Introduction – online medical content management

In the private and medical professional sector people increasingly surf on the World Wide Web. Why? Its ease of use has made it a convenient and casual vector through which we can share information. Not only do we increasingly find medical literature, but we also use it in order to access specific applications, most of them related to medical practice, group organization and training. While it seems easy to access information online, it is however more complex to publish it when the needs are beyond all-access static documents, as it can be in e-learning applications. There are definite needs for a system that can readily differentiate users, simplify editions and online publications while offering simple access to a wide range of interactive applications, many of which help us to maintain and update the incredibly expanding medical-related knowledge.

In addition to share ubiquitously with professional and public audiences (texts, images, diagrams), we need to use specific applications (calculators, quizzes, libraries, decision-support) and centralise and archive valid information (links to other databases, libraries, users), directly or indirectly enhancing our medical education and work. All of these a content management system (CMS) can provide. We believe e-learning applications will have to support and integrate this web of continuously changing knowledge and publication habits. New means need therefore to be explored in that goal, and understanding diffuse integration of e-learning tools as expansions of published data might be an interesting approach.

Objectives – unification of all web contents through a single unifying tool

Starting in January 2001, in continuity with previous initiatives, all members of the Department had to be able to participate in the creation, and publication of centralised online material. A simple tool, requiring no more than entry-level computer knowledge, was therefore necessary. This would provide global access to professional resources and organizational data. For that purpose, we decided to use and develop a content management system named BolinOS.

Users had to benefit from the tool: unique Hospital-wide identification, personal data storage (eg e-mail client, agenda, personal web space, history, bookmarks, and more) and all-nature digital contents integration and centralisation. The resulting web platform would have to be efficient, sturdy, and secure, but also well accepted by users. It would create a centralised ‘what you see is what you get’ (WYSIWYG) publication space with user-validation management of documents. At the same time it would blend with other active in-house information systems. It should enable easy and transparent backup and archiving of all contents and logs. E-learning applications’ development should be facilitated not only by new interactive tools, but also by enabling fast access to already existing educative material.

Open-source development was chosen to give greater independence and functionalities to the project. Not only offered this licensing scheme a clear and free way for BolinOS to be used and enhanced by other interested groups, regardless of their financial and academic dimension, but it also seemed to us one of the most pragmatic and efficient peer-reviewing systems for software development.

There are many other CMS available, but the choice was BolinOS because of the reduced cost of acquisition (open source), our sturdy knowl-
edge of it, and because of our will to guarantee essential functionality from the beginning, which was only incompletely offered by other platforms. The medical environment, where privacy and accuracy of the information flow are essential, made it essential to have a tool that could enable great security, traceability, reliability, and robustness while remaining independent of peripheral factors (e.g., commercial-licenses, technical black-boxes). BolinOS explicitly presents many complementary potentialities which by combining can reach any desired state of information integrity and availability.

We expected to answer present and future needs. The modular, lego-like structure, helps us be able to adapt. Three basic types of modules co-exist:

1. **text-contents** (html, texts, javascripts, xml, …)
2. **binary-contents** (jpegs, pdfs, movies, …)
3. **applicative-contents** (aka one bolino, many bolini, aka plug-ins)

The plug-ins were to coexist in a small number, offering ‘fundamental abilities’ that together would enable the creation of a website by individuals or groups, and the integration of other types of contents for the creation of almost any online application. This is important as it enables the creation of e-learning material directly linked to other ‘casual’ sources of data, that can in turn also use and link to other everyday-expanding contents. These are easily manageable and combinable through a coherent and simple web interface. The construction of the multimedia web pages from the modules is sequential and each is linked to a unique URL / file-system-folder.

The system is computer operating system independent, therefore of the future computer infrastructure means and trends, and can work on even a very economical infrastructure. One last but not least ability is the system’s management of multilingual contents, not only during creation and publication, but also towards targeted end-user display.

**Materials and methods – technical specifications and infrastructure**

We chose PHP’ as the core language for development as its worldwide community is not only one of the largest and most active, but as it includes very variable levels of expertise. Individuals in this community range from personal-homepage week-end leisurely developers to extremely dedicated professional senior coders. This is important as it merges the very diverse point of views on what web publication must provide, much more than those alone of computer-scientists. This is essential to the development of a better-suited platform for the development of real-world contents and applications destined to medium computer-knowledge savvy users, as are average healthcare professionals. Moreover BolinOS can be installed on almost any of the machines we already had, have and might get, enabling coexistence with other non-BolinOS in-house applications.

From image manipulation libraries to pdf creation, encryption, data-analysis, file management, network access, binary compression and decompression most of what we needed for medical content management and applications was readily available. We ‘only’ needed to insert it into our BolinOS framework.

The project was launched in February 2001, with our first Mac OS X development server

1. **PHP** Pre Hypertext Processor language: open source web programming language official home page. www.php.net

MySQL database: open source database official home page. www.mysql.com
(G3 400Mhz), and pre-production and intranet server running Windows 2000 (Pentium 3 400Mhz). Currently we also use Linux and Solaris based machines, both for production and development. The network connectivity was provided by the pre-existing Geneva University Hospitals’ infrastructure. BolinOS was already used in various non-medical websites, and while many of today’s capabilities where not present, the main concepts and architecture had already been implemented. Our first web pages where published with it in less than half a day.

The IntRad development workforce until March 2005 ranged between a one (20 h/week total) and a three (84 h/week total) person workforce, including occasional medical informatics students. These individuals have been active in coding, editing instruction of documents, and managing website contents and applications.

Results – non exhaustive realisation and observations

Today, all our employees use BolinOS. Other in-house projects started using BolinOS for their web-side applications (eg Dr Mathias Tschopp’s Palm HUG online and handheld medical files database for PalmOS and Pocket PC, GRAC’s Radioanatomic Files for PDAs and the web[^2], Etude Dames random multi-centric study on macrosomia[^1], Wadi Lotfi’s Surgery Department Library[^4], the FMH Radiology Quiz[^5]). The platform has transparently gained a wide user base, actively accessing online databases, applications, and schedules.

Using basic document management plug-ins, users have been able to publish agendas, charts, plans, lists and many casual-use documents, thousands of pages now ubiquitously available. Using simple cut and paste between third-party applications and the BolinOS interface, useful information has been easily published on our websites, ranging from standard descriptive pages to radiological-report templates used in dictation.

[^5]: FMH Online Radiological Examination: [http://www.intrad.ch/intrad/quiz/](http://www.intrad.ch/intrad/quiz/)
of radiological-interpretations, through guidelines, bulletins, research notes, image collections, and url bookmarks. This implicitly integrated e-learning in a transparent mesh throughout the department’s web pages.

Individual users have created quick notes using simple cut-and-paste text editing, or have included Flash, Word and PDF documents for others to download. Others simply use the system as a files-container, to securely access them from any place on the Internet (eg PowerPoint presentations, publications, images, etc.). Forums have been used to manage group task-lists, and the data-manager plug-in has been devoted to store and recall many data types, using simple web interfaces. Today’s casual uses are numerous. For instance, there is a webcam integration that warns radiologists who work most of the time away from windows (the Radiodiagnostic division is located in the basement), to not forget an umbrella when going out. As this seems trivial, it has however increased the implicit attractiveness of educative material by enlarging the digital-vicinity of the diverse educative contents.

Our team has developed tools explicitly aimed at e-learning or knowledge evaluation (eg the secure quiz / image collections management, efficiently replacing standard film duplication of radiological images used in the course of second-part FMH specialisation examinations [3], for the Palm medical files applications [1], …), but most of the educative content is dispatched on numerous webpages using hyperlinks and BolinOS data-cloning.

To widen the audience of scientific posters, the use of ‘content collection’ and ‘image collection’ plug-ins have for example made it easy to create an online version, with zooming and image navigation capabilities, from the source poster data. Again the readily available CD-ROM exportation of BolinOS can here be used to make an easily shareable offline version.

To add user-attractiveness to online contents, we have designed nearly 100 specific plug-ins. The BolinOS core-system relies on an interesting architecture, the tools we use to integrate contents are plug-ins themselves (it is a bit the chicken and egg idea: once the system is up both generate one another). Combining these blocks with texts, html and binary files (images, videos, pdf, word docs, …) can result in complex web pages construction, therefore rich e-learning material, simply.

Discussion – what we have gained, what we expect of the future, what we can hope

The many positive results can be resumed in a few non-exhaustive points. We have a working and stable web publication and applicative platform including many applications we would have probably never had otherwise. We delivered 100% of the tools we were asked for. This is a major success. During the years, cost of development and maintenance were kept within what was available to the one web-master. This last activity often actually transformed into a new publication-tool refinement, thus achieving recurrently useable features for all instead of punctual publications.
We gained valuable expertise in extremely diverse web applications development. From image-manipulation to XML-generation and parsing, through graphical-user-interface design and network optimisation. Though we did develop some applications without end-user request, most of our work was end-user-centric. The range of applications we now propose exceed far beyond what we imagined, and far beyond what we thought would suffice for medical use due to continuous user feedbacks. We have directly and indirectly integrated much of the know-how that the open-source communities we worked with had. While this doesn’t mean we can do anything anytime, our global knowledge makes it much clearer for us now to evaluate future applications, and readily work on it.

However, the relative originality and youth of the open-source nature of the solutions often inspired cautiousness and even reluctance from colleagues. The lack of open-source-aware computer programmers and decision-makers in-house was and still is not in our favour. Together with in-house competing projects or objectives this has led to rejections of BolinOS applications, although they technically fulfilled what they where designed to, or would definitely have been easily implemented on our platform. For example, the in-house physicians’ agenda plug-in, never gained any support from those who managed it. Nor was the system ever granted the secure access to an external radiological case-database, although it could have brought many potent education-oriented contents to all users.

**Conclusion – e-learning tools integrated as extensions of pre-existing online material is promising**

After nearly four and a half years of health-oriented BolinOS development, we have seen our websites develop, slowly but steadily. The BolinOS project has not reached all goals, but the positive results overshadow the negative ones. Today, we do have a pragmatic, economically sound and efficient tool, which has integrated many educative contents as well as new applications readily available for e-learning purposes. Thought it was not the prominent goal of the project, it has enabled the implicit integration of these into the all so numerous casual uses one can have in our department. This was achieved while we gained an expertise of what web content creation and publication in the medical field can be.
Our relative focus on enhancing fine-tuned content-creation plug-ins has shown mid and long-term advantages over content-creation only: the latter is increasingly being taken care of by non-webmaster users, thus creating more and better contents than what we could have done as webmasters. We can only hope now that the people who would be most potent for e-learning content creation will take the opportunity to use these. Today, we have a strong and sturdy open-source application platform on which we cannot only store data but also build new means for users to enhance their education while easing their work.

Exportation of our source code enhancements to the worldwide open-source community has provided us with many feedbacks, bug-reports, enhancements, comments and contacts; many other groups are studying the tool, while some have already chosen it (in our Hospital, and worldwide: 50'000+ installer downloads in more than 120 countries according to statistics of the BolinOS.net website as of December 2004).

Finally, and not the least, the BolinOS project has made it clear that the open source philosophy in medical application development is not just a nice concept. It is an efficient and powerful mean to reach economically sound applications for online contents and groupware creation, opening new paths for e-learning applications creation.

Figure 10. Creation of static versions of online BolinOS contents has made it a practical way to rapidly create interactive CD-ROMs.

Figure 11. Cut and paste abilities combined to the image collection plug-in enables fast interactivity addition to previously released material, here an example using a poster about orbital pathology.

Figure 12. Templating of pages included in the system enables simple maintenance of specific graphic designs in websites, here the Department of Radiology’s extranet.
Non-exhaustive list of BolinOS plug-ins up and running.

**Medical**
- ACR code – American College of Radiology anatomopathological classification interactive dictionary
- Blast – nucleotide code analysis plug-in
- ICD10 – international classification of disease interactive dictionary

**Data**
- Bibliotheque – multimedia library management plug-in
- Bozilla – version and software development suite
- Customisable bibliotheque – advanced library management plug-in
- Data manager – simple online spreadsheet
- Glossary – glossary manager
- Help manager – online documentation management plug-in
- Palm pdb manager – converter for Palm format databases
- SyncPad 2 – multimedia files authoring tool for Palm and Pocket PC uses
- DB manager – multiformat db browser and editor
- phpMyAdmin includer – BolinOS integration of the popular phpMyAdmin open source mySQL managing suite

**User interface**
- Language selector – offers pages’ navigation between languages
- Page editor – complete editing suite for BolinOS pages
- Connexion – login and logout session manager, and interface
- User bar – the virtual desktop application
- Page refresh – enables automatic page refreshment

**Administration**
- About – offers commentary capabilities to web contents
- Benchmark – enables comparison between servers running BolinOS
- Plugins Editor – enables fast plug-in edition
- Plugins informations – manages plug-in related information
- Scheduled actions – to manage scheduling of diverse scripts
- Sites statistics – suite to analyse logs and audiences
- Synchro Bolinos DB – File System
- User registration – simple tool to register new users for specific events
- Admin bolinOS securities – generic tool to administer security schemes related to BolinOS
- Admin bolinOS sites – complete tool for website administration
- Admin groups – generic tool to manage groups and their users
- Admin pages – page administration tool, to edit all specific parameters
- Admin sessions – viewer and interactive tool to manage online sessions
- Admin users – generic tool for user administration, and their parameters and rights
- Apache security – generic tool to manage all that has to do with ht. access security parameters
- Script embedded – php script integrator to include php code, fast

**Communication**
- Agenda – complete time management suite for users, events and groups
- Planning – event management set for specific locations and uses
- Contact form – simple email contact form
- Contact group – simple group mailing list manager
- Forum – basic forum publication and authoring tool
- Meta forum – complex multi-thematic forum management tool
- Mailbox – multi account webmail interface for pop, imap, and BolinOS mail messages
- Mail access – interface to mail functionalities

**Workflow**
- Atlas – complex image collection publication tool, with key imaging, multimedia linking and zone definition
- Bulletin – bulletin creation tool
- Document workflow – set of tools to follow document workflow online
- Form – easy web form creator
- Multiple-choice questionnaire – simple set for multiple choice questionnaire making
- SyncPad – multimedia file authoring and publication system for the web, palm, pocket pc and smartphones
- Tests on line – online evaluation tool
- Users vacancies – tool for employee vacation management

**Page construction**
- Background – easy page background manager
- Banners – banner management set of tools
- Full screen – adds full-screen capabilities to any BolinOS webpage
- Page footer – management of page footers
- Page skin – complete set to manage locally graphical skin parameters
- Page formatter – tools to set page format
Contents collections / manager
Blog – simple blog like displayer
Conditional displayer – adds complex filters for content publication
Contents collection – displays multimedia contents in diverse collection looks
Contents selector – enables multimedia collection display under diverse looks
Embedded contents – integrates any content into a page
Embedded HTML – integrates HTML as well as parses it into other standard BolinOS contents
Files collection – displayer for binary file collections
Images collection – image displayer for large image collections, includes diverse pop-up viewers and image manipulators
Photo collection – complete photo album displayer and manager
Texts collection – displayer of text collections
XML displayer – parser for XML code

Games
Battleship – get the computer’s ships before he gets yours
Find number – find the right number
Mine Sweeper – find where all the mines are without exploding one
Tic tac toe – a simple game of tic tac toe against the computer

Navigation
Customisable Links Collection – simple tool to manage links’ collection
Groups navigation – tool to enable navigation between users’ data and personal pages
Links collection – complete links collection manager
Navigation – creates basic navigation menus between pages
Navigation menu – creates complex navigation menus between pages
Navigation restriction – plug-in that restricts access to certain pages
Previous / Next – plug-in that displays back and forth navigation through complex get and post environments
Site plan – display plug-in for definable parts of a website

Search
Search engine – plug-in to enable search into a website’s contents
Search user – plug-in to easily search into the user database
Google search engine – plug-in for google search interface insertion and management

Miscellaneous
DICOM Digital Imaging and Communications in Medicine – plug-in to enable DICOM format images to be used by all plug-ins and for web transformation
ImageJ – integration of the open source Java application for image manipulation
Viper Visual Information Processing for Enhanced Retrieval – complete tool for interfacing searches compatible with VIPER analysis software
HUG
HUG directories – plug-in to connect and interact with the centralised user database
HUG user profiles – plug-in to enable unified logging, tracking and user rights’ management in our hospital
IntRad quiz – complete and powerful online radiology examination tool

References
1 Tschopp M, Geissbuhler A. Use of handheld computers as bedside information providers. Medinfo Division of Medical Informatics, Geneva University Hospital) 2001;10(Pt 1):764–7.