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Use cases of Application-aware Networking (APN) in Edge Computing
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Abstract

The ever-emerging new services are imposing more and more highly demanding requirements on the network. However, the current deployments could not fully accommodate those requirements due to limited capabilities. For example, it is difficult to utilize the traditional centralized deployment mode to meet the low-latency demand of some latency-sensitive applications. Moreover, the total amount of centralized service data is growing exponentially, which brings great pressure on the network bandwidth. There has been a clear trend that decentralized sites comprising of computing and storage resources are deployed at various locations to provide services. In particular, when the sites are deployed at the network edge, i.e. the Edge Computing, it can better handle the business needs of the users nearby, which provides the possibilities to provide differentiated network and computing services. In order to achieve the full benefits of the edge computing, it actually implies a precondition that the network should be aware of the applications' requirements in order to steer their traffic to the network paths that can satisfy their requirements. Application-aware networking (APN) aims to accommodate the edge services' needs, fully releasing the benefits of the edge computing.

This document describes the various application scenarios in edge computing to which the APN can be beneficial, including augmented reality, cloud gaming and remote control, which empowers the video business, users interaction business and user-device interaction business. In those scenarios, APN can identify the specific requirements of edge computing applications on the network, process close to the users, provide SLA guaranteed network services such as low latency and high reliability.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

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1. Introduction

Edge computing is to deploy service sites near the user side to provide users with better network and computing services. The services of edge computing can not only be implemented in the edge data center, but also be integrated in the network equipment, which brings the possibility for the convergence of network and computing, and also puts forward the requirements for the technology combining of different industries. On the one hand, the demand of different applications for the network need to be exposed; on the other hand, the network needs to be aware of computing power and steers the traffic along the appropriate path towards the suitable sites.

The existing network can only identify the application demands in a coarse granularity. When the application demand is high causing the heavy network load, it usually fails to guarantee the latency and reliability of the applications especially the mission-critical applications. Application-aware networking (APN) facilitates service provisioning in a fine granularity, and then either steer the corresponding traffic onto the appropriate network path (if exist) that can satisfy these requirements or establish an exclusive network path which wouldn't be influenced by other applications' traffic flow.

2. Edge Computing and APN

In a whole edge computing network, there are user terminal, edge gateway and edge data center. The edge gateway can be the UPF In 5G network. Edge data center is usually close to users and serves a limited group of users, the network and computing tasks performed by edge computing are more specific and customized. Both computing resources and network resources need to be able to provide fine-grained service guarantee. The goal of APN is to provide fine-grained network service, including latency, jitter, reliability and others, which can be well matched with edge computing.

Application-aware networking includes the app-aware edge (APN-Edge), app-aware process head-end (APN-Head), app-aware process mid-point (APN-Midpoint) and app-aware process end-point (APN-Endpoint). A user's request is sent from the client, and then passes through all the nodes of the APN network to the server. The function of APN-Edge can be deployed in the edge gateway, so the request traffic of client can be distinguished by the edge gateway/APN-Edge and sent to the edge data center through the APN. In some cases, the reply of the edge data center will not return to the original client, and may be sent to another client through the APN. The APN network can use the existing technologies such as deterministic network, network slicing, SR policy, etc. which could coordinate well with the APN-Edge to guarantee the network service by encapsulating the requirement information in the packets.

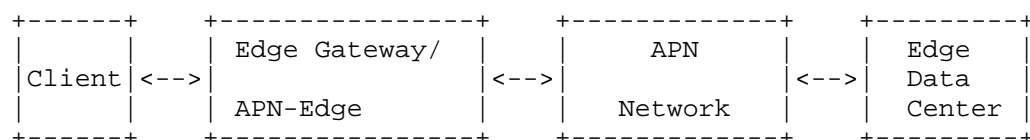


Figure 1: Edge Computing and APN

3. Usage Scenarios of APN in edge computing

This section presents several typical scenarios which require edge computing to interconnect and to co-ordinate with APN to meet the service requirements and ensure user experience.

3.1. Augmented Reality (AR)

3.1.1. Use Case Description

Augmented reality is a relatively new application that promotes the integration of real world information and virtual world information content. It includes several technologies, such as track registration, display, virtual object generation, interaction and merging.

3.1.2. Augmented Reality Today

AR gives users an immersive experience. It is widely used in the consumer industry presently, and may also be applied in industrial fields such as health care and education in the future. The general process of AR / VR is as follows:

* Image acquisition equipment (such as camera) collects image or video information and sends it to data center.

- * Data center carries out identification, feature extraction and template rendering, and sends them to AR terminal.

- * The AR terminal plays the synthesized information.

Considering the user experience, AR usually needs a high bandwidth of 100mbps due to multi-channel acquisition of image or video data, and a low end-to-end latency less than 60ms. With centralized deployment, the network transmission distance is too long, so the latency demand can't be met; the large volume of traffic load also imposes high challenge on the network bandwidth.

3.1.3. Augmented Reality with Edge Computing and APN

If the deployment mode of edge computing is adopted, the following functions can be realized:

- * The collected image or video information can be encoded/decode and compressed by the edge equipment to reduce the bandwidth requirements of data transmission.

- * The edge data center can process the collected image or video data nearby and send it to the AR terminal equipment, which reduces the distance of network transmission and greatly reduces the latency.

Although edge computing can reduce the overall latency of services and reduce the demand for network bandwidth, it still needs differentiated network services to provide the ultimate guarantee for application with high SLA requirements. APN can achieve:

- * Edge device obtains and encapsulates AR application feature information and sends it to the headend node.

- * Headend node in the APN identifies the AR data flow and steers it into a specific transmission path according to the demanded bandwidth, latency and reliability.

- * Mid point in the APN forwards the data stream along the specific path.

- * End point in the APN receives AR data stream and forwards it either to Data Centre for processing or to the AR player for playing.

In the whole process, because APN identifies the traffic of AR application, it can provide corresponding network services to provide customized high reliability, low latency and other SLA guarantee.

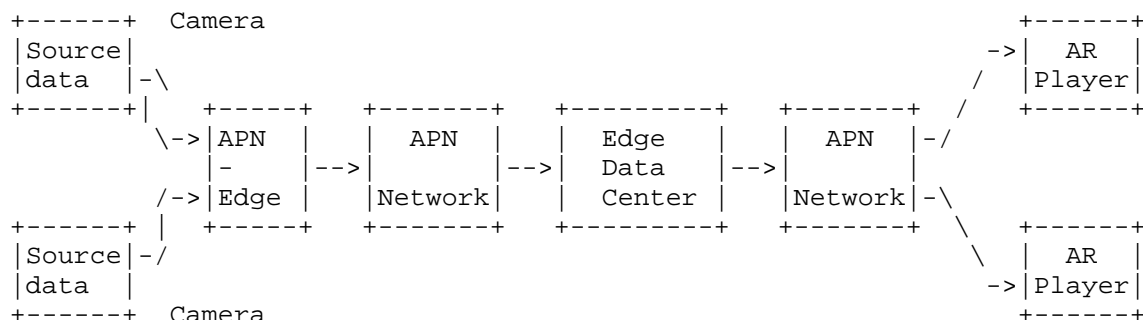


Figure 2: Augmented Reality with Edge Computing and APN

3.2. Cloud Gaming

3.2.1. Use Case Description

Cloud gaming is to deploy the game application in the data center, and realize the functions includes the logical process of game command control, as well as the tasks of game acceleration, video rendering and other tasks with high requirements for chips. In this way, the terminal is a video player. Users can get a good game experience without the support of high-end system and chips.

Compared with the traditional game mode, there are several advantages of cloud game, such as no installation, no upgrade, no repair, quick to play and reduce the terminal cost, so it will have stronger promotion.

3.2.2. Cloud Gaming Today

The biggest feature of cloud games is that users interact with each other through the network. The general process is as follows:

- * The data center sends game video streaming information to the terminal, including game background picture, characters, etc.
- * The user makes corresponding operation instructions according to the received game video stream information and sends them to the data center.
- * The data center constantly updates the video stream and other data of the game according to the user's operation instructions.

Game users usually pursue consumption experience. Currently, most users are willing to spend extra money in order to obtain better user experience. Generally speaking, the network latency of game is

required to be less than 30ms. For competitive game, the latency will be required to be less than 10ms, because professional players usually can feel the millisecond level latency difference. With centralized deployment, the network transmission distance is too long, which is a huge challenge to the network load, so the latency demand can't be met; the large volume of traffic load also imposes high challenge on the network bandwidth.

3.2.3. Cloud Gaming with Edge Computing and APN

If the deployment of edge computing is adopted, the following functions can be realized with the deployment of edge data center:

- * The edge data center sends the game video stream information to the terminal, and receives the user's control instruction information for processing.

- * users can make corresponding operation instructions according to the received video stream information, and get quick response.

Edge computing can reduce the latency of game data transmission as a whole, but it should be noted that cloud games usually have multiple players playing a game together, which requires the deterministic latency of multi-party network path, which needs to be realized with APN:

- * Multiple edge devices obtain and encapsulate cloud game application feature information and send it to the head end node.

- * Headend node in the APN identifies the data flow of cloud games (maybe the same game), and steers it into a specific transmission path according to its requirements for bandwidth, delay, reliability, etc., which needs to ensure that the latency of multi-user control instructions arriving at the edge data center is consistent.

- * Midpoint in the APN forwards game data stream according to the predetermined path.

- * The endpoint in the APN receives the cloud game data stream and steers it either to the data center for processing the users' control instruction or to the user for playing.

The whole process requires APN not only to identify the cloud game traffic and provide customized network forwarding services for it, but also to ensure the deterministic latency of multi-user in the same game and provide better game experience.

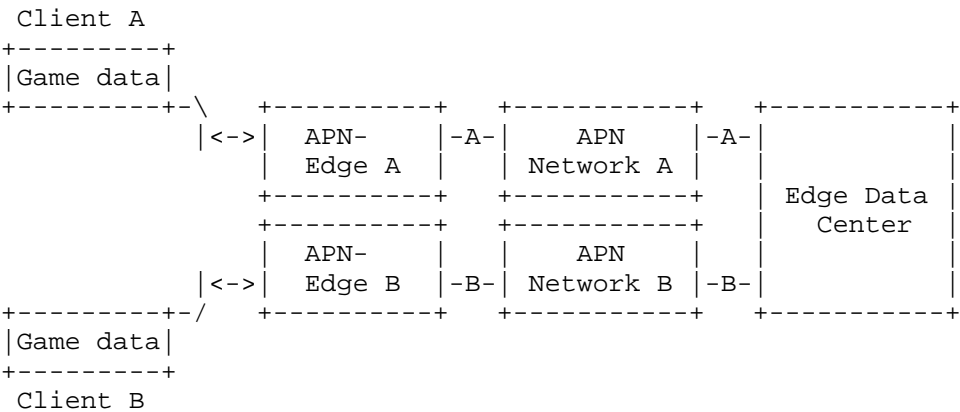


Figure 3: Cloud Gaming with Edge Computing and APN

3.3. Remote control of industry

3.3.1. Use Case Description

Industrial remote control refers to the remote control of field equipment in areas that are not convenient for manual field control, such as high-temperature and high-risk areas. In the past, signaling was usually transmitted through industrial private networks and protocols. With the development of industrial Internet, the industry also gradually has the demand of network interconnection. Its network tends to adopt L3 protocol and flat architecture, which makes it possible for cross distance remote control service.

3.3.2. Remote control of industry Today

In the process of remote control, workers constantly make control instructions according to the received image or video information of field equipment, which requires interaction between personnel and equipment through the network. Because the field environment that needs remote control is generally poor, it is also a challenge for the security of the operation equipment. If the latency is too large or the reliability is not enough, it may cause the operation failure, equipment damage and other serious consequences. Therefore, the remote control service requires low latency and high reliability. The general process of remote control is as follows:

- * Field equipment (such as camera) collects image or video information and sends it to data center.
- * The data center receives the field information of the equipment and sends it to the workers in the office.

- * Workers send control instructions and control equipment according to the received field information.

Many industrial enterprises rent public cloud resources to construct their own data center, but the long distance of network transmission is not conducive to the timely transmission of image / video data stream, which will cause large latency and packet loss.

3.3.3. Remote control of industry with Edge Computing and APN

If the deployment mode of edge computing is adopted, and the data center and edge computing access equipment (such as gateway) are deployed in a location or enterprise park close to the business site, the following functions can be realized:

- * The collected image or video information can be encoded/ decoded and compressed by edge access equipment to reduce the bandwidth requirements.
- * The control instruction information can be identified by the edge equipment, so as to provide exclusive network transmission service.
- * The forwarding path of image / video and control information is shortened, which can greatly reduce the latency.

Although edge computing can reduce the overall delay of services and reduce the demand of network bandwidth, it still needs to achieve differentiated network services through APN to provide the ultimate network guarantee for the services with the highest network requirements.

For users, APN can realize those functions.

- * Edge device obtains and encapsulates the image or video information of the remote field device, then sends it to the headend node.
- * Headend in the APN identifies the information and steers the flow into a specific transmission path according to its requirements for bandwidth, delay, reliability, etc..
- * Midpoint in the APN forwards along the specific path.
- * Endpoint receives image or video data stream of field equipment and forwards it to users.

For field equipment, APN can realize those functions.

* Edge device obtains and encapsulates the control instruction information and sends it to the head end node.

* Headend in the APN identifies the control data flow and steers into a specific transmission path according to the demand for bandwidth, latency and reliability.

* Midpoint in the APN forwards along the specific path.

* Endpoint receives control information and forwards to the field equipment.

In the whole process, APN identifies the traffic of remote control service, which can provide customized high reliability, low latency and other network guarantee.

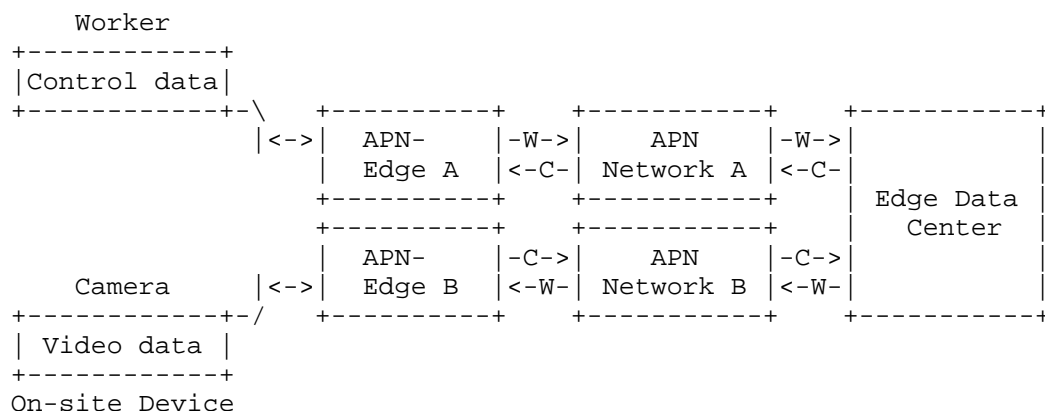


Figure 4: Remote control of industry with Edge Computing and APN

4. Conclusion

APN enables low latency and high reliability network services in various edge computing scenarios such as AR, cloud gaming, remote industrial control, etc.

5. Security Considerations

TBD.

6. IANA Considerations

TBD.

7. Normative References

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