Efficient Retrieval of User Contents in MANETs

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Work overview

- Aim: reduce query/messages overhead from broadcast storms in a cooperative MANET environment
- **Eureka**: methodology to identify regions of the network where the required info is more likely to be stored and steer queries there
- Regions identified through their *information density*
- Performance evaluation in realistic vehicular scenarios:
  - Highway
  - City

System assumptions

- Finite set of information items: each item has an identifier $\mathbf{0} \le \mathbf{id} < \boldsymbol{N}$ and it is divided into *chunks*
- Nodes query other nodes for missing information items. Each node generates queries for as many as $\boldsymbol{C}$ chunks of the missing items according to i.i.d. Poisson processes with rate λ
- Queries are broadcast and relayed by other nodes
- Nodes with all, or part, of the requested information chunks reply to the query. Chunks are returned through an application-driven unicast path
- Nodes receving the requested information item cache it for an exponentially distributed random time with mean $1/\mu$

Message exchange

- Queries:
  - broadcast by issuing and relaying nodes
  - Before relaying a query, a node records its "routing tracks" (ID, source, last hop).
- Responses:
  - MAC-layer unicast transmission by issuing and relaying nodes.
  - Next-hop chosen by routing tracks stored at relays
  - *Promiscuous* mode allows overhearing nodes to toggle the status of pending queries

Eureka and Information density

- Provide each node in the network with an *estimate* of information density in its proximity
- Differences between local and other nodes' estimates are used to decide whether a query must be forwarded
- Thus, queries travel toward areas where it is more likely that information is found

Eureka: density estimation

- Fully distributed process, run by all nodes
- Information Density Function $\delta_i(x,y)$: spatial density of information item *i*, cached at nodes around point (x,y)
- Two contributions:
  - $s^l_{i,j}$: locally-computed density sample from generated, overheard and received information messages of type *i* at step *j*
  - $s^d_{i,j}$: density sample computed from advertised samples by neighboring nodes
- A Moving Average filter weighs the contributions and returns the density estimate $\hat{\delta}_i(x,y)$

Eureka: overhead reduction

- Three steps to counter broadcast storms
  1. Queries are issued with a TimeToLive (TTL)
  2. Relay nodes delay query forwarding by a Query Lag Time, in the hope that a response is returned by neighboring nodes

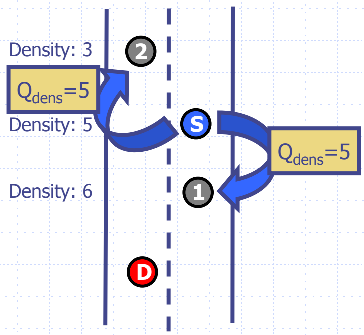
Mitigated Flooding

Eureka: overhead reduction

- Three steps to counter broadcast storms
  1. Queries are issued with a TimeToLive (TTL)
  2. Relay nodes delay query forwarding by a Query Lag Time, in the hope that a response is returned by neighboring nodes
  3. Queries include *info density* as seen by issuing node; relay nodes forward query only if they "see" higher info density

Eureka: overhead reduction

- Three steps to counter broadcast storms
  3. Queries include info density as seen by issuing node; relays forward query only if they “see” higher info density



Eureka: overhead reduction

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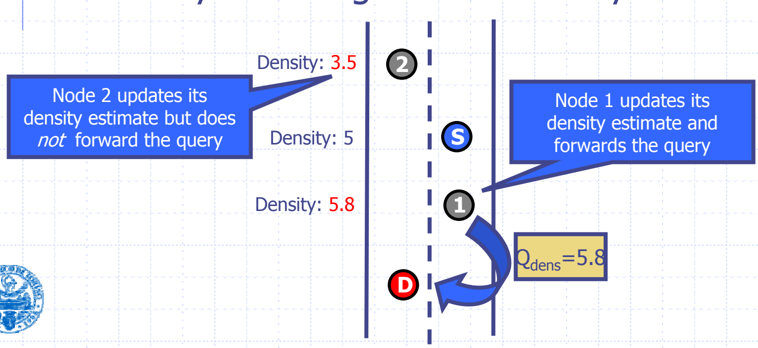


Case study: Vehicular mobility

- Car-to-car and car-to-infrastructure micromobility modeled realistically (Intelligent Driver Model and MOBIL)
  - cars stop, slow down at traffic lights
  - cars queue at intersections
  - cars decelerate in presence of slower vehicles, or pass them

Performance evaluation

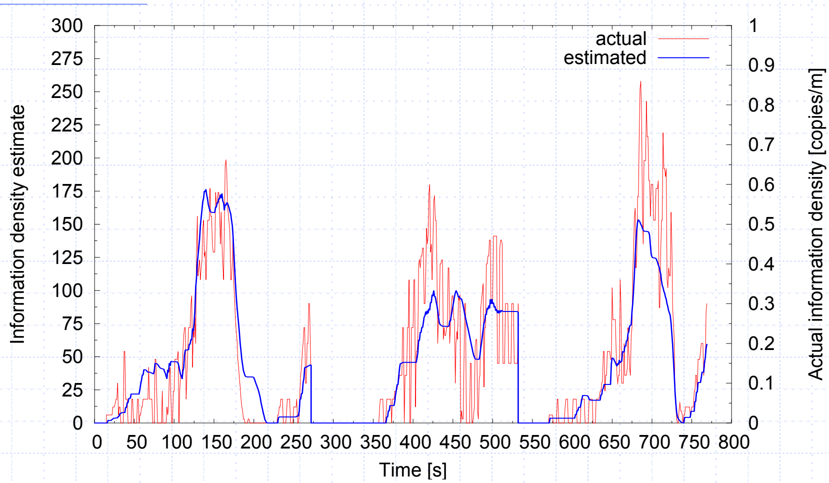
- Simulation with ***ns-2***
- Scenario parameters
  - information set cardinality, $N=[1,25]$
  - each information item divided into up to 30 chunks
  - queries generation rate, $\lambda=[1,6]$ queries/ms
  - cached information drop rate, $\mu=[5,50]$ drops/ms
  - queries Time To Live, $TTL=5$
- Topologies:
  - Highway
  - Urban
- Nodes have a 802.11 MAC layer

Road Scenario: Highway

- 5-km straight unidirectional road with three parallel lanes at different speeds
- Lane changes allowed when overtaking
- Speeds ranging from 15 m/s to 45 m/s
- An "information gateway" sits midway on the stretch of road

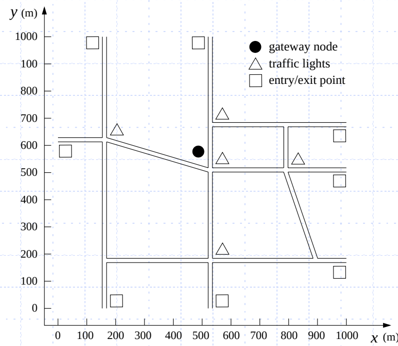
Estimation Accuracy – Highway

λ= 3 queries/ms; μ= 25 queries/ms



Road Scenario: City

- City sections with traffic lights and stop signs
- Vehicles enter/exit at random from entry/exit points
- Speeds ranging from 10 m/s to 20 m/s
- On average, 70 vehicles at 21 km/h
- One "information gateway"



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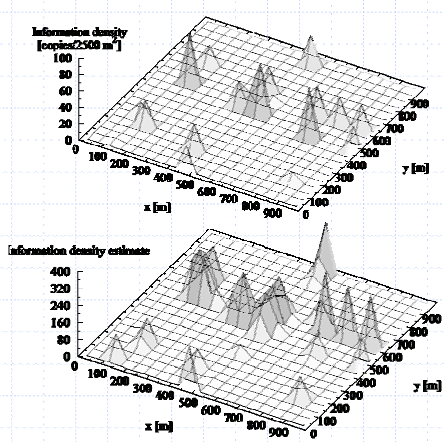
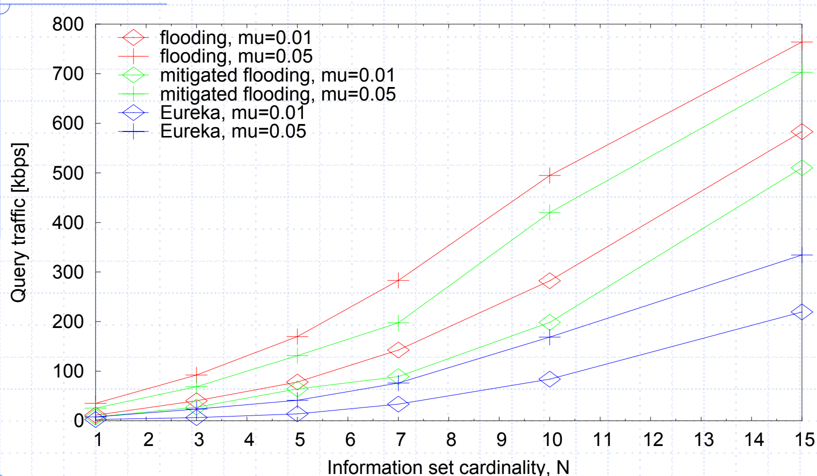


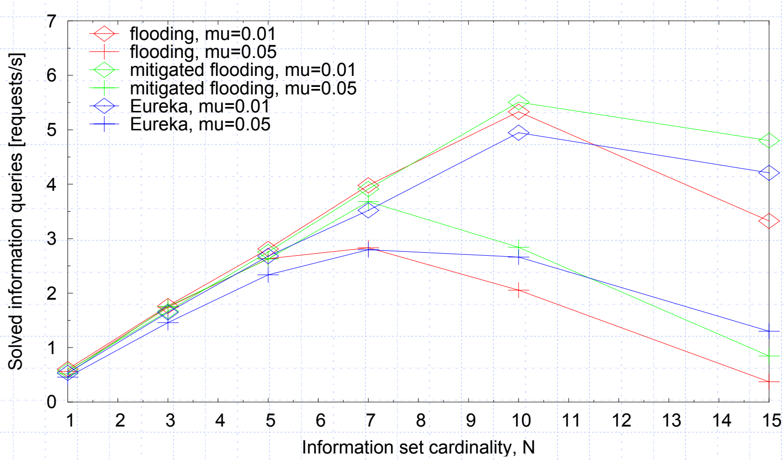
actual

estimated

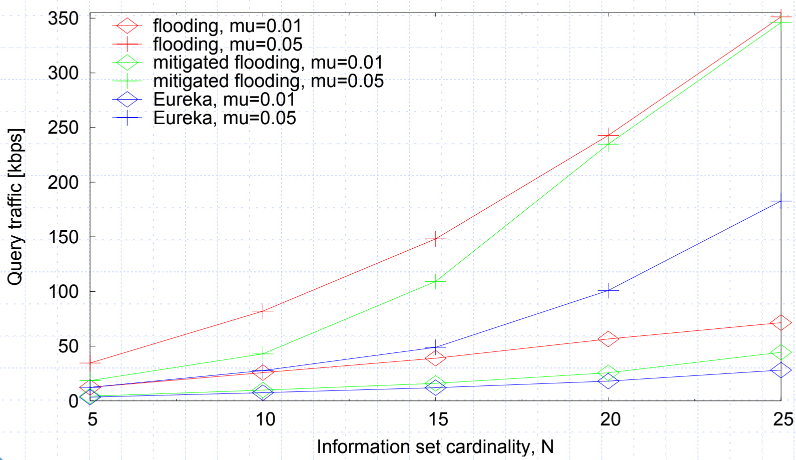
Overhead reduction - Highway



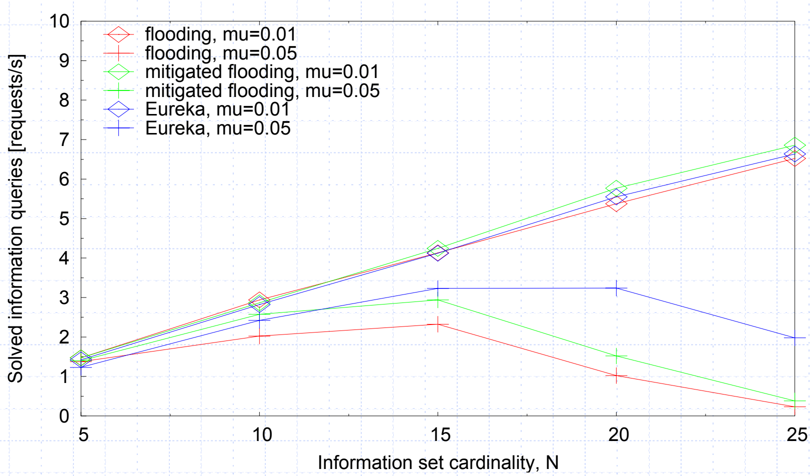
Overhead reduction - Highway



Overhead reduction - City



Overhead reduction - City



Conclusions

- Eureka provides effective overhead reduction
- Broadcast storms are prevented and congestion is reduced, resulting in higher response throughput
- May be used in conjuction with GPS to complement it or to replace it if coverage is missing