Science-Forums.net: A Platform for Scientific Sharing and Collaboration

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ABSTRACT

The beta website of Science-Forums.net was developed by Information International Associates, Inc. (IIa) through the Department of Energy (DOE) Small Business Innovation Research (SBIR) program. By leveraging scientist/researcher information in databases managed by DOE's Office of Scientific and Technical Information (OSTI), Science-Forums.net will allow scientists to easily collaborate on a scientific topic of interest. In addition to potentially yielding commercial applications, the functionality of Science-Forums.net is well suited to OSTI's family of scientific and technical information (STI) websites for research and development.

The objective of the SBIR—"Interactive Peer-to-Peer (P2P) Scientific Communication in the Digital Library Environment"—was to research and identify web-based tools and other concepts that will foster online interaction and collaboration among scientists and researchers. These tools can facilitate scientific discovery and innovation.

Phase I methods included (1) survey of available technologies, (2) analysis and prioritization of technologies, (3) design and planning of a foundational tool for online interaction, (4) development and implementation of approaches to obtain feedback from researchers and scientists, (5) research into privacy and communications examples and guidelines to address government privacy and survey requirements, and (6) investigation into scientists' use and interest in social media tools for research and communication.[1]

Phase II has focused on (1) development of the tool into a beta-ready site for feedback from a test group of previously identified, interested researchers, (2) refinement of the privacy policy and user terms and conditions documents, and (3) further research of bibliographic/metadata

controls to create and exchange documents and other content.

BACKGROUND

Motivation/Justification for the Research

This project began with the hypothesis that web 2.0 technologies can promote information exchange, collaboration, and networking among scientists (P2P) and that they can also facilitate scientific discovery and innovation. Furthermore, there was a strong belief that scientific researchers would want to collaborate in a different manner than that provided by the typical social network (e.g., Facebook, LinkedIn, Second Life, or Twitter). The system should support a broad range of information types: technical reports, grey literature, theses, research notes and papers in progress, as well as social interaction among users, blogs and forums open to the general research community, and those open only to a select group of members.

The primary goal of the project was to research and develop a prototype tool to enable interactive P2P scientific communication in the digital library setting. This prototype tool would provide mechanisms to enable scientific and research communities, as defined by common interest, to communicate based on content provided by a digital library or another collection of information (e.g., grey literature in a specific topic). By increasing the ability for collaborators to interact, this tool will improve the diffusion of scientific knowledge.

These digital libraries, or literature collections, provide a unique opportunity to facilitate communication between scientific communities of common interest. These groups can add functionality to their electronic dissemination products (i.e., web-based database search products) to allow users to communicate and collaborate using the technical information they seek as the catalyst for discussion and collaboration. To date, agencies within the governmental digital library environment have not deployed this type of collaboration technology. This P2P communication is a less formal scientific mechanism than a technical report. Because authors

typically have some mechanism for users to contact them directly, implementation of P2P communications should be straightforward.

Discussion and collaboration invariably lead to creation of new content. Collaborative technology enables informal content creation through comments and discussion, along with the more formal creation of published and grey literature, using document and bibliographic/ metadata formatting interchange standards. Mechanisms to perform a literature search and to access, import, share, view, and cite other published and grey literature are also necessary to facilitate creation of new content.

Other Benefits

IIa anticipates that the project will result in a P2P system that is easy to use, configure, and administrate. The approaches developed and implemented for this project are important for government agencies and for corporations providing public information to various consumers on widely accessible terms, as well as through more restricted access. Any research institution or information provider that makes a body of STI available will greatly benefit from this project. This communication mechanism will enable members of scientific communities to discover others with common interests, facilitating a broader perspective on specific topics, and increasing and enhancing the amount and quality of information available for a specific community of interest.

This system will also accelerate knowledge discovery. Having the ability to communicate instantly with peers and to identify a broader field of members within communities of interest will facilitate discovery and synthesis of STI. Furthermore, enabling the development of new scientific grey literature in standard bibliographic/metadata formats will facilitate retrieval by librarians and other information professionals. Not only is this concept useful to traditional government research agencies, but it is also applicable to universities, pharmaceutical

companies, and all organizations involved in scientific research.

PHASE I

Experience, Goals and Accomplishments

Based on our analysis of the requirements during Phase I, we identified appropriate DOE libraries and other agency libraries to participate in the prototype. We conducted joint application design (JAD) sessions to determine the type of P2P communications desirable in this environment. We used a structured questionnaire to poll representatives from selected agencies and national laboratories, as well as local information analysts, to determine how they currently collaborate and how they would like to collaborate in the future. IIa developed and refined requirements through an iterative effort with DOE and other agency stakeholders.

Phase I also included a comprehensive survey of available commercial technologies and standards to determine what commercial-off-the-shelf (COTS) or shareware products provide P2P communications to satisfy some or all requirements. Technologies in development at universities, within DOE, and within other government agencies were also surveyed. IIa anticipates that available technologies will provide 60 percent of the solution.

User Input Process - Interviews, Polls, etc. A two-pronged approach was used to determine baseline requirements.

1. We interviewed individuals in a small, hand-selected focus group in person to define a useful set of collaboration tools. In one of the focus group interviews, we asked a DOE nuclear researcher his opinion of new social media. A few of his quotes follow:
    - "If there are ways to have a social networking site devoted to narrow topics, that might be of value. So, making that easy for someone to establish something like that. But it would have to be bottom-up, researcher-driven."
    - "I'm working now in the area of thermodynamic modeling of nuclear fuel. I have some

colleagues in that area. I hear from them occasionally. It would be nice to foster a little more communication on that."

- "There is a potential that we're overlapping in work, and we want to avoid that. So-and-so has developed an understanding of this chemical system. I don't want to do the same thing. I want to leverage what he's already done, and vice versa."

2. We identified a larger group to answer a questionnaire and provide feedback on a regular basis. To identify this group, emails were sent to more than 11,000 DOE researchers and authors explaining the project and asking for their assistance. Based on their responses, 136 respondents were selected to participate in the feedback.

Summary

There were three objectives in Phase I: (1) determine the high-level requirements for the system, (2), conduct a survey of COTS/open source systems, and (3) produce a prototype for evaluation. These goals were met, with results as discussed below.

Requirements

Several critical themes were almost universal among the respondents. Simplicity and ease of use were the first requirements identified by interviewees. In virtually all instances, the researchers said they did not have the time or the inclination to wade through a system of complex screens and infrastructure to try and use the system. They wanted to keep the focus on their research and publication rather than become the master of a complex tool. Another common theme was the need to efficiently access, import, and share content (especially from library collections), in-process work, lab notes, and other unpublished information. While this was not a focus in the initial phases of the project, it quickly became apparent that this system could be an extremely useful tool for the GreyNet community by providing the platform to make collections of grey literature available to select communities of interest using the uploaded information and

other databases as a basis for discussion and collaboration. Likewise, forum members can upload their own collections of grey literature to use as a basis for discussion in their forum.

Sensitivity to the conflict "between collaboration and competition inherent to science"[2] was another theme. Interviewees want to be confident that adequate security safeguards are in place to ensure that information is shared only by trusted individuals who are members of their forum.

Market Survey

When the initial marketplace review was conducted early in Phase I, very few scientific collaboration products were available. Almost all of products were narrowly focused on specific scientific communities. During Phase I, extensive web research was conducted, and university and national laboratory work in this area was examined. While some products were partially related, in the end, no technologies were uncovered to fully solve the problem.

Prototype

The other primary purpose of the research was to develop a limited prototype with some of the planned functions for evaluation by DOE. The prototype was to demonstrate the concept's usefulness and desirability. The prototype was constructed and shared with DOE, who concurred that the concept was viable and would be a valuable addition to existing OSTI STI web products.

Our Phase I final report states: "The project team designed, prototyped, and integrated a web-based application feature called 'Author and Subject Clustering' into the OSTI Information Bridge web site. Author and subject clustering allows researchers to view a list of prominent authors and subjects for each topical search they perform."[3]

PHASE II

Prototype Development

For the enhanced prototype in Phase II, we developed and refined requirements through an iterative process among DOE stakeholders and IIa. Therefore, the initial requirements were

expanded as needed by analyzing, documenting, and reaching consensus on requirements through prototype functions in the following areas:

- User interface
- Model to identify common interest groups
- Cost-effective, real-time, interactive P2P communication
- Capability to access, import, create, search various documents/content
- Privacy
- Security
- Data protection
- Reporting

The main focus of Phase I was to develop a questionnaire for use throughout the user community to determine the system's operational requirements. Based on this feedback, a system was designed to enhance collaboration within the scientific community, and a limited, prototype was developed to highlight authors within DOE online repositories.

For Phase II, we revisited a survey of currently available commercial technologies, including COTS or shareware products with P2P capabilities that may be adapted to the digital library environment. We expected and confirmed that there was considerable development in P2P collaboration between Phase I and Phase II surveys. In fact, some commercial products were released during this time. However, they were either so complex that target scientists were unlikely to adopt them, or they did not include important functionality needed to ensure effective performance for this audience. We did find that a significant number of shareware or open source products were highly customizable out of the box to fulfill many project requirements.

Before selecting a technology for the enhanced prototype, we identified barriers to adoption for the scientific community. Along with thorough evaluation of comments from the Phase I interviews and questionnaires, we also analyzed studies, literature, and online discussions of scientists. A recurring theme is summarized in this quote: "Most scientists were reluctant to invest more than a very small amount of time to learn to use new technologies unless the benefits were substantial and related directly to their research." This observation is consistent with earlier

conclusions, underlining the importance of creating an intuitive, simple prototype with valuable tools and functionality. It also reinforces the conclusion that the flexibility of today's technology—doing everything for everybody—results in complex tools that are difficult for many scientists to use.[4] This exercise resulted in a list of obstacles that the enhanced prototype would need to overcome to ensure success (see Appendix 1).

Technology

During the Phase I technology survey and review of the existing technologies, we determined that there was no COTS product to meet project needs and that a prototype was needed. Therefore, we had to determine whether to develop something from the ground up, or whether we should select an open source framework to offer some initial desired functionality and to provide a development framework so that we could quickly add and evaluate new features. After a thorough evaluation of existing technologies, we focused on an open source content management system (CMS) to provide the most functionality out of the box while also providing a development environment in which features can be added as needed. We considered Ning, Drupal, Mambo, Joomla!, Taverna, and SupportMaster. Drupal was chosen based on several factors. Drupal is open source software maintained and developed by a community of hundreds of thousands of users and developers. It is distributed under the terms of the GNU General Public License (GPL), so it is free to download and share, and users can also contribute back to the project. This open development model ensures that people are constantly working to make sure Drupal is a cutting-edge platform that supports the latest technologies that the web offers. In addition, OSTI had selected Drupal for several applications (e.g., OSTIblog), so local expertise is available on the product. The Drupal CMS was chosen to allow for rapid prototyping of basic functions. Once it was determined that the tool met expectations for rapid prototyping, modifications and add-ons were made to make Drupal accommodate unique functional

requirements and address performance issues. Drupal also paid big development dividends since there are literally thousands of contributed modules available to help solve unique requirements. However, because Drupal is so rich and flexible, performance is impacted. As established earlier, poor performance is not likely to be tolerated by busy scientists. However, the intent was to use Drupal as the prototype, rewriting the system if the concept is commercially viable.

Because a major part of the system's functionality is to serve as a repository (library) for scientific research information, we determined that it was important to use open access standards for importing documents in the library function. We analyzed document metadata using digital object identifier (DOI), ISBN, Dublin Core, (along with OSTI DOE documents), and other standards for interoperability. The Library of Congress (LOC) website was used as a model for document interchange and standards. The result of the research and development is a web-based CMS that enables self-forming groups where researchers can create useful websites around scientific topics of interest to those groups. The project team named the website and system "Science-Forums.net."

Beta System Functionality

The purpose of the "Profiles" function is to encourage and support interaction among users of Science-Forums.net and ultimately of OSTI web portals. Profile information enables users to accomplish the following:

1. ***Verify the identity of other users.*** This is especially valuable when users have similar last names. For example, when a user's affiliation is provided in a profile, it can help end-users determine which "Smith" is the author of a particular document.
2. ***Specify other names under which authors have published.*** When an author has published under more than one name, the ability to make other names known can help users identify other works by the same author.

3. ***Provide more detailed background.*** Profiles can include information on education or work history to let other users know more about a particular user's credentials or experience with a subject. This is often of interest to researchers performing topic or author searches, viewing answers to questions, and understanding the context of online discussions.
4. ***Declare research areas and fields of interest.*** Profiles with this information can facilitate connections and dialog on topics of mutual interest.
5. ***Broadcast a user's interest in collaborative opportunities***. This information can help users who are seeking or offering partners for proposals.
6. ***Identify and locate researchers with similar interests***. This occurs in social networking websites and can be emulated here.

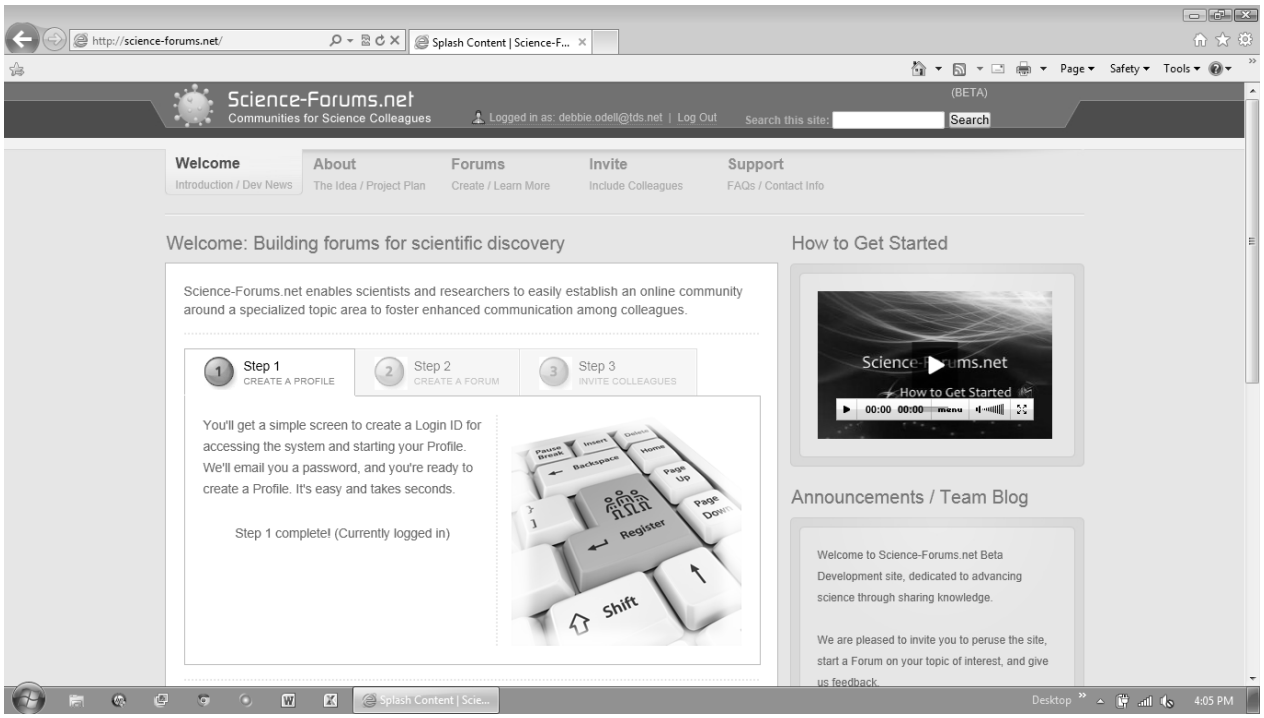
Trust is a critical element for effective online interaction. Without trusted communication, collaboration cannot take place. In order to achieve the project vision of researchers meeting, talking, and collaborating online, it is essential to provide a reliable level of trust for those interactions. This can be achieved through identification and verification of forum participants. The use of profiles is widely accepted and is scalable for different purposes. Profiles can be used on networked systems to identify and nominally authenticate users.

During the design phase, we considered providing a trust service that authenticates new participants by verifying some of the user-provided background information. We determined that this process would be too resource-intensive for the prototype, so the trust service will be explored by stakeholders for inclusion in subsequent increments.

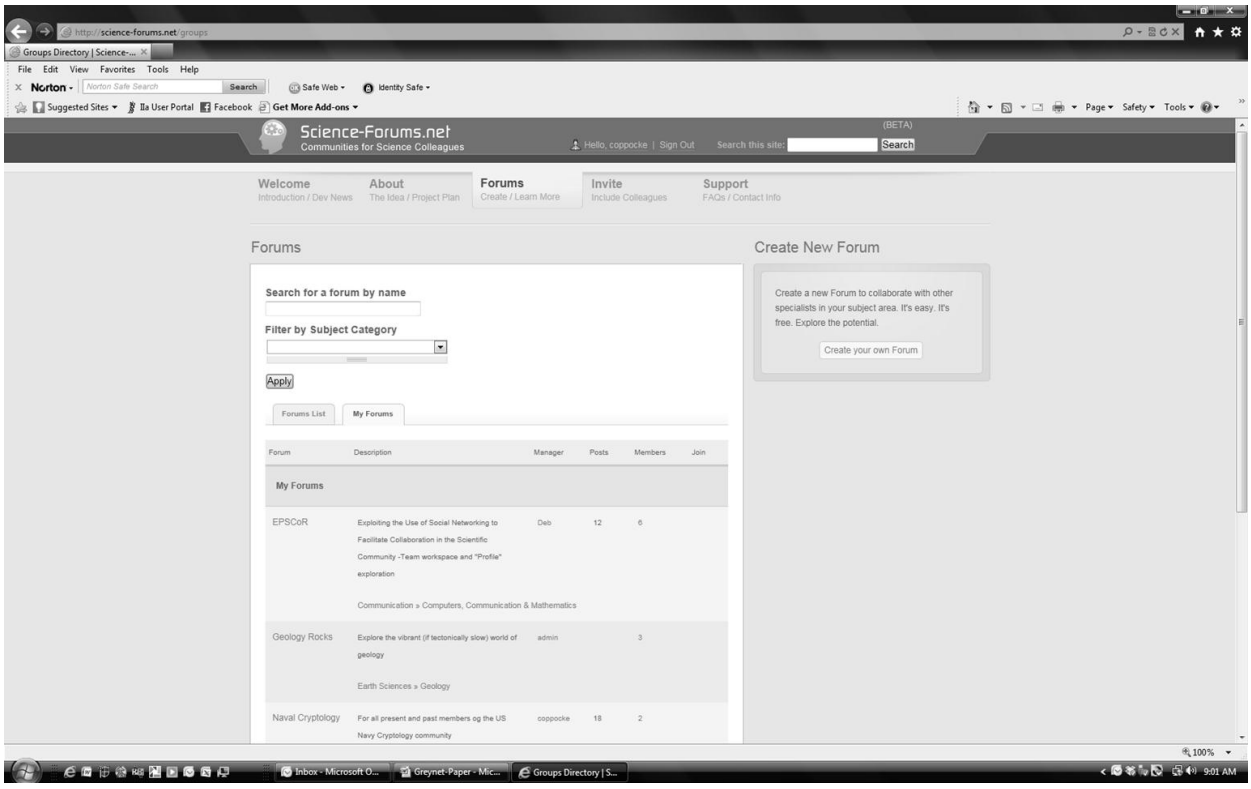
Other trust services that Science-Forums.net profiles can provide include introductions and messaging between previously unacquainted users while protecting user privacy. Researchers/users that express interest in providing feedback will be the first invited to create profiles to test the forum system.[5] Authors with articles in OSTI collections may also be invited

to create forums and profiles. When the Science-Forums.net framework is integrated with OSTI web portals, a profile link will be available for authors who have provided profiles.

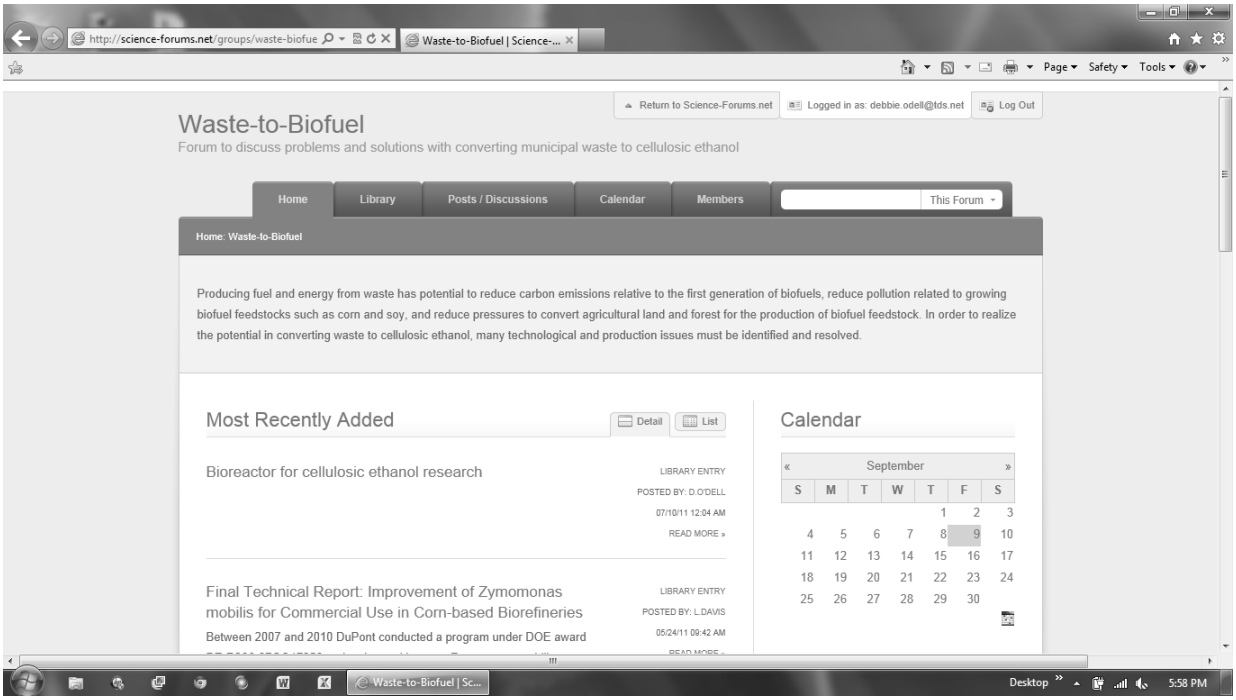
We considered a broad range of options for the type of information to include in user profiles, ranging from a minimal amount to a very robust profile like that used for LinkedIn or Facebook. Based on feedback during requirements analysis, a baseline model was chosen at this stage, with added features to address unique requirements of scientists and professionals. After the user creates a user profile and initially logs onto the system, then he or she is presented with the following screen.



It provides the user with access to the Forums screen.



At this point the user can search or browse the existing forums or create his or her forum. There are two types of forums that can be created - public and private. In a public forum, any user can join, search, view and contribute. In a private forum, membership is controlled by the forum creator and can only be viewed and contributed to by invited members. Once a forum is created and selected, the user is presented a screen like the one below.



Note that the navigation bar has now changed to display the following headings.

- **Library:** the main repository for existing technical content. The user can add content directly from DOE holdings, search and add content based on ISBN or DOI, cut/paste from existing metadata (e.g., BibTex or EndNote), and manually enter metadata for user-created documents. If they are available, the user can upload the full-text documents associated with the metadata in common document formats such as pdf, xls, doc, jpeg, etc.
- **Posts/Discussions:** blog posts, announcements, Q&A, and other communications for review, feedback and discourse. Other members can comment on posted entries, and users can view threads of conversations on a topic and respond to one or more previous posts. References or links to related information can be included in the body of the comment to support any point of view.
- **Calendar**: allows forum members to add event entries to mark meeting dates, conferences, or other events of interest.
- **Members:** allows the user to view all forum members and to manage privileges. In addition,

it allows the user to invite colleagues to join the forum.

The system also supports other features, such as notifications via RSS feeds, forum administration, user feedback, searches, and user support such as FAQs and contact information. In addition, a full user profile management subsystem is provided.

CURRENT STATUS

The system is nearing the end of beta testing and is under consideration by several scientific groups for adoption as their collaboration portal.

FUTURE DIRECTIONS

Depending on the level of system adoption and the availability of future funding, several enhancements have been identified and will be included in the system. In addition, if the level of performance does not meet users' needs, we will consider a customization that relies less on Drupal modules to provide better performance.

APPENDIX 1: Barriers to Adoption of Social Networking by Scientists, Businesses, Workers

Type of Barrier	Description / Excerpt from Source
Benefits of social networking are not obvious to researchers	**The major barrier to take-up of web 2.0 tools and services is lack of clarity – even among some frequent users – as to what the benefits might be.** The costs of adoption are not always trivial, and unless researchers receive active support and see clear and quick benefits, they tend to keep to the tools and services that they know and trust. Moreover, the rapid development and proliferation of web 2.0 services mean that it is hard to keep track of them, or assess their potential benefits.[6]
	Some applications promise a lot of value, but people may not see the immediate value.[7]
	Scientists are not really interested in social networking as an end in itself. They network to boost productivity.[8]
Must be easy to use, and take little time/effort to learn	While the technologies used to collect and analyze the data often must be cutting edge, specifically collaborative technologies are often best served by technologies that are simple, require very little learning, and are already easily accessible (e.g. wikis, and telephones). **Most scientists were reluctant to invest more than very small amount of time to learn to use new technologies unless the benefits were substantial and related directly to their research.**[9]
	Widespread adoption of web 2.0 services by researchers depends on their being intuitive and easy to use, and incremental in building on existing practices. Above all, they must offer clear advantages to users, and near zero adoption costs.[10]
Perceived lack of Quality and Trust (without traditional peer-review)	But a second major set of barriers revolve around perceptions of quality and trust. Both as producers and consumers of information, **researchers seek assurances of quality; and many of them are discouraged from making use of new forms of scholarly communications because they do not trust what has not been subject to formal peer review.** A significant minority of researchers believe that peer review in its current forms will become increasingly unsustainable over the next five years, and nearly half (47%) expect that it will be complemented by citation and usage statistics,

Type of Barrier	Description / Excerpt from Source
	and user ratings and comments. But at present they do not see such measures as an adequate substitute for peer review. **Trust is also a concern for researchers who are producing, rather than consuming, information; they are cautious about sharing results and findings in a medium which, as yet, has no standardised way to formally attribute authorship.**[11]
	But the major disincentive for many researchers may be lack of trust. Both as creators and consumers of content and services, researchers seek assurances of quality. Our study indicates that many researchers are discouraged from using new forms of scholarly communications because they do not trust what has not been subject to formal peer review. **These findings are consistent with other studies (e.g. Ware and Monkman 2008) which suggest that researchers seek assurances of quality above all through peer review, and that they do not see citation counts, usage statistics or reader ratings or other 'wisdom of the crowds' tools as providing an adequate substitute.**[12]
	David said that some of the barriers to adoption include the lack of reputation information,[13] lack of confidence in individual networks,[14] and concerns that personal data might be sold,[15]
	Users may also be suspicious of a site's commercial intentions.[16]
	Data used in networks need provenance and structure - some kind of hosting institution or scientific society verifying the credibility of data.[17]
	Sites with no checks on data run the risk of offering less valuable information.[18]
Waste of time	some researchers regard blogs, wikis and other novel forms of communication as a waste of time or even dangerous[19]
	Some non-users go further, and believe that novel forms of scholarly communications bring no benefits or are even a 'waste of time.' 'I'd rather spend the time thinking about what I'm going to do next rather than spend it telling others what I'm doing… I think it's definitely a younger person's thing.'[20]

Type of Barrier	Description / Excerpt from Source
Needs critical mass of users to be effective	These problems are exacerbated by the fragmentation of the user-base: **few services have yet achieved the critical mass needed to achieve the positive network effects that stimulate pervasive use by particular communities**. Researchers may well be right to defer a decision to take up a particular service until they are sure that large numbers of their colleagues have done so.[21]
	But there is some debate about whether many of the web 2.0 services for researchers – particularly social network services – provide sufficient added value to stimulate widespread adoption.[22]
	Moreover, the plurality of services results in fragmentation of the potential user base, which is especially problematic when benefits are closely related to number of users. Researchers may well defer a decision to adopt until they are sure that large numbers of their colleagues have done so. Thus the advantages for late movers may outweigh those for early adopters.[23]
	Social networking does not have value if you are just talking to yourself. (Ressequie, 2010)[24]
	no one site provides tools or features valuable enough to lure a majority of busy scientists[25]
	What can they offer that more established sites, such as Facebook, don't?[26]
Applications not integrated	David said that they've tried Yammer here and a wiki there, but when the applications are not combined in one product, it splits people's attention and the usage falls off. … Some don't know how to use applications together.[27]
Change may conflict with existing practices	Changes are usually incremental, for a number of reasons. **Introducing changes without input from users may conflict with existing practices and be rejected. Moreover, it takes time for new practices to develop around new features, especially if these radically challenge existing disciplinary patterns of use.** Providers therefore generally seek to align new features with existing services and patterns of usage. Thus, the fora on Nature Networks are very much in the style of

Type of Barrier	Description / Excerpt from Source
	conventional bulletin boards, with implicit social rules of behavior and a reasonably active moderator.[28]
	Adoption of web 2.0 tools and services, and of novel forms of scholarly communication associated with them, has reached only modest levels up to now. Use is both fragmented and uneven, and tends to support well-established practices.[29]
Institutional policies can discourage use	We also found some evidence that emerging institutional policies may act as a barrier: 'In our university we have a guideline on what may or may not be put onto the blog. I have to agree that something needs to be saved and I don't want people to say: we just discovered X.' [30]
Conflict between cooperation and competition	Some scientists may be wary of sharing too much, which probably hinders network adoption. There is tension between collaboration and competition inherent to science.[31]

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