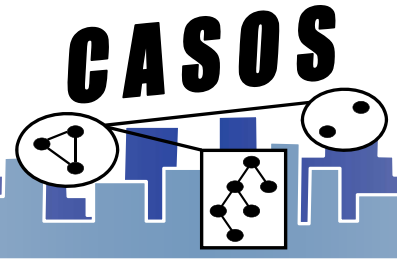

Case Study: Trails

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CASOS

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- Introduction of trail, Markov transition network
- Case study of health trails
- Current research progress
- Hands on session

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Introduction

- Trail: a path of an object through time and space
-

Time	4 pm@Apr. 1	3 pm@Apr. 2	9 am@Apr. 3	1 pm@Apr. 3	2 pm@Apr. 4	4 pm@Apr. 5
Trail 1	L1	L2	L3	L2	L1	L2
Trail 2	L2	L3	L4	L2	L1	L1
Trail 3	L2	L3	L1	L1	L2	L3

	L1	L2	L3	L4
L1	2	3	0	0
L2	2	0	4	0
L3	1	1	0	1
L4	0	1	0	0

Traffic flow network

$$P(L_i \rightarrow L_j) = \frac{N(L_i \rightarrow L_j)}{\sum_j N(L_i \rightarrow L_j)}$$

	L1	L2	L3	L4
L1	0.4	0.6	0	0
L2	0.33	0	0.67	0
L3	0.33	0.33	0	0.33
L4	0	1	0	0

Markov transition network

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Introduction

- Adding BEGIN/END locations to capture more information
-

Time	4 pm@Apr. 1	4 pm@Apr. 1	3 pm@Apr. 2	9 am@Apr. 3	1 pm@Apr. 3	2 pm@Apr. 4	4 pm@Apr. 5	4 pm@Apr. 5
Trail 1	BEGIN	L1	L2	L3	L2	L1	L2	END
Trail 2	BEGIN	L2	L3	L4	L2	L1	L1	END
Trail 3	BEGIN	L2	L3	L1	L1	L2	L3	END

Traffic flow network

	B	L1	L2	L3	L4	E
B	0	1	2	0	0	0
L1	0	2	3	0	0	1
L2	0	2	0	4	0	1
L3	0	1	1	0	1	1
L4	0	0	1	0	0	0
E	0	0	0	0	0	0

Markov transition network

	B	L1	L2	L3	L4	E
B	0	0.33	0.67	0	0	0
L1	0	0.4	0.6	0	0	1
L2	0	0.29	0	0.57	0	0.14
L3	0	0.25	0.25	0	0.25	0.25
L4	0	0	1	0	0	0
E	0	0	0	0	0	0

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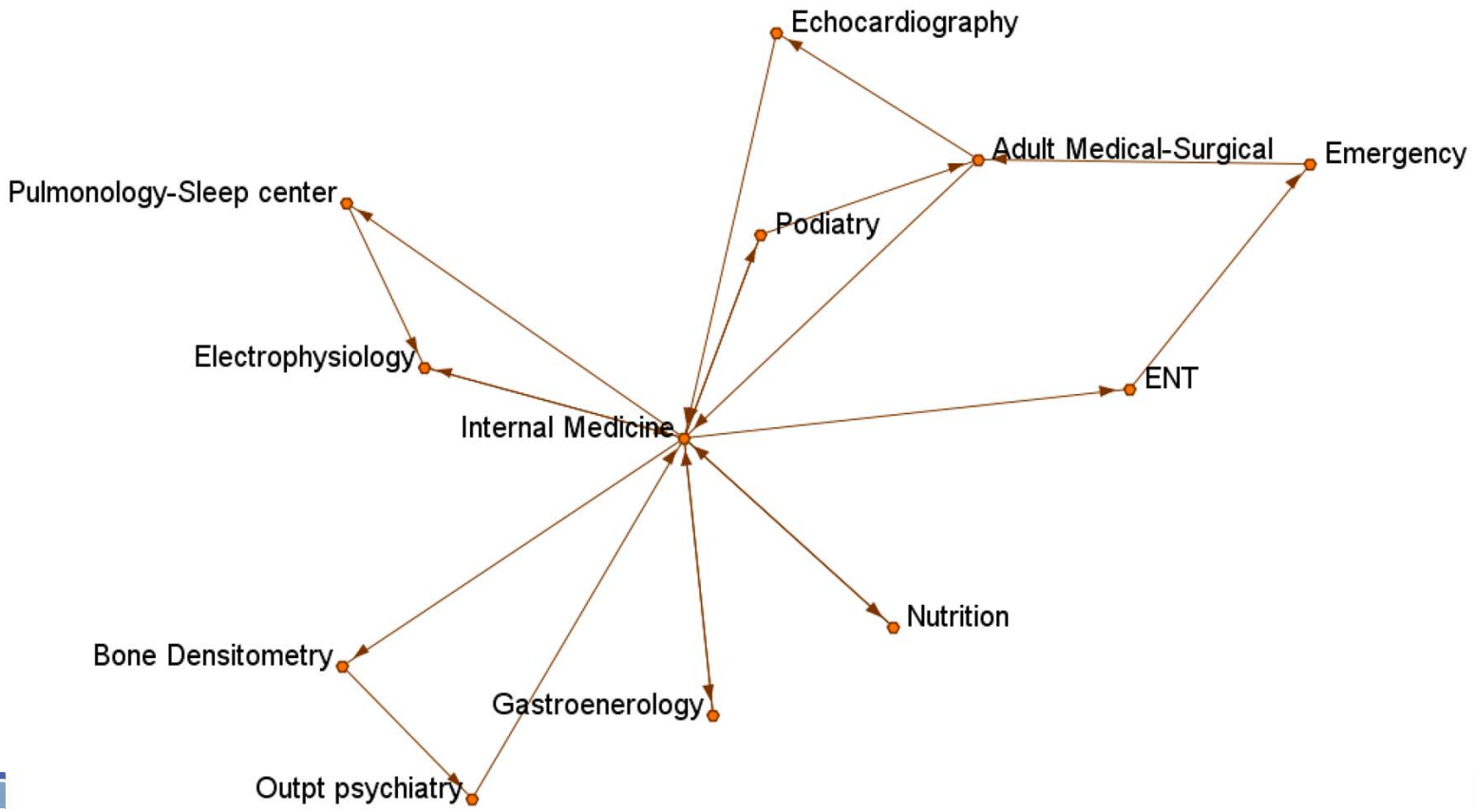
Case study

- Case study: one patient health trail
-



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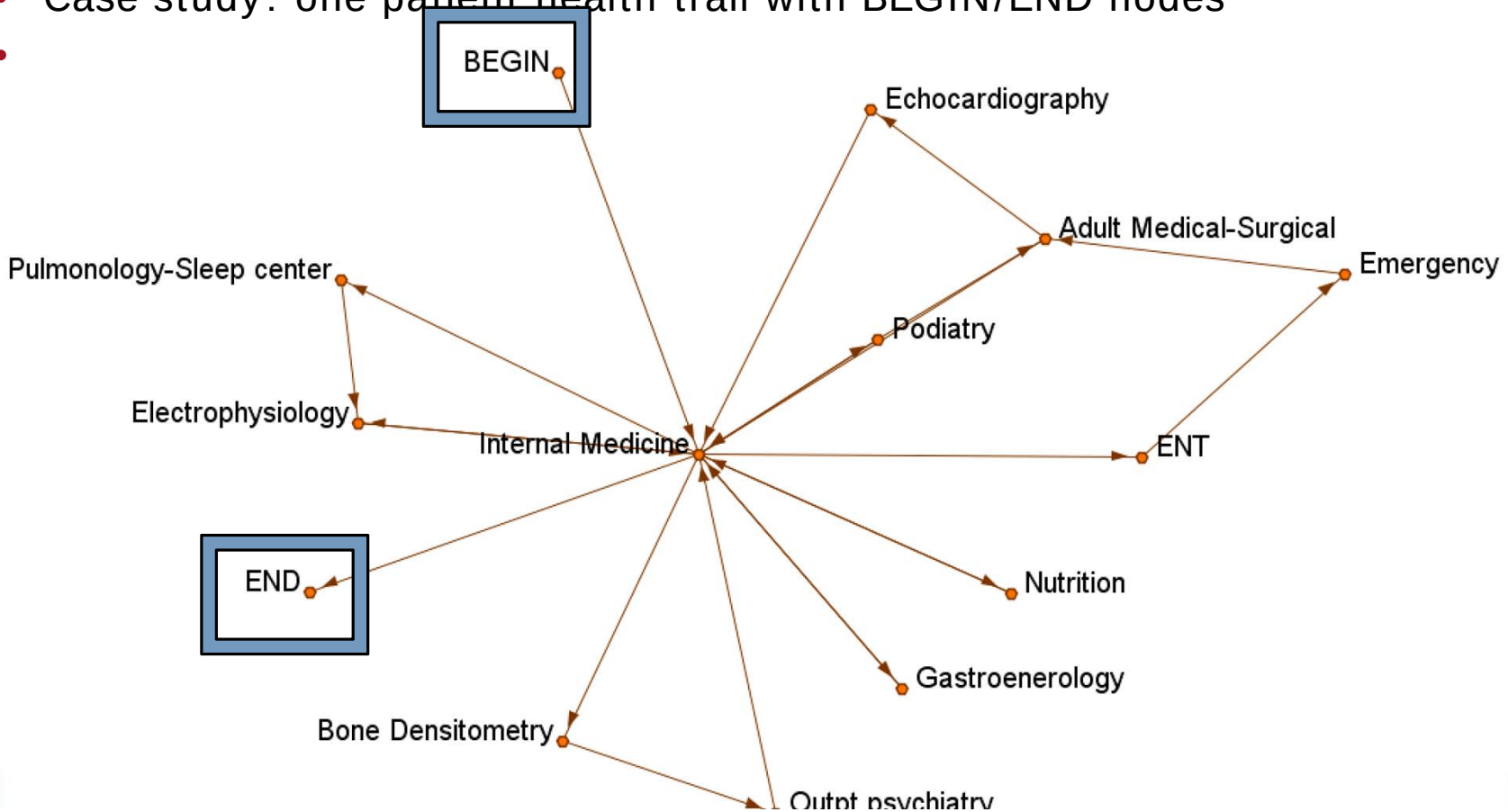
Case study

- Case study: one patient health trail with BEGIN/END nodes
-



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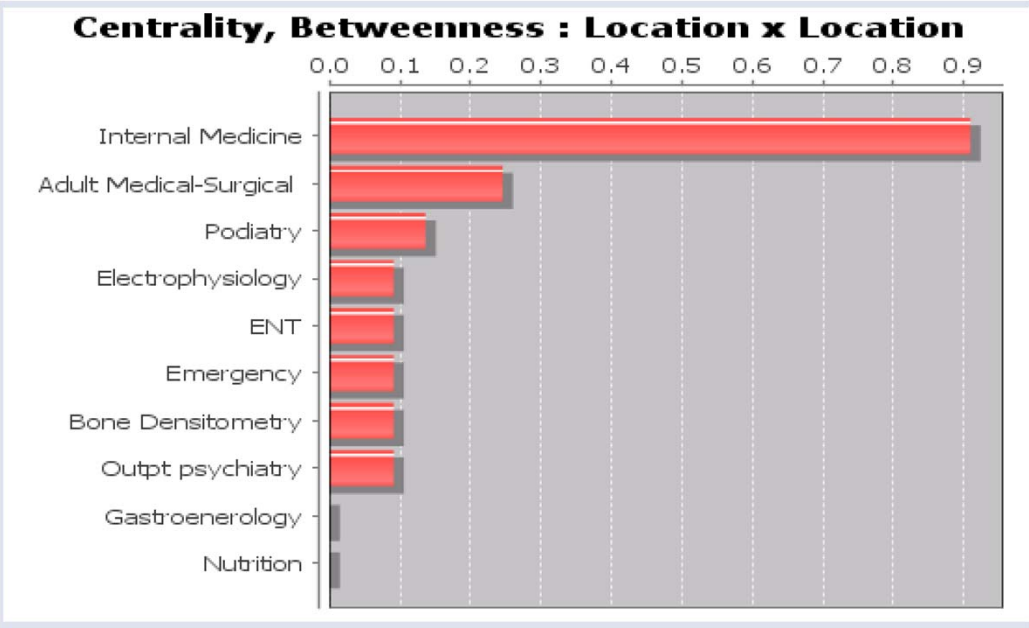
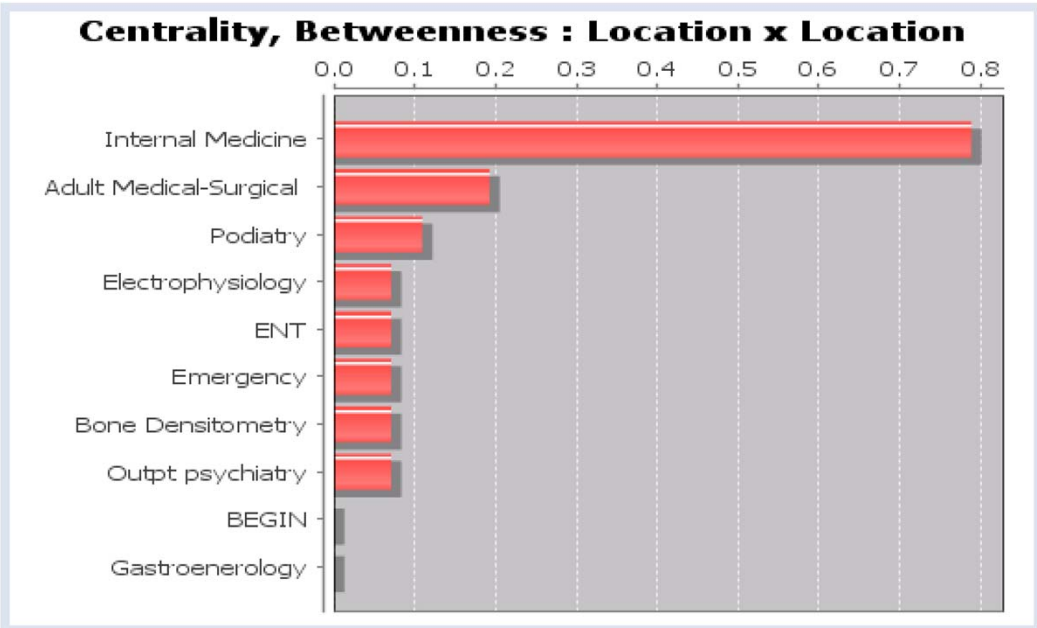
Case study

- Compare between one patient health trail with/without BEGIN/END
- Without BEGIN/END



With BEGIN/END



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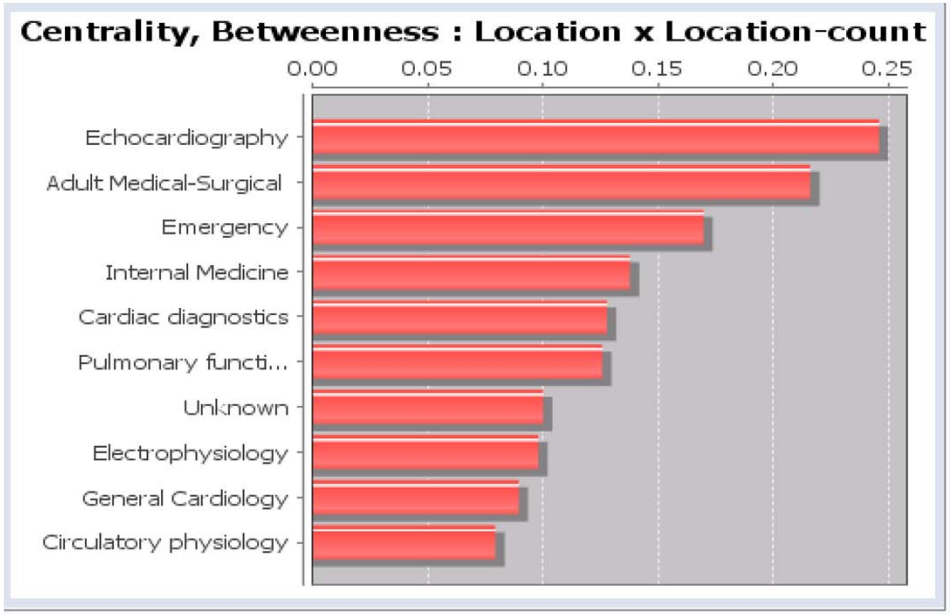
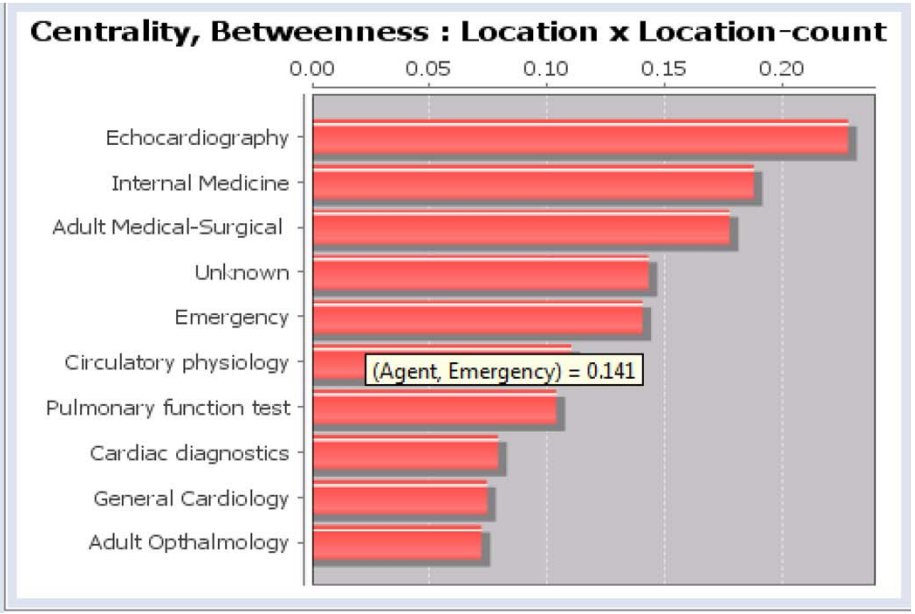
Case study

- Compare between group of health trails with/without BEGIN/END

Without BEGIN/END



With BEGIN/END



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Current progress: Overcome the Low Time Resolution in Trails

Time	4 pm@Apr. 1	3 pm@Apr. 2	9 am@Apr. 3	1 pm@Apr. 3	2 pm@Apr. 4	4 pm@Apr. 5
Trail 1	L1	L2	L3	L2	L1	L2
Trail 2	L2	L3	L4	L2	L1	L1
Trail 3	L2	L3	L1	L1	L2	L3

Lower time resolution

Broken point

Time	Apr. 1	Apr. 2	Apr. 3	Apr. 3	Apr. 4	Apr. 5
Trail 1	L1	L2	L3	L2	L1	L2
Trail 2	L2	L3	L4	L2	L1	L1
Trail 3	L2	L3	L1	L1	L2	L3

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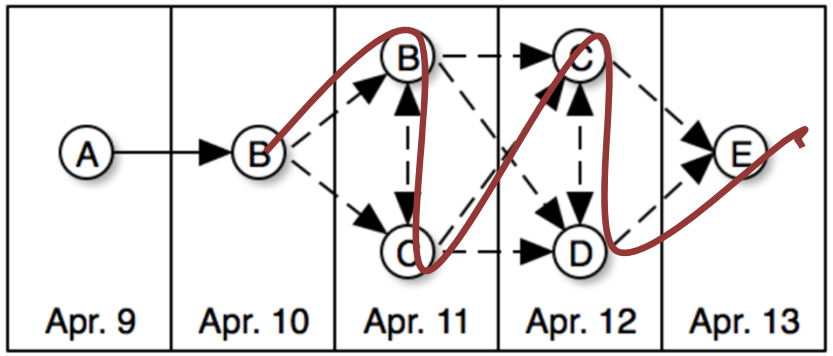
Current progress: Overcome the Time Resolution Issue in Trails

- For a location sequence in a broken point: Find a location sequence with maximum transition probability product
  - $p(l_1 \rightarrow l_2 \rightarrow \cdots \rightarrow l_n) = p(l_2|l_1)p(l_3|l_2) \ldots p(l_n|l_{n-1})$
- Relation with Asymmetric Traveling Salesman Problem(ATSP): visit each location exactly once and find the minimum travelling cost(NP-hard)
  - *-lo*

Time	2016.4.9	2016.4.10	2016.4.11	2016.4.11	2016.4.12	2016.4.12	2016.4.13
Location	A	B	B	C	C	D	E



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Current progress: Overcome the Time Resolution Issue in Trails

- Four algorithms
  - Random: Randomly pick the location order
  - Greedy: At each step, select next location with maximum transition probability.
  - Exact algorithm: enumerate all the possible routes.
  - Ant Colony System(ACS): an approximate algorithm designed for ATSP

- Partition trails when time intervals are larger than a threshold.

Time	Apr. 1	Apr. 1	Apr. 2	Apr. 3	June 3	June 4	June 5	June 5
Trail 1	BEGIN	L1	L2	L3	L2	L1	L2	END

Time	Apr. 1	Apr. 1	Apr. 2	Apr. 3	Apr.3	June 3	June 3	June 4	June 5	June 6
Trail 1	BEGIN	L1	L2	L3	END	BEGIN	L2	L1	L2	END

Current progress: Overcome the Time Resolution Issue in Trails

- Datasets:
  - Health record data
    - Location: health service
    - Agent: patient
    - Record: (patient, health service, date)

	# of Records	# of Agents	# of Locations
Health data	94885	5055	115

Use 814 unbroken trails as testing data

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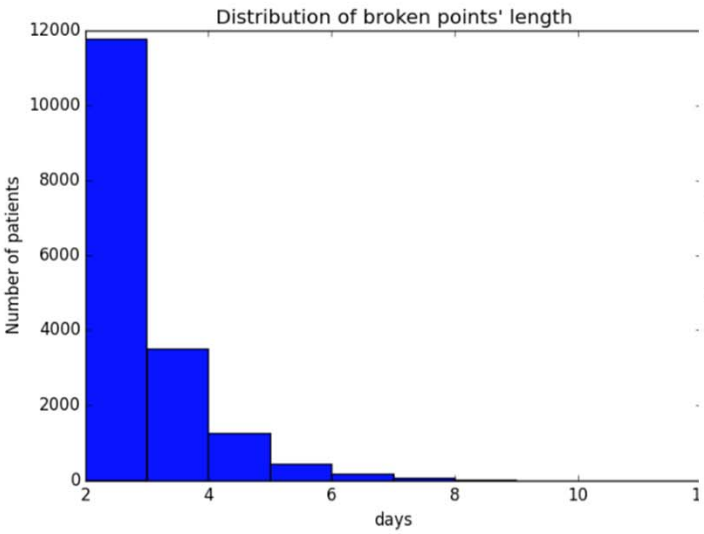
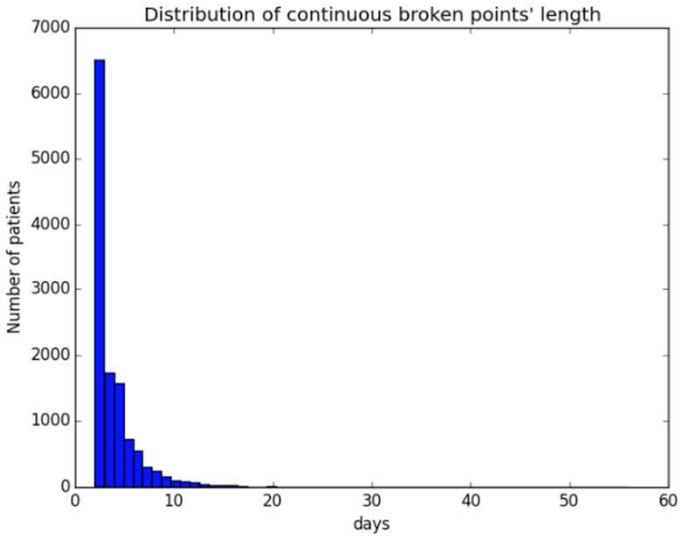
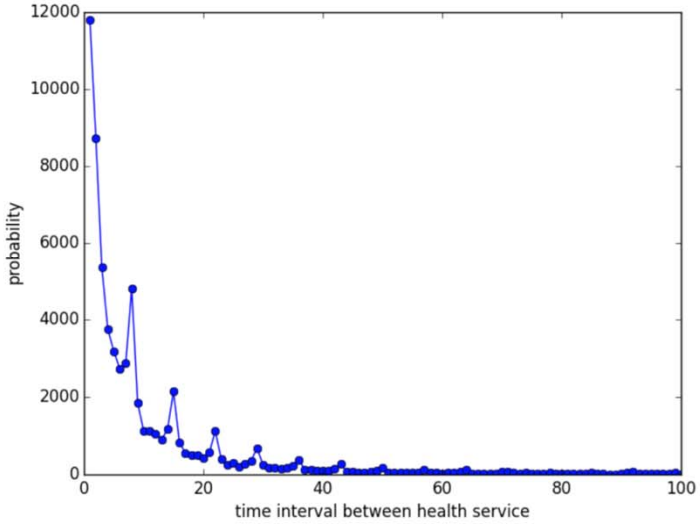
Current progress: Overcome the Time Resolution Issue in Trails

- Statistics of health dataset







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Current progress: Overcome the Time Resolution Issue in Trails

- Experiments setup
  - Artificially change the time resolution of 814 unbroken health trails
  - $timestamp' = \lfloor \frac{timestamp}{\text{resolution}} \rfloor * \text{resolution}.$

Time resolution(day)	2	3	4	5	6	7	8	9
# of broken trails	164	213	250	263	268	278	294	297
# of broken points	178	251	296	319	340	353	374	389
Avg. length of broken points	2.073	2.223	2.284	2.426	2.482	2.586	2.591	2.627
Avg. length of cont. broken points	2.121	2.364	2.449	2.650	2.749	2.916	2.909	3.041
Max. length of broken points	4	5	6	5	6	6	6	7

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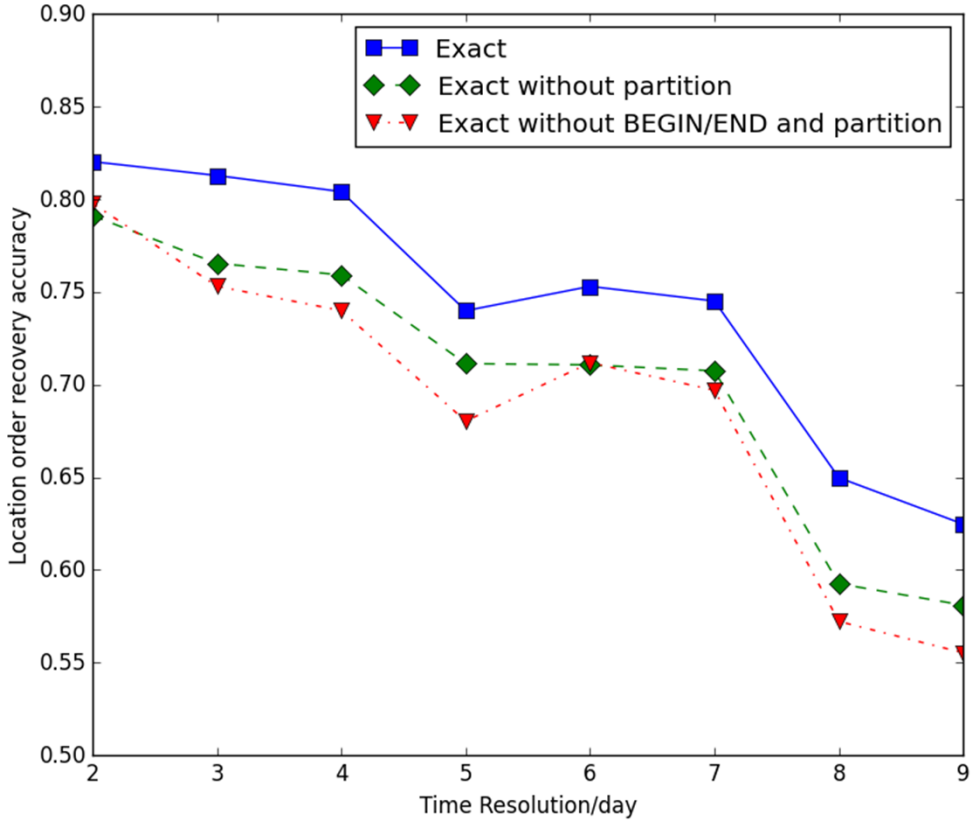
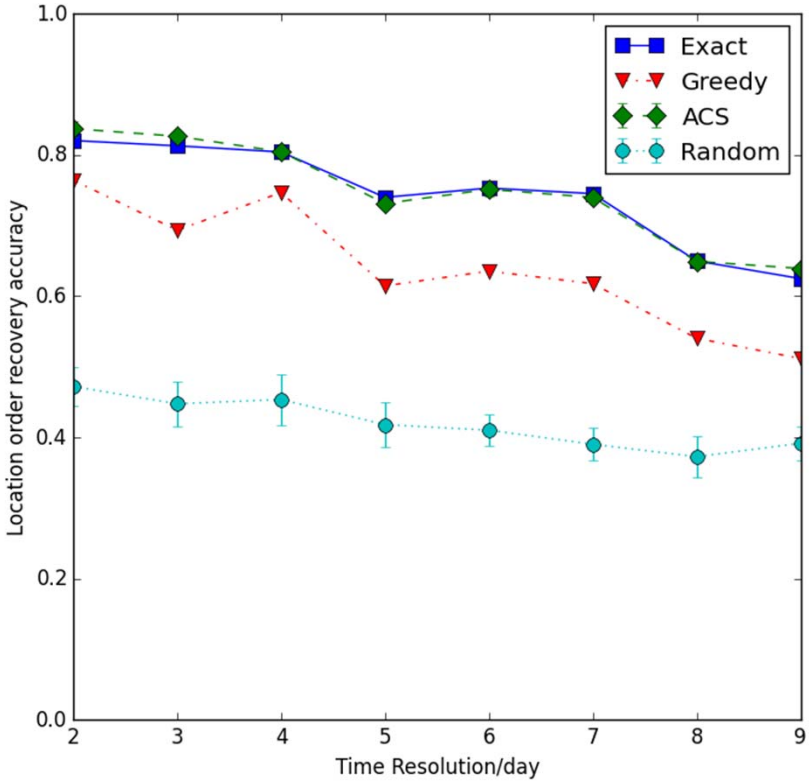
Current progress: Overcome the Time Resolution Issue in Trails

- The effects of BEGIN/END nodes and partitions



Current progress: Overcome the Time Resolution Issue in Trails

Comparison between four algorithms



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Hands on

- Data preparation: program function call data

id	timestamp	location
0	553987065457672.00	class edu.umd.cs.findbugs.PluginLoader
0	553987065574331.00	class edu.umd.cs.findbugs.PluginLoader
0	553987065768508.00	class java.lang.Class
0	553987065819048.00	class edu.umd.cs.findbugs.PluginLoader
0	553987100679470.00	class java.net.URL
0	553987102005655.00	class edu.umd.cs.findbugs.PluginLoader
0	553987102202112.00	class edu.umd.cs.findbugs.PluginLoader
0	553987102260252.00	class edu.umd.cs.findbugs.PluginLoader
0	553987102331691.00	class edu.umd.cs.findbugs.PluginLoader
0	553987102384890.00	class edu.umd.cs.findbugs.PluginLoader
0	553987102425550.00	class edu.umd.cs.findbugs.PluginLoader
0	553987476519118.00	class edu.umd.cs.findbugs.PluginLoader
0	553987476619437.00	class java.net.URL
0	553987476664276.00	class edu.umd.cs.findbugs.PluginLoader
0	553987476741035.00	class java.lang.String
0	553987476797655.00	class edu.umd.cs.findbugs.PluginLoader

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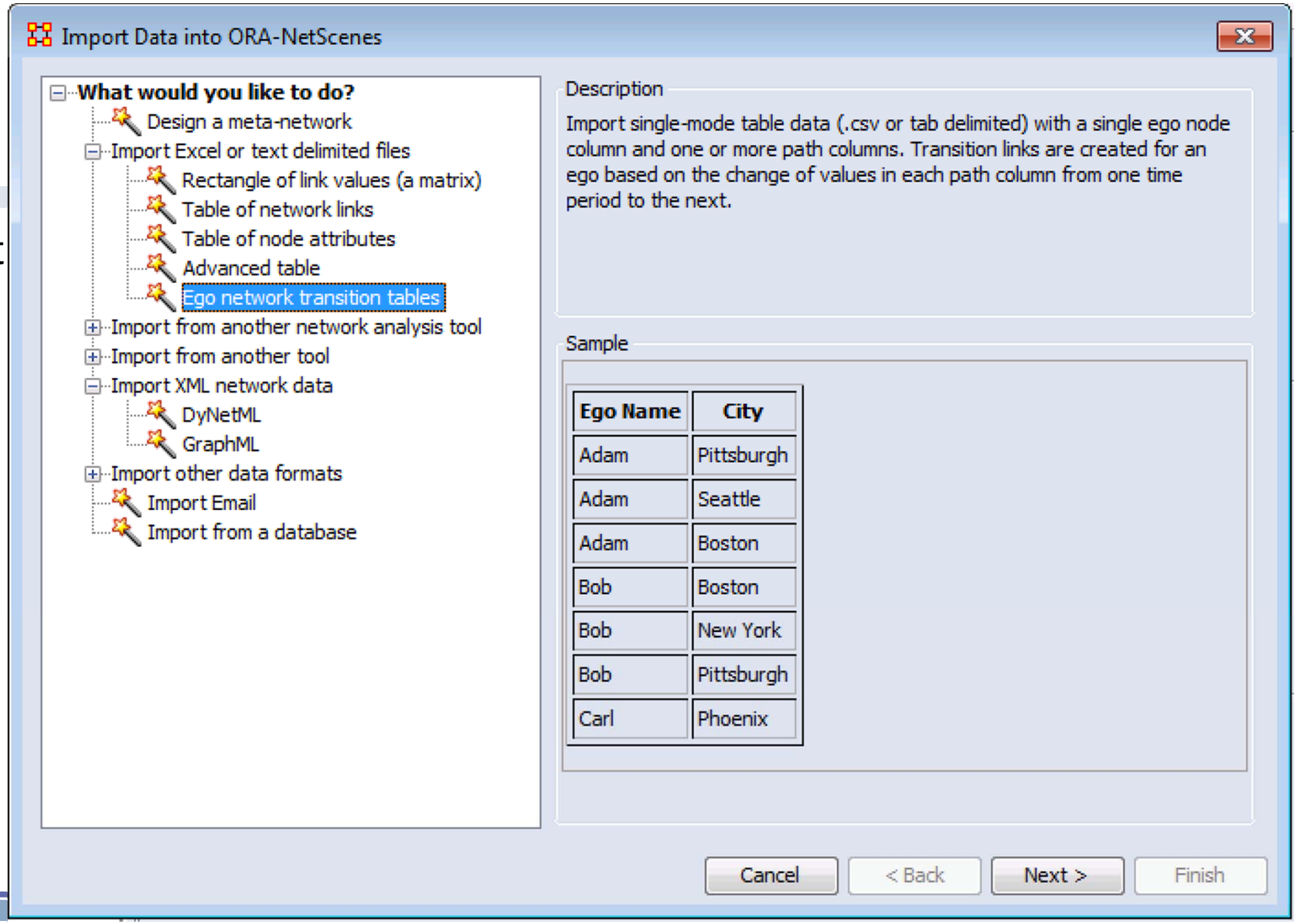
- Data import



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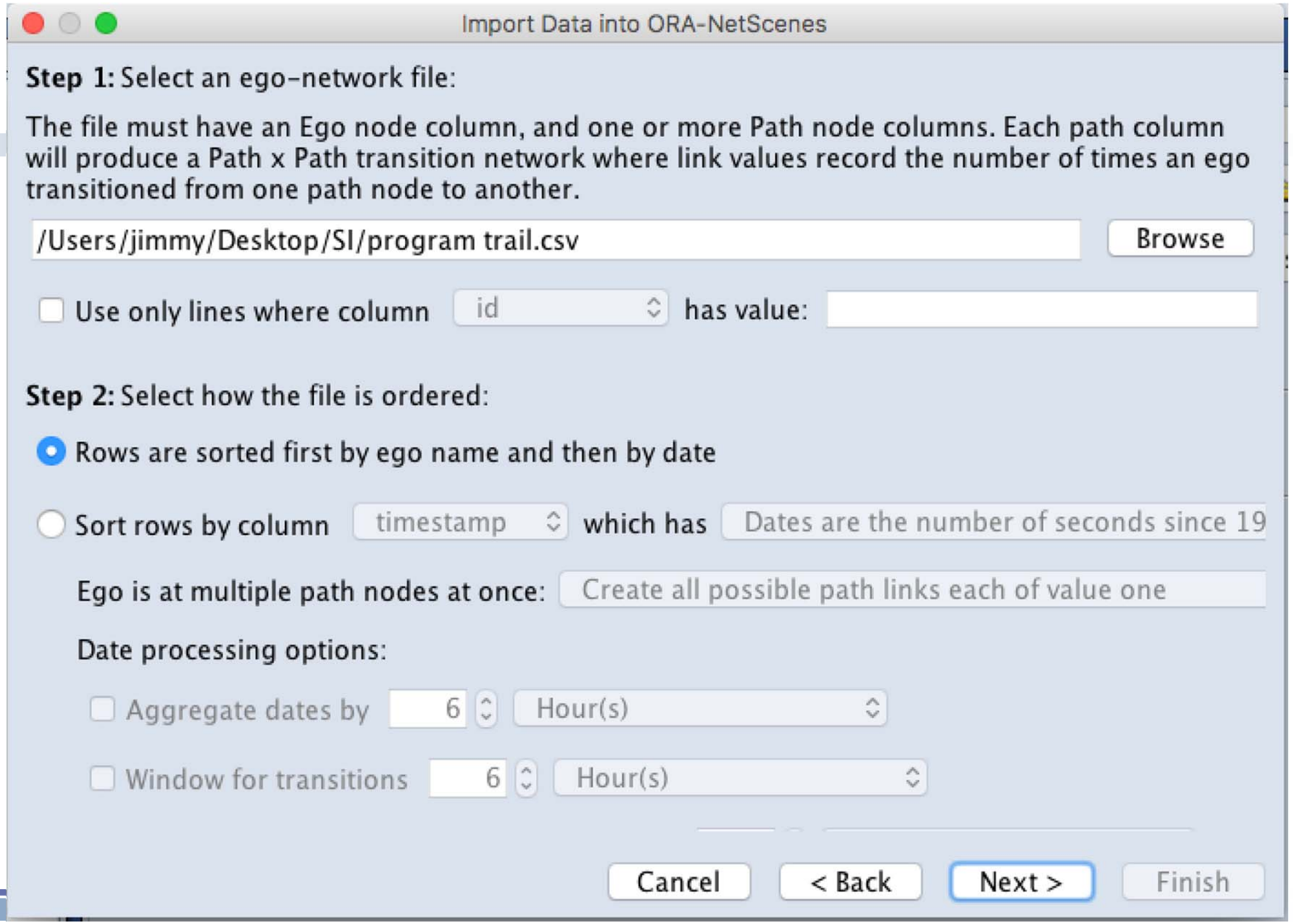
- Data import



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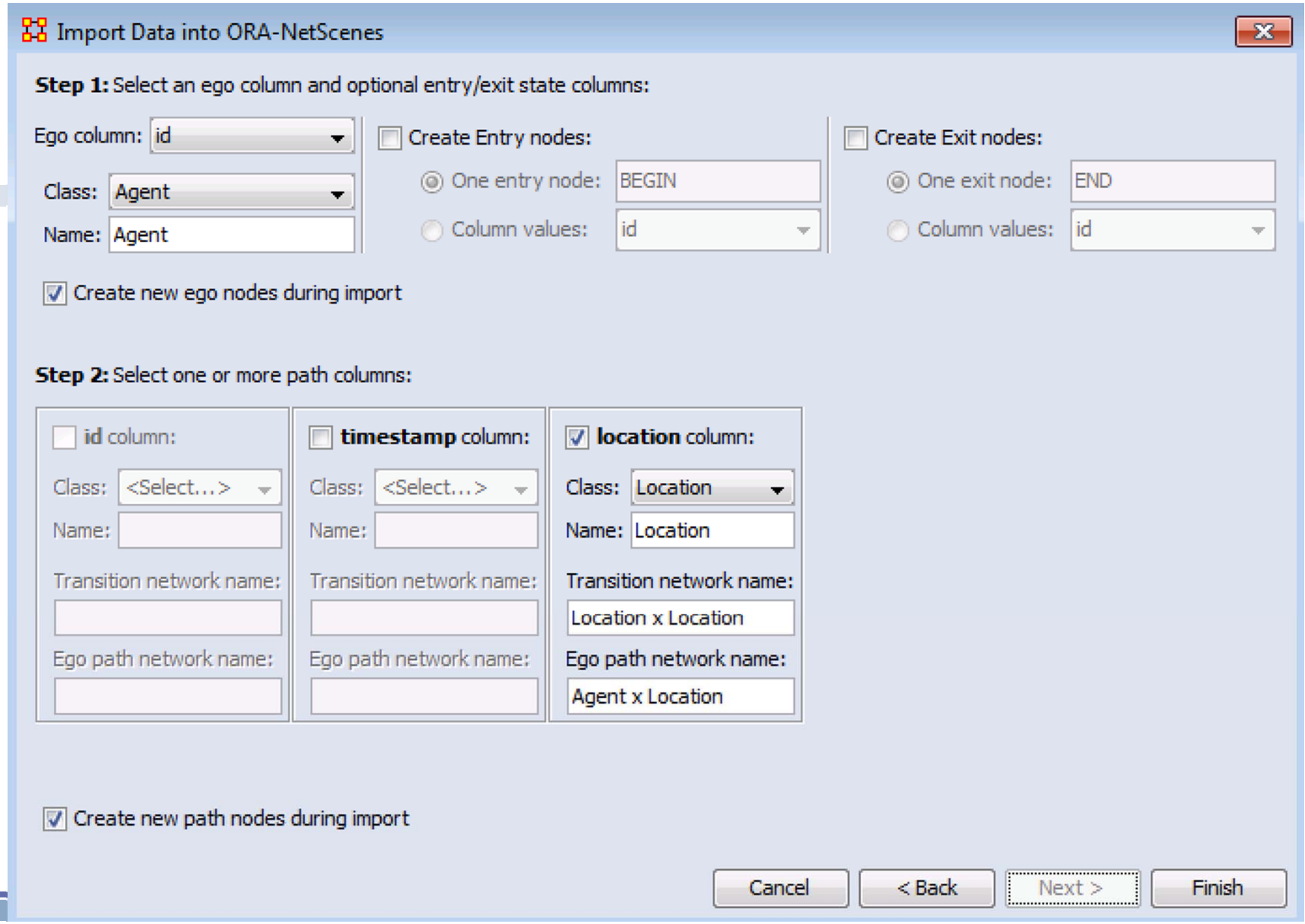
- Data import



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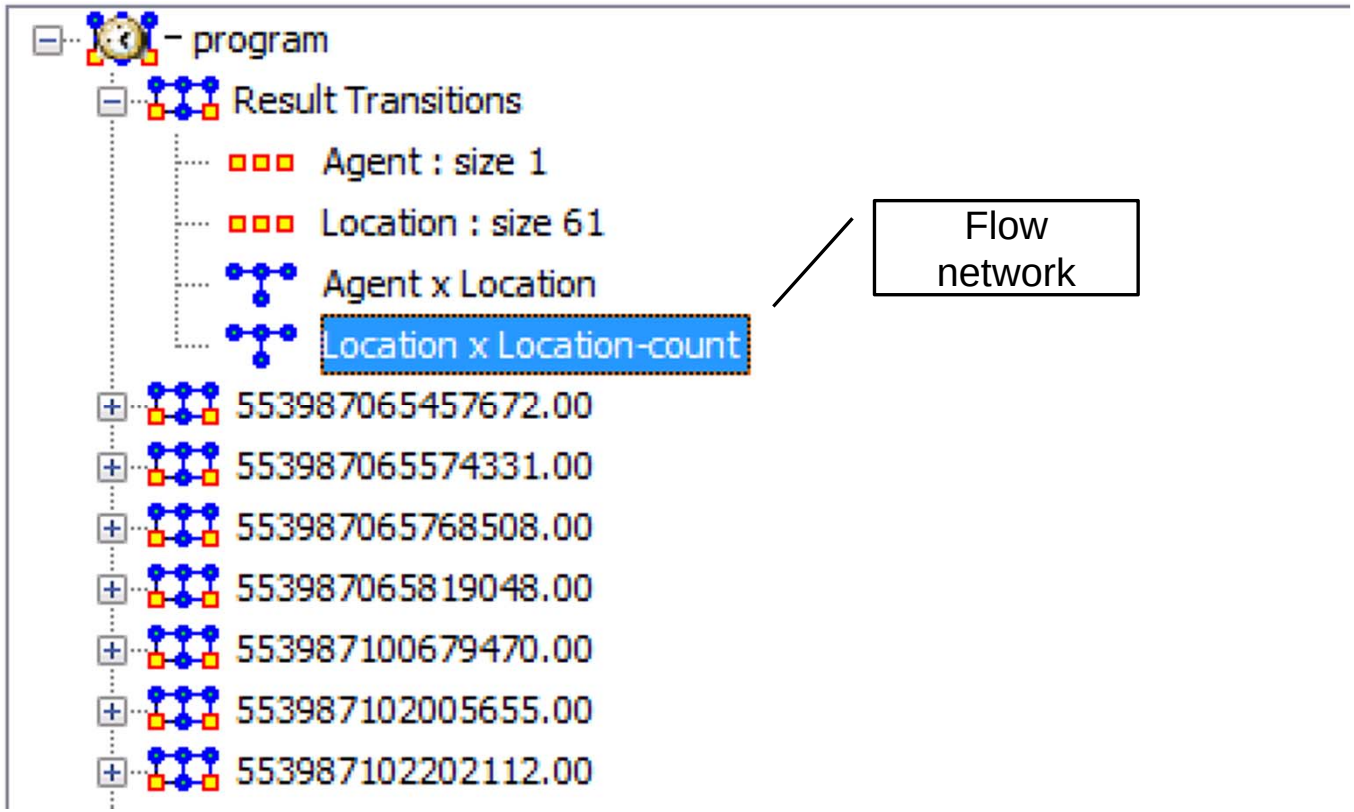
Hands on

- Data transform



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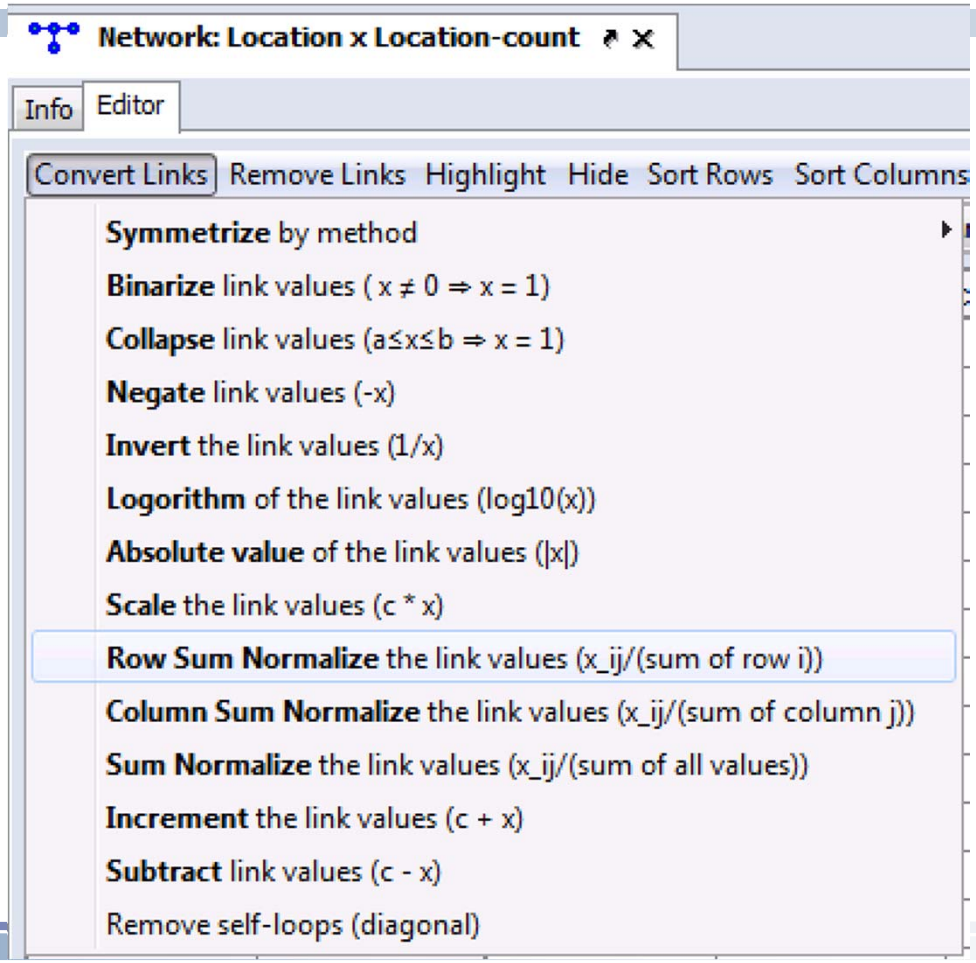
Hands on

- Data transform



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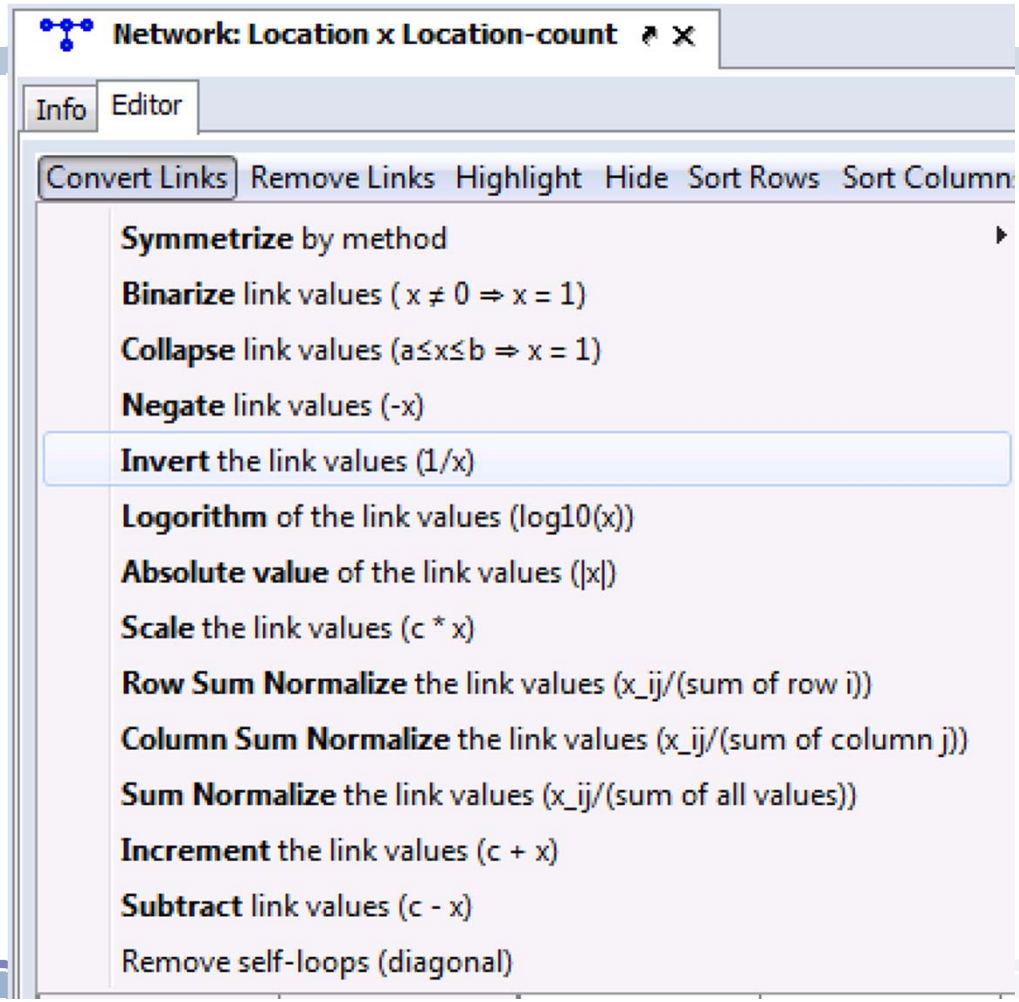
Hands on

- Data transform



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Hands on

- Analysis