Profile-cast: Behavior-Aware Mobile Networking

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Outline

• A new communication paradigm: message delivery to users with similar behavior (Profile-casting)
• Background: Delay Tolerant Networks (DTN)
• Similarity-based profile-cast protocol
• Evaluation
• Future work and conclusion

Contribution: Show-casing the potential of a behavioral-aware communication paradigm in mobile networks.
Profile-cast Paradigm

• The introduction of portable/personal communication devices leads to a tight user-device coupling.

• How can the user-device coupling be leveraged to design new services?
Profile-cast Paradigm

• We focus on message delivery to a group of hosts with similar behaviors (profile-cast)
  – (VS multi-cast) Group membership is implicit
• We use mobility profile as an example
  – Targeted announcement
  – Lost-and-found
  – (VS geo-cast) Definition of user group based on long-run mobility characteristics
Background (DTN)

- Delay Tolerant Networks (DTNs) are mobile network with sparse, intermittent nodal connectivity.
- Messages are stored in memory and moved across the network with nodal mobility.
- Encounter events provide the communication opportunities among nodes.
Background (DTN)

• DTN routing protocols are de-centralized
  – Each node relies on local information to make forwarding decisions
    • High overhead for directory-based services
      – The decisions have direct impact on performance
        • Delivery probability
        • Overhead (transmission and storage)
        • Delay
Similarity-based Profile-cast

1. Profiling

2. Forwarding decision

Scoped message spread in the profile space
Similarity-based Profile-cast

Profiling user mobility [Hsu07]

- Singular value decomposition provides a summary of the matrix (A few eigen-behavior vectors are sufficient, e.g. for 99% of users at most 7 vectors describe 90% of power in the association matrices for 94 days)

Each row represents an association vector for a time slot

Sum. vectors

An entry represents the percentage of online time during time slot $i$ at location $j$


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Similarity-based Profile-cast

1. Profiling
   - Determine user similarity
     - Nodes exchange their eigen-behaviors and the corresponding weights at encounter
     - Similarity of user mobility are evaluated by weighted inner products of eigen-behaviors
     \[
     \text{Sim}(U, V) = \sum_{i,j} w_i w_j |u_i \cdot v_j|
     \]
     - Message forwarded if Sim(U,V) is higher than a threshold (recall that the goal is to deliver messages to nodes with similar profile)
Similarity-based Profile-cast

• This is a different approach to disseminate messages in DTN
  – Use *behavior* as the target as opposed to IDs[1][2]
  – Avoid persistent exchanges of control messages[2]; nodes profile itself silently

• The idea is related to the Mobility Space routing[3] or social network-based routing[4], but the goal is different

Evaluation

- Based on USC WLAN trace for realistic user mobility[1] (2006 spring, 94 days, 5000 users)

- We use hierarchical clustering to identify 200 distinct groups based on mobility profile.

- We pick groups with 5 or more members and randomly pick 20% of the members in these groups as senders

Evaluation

- Spanning the spectrum of grouping knowledge

Complete user grouping info

Centralized protocol
- Highly efficient
- But not practical

Inferred user grouping info

Similarity-based protocol

Epidemic and Random Tx.
- Simple
- Not optimized

No user grouping info
Evaluation - Result

• Goal: get as close to the centralized as possible
  – RTx without TTL limit degenerates to flooding as number of copies increases
  – Similarity-based has better delivery ratio-overhead tradeoff and low delay
  – Well-scoped RTx has longer delay
Future Work

• Can we send to a specified target profile not necessarily similar to the sender?

• Can we specify the target profile in different contexts?
  – Affiliations, interests, etc.
Conclusions

• Tight user-device coupling in mobile networks enables behavior-aware service/protocol design

• Behavior-aware protocol design shows good potential for performance improvement
Thank you!!

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http://nile.cise.ufl.edu/MobiLib
Evaluation - Result

- Centralized: Excellent success rate with only 3% overhead.
- Similarity-based:
  1. 61% success rate at low overhead, 92% success rate at 45% overhead
  2. A flexible success rate - overhead tradeoff
- RTx with infinite TTL: Much more overhead under similar success rate
- Short RTx with many copies: Good success rate/overhead, but delay is still long