PHASE TRANSITIONS OF OPPORTUNISTIC COMMUNICATION

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Introduction

- Two trends observed
  - Lots of work done on opportunistic networking/DTN
  - Coverage of WiFi and similar technologies increasing
  - So what's the point of opportunistic networks???
    - We have infrastructure!
- Can opportunistic communication and infrastructured networks complement each other?

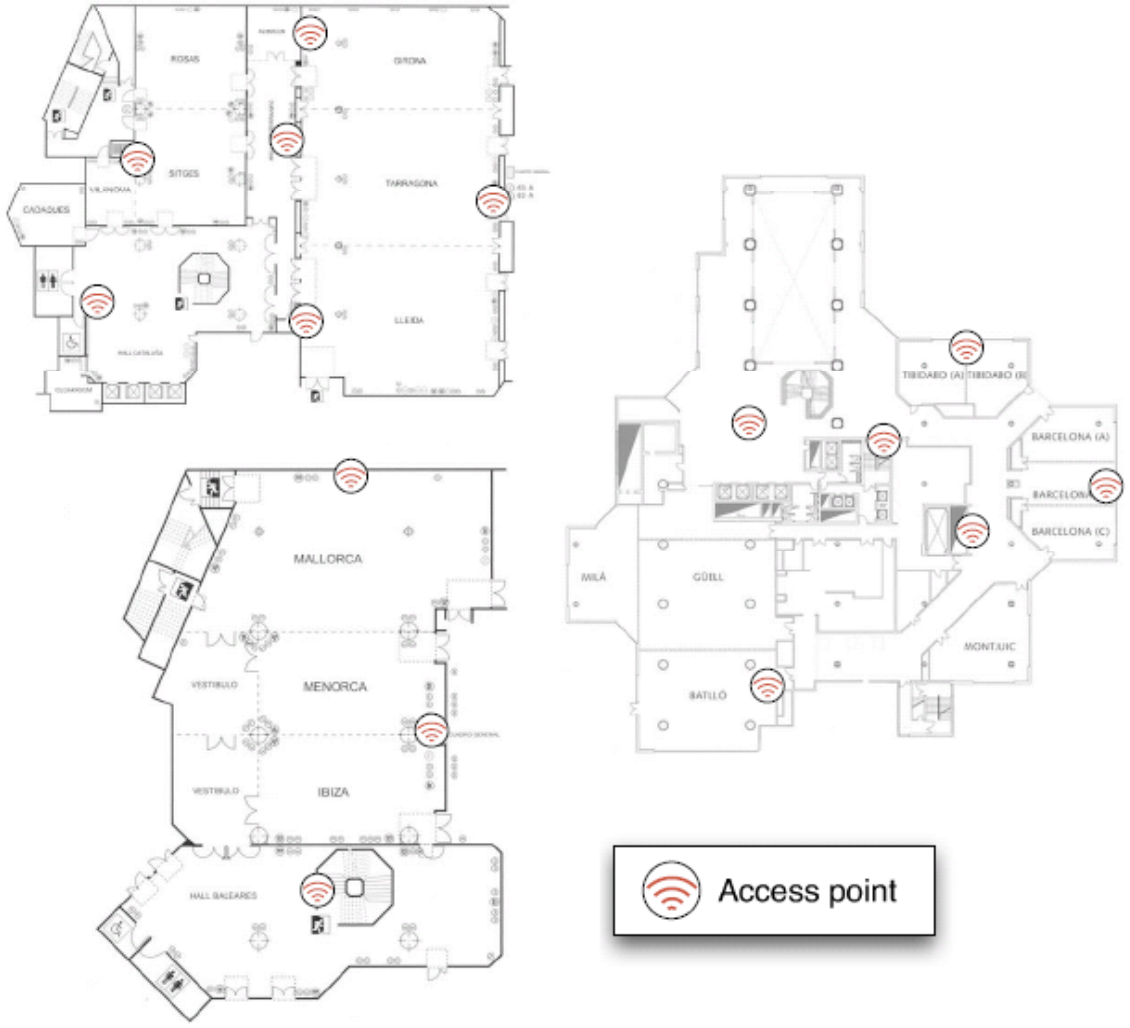
Introduction (2)

- Under which conditions is opportunistic communication necessary or useful for network operation?
  - Different levels of participation among mobile nodes.
- How is the performance of opportunistic networks improved by the addition of partial infrastructure?

Dataset

- Collected at the Infocom 2006 conference
- Bluetooth contacts (collected through the use of iMotes)
- 80 mobile devices (conference participants)
- 20 stationary devices (”access points”)

Access point placement

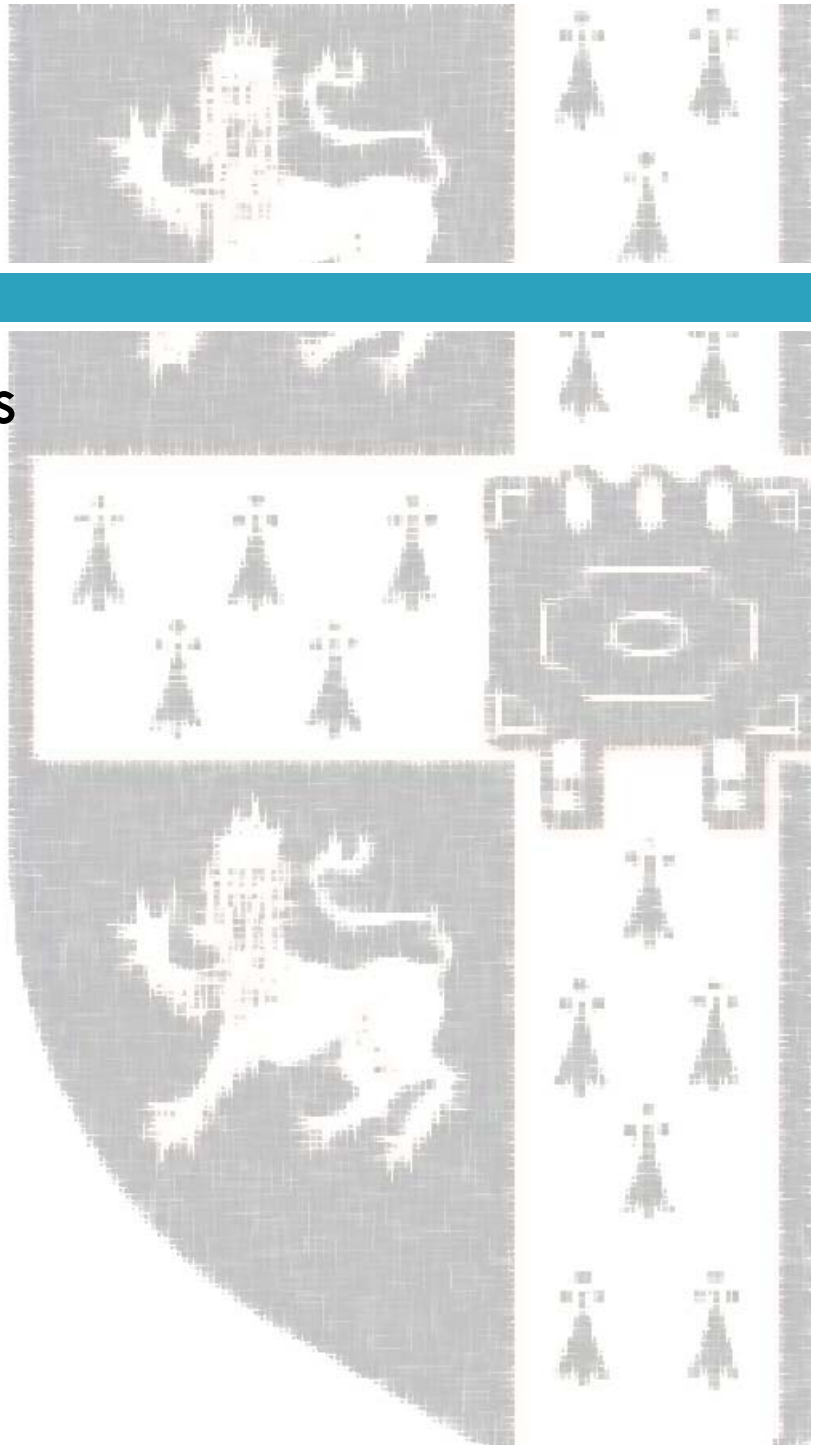


Application Scenarios

- Asynchronous Messaging
  - Peer-to-peer exchange of messages between mobile nodes
  - Direct contact, opportunistic forwarding, infrastructure support
- Data Push
  - Data delivery service (e.g. email delivery)
  - Messages generated at infrastructure
  - Delivered directly to destination upon contact with infrastructure, or with opportunistic forwarding

Methodology

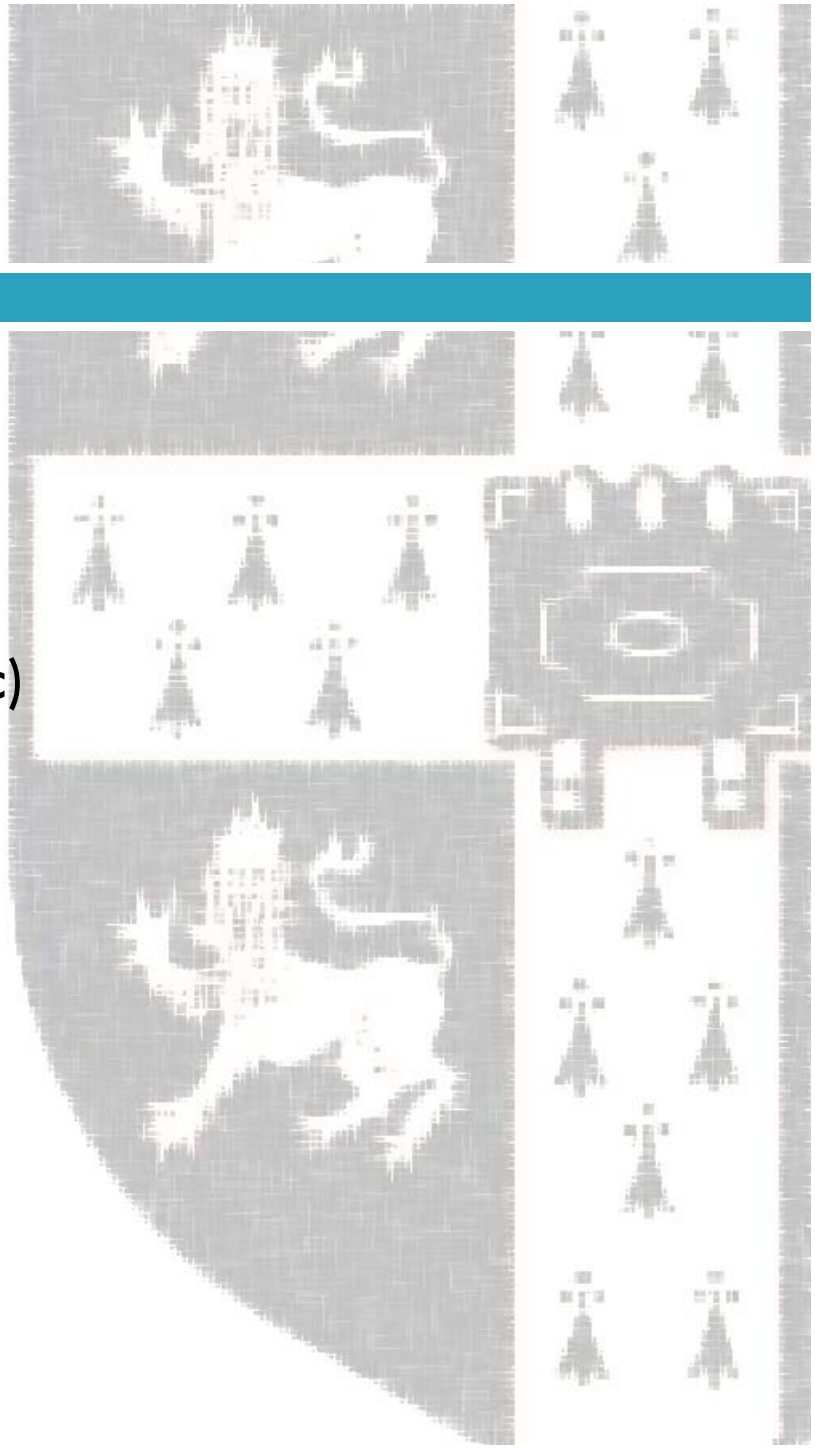
- Based on experimental traces
- Numerical Analysis
- Simulations



Numerical Analysis

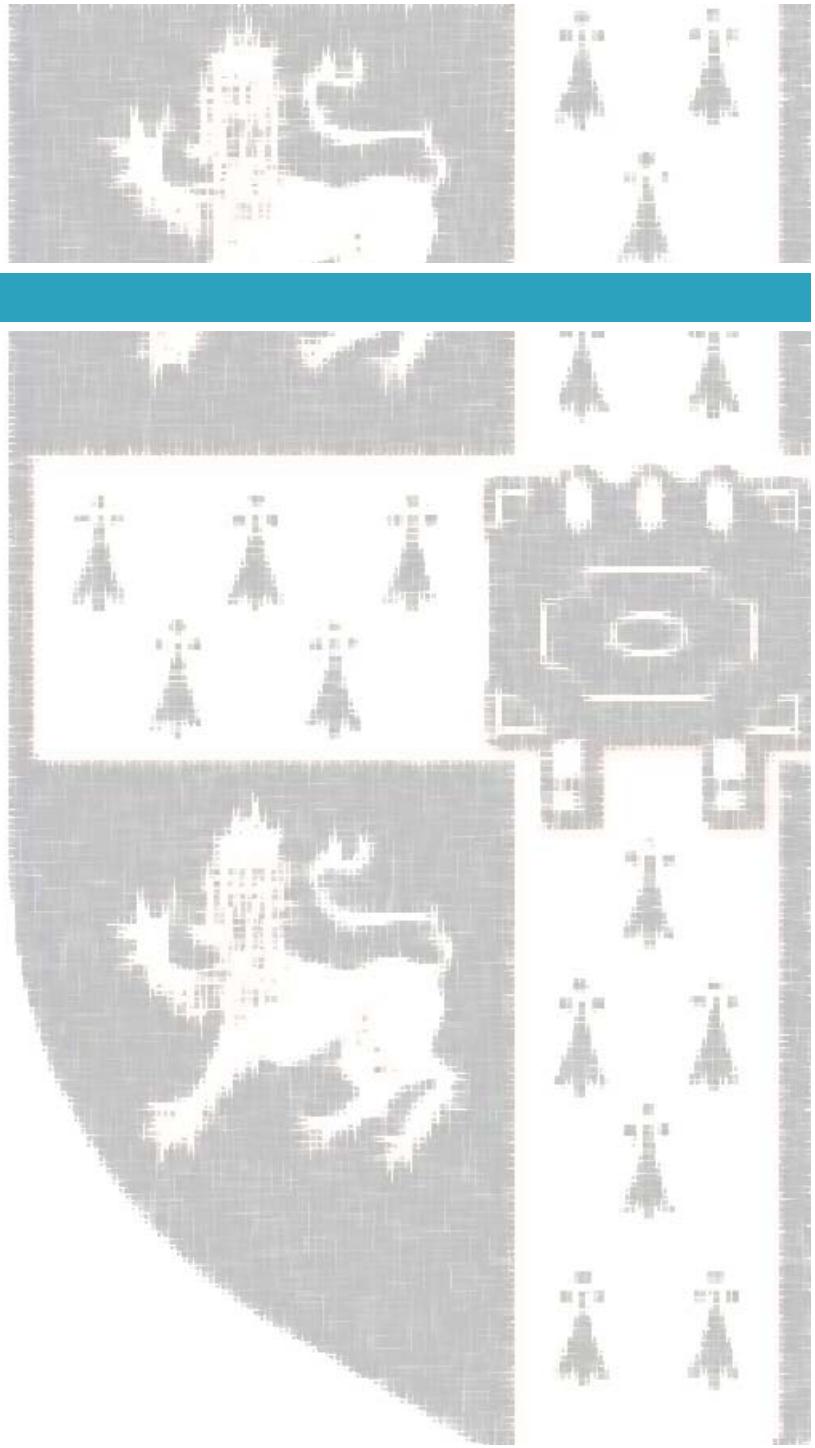
- Theoretical minimum possible achievable multihop delay calculated for each point in time
- Averaged over time

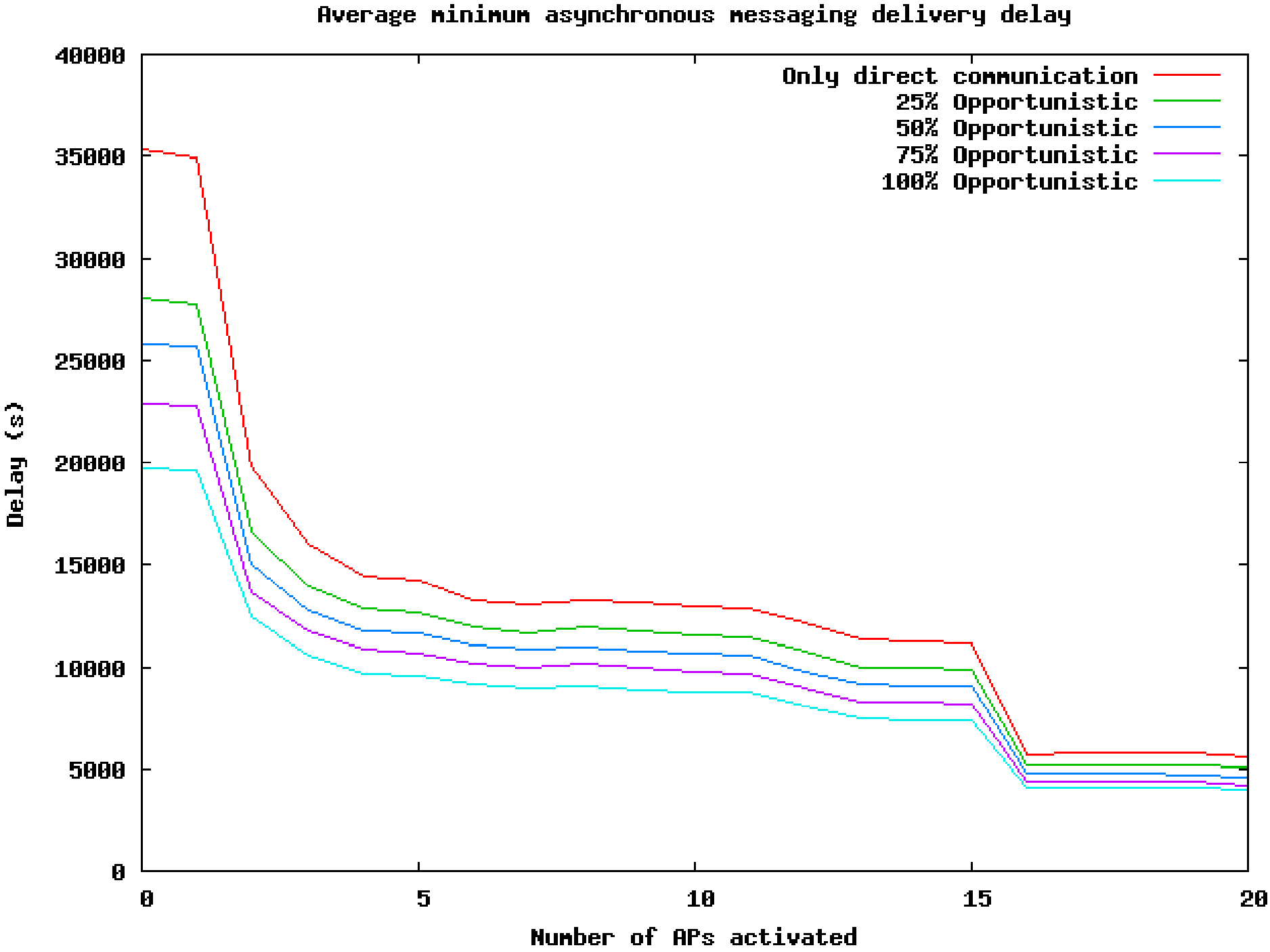
Simulations

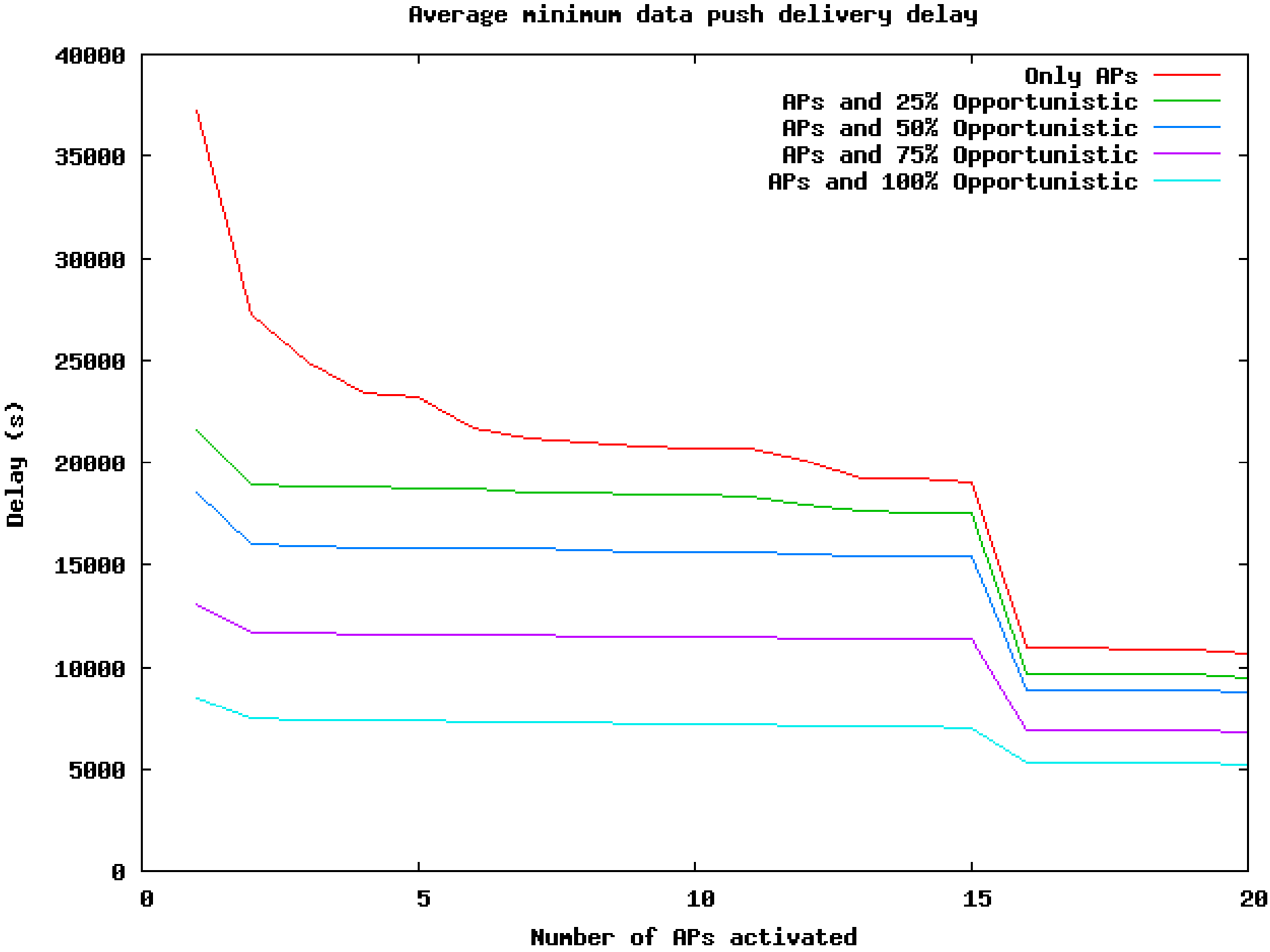


- HaggleSim
- Trace driven simulator
- Forwarding schemes
  - Opportunistic flooding (epidemic)
  - Opportunistic MCP
  - Only APs
- Metrics
  - Throughput, given TTL
  - Utility
    - $U(O) = \frac{T(O + I) - T(I)}{T(O + I)}$

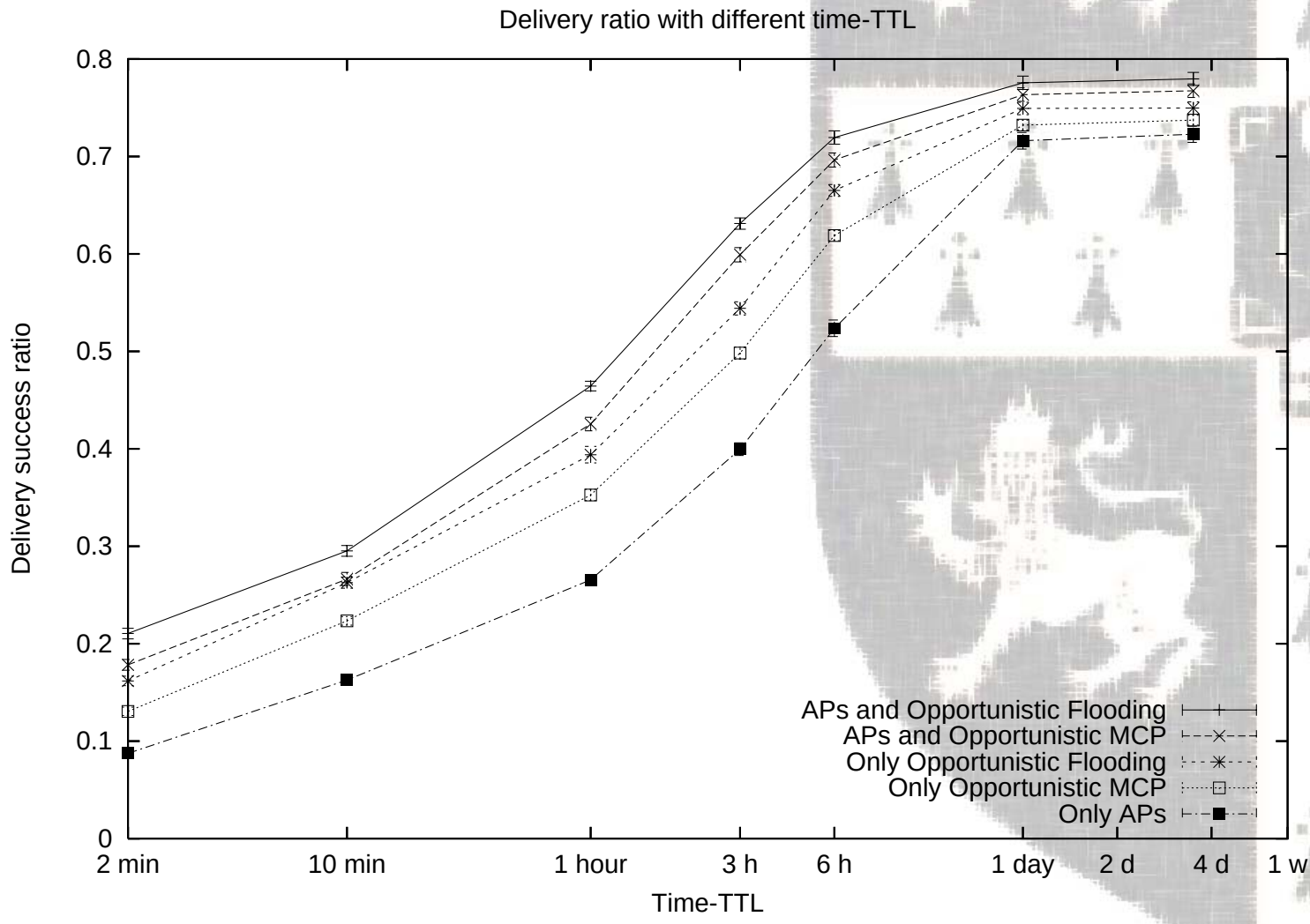
Results



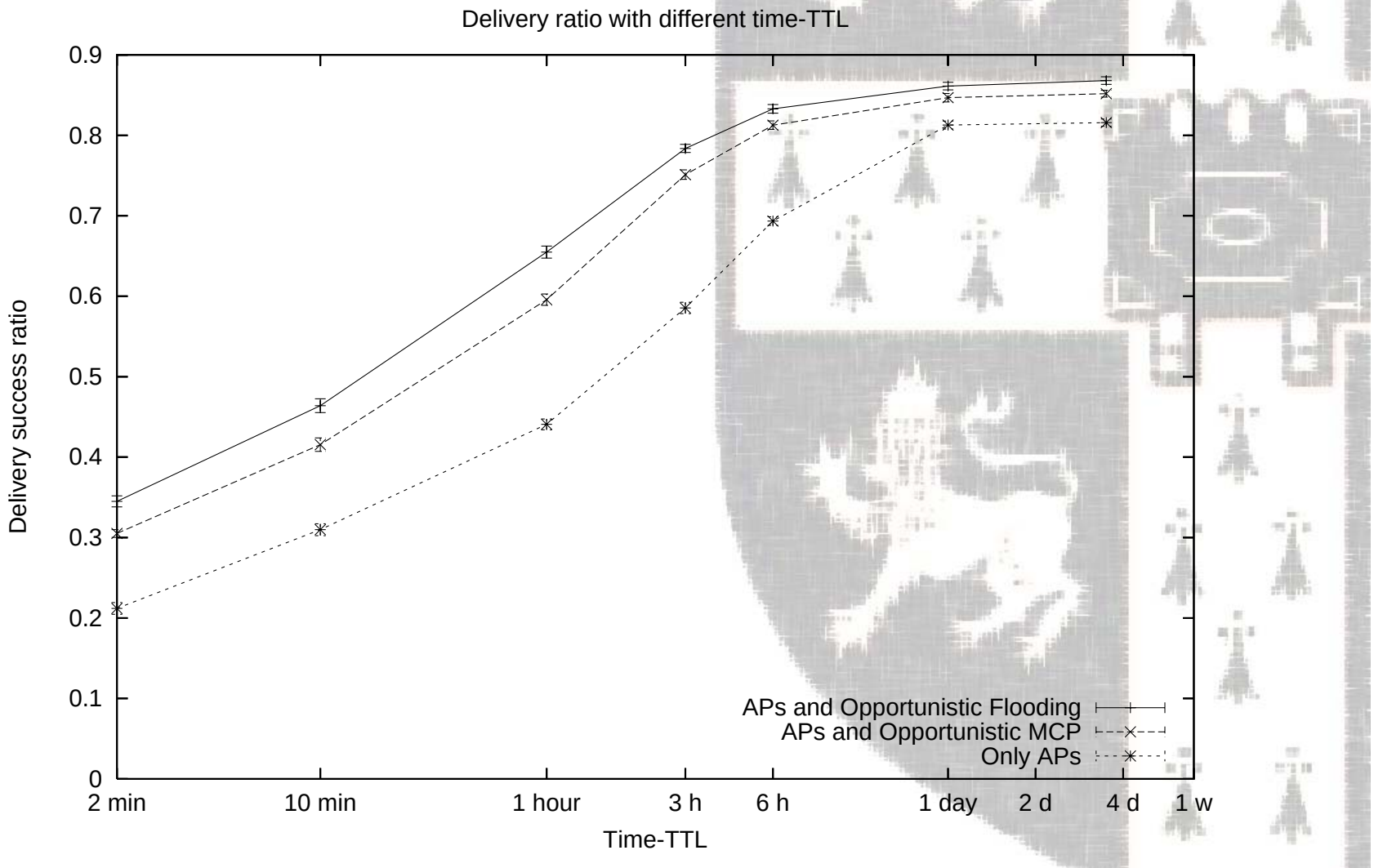

Average minimum asynchronous messaging delivery delay
Only direct communication
25% Opportunistic
50% Opportunistic
75% Opportunistic
100% Opportunistic
Delay (s)
40000
35000
30000
25000
20000
15000
10000
5000
0
0
5
10
15
20
Number of APs activated


Average minimum data push delivery delay
Only APs
APs and 25% Opportunistic
APs and 50% Opportunistic
APs and 75% Opportunistic
APs and 100% Opportunistic
Delay (s)
40000
35000
30000
25000
20000
15000
10000
5000
0
0
5
10
15
20
Number of APs activated

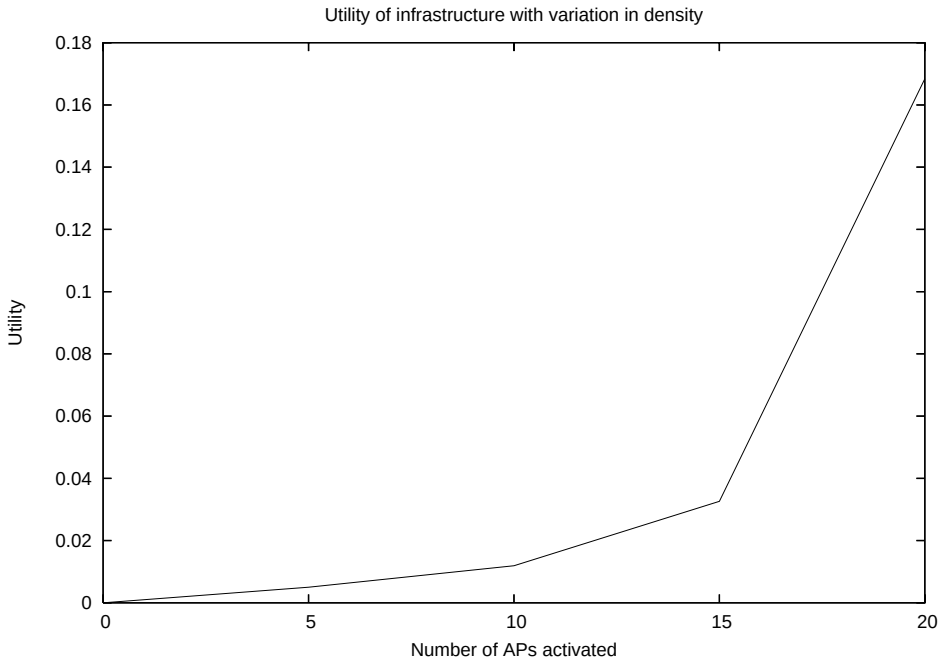
Asynchronous messaging

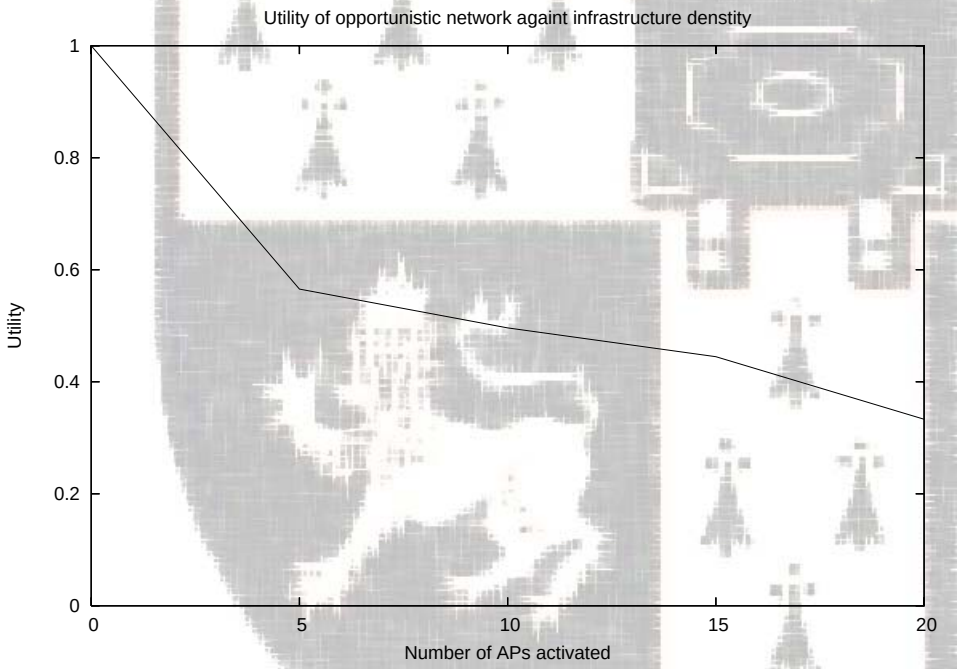


Data push

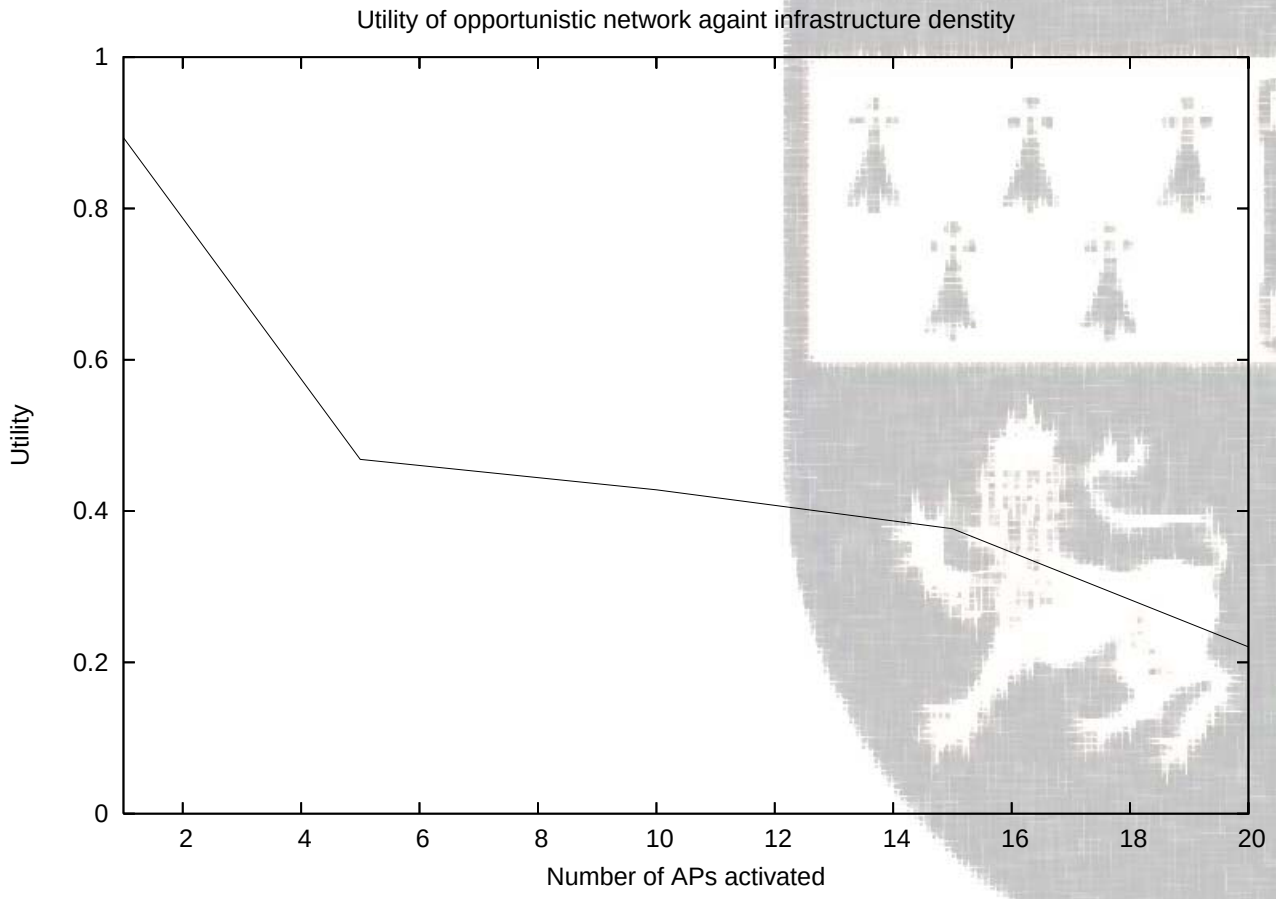

Delivery ratio with different time-TTL
Delivery success ratio
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
2 min
10 min
1 hour
3 h
6 h
1 day
2 d
4 d
1 w
Time-TTL
APs and Opportunistic Flooding
APs and Opportunistic MCP
Only APs

Utility (asynchronous messaging)





Utility (data push)



Conclusions and Future Work

- Opportunistic communication can yield a significant increase in network performance, even if infrastructure is present
  - Supported by both evaluation methods
- Other traces (e.g. RealityMining)
- Include cost tradeoffs in the evaluation
  - System costs
    - Bandwidth & energy usage
  - Monetary costs
    - Access Point deployments

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RealityMining Data