AIMM

CELTIC-NEXT

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AIMM Use Cases Defined

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AIMM (Artificial Intelligence-enabled Massive MIMO) is a two year CELTIC-NEXT European collaborative project started in the autumn of 2020 with the aim of using AI and other advanced data analysis techniques to improve the efficiency of mobile radio networks. Efficiency measures include increased spectral efficiency for capacity, improved range from existing base stations for coverage and reliability, reduced power consumption for energy efficiency and growth in economic efficiency through new deployment techniques and support for new services, including enhanced security.

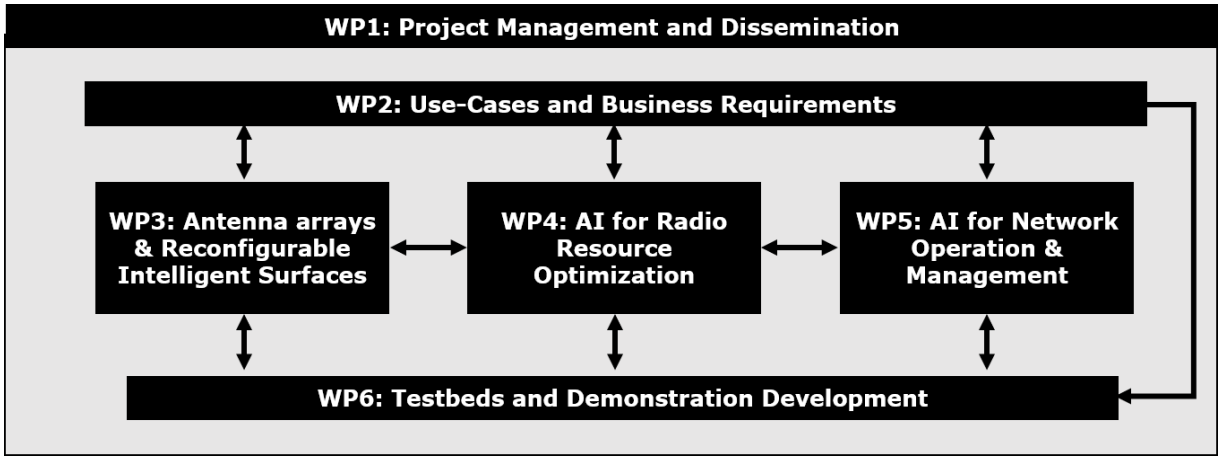
To link the activities of the different AIMM work-packages to user requirements, AIMM has defined specific use cases. This document describes those use cases.

The scope of AIMM

A fundamental assumption for AIMM is the deployment of advanced MIMO systems, comprising many elements to enable spatial reuse of radio spectrum from the same antenna. AIMM considers such active antennas deployed on existing base station and terminal structures, amongst other items creating new methods to estimate and control the constantly changing radio channel between base station and terminal. AIMM also looks to the future by geographically distributing MIMO antenna elements to create a more uniform user experience with increase capacity and reliability. The addition of novel RAN features, including Reconfigurable Intelligent Surfaces (RIS), is also considered.

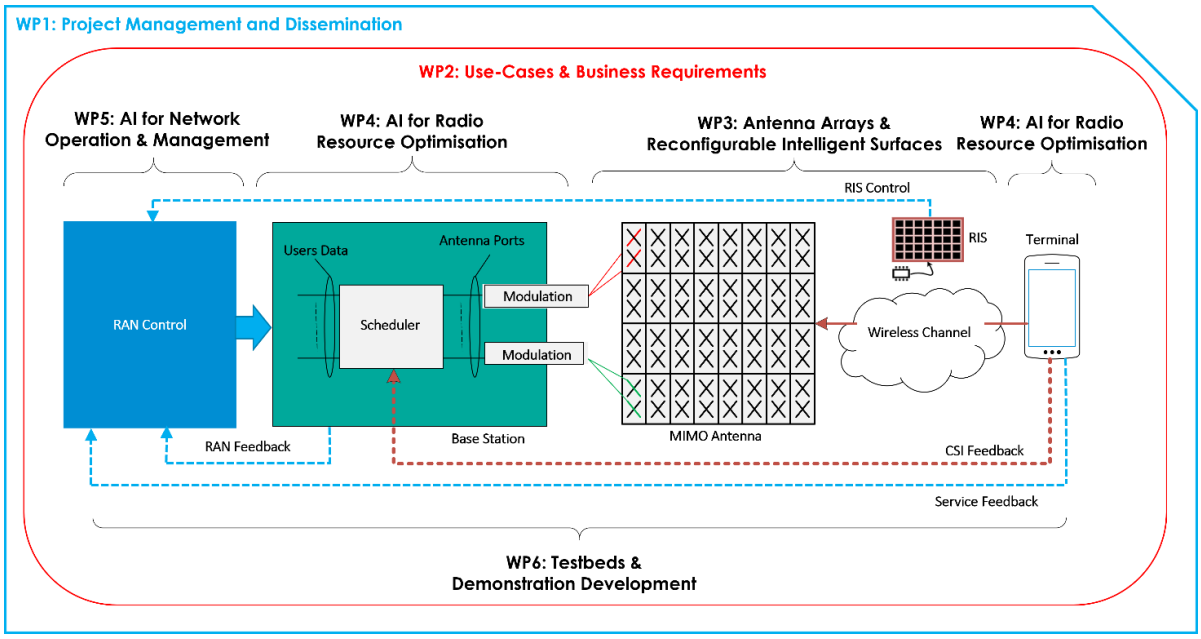
AIMM has organised activities into three main study work-packages, supported by an additional technical workpackage to define and implement testbeds to demonstrate the techniques developed on the project. A further area of activity defines the requirements, societal and commercial implications and benefits of the solutions studied within AIMM. The mechanism to achieve this link between requirements and technical solutions is through the definition of the use cases. A final activity provides the overall project management and dissemination support.

The figure below shows the schematic diagram of how the various work packages (WP1-WP6) link together.



AIMM in the RAN

The different work-packages are broadly defined by the area of the end to end RAN delivery chain that they consider. This is illustrated in the figure below, which shows a simplified schematic diagram of RAN functions from higher protocol layer resource management at the left, through precoding and advanced antenna structures, across the radio interface to the services deployed by the end user. The areas of application of the different work-packages are illustrated below.



The work of AIMM focuses on novel approaches to the use of network data to drive efficiencies. Access to such data at different levels in the RAN architecture implies the availability of open interfaces where this data can be made available. An assumption within AIMM is that the RAN architecture will follow the principles of the emerging O-RAN standards and potential evolution of that standard.

Data and simulation

An early activity for AIMM is to identify and seek sources for the data necessary to train and test advanced algorithms in the network. Where appropriate, this data will be supplied from the existing trial networks of consortium partners. A key activity of the testbeds and demonstrators workpackage is also to produce to produce data that can be used by the analysis approaches of other technical studies within AIMM. Where measurement data is not available, this is being produced by simulation activities.

To facilitate the exchange of data and comparison of new techniques in a consistent manner, a modular simulation framework is being created. This will enable different deployment scenarios, including traffic profiles, network topology and technical capability to be defined and implemented once. Deployment scenarios include those defined by 3GPP but also examples for existing network deployments. AIMM collaborating organisations will create simulation modules that can be integrated into the overall framework.

This approach to a common simulation environment enables a unified test of the benefits of a new technical proposal. It also provides a mechanism to identify and quantify the required data flows across open interfaces between functional modules in the RAN.

Use Case Details

To fully consider the different aspects of RAN optimisation and evolution that is being considered by AIMM, an extensive list of use cases for study have been established as shown in the table below.

Each of the technical activities within the AIMM workpackages have been aligned to one or more of these use cases.

Use Case Name	Description
1. Smart Interference Management	The development of novel intelligent interference and handover techniques using AI/ML-based approaches.
2. Broadcast Beam Optimisation	The use of AI techniques trained on real network data to optimise broadcast beam patterns in 5G and enhance coverage.
3. AI-based Channel Estimation and MIMO Detection	The application of AI and ML techniques to improve the assessment of the radio channel between user and base station.
4. AI-based Massive MIMO Precoding and Scheduling	Improvements to spectral efficiency on the air interface by the use of AI to optimise the allocation of temporal, spatial and frequency resources on the air interface.
5. Distributed and Cell-less Massive MIMO	A use case to consider alternative MIMO architectures based on joint transmission between geographically separated radio access points.
6. Disaggregated and Open Massive MIMO.	Examining the techniques to optimise the performance of distributed RAN architectures based on the different functional splits.
7. AI for RAN Energy Efficiency	The use of AI techniques to identify opportunities for RAN power reduction based on network data.
8. Reconfigurable Intelligent Surfaces	A study of the use cases and potential benefits of RIS-based communications supported with AI-based air-interface and control techniques.
9. Self-Organising In-building Small Cells	The use of ML techniques to calibrate propagation prediction models and optimise system design for coverage provision.
10. Massive MIMO Power Amplifier Enhancements	Investigation of advanced techniques to reduce the power requirements for the amplifiers deployed in Massive MIMO.
11. AI for RAN Security	The detection and location of adversarial devices and users within the RAN using AI techniques. This use case will also consider the wider security implications of distributed RAN systems.

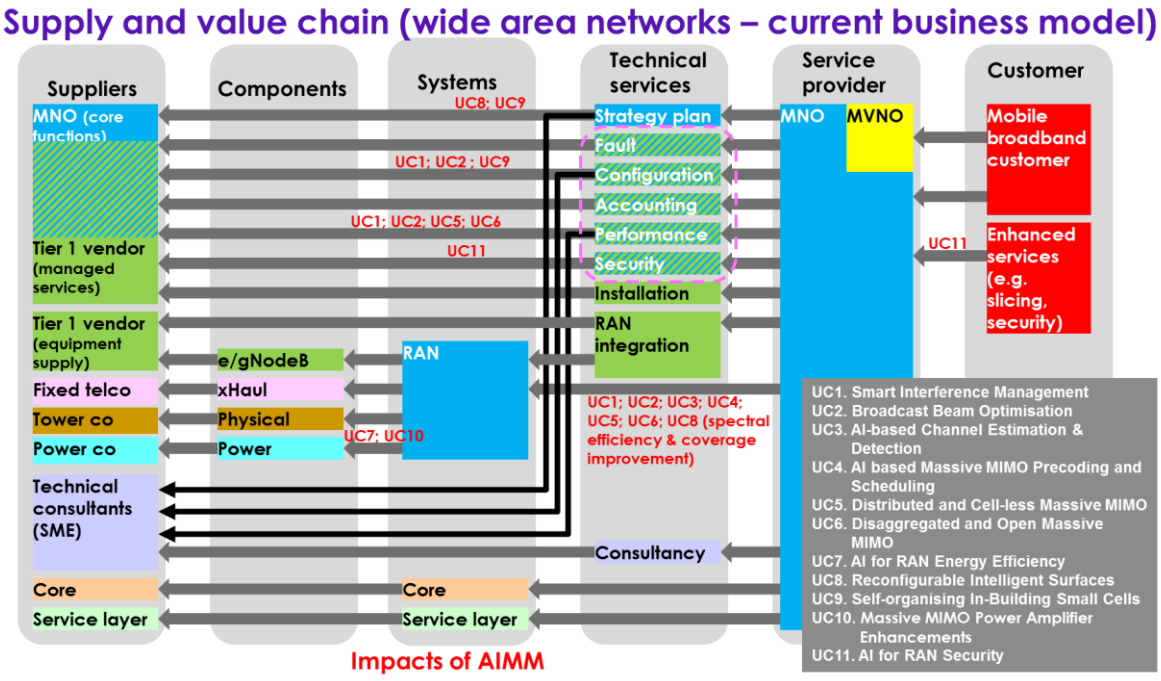
Quantifying the benefits of different use cases

The use cases have been prioritised and work is ongoing on a subset of these, with the aim that all use case will be considered over the lifetime of the project.

One aspect of AIMM is to consider the financial and societal benefits of the different use cases. To enable this a framework for the flow of value through the mobile ecosystem has been established, an example of which is given below. In this diagram the “value”, most easily considered in terms of financial value but also including wider society benefits, flows from the customer at the right, through the mobile network service provider to various component and technical service providers. At each point value can be retained by ecosystem participants.

The use cases in AIMM are mapped onto the value flows of the ecosystem framework (UC1-11) and will affect these flows of values either by increasing revenue, reducing cost or reducing factors such as time to market deployment. Within AIMM the effect on the value flows will be quantified.

The diagram below represents a single draft business model, being a national public mobile network operator with RAN supplied by a major (Tier 1) vendor. This will be developed through the life of the project and other business models added, including the supply of disaggregated RAN equipment by a more diverse ecosystem and the provision of indoor and private mobile networks.



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