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# An Approach to Fitting Transmission Models to Seriations for Regional-Scale Analysis

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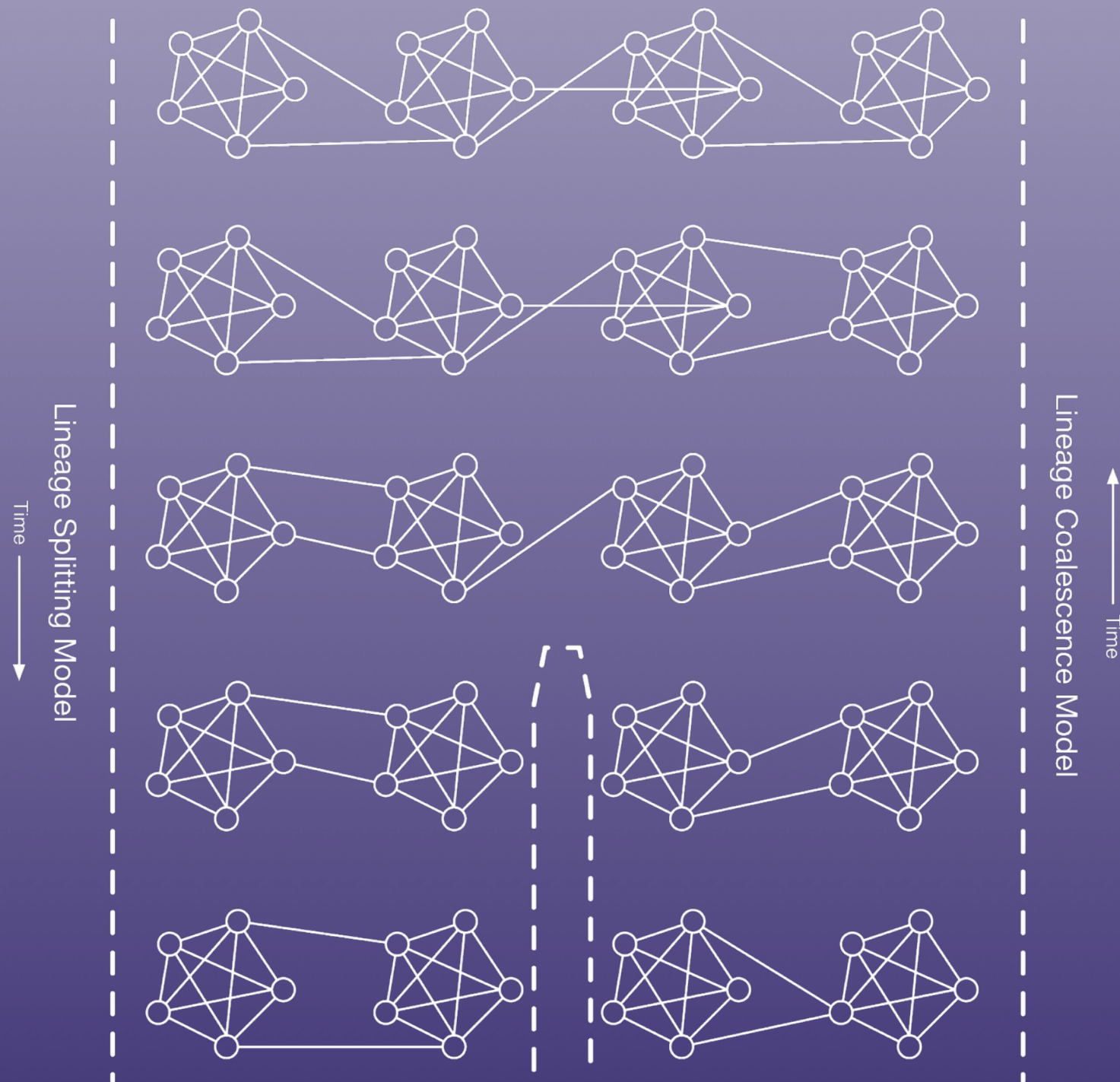
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*CSU Long Beach*



# Regional Scale CT Models

- Coarse grained compared to cognitive social learning within a population
- Finer grained compared to largest-scale phylogenetic models
- Basic question is: can we infer changing patterns of interaction within an evolving settlement system?
- THIS STUDY: Can we recover the overall interaction pattern from time-averaged type frequencies, using a diachronic tool like seriation?

# Inferring Regional Interaction

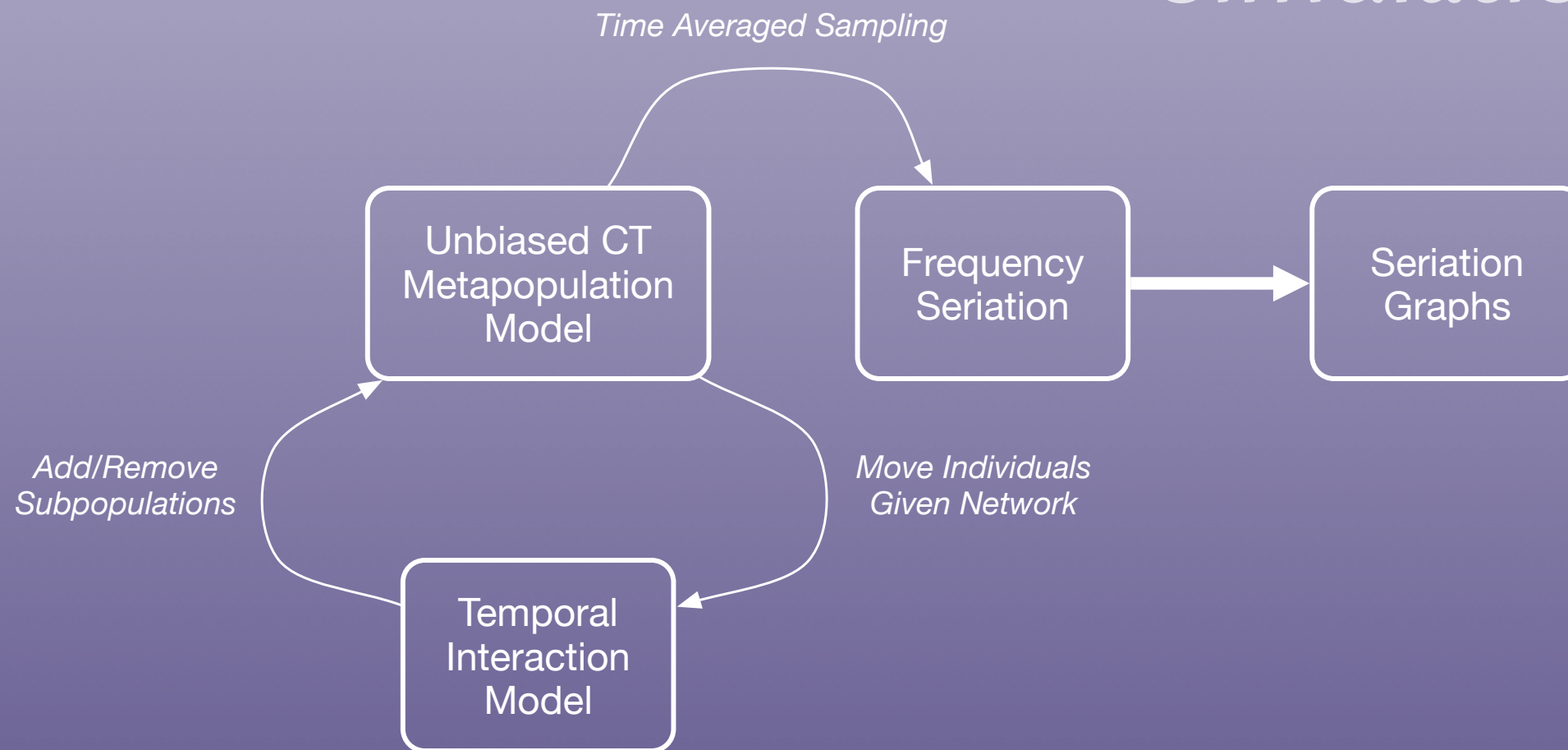


Temporal Network Model

- Links represent interaction, trade, migration
- Persistent changes to linkage patterns creates historical “lineages”
- These lineages should appear archaeologically as groups of assemblages which can seriate together



# Simulation Overview



- Each community contains 100 agents
- TN model: 6-8 graph “slices” — each applies for a duration
- Individual communities have short duration
- Unbiased copying within communities, migration according to network edges, and innovation at low rates
- Samples of individuals recorded and time-averaged over community duration — samples are then seriated



# IDSS Frequency Seriation

- Basic principle: not all assemblages were part of the same flow of traits, and thus will not seriate together.
- The seriation problem is thus to find all sets of assemblages that DO seriate together
- And then work out the relationship between these partial solutions

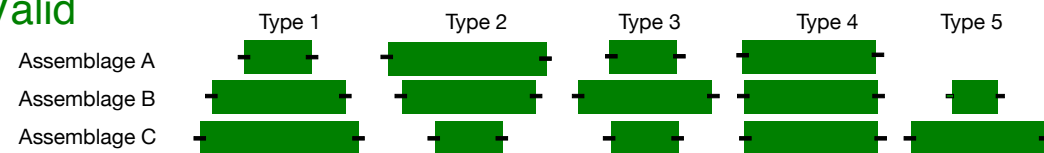
## Core of algorithm:

- Find all valid triples
- Grow triples by combining with other assemblages
- Use bootstrap CI to determine “fit” of ordering
- Use threshold for pairwise differences to reject bad orders
- Combine partial solutions using overlaps and min summed frequency differences

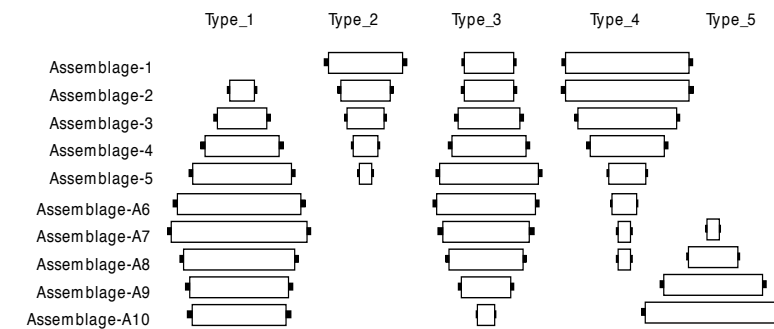
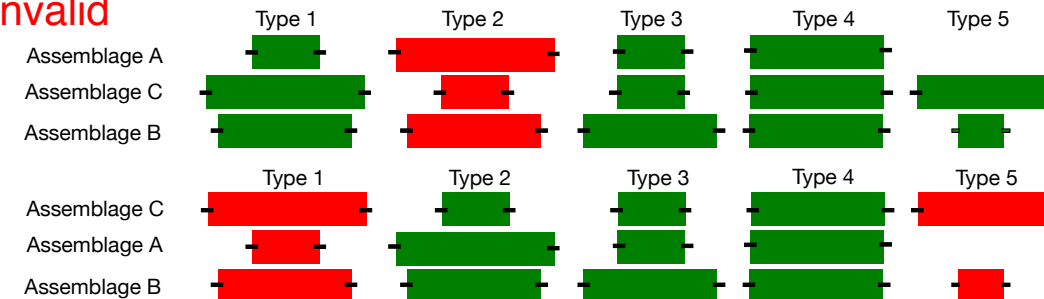
Assemblage Name	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Assemblage-1	0	30	20	50	0	0
Assemblage-2	10	20	20	50	0	0
Assemblage-3	20	15	25	40	0	0
Assemblage-4	30	10	30	30	0	0
Assemblage-5	40	5	40	15	0	0
Assemblage-A6	50	0	40	10	0	0
Assemblage-A7	55	0	35	5	5	0
Assemblage-A8	45	0	30	5	20	0
Assemblage-A9	40	0	20	0	40	0
Assemblage-A10	38	0	7	0	55	0
Assemblage-B11	44	4	35	12	0	5
Assemblage-B12	45	3	30	10	0	12
Assemblage-B13	43	2	25	8	2	20
Assemblage-B14	40	0	20	5	5	30
Assemblage-B15	36	0	10	4	10	40

# IDSS Seriation

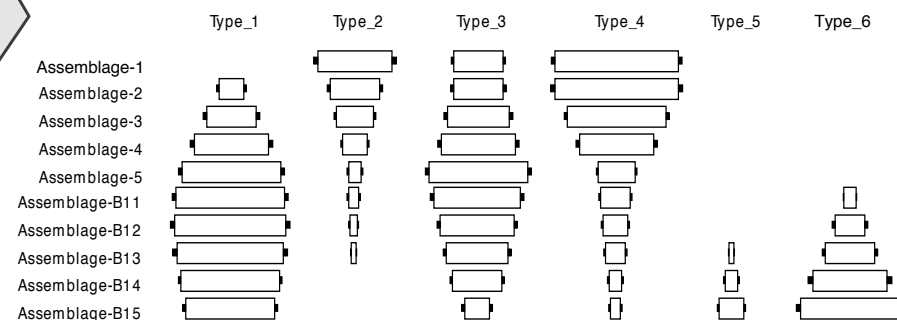
Valid



Invalid



- Assemblage-1
- Assemblage-2
- Assemblage-3
- Assemblage-4
- Assemblage-5
- Assemblage-5
- Assemblage-A6
- Assemblage-A7
- Assemblage-A8
- Assemblage-A9
- Assemblage-A10

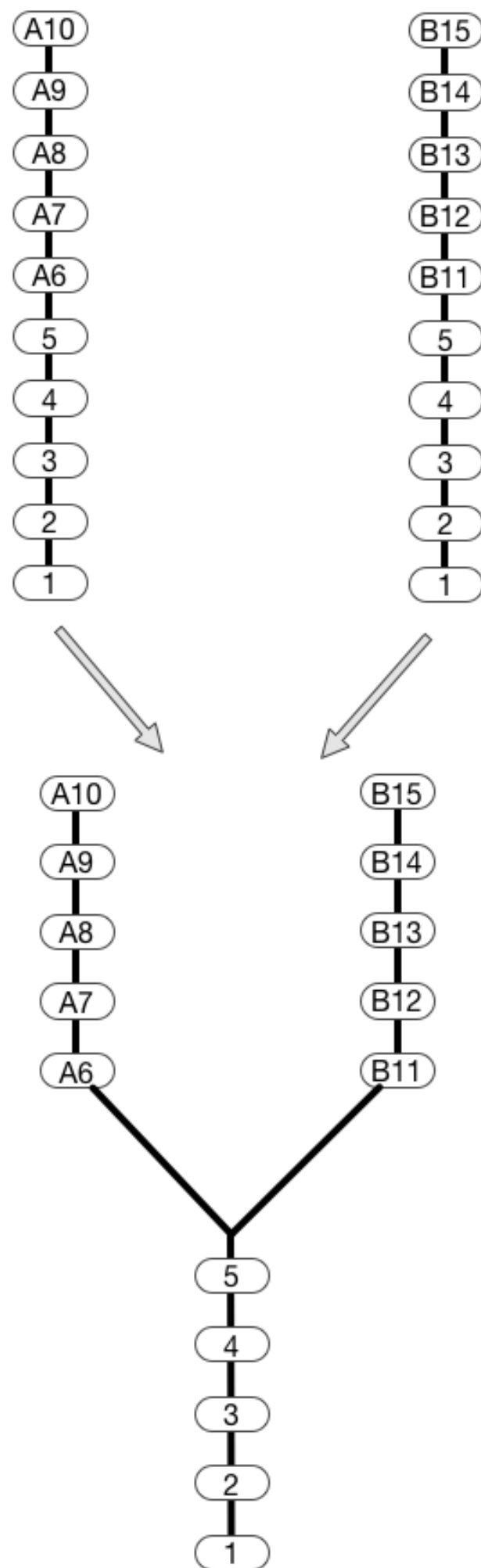


- Assemblage-1
- Assemblage-2
- Assemblage-3
- Assemblage-4
- Assemblage-5
- Assemblage-5
- Assemblage-B11
- Assemblage-B12
- Assemblage-B13
- Assemblage-B14
- Assemblage-B15

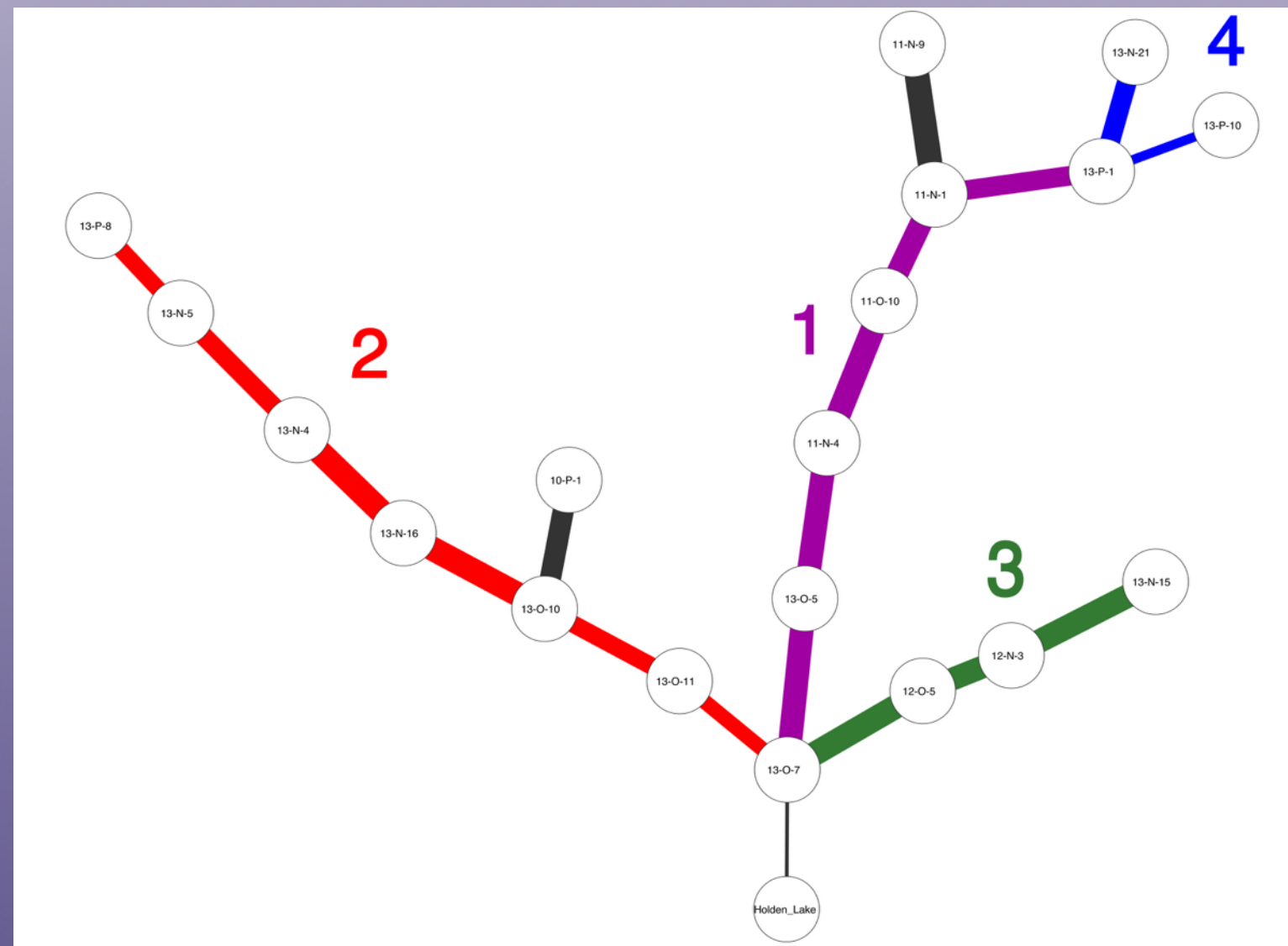
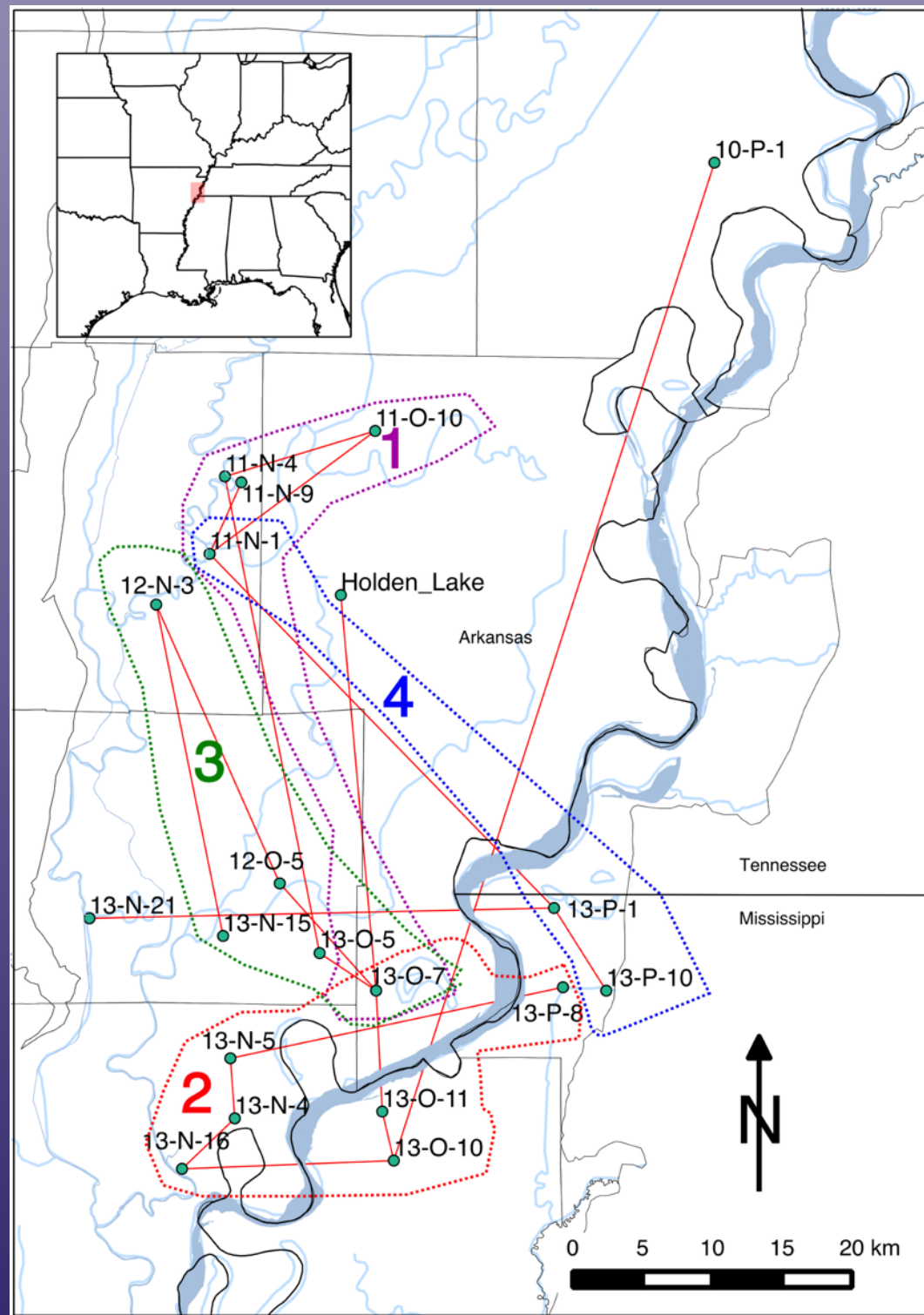
Note the compact graph representation of the solution on the right. This is useful when sets of assemblages partially overlap and diverge or coalesce

# Combining Solutions

- Create a single solution using all of the vertices in the partial solutions (1-5, A6-10, B11-15)
- Edges are kept which have the smallest total frequency differences between vertices
- Creates branching points and tree-like solutions, preserving overlapping portions.
- Result is the “maximal” size solution with the “minimal” total frequency distance, hence “minmax” graph

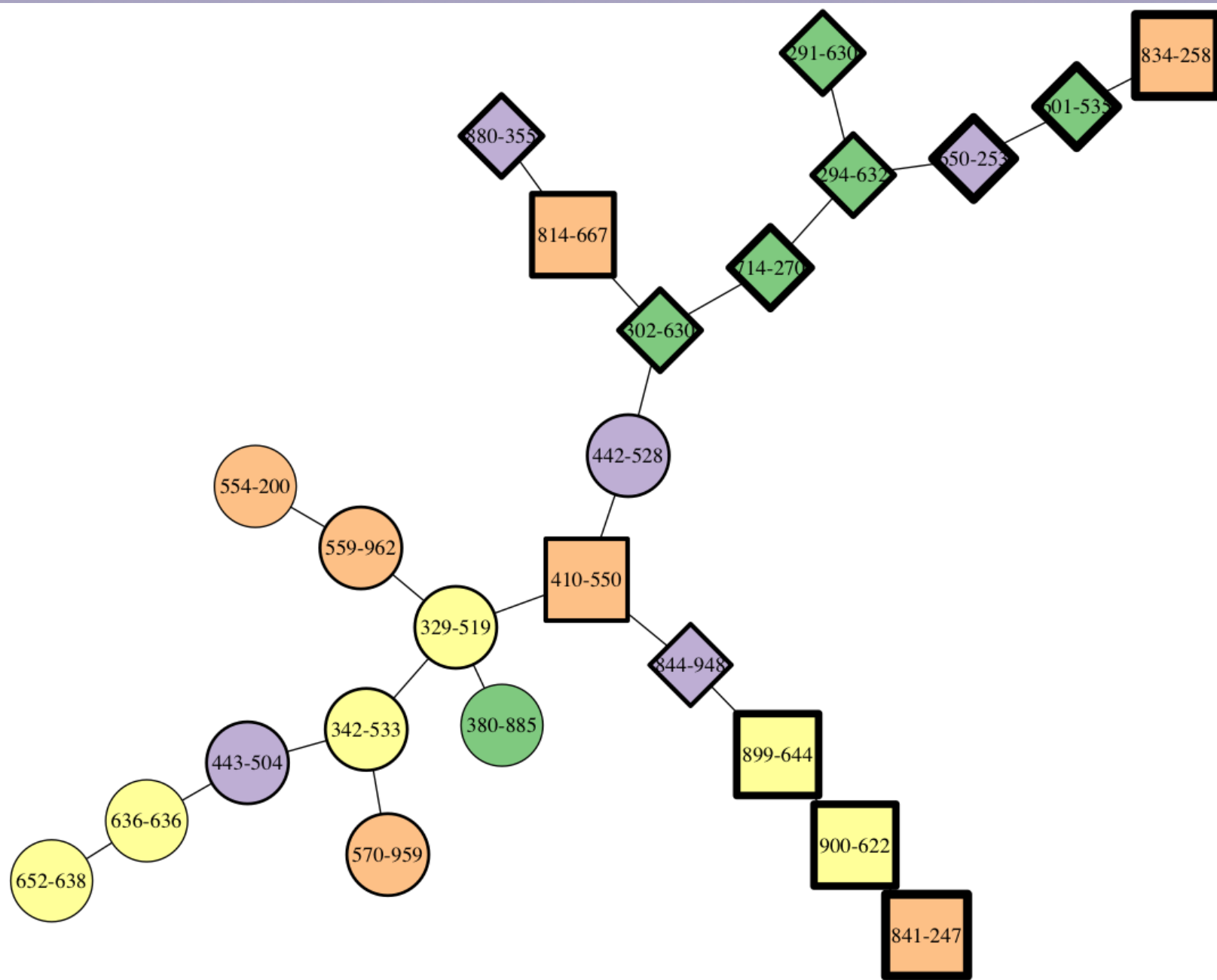


# LMV Ceramic Seriations



- “Minmax” solution for the Memphis and St. Francis areas
- Combines 97 valid partial solutions
- Two sites (Parkin, Beck Place) link multiple spatial clusters
- Potentially shows lineage structure as well as chronology





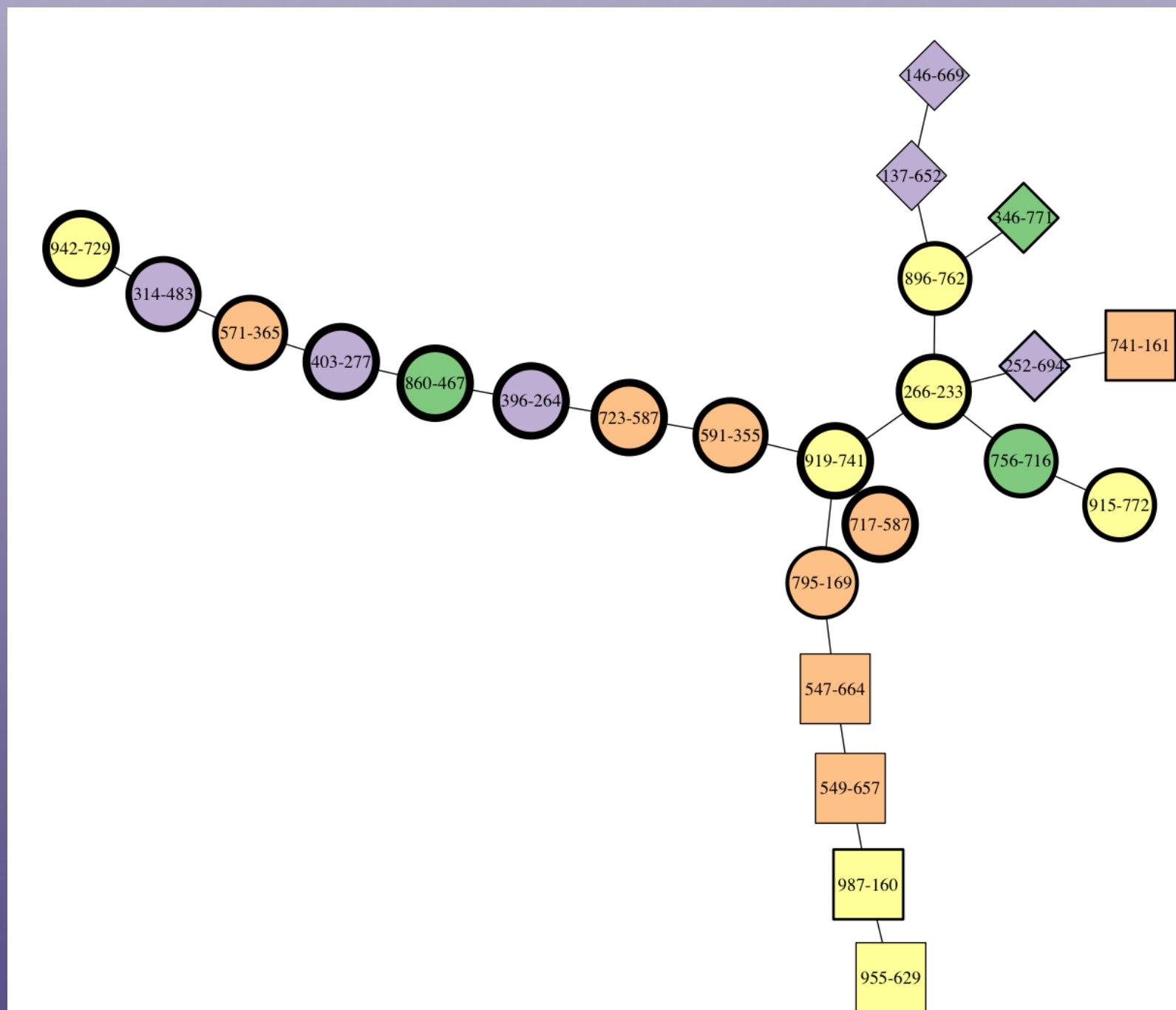
## Legend

Color: cluster of sites  
 Shape: lineage  
 Thickness: chronology  
 thin = early  
 thick = late

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## Lineage Splitting Example

- 4 clusters of 10 communities interconnected in 1 lineage
- Split into 2 lineages with 2 clusters of communities
- 240 possible assemblages spatially resampled to 24



## Legend

Color: cluster of sites  
 Shape: lineage  
 Thickness: chronology  
 thin = early  
 thick = late

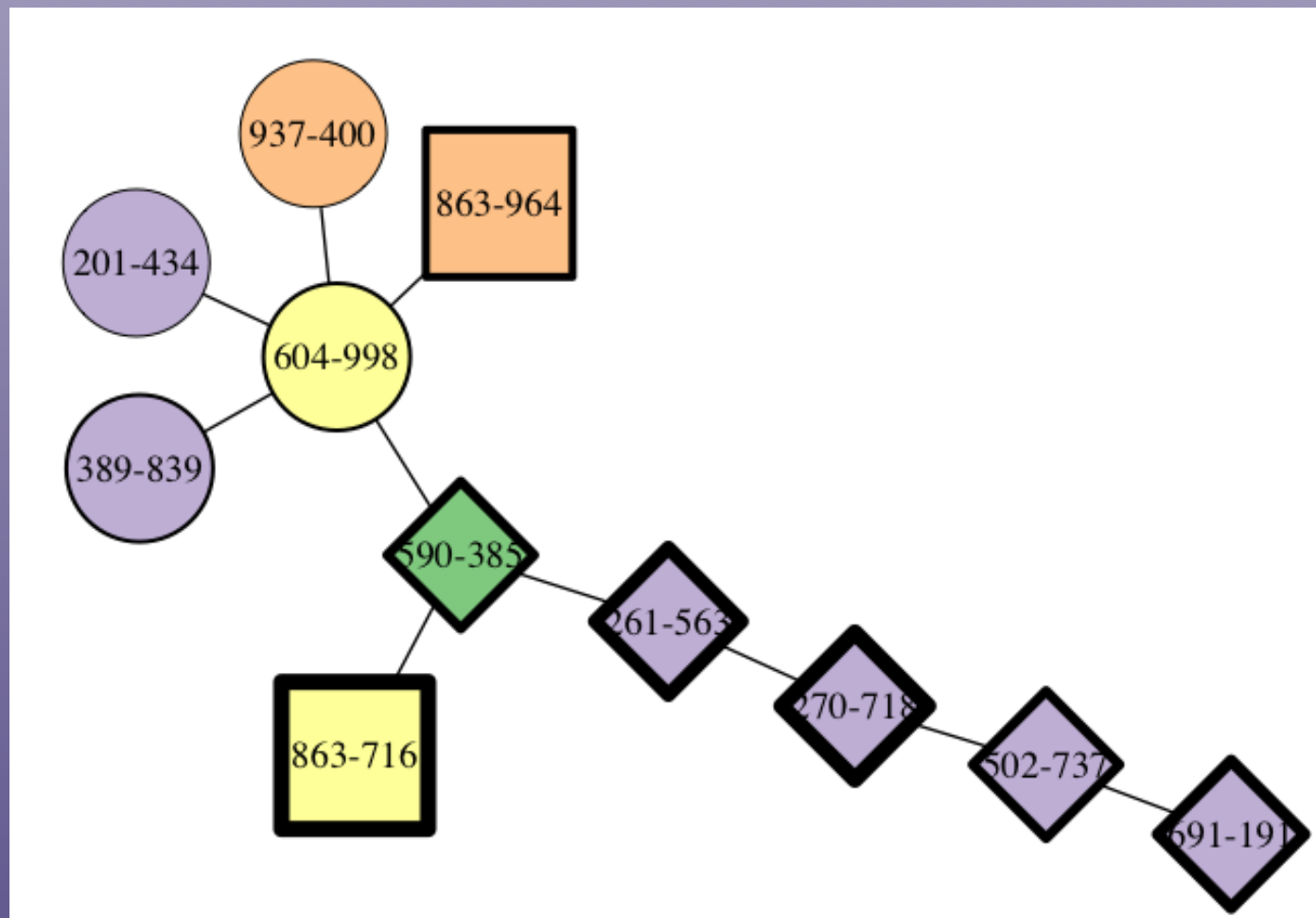
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## Lineage Merging Example

- Same temporal network as lineage split, except...
- Begin with 2 lineages of 2 clusters of communities each
- Merge into a single regional lineage of 4 clusters

# Observations and Conclusions



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- Previous examples seem to have lower migration and innovation rates
- Higher migration and innovation rate in this example
- Some chronology, but no recovery of regional structure

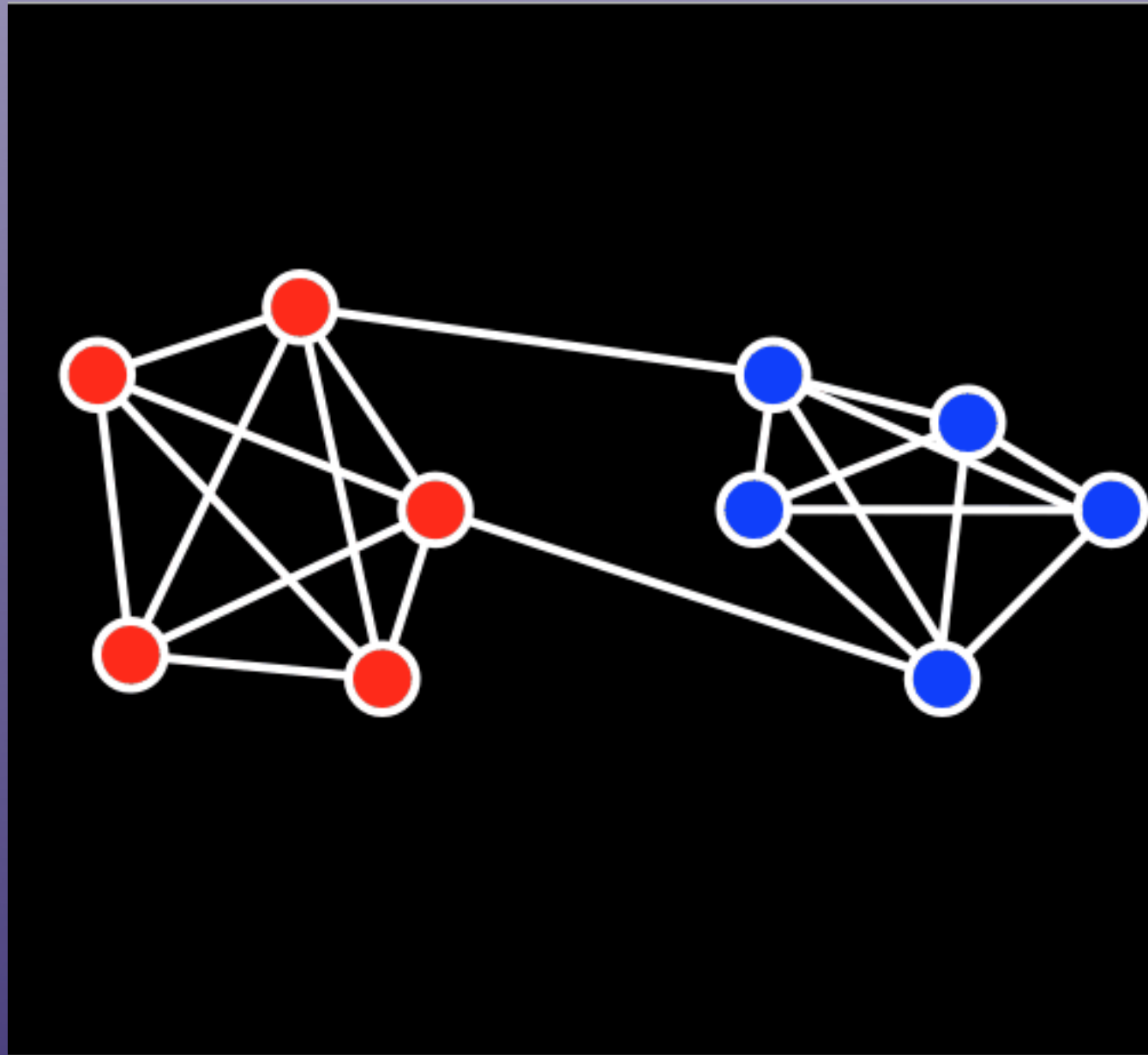
- Chronology is very robust across innovation and migration rates
- Regional interaction structure more sensitive to the balance of population size, innovation, migration, and network structure

# For more information

- Simulation: <https://github.com/mmadsen/seriationct> (rel v1.2)
- Seriation: <https://github.com/clipo/idss-seriation> (rel v2.1)
- Analysis: <https://github.com/mmadsen/experiment-seriationct> and <https://github.com/mmadsen/experiment-seriationct-2>
- Notes: <http://notebook.madsenlab.org>



# Lineage “Split” Animation



- One lineage
- Two clusters of sites
- Start with weak links between clusters
- Between cluster links go away
- Yielding separate evolutionary histories after split

