To enable connectivity and trust everywhere

Radio Composer, Building an Intelligent Orchestration Radio Network

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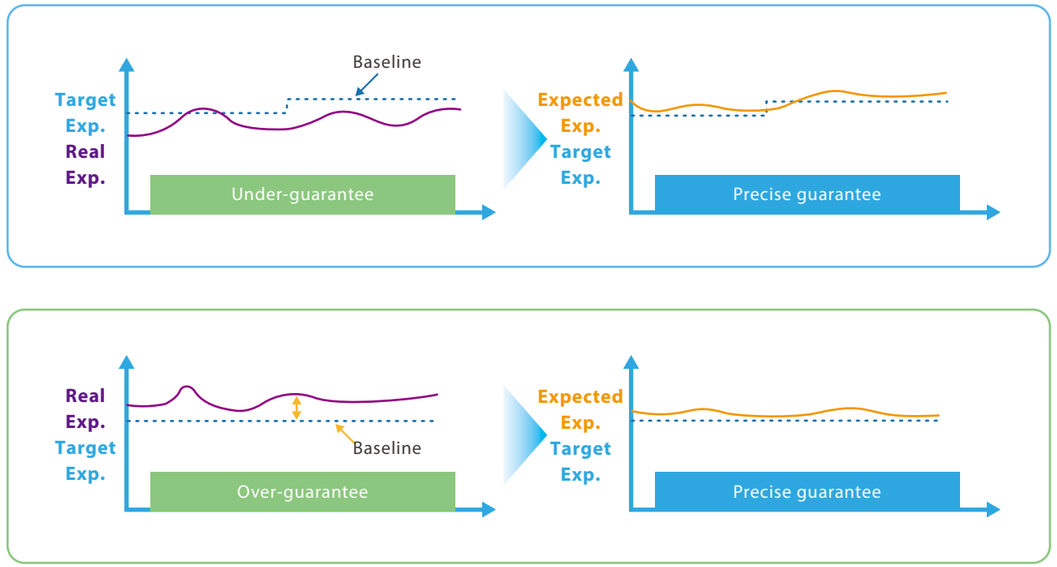
FIGURES

Development Tendency and Requirements of Network

With the scaled deployment of commercial 5G networks, high-quality 5G experience becomes essential to the continuous development of 5G users, the release of 5G potential and improvement of 5G network value and economic benefits. However, the contradiction between the increasingly diversified 2B/2C services and the relatively fixed network resource policies is becoming increasingly prominent. The traditional network resources configuration policy "one-for-all" which focuses on network quality and performance is no longer sufficient to guarantee the demand for differentiated experience with the service diversification. Specifically, the network-centered policy will cause under-guarantee and over-guarantee regarding the user experience in the 2C and 2B networks respectively. For the under-guarantee of 2C, on one hand, it will cause the direct income loss due to passive service adaptation to network (for example, service dpi is adjusted automatically from 720P to 480P due to the poor network). On the other hand, it will lead to some indirect loss due to poor user experience, low satisfaction and high risk of quitting the network. As for the over-guarantee of 2B, due to the lack of precise user-centric policy of resource configuration, resources are usually over-configured to meet the high requirements of service experience, which causes



the waste of network resources and insufficient system service capacity and then further restricts the network profitability. Therefore, as illustrated in the following figure, in order to provide better and differentiated services for users, it is necessary to transform from "network-centered" to "user-centered" to achieve the optimal balance between the user experience and network efficiency.

However, the multidimensional complexity of 5G is posing tremendous challenges to the transition from network-centered to user-centered, the most critical of which are the following two points:

1.Network complexity: Multiple network resources, such as multi-band, multi-mode, multi-carrier, multi-frame structure, multi-beam, etc. can be combined flexibly; it's very complex to predict and select the resource combination capability in the violently changing radio environment.

2.Terminal complexity: Due to industrial evolution and diverse application scenarios, terminal capabilities vary greatly in terms of support for system, mode, feature and 2B/2C services, which is an important constraint for scenario-based and personalized services.

In summary, how to agilely and precisely perceive personalized service requirements and dynamic capabilities of network service in differentiated 5G scenarios and variable radio environments and how to implement precise match between them under different terminal service capabilities is the key to the transformation. Therefore, there comes the intelligent wireless orchestration network based on the intrinsic AI computing capability and orchestration engine of base stations, which can provide adaptive and flexible orchestration services of network resources based on user requirements to achieve the best service quality and network efficiency.

Architecture of Radio Composer

Based on the precise user experience perception in the differentiated 5G service scenarios, ZTE innovatively proposes Radio Composer, an intelligent orchestration radio network solution, which employs smart orchestration engine to implement flexible network service capabilities in the multi-layer network through user orchestration and network orchestration, empowers the network with optimized user experience based on flexible orchestration capability. Smart orchestration engine coordinates between BBU intrinsic and industry enhancement engine to incorporate multiple telecommunication variables to build multi-dimensional perception and learning capability. The Radio Composer can be illustrated by following formula:

$$P_{\text{opt}} = \mathbf{f}\{N_1^x, D, S, L, \Delta\}$$

Export

Perception Factor

Popt：Optimal performance

N: Network

D: Device

S: Service

L: Location

Δ：Cross-domain information (navigation, environment, etc.)

Figure2 1 Key Idea of Radio Composer

- The network service capability includes the multiple frequency service capabilities combination when the spectrum configuration remains unchanged. It also includes the adaptation of spectrum configuration according to service trend.
- The cross-domain information refers to the data of the AI knowledge plane, which opens the door to a new world for the wireless network. Taking the distance calculation as an example, compared with the TA in the communications network, the user service quality can be orchestrated according to pre-predicted user navigation route based on third-party navigation information, thus reducing the user's stay in the 5G weak coverage. To acquire the cross-domain information, subscription with the third party for authorization as well as the data de-sensitization is essential.

User orchestration

User orchestration facilitates x frequency service capabilities combo in the network to improve user experience under the given network service capability, that is, the spectrum configuration remains unchanged. When the user experience is lower than the service perception baseline, user orchestration helps to achieve the optimal user experience according to the service demands and terminal capability, with which the user is guided to the cell of better service experience. The user orchestration is mainly based on BBU native intelligence capability. When there are industry application requirements, the industry enhancement engine can be used to implement precise identification of diversified 2B services and SLA closed-loop scheduling enhancement, so as to guarantee the rigid demands from industry and empower thousands of industries.

Network orchestration

Network orchestration is aiming at improving network service capability N based on spectrum, carrier, frame structure and beam according to a given traffic distribution. If the current network configuration cannot meet the user experience requirements, network orchestration implements flexible network service capability adaption based on traffic trend prediction, thus getting the optimal network service capability and improving user experience. The network orchestration implements training and reasoning through the intelligent module of EMS system on top of BBU intrinsic, and saves the calculation power requirement of BBU. Combined with the industry enhancement engine, it achieves precise empowerment in the 2B and 2C network, improving the network efficiency.

Introduction to Key Technologies

3.1 Network Orchestration Principles and Applications

3.1.1 Introduction to Network Orchestration

Network orchestration is self-learning based on the service model and interference model to achieve precise deployment of network resources. Through adaptive and dynamic adjustment of the spectrum, carrier, beam, and frame structure, the network traffic is maximized, greatly improving network service capabilities.

On one hand, network orchestration uses grids (clusters) as its units and independently learns network service capabilities under different current resource combinations (spectrum, carrier, beam and frame structures) to generate a grid knowledge library. The knowledge library stores the capability sets of all grids in the current network based on different resource combinations.

On the other hand, the network orchestration performs deep learning of the traffic requirements of different technologies, uplink and downlink, and different spatial directions, and generates a traffic mode knowledge library, accurately predicting the future traffic requirements of the network.

With different orchestration strategies and interference adaption policies, the network orchestration can precisely deploy resources for the current network to meet the service requirements of 2B and 2C with better network capability and efficiency. The network service capability is optimized under the specific time and space distribution of traffic. Through AI-based intelligent traffic prediction, automatic resource determination, intelligent interference detection and avoidance, the network configuration can be flexibly and reasonably adjusted to meet service requirements accurately.

For users, the network orchestration benefits in the following ways:

1.The complexity of network planning is reduced. The network can be adjusted adaptively after one planning.

2.Network resources adaptively meet traffic requirements, improving network service capabilities and network efficiency.

3.1.2 Network Orchestration Applications

3.1.2.1 Spectrum Orchestration

For the 4G/5G dual-layer network, 4G and 5G are usually configured with fixed spectrum resources respectively. As a result, the 4G spectrum resources are not fully utilized.

After adopting the intelligent spectrum orchestration, the 4G spectrum is set to 4G/5G dynamic spectrum sharing (DSS). Through intelligent traffic prediction, intelligent traffic guidance and intelligent interference avoidance, the spectrum can be configured adaptively, which can greatly improve the resource utilization efficiency of the 4G spectrum, thus improving the 5G user experience.

3.1.2.2 Carrier Orchestration

When 5G is applied to the industrial scenario, the interference may change greatly due to the machine operation, seriously affecting the service experience. How to guarantee key services with extremely high requirements for latency and reliability?

Traditionally, the multi-carrier configuration is used in the case of the strongest interference, resulting in extremely low network efficiency. In this case, 4CC multi-carrier and PDCP replication are configured to ensure high reliability. However, the configuration cannot be adjusted in time after the interference is reduced. It causes network resources being over guaranteed and low network efficiency.

After adopting the intelligent carrier orchestration, the carriers can be configured adaptively. Through intelligent traffic prediction, intelligent traffic guidance and intelligent interference avoidance, the carrier configuration reaches self-adaptive. The optimal mode is selected from the 1CC/2CC/4CC to ensure high reliability and maximize the network efficiency.

3.1.2.3 Frame Structure Orchestration

In order to adapt to the traditional 2C services, the frame structure mainly focuses on the downlink, and it is fixed in the whole network. With the booming of new services brought by 5G industry demands, more and more uplink large-bandwidth services are emerging. In this case, the uplink frame structure needs to be adjusted manually, resulting in a huge maintenance workload and delayed response. It's apparent that the traditional method cannot meet service requirements.

The intelligent frame structure orchestration can flexibly

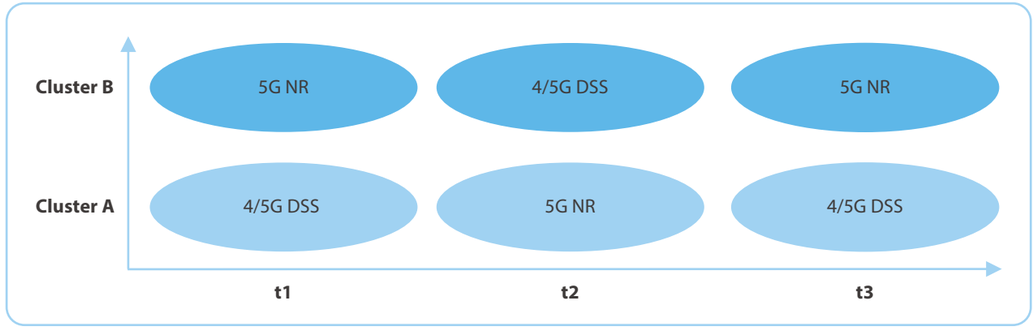


Figure3 1 Spectrum Orchestration

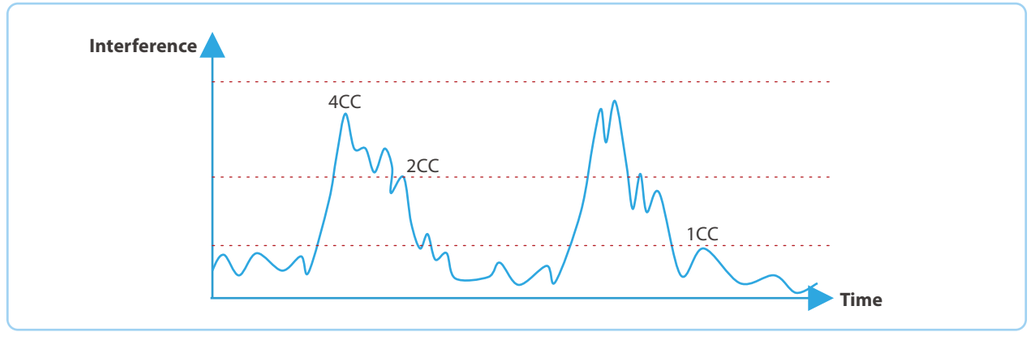


Figure3 2 Carrier Orchestration

adapt to the uplink large bandwidth requirements of B2C and B2B services. Through intelligent traffic prediction, intelligent traffic guidance and intelligent interference avoidance, the frame structure reaches self-adaptive.

3.1.2.4 Slicing Orchestration

Generally, the slice resources allocated to vertical industry is fixed which leads to low network efficiency. With resources estimation and service guarantee capabilities improvement, the slice resource used by industrial applications can be adaptively allocated based on service demands.

The intelligent slicing orchestration helps operators to deploy more slices without changing the spectrum resources to improve the network utilization and efficiency.

3.2 User Orchestration Principles and Applications

3.2.1 Introduction to User Orchestration

User orchestration achieves optimal guidance and scheduling of different users in different scenarios through the self-evolving network service capability knowledge library and service knowledge library.

Network service capability knowledge library, which is built on logical grids of various scenario capability, predicts the different cell's network service capability (achievable rate and time delay) of different frequent layers through learning the history data (such as spatial coverage and spectrum efficiency), and combining the interaction of real-time information (such as network load). Service knowledge library identifies user's requirements accurately in accordance with slice IDs, service types, and service policies through hierarchical characteristic learning by stream or packet level.

According to UE's capabilities, user orchestration precisely guide and schedule users with differentiated service requirements by using network service capability knowledge library and service knowledge library.

Compared with traditional solution, intelligent user orchestration focuses on how to improve user experience and guarantee continuous better perception in the network.It aims at scheduling less resources to ensure users getting better experience with following highlights.

1.Evolution from network-centered to user-centered network, guide users camping suitable network layer in accordance with users' service requirements.

2.Through deep learning of network capabilities, users' service experience can be guaranteed with more suitable resources.

3.2.2 User Orchestration Applications

3.2.2.1 2B Cases

In a certain warehouse, the wireless solution is used to provide video monitoring and remote control of bridge cranes. The video system is deployed with multiple sets of HD cameras, which provide monitoring surrounding environment and the cranes status during the

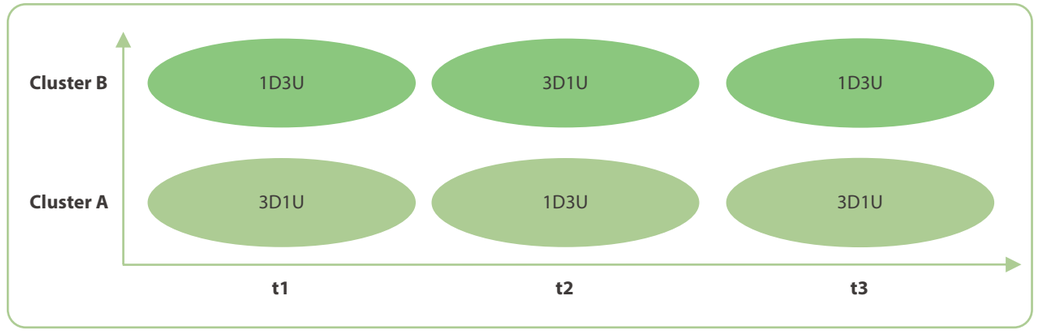


Figure3 3 Frame Structure Orchestration

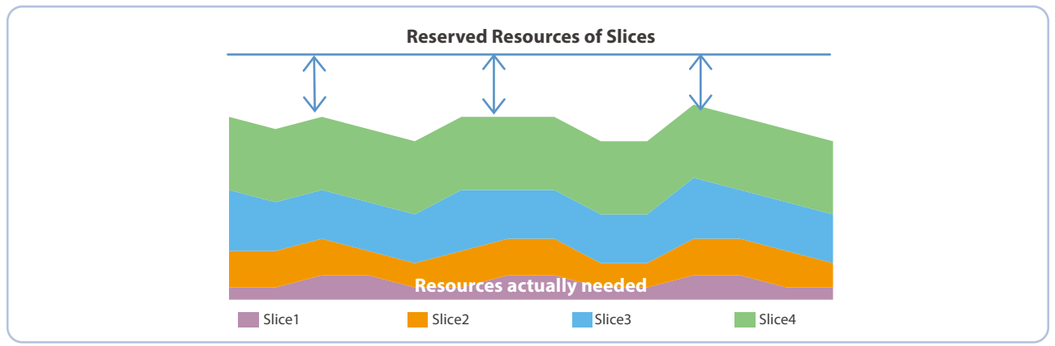


Figure3 4 Slicing Orchestration

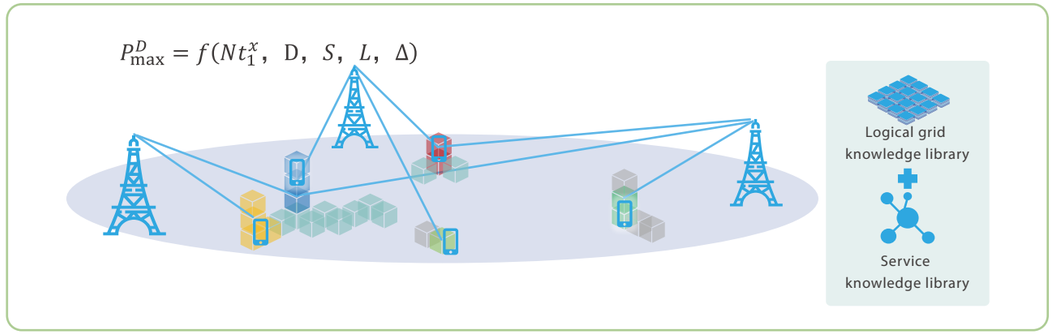


Figure3 5 User Orchestration

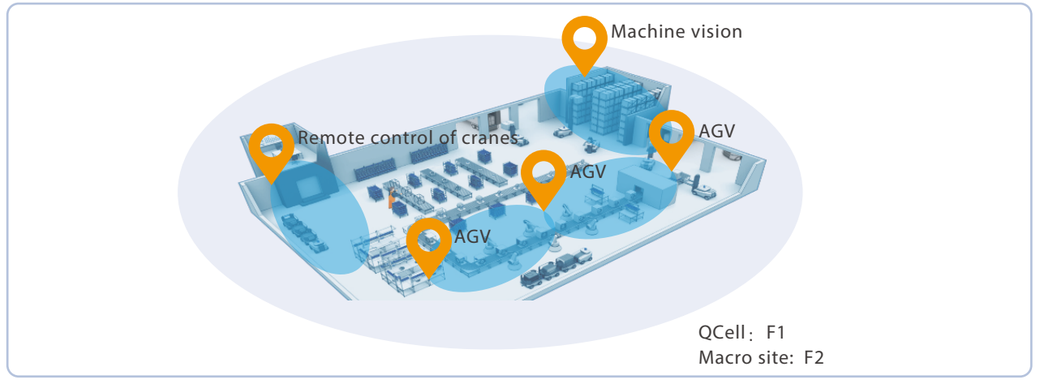


Figure3 6 2B Case for User Orchestration

operation .Operator may control the cranes in real-time with operating system in the operating room instead of climbing to control room on cranes, the real-time monitoring video provides the convenience for remote observation of operations of cranes. The AGV trolley system transports goods through a remote operation vehicle.

The whole workshop is covered by two frequency points "NR F1 + NR F2", providing services for cranes remote control, remote video and AGV trolley connection.

In normal scenario, F1 is preferred as the primary serving cell for all three service types in the ware hours, which causes F2 with low frequency utilization rate.

With user orchestration, it adjusts the strategy of network so that the AVG trolley service selects F2 cell as 1st priority, while the cranes remote control service selects F1 cell as 1st priority. The remote HD video selects the F2 or F1 cell according to the real-time cell service load. Once the service is identified, the network will schedule service in accordance with the user orchestration policy. Compared with traditional policies, intelligent orchestration achieves more flexible and precise arrangement for services.

3.2.2.2 2C Cases

A certain NSA network has two NR frequency and four LTE frequency. According to the test in existing network, NR F1's indoor coverage is poor due to the high penetration loss , and NR F2 only provides relatively limited rate due to its narrow bandwidth. As the number of NSA-capable UEs grows in the network, the load of NR F2 is increasing day by day.

Operators usually prefer to set the priority of the EN-DC as 1st priority. Therefore, the load of NR F2 becomes higher and higher which deteriorates the user experience, while some LTE cells' utilization is low.

After user orchestration is introduced, some terminals with poor EN-DC aggregation capabilities will select LTE CA as 1st priority, which schedules some users camping to idle LTE cells rather than high load NR cells.

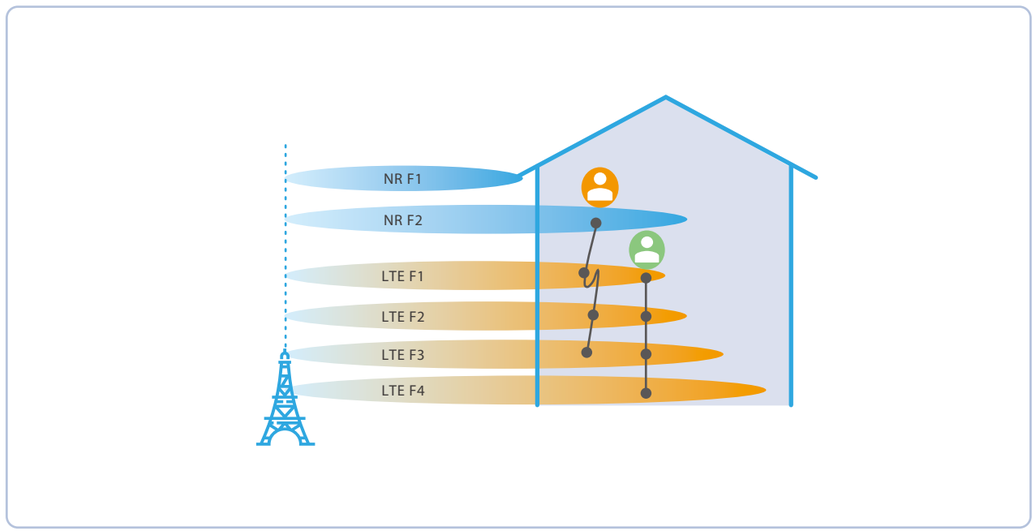


Figure3 7 2C Case for User Orchestration

Future-Oriented Intelligent Orchestration Network Evolution

Facing the future, 5G evolution will further present the trend of network as a service, scenario-based service, all-scenario intelligence and BBU intrinsic.

- Network as a service: Based on the atomized and modularized network capabilities, network service capability are flexibly combined to adapt to various service requirements.
- Scenario-based service: Flexibly adapting to the value targets and requirements of different scenarios, Radio Composer can provide customized network service capability to achieve optimal user experience with highest network efficiency in a variety of scenarios.
- All-scenario intelligence: Efficient and accurate scenario-based services can be achieved and continuous evolution can be implemented through definable utility, perceptible scenario, flexible strategies and controllable closed-loop intelligence.
- BBU intrinsic: The smart orchestration engine deeply integrates AI computing with present computing capability to fully improve the intelligent learning and scenario-based capabilities adaptation of different levels (physical layer, MAC layer, network layer, etc.), consequently, personalized intelligent network capabilities can be supported for the continuous evolution.

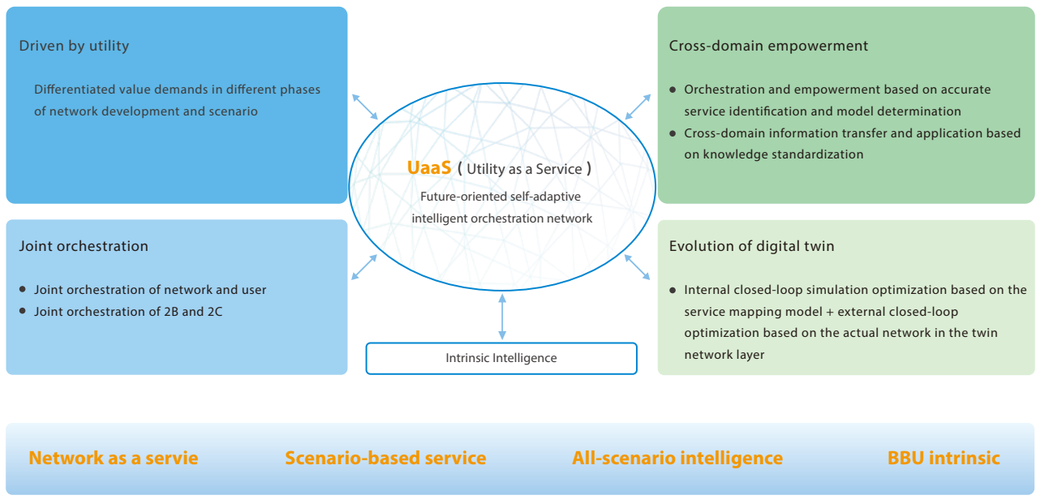


Figure4 1 Evolution of Intelligent Orchestration Network

To meet the growing requirements for flexible scenario-based services capability with differentiated value demands in different phases of network development, Radio Composer will fully integrate with the four major trends. Based on the vision of "orchestration going with service demands" and the basic architecture of BBU intrinsic, the intelligent orchestration capability will continue to evolve from the following four aspects to facilitate scenario-based and intention-adaptive intelligent orchestration.

1.From “experience-driven” to “utility-driven”: Aiming at the differentiated value demands in different phases of network development and scenarios, Radio Composer will achieve the precise match of the network operation objectives and self-adaptation of orchestration capability.

2.From “Intra-domain orchestration” to “Cross-domain orchestration”: From single-domain orchestration driven by user experience to cross-domain orchestration based on AI empowerment, Radio Composer will drive the evolution of diversified intelligent service capabilities covering user experience and network value;

3.From “Independent orchestration” to “Joint orchestration”: Through deep coordination of network orchestration and user orchestration, Radio Composer will achieve the optimal performance based on intention-driven. In addition, based on the integrated orchestration of 2B/2C and the evolution of multi-target intelligent resource management capability, it achieves the best consistency of service differentiation and network service capability.

From “Single-layer closed-loop” to “Dual-layer closed-loop”: Relying on the high-precision digital modeling and simulation capabilities provided by the digital twin technology, it can implement the optimal orchestration solutions based on efficient search, precise prediction and closed-loop optimization of the virtual network. It also provides the optimal and accurate orchestration capability with the digital twin technology and the closed-loop optimization of the physical network.

Acronym

Acronym	Full Name
AGV	Automated Guided Vehicle
AI	Artificial Intelligence
CA	Carrier Aggregation
CC	Component Carrier
EN-DC	EUTRA-NR Dual Connection
PDCP	Packet Data Convergence Protocol
TA	Time Advance
2B	To Business
2C	To Customer
UaaS	Utility as a Service