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VIP Voices

Vega CEO: New Telecom Solutions Need New Speed Connection

Tech Forum

Evolution Trends of 5G Microwave Backhaul Transmission

Special Topic: 5G Microwave Backhaul

Leading Innovation in Microwave Broadband Transmission for Pre5G/5G

Murat Cinar, CEO of Vega telecommunication group

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A technical magazine that keeps up with the latest industry trends, communicates leading technologies and solutions, and shares stories of our customer success

ZTE 9-Month Profit Grows 36.58% to RMB 3.905 Billion

26 October 2017, Shenzhen, China — ZTE reported net profit of RMB 3.905 billion, a 36.58% surge for the first three quarters. According to ZTE's results announcement, revenue of the first nine months increased 7.01% to RMB 76.580 billion. ZTE posted positive operating cash flow of RMB 1.036 billion in the third quarter.

ZTE's R&D spending increased to RMB 9.197 billion in the first nine months, covering 12 % of revenue. ZTE's increasing investment in innovative fields such as 5G, IoTand chips is leading the company to a number of technical breakthroughs: ZTE's self-developed NB-IoT chips, the industry's first T-grade 5G flagship bearer platform, the industry's first ultra-large capacity cross platform based on the optical transmission technology, and the foldable smartphone Axon M launched in the U.S and Japan. ZTE also passed the lab trial of China Mobile's 5G bearer SPN prototypes; and launched the industry's first commercial cloud native Carrier DevOps Builder, winning the "Oscar" Award of SDN NFV Global Conference.

Bolstered by leading 5G technologies and on-going strong partnerships with mainstream European operators, the company recently announced an innovation partnership with Orange, and cooperation with Wind Tre and Open Fiber to build Europe's first 5G pre-commercial network in the 3.6–3.8GHz band. Meanwhile, the company announced recently that it has teamed up with Telenet Belgium to complete the first FDD Massive MIMO field application in Europe, and successfully verified 1Gbps peak data rate in Pre5G Massive MIMO Test with SoftBank.

Meanwhile, the company forecasts that the net profit attributable to holders of ordinary shares of the listed company is to reach RMB 4.3–4.8 billion for the entire year, bolstered by the growth of operations in carriers' network and consumers business.

ZTE and Telefonica Complete 5G Transport Test

2 November 2017, Shenzhen, China — ZTE completed phase-1 5G transport test in cooperation with Telefonica at its Future Networks Lab in Madrid, Spain. It marks the two parties have been standing at the forefront of 5G industry chain.

Telefonica has very positive comments on the test results. "The test results completely meet the expectation," said Mr. Luis M. Contreras, Telefonica GCTIO. According to the plan, Telefonica will continue to perform phase-2 transport test with ZTE and will further test and verify 5G end-to-end solutions.

In this test, ZTE provided new 5G Flexhaul, a transport solution integrating fronthaul, midhaul and backhaul features. It comprises ZXCTN 609 based on innovative FlexE tunnel technology and ZXMP M721 CX66A based on low-latency OTN technology.

By virtue of the innovative FlexE tunnel technology, the forwarding latency, in the test of ZXCTN 609, is less than 0.5 μs per node, and the protection switching time is less than 1 ms, meeting the requirements of 5G uRLLC service for super-high reliability and ultra-low latency. ZTE also completed the integrated transport of CPRI/eCPRI and backhaul services, demonstrating the distinctive feature of ZTE 5G Flexhaul solution, namely, unified transport of fronthaul and backhaul, winning high recognition from experts of Telefonica. ZTE's innovative FlexE tunnel technology extends FlexE from a point-to-point interface technology to an end-to-end networking technology and provides industrial-grade ultra-high reliability of 99.9999%.

Vega CEO: New Telecom Solutions Need New Speed Connection

Reporter: Yang Hao

Murat Cinar, CEO of Vega telecommunication group

The telecom industry is witnessing dramatic and rapid changes. But all these changes are only possible if networks with high capacity expand, according to Murat Cinar, CEO of Vega telecommunication group. A Ferrari won't pass your house if there are no good roads, he said. Vega is an umbrella brand for business units of Farlep-Optima telecommunication group. As a leading fixed-line operator in Ukraine, it is now replacing copper with fiber in several cities and is building a backbone network that will connect the whole Ukraine.

What trends and opportunities do you observe in Ukraine's fixed market?

One of the main trends in Ukraine's fixed market is that broadband subscribers are migrating towards high speed connections.

As a result, a new generation technology GPON is gaining popularity, which allows for a speed of up to 1 Gbit/s and even higher.

Another trend is the migration of fixed voice subscribers towards mobile phones. To compete with the mobile network we develop IP-telephony and provide our own over-the-top (OTT) applications for Android and iOS.

At the same time it is important to understand that no matter what decisions are taken for reaching the last mile, the establishment of the backbone network plays the key role.

A Ferrari won't pass your house if there are no good roads. So it does not matter whether it is a fixed or mobile network. The basis is a quality fixed network. Well-developed infrastructure capable of providing data transmission in the networks of a new generation is required.

Can you describe Vega's plans for high-speed broadband?

We are upgrading existing networks—decreasing a copper ADSL network and connecting our subscribers to the high speed optical network using the GPON equipment.

We have two pilot projects—in Kiev and Odessa in the city center. The project in Kiev is carried out with ZTE.

By the end of this year, the projects will be fully implemented. We expect up to 2000 connections in each of the zones in the two cities. And we are also developing important projects for network modernization in other cities and regions of Ukraine.

How do you lower the cost of fiber network roll-out in order to make them more affordable for the customers?

Vega already has in-city fiber-optic lines. During GPON implementation we just have to complete the last-mile fiber optic installations, and this allows us to reduce spending and as a result affordable prices for the customer.

What do you think of ZTE as a partner?

We consider ZTE as a reliable partner who has modern telecom equipment in its portfolio and is able to handle complicated projects.

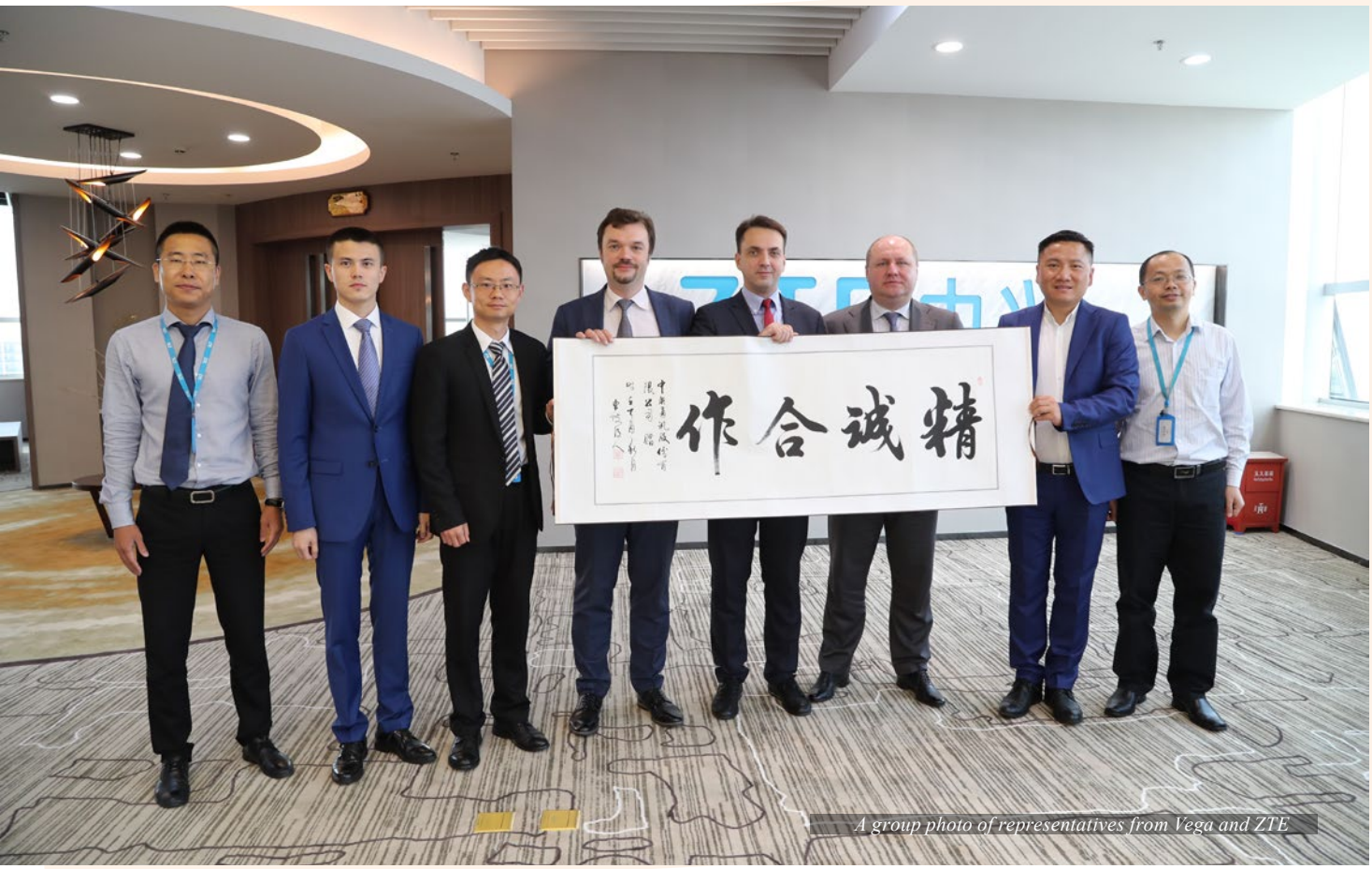
We are pleased that our partner can support us in our pilot project—the building of GPON in the capital of Ukraine.

What are the biggest challenges in delivering high-speed broadband?

Vega has set a goal—to become the No. 1 national telecom operator in terms of quantity and quality. We focus on the business segment, but work in B2B as well as B2C segments. There are three main components for our future success.

The first is speed competition. Of course, copper speed is not enough; there is a need for high speeds. Now there is not enough demand for 1 Gbit/s. But in practice we form this request.

The second is the complex service. Today people do not want to pay separately. That's why one of Vega's focuses today is provision of a complex modern telecom service. We are strengthening the internet services and related services—SIP, IP PBX and IPTV.



A group photo of representatives from Vega and ZTE

New service GPON is a multiservice platform, so a customer needs only one cord to get everything—broadband, telephone, modern 2K TV, video security and any components of IoT.

And last, but not least is the focus on the customer. The internet speed and even the price are not the main things. Customer approach is important. And those operators win who work honestly on the market and honor the clients.

What are your marketing strategies for the B2B and B2C segments? What progress is being made?

Our marketing strategy today is transforming the company into a complex provider of integrated telecom and IT solutions, with a focus on B2B services development. There are several key points for this.

The first is modernizing our core business including data and voice. We extensively upgrade our broadband network to GPON, which provides internet access at speeds of up to 1 Gbit/s for the B2B and B2C segments. Telephony is developing as well. Our B2B and B2C customers have already got IP telephony via the mobile and desktop application VegaPhone, which significantly improves user experience.

The second is developing new services. This year we made new steps in IT transformation with the Microsoft cloud solution partnership. Also the B2B clients in the near future will be offered the new IP PBX solution from Vega telecommunication group and

Vega's telephony with Skype for business. In addition, we are in the process of implementing a big range of services, such as anti-DDoS solutions, partnership with Amazon.

The third is a heavy focus on converging the fixed business and mobile.

What does 4G and 5G mean for you? Does that change your network strategy? If so, how?

4G and 5G is the future of broadband access. Using 4G network and eWBB technology, subscribers can easily get access to the high speed internet without laying any cables. It does not necessarily mean that cable infrastructure should not be developed; it should be developed even more to make high speed connection of new eWBB base stations possible.

To be ready for new challenges, Vega is now building a fully functional backbone network that will connect the whole Ukraine. This is a complex project. But it will give us the potential for growth. The throughput of the backbone network will increase to 9.6 Tbit/s.

With several business units, how do you drive the synergy between them?

There are standard things in our company—general KPI and cross-functional projects.

In the most important areas, steering committees have been created. We call them CARE—according to the capital letters of the directions of our operational strategy. They monitor the implementation of key projects in all structural divisions.

How would you explain the concept of CARE?

Philosophy and Vega's work approach are realized in the "CARE formula". On the one hand, it means the company cares about its employees. On the other, each member of Vega's team cares about the customers and the overall results of the company's work.

Each of the four letters indicates a certain direction of the team's work for the best business results:

• C — connection and churn. We connect more subscribers to reach 1 million subscriber base by 2021. We work with current clients in such a way that they stay with us.

• A — accountability. If we take the obligation, we do it on time and as well as possible!

• R — reliable network. We build quality networks. We restore the connection on optic lines in 24 hours.

• E — efficiency. We achieve the best result with minimal costs and efforts.

What do you look forward to in the next three years?

The increase of broadband speed and close integration between telecom and IT will lead to the appearance of new services—the transfer of video information, financial transactions, medical services and e-governance. In the EU, for example, the practice of paying for travel in transport using a smartphone from a mobile operator account is already not even a bank transaction.

The mobile and fixed network will merge. At the same time, voice traffic will decrease several folds and the internet-based OTT solutions will replace the "voice".

But it's important to remember: all these changes are possible if networks with high capacity expand. New telecom solutions need new speed connection. ZTE TECHNOLOGIES

A Vega store

Open Fiber: To Accelerate Fiber Broadband Development in Italy

Reporter: Liu Yang

Domenico Angotti, Head of Access and Transport Engineering at Open Fiber

According to European 2020 Digital Agenda and the Strategy for high-speed broadband defined by Italian Government, Open Fiber is carrying out an extensive FTTH project that will reach more than 9.5 million homes for the main 271 Italian cities, as a first step. This plan will contribute to reducing the gap of Italy in broadband access speed compared with other main European countries. "This is an effort that will be rewarded because fiber infrastructure is future-proof and will enable future ultra-broadband services," says Domenico Angotti who is responsible for Access and Transport Engineering at Open Fiber, speaking to *ZTE Technologies* about the company's project plan and approach to 5G. Open Fiber is a "wholesale only" operator owned by multinational Enel and state lender CDP (Cassa Depositi e Prestiti).

What's the driver of the FTTH uptake in Italy?

Our Ministry of Economic Development (MISE) is publishing in its insight an observatory tool, which monitors the current broadband situation in Italy. It turns out that just 35.4 percent of the Italian population has a broadband speed of over 30 Mbps and just 11 percent has a broadband speed of over 100 Mbps. These numbers are evolving because the FTTH market is changing rapidly in Italy. Our mission is to accelerate broadband development and to enable Italy to fill the gap compared with other much more evolved broadband markets. The goal set by the European Digital Agenda is that 85 percent of the Italian population should have at least 100 Mbps broadband speed and all the Italian population at least 30 Mbps broadband speed by 2020. Offices and public buildings (particularly schools and hospitals) should be covered with at least 100 Mbps. The Italian government set a strategy following this agenda and Open Fiber is making all possible efforts to comply with these guidelines. The Italian Strategy for high-speed broadband is only the first step of a wider project that incorporates European Digital Agenda objectives, invests in future-proof infrastructure and, thanks to the development of services, creates a fully inclusive digitized society.

What's Open Fiber's fiber deployment plan?

We've released a phased plan because Italy has complex demographics, highly distributed among many small, medium and big municipalities. We declared that by 2022 we will bring 1 Gbps FTTH to 271 municipalities, involving about 9.5 million dwellings. This comes with an announced investment of 3.7 billion euros and about 4 million kilometers of fiber optics. With the acquisition of Metroweb, Open Fiber already has 1.2 million dwellings covered with FTTH in big cities like Milan (0.8 million), Turin and Bologna. This is the current picture today. Our goal is to cover at least 2.5 million households at the end of this year, expanding our coverage to other cities. This plan is for the main Italian areas, so-called Cluster A and B according to Infratel naming.

We participated in a public auction for the white areas or market failure areas (for example, rural areas where nobody decides to invest in a massive way). According to the auction guidelines, in the white areas grouped in Cluster C, implementation of infrastructure that can support connectivity services will take place, guaranteeing a stable, continuous and predictable connection speed higher than 100 Mbps downstream and at least 50 Mbps upstream to every customer in 70% of REUs and a connection speed of at least 30 Mbps downstream and at least 15 Mbps upstream to each customer in the 30% of the remaining REUs.

In the white areas grouped in Cluster D, infrastructure that can support connectivity services will be implemented, guaranteeing a stable, continuous and predictable connection speed of at least 30 Mbps downstream and at least 15 Mbps upstream to each customer in all REUs.

The first auction involves six Italian regions. Open Fiber won this auction with more than 4 million dwellings to be covered. This means that apart from the residential areas we will also cover industrial areas, public administrations and schools. This is a huge task for us because it is quite challenging to enter these

Domenico Angotti with Massimiliano Bonola (L), Director of 5G at Open Fiber, and Massimiliano Montesi from ZTE Italy (R)

smaller and remote areas. In parallel, Open Fiber is participating in the second auction of the government for other 11 regions, involving 4.6 million households.

What's the impact of your plan?

A huge expectation has been arisen among our partners, telcos, service providers and content providers. They are interested in our plan because they see it as a big opportunity to offer a wider service portfolio to their customers and to support the evolution of the ultra-broadband services over fixed as well as the wireless networks, efficiently leveraging on a shared infrastructure. No one can have at this point a clear picture of the evolution of the market but the outlook is very promising and we are confident that it will be a successful project.

Open Fiber partners ZTE for FTTH deployment. Why did you choose ZTE?

We think that ZTE is among the worldwide leading vendors and can significantly contribute for the innovation we need for the evolution of our network. ZTE for us is a reliable partner with strong R&D areas and is also steadily increasing its market and technical footprint in Italy. We are confident that in the future ZTE can support us in product and service evolution, and development of our network plan. As an expectation of ours, we would like that ZTE could further develop its local organization and gain a wider local technical competence.

What challenges do you foresee for the project?

The FTTH project is very complex from different perspectives. I am involved in the engineering of active services. At the moment the biggest challenge of our company is developing the basic physical passive infrastructure. We think that this is an effort that will be rewarded because the infrastructure we are building is greenfield and future-proof. Not dealing with legacy system draws many advantages. On top of this passive infrastructure, you can develop the active network architecture leveraging on fiber high bandwidth, performance and very low line attenuation.

Specifically on the access layer we are developing the FTTH infrastructure using ZTE GPON products. This is just the first step. FTTH has a clear technological roadmap and GPON is only the first step for us. We will evolve to other FTTH steps, such as 10-Gigabit-capable XG-PON and 40-Gigabit-capable NG-PON2, as the demand for bandwidth is expected to increase over the next few years.

What's your plan for bandwidth?

Based on the feedback from our customers, we will decide how to scale up the capacity of our network. For the moment, GPON is the right choice because it is robust, well-proven and reliable. It seems enough for the market requirements we have received so far. We will be able to upgrade the network and scale up the capacity according to the market demands.

What will be the key applications for FTTH

in Italy?

IP traffic is increasing at a high speed and is already representing the vast majority of the traffic. We believe that video will be the content contributing most and is expected to account for the highest proportion of all the traffic on our network. Research data shows that there is a strong correlation between the evolution of the broadband speed and the minutes of video spent by households. We see that the volume and throughput demand specifically for video will increase in the next few years. The most challenging thing is that traffic intensity during busy hour will increase more rapidly than daily traffic volume, and therefore network should be flexible and capacity should efficiently scale-up without jeopardizing our TCO. Other applications such as virtual reality (VR) and augmented reality (AR) have in our country just few early adopters and will demand both a huge bandwidth and a very reduced latency. We are very interested in the surveys among these early adopters to understand how long it will take for VR and AR to gain momentum, scale up and which will be the most promising marketing segments such as gaming, watching video, education, shopping, tourism, social interaction, retail and real estate.

How will Open Fiber accelerate the return on investment?

As a wholesale operator, we have a particular advantage here. We know we are building a costly infrastructure but we are sharing this infrastructure among other players, which can accelerate the return on investment, resulting in a win-win solution. If such big infrastructure is just for one player, that would be inefficient considering the competition on the service prices. Our goal is to share as much as possible, particularly active network. We are not building something intended only for one partner.

What is the role of FTTH in 5G development?

One of the assumptions of the project is that fiber infrastructure is one of the pillars to enable the three use cases defined by ITU, including enhanced mobile broadband, ultra low latency and massive machine type communications. Our network infrastructure can be a valuable asset for enabling 5G in synergy with wireless operators. 5G will support multi-tenancy models, enabling operators and other players to collaborate in new ways, and a new open architecture is required, overcoming traditional network vision and constraints, getting connectivity, content and computing closer to the end user. We believe that the sharing of our infrastructure goes in the right direction also because of the need of operators to find more efficient solutions for deploying their 5G networks.

What's your approach to 5G?

We see 5G as a technology that can really boost the fourth industrial revolution according to World Economic Forum and Industry 4.0 framework whose pillars are Advanced Automation, Seamless Connectivity, Sophisticated Data Analysis and Industrial Cybersecurity, and it will also enable social and economic growth, and moreover new business models and sustainability.

In its Action Plan for the 5G, the European Commission called on Member States to identify at least a city for 5G testing by 2018, with a commercial launch of 5G in 2020. Our government has recently issued a tender, for a trial that will last until 2020, with three lots: the first concerns the territory of the city of Milan; the second will include the city of Prato and LAquila; and the third Bari and Matera. This auction requires bidders to present not only a technical solution but also use cases for the pre-commercial phase.

We are observing the evolution of this process and the outcomes and opportunities it can create on the wholesale market. At the moment we have not set a clear strategy on 5G but at this stage we cannot avoid exploring business opportunities with any player of the 5G ecosystem (telcos, service providers, utilities, industries, etc) that will be interested in synergies with our network infrastructure.

Barki Tojik:

Powering the Future with Smart Meters

Reporter: Wang Qiang

Shodkom Subhonkulov, Chief Engineer of Project Realization Group of Energy Loss Reduction at Barki Tojik

Tajikistan is rich in hydropower resources. However, insufficient use of water resources and energy is a big challenge for the country. In 2014, Barki Tojik, the national integrated national power utility of Tajikistan, began to implement the Energy Loss Reduction Project in Khujand and its surroundings for about 80, 000 customers. According to Shodkom Subhonkulov, Chief Engineer of Project Realization Group of Energy Loss Reduction at Barki Tojik, the project has achieved fruitful results with smart meters playing a significant role in it.

Rich in hydropower resources, what is Tajikistan's energy development strategy?

Tajikistan is an intriguing country for hydropower activity with an installed hydropower capacity of 5,190 MW, and an estimated hydropower potential of 527 billion kWh per year.

Tajikistan's hydropower potential is ranked eighth in the world, three times higher than the current electricity consumption throughout Central Asia. The effective use of these resources will provide the region with inexpensive and green power.

Hydropower supplies nearly 100 percent of Tajikistan's electricity, which is used for both domestic supply and export. Recent projects in Tajikistan include full commissioning of Sangtuda 1 (670 MW) in 2009, Sangtuda 2 in 2011 (220 MW), and the planned rehabilitation of the Kairakkum and Nurek HPPs, which is expected to begin in 2018.

Tajikistan's largest hydropower station is Nurek, with an installed capacity of 3,000 MW.

Rogun HPP, which is under construction, when completed, will become Tajikistan's largest hydropower project at 3,600 MW, and will turn Tajikistan into a net

exporter of electricity. Rogun will also be the world's tallest dam, at 335 meters.

Tajikistan's hydropower resource experiences high seasonal variations, leading to excess summer supply and significant shortages during the winter months. This imbalance has set the stage for electricity trade with neighbouring countries.

While current exports of excess summer capacity to Afghanistan are conducted on a bilateral basis, the proposed CASA-1000 regional interconnection would link Tajikistan and Kyrgyzstan's hydropower into a regional grid including Kazakhstan, Afghanistan, Uzbekistan and Pakistan.

Beyond this new capacity in the planning stages, there is significant scope for rehabilitation and modernisation in Tajikistan. Around three-quarters of the country's installed infrastructure is over 30 years old, and is thus affecting output from the country's existing hydropower facilities.

Most significantly, the Nurek project, which was commissioned in 1979 and produced over 70 percent of Tajikistan's power, is in desperate need of rehabilitation. In 2014, the Asian Development Bank funded the reconstruction of Nurek's switchyard, and the World Bank issued a contract for the techno-economic assessment study for Nurek's rehabilitation. Currently, the tender for rehabilitation of the HPP has been announced.

In addition, the European Bank for Reconstruction and Development is providing concessionary financing for the rehabilitation and upgrade of the Kairakkum hydropower project, which will increase its capacity from 126 MW to 170 MW.

The rehabilitation is focusing on incorporating climate resilience into the project's design and operation, enabling it to also access funding from the Climate Investment Funds (CIF), marking the first ever use of the CIF for hydropower.

What challenges is the energy sector facing and how do smart meters help solve the challenges?

Much of the infrastructure in the electricity sector in Tajikistan was installed in the Soviet era and though significant efforts have been made over the past 15 years to rehabilitate old facilities and build new infrastructure, it is estimated that about 74% of generation assets are over 30 years old and are in urgent need of rehabilitation.

Nowadays however, the bulk power grid is simply wearing out. Electrical lines and transformers are overloaded, the condition of the electrical network is unsatisfactory, and most of the existing electric meters are of old inductive/mechanical type.

Because of the above-mentioned, we are facing one of the main challenges—the high rate of energy loss.

The Government of Tajikistan has therefore drawn its attention to energy efficiency, and the reduction of technical and commercial losses of electricity. The state joint-stock holding power company for generation, transmission and distribution of electricity in Tajikistan, OSHC "Barqi Tojik", gradually introduced in recent years new technologies with regard to electricity supply with the aim of minimizing energy losses in the power networks.

For smooth implementation of the Energy Loss Reduction Projects, a project realization group (PRG) has been set up. Currently, the PRG is implementing "Sugd Region Energy Loss Reduction Project", which is financed by the European Bank for Reconstruction and Development (EBRD), the European Investment Bank (EIB) and the European Union's Investment Facility for Central Asia (EU IFCA).

One of the Project's components is Lot-1 "Supply and Installation of Smart Meters, Meter Reading System Equipment, Auditable Billing System in Khujand and Surrounding Municipalities". The contractor of this Lot is the Chinese Consortium of "ZTE Corporation and Hexing Electrical Co. Ltd."

The main purposes of Sugd Energy Loss Reduction Project are to reduce the losses, increase collections and increase the energy efficiency through the supply and installation of smart meters, Billing and AMI smart meter reading systems and the rehabilitation of networks in the Sugd region, in

particular in the city of Khujand, the second-largest city in Tajikistan, and its surroundings.

It should be noted that the comparative analysis of the project shows that the main purposes of Sugd Energy Loss Reduction Project have been achieved. The project presents fruitful results and has led to the decrease in energy loss, the increase in the volume of useful energy and a high level of electricity fee collection. At the same time, we can confidently note that the project encourages the rational use of electricity, which is indeed quite noticeable.

It is necessary to point out that smart meters play a significant role in achieving the above-mentioned goals. Smart meters allow us to control and monitor all the events, such as tampering, at all the electrical network levels. They allow us to make up the energy balance at different voltage levels of the chain, control the energy demand and control debts.

What's your next step? What are your major concerns for implementing the smart-meter project?

Our company has about 1.3 million customers, including residential, commercial, industrial and business customers. The ongoing project covers 6.15% of total customers. Taking into account the encouraging and fruitful results of Sugd Energy Loss Reduction Project, OSHC "Barki Tojik" has started negotiations with the Government of the Republic of Tajikistan and foreign financial institutions for the extension of the project area and implementation of such a project in other regions of Tajikistan. New projects will include the replacement of old inductive/mechanical electrical meters with new smart meters.

Our plan is to replace all of the existing old meters with new smart meters. Regarding our major concerns, I can list at least two. The first one is the investment issue and the second is the smart grid and smart meters' security.

It should be noted that new technologies, such as smart meters, are not only revolutionizing the grid from the edges inward. They are at the same time making it possible to meet the challenges that they cause and entirely meet new opportunities that they afford. Utilities must stay abreast of what they are, what they do, and how they can be best utilized to plan, operate and manage this increasingly complex and challenging business. Changes in technology in the energy sector are the biggest challenge cited by power companies around the world. Another important related issue right now is cybersecurity. The energy/utilities industry "has become more dependent upon technology and become more digitized". It's one of the last big industries to digitize. It's made the industry more vulnerable to cyberattacks.

What do you think of ZTE's smart metering and billing solution? How is it tailor-made for your operation?

The smart meter project, including billing and AMI solutions implemented by ZTE in Sugd Region, has become a showpiece for our engineers and our company's guests from surrounding countries. Every single detail and function is designed by taking into account our companies' requirements and Tajikistan's and international standards and regulations. So, we are very happy with the infrastructure, interfaces, functions, and the output of ZTE's smart metering and billing solution.

What do you think of the cooperation with ZTE? What are your expectations for the future?

For our company and for me as a chief engineer of "Energy Loss Reduction" Project Realization Group, it is a privilege to cooperate with ZTE and ZTE's team of experts. ZTE's team is well organized, motivated and knows one's onions. It is therefore a pleasure to maintain our mutually beneficial partnership in the future.

Taking into account the above-mentioned, we are working on a new proposal for new smart meter projects, which will hopefully become the start of a new long-term mutually beneficial partnership between Barki Tojik and ZTE. ZTE TECHNOLOGIES

GSMA: Helping Society Benefit from 5G

Reporter: Liu Yang

Michele Zarri, Technical Director of the GSMA

The GSMA is looking at "how society could benefit from 5G and is working on the business models", says Michele Zarri, Technical Director of the GSMA, speaking to *ZTE Technologies* about the GSMA's role in the 5G era at the 5G Summit held during MWC Shanghai 2017. He also talked about challenges facing 5G, future 5G developments and his vision for the industry. The GSMA is a trade body that represents the interests of mobile operators worldwide and organises a wide range of events around the world.

How has 5G changed what the GSMA was doing in the past?

5G creates a new type of ecosystem where not only would traditional mobile operators play a role but also new vertical industries would start to become users of mobile communications. So we move from primarily a business to consumer (B2C) market, which is about selling mobile broadband to people, to a business to business (B2B) market where on top of connectivity operators offer solutions to companies that use mobile technologies for their customers. So the operators, instead of directly talking to their customers, will talk to organizations who package mobile communications as part of their products. That's a shift from B2C to B2B creating new revenue opportunities.

Among the major organizations that are working on 5G, what role is the GSMA playing? What are its focus areas?

We have a very healthy relationship with all of the organizations that have shaped 5G in the past few years, starting from the 5G Forum, NGMN, and now to 3GPP who are the architect of 5G standards. As a trade association, we see our role, as facilitators of the growth of the ecosystem, that is, to help our members, operators, vendors, and vertical industries to benefit from the introduction of 5G. We see the GSMA playing a role in four areas: influencing the standards; ensuring there are no blocking points in deploying 5G from regulations; working on new business models and promoting 5G.

The GSMA is playing an increasingly important role in 5G.

What we give to our industry is a less technical approach because 3GPP does exceptionally well in this area; we focus on exploring how society could benefit from 5G and on the future business models so that the value generated is shared fairly in the ecosystem. We will continue driving connectivity and access to digital services for everyone, in other words, we are working to make the benefits of mobile technology available to as many people as possible. At the same time, we want to ensure that our members and associate members can build a profitable business out of 5G.

How does the GSMA balance between competition and collaboration?

We think that competition is essential and welcome it. Healthy competition leads to innovation and pushes everybody to improve. But at the same time, we think there are many areas where there are bigger benefits from sharing experience and constructive collaboration. For example, we've developed case studies that are released publicly so that people can learn from what other companies have done. We did this for services like VoLTE and RCS and are planning to do more of those, for example on infrastructure sharing and on the closure of legacy networks. One aim of these case studies is to reach an as large as possible section of our 750 operator members so that they do get information from us as a trusted neutral party.

What is the current state of the 5G ecosystem? What problems or challenges do you think it has?

The standards are coming soon and we will see pre-5G in Korea by next year. We expect China to become the dominant market in terms of the number

of connections by 2025. It all seems to be going very well so far and things are falling into place. But there are also challenges the industry will face. For example, the deployment of 5G may be very expensive compared to the additional revenues it will produce initially. This is why the GSMA is trying to find ways that would simplify the realization of infrastructure sharing and making it less of a burden for operators to deploy 5G systems. That requires the support of the regulators and more collaboration between operators as we discussed before.

We also see the challenge of frequency allocation. We know that there are some bands and spectrum that seem good for global harmonization, but it is not good enough. We have to work at global level to ensure that frequencies are allocated in sufficient amounts including in spectrum below 1 GHz that can ensure cheaper and more effective deployment.

Despite the challenges, what are the promising achievements made?

We are conducting activities in the area of network economics and also working on new types of business models enabled by network slicing. We think those are the key ways to engage a wider community and to prepare for this shift from B2C to B2B we discussed before. We are gearing up to widen the traditional ecosystem involving vertical industries. We pin a lot of hope on network slicing also because it fits our DNA in enabling roaming and interoperability.

Could you tell us more on the 5G business models?

We are just at the beginning of this activity. What we are trying to do now is to understand what segments of the industry would require from mobile technology then what mobile operators could offer in terms of functionality and capability to meet those requirements. We are looking at the automotive and healthcare industries as well as the IoT ecosystem in general. We believe that the business models of the future will be a combination of traditional charging based on usage but will also take into consideration parts of the value chain that are currently not addressed by the operators. Data analytics could be one additional service, just like security as a service (SaaS). We will work with the whole ecosystem to ensure that the new business models are fit for purpose in the future.

What will be the most critical development in 5G in the next few years?

First of all, we hope that the promise of new radio will be delivered in terms of higher speeds and reduced latency. But we know that this is a long-term process and enhancements of the capabilities will be introduced over time. We think that the critical development will be in virtualization and the ability to do network slicing because this allows an operator to generate multiple types of networks from the same infrastructure and support multiple types of businesses associated with them. For us, virtualization and the new architecture that is designed around it is the major revolutionary aspect of 5G, which is otherwise more evolutionary.

What is the contribution of vendors like ZTE to the GSMA?

We strongly value the contribution of vendors.

Especially in the last few months, we had a very fruitful collaboration with ZTE, starting with RCS, something we are working closely together to scale, but also on a number of other projects. Without the contribution of the associate members, the GSMA would not be able to deliver the same level of quality.

What's your expectation for vendors and operators in the future?

We really hope that while competing in the market they can use the GSMA as a place to work together to ensure that the 5G ecosystem is the best it can possibly be. We really welcome more participation and contribution towards our projects from our associate members. To facilitate it we are making sure that our projects are as open as possible.

The theme of MWC 2017 Shanghai is the 'human element'. What's your interpretation on that?

The human element is a reflection of the digitalization of society through mobile communications. Mobile communications have an impact on all of our lives, changing the way we conduct business, interact with each other and with the government. So besides the technology element, there's been an increase of a human element in mobile communications. That's what we explored at the event. We want to see what technology can do for humanity, not for just as a means of shifting data from A to B.

The GSMA plays an important role in achieving the UN's Sustainable Development Goals.

The Sustainable Development Goals (SDGs) are something we support and care about at the GSMA. The United Nations wants to achieve 17 specific goals by 2030 to end poverty, protect the planet and ensure prosperity for all. We think as a trade association representing the mobile community that we have a duty to ensure that our our technology contributes towards these goals. This is why, besides the conferences and the projects on 5G, we are investing a lot of our efforts into our Mobile for Development program to ensure that mobile technology helps to achieve the SDGs.

How do you help implement the SDGs?

We are looking at a number of opportunities, for instance, how we connect the unconnected, which is still unfortunately the majority. Also, how digital services can improve the quality of people's lives. So we are working in developing countries where there is a lower penetration of technology. We want to make sure that we put sustainable types of solutions in place. For example, we are looking at how mobile payment technologies enable people to get access to their money and make payments.

What mobile technologies are you most excited about?

As an engineer, it is hard not to be excited about 5G. New technologies and strategies like cloudification and softwarisation will bring a new wave of transformation. 5G is not just about the speed of the new radio and its super low latency; it's about creating a system that does so many different things for society.

What are you most looking forward to about the mobile industry?

I am looking forward to the industry being able to provide access to technology to as many people as possible. We have seen how access to the internet has changed and improved lives. I am looking forward to a future where telemedicine, e-education or e-government services or other internet based services are available to everyone. Ultimately I hope 5G will deliver on the promise of connecting everyone and everything to a better future. ZTE TECHNOLOGIES

Leading Innovation in

Microwave Broadband Transmission for Pre5G/5G

By Yao Wei, Li Changxing

Yao Wei
Senior System Engineer of Microwave Product Team, ZTE

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With the continued evolution of Pre5G/5G applications in the telecom market, mobile backhaul has posed increasingly higher requirements on transmission capacity and delay of microwave devices. It is therefore necessary to constantly innovate and enhance the technologies to increase transmission throughput and reduce the delay.

High-Order Modulation and High Bandwidth

The most direct way to improve transmission bandwidth is higher-order modulation. The improvement in modulation from 1K QAM to 2K QAM and 4K QAM can lead to the increase of bandwidth by about 10% and 9% respectively. At present, the mainstream modulation in the industry is 4096 QAM. It is expected that the highest modulation will increase by one order every one to two years. With the hybrid automatic repeat request (HARQ) technology, microwave equipment should be able to support 8192 QAM and even 16384 QAM. Another consideration is to expand the spectrum bandwidth from 56 MHz to 112 MHz, which increases transmission capacity by 100%. Conventional microwave spectrum resources are limited and cannot be expanded freely. E-band has rich spectrum resource and can support a maximum of 2 GHz bandwidth, in which a wider frequency band uses relatively lower-order modulation. For example, 256 QAM can achieve a transmission bandwidth of 10 Gbps. E-band is one of the optimal routes to wireless x-haul and will play a more important role in future 5G transmission applications due to its high capacity and low delay. The study of higher frequency bands such as W-band (92–114.5 GHz) and D-band (130–174.7 GHz) is underway in the industry, which can provide higher

spectrum bandwidth.

Spatial Multiplexing

In addition to enhancing modulation and expanding spectrum bandwidth, spatial multiplexing can also be used for improving channel capacity. Co-channel dual-polarization (CCDP) is commonly used to provide twice the transmission capacity of single polarization. Also, 2×2 line of sight multiple input multiple output (LOS MIMO) can be used to achieve twice the transmission capacity of single polarization. Therefore, the combination of CCDP and 2×2 LOS MIMO can enable four times the transmission capacity of single polarization. In the future, LOS MIMO can extend to a higher level, for example, 4×4 LOS MIMO and N×N LOS MIMO.

Take 2×2 LOS MIMO as an example (Fig. 1), the spacing of antenna arrays should meet certain requirements, depending on the one-hop link distance and operating frequency. At the receiver end, any Rx can receive a primary signal and a cross signal. For the cross signal, there is a path distance difference (Δ) on the propagation path, which finally shows up as a 90° of phase delay in the cross path. During the baseband processing, as the receiver changes its mode from single-channel receiving to dual-channel receiving, the baseband algorithm must support more efficient phase noise suppression to ensure that MIMO antennas can stably operate in the high-order modulation and high-bandwidth mode. In actual applications, the issues concerning power imbalance between channels, asymmetric antenna spacing, and pole tilt need to be considered and coordinated in the system in terms of RF circuit and baseband processing.

To meet the strict requirements of microwave LOS MIMO for the spacing of antenna arrays, two solutions will be used in the future for easy deployment. One solution is closed-loop LOS MIMO, in which the phase difference between signals received from two channels is estimated at the receiver end, and then the phase is compensated, so that the two signals are orthogonal to each other. The other solution is phased array

antenna-based LOS MIMO, where the phased array antenna consists of a set of independent antenna array elements whose relative amplitude and phase relationship are regulated by control circuits. The orthogonality of LOS MIMO is controlled by control circuits of the phased array antennas rather than relying on the path delay of space links.

As the planar phased array antenna technology develops, innovations in an antenna system have gradually applied for microwave devices. For a high-frequency band system (E-band), digital beam forming (DBF) can be used to achieve uniplanar antennas while allowing for multi-beam forming. The DBF technology similar to massive MIMO will enable a perfect combination of high bandwidth and high spectrum utilization, making it possible for a microwave communication system to dramatically increase its capacity in the Pre5G/5G era.

Innovation on the Service Side

Facing the challenges of low delay and high bandwidth put by 5G networks, ZTE has put forward its MultiBand-based solution that can use efficient PLA and flow control technologies to intelligently divide traffic flow by service priority. The solution can also balance the transmission capacity and service priority by binding wireless channels of conventional and E-band microwave devices. For the changing channel conditions, ACMB and QoS technologies can be combined to achieve lossless switching and transmission of high-value traffic flow.

From the perspective of baseband service processing, the high-capacity low-latency compression algorithm based on Ethernet packets has been widely applied in fronthaul, backhaul and hybrid haul scenarios. As new demands for MPLS and eCPRI emerge, the corresponding efficient service compression technologies are also evolving.

Innovative Techniques

Co-time co-frequency full duplex (CCFD) is a kind of technique that can improve spectral efficiency. Compared with traditional microwave

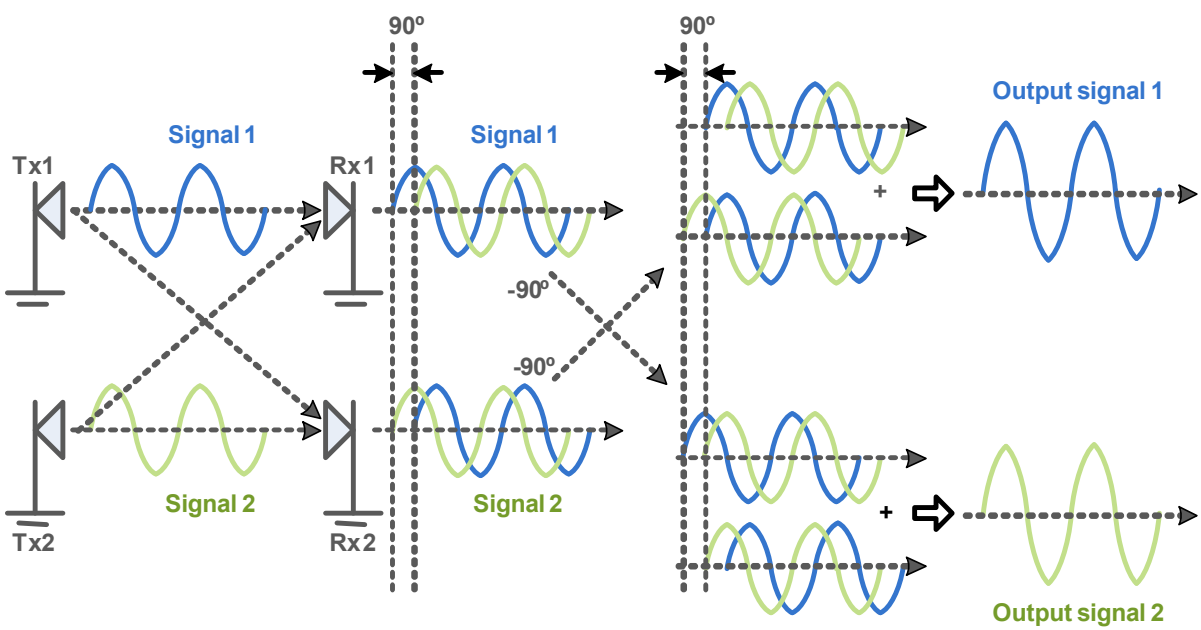

Figure 1. 2×2 LOS MIMO schematic diagram.

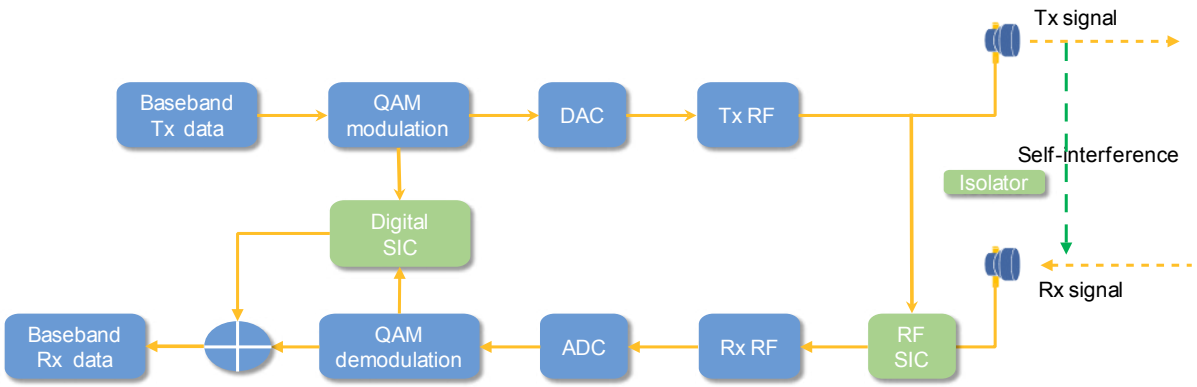

Figure 2. CCFD schematic diagram.

transmission, CCFD saves half of spectrum resources because it can achieve full duplex by occupying only a single frequency point. However, CCFD can lead to co-channel interference also called self-interference (SI) between the Rx and Tx. Therefore, the key to CCFD lies in self-interference cancellation (SIC). At present, there are three types of SIC: antenna isolation, analog-domain SIC (RF SIC), and digital-domain SIC. In the antenna isolation mode, Rx and Tx antennas are separate from each other at a certain distance by an in-between isolator. In the digital-domain SIC mode, the transmitted digital signals are sent to the Rx baseband module where SI signals are eliminated through a specific algorithm (Fig. 2).

The orbital angular momentum (OAM) modulation technique uses OAM modes carried by carriers as modulation parameters and also uses inherent orthogonality of the OAM modes to modulate multiple signals onto different OAM modes, which provides a new degree of freedom. The basic principle is as follows: A rotation factor related to the spatial phase angle is added to a normal electromagnetic wave, and then the normal electromagnetic wave is converted to a vortex electromagnetic wave. Vortex electromagnetic waves in different modes have different eigenvalues, and they are orthogonal to each other. This feature allows multiple vortex electromagnetic waves to be transmitted in parallel on the same frequency point. In theory, the vortex electromagnetic waves with different eigenvalues do not interfere with each other. The challenges of OAM lie in how to generate vortex electromagnetic waves that have different eigenvalues, how to isolate the vortex electromagnetic waves with different eigenvalues at the Rx end, and how to compensate channel distortion when orthogonality of the electromagnetic waves is impaired during the transmission in the atmosphere.

Conclusion

This paper gives a technical illustration of future microwave transmission evolution. Although some techniques are not yet mature, they have become hot topics of research in the industry. Some of them have made significant achievements in the lab. As innovative techniques continue to evolve, microwave devices will be poised to meet the challenges of large capacity and low delay in the Pre5G/5G era. ZTE TECHNOLOGIES

An Analysis of High-Frequency Microwave Technologies

By Liu Jianchi

Liu Jianchi
Engineer of Microwave System Planning, ZTE

With worldwide 4G deployments nearing completion, 5G network construction has been listed on the agenda for the next few years by many operators. While 5G solutions are attracting increasing attention, microwave technologies are challenged to provide larger transmission capacity, lower latency, lower TCO and complex traffic control in mesh networks.

Microwave Spectrum Status

Traditional microwave spectrum is nearing exhaustion. To meet the large transmission capacity of future networks, the industry has proposed many new solutions that use higher frequency bands, higher modulation, MIMO, co-frequency co-time full duplex (CCFD), faster than Nyquist (FTN), and orbital angular momentum (OAM). This article focuses on technologies and applications of high frequencies (60 GHz and above).

ITU has regulated the microwave spectrum below 134 GHz. The spectrum below 42 GHz is referred to as the traditional bands. The 57–66 GHz band is referred to as V-band. The 71–76 and 81–86 GHz bands are referred to as E-band. However, there is not an industry-wide definition of W-band and D-band. Currently, W-band refers to the spectrum around 100 GHz and D-band refers to the frequency range from 130 to 175 GHz. Figure 1 shows how the spectrum is divided.

Features of High-Frequency Microwaves

High-frequency bands (>60 GHz) have a more extensive spectrum and wider bandwidth. Such frequency bands have the following features:

- Narrow beam: In a point-to-point microwave transmission system, antennas operating at higher frequencies emit a narrower beam and more concentrated energy. For example, an E-band parabolic antenna with a gain greater than 50 dBi has half-power beamwidth of less than one degree. This means lower risk of interference in space transmission and more flexibility in frequency planning. High-frequency microwave equipment is more

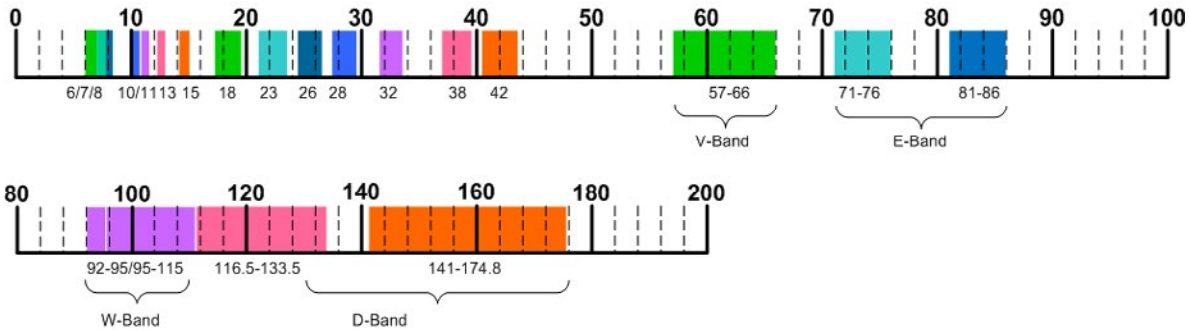

Figure 1. Microwave spectrum distribution.

suitable for large-scale deployment in densely-populated urban areas. However, it is inconvenient to adjust these devices. During engineering commissioning, some measures need to be taken to facilitate microwave link provisioning.

- Short transmission distance: With very short wavelengths, high-frequency microwaves are highly influenced by free space loss and rain attenuation, and the transmission distance is short in most cases. V-band has high oxygen absorption and the shortest transmission distance (Fig. 2). However, attenuation is less pronounced at E-band, W-band, and D-band, which deliver transmission distances of around 1 km and availability of up to 99.999%. In some particularly arid areas or over links without high availability requirements, the transmission distances can be extended to 3 km or even longer.
- Low latency: In a 4G network, the main application scenario for microwave is still backhaul that provides millisecond-level latency. 5G will require bigger capacity and lower latency. The 5G midhaul and backhaul require latency ranging from 100 us to several ms, while the 5G fronthaul requires latency of less than 50 us. Conventional microwave equipment is difficult to meet the much stricter capacity and latency requirement for fronthaul. High-frequency microwave equipment offers larger capacity, greater bandwidth, and thus greatly reduces latency in transmission. Take an E-band device as an example. When using 2 GHz bandwidth and 128 QAM, it can deliver 10 Gbps throughput per link with less than 20 us latency. This meets the low-latency requirements of 5G fronthaul.
- Low TCO: Due to the large capacity supported by high frequencies, the average transmission cost per bit is gradually reduced. Usage fees for high-frequency resources vary from country to country, but they are still much lower than those for the traditional frequency bands. V-band is an unlicensed band for general public use. E-band is lightly licensed, which requires low spectrum fees. W-band and D-band have not yet been used. However, it is worth noting that, in recent years, with the increased adoption of E-band, usage fees for it are on the rise. Some countries have increased usage fees for E-band to the same level as those for the traditional frequency bands.

High-Frequency Microwave Applications

E-band (71–76 GHz and 81–86 GHz) used for FDD mode is a pair of 5 GHz channels. It offers bandwidth of 62.5 MHz to 2 GHz and delivers up to 10 Gbps throughput at 128 QAM. In a 4G network, E-band can be used alone for short-distance large-capacity backhaul and CPRI fronthaul, or used together with the traditional bands to support large-capacity, long-distance and multi-band backhaul. With the move to 5G, fronthaul and midhaul applications will gradually increase. Fronthaul connections will need to scale up to 30 Gbps with the latency requirements lower than 30 us. E-band featuring large capacity and low latency

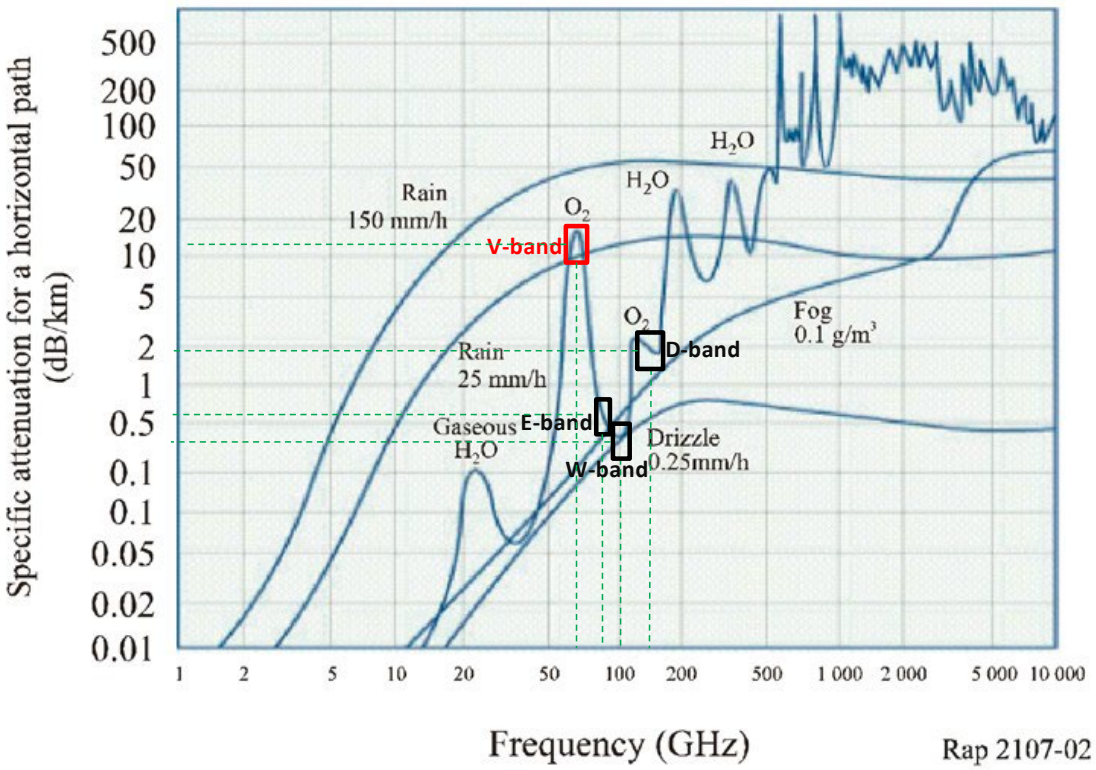

Figure 2. Attenuation due to gasses and hydrometeors for transmission through the atmosphere.

is preferred for such a scenario. The 5G midhaul and backhaul will still mainly use the multiband approach to provide 10 Gbps to 25 Gbps capacity while meeting the latency requirements of 100 us.

V-band (57–66 GHz) offers bandwidth of 50 MHz to 2 GHz. V-band can be used for both FDD and TDD modes. This band is greatly affected by oxygen absorption, so the transmission distance is usually within 300–800 meters. This makes V-band the suitable solution for street-level connectivity. When a V-band product operates in FDD mode, the point-to-point solutions are deployed in most cases to provide data transmission for enterprises and small cells. When a V-band product operates in TDD mode, uplink and downlink transmissions occur simultaneously and PtMP solutions are often deployed. V-band is open for unlicensed operation in many countries and is used primarily by enterprise users in actual deployments.

W-band (92–115 GHz) and D-band (130–175 GHz) are not clearly defined by standard bodies. However, higher microwave frequencies will be used in the future to handle the growth of wireless data traffic and the increasing capacity demands of 5G. The atmospheric absorption in W-band and D-band does not increase sharply with increasing frequency (Fig. 2), which is similar to that in E-band. The gain of high-frequency antennas is big. Therefore, these two bands can be used to enable high capacity connectivity. Some companies and organizations are now able to provide relevant product demos.

Conclusion

With the increasing demands for large capacity and low latency in future networks, high-frequency microwave technologies will be more widely used in microwave systems.

Application of SDN in Microwave Transmission

By Li Dong

Why SDN?

Since its inception in 2006, software defined network (SDN) has brought tremendous changes to networks. In the areas from data centers to enterprise networks and WANs, SDN has been widely deployed and applied. With the features of centralized control and openness, a network becomes simpler and its O&M is more efficient. The network is no longer "dead", but can have service awareness. According to service features, the network is automatically adjusted to improve its quality and ensure service level agreement (SLA). As the rise of 5G needs simple operations of many technologies and efficient service configuration, SDN is also the choice that brings highly-efficient automatic O&M and end-to-end service configuration.

SDN has found typical application scenarios in the transmission field such as SD-WAN and IP+OPTIC multi-layer synergy. As SDN in microwave transmission is still in its infancy, operators and equipment vendors have different views on it. However, standards organizations and European and American operators, such as ONF and AT&T, have begun to study SDN standards and application scenarios in microwave transmission.

SDN Architecture for Microwave Transmission

In compliance with the transmission architecture, microwave has its own characteristics that are reflected in northbound and southbound interfaces and cascaded controllers. The SDN architecture for microwave transmission contains three layers: application, controller, and microwave transmission equipment or network. The controller can also be divided into H-Controller and D-Controller. When the network under control involves devices from different vendors or covers microwave, IP, and optic fields, different D-Controllers are needed to control the devices of different vendors or their corresponding technical domains, and H-Controllers are used for inter-domain or end-to-end functional coordination.

Interfaces between the controllers and devices include Openflow, Netconf, and

Li Dong
Microwave Product Planning Engineer, ZTE

PCEP/BGP-LS. In terms of smooth network evolution and scalability, Netconf is more suitable for existing microwave scenarios and services. As microwave services evolve from Native ETH to IP/MPLS, PCEP/BGP-LS will be an option in the future. Some operators are also considering using Openflow. As an alternative choice for future SDN, Openflow might come in handy because the operators hope all future devices will be white-box devices. Control devices deployed at a higher layer will bring more flexible programmable networks and more innovative business models. The industry and certain standards organizations are also studying a better southbound protocol such as P4 to replace Openflow.

Features of Microwave Transmission

Microwave transmission has the following features:

- It has dynamic features at the air interface such as frequency interference, fading, and multipath. The corresponding function includes adaptive modulation and coding (ACM). A change in the weather brings dynamic adjustment to air interface modulation and accordingly results in dynamic bandwidth adjustment.
- It is sensitive to bandwidth capacity, so an important function—physical link aggregation (PLA) is introduced. The insufficient capacity at the air interface can be addressed by binding links.
- It has a tree or chain network topology in most cases and a ring topology in a few cases. This topology results in few redundant paths. For 5G backhaul, such as small cell backhaul or dense site deployment, there will be more mesh networks.
- It is in the access part of transmission and has a large number of nodes.
- Microwave devices are geographically distributed. The bandwidth of the control channel is limited and unreliable, and the real-time requirement is also difficult to meet.

Analysis of SDN Application in Microwave Transmission

Compared to the almost static configuration and management in a traditional O&M, SDN offers an automatic end-to-end O&M to microwave transmission.

Network Topology Discovery

A centralized controller brings not only centralized management but also an overall network view including the global topology view and global resource view. With standard southbound interfaces, the wireless link topology of microwave transmission involving different vendors can be easily shown on the same view, which makes significant progress over the traditional EMS.

Wireless Link Configuration

The standards organization ONF committed to standardizing microwave air interface data models has introduced the TR532 technical standard that

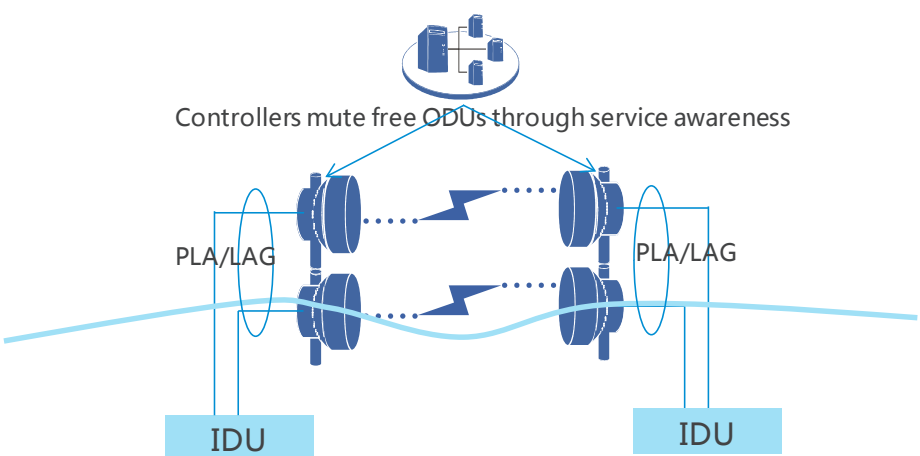

Figure 1. Air interface adjustment based on service awareness.

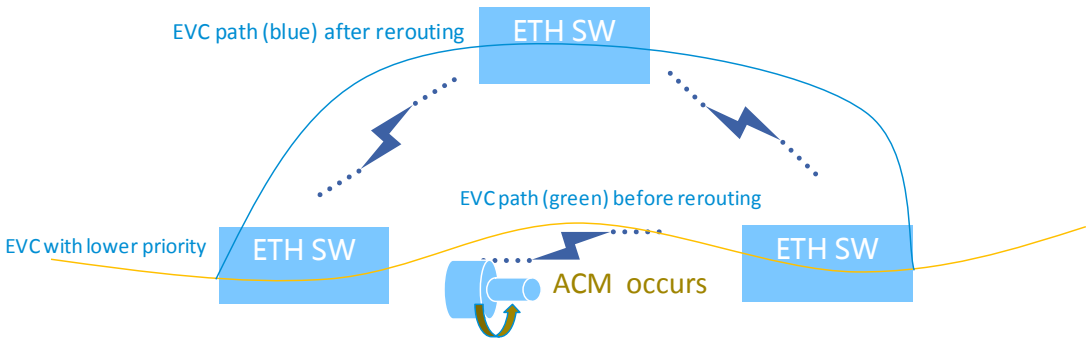

Figure 2. ACM triggers rerouting.

provides a new way to automatic configuration of cross-vendor wireless air interfaces. Wireless links of NEs including the frequency, modulation, and XPIC, can be configured by the controller or through flexible applications. With programmed applications, changes to wireless link configuration can be automatically triggered by an event such as weather.

End-to-End Management

End-to-end service management is an important feature of microwave transmission. The SDN architecture can be used to effectively enhance end-to-end service capabilities of microwave transmission. Through open northbound and southbound interfaces and cascaded multilayer controllers, end-to-end cross-domain and cross-vendor management that is unavailable in the traditional O&M can be supported. In addition to multi-vendor management, operators also hope to deliver end-to-end cross-domain services that cover microwave transmission, IP, and optic domains.

Energy-Efficient Wireless Links Based on Service Awareness

Microwave transmission has a unique PLA/LAG function that aggregates wireless links. Traditionally, modem boards and outdoor units (ODUs) at the air interfaces are all open, regardless of air interface traffic. However, the traffic flow at night or before dawn reduces dramatically compared to that at busy hours, and one or more aggregated air interface channels may be free. In this case, a centralized controller can be used based on certain policies to close some free channels or mute ODUs to save energy (Fig. 1). When the traffic flow is predicted to rise, the free channels can be open again by the controller.

Rerouting Triggered by ACM

Rain fade triggers adaptive coding and modulation (ACM), which results in bandwidth decrease at the air interfaces and damage caused to lower-priority services (Fig. 2). For a ring network, the traditional solution is to upgrade existing protocols to trigger service switching such as ERPS. However, SDN can be an easier solution and brings more adaptability such as MESH. When a service fault is detected through the corresponding O&M, a controller can receive the fault notice, obtain a redundant path through the path algorithm, and reroute the damaged service to the redundant path.

5G Application Prospect

There will be more SDN scenarios for 5G networks. For example, frequencies can be automatically allocated for unlicensed bands. This reduces interference and maximizes frequency utilization. Advanced features such as ad hoc networks and network slicing may also be introduced. These application scenarios need to be further studied.

Conclusion

Although SDN is relatively new to microwave transmission, it will be practically applied as the SDN standards and applications have gradually matured. Microwave transmission is a part of the transmission network, and SDN will be more widely used as the entire transmission network is restructured and upgraded.

Clock Synchronization Solution for 5G Microwave Backhaul

By Hu Bing, Li Leiming

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Chief Software Engineer of Microwave Products, ZTE

Li Leiming
Chief Hardware Engineer of Microwave Products, ZTE

In a radio backhaul network, the frequencies and time of base stations need to be synchronized. Timing signals can be given to base stations through microwave. FDD base stations require frequency synchronization, while TDD base stations or FDD base stations that need to support advanced features require time synchronization. In the on-site deployments, each base station is usually equipped with a GPS system. The frequencies and time can be synchronized through a GPS lock.

In addition to GPS synchronization, an operator may also use 1588V2 and SyncE as an alternative solution. In case of GPS failure, base stations may synchronize frequencies through 1588V2 or SyncE, or synchronize time through 1588V2 plus SyncE.

Clock Synchronization for 3G/4G Microwave Backhaul

Frequency Synchronization

The frequency synchronization accuracy of base stations is less than 50 ppb. When base stations use 1588V2 as their frequency synchronization mode, the1588 solution need to comply with the ITU-T G.8265.1 profile, where 1588 servers are deployed in the central equipment room, 1588 packets are transmitted to base stations through the IP backhaul network, and base stations restore frequencies through locking 1588 packets. ZTE's BBU can effectively remove the 1588 packet jitter in several milliseconds and lock the frequencies that meet the requirement. A microwave device is used as the access part of an IP backhaul network. In most cases, the 1588 packets, similar to common service packets, are not processed but are only provided with QoS guarantee to ensure that the PDV introduced in 1588 packet transmission is relatively small. However, improper network bandwidth planning may cause packet congestion. This will increase the PDV of the 1588 packets and has an adverse impact on 1588 packet locking by the base stations. In this case, the microwave 1588 TC function can be enabled. ZTE's MW TC correction

precision per hop is less than 50 ns. Suppose there are 10 hops in a microwave transmission link when the 1588 TC function is enabled, the introduced PDV is less than 0.5 µs, which has an extremely low impact on frequency restoration for base stations. Therefore, the PDV introduced in 1588 packet transmission can almost be ignored.

When base stations adopt SyncE as their frequency synchronization mode, the microwave clock transmission specifications must follow the ITU-T G.8262 standard to ensure that the clock information transmitted to the base stations can meet the ITU-T G.823 requirement and also satisfy frequency synchronization requirements for base stations.

Time Synchronization

Time synchronization is mandatory for TDD base stations and FDD LTE base stations that support advanced features. TDD base stations and LTE-A functions require that the time deviation between base stations should be less than 3 µs. When 1588V2 is used as the time synchronization mode, the time deviation between the base station and time source must be less than ±1.5 µs. In the case of BC cascading, the maximum error precision of ZTE's microwave device is less than 50 ns. Time synchronization errors are estimated in accordance with the ITU-T G.8271.1 standard (Fig. 1). ZTE's microwave device can also meet the precision requirement of time synchronization in a 10-hop link.

Clock Synchronization for 5G Microwave Backhaul

5G backhaul networks have higher requirements for frequency synchronization and time synchronization, and the relevant standards are under study. Frequency synchronization is defined in the ITU-T G.8262.1 standard (draft), in which frequency drift and transient change are specified in detail to

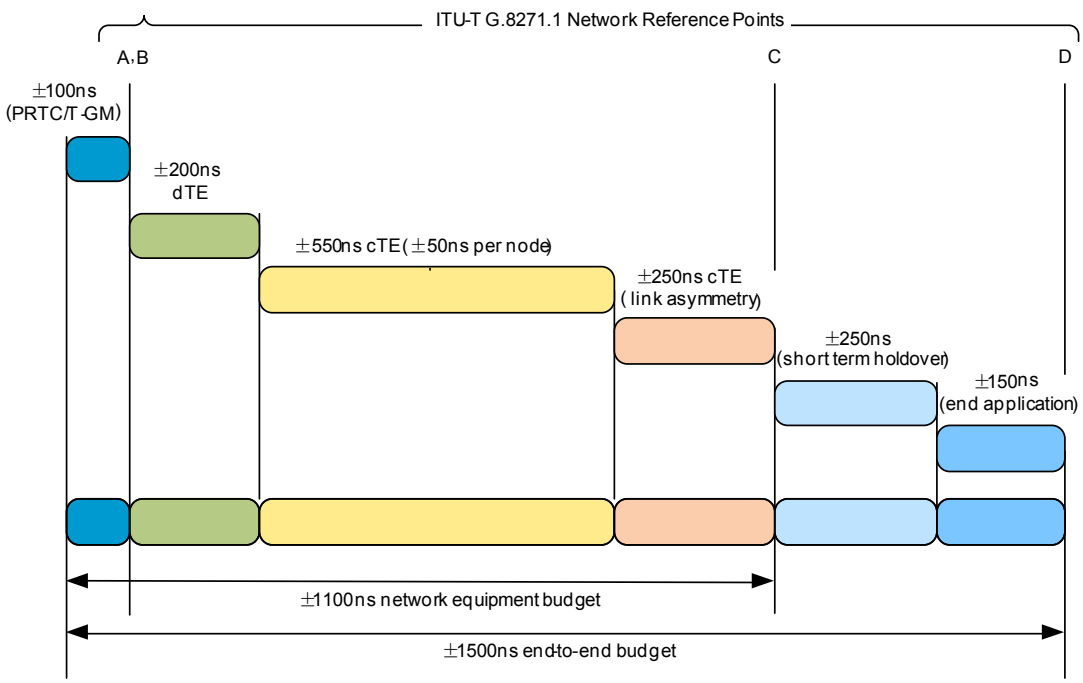

Figure 1. End-to-end budget for backhaul network (Source: ITU-T G.8271.1).

Table 1. Time synchronization requirements of 5G NR.

System	Phase	Notes
5G new frame structure	±390 ns (under study)	60 KHz subcarrier
Inter-band CA	±130 ns	3GPP TS 36.104
5G high-accuracy location service	10 ns for 3 m accuracy (under study)	Only for local use

provide a basic guarantee for improving the precision of time synchronization.

Table 1 lists the time synchronization requirements of 5G NR. 390 ns is a basic requirement of time synchronization for 5G NR, while 130 ns is a high-level requirement of time synchronization for 5G NR.

The original standards are no longer applicable to 5G time synchronization scenarios. Now 5G-oriented technical standards are being developed, and networking models and device specifications have not yet been determined. In the current draft standards, the requirements are much higher than the original ones. This raises higher requirements on developing future 5G microwave equipment. In addition to keeping pace with the standards development and improving equipment capabilities, ZTE has also proposed a new microwave solution to meet the challenge.

After locking a GPS system, ZTE's BBU is used as a time synchronization source because its time precision can satisfy the related technical requirements. ZTE's microwave device can interchange time information with the BBU and take the BBU as a standby time source through the clock source selection algorithm. When the GPS system of the BBU is operating normally, the BBU will be selected by a microwave device as its active time source. If the GPS system of the BBU fails, the microwave device may detect the failure by interacting with the BBU, and the time source can be switched to a neighbor microwave device through the clock source selection algorithm. If there are multiple BBUs whose GPS systems are available, the microwave device will select the nearest BBU as its time source so that the microwave time precision can be guaranteed. In practical deployment, a GPS system can be deployed on several BBUs in accordance with the time precision requirement. This satisfies the precision requirement of time synchronization while reducing the cost of GPS deployment.

Currently, the one-hop time synchronization precision of ZTE's microwave devices is less than 50 ns in the case of BC cascading. According to 5G standards, the reserved time synchronization precision should be corrected accordingly. Suppose the PRTC error is less than 20 ns, the phase error caused by holdover is less than 40 ns, the internal error of the base station is less than 20 ns, and the asymmetric error is 0 (back-to-back networking mode is often used in microwave transmission, and there is no fiber asymmetry problem). To meet the basic requirement of 5G time synchronization, the reserved time synchronization precision for a microwave link is 390 – 80 = 310 ns. If the maximum precision error of one-hop microwave is 50 ns, four-hop microwave can be supported. The high-level time synchronization requirement is 130 ns, which means one more hop can also be supported.

Today, microwave clock synchronization technology has been widely applied in 3G and 4G networks, and will have a more promising application prospect in 5G networks. As the industry continues to develop mature 5G standards and solutions, the clock synchronization solution for 5G backhaul networks will face higher requirements and challenges.

Evolution Trends of 5G Microwave Backhaul Transmission

By Guo Jinghui, Li Jian

As 4G networks are widely deployed for commercial use, the fifth-generation (5G) mobile communications system for the year 2020 and beyond has become the R&D focus around the world. 5G application scenarios will cover every field of future society for intelligent man-to-man, man-to-machine, machine-to-machine interconnections. The 3GPP 5G standardization work is divided into two stages. At the first stage, the R15 standard will be released by June 2018, aiming to satisfy eMBB and uRLLC application requirements. At the second stage, the R16 standard will be released by Q4 2019 to completely satisfy the requirements of various scenarios including eMBB, uRLLC, and mMTC. By 2020, the conditions for commercial 5G deployment will fully mature. As an important transmission method for mobile backhaul, microwave boasts low cost, flexible deployment and rapid network construction, and has played a critical role in 2G, 3G and 4G network construction. However, 5G networks require enormous transmission capacity and ultra-low transmission latency, which poses greater challenges to microwave transmission devices.

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5G RAN Architecture and Backhaul Requirements

5G RAN Architecture

It has been proven that C-RAN is a flexible and efficient RAN architecture for LTE networks. C-RAN

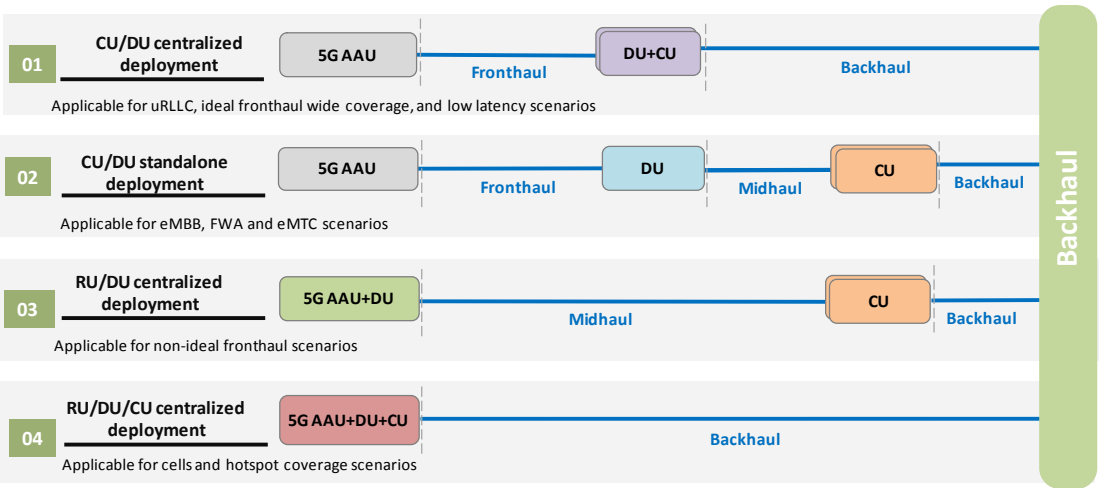

Figure 1. Multiple CU and DU deployment modes.

can reduce the number of BBU equipment rooms, lower energy consumption, and improve spectrum efficiency and network performance. However, the traditional C-RAN uses CPRI interfaces that are difficult to offer hundreds of Gbps or even Tbps of bandwidth for 5G networks where high bandwidth and MIMO configuration are required. Therefore, a consensus has been reached in the industry that 5G RAN functional modules should be further sub-divided. According to 3GPP TR 38.801, a 5G base station will be logically split into central units (CU) and distributed units (DU). Functional modules will be flexibly configured between CU and DU, which can support either distributed or centralized base station deployment. The physical interfaces between CU and DU will adopt the Ethernet standard. In practice, the CU and DU can be deployed in multiple modes (Fig.1).

Network Cost and Energy Consumption

To meet the 5G requirement for high transmission capacity, 5G base stations are more densely deployed and network architecture becomes more complicated. In 5G network construction, costs will become a key factor. A new network architecture based on NFV/SDN will be used to decouple software and hardware, to replace dedicated hardware with general-purpose hardware, and to support network slicing. This can effectively reduce the cost of infrastructure construction. Moreover, a real cross-domain and cross-vendor end-to-end operation and management will enable operators to offer 5G services in an economically sustainable manner.

Energy consumption is a key factor for TCO reduction. In the future, 5G will support 1000-fold business growth while consuming half the energy of current networks. This will increase energy efficiency by a factor of 2000.

Technological Evolution for 5G Backhaul Microwave

Capacity Increase

Driven by the 5G eMBB scenario, the RAN backhaul capacity will reach several Gbps or tens of Gbps. Increasing transmission capacity has become a challenge to microwave transmission.

The traditional 6 to 42 GHz microwave bands have been widely deployed for commercial use. Because the frequency resources are limited, transmission capacity can be increased by improving spectrum efficiency. 2048 QAM and 4096 QAM have become dominant modulation techniques thanks to mature commercial applications of modulation and demodulation technologies, the increase in key chip speeds, and cost reduction. The devices supporting 8K/16K QAM modulation are under development and will soon be available.

MIMO is just beginning to be used in the

microwave transmission field, and 4×4 MIMO can increase the transmission capacity of a single carrier by four-fold. However, MIMO antennas are difficult to install and debug, and there are many application restrictions. Therefore, the focus of future MIMO research is lowering the MIMO deployment requirements and debugging difficulty for large-scale commercialization.

High bandwidth can directly increase microwave transmission capacity while reducing the size and cost of microwave transmission equipment. Bandwidth increase can especially expand trunk microwave applications. It has been placed on the agenda of microwave vendors that frequency bands lower than 18 GHz will support a bandwidth of 112 MHz in the future.

High-band spectrums have many distinct advantages such as abundant frequency resources, low price for spectrum usage, and dense deployment with high-band narrow beams. The abundant spectrum resources make it easy for microwave transmission devices to provide huge transmission capacity, reduce transmission latency, and better satisfy the 5G RAN backhaul requirements. Microwave devices operating at the E-band (71–76 GHz and 81–86 GHz) have been commercially deployed. Currently, the transmission capacity can reach 10 Gbps under the 2 GHz/256 QAM configuration. As higher-order modulation and CCDP/XPIC techniques are applied, the transmission capability will reach 20–40 Gbps per carrier. The W-band (92–115 GHz) and D-band (130–175 GHz) have more than 15 GHz and 30 GHz spectrum resources respectively, and also high antenna gains. These help to develop small-sized microwave transmission devices with large bandwidth and low power consumption and to better satisfy the 5G small cell backhaul and large-capacity fronthaul requirements.

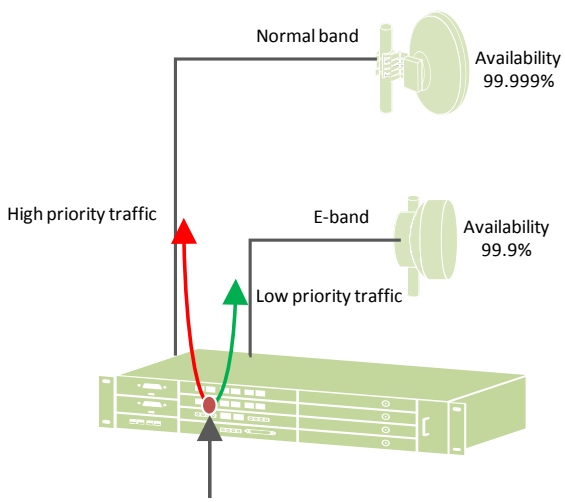

Figure 2. Multi-band solution.

Multi-band applications can significantly increase transmission capacity. The E-band microwave provides larger transmission capacity, but it is greatly influenced by rainfall. In most cases, the annual microwave link availability is 99.999%. The transmission distance of an E-band microwave hop is about 1 km. Multi-band is used by combining the E-band and normal band. By reducing the availability of E-band links, multi-band increases the transmission distance. Normal band links are used to guarantee the reliability of high-priority services. Figure 2 shows the large-capacity microwave solution for midhaul transmission distances of 3 to 10 km. The multi-band solution supports priority-based traffic load balancing and inter-link protection to guarantee reliable service transmission.

Latency Reduction

A 5G system can deliver end-to-end common services with a latency of 10 ms and end-to-end uRLLC services with a latency of 1 ms. Except for service processing at the terminals and base stations, the latency reserved for fronthaul and midhaul is estimated to be below 50 μs and 150 μs respectively.

The transmission latency of microwave devices mainly involves service processing, switching networks, and modulation and demodulation. The service processing time can be effectively reduced by increasing service interface rates and microwave air interface capacity. Thus, there will be more and more applications of high-speed interfaces with data rates above 10GE. Accordingly, the switching capacity and packet processing rate of switching chips have to be improved to reduce packet forwarding latency. Moreover, latency can also be greatly reduced by

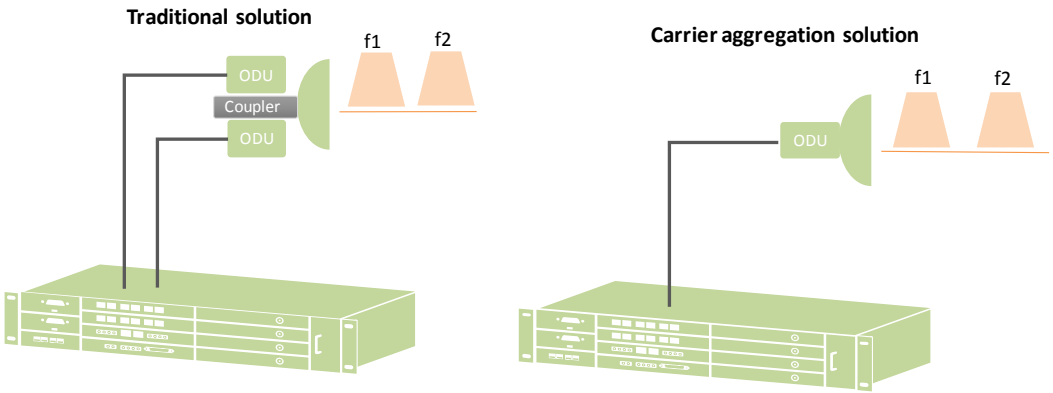

Figure 3. Carrier aggregation technology.

optimizing modem algorithms and increasing the air interface bandwidth.

Flexible Networking

To satisfy 5G network slicing requirements, microwave devices need to manage forwarded resources in logical slices. Different slices should have different transmission bandwidths, network delays, and QoS guarantees. Considering various 5G requirements such as super-dense 5G mesh networking, rapid service deployment, low-cost operation, and real-time performance optimization, the evolution of microwave transmission devices to SDN has been put on the agenda, and the related standards are under discussion. Now there are many issues that need to be addressed, such as the device management issue, the security and stability issue of SDN controllers, and the issue of multivendor collaboration and interoperability.

Low TCO

- Higher integration: Highly-integrated devices can reduce installation space, equipment cost, and power consumption. All this helps operators reduce their network TCO. The next-generation microwave devices will have higher integration. For example, miniature RF units and split-type microwave products will support more air-interface aggregation directions, and full-outdoor integrated microwave products will support 2T2R.
- Carrier aggregation: The carrier aggregation technology can significantly reduce the size and cost of outdoor RF units (ODUs). A traditional ODU can only transmit one carrier signal, but the carrier aggregation technology can aggregate some discrete spectrums and send them out through one ODU. This allows one TRX to transmit multiple carriers. Through carrier aggregation, the number of ODUs is reduced by half (Fig. 3).
- Large-capacity trunk: As transmission capacity continues to grow, there are more and more applications of large-capacity trunk products. However, their application scenarios are restricted, because trunk products are large-sized and high-cost. If the carrier aggregation technology is used, the size, cost and power consumption of trunk products can be considerably reduced. The environment requirements for their installation can also be lowered. This makes it possible to apply trunk products in urban dense deployment scenarios.

Conclusion

It is a great challenge for microwave transmission to satisfy the 5G RAN backhaul requirements. Microwave devices need to combine a variety of technical schemes to continually improve transmission capacity and reduce their size, transmission latency, and power consumption. In this way, they can adapt to the new NFV/SDN network architecture, leverage their advantages in 5G RAN backhaul networks, and create more value for operators.

END-TO-END MICROWAVE SERVICE TOOL SOLUTION

By Hu Hejun, Li Dongsheng

Microwave is an important part of mobile backhaul. With widespread applications of 4G networks and the deployment of Pre5G, microwave networks have grown constantly and their topologies have become increasingly complicated. Microwave is characterized by multiband and difficult antenna adjustment. To meet operators' needs for growing business development, rapid and accurate deployment of microwave networks at an optimal cost is required, which has great impact on the project construction cycle. During the maintenance phase, a complete network monitoring is also required, which helps to find hidden dangers in time and to implement network optimization and adjustment. This ensures transmission quality and provides secure transmission channels for traffic at the base stations.

A microwave project contains two key phases: network construction, and network operation and maintenance. Network construction involves network planning, site commissioning, and site acceptance. There are also some problems in the on-site microwave project (Table 1).

ZTE's microwave system provides an end-to-end service tool solution that covers all key scenarios from network construction to network operation and maintenance (Fig. 1). The solution can maximize efficiency and minimize costs.

Tools Used in Key Scenarios

Network Planning Tools

CXP-MW is a special microwave planning software used in the preliminary planning phase. Based on the information about frequency bands, sites, and base stations provided by an operator, CXP-MW can quickly calculate the data concerning network topology and link capacity.

PL5, short for PathLoss 5.0, is universal network planning software used in the industry. Based on the information about frequency bands, sites, and base stations provided by an operator, PL5 can calculate the data concerning network topology and radio links and output the planning files such as Linksummary and Sitelist. PL5 is third-party software that has an advantage in accurate radio link

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planning and is chiefly used for network planning in the engineering phase.

ETP-Designer is ZTE's microwave equipment planning software that converts the Linksummary and Sitelist files output by PL5 into ZTE's microwave hardware configuration parameters. ETP-Designer outputs hardware configuration for the network and sites, rack diagrams, NE configuration parameter files, and DLD files.

Site Commissioning Tool

ETP-Genius is Android-based app that imports the NE parameter configuration files generated by ETP-Designer into NEs for site commissioning. ETP-Genius can also upgrade the version of NE software and provide antenna-assisted debugging. After completing site commissioning and debugging, ETP-Genius automatically collects site information for site acceptance.

Operation and Maintenance Tools

ETP-Debugger is fault diagnosis and maintenance tool for microwave sites. It can extract information via one button, analyze information, and remotely extract information.

U31 EMS is microwave network management platform that provides all-round management of microwave networks and sites, including batch NE configuration, remote batch upgrade, and one-button inspection.

Key Function and Procedure Analysis

Network Construction

Based on the requirements and site information provided by operators, network planning engineers design radio links with CXP-MW or PL5, export Linksummary and Sitelist files, import the files into ETP-Designer, and then set parameters as required by projects. Based on the configured parameters, ETP-Designer automatically calculates hardware configuration, plans IP and DCN data as well as topology connection, and outputs site BOM and DLD files, board position and connection diagrams, EMS parameter planning tables, and NE configuration parameters. NE configuration files are also automatically generated.

When a site is commissioned, ETP-Genius directly imports the configuration files into NEs for automatic configuration. After the NEs are restarted, the configurations take effect, and the NEs report the operating status information to ETP-Genius for site acceptance.

Network Operation and Maintenance

Version upgrade, fault handling, and routine inspection are implemented in the network operation and maintenance phase. ZTE's microwave system provides a full range of tools. U31 EMS provides a remote batch upgrade module that can automatically identify network topology, check system security before and after the

Table 1. Problems in the on-site microwave project.

Items	Problems	Impact analysis
Network planning	Unable to automatically generate configuration data due to lack of complete network planning tools	Low efficiency and high cost due to multiple optimizations of hardware configuration
Site commissioning	Manually configure commissioning parameters	Time-consuming and low-efficiency site commissioning, and high technical requirements for commissioning engineers
Site acceptance	Manually fill out an acceptance form	Low acceptance efficiency and data likely to be omitted
Operation and maintenance	Low upgrade reliability	Manual duty is required due to a long upgrade period
	Manually inspect the project engineering	Low inspection efficiency and high cost
	Difficult troubleshooting because data is obtained from full-outdoor sites	High cost and low efficiency due to climbing to the tower by engineers

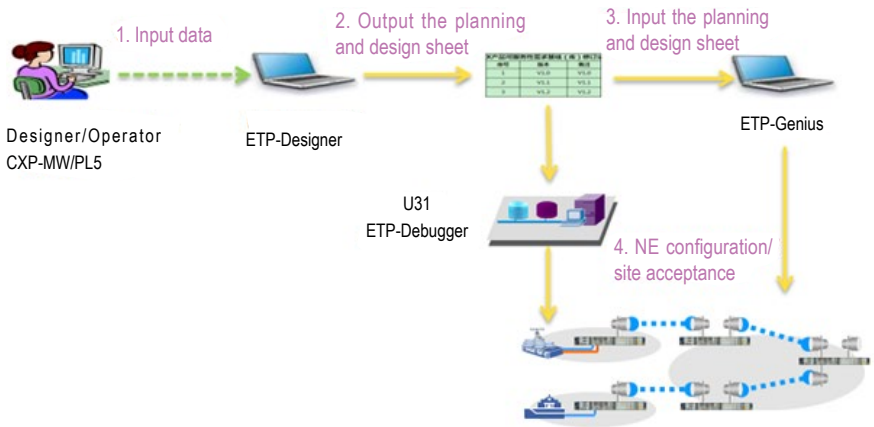

Figure 1. ZTE's end-to-end microwave service tool solution.

upgrade, and upgrade the system to ensure security and efficiency of the version upgrade. U31 EMS also provides a one-button network inspection module that can collect, summarize, and analyze network data and give suggestions for improvement according to the user-defined rule sets. ETP-Debugger collects and analyzes the information about indoor and outdoor units, and maintains full-outdoor and silo sites.

Tool Value Analysis

Configuring Consistent and Accurate Data

The data input to and output from key scenario tools are fully consistent with each other, ensuring the consistency and accuracy of data transmission. This provides end-to-end support for the project, reduces the difficulty of project management, and improves project efficiency.

ETP-Designer generates synchronously hardware configurations, DLD files, and NE configuration parameters to ensure data consistency in the network design and engineering phases. This reduces human design errors.

Improving Network Planning Efficiency

ETP-Designer reduces the complexity of generating specific device configurations, and automatically calculates hardware configurations of the network and sites according to user settings and the cost optimal principle.

Lowering Personnel Skill Requirement and Site Commissioning Cost

The configuration parameters and versions can be downloaded with one button for site commissioning. ETP-Designer generates configuration parameter files necessary for site commissioning. When a site is commissioned, ETP-Genius imports the parameters into NEs in one effort without complex on-site configuration. This lowers the personnel skill requirement and site commissioning cost.

Reducing the Maintenance Difficulty and Cost

High maintenance efficiency and low maintenance cost are achieved due to the tower climbing-free maintenance for full-outdoor products. ETP-Genius extracts information and locates faults by connecting full-outdoor NEs via WiFi, saving engineers the bother of climbing towers.

Based on user settings, one-button network inspection makes complete statistics and analysis on microwave network KPIs and automatically generates reports, providing basic data analysis for network optimization.

The development of large-capacity and IP-based wireless networks poses new challenges to microwave networks. To satisfy the new requirements of wireless backhaul in the future, ZTE will continue to explore in the fields of new service support, intelligent networking, and cloud data processing to offer optimal microwave service tool solution that will create greater value for operators. ZTE TECHNOLOGIES


Leading 5G
Innovations