OKOS VÁROS @ BME TMIT

Mobility and MANET

Intelligent Transportation Systems

Rolland Vida

Restricted directional flooding

Location-Aided Routing (LAR)

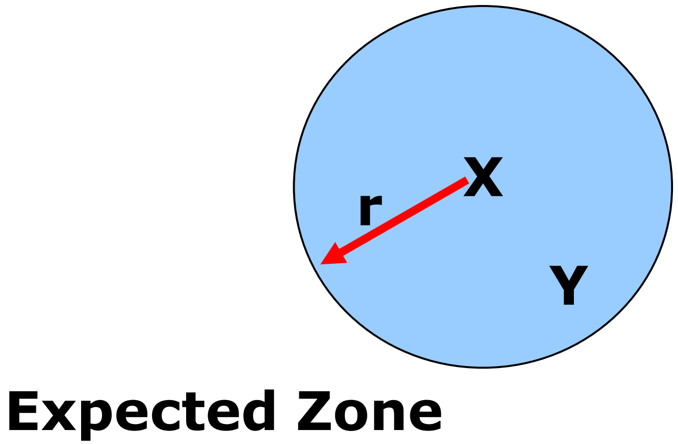
- Use the position information of the destination node to limit the flooding
- Introduces the notion of **Expected Zone**
  - The zone where the destination is expected to be
  - Estimation, based on the previous location of the destination, its speed and direction information
- RREQ messages forwarded only inside a **Request Zone**
  - The Request Zone includes the Expected Zone, together with the area linking the source with the Expected Zone

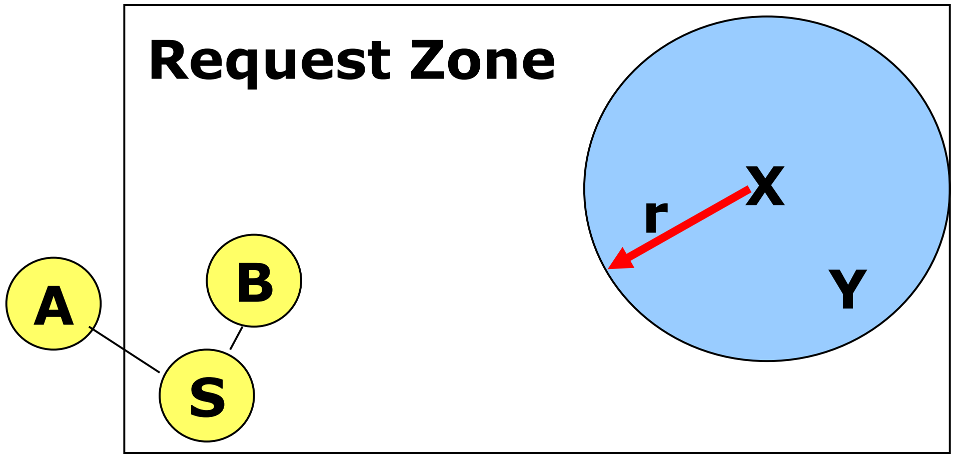
LAR Expected Zone, Request Zone

X = the last known position of the destination **D,** at time t_0

Y = the current position of the destination node **D** at time t_1 (S is not aware of it)

r = $(t_1 - t_0)$ * [estimated speed of **D**]





LAR Request Zone (2)

- RREQ messages forwarded only inside the Request Zone
  - The Request Zone **might be** the smallest rectangle including the source and the Expected Zone
  - E.g., in the example, B forwards the RREQ, but A does not

- The Request Zone explicitly defines whether the RREQ message should be dropped or not

- Each node knows its own position, knows if it is inside the Request Zone or not

LAR Request Zone (3)

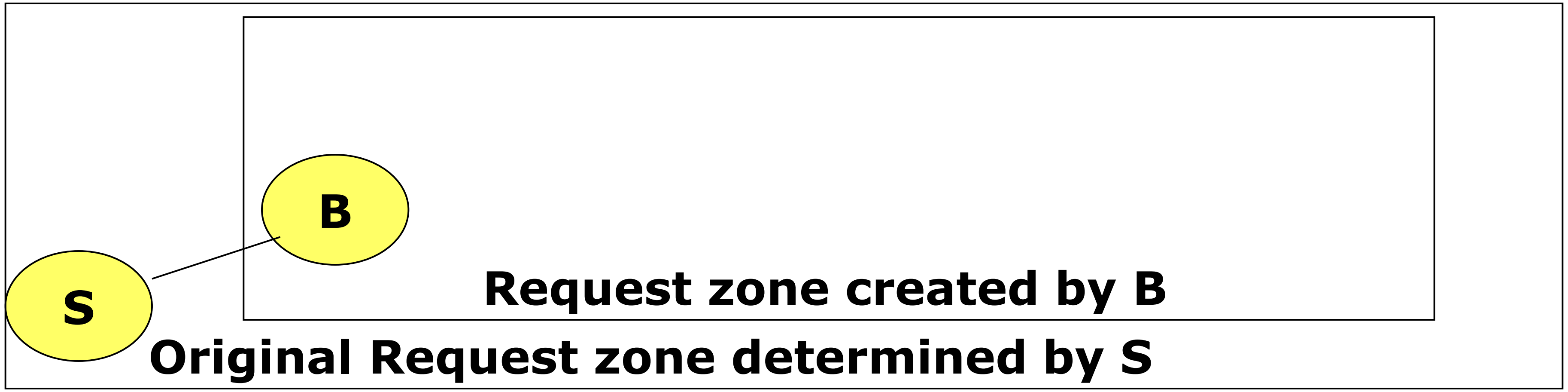
- If the source did not estimate well the position of the destination, the Request Zone might not contain it
  → the route discovery will fail*!*

- After a timeout, the source starts a new search…
  - Increases the size of the Request Zone;
  - If needed, the entire network is included in the Request Zone

- The following steps of LAR are similar to **DSR**
  - In the RREQ message we include the path, step by step
  - The destination sends back a RREP, following this path
  - The path is then included in the header of the data packet
  - Routes have to be refreshed from time to time

LAR versions: Adaptive Request Zone

- The Request Zone stored in the RREQ can be modified by each internal node, if
  - It has fresher information about the destination
  - **AND** the resulting Request Zone is included in the original one



LAR overview

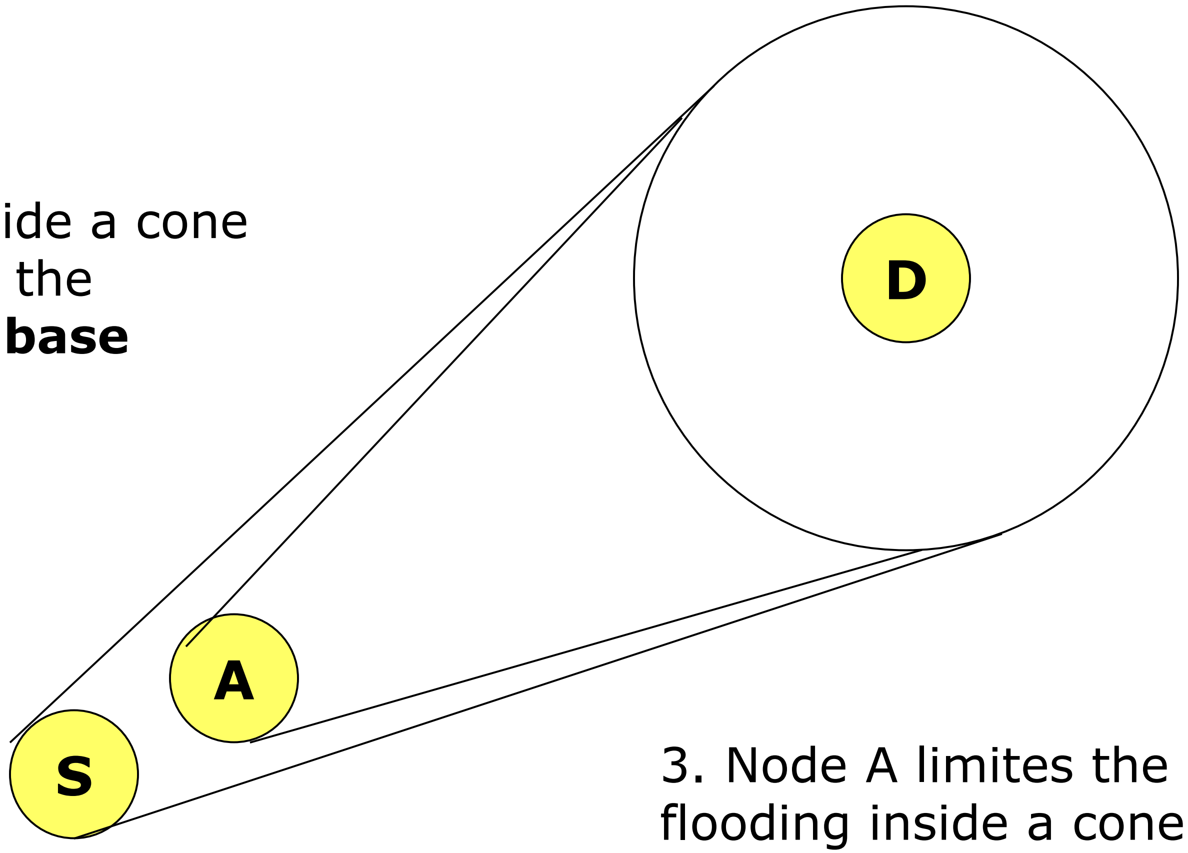
- Advantages
  - The area of spreading of the RREQ message is limited
  - Smaller overhead for route discovery

- Drawbacks
  - Nodes have to know their location

Distance Routing Effect Algorithm for Mobility (DREAM)

- Uses information about position and speed (as in LAR) for reducing the area flooded with **data packets**
- Data is distributed by flooding, as opposed to LAR, where we only use flooding to discover the best route

DREAM localization



1. Expected zone („as in LAR”)

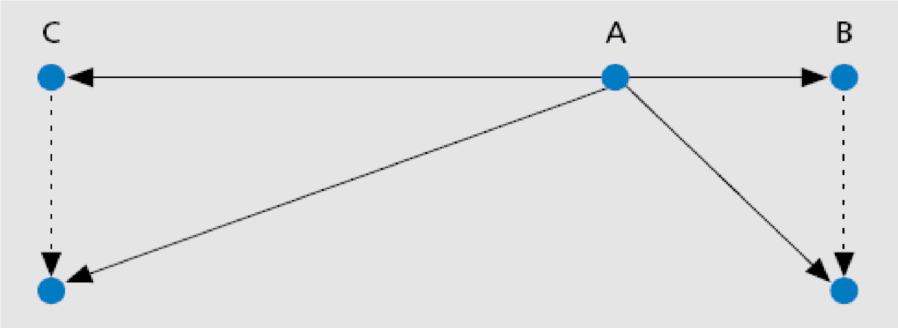
2. Data is flooded inside a cone where S is the **apex,** the expected zone is the **base**

3. Node A limites the flooding inside a cone where A is the apex

DREAM distance effect

- Nodes periodically broadcast their position

- „Distance effect” = Remote nodes move with a smaller angular speed.



→ *Close nodes should refresh their data more often*

  - Playing with the *time-to-live* (TTL) field
  - Adaptive TTL

CBF (Contention Based Forwarding)

- In position-based routing solutions a node learns about the position of its neighbors via periodic beacon messages
  - Mobility and energy-efficiency should be taken into account when calculating the frequency of beaconing
- Proposal CBF (Contention Based Forwarding)
  - **Greedy forwarding, without any knowledge on the position of the neighbors**
  - Distributed next hop selection, hop-by-hop
  - Advantages:
    - Each node has to know only its own position
    - No burden on the network because of the beacon (hello) messages
- Comment: In some cases, if local maximum is reached, recovery mode might have to be activated, but this is a different problem.

Contention Based Forwarding

- How it works:
  - The next hop is selected based on a **contest**
  - **Suppression**: lowers the probability of collisions, as normally just one node is selected as next hop
- Steps:
  1. The source broadcasts the message to its neighbors.
  2. Each node sets a timer for its own retransmission
     - The timer inversely proportional to the distance form the source
  3. The timer of the furthest away node will expire first
  4. He retransmits, all the others hear it, and cancel their own retransmission
- Decentralized selection of the next hop

Vehicle-to-vehicle communication

- „Traditional” ad hoc protocols:
  - Proactive: DSDV (not detailed)
    - High signalling to build and maintain routes that will constantly change in case of cars
  - Reactive: AODV, DSR
    - Slow topology discovery and route setup
    - Not efficient for cars, as they move faster
  - Position-based: LAR, DREAM
    - Needs localization service
    - In some cases it leads to local maximums, needs a recovery mode
    - In urban scenarios there is a high chance for such local maximums, the physical distance is not so relevant when many buildings obstructing the communication

- New solutions needed for vehicle-to-vehicle (V2V) communication

AODV versions for VANETs

- **AOMDV: Multipath**
  - Not only one path is stored, but all those that were discovered
    - This can be done without extra burden, as the path discovery is anyhow based on flooding
  - If the primary path is broken, we can switch rapidly to a back-up path
    - We need to search for new paths only if all the previously known paths are broken (or their number is getting very low)
- **SD-AOMDV: Speed and Direction**
  - The speed and direction of nodes is taken into account when selecting the best path out of the discovered ones
  - A node can be next hop only if it goes in the same direction, with roughly the same speed
- **R-AOMDV: Retransmission count**
  - Takes into account the quality of the links, besides the hop count
    - Link quality: number of retransmissions at MAC layer, until a successful retransmission
  - **Problem:** link quality changes rapidly
  - Cross-layer optimization – information from lower layers is used for routing at networking layer

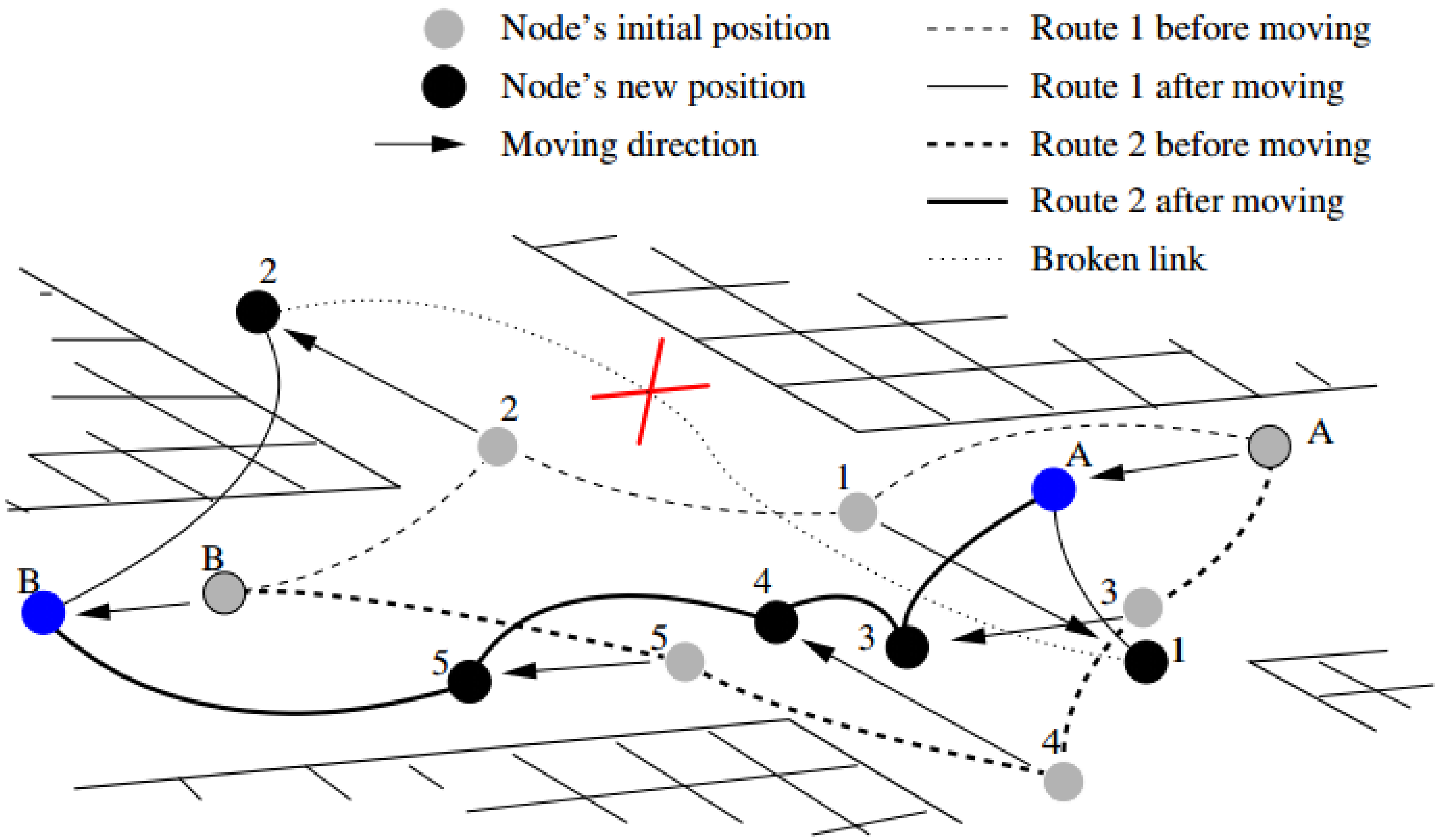
AODV versions for VANETs

- **AODV+PGB: Preferred Broadcast Group**
  - If the next hop is too close, the message does not advance rapidly
  - If the next hop is too far, there is a high chance for the link to break
  - **Proposal**: select as next hop nodes which are at a medium distance (the signal strength is average), they will form the Preferred Group

- **BAODV: Bus-AODV**
- **P-AODV**
- **I-AODV**
- **Improved-AODV**
- **AODV-BD**
- **AODV-VANET**
- **etc.**

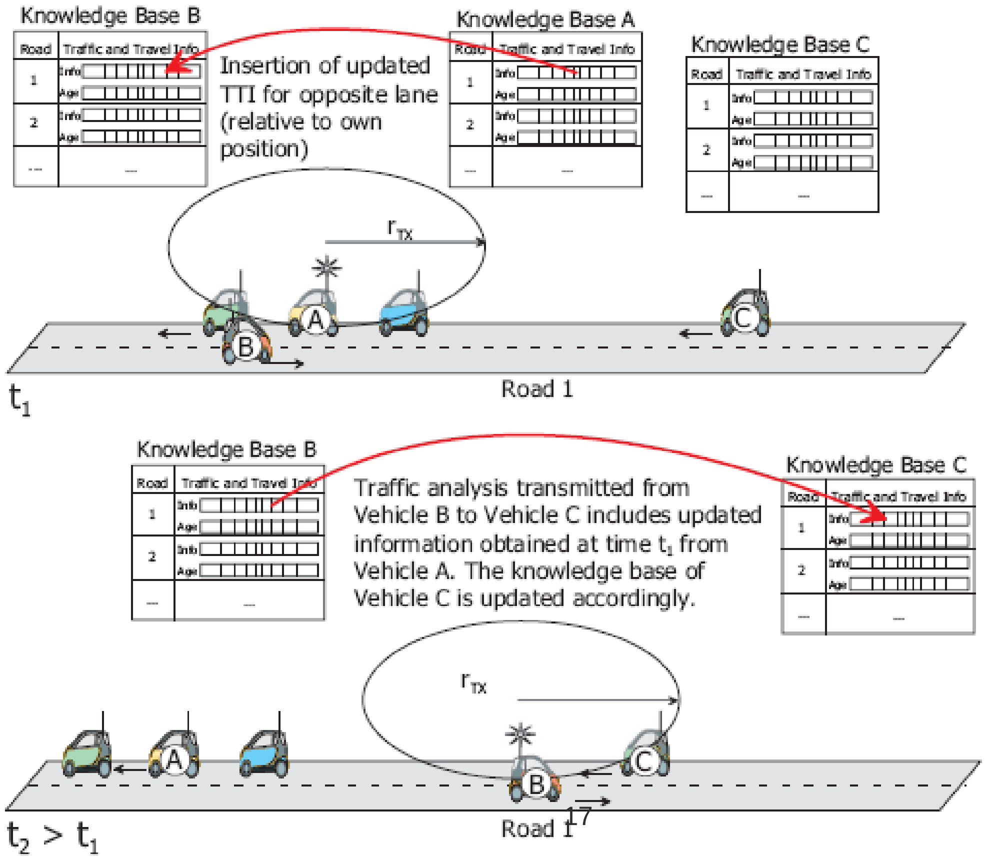
Link-stability based routing

- **Movement Prediction based Routing (MOPR)**
  - Takes into account the position, speed and direction of the cars
  - Builds routes with nodes that move in similar ways



DTN: Delay Tolerant Network

- If nodes are sparse, the network connectivity can be broken
- Topology holes will appear
- This can be handled by the **carry-and-forward** method
  - **Data-mule**s
- It is possible if the message is still valid in spite of the delay
- Mobility prediction is very useful

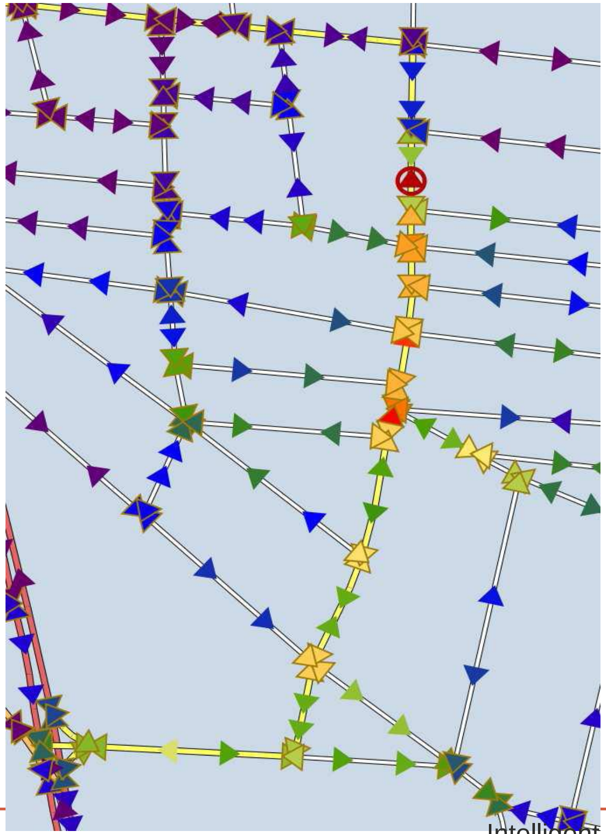


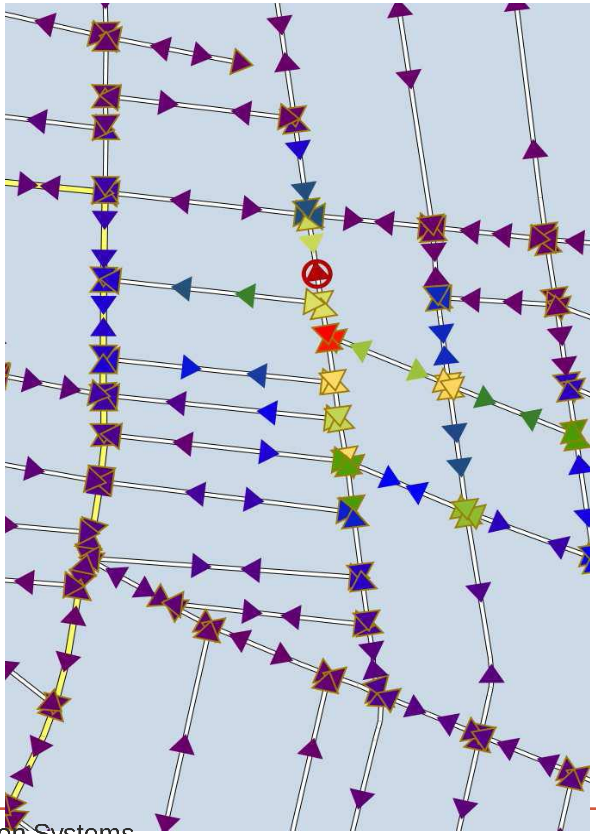
Intelligent flooding through gossiping

- Messages are rebroadcast or dropped with a given probability *p*
  - **Carefully Localized Urban Dissemination (CLoUD)**
- The drop probability on a given road segment depends on the probability of cars on that segment heading towards the source of the flooding (where the danger was detected)
- Needs a traffic database
  - Turn probabilities at each intersection
  - Stop probability on each segment
  - Average traffic density in different periods of the day
- Increasing reliability with a voting mechanism
  - The message is dropped only if there are sufficent votes to drop it
- Miklos Mate, Rolland Vida, „Reliable Gossiping in Urban Environments”, in Proceedings of 72nd IEEE Vehicular Technology Conference VTC-Fall, Ottawa, Canada, September 2010.

Intelligent flooding through gossiping

- Simulation results for the CLoUD protocol
  - Digital map of Budapest, warmer colors mean more messages received by that car
  - If the problem occurs on a main road (left), the message is spread more broadly
  - If the problem occurs on a side road (right), the flooding dies out fast





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