Advanced radio technologies for fairer 4G communications

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Credit: AI-generated image (disclaimer)

If you live in one of the dozen or so European countries with an up and running 4Gmobile network, you may have already bought a 4G-enabled phone, hoping to enjoy the blisteringly fast data rates your operator is advertising. 4G services are undoubtedly a big improvement on their 3G predecessors, but significant discrepancies in user experience remain.

EU-funded researchers are trying to solve the problem.

'Long-Term Evolution' (LTE) is one of the latest commercial standards for high-speed wireless communication, building upon the GSM/EDGE and UMTS/HSPA network technologies. Besides offering a range of core network improvements and increased functionality, LTE's biggest selling point is its promised increase in network capacity and data transfer speed. Theoretically, LTE offers download rates of up to 300 Mbps and upload rates of 75 Mbps - around 10 times faster than its 3G predecessor. Operators are not claiming that their networks can achieve those rates in the real world at present, but they are promising LTE clients big gains in speed over 3G. And, while some clients are able to enjoy that, some still do not.

'The advertised rate is essentially the peak rate and that's only possible to reach if you are standing right next to the base station in perfect radio conditions with no one else using the network, if, indeed it's attainable in a real-world setting at all,' explains Alexandre Gouraud, an R&D project manager at Orange's Wireless Interfaces Lab in France. 'For average users, data rates are much less, and for those on the edge of the coverage area, they are even lower still.'

Mr Gouraud points out that each change in version and generation of mobile technology has resulted in an approximately factor of 10 difference between peak data rates and average data rates in a cell (the area of coverage of a cellular base station), and a further factor of 10 divergence between average rates and the rates attained by users located at the edge of a cell. In the case of the LTE standard, this has happened in part because LTE has been competing with WiMAX as an alternative high-speed technology, and developers have focused on peak data rates to win the battle.

'It was important to show the best performance and everybody was

focusing on peak rate, but the cell edge has been somewhat ignored,' Mr Gouraud notes. 'Evidently, for operators, this isn't a good thing, as some customers will sometimes experience poor coverage and much lower data rates than advertised.'

In order to address that issue and try to ensure a fair service for all LTE users, Orange teamed up with 14 partners, including other mobile operators, equipment vendors and research institutes, to develop and test techniques to boost performance at the cell edge. Their work, carried out in the 'Advanced radio interface technologies for 4G systems' (Artist4G) project and supported by almost EUR 8.7 million in funding from the European Commission, is feeding into updates of the LTE standard - and will all but certainly be put to commercial use in the near future.

Focusing on interference

The focus of the team, coordinated by Mr Gouraud, has been on two key aspects of cellular networks: reducing interference and advanced signal-relaying techniques.

'If you want to improve cell-edge performance, there are two ways to go about it. One is to densify the network by adding more antennas and making cells smaller, for example, but that is expensive. The second approach is to deal with interference,' the Artist4G technical manager explains.

Interference in a mobile network can be thought of as a little like the background chatter at a cocktail party. With many conversations going on at the same time, it can be hard for someone to concentrate on the voice of the person they are speaking to. But if they could easily identify those other conversations and separate them from their own, they could easily blank them out.

That, in grossly simplified terms, is the approach the Artist4G researchers took to cancel interference at the receiving end and hence improve data rates and coverage.

Though modern mobile networks were conceived around 'orthogonality', derived from the Greek words for 'straight' and 'angle' implying no overlap, the reality is that transmitted signals will always cross, creating some degree of interference. And though interference can be avoided as much as possible at the transmitter, ultimately it also needs to be dealt with by the receiver.

'Orthogonality does not really exist in practice, there is always some interference. So rather than designing a network around orthogonal signals, we take into account the fact that there will be interference. If we accept that, then we can exploit the interference at the receiving end and hook into the system technologies to cancel it,' Mr Gouraud explains.

Among other techniques, the Artist4G team developed and implemented a new framework to improve 'Coordinated multipoint transmission' (CoMP), a 'Multiple-input and multiple-output' (MIMO) technology using multiple antennas to serve cell-edge users from two or more base stations. And they worked on iterative receivers to decode both the core signal and the interference, and cancel out the latter. The team also demonstrated 3D beam-forming in which a signal is directed toward the receiver not just along the horizontal plane as at present but also vertically, greatly reducing interference.

With regard to relays, the team worked on moving relays, which could be placed on the roof of a car or bus, to enhance coverage, as well as deploying so-called Type 2 relays that extend signals from a master base station, with better resource control than Type 1 relays that effectively behave as base stations themselves.

'We developed proof of concept hardware and conducted a large-scale field trial using 15 base stations in Dresden, and some of the technology was demonstrated at the Mobile World Congress 2012 in Barcelona,' Mr Gouraud explains. 'The results have been very promising.'

The project manager points out that the partners have made around 150 contributions to ongoing revisions of the LTE standard, and much of the technology they developed is likely to make its way into commercial use.

'The different partners are using the results of our work internally, and we are also looking to launch a follow up project to continue the research,' Mr Gouraud says.

More information: 'Advanced radio interface technologies for 4G systems' project website

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