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Caching Support for Low-Latency Communication using ICN

Motivation

Information-Centric Networking (ICN) [1] and Named-Data Networking (NDN) [2] bring a new concept into computer networking where the data instead of the endpoints of a connection is addressed. Instead of sending a request to a specific server, the user can send out a request (interest) for a specific piece of information. The network then handles the request, routing the interest towards the information producer. The producer then returns the information (data packet) to the user/client with the help of forwarders distributed across the network. These forwarders also offer the possibility of caching the forwarded data in their content stores for a short time so that subsequent requests may be served quicker, minimizing the load on the network.

Such load optimization is interesting in the context of Time-Sensitive Networking (TSN), which requires low and deterministic latencies with high reliability and redundancy. Caching of less critical data could result in lover overhead and better guarantees for highly critical traffic which depends on tight latency bounds. However, caching introduces additional delay to communication, as packets can be stored for an undefined period at the content stores.

Your goal will be to investigate the impact of caching duration on latencies in a TSN scenario using the EnGINE Framework [3,4]. EnGINE already provides configuration support for NDN caching, however it and the utilized implementation of the NDN forwarder will need to be extended for this work. You will need to consider best- and worst-case interest arrival times, as well as different packet arrival rates. In addition, we will seek to expand this evaluation to the concept of LL interests introduced in [5]. The outcome should include guidelines on cache configuration, as well as a thorough assessment of its impact on the network, focusing on producer-consumer latencies and network load.

Your Tasks

- Propose and implement optimizations for NDN forwarder to enable sub-millisecond caching durations, extending caching support
- Investigate caching duration and its impact on latency in a TSN scenario using the EnGINE Framework [3,4]
- Define boundaries within which caching can be feasible for various TSN traffic classes

Requirements

- General knowledge of computer networking
- Good understanding of C and C++
- Knowledge of ICN/NDN and Ansible is a plus, but can be learned during the thesis

References

[1] Dirk Kutscher, Suyong Eum, Kostas Pentikousis, Ioannis Psaras, Daniel Corujo, Damien Saucez, Thomas C. Schmidt, and Matthias Wählisch. 2016. Information-Centric Networking (ICN) Research Challenges. RFC 7927.
[2] Lixia Zhang, Alexander Afanasyev, Jeffrey Burke, Van Jacobson, kc claffy, Patrick Crowley, Christos Papadopoulos, Lan Wang, and Beichuan Zhang. 2014. Named Data Networking. SIGCOMM Comput. Commun. Rev. 44, 3 (jul 2014), 66–73.
[3] Rezabek, Filip, Marcin Bosk, Thomas Paul, Kilian Holzinger, Sebastian Gallenmüller, Angela Gonzalez, Abdoul Kane et al. "Engine: Flexible research infrastructure for reliable and scalable time sensitive networks." Journal of Network and Systems Management 30, no. 4 (2022): 74.
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[5] Marcin Bosk and Jörg Ott. 2024. Towards Domain-Specific Time-Sensitive Information-Centric Networking Architecture. In 4th International Workshop on Time-Sensitive and Deterministic Networking (TENSOR), co-located with IFIP Networking 2024.

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