Time Geography for Activity Modeling with GPS Tracking Data

GPS Tracking and Time-Geography Applications for Activity Modeling and Microsimulation –

FHWA-sponsored Peer Exchange and CSISS Specialist Meeting

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Shih-Lung Shaw

Professor, Department of Geography

University of Tennessee

Knoxville, TN, USA

Email: sshaw@utk.edu

Acknowledgment: Hongbo Yu, Geography, Oklahoma State University

Activity Modeling and GPS Tracking Data:

- GPS tracking data provide useful information of *where* and *when* people or vehicles are located.
- GPS data *per se* do not indicate *who, what* and *why* people and vehicles are at particular locations at certain times.
- In other words, GPS helps collect data of *movements* rather than *activities*.

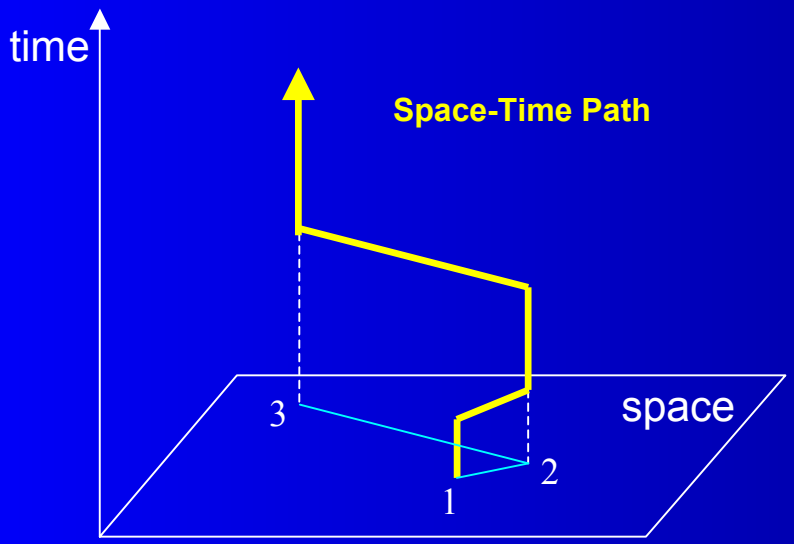
- For activity modeling, it is also important to collect and/or derive additional information such as:
  - individual/household characteristics
  - activities and opportunities
  - constraints/interdependency of scheduling/performing activities, among others

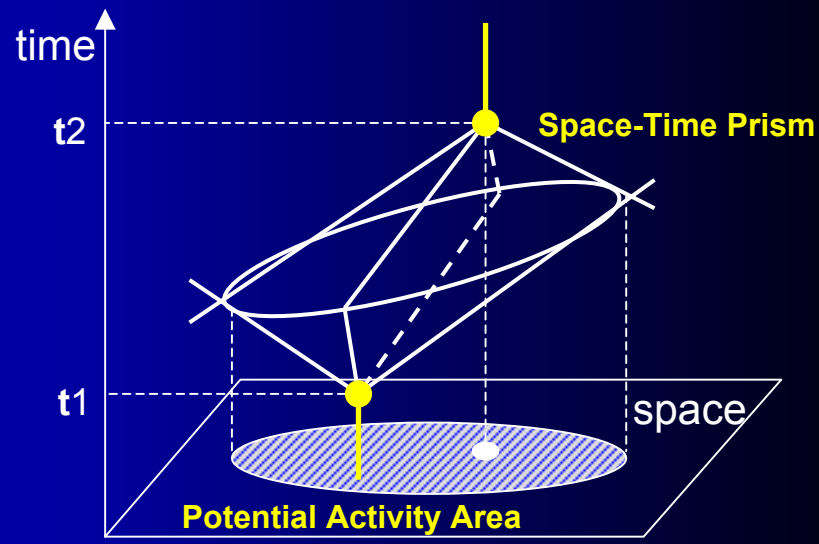
- Furthermore, information and communications technologies (ICT) have permitted people to expand their activities from physical space (e.g., shopping trips) to virtual space (*e*-shopping).
  - Research has speculated that ICT could lead to important changes in human activity/travel patterns.

- Therefore, it is important to ask questions such as:
  - What GPS data can and cannot tell us?
  - What kinds of information can we derive from the raw GPS tracking data using other technologies such as geographic information systems (GIS)?

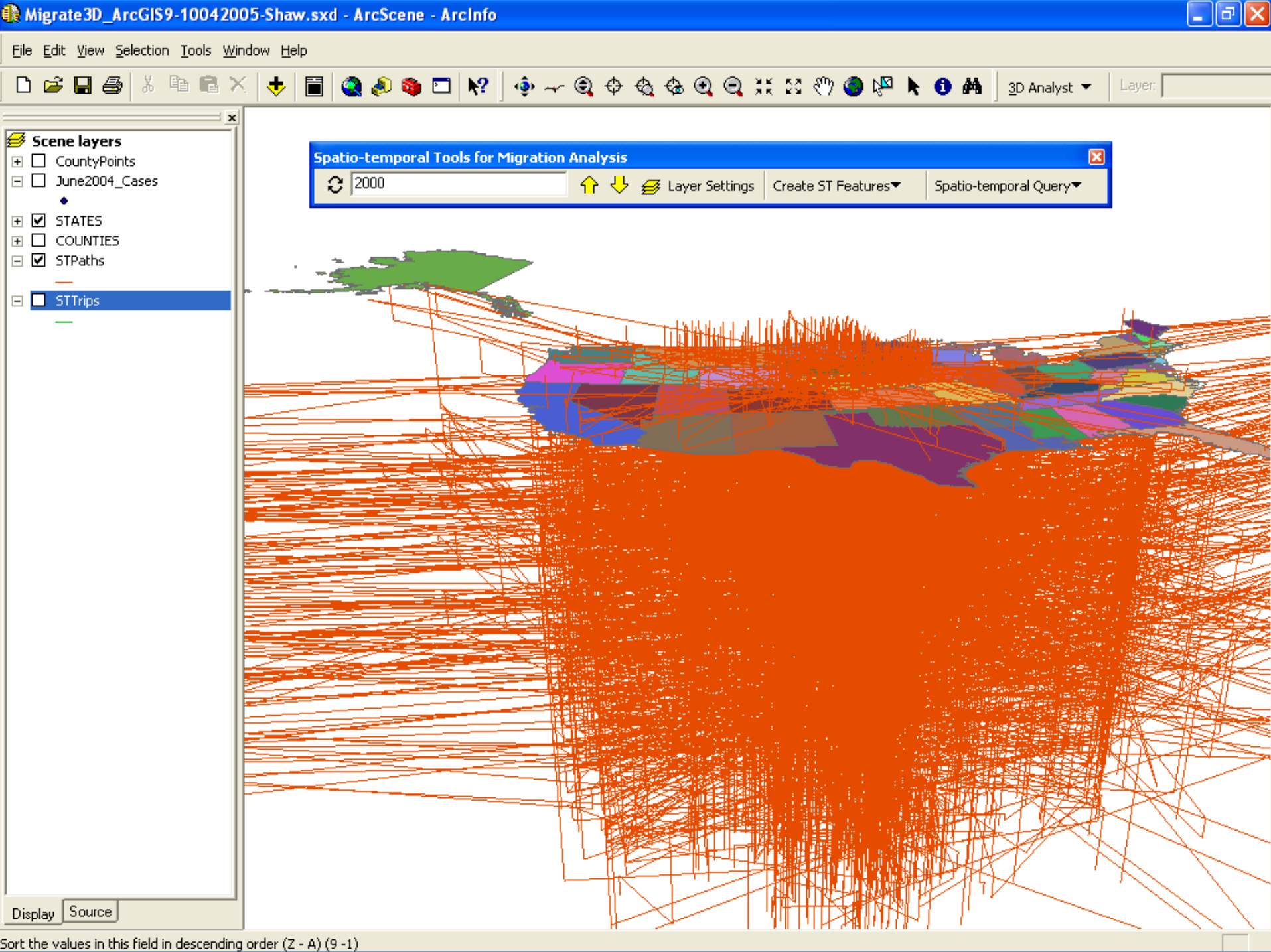
Time Geography, GPS Tracking Data & GIS:

- Time geography is suggested as one of the origins of activity-based approaches (McNally 2000, Jones 2003).
- With dense GPS tracking data, time-geographic concepts such as space-time path and space-time prism can be examined at finer spatial and temporal resolution levels.





- Although time geography offers an elegant conceptual framework for studying individual activities under different constraints in a space-time context, performing *measurements* and *analyses* under the time-geographic framework can be challenging. For example,
  - how can we analyze interactions among numerous space-time paths derived from GPS tracking data?
  - How can we measure and identify spatiotemporal clusters among the space-time paths?


Migrate3D_ArcGIS9-10042005-Shaw.sxd - ArcScene - ArcInfo
File Edit View Selection Tools Window Help
3D Analyst
Layer:
Scene layers
CountyPoints
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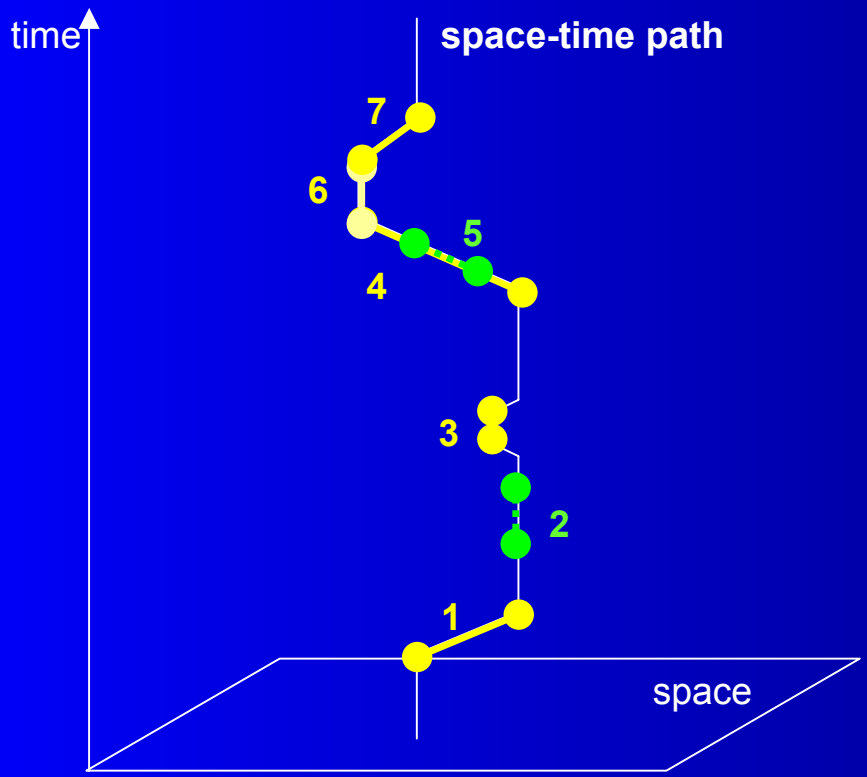
STATES
COUNTIES
STPaths
STTrips
Spatio-temporal Tools for Migration Analysis
2000
Layer Settings
Create ST Features
Spatio-temporal Query
Display
Source
Sort the values in this field in descending order (Z - A) (9 -1)

Representation of Individual Activities in GIS:

- Create 3D spatio-temporal features (x, y, t)
- Represent individual activities on a space-time path using *spatio-temporal dynamic segmentation*



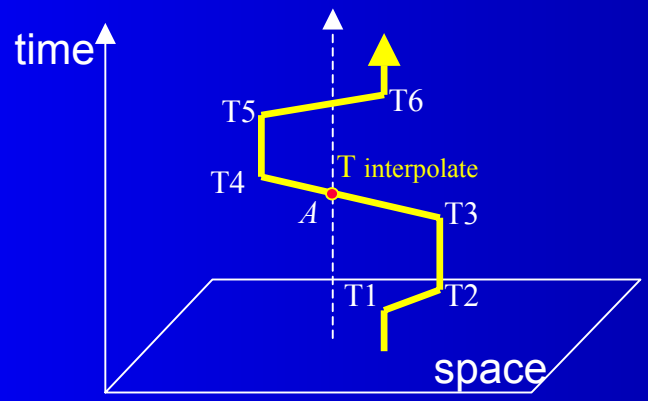
Physical activities:

1. Drive to work
3. Have lunch
4. Drive back home
6. Grocery shopping
7. Return home

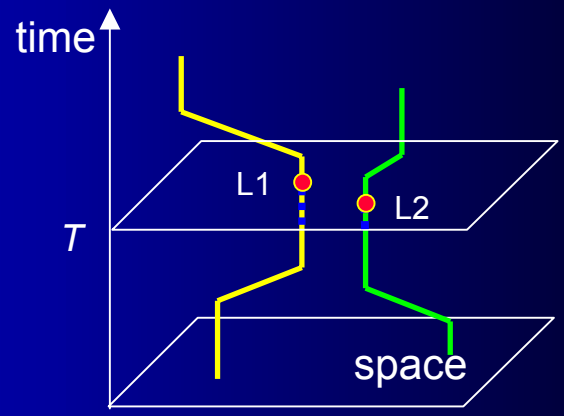
Virtual activities:

2. Instant messaging with colleagues
5. Receive a cell phone call from spouse to do grocery shopping

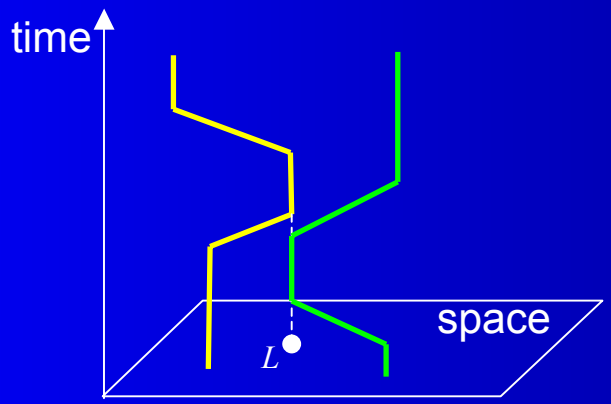
Exploratory Analysis of ST Relationships:



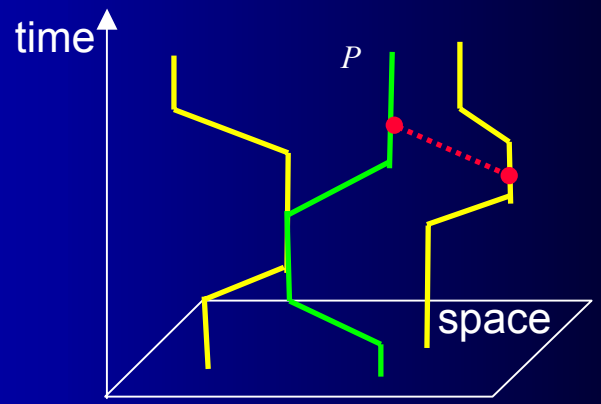
Locate time for point *A* on the ST path



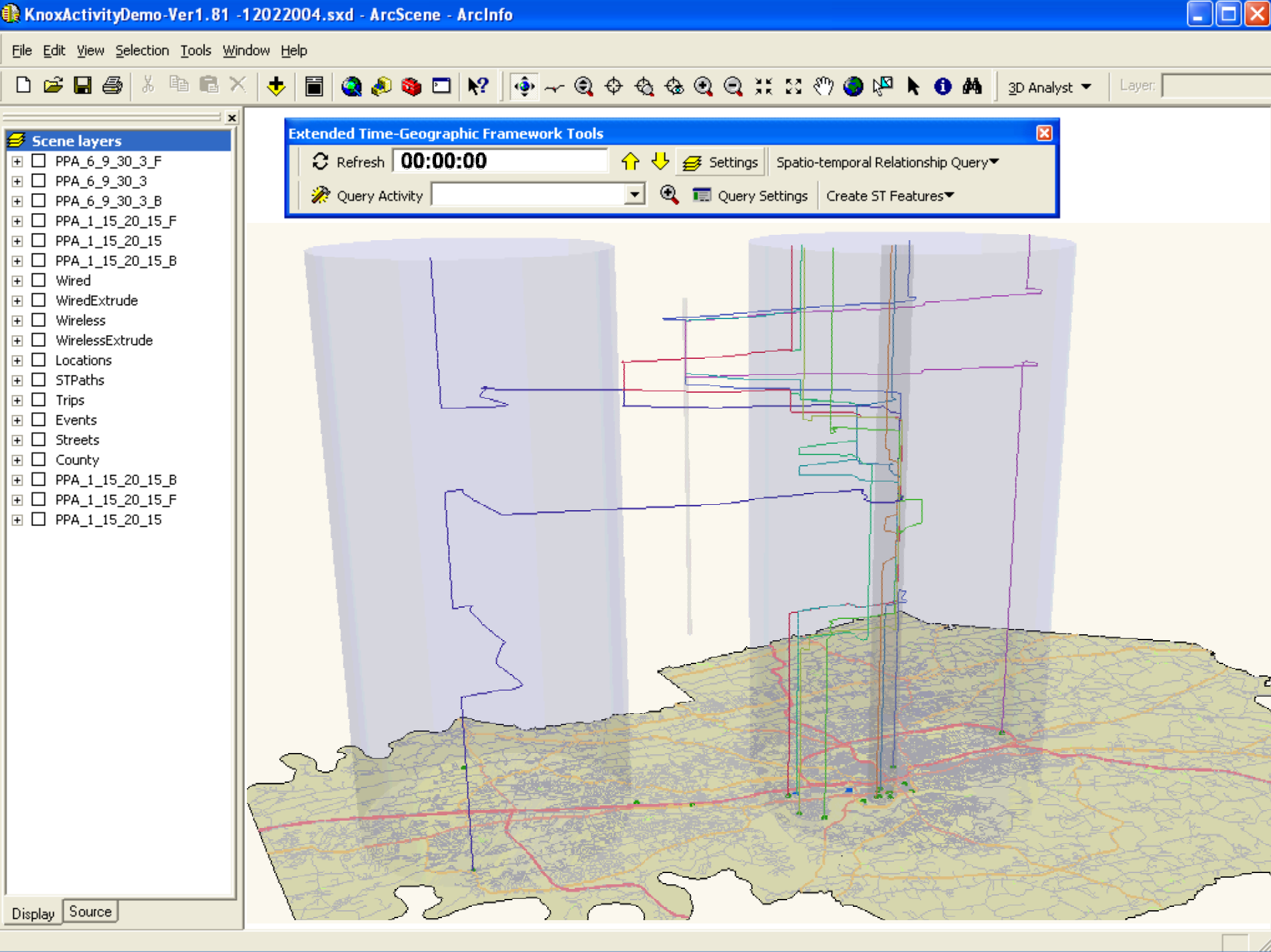
Find locations of ST paths at time *T*



Find ST paths visiting location *L*



Find ST paths interacting with person *P*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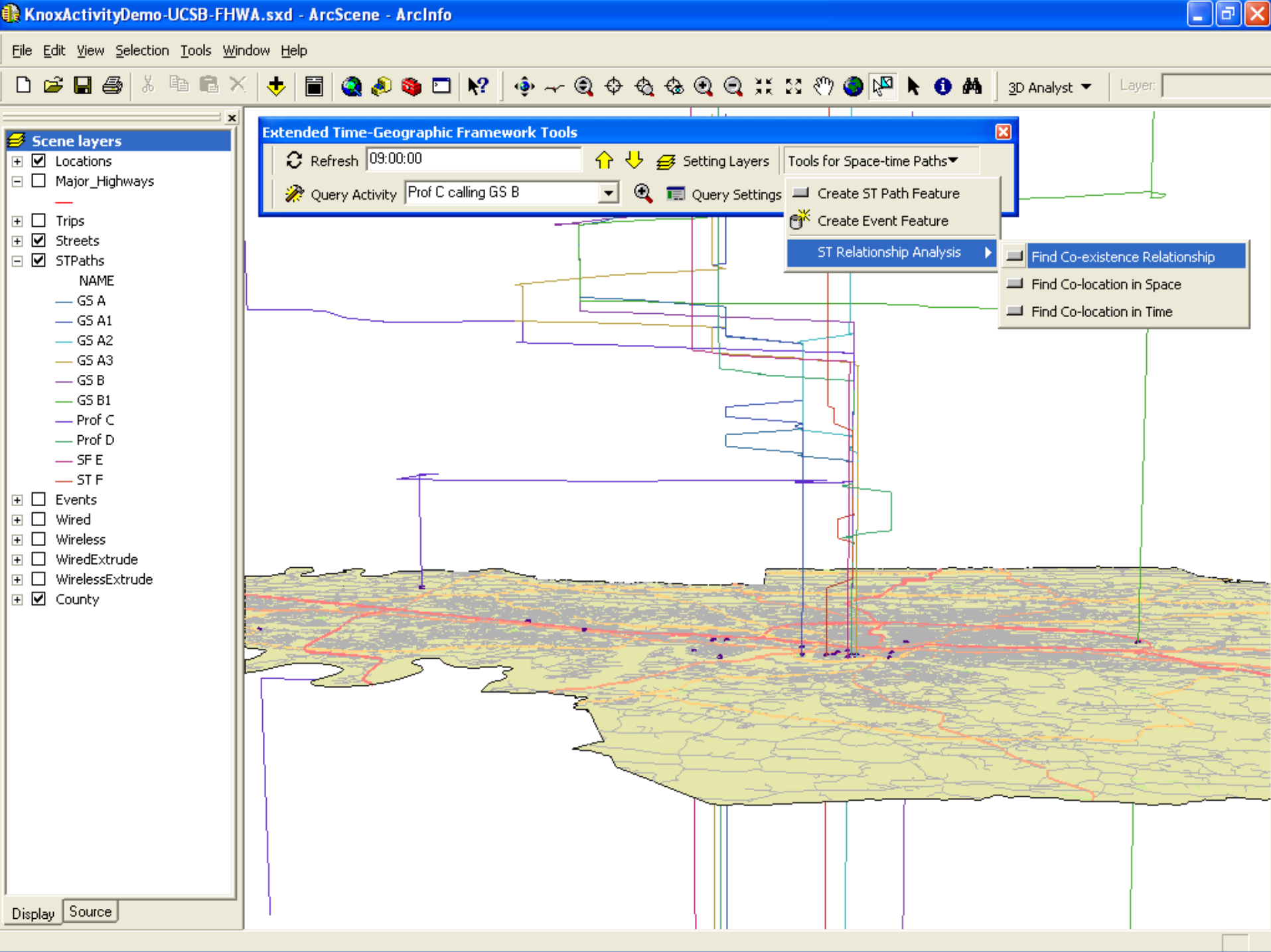
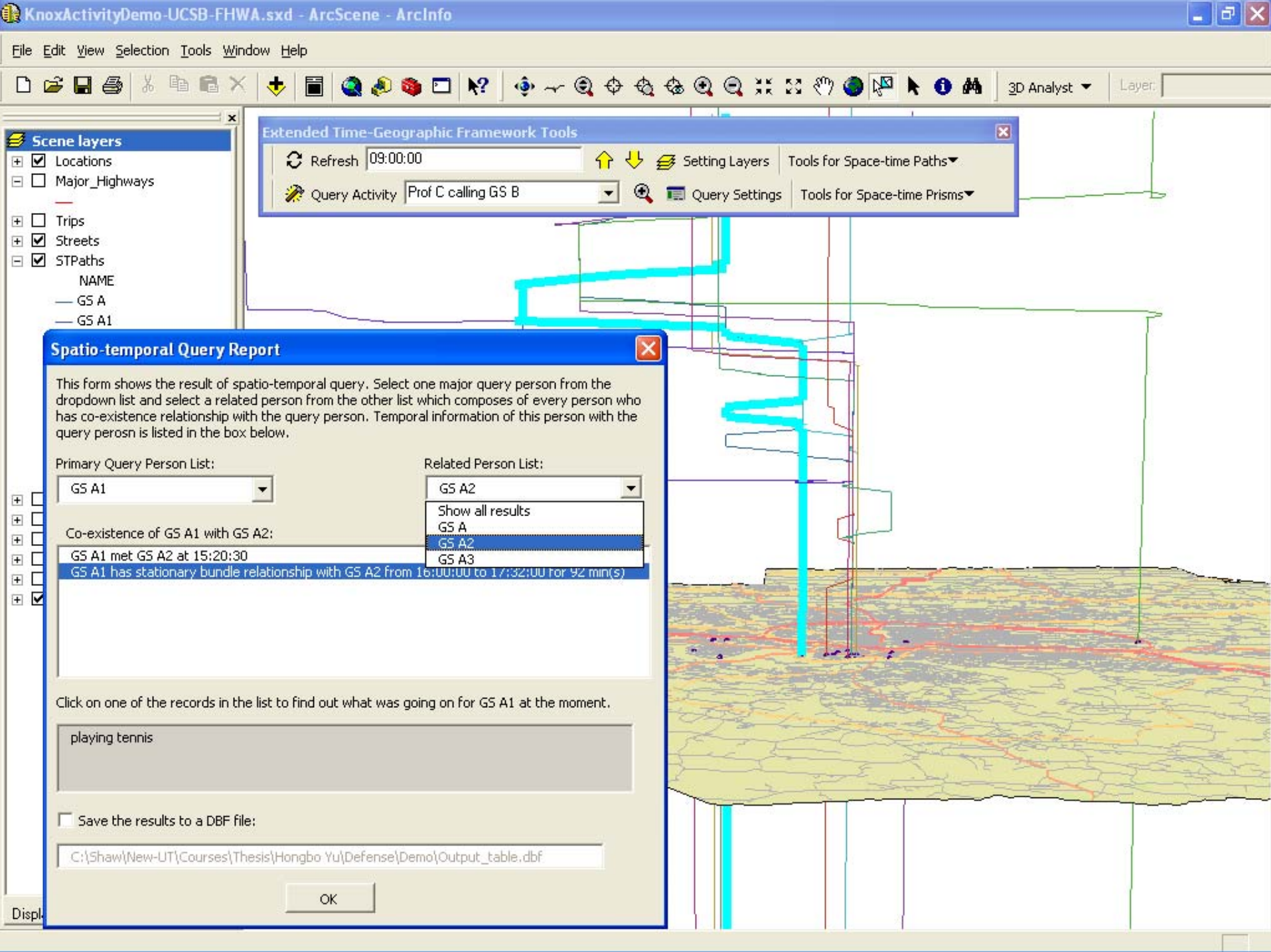
File Edit View Selection Tools Window Help
3D Analyst
Layer:
Scene layers
PPA_6_9_30_3_F
PPA_6_9_30_3
PPA_6_9_30_3_B
PPA_1_15_20_15_F
PPA_1_15_20_15
PPA_1_15_20_15_B
Wired
WiredExtrude
Wireless
WirelessExtrude
Locations
STPaths
Trips
Events
Streets
County
PPA_1_15_20_15_B
PPA_1_15_20_15_F
PPA_1_15_20_15
Display
Source
Extended Time-Geographic Framework Tools
Refresh
00:00:00
Settings
Spatio-temporal Relationship Query
Query Activity
Query Settings
Create ST Features


KnoxActivityDemo-UCSB-FHWA.sxd - ArcScene - ArcInfo
File Edit View Selection Tools Window Help
3D Analyst
Layer:
Scene layers
Locations
Major_Highways
Trips
Streets
STPaths
NAME
GS A
GS A1
GS A2
GS A3
GS B
GS B1
Prof C
Prof D
SF E
ST F
Events
Wired
Wireless
WiredExtrude
WirelessExtrude
County
Display
Source
Extended Time-Geographic Framework Tools
Refresh
09:00:00
Setting Layers
Tools for Space-time Paths
Query Activity
Prof C calling GS B
Query Settings
Create ST Path Feature
Create Event Feature
ST Relationship Analysis
Find Co-existence Relationship
Find Co-location in Space
Find Co-location in Time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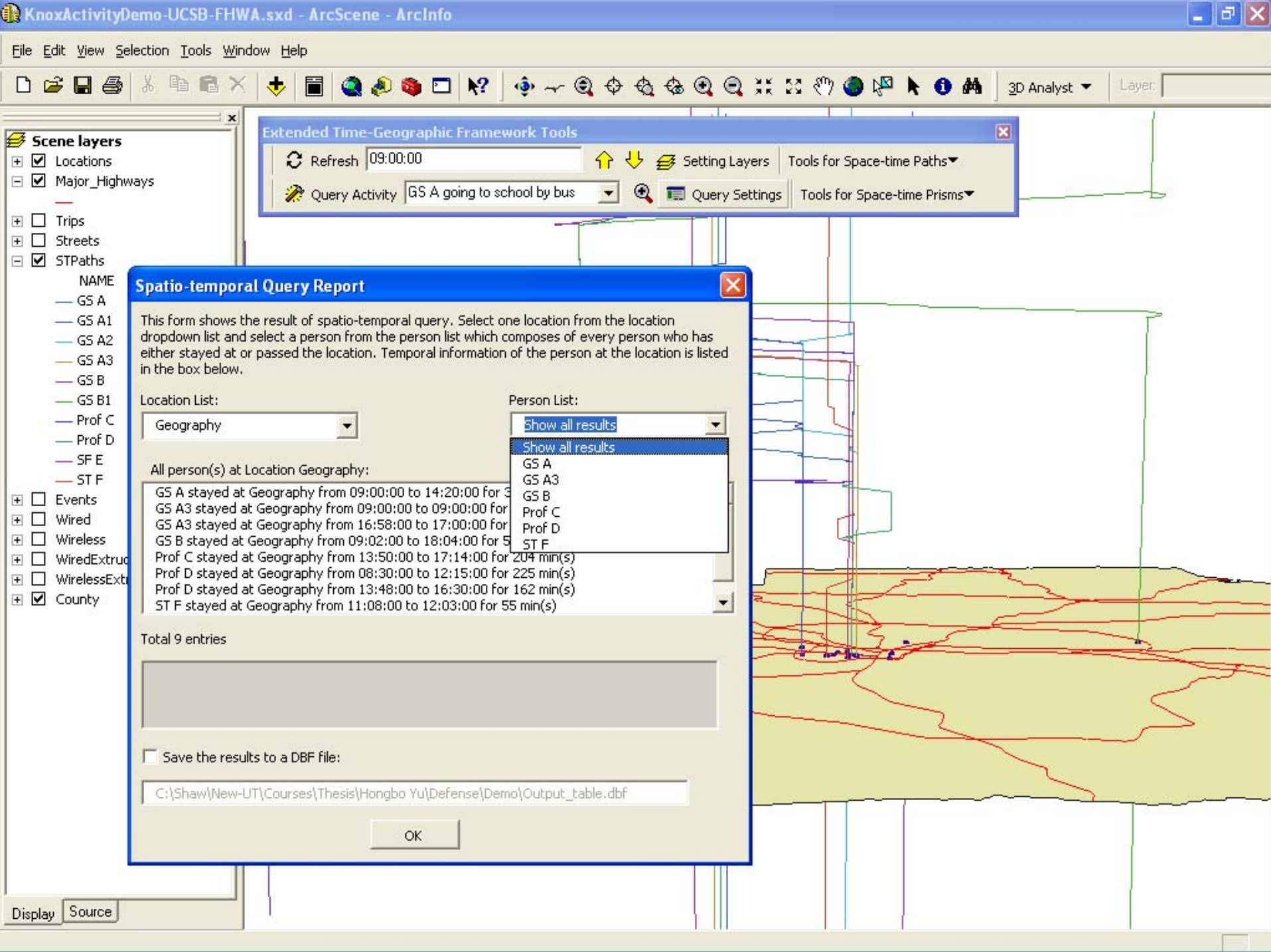
Scene layers
Locations
Major_Highways
Trips
Streets
STPaths
NAME
GS A
GS A1
Extended Time-Geographic Framework Tools
Refresh
09:00:00
Setting Layers
Tools for Space-time Paths
Query Activity
Prof C calling GS B
Query Settings
Tools for Space-time Prisms
Spatio-temporal Query Report
This form shows the result of spatio-temporal query. Select one major query person from the dropdown list and select a related person from the other list which composes of every person who has co-existence relationship with the query person. Temporal information of this person with the query perosn is listed in the box below.
Primary Query Person List:
GS A1
Related Person List:
GS A2
Show all results
GS A
GS A2
GS A3
Co-existence of GS A1 with GS A2:
GS A1 met GS A2 at 15:20:30
GS A1 has stationary bundle relationship with GS A2 from 16:00:00 to 17:32:00 for 92 min(s)
Click on one of the records in the list to find out what was going on for GS A1 at the moment.
playing tennis
Save the results to a DBF file:
C:\Shaw\New-UT\Courses\Thesis\Hongbo Yu\Defense\Demo\Output_table.dbf
OK


KnoxActivityDemo-UCSB-FHWA.sxd - ArcScene - ArcInfo
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3D Analyst
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Trips
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STPaths
NAME
GS A
GS A1
GS A2
GS A3
GS B
GS B1
Prof C
Prof D
SF E
ST F
Events
Wired
Wireless
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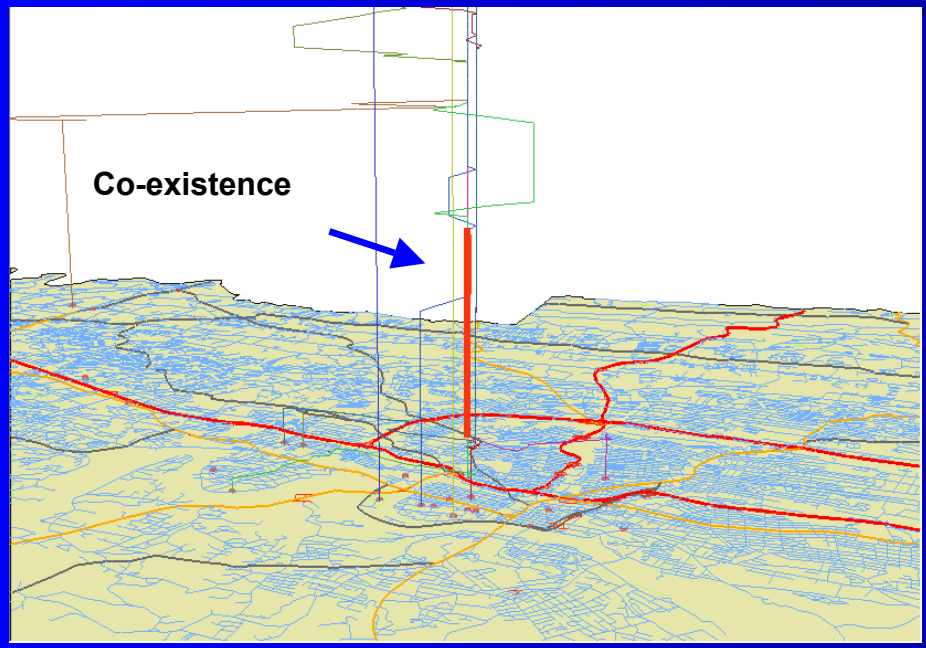
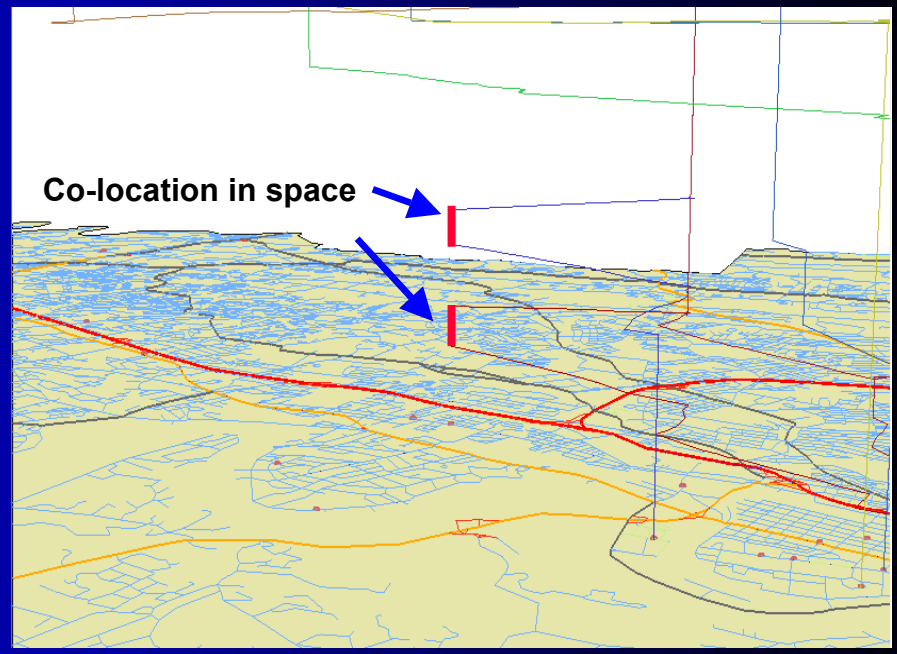
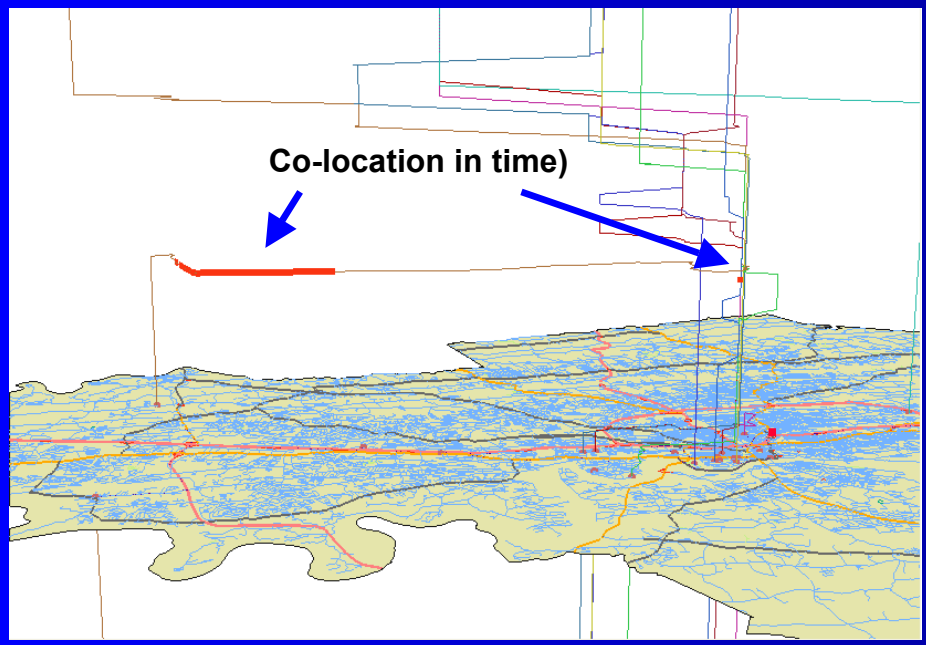
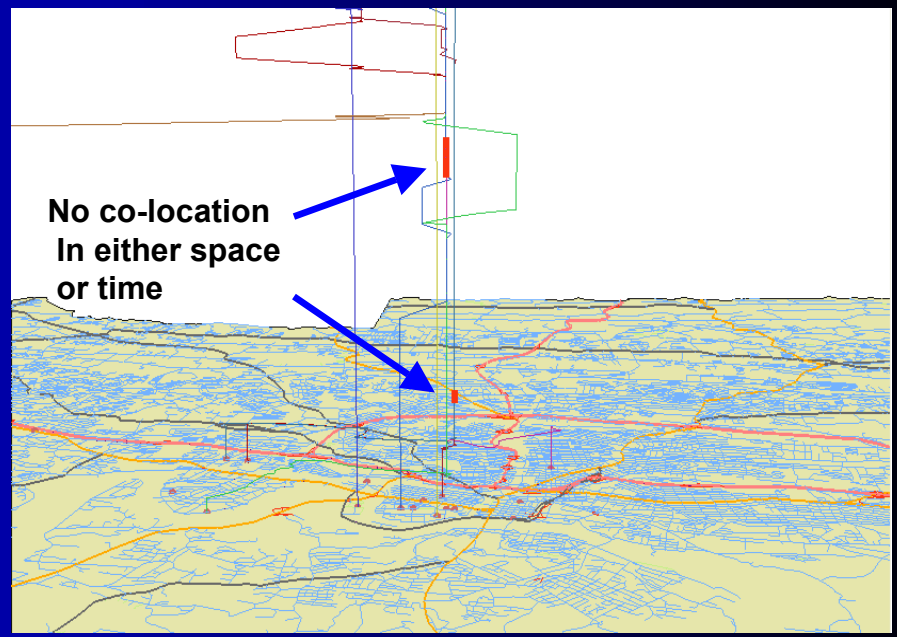
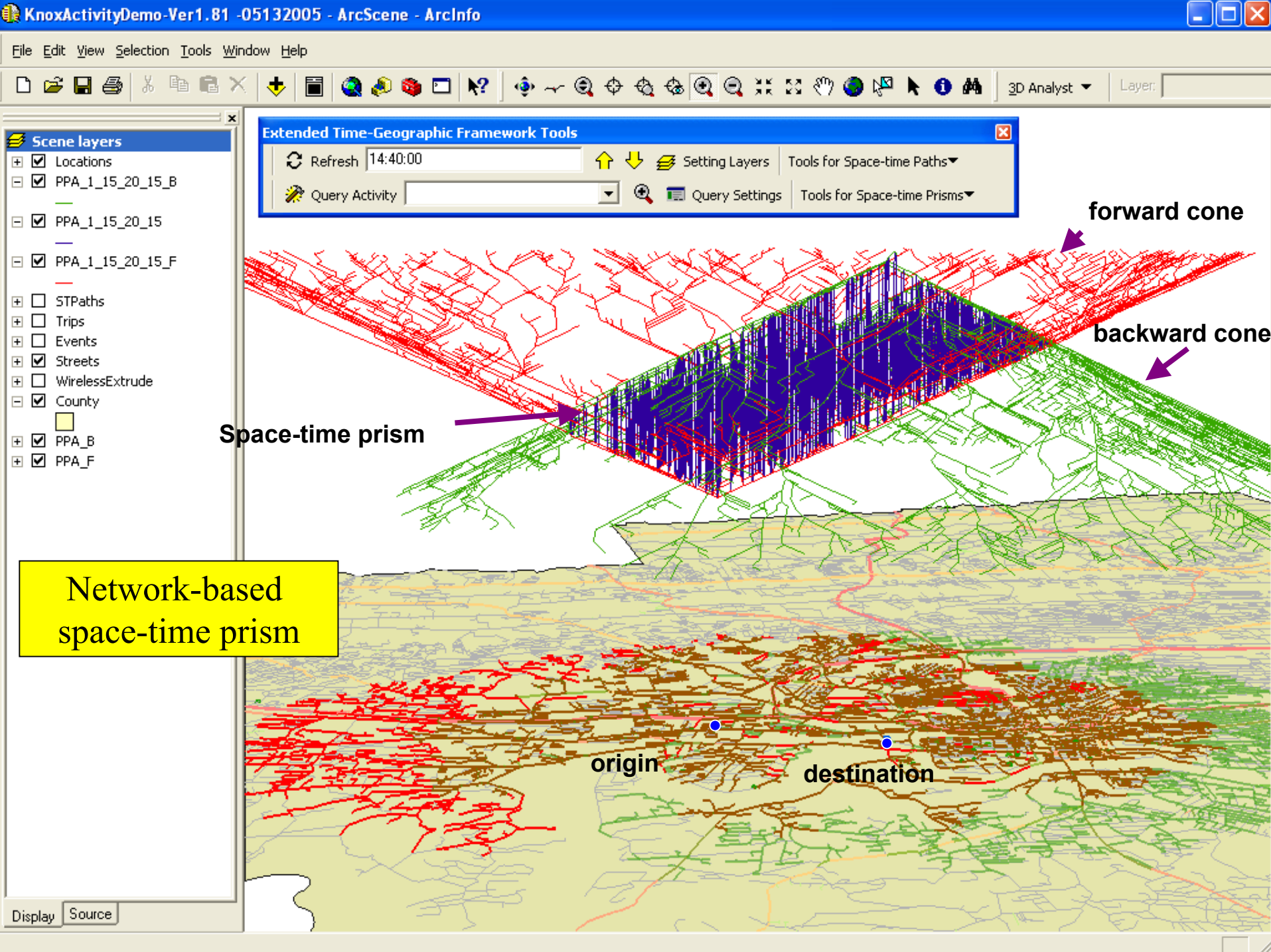
WirelessExt
County
Display
Source
Extended Time-Geographic Framework Tools
Refresh
09:00:00
Setting Layers
Tools for Space-time Paths
Query Activity
GS A going to school by bus
Query Settings
Tools for Space-time Prisms
Spatio-temporal Query Report
This form shows the result of spatio-temporal query. Select one location from the location dropdown list and select a person from the person list which composes of every person who has either stayed at or passed the location. Temporal information of the person at the location is listed in the box below.
Location List:
Geography
Person List:
Show all results
Show all results
GS A
GS A3
GS B
Prof C
Prof D
ST F
All person(s) at Location Geography:
GS A stayed at Geography from 09:00:00 to 14:20:00 for 3
GS A3 stayed at Geography from 09:00:00 to 09:00:00 for
GS A3 stayed at Geography from 16:58:00 to 17:00:00 for
GS B stayed at Geography from 09:02:00 to 18:04:00 for 5
Prof C stayed at Geography from 13:50:00 to 17:14:00 for 204 min(s)
Prof D stayed at Geography from 08:30:00 to 12:15:00 for 225 min(s)
Prof D stayed at Geography from 13:48:00 to 16:30:00 for 162 min(s)
ST F stayed at Geography from 11:08:00 to 12:03:00 for 55 min(s)
Total 9 entries
Save the results to a DBF file:
C:\Shaw\New-UT\Courses\Thesis\Hongbo Yu\Defense\Demo\Output_table.dbf
OK


Co-existence


Co-location in space


Co-location in time)


No co-location
In either space
or time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File Edit View Selection Tools Window Help
3D Analyst
Layer:
Scene layers
Locations
PPA_1_15_20_15_B
PPA_1_15_20_15
PPA_1_15_20_15_F
STPaths
Trips
Events
Streets
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County
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PPA_F
Display
Source
Extended Time-Geographic Framework Tools
Refresh
14:40:00
Setting Layers
Tools for Space-time Paths
Query Activity
Query Settings
Tools for Space-time Prisms
forward cone
backward cone
Space-time prism
origin
destination
Network-based space-time prism

Thank You!

Comments & Questions …