

SCARI: A Strategic Caching and Reservation Protocol for ICN

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ABSTRACT

The point-to-point resource reservation solutions over IP networks are often end-to-end, and data flowing through these reserved tunnels are not reusable. As a result, the in-network resources are not optimally utilized. Information Centric Networking (ICN) has several properties that can more intelligently facilitate resource reservations. In this paper, we present Strategic Caching And Reservation in ICN (SCARI) for reserving resources on ICN networks. Preliminary simulation results indicate that SCARI can reduce bandwidth consumption and free up network resources by aggregating reservation requests and strategically caching content in the network.

CCS CONCEPTS

• **Networks** → **Network protocol design; Network performance evaluation; Network simulations;**

KEYWORDS

Named Data Networking, Network Bandwidth, Reservation

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1 INTRODUCTION

Today's Internet applications, such as large scientific applications, streaming video applications, CDNs, and others that require various guarantees from the network such as dedicated bandwidth, a limited amount of jitter or packet loss, cannot rely on IP's best-effort service model. Any congestion or packet loss using TCP/IP can dramatically reduce transfer performance [1], leading to missed deadlines and wasted resources. Due to the dynamic change of the traffic and contention for resources, the only way to reasonably guarantee transfer deadlines is to reserve dedicated resources.

Currently, end-to-end channels with reserved bandwidth are created using protocols built on top of RSVP [4]. However, the current model of resource reservation is cumbersome and inefficient. A user trying to reserve bandwidth requires to know the data source and the destination. They need to make sure the chosen source

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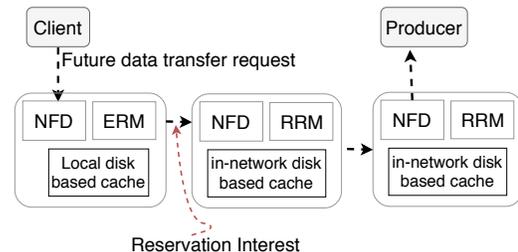


Figure 1: Reservation Communication Overview.

and the destination are optimal in terms of capacity, need to know the operational details of the network and its capacity. From the network's point-of-view, there is also no way to reuse content from end-to-end flows even if multiple channels share the same path and retrieves the same content.

In this work, we present a new protocol for Strategic Caching And Reservation in ICN (SCARI). Similar to RSVP [4] SCARI contains a signaling mechanism that sets up in-network state for upcoming data transfers. But unlike RSVP, SCARI operates on per name-prefix basis and takes into consideration ICN's in-network caching capabilities. Using Named Data Networking (NDN) for our prototype implementation, simulation results show how SCARI enables hop-by-hop reservation of in-network resources such as bandwidth and in-network disk-based caches.

To the best of our knowledge, this is the first work that explores resource reservation in the context of NDN. While the motivation for our work came from deadline based large scientific data transfers [2, 3], our protocol is intended to be generic.

2 PROTOCOL OVERVIEW

SCARI's architectural design is shown in Figure 1. Each router has a reservation manager (RM). Two types of reservation managers are used; (a) reservation managers located on end nodes (ERM), and (b) reservation managers located on router nodes (RRM).

The RRM track available resources, reserve resources according to incoming requests, aggregate reservations if they are temporally close, and strategically cache content if the requests are not temporally close (what qualifies as "temporally close" depends on the local policy). ERMs perform all services that RRM perform and also act as a liaison between the network and the applications. In addition to reserving resources, ERMs translate client requests to reservation Interests that then forward upstream.

A reservation Interest for content under namespace `/xrootd` might look like this: `</xrootd/reservation/</data1/dataSize/startTime/deadline/bandwidth>`.

If enough resources are available, the RRM on a router reserves resources and forwards the Interest upstream. If not enough resources are available, the network returns a NACK along with the

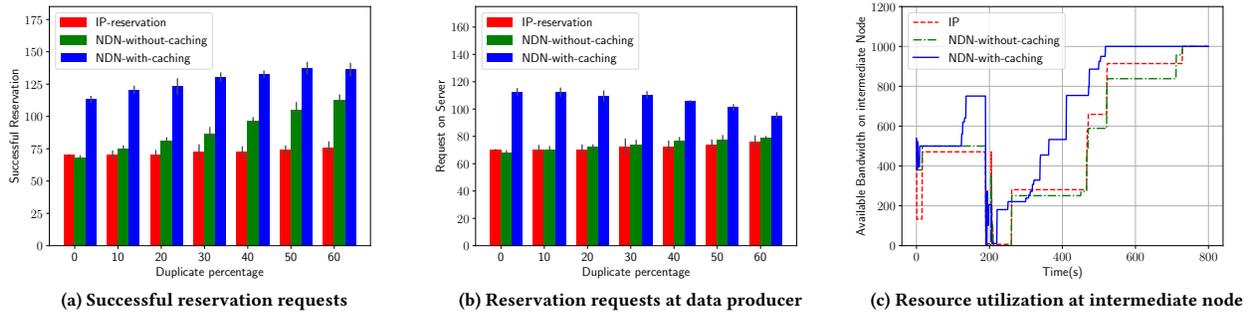


Figure 2: Preliminary Performance Results.

reason for failure. This message may also include a hint for the client and the ERM when they should try again. The failure reason may report if a request exceeds allotted quota, resources are not available, or other higher priority requests must be satisfied. On receiving the NACK the application and an ERM decide together what to do next. They might reduce the amount of requested resources or try the reservation at a later time. Each RM maintains a reservation table at the forwarding strategy layer. This table keeps reservation states based on name prefixes and allows SCARI to deduplicate reservation requests. Currently, SCARI supports two types of reservations:

- **Bandwidth Reservation** Nodes reserve the appropriate amount of downstream bandwidth for future incoming Data Packets under a namespace.
- **Caching Reservation** Nodes reserve space in the network caches to reduce bandwidth consumption.

3 EVALUATION

We use a simple topology shown in Figure 3 in ndnSIM to evaluate SCARI. We randomly pick two hundred requests from a real scientific data access log, and then randomly but equally divide the requests between our two clients. The size of the chosen files varies between 5 MB and 4.1 GB. For creating duplicate requests, we substitute some of the second client’s requests using randomly chosen requests from the first client’s request set.

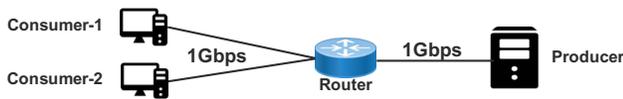


Figure 3: Evaluation topology for SCARI

Figure 2a shows the number of successful reservation requests. Since IP must reserve bandwidth on all the nodes along the path up to the server for each request, the number of successful reservations remains constant around 70 (out of our 200 requests) even when many reservation requests are duplicates. SCARI can aggregate temporally close reservation requests, so the number of successful reservations grows as the number of duplicate requests increases. With 60 percent duplicates, the number of successful reservations

grows to 110 (out of 200) for NDN-without-caching. With caching, 140 (out of 200) reservation requests could be satisfied, effectively doubling the number of reservations compared to IP.

SCARI also benefits data producers. In Figure 2b we find an equal number of requests reach the data producer both for IP and NDN-without-caching requests, but the number of reservations that NDN-with-caching can accommodate is much larger. This is due to the fact that the intermediate router does not have enough bandwidth and therefore rejects most of the reservation requests before they reach the data producer in IP and NDN-without-caching. With caching, the intermediate node can release the previously reserved bandwidth when it can cache the content; trading storage for bandwidth frees up resources so that other reservation requests can go through.

SCARI also benefits the network by reducing bandwidth consumption at the intermediate nodes. Figure 2c shows the amount of available bandwidth over time at the intermediate router with 60 percent duplicate reservation requests. We find that both NDN scenarios, with and without caching, use less bandwidth compared to IP, which means the network can support more data flows using the same amount of bandwidth.

4 CONCLUSION

In this work, we presented the design of SCARI, a strategic caching and reservation protocol for ICN. Our simulation results show SCARI aggregates requests and efficiently frees up available bandwidth by utilizing in-network storage. Leveraging the properties of ICN, SCARI demonstrates how ICN can be used for applications requiring reservations to achieve their performance requirements.

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