Heritage and the Role of Data Management Systems: A Prototype Model for New Zealand

Bader H. D. & Gibbs R. (Geometria)

Abstract

Heritage management in New Zealand is data rich but information poor. For nearly 50 years, the New Zealand Archaeological Association has maintained a paper based, largely textual, database of prehistoric and historic archaeological sites. While originally set up as a research tool, this database now serves a major management role. However, the increasing pace of development in New Zealand means that information delivery to an expanding range of stakeholders is beyond the capabilities of the current system. Here we propose a model for an information management system designed to replace the paper record and to provide maximum flexibility of storage and access to data. The model is described is based on a prototype implementation.

1. Introduction

This paper describes the preliminary results from multi-disciplinary research aimed at developing a web-based archaeological data sharing structure, as a prototype for a comprehensive heritage management system. New Zealand is data rich information poor with respect to cultural heritage; with much of this valuable data being held in paper form, including maps, plans, photographs, measurements and text. Population growth and associated land use change create a situation where information is required from this data in order to protect and preserve significant examples of cultural heritage. Although some aspects of New Zealand's heritage are unique, the research reported here potentially has applications in many countries particularly those located in Polynesia.

The project is based in New Zealand where a rich prehistoric and historic record is available with which to illustrate Maori and later European (Pakeha) heritage. The early Maori were agricultural and hunter-gatherer peoples who created a range of archaeological sites, from large earth work fortifications (pa) through to gardening areas with storage pits and terraces, and refuse dumps or middens. European settlers extended this range of evidence, adding sites connected with the extraction of resources (e.g. gold and timber), their own brand of fortifications (redoubts) as well as various types connected with agriculture and settlements.

Our project goal, therefore, was to develop ways of managing heritage data within a complex environment. Here we discuss all aspects relating to the design and implementation of a web-based information sharing system intended to provide both those concerned with conservation, management, development and planning, ready access to data that is both accurate and relevant, to facilitate data collection, verification and modelling.

2. Heritage Management

New Zealand is not unique in experiencing land pressures as its population, increasingly located in the cities, continues to grow. With more demands on the land, destruction of heritage sites is inevitable. The goal of heritage management is, therefore, to limit the impact of developments while allowing development to continue. Critical to managing the impact of development on heritage is information sharing. The ease with which heritage places can be identified varies enormously, partly as a reflection of the visibility (some types of archaeological site have little if any surface evidence) but also as a reflection of cultural values. In New Zealand, places of heritage significance to Maori may not be recognised as easily by other ethnic groups. In many cases specialist knowledge is needed to identify such places. Archaeologists are able to identify parts of the landscape modified by people in the past that would pass as natural features to the untrained eye, while in other instances the identification of heritage locations will rely on the knowledge of local interest groups including Maori. In sum, information relating to heritage places is often disparate, largely paper based and thus time consuming to retrieve. Added to this, relatively few people are aware of all sources of information. The information management problem we face, therefore, is how to create an effective data capture system and how to provide appropriate information to a range of stakeholders.

Responsibility to protect and preserve heritage places within New Zealand is supported by legislation in both the Historic Places Act 1993 [1] and the Resource Management Act 1991 [2]. Legislation binds both national and local government not only to conserve heritage sites but also to develop and maintain...
information related to their significance. Modification of an archaeological site requires an authority (issued by the New Zealand Historic Places Trust) and the onus is on the developer to meet the cost of any investigation the Trust may require before development can proceed. Clearly, in this situation, planning is paramount since foreknowledge of any development impact on an archaeological site can potentially save much time and money. Archaeological excavation, for instance, is a slow process that has to be undertaken by trained professionals who charge accordingly. Obviously for all concerned, it is better to plan around heritage sites rather than halt projects or require that large sums of money be spent for their investigation, often at the last minute.

3. Understanding Heritage Data

Conceptually, heritage data may seem easy to understand. People lived in particular places in the past and left a variety of things that allow us to draw inferences about the nature of their life. Archaeologists, as well as a range of other professionals, study these remains and draw inferences about past ways of living (life-ways) based on an established set of techniques. Broadly speaking this statement is correct but because what we recognise as heritage places today are the outcome of a combination of events that went on through time so their structure can be more complicated than originally implied.

In the archaeological literature there are two different views of how to interpret the past [3], [4]. According to the first view, people in the past produced and abandoned a range of objects (i.e. artefacts) and features (i.e. structures like the pits and terraces mentioned above) that are apparent today. These objects and features are clustered together forming what archaeologists call ‘sites’. The degree to which archaeologists and others can identify these sites depends on a number of factors, these may include the degree to which they are exposed on the surface, the nature of the surface vegetation and the methods adopted by the archaeologist to discover them. According to this view, sites represent the outcome of the life-ways of groups of people in the past. The difficulties in identifying sites, particularly in defining their boundaries, are mechanical ones connected with the problems of visibility.

Under the second view, it is accepted that people in the past lived in communities, formed settlements, and deposited objects and created features but in contrast to the view discussed above, this approach adds time to the mix. In this case, the problem that heritage managers face is that the record was not deposited all at one time. Instead we must deal with a record that saw the steady addition of objects and features deriving from many settlements and associated activities that may well have changed through time. The archaeological record is something of the present not the past [5]. Taken as a whole the record provides a kind of concertina effect, with all the objects and features created in the past distributed across a single, modern surface. While archaeologists can use this record to draw inferences about what went on at any particular point in the past, the record as it stands is not easily interpretable in terms of past life-ways.

The application of these two approaches to heritage management in New Zealand can be illustrated by looking at one of the small off shore islands in the Hauraki Gulf near the city of Auckland. Today, the island is a Reserve owned by Auckland City and administered by the Department of Conservation, a government department charged with looking after state owned lands and resources. Very little development has occurred on Motukorea in recent times. Both Maori, and the first Europeans (Pakeha) to settle Auckland, made use of Motukorea. Thus it has, by New Zealand standards, a long heritage record and exceptional preservation of both prehistoric and historic heritage places. A number of archaeologists have surveyed the island, including Ian Smith’s survey conducted during the 1980s when the island was infested with rabbits [6]. Because the rabbits had eaten much of the vegetation, Smith was able to identify a large number of heritage sites. However, removal of the rabbits during the 1990s allowed regeneration of vegetation. Thus our work on the island in 2001 failed to relocate many of the places that Smith had identified. The Browns Island experience illustrates that identifying archaeological sites is very much influenced by visibility thus this criteria needs to be included in any data management system.

However, visibility is important at another level. While Smith’s survey during the 1980s revealed a large number of places, the boundaries of individual sites were often definable only on the basis of obscuring vegetation. If all the sites Smith identified were to be occupied at the same time, then there would be standing room only on Motukorea! The present surface on Motukorea preserves a summation of all the times objects were dropped or features were constructed in the past. For heritage managers charged with assigning significance to archaeological sites this raises an obvious problem: what is being assessed – the integration of objects and features at one time in the past as illustrative of a particular life-way – or the net result of multiple settlements through time?

3.1. Issues with Boundaries

For those charged with managing heritage information, the inability to define absolute site boundaries is of major concern. In a development situation it is obviously highly desirable to ensure there is no impact on a heritage site. However, if the boundary of
a site is variable, it is much harder to ensure that the impact does not occur. There are two issues with boundaries. First, boundaries are at least partly determined by visibility yet, as discussed previously, visibility is rarely constant. If boundaries change with environmental conditions (like the removal of rabbits discussed in section 3.0), how is this change to be modelled in a data management system? Second, boundary definition is connected to the notion of time. Site boundaries are, like the sites themselves, a product of the history of site formation. They may not relate in any simple way to a life-way interpretation of the place. It is quite likely, for instance, that the boundary of a site may reflect a number of distinct occupations. Site boundaries reflecting discrete uses of a place by distinct groups of people may be able to be defined but such a definition is only possible as an outcome of archaeological analysis. It is not generally possible to identify discrete occupations on the basis of surface evidence alone. The effect of these boundaries will be discussed later with regard to data handling.

3.2. Discussion on Categorisation

Objects and features must be described as part of any data acquisition exercise with units that are appropriate for the task at hand. The difficulty is that the purpose for which the material was measured is usually inherent in the structure and grouping of the materials.

This is clearly the case with heritage data where changes in the way archaeologists and other interested professionals understand the past have led to differences in the way ‘sites’ are recorded. In New Zealand, for instance, a New Zealand Archaeological Association site-recording scheme was set up in the 1950’s for research purposes. It has at its core the site as the primary unit that defines as a place where activity occurred. Initially, the scheme was limited to prehistoric Maori sites. Later, sites produced by early European settlers were added. As knowledge about New Zealand’s past grew, new categories of sites were added. In addition, the way sites were grouped together changed, from approaches that sought to identify ‘settlements’ to an appreciation of an archaeological ‘landscape’ made up of features derived from many occupations spread through time. In effect, the discipline moved on from an interest in individual places where activity occurred, towards a view of where activity is seen as continuous across space and time [7].

However, in the mean time, the site as an individual place, became fixed in law. The Historic Places Act 1993 defines archaeological sites and courts impose penalties based on this definition. In addition, there is a public awareness of archaeological sites. In common sense terms, individual large fortified structures (pa) are regarded as ‘sites’.

Obviously for heritage managers, this series of changes in the concepts that lead to site definition are of fundamental importance since they have an effect on the design of the underlying data model. Information recorded at different times in the past cannot be directly translated into individual records within the database model. There is also a need to relate changes in the data model to current legal definitions.

4. Archaeological Databases

New Zealand is fortunate in having a long running national archaeological site recording scheme begun in the late 1950s. The scheme now boasts in excess of 54,000 records that are held by a series of 20 regional file keepers. Records are based on paper forms organised around the New Zealand 1:50,000 map series. The file keeper allocates site numbers sequentially, as sites are found with a separate number series for each map sheet. A copy of the complete record scheme is held in the New Zealand capital, Wellington, under the control of the Department of Conservation. New sites are added to the scheme continuously while additionally over the last three years an update project has aimed to validate and correct sites already recorded in the scheme. At present only a small portion of the update information has been added to a computerised system, which locates each record as a single geographical point (CINZAS) Figure 1.

The advantages of the New Zealand Archaeological Site Recording Scheme are its size, the length of time it has been in operation, and the fact that it has national coverage. However, the disadvantages also reflect its history. Partly because an amateur association runs the scheme and receives very little funding for its maintenance, it has not been possible to redesign the scheme to cope with the increasingly diverse demands from users. As a consequence, some alternative schemes have been started.

Of these, the Cultural Heritage Inventory (CHI) is the best-developed. This scheme was established by the
Auckland Regional Council and is limited to the greater Auckland region, which incorporates seven territorial authority areas (City & District Councils). Like the NZAA Site Recording Scheme it is site based, but unlike the national scheme, CHI is fully computerised using a text based database and a GIS.

In sum, compared to many places in the world, heritage management in New Zealand is potentially well served with the existence of a national scheme. Thus the problem is not so much with the quantity of data, but in the way it is organised and the limited development of methods for disseminating this information in a form appropriate for a variety of users. The structure and nature of data collection in New Zealand is fragmented. Subsets of data are held in various organisations in differing formats and levels of accuracy and precision. Clearly, there is a need for a robust data handling technology but based on the discussion above, there is also a pressing need to better understand and model the process of data collection and use.

5. A Framework for Heritage Data Handling

The discussion so far has concentrated on the field evidence and the problems inherent in recording a modern archaeological landscape made up of objects and features deposited at different times in the past. At issue is the temporality of the record since this is at the same time critical to significance assessment and something that cannot be determined by simply recording surface evidence. However, field evidence is not the only source of historic information available to the heritage manager. Both oral traditions and historic documents inform on the past, and for some user groups, these information sources may be of greater interest, and therefore of more importance in assessing significance, than the archaeological sites themselves. In addition, therefore, to model archaeological objects and features, attention must be given to oral traditions and historical documents.

As discussed above, archaeological data is something of the present even though the actions that created the objects and features occurred in the past. Inferences can be made about these actions based on the modern day material record, but heritage managers are charged with conserving a present day record. More over, the inferences that can be made generally lack temporal precision. Archaeology is not about documenting the occurrence of individual events; it deals instead with patterns created through the objects and features resulting from multiple events. Contrast this with the temporality of historical documents. By and large such resources deal with single events that occurred over a limited time frame. While they may be used to draw inferences about longer duration social, political or economic processes, the time depths involved are often different by an order of magnitude or more from those discussed in archaeology.

Oral traditions represent a third form of data, also with a distinct temporality. They are concerned with the motivations and conditions of human interaction, and they are usually situated in a timeframe of longer duration than historical records, but told in the form of a series of short timeframe events. Thus, somewhat confusingly, oral traditions incorporate a dual temporality. They commonly use the description of an event to either rationalise or explain the conditions surrounding common actions in the past and so they are an interpretation of historical events. Unlike historical events, the focus is on society as a whole. The rhetoric style is personified and event driven, but the underlying reason for the story to be told is to rationalize the society of the past and link it to the current social developments.

In constructing a data management system we do not seek to prejudice one data source over another, but we do seek to design a system where the structure of each data set is understood to be different. Location forms a common element in all three data sets (Figure 2). By this we mean geographic location rather than the location of an object or feature modified by people. The distinction is important because while archaeology works with material things this is not necessarily so of either oral traditions or historical documents. By emphasizing location as the common element in all three we are admitting the possibility that natural features (e.g. a beach where an important historical event occurred, or a tree of spiritual significance) will form records in our data management system. We are also structuring the way that we categorize oral traditions and historical events. The ‘date’ of the event is not the primary tool for

Figure 2: Conceptual model of space time relationships

Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS'03)
organizing these events. Rather, it is the space in which they occurred that becomes the key.

Archaeological objects and features found together can be organized into groups (Figure 2). The number and nature of these groups reflects the range of processes that have led to their survival, and, as discussed in detail above, their discovery. The boundaries of these groups are flexible, changing in time as the conditions that led to their discovery change. To some degree, locations associated with oral traditions and historical events also form groups however these groups inform on conditions surrounding common actions in the past in the case of oral traditions, and generalizations concerning social, political and economic processes in the case of historical events. Thus we prefer the term landscape to describe the way groups of archaeological objects and features, together with the locations associated with oral traditions and historical events, are integrated. For us, significance assessment is a process carried out at the level of the landscape where the groups and locations can be integrated and compared as separate data sets. Clearly, the spatial integration suggests the use of a Geographic Information System model for organizing data.

Landscape as space provides a picture of the density of heritage data derived from all sources. But it is not density alone that it the key for significance assessment. There is a danger of selecting the most easily identifiable sites as significant simply because they fit within the definition of sites that have a relatively simple history of use. Landscapes with many spaces may be significant because of the complex, even 'messy' history that they reflect. Data sets may seem hopelessly mixed, with events piled on top of one another, at times later events removing traces of earlier activity. However, these are potentially very significant places since the landscape records such a wealth of activity, even if individually, the events represented are hard to isolate. At the other extreme, what appear to be almost empty landscapes may in fact represent places with ancient locations, the lack of repeated use preserving an aspect of a landscape that has not survived in other regions. Thus, overly used, messy landscapes and those that are almost empty should be assessed for their significance.

The example introduced above, Motukorea, illustrates many of the elements that a heritage data structure must incorporate. The elements common to New Zealand archaeology are visible on the surface. Terraces, pits, bank and ditches, shell midden together with agricultural stone mounds and small walls have been recorded [6]. Also present is evidence of the early impact of Europeans: house sites, plough lines, stone walls and middens containing European material (broken china, bricks, etc.). Many Maori groups occupied Motukorea and there are a number of oral traditions relating to the general area and the island in particular. Historical records tell us of the early ventures in pig farming by John Campbell, the founding father of Auckland while early maps and drawings give an idea of space use at this time. The data structure we have modelled seeks to integrate this information initially through the common use of location but ultimately through the notion of a landscape from which significance statements can be made.

Unlike the traditional site based model, our data structure separates the location from information related to interpretation. Thus, we do not label places as fortifications (pa), gardens or storage pits etc. Rather the location of a feature (i.e. individual depressions and terraces) becomes our minimum recording unit and we record sets of descriptive information about these features in a number of tables. Interpretation of the meaning behind sets of feature locations and their significance can occur as a separate exercise, the results of which will be represented by a separate layer of information that binds a number of feature locations together.

Essential to the successful application of this model is the ability to tie the heritage data management system into databases that hold information on non-heritage matters. Today Motukorea is used for recreational purposes as well as the grazing of domestic stock. There is pressure to re-plant parts of the island with forest. Thus, from the management perspective, cultural heritage forms only one of a number of conservation issues that need to be considered together. Effective management needs a tool where the rich data sources whether connected to heritage or not, can be effectively integrated.

6. Development of a Heritage Information System

In common with any implementation of information and communication technology system the design needs to accommodate existing methods and models of working practice.

Unlike many corporate information system implementations this system has a diverse range of potential users with access to a varied range of technologies, solutions and expertise. The primary source of data are the archaeologists who survey, photograph, document and record features, together with the district file keepers, who are volunteers within the New Zealand Archaeological Association. These latter individuals may have may have limited access to information technologies and may not wish to dramatically change their mode of working. At the other end of the scale, many of the larger local authorities have Geographic Information Systems to assist in their land management roles and research archaeologist typically have access to a wide range of analytical software. Any system, therefore, must be able to present multiple views,
each appropriate to the expectations and expertise of the stakeholder.

Research was carried investigating different international examples, which address the data storage and information retrieval problems. Many archaeologist and heritage organisation were surveyed, and where possible, their data models examined. Evaluation suggested that only two of the models had potential [8], [9], and based on these the research team began to look at the fundamental issues of modelling. These issues are discussed next.

6.1. The Proposed System

Overview

The final delivery of the information in a form suitable for each of the user groups can be effectively achieved using web browsers. This approach can also be utilised for recording new discoveries and updating existing records. This allows for the variety of hardware and operating systems combinations that exist, some of which are not contemporary. This also allows the future possibility of expanding into direct field data entry using wireless technologies (e.g. WAP).

The various information views on the data will be generated from a database using appropriate web server technologies. The modular design of the overall system will allow the flexibility to change components as technologies emerge and allow access via alternative routes (ODBC or web browser).

Although access methods are challenging from an information systems perspective the key to the eventual effective widespread and alternative uses is the database structure, this is the primary focus of the following discussion.

The Data Model

Within the modelling of the system, the use of the Anybody entity relationship modelling style is employed [10]. This facilitates the integrity of data storage whilst allowing flexibility in the storage of multiple record types and differing levels of precision and accuracy.

The underlying model has been designed for maximum flexibility of storage, and access to data. To assist multiple views of data, relational technologies were selected after assessing alternatives including object relational, object oriented and web based technologies.

Figure 3 Schematic diagram of the proposed system

![Figure 3 Schematic diagram of the proposed system](image-url)
(e.g. HyperWave, [11]). Each of these was discarded for reasons of compatibility or performance.

Using database query systems, the delivery mechanism will be independent of database itself, which will allow for emergent technologies to be easily incorporated without impacting on the database structure. The database itself is complex in its structure and needs to incorporate many varied media.

Much emphasis has been placed on preservation and enhancement of all exiting data sources. Ranging from paper copies with hand drawn maps and measurements made using hand tapes, through to electronic data recorded with differential GPS accurate to 3 metres and emergent laser scanning technologies accurate to millimetres. Thus the extract from the model shown in Figure 7 has been designed to facilitate the varied nature and precision.

Particular attention has been paid to the modelling of spatial and temporal data. The employment of date estimates where artefacts may be placed to the nearest 10 years is recognised as an important issue. Usually for data modelling, aspects of date are predominantly tied to issues of time stamping, start and stop date or date of birth etc. Usually single predictable dates. Within heritage data it is possible to have date ranges and estimates based on the assessment of the individual surveying the site. Our data model, therefore, makes allowance for these data ranges and is able to apply these to the individual artefacts as well as sites. The reason for this is that sites are often reused, for example, after abandonment by one group, the site may be inhabited at a later stage by a different group. Upon excavation artefacts associated with each era may be located. These may then help to explain the history of the site as well as the movements of a particular group over time.

In essence much of the nature of Archaeology has a spatial component. All sites, finds and migration data can be located in time and space. Hence our data model has significant spatial components designed to allow visual exploration of this data using Geographic Information Systems (GIS) techniques.

From a researchers point of view the characteristics of each view may have varying interest. For example the spatial distribution of cutting tools may be of interest to one researcher while another researcher may be interested in the cutting edges of these same ‘finds’. Such are the intricacies of stories data regarding finds that we have thought long about the correct modelling of this on a relational field.

### 6.2. Interface Issues

Care has been taken to design conduits for interaction with the underlying data structures. These interactions will be available through two routes locally using SQL reports directly manipulating the database and also via the internet. It is envisaged that most interactions will be gained through via the internet. New Zealand is a geographically diverse landscape where transportation is both time consuming and expensive. Telecommunications and internet provision are of high quality and to the majority well understood and utilised. The deployment, therefore, of a web interface onto the database this will provide individuals and organisations with instant access to heritage information.

Figure 4 indicates a sample of an internet based site recording form. Screens were designed using standard software engineering guidelines [12]. With a long tradition of manual paper-based recording which work effectively for recording purposes, interfaces for the initial designs have been designed as closely as possible to the paper forms and reports. This has been purposely done to provide an environment that allows reassurance by the use of common terms of reference. Over time and in the light of feedback and feature requests these interfaces will evolve.

The current data entry module has been designed to provide an optional, familiar interface for the record keepers by replicating the existing site record form. The record keeper can, therefore, maintain continuity in the method of work even though the data are stored in a more appropriate structure.

Through these interfaces information will be available to the individual and also to interested parties/organisations. Issues of privacy are still under discussion as New Zealand has many sites that are both sacred (wahi tapu) and secret to different cultural groups, access to these records will require security aspects these will be implemented based upon the outcome of these discussions.
There are no such constraints on the development of the query interfaces for the system. Our design criteria included the requirement for a solution that could be deployed to locations with limited Internet bandwidth and that avoided any requirement for GIS software to be installed at the client.

The most flexible and widely available delivery method currently available is the Internet, using thin client/server technology. The primary method of user access chosen is to use Web browsers with the link to the database being provided by proprietary spatial database engines (SDE), bespoke JAVA code together with XML and java server pages (JSP) or active server pages (ASP). The final method has yet to be identified by the research team and, given the flexibility of web-based provision, a combination of the above may eventually be more effective.

As the range of hardware and software available to organisations and individuals is diverse ranging from fully specified GIS installations to basic personal computers, a prototype of a vector based map viewer has been created (Figures 6a, 6b). Thus individuals requiring map information will be able to view this data without the need for additional software purchase.

Clearly, solutions based on raster graphics were unlikely to be suitable, given that they typically require large file sizes. The current interface makes use of the emerging Scalable Vector Graphics (SVG) standard [13]. This vector image format is based upon XML and may be displayed in a standard web browser using a freely available viewer plugin [14]. There are extensive zoom and pan capabilities built into the viewer. The accompanying figures show two images of the same map at increasing zoom levels. Embedded hyperlinks (see Figure 6b) enable intuitive spatial navigation to the records.

6.3. Current Prototype Implementation

The full application will reside within an Oracle 9i database management system. Oracle has comprehensive facilities for data management, multi media handling, internet communication and provides the relevant hooks for the spatial data elements of the data structure. The prototype uses a standard three-tier architecture, utilising Microsoft Internet Information Server (IIS 5) for delivery of web pages.

A prototype implementation has been created using MS Access to show proof of the concept. This has provided a rapid application development prototype to test ideas prior to development commencing on the production system. The information held in the system may be accessed locally using traditional SQL reports or by Internet access in the manner described above.

The existing data have been collected over a considerable period of time and the completeness and precision are variable. Incomplete records could not be simply discarded, since changes in the landscape might have made the original surveys difficult or impossible to replicate – human and animal activity may have destroyed aspects of the original findings. We needed a strong conceptual foundation to avoid later, possibly problematic [15], changes to the core entities and relationships, while concurrently recognising that the expected relational constraints may need to be relaxed to accommodate some existing data.

With this in mind, we have commenced an initial normative design that incorporates aspects of our three views of heritage: archaeology; historical events and oral traditions. As part of this process we have examined
existing European systems. We had initially hoped that a suitable schema might already be available, however this has not proven to be the case. Primarily, this is due to the motivation behind the existing designs. We note that “site” or “monument” is often the key unit of analysis and we consider this level to be insufficiently granular. New Zealand surveys may encounter “layers” of European and pre-European (Maori) activity at the same geographic location.

The most obvious departures of our current model from those developed elsewhere relate to our specific intention to support the disaggregation of site-based data into individual artefacts and our explicit treatment of temporal issues. The increased precision of current archaeological methods makes this not only feasible but also prudent, in anticipation of possible future uses of the data.

6.4 Temporal Issues

The schema must accommodate at least three classes of temporal concerns. Firstly, it must recognise that historical events can often not be located precisely in time. Some measurement techniques are intrinsically imprecise and may produce only approximate dates. It is therefore inappropriate to attempt to attribute greater precision than is known to be available by recording precise values. Secondly, most historical events are not instantaneous; rather they occur over some interval. Thirdly, future archaeological or historical interest in artefacts might require them to be grouped and regrouped into arbitrary time periods, for example a particular cultural period or century.

We therefore propose the adoption of a time period entity similar to that of Fowler [16]. The primary responsibilities of this entity include the ability to determine whether it contains or is contained by another time period. An example of our structure’s use is contained within the oral traditions subschema (see Figure 7). We extend Fowler by explicitly recognising the temporal precision of our measurement.

It can be observed that the only embedded datetime values in the model are system generated (e.g. modification timestamps). Even occasions such as births and deaths may not be accurately recorded prior to the twentieth century. Database views can be employed to simplify the resulting relational table structure for query purposes.

The Internet facilities on the system have been created using Dream Weaver. The web based data entry module has been designed to provide an optional, familiar interface for the record keepers by replicating the existing site record form. The record keeper therefore can maintain continuity in the method of work even though the data are stored in a more appropriate structure. The embedded hyperlinks in SVG image currently (figure 6a and 6b) linked to static HTML pages, however a dynamic page delivery solution is currently under development.

7. Discussion

The nature of the data, the theoretical approaches to understanding the past and the overall complexity of the data ownership, access and application all show that the heritage management in New Zealand is an area where skilful management of all parties and data access are paramount to the successful implementation of cultural heritage preservation. The variety of users, who display a wide range of familiarity with data management systems, means that a unified data model, like that described in Section 5 with an Internet based data repository, is a likely candidate to fulfill the needs of all parties. The initial cost outlays associated with the keying of data and hardware costs are significant but are considerably less than the amounts currently paid out by developers to mitigate the effects of destruction of heritage sites. Any initial financial outlays in implementing this data model will be rapidly outweighed by the savings made to developers in time and the reassurance that significant heritage sites will not be impacted by any proposed development.

In addition, application of this model may go further by providing decision support functions based on the geographically located data, in point and region form,
allowing estimates of the likelihood of undiscovered settlements or features being uncovered in areas where there are few surface indications of heritage sites or where adequate survey has not been undertaken.

By fuzzy logic based estimation it is possible to calibrate a DSS to indicate the likelihood for such areas. This would be a useful tool with which to look for patterns in a variety of terrains, and it would provide a comparatively cheap option for the developer, who otherwise may face such long stoppages and investigations while conventional research is undertaken, that a venture may become unprofitable. Given the political will, the ability to access and share multimedia data has the potential to enrich our knowledge and understanding of heritage data.

With so many stakeholders, issues of data ownership will need to be considered carefully. Some cultural groups, for instance, have strict protocols that must be followed to determine who gains access to certain types of information. In these situations, appropriate safeguards will need to be implemented. Our data structure deals effectively with the need to restrict access to certain types of information (e.g. information that is considered sensitive by Maori) by indicating location but separating this location from information that describes what this location represents [17]. Its flexibility also permits a range of information to be stored, including for instance, that related to changing conditions of visibility.

Acknowledgements:
We would like to thank Dr. Harry Allen for commenting on a draft of this paper

8. References


