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DATA TRANSPORTATION BY USING INTELLIGENT RAN

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Abstract:
Communication technologies supply the blood for smart city applications. In view of the ever-increasing wireless traffic generated in smart cities and our already congested radio access networks (RANs), we have recently designed a *data transportation* network, the vehicular cognitive capability harvesting network (V-CCHN), which exploits the harvested *spectrum opportunity* and the *mobility opportunity* offered by the massive number of vehicles traveling in the city to not only offload delay-tolerant data from congested RANs but also support delay-tolerant data transportation for various smart-city applications. To make data transportation efficient, in this paper, we develop a *spectrum aware* (SA) *data transportation* scheme based on Markov decision processes. Through extensive simulations, we demonstrate that, with the developed data transportation scheme, the V-CCHN is effective in offering data transportation services despite its dependence on dynamic resources, such as vehicles and harvested spectrum resources. The simulation results also demonstrate the superiority of the SA scheme over existing schemes. We expect the V-CCHN to well complement existing telecommunication networks in handling the exponentially increasing wireless data traffic.

Introduction

THE initiatives on smart cities have offered us an informative and smart living environment where we can enjoy better and more convenient daily services, such as transportation, healthcare, and entertainment. To support smart-city applications, numerous devices, such as sensors, cameras, and vehicles, are expected to connect and interact with each other for information sharing and delivery, intelligence extraction, and decision making, which will generate tremendous amount of wireless data traffic. Although 4G/5G have great potential in dealing with huge mobile wireless data demands, they will face challenges in handling their promised servicesdue to tremendous popularity of smart devices and soaring mobile applications (e.g., virtual reality and high definition video streaming) [6]. As a result, how to handle the huge amount of wireless data traffic is still challenging, particularly in a smart city environment To address this challenge, we have recently designed a data transportation network, called vehicular cognitive capability harvesting network (V-CCHN), to support delay-tolerant data transportation for various smart-city applications. Our basic idea is to employ vehicles traveling in cities as opportunistic data carriers to transport data from where it is collected to the places where it is consumed or utilized. Specifically, in the V-

CCHN, data is delivered via the store-carry-forward mechanism by exploiting the opportunistic presence of vehicles and their mobility, under the supervision/management of a secondary service provider (SSP). Since the SSP might not gain full control of the mobility of these vehicles,1 it often needs to count on a series of vehicles to carry and forward data in succession so that data can be delivered to intended locations. During this data delivery process, cognitive radio (CR) technologies are utilized to harvest spectrum resources for short-range high-speed data transmissions between vehicles. To facilitate efficient data delivery, the SSP collects various kinds of information, such as the availability of licensed/unlicensed bands, and makes spectrum allocation and data routing decisions to help data-carrying vehicles select data forwarding actions. The detailed introduction to the V-CCHN will be provided in Section III.A. Noticing that the data transportation services of the V-CCHN is built on dynamic resources, such as harvested licensed/unlicensed bands, i.e., harvested bands, and the opportunistic presence of vehicles and their mobility, the SSP needs effective schemes to exploit these dynamic resources for data transportation.2 Since only the conceptual development of V-CCHN has been presented , in this paper, we attempt to develop an effective data transportation scheme for the V-CCHN. Specifically, we seek for good data routing decisions at road intersections to fully exploit the harvested bands and the mobility of vehicles for data transportation. On the one hand, the data-carrying vehicles have more choices at intersections. On the other hand, the data routing decisions made at intersections determine the moving direction of carried data. If data routing decisions are not properly made, the SSP needs to dedicate extra resources to adjust data delivery and the corresponding data blocks could not even be delivered. With good data routing decisions at intersections, we could facilitate efficient operation of the V-CCHN and thus have a large-capacity data transportation network to complement existing telecommunications systems in handling the exponentially increasing wireless traffic generated from mobile and smart-city applications. In this paper, under our V-CCHN, we carefully study how the SSP makes data routing decisions to help data-carrying vehicles select their data forwarding actions at intersections so that the considered data block can be efficiently delivered from the source to the destination. To make the data transportation processes effective, we introduce a *spectrum-aware (SA) data transportation* scheme where the effects of spectrum availability, the uncertain activities of licensed/unlicensed spectrum users, contention among different data-carrying vehicles, the mobility of the data-carrying vehicle, and the availability of relaying vehicles in each direction are jointly considered during the SSP's decision making process. We model the data delivery process as a Markov decision process (MDP) by observing that it involves a sequence of data routing decisions made at intersections. The optimal data routing decisions for the SSP are obtained via dynamic programming. Through extensive simulations, we thoroughly discuss the impacts of various parameters on the data delivery process. The results validate the effectiveness of our V-CCHN in handling the envisioned delay-tolerant data transportation services. Moreover, the results also demonstrate that, when compared with existing schemes, the SA approach can more efficiently support the data transportation in the V-CCHN.

Existing system:

Recently designed a data transportation network, called vehicular cognitive capability harvesting network (V CCHN), to support delay-tolerant data transportation for various smart-city applications. Our basic idea is to employ vehicles traveling in cities as opportunistic data carriers to transport data from where it is collected to the places where it is consumed or utilized. Specifically, in the V-CCHN, data is delivered via the store-carry-forward mechanism by exploiting the opportunistic presence of vehicles and their mobility, under the supervision/management of a secondary service provider (SSP). Since the SSP might not gain full control of the mobility of these vehicles, it often needs to count on a series of vehicles to carry and forward data in succession so that data can be delivered to intended locations. During this data delivery process, cognitive radio (CR) technologies are utilized to harvest spectrum resources for short-range high-speed data transmissions between vehicles. To facilitate efficient data delivery, the SSP collects various kinds of information, such as the availability of licensed/unlicensed bands, and makes spectrum allocation and data routing decisions to help data-carrying vehicles select data forwarding actions.

Proposed system

Attempt to develop an effective data transportation scheme for the V-CCHN. Specifically, we seek for good data routing decisions at road intersections to fully exploit the harvested bands and the mobility of vehicles for data transportation. On the one hand, the data-carrying vehicles have more choices at intersections. On the other hand, the data routing decisions made at intersections determine the moving direction of carried data. If data routing decisions are not properly made, the SSP needs to dedicate extra resources to adjust data delivery and the corresponding data blocks could not even be delivered. With good data routing decisions at intersections, we could facilitate efficient operation of the V-CCHN and thus have a large-capacity data transportation network to complement existing telecommunications systems in handling the exponentially increasing wireless traffic generated from mobile and smart-city applications.

Module Implementation

Secondary Service Provider

The SSP is an independent wireless service provider with its own reliable bands (called basic bands in the subsequent development). For example, if cellular are the SSPs, the cellular bands can serve as the basic bands. The SSP recruits or deploys CRVs to provide delaytolerant data transportation services in smart cities.

CR Router:

All CRVs and CRSUs are equipped with CR routers as communication devices. CR routers are powerful communication devices with agile communication interfaces, abundant computing resources and storage space. The agile communication interfaces of CR routers have cognitive radio (CR) capabilities and reconfigurability. Their CR capabilities allow CR routers to sense idle spectrum and exploit a wide range of under-utilized licensed/unlicensed spectrum for high-speed data transmissions

CRSUs

are the partial roadside infrastructures deployed by the SSP to improve the efficiency of data transportation. Generally speaking, there are two types of CRSUs in the V-CCHN. The first kind of CRSU does not have wired connections to data networks and are deployed by the SSP to deal with the uncertainty/ dynamics in the V-CCHN and improve the efficiency of data transportation. For ease of presentation, this kind of CRSU will be called r-CRSU.

Data Transportation in the V-CCHN

In the V-CCHN, the data transportation processes are supervised by the SSP.3 Specifically, the SSP coordinates CRVs and CRSUs for spectrum sensing in order to build up spectrum map and collect spectrum statistics. With collected statistics, the SSP makes data routing decisions which help CRVs route data at various intersections with various spectrum and CRV availability and diverse levels of contentions. When selecting data forwarding actions at the intersections, the data-carrying CRVs query c-CRSUs in charge of the corresponding cells about available spectrum bands and determine whether to transfer data to another CRVs based on the data routing decisions received from the SSP.

Conclusion:

In this paper, we design a spectrum-aware data transportation scheme for our recently proposed V-CCHN architecture by formulating the data delivery process as a Markov decision process. Through extensive simulations, we demonstrate that the obtained data transportation scheme can effectively utilize the spectrum opportunity and mobility opportunity in the VCCHN for data transportation. This implies that, with properly designed data transportation schemes, our V-CCHN offers us a very promising alternative to handling the soaring wireless data traffic in the incoming era of smart cities.

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