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REVIEW ON COGNITIVE COOPERATIVE WIRELESS SENSOR COMMUNICATION IN VARIOUS APPLICATIONS

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Abstract: The effective utilization of the spectrum available is a great challenge now days. Cognitive Radio Net work is an intelligent wireless communication network in which the transmitter and receiver can intelligently sense the spectrum which is in use and not in use and subsequently moves to the vacant channels when the license d user starts using the spectrum. The movement is done by intelligently adjusting the network parameters with respect to the vacant channels. Cognitive Radio solves the problem of spectrum underutilization. The mobile frequencies are overcrowded by the users. CR helps the mobile user to make use of any channel by sharing the bandwidth. There are various applications that make use o f the Cognitive network concept. Few of them are under water acoustics, industrial applications, public transport journey planning, intelligent vehicles, object tracking, intelligent buildings, cognitive positioning systems etc. A Cognitive thinking can be applied on a Cooperative n network to induce cooperative spectrum sensing by the neighboring nodes to enable effective transmission between the transmitter and the receiver. A survey is done on these applications and explained brief in this paper. The methodologies used in various applications are also studied. Underwater surveillance is an important application that needs more focus to improve underwater communication.

Keywords: Cognitive Radio-Wireless Sensor Network (CR-WSN), Cooperative Communication, PROF IBUS, Dijkstra’s Algorithm, Change Detection Test (CDT).

1. INTRODUCTION

The Wireless Sensor Network is a collection o f Wireless Sensor Nodes that does the process of sensing, Collecting, Computing and Communicating. The communication in wireless sensor network is event-driven When an event occurs, the sensor node generates bursty traffic. The sensor nodes are deployed at a regular distance between them usually in terms of meters in a parti ular area. Each wireless sensor senses the environment and the sensed data from all the nodes are collected by the sink and via the

gateway it uses any of the communication channel (internet) to reach the users. The basic architecture is given below in fig 1.

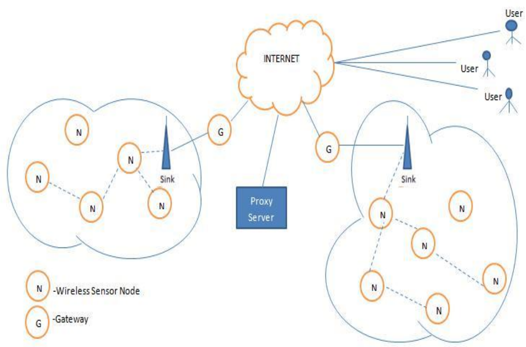

Fig 1: Wireless sensor networks architecture

The term Cognitive involves thinking, reasoning and remembering. The cognitive radio enables the opportunistic usage of the spectrum hole by intellectual thinking through perception, planning, acting and continuously updating and upgrading the spectrum knowledge. The cognitive thinking capability can be applied to the wireless sensor networks to gain more functionality and advantages.

The Cognitive Radio Wireless Sensor Nodes (CR-WSN) communicates the sensed reading dynamically over the available spectrum bands in a multi-hop manner. The architecture of CR-WSN is shown in fig 2. T he basic functionalities of CR-WSN are sensing the spectrum for unused spectrum holes, sharing the sensed spectrum, predicting the arrival of the primary user, distributing the spectrum fairly, routing the packet efficiently with additional functionalities like reconfiguration cap ability, environment sensing, power control, trust and security.

In Cooperative Communication, the neighbouring nodes are called relay nodes that actually don’t have data for communication but they can aid the source and destination to communicate by forwarding the data between them. The applications based on the technologies discussed are explained below in brief.

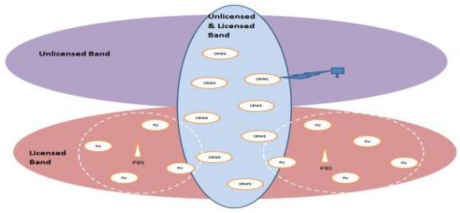

Fig 2: CR-WSN Architecture

Existing systems:

1. Underwater Acoustics Communication
2. Industrial Application
3. Public transport journey planning
4. Contamination and fault detection in intelligent t building
5. Intelligent vehicles
6. Object tracking
7. Cognitive Positioning System
8. Air vehicles

Underwater acoustics communication:

Underwater Acoustics Communication happen by sending and receiving messages under water by kno wing the propagation of sound in water and the sound d uring the interaction of the waves that is the sound with water and boundaries. The architecture of Underwater CR-WSN Surveillance is shown in the figure 3.

Underwater Surveillance not only helps in detecting the targets under sea but also in climate (all hydrological parameters) monitoring, natural calamity emergency like drowns, tsunami, monitoring the sea wealth (species) by staying on the shore and most importantly for security i.e., detecting the intrusion of foreign ships or terrorism through sea.

The Spectrum Access in Spectrum aware underwater networks (SUNs) uses Dynamic Spectrum Access (DSA) and Opportunistic Spectrum Access (OSA). The scarce spectrum in SUNs is used effectively with Cognitive Acoustic Communications [1] (CACs).The Cooperative Cognitive Control Autonomous Underwater Vehicles represents a robotic research for 2D and 3D underwater mapping, cooperative navigation and motion control.

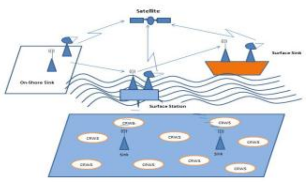

Fig 3: Underwater CR-WSN Architecture

The cooperative communication on motion control avoids collision by implementing a hierarchical model[2].

Industrial Application:

The tethered connections are replaced with wireless solutions by designing and implementing a cognitive radio (CR) prototype of process fieldbus (PROFIBU S). The prototype operates in 2.4 GHz industrial, scientific and medical (ISM) band by integrating an adaptive filter bank-based physical layer with a cognitive medium access control layer in order to meet the QoS requirements in terms of delay and packet loss. The communication process in PROFIBUS[5] is master-slave based, where the master is an active node such as computer or control systems and slave is a passive node such as sensors, actuators and field devices. In a factory automation environment there can be one PROFIBUS master and several slaves. The overall architecture of the CAROUSAL transceiver in figure 4 shows the integration of PHY and MAC layer with RF front end.

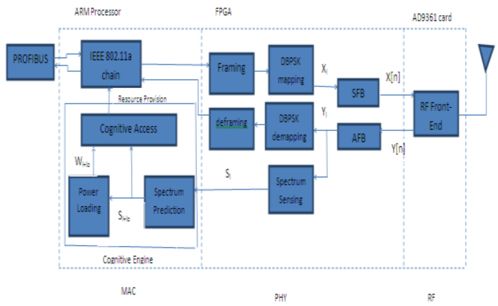

Fig 4: CAROUSAL transceiver Architecture

Filter Bank based PHY processing:

The Filter Bank (FB) in the PHY layer makes u se of the discrete Fourier transform modulation (DFT) which can transmit parallel data streams within the covered bandwidth with no guard p eriod and the parameters of the transceiver are optimized with certain flexibility and constraints. The spectrum sensing is done in PHY layer in the form of a conventional hypothesis testing with respect to the primary user signal and unlicensed user interference as the interference is unknown.

Cognitive MAC layer:

The data packets are recognized individually and the cognitive access is based on the opportunistic use of spectrum holes. The functions in t his layers are spectrum prediction or channel state prediction, power loading and cognitive medium access. The spectrum occupancy is predicted in the first step by analyzing the traffic pattern and according to that the unoccupied sub carrier are power loaded in the second step and finally the medium is access successfully where the CSMA/CA is replaced by prediction.

Public transport journey planning:

Cognitive science plays a vital role in public transport journey planning. The possible and best ways to get from one place to another place is decided using the Dijkstra's algorithm [6] to find the shortest path. The use r should specify the passenger layer they belong to before the planning is done. The logical structure of the cognitive algorithm is shown in figure 5 below.

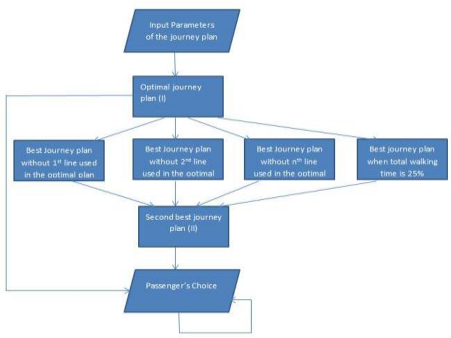

Fig 5: Logical structure of Cognitive Algorithm

Contamination and fault detection in intelligent building:

A Cognitive Monitoring System is proposed for the detection and isolation of both contaminants and sensor faults in intelligent buildings. The CMS contains three layers as shown in the hierarchical architecture below in figure 6.

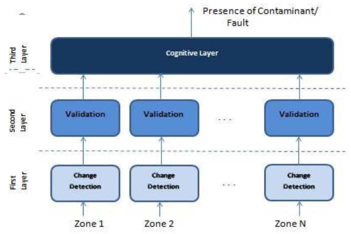

Fig 6: CMS Hierarchical Architecture

The first layer is the change detection layer, the second layer is the validation layer and the third layer is the cognitive layer. Sensor devices are fixed in the building to measure the concentration of specific contaminants using an intelligent algorithm and report an alarm when contaminant is detected. At the same time, the sensors are not supposed to induce false alarms. The Change Detection layer involves a sequence of Change Detection Test(CDT) running at each sensor. The goal of this layer is to guarantee prompt detection of any anomalous concentration of contaminants. The zone where the CDT detects a change is called as detection zone and denoted by î. The validation layer involves Change-Point Methods [9](CPM) that helps to reduce t he false positives raised by the change detection layer. Finally the cognitive layer addresses two relevant tasks: i). Isolating the zone where either contaminant has released or sensor fault has occurred. ii). Determine whether the validated detection is due to contaminant source or fault affecting the sensor apparatus. Now the cognitive layer builds two propagation trees to arrange the zones according to the expected contaminant propagation. The first two layer works in hierarchical manner and the third layer works in a centralized manner.

Object Tracking:

The change in object size introduces heavy issue in object positioning and data association. Cognitive Dynamic Systems (CDS) is designed for incorporating s elf-adaptability and self-awareness. The two major part s of CDS are perceptron and actuator. The Perceptron perceives the surrounding information and gives internal representation for it. The Actuator transfers the decision into action that is to be performed on the environment. There are three main blocks in the CDS architecture [10] namely Cognitive Perceptor (CP), Cognitive Controller (CC) and Probabilistic Reasoning Machine (PRM). The Cognitive Perceptor unit processes the measurements coming from the external environment. The CC unit compares the previous errors to decide on the action to be taken. The third component PRM provides a statistical coupling between perception and action.

Cognitive Positioning System:

Cognitive Positioning System (CPS) achieves location awareness in Cognitive Radio. The modes in C PS are: Bandwidth determination and Enhanced Dynamic Spectrum Management [11] (EDSM).

The bandwidth is determined through Cramer-Rao Lower Bound[11](CRLB) which gives the following bandwidth determination equation.

$$\beta = \sqrt{\frac{\vartheta^2 M(\tilde{d})}{K\gamma_s}}$$

The Spectrum sharing in EDSM have two approaches namely overlay (opportunistic) and underlay (non -interfering) approaches.

Intelligent vehicles:

The vehicles are made intelligent by providing cognitive thinking and fully automated. The intelligent vehicle designed leads to an environment where the crashes are rare, carbon emissions are reduced and mobility is extended to a large population. The experimentation of the intelligent vehicle is done at four different levels [12]. At level 1, the vehicle is completely under the driver's control. At level 2, the (Driver Vehicle Interface) D VI does not support complete automation and the driver acts as the supervisor. At level 3, ADS controls all the d riving functions. The level 4 is completely automated. T here is no driver interaction. This critical driving system m works even on technology failure.

CONCLUSION

The Cognitive thinking on various applications and the methodologies used are discussed in this paper. Out of all the above applications, the importance of Underwater Communication motivated the research work on designing effective routing technique by incorporating cognitive thinking on cooperative communication. T he underwater surveillance are used for various security reasons where communication plays an vital role by improving the energy efficiency of the sensor nodes, reducing packet loss and utilizing the spectrum effectively.

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