

Project no. 018340

Project acronym: EDIT

Project title: Toward the European Distributed Institute of Taxonomy

Instrument: Network of Excellence

Thematic Priority: Sub-Priority 1.1.6.3: “Global Change and Ecosystems”

WP 5.7.

D5.51 (formerly D5.2.4.1)

**Draft list of suitable communication / work group tools for platform
environment**

Due date of deliverable: Month 14

Actual submission date: Month 14

Start date of project: 01/03/2006

Duration: 5 years

Organisation name of lead contractor for this deliverable:

Freie Universität Berlin, Department Computer Science

Networked Information Systems

Lutz Suhrbier, Marko Hasaric

Revision [final, 1]

Table of Contents

1	Preface.....	4
2	Communication Tools.....	5
2.1	Email.....	5
2.1.1	Popular applications.....	5
2.2	Mailing-Lists.....	5
2.3	Newsgroups.....	6
2.4	Web Forums.....	6
2.4.1	Popular platforms or forums.....	6
2.5	Chats.....	6
2.5.1	Popular applications.....	7
2.6	Voice over IP.....	7
2.6.1	Popular applications.....	7
2.7	Video Conferences.....	7
2.7.1	Popular applications.....	8
2.8	Shared Storage.....	8
2.8.1	Popular platforms & resources.....	8
2.9	Group Ware.....	8
2.9.1	Popular products.....	9
2.10	News feeds.....	9
2.10.1	Popular Software.....	9
2.11	Blogs.....	9
2.11.1	Popular Platforms.....	10
2.12	Folksonomies (Tagging).....	10
2.12.1	Popular platforms.....	10
2.13	Collaborative Text Editing.....	10
2.13.1	Popular Applications.....	11
2.14	Content Management Systems.....	11
2.14.1	Popular Platforms.....	11
2.15	Wikis.....	11
2.15.1	Popular platforms.....	12
2.16	Mashups.....	12
2.16.1	Popular platforms.....	12
3	Communication Tool Requirements.....	13
3.1	Document Management.....	13
3.2	Project Coordination.....	14
3.3	Content Management.....	14
3.4	Work flow Integration.....	15
4	Evaluation of suitable platforms for Communication Tools.....	16
4.1	Content Management Systems.....	16
4.1.1	Drupal.....	17
4.1.2	Typo 3.....	18
4.1.3	eZPublish.....	20
4.1.4	Joomla.....	21
4.1.5	Plone.....	22
4.2	Wikis.....	24
4.2.1	TikiWiki.....	24
4.2.2	TWiki.....	25
4.2.3	JSPWiki.....	27
4.2.4	XWiki.....	28

4.3	Web Operating Systems (Web OS).....	29
4.3.1	eXoPlatform.....	29
4.3.2	eyeOS.....	30
5	Conclusion (Recommendation).....	32
6	Bibliography.....	33

1 Preface

The task of EDIT work package 5.7 is to “Identify suitable communication tools as platform components and provide test implementations for perusal of work package 6 and (in close cooperation with Operation 7.3.) WP7”. The aim of this deliverable is to draft a list of suitable communication tools for platform environment first. Second, requirements for a suitable platform environment have to be researched and defined. Third, a selection of suitable platform has to be investigated and evaluated regarding the formerly defined requirements. Finally, the results of the evaluation process have to be concluded and should lead in a recommendation regarding the platform to be selected.

Along with these aims, the following sections start with an overview of currently available communication tools in the Internet. Next, a subsumption of the given requirement evolved from the present interview results of the work package 6 modellers is given. Then, the results of the evaluation process regarding a suitable platform environment for communication tools is presented. Finally, the results of the evaluation process are analysed and a final recommendation is deduced.

2 Communication Tools

Since the first steps of the Internet communication between people was one of most fascinating usages of this medium. Nowadays, system engineers and software developers created a lot of techniques and applications improving all our lives. This chapter aims to present an overview of currently available and popular communication tools. The next sections shortly introduce the main features of the following tools:

- Email
- Mailing-Lists
- Newsgroups
- Web Forums
- Chats
- Voice over IP
- Video Conferences
- Shared Storage
- Group Ware
- News feeds
- Blogs
- Folksonomies (Tagging)
- Collaborative Text Editing
- Content Management Systems
- Wikis
- Mashups

2.1 Email

Email is the classic communication form over the internet, almost known since the first days of the internet itself. It can be simply described as an electronic form of the classic paper based mail system. Each user has its own address under which he can send and receive messages. These mails are delivered over the internet via several mail servers using the SMTP protocol [1] and finally stored on the server corresponding to the receiving address. There, emails can be managed remotely with email clients using the IMAP protocol [2] or simply fetched to the local machine (POP3 [3]). Email provides a mechanism for attaching arbitrary files to the message, which will also be delivered to the receiver. Many mail providers limit the size of these files, often to 4 MByte. The space for incoming messages is also limited. Usually, a client software like Microsoft Outlook [4] or Mozilla Thunderbird [5] is used for reading and composing mails. But, today many providers offer web interfaces accessible with an ordinary web browser.

2.1.1 Popular applications

- *Microsoft Outlook [4]*
- *Mozilla Thunderbird [5]*

2.2 Mailing-Lists

Based on the email system, a form of group communication exists nearly as long as the medium email exists, called mailing lists. Users either subscribe themselves with their email addresses on the list or

were added as part of the management tasks of closed communities or groups. Any email written to the email address of the list is then delivered to each subscriber by a server managing the list.

The list requires an administrator responsible for adding and removing users and setting a topic. The messages are often stored in an archive for reading them later, even if someone has deleted his messages or accessing them with a browser. Thus, a possibility of discussion between several people is provided by this medium.

2.3 Newsgroups

Newsgroups are similar to the mailing list system, but use a different approach. A newsgroup is a repository for messages posted by many users on different locations. Usually e-mail is used for posting new messages. These messages are sent to the news server and stored for further access. Many news servers provide a web page for accessing or searching for messages. Otherwise, a newsreader client is needed which is integrated in most popular mail readers or web browsers.

Newsgroups are ordered hierarchically to find related topics easier. So, newsgroup names starting with “*comp.**” comprise computer related topics or “*sci.**” for scientific topics. They are separated further into more specific groups. In distinction to mailing lists, new postings are not sent to the subscribers, they have to check new postings by themselves. Sometimes, a notification email announcing new content is offered.

2.4 Web Forums

Web forums offer a similar functionality as newsgroups for discussing. Technically they are completely different and provide a broader functionality. Web forums are suitable for discussions first, but may also be used to publish content or arbitrary files. Web forums are web applications and are accessible with an web browser.

Forums subdivide themes into different sub-forums which are further separated into different threads. Some modern web forums provide a simple syntax to ease formatting content or adding media. Typically, forums are moderated and therefore cleaned from off-topic threads or closed by moderators (e.g. if the discussion concern illegal statements or provides illegal content). All threads remain on the server for further reading or editing by the creator or moderator.

2.4.1 Popular platforms or forums

- *PHPBB [6]*

2.5 Chats

Chats are computer based symmetric (real-time), direct conversations between two or more persons (ICQ [7], AIM [8], MSN [9]) or a multiplicity of people joining into so called chat rooms. Usually, chats consist of text-based messages directly transmitted to all communication-partners when writing is committed by the author.

Unlike asymmetric types of communication (e.g. email, web forum or newsgroups) chats require all communication partners being on-line simultaneously. So, even if one partner leaves the computer, he still receives messages as long as its client is activated (called idling). But, the other partners do not know that he has left.

The classic form of chats are Chatrooms based on the IRC protocol [10]. Therefore, each participant requires a compatible client connecting to an IRC-server. Some clients provide build-in commands

introducing a simple syntax alleviating users to learn the standard syntax of the IRC protocol. Usually, IRC servers offer several Chatrooms with different topics where users can join. These rooms are managed by moderators called operators responsible for on-topic discussion. An moderator can delegate these tasks to other moderators.

Today, instant messengers are preferred by users. These clients provide point-to-point connections between two partners, although conference chatting is supported by e.g. MSN. Users manage their contacts maintaining contact within these clients. Additionally, clients often support functionality for sending and receiving files.

2.5.1 Popular applications

- *Windows Live Messenger [11]*
- *ICQ [7]*
- *Trillian [12]*
- *Xchat [13]*
- *MIRC [14]*

2.6 Voice over IP

Voice over IP is the technical term describing spoken conversation through IP-based networks. They are the counterpart of telephone calls, where the communication partners are connected via the Internet. Voice based conversations require a higher bandwidth in comparison to text-based communications like chats or e-mail. To drive these conversations, a special client software is necessary. Often, these clients offer additional functionalities than voice conversations like chat function or file transfer. Today, two mainly used clients each based on proprietary protocols exist:

- Skype
- TeamSpeak

Skype uses a HTTP-based protocol, so it has no connectivity problems caused by firewalls. In comparison to other VoIP software, Skype offers a very good voice-quality and supports conferences up to 5 persons without quality loss. Also, there is a special syntax to integrate Skype commands into websites via so called anchors.

TeamSpeak uses a different approach and requires a server where all clients have to connect. This may raise problems to use TeamSpeak behind firewalls. In comparison to other systems like Skype, TeamSpeak needs a smaller bandwidth and provides for conferences up to 32 persons. Furthermore, it supports sending of chat messages, but no file transfer functions. Accompanied by the smaller bandwidth requirements, TeamSpeak's audio quality is reduced, but there are new bandwidth-optimized codecs on the way proposing a better quality.

2.6.1 Popular applications

- *Skype [15]*
- *TeamSpeak [16]*

2.7 Video Conferences

Video conferencing extends VoIP communication by simultaneously transmitting real-time visual information. Some platforms support sharing of application or other data also. Video conferencing requires additional hardware like video cameras, microphones or speakers and a very high network

D5.51 Draft list of suitable communication / work group tools for platform environment

bandwidth when conferencing with multiple communication partners.

The client opens a single connection to each partner (TCP-protocol [17] does not support support multicast) increasing the bandwidth needed by each additional participant. Current video codecs can not compress videos in real time with normal (desktop) computing power, thus the video size is often limited to a very small size. Furthermore, network interferences may cause transmission lags leading to unsynchronised voice and image streams.

There are several different protocols standards like H.323 [18], H.320 [19], T.120 [20] or SIP [21].

2.7.1 Popular applications

- *Netmeeting* [22]
- *Skype* [15]
- *OpenH323* [23]

2.8 Shared Storage

The term shared storage determines a server, where several users can up- and download arbitrary files using a browser. Usually, those servers are managed and accessible from anywhere over the Internet.

The classic type of these storage servers use the File Transfer Protocol(FTP) [24], which is up to now one of the most efficient methods transferring files. Although most web browsers provide rudimentary support of the FTP protocol, exploring the protocol's full potential requires special client software. FTP supports several access control mechanisms.

Several internet provider offered some limited amount of storage space (called web space) for free. Nowadays, this web space is often combined with other "socialising" web applications (e.g. picture galleries, friendship networks) but accessible via web browsers. Larger amounts of space may cause to pay fees. Uploaded content may be protected by logins on user name/password base. Some platforms support group management also.

An interesting alternative represents the WebDAV protocol [25]. The protocol is an extension the HTTP-protocol and integrates web storage as network resource e.g. into Windows XP, Apple or Linux operating systems. Furthermore, WebDAV supports versioning of files (e.g. in combination with the Open Source tool *Subversion*), despite lacking some features like e.g. commenting on new versions. WebDAV supports the integration access control mechanism e.g. of the Apache web server.

2.8.1 Popular platforms & resources

- Web space
 - *Rapidshare* [26]
- Subversion
 - *Subversion* [27]
 - *Tortoise* [28]
- WebDAV [25]

2.9 Group Ware

Group ware, also called collaborative software, is software for planning and supported distributed teamwork over the Internet. Most group ware tools integrate several communication tools like E-Mail, VoIP or Instance Messengers. In addition, they provide personal information manager functionalities

D5.51 Draft list of suitable communication / work group tools for platform environment

like (group)calendars, contact and project management, notebook, news board etc. or data synchronisation with Personal Data Assistants (PDA). Also, a basic functionality is document management (up/download of arbitrary files). Some tools provide collaborative (simultaneous) editing, versioning or What You See Is What You Get facilities on these documents.

Concerning basic project management skills, Trac is an easy to use alternative to complex group ware applications. It provides a Wiki engine and minimal task management features like e.g. ticketing or tracking.

2.9.1 Popular products

- Lotus Notes [29], Groupwise [30], Microsoft Exchange [31], Microsoft-Sharepoint [32], BSCW [33] (commercial)
- Kolab [34], OpenGroupware.org [35], Open-XChange [36](freeware)
- Trac [37]

2.10 News feeds

News feeds represent data formats like Atom [38] or RSS [39] serving frequently updated content to users. So, dynamic websites like Blogs or web forums offer news feeds for subscription, so that any subscriber will automatically be informed on any new content on the website, without checking the website themselves frequently.

For that, users simply subscribe to the news feeds of their choice using an aggregating software and will receive new content whenever a site will be updated. Typically, feeds are delivered in HTML [40], so modern web browsers and mail client support news feeds. Sites supporting news feeds can be identified with the following icon:



figure 1: News feed icon

2.10.1 Popular Software

- *Mozilla Firefox [41]*
- *Thunderbird [5]*
- *Internet Explorer [42]*

2.11 Blogs

The term Blog is the short form of Web log and determines a user generated, journaling style website. Often, Blogs provide news or comments about specific topics or serve as a kind of on-line diary in the web.

In general, Blogs offer a simple syntax like Wikis, to ease publishing of content for users with small web experience. They combine text, images, other media or links to other Blogs or websites, so any kind of content may be aggregated into a Blog. The design is provided by templates selectable by the user.

Usually, the editors of a Blog (called “Blogger”) frequently generate new content and offer news feed subscription to keep their users up to date.

2.11.1 Popular Platforms

- *Technorati [43]*
- *BoingBoing [44]*
- *Google BlogSearch [45]*

2.12 Folksonomies (Tagging)

Folksonomies are user generated taxonomies used to categorise websites, images, documents, videos etc. Several people "tag" the content with their vocabulary. The intend is to make the media easier to search, since the information grows over the time and a human readable vocabulary is used for categorizing. This vocabulary follows no specific definition, each user tags the content with its own words. The vocabulary grows over the time and the categorisation of the content becomes finer. Persons can search by tags or for a specific author. Problems of tagging are the use of different expressions for the same content, the use of native language for tags or the ambiguity of words. So, the search can follow some weird results or does not find all relevant tags (e.g. the English term “sunset” compared to the German term “Sonnenuntergang”). Therefore, the Darwin Core standard [46] offers well-structured general taxonomy of expressions, which may be a good starting point to build up more specialised folksonomies.

2.12.1 Popular platforms

- *Delicious [47]*
- *Connotea [48]*

2.13 Collaborative Text Editing

Collaborative text editors support multiple authors editing the same document simultaneously or sequentially. Any participating author can modify any part of the edited content.

Particularly in simultaneous environments, text is edited in real-time by different authors and text is highlighted in different colour per author. This show which author is currently working on which part of the document. In sequentially working systems, the document can only be edited by one author at time and is blocked for other authors.

Usually, the current state of the document is versioned when saved by any author. So, any state of the document may be recovered later. Some web based applications like Google Docs & Spreadsheets support import and export of common document formats like Microsoft Word or Open Document [49]. Other only support editing of unformatted text.

2.13.1 Popular Applications

- *MoonEdit [50]*
- *Gobby [51]*
- *Google Docs & Spreadsheets [52]*
- *Zoho Office Suite [53]*

2.14 Content Management Systems

Content Management Systems (CMS) are on-line platforms supporting creation and editing of documents or other media such as images or videos. Often, they support the collaborative work on the same content also and concern about the consistency and organisation of these documents.

A special type of CMS are Web Content Management Systems (WCMS). They are suitable to publish a large amount of Websites. A further benefit of WCMS is the strict separation of content and design. The design is usually defined within templates, which can easily be exchanged. In general, users are not required to have special knowledge in creating websites, since they either provide a simplified syntax to aggregate site elements or have a built in What You See Is What You Get(WYSIWYG) editor. Technically, WCMS base on a database storing website content and other media. Often, a version control is offered also. Furthermore, multiple content languages are supported and following the design determined within templates.

Because of the modular design of many WCMS, existing websites can easily by upgrades with new functions. Additionally, access control and fine granular access rights management for users and groups were supported in modern platforms. But, a WCMS is more a website maintenance tool than a website creation tool.

2.14.1 Popular Platforms

- *Plone [54]*
- *Drupal [55]*
- *eZpublish [56]*
- *Joomla [57]*
- *Typo3 [58]*
- *OpenCms [59]*

2.15 Wikis

Wikis are websites, which allow users to add, edit and remove content in form of articles. These articles are dynamically rendered as HTML-pages. Wikis support a very simple syntax, which eases the creation of documents even for users with a small programming knowledge. In general, Wikis are easier to handle than content management systems or simple web pages.

Any change in the Wiki articles is versioned and such recoverable at any point later in time. Also, they provide an easy to use link mechanism among Wiki pages. The editing process is done using a common web browser. So, no additional software is required and Wikis are easy to use tools for collaborative editing of web content.

Firstly, Wikis were platforms for open community content editing, disregarding authentication and access control. Everyone could edit the sites or create new ones. Today, modern Wikis support a fine granular and role based access control. They support a plug-in interface, which makes them highly extensible for new features like e.g. the integration of any other communication tools (Instant

D5.51 Draft list of suitable communication / work group tools for platform environment

Messenger, E-Mail) or the export of documents in an other format like TeX [60] or PDF [61].

2.15.1 Popular platforms

- *TikiWiki* [62]
- *TWiki* [63]
- *JSPWiki* [64]
- *MediaWiki* [65]
- *XWiki* [66]

2.16 Mashups

Mashups are websites (re)combining content from more then one source to a new content aggregation. The term is often used in Web 2.0 context, where different types of web content like text, images and videos generate a new "web experience". So, many web portals combine e.g. Google-Maps [67] with other content like images or addresses.

Content is sourced from other websites using public interfaces like Web feeds or SOAP [68]. Popular Mashups use e.g. the APIs from eBay [69], Amazon [69], Google [70] etc. to enlarge the functionality of their web site. In combination with asynchronous web concepts like Ajax [71], Mashups lead to the development of a new generation of web portals ("on-line desktops", "web OS"), integrating several content sources into web applications with the look-and-feel of an ordinary pc-desktop.

2.16.1 Popular platforms

- eyeOs (GPL) [72]
- Netvibes [73]
- Pageflakes [74]
- YouOs [75]
- Windows Live [73]

3 Communication Tool Requirements

The chapter above presents a large catalogue of established and modern kinds of communication tools. These tools address various as well as somewhat specialised communication skills. Thus, to evaluate those tools providing significant improvements of cooperation issues for taxonomists, further information concerning their current work flow and conditions as well as their proposals for future enhancements would be indispensable.

Currently, requirements identification founds on the following input documents:

- Communication Tools for Taxonomy – Planning a Cyber-Communication Platform [76]
- Revisionary Models [77]

The first document presents some possible scenarios, where the implementation of communication tools seems to make sense. The latter evaluates models from interviews with taxonomists and describes their current work flow and software applications being used.

Based on these documents, we deduced some general requirements on communication tools for taxonomist. The subsequent sections define and comment on these requirements. For that, the requirements are partitioned addressing the following issues:

- Document Management
- Project Coordination
- Content Management
- Work flow Integration

3.1 Document Management

The evaluation of the taxonomic work flow models shows that most of the activities of the taxonomists target at the publication of documents (e.g. scientific papers, monographs). Furthermore, exchanging these documents via email appears to be the main communication tool used for this purpose. Some taxonomic groups are extensively including high-resolution images within their documents, demanding an high amount of storage space. Usually, common internet providers limit the maximum size of email attachments. So, exchanging documents by email becomes a very uncomfortable task.

Therefore, the provision of the following document management facilities is a useful and highly requested feature:

- Up/Download of any kind of (large) documents
- Version control
- Annotation of meta-data
- Role Based Access Control

Up and download facilities of potentially large documents are prerequisites to alleviate exchanging large documents comparing to email communication. This service should be accessible via internet and should provide version control, that is a functionality permitting to recover any version of the document stored on the platform before.

Document annotation means that the platform offers measures to describe the content of stored documents, such as text annotations, community-wide tagging or semantic classification features. In particular, image annotation is a demanded feature from [76], which means facilities to highlight interesting image details introducing e.g. pointers or circles and store them as meta-information within the image file.

D5.51 Draft list of suitable communication / work group tools for platform environment

Finally, the platform must provide measures to protect documents against unauthorised access e.g. to keep the secrecy of new species before they are published officially. This affects not only the authentication of users, but the definition of access rights policies for groups(roles) also.

3.2 Project Coordination

Another characteristic of the taxonomist's work flow deduced from the interview model is that they tend to dynamically constituting communities or group working on specific research topics. These topics may consist of e.g. the analysis of new species organising field trips or the revision of known species groups. Therefore, a platform may be useful providing community, group or project related support of

- address books
- calendars
- task/project management

Address books serve to manage on-line all relevant contact information related to the different groups or the whole taxonomic community as well. Personal or group calendars may support on-line planning of meeting, conferences or field trips. The latter may demand high preparatory efforts which could be supported providing an on-line task management system (e.g. a ticket system).

3.3 Content Management

Besides the coordination aspect of dynamically constituting taxonomic work groups, taxonomists may want to set up web representations for

- communities
- groups
- projects or
- single users

These web representation may be used for (group-)internal communication or cooperation purposes or to represent the group and their research to the public. Cause taxonomists can not be supposed as computer experts, they need an easy-to-use system to manage all the content they like to publish or share with others. Such content management system should integrate group or community-wide facilities such as

- document management
- project coordination
- cooperate editing of documents

The first two points mean that the content management platform should provide measures enabling groups to easily integrate features like annotated document stores, discussion forums, group calendars or task management skills within their web representations. Additionally, groups have to be enabled to define access control policies for the provided content.

The latter call for platform functionalities providing features like

- collaborative document editing
- import/export of documents
- bibliographic support (e.g. scientific publications)
- access to document management facilities

Collaborative document editing describes the synchronous or asynchronous process enabling multiple authors creating or modifying the same document together. Currently, the mainly used work flow

D5.51 Draft list of suitable communication / work group tools for platform environment

creating documents consist in distributing Word files via email and use Word's track change mechanisms to integrate modifications of co-authors. The aim of the platform should be to introduce mechanisms allowing users to edit documents on-line and to import and export documents (partially) for off-line editing.

Regarding import and export facilities the platform should realise or at least support a round trip work flow of documents or parts of it. Thus, documents may be edited off line and imported later to the platform. Additionally, documents may be edited cooperatively on the platform and exported later for off line editing. This requires, that methods must be evaluated, which enables users to import and export documents without losing any significant information(e.g. formatting styles).

The modeller's interview results show that taxonomists mainly produce Microsoft Word Documents (e.g. monographs, manuscripts). Thus, the platform should support this or other Microsoft Word compatible tools. Also, it should be possible to generate and export printable documents (e.g. PDF).

Finally, the work in progress should be accompanied by methods for annotating, commenting or simply discussing any part of the document. This may be achieved in a common approach with the integrated access to the document management facilities sketched above.

3.4 Work flow Integration

One of the main tasks of the EDIT Work package 6 group is to map the taxonomic work flow derived from the models on existing applications and to discover missing functionalities. This is work in progress and the following figure sketches out the current state modelling state.

The communication tools are an integrating part of the model. This means that the platform must be enabled to integrate work flow components like repositories, data warehouse, analyser or mark-up engines. In a supposable scenario communication tools might import documents from the data warehouse, modify it using collaborative document editing facilities (discussion, comments), validate the modified version of the document using the analyser component and rewrites the final version to the data warehouse.

For that, the platform has to be extensible and must provide interfaces to integrate additional functionalities. These interfaces should enable software developers to adept the platform to the work flow conditions or to develop and install additional applications.

The current draft supposes that all work flow components will be attached to the system using web services based on the SOAP protocol [78] and defining interface using the WSDL standard [78]. Therefore, the platform has to provide basic interfaces or APIs enabling platform internal application to address these web services. An advantage of the implementation of web service based work flow components is that specialised, platform external tools (e.g. Greuther tables) will be able to address these components too.

4 Evaluation of suitable platforms for Communication Tools

Among the different types of available communication tools outlined in chapter 2, the following types are supposed to comply with the requirements evaluated within the last chapter:

- Content Management Systems (CMS)
- Wikis
- Web Operating Systems(Web OS)

The following sections provide an overview of a selected set of system platforms. Today, a lot of CMS and Wiki systems have been developed particularly. Thus, to evaluate suitable platforms we used the following catalogues to compare and preselect appropriate systems for further evaluation steps according to the sketched requirements:

- WikiMatrix [79]
- CMSMatrix [80]

Web Operating Systems are quite new on the market. Additionally, most of them are in beta state currently. So, we researched them using search engines or from actual articles of common computer magazines.

Furthermore, the selection focus only on Open Source systems, which can be used for free and can be subject of adaptation whenever needed.

Finally, all selected platforms include, support or can be extended in order to provide the following communication tools:

- creation of web pages
- forums
- comments
- news feeds
- Blogs
- Wiki-like features

The next sections cover the evaluation of these preselected systems grouped by platform types. The evaluation process is geared by the list of communication tools requirements and discusses to what extend they are satisfied.

4.1 Content Management Systems

The website CMSMatrix lists more than 700 CMS systems. Most of them could be excluded cause of security requirements. The remaining set was manually filtered through information found at Wikipedia [81] or by visiting their web representations. Finally, the research reduced the set of candidates to the following, quite popular platforms:

- Drupal
- eZPublish
- Joomla
- Plone
- Typo3

The following sections evaluate the candidates stated above regarding the requirement for communication tool platforms.

4.1.1 Drupal

License: Free (GPL)

Language: PHP

URL: <http://drupal.org/>

Version: 5.1 (29/01/2007)

Besides the customary features of content management systems, Drupal features the build-up of Communities through the realisation of social software aspects like Blogs, forums or collaborative editing. Accompanied by fine granular role based access rights management system, Drupal provides a very flexible system architecture. The architecture consists of a core system providing the basic system functionality, which can be extended through modules. Other highlight are the multi-site capability, providing the installation of isolated sites within one installation, a taxonomy system offering categorisation of content and the integration of AJAX-facilities (since version 4.7).

Document Management Features

Drupal supports uploading of any kind of files to the site through the core module "Upload". Individual content types can be enabled or disabled, file attribute like size limits may be defined per user role defaults and other fine granular access control rights may be specified. Several contributed modules provide the integration of various file management features.

Drupal organises content in form of nodes. Any kind of content like documents, comments, forums represents a node within the Drupal terminology. Any node is submitted to version control and can be recovered.

The Drupal core module "Taxonomy" provides comprehensive support for categorisation and classification schemes for every node. This includes free tagging, hierarchical classification up to the definition of vocabularies, thesauri and folksonomies.

The content retrieval of classified content will also be supported by the (also) comprehensive core module "Search" and a lot of other contributed modules.

The Drupal core itself supports access control on node level. The definition of access rights can be specified for users, groups and roles. The latter can be assigned to users and groups.

Additionally, Drupal provides the concept of organic groups. This means, that any user or group can define and manage own groups and assign access rights to them (within the limit of the access rights of the defining user/group).

Drupal provides an own authentication mechanism based on user name/password. Furthermore, there are contributed modules supporting authentication against LDAP servers or inheriting the results of any authentication mechanisms provided by the Apache web server [82].

Regarding single sign-on facilities there are Drupal modules available supporting a simple Drupal-to-Drupal SSO mechanism "Single Sign-on" as well as the module "CAS" supporting the Central Authentication Service [83].

Project Coordination Features

Besides the simple "AddressBook" module, there are two other contributed modules supporting address books.

First the "CivicCRM" module provides a wide range of customer relationship management facilities to

D5.51 Draft list of suitable communication / work group tools for platform environment

manage community contacts. Second, the "LDAP AddressBook" module manages address books stored on LDAP server, enabling further usage of the contact information with other applications.

Drupal support basic calendar functions within the "Calendar" module. Besides this, there is the "WebCalendar" module integrating the well-known WebCalendar [84] into Drupal. The latter supports group calendars as well as PDA synchronisation also.

There are two modules providing project management functionalities. First, the "Project" module comprises a set of tools for providing functionality for managing and carrying out collaborative projects. But the main focus of these tools is on software development projects. "Case Tracker" is another module dealing with task management. Its focus is more on issue tracking and is an rewrite of the "Projects" Module.

Drupal's "multi-site" feature supports hosting of several websites with different domains also.

Cooperative Document Editing Features

Collaborative work on documents is supported by Drupal's "Book" module. This module provides merging of any pages or articles into a single document. So, simultaneous work can take place on different parts of the document, but not on the same part (article). A module supporting simultaneous real-time text edition on the same text area is currently under development ("Collaborative Editor"). Drupal offers various mechanisms to assist inexperienced users creating content:

- WYSIWYG editors
- BBCode syntax
- Wiki support

There exist several modules offering WYSIWYG text editing, where the TinyMCE editor [85] appears to be the most supported. Using the BBCode module, Drupal offers a simple syntax and easy to learn syntax (similar to Wiki syntaxes) enabling users to create content quickly. Finally, there is an ongoing project working on a module ("Wiki") integrating wiki features into the Drupal system.

Regarding import and export of documents there is a module called "Import/Export API" supporting basic formats like XML [86] and CSV [87]. Actually, this API is beta mode. So, this API can be used to develop filters for any document format. There are some other modules offering the export of documents (e.g. books) into formats like PDF[61], DocBook [88], or Drupal specific formats to support backup or import of some content types of Drupal nodes.

Using the "Biblio" module, Drupal supports management and usage of bibliographic information e.g. within books.

Due to Drupal's universal node concept, any node can be linked with any other node or function within Drupal.

Conclusion

Basically, Drupal appears to satisfy all requirements on a communication tools platform more or less. The most obvious flaccidities concern the import/export facilities to support off line editing and reintegration of documents edited in collaboration. The strengths are the open and flexible concept, extensibility via modules, easy usage and administration, a quite good documentation and the wide support of developers.

4.1.2 Typo 3

License: Free (GPL)

Language: *PHP*

URL: *<http://www.typo3.com/>*

Version: *4.1 (06/03/2007)*

Typo3 is a PHP and MySQL [89] based Content Management System for medium to large sized Websites. It provides some core functionalities and can be easily adapted to specific situations with plug-ins called extensions. Over 2000 extension exists like Web forums, Wikis and Blogs but often compatibility issues occur between these extensions. The system is divided into a front- and a back end. The front end is the user visible part of the site and the back end, only visible to editors and the administrator, used to manage the content of the site. The editorial part requires only a couple of hours to train, since a Rich-Text editor with a Word-like handling is offered, but for Website-Developers the access requires much more time, because the TYPO3 syntax called Typo-Script has to be learned. Design is done by templates, which can be adjusted or completely created new.

Document Management Features

TYPO3 has an extension, which allows users to upload or download arbitrary files. It even allows to specify the path under which the file can be stored and the maximum file size. The administrator can specify the allowed file-types by setting up the allowed mime-types in the extension. No fine user control is provided like Drupal offers.

TYPO3 offers an unlimited versioning of content. This content is stored in an internal database and every change is saved. So an unlimited history is provided and you can "undo" every change.

The TYPO3 extension Digital Asset Management (DAM) provides the possibility to attach meta-data to uploaded files. DAM replaces the normal file upload and provide a search-engine for tagged media. TYPO3 has a built-in meta data functionality. Each page can be tagged with meta-data, even in different languages.

TYPO3 provides a user name/password authentication. With the appropriate extension, an LDAP Authentication is offered. Administrators can grant as little or much control to users or groups as needed. They can add or remove extensions for different users or groups as needed.

Project Coordination Features

TYPO3 offers an address book functionality with the extension Partner Management. Partner Management handles anything related to a person like name, phone number and addresses. It even has the possibility to maintain the relationships between several people (like "is member of" or "is supervisor of"). The content of the address book can be exported in XML or PDF.

For TYPO3 exists several calendar extension. Each of them offer a basic calendar functionality, but some have a richer feature set like recurring dates or export to PDAs.

There exists one extension for project management called Project Management Suite. It has built in features to create a project plan and split it into smaller tasks shown in a time line. These tasks can depend on each other and several people could be assigned to them. The other extension is User Task Centre. It provides a list of To-do-Items and can be extended with a work flow diagram.

Multiple sites can exist in one TYPO3 installation and database. Multiple domains can point to one TYPO3 site within the same database and installation. They can be attached to other sites in the database, too.

Cooperative Document Editing Features

TYPO3 does not support a collaborative creation of content. This can only be done indirectly with the WIKI - extension. It has a built in WYSIWYG editor, but it only shows a small warning message, if several people work on the same content. So data-loss is possible. The only WYSIWIG editor is tinyMCE, mentioned in Drupal and only one WIKI extension exists with an easy to learn syntax.

With help of external tools, TYPO3 can read PDF - and Microsoft-Word [90] documents. It has a build-in RTF [91] engine which can be used for creating RTF-documents. There are some extensions which allow sites to be exported in formats like PDF or HTML.

TYPO3 has a built in Link-management, which makes it easy to link pages and documents. It ensures, that no "broken" links are within the system. If a page is moved or deleted, it will point the links to the new location or remove the links, so only the text or image will remain on the website.

Conclusion

TYPO3 does not satisfy all of the requirements, since a collaborative editing of articles is not offered directly. The learning time for developing new features is much longer than Drupal and the compatibility of all required abilities of this platform is not assured. The strength of this platform is the import of Word and PDF documents and a very active community behind this project. Even some big companies use TYPO3 as their web presence. But because of our requirements, Drupal seems to be the better choice as CMS than TYPO3.

4.1.3 eZPublish

License: *Free (GPL)*

Language: *PHP*

URL: *<http://ez.no/>*

Version: *3.9.1 (14/03/2007)*

eZPublish has an interesting licensing model. It is available as well as open source under the GPL licence, but there are also supported licenses available including automatic updates and professional support. eZPublish builds up on an object oriented model including class definitions. Content is organised within a special content node class. Nodes can be interlinked and new object classes can be implemented when needed. Currently, there is a new API in development, permitting to use powerful eZPublish functions. This can also be addressed as web service via SOAP. Furthermore, there are several extensions integration AJAX functionalities.

Document Management Features

eZPublish supports uploading of any kind of documents. This can be done also via the WebDAV protocol and can be configured such as uploaded documents will be published immediately.

Version control applies to any object within the eZPublish system.

Meta-data annotation is mainly supported by the "keyword" feature, which may be assigned to any object. The "ezLabel" extension provides a way to label objects with self defined catchwords. Additionally, there is an extension in development managing the assignment of categories to objects.

eZPublish has a built-in role based access control system basing on users, groups, roles and policies. Groups consist of users or groups. Roles can be assigned to users and groups and consist of a set of policies. A policy is a rule defining access rights to specific functions or modules. Authentication can be

D5.51 Draft list of suitable communication / work group tools for platform environment

done against the eZPublish built-in system, LDAP server or text files similar to *NIX systems. The "Smile CAS" extension provides integration of the CAS single sign-on service into eZPublish.

Project Coordination Features

eZPublish has an built-in address book application. There is an existing extension permitting to integrate the open source CRM system SugarCRM [92].

There are several calendar applications extensions available, where the most advanced "ezAgenda" is included in the system kernel now.

It appears, that there is no explicit issue tracker or project management application extension for eZPublish. But, it incorporated a very powerful work flow component, which is addressed by a graphical editor extension.

eZPublish supports multi-site installations as well as cluster installation over several web servers.

Cooperative Document Editing Features

Collaborative content editing is mainly supported by the including versioning system. eZPublish offers a powerful WYSIWYG editor and supports round trip conversion of Open Office [91] and Microsoft Word Documents. Those documents can be edited directly using the WebDAV capabilities of eZPublish, i.e. editors can load content files directly into e.g. OpenOffice or Microsoft Word via the attached network folder.

eZPublish supports import and export of OpenOffice and Microsoft Word documents. This is done integrating the corresponding conversion library from the open office suite. Furthermore, PDF export is supported providing the configuration of some layout options.

eZPublish has no special bibliographic support.

Within eZPublish, any (content) is connectible to any other object in the system.

Conclusion

Except for bibliographic support, eZPublish meets all requirements on a communication platform. A big highlight are the import and export facilities for Word and OpenOffice documents. So, also web aware users can easily contribute content on websites. Other strengths are the WebDAV features, the role based access control system and the accessibility of API functions via web services currently in development. Regarding the available, powerful WYSIWYG editing and document management facilities, the poor support of Wiki functions (beta status since more than one year) is neglectable. Furthermore, the system is relatively easy to install, maintain and well documented.

4.1.4 Joomla

License: *Free (GPL)*

Language: *PHP*

URL: *<http://www.joomla.org/>*

Version: *1.0.12 (23/12/2006)*

The Joomla website proclaims this CMS itself as the "most powerful Open Source Content Management Systems on the planet. It is used all over the world for everything from simple websites to complex corporate applications. Joomla! is easy to install, simple to manage, and reliable."It emerged

D5.51 Draft list of suitable communication / work group tools for platform environment

from the former Mambo project, so Mambo version 4.5.2.3 becomes Joomla 1.0

Document Management Features

Joomla supports file management including up/download of large documents with the extensions joomlaXplorer or Jxplorer (only for Joomla v1.5).

Joomla version control system does not cover any kind of content(e.g. files). This shall be revised in future versions.

The extension "iJoomla Metatag Generator" seems to widely support meta-data annotation and tagging of content.

Initially, Joomla distinguishes only seven predefined user groups. There is an extension called "JACLPlus" enabling to create new users, user groups and access levels. Regarding authentication, besides the built-in user database, there is an extension in beta state called "LDAP Tools" providing LDAP user authentication, synchronisation and single sign-on. Furthermore there is an extension support for RADIUS server authentication [93]. The whole authentication and access control system shall be revised in future versions.

Project Coordination Features

Joomla has several contact management and community builder extensions.

There are more than twenty different calendar applications extensions available. There is also LDAP support, which will be enhanced in version 1.5 of Joomla.

There are Joomla extensions providing task management, project management and issue tracking.

Joomla supports multi-site installations on one server.

Cooperative Document Editing Features

There is no deeper support for collaborative editing besides some WYSIWYG editors, version control for content and some wiki extension(e.g. OpenWiki or MamboWiki)

OpenOffice, Microsoft Word and PDF document can be uploaded for viewing, but not editing. Content can be exported as PDF.

Joomla has no special bibliographic support.

Any Content pages can be linked together.

Conclusion

Joomla claims to be "most powerful Open Source Content Management Systems on the planet", but it lacks on critical security functions as well as on useful collaborative tools and a complete version control. Furthermore, the documentation is very unstructured and it is hard to find the information wanted. Currently, the system is in an reengineering phase towards a new version 1.5. The aim is to improve a lot of things, hopefully the documentation too.

4.1.5 Plone

License: Free (GPL)

Language: Python

D5.51 Draft list of suitable communication / work group tools for platform environment

URL: <http://plone.org/>

Version: 2.5.2 (17/01/2007)

Plone is built on the free web application server Zope. Plone aims to be easy to set up, flexible, extensible and a content management system for project groups, communities and web sites and supports document publishing as well as group ware functions. Plone focus on professional use.

Document Management Features

Plone supports management of any kind of documents. It support the WebDAV protocol to update and edit content on-line also.

Version controls applies to any content in Plone.

Meta data is supported by the underlying CMFMetaTag Zope library. There are several plug-ins supporting keywords, Vocabularies and ontologies even.

Since version 2.5 Plone introduces a pluggable authentication service(PAS) which can be used to configure any available authentication mechanism. Plone provides a role based access control system, where permissions are assigned to roles, and users and groups are assigned to (several) roles.

Project Coordination Features

There are several Plone products supporting contact management issues(e.g. MxmContact).

Calendar and event functionality is included within Zope. There are several products addressing calendar functions.

There are several products addressing task and project management, issue tracker and connectors to external system like Trac [37].

Several sites can be run in the same Zope instance.

Cooperative Document Editing Features

Plone integrates the ZWiki engine also running on the Zope platform and all documents can be versioned. Content may be edited by Wiki-like syntax or using powerful WYSIWYG edit. For text-only purposes, there is an real-time editor extension enabling the editor JEdit [94] for simultaneous content editing. There is an product called "mxmWorkgroup" managing ad hoc work group including work flow development.

The Plone product "PloneOOoTransforms" handles any import and export functionality for Microsoft-Office, OpenOffice, PDF or TeX documents.

Plone supports handling of bibliographic reference via the CMFBibliographyAT. The main exchange format is BibTeX [95], but others can be configured.

Any Content pages can be linked together.

Conclusion

Plone appears to meet all requirements for a communication tools platform. It is assumed to be secure, has a wide community of developers and users, a lot of further plug-ins and is easy to install and maintain. Furthermore, the documentation is good, enfolding and well structured and searchable.

4.2 Wikis

The website WikiMatrix [79] lists more than 80 different Wiki platforms. Alike Content Management Systems, most of them could be excluded cause of security requirements(e.g. MediaWiki). Also, the remaining set was manually filtered through information found at Wikipedia or by visiting their web representations. Finally, the set of candidates was reduced to the following platforms:

- JSPWiki
- TikiWiki
- TWiki
- XWiki

The following sections evaluate the candidates stated above regarding the requirement or communication tool platforms.

4.2.1 TikiWiki

License: Free (LGPL)

Language: PHP/JavaScript

URL: <http://tikiwiki.org/>

Version: 1.9.7 (25/11/2006)

TikiWiki is a Wiki based Content Management System and Group ware web application enabling the realisation of websites or portals. It is a customisable modular system, where each function can be enabled or disabled. Unlike other CMS, TikiWiki is extendible via modules, but developers prefer to integrate new features into the platform to keep installation stable regarding software updates. It provides fine granular access control, where any page/function may be controlled via Access Control Lists (ACLs) supporting hierarchical groups, i.e. inheriting access right from other groups. Another feature is that every user can configure its own design themes independently from the platform.

Document Management Features

Uploading of any kind of files is supported through the file gallery module. Uploads can be commented on, but can not be versioned.

TikiWiki appears to provide versioning functions only to Wiki pages. Thus, Wiki pages recoverable, but uploaded documents are not.

TikiWiki supports hierarchical categories. This means, objects in TikiWiki may be classified by one or more categories defined by users with appropriate access rights. The content retrieval of classified content will also be supported by the search component.

The TikiWiki platform supports access control on object and function level. The definition of access rights can be specified for users, groups. Groups can be hierarchically organised i.e. groups can inherit access rights from other groups.

TikiWiki offers an own authentication mechanism based on user name/password. Furthermore, authentication against LDAP servers, web servers or operating system authentication is possible. Regarding single sign-on facilities TikiWiki also supports Central Authentication Service (CAS).

Project Coordination Features

TikiWiki appears to not support any kind of address book.

TikiWiki provides a calendar providing "channels" for users and groups.

TikiWiki just offers a simple user task application, similar to a to-do list. It can be used to define group task also, but has a basic functionality.

TikiWiki is capable to host multiple sites on a single server. Besides this, TikiWiki supports group pages as well as enables every user to assign access rights to any of his content objects, e.g. wiki pages.

Cooperative Document Editing Features

The only suitable way to edit documents in collaboration is using the TikiWiki's Wiki functionality, because this is backed up by version control. TikiWiki does not have a WYSIWYG editor. Thus, inexperienced users are assisted by the Wiki syntax only.

Documents can easily exported and imported enabling their related export and import functionality. But, the functionality is reduced to the Wiki syntax or for backup purposes. TikiWiki supports exporting Wiki documents as PDF files. It seems, that there are modules providing export/import of the DocBook format and to the OpenOffice writer. But they have limited functionalities and seem to be not maintained anymore.

There is no bibliographic support within TikiWiki.

Content can be linked with other objects in the system, but this is somewhat limited to some particular components like e.g. commenting.

Conclusion

TikiWiki does not fulfil the requirements entirely. Besides missing of some features, it is quite extensible, but it does not appear to be as flexible enough to serve as a communication tool platform. Furthermore, the available documentation seems is not detailed enough and sometimes not complete. The strength of TikiWiki is it already ready has a lot of build-in features which are easily to set up and quite comfortable to configure and to administer.

4.2.2 TWiki

License: *Free (GPL)*

Language: *Perl*

URL: *<http://twiki.org/>*

Version: *4.1.2 (03/03/2007)*

TWiki is a web based collaboration platform for document management, project development and other kind of group ware tools. TWiki stores any content as files and keeps track of these files using the versioning software RCS [96]. So, any content can be recovered. Wiki pages are organised as "webs". Webs are sub-Wikis, which are determined as areas for collaboration. Practically, this is an easy way to quickly set up group areas or subgroup areas(web pages). Furthermore, it supports access control list for any content type.

Document Management Features

Uploading of any kind of files is supported by attaching them (similar to e-mail attachments) to a wiki

page.

TWiki stores any content within files which are tracked by a version control system. So, documents are under version control also.

TWiki supports categories as a matter to relate wiki pages to each other. Additionally, the plug-in "Tag-me" provides tagging functionalities including support to build up user taxonomies.

TWiki offers an internal user/password login procedure. Furthermore, TWiki can be enabled to use any authentication mechanism supported by the Apache web server. Finally, the plug-in "LdapContrib" provides authentication against a LDAP server.

Access control can be executed on Webs, Topics and attachments, where only simple access rights like view, change, rename and manage can be assigned. Access control applies on users and groups, whereas groups can also be included in other groups.

Project Coordination Features

TWiki appears to not support any kind of address book.

TWiki provides some more or less simple calendar plug-ins. It appears that none of them supports group calendars.

There are the extensions "OoProjectPlannerPlugin" and "Action Tracker Plugin" supporting task/project management facilities. Whereas the first is a full project planning system, the latter provides the functionality of a to-do list and supports TWiki defined groups.

It appears that there is no special support for multi-site set-ups for TWiki. So, the only way to offer group specific pages is to create group specific sub webs.

Cooperative Document Editing Features

Currently The support for collaborative editing does not transcend the intrinsic wiki and version control capabilities. Installing the plug-in "RevComment" enables users to comment any newly created version of topics or file attachment. But, there are some ideas integrating of SynchroEdit [97], a browser based simultaneous multi-user editor currently in beta status. Nevertheless, TWiki supports WYSIWYG editing of content.

Documents can easily exported and imported enabling their related export and import functionality. But, the functionality is reduced to the Wiki syntax or for backup purposes. There are some plug-ins allowing users to generate PDF files from Wiki pages with some influence on the final layout.

Furthermore, there are some plug-ins and add-on supporting the export or import of Wiki pages from or to OpenOffice Writer or Microsoft Word or Microsoft Excel [98] respectively. All of them are far from being complete and so do not promise a seamless round trip editing of documents.

There is no bibliographic support within TWiki.

Content can be interlinked with other objects in the system including attachments.

Conclusion

TWiki does not meet the requirements entirely cause some basic features are missing. Despite, it appears to be quite extensible through its plug-in API and provides flexible interconnection between site element. But, the provision of missing features requires some extra efforts. One of the strengths of TWiki is the uncompromising application of versioning through the whole system. Other advantages

D5.51 Draft list of suitable communication / work group tools for platform environment

are easy set-up and maintenance tools.

4.2.3 JSPWiki

License: Free (LGPL)

Language: Java (Java Server Pages (JSP))

URL: <http://www.jspwiki.org/>

Version: 2.4.100 (02/03/2007)

JSPWiki is built upon the standard Java EE [99] components like Java, servlets and Java Server Pages(JSP) [100]. For that, JSPWiki appears being a good platform to be extended by software components depending on libraries not supported by common script programming languages. Its basic functionality comprises a Wiki software with some support for communities and document management.

Document Management Features

Uploading of any kind of files is supported by attaching them (similar to e-mail attachments) to a Wiki page. Attachment can also be managed via the WebDAV protocol.

Version control applies not only on Wiki pages, but also on page attachments. So, any state of an attachment can be restored.

JSPWiki supports categories permitting to group Wiki pages along a specific topic.

JSPWiki supports authentication using the Java Authentication and Authorization Service(JAAS) API [101]. JAAS provides integration of plug-ins performing authentication and authorisation with any available authentication or authorisation mechanism. Thus, JSPWiki's security subsystem is highly customisable. Particularly, JSPWiki can connect to the web containers authentication and authorisation mechanisms and therefore use components like LDAP, Single Sign-On, Kerberos [102] and Active Directory [103].

Regarding authorisation, users, groups and roles are supported. Groups may be defined by users on-the-fly also. Some Roles are predefined like "authenticated" or "admin", but JSPWiki can be configured to consult external authorisers (e.g. web container) to determine roles. Access rights can be defined on Wiki level and on Wiki pages, where access rights may be defined to the given functions on these objects.

Project Coordination Features

JSPWiki appears to not support any kind of address book.

JSPWiki provides a minimal "Calendar" plug-in, which may be used as group calendar on group pages only.

Besides the simple "ToDoList" plug-in, JSPWiki comes with the "WikiProject" providing a basic project/task management plug-in, integrable on any Wiki pages.

JSPWiki can be set up to support multiple sites on the same server. For that, some configuration within the web container have to be done.

Cooperative Document Editing Features

Currently The support for collaborative editing does not transcend the intrinsic Wiki and version

D5.51 Draft list of suitable communication / work group tools for platform environment

control capabilities. Currently, a WYSIWYG editor is planned for version 2.6.

JSPWiki exports Wiki pages as PDF files. Furthermore, it is able to show Excel spreadsheets [98].

There is no bibliographic support within JSPWiki.

Content can be interlinked with other Wiki pages, but quite any content can be referenced as Wiki page.

Conclusion

JSPWiki misses some requirements, especially those concerning group ware applications as well as import/export formats. One of its strengths is, that plug-ins can developed in a "full" programming language like Java. So, JSPWiki can be recommended, whenever custom components have to be integrated or implemented. To integrate scripting languages, JSPWiki Another strength is the highly customisable access control subsystem, permitting to integrate quite any access control scheme into the site. Using the "Applet" plug-in, the platform can be extended by any kind of Java based application.

4.2.4 XWiki

License: Free (LGPL)

Language: Java

URL: <http://www.xwiki.org/>

Version: 1.0 beta5 (16/02/2007)

XWiki proclaims itself to be a second generation Wiki (application Wiki), suitable to develop collaborative web applications. It offers a programming API supporting the scripting languages Velocity and Groovy. XWiki can be integrated in all web portals supporting the JSR 168 Portlet specification [104]. Currently, this feature works with the exoPlatform [105].

Document Management Features

Uploading of any kind of files is supported by attaching them (similar to e-mail attachments) to a Wiki page.

Version control applies on Wiki pages including attachments. So, any state of an attachment can be restored.

XWiki introduces the concept of spaces to organise content. Spaces are sets of pages grouped together under the same name. Additionally, XWiki supports the creation of own folksonomies using tags. The tag feature let users add keyword to Wiki pages and retrieve those keyword associated pages.

Besides the default form based authentication, XWiki supports authentication using LDAP servers, Active Directory and the exoPlatform. Furthermore, any existing authentication mechanism can be plugged in. XWiki allows to control access rights at Wiki, space and page level. These rights are cumulative, i.e. space level access rights overwrite those for the Wiki level, and page level access rights overwrite those of the space level. Access rights can be defined for users and groups

Project Coordination Features

XWiki appears to not support any kind of address book.

XWiki seems to provide a minimal "Calendar", but this feature is undocumented.

It appears, that there are no special task/project managements currently available.

D5.51 Draft list of suitable communication / work group tools for platform environment

XWiki supports multiple Wiki sites on the same server via its unique virtual wiki feature.

Cooperative Document Editing Features

XWiki supports collaborative editing through its version control capabilities. A WYSIWYG editor is available for editing content.

XWiki exports Wiki pages as PDF files.

There is no bibliographic support within XWiki.

Through the internal object oriented concept, any object can be linked with other objects.

Conclusion

XWiki is currently in beta status. Additionally, There are only few plug-ins available. Most of the required web applications are not available. It should be possible to integrate Perl based plug-ins from the TWiki platform into this Wiki, but an explicit documentation is missing. So, XWiki is just an interesting approach for the future.

4.3 Web Operating Systems (Web OS)

Unlike CMS and Wiki platforms, there is no website listing available Web Operating Systems or Desktops. Here the problem is, that there are many websites offering Mashup services or web OS platforms as well. But currently, there is only a very limited amount of Open Source stand-alone platforms.

A quite good source of information was Wikipedia again and a bit of hazard. So, only the following two candidates could be emerged:

- eXoPlatform
- eyeOS

The following sections evaluate the candidates stated above regarding the requirement for communication tool platforms.

4.3.1 eXoPlatform

License: *Free (GPL)*

Language: *Java (Portlets, Java Server Faces)*

URL: *<http://www.exoplatform.org>*

Version: *2.0 beta (23/03/2007)*

The eXoPlatform is one of the first Open Source portals certified JSR 168, the Java Portlet Specification. Portlets are Java based pluggable user interface components processing dynamic content on request. The aggregation of portlets builds up a web portal. Portlets are managed within a portlet container, which can be executed by any J2EE application server. Besides the core components like the platform, the portlet container and the portal, the eXoPlatform provides further applications like Enterprise Content Management (ECM) based on the Java Content Repository Specification (JSR 170) [106] and group ware. The first provides basic and advanced document management functionalities like searching, import/export, locking, versioning, WebDAV and several web publication channels. The latter is a set of services supporting collaboration functionalities like forum, calendar, mail or Wiki(XWiki).

Document Management Features

Any kind of document can be uploaded. Content is accessible via the WebDAV protocol. Uploading of documents can be combining with work flow logic, e.g. to automatically publish uploaded content documents like Microsoft Word.

Version control applies to any content changes in the platform.

The ECM application provides meta data management based on ontologies (native Dublin Core [107]) and the creation of taxonomies.

The platform supports a special kind role based access control concepts where users are related to groups by a membership type to be defined. Permission will be set according to these membership types. Authentication is done using the JAAS-framework, so any kind of authentication mechanism could be used. There is an special support for LDAP servers. The single sign-on solution CAS v2 is supported by default.

Project Coordination Features

Currently, there is no special application supporting contact management.

A shared calendar application is part of the group ware application.

A project manager is part of the group ware application.

Through the multi-portal concept, several portals can be hosted on the same application server.

Cooperative Document Editing Features

Besides version control, the eXoPlatform integrates a Wiki engine(XWiki) for collaboration. Furthermore, there is an WYSIWYG editor to create content.

Apparently, there is only support to import Microsoft-Word document into the document repository and to transform this automatically into content (pages).

Currently, there is no special bibliographic support available.

Grace to the node concept, any node can be linked with other nodes.

Conclusion

In the current state, the eXoPlatform does not meet the demands on a complete communication tools platform. But, the ability to dynamically rendering web pages, and the underlying platform functionalities predestine this platform for a future upgrade of a communication tool platform with a modern, desktop like user interface. So, the further development of this platform should be kept track of.

4.3.2 eyeOS

License: *Free (GPL)*

Language: *PHP*

URL: *<http://www.eyeos.org>*

Version: *0.9.3-5 (19/12/2006)*

eyeOS is a web desktop, which allows users to upload their files to access and view them from any

D5.51 Draft list of suitable communication / work group tools for platform environment

computer with internet access. It is installed on server which requires only a PHP compatible web server. On the client side, only a browser with CSS [108] support is needed. For eyeOS exists several small applications like a music-player or a PDF-viewer, which run in a browser and it is upgradeable with several small so called "Apps". Version 1.0 should be released within this year, based on Ajax. So the old version is no longer developed.

Document Management Features

Arbitrary files can be uploaded and stored into a public folder accessible for every user.

No version control or meta data functions are supported.

Authentication is done by user name/password. No groups can be assigned. Each user has its own personal folder and a global public folder for all users under which files can be stored exists.

Project Coordination Features

eyeOS has a built in address book, reachable under eyePhones.

eyeOS provides a simple calendar functionality.

eyeOS does not support project management features.

eyeOS is not multi-site capable.

Cooperative Document Editing Features

There is a Word-like editor, which offers a WYSIWIG functionality. These files can be stored in a public folder for public access, but no simultaneous editing is supported. Public notes can be edited by every user.

The notes can be exported as HTML-files, but no other functionality exists. A new extension allows the read of PDF-files.

eyeOS does not have any bibliographic support.

Conclusion

eyeOS does not fulfil the requirements for the platform, but shows, how a user interface displayed in a browser can look like with the use of Web 2.0.

5 Conclusion (Recommendation)

The evaluation of totalling eleven platforms potentially suitable for the overall integration of communication tools offers a differentiated view regarding the different kinds of platform types.

Primarily, Wiki systems are suitable to collaboratively and easily edit content for the web. Most of them are also convenient to share documents related to articles and offer some interesting extensions too. But, every Wiki system either lacks on the availability of more or less required extensions or the core system misses some required features. In general, the inherently architecture of Wikis appears to reduce the flexibility and therefore the acceptability of those platform types regarding the requirements for communication tools.

Both researched Web OS platforms demonstrate the look-and-feel and the handiness for a final solution to be envisioned. Unfortunately, their current development state does not appear being sophisticated enough to immediately serving as a base for a communication tools platform. Despite, the eXoPlatform includes all basic functionalities to realise the required platform, mainly the missing availability of technically mature extension inhibits recommending this platform.

Ultimately, the remaining group of content management systems appear to be suitable for using. Excepting Joomla, all CMS platforms meet quite all the demands for the platform, are sophisticated and supported by a great community of users and developers, are well-documented and offer a wide range of also useful extensions.

The big handicap of the Typo3 platform is the predictable effort for developers to familiarise with the platform. Either, this work must be done by some Typo3 experienced web developers, or new developers will have to spend several week studying the system.

The remaining three candidates are quite on a par. The shortcoming of Drupal base on the unsophisticated import and export facilities of Office documents. Here, the other candidates overpass Drupal, even though Drupal meets all other demands quite well. As a result of this strength, the missing bibliographic support of eZPublish should be neglectable. Finally, the Plone platform does not only meet all required features, but relies on the quite stable and secure Zope application server platform, is well-documented and thus results as the first choice platform to build up the communication tools platform.

6 Bibliography

- [1] J. Klensin: Simple Mail Transfer Protocol. In: Internet Society: Request for Comments (2821), 2001.
- [2] M. Crispin: INTERNET MESSAGE ACCESS PROTOCOL. In: Internet Society: Request for Comments (3501), 2003.
- [3] J., Rose, M. Myers: Post Office Protocol. In: Internet Society: Request for Comments (1939), 1996.
- [4] Microsoft Corporation: Outlook Home Page - Microsoft Office Online. In: <http://office.microsoft.com/en-us/outlook/FX100487751033.aspx>, last seen on 07 May 2007.
- [5] Mozilla: Thunderbird - Reclaim your inbox. In: <http://www.mozilla.com/en-US/thunderbird/>, last seen on 07 May 2007.
- [6] phpBB Group: phpBB - Creating Communities Worldwide. In: <http://phpbb.com/>, last seen on 07 May 2007.
- [7] ICQ Inc.: ICQ.com - community, people search and messaging service!. In: <http://www.icq.com/>, last seen on 07 May 2007.
- [8] AOL Deutschland: AOL - AIM Center - AOL.DE. In: <http://www.aol.de/AIM/>, last seen on 29 May 2007.
- [9] Microsoft Corporation: MSN.com. In: <http://www.msn.com/>, last seen on 29 May 2007.
- [10] J. Oikarinen, D. Reed: Internet Relay Chat Protocol. In: Internet Society: Request for Comments (1459), 1993.
- [11] Microsoft Corporation: Windows Live Messenger. In: <http://get.live.com/messenger/overview><http://get.live.com/messenger/overview>, last seen on 07 May 2007.
- [12] Cerulean Studios: Cerulean Studios - Creators of Trillian and Trillian Pro Instant Messengers. In: <http://www.ceruleanstudios.com/>, last seen on 07 May 2007.
- [13] Peter Zelezny: XChat - Multiplatform Chat Program. In: <http://www.xchat.org/>, last seen on 07 May 2007.
- [14] Tjerk Vonck: mIRC Co. Ltd.: mIRC - An Internet Relay Chat program. In: <http://www.mirc.com/>, last seen on 07 May 2007.
- [15] Skype Limited: Skype - internet calls. In: <http://www.skype.com/>, last seen on 08 May 2007.
- [16] TeamSpeak Systems: TeamSpeak. In: <http://www.goteamspeak.com/>, last seen on 08 May 2007.
- [17] Information Sciences Institute University of Southern California;: TRANSMISSION CONTROL PROTOCOL. In: Internet Society: Request for Comments (793), 1981.
- [18] International Telecommunication Union: Packet-based multimedia communications systems. In: International Telecommunication Union: SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS (323), 2006.
- [19] International Telecommunication Union: Narrow-band visual telephone systems and terminal equipment. In: International Telecommunication Union: SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS (320), 2004.
- [20] International Telecommunication Union: Implementors' Guide for ITU-T Rec. T.120 and T.130 sub-series: Data protocols for multimedia conferencing. In: International Telecommunication Union: SERIES T: TERMINALS FOR TELEMATIC SERVICES (120), 2005.

D5.51 Draft list of suitable communication / work group tools for platform environment

- [21] J. Rosenberg, H. Schulzrinne, G. Camarillo, A. Johnston, J. Peterson, R. Sparks, M. Handley, Schooler, E.: E.: SIP: Session Initiation Protocol. In: Internet Society: Request for Comments (3261), 2002.
- [22] Microsoft Corporation: NetMeeting Home. In: <http://www.microsoft.com/windows/netmeeting/>, last seen on 08 May 2007.
- [23] Equivalence Pty Ltd: OpenH323 Project. In: <http://www.openh323.org/>, last seen on 08 May 2007.
- [24] J. Postel, J Reynolds: FILE TRANSFER PROTOCOL (FTP). In: Internet Society: Request for Comments (959), 1985.
- [25] Jim Whitehead: WebDAV Resources. In: <http://www.webdav.org/>, last seen on 08 May 2007.
- [26] RapidShare AG: RapidShare - 1-Click Webhosting. In: <http://rapidshare.com/>, last seen on 08 May 2007.
- [27] CollabNet: subversion.tigris.org. In: <http://subversion.tigris.org/>, last seen on 08 May 2007.
- [28] CollabNet: tortoissvn.tigris.org. In: <http://tortoissvn.tigris.org/>, last seen on 08 May 2007.
- [29] IBM: IBM Lotus Software. In: <http://www-306.ibm.com/software/lotus/>, last seen on 08 May 2007.
- [30] Novell Inc.: Novell GroupWise. In: <http://www.novell.com/products/groupwise/>, last seen on 08 May 2007.
- [31] Microsoft Corporation: Microsoft Exchange Server - E-mail messaging and collaboration software. In: <http://www.microsoft.com/exchange/default.mspx>, last seen on 08 May 2007.
- [32] Microsoft Corporation: SharePoint Server Home Page - Microsoft Office Online. In: <http://office.microsoft.com/en-us/sharepointserver/default.aspx>, last seen on 08 May 2007.
- [33] OrbiTeam Software GmbH & Co. KG: OrbiTeam - BSCW. In: <http://www.bscw.de/english/index.html>, last seen on 08 May 2007.
- [34] Intevation GmbH: Kolab Groupware. In: <http://kolab.org/index.html>, last seen on 08 May 2007.
- [35] SKYRIX Software AG: OpenGroupware.org. In: <http://opengroupware.org/>, last seen on 08 May 2007.
- [36] Open-Xchange Inc.: Open-Xchange - Community Area. In: http://www.open-xchange.com/header/community_area.html, last seen on 08 May 2007.
- [37] Edgewall Software: The Trac Project - Trac. In: <http://trac.edgewall.org/>, last seen on 08 May 2007.
- [38] M. Nottingham, R. Sayre: The Atom Syndication Format. In: Internet Society: Request for Comments (4287), 2005.
- [39] RSS Advisory Board: RSS 2.0 Specification. In: <http://www.rssboard.org/rss-specification>, last seen on 12 August 2006.
- [40] Dave Raggett, Arnaud Le Hors, Ian Jacobs: HTML 4.01 Specification. In: W3C: (1999)
- [41] Mozilla: Firefox - Rediscover the web. In: <http://www.mozilla.org/products/firefox/>, last seen on 07 May 2007.
- [42] Microsoft Corporation: Internet Explorer - Home Page. In: <http://www.microsoft.com/windows/products/winfamily/ie/default.mspx>, last seen on 08 May 2007.
- [43] Inc Technorati: Technorati. In: <http://technorati.com/>, last seen on 08 May 2007.
- [44] BoingBoing: BoingBoing - A Directory of Wonderful Things. In: <http://boingboing.net/>, last seen on 08 May 2007.

D5.51 Draft list of suitable communication / work group tools for platform environment

- [45] Google: Google Blog Search. In: <http://www.google.de/blogsearch?hl=en>, last seen on 08 May 2007.
- [46] Biodiversity Information Standards (TDWG); Darwin Core - TWiki. In: <http://wiki.tdwg.org/twiki/bin/view/DarwinCore/WebHome>, last seen on 29 May 2007.
- [47] del.icio.us: del.icio.us. In: <http://del.icio.us/>, last seen on 08 May 2007.
- [48] Nature Publishing Group: Connotea - free online reference management for clinicians and scientists. In: <http://www.connotea.org>, last seen on 08 May 2007.
- [49] OASIS: OASIS Open Document Format for Office Applications (OpenDocument) TC. In: http://www.oasis-open.org/committees/tc_home.php?wg_abbrev=office, last seen on 30 May 2007.
- [50] Tom Dobrowolski: MoonEdit. In: <http://moonedit.com/indexen.htm>, last seen on 09 May 2007.
- [51] 0x539 dev group: Gobby - Trac. In: <http://gobby.0x539.de/>, last seen on 09 May 2007.
- [52] Google: Welcome to Google Docs & Spreadsheets. In: <http://docs.google.com/>, last seen on 09 May 2007.
- [53] Inc AdventNet: Online Office Tools - Productivity Applications and more. In: <http://www.zoho.com/>, last seen on 09 May 2007.
- [54] Plone Foundation: plone.org. In: <http://plone.org>, last seen on 09 May 2007.
- [55] Drupal: drupal.org - Community plumbing. In: <http://drupal.org/>, last seen on 09 May 2007.
- [56] eZ Systems AS: ez Publish Open Source Enterprise Content Management System. In: <http://ez.no>, last seen on 09 May 2007.
- [57] Rochen Ltd.: Joomla!. In: <http://www.joomla.org>, last seen on 09 May 2007.
- [58] TYPO3 Association: typo3.org: TYPO3 Content Management System - Developer Resource. In: <http://typo3.org/>, last seen on 29 May 2007.
- [59] Alkacon Software GmbH: opencms.org: OpenCms - The Open Source Content Management System. In: <http://www.opencms.org/>, last seen on 29 May 2007.
- [60] TeX Users Group; TeX Users Group (TUG) home page. In: <http://www.tug.org/>, last seen on 29 May 2007.
- [61] Adobe Systems Incorporated: Adobe Portable Document Format. In: Adobe Systems Incorporated: PDF Refenece, (2006)
- [62] Tikiwiki Community: tw.o : Home. In: <http://tikiwiki.org/tiki-index.php?page=Home>, last seen on 29 May 2007.
- [63] Peter Thoeny: TWiki - Enterprise Wiki & Collaboration Platform. In: <http://twiki.org/>, last seen on 29 May 07.
- [64] David Au: JSPWiki: Main. In: <http://jspwiki.org/>, last seen on 29 May 2007.
- [65] MediaWiki.org: MediaWiki - MediaWiki. In: <http://www.mediawiki.org/wiki/MediaWiki>, last seen on 29 May 2007.
- [66] Ludovic Dubost: XWiki.org - Main - WebHome. In: <http://www.xwiki.org>, last seen on 29 May 2007.
- [67] Google: Google Maps. In: <http://maps.google.com/>, last seen on 30 May 2007.
- [68] Nilo Mitra: SOAP Version 1.2 Part 0: Primer. In: W3C: (2003)
- [69] Amazon.com: Amazon.com: Homepage: Amazon Web Services. In: <http://developer.ebay.com/common/api/>, last seen on 30 May 2007.
- [70] Google: Google Code - Google APIs. In: <http://code.google.com/apis/>, last seen on 30 May 2007.

D5.51 Draft list of suitable communication / work group tools for platform environment

- [71] OpenAjax Alliance;: OpenAjax Alliance. In: <http://www.openajax.org/>, last seen on 29 May 2007.
- [72] eyeOS Project: eyeOS Home | Web Desktop - Web OS - Web Office - your files and applications everywhere. In: <http://www.eyeos.org/>, last seen on 29 May 2007.
- [73] Microsoft Corporation: Live Search. In: <http://www.live.com>, last seen on 29 May 2007.
- [74] Pageflakes Ltd.: Pageflakes - Get it Together. In: <http://www.pageflakes.com/>, last seen on 29 May 2007.
- [75] Inc. WebShaka: Welcome to YouOS. In: <http://youos.com/>, last seen on 29 May 2007.
- [76] Lutz Suhrbier: Communication Tools for Taxonomy - Planning a Cyber-Communication Platform. In: <http://ww3.bgbm.org/EDIT/ComunicationTools#preview/>, last seen on 25 March 2007.
- [77] David Taylor: Revisionary Models. In: http://ww3.bgbm.org/EDIT/Revisionary_Models/, last seen on 15 March 2007.
- [78] Erik Christensen, Francisco Curbera, Greg Meredith, Sanjiva Weerawarana: Web Services Description Language (WSDL) 1.1. In: W3C: (2001)
- [79] CosmoCode: WikiMAtrix - Compare them all. In: <http://www.wikimatrix.org/>, last seen on 29 May 2007.
- [80] Plain Black Corporation: The CMS Matrix - cmsmatrix.org - The Content Management Comparison Tool. In: <http://www.cmsmatrix.org/>, last seen on 29 May 2007.
- [81] Wikimedia Foundation: Home - Wikimedia Foundation. In: <http://www.wikipedia.org/>, last seen on 29 May 2007.
- [82] The Apache Software Foundation: The Apache HTTP Server Project. In: <http://httpd.apache.org/>, last seen on 30 May 2007.
- [83] JA-SIG: JA-SIG Central Authentication Service (CAS). In: <http://www.ja-sig.org/products/cas/>, last seen on 29 May 2007.
- [84] Craig Knudsen: k5n.us: WebCalendar Home Page. In: <http://webcalendar.sourceforge.net/>, last seen on 29 May 2007.
- [85] Moxiecode Systems AB: TinyMCE Javascript Content Editor by Moxiecode Systems AB. In: <http://tinymce.moxiecode.com/>, last seen on 29 May 2007.
- [86] Tim Bray, Jean Paoli, C. M. Sperberg-McQueen, Eve Maler, François Yergeau, John Cowan: Extensible Markup Language (XML) 1.1 (Second Edition) - W3C Recommendation 16 August 2006, edited in place 29 September 2006. In: <http://www.w3.org/TR/2006/REC-xml11-20060816/>, last seen on 16 August 2006.
- [87] Y. Shafranovich: Common Format and MIME Type for Comma-Separated Values (CSV) Files. In: Internet Society: Request for Comments (4180), 2005.
- [88] Norman Walsh: The DocBook Document Type. In: OASIS Open: (2006)
- [89] MySQL AB;: MySQL AB - The world's most popular open Source database. In: <http://mysql.com/>, last seen on 29 May 2007.
- [90] Microsoft Corporation;: Office Online Homepage - Microsoft Office Online. In: <http://office.microsoft.com/>, last seen on 29 May 2007.
- [91] Inc. Sun Microsystems: OpenOffice.org: Home. In: <http://www.openoffice.org/>, last seen on 29 May 2007.
- [92] SugarCRM Inc.;: SugarCRM - Commercial Open Source CRM. In: <http://www.sugarcrm.com/crm/>, last seen on 29 May 2007.

D5.51 Draft list of suitable communication / work group tools for platform environment

- [93] C., Willens, S. Rigney, A. Rubens, W. Simpson: Remote Authentication Dial In User Service (RADIUS). In: Internet Society: Request for Comments (2865), 2000.
- [94] jEdit.org: jEdit - Programmer's Text Editor - overview. In: <http://www.jedit.org/>, last seen on 29 May 2007.
- [95] Dana Jacobsen: The BibTeX Format. In: <http://www.ecst.csuchico.edu/~jacobsd/bib/formats/bibtex.html>, last seen on 30 May 2007.
- [96] RCS Maintainers: Official RCS Homepage. In: <http://www.cs.purdue.edu/homes/trinkle/RCS/>, last seen on 29 May 2007.
- [97] Alacrity Management Corporation: SynchroEdit. In: <http://www.synchroedit.com>, last seen on 29 May 2007.
- [98] Microsoft Corporation: Excel Home Page - Microsoft Office Online. In: <http://office.microsoft.com/en-us/excel/FX100487621033.aspx>, last seen on 29 May 2007.
- [99] Inc., Sun Microsystems: Java EE at a Glance. In: <http://java.sun.com/javaaee/>, last seen on 29 May 2007.
- [100] Inc., Sun Microsystems: JavaServer Pages Technology. In: <http://java.sun.com/products/jsp/index.jsp>, last seen on 29 May 2007.
- [101] Inc., Sun Microsystems: Java Authentication and Authorization Service (JAAS). In: <http://java.sun.com/products/jaas/>, last seen on 29 May 2007.
- [102] C. Neuman, T. Yu, S. Hartman, K. Raeburn: The Kerberos Network Authentication Service (V5). In: Internet Society: Request for Comments (4120), 2005.
- [103] Microsoft Corporation: Microsoft Technet Windows Server 2003 Active Directory. In: <http://technet2.microsoft.com/windowsserver/en/technologies/featured/ad/default.mspx>, last seen on 29 May 2007.
- [104] Sun Microsystems Inc.: JSR-000168 Portlet Specification - Final Release. In: <http://jcp.org/aboutJava/communityprocess/final/jsr168/>, last seen on 29 May 2007.
- [105] eXo Platform SAS: Exo Portal. In: <http://www.exoplatform.org>, last seen on 29 May 2007.
- [106] Sun Microsystems Inc.: JSR-000170 Portlet Specification - Final Release. In: <http://jcp.org/aboutJava/communityprocess/final/jsr170/>, last seen on 29 May 2007.
- [107] DCMI: Dublin Core Metadata Initiative (DCMI). In: <http://dublincore.org/>, last seen on 30 May 2007.
- [108] Bert Bos: Cascading Style Sheets. In: <http://www.w3.org/Style/CSS/>, last seen on 29 May 2007.