論 文 内 容 の 要 旨

博士論文題目 A study of wide-area geographical resource discovery for vehicular communication systems
(車両通信システムのための地理位置を用いた広域分散型モバイルリソース発見に関する研究)

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Discovering resources in mobile networks is one of essential tasks for mobile applications of location based services. One of the most important emerging services is Intelligent Transport System (ITS) service. ITS services are integrated into vehicles connected to Vehicular Communication systems (VCs) and provide a wide variety of advanced location based services for road users. An important question in such environments is how to discover necessary resources. While there have been a wide variety of resource discovery technologies for a specific type of network such as LAN, MANET, mobile applications for VCs raise further challenges: discovering resources according to geographical position, and supporting a huge number of vehicles. The capability of the geographical discovery, appropriate discovery scope selection, and mobility support for huge numbers of nodes are essential for future resource discovery systems.

This dissertation presents a geographical location based resource discovery mechanism for vehicular communication systems. To study the issues and analyze solutions, the dissertation takes two approaches, the one is a small scope resource discovery mechanism for single mobile network relying on IPv6 multicast and the GeoNetworking protocol, and the other is a wide-area geographical mobile resource discovery mechanism. The latter approach is built on a hierarchical publish/subscribe architecture and the GeoNetworking protocol so that users can locate resources according to geographical coordinates without scalability issue. Evaluation results show that the proposed mechanism locates mobile resources among a large number of candidates according to geographical position without overloading both mobile and core network.

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(Summary of the result of dissertation defense)

This dissertation presented a set of mechanisms to discover network resources according to geographical position focusing on Cooperative Intelligent Transport Systems (C-ITS) applications. It supports the wide-area discovery rather than the in-network discovery by a publish/subscribe architecture on a structured overlay network and IPv6 GeoNetworking-based Vehicular Ad hoc NETworks (VANETs). The dissertation described the weakness of existing solutions and evaluated how the proposed scheme can overcome the weakness. The proposed scheme was designed by classifying a number of existing solutions and analyzing the standardized IPv6 GeoNetworking technology.

The contribution of this dissertation is outlined as follows.

This research focused on the resource discovery for upcoming C-ITS applications in Vehicular Communication systems (VCs). It tried to enable to dynamically discover large numbers of resources in vehicles according to geographical position. Existing solutions cannot be used for VCs, which are composed of a wide variety of heterogeneous networks, since they were designed to specific types of networks, such as a small-scale static network, a mobile ad-hoc network, etc. They therefore lack scalability and latency. Furthermore, existing solutions do not support the geographical resource discovery, which is an essential capability of C-ITS applications. The only way to support geographical position in existing solutions is to use position as one of attributes of resources, however, this solution incurs unnecessary bandwidth usage.

Therefore, this research designed a publish/subscribe resource discovery scheme by combining the standardized IPv6 GeoNetworking technology and the structured overlay networking technology. The proposed system enabled to discover resources not only inside a VANET but also through the Internet. It has an algorithm to adaptively select the manner of discovery: distributed discovery within a VANET and centralized discovery using the core overlay network. This algorithm exploits the virtual network separation mechanism of IPv6 GeoNetworking protocol, which maps a topological network to a geographical area. Using this mechanism, the proposed algorithm enables resource consumers to detect whether requested area is reachable by distributed messaging or not. In addition, the proposed system has a mobility-aware location update mechanism that contributes to reduce periodic updates from vehicles.

Hence, the proposed publish/subscribe architecture, structured overlay network, IPv6 GeoNetworking, discovery mode selection algorithm, and mobility aware location update mechanisms enabled a scalable and rapid resource discovery according to geographical position in VCs.

In summary, this dissertation has proposed the wide-area geographical resource discovery scheme, which can provide scalable and rapid resource discovery for emerging C-ITS applications in VCs. Its effectiveness has been well evaluated through numerical analysis, simulation, and actual implementation to vehicles. The dissertation has taken into account the existing Internet architecture and ongoing ITS standardization, therefore the proposed scheme will contribute to actual field. Consequently, this dissertation deserves the Ph.D. degree (engineering).