Named Data Networking:
A realization of information centric networking

The Internet is no doubt one of the greatest technological inventions by mankind. At the heart of its hourglass shaped architecture is a simple yet versatile and elegant network layer implementation, the Internet Protocol, more famously known as IP. Since the Internet's invention, which is more than 50 years ago, much innovation and iterations have been made on the transport and application layer, while IP has stayed the same. It is the key of the Internet's success, but it is also the root cause of many problems.

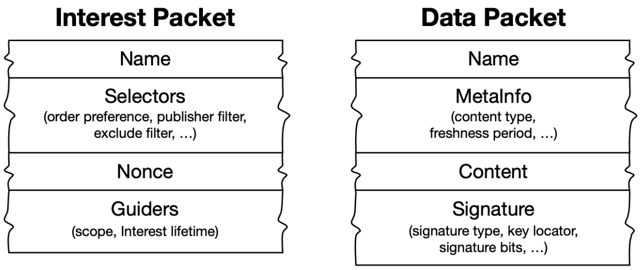
From naming entities to naming packets

IP's most important design concept is Packet Switching: as long as the two end entities in the network have been identified, data sent by either party can be encapsulated into packets that route to the other. Under such a design, the "client-server" model is naturally developed, and it is still the dominant model used today. However, with the development of decentralized technologies such as the blockchain, and with the growing demand in distributed applications such as social-networking, a centralized "client-server" model is becoming less desirable. People want a distribution network. Information Centric Networking (ICN) is thus proposed. Instead of identifying the end entities, ICN suggests identifying each data packet, while entities simply ask for that specific named data.

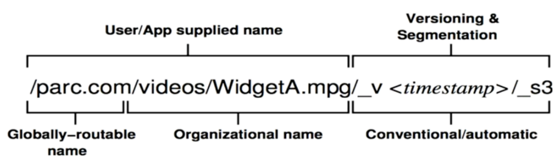
Named Data Networking - what is it, how does it work?

Named Data Networking is an implementation of ICN. On the high level, when an entity needs a specific chunk of data from the network, it broadcasts its need in a interest packet. Whichever entity in the network that is able to satisfy the need will send the data back. This seemingly straightforward workflow actually has many details that need to explained.

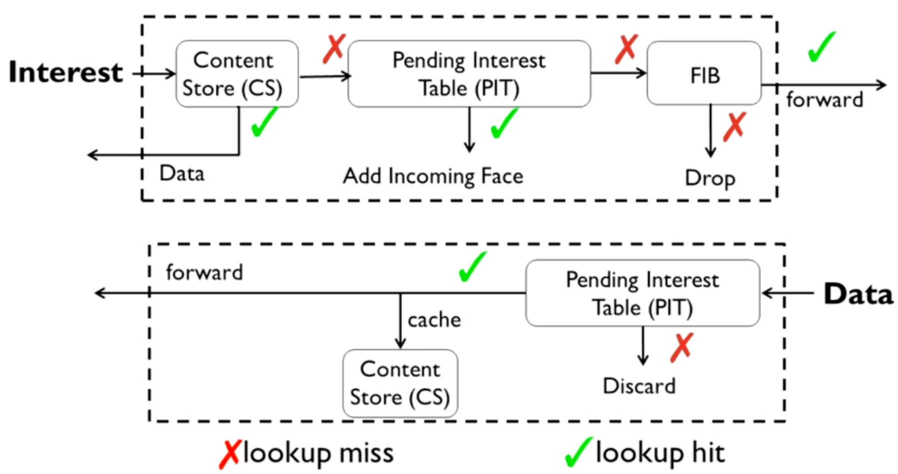
First, there are two main types of packets, an interest packet and a data packet. An interest packet has four fields: 1. Its name, which not only identifies the packet itself, but also contains information about the requester and the requested data; 2. A selector, which enables the requester to filter out unwanted or malicious data; 3. A Nonce; 4. Guiders, containing information such as the interest's lifetime. A data packet has four fields as well: 1. Its name, which has similar functions as an interest packet's; 2. Meta info; 3. Signed info, which encrypts the data and contains important information for the packet receiver to verify the security related facts of the data; 4. The data itself. (NDN, 2021)



The name of either packet is no doubt the most essential part of it, and the process of creating such a name by an entity is called Naming. Naming are performed by applications, and the final name is transparent to the network layer. Names can vary a lot depending on the usage of the packet, for instance, the names below specifies a video segment and a certification revocation record respectively (Tianyuan, 2022).



After defining the packets, the entities in the network must know what to do with them. Since NDN is a distributed network, nodes and routers are no longer separated. Their responsibilities are combined, forming the entities in a NDN network. A sample entity processes packets as the following.



In short, if an entity receives an interest packet, it will take three procedural steps. First, if the data requested, which can be obtained from the packet's name, is cached in the local Content

Store, the entity simply returns the data. If not, it adds the interest to a Pending Interest Table (PIT), and check whether it can route the interest packet to the next entity based on its own Forwarding Information Base the name of the packet. Finally, it either drops or forward the interest packet. On the other hand, if an entity receives a data packet, it determines whether another entity requested it by looking up in its PIT, and simply discards the data or forward it to the requester entity. An additional step that needs to be taken on PIT hit is to cache the data. (NDN, 2021) What used to be merely routers in the traditional IP architecture now have more responsibilities and necessary computation to perform during data transfer. This design is not seem possible in the early days when the Internet was just invented due to a lack of clients and computation power. However, nowadays, with the exponentially growing number of connected nodes in the network, NDN's design utilizes this opportunity to create a more efficient distributed network.

How can we use NDN?

NDN has its own GitHub repo, which contains all the components needed to build a local small NDN network, and it can be accessed from: https://github.com/named-data/ndn-cxx. This is a complete C++ implementation, while there is also a python NDN client implementation: https://github.com/named-data/python-ndn. Since building the application layer from scratch may not be desirable for most users, there are also many pre-constructed frameworks that can be easily integrated into the applications. For instance, NDNoT is an IoT framework that "aims to create an open environment where IoT applications and different services can easily cooperate and work together" (Zhiyi, 2021). (https://github.com/named-data-iot) It can run on the RIOT operating system and on Arduino compatible hardware, and it has been tested on Expressif ESP32 boards.

References:

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2. Zhiyi Zhang, Edward Lu, Yanbiao Li, Lixia Zhang, Tianyuan Yu, Davide Pesavento, Junxiao Shi, and Lotfi Benmohamed. 2018. NDNoT: a framework for named data network of things. In Proceedings of the 5th ACM Conference on Information-Centric Networking (ICN '18). Association for Computing Machinery, New York, NY, USA, 200–201. https://doi.org/10.1145/3267955.3269019
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