Fostering Active User Involvement in the Specification of Network Information Systems[1]

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Abstract

In this paper we propose a strict separation between the information system specification and implementation stage. In order to allow for more active user participation in the information system specification process we also advocate a strong connection between the information use and specification stage. Some deficiencies of current approaches are criticized. A specification method aimed at research networks, RENISYS, is introduced that is being constructed on the basis of the proposed ideas. Its application is shown by analyzing a case on an Internet-based research network experimenting with writing group reports.

1. Introduction

Professional communities are formed by people who share some common goals and actively cooperate to achieve them. A good example of a professional community is a research network. It represents a goal-oriented network of professionals that focuses on supporting certain stages of the research process like the planning and conduct of research and the dissemination and implementation of the results. Research networks are expected to quickly gain importance as catalysts of research collaboration [DeMoor96]. From an information scientific point of view the research network is especially interesting because it consists of stakeholders with sometimes very diverging goals, backgrounds, and interests. This results in an even larger need for structured, yet at the same time flexible workflow support and information and communication management than required in more homogeneous networks.

Concurrently with the rising interest in the research network phenomenon we see a dramatic increase in the availability and use of advanced information technologies, especially those that are based on the Internet. Many research networks already make use of them, and are supported by tools like mailing lists and the World-Wide-Web. These tools have already proven to be able to substantially improve human communication, with often great positive impact [Perry-Adarn92]. However, the full potential of modern information technology is often not yet realized, especially not in complex organizations like the research network. Major barriers exist that are in the way of more satisfactory applications, such as those concerning information control and information overload. To solve these problems, there is a strong need for more integrated and customized network information systems [DeMoor96]. Of course, much human communication can be done without tool support, but ever more (global) networks are completely dependent on information technological support for the coordination of their work activities. It is this kind of computer mediated research networks that we are focusing on.

Such complex collaboration systems cannot be developed in an uncoordinated way for them to truly live up to the expectations of the intended users. To systematically create adequate systems, a lot of attention needs to be paid to structuring the information system development process. In general, this process can be viewed as consisting of an analysis, design, and implementation stage. In the analysis stage, a perceived real-world system is transformed into a conceptual model of that system. During the design process, this conceptual model is translated into a model of the information system. Subsequently, the latter model can be turned into a (partially) machine-executable implementation [Wand-oth95]. Traditional system development approaches, based on the waterfall paradigm, are

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suitable for single time analysis and design, fixing most of the degrees of freedom in the implementation. However, in the Internet-environment many implementations, in the form of generic information tools already exist. In order to apply these tools in a more useful way, we are especially interested in the analysis and design stages, which together we call the specification process. The boundary between these stages is often a fuzzy one, and in many cases the specification even is the implementation. In the rapidly approaching era of modular system development, applications are ever more being constructed out of loose, independent network resources, united by mediators [Wiederhold92]. World-Wide-Web browsers, mailing lists, information servers, search engines are standard products which are an indispensable part of the implementation of the network information system. These tools may be optimized and interpreted by setting preferences and generating (inter)mediating code, such as Unix scripts. The specification process should thus concentrate on assembling an 'orchestra of information tools' in terms of requirements, identifying the role that they play in the collaborative activities of the specific user community, rather than forcing requirements to be expressed in the primitive information processing terms of coincidentally available technologies. Tool implementation, on the other hand, should focus on optimizing separate units of functionality, such as needed for information navigation or decision support. Thus, the specification of a network information system abstains from technical details such as user interfaces or operating systems. Instead, the specifications indicate the 'collaborative role' of the tools by stating minimum requirements in terms of information and communication processes.

In the remainder of this paper we introduce a user-driven approach to the specification of network information systems. Users can be regarded as important contributors to the analysis and design of their own network information system. In section two we first define the specification process. After identifying some deficiencies of current approaches, we present an outline of the RENISYS specification method. In section three we select relevant coordination principles for system specification by users. Finally, we illustrate the introduced concepts by means of a concrete case.

2. Redefining the Specification Process

In order to more precisely define the role of the specification process, we distinguish three processes in information system development: the specification, implementation, and additionally the use process. In our view, the latter process needs to be much more closely connected to the specification because during the use of the network information system its requirements and thus its specifications evolve. In figure one, we show how the development stages and their outputs are related.

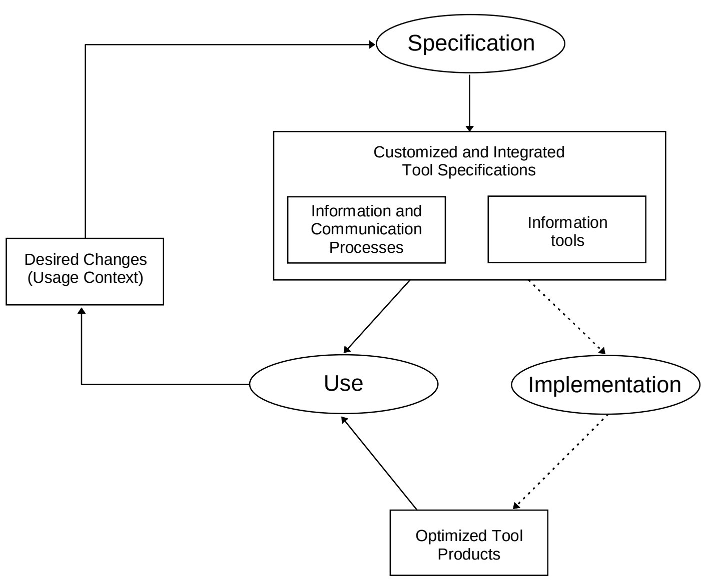

Figure 1 A User-Centered View of the IS Development Process

In our definition, in the specification process an abstract representation of the network information system is generated by first identifying the user information needs. Then they are translated into a set of required information and communication processes, and mapped onto enabling tools. In order to construct the technical information system, these tools are matched with functionality components provided by information tools and environments in the implementation stage. An information tool is a piece of software that embodies a certain standard amount of functionality, whereas an environment consists of a set of basic software elements that can be used to construct a variety of tools. Notice the two different perspectives possible when looking at the network information system: from the implementation perspective the system is a set of loose tools consisting of a human-computer interface with generic services. From the specification perspective, however, the system is seen as a set of functionality providing components that enable processes that have been defined in the usage context. The user/specifier views the tools that comprise the information system as a set of use-options which allow the user to carry out relevant activities. In order to let the user make significant changes in the network information system, he or she must be able to express desired modifications in terms of the currently allowable processes which have been defined in terms that are closely related to the user's universe of discourse. For example, from the implementation perspective a Web-browser allows a user to access hyperlinked documents. From the specification view though, the same Web-browser allows a network participant to easily retrieve background material for a research paper.

In practice this link is still very underdeveloped in most current specification approaches. In the following section, we will first describe one representative user-adaptable tool (OVAL) and discuss its deficiencies when analyzed using the model of the development process presented here. After that, we will describe the way in which a specification method specifically being developed for research networks will deal with those issues.

2.1. Current Approaches: From Ignoring to Involving the User?

In more traditional system development approaches, after implementation the user can only change the information system by setting preferences, while the core information and communication processes and data structures remain unchanged. However, we also want the user to be able to radically tailor the system. This means that end users can make major changes to their own information system without having to leave the application domain [Malone-oth95]. This view is in line with new approaches for process support, which suggest that participants can compose their own processes within a bounded process space that captures the bounds and features of the processes and the way they can be used [Fitzpatrick-Welsh95]. Ideally, instead of their collaboration processes being hindered by inflexible, technology-defined work processes, users should now be able to adapt their tools to their needs as they change. A major problem with popular approaches that allow for incremental information system specification such as prototyping [Budde92], is that they are very implementation-oriented. This means that again the specification discourse is to a large extent determined by technological aspects of the implementation (such as human-computer interface), even though it should focus on the definition of collaborative work requirements.

Ideally, a user does not need to know information technological jargon, but instead by expressing herself in her own, familiar terminology, she can automatically trigger the specification processes that are necessary to define and update the system. A typical state-of-the-art radically tailorable tool which claims to support such a user-driven specification process is Oval [Malone-oth95]. It well represents current trends in user-tailorable tools and systems. In Oval, users can construct a wide range of integrated information management and collaboration applications by combining a small number of tailoring primitives, namely objects, views, agents and links. However, two major obstacles to the successful use of the tool in a network context can be observed. First, Oval is a mixture of a method and a tool. Specification and implementation are one and the same activity, resulting in a tight coupling of requirements with tool functionality. In OVAL it is not possible to (re)compose a network information system out of a wide variety of changing technical resources. This is because there is only one uniform and fixed set of functionality primitives. In other words, there is no meta-language to express specific dependencies between required and provided functionality. Such a language is necessary to answer questions as whether specific requirements go unsupported, what are the effects of modifying a set of tools, etc.

A second problem is that of picking a set of specification building blocks at the 'right' level of abstraction. In Oval, this is done by introducing the already mentioned, rather artificial set of tailoring primitives. These, however, can hardly be called concepts taken from the user application domain. A non-trained user will still not be able to express desired changes in the information system in natural concepts taken from her own universe of discourse. It seems that another, more context-based layer of concepts is needed before effective user-driven system specification is possible. These concepts should be rooted in terminology typical for the specification discourse occurring in a user community. In research networks, a characteristic activity is for instance the writing of group reports. Thus, desired functionality changes should be expressible in such primitive objects as ‘reports’ and ‘discussion topics’, such primitive actors as ‘editors’ and ‘group members’, and primitive processes as ‘writing’ and ‘discussing’. It is up to the specification method to determine how changes in these concepts affect the tool specifications.

2.2 RENISYS: A User-Driven Specification Method

In order to develop more adequately customized and integrated information systems, specification methods are needed that allow users to efficiently model genuine collaborative information needs. This knowledge can then be used to describe a set of enabling information tools in requirement terms, and identify lacking information system functionality. It is the role of the method to facilitate the construction of virtual network information systems out of a change-prone set of available resources. When applying such a specification method, users no longer necessarily have to constrain the expression of their information needs to the limited technical vocabulary provided by the functionality of the implementation at hand. At the same time developers are free to build more sophisticated tools that do not necessarily have to be molded to the fluctuating demands of a specific user community. Pieces of the specification puzzle are provided by workflow modeling, norm-oriented and neo-humanist methods [DeMoor96-2]. Each of these classes of methods on its own is insufficiently capable of dealing with the particular specification problems encountered in research networks. Some methodological design principles to be used in the creation of an integrated method, as well as some initial work on its construction are described in [DeMoor96-2]. In this paper, we will not focus so much on the outline of this specific method. Rather, we would like to explain in more detail the role that the specification process plays in the overall network information system development.

The integrated method that aims to deal with above mentioned problems is currently being constructed: the REsearch Network Information SYstem Specification method (RENISYS) [DeMoor-VanderRijst95]. It will allow the users themselves to create and update the specifications of complex network information systems. Some of the intended features of the method most relevant to the scope of the paper are its user-drivenness, context-sensitivity, and discoursiveness [DeMoor96-2]. RENISYS will be user-driven in that users can define their information needs themselves, as well as the specification solutions in usage-context terms. To this purpose, the method also needs to be context-sensitive. This means that it allows for the easy detection and representation of relevant changes occurring in the context in which the information system is used, after which it takes the necessary specification steps. Another key characteristic is that the method should be discoursive: it not only assists in the representation of specifications, but also facilitates and guides the human discoursive process of arriving at acceptable process specifications. Such a method should provide one way in which this very dynamic type of information system can remain adequately tailored to the complex and quickly changing needs and available technologies of a research community. When using the method, one is not forced to be preoccupied with implementation aspects, so that one is not restricted to defining less than optimal technological solutions. Instead, the role that the technological tools play - or do not play - in the collaborative user community becomes much clearer, thus allowing for a more structured evolution of the technological support.

At the heart of RENISYS is a reference framework that allows the users to efficiently model the usage context of the information system and the effect that this context has on the information system specifications (see figure 2). The usage-context consists of two domains. In the problem domain the universe of discourse is interpreted from a task perspective. In the human network the universe of discourse is seen from an organizational point of view.

First of all, it is important to realize that the method takes a horizontal, non-hierarchical process view on the information system. Network participants are involved in many different processes, depending on the roles they play. Via these processes they interact and change their interpretation of the universe of discourse, as well as the definition of the information system itself. A good understanding of the relevant kinds of interpretation processes involved, as well as of their interdependencies, is thus a proper starting point for being able to specify more useful and comprehensive network information systems.

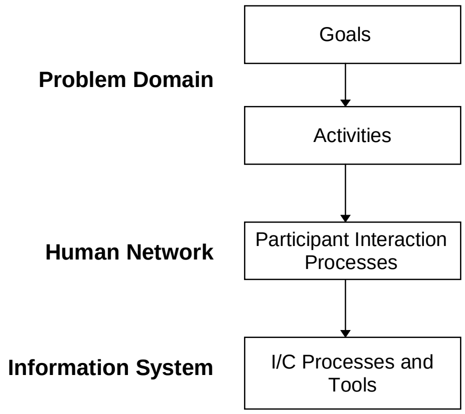

Figure 2 The RENISYS Framework

When analyzing the activities carried out in these research networks it is important to look at the organizational structure supporting the underlying processes. Even though research networks are no hierarchies, their organizational structure is still an essential determinant of the requirements specification, as it constrains the possible activities the user of a network information system can perform. For example, a public Web-site can be accessed by any user who has a Web-browser. However, only group members jointly working on a group report are allowed to contribute documents to this Web-site. Without an organizational layer, this kind of constraint cannot easily be expressed. This view is reflected in the structure of the reference framework, which consists of a top-level problem domain, modeling the goals and activities of the network, a human network level, representing its organizational structure and dynamics, and an information system level, at which the abstract information system is specified as an ensemble of customized and integrated tools. The reference framework offers a coherent process view on the network information system, by translating network problem domain goals and activities (e.g. organizing a conference) into participant interaction processes at the human network level (like organizational discussion and decision making). These processes in turn are mapped to a number of tool-enabled information and communication processes, such as information retrieval and data exchange [DeMoor-VanderRijst95]. The framework helps to ensure that users do not have to descend into the depths of abstract specification languages, but instead can express desired changes in the more natural terminology of the appropriate usage context level: the problem domain, human network, or a combination of both.

2.3 Strongly Connecting Use and Specification

Although we have indicated that in RENISYS goals and activities are important root determinants of the network information system specifications, we have not yet described how exactly the use stage influences the specification stage. Two basic issues need to be dealt with. The first one, concerning the user being able to express herself in usage context terminology, is addressed by applying the reference framework. Some initial work on how to build and apply the framework has been described in [VanderRijst-DeMoor96]. Basically, it allows the method to model user information needs in a formal, yet domain-specific way.

However, the framework by itself is not sufficient. It is only the conceptual foundation of the specification method. The network information system is to coordinate and support the collaborative processes. A characteristic of professional networks is that in general none of the network members has a complete overview of the possible interactions between these processes, hampering their improvement. The specification method therefore has to assist in locating breakdowns in processes and help to optimize the definition of the required functionality. Coordination can be defined as managing dependencies between activities [Malone-Crowston94]. Through RENISYS users are capable of efficiently modeling their usage context changes. The method will be able to propagate these changes through the reference framework and update the (mismatches in required and provided functionality) specifications of the network information system. These specifications can then be used to either automatically or by human intervention modify the system implementation. In the rest of this paper we explore how to accomplish such coordination of the specification process in RENISYS.

3. Coordinating the User-Driven Specification Process

In traditional database or production management information systems, the order and make up of the activities to be supported are often predetermined. This is not feasible in research networks, as their workflows are much less constrained. However, having no workflow definition at all is also not practical, because in that case group productivity generally is very low. This can be seen from the disappointingly low amount of useful group output that is realized on an average mailing list.

In many cases, research networks differ from traditional organizational structures, for example on the kind of goals and the diversity of knowledge requirements. Research networks are in many aspects comparable with adhocracies. These are very flexible organizations, including many shifting project teams and highly decentralized communication networks among relatively autonomous groups [Mintzberg79]. In many of these groups substantial amounts of unplanned communication and coordination take place for which computer support is useful. Lowering the cost of coordination and communication by means of information technology could result in a shift towards smaller firms and proportionately more use of markets (read: networks) [Malone-oth87].

Because of this transformation towards smaller, more independent organizations and as groups of professionals are working together in less predefined ways, coordination primitives such as described in standard organization theory and management science do not necessarily apply to these new network-like organizations. In [Desanctis-Jackson94], five functional coordination modes are defined that apply to the horizontal coordination between (IT) units, which do reflect a newer way of thinking about coordination. The first and simplest mode is concerned with information passing. It consists of sending and receiving messages without extensive dialog or follow-up exchange between the coordinating parties. Complexity increases in the case of discussion of the relationships, the roles and responsibilities of the various partners. This also applies when coordination is directed towards the formulation of procedures, such as creating a policy. A further increase in complexity is observed when the context of communication is aimed at task accomplishment. When coordination takes the form of issue analysis, communication will consist of a rich dialog among parties. Often, this process is referred to as a discourse in the area of language philosophy (see e.g. [Habermas81]). Coordination in this last case is the most difficult to achieve, since the complexity of the communication is very high, which is a very typical characteristic of research networks.

Thus adhocracies have a large variety of coordination modes which are difficult to support in practice. What we would like to have is a more generic yet powerful coordination primitive. In [Malone-Crowston94], the process of goal management is described as a suitable coordination principle for interdisciplinary research groups. Two constituting strategies to be supported can be summarized as goal-identification, and goal decomposition. They are the primary way of managing dependencies between network activities. Thus, first, goals need to be identified by the network which, as work progresses, are often decomposed into many different activities, influencing the workflow processes and the supporting information system. The process of goal identification is called a bottom-up process, which often engenders more commitment from the actors than a top-down assignment of responsibility and is thus more suitable for non-hierarchical type of organizations. The group decides to pursue a goal and then, guided by the specification method, decomposes this goal into sub-goals (or activities), which together will accomplish the original goal.

As use and specification are so closely entwined, goal management can also be applied to the coordination of not only the work process, but also of the specification process itself. Coupling the RENISYS reference framework with coordination mechanisms that allow for goal management, help to ensure more active user-involvement in the network information system specification process. One formal approach suitable for representing coordination is provided by the DEMO method [Dietz94], of which some connections with RENISYS were already previously described in [DeMoor-VanderRijst95] and [VanderRijst-DeMoor96] which we will therefore not discuss here. To illustrate the theoretical notions introduced so far, we will give a rather informal analysis of a specification problem that occurred in a concrete Internet-mediated research group, the Project Group on B.C. Forests and Forestry (BCFOR).

4. An Example Case: Writing a Group Report in an Internet-Based Research Community

BCFOR is a group of about seventy people interested in analyzing the deforestation crisis that has emerged in the Canadian province of British Columbia. Its members include a wide range of stakeholders in the conflict, from academics, representatives of industry and government to environmentalists. The group is part of the Global Research Network on Sustainable Development (GRNSD), a network which among other things aims to find new ways to use modern information technologies for international and interdisciplinary research collaboration[2]. After its inception, for communication purposes the group was only supported by a standard mailing list, which was used both by individual members to make announcements (a form of information exchanging) and by the group as a whole to conduct free-form discussion (requiring more complex coordination).

Although these debates were interesting, the members wanted to become more productive after a while, since the professional quality of the interaction and the involvement of the members was high. Therefore, the group decided to write a joint report on a topic relevant to its scope.

4.1 Getting Started

The RENISYS framework is now applied to analyze the co-evolution of both the usage-context (problem domain and human network) and the enabling information tools. In this section we show how by combining the reference framework with a goal management approach, users can define complex collaborative requirements of their network information systems. Initially we have a network group, consisting of a number of equally important members (human network level). Two types of participant interaction processes can be distinguished: a group member informing the group, and free-form discussions taking place within the group as a whole.

```
Date:      Mon, 1 Apr 1996 17:46:56 +0200
Sender:    "GRNSD B.C. Forests and Forestry Project"
           <GP-BCFOR@NIC.SURFNET.NL>
From:      Aldo de Moor <ademoor@KUB.NL>
Subject:   Jobs or Forests?

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Date:      Mon, 1 Apr 1996 09:54:00 PST
Sender:    "GRNSD B.C. Forests and Forestry Project"
           <GP-BCFOR@NIC.SURFNET.NL>
From:      Chris Hermansen <###@####.##.##>
Subject:   Re: Jobs or Forests?

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Date:      Mon, 1 Apr 1996 13:10:21 PST
Sender:    "GRNSD B.C. Forests and Forestry Project"
           <GP-BCFOR@NIC.SURFNET.NL>
From:      Richard Kool <#####@###.###.##.##>
Subject:   Re: Jobs or Forests?

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Figure 3 Single Discussion Thread from the Mailing list

To enable these processes, only one type of information tool is available, the mailing list (information system level). A user can send a mail to the list, which then redistributes it to all members of the list. It is also possible to reply to a received message, which is either an original message or itself a reply. A sequence of such messages is called a thread. It is possible to distinguish mails belonging to the same thread from unrelated mails by looking at the message header: the subject line contains either a topic label (original mail) or a topic label preceded by an indication that the message is a reply (usually ‘Re:

[2] More information on the research network is available at: http://infolabwww.kub.nl:2080/grnsd.

<Topic>’). It is important to note that a discussion is thus represented as a single sequence (see also figure 3).

Both the information exchange and the free-form discussion processes relevant in the human network level are mapped to a single set of information and communication processes at the information system level: a user sends a mail to the list, the list redistributes it, and in case of discussion adds it to the (single) sequence stored in the list archive.

4.2 Getting Serious

Once the group has decided, after informal discussions, to write the group report, a goal has been established (problem domain level). At first, this is seen as a single activity, the writing, which can be mapped to the free-form discussion process at the human network level. However, soon it is felt that too little structure is provided by this activity. Therefore, the writing activity is subdivided into three separate activities[3]: announcing the topic, authoring, and presenting the finished group report to the outside world. The first and third activity are - from a coordination point of view - examples of the simple information exchanging processes at the human network level. The authoring, however, must now conform to much stricter rules of proper (scientific) collaboration than the previous informal writing. For instance, authors can now state issues, take positions, make various kinds of claims etc., introducing complex (sub)activity dependencies. Now these activities of the problem domain have to be mapped on the human network level.

It is found that the ‘simple’ free-form discussion in the human network level is no longer sufficient. Therefore, a second type of discussion is introduced here: structured discussion. Only a subset of the group members is interested in participating in this process, namely those who are actively involved in the authoring activity.

Finally, at the information system level it turns out that the mailing list does no longer provide functionality of sufficient ‘granularity’. Instead of a single sequence representing a complete discussion, multiple sequences are now required, for instance one to represent each issue dealt with in a structured discussion or sub-discussion to investigate the validity of claims. As the mailing list is not capable of providing this coordinative functionality, another tool is needed, which was selected to be HyperNews, a Web-based discussion tool[4] (see figure 4).

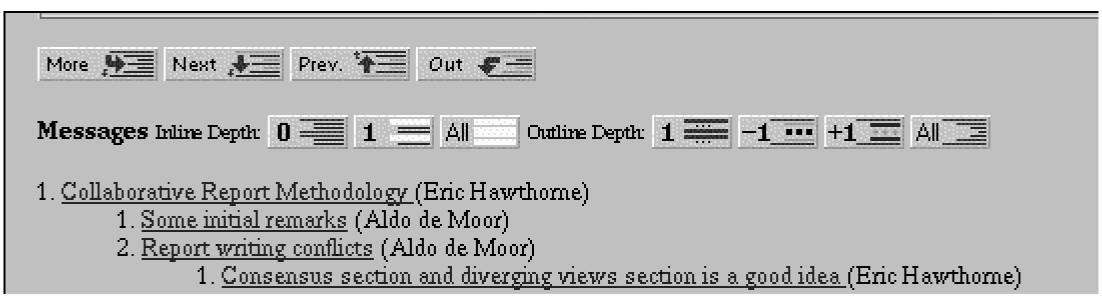

Figure 4 Multiple Discussion Threads in the HyperNews Tool

The analysis so far has focused on the way the actual work processes are (intended to be) supported by the network information system. However, the same system has also been used to support the specification process. The experiences with the use of the mailing list and the HyperNews tool however showed that they more or less adequately supported the work activities made possible by the structured discussion but not the specification process. In the near future more of these similar case studies will be carried out, which provide opportunities to refine RENISYS.

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[3] In reality a much more complex activity subdivision emerged in the group, to clearly demonstrate the gist of the ideas proposed in this paper, however, only a simplified version is described.
[4] See: http://union.ncsa.uinc.edu/HyperNews/get/hypernews/about.html.

5. Conclusions

As discussed in the introduction, research networks can benefit considerably from the support of information tools to enable the research process. Widely different and quickly changing activities need to be supported in order to accomplish network goals. The development of a structured specification approach capable of capturing the information requirements of the users of research networks, and the mapping of these requirements to functionality provided by available information tools is a prerequisite for them to function adequately.

In this paper, two important issues encountered in the user-driven specification of network information systems were addressed. The first problem concerned the distinction between specification and implementation. Radically tailorable tools, such as OVAL, are built in such a way that this distinction becomes blurred. This makes it difficult to see how exactly a change in concept of the application domain relates to changes in the technical information tool functionality. In our approach, this distinction is explicitly made, so that system specifications can be constructed without the specification process being subjected to technology-imposed constraints. This permits more easily system designs that can be used on multiple platforms.

The second problem concerned the introduction of the right information system building blocks at the right level of abstraction. In OVAL, the user who wants to make changes to the information system is given a few abstract specification primitives. A user will not be able to capture - in a natural way - the processes taking place at the problem domain (and other levels), using these artificial concepts. In the user-driven REsearch Network Information SYstem Specification method (RENISYS), users define their requirements, including their dependencies, using situated processes at two reference framework levels: the problem domain and the human network. The method then assists the users in mapping these requirement definitions into the required low level information and communication processes. By matching the required process definitions with the processes enabled by the information tools, mismatches between information need and provided functionality can be identified

Next we discussed goal management as one particular coordination mechanism of specific importance to research networks. The (meta-)process consists of two subprocesses: goal identification and decomposition. This is the main coordination primitive currently incorporated in the RENISYS method. Goal management can partially be supported using the functionality of existing tools, such as mailing lists. However, much more work needs to be done before complete coordination of the system specification process can be achieved. Our intention was just to give some indication of which avenues to enter.

The RENISYS approach applied to the BCFOR case showed that it should be suitable for an adequate description of user requirement evolution, and information tool functionality assessment. The BCFOR case study also functioned as an example of the case study research strategy that will be employed in the further development of the RENISYS method. Work is currently in progress to formalize the methodological framework and its support of the dynamics of the user-driven specification process.

The RENISYS method, once operational, should allow for the relatively simple, and robust facilitation of the complex dynamics of the user-driven specification of network information systems. It permits the definition of complex collaboration and coordination constraints. These constraints form the core requirements to be used in the selection, configuration and linking of standard information tools, and if necessary in the production of additional customized functionality in case they do not suffice.

The aim of the RENISYS project is to provide a method that allows for the more efficient mapping of high level, user-defined requirements, to the low-level, information system specifications. This will allow the network participants to adequately adapt the information system to their real information needs, while not being forced to go into information technological details. We believe that the RENISYS approach is one step further on the way to the realization of this difficult, but essential ideal.

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