

Web Search Engines

T.B. Rajashekar
National Centre for Science Information
Indian Institute of Science
Bangalore – 560 012
(E-Mail: raja@ncsi.iisc.ernet.in)

The World Wide Web is emerging as an all-in-one information source. Tools for searching Web-based information include search engines, subject directories and meta search tools. We take a look at key features of these tools and suggest practical hints for effective Web searching.

1. Introduction:

We have seen phenomenal growth in the quantity of published information (books, journals, conferences, etc.) since the industrial revolution. Varieties of print and electronic indices have been developed to retain control over this growth and to facilitate quick identification of relevant information. These include library catalogues (manual and computerised), abstracting and indexing journals, directories and bibliographic databases. Bibliographic databases emerged in the 1970's as an outcome of computerised production of abstracting and indexing journals like Chemical Abstracts, Biological Abstracts and Physics Abstracts. They grew very rapidly, both in numbers and coverage (e.g. news, commercial, business, financial and technology information) and have been available for online access from database host companies like Dialog and STN International, and also delivered on electronic media like tapes, diskettes and CD-ROMs. These databases range in volume from a few thousand to several million records. Generally, content of these databases is of high quality, authoritative and edited. By employing specially developed search and retrieval programs, these databases could be rapidly scanned and relevant records extracted

If the industrial revolution resulted in the explosion of published information, today we are witnessing explosion of electronic information due to the World Wide Web (WWW). The Web is a distributed, multimedia, global information service on the Internet. Web servers around the world store Web pages (or Web documents) which are prepared using HTML (HyperText Markup Language). HTML allows embedding links within these pages, pointing to other Web pages, multimedia files (images, audio, animation and video) and databases, stored on the same server or on servers located elsewhere on the Internet. Web uses the URL (Uniform Resource Locator) scheme to uniquely identify a Web page stored on a Web server. URL specifies the access protocol to be used for accessing a Web resource (HTTP-HyperText Transfer Protocol for Web pages) followed by the string “://”, domain or IP address of the Web server and optionally the complete path and name of the Web page. For example, in the URL, “http://www.somewhere.com/pub/help.html”, “http” is the access protocol, “www.somewhere.com” is the server address and “/pub/help.html” is the path and name

of the HTML document. Using Web browser programs like the Netscape and the Internet Explorer from their desktop computers connected to the Internet, users can access and retrieve information from Web servers around the world by simply entering the desired URL in the “location” field on the browser screen. The browser program then connects to the specified Web server, fetches the document (or any other reply) supplied by the server, interprets the HTML mark up and displays the same on the browser screen. The user can then “surf” (or “navigate”) the net by selecting any of the links embedded in the displayed page to retrieve the associated Web document.

From its origin in 1991 as an organization-wide collaborative environment at CERN (the European Laboratory for Particle Physics) for sharing research documents in nuclear physics, the Web has grown to encompass diverse information sources: personal home pages; online digital libraries; virtual museums; product and service catalogues; government information for public dissemination; research publications and so forth. Today the Web incorporates many of the previously developed Internet protocols (news, mail, telnet, ftp and gopher), substantially increasing the number of Web accessible resources. Popularity of the Web lies in its integration of access to all these services from a single graphical user interface (GUI) software application, i.e., the Web browser. It would appear that most information related activities in future will be Web-centric and Web browsers will become the common user interface for information access.

2. Accessing Information on the Web:

Given the ease with which Web sites can be set up and Web documents published, there is fantastic growth in the number of Web-based information sources. It is estimated that there are currently about 3 million Web servers around the world, hosting about 200 million Web pages. With hundreds of servers added every day, some estimate that the volume of information on the Web is doubling every four months. Unlike the orderly world of library materials, library catalogues, CD-ROMs and online services discussed above, Web is chaotic, poorly structured and much information of poor quality and debatable authenticity is lumped together with useful information. However, Web is quickly gaining grounds as a viable source of information over the past year or so with the appearance of many traditional (e.g. science journals and bibliographic databases) and novel information services (e.g. information push services) on the Web.

Given the sheer size of the Web and the rapidity with which new information gets added and existing information changes, finding relevant documents could sometimes be worse than searching for a needle in a haystack. One way to find relevant documents on the Web is to launch a Web robot (also called a wanderer, worm, walker, spider, or knowbot). These software programs receive a user query, then systematically explore the Web to locate documents, evaluate their relevance, and return a rank-ordered list of documents to the user. The vastness and exponential growth of the Web makes this approach impractical for every user query.

Among the various strategies that are currently used for Web searching, three important ones are:

1. Web search tools
2. Subject directories, and
3. Meta search tools

Ideally, it is best to start with known Web sites, which are likely to contain the desired information or might lead to similar sites through hypertext links. Such sites may be known during previous Web navigation, through print sources or from colleagues. It is best to bookmark such sites (a feature supported by all browsers) which will simplify future visits. Another simple strategy is to guess the URL, before opting to use a search tool or a directory. URLs can be guessed by starting with the string “WWW”. To this add first the name, acronym, or brief name of the organization (e.g. “NASA”), then add the appropriate top level domain (e.g. COM for commercial, EDU for educational, ORG for organizations, GOV for government), and finally the two letter country code if the Web site is outside USA. Thus the URL for NASA would be WWW.NASA.GOV, for Microsoft it would be WWW.MICROSOFT.COM.

3. Web search tools:

Just as bibliographic databases were developed to index published literature, search tools have emerged on the Internet which attempt to index the universe of Web-based information. There are several Web search tools today (see the box “*Major Search Tools*” for details of some of these). Web search tools have two components - the index engine and the search engine. They automate the indexing process by using spider programs (software robots) which periodically visit Web sites around the world, gather the Web pages, index these pages and build a database of information given in these pages. Many robots also prepare a brief summary of the Web page by identifying significant words used. The index is thus a searchable archive that gives reference pointers to Web documents. The index usually contains URLs, titles, headings, and other words from the HTML document. Indexes built by different search tools vary depending on what information is deemed to be important, e.g. Lycos indexes only top 100 words of text whereas Altavista indexes every word. Robots also automatically update information and change or eliminate dead links. Robots work in either of three ways:

- Providing the robot a “seed URL” to initiate exploration. The robot indexes the seed document, extracts URLs pointing to other documents, and then examines each of these URLs recursively in a breadth-first or depth-first fashion.
- Starting with a set of URLs determined on the basis of a Web site’s popularity and searching recursively.
- Partitioning the Web space based on Internet names or country codes and assigning one or more robots to explore the space exhaustively. This method is used more widely than the first two.

At the heart of a search tool is the search engine, which is responsible for searching the index to retrieve documents relevant to a user query. They provide a forms-based search interface for the user to enter the query. Most search tools support simple and

advanced query formulation strategies. A key feature is their ability to support queries expressed in natural language, for example, “modeling and simulation of activated sludge process”. They also support Boolean searching (e.g. “plastic waste AND recycling”). Other search capabilities include proximity, parentheses, truncation and file-specific (title, URL, host, links) searching. The search results are returned in the form of a list of Web sites matching the query. Using embedded hypertext links in the result set one can then connect to each of these sites.

Another key feature of search tools is relevance ranking of search results. The list of URLs in the search result set is arranged by decreasing order of their relevance to the user query. This is achieved by assigning a “relevance score” to retrieved Web pages, calculated by applying a document-query similarity algorithm. These algorithms are based on statistical information retrieval techniques developed by Gerard Salton and others. These methods mainly depend on query term frequencies within the document, across the database and within the query.

Limitations of Web search tools:

Search tools suffer in several ways in spite of their search sophistication, power and massive index sizes. Major problem is to do with their relatively poor retrieval effectiveness, which is measured in terms of *recall* and *precision*. Recall is the ratio of the number of relevant documents retrieved to the total number of relevant documents in the collection. Precision is the ratio of the number of relevant documents retrieved to the total number of documents retrieved. Use of specific index terms yields higher precision and use of broad index terms yields higher recall. A retrieval system should support features that help the user in maximising precision, recall or both. This is very hard to achieve using the Web search tools. They employ automatic indexing methods and use words extracted from the Web pages for this purpose, and Web page developers are usually not careful in using precise terms. They neither use any controlled vocabulary (e.g. subject thesauri) in selecting terms to be used in their documents nor any classification scheme (e.g. Dewey Decimal Classification) to assign subject categories. It is not surprising to see Web searches resulting in thousands of hits with a large proportion of irrelevant documents. For example, a search for the insect beetle using the keyword “beetle” would retrieve pages related to insects and also the automobile model. There is no straightforward way of telling a Web search tool that you are looking for beetle as a zoological term. To some extent this problem has recently been addressed by recommending Web page developers to use the “META” tag to provide information like author, date of creation and keywords. The meta information is meant to be used by search tools to improve search quality. The problem of vocabulary control however still remains. Web search tools have also been adding additional search features at a rapid rate (e.g. proximity and phrase searching, “must be present” terms, etc.) with a view to help the searcher in improving quality of search results.

Secondly, none of the search tools come close to indexing the entire Web, much less the entire Internet. Some of the sources missing include documents formatted in Adobe PDF (Portable Document Format-a popular full text document format), content in sites

requiring log in, databases which are searched through CGI (Common Gateway Interface) programs, and Web documents on intranets sitting behind fire walls.

New modes of Web searching:

Attempts are being made to develop solutions that can make Web searching more effective. Push technology is one such solution (see the box *“Information Push services on the Internet”*). Push technology products deliver profile-based information to users. Appearance of domain-specific search tools is another interesting development. These are Web search tools that index Web pages related to specific fields of specialisation. An example is MathSearch (www.maths.edu.au:8000/MathSearch.html). MathSearch can search a collection of over 140,000 documents on English-language mathematics and statistics servers. It uses a robot called Peregrinator that traverses and indexes Web sites related to mathematics and statistics. A new method of Web searching that does not depend on keywords has recently been developed. HITS (Hyperlink-Induced Topic Search), developed by Jon Kleinberg of Cornell University, is based on the well-known citation indexing used in the academic world. When hypertext links are built into a Web page, the designer is indicating which other pages are related to this page. These links are not reciprocal, i.e., building a link from “A” to “B” does not create one from “B” to “A”. Thus, a document that is linked more number of times is likely to be more important. HITS works out which Web pages are much cited (i.e., linked to) and also which pages do the most citing. These pages can act as jumping-off points for those interested in a subject. IBM, Digital (which owns the AltaVista search engine) and Inktomi (the firm that writes the software for HotBot and Yahoo!) are said to be considering commercialisation of this new method of Web searching.

4. Subject Directories:

Internet resource directories, which are also called as “meta sources”, “virtual libraries” and “resource guides”, catalogue Internet resources, organize these into hierarchical subject groups and sub-groups and provide hypertext links to individual sites. Many directories categorise resources both by subject and resource type (e.g. Usenet newsgroups, patents, and institutes). Many of these use human experts in source selection, indexing and classification. Some include reviews and/or ratings of the individual sites listed in the directory. Directories are excellent as starting points for resource identification and navigation. Broadly, there are two types of resource directories - Omnibus and subject/ resource specific. Omnibus directories attempt to cover several areas. Examples include Yahoo, EINET Galaxy, and WWW Virtual Library. Subject or resource-specific directories are usually maintained by science and engineering societies and organizations (e.g. American Mathematical Society and American Chemical Society), departments or libraries in universities and research institutes. Many directories are both browsable and searchable. Details of a few well-known Internet directories are given in the box *“Major Subject Directories and Meta Search Tools”*.

5. Meta search tools:

To exhaust a Web search, one often has to use several search tools and has to be familiar with the different interfaces and searching rules. It would be desirable to have a central place with a uniform interface, where a query can be entered and the search conducted simultaneously in as many search tools and directories as necessary, and search results brought back and displayed in a consistent format. Tools with these features have come to be called meta search tools. Unlike individual search tools, meta search tools do not have their own databases, do not collect Web pages, do not accept URL additions and do not classify or review Web sites. Instead, they send queries simultaneously to multiple Web search tools and/or directories. Many of the meta search engines integrate search results by removing duplicate hits, some rank the results according to various criteria, some allow selection of search tools to be searched and some check links. See the box *“Major Subject Directories and Meta Search Tools”* for details of a few popular meta search engines.

6. Web search strategies:

Several practical hints have been developed by experienced searchers for effective Web searching. Following are a few important ones:

- For broad or general concept searches start with the directory-based services like Yahoo so that you can see the range of what's available and take advantage of subject heading structure to move you towards more relevant documents.
- For highly specific or obscure topics, use the search tools. Often it can take a long time to figure out where in a subject hierarchy a particular term belongs, a large keyword searchable database can home in on the term quickly.
- Look for a help page -- search tools handle combining terms and searching for phrases in different ways; the help page will describe the correct way to state your search for that search tool.
- Have sufficient information on the search topic before starting the search You should be aware of spelling variations, synonyms, broader and narrower terms that can be used in the search.
- Select the search tool with a large database, to start with.
- Use specific keywords. Rare or unusual words are better than common ones.
- Search for phrases when possible; Boolean “and” does not perform the same function (e.g. “stuffed animal” than “stuffed AND animal”).
- Use many synonyms to describe the question- statistical retrieval technique used by search tools produce better results and relevancy rankings if they work with more query words
- Avoid use of very common words like “computer” - they will retrieve too many hits.
- Enter the search terms in lower case. if you want to force exact match then use upper case letters.
- Use “More like this” queries. Many search tools offer this feature. This is query by example (QBE) searching and a variation on using a lot of words in the query.

Rather than you selecting all possible terms, let the system use the document terminology to expand the query.

- Use the “refine” feature offered by many search tools. This will limit further searches to the retrieved set only.
- If the first strategy does not give good results, repeat the search by varying the terms and combinations. Try this in different ways in different search tools.
- Some search tools are sensitive to word order. So the most important words should be entered first.
- Use the NOT operator to exclude unwanted Web pages like job resumes, biodata, courses, degrees offered and such general aspects (unless the search is on these aspects).
- Many top-ranking documents will not be relevant. Before giving up scan through at least 5 pages of search results.
- Avoid getting side tracked while viewing the search results.
- Bookmark the useful documents and list of links.
- Select two or three search tools and master the search techniques.

A few example searches are discussed in the box “*Sample Web searches*”.

7. Conclusion:

The World Wide Web and the tools that have been developed for Web searching are relatively very young technologies compared to bibliographic and online databases and other traditional electronic information services. With the rapid growth in publishing activities on the Internet, including the entry of well known publishing agencies (e.g. Elsevier, American Chemical Society, IEEE), database and information service companies (e.g. Dialog, Institute for Scientific Information, and STN International), etc. it is expected that Web will quickly mature into a reliable and useful source of information.

References and further reading:

1. Feldman, Susan. The Internet search-off. Searcher, Vol 6, No.2, February 1998.
2. Gudivada, Venkat N, et al. Information retrieval on the World Wide Web. IEEE Internet Computing, September-October 1997, pp. 58-68.
3. Herther, Nancy K. Push and the politics of the Internet. Electronic Library, April 1998, pp. 109-116.
4. Hobbe’s Internet Timeline, April 1998.
<http://info.isoc.org/guest/zakon/Internet/History/HIT.html>.
5. Liu, Jian. Guide to meta-search engines. May 1998.
<http://www.indiana.edu/~librcsd/search/meta.html>.
6. Nicholson, Scott. AskScott. <http://www.askscott.com>. Provides a very comprehensive tutorial on search engines.
7. Notess, Greg R. Search engines showdown. <http://imt.net/~notess/search/index.html>
8. Salton, G. and McGill, M.J. Introduction to modern information retrieval. McGraw-Hill. 1983.

9. SearchEngineWatch. <http://www.searchenginewatch.com>. The site offeres information about new developments in search engines and provides reviewes and tutorials.

Major Subject Directories and Meta Search Tools

Directories: These feature a hierarchically organized subject catalogue or directory of the Web, which is visible to users as they browse and search.

- **Yahoo** (www.yahoo.com) is a semi-automatically constructed, hierarchically organized Web subject catalogue that is both browsable and searchable. Links to various resources are collected by user submissions and by robots that retrieve new links from well-known pages. Yahoo indexes Web, Usenet news, and e-mail addresses. It provides Boolean operators and phrase searching. Query output is a list of documents and related Yahoo categories, along with the first few lines of the document.
- **Magellan** (www.mckinley.com) indexes Web sites, FTP and Gopher servers, and Usenet news and telnet sessions. Included Web sites are rated and reviewed by a team of editors according to factors such as comprehensiveness and ease of exploration. Users can submit URLs for review. The query output is ranked.
- **WWW Virtual Library** (vlib.stanford.edu) is a distributed subject catalogues, browsable and maintained by volunteers. No engine is provided for searching the catalogue.
- **Galaxy** (galaxy.einet.net) indexes Web and Gopher documents. Its index is both searchable and browsable.

Meta Search Tools: These broadcast user queries to several search tools and directories simultaneously and present the merged result list as an HTML page with clickable URLs. Following are a few important meta search tools

- **Dogpile** (www.dogpile.com) can search 25 search tools and directories covering Web and FTP sites, Usenet news and newswire. Searches three sites at a time and if enough results are not obtained it continues with the next three sites. Supports Boolean searches. Results are not integrated.
- **MetaCrawler** (www.metacrawler.com) is one of the earliest meta search tools. Searches Lycos, Infoseek, WebCrawler, Excite, Altavista and Yahoo. Searches can be limited by domain and country codes. Results are displayed with summaries, integrated and ranked.
- **MetaFind** (www.metafind.com) searches six search engines, returning the links and organizing the results. Search results can be sorted by keyword and domain.
- **ProFusion** (profusion.iitc.ukans.edu) One can chose the best three, fastest three, all or any of the available search tools. Boolean and phrase searches are supported. Searches the Web or Usenet. Search results can be displayed with or without summaries. Results are integrated and number of hits from each search engine is reported.

Major Web Search Tools

The features supported by search tools and their capabilities are dependent on several parameters: method of web navigation, type of documents indexed, indexing technique, query language, strategies for query-document matching and methods for presenting the query output. A brief description of major search tools is given below. Popular browsers like Netscape and Internet Explorer enable convenient linking to many of these search tools through a clickable search button on the browser screen.

AltaVista (www.altavista.digital.com): Covers Web and Usenet newsgroups. Indexing is based on the full text of the document. First few lines are used as an abstract. The index is updated at least once a day. Altavista supports full Boolean, phrase, and case-sensitive searches. Results are relevance ranked and include the title, a short abstract, size, and date of the last modification for each retrieved document.

Excite (www.excite.com): Covers Web and Usenet newsgroups. Indexes full text of documents. Users can submit URLs for indexing. Indexer generates index terms and a short document summary. It supports proper name searches and Boolean queries. Search results are rank-ordered, and a summary is provided for each retrieved document. Excite provides a “similar” query and a “sort by site” option to display sites rank ordered according to the number of documents retrieved from the site.

HotBot (www.hotbot.com): Indexes the full text of only HTML and plain-text documents. Users can also submit URLs for indexing. Terms are weighted, and the indexer generates a short abstract. Users can search by a term, phrase, proper noun, or URL. Case-sensitive and Boolean searches are supported and searches may also be limited by type of media or format and Internet domains. Search results are rank-ordered. HotBot provides the last modified date and a short abstract.

InfoSeek Guide (www.infoseek.com): Indexes full text of Web, Usenet newsgroups and Web FAQs, and generates a short summary of each document. It supports case sensitivity as well as searches for symbols, phrases, and proper names. Allows image searches based on captions or index terms assigned to images. InfoSeek ranks its output and returns a short summary, relevancy score, and document size. It also provides a “similar pages” query.

Lycos (www.lycos.com): Lycos indexes titles, headings, and subheadings of HTML, FTP, and Gopher documents. Only the 100 most-weighted terms are retained. Users can submit URLs for indexing. It has options for matching any term, all terms or some number of terms. It has options for loose, fair, close, good, and strong matches. The output is ranked and includes URLs, document size, first 20 lines of the document and relevance score.

OpenText (www.opentext.com): It indexes full text of HTML documents and updates its index continuously. Users can submit URLs for indexing. The indexer generates a short summary consisting of the first 100 words of the document. It supports full Boolean searching as well as searches for proper names, symbols, and phrases.

WebCrawler (www.webcrawler.com): It indexes both the title and full text of HTML documents, and the index is updated weekly. Users can also submit URLs for indexing. WebCrawler supports full Boolean and phrase searches. The output is rank-ordered and includes a short summary, URL and relevancy score. It also provides a “similar pages” query.

Worldwide WebWorm (WWW) (www.goto.com): It indexes the titles, anchor text and URLs of HTML documents. To that extent WWW lacks content-based indexing as these fields alone cannot represent document content. It also indexes in-line images by indexing their HTML titles and clickable hypertext. It supports Boolean searching.

Sample Web Searches

Topic-1: To identify Web sites of companies dealing with rare earth elements.

Doing a keyword search on search tools like Altavista is likely to retrieve too many Web pages that deal with this subject only peripherally. Directory sources are better suited for this type of search. For example, from the main subject listings in Yahoo! (www.yahoo.com) we can reach the desired information by following these categories in the subject hierarchy: *Business and Economy; Companies; Chemical; and Rare Earth Elements*.

Topic-2: To identify Web pages related to Light Combat Aircraft (LCA).

Search tools are very effective for this type of search where the keywords are unique. For example, searching for *LCA OR "Light Combat Aircraft"* on Altavista brings out many useful hits. Note the use of upper case letters and also the use of double quotes, which will force the search engine to consider the set of keywords as a phrase. Further the search may be limited to specific dates and/or Usenet news groups.

Topic-3: To identify American universities and colleges offering post-graduate courses in East Asian studies.

For this search starting with a subject directory like Yahoo! gives better results. From the main page of Yahoo! select the category *Education*, followed by *Regionals-Countries: United States*, and *Colleges and Universities- Complete Listing*. Within this category conduct search for the keywords *East Asian studies*. By narrowing down the keyword search to Web sources within a domain improves the relevance of search results.

Topic-4: To identify Web sources related to simulation or modeling of activated sludge process.

This is a concept search. Search tools are better suited for this type of search. This topic has to be formulated as a Boolean query. For example, using the advanced search features of Altavista, the query may be submitted as *(simulat* OR model*) AND (activated NEAR sludge NEAR process)*. Note the use of "*" to cover word variations like simulation, simulate, models, etc., and the use of NEAR operator to force the search engine to look for co-occurrence of the words "activated", "sludge" and "process". Use of the NEAR operator is essential to improve relevance.

Topic-5: To identify home pages of mathematics research institutes and university departments.

One can consult omnibus subject directories like Yahoo! or subject-specific resource catalogues, for this type of search. For example the World Wide Web Virtual Library for Mathematics (<http://euclid.math.fsu.edu/Science/math.html>) can lead to very useful information. Web sites of professional societies and organizations are also very good sources. For example, American Mathematical Society (www.ams.org) web site provides pointers to worldwide resources related to mathematics.

Information “Push” services on the Internet

Traditionally, the Internet has worked as a “pull” system. Users go out on the Web, searching for information and then individually, as desired, “pull” the information down into their computer. However, this can be tedious and inefficient, especially when one needs updates to information on a regular basis or needs to have some information (software, reports, news, etc.) sent to multiple locations. There are now tools available which make this possible, using a technology known as “Push”. Push technology emulates television broadcast. Most of us know, for example, that *Surabhi* will be delivered to us by Doordarshan at certain time of the week on its network channel. All we have to do is switch on at the correct time and sit down to watch. Push technology brings this model to the Internet. Typically, a user could initially choose to subscribe to a number of channels. These channels could be content delivery services maintained by commercial information service providers on the Internet. After installing a viewer that can be downloaded freely from the information provider’s Web site, a user can receive regular updates of information, as and when new information content is added to the provider’s databases. Thus the user need not have to do any active Web browsing to seek this information. Push technology has a number of advantages over the television model. User can select specific channels; set-up an individual profile describing the type of content he/she wishes to receive; specify how frequently updates are required and mode of delivery (for example e-mail and Web); and type of objects to receive-multimedia objects, text, software, etc.

There are several information providers offering pushed services on the Internet. The pioneer in this area has been PointCast Network (www.pointcast.com). They offer a service that broadcasts international news, stock information, industry updates, weather information and sports and entertainment coverage since 1996. PointCast takes its information content from providers such as CNN, Time magazine and Reuters. A free subscription to PointCast is available and a customisable viewer can be downloaded from their Web site. A user can set-up a customised profile to receive, for example, regular updates about the weather in a chosen place in the world, or news information relating to a particular topic. PoinCast has also developed services for specific business information needs and also for university and college students. Other major push vendors include Marimba (www.marimba.com), BackWeb (www.backweb.com), and IBM (IBM NewsTicker, www.infomarket.ibm.com). All of these deliver information using a specially customisable screen saver, or a dedicated taskbar on a Windows desktop. This means that a user can receive the latest updates while working on other projects. Netscape and Microsoft have recently jumped into the push bandwagon with the release of push-enabled versions of their Web browsers.

Push technology, however, is not without its share of problems. Push technologies hog network bandwidth and could increase time delays. Users could be overwhelmed with information brought about by a torrent of alerts disrupting their productivity. Potential risks are also involved when automatic program upgrades are carried out through push delivered software.