On the Problem of Multi-Channel Communication

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Abstract. This paper discusses the issue of multi-channel communication. Multi-channel communication is a vision of future electronic business communication that is based on abstract messages, formal domain descriptions, formal communication channel descriptions and context-aware computing. We present research questions related to this vision together with a solution in form of a self-managed communication service. We propose the use of ontology-based approach for modeling and utility functions for decision making. Such a service can be proactive, capable of learning and improving itself.

Keywords: communication, ontology, adaptive system, context-aware system, B2C

Key Terms: InformationTechnology, BusinessIntelligence

1 Introduction and Motivation

Nowadays, businesses communicate using various electronic communication channels such as text messages, e-mails, newsletters, etc. The communication happens in both directions – inbound and outbound. It is difficult to keep track of messages on different media and in both directions at the same time. Since every communication channel is different in its nature, each one requires a different method of message composition. Therefore the channel has to be known before the message is written.

In this paper we are trying to identify problems related to business-to-customer (B2C) multi-channel communication and propose a set of techniques that could solve these problems. In section 2 we define multi-channel communication and terms related to it. Section 3 addresses problems of multi-channel communication and raises several research questions. In section 4 we propose an approach based on a self-managed system. Finally, section 5 discusses the future work and concludes the paper.

2 Multi-channel Communication

Human-to-human electronic communication can be understood as a process of information exchange between two or more parties. Information is usually exchanged in a form of messages. These messages can be e-mails, spoken sentences, text messages, blogs, etc. In general, communication can follow many patterns and have different requirements on the communicating parties. We concentrate on business communication, mainly on business-to-customer communication.

Let's imagine that an Internet store wants to advertise a new computer model. Therefore the store composes a newsletter and sends it to its customers. One of the customers is interested in the computer and asks a question about this product by e-mail. The shop also answers by e-mail. After a week the customer decides that he wants to buy the computer and makes an order using a form on the Web page of the store. The store confirms the order by an email. This part of the communication involved several communication channels – newsletter, e-mail and a Web form. If we are looking at this communication from the store's perspective, all these messages are interconnected, even though they originated from different communication channels and at different times. A system that can seamlessly integrate these messages would detect a new pattern that is valuable for the Internet store. A system that could also target the right customers using the right channels would be even more beneficial. In order to understand such a system we have to understand its components.

Communication happens through media. In general the definition of the medium depends on the abstraction level. On the level of signaling, medium can be understood as the surroundings that are used to transfer the signal. An example would be copper wire, optical fiber, air, etc. On a higher level, medium can be considered to be a method of communication that follows certain high-level network protocols. An example would be a computer network, telephone network, etc. Let us call this higher level medium a logical medium. One logical medium can operate on several physical media – e.g. a computer network can operate on copper wires, fiber optics or wirelessly.

One logical medium can host different types of communication channels. Under a communication channel we understand a set of communication methods that cover a way of business-customer communication. An example of such a channel could be e-mail channel, telephone channel, text message channel, instant messaging channel, etc. We introduce this term as an abstraction from the low level communication method. The relationship between media and communication channels is shown in Figure 1.

Each communication channel has its advantages and disadvantages in terms of speed, clarity, maximum size of the message transferred, cost, etc. Therefore it is reasonable to assume that each channel is suitable for a different set of circumstances. There are several things that are relevant to the interaction between the user and the system. Information about these things forms the context [1]. Therefore, in order to find the best channel, we need to make the system context-aware.

Based on the direction of communication we identify two main types of communication channels – simplex and duplex. FS-1037C defines simplex circuit as "a circuit that provides transmission in one direction only" [2]. Similarly, simplex communication channel is a channel where the communication is possible in one

direction only. Duplex communication channel is a channel which both parties can use to communicate with each other. A system using duplex communication has to be able to analyze communication in both directions. This might be a problem, because whereas the meaning of an outbound message is clear, an inbound message received by the system has to be analyzed first.

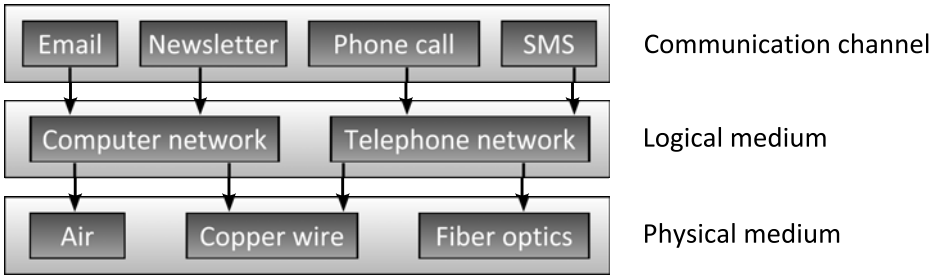

Fig. 4. The relationship between media and communication channels

3 Issues Related to Multi-channel Communication

Nowadays, we have many services that allow us to communicate using a variety of communication channels. Every communication channel has its limitations and those have to be taken into consideration when writing a message. Therefore it is necessary to know which communication channel will be used before the message can be composed. Also, if several communication channels are used, it is difficult to integrate them into one communication thread due to their heterogeneity.

What we are lacking is a system that would seamlessly integrate several communication channels and allow us to think of communication in more abstract terms. A system like this could choose the best possible communication channel based on the communication context and an abstract message. Rather than containing concrete text, an abstract message could contain a set of goals. In such a case, the knowledge of the communication channel would not be required in time of message composition. The system would also be able to integrate a reply, even though it was received from another channel. Therefore the communication would be transparent to the user of the system. We call this the vision of autonomous multi-channel communication. Figure 2 explains the vision in more detail.

Before this vision can become reality, several issues must be solved. Firstly, there has to be a way to model the abstract message and communication context. A modeling method like this should offer sufficient flexibility and expressiveness, but on the other hand keep good computational properties. Secondly, an abstract message has to be translated into a concrete message by taking the communication channel into account. This issue is closely related to the first one. Thirdly, the system has to be able to extract information elements from a received message. This would vary based on channel used. In some channels, the form of the message can be controlled by the system (e.g. a Web form). In other channels a deeper analysis is needed (e.g. e-mail

written by a human). Moreover, there is the issue of the communication channel selection. Knowing the communication context and abstract message definition, which channel is the best to use? Lastly, we assume that every communication is happening for a reason. That means it has a purpose/goal. This goal is related to a certain domain. If we want to formally describe a message, then there is a need to have a formal description of the domain the message is about. Also, a formal description of the communication itself is required. How can we model these domains so that they are compatible with other elements of the system?

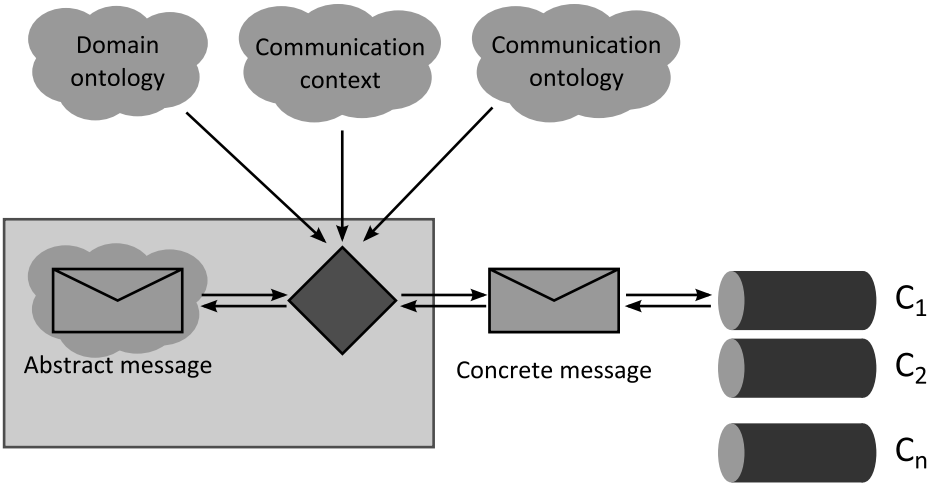

Fig. 5. Vision of autonomous multi-channel communication

4 Self-Managed Multi-channel Communication Service

Our proposed solution consists of a cloud communication service that would enable transparent multi-channel communication.

Strang and Linnhoff-Popien analyzed several context-modeling approaches based on six criteria [3]. We believe that the most relevant criteria are the following. Firstly, it is the ability to partially validate context information against a context model. This property is important for proper decision making. The second property is the ability to deal with incomplete and ambiguous information. This property is important during the examination and information elements extraction of the received message. These elements might be ambiguous, due to the nature of human language. The third criterion is the level of formality. A high level of formality is a way to avoid misinterpretations of the data. Based on these criteria, the most suitable way to model the context is an ontology-based approach.

In case of information elements extraction from a received message, some information channels are inherently easier to work with than others. Among information elements, there are two important ones that can greatly reduce the context

– the sender of the message and the topic of the communication. In case of electronic communication the sender can be determined based on the source address (e.g. e-mail address, phone number, etc.). The topic of the communication can be determined by using reference numbers, which is a well-known technique.

We suggest utility functions as methods of channel selection. According to Kephart and Das they are superior to action rules and pure goal policies, due to their ability to assign a numeric value representing the desirability of a future state [4]. The future state can be represented as a state when a particular message is sent to a particular channel under a particular context. Therefore the abstract message, communication context and channel description determine the inputs of the utility function.

A possible solution to the problem of abstract message transformation is a template-based approach. There will be a set of message templates and each template will have a formal specification of an abstract message that it needs in order to generate a concrete message. Similarly to channel selection approach, we can use utility functions to choose the proper template based on the communication context, abstract message and the template description.

Closely related to context modeling is domain modeling. We suggest ontology-based modeling as in the previous case for the compatibility reasons.

We believe that it would be of great benefit to design this system as a self-managed system. Self-managed system is a system which can maintain itself without human's intervention [5]. Cheng et al. believe that self-management can be achieved using closed-loop control based on reflection [6]. We believe that this solution might be feasible due to the fact that many components of the system would be formally described (e.g. template rules, utility functions, etc.) and thus easy to reason about. Such a system could optimize itself by modifying these components.

5 Conclusion and Future Work

In this paper we presented an issue related to the area of human-to-human business communication using electronic media. We present a vision that would allow businesses to integrate all the communication from and to their customers using any electronic communication channel. We call it the vision of multi-channel communication.

There are several issues related to this vision. We believe that there are a few important ones. Firstly, it is the issue of abstract message modeling and communication context modeling. Secondly, there is a problem related to message transformation from its abstract form to its concrete form. Thirdly, a way has to be found that would allow extraction of information elements from inbound messages. Fourth of all, we need a method of finding the best communication channel based on the communication context and the abstract message being sent. Lastly, it is the question related to the model of the communication domain.

We also provided a short description of a service that could solve these issues. We suggested an ontology-based approach to the problem of domain modeling, communication context and abstract messages. In case of message conversion we suggested a template-based approach, where each template would formally describe

what messages it can consume. We believe that the problem of inbound message element extraction can be solved by reducing the context and thus decreasing the ambiguity of the data. The problem of suitable communication channel selection can be solved by the use of utility functions. Finally, we proposed an ontology-based approach for the domain description as well.

In the future we plan to develop an ontology reflecting the domain of communication. At this point it appears that the use of description logic is the most appropriate way, since it has been well studied and the market offers high quality tools. We also would like to look at the area of context modeling using description logic. This is closely related to utility functions.

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