Savant: Aggregated Feedback and Accountability Framework for Named Data Networking

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Introduction

Problems:
- No accounting or accountability in ICN architectures.
- Content distributed from trusted and untrusted infrastructure.
- Cannot determine ISP performance.
- Cannot adapt to failures.
- Cannot detect misbehavior.
- Cannot bill customers.
- Cannot track audiences.

Feedback: is the information returned to a content provider so that future on- or in-progress operations can be monitored, supported, altered, or corrected (e.g., QoE, buffering time, buffering ratio, rendering quality, end-user engagement (e.g., content views, advertising impressions), user demographics (e.g., geographic location and device type), etc.).

Accountability: is the willingness of trusted or untrusted communicating entities to produce accurate and verifiable information about the content distribution process. Accountability is the ability to establish integrity, provenance, availability, and non-repudiation in the accounting information received.

The Savant Framework

- Savant pushes primary responsibility for accounting out to the NDN caches and NDN clients (collectively referred to as NDN agents).
- The content ingestion process prepares content for distribution to many different users, devices, and networks, performing tasks such as transcoding, resolution conversion, encryption, and adding metadata.
- The metadata specified during ingestion identifies the content provider. This helps the NDN agent establish contact with the closest available accountability engine responsible for collecting information for that content provider.
- The accountability engine is composed of geographically dispersed infrastructure located close to the end-user (similar to CDN infrastructure). It has primary responsibility for collecting, aggregating, and validating published feedback and accountability information collected from NDN agents.
- The configuration manager installs/installs aggregator functions, manages the publication of key/value pair attributes and aggregator function output for collection by accountability engine infrastructure. Both the accountability engine and NDN agents run a configuration manager and aggregator functions.

Aggregator Functions [2]

- Based on event processing languages.
- Run queries continuously as new data arrives.
- They filter, summarize and publish metadata from content that satisfies specific attributes.
- Monitor for patterns of complex events notifying interested parties on occurrence (e.g., frequent content)
- Turn off accountability
- What feedback information collected, the frequency to collect it, and how to aggregate data returned.

Use Authenticated Interests [3] to commands and authentication tags (i.e., digital signatures or message authentication codes (MACs)) to NDN Interests to support applications efficiently running commands on remote futures.

Named Data Networking: Natural Support for Accountability [4]

- Strong public/private key pairs to nodes to: key
- Trust, integrity and provenance can be established in published NDN content.
- Hash function e.g., SHA-256
- Digital signatures
- Deterministic inputs and outputs (Interests and Data)

Savant Accountability Framework [1][3][4]

- Log entry \( \ell_i = (\ell_i, s_i, v_i, c_i) \)
- Recursive hash value \( h_i \), sequence number \( s_i \) always increasing, type (e.g., Interest or Data) and type specific content \( c_i \) (e.g., message id=message)
- Authentication \( \alpha_i = (s_i, h_i, c_i) \) attached to each message sent, signed by the private key \( \ell_i \).
- Accountability engine collects authenticators for both agents
- Separate hash chain maintained for each communicating node. Also a separate set of authenticators.
- Authenticators are cumulative (similar to RCA [1]).
- Consequently, a certain amount of privacy can be maintained between NDN agents.
- Logs are tamper evident.
- \( \ell \) contains accounting information e.g., QoE, bitrate, etc.

Savant: Accounting and Accountability Collection from ingress/egress/ISP cache or NDN cache

- Amazon Elastic Compute Cloud (EC2) micro-instance machines (i.e., Ubuntu-12.04.3 64 bit; memory; 51.34MB and disk: 8GB).
- Modified NDN Video Client to publish accounting events as it receives and renders video content from the NDN Video Server [8]:
- Measured the following accounting metrics (i.e., a subset of metrics from Conviva [1] study on the impact of video quality on end-user engagement): time-frame, session duration, buffering rate of buffering events and average bitrate.
- Scalability: we extrapolated that Savant could support 104 busy concurrent NDN agents for each Amazon EC2 micro-instance using only about 61% of network resources used by one NDN Video [6] content distribution session.

Future Work

- Enhance accountability
- Enhance accounting
- Analyses in larger environment

References


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