The Life of a Tie: Formation, Persistence, and Development of Social Ties in a College Student Cohort

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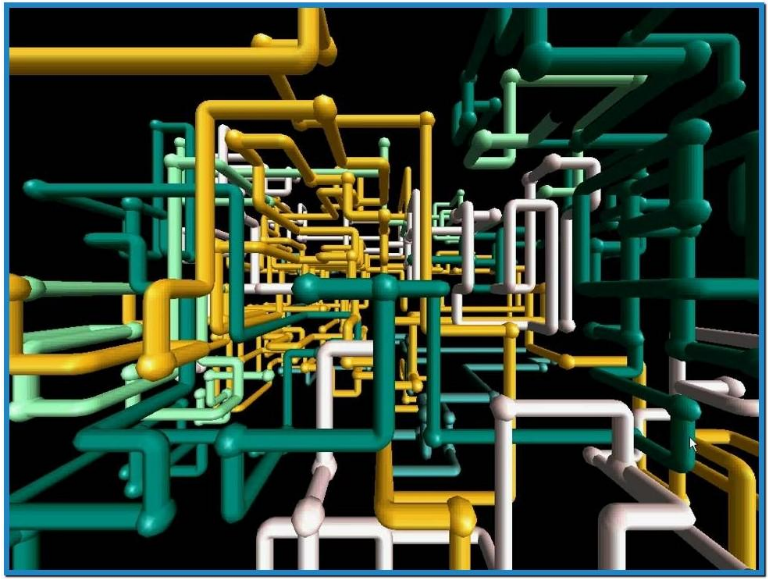
Network Research at a Crossroads

- Static → Dynamic
- Self-reports → Sensor data

Static → Dynamic



- Social Network Analysis (SNA): Adjacency Matrix
  - Pipes and Flows Model
- Dynamics
  - Diffusion on a static network
  - Counts of events -- weighted networks
  - Panel Data (Siena Models)
  - Event Sequencing
  - Tie formation, development, persistence/decay

Self-reports → Sensor

- Unobtrusive data collection
  - Call Detail Records (CDR)
  - Large N (Big Data)
  - Data Streams
- Analyzing data streams
  - aggregate to counts within discrete time windows
  - sequencing of events
  - life-course of a tie

Interaction Events and Social Networks

- What is a social network?
  - Sets of vertices and edges: G(N,M)
  - When does an edge between two vertices exist?
  - Social interaction event: $a_{ij}(t_k) = 1$
    - communicative interaction
- Social Network Dynamics
  - temporal pattern of the interactions
  - Begin and end to a sequence of interactions

Dating Social Ties

- Social Ties: Pattern of social interaction between two persons that begins at some time point t and ends at at a latter time point $t + \Delta t$
- Life-course of a tie: formation, development, persistence
- Event data streams → Tie birth, interaction and death

Dating Social Ties

- Begin date: time of first interaction
  - $a_{ij}(t_k) = 1 \mid a_{ij}(t<t_k) = 0$ for all time points $t < t_k$
- End date: time of last interaction
  - $a_{ij}(t_k) = 1$ and $a_{ij}(t>t_k) = 0$ for all time points $t > t_k$
- left and right censoring

Effective and Active Ties

- Active Tie: Discrete Time period
  - $a_{ij}(t_k, t_{k+\Delta t}) = 1$
- Effective Tie:
  - $x_{ij}(t_k, t_{k+\Delta t}) = 1$ if
    i. $a_{ij}(t) = 1$ at some point in time t prior to t_k
    ii. $a_{ij}(t) = 1$ at some point in time t after t_k
  - Effective tie implies there could be interaction between i and j at any time between t_k and $t_{k+\Delta t}$

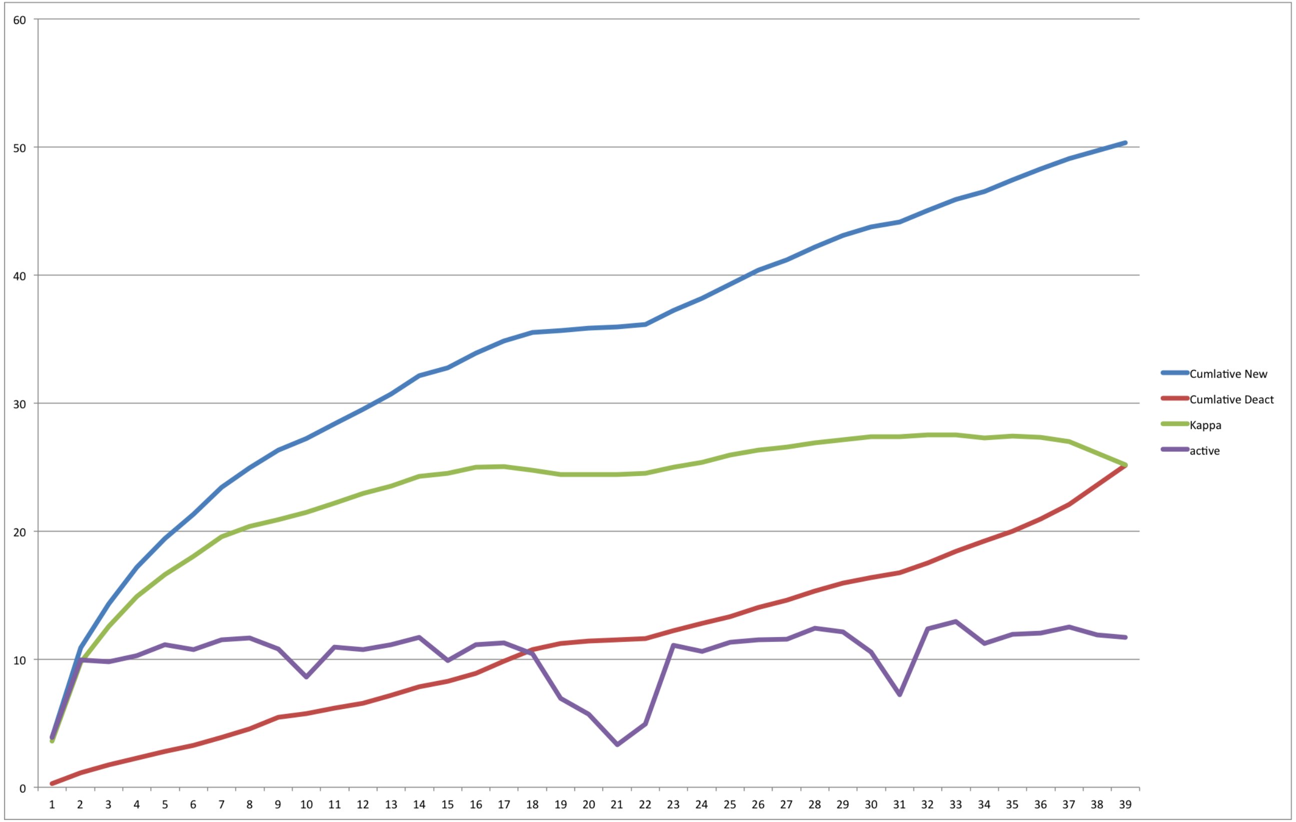
Effective and Active Degree

- Effective Degree: Number of persons that an individual can potentially interact with during a given time period $\kappa_i(t_k) = \kappa_i(t_{k-1}) + [n_{\alpha,i}(t_k) - n_{\omega,i}(t_k)]$
- Active Degree: Number of persons that an individual has interacted with during a given time period $\kappa_i^*(t_k) = \sum_j a_{ij}(t_k)$

NetSense Study

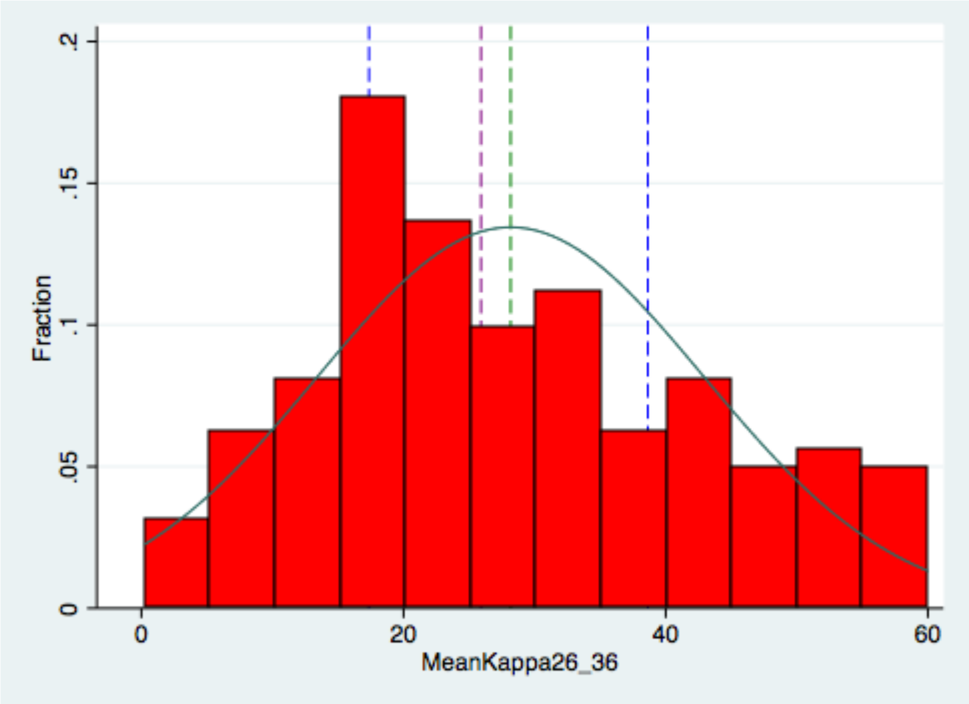
- 2-year data collection effort using CDRs obtained from smartphones
- 161 Notre Dame students full data for 70 weeks
  - 6 million communication events
  - 55,000 alters
  - 25,000 mutual dyads, 13,000 with other ND students
  - ~650 mutual dyads in which both persons are in NetSense study
- No ties with other ND students prior to arrival so students begin with no ND friends
- Watch as people forms ties and their degree grows

Mean weekly values of Cumulative Degree, Cumulative Deactivated Ties, Effective Degree and Active Degree over 40 weeks



- Growth Period (weeks 1=15)
- Mean Effective Degree fairly stable, μ = 25-28
- Mean Active Degree fluctuates because of period effects
- Cumulative New and Cumulative Deactivated captures churn

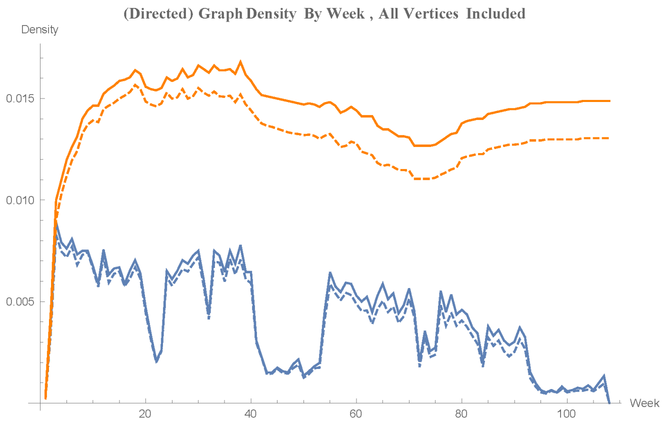
Effective Degree Distribution

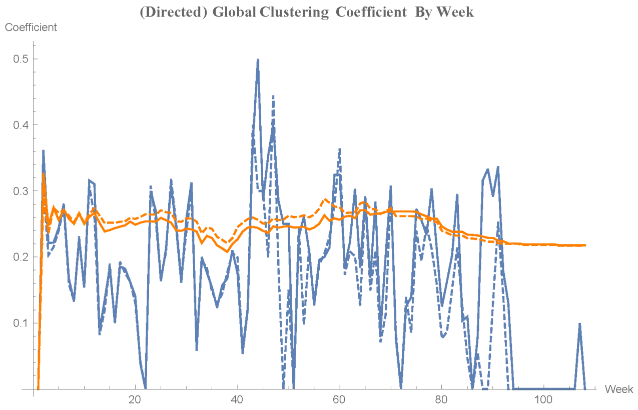


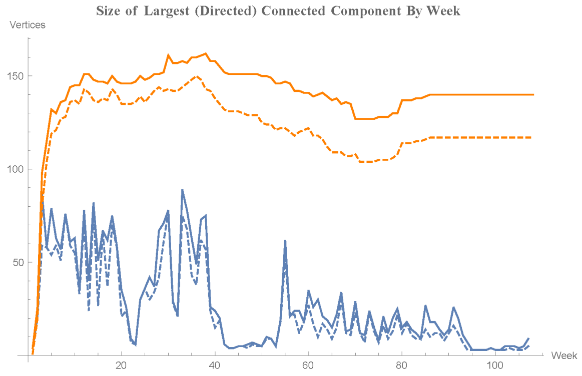
- μ = 28.5
- st. dev. = 16
- intraclass correlation = .984

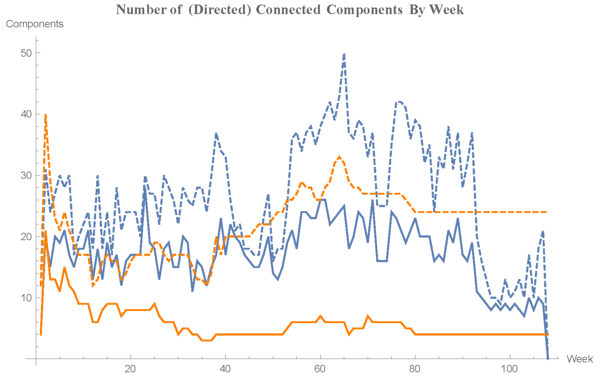
- Individual level Dunbar Number
- Very stable
- Varies across persons
- Capacity to interact
- Correlated with personality

Effective & Active Ties: Within Study









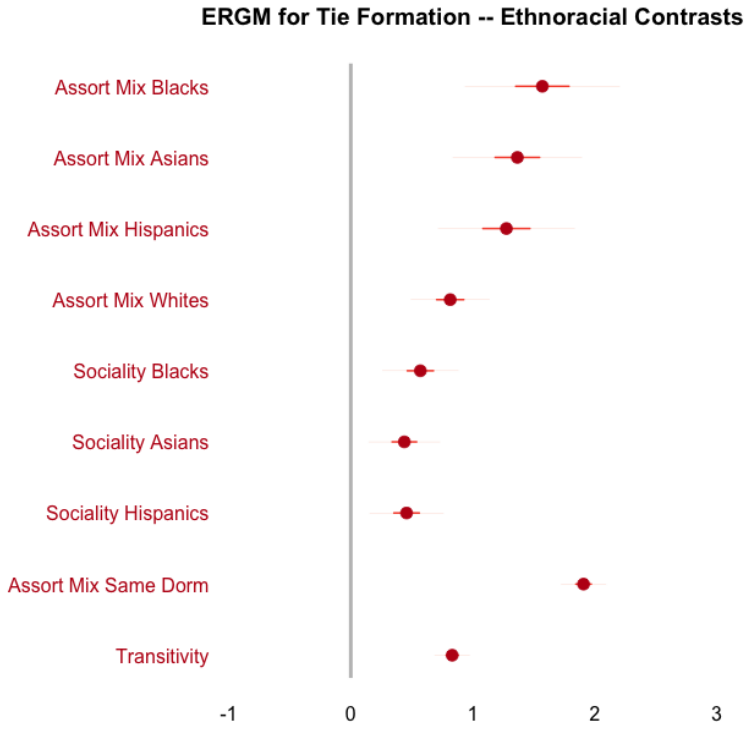
Tie Evolution: The Missing Link

- SNA - focus has been on tie formation
  - Choice homophily
  - Without longitudinal data can not look at tie persistence and evolution
- Tie Persistence/Decay is the critical process
  - liability of newness
  - link tie development (e.g. strengthening) to persistence

Tie Formation: Predictors

- Individual propensity to form ties (Vertex traits)
    - Sociality (effective degree)
    - Degree is related to many status traits
- Dyadic Similarity (Homophily)
    - Induced homophily: random matching with unbalanced proportions (Blau effect)
    - Choice (status) homophily: preference for similar alters
        - Visible and invisible traits
- Social Foci
    - Propinquity (dorm)
    - Organizational affiliations (clubs, work, classes)
- Endogenous: Transitivity (triadic closure)
    - common friend → tie formation

Parameter Estimates from ERGM Models

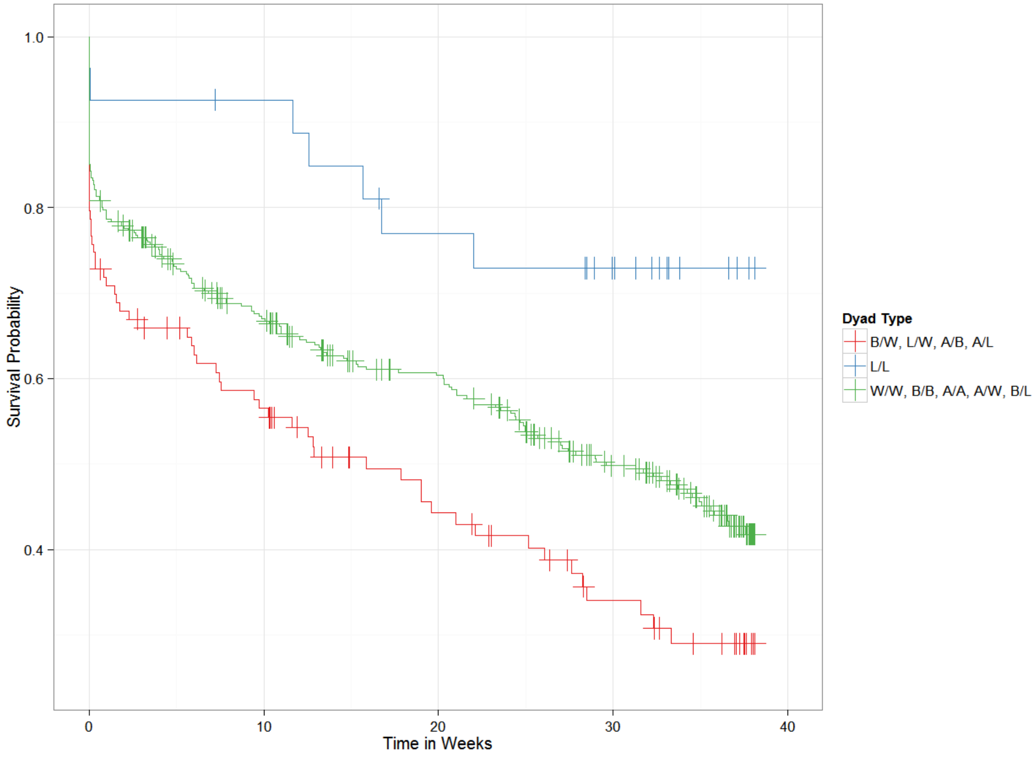


- Minorities have higher degree (sociality) than Whites
- Preference for same group ties (Assortative Mix)
    - No significant homophily effects for less visible traits
    - Propinquity: Students in some dorm more likely to form ties
- Transitivity: the more common friends the greater the probability of a tie

Tie Persistence: Predictors

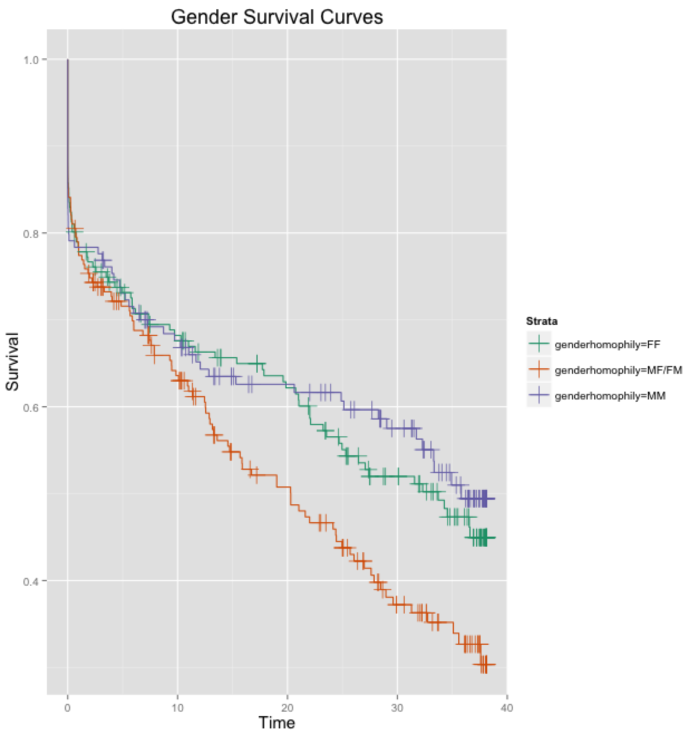
- Effective Degree
  - Do higher degree person have more turnover in their social networks?
- Homophily
  - The more similar two persons are the lower the decay rate.
  - But what about disassortative pairings?
- Simmelian Ties: Embeddedness
- Tie Development

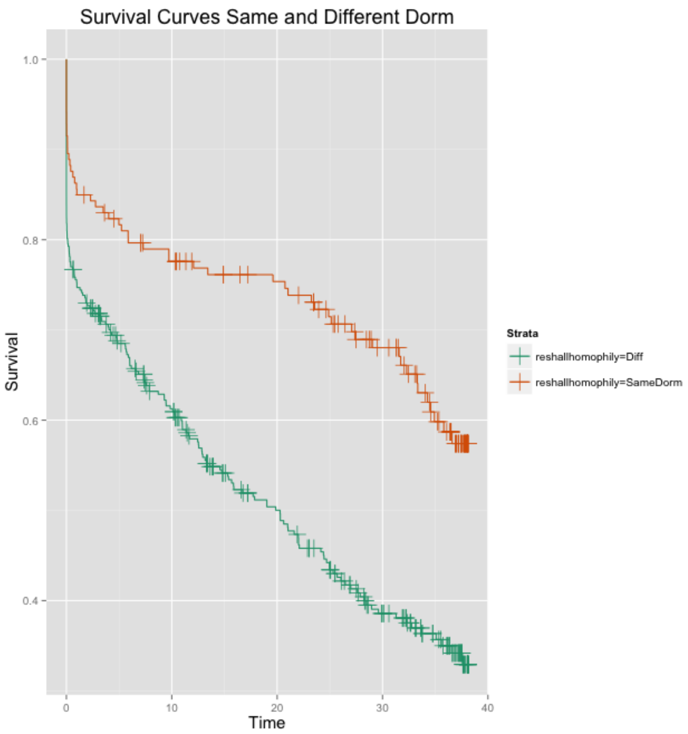
Survival Curves by Race



- Liability of Newness:
  - 22% of ties die within 1 week, 33% by 10 weeks
- Assortative Pairings high persistence
  - L/L : 75% survive 40 weeks
  - Assortative and “Close” pairings: 50% over 24 weeks
  - “Far” pairings: 50% only 10 weeks

Other Survival Curves





Simmelian Ties

- Free-standing vs. embedded dyads
  - Free-standing: no mutual friends
  - Embedded: mutual friends create indirect connections
  - Simmelian Ties are different from free-standing ties
  - Embeddedness: critical mechanism that mediates the effect of mixing pattern on persistence
- Findings
  - Each mutual friend decreases hazard rate by 81%
  - Racial pairing differences are explained by embeddedness

Does the developmental pattern affect the survival probability?

- Developmental Model: As ties become stronger, more reciprocal, more responsive, the probability of surviving increases.
- Settling Model: Ties that settle into a stable pattern are more likely to survive than those with temporally varying qualities.
- Similarity Model: Ties in which the vertices become more similar over time are more likely to persist.
- Embeddedness Model: Ties that become (more) embedded are more likely to survive.
    - Ties that become less embedded are more likely to die.

Conclusion

- Life of a Tie
  - Static → Dynamic
  - Self-reports → Sensor data streams
- Dating Social Ties
  - Effective and Active Ties (Degree)
  - Tie formation, persistence, evolution
  - Persistence / Decay critical process
- Simmelian (Embedded) Ties
- Diffusion
  - Diffusion of objects, ideas, disease within a static network
  - Diffusion of tie formation and decay in a dynamic network.