Social-Aware Data Diffusion in Delay Tolerant MANETs

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Introduction & Motivation

- Delay Tolerant Network (DTN)
  - Node mobility
  - Frequent, long-lived disconnections
  - Unpredictable network topology changes
- Mobility-assisted Data Access
  - A node physically carries data and propagates the data to others only when it encounters some other nodes (i.e., contact)

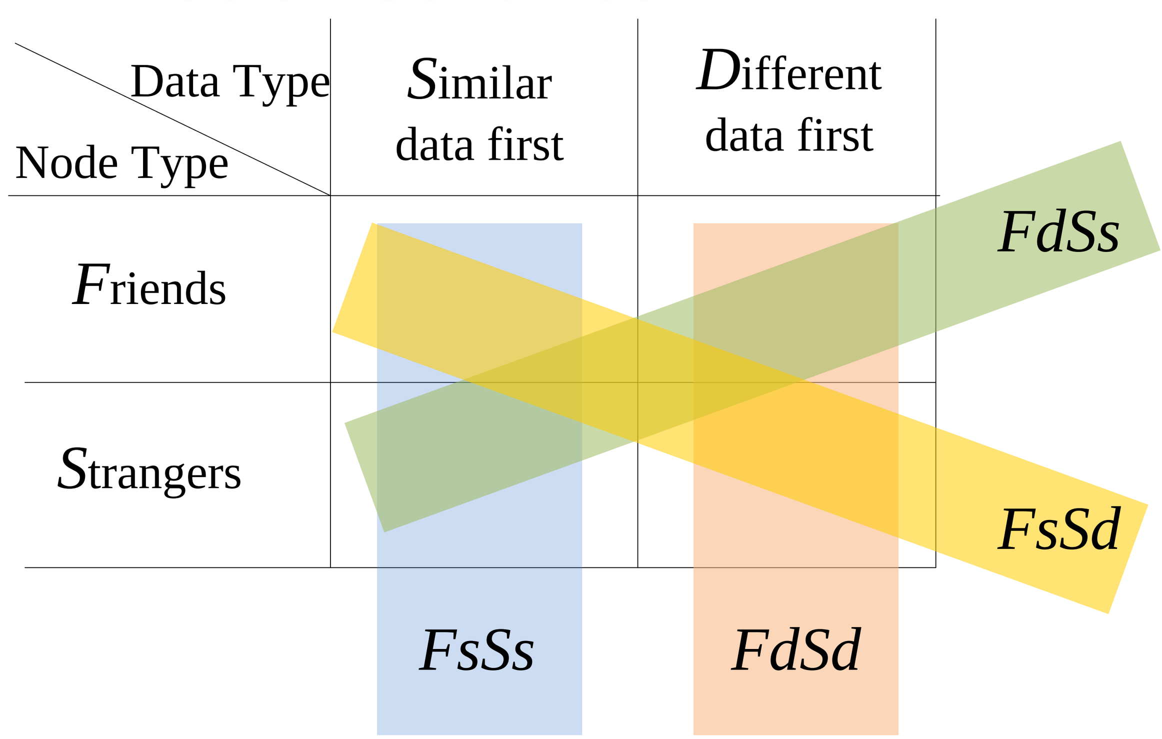
- Data Diffusion
  - Data is diffused throughout the network and replicated in advance.
  - Challenges:
    1) Short contact time;
    2) Limited buffer size.
  - Problems:
    1) What data should be propagated first?
    2) What data should be replaced first?

- Social Network Analysis
  - Map relationships between individuals in social networks
- Contribution of Our Work
  1) How does data diffusion affect the diffusion speed and the data access delay?
  2) How to design better data diffusion schemes based on social networking results?

Social Aware Data Diffusion

- Friends and Strangers
- "Homophily" Theory
  - Friends share more common interests
    - Individuals often befriend others who have similar interests
    - Friends perform similar actions
  - Friends have higher contact frequencies
    - Friends have a higher possibility to meet with each other

- Diffusion Schemes

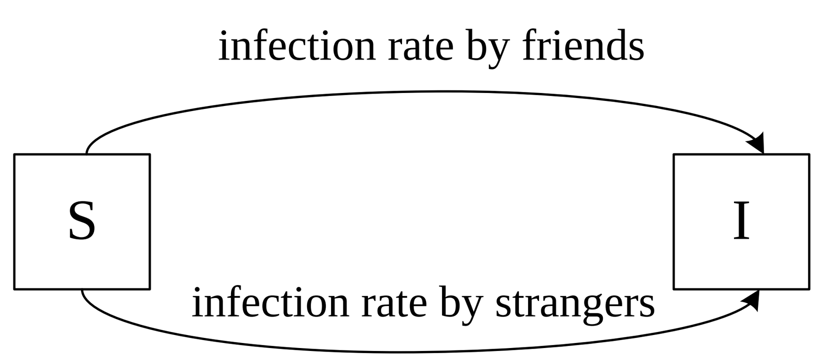


Analysis Model

- Disease Spreading
  - I: infectious, if one node has the data buffered in its memory
  - S: susceptible, if one node does not have the data, but could potentially get the data from other nodes
  - R: recovered, if one node does not have the data, and is immured

Performance Analysis

- Infinite Buffer Case



- *Total infection rate of interested node*
  = infection rate by friends
  + infection rate by strangers

$$I_i(t) = \frac{N_i}{1 + e^{-(\beta_f\gamma_f + \beta_s\gamma_s)N_i t}(N_i - 1)}$$

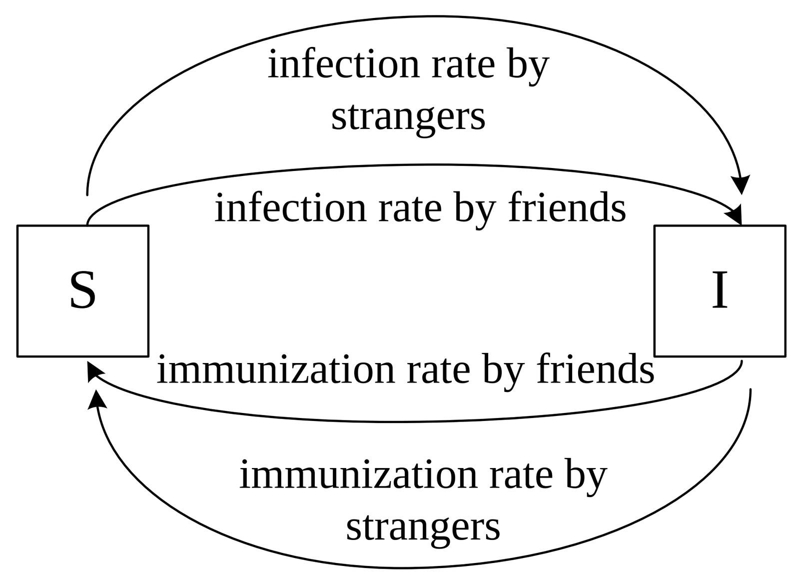
- *Total infection rate of uninterested node*
  = infection rate by friends
  + infection rate by strangers

$$I_u(t) = \begin{cases} 0 & t \le \frac{1}{\beta_s \cdot N_u \cdot \gamma_s} \\ \frac{N_u}{1+e^{-(\beta_f\gamma'_f + \beta_s\gamma'_s)N_u(t - \frac{1}{\beta_s \cdot N_u \cdot \gamma_s})}(N_u - 1)} & \text{else} \end{cases}$$

- *Query delay*

$$\begin{aligned} E_Q(t) =& E(query\ delay\ of\ interested\ node) \cdot P_i \\ &+ E(query\ delay\ of\ uninterested\ node) \cdot P_u \\ &= min\{\frac{1}{I_i(t)\beta_f}, \frac{1}{I_u(t)\beta_s}\} \cdot P_i \\ &+ min\{\frac{1}{I_i(t)\beta_s}, \frac{1}{I_u(t)\beta_f}, \frac{1}{I_u(t)\beta_s}\} \cdot P_u \end{aligned}$$

- Finite Buffer Case

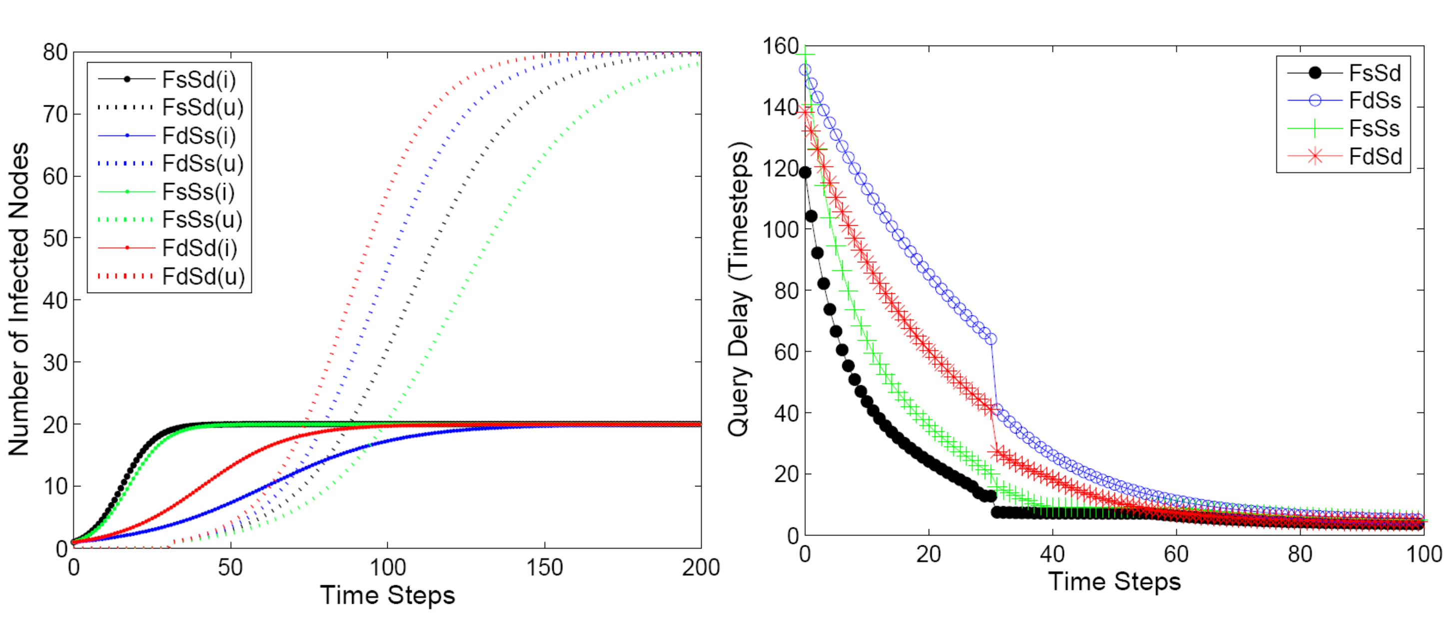


- When endemic equilibrium reached

$$I_i = N_i - \frac{N_i\beta_f\alpha_f + N_u\beta_s\alpha_s}{\beta_f\gamma_f + \beta_s\gamma_s}$$

$$I_u = N_u - \frac{N_i\beta_f\alpha_f + N_u\beta_s\alpha_s}{\beta_f\gamma'_f + \beta_s\gamma'_s}$$

- Preliminary Results



Numerical results for the infinite buffer case

	$\alpha_f = 0.1, \alpha_s = 0.9$			$\alpha_f = 0.3, \alpha_s = 0.7$			$\alpha_f = 0.5, \alpha_s = 0.5$		
	I_i	I_u	Delay	I_i	I_u	Delay	I_i	I_u	Delay
FsSd	19	48	4.63	14	57	5.57	7	67	6.27
FdSs	0	75	5.60	0	70	6.00	7	67	6.27
FsSs	18	0	10.00	12	49	7.07	7	67	6.27
FdSd	2	79	5.32	5	74	5.68	7	67	6.27

Numerical results for the finite buffer case

Conclusion

To achieve better diffusion performance, a node should first diffuse the data most similar to their common interest when it meets a friend, and it should first diffuse the data most different to their common interest when it meets a stranger.