Prefetching

Mike Bailey
mjb@cs.oregonstate.edu

Oregon State University
Prefetching is used to place a cache line in memory before it is to be used, thus hiding the latency of fetching from off-chip memory.

There are two key issues here:
1. Issuing the prefetch at the right time
2. Issuing the prefetch at the right distance

**The right time:**
If the prefetch is issued too late, then the memory values won’t be back when the program wants to use them, and the processor has to wait anyway.

If the prefetch is issued too early, then there is a chance that the prefetched values could be evicted from cache by another need before they can be used.

**The right distance:**
The “prefetch distance” is how far ahead the prefetch memory is than the memory we are using right now.

Too far, and the values sit in cache for too long, and possibly get evicted.

Too near, and the program is ready for the values before they have arrived.
#define WILL_READ_ONLY 0
#define WILL_READ_AND_WRITE 1
#define LOCALITY_NONE 0
#define LOCALITY_LOW 1
#define LOCALITY_MED 2
#define LOCALITY_HIGH 3

#define PD 32 // prefetch distance (fp words)

for( int i = 0; i < ArraySize; i++ )
{
    if( (i%16) == 0 )
    {
        __builtin_prefetch ( &a[i+PD], WILL_READ_AND_WRITE, LOCALITY_LOW );
        __builtin_prefetch ( &b[i+PD], WILL_READ_ONLY, LOCALITY_LOW );
    }
    a[i] = a[i] + b[i];
}
Prefetching in icc and icpc

Overall, icc and icpc seem to do a good job of prefetching without you doing anything extra, but if you want to be sure:

```
#pragma prefetch var:which-prefetch:#vector-iterations
```

```c
#pragma prefetch a:0:8
#pragma prefetch a:1:32
#pragma prefetch b:1:32
for( int i = 0; i < ArraySize; i++ )
{
    if( (i%16) == 0 )
    {
        __builtin_prefetch ( &a[ i+PD ], WILL_READ_AND_WRITE, LOCALITY_LOW );
        __builtin_prefetch ( &b[ i+PD ], WILL_READ_ONLY, LOCALITY_LOW );
    }
    a[ i ] = a[ i ] + b[ i ];
}
```

There can be two memory prefetches inside a loop.
Prefetching in Visual Studio

void _m_prefetch( void * );

Loads a cache line into cache and sets the cache line state to exclusive.

#define PD 32 // prefetch distance (fp words)

for( int i = 0; i < ArraySize; i++ )
{
    if( (i%16) == 0 )
    {
        _m_prefetch( &a[ i+PD ] );
        _m_prefetch( &b[ i+PD ] );
    }
    a[ i ] = a[ i ] + b[ i ];
}
The Effects of Prefetching on SIMD Computations

Array Multiplication Example
Length of Arrays (NUM): 1,000,000
Number of pairs of floats processed per SIMD call (SIMDSIZE): 4
Prefetch Distance (PD): 32

```c
for( int i = 0; i < NUM; i += SIMDSIZE)
{
    __builtin_prefetch ( &A[i+PD], WILL_READ_ONLY, LOCALITY_LOW );
    __builtin_prefetch ( &B[i+PD], WILL_READ_ONLY, LOCALITY_LOW );
    __builtin_prefetch ( &C[i+PD], WILL_READ_AND_WRITE, LOCALITY_LOW );

    SimdMul( &A[i], &B[i], &C[i], SIMDSIZE);
}
```
The Effects of Prefetching on SIMD Computations

![Graph showing the effects of prefetching on SIMD computations. The graph plots speed (in MegaMults/Second) against array size (in M). The lines represent different scenarios: SIMD with prefetch, SIMD without prefetch, non-SIMD with prefetch, and non-SIMD without prefetch. The y-axis represents speed ranging from 0 to 600, and the x-axis represents array size ranging from 0 to 4.5.]