

A Generic Architecture of Community Supporting Platforms based on the Concept of Media

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Abstract

Online communities emerged as a new communication and cooperation paradigm around new media based on information and communication technology. At the beginning they were considered a social phenomenon, but soon it became clear that online communities can be of great economic importance and might provide efficient organization forms in certain application areas. This provoked the need for their systematic initiation and support by comprehensive community supporting platforms. This paper defines online communities and their features and proposes a concept of a component-based architecture for community supporting platforms. The generic concept of media and the related media reference model are applied as a framework for component identification.

1 1. Introduction

The convergence of information and communication technology results in a new information carrier, i.e. in a new communication medium represented by Internet with exceptional capabilities:

- Ubiquity – information is now available without space and time barriers.
- Interactivity – information access can be combined with direct interaction and communication.
- Intelligent behaviour – due to computational capabilities the medium can mimic human behavior and intelligence [36], [29].

Mediated by the new carrier innovative forms of communication, co-operation and doing business are

emerging. One of the new paradigms are online communities, by some authors called virtual communities. An online community is an association of agents, which connected by an electronic medium share a common language, world and values as well as pursue common interests.

Some, perhaps most of the Internet communities emerged in a more or less self-organizing way. At the beginning they were considered mainly as a social phenomenon. But, latest with the bestsellers of Armstrong and Hagel [3], [4], as well as with the discussion of the value of community oriented knowledge sharing in organizations [25], [39], the awareness of economic importance and potentials of online communities has been widely spread. This provokes the demand for their organized stimulation and creation as well as the development of methods [25] and tools for the construction of platforms for their support.

First attempts to define the critical success factors from an economic [13] or social point of view provide guidelines how to initiate and coordinate online communities. But, there are little guidelines for building the technical platforms for their support.

At the beginning online communities emerged around single technologies as chats, BBS or newsgroups with simple management procedures for members. At present the requirements on the functionality of such platforms are rising. As a result community supporting platforms are becoming complex platforms combining numerous communication and coordination mechanisms as well as knowledge representation technologies. The topic of design and implementation of community supporting plat-

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forms is not addressed in a systematic and generic manner.

This paper tries to contribute to fill this gap and proposes a generic component-based architecture for community supporting platforms based on the media concept of [29] and the related media reference model [20], [31].

In section 2 first online communities are defined and their basic features are described. Section 3 introduces the concept of media as a basic framework for defining the required components of community supporting platforms. In section 4 the media reference model is described. Section 5 presents a component-based architecture of media supporting platforms. Section 6 concludes the paper with a summary of achieved results and a description of further work.

2 Online Communities – Definition and Features

The emerging communication and organizational paradigms on Internet are perhaps mostly named by using the attribute “virtual”. Despite of the huge discussion, provoked by the new “virtual” phenomenon in different areas of science, researchers still have difficulty to provide a generally acceptable definition for virtuality. What counts here is the fact that communication is mediated by information and communication technology, i.e. it is online. For that reason in this paper the term online communities will be used.

We define online communities as associations of agents, who share a common language, world, values and interests and which are connected by electronic media, i.e. communicate and cooperate ubiquitously and possibly through avatars. This definition shows that online communities have many identical features as ‘conventional’ communities:

- a common language enabling communication,
- a common world subject to discourse,
- common interests, values and targets
- persistence of common meaning and continuity of communication.

But it also points to some distinguishing features of online communities, which can be summarized as follows:

- *Technological mediation* – the community members are connected through a digital medium, which replaces the physical, geographically delimited meeting space.
- *Ubiquity* – due to the interactivity and ubiquity of the digital medium community building is possible without space and time barriers.

- *Replacement of physical presence with digital substitutes, i.e. different forms of avatars* - The avatars can even represent a different personality.

At the beginning online communities have mainly been considered as a self-emerging social phenomenon. But, a nearer investigation showed, that online communities emerging around information and communication technology can have considerable economic effect and influence on existing organizational structures [Stefik, 96]. This provoked the need for their targeted organization, initiation and stimulation.

In order to be able to initiate or support and foster online communities properly, a deep knowledge of their structure and components is required. Online communities exist at the intersection of complex technical and social systems. “Neither technology or sociality can supplant the need for the other, and the two are conceptually inseparable” [27]. Therefore, online communities have two interrelated constitutional elements [32]:

- the association of member agents and
- the enabling electronic medium

Agents are proactive, autonomous entities capable of communicating and processing information. They dispose of a representation of the environment, which might differ in scope and complexity for different agents and are able to receive and process information as well as to act and react. In the context of electronic media agents might be humans, organizations or other communicating entities as well as artificial agents, i.e. avatars for real entities.

The association of agents has furthermore a clearly defined organizational structure with a detailed description of possible roles, i.e. types of participants and allowed processes and protocols of communication [8], [29], [35]. The organizational form can vary from a very simple regulation of membership to a tightly defined hierarchy or complex society (an example of the later is the online community Cybercity www.cybercity.com).

The second constitutional component of online communities is the enabling electronic medium. In a general sense the word medium denotes the middle, the meeting place where everybody comes together. The enabling electronic medium connects, i.e. mediates between the members of the community by providing a metaphor of a physical meeting place.

Between the two constitutional elements of an online community, there is the following division of tasks: The agents communicate through the electronic medium and thereby generate common content and meaning. The electronic medium provides communication channels without time and space barriers and takes over the task to save and provide availability of content, i.e. provides the memory of the community [32]. Given its computational capability it is also capable of taking over intelligent tasks as search, bundling and organizing of content as well as

coordination of communication. In summary the medium provides a metaphor of the community meeting place.

The interdependence of the two constitutional components of online communities implies that in order to support communities the appropriate medium has to be build, which enables the required communication and coordination forms and storage facilities required by the community. Thereby the physical realization of media based on information and communication technology is called community supporting platform.

In order to determine the necessary components of community supporting platforms we refer to the generic concept of media defined by Schmid [29] and the related media reference model [20, 31], which will be described in the next section.

3 The Concept of Media

We define media as information and communication spaces, which based on innovative information and communication technology (ICT) support content creation, management and exchange within a community consisting of human and artificial agents. The media concept is a first step towards formalization of media based on the new interactive and ubiquitous carrier Internet [17], [20]. It provides a general model, which describes media as a multi-agent system in terms of computer science and proposes representation and organization of communication and content in a manner understandable by computers. Thus, it provides a virtual space, where communication is mediated by formal representations of both the communication patterns and the common domain of discourse (see also [11]).

According to [29] a medium is used by a community of agents and consists of the following components: 1) a logic space, 2) an organizational structure mirroring the organization of the using community and 3) channels, i.e. carriers of information. Following the basic components of media and their relationships will be described in more detail.

Logical Space

As mentioned above a common language is the necessary prerequisite for communication. The logical system of a medium denotes the language, which is used in order to communicate.

It furthermore comprises syntax and semantics. The syntax defines the language, the grammar and the rules according to which correct sentences can be defined in the chosen language. The syntax must be implementable on the carrier and applied by the agents of the medium. Se-

mantic defines the meaning of the used language constructs and has to be clearly defined by the community using the language.

The logical systems may have different forms from natural language to a formal representation of the domain of discourse. In a medium based on ICT we want to take advantage of the ability of the new carrier to enhance human intelligence and reasoning. In order to achieve a symbioses of artificial and human reasoning, the language should be understandable for humans and for computers. Thus, the language has to have a representation in machine readable form. The machine readable part is providing a meta-layer over the content and channels of the medium enabling classification and structuring of content as well as allowing for its automatical retrieval and combination. Within the two representation forms, the logical system is the binding element, i.e. the medium connecting agents.

The content of the medium, created using the chosen language is a representation of the world observed by the community. One particular world can be modeled by different communities. If a semantic connection between the languages of such media can be established, than a knowledge exchange between them can be facilitated by automatical translation of language concepts in each other.

Organisational Structure

As mentioned above a medium is a methaphor of a meeting place providing communication channels and common memory. The entrance of the space, i.e. the usage of the medium is usually subject to certain rules defined in its organizational structure.

Components of the organizational structure of a medium are: roles and processes. The roles bundle combinations of necessary capabilities, rights and obligations into a special function within the community. They represent specific types of community participants.

The second component of organizational structure are protocols. Protocols define the rules and sequence according to which communication takes place. Protocols are therefore processes, which are necessary for the correct functioning of a medium. Protocols are defined over roles of agents and follow predefined rules, which regulate and co-ordinate the interaction of agents in order to achieve a common goal.

The organizational structure is represented in the logical system. Thus the automatic deduction of processes out of the organizational and agent description is possible.

Channels

Channels are a system of information carriers connected to a network of transportation means for information. Channels are storage facilities capable of capturing information and of distinguishing and distributing information without time and space barriers. Thus, they form communication systems, which are responsible for the transportation of information. Channels can be named and represented in logic.

Channels containing pieces of information are called information objects. Information objects are active carriers of pieces of information. Most prevailing information objects in companies are for example electronic documents. Information Objects are ubiquitous through their connections to channels based on ICT. All information objects of a medium provide the memory, i.e. library of the community, which connects participants over time and space barriers.

In summary a medium consists of a channel system for the transport of information over space and time, a logic, for capturing syntax and semantics of the information and an organizational system (roles and protocols) for structuring the behavior of its agents. [20].

The above described components of media are interwoven with each other and form an entity of human and artificial agents connected through a semantic space facilitating communication. Communities of agents, striving towards a common aim, employ the above described organized channel structure to process and to communicate information.

4 The Media Reference Model (MRM)

While the concept of media defines in a generic manner the notion of media based on ICT and its components, the reference model for media provides a first guideline for answering the question how to build a medium (c.f. 1).

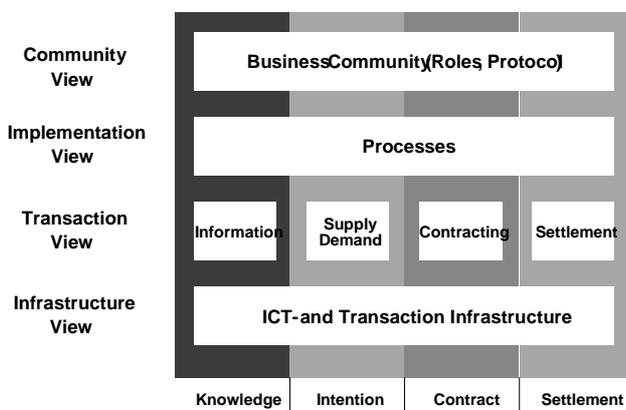


Figure 1. Media Reference Model (MRM)

The media reference model distinguishes according to [20] four layers or views and four action types or basic services. The layers denote different stages in the design and implementation of a medium and the basic services refer to generic modes of interaction. In the next section the layers and services will be described briefly. For more detailed description, refer to [31,20].

4.1 Views of the MRM

A medium should enable and support a community of agents. Consequently the first step of the design should be the identification of the community of agents, which should be supported. This step is represented by the community view.

The *community view* deals with the aspects relevant for modeling the community. In particular this means:

- Modeling of the domain of discourse as the base for common language and meaning.
- Identification and modeling of the participating agents in terms of beliefs, intentions, desires, capabilities and preferences.
- Identification and modeling of roles and processes applied by the community
- Identification and modeling of applied communication patterns.

The above models define on the one hand the logical space on the other hand the common language and organizational structure.

In a next step in the *implementation view* the necessary processes, i.e. the sequences of necessary tasks to achieve defined goals are identified and modeled. Each task draws from the logical space and accesses the basic services. Processes therefore represent sequences of usage of basic services and bind descriptions or models to service providing modules.

The *service view* (transaction view) provides the generic interaction or communication services: sharing of information, signaling of intentions, as for example offers and demands in commerce, negotiation of obligations and settlement, i.e. performance of tasks.

The *infrastructure view* provides the means to physically implement the services of the service layer onto communication infrastructures as Internet. Here, the respective needs for security, or safety of the infrastructure are of importance.

4.2 Basic Services of the MRM

The basic services of the MPM distinguish the fundamental interaction acts part of any communication between the agents [26]:

In the *Knowledge Phase*, assertive information about the world, the agents, or the medium is provided and communicated in form of information objects. Information objects are constructed by using the logical system and carry information about the domain, the channel system as well as the organization. By accessing the available information objects agents may obtain knowledge about the behavior expected from them, about the channels on which to exchange information, about the protocols to follow in communication or about previous communication. In short the knowledge phase offers information about the community and the medium as well as information created by the community.

Basic services offered in the knowledge phase are such for classification, retrieval, sorting and combination of information objects as well as for creation and sharing of information. An important input for this services is the domain description and the other models provided in the community view.

In the *Intention Phase*, agents signal their intentions, developed from the knowledge provided in the knowledge phase, and from their desires and goals and by linguistic means of the common logical space. For example supply and demand are the generic intentions agents signal within this phase in commerce. Basic services required in the intention phase are such allowing the expression and management of intentions.

In the *Contracting Phase*, agents negotiate tasks or obligations, which might be recorded in contracts. The messages in this phase are binding, in the sense that they oblige agents to act as indicated in those messages. Offer, counteroffer, accept and reject are such messages. This phase ends – in the case of success- with a contract, i.e., with an externalization of a binding protocol. Basic services required in this phase are support for negotiation, recording of negotiation steps and for creation and management of contracts.

In the *Settlement Phase*, agents act according the negotiated contract, using special services offered for performing the defined tasks. In commerce for example, this means, e.g., shipping of goods and transaction of money. The actions within this phase are performed according to the agreed upon protocols.

5 A Generic Component-Based Software Architecture for Community Supporting Platforms

The realization of media are community supporting platforms, which consist of software components providing the above mentioned services. The concept of media provides a generic framework for understanding online

communities, media and their components. In this section it will serve as a base for the instantiation of a component-based architecture for community supporting platforms. Against this background the following components of community supporting platforms were identified (c.f. 2) and will be explained in more detail in the next sections:

- a user and agent interface
- logical system
- a process module
- basic services
- additional service connected to the communication infrastructure.

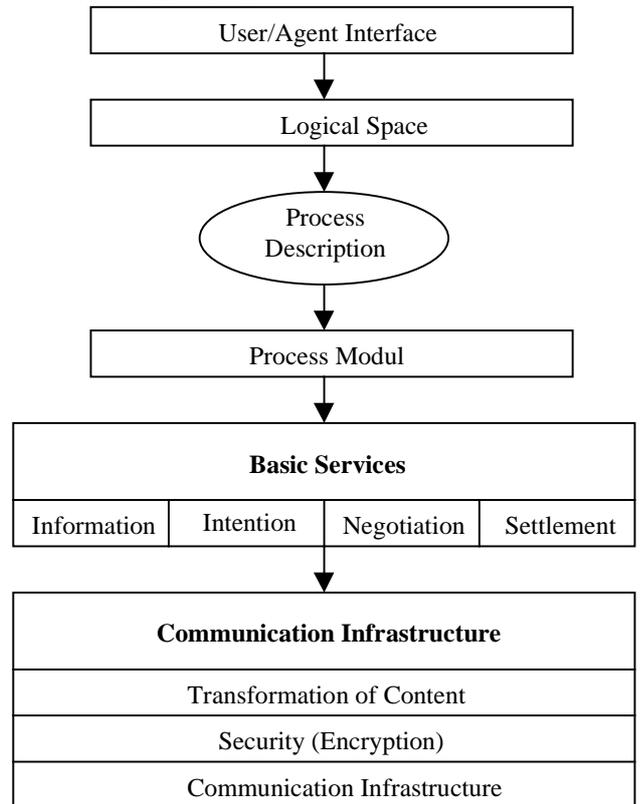


Figure 2. The components of community supporting platforms

5.1 User and Agent interface

The user and agent interface provides the interface for entering the medium by the community participants. Participants of online communities can be humans and artificial agents, i.e. avatars. Thus, a community supporting platform has to provide appropriate interfaces for both type of agents.

Human agents prefer multimedia interfaces with natural language. It can have a different appearance depending on the access infrastructure of the participant (for example

the content might be provided in 3D or 2D format (see for example www.cybercity.com)).

The interface for artificial agents should provide access to the medium in a manner which allows artificial agents to use it, i.e. in a more formalized manner. Possible approaches for realizations of such interfaces are for example by using the Agent Communication Language (ACL) [7] and KQML or by providing special agent context capable of hosting mobile agents (see for example Mobile Agents developed with Applets [16]).

5.2 The Logical System

The logical system consists of several formal representation systems or models with clearly defined tasks:

- *Formal representation of the specific domain of discourse.* Concepts and objects as well as their relationships are defined and possibly modeled in a formal language. The definitions represent the basic concepts of the common language and can be realized in form of simple glossaries or vocabularies or in form of intelligent vocabularies as ontologies [10].
- *Description of the agents participating in the community.* The description contains a combination of agent description according to the Belief-Desire-Intention Architecture (BDI) [26] guiding the agent's interaction as well as different profile descriptions (for a detailed overview of possible profiles see [35]):

<p>AgentRepresentation: = <i>BDI X Identification Profile X DemographicProfile X PreferencesProfile X TransactionProfile</i></p>

The base for agent and profile description are available concepts from the representation of the domain of discourse.

- *Representation of the organizational structure, i.e. of roles and protocols:* Roles are represented by rules defining necessary capabilities, rights and obligations to perform tasks:

<p>RoleRepresentation: = <i>NecessaryCapabilities X Rights X Obligations</i></p>

The concepts for modeling of capabilities, rights and obligations are derived from the model of the domain of discourse.

Protocols describe in a formalized manner the flow of information and tasks during communication and task performance. Possible realization forms of process descriptions are for example formal models based on Petri

Nets [21] or based on the standard by the Workflow Management Coalition [23].

Each of the formal representation is accompanied with a respective specialized inference engine. The overall coordination is performed by inference coordinators, which act according to knowledge about coordination patterns.

Taken together the components of the logical system provide a formal description of the participants and their interaction, i.e. of the underlying services on a meta level.

5.3 Process Modules

The options selected from the formal representation result in a complex process description and provide the input for coordination modules capable of executing such descriptions. Representatives of process modules are transaction or file based workflow management systems (for a detailed overview see [23]). File based workflow systems have no central control and the coordination of tasks is performed by intelligent documents containing process descriptions. Compared to document-oriented workflow systems, transaction based workflow management systems have a central coordination module, which coordinates the work of different modules and agents during performing a specific task.

Process modules coordinate the access and execution of the different available services.

5.4 Basic Services

Processes are defined upon basic services. According to the MRM there are four basic services knowledge, intention, negotiation and settlement. Following the most important software modules for the different services will be described.

Knowledge Services provide services for creation, management and sharing of information, i.e. for the creation, management and dissemination of information objects. Information objects are stored in a special repository and form together the knowledge base of the community. In addition to a selective integration of legacy information, information objects are also enriched with a description of the context in which the knowledge was created and are related to a basic language or glossary typical for the community using the platform. The context and the glossary are expressed in the logical system of the platform.

The services required in the knowledge phase can be realized by knowledge management systems (for an overview see [32]) as for example document management systems, intranets or extranets.

As mentioned above information objects can contain information created by the community or information and knowledge about the community. A significant part of the knowledge about the community is created by observation of the transactions taking place on the platform. Modules supporting this are tools for following clicks and creating statistics as well as for analysis of statistical information as data mining and OLAP tools.

Intention Services enable the expression of intentions and their management. Prevailing forms of realizing intention services in electronic commerce are electronic product catalogs (EPC) [32]. On the one hand EPC are used by suppliers to express offers online. On the other hand they are used by buyers to express their choice in form of a counter-offer.

Contracting Services enable negotiation of offers and counter-offers, of obligations and conditions for performing tasks. Two types of services can be distinguished here negotiation and contracting. Negotiation refers to the process of arguing about given proposals. For this type of services first systems can be observed in the form of online auctions (for a detailed overview see [5], [24], [6]). Contracting is the process of online establishment of legally binding contracts [34]. In this area, several approaches can be observed, which have not reached market maturity yet [33,34].

Settlement Services provide support for performing agreed upon actions, i.e. performing contractual obligations. In the context of electronic commerce settlement refers to delivery of goods and payment [31]. The delivery of goods is supported by logistic services. Payment enabled by different modules as micro-payment, e-check, credit card, etc.

5.5 Additional Basic Services

Besides the above specific services and modules necessary for performing tasks in the medium further services are required necessary for transportation of information. This type of services is realized through connections to communication infrastructure.

Community participants might have different access infrastructure to the medium. In order to prevent that lack of sophisticated access infrastructure becomes the major barrier to join the community, the available content should be adaptable to different access devices and communication needs. In addition it should meet the security and privacy requirements defined by the community. The platform should therefore provide services for transformation and communication of content as:

- content transformation according to different users and user profiles or access devices.

- security services providing encryption and decryption functionality, and enabling privacy.
- communication services with interfaces to lower communication layers.

5.6 Community Supporting Platforms as Complex Information Systems

The above description of the necessary software modules for the realization of community supporting platforms shows, that they are complex information systems providing at the same time coordinated support for human and artificial agents. They should be build by combining the paradigms of multi-agent systems and conventional systems for human agents. They are a new type of information systems, which explicitly enables and supports the cultivation of a common language in the form of the logical system mediating between human and computer agents.

It furthermore points out, that community supporting platforms are complex systems, which can only be build by applying the paradigm of component-based software development. In order to achieve this comprehensive reference models and standardization efforts are required, which will provide guidelines to integrate existing modules and guide the development of new one.

6 Current State of Implementation and Application of Community Platforms

The above described architecture and concept was applied for the design and implementation of platforms for online communities in several application areas based on different types of technologies. A special emphasise was given to the implementation of the logical system. Based on the Q-Technology for the representation of objects [30] and an innovative system for the classification of objects was developed in and was combined with different technologies as document management systems and workflow management systems (<http://arabella.mcm.unisg.ch>). Following the experiences will be described shortly with pointers to a more detailed description:

- In the international project IBIS (Integrated Business Information Systems), a platform for communities involved in corporate planning processes was designed and implemented [37]. www.knowledgemia.org/knowledgemia/knowledgemia.nsf/pages/ibis_home.html. In this project a special emphasize was put on the design of integrated planning documents, i.e. information objects and their meta-description with the Q-Technology. In addition the logical system was enlarged with comprehensive organizational de-

scriptions, which allowed a flexible guidance of workflow management systems by the introduction of “organizational resolution”.

- In the project NetAcademy a platform was designed and implemented for scientific communities of interest [19] (<http://www.netacademy.org>)
- In the project SHCS (Swiss HIV Cohort Study) the concept was applied for defining self-contained XML based documents for the interorganizational exchange of medical data, http://www.knowledgemedia.org/knowledgemedia/knowledgemedia.nsf/pages/shcsweb_home.html [12].

Through the projects the concept and the general architecture were validated and further developed.

7 Conclusion and Outlook

In the paper we first defined virtual communities and summarised their features and requirements on community supporting platforms. Then based on the generic concept for media and the related MPM a component-based architecture for community supporting platforms was suggested. In the last section we presented the application of the architecture for different virtual communities. As a next step we plan to apply the above concept to other communities and to synthesize the results in a general methodology for implementation and design of community supporting platforms.

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