Taking networks to the streets

Early insights for robust ad hoc applications in the urban world

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Who I am, where I come from

- Guillaume-Jean Herbiet (Supélec ‘07, MSCS GIT ’07)

- R&D for tactical ad hoc communications (Thales)
  - Channel resource allocation mechanisms (TDMA-based)
  - Traditional routing scheme (proactive)
  - QoS management (RSVP-like scheme)

  - Network simulation
    - High fidelity protocol simulation (down to MAC layer)
    - Low to medium fidelity for physical layer
    - Scenarios were “test cases” or taken from real operation traces

A vision of ad hoc networks

- Closed environments
  - Military networks
  - VANETs
  - Isolated bubble of ad hoc users (labs, conferences, …)
- Not a suitable approach to manage an extensively large network (e.g. should not propagate data from the other side of the country)
- Underused potential
  - The accounting problem
  - No sharing bandwidth nor storage unless in a **trusted** (hence closed) **environment**
  - Makes hard to develop and market applications
    - Except in “niches” like VANET communication ?
- Is there other ”niches”, open for ad hoc communication?

A possible field of application

- Nomadic life is developing
  - Commuters, development of public transportations
  - Concomitant boom of communicating mobile devices
  - **Nomad users search entertainment while on the move**

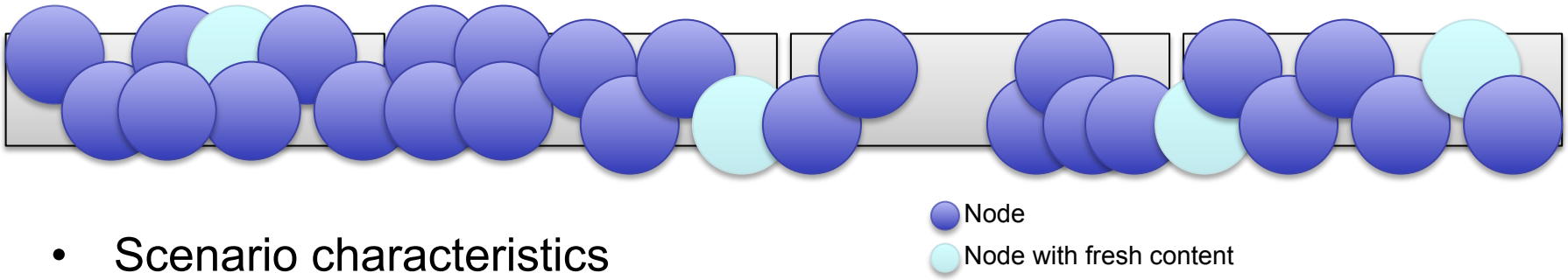
- Social networking
  - Great to for socializing and providing home-made content
    - Find friends, keep in touch, create community
    - Share photos, files, music, videos,…
  - Now extension to IM, status display, and more interaction
  - But still **only using a centralized platform**

Can ad hoc networks take social networking to the next level ?

- Offer nomad users a way to
  - Enhance their social interaction
    - Profile display with neighboring users, instant messaging
  - Entertain them !
    - Access in ad hoc mode to information grabbed from the Internet or generated by the nodes and stored (somewhere…) on their extended neighborhood
    - Files and documents sharing (music, videos, …)
  - Inform them: general important information can cover a wider area to touch all users

- Use the network, not misuse it!
  - Each nodes stores it own data plus a fair amount of other users data (for improved dissemination)
  - Fair use of the resources
  - Trusted environment (no viruses nor spams)

Use case #1: A trip in train



- Scenario characteristics
  - High density (depending on application popularity) of stable links
  - Several partitions may exist
  - No external connection is available
  - But some nodes (light blue) have fresh content from the Internet (downloaded before departure)
  - All users share a profile and some files contained in their device

- Objectives
  - Learn about present users in extended neighborhood (what diameter ?)
  - Learn about data available in extended neighborhood
  - Efficiently share data

Use case #2: Metropolitan area

- Scenario characteristics
  - Variable density (attraction points)
  - Variable duration of links (with fast movers, e.g. users inside a car or a bus)
  - Several partitions may exist
  - Limited external connections are available

- Objectives
  - Efficiently use ad hoc links to make data from external networks available to neighboring users
  - Determinate the appropriate size for data propagation
  - Adapt to density conditions
  - Try to use sporadic links to propagate information that should travel fast and far

Use case #3: Campus life

- Scenario characteristics
  - Variable density (classroom vs. outside paths)
  - Variable duration of links
  - Several partitions may exist
  - Many external connections are available
  - But ad hoc sharing is useful for social applications and direct file sharing + diminishing load on access points

- Objectives
  - Efficiently use ad hoc links
  - Determinate the appropriate size for data propagation
  - Adapt to density conditions
  - Use less stable links (e.g. between students meeting while moving from a building to another)

Other fields of application

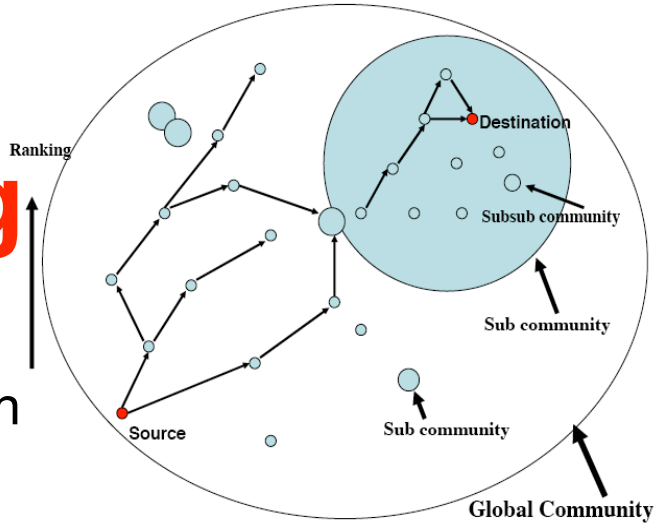
- Similar issues apply to VANET communications
  - Varying link stability (same/opposite directions)
  - Outside sources can be sparse
    - e.g. only at fuel stations on highways
  - Node density variation (traffic jam vs. highway at night)
  - How to limit diffusion of a message to the relevant area only?

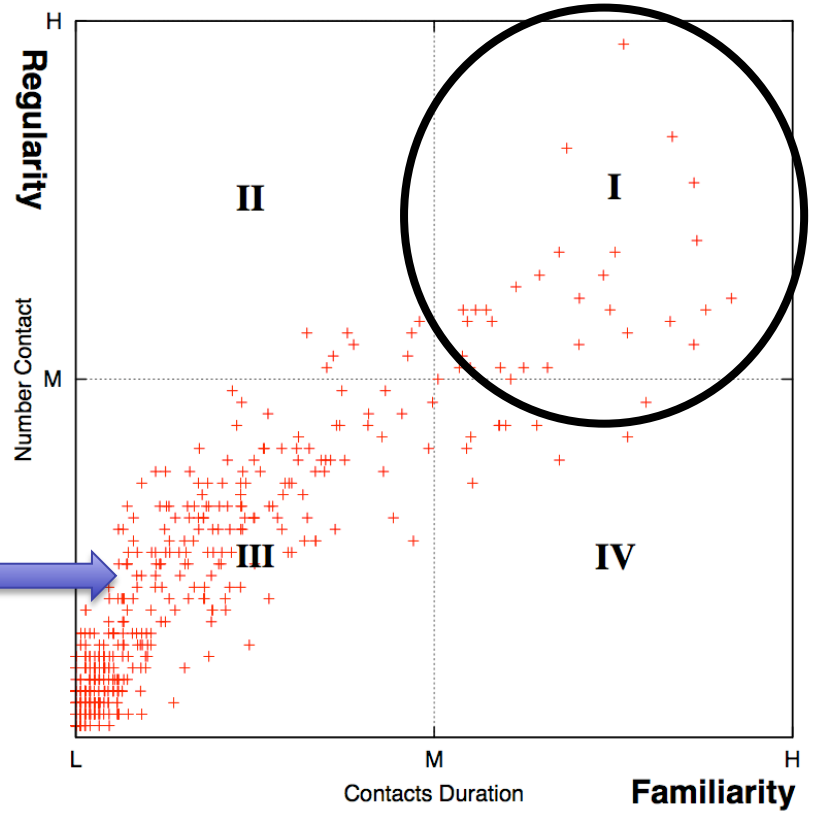
- Possible extension to military communications
  - Size-limited networks
  - Only HQ are connected to external information system
  - High level of robustness is also required

Related work: PSN and social-based forwarding

- Initiated by Hui et al.
- Studied real-world traces of human interaction (connections of Bluetooth devices)
- Find a social pattern (k-clique) to improve forwarding in DTN
- However, most of the connections are short and non recurring (Hui work only focuses to 2% to 3% of the connections for clique computation)

- How to use the irregular and short connections for some data transfer ?

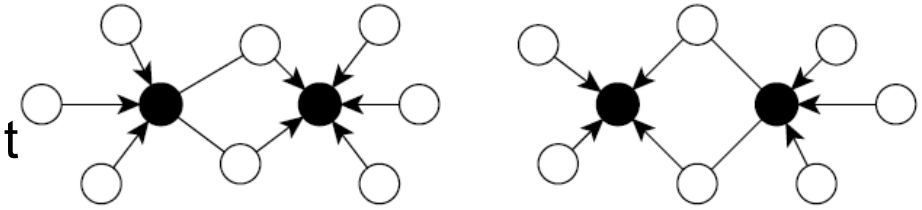




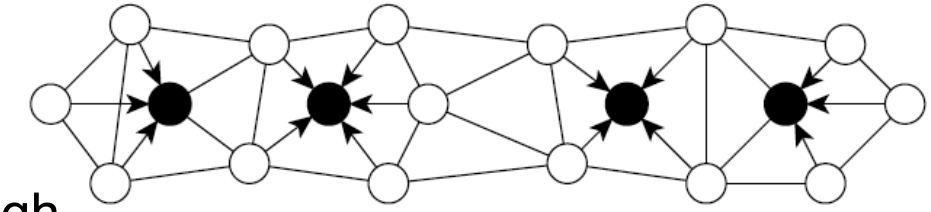
Related work: Backbone-assisted MANETs (HyWERCS)

- Middleware and communication protocols presented by Andronache

- Nodes are clustered around a master with a “backbone” link to external networks (injection)
- Clustered nodes are only one-hop away from injection point
- Data are exchanged as chunks
- Links/nodes are weighted to prevent clusters disruption



Backbone cluster overview



Mobile ad hoc network organized by NLWCA

- Makes the assumption that enough entry points exists, so a DS can be created

Related work: To organize or not to organize?

- Giving the network a structure is tempting
  - Makes resources management and routing easier (backbones and trees)
  - Helps disseminating information (opportunistic overlay structures)

- Is it valuable for the considered application ?
  - Limited span for information validity
  - Link breakage rate

Related work: Epidemic broadcasting

- DFCN and associated extensions (Hogie et al.) have the following properties
  - Adaptive to density condition (dual proactive/reactive nature)
  - Priority management (CABP)

- Delayed-based nature
  - Missing some sporadic connections
  - Global channel under utilization

Open questions and ideas (1/2)

- Is it valuable to consider unstable links?
  How to maintain delivery robustness?
  - Probably as they represent the largest part of communications
  - What is a meaningful stability threshold for robust delivery?
  - Usage of a link should depend on what kind of data is to be sent (size, importance, etc..)
  - Dynamic chunk size adjustment

- What is an appropriate network size/diameter for information propagation?
  - Does this depend on the message kind/priority?
  - This should surely be dynamically adjustable
    - Why keep on broadcasting an expired message?
    - Why keep on broadcasting a message already present (duplicated chunks) in the vincinity?

Open questions and ideas (2/2)

- How to keep misbehaving nodes apart and favor trusted (or fair playing) nodes?
  - Prevent junk messages from being propagated
  - Penalize nodes not participating in the relay and information storage effort
- Improved prioritization management
  - Not a static parameter anymore
  - Rarest first, helpful in dense areas
  - Closest first, to limit network usage and better energy efficiency

The importance of simulation

- “Real world” protocols deserve a “real world” simulation
- Physical layer and propagation condition are the poor relations of network simulation
- Get beyond Random Waypoint and free space propagation

- Accurately model topology, environment and propagation is hard
  - Model of the environment (streets, buildings, …)
  - Propagation characteristics of the environment elements

- Accurately model users behavior and mobility is even harder
  - Capture and replay real traces
  - Find mathematical characteristics of traces to play scenarios with variations

Thanks for your attention

Questions and input are welcome…

and encouraged!