AIMM

CELTIC-NEXT

Newsletter

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Issue 1

Business Benefits and Ethical Considerations

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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.

Work-package 2 (WP2) of AIMM has the responsibility to identify the benefits to the overall mobile industry ecosystem of the application of the advanced techniques explored by AIMM. This document describes the deployment models that will be used to assess AIMM solutions and how these could be affected. WP2 is also responsible for considering the ethical implications for the use of AI in radio access networks (RAN). The conclusions of the initial assessment of this ethical approach are also presented in this newsletter.

Assumed RAN Architecture

It is one of the assumptions of AIMM that the efficiency of the RAN can be improved by taking more detailed account of the conditions in individual radio environments. This requires improved measurement of both the radio environment at the physical layer and the interaction between the multiple users and multiple radio access points at the system level. Altering the response of the RAN at both the physical layer and the system level dynamically is the mechanism by which AIMM solutions meet these requirements.

The network architecture being developed by the O-RAN Alliance supports this approach, in an approach often referred to as OpenRAN. O-RAN is a disaggregated and virtualised RAN architecture, providing the opportunity for different suppliers to create the necessary measurement and control algorithms. This expansion of availability of algorithms promises the opportunity for specific solutions to different deployment scenarios.

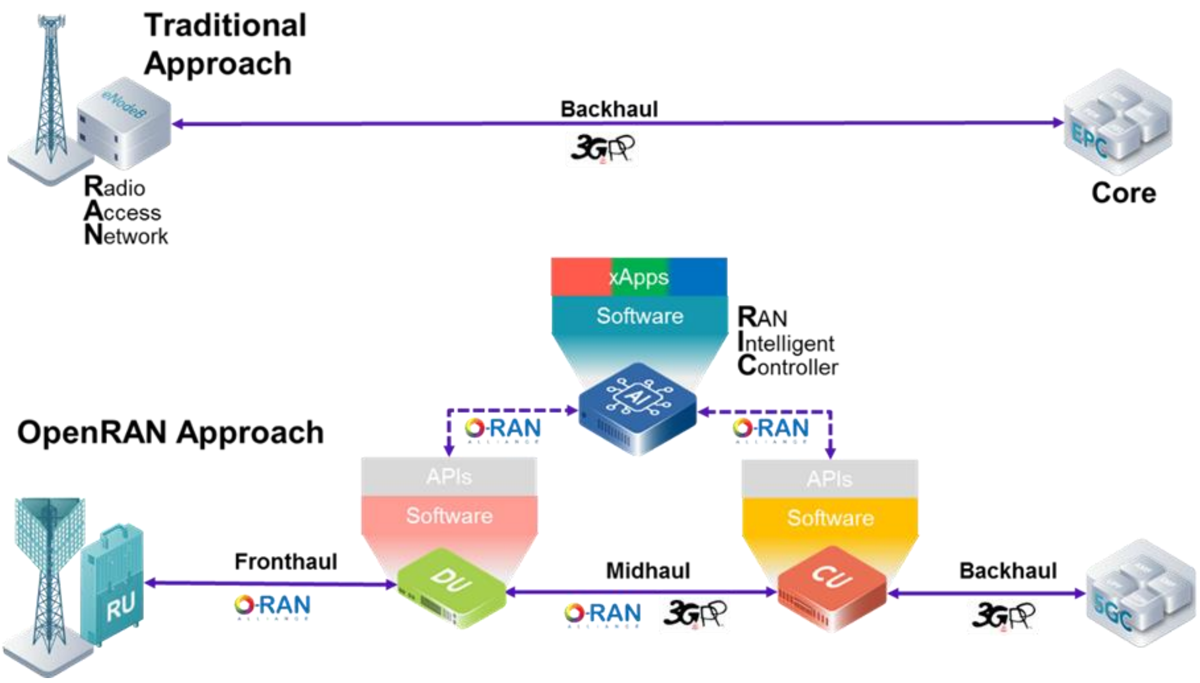
One of the aims of 5G is the move of mobile radio networks from the domain of wide area public access to a wider deployment of private networks. These private networks will serve a variety of different industrial and commercial requirements for specific customers on campuses. Optimising the RAN for these different private network service needs and radio environments at an acceptable cost will require significant automation.

The figure below shows a simplistic schematic diagram of the OpenRAN approach, contrasting it with a more traditional RAN. In the traditional approach the intelligence in the RAN is concentrated in a single logical node, the eNodeB in 4G that is historically located at the base station with the antennas.

In the OpenRAN approach, the base station is disaggregated into hardware components of the Radio Unit (RU), Distributed Unit (DU) and Centralised Unit (CU). Additional interfaces are defined by O-RAN and the physical location of the different components can be changed according to the needs of the particular deployment model.

A new component specified by O-RAN, the RAN Intelligent Controller (RIC), is of particular relevance for AIMM. The RIC can take measurements from the RAN nodes, use specific applications (referred to as xApps for near real time and rApps for non-real time) to make control decisions and manage the operation of the RAN. Application Programming Interfaces (APIs) are provided for xApps and rApps to be created by different organisations. AI is expected to be a key component of these Apps.

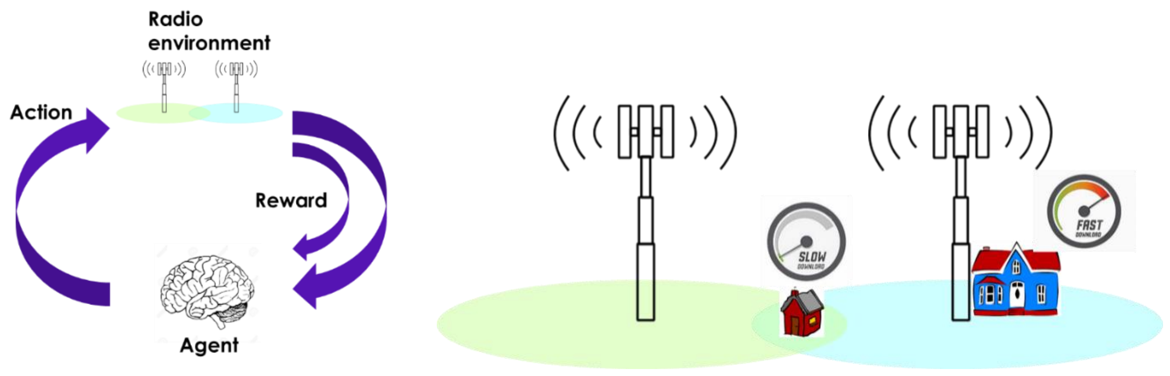
In the figure the different colours of the software and hardware components indicate that these could be procured from different suppliers, with associated system integration requirements.



Ethical Use of AI in the RAN

The use of AI, with the collection of large volumes of additional data, does raise concerns regarding how this data could potentially be used to disadvantage individuals or groups of people who share a particular characteristic. In current mobile network deployments, specific details regarding individuals are maintained in the operational support systems connected to the core network. In the RAN, user identifiers provide an abstraction from the personal data of individuals. If the AI applications, typically located in the RIC, operate on these abstract identifiers then direct bias against individuals can be avoided.

In WP2 consideration has been given to the introduction of unintentional bias through the use of AI in the RAN. The figure below provides a simple illustration of how such bias might occur.



Reinforcement learning is a technique being investigated in AIMM to minimise interference. The left of the illustration shows the operation of reinforcement learning where a software agent samples the radio environment and determines a course of action to maximise a goal. This goal could be to maximise overall data throughput on the network. The agent then assesses the impact of the action via a reward measure that indicates the success of the action to achieve the goal. In this way the benefit of certain actions by the agent are reinforced.

The right of the illustration shows a potential result of the approach if the chosen goal is to maximise network capacity. The outcome has been to maximise the resources and hence the data throughput in good radio conditions close to the base station at the expense of users in poorer radio conditions at the edge of coverage. If there is a correlation between the areas of improved service and different socio-economic groups (indicated by different house size in the diagram) then bias will be introduced.

The type of bias that is illustrated here would be difficult to identify in advance. The approach that has been taken in AIMM is therefore to promote the use of explainable AI, where sufficient information is collected and maintained to allow future identification of the reasons for any bias. Following a literature review the following features of an AI application in the RAN have been identified as desirable.

Feature	Description
1. Human centricity	The development of AI must be in line with common societal values that are well accepted. The outcome of AI must serve as a betterment to human society as a whole.
2. Establish a baseline	Establish a combination of non-technical and technical safeguards. Non-technical measures include initiatives against discrimination and bias, technical measures involve ensuring compliant algorithms.
3. Monitor and control	Provide continual assessment and improvement to support risk mitigation activities.
4.Transparency and auditability	Ideally AI models should be capable of explaining to users the logic between the training and inference processes: • *AI models should be able to explain themselves, if possible;* • *AI developers should provide documentation relating to the decision making mechanism and processes which is made available for audit purposes.*

In the final report of AIMM, WP2 will review the solutions arising from the project in the context of these features.

Deployment Scenarios

In the architectural discussion above, it was noted that 5G and its evolution is intended to move beyond the traditional focus of RAN on mainly nationwide, public access implementations to private networks. When determining the value of the AIMM solutions, WP2 is therefore considering three deployment scenarios against which to assess the resulting value. These three deployment scenarios are: public networks; private networks and in-building networks.

These three have been chosen since they have significantly different characteristics in terms of the radio environment, which will affect the physical layer solutions of AIMM, but also in terms of the system level and time to deployment. For example, a public network implementation that involves changes to customer handsets will have to wait until a significant proportion of the customer base have purchased new devices that contain the feature. This is in contrast to private networks where handsets can be simultaneously changed for all users as part of the network supply contract if the benefits are considered to be worthwhile. In the table below, the characteristics of the different deployment scenarios are described.

Public Networks
An existing national network operator providing wide area public access coverage. There is already be an installed base of 2G / 3G / 4G / 5G equipment providing macrocell coverage and a customer base with existing handsets and contracts. New features will be introduced taking account of the legacy position of deployed base stations and handsets. Any introduction of new features will require significant scale of demand to be successful.
Key features 1. Basic coverage from macrocells already meets most outdoor and rural coverage requirements – improved indoor and rural coverage would be an advantage. 2. A range of mobility requirements from high speed in rural areas, to low mobility in high traffic density urban areas. 3. Traffic demand for enhanced Mobile BroadBand (eMBB) service growing at 35% per year with customer revenues remaining constant. 4. New service and revenue streams required to justify network investment. 5. Power consumption ~ 20% of network operating cost.

Private Networks
Building a new network to support mobile operations for a specified user group of devices, including IoT. The devices will normally be supplied with the network and so legacy support is not an issue. Capacity will be designed to meet specified customer requirements and so is more predictable although spectrum availability could be limited. Suppliers will compete on features (e.g. security, QoS) and price of installation and operation.
Key features 1. New coverage is installed for the private network. 2. Mobility will generally be lower than for public networks with more control over the interaction between different radio access points. 3. Traffic levels are better understood than public networks but stretching requirements exist for performance (e.g. latency, security, availability). 4. Installation, optimisation and operating costs will be a key differentiator between private network suppliers. 5. Features that enable operators to differentiate services will affect market share.

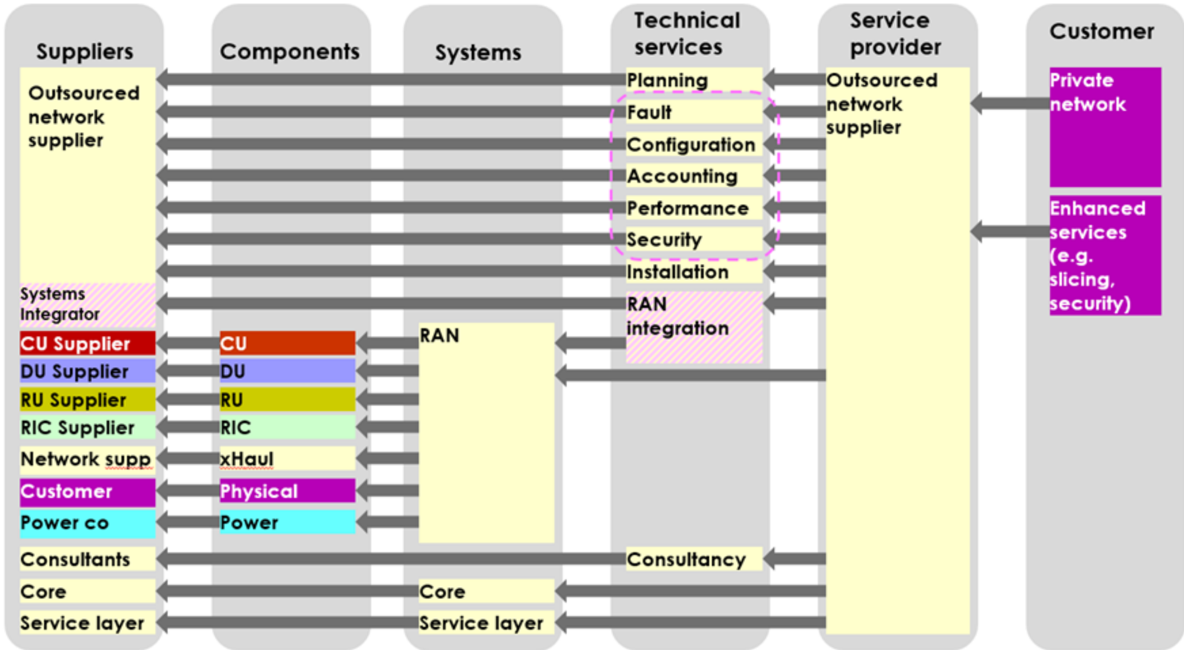
In-Building Networks
The provision of mobile radio coverage to in-building locations. These include both private networks and public access areas with the requirements for legacy support of handsets being different between these two. For public access areas, neutral host solutions are particularly attractive to reduce costs. Automation of network design, installation, configuration, optimisation and management is required to reduce costs and so expand the size of the in-building market.
Key features 1. New coverage installed for either public or private networks (or a combination of both). 2. Capacity growth can be driven by public access or private network. Spectrum availability will be limited. 3. Installation and operating costs must be low to justify deployment. 4. Features must match the public network (for public access) and/or provide a differentiated service for private networks.

Different use cases in AIMM are applicable to different deployment scenarios.

Quantifying the Flow of Value

With most RAN deployments it is tempting to assume that all value through efficiency is gained in terms of overall cost savings for a network deployment. This has traditionally been the approach on public networks where equipment, installation and operational services are concentrated in a small number of large operators and equipment vendors.

The emergence of private networks and move to disaggregated and virtualised architectures such as O-RAN potentially open the supply chain to new organisations to provide innovative software and hardware components and services, generating opportunities for new revenue.



The diagram above shows the potential flow of value through the RAN ecosystem for a private network following an O-RAN architecture. Value flows from the customer at the far right, along the arrows to the network provider and onwards through components and systems to the ultimate suppliers. The colour of the different boxes indicates different commercial organisations. In this particular example the private network supplier, coloured yellow, is responsible for many of the installation and optimisation services.

The right of each arrow represents a cost to the organisation that it is leaving. The left of the arrow represents a revenue to the organisation where the value is flowing into. Recent activities of WP2 have been mapping the different flows of value for the different use cases, with particular emphasis on new revenue opportunities at different points in the supply chain.

Data on the factors that affect these value flows is currently being collected from external sources, and also from the other work-packages in AIMM. In the remainder of the project this data will be analysed, reviewed and refined to create a quantified view of the benefits that could arise from the solutions delivered by AIMM.

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