

# Gazetteer Development for the China Historical GIS Project

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## 1.1 Project Background

The China Historical GIS project is developing a set of free tools and datasets covering the geographic space that has, at one time or another, been nominally part of China. The idea is to provide a generic digital platform for historical places that can be seamlessly integrated with a wide variety of contemporary GIS data, but which is not tied to a single data source. The CHGIS data model enables the user to overlay and visually compare many different “interpretations” of historical places, and to add their own data as well.

The primary components of the CHGIS are:

- (a) a database of historical places
- (b) a relational database model for tracking changes of places in space and time
- (c) a GIS dataset of spatial objects representing historical places

## 1.2 Database of Historical Places

The Center for Historical Geographic Studies, Fudan University, has completed a database of historical places for the year 1820 (Qing Dynasty), based primarily on the source materials that were used to create the “Historical Atlas of China.”<sup>1</sup> The database contains more than 10,000 records, consisting of administrative units, populated places, and a selection of other important sites.<sup>2</sup> Each record includes a number of attributes:

- (a) placename
- (b) administrative status
- (c) effective dates
- (d) position in the administrative hierarchy
- (e) present location
- (f) historical source citations, quotes, and commentaries.

| place_present | dyn_ch | prov | level2_py_name | level2_ch |
|---------------|--------|------|----------------|-----------|
| 山西曲沃县西南隘口     | 清朝     | 山西   | Pingyang Fu    | 平陽府       |
| 山西潞城市西安昌      | 清朝     | 山西   | Lu'an Fu       | 潞安府       |
| 山西左云县北宁鲁堡     | 清朝     | 山西   | Shuoping Fu    | 朔平府       |
| 山西大同市西南安宿疃    | 清朝     | 山西   | Datong Fu      | 大同府       |

Figure 1: partial view of CHGIS historical places working table

Note that a great many values in the working table (Figure 1) are repeated, such as “Qingchao” and “Shanxi.” This is due to the “time slice” model that was used to produce the initial database for the Qing Dynasty, and specifically for the year 1820 C.E. Now that the 1820 layer is nearing completion, we will implement a relational database model for tracking continuous change of historical places over time, and begin to build out the database backwards in time.

1.3 What Is a Place?

The basic difficulty faced by any historical gazetteer project arises in the definition of a “place.” What exactly is a “place?” And what is the precise difference between a place that is changing, and a place that is replaced by a new “place?”

Let us consider a few problematic cases. Place A experiences a flood and relocates to higher ground keeping the same name. We consider this to be the same place, with a new location instance (as in Figure 2).

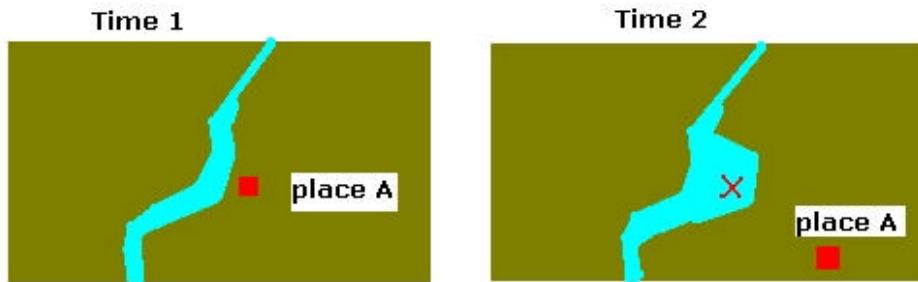


Figure 2: new location instance

What if Place B expands to both sides of a river, then splits into two different administrative units, each with new names (as in Figure 3)? Is either one of the new units the same place as the original Place B? In this particular case we would consider the earliest site of the settlement which later expanded to become Place B as being a new instance of Place B, while the area across the river, the site of Place B’s later expansion, to be a new and unique place to be tracked in the database.

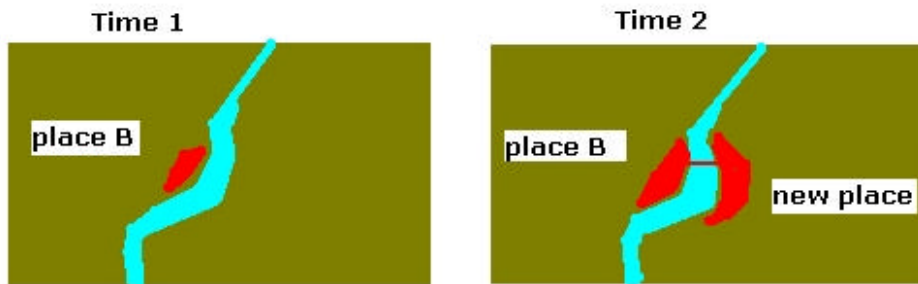


Figure 3: splitting both preserves a place and creates a place

One more example: what if three places, X, Y, Z, merge into a new unit, keeping the name for X and locating the administrative seat at Z (as in Figure 4)?

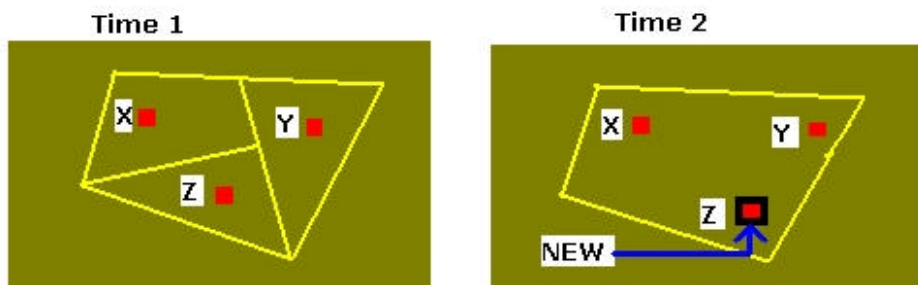


Figure 4: merging creates a new administrative unit and yet preserves named places

Is this a single new Place? Have the original three places now ceased to exist? We consider this to be a case in which a new unique place as been created, with the name of X, the seat at Z, and the total area of X,Y,Z; and at the same time we would record new instances of X, Y, Z, in which their admininstrative instances have changed, but all three continue to exist as named places.

The definition of what constitutes a place can be fairly complex, as are the rules needed to construct the database to follow the transformation of a place over time. Unfortunately our working definition is unsatisfyingly vague:

“a unique place in the database is the first (but not necessarily earliest) known named instance of a human settlement, historical administrative unit, natural feature, or spot feature at a known location in geographical space and existing at a known date or extent in time.”

The fact is that we must at least attribute some extent in space and time to any place that we want to add to the database. The spatial and temporal values may be fuzzy or even imaginary, but they must have the minimum requirement of one point location related to the surface of the earth, and one date value on the Common Era scale. Once we have identified such a place, we assign it a unique ID, which becomes the primary key for establishing relationships among the tables. In the case where the place we have assigned a unique ID turns out to have earlier incarnations, we continue to use the same ID and create Instance records for the earlier Placenames, Administrative Units, and locations as needed.

Once we have designated a place as unique from other places, we can track its transformations, either forward or backward in time, as well as in space. The attributes of each place object being followed are given a new record for each instance of change, and are stored in separate tables of the relational database.

2.1 The Relational Database Model for Spatio -Temporal Features

The first draft version of a Spatio -Temporal Database Design<sup>3</sup> for CHGIS envisioned a generic relational database model that was software and platform independent, and allowed for multiple “interpretations” or versions of the data to be held simultaneously for comparison by the user. The design also called for an elaborate hierarchical geocoding system, adapted from an earlier historical GIS project based on “slices of time.”<sup>4</sup> But this strictly hierarchical coding, when applied to constantly changing Chinese administrative units proved to be unworkable. Consequently, a revised CHGIS Data Model has been developed,<sup>5</sup> which allows for attributes of any historical place, such as changes in name, changes in administrative status, and changes in location to be tracked as separate variables.

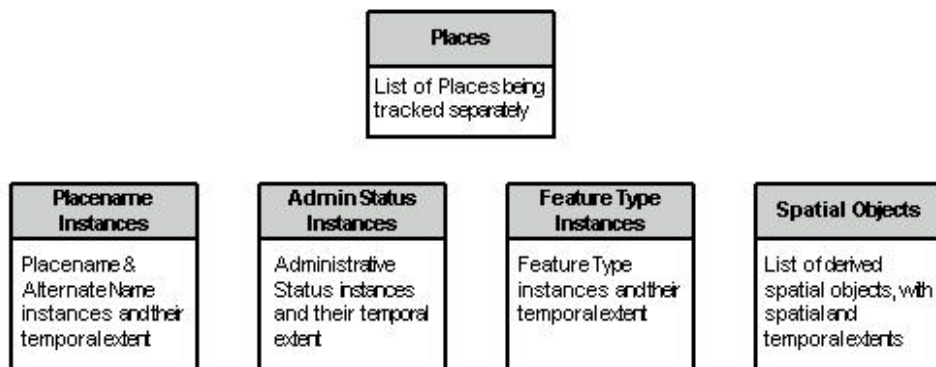


Figure 5: attribute variables for historical places (see also Figure 13)

The historical changes over time are to be recorded in three “Instance” Tables, and one Spatial Objects table (shown in Figure 5). Each record in the four tables will represent a “temporal instance,” or span of time, during which the attribute variable or spatial object remained constant. The instances have temporal extents defined by Beginning and Ending dates, as well as a Change Type value, indicating what sort of changes triggered the instance.<sup>6</sup>

Because the values in the four tables can change independently of one another, they are tracked in separate tables and linked back to the same “place” with a unique ID number. In other words, the temporal extent of a particular Placename Instance might contain, or partially overlap, or be adjacent to, or come before, or come after the Admin Status Instances that are related to the same place. By keeping separate timelines for these variables, if we discover a new piece of evidence that shows a particular place changed its administrative status at Time1, we can enter it as a new “instance” of admin status, without impacting any of the other tables. Similarly, we might discover that a place, which was once a village, became a periodic market town at Time2, which can be recorded as a new Feature Type instance, while the placename and location remain unchanged.

Having establishing some ground rules about what constitutes a “place” to be tracked in the database, we can use the Instance tables to follow the transformations of places over time. We can also define relationships between the instances themselves.

For example, the administrative hierarchy is defined as a relationship between administrative instances, and recorded in a separate “Instance Relation Table,” where Place 25 is shown to be “part of” Place 22, and Place 26 is “part of” Place 25 (Figure 6). The temporal extent is recorded, so that the administrative hierarchy can be reconstructed for any particular time based on a query, while updates need only effect the records kept in the Instance Relation Table.

| <i>key_id</i> | <i>place</i> | <i>relation_type</i> | <i>related_id</i> | <i>begin</i> |
|---------------|--------------|----------------------|-------------------|--------------|
| 22            | Shanxi Sheng | partof               | 11                | 1680         |
| 23            | Taiyuan Shi  | partof               | 22                | 1750         |
| 24            | Datong Shi   | partof               | 22                | 1680         |
| 25            | Yangquan Shi | partof               | 22                | 1842         |
| 26            | Pingding     | partof               | 25                | 1942         |

**Figure 6: defining the administrative hierarchy in the Instance Relation Table**

The temporal sequence of administrative unit changes is also defined in the Instance Relation Table. For example, if Admin Instance 33 changed into Admin Instance 34 at Time8, then split into Admin Instances 55 and 56 at Time9, we can follow the sequence in the table using a “Preceded By” relationship as shown in Figure 7.

| <i>key_id</i> | <i>relation_type</i> | <i>related_id</i> | <i>begin</i> |
|---------------|----------------------|-------------------|--------------|
| Admin#55      | preceded by          | Admin#34          | Time9        |
| Admin#56      | preceded by          | Admin#34          | Time9        |
| Admin#34      | preceded by          | Admin#33          | Time8        |

**Figure 7: defining the temporal sequence in the Instance Relation Table**

Another table in the spatio-temporal database model is used to record “Events,” which can be any sort of recorded event with a known date or duration. Events need not be directly

connected to any of the database contents. For example, the birthdate of a famous poet can be recorded as an event (Event#1). Although such an event has no direct relationship with the other historical instances in the database, the user may want to use such Event records as a component of their queries, ie. “select all records that spatially overlap the area within a 100 km radius from place A, and with an overlapping temporal extent within 20 years after Event#1.”

On the other hand, Events may be directly related to historical instances in the database, the date of a great flood, for instance. These events may be explicitly related to instances and vice-versa using a many-to-many linktable, or Event Records themselves can be related to each other by using the Instance Relation Table. An example of the latter could define a relationship along the lines of: “Event#CC [burning of Town X] is the “ResultOf” Event#BB [invasion of Town X]” which can be recorded as shown in Figure 8.

| <i>key_id</i> | <i>place</i> | <i>relation_type</i> | <i>related_id</i> | <i>begin</i> |
|---------------|--------------|----------------------|-------------------|--------------|
| Event#CC      | Town X       | resultof             | Event#BB          | 1622         |

**Figure 8: defining relationships between events**

The tables for Placename Instances, Administrative Status Instances, and all other Feature Type Instances might, in fact be stored in a single Feature Instance Table, but we have separated them for ease of use and because attributes may vary between these three essential aspects of historical places. Placenames, for example, will be linked by unique Name IDs to separate tables for each language (and character set encoding) as needed. Any particular place can then have names in many languages: Chinese, Mongol, and Tibetan for instance. Each of these, in turn, might have alternate written forms or variant pronunciations, not to mention a variety of transliterations depending on which romanization system is used. Similarly, our Administrative Units will be tracked in their own table, convenient for those whose primary interest is in administrative hierarchies and their transformations.

Feature Type Instances are especially useful for keeping track of populated places, land use, and many other phenomena with spatial characteristics. Consider the case of a stream, known to flow at a particular time, but for the last few centuries nothing but a patch of sand. Having established the feature as a place in the database, we can then create a Feature Type Instance, “stream,” with an ending date of 1800, and a subsequent Instance, “arroyo,” with a beginning date of 1800. There is no need to assign a name to the same feature. For Feature Types, we should make every effort to create lookup tables to any existing standards, such as the Alexandria Digital Library Gazetteer Feature Types,<sup>7</sup> or the National GIS Cartographic Classifications (Taiwan),<sup>8</sup> so that queries may be successfully passed from one system to another.

## 2.2 Tracking Complex Temporal Changes

The ability to track Feature Types and Events may prove to be one of the most interesting applications of the spatio-temporal database model. For example, we can create a group of unique Places along a river with the Feature Classification “Measurement Stations.” Then for each Measurement Station, we can create Feature Type Instances for “flow gauges.” Finally, each Instance of “flow gauge” can be associated with an unlimited number of Events such as “flow rate,” and in the Events table, each separate “flow rate” event is assigned a value and date (as shown in Figure 9). In this way, we can allow for a meaningful series of phenomena to be tracked over time.

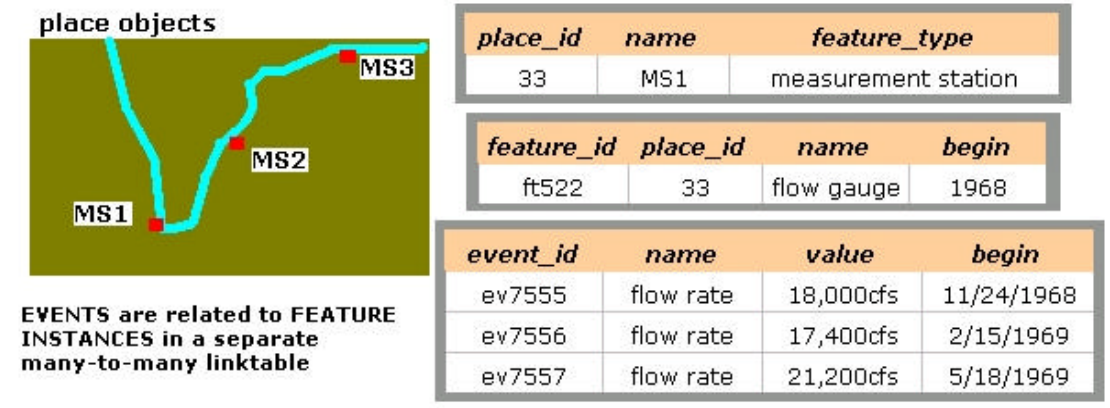


Figure 9: time series of events linked to feature type instances

Identifying a group of Measurement Stations as points and creating unique IDs for them as places is one way to track a series of events taking place at each station. But what about events that move through space and time? We can use the same method just described for tracking a flood event in a valley, or the path of a hurricane, but first we must expand our concept of “place.” In our previous discussion of what constitutes a “place” we focussed on human settlements and administrative divisions. But when we used the term “place” for convenience, what we are in fact describing are spatio-temporal entities, which is to say, some entity which can be defined as occupying some physical space at a particular time. Therefore, when we think of the growth and expansion of an urban area, we could just as well be thinking of a fast moving, swirling hurricane. If we sped up an animation of a growing metropolis to a sufficient speed, or if we slowed down an animation of a hurricane’s movement sufficiently, the visual patterns of the animation might be very much the same. The important thing to consider is whether or not we can devise a way to record such changes in our data model.

If we stretch our meaning of “place” to include any spatio-temporal entity, then we can assign a unique place object ID to “Hurricane Smiley.” Features of the hurricane, such as “wind speed” are given Feature Type Instances, then a series of events are linked to the “wind speed” instance.

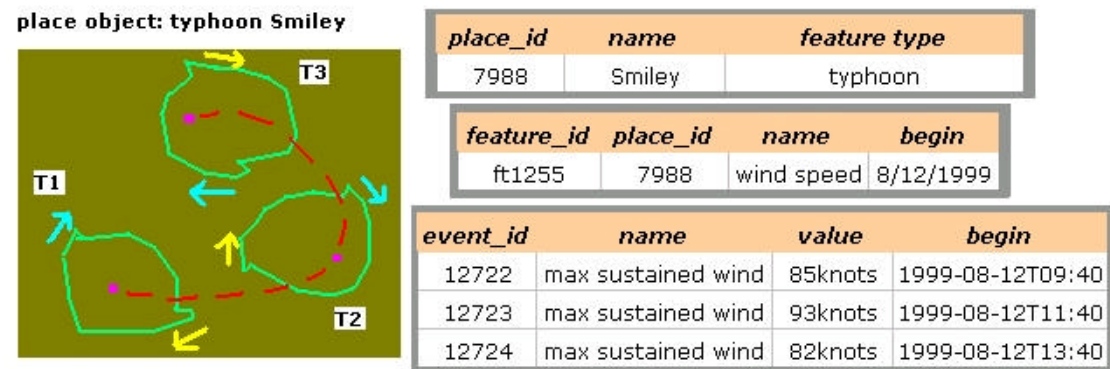


Figure 10: tracking other types of spatio-temporal entities



The method of dating events, such as flow rates for a particular date, or maximum sustained wind speeds for a particular minute, can be pushed to greater or lesser levels of temporal granularity if necessary, down to thousandths of a second or up to millions of years. For the CHGIS project, we advocate the adoption of a dating format like the one proposed in the basic services draft for the Open GIS Consortium, which makes use of a straightforward syntax.<sup>9</sup>

Examples of the proposed OGIS dating scheme:

1) yyyy-mm-ddThh:mm:ss.sss or **1999-08-12T09:40:23.558** Where T = Time

2) Period events are indicated with a P then a value and unit measure, as in:

yyyy-mmPunitY or **1980-06/2000-06/P1M**

Which means: a periodic interval lasting 1 Month and beginning June 1980 / ending June 2000.

3) BCE dates take the letter "B" as a prefix, so **B221** = BCE221.

4) Geologic dates in the distant past take the letters "K, M, G" as prefixes, meaning thousands, millions, and billions of years before the present, respectively.

**K16** = 16,000 years ago  
**M120** = 120,000,000 years ago  
**G3** = 3,000,000,000 years ago

Another aspect of Event Dating is to allow for the duration of the event, as well as a time lag until the "next" event. For example, an Event record can be created for "harvest," an activity which lasted for two weeks, but was not followed by another harvest until the following year. So an Event record may contain dates along the lines of:

Begin Date = 1974-09-11  
 End Date = 1974-09-24  
 Next Event = 1975-08-28

The CHGIS model makes use of this idea, which is presented in an ESRI White Paper on Forest Management.<sup>10</sup>

Even if we standardize our date formats, it won't help us when dealing with historical records for which the dates are not accurate. Since many of the records in the CHGIS database will fall into this category, we have come up with a method of dealing with temporal uncertainty that will allow us to assign specific years to each record according to established guidelines.

### 2.3 Handling Temporal Uncertainty or "Fuzzy Dates" for Historical Features

There are four date fields for each historical instance records in the CHGIS data model, two for the Beginning and Ending Dates, and two more that provide a standard value for the Temporal Uncertainty about the date, which we call Begin Date Rule and End Date Rule. These Date Rules were developed by the Center for Historical Geographic Studies, Fudan University, so that we can enter fixed dates to allow for temporal search procedures, even when our data does not provide fixed dates. The Rules establish a set of guidelines for the dating process:

**Rule 1: Year is set according to a pan-Dynastic period, such as "Qin Han," or " Song Yuan"**

**Rule 2: Year is set according to a Dynastic period, such as "Tang," or " Ming"**

**Rule 3: Year is set according to a Dynastic Title or Reign Period, such as "Shundi," or "Zhizheng"**

**Rule 4: Year is specified, such as "13th Year of the Kangxi Reign Period"**

**Rule 5: Season or Month is specified, such as "4th month of the Lunar year," or "autumn"**

**Rule 6: Date is specified, such as "jiachen day, 5th month, 14th Year of the Jiaqing Reign Period"**

**Rule 7: Uncertain beginning or ending date, adopts next previous or subsequent value**

The rules allow us to enter searchable dates in the database, regardless of whether our source information is as vague as a pan-Dynastic period, or as accurate as a particular day. In addition, Rule 7 provides even more flexibility, allowing us to make entries for places without any known temporal extent, and borrowing the values for the next previous or next subsequent instances.

Having discussed various ways to handle the definition of “places” as spatio-temporal entities, and how to track the changes of our “place” attributes over time, we now turn to methods for representing our places as spatial objects.

### 3.1 GIS Dataset of Spatial Objects

The primary spatial data sources being used are the eight volumes of Tan’s “Historical Atlas of China,” and ArcChina, which is the GIS basemap for the project.<sup>11</sup> For spatial representations of historical places, the CHGIS project requires a minimum of one point location for each record. Boundaries will be defined for administrative divisions at least down to the prefecture (“fu”) level. For certain areas where reliable historical evidence exists, boundaries for county level units (“xian”) will also be delineated, but not for all of China. Instead, CHGIS will focus on the location of settlements and administrative seats as points.

Our energy will be used to increase the number of points in the database, and to rectify or “snap” them to their appropriate geographical locations in the context of the ArcChina GIS base map. The resulting base map of historical points will then be enriched as more evidence is collected, and will help to clarify which places were under a particular jurisdiction for particular periods of time. This process will help us to recreate historical county boundaries in the future, if we feel that enough documented proof exists to do so.

We should also maintain a certain amount of skepticism as to what constitutes a boundary line as we delve backwards in time. Were administrative divisions in ages past demarcated with clear and definable boundaries? In the case of scattered and interspersed land holdings under different jurisdictions does it make sense to gerrymander a boundary between them? Or do we draw a simpler line, then identify the isolated parcels as enclaves or exclaves? Recent work on historical landholdings in Vietnam suggest that we might be better off not creating artificial boundaries based on modern cartographic methods, when the way in which administrative space was conceived of in the past did not include those boundaries.<sup>12</sup>

That being said, CHGIS will certainly digitize boundary lines for administrative divisions down to the prefecture level. The procedure involves coding each arc segment of the boundary line to indicate the spatial data source. The resulting arc segments are then aggregated and saved as a single polygon feature. An example of this process is shown in Figure 11, where red squares indicate the end nodes of arc segments, and the segments AA, BB, CC, DD comprise polygon 1.



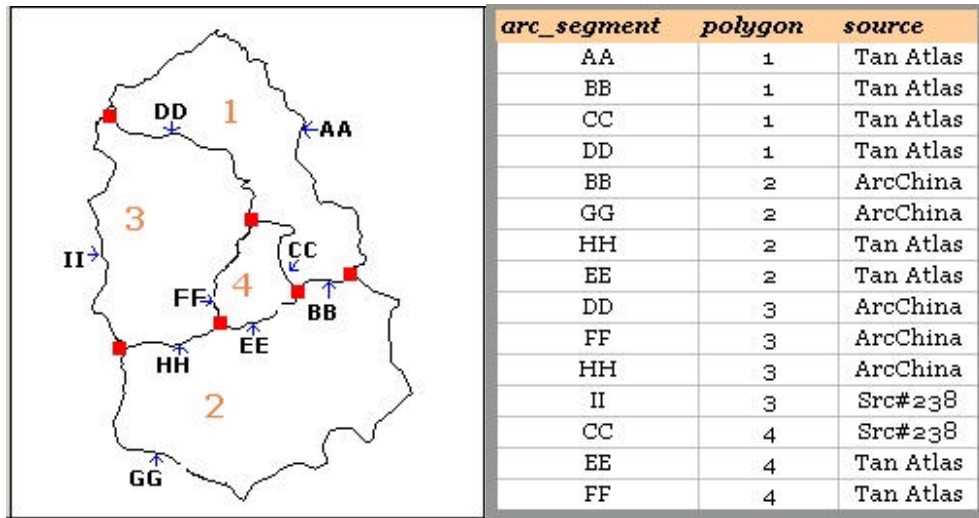
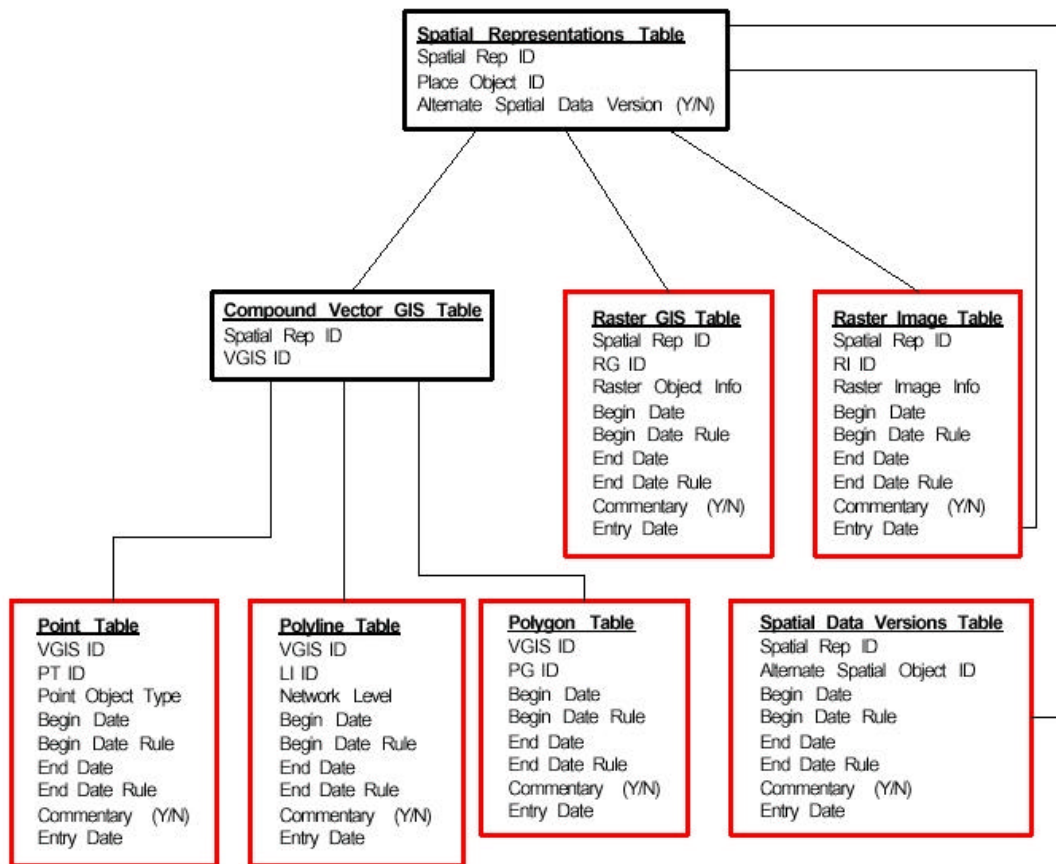


Figure 11: coded arc segments and their spatial data sources

The coded arc segments in polyline layers are saved for future consultation and updates, but are not used for the assembly of spatial objects in the database “on-the-fly” as in the Least Common Geography model. Each of the areas defined by the coded arc segments is converted into a unique polygon object and given appropriate temporal attributes. The CHGIS datasets will default to the individual spatial objects for visualization and mapping purposes, while the original polyline layers (with coded arc segments) will be available if needed. We feel this method will best utilize new object oriented features of the ArcGIS 8.1 platform, which include assignment of representation schema and behaviors to individual objects and classes of objects. Even though the spatial data has been optimized for ArcGIS 8.1, we intend to release the datasets in both ordinary ArcView Shapefile format and MapInfo Tables, which are the two most common desktop GIS applications.

### 3.2 Linking Places to their Spatial Representations in the Relational Database

From the outset the CHGIS project has been designed to first query items in the RDBMS, and then pass the selected records to a GIS application as a subsequent step. The spatial objects and the attributes being queried might vary independently of one another, and are only linked by the unique Place Object ID. This is quite different from many GIS implementations which treat the spatial objects as primary and directly connects them to attributes in either GIS tables or related tables. One of the issues we faced was that we needed to allow the user a **choice** of multiple representations for any given object. Another problem was the fact that spatial objects have their own unique timelines independent of the attribute variables, such as Placename, Administrative Status, and so on. Therefore, our data model developed in the direction of allowing multiple spatial objects **each** one of which had their own footprint and timestamp.



**Figure 12: multiple spatial representations**

The place object IDs are related to unique Spatial Representations, each of which can be represented simultaneously by one or more Compound Vector GIS objects, Raster GIS objects, or Raster Images. Compound Vector GIS objects are composed of one or more Spatial Primitive objects (point, line, polygon), which may be regionalized and assigned a unique VGIS ID. For example, all the polygons needed to represent small islands along the coast of a particular county may be regionalized into a single Compound Vector GIS object. If the user is implementing their GIS with software that allows for point, line, polygon data to be stored together in the same layer, then the regionalized object may also contain points or lines. The current CHGIS model requires a VGIS ID to be created for each vector GIS representation, even if that representation consists of only a single point, for two reasons. First, this allows us to easily add other spatial primitives to the same representation in the future, and second, this allows us to assign particular behaviours (symbols sets, for example) to each VGIS Object which can be inherited by any spatial data primitives associated with that Object.

Raster GIS objects, such as grids, are handled in their own. Although we are not supplying grids as part of the official CHGIS datasets, we expect many users to import them from other sources. One example of using raster data would be to track Typhoon Smiley (Figure 10), for which the individual pixels (with timestamps and other raster values) can be displayed in a time series or animated. Raster images, or simply scanned images, are yet another type of spatial representation that can be linked to each place object. Scanned images of historical maps would fall into this category, either georegistered or unregistered scans.

All spatial data records, regardless of whether they are compounds, primitives, raster GIS, or scans, will have certain essential spatial information, such as: bounding boxes, latitude – longitude coordinates, and scale, derived and extracted into a flat table called “Spatial Objects Table.” The Spatial Objects Table is kept in the RDBMS so that basic types of spatial queries and discovery of spatial objects can be easily combined with queries to the Instance and Event tables, without ever having to open the GIS application.

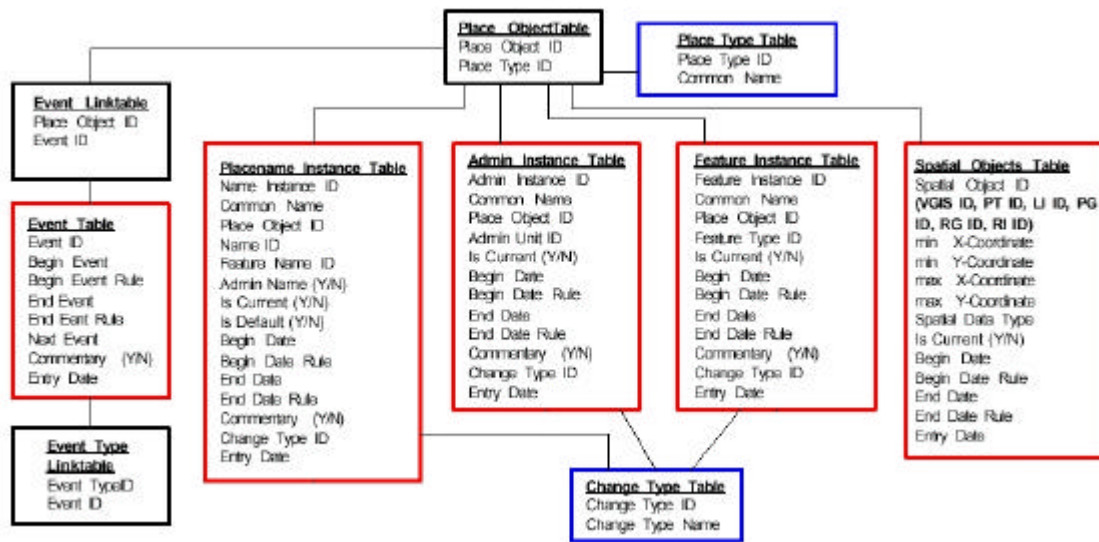


Figure 13: detailed view of main tables in CHGIS data model

As shown in Figure 13, the main tables held in RDBMS will provide great flexibility in developing queries. For example, the user might wish to find all the records that had promotions of administrative status within a certain amount of time from a particular event. The query would join all the tables on Place Object ID, where the Change Type (promotion of status) occurred between the Event Record date and the chosen time buffer. Similarly, the user might wish to know all the placename changes that occurred in a particular county over a period of five hundred years. In this case, the Spatial Objects table is joined with the Placename Instance table on Place Object ID where the Place Object ID represents the desired county only, and where all the records in the Placename table fall within the selected five hundred year range. Countless other types of queries can be devised among the five main tables.

Once the subset of desired items has been selected in the RDBMS, the records can be exported to a separate table, or linked to their related Spatial Representations. Once the subset of records has been passed to the GIS application, the related spatial objects can be visualized or used to represent data that the user has joined to them. More complicated types of spatial analysis, such as clipping, merging, buffering, etc may also be performed once the appropriate spatial objects have been selected in GIS.

### 3.3 Distributed Applications for Historical Gazetteers

At this early stage in development, the CHGIS project hopes to collaborate with others who are building databases that must deal with historical change so that, some day, we will be able to establish queries that pass transparently from one database to another over the Internet. One basic problem that must be dealt with is that each project is developing its own independent data model to meet their own needs, and in many cases the objects being tracked in the database

are defined quite differently, so matching them up later is really like mixing apples and oranges. On the most elementary level, the projects that have included GIS and spatial objects in their system are dealing with Spatial Data Versions and with Features that change over time. The majority of projects, begin with the spatial object as the concrete basic unit and associate attributes to the object based on its changes over time. In developing the CHGIS model, we found that this can be done but requires a great deal of redundancy in the database, because there exist parent-child dependencies among the attributes that must be associated with the spatial objects, and whenever a spatial object changed in a way that impacted those relationships, it required the creation of more and more records to keep track of those dependent records.

What we realized is that the locations and footprints associated with historical places vary independently from the other attributes of historical places (most important of which are Placename, Administrative Status, and Feature Type). So the best thing to do, we argue, is to create records for the changes only, then associate them to a "place" using the RDMS. This, in a nutshell, is what we have attempted to accomplish with the current data model. Other historical gazetteer projects, even if they do not wish to incorporate spatial representations into their data models, will still face the same problem of non-synchronous changes among their attributes.

To facilitate queries among separate databases, we ought to begin with the most expedient means available. Look-up tables of Feature Types would be a good place to start. Although there is a great deal of momentum being built up by the Alexandria Digital Library to establish an authority file of nested Feature Classifications, in my view such standards will never be able to accommodate all the specific needs of historical geographic research. To begin with, there are field-specific vocabularies for everything under the sun, from archaeology to train-spotting. In the case of CHGIS, we have begun with research on mountain gazetteers,<sup>13</sup> that include such items as "rock face with waterfall," and "Chan Buddhist Temple," and we then expand that to include any sort of specific Chinese term that we might discover, such as "drum tower" and "right wing front banner."

It is not reasonable to assume that "right wing front banner," being a legacy administrative unit left over from Manchu military organization, will have any corresponding feature type in ADL or any other Feature Type standard. And if we presumed that the users of various databases will pore through various possibilities and try to figure out whether "right wing front banner" falls under some category or other we would be presuming a bit too much. I would advocate the use of a simple Place Classification, such as the Feature Class Designations from NIMA.<sup>14</sup> The nine categories:

- A Administrative Boundary Features
- H Hydrographic Features
- L Area Features
- P Populated Place Features
- R Road / Railroad Features
- S Spot Features
- T Hypsographic Features
- U Undersea Features
- V Vegetation Features

would be simple enough for various databases to implement as basic categories for their Feature Types, regardless of their specific requirements. This will enable users a rough sort across distributed datasets.

CHGIS also plans to develop an extensive multi-lingual Feature Type thesaurus which will include code numbers from the National GIS Feature Type standard<sup>8</sup> published in Taiwan, any PRC counterparts that become available, and CHGIS historical Feature Types. The objective is to create a look-up table that will allow for passing queries from one standard to another, as well as providing transliterations and translations (in Chinese, English, and Japanese). Although the Taiwan NGIS contains a nested hierarchy, the CHGIS lookup table will not attempt to project

such a structure onto other standards. The best solution would be to enable the user to first discover which datasets can be searched, and then to determine what unique Feature Types are used for each database. In this way development of historical gazetteers can continue along separate tracks, using different data models, and still be able to pass queries to one another.

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<sup>1</sup> “Zhongguo lishi dituji” [The Historical atlas of China], 8vol. Chief editor, Qixiang Tan. Shanghai: Ditu chubanshe, 1982.

<sup>2</sup> A pre-release version of the CHGIS 1820 Datasets is available for download:  
<http://fas.harvard.edu/~chgis/data/chgis/>

<sup>3</sup> “CHGIS Draft Database Design and Geocoding System.” Lawrence Crissman. CHGIS, Dec 2000.  
<http://fas.harvard.edu/~chgis/work/design>

<sup>4</sup> “China Historical Studies [GIS dataset].” Robert Harwell. 1992-1996. Available from CHGIS:  
<http://fas.harvard.edu/~chgis/data/hartwell/>

<sup>5</sup> “Relational Data Model for Spatio-Temporal GIS Allowing for Attributes with Independent Temporal Extents.” Lex Berman. <http://fas.harvard.edu/~chgis/work/design/>

<sup>6</sup> Description of Change Types, and table available for download at:  
[http://fas.harvard.edu/~chgis/work/downloads/faqs/change\\_types\\_faq.html](http://fas.harvard.edu/~chgis/work/downloads/faqs/change_types_faq.html)

<sup>7</sup> Alexandria Digital Library Gazetteer Feature Type Thesaurus.  
<http://alexandria.sdc.ucsb.edu/gazetteer//FeatureTypes/index.htm>

<sup>8</sup> “Jiben dixingtu ziliaoku dixingtu fenlei bianma biao” [Basic Cartographic Materials Cartographic Classifications Coding Chart]. Dept of Land Administration, Ministry of Information, Republic of China, Taipei. <http://ngis.moi.gov.tw/doc/stan/proper%20noun..htm>

<sup>9</sup> Appendix B: Formatting Dates and Times, in “Basic Services Model Draft Candidate Implementation Specification -- Open GIS Consortium Discussion Paper #01-022r1.” Jeff de La Beaujardiere. Draft Version, March 5<sup>th</sup>, 2001.

<sup>10</sup> “An Event Area Management System for Forest Management History.” ESRI White Paper, April 1999.

<sup>11</sup> ArcChina, the official basemap for the CHGIS project, is available from ESRI. See:  
[http://gisstore.esri.com/acb/showdetl.cfm?&DID=6&Product\\_ID=309&CATID=15](http://gisstore.esri.com/acb/showdetl.cfm?&DID=6&Product_ID=309&CATID=15)

<sup>12</sup> “Examining Pre-Modern Vietnam With Historical GIS.” Brian Zottoli. International Workshop on Historical GIS, Shanghai, 2001.

<sup>13</sup> “Spatial Elements for Mountain Gazetteers.” Thomas Hahn.  
<http://www.library.cornell.edu/wason/gazetteers/>

<sup>14</sup> “GNS Feature Designation Cross Reference.” National Imagery and Mapping Agency.  
[http://164.214.2.59/gns/html/fd\\_cross\\_ref.html](http://164.214.2.59/gns/html/fd_cross_ref.html)