# Digital Revolution Using Novel Wireless Statement Design with Cognitive Radio Network Service for Rural Enlargement

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**Abstract -** *The coverage area and demand of service are mismatching in rural communication. Due to the wide coverage area and low demand of service, the service cost of the rural communication is increased. To provide a viable cost communication service in the rural area, novel wireless communication design has been introduced in this research. This novel wireless communication design has been proposed with Cognitive Radio (CR) technology. CR is an emerging technology to provide suitable service model to the rural area based on efficient use of statically allocated unused spectrum. To improve the spectrum efficiency, Cognitive Radio technology is introduced with dynamic spectrum access. The challenges in rural communication and existing wireless technologies are reviewed. This novel wireless communication design proposed to provide a low cost and large area coverage service.*

***Key Words*:**

## 1. INTRODUCTION

According to the census reports more than half of the people in India living in rural areas. These peoples are spread far and wide in geographical area. To develop the nation, it is believed that providing communications services are an important step to facilitate development and social equity. The cost to provide the communication service is very high due to the coverage more geographical area. Apart from that, rural communications networks are crucial in disaster/emergency response scenarios.

However, providing rural communications is often challenging due to the mismatch between costs and demand. Most rural areas have low population density and the demand for services per individual or household can be much lower in rural areas if compared to urban areas. To create a viable business, operators must aim for low-cost solutions. However, the deployment and maintenance of rural communications networks can be costly due to large areas requiring coverage, lack of transportation, and difficult terrains. This is particularly true for wired networks because wires or cables must be laid all the way to the destinations. As a result, wireless technologies usually are preferred for rural connectivity [4].

In fact, there are various approaches that consider wireless technologies for rural communications. Recently, with the proliferation of Wi-Fi, there have been proposals to extend this short-range/local-area-network technology for rural coverage. Nevertheless, the challenges of providing low-cost services to a low-demand market still remain.

Cognitive radio is an emerging technology that promises to overcome one of the most challenging problems of modern wireless communications, namely, spectrum scarcity. Access to radio spectrum today is based largely on fixed allocation, that is, different frequency bands are allocated to different services. With the proliferation of wireless applications and services in many countries, most of the available spectrum has been allocated. On the other hand, careful studies reveal that most of the allocated spectrum experiences low utilization. By intelligently detecting and making use of the allocated but under-utilized spectrum, cognitive radio enables wireless networks to operate without requiring dedicated spectrum. This, in the context of rural communications, means cognitive radio networks can be deployed at lower costs.

The most notable example of cognitive radio technologies for rural communications is the IEEE 802.22 wireless regional area network (WRAN) standard that is currently being developed, which is based on time division duplexing (TDD) to opportunistically use of very high frequency/ultra-high frequency (VHF/UHF) TV bands. Apart from the fact that IEEE 802.22 technology does not require dedicated spectrum, which significantly saves deployment costs, the large network coverage makes this technology particularly suitable for rural deployment [6]. Due to the favourable propagation condition in the VHF/UHF bands, an 802.22 WRAN signal can reach a much longer distance, compared to Wi-Fi and Wi-MAX signals transmitted on frequencies above 2 GHz. In fact, 802.22 WRAN is designed to provide wireless broadband access to rural and suburban areas, with an average coverage radius of 33 km that can increase to 100 km.

To realize the advantages of IEEE 802.22 technology, there are many technical challenges that must be overcome. For example, to avoid causing interference to incumbent users, namely, TV receivers, WRAN systems must be able to perform spectrum sensing and detect these incumbents at very low signal strength. Another challenge is how multiple

WRANs can coexist and interact with networks of other types. Whereas these challenges are general in any 802.22 deployment, for rural scenarios the success of IEEE 802.22 technology and the like depends on two important factors, namely:

- Whether service providers can offer attractive low cost service for the rural market

- How to ensure the efficiency of operation in large coverage scenarios

In terms of service content, it should be noted that customers in rural communities are more familiar with and have higher demand for traditional applications such as telephony and TV broadcasting, than for the Internet, data, or other multimedia applications. To account for this, we propose a service model that combines TV broadcasting and data services to facilitate the growth of rural demand for connectivity.

To reduce costs and increase customer population, rural wireless networks must be deployed in large coverage areas. In such cases, if TDD is used as in 802.22 WRAN, the system efficiency will be seriously affected by the TDD turn-around time which the time a system must stay idle for nearby and faraway subscribers to synchronize their uplink transmission. To address this problem, we propose an adaptive TDD technology that effectively eliminates the requirement for long TDD turn-around time and thus increases the efficiency of large coverage rural networks [7].

## 2. RESEARCH CHALLENGES

In this section, we highlight the challenges faced by service providers in the rural information and communications technology (ICT) market. This is followed by a discussion of existing technologies that were proposed or deployed for rural communications. Compared to the urban ICT market, the rural market exhibits a significant mismatch between costs and demand. In particular, the rural ICT market can be characterized as follows.

- *High deployment/maintenance cost*: Deploying and maintaining a communications network in rural areas often incurs higher costs, compared to doing so in urban areas. This is due to large coverage areas, difficult terrains, lack of transportation, and often a shortage of local trained staff.

- *Low customer density and demand*: Most rural areas are sparsely populated. Moreover, customers in the rural market often have lower incomes than those in urban areas and therefore, have less to spend on ICT services. The low service demand also is due to low customer awareness and expertise. This is particularly true in developing countries.

- *Slow service adoption rate*: It has been observed that it takes longer for consumers in rural areas to adopt new services compared to those in urban areas.

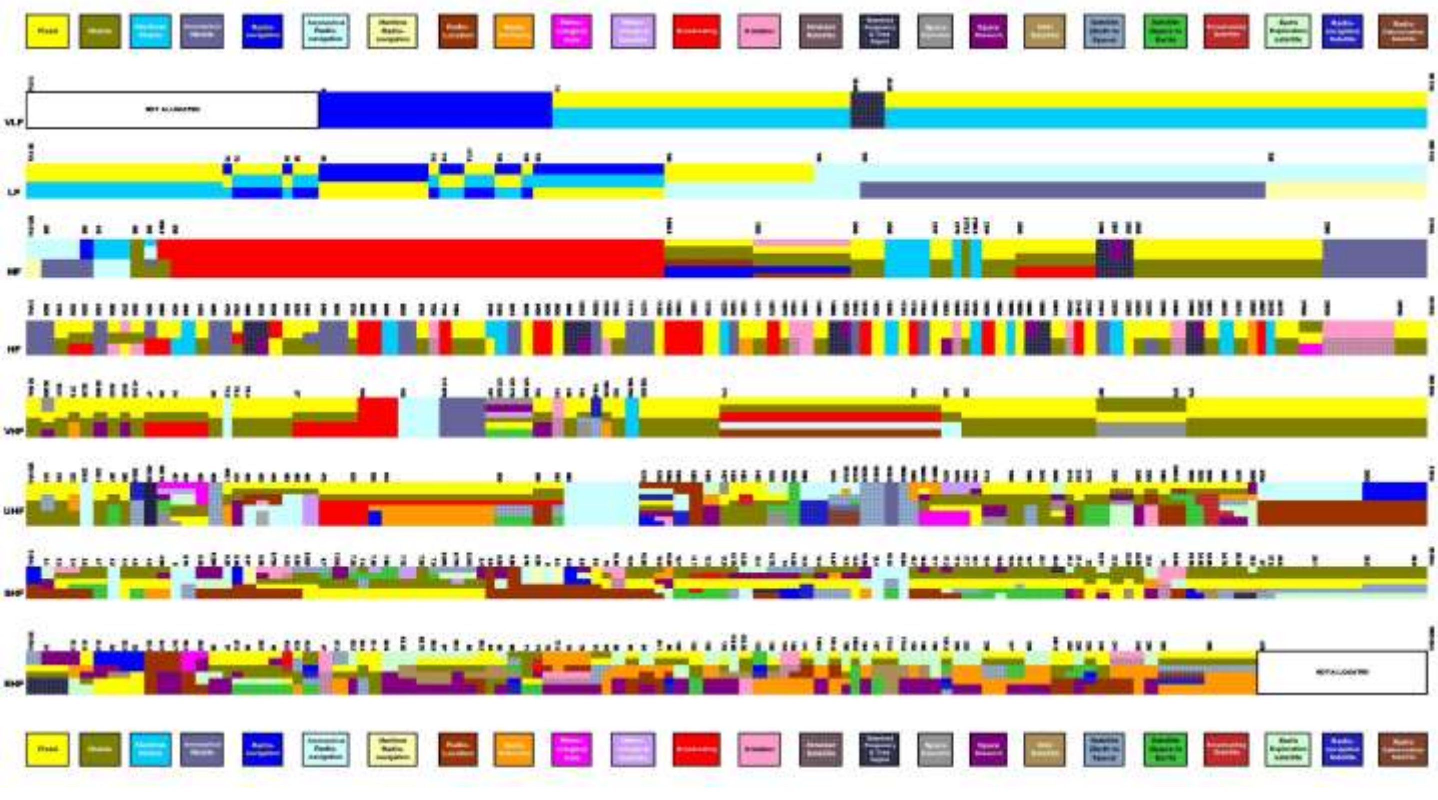

Figure 1. Spectrum Allocation Chart by Govt. of India (As per NFAP 2002)

With the previously mentioned characteristics of the rural ICT market, service providers tend to face the following chicken and egg problem. To reduce the service costs, network providers require a large or fast-growing customer base; however, in rural markets, the customer demand can only be increased if services are offered at sufficiently low rates. To overcome this problem, rural network providers should aim for solutions that incur low costs and offer large coverage.

## 3. EXISTING TECHNOLOGIES

*Cellular/Wireless Local Loop/Satellite:* Fixed cellular and wireless local loop (WLL) technologies have been proposed for rural communications. Their advantage is the relatively short deployment time. Moreover, with the proliferation of cellular technologies, the cost of portable devices has decreased significantly. Nevertheless, these technologies still require a large user base to offset their costs. Small satellite earth stations are widely used in developing regions, usually for distribution of TV signals and interactive voice/data. Examples include the bank networks in remote parts of Brazil and the India National Information Center Network for government data services. However, the hardware costs and service charges of satellite communications are relatively high for the rural market.

*Wi-Fi and Wi-MAX*: With the success of Wi-Fi technology for short-distance, local area network applications, there has been significant interest in using this technology for rural connectivity. An example is the Digital Gangetic Plain project, developed jointly by IIT Kanpur, India and Media Lab Asia, where IEEE 802.11 technologies are used to provide long-haul access links. This is achieved by using highly directional antennas mounted on tall structures and tuning 802.11 protocols to obtain a much longer coverage (more than 30 km). Compared to cellular and satellite technologies, the advantages of Wi-Fi include ease of set-up and maintenance, relatively high bandwidth, and low costs for both users and providers. Another candidate technology is Wi-MAX, which is based on the IEEE 802.16 standards. Wi-MAX is described as an enabling technology that provides last mile wireless broadband access as an alternative to cable and DSL. Currently, Wi-MAX trials are being performed in several countries.

*DakNet Asynchronous Service Network:* DakNet is a network architecture based on store-and-forward. Instead of real-time services, DakNet provides remote communities with useful asynchronous Internet access. The rationales are:

- Real-time communications are generally too expensive as a widespread investment for the nascent rural ICT market.

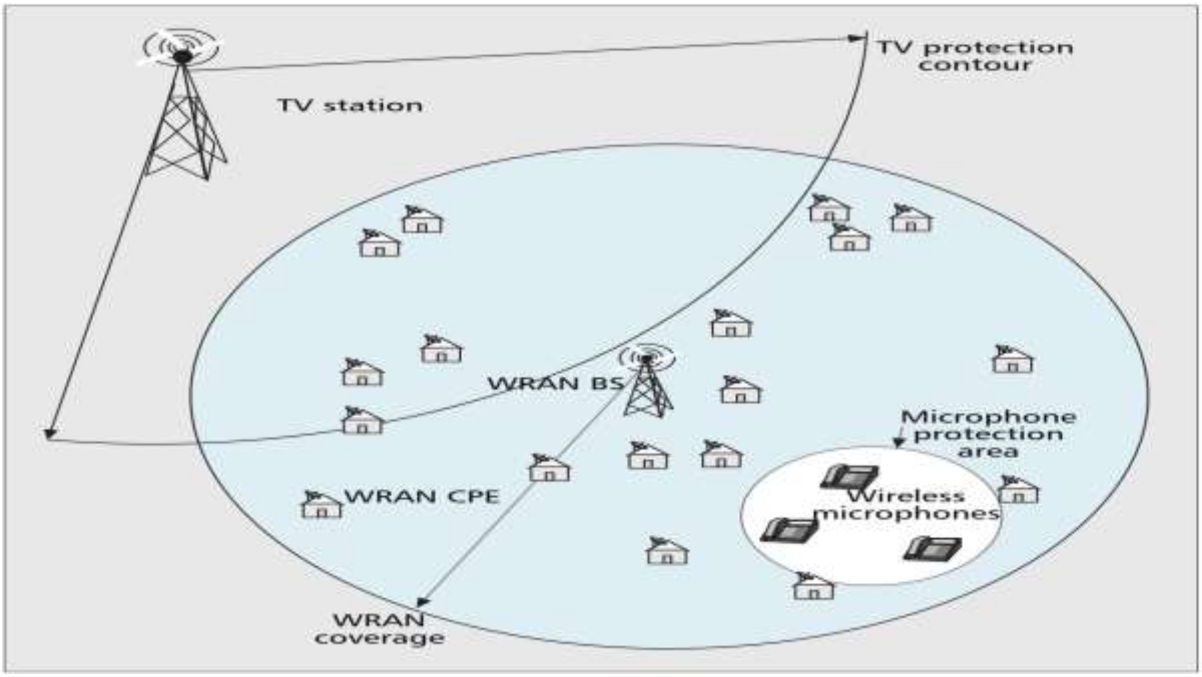


Figure 2. Rural Communication Environment

- Asynchronous ICT services appear to be sufficient to meet most of the needs of rural communities.

- Local information caches can be used to provide local users with immediate access to commonly requested information without the need for real-time Internet access.

The three major entities in DakNet are the hub, the mobile access point (MAP), and Info Kiosk. A physical transport vehicle, for example, a car or motorbike, carries a MAP through a rural area where the DakNet service is provided. When a MAP reaches within the communication range of an Internet hub or an Info Kiosk, it uploads or downloads e-mail, voice mail, and other offline data content. However, due to its asynchronous nature, DakNet is not suitable for disaster/emergency relief situations [5].

## 4. COGNITIVE RADIO TECHNOLOGY

The radio frequency spectrum, as a natural resource, is a crucial medium bridging transmitters and receivers in wireless communications. The frequency spectrum is regulated and licensed by the government or some other government-aided organizations such as Federal Communication Commission (FCC) in United States. Under the regulation of the governments or such organizations, frequency bands are statically assigned to different means or purposes for wireless communications in military or civil use. Users that are allowed to use a specific band are called licensed (Primary) users and others are regarded unlicensed (Secondary or CR) users.

In Figure 1 illustrate the radio spectrum frequency allocations in India (as of 2002) [3]. In the static spectrum allocation is almost no available band left for the future wireless network use. To address this problem, cognitive radio arises to be a tempting solution to the spectral congestion problem by introducing opportunistic usage of the frequency bands that are not heavily occupied by licenced (Primary) user [11]. Cognitive radio definition adopted by FCC is " Cognitive radio: A radio or system that senses its operational electromagnetic environment and can dynamically and autonomously adjust its radio operating parameters to modify system operation, such as maximize throughput, mitigate inference, facilitate interoperability, access secondary markets" [1].

The goal of cognitive radio can be realized only through dynamic and efficient spectrum management techniques. The challenges faces by the cognitive radio user in cognitive radio network are

- Check availability of spectrum hole in statically allocated channel [8]

- Choose the best available channel [9]

- Organise use of this channel with other user

- Leave the channel with detect primary user

To address this problem, cognitive radio focusing four key spectrum concepts: spectrum sensing, spectrum management, spectrum sharing, and spectrum mobility [2, 10].

## 5. PROPOSED DESIGN

The IEEE 802.22 Working Group was formed in 2004 to develop a standard for wireless regional area networks (WRANs), based on cognitive radio technology. WRAN systems will operate on the VHF/UHF TV bands, that is, from 54 MHz to 862 MHz, by opportunistically making use of the unused TV channels. While doing so, it must ensure that no harmful interference is caused to the incumbent users, which include TV receivers and microphone users. Figure 2 illustrates a typical WRAN deployment that consists of a WRAN base station (WRAN BS) serving multiple fixed-location wireless customer premise equipment (CPE). Figure 2 also shows a TV station and a wireless microphone system. The WRAN must ensure that interference caused to all TV receivers within the TV protection contour (around 150 km from the TV station) is below a predefined threshold. Similarly, there is a protection area for the microphone system, but with a much smaller size (a few hundred meters).

For rural communications, IEEE 802.22 technology offers two main advantages, that is, no dedicated spectrum is required, and the coverage is large. These two advantages help service providers address the cost-demand mismatch discussed earlier. In particular, as no dedicated spectrum is required, service providers can save the cost of obtaining a spectrum license. In addition, wide coverage is essential to reach a large customer base in rural areas. IEEE 802.22 technology is designed to provide the average coverage of 33 km and can increase to 100 km.

Although most of the 802.22 related works has focused on various technical challenges, such as designing advanced spectrum sensing to detect weak TV and microphone signals or providing coexistence for multiple WRANs, we contend that these issues may not be critical for remote, rural WRAN deployments. In particular, in remote areas, there may be TV channels that are always available for 802.22 access, that is, without any need of spectrum sensing. Also, it is not likely that multiple WRANs will be deployed in a sparsely populated region. Based on the previously mentioned arguments, we believe that the success of 802.22 as a technology for rural communications significantly depends on whether a scalable service model can be introduced for the rural market, and whether the technology can be deployed in an efficient way.

Two important factors that determine the growth of the rural ICT market are cost and service content. In terms of service content and other surveys, although there are many potential applications, in the short-term, only email, scan-mail, voice-over-e-mail, and chat are likely to be revenuegenerating applications for the rural market. We further contend that to increase the demand in the initial phase of network deployment, service providers should focus on traditional applications such as telephone and TV broadcasting. Data services such as e-mail, Internet access, and video streaming, should be introduced gradually, in accordance with the adoption and awareness of rural customers.

Based on the above arguments, we propose that service providers start with a TV broadcasting service, as the demand and awareness already exist in rural communities. This TV broadcasting can be combined with delay-tolerant, asynchronous data applications such as e-mail and voice mail. These data applications can be scaled up in accordance with demand. Furthermore, when the need arises, such as in emergency/disaster responses, TV broadcasting can be switched off to deliver command, control, and rescue information. With this, we can eventually create a widespread wireless infrastructure that grows seamlessly with the rural communications market.

## 6. CONCLUSION

This research starts with mismatching factors in rural communication like cost and coverage area. The challenges in rural communication and existing wireless technologies are reviewed. In this research provide the novel design for rural communication with cognitive radio technology and IEEE 802.22 WRAN. This type of rural communication reduces the cost of the service and covers the more geographical area. Further, this research is going to concentrate on development of algorithms to improve the efficiency and throughput of the rural communication service.

## REFERENCES

[1] Federal Communications Commission “Notice of proposed rulemaking and order: Facilitating opportunities for flexible, efficient, and reliable spectrum use employing cognitive radio technologies” ET Docket No. 03-108, Feb 2005.

[2] K.S. Yuvaraj and Dr. V. Thiagarasu, “A study and analysis the spectrum key functionalities in Cognitive Radio Network,” International Journal of Advanced Research in Computer Science, vol.4 no.8, May–June, 2013, pp. 233-237

[3] Government of India, Ministry of communication and IT, department of Telecom, WPC Wing Spectrum Allocation Chart, April 2007.

[4] R. Westerveld and R. Prasad, “Rural Communication in India Using Fixed Cellular Radio Systems,” IEEE Commun.Mag., Oct. 1994, pp. 70–74

[5] A. Pentland, R. Fletcher, and A. Hasson, “DakNet:Rethinking Connectivity in Developing Nations,” IEEE Computer, vol. 37, no. 1, Jan. 2004, pp. 78–83

[6] IEEE 802.22 Wireless RAN, “Functional Requirements for the 802.22 WRAN Standard, IEEE 802.22-05/0007r46,” Oct. 2005

[7] Ying-Chang Liang and Anh Tuan Hoang, “Cognitive Radio on Tv Bands: A New Approach To Provide Wireless Connectivity for Rural Areas”, IEEE Wireless Communications, June 2008, pp-16-22

[8] Y.-C. Liang et al., “Sensing-Throughput Tradeoff for Cognitive Radio Networks”, IEEE Trans. Wireless Commun., vol. 7, no. 4, Apr. 2008, pp. 326–37

[9] Ian F. Akyildiz, Won-Yeol Lee, Mehmet C. Vuran and Shantidev mohanty “A Survey on Spectrum management in Cognitive Radio Networks” IEEE communications, Apr 2008

[10] Ian F. Akyildiz, Won-Yeol Lee, and Kaushik R. Chowdhury “Spectrum Management in Cognitive Radio AD Hoc Networks”, IEEE Communication, July/Aug 2009

[11] J. Mitola III “Cognitive radio: an integrated agent architecture for software defined radio”, Ph.D. Thesis, KTH Royal Institute of Technology, 2000.