The Power of Prediction: Cloud Bandwidth and Cost Reduction

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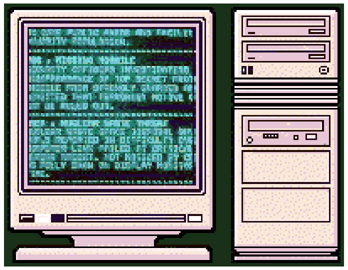
Traffic Redundancy Elimination (TRE)

Traffic redundancy stems from downloading same or similar information items.

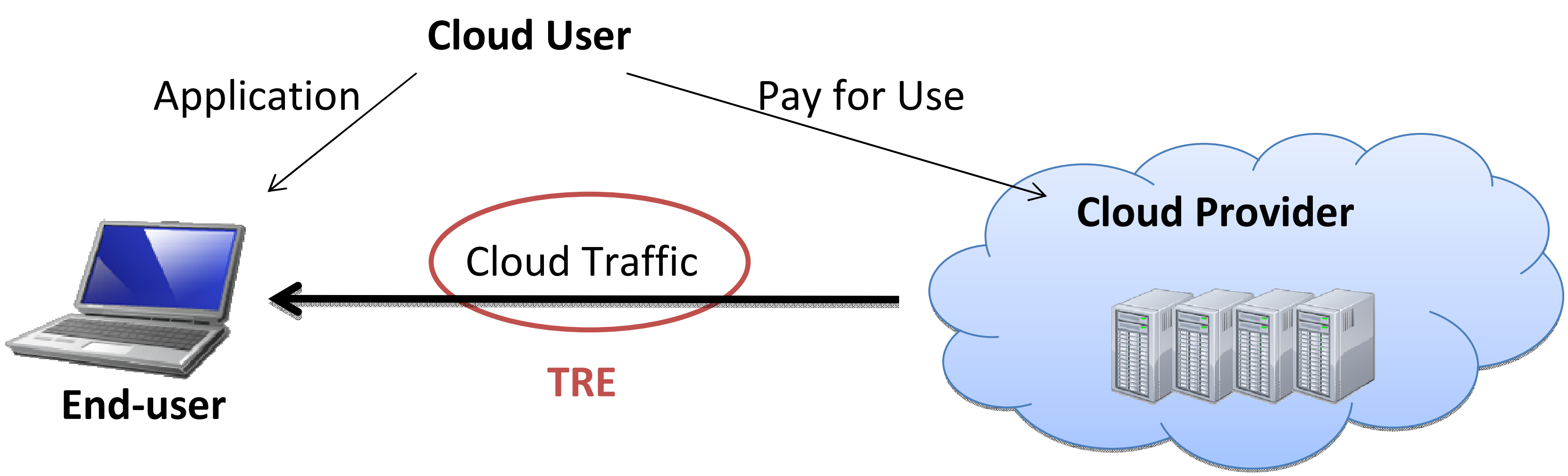
We found around 70% redundancy in end-clients traffic, compared with past traffic and local files.



TRE Importance

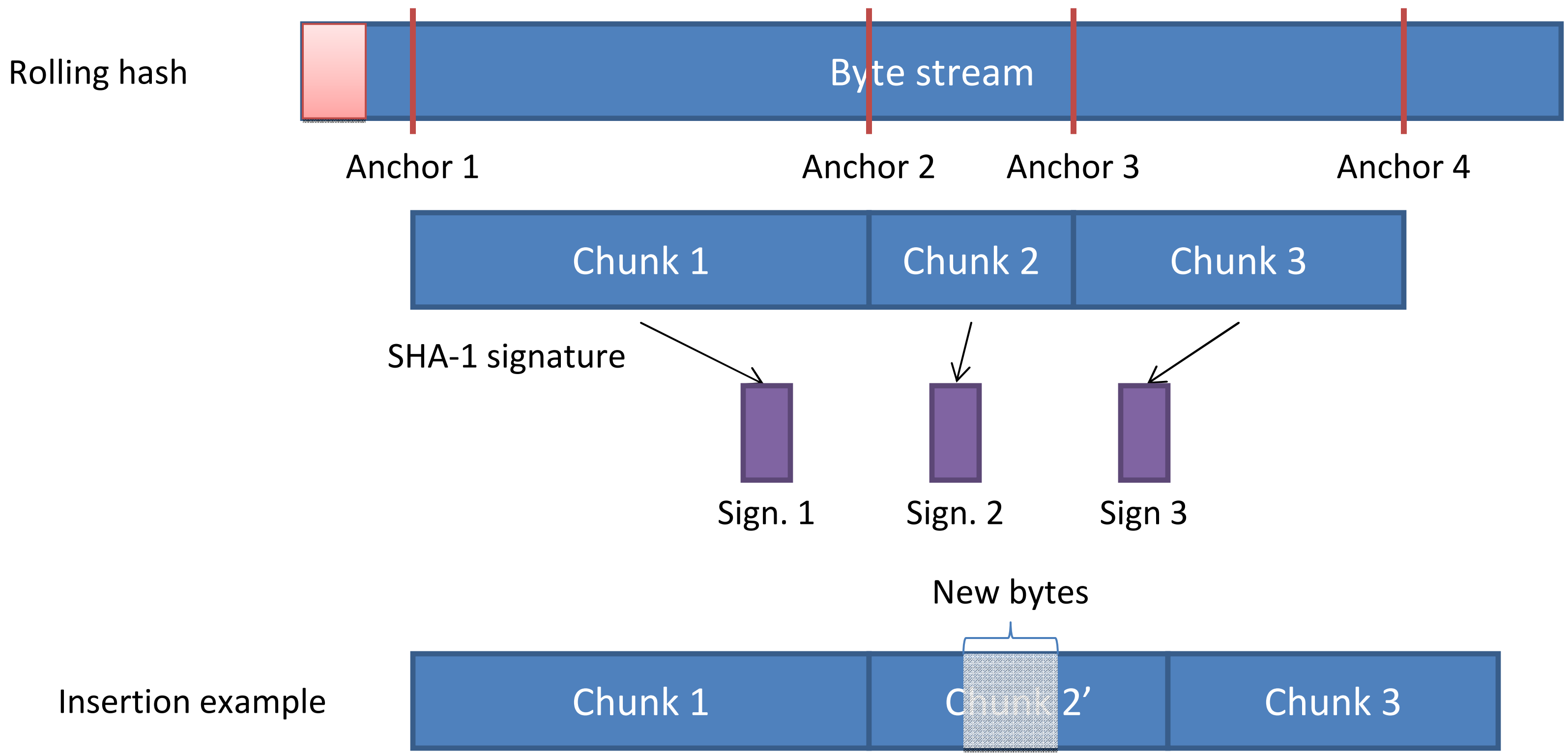
Moving to the cloud => higher e2e traffic.

Cloud users pay for traffic used in practice => incentive to use TRE.



How TRE Works

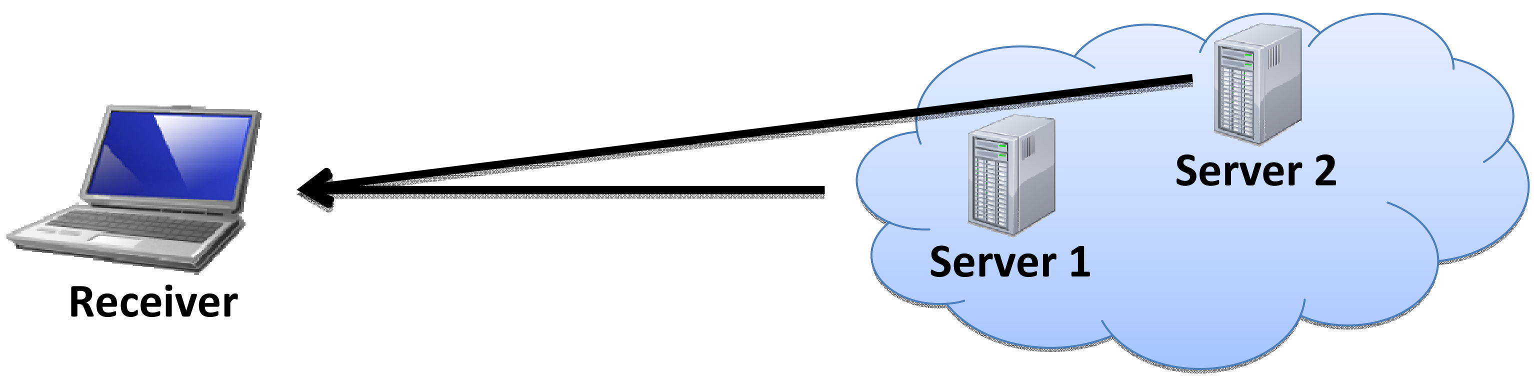
Server parses the outgoing stream to content-based chunks and signs with SHA-1



Problems in Existing Solutions

In the cloud environment:

1. High processing costs in the cloud.
2. Scalability – remember each client.
3. Elasticity - unaware of data from other sources.
4. Do not handle long-term repeats (days/weeks).



Our Solution: PACK (Predictive ACK)

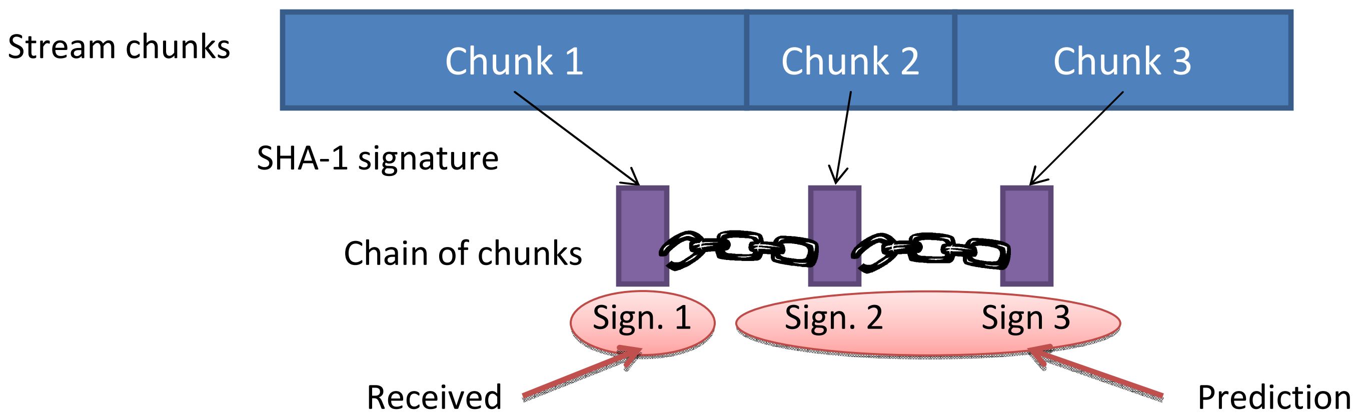
Redundancy detection by the client.

Repeats appear in chains.

Tries to match incoming chunks with a previously received <u>chain</u> or local file.

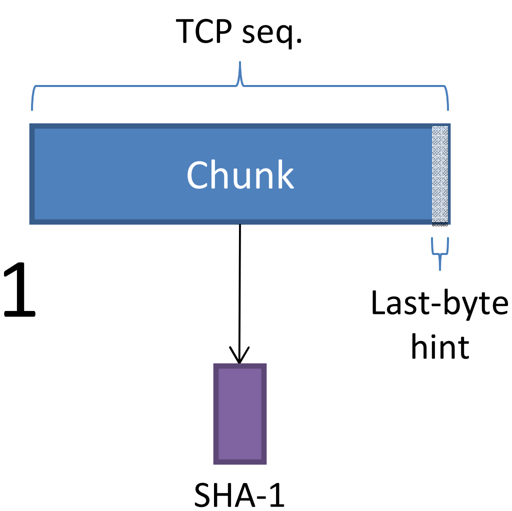
Sends to the server <u>predictions</u> of the future data.

PACK: The Client Prediction



Each prediction:

1. TCP seq. – no server parsing
2. Hint – spare unnecessary SHA-1
3. SHA-1 signature



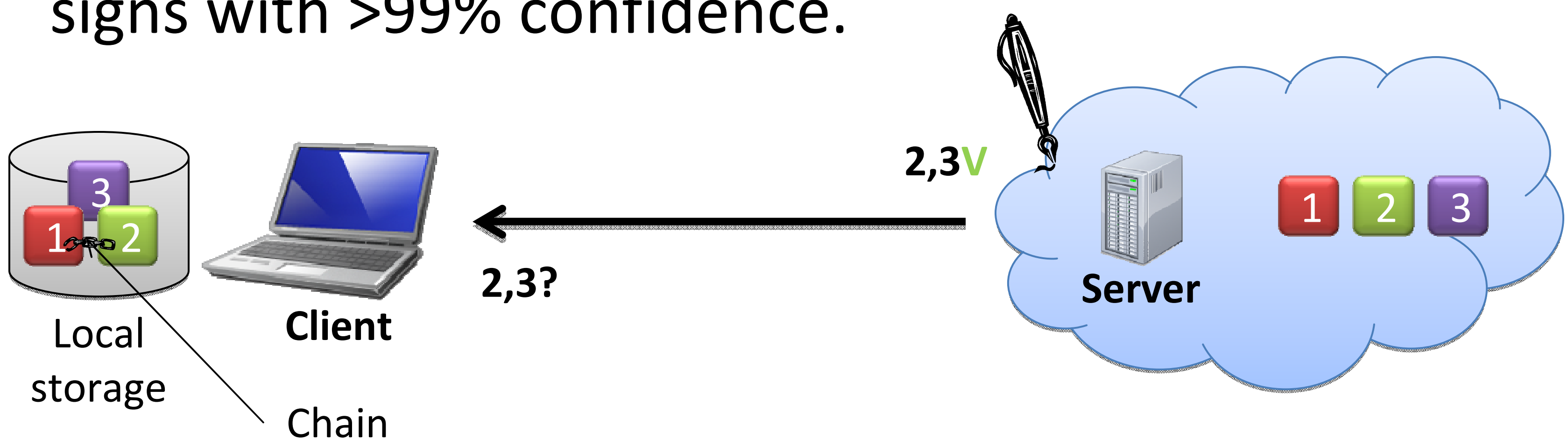
PACK: Server Operation

The server compares the hint with the last-byte to sign.

Upon a hint match it performs the expensive SHA-1.

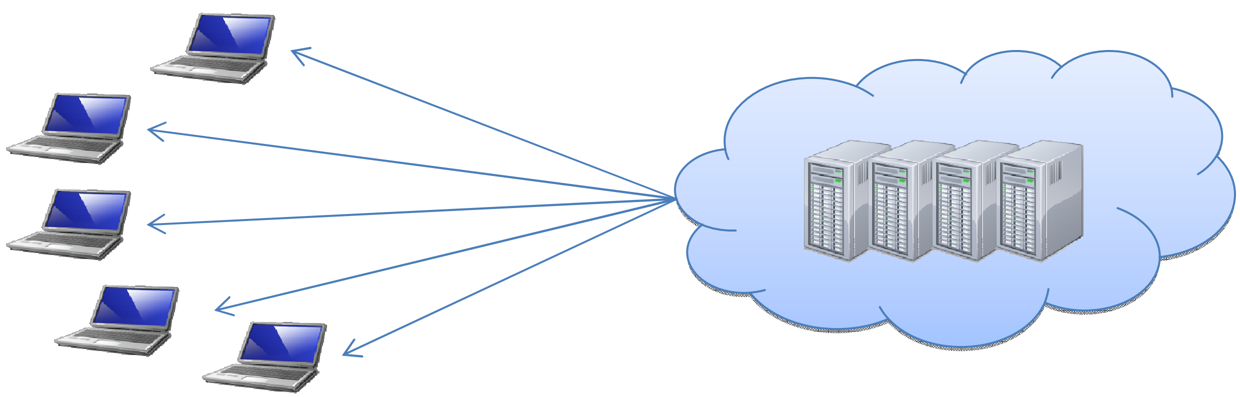
PACK saves cloud's computational effort in the absence of redundancy.

First receiver-based TRE: the server does not parse. It signs with >99% confidence.



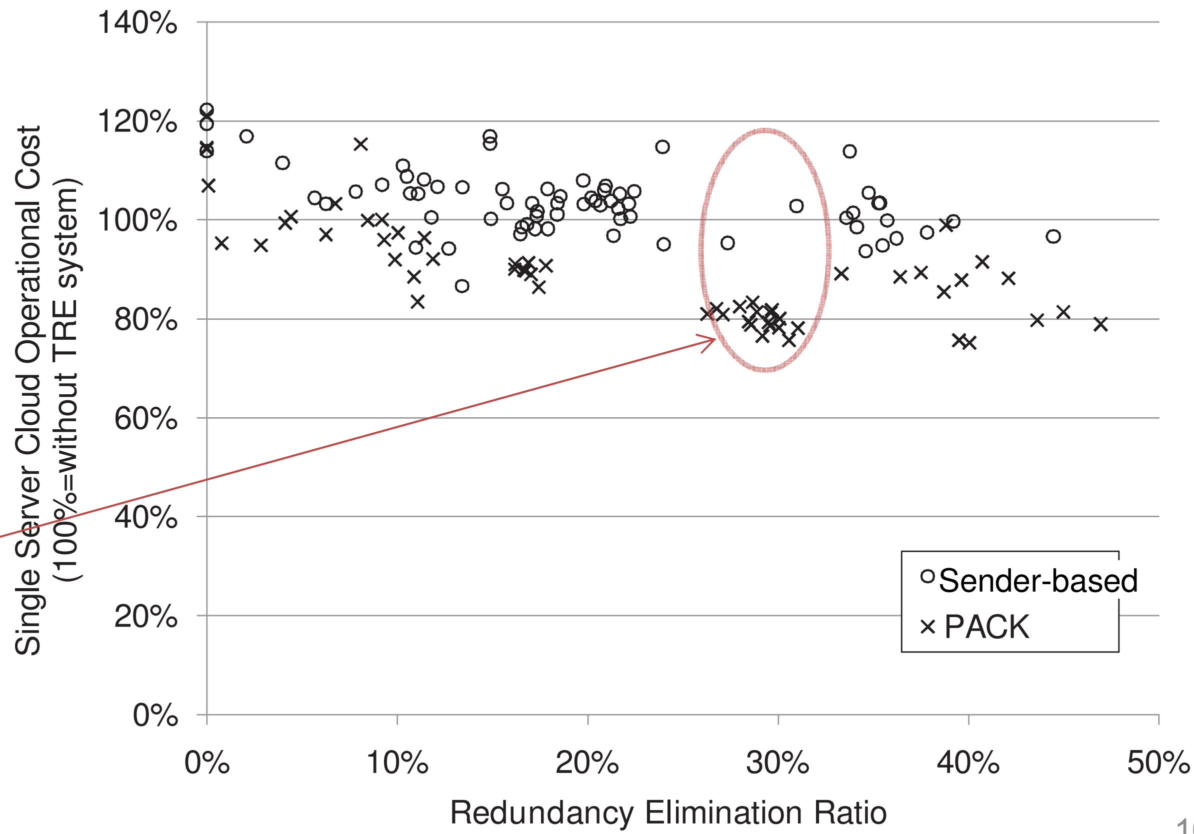
PACK Benefits

- Minimizes processing costs induced by TRE.
  - Signs with SHA-1 in the presence of redundancy.
- Receiver-based end-to-end TRE => suitable for cloud server elasticity and client mobility.
  - Does not require the server to continuously maintain clients' status.



Server Effort Experiment

Several data-sets in 3 modes: baseline no-TRE, PACK and a sender-based TRE.

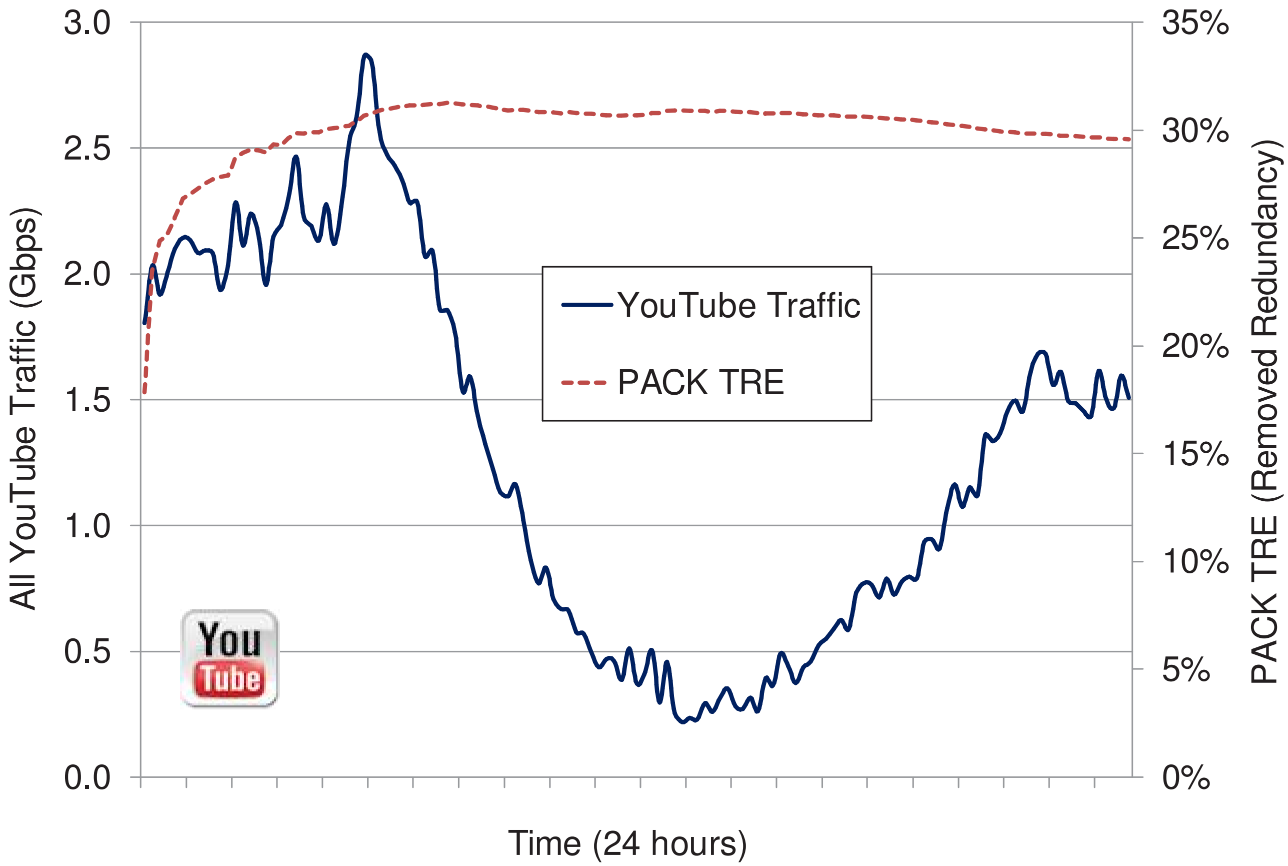


25%-30% redundancy: common to many data-sets

YouTube Redundancy

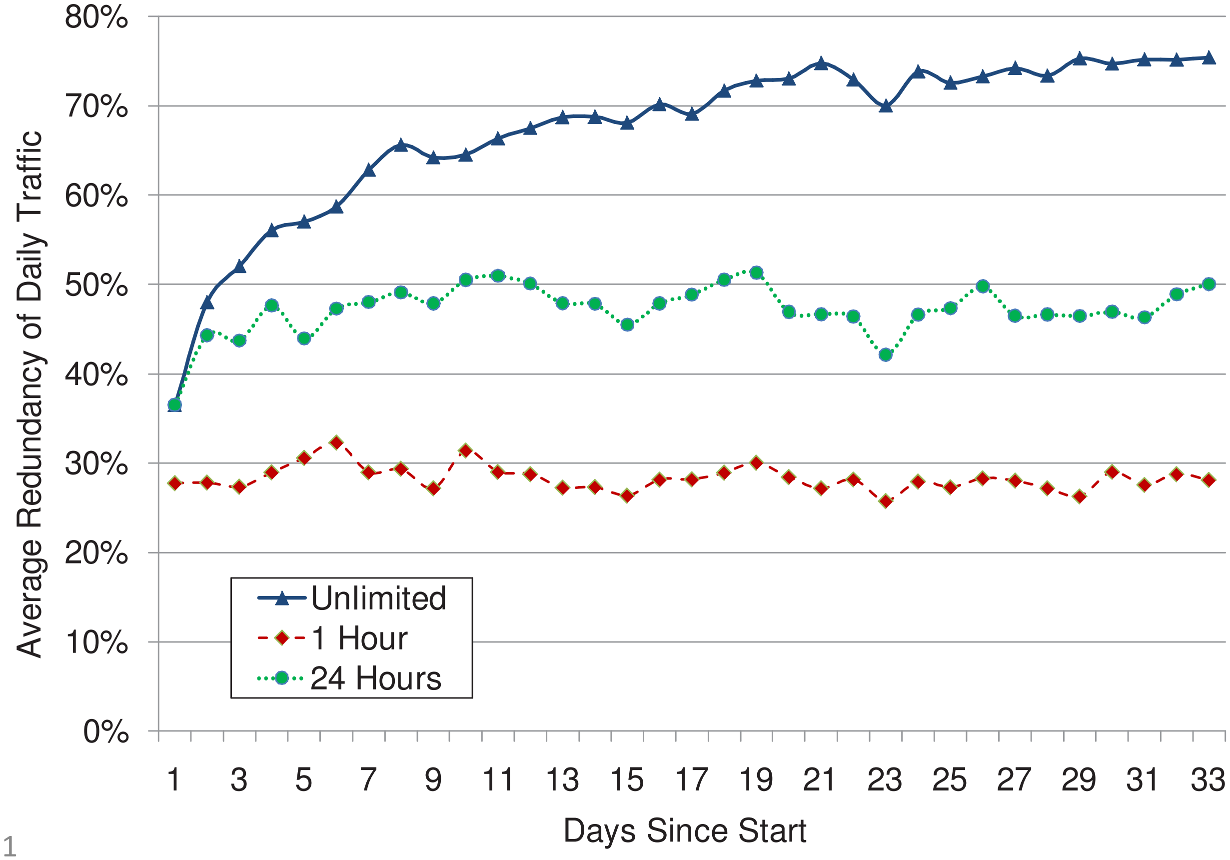
Traces of 40k clients, captured at an ISP.

Found 30% end-to-end (personal) redundancy.



Long-Term TRE

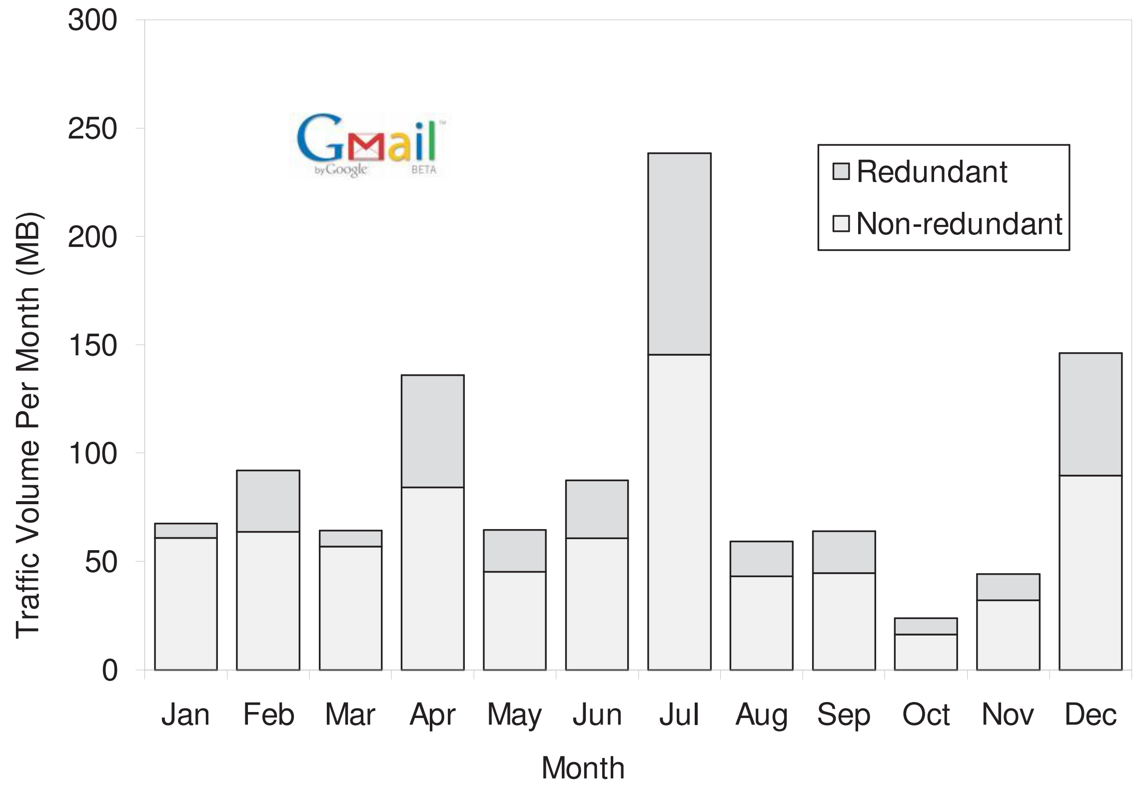
Social network: eliminated <u>30%</u> with one hour cache and <u>75%</u> with a long-term cache.



Cloud Email Redundancy

Gmail account with 1,000 Inbox messages.

Found <u>32%</u> static redundancy (higher when messages are read multiple times).

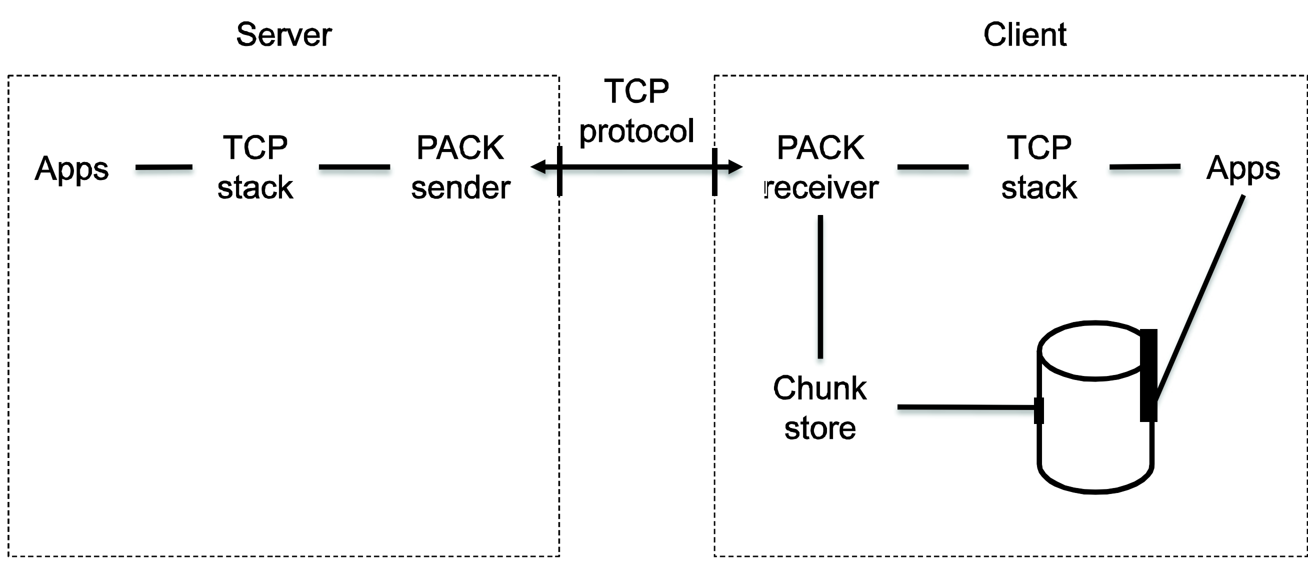


Implementation

Linux with Netfilter Queue, 25k lines of C and Java, available for download.

Receiver-sender protocol is embedded in the TCP Options field.

Transparent use at both sides.

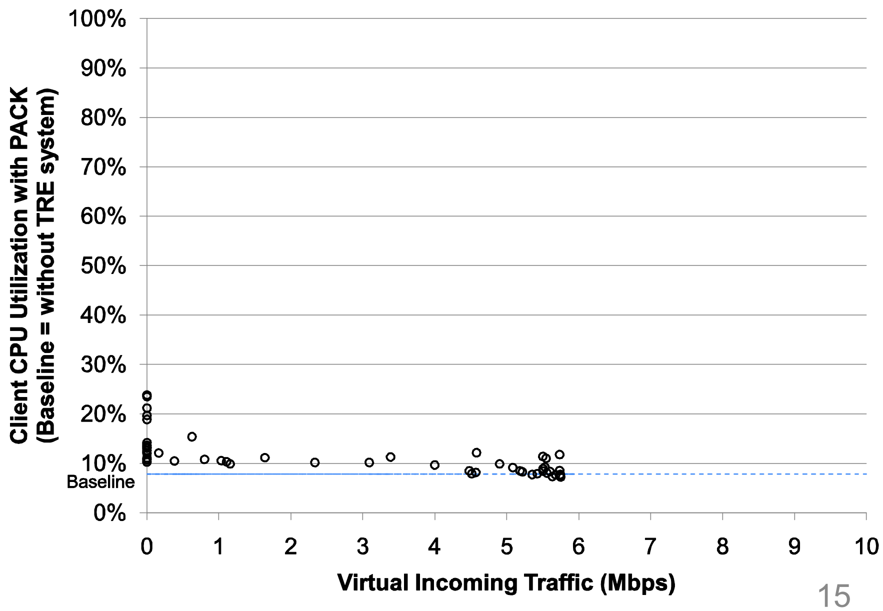


Processing Effort in the Client

Laptop experiment: PACK-related CPU consumption is ~4% when playing HD video (9 Mbps with 30% redundancy).

Smartphone experiment: PACK consumes ~3% of the battery power when processing 1 GB video (avg. monthly data plan).

<u>Virtual</u> traffic saves the client the need to chunk or sign.



New Chunking Algorithm

Most existing solutions use Rabin fingerprint.

Proc. 8 PACK chunking algorithm

1. $mask \Leftarrow 0x00008A3110583080$ {48 bytes window; 8 KB chunks}
2. $longval \Leftarrow 0$ {has to be 64 bits}
3. **for all** byte $\in$ stream **do**
4.   shift left $longval$ by 1 bit {lsb $\leftarrow$ 0; drop msb}
5. $longval \Leftarrow longval$ bitwise-xor $byte$
6.   **if** processed at least 48 bytes **and** ($longval$ bitwise-and $mask$) $==$ $mask$ **then**
7.   found an anchor
8.   **end if**
9. **end for**

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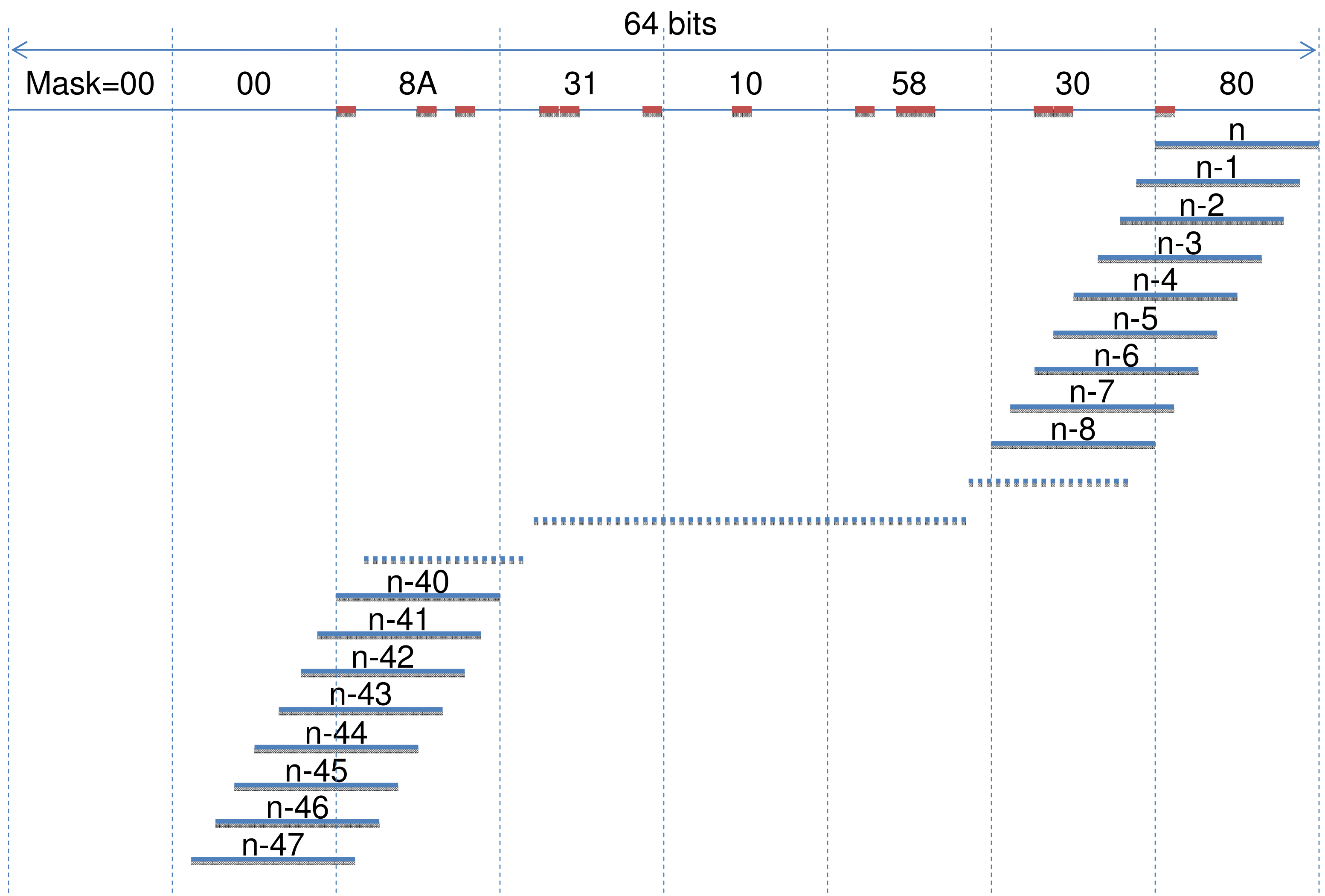

Summary

Current TRE solutions may not reduce cloud cost.

PACK is the first receiver-based TRE – leverages the power of prediction.

Minimizes processing costs induced by TRE.

Suitable for cloud server migration and client mobility.

Implementation is available for download.