CombiHeader: Minimizing the Number of Shim Headers in Redundancy Elimination Systems

Sumanta Saha,
Andrey Lukyanenko and
Antti Ylä-Jääski
Aalto University School of Science, Finland
(Formerly, Helsinki University of Technology)

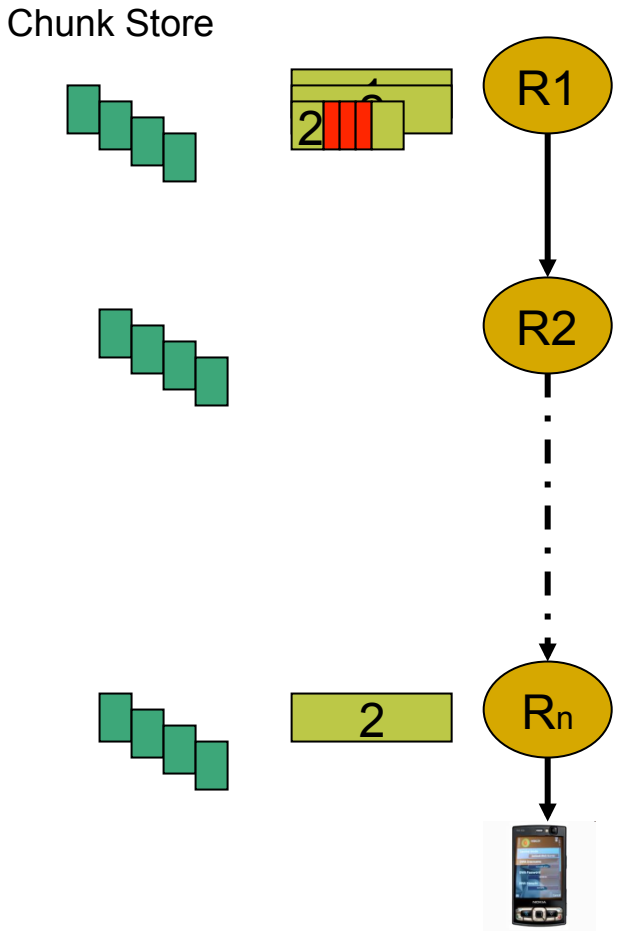
Outline

- Redundancy elimination systems
- Finer vs. coarser chunk size
- CombiHeader algorithm
- Proof-of-Concept implementation
- Evaluation
- Summary

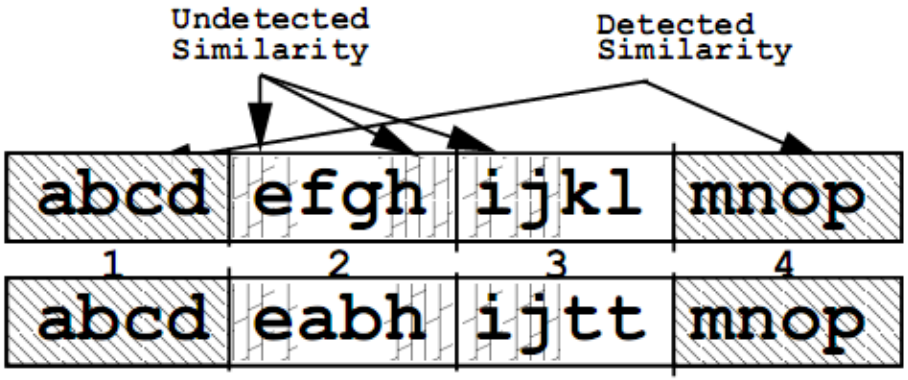
Redundancy Elimination Systems

- Redundancy Elimination (RE) systems work on packet payload level
  - Chunks the payload using Rabin Fingerprinting
  - Content based
  - Application independent
- The idea is complementary to traditional caching
  - Aims to remove redundant content from upstream nodes to downstream
- Eliminates duplicate traffic when traditional caching fails

Redundancy Elimination Systems



Finer vs. Coarser Chunk Sizes



- With coarser chunk size there is always a possibility of missing possible matching regions
- Finer chunk sizes have more protocol overhead
- The proposed algorithm, CombiHeader, uses an adaptive method to dynamically choose the best chunk size
- Please refer to the paper for a mathematical interpretation

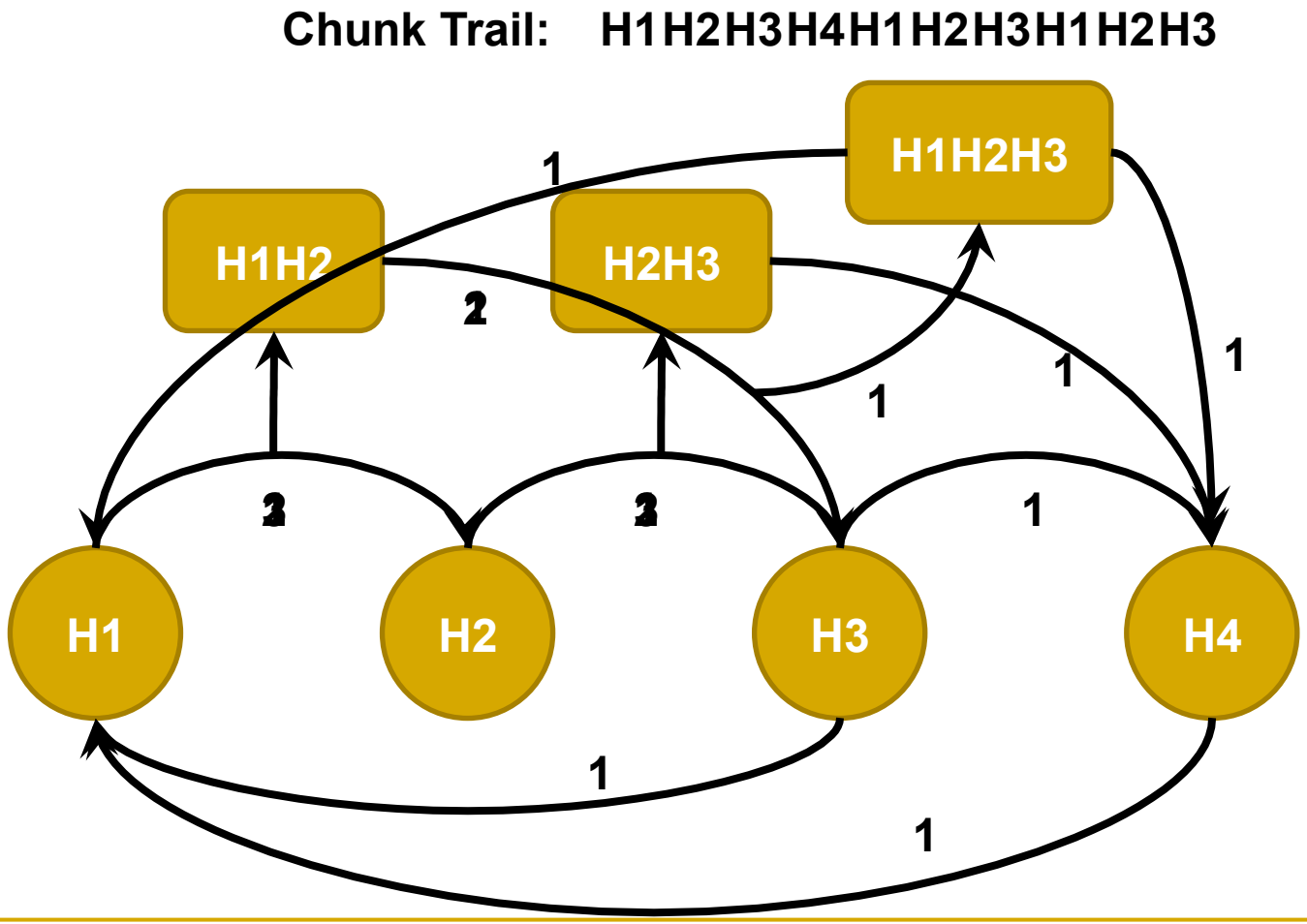
CombiHeader

- We need a dynamic system to adapt to the content type, and chunk popularity to get the best out of it
- CombiHeader works on chunk popularity to generate bigger chunks out of smaller ones
- Optimized to deliver least memory access while matching to the largest chunk possible

Algorithm 1 Pseudocode of CombiHeader algorithm

```
if current chunk is cache miss then
    if miss streak = 1 then
        Update last seen Combi and Elementary node
        Create new complex CombiNode if possible
    else
        Clear last CombiNode and transmit it
        Update last seen elementary node
    end if
    Transmit full text of current chunk
else
    if miss streak = 1 then
        Start fresh, clear last seen CombiNode
        Do not transmit anything
        Buffer current chunk as last seen elementary
        miss streak← 0
    else
        Update last seen elementary node
        Try to create new CombiNode with (Last CombiNode, current Node)
        if Try failed then
            Transmit and clear last CombiNode
        else
            Do not transmit anything
            Complex CombiNode is accumulating chunks to transmit
        end if
    end if
end if
```

CombiHeader



CombiHeader

Insertion of CombiHeaders to the outgoing stream

Trail:	h1h2h3h4h1h2h3h1h2h3h5										
Last elementary:	h1	h2	h3	h4	h1	h2	h3	h1	h2	h3	h5
Last CombiNode :	-	-	-	-	-	h1h2	-	-	h1h2	h1h2h3	-
Cache hit/miss :	M	M	M	M	H	H	H	H	H	H	M
Insert in trans:	F(h1)	F(h2)	F(h3)	F(h4)	-	-	h1h2	h3	-	-	h1h2h3 & F(h5)

$F(h_x)$ = Full payload for chunk x

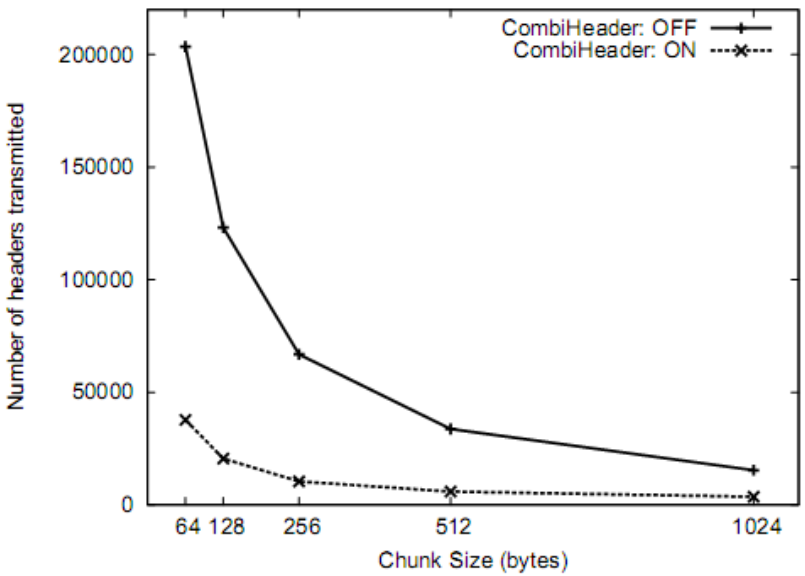
h_x = Elementary header for chunk x

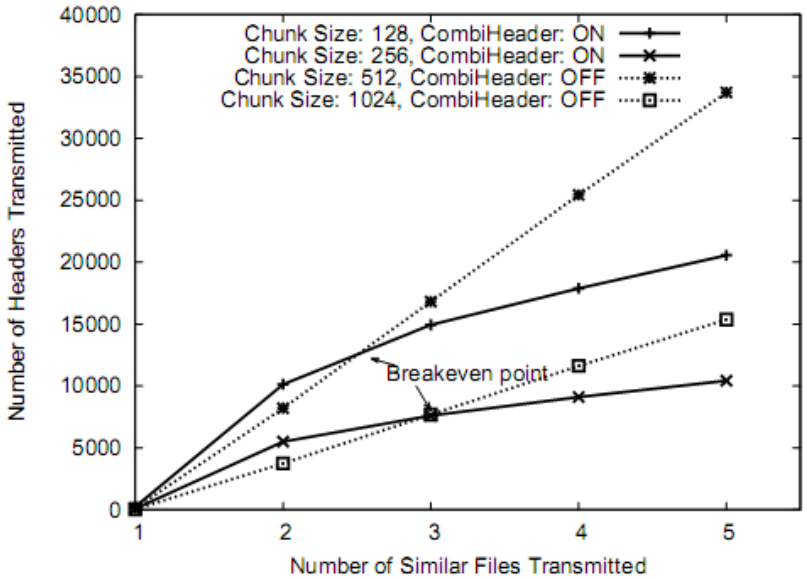
h_xh_y = CombiHeader for combined chunks x and y

Proof-of-Concept

- Implementation done in pure C
  - Chunking engine
  - CombiHeader plug-in
- Rabin fingerprinting for RE
- SHA-1 hashing for fingerprinting
- Chunking can be done in both IP and TCP layer
  - Experiments were done on TCP layer
- Directed graph to keep track of all the CombiHeaders generated
- A threshold parameter θ is used to control the CombiHeader generation process

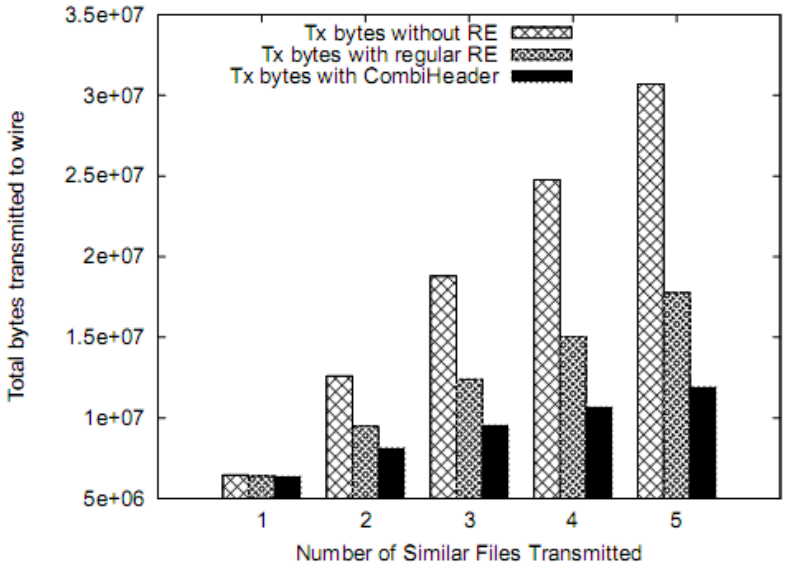
Evaluation



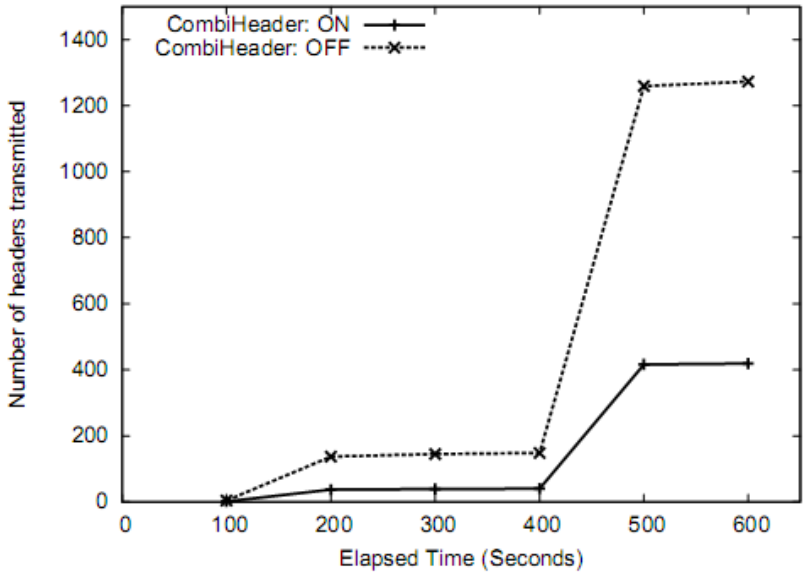


- Effect of CombiHeader over header transmission
  - X-axis represents initial preliminary chunk size
  - Traffic comprises of video files with intermittent similarity
- CombiHeader allowing smaller chunk size with the same benefit as larger ones

Evaluation



- Effect of CombiHeader over total bytes transmitted to wire
  - X-axis represents the number of files transferred through the router



- Running CombiHeader on real world HTTP traces

Summary

- CombiHeader addresses the question of what should be the optimal chunk size for a particular traffic
- Depending on the dynamic nature of the user traffic and the underlying similarity, CombiHeader adapts itself to deliver the best possible chunk size
- Helps to reduce protocol overhead to the wire
- Possible deployment challenges:
  - Cache synchronization among routers
  - Routing decision making