Modeling Time, Dates, & Periods for Historical Geographic Data

DH 2013 Lincoln

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Harvard CGA

Core decision points for modeling space-time objects

Space

- geographic scope
- fundamental geographic unit

Time

- temporal range
- temporal granularity

Description

- names
- ontologies

Time range and date definitions: an example from CHGIS

Space

- geographic scope
- fundamental geographic unit

Time

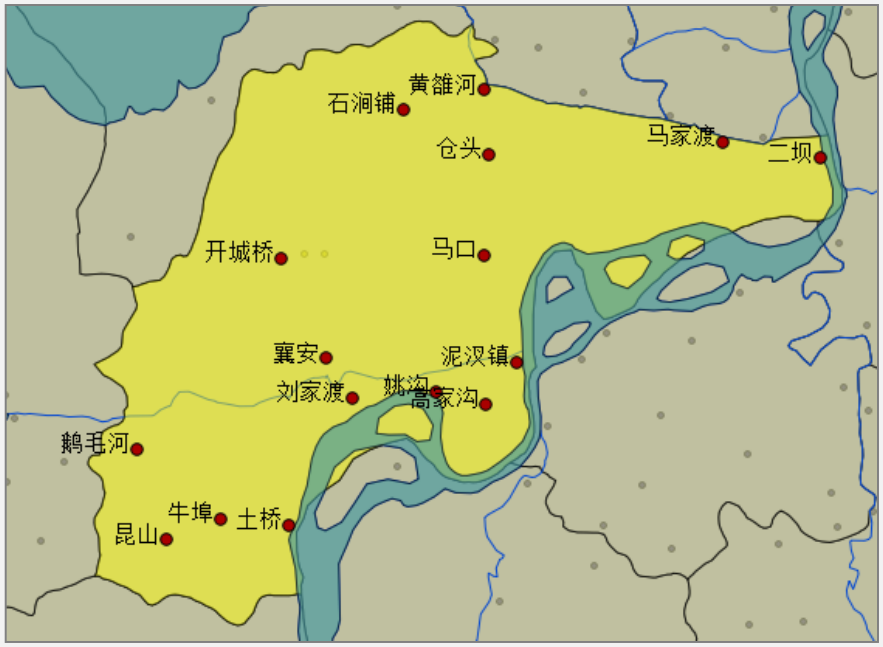
- temporal range
- temporal granularity

Description

- names
- ontologies

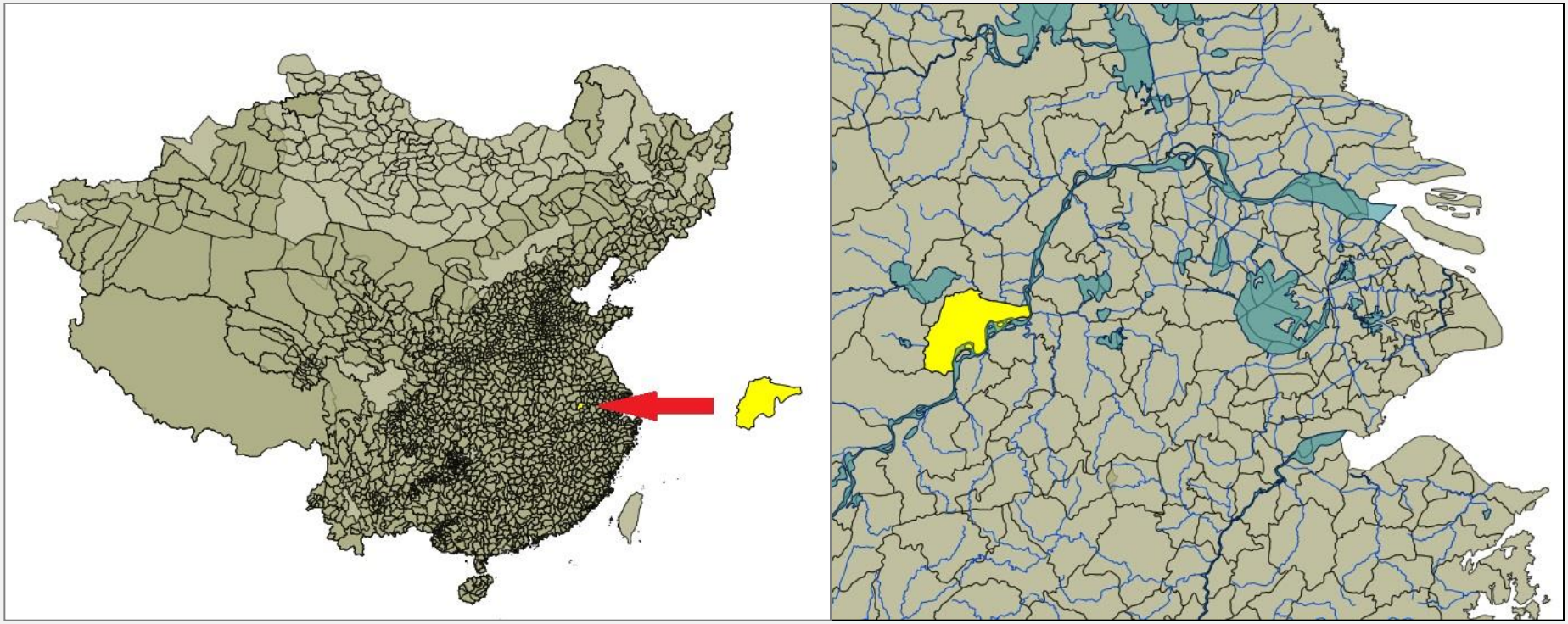
CHGIS - Fundamental Geographic Unit: County

Historical map source for 1911



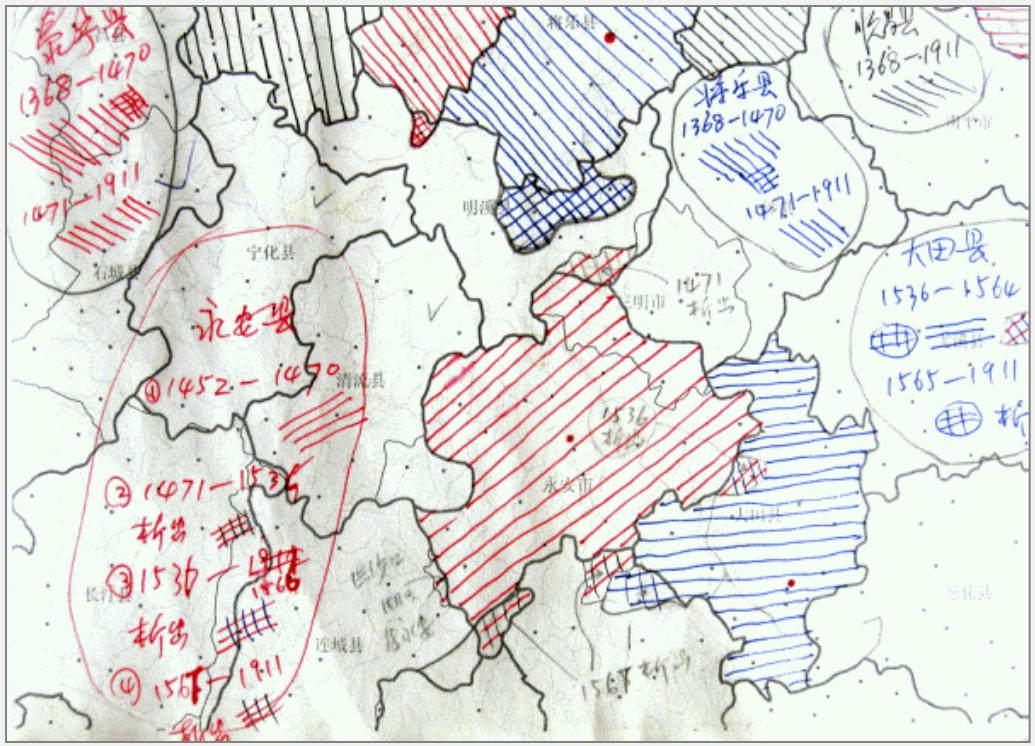
Historical locations pinned to modern basemap

CHGIS - Base layer of 1911 counties

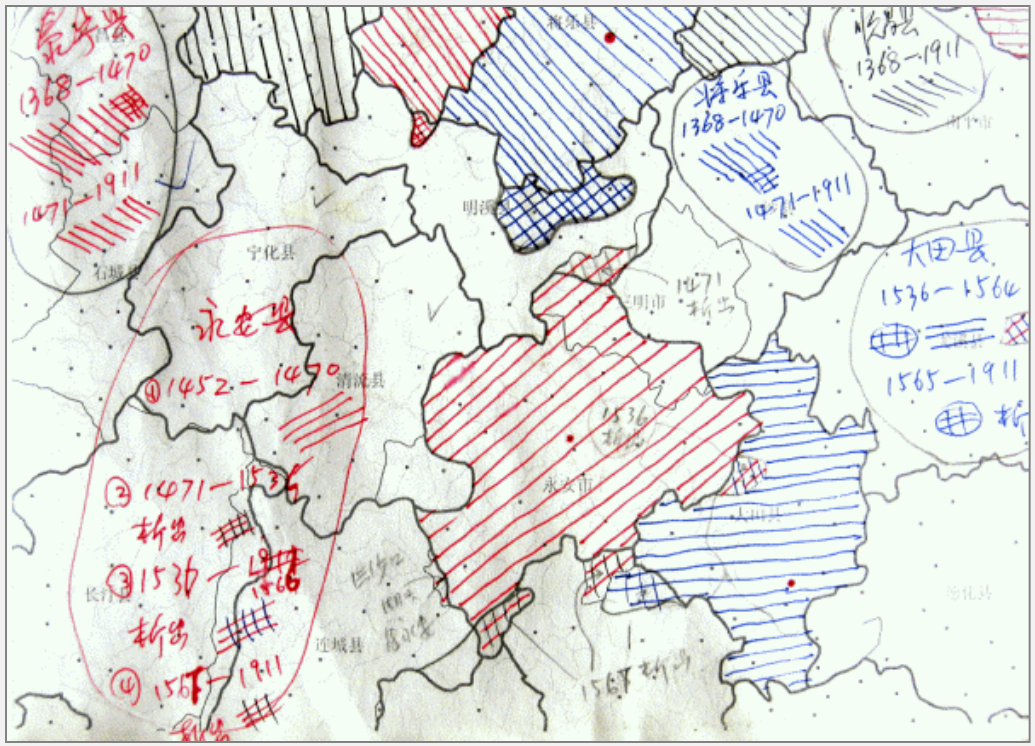


CHGIS - time series of county boundaries

boundary changes annotated on printed maps



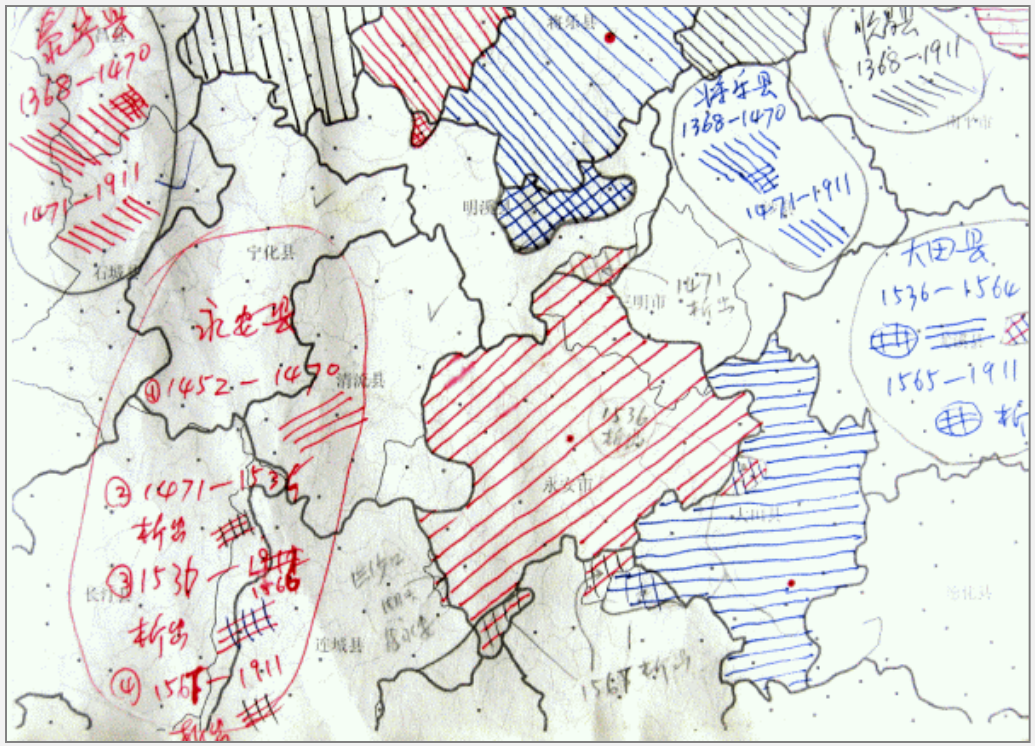
CHGIS - time series of county boundaries



sys-id	hist-place	begin	end
333	Province T	1200	1350
334	Prefecture A	1200	1249
335	Prefecture B	1250	1350
336	Prefecture C	1200	1350
337	County X	800	1500
338	County Y	1200	1320
339	County Z	1321	1340
340	Town 1	200	1700
341	Town 2	100	1500

Each space-time object gets a new row

CHGIS - time series of county boundaries



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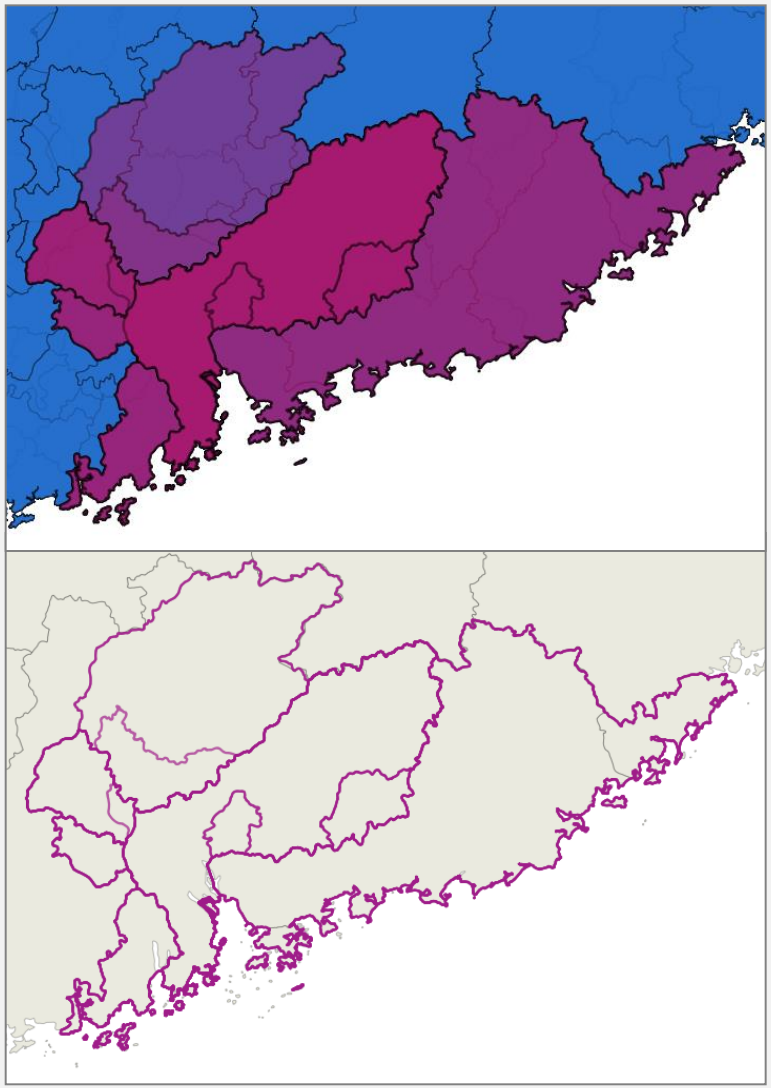
336	Prefecture C	1200	1350
337	County X	800	1500
338	County Y	1200	1320
339	County Z	1321	1340
340	Town 1	200	1700
341	Town 2	100	1500

sys-id	place-name	part-of	part-of-name	begin	end
334	Prefecture A	333	Province T	1200	1249
335	Prefecture B	333	Province T	1250	1350
336	Prefecture C	333	Province T	1200	1350
337	County X	334	Prefecture A	1200	1249
337	County X	335	Prefecture B	1250	1350
338	County Y	336	Prefecture C	1200	1350
339	County Z	336	Prefecture C	1200	1350
340	Town 1	337	County X	1200	1350
341	Town 2	338	County Y	1300	1320
341	Town 2	339	County Z	1321	1340

Relationships for hierarchy & sequence

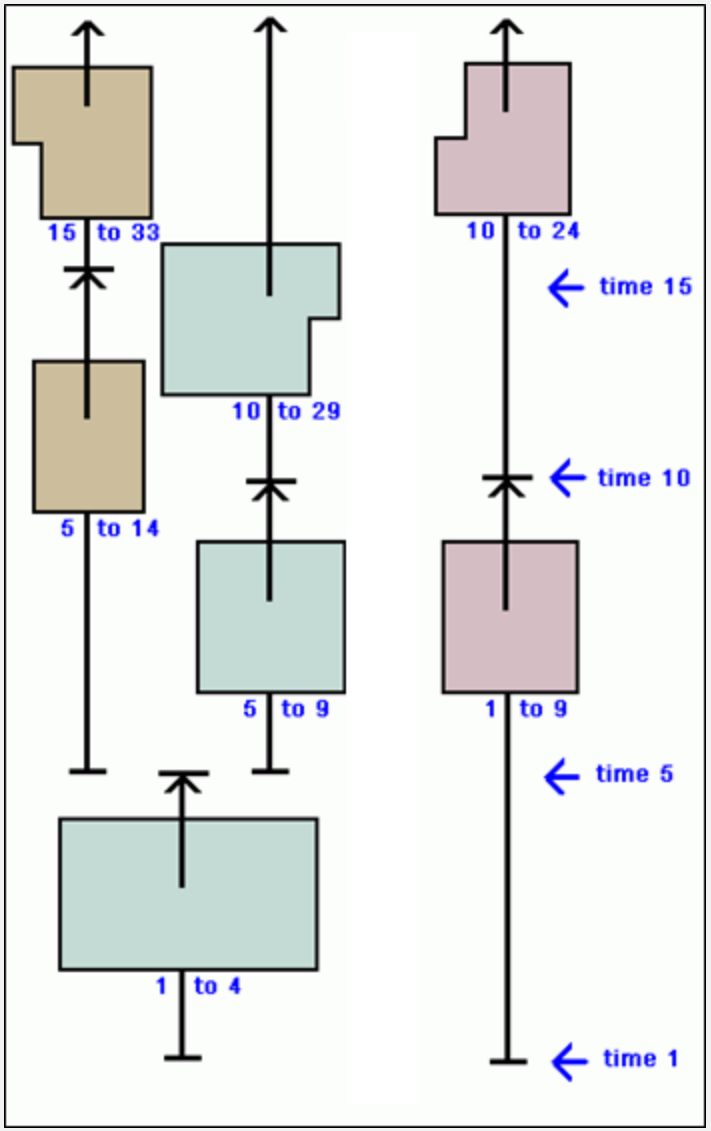
CHGIS - Resulting Time Series Vectors are *Asynchronous Objects*



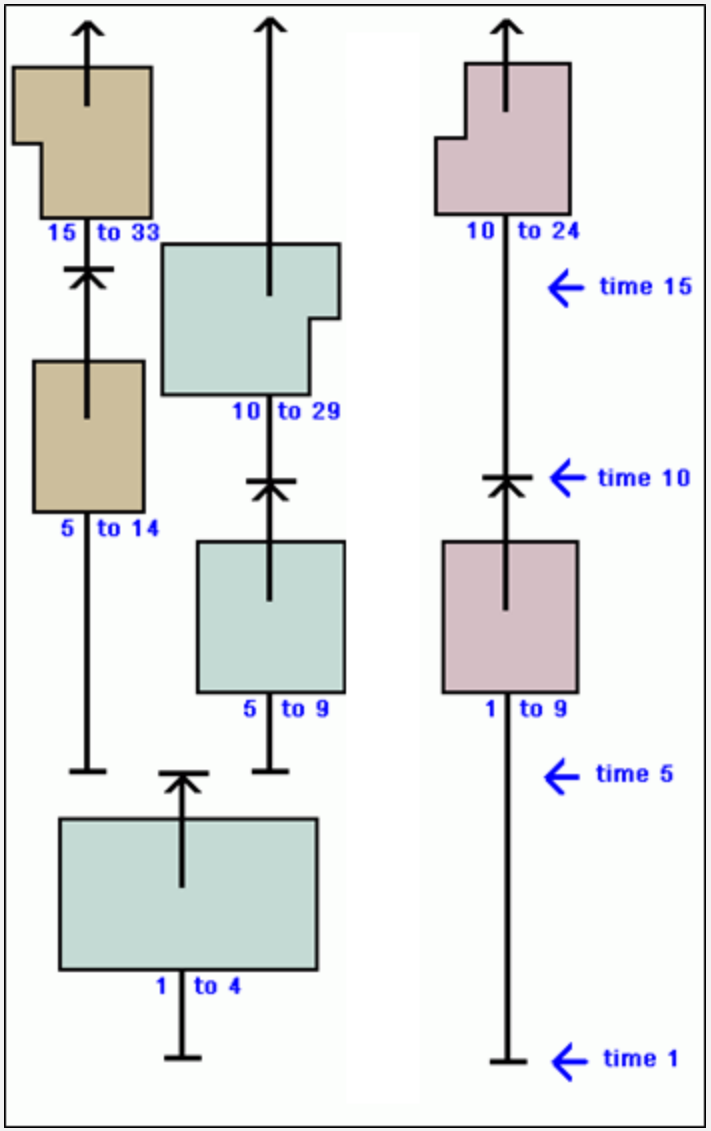
Each object is a row with Begin and End Dates

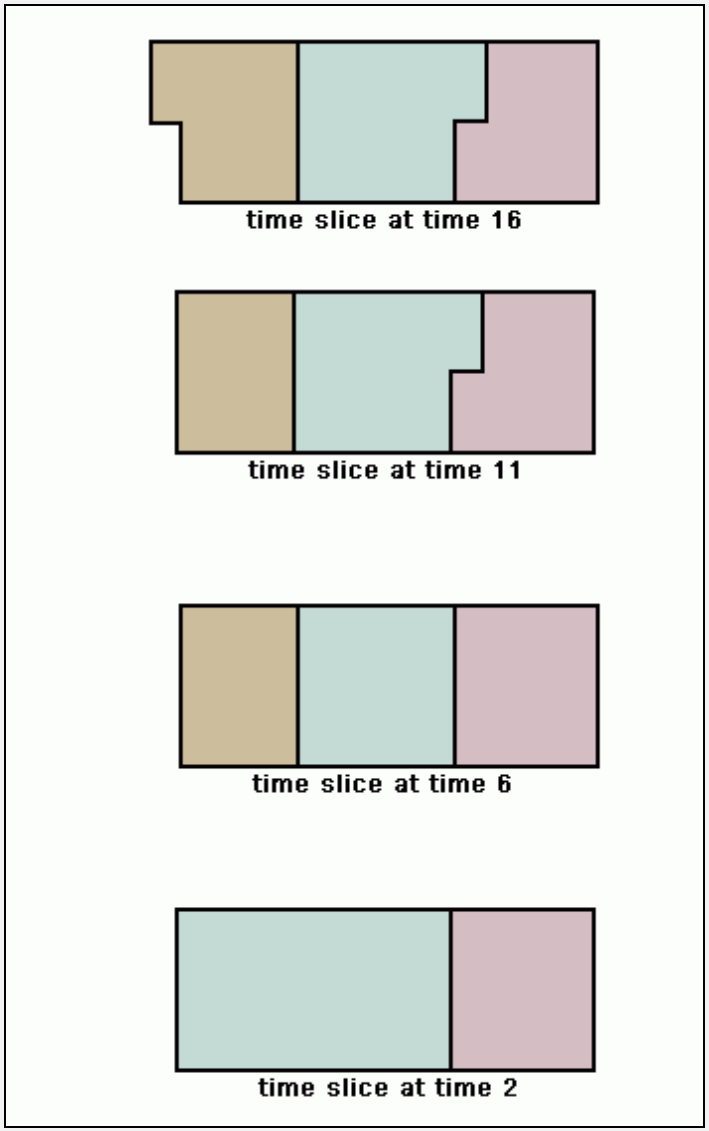
	SYS_ID	NAME_PY	NAME_CH	BEG_YR	END_YR
0	92250	Nanhai Jun	南海郡	-214	-207
1	92251	Nanhai Jun	南海郡	-206	-111
2	92252	Nanhai Jun	南海郡	-110	264
3	92253	Nanhai Jun	南海郡	265	330
4	92254	Nanhai Jun	南海郡	331	419
5	92255	Nanhai Jun	南海郡	420	420
6	92256	Nanhai Jun	南海郡	421	435
7	92257	Nanhai Jun	南海郡	436	442
8	92258	Nanhai Jun	南海郡	443	477
9	92259	Nanhai Jun	南海郡	478	510
10	92260	Nanhai Jun	南海郡	511	537
11	92261	Nanhai Jun	南海郡	538	589

Time in GIS - *Asynchronous Objects*



Time in GIS - *time slices* can be derived from *Asynchronous Objects*





Time Definition - Format, Granularity and Fuzziness

format: **day, month, year?** ISO 8601 format: YYYY-MM-DD or YYYYMMDD

granularity: **year** [for CHGIS time range of 2,100 years]

date rules:

fuzzy >

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"

precise >

Rule 6: Date is specified, such as "*jiachen* day"

Time Definition - *Pre* and *Post* buffers for fuzziness

Common Eras **http://commoneras.ecs.soton.ac.uk/**

Buffer between Outer and Inner time bands >

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  ▼<era>
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     <primary_name>The Fourth Doctor (Tom Baker)</primary_name>
     <primary name lang>en</primary name lang>
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     <end_inner>1981-03-21</end_inner>
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     <labels/>
     <regions/>
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     </succeeds>
    ▼<proceeds>
       <proceed>10</proceed>
     </proceeds>
   </era>
 </eras>
```

Time Definition - Dates based on *Named Time Periods* or *Chronologies*

For the Placename:

Rutu-piae (lat) [georeferenced to modern location: Richborough (eng)]

Dates:

43 CE (begin) – 43 CE (end) (authority: x) (note: invasion landing site)

Period:

41 CE - 54 CE (Claudius reign)

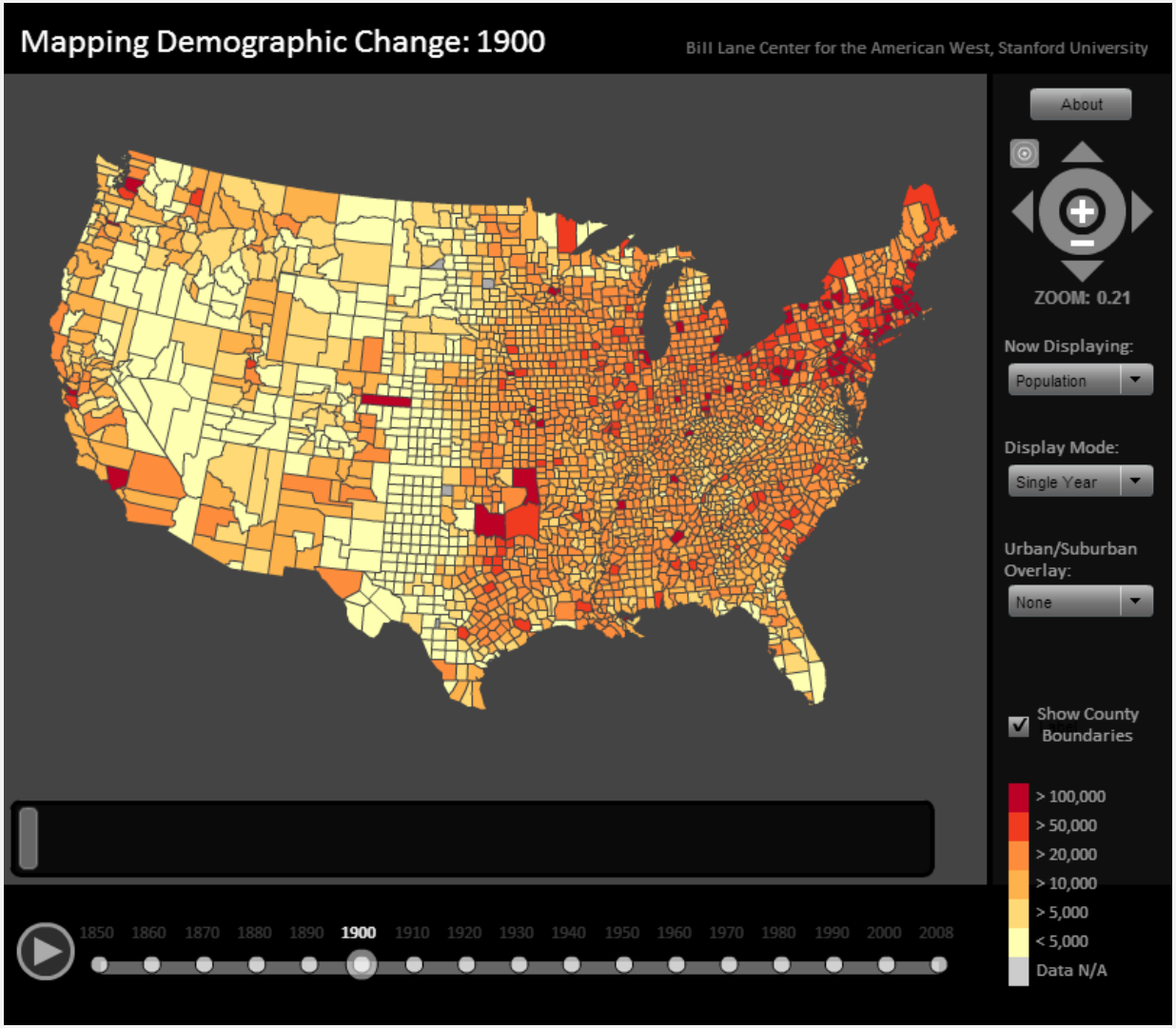
Context:

44 BCE – 395 CE (-0044 to -395) (Roman Empire)

Time in GIS - Visualization methods

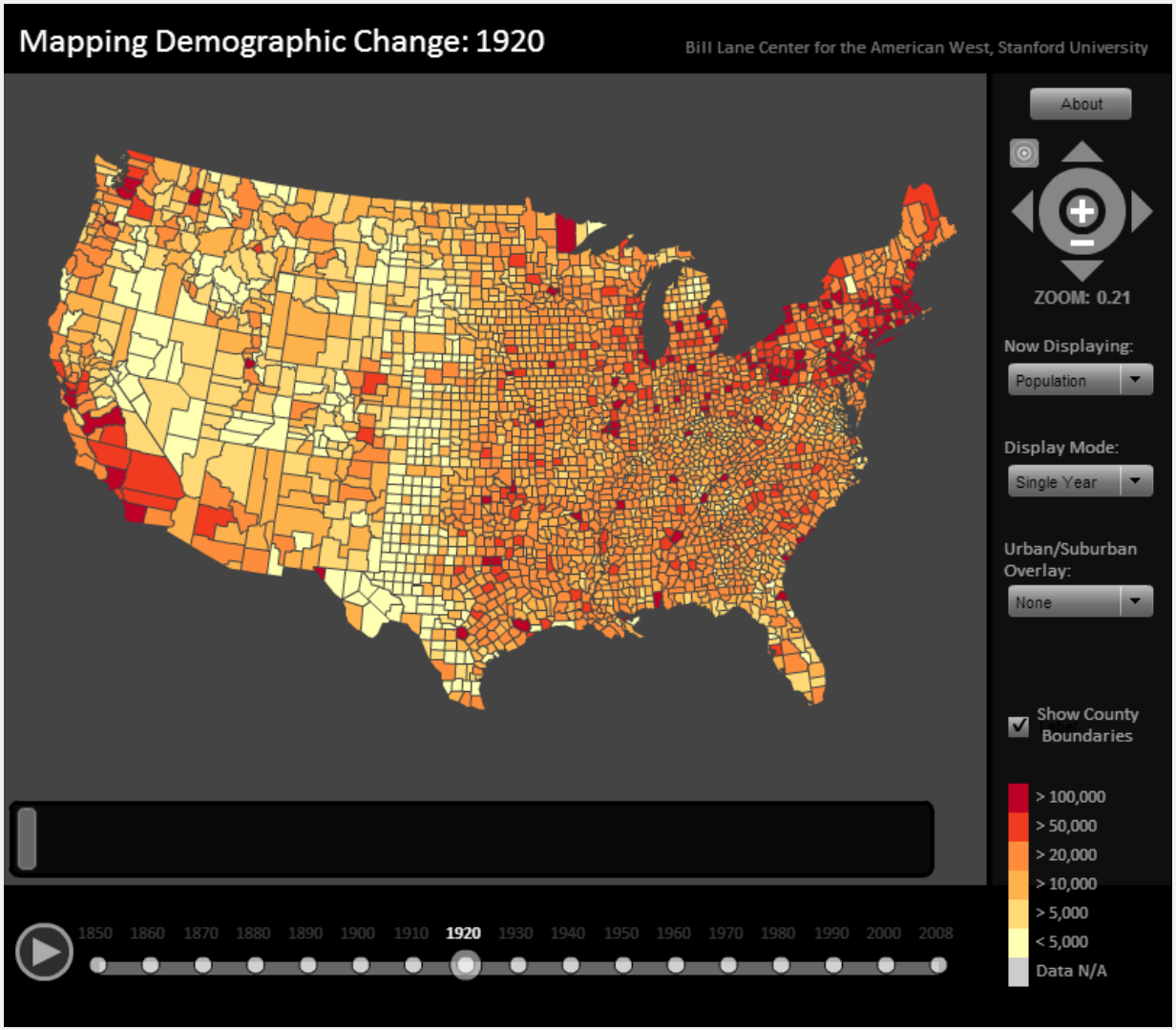
- Time Slices
- Time Series
- Networks

Time in GIS - Time Slices



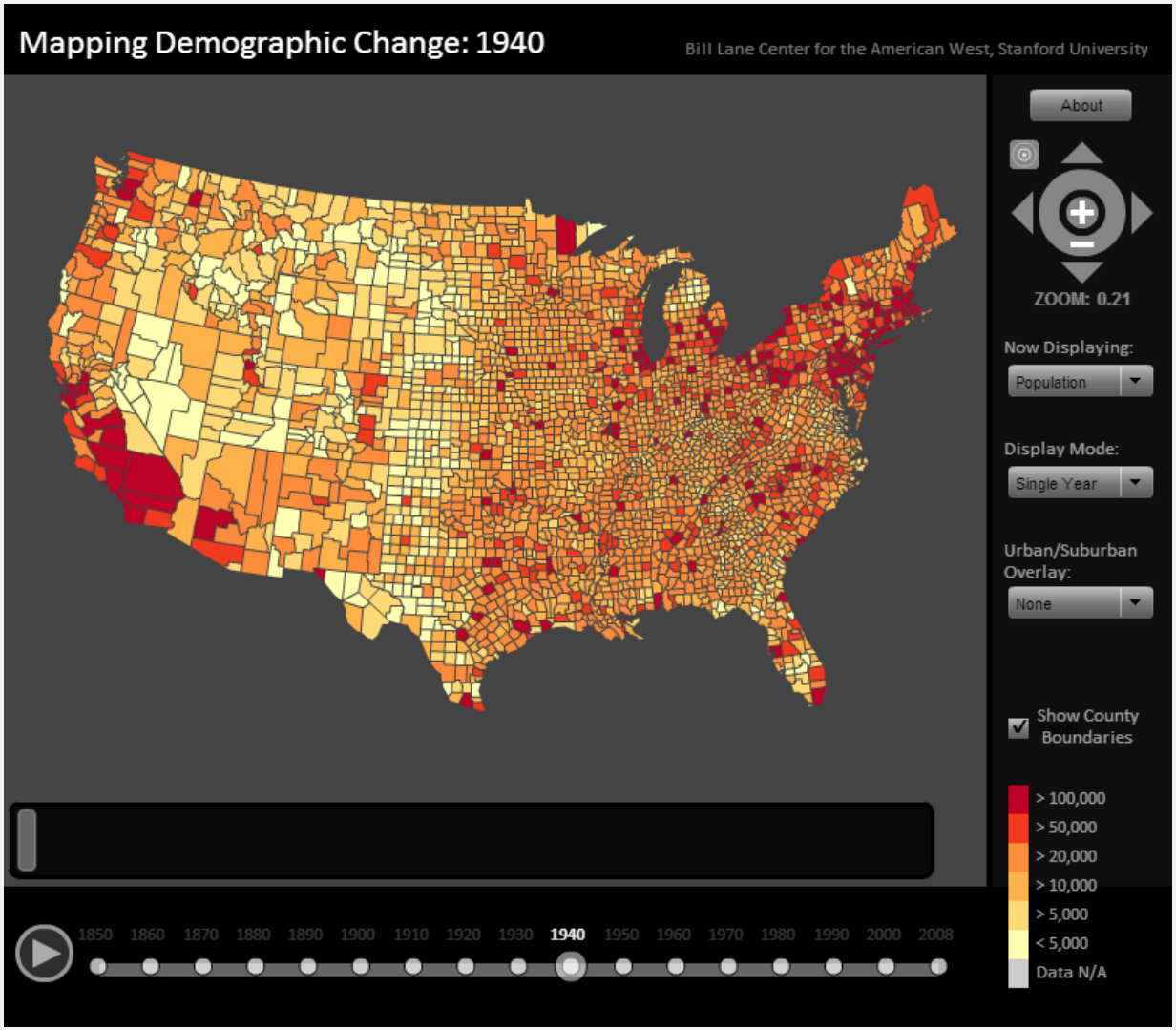
Data: NHGIS https://www.nhgis.org/
http://ruralwest.stanford.edu/cgi-bin/web/Viz_DemographicChangePage.php

Time in GIS - Time Slices



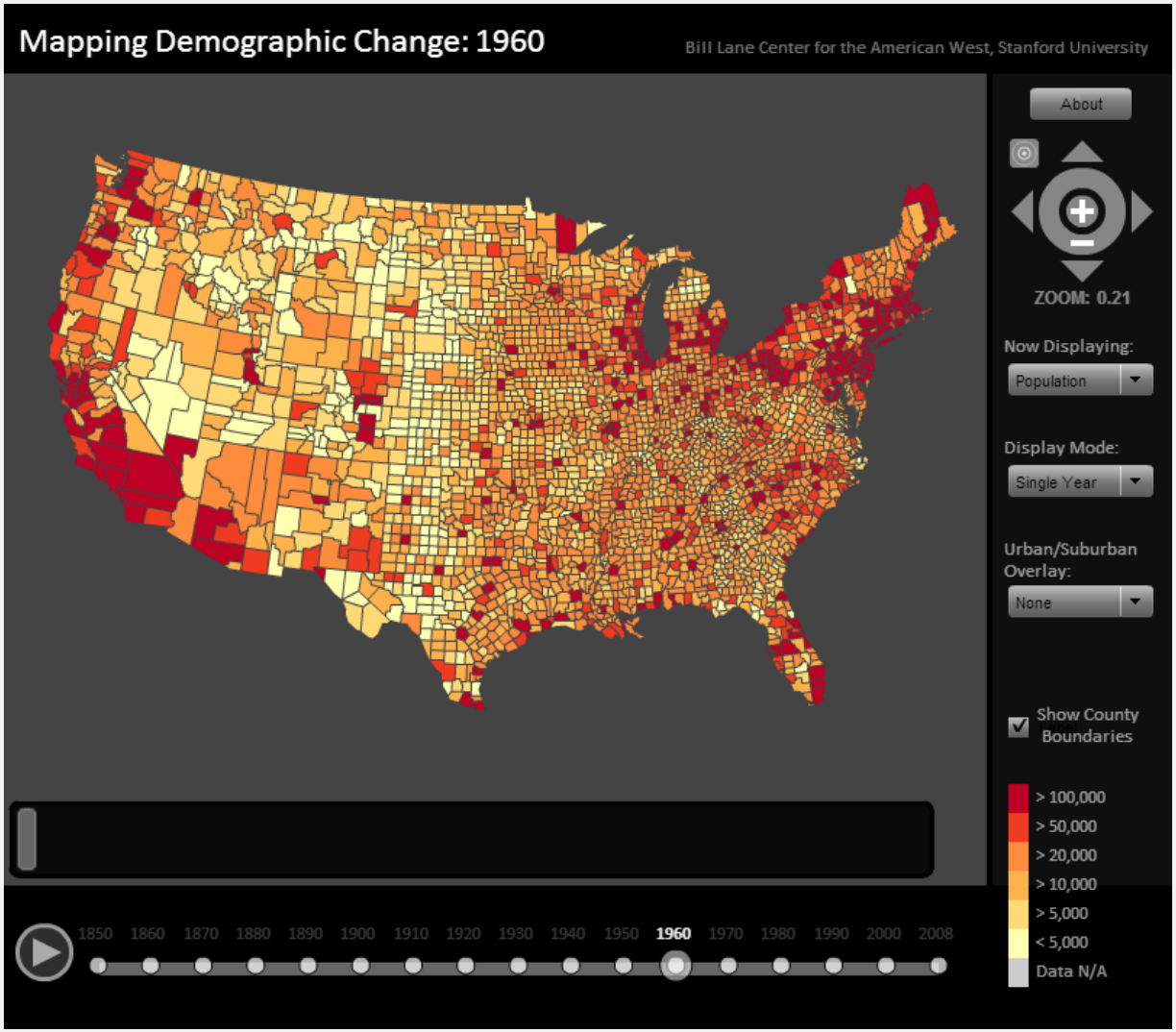
Data: NHGIS https://www.nhgis.org/
http://ruralwest.stanford.edu/cgi-bin/web/Viz_DemographicChangePage.php

Time in GIS - Time Slices



Data: NHGIS https://www.nhgis.org/
http://ruralwest.stanford.edu/cgi-bin/web/Viz_DemographicChangePage.php

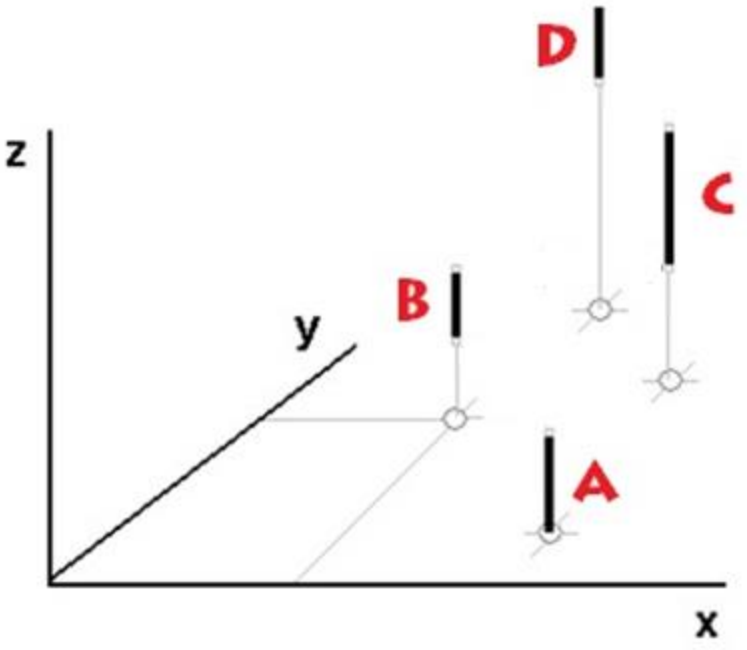
Time in GIS - Time Slices



Data: NHGIS https://www.nhgis.org/
http://ruralwest.stanford.edu/cgi-bin/web/Viz_DemographicChangePage.php

Time in GIS - Point-phases

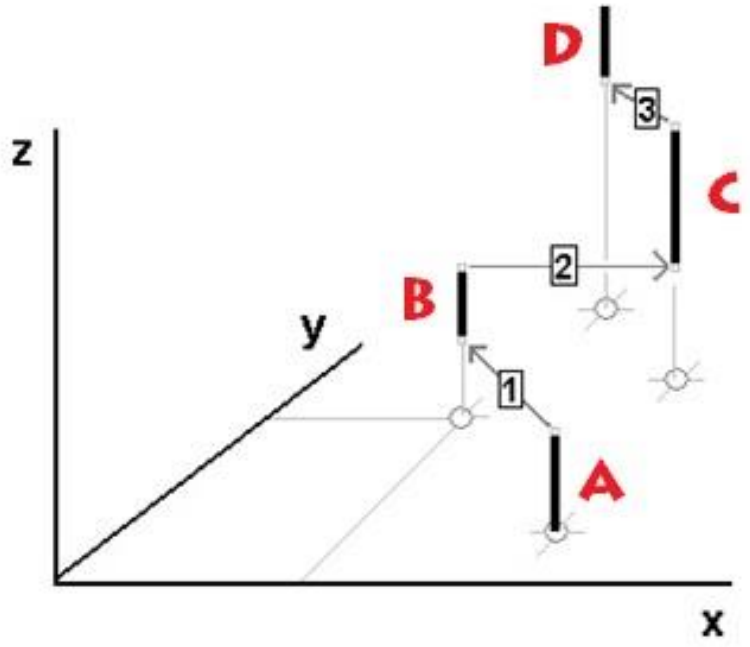
object	begin	end	precBy
A	t1	t2	
B	t2	t3	A
C	t3	t4	B
D	t4	t5	C



z-axis as time (earliest at bottom)

Time in GIS - Point-phases and transitions

object	begin	end	precBy
A	t1	t2	
B	t2	t3	A
C	t3	t4	B
D	t4	t5	C



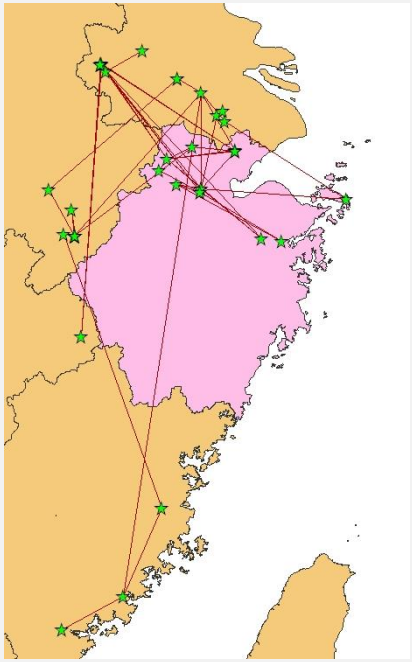
Transition Table

prevID	*transition*	*subsID*
A	type 1	B
B	type 2	C
C	type 1	D

Transitions can have durations and can be classified…

Time in GIS - Nodes in a sequence of movements

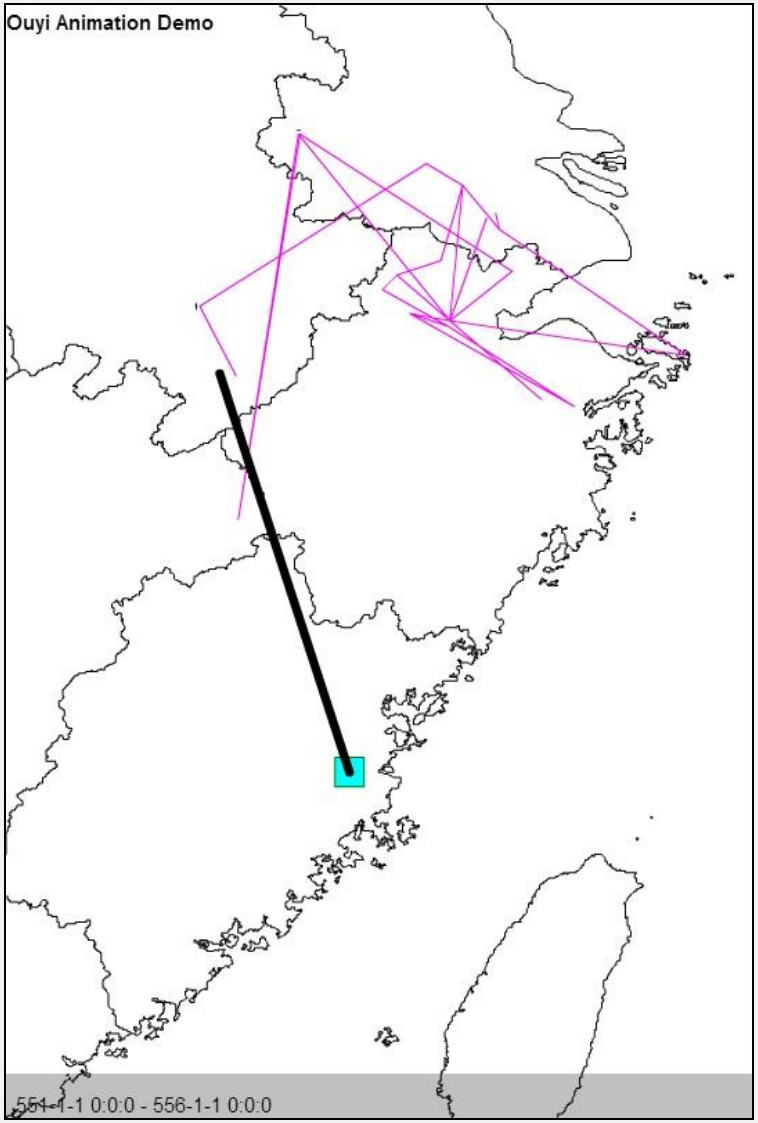
object	begin	end	precBy
A	t1	t2	
B	t2	t3	A
C	t3	t4	B
D	t4	t5	C



Time in GIS - Nodes in a sequence of movements – Animation triggers

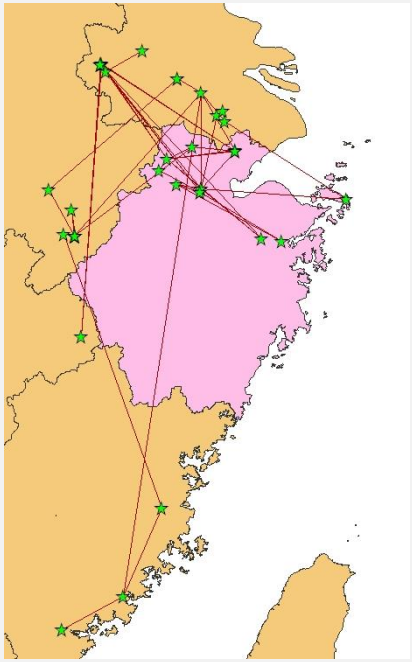
Animation triggers

1) Transition Vector Appear
2) Node Appear
3) Transition Vector Disappear
4) Transition Vector Trail Remains
5) Node Exist
6) Next Transition Vector Appears
7) Node Disappear

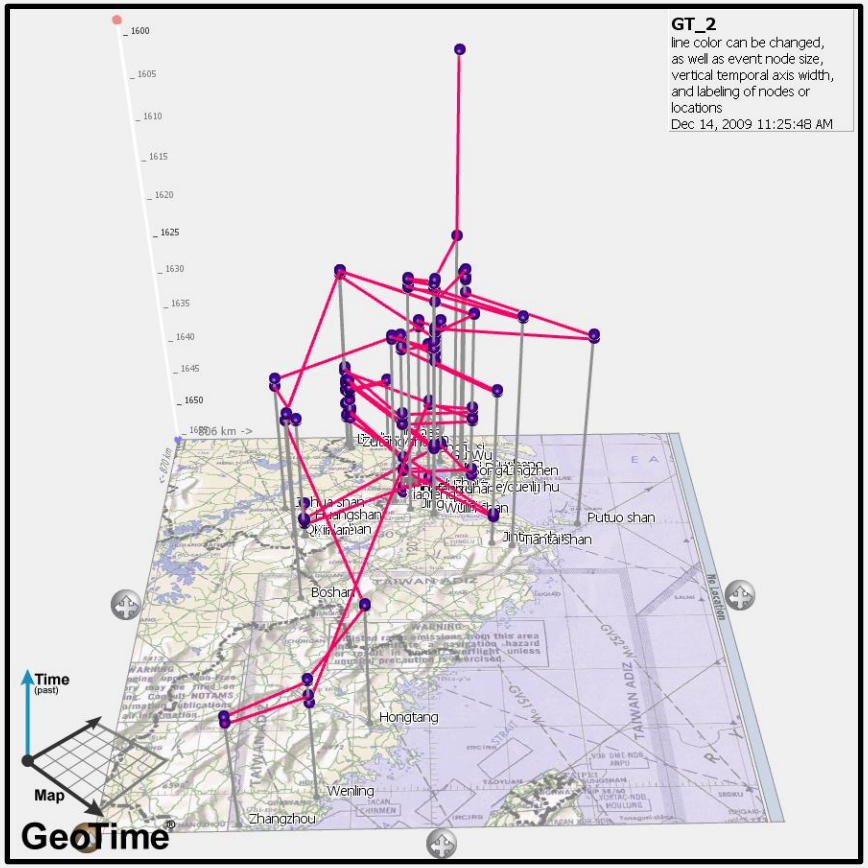


http://www.fas.harvard.edu/~chgis/work/docs/papers/ouyi_flash_demo.swf

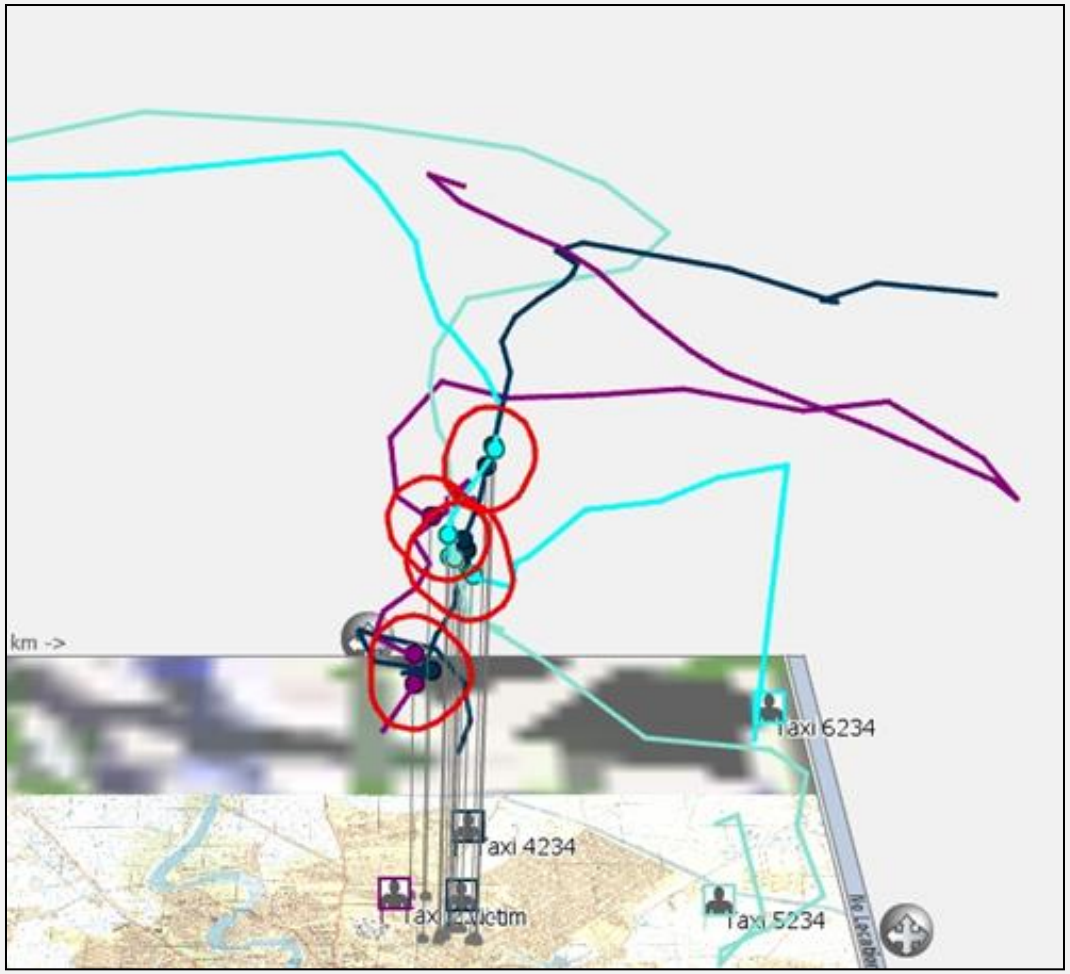
Time in GIS - Nodes in a sequence of movements = spatio-temporal paths



z-axis as time (earliest at top)



Time in GIS - Proximity queries on spatio-temporal paths



Combining both distance and time buffers

Time in GIS - Nodes as hierarchical elements of a *network model*

Historical Instances Table

sys-id	hist-place	begin	end
333	Province T	1200	1350
334	Prefecture A	1200	1249
335	Prefecture B	1250	1350
336	Prefecture C	1200	1350
337	County X	800	1500
338	County Y	1200	1320
339	County Z	1321	1340
340	Town 1	200	1700
341	Town 2	100	1500

Part-Of Table

sys-id	place-name	part-of	part-of-name	begin	end
334	Prefecture A	333	Province T	1200	1249
335	Prefecture B	333	Province T	1250	1350
336	Prefecture C	333	Province T	1200	1350
337	County X	334	Prefecture A	1200	1249
337	County X	335	Prefecture B	1250	1350
338	County Y	336	Prefecture C	1200	1350
339	County Z	336	Prefecture C	1200	1350
340	Town 1	337	County X	1200	1350
341	Town 2	338	County Y	1300	1320
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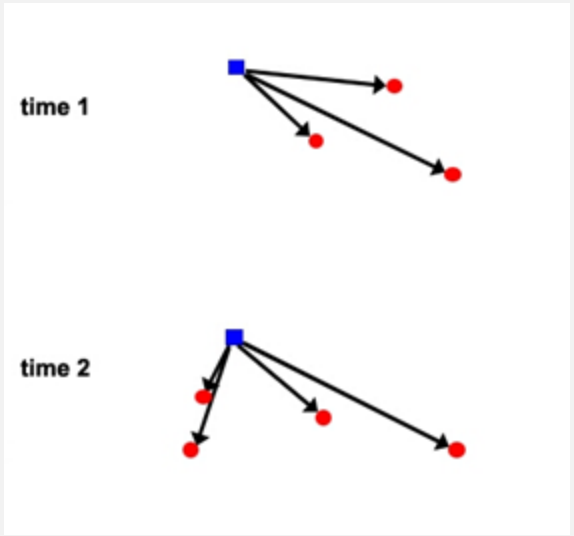
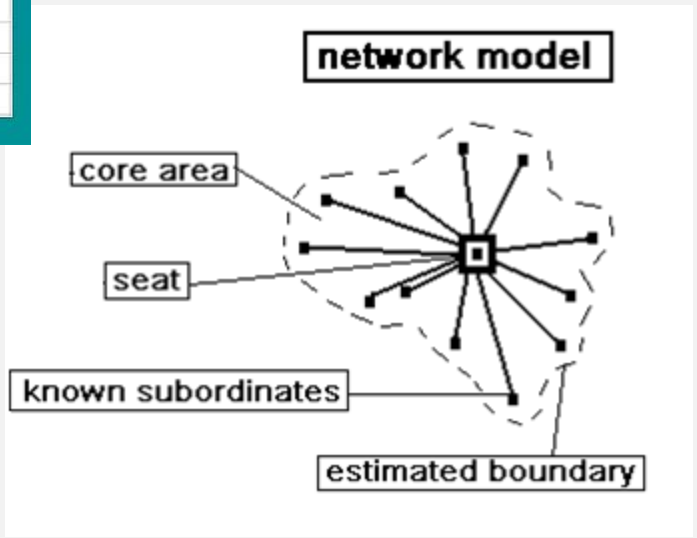
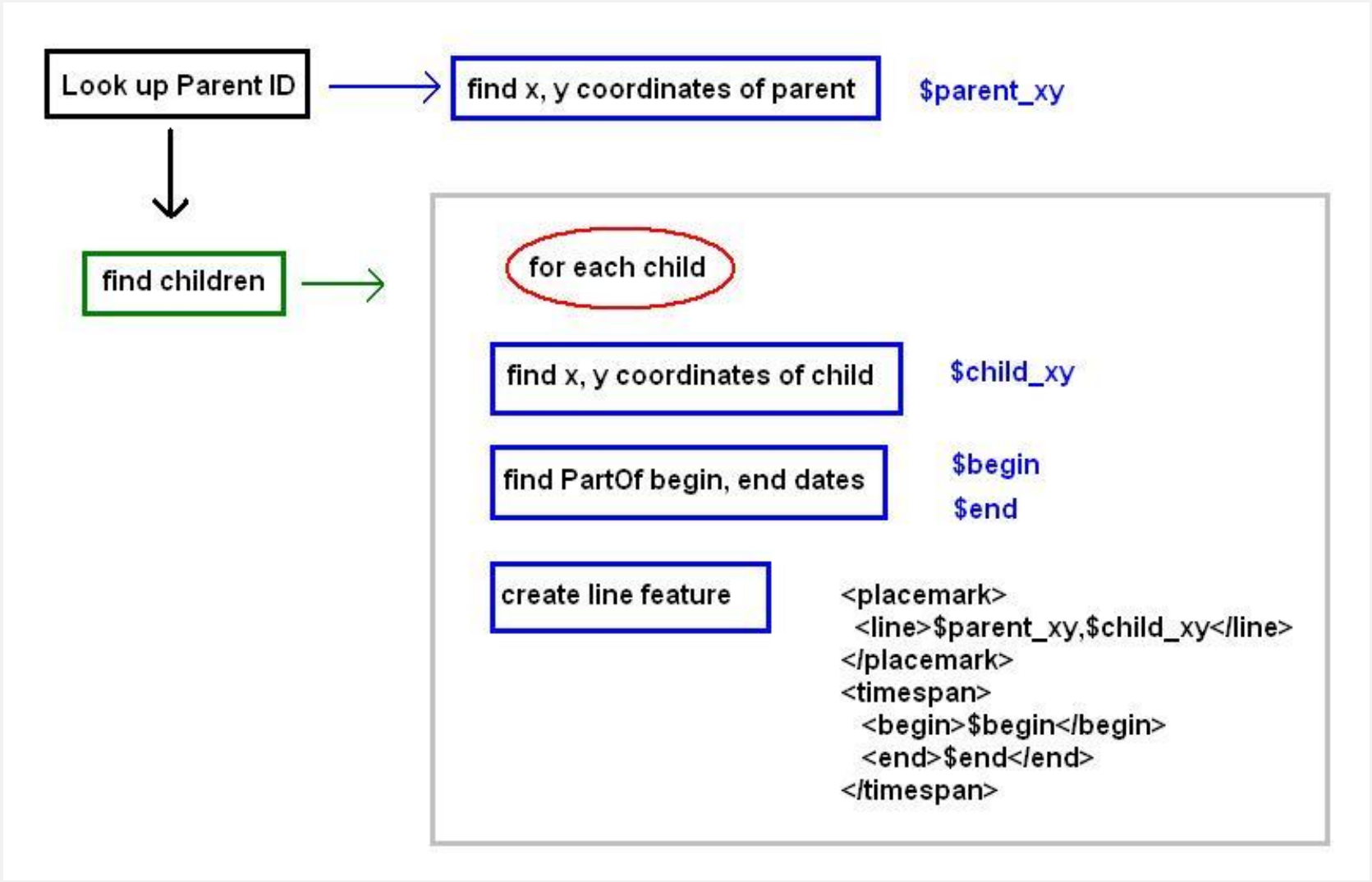
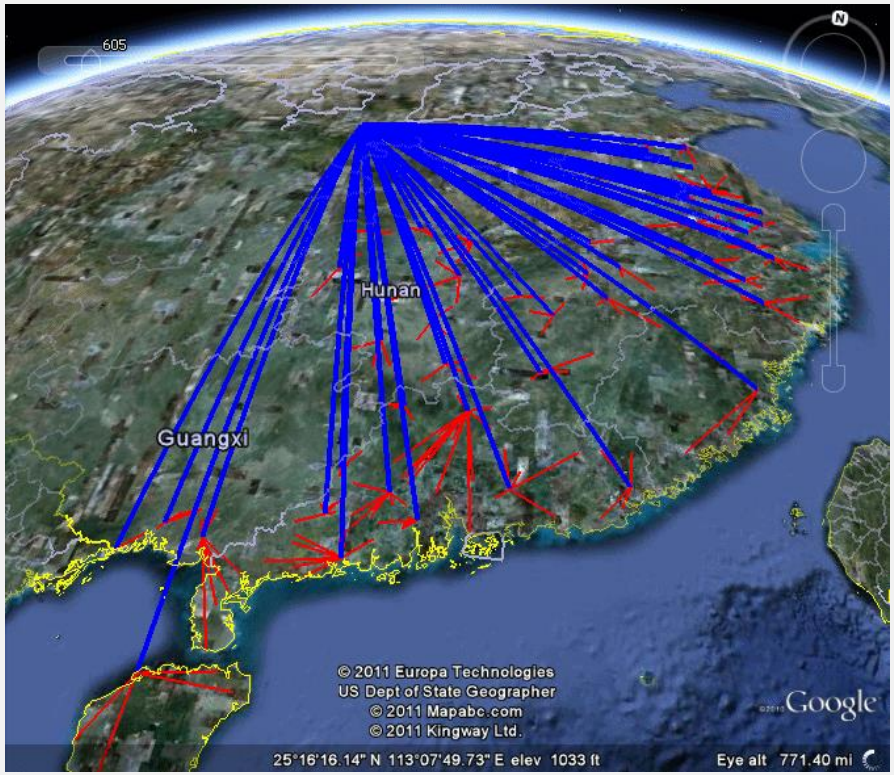




Time in GIS - Spatio-temporal point objects -> network model in KML

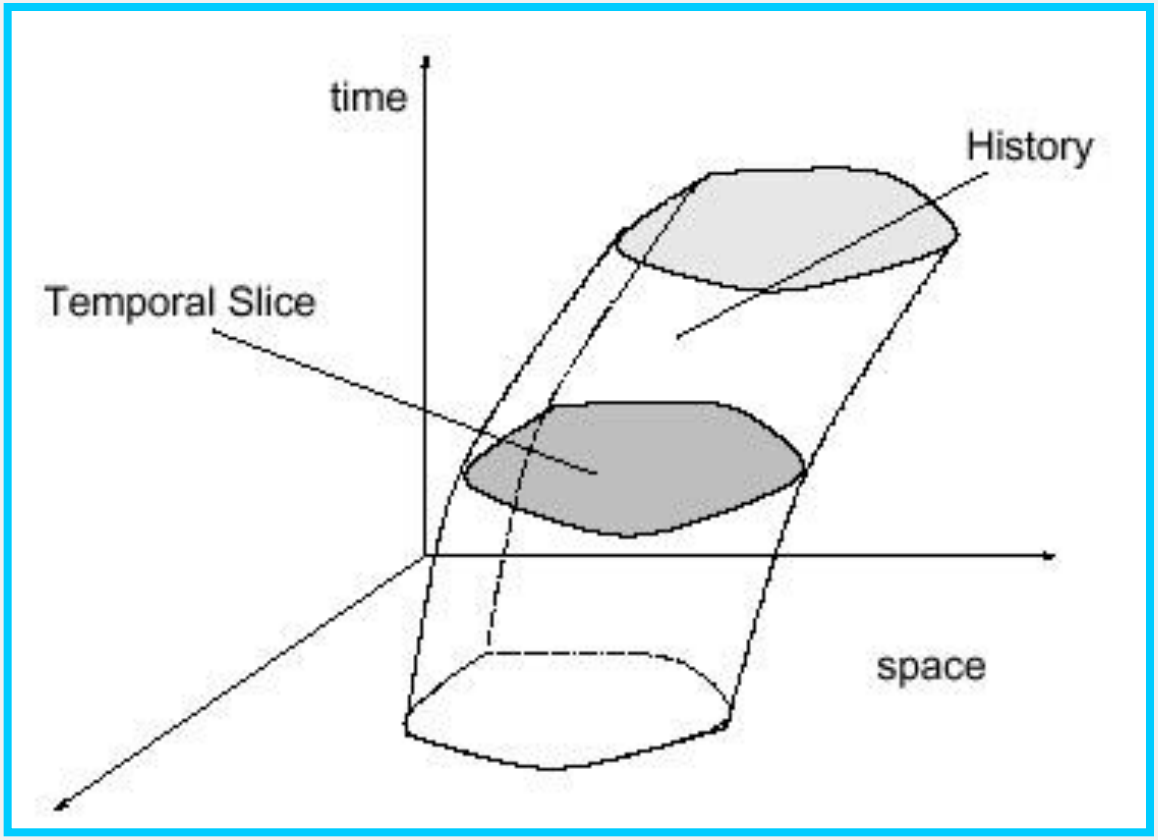


Time in GIS - Animation of network model in Google Earth

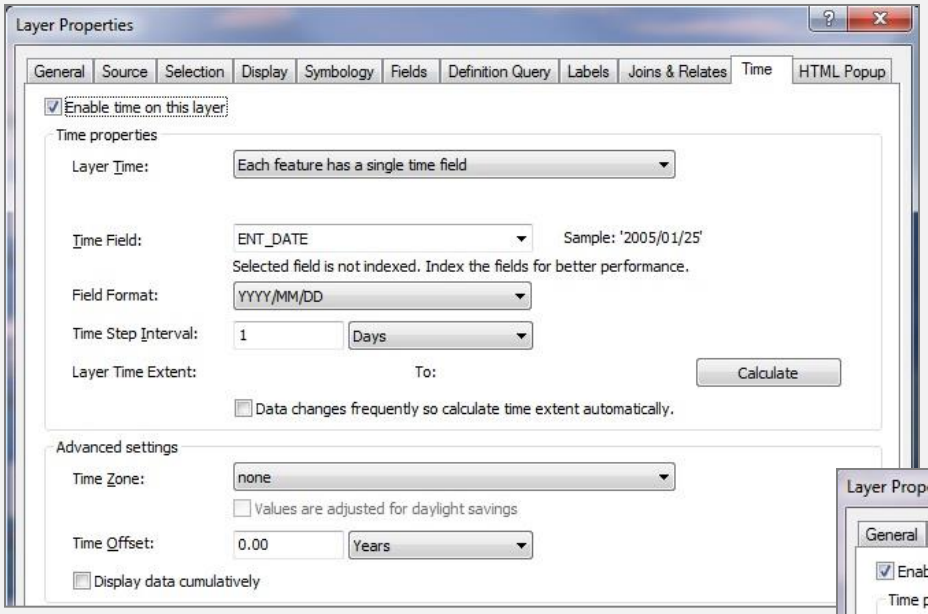


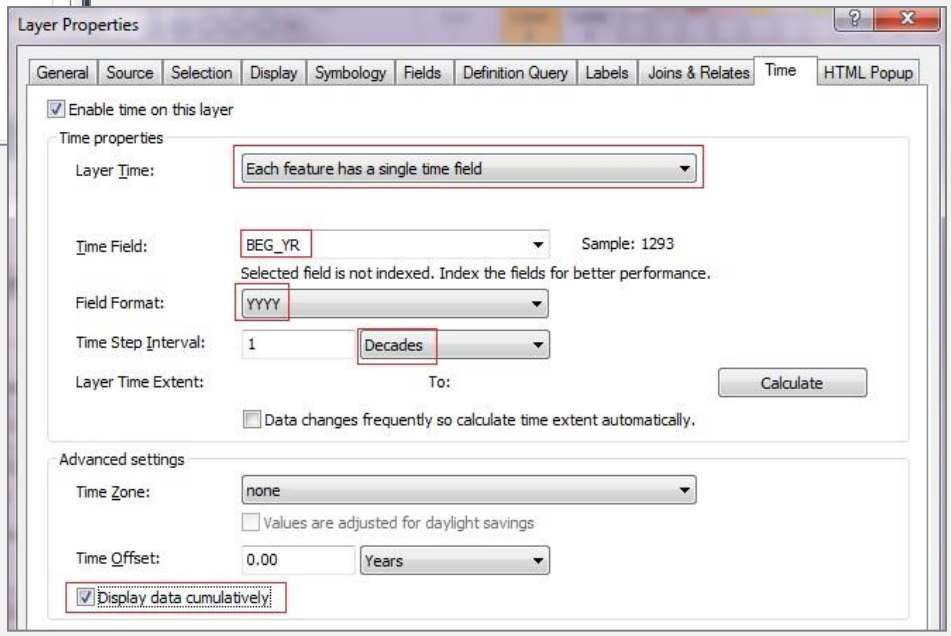
https://cga-download.hmdc.harvard.edu/publish_web/Geo_Tools/teKML/examples/

Time in GIS - Visualization of spatio-temporal polygon objects

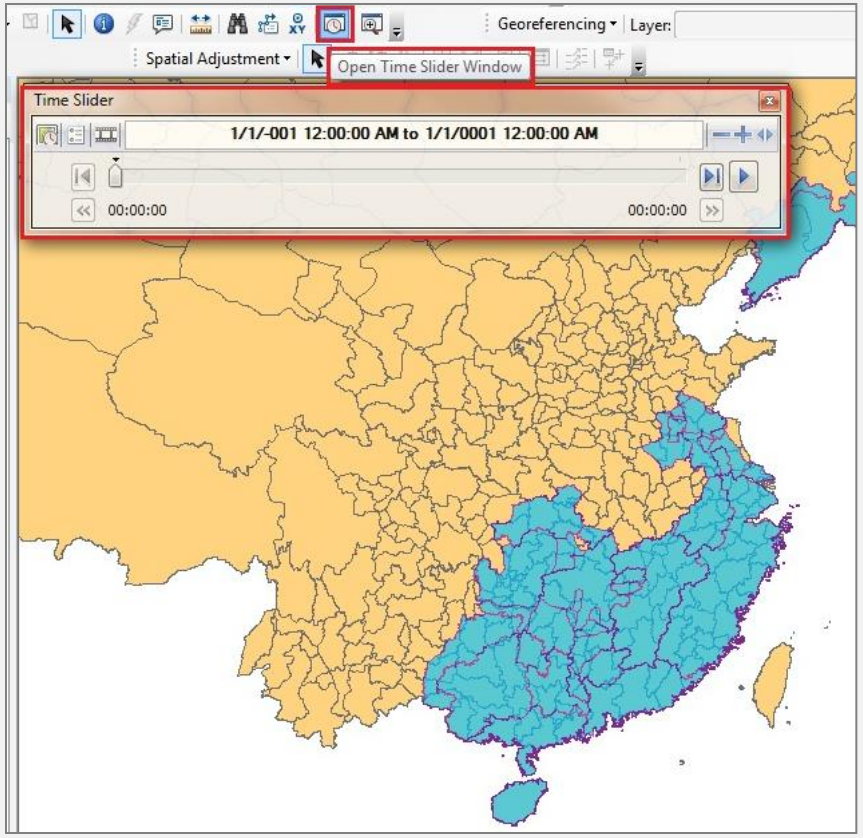


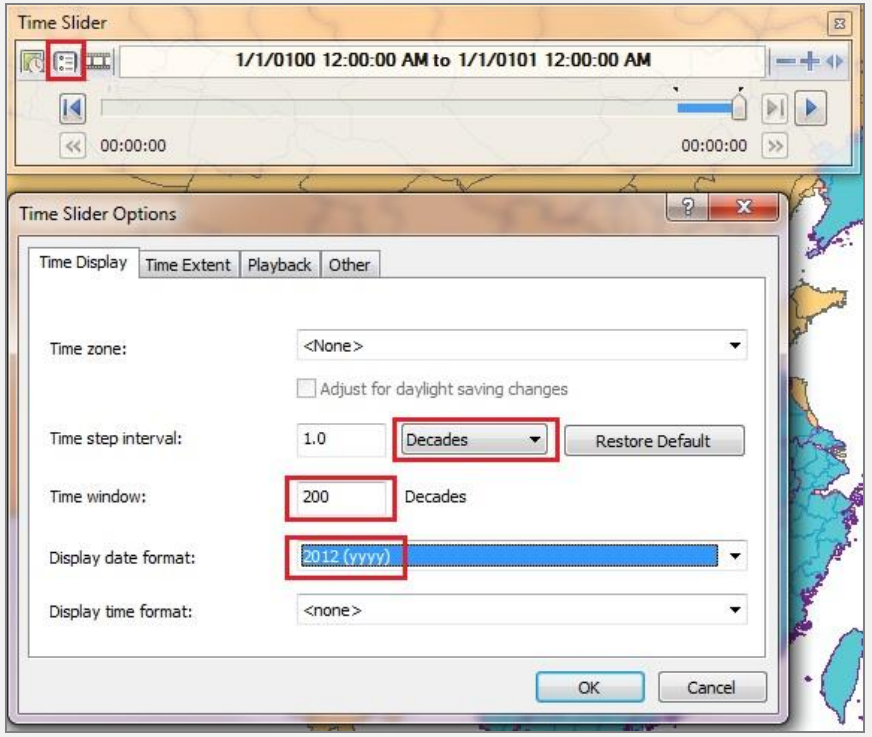
Time in GIS - Visualization in ArcGIS 10: Time Properties



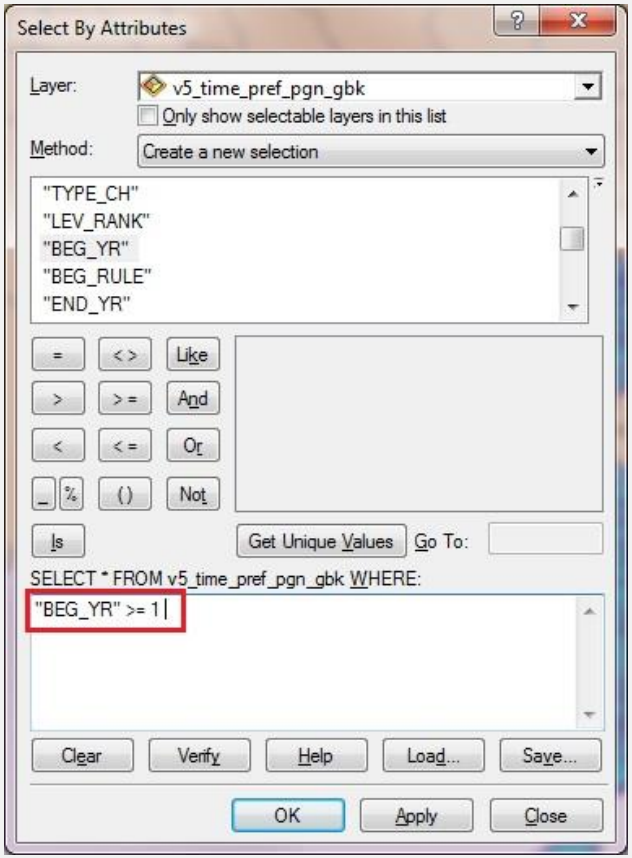


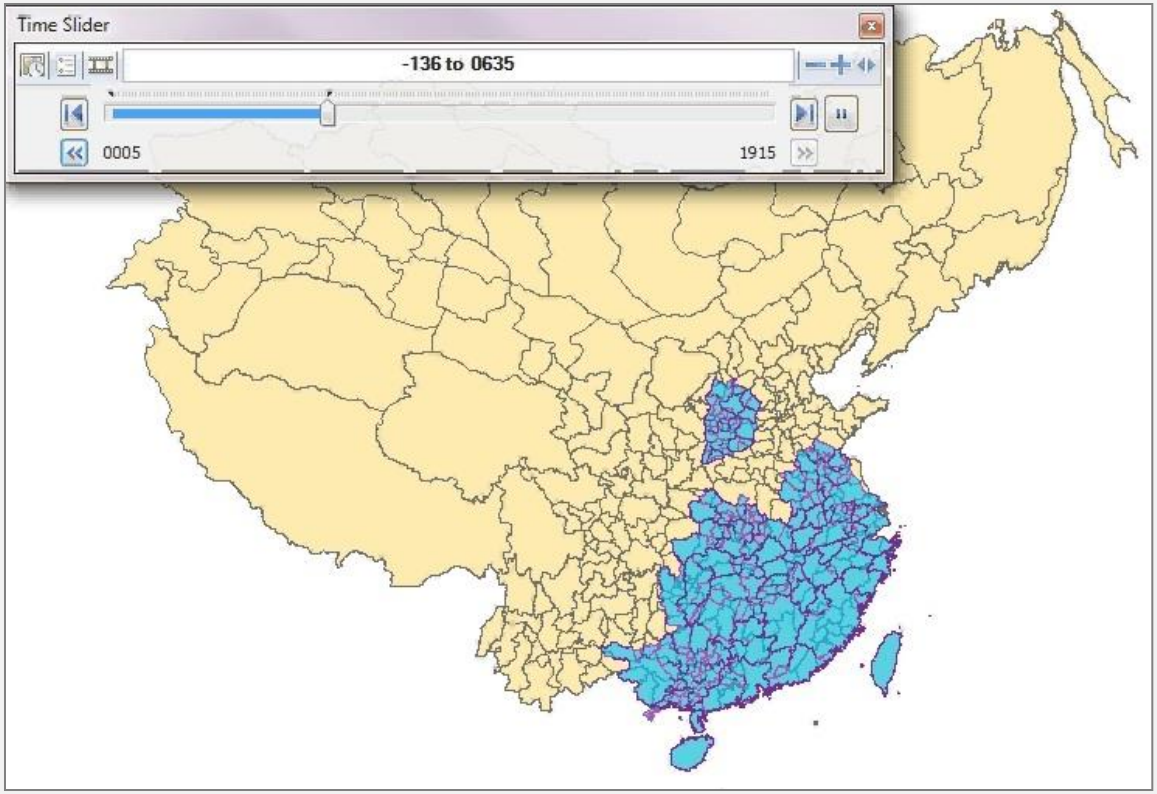
Time in GIS - Visualization in ArcGIS 10: Time Slider



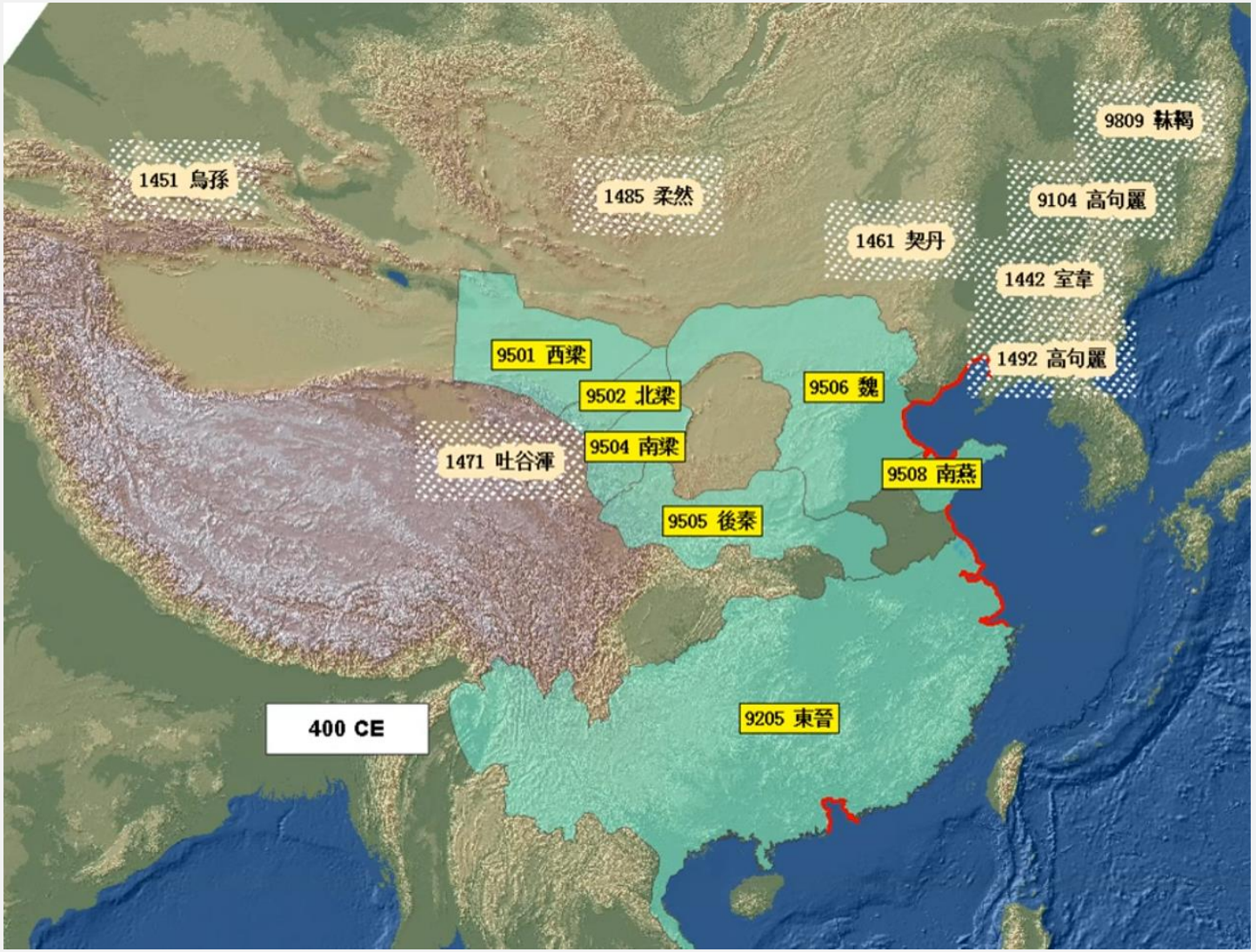


Time in GIS - ArcGIS 10 Time Slider cannot use negative years



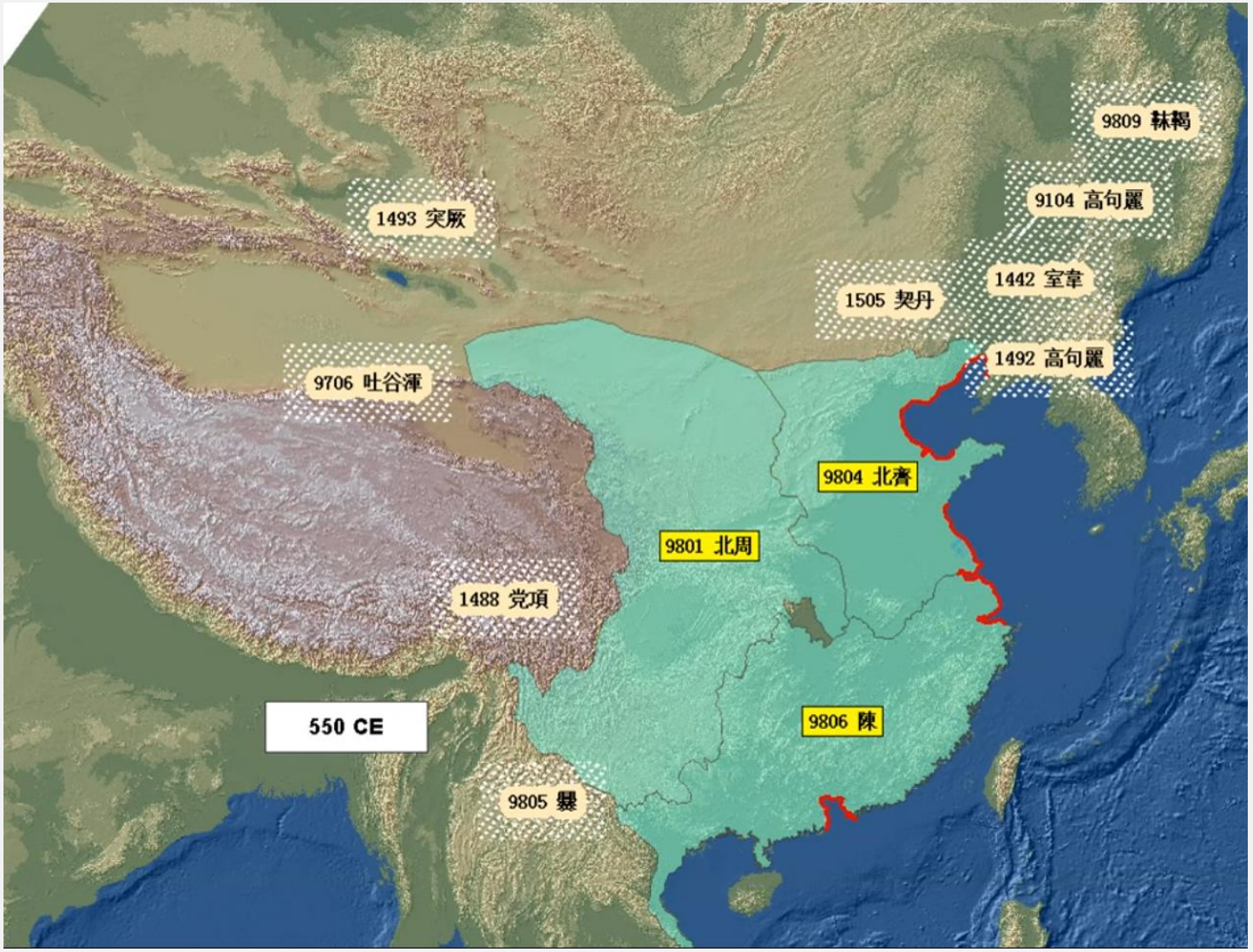


Time in GIS - Asynchronous polygons for animations



http://www.youtube.com/watch?v=ew1xaUiBQC4

Time in GIS - Asynchronous polygons for animations



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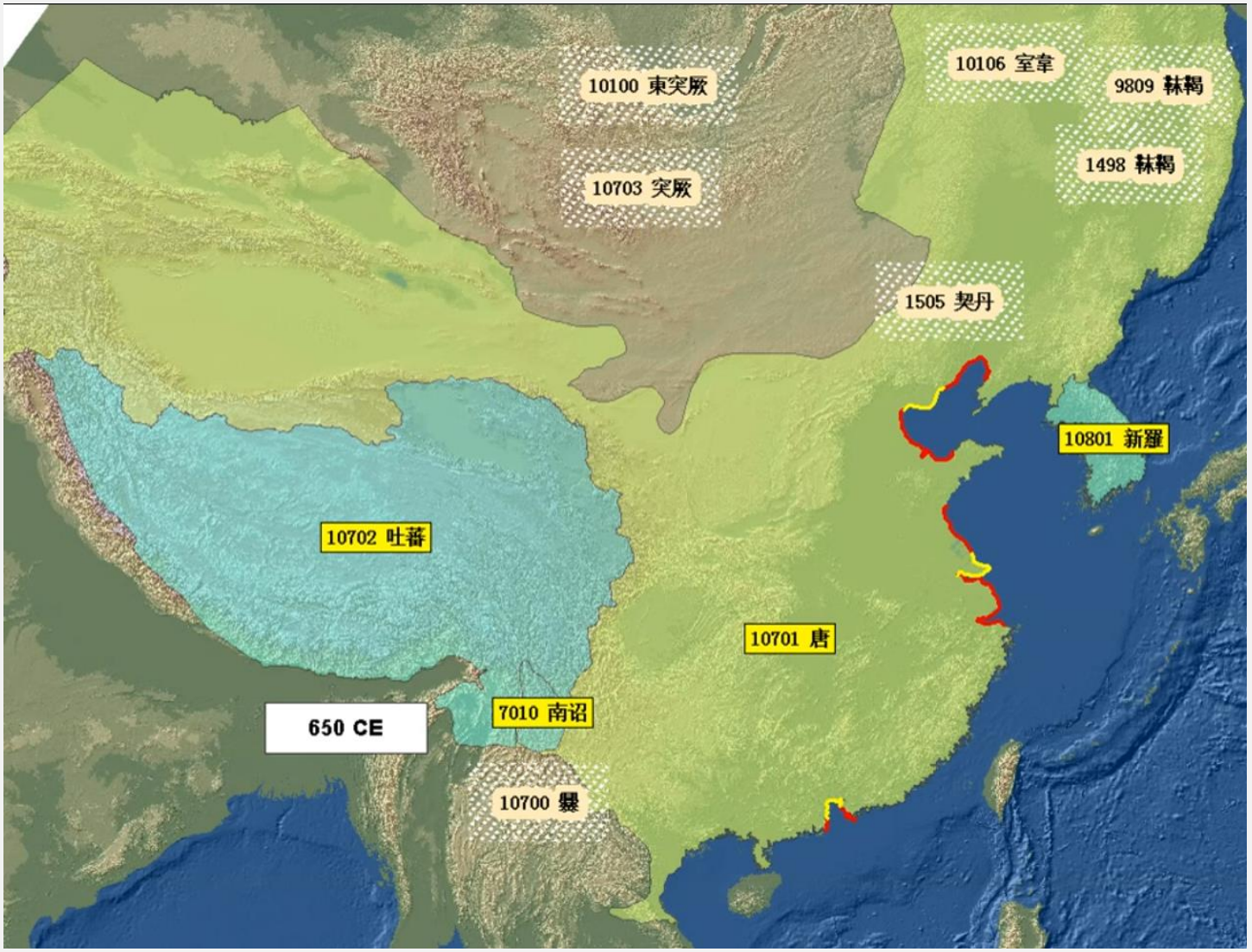
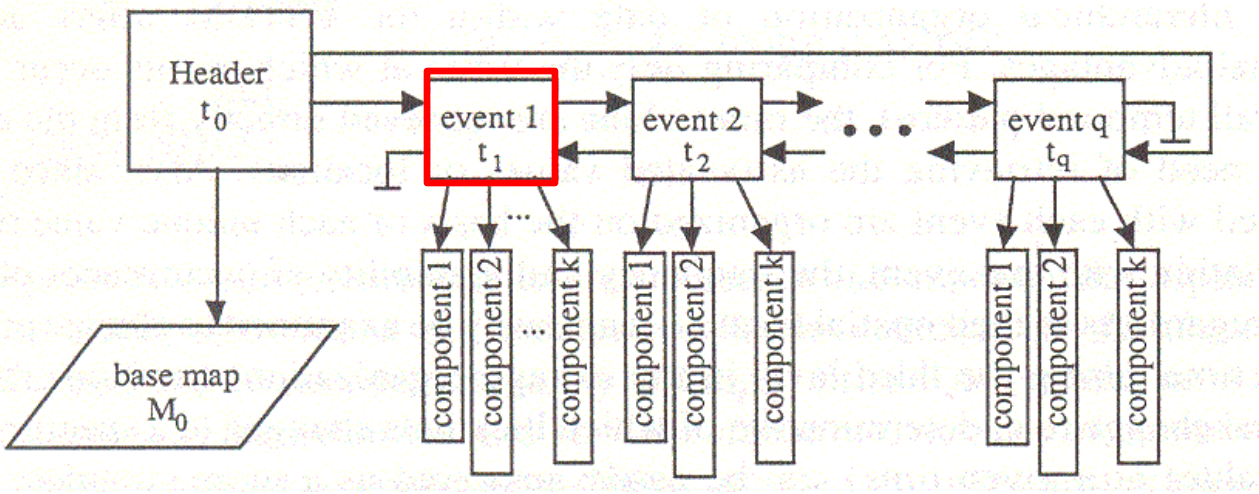
Time in GIS - Asynchronous polygons for animations

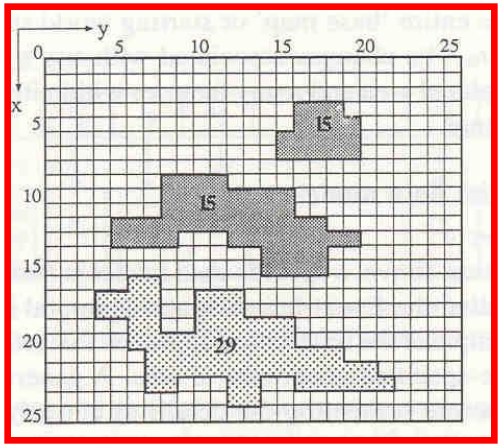


http://www.youtube.com/watch?v=ew1xaUiBQC4

Event-based space time model

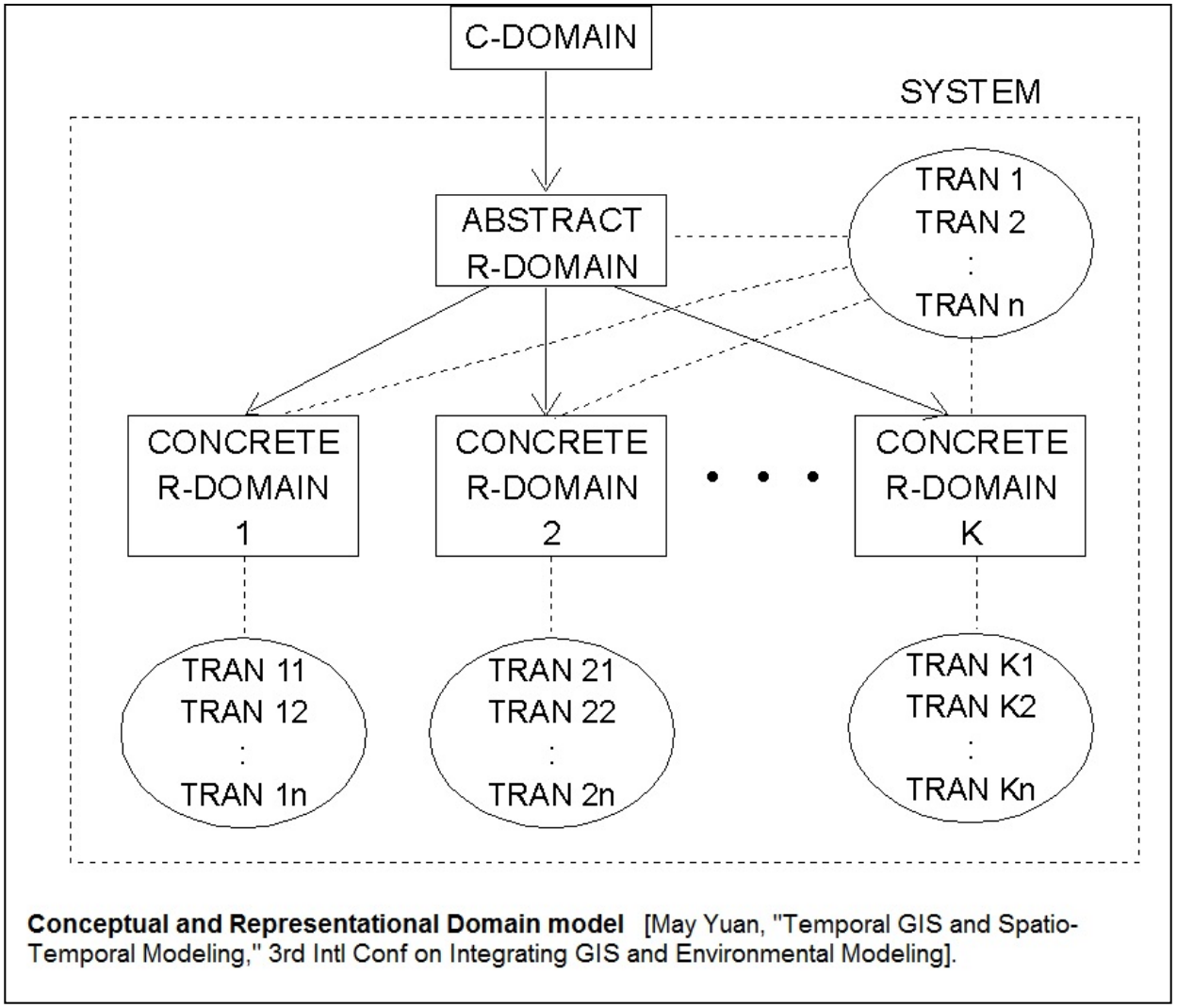


event 1



See: Peuquet and Duan (1995) http://www.tandfonline.com/doi/abs/10.1080/02693799508902022

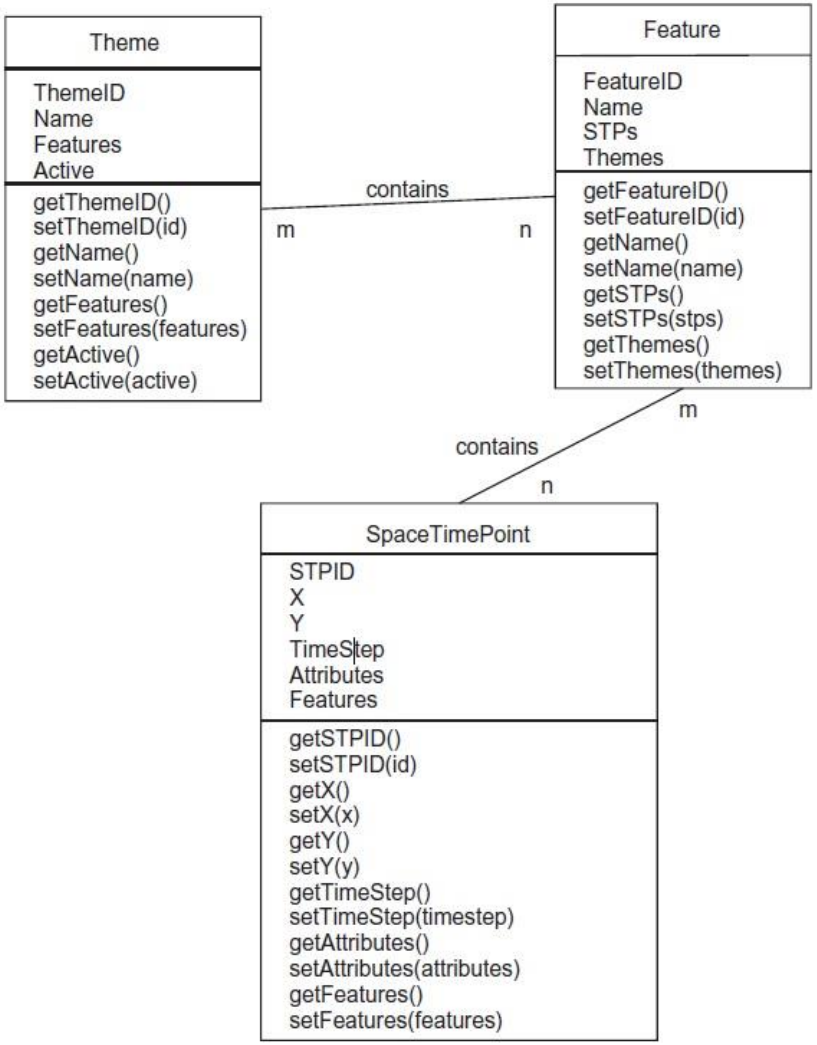
Temporal GIS model



Conceptual and Representational Domain model [May Yuan, "Temporal GIS and Spatio-Temporal Modeling," 3rd Intl Conf on Integrating GIS and Environmental Modeling].

http://ncgia.ucsb.edu/conf/SANTA_FE_CD-ROM/sf_papers/yuan_may/may.html

Extended Dynamic GIS Model - EDGIS



UML Diagram of EDGIS classes. [Pultar, Cova, Yuan, Goodchild. "EDGIS: a dynamic GIS based on space time points," in Geographic Information Science, Apr 2012]

http://www.geog.ucsb.edu/~good/papers/491.pdf

Thanks!

mberman [at] fas.harvard.edu

http://www.fas.harvard.edu/~chgis/

http://www.fas.harvard.edu/~chgis/gazetteer/