



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

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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.

Continuous space

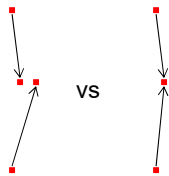
Aggregate

Discrete location node

Continuous time

Slice

Discrete time



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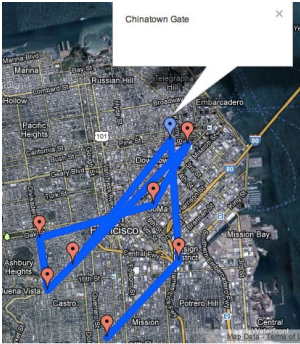
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Geospatial Trails



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

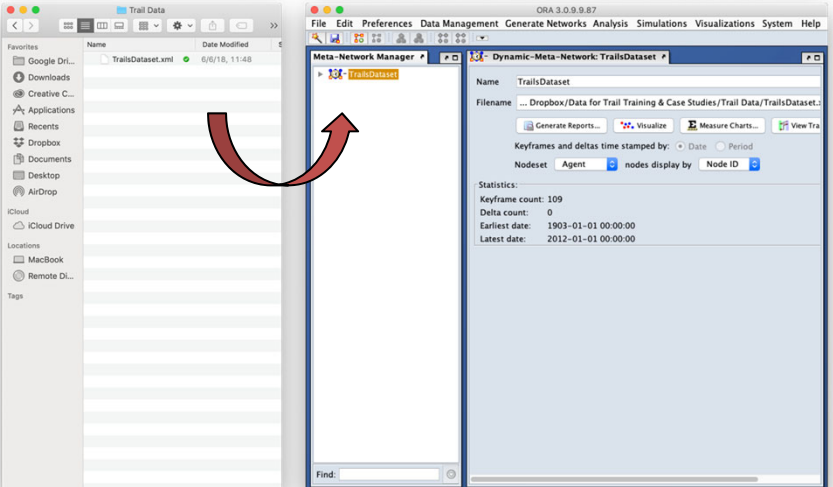


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Importing



ORA 3.0.0.9.87

File Edit Preferences Data Management Generate Networks Analysis Simulations Visualizations System Help

Meta-Network Manager

Dynamic-Meta-Network: TrailsDataset

Name: TrailsDataset

Filename: ... Dropbox/Data for Trail Training & Case Studies/Trail Data/TrailsDataset:

Generate Reports... Visualize Measure Charts... View Tra

Keyframes and deltas time stamped by: Date Period

Nodeset Agent nodes display by Node ID

Statistics:

- Keyframe count: 109
- Delta count: 0
- Earliest date: 1903-01-01 00:00:00
- Latest date: 2012-01-01 00:00:00

Find:

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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

	New York	Portland	Oakland	Montreal
The Commissioner	1	0	0	0
Mr. O'Brien	0	1	0	0
Vince Lombardi	0	0	1	0
Lord Stanley	0	0	0	1

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Networks Over Time Visualizer

Name	TrailsDataset
Filename	/Users/Mihovil/Dropbox/D
Keyframes and deltas time s	
Nodeset	Agent
Statistics:	
Keyframe count:	109
Delta count:	0
Earliest date:	1903-01-01 00:00:00
Latest date:	2012-01-01 00:00:00

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Networks Over Time Visualizer

The screenshot displays the 'Networks Over Time Visualizer' application. The interface includes a menu bar with options like File, View, Actions, Tools, Layouts, Meta-Nodes, Node Appearance, Link Appearance, Display, and Help. A toolbar below the menu bar contains icons for Rotate, Play, Stop, Font Size, Node Size, Link Width, and Hide Components. The main visualization area shows a network graph with nodes labeled 'Tampa Bay', 'Lord Stanley', 'Detroit', 'Mr. O'Brien', 'Vince Lombardi', 'The Commissioner', and 'Boston'. The nodes are connected by red lines. A '2-D Visualizer' panel on the left shows settings for 'Phase Duration' (1.5 sec), 'Node Position' (Constant), and 'Autozoom'. A 'Legend' panel on the right shows 'Agent' (red dot), 'Location' (orange dot), and 'Agent x Location' (red line). The status bar at the bottom indicates '7 Nodes, 4 Links', 'Current Time: Thu Jan 01 00:00:00', 'Hyperbolic: 0', and 'Zoom: -6'.

The screenshot displays the Geospatial Visualizer application window. The 'Visualizations' menu is open, highlighting the 'View Trails in GIS...' option with a red circle. The main window shows the 'Meta-Network Manager' with a 'TrailsDataset.xml' file loaded. The 'Statistics' section shows: Keyframe count: 109, Delta count: 0, Earliest date: 1903-01-01 00:00:00, Latest date: 2012-01-01 00:00:00.



The screenshot displays the Geospatial Visualizer application. The main window is titled 'Dynamic-Meta-Network: TrailsDataset'. On the left, there is a 'Meta-Network Manager' pane showing a tree view with 'TrailsDataset' selected. The main area contains a 'Statistics' dialog box with the following content:

- Name:** TrailsDataset
- Filename:** /Users/Mihovil/Dropbox/Data for Trail Training & Case Studies/Trail Data/TrailsDataset.xml
- Buttons:** Generate Reports..., Visualize, Measure Charts..., View Trails...
- Keyframes and deltas time stamped by:** Date (selected), Period
- Nodeset:** Agent (selected), nodes display by: Node ID (selected)
- Statistics:**
 - Choose a Network:** A dialog box with a grid of network icons. The first icon (a 2x2 grid of red squares) is selected.
 - Please select a single network to view over time:** A dropdown menu showing 'Agent x Location'.
 - Buttons:** Cancel, OK

The background shows a map view with a toolbar and a 'Find:' search bar at the bottom left.

Geospatial Visualizer

The screenshot displays the 'Ors-GIS Visualizer' application window. The interface includes a menu bar (File, Modify Network, Analyze Network, Tools, Map Options, Shapefiles, Options, Help) and a toolbar with icons for adding, deleting, and zooming. A status bar at the top indicates 'Font Size 10', 'Minimum Node Size 1', 'Maximum Node Size 1', and 'Link Width 1'. Below this, a filter bar shows 'Hide links with value: Less Than 0.00'. The main map area displays a network graph with red nodes and lines. Three large red 'X' marks are overlaid on the map. A 'GIS Layer Manager' panel on the right shows a list of layers: 'Dynamic Network Layer' (Location, The Commissioner, Lord Stanley, Mr. O'Brien, Vince Lombardi, The Commissioner x Loc, The Commissioner trail) and 'GIS Layers'. The bottom of the image features a 'CASOS' logo and the text 'June 2019' and 'CASOS Summer Institute 2019'.

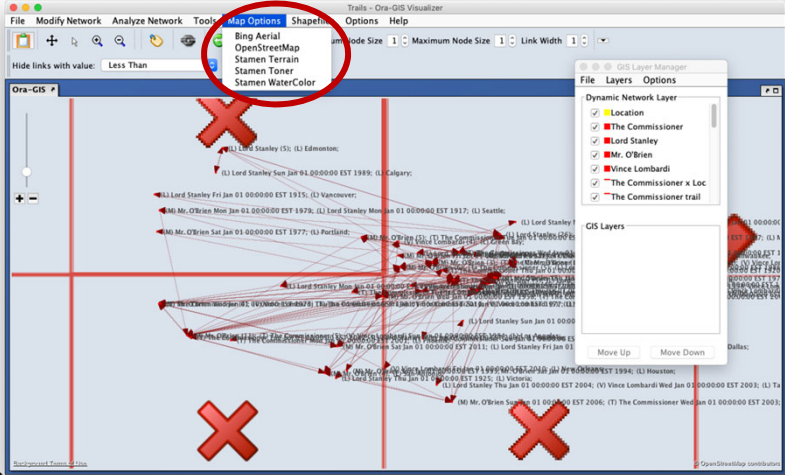


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Geospatial Visualizer



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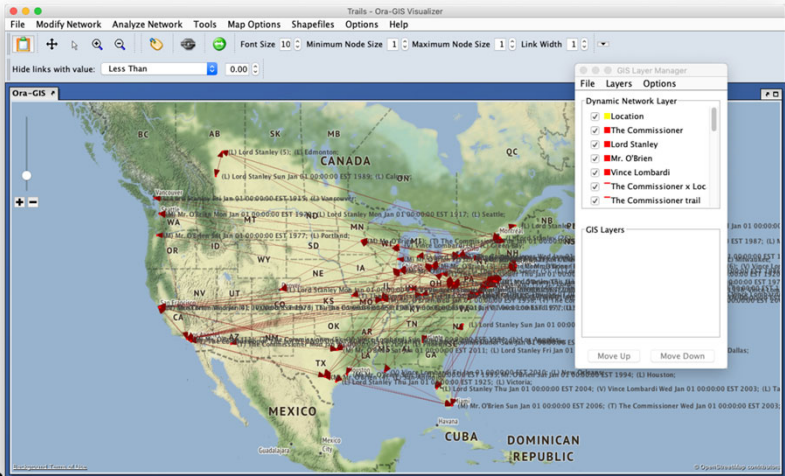
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Geospatial Visualizer



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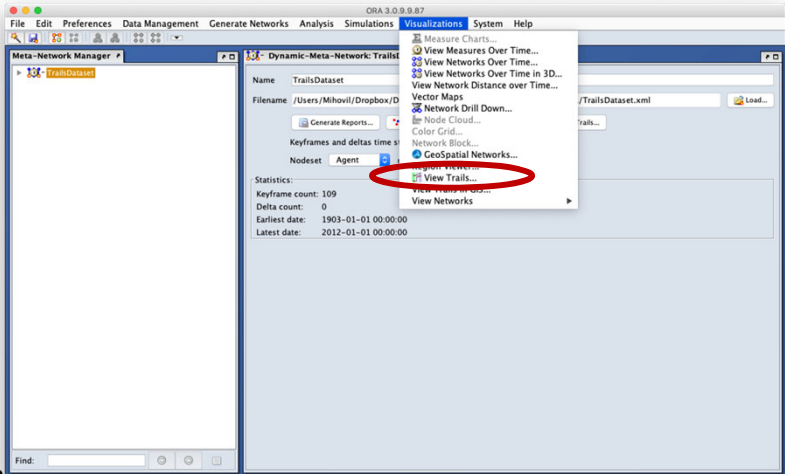


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Loom



The screenshot shows the Loom software interface. The 'Visualizations' menu is open, and the 'View Trails' option is highlighted with a red circle. The interface includes a 'Meta-Network Manager' on the left, a central panel for 'Dynamic-Meta-Network: TrailsDataset', and a right panel for 'TrailsDataset.xml'. The central panel displays statistics for the dataset, including keyframe count, delta count, and dates.

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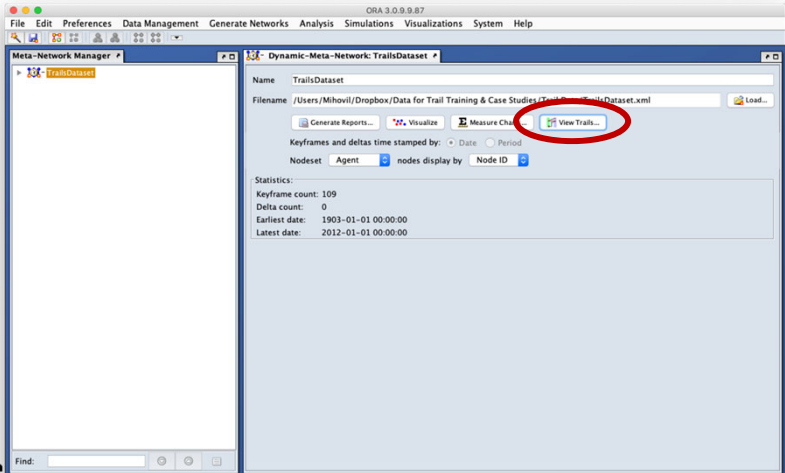
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Loom



The screenshot shows the Loom software interface. The 'View Trails' button is highlighted with a red circle. The interface includes a 'Meta-Network Manager' on the left, a central panel for 'Dynamic-Meta-Network: TrailsDataset', and a right panel for 'TrailsDataset.xml'. The central panel displays statistics for the dataset, including keyframe count, delta count, and dates.

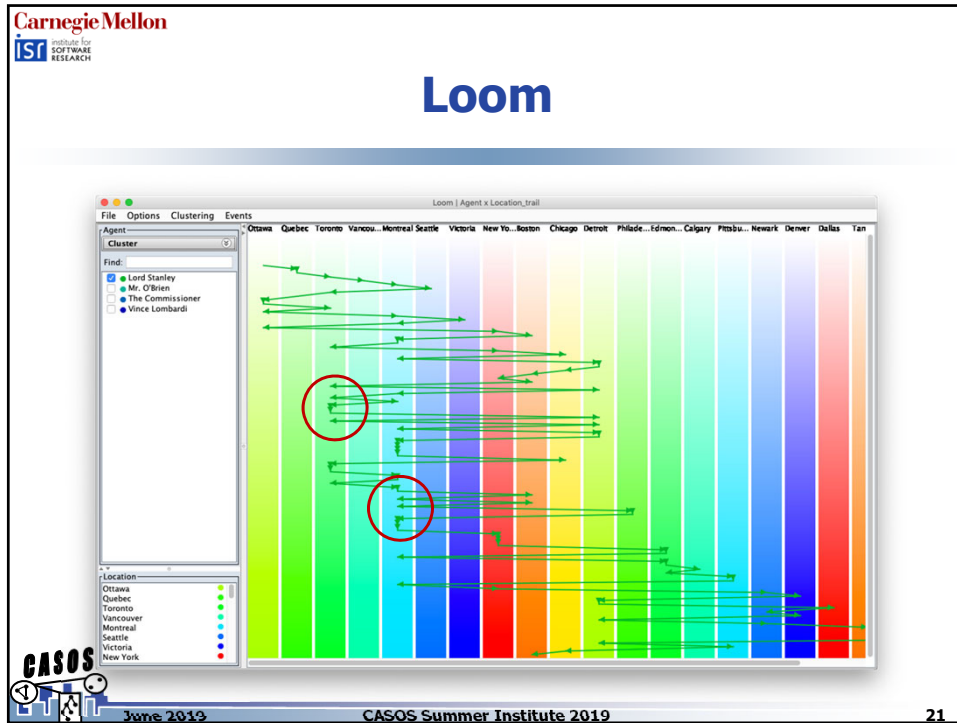
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Trails and Loom

- **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

βααβαββααββααββα.....

Depth = 1

Depth = 2

Depth = 3

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

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

Cluster

Trail pattern depth: 1

Cluster quality: 1.0

Clear Compute

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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 AANA

Longest common string Longest common subsequence

New York St. Louis San Franc...


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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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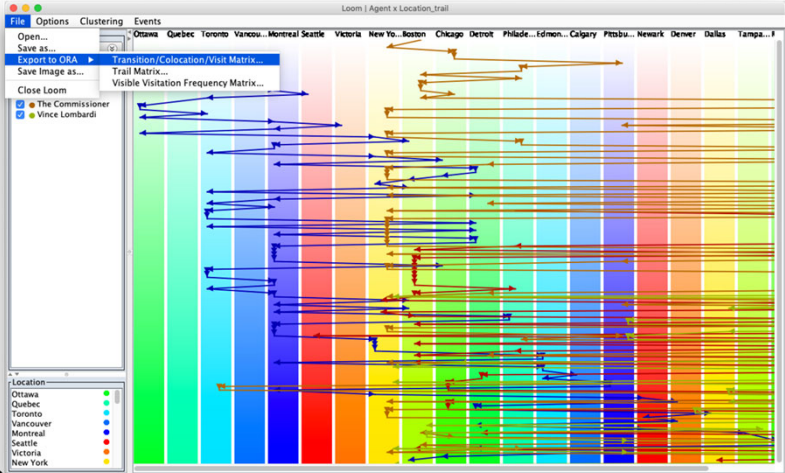
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Exporting the Matrices

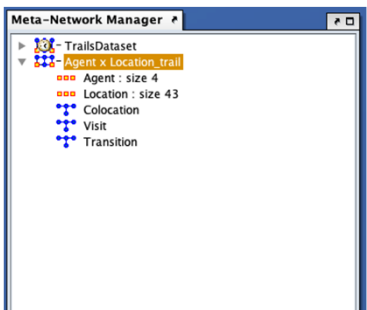


File Options Clustering Events
Open... Save as... Export to ORA Transition/Colocation/Visit Matrix... Trail Matrix... Visible Visitation Frequency Matrix...
Close Loom
The Commissioner
Vince Lombardi
Location
Ottawa
Quebec
Toronto
Vancouver
Montreal
Seattle
Victoria
New York

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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}

```
graph TD; VC[Vince Lombardi] --- TC[The Commissioner]; VC --- MOB[Mr. O'Brien]; VC --- LS[Lord Stanley]; TC --- MOB; TC --- LS; MOB --- LS;
```

powered by ORA-NetScapes, CASOS Center @ CMU

