Chapter 14
The Evolution of Healthcare Applications in the Web 2.0 Era

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Abstract. Healthcare refers to the diagnosis, treatment and management of illness, as well as to the preservation of health through specialized services. Healthcare services are offered by medical practitioners and organizations and directed to individuals or to populations. The advent of the Web increased the pervasiveness of healthcare services and attracted the interest of both practitioners and patients. In its turn, Web 2.0 brought people together in a more dynamic and interactive space. With new services, applications and devices, it promises to enrich our web experience, and to establish an environment where virtual medical communities may flourish away from private interests and financial expectations. This article performs a bird's eye view of Web 2.0 novelties, portrays the structure of a community for healthcare and describes how medical information can be exploited in favor of the community. It discusses the merits and necessities of various approaches and tools and sheds light on pitfalls that should be avoided.

1 Introduction

Medical informatics and Healthcare applications have been devoted to the study and implementation of structures to improve communication, understanding and management of medical information and promote public health. Their main objective is the extraction, storage and manipulation of data and information and the development of tools and platforms that apply knowledge in the decision-making process, at the time and place that a decision needs to be made.

The advent of internet introduced the idea of tele-application of medical practices. Tele-medicine, tele-education of practitioners and nurses, tele-healthcare and tele-consultation are rapidly developing applications of clinical medicine, where medical information is transferred via telephone, the Internet or other networks for the purpose of consulting, and sometimes remote medical procedures or examinations.

Internet has broaden the scope of medical information systems and led to the development of distributed and interoperable information sources and services. In the same time, the need for standards became crucial. Federated medical libraries, bio-medical knowledge bases and global healthcare systems, offer a rich information sink and facilitate mobility of patients and practitioners.

The Web attracted more patients and increased the popularity of freely available medical advice and knowledge. The abundance of web sites that offer medical content affected the way patients face their doctors, gave them a second opinion and increased their awareness.

Its' successor, Web 2.0, was built on the same technologies and concepts but added a layer of *semantic abstraction*, offered a *network as a platform sensation* and gave a *social networking aspect* to medical information systems.

Patients, instead of seeking medical information and requesting medical advice on their issues, are supplied with useful news, when medical advances take place. Patients are able to discuss their issues with other patients and collectively develop a medical knowledge base with easy to use tools. The plethora of tools and platforms available enhances the inventory of medical practitioners and can be of value to them and their patients if properly exploited. This paper gives an overview of these tools, discusses the merits of their use and the potential hazards that should be avoided.

In the following section we enlist the major technological novelties of Web 2.0 under the prism of certain applications and explain how they led to Heath 2.0. In section 3 we examine a community based approach, which combines the aforementioned novelties, under the prism of intelligent information management and in section 4 we discuss the potential merits of this approach and the issues that should be considered.

2   From Web to Web 2.0, Health 2.0 and Medicine 2.0

Internet and its services had a major impact on health care and medical information. First, it opened public access to medical information, which was previously restricted to health care providers. Of all searches on the Internet, 4.5% have been calculated to be health-related [7]. The patients feel empowered before reaching their doctors [1], since they find or ask for information on the web. They get an idea about their diagnosis and treatment options and want to actively participate in therapeutic decisions. As a result, the way of interaction between the patient and the doctor, has changed. Similarly the way people perceive medical information has changed.

2.1   Medical Information and Web-Based Applications

The seek for direct medical consultation gained place from searching and browsing of medical information and this is another fact of change in the way of communication between doctors and patients. "Ask the doctor services" [25], initially deployed through e-mail, kept record of questions and replies by expert physicians and published results to the web for further reference [26]. Web sites have been also created in order to alert or support patients [12] and offer informative content, provide directions for prevention, cure and symptoms' handling and of course sample questions and feedback from physicians.

Electronic assessment is another healthcare application which gained great attention. Online questionnaires, symptom checklists etc. were used in order to increase the interactivity of web based medical applications. Short screening tests [13], [21], helped people to detect and overcome their addictions, alerted them and reminded

Table 1. Web based medical services

Web applications	Purpose	Services
Ask the doctor	Offer medical consultation on demand	E-mail
Medical chats	Offer medical consultation on demand, group therapy	Chat
Medical forum	Offer medical consultation on demand, retain archive	Forum
Ask the doctor website	Archive medical consultation	Dynamic Web site
Patient support websites and mailing lists for alerts	Provide informative content, support and prevention guidelines	Email, Static Web site
Online assessment	Prevent maladies, detect additions	Active Web Site
Tele-healthcare, medicine, homecare etc.	Remotely provide clinical care, diagnosis, medical education	Tele-conference, Voice and Video over IP

them to visit their doctor. Mailing lists were another solution for supporting patients in a constant manner.

Table 1 summarizes medical applications and services delivered over the web.

Tele-healthcare, tele-medicine [14], tele-homecare and other applications make use of Web and the whole Internet infrastructure in order to offer clinical and non-clinical services (medical education, information and administrative services).The main aim of these application is the transfer of medical information and advices between the hospital and the remote patient, or the remote care provider, thus removing geographical and time zone barriers. In the same direction, interoperable medical information systems have been developed to support exchange and utilization of medical information across different hospitals, different healthcare providers or even across different countries [4], [3]. Web is mainly employed to achieve better coordination of all the participants in the medical process.

All the above applications created a critical mass of people, practitioners, patients, care providers and care givers that requests medical information and advice in health related issues in an everyday basis. People gathered in virtual communities and started seeking for more flexible and collaborative solutions on their issues. The interest for ubiquitous medical information and pervasive solutions [5], created new web applications that facilitate people in sending, processing and receiving medical information. At the same time a lot of Web 2.0 applications and standards emerged.

The original definition of Web 2.0 by O'Reilly [18] summarizes the characteristics of Web 2.0 applications as: (1) data sources that get richer as more people use them, (2) collective intelligence, and (3) lightweight components and APIs that can be easily assembled, (4) rich user experiences. Other researchers view Web 2.0 in its widest sense, incorporating all existing web tools, user produced content (blogs, podcasts and vidcasts), protocols and semantics that allow harnessing collective intelligence [11].

Although the definition of term Health 2.0 is still under development, it is certain that it will stand in the common ground of social-networking and health care. Emerging internet technologies and applications aim to transform health care into a collective social service. Health 2.0 mainly focuses on actors such as patients, care-givers and, care-providers and their roles in the collective approach [22].

The term Medicine 2.0 [8] has been introduced by the Journal of Medical Internet Research (JMIR) (http://www.jmir.org) and the International Medical Informatics Association (http://www.imia.org) as name for a conference series (http://www.medicine20congress.com). Medicine 2.0 has a broader scope than Health 2.0 and its applications, services and tools are Web-based services for health care consumers, caregivers, patients, health professionals, and biomedical researchers, who use Web 2.0 technologies as well as semantic web and virtual reality tools, to enable and facilitate specifically social networking, participation, collaboration, and openness within and between these user groups.

A survey of collaborative services and their applications in Healthcare and Medical communities is presented in the following section.

3   Collaborative Services in Medical and Healthcare Communities

Despite the achievements of web and its services, it was necessary that patients seek for medical information and that patients contact their doctors for consultation, diagnosis or treatment. The advent of Web 2.0 changed this uni-directional flow of information. Now, all community members, even patients are able to feed the community with news, advices and personal experiences. Moreover, the request-serve model has changed towards a push-pull model where information is accumulated by community members and is made available to all community members through intelligent services. Patients receive useful alerts and doctors get notifications on medical advances, new medicines and therapies.

In [18], the term Web 2.0, is perceived to encompass a set of services, which extend Web 1.0 capabilities and emphasize on the community and collaboration aspects. In [22] and [23] authors present how medical communities can be used in favor of patients and how communication and collaboration between members of the healthcare community can be hosted in a community platform. The utter aim of any medical and healthcare community is to assist patients, either directly by providing medical care or indirectly by improving medical knowledge. Depending on the specific targets of the community (e.g. practitioners' education, patients' support, etc.) the members, the roles and the use of web 2.0 services differentiate.
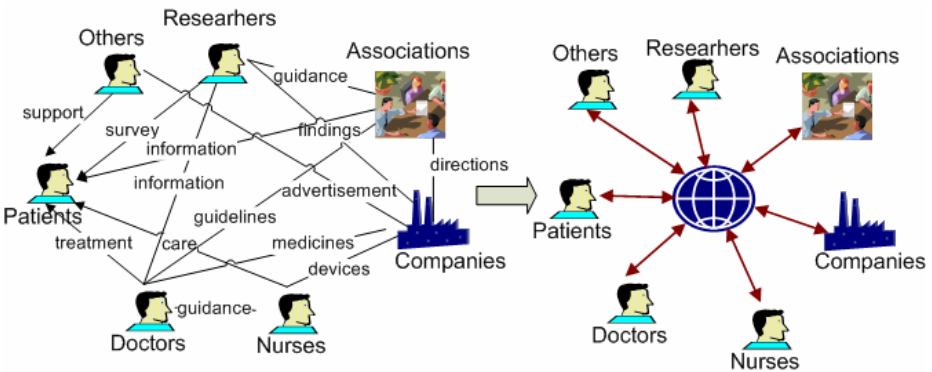

Fig. 1. How the medical mesh transforms into a community

In the following, we provide an overview of the most popular Web 2.0 services, present their main features and give reference to several online implementations in medical applications.

3.1 Web 2.0 Services

There is already an important amount of Web 2.0 applications [6], [7], [15], [16], which are related to medical issues. Blogs, wikis, folksonomies, podcasts and vidcasts are among them. In the following we give details on these applications, on the way information is published, annotated and consumed and on their potential use in favour of the medical community.

The main characteristics of all Web 2.0 services, which are presented in Table 2 are: a) contribution is communal, b) publishing has been replaced by participation and c) access is public or at least is granted to the members of the medical community. Anonymity and identity issues are solved with the use of virtual identities. They are mainly asynchronous since it is infeasible for all community members to be concurrently online.

Blogs
Blogs (Weblogs) are Web sites that function as online journals. They present published content in reverse publication date blogs. One or more persons may contribute with articles (posts), comments, links to other Web sites and multimedia content. Blog participants form virtual groups based on their common interests.

Table 2. Web 2.0 applications. Examples and open source solutions

Web 2.0 apps	Purpose	Online examples/tools
Blogs, photo blogs	Provide medical consultation, news, announcements, photos, allow comments	www.docnotes.net http://casesblog.blogspot.com www.wordpress.com www.flickr.com
RSS feeds and news syndication	Instantly receive medical information right after it is published	http://www.doctorslounge.com/rss http://www.rss4medics.com www.medicalnewstoday.com http://www.feedforall.com
Podcast and Vidcast	Provide consults, courses and information in audio and video stream format	http://conversations.acc.org/ http://www.annals.org/podcast/index.shtml http://www.clevelandclinic.org http://video.google.com/ http://www.archive.org/details/movies
Wiki	Collaboratively construct an archive of medical knowledge	http://askdrwiki.com/mediawiki/ http://www.radiopaedia.org http://www.mediawiki.org/ http://www.splitbrain.org/go/dokuwiki
Collaborative Tagging and Social bookmarking	Link to informative content, evaluate sources and organize knowledge	http://www.bibsonomy.org/ http://www.citeulike.org/ http://www.flickr.com/ http://www.connotea.org/
Cyberspaces	Provide a virtual and interactive learning environment	http://www.secondlife.com http://opensimulator.org/

The easy and immediate publishing made them very popular. The posting of a clinical photo from a digital camera or a mobile phone directly to a blog after optimisation and commenting can be made at the touch of a button. Medical blog examples include Clinical Cases and Images, Family Medicine Notes etc.

RSS

RSS stands for "Really Simple Syndication." It is a standard format used to share content on the Internet. Many websites provide RSS "feeds" that describe their latest news and updates. They play the role of newsletters but offer information in pieces, at the moment it is created (feeds) and can be accessed by various devices and systems grace to the standard format. The doctors' lounge, RSS for medics and Medical News Today are a few medical RSS news syndication services. Most blogging services offer the ability to create RSS feeds and an RSS reader is the only tool needed to process this feed.

Audio and video podcasts

They can be employed similar to RSS for providing medical information on emerging issues. Moreover, the power of image and the ease of listening instead of reading make them ideal for the dissemination of medical information and for online courses. In a project developed at St George's, University of London, UK, named Clinical Skills Online (CSO) [8], online videos demonstrate core Clinical Skills common to a wide range of medical and health-based courses in Higher Education. The video courses are categorized by topic, by user's expertise and occupation and are available to the public. The option of user feedback is available through a questionnaire and a free text comments form. Other interesting examples include: the Annals of Internal Medicine, the podcasts of the American College of Cardiology (Conversations with Experts) and the vidcasts of Cleveland Clinic.

Wikis

Wikis are considered to replace content management applications by allowing users to easily publish articles, images and video. They can start to cover the lack of free online medical information and function as a repository of medical information that could be readily accessed for reference. They are built and populated collaboratively by domain experts and are accessible to patients, doctors or trainees and the public. In a medical wiki, the group of editors creates and contributes with article reviews, disease definitions (symptoms, cure etc), clinical notes, medical images or video. Editors have the ability to alter content published by other editors and have their articles edited by others hoping that the wiki will finally converge into a widely accepted final version.

Social bookmarking

Medical bookmarking is aimed to promote the sharing of medical references mainly amongst practitioners and researchers. Scientists can share information on academic papers, are able to collaboratively catalog medical images with specific tools developed for that purpose. Article readers can organize their libraries, which can comprise Medline articles, with freely chosen tags. The result is a multi-faceted taxonomy, called folksonomy of tags (topics) and associated sources. Many medical information

sources support tagging by users (i.e. JSTOR, PLoS, PubMed, and ScienceDirect). Human knowledge, captured in the categorization and characterization of articles, or web sources in general, can be exploited by intelligent agents in order to provide recommendations about related sources or tags.

Cyberspaces
Although the term ***cyberspace*** dates back into 80's, it is becoming more and more realistic nowadays. The improvement of 3-D visualization technologies and the need to refurbish the link-based Web surfing allowed the development of new platforms and virtual environments, which allow users to replace accounts with avatars, hypertext with interactive 3-D objects and browsing with walking, flying and teleporting. The educational possibilities of these virtual environments are many [2] and the projects and workgroups that have been created are numerous [20] (e.g. the IBM 3D Virtual Healthcare Island in Second Life, the OpenSim project that can be deployed individually).

It is obvious, that all the services presented above, differ from typical web services, in the multitude and nature of information sources they cover and the way of enhancing and exploiting this information.

3.2   The Structure of Medical Community

A medical community that will encompass all the people interested in medical issues should be open to new members. Trustfulness is critical in medical issues and specifically in medical consultation, so the identity of consultants has to be valid and accessible to the community members. In the same time, the anonymity is necessary (or at least helpful) for patients that seek for consultation.

Information/content providers and information consumers are the two main types of users. The former should necessarily use their real identities, whereas the latter can remain anonymous or behind use virtual personas. Information consumers (i.e. patients, people asking about medical issues etc) can potentially become providers, since their questions, remarks and bookmarks are made available to the community. However, the quality of this content is questionable. Moderators, administrators and facilitators stand in-between the two types of users and are responsible for the smooth operation of the community. They control the registration process and guarantee the validity of expert members' identities.

The community members are able to form groups inside the community based on common needs and interests. The needs of each group are different and sometimes contradictory. It is necessary for the community to allow members to communicate their similarities and join their forces, whilst protecting their individuality. A healthcare community can attract scientists and researchers, doctors and nurses, patients and people with personal interests in medicine and healthcare, companies. More specifically:

- Scientists and researchers join the community in order to exchange knowledge and promote their science. They communicate with patients, analyze surveys' results and population statistics and get useful feedback on patient needs, on medical issues that arise etc. They co-operate with other scientists for their experiments and disseminate their findings to companies and individuals. They also give useful directions to medical associations concerning public health.

- Medical associations provide the professionals with guidelines on patient treatment and inform patients on topics such as prevention, self protection etc. They issue specifications for companies that produce medical devices and medications.
- Healthcare companies advertise their products (devices, therapies, medical applications) to doctors, nurses and patients.
- Healthcare practitioners get informed on new findings, emerging therapies and medical approaches and sometimes get online training. In parallel, they guide nurses and patients' families on patient-care and provide researchers and associations with useful feedback on emerging patient needs.
- Patients are *receivers* of support, treatment, care, information and advertisement from all other participants. They contribute to the community, as end users of the community outcomes and as specimens of surveys.
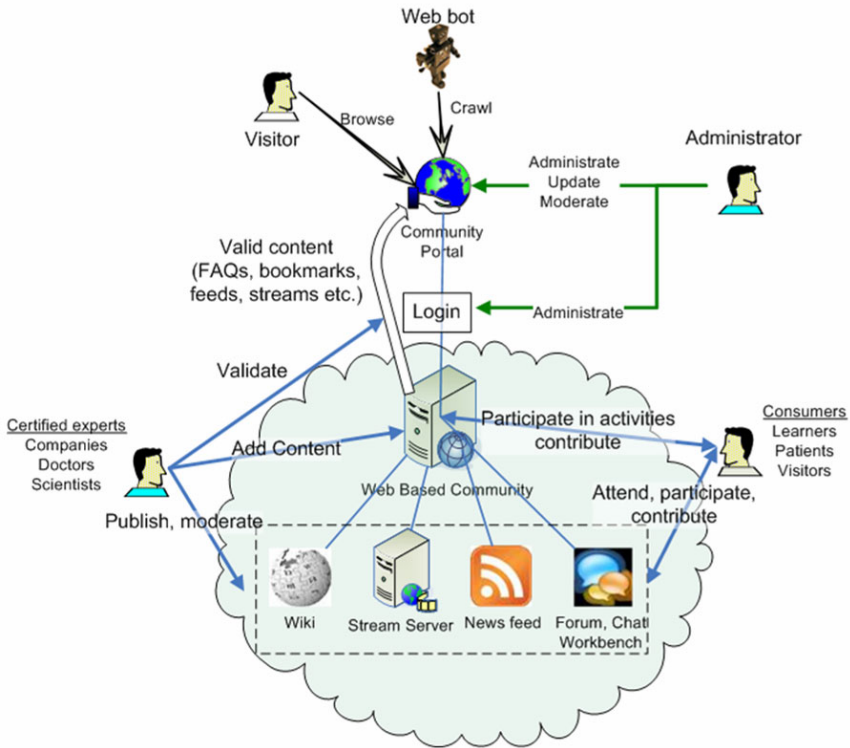

Fig. 2. The medical community structure

As it is depicted in Figure 2, the medical community should provide different level of accessibility to visitors, registered members and special members such as doctors or scientists. The nucleus of the virtual community should be equally accessible to members and visitors. More specifically, the community portal must be accessible to every web visitor or web service (bot) that wishes to browse or process the published

content. Community members, should register once and login every time they want to join the community. The registration of new members should be controlled by the administrators. The identity of expert members (doctors, company officials, scientists etc) should be checked and certified by the administrators, where as simple members can join by giving a contact e-mail address.

Once inside the community, registered users are able to participate in the various activities (i.e. chat with doctors or other members, perform public discussions, attend a video podcast or register to news feeds). The community experts create and publish new content and are charged with the moderation of group discussions, and the filtering of content uploaded by non experts. They use the wiki and tagging services to accumulate and organize the knowledge base of the community and inform on new findings using the news feeds.

3.3   The Assembly of Web and Web 2.0 Tools

A *web site* is necessary to welcome web visitors and guide potential members into joining the community. The site should provide informative content on the community aim and structure and can be created as a joint effort of the universities or educational institutes that support the community. The web site will advertise the educational programs and will provide information concerning every day activities of each course, news and announcements of interest to the students.

The web site administration should be performed by technical staff from the educational partners of the community (i.e. the university). Coordination tasks will be held by the registrar office, who will be responsible for the members' accounts, their participation in virtual classes etc.

A smart and cost free solution for the web site is presented in [24]. There, the web site was a blog, created by the university. The blog was visible to anyone, but practically only registered community members were allowed to update content or comment. In an effort to delegate administration tasks, a "weblog umbrella" can replace the community portal (see Figure 3). Another solution, which requires access to a web server, is to deploy the web site in an open source Content Management System.

Blogs (or web logs) are easily updatable websites where administrators can post messages by filling a few forms and without special knowledge on web design technologies. Separate blogs for each field of interest allow *experts* to distribute news and knowledge in an organized manner, to add or drop material, to add short notices or announcements and manage the comments or posts of the community members. The *registered members* are permitted to comment on the blog posts thus providing the community with useful feedback. The *visitors* are able only to read announcement or comments.

Educational activities of the community can be ideally supported by a *web based course management system* (i.e. Moodle, Mahara, WebCT, Blackboard etc). Such systems are specialized in managing and delivering on line courses, and assemble various community tools such as forums, wikis etc. In the majority of courses tutors use the community application solely for provided reading material to students. However, in several cases, students and professors need the forum, chat and other services in order to coordinate their actions. When an integrated course management system is not available, the community can be still operational by combining various open source tools.
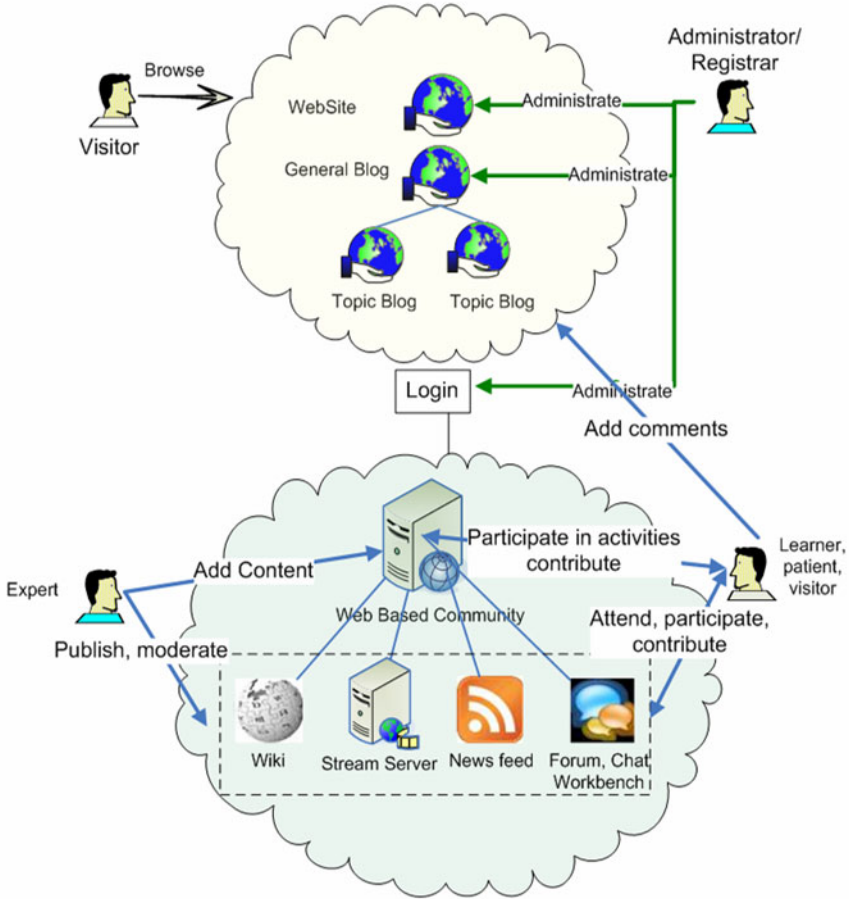
Fig. 3. The 'blog umbrella' alternative to the community portal

Computer-mediated *chat*, *discussion forums* and *newsgroups* can be formed and supported by the community administrators. Such forums will host discussions focused on the healthcare issues [2] and will be used from doctors to provide guidelines. *Mailing lists* and *web feeds* can be in assistance of doctors and patients. For example the doctor will be able to inform patients for an upcoming medical examination.

When there is need for building collaborative knowledge and making it available to medical researchers and practitioners, wikis are a cost-free, open-source solution. A *wiki* is the collaborative coverage of a topic from the members of a community. Any member can contribute or modify the content under conditions (proper reason, provide references etc.). The vast number of medical wikis currently available [17] is an indication of their popularity and their importance for medical matters. A wiki can be created and moderated by the domain experts in order to quickly build a terminology source for students.

Other collaboration services comprise, ***virtual workbenches, virtual blackboard*** etc. The results and history of collaboration services are usually stored and used as a reference by other community members. Such applications usually require specialized software and dedicated sources and thus are not widely used for medical education. The educational potential of ***virtual worlds*** has attracted the interest of medical communities, and created new opportunities for medical education in the cyberspace [2], [19].

When a teleconference room is available, distant courses can be performed from the joint institutes. Tutors and students communicate using real-time video over a streamed media server. Educational ***multimedia content*** (i.e. medical videos from surgeries, recorder sessions or courses etc.) can be stored in media repositories, and made available to community members. Free video hosting servers can be used for this task, however, bandwidth and storage limitations, restricted access and other issues should be considered.

The applications presented in the bottom section of figure 2, can be accessible both to students and tutors, however the degree of participation increases for students as moving from left to the right. All these services (i.e. wikis, streaming media, news feed, forum, chat, workbench etc.) can be offered through separate tools and platforms or ideally through the same Web Based CMS.

The next section illustrates the gains from the use of Web 2.0 tools for individuals, companies, organizations and healthcare and medicine in general.

4   Discussion

The merits that arise from the community approach are many. First of all the human knowledge is captured, is enriched with semantics (i.e. tags) and is organized collaboratively (i.e. folksonomies, wikis) in a mechanically readable way. Instead of a multitude of distinct applications that do not cooperate, the community platform is the World Wide Web, and the community activities and services can be developed using commonly agreed standards and common terminology. Web offers ubiquitous access to the community services, since web 2.0 applications are light and can be accessed by mobiles, PDAs, or even tv-sets. New content (i.e. video blogging or podcasting), requests for advice, patient related information or input to surveys can be attached using the same devices (e.g. patient can select their symptoms from a list and communicated them to the community experts).

The personalization of the community content to the specific needs of each member can be done by selecting the mini-applications (widgets) that fit each patient's needs. Smart alert systems can be developed that will remind patients of their scheduled treatment or that will inform doctors on their patients health status.

All community transactions and communications must be secure and various access levels can be used. Trust inside the community can be guaranteed by a strong administrator organization through the use of proper technologies, validation mechanisms and security structures. Trust can also be developed by using an evaluation and reputation system. In this system, expert users will be able to validate content, and all community members will be able to judge, vote and tag content in order to make it useful for others.

As it is the case with all communities, the administrators should be careful to avoid several dangers. Most of the efforts we mentioned in section 2, are made by individuals, or by a single institute or university and are not supported by a big organization or a medical forum. A centrally co-ordinated effort is necessary for a successful and effective community. Administration should be performed in co-operation with companies and associations. When the community serves for patients or doctors to support other associates, the advices and information exchanged between individuals should be validated. Group moderators need monitoring tools in order to proactively coordinate groups, and would be pleased to have collaborative platforms to support their groups. Validity can be achieved through monitoring, although, it is preferable to replace monitoring with an authorization mechanism. Advices, comments or opinions that are not signed are considered of low quality and consequently invalid. Valid information and services are issued by authorized community members only and are always signed.

The diversity of web 2.0 tools can be confusing to the community members, especially when all novelties are introduced in one step. Changes and new services should be added slowly and training, facilitation and user feedback are advisable.

Another issue that must be considered in a medical community relates to the amount and quality of information offered. The flood of information can be confusing both to patients and doctors and for this reason, information must be filtered and organized. Since anyone is able to publish information and since it is not always easy to see the origin of the information, users could be making decisions on the basis of a source that might not be quality assured. A certification authority is necessary to guarantee the expertise level of every user, control the quality of the published information and build trust among the community members. Even when the information is of high quality, users are not capable to make their own judgments and need support from the experts. Other issues relate to the expertise of all members in handling virtual discussions or providing diagnosis remotely. These issues should be considered in the design phase in order to increase members' participation and improve the quality of the community services.

5   Conclusions

This paper performed an overview of web 2.0 applications and compared their features to traditional web services under the prism of the medical community and its needs. Current attempts in using web 2.0 applications in favor of the medical community are fragmented, so we present a structure that will allow their interconnection. The community will bring together doctors, nurses and volunteers around patients and will provide the tools for requesting and providing medical information, advices and psychological support. Healthcare associations, companies and researchers will be able to join the community, disseminate their instructions, products and findings respectively and undertake crucial tasks such as the quality control of services and information. The use of community services will load the community database with valuable information concerning user feedback, patient needs, treatment suggestions, patient profiles and medical record history. The stockpiled information can be analyzed: by the community administrators who want to improve services, by scientists

who perform medical research, by future patients who seek for a quick advice from a fellow-sufferer. The knowledge produced inside the community will be continuously filtered and managed in order to maintain quality.

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