Paper Review

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Paper Title

The paper is titled "ARC: A Self-Tuning, Low Overhead Replacement Cache". It was written by Nimrod Megiddo and Dharmendra S. Modha.

Summary

This paper describes the Adaptive Replacement Cache (ARC). While most replacement caches have fixed policies, ARC's policy adapts itself according to the workload in an online fashion. It works on the following key ideas:

1. Ghost Caches.
2. Keeping track of both frequency and recency of access of a page.
3. Updating policy on cache misses.

In the design of the ARC adaptive policy, the authors made the following assumptions:

1. All pages are of the same size.
2. The recency and frequency of access of a page can determine if it will be accessed in the future. Further, a weighted combination of both is a stronger determiner than either one individually.

Details

The ARC algorithm uses four lists T1, T2, B1 and B2. T1 stores pages accessed once, T2 stores pages accessed twice and B1 and B2 are ghost caches storing pages evicted from T1 and T2 respectively. The total size of T1 and T2 is c and the total size of B1 and B2 is c. On each cache miss, we update the policy parameter p. The policy parameter p describes the target size of T1. So, the target size of T2 is c - p.

Figure 1 shows the movement of pages among these lists

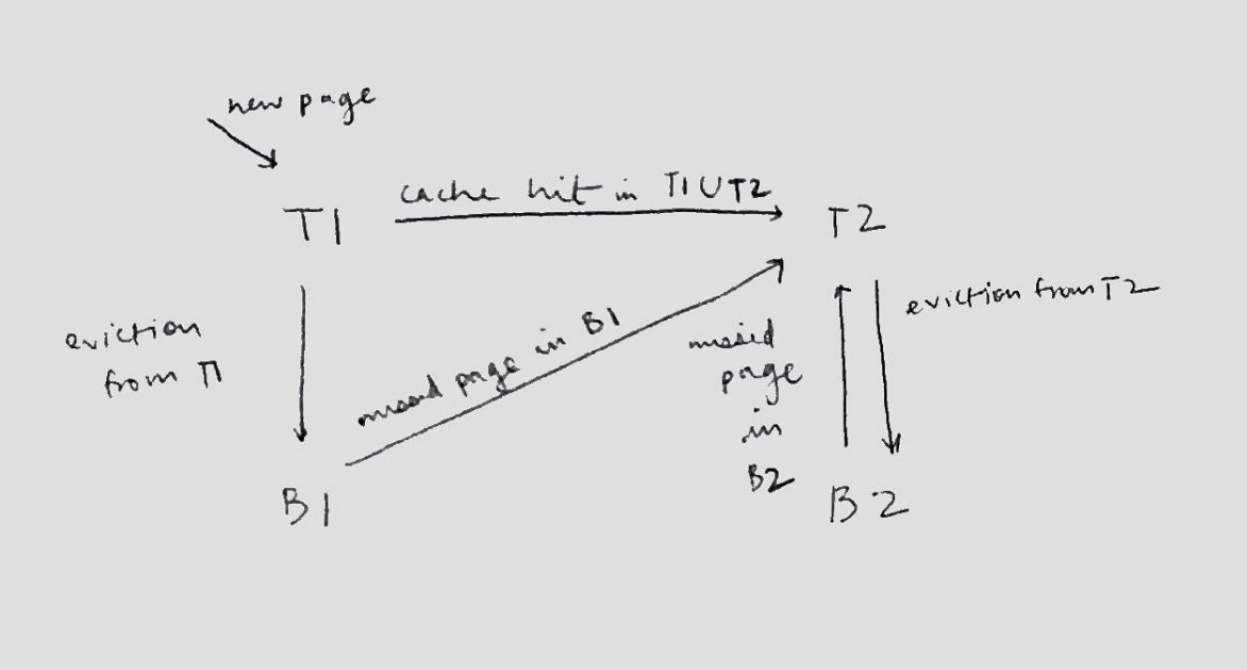

Figure 1: Movement of pages among the ARC lists

Positives

There are many advantages of ARC . The key advantages are as follows:

1. Ease of implementation. An LRU implementation can be converted to an ARC implementation trivially. This is in comparision to a system of multiple experts which requires implementing many algorithms and evict pages on the basis of majority vote.

2. Continuous learning. If the cache access load suddenly changes, ARC adapts and thus minimizes future cache misses with each cache miss.

3. Low memory overhead. As compared to the MQ (M = 8) algorithm which can need 8c memory for its implementation, ARC needs only 2c memory.

What I really liked about this paper that the authors combined the ideas from best page replacement policies from the entire literature into one without combining all implementations. For specific values of p, ARC can act as one of those algorithms and even go from being like 100% one algorithm to 100% a completely different algorithm.

Significance and Relevance

Since it can adapt to any type of workload, ARC has been used in modern scalable systems which make very few assumptions about their usage. The ZFS file system uses ARC with some modifications to allow pinning pages such that they are not moved. VMWare's vSAN, a software-defined storage system also uses a variant of ARC.