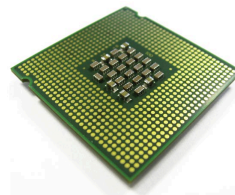
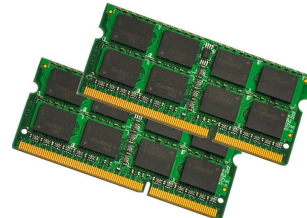
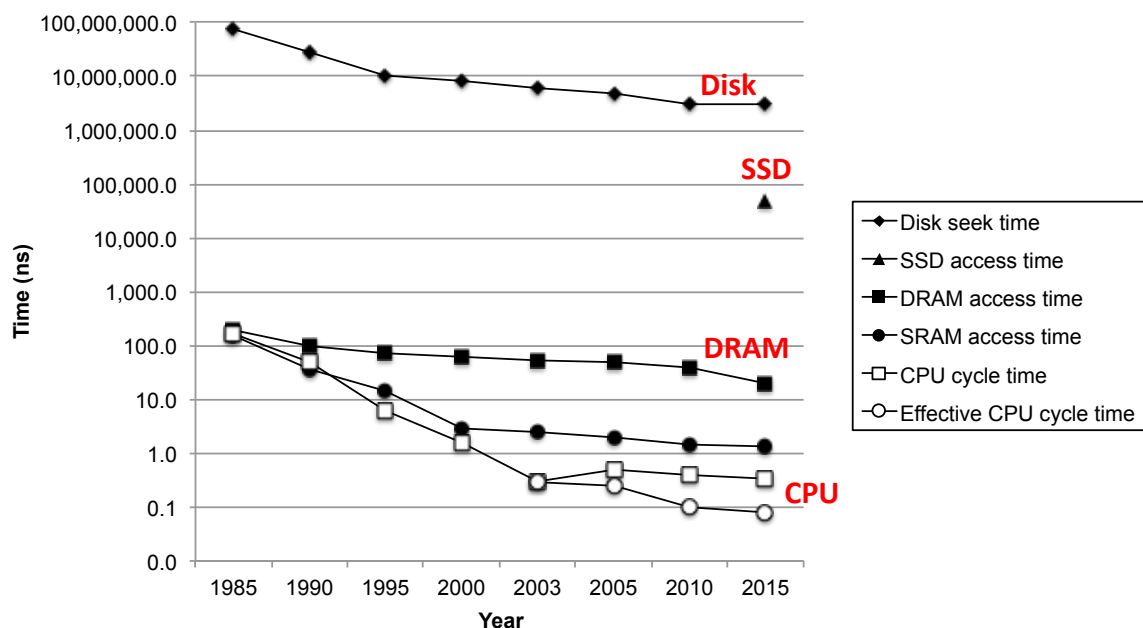


Data Storage

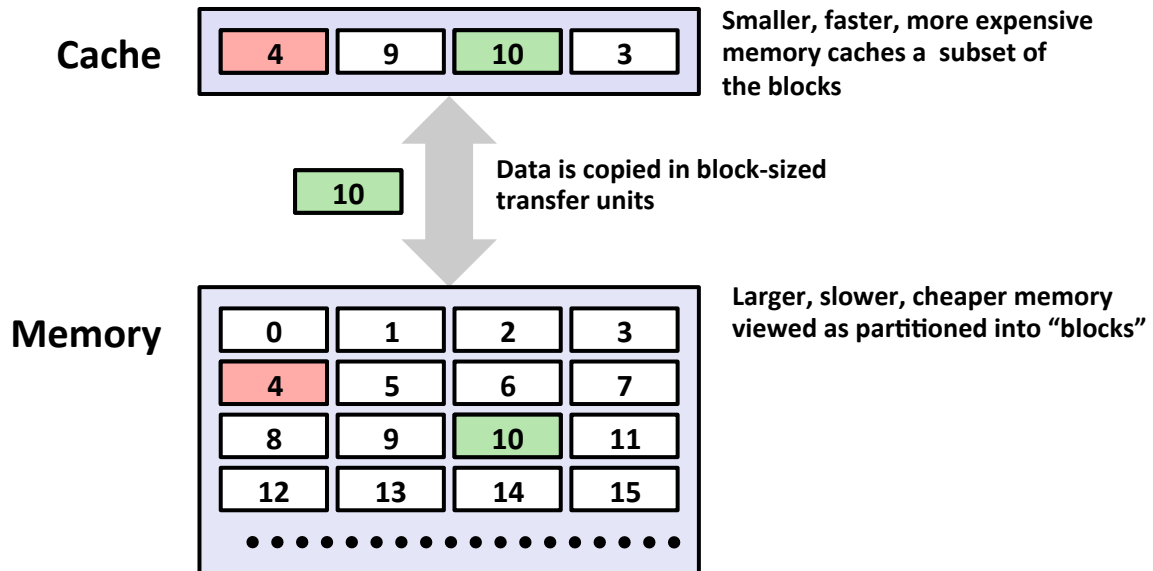
- Disks
 - Hard disk (HDD)
 - Solid state drive (SSD)
- Random Access Memory
 - Dynamic RAM (DRAM)
 - Static RAM (SRAM)
- Registers
 - %rax, %rbx, ...



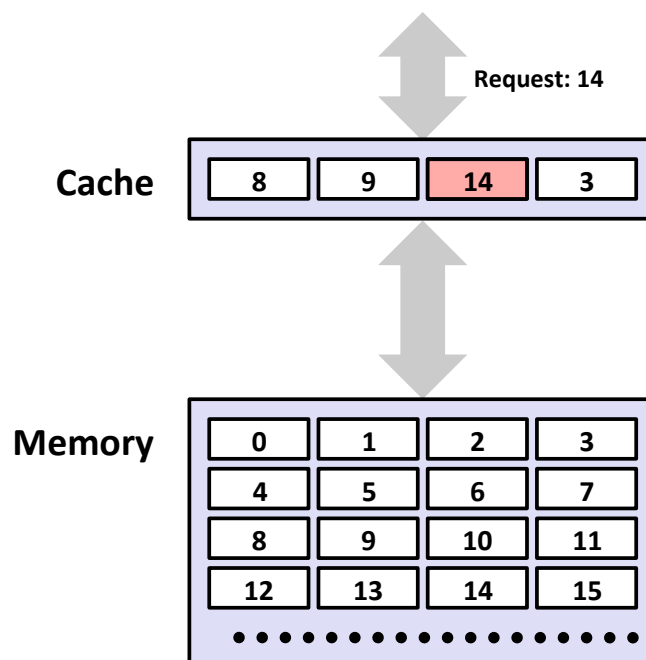
The CPU-Memory Gap



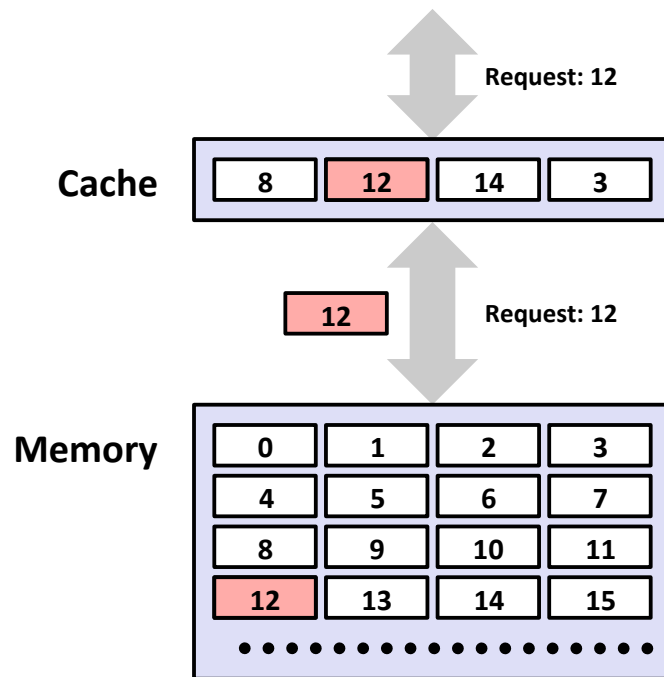
Caching



Cache Hit

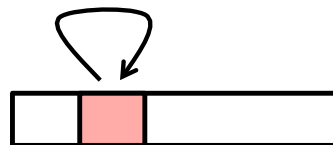


Cache Miss

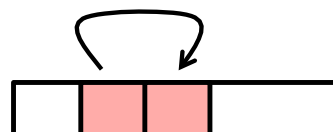


Locality

■ Temporal locality:



■ Spatial locality:



Locality Example (1)

```
sum = 0;
for (i = 0; i < n; i++)
    sum += a[i];
return sum;
```

Locality Example (2)

```
int sum_array_rows(int a[M][N]) {
    int i, j, sum = 0;

    for (i = 0; i < M; i++)
        for (j = 0; j < N; j++)
            sum += a[i][j];
    return sum;
}
```

Locality Example (3)

```
int sum_array_cols(int a[M][N]) {  
    int i, j, sum = 0;  
  
    for (j = 0; j < N; j++)  
        for (i = 0; i < M; i++)  
            sum += a[i][j];  
    return sum;  
}
```

The Memory Hierarchy

