CACHE CONTENT PLACEMENT USING TRIANGULAR NETWORK CODING

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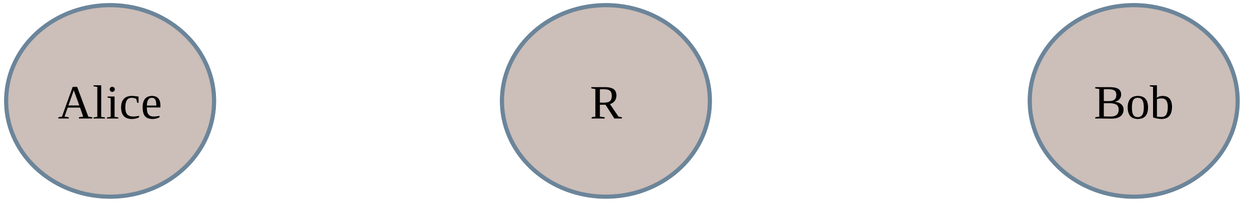
Agenda

- Introduction
- Motivation
- Content placement algorithm
- Simulation
- Conclusion

Alice and Bob (No coding)



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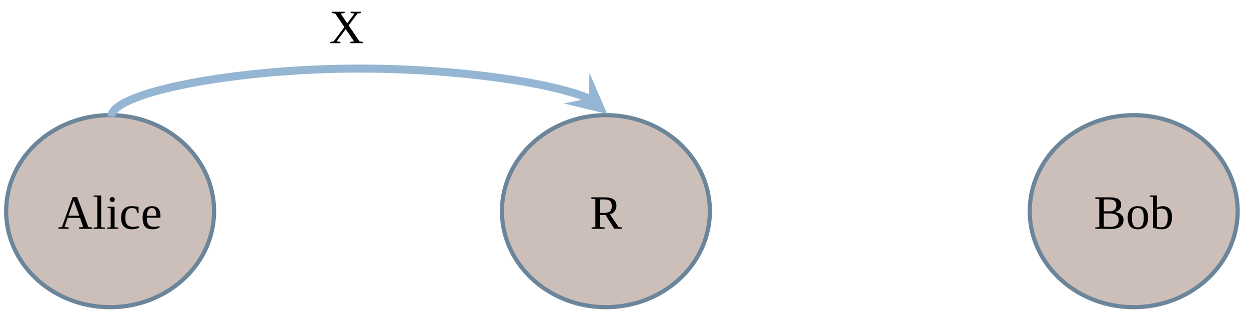

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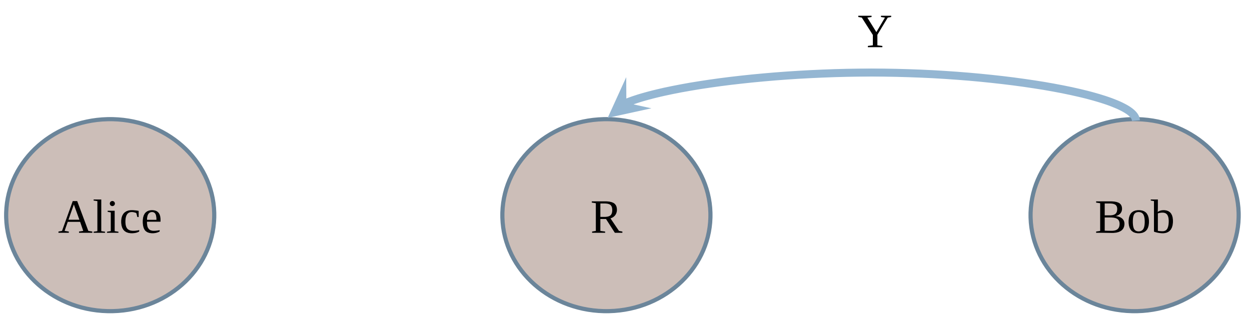

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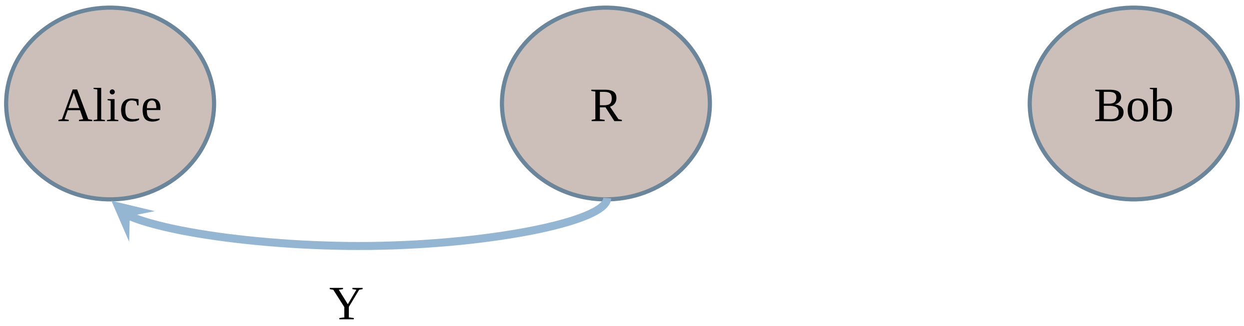

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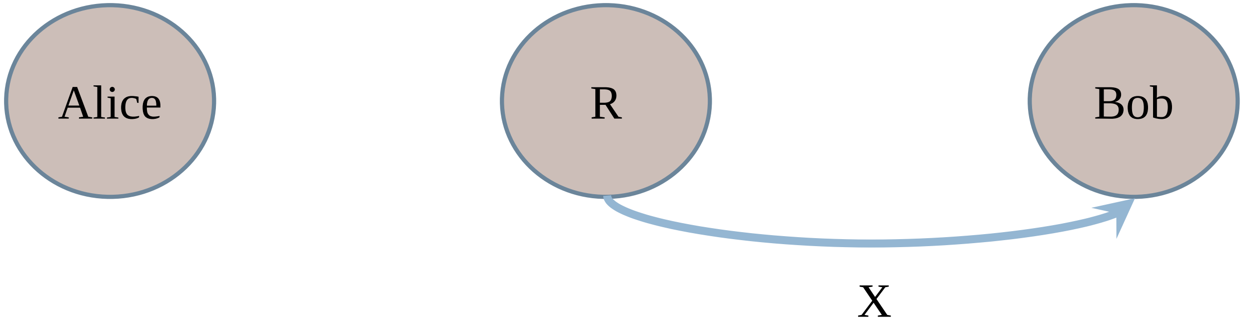

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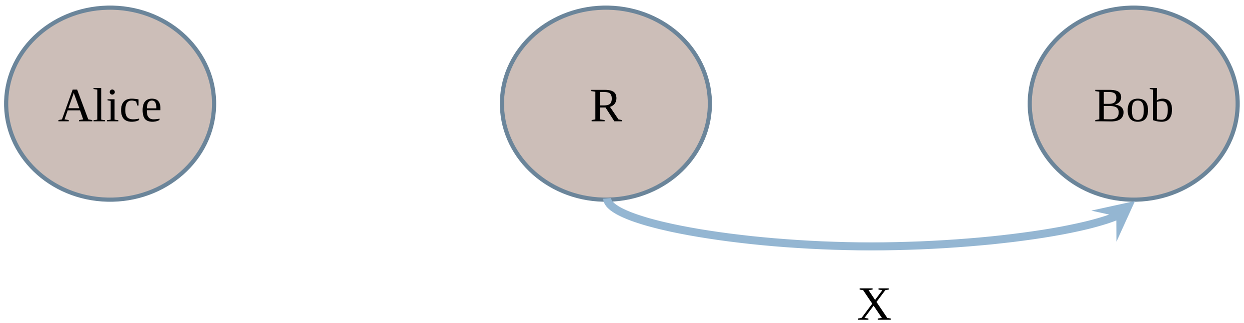
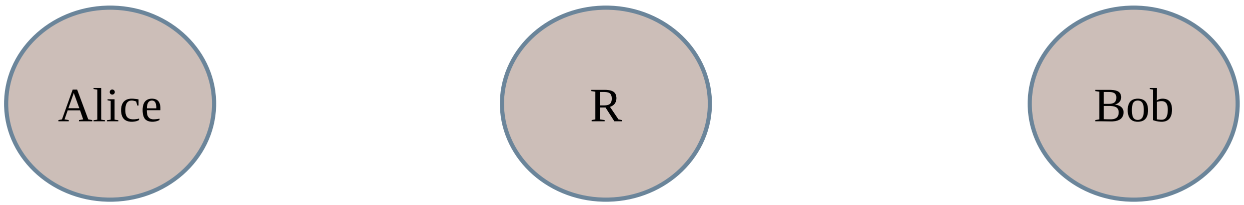


4 transmissions

Alice and Bob (Coding)



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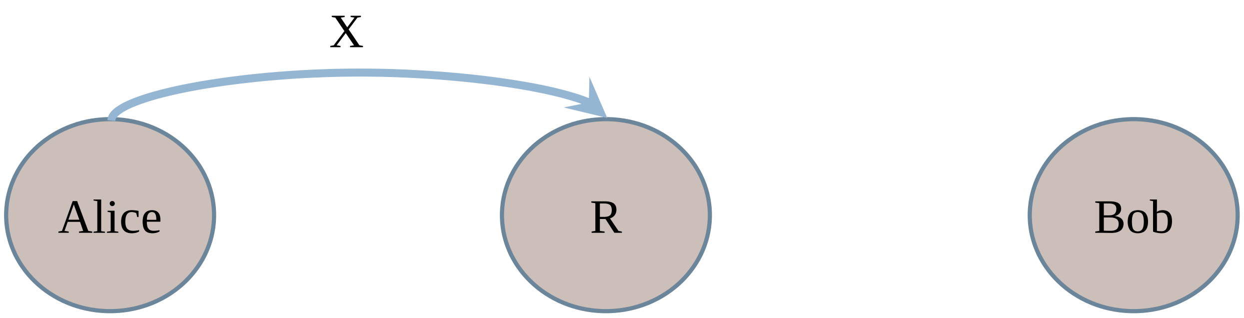

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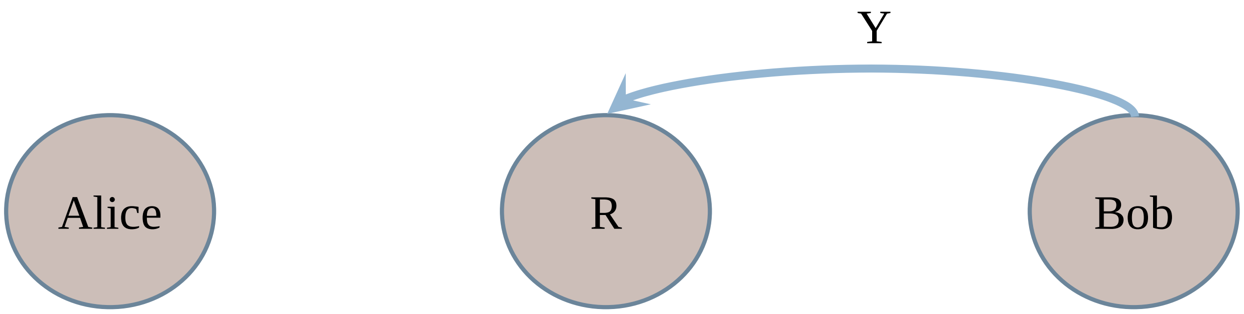

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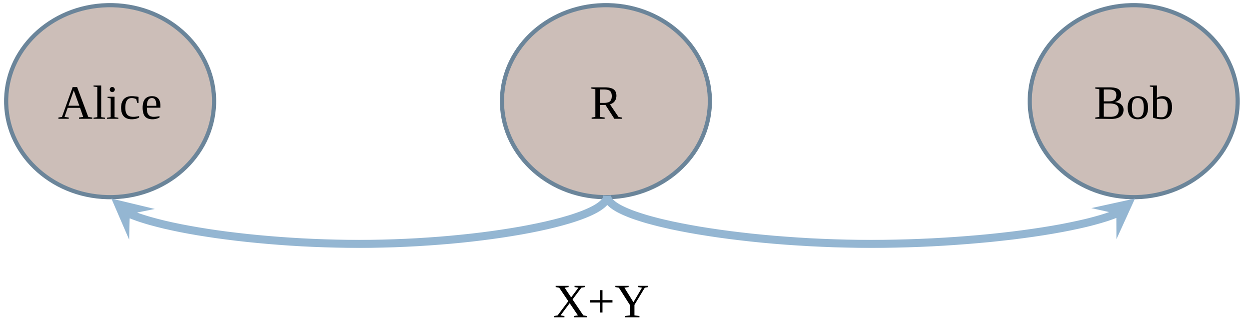

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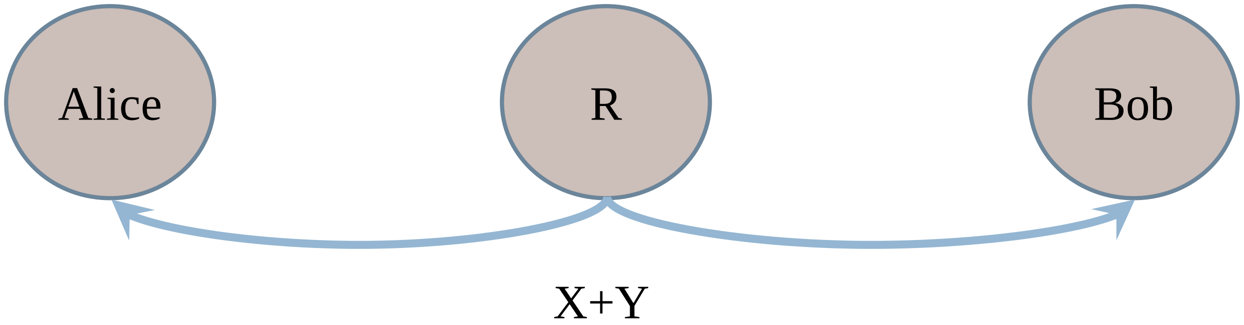
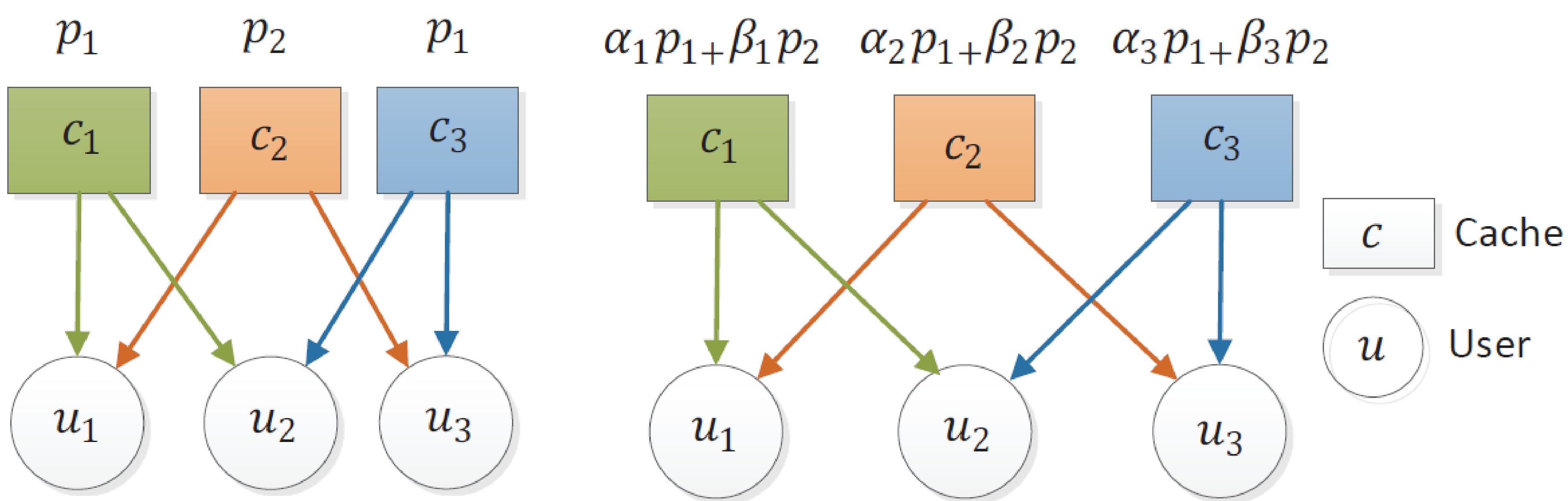


3 transmissions

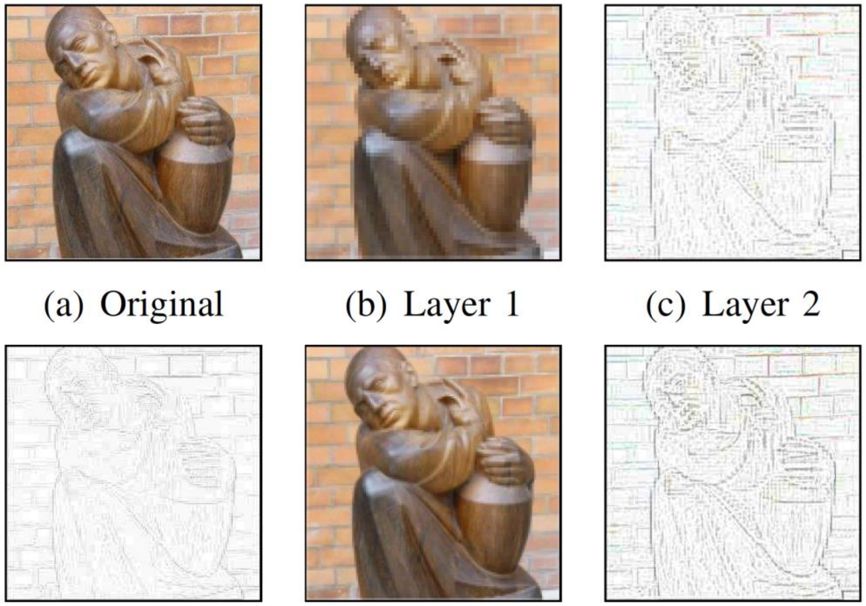
Motivation

- Providing more amount of data to the users.



Setting

- h video layers on the server: $p_1, .., p_h$
- Layer p_i is not useful without the layers with a smaller index.



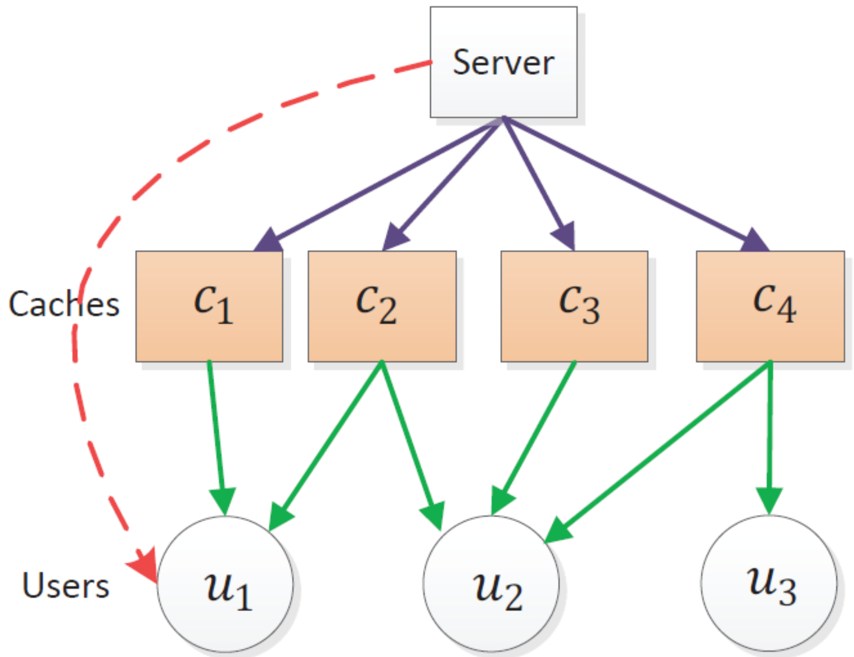
(a) Original (b) Layer 1 (c) Layer 2

(d) Layer 3 (e) Layers 1 & 2 (f) Layers 2 & 3

Setting

- Capacity=size of the video layers
- Objective: maximizing the total number of available layers.

$$\max \sum_{i=1}^{h} \sum_{j=1}^{n} z_{ij}$$



Triangular Coding

- Linear Coding
  - $2^h - 1$ ways to code *h* layers.
  - $(2^h - 1)^n$ different possible placements for *n* caches.
- Triangular network coding
  - The encoded video layers are in the form $\sum_{j=1}^{k} \alpha_j p_j$.

Original packets

$$\begin{cases} p_1 \\ p_2 \\ p_3 \end{cases}$$

Linear coding

$$\begin{cases} p_1,\ p_2,\ p_3 \\ p_1 + p_2,\ \ p_1 + p_3,\ \ p_2 + p_3 \\ p_1 + p_2 + p_3 \end{cases}$$

Triangular coding

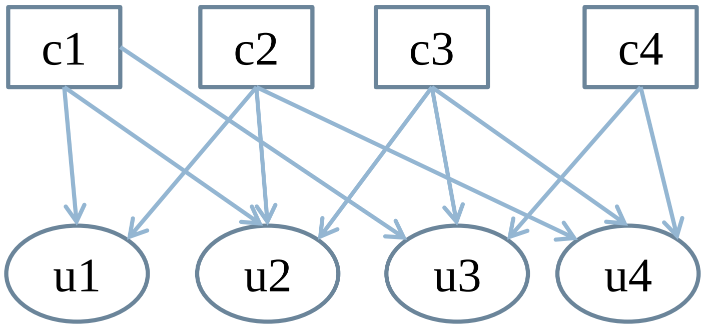
$$\begin{cases} p_1 \\ p_1 + p_2 \\ p_1 + p_2 + p_3 \end{cases}$$

Content Placement Algorithm

- The problem of efficient content placement on the caches is an NP-complete problem.
- The greedy algorithm fills-up the caches in rounds.
- In each round, we select a user and fill-up its adjacent caches.
- Selection rules
  - **Rule 1**: the user with the minimum degree.
  - **Rule 2**: the user with a larger number of filled-up caches.
  - **Rule 3**: the user whose adjacent caches have less cumulative ranks.
- The algorithm fills-up the empty adjacent caches to user u_i with a random linear combination of the first $d_i - v_i + r_i$ video layers.

Example

- Step 1: user u_1 has the minimum degree.
  - 2-0+0=2
- Step 2: user u_2 has 2 filled adjacent caches.
  - 3-2+2=3
- Step 3: select u_3 or u_4 randomly (assume u_3).
  - 3-2+2=3



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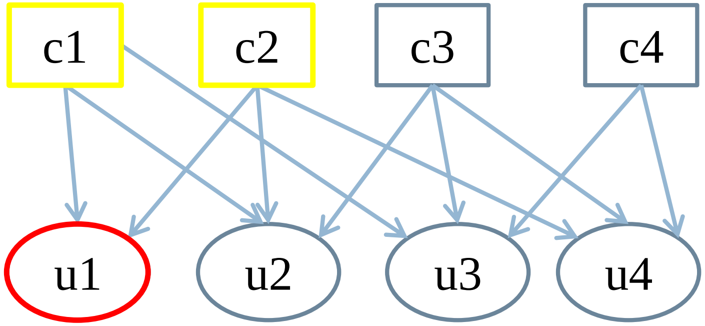

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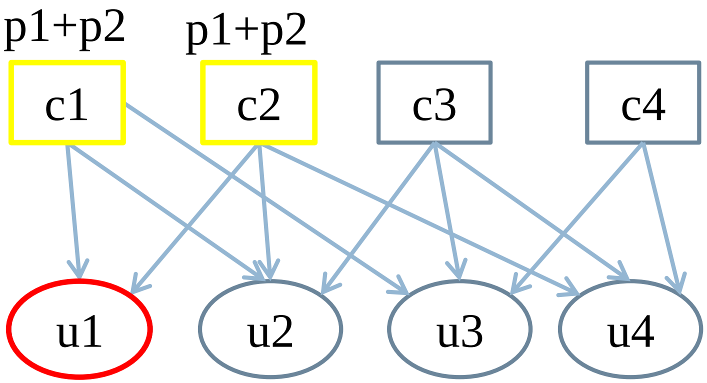

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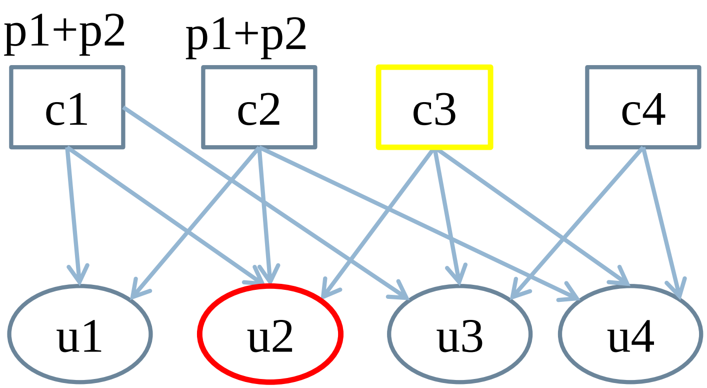

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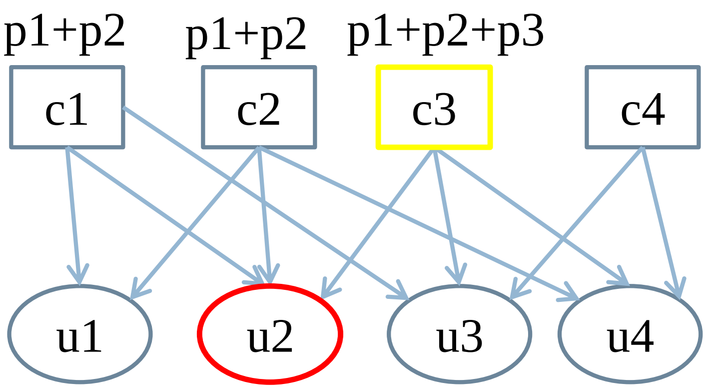

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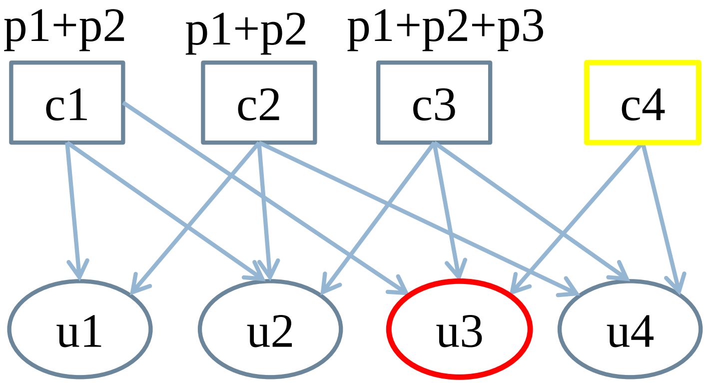

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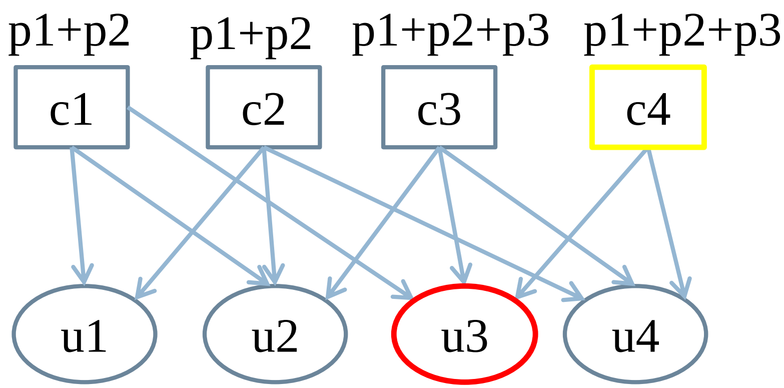


Simulation Setting

- Simulator in the MATLAB environment.
- Comparison
  - Number of available layers to the users.
  - Average utility: the number of available layers to a user divided by its degree.
  - Fairness: we define unfairness as the average difference between the number of available layers to each user and the average number of available layers to the users.

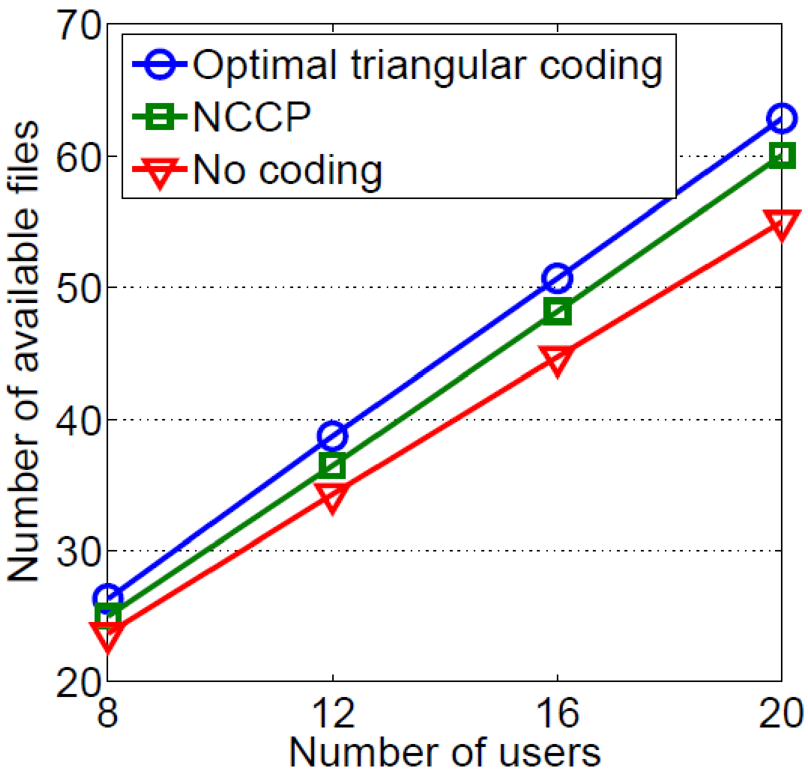
$$f' = \frac{\sum_{i=1}^{m} |q_i - e|}{m}$$

$$e = \frac{\sum_{i=1}^{m} q_i}{m}$$

$$f = \frac{1}{f'}$$

Simulations

- Number of caches: 5
- Number of layers: 4



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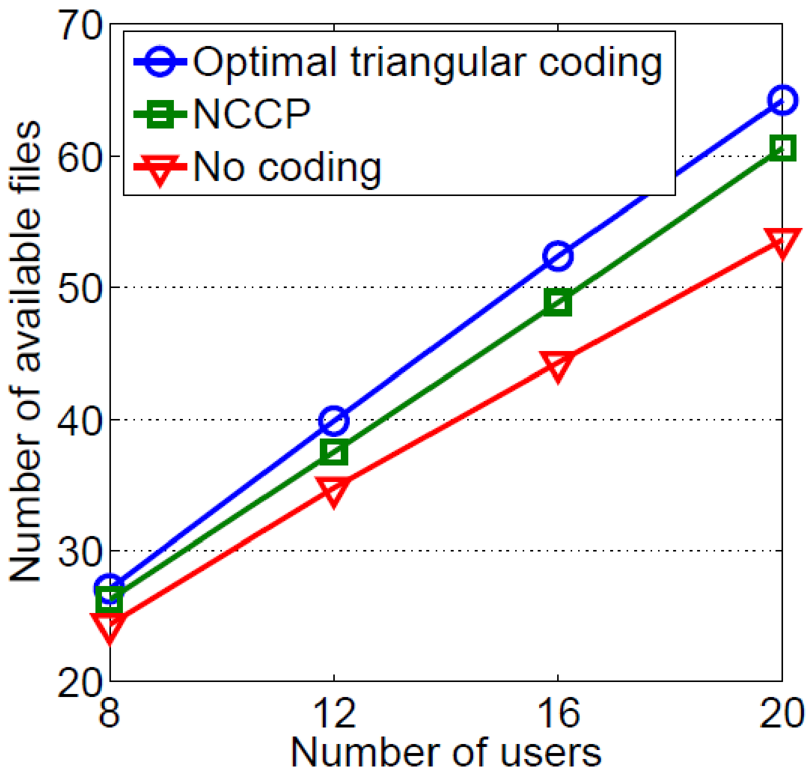

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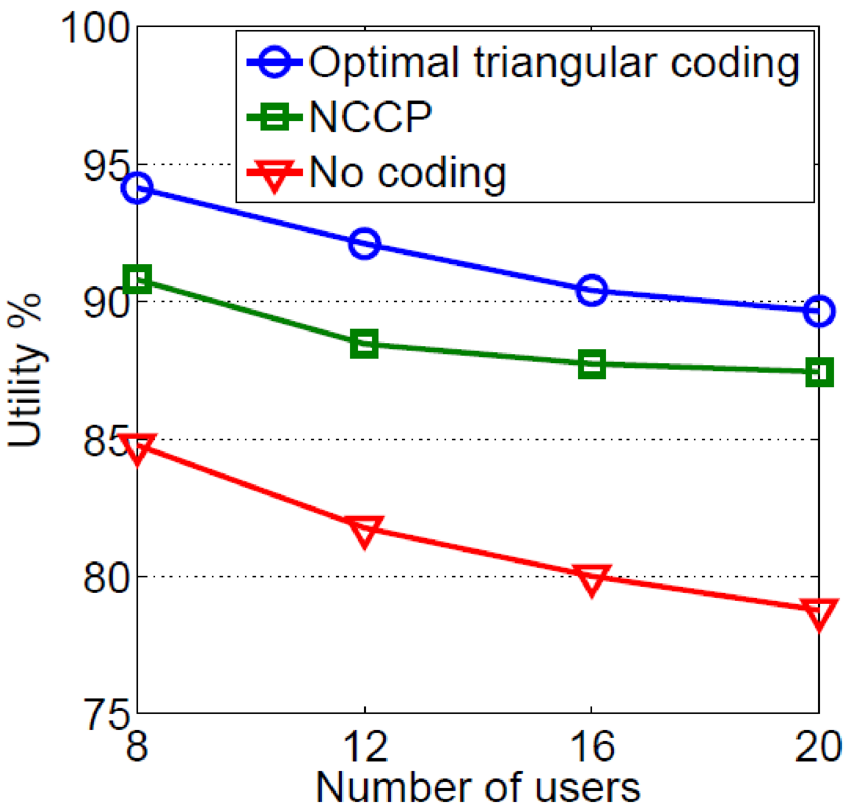

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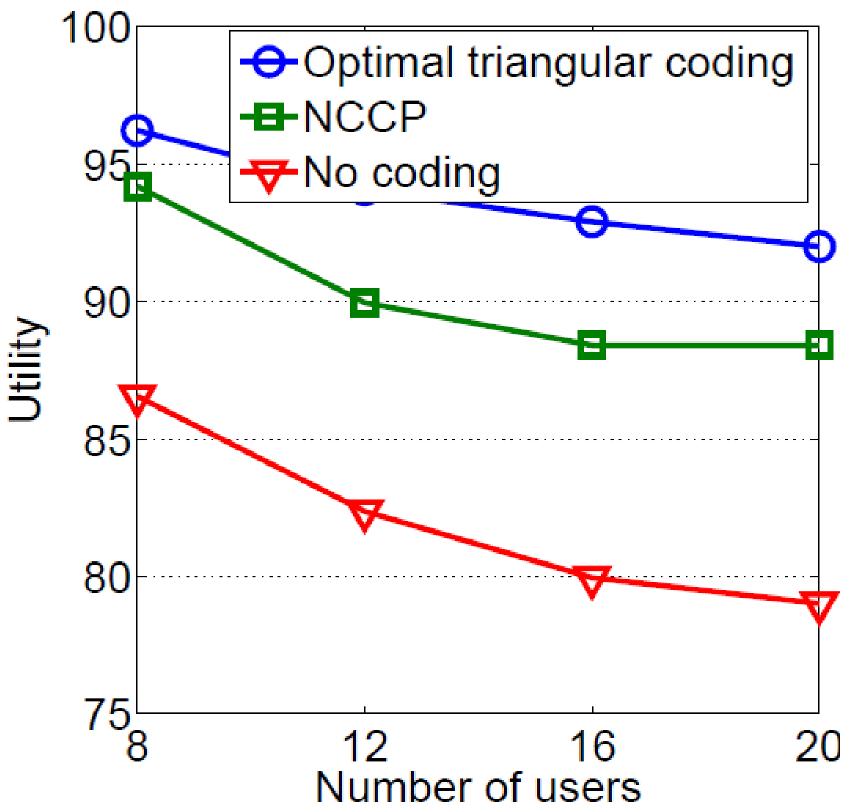

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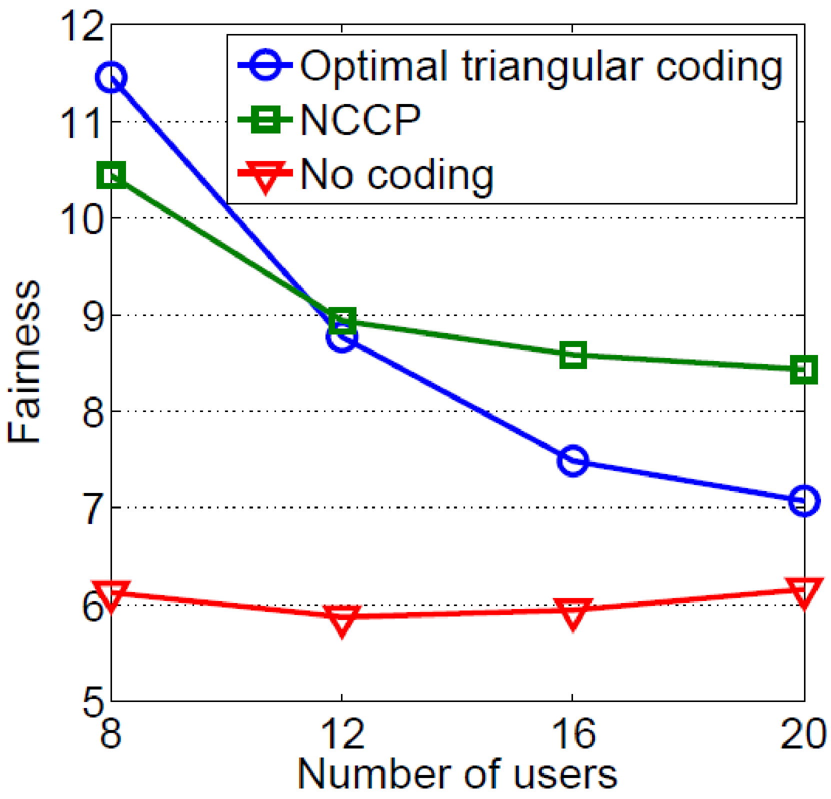

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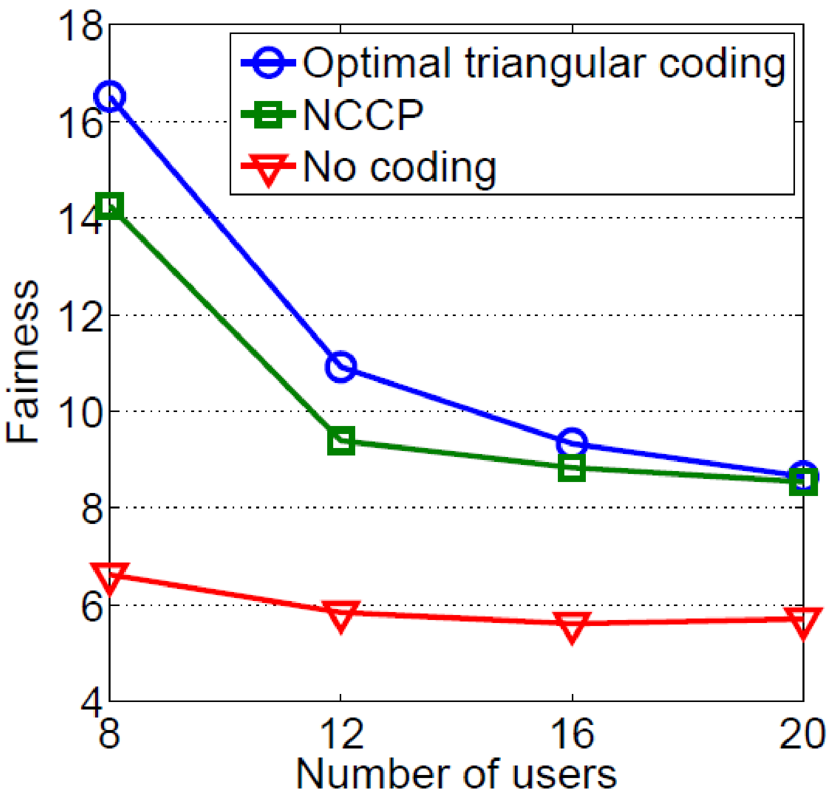

Summary

- The problem of efficient content placement.

on the caches is known as an NP-complete problem.

- Triangular network coding can reduce the complexity of content placement compared to the general form of coding.
- We propose a heuristic algorithm to solve the problem.

Questions