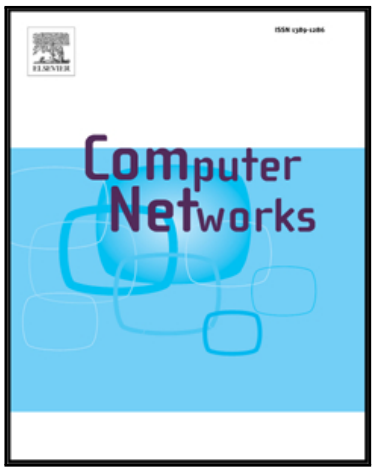

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PII: S1389-1286(18)30843-0
DOI: https://doi.org/10.1016/j.comnet.2018.08.023
Reference: COMPNW 6582

To appear in: *Computer Networks*

Received date: 25 December 2017
Revised date: 22 April 2018
Accepted date: 31 August 2018

Please cite this article as: Ismaeel Al Ridhawi , Moayad Aloqaily , Burak Kantarci , Yaser Jararweh , Hussein T. Mouftah , A Continuous Diversified Vehicular Cloud Service Availability Framework for Smart Cities , *Computer Networks* (2018), doi: https://doi.org/10.1016/j.comnet.2018.08.023

A Continuous Diversified Vehicular Cloud Service Availability Framework for Smart Cities

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***Abstract*— The Intelligent and Connected Transportation System (ICTS) is a significant and mandatory component of the smart city architecture. Multimedia content sharing, vehicle power management, and road navigation are all examples of ICTS services. As smart cities continue to deploy different technologies to improve the performance and diversity of vehicular cloud services, one of the main issues that prevails is efficient and reliable service discovery and selection for smart vehicles. Furthermore, cloud service providers (SPs) are limited to the availability, variety and quality of services made available to vehicular cloud subscribers. Smart vehicles rely on a number of SPs to acquire the required services while moving. It therefore becomes challenging for vehicular cloud subscribers to acquire services that meet their Quality of Experience (QoE) preferences. This paper introduces a new service provision scheme to provide continuous availability of diversified cloud services targeting vehicular cloud users through a cluster-based Trusted Third Party (TTP) framework. TTPs act as cloud service mediators between cloud service subscribers and providers. Vehicles that are considered to have similar patterns of movement and service acquisition characteristics are grouped into service-specific clusters. TTPs communicate with service providers and cluster heads to negotiate for services with high QoE characteristics. A location prediction method is adopted to determine a vehicle's future location and allow services to be negotiated for before the vehicle's arrival. We provide simulation results to show that our approach can adequately discover and deliver cloud services with increased QoE results, minimal overhead burden and reduced end-to-end latency.**

Keywords*— *ITS, ICTS, vehicular cloud, smart city, trusted third party, service-specific cluster, QoE, location prediction, mobility.

I. INTRODUCTION

Smart cities enhance the quality and performance of urban services, including transport, energy, healthcare and traffic, while reducing the cost of delivery [1]. Cloud computing is a key technology that enables the smart city vision through large scale computational and data storage services [2]. Creating and sustaining a smart city requires the cooperation and integration of many cloud entities, and the major contributor is the availability and the technological advancements of edge devices [3]. Edge devices, which incorporate vehicular cloud subscriber nodes, are now smarter and more capable of performing data collection, forwarding and decision-making [4]. Mobile Edge Computing (MEC) is a new paradigm that extends cloud-computing capabilities to the edge of the network [5]. It supports smart city infrastructure by providing services with reduced latency and improved service quality, due to its close proximity to mobile users. On-demand applications, such as multimedia streaming and content sharing between vehicular nodes, has now become a trend.

Similarly, intelligent and connected vehicles enhance and improve the smart city life quality, safety, and traffic operations. With the fast pace of the advances in 5G communications development, intelligent and connected vehicles are capable of handling complex operations and functions, on-demand services, storage and computation, and location-based services [6]. Internet of Vehicles (IoV) in smart cities has been attracting attention in the past couple of years and is playing an imperative role in ICTS. IoV deals with an excessive amount of data, which is considered an advantage for real-time services such as multimedia content sharing, if the smart city architecture is capable of aggregating and analyzing the data effectively and efficiently. To do so, a cooperative fog computing architecture for IoV applications (CFC-IoV) has been proposed in [7]. Moreover, VANETs have also been a contributing factor to ICTS. An efficient management system for preventing and managing the response time of accidents in smart cities has been proposed in [8]. The solution relies on a new routing protocol for VANETs to send a short video documenting the accident. Additionally, partitioning and multiplexing the computation and cloud resources among all nearby network devices is an important solution to cope with the increase and diversity of connected vehicular services [9]. A comprehensive study highlighting how urban areas make use of available ICTS, in addition to methods to improve the quality of the provided services, was presented in [10].

Vehicular cloud subscribers now expect unrestricted network connections from cloud service providers (SPs), as well as greater variety, availability and quality of vehicular services. However, due to the limited availability and quality of services that cloud SPs offer, smart vehicles must rely on multiple SPs to acquire the required services. This is not only the case for static or mobile cloud subscribers, but for roaming vehicular cloud subscribers as well. For instance, if a vehicular cloud subscriber acquires a service from a specific SP while in motion, and the service quality and experience deteriorates due to the vehicle moving beyond the cloud's service area, the subscriber must acquire another SP that provides a similar