National Journal of Antennas and Propagation, ISSN: 2582-2659 Vol. 6, No. 3, 2024 (pp. 1-7)

RESEARCH ARTICLE

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Optimization of Spectrum Handoff in Cognitive Radio Networks using Markov Decision Processes and Deep Learning

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KEYWORDS:
Cognitive Radio,
spectrum,
Multiple Attributes Decision Making,
Handoff

ARTICLE HISTORY:
Received 25.09.2024
Revised 23.10.2024
Accepted 05.11.2024

DOI:
https://doi.org/10.31838/NJAP/06.03.01

Abstract

The goal of dynamic spectrum access is to resolve the recent concern of remote spectrum inefficiency while also meeting the expanding demands of wireless networks. As a result, a new field of study and development is created for Cognitive Radio (CR) technology, which is essential for utilizing underutilized spectrum through dynamic spectrum access. Therefore, it is guessed that future vehicular correspondence would be CR empowered, utilizing more spectrum options to increase the effectiveness of vehicular communication. Spectrum handoff is a way to dynamically use underused spectrum. A few radio access network could exist together in the execution of CR vehicular network later on. It's conceivable that these network vary essentially in various ways. Consequently, picking the best organization for the spectrum handoff decision among a few radio access networks with differing qualities as far as different boundaries turns into a difficult undertaking for the CR vehicular hub. This supports the utilization of Multiple Attributes Decision Making (MADM) methods to think up a spectrum handoff technique for the best organization choice in CR vehicular network. The spectrum handoff procedure for the best organization determination in CR vehicular networkis the subject of this paper. Given the preferences of CR vehicular nodes, the system offers a greater and optimal selection among the various networks that are available.

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How to cite this article: Nayak A, Raja A. Optimization of Spectrum Handoff in Cognitive Radio Networks using Markov Decision Processes and Deep Learning. National Journal of Antennas and Propagation, Vol. 6, No. 3, 2024 (pp. 1-7).

Introduction

The rapid expansion of wireless networking is one of the main obstacles facing wireless communication today.[1-2] Cisco predicts that versatile information traffic will increment eightfold somewhere in the spectrum of 2015 and 20.[3] Broad examination is expected to increment spectrum productivity for better vehicular correspondences because of the outstanding development in the quantity of vehicles out and about.[11] Decreased vehicular communications efficiency could occur from the overpopulation of the allotted spectrum bands caused by the notable increase in vehicular communications applications. To resolve the issues of spectrum deficiency, it has expanded interest for extra recurrence groups. The extending request of remote network can't be met by the public authority offices' ongoing fixed spectrum distribution strategy. In fact, a portion of the distributed groups — like a small part of television VHF/UHF stations, or "Television blank areas" — are underutilized.[3] The US Federal Communication Commission (FCC) claims that because fixed spectrum bands are distributed, the majority of the spectrum is unused. This results in a significant discrepancy between the established spectrum allocation strategy and the current, rising need for additional spectrum groups. The FCC has suggested utilizing underutilized data transmission and unutilized spectrum groups, frequently known as empty spectrum groups or void areas, to close this hole. Unlicensed gadgets can utilize the authorized frequencies through an interaction called dynamic spectrum access. The objective of dynamic spectrum access is to resolve the recent concern of remote spectrum shortcoming while also meeting the expanding

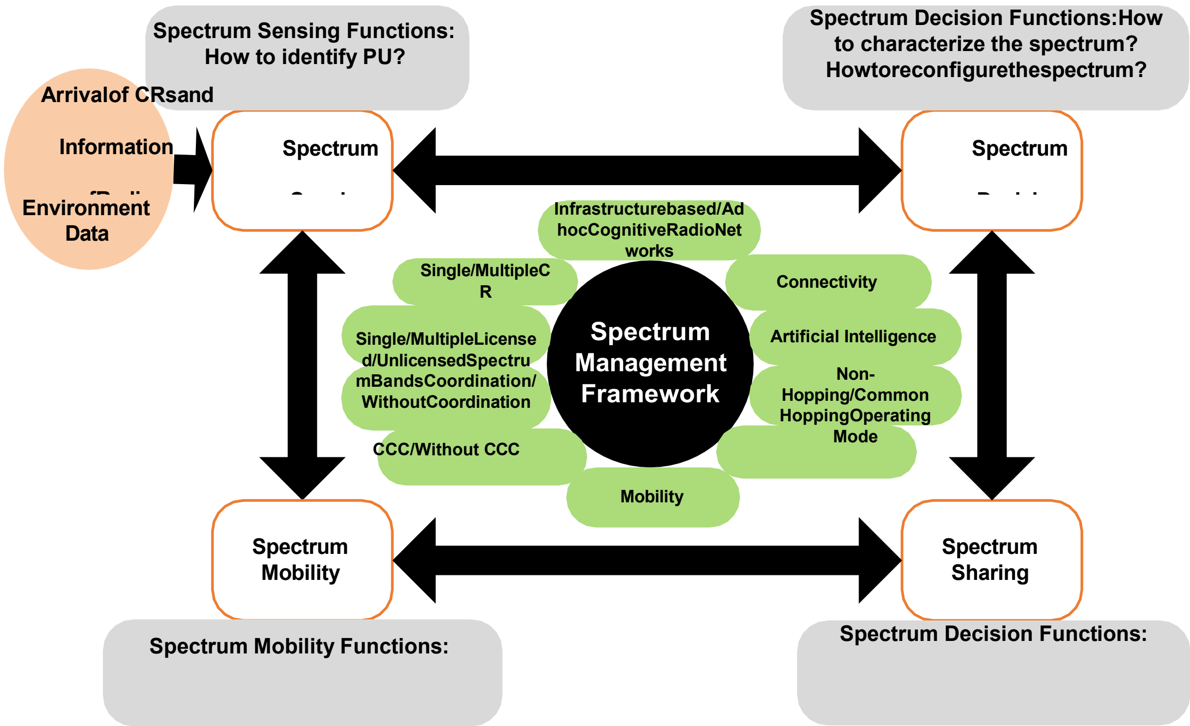


Fig. 1: CR network spectrum management framework

demands of wireless networks. As a result, a new field of study and development is created for Cognitive Radio (CR) technology, which is essential for utilizing underutilized spectrum through dynamic spectrum access. Therefore, utilizing more spectrum options to increase the efficiency of vehicular communications. Spectrum handoff can be used to dynamically utilize underutilized spectrum.[4,13] The framework model delineating the different spectrum handoff types in CR vehicle networks is displayed in Figure 1. It is exhibited that while between network spectrum handoff happens between heterogeneous radio access advances, intra-network spectrum handoff happens inside a similar radio access innovation.[14] It is shown that while specific CR vehicular hubs are connected to a solitary radio access innovation, others are connected to a few different radio access innovations. It is hard for the CR vehicular hub to pick the best organization for the spectrum handoff choice when it is associated with a few radio access innovations. The most vital element of the CR network is the spectrum the executives framework.[12]

Literature Survey

The allotted spectrum bands may become overcrowded as a result of the exponential rise in automotive communications. The need for additional spectrum bands to increase spectral efficiency and enhance vehicle communications has increased as a result. Finding distinct available spectrum to meet the increasing demands is challenging. The only practical approach is to increase the wireless system's spectrum efficiency in order to exploit the accessible spectrum. CR innovation has been concocted in light of the FCC's new regulations[5] that allow licensed underused radio spectrum to be used opportunistically. In order to increase the efficiency of vehicular communications, it is therefore anticipated that future vehicles would be CR enabled, utilizing unused spectrum opportunities.[6,15] Spectrum handoff can be used to dynamically utilize underutilized spectrum.[7] It is shown that while between network spectrum handoff happens between heterogeneous radio access advances, intra-network spectrum handoff happens inside a similar radio access innovation. It is demonstrated that while certain CR vehicular nodes are linked to a single radio access technology, others are linked to several different radio access advancements. It is challenging for the CR vehicular hub to pick the best organization for the spectrum handoff choice when it is connected to several radio access technologies.

Spectrum handoff in CR networks has been demonstrated to be a troublesome issue that actually needs the exploration local area's consideration. Sadly, the spectrum handoff frameworks for CR networkthat are now available do not adequately reflect a variety of characteristics with thorough investigations for practical implementation. Forming a spectrum handoff system that is genuinely advantageous in a unique climate over a wide spectrum of organization conditions, hub inclinations, and application-situated is the essential test. In order to make an intelligent spectrum handoff choice that takes into account the preferences of CR nodes and is application-oriented depending on the conditions of the dynamic network environment, the extensive survey[1-7] on CR networks spectrum handoff methods recommends the extensive use of numerous attributes. In certain CR networks, including CR vehicular networks, this issue is considerably more difficult. As a result, CR vehicular networks have been examined in this research.[16]

The authors in[7] have developed a novel vehicle aided cross layer handoff based vertical handoff algorithm based on Internet Protocol version 6 (IPv6). This kind of handoff technique works with NEMO in VANET. The scheme's primary characteristic is that it performs better than the IETF NEMO basic support protocol in terms of packet loss and handoff latency. Another NEMO-based handoff system for the vehicular environment was also presented by the authors in.[8] The effectiveness of the handoff mechanism is examined in mobile networks that are based on several Mobile Routers (MR). In this case, packet loss during handoff is much decreased as MRs collaboratively accept packets intended for one another. For IPv6-based NEMO heterogeneous wireless networks, the authors in[9] have put forth a dynamic mobility management architecture that incorporates the GRA technique to enhance decision-making.

Spectrum Management Framework

It exhibits that the four essential strides of the CR spectrum the board engineering are spectrum detecting, spectrum navigation, spectrum sharing, and spectrum portability. These are recorded with their main roles. At the point when CR shows up, the spectrum detecting

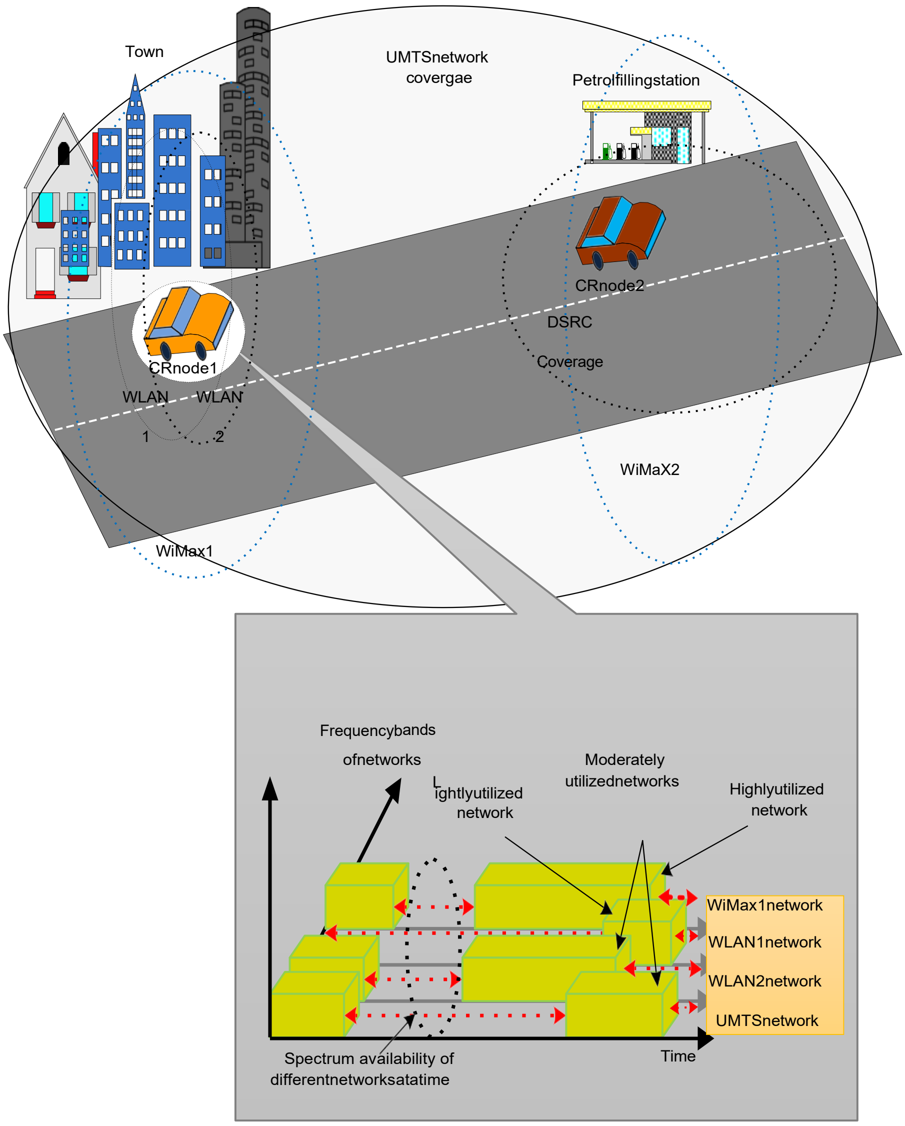


Fig. 2: CRN architecture

capability starts the principal stage. Information about the radio climate is additionally assembled. Target channel ID, channel exchanging delay, channel limit, channel holding time, channel obstruction, channel blunder rate, way misfortune in the channel, and hub area are the essential parts of radio climate information.[10] These are alluded to as CR network pre-spectrum the board structure components. Numerous common factors influence the CR network spectrum management framework, including the type of CR network—whether infrastructure-based or ad hoc—the quantity of CRs, connection, etc.

The fundamental CR network architecture is depicted in Figure 2. It demonstrates that there are two fundamental kinds of networks: the essential organization and the CR organization. Any major authorized network with the sole power to use explicit spectrum groups is viewed as the essential organization. The expressions “essential organization base station” and “Discharge” allude to the base station and different hubs in the essential organization, separately.

Discharge, which have the sole right to use explicit authorized spectrum groups I and II, utilize the significant network. CR network can be separated into two classifications: framework based and foundation less. A focal regulator, like a base station in a cell organization, is essential for the framework based CR organization. In a foundation less CR organization, there is certainly not a focal regulator to assist CR clients with conveying. In the organization, clients are responsible for each method. There are two sorts of heterogeneous remote network: heterogeneous CR network, which are furnished with CR organization, and heterogeneous CR adhoc networks, which are fitted with CR organization. The base station is known as CR base station and hubs are known as CRs. CR organization might utilize PU empty authorized groups without having permit.

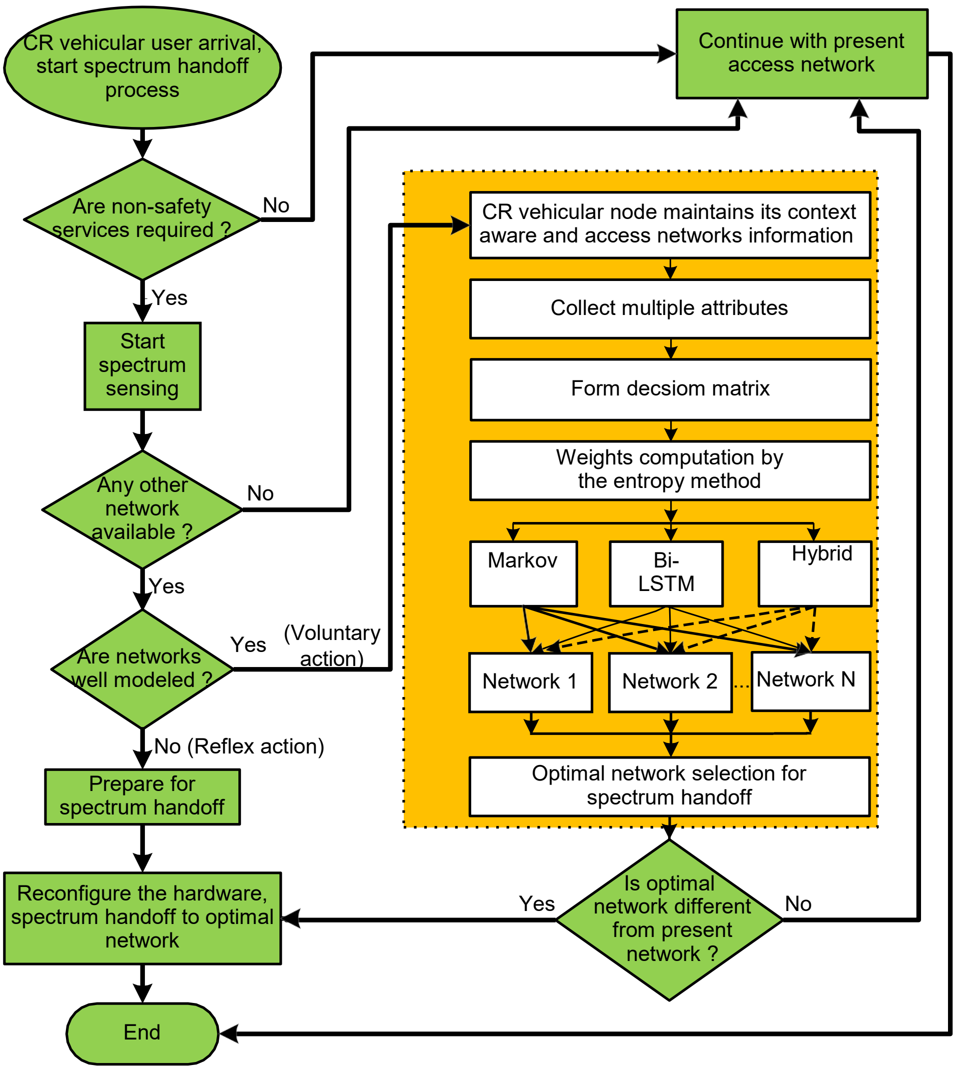


Fig.3: Flowgraph of proposed spectrum hand off scheme

Methods

1. When node arrives, the spectrum handoff procedure begins.
2. Spectrum sensing begins to locate access networks; if not, CR keeps transmitting within the current access network.
3. Voluntary spectrum handoff occurs if the access networks are accurately represented; if not, reflexive spectrum handoff occurs.
4. The primary portion of the spectrum handoff method that is represented as
    - A. To begin, the CR vehicular node accesses network data in terms of many properties and keeps itself context aware.
    - B. The choice matrix, a multiple attribute matrix, is created.
    - C. The entropy approach is used to calculate the weights, either with or without user preferences taken into account. Weights are calculated using the choice matrix.
    - D. Bidirectional LSTM model-based techniques and the Marcov process are used to choose the best network for the spectrum handoff decision.
5. Hardware reconfiguration is necessary ideal network differs from the current network. If not, the CR vehicular node keeps transmitting over the current access network.

Evaluation:

The presentation of the recommended spectrum handoff component is inspected in this section using the straightforward network configuration depicted in Figure 4. A CR vehicular node that combines four access networks is incorporated into the network architecture.

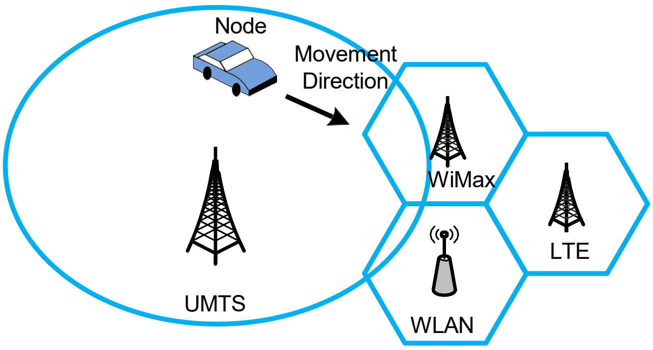


Fig. 4: Network configuration

The weights of several qualities produced by the entropy technique without taking into account the preferences of CR vehicular nodes are shown graphically in Figure 5. When the sum of these is 1, they are referred to as objective weights. Figure 6 shows the organization determination positioning for spectrum handoff utilizing these loads, barring CR vehicular hub inclinations

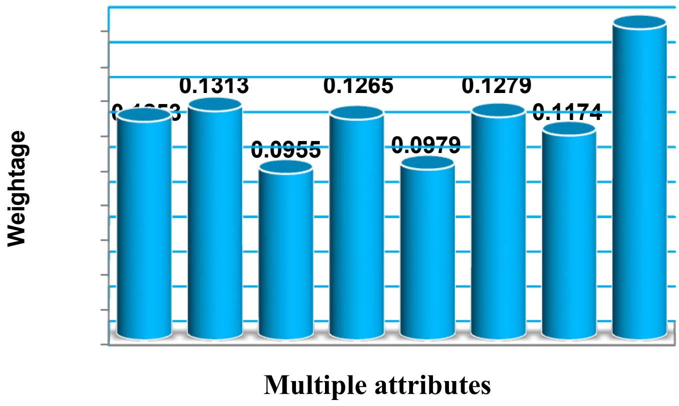


Fig. 5: generation of weights

It exhibits that the best organization for spectrum handoff is WLAN, while Marcov and the recommended Bi-LSTM approach pick LTE. This is the static strategy for picking the best organization for the decision of spectrum handoff. Not all non-wellbeing administrations for CR vehicular network are best served by these networks.

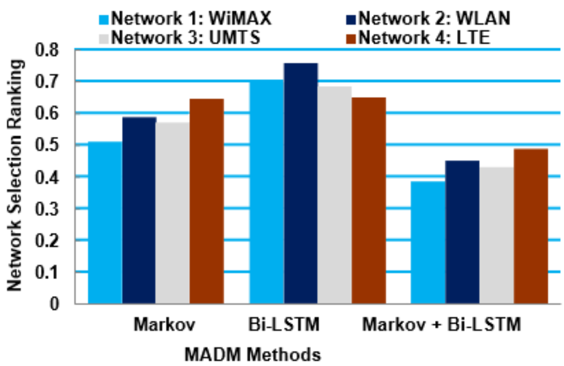
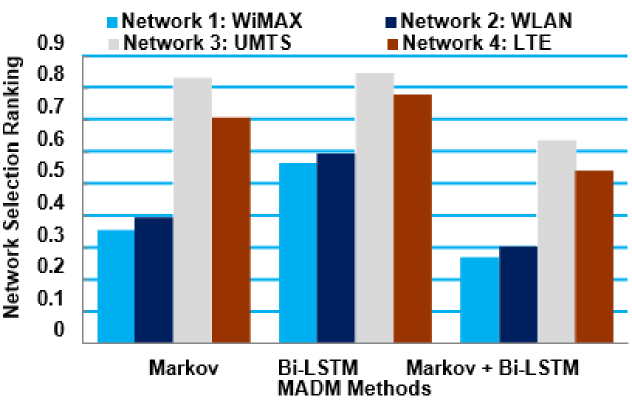
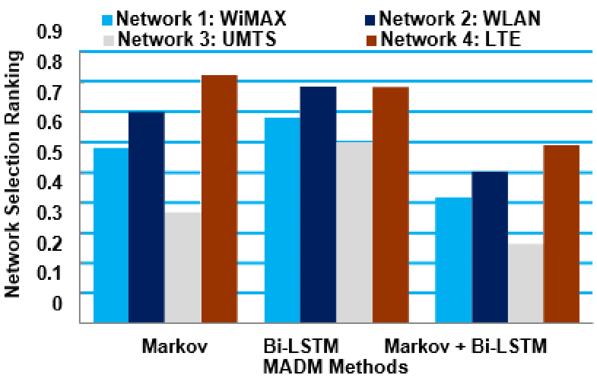


Fig. 6: Network selection

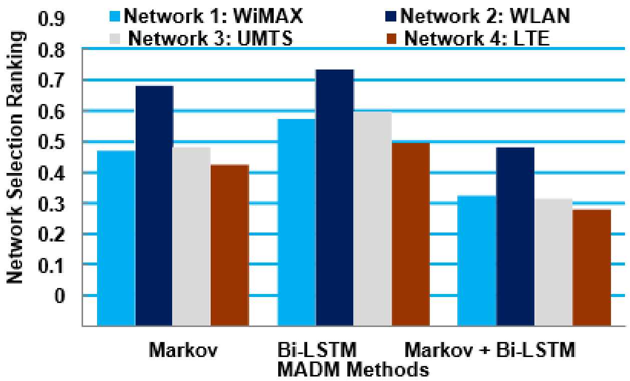
Since the CR vehicular node is traveling at a typical speed, the low preference level is taken into account for the direction property. Data rate is the most important factor for video services. A high degree of preference is therefore taken into account for it. High preference levels for PLR and price per unit are taken into account for the best effort service. For a given service, the total of all preference levels for several attributes equals 1. The CR vehicular node does not require the background service. Therefore, without taking into account the preferences of CR vehicular nodes, the best network will be chosen using weights produced by the entropy technique. Therefore, background service is not taken into account while making the spectrum handoff decision in the explanation that follows. Figure 6 shows the best network choice for spectrum handoff for background service in each scenario.



(a)



(b)



(c)

Fig. 7: Network selection for various cases

It is evident from the graphical representation in Figures 7(a), 7(b), and 7(c) that all MADM techniques, including the hybrid approach, choose UMTS, LTE, and WLAN for voice, video, and best effort services, respectively.

When the network ranking is calculated, as illustrated in Figure 8, an LTE network is considered ideal when

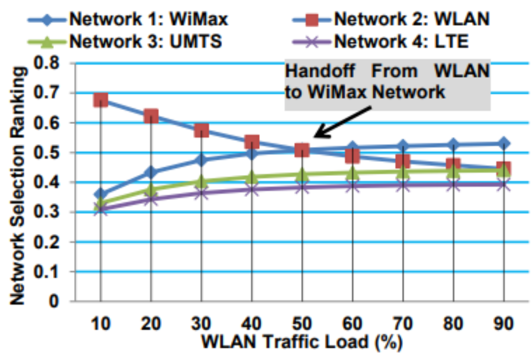


Fig. 8: Spectrum handoff when traffic load in WLAN increases

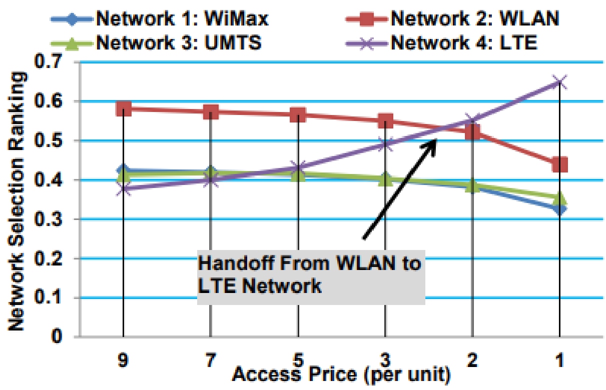


Fig. 9: Effect on the network selection ranking

its access price per unit is lowered to 2. As Figure 9 illustrates, alternative networks also begin to gain appeal for spectrum handoff when the UMTS network's latency grows. It demonstrates that the LTE network's network selection ranking surpasses that of the UMTS network when the latter's latency reaches 25%. LTE thus emerges as the best network for spectrum handoff.

Conclusion:

This research proposes a context-aware spectrum handoff system for CR vehicular networks that optimizes network selection for non-safety services. Weight estimate is done using the entropy method. For the best network selection for the spectrum handoff decision, Markov, Bi-LSTM, and the proposed Markov plus Bi-LSTM based MADM techniques are employed. Based on context-aware information from the CR vehicular node, including its velocity and time of call, the scheme's ability to react to different conditions is assessed. All MADM techniques are efficient for the best network selection for the spectrum handoff, as shown by the obtained numerical results. For non-safety services, the suggested Markov with Bi-LSTM approach performs better than other MADM techniques with the largest relative standard deviation. It is found that there is a considerable shift in the ideal network for spectrum handoff when the values of the delay attribute for voice, data rate for video, and pricing for best effort service are changed. The suggested cost-I based approach for the spectrum handoff choice is found to be more sensitive for phone service than for video and best effort service in a dynamic network environment.

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