교통 기관 애드혹 네트워크 와 Proximity기반 서비스의 통합

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Integration of Proximity-based Services with Vehicular Ad-hoc Networks

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요 약

최근 단말간 직접 통신이 가능한 단말대단말 통신 기술이 많은 관심을 받고 있다. 따라서 단말대단말 기술이 셀룰러 통신 시스템 및 차량 통신 시스템에 접목되고 있다. 본 논문에서는 Evolved Packet Core Network 기반 단말 탐색 시뮬레이터 개발에 대해서 살펴보고, Proximity기반 서비스의 차량간 애드혹 네트워크로의 적용 가능성에 대해서 살펴보았다. 개발된 시뮬레이터를 활용한 성능 분석을 통해서 유저들이 비슷한 위치에 모여 있는 환경, 즉대중교통과 비슷한 환경에서 LTE 네트워크의 트래픽이 Wi-Fi통해 단말대단말 통신으로 효율적으로 오프로딩될 수 있고 교통 관련 정보 멀티캐스팅에 효율적으로 활용될 수 있음을 보였다.

ABSTRACT

Device-to-device (D2D) communications, a subset of Proximity-based Services that enables direct communication between LTE network subscribers, is gaining popularity. It is well underway to be adopted in cellular communication systems for pedestrian and connected-vehicles alike. In this paper, we briefly present our model of an Evolved Packet Core Network-assisted device discovery simulator and show the applicability of Proximity-based Services for Vehicular Ad-hoc Networks. Through the performance evaluation based on the developed simulation environment, it is shown that in case when users gather in the same vicinity, as in public transportation, LTE network data can be efficiently offloaded and multicasted through Wi-Fi for e.g. delivering traffic-related information and for the benefit of infotainment service consumers.

키워드

근접 기반 서비스, Proximity-based Services, D2D, VANET, NS-3

Ⅰ. NTRODUCTION

The latest release of the 3GPP Long Term Evolution (LTE) cellular network standard includes promising communication features, among which are Proximity-based Services (ProSe). ProSe takes advantage of the location of network equipments to prioritize shorter or direct communication channels over common multi-hop paths. It can be seen as a future evolution of today's widespread location- based services and Peer-to-Peer networking.

Following the ongoing development of our ProSe simulation environment based on the open-source network simulation platform NS-3 [6], we evaluated the potential of integrating it with Vehicular Ad-hoc networks (VANETs). VANETs are mostly operated under the Intelligent Transportation System (ITS) G5 standard, using the WAVE protocol, a variation of IEEE 802.11 Wireless Area Networks. It requires the deployment of Road Side Units (RSU) along the pathways taken by vehicles.

Our proposal, which we will refer to as **ProseVANET**, intend to complement the Vehicle To Infrastructure (**V2I**) paradigm, by using the cellular network to provide coverage in areas with few or no RSUs. LTE has the advantage of low data transmission delays and high throughputs [3] that could efficiently deliver critical safety messages, navigation information or traffic relating to infotainment services, as online radio, mobile TV, streaming ...etc.

This paper is outlined as follows: Section 2. describes publications pertaining to our solution; Section 3. highlights the involved network components, their roles and experimentation results; followed by the conclusion in Section 4, along with future perspectives.

Ⅱ. RELATED WORK

The EURECOM research group developed the iTETRIS VANET platform [4] that includes NS-3 and **SUMO** (Simulation of Urban MObility). It aimed to provide Cooperative Heterogeneous Communications simulations with UMTS and WAVE as access technologies, however it seems no longer maintained.

SUMO, an open traffic simulation package [5] is quite popular in the VTC community for modeling intermodal traffic systems. It can generate vehicular mobility traces for NS2/3, which we use to experiment with a real-world urban traffic model. Our solution differs from the above as it is implemented solely with one platform and leverage the latest features of the LTE standard.

Ⅲ. ProseVANET ENTITIES

We consider RSUs and vehicles, whether cars, metro or buses as nodes equipped with Wi-Fi and LTE network devices that can connect to the ITS management platform, and assume that mobile networks' Evolved NodeBs (**eNB**) are deployed in the area of interest.

The ProSe specifications include a Proximity Function Network Entity (**ProseFcn**), which is part of the Evolved Packet Core (**EPC**) network. It is the central part that handles *discovery requests* sent by nodes to identify potential peers that are in a certain range where D2D communication is feasible. The distance is set up to 500 meters for LTE, and 250 meters for Wi-Fi adhoc. One of the potential benefit of this solution is in traffic management, where drivers can be notified in advance through their car navigation system when long road congestions occur towards their target destination, thus allowing them to choose a different path.

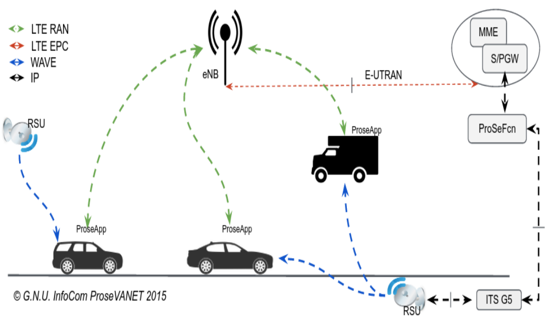

Figure.1: ProseVANET architecture.

The main components of our solution shown above are aligned with the 3GPP reference architecture [1]. It includes the EPC's Serving / Packet Data Gateway (S/PGW), combined in a single node in charge of the internetworking in LTE networks.

The ProseFcn is a logical network entity part of the EPC, embedding an HTTP server that listens for requests coming from vehicles. It is interconnected with the PGW through a high speed Point-to-Point link and routed towards the vehicles' address space. The traffic handled by the ProseFcn can be modeled with Markov chain as a Poisson process, since it acts as a server.

The ITS G5 management platform also communicates with the ProseFcn to deliver information to vehicles.

Each vehicle and RSU has a Proximity Application (**ProseApp**) installed, with HTTP client capabilities. It permits their provisioning with the network information of the ProSeFcn and an application identity (AppId) [2] to be included in discovery requests. The discovery mode for vehicles is by default set to **MONITOR** mode, putting them in listening state, ready to join any multicast group in range to receive data. RSU's discovery mode is set to **ANNOUNCE** state for transmitting data to nearby vehicles.

For brevity, we omitted the Home Subscriber Server (HSS) and SUPL Location Platform (SLP) which also play critical roles in LTE networks, but are not yet modelled in NS-3. To obtain a realistic vehicular mobility environment, we exported the map of a city area from OpenStreetMap [7] and processed with SUMO to generate the mobility file to read by NS-3 and dynamically position the nodes accordingly at runtime.

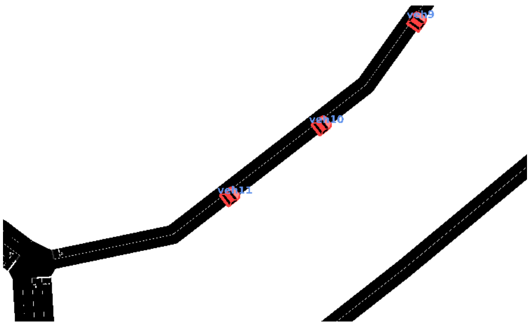

Figure 2. Runtime layout of vehicles with SUMO.

Besides, ProSe also include Device-to-Device Communication (D2D) capabilities that allow direct data exchange with limited network support, but is more suitable for users with low velocity. Nonetheless, it can be noted that in public transportation, when entities move in the same direction and relatively similar speeds, channel state variations have less negative impact. Since D2D is not yet implemented in our environment, we use WiFi-adhoc for direct communication as allowed by the specifications.

More over, public Wi-Fi hotspots are now widely integrated within transportation means, and can be used to offload the data from the mobile network for transmission to nearby users, thus achieving capacity expansion into license-exempt spectrum bands [3].

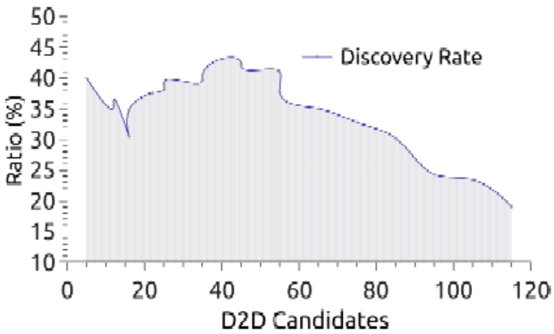

Figure.3 Discovery ratio

The measurements of the number of vehicles that are in range coverable by D2D over Wi-Fi adhoc is show in Fig.3. The ratio fluctuates between 14 and 45%, and represents the amount of traffic that can be offloaded from LTE to Wi-Fi, thus considerably alleviating the network.

Ⅳ. CONCLUSION

The solution presented in this paper can be seen as an enhanced VANET architecture based on the latest LTE Proximity-based Services features. It will hopefully grow alongside our simulation platform that uses NS-3 to provide D2D direct communication between vehicles and/or nearby infrastructure. Besides, we are progressively adding IPv6 stack support to the LTE module to potentially leverage the benefits for mobile IPv6 and geonetworking.

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