SAPIENZA
UNIVERSITÀ DI ROMA

5G Cellular systems

Wireless Systems, a.a. 2019/2020

Un. of Rome "La Sapienza"

Chiara Petrioli[†]

[†] *Department of Computer Science – University of Rome "Sapienza" – Italy*

5G vision

- 2014 technologies: Connectivity at High Speed + Cheap high computing power (over the Cloud, and at the edges of the network ← fog/edge computing technologies)
- Mobile access does not meet the required QoS
  - achievable coverage, data rates, latency, reliability, energy consumption
- Strong need for next generation ubiquitous ultra-high broadband mobile computing infrastructure

→ 5G under discussion ← many paradigms shifts to overcome current barriers in terms of performance and scalability

→ Objective: provide delay critical, ultra reliable, dependable secure broaband communications services to mobile users

→ not only to humans but also to tens of bilions of smart objects, cyber physical systems (e.g., cars, robots, drones) that are being deployed as part of the Internet of Things emerging paradigm

5G vision

- Convergence of different wireless systems
  - Vision: moving away from one architecture fits all towards a "Multiple architectures adapted to each service" concept
    - ✓ LTE, 3G, 2G, WiFi and satellite networks should cooperate and interwork seamlessy
    - ✓ Multi technology (different phy but also different kinds of network)
  - 5G pan european research infrastructures
  - Security, privacy and IoT support some of the key aspects of the vision
  - To change user experience disruptive change in performance & system optimization; service support; change in business models
    - → Examples: extension of usable bandwidth; Reduction of cost per bit; Programmable network; Low energy consumption & long lifetimes (also through harvesting); Security by design,…

5G KPIs

- Throughput: provide 1000x more available throughput in aggregate, as well as 10x more speed to individual end users (full immersive experience)
- Latency: down to 1ms when needed for tactile Internet
- Energy efficiency: 5% of global energy consumption is due to ICT
  - 90% increase in energy efficiency
  - 10x better battery lifetime for low power devices
- Coverage (really everywhere everytime: from planes, to trains etc.)
- Novel business models (service based)+ reduction of service creation times

System level challenges

- Privacy by design
- Quality of Service/Quality of Experience challenge: differentiated services across various dimensions (throughput, latency, resilience, costs but also security, availability, resilience)
- Simplicity challenge (seamless service provisioning even for inter RAT switching)
- Multi-tenancy challenge: provide services across different infrastructure ownership, with different networks coexisting and providing an integrated efficient interaction between mobile systems and the backhaul
- Density challenge (e.g., brought in by IoT devices)

System level challenges

- Diversity challenge
  - must support the increasing diversity of optimized wireless solutions, the diversity in traffic types and number of connected devices
- Harnessing challenge: exploit any communication capability, including device to device for optimizing communication at each time
- Harvesting challenge: exploit energy harvesting to improve lifetime
- Mobility challenge: seamless mobility across networks/technologies
- Location and context information challenge: submeter localization accuracy
- Hardening challenge: making communication system robust to attacks and natural disasters

System level challenges

- Resource management challenge
  - provide access agnostic control, policy and charging mechanisms and protocols for dynamic establishment, configuration, reconfiguration and release of any type of resource (bandwidth, computation, memory, storage) for any type of device and service.
- Flexibility challenge: device truly flexible control mechanisms and protocols for relocating functions, protocol entities an states relying on technologies such as SDN and NFV
- Identity challenge: provide identity management for any type of device with access agnostic authentication mechanisms
- Manageability: improve menageability of networks (reducing human intervention)

Flexibility, programmability, openness

5G Areas some examples

-**Cognitive access**, frequency agile

-Large bandwidth (**mmwave comm.**)

-Novel air interfaces

-Different communication models (unicast/multicast/ Broadcast/**D2D**),

Extensive reprogrammability & reconfigurability

System optimization and adaptive cognitive operation based on context

Use of data analytics, **NVF and SDN**

Harmonization of processes (Wireless/wired technologies)

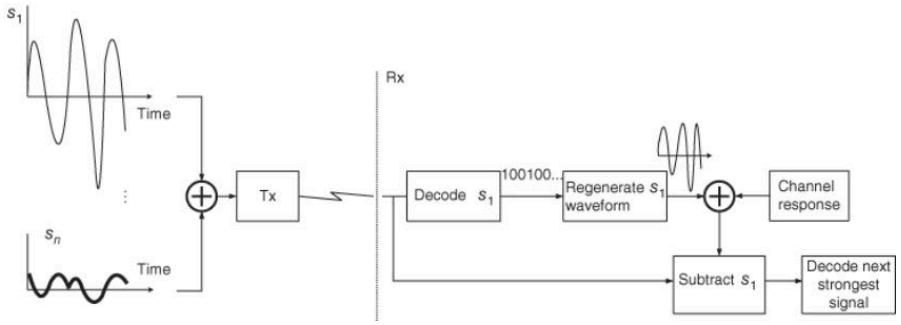
Authentication/authorization

QoS

Network view

IoT Support

Phy Layer Asdvancements



different users are superimposed into a single waveform. The receiver tries to decode the strongest signal while the other signals are treated as interference. The decoded signal is then regenerated into a waveform and subtracted from the composite received signal. The process is iterated for all desired signals. This method is called Successive Interference Cancellation (SIC), illustrated in Figure 13.2 for n user signals, $s_1 \cdots s_n$, where s_1 is a strongest signal.

Antenna Arrays,
MIMO, Beamforming,
Novel Modulations,
SW Defined approaches

From orthogonal to
Non orthogonal
Approaches

Beyond radio?
Hybrid VLC/Radio
For higher densification

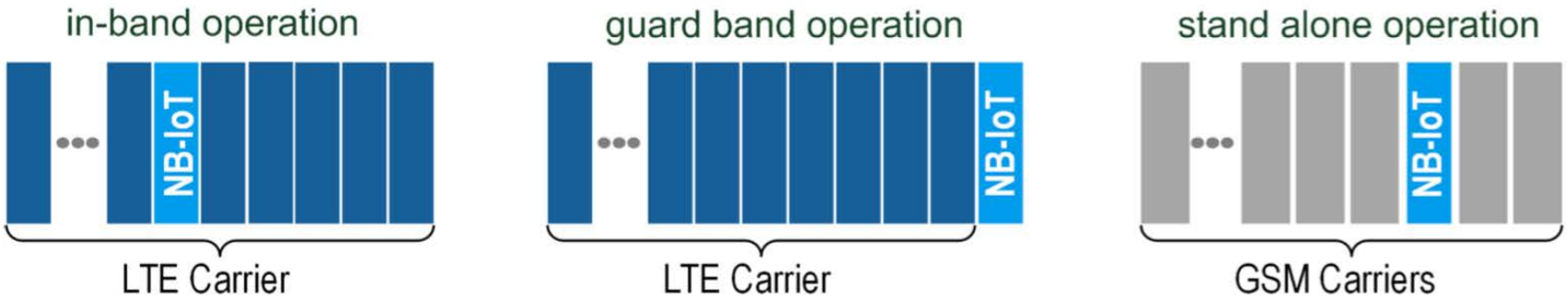


Table 3-1: Allowed LTE PRB indices for cell connection in NB-IoT in-band operation

LTE system bandwidth	**3 MHz**	**5 MHz**	**10 MHz**	**15 MHz**	**20 MHz**
LTE PRB indices for NB-IoT synchronization	2, 12	2, 7, 17, 22	4, 9, 14, 19, 30, 35, 40, 45	2, 7, 12, 17, 22, 27, 32, 42, 47, 52, 57, 62, 67, 72	4, 9, 14, 19, 24, 29, 34, 39, 44, 55, 60, 65, 70, 75, 80, 85, 90, 95