Dynamic Resource Allocation for Heterogeneous Services in Cognitive Radio Networks-Literature Survey

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Abstract
Cognitive Radio Network (CRN) is a promising worldwide network. It meets challenges of efficient spectrum or resource allocation and also lack of spectrum. Efficient resource allocation methodology becomes a new research problem in use of CRN. A most important challenge to this new technology is how to make fair task of available spectrum to unlicensed users. The suitable allocation of idle frequency spectrum coexisting cognitive radios while maximizing total bandwidth utilization and diminishing interference is required for the efficient spectrum utilization in CRN. In this article we study the various methods are used to improve the performance, fairness, effective utilization if unused spectrum by secondary network and present the literature survey on cognitive radio networks, spectrum sensing, challenges and different recent methods analysis for resource allocation.

Keywords
Cognitive Radio Networks, Resource allocation, Energy

I. Introduction

In CRN, the radio frequency spectrum is quiet limited and still increasing the demand of the wireless communication applications and services. Each user wants to utilize the specific frequency band they can assign a license to them. Most of time the frequency spectrum is not used and it is very difficult to identify the unused spectrum. The allocated spectrum utility has not been used properly. These differ from its characters such as time, frequency and geographical locations. Cognitive radio (CR) and dynamic spectrum access (DSA) is new technologies which support to overcome the spectrum scarcity and unutilized frequency band [1]. The CR plays a vital role in wireless communication system in which the transceiver can recognize, which communication channels are in use and which is not in use, and accordingly toggle into empty channels while avoiding busy ones. These techniques are minimizing interference to others and optimize the usages of available frequency radio spectrum. The software defined radio is support to spread spectrum communication. The DSA technology permits unlicensed secondary system to share the spectrum with licensed primary system [2].

CR has a capability that senses neighbouring environment and dynamically adjusts its radio parameters to communicate efficiently. The cognitive radio network architecture is shown in the fig. 1.

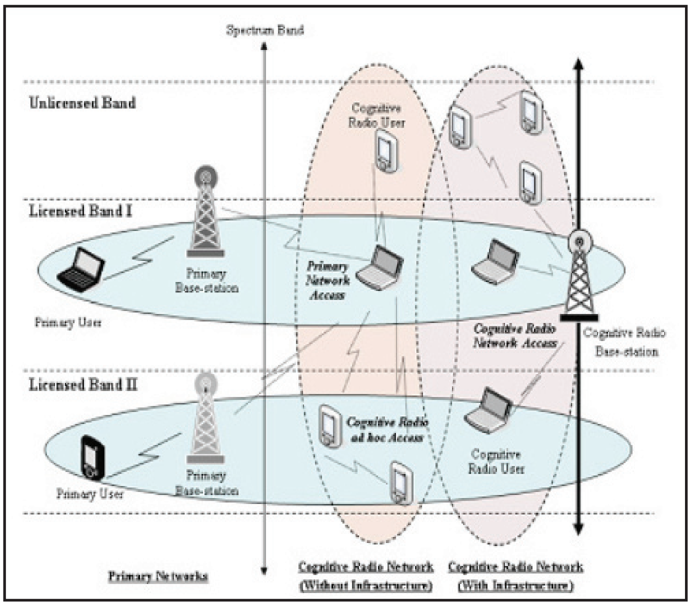

Fig. 1: Cognitive Radio System Architecture [2-3].

We can improve the efficient spectrum utility by allowing the Secondary User (SU) to utilize the licensed spectrum when the licensed user becomes absent. Here spectrum-hole detection is most important; the fig. 2 shows the structure of spectrum-hole architecture.

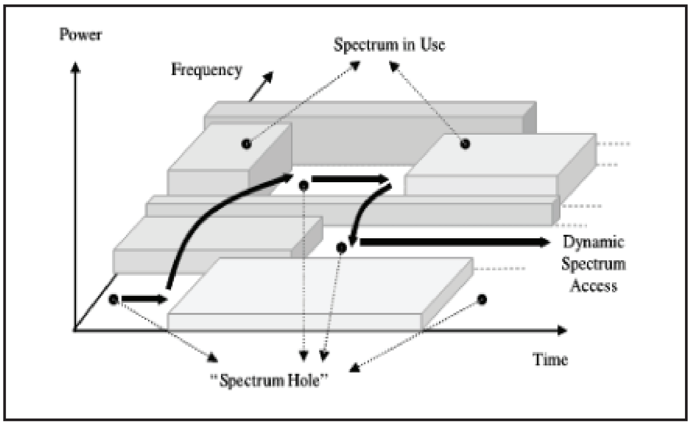

Fig. 2: Spectrum Hole Concept

In CR technology channel sensing is based on priority, Primary User (PU) normally have higher priorities to use the specific frequency spectrum. Secondary User (SU) have lower priority, it uses the spectrum without causing harmful interference to PU [1-2].

Cognitive capability permits the cognitive radio to sense the information from the radio environment in order to find out the unused radio spectrum at a precise time or location. Then the appropriate portion will be selected for the communication without causing harmful interference to the other users [3].

Cognitive radio cycle contains three major parts; they are spectrum sensing, spectrum analysis, spectrum decision. The cognitive radio cycle is shown in the fig. 3.

A. Spectrum Sensing

Determine which section of spectrum is available and detect the occurrence of licensed users and spectrum hole.

B. Spectrum Analysis

It will make view of spectrum hole through spectrum sensing.

C. Spectrum Decisions

A CR determines the channel capacity, spectrum-hole information along with data rate and bandwidth of the transmission. Appropriate spectrum band is chosen for transmission of the signal.

D. Reconfigurability

Reconfigurability implies the radio spectrum to be dynamically changes the functions according to surrounding i.e. cognitive radio can change the radio frequency, transmission power, modulation scheme, communication protocol without any modification of the hardware environment.

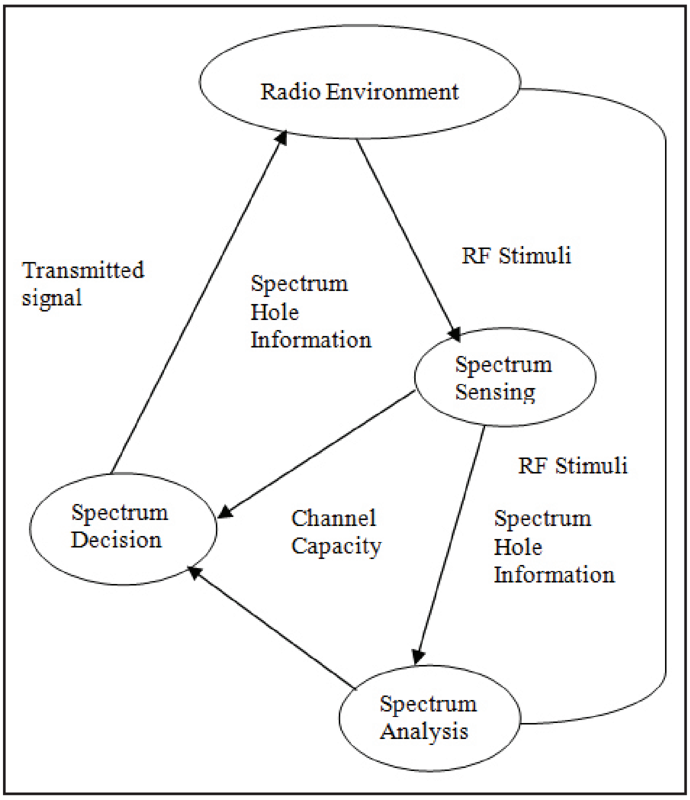

Fig. 3: Cognition Cycle

E. Spectrum Mobility or Handoff

- Spectrum mobility permits the CR user to modify its operating frequency. CR networks are trying to use the spectrum dynamically allowing radio terminals to functioning in the best available frequency band, to maintain transparent communication requirement during the transition to a better frequency.
- The following figure shows the spectrum management functionality and it contains the functions such as spectrum mobility, spectrum analysis, and spectrum sensing and spectrum decision.

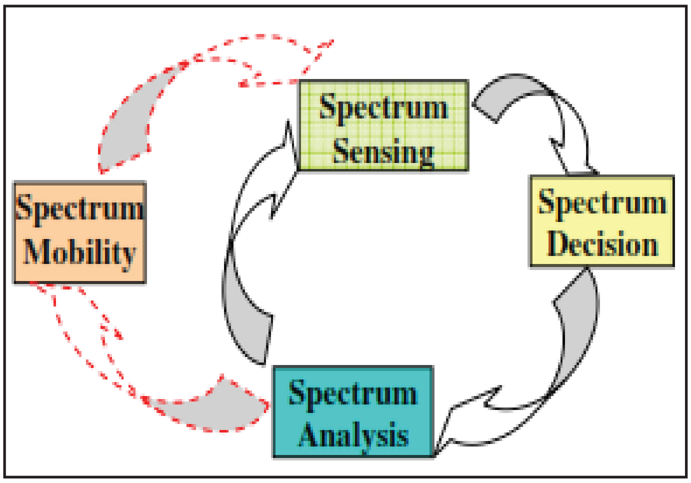

Fig. 4: Spectrum Management Functionality

II. Dynamic Spectrum Access

Dynamic spectrum access (DSA) plays vital roles in wireless communication system and in order to allocate the available bandwidth in efficient and effective mode. It supports to minimize unused spectrum bands or white spaces. Cognitive radio has the characteristic that it must not interfere with licensed band. When the primary user wants to start transmission, the CR enabled device free that band and switch to another free band. This technique of the dynamically accessing the unused bands for proper utilization is known as DSA [4].

III. Dynamic Spectrum Access Technology

Several methods are there for dynamic spectrum access methods. There some models like game theory approach, measurement–based model for dynamic spectrum access, Dynamic Spectrum Access Using a Network Coded Cognitive Control Channel, Fuzzy Logic Based System, Spatio-Temporal Spectrum Management Model, Markovian Queuing Model for Dynamic Spectrum Allocation etc,

A. Game Theory Approach

Game theory technology plays important roles like unused resources are dynamically allocate to others. It has multiple decision architects [5].

1. Decision Makers (N)

Every game is considered to have a finite number of decision makers or players N.

2. Action Space (A)

Every player "i" has its individual action space (Ai). The set of actions including all possible actions that player can desire. The total action space 'A' is calculated by multiplying all action sets [5].

A= A1×A2×A3×…AN

3. Utility Set (U)

This consisting utility or payoff functions for all players

U= $\{U_1, U_2, U_3 \ldots U_N\}$

The game approach contains models, functions, and technology of mathematical framework [5].

4. Cooperative Games

Everyone is very interested about all overall benefits but not very concerned about their own personal benefit.

5. Competitive Games

Every user is principally concerned about his private payoff; therefore all decisions are made competitively and selfishly.

B. Measurement-based Model for Dynamic Spectrum Access

It is fully based on measurement approach. WLAN provide good performance due to Markova measurement is used to capture its activities. The decision framework based on its actual measurements in the 2.42.4GHZ ISM band using a vector signal analyzer to get composite base radio band data.

Unlike from existing publication a viable WLAN adapter card is used to get packet trace but here a vector signal analyzer.

The measurement setup architecture contains a wireless router (Netgear WGT624) and wireless adapter cards (two number of Netgear WG311T and one WG511T) with three computers in the WLAN. After capturing the transmission of WLAN, vector signal analyzer accumulates the complex data base band models and it within down converts 2.462GHz to an internal Intermediate Frequency at a sample rate of 44MHZ. Continuous-time Semi-Markov method allows an arbitrary specification of temporary time distribution in each state.

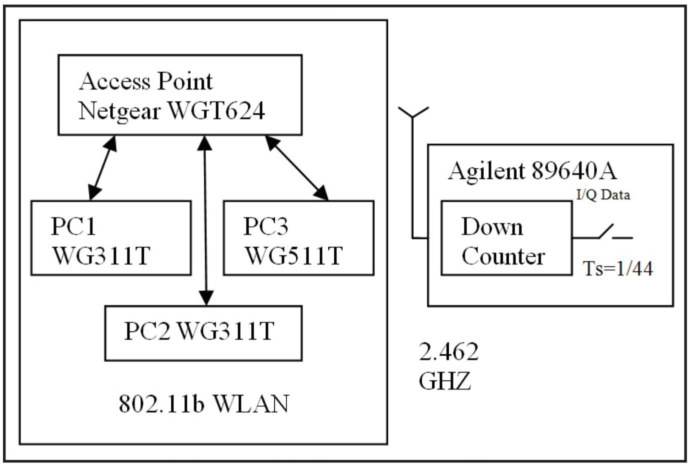

Fig. 5: Measurement Setup

C. Fuzzy Logic Method

Fuzzy logic provides some way to get the resolution to a drawback primarily based on inaccurate, noisy, and incomplete info. Symbolic logic uses a group of fuzzy membership functions and indirect rules to get the answer that meets objectives fascinating. Symbolic logic management contains fuzzifier, symbolic logic processor and defuzzifier. The fuzzifier is employed to plot the particular inputs by creating them fuzzy, the symbolic logic processor provides associate abstract thought engine to induce an answer supported sets of predefined rules, and also the defuzzifier is applied to convert the answer to real output.

It has ambiguous logic. Several input parameters area unit accustomed take the choice like distance, signal strength, speed and spectrum potency area unit referred to as input parameters. The possibility of taking call is accumulated if the channel that offered by atomic number 94 signals is high and distance between atomic number 94 and SU is low. If the space is tiny, the speed will increase the possibility of the spectrum accessing is a lot of [6-7].

IV. Multi-Dimensional Spectrum Awareness

The definition of chance is outlined as a band of frequencies that aren't getting used by the first user of that band at explicit selected time in a very particular geographic square measures" [8] the spectrum area contains a significant 3 components are frequency, time and area. Standard sensing methodology is depends on frequency, time and area. Recent multi antenna technologies square measure raised and with the recent advances in multi-antenna technologies, e.g. beamforming, multiple users are often multiplexed into identical channel at identical time within the same geographic region, the various kinds of fuzzy logic examples as given below [15].

Multi-Dimensional radio-frequency spectrum area and Transmission Opportunities as shown below

Scenario I

1. Dimension: Frequency
2. Technique: Opportunity in the frequency domain.
3. Commands:
   - Accessibility in part of the frequency radio spectrum.
   - The available radio spectrum is divided into narrower chunks of bands.
   - Spectrum opportunity dimension means all the bands are not used simultaneously at the same time, i.e. some bands might be available for opportunistic usage.
4. Illustration

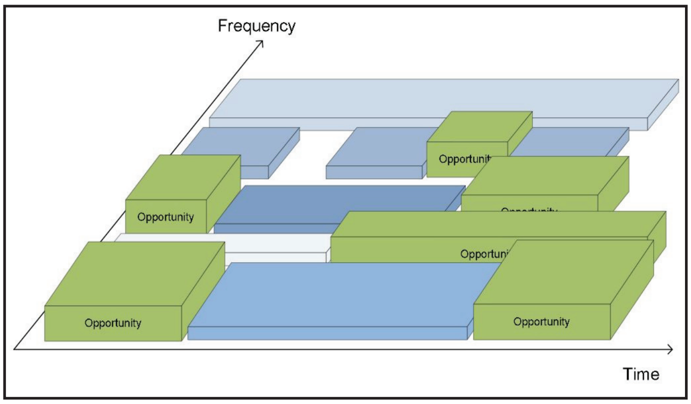

Fig. 6: Spectrum Opportunity illustration

Scenario II

1. Dimension: Time
2. Technique: Opportunity of a specific band in time.
3. Commends:
   - This involves the availability of a specific part of the spectrum in time.

Scenario III

1. Dimension: Geographical space.
2. Technique: Location (latitude, longitude, and elevation) and distance of primary users.
3. Commands:
   - The spectrum resource may be available in some parts of the environmental area even as it is occupied in some other parts at a given time. This takes improvement of the propagation loss (path loss) in space.
   - The spectrum resource could be on the market in some components of the environmental space even as it is occupied in some alternative components at a given time. This takes improvement of the propagation loss (path loss) in area.
   - These measurements will be avoided by merely showing at the interference level. No interference suggests that don't primary user transmission in an exceedingly native space. Though, one has to take care due to hidden terminal downside.

4. Illustration:

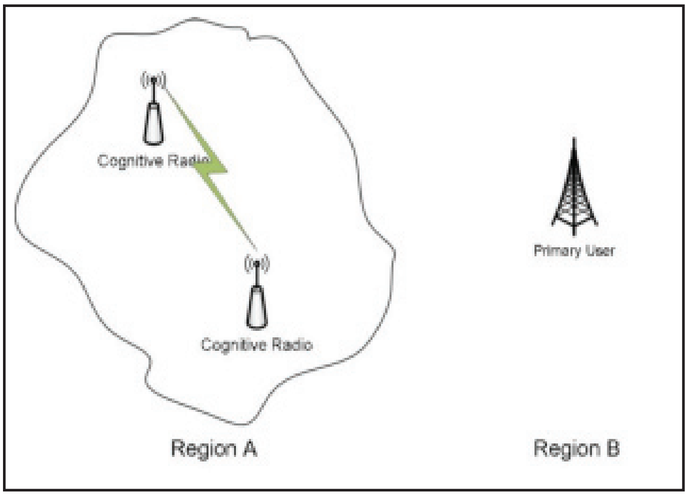

Fig. 7: Geographical Space for Spectrum Access

Scenario III

1. Dimension: Code
2. Technology:
- The primary users are used the spreading code, time hopping (TH), or frequency hopping (FH) sequences.
- Secondary users required for timing information for synchronize their transmission with respect to primary users.
3. Commands:
- The spectrum over a band may be used at a given time through unfold spectrum or frequency hopping.
- Simultaneous transmission while not intrusive with primary users would be doable in code domain with Associate in nurture orthogonal code with relevancy codes that primary user's square measure victimization.
- This needs the chance in code domain, i.e. not solely detection the usage of the spectrum, however additionally deciding the used codes, and probably multipath parameters similarly.
4. Illustration:

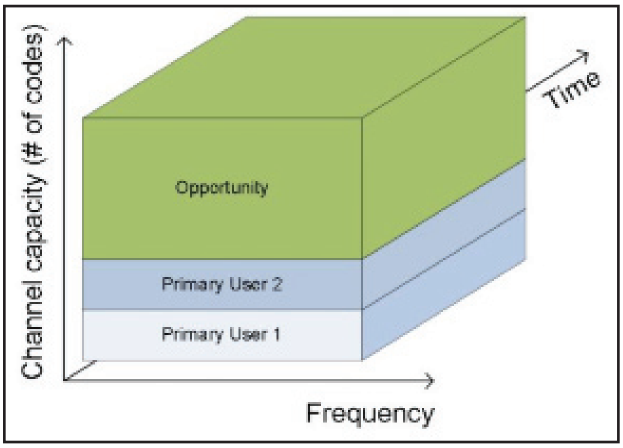

Fig. 8: Code Domain

Scenario IV

1. Dimension: Angle
2. Technology:
- Directions of primary users' beam (azimuth and elevation angle) and locations of primary users.
3. Commands:
- Along with the data of the location/position or direction of primary users, spectrum opportunities in angle dimension will be created.
- For example, if a primary user is sending during a specific direction, the secondary user will transmit in different directions while not making interference on the first user.
4. Illustration:

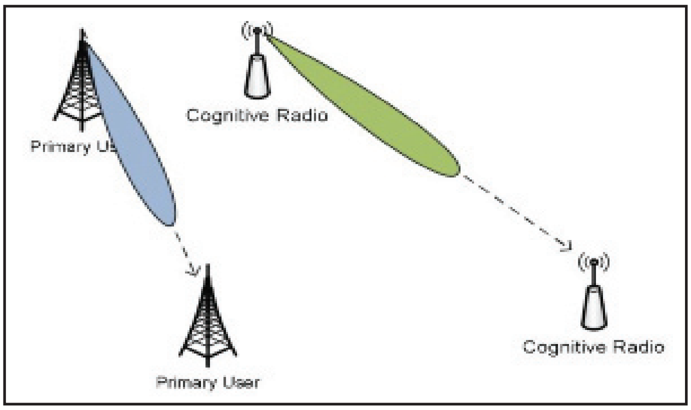

Fig. 9: Angle Architecture

V. Comparative study of DSA

Table 1: Comparative Study of DSA Analysis

Years of Publication	Methodology	Result
2010 [13]	RA-Game and PS-game approach	Significant improvement of throughput
2003 [14]	They have been formulated a general power allocation problem for a multi-node wireless network with time varying channels and adaptive transmission rates. Control algorithm also proposed	Solved a constrained optimization problem each timeslot, and achieved a significant performance.
2008 [15]	A novel Multi-Channel Contention Graph (MCCG) and an optimal algorithm to compute maximum throughput solutions. Heuristic algorithms also used.	Achieved a good trade-off between throughput and fairness.
2008 [16]	Lyapunov Optimization and scheduling and resource allocation algorithm	Achieved explicit performance.
2008 [17]	distributed power conserving PU detection architecture and investigate the impact of PU detection accuracy on DSAN performance are proposed	Achieved good performance
2014 [18]	Proposed a spectrum resource utilization maximization scheme with joint consideration of relay selection and spectrum scheduling problems.	Achieved outperforms the existing schemes in terms of secondary network throughput.
2009 [19]	Developed a set of node-based iterative power control algorithms for solving the MDB optimization problem using the high-SINR approximation of the link capacities.	Achieved optimal throughput
2010 [20]	proposed a Dynamic Spectrum Access scheme which allows the users to opportunistically and efficiently access the channels available for communications.	proposed solution is feasible, capable of providing satisfactory performance, and suitable for implementation in real systems.

2015 [21]	They proposed a new approach to improve scheduling of resources for RT and NRT traffic and to facilitate heterogeneous traffic in virtualized LTE networks.	Improved the performance (reducing the blocking of real-time flow and improving the throughput of non real-time flow).
2007 [22]	Developed QoS-aware distributed DSA schemes using game-theoretic approach. propose two game-based DSA algorithms:- One resorts to proper scaling of the transmission power according to each user's useful utility range. Second Embeds the QoS factor into the utility function used during gaming.	Simulations confirm that the proposed DSA techniques outperform existing QoS-blind game models in terms of the spectrum sharing efficiency in heterogeneous networks.
2016 [23]	They have been proposed an algorithm to divide the propose Problem into three sub-problems, which can be solved using the convex optimization methods.	Achieved significant sum MSE performance Gain over the non-robust algorithm.
2016 [24]	They are proposing a novel cooperative sensing scheme with attack aware capability in the presence of a malicious PUEA.	Simulation results are presented to indicate the performance improvement of the proposed method against PUEA compared with the conventional method.
2015 [25]	develops an analytical framework to model the steady-state sending rate of collecting cognitive radio (CR) sensors in rate-based generic additive-increase multiplicative-decrease (AIMD) and additive-increase additive-decrease (AIAD) congestion control schemes. They formed the queue length distribution of a CR node by a semi-Markov chain (SMC) with assuming general probability density functions (PDFs) of input rate and attainable sending rate of the node.	These PDFs are derived based on the parameters of MAC and physical layers and CRSN configuration. The proposed models are verified through various simulations and achieved significant performance.
2016 [26]	Stackelberg game algorithm is proposed	Achieved optimal performance
2016 [27]	Stackelberg game algorithm is proposed	Achieved significant improvement of throughput.
2015 [28]	They proposed low VDF and Nyquist band improvement algorithm.	Improved power consumption and battery usage.
2016 [29]	Distributed correlated equilibrium approach is proposed	Achieved a significant efficiency and throughput.
2015 [30]	Proposed a user mobility prediction algorithm	Achieved a significant performance
2012 [31]	Adopted modulation and automatic repeat request approach	Achieved performance in Rice channel is effectively improved as Rice factor increases
2016 [32]	Fuzzy logic algorithm is proposed	Achieved effective channel selection
2012 [33]	Proposed a novel pre-equalization stage for Spatial modulation (SM) which allows mitigating the fading effect of the wireless channel.	Achieved significantly enhances the performance of SM.
2013 [34]	Nash bargaining approach is proposed	Achieved efficient throughput
2013 [35]	They proposed a new resource allocation optimization framework	Significantly increased the efficiency
2016 [36]	Markov chain and the matrix-analytic method is proposed	The performance of the system is satisfactory when primary and secondary users share the network.
2010 [37]	Discrete Time Markov Chain (DTMC) model.	Achieved Maximize throughput

VI. Conclusion

In this literature review, we have presented various techniques of dynamic spectrum access in cognitive radio networks. We studied the various methods of implementing techniques and results. Finally we presented comparative analysis of resource allocation by dynamic access method. Each method could have been achieved significant improvements like throughput, performance, efficiency, channel allocation, efficient usage of unused radio spectrum are summarised.

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