ALIENS: OUR ALLIES ON THE OPTICAL NETWORK

Photonic signals generated by different technologies share the same optical infrastructure and anticipate its future evolution by making 100G Ethernet services available throughout the network

Words
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Optical networks are infrastructures based on fiber-optics cables; nodes, where signals are generated, multiplexed and transmitted; and amplifiers at regular intervals that allow these signals to reach their destination. On a single-vendor network, the same manufacturer provides all components of the hardware platform, such as nodes and amplifiers. The management system, which is vendor-specific, enables the network operator to remotely manage, monitor and configure both the network equipment and the optical circuits.

Such infrastructure has some limitations in terms of flexibility in service provisioning and ability to follow the swift evolutions of optical communications. These limitations can be overcome with the integration of heterogeneous optical platforms. Thanks to this approach, it is possible to provide next-generation transmission services over the existing transport and regeneration equipment. At the same time, the integration allows for the evolution of the optical network by means of targeted interventions, while ensuring service reliability.

For GARR network, we have field-tested the alien wavelength technique, a hybrid solution based on the transmission and reception of optical signals generated by an infrastructure, which is different from the transport one. These two optical platforms need to interoperate at a very deep level, as the operational functionalities of the transit nodes (i.e. multiplexing, optical switching, routing, and amplification) must act in the same way both on native and alien signals.

However, alien wavelengths need to be adapted to the technology of the hosting platform, without disrupting its functionality, or its performance in transporting native lambdas. The management systems of the two interoperating platforms provide information only on their own network, as they are completely blind to each other's domain.

While planning this field test and considering its complexity, we realised that working with aliens was going to be very different from our daily operations. We took up the challenge with curiosity and with the hope that, should the technique work on our production infrastructure, we would be able to enhance and harmonise the optical transport network on a national scale only by letting alien wavelengths "invade" it.

ALIENS IN GARR-X

Our national optical network is based on technologies from two different vendors, which were deployed about four years apart. The older solution, Huawei, is in operation in Northern and Central Italy. The newer solution, Infinera, recently implemented within the GARR-X Progress initiative, is operational in Southern Italy. The two infrastructures are very diverse from the technological point of view. On the one hand, Huawei platform is based on non-coherent signals and it is equipped with compensation modules to correct chromatic dispersion, which are needed for 10 and 40 Gbps optical channel transmission, modulated in intensity on-off. On the other hand, Infinera platform exploits the innovative coherent signal transmission that can reach higher bit rates with a 500 Gbps super-channel including 10 carrier waves with phase modulation (e.g. QPSK or BPSK).

This heterogeneity between the technologies involved made the alien wavelength field test even more interesting. The field test was implemented at first between the two GARR PoPs in Rome and Naples, firstly over about 345 km of optical network (without any production traffic), and then over the live production network on a 1.200 km path.

In order to implement the alien wavelength technique on GARR network, we proceeded with the following steps. First, Infinera nodes are installed in the sites where the 100G Ethernet services are needed. Between the nodes, an adaptation layer is created, including an amplifier and a filter to split up the Infinera super-channel in its 10 carrier waves, which then need to be inserted one by one through the ADD/DROP section in the Huawei node and on the corresponding amplification chain. The Huawei platform sees each of the carriers as an alien signal; nevertheless, it manages to transport each of them over a pre-configured path from the ingress to the destination site.

Alien and native wavelengths passing through the network cannot overlap and need to be equalised. This is possible due to the presence of two elements within Huawei nodes, both of which can be remotely operated: spectrum monitoring boards and variable attenuators, both enabling the equalisation on each channel. Last, but not least, alien and native channels are monitored from the respective management systems.

RESULTS

The field test was a success: we were able to demonstrate - in a production environment - that the Infinera super-channel can be transported over the Huawei infrastructure with performance comparable to the one achieved on a single-vendor amplification chain. Furthermore, we proved that the signal to noise ratio (OSRN) is only marginally influenced by the presence of native signals on frequencies adjacent to those of the super-channel carriers. With a QPSK phase modulation, we ascertained that a 1.200 km distance could be covered with satisfactory performance. With BPSK modulation, which only transports half of the QPSK capacity, performance is even better, which suggests that longer distances could be covered without a complete regeneration of the signal. Stress and bit-error rate tests carried out on 100G Ethernet client circuits did not show any error. Huawei native channels proved robust as no changes were highlighted in their performance even when alien wavelengths used adjacent channels.

Thanks to these encouraging results, GARR is now planning to use the alien wavelength technique to provide 100G Ethernet client services also on the main backbone nodes of Huawei infrastructure, in the Northern and Central part of Italy. Indeed, the distance to cover to connect the BA1-BO1-MI1-MI2-RM2 nodes with a closed topology is compatible with the field test results. In this way, it will be possible to make available at least one super-channel, by equipping the MI1, MI2, B01 PoPs with Infinera nodes and upgrading the one in RM2. From the perspective of the user community, the most important effect of this field test will be an increased availability of bandwidth, as Infinera platform is far more spectrum efficient, and a larger accessibility of 100G Ethernet services in these nodes. In conclusion, we can say that the 100G Age begins with the next-generation aliens on the optical infrastructure!

Moreover, at the European level, we are working to help the aliens invade also the GÉANT pan-European backbone. Indeed, GARR is actively involved in an area of the GN4-2 project whose aim is guiding the evolution of optical infrastructure interconnecting national European NRENs. The idea is that NRENs could share part of their infrastructure and use the alien wavelength technique to transmit signals and create Cross Border Fibers across different platforms. The approach studied in this field test could be especially beneficial in this context, as it is not possible (nor, maybe, desirable) that all NRENs build their infrastructure using a single-vendor technology.

THE ALIEN TEST FIELD STEP-BY-STEP

- Installation of Infinera nodes at the terminal sites, back to back with Huawei equipment.
- Configuration of an alien super-channel on the Infinera node.
- Implementation of the adaptation layer (amplifier + filter to split up the super-channel into its 10 carrier waves).
- Configuration of paths across the Huawei infrastructure for each of the alien carriers, and check for possible conflicts.
- Equalisation of alien and native wavelengths transported.
- Performance monitoring for both alien and native channels (using the management systems of the two platforms).

GARR is the Italian Academic and Research telecommunication network. Its main goal is to provide high-bandwidth connectivity and advanced services to the national scientific and academic community. Consortium GARR is a non-profit organization constituted under the aegis of the MIUR (Ministry of Education and Scientific Research), and is a member of the GÉANT Association and partner in the GÉANT Project (GN4-2).

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