Memory & Caches II

CSE 351 Winter 2024

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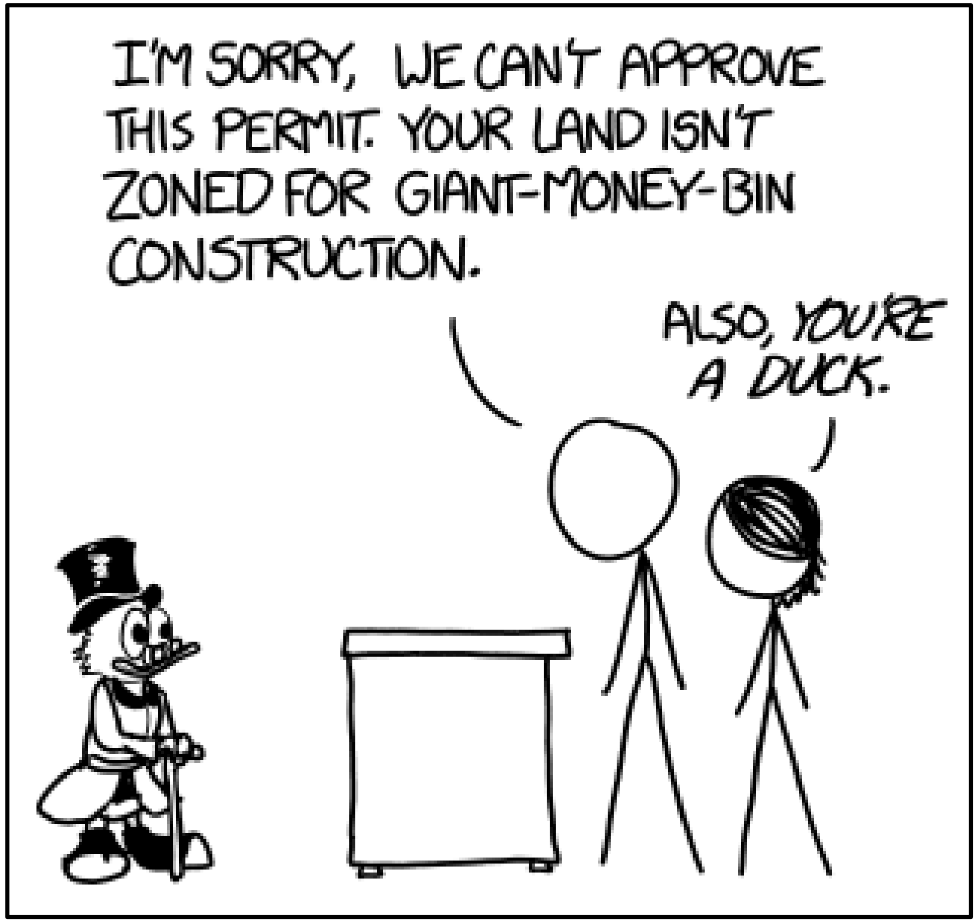


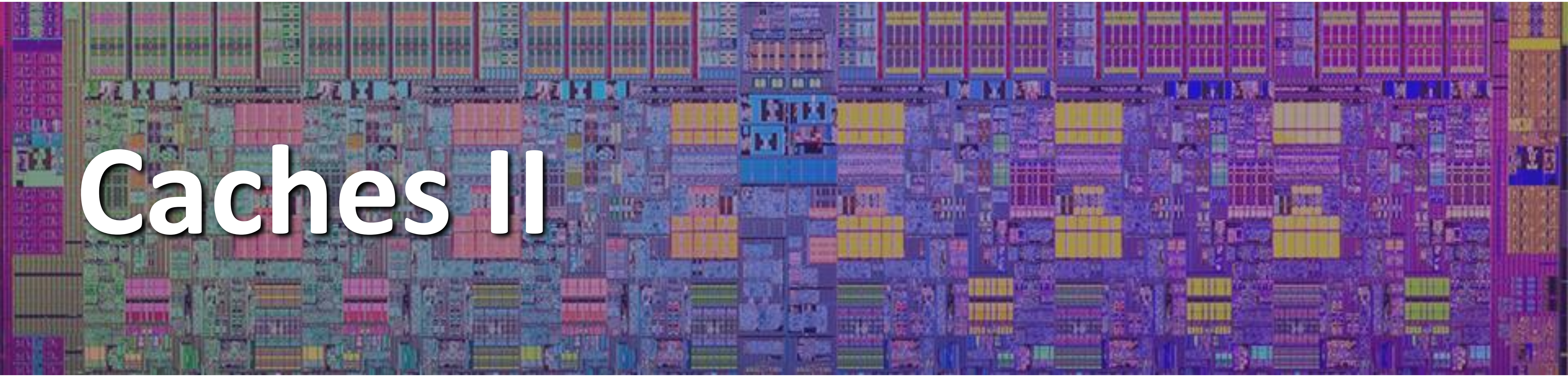
https://what-if.xkcd.com/111/

Relevant Course Information

- HW14 due tonight, HW15 due Wednesday, HW16 due Friday
- Lab 3 due Friday (2/16), late deadline is Monday (2/19)
  - President’s Day: no lecture, but some support hours (see Ed)
- Midterm grades will be released when we can
  - Regrade requests will be available afterward

Mid-Quarter Survey Summary

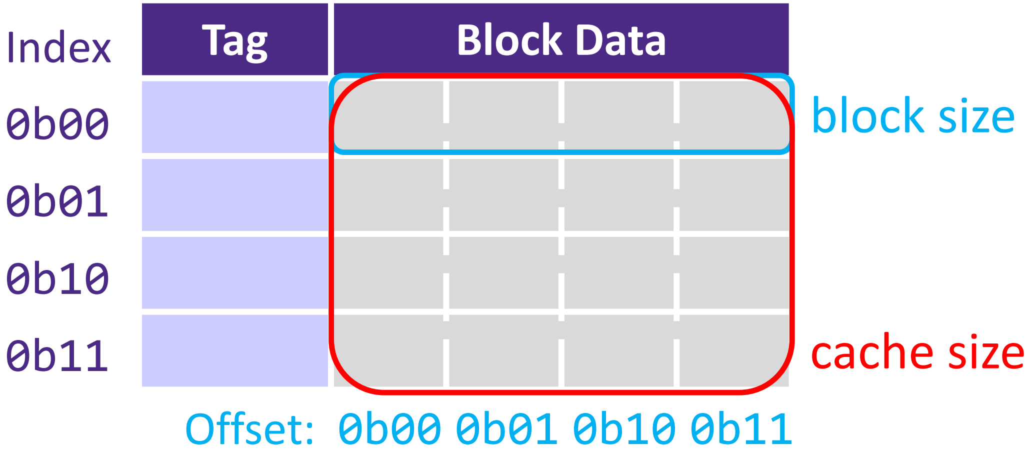
- Lessons:
  - There's a lot of content… some lessons (videos) are too long
  - Wish there were more practice problems and worked examples
  - Would like if the slides used in the videos were posted (will do)
  - Organization of Ed Lessons could be improved (FYI, website schedule by due dates)
- Lecture:
  - Would like a different balance of content review & work time (but no agreement)
  - Would like more practice problems and worked examples
- Section: want more practice problems (?)
- Support hours: want more total, more later in day, more on Zoom



Caches II

Lesson Summary (1/2)

- Cache parameters define the cache geometry:
  - **Block size** is number of bytes per block
  - **Cache size** is number of bytes (or blocks) of data the cache can hold
- Finding a byte in the cache:
  - **Offset** refer to which byte in block
  - **Index** refers to which block in cache
- Example:
  - K = 4 B, C = 16 B = 4 blocks



Lesson Summary (2/2)

- **Direct-mapped cache:** each block in cache is assigned a unique index
  - Uses hash function of (block number) mod (# of cache indices)
    - Deterministic placement of each block, with many blocks mapping into the same index
    - Tag bits stored in cache and used to distinguish between blocks that map to same index

- Accessing the cache:
  (TIO address breakdown)

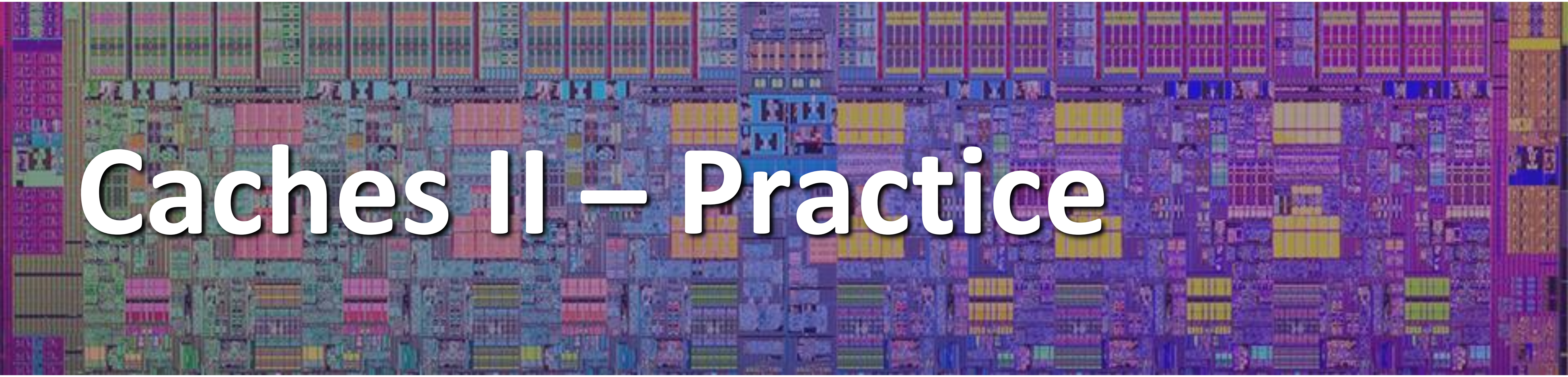
$\boldsymbol{m}$-bit address: $\underbrace{\boxed{\text{Tag } (\boldsymbol{t})}\boxed{\text{Index } (\boldsymbol{s})}}_{\text{Block Number}}\boxed{\text{Offset } (\boldsymbol{k})}$

1) **Index** field tells you where to look in cache (width $s = \log_2 S$)
2) **Tag** field lets you check that data is the block you want (width $t = m - s - k$)
3) **Offset** field selects specified start byte within block (width $k = \log_2 K$)

Lesson Q&A

- Learning Objectives:
  - Determine how memory addresses and data interact with the cache (*i.e.*, cache lookups, data movement).
  - Analyze how changes to cache parameters [and policies] affect performance metrics such as AMAT.

- What lingering questions do you have from the lesson?
  - Chat with your neighbors about the lesson for a few minutes to come up with questions



Caches II – Practice

Polling Questions (1/2)

- We have a direct-mapped cache with the following parameters:
  - Block size of 8 bytes
  - Cache size of 4 KiB

- How many blocks can the cache hold?
- How many bits wide is the block offset field?
- Which of the following addresses would fall under block number 3?

A. 0x3 **B.** 0x1F **C.** 0x30 **D.** 0x38

Polling Questions (2/2)

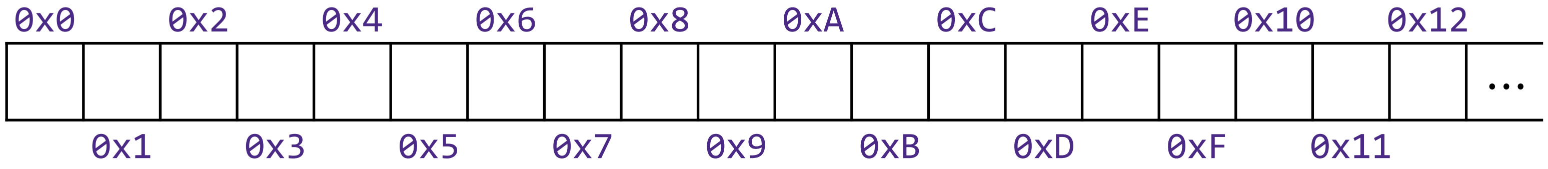
- Based on the following behavior, which of the following block sizes is NOT possible for our cache?
  - Cache starts *empty*, also known as a *cold cache*
  - Access (addr: hit/miss) stream:
    - (`0xE`: miss), (`0xF`: hit), (`0x10`: miss)

A. 4 bytes

B. 8 bytes

C. 16 bytes

D. 32 bytes



Homework Setup (1/2)

```
struct WolfPos {
   float x;
   float y;
   float z;
   int id;
};
struct WolfPos grid[16][16];
```

- Assume `&grid = 0`

- What are the addresses of the following pieces of data?
  - `&(grid[0][0].id) =`
  - `&(grid[1][0].y) =`
  - `&(grid[3][4].x) =`

Homework Setup (2/2)

```
struct WolfPos {
   float x;
   float y;
   float z;
   int id;
};
struct WolfPos grid[16][16];
```

- Assume `&grid = 0`

- Cold direct-mapped cache with $C = 1024\text{ B}$ and $K = 16\text{ B}$
  - What happens if we access `grid[0][0].x` and then `grid[4][0].x`?

Group Work Time

- During this time, you are encouraged to work on the following:
  1) If desired, continue your discussion
  2) Work on the homework problems
  3) Work on the lab (if applicable)

- Resources:
  - You can revisit the lesson material
  - Work together in groups and help each other out
  - Course staff will circle around to provide support