Demo: OverDrive - an Overlay-based Geocast Service for Smart Traffic Applications

Martin Florian, Simeon Andreev, Ingmar Baumgart
Institute of Telematics
Karlsruhe Institute of Technology (KIT)
76131 Karlsruhe, Germany
florian@kit.edu, simeon.andreev@student.kit.edu, baumgart@kit.edu

ABSTRACT

For smart traffic applications like dynamic route planning, communication between traffic participants is of high importance. Traditional approaches rely on centralized, server-based communication architectures, which raises scalability and privacy concerns. To address these problems, we proposed *OverDrive* [5], an overlay-based geocast service that is applicable in smart traffic scenarios and not prone to the shortcomings of centralized designs. Here, we present an interactive demonstrator of the OverDrive protocol that visualizes OverDrive's neighborhood structures and routing approach in a realistic and highly mobile traffic scenario. Our demonstrator is realized as an extension to the overlay simulation framework *OverSim* [2].

Categories and Subject Descriptors

C.2.1 [**Network Architecture and Design**]: Distributed networks; C.2.2 [**Network Protocols**]: Routing protocols

Keywords

Geocast, Overlay networks, Peer-to-peer

1. INTRODUCTION

The increasing availability of Internet access in vehicles offers a variety of new opportunities to assist road users. Examples for such *smart traffic* applications, which leverage communication capabilities, are *dynamic route planning* (e.g., *Waze*[1]) or the *localization and reservation of charging stations* for electric vehicles. Current solutions mainly follow a centralized, server-based approach for communication, which has several inherent drawbacks:

- Lack of privacy, as all communication and service provision is handled by the service provider. Even given approaches for increasing the privacy in centralized setups, providers might not be motivated to implement them.
- Questionable scalability: With over 50 million vehicles in Germany alone, centralized solutions might quickly lead to performance bottlenecks.
- Inhibited innovation potential and service quality, as successful services are unlikely to share their user base with competitors. In this way, service models that depend on a large user base are difficult to deploy and cannot develop their full potential.

Decentralized overlay networks providing *geocast* services [5, 4, 6] are a recent development with a lot of potential for resolving these drawbacks. Roughly, the idea is the creation of a logical *overlay network* on top of a cellular communication network based on the *Internet Protocol (IP)*. In this overlay network nodes propagate their location to other participating nodes and use this information for choosing overlay neighbors and forwarding messages. With *OverDrive* [5], this approach was specifically adapted to smart traffic scenarios, introducing mechanisms for dealing with high degrees of node mobility.

In the following, we present a demonstration of the applicability of OverDrive in realistic traffic scenarios with high degrees of mobility. Since a demonstration with real vehicles would be unfeasible, we simulate the mobility and communication behavior of participating nodes using the overlay simulation framework *OverSim* [2]. Two of the simulated nodes are tracked and controlled using tablet computers, giving a feel for a possible implementation in real life. Through user interaction, these nodes can initiate the sending of geographic queries to arbitrary points in geographic space. The messages are routed over the overlay and answered by the traffic participants currently residing closest to the target point, all without requiring any form of centralized coordinator. On a separate monitor, the internal functioning of the OverDrive protocol can be observed. Both the neighbor selection logic and the routing mechanism are visualized on top of real street maps.

2. THE OVERDRIVE PROTOCOL

As a geocast overlay, *OverDrive* [5] provides an interface for delivering messages to geographic regions, respectively to the nodes within these regions. In the scope of this demo,

[1] `http://www.waze.com/`

MobiCom'13, September 30–October 4, Miami, FL, USA.
ACM 978-1-4503-1999-7/13/09.
http://dx.doi.org/10.1145/2500423.2505297.

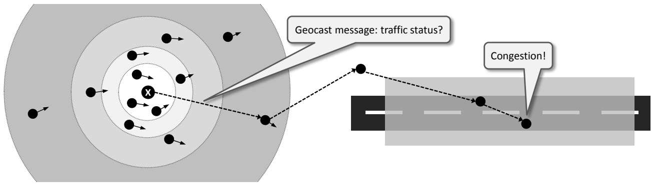

Figure 1: Geographic routing and neighborhood structure in OverDrive.

we will focus on *geographic unicast messages (GUMs)* addressed to points in geographic space and delivered to the one overlay node that is closest to the target point in terms of geographic distance. Technically, OverDrive is based around two concepts:

- An overlay neighborhood structure based on a partitioning of geographic space into concentric rings with exponentially increasing radii. Each node attempts to *satisfy* all of its rings, i.e., for each ring, to form connections with a certain number of nodes in the geographic area covered by that ring.

- A greedy routing mechanism for forwarding messages to nodes in a desired geographic area. Messages are forwarded using connections from the aforementioned overlay neighborhood structure.

The neighborhood structures of individual nodes are maintained using *find neighbor requests* and *location update* messages. Find neighbor requests are sent to random points within unsatisfied rings. The requests are routed like regular GUMs. The final recipient of the request answers with a list of nodes suitable as overlay neighbors to the requester. The speed and movement direction of nodes is also taken into account when considering their suitability as overlay neighbors, as similar movement patterns between overlay neighbors leads to a higher stability in overlay links. Location updates are used for the communication of a node's current location and speed to its overlay neighbors. This is done as rarely as possible, by keeping the information up to date only to the extent that a correct allocation to rings is possible.

An overview of the routing in OverDrive can be seen in Fig. 1. The figure depicts a possible application for the geocast service, namely the sending of a GUM to a road segment lying ahead of the requester. From all of its neighbors, the requester greedily choses the one neighbor that is closest to the destination region in terms of geographic distance. The request is sent via the cellular network and standard IP to this neighbor, who then forwards it according to the same rule, sending it to the one of its overlay neighbors that is closest to the destination. Once the message arrives at a node residing in the target area, that node might, depending on the application, decide to answer the query by directly sending a response (via IP) to the requester.

More details about the mechanisms involved in the overlay-based geocast service OverDrive can be found in our original publication [5].

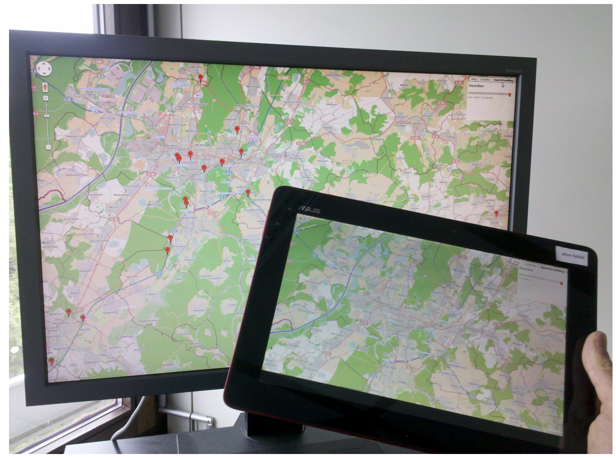

Figure 2: Visualization view and tablet computer showing application view.

2.1 Demo Setup and Functionality

Hardware-wise, our demo consists of a notebook computer, two tablet computers and an optional additional computer monitor. Since the demonstration of a geocast protocol using a large number of vehicles moving on real streets is unfeasible, the mobility and communication behavior of around 1000 vehicles is simulated instead on the notebook using and extended version of the overlay simulation framework *OverSim* [2].

The two tablets are used for tracking the movement of two of the simulated vehicles. They provide an *application view* similar to that of popular navigation applications, with a map centered on the current position of the tracked vehicle. The application view allows the initiation of GUMs to arbitrary points on the map. These messages get routed according to OverDrive's routing logic. Once a GUM reaches its final recipient, the location of this recipient is shown on the application view. Clearly, this functionality is only a placeholder for more sophisticated real-life applications like querying about the traffic situation at a given location.

On an additional *global view* on a separate monitor, the internals of the OverDrive protocol can be inspected. This includes the neighborhood structures of nodes, parts of the neighbor selection logic and the path that GUMs initiated from the application views take through the network.

Internal Realization

In [5], OverSim was extended by a new geographic underlay abstraction that allows the modeling of nodes moving in geographic space that communicate using cellular communication technologies. Communication latencies are influenced by the location of a node. The node positioning information is available to overlay implementations and applications running on the simulated nodes, thus emulating the existence of positioning sensors like GPS receivers. Additionally, a *pathfinding* movement model was implemented for the simulated vehicles. Vehicles choose random start- and endpoints upon joining the simulation and follow a shortest-path route between these points. For the road network underlying the simulation, the highway network of the German state of

Figure 3: Demonstrator setup and global view.

Baden-Wuerttemberg, as extracted from *OpenStreetMap*[2] map data, is used.

For the purposes of this demo, and for allowing the better visualization of any type of protocol for which the geographic location of nodes is of importance, additional extensions were made to OverSim. A new *dynamic scheduler* was implemented that allows the explicit setting and on-the-fly changing of the simulation speed. In our demo, we use this functionality for aligning the simulation time with real time and speeding up the simulation when this is more convenient for explaining the inner workings of OverDrive. In addition to the new scheduler, we integrated a lightweight *webserver*[3] into OverSim that allows the visualization of OverDrive nodes and data structures as well as the tunneling back, via a web interface, of commands into the running simulation in OverSim. The actual web-based demo views are based on the *Google Maps JavaScript API*[4] and map material from the OpenStreetMap project. From the views, the running simulation can be influenced directly, e.g., by initiating the sending of GUMs or by changing the simulation speed. A schematic of the demo setup, together with a screenshot of the global view, can be seen in Figure 3.

As mentioned, the additions to OverSim made for this demo can easily be reused for visualizing other protocols and scenarios in which node movement and the geographic location of nodes is of importance. In addition to overlays for smart traffic scenarios, this includes, for example, works in the area of user-centric networking [1].

3. CONCLUSION

We present a live demonstration of the overlay-based geocast protocol *OverDrive* applied in a realistic traffic scenario with a high degree of mobility. Since a demonstration using real vehicles moving on real streets is unfeasible, node movement and communication behavior is simulated instead using the overlay simulation framework OverSim. Using application views running on tablet computers and a separate global view on the whole simulation, both a possible real-life application of OverDrive as well as the internal workings of the protocol can be demonstrated. Future work on OverDrive includes the assessment of the privacy characteristics of the approach [3] and the development of privacy-preserving mechanisms specifically tailored for geocast overlays. Additionally, the potential for leveraging existing cellular network infrastructure for minimizing the communication load in the wireless segment will be explored.

4. REFERENCES

[1] I. Baumgart and F. Hartmann. Towards secure user-centric networking: Service-oriented and decentralized social networks. In *Proceedings of the 5th IEEE Conference on Self-Adaptive and Self-Organizing Systems Workshops (SASOW)*, pages 3–8, Ann Arbor, Michigan, USA, Oct. 2011.

[2] I. Baumgart, B. Heep, and S. Krause. OverSim: A Flexible Overlay Network Simulation Framework. In *Proceedings of the* 10^{th} *IEEE Global Internet Symposium (GI '07) in conjunction with IEEE INFOCOM 2007*, pages 79–84, Anchorage, AK, USA, May 2007.

[3] M. Florian and I. Baumgart. Privacy in Overlay-based Smart Traffic Systems. In *Proceedings of the IEEE Workshop on Privacy and Anonymity for the Digital Economy (PADE 2013)*. IEEE, Oct. 2013.

[4] C. Gross, D. Stingl, B. Richerzhagen, A. Hemel, R. Steinmetz, and D. Hausheer. Geodemlia: A Robust Peer-to-Peer Overlay Supporting Location-Based Search. In *Proceedings of the* 12^{th} *IEEE International Conference on Peer-to-Peer Computing (IEEE P2P'12)*, pages 25–36, Tarragona, Spain, Sept. 2012.

[5] B. Heep, M. Florian, J. Volz, and I. Baumgart. OverDrive: An Overlay-based Geocast Service for Smart Traffic Applications. In *Proceedings of the 10th Annual Conference on Wireless On-Demand Network Systems and Services (WONS)*, Mar. 2013.

[6] M. Picone, M. Amoretti, and F. Zanichelli. GeoKad: A P2P Distributed Localization Protocol. In *Proceedings of the* 8^{th} *IEEE International Pervasive Computing and Communications Conference (PERCOM 2010) Workshops*, pages 800–803, Mannheim, Germany, Mar. 2010.

---

[2] `http://www.openstreetmap.org/`

[3] `http://code.google.com/p/mongoose/`

[4] `https://developers.google.com/maps/documentation/javascript/`