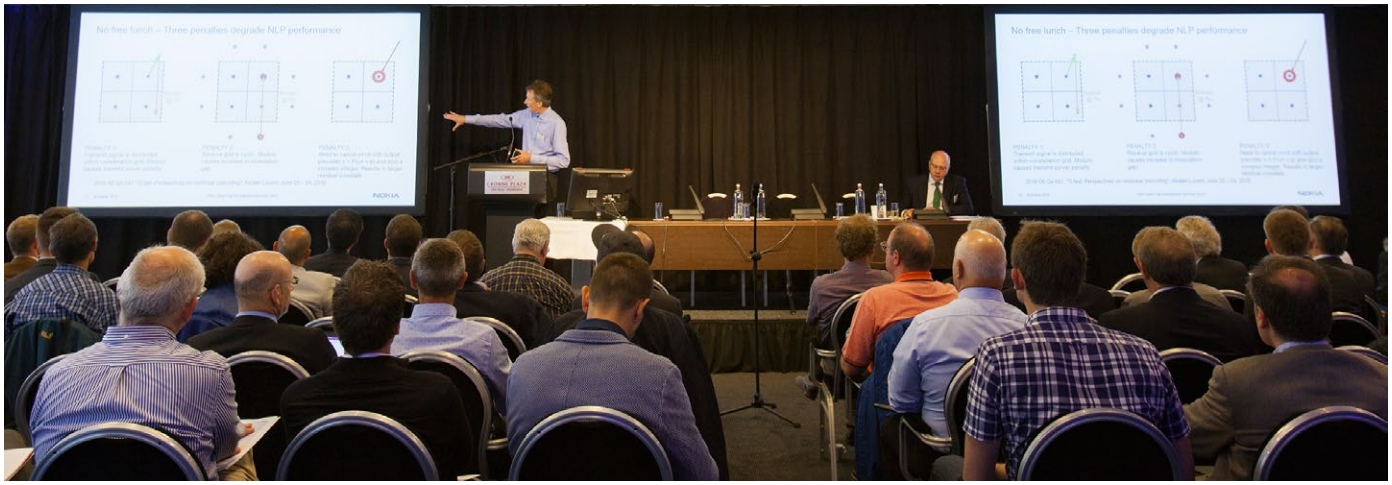
THE AGE OF THE GIGABIT HAS DAWNED



TNO innovation for life

‘Copper has a golden future’. Just a few years ago, this was the conclusion drawn at the former DSL seminar, now known as the Ultra-Fast Broadband seminar (UFBB). G.fast technology was promising speeds that could easily compete with cable and optical fibre. “Back then, it was still only theory, but now we are seeing that operators in various European countries have begun to offer their clients 1 Gbps using age-old copper line broadband. The age of the gigabit has dawned for copper”.

This was the conclusion drawn by TNO’s senior consultant Teun van der Veen, which convenes global experts in the field of broadband every year. G.fast – which was declared a global standard by the ITU in late 2014 – is the brainchild of TNO, organizer of the event. In a few years’ time, a technology that merely looked promising in lab tests has been developed into a technology that operators are beginning to rollout for both individual and corporate customers.

We are very proud of the overall rating of 8.7 that we received from our participants. Our goal is to at least equal this score in 2017.

GLOBAL INTEREST

The four-day UFBB seminar was attended by almost 150 participants, 10% more than the previous year. Most of them were there on behalf of European operators, vendors and manufacturers, but there were also parties from the US (AT&T) and Asia (Telecom Malaysia). “G.fast technology is attracting global attention and is also being applied outside Europe. What’s new is that cable companies are also showing interest in it. Along with technologies such as VDSL2/35b (some operators call it Vplus), pair bonding, vectoring and the use of higher frequencies, G.fast has become indispensable. These technologies connect perfectly with the growing importance of fibre optics in telecommunication networks. Operators can now choose the most straightforward solution for providing fast broadband for each individual region, neighbourhood or street. To do so, they are using knowledge that TNO has developed

Wim Verkerk, Nokia — *Technical excellence, very good overview of the situation with regard to suppliers, operators, home devices and regulation*

in this area; use cases and models that we have built for making technical and economic calculations. The landscape is about to change completely," said **Teun van der Veen**.

BT: THOUSANDS OF G.FAST CONNECTIONS HAVE BEEN TESTED

Various European operators, including BT, A1 Telekom Austria and Swisscom, have already carried out advanced field tests for groups of clients.

G.fast is at the heart of BT's vision on ultra-fast broadband, according to **John MacDonald** who works for this British operator. 500 Mbps will be available in most parts of the country within ten years. By the end of 2020, at least ten million households and SMEs will have ultra-fast connections. Together with ADTRAN, Huawei and Nokia, BT conducted large-scale field tests with G.fast at three locations in the UK, connecting more than 4,000 households to the new technology. Most clients reached 300 Mbps downstream and 30-50 upstream, speeds that were possible over a distance of 400 metres. "The industry has made enormous advances. Things that were impossible just one and a half years ago are now available. This is really going to speed up the rollout".

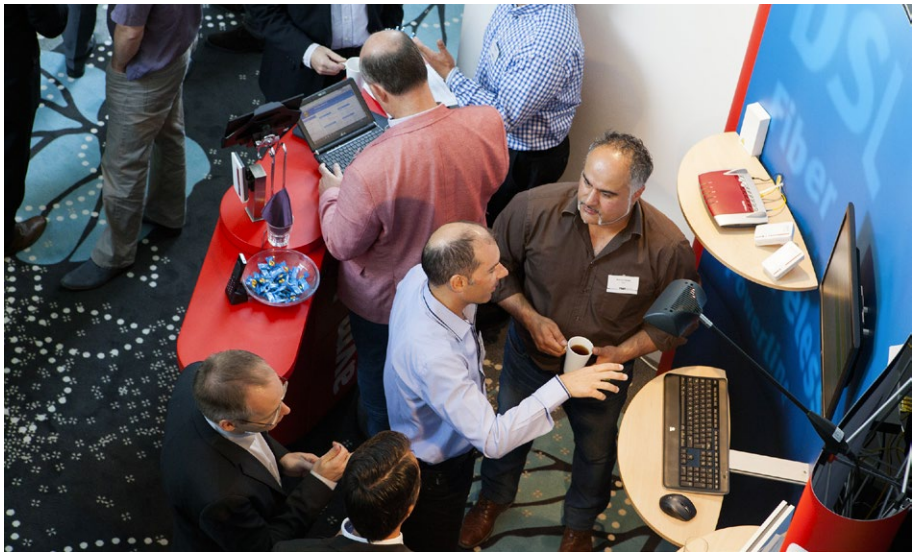
In recent years, Openreach in the UK has invested billions in FTTC, so that vast numbers of clients can now be connected to ultra-fast broadband over distances of 300 to 400 metres. "However, 'good enough' is not good enough", was MacDonald's conclusion. "We need better vectoring cancellation, improved transmission performance plus interoperability to meet our long term ultra-fast vision."

AMBITIOUS PLANS FROM ORANGE

Orange has ambitious plans for the next five years in markets that include France, Spain and Poland. In France, investments in fibre optics will be tripled and the number of connections is set to increase from 3.6 million in late 2014 to 20 million in 2020. Orange is preparing a fibre optic network in Spain and rollout is set to commence in Poland.

Hubert Mariotte from Orange Labs told us about three possible strategies for G.fast: FTTCab, FTTdp and FTTDoor. Which of these three options they choose will depend upon regulations, topology and whether or not it is possible to use the existing fibre optic network. Orange has conducted extensive laboratory tests with G.fast in various configurations, and considers FTTH as the target technology for very high broadband. G.fast is also continuing to attract a great deal of interest. Tests have proven that 600 Mbps is possible, provided that crosstalk can be suppressed.

This was confirmed by **Robert Staniszewski** from Orange Poland. Field tests comparing G.fast with MoCA have been conducted in the Polish capital, Warsaw. In terms of gigabit speed, it looks as if FTTH, MoCA and G.fast will be the available technologies in the long-term.



Bjorn Czerwinski, Vodafone — *A must for anyone who deals with xDSL or access technologies*

SUCCESSFUL TESTS AT A1

Gerald Clerckx, head of fixed access at A1 Telekom Austria, stated that rolling out the fibre optic network as close as possible to their clients will be a top priority. Depending on the geographical situation, which can range from inner cities to rural areas, they will choose either FTTCurb, FTTBuilding (dp) or FTTHome. Some areas, however, will only be able to receive broadband via LTE. If the optical fibre is close to the client, VDSL2 (17a or 35b) can provide speeds of up to 200 Mbps over a distance of 600 metres. G.fast currently reaches 600 Mbps, provided that the distance between the fibre and the client does not exceed 300 metres. The rollout of G.fast has been planned in phases between 2016 and 2018. In field tests of G.fast in coexistence with VDSL2 in apartment complexes, conducted together with Nokia, the connections were stable and the envisaged speeds were achieved. The bitrate per client, however, was difficult to predict as the quality of the copper cables varied per client. As far as the operator is concerned, G.fast is the right technology within the FTTx strategy to rollout in FTTB/dp areas, while Vplus is suitable for FTTC areas.

Hubert Mariotte, Orange — *The place to be*

… MEANWHILE AT SWISSCOM …

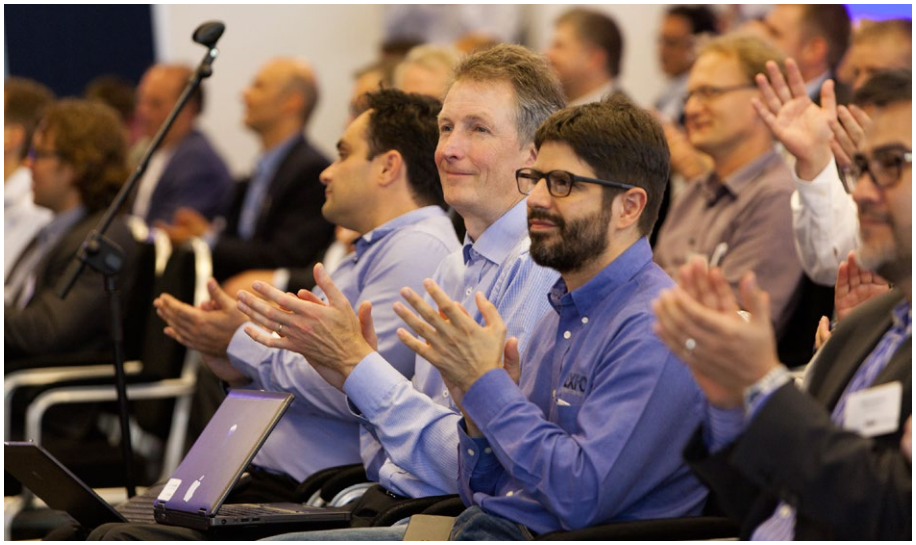
Swisscom has also committed to using a mix of technologies to provide ultra-fast broadband for their clients, told **Peggy Stergiou** and **Andreas Thöny** from the Swiss firm. They aim to provide FTTH up to 1 Gbps, FTTB and FTTS (currently 100 Mbps, but with G.fast this is set to increase to 500 Mbps in the second half of 2016), FTTC and wireless up to 300 Mbps using a combination of DSL and LTE.

For Swisscom, the path forward with G.fast is clear: in 2012 the operator conducted cable measurements and simulations, followed by lab and field testing. Rollout and migration commenced in the second half of 2016. In the next few years, the system will migrate from VDSL2 via dual mode VDSL2/G.fast to full G.fast, with aguard band ensuring the stable coexistence of G.fast and VDSL2 from the same DSLAM.

G.fast field tests are already being conducted among 200 clients in the Swiss municipality of Wattwill. The first practical results seem to correspond to earlier lab tests, whereby only slight deviations in either direction have been observed.

KPN OPTS FOR VDSL2/35B AND PAIR BONDING

The Dutch operator KPN has not yet decided whether to use G.fast technology in its network. Following a successful pilot with VDSL2/35b (which Nokia and KPN call Vplus) in 2015, in which the frequencies in the copper cable were increased from 17 to above 30 MHz, the operator will commence field tests with Vplus technology in two cities this autumn to enable download speeds of 400 Mbps. The new technology will first be tested over one pair. Speeds of 200 Mbps down and 30 Mbps up are possible. In the future, the combination of two copper pairs – known as pair bonding – should make it possible to double these speeds from 200 to 400 Mbps. Upload will then be 80. The extra speed afforded by Vplus depends upon the distance from the ROP. Using G.fast at a later stage could achieve up and down speeds of 500 Mbps, whereby KPN could even provide 1 gigabit per second using a combination of optical fibre and copper.



WIFI WILD WEST

Jan de Nijs, senior consultant of TNO, presented a proposal for a Wi-Fi Community Network with a Radio System Operator, an independent Spectrum Usage Broker and Community Control. His aim was to solve the problem of WiFi spectrum congestion among consumers. Despite – or maybe because of – improved technology, WiFi congestion is a growing problem. We now have a 'WiFi Wild West'. The number of connected appliances has risen to above twelve billion. But although speeds are approaching 1 Gbps, WiFi coverage in and around the home often leaves a lot to be desired. The answer does not lie in government regulation, but in intelligent management within networks. TNO is working together with several parties within the Wi-5 consortium to find solutions. There are three main routes that network management can take: *specification of the network services* including price and volume caps to steer traffic demand; *radio resource management* to optimize the use of the existing network resources, and *capacity management*, whereby additional base stations can be installed if traffic demand exceeds the available network capacity.

At system level, *WiFi community networks* must be set up to work together with a *WiFi network management service provider.* This will ensure optimal channel allocation for the modems of the various providers in a street or neighbourhood. This can be taken a step further with access and spectrum sharing. Organizationally, legally, financially and technically, this will be an enormous challenge demanding cooperation between providers, manufacturers and clients.
Jan de Nijs also envisages a role for a new party: *the independent spectrum usage broker.* "Congestion cannot be solved by technological improvements on their own. What we need is an independent spectrum usage broker and control by communities of users", he concluded. As expected, this is a controversial viewpoint that will inspire debate. Therefore the consortium is inviting operators to join the operator board of the Wi-5 project.

Martin Kuipers, ADTRAN — ***Best event for technical xDSL/ G.fast discussions***

DUAL-SLOPE EFFECT IN CROSSTALK

Senior scientist **Rob van den Brink** from TNO talked about 'Understanding the dual-slope effect in crosstalk (EL-FEXT)'. DSL modems have to detect weak signals affected by unfavourable signal-to-noise ratios (SNR). This is caused by crosstalk between copper pairs, which increases along with frequency. For the past twenty years, people have assumed that the SNR deteriorates linearly with the frequency, but in 2012 TNO revealed measurements at ITU that showed that at higher frequencies, SNR suddenly declines quadratically with frequency. This observation was soon confirmed by other laboratories. Since then, manufacturers have taken the "dual slope effect" into account and once above a few MHz, their modems (VDSL and G.fast) must be able to cope with crosstalk values that are much more unfavourable than previously assumed.

Koen Berteloot, Proximus — *A perfect occasion to align with people from other operators and the industry who are passionate about access technologies*

Until recently, there was no satisfactory explanation for this effect. It was also not possible to estimate how that effect was in scale to the length of the cable. In his presentation, Rob used physical modelling to demonstrate the cause of this effect, how it changes along with the geometry of the cable and scales-up with its length. He ended his presentation with a proposal for a more simple calculation model that is sufficient for modem performance calculations for different cable lengths. This model has since been introduced within the relevant work groups of ITU and the Broadband Forum.

INTELLIGENT HOME NETWORK MONITORING

Teun van der Veen has also been working on the challenges posed by home networks. Today's home networks are not yet ready for gigabit speeds. The number of devices in each household is increasing – as is frustration when connections in the attic or garden still leave a lot to be desired! On an annual basis, one in four customers phone their operators with a complaint. This costs ten euros on average. At European level, these costs are estimated at around 400 million euros per year.

"When trying to achieve ultra-fast broadband, wireless in-home has become a real bottleneck", he explained. "To ensure a good home connection, operators must have a clear picture of the exact situation in their clients' homes. This is currently lacking."

Automatic data collection may be able to give operators a better overview of their clients' situation. But questioning clients on the phone costs unnecessary amounts of time and money. Operators must be able to see which appliances are present and what their capabilities are, which connections they make use of (Ethernet, WiFi 2,4 of 5 GHz, PLC), how they perform now, and how they used to perform. Data about connections and appliances in the same street and historic data complete the picture. TNO conducted a field test whereby data from clients were sent automatically to their server so that they could analyse complaints more effectively and quickly. On the technical side, it is necessary to develop smart algorithms and machine learning. It is also necessary to answer questions such as exactly what data to collect, where to save it, how to analyse it, how to present it and to whom. Equally important is the question of how to guarantee consumer privacy. This is something that must be taken into consideration from day one.

"A Smart Home needs intelligent home network monitoring. Combining data in an intelligent way has huge potential", said Teun van der Veen.

OPTIMIZING PLANNING

TNO is developing methods and algorithms that operators can use for multi-topology migration planning, said **Daniël Worm** from TNO Networks & Systems. There are several reasons why FTTH is not a realistic option in the short term, even though it is necessary to upgrade the network to meet increasing demand. Deciding which access technology is the most cost effective for each broadband and geographical area is an incredibly complex puzzle. Advanced algorithms can optimize planning to produce enormous savings in investment costs.

SALES PITCH AND DEMONSTRATIONS

Various sponsors held a two-minute sales pitch on the second day. This half-hour long 'commercial break' was a welcome interlude after all the technical stories. ADTRAN, Attema, AVM, EXFO and TNO also demonstrated their latest technological concepts.

Save the date: The 9th edition of the Ultra-fast Broadband Seminar will take place from 12-15 June 2017 in the Netherlands.

www.ultrafastbroadband.nl

ABOUT TNO

TNO is an independent research organization that connects people and knowledge to create innovations with a strong focus on sustainability and building a better future.
TNO makes things happen by pushing the limits of technology. We often present surprising combinations enabled by a variety of knowledge and expertise in our organization.
For your organization this means that we can help you create value if you are faced with technical challenges which are seemingly impossible to solve. A clear example of this is TNO's contribution to the development of G.fast. This has been acknowledged with several awards, including the EUREKA innovation award in 2016: www.tno.nl/en/about-tno/news/2016/4/g-fast-technology-enables-internet-speeds-of-up-to-1-gb-s-over-copper/

TNO organizes the Ultra-fast Broadband seminar to connect the industry and create excellent content. This furthers our goal of enabling Ultra-fast Broadband everywhere and making it available for society as a whole. TNO's current R&D topics for Ultra-fast Broadband include Migration to Gigabit access, Intelligent In-Home Networking, Improving Consumer WiFi and Development of 5G.

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