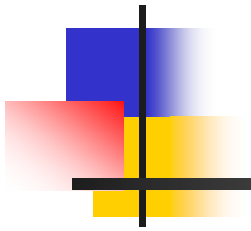

Assignment 1

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1.2.05

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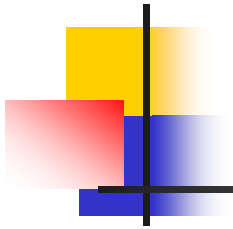


Overview

- Question
- Basic Matrix Multiplication
  - C warm up
- Re-arranged Matrix Multiplication
  - cache effect
- Block-Matrix Multiplication
  - cache effect

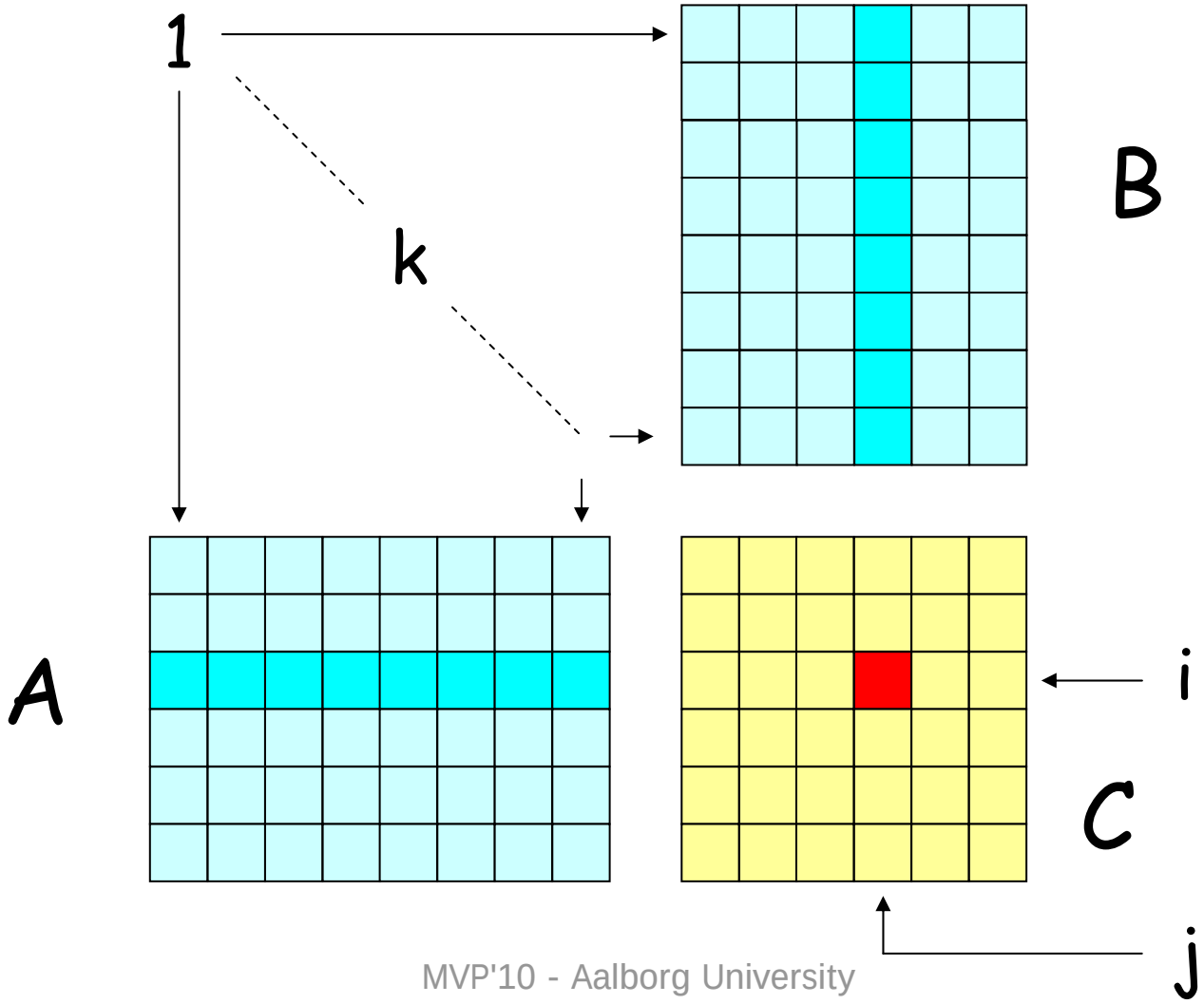
Matrix Multiplication Example

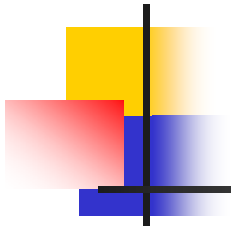
- Common example, will be used many times in the course.
- C=A*B, where A, B , and C are matrices.

$$c_{ij} = \sum_{k=1}^{n} a_{ik} b_{kj}$$

? Complexity?

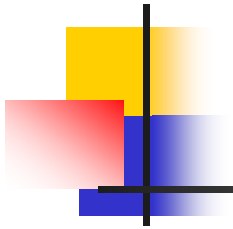
Matrix Multiplication Example





Cache Characteristics

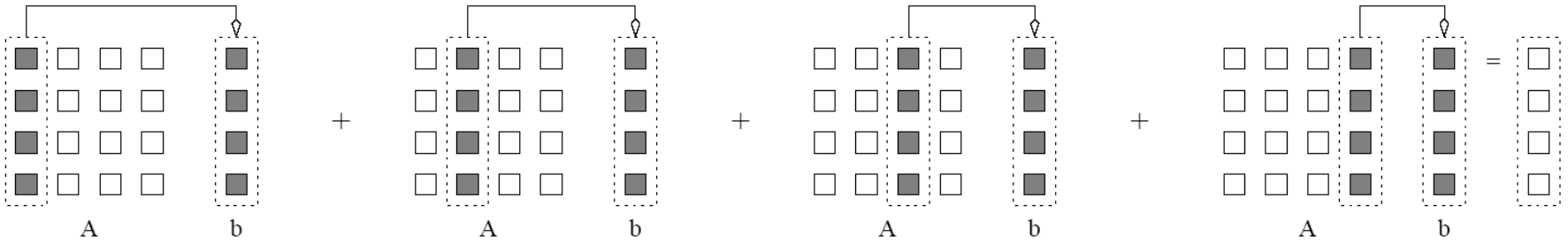
- Hit ratio (behavior): fraction of references satisfied by the cache.
- Cache line (= bus width): granularity.
- Associativity (architecture): “collision list” to reduce *cache eviction*.
- For the matrix: $2n^2$ fetches from memory to *populate the cache*, and then n^3 direct accesses at full speed.



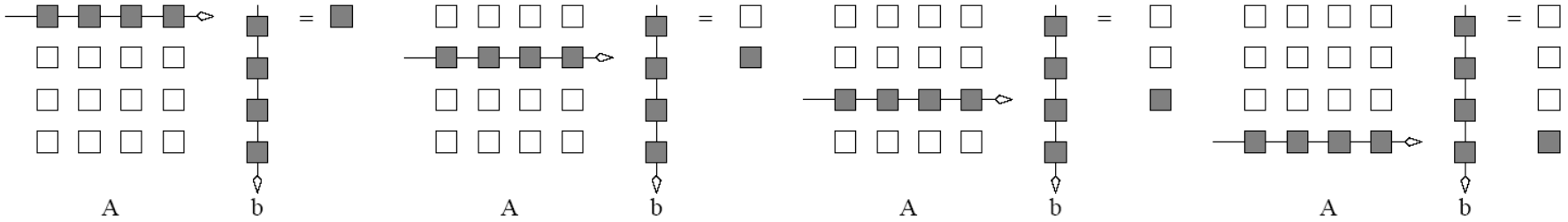
Impact on Memory Bandwidth (and Latency)

- Access to successive words much better than random access.
  - Higher bandwidth (whole cache line at once)
  - Better latency (successive words already in cache)

Example: Strided Access

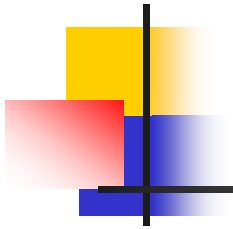


(a) Column major data access



(b) Row major data access.

Figure 2.2 Multiplying a matrix with a vector: (a) multiplying column-by-column, keeping a running sum; (b) computing each element of the result as a dot product of a row of the matrix with the vector.



Programming

- Add functions to
  - matrix_fibo.c
  - pmatrix.c
- Read-only the rest.
  - precision issues
  - Gauss elimination with pivoting