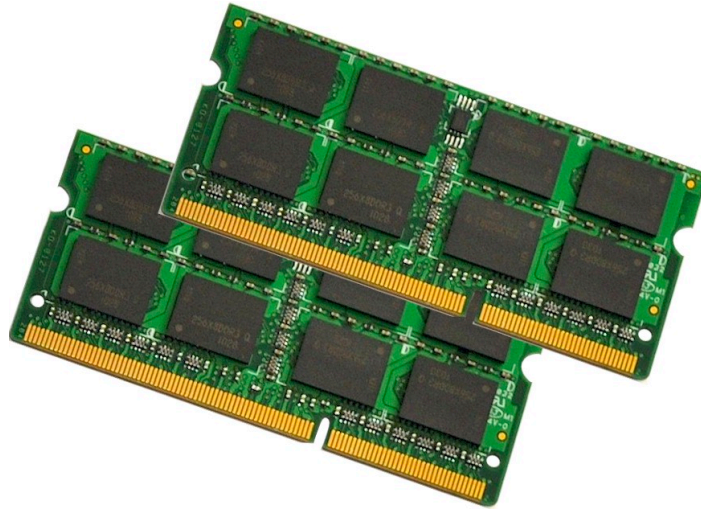
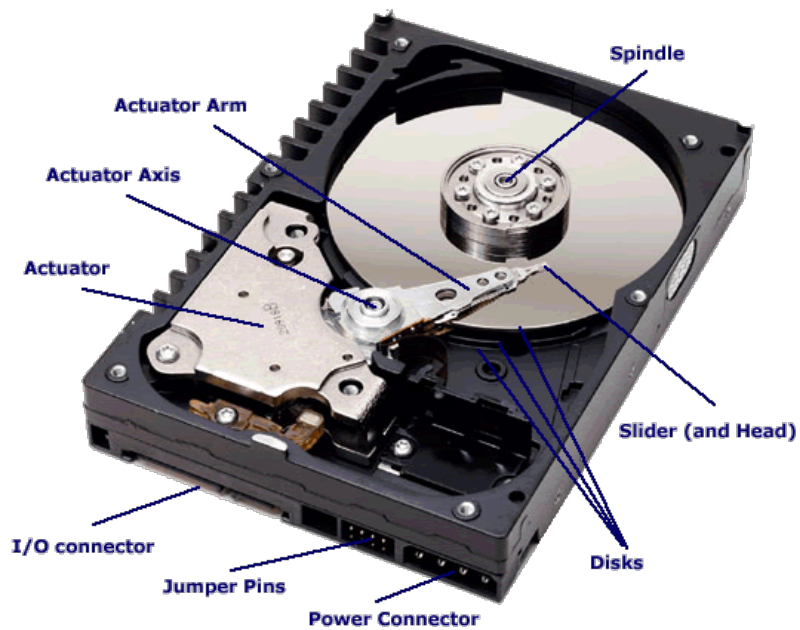


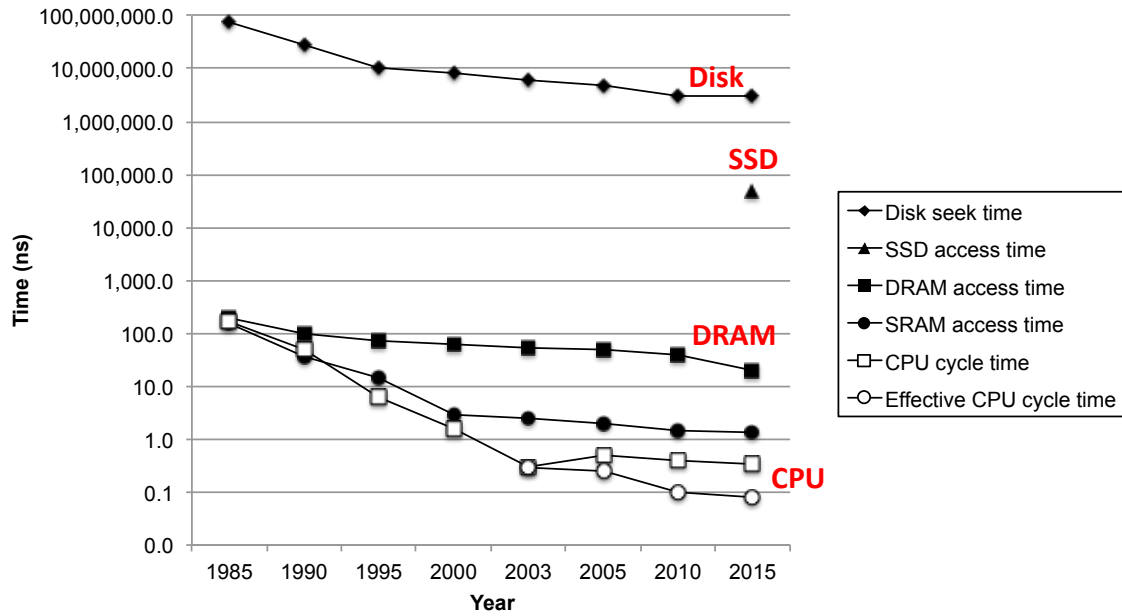
The Memory Hierarchy



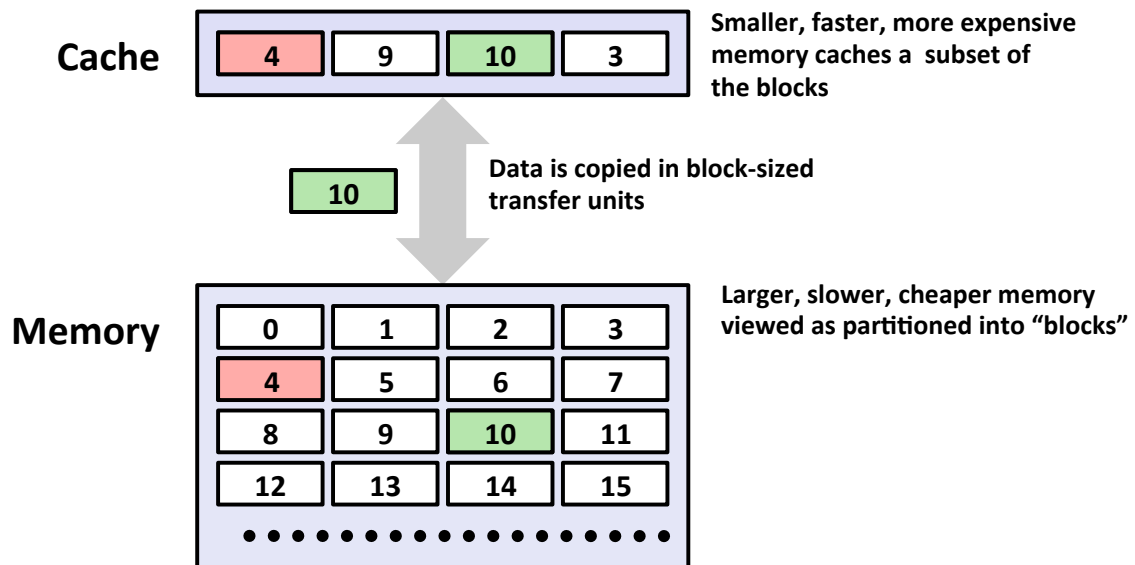
Hard Disks



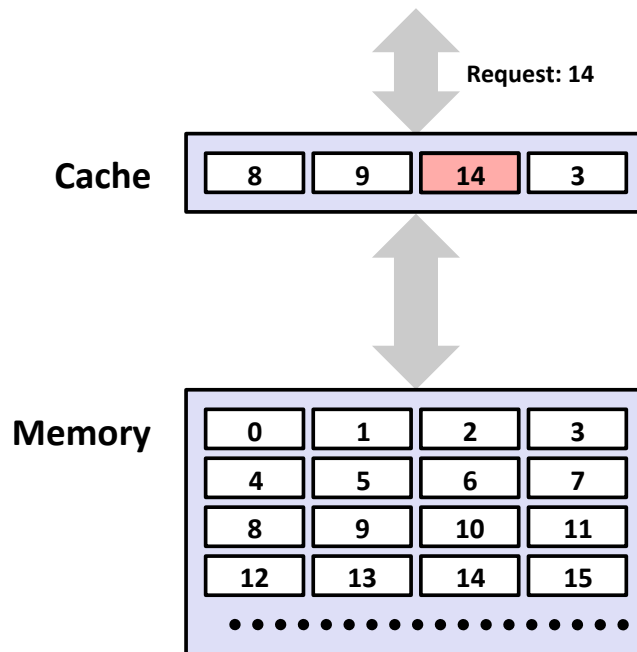
The CPU-Memory Gap



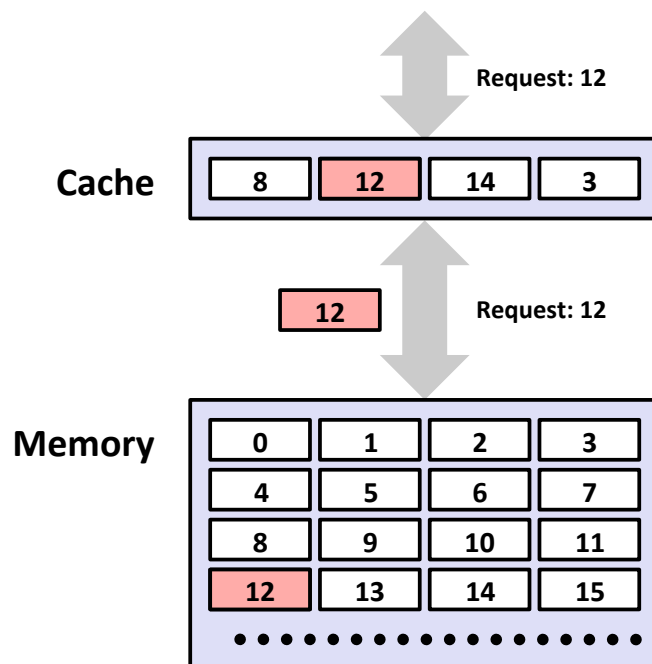
Caches



Cache Hit

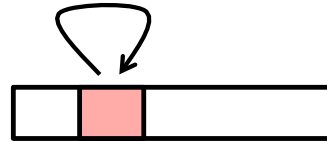


Cache Miss

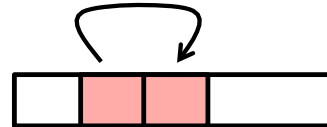


Locality

- **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;
}
```

Locality Example (4)

```
int sum_array_3d(int a[M][N][N]) {
    int i, j, k, sum = 0;

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

    return sum;
}
```

The Memory Hierarchy

