations is still to a large extent unexplored. Standards are claimed to help achieving interoperability. However, experience with the implementation of EDI standards shows that many EDI implementation projects led to technical solutions with unclear business benefits. New standards are currently being developed, however their implementation can also lead again to purely technical solution, if the social context is not taken sufficiently into account. In this paper we address the problem on how to identify interoperability problems on a pragmatic level that can occur between organizations that want to carry out business transactions electronically. We also point out that, in order to identify interoperability problems on a pragmatic level, it is necessary to capture the communication requirements of the business parties and to evaluate to what extent a standard is capable to meet these requirements. To perform that evaluation we develop a meta model for describing communication. The meta model is based on theory of speech-act and communicative actions. The use of the meta model to identify interoperability problems on a pragmatic level is illustrated with an example.

1 INTRODUCTION

The developments in the area of ICT made possible disparate information systems to exchange data electronically. This raised the question of how to achieve interoperability. The issue of interoperability between software systems has already been widely addressed (Goh et al., 1999; Heiler, 1995; Wegner, 1996). Further, it is expected that the use of standards can help in resolving the interoperability problems. However, experience with the implementation of EDI standards shows that often the result is a technical interoperability between software systems with unclear business benefit (Covington, 1997; Huang, 1998). Other standards are currently being developed. Examples are RosettaNet, and HL7. However, there is a danger that an implementation of such a standard could lead again only to a technical solution, rather than improving the way of doing business. This means that more than technical interoperability between computer systems is needed, but rather interoperability between organizations (business information systems) is to be achieved (Stegwee & Rukanova, 2004).

To achieve interoperability between organizations, it is important to realize first, that an organization is a combination of people and technology. Second, each organization operates in its own context. Thus, the organizations need to define a shared communication context in order to enter into business transactions together (Stamper, 1996; Vermeer, 2000).

If the business parties decide to use computers to perform parts of the business transaction electronically, then the relevant shared context needs to be made explicit, formalized and embedded in the computer systems. In case where standards are used to formalize the relevant shared context, a standard needs to be evaluated to what extent it is capable to cover the relevant shared context (Rukanova et al., 2003a). This check is important to indicate where interoperability problems might arise. One possibility to make the comparison between the requirements of the communication context and the

Rukanova B., van Slooten K. and A. Stegwee R. (2004).
TOWARDS A META MODEL FOR DESCRIBING COMMUNICATION - How to address interoperability on a pragmatic level.
In *Proceedings of the Sixth International Conference on Enterprise Information Systems*, pages 375-382
DOI: 10.5220/0002636903750382

capabilities of a standard is by using a meta model, which captures elements of a business transaction (Rukanova et al., 2003b).

To capture the context of a business transaction, a number of views can be defined (Rukanova et al., 2003c). These views can help to look at the business transaction from different perspectives and provide a holistic understanding of the context of a business transaction. The analysis of the different views can contribute to the identification of interoperability problems that can occur, when different organizations decide to do business transactions electronically.

In this paper we will investigate only one of the views: “the communicative acts view”, which is concerned with how to describe the conversations and the intentions in a business transaction. This view is concerned with the pragmatics aspect in a business transaction. The pragmatics underlines the importance that it is not sufficient to understand what is communicated, but also what is the intention behind it, how you interpret the communicated information and how you act upon it. This paper is concerned with *how to identify interoperability problems on a pragmatic level.*

To achieve interoperability on a pragmatic level, it is necessary to be able to express and compare the requirements of the business transaction (on a pragmatic level) and the capability of the standard to cover these requirements. In this paper we create a meta model for describing conversations to help make that comparison.

The remaining part of the paper is structured as follows. In part two, a number of theoretical constructs to describe communication are identified. In part three these constructs are used as a basis for defining a meta model for describing communication. In part four we use the meta model to evaluate the capabilities of a standard to cover the business requirements (on a pragmatic level).

2 ELEMENTARY UNITS TO DESCRIBE COMMUNICATION

As it was mentioned in the introduction, the main concern in this paper is how to achieve interoperability on pragmatic level, if organizations want to use standards in order to carry out their business transactions electronically. Thus, it is necessary to identify key elements that can capture communication requirements of a business transaction and further to use these elements to evaluate the extent to which a standard is capable of capturing the communication requirements. As we are currently interested in the pragmatic aspect of communication, it means that the elements that we need to identify have to address the problem of what is communicated, and how is it interpreted. Further, as we are interested in the whole business transaction, we need to identify what communication takes place during the entire transaction lifecycle.

2.1 E-message and Ae-message

The research done in the area of information systems and language-action perspective can provide us with substantial input to be able to identify key elements, which describe communication. As this research addresses communication in general, we can apply some of the findings to describe communication specific for business transactions. To define what is communicated and what is the intention behind the communicated information, we will make use of the notions of elementary message (e-message) and action elementary message (ae-message).

The notion of e-message is defined by Langefors (Langefors, 1973). According to Langefors, an e-message consists of four basic terms to give information about the property of an object: the identity of an object, the kind of property, the specification of that property for that object, the point in time at which the information is valid. Further we add that an object can have multiple properties. Thus each combination of object (id), property, property value and time can result in an e-message. If we want to describe the different properties of an object at a given time, a number of e-messages can be defined. This can be schematically presented as illustrated in figure 1. The ORM notation (Halpin, 1996) is used as a means for representation of the models in this paper.

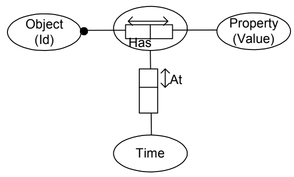

Figure 1: An object defined in terms of elements of e-messages.

Although using the elements of e-message is a good starting point for describing communication, it provides a limited view, as it implies a purely descriptive approach toward information. (Goldkuhl & Lyytinen, 1982; Winograd & Flores, 1986). However, language can be used not only to describe things, but also to perform actions (Austin, 1962; Goldkuhl, 1995; Habermas, 1984; Searle, 1969). In order to capture the intention behind the communicated information, the notion of action elementary message (ae-message) can be used (Agerfalk, 1999, 2002; Goldkuhl & Agerfalk, 2002). The notion of the ae-message is built upon the notion of e-message, and extended to capture the intention. An ae-message is composed of four elements: the communicator, the interpretor, the propositional content (the content that is communicated), and the communicative function (the intention behind the communicated information) (see Figure 2).

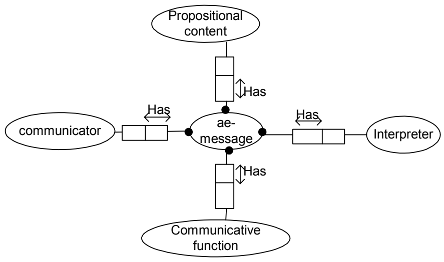

Figure 2: Elements of an ae-message.

We will elaborate further on the concepts of communicative function and the propositional content. The propositional content consists of a number of e-messages. The propositional content is the content, which is communicated, that is information about objects and their properties at a certain time. (See Figure 3)

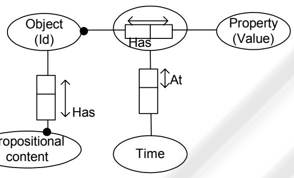

Figure 3: Elements of a propositional content.

There are relationships between the objects, which are part of the prepositional content, however, for simplicity reasons this relationship is not explicitly represented in the model

The other concept included in the ae-message, which deserves attention, is the communicative function (synonyms are illocutionary acts and action mode). The communicative function contains the intention of the speech act. Different types of communicative functions (illocutionary acts) can be identified (see (Habermas, 1984; Searle, 1969)). Examples of communicative functions are order and promise. The main point that we want to make here is to stress the importance of the communicative function in capturing intentions behind the communicated information. We will not go further into describing the different types of communicative functions. However, in part 2.2 of this paper, we will come back to the concept of communicative functions to explore their role in forming patterns of conversations.

So far we have identified some elementary constructs for describing communication. However, although describing ae-messages is a big step in describing communication, the speech acts theories are criticized in two directions. The first one is that they do not pay much attention to the content of what is communicated (the propositional content) (Schoop, 2003). The second one is that they focus mainly on the individual speech acts, and not on the whole conversation. This issue will be further addressed in the next section.

2.2 Sequence of Utterances

The Speech-act approaches focus mainly on the individual speech-acts rather than the whole conversation, thus the speech-act theory cannot be used to explain the organization of communication (Goldkuhl, 2003). The research done by Winograd and Flores (Winograd & Flores, 1986) can help in addressing this problem, as the authors argue that the main focus should not be on the individual speech-acts, but the conversation, in which individual speech acts are related to one another. Their key contribution is in the identification of basic patterns for describing conversations- the "conversation for action" scheme (see figure 4).

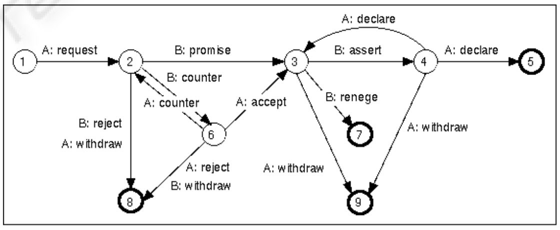

Figure 4: The basic "Conversation for Action" Adopted form Winograd and Flores, 1986, p. 65

The schema describes different states that a conversation can take and how the states are altered through the performance of speech acts. For example, actor A can make a request to another actor B. B can either promise to fulfil the request, counter the request or reject it. Here we can see how different communicative functions (e.g. request, promise) can interplay to form a conversation. Flores and Winograd have influenced a number of researchers in the field of Language action perspective. Based on the conversation for action scheme, a number of communication patterns have been derived. However, the derived patterns seem to be rather prescriptive. The result of this is that, when describing a real life situation, one might end up with actually changing the requirements of the real-life situation so that they can fit into the pre-defined pattern. This however is undesirable. Thus, although interaction patterns can be helpful in eliciting the conversation requirements, their use should be done with caution (Goldkuhl, 2003).

In the introduction we started with the problem of how to identify interoperability problems (on a pragmatic level) that can occur if companies decide to do business transactions electronically by using standards. So far, we have identified a number of elements, which can help us to describe conversations. This enables us to move to the next step for addressing the interoperability on pragmatic level: linking these elements in a meta model for describing conversations.

3 A META MODEL FOR DESCRIBING CONVERSATIONS

In the previous section we have identified a number of concepts to describe a conversation. However, these concepts alone provide a fragmented view of elements of conversation. In this section, we link these concepts into a meta model.

The meta model is presented in Figure 5 below.

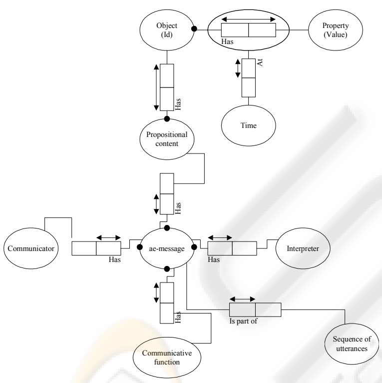

Figure 5: A meta model for describing conversations

Although most of the concepts were already introduced earlier, a brief description and explanation of the meta model is provided below. A key concept around which the meta model is built is the ae-message. An action elementary message has a communicator, an interpreter, a propositional content, and a communication function. Further, an ae-message is part of a conversation, and the conversation can be described with sequence of utterances. We consider the real life situation as a starting point for identifying sequence of utterances. Communication patterns (such as the "conversation for action" scheme of Winograd and Flores) can be used as a support tool to describe the sequence of utterances, once they have been identified based on the real-life situation. Although the scheme of Winograd and Flores is very powerful in expressing different possibilities that a conversation can follow, there could be real-life situations, where this scheme can turn to be limited. Thus, the Winograd and Flores scheme, as well as any other patterns of conversations (whenever available) should be used with caution.

To overcome the critique that speech acts do not focus on the content of what is communicated (see 2.1), the notion of propositional content is explicitly includes in the model. The propositional content contains information about objects, the properties of objects, the values of the properties and the time the value is valid.

In that way, the meta model captures information about the content of the message that is communicated, who is the communicator and the interpreter of that message, what is the intention of that message and how it forms part of a conversation.

The main benefit from the meta model is that it can be used to describe both the communication requirements of a business transaction and the capabilities of the standard in the same terms. When both, the requirements of the business transaction and the capabilities of the standard are expressed in terms of the meta model, they can be easily compared (see also (Rukanova et al., 2003a, b). A mismatch between the two will mean that some of the requirements of the business transaction cannot be covered by the standard, which would signal interoperability problems (on a pragmatic level). In the section below we will illustrate the use of the meta model.

4 THE META MODEL IN USE

In this section we will illustrate the use of the meta model to identify whether interoperability on a pragmatic level can be achieved. We will first introduce a standard (the (HL7) standard will be used for our example). Further we will describe a simple business transaction, which needs to be automated using the HL7 standard. We will translate the requirements of the business transaction in terms of the meta model. We will also translate the capabilities of the standard in terms of the meta model. Once expressed in the same terms, we will be able compare the requirements of the business transaction and the capability of the standard to meet these requirements. A mismatch between the two will mean that there could be interoperability problems on a pragmatic level, which can hinder the way of doing business. Due to space limits, in this example we will not elaborate in full detail the elements describing the propositional content. However, such a description can be done and is important part of the analysis.

4.1 The HL7 Standard

For this example we will look at the HL7 v.3 standard. HL7 is one of the leading Healthcare standards for clinical data interchange. The standard covers transactions in several areas, some of which are accounting and billing, claims and reimbursement, and diagnostic orders and observations. For the purpose of this example we will look at how the interactions are defined in the HL7 standard and we will limit our analysis to the interactions related to Laboratory observations. Before going further we will provide some background information about the HL7 v.3 standard.

In the basis of the HL7 v.3 is the HL7 Reference Information Model (RIM). The RIM models, on a very high abstract level, the major things of interest in the healthcare domain. It consists of six major classes, defines the attributes of these classes and the relationships between them. The messages that are exchanged in the clinical communication are derived from the RIM. However, the link between the RIM and the message that is actually exchanged is not straightforward, but it requires intermediary steps. As the concepts in the RIM are very general, a procedure called cloning is defined. After this procedure, a domain message information model is defined (DMIM). This model is derived from the RIM, and provides further restrictions on the defined information (by for example restricting the attributes of the classes). This domain message information model is then used to create the Hierarchical message description, which defines in full detail the messages that are later exchanged in the interactions. A central class in the RIM is the “Act”. The act represents actions that are executed and must be represented as the healthcare processes take place. An example of Act is (Lab) Order. The information provided above is important in order to understand how interactions are defined in the HL7 standard.

In the HL7 v.3 Guide, an interaction is defined as “ a unique association between a specific message type (information), a particular trigger event, and the application roles that send and receive a message type. It is a unique, one-way transfer of information.” From this definition we can derive, that an interaction is uniquely defined using four components: the sending application role (a system component which sends a message), the receiving application role (a system component, which receives the message), the trigger event (the reason to send a message), and the message type (what message to send) (see Figure 6).

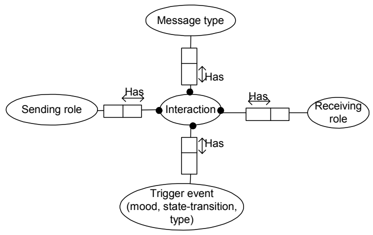

Figure 6: Description of the HL7 interactions

To better understand the interactions, as defined in the HL7 standard, some further elaboration is needed on the notion of a trigger event. According to the HL7 v.3 Guide, “a trigger event is an explicit set of conditions that initiate the transfer of information between system components (application roles). It is a real-world event such as the placing of a laboratory order or drug order.” The trigger event is expressed as a combination of mood, state-transition, and type. The “mood” is a very important concept in the HL7 v.3 standard. It distinguishes between statements of facts that the ordered service (act) has been completed, or it specifies the intent to perform such a service. Examples of moods as defined in the HL7 are “order” (an order of a service), “promise” (a promise that the service will be performed), and “event” (a statement that the service has been performed). Another important attribute of act is act status. The act status captures the defined state of an act. Examples of act status are “active” (the act can be performed or is performed), and “completed” (an act that has terminated normally after all of its constituents have been performed). A change in the act status can lead to a state-transition (for example an act status can become from “active” to “completed”. The third element defining the event is type. There are three types of events defined in the HL7 standard: user request based, interaction based and state-transition based trigger events. Within this paper we will not go into describing these concepts into full detail. However, it is important to say that the combination of mood, state-transition, and type can capture the intent behind the message.

Based on the analysis of the HL7 concerning lab order, we found out that the HL7 trigger events supports the following intentions: request to fulfil an order, promise to fulfil the order, rejection to fulfil the order, statement that the order has been fulfilled. We will come back to these elements in the next section.

4.2 Evaluation of the HL7 Standard

In section three of this paper we have presented a meta model for describing conversations. In section 4.1. we have introduced a brief description of how interactions are described in the HL7 standard. The aim of this section is to express the capabilities of the HL7 standard concerning Lab order in terms of the meta model.

From the meta model for describing conversations it can be said that an ae-message has propositional content, communicator, interpreter, and communicative function. The interactions defined in the HL7 standard correspond to the ae-messages defined in the meta model. The sending role and the receiving role (as defined in HL7) can be translated as communicator and interpreter in terms of the meta model. The trigger event can be translated as communicative function in terms of the meta model and the hierarchical message description can be seen as propositional content. Further, the trigger events defined for Lab order in the HL7 standard support the following communicative functions: request to fulfil an order, promise to fulfil the order, rejection to fulfil the order, statement that the order has been fulfilled. For illustrative purposes, we can map these communicative functions to the scheme of Winograd and Flores (see figure 4). Note, we have first identified the interactions supported by the standard and after that we check whether the interactions can be mapped to the scheme of Winograd and Flores. Further, for this example the scheme provides a good visualization of the different interactions. From the mapping we can see that the HL7v.3 standard supports the individual interactions *request (1,2)*, *promise (2,3), reject (2,8)* and *declare (3,4)* (see Figure 4).

Different elements of the propositional content are covered in an HL7 message. In the HL7 message, information about objects of interest for the transactions is captured. Examples of such information is information about the patient (and how one can identify a patient), or the about the properties of a patient, such as name and the sex. Further, the HL7 standard defines the reference values for such properties. Although we will not be able to further elaborate on the propositional content due to limitations of space that we have for this paper, such an analysis is important and can be done in practice.

In the next section we describe a business transaction, parts of which would need to be automated using the HL7 standard.

4.3 Description of the Business Transaction

For the purpose of this example, we use an imaginary business transaction, which we describe below. Let us imagine that a doctor sees a patient and decides to order a lab tests for him. Thus, the doctor has to enter into a business transaction with the Lab. For the communication between the doctor and the Lab there is an agreement to communicate in the following way. The doctor orders a lab test. The Lab either accepts to perform the lab test and confirms the order, or rejects the order. Once the lab test is performed, the Lab sends the Observation result to the doctor and the doctor either does not communicate back (in case that he does not have objections to the test result), or asks for correction, if he thinks that there is a mistake. Currently this communication is paper-based. However, this way of communication is time consuming and time is critical in the Healthcare domain. Also, a double entry of data is required.

To reduce the time for carrying out a transaction and to avoid double entry of information, a decision is made to automate the communication between the doctor and the Lab. Further, the HL7 standard is chosen to support the electronic communication.

4.4 Describing the business transaction in terms of the meta model

In this section we will translate the requirements of the business transaction described in 4.3. in terms of the meta model. We start with analysing the elements of an ae-message again. If a message is send from the doctor to the Lab, then the doctor can be translated as a communicator in the ae-message and the Lab as the interpreter of the ae-message. If the Lab sends a message to the doctor, then the Lab is the communicator of the ae-message and the doctor is the interpreter. In case the transaction is electronic, these roles can be played by the applications used by the doctor and the interpreter.

The propositional content corresponds to the content of the paper documents exchanged between the Doctor and the Lab. The communicative functions that are used in the communication between the doctor and the Lab are: Ordering of a lab test, acceptance to perform the lab test, rejection to perform the test, statement that the test is completed, questioning of the result of the test. To visualize the communicative functions, we can again map them to the scheme of Winograd and Flores. This would result in the following interactions:

request (1,2), promise (2,3), reject (2,8), assert (3,4), declare (4,3).

So far, we have expressed the requirements of the business transaction and the characteristics of the standard, both in terms of the meta model. This enables us to compare the two, which will be done in the next section.

4.5 Comparing the standard and the requirements

Table 1 below provides a comparison of the requirements of the business transaction and the characteristics of the HL7 standard.

Table 1: Comparing the requirements of the business transaction and the capabilities of the HL7 standard

Meta model element	**Requirement of the Business Transaction**	**HL7 Standard Lab Orde**
Specification of the propositional content	Required	Capable to cover (only for the communicative functions supported by HL7)
Identification of the communicator	Required	Capable to cover (identification of the sending application role)
Identification of the Interpreter	Required	Capable to cover (identification of the receiving application role)
Communication functions	Required: *Request (1,2), promise (2,3), reject (2,8), assert (3,4), declare (4,3).*	Capable to cover: *Request (1-2), promise (2,3), reject (2,8), assert (3,4),*
Sequence of utterances	Successful completion *(1,2), (2,3), (3,4)* Failure *(1,2), (2,8)* Questioning the outcome *(1,2), (2,3), (3,4), (4,3)*	Successful completion *(1,2), (2,3), (3,4)* Failure *(1,2), (2,8)*

From the analysis it is clear that the HL7 standard (concerning Lab orders) is a good standard to cover the communication requirements between the doctor and the Lab. It has the capability to identify the communicator and the interpreter of a message, as well as the content of the message and the intention behind it. It can support both the conversation that can lead to successful completion of the business transaction as well as to failure. For the interactions that are supported by the HL7 standard, the HL7 standard specifies in detail the propositional content in terms of objects, properties, and it defines the reference values that these properties can have. Thus, we consider that the propositional content defined in the HL7 standard can cover the requirements of the business transaction. However, as we mentioned earlier, we will not go further in detail in elaborating the propositional content.

However, the HL7 does not support situations where the doctor can question the results of a lab test, thus a conversation that can lead to questioning of the outcome is not supported. Neither is the propositional content for this type of interaction. This can be a problem for achieving full interoperability between the Doctor and the Lab, unless additional measures to compensate for that are undertaken.

The aim of this example was mainly to illustrate how the meta model can be used. Although we looked at a simple transaction, the principles of the analysis can be applied to analyse very complex situations. This can be done by first, identifying the different parties that take part in a business transaction. And second, by applying a separate analysis of the conversations between each two parties separately, as illustrated in the example.

5 CONCLUSIONS AND FURTHER RESEARCH

In the introduction we stated that it is important to explore the concept of interoperability, going beyond interoperability between software systems. We further addressed the issue of interoperability on a pragmatic level between organizations, which would like to do business transactions electronically by using standards. We also pointed out that in order to identify interoperability problems on a pragmatic level, it is necessary to capture the communication requirements of the business parties and to evaluate to what extent a standard is capable to meet these requirements. The contribution of this paper can be seen in two main directions. It stresses the importance to look beyond the interoperability between software systems. Second, it addresses the issue of identifying interoperability problems on a pragmatic level and provides a meta model to help in that problem identification. We also provided an example on how the meta model can be used in practice.

The example used in this paper describes a rather simple transaction. The purpose of the example was to illustrate how the meta model can be used. However, the steps illustrated in this example can be used to analyse very complex transactions.

The future research on this topic can continue in two main directions. The first one is to empirically test the usefulness of the meta model in real life situations. The second one is to explore the concept of interoperability between organizations, capturing other aspects, apart form pragmatics.

REFERENCES

Agerfalk, P. J. (1999). *Pragmatization of Information Systems: A Theoretical and Methodological Outline*, Licentiate Thesis. Linkoping University.

Agerfalk, P. J. (2002). Messages are Signs of Action- From Langefors to Speech Acts and Beyond. *In Proceedings of LAP'02*, 80-100

Austin, J. L. (1962). How to do Things with Words, Oxford University Press.

Covington, M. A. (1997). On Designing a Language for Electronic Commerce. *International Journal of Electronic Commerce* 1(4): pp. 31-48.

Goh, C. H., S. Bressan, et al. (1999). Contex Interchange: New Features and Formalisms for the Intelligent Integration of Information. *ACM Transactions on Information Systems* 17(3): pp.270-292.

Goldkuhl, G. (1995). Information as Action and Communication. *The Infological Equation: Essay in the Honour of B. Langefors*: 63-79.

Goldkuhl, G. (2003). Conversational Analysis as a Theoretical Foundation for Language Action Perspective.*In proceedings of LAP 2003*, 51-69

Goldkuhl, G. and P. J. Agerfalk (2002). Actability: A Way to Understand Information Systems Pragmatics. In Liu K. Clarke, R., Andersen, P., Stamper, R. (eds.) *Coordination and Communication Using Signes*. Boston, Kluwer Academic Publishers.85-115

Goldkuhl, G. and K. Lyytinen (1982). A Language Action View on Information Systems. In proceedings of the *Third International Conference on Information Systems*, Ann Arbor, MI.

Habermas, J. (1984). *The Theory of Communicative Action 1. Reason and the Rationalization of Society*. Cambridge, Polity Press.

Halpin, T. (1996). Business Rules and Object Role Modeling. Database Programming and Design (October 1996).

Heiler, S. (1995). Semantic interoperability. *ACM Computing Servey* **27**(2).271-273

HL7 "http://www.hl7.org/."

Huang, K. (1998). *Organizational Aspects of EDI: a Norm-oriented Approach* (PhD thesis).

Langefors, B. (1973). *Theoretical analysis of Information Systems*, Studentlitteratur.

Rukanova, B. D., Slooten, C. v, Stegwee, R.A. (2003)a. Beyond the Standard Development and the Standard Adoption. In proceedings of *8th EURAS Workshop on Standardization, Germany*., Mainz Publishers. 120-138

Rukanova, B. D., Slooten, C. v, Stegwee, R.A. (2003)b. Towards a Meta Model for Distributed Business Transactions. In proceedings of *CAiSE '03 Forum Information Systems for a Connected Society*.141-144

Rukanova, B. D., Slooten, C. v, Stegwee, R.A. (2003)c. Capturing the Context of a Business Transaction. In proceedings of *3rd International Interdisciplinary Conference on Electronic Commerce"ECOM-03"*, Gdansk, Poland. 135-141

Schoop, M. (2003). A Language-Action Approach to Electronic Negotiations. *In proceedings of LAP 2003*, 143-160

Searle, J. R. (1969). *Speech Acts. An Essay in the Philosophy of Language*. London, Cambridge University Press.

Stamper, R. (1996). Organisational Semiotics. F. S. J. M. (eds*.). Information Systems: An Emerging Discipline*. London and New York, McGraw-Hill.

Stegwee, R.A., Rukanova, B.D. (2003). Identification of Different Types of Standards for Domain-Specific Interoperability. In: *Proceedings of MIS Quarterly Pre-Conference Workshop* ICIS 2003. pp. 161- 170, Retrieved January, 2004 from http://www.si.umich.edu/misq-stds/proceedings/

Vermeer, B. (2000). How Important is Data Quality for Evaluating the Impact of EDI on Global Supply Chain. *Proceedings of the 33 Hawaii International Conference on System Science.*

Wegner, P. (1996). "Interoperability." *ACM Computing Servey* 28(1): 285-287.

Winograd, T. and F. Flores (1986). *Understanding Computers and Cognition: A New Foundation for Design*. Norwood, Ablex.