The Role of Information Technologies in Indigenous Knowledge Management

Jane Hunter, The University of Queensland, St Lucia, Queensland

Introduction

Increasingly, communities and organisations around the world are realising the value and significance of Indigenous Knowledge and the importance of preserving it for future generations. Indigenous Knowledge Centres (IKCs) are being established globally, but particularly in Australia, Africa, Latin America and Asia. The capture and preservation of Indigenous Knowledge is being used to revitalise endangered cultures, improve the economic independence and sustainability of Indigenous communities and to increase community-based involvement in planning and development. In parallel with the increasing recognition of the value and relevance of Indigenous Knowledge to today's world and the need to preserve it, is recognition of the role that Information Technologies (IT) can play in its capture, management and dissemination. This chapter provides an overview of the current state of IT tools, services, and projects relevant to Indigenous Knowledge management. In particular it describes information technology tools being developed at DSTC (in consultation with numerous Indigenous and cultural organisations) that have been designed to enable Indigenous communities to capture, control and share their knowledge within local knowledge bases according to their unique, specific local needs. Finally this chapter identifies unresolved issues that will require further collaborative research and development and cooperation between Indigenous communities, researchers and software developers.

Indigenous Knowledge Capture

> Indigenous knowledge, also referred to as traditional or local knowledge, refers to the large body of knowledge and skills that has been developed outside the formal educational system. IK is embedded in culture and is unique to a given location or society. It is the basis for decision-making of communities in food, security, human and animal health, education and natural resource management.[1]

Indigenous knowledge encompasses many forms. It includes cultural heritage in the form of traditional stories, songs, dances and ceremonies that reflect beliefs related to spirituality, family, land and social justice. It includes potentially patentable knowledge about traditional medicines, foods, farm practices, architecture and construction, handicrafts, artwork and folk music. It includes knowledge about people, places, plants, animals, historical events associated with a particular community.

The first steps in many Indigenous Knowledge projects involve identifying the material to be preserved and then capturing it in a digital form so that it can be systematically documented, shared, and re-used by permitted groups or individuals. Determining the optimum and most culturally appropriate approach to selecting, eliciting, recording, describing and disseminating this knowledge without insensitivity, intrusion, constraints, degradation or misrepresentation of the content, is a challenge that is often underestimated.

Appropriate consultative processes need to be established to identify and prioritise the material to be captured. Alternative digital technologies and environments for recording and storing the data need to be compared and evaluated. Because of the oral tradition of Indigenous knowledge, audiovisual digital recording devices such as digital video cameras and audio recorders are a primary tool for capturing techniques, practices, stories, language, songs and dances. Scanners are being used to digitise photographs, manuscripts, maps and historic documents. Increasingly 3D scanners are used to generate 3D digital surrogates of physical artifacts in museums and cultural institutions, such as tools, shields, carvings, clothing and baskets.

But there are still many issues which still need to be resolved. For example, should audio be saved as WAV or MP3 files? Is QuickTime, MPEG-4 or MPEG-2 the best format for archiving video content? What digital media should be used for storing the content e.g., hard disk, DAT, CD, DVD or FlashRAM? What are the advantages and disadvantages of recording in a controlled environment such as a studio, as opposed to in the field or from a live performance? Should the content be edited to improve or enhance it afterwards? Solutions to many of these questions will depend on a detailed analysis of the specific project and community needs.

Rather than attempt to provide answers to these issues, in the next three subsections, I will describe three projects that illustrate the potential of applying innovative technologies to recording, sharing and utilising Indigenous Knowledge:

- Virtual repatriation at the Smithsonian National Museum of the American Indian (NMAI)
- Community mapping
- Digital libraries of traditional medicine.

Virtual Repatriation

Many museums, archives, libraries and cultural institutions throughout the world hold large collections of objects that are of cultural or historical significance to Indigenous communities. Because many of these objects were collected without the consent of the traditional owners, the custodial organisations are now facing the challenges of determining ownership, seeking direction from the traditional owners on the future of such objects and either repatriating them, storing them or exhibiting them appropriately as requested. This process is made more difficult because colonisation has caused many Indigenous communities to become dispossessed of their lands and widely dispersed geographically. New, innovative high quality 2D and 3D scanners,

collaborative interactive software tools, high-speed networks and emerging Grid technologies that facilitate communication and the sharing of resources and knowledge between geographically dispersed groups, are providing an infrastructure that is ideally suited to the implementation of such digital and physical repatriation programs.

DSTC is currently working on one such collaborative project with the Smithsonian National Museum of the American Indian (NMAI). In the United States, the Native American Graves Protection and Repatriation Act (NAGPRA) specifies the types of objects and sites to be protected and/or repatriated. Going beyond the requirements of NAGPRA, the NMAI has established a *Culturally Sensitive Collections Care Program* (CSCCP) to respond to areas of concern of Native peoples with regard to the maintenance, presentation, and disposition of sensitive materials and information in the collections of the museum.

The aim of the NMAI's *Spiral of Knowledge* project is to provide an IT framework which will support its *Culturally Sensitive Collections Care Program*. (Although the repatriation of human remains are of particular importance to many communities, they are outside the scope of this project.) Past experience has indicated that many tribal communities would initially like access to the records of all objects in institutional collections associated with their community. After reviewing these, some communities may request that the actual physical artefact be repatriated but many communities will be satisfied with copies of digital surrogates and access to physical objects when requested. Figure 1 illustrates the NMAI's 'Spiral of Knowledge' workflow that corresponds to the NMAI's virtual repatriation program currently under development.

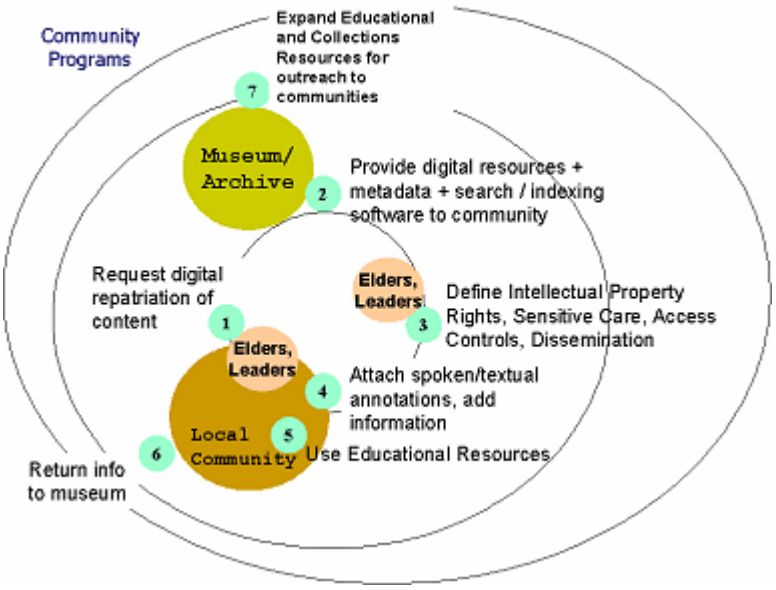


Figure 1: Information workflow for NMAI's Spiral of Knowledge Project [2]

There are eight stages within the NMAI's virtual repatriation workflow:

1. Generation of a digital information request by community elders
2. Submission and review of a digital information request by the custodial institution (NMAI)
3. Organisation and provision of these resources to the native community—through the transferral of digital objects plus metadata to a local knowledge base
4. Attachment of access rights and sensitive care constraints by community elders
5. Attachment of annotations, metadata corrections by community elders and other community members
6. Disposition of information by the native community. Some subset of the local knowledge base may go back to the cultural institution
7. Review of information by the custodial institution
8. Disposition of information by the custodial institution (e.g., in exhibitions, databases, online and educational resources).

The transfer and exchange of requests, digital objects and associated information is all carried out electronically using XML (Extensible Markup Language) packages that contain structured data which can be understood and uploaded to the databases within the local Indigenous Knowledge Centres or within the custodial institution. Digital objects that have been scanned and indexed within the NMAI are transferred over networks to the local knowledge base within the community.

The IKM software system (described in detail in Section 4) is an open-source software system developed at DSTC, in collaboration with the NMAI, that was designed to enable Indigenous communities to develop, support and maintain their local knowledge bases and to define access constraints and rights management in compliance with traditional laws.

Community Mapping Projects

Indigenous communities have close ties to the land, which is not only seen as a means of production and livelihood e.g., for hunting and gathering, but also as part of Indigenous people's spiritual and cultural traditions. Consequently a significant proportion of Indigenous Knowledge is directly related to land. Community-based mapping projects have been established within a number of Indigenous communities to delineate and document the native customary land boundary and thus help preserve the community's traditional knowledge related to their customary land. Once documented, the community map can be used as a tool for negotiation and resolving disputes between the community and outside parties or within the community itself and to strengthen the community's land, fishing and hunting claims. Community maps can also be applied as a tool for community-based resource management. To date, they have been used to identify sites or landscape features of cultural significance, to document flora and fauna distribution and Indigenous biodiversity knowledge and to provide input to land, forest and fire management, conservation and planning.

Community mapping projects are being undertaken in Australia, Malaysia, Indonesia, Philippines, Cambodia, Mozambique and Ecuador.[3] Over the past 10 years, community mapping has seen significant transformation. The technologies and methods used by Indigenous communities has advanced from basic compass and tape with hand plotted map to modern sophisticated GPS mapping and the use of portable digital assistants (PDAs), digital cameras and GIS software to produce community maps and related, spatially-indexed knowledge. Additional benefits from such projects include training of Indigenous staff and the production of reference materials on community mapping in the local language.

Digital Libraries of Traditional Medicine

A number of countries are using information technologies to develop digital libraries of traditional knowledge both to use the knowledge in current community projects but also to prevent misappropriation of the knowledge through commercial patents.

India in particular has developed a Traditional Knowledge Digital Library that contains information on 36,000 formulations used in *Ayurveda*—India's 5,000-year-old system of traditional medicine. The information—presented in English, French, German, Spanish and Japanese—was created in a format accessible by international patent offices to prevent the granting of inappropriate patents.

The Indian system uses a classification system similar to that used by the International Patent Classification (IPC). The IPC has agreed to include the Indian system in its own classification, which will be expanded to include about 200 sub-groups of drugs derived from Indian medicinal plants. This will significantly aid patent offices who can search the databases to ensure that proposed patents are truly novel and have not been previously reported.

Following the success of the Indian system, other South Asian countries (Bangladesh, Bhutan, Maldives, Nepal, Pakistan and Sri Lanka) that are members of the South Asian Association for Regional Cooperation (SAARC), have decided to create a composite digital library that will network the individual Traditional Knowledge Digital Libraries (TKDL) from each country.[4] The SAARC TKDL will provide a uniform system for organising, disseminating and retrieving traditional knowledge seamlessly across regions or countries. Accessible via the Internet, the library will initially contain information on traditional medicine including:

- materials used for treatment e.g., plants, animal products, minerals
- their generic or specific method of preparations or designs
- their dosage, mode and time of administration
- their therapeutic action or application.

The SAARC digital library will be used to fight contentious patent claims by proving the prior existence of knowledge, as well as promoting research on novel drugs, enhancing the region's share of the global herbal medicine market and helping set the international agenda on intellectual property rights.

Local Knowledge Bases

Many Indigenous communities are developing local Indigenous Knowledge Bases either informally or within Indigenous Knowledge and Cultural Centres (IKCs) established specifically for this task. The digital content being assembled and presented within these IKCs is either captured locally, donated or repatriated from external private and public collections belonging to museums, church archives, community members, anthropologists, missionaries, and others. Determining the optimum software solutions to support such knowledge bases requires an analysis of the communities' needs and objectives. Prior to the development of the IKM system, we identified the following set of generic requirements that apply across many Indigenous Communities' Knowledge Bases:

- Security: Because of the sacred/secret nature of the content, it is essential that robust, reliable IT security mechanisms are employed. The specific rights management requirements corresponding to customary laws associated with secret or sacred knowledge are described in detail in Section 4
- Simple user interfaces: Many of the potential users of this system will have limited computer literacy and poor keyboard skills so simple intuitive user-friendly interfaces are essential.
- Robustness: The system must be able to stand up to the rigours of unexpected input by users with little prior computing experience
- Low cost: In order to make the software open source and widely accessible to Indigenous and grassroots communities, it must be built as inexpensively as possible, ideally using components that are freely available
- Interoperability: The software tools should be built on international standards (e.g., Dublin Core, XML) in order to ensure maximise the interoperability between disparate databases
- Portability: It should be able to run on a range of platforms and operating systems including Windows, Linux and Macintosh. Within the IKM software we employ Java, XML and SMIL (Synchronised Multimedia Integration Language) for the software development environment to ensure transparent portability across platforms
- Flexibility: The customary laws and intellectual property needs of traditional knowledge holders vary enormously among Indigenous communities throughout the world. Quite often the views within a single clan can vary significantly and they may also vary over time. Our system attempts to support by default, the common notions across most Indigenous communities. In addition, we have provided Schema editing tools in order to provide maximum flexibility and to enable easy customisation of the software
- Adaptability: Both Indigenous Knowledge and knowledge management technologies are dynamic and constantly evolving—the corresponding systems and infrastructure must be designed to be flexible and adaptable in order to support these changing needs. As new

relevant technology becomes available and affordable (e.g., voice recognition for spoken word interfaces) it should be able to be incorporated with minimum cost or effort

- Scalability: The size of collections within IKCs can reach hundreds of thousands. The software should be capable of efficiently performing fine-grained search and retrieval across very large sets of resources. Attribute-based rights management, which involves comparing the user profile of the searcher against the rights metadata for each object, may substantially affect the speed of query retrieval for large data sets.

Although a number of other projects have investigated the application of information technology tools to the protection and management of Indigenous collections according to customary laws[5-7], they have not approached the problem using international metadata standards or developed systems that are capable of easily being customised or modified to support changing local needs. They are also not free or open source and are built on databases such as FileMakerPro which do not scale well and do not support the attachment of spoken annotations. In the next section I describe in detail the IKM system, developed by DSTC in collaboration with the NMAI.

The IKM Software System

The IKM (Indigenous Knowledge Management) system[8] was designed as a low-cost, simple robust system to enable Indigenous communities to manage their own digital collections within local Indigenous Knowledge Bases. It comprises two major components:

1. The XMEG tool: This enables users to describe digital objects (based on an underlying, customisable metadata schema), attach annotations to the objects and define access rights and traditional care constraints. It also enables user profiles to be defined. A Schema Editor allows the underlying metadata schema to be edited – this is reflected in the user interface. Descriptive and rights metadata and annotations can either be saved to a MySQL relational database or flat XML files which can be indexed using an XML database such as Tamino or Xindice or parsed and uploaded to any relational database. In addition to the metadata that is explicitly saved to the database through the user interface, *meta-metadata* is also recorded—all changes to the metadata, who was responsible and the date/time of the changes are recorded within the database. This represents an important component of the system's built-in security framework.
2. The Search interface: This uses standard Web Browser technologies (Internet Explorer, Netscape) to enable users to search, browse and retrieve objects from the collection. The advantages of using a standard web browser interface, are their familiarity and widespread availability and the lack of re-engineering necessary should collections eventually be disseminated over wider networks. To access the collection, users must have been allocated a login ID and password and a user profile. The user profile includes information such as tribal names, native/non-native heritage, tribal/clan membership, gender, status, role, etc. After a user performs a search, the system compares the matching objects' rights constraints

with the user's profile to determine whether or not the user is permitted to access this object. If they are, then the object will be retrieved and displayed; along with any rights constraints, which appear as icons. Users can click on individual objects to view/play the high resolution object and to view the metadata details and any annotations. The system also includes software that can automatically aggregate selected mixed-media objects (images, audio clips, video clips, text), and dynamically generate a SMIL (Synchronised Multimedia Integration Language) presentation which is presented to the user.

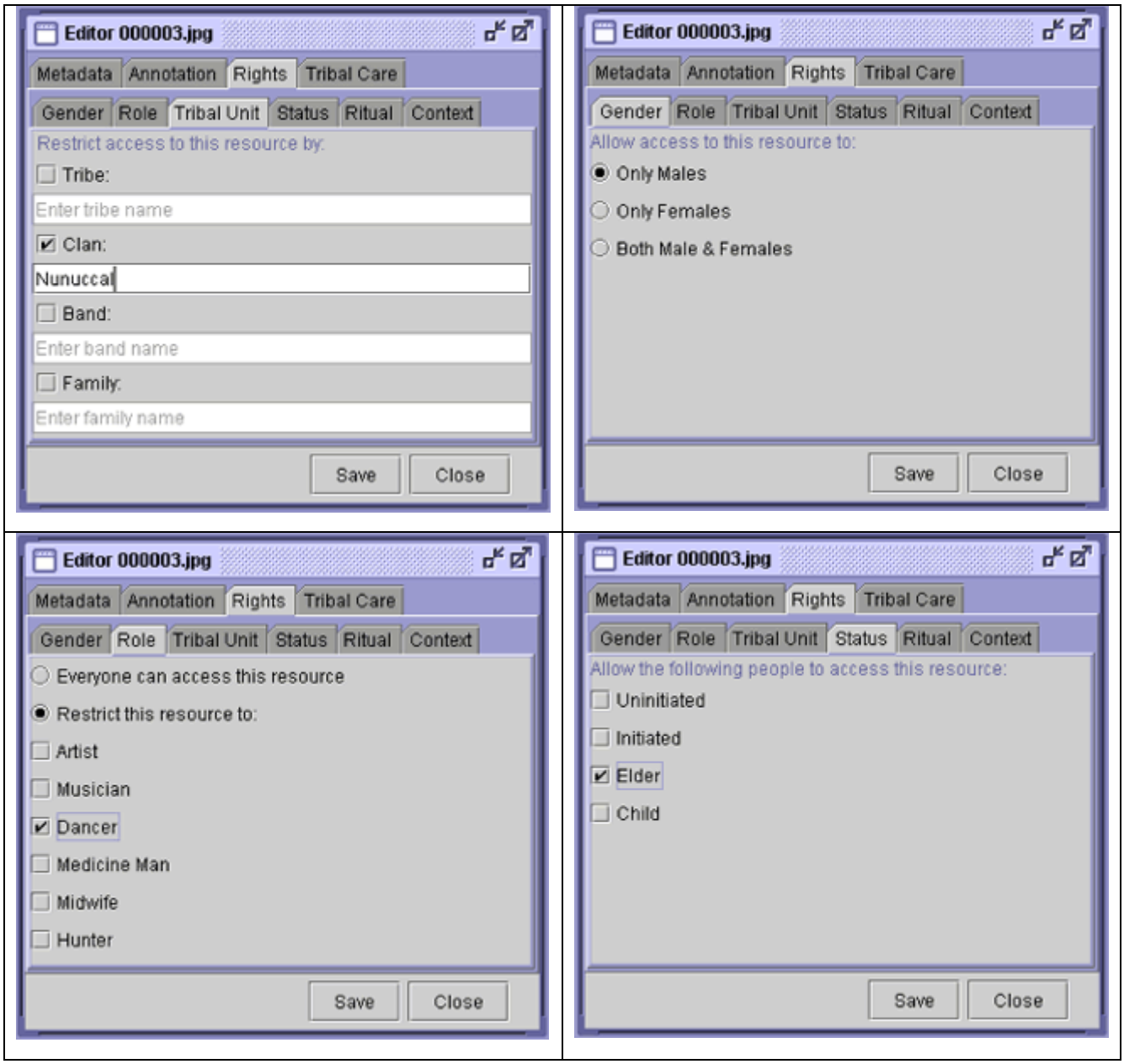
Rights Management

A significant amount of international effort has been focused on technologies for managing rights associated with digital content (e.g., MPEG-21[9] (Multimedia Delivery Framework) and XrML[10]. However because these initiatives are primarily concerned with e-commerce and protecting the commercial rights of content owners, they do not support the specific features needed to protect Indigenous Knowledge or to enforce tribal customary laws. They are built on the premise of modern intellectual property law regimes and the notions of individual property ownership for a limited duration, which are alien and detrimental to Indigenous cultures.

In an earlier paper[11], specific extensions to XrML, in the form of customary constraints, were developed to support the description of customary or traditional laws which commonly affect access. An analysis of tribal laws across Aboriginal and Native American communities revealed that there are a number of common restrictions that apply to Indigenous Knowledge across communities. Consequently within the IKM system we provided an interface to enable elders or other authorised members of the community to input and edit rights metadata. Support has been provided to enable the definition and application of restrictions based on:

- the user's membership of a particular clan or tribe
- the user's status within the tribe
- the user's role within the tribe
- the user's gender
- the relationship of the user to people, animals or objects depicted in the resource
- the death of people recorded in a resource
- the context in which the resource will be reused or reproduced.

Figure 2: User interface for defining access restrictions which depend on the users' tribal affiliation, gender, role and status.



Authorised persons are also able to specify temporal access restrictions, either for a set duration from a start time or recurring (on a monthly or yearly basis). This functionality has been provided to support customs such as sorrow business, in which photographs or video recordings of recently deceased people are inaccessible for a mourning period, or seasonal restrictions (see Figure 3 below).

Figure 3: User interface for defining temporal access and warnings.

In addition, we provide a user interface to enable the input and editing of user profiles, for either individuals or user groups (e.g., Nunuccal elder) which record information about the users' tribal affiliations, gender, role, status, family relationships etc. The system compares a users' profile with the rights metadata for objects in the collection to determine access permissions. The major challenges with this approach are not technological but are: identifying the authorised elders who can make decisions about access constraints; reaching community agreement on both access constraints and individuals' attributes and authority; and building community trust in the system.

Indexing, Search and Retrieval

Metadata is crucial to the accessibility of the captured knowledge. Within the IKM system, we provide Dublin Core [12] as the default metadata schema, with extensions for the rights metadata. But we also provide a metadata schema editing tool to enable this to be easily modified. By storing the metadata in XML files, we are not restricted by legacy database structures. The metadata input tools should also be as simple and streamlined as possible. If pre-existing metadata is available (e.g., through the custodial organisation) then it should be re-used. New technologies such as voice recognition and image and video analysis tools, are also capable of generating metadata automatically. Controlled vocabularies thesauri (e.g., based on AIATSIS or AusAnthrop databases of tribal names, languages and places) and pull-down menus should be used where possible to reduce the effort involved in metadata capture and to control the quality of the metadata. Ontologies also provide a way of defining and inferring richer implicit relationships between objects: in different databases; of different media types; or described using different metadata schemas. They offer significant potential for structuring, integrating and assimilating

multimedia information and digital objects drawn from distributed archives, into local Indigenous Knowledge Bases.

Search interfaces should be designed to support the user-interface needs of the Indigenous communities who want to access the content. The ability to search and browse multimedia collections using techniques other than simple text-based or keyword search will be vital. Within DSTC, we are investigating an array of possible search and browse mechanisms including: maps, timelines, genealogies, lexicons and ontologies.

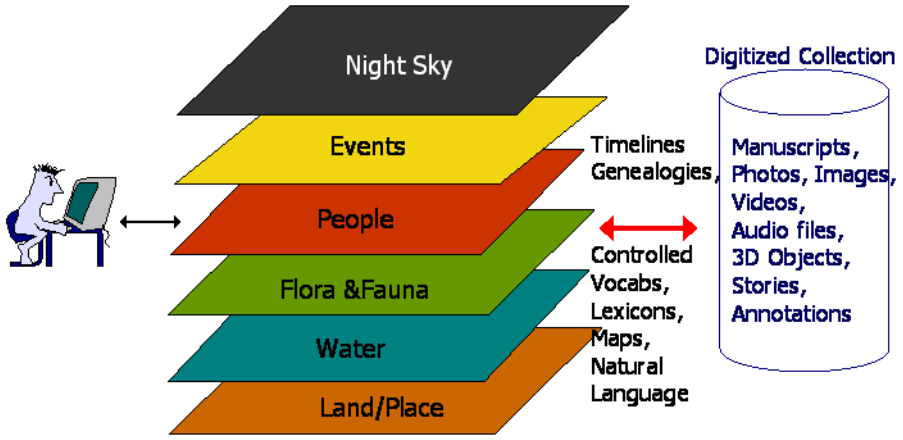


Figure 4: Approaches to navigating content in Indigenous Knowledge Bases

Annotation and Discussion Tools

Annotation tools enable the traditional owners to describe, contextualise and annotate resources in their own words, their own languages and from their own perspectives. Within the IKM system, authorised users can input, record and attach either textual, spoken annotations or hyperlinks to specific digital objects (photos, videos, 3 D models) or regions or segments within those objects.

The ability to enter spoken annotations is an especially powerful feature; it provides a natural user interface which supports the oral tradition and allows users to express their stories in their own words and languages. This is ideal for communities or elderly users with limited computer literacy or poor keyboard skills. They may also generate new language resources and can contribute to the preservation of endangered languages. Figure 5 below, illustrates the annotation interface for the IKM system. Users can also browse the list of previously attached annotations and view/listen to who said what and when about a particular resource.

This approach supports the unambiguous documentation and attribution of all views/perspectives; even if they are different or contradictory. The software explicitly displays 'who said what and when' rather than displaying only the view of a museum curator which may have been deduced from a number of different sources of varying reliability.

Figure 5: Annotation interface for the IKM system.

In addition to stand-alone textual and spoken annotation tools, at DSTC we have been developing a system called Vannotea[13] that uses broadband networks and videoconferencing to enable real-time collaborative annotations of digital content by groups of geographically dispersed users. By sharing an application that allows the search, retrieval and browsing of images, video and 3D objects, geographically distributed users can collaboratively attach annotations to selected regions within images, selected segments, frames or frame regions within videos, or areas within 3D objects. Currently annotations can be either plain text or a URL. Users can view the list of annotations (details of who and when) for an object and also search and browse the annotations.

The aim is to deploy and test this software in a collaborative project between the Smithsonian National Museum of the American Indian (NMAI), the American Indian Higher Education Consortium (AIHEC) Tribal Colleges and American Indian communities. This system will enable the groups to discuss the maintenance, presentation, disposition and repatriation of sensitive materials and information in the museum's collections; and the virtual meeting to be recorded.

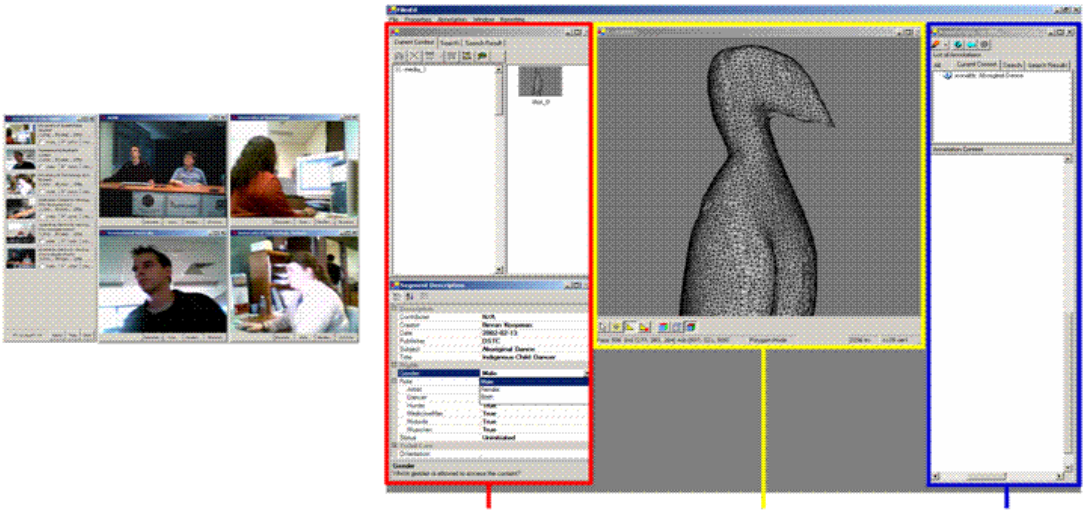


Figure 6: Collaborative Annotation of 3D Artefacts using Vannotea

Evaluation

As the number of ICT-based Indigenous Knowledge projects proliferates, it has become increasingly clear that there is an urgent need to carry out in-depth evaluations of alternative approaches to the implementation of such projects. This is necessary to identify the optimum technologies, procedures and best practices and to prevent scarce funding and resources being wasted on replicating systems that are ineffective, inefficient or unwanted.

The Netherlands Organisation for International Cooperation in Higher Education (NUFFIC's) Indigenous Knowledge Unit in co-operation with UNESCO's Management of Social Transformations Programme (MOST) has identified a number of projects that demonstrate 'Best Practices Using Indigenous Knowledge'[14]. These are the projects that illustrate the use of IK in developing cost-effective and sustainable survival strategies for poverty alleviation and income generation (e.g., Indigenous land use systems to encourage labour-sharing arrangements among farmers; using IK to increase the fuel-efficiency of local stoves instead of replacing them; using Indigenous institutions by extending credit through existing village loan groups etc.). However the report by NUFFIC and MOST does not specifically evaluate the use of information and communication technologies in capturing, organising, managing or disseminating Indigenous Knowledge.

There is an urgent need to study and evaluate existing IK projects that employ ICTs to determine the optimum procedures and technologies. In particular the following activities and issues should be considered high priority:

- Determining the best process for selecting and prioritising Indigenous Knowledge to be recorded. Standard selection criteria for digitisation projects may not apply or have different weightings when applied to Indigenous Knowledge. Consultation and input from the community elders is essential
- Determining qualitative and quantitative metrics for identifying successful technologies or technological approaches – what are the benefits and cost-effectiveness? How should relevance, usage, usability and community benefits be measured? Will the system scale and is it sustainable? What is the best way to acquire users' feedback?
- Evaluating existing systems, projects and IKCs based on the metrics determined above
- Identifying those practices and system components which are successful, those that appear to have failed and those that could be improved through extensions, modifications or refinements. Identify issues requiring further research and improvement
- Identifying barriers to success, causes for project failure and how these might be overcome. Are the issues technological, social or economic? Is further training of local staff required? How can the system be made more relevant, useful, cost-effective or sustainable?

- Disseminating Best Practice Guidelines and databases of projects demonstrating Best Practice for the use of ICT within Indigenous Knowledge Management Projects

It is essential that the costs, benefits and outcomes of IT-based Indigenous Knowledge projects are accurately reported and disseminated. Failed projects should not be whitewashed or swept under the carpet. Negative experiences should be shared so that the wider community can learn from past mistakes. It is also essential that additional funding be provided for existing projects or included in new projects, to cover the costs of continual, ongoing evaluation, adaptation and improvement.

Conclusions

There is no doubt that ICTs hold significant potential for supporting the recording, management, dissemination and long term preservation of Indigenous Knowledge. But there remain significant challenges which will need to be overcome to ensure that such projects deliver real benefits to both the Indigenous communities who own the knowledge and the wider community at large. Although some of the challenges are technological, many of the most difficult issues are social, political or economic and overcoming these will require significant time, patience, funding, resources, support, training and a collaborative effort by Indigenous Communities, multidisciplinary researchers, staff from cultural institutions and software engineers and designers to establish mutual trust, respect and a common understanding of: what the users want; the issues involved; and the possibilities that both current and future technologies hold.

---

[1] Indigenous Knowledge Program, World Bank http://www.worldbank.org/afr/ik/index.htm

[2] NMAI XML Metadata Repository Proof of Concept Functional Specification, Infrastructures for Information Inc, August 2004

[3] IAPAD Community Mapping PPGIS, PGIS, CiGIS and P3DM Virtual Library http://www.iapad.org/bibliography.htm

[4] SAARC to set up traditional knowledge digital library, Financial Express, January 04, 2005 http://www.financialexpress.com/fe_full_story.php?content_id=78706

5 "Ara Irititja Archival Project." South Australia. Available: http://waru.org/arairititja

6 "First Voices Project." Available: http://www.firstvoices.com

7 "Special Issue on Digital Technology and Indigenous Communities," in *D-Lib Magazine*. Vol 8 No. 3 March 2002, Available: http://www.dlib.org/dlib/march02/03contents.html

8 J.Hunter, B.Koopman, J.Sledge, "Software Tools for Indigenous Knowledge Management", Museums and the Web 2003, Charlotte, March 2003

9 ISO/IEC TR 21000-1:2001(E) (MPEG-21) Part 1: Vision, Technologies and Strategy, MPEG, Document: ISO/IEC JTC1/SC29/WG11 N3939 http://www.cselt.it/mpeg/public/mpeg-21_pdtr.zip

10 XrML - The Digital Rights Language for Trusted Content and Services http://www.xrml.org/about.asp

11 J. Hunter, "Rights Markup Extensions for the Protection of Indigenous Knowledge," in The 11th International World Wide Web Conference - Global Community Track, Honolulu, 2002.

12 Dublin Core Metadata Element Set, Version 1.1: Reference Description, Dec, 2004 http://dublincore.org/documents/dces/

13 J.Hunter, R.Schroeter, B.Koopman, M.Henderson, "Using the Grid to Build Bridges between Museums and Indigenous Communities", GGF-11, Semantic Grid Applications Workshop, Homolulu, 10 June 2004

14 Best Practices Using Indigenous Knowledge, A Joint Publication by Nuffic and UNESCO/MOST, November 2002. http://www.unesco.org/most/Bpikpub2.pdf