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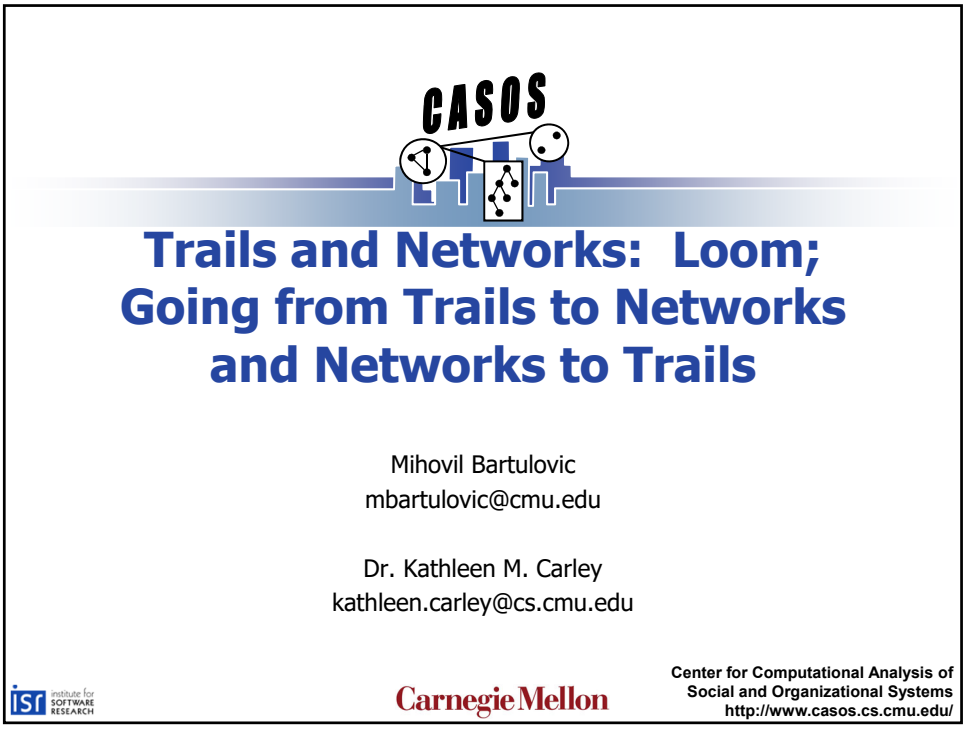

Trails and Networks: Loom; Going from Trails to Networks and Networks to Trails

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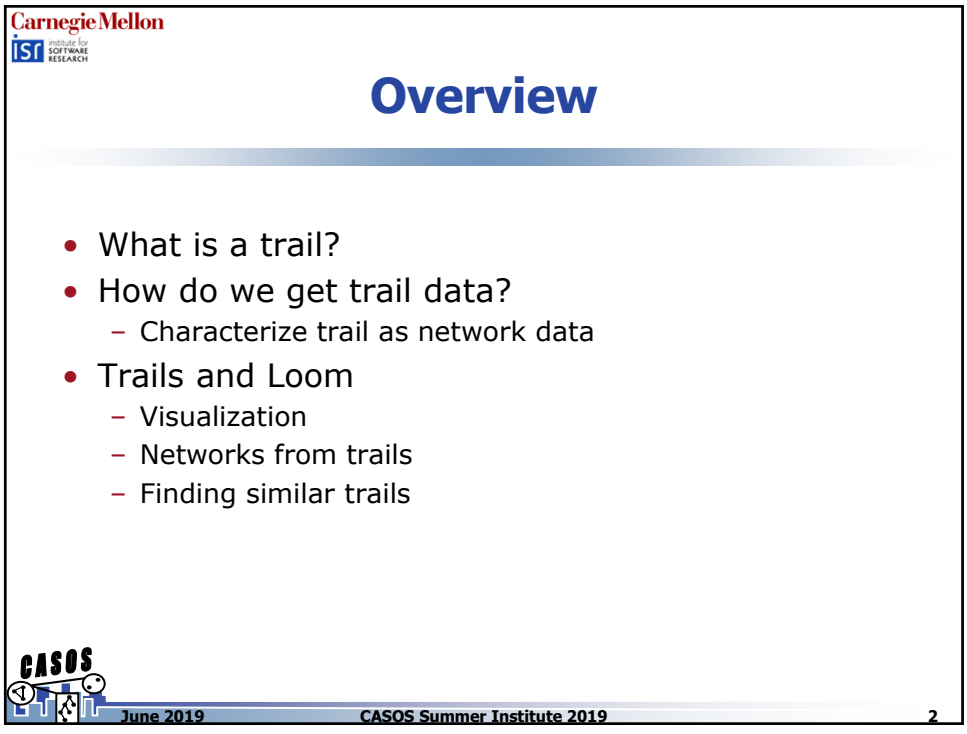
Center for Computational Analysis of Social and Organizational Systems
http://www.casos.cs.cmu.edu/



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Overview

- What is a trail?
- How do we get trail data?
  - Characterize trail as network data
- Trails and Loom
  - Visualization
  - Networks from trails
  - Finding similar trails

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What is a Trail?

- A **trail** is a **trace** of the **movement** of something **over time**
- For example, the movement of an attachment through a series of email communications creates a *trail*
- What are some other examples of trails?
  - People moving from place to place – geospatial trails
  - Twitter hashtags
  - …

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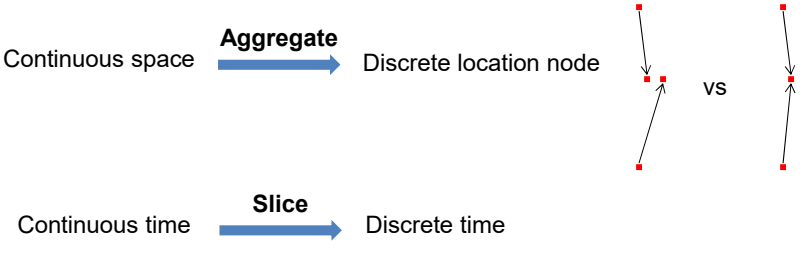
Geospatial Trails

- Usually geospatial trails represent agents travelling in continuous space and time.
- Network data: discrete node and discrete time.



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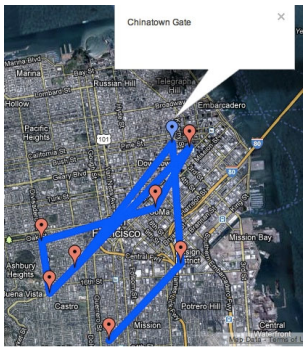
Geospatial Trails



Aggregate

Slice

Time	Location
2017, June 7, 9 am	Green St.
2017, June 7, 10 am	Design District
2017, June 7, 11 am	Chinatown Gate
2017, June 7, 12 am	16 th st.
…….	…….

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Trails visualization

- ORA Over-time visualizer
  - Benefit: Can see changes in network structure over time
  - Drawback: For sparse trail data, not very effective
- ORA GIS Visualizer
  - Benefit: Can see the spatial distribution of trails
  - Drawback: Lose the temporal information
- Loom
  - Benefit: Can see the temporal distribution and the places travelled to
  - Drawback: Spatial distances, where they exist, are not preserved

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What we'll do

- Import a "DynamicMetaNetwork" with spatial information
- Visualization
  - Understand the benefits and drawbacks of different visualizations of trail data
    - ORA Over-time visualizer
    - ORA GIS visualizer
    - Loom
- Finding Similar trails
  - Use Loom to cluster trails
- Obtain networks from trails

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Import a dynamic meta-network

- Same as importing a regular meta-network
  - Drag-and-drop
  - File->Open Meta Network
- Import TrailsDataset.xml

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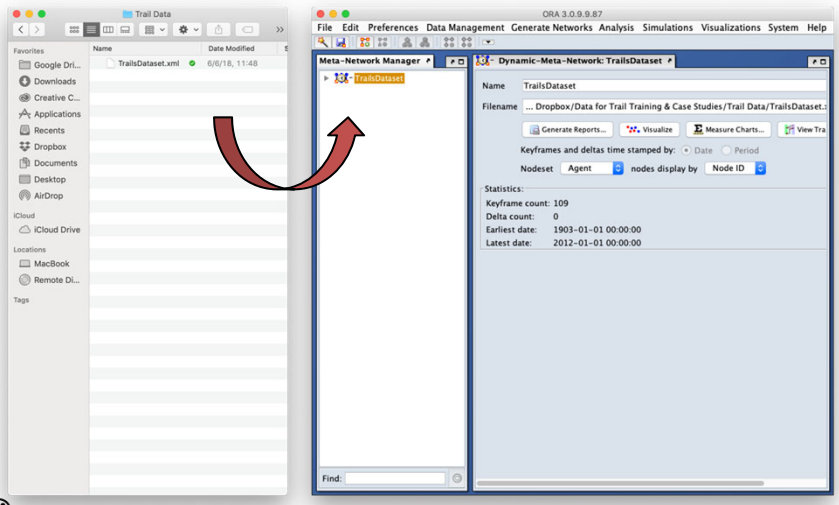
Importing



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The Data

- Our trail:
  - Locations are our nodes
  - Agents are what is moving between them
- Lets explore the data
  - In ORA
  - Networks over time visualizer
  - Geospatial visualizer

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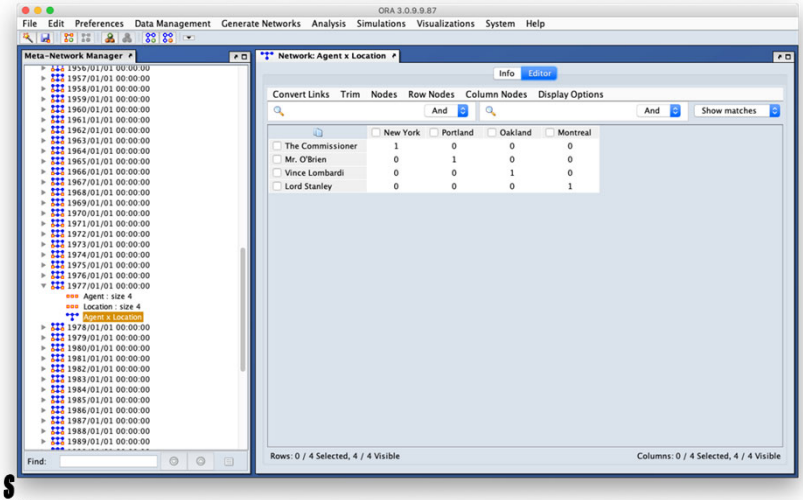
ORA Main Window



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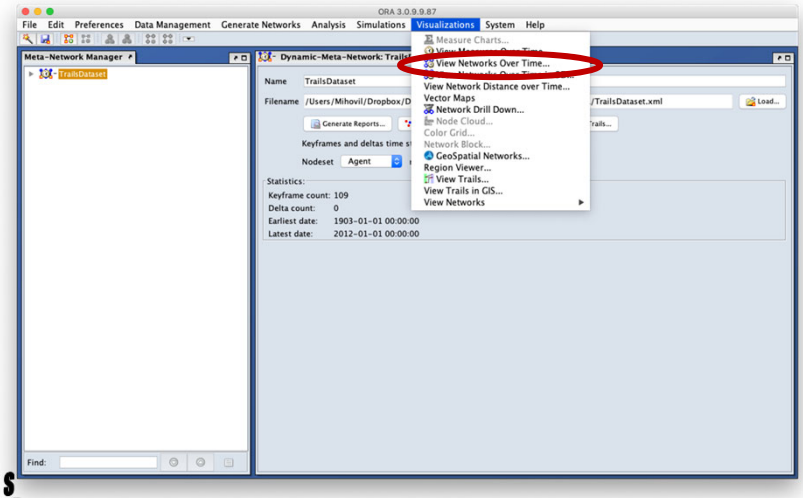
Networks Over Time Visualizer



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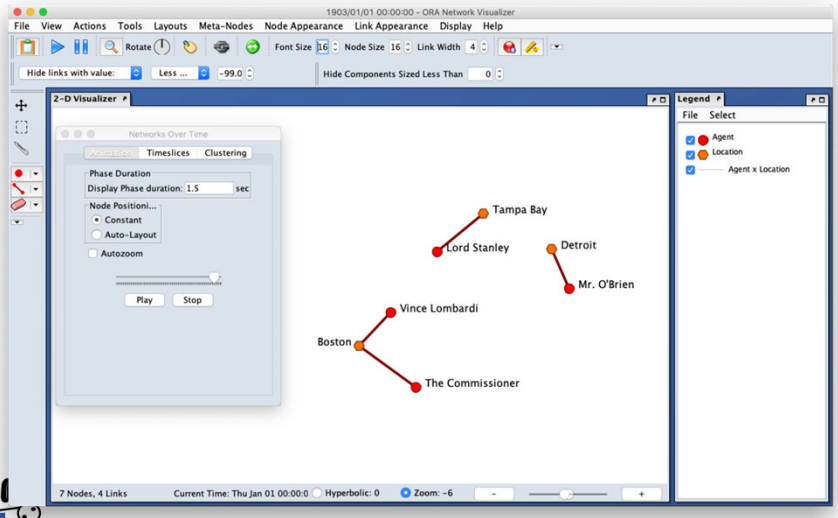
Networks Over Time Visualizer



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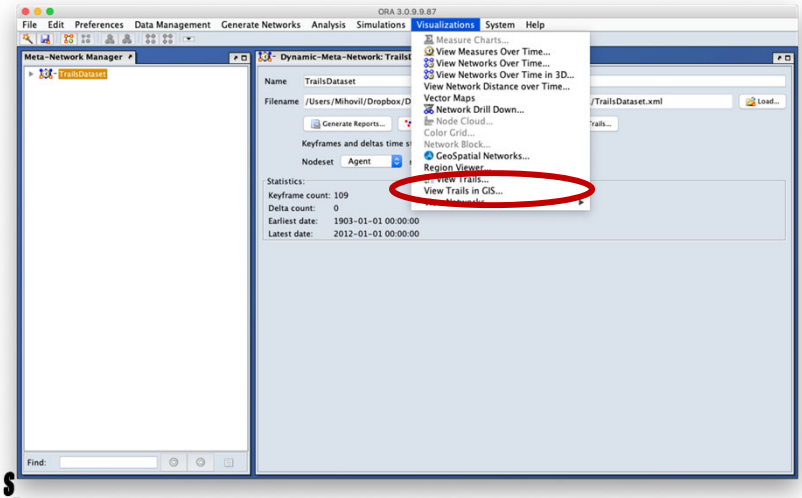
Geospatial Visualizer



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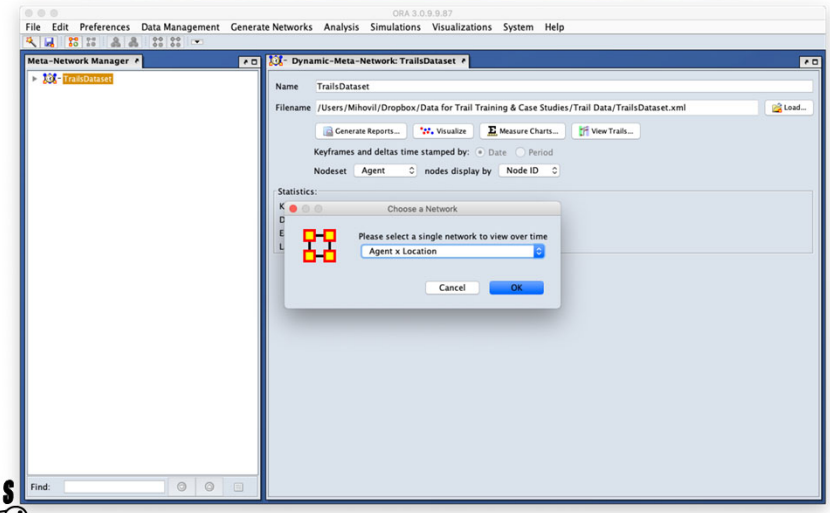
Geospatial Visualizer



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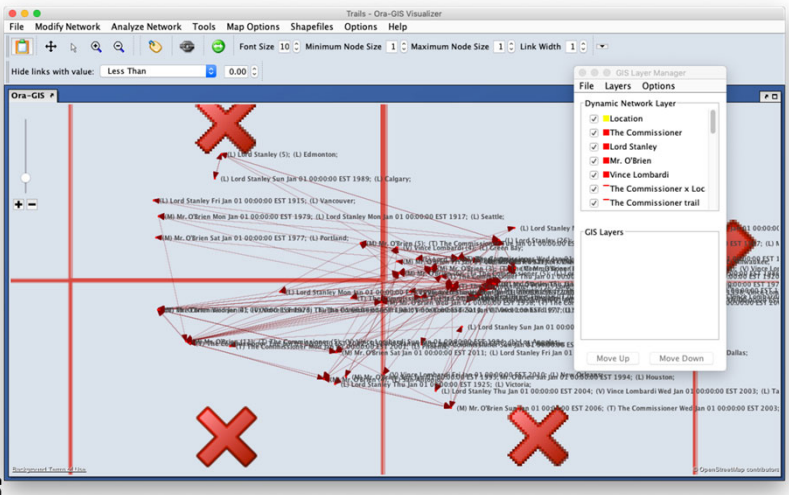
Geospatial Visualizer



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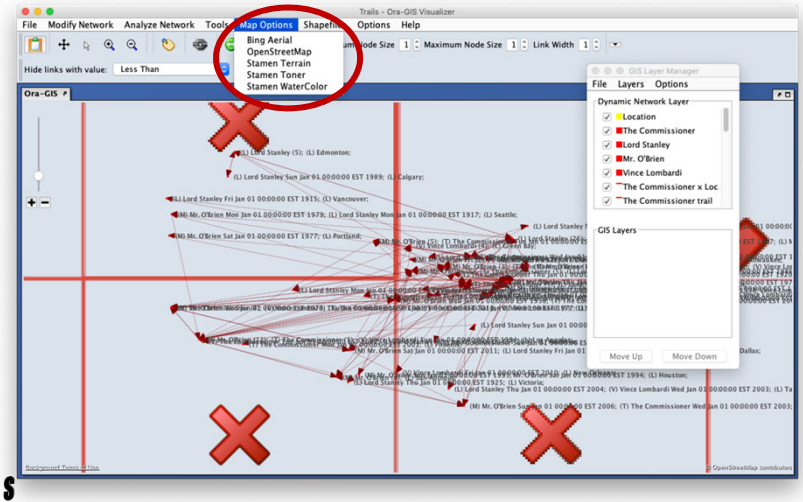
Geospatial Visualizer



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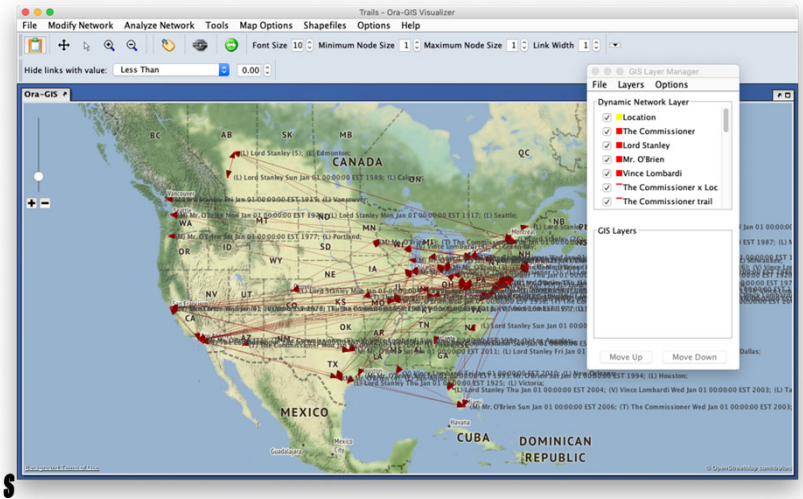
Geospatial Visualizer



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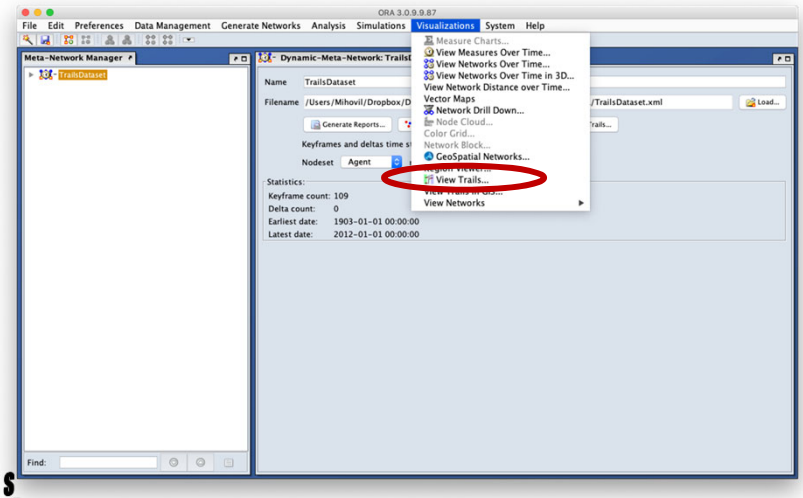
Loom



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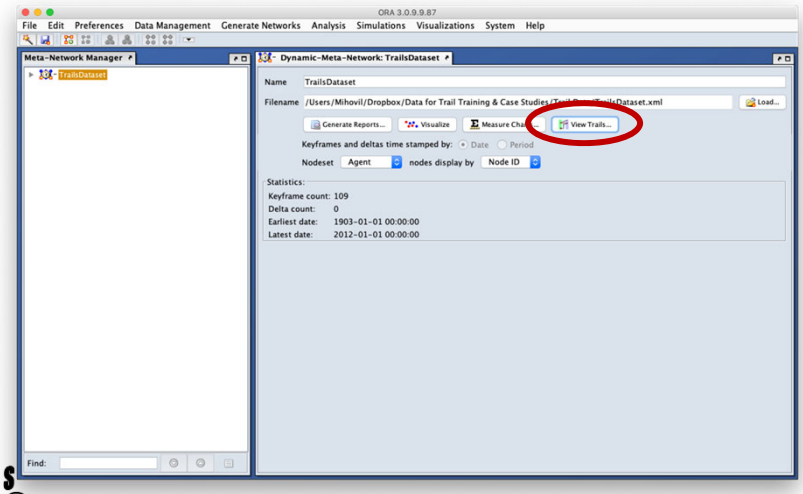
Loom



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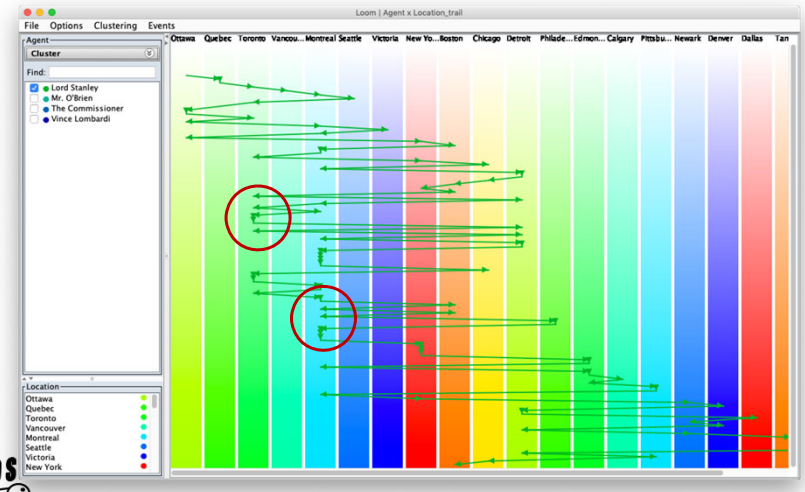
Loom



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Trails and Loom

- **Visualization** over time is hard
  - State of the art revolves around animation
  - Loom allows us to visualize trails over time in a static, understandable environment
- Trails may have similar **patterns**, but these are difficult to observe
  - Loom allows us to cluster similar trails together
- We can get **networks from trails**, for example, who is connected by the given attachment?
  - Loom allows us to easily export such networks to ORA

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What we'll do

- ~~Import a "DynamicMetaNetwork" with spatial information~~
- ~~Visualization~~
  - ~~Understand the benefits and drawbacks of different visualizations of trail data~~
    - ~~ORA Over-time visualizer~~
    - ~~ORA GIS visualizer~~
    - ~~Loom~~
- **Finding Similar trails**
  - **Use Loom to cluster trails**
- Obtain networks from trails

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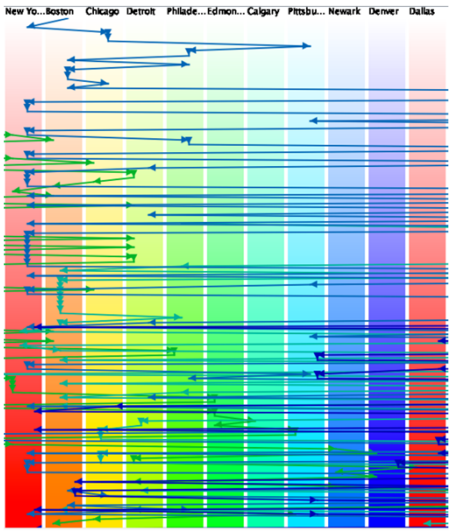
Why cluster?

- Why are we interested in trails and trail clustering?
  - Gain information by analyzing agents across space and time together.
  - Interested in grouping agents that display same behavior across time. E.g. visit the same locations across time.



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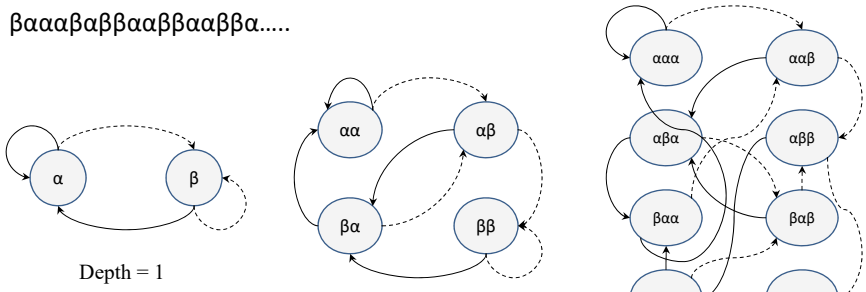
Feature vector representation using PFSA

βααβββααββααββα.....



$$\vec{p} = \begin{bmatrix} p_1 \\ p_2 \\ p_3 \\ p_4 \end{bmatrix} \qquad \Pi = \begin{bmatrix} \pi_{11} & \pi_{12} & 0 & 0 \\ 0 & 0 & \pi_{23} & \pi_{24} \\ \pi_{31} & \pi_{32} & 0 & 0 \\ 0 & 0 & \pi_{43} & \pi_{44} \end{bmatrix}$$

State Probability Vector *State Transition matrix*

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Clustering of Trails using PFSA

- Each trail is now represented by a numerical feature vector, the state probability vector of the derived PFSA (the model of the generative process).
- To look at joint spatiotemporal behavior we now cluster the agent trails based on their feature vectors.
- This is done using a two step process.
  - A coarse clustering step : Trails are initially grouped coarsely according to the locations visited, irrespective of the frequency of the visits.
  - A cluster refining step : The coarse clusters are each then clustered using agglomerative clustering to derive groups of trails which visit "similar" locations with "similar" frequencies.

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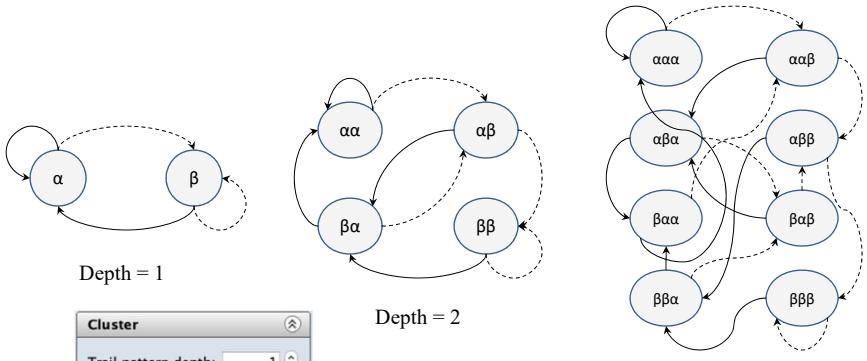
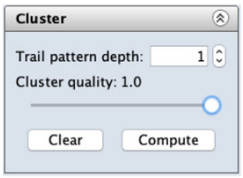
Refining the Coarse Clustering



Depth = 1

Depth = 2

Depth = 3



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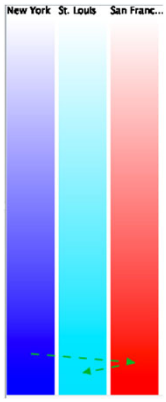
Viewing time sequences

- Each cluster contains trails with similar patterns in the sequences of locations visited
- Thus extract the longest common subsequence amongst all the trails belonging to a cluster.

BANANA
ATANA

ANA — Longest common string

AANA — Longest common subsequence



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What we'll do

- ~~Import a "DynamicMetaNetwork" with spatial information~~
- ~~Understand the benefits and drawbacks of different visualizations of trail data~~
  - ~~ORA Over-time visualizer~~
  - ~~ORA GIS visualizer~~
  - ~~Loom~~
- ~~Use Loom to cluster similar trails~~
  - ~~The high level concept~~
  - ~~The details~~
- **Obtain networks from trails**

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Generating Networks from Trails

- We can better understand how different cities relate via championships by getting networks out of them

What we'll do

- Generate the networks
- View them in ORA
- Use ORA Network Visualizer

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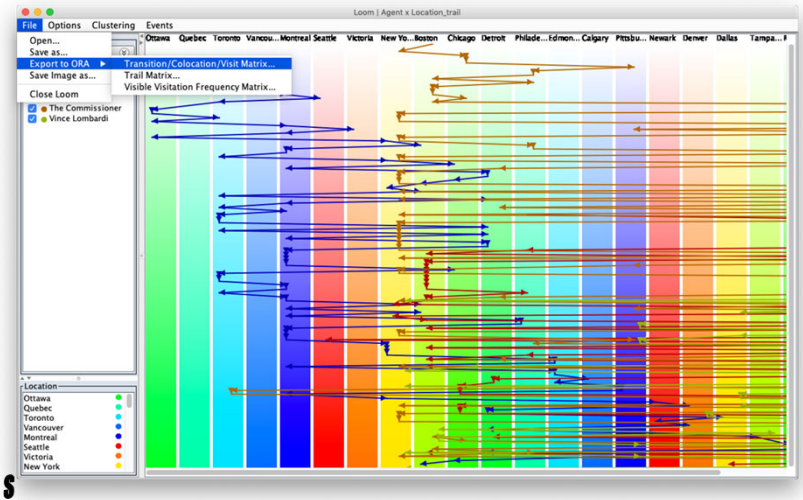
Exporting the Matrices



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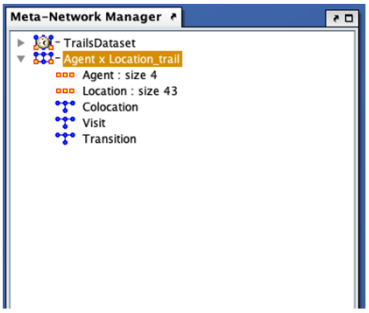
What we now have



- ORA uses all of the trails and outputs a single meta-network
  - **Colocation** – An edge is created between the trophies if they ever existed at the same place at the same time
  - **Visit Matrix** – An edge is created between city and trophy if the city ever won that trophy
  - **Transition** – An edge is created between cities if a trophy ever traveled from one to the other in consecutive years

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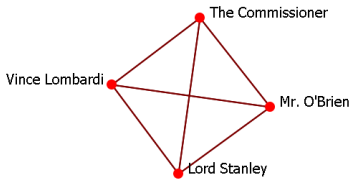
Colocation

Agent x Location_trail



powered by ORA-NetScenes, CASOS Center @ CMU

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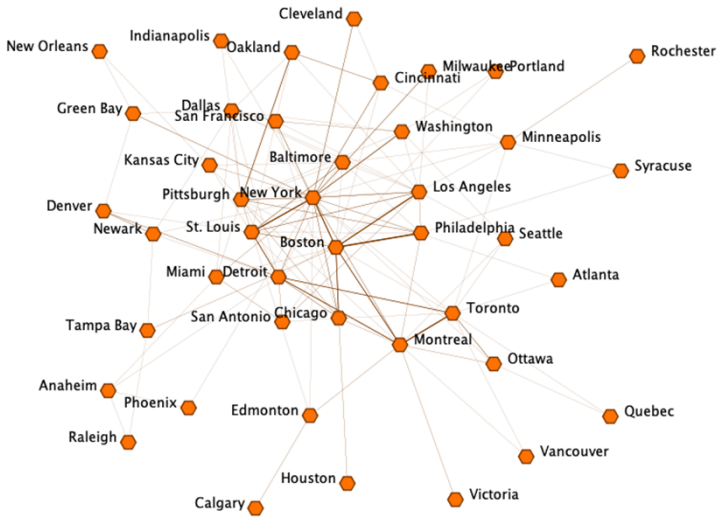
Transition



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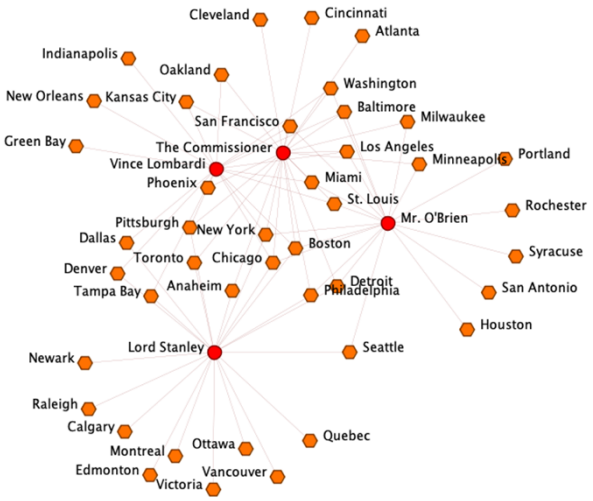
Visit



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Summary

- We discussed what a trail was – a trace of the movement of something through a network over time
- We used an example dataset and looked at trail data three different ways – in the Networks Over Time visualizer, the GIS visualizer and Loom
- We talked about how to find similar trails in Loom
- We looked at how we can get new, interested networks out of our trail data