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Workgroup Computing Competence Center Paderborn

- Project group Wide Area Workflow Management -

The project scope of the Workgroup Computing Competence Center Paderborn encompasses research, prototyping, product development, system implementation, project management, transfer of technology, consulting and training in the field of groupware-based applications for information management. We focus mainly on business- and technology-frameworks for office systems, workgroup computing, workflow management, project management und connectivity systems in client-server architectures. The Workgroup Computing Competence Center Paderborn consists of common workgroups at the University of Paderborn and at PAVONE information systems Inc. in Paderborn.

Paderborn, April 1996

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Workflow Management between distributed organizations - the Wide Area GroupFlow Approach

Outline

Summary

Concepts and solutions for workflow management today mostly focus on processes performed within single organizations. Yet the exchange of information between organizations is not integrated with the internal workflow management. To overcome the resulting inefficiencies and to enhance quality and response-time of external communication processes remains challenging. Therefore general conceptions for distributed workflow management are discussed in this paper. Additionally the Wide Area GroupFlow System for Groupware-based workflow management between distributed organizations is introduced.

1. Introduction

Communication and cooperation between different organizations is highly important in times of international business with short product lifecycles. Dynamic global markets call for organizational structures of distributed enterprises that are shaped like dynamic networks of persons and the information they want to exchange. One possible concept to react on the changing organizational needs arising from this development are virtual teams or corporations as

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referred to in (Hammer/Champy 1993, Moad 1994 or Clemons/Row 1992): Such virtual organizations may on the one hand embrace a short term arrangement in order to complete one particular, episodic task or on the other hand be based on a strategic partnership.

In order to reflect and to support those and other dynamic business forms efficiently new architecture concepts and technologies are necessary. Besides the required basic technological support of e.g. appropriate transfer media, general concepts for wide area-oriented, distributed workflow management and business processes design are required.

Today Groupware platforms already allow for the realization of internal workflow management as they support secured internal communication and information sharing on local area networks. For the external communication, electronic mail is already widespread besides the still dominant distribution of information on paper. Yet standard E-mail is only capable of transferring rather simple, mostly textual information between personal environments. This is not sufficient for the enabling of distributed workflow management where highly structured contents, routing logic and representation have to be handed over between shared workflow environments in different organizations. To achieve this exchange of information (not data) between these shared workflow environments in a powerful and flexible way, the concept of intelligent Message Objects was introduced in (Riempp/Nastansky 1996). Message objects build a specific class of network agents by combining content, logic and representation of workflow information for distributed workflow purposes. They thus build self-navigating information carriers that can be transferred by using different systems including routers or replication technology.

The Wide Area GroupFlow approach discussed in this paper is based on the GroupFlow System developed at the institute of Business Computing, University of Paderborn and then joined with PAVONE Information Systems GmbH, Paderborn in order to release GroupFlow as a commercially available workflow management software in early 1995.

The GroupFlow System, as it is described in (Nastansky/Hilpert 1994, 1995 and Nastansky/ Hilpert/ Riempp 1995), is a versatile workflow management platform supporting a wide range of workflow types from structured, predefined workflow to guided ad-hoc-workflow. The runtime system of GroupFlow is completely developed using the Groupware platform Lotus Notes with its Compound Documents in distributed databases synchronized by replication.

The Wide Area GroupFlow System is a further development of GroupFlow enabling additionally the connection of several „local area workflows“ between distributed organizations. It comprises basic concepts to describe the new challenges arising from distributed workflow management on the one hand and on the other hand includes extensions and new tools for the runtime and the tool layer of the existing GroupFlow and thus building the new Wide Area GroupFlow System.

In this article the conceptual background of Wide Area GroupFlow is discussed and the architecture concept as well as implementation aspects of the prototypes developed up to now are described.

The authors are convinced that the seamless integration of workflow processes across the borders of distributed organizations offers an enormous potential in enhancing quality, response-time and reliability of communication and information exchange processes. Yet most workflow management systems are focused on enabling workflow management in local area networks and there is a need for concepts as well as for practical solutions to enlarge the scope of workflow management using the possibilities of wide area networks.

2. Basic concepts of Workflow Management between distributed organizations

2.1. Three new dimensions

Workflow management within a single organization at one location has been subject of science, research and product development for a longer time. Thus various theoretical concepts and ready-to-use systems (as described in Erdl/Schönecker 1995, Weber/Karl 1994) are available, but they are all based on the following fundamental prerequisites:

- The persons and groups involved in the workflow process are known in advance. Their competencies, rights and addresses in the organizational network are known and mostly laid down in directory services (e.g. X.500) or similar structures.
- Legal and organizational aspects are under control of a single management and thus are known and can be influenced.
- Possible routing paths of workflows and storage locations of the information processed are known, too. Thereby it is possible to display the current status of a workflow process, for example to remind actors of tasks that are due or to perform statistic evaluations.
- Security aspects are under control of one single organization. Thus it can be described within the workflow system which actors in the workflow can read or change certain information and who is explicitly excluded from access.
- Technical aspects like hardware, operating systems and workflow management applications are mostly homogenous. The transfer rates in local area networks are mostly high.

As we enlarge the scope of workflow management and try to connect several internal processes across the borders of distributed organizations in the sense of a **Wide Area Workflow Management**, the prerequisites described above are no longer given.

To specify this new term more precisely, a definition of Wide Area Workflow Management in office work is given[1]:

[1] General definitions of workflow management are given by Hasenkamp/Syring (1993), Marshak (1992), Hollingsworth (1994) and others

> Workflow Management describes the analysis, modeling, use, control and optimization of computer-based support for structured, goal-driven information exchange and improvement processes between multiple agents in office work, including all necessary communication. Workflow Management Systems coordinate the participants in serial or parallel working order, route information to the next agent according to predefined rules or interactive control, provide all information necessary, control the punctual completion of tasks and are able to monitor the current status of workflow processes. In addition *Wide Area Workflow Management (WAWM)* aims at the support of processes that during runtime phase at least once cross the legal or geographical borders of two or more organizations and thus connect at least two processes internal to the organizations involved.

According to the prerequisites for internal workflow management described above, we can state the following for Wide Area Workflow Management:

- The persons participating in a workflow while it is processed in a partner organization are partially or completely unknown.
- Legal and organizational aspects in the partner organization cannot be influenced. Setting up workflow management is thus more difficult and needs much more coordination efforts.
- Routing paths and storage locations of external process parts are unknown. Tracking of processes or reminding of actors can only be realized if it is allowed by the partner organization.
- Security problems are more complex. Information leaving the own organization has to be actively filtered and hostile access to it is more likely.
- Hard- and software are heterogeneous and transfer rates are mostly low.

We face a variety of new challenges to be mastered in order to integrate workflow processes between distributed organizations in a seamless and sound manner. These new aspects can be summarized within three orthogonal Dimensions of Wide Area Workflow Management.

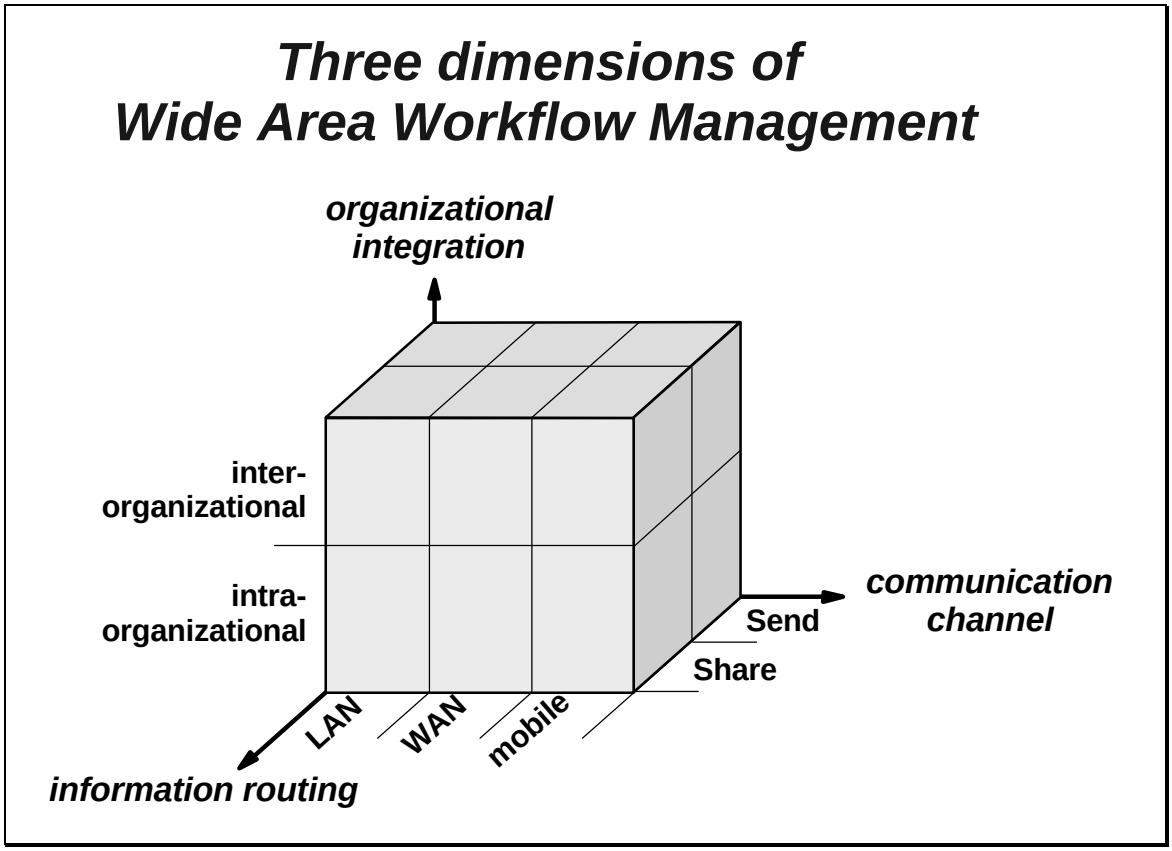


Fig. 1: Three dimensions of Wide Area Workflow Management

As indicated in Fig. 3, the three dimensions line out challenges and possible solutions for distributed workflow management in a cube that is divided into 12 segments. Each segment describes a certain constellation that requires special technical and organizational measures to enable a workflow connection between the partners involved. For example the case of a sales engineer requesting quotations provided in shared databases of project partners via notebook, modem and cellular phone while being at a construction site would be located in the upper right segment in the front row. Solutions provided for this case are likely to be applicable to similar situations and thus form a distinguished class within the general topic of Wide Area Workflow Management. The arrows at the axes indicate the direction of increasing complexity for the respective dimension.

2.1.1. Information Routing

Generally speaking, the access and transfer of information within a group of persons can be achieved in two different ways: All pieces of information can be routed from one person or group to another by sending messages (Send Model), or by giving access to common information bases (Share Model). In the paperbased office communication, we know the Send Model from letters or faxes and the Share Model from black boards or libraries.

Send Model

The Send Model bases on the routing of information from one point to the next in a store-and-forward manner. The use of electronic mail as one application of the Send model is already widespread. It is applicable for rather simple ad hoc routing situations and thus allows simple workflow actions that are easy to set up. For more complex workflow scenarios, E-mail based workflow lacks certain features. The most important are the absence of custom forms and fields for each single actor in the workflow and that the tracking of the current status of multiple workflows at a given time is to be regarded as practically impossible.

As a main advantage of the Send Model it is easy to enable workflows across distributed locations because of the widespread availability of E-mail. When using the Send Model for Wide Area Workflow Management, the information within the participating organizations remain completely separate and only defined information items are transferred. For loose cooperation, this is useful because no security or access control problems arise.

Share Model

Giving a group of persons access to a shared database environment is the basic principle of the Share Model. Information processed in standardized and often repeating workflows are best handled in such a shared database environment with adaptable access rights like reader, author, editor etc. Also open team tasks within self-managing workgroups, for example forming a non-regulated step within a predefined workflow, can be very well managed within shared document databases like they are offered by modern Groupware platforms. Each actor gets a personal view on the one, single information pool from his or her individual, customized perspective. Flexible reaction on problems and exceptions because of a larger group of actors regularly checking for pending tasks in a common work environment has proven to be one of the biggest advantages of the Share Model.

Individual forms for each actor, detailed tracking of several processes, fine graduations of access to information as well as splitting and joining of partial processes, among others, are much easier to handle within shared databases. The setup of a workflow system in a shared database environment though requires more efforts than the application of the Send Model.

The distribution of information across different locations can be realized by placing (partial) copies of the document databases at the involved sites and regularly synchronizing them by means of selective replication. This implicates a certain level of trust between the partners of a distributed workflow, because they work in a common „virtual“ workflow sphere.

Send and Share Model are to be regarded as complementary. In combination they allow the enabling of structured but flexible workflow management across a wide spectrum ranging from singular, non-predictable ad hoc processes to rigidly structured standardized workflows. For practical work, the steps in between these two extremes are the most important: On the one hand giving ad hoc processes as much structure as possible through tracking and process pattern extraction and on the other hand the opening of rigidly structured workflows with controlled exceptions as well as „soft“ assignment of tasks to groups.

2.1.2. Communication Channel

The communication channels that are available for distributed workflow management include a much wider range than the use of LANs mostly found in known workflow management systems. The use of WAN carriers usually allows for much lower transfer rates and includes the danger of hostile access to information. Even more, these limitations are especially true for mobile connections via wireless communication systems. When planning a system for WAWM, in addition to the possible transfer rate during one session, the frequency of communication has to be regarded. Intensive cooperation will most likely implicate a high information exchange frequency and therefore justify a higher amount of setup costs for a stable and performant communication channel.
Distributed workflow management systems have to adapt to these limitations and requirements by choosing different channels according to the actual communication load or because of varying costs at different times of the day. In addition the encryption of information with reliable mechanisms like RSA is very important because information processed in workflows is mostly confidential. These strict security requirements make it dangerous to realize Wide Area Workflow Management using the World Wide Web (WWW) in its current technological state. The enormous growth of the WWW and different attempts to implement reliable security standards (e.g. PGP) indicate that this global network could become a powerful environment for distributed workflow management in the future.
As it is generally very important in workflow management systems to provide only and exactly the information needed by the performer of a certain task, this necessity for *Content Management* becomes even stronger when distributed workflow management has to be realized. Here the main reasons for *Content Management* are:

- Providing, filtering and assigning the information needed to perform a certain task within a workflow, including the access to related and the denial of access to restricted information.
- Realizing a reliable system of information protection against hostile access.
- Adjusting the work load according to the availability, transfer rates and costs of possible communication channels at different times as well as the communication frequency.

2.1.3. Organizational Integration

Processes supported by a workflow management system can be divided into two categories: Internal processes that are merely bound to the one organization where they are performed and are thus called ***intra****organizational*. In distinction from this, we will call processes that cross the organizational boundaries of an enterprise at least once *external* or ***inter****organizational*.
A brief look at the different organizational forms shows a wide range of possibilities to integrate different enterprises. Thus we want to define a simplified *Continuum of Organizational Integration* that helps us to distinguish different forms of cooperation and thus different requirements for distributed workflow management.

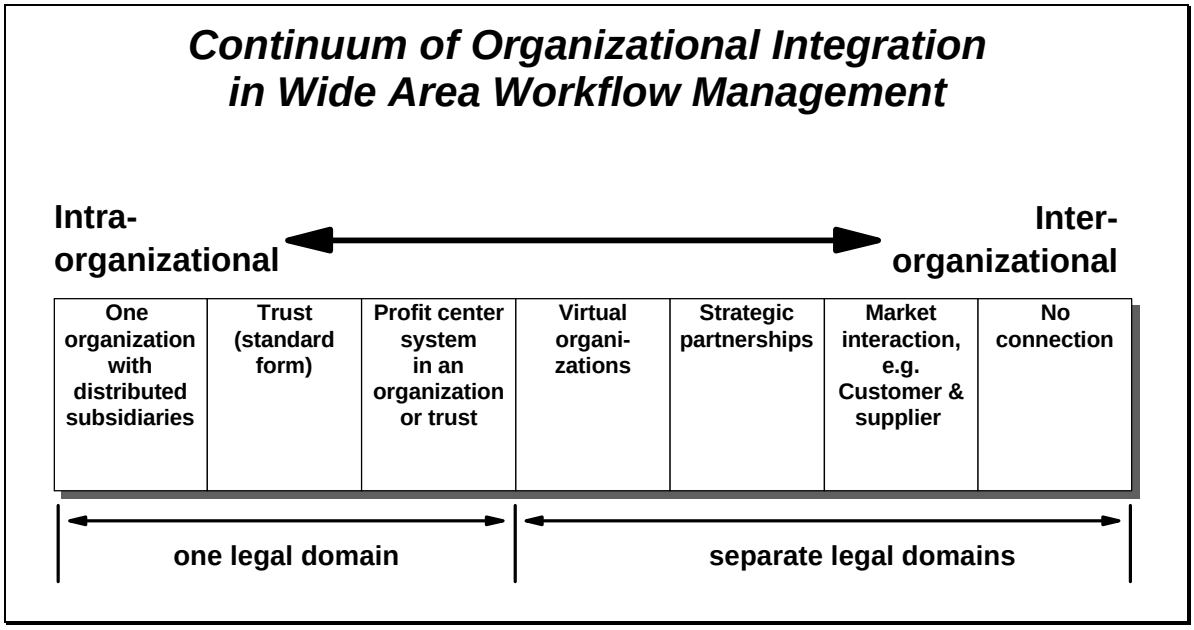


Fig. 2: Continuum of Organizational Integration

As a first approach towards a useful combination of the dimensions of organizational integration and information routing, the following statements can be given as rule of thumb:

- *Intra*organizational Wide Area Workflow Management will mostly be handled by using the Share Model because of its advantages stated in chapter 2.1.1.
- *Inter*organizational WAWM is best realized in application of the Send Model because of its simple setup and the remaining complete separation of internal workflow information.

As we will see in the following, these rules have exceptions in certain situations.

On the left side of Fig. 2 we find organizational forms under a single legal control. By using the *Share Model* a single workflow sphere across multiple locations is virtually formed. In case of a trust or a company organized according to the profit center system, we might also apply the Send Model. This is useful when different sub-units of an organization only cooperate loosely and with low frequency. Setting up one workflow sphere may then not be worth the costs. For a cooperation between legally autonomous organizations on the right side of Fig. 2, the *Send Model* will be the information routing approach to be chosen. In the case of a virtual organization or a very close strategic partnership there might also be the possibility to set up a common workflow structure using the *Share Model*. This is for example helpful for distributed product development teams with the members located in different organizations.

In addition to the *Continuum of Organizational Integration (*Fig. 2*)* we want to connect the dimensions of organizational integration with the one of the communication channel by using the distinction between *regularly connected* or *occasionally connected* distributed organizations in the following Fig. 3. These two extremes help to understand possible strategies even though in reality the frequency of communication will most likely vary in between.

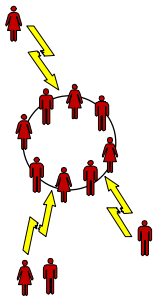
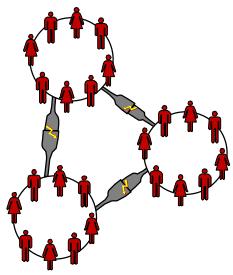
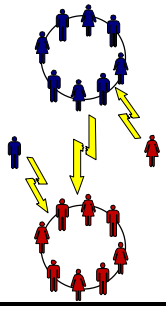
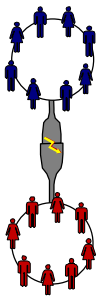
Organizational integration	**Intra-organizational**		**Inter-organizational**	
Communication frequency	occasionally connected	regularly connected	occasionally connected	regularly connected
Location	mobile /static	static	mobile /static	static
Connection between	client / server	server / server	client / server	server / server
Security, autonomy	shared computing, identical access level as local team members, „virtual office“, encryption	shared computing, partial access overlap, same access as one team, „virtual office“, encryption	protected computing, complete autonomy, well-defined information items accessible, encryption	protected computing, complete autonomy, interface with fixed interchangeable information, encryption
Information routing	Share Model: adaptable selective replication model, exceptions: Message Objects	Share Model: predefined selective replication model, exceptions: Message Objects	Send Model: Message Objects, sporadic information push or pull	Send Model: Message Objects, mail-in databases
Sample scenario	sales force	subsidiaries	customer / supplier	strategic partners, virtual organizations
Visualization				

Fig. 3: Organizational integration and communication frequency in Wide Area Workflow Management

In Fig. 3 different strategies of implementing distributed workflow management are sketched according to the three dimensions of WAWM. In the case of *intra*organizational WAWM, the use of the Share Model is realized by implementing selective replication between the runtime applications of the internal workflow management systems. For *inter*organizational WAWM the possibilities range from a very loose and seldom contact with occasional connection realized with Message Objects between the workflow spheres of different organizations. When the frequency rises, it is useful to implement interfaces in form of gateway databases (so-called mail-in databases) that handle the internal and external routing of Message Objects between several internal workflows to be connected between the organizations.

3. Architecture of the Wide Area GroupFlow System

We now want to introduce the architecture concept chosen to realize the Wide Area GroupFlow System (WAGS). First it is explained, how the conceptional fundaments described in the

preceding chapter have influenced the design of the system and secondary an introduction into its structure is given.

3.1. From conception to design

As stated in chapter 2.1.3, the degree of organizational integration determines the form of cooperation within or between organizations. In the case of intraorganizational WAWM, all persons involved are known in advance and a comparably high level of trust can be assumed. For the technical implementation, this means that information routing can be realized with the Share Model (see chapter 2.1.1.) in form of shared databases with controlled access for all actors in a workflow. Generally the WAGS stores all *internal* workflow information in shared databases of the underlying Groupware platform Lotus Notes. By the means of selective replication, these databases can be spread and synchronized between different locations of an organization and thus distributed workflow management can be enabled. To incorporate this distribution feature into the design of workflow types, synchronization points have to be included as special workflow tasks and filtering strategies have to assure that only necessary information items are transferred to the respective locations. In the WAGS, this is realized with the help of the Wide Area GroupFlow Modeler (see Fig. 4 and the following section).
The case of interorganizational WAWM is more challenging: a comparably low level of trust makes it impossible to share the same workflow information and specification between different organizations. Therefore the WAGS has to provide possibilities for an organization to publish certain workflow specifications (e.g. tasks) to external partners without giving direct access to the internal workflow management system. This is realized by inventing a directory service commonly shared between different organizations that is called External Directory.
A special, process-oriented addressing system was chosen for the External Directory: because the main focus is the flexible connection of workflows between distributed organizations, not persons and static hierarchies but externally available workflow tasks are published. Information about persons and their responsibilities change quickly and are mostly confidential. Telephone directories or organizational charts only represent hierarchical structures of persons, not describing their roles in the multitude of internal and external processes.
The actual workflow information are transferred with Message Objects (see Riempp/Nastansky 1996) that navigate according to task addresses stored in the External Directory. Thus the WAGS uses the Send Model for information routing to enable interorganizational WAWM.
The aspect of Content Management (see chapter 2.1.2.) is covered within the WAGS by actively filtering the information processed in the internal workflow management before they are send to external partners. For secure information transfer, RSA encryption is applied. To chose the appropriate communication channel according to a *least cost routing*, each partner can declare the communication channels he is connected to. Thus channels can be selected depending on work load, priority, transfer rates and costs.

3.2. Structure

The Wide Area GroupFlow System is designed following a layered structure necessary to distinguish the different parts of the framework and to show their interdependencies (Fig. 4).

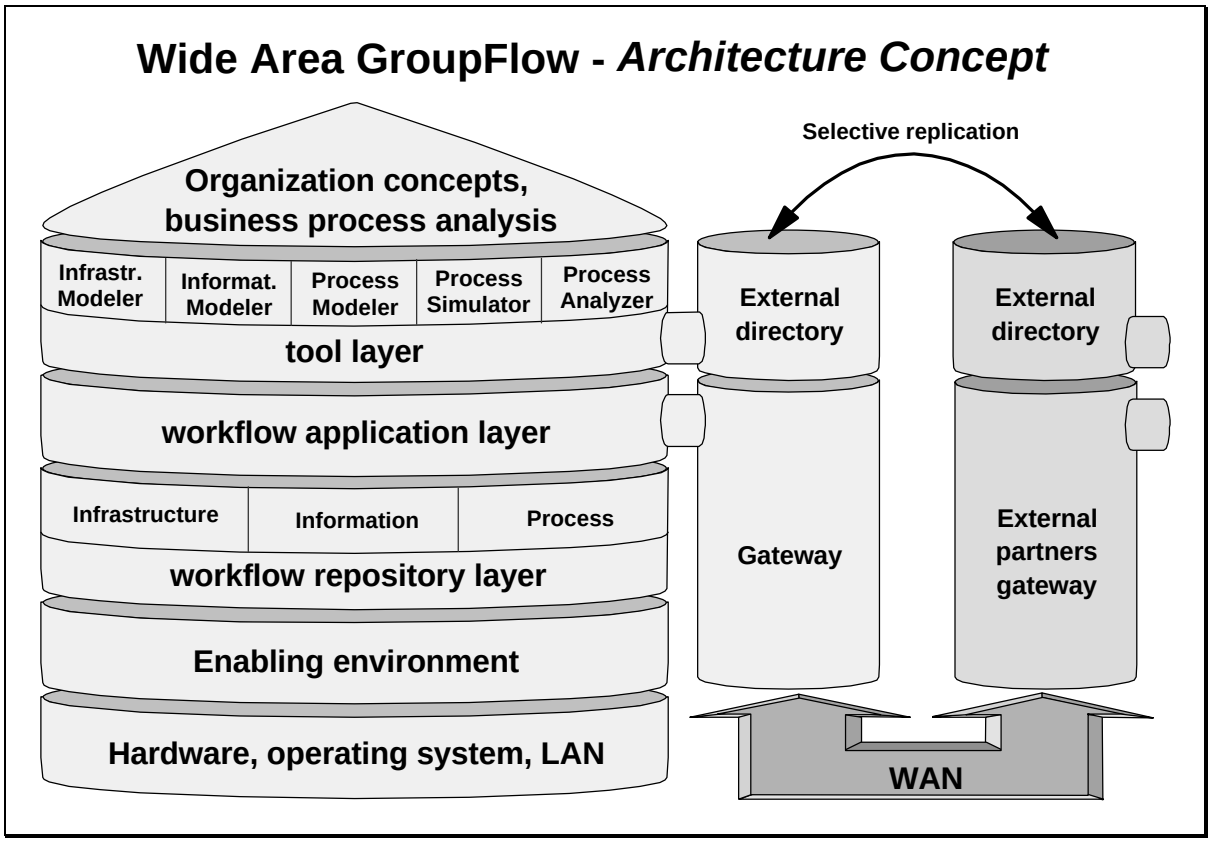


Fig. 4: Architecture Concept of the Wide Area GroupFlow System

Wide Area GroupFlow follows the concepts initially used to implement the GroupFlow System. As enabling environment, the Groupware platform Lotus Notes has been chosen that covers mostly all available hardware, operating system and LAN standards. The workflow repository layer consists of three applications realized in Lotus Notes that are capable of handling outgoing and incoming documents (Message Objects) used to connect distributed workflow parts. The workflow application layer combines the three parts of the repository in its consistent user interface and performs processing and routing of tasks. As it builds the run-time system of Wide Area GroupFlow, it initiates and controls external workflow parts automatically or interactively according to the process design chosen.

The interactive graphical tools of the tool layer are used to configure the corresponding applications in the workflow repository. The central tool is the process modeling software, called *Wide Area GroupFlow Modeler*, that is used to design the workflow process with its consecutive task-and-arrow structure (as described in Nastansky/Hilpert/Riempp 1995). To enable distributed workflow management, new features like special nodes for outgoing and incoming tasks, synchronization nodes, filtering sets, hierarchical clustering for building

process parts on different levels and a browser for the External Directory are included in the Wide Area GroupFlow Modeler.

For routing of outgoing as well as incoming E-mails or Message Objects and for replication purposes, the *Gateway* application was invented. It performs Content Management, tracking, reminding, routing, converting to foreign systems, communication channel selection as well as splitting and joining of all information objects that are transferred between distributed workflow parts. The *External Directory* contains global routing information (GRI) that are published to the respective partners via selective replication and is thus common to all partners participating in the Wide Area Workflow Management. The GRI consists of an abstract address and a functional description of the tasks performed under this address. It is mapped with the internal routing information (IRI) that describes the task, role and organizational unit responsible for performing this tasks. The IRI is used by the Gateway application to transfer incoming workflow information objects to the workflow application where the respective tasks are to be performed and is not public to external partners. The connection and synchronization between GRI and IRI are realized with the help of a special browser included in the Wide Area GroupFlow Modeler.

The distinction between external task address (GRI) and internal task address (IRI) was chosen for several reasons:

- Dynamic mapping of incoming Message Objects to workflows, tasks and thus persons.
- Publishing of distinguished sets of GRIs for each partner in order to adjust the amount and depth of workflow connection points visible from outside individually.
- No possibility of gaining knowledge about the internal structure or actual processes of an organization from outside because the GRI is completely abstract (e.g. PX130/55BD).

It is not likely that an organization would open its internal workflow repositories to external partners because of the highly confidential information about persons and processes stored here. Therefore internal and external workflow information are kept completely separate.

Once the addressing system between the involved organizations is set up in the External Directory, it allows an intuitive handling of external workflow connections during design and runtime phase: the laying out of a workflow type in the Wide Area GroupFlow Modeler normally starts with one or several internal tasks, symbolized by icons connected with arrows. To include a task performed at an external organization, a special kind of node is drawn. In order to assign a certain external task to this node, a browser is opened that reads the GRIs stored in the External Directory. The partner organizations are shown on the top level of a tree structure and below each partner organization, all available GRIs and their functional description are displayed in a hierarchical manner. A certain GRI is chosen by dragging it onto the respective node. In the following this node is displayed with the company logo of the organization that has published this task and the functional description below it. As a second step, a certain type of Message Object is selected and it is defined, which information from the internal workflow are of interest for the external organization and thus should be transferred into the Message

Object (Content Management). When storing the workflow type into the workflow repository, all information necessary to enable the external workflow connection during runtime phase are automatically set.

External Directory and Gateway application are set aside from the core workflow management system (on the left side in Fig. 4) and normally exist only once per organization. This design was chosen to allow several workflow applications to be used separately in different parts of the organization and at the same time centralize all processing of external workflow interaction. Thus all tracking of distributed workflow management can be performed by evaluating the Gateway application with the Wide Area GroupFlow Analyzer. A more detailed look at the function of the Gateway application and the External Directory during the runtime-phase connection of workflow parts with the Wide Area GroupFlow System is given in the following Fig. 5.

External workflow connections can be initiated in two ways: predefined during design phase in the Wide Area GroupFlow Modeler as described above with automatic start at runtime when the actor in the preceding task finishes work, for example by clicking a „Next Task“ button. Additionally an actor can decide at runtime to invoke an ad-hoc external workflow connection in form of an exception. In this case the actor is presented a browser to select the respective GRI of a partner organization. In a second step the actor interactively filters the internal workflow information for the external partner in the sense of Content Management.

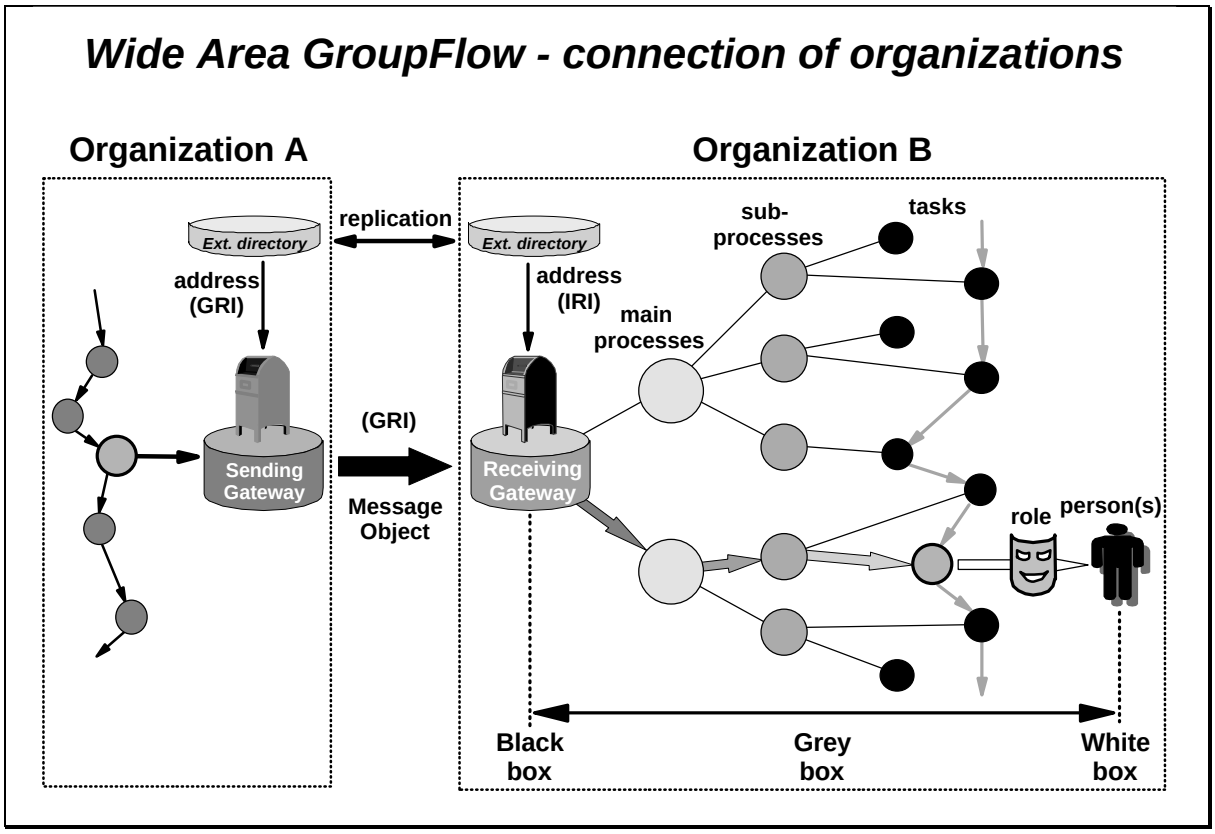


Fig. 5: Basic concept of connecting workflows between organizations with Wide Area GroupFlow

In both cases of predefined or ad-hoc external workflow connections, the sending workflow application in organization A addresses a Message Object with the GRI of the receiving task in organization B and posts it to its Gateway application (Fig. 5). Here the GRI is checked with the External Directory to set the address of the receiving Gateway application in B (e.g. Lotus Notes mail address). Further certain tasks are performed like tracking, reminding and the deletion of confidential fields. Finally the Message Object is sent to the Gateway application in B using the communication channel(s) specified by B in the External Directory. The receiving Gateway application in B maps the GRI included in the Message Object with the IRI in the confidential part of the External Directory and sends it on to the workflow application where the task is actually performed. The response to A will be processed exactly vice versa.
According to the level of trust between the partner organizations participating in the Wide Area Workflow Management, the depth of the process hierarchy published to the partners is adjusted. In the case of a very loose contact, an organization will most likely only publish the address (GRI) of its Gateway application and thus is a „black box“ for outside organizations. The Message Objects arrive with a processing wish like „please make an offer for your product XYZ“ and are manually mapped with the workflow performing this task. The more trust exists between the partners, the more of the process hierarchy is published and can be addressed. This process hierarchy starts from main processes like „quotations“ going down to single workflow tasks published to the partner with whom the workflow is shared („white box“). Each main process, sub-process or task is combined with a role. One or more persons, groups or departments are assigned to the role so that task - role - person(s) always build a unit. This structure allows for stable design and flexible job assignment during runtime phase.
The concept of a process hierarchy was chosen to reflect the process-orientation of workflow management. Tasks to be published with a GRI are aggregated into different levels in a bottom-up approach or can be planned top-down according to the organizations strategies and main competencies. The process hierarchy has analogies with the object orientation in programming: tasks are derived from object classes (main processes, sub-processes) and can inherit properties from them. Main processes, sub-processes and tasks can be stored in module libraries for re-use.

4. Outlook

The intention of this article was to discuss conceptions to structure the new requirements arising from Wide Area Workflow Management and to introduce the Wide Area GroupFlow System (WAGS) as a solution attempt on the basis of Groupware. Only a brief overview could be given due to the limited size of this article. More detailed reports about principles for the

connection of distributed workflow parts and the introduction of the Wide Area GroupFlow Implementation Model will follow.

The prototypic implementation of the different parts of the WAGS is still going on. It is not intended to lead to a commercial product release but to illustrate possibilities and to provide a testing environment for distributed workflow management. A main focus of the further development is to integrate the conversion of exchanged workflow information to standard formats like X.400, SMTP, HTML, SGML or EDIFACT. This feature allows to connect *heterogeneous* distributed workflow management systems, especially including the use of the Internet as carrier and the WWW as front-end system. The opening to standard formats and thus other communication and groupware platforms is of high importance for practical implementations.

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