An Adaptive Peer-to-Peer Overlay Scheme for Location-based Services

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Outline

- Motivation
- Related Work
- ADGT Architecture
- Simulations
- Results
- Conclusion
- Future Work
Motivation

● Smart City paradigm: citizens, institutions, machines are increasingly connected

● Location-Based Services: design challenges
  ○ Reliability
  ○ Privacy preservation
  ○ Scalability

● Peer-to-peer solutions have been proposed
  ○ Pros: no bottlenecks, no single point of failure
  ○ Cons: increased architectural complexity
Motivation

Centralized LBS

Peer-to-Peer LBS
Related Work

- Traditional P2P overlay schemes are not suitable for LBSs, as they ignore geographical locations and distances between peers.
Related Work


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ADGT Architecture

- General concepts
  - Peer = (unique identifier, geographical location)
  - Distance between two peers = great-circle distance
  - Neighborhood of a geographical location = set of peers close to that location
ADGT Architecture

- Data structures

**Elliptical GeoBuckets** → the higher the speed of the peer, the higher the eccentricity of the ellipses.
ADGT Architecture

- GeoBucket structure = a group of $K$ concentric ellipses.
- Semi-major and semi-minor axes of the $i$-th ellipse:

$$a_i = i \cdot t_i \cdot (1 + S \cdot \frac{u}{V_{max}})$$

$$b_i = i \cdot t_i \cdot \frac{V_{max}}{V_{max} + S \cdot v}$$
ADGT Architecture

- Geolocated neighborhood discovery
  - Recursive approach:
    - to discover the neighborhood of a given location, peer P1 sends the discovery message to the peer that is closest to the target location
    - P2 replies to P1 with a list of $B$ closest peers to the specified location
    - P2 forwards the discovery message to the peer (P3 != P2) that is closest to the target location
    - etc. (until Pi is the closest peer to the target location)
ADGT Architecture

- Publish/subscribe mechanism
  - While in the original DGT every peer had a unique GeoBucket structure, in the ADGT it can have multiple GeoBucket structures, associated with different locations.
  - In this way, it is possible, for example, to place a GeoBucket structure on a particular road junction to be automatically notified about any related warning.
Simulations

- ADGT (deployment Java code)
- Mobility model
- Communication model
- General-purpose discrete event simulation engine
Simulations

- **OSMobility**
  - integrated with OpenStreetMap, an open database which provides geographical data, and uses such data to compute trajectories
  - allows to simulate vehicles, pedestrians, bicycles etc.
Simulations

- Communication between nodes
  - ns-3 with Lena package used to simulate the end-to-end IP connectivity over LTE-EPC
  - the resulting delay models have been included into large-scale, DEUS-based simulations

Simulations

• Configuration parameters
  ○ \( B = 20 \) (max # peers returned by discovery msg)
  ○ \( \varepsilon = 1 \) km (min displacement before notification to neighbor peers)
  ○ \( K = 5 \) (number of GeoBuckets in a data structure)
  ○ \( t = 0.4 \) km (thickness of each GeoBucket)
  ○ \( L = 20 \) (max # peers in a GeoBucket)
  ○ GeoBucket’s shape control:

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Simulations

- Evaluation metrics
  - **Data Rate (DR)** = avg # of bits that are transmitted per unit of time by each peer (dimension: [kbit/s/peer])
  - **Coverage Percentage (CP)** = # of peers that have actually received a warning msg / # of peers that should have received it
  - **Distance From Events (DFE)** = avg distance between peers not (yet) notified and related event (dimension: [km])
Results

- Inside the university campus
Results

- Inside the city of Parma
Results

- Inside the city of Parma
Results

- Along the highways
Conclusion

The ADGT

- is an adaptive peer-to-peer overlay scheme that allows the realization of LBS for mobile peers
- takes into account the speed and the direction of the peers to improve its performance
- with respect to the state of the art, provides more location-based functionalities
- has been implemented as a Java API
- has been evaluated by means of simulations of three very different scenarios
Future work

● Further methods for the adaptivity of the overlay scheme to peers’ mobility, for example based on information of the road shape obtained from a map, will be investigated.

● The preservation of the privacy of peers will be taken into account in the architecture of the overlay scheme.

● ADGT-based applications for Android will be released.