Cognitive Radio Networks : Implementation and Application issues in India

By

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Contents

Result of India's 3G Spectrum Allocation

www.telcoma.in

Circle and Operator Wise Data

In Rs. Crores	Telecom Operator							
Service Area	Aircel	Bharti	Idea	Reliance	STEL	Tata	Vodafone	Circle Total
Delhi		3,316.93		3,316.93			3,316.93	9,950.79
Mumbai		3,247.07		3,247.07			3,247.07	9,741.21
Maharashtra			1,257.82			1,257.82	1,257.82	3,773.46
Gujarat			1,076.06			1,076.06	1,076.06	3,228.18
Andhra Pradesh	1,373.14	1,373.14	1,373.14					4,119.42
Karnataka	1,579.91	1,579.91				1,579.91		4,739.73
Tamil Nadu	1,464.94	1,464.94					1,464.94	4,394.82
Kolkata	544.26			544.26			544.26	1,632.78
Kerala	312.48		312.48			312.48		937.44
Punjab	322.01		322.01	322.01		322.01		1,288.04
Haryana			222.58			222.58	222.58	667.74
Uttar Pradesh (E)	364.57		364.57				364.57	1,093.71
Uttar Pradesh (W)		514.04	514.04			514.04		1,542.12
Rajasthan		321.03		321.03		321.03		963.09
Madhya Pradesh			258.36	258.36		258.36		775.08
West Bengal	123.63	123.63		123.63			123.63	494.52
Himachal Pradesh		37.23	37.23	37.23	37.23			148.92
Bihar	203.46	203.46		203.46	203.46			813.84
Orissa	96.98			96.98	96.98			290.94
Assam	41.48	41.48		41.48				124.44
North East	42.3	42.3		42.3				126.90
Jammu & Kashmir	30.3	30.3	30.3	30.3				121.20
Telco Total	6,499.46	12,295.46	5,768.59	8,585.04	337.67	5,864.29	11,617.86	50,968.37
No Spectrum	1959-1964 Mhz		1969-1974 Mhz		1974-1979 Mhz		1964-1969 Mhz	

Fig 1 Ref. from www.telcoma.in

Introduction

Wireless Radio Spectrum Environment

- Fixed Spectrum Assignment
- Shared Spectrum Concept

Dynamic Spectrum Access

NeXt Generation (xG) Network

- DARPA Dynamic Spectrum Access
- Intelligent Radio N/w (Cognitive Radio)

Hole or White Space Concept

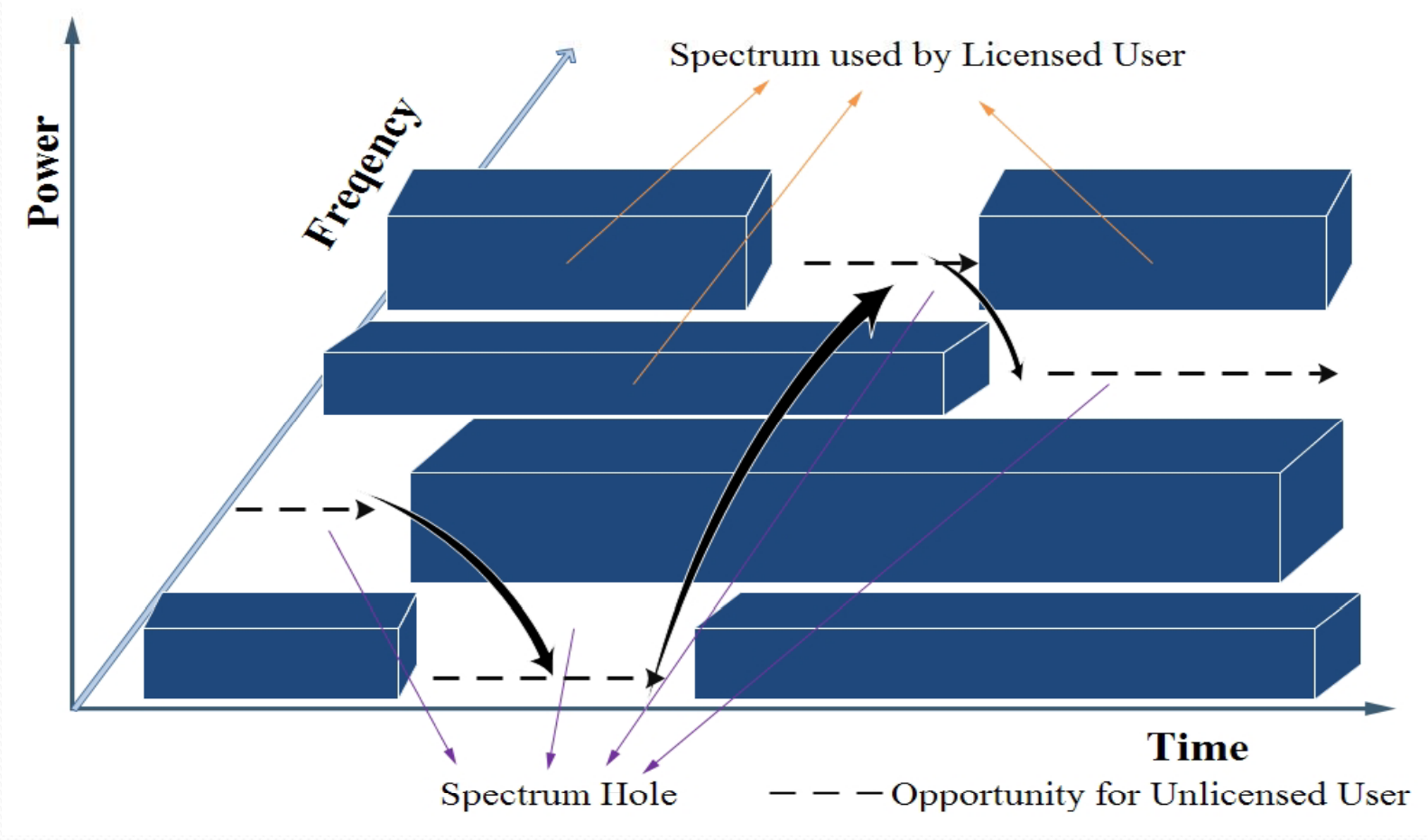

Fig. 1: CRN Concepts

Cognitive Radio Network

Wireless communication in which the transmission or reception parameters are changed to communicate efficiently without interfering with licensed users.

Parameter changes are based on the active monitoring off several factors in the radio environment (e.g. radiofrequency spectrum).

This approach is enabled by software-defined radio frequency spectrum.

Literature Review

- CRN was first described by **Mitola** in his Ph.D Thesis, "Cognitive radio: integrated agent architecture for software defined radio" in 2000.
- **FCC** has given the report in 2003.
- DSA concept was firstly implemented by **DARPA** in 2003.
- Radio-scene analysis, Channel-state estimation, predictive modeling, Transmit-power control, dynamic spectrum management are described extensively by **Simon Haykin** in Feb. 2005.

Literature Review

Dynamic Shared Spectrum access concept is described by **I.F. Akyildiz** in 2006 and also introduced concept of **Cognitive Radio Ad Hoc Network (CRAHN)** which is infrastrureless cognitive radio network in July 2009.

Wireless Regional Area Network (WRAN), also known as IEEE 802.22 Working Group on Wireless Regional Area Networks.

Brief detail of CRN platforms : **Universal Software Radio Peripheral** (USRP), **Wireless open Access Research Platform** (WARP) and **Sundance** .

CRN Architecture

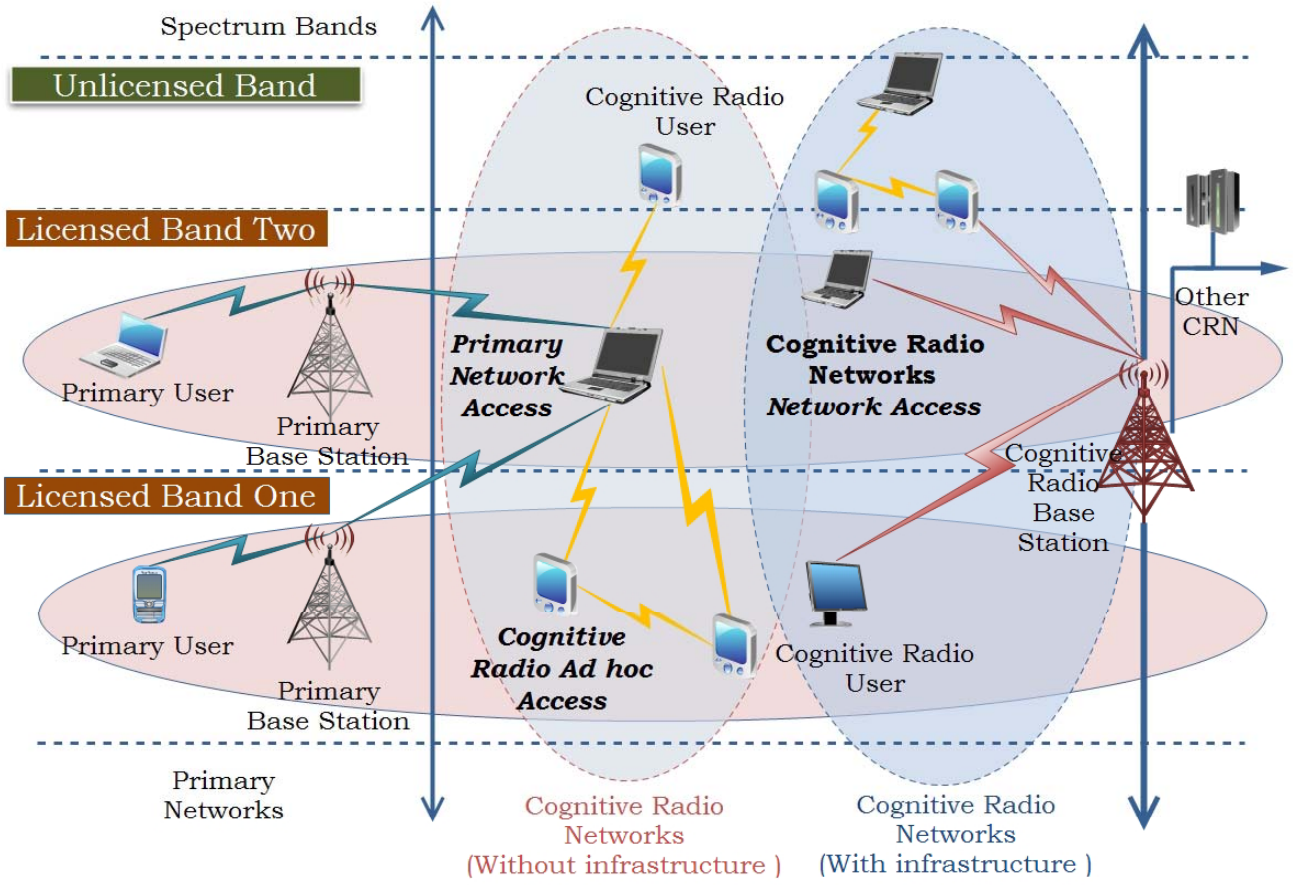

Fig. 2: CRN Architecture

CRN Functions

Spectrum sensing

Detecting unused spectrum and sharing the spectrum without harmful interference with other users.

Spectrum management

Capturing the best available spectrum to meet user communicati on requirements.

Spectrum mobility

Maintaining seamless communicati on requirements during the transition to better spectrum.

Spectrum sharing

Providing the fair spectrum scheduling method among coexisting CR users.

Cognitive Cycle

Cognitive capability

Reconfigurability

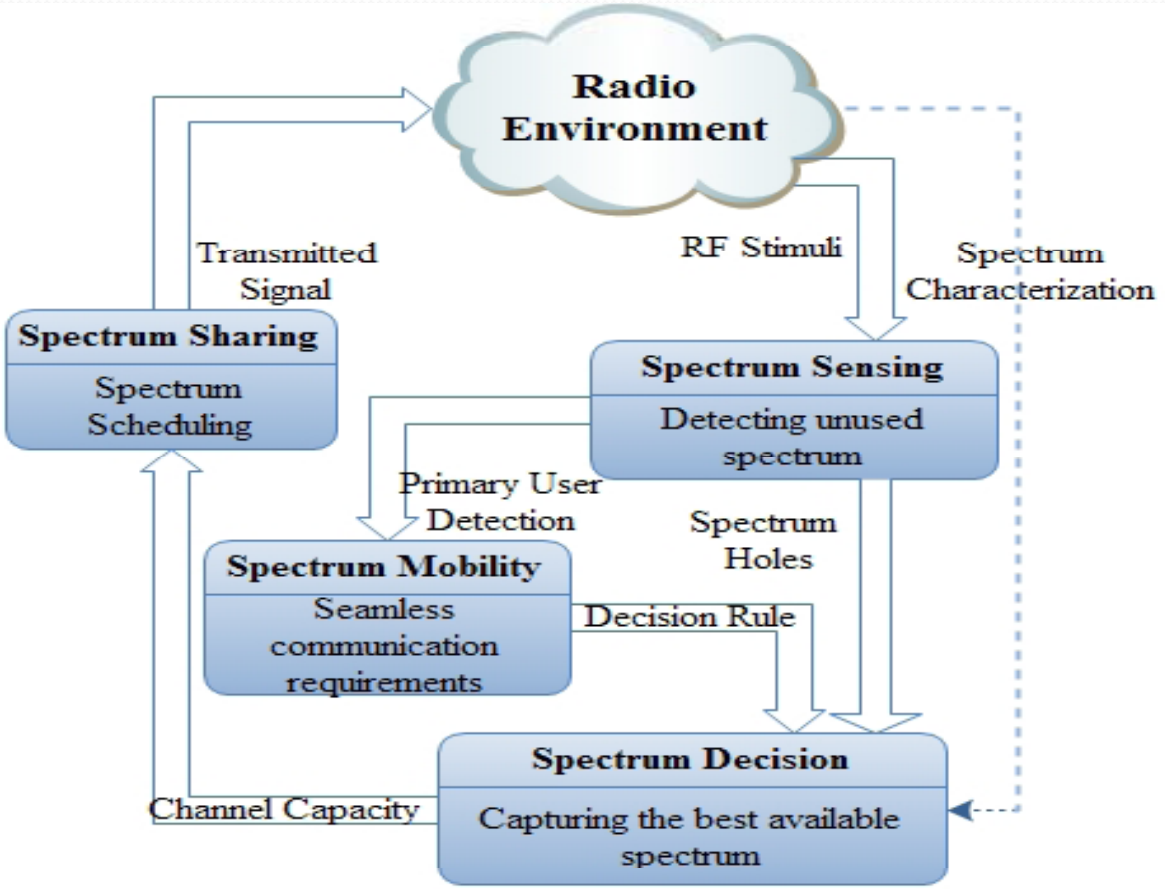

Fig 3: Cognitive Cycle

Challenges in spectrum sensing

- Interference temperature measurement
- Spectrum sensing in multi-user networks
- Detection capability

Spectrum management challenges

- Decision model.
- Multiple spectrum band decision.
- Cooperation with reconfiguration.
- Spectrum decision over heterogeneous spectrum bands.

Challenges of spectrum mobility

- Spectrum handoff.
- Spectrum mobility in multiple users.

Spectrum sharing challenges

- Common control channel (CCC).
- Dynamic radio range.
- Spectrum unit.

Implementation issues

- Readiness of the CRN backbone
- Defining point of Interconnect and Interface.
- Definition of Uniform service based priorities.
- Default service and routing requirement.
- Service authentication and Authorization.

Regulatory issues

- Migration from service based licensing to service neutral licensing regime.
- Issues related with converged licensing.
- Re-classification of the licenses.
- Pricing issues to end users.
- Migration from service based pricing to service neutral pricing.
- Revenue settlement of the operators in CRN environment.

QoS issues

- Need to define Quality of services parameters in CRN environment.
- Monitoring QoS in various networks and ensuring compliance to defined QoS parameters in CRN environment.
- Ensuring End to End QoS across the networks.
- Need to define unique service based priorities.
- Reliability across diverse applications.

Security issues

- Protection from various protocol attacks.
- Application attacks.
- Unauthorized user introduction.
- Unauthorized access to system data.
- Denial of services (DOS) and Distributed Denial of services attacks (DDOS).

Issues

Routing challenges

- Common control channel
- Intermittent connectivity
- Re-routing
- Queue management

Transport layer challenges

- RTT
- Spectrum Handoff Latency

Cross-layer challenges

Challenges in spectrum management

- Dynamic Nature and Re-routing

Challenges in spectrum handoff

- Spectrum Handoff Latency, Route Failure and Recovery

Challenges in spectrum sharing

- Spectrum Sensing Capability and Sharing Delay

Challenges in upper layers

- Dynamic Frequency, Multiple Hops and Spectrum handoffs,

CRN Applications

Military Network

CR Mesh Network

Emergency Network

Multimedia

Leased Network

CRN Applications

Cellular Networks

Conclusion

- Spectrum Awareness Concept.
- Very Useful for B3G Networks.
- Spectrum sharing techniques can help us fill the regulatory "gaps" in a particular interference environment.
- A great deal of research still needs to be done on simulating and explore these intelligent network ideas.

Conclusion

Cognitive radio technology can solve the problem of spectrum underutilization.

Channel assignment in cognitive radio networks is especially challenging in CRN.

Main aim of this research is Characterize and analyze, and enhance the throughput and provide security solutions

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Thank You

xG Network Architecture

- xG network functions
- xG network on licensed band
- xG network on unlicensed band

xG Network

- xG network applications
  - Leased Network
  - Cognitive Mesh Network
  - Emergency Network
  - Mililatry Network
- Existing architectures
  - Spectrum polling
  - CORVUS
  - DIMSUMnet
  - DRiVE
  - OCRA

Spectrum Sensing

- In order to avoid interference the spectrum holes need to be sensed
  - primary user detection the most efficient way.

Spectrum Sensing

- Transmitter detection
  (non-cooperative detection)
- Matched filter detection
- Energy detection
- Cyclostationary feature detection
- Cooperative detection
- Interference-based detection
- Spectrum sensing challenges

Spectrum Sensing

- Transmitter Detection
  - whether the signal from a primary transmitter is locally present in a certain spectrum or not
  - Three different approaches
    - matched filter detection
    - energy detection
    - Cyclostationary detection
- Cooperative Detection
  - method where information from multiple users are incorporated for primary user detection

Spectrum Sensing

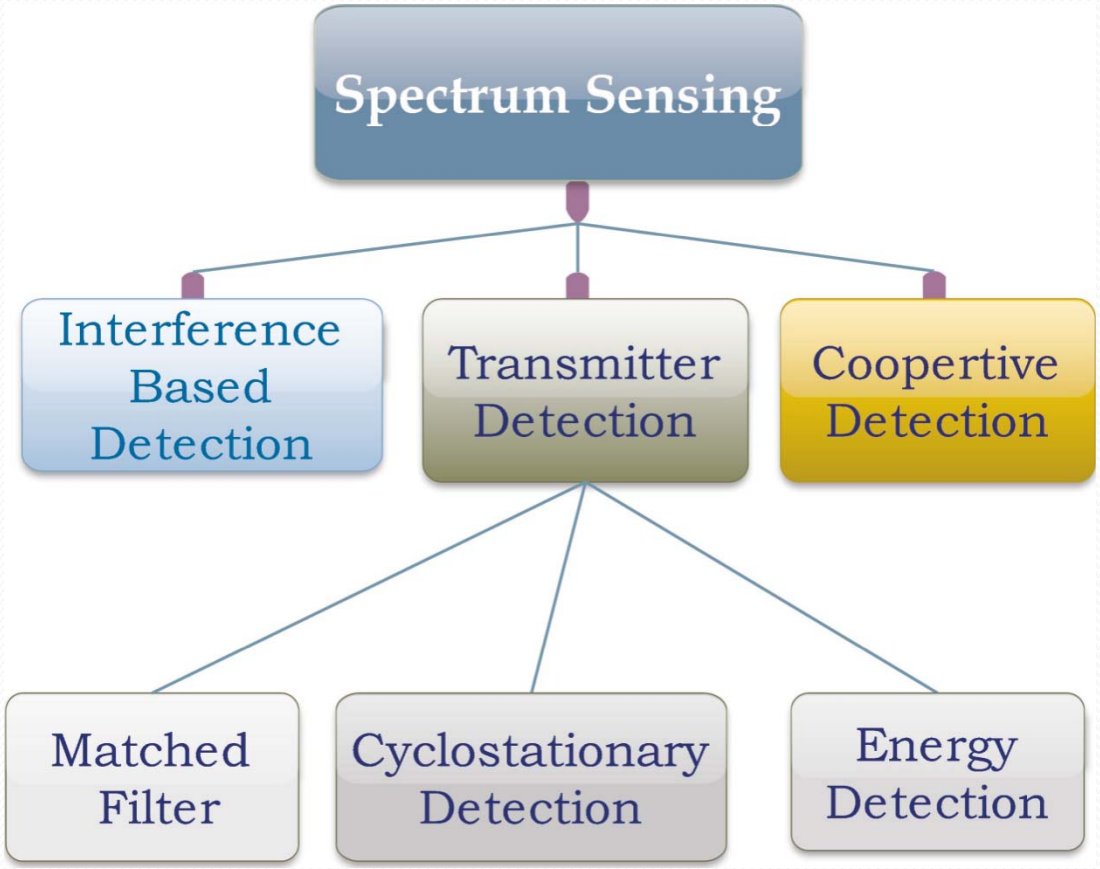

Fig. 5. Classification of spectrum sensing techniques

Spectrum Management

- Needed to capture the best available spectrum to meet user communication requirements
- Cognitive radios should decide on the best spectrum band to meet the QoS requirements over all available spectrum bands.
- management functions classified as
  - spectrum analysis
  - spectrum detection
- Spectrum management challenges.

Spectrum Mobility

- The process where a cognitive radio user exchanges its frequency off operation.
- Target to use the spectrum in a dynamic manner by allowing the radio terminals to operate in the best available frequency band.
- Seamless communication requirements during the transition to better spectrum must be maintained.
- Spectrum handoff
- Spectrum mobility challenges in xG networks

Spectrum Sharing

- Providing the fair spectrum scheduling method
- Sharing is a major challenge in open spectrum usage.
- Corresponds to MAC problems in existing systems.

Spectrum Sharing

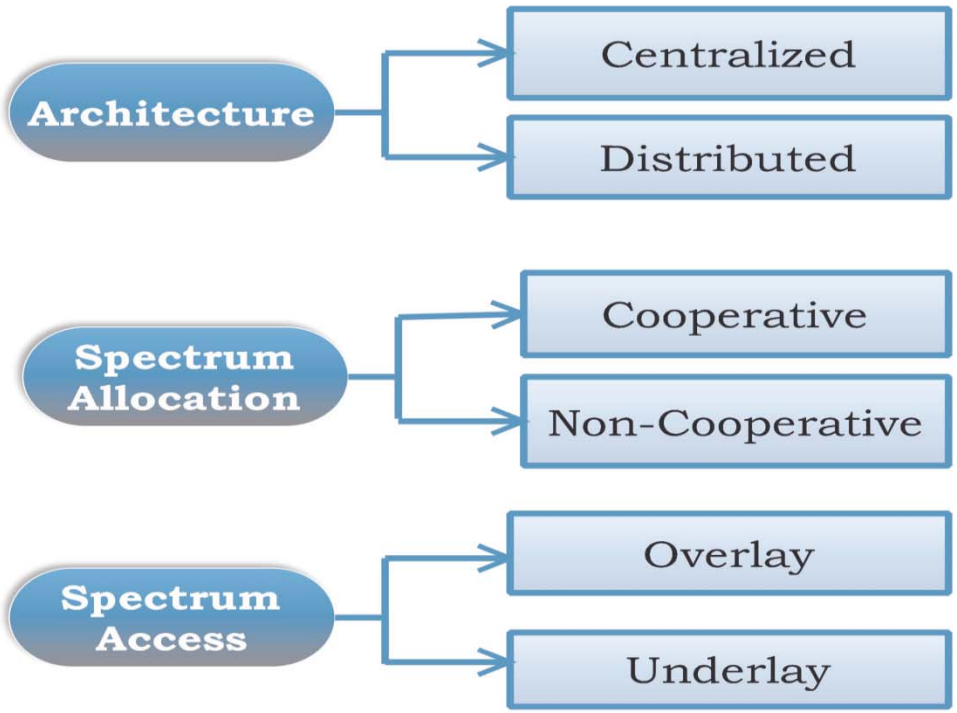

Fig 6 Classification of spectrum sharing in xG networks based on architecture, spectrum allocation behavior, and spectrum access technique