Unit 4:Cognitive Radio Networks

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Contents

- Fixed and dynamic spectrum access;
- Direct and indirect spectrum sensing;
- Spectrum sharing;
- Interoperability and co-existence issues;
- Applications of cognitive radio networks.

What is CR

- Cognitive radio (CR) is a form of wireless communication in which a transceiver
  - intelligently detect which communication channels are in use and which ones are not.
  - The transceiver then instantly moves into vacant channels, while avoiding occupied ones.
  - Helps to optimize the use of the available radio frequency (RF) spectrum.
  - minimizes interference to other users, by avoiding occupied channels, it increases spectrum efficiency and improves the quality of service (QoS) for users.

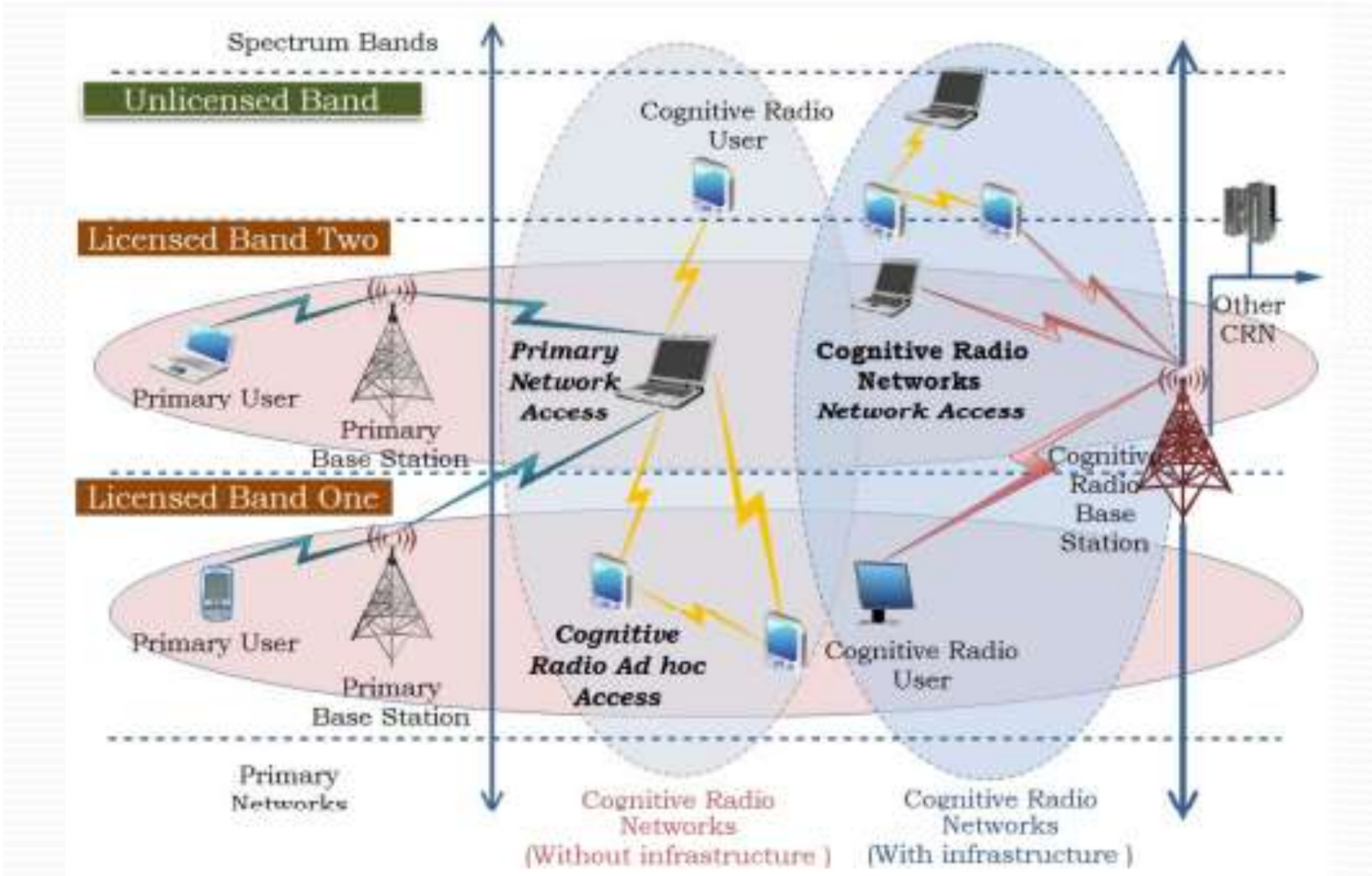
Wireless RF spectrum

- It is a limited resource, allocated through a licensing process
- The allocated (licensed) spectrum is not always used optimally.
- Some bands are overcrowded (e.g., GSM cellular networks), others are relatively unused (e.g., military).
- spectrum inefficiency limits the amount of data that can be transmitted to users and lowers service quality.
- Cognitive radio is an efficient way to use and share this resource intelligently, optimally and fairly.

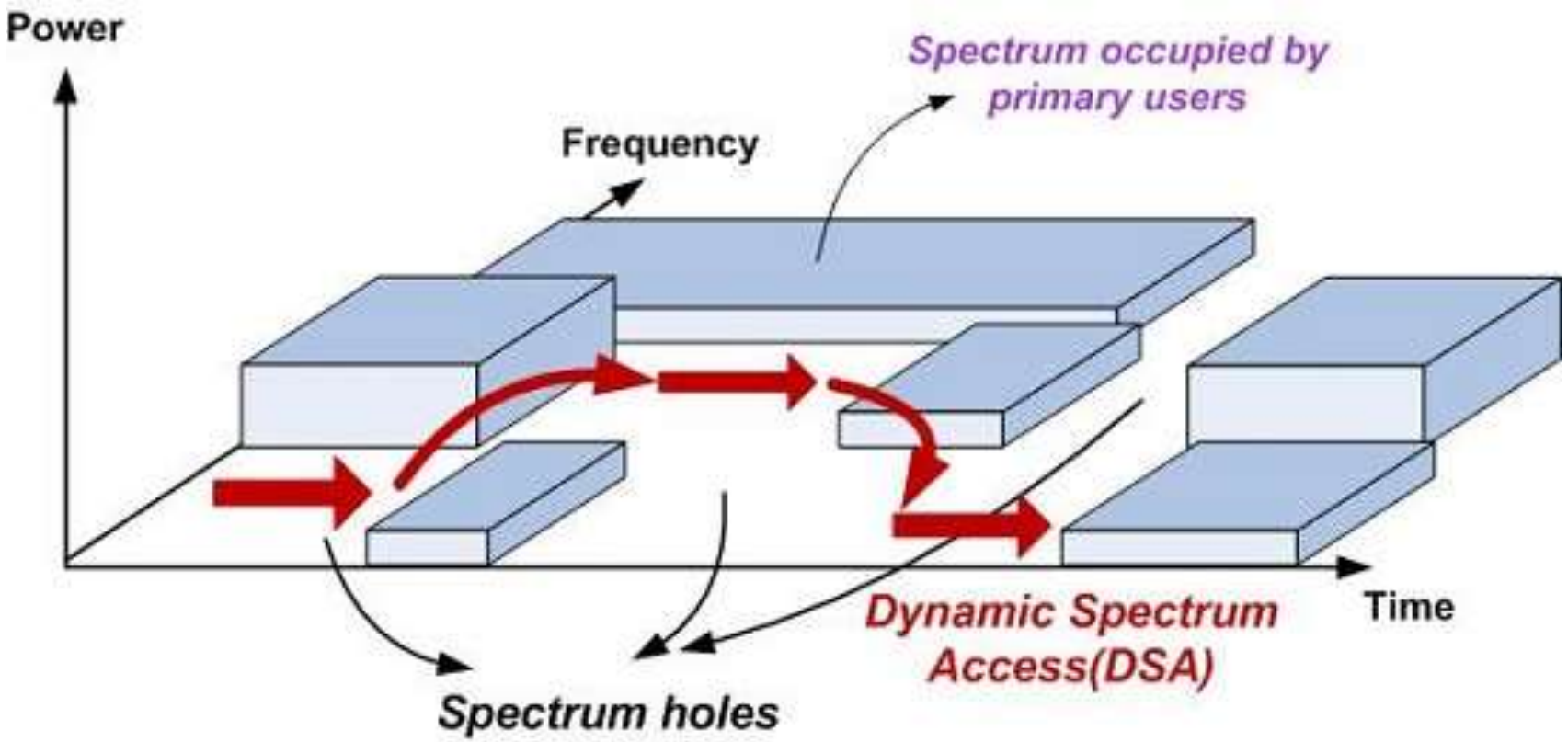
cognitive radio network (CRN)

- CRN has two main networks, a primary network and a secondary network.
  - The primary network owns the licensed band and consists of the primary radio base station and users.
  - The secondary network shares the unused spectrum with the primary network. It consists of the cognitive radio base station and users.

- The three key capabilities that differentiate cognitive radio from traditional radio are:
  - Cognition: CR understands its geographical and operational environment.
  - Reconfiguration: CR can decide to dynamically and autonomously adjust its parameters.
  - Learning: CR can also learn from the experience, and experiment with new configurations in new situations.


Spectrum Bands
Unlicensed Band
Licensed Band Two
Licensed Band One
Cognitive Radio User
Primary User
Primary Base Station
Primary Network Access
Cognitive Radio Networks Network Access
Other CRN
Cognitive Radio Base Station
Primary User
Primary Base Station
Cognitive Radio Ad hoc Access
Cognitive Radio User
Primary Networks
Cognitive Radio Networks (Without infrastructure)
Cognitive Radio Networks (With infrastructure)

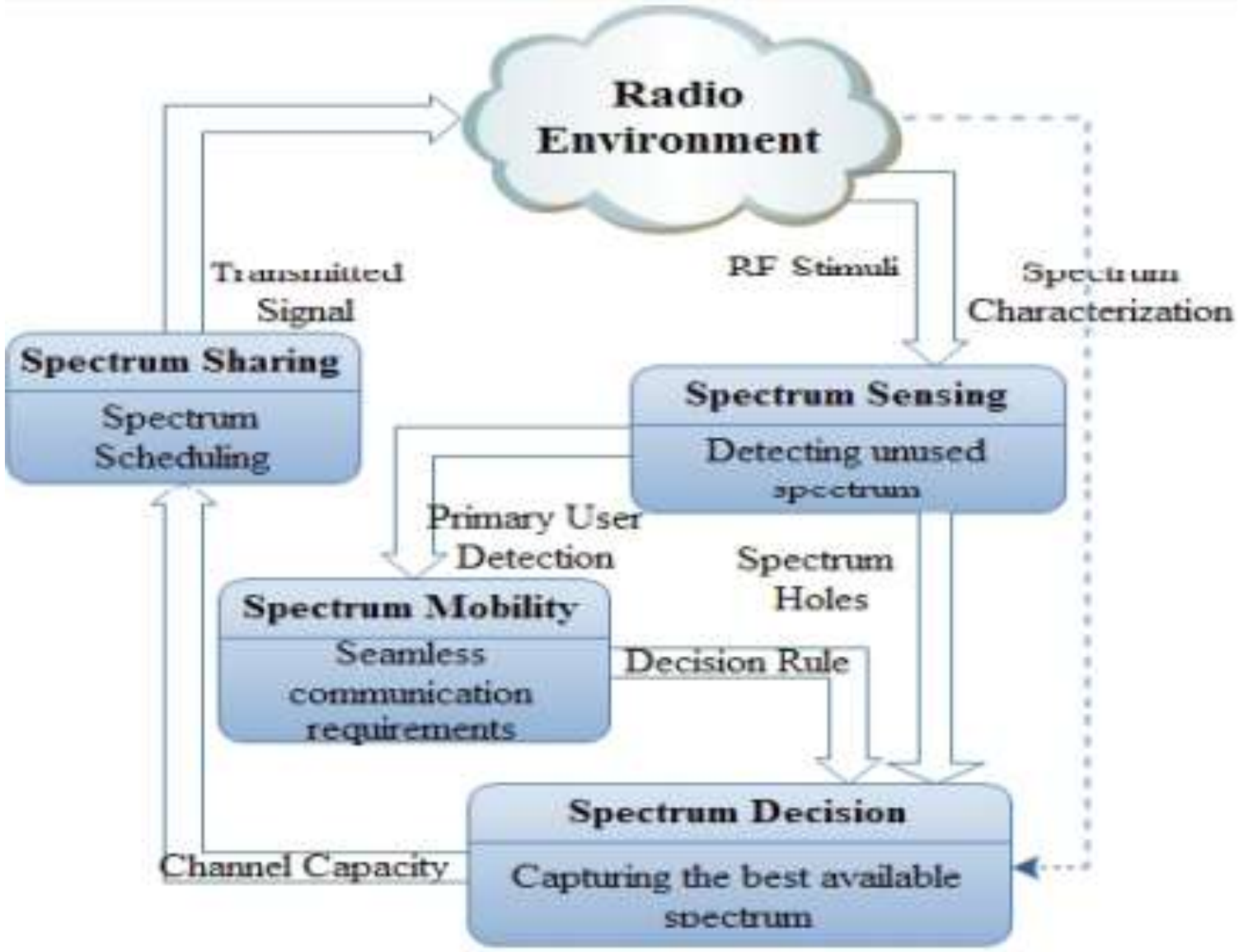
Spectrum Holes



Cognitive radio facets

- *spectrum sensing*
  - CR devices track the spectrum bands in their neighborhoods to identify users licensed to operate in that band.
  - look for unused portions of the RF spectrum known as white spaces or spectrum holes.
  - These holes are created and removed dynamically and can be used without a license.
- *spectrum database*
  - TV stations update their next week's use of the RF spectrum in a database that the FCC maintains. Cognitive radio devices can seek information about free spectrum from this database

CRN Life cycle



spectrum sensing is that the secondary users have to detect the presence of the primary users in the licensed spectrum and quit the frequency band as quickly as possible if the corresponding primary radio emerges so that the primary user does not face any interference.

The Spectrum sensing techniques are classified into 3 main types,

- Transmitter Detection (Non Cooperative Sensing),
- Cooperative Sensing and
- interference based testing.

Applications of CRN

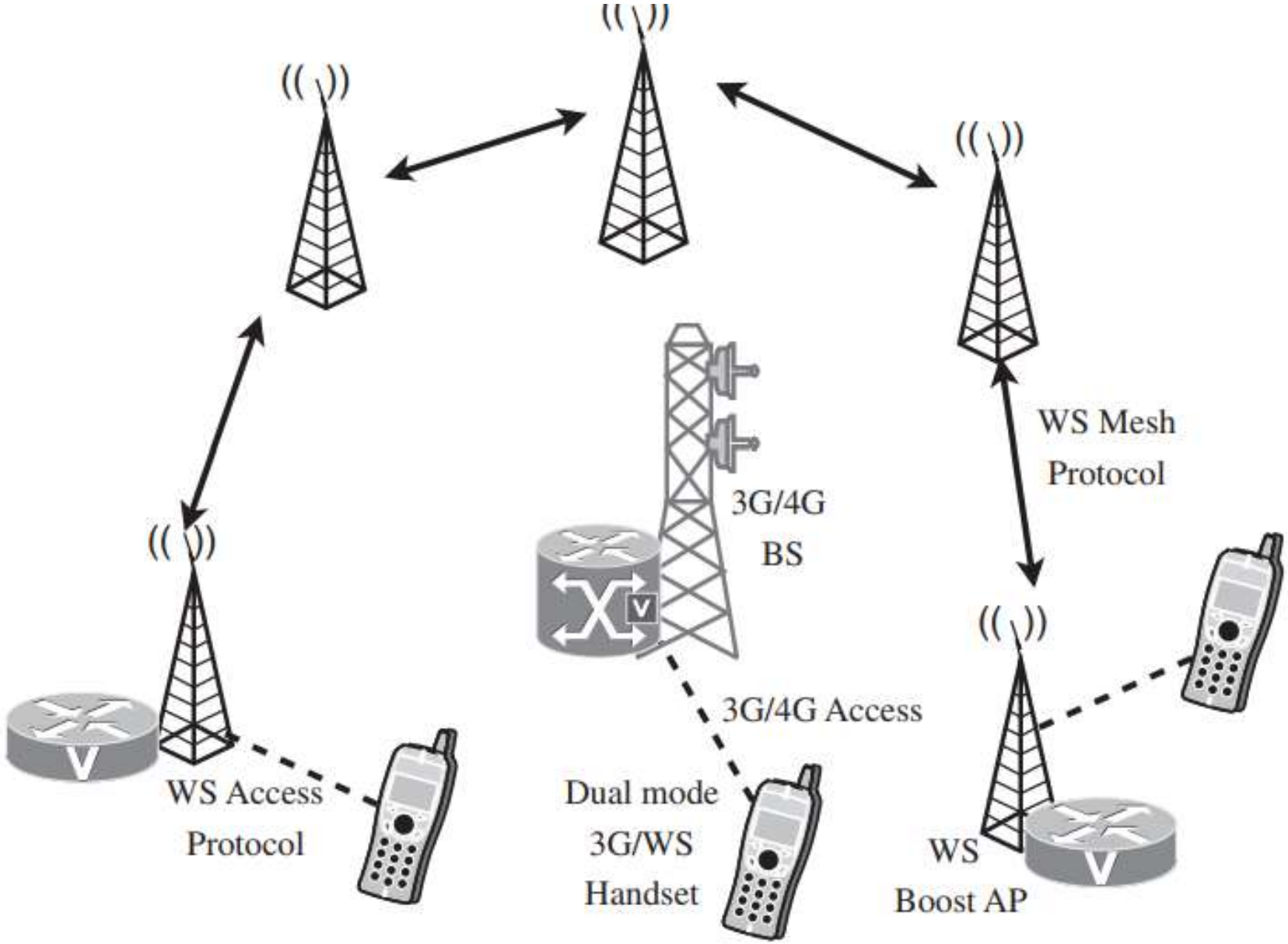
- CR is a disruptive new technology with many potential applications. This is why it is also known as a next-generation communication network.
- For example, CR can help address connectivity problems in rural areas. It can also optimize RF operations for smartphones and IoT devices, content delivery networks, also known as content distribution networks, and giant wireless hotspots.

Types of CRN

- *heterogeneous*
  - In heterogeneous CR, operators run several radio access networks (RANs) using the same or different radio access technology (RAT) protocols.
  - Heterogeneous cognitive radio uses a network-centric approach, and the frequency bands allocated to the various RANs are fixed
- *spectrum-sharing*
  - Several RANs share the same frequency band.
  - They also coordinate with each other to use unoccupied sub-bands intelligently and optimally.

DSA

- **The technique of dynamically accessing the unused spectrum band is known as Dynamic Spectrum Access (DSA)**. The dynamic spectrum access technology helps to minimize unused spectrum bands.
- To regulate the use of this limited resource, fixed spectrum access policy (FSA) was adopted by spectrum regulators. Under this policy, **a fixed piece of spec- trum is assigned for a dedicated purpose which is further distributed to the users for access to wireless services**.


WS Mesh
Protocol
3G/4G
BS
3G/4G Access
WS Access
Protocol
Dual mode
3G/WS
Handset
WS
Boost AP

cognitive radios : alleviate high loads on the cellular network.

- an overlay mesh network of white space hot-spots can carry non-real-time or delay tolerant data like mail, content, file transfer, etc.
- The hot-spots can operate either in the licensed or unlicensed band. Off-loading part of the delay tolerant data traffic from the cellular network helps operators to meet the quality of service (QoS) requirements of delay.
- The boost in the capacity comes at no additional cost, but from the detection of available white spaces and the opportunistic transmission over white spaces using the hot-spot mesh network

Issues in CRN

Interoperability challenges

- – CRN based device-to-device communications
- – CRN based device-to-network communications
- – CRN based machine-to-machine communications
- – CRN based service-to-service communications

Co-existence network technologies challenges

- – CRN based radio access
- – CRN based medium access control (MAC)
- – CRN based handover between multiple communication standards
- – CRN based channel hopping

Communications

- M2M communications refer to **automated applications which involve machines or devices communicating through a network without human intervention**.
- Device-to-Device (D2D) communication refers to **a radio technology that enables devices to communicate directly with each other, that is without routing the data paths through a network infrastructure**.
- **The client can make a REST call to interact with other services**. The client sends a request to the server and waits for a response from the service (Mostly JSON over HTTP). <Service to service>