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Establishing a Biomedical Virtual Organisation through a Portal: Lessons Learned from HEALTHAGENTS

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Abstract: HEALTHAGENTS is a trans-European interdisciplinary project for the diagnosis and prognosis of brain tumours through the use of imaging and spectral data with semantic web and agent technologies. The core of the HEALTHAGENTS virtual organisation, the HEALTHAGENTS portal fosters the consortium internal collaboration process. The website accomplishes a repository of data concerning the development and management of the HEALTHAGENTS project as well as a meta-information repository, composed of comments, discussions and other contributions from the HEALTHAGENTS consortium. From a technical perspective, the HEALTHAGENTS portal is a content management system comprising groupware, collaboration, and workflow services. It has also become an effective project management tool and a document publishing system with data provenance. The award for the best IST project website for EC-funded research projects was conferred upon the portal in 2006.

Keywords: eScience; Content Management; Virtual Organisations

1. Introduction

HEALTHAGENTS is a 3-year EU-funded trans-European interdisciplinary project for the diagnosis of cancer tumours using magnetic resonance imaging and spectroscopy and agent technologies [1]. The HEALTHAGENTS project plans to create a distributed and multi-agent-based data warehouse, and an associated distributed decision support system, that will provide advanced and distributed functionalities of data mining for the analysis and interpretation of brain tumour imaging and spectral data [9]. The data warehouse will include a large network of interconnected databases (data marts) containing the clinical, histological, and molecular phenotype data of brain tumour patients. The decision support system will facilitate evidence-based clinical decision-making, using MR and genetic based tumour classifications, and will include new criteria from the automated analysis of each local database. The HEALTHAGENTS project aims to ensure that all information about patients is kept confidential and stored securely.

The HEALTHAGENTS consortium has evolved from a cross-disciplinary collaboration among European partners, to a unique amalgam of areas of expertise over the past decade. It comprises two commercial companies, one research institute, and six universities, and provides service for an amalgam of highly computer-literate users, most with doctoral degrees in medicine, biology, mathematics and computer science, from renowned educational, research, and commercial organisations across Europe.

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It is very natural to think of the HEALTHAGENTS consortium as a virtual organisation. A virtual organisation is defined as a group of people who interact through independent tasks, guided by a common purpose [15]. Virtual organisations are structured around information, rather than regulations, control, and power. When widely disseminated, information appears to be instrumental in the efficacy of a virtual organisation. Virtual organisations can be simply conceived as ways of structuring, managing, and operating [16].

The core of the HEALTHAGENTS virtual organisation is the HEALTHAGENTS web portal (hap) [21,5]. Web portals are sites on the World Wide Web which provide personalised capabilities to their visitors, such as information of interest, services, and groupware [i].
Being that the HEALTHAGENTS community is a geographically-dispersed group by nature, the portal plays a key role in binding it together. Although anyone can access the web site, the hap is the main tool for carrying out internal dissemination in the project. Since a virtual organisation brings identity to a team which would otherwise not be cohesive, it is arguable that the hap fosters the HEALTHAGENTS virtual organisation. This is because project participants are employees of diverse research institutions, and their common goals are information-centric rather than organisationally or hierarchically motivated. It is important to stress that the portal is not the front-end of any of the HEALTHAGENTS software (d-DWH, d-DSS), but a web based platform for the virtual community.

The main aim of this paper is to show how the hap contributes to the dynamics of the HEALTHAGENTS virtual organisation. The main objectives of this virtual organisation are:

- Sharing of results among participants
- Completing and delivering tasks
- Fostering participation and the exchange of ideas

As the term groupware is used to describe software intended to enhance group productivity, the hap can be seen as a web-based groupware platform for the HEALTHAGENTS virtual organisation.

From a technical standpoint, we have achieved web-groupware functionality on an open source content management platform, and built a repository for both specific project contents (such as reports, deliverables, papers, fact sheets, news, etc. and also for meta content, for example comments and discussions from the experts: what we consider to be valuable knowledge for the project that can be searched and remains available to the consortium at space for future reference.

Although there are now dozens of web-based groupware systems [22], the ideal platform is required to be web-accessible, secure, easy to learn and manage, localisable, configurable and preferably, open-source. It should also fit the HEALTHAGENTS virtual organisation and improve its productivity in order to achieve the project goals.

We believe that a groupware tool for the HEALTHAGENTS project must reflect the structure of the project in terms of users and tasks. Thus, the hap has been implemented using the Plone and Zope web development tools, following technological and interactive groupware guidelines, and currently runs on Linux servers.
The paper is organised as follows. Firstly, we consider the motivation for this work, moving on to a description of the HEALTHAGENTS portal design. We then describe our main case study. Finally, we identify future directions for this work.

2. Motivation

Since the HEALTHAGENTS consortium is a cross-disciplinary geographically distributed team, we can consider that the internal collaboration process for the development of the HEALTHAGENTS project is per se a study case of e-science, process which is fostered by the HEALTHAGENTS website.

After some twelve months of intensive use, we can now say that the HEALTHAGENTS portal plays a key role in binding the HEALTHAGENTS consortium together. It brings

identity to the internal project team which otherwise would not be cohesive, and arguably fosters the HEALTHAGENTS virtual organisation since project participants are employees of diverse research institutions with different administrative and academic objectives. Furthermore, the HAP is also the main tool for carrying out external dissemination, serving as the main repository of information to the public.

To benefit from the unique amalgamation of areas of expertise achieved by the HEALTHAGENTS consortium, it is worthwhile to store all kinds of interaction as well as any information content produced. Besides providing groupware tools, the aim of the HEALTHAGENTS website is to build a repository for both specific project contents and meta-information content.

Considering that HEALTHAGENTS als with medical information, other issues regarding handling information due to the scope of the project arise. Access to medical information on the Internet is a complicated matter since it must adhere to well-documented criteria, such as quality and labelling [7]. Quality indicators must ensure that the information meets the standards set by governing bodies. Labelling enables the display of information using a validated core vocabulary. While the definition of standard policies for quality and labelling are beyond the scope of this work, it is important to note that both criteria intrinsically assume the presence of a governing body and a semi-homogeneous audience.

Scant research has been devised on the development of a web-based system to accrue biomedical information incorporating quality and labelling which can be used effectively by a multi-disciplinary team. While previous work such as the InterMed collaboratory [19] and the GLIF system [11] provide useful examples of the management of clinical information, they pay little attention to the secure exchange of such information among geographically distributed locations. On the other hand, organisational content management theory addresses systems integration issues related to group and organisational work in general [18], but provides no tangible examples of managing interdisciplinary scientific teams pursuing a common goal and does not incorporate quality or labelling issues. From a computational side, intensive research has led to landmark efforts in grid-oriented virtual organisations [8], but provides limited guidance on the human-centric side of establishing the virtual organisation.

Moreover, two key factors in content management, such as the organisational impact of distributed applications and the behavioural and technical aspects of computer-supported cooperative, collaborative, and competitive work, still remain an open issue. We have decided to explore the use of a content management system (CMS) which has primarily been designed for organising and facilitating collaborative creation of documents and other content [3]. Although similarities can be drawn upon, the HEALTHAGENTS virtual organisation presents a different set of challenges, since its user community does not belong to the same institution and the requirements for one set of users differ from those for another, due to their separate areas of expertise.

It is important to highlight the role of documents in the scope of a research project, since the document is the medium through which much explicit knowledge is shared, and additional facilities such as annotation can make them active knowledge repositories, through which the latest version and thinking is readily shared amongst project teams [20]. Although the HAP does not enforce an explicit quality and labelling policy, every document must meet quality standards since it is generated by field experts and in terms of labelling, represents a core vocabulary for brain tumour analysis and prognosis using images, spectra, and agents.

3. The HEALTHAGENTS Project Structure

The structure of the HEALTHAGENTS project, defined at the time the project was conceived, is also the base for the structure of the virtual organisation, providing in the virtual

environment the same context of work experienced in conventional (non-virtual) interaction. Table 1 presents the nine participants of the HEALTHAGENTS project.

Table 1. HEALTHAGENTS Project Participants

PARTICIPANT			
No	Name	Short Name	Country
1	MicroArt, SL	MICROART	Spain
2	Universitat de València	UVEG	Spain
3	Universitat Autònoma de Barcelona	UAB	Spain
4	Instituto de Aplicaciones de las TIC Avanzadas	ITACA	Spain
5	Pharma Quality Europe	PQE	Italy
6	Katholieke Universiteit Leuven	KULeuven	Belgium
7	University of Birmingham	UniBHAM	UK
8	University of Edinburgh	UEDIN	UK
9	University of Southampton	USOU	UK

The HEALTHAGENTS project is divided into six different areas, known as workpackages (WP) as shown in Table 2. Each WP has a leading partner, who is in charge of:

- coordinating and managing clearly defined tasks within their WP;
- ensuring the WP deliverables are produced on time; and
- linking the project coordinator and WP people.

Table 2. HEALTHAGENTS Workpackage Overview

WP	WP Name	Partners
1	Management	MicroArt (Leader). Involves all Partners.
2	d-DSS development	U Birmingham (Leader). Includes MicroArt, UABarcelona, ITACA, KU Leuven, U Edinburgh, and U Southampton.
3	Data management	UABarcelona (Leader). Includes U Valencia and U Birmingham.
4	Quality assessment and Software validation	PQE (Leader). All partners included.
5	Dissemination	U Edinburgh (Leader). All Partners contribute.
6	Industrialisation	Microart (Leader) with all partners participation

Each WP comprises multiple deliverables. Deliverables are the final products of the project and are typically written reports, technical documentation, software components or program prototypes. Each deliverable has a leading partner who is responsible to the WP leading partner for compiling and submitting all work within the fixed project schedule. Overall project success is measured in terms of deliverable quality, timing, and accuracy.

Deliverables are divided into independent tasks. A task may involve many participants in different partners and each task has a lead participant responsible for overseeing its progress and the agreed contribution from the involved partners. While cross-pollination is encouraged, dependencies between concurrent tasks are negligible.

The HAP must not only reflect the aforementioned project structure but must also help to organise tasks, documents, users and WPs, and improve collaboration and group productivity, since the web site is ultimately the official communication tool storing the different versions of all deliverables.

There is a 1-to-n correspondence between members of the HEALTHAGENTS virtual organisation and the WPs, i.e. a member may have several roles on the project, contextualised by the WPs. A WP can also be formed by a multidisciplinary team, which means that the collaboration activities and the types of contributions can vary.

The WPs have special needs on the HAP, depending on the function carried out. For example, WP1 (management), requires management functionalities over the deliverables

and tasks. WP6 (Industrialisation) requires functionalities for managing contact information and groups of interest. The HAP is the platform to provide these functionalities to the virtual organisation.

4. Implementation

The HAP design aims at reproducing the WP structure and forming a virtual organisation, which encompasses a series of experts from different real-world groups. Following the interactivity groupware guidelines, shared visual workspaces were created for each workpackage and for the project management committee, the HEALTHAGENTS internal governing body. From a technical point of view, the HAP consistently maps distributed participants from distinct partners working on different WPs into the virtual organisation interaction whilst enforcing provenance, quality, and labelling.
The HAP covers three main functions:

1. Content management
2. Project management
3. Document publishing

In observance of the HEALTHAGENTS philosophy, the HAP employs open standards as well as open-source software to the largest extent possible in order to facilitate its extensibility and support.

4.1 Content Management

The main activities carried out by the virtual organisation on the HAP involve content management tasks. As it is also a result of group work, they lie among the groupware features of the HAP. We use the “mechanics of collaboration”, a framework that articulates the mechanics of collaboration for shared-workspace groupware as described in [2], to present the groupware features of the HAP. Presenting the HEALTHAGENTS groupware features in this way avoids the need for detailed workflow descriptions, and gives the reader an holistic view of how (and why) groupware features were defined.

The mechanics of collaboration framework articulate the small-scale actions and interactions that group members must perform in order to complete a task in a collaborative fashion, that are considered as the base for usability evaluation methods for shared workspaces [12].

The mechanics describe the low level actions and interactions that small groups undertake to complete a task effectively. The main ones are communication, planning, monitoring, assistance, coordination, and protection. A description of the way each of these actions is carried out on the HAP is given below:

Communication: Besides Plone communication mechanisms, members of a workspace have support to discuss all contents at a workspace. Any discussion is presented as a structured conversation linked to the respective content.

Planning: Each workspace leader is responsible for task division and content organisation at a workspace, though all members have available mechanisms to enable them to do so themselves, for example, dividing and redividing the task as they go along, reserving areas of the workspace for their own use, discussing how work is being conducted, including deadlines at the common calendar, etc. There are multiple possibilities to be explored, and members do this quite often, finding out new ways to "help themselves" with the services provided and sharing the acquired knowledge with those whom they are working with.

Monitoring: Plone already provides good features with which to monitor collaboration. Regarding workspaces, the basic functionality of gathering information about members of workspaces and their contributions to the work being done (more specifically, their

contributions to the contents added to a workspace) is available. This can be restricted to workspace members only or opened to the whole HEALTHAGENTS team, which is the case right now, as we consider a way to improve integration among the WPs.

Assistance: Besides the knowledge which members exchange among themselves, both about their work and about using the HAP, an area of the HAP is dedicated to user assistance. There, users can find short texts addressing how to do specific, common or "tricky" tasks such as sending a document to review, sharing a file with a subgroup of users, changing passwords, etc. The assistance area is enriched with questions and comments that users add as they need help on a specific functionality or when they think about a different way in which they would like to conduct collaboration and ask how that could be done at the HAP.

Coordination: To avoid conflicting use of shared contents, a simple version policy is implemented. All content added to a workspace is accessible to all members of the workspace, but may only be removed by the workspace leader. Discussion features should be used to determine how content is updated, and who is appointed to do so.

Protection: Besides the basic Plone publishing workflow (with its public, published, private and pending content states), workspaces benefit from the protection of the version control policy and form a special workflow for the workspace (open and closed states regarding access for external members of a workspace).

We have extended the traditional Plone environment with shared visual workspaces. Shared visual workspaces are defined as medium sized flat work surfaces where people collaborate by manipulating visible tools and task artefacts [13]. Plone does not provide workspaces. However, the Plone community has already developed some tools. Our choice for the HAP was GrufSpaces [14]. GrufSpaces is an open-source product that provides a GroupSpace content type that is used to allow groups of users to work together on a project (GPL license for versions before 2.0, ZPL license otherwise).

4.2 Project Management

The HAP membership policy follows a matrix structure in order to deal with roles and activities. The matrix rows represent the project partners and the columns represent the WPs. All participants (HAP users) belong to one partner, and partners participate in at least one WP. Thus a participant cannot be enrolled in a WP which his/her partner institution is not registered with. Furthermore, external users cannot obtain membership unless they belong to a partner. Explicit login and password are required for accessing most of the content since it has been agreed by the HEALTHAGENTS consortium that the working documents and in-progress activity details should not be available to the public. This choice concerns privacy for the virtual community activities, and is part of the social process of virtual group work.

We can summarise the relevant security and membership configurations as follows:

- Stop external (anonymous) users joining the site
- Standardise user names for all members, and have the administrator register them, according to their institution group membership settings
- Create the institution groups for all participant institutions
- Create the WP groups, and link membership of these groups to membership of institution groups, according to what was defined for the HEALTHAGENTS project

4.3 Document Publishing

Besides addressing internal dissemination, the portal should be able to be extended to accomplish external dissemination as well. Disseminating medical information is a delicate

task, as medical information requires a careful system that can trace back content to its originator and keep high accreditation control (known as medical quality labelling criteria).

Version control is enforced to maintain coherence across the portal. A provenance control system is embedded in the portal, as part of security. Security features address internal dissemination needs, but, as the web is an open space for all virtual users, the more straightforward matters concerning external dissemination have already been covered, e.g. ensuring that all content available at the portal is created and reviewed by experts.

Figure 1 The Welcome Screen of HEALTHAGENTS portal



Therefore, the HAP is by design both a reliable source of biomedical information, which encompasses the vision of Nupedia [17], the predecessor of Wikipedia: "we wish editors to be true experts in their fields and (with few exceptions) possess Ph.D.s", and a collaborative tool to conduct interaction among experts from multiple disciplines. Figure 1 presents a screenshot of the HAP. The improvements in security and collaboration features of Plone + Zope were designed to address the needs of the HEALTHAGENTS virtual community, and were concerned mainly with communal identification and group activities.

5. Results

Since it was launched to the HEALTHAGENTS consortium, the portal has had nearly a thousand contributions, excluding the forums. Contributions are mainly documents and comments that reflect the interaction of the HEALTHAGENTS virtual organisation. Feedback from the users indicates that these contributions are constantly searched and reused, confirming the value of the website to the development of the HEALTHAGENTS project.

Though no formal requirement was established for the portal usage, it became the main collaboration platform for the project. As a result of this confirmation, as an example, we can mention specifically the production of scientific papers as one of the tasks for which the HEALTHAGENTS team intensively utilises the portal for [4]. When calls for papers are published, virtual groups of people interested in responding to the call are formed, tasks are identified and assigned, and all of this is registered and can be traced. Such dynamism in the virtual organisation has helped to enhance the overall dissemination in the project.

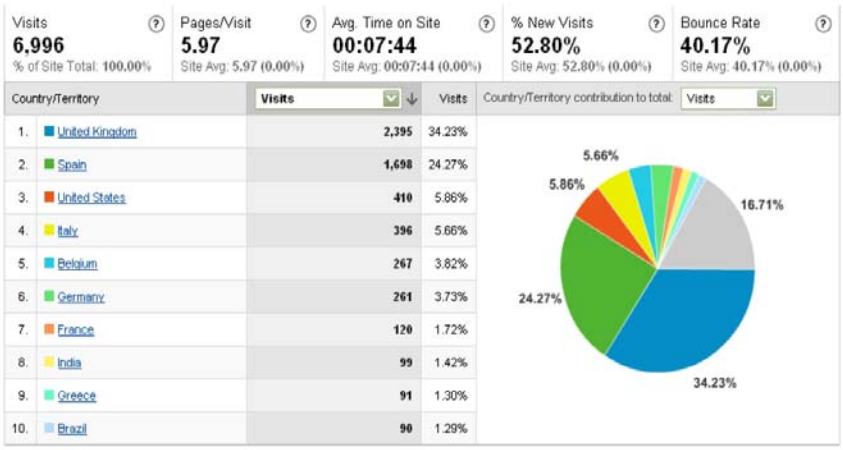


Figure 2 *Google Analytics Visits Summary for HEALTHAGENTS Portal (15 Jul 2007)*

Portal traffic is tracked using Google Analytics [10], a free and safe high-end web statistics tool. Although the portal started to operate as a document repository following the start of the project, the complete version, including the reviewed content for the external section and the statistics tool, was launched on 24 September 2006. Figure 2 presents the visits summary as of 15 Jul 2007. We have filtered out the visits from the University of Edinburgh developing team in order to provide a more accurate scenario.

- We have recorded 6996 visits with 5.97 page views per visit.
- 47% of our visitors are recurrent while 53% are new
- While most of the traffic originates in Europe, we have also received visits from the States, Latin America, China, Israel, south-east Asia, and Africa
- Most of our visitors access the site directly (around the same number of returning visitors) while the additional new traffic comes from references from European Commission sites, the School of Informatics in Edinburgh and Google searches

It is also worth mentioning that the website won the Best IST project website award (Information Society Technologies 2006), established for the IST event 2006 [6].

6. Conclusions

In this paper we have presented a case study for the HEALTHAGENTS virtual organisation, and have discussed our approach to using the HAP as its central point in order to manage and exchange ideas in a multi-participant biomedical project.

Following the principles for an effective virtual organisation, the HEALTHAGENTS virtual organisation is structured around information, reproducing the structure of WPs through a groupware environment and operating over a well known web-based content management system.

Feedback from users attests that the HEALTHAGENTS virtual organisation brings many benefits to the HEALTHAGENTS project. Firstly, it brings together the HEALTHAGENTS team as a coherent community. Secondly, it improves the task of structuring, managing, and operating the team towards the project goals.

From a technical perspective, the HAP encompasses a content management system comprising groupware, collaboration, and workflow services, an effective workflow/project management tool, and a document publishing system which enforces data provenance. For this, we have augmented the traditional Plone + Zope environment in two areas: security and collaboration.

We consider that the HAP achieves a successful balance of time, cost and functionality. Working completely with open source and free software we have been able to fulfil all system requirements, comply with time constraints and the established hardware and software standards of the hosting institution (the University of Edinburgh), and elicit a very positive response from active users.

There is still enough room for improvement, as it is expected that users manifest more elaborate groupware needs the more they explore the available services. But we strongly believe our case study may suit many other projects with the same distributed and multi-disciplinary nature as that of HEALTHAGENTS.

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[i] The terms "web portal", "portal" and "website" will be used exchangeably in this paper