                 Computing-aware Networking Use case of ALTO
                     draft-liu-alto-can-usecase-00

Abstract

   The ever-emerging new services are imposing more and more highly
   demanding requirements on the network. In order to meet these
   requirements, some new technology trends of network emerge as the
   times require. On the one hand, for the selection of service node
   and forwarding path, in addition to considering the network topology
   and link state, more factors are also considered, such as the
   computing properties of service node; On the other hand, network and
   application present the trend of mutual perception, including
   application to perceive the state of network path, or network to
   perceive the demand of application.

   This draft describes a new network scenario and architecture
   considering computational properties, and assumes that Alto could be
   used as an important node to realize the deployment of services, and
   to assist in the selection of service nodes.

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](1). Introduction

For new services with heavy computing tasks, such as AR/VR, video
recognition and so on, the computing time and network transmission
delay are almost the same order of magnitude. In this kind of
scenario, computing attributes become more important than traditional
services.

The generation of edge computing is to solve such problems. Edge
computing is to deploy service nodes close to the user side, which

shortens the distance of network transmission. Moreover, it can
deploy specific computing resources, such as CPU/GPU, to meet the
needs of different services.

It is predicted by Gartner that by 2025, more than 50% of the
computing data needs to be analyzed, processed, and stored at the
edge. Since the service providers begins to offer the edge computing
infrastructure to provide better response time and transfer rate.
There are also some challenges of edge computing itself, which are
pointed out in the work of dyncast [draft-liu-dyncast-ps-usecases-
01], [draft-li-dyncast-architecture-00] :

* Geographically Scattered Large Number of Edge Sites. The edge
sites are highly distributed and may not have proximate distances to
user.

* Resource Limitation. There are fewer servers of server per node.

* Heterogeneous Hardware, such as CPU, GPU, Memory, ASICs.

* Dynamic Load. The available resources may change quickly.

* Edge-cloud Coordination. Edge does not solve all requests.

* High Cost. On-site maintenance is expensive.

* Mission Critical. Users are counting on you for 100% reliability
of industry automation.

So how to collaboratively deploy and computing services based on the
computing resources in network to meet the diverse computing
requirements, and achieve the on-demand allocation and dispatch of
service request needs be studied.

Some existing works have begun to consider the computing attributes.
For example, coinrg initiated the consideration of computing and
storage resources. Dyncast proposed how to introduce the scheme of
computing metric at the routing level. Semantic routing[], which
also extends the semantics of routing in a broad sense. However,
today's routing system and technology has been relatively good, the

introduction of more metric in routing still need more theoretical
and experimental verification. In the work of ITU, it is more from
the perspective of architecture, such as ITU Y.CAN-reqts [Y.CAN-
reqts: "functional requirements of Computing-aware Networking"]
proposed a new network architecture-computing-aware networking (CAN),
CAN schedules service request to the optimal computing site along
optimal path to meet service requirements both on network and
computing. ITU.Y.CPN-arch [Y.CPN-arch: "Framework and architecture
of Computing power Network"]provides the framework and architecture
of Computing power Network, specifies its functional entities and
defines the functionalities of these functional entities. So the
convergence of network and computing brought by edge computing

includes the issue of service deployment and service request
scheduling. ALTO has done the work of collect the network
information for application, it may help to do some work in the two
important issues:

How to deploy service nodes based on computing resources. For this
point, [draft-contras-alto-service-edge-02] gives the corresponding
idea of using Alto to deploy edge computing nodes. Alto can better
interact with the upper application, fully understand the
requirements of the application, including computing requirements and
collect the information of infrastructure resources.

How to select the most suitable node for service request. Alto can
also help this kind of work to a certain extent. Centralized
selection of service nodes and paths is relatively easy to implement,
such as SDN. However, emerging service requests require high real-
time performance, and there may be some efficiency and complexity
problems, which have been analyzed in the work of dyncast.

2. Usage Scenarios of CAN

Any multi-point deployment service that requires high computing power
or low latency will involve the joint scheduling of network and
computing resources.

2.1. AR/VR

Take the AR/VR as an example. The upper bound latency for motion-to-
photon (MTP) is less than 20 milliseconds to avoid the motion

sickness. It consists of four parts, and the frame rendering
computing delay is 5.5 milliseconds, so the network delay demand can
be calculated as 5.1milliseconds.

```
+----------------------+--------------------+
|    Total MTP delay   |       50ms         |
+----------------------+--------------------+
| sensor sampling delay|      <1.5ms        |
+----------------------+--------------------+
| display refresh delay|       5 ms         |
+----------------------+--------------------+
| frame rendering delay|       5.5ms        |
| computing with GPU   |                    |
+----------------------+--------------------+
|    network delay     | 20-1.5-5.5-7.9=5.1ms|
+----------------------+--------------------+
```

                        Delay of MTP

   So the budgets for computing delay and network delay are almost
   equivalent. Considering another factor that the computing resources
   have a big difference in different edges,it is necessary to apply
   dynamically steer traffic to the 'best' edge.

2.2. Internet of Vehicles

   Under the scenario of Internet of Vehicles, the services are divided
   into auxiliary driving and on-board entertainment services . For the
   auxiliary driving function, for road traffic conditions outside the
   line of sight due to obstructions, blind areas, etc., the edge
   computing node obtains comprehensive road traffic information around
   the location of the vehicle, performs unified data processing, and
   sends out warning signals for vehicles with potential safety hazards,
   to assist the safe driving of vehicles.

   Apparently, there are obviously differences between services
   requirements of auxiliary driving services and entertainment
   services, which needs to be processed by different edge nodes

3. CAN Framework and ALTO

In order to realize ubiquitous computing and service awareness,
interconnection and collaborative scheduling, the computing-aware
networking architecture can be divided into computing service layer,
computing resource layer, computing routing layer, network resource
layer, and computing and network management layer. Among them, the
computing routing layer contains the control plane and data plane
which is shown in Figure 2. Based on the ubiquitous computing
resources of the network, the computing resource layer abstracts and
models based on a unified measurement and modeling template, and
announces computing information to the computing routing layer. And
then the computing routing layer comprehensively considers user needs
and network resource status and computing resource status, to
schedule service requests to appropriate computing nodes. In
addition, the computing management layer completes the control and
management of computing resources.

                 Computing-aware Networking Framework
```
+---------------------------------------+   +-----------------------+
|       Computing Service Layer         |<->| Computing and Network |
+---------------------------------------+   |    Management Layer    |
|      Computing Resource Layer         |<->|+---------------------+|         +
+---------------------------------------+   || Service Orchestration|<--------|
|      Computing-aware Routing Layer    |   |+---------------------+|         |
|  +---------------+ +---------------+   |<->||    Computing OAM    |<--------|
|  | Control Plane | |  Data Plane   |   |   |+---------------------+|         |
|  +---------------+ +---------------+   |<->||  Routing Management |<--------|
+---------------------------------------+   |+---------------------+|         |
|         Network Resource Layer        |<->||  Resource Management |<--------|
+---------------------------------------+   |+---------------------+|         +
```

                        CAN Framework and ALTO
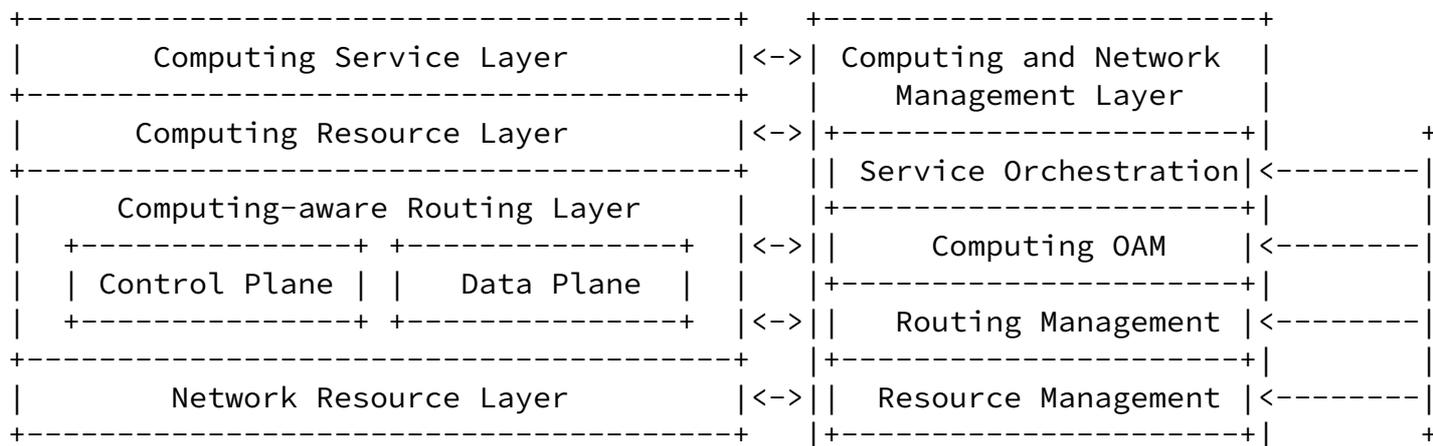
* Computing service layer: computing service layer is computing
   service provider, which deploys, operates and manages many kinds of
   computing services and applications. In addition, it can realize the
   functions of service decomposition and service scheduling through the
   API gateway.

   * Computing resource layer: it is based on the existing computing
   infrastructure, and includes a combination of computing resources
   from single-core CPU to multi-core CPU, CPU+GPU+FPGA, etc. And it
   could supply computing modeling function, computing API function,
   computing resource identification and other functions to meet the
   diverse computing needs of different applications based on physical
   computing resources.

   * Computing-aware routing layer: It contains control plane and data
   plane, performs computing-aware routing and generates service
   scheduling policy in network layer. Based on the discovery of
   abstracted computing and network resources, computing routing layer
   generates new routing tables which include the information of
   computing in network, considers the state of network and computing
   comprehensively, and thus generates routing policy for different
   service requests. Network resource layer: It utilizes the existing
   network infrastructure, which includes access network, metropolitan
   area network and backbone network, to provide ubiquitous network
   connection.

   * Computing and network management layer: It adds management
   functions towards computing resources and computing services based on
   the traditional network management function. Therefore, the
   computing and network management layer performs service
   orchestration, resource management, routing measurement and computing
   OAM. In addition, the computing and network management layer could

   be used to perform the pre-configuration function and management
   function, which interacts with each functional layer.

   * Network resource layer: using the existing network infrastructure
   to provide network connection, network infrastructure includes access
   network, metropolitan area network and backbone network.

   Based on the five functional modules defined above, computing-aware

networking can realize the awareness, control and scheduling of computing and network resources, and further perform dynamic and on-demand service scheduling. The function of computing and network management layer may be realized by Alto or by opening interface with Alto server.

4. Deployment of CAN with ALTO

   With the development of edge computing, there is multiple services duplication deployed in different edge nodes. To improve the effectiveness of service deployment, the problem of how to choose optimal edge node to deploy services needs to be solved. More stable static information should be considered in service deployment, such as:

   * Network topology: the overall consideration of network access, connectivity, path protection or redundancy

   * The topology of computing resources: including the location and overall distribution of computing resources in network, and the relative position towards network topology.

   * Types of computing resources of edge nodes: such as CPU / GPU, etc

   * Location: the number of users brought, the differentiation of service types requested by users, etc

   * Location of edge nodes: for edge nodes located in popular area, which with large amount of users and service requests, the service duplication can be deployed more than other areas.

   * Capacity of multiple edge nodes: not only a single node, but also the total number of requests that can be processed by the resource pool composed of multiple nodes

   * Service category: different types of services require different computing resources. It's necessary to consider the e category of computing resources required by the services to deploy services. For example, whether the business is multi-user interaction, such as video conferencing, games, or just resource acquisition, such as

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   short video viewing Alto can help to obtain one or more of the above

information, so as to provide suggestions or formulate principles and strategies for service deployment.

For the collection of those information, second level or minute level frequency is enough, while serious real-time processing isn't necessary. For example, periodically collecting the total consumption of computing resources, or the total number of sessions accessed, to notify where to depoly more VMS or containers. Unlike the scheduling of request, service deployment should still follow the principle of proximity. The more local access, the more resources should be deployed. If the resources are insufficient, the operator can be informed to increase the hardware resources. Alto can be used to transmit information.

5. Scheduling of CAN with ALTO

Compared to the deployment, scheduling needs to consider more dynamic information to select and adjust the optimal (rather than the shortest) path in real timesuch as:

* Mobility: CAN schedules service request to the optimal service node among several service nodes near to users. So when user mobiles, the nearby service nodes changes and new scheduling are needed to chooses new path and new service node.

* Real time delay of network: network delay is always in the process of dynamic change, and more and more services propose strict time requirements, which is one of the most important factors affecting user experience.

* Real time status of computing resources: computing resources change frequently and the status of computing resources heavily affect the completion time of service, which is also one of the most important factors affecting user experience.

* Comprehensive status of network status and computing status: the update frequency of computing status and network status is different, it is necessary to generate a comprehensive value to reflect the status of them.

* Various service requirements: different services propose different service requirements on computing and network, including bandwidth, latency, computing resources etc, and the latency includes both transmission latency in network and processing latency in service node, for transmission-intensive services, the transmission latency accounts a lot , so the network latency of services are more important.

Availability of network or computing resources: such as temporary
unavailability caused by network equipment or service node failure.

Alto can still help collect real-time network and service node
information：

* Providing the best choice of network and service nodes. Based on
the collected network information, computing information, and service
requirements on network and computing, Of course, there are still
some real-time and complexity problems.

* Providing data analysis and policy distribution, real-time node
selection still depends on distributed routing, such as dyncast.

6. Summary

The converge of network and computing, as well as the interaction
with applications has become one of the current technical development
directions. This draft analyzes the development status of the
current computing aware network and the functional modules in its
architecture that can interact with Alto. As a protocol to connect
networks and applications, Alto may play a more important role.

7. Security Considerations

TBD.

8. IANA Considerations

TBD.

9. Acknowledgements

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10. Normative References

[I-D.li-dyncast-architecture]
          Li, Y., Iannone, L., Trossen, D., and P. Liu, "Dynamic-
          Anycast Architecture", draft-li-dyncast-architecture-00
          (work in progress), February 2021.

[I-D.liu-dyncast-ps-usecases]
          Liu, P., Willis, P., and D. Trossen, "Dynamic-Anycast

(Dyncast) Use Cases & Problem Statement", draft-liu-
dyncast-ps-usecases-01 (work in progress), February 2021.

   [RFC2119]   Bradner, S., "Key words for use in RFCs to Indicate
               Requirement Levels", BCP 14, RFC 2119,
               DOI 10.17487/RFC2119, March 1997,
               <https://www.rfc-editor.org/info/rfc2119>.

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