Cognitive Radios and the Vehicular Cloud

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ABSTRACT

Cognitive Radios can sense the radio environment and can dynamically reconfigure their parameters to best support the user needs. This "intelligence" has been made possible in part by recent advances in Software Defined Radios. An important motivation for using Cognitive Radios has been mobility. Mobile Cognitive Radios can dynamically adjust to new environments and mission needs. An example is the multibillion dollar JTRS (Joint Tactical Radio System) project. Recently, Cognitive Radios have been engaged in making efficient use of the scarce spectrum, for example, exploiting White Spectrum and opportunistically sharing allocated but underutilized spectrum (Dynamic Spectrum Sharing). The crowded spectrum is a critical problem in urban environment and effects the deployment of new Vehicular Applications. In this talk we briefly review the evolution of cognitive radios in commercial environments. We then propose the aggressive use of Cognitive Radio technologies to allow vehicles to open "radio trails" in the urban grid and advocate the development of a "cognitive spectrum service" for the Vehicular Cloud.

Categories and Subject Descriptors

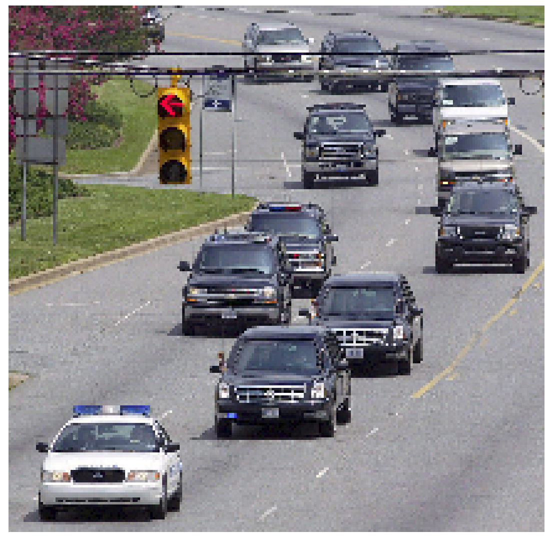
C.2.1 [**Network Architecture and Design**]: Wireless communication

Keywords

Cognitive Radio; Multicast; VANET; Wireless Mesh Network

1. COGNITIVE RADIOS FOR EFFICIENT MEDIA DISSEMINATION

Consider the Presidential motorcade shown in Figure 1 below. The motorcade must be protected by possible attacks from the roadside. To this end, escort cars transmit video streams to agents in the motorcade using WiFi radio. We assume that DSRC channels are not available for this application. The problem is that urban WiFi is becoming increasingly congested because of residential and mobile (smart phones, other vehicles) use. The proposed approach is to use Cognitive Radios to carefully select the channels in the urban WiFi spectrum in order to minimize the interference between the presidential motorcade video streams and the other users (residential and mobile).



presidential motorcade

Figure 1:

Ignoring for a moment the other mobile users, this problem can be cast as a Primary/Secondary spectrum sharing problem where: (1) the Primary network is represented by the residential WiFi users, and (2) the Secondary users are the Presidential platoon Escorts Vehicles and Patrol Agents. We assume that Escorts generate surveillance video streams and multicast to patrollers. All the vehicles in the motorcade participate in the store and forwarding of the video streams within the motorcade.

We assume dense WiFi access point deployment, with APs spaced every 50m say and pre allocated different channels so as to minimize the interference among them. It is fair to expect that the motorcade minimize the disruption caused to residential WiFi users. In turns, the motorcade cars will select lightly utilized channels so as to minimize the interference caused by residential traffic onto the motorcade streams. Assuming that the motorcade spans several

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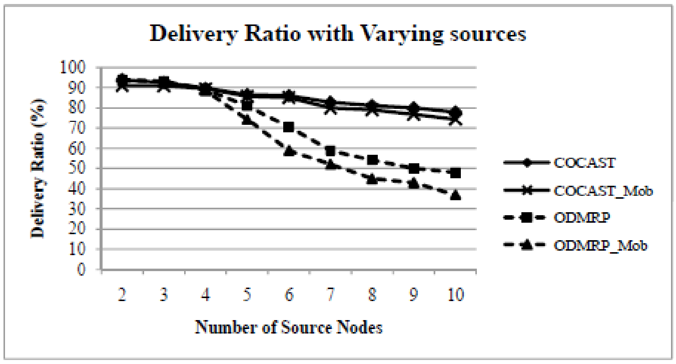

Figure 2:

hundreds meters, the motorcade vehicles must select different channels in different sections of the motorcade, the packets will hop in frequency as they hop from source to receivers. To this end a well known On Demand Multicast Routing Protocol (OMDRP) was extended to dynamically construct the multicast tree from each source to the receivers. ODMRP was refreshed every 4s and reselected a new set of channels for the motorcade nodes at each iteration, exploiting the Cognitive capabilities of the car radios. The scheme was called Cognitive Multicast, or for short, Co-CAST.

Native ODMRP and Co-CAST where compared in a scenario where a variable number of video sources (ranging from 2 to 10) were streaming video to approximately 100 vehicles stretching over a 1.5KM x 1.5KM area. In ODMRP, the vehicles are set to frequency 1, while in Co-CAST the vehicle dynamically select the best frequencies. The comparison between ODMRP and CoCAST in terms of delivery ratio, for both static and mobile case is shown in Figure 2. It is easy to see that CoCAST scales better than ODMRP for increasing number of source nodes. A nice and unexpected bonus in this experiment was to discover surprise than frequency switching along the path mitigates the Hidden Terminal.

Since the publication of the Co-CAST paper similar performance improvement were obtained by the introduction of Cognitive Radios in other vehicular application including routing on the vehicular grid. Moreover, Network Coding was used to mitigate the possible inaccuracies in the dynamic selection of the least used channels. Finally, the maintenance of a Channel Utilization data base for each locality was proposed as a Service to the Vehicular Cloud, allowing the vehicles to preplan the channels to use as they progress in their journey. References to the above studies are reported in the Reference Section.

2. SHORT BIOGRAPHY

Dr. Mario Gerla is a Professor in the Computer Science Dept at UCLA. He holds an Engineering degree from Politecnico di Milano, Italy and the Ph.D. degree from UCLA. He became IEEE Fellow in 2002. At UCLA, he was part of the team that developed the early ARPANET protocols under the guidance of Prof. Leonard Kleinrock. He joined the UCLA Faculty in 1976. At UCLA he has designed network protocols for ad hoc wireless networks (ODMRP and CODE-Cast) and Internet transport (TCP Westwood). He has lead the ONR MINUTEMAN project, designing the next generation scalable airborne Internet for tactical and homeland defense scenarios. His team is developing a Vehicular Testbed for safe navigation, content distribution, urban sensing and intelligent transport. These protocols and services are folded in the emerging Vehicular Cloud paradigm. He serves on the IEEE TON Scientific Advisory Board. He was recently recognized with the annual MILCOM Technical Contribution Award (2011) and the IEEE Ad Hoc and Sensor Network Society Achievement Award (2011).

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