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ZTE TECHNOLOGIES

VIP Voices

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Expert Views

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Special Topic

Fixed Line Intelligence

Cover Figure | *Joddy Hernady, senior advisor for digital business at Telkom*

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WindTre: Making Rapid Progress with 5G

Reporter: Sarah Ginevra Pace Botteri

Benoit Hanssen, CTO of WindTre

Italian telecommunications operator WindTre is accelerating the rollout of a nationwide 5G network. Benoit Hanssen, CTO of WindTre, shares the company's efforts in the on-going deployment of the 5G technology as well as his perspective on how to unlock the revenue potential of 5G.

As an excellent operator in Italy, WindTre started 5G deployment last year. How does WindTre achieve rapid commercial use of 5G in the entire network?

When WindTre merged a few years ago, we did a lot of preparation work that helps us now in a very smooth and rapid deployment of 5G. As a matter of fact, we've already achieved national coverage on 5G using the technology called the dynamic spectrum sharing (DSS). That means that the 5G is deployed on existing 4G frequencies. As customers start to use 5G, the network automatically switches between them. That's given us a very big advantage, because that way we have been able to deploy 5G nationally very quickly. Now, in the second phase, we're adding capacity as more customers start to use 5G.

As is known to all, Italy was seriously affected by the epidemic in 2020. How does WindTre effectively promote and guarantee the progress of 5G project construction in accordance with the established 5G deployment milestones?

The COVID-19 pandemic also hits Italy pretty badly. We've seen several national lockdowns in the last 18 months. Despite the sadness of all the people that were affected by that, as WindTre, we've been able to continue our operations. Thanks to the tremendous efforts of all the teams from WindTre, from ZTE and all of our other suppliers, we've been able to continue to roll out the network.

As a matter of fact, as customers can work more from home and as children took their classes using Google Meets or ZOOM, we saw that the network usage went up tremendously. But as I said, thanks to the tremendous efforts of our teams, we've been able to keep the network in good shape and also augment the services so that everybody could do what they needed to do from home.

How does WindTre consider the evolution of 5G networks, such as mmWave and SA? What's your view on the introduction of new 5G services? How to further improve the stickiness and ARPU of 5G users and reduce the scissors gap of data services?

We're also making steps to go to the next version of 5G—the so-called standalone (SA) where it does not depend anymore on the 4G network, where customers can develop and use the new capabilities of 5G such as ultra low latency or mass connectivity of machine to machine devices. With those features, we'll see quite a lot of new applications being launched in part by WindTre, but also by other partners (e.g. application developers) who see a benefit of the new technology.

Establishing national coverage was a big job and an important first step to take. But the evolution of 5G will take at least another 10 years, and we'll see lots of new things that today we cannot say what they are or even anticipate what they are. I'm sure just as previous generations I see a lot of opportunities, a lot of hope for new businesses to start and new things that we will do together and also for individuals. ZTE TECHNOLOGIES

Telkom Talks Transport Network, Video Service in New Era

Reporter: Shena Agusta

Joddy Hernady, senior advisor for digital business at Telkom

Joddy Hernady, senior advisor for digital business at Telkom, talks about how to prepare the transport network for the 5G era and new trends in video service development. As the leading telecommunications operator in Indonesia, Telkom faces such challenges as rapid changes in technology.

"The transport network should be very precise to support services of different SLAs"

What challenges do you think the transport network is facing in the era of 5G?

The 5G era has come. With a 5G network we will be able to deliver not only traditional consumer services but also many kinds of new 2B services for various industries.

First, the 5G network is considered as one network for diverse industries, so the transport network should be very precise to support services of different SLAs with deterministic latency for example.

Second, the 5G network is considered as one network connecting multiple clouds, so the transport network should have the capability of integrated cloud network provisioning with one touch deployment.

Third, the 5G network is also considered as one network on demand, so the transport network should meet the large capacity and small granularity requirements to provide multiple cloud services.

In short, to support various kinds of B2B services, the challenge is not only on the 5G network but also on the entire network.

What has ZTE done to help Telkom Indonesia meet the challenge?

Telkom and ZTE have been collaborating for more than 15 years and there are several key milestones that we've been together. If we go back to 2005, Telkom built a backbone network in Java Island, the main island in Indonesia. We constructed two rings. The second milestone was made in 2015 when ZTE helped Telkom finish the network upgrade to 100G. The third one was in 2018 when we also started to deploy a metro OTN. Last year ZTE helped us finish network expansion to 200G and 400G.

With these milestones, we are very optimistic that we can provide many kinds of services that can be provided by a 5G network. In the future, we'll continue the innovation and improvement to continue being the No. 1 operator in Indonesia. With the cooperation with ZTE, we will be able to meet many kinds of network demands, especially for the digital transformation in Indonesia.

"We are becoming the No.1 video operator in Indonesia"

To enrich users' experience, Telkom has partnered with many third parties to introduce premium OTT videos services, including iFlix, HooQ, and Catchplay. Meanwhile, Telkom has also developed value-added services such as Message, Game and Online shopping services to seize the TV market opportunities. What is your opinion on the video service development in Telkom?

Video services are becoming the main services in Telkom besides the telecommunication itself, so we have been deploying the video services for more than ten years. Especially in the last six years we have been actively deploying IPTV services. Now we are becoming the No.1 video operator in Indonesia. We need to keep up with the changes of the technology. About four

years ago we introduced the hybrid STB between IPTV and OTT because the trend is moving to OTT. Last year we introduced Android TV set-top boxes because Android TV is the direction of the video services.

Android TV is very rich in terms of ecosystem ranging from applications, contents and terminals that give more experiences to users. We will continue to collaborate with partners and leverage the Android TV technology to meet the video service requirements of the users, which are in the direction of OTT now.

What do you think of the future development trends of IP video services for Telkom?

I think there will be three development trends. The first one is the improvement of user experience including the introduction of high quality content. The improvement of the user experience will also be supported by several technologies such as voice control and a more vivid UI.

The second trend is the evolution from IPTV to OTT. I think it is becoming the key if we look at the capability of the Telkom network. Telkom's network will improve signicantly and the user terminals will be very diverse in the future if we look at the OTT technology. I think for sure OTT will be the deterministic direction.

The last trend will be cloudification. With the micro-services and containerization technology, the platform element will be migrated to the cloud to achieve flexible deployment and unified operation.

What are your expectations for the future cooperation with ZTE?

We do hope that we can continue to collaborate with ZTE. Telkom is a leading telecom operator in Asia Pacific and ZTE is a leading technology provider in the world especially in video services. I think there are several areas that we can collaborate in video services. For example, we can innovate new services together, operate the Android TV ecosystem together, and in terms of operation we can introduce cloudification to our platform so we can have flexible operation and in the end provide more immersive user experience to our costumers. ZTE TECHNOLOGIES

A1 Belarus: Driving Digitalization Forward in Post-Pandemic World

Reporter: Veronica Karliukevich

Christian Laque, Senior Director for Technology at A1 Belarus

Christian Laque, Senior Director for Technology at A1 Belarus, shares his insights on the pandemic's impact on the telecom sector and discusses key trends in 5G. A1 Belarus is the largest private telecommunications, ICT and content services provider in Belarus. In 2020, A1 Belarus made the first VoNR call in the CIS and launched the first autonomous 5G SA network in Belarus in the test mode.

What do you think of the post-pandemic new normal in the telecom sector?

Everything is becoming online. A story that is going step by step has jumped just by the beginning of the epidemic. It is impressive how digitalization is taking over everybody. Online schooling, remote work, online studying, online conferences—these are the new normal. And it was not a process that took years for us to wait. It was more or less on the next day. How we have dealt with it as telecom operators is important because it was creating a huge amount of data and relying much more than any time before on availability and high performance.

Luckily, our networks, mobile and fixed, have been able to deal with this challenge. This is impressive—what we have been able to provide to deal with the pandemic, not only as individuals, but now as a society. We had, for instance, enabled customers to stay online and run the things they have done before in an online environment. It is important to go further because this is after the pandemic. So, the new normal is really online. The educational process which normally takes years was taken in a snapshot, which was forced by something nobody had expected, nobody could dream of or think of. It is good for us to seize this because it has really helped us to press forward, even though it was not always easy to do.

Which aspect of network infrastructures needs to be further developed?

A key point to handle all this growth is fiber—fiber to the customer, fiber to the base station, because we see exponential growth in data, but also high reliability requirement. So robust networks are needed, using all the technology capabilities we have today, which means getting rid of legacy and moving into the new world. We have really to ride this wave as telecom operators, but together with our partners to bring customers highly available, robust networks with high capacities, high bandwidth and low latency. This is the key point to attain all these online things and digitalization in the world.

In Belarus, the IT industry is very developed. 5G empowering traditional industries will be a new growth engine for telecom operators. What is your view on 5GtoB services?

What we all have done as persons is to step into the online world. Enterprises are doing this on another scale. The IT industry and telecom industry are becoming solution providers together. Partnering is now key because the innovation flow is accelerating. IoT will enable businesses to run in a completely different manner. If you look at the pandemic, instead of developing a vaccine in 10 years, it was done in 10 months. Only by digital ways can this process be supported.

This is going into the other areas as well. A conference like that in Barcelona is becoming digital. A lot of us are joining things online today. And it is not an excuse. This is a new way. And only because we are bringing things together in a completely new manner. The telecom industry and IT, which were different things before, are joining forces to drive a completely new wave. I am thrilled, curious and happy to work in an industry and in a country that is really driving it forward.

In the 5G era, what will be your expectations or suggestions for the vendors of RAN, core networks, transport networks, terminals or service platforms?

Innovations in the complete networks, applications and service domains are getting faster and faster. Key points that I am really expecting to bring together as an industry is working with open standards, working with open source, and working together as partners, because only if together are we able to deal with the innovation speed.

Open source is a key point. Cloud is a key point, which is an IT thing originally. We have to implement it in all our parts. Hardware is becoming a commodity. The intelligent management of things is now the key. We have to bring the key elements for the future together—intelligence, automation, and digitalization. These are the new trends, which I am expecting to work on with partners like ZTE.

How do you see 5G SA development in the next few years?

5G is a key point in the development of the mobile network. It's a new generation of technology enabling many new features. 2G was voice, 3G enabled us to have some data, 4G was data, and 5G is bringing data to everybody, now even to every device, every sensor. The real challenge now in this digitalization as I've described is that we need so many sensors and terminals to connect that we need another network capability.

5G is made for mobile applications, and it has to be combined with a fixed line. For the end user, it must be seamless; for an application it must be seamless. So 5G will not be standalone. It will be combined with fixed access. This is key because so many applications will use data in mobile much more intensely. So whatever is possible in fixed, keep it in fixed and drive it further.

5G is not a new thing alone. It is all the new things in convergence to bring things forward. It is a number of devices, is how we are dealing with latency, and is the era of "click-boom". Don't wait, get it now. Although cloud is not something centralized somewhere, you are going back and bring it to the customer. So distribution going to the edge will be a key for the applications to run.

All these things that I've described are only possible with a higher level of automation. Autonomous networks will be necessary to deal with the complexity, to make an application for the end user simple in the usage. And 5G is not only for us as individuals, as it was with all the standards before, but much more now for machines that are doing things in an autonomous manner. For this, we need autonomous capability and provisioning must also be automated in all levels.

It is a great future in front of us. Let's move out of legacy, and join 5G as soon as possible but with all the consequences—re-use of the spectrum, which we've raised in comparison with older technologies, get the devices enabled for 5G, because these are the only ways to be efficient and be prepared for the demand that is dramatically growing.

It is a thrilling future. Let's join the journey. ZTE TECHNOLOGIES

Knowledge and AI Pave Way to Network Intelligence

Bo Kaitao, Chief Engineer of BN Management and Control Planning, ZTE

Evolution Trend of Network Intelligence

Since its birth, telecom network has undergone several stages such as analog, digital, Internet, and mobile Internet communications. Each stage has greatly improved social productivity and the development of new industries. The emergence of 5G, one of key technologies in the Fourth Industrial Revolution, will lead to great changes in social production and human life. Because of its digital, cloud-based and micro-service features, 5G network will give rise to a large number of new services for vertical industries, so it will also have to face the differentiated customer requirements and improved standards brought about by the new services. This will make network operation and maintenance (O&M) increasingly complicated, and intelligence is the key to solving these problems.

130 representatives from 33 companies, led by Deutsche Telekom, held a seminar on future network and service management in December 2016, which was a prelude to network automation. At that time, the network adopted the traditional network management (NM) and manual management mode, and its O&M mode was also passive to solve problems. With the applications of SDN, the network has become programmable, and NM no longer merely plays a management role. With the help of the controller, the network can perform some active O&M operations such as network simulation and early warning. 5G networks have been gradually deployed across the world since 2019, and the world has ushered in the era of network intelligence. With the development of big data collection and analysis as well as the introduction of AI, the network can intelligently process all kinds of network information in real time, such as service provisioning, intelligent fault location, and automatic network optimization. The network will evolve to an autonomous network in the future. As the intention concept is introduced, the network will have the same "self-awareness" as the human brain. Based on the rules set by the network manager, the network implements closed-loop self management of requirements, policies, decisions, implementation, maintenance and optimization, which can completely liberate the manpower.

Knowledge: Core of Network Intelligence

Just as human wisdom comes from

> The core of intelligence is to have systematic knowledge and the ability to effectively use and automatically update the knowledge. In network intelligence, knowledge and AI complement each other.

Bo Kaitao

production, living and learning activities, network intelligence is also gradually formed after repeated training based on massive data. The current network adopts SDN architecture, collects various network data through Telemetry, and uses AI algorithms to learn, so it has a certain degree of intelligence. However, as the requirements for intelligence become more and more specific, the amount of network data that needs to be collected increases exponentially. When actual computing resources are limited, if data is processed only through the AI algorithms, it will be difficult for the network to provide the intelligence of self management and control. To get out of this difficulty, it is necessary to make use of knowledge, including the knowledge extracted from human experience and discovered through the AI technology. The organic cooperation of knowledge and AI can lower the requirements for data processing and computing resources, and improve the efficiency and capability of network intelligence.

The difference between human beings and other living creatures is that they can constantly form systematic knowledge and use it to transform the world. In general, knowledge is systematic and verifiable information that can be formalized and normalized. At present, the AI technology used in telecom networks is to solve a problem in a scenario by using an AI algorithm. There is no accumulation of knowledge points in the system, let alone the establishment of a systematic knowledge set, so it is impossible to realize knowledge-based reasoning, decision-making and high-level intelligence like human beings. Therefore, in terms of intelligence development, having some AI algorithms and capabilities is not equal to intelligence. The core of intelligence is to have systematic knowledge and the ability to effectively use and automatically update the knowledge.

Knowledge and AI Complement Each Other in Network Intelligence

In network intelligence, knowledge and AI complement each other, just like a person's left hand and right hand. AI helps to find the intrinsic chain of relationships hidden in isolated information, which accelerates knowledge acquisition and system establishment, while knowledge can help to remove invalid information among massive raw data during AI learning and improve the speed of AI learning and training.

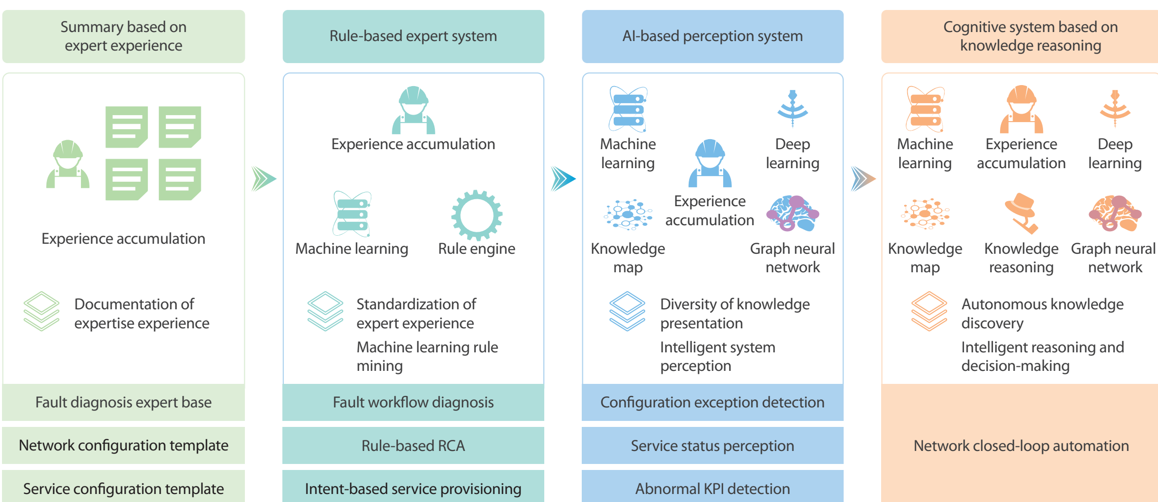
AI Enhances Knowledge Acquisition

Before AI, knowledge acquisition is achieved by standardizing expert experience and formalizing network technologies. As expert experience is different, incomplete and not updated in time, it cannot meet the actual network requirements. The introduction of AI makes knowledge acquisition more active and effective, and forms a complete, standard, and available set of systematic network knowledge through the knowledge management. AI algorithms for knowledge acquisition include clustering analysis, time series, maximum entropy model, decision tree, isolation forest, vector machine, and hidden Markov model. Moreover, new algorithms continue to emerge. The knowledge acquired by AI can extract entities, relations, attributes and rules, such as abnormal features, correlations, fault types, and number of faults. Such knowledge can be integrated with the knowledge provided by human experts such as network architecture, resource data, service models, O&M modes, and processing procedures to form associated, scenario-based, and systematic network knowledge sets. The combination of human intelligence and AI ensures effective knowledge generation and update. Take alarm processing as an example, after the alarms are suppressed according to the experience of experts in operation and maintenance, the number of alarms is reduced by 50%. Through the AI-based rule mining, the number of alarms is further reduced to the initial 10%.

Knowledge-Based Data Selection Improves AI Efficiency

Data is the basis of network intelligence. Due to the wide coverage and complexity of network data, the collection, processing, and storage of massive data is a great challenge. With the improvement of network intelligence and the richness of network knowledge, precise data can be selected through knowledge management and decision making, thus improving the AI processing efficiency. In the 5G era, network experience can be achieved in seconds or even milliseconds. But if all network information is reported and processed in this order of magnitude, the existing network cannot support it with its current communication capability, computing power and storage capacity. However, using certain knowledge rules, the system can determine what data can be collected in seconds for a period of time as required, and other data can be collected in minutes or even hours. The optimal AI algorithm can also be matched to achieve efficient and intelligent network experience based on precise data selection.

Fig. 1. Development route of knowledge and AI in network intelligence.



Reasoning Enables Knowledge Discovery

The AI technology plays an important role not only in knowledge acquisition but also in knowledge update and discovery, which is achieved through knowledge reasoning. AI algorithms for knowledge reasoning include reasoning based on rules (such as first order logic and deductive reasoning), reasoning based on statistical learning (such as machine learning, Bayesian reasoning, and Markov logic network), reasoning based on graphs (such as semantic reasoning, structure-based reasoning, and reasoning based on knowledge graph representation and learning), and integrated reasoning that combines knowledge graphs and deep learning. The AI-assisted knowledge reasoning helps to discover new knowledge or incorrect knowledge more quickly and supports decision-making to dynamically update and maintain knowledge. Taking the fault analysis and location function as an example, the knowledge graph is completed through AI or expert experience. In addition, the AI-assisted knowledge reasoning can also help to build a fault transmission chain and finally identify the root cause of faults. It can be seen that AI simplifies and accelerates the discovery of network knowledge, and improves the self-development capability of network intelligence. Therefore, the network knowledge without AI is incomplete, and the AI without network knowledge is unreal.

Development Route of Knowledge and AI in Network Intelligence

Knowledge and AI play a major role in the development of telecom network intelligence, and their development route can be divided into four stages (Fig. 1). The first stage is a summary based on expert experience, where the knowledge based on human expert experience is presented as knowledge questions and answers, or presented as fault diagnosis expert base, network configuration template, and service configuration template in the system. In this stage, AI is introduced, the content of knowledge is fixed, and its expression is not planned or systematic, so the role of knowledge is quite limited. With the preliminary introduction of AI, the system evolves to a rule-based expert system. In this stage, the experience of human experts is regulated, and new rules are mined through machine learning to form a series of standardized knowledge. The rule engine can be used to automatically execute some functions, such as fault workflow diagnosis and rule-based RCA. With the further development of AI, the system evolves to the AI-based perception system. In this stage, multiple AI technologies such as graph neural network, deep learning, and knowledge graph, are used to acquire and present knowledge in a different way, and gradually form a systematic knowledge set to achieve intelligent network perception. The application instances available include intelligent configuration exception detection, service status perception, and abnormal KPI detection. With the in-depth understanding of knowledge and AI technologies, a cognitive system based on knowledge reasoning will be formed finally. In this stage, a complete, dynamic and systematic knowledge set will be established, with the intent-based network as the core to realize autonomous knowledge discovery as well as intelligent reasoning and decision-making, thus enabling a closed-loop network and service intelligence during their whole lifecycle.

As 5G networks develop rapidly, it is believed that practice and demands are the strongest impetus for technological development, and the closer combination of knowledge building and AI technology may generate new systems that exceed our expectations. With great technical strength and rich experience in the telecom field, ZTE will actively work with partners to lead the future development of network intelligence and carry out its great mission of being a road builder of digital economy. ZTE TECHNOLOGIES

5G-Advanced: The Next Step of 5G Evolution

Wang Xinhui
General Manager of Wireless Standardization and Industrial Relations

Status of 5G Standard

Since the first release (Rel-15) of 5G NR was issued in 2019, the global campaign of 5G commercialization has been in full swing. In later releases, apart from further technical enhancements towards traditional eMBB scenarios, the standardization society envisions more vertical applications as the enhancement of 5G. For example, Rel-16 explored more on some emerging use cases like Industrial IoT, V2X, broadcasting and positioning. The on-going Rel-17 is intended to further expand the 5G networks from various aspects: to further optimize the IoT features for vertical industry applications; to support more types of devices and applications, such as wearables, video surveillance, industrial wireless sensors, and XR devices; to explore more spectrum at even higher mmWave frequency bands from 52.6 to 71 GHz; and to support new network topologies such as non-terrestrial network, integrated access and backhaul, and sidelink transmission.

Emerging of 5G-Advanced

With the massive deployment of 5G base stations and widespread use of 5G cell phones, people are beginning to think about the future, i.e. 6G. Recently, IMT-2030 disclosed a white paper for 6G vision and potential techniques, in which some popular directions and use scenarios have been identified, such as immersive cloud XR, integrated terrestrial and non-terrestrial networks, integrated sensing and communications and holographic communication.

From the standardization point of view, the first release of 6G specification from 3GPP is likely to be ready by 2029-2030. Before that, there will be another three or four releases for the evolution of 5G. In the recent 3GPP/PCG#46-e meeting held in April 2021, it has been agreed that "5G-Advanced" will be used to identify 3GPP specifications and reports from Release 18 onwards. With the new marker adopted mainly for the marketing interests towards 2025, it is important to keep digging the potentials of 5G network to continue the prosperity of 5G industry. Actually, many of the "6G techniques" under hot discussion can be built on 5G framework, and thus it would be better to also include them in the visions of 5G-Advanced as long as the use cases are clear and the techniques are expected to be mature enough in the next few years.

Key Techniques for 5G-Advanced

The 3GPP wireless standards evolve continuously and gradually. In every new release, there will be some continuous work either for the left-over issues or for further enhancements on the past release. It is foreseen that the natural overlapping exists as well between 5G stage-I and 5G-Advanced, or between 5G-Advanced and 6G. On the one hand, some continuous work from Rel-17 can be expected to be further specified in Rel-18. On the other hand, the 5G NR should be further extended to support more scenarios and use cases that have real market need by 2025, in particular for IoTs and verticals from different dimensions. Those potential enhancements are shown in Fig. 1, where some new requirements in terms of the combination of KPIs are considered.

Intrinsic AI

AI is expected to be the core functionality with standard support in 5G advanced networks. The meaning of “intrinsic AI” is reflected on two folds, one is “AI for 5G advanced” which means the design of AI to enhance communication systems, and the other is “5G advanced for AI” which means the design of systems should also be applicable for better support of AI.

In Rel-17, 3GPP picked three most popular use cases to be studied firstly: network energy saving, which enables smart switch on/off of certain base stations or certain carriers according to the traffic tide prediction and scenario recognition; load balance, which enables ML model based load prediction to improve load balancing performance; and mobility optimization, as many radio resource management actions related to mobility can benefit from the predicted UE location/trajectory.

Other than the network aspects, AI applications to the physical layer processing are much more challenging, especially for the fundamental channel coding and modulation. Nevertheless, for some procedure-wise designs with the need of prediction or estimation, AI can be applied to avoid potential mismatch of information and therefore enhance the system performance, for example for the beam management or CSI compression. In short, although the physical layer applications are quite challenging, it is definitely the right time to study those possibilities in the 5G-Advanced time window, starting from identifying the typical use cases, the system models, and the corresponding evaluation methodology in Rel-18.

Ubiquitous Network

FR2 at millimeter wave band is a key enabler for 5G-Advanced, which can unlock wider bandwidth, higher throughput, and lower latency compared with FR1 operating in sub-6 GHz. Although FR2 is supported from the beginning of 5G NR, there are still some challenges for the FR2 deployment, e.g. coverage limits due to blockage, frequent handover and inter-cell interference due to the ultra-dense small cells. Further improvements in terms of network robustness are needed to make it more widespread worldwide in the 5G-Advanced timeline.

Reconfigurable intelligent surfaces (RIS) is a promising technique for the future wireless network, especially when the frequency range goes higher and the coverage is the key issue to be solved. As an energy-efficient and cost-effective solution, RIS can be applied to effectively control the wavefront (e.g. phase, amplitude, frequency, and even polarization) of the impinging signals in an active or passive way. Appropriate deployment of RIS can be used to provide reliable non-line-of-sight propagation when the line-of-sight path is blocked, or to create either beam-formed signals to the target users or beam-nulled signals to the interferers, and therefore to improve the throughput and energy efficiency for the cell-edge UEs. It is envisioned that RIS would be a good candidate for 5G-Advanced deployment based on the existing 5G framework. In long run, RIS technique could go further to build up smart network paradigm, based on a joint optimization taking into account not only the transceiver design but also the wireless environment. In addition, multiple connectivity can be used to improve the robustness which can be fulfilled basically by the extension of existing dual-connectivity.

NR Based Massive IoTs

Although it has been claimed that the requirements of mMTC can be fulfilled by LTE NB-IoT/eMTC with the original individual KPIs of connection density, coverage and power consumption, it may not be suitable for the modern MTC scenario, for example, the use case of wide area sensor monitoring and event driven alarms which requires not only massive connections but also highly efficient data transmission; and also the smart grid use cases, where the advanced smart metering requires very high connection density with good coverage, decent data rate, low latency and high reliability. Similar requirement on both massive connection and certain URLLC requirements can be found in the modern factories, such as condition monitoring for safety, packaging machine, process automation, motion control, mobile robots, etc.

Compared with the LTE based solutions, massive IoT based on NR is more attractive because of the superiority on the availability of more spectrum, flexibility of scheduling/allocation, and additional spatial domain resources given by beam based operation. Grant-free non-orthogonal multiple access (NOMA) is a promising technique for NR-based massive IoT in 5G-Advanced. On the one hand, grant-free allows uplink transmission with lower latency and more energy efficiency, because the random access procedure and data transmission are completed simultaneously. On the other hand, NOMA is a perfect solution to cope with the potential collisions among multiple UEs performing grant-free transmission, so as to achieve highly efficient transmission for massive

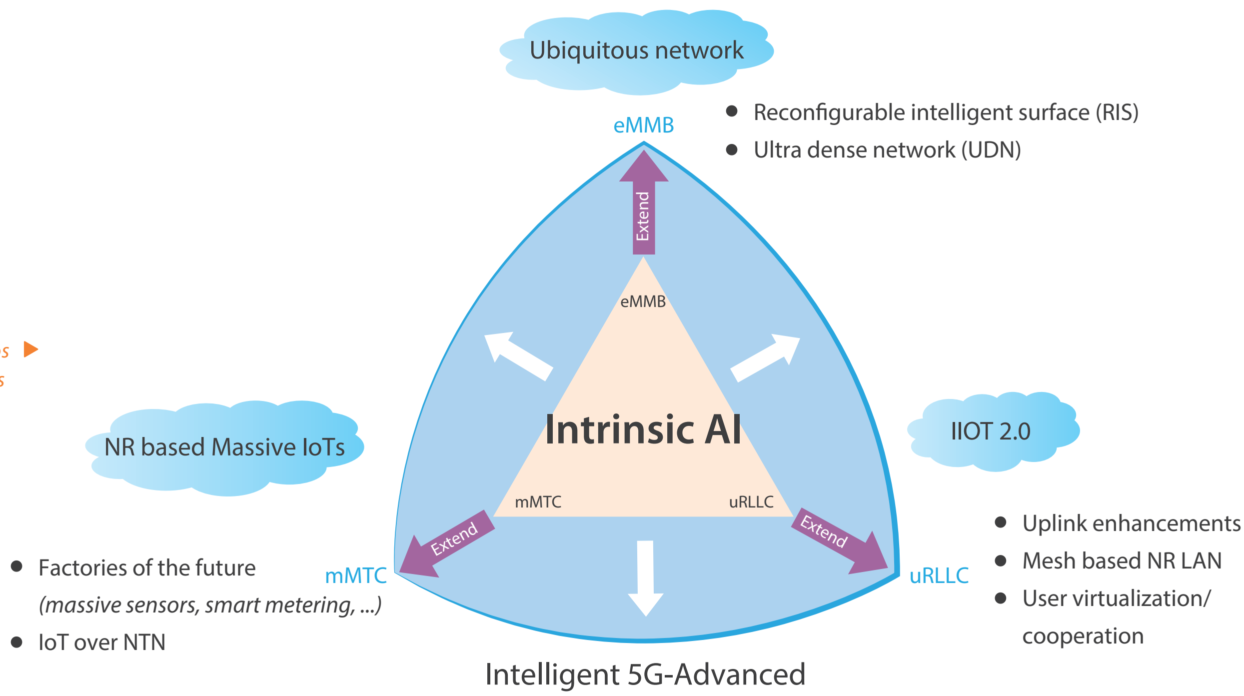


Fig. 1. Use scenarios and key techniques for intelligent 5G-Advanced.

devices without loss of reliability. In addition, higher layer optimization such as intelligent distribution of UEs in different RRC states can be studied to minimize the need for load triggered handover and therefore improve the transmission efficiency and connection density.

Industrial IoT 2.0

For IIoT 2.0, it is mainly concerned about the application of UL heavy scenarios. With some extreme use cases such as the machine vision applications in the modern factory, or the broadband access in a crowd at stadiums or concerts where the users want to share what they see or they hear, a higher throughput requirement is put on the uplink than the downlink. In addition to a very high connection density, the required uplink data rate could be in the order of Gbps or 10Gbps with quite low latency requirement, which can be hardly fulfilled by the current NR design.

One possible way is to support enhanced features based on the existing NR design, such as higher number of antennas or MIMO layers. However, these enhancements require the initiating device for the uplink transmission to be powerful enough, while usually the capability of a UE is quite limited compared to a base station. The idea of boosting the UE capability can be realized through user virtualization and cooperation for the devices in proximity or those belonging to the same owner. Multiple devices can form a virtual user by sharing their capability of MIMO, carrier, etc., and collaboratively transmit and receive data from the network to enhance the quality of transmission.

Another bottleneck for the UL heavy applications is about the traffic congestion. There could be more fundamental enhancements based on the idea of MESH network. For example in modern factory, many of the communications are actually local between the proximate devices. In such case, Mesh based networking can be helpful to offload the traffic between proximate devices to sidelink, so as to alleviate the traffic load going through the core network. Those design aspects include intelligent routing path discovery, latency/load aware routing, etc.

Security/Blockchain

Blockchain has the ability to achieve secure, immutable and decentralized data storage with low latency in 5G-Advanced, enabling trustworthy network sharing among the operators.

Some key data, such as cell resource or spectrum utilization, can be uploaded to the Blockchain platform through the sharing base stations of the hosting operator. The Blockchain platform is used to guarantee the trustworthiness and transparency of network sharing, and avoid disputes among operators. Other participating operators or non-operator participants can access to the Blockchain platform to get the trusted data according to the operators' policy and regulation needs. In addition, the hosting operator can optimize the allocation of system resources in a high-efficiency mode based on the operators' resource occupancy from the Blockchain platform. The host operator is responsible for providing services to the customers of participating operators in network sharing, and reporting the faults from those customers to the Blockchain platform to prove they are treated equally as the host operator's customers. Participating operators can acquire the fault reporting of their customers through the Blockchain platform. With that, a secure and trustable network operation can be achieved.

Conclusion Remarks

There is no doubt that 5G-Advanced will be the next era to continue the prosperity of communication industry and to bridge the gap from 6G vision. ZTE is willing to work together with our industry partners, to jointly build a safe, intelligent, and sustainable 5G-Advanced standardized industry. ZTE TECHNOLOGIES

Promoting Evolution Towards Intelligent Autonomous Networks

—ZTE Wireline Intelligent Network Solution Athena 2.0

Xiao Hongyun

Director of BN Product Solution Planning, ZTE

With the gradual commercial use of 5G networks, three challenges have become increasingly apparent and urgent. The first challenge is complex network management. The network needs to meet users' higher requirements for service quality, including performing real-time perception, analysis, processing and recovery for traffic, packet loss, delay, and jitter, while achieving fast deployment, agile adjustment, and timely expansion. The second challenge is maximizing network benefits. With unprecedented pressure placed on network resources, the network needs to analyze resource utilization in real time, accurately predict future changes, and optimize network resources. The final challenge lies in user experience. To ensure a high-quality user experience, functions like fast service provisioning, automatic restoration and optimization are critical. Traditional telecom technologies and O&M modes cannot tackle these challenges. As the industry explores into new technologies, intelligence has been recognized as the core capability of 5G and future networks.

Based on a deep understanding of the new requirements on the 5G wireline network and strong technical strength in the fields of SDN, machine learning, big data, knowledge graph and intent-based networking (IBN), ZTE proposes its intelligent network solution uSmart Athena 2.0 (Athena 2.0 in short). As the wireline network part of ZTE's autonomous evolving network solution, it aims at constructing a simple, full-lifecycle, IBN-oriented new-generation wireline network to eventually realize the autonomous network.

Athena 2.0 Architecture

Athena 2.0 consists of ZENIC ONE, a new-generation intelligent management and control system, and a wireline equipment network with super-strong capability.

The ZENIC ONE achieves the intelligent closed-loop of the network. After users express their intent via a concise interactive interface, the system understands and

translates the intent, selects the service solution, and automatically verifies it and delivers it to the physical equipment. During the entire period when the user intent exists, the system monitors the intent quality in real time and makes it visual. It can automatically identify, analyze and diagnose the network faults based on AI technology, and automatically restores the faults in accordance with the policies. At the same time, it can predict network traffic based on the network model formed by big data learning and training, and optimize service bandwidth, delay, and routes timely based on the user intent, in order to completely comply with the user intent.

The new-generation wireline equipment is the cornerstone to implement user intent. The wireline equipment can provide ultra-high capacity bandwidth, and support large-scale networking of tens of thousands of devices to meet the requirements of 8K video, cloud computing and 5G applications. It supports various network technologies such as SPN, IPRAN, OTN, switches, broadband access and microwave to meet the network requirements of different scenarios, systems and users. E2E SR technology is provided to simplify control protocols, which greatly reduces network complexity and allows fast end-to-end service provisioning. FlexE, FlexO and fine-granularity technologies are also provided to achieve network slicing at different granularities so that multiple logical networks can be created on a unified physical network to meet differentiated requirements of customers in different industries or in specific scenarios.

Referring to human intelligence, the ZENIC ONE is a system architecture of the perception, intent, control engines supported by the BigData and AI platforms (Fig. 1). The intent engine converts the intent input by the user through voice and text into the network intent expression model, and designs and verifies the solution in advance. The control engine supports network orchestration, control and management services, cross-domain cross-vendor coordination, fast end-to-end service provisioning, and multiple networks including IP, IPRAN, PTN, SPN and OTN. The perception engine through association analysis and in-depth mining of mass data truly implements end-to-end network optimization oriented to service and customer experience. Such continuous optimization improves the capabilities of traffic optimization, traffic warnings and problem prediction.

The BigData platform provides abundant data services at all levels, including structured, unstructured data services, and knowledge graph based on graph database. The AI platform is ZTE's unified AI platform uSmart Insight. It provides AI algorithms and services for the other parts of Athena 2.0 to improve the intelligence level of the whole solution, and makes continuous improvement and optimization based on the data at the BigData platform. Meanwhile, Athena 2.0 provides northbound interfaces to interconnect with the upper-layer system, which keeps the network open.

The new-generation wireline equipment has "nerve endings", including inband OAM, TWAMP, NetFlow, performance and alarm monitoring. They can capture the operating status of the network and services in real time and report it to the ZENIC ONE through the "neural network" telemetry. Based on the information captured by the "nerve endings", the ZENIC ONE can make intelligent analysis and decisions to achieve network optimization.

Athena 2.0 covers all scenarios of the wireline network, including 5G mobile service, broadband access, enterprise service, vertical industry service, cross-domain end-to-end service, campus network and data center network (Fig. 2). Its typical intelligent applications will be described below through the 5G mobile service scenario.

Intelligent Applications in 5G Mobile Service Scenario

Athena 2.0 provides a full lifecycle solution

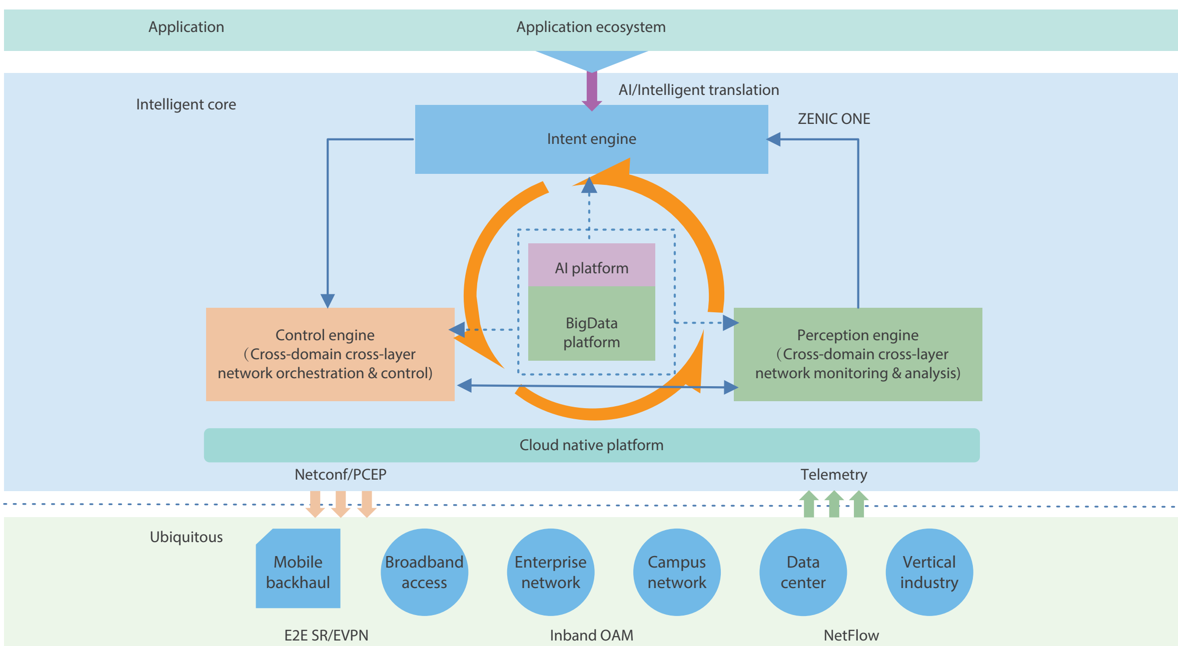


Fig. 1. Athena 2.0 system architecture.

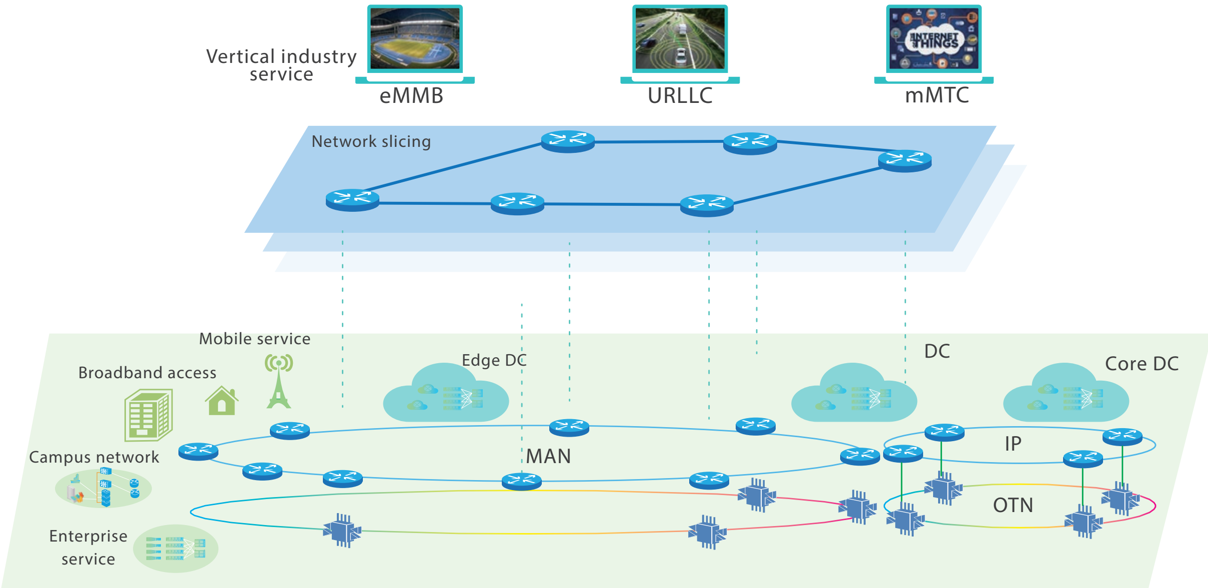


Fig. 2. Athena 2.0 covering all wireline scenarios.

for the 5G network and supports fast network construction, fast base station service provisioning. It monitors and maintains the service IP traffic in an all-round way through inband OAM and telemetry, and relieves the difficulty in network fault location through the intelligent diagnosis tool.

Intent-Based Service Provisioning

Traditional service provisioning requires complicated service parameter configurations. The workload is heavy, the provisioning time is long, the operation is error-prone and the O&M costs are high.

The automatic service provisioning based on user intent is visible throughout. After a user selects a service scenario, the system automatically prompts the information that the user must enter, including the device endpoints to add/drop services. The system provides the recommended default SLA information according to the intent reflected by the selected scenario and the user input history. When the user intent is confirmed, the system will automatically form multiple service solutions that conform to the user's intent, covering the service type, service topology, tunnel type and route computation result. The system displays all solutions and recommends the best solution to the user. The user can select a service solution, or use the default recommended solution and let the system directly deliver it. The system converts the contents of the solution into various configuration information, and delivers the information to related devices after verifying the configuration parameters. Intent-based service provisioning, with simplified configuration and visualized process, increases the service provisioning efficiency by 80% and significantly improves user experience (Fig. 3).

Intent Maintaining Based on Real-Time Perception

When the intent is created successfully, the system uses the corresponding policy to accurately perceive the service according to the SLA. Athena 2.0 uses the in-band OAM to collect the quality data such as packet loss, delay and jitter of the service flow, and reports the data to the ZENIC ONE by telemetry in seconds. The BigData platform performs data storage and association, and the perception engine performs real-time analysis and

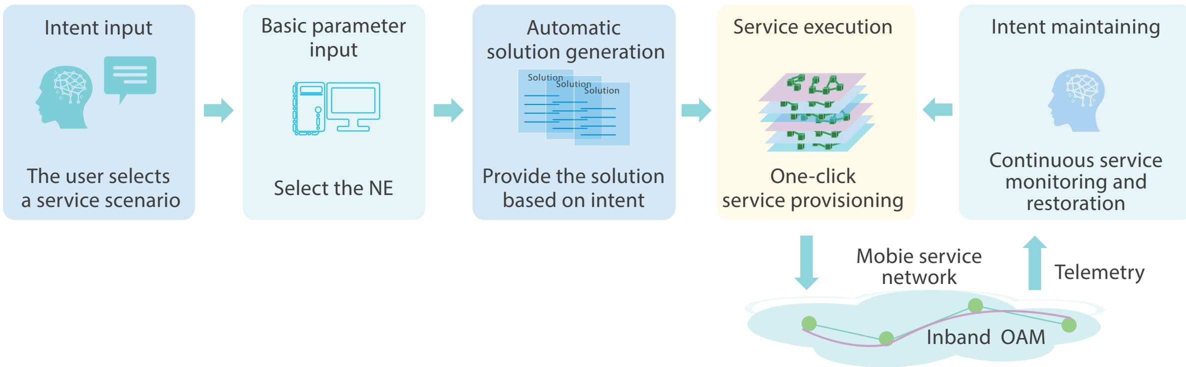


Fig. 3. Intent-based service provisioning and maintaining.

evaluation. If a service quality feature falls outside the set threshold value, accurate hop-by-hop monitoring is triggered automatically. The system automatically analyzes and determines the location of the fault (e.g. a specific faulty NE or port) based on the service knowledge graph and AI algorithm of the AI platform. If the service degrades to the set threshold and needs to be adjusted, the intent engine triggers service route optimization in accordance with the predefined policy, and delivers it to the equipment through the control engine so that the service quality can be automatically restored without user participation. The intent retaining based on real-time perception provides timely and proactive service quality management, and improves the service guarantee capability and O&M efficiency.

Intelligent Fault Diagnosis

The intelligent fault diagnosis function includes two parts. The first part is to form and update the network fault knowledge base. The BigData platform is responsible for preprocessing the fault data generated by the network, including data extraction, cleansing and aggregation. On this basis, the AI platform executes the fault-associated learning algorithm to form the associated rules and update the results in the network knowledge base. In the second part, when the fault diagnosis function is triggered, the system identifies the root cause alarms based on the knowledge base rules, and then locates the root cause of the fault in accordance with the knowledge base rules, monitored data and logs, and finally provides the solutions and suggestions. The diagnosis function records the execution results and continuously improves the knowledge base, thus improving the efficiency and accuracy of fault diagnosis.

Intelligent networks have arrived with the 5G. ZTE's intelligent network solution Athena 2.0 has been put into commercial use or trial commercial use by operators across the world including China Mobile, China Unicom, China Telecom, A1 Belarus and Columbia TEF, and has been continuously improving user efficiency and user experience. ZTE will work closely with operators and partners to promote the development of intelligent networks and facilitate the advent of autonomous networks. ZTE TECHNOLOGIES

Intent-Based Automatic Service Provisioning

Intent Network: Key to Autonomous Network

With the rapid development of globalization and informatization, the 5G network with customer experience as the center is accelerating the digital transformation of various industries. The intent-based network (IBN) technology oriented to 5G networks and combining SDN and AI has also become a hot topic for operators and manufacturers.

Since Gartner proposed the IBN concept in 2017, standard organizations such as 3GPP, ETSI and CCSA have also initiated research into IBN. With the introduction of IBN, network intelligence has a clear goal, gradually develops into self-planning, self-management, self-adaptation and self-optimization, and finally realizes the autonomous network.

Based on deep understanding of IBN, ZTE has launched Athena 2.0, the wireline intelligent network solution that contains the IBN-based full-lifecycle intelligent management and control system (ZENIC ONE). It has also cooperated closely with operators around the world to implement innovative intent-based functions. The intent-based automatic service provisioning is an innovative function of ZENIC ONE that continues to guarantee user intention, improves a service level agreement (SLA) by introducing big data and AI, and brings customers better service experience.

ZENIC ONE Architecture

The ZENIC ONE architecture consists of intent, control and perception engines (Fig. 1). As the link and bridge for interaction between O&M personnel and ZENIC ONE, the intent engine is the core of ZENIC ONE that contains intent translation, intent perception, and intent guarantee. The intent engine supports WEB and the third-party northbound interface. The intent management component (intent input) is responsible for inputting user intent, while the intent management component (intent status) for presenting the state in the intent lifecycle. The intent translation component interacts with the intent management component. After a user expresses his intent through voice, text, and other input modes, the intent translation component interacts with the user to ensure the integrity and defuzziness of the intent expression and build a bridge between the user and the machine. The intent perception component sends the analysis results to both the intent status and the intent guarantee components after analyzing network data reported by the perception engine based on the specific intent. The intent guarantee component carries out corresponding guarantee processing according to the established

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guarantee policies such as bandwidth adjustment, path adjustment, and protection/recovery SLA to ensure continued quality of user intent.

Automatic Service Provisioning Mechanism

The automatic service provisioning capability can continuously assure user intent. When the system fails, network analysis is carried out through the AI technology and fed back to ZENIC ONE for self-decision to assure the user intent. The intent-based automatic service provisioning architecture of ZENIC ONE is based on the draft proposed by IETF.

For example, if there is an intent of a 5G base station in the transport network to access the L3VPN, the intent engine will set a series of templates associated with the intent. These templates describe how to modify L3VPN traffic that involves adding, deleting and modifying site data, and how to maintain the health of L3VPN or the blueprint for assurance graph.

The workflow of automatic service provisioning is illustrated in Fig. 2.

- The monitoring data of L3VPN traffic is collected by inband OAM (IOAM) mechanism. ZENIC ONE uses Netflow to automatically detect existing network traffic and create an end-to-end IOAM measurement task for the corresponding traffic.
- The BIGDNA module (perception engine) judges whether the measurement result of the IOAM task is abnormal. With the IOAM detection mechanism, abnormal flow, node and link can be located, reported and stored in the BIGDNA database.
- After receiving the report, the intent engine adjusts the state of the corresponding monitoring intent to unhealthy, determines whether there are routes to be adjusted and makes route adjustment.
- A new IOAM task is created after the switching. If the measurement result is normal, the intent engine will adjust the state of the monitoring intent state to healthy according to the result reported by BIGDNA.
- For a fault that cannot be fixed, the intent engine raises an alarm that the fault cannot be fixed, and the intent

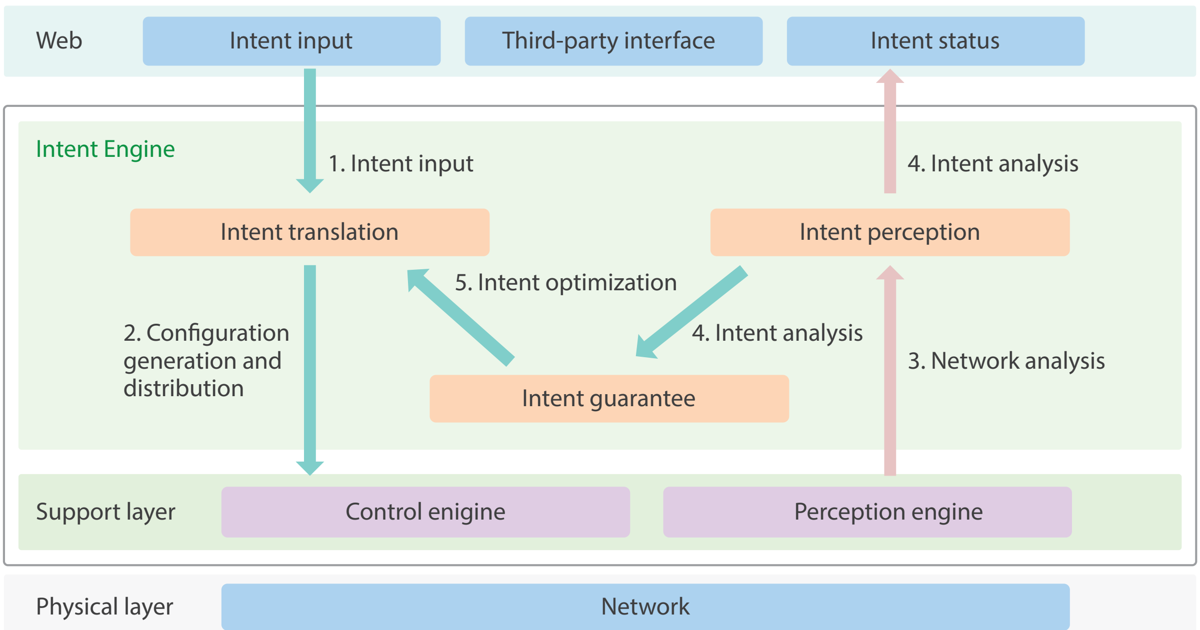

Fig. 1. ZENIC ONE architecture.

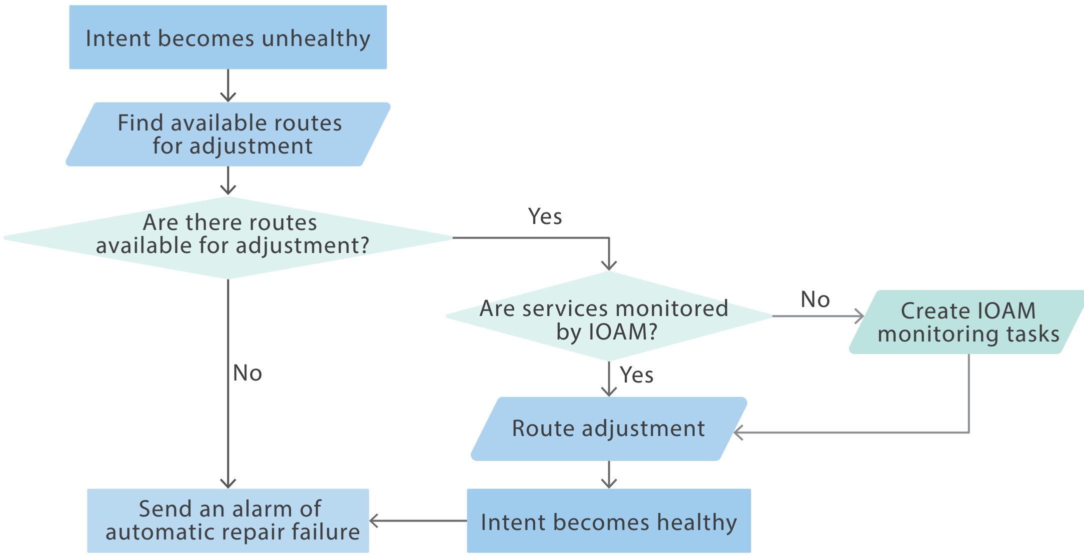

Fig. 2. Automatic service provisioning workflow.

management interface displays "automatic repair failure".

IOAM and Telemetry

The intent-based automatic service provisioning depends on the underlying core technology—IOAM. By adding flow ID tags into the traffic, IOAM can detect each network node that the traffic passes through one by one. Two original data such as the number of packets and timestamps can be measured. After summary and calculation by the controller, IOAM can obtain the following performance data:

- **Number of packets** sent and received in each detection period or the total number of packets sent and received in a period of time (several periods)
- **Packet loss rate** in each detection period or the average packet loss rate in a period of time (several periods)
- **One-way/two-way delay** of a packet in each detection period
- **Delay jitter** in a period of time (several periods).

Moreover, telemetry is used to achieve node-by-node reporting of millisecond-level performance data such as packet loss and delay. It is a technology that remotely collects data from physical or virtual devices at a high speed. The equipment periodically sends interface traffic statistics, CPU or memory data to the collector in a push mode. Compared with question-and-answer interaction of the traditional pull mode, telemetry provides a more real-time and higher-speed data collection.

Trial and Verification

Compared with the traditional service guarantee mechanism, the intent-based automatic service provisioning solution can achieve full-lifecycle closed-loop service provisioning from planning, creation to optimization. With the IOAM and telemetry technology, the solution can report information in milliseconds and locate fault in seconds. When combined with multiple SLA mechanisms of the controller, the solution can finally bring users zero perception when a fault occurs.

ZTE and China Mobile Zhejiang Branch have run a trial on the intent-based automatic service provisioning solution since the second half of 2020. They have verified and improved the solution to facilitate commercial deployment and intelligent O&M of the intent network and to accelerate large-scale commercial use of 5G transport networks. ZTE TECHNOLOGIES

iFLOW: Enabling Flow-Based Insight and Precise Fault Diagnosis

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With the gradual commercial use of 5G, customers require higher service quality for new 5G services, and fast fault location and recovery are becoming increasingly critical to ensure service reliability. To make 5G network O&M precise, ZTE's insight Flow (iFLOW) solution provides multi-level in-depth perception and accurate fault diagnosis.

Current Network O&M

The traditional network monitoring tool uses out-band or low-precision in-band measurement for network O&M. Due to a lack of real-timeness and low detection accuracy, the obtained information is limited in guiding network fault diagnosis. The problems include:

- Inability to monitor and analyze dynamic IP routes of wireless base stations and core networks, nor perceive and trace the service flow path changes and root causes.
- Unmeasurable service SLA and low measurement accuracy: The network quality is detected indirectly by sending analog packets that may not be consistent with the real service path, thus failing to completely reflect the service-level SLA. The service packet loss detection accuracy is only 0.1%. Faults may not be detected when services like AR/VR incur packet loss.
- No real-time fault perception and poor passive O&M experience: With the traditional minute-level information collection, the transport network cannot perceive network changes in real time, and only responds passively when the service fails or the quality has deteriorated.
- Difficult fault localization & delimitation and no self-healing capability: It is hard to delimit faults accurately since hop-by-hop detection cannot be performed and service status during the fault period cannot be recovered. Therefore, teams on the wireless side, network side, and core network side need to cooperate with each other to locate the faults, which takes several days or even weeks.

iFLOW Solution

To address low-precision network status perception and long fault localization & recovery in traditional network O&M, the iFLOW solution

(Fig. 1) enables in-depth perception and precise fault diagnosis at three service layers. First, at the service routing layer, VPN route information and status are monitored through the BGP monitoring protocol (BMP) in real time for precise analysis. Second, at the service path layer, the path computation element (PCE) is used to uniformly compute and optimize LSP paths of the entire network and precisely control service paths for rapid service self-healing. Finally, at the service forwarding layer, the in-band OAM (IOAM) is used to accurately monitor service flows, and analyze, diagnose their performance (delay, packet loss, and jitter).

Precise Network Insight

The iFLOW solution supports in-depth network perception and automatic monitoring through end-to-end multidimensional visualization and accurate service parameter collection and analysis.

The iFLOW collects VPN routes through the intelligent management and control system ZENIC ONE, presents the routes of the whole network in real time, and monitors and counts their changes, including peer up/down, incremental route advertisement and recycling, status report, statistics, path mirroring, TOPN route and timestamp. In addition, it displays the service quality and traffic information related to base station, signaling plane and data plane in multiple dimensions, helping users to quickly learn the service quality of the network.

It also carries out security analysis by monitoring VPN prefix route information and status, analyzes the corresponding paths through route drilling to quickly learn about

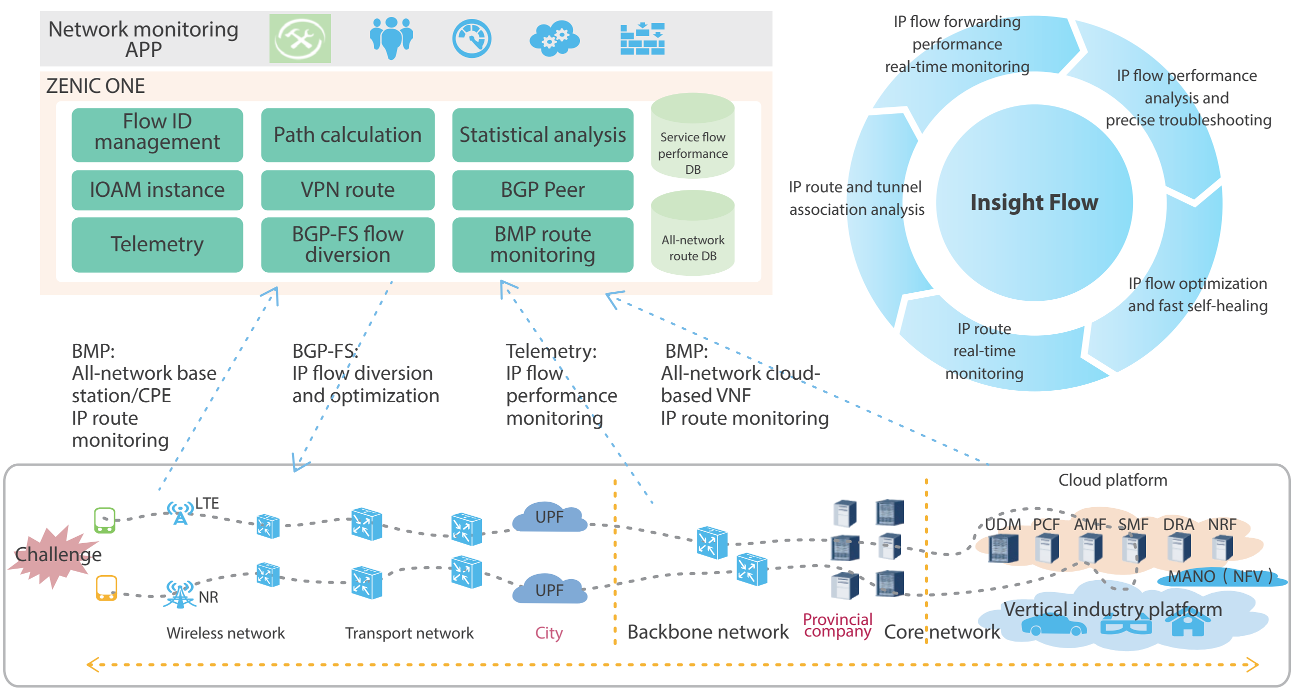

Fig. 1. Overall architecture of the iFLOW solution.

the path information of service flows, and accurately locates the path adjustment and root cause by tracing the historical paths.

The solution offers end-to-end and hop-by-hop measurement at the IP service level, identifies the base station, tunnel and NE that the service passes through, and rapidly recovers the real-time service path. In combination with active monitoring and all-network status & big data analysis, it can perceive and handle possible faults in advance to allow fast service self-healing and ensure network transport quality.

Intelligent Fault Localization & Delimitation

The iFLOW solution collects statistics on the number of real service packets through the GTP tunnel, identifies the packet feature fields through the SCTP signaling, and precisely locates faults in real time through path restoration, hop-by-hop detection and SLA analysis.

It can rapidly delimit transport/wireless faults based on the E2E detection at the base station flow level or quickly locate fault points based on the hop-by-hop detection at the flow level. It can also rapidly find out historical and root causes of the service flow deterioration by backtracking historical paths and performance of service flows.

When a fault point is accurately located, the controller's all-network data and multi-constrained path algorithm can be combined to compute a TE path that meets the service SLA requirement and bypasses the fault point, and switch service flows to a new path for their fast self-healing.

iFLOW Application

Targeting the pain points of the existing network O&M, the iFLOW solution accurately presents the network information that the customer is most concerned about through three ways (route insight, service performance insight and fast fault insight), and enables quick service self-healing in case of a failure.

Precise Route Insight and Security Analysis

The iFLOW monitors VPN route information and status in real time through BMP, and precisely analyzes service routes.

When a route is added abnormally, the BMP can be used to monitor the changes of VPN prefix route information and status and perform security analysis. Another function of the BMP is to supervise the IP routes of the whole network and detect the address conflict, so as to find the base station IP address planning error and provide timely warnings.

With network cloudification and cloud-network synergy, the BMP can be used to further monitor the VNF changes and status in the DC cloud and raise the end-to-end intelligent O&M capability of cloud-network synergy.

Precise Service Performance Insight

The IOAM is used to monitor and analyze the precise performance of service flows, and perform hop-by-hop precise analysis and rapid diagnosis of the real service flow performance (delay, packet loss and jitter).

The user subscribes to the statistical data of the NE in the service flow path through the controller, and enables the calculation of packet loss and delay (the controller can know which NEs are configured and subscribed to according to service configuration or other auxiliary means, such as the trace function of the SR tunnel). After the subscription, the device reports the statistical data, and the controller calculates it and presents the results to the user. Finally, visualized analysis of historical performance data is realized based on the big data platform.

Precise Fault Insight for Quick Diagnosis

The solution adopts source IP + destination IP + color id or tunnel policy configuration to drill down to the corresponding slice and tunnel/SR policy/VPN, and precisely analyzes according to the associated path/SR policy the SLA attributes and connectivity such as passing nodes, links, hops, cost/metric, BW and E2E delay.

When the network fault causes path adjustment and SLA deterioration (e.g. the increased delay), the affected services and routes are found through the color id and destination address of the SR policy, and visually displayed. The bandwidth, delay, jitter, and packet loss of the passing nodes and links are further analyzed based on the path information to find out the causes affecting the service SLA and precisely locate the fault source.

After the fault source is located, the service can be rapidly diagnosed through tools such as ping/trace/twamp/ioam and configuration check. The specific fault cause and location (e.g. node, link, port and queue) are analyzed with the diagnosis results and troubleshooting suggestions given.

Fast Service Self-Healing Based on Flow

When the service performance deteriorates, the controller can quickly locate the fault cause with the accurate iFLOW network insight, and automatically recalculate a new path through the SLA performance algorithm. In this way, the service flow is diverted to a new path that meets the SLA requirements, leading to fast service self-healing, lower complexity in manual process and better user experience.

The iFLOW solution employs multiple innovative technologies to enhance the real-time monitoring and analysis of global service routes and allows in-depth perception at multiple layers. Combined with historical information backtracking and recovery, it can fulfill rapid and accurate fault localization and root cause analysis, thus strengthening the control of network information by the O&M personnel, significantly shortening the time of network fault processing, and effectively improving customer service quality. ZTE TECHNOLOGIES

Adaptive Optical Network Solution for a Simple, Efficient, Flexible and Open OTN

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Director of BN Management and Control Product Planning, ZTE

In the era of 5G mobile Internet, higher requirements are put forward for optical transport network (OTN): larger bandwidth, longer haul, more flexible service types, higher quality and lower latency, and more flexible granularity-based scheduling. Optical network devices and management systems also evolve to be programmable, open, SDN-based, automated, and intelligent.

Physical restrictions on the optical transport layer should be considered for an automated, intelligent OTN. On the one hand, network provisioning involves service logic and physical parameters. In addition to accessible service routing, optical path indicators such as OSNR should meet the requirements to provide high bandwidth, long haul and high spectrum utilization while reducing relays and costs. On the other hand, environmental changes and the aging of optical components in network operation may lead to the deterioration of line quality, thus affecting service quality. Therefore, these factors must be taken into account in network maintenance in order to optimize and adjust automatically.

The physical restrictions on the optical transport layer are one of the difficulties in OTN automation and intelligence. Through an in-depth understanding and research into the issues, ZTE has launched its adaptive optical network solution.

Overview

The adaptive optical network has such capabilities as beyond-100G software defined optics (SDO), automatic power optimization (APO), optical loss compensation, Flexgrid adjustment, and wavelength selective switching (WSS). It also supports AI, and can intelligently control programmable optical network operations based on the big data machine learning model to realize adaptive network O&M.

SDO

The beyond-100G OTN can choose different modulation modes and code patterns to meet the requirements of bandwidth, distance, and transmission quality in different application scenarios. ZTE's adaptive optical network has the SDO intelligence that can perceive network service status and transmission quality in real time, automatically select the appropriate rate, modulation mode and code pattern through an intelligent algorithm, and flexibly adjust the rate (100 Gbps to 800 Gbps) and set the modulation mode (PM-QPSK/PM-8/16/64/256QAM). The service signals of fixed rates and fixed modulation modes can also be slightly optimized and adjusted, so as to balance the transmission distance and spectrum bandwidth and achieve the best match between the transmission bandwidth and existing application requirements.

When the transmission distance is long, the service path deteriorates or traffic changes at the client, optimal adjustments can be made in time such as modifying the rate and modulation mode or shaping proper beams to improve transmission capacity. Operators can get a variety of solutions by investing in a single OTN board, and their networks are more adaptive to reduce the difficulty in network design and routine O&M and also lower the Capex and Opex.

APO

In network operation, the changes of power parameters caused by network environment, human operation, and aging of optical components may affect the quality of services. ZTE's adaptive optical network has the APO function that can perceive the power status and changing trend of optical network in real time. If optical power parameters are degraded in the scenarios of network deployment, service scheduling, fault recovery, network adjustment, network optimization and long-term O&M, the adaptive intelligent control is used to balance the power of the multiplexing section and the channel layer and obtain a better optical signal-to-noise ratio (OSNR) before the service is damaged, so the impact of network changes on the service can be minimized.

Architecture

ZTE's adaptive optical network consists of programmable adaptive optical network infrastructure and intelligent brain control layer (Fig. 1). The programmable adaptive optical network infrastructure is built in the OTN equipment such as ZXONE 19700/9700 and ZXMP M721, and the intelligent brain control layer in the management and control system ZENIC ONE. They communicate with each other via a NETCONF interface to intelligently control the adaptive optical network.

The functional components of the adaptive optical system serve as a collector that perceives the changes in the physical network, collects optical parameters and reports them to the management and control system for analysis and decision making. They also function as an automatic executor that receives control instructions from the control and management system for adaptive network adjustment.

The functional components of the adaptive optical management and control system have the AI function that can generate an automated network model based on big data learning. They receive and analyze the optical parameters reported by the adaptive optical system, match learning models based on user-specific policies, and invoke intelligent algorithms for network control, including route scheduling, power

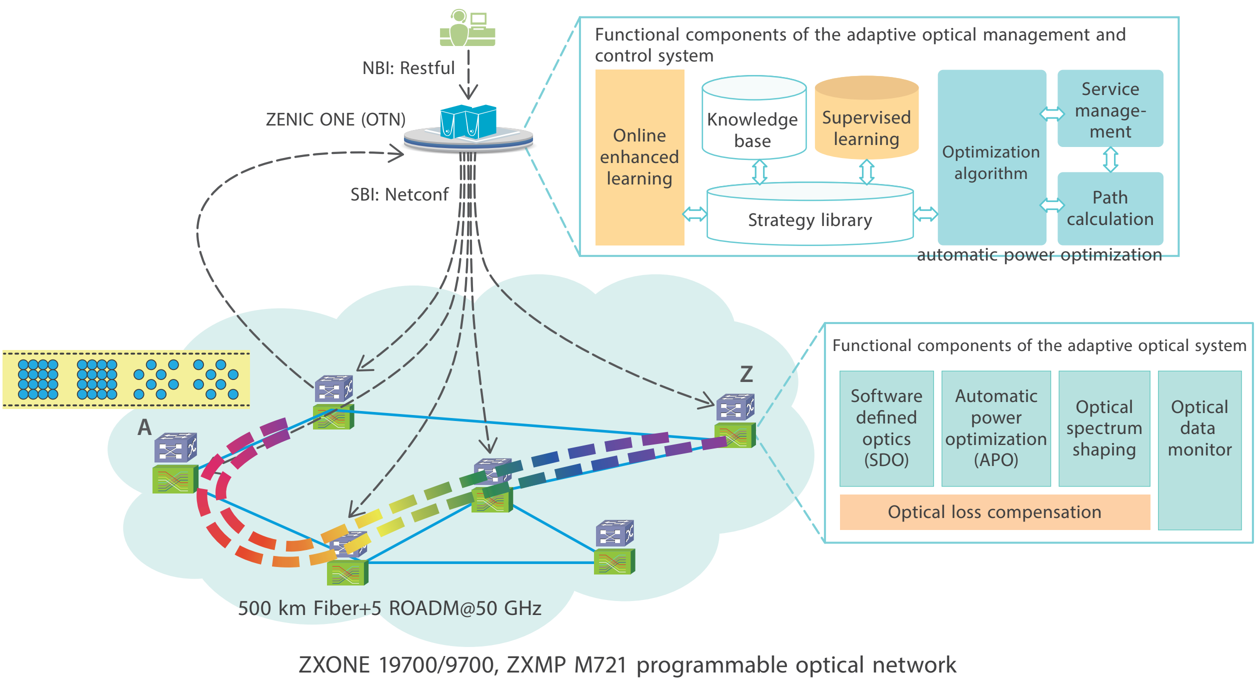


Fig. 1. Adaptive optical network architecture.

adjustment, modulation modification and rate change, to adaptively adjust optical networks.

Scenarios

Through the automated optimization and on-demand modulation of the adaptive optical network, the spectrum utilization of the optical system can be significantly raised to get better system performance. More and more flexible collection of available path resources can also be provided to maximize transport and service recovery capacity and greatly improve OTN intelligence.

Constant Modulation Modes, Constant Transmission Rates

The scenario is applied to performance optimization of new or existing optical-layer services that have constant transmission rates, spectrum spacing and modulation modes. Through intelligent algorithms and APO, the adaptive optical network gains better OSNR and more WSS pass-through levels. When it predicts a degradation in the performance of optical-layer services, the following will occur:

- The priority is not to change the service route, and the optical power of optical-layer paths is automatically adjusted to compensate for degradation and restore the quality of service quickly.
- When the performance deterioration is too serious and the automatic optical power adjustment cannot achieve the goal, the current services can be adjusted to other physical routes with better optical performance, and the optical power can be optimized automatically.

Variable Modulation Modes, Constant Transmission Rates

The scenario is applied to long-haul route recovery of new or existing optical-layer services. According to specific networking routes and optical fibers, the adaptive optical network uses AI learning models and intelligent algorithms to select policies, change modulation modes, or adopt the mixed modulation to improve transmission distance and performance.

For example, the original 2×200G/16-QAM can be adjusted to 2×200G/8-QAM, which can extend the transmission distance and reduce the cost and complexity of electronic relay.

Variable Modulation Modes, Variable Transmission Rates

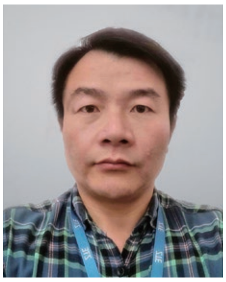
The scenario is used for data center interconnect (DCI) over OTN that has variable modulation modes and transmission rates. According to periodic traffic changes between data centers, the adaptive optical network can intelligently and dynamically adjust transmission rates and modulation modes to achieve higher spectrum efficiency and consume less energy.

The change of transmission rate from low to high as well as low power consumption are applicable to the scenario that requires short-term bandwidth growth, while the change of transmission rate from high to low suits the one with small traffic, where the reduced optical-layer rate at the line side leads to lower power consumption. For example, when the transmission rate at the line side goes down from 400 Gbps to 100 Gbps in the 400G/16QAM→100G/QPSK scenario, the power consumption of a single carrier may decline by 31% from 80W to 55W.

Conclusion

Simplicity is the key to success. Based on the programmable optical network and intelligent management and control algorithms, ZTE has developed its adaptive optical network solution. The solution can be used to intelligently select and optimize optical network parameters in network deployment, adjustment and O&M, gradually replace manual operations and create a simple, efficient, flexible and open OTN for operators to cut their Opex and improve customer experience. ZTE TECHNOLOGIES

AI-Based Precision Location Solution for Weak Optical Power Improves Home Broadband Quality



Shao Zhong

Director of Fixed Network Product Planning, ZTE

With the implementation and promotion of the "Broadband China" strategy, broadband users in China are developing rapidly, and the broadband popularity is soaring. The number of internet broadband access users has exceeded 480 million, of which the number of fiber-to-the-home/office (FTTH/O) users has exceeded 448 million, accounting for 93.3% of the total internet broadband access users. In addition, increasingly diverse home services such as high-definition videos, VR/AR and cloud games make home broadband users pay more attention to service experience, thus posing higher requirements on broadband network quality.

Problems

As the number of optical broadband users grows at an explosive rate, weak optical power problems on fiber broadband links have become increasingly prominent. According to the analysis of user complaints of an operator in China, the proportion of user complaints caused by weak optical power on fiber broadband links reaches 36%, so weak broadband optical power is an important factor that affects service experience of the broadband users and may even cause service failure.

Traditionally, weak optical power faults are identified and located manually. Due to the large number of optical broadband users, the problems of weak optical power are quite common. The diversity of topology distribution also makes rectifying weak optical power difficult, time-consuming and inefficient. Moreover, rectifying weak optical power on ODN fiber links involves OLT PON interface, backbone optical fiber, level-1 splitter, branch optical fiber, level-2 splitter, to-home optical fiber and ONU. It takes a lot of time and manpower to sort out the faults one by one. Since it is impossible to determine the unreasonable networking mode of multi-level splitters, it is also very difficult to check the weak optical power faults manually.

Solution

ZTE's AI-based precision location solution for weak broadband optical power is an automatic fault location system using big data and AI analysis based on Athena 2.0. The system automatically, frequently and fully collects various optical link feature data of OLT and ONU in the optical broadband access network. After denoising, converting and analyzing the optical link feature data, it uses AI clustering algorithms for intelligent analysis, compares and learns based on the background knowledge base and optical link fault model base, and finally accurately identifies the location and cause of weak optical power links. The solution can guide O&M personnel to actively and efficiently rectify weak optical power links, implement network O&M, and reduce the number of fault reports.

The Athena 2.0-based precision location system for weak broadband optical power is easy to deploy and use (Fig. 1). It is deployed on a PC server and uses the TL1 interface to connect EMS for automatic synchronization of resource data in the optical broadband access network. It uses the SNMP protocol to directly access OLT to collect optical link data of the entire network, and automatically locates and analyzes the cause of weak optical power based on AI. The O&M personnel can log in to the system through WEB, obtain an report on rectifying weak optical power links, and complete the fault rectification with ease according to the report.

Automatic, Frequent and Full Optical Link Data Collection

The Athena 2.0-based precision location system for weak broadband optical power automatically collects dozens of optical link feature data of OLT and ONU in the optical broadband access network, including optical module type, optical layer alarm, OLT receive/transmit power, ONU receive/transmit power, packet loss rate, bit error rate and optical distance. The system also adopts multiple policies such as incremental collection and differential avoidance to improve the collection rate of weak optical power.

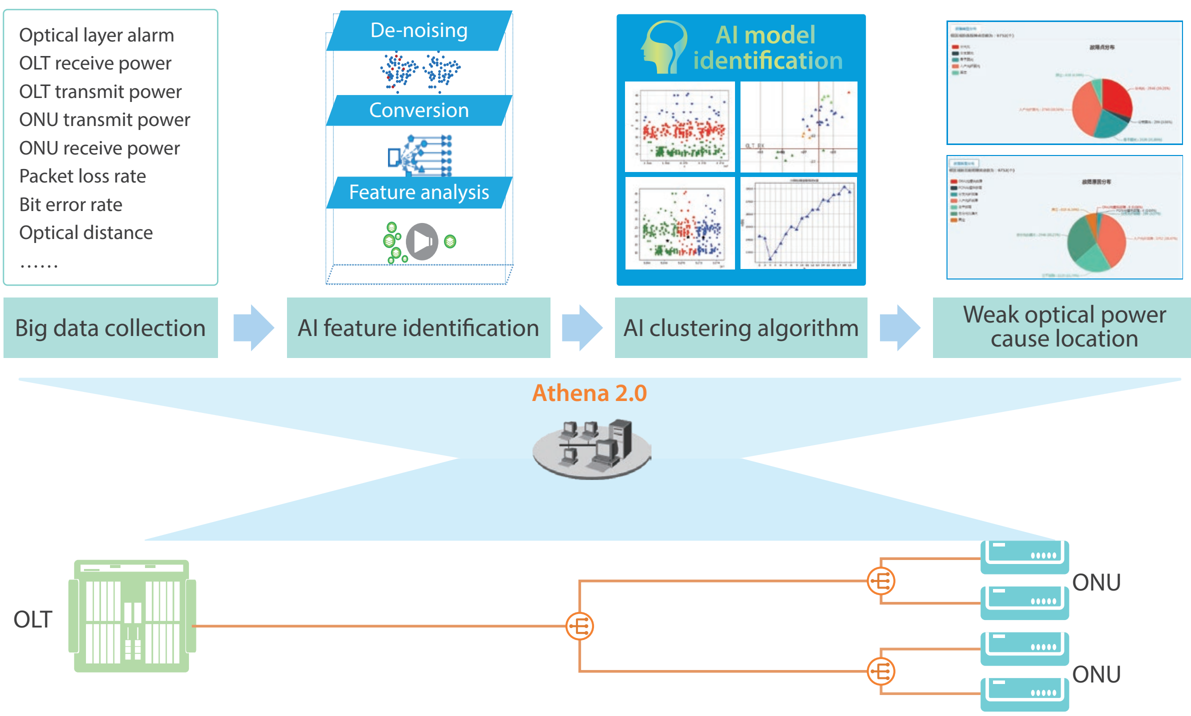


Fig. 1. Athena 2.0-based precision location system for weak broadband optical power.

The actual collection rate of weak optical power verified in the existing network reaches 95%.

Weak Optical Power Delimitation and Location by Big Data and AI

The PON access network divides ONUs in the same PON into different groups due to level-1 and level-2 optical splitting. These groups have certain cohesion and regularity in terms of optical power and distance. However, these features are dynamic rather than static, and their thresholds and rules identified manually cannot fully meet and cover all dynamic data distributions. It is therefore necessary to use AI-related algorithms to implement weak optical power detection. The AI-based weak optical power detection mainly uses the dynamic K clustering algorithm and the DBS fault detection algorithm to find the best clustering parameters in accordance with the constraints of optical splitting scenarios, and the contour system to dynamically evaluate the clustering effect. Based on the clustering result and distribution, the AI algorithms delimit and locate the causes of weak optical power, which involves determining fiber backbone, branch and to-home link failure, or optical split ratio over threshold. The actual accuracy of weak optical power fault delimitation and location verified in the existing network is up to 95%.

Visual Display of Weak Optical Power Causes

The Athena 2.0-based precision location system for weak broadband optical power automatically displays in charts the weak optical links analyzed by AI as well as their delimitation and location causes. The O&M personnel can access the system through WEB, obtain the data and causes of weak optical links, and efficiently complete the rectification task. As verified in the existing network, the rectification efficiency is increased by more than five times.

The system can also be interconnected with the work order system of a network operator, so that the weak optical link list can be automatically sent to the work order system for rectification. The work order of weak optical power rectification is linked with the weak optical power diagnosis of the precision location system, which ensures a closed-loop workflow. The system provides a variety of statistical charts for the O&M personnel to learn about the progress and effect of weak optical link rectification.

Applications

After the Athena 2.0-based precision location system for weak broadband optical power was deployed in three cities of an operator in China, it helped the O&M personnel accurately locate the causes of weak optical power, reducing the weak optical power ratios in the three cities from 6.14%, 10.49% and 9.01% to 3.11%, 3.42% and 3.48% respectively in a short period of time.

The system has been commercially deployed by Chinese operators in Guizhou, Yunnan and Zhejiang and will be widely promoted throughout the country. It helps operators rapidly identify weak broadband optical links, precisely locate the causes, and substantially improve the efficiency of weak optical power rectification. In this way, operators can actively eliminate the potential quality problems of their optical broadband networks, thereby enhancing user experience. ZTE TECHNOLOGIES

China Mobile Zhejiang Succeeds in Automatic 5G SPN Deployment

Bao Huidong

Director of ZTE BN Management and Control Product Solution

New infrastructure is China's national strategy that has flourished since 2020. As the leader of new infrastructure, 5G has embarked on a fast track of deployment. Operators need to deploy their transport networks ahead of their 5G service launches. So the deployment of 5G slicing packet network (SPN) has also become a major concern of operators.

China Mobile Zhejiang took the lead in 5G deployment in China. Since the beginning of deploying 5G SPN in 2019, it has cooperated with ZTE to carry out in-depth exploration and research on how to fast build a 5G SPN and efficiently provide 5G new radio (NR) services. They put forward an automatic deployment solution for 5G SPN and made technological innovations such as easy and fast service provisioning and rapid network construction. The solution was verified and applied in the existing network of China Mobile Zhejiang, helping the operator improve its efficiency of deploying 5G transport network, quickly deliver 5G NR services on a large scale, and speed up implementation of the new infrastructure strategy.

Unlike the traditional 4G network, the 5G transport network involves complex configuration of protocols such as BGP-LS, PCEP and IGP, as new technologies such as SR and FlexE are introduced. If the traditional mode is adopted, the network deployment would be a heavy work, time-consuming, involving many steps, and easy to make mistakes. The management and control plane would also evolve from the traditional management of a single city to the deep integration of the management plane and SDN control plane, and to the centralized cloud-based deployment across the entire province. This would pose a severe challenge for network construction, implementation of basic configurations, and service provisioning efficiency. The existing O&M methods and concepts are difficult to meet the actual needs of 5G deployment, so it is necessary to develop a precise SPN-based deployment system to shorten the deployment period and improve the accuracy.

To address the above difficulties, China Mobile Zhejiang has partnered with ZTE to complete automatic 5G SPN configuration and deployment. The automatic go-live function of network elements (NEs) makes the deployment possible without site entry and configuration, followed by automatic topology generation as well as automatic discovery of NEs, boards and links. The technologies like modular basic configuration, flexible customized template and one-click configuration are adopted to enable fast deployment of 5G SPN basic data, remarkably raising the efficiency.

The automatic 5G SPN deployment solution includes:

- **Global resource planning:** The network planning tool can be used to plan available configuration resources for the area that NEs belong to, including N-side IP addresses, NE loopback IP addresses, interior gateway protocols (IGP) and autonomous system (AS) numbers. It offers visual basic configuration planning, so that basic network resources can be managed and controlled visually.
- **Automatic NE go-live:** New NEs allow batch configuration delivery, NE creation, NE go-live, NE attribute (e.g. NE name, management IP, device layer, and area) configuration, port mode switching, and automatic topology connection between old and new NEs. The devices can automatically go live without deployment and identify neighbor parameters. A user does not need to enter the site to commission the devices one by one, which significantly cuts the device provisioning cost.
- **Rapid deployment of basic data:** Basic device configuration is based on templates, and NEs need to be deployed after the go-live. The deployment tool (including for batch deployment) is used to adjust FlexE interface configuration between old and new NEs, and to adjust basic data configuration (such as new NE IGP) and relative tunnel paths. In rapid network creation, batch deployment policies can be set by configuring data templates, including N-side port policy template, L3 link rule template, BGP template and PCEP template. The above templates can be flexibly customized to build basic network data quickly, and the one-click configuration enables the network to meet the requirements for service provisioning.

The automatic deployment function has a visual and flow-based interface, and wizard operation, making it easy to understand and control. This functional module is integrated into the new-generation intelligent management and control system ZENIC ONE (UME). The user can directly operate on the corresponding NM interface without installing a separate tool. It is applicable to the typical SPN expansion scenario, including new SPN NE go-live and single NE expansion. It also supports batch NE operation and basic configuration, facilitating fast and efficient 5G NR service provisioning.

The above functions were deployed and verified in the existing SPN of China Mobile Zhejiang in Huzhou, and NEs went live quickly and smoothly. Relying on the graphical interface of the intelligent management and control system, the relevant functional modules can be used to visualize global network resources and flow-based wizard operations, change manual network deployment mode to automatic one, and select data templates to operate NEs in batches according to the scenario. With the automatic NE go-live technology, the equipment O&M personnel do not need to enter the site for debugging, thus increasing the deployment efficiency of a single NE by 70%. The efficiency of network deployment is greatly improved, and the cost of equipment debugging and network deployment is also significantly reduced.

ZTE has continued to innovate and invest in the new technologies of 5G intelligent transport management and control. China Mobile Zhejiang will cooperate with ZTE to further build high-quality, high-speed, high-reliability intelligent 5G transport networks. ZTE TECHNOLOGIES

ZTE's Intelligent Management and Control System Helps China Mobile Guangdong with Efficient PTN/SPN O&M

Yue Chaohu

Marketing Manager of ZTE BN Management and Control Products

In 2020, China Mobile Guangdong accelerated the innovation of the 5G industry to boost industrial transformation and upgrade and achieve high-quality economic growth in Guangdong Province. To drive 5G development and simplify network O&M, the operator combines the PTN carrying 2G/3G/4G services with the new SPN transporting 5G services for provincial-level centralized deployment.

Challenges for Existing Network

In view of 5G deployment, increased SPN scale and large quantities of existing PTNs, China Mobile Guangdong begins to focus on how to manage the PTNs and SPNs in a unified manner to raise network O&M efficiency and save OPEX. Some challenges stand out:

- **Independent NM deployment in different regions leads to low O&M efficiency:** The PTNs in 13 prefecture-level cities are managed by six region-level U31 systems. Each region is deployed with its own control and data analysis system. The U31 system reports network alarms and performance, the DC controller activates service configuration, and the data network analysis (DNA) system analyzes data quality in the region. In this way, some problems have emerged, such as difficulty in unified O&M, heavy workload for multi-region NM upgrade, and low service configuration efficiency across regions.
- **5G SPN and 4G PTN need to be managed uniformly:** The operator adopts newly built SPN and L3-to-edge service configuration, and needs to provide SR, FlexE and network slicing functions, which cannot be supported by the traditional U31. Additionally, as the SPN scale is growing rapidly, the unified management of PTN and SPN requires the NM system to have large-scale network management capability.
- **The conventional mode cannot meet the 5G SPN O&M requirements:** With the addition of a new FlexE layer in SPN, L3-to-edge, and deployment of SR-TP service via a centralized controller, the traditional manual service configuration cannot address the network O&M needs.

ZTE Cloud-Based OMC Solution

ZTE's ZENIC ONE (UME) is a new generation B/S management and control system based on microservice technology. It offers cluster high availability and elastic system scalability, and has an ability to manage 300,000+ equivalent NEs. It supports the unified management of PTN/SPN, IPRAN, OTN and IP networks, combines AI and big data for the first time to integrate management and control as well as tools.

From July to December 2019, China Mobile Guangdong worked with ZTE to deploy the ZENIC ONE (UME) in its existing network, verified the system functions covering northbound interface, all-network topology, alarms and performance reporting, and conducted China's largest PTN monitoring (about 160,000 equivalent NEs) in the existing network for the first time. In 2020, the system managed and controlled SPN networks with 30,000 equivalent NEs, and started to take over the management of the PTNs in 13 cities step by step. It will eventually manage and control the existing PTN/SPN networks containing 190,000 equivalent NEs in the province.

The new-generation intelligent management and control product of ZTE has solved the bottlenecks in current PTN/SPN O&M of the operator, and enabled provincial-level centralized O&M and unified PTN/SPN management, along with intelligent O&M of 5G SPN.

Customer Benefits

China Mobile Guangdong uses the cloud-based OMC solution of ZTE to realize unified PTN/SPN management and better network automation, laying the foundation for intelligent O&M.

- **Higher management efficiency:** One set of UME system which integrates management, control and big data analysis allows provincial-level centralized O&M. It replaces six sets of management system (U31), six sets of service automatic activation system (DC) and six sets of big data analysis system (DNA) based on local O&M in the existing network. The NM for different regions is based on a unified architecture, platform, portal, authentication mode, northbound interface and deployment, thus cutting deployment and maintenance costs.
- **Smooth evolution and expansion:** The new-generation management and control product of ZTE is deployed in the cloud resource pool of the operator in the form of cloud-based VMs. With the data imported into UME, the PTNs managed by U31 in the existing network are smoothly migrated to UME so that 5G SPN and 4G PTN in the province totaling 70,000 devices can be managed uniformly. UME has the ability to manage 300,000+ equivalent NEs. As the networks expand, VM resources can be added for stronger UME management capability, achieving a smooth, imperceptible expansion.
- **Intelligent O&M:** UME enables closed-loop management encompassing intelligent monitoring, intelligent analysis and intelligent control. It reports network data in real time and controls the networks quickly and accurately in cooperation with intelligent AI analysis for intelligent O&M. UME makes SPN deployment more efficient by reducing the basic configuration steps and increasing NE deployment and provisioning efficiency by 70%. It automatically activates 4G PTN and 5G SPN services, reduces the average service delivery time to less than two minutes from 15 minutes required by the traditional manual configuration mode, and improves the efficiency by 87%. The in-band OAM supports accurate perception of network status, hop-by-hop performance detection and reporting to facilitate network fault localization. With equipment SR-TP protection, IGP convergence-based SR-BE escape path protection and controller dynamic rerouting, SPN enables service protection switching and subsecond-level dynamic recovery against multi-point failures, improving service security and recovery efficiency.

China Mobile Guangdong boasts the largest mobile communication network in the country, and demands a high network quality. The 5G SPN commercialization has exemplary significance in the country. Based on the commercial deployment of ZENIC ONE (UME), ZTE will further improve 5G SPN O&M capability, and speed up the deployment of functions like fast NE provisioning, automatic service activation, dynamic bandwidth adjustment and in-band OAM to make O&M intelligent and convenient, building a superb network for the operator. ZTE TECHNOLOGIES

5G Messaging

Source: FierceWireless

Jul 19, 2021

Recently, ZTE's Executive Director of 5G Messaging, Mr. Zhou Xiaojun provided some important insights on the topic.

What is 5G messaging?

5G Messaging is constructed based on the GSMA RCS UP standard. It enables multimedia and lightweight messages and achieves the interaction of industry messages by introducing the MaaP technology. 5G Messaging brings brand-new man-machine interaction modes. Users can enjoy one-stop service experience such as service search, discovery, interaction, and payment in the message window. 5G Messaging builds a new information service entrance.

What is the difference between 5G Messaging and OTT apps? And what new capabilities or features does 5G messaging offer versus current SMS or OTT apps?

Compared with OTT messages, 5G Messaging brings differentiated functions and advantages, and is a better channel for providing business messages.

Full coverage: Based on native terminals and mobile phone numbers, 5G Messaging requires no subscription, and the service reachability is 100%. For example, in the commercial promotion scenario, the service opening rate is 10 times higher than that of the OTT channel.

Efficiency: Messaging as a service. Notifications and services are completed on the same interface. A closed-loop service can be implemented in 3-5 steps. For example, in a life payment scenario, the business conversion rate is 95% higher than that of OTT channel.

Intelligence: AI-based intelligent chatbot service, such as customer service scenario, increases the response rate by 40% compared with OTT and WEB channels.

Security: Operators implements real-name verification to both UE and the enterprise terminal. The user account is encrypted and authenticated based on the 128-bit SIM card. Thus, it can be widely used in the financial service with the highest security requirement.

How is 5G Messaging different than what has historically been done on 4G LTE?

5G Messaging is the upgrade of traditional message services in the 3G/4G era. 5G Messaging is not only available in the 5G network. Constructed based on the GSMA UP2.4 standard, 5G Messaging is compatible with 3G/4G/WIFI network access. Ordinary terminals can be used as long as they support UP2.4 upgrade. For the terminals that do not support UP2.4, 5G Messaging can fallback to support MMS or SMS. Thus, it can cover all terminals and users.

Zhou Xiaojun, ZTE's Executive Director of 5G Messaging

"5G Messaging brings brand-new man-machine interaction modes. Users can enjoy one-stop service experience such as service search, discovery, interaction, and payment in the message window. 5G Messaging builds a new information service entrance."

How does the technology work across different providers and devices?

5G Messaging is based on the GSMA international standard, so it supports cross-vendor, cross-operation and cross-terminal interworking.

How will operators be able to monetize 5G Messaging? And who are the ideal users (specific consumers, businesses)?

5G messages bring operators more B2B business models. The revenue comes from channel revenue and the entrance revenue of the Internet mode.

First, 5G Messaging can upgrade the existing channels smoothly. Through the A2P messages with higher quality and higher quantity, it enlarges the channel scale to build a foundation for creating the entrance to the traffic and application distribution market.

Secondly, 5G Messaging enables the upgrade from the "pipe mode" to the "entrance ecology mode." By learning from the Internet business mode, 5G Messaging expand backward entrance revenues based on traffic and effect conversion, such as advertisements, search rankings, and certification.

In addition, 5G Messaging is based on operators' networks and use mobile phone numbers as accounts. Theoretically, 5G Messaging can cover all mobile subscribers. Based on the MaaP technology, 5G Messaging can serve thousands of industries. All services to reach users can be provided based on 5G Messaging. In the early stage, it is recommended that 5G Messaging be first used in the top industries that have a wide audience and great influence on government affairs, people's livelihood and finance. Through "one-click success and multi-point replication," a mature application ecosystem can be rapidly built.

For ZTE specifically, can you mention who you are currently working with on this, and what type of results they've been seeing?

As a pioneer in promoting the construction of the 5G Messaging ecosystem, ZTE is committed to providing operators with end-to-end solutions from platforms, terminals, applications to business information.

In terms of platforms, as the world's leading 5G Messaging platform provider, ZTE is the dominant player with the largest market share among the three major operators in China, and ZTE has helped Chinese operators build the world's largest 5G Messaging platform.

In terms of terminals, ZTE has released 10 5G Messaging terminals. From this year, full series of 5G mobile phones released by ZTE will support 5G Messaging.

In terms of vertical industry applications, ZTE has established the Openlab and collaborates with over 70 CSPs to incubate more than 150 5G Messaging chatbots, covering industries such as financial, government affairs, tourism, e-commerce, smart home and smart manufacturing. ZTE TECHNOLOGIES

To enable connectivity and trust everywhere