

# Dynamic spectrum allocation and energy efficiency in 5G systems

## The SPEED-5G perspective

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# Outline

- ▶ EE as a key pillar in 5G systems
  - ▶ Heterogeneous Networks Slicing
  - ▶ Network programmability
  - ▶ Virtualization of resources
  
- ▶ SPEED-5G quick overview
  
- ▶ SPEED-5G original technical contributions
  - ▶ eDSA definition
  - ▶ Heterogeneous architecture proposal
  - ▶ Multi-RAT capable system
  - ▶ RRM enhancements

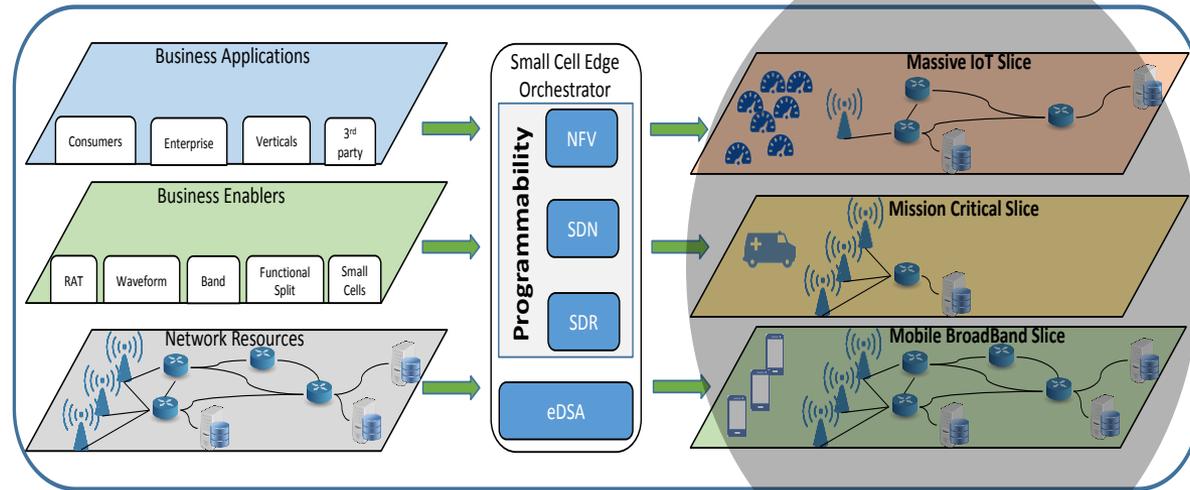
# Energy Efficiency as a key 5G architecture pillar

- ▶ Joint optimization of **Spectral Efficiency** and **Energy Efficiency** is a key pillar of future 5G network deployments
  
  - ▶ **SPEED-5G** is addressing this challenge by:
    - ▶ using in a novel way already existing concepts:
      - ▶ **Heterogeneous Networks Slicing**
      - ▶ **Network programmability**
      - ▶ **Virtualization of resources**
  
    - ▶ providing original contribution on:
      - ▶ **Optimization of Radio Resource Management (RRM) procedures**
      - ▶ Introduction of the **Extended** Dynamic Spectrum Allocation (eDSA) concept
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# Network slicing architecture and SPEED-5G use cases

- ▶ The **network slicing** concept:
  - ▶ enables one operator to deploy, on demand, multiple logical instantiations of its physical network, each one isolated and fully dedicated to a specific service
  - ▶ leads to high resource utilization efficiency, scalability and adaptability since each slice is designed and managed to dynamically provide the required level of resources

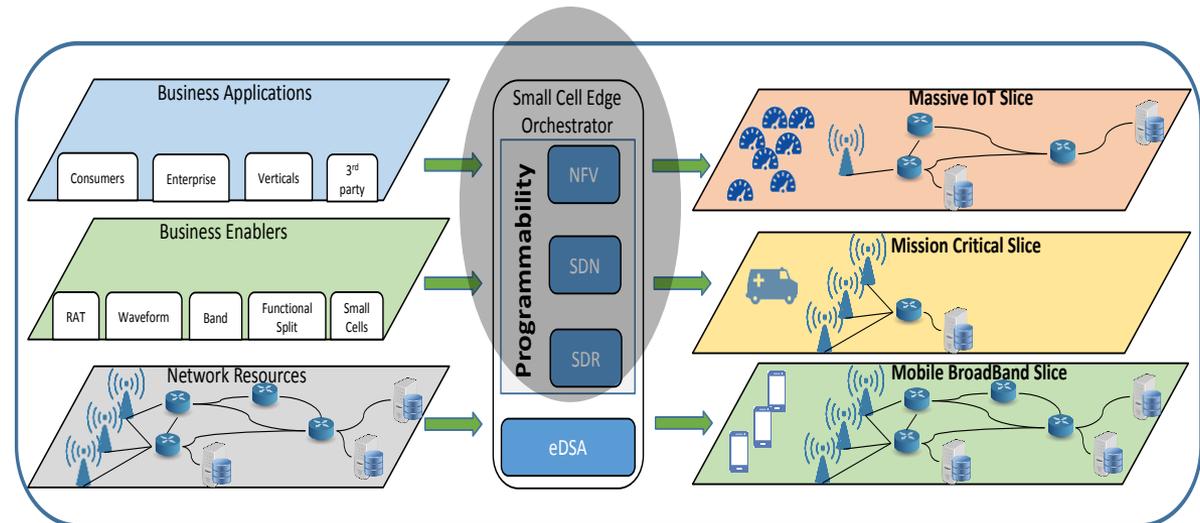
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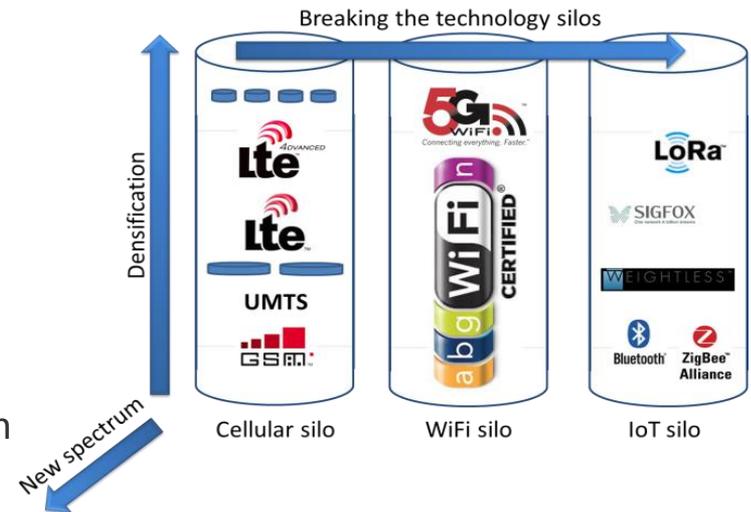
# Network programmability and virtualization of the resources

- ▶ The **network programmability** paradigm makes the following concepts interact :
  - ▶ NFV (Network Function **Virtualization**): separating network functions from the hardware they run on
  - ▶ SDN (SW Defined Network): decoupling the control-plane from the data-plane so to instantiate and configure network elements in the most appropriate way
  - ▶ SDR (SW Defined Radio): providing in the most flexible way the different blocks composing a RAT access stratum (MAC, RLC, RRM, PHY, etc)

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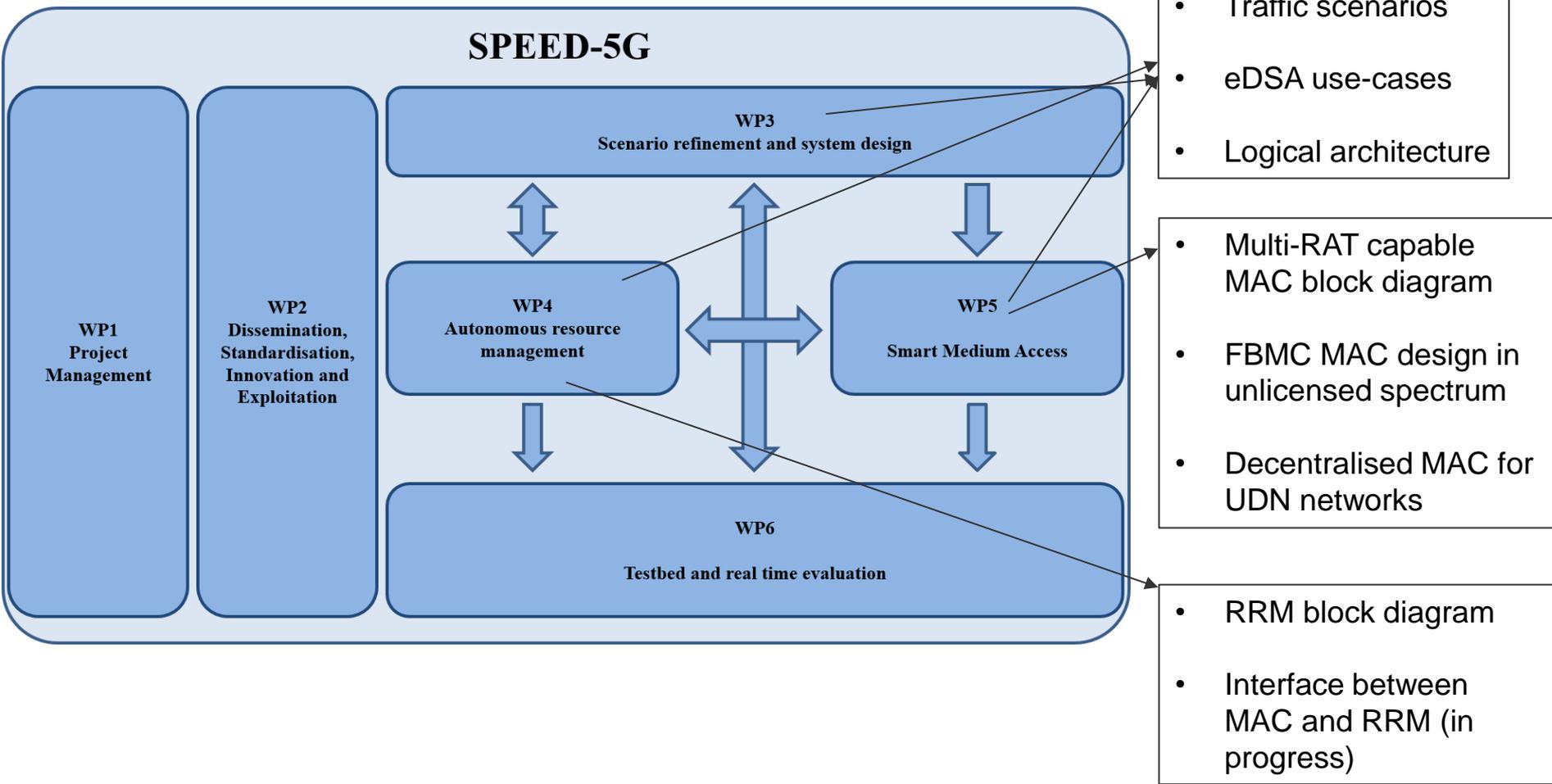
- ▶ The main objective of SPEED-5G is to achieve a significantly better exploitation of **heterogeneous wireless technologies**, providing higher capacity together with the **ultra-densification of cellular technology**, and effectively supporting the new 5G Quality of Experience (QoE) requirements.
- ▶ In SPEED-5G we will develop new techniques for optimizing spectrum utilization, following three main dimensions:
  - ➔ Ultra-densification through small cells,
  - ➔ additional (shared) spectrum,
  - ➔ exploitation of available resources across technologies
- ▶ In SPEED-5G this three dimensional model is referred to as **eDSA**, where several spectrum bands, cells and technologies are jointly managed in order to offer improved QoE and a tremendous capacity increase in a cost-efficient manner.

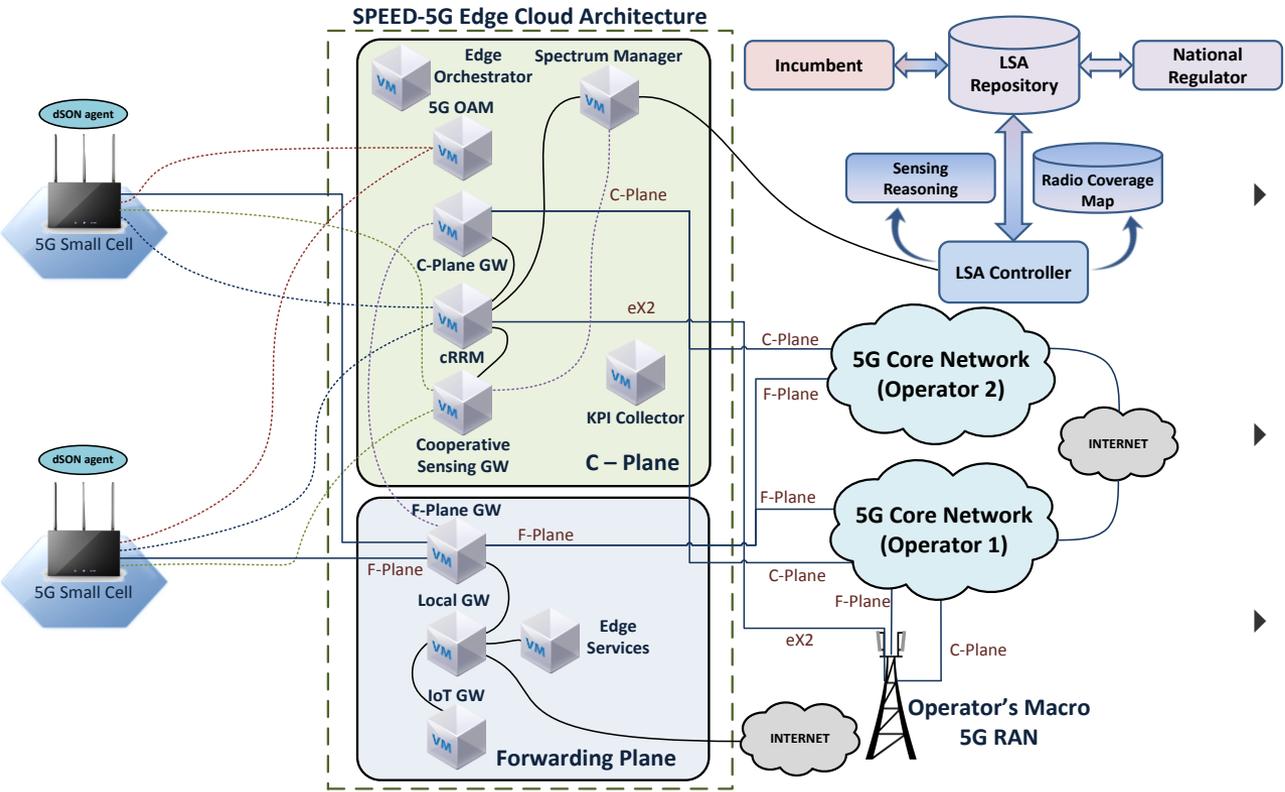


**Project Coordinator:** Sistelbanda  
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**More information at:** <https://5g-ppp.eu/speed-5g>  
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- ▶ SPEED-5G targets providing solutions at Layer 2, Layer 3 and above to enable eDSA with multiple RATs, and especially with FBMC, a non orthogonal multicarrier waveform.
  - ▶ SPEED-5G doesn't work on physical layer design but provides the enablers for using in a coordinated way licensed, lightly-licensed and unlicensed spectrum mostly in dense and ultra-dense small cell networks.
  - ▶ A new MAC for the 5G will be developed and evaluated throughout different use cases and scenarios
  - ▶ New RRM mechanisms will be explored in order to enhance and enable a real Dynamic Spectrum Access using in a well defined set of Use Cases and scenarios mainly from 3GPP and METIS
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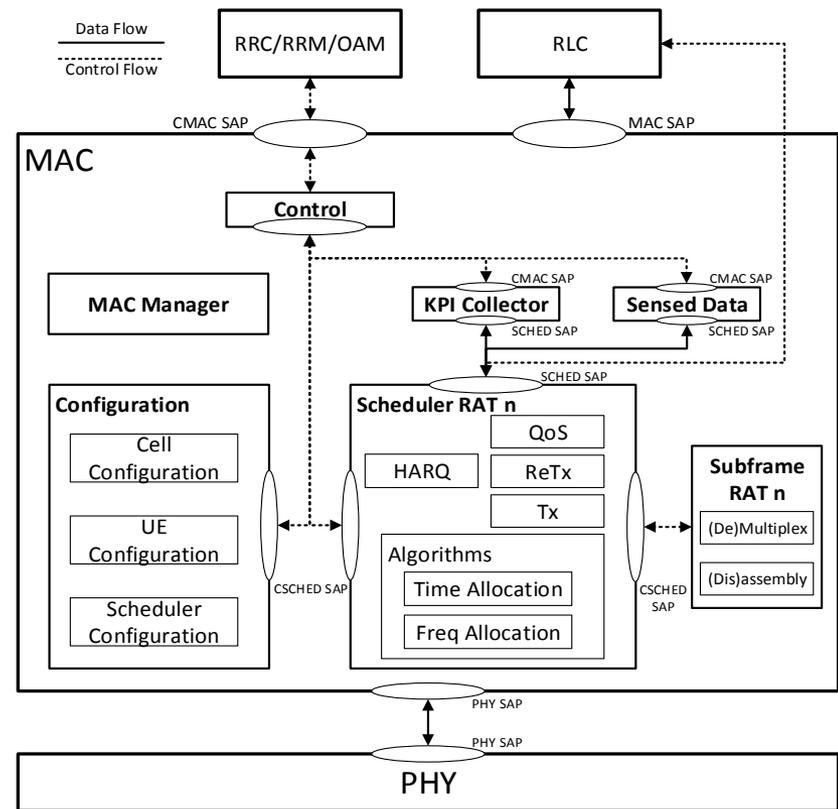
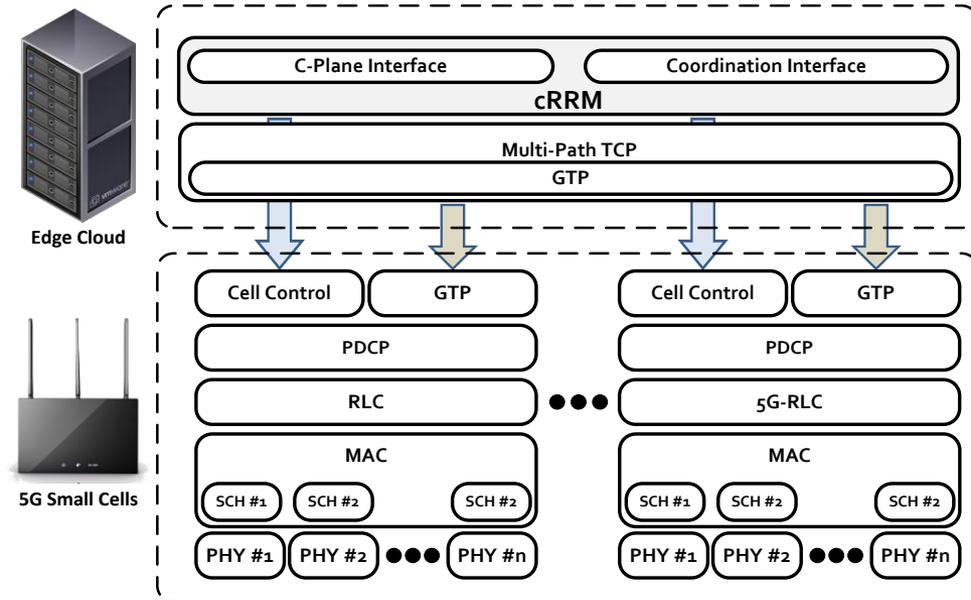
- ▶ Capacity enhancement by means of selecting or aggregating different RATs on various spectrum license regimes
  - **Licensed, unlicensed** (mainly 5 GHz) and **lightly licensed** spectrum; examples for lightly licensed: TVWS or LSA bands (2.3 GHz, 3.5 GHz)
  
- ▶ **Examples of key eDSA use-cases**
  - **Capacity improvement** with a supplemental carrier on non-licensed spectrum using any RAT (extended LAA)
  - **Interference reduction** on a group of small cells by offloading traffic on non-licensed spectrum (coordinated or autonomous manner)
  - These use-cases rely on the ability to dynamically **select a suitable channel** in a list of candidates, depending on the traffic type and interference context (cognitive radio concept)

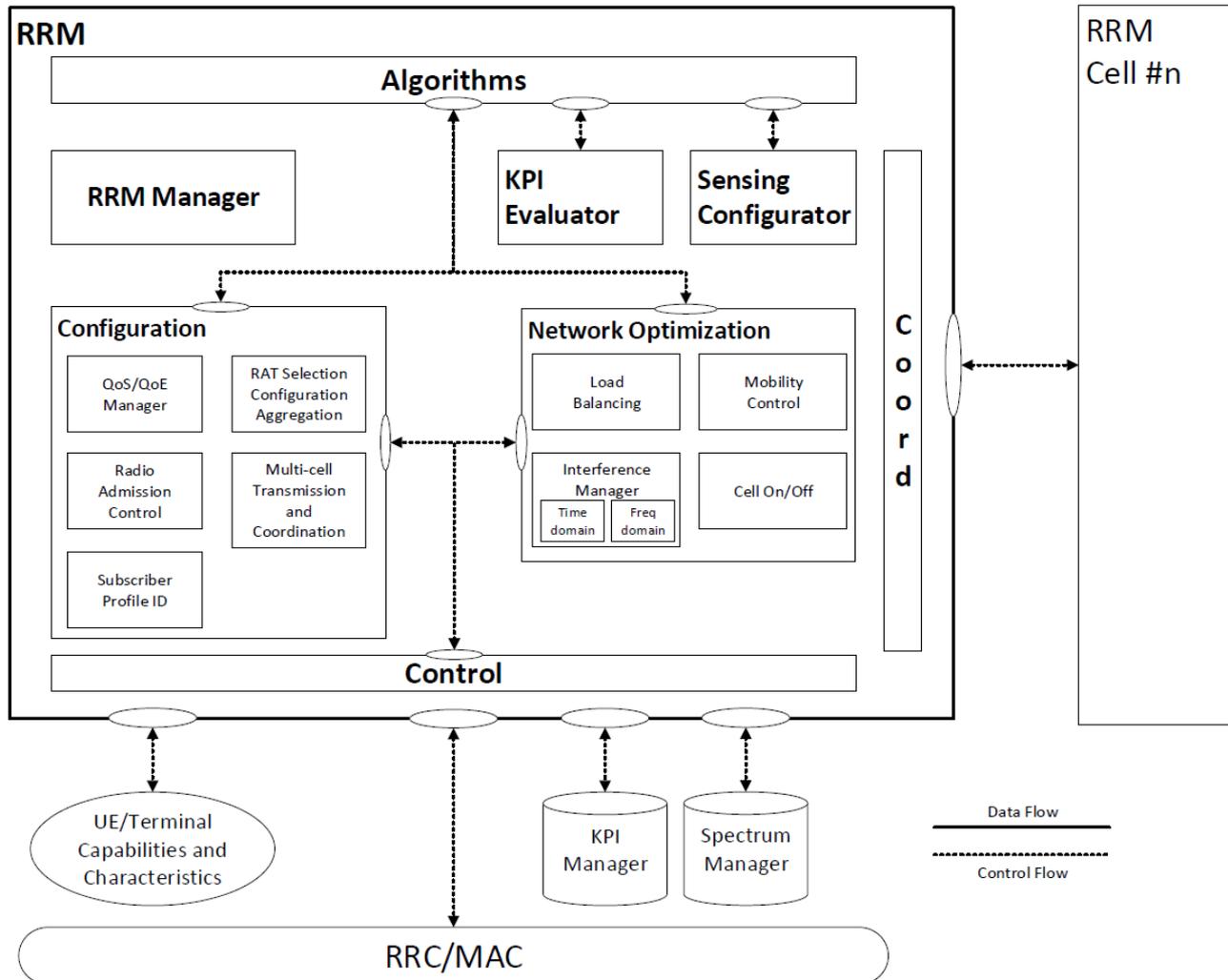




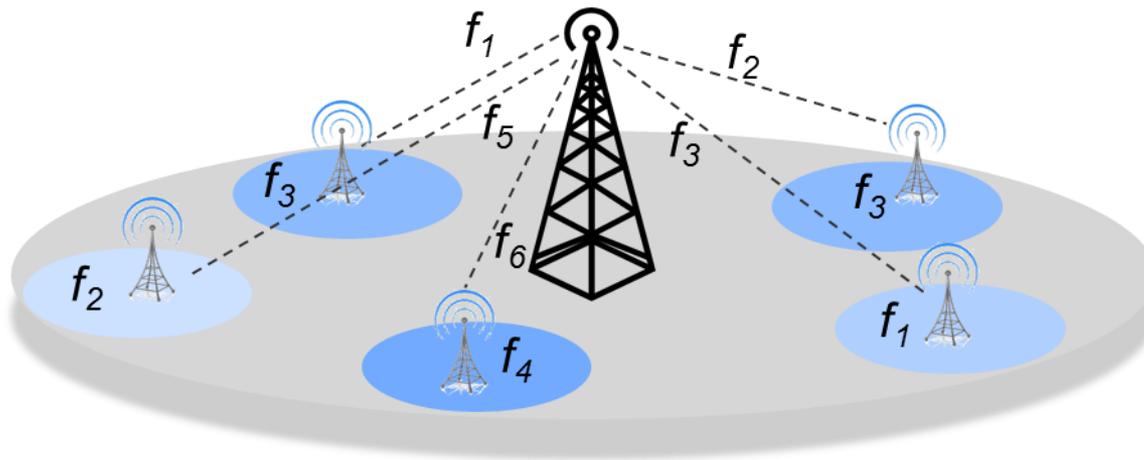
- ▶ Deployment of edge gateways (both in C and F-Plane) to geographically distribute resource control and access to service content
- ▶ cRRM deals with resource allocation, inter-cell cooperation ; it is linked to spectrum management aspects for operating in shared spectrum bands
- ▶ cRRM is responsible of addressing the high SINR level by using smart interference management techniques, linked to distributed protocol in small cells.

- ▶ Because eDSA requires opportunistic operation on various license regimes,
  - ➔ Interworking multi-RATs MAC and RRM frameworks have been defined





- ▶ The proposed solutions will leverage the advantage of flexible waveforms and interference management schemes by using:
  - Dynamic Channel Selection
  - Channel Segregation techniques
  - Load balancing among a group of neighboring cells/small cells
  - Co-locating WiFi access points, sharing site-lease agreements and backhaul



$f_i$ : Different frequencies in a multi-RAT environment

- ▶ RRM enablers envisaged to support different types of wireless services and use cases through non-continuous spectrum aggregation and multi-RAT technologies
  - ▶ Traditional RRM were mainly seeking spectrum efficiency and QoS
  - ▶ RRM could also play an important role in **reducing energy consumption** and thus improve the whole system resource and energy efficiency
  - ▶ Means for achieving resource/energy efficiency:
    - Transmission power control scheme
    - Base station sleep process
    - Boost of Capacity/Throughput (by transmitting more data in shorter period of time – enabling for example sleep mode)
    - Reduce the interference level and packet drops (due to less retransmissions –hence less energy consumed for transmission)
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- ▶ Speed-5G project deals with the capacity improvement of 5G ultra dense heterogeneous networks, developing the novel concept of eDSA
  - ▶ eDSA is about relying on new spectrum resource with various license regimes so that new operation modes of RATs could be used to improve the capacity either by aggregating carriers and/or by managing the interference
  - ▶ The logical architecture relies on a slice-based virtualised edge architecture able to cope with centralised management of resources and a (distributed) multi-RAT MAC protocol
  - ▶ This proposal is designed to allow for many optimisations: resource and spectrum utilisation, capacity maximisation, interference management
  - ▶ **Energy efficiency is a criterion this architecture is able to play on**
  - ▶ Performance evaluations will start soon, based on realistic scenarios (virtual office, outdoor hotspot, extended sub-urban) implying a representative mix of traffic
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# Thank you for your attention!

*Find us at [www.speed-5g.eu](http://www.speed-5g.eu)*

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