Consideration on Applying ICN to Edge Computing
draft-wang-icnrg-icn-edge-01

Abstract

   Aiming at research on applying Information Centric Networking (ICN)
   technology to Edge Computing, this document analyzes the reasons and
   opportunities of applying ICN to EC. As well, towards this end,
   technical considerations are described and relevant scenarios are
   shown in the document. Benefits of deploying ICN at edge is analyzed
   in the document.

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1. Introduction

   Information Centric Networking (ICN) takes significant technical
   revolution and fundamental change on communication and networking.
   It uses content/information centric networking to replace traditional
   address-centric networking which change the existing networking model
   essentially. It can also be regarded an Internet structure evolution
   from host-centric structure to data-centric structure which means
   accessing data by naming. This structure enables to make the data
   relating application more independent of its location and
   transmission method. What's more, security mechanism is based on
   information instead of host and the caching in forwarding process
   that promotes huge information transmission efficiently. It is very
   promising to apply ICN to some popular network architecture.

   Meanwhile, Edge Computing (EC) is becoming important network
   architecture because of its outstanding performance in real-time,
   reliability, security, etc. It deploys services on the edge of
   network to be close to consumers, and offers decentralized function
   to enable excellent properties in local computing, storage,
   connectivity and so on. At present, Edge Computing works broadly on
   IoT and industrial verticals such as Energy, Manufacturing, Smart
   City and Smart Grid.

   Therefore, it is worth attempting the possibility of using ICN on EC.
   ICN naturally supports decentralized caching, self authentication and

multicast that can enable EC deployment. The combination of ICN and
EC is able to offer a win-win approach and benefit mutually for
maximum performance. In the following sections, we will seek the
opportunities of applying ICN to EC, and outline the correlative
properties of both. The technical consideration of the approach and
relevant scenarios will be described as well.

2. Terminology

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 [RFC2119].

EC- Edge Computing, an network architecture that provides local
compute, storage and connectivity services

Other ICN related words used in this document are interpreted as
description in [ICNRG-Terminology].

3. Opportunitiesof Applying ICN to EC

3.1. ICN Enable Traffic Convergence

In traditional networks most typical service nodes are deployed in
centre, so the network flow are transferred from the centre to the
edge and downlink traffic is dominant. But as the IoT highly
developed, a large amount of devices are deployed on the edge, which,
therefore results in considerable uplink traffic. The requirement of
traffic service flattening requests the technique that is able to
make local communication for traffic convergence. This could be the
entry point of applying ICN to EC.

3.2. Functionality Complementary

Both ICN and EC possess some correlative properties, such as
decentralized deployment, local communication capacity, producing
abundant uplink traffic flow, etc. However, there are also some
other properties they posses respectively which are complementary.

For ICN, caching and forwarding are two basic functions which are
more about connectivity. But in practical cases, ICN node devices
such as gateways demand for light computing and storage functions as
well. Light computing and storage can make the network more dynamic,
flexible and enable some AI deployments as well. Fortunately, edge
computing is able to support storage and computing naturally. A
combination of both ICN and edge computing can be mutually benefitted
for maximum performance.

3.3. Practicality of ICN Deployment on Edge

   TCP/IP network model has been used for quite a while and is worldwide
   deployed now. No matter according to cost, difficulty, risk or other
   consideration, it is not realistic to deploy ICN on the whole
   network. However, the partial deployment of ICN can have a chance,
   such as ICN over IP or IP over ICN. Deploying ICN on edge service
   not only can help to mitigate the ICN whole-network deployment
   complexity, but also makes the network model more flexible.

4. Technical consideration of applying ICN to Edge Computing

4.1. Optimizing EC Network Disconnection Solution

   In some scenarios that the network is not able to offer end to end
   communication such as power failure or natural disasters that could
   result in the interruption of the network and other local
   disconnections problems. Often such failure can cause a series of
   accidents and even chain reaction, resulting in the loss of
   enterprises and production. In the case, edge computing enable to
   supply service which is closer to the edge of data generation and
   business control deployment, making the computation much closer to
   the data source. Even if the network fails to get connected, the
   device can rely on local networks for data communication and
   processing.

   However, (a) sometimes the data stored on the edge is "staleness" due
   to incapacity of updating timely. This could result in the mistake
   or staleness data transmission. (b) Furthermore, the storage space on
   edge is limited. For instance, it is not able to update new content
   if there is no spare space when storage on edge which normally is
   small storage capacity, is full. This can also cause the (a)
   problem.

   In ICN network, the content is cached along the path it delivery. So
   the objective content can be from the source node or the other
   content caching nodes. When the network is disconnected, the caching
   content or data in decentralized nodes can be used in edge computing.
   Caching algorithm of ICN is able to solve two problems stated in
   previous paragraph by updating data efficiently and dynamically.
   This benefits from the caching replacement policies of ICN. The
   policies, such as LRU or LFU, provide mechanism how long or how often
   the data will be updated. Therefore the data is either the newest or
   the most popular. Decentralized content caching of ICN strengthens
   EC network disconnection solution and make more flexible networking.

4.2. Reducing Traffic Congestion

   In IoT industry, there are a huge number of devices deployed on the
   edge which result in a significant amount of uplink flow traffic. In
   EC, the prominent quantity of traffic is easy to cause traffic
   congestion.

   In ICN network, the data content not only from the source node, but
   also it is cached in other nodes along the delivery path. So when
   the edge node request the data, it is not necessary to deliver data
   from the source node. For instance, in the figure, if node 1 is
   source node. When node3 requests data from node1, the content will
   be cached in both node A and node B. So next time when node4 needs
   the same content data, node B will deliver it, and vice versa. In
   the case, the traffic is not from node1(source node) to node3 or
   node4 anymore, but mainly from A to B. Therefore, ICN decentralized
   content caching enable traffic convergence.to reduce traffic
   congestion.
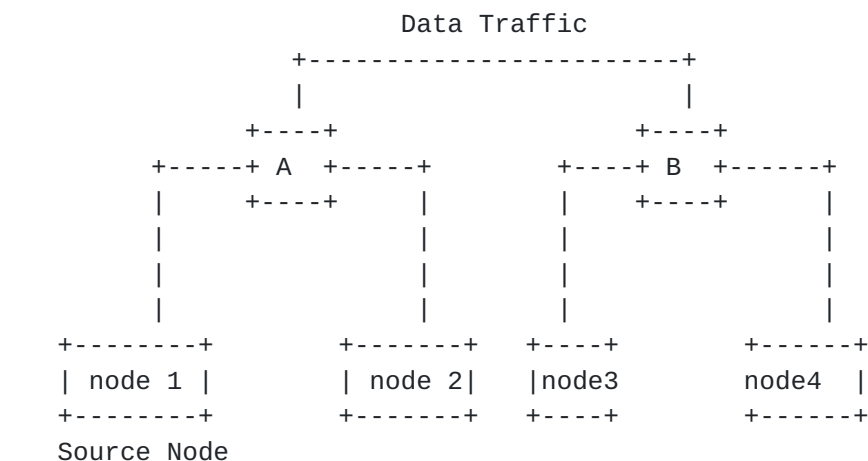
```
                           Data Traffic
                 +-------------------------+
                 |                         |
            +----+                     +----+
         +-----+ A  +-----+         +----+ B  +------+
         |     +----+     |         |    +----+      |
         |               |         |               |
         |               |         |               |
         |               |         |               |
      +--------+     +-------+   +----+         +------+
      | node 1 |     | node 2|   |node3          node4  |
      +--------+     +-------+   +----+         +------+
       Source Node
    Figure 1


                  Traffic Convergence in ICN
```

4.3. Security Consideration of Using ICN

   Security problem is crucial and urgent to the EC applications.
   Firstly, there are many devices on edge are exposed to users which is
   easy to be attacked. Secondly, although authority level on edge is
   lower than host and cloud, there are more people can get access to
   the devices and application. This is in consideration of the
   consumer convenience and deployment flexibility. Hence, application
   and services are vulnerable on edge.

Instead of binding security to host node, ICN advocates the model of trust in content. This offers host-independent security mechanism which focuses more on securing information object and content trust. It means host attack no more can interfere edge application. Furthermore, self-certify names model of ICN enable to verify the binding between public key and self-certify name in distributed system without relying on a third party. This can reduce the security risk of involving a third party.

4.4. Content Centric Networking values edge devices

No matter ICN or CCN, they all promote content centric communication model. Independent from host node, naming on edge node gain more valuation on edge devices.

4.5. Partial deployment of ICN on Edge

In consideration of cost and complexity of deploying ICN, it is not necessary to use ICN in the whole network. ICN using on edge is enough to highlight its advantage. Furthermore, there can be a corporation between ICN edge service and IP network.

5. Reverse and Cooperation with CDN

Content Delivery Network (CDN) system, based on IP, composes a couple of servers that deliver content to a user, based on the geographic locations of the user, the origin resource and the CND server nodes. Normally, the resource is distributed in a downlink traffice in figure2.

However, in a ICN network, resource or origin node is not the central node anymore. An edge device can be the origin node that provides the resource which is delivered to ICN servers, and further distributed to the receiver nodes. As a consequence, the routing is from edge to central, or there will be an uplink traffic. This just reverses the CDN Mechanism, which is shown in figure3.

Therefore, deploying ICN network at edge that pulls the requested data from resource edge node to the servers can cooperate with CDN network. An ICN/CDN server is anticipated to translate the protocol between both and deliver the data to the receiver nodes which can be ICN network or IP network.
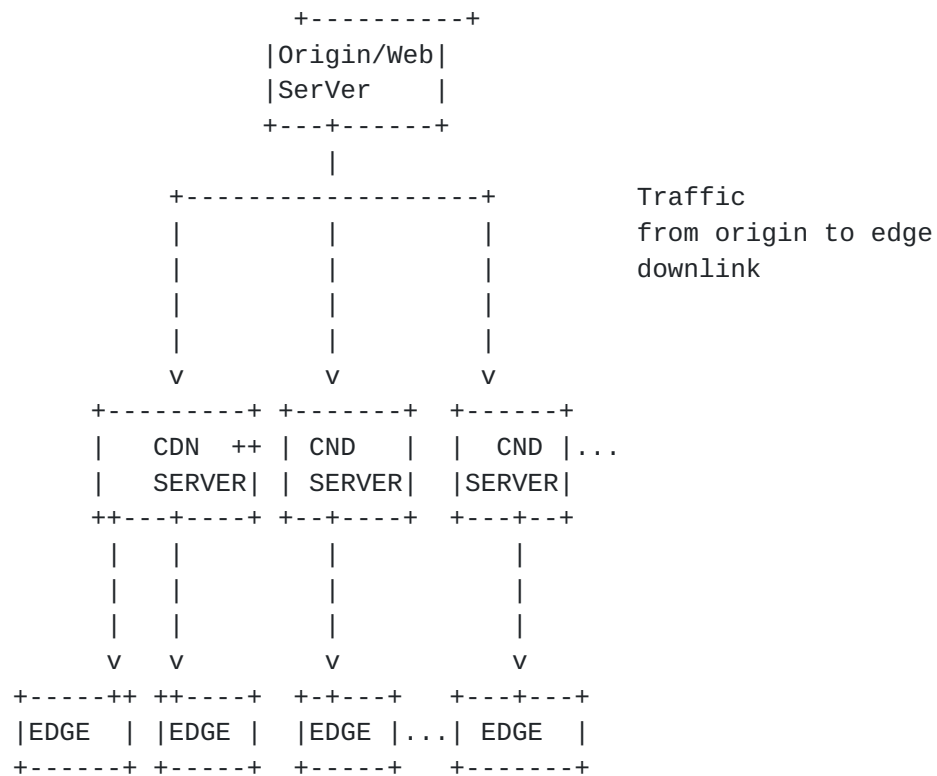
```
                    +----------+
                    |Origin/Web|
                    |SerVer    |
                    +---+------+
                        |
              +-------------------+       Traffic
              |        |          |       from origin to edge
              |        |          |       downlink
              |        |          |
              |        |          |
              v        v          v
         +---------+ +-------+  +------+
         |  CDN  ++ | CND   |  | CND  |...
         |  SERVER| | SERVER|  |SERVER|
         ++---+----+ +--+----+  +---+--+
          |   |         |           |
          |   |         |           |
          |   |         |           |
          v   v         v           v
      +-----++ ++----+  +-+---+   +---+---+
      |EDGE | |EDGE |  |EDGE |...| EDGE  |
      +------+ +-----+  +-----+   +-------+
```

    Figure2 CDN Mechanism

                                  ICN/CDN SERVER deliver data to
receivers

```
                    +----------+              +------+
           +---------->+ ICN/CDN SERVE+---------->+Receiver
           ^          |         |  |           +Node--+
           |          +----------+   |
           |                         |          +------+
           |                         +---------->+Receiver
       +----+-----+                             +Node--+
       | ICN server
       +-+--------+
         ^        ^
         |        | Traffic from Edge to ICN server
         |        | uplink, reversed CND
         |        |
      +---++   +-+--+
EdgeNode|Origin |   |
        |Resource|   |
       +----+   +----+
```
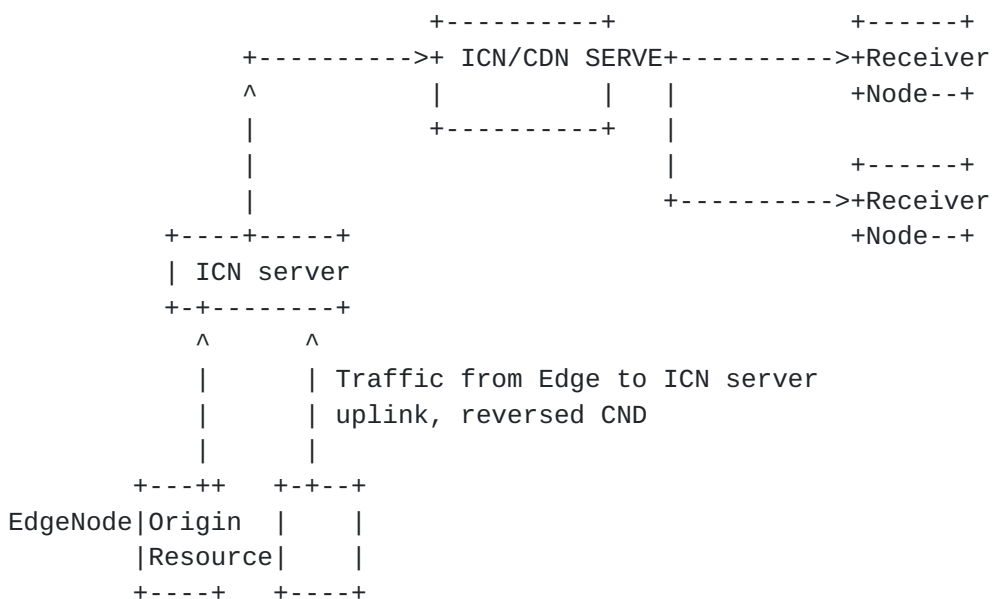
Figure3 ICN Mechanism

6. Conclusion

This draft described the correlative properties of ICN and EC to
analyze the opportunity of applying ICN to edge computing. The
traffic uplink flow model is the entry point of this research. We
could see ICN deployment is beneficial to EC by combining the
outstanding performances of both. Furthermore, a win-win model is
schemed in the document by means of mutual complementing. However,
there are still challenges on deploying ICN on edge such as high
speed mobility, fast context resolution and so on. These questions
need to be answered in the future.

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