Facilitating the Evolution of Electronic Healthcare Networks: Framing the Changing Socio-Technical System[1]

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Abstract

Healthcare networks are increasingly supported in their operations by advanced information and communication technologies. However, the adoption and diffusion of enabling technologies in their complex workflows, organizational structures, and professional sub-cultures is not trivial. Electronic healthcare networks are strongly evolving professional communities that involve different stakeholder constituencies in both operational and strategic change processes. The timely involvement of relevant stakeholders and enabling technologies is essential to the successful development of electronic healthcare networks. In this article, the strategic change processes of the socio-technical system of a successful electronic rheumatology network are analyzed. Subsequently, a framework to model and manage the evolution of electronic healthcare networks is described. The theoretical and practical implications of the results are discussed.

1. Introduction

The network economy, while an over used phrase, remains an appropriate metaphor to explain significant changes across the health care landscape, and to understand and design new emerging organizational forms. The network economy is challenging traditional health care institutions to develop new patient-oriented business models and invest in information and communication technologies (ICT). With the advent of changing government policies and regulations, increasing patient demands, emerging communities of expertise, and enabling digital technologies, the health care industry is undergoing a fundamental transformation [11][14][17]. Once a cottage industry of physicians, hospitals, medical centers and consultants, healthcare organizations are now becoming aware of the potential value of integrated services and the collaborative advantage of networking. Institutional forces have driven physicians, consultants, hospital staff and other stakeholders to develop new professional networks and communities, and electronic healthcare networks are rapidly becoming a strategic necessity [22][16].

Electronic network organizations are characterized by non-hierarchical, long-term commitments; multiple distributed stakeholder roles and responsibilities; interdependent decision-making and workflow processes; and an ICT-based network infrastructure [21]. A professional electronic network consists of different stakeholders involved in a collaborative relationship, that exploit ICT to develop and share expertise and competencies for enabling and enhancing complex knowledge-intensive work processes [29]. An electronic network organization thus intertwines both social, organizational and technical webs [8][17][21].

While previous studies have focused on the use of ICT to co-ordinate network interdependencies in production work and transaction services (e.g., [32][30]), the role of ICT in the evolution of electronic

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healthcare networks remains understudied and a void in empirical research. More importantly, the framing of changing socio-technical systems in professional electronic networks is still in an embryonic stage. Recently, Savitz et al. [24] conclude that while increasing attention has been given to the initiation of electronic health care networks, the understanding of how best to shape and support their development is limited. Management not only requires a detailed understanding of the critical success factors of electronic healthcare networks, but also of their specific change processes, in order to design interventions that adequately facilitate their evolution. From a research perspective, the challenge is how to develop theoretical frameworks and management tools that organise and guide research efforts and provide relevant insights and practices for understanding and governing changes in the socio-technical systems formed by electronic health care networks.

This paper examines the design and development of the successful Electronic Rheumatology Network (ERN), from its conception to implementation (Section 2). The ERN has led to improved flexibility and quality of patient rheumatology treatments, improved cost-effectiveness and the shared development expertise regarding rheumatology treatments and care. In order to model the successful evolution of such networks, a model of change in electronic network organisations is presented in Section 3. To adequately facilitate the change process, we introduce RENISYS: a method for legitimate user-driven system specification (Section 4). Combining RENISYS with a best-practices high-level reference model derived from the analysis of ERN, we propose a concrete approach for facilitating the evolution of similar electronic healthcare networks. This paper concludes with a discussion of the theoretical and organisational implications of the foregoing analysis (Section 5).

2. The Electronic Rheumatology Network

In this section, the evolution of an electronic health care network in the field of rheumatology services is discussed. The case describes the design and development of the successful Electronic Rheumatology Network (ERN) over a period of five years. First, a general background of and introduction to the Electronic Rheumatology Network is provided. Then, the evolutionary stages of the network are described, including its conception , experimentation , and transformation. Appendix A. summarizes the changes in the key socio-technical entities during the different stages of the ERN-evolution.

General Background

The Rehabilitation Care Center (RCC) is a large medical center for rheumatology patients and rehabilitation treatments. It accommodates approximately 140 beds and treats approximately 50.000 patients each year. The organization consists of three business units: Products and Services, Motor and Cognitive Functions, and Rehabilitative Research and Development. Aware of the changing and dynamic health care environment, RCC is transforming itself to meet the demands of patients in the 21st century health care environment. Rehabilitative Research and Development (RRD) is the key driver in the realization of the RCC's vision in conducting research and development activities in the field of rehabilitation. Its mission is adding value to patient care by developing new methods and methodologies for rehabilitation in order to improve treatments by using innovative technologies. RRD's strategy is geared at improving the quality of rehabilitation by improving the effectiveness of rehabilitation treatments through the use of innovative methods and technologies. The core operational processes of RRD involve the development and application of professional knowledge and skills for the treatment of patients in rehabilitation.

Conception

In order to streamline patient care processes and provide efficient and effective care services, RCC commenced an organisation-wide change program in 1996. ICT played a key role in this transformation, as it allowed the organisation to store and share information across the different departments for decision-making and patient care purposes. Recognizing the fundamental changes accruing in the health care environment, and having gained experience with ICT-based change within the organization, RRD set out to improve their patient care and rehabilitation cure processes through the innovative use of information and communication technologies. Management and specialists at RRD conceived of an experiment in which geographically dispersed medical specialists would use a multimedia videoconferencing system to conduct electronic consultations on rheumatology patients. Rheumatology treatments require a multidisciplinary approach across different fields of expertise in health care, e.g., general practitioners, physiotherapists, rehabilitation physicians, rheumatologists. The idea for the ERN -Electronic Rheumatology Network- was conceived and widely supported by management, medical and technical specialists. Proposals were developed and much lobbying was conducted amongst technology vendors and developers, funding organizations and government agencies.

Experimentation

By late 1996, a consortium was formed to develop and advance flexible multimedia electronic consultation services for rheumatology, specifically in the area of clinical research and development. The consortium involved medical specialists from RRD and an Academic Hospital (AH), and technical specialists from service vendors and technology development teams. The development of this network of organizations and specialists spanned a period of two years. The electronic network system consisted of digital video recordings of patient movements and measurements of muscle activity and force patterns, supported by videoconferencing facilities including audio, video and graphs. The primary processes supported and enabled by the electronic network system were requesting, diagnosing, consulting and reporting treatments for rheumatology patients. The electronic network system was based on ATM network technology. The broadband network feature, which is necessary for conveying and sharing dynamic information, was the primary reason for choosing ATM. While the technical network was an important requirement for developing the ERN, the social network of stakeholders was regarded as fundamental to the direction and development of the ERN. In the words of the project manager:

> *"Because of the complex nature of the inter-organizational relationships, formal and informal communication between the different stakeholders involved is the key to the success of the ERN".*

Late 1998, the experiment was successfully completed. The ERN-project was perceived by all stakeholders as a major success. During the ERN-project, the different stakeholders exchanged information and collaboratively developed expertise with regard to the use of advanced electronic information and communication systems in human motion analysis. Evaluations indicated that the quality of rheumatology treatment plans had increased for the select group of patients participating in the experiment. The experiment had enabled RRD to achieve their objectives, i.e., develop knowledge and skills regarding the application and exploitation of ICT in clinical movement analysis, rehabilitation diagnosis and consultation. However, in finalizing the ERN-project, the viability of the ATM network was questioned by health care managers and physicians due to the investments required in applying the technology organization wide. A cheaper, but equally functional approach was subsequently sought by technical specialists, in collaboration with physicians. After some initial experimentation, health care management made the decision to use Internet and web-based videoconferencing as an alternative. Web-based technology was chosen as a strategic opportunity to expand the experiences gained with the ERN-experiment. The strategic choice for web technology was motivated by it being relatively inexpensive, more standardized, and flexible than the proprietary information technologies used thus far.

Transformation

Late 1998, a proposal was submitted to funding health care agencies requesting additional investments for formalizing and institutionalizing communication lines and rheumatology services between the Medical Hospital Center (MHC) and local clinics, and the University Medical Center (UMC) and local clinics. The proposal was submitted as a joint effort by both MHC and UMC. In effect, RCC and RRD were asked to join this second Electronic Rheumatology Network (ERN-2) in order to provide the technological know-how in supporting and enabling e-rheumatology services. The strategic objective of the ERN-2 was to improve the efficiency and effectiveness of rheumatology services in order to meet patients' needs and care, across time and distance.

The key driver in ERN-2 was the collaborative advantage by leveraging knowledge and expertise across the network and developing shared competencies and capabilities. Building stakeholder commitment, communication, and trust were critical in this endeavor. By commencing on a small experimental scale, based on the lessons learned in the first experiment, the ERN-2 slowly took shape. ERN-2 involved a completely new set of stakeholders (Figure 1):

1. Medical Hospital Center (MHC) and the local network of physiotherapists;

2. University Medical Center (UMC) and the local network of physiotherapists;
3. Rehabilitation Care Center (RCC) and rheumatologists;
4. Rehabilitative Research & Development (RRD) and technology specialists.

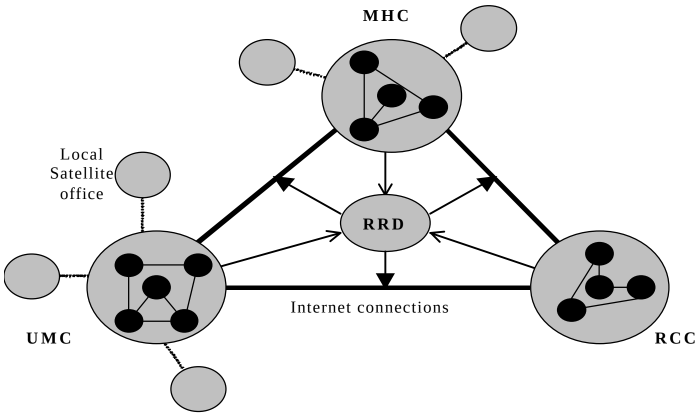

Figure 1. Configuration of the Electronic Rheumatology Network.

Within each institute different stakeholders were involved from levels of general management to the physiotherapists and rheumatologists using the telerheumatology services. The technology services and development role was taken over by RRD, as it had gained this experience during ERN-1 in the previous years. RRD was in effect strategically positioning itself in the health care sector as an 'e-care broker'. RRD was involved in the provision of telerheumatology services across the network, the leveraging of rheumatology expertise across the network and the development and supply of multimedia technology.

The electronic network system again comprised digital video recordings of patient movements and measurements of muscle activity and force patterns, and videoconferencing facilities including, audio, video and graphs. Only this time, the underlying technology platform was Internet-based. The system now also featured a multimedia database -'the post office' - used to facilitate the consultation and diagnosis of rheumatology cases by allowing for the efficient exchange of multimedia patient files. Critical requirements were to support both synchronous and a-synchronous multimedia communications in order to provide efficient, flexible and reliable e-rheumatology services. More importantly, not only was the electronic network being used for e-rheumatology services, it was, by late 1999, also used for virtual teaching and management meetings. The ERN was now used for informal communication purposes as well, thereby creating a virtual community of medical and technology specialists. During this same period, ERN-2 was integrated in the rheumatology services provided by the different institutes in a concerted manner.

Within the ERN, RRD repositioned itself as playing a strategic integrator role in an increasingly complex and dynamic healthcare environment. The experiences with ERN-2 were successful. Inter-institutional collaboration and communication were enhanced and participating stakeholders were satisfied. More specifically, stakeholders experienced the advantage of collaborating, sharing knowledge, and developing expertise together. Stakeholders indicated that they were satisfied with the multimedia database application as it met their needs to conduct asynchronous rheumatology diagnosis. In the words of the unit manager:

> *"By connecting our specialists in a professional network, we now have the means to use the existing knowledge and skills more effectively, develop and share expertise, and provide high quality services, in order to meet patient care demands".*

Now that the transformation stage of the ERN has been successfully concluded, its participants are discussing the future development of the network, the direction of which is still unknown.

3. Modeling Change in Electronic Network Organizations

As portrayed in the case of ERN, one of the key characteristics of electronic healthcare and other professional networks is their complex and dynamic nature. Electronic network organizations are based on the fluid exchange of information and knowledge, and are in essence dynamic learning networks of work processes and professionals [21]. Before we can study ways to *facilitate* and improve the evolution process of health care networks, we first need to understand and *model* the intricacies governing electronic network organizations.

In the previous section, the emergence of a successful electronic healthcare network was described by analyzing a real-world case. Next, we draw upon the case study to facilitate the evolution of similar networks. To this purpose, we adopt a workflow modeling approach to network information systems development. This approach is tailored to the development of electronic network organizations in that it pays explicit attention to the need for different levels of detail of system specifications and the precise roles of different stakeholders in the various stages of the network evolution. The focus is thus specifically aimed at the co-evolution of the social and the technical system.

In Section 3.1, we look at the principles of modeling the workflows that require support. In Section 3.2, we introduce a model of change in network organizations that can be used to facilitate the modeling process.

3.1 Workflow modeling

Traditional workflow modeling methods, often used in logistical planning, prescribe workflows in the greatest level of detail. However, many workflows in electronic healthcare networks can only be partially structured in advance. To guide the evolution of those workflows, a high-level workflow model is therefore needed, so that context-dependent details can be filled in at later stage. To structure the dependencies between these high-level entities, ontologies play an important role.

Partially Structured Workflows

A workflow is a recurring unit of work of which the coordination, control, and execution can be partially or completely automated [6]. Workflow modeling methods can be used to capture changes in workflows, which can then be implemented and supported using dedicated workflow management systems or a more generic suite of information tools such as e-mail and a wide range of web servers. For our purpose, the most interesting workflow approaches are the ones that focus on capturing *partially structured* workflows. These approaches allow both frequently recurring, well formalized processes to be captured, and more creative processes that have more degrees of freedom. In the latter case, procedures are not rigidly predefined. Instead, the support consists of defining *boundary objects* to ensure that the proper users are optimally involved in the triggering, execution, and evaluation of the 'ad hoc' workflows and that they are supported by an adequate set of information tools. Thus, unlike in traditional workflow modeling approaches, there is no need for prescribing in exact detail which functionality of the information system is to be used for what purpose. Instead, ad hoc workflow modeling approaches only indicate the main business processes, users, inputs and outputs of the workflows, and the suite of information tools to be used. The details of the application of this functionality in actual work situations are then left to the judgment of the user. Such a workflow modeling approach is important when capturing healthcare workflows, since the workflow entities are often only partially known in advance, or remain tacit in the different procedures of health care professionals. Thus, workflows are typically *situated* in the sense of being similar only at the aggregate level, while workflow details differ per case. For instance, it may be known that *some* specialist should supply a diagnosis, that the diagnosis files can have *different* formats, depending on the exact details of the request, and that *either* the multimedia conferencing system *or* e-mail should be used to communicate the diagnosis to the recipient. The remaining – still unknown - details are provided when the workflow process is actually executed.

A high-level workflow model

Based on the foregoing outline, it can be derived that by *circumscribing* instead of prescribing workflows, the main responsibilities, workflow outputs, and process dependencies can be guaranteed, while over-specification can be prevented. This view on workflow modeling is similar to the perspective of Fitzpatrick and Welsh [10], who see it as a form of *process composition*. One of their core concepts is that of *process space:* 'a semantically rich and relatively well-defined space, both physically and conceptually, which constrains and bounds the very possibilities of work.' An advantage of their approach is that much needed *flexibility* remains and that only the necessary boundaries of the socio-technical system are defined, thus focusing user-involvement on the essential change aspects of their system of collaboration.

Key to the successful definition of changes in the complex and dynamic socio-technical system is how to support the ongoing *articulation* of distributed activities, which means users providing increasingly more details to existing system specifications if and when necessary. Sufficient articulation not only means paying attention to workflow modeling in the strict sense (users modeling their interrelated *tasks*), but also to users being able to define their *common information space* [25]. This space consists of information objects that are common in the sense that they have been actively constructed, and that their meaning is understood and shared by a relevant subset of community members. New common information objects are produced in these workflows out of existing information objects. An input object in the *design treatment plan* workflow could be the diagnosis of the patient, the output object the completed treatment plan. Characteristic for such common information objects is that they have meaning across the network, although this meaning may differ per actor: a treatment plan means something for both a specialist and a patient, although they may have different views on the same information. Our articulation view on workflow modeling entails that the network stakeholders (*actors)* to a large extent themselves define the workflows in which they are involved, since they know best the timing, contents, and form of the changes required. Still, the actors who execute the workflows are not always necessarily the same as the actors who articulate them. For instance, the *design treatment plan* workflow is executed by the physiotherapist treating a particular patient. The (partially structured) workflow in which this takes place, however, has been designed by the RRN, i.e., the rheumatologists. The *high-level workflow* model of the ERN now looks as follows (Figure 2):

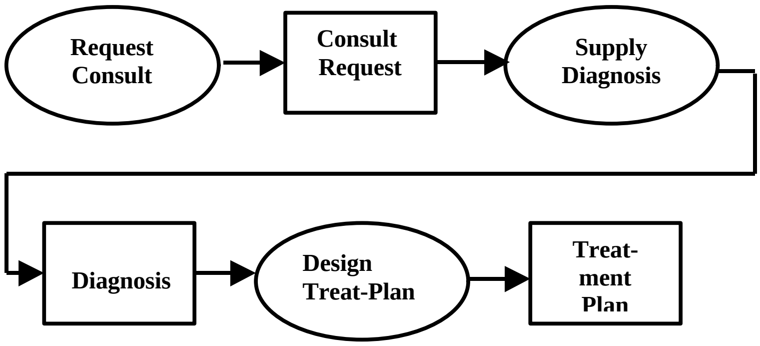

Figure 2. A High-Level Workflow Model of the ERN.

In the abovementioned workflow model, three main entities were distinguished: actors, workflows, and information objects. The fourth entity, information technology, is used to enable the workflows. This important class of entities refers to the *information tools*. Originally, many information systems were implemented as customized programs, specially developed or tailored for large-scale information processing operations, such as banking software. However, many contemporary virtual communities make use of a suite of off-the-shelf software products that offer a predefined set of functionality options [9]. Of course, some tailored software such as special web server scripts, may still be required, especially for back-office systems. However, the functionality of most applications that users have direct access to, such as web browsers and all kinds of application programs, is standardized and does not need to be implemented from scratch.

Ontologies

To define -and refine- partially structured workflows it is essential that the entities mentioned can be referred to at different levels of aggregation (or genericity). For instance, it may be known that some multimedia tool is to be used to support the *supply diagnosis* process, but it is not yet or necessary to be known if the tool that is used to support this process is the multimedia conference or database. Likewise, there may be different kinds of requests, diagnoses, and treatment plans, just as there are different kinds of technologists or specialists.

To organize the different kinds of relationships that exist between entities of different kinds and aggregation levels, *ontologies* have proved to be very useful. Such an ontology is an explicit specification of a conceptualization, which itself is an abstract, simplified view of the world that needs to be represented for some purpose [13]. One of the simplest forms of an ontology is a *type hierarchy* in which a number of entity types is ordered by so-called *is-a* relations. An example of such a relation is: `A multimedia-tool is-an information tool`. In this case, the multimedia-tool is a *subtype* of an information tool. Likewise, both the multimedia conference and a multimedia database distinguished in the ERN are subtypes of multimedia tools.

Part of the ontology of the ERN, describing the workflow type hierarchy, could be represented as follows:

```
Business Processes >
  Care Processes >
    Request Consult
  Support Processes >
    Teaching
```

Even such simple ontologies can be useful instruments for facilitating change. Among other things, they can be used to reach a common understanding of terms in the domain, generate commitments for participants playing network roles, and enable the reuse of knowledge for building new applications [5]. The members of a community should play an active role in the construction of their ontologies, if only to prevent *ontological drift* [23]. This refers to the shift in meaning that occurs when terminology is moved between different semantic communities. Often, serious problems arise when the *definers* and *users* of terminology are not the same, which is certainly the case in highly professional and political-laden health care communities. Studies indicate that such ontological drift or *semantic gulf* impedes the successful realization of change [20].

3.2 A Model of Change in Network Organizations

Given that electronic healthcare networks can be modeled by partially structured workflow models based on a simple ontology, we now turn to the problem of how to model and facilitate their *change* (Figure 3). In such a change process, one or more entities of the socio-technical webs making up the network are changed. Such change does not happen automatically, but is influenced by network participants, which we call *change agents*. In motivating these agents to become actively involved, *change drivers* play an important role. Social norms acting as change mediators (*change norms*) regulate the way in which the change process is conducted. Using this change model, a number of *change scenarios* can be defined that help to guide actual change processes.

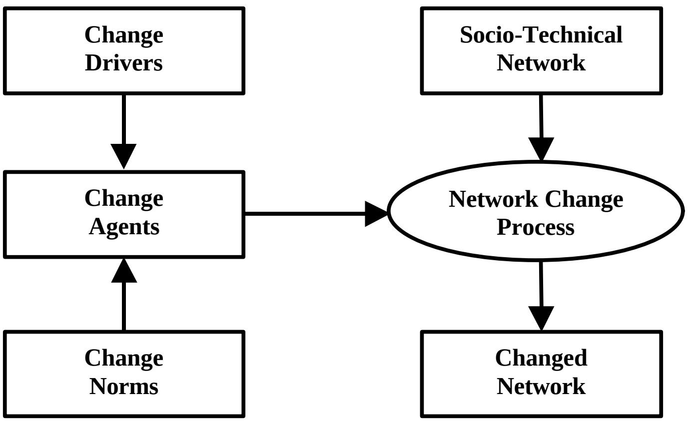

Figure 3. A Model of Change in Network Organizations

Change Agents

Healthcare networks are highly complex systems , in which many factors contribute to the need for change. Obviously, , not everyone is involved in each change process, but always a certain subset of the network participants is to be involved in assessing the need for and the formulation of a particular change. We call these participants in their actor roles *change agents.*

In the ERN case, three main types of stakeholders, out of many more, were involved in the change process: unit managers, medical specialists (physiotherapists and rheumatologists), and technical specialists (e.g. infrastructure and applications specialists).

Change Drivers

A set of five -interrelated- environmental forces or drivers can be distinguished that play a pivotal role in stimulating change in the health care industry [3][21]. These forces include *social* (e.g., demographics), *political* (e.g., health care regulations), *organizational* (e.g., quality and costs of care), and *technical* (e.g., advanced ICTs) factors. In successful networks, designated change agents are to be made responsible for monitoring these factors and assessing if they have consequences for the design of the socio-technical network. For instance, an ICT manager is to be on the lookout for new network technologies and should determine when the time has come to investigate the need for upgrading the facilities used to support the current workflows. Similarly, a medical specialist can be assigned to keep track of changes in medical protocols issued by their standards boards, and alert the network when, for instance, the *design treatment plan*-workflow is to be changed.

Previous studies identify several critical factors that enable the adoption and diffusion of ICT-based health care innovations [15][28][14][21][17]. *Economic* factors, such as investments and costs, played an important role during the transitions in the evolution of the ERN. In each phase of transition (conception-experimentation, experimentation-transformation), investments were required and costs were assessed. *Technical* factors, such as infrastructure standards and connectivity, were equally important to the development of the ERN. ATM for its broadband characteristics and Internet technology for its standardised and flexibility features. Of crucial important were the development of medical protocols for the standardisation and formalisation of diagnosis, consultation and treatment processes. These *organisational* factors were essential in advancing the ERN from an experimental stage towards a transformation stage. Throughout the evolution of the ERN, *social* factors fulfilled a strategic enabling role in shaping and directing the ERN. Gathering political momentum and building partnerships assisted in overcoming economic, technical and organisational barriers to the further development of the ERN. The case of ERN indicates that as economic and technical factors become more feasible, organisational and social factors become more critical for the successful development of the electronic healthcare network. As such, stakeholder roles and relationships, and the underlying social norms and values of the network, are pivotal to the success of electronic network organisations.

Change Norms

Not every agent is allowed to change every workflow definition, while at the same time it must be ensured that all stakeholders who should, do indeed have a say in network changes that are relevant to them. Therefore, once change drivers and change agents have been identified, they need to be coupled to specific change processes. This needs to be accomplished in a conscientious manner , as the legitimacy of changes in developing professional communities is crucial for their viability [1](p.321). The acceptability of couplings is determined by the social norms that mediate the change processes in the network. There are many classifications of norms that govern socio-technical system behavior, many of which are implicit [27]. Thus, it is important that (1) change norms are articulated and only formalized (i.e. defined) when necessary and (2) are operationalised in such a way that they are useful for the purpose at hand. Since our objective is to ultimately facilitate change in healthcare networks, we have to ground them in the model developed so far. What the are components of change norms?

First, the components must indicate the agent who is to be involved in the change process, for instance, a medical or technical specialist. Second, they should indicate what the role of the agent in the change process is: whether it concerns its initiation, execution, or evaluation of the change process result. Third, the *deontic effect* should be known: is the agent permitted, required, or forbidden to be involved? Last, but certainly not least, it should be known exactly which part of the socio-technical web the actor is allowed to change. For instance, the board of the hospitals participating in the network will be involved in goal setting. Medical specialists take part in the definition of the exact workflows, such as the design of treatment plans, whereas technical specialists will focus on the exact role that the various information tools play in supporting the workflows. Explicating norms and stakeholder roles is crucial to the success of changing organizations and evolving networks.

Based on an in-depth analysis of six large organizations, Peterson [20] concludes that different stakeholders are to be involved in the initiation, execution, and evaluation of strategic change processes. For instance, in successful organizations, corporate and business managers are to initiate change, and IT managers and specialists are to execute change, while all of them are to evaluate change processes of the socio-technical system. In unsuccessful organizations, these roles are often less well-defined or even lacking. In network organizations, such clear delineation of responsibilities is even more important. Thus while boundaries are spanned in electronic network organizations, some boundaries (i.e., stakeholder roles) should not be blurred.

Change Scenarios

The change model outlined in Figure 3, can be used to represent a number of key *change scenarios*. These capture the high-level change processes that are part of successful network evolution. In Figure 4, an example is given of the change process required to formalize previously informal diagnostic procedures. This scenario is derived from the ERN-case, in which such a successful change practice occurred in the conception and transformation stages (Appendix A).

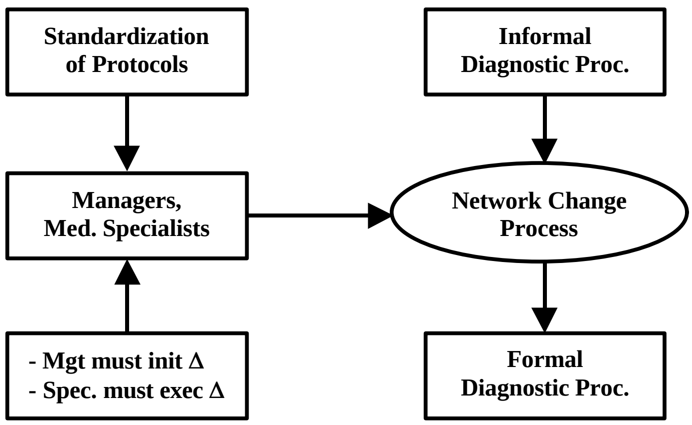

Figure 4. A Scenario for Diagnostic Procedure Change.

4. Facilitating the Change Process

Until now, we have made the case for the need for the proper definition of change norms in electronic healthcare networks. In this section, we introduce an approach that can be used to provide concrete support for the change process in these networks: the RENISYS specification method. Thus, from the *description*, we now move to the *facilitation* of change processes.

4.1. The RENISYS method

The RENISYS (**RE**search **N**etwork **I**nformation **SY**stem **S**pecification) method supports a legitimate user-driven specification approach for specifying the network information systems of virtual professional communities [5][6]. These communities are goal-oriented (and thus have a need for workflow support) and to a great extent enabled by ICT. The method supports a *user-driven* approach, because it allows users facing some breakdown in their work to initiate a change process themselves. More importantly, the approach is *legitimate*, because definition changes are not only meaningful (defined in terms of community ontologies) but also *acceptable* to all members of the community. To accomplish this, all change processes are governed by a set of *composition norms*. A composition norm can be very generic, for instance: ‘all members of the community must be involved in all change processes of all definitions (of the socio-technical system)'. It can also be very specific: 'a medical specialist may initiate the change process of the supply diagnosis workflow', or 'a technical specialist must be involved in the definition of the tool support of any workflow'. An initial set of such composition norms is defined at the conception stage of the network. As the network evolves, the composition norms themselves can also be changed, reflecting the subdivision of responsibilities for change as the socio-technical system grows more complex.

Using these composition norms, the following support is provided. Any participant in the network can, at any time a breakdown is faced, invoke the RENISYS method. The method then helps this user to identify the *problematic knowledge definition(s).* For instance, a user may feel that the definition of the request consult workflow should be changed, because of changing practices in the field. For each of these problematic definitions, RENISYS then calculates the *relevant user groups* who should be involved in the process in which a problematic definition is changed. To do so, the change process is subdivided into three stages or *compositions*: the initiation, execution, and evaluation of the change process (which is a creation, modification, or termination of a knowledge definition). In our example, these compositions comprise the 'initiation of the modification process of the request diagnosis workflow', etc.

For each composition and user in the network, a set of *applicable norms* is calculated. This is a subset of all composition norms. This subset is first of all determined by the particular actor roles that each user plays (which, as we have seen are part of the composition norms). Second, the type hierarchy of concepts laid down in the ontology can be used to determine whether a norm is generic enough to apply to the particular change process requested. Thus, in the case of a proposed modification of the request diagnosis workflow, the composition norm 'all specialists may evaluate modifications of diagnosis workflows' is in the applicable norm set for composition 'evaluation of the modification process of the request diagnosis workflow' and user John, if John is a specialist. To deal with the representation and calculation of these complex definitions of different genericity, RENISYS uses conceptual graph theory [26], which is well suited for such operations. However, an additional problem transpires when the applicable norms have different or even opposite effects, for example one norm implying that a physician is permitted to change the problematic definition, another one saying that he is prohibited from doing so. RENISYS therefore also includes a mechanism to deal with such norm conflicts, so that a single *resultant deontic effect* like 'permitted' or 'forbidden' can be calculated for each applicable norm set. In this way, RENISYS can determine exactly which users are permitted, required, or prohibited to take part in the initiation, execution, and evaluation of the specific change process at hand. Once the relevant user groups have been determined, the next step is to define the conversation models in which the definition changes are discussed and finalized. The method also provides these models, based on theories and workflow modeling approaches from the language/action perspective (e.g. [27][7]). These theories pay much attention to normative aspects and such issues as who is entitled to make what conversational moves in system specification. Using these theories, both the selection of the right participants and a fair discussion about the change processes of the socio-technical system can be guaranteed. A much more detailed treatment of these ideas can be found in [5][6].

4.2. A Facilitation Approach for the Evolution of Electronic Healthcare Networks

How does all this add up to increase the efficacy of electronic healthcare network evolution? A concrete facilitation approach requires an informed reference model plus a mechanism to manage evolutionary processes of the socio-technical system of the network.

1. Define a high-level change reference model

First, some high-level reference model of evolution of the 'best practices' is needed for a particular type of healthcare network. Such a reference model contains key entities and change points for the successful workflow evolution, without going into those details that are irrelevant for future networks making use of the model. Given its success, the analysis of the ERN can contribute to the construction of such a model. We defined the basis for such a model in Section 3.1 and Appendix A, leading to a number of change scenarios as described in Sect.3.2.

The core of the scenarios is formed by the change norms. A reference model for electronic healthcare network could include such norms as:

1. Managers must initiate and evaluate the creation of all new workflow definitions.
2. Medical specialists (e.g. rheumatologists) must execute and evaluate the creation of all new diagnosis workflow definitions.
3. Managers must initiate and evaluate the modification (refinement) of initial workflow definitions.
4. Medical specialists may initiate the modification of existing workflow definitions.
5. Technical service vendors and technical application developers must execute the modification of information tool definitions.
6. Etc.

2. *Develop a mechanism for network evolution management*

Second, a mechanism is needed to operationalise the change model of network organizations. RENISYS provides one such mechanism. It allows for the relevant users to be selected once some user has identified the need for a change process, and for communication support to be provided so that fair and open discussion is possible that takes into account the prevailing change norms. In RENISYS, the best practices model would be translated into an ontology such as described in Sect.3.1 and a set of composition norms. An example of these norms (here in informal notation) could be "*Required*: Medical Specialist – Executes – Modification Process – Diagnosis Definitions"

When operationalising the change scenarios included in the reference model, the change drivers that go together with the change norms need to be identified and made explicit. For instance, there could be a free text rulebook for medical specialists, which could include this rule:

> "As a medical specialist, you are responsible for monitoring any changes in practices of supplying diagnoses. As soon as you think that there are problems in the way these processes are carried out in the current network, please start up RENISYS. When you are asked to classify your problem, select *modify workflow*. When asked which workflow is to be changed, select *supply diagnosis*"

This explicit attention for stakeholder motivation to reshape the network so far has been lacking in RENISYS, which just assumes some user to have some 'breakdown'. However, informed by the best practices model, specific users assuming specific roles need, in addition, to be made responsible for *detecting* needs for change, after which they can start a legitimate user-driven specification process to have the relevant knowledge definitions changed. In this way, human conceptualization skills and subtle tacit knowledge can be used to monitor the complex socio-technical system and assess what needs to be changed and at what time. The computer is subsequently applied to manage definitions, norms, and change processes. Maintaining this fine balance between what to formalize and what to leave in the human domain, is becoming ever more important in electronically mediated human collaboration systems [31].

4.3. Discussion and Related Research

As a new practice, the design, development and evolution of electronic healthcare networks can be regarded as a change process. The adoption and diffusion of electronic healthcare services is a complex and dynamic process, in which learning and knowledge creation transpires through both explicit and implicit modes. Previous studies on applications such as telemedicine and telecare [2][4][15][18][28] describe the complexity in the structure and dynamics of electronic healthcare networks. These studies illustrate the need for incorporating in the design of electronic healthcare networks not only features of the underlying technical architecture [12], but also the strategic drivers, organizational work-flows and stakeholder roles. As the case of ERN indicates, the latter factors are essential to the effectiveness and innovativeness of electronic healthcare networks. However, previous telemedicine work does not pay specific attention to the evolutionary change processes occurring in these professional communities, and how different drivers can precisely influence the design of the information systems serving electronic healthcare networks. On the other hand, existing workflow modeling methods do not give guidance on *when* and *how* changes should take place and *who* should control them.

The main contribution of the underlying article is that it outlines a concrete approach for the evolutionary design of the socio-technical system of electronic networks in the healthcare domain. This approach is sensitive to the full complexity of dealing with real-world change drivers by using change norms to identify *who* should be involved in the evolution of the network information systems. By combining a norm-governed workflow modeling approach such as RENISYS with a 'best practices' healthcare reference model derived from empirical case research, it can be determined very precisely who is to interpret complex reality at which moment. These stakeholders can then use their full experience, and tacit knowledge to produce the right advice and decisions for the change processes of their socio-technical system. In other words, socio-technical workflow modeling methods such RENISYS provide the mechanisms of change, while healthcare governance research distills the relevant change scenario entities with which to initialize these mechanisms. Together, these fields of research can prove to be a strong combination for the fostering of healthy change of electronic healthcare networks.

5. Conclusions

In this article, we investigated how to better facilitate the change processes in electronic healthcare networks. To this purpose, we first examined the evolution of the successful Electronic Rheumatology Network. Using the analysis of the key entities and change processes in this network, a high-level *reference model* was derived that can be used to describe evolving best practices in similar electronic consultation networks. To facilitate the evolution of such practices, we proposed to use the existing RENISYS method that supports the legitimate user-driven specification of the network information systems of virtual professional communities.

This combination of reference model derived from best practices case analysis with specification method tailored to evolving virtual professional communities provides theoretical and methodological foundation for understanding and improving the development of electronic network organizations. . When using a computer metaphor to describe an electronic healthcare network, then the reference model provides the potential, while the specification method forms the circuitry. Together, they allow a strong current to flow, bringing the network to live. It is essential that only the key change scenario entities are captured, that all change processes are governed by a set of change norms, and that the change norms themselves can change over time.

The reference model was developed on the basis of a successful real-world case, the electronic rheumatology network. Obviously, this reference model, as yet, does not have universal validity. However, it forms a starting point for more systematic support for healthcare network evolution. Furthermore, the change mechanisms outlined in the described approach allow for the facilitation of the evolution processes of similar networks to systematically tailored to their unique context. Finally, when implemented and applied to several cases, the change patterns and norms comprised in the reference models will be extended and refined. Of course, we have only presented a first step on the way to a complete and robust facilitation approach. The next steps include implementing and testing it in several concrete cases in the healthcare domain. Subsequently, it can also be extended to other domains, to discover the universals and particulars of electronic network evolution across domains. Required future theoretical research includes the development of detailed change scenarios, change typologies of electronic networks and much more refined reference models.

Driven by these new theoretical and practical insights, the facilitation of the change processes embodied in the network life cycle will continue to be improved. By providing facilitation support as described in this paper, much of the burden of keeping track of the complex and ever changing picture of the evolution of electronic healthcare networks can be taken away. Those involved can then focus on the creative work of *shaping* change. By giving them the opportunity to create stronger socio-technical systems, we can contribute to healthcare networks that can provide more and higher quality care.

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Appendix A: Schematic overview of change in the Electronic Rheumatology Network

Time path	**1996**	**1997 - 1998**	**1999**
Network Development Stages	**Conception**	**Experimentation ERN-1**	**Transformation ERN-2**
Actors	+ managers RRD + rheumatologist. RRD + technology staff	+ Care Funders + managers AH + physiotherapists. AH + tech. service vendors + tech. app. developers.	- managers AH - physioth. AH -tech. service vendors -tech. app. developers + managers MHC + specialists MHC + managers UMC + physioth. UMC + physioth. RCC
Workflows	+ request consult + supply diagnosis + design treatment plan	Δ request consult Δ supply diagnosis Δ design treatment plan	Δ (refinement)
Information Objects	+ consult request + diagnosis + treatment plan + medical protocols	Δ consult request Δ diagnosis Δ treatment plan Δ medical protocols	Δ (refinement)
Information Tools	+ telephone + telefax + video	+ e-mail + ATM + video-conf. + shared whiteboard	- ATM + Internet + MM-conferencing (synch.) + MM-database (a-synch.)