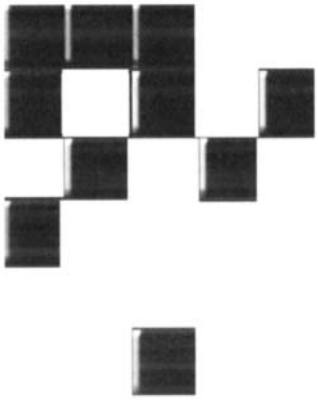

SECTION III

Information Systems

CHAPTER 6

Museum Informatics

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Introduction

Museum informatics is the study of how information science and technology affect the museum environment. This kind of study can be undertaken from multiple perspectives, including those of museum professionals and museum visitors. Over the past few decades, new information technologies have dramatically changed museums' capabilities. These changes have influenced how people think about museums and they have had a profound impact on the social interactions that take place in museums. Museum professionals and visitors alike have developed new conceptions of why museums exist and new expectations of what they should offer.

An extensive literature on museums and information technology exists (Keene, 1998; Morrissey & Worts, 1998; Orna & Pettitt, 1998; Thomas & Mintz, 1998). Several recent books, including *The Wired Museum* (Jones-Garmil, 1997, published by the American Association of Museums), cover the many ways museums have been influenced by technology. Proceedings from a variety of conferences deal with topics in museum informatics, including the Museum Computer Network Conference, the Museum Documentation Association Conference, the Conference of the International Committee for Documentation of the

International Council of Museums, the International Cultural Heritage Informatics Meeting (formerly the International Conference on Hypermedia and Interactivity in Museums), and Museums and the Web. Journals such as *Archives and Museum Informatics* (recently incorporated into *Archival Science*) and newsletters such as *Spectra*, a publication of the Museum Computer Network, regularly touch upon issues of museum informatics. A special issue of the *Journal of the American Society for Information Science* (Bearman & Trant, 2000) was devoted to museum informatics.

This material is very idiosyncratic in nature, in part because the literature covers different types of museums, with different collections, audiences, capabilities, and needs. Nevertheless, it is possible to find within this literature underlying commonalties that bridge the concerns of disparate museum professionals. One basic issue, for example, is the search for shared data standards to be used in museum automation. The majority of these commonalties, however, are more general and wide-ranging in their implications. Museum professionals have found that information technologies provide a new range of functionalities to enhance what can be done within the museum environment. The possibilities go well beyond simple computer automation, raising fundamental questions about the job of the museum professional, the experience of visiting a museum, and the very definition of what a museum is.

These questions constitute a new field of study, a field called museum informatics; this contribution is the first *ARIST* chapter on the subject. Like most new fields, museum informatics draws upon many related areas, from social informatics (Kling, 1999) to research into digital libraries (Bishop & Star, 1996). Until recently, most authors writing about museums and technology were more concerned with a narrow and systems-driven approach to how information technology should be used in museums than with how new technologies would change the social relationships that take place both within and outside museum walls. However, given recent developments, it is now virtually impossible to discuss museum technologies in the abstract without touching in some way on the changing role of the museum in the information society.

This chapter examines the nature and status of the technical issues museum professionals face as they take advantage of modern information technologies, while acknowledging that these technical issues are

nested within complex and interlocking organizational and social contexts that affect both the nature of museum work and the expectations of the museum's clientele. It is an attempt to take different threads from the existing literature on information technology in museums and spin them into a systematic study of museum informatics. In doing so, it attempts to draw from the literature a coherent account of an emerging field, identifying the main areas of concern and topics of study for researchers interested in the changing sociotechnical nature of museums.

The chapter is organized into three sections. The first part provides an historical perspective covering the use of new technologies in museums over the past few decades and identifying the technological challenges faced by modern, digital museums. The second examines the social effects of computerization on the museum environment from the perspective of all who use museum resources—from the museum professional to the museum visitor. The third explores how these changes are bringing about a redefinition of the museum as part of the information society.

Museums and the Digital Revolution

This section explores the historical progression of the use of computers in museums. It begins by examining the nature of information resources in museums and the traditional ways in which museum professionals have organized these resources. It then explores the changes brought about by advances in computer technologies, the challenges of digitizing museum collections, and the difficulties of developing standards for data sharing.

Museum professionals started using computers for information management in the 1960s. Early advocates of computerization in museums, like those who were advocating the use of computers in libraries at the time, emphasized the computer's value for automating repetitive and time-consuming tasks: sorting records, searching for information, and tabulating results (Varveris, 1979). These functions were tasks of the museum registrar, familiar to every museum professional; organizations such as the Museum Computer Network (http://www.mcn.edu/), established in 1967, could rely on this familiarity when they encouraged museums to use computers (Vance, 1975). However, museum professionals soon realized that the use of computers in museums would involve

more than just automating existing tasks. The digital revolution would change not just *how* they managed their records but *why* they managed records in the first place.

Information Resources in Museums

Whether they work in a museum of art, natural history, cultural history, or science and technology, museum professionals must manage a wide variety of information about their collections. This information is needed to identify and describe museum objects and integrate them into particular collections. These extremely complex tasks involve different kinds and levels of information. From the moment an artifact enters a museum, registrars, curators, and other museum professionals examine it and assemble information to be recorded. The object must be accessioned, weighed and measured, photographed, marked with a unique identification number, and so on. Information about how the museum received the object, how long it will be in the museum's collections (if it is on loan), and where it will be stored or displayed must be recorded. Details of the object's provenance, historical importance, and cultural significance must be researched. The specific information generated about any one object becomes part of a vast array of information about the museum's collections, exhibits, and educational potential as a whole. Information about a museum's exhibits forms part of a broader spectrum of knowledge about art, culture, and history.

The identification and gathering of this information are driven by the requirements of different museum professionals as they assess what is needed for their own use and for the use of potential museum visitors. These needs often vary from institution to institution and from visitor to visitor. Students in an art history class, for example, come to a museum searching for appropriate examples to use in their papers. Scholars researching a particular topic need to know how many prints by a given artist exist in the museum's collection or how many paintings deal with a certain subject. Museum curators planning a new exhibit require information about each object's historical significance, in order to select the best artifacts for a given display. The museum's information resources can respond to this variety of needs only if the necessary information has already been gathered, properly organized, and made accessible.

Information Organization and Access

The organization of information about museum artifacts has always been an important topic for museum professionals (Buck & Gilmore, 1998; Dudley & Wilkenson, 1979). Traditionally, museum information resources have been organized into card and ledger files. Such files have a necessarily limited number of access points; information was typically arranged by accession number, donor name, and object name. However, few organizational standards existed for recording and managing this information that held true across different museums. Some museums might use different or additional kinds of card files, organizing objects by material type, for example. A number of methods of assigning accession numbers were available, although most museums now use the tripartite numbering scheme recommended by the American Association of Museums, and a variety of different schemes were in use for classifying museum artifacts.

The traditional card and ledger files and the information they organized, as primitive systems for information storage and retrieval, could answer only a few types of questions about objects in a museum's collections: "How many objects has any one particular donor provided to the museum?" "How many objects were accessioned in the year 1973?" Such questions could be answered easily. However, answering even relatively straightforward questions like "How many lamps does the museum have in its collection?" depended greatly on whether objects were consistently classified when they were accessioned. Questions of a more complex nature were nearly impossible to answer: "How many Attic Red-Figure vases does the museum have from the late fourth century B.C.?" "How many paintings depict the labors of Herakles?" Even the most skilled museum professional would be unable to answer such questions without reading each card entry individually.

Potential and Pitfalls of Automation

When museum professionals began automation projects, they expected computers to provide better organization of records and faster access to information (Rush & Chenhall, 1979). Electronic databases had the potential to provide more access points, faster searching and sorting, and the ability to compile and print lists more quickly (Abell-Seddon,

1988; Vance & Chenhall, 1988). For these reasons, there were many early attempts to computerize museum collections, most notably in the late 1960s at the Smithsonian Institution. Soon, museum professionals around the world were beginning the complicated task of taking data about artifacts from their card or ledger files, converting them into electronic format, and storing them in large, mainframe, networked systems (Chenhall, 1975). Within a few years, organizations such as the Museum Computer Network were experimenting with data collection standards and formats that would enable museum professionals to share data across multiple institutions (Vance, 1975).

Despite this promising beginning, however, computer automation in museums quickly bogged down in a morass of technical problems that undermined even the best attempts to create uniform standards for automation within museums. The inherent uniqueness of museum artifacts meant that there was and could be no organization equivalent to the library world's Ohio College Library Cooperative (now the Online Computer Library Center, http://www.oclc.org/) to help museums develop a shared database of museum records; each institution had to tackle the task of cataloging its collections individually. Additionally, museum professionals, primarily curators, wanted their records to contain extensive data about artifacts that went far beyond the essentially inventory data typical of library catalogs. What these data were, however, often varied from curator to curator, and the creation of a database system that could satisfy the needs of individual institutions was extremely complex and expensive. For these reasons, most museums in this period remained stuck in a world in which automation was considered difficult if not impossible (Doty, 1990; Williams, 1987). Throughout the 1970s, advocates of museum automation saw their efforts rapidly fall behind and diverge from the field of library automation.

Nevertheless, some important general developments occurred at this time in the field of museum automation. The first conference about computers and their potential application in museums was held at the Metropolitan Museum of Art in New York in 1968 (Metropolitan Museum of Art, 1968). The Museum Documentation Association (http://www.mda.org.uk/), established in 1977, drew up and attempted to promulgate minimum information standards in the form of SPECTRUM, a guide to electronic collections management (Cowton, 1997).

Meanwhile, other organizations, such as the International Committee of Museums and the Getty Information Institute (formerly the Getty Art History Information Program) joined the Museum Documentation Association in exploring more general models for knowledge sharing (Bower & Roberts, 1995). Such efforts, however, were few and far between. Most museum professionals found themselves in a difficult situation where they were (a) unable to solve the problems involved in automating their collections cooperatively, and (b) unable to afford the high expense incurred in doing it on their own. A possible solution to this dilemma was not found until the 1980s, with the widespread use of the personal computer.

Digitization, Personal Computers, and the Internet Revolution

After two decades of struggle, museum professionals finally had a practical, inexpensive, and easy-to-use tool for digitizing information about their collections: a stand-alone database on a personal computer. As a result, during the late 1980s, the number of museums using computers to store information about their collections began to grow rapidly (Jones-Garmil, 1997). As personal computers became cheaper and easier to use, they were deployed more widely and for more tasks in the museum environment (Hooper-Greenhill, 1995; Thomas & Mintz, 1998). New technologies allowed for the digital imaging of museum artifacts. Multimedia kiosks were used in exhibit galleries to present more detailed information about museum collections. With the arrival of CD-ROM technology, museums began to create multimedia CD-ROMs about their collections to distribute to educational organizations.

Despite these technological advances, however, digitizing information about artifacts remained a stubbornly difficult task. Digitizing an artifact requires much more than simply creating a digital image of the object. A great many fields are needed to describe an artifact completely and thoroughly, and different kinds of artifacts may well need different fields. Thus, most off-the-shelf database systems for museums use relational records with hundreds of fields to describe each artifact. The inherent uniqueness of museum artifacts remained a problem. No two museums can possess exactly the same historical object or work of art;

even reproductions vary greatly in such crucial identifying features as size, material composition, and provenance. These factors not only make describing each object a time-consuming and individual task, they also make it very difficult to share this task among institutions.

Despite advances in digitization technologies, and despite advances in the parallel world of library automation, the problems of inter-museum cooperation remained mostly unsolved. Little coordination of work or sharing of information existed; only limited consideration was given to either standards or accessibility issues (Jones-Garmil, 1997). The same problems that made museum automation virtually impossible in the 1960s and 1970s caused individual museums in the 1980s and 1990s to develop their own, unique solutions to these previously unsolvable problems. It was in this environment that the Internet revolution occurred in the mid-1990s.

Museum professionals quickly began exploring the potential of the Internet for providing greater access to information about their collections than had hitherto been possible. By the time of the first Museums and the Web conference in 1997, many museum professionals were already online—bringing information about their institutions, their collections, and their exhibits to the public as fast as possible over the Internet (Bearman & Trant, 1997). They dreamed of a world in which researchers were able to access online databases of museum collections from their homes or offices over the Internet, where visitors could access additional information about the artifacts on display, and where online educational outreach programs would allow museum professionals to reach wider audiences than ever before (Besser, 1997b; Blackaby, 1997; Frost, 2001). Many museum professionals soon realized that they could provide greater and more useful information online if they shared information about their collections electronically (Hickerson, 1997; Hoopes, 1997; Keene, 1998). Without common, shared standards to draw upon, however, providing access to information in an organized and useful fashion has proven to be very difficult.

Data Sharing and the Search for Standards

The lack of acceptable standards in the museum community was recognized as a serious obstacle for museum professionals who wished to create a shared repository of digital information about their collections

(Bearman, 1994; Dunn, 2000; Fox & Wilkerson, 1998). Developing a common standard for documenting museum artifacts was considered extremely valuable because of its potential to improve (a) communication among institutions, (b) the quality of museum data, and (c) access to museum information resources worldwide. Therefore, museum professionals turned again to the problem of standards, despite the fact that the problems of inherent uniqueness and the difficulty of describing artifacts had not been satisfactorily resolved. This time, however, the focus was on developing standards that could help museum professionals share data among institutions, even if those institutions used different information systems internally. Instead of requiring all museums to use one standard for data entry, many organizations now encourage museums to use their own individual systems as long as their records are exportable to a common standard (Perkins, 2001).

To this end, many professional associations have been actively involved in creating potential standards for data sharing. Object ID (http://www.object-id.com/), for example, developed by the Getty Museum (http://www.getty.edu/) and administered by the Council for the Prevention of Art Theft (http://www.copat.co.uk/), was created to provide guidelines for descriptions that could be useful in recovering lost or stolen museum artifacts (Thornes, 1999). The Research Libraries Group (http://www.rlg.org/) was responsible for a number of efforts, including the Cultural Materials Initiative begun in January 2000. The Visual Resources Association (http://www.vraweb.org/) developed their Core Categories for describing information about collections and their visual representations. The Consortium for the Computer Interchange of Museum Information (http://www.cimi.org/) has explored the possibilities of using a variety of established standards, including XML and the Dublin Core, when describing museum artifacts (Perkins & Spinazze, 1999). The International Committee for Documentation of the International Council of Museums (http://www.cidoc.icom.org/) has promoted the development of standards for museums internationally.

Many attempts have also been made to develop standardized terminologies and controlled vocabularies for museum professionals to draw upon when documenting collections. Such standards would make it even easier for museums to share information about their artifacts. Many cultural heritage institutions, for example, classify their collections of

fabricated objects using a standard called Nomenclature (Blackaby & Greeno, 1988; Chenhall, 1978). The Getty Research Institute has developed a series of structured vocabularies, such as the *Art and Architecture Thesaurus* (Petersen, 1990), specifically for the use of museum professionals at a variety of institutions (Lanzi, 1998). Nevertheless, despite this activity and effort, it has proven difficult for museum professionals not only to agree on standards for inter-museum communication, but even to use those standards consistently in their own institutions.

Toward the Wired Museum

Now, in the early 21st century, museum professionals realize that being a "wired museum" involves far more than simply gathering electronic information about artifacts into a digital collection; new technologies can revolutionize information management in museums. The volume of scholarly research that often takes place in museums provides a good example. Many museums hold extensive research files, which usually are not integrated into their collections management databases. Valuable data about the importance of a museum's collections, not just what the museum has, is often lurking just beneath the surface. One challenge facing museum professionals lies in integrating as much related information as possible so that museums can better serve the needs of all their constituents (Blackaby, 1997). Rayward and Twidale (2000), for example, explore the idea of using new technologies to add a user-managed virtual layer of information onto pre-existing artifact descriptions.

Attempts to deploy rapidly evolving information technologies in museums have begun to change the way museum professionals work, and have also gradually fostered new initiatives that open up opportunities for reconceptualizing the role and function of museums in society (Besser, 1997b). It has become clear that museums are complex social environments, in which new information technologies have the potential to affect much more than the ways museums manage their collections. The next section of this chapter explores the wider, sociotechnical impact of information technology on museums, museum professionals, and museum visitors.

The Social Impacts of New Museum Technologies

Information technology has changed the way museum professionals work in-house, from collections management to exhibit design. It has changed the way museum professionals work online, from inter-institutional collaboration to educational outreach. It has changed the way museum visitors approach the museum, its holdings, and educational potential. It has changed what museum visitors expect from a museum, both in real life and online. This section examines the impact of museum informatics on both the museum professional and the museum visitor, exploring information management in museums, collaborations between different museum institutions, educational outreach from museums to schools, interactions between museum professionals and scholarly researchers, multimedia exhibits in museum galleries, virtual museums on the Web, and new methods of personalizing the museum-going experience.

Managing Information within the Museum

New information technologies have meant new methods of performing the various jobs of the museum professional. Registrars can organize and access artifact records more effectively and efficiently with electronic databases. Curators can have immediate access to information about artifacts—information that can help them research their collections and plan exhibits without having to bring artifacts out of storage or off display. Collections managers can have access to state-of-the-art storage and climate control systems to help keep artifacts in good condition. Conservators have new tools that help them analyze and restore artifacts that are in poor condition or damaged. New communication systems and computer-assisted design tools can help exhibit designers plan exhibits and casework, integrating information about artifacts, label copy, and graphics in formats that can be easily shared with curators and collections managers. Educators have access to new tools for informing museum visitors and new opportunities for educational outreach over the Internet.

These possibilities require a new approach to information management, and museum professionals have sought ways to improve their deployment of information resources. Orna and Pettitt (1998), for example, discuss the meaning of information in the museum context, identify the different users of information resources in museums, and explore ways of making information in museums more accessible. They cover a variety of topics from strategies for implementing information policies in museums to the technical details of purchasing and installing collections management systems for tracking information about museum artifacts. They also provide a series of case studies about how different museums around the world have employed information technologies to achieve various goals.

Marty (2000) examines how information and communication technologies changed the social dynamics in a university museum. At the University of Illinois, museum professionals, curators, and exhibit designers collaborated in designing a new museum facility. As part of this process, a new information system was developed to help museum curators communicate their proposed designs more efficiently to the exhibit designers. The new system allowed exhibit designers, working remotely, to access online information about museum artifacts and their proposed placement in museum exhibits. In response to these new information systems the social dynamic that had previously existed between museum professionals, museum curators, and exhibit designers changed significantly. The technology fostered greater collaboration among the participants. Now that it was possible for them to communicate dynamically, exchanging information about artifacts in real time, they found themselves collaborating more frequently and more intensively.

Collaborations and Consortia

One immediately positive outcome of standards development as discussed here has been the number of efforts to encourage data sharing across organizations by building centralized repositories of museum information resources. The Canadian Heritage Information Network (http://www.chin.gc.ca/) and the Art Museum Image Consortium (http://www.amico.org/) provide good examples of organizations that encourage participating institutions to contribute to a centralized database accessible to all members. The Canadian Heritage Information

Network (CHIN), for example, has developed a centralized repository to store information about Canadian cultural heritage. CHIN offers a searchable index, called "Artefacts Canada," that provides access to over 2 million artifacts from hundreds of Canadian museums. Member museums individually submit and update information, including images, about their artifacts using CHIN's own software; guidelines are provided for standardized terminology as well as instructions for converting each museum's records to CHIN's data structure format. In addition, CHIN has used information about its member museums to build a guide to Canadian museums called the "Virtual Museum of Canada."

The Art Museum Image Consortium (AMICO), which documents information about more than 65,000 works of art from over 30 art museums, has been able to use its resources to develop guides for institutions creating digital libraries of museum artwork. AMICO has served as a model for collaboration; helping museum professionals understand why collaboration is important; developing standards to aid museum professionals document and distribute information about their collections; and tackling difficult questions of intellectual property, information access, and economic benefits for participating organizations (Trant, Bearman, & Richmond, 2000).

Many other projects have explored how museums could share data and images. One of the most significant was the Museum Educational Site Licensing Project (MESL), which was initiated by the Getty Art History Information Program and ran from 1994 to 1998 (Trant, 1996). Although this project was primarily concerned with the issues of licensing involved in distributing content from museums and libraries to educational institutions (McClung & Stephenson, 1998), it also broke new ground in exploring technical standards for sharing images and textual data among different institutions (Besser & Stephenson, 1996).

The formation of museum information repositories offers the potential to learn more about inter-institutional collaboration. These consortia have the opportunity to test the suitability of standards for sharing museum information resources and recommend best organizational practices to others. The members of Australian Museums and Galleries Online (http://amol.org.au/) have integrated data for hundreds of thousands of Australian artifacts into one searchable collection. Researchers at the University of Sydney have been studying the efforts of these

museum professionals to learn how the implementation of the AMOL project has affected the distribution, access to, and use of museum information resources across Australia (Mack & Llewellyn, 1998).

Research on how museums collaborate can produce useful models for museums and other institutions, such as schools or libraries. The Digital Cultural Heritage Community project (Bennett & Sandore, 2001), at the University of Illinois, studied how museums, libraries, and schools collaborated to achieve specific educational goals. Project participants explored how museums and libraries could take primary source material, digitize it, and deliver it directly to the classroom. In this project, researchers were able to evaluate different standards for information organization and access, assess intellectual property concerns, and determine the suitability of primary source material in digital format for educational purposes.

Other researchers have focused on building a theoretical understanding of how diverse museum groups negotiate different interests when collaborating on a common project. Martin, Rieger, and Gay (1999) analyzed the interactions among a research lab, a human-computer interaction lab, and two museums as they collaborated to build a prototype "Global Digital Museum." Each group approached the project from a different perspective and with different beliefs about the content, format, and educational potential of the proposed design. The researchers developed their own theories about the creation of collaborative online learning environments, culminating in a framework for designing and developing virtual museums based on the social construction of technology model (Gay, 2001). In these ways, museum informatics researchers have been able to help museum consortia collaborate more effectively, setting and achieving goals for the mutual benefit of consortia members.

Educational Outreach from Museums to Schools

New information technologies have enabled museums and schools to connect in innovative ways. The Internet has offered museum educators the ability to bring the resources of the museum directly to students who may be unable to travel to the museum itself. Teachers, no longer limited to one or two field trips to museums each year, can integrate digital

museum resources into their lesson plans regularly, even from museums halfway around the world. Yet how effectively do these new technologies support educational goals? It is not enough simply to place a digital photograph of a museum artifact on the museum's Web site and expect students to find it educational. Online museum resources must be explicitly designed for educational purposes and carefully integrated into school curricula. Sumption (2001) critically evaluates several different approaches to Web-based museum education, offering strategies to help museum educators create more effective educational resources online.

As museum educators continue to create new programs, it is important for museum informatics researchers to devise models capable of evaluating these new resources and activities so that they can assist museum educators in their development efforts. Milekic (2000) has discussed the potential of "digital environments" for enhancing art education and exploration in museums. Arguing against technologically focused design concepts, he proposes a human-centered approach to the development of educational technologies for museums. Researchers at the University of Michigan have explored how museums and schools can work together to enhance the online museum experience, placing digital museum artifacts in context and promoting a greater awareness of different cultures among K-12 students (Frost, 1999). They have formulated a model program that engages students through active learning, encourages greater community involvement, and fosters a closer relationship between museums and schools. This initiative has also helped create a better understanding of how museum professionals, content specialists, K-12 teachers, and information specialists can collaborate to produce educational materials (Frost, 2001).

Research Activities Involving Museums and Scholars

As museum professionals use new technologies to improve access to their collections, they are often better able to assist researchers interested in the museum's artifacts. The Internet allows scholars, academics, and other researchers to access detailed information about a museum's collection in a fraction of the time it would have taken them to visit the museum in person. Moreover, since only a small percentage of a

museum's collection is ever on display at any one time, access to electronic records describing the museum's entire holdings is of great benefit to scholars who may not otherwise have known the full extent of the collection. As Hickerson (1997) recognizes, these new electronic possibilities have created a different understanding of the value of research collections and the nature of research. He describes many early projects dedicated to improving online access to research collections and considers the challenges and implications for both individual researchers and research institutions. Similarly, Hoopes (1997) explores the potential of the Internet to change the way archaeologists and anthropologists conduct research. He describes many different ways in which the World Wide Web has helped these researchers obtain improved access to information about museum collections, and identifies the challenges that remain if online museum resources are to be truly integrated into the research process.

The Opales project of the French Ministry of the Economy is an example of an innovative use of the Internet for research activities, including the potential for online collaborative knowledge sharing (Betaille, Nanard, & Nanard, 2001). Opales provides a mechanism for external experts to annotate digital records maintained at a centralized location and then to share these annotations with other experts. With this project, researchers are attempting to build a collaborative environment that encourages scholars to add value to databases as they use them. Currently, Opales is operating on a multimedia archive of video and audio records; the technology, however, has the potential to be applied to collections of digital artifacts of all types. It raises the possibility that it may soon be commonplace for remote scholars and researchers to access collections information online and also to add their own expertise to a museum's databases.

Multimedia Exhibits in Museums

The use of interactive multimedia is popular with museum professionals as well as the general public, and several studies have been conducted about the effectiveness of hypermedia applications in attracting and educating museum visitors (Bearman, 1991; Thomas & Mintz, 1998). It is common for museums to install multimedia applications—often computers with touch screens located in standalone kiosks—in their exhibits.

These applications have the potential to convey much more information than can be placed on display in gallery text labels, and so allow museum visitors to explore topics in greater detail, according to their own particular interests, and at their own pace. Some visitors approach an interactive kiosk or multimedia display in a cursory way for brief, top-level information, while others remain with the application for considerable time, reading in-depth material about the exhibit. Carefully designed multimedia applications allow digital representations of artifacts to be placed in context, showing the visitor how a particular historical object, for example, might have been used or why a given work of art might have been created.

Many museum professionals have expressed concern about the effectiveness of multimedia exhibits for education, as well as the possibility that interactive multimedia might distract the museum visitor from the objects on display (Economou, 1998). Some argue that, once the decision has been made to integrate multimedia into an exhibit setting, it is important that the interactive components be developed as part of the normal design process; if they are not properly integrated into the exhibit, such applications may detract from the visitor's experience (Semper, 1998). The suitability of interactive applications on the exhibit floor is something that needs to be researched, and all multimedia applications should be evaluated (Sayre, 1998). Thomas (1998) tells the story of a nine-year-old girl who approached an interactive video application in the National Museum of American History. The application used the story of "Goldilocks and the Three Bears" to illustrate a lesson on materials testing. Just as the girl was about to watch Goldilocks test the suitability of a chair, her mother pulled her away, saying, "This is a museum. We did not come here to watch cartoons." The success or failure of multimedia applications in museums depends heavily on the expectations and preconceptions of the museum visitor.

Virtual Museums on the Web

Once museum professionals discovered the potential of the World Wide Web for attracting visitors to their facilities and distributing information about their collections, they quickly seized the opportunities offered; by the time of the first Museums and the Web conference, thousands of museums had developed Web sites (Bowen, 1997). However, for many museum professionals, Internet presence for their museums was

initially problematic. It was relatively simple to put basic information online about an institution, its location, hours of operation, and the nature of its collections; but what about placing information about artifacts online and using the Web for educational purposes or multimedia presentations? Some decisions led to surprising results. The French Ministry of Culture provides a good example of how museums initially approached the Internet and the early problems they faced when bringing their institutions online (Mannoni, 1996). When the discovery of a new cave with 30,000 year old paintings was announced in January 1995, the Ministry of Culture was the first institution to post four pictures of the just-discovered artwork on its Web site; within 24 hours, Internet traffic to the site had increased 22-fold. Astonished by the unexpected interest, the museum had to purchase a new server and a faster Internet connection to keep up with demand to see the four pictures.

Today, museums are well aware of the Internet's potential to attract students, scholars, and the general public. Online visitors can take interactive tours that mimic the experience of visiting a museum in person, with various degrees of completeness. They can browse virtual exhibits on a variety of topics illustrated with museum artifacts. They can access databases, complete with text and images that document millions of artifacts of cultural heritage or great works of art. Museum Web sites offer everything from virtual galleries to three-dimensional representations of artifacts—for any number of examples of how museum professionals make use of the Internet see the conference proceedings from the Museums and the Web conferences (e.g., Bearman, & Trant, 2001).

Museum professionals are able to do many new things online that are impossible in traditional museum settings (Schweibenz, 1998). Connections can be made online that are difficult to make in the physical museum gallery (Hoptman, 1992). Objects not normally on display together, for instance, can be displayed side-by-side on the screen in a virtual gallery (Besser, 1997a). New connections can also be made between museum staff and museum visitors, increasing the potential for educational outreach. The Exploratorium (http://www.exploratorium.edu/) in San Francisco uses Webcasting to connect museum audience members, both in-house and online, with live events worldwide; in 1999, the Exploratorium Webcast the total solar eclipse from Turkey

(Spadaccinni, 2001). In all these ways, the virtual museum offers new possibilities for changing the experience of the museum visit.

Personalizing the Museum Experience

New information technologies can revolutionize the experience of visiting a museum by personalizing it for each visitor. Traditionally, museum visitors see the same objects, read the same label copy, follow the same tour guides, and hear the same information from museum docents. Today, it is common for visitors to be offered some kind of handheld device—typically audio devices, anything from headphones connected to a CD player to a handheld wand-like device that plays MP3s—designed to augment and personalize the museum-going experience. As museum visitors wander the galleries with these devices in hand, they can stop in front of a particular item, enter an identification number, and listen to a recorded message about the artifact in question. Such devices allow exhibit designers to provide museum visitors with more detailed information than could reasonably be placed on exhibit label copy.

Many museums have begun exploring the potential of Personal Digital Assistants (PDAs). These handheld computers allow visitors to retrieve extensive information about a variety of artifacts and exhibits by accessing a wireless network built into the museum itself. An early experiment with PDAs was performed at the Berkeley Art Museum in 1995 when Apple Newtons, loaded with text and images relating to select museum artifacts, were distributed to museum visitors as they entered. However, the difficulty of updating information (combined with the subsequent obsolescence of the hardware itself) caused this, and other similar experiments, to fail (Schwarzer, 2001). Recent studies have focused on determining the factors that contribute to the success or failure of PDAs in museums. Researchers at Xerox PARC have developed a task-oriented model for analyzing how museum visitors make use of handheld devices in museum galleries (Aoki & Woodruff, 2000). Other researchers have investigated the educational potential and use of PDAs in museum galleries, the design and development of applications for PDAs, and the evaluation of these applications from the perspective of museum staff and visitors (Evans & Sterry, 1999).

Museum professionals are only now beginning to realize the full potential of handheld devices. PDAs have the potential to revolutionize the museum visit. Some museums, for example, have integrated the use of handheld computers with their Web sites. The Experience Music Project in Seattle (http://www.emplive.com/) distributes handheld devices to visitors that allow them to "bookmark" artifacts they find interesting while in the museum. After their visit, they can log on to the museum's Web site and download additional information about those selected artifacts. It is possible to envisage a time in the near future when museum visitors will be able to plan out an entire visit ahead of time using the museum's Web site and then download this information to a PDA upon entering the museum itself. There is so much interest in the subject that the Consortium for the Interchange of Museum Information (http://www.cimi.org/) has recently launched a project called Handscape to explore the potential uses of handheld devices in museums. These devices instantiate what Rayward and Twidale (2000) call the Cyberdocent; and they raise questions about the impact of such devices on the social experience of visiting a museum. How does use of handheld devices affect the experience of visiting a museum with other people? How does it affect the way museum visitors access and interpret information about museum artifacts? How does this change the educational mission of the museum? These sorts of questions need to be addressed as more museums integrate handheld devices into their exhibits.

Equally revolutionary trends in personalization are occurring in the online museum environment. Many museums with digital collections have offered their virtual visitors the ability to mark selected records and save them online, creating their own set of personal favorites. Visitors can return to view them whenever they wish, add or remove artifacts at will, and even share their favorites with other online visitors. The Metropolitan Museum of Art (http://www.metmuseum.org/) offers a feature called "My Met Gallery," which allows visitors to build their own collections from the set of artifacts available online. ArtsConnectEd (http://www.artsconnected.org/), a joint project of the Minneapolis Institute of Arts and the Walker Art Center, offers a more advanced option called "Art Collector," in which visitors can group records of digital artifacts into multiple sets, annotate them with textual descriptions, and then distribute them to other individuals. The Fine Arts Museums of San

Francisco (http://www.thinker.org/), for instance, allow online visitors to choose from over 70,000 works of art and arrange them into their own private galleries.

The popularity of such activities raises a variety of questions about the consequences of allowing virtual visitors to access and manipulate information about museum artifacts. Some researchers have focused on the educational potential of allowing museum visitors to build their own virtual collections. Educators at the Seattle Art Museum (http://www.seattleartmuseum.org/), for example, have investigated the effect of allowing middle school students to act as virtual curators of an online art gallery using the a feature called "My Art Gallery" (Adams, Cole, DePaolo, & Edwards, 2001). These individualizing capabilities have led some museums to explore the potential of building dynamic, adaptive virtual museum environments based on user profiling. The Marble Museum in Carrara, Italy, offers visitors a virtual tour that varies in content according to a user-definable profile selected by the virtual visitor (Paterno & Mancini, 2000).

New information technologies, it is clear, have radically altered not only the experience of working in a museum, but also the experience of visiting. For museum professionals and museum visitors alike, museum informatics—the information systems and technologies, and the professional practices in which they are embedded—has redefined the common conception of what a museum is in almost every respect.

Museums as Information Environments

Museum professionals and information scientists have begun to explore the broad implications of viewing the museum as an information environment. This section explores how new information technologies have redefined the role of the museum in the information age. It examines issues of significance to both the museum professional and the information scientist, including the changing notion of the museum's identity in the online world, intellectual property and copyright concerns, and the development of integrated information infrastructures, information storage and retrieval, and human-computer interaction.

The Changing Identity of the Museum

The most important information resource any museum possesses is its collection of artifacts. For thousands of years museums have been collecting a wide variety of objects that document and preserve the record of the past (Pearce, 1992). These objects can be works of artistic achievement, cultural heritage, natural history, or scientific endeavor; they represent the history of human society and the natural world. However, the purpose of museums is not merely to house collections of objects; rather, museum professionals collect objects for the purposes of preservation, research, and education (Burkaw, 1995). To accomplish these goals, they must gather extensive information about the objects in their care. For many museum professionals, this information is at least as important as the objects themselves (Pearce, 1986; Washburn, 1984).

The past few decades have seen a shift away from the idea that museums are repositories of objects to the notion that they are repositories of knowledge (Cannon-Brookes, 1992; Hooper-Greenhill, 1992). The museum is now seen as an information utility (MacDonald, 1991), and the information contained in museums has become a resource that must be maintained and managed in order to be useful. Simultaneously, new information technologies have helped to make the organization of and access to museum information resources faster and easier. It is perhaps ironic that the new technology has helped re-create a view of the information-intensive modern museum that harks back to the idea put forward at the end of the nineteenth century by G. Brown Goode, namely, that a well-arranged museum is actually no more than "a collection of instructive labels illustrated by well-selected specimens" (quoted in Bennett, 1995, p. 42).

Information technology-driven changes in museum practice have important implications for both the purpose and the identity of the modern museum. As the amount of information about museum artifacts available online—including high quality digital images—continues to grow, important questions are being raised that concern museum professionals. How will the availability of online information change the way the general public feels about the museum artifact, let alone the museum? Will electronic visitors confuse the digital representation of a work of art with the real thing? Will they consider an online visit to a museum equivalent to visiting the museum in person? Will the physical

object itself become less significant? Will the differences between reproduction and original, surrogate record and authentic artifact, fade away? These, and many similar concerns, continue to remain vital areas for further research (Besser, 1997; Rayward, 1998; Weil, 1996).

Additionally, museum professionals continue to struggle with establishing an online identity. They worry that the virtual museum will take away from what Benjamin (1968) calls the "aura" of the object, the special feeling that makes seeing a museum artifact in person different from seeing a photograph of it. Accustomed to controlling every aspect of in-house exhibits, museum professionals fear losing control over the context in which museum artifacts are viewed in the online world. They worry that if potential visitors can find everything they want online, they will be less likely to visit the museum in person (McKenzie, 1997). Despite the potential problems, many museum professionals have faced these concerns head on, working to build an identity for the virtual museum. Recent studies have explored how museum professionals can best keep the interest of their online audiences (Karat et al., 2001). Growing evidence suggests that an online presence actually increases in-person museum visits, since it raises awareness of the museum and its collections for the general public (Bowen, 1999). In addition, museum professionals, as a group responsible for a distinctive aspect of the Web, took a major step in establishing their own online identity in 2001 when they received their own top level Internet domain, dot museum (http://www.musedoma.org/). Some writers are beginning to explore the notion of a "virtual aura" for the museum itself, taking the first steps to creating a new, more powerful identity for the online museum community (Hazan, 2001).

Intellectual Property and Copyright

Increased access to museum information resources online has meant new concerns about intellectual property and copyright for many museum professionals (Steiner, 2000). These issues invariably arise whenever museum professionals begin a project to digitize their collections and make this information available online. How can they ensure that their intellectual property is properly protected? How can they be certain that their resources, particularly digital images, will not be illegally copied and distributed? Many institutions have sought technological solutions to

these problems, such as embedding watermarks in digital images. As a basis for dealing effectively with intellectual property issues and copyright, museum professionals are re-evaluating traditional approaches to content distribution and rights administration and are developing new models for managing their information resources (Bearman, 1997; Zorich, 1999).

Museum professionals are also struggling to identify the potential economic benefits of making information about their artifacts available online. This involves identifying potential markets for online museum resources and developing new economic models, such as site licensing, for distributing their intellectual property. Even the traditional museum gift shop has found a new role in the online world as museum professionals explore e-commerce initiatives and forge alliances with e-commerce vendors (Tellis & Moore, 2000).

Integrated Information Systems and Information Infrastructures

Most of the technology-driven changes in museum information management have occurred piecemeal, affecting some museum departments more than others. The museum registrar, for example, may find that a new information system affects his or her job more than it does the museum curator, even though they may both make use of the same data. For this reason, many researchers now argue that it is necessary to take an holistic approach to information management in museums, building integrated systems that manage all aspects of a museum's information resources (Blackaby, 1997; Zorich, 1997). Such systems would allow museum professionals to access all available information on any given topic no matter where in their institution such information was located (Blackaby & Sandore, 1997). Designers of such a system would face many technical problems. However, the desire for an integrated information system reflects the museum world's evolving perspective on information.

As indicated above, new communication tools have changed the way museum professionals interact with scholars, educate students and visitors, and manage their information resources. These changes are reflected in museum work practices and the ways in which museum professionals collaborate among themselves to achieve common goals.

Researchers have already begun to analyze the sociotechnical information infrastructures of museums to understand how information objects are created, handled, and used from a variety of perspectives. Star and Griesemer (1989), for example, developed their influential concept of the "boundary object" at the Berkeley Museum of Vertebrate Zoology to show how such objects were used to mediate different needs and the viewpoints of different groups within the institution. Marty (1999b) studied how the development of a new information infrastructure at the University of Illinois' Spurlock Museum affected the way different museum professionals within the institution collaborated to achieve a common goal.

As museum professionals come to rely on information technologies in the operations of their organizations, the museum itself becomes an interesting site to study how the collaborative activities of the museum staff are influenced by new technologies (Marty, 1999a). Several researchers have begun to explore the notion of the museum as a complex, sociotechnical environment. Hemmings, Randall, Francis et al. (1997) conducted an ethnographic study of the work practices of museum staff members in two English museums: the Museum of Science and Industry in Manchester and the National Railway Museum in York. They analyzed the nature of museum classification work and the way in which these activities were influenced by new technologies, such as database systems (Hemmings, Randall, Marr et al., 1998). Twidale and Marty (2000), similarly, conducted an ethnographic evaluation of how museum professionals at the University of Illinois developed a collaborative system to inventory, pack, and ship a collection of 30,000 museum artifacts. They stressed the need to develop a robust, sociotechnical system that was flexible enough to adapt to new situations, allowing for the possibility of continuous process improvement. Such studies are only beginning to explore the complicated processes of information management and the evolution of sociotechnical systems in museums.

Information Storage and Retrieval

The problems of providing access to information about museum artifacts are of growing interest to researchers studying information storage and retrieval. Researchers at the University of Bologna explored the potential for mobile agents to access distributed sets of heterogeneous data about museum artifacts (Bellavista, Caorradi, & Tomasi, 2000).

They have programmed a set of information agents that dynamically creates a "virtual museum" to the specifications of the user, querying thousands of museum information records remotely and consolidating the results. Their system accommodates a variety of user profiles and usage patterns, from simple database searches to the automatic updating of pre-specified queries. Researchers at the University of Pennsylvania have explored the possibilities of pattern-directed searches of museum information systems (Dworman, Kimbrough, & Patch, 2000). Unlike traditional record-oriented searches that query a database for records that meet a certain condition, pattern-oriented searches derive from questions that seek relationships between variables in records: for example, how does the production of glassware in Italy vary over the life of the Roman Empire? The researchers have developed a prototype system to find and test patterns in collections of text; they are currently testing this system using textual descriptions from a collection of historic New Orleans photographs.

The problems associated with developing a digital image library for museum collections have intrigued researchers interested in information storage and retrieval (Gladney, Mintzer, Schiattarella, Bescos, & Treu, 1998). Given the visual nature of museum exhibits and collections, it is not surprising that museum professionals are interested in digital imaging (Besser & Trant, 1996; Johnston, 1997). This research has the potential to benefit museums, as well as other organizations conducting advanced research into digital imaging technologies. IBM, for example, has been working with museums since the mid-1990s to develop digital imaging technologies (Gladney et al., 1998; Mintzer et al., 2001). By collaborating with the Vatican Library and the Hermitage Museum in St. Petersburg, for example, IBM has developed new techniques for embedding digital watermarks (visible and invisible) into digital images. Tools such as IBM's Query by Image Content (http://wwwqbic.almaden.ibm.com/) or the University of California Berkeley's BlobWorld (http://elib.cs.berkeley.edu/photos/blobworld) have also contributed to digital image search and retrieval technologies.

Researchers continue to investigate the lack of standards for documenting and sharing information about artifacts. Rinehart (2001), for example, describes the Online Archive of California, an initiative begun in 1995 to test the suitability of the Encoded Archival Description (EAD)

standard for describing archival collections. Over the past few years, this initiative has expanded so that it now aims to connect the collections of every library, archive, and historical society in the state of California. In 1999, project participants began a new collaboration (Museums and the Online Archive of California) with the intention of testing the suitability of EAD for use in museums. The Consortium for the Computer Interchange of Museum Information (CIMI) has conducted research into standards for accessing distributed collections of museum information resources. For example, CIMI explored the potential use of the Z39.50 standard, creating an application profile to connect multiple sources of museum data while accounting for different data types, query terms, and record structures (Moen, 1998). Along the same lines, CIMI recently studied the suitability of the Dublin Core for describing museum artifacts and for sharing these data among different institutions (Perkins & Spinazze, 1999). After a two-year study of over 200,000 artifact records, CIMI concluded that the Dublin Core provides a useful framework for museum professionals seeking general guidelines in organizing information about collections, but may prove problematic when applied to the specific needs of individual institutions (Consortium for the Computer Interchange of Museum Information, 2000). Currently, CIMI is investigating the use of XML for describing museum artifacts and exploring the potential of the Open Archives Initiative (Perkins, 2001).

Human-Computer Interaction

Museum applications have proven to be extremely fertile grounds for researchers interested in human-computer interaction. From interactive exhibits in the galleries to online virtual environments, multimedia developers have been able to explore a variety of issues. Researchers have emphasized the importance of usability engineering and user testing when designing museum Web sites (Harms & Schweibenz, 2001). Other researchers have explored the requirements involved in building museum applications, in an effort to streamline the design process. Researchers at the Vienna University of Technology have developed a reusable framework for authoring online museum exhibits (Breiteneder & Platzer, 2001). By separating issues of context creation, data structures, and interface design, they were able to create a system that

allowed museum professionals to focus on developing content for the virtual exhibit.

Some museums have experimented with three-dimensional, interactive, virtual environments; these can be electronic representations of existing museum installations or exhibits that have no real-world equivalent. Some researchers have wondered if the virtual environment might offer online visitors more than static online exhibits. Paolini et al. (2000) explored the potential for online collaborative visits to virtual museum environments. They developed a virtual version of the Museum of Science and Technology in Milan, Italy. When online visitors enter the virtual museum, they are represented on screen as avatars and see the museum through the eyes of their own avatars. They can move around the virtual museum at will, see and communicate with the other avatars, and go on a virtual tour by following the avatar of a tour guide. The researchers are currently analyzing the impact of these interactions on the virtual visitor to determine whether collaborative visits to virtual worlds are more effective than individual visits. Other researchers have explored the capabilities of dynamic three-dimensional environments that adapt to the user's needs and requirements automatically. Shiode and Kanoshima (1999) developed a prototype system that allows virtual visitors to enter their preferences and explore a three-dimensional art gallery custom-designed for them. Such research underscores the novel possibilities of the online environment, where visitors can interact with museum artifacts in ways impossible in real life.

Information Science and the Future of Museums

This chapter has shown how, over the past few decades, the museum environment has been radically changed by new information technologies. Perhaps the greatest change has been the realization that the museum is an environment where information about artifacts is as important as the collections themselves. Museum professionals have developed new methods of organizing and accessing information about their collections. They have digitized information about millions of artifacts and made this information available over the Internet to scholars, students, and the general public. They have integrated new technologies

into their exhibits and galleries, in-house and online. They have even begun to explore the possibilities afforded by virtual environments, personally tailored to each individual museum visitor.

The future, one may be sure, will bring even more innovation as new technologies are developed and implemented in the museum environment. Three-dimensional representations of museum artifacts will become more common. Once information about museum artifacts has been digitized for one purpose, it can easily be used for many others. Integration of information, both within and among museums, offers many new possibilities. Searching across distributed sets of heterogeneous museum data will become easier. The boundaries of distance and time will continue to erode as museum collections around the world are increasingly integrated, providing new ways for scholars and students to interact with the information. The linking and cross-linking of ideas embodied in museum artifacts has been at the core of collection development and exhibit design, regardless of computer use. With increasing digitization, it is possible for such links to become more explicit (in the form of hypertext and hypermedia) and to accommodate more narrative and interpretation than the limitations of physical space allow. This opens new areas of research for exhibit design, tours, education, research and visitor experiences, and contributes to ongoing research in understanding hypermedia design and use. The physicality of museums is a reminder that one should explore the incorporation of virtual information into a physical world, and not merely seek to replace the physical with the virtual. In ways such as this, work in museums can both inform and draw upon research in information science.

These possibilities are dramatically changing the experience of working in, or visiting, a museum, and they are altering our conception of what a museum is. It is tempting to believe that the groundwork has been laid for the functional integration of libraries, museums, and archives, as foreshadowed by Rayward (1998). Museum informatics research and development ought to consider not only what can be built with new technologies but also what should be built. We can learn from earlier computerization efforts, from traditional information use in museums, and from other disciplines. The education of new museum personnel with information expertise (Hermann, 1997) is needed to handle the flood of new hardware and software possibilities. The aim of museum

informatics researchers and practitioners should be to guide the selection and use of these technologies to serve the numerous and evolving purposes of museums.

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