The need for cloud-radio access networks (C-RANs) in future (5G) mobile communication systems is the basic premise of iCIRRUS. To enable higher data speeds for users and to allow more users and devices to access the network simultaneously, the distance between users and the base station has to be dramatically reduced. This either means more base stations, which would be very expensive, or moving antennas nearer to the users. Distribution of antennas is the first step towards the C-RAN. A number of base stations can be collocated, and their antennas distributed. Different antennas can be switched on to different base stations depending on demand, providing a centralised RAN. Then, the base station functions can be ‘amalgamated’, perhaps in common hardware, and defined as required. This virtualisation of functions leads to the C-RAN.

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What is the function of the ‘fronthaul lite’ that you are developing?

The function of the fronthaul is to connect the main processing functions of the base station(s) to the radio and antenna functions at a remote radio site. Up to now, this has been done using the same type of technology for connecting base station units at the bottom of a mast to the antennas at the top – sending samples of the radio waveform, which are then converted to a continuous signal at the antenna. The problem is that the approach uses an enormous amount of bandwidth. This becomes a very serious problem for 5G, where bandwidths are expected to be much higher than for 4G, and the aggregate bit rates at least 10 times greater. If achievable, the cost would be huge for an extensive network. Also, the radio signals are continuously on, independent of how many users need connecting to a cell, or their requirements – so the bit rate demand for the fronthaul is continuous.

The fronthaul lite is aimed at transmitting user data and some control data over the fronthaul, thereby reducing bit rate needs. Statistical fluctuations of some users requiring more when others require less can be used to provide further gains for the same bit rate provision.

How might use of Ethernet in the fronthaul lead to lower costs?

As it is ubiquitous, Ethernet is relatively low cost, and has been extended with many useful network management features. Using Ethernet in the fronthaul, instead of a technology dedicated only to fronthaul transmission, would more easily allow the same infrastructure to be used for different types of traffic: fronthaul, backhaul and fixed access.

Can you explain how the iCIRRUS, RAPID and NIRVANA projects are linked?

NIRVANA investigates many similar concepts to iCIRRUS: the ideas for iCIRRUS were born when putting together the NIRVANA proposal. We realised that in a solely UK project we could not really deal with all of the important challenges. In iCIRRUS, leading EU partners work alongside us and push the work forward. They are involved in international standards bodies, so they keep us informed of the latest trends in industry thinking.

In iCIRRUS/NIRVANA, we reduce the bit rate requirement on the fronthaul by moving a few functions to the remote radio/antenna unit. RAPID takes quite a different approach. RAPID focuses on the use of millimetre-wave, 60 gigahertz signals for short-distance wireless transmission and the use of a fibre fronthaul for them. We also simplify the remote radio unit and transport the radio signals modulated onto the light sent through fibre in the fronthaul directly. However, the signal degrades in the fronthaul, and cannot be regenerated as in a digital system. Thus, degradation has to be minimised. RAPID involves five EU and six Japanese partners.

What is your ultimate goal?

The ultimate goal is to enable the development of C-RANs at a low enough cost to make them readily deployable. The quicker these are deployed, the sooner we will see real 5G type bit rates and services – HD video to your mobile device, augmented reality applications for help on what is available locally, and so on. In truth, there may be many other applications that we haven’t even thought of yet.
In about five years’ time, it is estimated that anywhere between 50 to 100 billion mobile devices will be connected to the internet – forming the Internet of Things (IoT), where devices exchange information with other devices and applications. The IoT-based vision of a world where everything – from mundane everyday processes to crucial services such as remotely-operated surgical procedures and driverless car operation – is automatically enabled through intelligent interconnected devices does, however, rely on a technological infrastructure with higher speed, greater reliability and lower latency than the current 4G communications networks available.

Even for the range of applications mobile communications currently deliver, the bandwidth in current provider radio spectrum allocations is under strain; yet it is envisaged that the range of bandwidth-hungry applications will grow exponentially. A further complication is that as populations increase, the communications infrastructure will need to cope with much higher user and device densities, also placing strain on capacity and throughput.

**INCREASED 5G DATA**
The struggle for wireless radio spectrum allocations and the need for operators to optimise usage may eventually disappear through making cells smaller by increasing the density of nodes. This would both accommodate more users and provide them with higher data allowances, as fewer users per cell means that fewer of them have to share the cell’s capacity, and the smaller cells – with shorter wireless distances – enable higher data rates to be transmitted and received.

**RADIO ACCESS VIA A CLOUD**
For Dr Nathan Gomes, Professor of Optical Fibre Communications at the University of Kent, electronic communications technologies have always held the potential to transform society in positive ways. This is especially true in the case of optical fibre communications. Currently, Gomes is the project coordinator of two correlated initiatives that aim to design a new radio access network (RAN) infrastructure with the performance and reliability necessary for the launch of 5G: the NIRVANA project, a UK industry/academia partnership, receiving advisory support from BT, EE, Qualcomm and NEC, and the iCIRRUS (Intelligent Converged network consolidating Radio and optical access aRound User equipment) EU project, with direct involvement from leading international companies such as Orange (France Telecom), ADVA Optical Networking, InterDigital and Viavi, and under the advisory support of Alcatel-Lucent.

The premise of both projects is that there are ways around the need for additional radio antennas and towers to meet 5G demands for fast, high-quality communications.

iCIRRUS is a three-year EU Horizon 2020 research and innovation endeavour that brings together 11 industry and academic partners from across Europe with the mission of examining the benefits and momentum is building for the rollout of the first 5G communications networks by 2020. Linked projects led by the University of Kent – iCIRRUS and NIRVANA – aim to define a robust, low-cost access network within the 5G architecture.
challenges of an Ethernet-based optical fibre fronthaul for 5G mobile networks, including particular provisions for device-to-device (D2D) communications and mobile cloud networking.

A fronthaul exists in a centralised RAN, which overcomes the usual RAN limitations of fixed numbers of tower sites, by aggregating base stations in a central location, and moving their (smaller size) antennas nearer the end users, eg. on lampposts, street corners and bus shelters. The aggregated digital processing functions are in centralised Digital Units (DUs), while the distributed antennas are in lightweight Remote Radio Units (RRUs).

**FRONTHAUL LITE**

Current mobile networks are limited in the data rates that can be provided by the radio access and by backhaul links from the base stations into the core network. The centralised RAN allows much improved use of the available spectrum for the radio access; also, by aggregating base stations, there are fewer backhaul links, and effort can then be placed on upgrading these to ultra-high-bit-rate optical links using the latest technologies. However, what this means is that the bottleneck is now the fronthaul between DUs and RRUs. The relatively infrequent instances of fronthaul implementation for current mobile networks carry digital samples of the radio signals – this gives rise to bit rates that are tens of times greater than the user data rates.

For 5G networks, this solution would be simply infeasible – it would result in bit rates used in data centre and transatlantic cable links being required through the cabling in every city centre street. To overcome this, a new interface for the 5G fronthaul is required, with lesser bit-rate demands – a fronthaul ‘lite’, as it has been termed in iCIRRUS. This new fronthaul will allow sharing of the same fibre infrastructure with other networks, such as the fixed network, and the backhaul of mobile networks. This will help to integrate management processes, too.

**INTEGRATING ETHERNET**

Ethernet is a 40-year-old software protocol for networks that has continuously evolved in line with market requirements while maintaining compatibility with earlier configurations. Because of its longevity, it is a tried and tested technology. And importantly, since the turn of the century, it has demonstrated the capability of transmitting frames of data at the rate of gigabits per second. It is ubiquitous in corporate networks, and is being increasingly deployed in carrier’s networks.

The iCIRRUS team selected Ethernet for the fronthaul because of its many advantages. As it is extensively available in industry standard equipment, it can be used in fixed access networks, so it would allow convergence between wireless and fixed communications across the entire infrastructure, it is scalable, it supports switching and routing and its operations, administration and management functions are standardised.

In the proposed infrastructure, Ethernet links will automatically switch between the pooled DUs and RRUs according to carrier demand, provide interconnections between the DUs and connect the DUs to the core network through the backhaul. Probes, intelligent systems and algorithms will continuously monitor the network for quality of service problems, flexibly reallocate resources and manage network optimisation as required. D2D communications will be used to relay information to devices, including communications between virtual clones of user devices, to expand RRU coverage.

**LOW-COST, HIGH-PERFORMANCE ARCHITECTURE**

Some aspects of Ethernet performance in terms of synchronisation, latency and bit rates still remain to be addressed. “Performance is a problem,” states Gomes. “The current, dedicated technologies for fronthaul are synchronous – they repeat continuously, regularly, accurately – which is very good for the stream-like transmission of radio waveform samples. Ethernet equipment deals with variable length frames and leads to variable and sometimes unpredictable delays.” However, Gomes and his team at the University of Kent believe that removing radio signal sampling from the fronthaul, as in their fronthaul lite solution, is essential, and there are solutions that will mitigate network delay problems.

5G is still really just a concept, so what services it will host in the future is uncertain. It is, however, sure that an intelligent, self-monitoring and self-optimising high-capacity communications infrastructure capable of delivering extremely high quality of service will lend itself to many so far undreamed of applications and market opportunities in a smart, connected world.

From the end user perspective, the iCIRRUS/NIRVANA 5G RAN architecture promises better quality, high-bandwidth services with low latency, extended device battery lifetimes and much greater reliability than current implementations. Use of the Ethernet for transport and switching in the fronthaul lite means that the infrastructure will enable convergence between fronthaul and backhaul, and fixed networks, and that costs will be kept low for providers and carriers, meaning lower costs for consumers: “A major effort in iCIRRUS is understanding what the remaining problems are and how to solve them,” concludes Gomes.