

Exemplo: *Loop Interchange*

```
/* Before */  
for (j = 0; j < 100; j = j+1)  
    for (i = 0; i < 5000; i = i+1)  
        x[i][j] = 2 * x[i][j];
```

```
/* After */  
for (i = 0; i < 5000; i = i+1)  
    for (j = 0; j < 100; j = j+1)  
        x[i][j] = 2 * x[i][j];
```

Acessos sequenciais ao invés de acessá-los
sequencialmente a cada 100 palavras

Exemplo: *Loop Fusion*

```
/* Before */
```

```
for (i = 0; i < N; i = i+1)
    for (j = 0; j < N; j = j+1)
        a[i][j] = 1/b[i][j] * c[i][j];
for (i = 0; i < N; i = i+1)
    for (j = 0; j < N; j = j+1)
        d[i][j] = a[i][j] + c[i][j];
```

```
/* After */
```

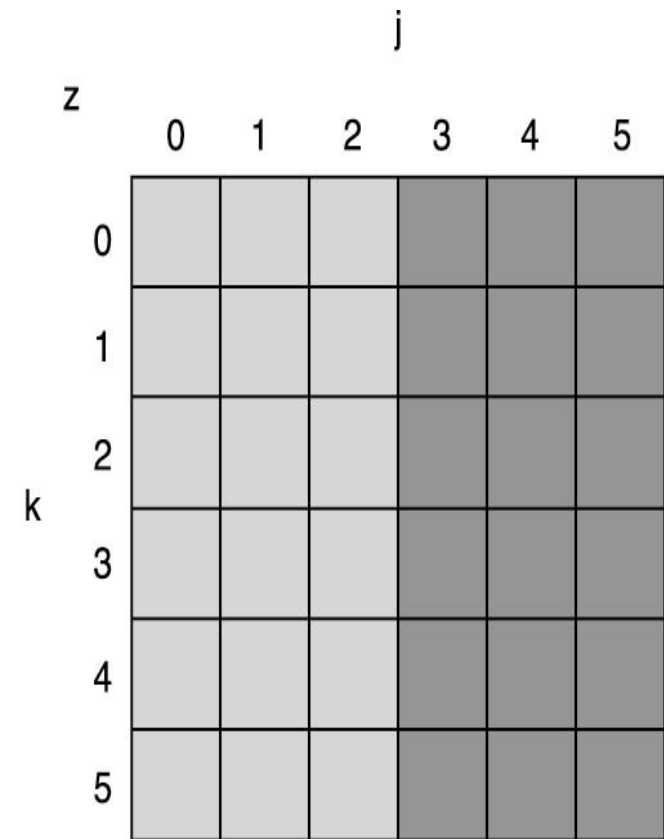
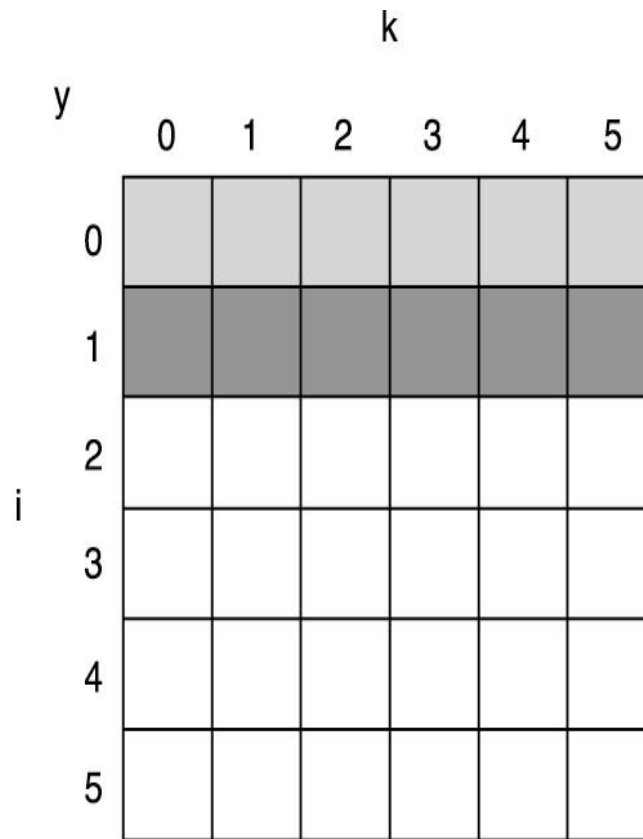
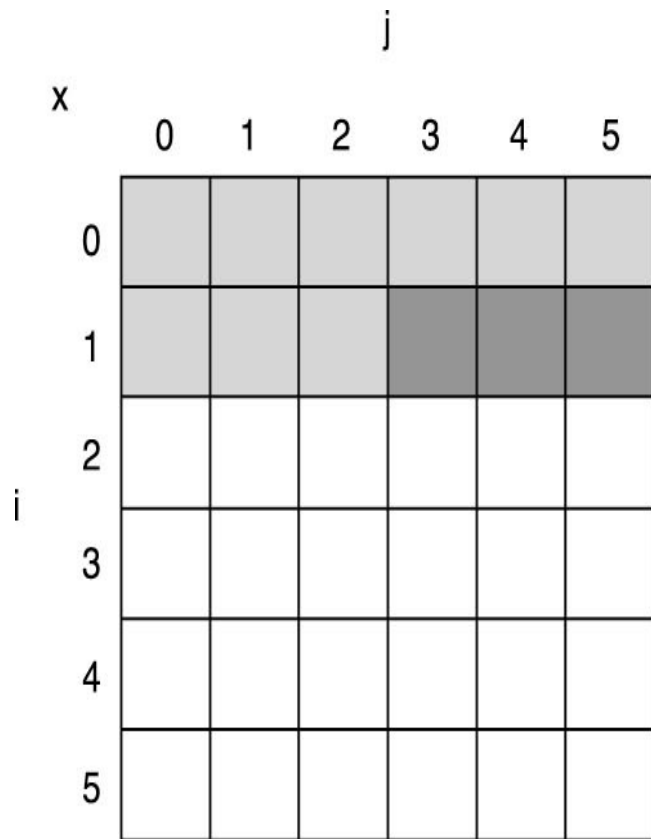
```
for (i = 0; i < N; i = i+1)
    for (j = 0; j < N; j = j+1)
    {
        a[i][j] = 1/b[i][j] * c[i][j];
        d[i][j] = a[i][j] + c[i][j];
    }
```

2 misses por acesso de a e c vs. um miss por acesso

Exemplo: *Blocking*

```
/* Before */  
for (i = 0; i < N; i = i+1)  
    for (j = 0; j < N; j = j+1)  
        {r = 0;  
          for (k = 0; k < N; k = k+1) {  
            r = r + y[i][k]*z[k][j];}  
          x[i][j] = r;  
        };
```

Blocking



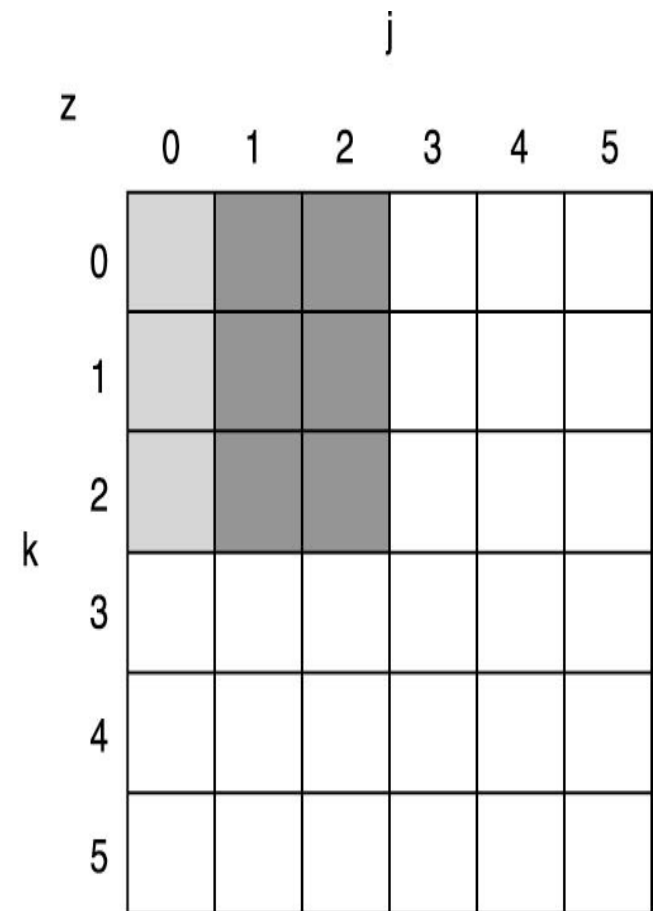
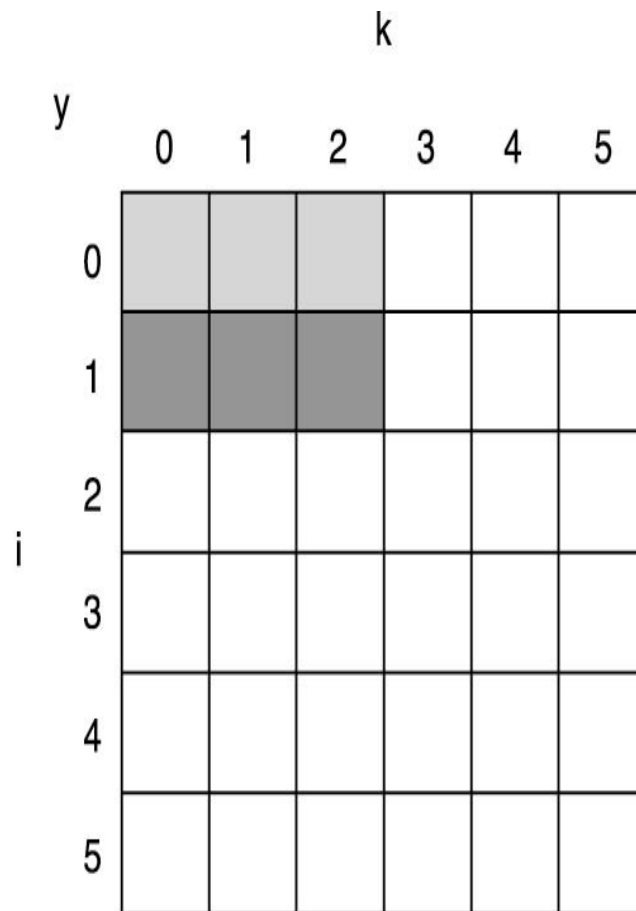
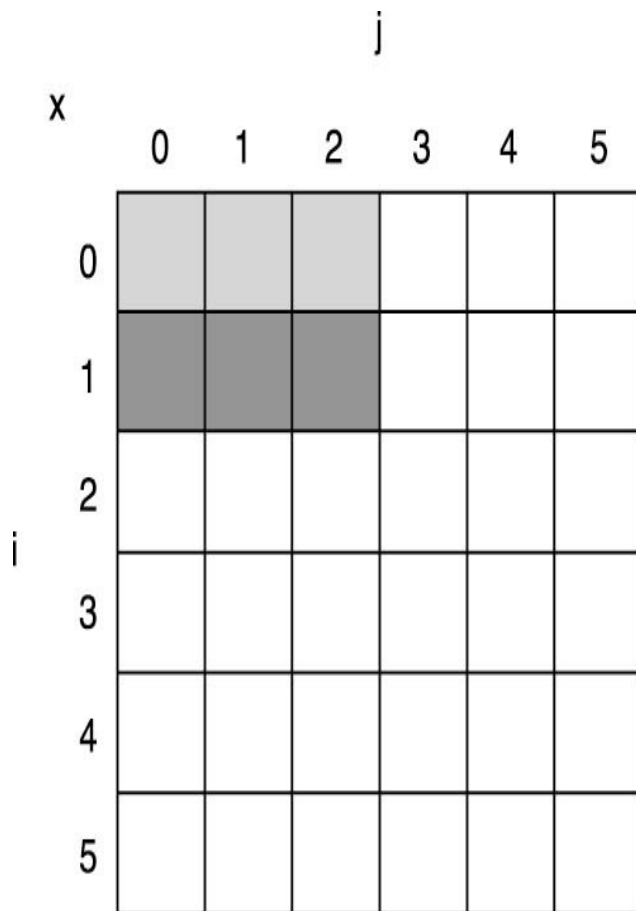
Blocking

- Dois loops mais internos:
 - Lêem todos $N \times N$ elementos de $z[]$
 - Lêem N elementos de 1 linha de $y[]$ repetidamente
 - Escrevem N elementos de 1 linha de $x[]$
- Misses de Capacidade são uma função de N e tamanho de cache ($3 N \times N$)
- Idéia: calcular submatriz $B \times B$ que cabe na cache

Blocking

```
/* After */  
for (jj = 0; jj < N; jj = jj+B)  
for (kk = 0; kk < N; kk = kk+B)  
for (i = 0; i < N; i = i+1)  
    for (j = jj; j < min(jj+B,N); j = j+1)  
        {r = 0;  
            for (k = kk; k < min(kk+B,N); k = k+1) {  
                r = r + y[i][k]*z[k][j];}  
            x[i][j] = x[i][j] + r;  
        };
```

Blocking



Exemplo: Blocking

- Misses de capacidade de $2N^3 + N^2$ a $2N^3/B + N^2$
- B é chamado de Blocking Factor