Content Dissemination in Mobile Wireless Networks

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Context / Objectives

- An activity running for couple of years, involving several people
  - Amir Krifa, Francisco Santos, Benjamin Ertl, Thierry Turletti
  - Thrasyvoulos Spyropoulos (Eurecom)

- To exchange data between mobile devices
  - Without infrastructure – disaster, censorship, etc
  - Multi-hop mode: I give you, you give the others, and so on
  - Often called Delay Tolerant Networks, Pocket switched Networks, etc

- Communication can be of different types
  - Point-to-point: I send a content/message to someone
  - Broadcast
  - Publish-subscribe: One publishes, others search and request
Difficulties

- Current Internet architecture does not work in this context
  - No end-to-end path, no TCP/IP
  - Network topology changes frequently
  - Opportunistic encounters

- Forwarding, replication and content-aware routing
  - Either give the content to encountered devices and get rid of it
  - Or simply give them a copy
  - How to know?
  - Several solutions in the literature: spray-and-wait, age-based routing, community-based routing, routing by social networks, etc

- Routing reduces the load, but does not provide explicit solutions in case of resource starvation
  - TCP and buffer management vs. IP routing
Our framework

- Transform the problem into a resource management problem
  - Set a global objective for the network
    - Maximize throughput, Minimize delay, being fair, etc
  - Devices take local decisions that push the network to its desirable global behavior (and keep it there)
  - Two main decisions:
    - When there is a need to drop some data, drop the least useful first
    - When there is a need to forward, forward the most useful first

- Control variable: The number of replicas …

- Control function: A utility per content
  - The marginal gain/loss upon drop/replication
Algorithm in a nutshell

Beforehand

- Write global objective as a function of number of replicas
- Differentiate with respect to number of replicas
- Get expression of utility $U$ per content

Locally, on the fly

- Estimate Utility $U$ for each content (ex. Gossiping)
- Pay attention to Bias
- Rank contents from most useful to least useful
- Drop from bottom
- Forward from top
HBSD: The point-to-point case

- History-Based Scheduling and Drop
  - http://planete.inria.fr/HBSD_DTN2/

- Contents/Messages appear at a device, try to find their way to some other destination device, then disappear

- Utility: A function of content age
  - By gossiping, HBSD finds this function by itself
  - Same function for all contents
  - Age of content indicates its utility

- Two variants: **Maximum delivery** and **Minimum delay**

For a lightly loaded network, utility decreases with age
- Best is to schedule youngest first and to drop oldest first
When the load increases, the shape of utilities changes
- Simple policies are no longer optimal
- HBSD can capture the optimal behavior whatever is the load

Samples of utility functions

Per-Content Utility
- Maximum delivery
  - prefer younger ones

Per-Content Utility
- Minimum Delay
  - help the content over younger ones
  - penalize – help – penalize
CODA: The publish-subscribe case (point-to-multipoint)

- Content Optimal Delivery Algorithm
  - [http://hal.inria.fr/hal-00742734/](http://hal.inria.fr/hal-00742734/)
  - [http://planete.inria.fr/Software/CODA/](http://planete.inria.fr/Software/CODA/)

- Developed within the CCN/NDN framework
  - Contents have universal names. Ex: \inria\team\diana\coda
  - Have different popularities (different request rates)
  - Users issue requests for contents, contents flow back, intermediate devices cache

- Again, control the number of replicas per content
  - Function of its popularity
  - Collaborative network-wide caching, taking mobility into account (vs. LRU, LFU)

- First solution that maximizes the number of satisfied requests (throughput)
  - Under some assumptions:
    
    \[ \text{Utility} \approx \text{miss rate} = \text{popularity} – \text{delivery} \]

    Maximize Throughput = Equalize miss rate
CODA: The publish-subscribe case (point-to-multipoint)

- Observed 50% more throughput than LRU
- And better protection of non popular contents
- Global network performance can be easily tuned
Open issues

Future activity will build upon CODA and transform it into a general solution for storage management and scheduling in mobile content-centric networks

- Scalability of signaling
- Fairness vs. Throughput
- Convergence vs. Reactivity
- Collaboration enforcement
- Heterogeneity of devices (battery, storage, etc)
- Large scale experiments
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