An approach to Cognitive Network Cooperation of TV station based Green Cellular Network

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ABSTRACT
Energy efficiency (EE) is very crucial for future wireless communication systems, especially for cellular devices. Cellular network can cooperate with other wireless infrastructure for exploiting the detected spectrum holes to support energy-efficient cellular communication. TV white space (TVWS) can be used for Base station (BS) to User terminal (UT) communication with the aid of the existing cellular infrastructure. Since different wireless networks cognitively co-operate with cellular networks, this approach is termed as cognitive network cooperation. In order to achieve energy efficiency, relay station can be used as a cooperative partner with cellular base stations. To achieve this goal, the unused TV spectrum has to be identified. Than these unused frequencies (TV white space) and intermediate node (relay) can be used for signal transmission and reception from cellular BT and UT. The energy efficient performance relies on channel state information (CSI) of channels. Hence for energy efficient transmission of signal interference should be low. For a given number of information bits to be transmitted, the total energy consumed is significantly reduced, when both cognition and cooperation used in cellular networks, as compared with the conventional direct transmission, pure cognition, and pure cooperation.

General Terms
CLOUD DATA CENTRE, RELAYS, SPECTRUM SENSING, TVWS

Keywords
Cognitive radio, co-operation, energy-efficiency, green communication, TV spectrum

1. INTRODUCTION
The significant growth in wireless communication e.g. CDMA,GSM,3G,4G,5G network etc. has resulted in increasing demand of energy consumption[1]. Battery capacity is limited and the progress of battery technology is very slow, with capacity expected to make little improvement in the near future. It is claimed that battery capacity has only increased by 80% within the last ten years, while the processor performance doubles every 18 months following Moore's law. As the device switch from lower evolution of network to higher, the energy consumption gets approximately double on each next evolution as shown in table 1.1. Due to this requirement of energy the higher evolutions e.g. 4G LTE operated devices restricted to certain locations. 4G LTE devices are expected to support higher data rates and multi standard radio interfaces (UMTS, LTE, and Wi-Fi, Bluetooth etc.) to provide users with a continuous connection.

Table 1.1 Power consumption comparisons at different network

S.No.	Network	Power consumption
1.	CDMA	0-1 watt
2.	2G,GSM	2-4 watt
3.	3G	4-6 watt
4.	4G, LTE	6-8 watt

However, state-of-the-art multi standard devices have high power requirement for maintaining two or more radio interfaces. We are moving from a relatively low to higher data transmission speed network and their power consumption also increasing with the speed. Approximately 1-2 watt power consume in the first generation devices and around twice in 3G mobile devices. The perspective for the future does not look encouraging in this aspect, as one could easily expect another doubling in the power demand for 4G devices. In the case of large path loss and deep fading, more transmit power is generally needed to maintain a target Qi's requirement. It is therefore extremely important to reduce the energy consumption at both the BS and UT. As the BS transmitted power is directly proportional to square of the distance between the BS and UT. Hence in cellular network, a UT at the edge of its associated cell significantly drains its energy much faster than the user terminal at the center of the cell. It is a worth notice to find the solution which can reduce power consumption at the both BS and UT. The ecological importance of energy efficiency is to reduce greenhouse gas emission. Cellular network energy consumes 3% of the total energy consumption and emits 2% of total co_2 emission [2].hence ecological importance of EE cellular network is to reduce Green-house gas emission Energy efficient network can be achieved by using cognitively cooperation of wireless networks [3]. Suppose in 4G wireless network a signal has to be transmit. Instead of transmit this signal at the cellular spectrum and with higher power, same signal can be transmitted at cooperative network's unused frequency band. And an intermediate node called relay can be used to reduce travelling distance of transmitted and received signal. The co-operation of an additional wireless network partner can help to reduce power consumption of cell-Edge user terminal. In the first of this paper discussion is about conventional cellular network and after this why cognitive radio came inPicture is described also. This paper also discussed about existing detection techniques which are used in cognitive radio and their drawbacks, how they play role in energy consumption etc. In the last section problem of existing cognitive radio are identified and the proposed solution of cognitive aided cooperative green cellular network is discussed.

2. SYSTEM NETWORK

2.1 Conventional cellular system

In India CDMA (900, 1800MHz GSM Band), 4G LTE (2300-2400MHz) operated at the given allotted frequency band. These bands are further distributed among number of mobile operators. Since number of users are increasing the allotted frequency bands traffic increasing also. Due to this huge traffic, interference of transmitting signal is increasing. In order to reduce the interference higher transmission power requires. Therefore the demand of more frequency spectrum is increased. Also the speed of network has growing day by day; to fulfill this requirement of high data rate the power consumption has also increased. Using a phone the average power output can vary between the minimum levels of about .001 watt up to the maximum level which is less than 1 watt.

Fig.2.1 shows conventional cellular system operated under 900MHz, 1800MHz, and 2300-2400MHz band while other services are operating in other frequency band. Because of increasing mobile users the traffic at cellular band is going too congested. It is clearly shown other services still have less number of users; hence these frequencies are not using all the time. To overcome spectrum

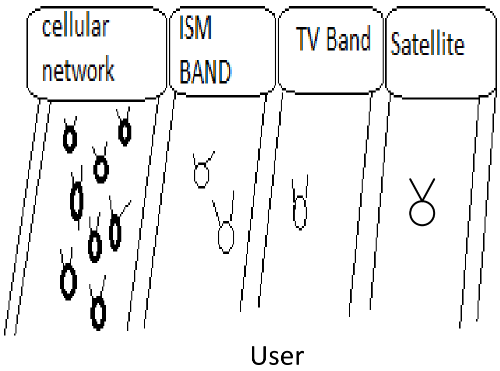

Fig. 2.1 Conventional cellular system

Scarcity cognitive radio comes in picture. CR enables the usage of temporally unused spectrum, referred to as *spectrum hole* or white space.

2.2 Cognition Added Cellular Network

As number of devices has increased, the traffic on RF spectrum has also increased. There are some unused frequencies or some frequencies in idle state which are not using all the time in spectrum band. These frequencies can be allotted to other users who are demanded it in order to reduce traffic in cellular band. For this cognitive radio is used. Cognitive radio is used to enhance spectrum efficiency by using white space in licensed spectrum.

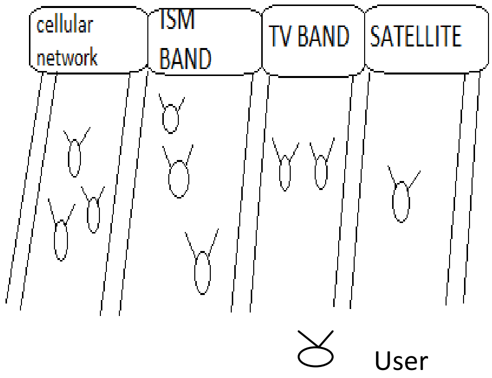

Fig.2.2 cognitive aided cellular system

Fig 2.3 shows cognitive radio cycle in which spectrum is sensed by the both transmitter and receiver in the surrounding environment. Spectrum first sensed than analyze and spectrum decision takes place.

In order to address the challenges of spectrum scarcity, each CR user in the CR network must:

- Determine which portions of the RF spectrum are available.
- Select the best available channel.
- Coordinate access to this channel with other RF users.
- Vacate the channel when a licensed user is detected.

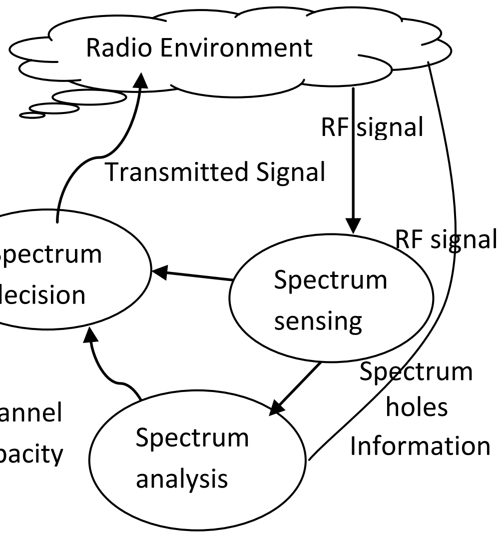

Fig 2.3 cognitive radio cycle

SPECTRUM SENSING PHASE	TRANSMISSION PHASE

Fig.2.4 cognitive transmission phase

The CR transmission process is generally composed of two essential phases:

Spectrum sensing phase: To detect the unused spectrum is known as spectrum sensing. When the channel is not using by primary users i.e. in idle state allot this channel to secondary users. There are many techniques are available for spectrum detection some of them are detection (ED), matched filtering (MF), and feature extraction (FE). Due to its high computational complexity, the FE detector consumes more energy than the ED and the MF detector.

Transmission phase: when the detected channel is in ideal state the process of transmission of secondary users takes place at that available frequency.

3. PROBLEM FORMULATION AND ANALYSYS

Today as digital communication is growing, because of its good quality and high speed. Analog Televisions are switching to digital Television. This switching from Analog to digital leaves analog frequency band free. These free Analog TV spaces which are not using by any services are known as TV white space [5]. TV band channels have a very good transmission and penetration capability. Therefore these free bands can be used by cellular network.

In cognitive radio certain problem has investigated some of them are as follow:

- Different spectrum sensing duration may lead to different number of transmitted bits in the data transmission phase.
- Problem of channel detection probability and false alarm probability.

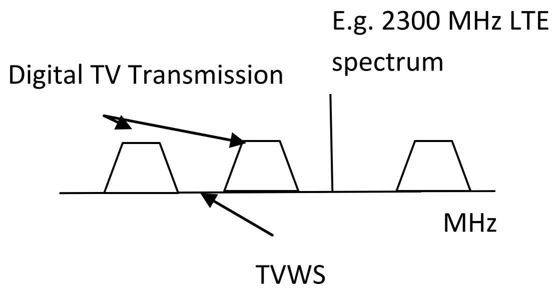

Fig.3.1 TV White spaces in TV spectrum

- Meanwhile since the power consumed for the spectrum sensing and the data transmission are generally different, different spectrum sensing duration cause different energy consumption [6].
- Relay to use or not: always cooperate, or use relay only when the direct link fails?
- Relay selection: if there are many relay selection nodes, how many and which one to select.

4. PROPOSED SOLUTION

Cognition and cooperation aided cellular network:

Cognition means use of unused spectrum while co-operation in the radio network stands for cooperation of other wireless network with the demanding network. Generally cooperated network can be considered as a relay which co-operate with user terminals and base station to transmit and receive signals. The superior propagation properties of TV spectrum allow a higher transmission range at much lower energy requirements [7]. They can offer more bandwidth to mobile users/devices by accessing extra spectrum with an already-deployed cellular spectrum. TVWS refers to TV bands that are not used by any particular geographical area. The problem is that how to find unused TV frequency band? Because in the process of detecting unused TV band, energy consumption at both the BS and UT increased. For finding the unused TV spectrum with less energy consumption, available solution is that, build a location-specific TVWS database, which provides a lookup table service for any D2D link to determine its maximum permitted emission power (MPEP) in an unlicensed digital TV (DTV) band [8]. To achieve this goal, the idea of mobile crowd sensing is first introduced to collect active spectrum measurements from massive personal mobile devices**.** This database can be stored in separate cloud data storage center. And the look uptable has to update time to time. And connect BS and TVS to cloud center through optical fiber cable**.** This can reduce energy consumption in detection of unused spectrum by both BS and UT.

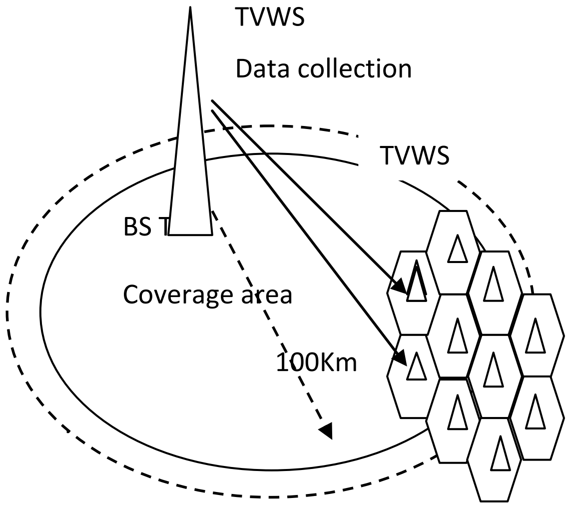

Fig4.1 TVWS database collection

Generally, base station cooperation with TV station consists of two phases:

1) BS transmits its signal to cooperative relay on cellular frequency band with low power.
2) The cooperative relay decodes and forward this received signals to the UT using unused TV frequency.

Fig4.1 shows the TV station coverage in a particular region. In the spectrum sensing approach the availability of TVWS at any location is modeled as a threshold-based hypothesis test. Since TVS coverage distance is very large as compared to mobile station, some of the region may remain uncovered because of terrain area, fading, path loss etc. [9]. This uncovered region can use the TV band for cellular communication with lower energy consumption.

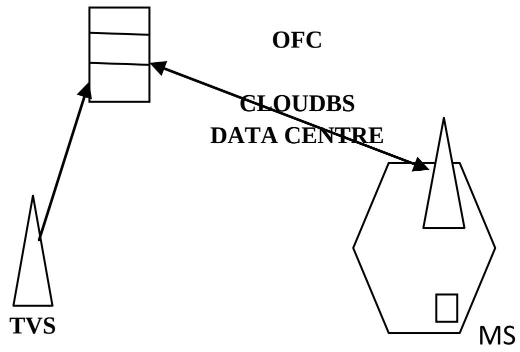

Fig4.2 TVWS information access

Fig4.3 shows proposed system model in which number of relay stations are using as an intermediate node between BS and UT. There is a direct line of sight path between BS and UT which are d distance far to each other. If the signal travels from BS to UT through intermediate relay the distance between the BS and UT can be split into d1 and d2.

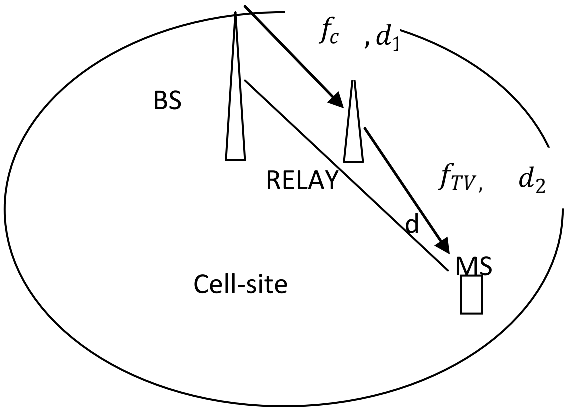

Fig.4.3 cognitive cooperation of BS and relays

Where

d1= is the distance between the BS and relay station, while d2= is the distance between the relay station and UT. It is clearly shown that

d2 << d

Hence, this time power transmission of UT to BS gets reduced because distance has reduced.

5. OVERVIEW

According to Shannon theory of channel capacity, channel capacity is linearly proportional to the bandwidth, but only logarithmically to the transmit power. Hence in respect of this, it can also be readily shown that as the bandwidth tends to infinity the capacity becomes also an increasing function of the power. Shannon's formulae [9] for the maximum channel capacity C of noisy channel is

$c = Blog_2(1 + \frac{S}{N})$ Bits/second (1)

C = Channel capacity

B = Bandwidth

S = average received signal power over the bandwidth

N =average power of the noise and interference over the bandwidth

Hence,

This indicates that given a certain target capacity, the use of additional spectral bandwidth can help in reducing the transmit power in order to maintain a given channel capacity. Hence these assumptions can be taken into account for demonstrating the classic trade-off between the power- and bandwidth-efficiency. Using this approach of transmission of signals on both the cellular band and TV band reduces bandwidth demand of BSs by half. And travelling distance of signal also reduce hence energy consumption will reduce by certain amount. Eq. (2) shows transmitted and received power relation to distance [10]

$P_r = P_{BS}\left(\frac{c}{4\pi d_{BU}}\right)^2 G_{BS}G_{UT}|h_{BU}|^2$Watt(2)

P_{UT} = received power at the user terminal

P_{BS} = Base station transmitted power

C = velocity of light

f_c = carrier frequency

G_{BS} = gain of base station antenna

G_{UT} = gain of user terminal's antenna

h_{BU} = Fading coeffiecient of channel spanning between BS and User terminal

Energy efficiency of cellular network given by

$\Upsilon = \frac{R}{P}$ **Bits / watt** (3)

Υ = Energy efficiency

R = Transmission rate

P = BS transmitted power

Equation (3) shows that to increase energy efficiency rate of transmission should be improved. Hence as the transmission bits per watt increases energy efficiency will be improved. A reliable cognitive radio with high data rates is achievable by using cooperative relays for both the spectrum sensing and secondary transmission. To increase the rate of transmission orthogonal channels can be used. Orthogonal channel will increase bandwidth, reduce bandwidth and transmit data with very low power because the interference will be negligible at the orthogonal channels.

6. CONCLUSION

Radio spectrum is a precious resource which has been used with poor efficiency. Moreover, energy consumption in mobile communications is an important issue, which like in all areas of technology must be reduced as much as conceivably possible to aid the environment The energy required to keep mobile devices connected to the network over extended periods of time quickly dissipates, and battery technology is not sufficiently mature to anticipate existing and future demands for mobile power. Without any new approaches for energy saving, 4G LTE mobile users will relentlessly be searching for power outlets rather than network access, and becoming once again bound to a single location. To avoid the "energy trap" and to making wireless devices more environments friendly, there is a clear need for disruptive strategies to address all aspects of power efficiency from the user devices through to the core infrastructure of the network and how these devices and equipment interact with each other.

7. FUTURE WORK

We have studied that how the energy consumption can be reduce to certain amount by using cooperation of wireless networks(TV and relays) with cellular network. The point of attraction is that how user terminal at cellular network will select the cooperative network which provides transmission at lowest energy. The interference of user terminal at cellular network from other network who invoked to use that unused TV spectrum is also the area of interest. In practical systems, negligible energy resources are spent in the upper-layer protocol management to tackle e.g. routing congestion and medium access collision. As a consequence, it is of high importance to explore the inter-network cooperation by jointly considering the network (NET), medium access control

(MAC), and physical (PHY) layers in minimizing the overall network energy consumption.

8. REFERENCES

[1] JIA ZHU AND YULONG ZOU, Cognitive Network Cooperation for Green Cellular Networks, , (Senior Member, IEEE) School of Telecommunications and Information Engineering, Nanjing University of Posts and Telecomm, Nanjing 210003, China.

[2] G. Y. Li et al., 2011, "Energy efficient wireless communications: Tutorial, survey, and open issues", IEEE Wireless common. Magi. 18(6), 28-35.

[3] L. Li, X. Zhou, H. Xu, G. Y. Li, D. Wang, and A. Soong, 2010, "Energy-efficient transmission in cognitive radio networks," IEEE Consum. Commun. Netw. Conf. (CCNC), pp. 1–5

[4] Y.-C. Liang, K.-C. Chen, G. Y. Li, and P. Mahonen, Sep. 2011, ''Cognitive radio net- working and communications: An overview,'' IEEE Trans. Veh. Technol., vol. 60, no. 7, pp. 3386–3407.

[5] J. Sachs, I. Maric, and A. Goldsmith, Apr. 2010, ``Cognitive cellular systems within the TV spectrum," in *Proc. IEEE DySPAN*, Singapore, pp. 1_12.

[6] L. Li, X. Zhou, H. Xu, G. Y. Li, D. Wang, and A. Soong, "Energy-efficient transmission in cognitive radio networks," IEEE Consum. Commun. Netw. Conf. (CCNC), 2010, pp. 1–5

[7] J. Sachs, I. Maric, and A. Goldsmith, Apr. 2010, ``Cognitive cellular systems within the TV spectrum," in *Proc. IEEE DySPAN*, Singapore, pp. 1_12.

[8] G. Ding, J. Wang, Q. Wu, Y.-D. Yao, F. Song, and T. A. T sifts is, Jan. 2016 ``Cellular-base-station-assisted device-to-device communications in TV white space," *IEEE J. Sel. Areas Communication.*, vol. 34, no. 1, pp. 107_121.

[9] C. E. Shannon, Feb. 1998, ''Communication in the presence of noise,'' Proc. IEEE, vol. 86, no. 2, pp. 447–457.

[10]A.F. Mulish, wireless communication, Wiley, 2011.

[11] www.engineersgarage.com550 × 263Search by image CR Technology. Cognitive radio

[12] M. Fitch et al., Mar. 2011, "Wireless service provision in TV white space with cognitive radio technology: A telecom operator's perspective and experience," IEEE Common. Mag., vol. 49, no. 3, pp. 64–73.

[13] http;//ethw.org/Cellular_base_station