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On the Content Retrieval In Information-Centric Network
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Abstract

Information-Centric Network(ICN), as an emerging network architecture, focus on delivering content more efficiently. This brief paper discusses some issues about content retrieval in the Information-Centric Network. It first lists a set of basic requirements on the basis of previous literatures. Then, it tries to identify the fundamental functionalities required to satisfy the foregoing requirements. Last, it summarizes the implementation status of such functionalities in various Information-Centric Network architectures.

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1. Introduction

Information-Centric Network (also known as content-oriented network [CON], data-oriented network [DON], or name-based network [NBN]) is a new communication paradigm which puts the content at the center of the network architecture. It is motivated by the mismatch between the increasing demand for highly scalable and efficient distribution of content and inefficiently content delivery of the traditional host-centric communication paradigm.

Content distribution, including file sharing and media streaming, has contributed to the ever-increasing Internet traffic nowadays. Content consumers, in general, are more concerned about what content they want than where that content resides. Unfortunately, current Internet is based on a host-centric communication paradigm where a consumer has to specify where the content is and the network only can deliver the content from the specified source to the consumer. Moreover, it is usually difficult to exploit many superior technologies, such as multicast, k-anycast, etc.

To overcome the aforementioned issues, several Information-Centric Network designs have been proposed. In these designs, each content is given a unique name which is not associated with its location. Consumers can use the content name to request the content which they intend to get. More importantly, all the routings are based on the content name, which enables the request to be routed to any potential content sources. Moreover, many technologies, including content replication, caching, k-anycast etc., can now be used to achieve faster content retrieval.

Although the Information-Centric Network is considered as a promising way to solve the aforementioned issues, ICN is still a work in progress and there is a long way to go for standardizing it. This paper tries to list a set of basic requirements and fundamental functionalities for content retrieval in ICN. We hope this work will benefit the design of ICN.

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].

Content original provider: an end entity that publishes and provides the content.

Content consumer: an end entity that wants to retrieve a content.

Content holder: any entity that has a complete copy of the content (including provider, router, cache, and other devices which hold the content).

Content name: every content is given a unique name. Content consumer requests the content by specifying its name rather than its location.

3. Requirements of content retrieval

To provide efficient content delivery, several requirements should be satisfied:

1. Persistency and unique content name. Each content should be given a unique name. This name should be valid as long as the corresponding content is available. In other words, the content name should not be changed no matter where it is.

2. Availability. Availability means the content should be reachable at all times with low-latency. Replication can be used to guarantee availability, and the network is responsible for finding the nearby copies which have low-latency.

3. Failure recovery. End-to-end communication is often disrupted due to the endpoint mobility and link/router failure. These disruptions should not disturb the content delivery.

4. Authenticity. Any communication entities, including router, end-device, application, etc., can verify whether the content comes from the authenticated source.

5. Bandwidth efficiency. Since the volume of content is huge, appropriate technologies should be used to minimize bandwidth consumption.

4. Fundamental functionalities for content retrieval

The requirements listed above are the most important ones. More requirements will be added further. To satisfy these requirements, several fundamental functionalities should be provided:

1. Content name resolution. Name resolution service translates content name into network location. In ICN, multiple content holders can provide the same content. The requests should be directed to the intended content holder according to some policies, such as lowest delivery latency, minimum bandwidth utilization, etc.

2. K-anycast. K-anycast is a communication model which allows K servers to cooperate with each other to accomplish content delivery. With k-anycast, the network can deliver the content much faster and provide quick failure recovery.

3. Multicast. Multicast can be used to deliver content to all the content consumers interested in the content. It can effectively save the network bandwidth.

4. Content replication. Content can be stored in end-hosts according to some off-line replication policies. Well-designed replication policy can reduce the content retrieval time.

5. In-network cache discovery. In-network caching is considered as one of the most significant properties of ICN. To fully utilize the caches, however, the network needs a mechanism to discover the caches.

5. Summary

This section summarizes the implementation status of the aforementioned fundamental functionalities in different ICN projects. In this draft, EU FP7 projects, US NSF projects and some academic projects are compared.

5.1. Content name resolution

SAIL/4 WARD	A Multilevel Distributed Hash Table (MDHT) is used to establish a global resolution system.
PSIRP/PUIRUIT	Following a pub-sub communication model, a rendezvous system is employed to notify the appropriate content holder to send content to the requested consumers.
CONVERGENCE	Dedicate Name-System-Nodes (similar to DNS) are deployed.
TRIAD	An Internet Relay Protocol (INRP) is designed to perform name-to-address conversion in TRIAD by using the routing information maintained by relay nodes.
COMET	A content resolution function is used to resolve content names to content properties.
COAST	Search engine is used to partially provide content name resolution service.
Postcards from the Edge	A File Name Resolution System is employed to resolve file names to potential cached locations.
MobilityFirst	A Global name resolution service (GNRS) is developed for Globally Unique Flat Identifier (GUID) to Network Address (NA) mapping. The GNRS is implemented based on DHT between routers.
NDN	Packets are routed based on the content name instead of resolving the content name to an underlying address.

5.2. k-anycast and multicast

SAIL/4 WARD	Different chunks are retrieved from different locations via several concurrent HTTP connections.
PSIRP/PUIRUIT	Forwarding Identifier (FID) is used for source routing. Multiple FIDs can be integrated to form a multicast tree.
CONVERGENCE	Traditional point-to-point sessions between two upper layer entities can be supported by coupling the upper layer entities with named-service-assess-points. This functionality can be extended to support multicast.
TRIAD	The EXPRESS single-source model of multicast can be supported.
COMET	NOT MENTIONED.
COAST	Multicast can be achieved through an Information Overlay.
Postcards from the Edge	Multicast trees are set up by using a Rendezvous Point (RP).
MobilityFirst	Multicast GUID are mapped to multiple consumers by GNRS.
NDN	Since PIT(Pending Interest Table) includes the set of interfaces over which Interests have arrived, multicast functionality can naturally be supported.

5.3. Content replication

SAIL/4 WARD	The content, called Information Objects (IOs), can be stored in the NetInf architecture to speed up content retrieval.
PSIRP/PUIRUIT	The most popular objects are replicated to different k storage devices by using a greedy algorithm.
CONVERGENCE	Multiple replica nodes can be provisioned as Content Delivery Network.
TRIAD	Content are replicated at multiple sites and DNS lookups will be redirected to the nearby site.
COMET	Replication can be supported. However, no concrete scheme is proposed.
COAST	The content may be stored/cached at the Information Overlay or at the lower hierarchy layer.
Postcards from the Edge	Replication can be supported. However, no concrete scheme is proposed.
MobilityFirst	The global GUID-NA mapping information are replicated in k different ASes.
NDN	Replication can be supported. However, no concrete scheme is proposed.

5.4. In-network cache discovery

SAIL/4 WARD	The cache information is advertised in local area.
PSIRP/PUIRUIT	The cache which is on the content request path can be used.
CONVERGENCE	The cache which is on the content request path can be used.
TRIAD	The cache which is on the content request path can be used.
COMET	The cache which is on the content request path can be used.
COAST	The cache discovery can be achieved by an Information Overlay.
Postcards from the Edge	A Caching Service Protocol is developed, which exchanges the cache information between different Cache-and-Forward Nodes (CNFs).
MobilityFirst	Delay-Tolerant Networking (DTN) liked Caching and forwarding design is proposed.
NDN	The cache which is on the content request path can be used. Cache can also be discovered through flooding content request.

6. IANA Considerations

This document makes no request of IANA.

7. Security Considerations

Security issues are not discussed in this memo.

8. References

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