Faster Content Distribution with Content Addressable NDN Repository

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I. Problem

Primary usage of Internet has shifted from point-to-point conversations to content distribution. Named Data Networking (NDN) [1] is an emerging future Internet architecture that transforms data into a first-class entity. NDN network supports universal caching, such that each router can opportunistically cache data, which could be used to satisfy a later request.

The effectiveness of universal caching relies on data naming. A router can satisify an Interest (request) with a cached ContentObject (data packet) only if their names match. The cache could not be used if the same data is published under a different name.

While data name should be the same if the data refers to the same block in the same file, there are many cases that the same data has a different name. (1) When a file is updated, the name will contain a different version marker [2]; a modified version of a text file is likely to share common blocks with its previous version. (2) When a file is included in an uncompressed tape archive (.tar), its data blocks will appear in the tape archive which have a different name prefix. (3) When certain web content is published as several formats, the different representations (such as HTML / plain text / RSS) may share common blocks.

In all these cases, NDN router cannot satisfy the Interest from the cache, and the Interest has to be served by the producer. If identical blocks under different names can be found, at least in the neighbor scope, we can save some bandwidth, and shorten download completion time.

II. Solution

We propose the following enhancement to NDN repository, so that identical blocks in neighbor scope could be found and serve download requests.

To publish a file:

1) The publisher segments the file using Rabin fingerprints [3], in order to maximize the possibility of having identical blocks with other files / versions.
2) The publisher puts into the repository not only the file segments, but also a metadata. The metadata contains SHA256 hash of every segment, and the metadata ContentObject is signed by the publisher.
3) The repository stores ContentObjects by the name defined by publisher. In addition, the repository maintains an index of ContentObjects keyed by the SHA256 hash of Content payload.
4) The repository responds to Interests `/%C1.R.SHA256/<hash>` if it has a Content with that hash. The ContentObject in reply could carry any signature, including using a ”nop” signature algorithm.

To retrieve a file:

1) The consumer fetches the metadata, and verifies that it trusts the signature on the metadata.
2) The consumer expresses Interests for hashes contained in the metadata. The scope of those Interests should be limited to local area network (scope=2).
3) For each segment received in reply to a hash Interest, the consumer must compute a SHA256 hash over its payload, and verify the compute hash equals to the requested hash. It's unnecessary to verify the signature on those ContentObjects. Such a segment can be trusted, because it has a hash contained in the metadata, and the metadata is signed by the publisher.
4) After a short wait, for any segments not satisfied by hash Interests, the consumer expresses Interests under the regular file name.
5) When all segments are retrieved by either hash Interests or normal Interests, the consumer reassemble the file.

References

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[2] “Ndnx basic name conventions.” [Online]. Available: http://named-data.net/doc/0.1/technical/NameConventions.html

[3] A. Muthitacharoen, B. Chen, and D. Mazières, “A low-bandwidth network file system,” *SIGOPS Oper. Syst. Rev.*, vol. 35, no. 5, pp. 174–187, Oct. 2001. [Online]. Available: http://doi.acm.org/10.1145/502059.502052