

Next Generation 5G Wireless Networks

A Comprehensive Survey

Mamta Agiwal, Abhishek Roy, and Navrati Saxena

IEEE COMMUNICATIONS SURVEYS & TUTORIALS, VOL. 18, NO. 3, THIRD QUARTER 2016

2018/04/08 陳廷易

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Outline

- What is 5G
- Background Knowledge
- 5G Architecture
- 5G Mac Layer
- 5G Applications
- 5G Quality Expectancy
- 5G Future

統計資料

- 於**2012**年多媒體影音流量就佔超過一半的行動流量，至**2014**年行動通訊流量成長**70%**。
- 多媒體行動影音呈指數成長，到**2020**年平均一個使用者會使用約**1TB**的流量。

What is 5G

- Very high data rates (Gbps)
- Extremely low latency
- Increase in base station capacity
- Improvement in QoS

What is beamforming

- 802.11ac
- Signal processing technique used in sensor arrays for directional signal transmission or reception

What is MIMO

- Multiple Input Multiple Output : 802.11n
- SISO (Single Input Single Output) : 802.11a/b/g
- Method for multiplying the capacity of a radio link using multiple transmit and receive antennas to exploit multipath propagation

What is SDMA

- Channel access method based on creating parallel spatial pipes next to higher capacity pipes through spatial multiplexing and/or diversity
- Offer superior performance in radio multiple access communication systems

What is SDN

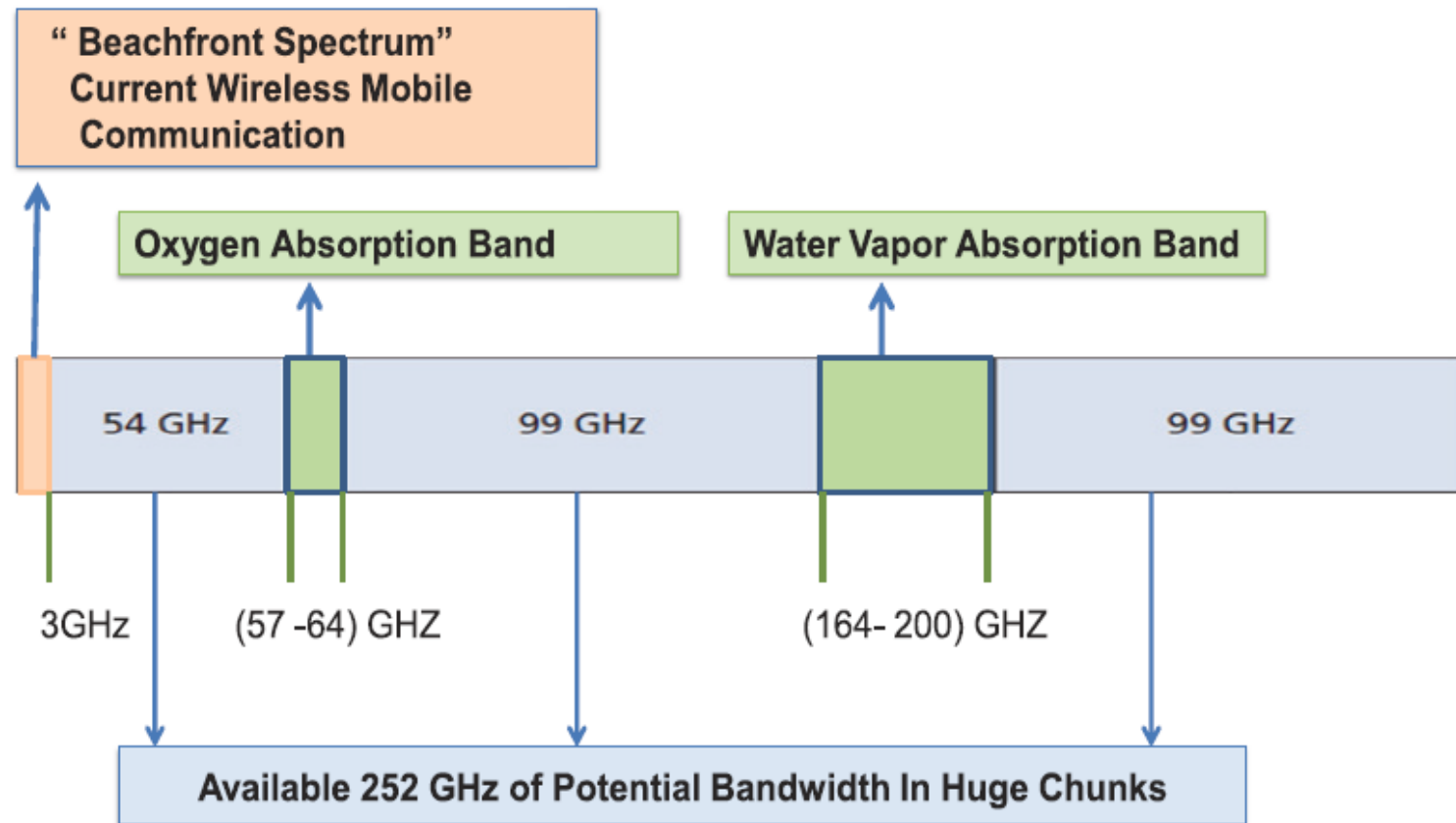
- Facilitates network management and enables programmatically efficient network configuration in order to improve network performance and monitoring
- Disassociating the forwarding process of network packets (Data Plane) from the routing process (Control plane)

What is Shannon Theory

- Maximum rate at which information can be transmitted over a communications channel of a specified bandwidth in the presence of noise
- $R_{\max} = W \log_2 (1 + S/N)$
 - R_{\max} 是最大傳輸速率； W 是頻寬； S 是信號功率； N 是噪聲功率
- Increase W
 - Mm-wave (EHF)
- MIMO、SDMA
- Beamforming、D2D

What is mm-wave

- Millimeter Wave: Extremely High Frequency , EHF
- 300Mhz~3Ghz:
 - sweet spot 、beachfront
 - almost all wireless comm
- 5G lies in exploring 3~:



5G Advantages & Vision

- First standard is expected to mature by 2020
- 1. 1~10Gbps data rates
- 2. 1ms round trip latency
- 3. Higher bandwidth
- 4. Enormous number of connected devices
- 5. Perceived availability of 99.999%
- 6. Almost 100% coverage for connectivity
- 7. Reduction in energy usage by almost 90%
- 8. High battery life

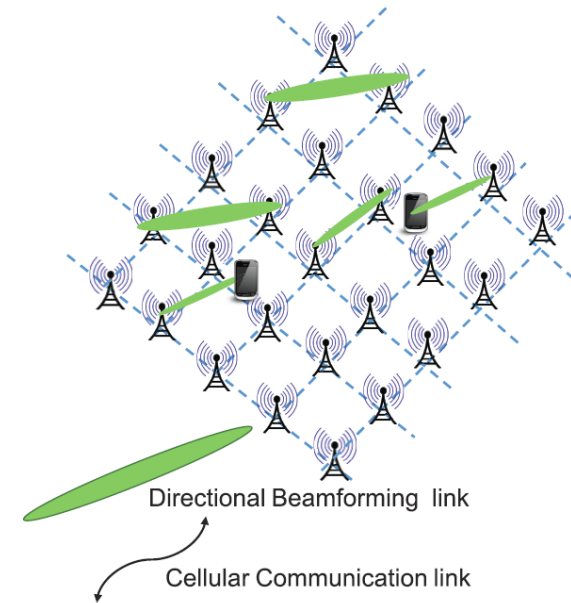
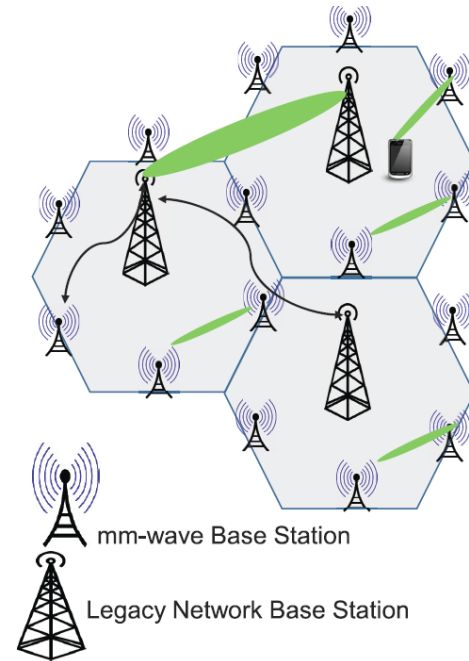


5G Architecture

Paradigm Shift

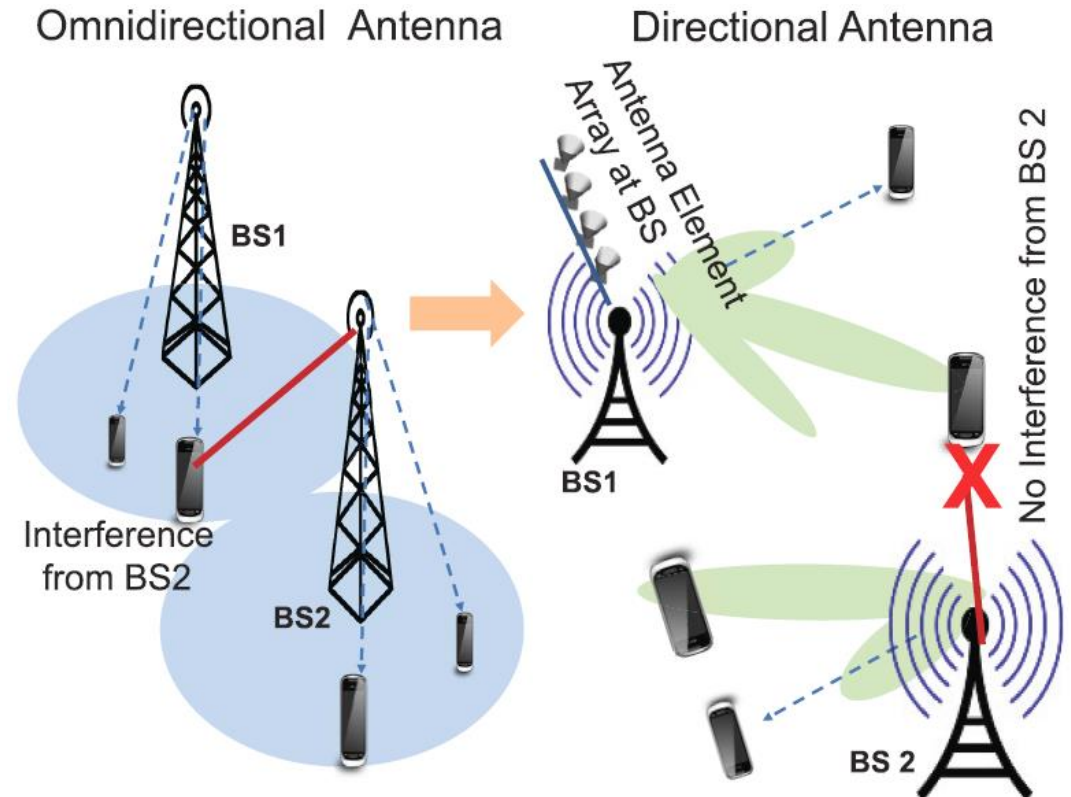
Radio Network Evolution

- LOS(Line of Sight) vs. NLOS(Non Light of Sight)
- Hybrid system of mm-wave(5G) and legacy 4G network
- Standalone 5G system



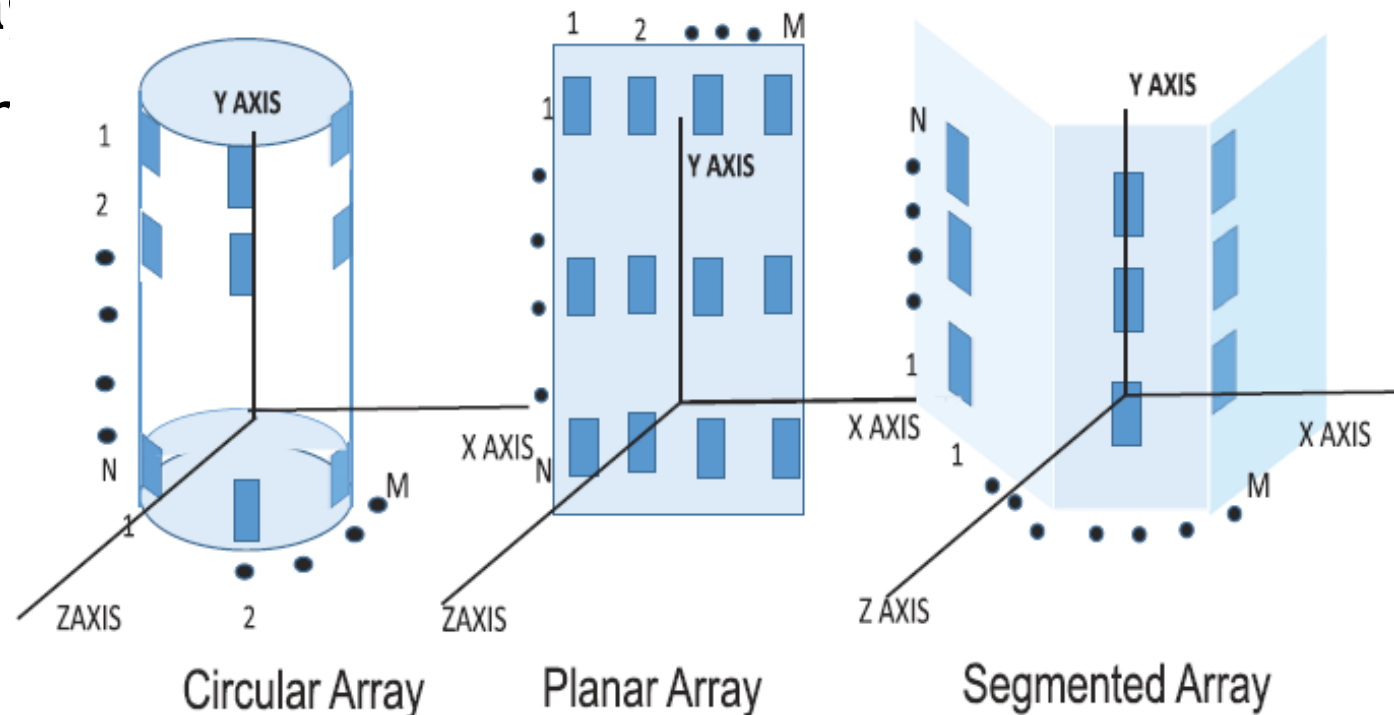
Advanced Air Interface

- Directional interfaces
- Omnidirectional antennas->smart beamforming directional antennas



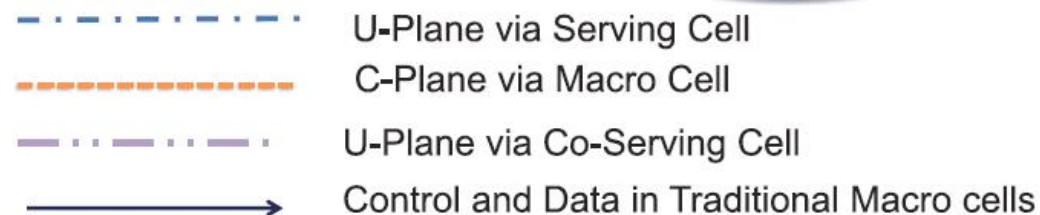
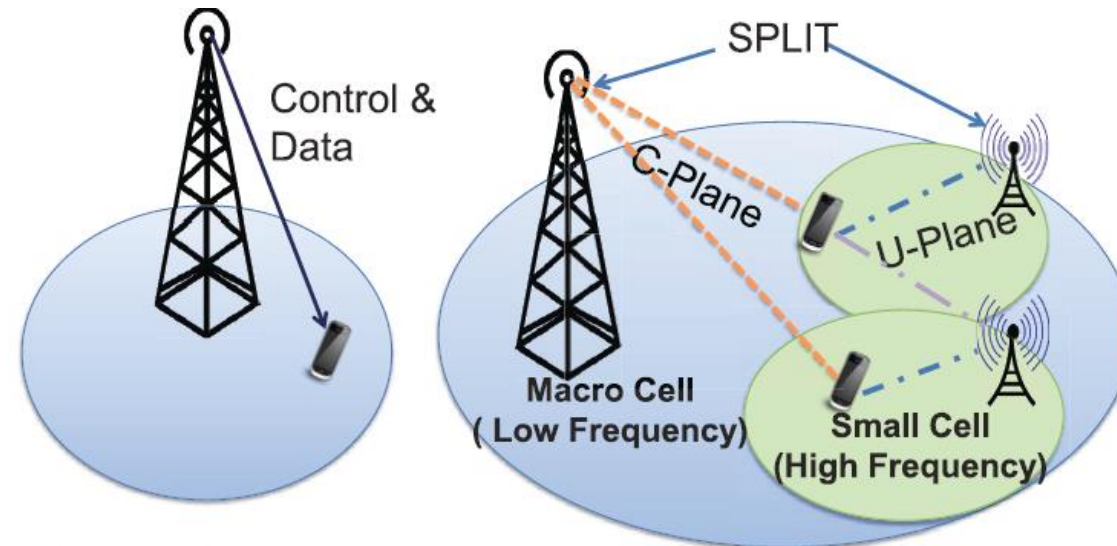
Next Generation Smart Antenna

- Interference mitigation
- Same channel can be used by different beams
- Optimal coverage
- Transmit power



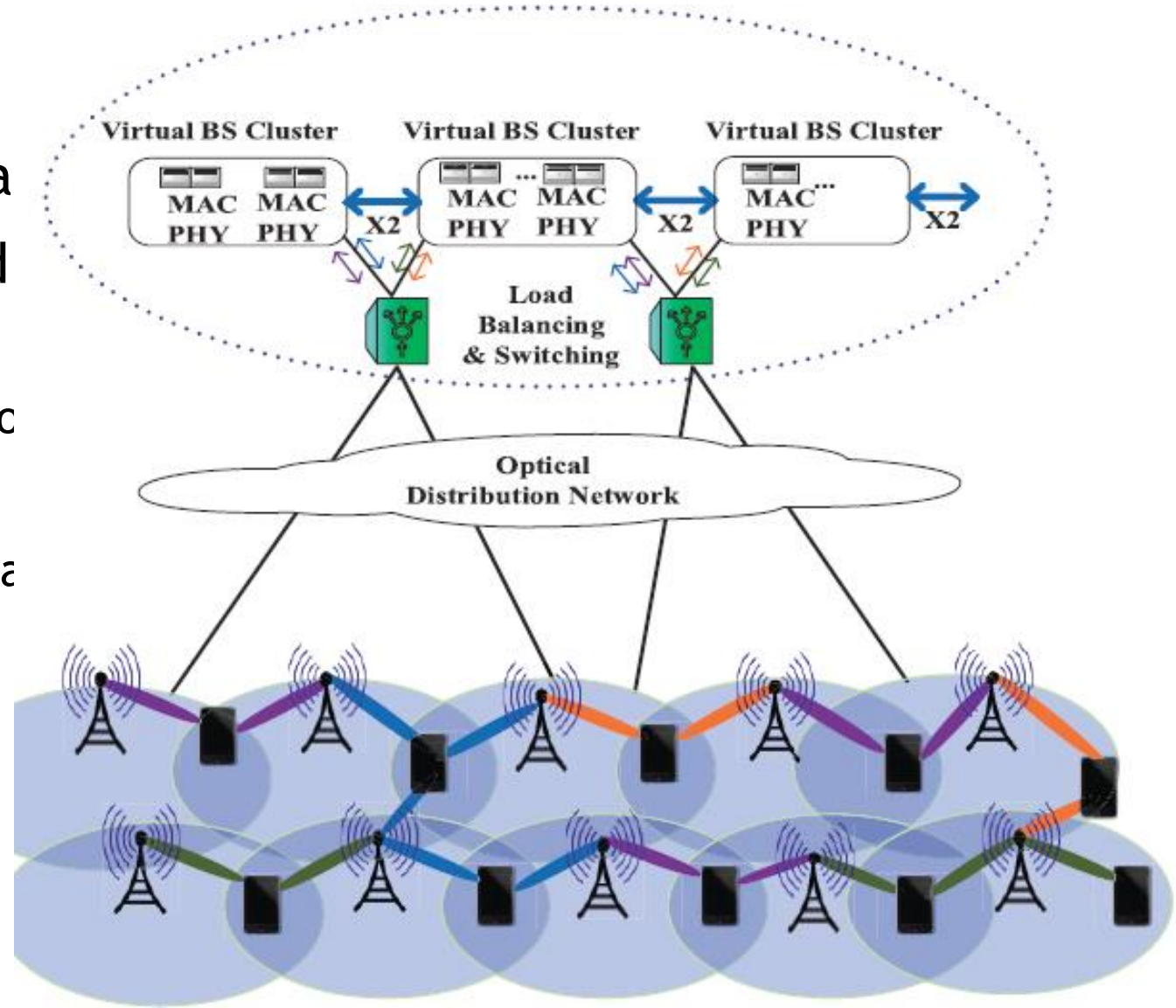
SDN—Agility and Resilience by Splitting of Plane

- SDN introduces swiftness and flexibility in 5G networks.
- SDN decouples the data and control planes by using the software components
- Interaction betw (OpenFlow)



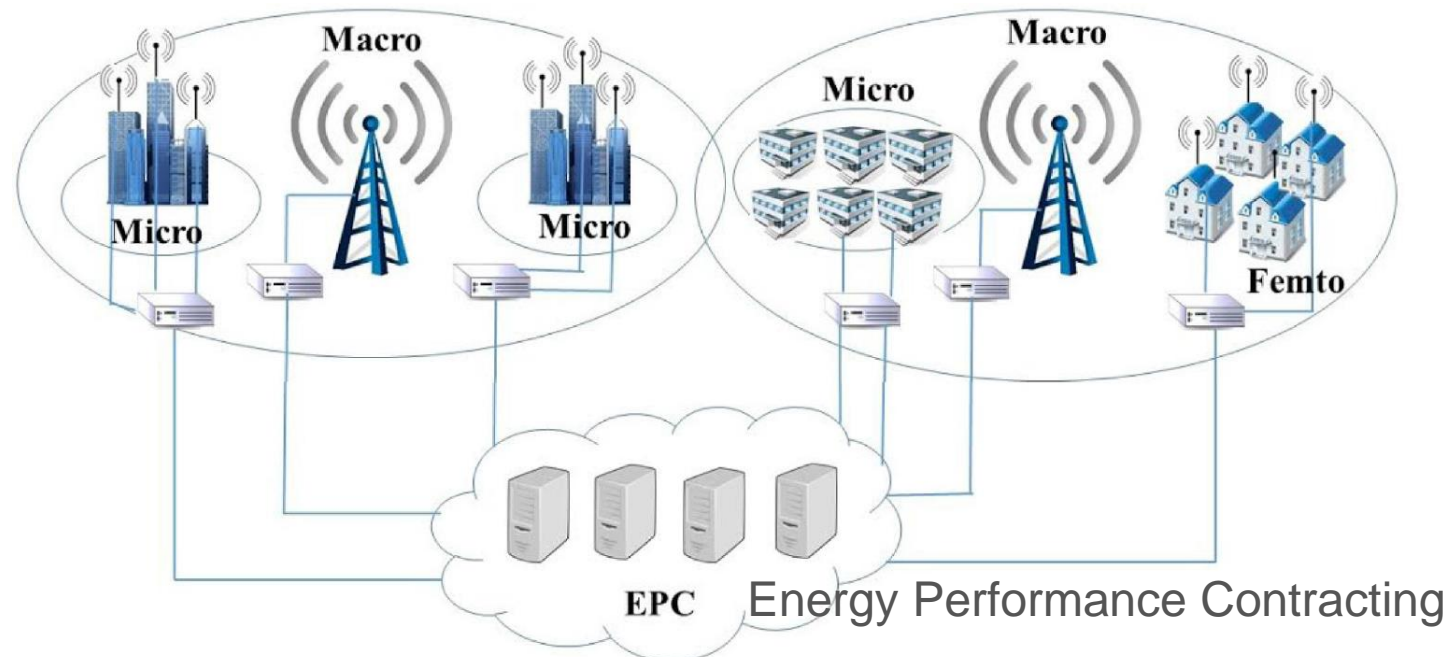
Cloud RAN—Centralized Architecture

- Increasing demands for high data rates
- Baseband resources are pooled
- Remote Radio Heads (RRH)
 - comprising of transceiver components
- RAN as a service (RANaaS)
 - centralized cloud platform with pooled resources



HetNets—Heterogeneous Approach

- Heterogeneous network: larger number of small cells
- Coordinated operation between traditional macro cells (multi-tier network)
- Reverse Time Division Duplex (TDD) protocol



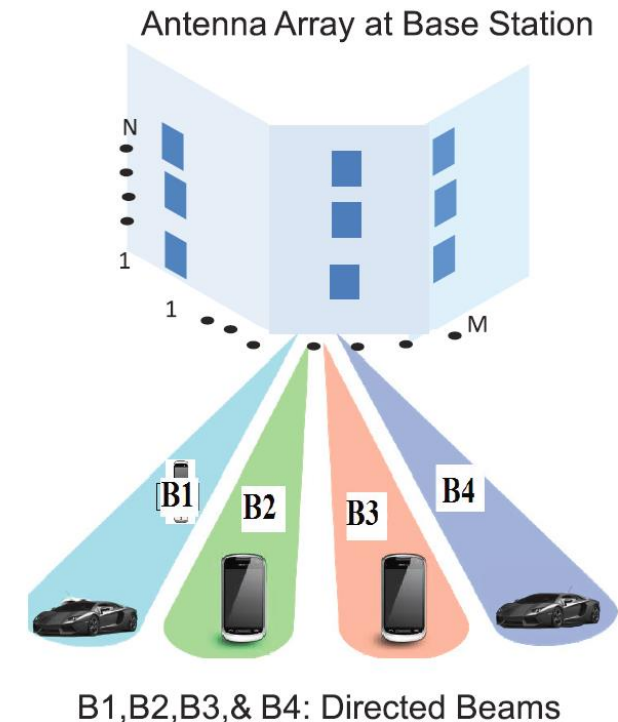


Mac Layer

Makeover

Special Beam Pattern

- BSs are required to simultaneously transmit and receive multiple beams in different directions



Directional MAC Protocols

- TDMA with time partitioned is suitable for 5G communications
 - CTA(Channel Time Allocation): time slot => spatial reuse
- Nodes need to transmit in the same direction from where it received CTS(Clear to Send)/RTS(Request to Send)
- Directional Network Allocation Vector(DNAV) table helps in tracking directions
- Multihop MAC
 - Direction-Omni(DO)
 - Direction-Direction(DD)

Alternate Methodologies

- Random Access Channel(RACH): non orthogonal waveforms
 - M2M 、IoT => bulky synchronization procedures of random access
- Cognitive Radio: Dynamic spectrum allocation algorithm, to improve resource utilization
 - Higher traffic load 、 lower delay
- Asymmetrical Duplex(A-Duplex): full duplex and half duplex may coexist in same application environment

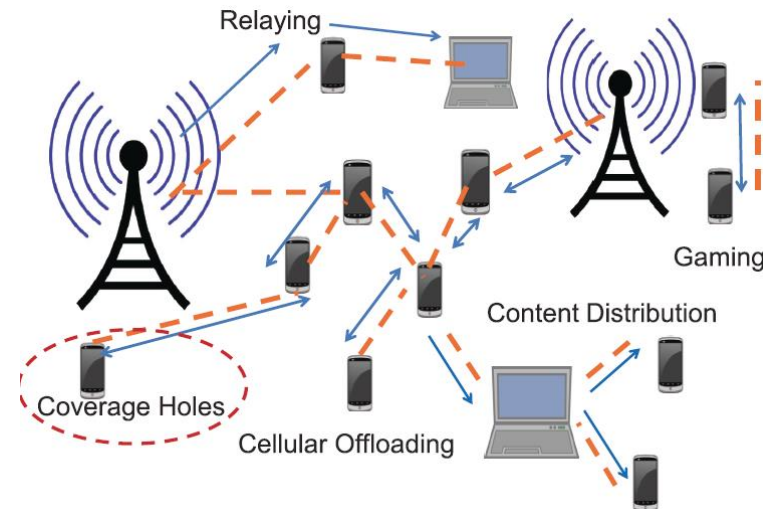


Emerging Applications



D2D Communication

- Adhoc Device-to-Device network: communicate directly bypassing the cellular BS
 - Low latency 、 energy efficiency 、 scalability
 - Decrease control signaling 、 decrease end to end latency
 - Local traffic



M2M Communication

- Machine-to-Machine communications: automated data generation, processing, transfer, and exchange, with minimum human intervention
 - Connect massive number of devices
- Envision umpteen number of devices with small data, sporadic transmission, high reliability, low latency and real time operation

Internet of Things

- High bandwidth 5G wireless networks
- Integrate with cloud
 - Large storage 、 computing 、 networking capabilities
- Social Internet of Thing(SIoT): relationship between objects and form a network

Advanced Vehicular Communications

- Internet of Vehicles(IoV): interconnected vehicles for robust traffic management and reduced collision probabilities
 - High bandwidth 、 pervasive availability 、 low latency
 - Social IoV (SIoV)
- Intelligent Internet of Vehicles Management System(IIOVMS): with cloud assisted data processing, over a wide number of vehicles helps in traffic management

Health Care and Wearable

- Body Area Network(BAN): real time data collection and monitoring
 - Huge data processing 、 real time communications
 - Bandwidth 、 data rates

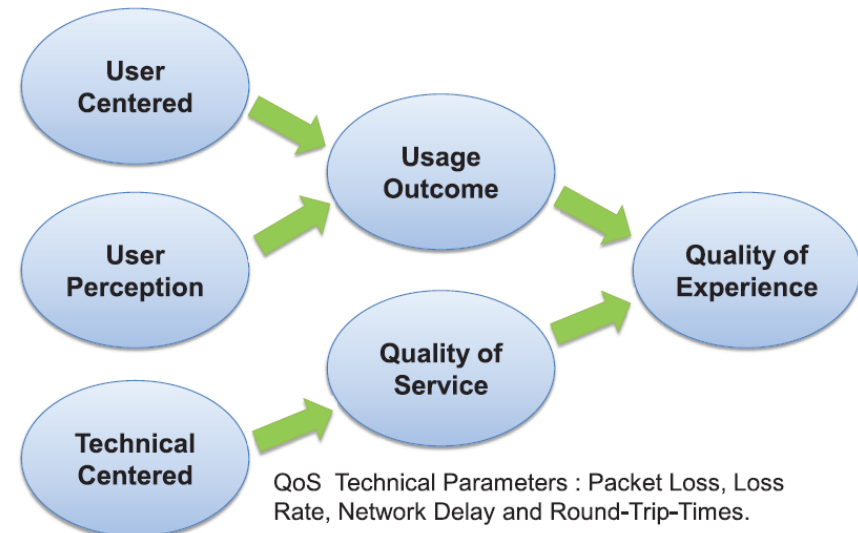


Quality Expectancy

5G Networks

Reinforcing QoS

- Quality of Service: guarantee real time, high quality multimedia traffic in time
 - Limited sources 、 shared medium
 - Mm-wave spectrum 、 beamforming antennas
- Bandwidth 、 error rate 、 signal strength 、 RTT delay



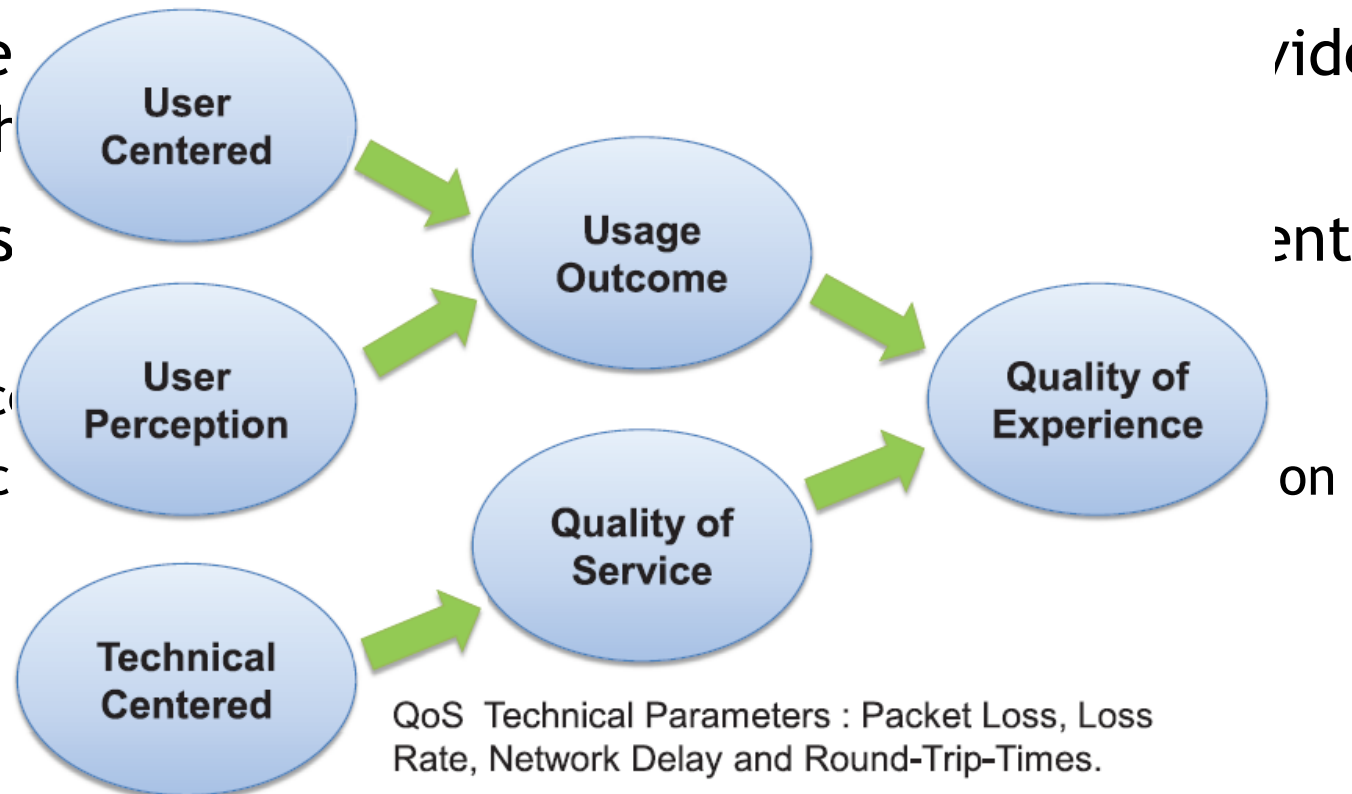
Refining QoE

- Quality of Experience(QoE): user's perceived satisfaction
 - Instructiveness 、 feeling of the products 、 ability to serve purposes

- HTTP Adaptive playback and h

- KQIs: correct s applications

- Network service
- Telecom applic establishment



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SON Enabled Quality Management

- Self Organizing Networks(SON): autonomic functionalities to wireless network
 - Self-configuration 、 self-optimization 、 self-healing
 - Improve user experience 、 reduce human intervention
 - Reduce operational expenses 、 increase network performance
 - Improve quality, robustness and longevity
- Online SON: do not require simulation models
 - Parameters are applied directly to the network
 - Large changes should avoid
- Offline SON:
 - Testing large number of parameters
 - Difficult to create precise environment



A Sustainable Future

Conclusion

Energy Aware BS

- Cell zooming: cell size is dynamically changed based on traffic load
- Renewable energy: incorporating energy harvesting from ambient resources
- eNB(Evolved Node B): self driven 、 takes decision based on local traffic changes without any load information exchange
- Network infrastructure as a resource

Energy-Efficient Backhaul

- Wired backhaul:
 - Higher reliability 、 capacity
 - Not flexible 、 economical
- Wireless backhaul
 - Lower power requirement
 - Unreliability
- Self organizing backhaul link
- Reinforcement learning based resource assignment

Energy and Cost Effective Network

- Energy efficiency VS. Performance
 - Transmission power 、 transmission time 、 channel conditions
 - Error detection 、 noise 、 interference
- Consumption factor(CF): evaluating power efficiency of a communication link
 - Maximum ratio of data rate to power consumption
 - Higher bandwidths with signal not severely attenuated
- Lower cost, redundancy and energy consumption
 - Smart antenna

Reduce overhead and Energy Drains

- C-RAN architecture
 - Simplification of conventional cell sites
 - Shift all processing to centralized cloud data center
- Cloud center
 - Increase in energy cost and carbon footprints
 - Workload prediction 、 virtual machine 、 workload consolidation
- H-CRAN = HetNet + Cloud(C-RAN)
 - Improve coverage, capacity and energy saving



**Thanks for
Listening**

