Agile Resource Management for 5G

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The Source

D5.1: “Draft synchronous control functions and resource abstraction considerations”

Website: https://metis-ii.5g-ppp.eu/documents/deliverables/

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Content

- Introduction
- Novel Agile Resource Management (RM) framework building blocks:
  - **Interference Management**
  - **Flexible Short-term Spectrum Usage**
  - **RAN Moderation**
  - **RM for Network Slicing**
  - **Tight Integration with Evolved Legacy AIs**
  - **Holistic RM and AI abstraction models**
  - **RM for Inter-Network Collaboration**
  - **Dynamic Traffic Steering**
  - **Context Management**

Foundation for Intra-AIV RM Functionality Framework

Foundation for AIV-overarching RM Functionality Framework

Enabler for Functionality Frameworks

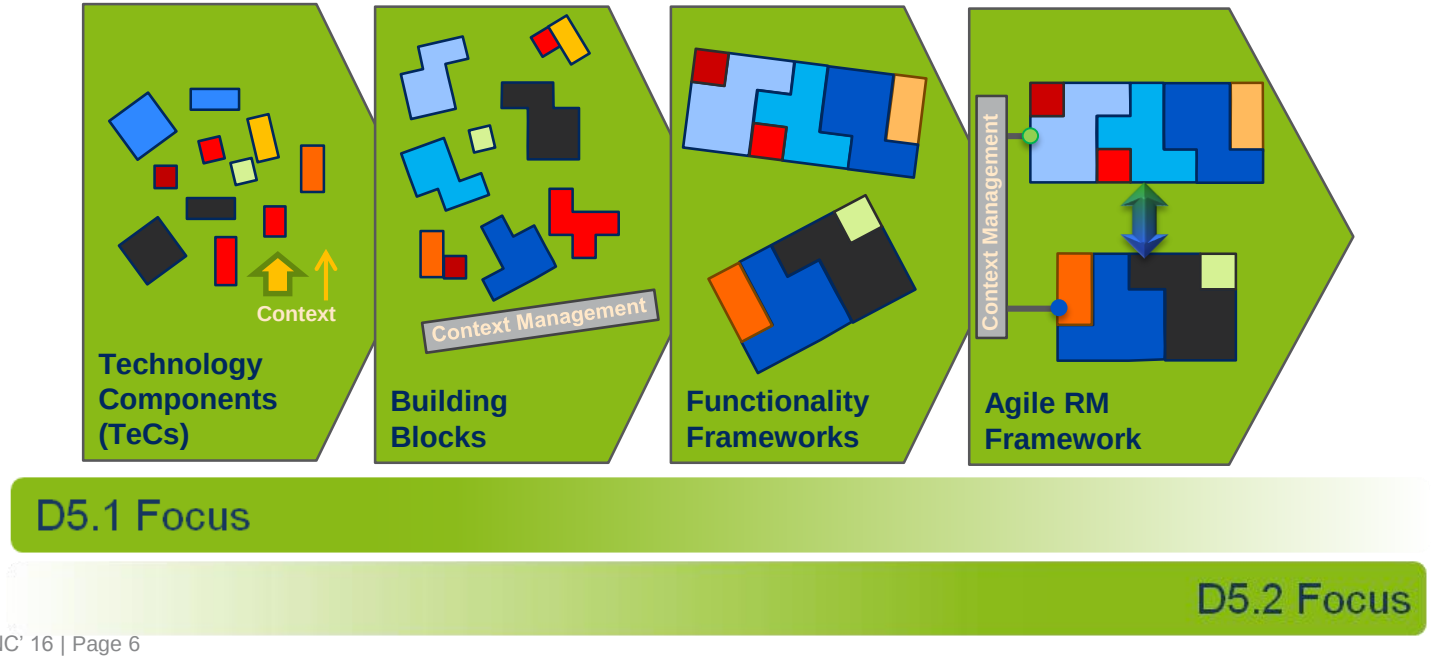
- Positioning of Enabling Technologies in 5G Landscape
- Conclusions & Outlook

Introduction

- D5.1 presents draft considerations on synchronous control functions & resource abstraction along with initial analyses and results
- Main research directions are depicted
- The initial concept of **Agile Resource Management (RM) Framework** is highlighted, which considers & exploits novel 5G aspects:
  - Diverse service requirements,
  - Overall Air Interface (AI) comprising multiple AI variants (AIVs),
  - Dynamic Topologies, and novel communication modes.
- **Main objectives** are defined as:
  - Efficient and effective use of any available resources when and where needed,
  - Extension of the notion of a resource beyond conventional radio RM (RRM),
  - The optimum mapping of 5G services to the resources taking into account target performance metrics, e.g., energy consumption, &
  - Network slice -specific RM comprising inter-slice and intra-slice RM schemes.

Development of Agile RM Framework

- The development of Agile RM Framework starts from technology components (TeCs) going toward building blocks and functionality frameworks
- D5.1 places the focus on the development of TeCs & building blocks, while providing the foundations for functionality frameworks
- D5.2 (*due in March 2017*) will place the focus on further refinement of functionality frameworks & inter-relations of building blocks toward the final design



Agile RM Framework (Conceptual View)

Slice

Services & Applications

Resource Abstraction Framework & AIV-agnostic Resource Management

Resource Modeling/Abstraction

Resource Modeling/Abstraction

Resource Modeling/Abstraction

AIV-specific Resource Management

AIV-specific Resource Management

AIV-specific Resource Management

Novel 5G AIV(s)
AIV (i): Service-oriented AIV
(xMBB, mMTC, uMTC, etc.)

Evolved LTE
AIV (j)

Evolved WiFi
AIV (k)

Information & measurements

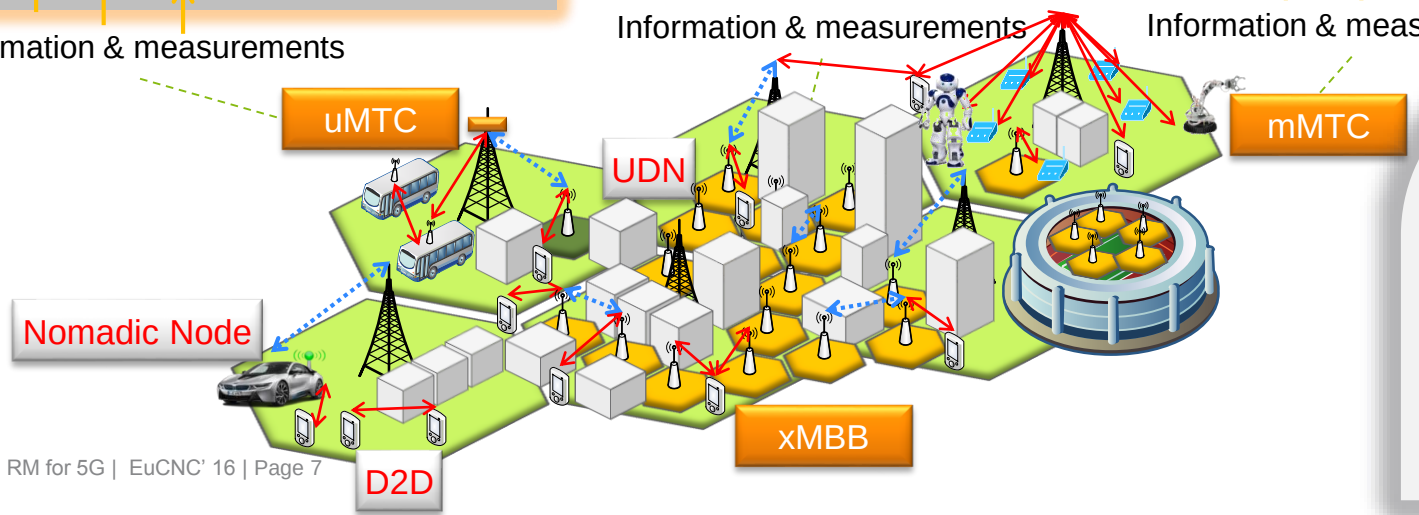
Information & measurements

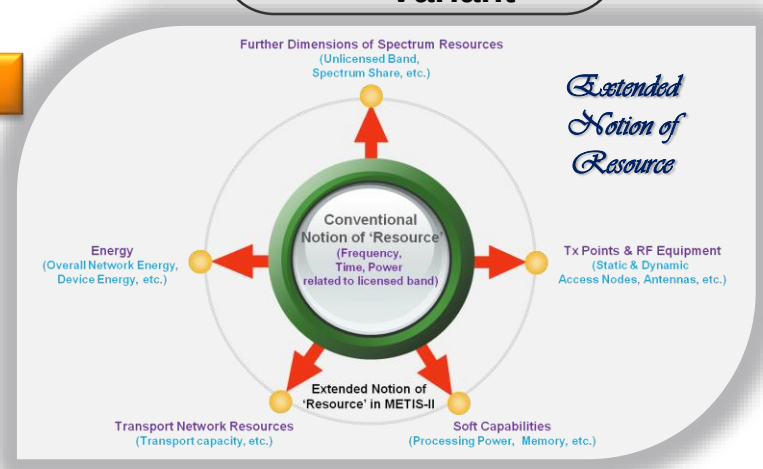
Information & measurements

Context Flow

Service Flow

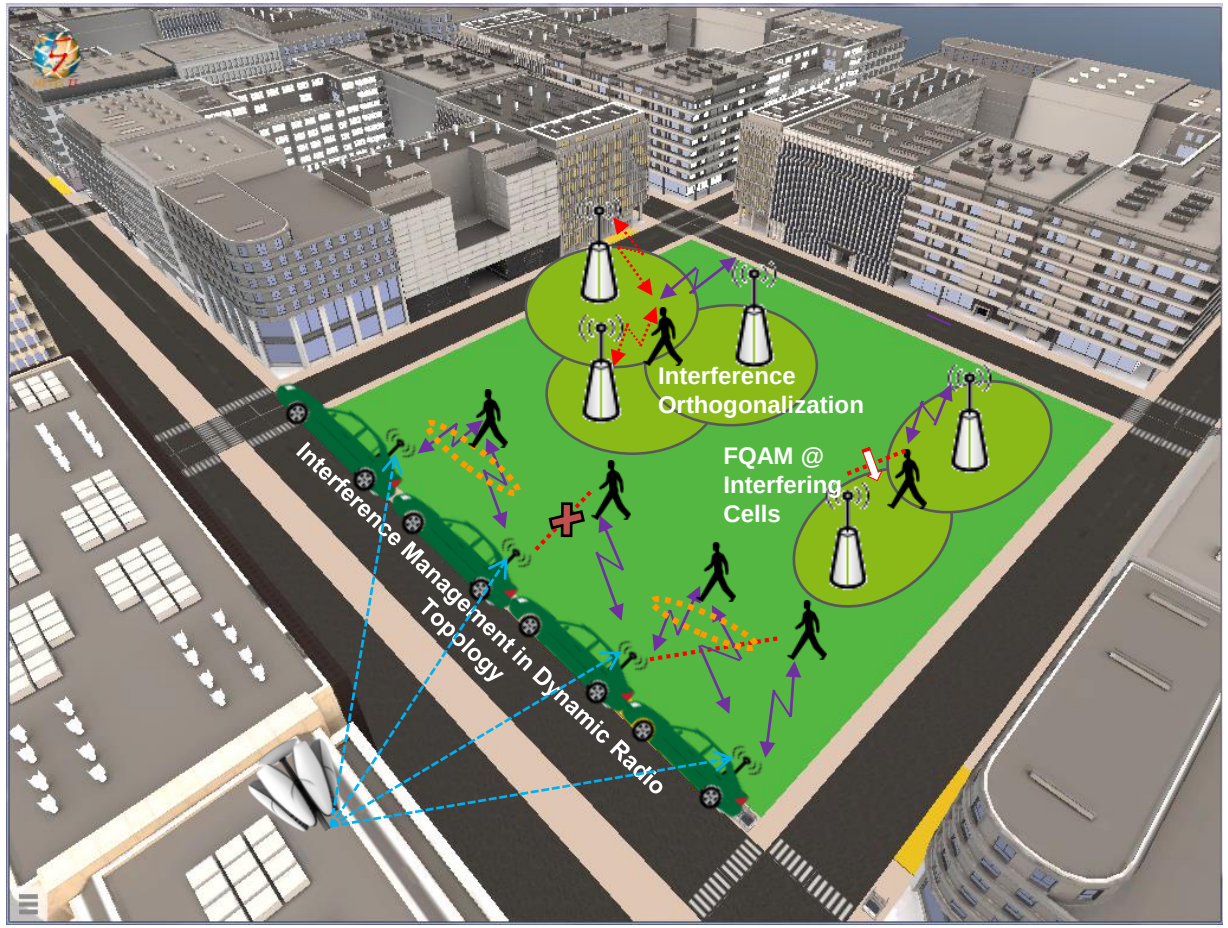
AIV Air-Interface Variant





Interference Management

Interference Management: Key Findings



With the rise of dense deployments & dynamic radio topology, interference generated among the entities can be vastly different

→ Interference Mitigation is crucial

Tune-able Interference Coordination (ICIC/ eICIC) and Cooperation (Coordinated Scheduling, Joint Transmission, Dynamic NN selection) can boost spectral efficiency in a user-centric manner.

A hybrid of Frequency Shift Keying and Quadrature Amplitude Modulation (termed as FQAM) can alter the distribution of ICI to non-Gaussian.
→ Advantageous in “high Interference” areas to improve the user experience.

Interference coming from neighboring cells at cell edge users can be orthogonalized by means of a precoding coordination pattern and a spreading factor

Interference Management
UE-centric Interference Management

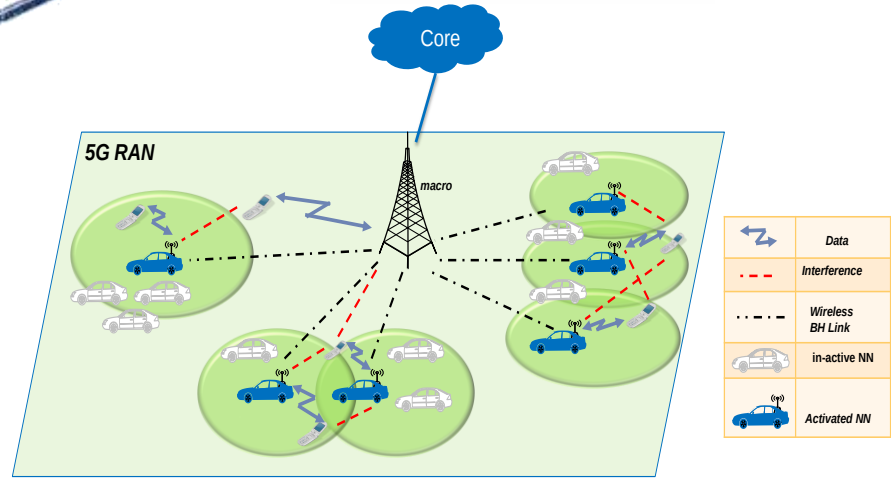
EXAMPLE

MOBILE WORLD CONGRESS BARCELONA 22-25 FEB 2016

METIS II

› Abstract:

- This work focuses on ultra-dense heterogeneous RAN, where a mixture of fixed (e.g. macro cell) and unplanned (small cells, nomadic nodes) utilize the same spectrum to enhance spatial reuse.
- Activation of Nomadic Nodes (NNs) can potentially provide high capacity and coverage gains
  - However by using the same spectrum between multiple NNs, the Inter-NN interference will be severe; thus limiting the gains which can be achieved by increasing the spatial reuse.
  - By means of effective interference mitigation techniques the gains can be further improved.

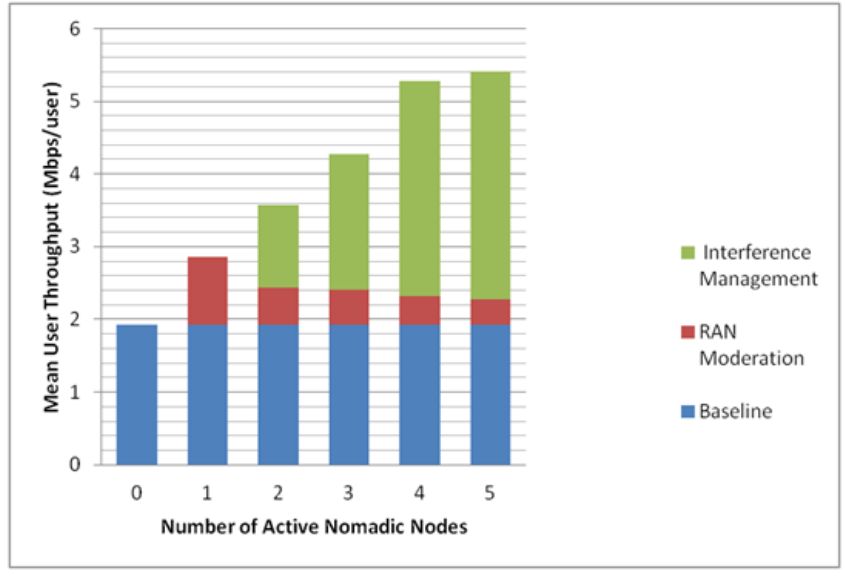


› Highlights:

- **Adaptive Interference Coordination and Cooperation (e.g., Coordinated Scheduling, Joint Transmission, Dynamic NN selection) mechanisms to improve spectral efficiency in Dynamic Radio Topologies as well as the user throughput.**

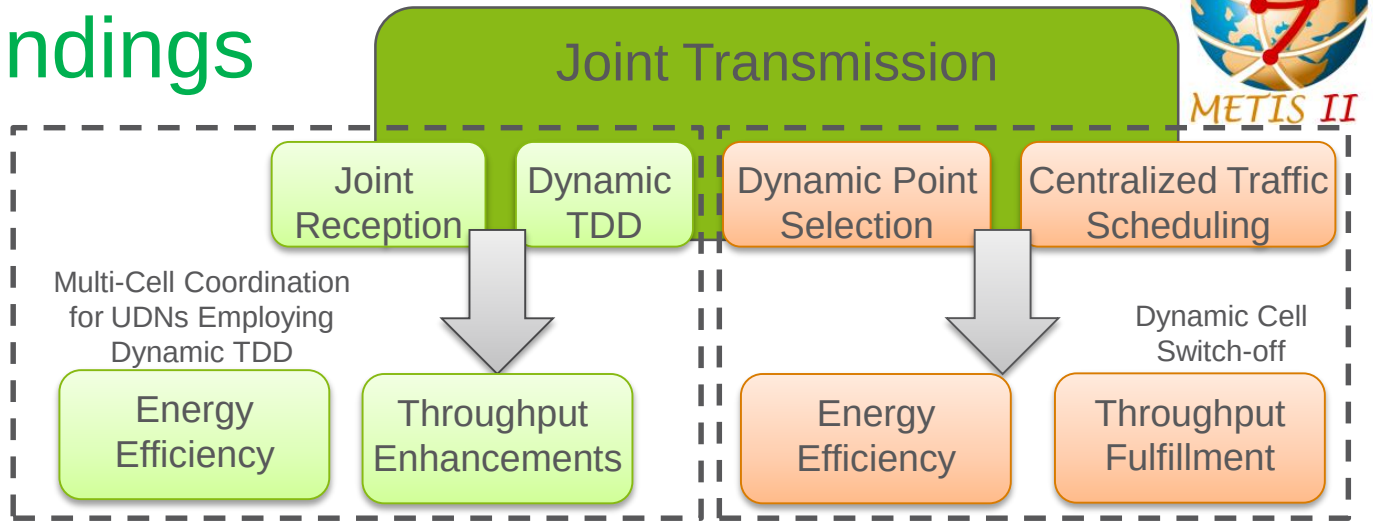
› Possible RAN design impact:

- Mainly new functionalities and interfaces will be required for inter-cell RM and for the coordination of the dynamic radio topology (e.g., due to NNs).
- The backhaul link measurements and activation commands imply new signaling elements on the wireless backhaul link.



RAN Moderation

RAN Moderation: Key Findings



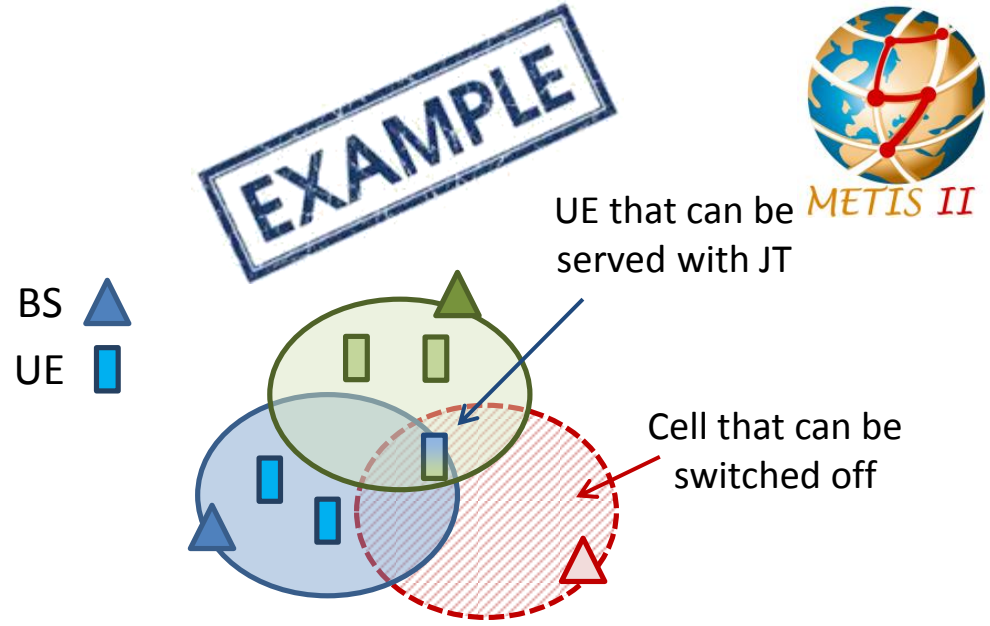
- In the RAN moderation building block, two key enhancements in 5G networks are considered.
  - The first enhancement proposes the use of multi-cell coordination through joint-transmission and reception, and the use of fully dynamic TDD
    - To enable throughput enhancements, especially at medium load conditions.
  - The second enhancement proposes the use of centralized traffic scheduling along with multi-cell coordination schemes such as dynamic point selection and joint transmission to operate an optimal amount of nodes in the network.
    - The main target here is energy efficient operation of ultra-dense networks.

RAN Moderation
Dynamic cell switch off

raffic scheduling to:

the signal transmitted from certain cells when the traffic
s peak, in order to reduce energy consumption

namic Point Selection and incoherent Joint
ion to further reduce required number of active signals.



ut using the simplified Madrid grid scenario
IS-I WP3

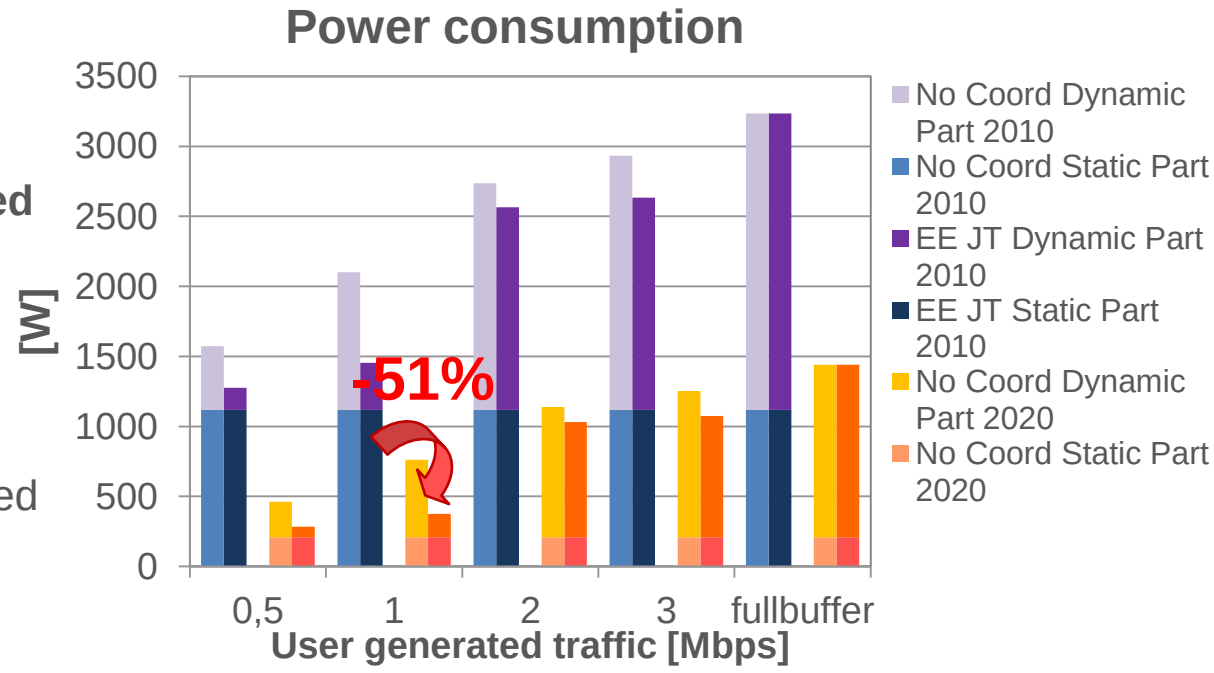
om METIS-I updated considering novel
del for 5G nodes

g scalability of power consumption granted
ver models allows even greater saving

l design impact:

on the MAC layer, through centralized
. A C-RAN architecture is preferred.

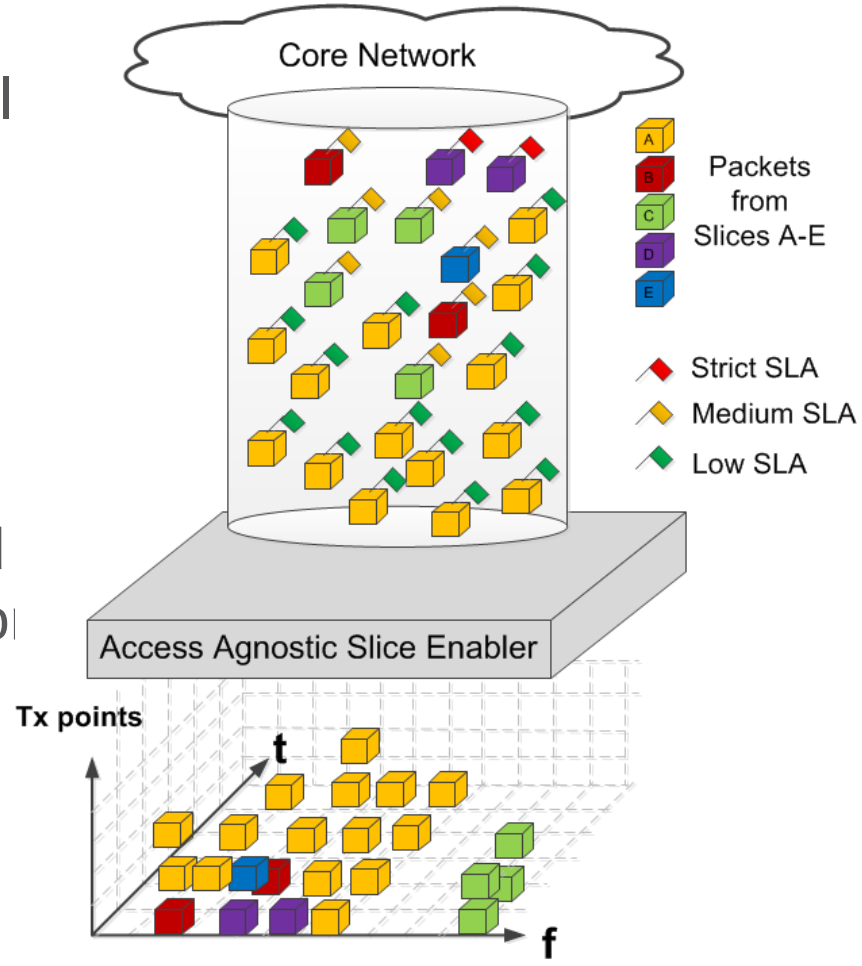
sm to assess channel quality also for switched
s needed (e.g. periodic beacon)



RM for Network Slices

RM for Network Slices: Key Findings

- Network slicing is a concept for running multiple logical networks as virtually independent business operations on a common physical infrastructure
- Novel resource management enables the sharing of a common RAN (consisting of multiple air interface variants) by multiple network slices
- Abstraction of RAN resources in a possible centralized logical entity to perform Inter-Slice RM with coordinatio of resource usage by different AIVs, offering a single control point for mobile network operators

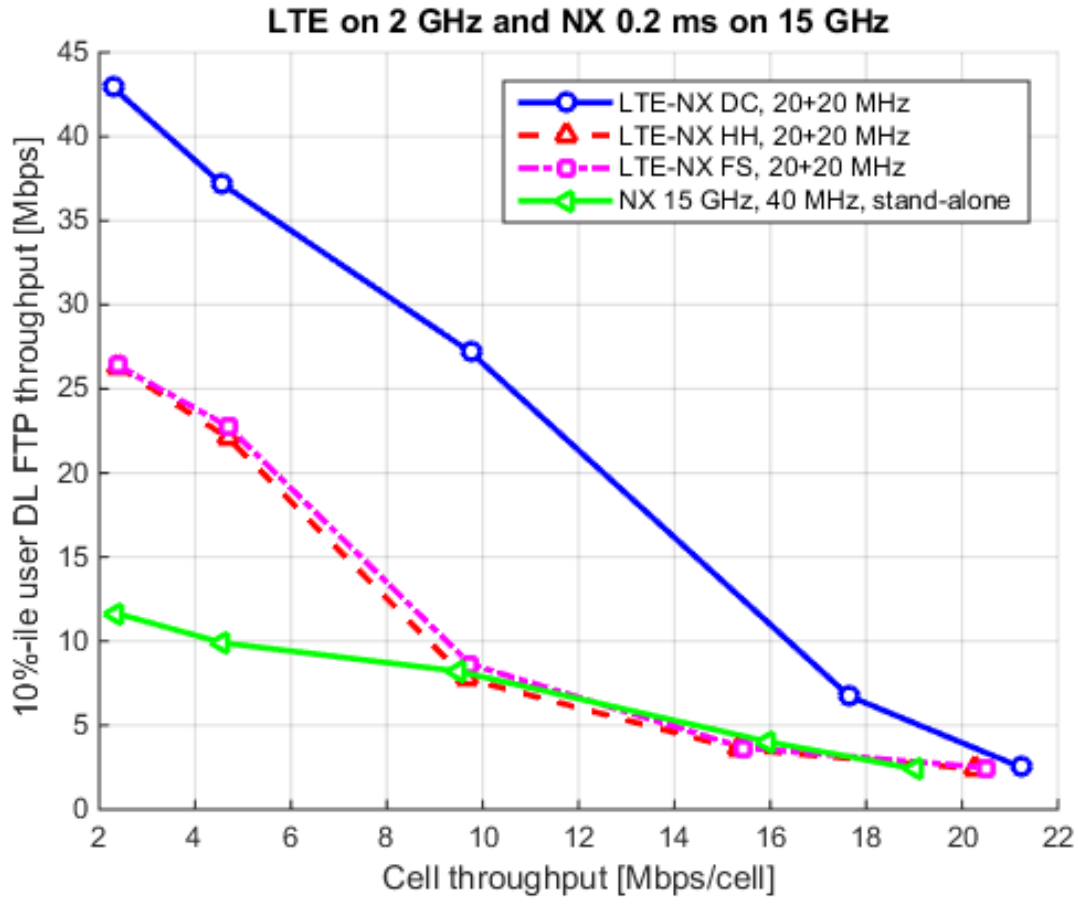


SLA: Service-Level Agreement

Tight Integration with Evolved Legacy AIVs

Tight Integration with Evolved Legacy AIVs
LTE & 5G Tight Integration

- Abstract:
  - The handover between 3G and 4G is an inter AI hard handover , i.e. causes an interruption
    - Thus, Hard handover between 4G and 5G may not be good enough
      - 5G may have spotty coverage
      - 5G requirements extremely high
        - Ultra reliable 5G
        - Extreme bit rates everywhere
  - One alternative is LTE and 5G* PDCP dual connectivity solution
- Key Findings:
  - **Initial simulations indicates large gains with a solution similar to dual connectivity compared to inter AI handover**
  - **Tight integration increases user bit-rate and connection reliability**
- Possible RAN design implication
  - Common LTE and 5G S1* for CN/RAN signaling.
  - New signaling for AIV quality metric.
  - Adding and deleting a new CP connection to a user, for the proposed tight integration concepts, must be very fast and lightweight in order to support ultra-reliability requirements.

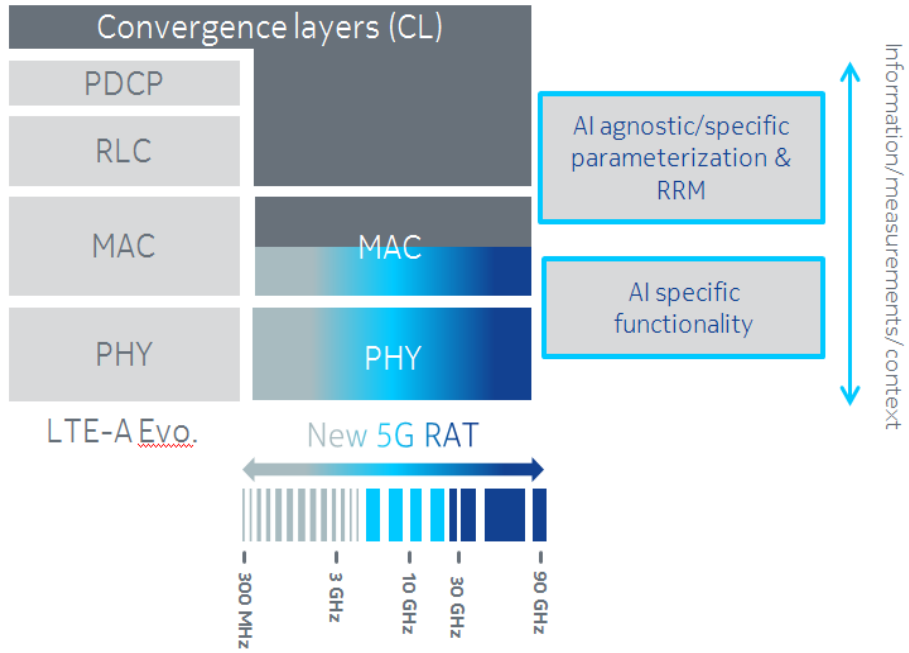


*5G/NX AI is here using a TTI of 0.2 ms, 20 subbands per 20 MHz and 15GHz as carrier frequency, compared to 1 ms TTI , 100 subbands and 2GHz for LTE, otherwise same as LTE.

Holistic RM & AI Abstraction Models

Holistic RM & AI Abstraction Models: Key Findings

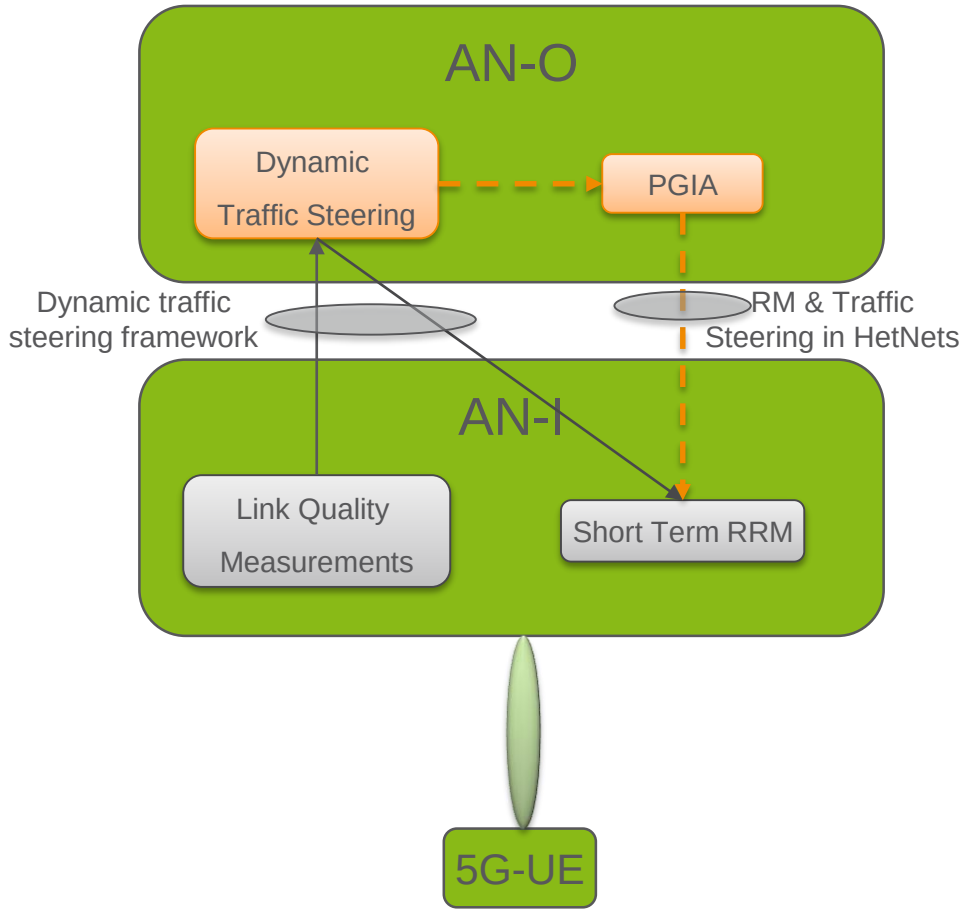
- Motivation and goal
  - Novel aspects in 5G systems with respect to previous generations in terms of diverse and challenging service requirements and use cases, existence of multiple AIVs, dynamic topologies, and novel communication modes (e.g., D2D)
  - The goal of this building block is to provide holistic RM solutions to deal with these novel aspects
- Novel Concepts
  - Flexible scheduling framework able to simultaneously accommodate users with very different service requirements
  - Analysis of AIV-specific vs. AIV-agnostic RM functionalities and related protocol stack implications
  - Abstraction models to achieve edgeless user experience in dynamic topology settings
  - Native D2D support and related RM concepts expanding the scope of scenarios and D2D communication variants beyond those under current standardization



Dynamic Traffic Steering

Dynamic Traffic Steering: Key Findings

- In the dynamic traffic steering building block, two key enhancements in 5G networks are considered.
  - The dynamic traffic steering framework proposes the use of link quality measurements and other real-time feedback from the access network – inner (AN-I) layers to enable fast traffic rerouting over multiple air interface variants.
    - Here the focus is mainly on enforcing QoS requirements in RAN.
  - The second enhancement considers the use of a proactive link activation mechanism, where a pre-emptive geometry-based interference analysis (PGIA) is done to estimate whether a mmW link should be created.
    - Here the main focus is efficient resource and interference management in heterogeneous networks (HetNets)



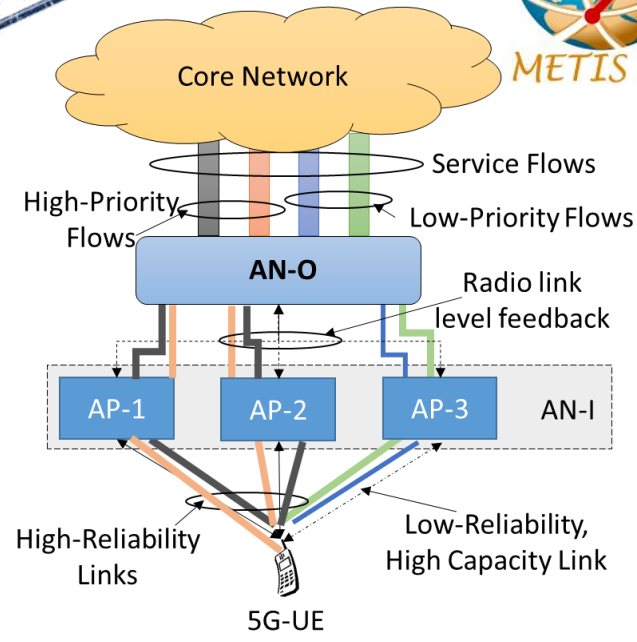
Dynamic Traffic Steering

Multi-AI Dynamic Traffic Steering Framework

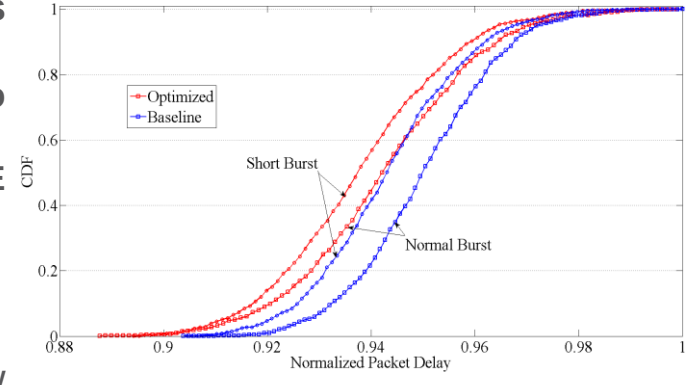
EXAMPLE

METIS II

- Abstract:
  - The 5G network will consist of multiple AIVs between the UE with the CN.
  - For efficient RM within interfaces & ensuring Quality-of-Service (QoS) requirements, a multi-AI dynamic traffic steering framework is proposed.
    - Takes real-time feedback from the multiple AIs currently serving the UE
    - Adjust the traffic flows on a synchronous timeframe with high priority flows served through reliable links with higher robustness.
    - Enables key 5G requirements.



- Highlights:
  - **Compared to the LTE, a dynamic QoS framework is proposed here, with QoS class identifier functionalities related to RAN relocated to the AN-O layer.**
    - **The dynamic QoS framework also requires enhancements in RAN design, in order to bring the QoS functionalities located in the core network to the RAN.**
    - **Results indicate significant gains compared to mechanisms available in LTE (Baseline).**

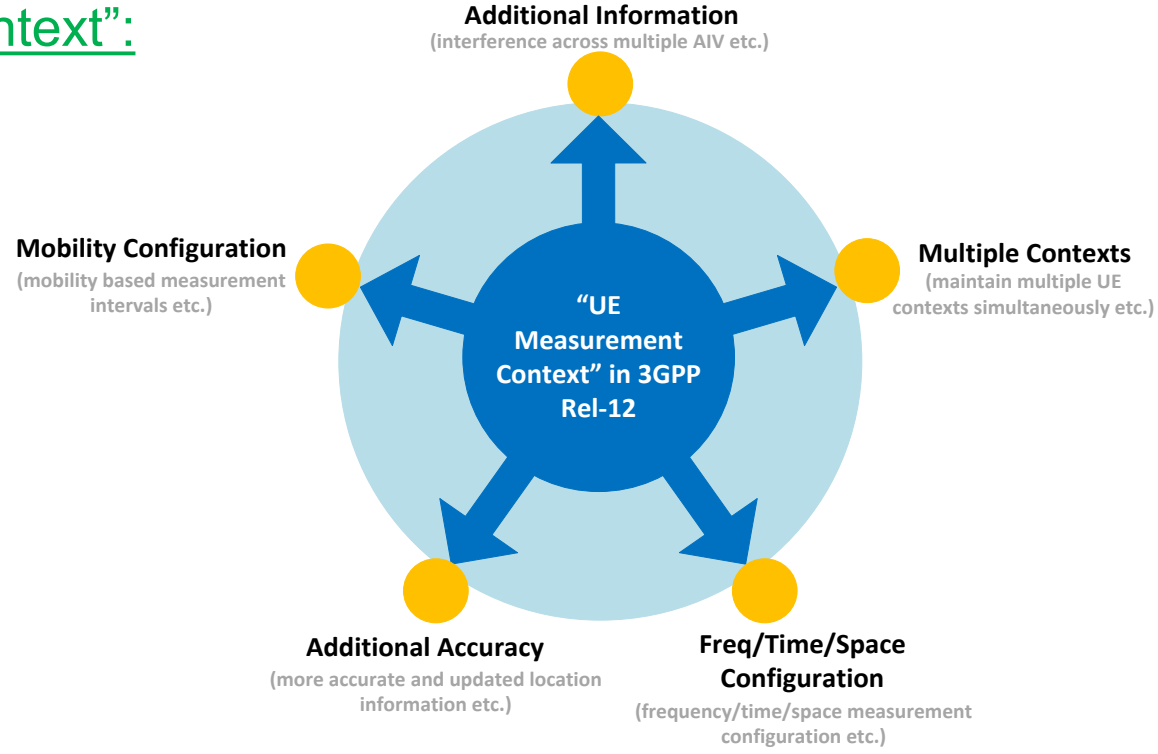


- RAN Design Impacts
  - Depending on the functionality split between the AN-O and AN-I layer, new information elements are expected to be defined over the interface between the two layers.

Context Management

Context Management
UE-centric Fast RM & Context Management

- To support the new features required by the fast RM for 5G AIs:
  - New elements in UE context are expected to be introduced.
  - Existing elements in UE context are expected to be refined.
- Design of the UE context: Trade-off between the network performance enhancements and the load imposed on the UE (data gathering, signaling, processing and storage, etc.).
- Functional Extensions in “UE Context”:

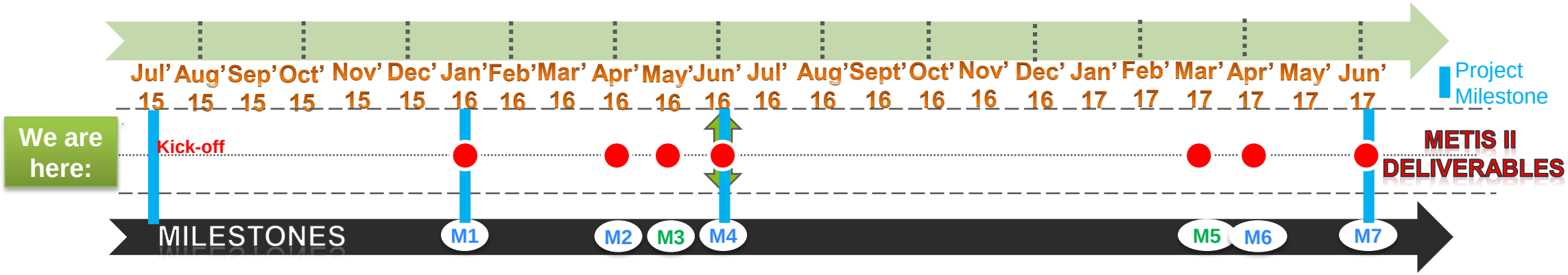


Conclusions

- First vision of the Agile RM Framework
  - Synchronous control functions operating over multi-AIVs
  - Holistic RM schemes considering novel 5G aspects
  - RM schemes for tight interworking with evolved legacy networks to avoid hard handover
  - Assignment of services to the most suitable resources via dynamic traffic steering & RAN moderation considering the extended notion of a resource
  - Enabling end-to-end slicing via RM for Network Slices
  - Extended UE context to support novel RM schemes
- Operation of traditionally slow control functions on a faster time scale
- Positioning of enabling technologies in the 5G Landscape

Outlook

- Further development of enabling technologies
- Harmonization of enabling technologies and building blocks on the foundations of functionality frameworks
- Further analyses, designs, and conceptual descriptions toward the final design will be provided in D5.2 (*due in March 2017*)



Milestones in 2016

- M1: Deliverables D1.1; Evaluation framework based on 5G PPP discussions
- M2: Deliverable D4.1
- M3: Deliverables D3.1, D5.1
- M4: Deliverable D2.2, D6.1; Key 5G RAN design questions clarified

Milestones in 2017

- M5: Deliverable D5.2
- M6: Deliverables D4.2, D6.2
- M7: Deliverable D2.4, D3.2; Final 5G RAN design and 5G roadmap proposal

Thank You

http://www.metis2020.com