Digital Library Metrics
Where we've been, where we are, and where we might be going

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Abstract:

This paper examines the current state of digital library metrics and seeks to provide the foundation from which to answer the question: What constitutes a comprehensive evaluation of a digital library? My small effort to address this question starts with an overview of key library characteristics. This leads to a survey of traditional physical library metrics and existing digital library metrics. After gaining a more complete understanding of library metrics, I refer to new examples of contingent valuation as a library metric and speculate on its potential efficacy.

Introduction:

The information world is dramatically changing every day. Stephen Harnad calls this the fourth revolution in knowledge production, with the Internet essentially reigning as king in this electronic telecommunications environment[1]. The Internet is the home to many new libraries – so called 'digital libraries' – and they are transforming the way that people and information interact. There is an intuitive recognition that digital libraries are important; the question at hand is what metrics can be applied to digital libraries so that their true value can be discovered?

This paper provides a very small initial step towards addressing the above question. An examination of key library characteristics provides the foundation to explore physical and digital library metrics. After gaining a more complete understanding of existing library metrics, the concept of contingent valuation is introduced. While not new to the environmental and economic world, but contingent valuation is quite new to the library world.

It is clear that determining the true value of a library is something that is likely never to be fully resolved. I do not pretend to answer the question, but rather hope to spark lively discussions that may possibly shed new light on how librarians can measure the social and economic value of digital libraries.

So, what is a digital library anyway?

Some define a digital library as the entire World Wide Web, others believe a digital library is a collection of digital objects available on a single website. Christine Borgman, Professor and Presidential Chair of Information Studies at UCLA, has written extensively on the diversity of opinion for digital library definitions. Her voice is one of many engaged worldwide across communities of practice in an ongoing debate about what actually constitutes a digital library. Here in the United States, the National Science Foundation (NSF) has convened several panels to discuss digital libraries. These talks have transformed into discussions of cyberinfrastructure-enabled communities, of which digital libraries merely a part[2].

In 1998, a D-Lib working group was formed to focus on metric creation for digital libraries. Even amongst these experts no common definition of digital libraries was accepted for widespread use; however, they were able to agree on the following definition for the purposes of their working group. I adopt the following definition here as it aptly represents the technical and service-related duality inherent in a digital library.

> "The Digital Library is the collection of services and the collection of information objects that support users in dealing with information objects and the organization and presentation of those objects available directly or indirectly via electronic/digital means."

The Role of Metrics for Libraries, or why care about metrics?

> "Evaluation, at its best, is a mechanism for understanding a system."
> *(Wallace and Van Fleet 2001)*

The truth of this statement reverberates throughout the social, economic and technical elements of libraries. Until it is known what is working – and what is not working - in any library, it is extremely difficult to make modifications and improvements. Libraries, both physical and digital, must be responsive to a global society that increasingly demands higher quality and better service.

Warning Signs

Salinas, California should be a warning sign to the library profession as a whole because it throws into sharp relief the current crisis of library evaluation and justification. In 2004/2005, Salinas library system narrowly avoided its death at the hands of city council when community members raised money enough so that it could continue to operate. The community effort required to save the library system is only a temporary solution, and only time will tell the eventual fate of this library system. With municipal, state and federal budgets being stretched as they are, there is a high potential for other libraries across the United States to face this situation.

Where Metrics Come In

This begs the question of the value of the library, and how it may be able to prove its worth. Many physical libraries are transforming into 'hybrid libraries', libraries which have a physical home as well as an online presence. Hybrid libraries, as well as

purely digital libraries, will be well served to consider metrics which will show their value so as to obtain the significant funding required for their creation, operation and maintenance.

Physical libraries have a long history, yet it appears that a truly comprehensive metric scheme is still forthcoming. They continue to evaluate services and collections, sometimes at a high staff and financial cost. Yet what is the outcome of these efforts? The ability to compare themselves against themselves or against other libraries is generally the end result. It is obvious that metrics exist and are heavily used; it is just not obvious what exactly they mean. In a conversation with a university librarian, he summed it up by stating "with our existing metrics we can look at trends but we don't necessarily know what is good".

There is no doubt that our existing metrics guide library collection development, policy and services. This is an important yet it only addresses one component of library value. Outcome-centered evaluation is introduced in the following section and begins to address a library's social value. Returning to my original question - what constitutes a comprehensive evaluation of a digital library - I believe the answer can be found by scrutinizing physical library metrics, adapting them when appropriate and creating new metrics when necessary.

Methodology

The methodology applied to this analysis is straightforward:

1) Determine key characteristics of physical and digital libraries;

2) Examine metrics for physical libraries,

3) Examine metrics for digital libraries, and

4) Consider possible ways to better measure the value of digital libraries based on what we have learned and continue to learn from physical libraries.

Quantitative Metrics

The overwhelming use of quantitative measures is clear and they are important. Libraries need to know how many items are in their collection, how many users there are and have statistics about the use of their resources. However, the quantitative represents only one piece of the library's value.

Qualitative Metrics

Why do we continue to see an overwhelming number of quantitative metrics? In an email dialogue with a well-known information economist, the potential reason for this lack of qualitative metrics may be because libraries, similar to many social services, have not historically had the best measures of benefits. His feeling was that the difficulty in measuring those benefits hindered their use, and that they are missing not because they are simply being ignored.

Qualitative metrics, also referred to as outcome evaluation by Durrance and Fisher, attempt to capture exactly those kinds of difficult-to-measure-benefits. However, by explicitly identifying 'success stories' and positive outcomes, libraries are better able to provide better indicators of the impact of their services[3]. OCLC has adopted this type of qualitative strategy for their current library advocacy campaign[4].

Fig. 1: OCLC Campaign Ad for Public Libraries

Contingent Valuation

Contingent valuation (CV) is an approach, a technique, used to quantify the qualitative. It seeks to measure all costs and benefits, whether direct or indirect. It was first introduced in 1947 by S.V. Ciriacy-Wantrop and while the survey technique has been tightened up, the basic idea remains the same. This idea is that through the use of surveys which are (now) carefully designed and controlled, people are asked how much value they would give to 'something'. Typically, that 'something' has been a natural resource, a land feature, a program, or an activity. The *contingent* part of CV comes into play because the 'something' to be valued often may not exist or may be an expected result of a program.

CV has been used extensively in environmental economics and natural resources. Carson, an states that: "CV has been in use for over 35 years, and there are now over 2000 papers and studies dealing with the topic. Illustrative applications of CV to estimated benefits include the following: increasing air and water quality; reduced risk from drinking water and groundwater contaminants; outdoor recreation; protecting wetlands, wilderness areas, endangered species, and cultural heritage sites; improvements in public education and public utility reliability; reduction of food and transportation risks and health care queues; and provision of basic environmental services such as drinking water and garbage pickup in developing countries. While the most visible applications are those for natural resource damage assessments such as the *Exxon Valdez* oil spill, the vast majority of CV applications have been undertaken for the purpose of assisting in policy evaluations" (Carson 2000).

The approach of contingent valuation has had minimal application in the library world. In 2003, the British Library showcased CV in its largest and most public relationship to libraries. The results of their work are groundbreaking and have been reported out through their website and at conferences worldwide. Here in the United States, the work of Donald W. King and Jose-Marie Griffiths will be instrumental in determining the success of CV metrics. King and Griffiths have undertaken a study on return on investment to taxpayers of Florida public libraries[5]. According to Mr. King's website, "the study includes such economic metrics as what users are willing to pay (WTP) and willing to accept (WTA) for their access to public libraries, the outcomes from use of information provided, what it would cost users to obtain library provided

information if there were no library conjoint measurement of service attributes, and statewide economic input and output."

CV, like most other techniques, has its fair share of critics and supporters. Critics tend to focus on the difficulty of assigning an actual dollar figure to 'willingness to pay' or 'willingness to accept' for contingent activities, services or institutions. The survey instrument used in a CV has also been the topic of disagreement and controversy. In 2002, the University of Chicago Cultural Policy Center sponsored a working conference to address the contingent valuation of culture. As part of this event, Epstein authored a paper titled "The Regrettable Necessity of Contingent Valuation" in which he raises issues with CV regarding how CV has the potential to become distorted when transitioning from the individual to the collective[6].

On the positive side, supporters of CV believe that it can "clarify the real value the American public assigns to cultural activities and products" (University of Chicago Contingent Valuation Workshop Description 2002). The British Library, in its economic impact assessment report[7] cites the 1993 report to the NOAA Panel on Contingent Valuation, stating that CV "permits a coherent quantitative evaluation of the total benefit to the nation of publicly funded institutions and programs." As I see it, the value of CV is largely derived from the breadth of benefits that it attempts to capture. Many of these benefits are intuitively known and rarely quantified, and generally they are ignored in decision-making and policy setting. A method such as CV that strives to quantify these benefits, while not perfect, is a substantive progressive move.

Library Fundamentals

Highlighting key characteristics of physical and digital libraries is instructive to an understanding of how metrics are derived. This section will analyze three characteristics common to all libraries: library user populations, information objects[8], and library services. From this analysis, relevant considerations are pulled forward into a metrics discussion.

Library User Populations

In general, the physical library serves a distinct geographic area. For public libraries, the user population tends to correlate to a municipal boundary and there may be a main library and branch libraries within that area. For academic libraries, the user population is bounded by membership in the academic community. Thus, geographic regions are a key determinate of physical library user populations[9]. Oftentimes, this limited geographic scope can lead to an inward focus for the library, with the goal of serving its own residents as best it can.

With a digital library, user populations have dramatically different characteristics. Not only are the human users typically dispersed across a wide geographic range, the user may not even be human[10]! Computer agents have entered the arena as digital library users and their use is becoming more prevalent. Where the physical library user population is defined by geography and limited to the human population, the digital library population has no true boundaries.

Information Objects

It is no surprise that information objects play an important role in libraries – after all, libraries have historically be thought to be sources of information. In the physical library, information objects include books, serials, audio and video collections and electronic resources. These objects form collections, surrounded by a set of collection policies, budgets and management issues.

Digital libraries push the envelope to modify the definition of information objects. These objects may take the form of:

- 'born digital' objects;
- digital objects created from an original print format;
- streaming audio tracks;
- software programs;
- simulation environments;
- sets of hyperlinks; or
- dynamic databases.

The list goes on and as technology grows, so will the variation in information objects available.

Services

Library services change with the demands of the time. Here in the United States, libraries in their inception strove to provide literature to the masses for 'enlightenment', following the guidance and funding from Andrew Carnegie. Over time, they have evolved to provide services that cover the range of literacy, English

as a second language, citizenship assistance, daycare visits, storytime and adult/senior computer instruction. As digital libraries become ubiquitous, there is no reason to believe that services demanded of them will increase as systems and users become more sophisticated.

Relationship of Users, Information Objects and Services

Borromean rings clearly illustrate how the three fundamental components of libraries – users, information objects and services – interact to create the true value of a library. With any one piece of the triad removed, the value of the library becomes weaker, if not disappearing altogether.

Users

Services

Value of
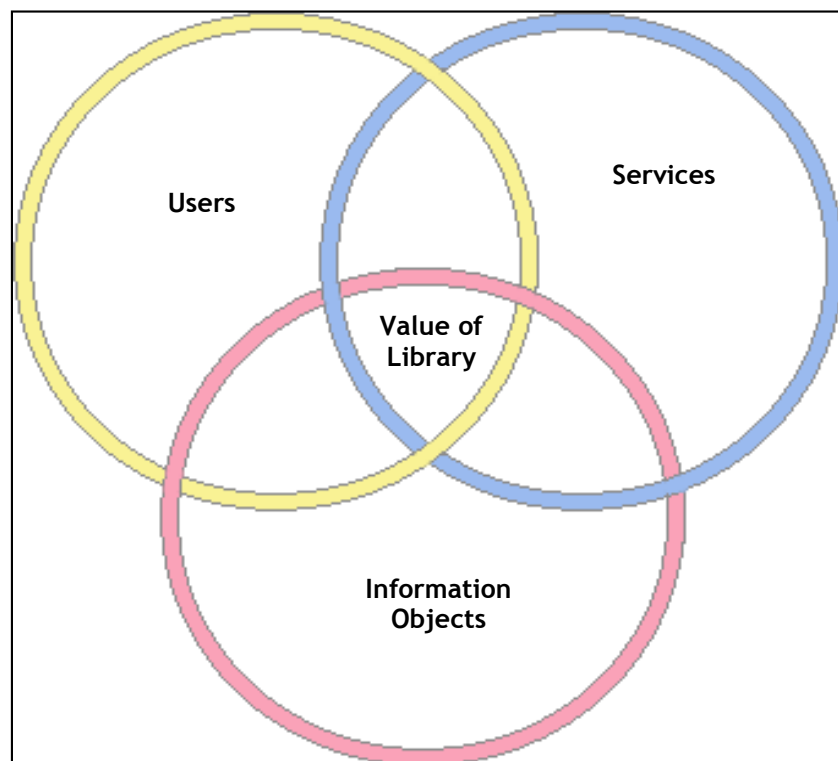Library

Information
Objects

Fig. 2: Key Characteristics Together Form the Value of the
Library

Physical Library Metrics

Table 1 is a listing of popular metrics for physical libraries. All have received tremendous attention in library and information science literature. Implementation of these metrics occurs slightly differently across libraries, but the basic concept remains intact. Comprehensive treatment of these metrics and case study evaluations abound in library and information science journals and texts[11]. I cannot do justice to the work previously done in this area and do not provide discussion on these metrics. Rather, they are here to show how they relate to key library characteristics as well as to inform the digital library metrics discussion.

TABLE 1: PHYSICAL LIBRARY METRICS	
RESOURCE METRIC IS BASED ON…	TYPES OF MEASURE
Users	Door counts Program participation Surveys Cost per user Library card statistics
Information Objects	Overall size Growth/decrease in size Circulation statistics by time period, individual item, genre and/or media type[12] Cost per item Cost per use of each item or media type
Services	Reference Question Statistics Online Database Access Programming – Children, Adult and Senior Storytime Community Meeting Space
Staff	Total staff Ratio of technical staff to professional staff Ratio of staff to patrons
Physical Facility	Operation Cost Maintenance Cost Public Access Computer Workstation Count Reading Rooms Internet Connectivity Cost per square foot

Digital Library Metrics

The arena of digital library metrics is exciting and continually evolving. The rapid development, implementation and evolution of digital library technologies have drawn the attention and energy of a great number of people. Now that there are many digital library projects up and running, research on metrics is following close behind. The task is huge – the D-Lib Metrics Working Group states quite bluntly that "the range of potential metrics relating to digital libraries is immense." Existing and potential metrics multiply in complexity as they become more understood. For example, a 2003 National Science Foundation and Library of Congress jointly supported report titled "It's About Time" focuses on digital archiving and long-term preservation – just one piece of the metrics pie. Its Executive Summary alone is over 18 pages!

Researchers are studying this topic at the individual and collaborative level[13]. The Association of Research Libraries (ARL) has been involved for over five years. In October 1999 ARL began its New Measures Initiative which moves beyond quantitative measures of evaluation. With a focus on outcomes, impacts and quality, ARL's E-Metrics and DigiQUAL+™ delve into qualitative issues directed exclusively at digital services and digital libraries. Choudhury et.al. report that in the United Kingdom, eVALUEd is working towards a similar goal. eVALUEd's website states that they have designed a toolkit to take "a user-focused approach to the evaluation of [electronic information services] EIS mainly through the use of qualitative data collection methods."

To address digital library metrics, I draw upon what is known about users, information objects and services specific to the digital realm. This information, in conjunction with the work of high-level task forces wrestling with the topic of digital library metrics, reveals the beginnings of a structural framework. The framework very much incorporates metrics in other fields such as physical libraries, computer science, human-computer interaction, usability, the Semantic Web, information search and retrieval, and economics.

Not only is the range of metrics immense, categorization of them is slippery as well. In particular, services become integrated into information objects, and website issues seep into every aspect of the digital library. Even though categorization of metrics is difficult, I have continued to impose somewhat false distinctions as they provide some structure to the discussion[14].   I only touch upon some of the larger metric topic areas in this writing simply because of the immensity of the task.

Users

Users of Content

As noted previously, digital library users can have substantially different characteristics than those of physical libraries. A digital library must account for both human and agent interaction, supportable over vast geographic and computational spaces, and be available twenty-four hours a day. Metrics addressing users are minimal at this time and largely consist of website counters and server logs. Website counters, while providing basic information on how many people have clicked on the site, do very little else to measure the success of a digital library. In fact, some of them cannot differentiate when an agent has visited the site rather than a human. Further, without counter statistics being coupled with detailed log information such as how long did the user stay at the site, how deep did they go into the site, and did they download any information, this measure remains somewhat arbitrary and wholly inadequate. Server logs are increasing being studied because of their importance and richness as a resource for digital library managers. A shift in focus from website counters to logs is occurring in part because practitioners and researchers are realizing the inadequacy of a simple count.

An example of this progression is JSTOR, a not-for-profit organization originally founded at the University of Michigan. JSTOR was originally created to serve as an archive of back issues of scholarly journals and as its materials were made available online, significant usage of these materials was seen. Recognizing that it would be important to understand who was using their collection and how they were using it, the JSTOR website[15], calculates their use statistics from "meaningful accesses, such

as page views, print requests, and searches. Raw web server hits are 4-5 times higher [than graphs provided on their website]."

Another example of innovative research comes from Bollan and Luce (2002), where they analyze server logs and user statistics for "determining the structure of relationships among documents from registered patterns of user retrieval, and the analysis of these relationships to determine document impact and the structure of the DL user community." In doing so, they hope to make digital library collection policy user-driven rather than being "largely informed by management intuition and coarse measures of user satisfaction."   In partnership with Old Dominion University's Computer Science Department they were able to develop the DEAN Project[16], an open source software to automate this process and thus significant assist digital library managers in collection decisions.

A New Kind of User: Creators of Content

In a digital library, the wall between the library and the information provider seems to be less opaque than in the paper world. More and more individuals and scholars are publishing their work in digital libraries and now represent a new and significant user group for the digital library itself. Thus these stakeholders have a significant investment in how their information is presented, maintained and offered up for use by larger online communities. Intellectual property protections, authentication, downloadability, and print-on-demand are all new services that are indirect outgrowths required to serve this new user group.

Information Objects

On the surface the metrics for physical and digital libraries may appear similar. After all, both track the number and diversity of information objects, costs per object, and use statistics. Both generate statistics on the cost per object by knowing how many objects they have and how many people visit the physical or virtual site. In both settings, the presence or absence of multimedia objects is something that is measured and touted.

These surface similarities paint a deceptive picture because metrics for physical and digital libraries pose separate and distinct challenges. In a physical library an information object – a book, video, CD-ROM, etc. – resides on in one physical location. Where it resides does not have any real effect any of the other information objects, except that an object occupies a physical space and another object cannot therefore occupy that same space. But in truth, the physical object has no 'relationship' to any other physical information object.

With a digital library, the location of the object is intimately tied to the other items in that particular digital library. And not only do the objects have to have context to each other in terms of site layout, but they must be cognizant of their place in the complex Internet. In this way, the digital library begins to take on characteristics of archives which utilize contextual organizational schemes.

Furthermore, without the physical realm, search and retrieval of information objects rely solely on technology. Thus the object must be searchable by not only the search

engine of its home digital library, but search engines of any number and type from across the globe. It must also be sensitive to the fact that the searcher may be human or may be automated.

Metadata

The D-Lib Metrics Working Group has focused its efforts on finding measures of sufficiency, currency, and quality for digital libraries. Here is where metadata emerges to address all three of their parameters. It rises as a component of the information object which is almost as critical as the content itself. Rousseau and Rousseau (2002) question just how high the quality and completeness of metadata will be in the digital world, asking "For instance; are creators of information sources for digital libraries willing to semantically enrich the information they create and maintain?"

This is a question that must be answered. Without complete metadata in a language and format that is understandable and somewhat universal, information objects become essentially useless, languishing in virtual space with no way for their content to be accessible. Much research is underway on automated metadata creation and extraction because there are simply not enough people to be able to create and organize metadata for the overwhelming number of digital information objects created each day[17]. Widely accepted metadata standards are being actively sought. The Dublin Core Metadata Initiative (DCMI), self described as "...an organization dedicated to promoting the widespread adoption of interoperable metadata standards

and developing specialized metadata vocabularies for describing resources that enable more intelligent information discovery systems." Hosted by OCLC Research and in its tenth year, DCMI boasts of an "international community of researchers and practitioners from more than 50 countries"[18]. Such is the success of DCMI that the Dublin Core Metadata Standard is becoming fairly widely adopted. The current metadata standard consists of the following elements: [19]

TABLE 2: DUBLIN CORE METADATA STANDARD AS OF APRIL 13, 2005		
Content	Intellectual Property	Instantiation
Coverage	Contributor	Date
Description	Creator	Format
Type	Publisher	Identifier
Relation	Rights	Language
Source		
Subject		
Title		
Audience		

It is important to recognize that research and development of the Semantic Web constitutes an integral part of metadata advancement. Both areas seek to find common languages, either through programming or vocabulary. Languages such as RDF and OIL attempt to cross the boundaries of media types and operating systems to address heterogeneous, distributed networks; ontologies attempt to normalize vocabulary so that objects are more uniformly described and searchable.

Intellectual Property Rights

While I do not elaborate on the topic of intellectual property, it has tremendous effect on digital library development and use. Concerns directly related to

information objects include copyright law and how it relates to digital publishing, access and creative reuse. These issues are under intense discussion and it is anticipated that the massive academic digitization project that Google initiated in 2004 will lead to litigation and perhaps legislative reform.

Services

Library service models dramatically alter when applied to digital libraries. Connaway and Lawrence (2003) state that "the arrival of digital media is providing opportunities and pressures to increase the variety of services that libraries offer, such as Internet reading rooms, printing services, and new reference services." In addition to the above-mentioned new services to support human users in the digital environment, digital libraries must offer purely technical services such as interoperability across distributed heterogeneous networks of information, digital preservation, personalization support/agents, search and retrieval strategies, and data mining.

Interoperability

Support for interoperability across distributed heterogeneous digital environments is a new service demanded by digital libraries. Media types, database structures, and operating systems vary widely. Because of this, a digital library must have a high degree of interoperability to thrive. To address this issue, the D-Lib Metrics Working Group, in conjunction with DARPA, created the D-Lib Test Suite project[20]. The Test Suite project is cutting edge and represents the only formal effort to date to develop

concrete, quantitative metrics for interoperability.   This effort also provides important data and insights into issues of digital archiving and metadata provision.

Digital Preservation

Perhaps Margaret Hedstrom said it best in her 2004 NSF/Library of Congress report titled "It's About Time". While the title may cause a chuckle, the issue is no laughing matter. Most users of the World Wide Web have experienced the lack of digital archiving first hand; one day you go to a site and get great information, and the next time you go back the site has vanished. For a digital library, this could be devastating.

In the United States, the Library of Congress was mandated to create an "infrastructure to support long-term preservation of digital content through the National Digital Information Infrastructure and Preservation Program (NDIIPP)" in 2002. "It's About Time" is the first of many documents that will shape the digital archiving movement for the next many years.

On the other side of the Atlantic, Chief Executive of the British Library Lynn Brindley reports in her 2000 D-Lib article, that in the United Kingdom and the Netherlands, IBM has partnered with the respective national libraries to support born-digital materials. This support is in the form of metadata storage and migration in a digital library system.

Archiving and trust are closely linked. Libraries in general have held the public trust for over a century. If the expectation is that digital libraries will be trustworthy, they must integrate a digital preservation regime that will allow for stability and

retrieveability of digital information objects. In some cases, this may mean migration to new technologies as they become available. In others, it may require a digital repository. Without stability, the establishment of trust is not likely – nor is resounding success.

Personalization Support/Agents

Digital library users are becoming more sophisticated. Personalized library services, such as agent support, have been developed to better support high-level needs. A simple example of an agent used by individuals is that of Travelocity's FareWatcher™ service. A user can easily enter their flight preferences and demanded price. The agent continually searches the 'library' of flights and fares, and then returns the information to the user when it is able to 'match' the users preferences and information found.

An agent application in a corporate setting might be found with data mining efforts. Applied heavily in the business world, data mining is the process of analyzing very large amounts of data and identifying patterns and relationships. With the extreme volume of digital data available, agents go out and 'read' the data for pattern detection and are able to return their results to the user.

A more complex example of an agent would be the CAPM project at Johns Hopkins University. CAPM, Comprehensive Access to Printed Materials, is an automated retrieval robot who performs on-demand browsing and scanning of printed materials. It is unique in that it is directed by a user located in the physical library to control the

robot in an offsite storage facility through use of "complete remote control to enable scanning pages, viewing images, searching full-text and printing pages". While the CAPM project focuses on agents performing library services in a hybrid library situation, Choudury et.al. (2002) believe their model has applicability and portability to other purely digital services.

Collaborative support is another form of personalization that digital library users are demanding. Communities of practice are realizing the value and opportunities available when working on interdisciplinary teams. A digital library is oftentimes at the core of the collaboratory – as such it is under heavy pressure to provide needed and novel services. Los Alamos National Laboratory Research Library offers an example of a model library that supports collaborative users through personalization and agent services. The Library continually improves its user services based on feedback through annual surveys, well-developed issue/problem tracking action, and personal visits to its customer base.

Search and Retrieval

Precision and recall are the two basic measures of search and retrieval success used in computer science. In digital libraries, the D-Lib Metrics Working Group has further defined needed metrics to include timeliness and effort in addition to precision and recall. They state that "objective metrics could address search complexity, including the number of times the user must interact with the system or iterate the query to get it correct. Subjective measures would consider the user's perception of the level of effort required. Is the system perceived as easy to use, for example, or does the user leave in despair, finding the system's operations too obscure to comprehend?" In

2002 metrics for precision and recall in digital libraries "proved to be beyond reach" and the D-Lib group is seeking to find scenario-based metrics that can be created with "the current state of technology".

Usability

Usability is a key evaluative factor for digital libraries. Components of usability include ease of navigability, intuitiveness of layout, aids to users, and time to load. Digital libraries rely heavily on the human computer interaction community of practice for their expertise as to how to incorporate best practices into digital libraries. Chi (2000) takes usability a step further to introduce "a new emerging approach…[to] employ software agents as surrogate users to traverse a Web site and derive various usability metrics." These metrics feed into the WebCriteria SiteProfile, which "uses a browsing agent to navigate a Web site" collecting data which are then "integrated into metrics". Chi also makes the point that "usability will have great effect on the ultimate success or failure of any given digital library."

TABLE 3: DIGITAL LIBRARY METRICS	
RESOURCE METRIC IS BASED ON…	**TYPES OF MEASURE**
Users	Website hit counters Humans & Agents Content Creators
Information Objects	Number of pages Growth/decrease in size Cost per item Diversity of media type Metadata completeness – semantics, ontology, comprehensiveness Intellectual Property Rights
Services	Interoperability Digital preservation Print on Demand Online Reference Query, Search and Retrieval Support (both formulation and execution) Personalization Support/Agents/Data Mining Collaboratory Support Usability: (ease of navigability, (content organization, access and human-computer interaction, browsing, visualization) Operation/Maintenance/Hosting Cost Universal Accessibility – Disabilities, Rights and privileges Preservation of content i.e. digital archiving and preservation Performance of site (speed, graphics, visualizations,)
Staff	Technical staff Reference staff Managing staff

Discussion

Much in the same way that "evaluation of digital archiving is impossible without concrete measures of costs, benefits and values of digital objects" (*It's About Time, 2003)*, a persistent lack of comprehensive metrics for libraries is detrimental to both physical and digital libraries. The ARL New Measures initiative recognizes this from the research library perspective and states that "the descriptive and input data traditionally collected by ARL, while useful for some purposes, fall short of meeting institutional accountability needs, and fail to provide any indication of impact on teaching or student learning." The University of Pennsylvania Data Farm[21] is the first initiative to start to capitalize on the digital quantitative data that they can collect. With careful analysis of user behavior and inputs, they intend to use these statistics to realize outcomes of: "high quality services, cost efficiency, organizational efficiency and effectiveness, and credibility within the University." (Zucca, ARL Presentation, April 2003.)

Further development of a comprehensive metric scheme is imperative for libraries to prove their worth. By building upon the revolutionary work of the British Library, with the Florida work and other case studies of American universities and/or public libraries, contingent valuation can be tested as a library metric. As digital libraries become more pervasive, evaluation models can be influenced by knowledge obtained from physical library CV studies. Furthermore, granting agencies such as the National Science Foundation and Institute for Museum and Library Services require institutions to address outcome as a significant portion of the application, CV may prove to be a valuable tool.

Digital libraries are fresh and exciting, viewed in a rosy glow of light that we imagine will only grow brighter and brighter. Yet this success is not ensured. I believe that digital libraries will have to make a concerted effort to become sustainable enterprises over the long term. In many ways, they will be required to sustain library traditions of objectivity, the provision of information objects supported by appropriate and high quality services. The quality of the information must be vetted and trusted by the user community. Intellectual property rights must be respected with the overall goal of increased knowledge ultimately served. Financially, digital libraries must remain flush enough to fund maintenance and continued development. Where appropriate they will be required to address issues of digital inequality.

What could be done is to build upon the work of the British Library by providing additional case studies. Plosker (2005) spoke with Denise Davis of the American Library Association's Office of Research and Statistics and she agreed that successful examples help advocacy and that "constituencies must hear 'look at the great things we have done; think of how much more we can do with a few more dollars.'"

We seem to know intuitively is that we have to prove the value of libraries. Contingent valuation offers a chance to provide economic justification for libraries. The benefits that appear appropriate for a contingent valuation scheme would address the substance of the digital library's responsibility to its community. They should include qualitative and quantitative measures to provide a comprehensive tool. Specific questions to be asked in the contingent valuation metric (CVM) could include:

- Quantitative

  - What is the constituency of the user group?

  - What services are being used by the group? What services are being demanded that are not being provided?

  - How many "meaningful accesses" of the site occurred?

  - Does the metadata for the information objects meet a high standard for completeness and accuracy?

  - Does the digital library pass periodic usability tests from its patrons?

  - Does digital archiving happen on a regular basis?

- Qualitative

  - What would the user population be willing to pay if the digital library left the marketplace? What would they be willing to pay for individual value-added services?

  - How many people are directly affected by the digital library in a given period of time?

  - Based on feedback and observation, how many people are indirectly benefited by the digital library?

- Value-Based

  - What is the return on investment for this digital library?

  - If the digital library were to leave the marketplace, is there a substitute for it in place?

By making explicit the value of the library, librarians can make public and visible what we have known all along – the library reaches far and wide, touching all corners of the globe. And besides, wouldn't it just be so interesting to know what the true value of something like the Library of Congress' American Memory project?

Reference List

1. Bollen, Johan and Rick Luce. 2002. Evaluation of Digital Library Impact and User Communities by Analysis of Usage Patterns. *D-Lib Magazine* 8 (6) (June).

> Available at: http://www.dlib.org/dlib/june02/bollen/06bollen.html

2. Borgman, Christine L. 1999. What are Digital Libraries? Competing Visions. *Information Processing and Management* 35: 227-243.

3. Brindley, Lynne. 2000. Taking the British Library Forward in the Twenty-first Century. *D-Lib Magazine* 6 (11) (November).

> Available at: http://dlib.org/dlib/november00/brindley/11brindley.html

4. Carson, Richard T. 2000. Contingent Valuation: A User's Guide. *Environmental Science Technology* 34 (8):1413 -1418.

5. Chi, E., P. Pirolli, and J. Pitkow. "The scent of a site: A system for analyzing and predicting information scent, usage, and usability of a Web site." Proceedings of the 2000
Conference on Human Factors in Computing Systems at CHI 2000, ACM, New York, NY.:161-168.
> Available at: http://www-users.cs.umn.edu/~echi/papers/chi2000/scent.pdf

6. Choudhury, Sayeed, Benjamin Hobbs, Mark Lorie, and Nicolas Flores. 2002. A Framework for Evaluating Digital Library Services. *D-Lib Magazine* 8 (7/8) (July/August).

> Available at: http://www.dlib.org/dlib/july02/choudhury/07choudhury.html

7. Connaway, Lynn Silipigni and Stephen R. Lawrence. Comparing Library Resource Allocations for the Paper and the Digital Library: An Exploratory Study. *D-Lib Magazine* 9 (12) (December).

> Available at:
http://www.dlib.org/dlib/december03/connaway/12connaway.html

8. Harnard, Steven. 1992. Post-Gutenberg Galaxy: The Fourth Revolution in the Means of Production of Knowledge. *Public-Access Computer Systems Review* 2 (1):39-53.

9. *It's About Time: Research Challenges in Digital Archiving and Long-Term Preservation*. Sponsored by the National Science Foundation Digital Government Program and Digital Libraries Program, Directorate for Computing and Information Sciences and Engineering and the Library of Congress National Digital Information Infrastructure and Preservation Program. August, 2003.

10. Jung, Jim Taek. 1997. "Measuring User Success in the Digital Library Environment: A Thesis Submitted to the Faculty of Drexel University." Doctoral thesis, Drexel University. Ann Arbor, MI: UMI Company.

11. Larsen, Ronald L. 2002. The DLib Test Suite and Metrics Working Group: Harvesting the Experience from the Digital Library Initiative.

Available at: http://www.dlib.org/metrics/public/papers/The_Dlib_Test_Suite_and_Metrics.pdf

12. Leiner, Barry M. The Scope of the Digital Library. Draft prepared by Barry M. Leiner for the DLib Working Group on Digital Library Metrics. January 16, 1998, revised October 15, 1998.

Available at: http://www.dlib.org/metrics/public/papers/dig-lib-scope.html

13. Matthews, Joseph R. 2004. *Measuring for Results: The Dimensions of Public Library Effectiveness.* Connecticut: Libraries Unlimited.

14. *Measuring Our Value.* Commissioned by the British Library in 2003 and available at http://www.bl.uk/whatson/valueconf/pdf/value.pdf.

15. Orr, R. H. 1973. Measuring the Goodness of Library Services: A General Framework for Considering Quantitative Measures. *Journal of Documentation* 29 (3) (September): 315-32.

16. Plosker, George. (2005). Revisiting Library Funding: What really works. *Online Magazine,* 29 (2) (March/April): 48-50, 53.

17. Pottenger, William M. and Robert E. McGrath. 1998. D-Lib Metrics Working Group Holds Workshop in Pittsburgh. *D-Lib Magazine* 4 (6) (June).

Available at: http://www.dlib.org/dlib/june98/06clips.html#METRICS

18. *Report of the NOAA Panel on Contingent Valuation.* Arrow, Solow, Portney, Leamer, Radner and Schuman. Federal Register, 58. Washington DC, 1993.

19. *Revolutionizing Science and Engineering Through Cyberinfrastructure: Report of the National Science Foundation Blue Ribbon Advisory Panel on Cyberinfrastructure.* January 2003. Panel members include Daniel E. Atkins, Kelvin K. Droegemeier, Stuart I. Feldman, Hector Garcia-Molina, Michael L. Klein, David G. Messerschmitt, Paul Messina, Jeremiah P. Ostriker and Margaret H. Wright.

20. Rousseau, Brendan and Ronald Rousseau. 2002. Some ideas concerning the Semantic Web. *Library and Information Service* 8: 39-49.

21. Wallace, Danny P. and Van Fleet, Connie. 2001. *Library Evaluation: A Casebook and Can-Do Guide.* Englewood, Colorado: Libraries Unlimited, Inc.

[1] Harnad uses the notion of 'revolutions' for the distinct phases of knowledge production. Electronic telecommunication networks, primarily represented by the Internet, are described as the fourth revolution. The first revolution was language, followed by writing and printing.

[2] Quoting from the January 2003 report on Report of the National Science Foundation Blue Ribbon Advisory Panel on Cyberinfrastructure, cyberinfrastructure is defined as: "infrastructure based upon distributed computer, information and communication technology. If *infrastructure* is required for an *industrial* economy, then we could say that *cyberinfrastructure* is required for a *knowledge* economy."

[3] Information obtained from IBEC website at http://ibec.ischool.washington.edu/ibec.

[4] Further information can be found at http://www.oclc.org/advocacy/default.htm.

[5] A brief description of this study is found on Dr. King's curriculum vitae at http://www2.sis.pitt.edu/~dwking/dwkingcv.pdf.

[6] Information on this conference can be found at http://culturalpolicy.uchicago.edu/cvmconf.html. The speakers prepared very thoughtful and honest assessments for the pros and cons of contingent valuation.

[7] Information on the British Library's use of contingent valuation and resultant studies can be found at http://www.bl.uk/whatson/valueconf/value.html.

[8] This term was coined by the D-Lib Working Group on Metrics in 1998.

[9] Interlibrary loan in physical libraries has blurred geographic boundary notion of user populations to a degree; however, the physical library is more heavily used by residents in close physical proximity far more than through interlibrary loan patrons.

[10] The D-Lib Metrics Working Group brought this fact to my attention in their draft paper titled The Scope of the Digital Library.

[11] Matthews (2004) and Wallace and Van Fleet (2001) are two (of many) recent resources that provide detailed information on physical library metrics.

[12] OCLC WorldCat now offers a computerized Collection Analysis service for its library members. Information on this service is available at http://www.oclc.org/collectionanalysis/default.htm.

[13] Groups studying this important topic include, but are by no means limited to, the DELOS Network of Excellence, the Digital Library Federation, D-Lib Metrics Working Group (formed in 1998), ARL, ARL E-Metrics Group, and IFLA.

[14] According to the D-Lib Metrics Working Group homepage, they have "identified at least seven dimensions against which performance could be measured." This focused on temporal granularity, service scalability, user scalability, and front-end versus back-end considerations. More information on this can be found at

[15] JSTOR is located at http://www.jstor.org/about/desc.html. Statistical information can be found under the 'Resources for Librarians' link.

[16] Information on this project is available at http://www.cs.odu.edu/~jbollen/dean/.

[17] The Dublin Core Metadata Initiative has a very nice section on automated metadata at http://dublincore.org/tools/.

[18] Information from DCMI's ten-year anniversary online news piece located at http://dublincore.org/news/#10yearsDC.

[19] Metadata elements as listed in the Dublin Core Metadata Standard Elements at http://dublincore.org/documents/usageguide/elements.shtml. A great deal of more in-depth information on the elements and standards are available online at http://dublincore.org/.

[20] DARPA is the acronym for Defense Advanced Research Projects Agency. The D-Lib Forum is based in the Corporation for National Research Initiatives. More information about the D-Lib Forum can be found at http://www.dlib.org/forum/forum.html. Please see http://www.dlib.org/test-suite/ for more information on the Test Suite project.

[21] The Data Farm is found online at http://metrics.library.upenn.edu/prototype/datafarm/.