A cheap and fully optical solution for ultra-fast internet

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Blisteringly fast Internet speeds, more robust connections and a big increase in network capacity at little extra cost, even in rural areas? It's the sort of fantasy that keeps telecommunication company executives and bandwidth-hungry Internet users awake at night... until now. Groundbreaking fibre-optic technology recently developed with EU-fundingis promising all those things and more.

A consortium of universities, research institutes, equipment vendors and one telecom operator joined forces in the 'Scalable advanced ring-based passive dense access network architecture' Sardana project to develop pioneering techniques to dramatically improve the scalability and robustness of the fibre-to-home networks that already serve millions of European internet users. Supported by EUR 2.6 million in research funding from the European Commission, the project not only demonstrated connection speeds of up to 10 Gigabits per second (Gbps), around 2,000 times faster than most Internet users experience today, but the researchers showed that such speeds can be achieved at relatively little extra cost using existing fibre infrastructure and off-the-shelf components.

Though still in the experimental stages, the fully optical technology, if deployed commercially, would mark a giant leap forward in fibre network performance, directly addressing one of the biggest challenges currently facing service providers and consumers.

According to some estimates, yearly global Internet traffic will need to

be measured in Zettabytes (one trillion Gigabytes) within the next three years, a four-fold increase from today and the data equivalent of all the movies ever made passing through operators' networks every five minutes. Streaming video from sites such as YouTube and Netflix will account for most of the traffic, alongside more widespread use of similarly bandwidth-demanding video conferencing and telepresence applications.

European network operators have been warning in recent years that in order to meet this ever-rising demand for more bandwidth and capacity they will be forced to invest billions in new infrastructure and that the cost will have to be passed on to end users.

The Sardana researchers believe they have found a viable alternative. 'We are proposing a new access network architecture using fibre to the home that provides new functionalities and extended performance,' says Josep Prat, a researcher in the Optical Communications Group (GCO) at the Universitat Politècnica de Catalunya (UPC) and the scientific coordinator of the Sardana project.

Conventional fibre-to-home networks, also known as Passive Optical Networks (PONs), have a tree-like structure with the telephone exchange central office at their root. 'Passive' refers to their use of optical splitters which do not require additional power. From there a thick main trunk of cables spreads out into smaller branches to homes and businesses. Conventional tree PONs use Time Division Multiplexing (TDM), a multiplexing method inwhich signals are transferred apparently simultaneously as sub-channelsin one communication channel, but are actually physically taking turns on the channel. In practice, this means that a 5 Gbps connection at the central office can turn into a 30 Mbps downstream connection by the timeit reaches someone's home, with upstream bandwidth usually a mere fraction of that.

From trees to rings

The Sardana researchers are proposing a different and totally new approach, enablingnot only much faster connections, but more capacity and robustness. Instead of a single big tree, they are proposing multiple smaller trees branching out to end users from a main ring. The ring transmits signals bidirectionally from the central office using Wave Division Multiplexing(WDM), a multiplexing technology that enables different signals to be carried simultaneously on the same optical fibre by using different wavelengths of laser light. At Remote Nodes along the ring, the signals split off onto single fibre trees to homes and businesses using TDM technology.

The bidirectional ring approach improves network robustness because if the cable is broken at any location on the WDM ring the signal will still reach end users from the other direction. It also results in massive increases in connection speed.

'Using WDM on the ring means we can multiply bandwidth by 40 wavelengths so individual users can enjoy 1 Gbps: not just in one direction, but in both directions, both upstream and downstream,' Prof. Prat says. 'This could open the door to entirely new applications that are simply not possible today, such as high definition video conferencing.'

Laboratory tests by Finnish equipment vendor Tellabs were followed by a field trial near France Telecom-Orange's facilities in Brittany, France,and a demonstration at the Fibre to the Home Council (FTTH) in Milan. Using emulation technology combined with real-world infrastructure, the tests showed that the network is able to serve between 1,000 and 4,000 users within 20 kilometres of the main ring with symmetric internet connections at speeds of around 300 Mbps. Separately, the researchers also demonstrated that the technology could be used to transmit optical signals up to 100 kilometres from the central

office in order to provideup to 250 homes with asymmetrical 10 Gbps downstream and 2.5 Gbps upstream connections. Crucially, from a commercial point of view, such improvements can be achieved at little extra cost and the technology maintains network transparency, supporting the use of the same infrastructure by multiple service providers.

'Our approach uses existing infrastructure or involves changing components that can be cheaply upgraded,' Prof. Prat notes. For example, all end users would need the same Optical Network Unit (ONU), a device that converts laser signals into electronic signals. In the trials, the Sardana team employed ONU chips developed by Alcatel-Thales, which do not require additional wavelengths to carry out the conversion and return an upstream signal - ensuring the entire network remains fully optical. Similarly, the Remote Node connections between the WDM ring and the TDM trees are also fully optical, drawing additional power from pump lasers at the central office.

'The architecture is completely passive - it can be buried entirely underground and doesn't require any maintenance,' Prof. Prat emphasises.'Much of the infrastructure is already there: rings exist in metropolitan areas and trees are widely used, though they currently workwith very different transmission technology. Our approach turns this infrastructure into a fully optical passive solution.'

The project partners are continuing to develop the technology, which has already elicited interest from operators in Europe, the United States and China. They are also contributing to several standards bodies, including the International Telecommunication Union (ITU) group NG-PON2,with a view to commercial deployments in the near future.

Sardana, which received research funding under the European Union's Seventh Framework Programme (FP7), was awarded the Global

Telecoms Business Innovation Award last year in recognition of innovations that 'will make a difference to the communications sector.'

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