

A WORKFLOW APPROACH TO DESIGNING COOPERATIVE SYSTEMS¹

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ABSTRACT

The design of computer networks for group communication includes setting network objectives, designing and specifying new group communication processes, including people's roles and responsibilities, and providing computer services to support these processes. This paper introduces the concept of a workflow communication node for specifying group communication processes in distributed systems. The paper then describes ways of implementing workflow communication node specifications by networking technologies and using the implementation to compose specific group communication processes.

1. INTRODUCTION

Computer networks based on Internet network technologies are increasingly becoming important for supporting group communications in distributed organizations. The paper uses the term group communications to cover the many different ways that people communicate to reach some desired goal. Such communication can be just exchanging messages using e-mail; it can also be the coordination needed when following a set of steps in a business process supported by workflow management systems, or it can concern the personal interactions found in group decisions. Computer services to support group communication are increasingly provided by networking technologies. In this paper, *network technologies* are usually provided by vendors and include workflow management systems, electronic mail systems, discussion databases and so on. *Computer services*, on the other hand, define the way that these networking technologies are presented to users. In some cases, the network technologies serve as computer services without any special adaptation to business activities. However, in most cases the networking technologies are adapted to meet special organizational requirements. Such adapted network technologies are called *value added services* (Hawryszkiewicz, 1997a) in this paper. Thus, for example, workflow management systems must be programmed or adapted to support a particular workflow.

In addition, value added services must satisfy any organizational standards and quality requirements. Quality standards often require computer services, which are provided by network technologies, to meet two conditions. Firstly, the computer services must be integrated with the business activity. Secondly, the services should be easily change to support evolution in communication practices. Such evolution often results from users adopting new processes as they learn to use the value added services more effectively. Or it can be the result of organizational change. The change requirement can be difficult to meet using traditional approaches, as any change often requires technologies to be reprogrammed leading to delays, which often result in users abandoning the system. What is needed is a value added service that allows users themselves to change it.

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Network technologies on their own, in most cases, do not meet the first quality condition. Thus giving access to e-mail will not necessarily make it easier for a manager to coordinate the activities of a complex project. The time spent adjusting the e-mail to the specific coordination process may far outweigh the benefits obtained in reduced communication times. This is where value added services come in. They directly match the semantics of the group communications processes.

Designers of value added services must analyze the semantics of communication processes, including the semantics of process change. The paper describes a method for modeling communication within business processes. The modeling method covers a variety of processes ranging from those that are preplanned and those that are situated. To do this the paper introduces a systematic way for specifying communication process semantics in terms of basic work units, here called workflow communication nodes (WCNs), which then become the basis for defining value added services. The paper shows how WCNs can be used to describe both planned and situated work. It will then describe how WCNs can be used to identify value added services that match organizational needs and illustrate them with case studies.

2. A METHODOLOGICAL APPROACH

Before proceeding further, the paper digresses to show how requirements for computer services are captured. Earlier work (Hawryszkiewicz, 1997a) has indicated that the design of computer networks to support group communications is an ongoing set of design activities shown in Figure 1.

The 'planning and project selection' process emphasizes alignment of computer services to enterprise goals. It concentrates on strategic goals and defines those business activities that will benefit most from the use of computer communication services. It also identifies those activity work practices and communities to be supported by the computer services, and broadly identifies how they can benefit from these computer services. Ways to provide the services are then proposed.

Once projects are identified, system design commences. Systems design carries out a detailed analysis of current work practices and their detailed communication processes that they use. At the same time any mutual impacts between work practices and communication processes are also identified with new work practices and communications processes proposed.

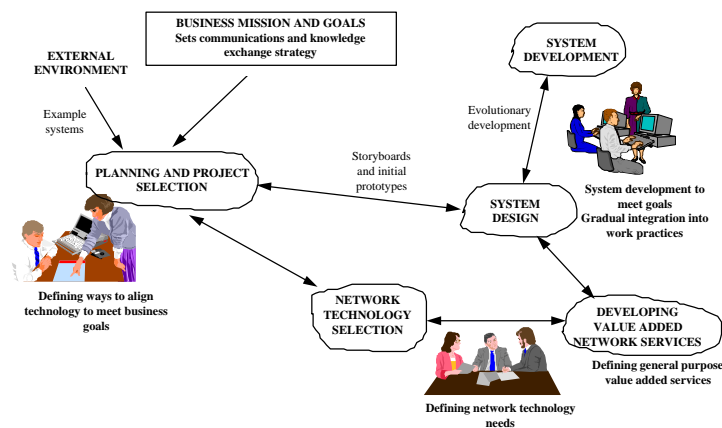


Figure 1 - Design Processes

This paper concentrates on system design, which itself is driven by the 'Planning and project selection' process. This process commences by listing business goals and gradually reducing goals to work practices, while identifying communities and the major interactions between them. It concludes by developing a rich picture that identifies the major activities that will benefit from computer services (Hawryszkiewicz, 1997b). Usually, planning and project selection also identifies the major networking technologies, as for example, whether systems will be based on the World Wide Web or LOTUS notes. System design continues by precisely defining how these technologies will be used and how they must be programmed to adapt them to the proposed work practices. Often prototypes are constructed at this

stage to elicit requirements from users and determine the feasibility of satisfying the requirements given the available networking technologies. This paper concentrates on the design process and specification techniques used by this process.

2.1 Defining broad requirements

One output of 'Planning and project selection' are rich pictures that were first proposed in soft system methodologies (Checkland and Scholes, 1990). Rich pictures are used here to identify the communities involved in the different system activities as well as the artifacts used in these activities.

One example is given in Figure 2. The rich picture comes from a study undertaken for the WHO on communication processes to support its research planning. The rich picture shows the major activities (as clouds) in the system together with communities (as icons) that participate in these activities. (Hawryszkiewicz, 1997b). The artifacts used and produced by the activities are shown as rectangles. Thus one activity is discussion of regional issues to identify deficits and set global priorities. Here regional officers, planners and advisors look at health profiles, developed form collected data, and research reports to identify world health problems to be solved. Then these problems are brought to the attention of researchers to address them.

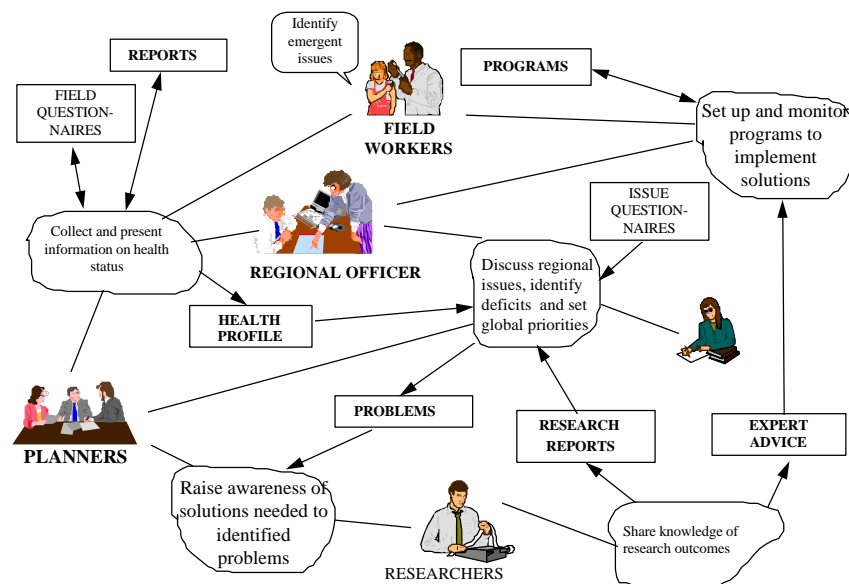


Figure 2 - A rich picture

Rich pictures provide the initial guidelines for identifying different communities. They also describe how these communities can benefit from computer communication services. The next design step is to more precisely define the communication processes within the activities and define the value added services to support these patterns. It becomes important here to precisely define the semantics of communication patterns so that value added services to meet all semantic requirements are constructed.

3. SEMANTICS FOR DEFINING COMMUNICATION PROCESSES

Defining semantics for communication processes is a challenging prospect as it needs techniques to describe widely different processes. On the one end there are the preplanned processes where activities are precisely scheduled with well defined inputs and outputs. At the other end are situated processes where activities depend on the current situation and cannot be predicted. Then there are those activities that are performed by individuals and those that require group agreement. Finally there is the need to ensure that any process both follows organisational standards and rules and possesses the general properties expected of quality processes.

What one is looking for is a set of concepts or semantically meaningful terms that provide a systematic way of describing or modeling communication processes.

3.1 Earlier modeling methods

One important aspect of system design is to specify the communication processes for the proposed system. Such processes have been defined in a variety of ways including:

- Workflow modeling methods, which can be broadly categorized (Sheth, et.al., 1996) into activity or conversation based methods. Conversational systems are those based on the language action paradigm, such as the well known Action Workflow system (Medina-Mora, et.al., 1993), and which represent commitments and action rules. Activity based methods on the other hand focus on process inputs and outputs. A typical example of such methods are those used for modeling logistic processes (eg. Van der Aalst, 1992).
- Decision support systems as those described by McGrath (1984) that provide process guidelines for selected process kinds,
- Empirical frameworks as for example that proposed by Sprague and McFurlin (1993) who have identified a number of different group structures. The design here offers a broad perspective but does not give sufficient structure for the choice of specific role responsibilities.

All of these approaches provide generic primitives for modeling specific kinds of business processes. They often lack the higher level theoretical constructs or guidelines to model the needs of distributed communities that can involve many groups each performing different but related concurrent business activities. One approach is to model such wider needs by using a different modeling method for each type of communicating process. However, this may become clumsy and difficult to use. Instead a synthesis from a set of common building blocks would be preferred. Such synthesis would start by first specifying global needs and then in a top down way identify specific communication processes. The paper proposes workflow communication nodes (WCNs) for this purpose. Thus each activity in the rich picture of Figure 2 would first become a WCN. Each WCN can then be decomposed into more detailed WCNs. The WCNs themselves are constructed from core concepts, which are sufficiently rich in terms meaningful to the communication process.

3.2 Workflow Communication Nodes

Workflow communications nodes (WCN) are proposed in this paper as the higher level building blocks for modeling communication systems. The WCNs go beyond simply showing how tasks combine to form workflow processes, but also provide a rigorous human role structure, and flexible ways to dynamically build evolving communication processes. WCNs themselves are defined in terms of the basic core concepts and can be used to model the variety of processes found in collaboration, ranging from highly planned to situated work. In a more general sense the WCNs can be extended to model workplaces appropriate to situated work.

The core concepts used to construct WCNs are the role, actor, interaction and artifact (Hawryszkiewicz, 1997a). The role defines a responsibility within a group whereas an actor is the physical entity that carries out the responsibility. An interaction is a group or roles that work together to achieve some goal. An artifact is an object used in the interaction. The rich picture in Figure 2 described a system in terms of these concepts. Thus field workers, researchers, planners, regional officers and advisors are the roles. One major interaction is to "collect and present information on health status", which involves three of the roles and uses both reports and field questionnaires to produce a HEALTH PROFILE.

4. SPECIFYING REQUIREMENTS USING WORKFLOW COMMUNICATION NODES

The WCN is derived from De Moor's specification method (1997) for information systems and suggests the structure shown in Figure 3 as a basic representation for communication. This paper shows

this structure defined in terms of the core concepts. Here an activity that takes a set of input artifacts to produce a set of output artifacts. The activity is initiated by some input event or artifact state. The activity itself is carried out by any number of interactions that involve set of roles. The triangles are role sets and are the placeholders of actors. Figure 3 shows three kinds of role sets that are often necessary for good communication practice. The initiator or goal setting states roles (I) initiate the activity and define its goals. The activity is carried out by the executor roles (X), and evaluator roles (E) moderates the process including deciding when to terminate it. The activity itself can be carried out as a set of interactions by the roles. The design goal is to provide the value added services to support these interactions.

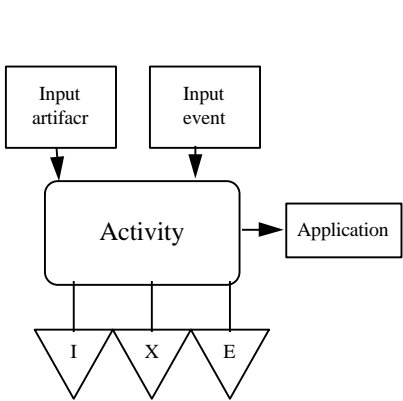


Figure 3 - An Elementary Workflow Communications Node

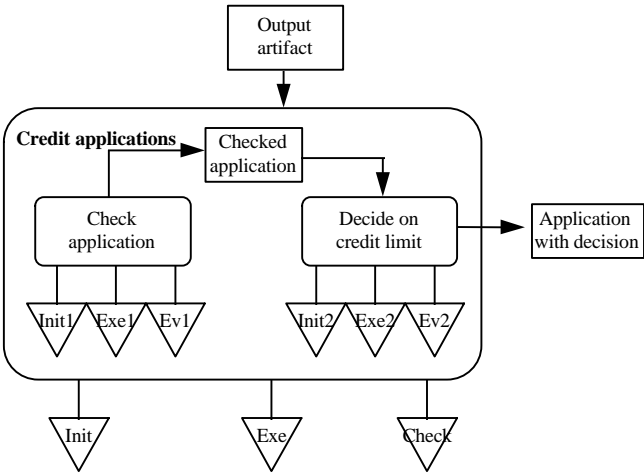


Figure 4 - Combining WCNs

WCNs provide the basis for specifying group communications. Such specifications are made up of two parts - the WCN and norms that specify role behavioural patterns. The three role types form one early basis for addressing quality. They include review processes that are now almost a standard in any quality assurance process.

The workflow communication node can be used to construct more elaborate communication processes by both combining nodes into higher level nodes or expanding them into more detailed nodes. Thus each WCN can itself be a subject of a larger activity. The roles in higher level activities can change or even create new WCNs during the collaboration process, and thus meet a quality condition.

Figure 4 illustrates one such expansion. Here 'Credit Applications' is defined itself to be made up of two other WCNs - checking the application and making a decision on the credit level. Each such WCN has its own role set. The role set Init, Exe, and Check themselves decide how the included WCNs operate and the roles that can participate in them. Roles in WCN can create new WCN during the life of a transformation if they are empowered to do so. Thus roles in Init, Exe, and Check can define the structure of its contained WCNs.

4.1 WCN Norms

The dynamics of each WCN has a number of associated control processes and constraints. The main processes are the initiation, execution and evaluation processes. Initiation processes serve to commence the activity. They can be a simple start in some activities, whereas in others they may be continuous and regularly change the WCN goals. Execution processes that carry out transformations on the artifacts Evaluation processes that monitor work process and can provide feedback to other roles. The way activities are carried out in a WCN are specified by norms. Norm rules include:

Role rules: Examples of role rules are those that identify those roles that must have different actors, define cardinality of role set, define actors to be included in role set and define actors to be excluded from a role set.

Action rules: Examples of action rules are those that define role responsibilities through actions assigned to roles. This strongly corresponds to the idea of empowerment in task oriented groups.

Sequence rules: These define the sequences in which actions are to be carried out.

Role relationships: These define relationships between the roles and those actions where roles must interact to produce an outcome. These rules serve to indicate the kind of communications support that will need to be provided for the roles.

4.2 A Formal definition

De Moor (1997) has used conceptual graph theory for specifying cooperative systems and thus ensure their completeness. This specification method is extended here to specify WCNs. Thus where a WCN is composed of other WCNs, as is the case in Figure 4, the specification takes the form:

```
type [CREDIT-APPLICATION: *x] is
  [APPLICATION: *x] -
    (part) --> [CHECK-APPLICATION]
    (part) --> [DECIDE-ON-CREDIT-LIMIT]
    (matr) → [APPLICATION]
    (rslt) → [APPLICATION-WITH-DECISION].
```

Type definitions use ideas from object modeling. New types are specified by specializing previously defined types. Thus CREDIT-APPLICATION inherits from APPLICATION. The (part) component states the APPLICATION is composed of two WCNs, CHECK-APPLICATION and DECIDE-ON-CREDIT-LIMIT. The relation (matr) defines the input artifact, whereas (rslt) defines the output artifact. Each of the parts itself can then be specified in more detail, as for example:

```
type CHECK-APPLICATION (x) is
  [CHANGE_DOC: *x] -
    (obj) ← [INITIATE] → (agnt) → [I]
    (obj) ← [EXECUTE] -
      (part) --> [CHECK-ADDRESS] -
        (agnt) → [X1]
        (agnt) → [X2]
        (attr) → [TASK: verify-address]
        (attr) --> [ARTIFACT: [APPLICATION]]
      (part) --> [CHECK-SALARY] -
        (agnt) → [X3]
        (attr) → [TASK: verify-salary]
        (attr) --> [ARTIFACT: [APPLICATION]]
    (obj) ← [EVALUATE] -
      (part) --> [APPROVE-CHECKS] -
        (agnt) → [X4]
        (attr) → [TASK: check-all-checks]
    (init) → [INITIATION-EVENT]
    (matr) → [APPLICATION]
    (rslt) → [CHECKED-APPLICATION].
```

Here CHECK-APPLICATION(x) is a specialization of CHANGE-DOC. The (obj) relation specifies the interactions carried out in the WCN. Two EXECUTE interactions are specified by the (part) relations, CHECK-ADDRESS and CHECK-SALARY. The roles are specified as (agnt). The structure (attr) defines the tasks associated with check-application - in this case, role X3 performs the task 'verify-address' on artifact, APPLICATION.

The assignment of actors to roles is defined by the NORMS. For example:

```
[PERM-ACT: [X1: [USER: John_Doe]] <-- (agnt) <--[CHECK-ADDRESS] -  
  (obj) --> [CHECK-APPLICATION]].  
[PERM-ACT: [X3: [USER: Bill_Brown]] <-- (agnt) <--[CHECK-SALARY] -  
  (obj) --> [CHECK-APPLICATION]].
```

where USER is the actual person or actor who carries out the role within an interaction. The person can take part in any interaction specified in the roles and perform all the tasks that are part of this interaction. Thus John Doe is empowered as role X1 in interaction CHECK-ADDRESS and can carry out any task in that interaction. Only one such task 'verify-address' is specified at present.

Formal methods can also be used to specify other requirements. For example, precedence is specified as

```
[CHECK-ADDRESS] -->(succ) --> [CHECK-SALARY]
```

to specify that 'CHECK-ADDRESS' must precede 'CHECK-SALARY'.

4.3 Standard WCNs

There are two ways to identify the semantics to be supported by value added services. One is to study particular enterprise needs and design specific value added services to support the communication processes in that enterprise. The second is to define semantics that support the communication processes commonly found in many organizations and which can then be customized to a particular organization's needs. The ultimate goal is to have a set of standard processes that can be combined to satisfy enterprise requirements. This can be achieved by defining WCNs that can be specialized to particular needs.

There are two alternatives for specialization. One is to define specialized WCNs for a particular context. The other way is to combine a set of such specialized WCNs to form a standard WCN. Such standard WCNs are sometimes called reference models (van der Rijst, De Moor, 1996). User specified requirements can then be used to select the appropriate reference model, which can then be customized to these requirements. At the implementation level reference models are the value added services. The reference models themselves need to be developed by studying a large number of communication processes in a variety of enterprises to identify the best practices for those enterprises. An example of such studies is that of Taylor (1993), who has analyzed a variety of such processes particularly with respect of identifying quality processes. This and similar studies provide a basis for developing reference models that can be used to generate quality processes. Thus for example in many processes evaluators may include reviewers with special responsibilities and constraints. One constraint may be that a reviewer actor can not be one of the executor actors.

4.4 Advantages of using WCNs

Workflow communication nodes can be well integrated into the design process described in Figure 1, which starts with rich pictures. The rich picture can be expanded into detailed WCNs. The design process defines the new group structures, identifies their roles and defines how the roles will coordinate their activities. In this case it is often necessary to take each interaction in turn and customize the services to meet its needs.

Another advantage is providing guidance to users in designing standard quality processes within organizations. In this case reference models can be used to specify the requirements of the quality process – in fact what might be considered providing a skeleton process – which is the customized to suit a particular requirement. The reference model can be presented to users as an interface providing the guidelines for definitions and automatically generating the service.

5. PROVIDING COMMUNICATION SERVICES

This section describes some value added services. The value added services are implemented by enhancing networking technologies. The value added services often combine a set of networking

technologies to provide an interface that matches the semantics of the group communication process. Definition of value added services must consider a number of factors. Some of these factors are specified by structure whereas others are specified by norms. Norms often define the reporting relationships implied by the organizational culture. For example, preplanned processes can be easily modeled by each WCN representing each task, and outputs from one task initiate the next WCN. For the more situated process, the WCN can take longer to complete but it can adapt itself to the situation by allowing roles to create new WCNs within it as the situation develops. We now give some examples of implementations.

5.1 Closed Systems

A structured preplanned system is illustrated in Figure 5. Here I0, X0 and E0 are the management roles responsible for the ‘production process’ - they can for example be a set of managers responsible for production. The production process WCN is expanded into a number of tasks, Task1, Task2 and Task3 to carry out the production activities. These tasks combine to take a requirement to produce a product. They are carried out sequentially with intermediate results passed as Document1 and Document2.

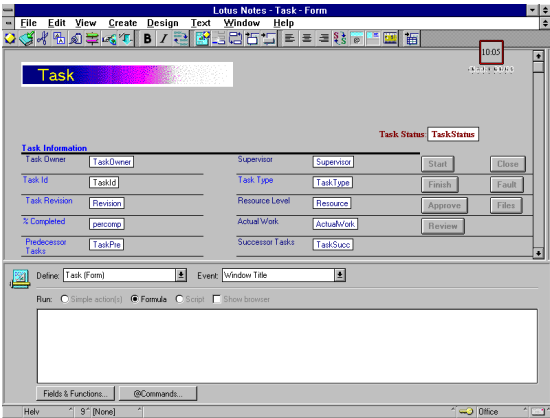
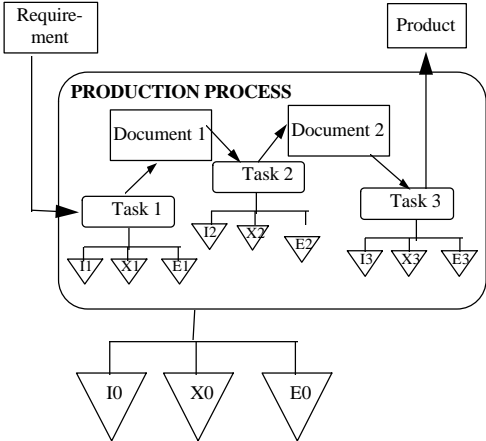


Figure 5 - Modeling closed processes Figure 6 - A Task form for Project Engineering

The definition of such tasks is the responsibility of the management roles. Apart from defining the structure, the process rules must also be defined. Part of the definition is the assignment of roles to each of the tasks. Furthermore role constraints may be included, such as for example the evaluator roles of tasks cannot be included in the executor roles. Organizational links can be used here to find the most relevant experts for review processes during the creation of WCNs. There is the possibility here of defining task structures to meet organization quality standards.

One example of such a process is software engineering. Quality standards in software engineering have been studied for a considerable time and good practices have been widely discussed. These include the need to include verification procedures in tasks through reviews. Tools to support software engineering should provide the facilities to enable such practices to be instituted and monitored. Particularly important in such tools (Gorton, et.al., 1987) is to provide the ability to ensure review processes are carried out and proper approval is instituted. Thus a standard task format has been developed to enable tasks that include such processes to be easily created. This closely corresponds to the model shown in Figure 5 and is illustrated in Figure 6. Here the task has a number of standard actions as defined by the top menu. Task users are required to execute these actions in prespecified ways. Furthermore, norms are often included to assure quality, as for example, actors that take reviewer roles cannot also take initiator or executor roles in a WCN.

5.2 Discussion systems

Here we look at basic groupings who generate information that is then passed on to other grouping. The

goal in such systems often is to adapt the discussion structure to the natural discussion processes followed in the organization. Any value added service should thus provide the actions needed to set up a variety of structured discussion processes.

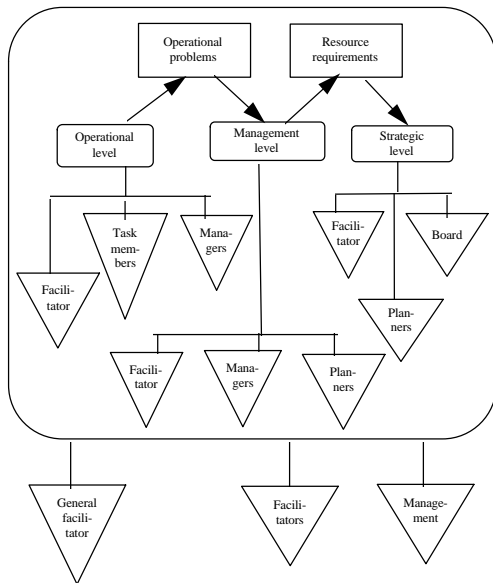


Figure 7 - Structuring discussion systems

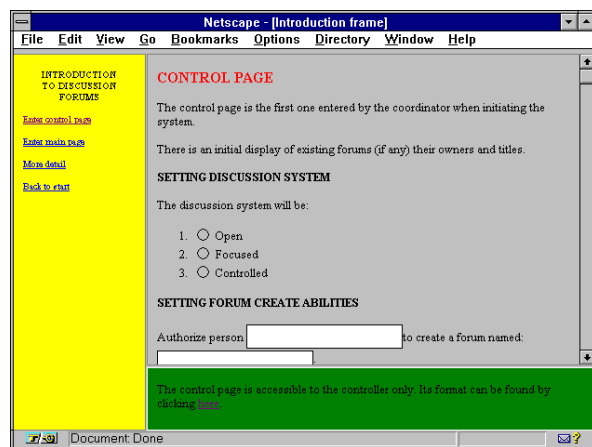


Figure 8 - Defining Discussion Structures

Such structures should include the ability to define roles that are to participate in the discussion, the ways that these roles can contribute to the discussions and relationships between any number of on-going discussions. Links to organizational structure can be of value here as for example the system can ensure that all people at a given organizational level are included in relevant discussion reducing the feeling, sometimes unwarranted, of having been left out of a particular discussion.

One example (Greiner, et.al. 1993) are discussions on health research objectives. The idea here is to allow discussion to proceed in a controlled manner that can for example be used to first identify significant local needs, pass them on to a higher level regional discussion and then move significant regional issues into the global forum. A value added system here must thus provide the ability to construct such discussion structures, and give various roles different abilities in these structures.

The example illustrated in Figure 7 provides such a facility by allowing authorized users to create any number of discussions and assign responsibility for their management to specified people. Figure 8 illustrates the interface that allows a coordinator to authorize people to create discussions and empower them with selected commands to add participants, create additional discussions or transfer issues to other related forums. The commands appear on the left of the screen.

6. CONCLUSION

This paper described a way of specifying group communication processes using workflow communication nodes. It proposed that WCNs can be used to define value added services for a variety of work processes and defined a way of modeling processes to identify such services, illustrating them with examples. The paper also showed that WCNs can be used to define effective ways of supporting communication processes in a wide variety of organizational cultures.

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RESUME

La conception de reseaux d'ordinateurs pour la communication de groupe comprend la definition d'objectifs en terme de reseau, la conception et la specification des nouveaux processus de communication de groupe, y compris des roles et responsabilites des acteurs, et la fourniture des services d'ordinateurs pour supporter ces processus.

Ce papier presente le concept d'un mode de communication pour le workflow, visant a specifier les processus de communication de groupe dans un environnement distribue. Le papier decrit les facons de mettre en oeuvre, Au moyen des technologies reseaux, les specifications du mode sus-mentionne de communication pour le workflow et de composer des processus specifiques de communication de groupe.