UNIT I-INTRODUCTION TO SOFTWARE DEFINED RADIO

PART – A

1. **What is Software-Defined Radio?**

The International Telecommunication Union (ITU) has proposed a definition of SDR as a "radio in which the operating parameters including inter alia frequency range, modulation type, and/or output power limitations can be set or altered by software".

2. **Evolution of Software-Defined Radio**

Tier 0 - describes hardware based radios, and is actually not considered to fall into the realm of SDR.

Tier 1 - The simplest SDR technology begins with Tier 1, which describes software controlled radios (SCR) with only the control functions being processed by software.

- The simplest example to this is a dual mode cell phone, which consists of two hardware radios for two different standards.
- The software simply controls which radio should be utilized.

Tier 2 - Reconfigurable software defined radios present Tier 2. SDR systems include reconfiguration by allowing control over modulation techniques, security functions (such as frequency hopping) and waveform requirements over a broad frequency range provided by software. Tier 2 SDRs include processing applications such as

- Application-specific integrated circuits (ASIC),
- Field-programmable gate arrays (FPGA) and
- Digital signal processors (DSP).

Although reconfigurable SDRs are the most commonly used systems today, especially for military applications, due to the rapid sophistication of the general SDR technology these systems become increasingly obsolete.

Tier 3 - Software defined radios, also called ideal software radios (ISR), will eventually become the mostly implemented systems within the near future. Based on the extended possibilities of programmability to the entire system, analog conversion will be completely realized only by the antenna, microphones and speakers.

Tier 4 -The SDR Forum declares that ultimate software radios (USR) as Tier 4 technologies "are defined for comparison purposes only". In theory, these USRs are supposed to be capable of supporting a broad frequency range, air-interfaces and applications, allowing switching between air-interface formats and different applications within only milliseconds

3. **List out the potential benefits of SDR.**

SDR concept started in the late 1970s with the introduction of multimode radios operating in VHF band

• U.S. Air Force Avionics Laboratory initiated the Integrated Communication, Navigation, Identification and Avionics (ICNIA) program in the late 1970s

– Developed an architecture to support multifunctional, multiband airborne radios in the 30 MHz -1600 MHz band

– Successful flight test and final report delivery in 1992 – ICNIA radio was the first programmable radio

• In the late 1980s, the Air Force Research Laboratory initiated the Tactical Anti-Jam Programmable Signal processor (TAJPSP)

– Developed a processor capable of simultaneous waveform operations using modular approach

– TAJPSP later evolved into the SPEAKeasy program

• SPEAKeasy was a joint U.S. Government program to develop the architecture and technology to meet future military requirements for multimedia networking operations

– The first significant military investment to integrate various existing radio families into one family

– COTS-based architecture

– Demonstrated multiband, multimode radio capabilities in 1998

– SPEAKeasy evolved into the Joint Tactical Radio System (JTRS)

• JTRS Joint Program Office was established in 1999

4. **Define dynamic spectrum access.**

Dynamic spectrum access is a new spectrum sharing paradigm that allows secondary users to access the abundant spectrum holes or white spaces in the licensed spectrum bands. DSA is a promising technology to alleviate the spectrumscarcity problem and increase spectrum utilization.

5. **What is the role of spectrum policy?**

Software radios may operate on any RF band that is within the capabilities of the underlying radio platform, and with any mode for which a software load-image is available. This raises the possibility of truly novel ap- proaches to spectrum management

6. **What are the tradeoffs required in SDR?**

Step 1 - Antenna Tradeoffs - The choice of antennas (step 1 in the figure)

Step 2 - **RF and IF Processing Tradeoffs -** determines the number and bandwidth of RF channels

Step 3 - **ADC Tradeoffs -** Constrains the numbers and bandwidths of ADCs

Step 4 - **Digital Architecture Tradeoffs -** Additional parallel IF processing and ADC paths may be necessary to support multiple-service bands simultaneously. The ADCs provide high-speed streams for heterogeneous multiprocessing

Step 5 - **Software Architecture Tradeoffs - -** General-purpose processors yielding a multithreaded, multitasking, multiprocessing operating environment. Software objects must be organized into real-time objects

Step 6 - **Performance Management Tradeoffs -** The effective hosting of these objects onto this complex operating environment requires a refined set of techniques unique to this text called *SDR performance management*

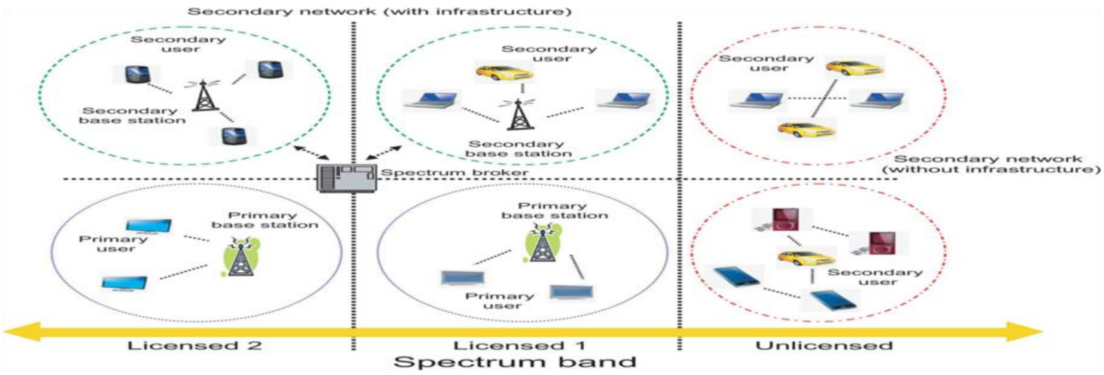
7. **What is agile radios?**

In order to support new services for some users, the networks will have to become more agile in their ability to tailor content for disadvantaged users (low-data- rate users; those in severe jamming environments; those with few batteries, etc.).

8. **Define the term data explosion.**

The information **explosion** is the rapid increase in the amount of published information or **data** and the effects of this abundance. As the amount of available**data** grows, the problem of managing the information becomes more difficult, which can lead to information overload.

9. **Draw the cognitive radio bands.**



10. What are the security aspects of cognitive radio?

CR technology is the "intersection of personal wireless technology and computational intelligence," where CR is defined as "**a really smart radio that would be self-aware, RF-aware, user-aware, and that would include language technology and machine vision along with a lot of high-fidelity knowledge of the radio environment**

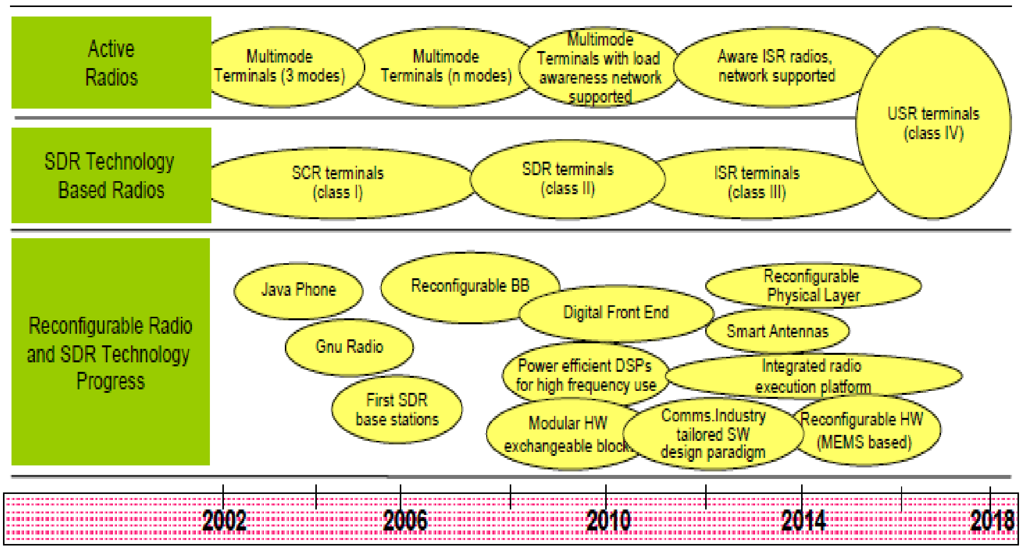
11. What are the potential benefits of SDR?

POTENTIAL BENEFITS

The militaristic developers hoped for the accomplishment of several benefits that a software based system could provide. These **potential benefits included**:

- **Interoperability** – Support of multiple standards through multimode, multiband radio capabilities
- **Flexibility –** Efficient shift of technology and resources
- **Cost reduction –** Less infrastructure, less maintenance, easier deployment
- **Adaptability** – Faster migration towards new standards and technologies through programmability and reconfiguration
- **Responsiveness -** To allow quick and easy incorporation of future developments

12. Draw the road map for SDR Development



13. What is the antenna design considerations in cognitive radio systems?

The antenna characteristics determine not only the gain due to aperture effects, but also several critical characteristics of the SDR, including:

- The number of antenna channels required to support multiband multimode operation
- Usually, the number of parallel RF conversion chains
- Often, the number of ADCs and DACs required Parallelism is a major cost driver for software radios.
- Higher-gain antennas achieve this gain over relatively small segments of RF

14. Mention the types of antenna's used in CR

Yagi uda

Microchip

Dish Antenna

Reconfigurable antenna

15. Define prototyping.

The **Prototyping** Model is a systems development method (SDM) in which a **prototype** (an early approximation of a final system or product) is built, tested, and then reworked as necessary until an acceptable **prototype** is finally achieved from which the complete system or product can now be developed.

16. What are the goals of RF Targeoffs?

The goal of this tradeoff is

- to balance the noise,
- spurious components,
- inter modulation products, and
- Artifacts.

17.Draw the tradeoff for Digital architecture.

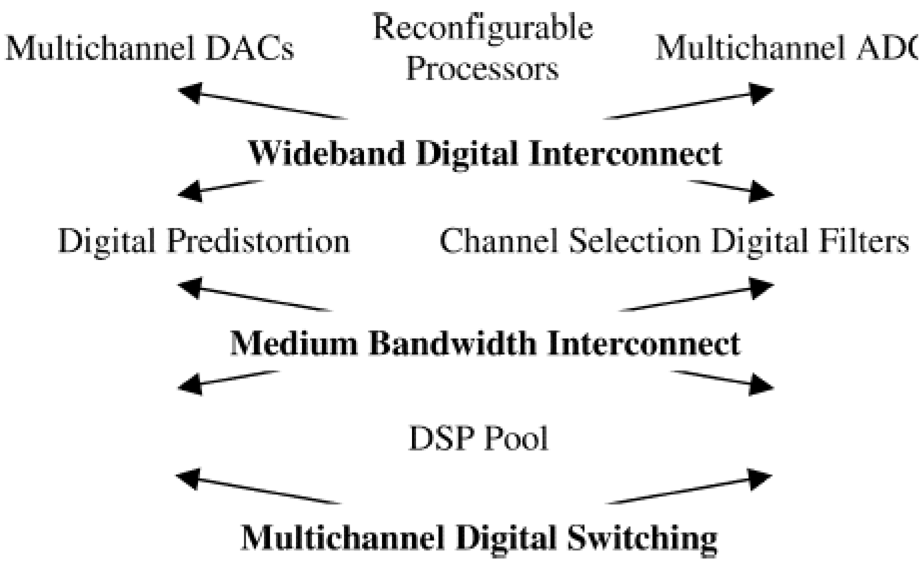


Figure 6-4 Digital architecture tradeoffs.

18.What are the implications in various architecture levels.

Architecture Implications

An architecture implication defines various architecture levels used in SDR to perform multimode processing like DSP, FPGA and ASICs architectures.

- Programmable DSPs have the required high order language (HOL) programmability, but they are inappropriate for frontend filtering tasks.
- These DSPs would have consumed much higher power than the Harris ASICs that were eventually chosen.
- The DSPs were more appropriate for channel modem and baseband signal processing tasks.
- FPGAs were also considered for front-end filtering.
- VHDL programmability provided flexibility, but these chips were also less power efficient for finite impulse response (FIR) filters and FFTs than dedicated ASICs.

- ASICs are most power efficient,
- The mix of ASICs, FPGAs, and DSPs reproduce different types of modules. It also reduces the number of backup modes.

19. What is meant by roofing filter?

A "**Roofing filter**" is simply a filter in the radio's first IF through which all signals must pass before they will be "seen" by later receiver stages.

20. Explain the significance of Performance Management Tradeoffs.

The final major tradeoff concerns the management of processing demand offered by the software against the resources provided by the hardware platform. Accurate characterization of processing demand requires benchmarking. Accurate prediction (e.g., at proposal time), can be accomplished using queuing theory techniques that have been refined and reduced to the structured method.

PART – B

1. What is software radio? Give the essential functions of Software Radio.
2. Explain the architecture of SDR with neat diagrams and its implications.
3. Discuss in detail about the potential benefits and technology in antenna tradeoff.
4. Discuss in detail about the potential benefits and technology in IF/RF tradeoffs.
5. Discuss in detail about the potential benefits and technology in ADC/DAC tradeoffs.
6. Discuss in detail about the potential benefits and technology in ADC/DAC tradeoffs.

UNIT-II- SDR ARCHITECTURE

PART-A

1. Define DDI?

The Defense Information Infrastructure (DII) of the United States consists of the fixed plant of telecommunications and information processing systems plus the mobile infrastructure that military forces must take with them on deployments around the world.

2. **What are the architecture goals of SDR?**

   In long term,software defined radios are expected by proponents like SDRForum to become the dominant technology in radio communications.

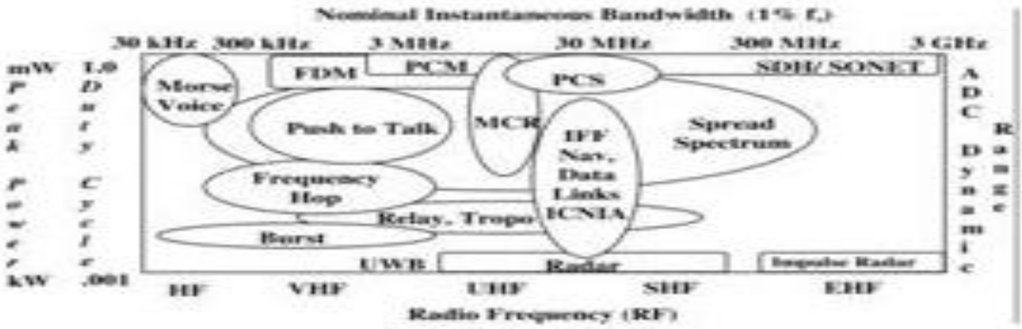
3. **What are the military requirements of radio services?**

   - Mobility of both subscribers and infrastructure
   - INFOSEC (TRANSEC and COMSEC)
   - Ruggedness and reliability in austere operating environments
   - Growth from voice and low-speed data to high-speed *tactical internets*
   - Interoperability with legacy radios and coalition partners
   - Affordability

4. **What is architecture revolution road map?**

   Software-radio architecture has been evolving from its roots in military communications. In addition to the traditional emphasis on radar and radar jamming, some developed wideband digital techniques for radio.

5. **Draw communication clusters in RF signal space?**



6. **Define software flexibility and affordability.**

   No air-interface-defining software (0), Single-supplier software (1), Multiple-supplier but single-host platform (2), Multiple-supplier multiplatform software

7. **Mention the applications of SDR**

   JTRS-used in military Amateur & home use USRP-uses a USB 2.0 interface

8. **Define low band noise?**

   The lower radio bands—HF, VHF, and lower UHF—include significant sources of radio noise and interference. The incidental and unavoidable interference includes automobile ignitions, microwave ovens, power distribution systems, gaps in electric motors, and the like.

9. **Define noise interference?**

   The noise/interference levels are defined with respect to thermal noise:

   $P_n = kTB$

where k is Boltzmann's constant, T is the system temperature (T_0 is the refer-ence temperature of 273 Kelvin), and B is the bandwidth (e.g., per Hz).

10. How VLHF multi channel air interference?

- FM frequency division multiplexing (FM/FDM) for military LVHF applications includes modes with four channels per RF carrier.
- These meet the con- nectivity needs of radiotelephony operations of relatively low-echelon military forces. Due to the relatively narrow coherence bandwidths of LVHF, conven- tional FM/FDM is limited to about 60 channels.

11. What is satellite communication mode?

Communications satellites operate in the three orbital regimes .Geosynchronous satellites have an orbital period which is nearly identical to the earth's rotational period, resulting in an apparent stationary position above the equator at an altitude of 22,500 miles, approx- imately.

12. Define disaster relief case study?

This case study considers a mobile communications capability for disaster re- lief. The capability includes mobile infrastructure, mobile nodes, and handsets. The design emphasis is on defining an open architecture for the infrastructure.

13. Expand and explain JTRS?

The Joint Tactical Radio System (JTRS) Programmable Modular Communications System (PMCS) integrated process team (IPT) recommended the consolidation of the more than 200 nomencla- tured U.S. radio families into a single program, JTRS, under the joint manage- ment of the three U.S. military services. The Joint Tactical Radio (JTR) mis- sion needs statement (MNS) and Operational Requirements Document (ORD) express the vision for the functional capability of the JTRS.

14. Define Transparent bridging?

Software radios not only support standard services, but they also can provide background routing services, which the military calls *transparent bridging*.

15. Define software objects?

One may apply the principles of object-oriented design to the design of an SDR node in a top-down way, as outlined in this section.

16. Define network layer?

The network layer contributes additional constraints on SDR design. First, the well-established network analysis tools may be employed to analyzing routing, queuing, and related aspects of the network. This level of analysis establishes resource bounds, such as maximum buffer sizes and processing latency in a node.

17. Define homeomorphism?

One may compare the range of one primitive to the domain of another using a topological map called a *homeomorphism*, a topology- preserving mapping.

18. Define Programmable Digital Radio (PDR)?

To develop the relationship between architecture and implementations, atten-tion turns to a series of case studies of the progenitors and research implemen- tations of the software radio.

19. What is industry standard zone archietecture?

The approach to defining open-architecture wireless taken by the SDR Forum is considered first. These are both open- architecture standards. There are many PDRs and touted SDRs in existence, but there is as yet no single manufacturer that so dominates the industry that one could say a de facto standard exists in the year 2000.

PART B

1. Define and explain each essential functions of the software radio.
2. What are the architectural goals of SDR? Explain with neat diagrams.
3. Explain the RF front-end architecture of SDR.
4. Discuss about the use of MEMS in RF for SDR.
5. With neat diagrams, explain the functional components and properties of SDR architecture.
6. Discuss briefly about architecture partitions of SDR with diagrams.
7. Explain RF conversation architecture?
8. Explain the Reviews of ADC fundamental?
9. Briefly explain the applications of SDR?

UNIT III INTRODUCTION TO COGNITIVE RADIOS

PART-A

1. How to make a radio cognitive?

We designed a cognitive radio software package, called a Cognitive Engine (CE), overlaid on radio hardware platform. CE manages radio resource to accomplish cognitive functionalities and adapts radio operation for performance optimization.

2. What is the cognition model?

A specific machine learning model (embedding the two-loop cognition cycle as the learning core) is designed to enable cognition capability for wireless applications. Case based reasoning and evolutionary search are combined in the learning process.

3. Which host radio architecture?

Any software defined radio platform and any radio with a certain level of reconfigurability can be supported by a cognitive engine with the platform independent radio interface.

4. Which communication layers have cognition?

Currently the cognitive radio functionality is focusing on the PHY and MAC layers for cross-layer optimization. The designed cognition algorithms can easily be extended to the network and application layers due to its general learning core.

5. How to establish a cognitive wireless network?

CWT2 provides a cognitive radio node which can be deployed for both centralized and distributed network intelligence. As network nodes, cognitive radios can work individually or jointly on resource management and performance optimization.

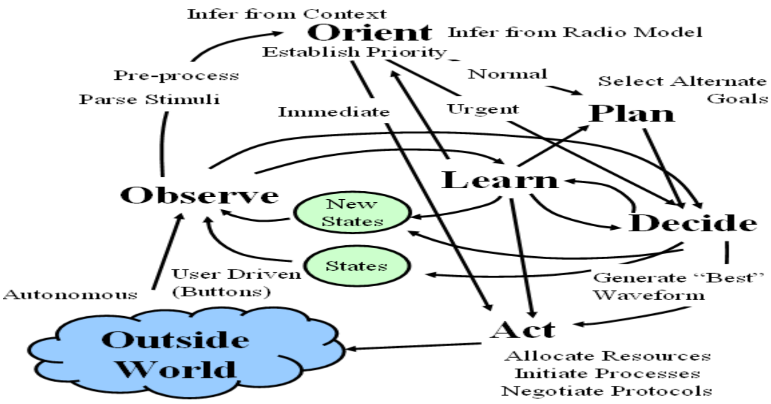
6. Define orient in Congnitive cycle.

The orient phase determines the significance of an observation by binding the observation to a previously known set of stimuli of a "scene." The orient phase contains the internal data structures that constitute the equivalent of the short-term memory (STM) that people use to engage in a dialog without necessarily remembering everything with the same degree of long-term memory (LTM).

7. What is cognition cycle?

This cycle implements the capabilities required of iCR in a reactive sequence. Stimuli enter the CR as sensory interrupts, dispatched to the cognition cycle for a response. Such an iCR continually observes (senses and perceives) the environment, orients itself, creates plans, decides, and then acts. In a single-processor inference system, the CR's flow of control may also move in the cycle from observation to action. In a multiprocessor system, temporal structures of sensing, preprocessing, reasoning, and acting may be parallel and complex. Special features synchronize the inferences of each phase.

8. Draw the cognition cycle.



9. What do you meant by Optimization?

Optimization is defined as a capability achieved through refining the solution and adapting practice accordingly. Optimal performance is a goal of such operations by directing the practice toward better results. List some characteristics of Radio Cognition Task.

10. What is meant by Waveform?

Waveform is defined as a super set of PHY parameters describing the format of a communication signal (PHY) and its related processing protocols (MAC, LLC, Net, etc.). This parameter set completely defines the wireless method of transceiving information between two communicating nodes. Such definition conforms to the waveform definition of the Software Communication Architecture (SCA) [41]. Such a waveform definition supports the standardization and portability of software defined communication applications.

11. What is position awareness in cognitive radio?

For cognitive radio (CR) to reach its full potential as an efficient member of a network or as an aid in users' daily tasks, and even to conserve the precious spectrum resource, a radio must primarily know its position and what time it is. From position and time, a radio can: (1) calculate the antenna pointing angle that best connects to another member of the network; (2) place a transmit packet on the air so that it arrives at the receiver of another network member at precisely the proper time slot to minimize interference with other users; or (3) guide its user in his or her daily tasks to help achieve the user's objectives, whether it be to get travel directions, accomplish tasks on schedule, or any of a myriad of other purposes. Position and time are essential elements to a smart radio. Furthermore, from position and time, velocity and acceleration can be inferred, giving the radio some idea about its environment

12. Define spectrum pooling.

Spectrum pooling is a spectrum management strategy in which multiple radiospectrum users can coexist within a single allocation of radio spectrum space.

13. What is a LORAN?

LORAN systems transmit a known burst signal from multiple transmitters with a known and published periodicity. Furthermore, the exact location of each transmitter is known. Three such transmitters cooperate to enable TDoA measurements. Ships at sea receive these transmissions and measure the time difference between each received signal. From these time differences, ships are able to calculate the TDoA hyperbolas. To simplify the process, the TDoA hyperbolas have been converted into published charts so that a navigator can directly look up the time differences for each transmitter pair and find an intersection of two time difference pairs to perform a location at sea

14. What is menat by OCON-ANN?

A One-Class-One-Network ANN (OCON-ANN) structure is constructed, in which one sub-network is created for each modulation type and these networks each output a value, a probability of a match according to the input signal. There is a judgment network, called MAXNET [101] collects the outputs from all these subnets, and the one with the highest output value wins as the modulation type

PART-B

1. Draw the cognitive radio framework and explain each block
2. With a neat diagram, explain the simplified cognition cycle.
3. List and explain the characteristics of radio cognition task.
4. Explain the structuring knowledge for cognition tasks

5. What are the primary concepts of location aware cognitive radio? Explain with neat architecture.

UNIT IV- COGNITIVE RADIO ARCHITECTURE

PART-A

1) What are the primary functions of Cognition?

Cognition function should:

- maintain a model of space-time
- reliably infer user's communication context & inform SDR
- model propagation of own radio signal (estimate interference)
- infer/adjust the parameters to support running applications
- administer the computational resources
- recognize preemptive actions by user and give control to him/her

2) What is the objective of cognitive radio architecture?

- make flexible use of Radio Spectrum (e.g. SDR)
- see what user sees (e.g. image/video pattern recognition)
- hear what user hears (e.g. voice/speaker recognition)
- protect user's data (e.g. soft/hard biometrics & encryption)
- judge Quality of Information (QoI) needed by user

3) What is waking behavior?

Waking behavior is optimized for real-time interaction with the user, isochronous control of SWR assets, and real-time sensing of the environment. The conduct of the waking behavior is informally referred to as the awake-state, although it is not a specific system state, but a set of behaviors

4) Define sleeping behavior.

Cognitive PDAs (CPDAs) detect conditions that permit or require sleep and dreaming. For example, if the PDA predicts or becomes aware of a long epoch of low utilization (such as overnight hours), then the CPDA may autonomously initiate sleeping behavior. Sleep occurs during planned inactivity, for example, to recharge batteries. Dreaming behavior employs energy to retrospectively examine experience since the last period of sleep.

5) **What is a conflict?**

Conflict is a context in which the user overrode a CPDA decision about which the CPDA had little or no uncertainty. Map _ may resolve the conflict. If not, it will place the conflict on a list of unresolved conflicts (map).

6) Define prayer behavior.

Attempts to resolve unresolved conflicts via the mediation of the PDA's home network may be called prayer behavior, referring the issue to a completely trusted source with substantially superior capabilities. The unresolved-conflicts list is mapped to RXML queries to the PDA's home CN expressed in XML, OWL, KQML, RKRL, RXML, or a mix of declared knowledge types. Successful resolution maps network responses to integrated knowledge.

7) Define world model.

The World Model, W, consists primarily of bindings between a priori data structures and the current scene. These associative structures are also associated with the observe phase. Dialog states, action requests, plans, and actions are additional data structures needed for the observe, orient, plan, and act phases, respectively.

8) What is meant by Biniding?

Binding occurs when there is a nearly exact match between a current stimulus and a prior experience and very general criteria for applying the prior experience to the current situation are met. One such criterion is the number of unmatched features of the current scene. If only one feature is unmatched and the scene occurs at a high level such as the phrase or dialog level of the inference hierarchy, then binding is the first step in generating a plan for behaving in the given state similar to the last occurrence of the stimuli

9) Define Scene.

A scene is a context cluster, a multidimensional space–time–frequency association, such as a discussion of a baseball game in the living room on a Sunday afternoon. Such clusters may be inferred from unsupervised ML (e.g., using statistical methods or nonlinear approaches such as SVMs).

PART-B

1. Discuss about the primary functions of cognitive radio with diagram .
2. What is behaviour? Explain the various modes of behaviour.
3. With neat architecture, explain the cognitive radio components.
4. Explain the various components of cognitive Cycle architecture.
5. Explain natural language encapsulation and Radio Procedure Knowledge Encapsulation
6. Describe the design rules in detail for cognitive radio.

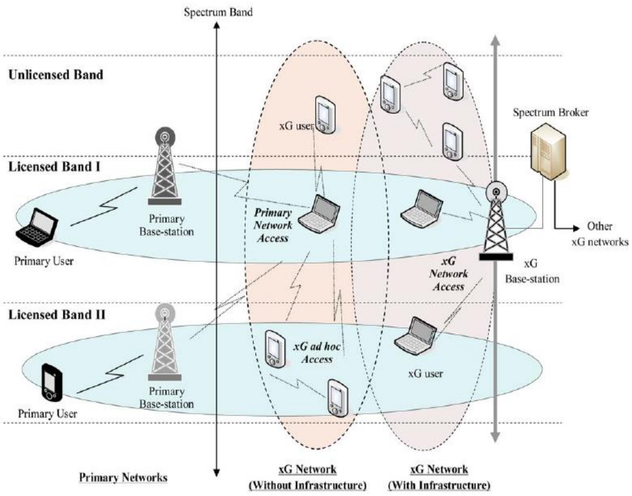
UNIT V NEXT GENERATION WIRELESS NETWORKS

PART-A

1. Define XG? What is the need of it?

Today's wireless networks are characterized by a fixed spectrum assignment policy. However, a large portion of the assigned spectrum is used sporadically and geographical variations in the utilization of assigned spectrum ranges from 15% to 85% with a high variance in time. The limited available spectrum and the inefficiency in the spectrum usage necessitate a new communication paradigm to exploit the existing wireless spectrum opportunistically. This new networking paradigm is referred to as NeXt Generation (xG) Networks as well as Dynamic Spectrum Access (DSA) and cognitive radio networks.

2. Draw the XG network architecture.



3. Mention the functions of cognitive radios in xG network.

A ''Cognitive Radio'' is a radio that can change its transmitter parameters based on interaction with the environment in which it operates

4. What is Spectrum sensing?

A cognitive radio monitors the available spectrum bands, captures their information, and then detects the spectrum holes.

5. What is Spectrum analysis:

The characteristics of the spectrum holes that are detected through spectrum sensing are estimated.

6. What is Spectrum decision?

A cognitive radio determines the data rate, the transmission mode, and the bandwidth of the transmission. Then, the appropriate spectrum band is chosen according to the spectrum characteristics and user requirements. Once the operating spectrum band is determined, the communication can be performed over this spectrum band. However, since the radio environment changes over time and space, the cognitive radio should keep track of the changes of the radio environment.

7. Define Reconfigurability.

Reconfigurability is the capability of adjusting operating parameters for the transmission on the fly without any modifications on the hardware components. This capability enables the cognitive radio to adapt easily to the dynamic radio environment.

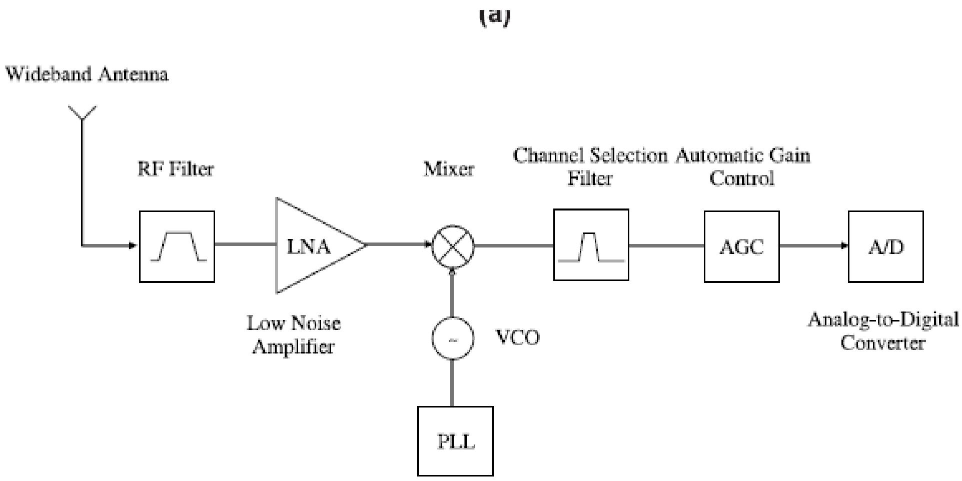
8. Define Operating frequency?

A cognitive radio is capable of changing the operating frequency. Based on the information about the radio environment, the most suitable operating frequency can be determined and the communication can be dynamically performed on this appropriate operating frequency

9. Define cognitive capability.

Cognitive capability refers to the ability of the radio technology to capture or sense the information from its radio environment. This capability cannot simply be realized by monitoring the power in some frequency band of interest but more sophisticated techniques are required in order to capture the temporal and spatial variations in the radio environment and avoid interference to other users. Through this capability, the portions of the spectrum that are unused at a specific time or location can be identified. Consequently, the best spectrum and appropriate operating parameters can be selected.

10. Draw the physical architecture of cognitive radio.



- List out some main components of wideband RF front-end architecture.
- RF filter: The RF filter selects the desired band by bandpass filtering the received RF signal.
- Low noise amplifier (LNA): The LNA amplifies the desired signal while simultaneously minimizing noise component. • Mixer: In the mixer, the received signal

is mixed with locally generated RF frequency and converted to the baseband or the intermediate frequency (IF).

- Voltage-controlled oscillator (VCO): The VCO generates a signal at a specific frequency for a given voltage to mix with the incoming signal. This procedure converts the incoming signal to baseband or an intermediate frequency.
- Phase locked loop (PLL): The PLL ensures that a signal is locked on a specific frequency and can also be used to generate precise frequencies with fine resolution.
- Channel selection filter: The channel selection filter is used to select the desired channel and to reject the adjacent channels. There are two types of channel selection filters [52]. The direct conversion receiver uses a low-pass filter for the channel selection. On the other hand, the super heterodyne receiver adopts a bandpass filter.
- Automatic gain control (AGC): The AGC maintains the gain or output power level of an amplifier constant over a wide range of input signal levels.

11. What are the steps involved in cognitive cycle?

- Spectrum Analysis
- Spectrum Decision
- Spectrum Management

12. Define Holding Time.

The activities of primary users can affect the channel quality in xG networks. Holding time refers to the expected time duration that the xG user can occupy a licensed band before getting interrupted. Obviously, the longer the holding time, the better the quality would be. Since frequent spectrum handoff can decrease the holding time, previous statistical patterns of handoff should be considered while designing xG networks with large expected holding time 120 sec

13. Define path loss.

The path loss increases as the operating frequency increases. Therefore, if the transmission power of an xG user remains the same, then its transmission range decreases at higher frequencies. Similarly, if transmission power is increased to compensate for the increased path loss, then this results in higher interference for other users.

14. Define spectrum handoff.

In XG networks, spectrum mobility arises when current channel conditions become worse or a primary user appears. Spectrum mobility gives rise to a new type of handoff in XG networks that we refer to as spectrum handoff. The protocols for different layers of the network stack must adapt to the channel parameters of the operating frequency. Moreover, they should be transparent to the spectrum handoff and the associated latency.

15. What is CCC?

Many spectrum sharing solutions, either centralized or distributed, assume a CCC for spectrum sharing. It is clear that a CCC facilitates many spectrum sharing functionalities such as transmitter receiver handshake [40], communication with a central entity [7], or sensing information exchange. However, due to the fact that xG network users are regarded as visitors to the spectrum they allocate, when a primary user chooses a channel, this channel has to be vacated without interfering. This is also true for the CCC.

PART-B

1. Explain the XG network communication components and their interactions with diagram.
2. Explain the each components and its functionality of xG network architecture.
3. Explain in detail about challenges in spectrum sharing.