Weaving the Museum Web:
Past, Present and Future

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Abstract— Museums are discovering the Internet like many other market sectors. Rather uniquely, they span both educational and commercial sectors, with a concentration of the original object even in this virtual world. The author has set up and developed the Virtual Library museums pages (VLmp) since 1994, an on-line international distributed museum directory. This is part of the WWW Virtual Library and is also supported by the International Council of Museums (ICOM). The directory is probably still the foremost such resource, but commercial pressures are building, and the resource must develop to ensure its long-term future. This paper explores the important developments so far, the current situation especially with regard to automatically collected virtual visitor statistics, and possible future directions, both commercial and non-commercial, for the directory and related resources.

Index Terms— World Wide Web, on-line museums, virtual library, education, e-commerce, museophile

I. BACKGROUND

The human race has used its developing knowledge and expertise to invent and create new technology since the dawn of civilization [30]. It is likely to continue to do so at an accelerated rate, poised as we are at the beginning of the Information Revolution. Previously, technologies such as the telephone took decades to become widely available in the home [17]. Now with the availability of the World Wide Web [1], advances in acceptance of this new technology's use are measured in years rather than decades.

Of course, new technology brings responsibilities as well as potential benefits [27]. In some computer-based applications, human lives can be at risk in the case of disaster, and in these cases, extreme care must be taken in their implementation [12]. Fortunately a failure in the web, although in widespread use, does normally lead directly to death or injury, but may cause considerable disruption. Witness the denial of service of several leading websites caused by a school child recently.

The web is being increasingly used by a wide variety of people, and in all important industrial and related sectors, such as broadcasting, newspapers, hospitals, police, government, etc. Like other sectors, museums have been learning to use the World Wide Web technology at a rapid rate since it has become widely available from the mid 1990s onwards [25].

Museums are somewhat unique in that their size and the resources available to them varies enormously. Large internationally recognized institutions may have the resources or be able to attract sponsorship for significant investment in their website. Smaller museums are often run almost completely with the support of volunteers and the availability of a website may depend on the interest and expertise of an enthusiastic individual.

The museum profession itself is quite widely fragmented on a worldwide scale. Countries with a significant number of museums tend to have national bodies, but even these may be split according to museum type. For example, within the UK, the Association of Independent Museums (AIM) is specifically for museums not set up by local or national government. Even where national bodies do exist, they have typically not led the way with respect to on-line development for museums (with a few notable exceptions). The availability of the Internet is an opportunity for the museum world to become less fragmented in the future.

This paper explores development of on-line museums, especially with respect to an on-line museum directory established by the author before many museums had even heard of the World Wide Web. Some current access statistics are given, which allow information such as the location of virtual visitors and their software/hardware platform to be monitored. On-line museum facilities are becoming more commercialized and the paper ends with a discussion of possible developments of on-line museum websites such as educational resources and e-commerce.

II. VIRTUAL LIBRARY MUSEUMS PAGES

The Virtual Library museums pages (VLmp) [3][4][5][6] [13] were first established in 1994 as part of the Virtual Library (http://www.vlib.org/). VL forms a distributed directory of on-line resources, originally established by Tim Berners-Lee, inventor of the World Wide Web [1]. The Virtual Library maintained by volunteer experts around the world. VLmp specifically provides a directory of museums that have their own associated website, organized by country. The directory has grown rapidly into a significant repository for use by the general public and museum professionals alike, allowing convenient and up-to-date access to a leading directory of global on-line museum information.

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In 1996, through the encouragement of Cary Karp (based at the Swedish Museum of Natural History in Stockholm, Sweden), the International Council of Museums (ICOM) adopted VLmp as their main on-line museum directory. ICOM allowed the directory to be included on its main Web site (http://www.icom.org/vlmp/) and its various mirror sites around the world [5]. There have been over four million virtual visitors to the VLmp homepage since the directory first started in 1994.

Given the number of museums around the world, VLmp cannot be maintained by a single person. Thus, the directory is gradually being split by country, with individual maintainers for each country [8]. The Canadian Heritage Information Network (CHIN) was the first to offer to maintain such a list for Canada and have been exemplary in their provision of support for museums on-line within that country. More recently, the MDA (Museum Documentation Association) in the United Kingdom have adopted the UK section of the directory.

A significant number of countries and continents now have separate lists as part of VLmp, often maintaining information pages in the local language as well as English.

See the list on the right of the VLmp homepage in Figure 1.

Despite the significant amount of participation international, there are still a number of notable countries with a large amount of on-line museum information that are not participating in the VLmp project. ICOM national committees in countries not listed on the VLmp homepage, especially those with their own Web pages and existing technological skill, are being encouraged to participate in VLmp if possible. In this way museums links for individual countries can be maintained by local experts with a good knowledge of the museums in their country (e.g., see [1][26]). Once set up, individual country pages can be conveniently and automatically mirrored around the world on a nightly basis for speed of access, and included in the search facilities of VLmp.

III. STATISTICS

The automatic collection of access statistics for the Virtual Library museums pages directory has been undertaken almost since its original establishment in 1994 [3]. Initially the number of accesses to the main homepage was monitored as an estimate of the number of virtual visitors

Figure 1. VLmp homepage.

Summary   **Period: 135 Days**

Daily Unique:		Totals:	
Today	**730 / 27 Apr, Thu, 2000**	**Unique Visitors**	**125729 - 68.24%**
Yesterday	**913 / 26 Apr, Wed, 2000**	**Visits incl. Reloads**	**184239**
Average	**931**	**Reloads**	**58510 - 31.75%**
Highest Day	**1457 / 08 Feb, Tue, 2000**	**Visitors via Referrers**	**49551 - 39.41%**
Weekly Unique:		**Website Referrers**	**1403**
Current Week	**3489 / Wk 17, 2000**	**JavaScript Enabled**	**118130 - 93.95%**
Last Week	**6667 / Wk 16, 2000**		
Average	**6286**	**Most accessed:**	
Highest Week	**8490 / Wk 05, 2000**	**Browser**	**MSIE 5**
Monthly Unique:		**Operating System**	**Windows 98**
Current Month	**24635 / Apr, 2000**	**Screen Resolution**	**800x600**
Last Month	**28689 / Mar, 2000**	**Screen Color**	**16 Bit (65K)**
Average	**25145**	**Search engine**	**MSN Search**
Highest Month	**34504 / Feb, 2000**	**Keyword**	**museums**
Highest Hour of the Day	**18:00 - 18:59**	**Domain/Country**	**- / Unknown**
Highest Day of the Week	**Tuesday**	**Continent**	**Unknown**

Table 1. Statistics summary (eXTReMe Tracking).

using the site.

In addition to automatic collection of statistics, several surveys have been undertaken, using the main homepage of VLmp to publicize them. Typically, users have been invited to complete an on-line questionnaire [9]

Since the end of 1999, VLmp has been linked to two on-line (and free) statistics gathering websites. One (NedStat, http://uk.nedstat.com/) provides a simple and fast facility consisting of a single page of statistics. The information presented includes on visitors per day for the previous three weeks and per day of the week, and pageviews per week, hour, Internet top-level domain and region (continent) [15].

The eXTReMe Tracking website (see under http://v.extreme-dm.com/) provides information that is more complete over seven web pages for each site monitored. In this section we present some recent results collected for the VLmp homepage using this site. Table 1 presents the main overview table provided by eXTReMe Tracking. The statistics have been collected over 135 days from 14 December 1999 to 27 April 2000. A summary of statistics is shown in Table 1.

An interesting addition to the information compared to NedStat for instance is the provision of details of the hardware/software being used by the virtual visitors. Currently the typical visitor is using the Microsoft Internet Explorer version 5 web browser under Windows 98 with an 800x600-pixel screen and 16-bit colour (i.e., around 65,000 different colours available for display).

The number of visitors per week is relatively steady. Table 2 shows the (unique) visitor numbers for each of the first 16 weeks in the year 2000. This provides a lower bound on the number of actual visits. In the early days of VLmp, visitor numbers rose exponentially [3]. This is no longer the case, probably due to increased commercial competition, of which more later.

The number of visitors by hours of the days follows US working hours (see Table 3), although the difference in the maximum and minimum levels is much less pronounced than it used to be [6]. Currently it is less than a factor of two (around 1.8) whereas it used to be more like 3.5 [4]. This may be an indication that the rest of the world is catching up a little with the US in Internet usage.

The variation by day of the week is also much less dramatic than in the mid 1990s, as shown in Table 4. Previously there was a significant dip in usage at weekends since many people accessed the Internet at work. Now, although Saturday is still the day of least usage, the variation is far less marked.

Table 5 shows the visitor by the main Internet domains (which in general correspond to countries) and Table 6 shows the visitors by continent. The number of unknown (numerical) domains is around a third of total accesses and this has not changed much over time [6]. The US educational accesses (.edu domain) continue to appear to diminish, although this is really an indication of the increase in web activity by everyone else since universities have been using the Internet for decades and their usage is likely to be relatively static.

For half the accesses, it is difficult to gauge the location of the virtual visitor (e.g., numerical domains, .net domain, etc.). Of the rest, North American (largely US) accesses account for half those that can be located with a reasonable degree of certainty. Europe is not far behind at around a third of locatable accesses. Asia accounts for 10% of accesses, over half of which emanate from Japan.

As previously mentioned, an interesting feature of the eXTReMe Tracking web statistics facility is the collection of information on the user platform. While Netscape used to be the leading web browser, it is now only used by about 31% of VLmp visitors. Now, Microsoft Internet Explorer is used by over twice as many (65%), leaving only 4% using other types of browser. Thus the variety of browsers is becoming less of an issue than it used to be. See Table 7 for further details of the different types of browser being used to access VLmp.
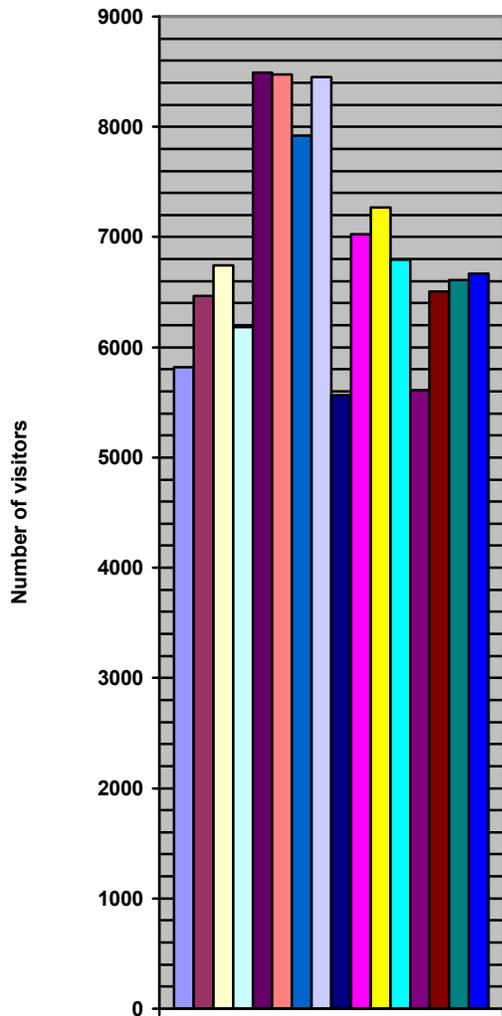
☐ Week 01	5820
■ Week 02	6467
☐ Week 03	6745
☐ Week 04	6183
■ Week 05	8490
☐ Week 06	8475
■ Week 07	7923
☐ Week 08	8450
■ Week 09	5567
■ Week 10	7026
☐ Week 11	7271
☐ Week 12	6794
■ Week 13	5612
■ Week 14	6504
■ Week 15	6611
■ Week 16	6667

Table 2. Unique visitors per week.

Hours of the Day

00:00 - 00:59 5681 4.51%

01:00 - 01:59 5547 4.41%

02:00 - 02:59 5191 4.12%

03:00 - 03:59 4689 3.72%

04:00 - 04:59 4050 3.22%

05:00 - 05:59 3474 2.76%

06:00 - 06:59 3474 2.76%

07:00 - 07:59 3788 3.01%

08:00 - 08:59 4274 3.39%

09:00 - 09:59 4852 3.85%

10:00 - 10:59 5282 4.20%

11:00 - 11:59 5207 4.14%

12:00 - 12:59 5752 4.57%

13:00 - 13:59 6035 4.80%

14:00 - 14:59 6012 4.78%

15:00 - 15:59 6018 4.78%

16:00 - 16:59 5594 4.44%

17:00 - 17:59 5864 4.66%

18:00 - 18:59 6188 4.92%

19:00 - 19:59 6058 4.81%

20:00 - 20:59 5823 4.63%

21:00 - 21:59 5625 4.47%

22:00 - 22:59 5524 4.39%

23:00 - 23:59 5727 4.55%

Table 3. Visitors per hour.

Days of the Week

Monday 17968 32.89%

Tuesday 19458 35.62%

Wednesday 18932 34.65%

Thursday 18095 33.12%

Friday 18243 33.39%

Saturday 15836 28.99%

Sunday 17197 31.48%

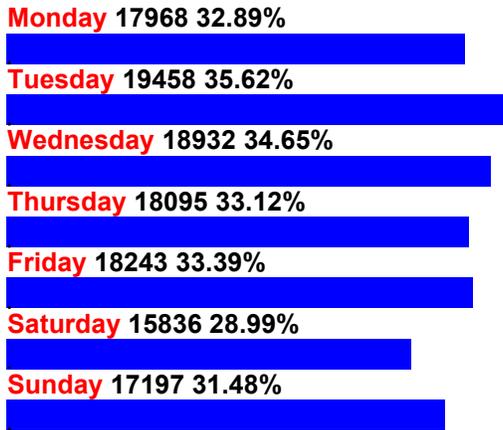**Table 4. Visitors per day of the week.**

Similarly, the Windows operating system is used by 90% of visitors. Mac users account for only 6.5%, Unix users 0.5% and others 3%. Table 8 provides further details, including lesser-used operating systems.

Over half (56%) of VLmp visitors have 800x600-pixel screens. 20% have 1024x768-pixel screens, but 13% still have 640x480 screens. Thus it is still important to cater for those with smaller screens. See Table 9 for fuller information.

About half (50%) of people using VLmp have 16-bit (65K) colour screens. 31% have 24-bit or 32-bit (16.7M) screens. However 12% still have 8-bit (256) colour screens and the remaining 7% has other indeterminate screens, a significant number of which could be monochrome. Thus it is still important to be careful with colour usage in graphics on web pages for museum sites. Table 10 gives the details.
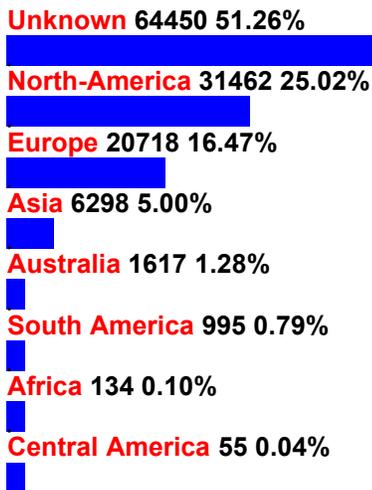
Continents

Unknown 64450 51.26%

North-America 31462 25.02%

Europe 20718 16.47%

Asia 6298 5.00%

Australia 1617 1.28%

South America 995 0.79%

Africa 134 0.10%

Central America 55 0.04%

Table 5. Visitors by continent.

Domains / Countries

1 - Unknown 42012 33.41%

2 .com US Commercial 22974 18.27%

3 .net Network 21463 17.07%

4 .uk United Kingdom 4238 3.37%

5 .edu US Educational 3856 3.06%

6 .jp Japan 3543 2.81%

7 .es Spain 2569 2.04%

8 .de Germany 2132 1.69%

9 .ca Canada 1766 1.40%

10 .it Italy 1641 1.30%

11 .us United States 1552 1.23%

12 .nl Netherlands 1441 1.14%

13 .fr France 1344 1.06%

14 .au Australia 1303 1.03%

15 .se Sweden 1126 0.89%

16 .at Austria 893 0.71%

17 .mx Mexico 878 0.69%

18 .il Israel 773 0.61%

19 .org Non-Profit Organizations 768 0.61%

20 .be Belgium 682 0.54%

21 .ch Switzerland 676 0.53%

22 .ru Russian Federation 658 0.52%

23 .dk Denmark 586 0.46%

24 .fi Finland 533 0.42%

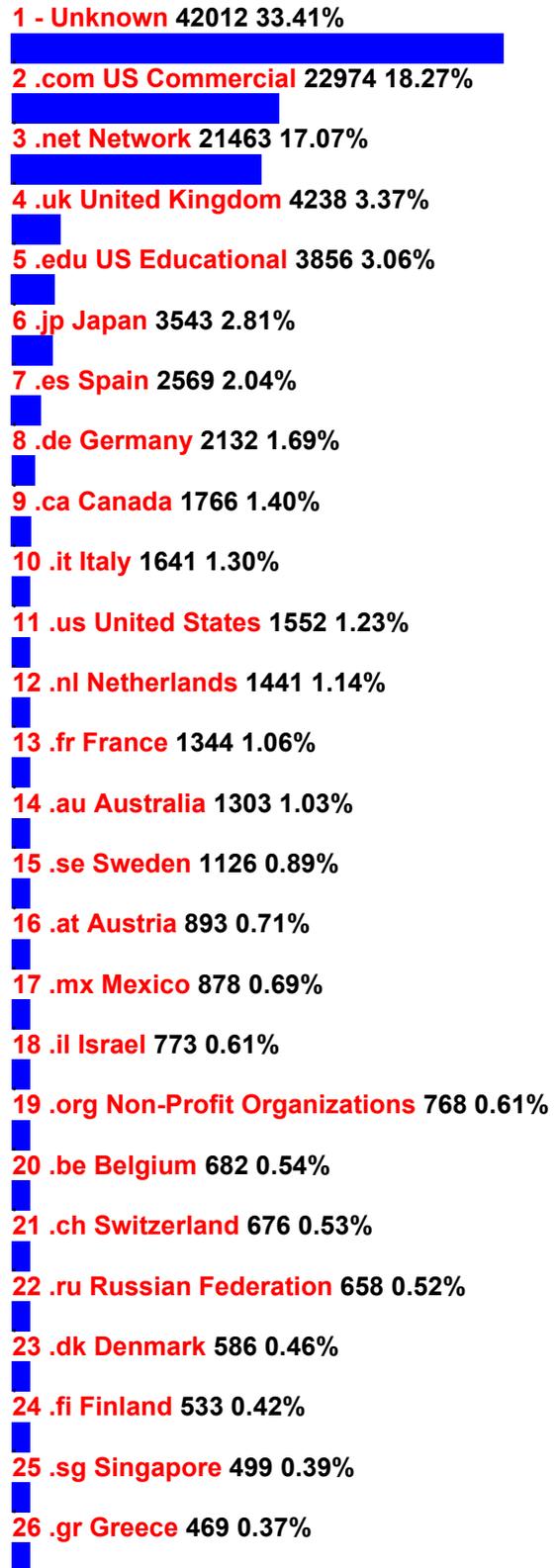**25 .sg Singapore 499 0.39%**

26 .gr Greece 469 0.37%

Table 6. Visitors by top-level Internet domain / country (>0.3% of total).

Browsers

MSIE 5 53445 42.50%

Netscape 4 33613 26.73%

MSIE 4 25479 20.26%

Netscape 3 5033 4.00%

AOL 4 3535 2.81%

MSIE 3 2440 1.94%

WebTV 1 1088 0.86%

Other 363 0.28%

Netscape 2 346 0.27%

AOL 3 264 0.20%

MSIE 2 57 0.04%

? 25 0.01%

Opera 3 13 0.01%

AOL-IWENG 3 13 0.01%

Netscape 5 7 0.00%

Amiga-AWeb 3 4 0.00%

AmigaVoyager 2 1 0.00%

Opera 2 1 0.00%

MacWeb 1 1 0.00%

Cyberdog 1 1 0.00%

Summary:

Web browser	Percentage share
MSIE	64.75%
Netscape	31.01%
Other	4.20%

Table 7. Web browsers.

Operating Systems

Windows 98 58747 46.72%

Windows 95 40170 31.94%

Windows NT 13217 10.51%

Macintosh 8282 6.58%

Other 2654 2.11%

WebTV 1096 0.87%

Windows 3.1 900 0.71%

Linux 2 284 0.22%

SunOS 5 199 0.15%

IRIX 40 0.03%

HP-UX 37 0.02%

? 25 0.01%

OS/2 24 0.01%

OSF1 20 0.01%

FreeBSD 14 0.01%

AIX 11 0.00%

Amiga 6 0.00%

SunOS 4 2 0.00%

BSD/OS 1 0.00%

Summary:

Operating system	Percentage share
Windows	89.90%
Mac	6.58%
Unix	0.48%
Other	3.00%

Table 8. Operating systems.

Screen Resolutions

800x600 66135 55.97%

1024x768 23953 20.27%

640x480 15378 13.01%

Other 8932 7.56%

1152x864 1921 1.62%

1280x1024 1600 1.35%

1600x1200 202 0.17%

? 25 0.02%
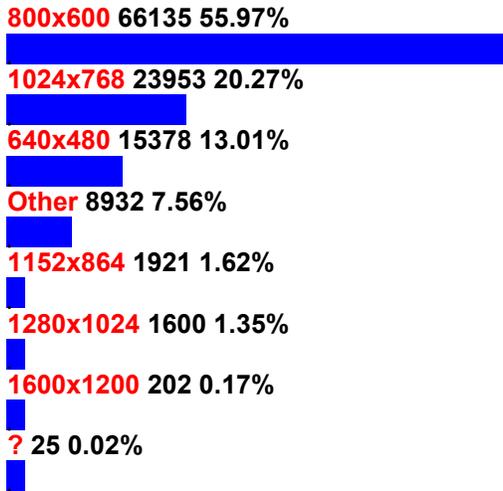
Table 9. Screen resolutions.

Screen Colors

16 Bit (65K) 59144 50.06%

32 Bit (16.7M) 24360 20.62%

8 Bit (256) 13936 11.79%

24 Bit (16.7M) 13048 11.04%

Other 7638 6.46%
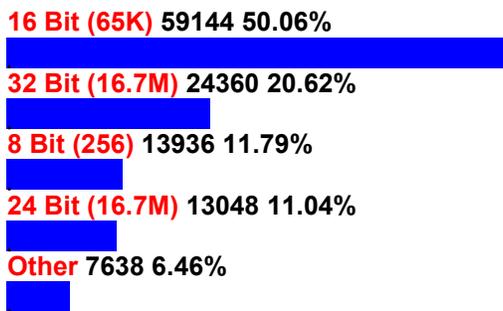
Table 10. Screen colours.

Referrer Totals: Sources

Website 58656 94.31%

Search engine 2860 4.59%

Hard disk 461 0.74%

Email 189 0.30%

? 27 0.04%
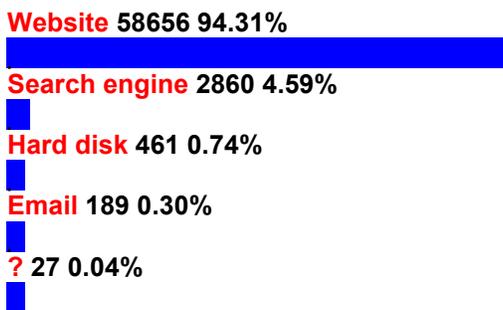
Table 11. Referrer sources.

Referrer Totals: Search engines

MSN Search 1132 39.58%

Yahoo 693 24.23%

Infoseek 254 8.88%

Altavista 134 4.68%

Excite 106 3.70%

Snap.com 104 3.63%

Lycos 76 2.65%

WebCrawler 76 2.65%

Realnames 62 2.16%

Goto.com 49 1.71%

Askjeeves 48 1.67%

Looksmart 42 1.46%

Search.com 29 1.01%

Magellan 20 0.69%

Galaxy 17 0.59%

Mamma 11 0.38%

Metacrawler 3 0.10%

Inference Find 3 0.10%

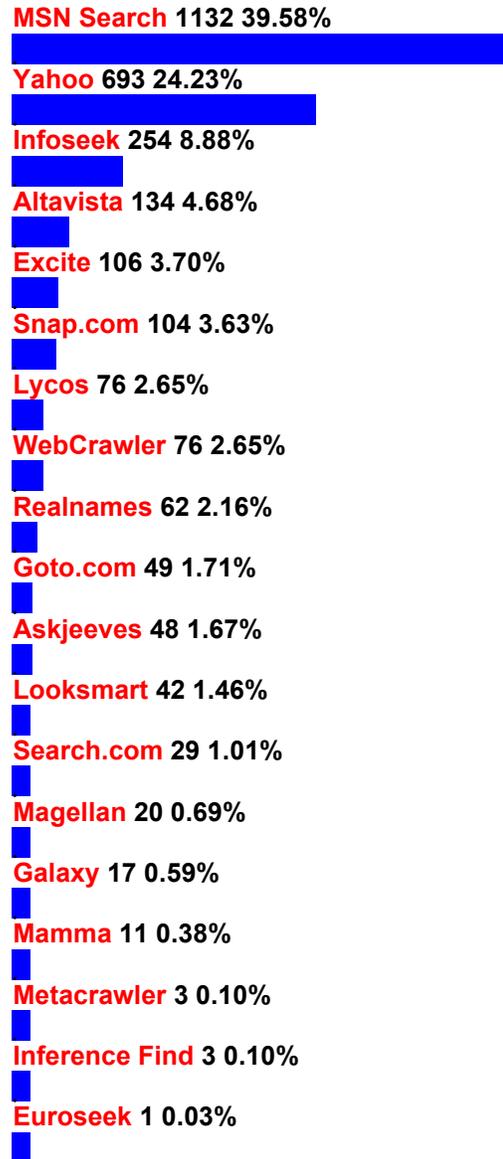**Euroseek** 1 0.03%

Table 12. Referrer search engines.

By far the majority of referrals to VLmp come from other websites (94%, see Table 11). However 5% come from search engines (Table 12). MSN Search generates around 40% of these referrals. Yahoo is also important with 24% of referrals.

25% of people are searching for the keyword "museums" when they follow a search engine link to VLmp. Other popular keywords can be found in Table 13.

Table 14 shows website referrers. 8% of sure referrals come from the main homepage of the ICOM website where VLmp resides. Many referrals come from other VLmp pages and museums.

In summary, the statistics packages connected to VLmp provide a useful source of information about the general on-line museum visitor. In particular, the changing platforms used by virtual visitors can now be easily monitored. For example, the access statistics presented in this paper could be directly compared with those in coming years to help detect changes in use, etc.

IV. ACCESS ISSUES

It is important that museum websites be as accessible as possible to a variety of web browsers, display screen capabilities, etc., especially for the main homepage and other major navigation pages. More exotic and less widespread features such as plug-ins should only be used internally (e.g., for a special on-line exhibition) with suitable warnings for those without the requisite facilities.

From the VLmp access statistics, although dominated by a small number of browsers and platforms, it can be seen that a small number of people do access VLmp using a diverse range of software and facilities. Museums aim to be inclusive in the availability of their resources in general, and this is an aim of VLmp too.

Access for the disabled is an important goal of most museums. On-line, specialized web browsers for the disabled are now available. For example, ProdWorks (http://www.prodworks.com/) produce an audio web browser for the blind that allows well-designed web pages to be reasonably easily navigated. This browser is available free for a trial period, so museums can easily test their web pages if they so wish.

WAP (Wireless Application Protocol) now allows another avenue for access to on-line museums via mobile phones. Information of particular relevance for museums includes opening times, prices and special exhibitions. The current limitations of monochrome and small mobile phone screens with limited bandwidth mean that web pages need to be designed in a minimalist manner. Many so-called "high-impact" web pages will not display well using WAP technology.

Access on other non-PC-based equipment such as WebTV, by users not expert in the use of computers is likely to increase. Future web access is likely to be increasing on devices that are not marketed as computers, even if they include computer technology.

The increasing use of new technologies such as XML (eXtensible Markup Language) is likely to augment and subsume the HTML (HyperText Markup Language) pages currently widely available on the web. VLmp will need to keep abreast of such developments to maintain its usefulness in accessing web pages in the future.

VLmp has been deliberately designed to be viewable on a wide range of different web browsers. Advanced features that may only work on the latest browser technology, or on a specific platform, have been specifically avoided. Hence disabled and mobile phone access, for example, should be possible with minimal or no changes.

All Keywords		Unique Visitors
567	25.16%	museums
241	10.69%	virtual
146	6.48%	museum
117	5.19%	library
92	4.08%	art
67	2.97%	wwwicomorgvlmp
43	1.90%	and
39	1.73%	british
39	1.73%	www
33	1.46%	web
30	1.33%	metasearch
29	1.28%	the
27	1.19%	world
27	1.19%	french
24	1.06%	vlmp
20	0.88%	online
15	0.66%	where
14	0.62%	directory
14	0.62%	can
13	0.57%	europe
13	0.57%	find
12	0.53%	gallery
12	0.53%	galleries
11	0.48%	german
10	0.44%	london
10	0.44%	list
9	0.39%	usa
9	0.39%	icomorgvlmp
8	0.35%	international
8	0.35%	architecture
8	0.35%	wide
8	0.35%	pages
7	0.31%	line
7	0.31%	spain
7	0.31%	exhibition
7	0.31%	munich
6	0.26%	libraries
6	0.26%	history
5	0.22%	germany
5	0.22%	exhibitions
5	0.22%	archives
5	0.22%	york
5	0.22%	wwwmuseumscom
5	0.22%	new
5	0.22%	arts
5	0.22%	museos
4	0.17%	italian
4	0.17%	visit
4	0.17%	aviation
4	0.17%	egypts

Top 50 Keywords from a total of 373 Keywords

Table 13. Keywords used for search.

All Website Referrers

4014	8.10%	http://www.icom.org/
1940	3.91%	http://www.icom.org/vlmp/world.html
1514	3.05%	http://archive.comlab.ox.ac.uk/other/museums.html
1413	2.85%	[unknown origin]
1333	2.69%	http://www.artchive.com/link_res.htm
1152	2.32%	http://www.vlib.org/
982	1.98%	http://www.google.com/search
936	1.88%	http://museoprado.mcu.es/prado/html/enlaces.html
769	1.55%	http://vlib.org/Overview.html
748	1.50%	bookmarks
706	1.42%	http://www.hart.bbk.ac.uk/VirtualLibrary.html
643	1.29%	http://www.museums.reading.ac.uk/vmoc/
632	1.27%	http://vlib.org/
492	0.99%	http://www.museum.or.jp/vlmp-J/
484	0.97%	http://www.diegorivera.com/links.html
472	0.95%	http://www.mda.org.uk/vlmp/
462	0.93%	http://www.walla.co.il/guide/tscs.cgi
404	0.81%	http://www.museum-london.org.uk/MOLsite/links.htm
404	0.81%	http://palimpsest.stanford.edu/icom/
376	0.75%	http://www.si.edu/nmai/natsite.htm
375	0.75%	http://www.nmsi.ac.uk/links/museums.html
345	0.69%	http://www.mcu.es/prado/enlaces_eng.html
330	0.66%	http://www.interlog.com/~joellong/musjobs/musjobs.html
329	0.66%	http://www.museums.reading.ac.uk/cgi/archive/htgrep/file=/museums/vlmp-db.html&style=ol
324	0.65%	http://www.museumofcostume.co.uk/mocpub/links.htm
324	0.65%	http://artchive.com/link_res.htm
317	0.63%	http://www.walla.co.il/guide/h_srch.cgi
308	0.62%	http://www.virgilio.it/canali/arte/mini_guida/004.html
306	0.61%	http://archive.comlab.ox.ac.uk/other/museums/world.html
300	0.60%	http://www.hccnet.nl/www/www.html
284	0.57%	http://vlib.org/Humanities.html
281	0.56%	http://www.icom.org/vlmp/galleries.html
281	0.56%	http://www.howstuffworks.com/webtools.htm
275	0.55%	http://www.icom.org/vlmp/uk.html
269	0.54%	http://www.icom.org/vlmp/sweden.html
252	0.50%	http://www.museums.reading.ac.uk/cgi/archive/htgrep/file=/museums/vlmp-db.html&style=ul
244	0.49%	http://www.museums.reading.ac.uk/
241	0.48%	http://www.museumstuff.com/museumsearch/welcome.html
240	0.48%	http://www.gti.ssr.upm.es/~vlmp/SPAIN/indexES.html
236	0.47%	http://www.icom.org/francais.html
229	0.46%	http://aolsearch.aol.com/cat.adp
227	0.45%	http://www.icom.org/vlmp/
226	0.45%	http://search.interfree.it/IT-Catalog/pagine/Catalogo/Viaggi%20e%20Turismo%20.shtml
225	0.45%	http://www.vlib.org/Humanities.html
222	0.44%	http://www.icom.org/vlmp/germany.html
215	0.43%	http://art-history.concordia.ca/AHRC/collect.htm
206	0.41%	http://search.aol.com/cat.adp
190	0.38%	http://www.museumoflondon.org.uk/MOLsite/links.htm
188	0.37%	http://www.si.edu/organiza/museums/amerind/natsite.htm
186	0.37%	http://www.hco.hagen.de/vlmp/vlmp-dt.htm

Top 50 Website Referrers from a total of 1403 Referrers

Table 14. Website referrers.

Museums are increasingly displaying their URL in promotional material, letterheads, etc., as a way of providing an extra gateway to their resources. Figure 2 shows an example of a museum that has decided to display its virtual address and to omit its physical address from a locally displayed advertising hoarding (but still including a mention of one of its sponsors) [15].

Figure 2. Museum advertising hoarding.

Two important areas for the development of on-line museum resources in the future are educational material and e-commerce facilities. The potential for a more interactive and collaborative learning experience on the web is great [16].

There is also potential for educational synergy if museums themselves can collaborate and be coordinated on-line. The United Kingdom *24 Hour Museum* portal (http://www.24hourmuseum.org.uk/) provides what is probably the leading gateway to all UK museums. The next major development expands this facility to aid the access of educational material in a pan-museum manner via a Curriculum Navigator, based on the UK National Curriculum. This aims to aid teachers and school children in using museums for educational purposes, perhaps before and after real museum visits.

E-commerce is increasingly important on the web [28] and companies are now realizing the possibilities of on-line shopping and other commercial ventures such a ticketing and digital image libraries with respect to museums. The MuseumShop.com site (see under http://www.museumshop.com/) was founded purely as a museum e-commerce company based in the US [29]. This provides a commerce shopping resource for a number of partner museums, mainly in America. Initially, product "fulfillment" was provided by the museums themselves, but now a central repository of items for sale is maintained.

For larger museums, it may be appropriate to set up an on-line shop themselves, especially if a traditional printed catalogue of items for sale and credit card facilities already exist. The Museum of Fine Arts in Boston is using the Yahoo store (http://store.yahoo.com/) to do this. The facility costs from US $100 per month upwards depending on the number of items and amount of trade involved.

MuseumCompany.com, a spin-off from an existing chain of shops marketing museum-related products, has also started marketing on-line. In 2000 MuseumNetwork.com, aiming to become a museum portal as well as exploiting on-line educational and commercial opportunities with museums, is being launched with US $10 million initial funding. All these commercial enterprises are currently US-based, but have their eyes on Europe as the next market of major interest.

Both business-to-consumer (B2C, or museum-to-visitor in this context) and business-to-business (B2B, including museum-to-business and museum-to-museum) e-commerce [21] will be increasingly possible and important in the future, provided a suitable infrastructure is available.

The European-based Virtual Library museums pages facility, run on a volunteer basis with no direct financial support, is unlikely to survive in the face of well-funded commercial concerns, even with the goodwill of the museum community at large. To help maintain VLmp as a leading museum portal for the future, a more commercially oriented initiative is proposed, dubbed Museophile.com (see http://www.museophile.com/). This is intended to provide a Europe based and internationally oriented museum facility for commercial on-line activities that can help support VLmp on a more financially secure footing. For most museums, e-commerce on their own does not make financial sense. If successful, Museophile.com and VLmp should act symbiotically to the benefit and ultimate survival of each other.

Some museums have already embraced web technology in interesting ways, both individually [11] and as a community [10]. The Internet has traditionally been very US-centric, but this is gradually changing as telecommunications throughout the world improves [20]. However, it should be remembered we are still at a relatively early stage in the development of the Internet. Compare, for example, the early days of radio when there was little regulation [24].

As the web increases in size, data mining of information will be increasingly important and difficult [19]. The next generation of web search engines, such as Google (http://www.google.com/), is likely to use the structure of the web increasingly to discover important web sites (those with many links to them) and major portals (those with many links from them). Automatic revision of a website's structure depending on the popularity of pages within the site could be a useful way of increasing the effectiveness of individual sites.

Weaving the web of the future will be an ever-challenging goal for individual museums as well as on-line museum communities and portals. Both museum curators and web technologists need to collaborate so that museums use this new medium effectively in the twenty-first century, for educational, commercial and other novel purposes.

VI. CONCLUSION

This paper has presented issues concerning development of access to museum-related resources on-line. In particular, automatically collected access statistics for a widely used on-line museum directory, the Virtual Library museums pages (VLmp), have been explored. These help in the assessment of the location of VLmp visitors, the types of hardware and browser software being used. Information on how users have discovered VLmp is also available.

Although many users are converging on using a small number of platforms and browsers, there is still a significant minority using non-standard facilities. What is more, the current convergence may be short-lived in that a wider range of browser devices such as mobile phones, interactive televisions, disabled access browsers, etc., may be easily and cheaply available.

In general, like much of the rest of the Internet, the museum sector will see increasing commercialization of relevant on-line facilities. Where previous efforts have relied on volunteer and ad hoc efforts, a more professional and well-funded approach will be required for success in the future. The situation is constantly changing of course and fast effective adaptation to any developments is required to keep ahead or at least abreast of others in the same field.

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