Preserving Link Privacy in Social Network Based Systems

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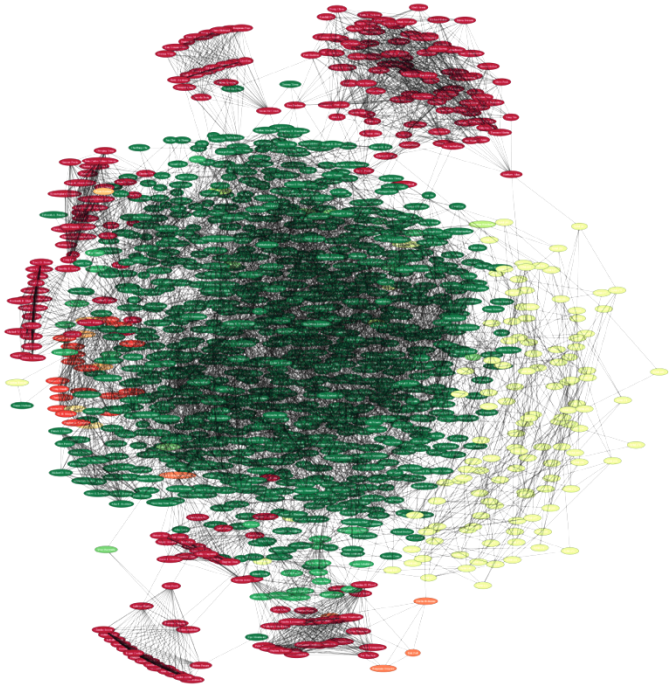
Social Networks

- Social links indicate shared interests and trust
- Social graph data is a key enabler



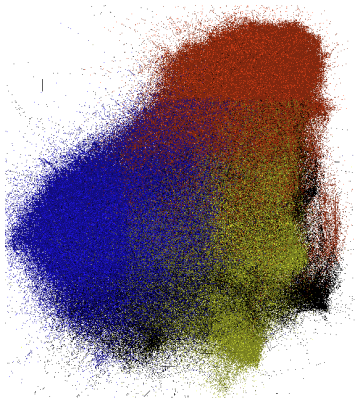
- Recommendation systems
- Reputation systems
- Sybil defenses
- Anonymous communications
- Censorship resistance

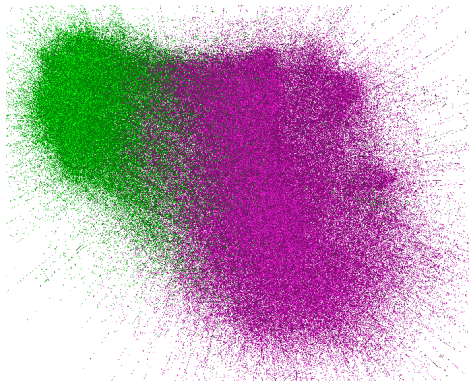
Lack of Privacy of Social Contacts

- Social contacts are private information
  - 52% Facebook users hide social contacts [NYU 2011]
- Problem: social contacts are revealed to adversaries in existing applications.

How to Balance Application Utility vs Link Privacy?

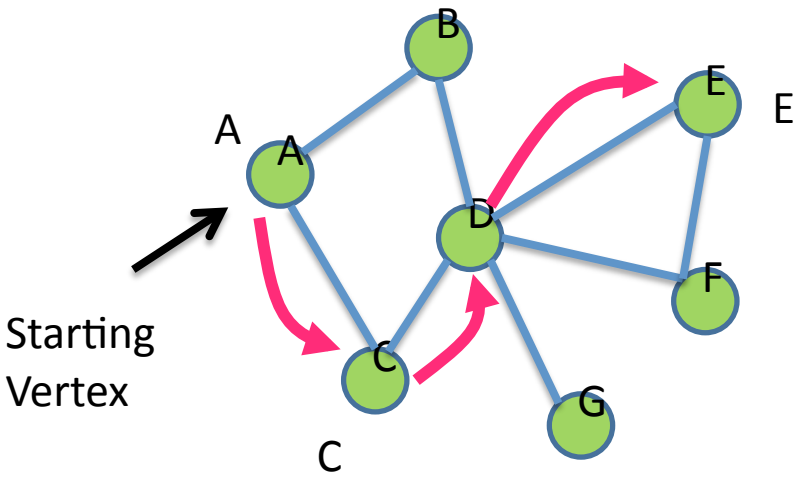
- Idea: OSN operator can add noise to the social graph
  - Delete real links
  - Add fake links
- Challenge: Need to preserve community structures in social networks



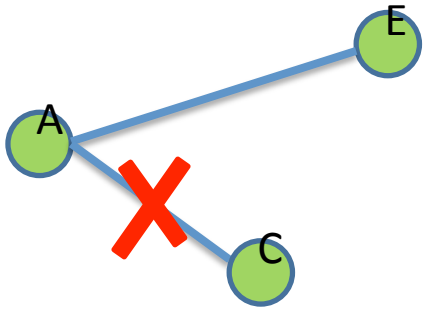


Structured Graph Perturbation

- Capture structural properties via random walks



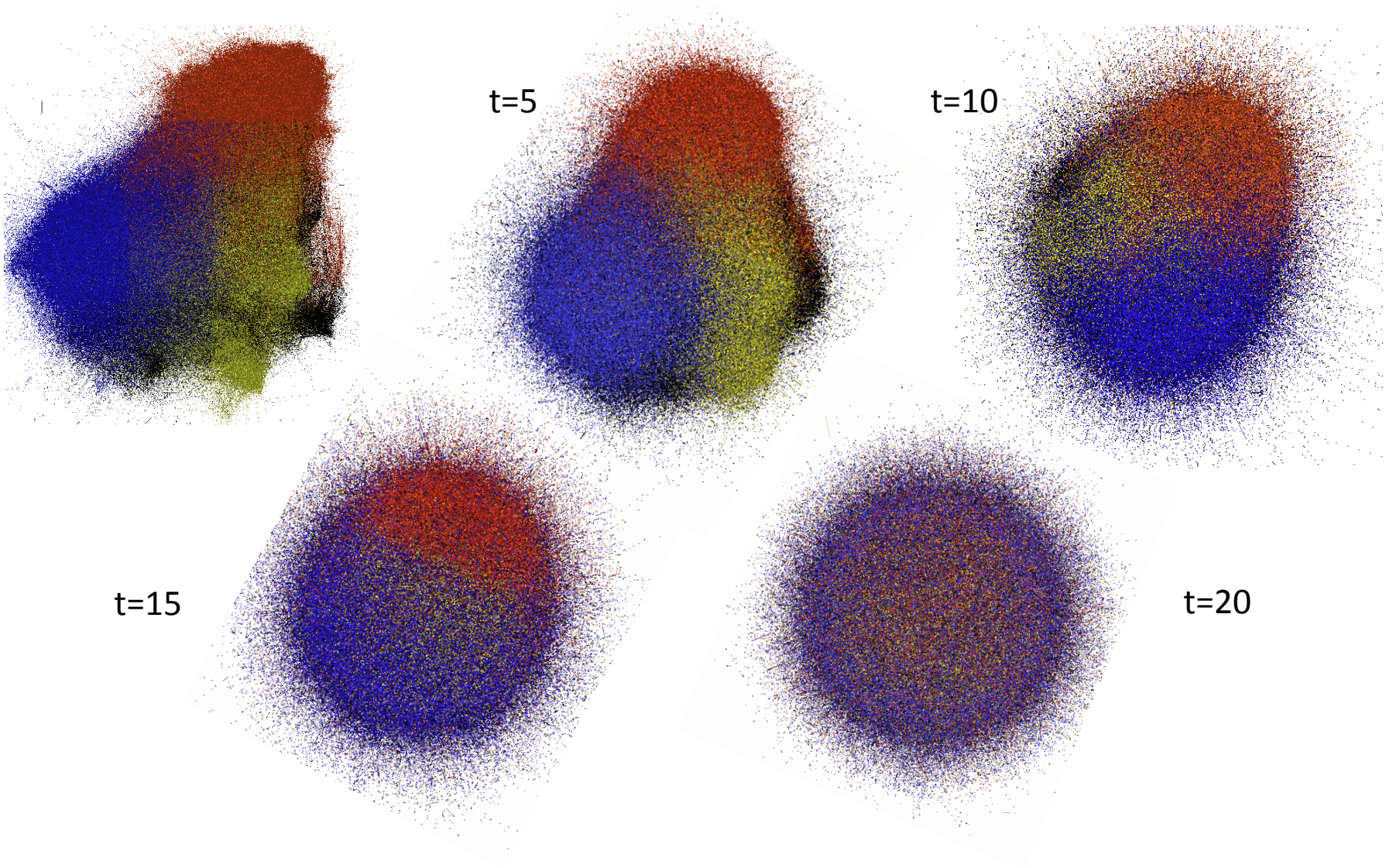
Original Graph G



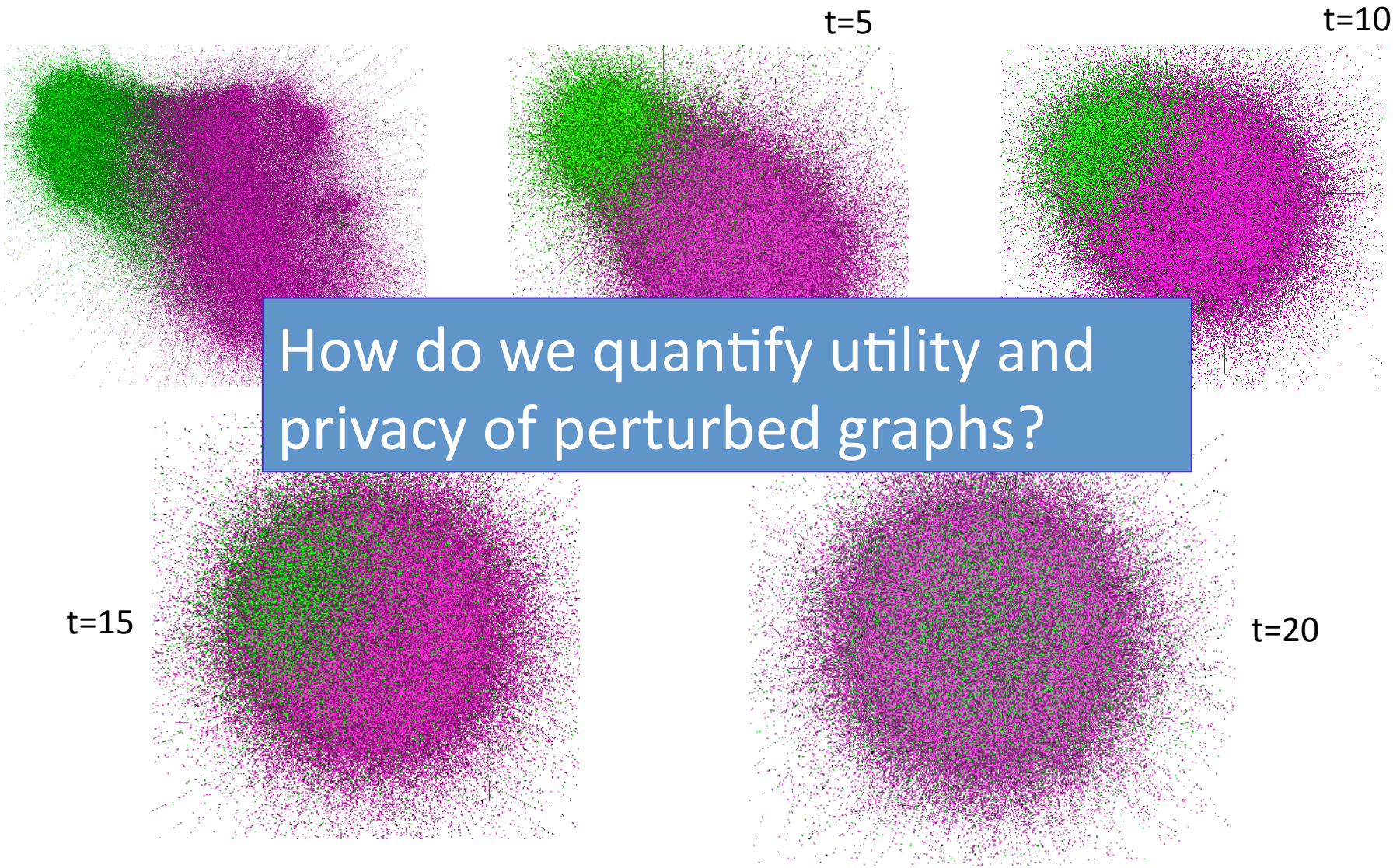
New Graph G'

t → random walk length. Trade off between privacy and utility

Facebook Friendship Subgraph: 63,392 users and 816,886 edges



Facebook Interaction Subgraph: 43,953 users and 182,384 edges



Key Results

- Characterizing Privacy
  - Bayesian approach
  - Risk based approach
- Characterizing Utility
  - Perspective of vertex
  - Change in vertex neighborhood
- Applications
  - Secure routing, Sybil defenses

Characterizing Privacy: Bayesian Approach

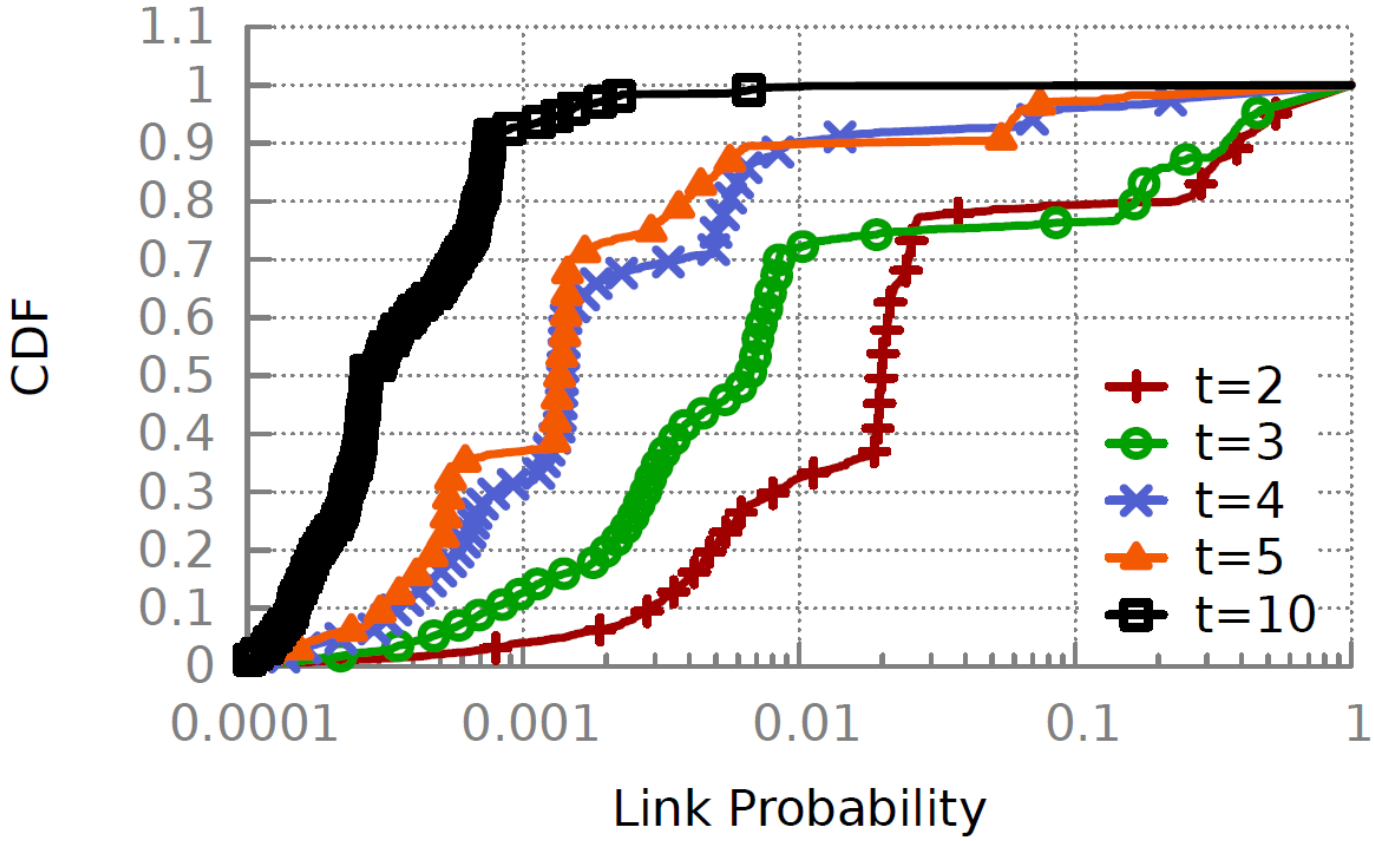
- Bayesian Formulation
  - G → original graph
  - G' → perturbed graph
  - H → prior information

Adversary has G' and H

- What is the privacy of a link L?
  - $P(L \in G \mid G', H)$
  - $P(L \in G \mid G', H) = \frac{P(G' \mid L, H) \cdot P(L \mid H)}{P(G' \mid H)}$

Probability of producing G' given L and prior H

Bayesian Privacy Analysis: Interaction Graph



Applications: Secure Routing
Sprout DHT (Chord + Social Links)

Table 1. Path reliability using Sprout for a linear trust decay model.

Facebook interaction graph		Facebook friendship graph	
Mechanism	Reliability	Mechanism	Reliability
Original	0.110	Original	0.140
$t = 3$	0.101	$t = 3$	0.126
$t = 5$	0.101	$t = 5$	0.121
$t = 10$	0.096	$t = 10$	0.118
Chord	0.075	Chord	0.072

Summary

- Structured Graph Perturbation
  - Preserves link privacy
  - Preserves community structures
- Metrics for utility and privacy
- Applications
  - Community structure based