CSE-530 Assignment 2 Report

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Experiment Design

In this study, I conducted a series of experiments to investigate the impact of cache size and associativity on cache performance, including area, energy consumption, and access time. The experiments were designed to provide insights into how different cache configurations affect these key performance metrics.

Experiment 1: Area

a. Impact of Increasing Cache Size with Fixed Associativity (4):

I analysed the effect of increasing the cache size while maintaining a fixed associativity of 4. Cache sizes ranged from 16 KB to 2 MB. The goal was to understand how changes in cache size influence the physical area occupied by the data array.

b. Impact of Increasing Associativity with Fixed Cache Size (128 KB):

I investigated the impact of varying associativity while keeping the cache size fixed at 128 KB. Associativity values were tested from 1 to 64. The objective was to determine how different associativity levels affect the area of the data array.

Experiment 2: Energy

a. Impact of Increasing Cache Size on Total Dynamic Read Energy per Access with Fixed Associativity (4):

I measured the total dynamic read energy per access for the data array while varying the cache size. The associativity was held constant at 4. Cache sizes spanned from 16 KB to 2 MB. This experiment aimed to quantify the energy consumption under different cache size conditions.

b. Impact of Increasing Associativity on Total Dynamic Read Energy per Access with Fixed Cache Size (128 KB):

I explored the effect of changing associativity on the total dynamic read energy per access with a fixed cache size of 128 KB. Associativity's were tested from 1 to 64. The goal was to understand how varying associativity influences energy efficiency.

Experiment 3: Access Time

a. Impact on the Access Time with Varying Associativity and Fixed Cache Size (512 KB):

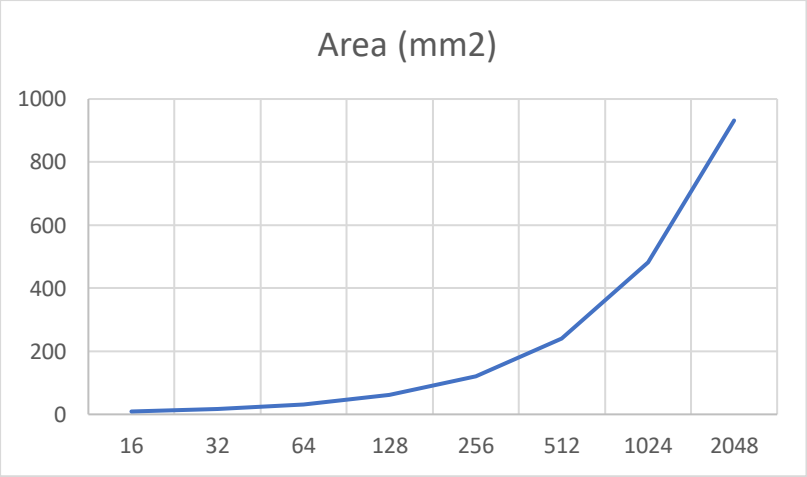
I measured access times while varying the associativity of the cache and keeping the cache size constant at 512 KB. Associativity values ranged from 1 to 64. This experiment aimed to assess how different associativity levels affect access latency.

b. Impact on the Access Time with Varying Cache Size (Range: 64 KB to 2 MB) and Fixed Associativity (4):

I assessed access times while varying the cache size within the range of 16 KB to 2 MB, with a fixed associativity of 4. The objective was to understand how changes in cache size influence access latency.

These experiments were conducted to provide valuable insights into the trade-offs and optimizations available when configuring cache memory systems for specific applications and performance requirements. The results will contribute to the understanding and improvement of cache design in computer architecture.

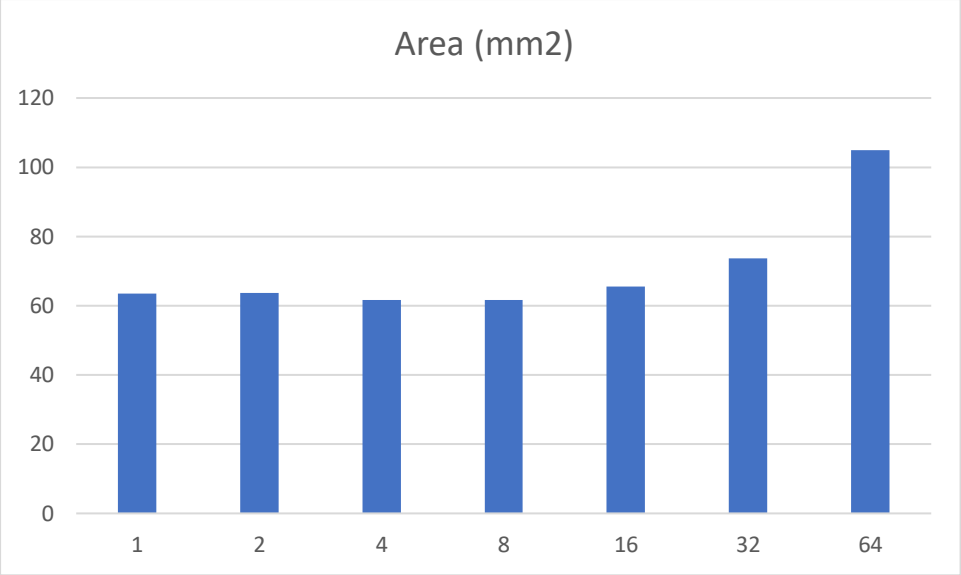
Experiment 1A (Cache size vs Area)



The experiments clearly show an exponential increase in cache area as cache size grows, underlining the trade-off between performance improvements and the substantial chip space required for larger caches.

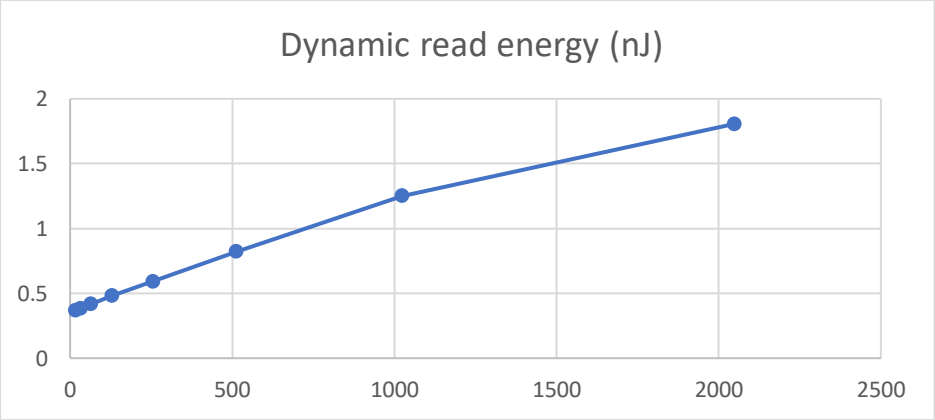
Experiment 1B (Associativity vs Area)

The data on cache associativity and their corresponding cache area measurements reveal interesting insights. At lower associativities, specifically 1 and 2, the cache area is relatively high, with values around 63.5 mm^2. However, as associativity increases to 4 and 8, there is a slight decrease in area to approximately 61.6 mm^2. Surprisingly, at even higher associativities like 16, 32, and 64, the cache area starts to rise again, with the highest area recorded at 104.982 mm^2 for an associativity of 64.



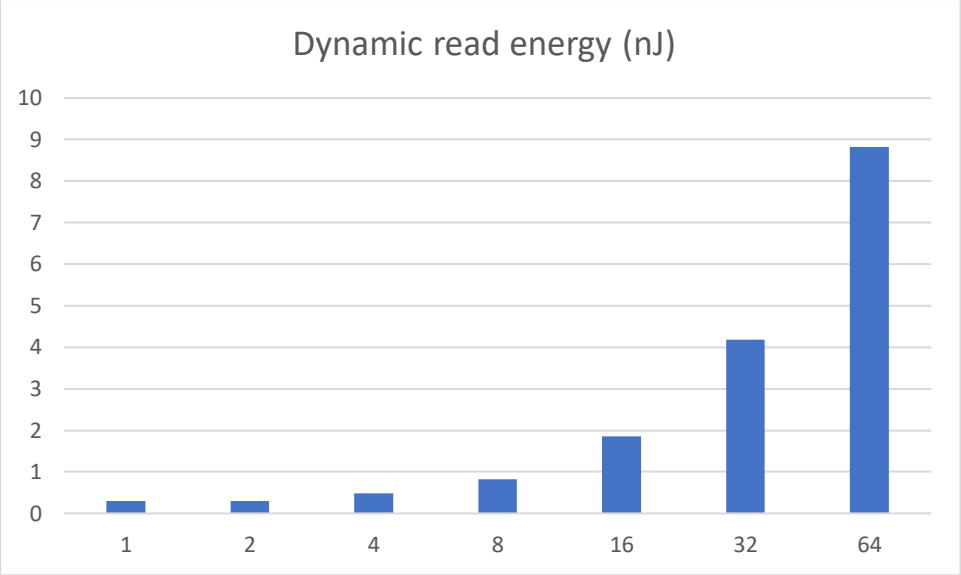
Experiment 2A (Cache size vs Energy)

In the experiments where cache size was incrementally increased while maintaining a constant associativity of 4, noteworthy observations were made regarding dynamic read energy consumption. As the cache size grew from 16 KB to 2048 KB, there was a clear upward trend in dynamic read energy consumption. The energy consumption per access increased progressively, reflecting the added power requirements associated with larger cache sizes



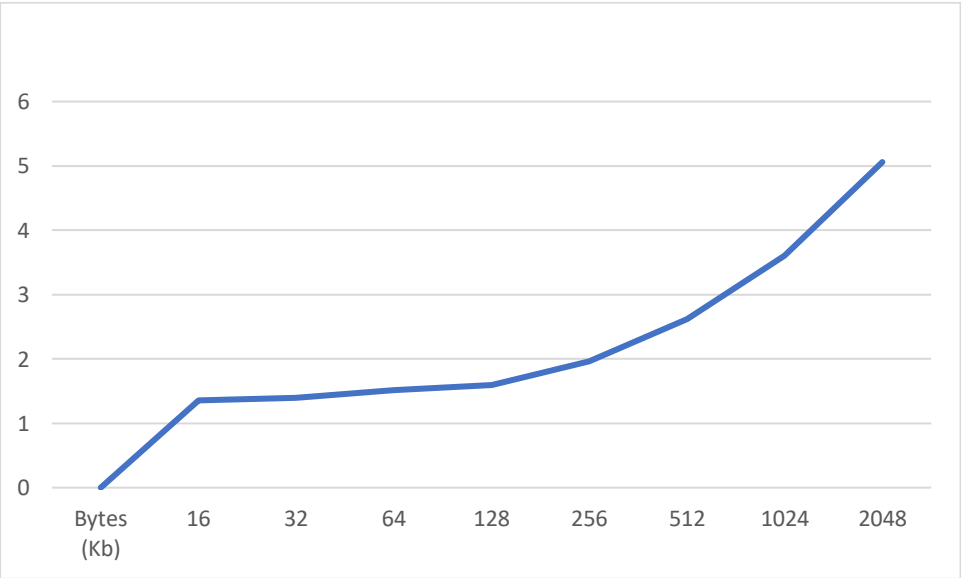
Experiment 2B (Associativity vs Energy)

In the experiments where the cache size was held constant at 128 KB while varying the associativity, a significant trend in dynamic read energy consumption emerged. Notably, as associativity increased from 1 to 64, there was a substantial rise in dynamic read energy per access. This increase indicated that higher associativity levels led to increased energy consumption, with the most dramatic surge observed at associativity levels of 16, 32, and 64.

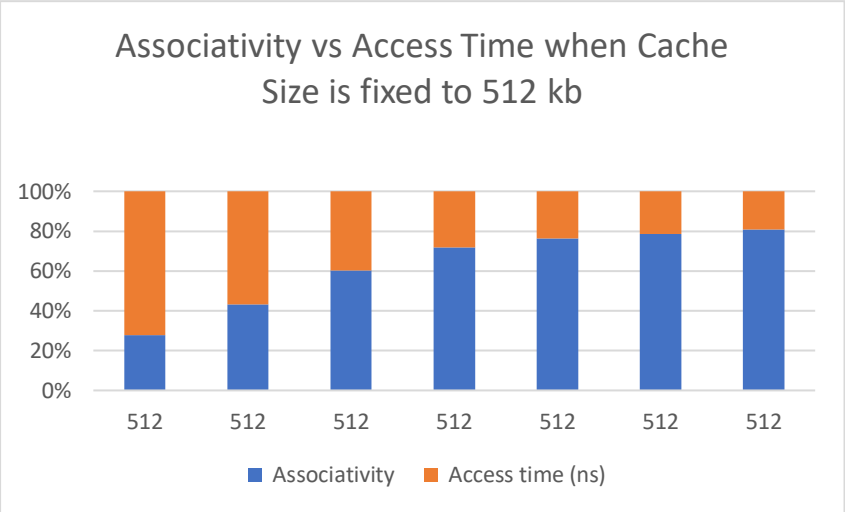


Experiment 3A (Cache size vs Access Time)

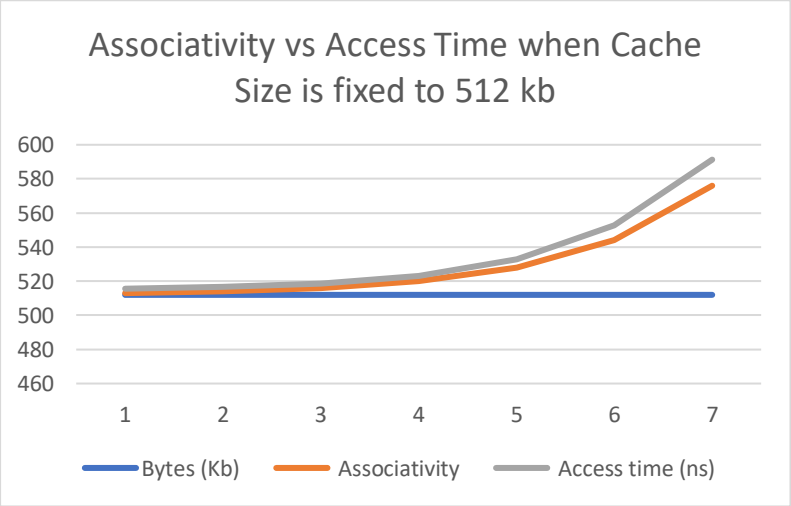
The experiment focused on the impact of varying cache size while keeping associativity constant, revealing significant insights into access time. As the cache size increased from 16 KB to 2048 KB, there was a noticeable increase in access time. This trend indicated that larger cache sizes were associated with longer access times, with the most pronounced jump occurring as cache size surpassed 256 KB. These findings underscore the trade-off between cache size and access speed, suggesting that larger caches may offer improved storage capacity but at the cost of increased access latency.



Experiment 3B (Associativity vs Access Time)



The experiment focused on the relationship between cache associativity and access time with a fixed cache size of 512 KB. As associativity increased from 1 to 64, a clear trend emerged in access time. Access time experienced a moderate increase at lower associativity's, with values ranging from approximately 2.615 ns to 2.623 ns. However, as associativity continued to grow, there was a more significant increase in access time, particularly at levels of 16, 32, and 64. These findings suggest that while higher associativity can improve cache performance, it comes at the expense of longer access times, highlighting the trade-off between associativity and access speed in cache design decisions.



In summary, our experiments uncovered vital cache design insights. Firstly, cache size showed an exponential relationship with area, energy use, and access time—larger caches increased these metrics, highlighting performance versus space, energy, and latency trade-offs. **Secondly**, cache associativity presented trade-offs. Lower associativity (1 and 2) meant lower energy use and access times but potential space requirements. Higher associativity (16, 32, and 64) led to longer access times and more energy use, demanding a balanced choice for specific applications. **In conclusion**, cache design demands careful optimization, considering cache size and associativity. Engineers must navigate trade-offs between performance, chip area, energy efficiency, and access latency for diverse applications.