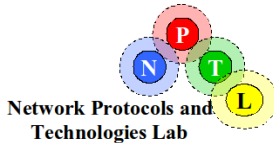




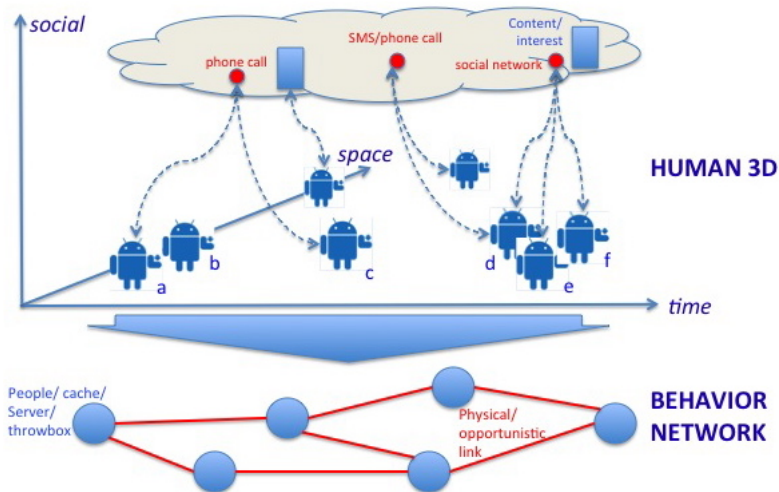
First PeopleNET Meeting



NPTLab and Mobility

- **Human Complex Network:** analysis and modeling of human mobility
- **Behavioral Networking:** enabling context- and social-aware routing in mobile networks

Human Behavior and Behavioral Networks



Human Complex Networks

- Mobile Networks: spatial-temporal behavior and aggregation points
- Static and dynamic social networks
- Human 3D - Multi-dimensional human network to predict spatial, temporal and social behavior

Human Complex Networks

Mobility Models

Analysis of mobility traces (GPS, AP, contact tracers, phone cells)

- Mobility models to predict next hop
- Identification of geo-locations
- Modeling aggregations and community formation: geo-communities
- Modeling spatial-temporal behavior: regularity and rare events

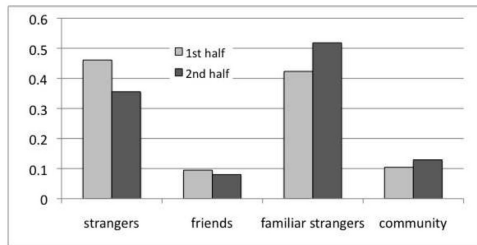
References

- S. Gaito, G.P. Rossi, M. Zignani. "Extracting human mobility and social behaviour from location-aware traces". In WIRELESS COMMUNICATIONS and MOBILE COMPUTING, 2012, to appear.
- S. Gaito, G.P. Rossi, M. Zignani. "From mobility data to social attitudes: a complex network approach". In Proceedings of the NEMO Workshop 2011, Athens(Greece), Sep. 9, 2011.
- S. Gaito, E. Pagani, G.P. Rossi. "Strangers Help Friends to Communicate in Opportunistic Networks". In COMPUTER NETWORKS, Volume 55, Issue 2, Feb. 2011, Pages 374-385.

Human Complex Networks

Mobility Models

- STRANGERS: few short encounters
- FRIENDS: few long encounters
- FAMILIAR STRANGERS: many short encounters
- COMMUNITY: many long encounters



Relation (percentage) between adjacent relays along the two halves of the paths.

Human Complex Networks

Social Networks

Static analysis of Social Networks (facebook, phone calls, e-mail, etc.)

- Community detection
- Network partitioning
- Identification of influential nodes
- Algorithms for information spreading

References

- A. Sala, S. Gaito, G.P. Rossi, H. Zeng, B.Y. Zhao. "Revisiting the Power-law Degree Distribution for Social Graph Analysis". In Proc. 29th ACM PODC, Zurigo (CH), July 2010.

Human Complex Networks

Social Networks

Modeling network dynamics and evolution for:

- Identification of active and sleeping communities
- Prediction of human behavior
- Identification of emerging and growing communities

Data source: Facebook and RenRen

Human Complex Networks

Human 3D – conjecture

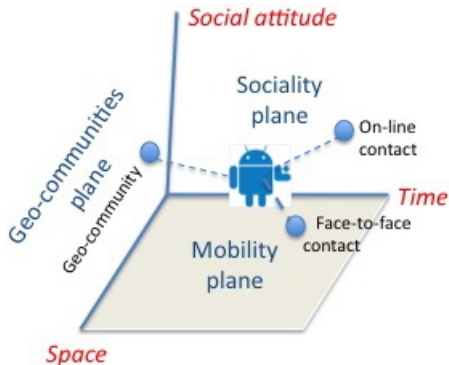
The human behavior derives from combining spatial-temporal (e.g. urban mobility) with social attitudes (e.g. friendship network and community membership)

We need a multi-dimensional model where all human dimensions are contemporaneously described

Data source: H3G cooperation
+ dedicated experiments

Human Complex Networks

Human 3D



geo-communities are defined as the combination of the spatial concept of location with the social concept of community

Behavioral Networking

- Unicast and Multicast Routing for Opportunistic and ad hoc Networks
- Sensing Human Behavior
- Context-aware and Behavior-sensitive APPs and Services

Behavioral Networking

Routing in Mobile Networks

- Study the impact of mobility on utility-based forwarding to design adaptive utility functions for unicast routing
- BehaviorCast: novel multicast to groups sharing common interests/behavior

Behavioral Networking

Routing in Mobile Networks – Unicast

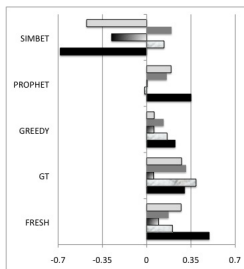
- performance of utility-based functions depends on characteristics of mobility and sociality of individuals
- mechanisms have been singled out that behave well in most environments
- mechanisms combined in order to determine good relays in changing environments

References

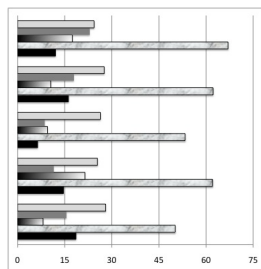
- E. Pagani, G.P. Rossi. "Utility-based forwarding: a comparison in different mobility scenarios". To appear in Proc. ACM MobiOpp 2012.

Behavioral Networking

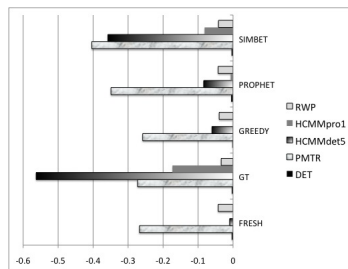
Routing in Mobile Networks – Unicast



(a)



(b)

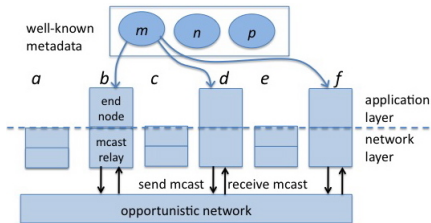


(c)

Comparison among approaches in terms of (a) Energy waste, (b) Latency, and (c) Percentage of reached destinations, in different environments.

Behavioral Networking

Routing in Mobile Networks – BehaviorCast



- *User behavior* – interests, social relations, on-line interactions, location ...
- group defined by a *similarity* matching between content profile and user behavior

References

- E. Pagani, G.P. Rossi. "Reasoning about Multicast in Opportunistic Networks". In Proc. 5th IEEE WoWMoM Workshop on Autonomic and Opportunistic Communications (AOC), June 2011.

Behavioral Networking

Routing in Mobile Networks – BehaviorCast

Next to come:

- design a novel multicast utility function able to follow group *behavior*, with the goal of:
 - maximizing coverage of grouped individuals
 - minimizing network load and latency
- study a caching policy able to:
 - dynamically adapt the number of copies according to the content popularity
 - bring copies near to interested individuals
- incorporate reputation and incentive mechanisms to foster cooperation

Behavioral Networking

Sensing Human Context and Behavior

Enabling context- and social-aware routing and services:

- Android-based experiment to sense:
 - geo-locations
 - sociality
 - interests
 - geo-communities
- Data analysis through Complex Networks

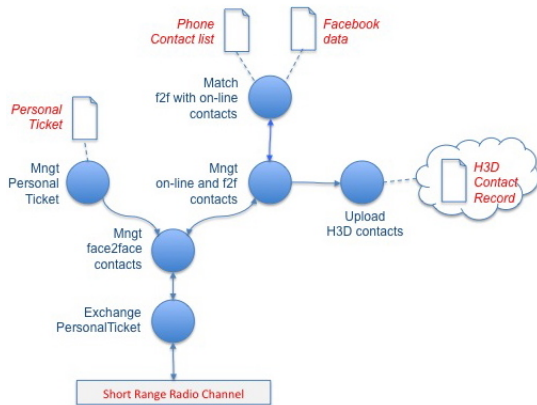


References

- S. Gaito, E. Pagani, G.P. Rossi. "Fine-grained tracking of human mobility in dense scenarios". In Proc. 6th IEEE SECON, (Poster Session), Roma (Italy), 2009.
- P. Meroni, E. Pagani, G.P. Rossi, L. Valerio. "An Opportunistic Platform for Android-based Mobile Devices". In Proc. 2nd ACM/SIGMOBILE MOBIOPP, (Demo Session), Pisa (Italy), Feb. 22-23 2010.

Behavioral Networks

Sensing human behavior



References

- S. Gaito, E. Pagani, G.P. Rossi, M. Zignani. "Sensing Multi-dimensional Human Behavior", DICO TR 2011.

Behavioral Networking

Context-aware app services

- Heterogeneous mobile network platforms for urban communication services: hybrid infrastructure supporting delay tolerant service in urban space
- Context-aware services

Behavioral Networking

Heterogeneous Urban Networking

- Bus Switched Networks: the urban backbone for delay-tolerant mobile computing applications
- Augmenting BSN through road-side infrastructure

References

- S. Gaito, D. Maggiorini, G.P. Rossi. "Bus Switched Networks: an Ad hoc Mobile Platform Enabling Urban-Wide Communications". In AD HOC NETWORKS Journal, to appear 2012.
- S. Gaito, D. Maggiorini, C. Quadri, G.P. Rossi. "Impact of Road-side Infrastructure on Delay-tolerant Urban Networks". DICO TR 2011.