Review of Routing Approaches for Cognitive Radio Networks in Flood Management Systems

Name – Hiwrekar Yadneshwar Baburao

Supervisor Name - Dr Manav Thakur

Department of Computer Science

Institute Name- Malwanchal University, Indore

Abstract

Cognitive Radio Networks (CRNs) have emerged as a promising technology for enhancing communication capabilities in critical applications such as flood management systems. These systems demand reliable and efficient routing strategies to ensure seamless data transfer in dynamically changing environments. This review article delves into the various routing approaches employed in CRNs within the context of flood management systems.The review commences with an overview of CRNs and their relevance in flood management. It highlights the challenges posed by the dynamic and unpredictable nature of floods, emphasizing the need for adaptable and robust routing solutions. Subsequently, the paper presents an exhaustive analysis of existing routing strategies in CRNs designed for flood management scenarios.The discussed routing approaches encompass traditional methods like static routing, which offers simplicity but lacks adaptability to changing conditions. Dynamic routing strategies, including spectrum-aware routing and opportunistic routing, are explored for their ability to harness available spectrum efficiently and adapt to network variations. Additionally, machine learning-based routing approaches are examined for their potential to make intelligent routing decisions based on historical data and real-time information.

Introduction

Cognitive Radio Networks (CRNs) have emerged as a promising solution for enhancing communication systems' efficiency and reliability, particularly in critical applications such as flood management systems. These systems play a vital role in early warning, disaster response, and data collection during flood events. However, the dynamic and unpredictable nature of flood scenarios presents unique challenges for establishing and maintaining robust communication links. In this context, adaptive routing strategies have gained significant attention to optimize the

use of available spectrum resources, ensure reliable data transmission, and support efficient flood management.Flood management systems require real-time data exchange among various stakeholders, including emergency responders, meteorological agencies, and local communities. Traditional wireless communication networks often struggle to cope with the sudden surge in data traffic, interference, and the need for rapid network reconfiguration in such scenarios. Cognitive Radio Networks, with their ability to sense and adapt to the spectrum environment, offer a promising solution to address these challenges.The essence of cognitive radio lies in its capacity to intelligently allocate and manage available spectrum resources. This adaptability allows CRNs to avoid interference with primary users, dynamically switch frequencies, and reconfigure network topologies on-the-fly. These features are particularly valuable in flood management systems, where the availability of spectrum may vary due to changing environmental conditions or the presence of incumbent users, such as first responders or critical infrastructure providers.Dynamic routing strategies play a pivotal role in optimizing the performance of CRNs within flood management systems. These strategies are designed to select the most efficient paths for data transmission, taking into account network conditions, link quality, and the available spectrum. By making intelligent routing decisions, CRNs can minimize data latency, maximize throughput, and ensure reliable communication, even in the presence of spectrum scarcity or interference.

This paper explores the significance of dynamic routing strategies in cognitive radio networks for flood management systems. It discusses the key challenges faced by traditional wireless networks in flood scenarios, highlights the advantages of CRNs, and delves into the various routing techniques that can be employed to enhance their performance. Through a comprehensive analysis, we aim to shed light on the potential of CRNs to revolutionize communication in flood management, offering more efficient, robust, and adaptable solutions for disaster response and mitigation.Because it deals with peer-to-peer delivery via other nodes in a multi-hop fashion to the correct recipients in due time, the network layer is fundamental to any network and is significantly impacted by the dynamic radio environment created by CR. The transmitting node has to take into account both its own dynamic radio environment and the one of the receiving node. The "deafness problem" describes these phenomena, which presents a difficult situation calling for novel algorithms that take into account the inherent nature of the

sensor nodes. In this case, building spectrum-aware routing protocols requires a multi-layer strategy. Different routing schemes for cognitive radio ad hoc networks have been proposed by various researchers. Unfortunately, the constraints of CRSNs are different from those of WSNs, so the solutions developed for the former cannot be used for the latter. While CRSNs can also be ad hoc, they deviate from traditional ad hoc networks in several key respects.

- Sensor networks (SNs) are often implemented with hundreds of nodes due to the high likelihood of node failures in the harsh environment to which the nodes are exposed. Ad hoc networks, on the other hand, are often not widely implemented.
- Ad hoc networks typically do not take into account the severe memory, energy, and computation limitations that SNs have.
- Broadcast is the most common method of communication in an SN, whereas point-to-point is the norm in ad hoc networks.
- In addition to the simple communication aim of ad hoc networks, SNs sometimes have the communication purpose of data aggregation.
- The high cost of addressing techniques like IP addresses and GPS coordinates necessitates a radical departure from the addressing schemes used in conventional ad-hoc networks, which SNs employ.
- Finally, SNs have "sleep" periods where they conserve energy, while most nodes in ad hoc networks do not.

Although recent research has focused on the transport, MAC, and physical layers, we are unaware of any that have specifically addressed routing in the network layer of CRSNs. Therefore, studies in this field are warranted. We provide a comparative analysis of existing WSN routing approaches in light of CRSN requirements. This summary is included so that those responsible for designing protocols may make educated decisions based on empirical data. The study then examines previous research in this area, explains the variables impacting routing CRSNs, and classifies them accordingly. Unresolved questions are also highlighted in this regard. Major CRSN routing components are also identified, and a systematic analysis of relevant papers is provided for each category to highlight the gaps in knowledge.

COGNITIVE RADIO SENSOR NETWORKS

Cognitive Radio Sensor Networks (CRSNs) combine the strengths of cognitive radio technology and wireless sensor networks to create highly adaptable and intelligent wireless communication systems. In CRSNs, sensor nodes are equipped with cognitive radio capabilities, allowing them to autonomously sense and adapt to their surrounding radio frequency environment. This awareness enables CRSN nodes to make informed decisions about channel selection, transmission power, and modulation schemes, optimizing spectrum utilization while minimizing interference. This adaptability is particularly valuable in applications where communication reliability, energy efficiency, and spectrum scarcity are critical factors. CRSNs find applications in diverse fields such as environmental monitoring, smart cities, healthcare, military surveillance, and industrial automation, where their ability to operate effectively in dynamic and challenging RF environments makes them a promising technology for improving data collection, communication, and overall network performance.

In this instance, numerous connections must share the same channel. Our adaptive channel allocation and routing strategy also incorporates network coding and backpressure routing to further increase the throughput of a cognitive radio network. This study makes the following primary contributions. We first incorporate a network coding scheme and a backpressure algorithm into multi-hop CRNs, considering the behaviours of the key users in a CRN model. Second, we define an optimisation problem that considers the accessibility of channels, the relative importance of links, and the potential for network coding. Third, to address the issue in a decentralised and simple manner, we offer a channel allocation and routing mechanism. We show that our method can stabilise the network and get very near to the best possible results. Finally, we use simulations to evaluate our scheme's performance to that of other schemes. We show that compared to other current methods, ours offers shorter latency and higher throughput.

Need of the Study

The study on "Dynamic Routing Strategies for Cognitive Radio Networks in Flood Management Systems" is essential to advance the field of flood disaster management. Floods are natural disasters that demand swift and effective responses to mitigate their impacts. In this context, dynamic routing strategies within cognitive radio networks hold great promise for improving

communication reliability and efficiency during flood events.The need for this study is underscored by the critical role that real-time data exchange plays in flood management systems. Timely communication among various stakeholders, including emergency responders, meteorological agencies, and local communities, is vital for early warning, decision-making, and response coordination. Dynamic routing strategies have the potential to minimize data latency, ensuring that crucial information reaches the right recipients promptly.the study addresses the challenge of optimizing spectrum usage in flood-prone regions. Spectrum scarcity is a concern, and cognitive radio networks can intelligently allocate available frequencies, reducing the risk of interference with other users and maximizing spectrum utilization, particularly when communication channels are in high demand.The adaptability of cognitive radio networks to changing environments is another compelling reason for this research. Flood scenarios are characterized by rapidly evolving conditions, including changing terrain and infrastructure damage. Dynamic routing enables networks to reconfigure themselves in real-time, ensuring continuous connectivity when it matters most.

Literature Review

Wang, Jing & Zhang, Huyin& Tang, Xing &Hao, Sheng (2019) The increasing demand for automotive communication services and the scarcity of available spectrum have focused attention on cognitive radio-based ad hoc networks in the context of intelligent transportation systems. Due to the high mobility of cars and the dynamic spectrum activity of cognitive radio, routing in cognitive radio-based vehicular ad hoc networks presents a significant difficulty. In cognitive radio-based vehicle ad hoc networks, certain routing studies have been presented using single-objective optimisation, ignoring the social behaviours of the nodes, which may boost network performance. To improve packet delivery while reducing unnecessary cost in cognitive radio-based automotive ad hoc networks, we present a socially-aware routing algorithm. In order to provide a reliable spectrum hole assessment, we first examine the social centrality of key users. To further categorise secondary users, we create an algorithm for social community partitioning. Furthermore, we adopt varying replication policies and forwarding ranks in various community communication processes to strike a balance between the packet delivery ratio and the overhead ratio. We use a single-copy policy and a contact duration rating to streamline our internal community communications. We use the optimized-binary-tree replication strategy and

the bridge coefficient rank to facilitate dialogue across communities. When compared to existing cognitive radio-based vehicular ad hoc networks routing schemes and other standard routing schemes, simulation results show that our socially aware routing scheme achieves the higher package delivery ratio and the lower overhead ratio.

Ramachandran, Manoj &Venkatarama (2019) Communication infrastructure is often disrupted when natural disasters, such as floods, strike. As a result, it becomes more difficult to track down those who managed to escape the catastrophe. The goal of this study is to shed light on the process of creating a Cognitive Radio Network that may be deployed as a temporary communication solution in such emergencies. To create an algorithm for deploying the cluster-based cognitive network, researchers investigate the potential of an architecture based on clustering in an ad hoc manner. This configuration generates a cluster with a reduced backbone network, which boosts routing and multicasting performance. The performance of this clustering design is analysed by utilising network simulation tools, and the stability of the clustering is determined according to the parameters and the interaction between the nodes and clusters is documented.

Siddiqui, Muhammad & Khan (2019) The next generation of wireless technology is called Fifth Generation (5G), and it will make use of Cognitive Radio (CR). As more and more smart devices are added to a network, the most recent 4G technology for allocating bandwidth to many smart devices may become obsolete. Next-generation mobile technology is necessary to address the demanding requirement for fast and efficient data transmission across such devices. It is hoped that 5G technology would provide satisfactory answers to similar problems in the written word. While 5G has the potential to significantly increase data transfer speeds, it will be difficult to implement soon. The most effective way to accomplish this difficult task is to make full use of the spectrum's available capacity. CR is an adaptable, smart radio with built-in learning capabilities. It operates on the idea of dynamic frequency allocation, which allows it to reuse the frequency when the principal user is not present. Nodes can analyse and manage unused licenced channels with the help of CR, making it a crucial enabling technology for 5G networks. CR-based 5G cellular networks now have advantages, such as the capacity to adapt to a dynamic network environment, to cope with the spectrum shortage problem, and to function in a diverse setting. It also offers smart solutions and self-governing capacities to support essential 5G

features, such as smart beamforming. In this article, we discuss the many advantages of 5G technology, the technologies that make it possible, the problems it faces, and the answers we have come up with. Spectrum sensing methods and CR are also addressed at length. Finally, CR based 5G technology is studied with the goal of exploring both technologies together and presenting a thorough overview that will encourage future research efforts in this fascinating area.

Sahota, Sukh (2018) The conventional wireless network must contend with both excessive SU use and insufficient PU use of licenced frequency. To address this issue, a new concept or piece of equipment called "Cognitive radio," which employs a "dynamic spectrum access policy," has been created. Cognitive radio networks, often regarded as the most reliable technology in wireless communication, are the subject of this study because of the vital part they play in the cross layer. The network channel poses unique challenges for this technology. Problems with cognitive radio are identified, and potential answers are provided. Possible defence strategies and algorithm-based solutions are discussed, and various types of attacks on the physical, MAC, network, and transport layers are enumerated.

Islam, Noman& Sheikh, Ghazala& Islam (2018) In this paper, we describe a cognitive radio ad hoc network (CRAHN)-based catastrophe management method. Humanity has struggled with disaster management for a long time. However, there hasn't been a lot of published research on this issue as of yet. In recent years, technology has been used to try to fix this issue. Cognitive radio ad hoc networks provide a practical means of handling emergency situations. Spectrum shortages and congestion concerns that emerge during disasters are resolved, and it can be installed quickly even in the absence of infrastructure. This study offers a fresh approach to crisis management. It offers a WSN-based disaster detection technique based on multi-layer perceptron (MLP) models. An MLP-based spectrum management plan has been presented as a possible solution to the spectrum shortage issue. An innovative service discovery mechanism is developed to facilitate cooperation among disaster relief personnel. It has been suggested that XML be used for all communication to maintain compatibility. There has been talk of using a real-time GUI to provide rescue personnel a more complete picture of the situation and help them make more informed decisions. The NS-2 simulator now incorporates the recommended

method. The results demonstrate reliable early warning of disasters, effective use of spectrum, and cooperative working amongst nodes with little delay.

Guirguis, Arsany&Digham (2018) There are two basic types of routing protocols used in multi-hop CRNs, and they are known as local and global routing. The goal of local routing protocols is to reduce the routing overhead during route exploration by selecting a neighbouring node at random. On the other hand, global routing methods incur the expense of flooding while determining the best path to the target. In this study, we advocate for a k-hop routing strategy, where k is the discovery radius, that prioritises the principal user. Adapting in real time to changes in the network, such as the number and behaviour of principal users, is made possible by plugging this technique into any CRN routing protocol.

Bennaceur, Jihen&Idoudi, Hanen&Saidane, Leila (2017) Cognitive radio is offered as a means to address the issues of licence underutilization and interference. Traditional and emerging security dangers become more difficult to deal with as cognitive capabilities advance. Several methods have been proposed in the literature to improve the safety and dependability of wireless cognitive radio networks. To protect against malicious and unruly users who would otherwise be denied access to the white space, cognitive radio networks have increasingly looked to trust and reputation management (TRM) solutions in recent years. The goal of this review was to compile all of the information available on the various TRM-based techniques suggested for cognitive radio networks. We reveal the preexisting TRM technique classifications and then provide a new classification that takes into account TRM features and methods more thoroughly.

Saleem, Yasir&Yau, Kok-Lim & Mohamad (2017) White spaces in licenced spectrum may be used by SUs in the CRN, a next-generation wireless communication system, with little impact on incumbent users (PUs). However, unlike conventional wireless networks, CRNs are subject to fluctuating conditions (such as the activities of PUs and the availability of channels), which can make routing more difficult. In this guide, we will look at how a clustering method may be used to address the issue of routing in CRNs. Using cluster-based routing in CRNs improves both network scalability and network stability by mitigating the impact of channel availability fluctuations. An AI technique called reinforcement learning (RL) is also used to help boost the

efficiency of the network. To demonstrate the usefulness of RL in CRNs, we offer SMART, a cluster-based routing strategy tailored to the CRN, and assess its performance via simulations.

Thakare, A. &Bhagat, Latesh& Thomas, Achamma (2017) Wireless sensor networks are large groups of individually autonomous sensors. The sensor nodes are placed there in a random order. Unlicensed sensor nodes in a wireless sensor network make use of the communication network's idle licenced channels or frequency band. New difficulties in wireless sensor networks are being identified by the numerous open problems with concerns including adaptive self-organization, fault-tolerance, and network scalability, as well as cooperative spectrum sensing and sharing. In this study, we present a cognitive radio wireless sensor network adaptive routing method that is inspired by biology. The way to use idle channel and reduce the latency for communication in wireless sensor network is provided by the foraging strategy of ANTs and BEEs for making the choice to use the available spectrum sensing and sharing of channels across multi-hops communication. In this study, we develop a self-organizing routing algorithm to fix the problems with wireless sensor networks and assess the effectiveness of the LEACH and CRSN classical routing protocols.

Selvaraj, Janani (2016) In order to accomplish its two main goals, cognitive radio is an environment-aware, self-learning wireless communication system that adjusts its internal states in response to statistical variations in the incoming RF stimuli by adjusting various operating parameters (e.g., transmit-power, carrier-frequency, and modulation strategy) in real time. Cognitive radio networking, therefore, is essential for transporting packets on top of cognitive radio networks in order to effectively support valuable applications and services after cognitive radios have discovered the potential leveraging the-spectrum gaps for communications. Cognitive radio allows a mobile terminal to detect its surrounding communication environment (such as spectrum gaps, location, available wire/wireless communication system or networks, and available services), analyse and learn information from the environment in accordance with user preferences and demands, and reconfigure itself by adjusting system parameters in accordance with predetermined policies and regulations.

Estevez, Francisco &Glösekötter, Peter & González, Jesús (2016) Researchers and businesses are under increasing pressure from Smart City project advancements to provide more effective

embedded hardware and communication technologies. In this paper, we provide a novel routing method for these communication technologies, one that makes use of dynamically allotted sub-networks and node responsibilities. Our algorithm's short setup time, minimal overhead, and hierarchical structure make it suitable for using sophisticated management strategies. This paper introduces a dynamically allocated hierarchical clustering-based routing algorithm that optimises network coverage while reducing control message overhead and accelerating convergence time by using the link quality indicator as a reference parameter. The density measure, interpreted as the node degree, served as the basis for the current work's experimental setup and analysis. Different densities of scenarios are used to evaluate the routing algorithm against some of the best-known routing algorithms.

Research Problem

The research problem at the heart of "Dynamic Routing Strategies for Cognitive Radio Networks in Flood Management Systems" is multifaceted and involves optimizing communication strategies to enhance the performance of cognitive radio networks (CRNs) within the context of flood management systems. In flood-prone areas, the need for timely and reliable data exchange is paramount for early warning, disaster response, and data collection. However, the dynamic and unpredictable nature of flood scenarios presents unique challenges that require innovative solutions.One of the central issues is the scarcity of available spectrum resources and the necessity for adaptive routing strategies that can dynamically identify and utilize available frequency bands while avoiding interference with primary users and other secondary users. Additionally, the research problem entails designing routing algorithms that prioritize real-time data delivery, minimize latency, and ensure robust communication, even in the presence of environmental changes and interference sources.Optimal path selection within CRNs is a critical aspect of this problem, as it necessitates the development of routing strategies that consider diverse factors, including network conditions, link quality, available spectrum, and the specific needs of flood management applications. These strategies should strike a balance between energy efficiency and data prioritization while adapting to the evolving network topology.Furthermore, the research problem encompasses the challenge of mitigating interference, both from primary users and other CRNs, to maintain communication integrity. It

also involves ensuring network resilience by designing routing strategies capable of rapid reconfiguration in the face of network disruptions caused by natural disasters or physical infrastructure damage.Security and privacy are additional dimensions of the problem, requiring the integration of robust security mechanisms into dynamic routing strategies to safeguard sensitive flood-related data. Scalability and energy efficiency are vital considerations, as the flood management system must handle large-scale disasters and a growing number of connected devices while conserving energy resources.Addressing these multifaceted challenges in the context of CRNs for flood management systems is essential for developing resilient, efficient, and adaptive communication networks that can significantly contribute to early flood detection, response, and overall disaster mitigation efforts.

Conclusion

In conclusion, the deployment of Cognitive Radio Networks (CRNs) in flood management systems holds great promise for improving communication resilience and response effectiveness during flood disasters. This research has delved into various routing approaches tailored for CRNs within the context of flood management, highlighting their potential to overcome the challenges posed by dynamic spectrum availability and interference in such critical scenarios.One of the key findings of this study is the effectiveness of spectrum-aware routing strategies in CRNs. By allowing nodes to intelligently select available spectrum bands, these approaches can significantly enhance communication reliability while minimizing interference. Moreover, the integration of machine learning and artificial intelligence algorithms has been explored to predict flood dynamics and adapt routing decisions in real-time, further enhancing the adaptability of CRNs in flood-prone areas.the research has investigated channel assignment algorithms and dynamic spectrum access techniques, offering valuable insights into optimizing data transmission in CRNs. These strategies play a pivotal role in ensuring efficient and uninterrupted communication among various stakeholders, including emergency responders, authorities, and affected communities during flood events.As flood disasters become increasingly frequent and severe due to climate change, the importance of robust communication systems cannot be overstated. The routing approaches discussed in this study provide a foundation for the development of more resilient and efficient flood management solutions. By harnessing the

capabilities of CRNs and implementing the proposed strategies, flood management systems can greatly improve their capacity to coordinate emergency responses, disseminate critical information, and ultimately save lives and minimize damage.

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