Datasheet

codeplay
www.codeplay.com

offload for Cell Broadband Engine™

Offload™: Community Edition is a development tool suite for writing real-world C++ applications for the Cell Broadband Engine™. Offload™ provides a simple method for offloading the parts of your code you want to execute on the SPE's of the Cell processor. All you need to do is mark up the code you want offloaded and Offload™ will automatically handle the scheduling, data transfer and execution.

The Offload™ tool suite includes everything you need; Compiler, Multi-Core Runtime Library, Source Level Debugger and an Eclipse IDE plugin for Linux developers. All of these components can integrate seamlessly with your existing development tools.

How Offload Works

Codeplay Offload™ takes in C++ source, with offload blocks marked out for call-graph-duplication and offloading to accelerator cores.

```
int ppu_function () {
    int x; // x is in shared memory
    __offload {
        int y; // y is in local memory
        y = f (&x, &y);
          /* 'f' is duplicated and called with
            a shared-memory-pointer
            (1st argument) and
            a local-memory-pointer
            (2nd argument)*/
    }
}
```

With little effort this allows the offloading of complex C++ code including virtual methods, multiple inheritance, function pointers, call-backs, etc .The system calculates the layout of the C++ data-structures and the calling conventions of the C++ functions and methods, and then outputs C code (including makefiles) for the different processors in the system with the structure layout and calling conventions hard-coded into the C. This allows different compilers, with different data-structure layouts, to compile for different processor cores, but they can safely be accessing the same data structures.

Offload™ handles GCC3, GCC4 and Microsoft C++ class layouts. The Offload™ tool also outputs C macros to handle shared memory access. In this way, the user of the system can define those macros to access shared memory in any way (dma, software cache etc)desired. This allows users to add in support for software transactional memory, for example, or data-dependency checking.

Also, the Offload™ tool can output advice to highlight places where it is not safe for the compiler to perform an optimization without the user changing the code. This allows streaming DMA, for example, to be easily inserted into existing source code.

Call-Graph Duplication

Call-graph duplication is the main hard work that the Offload compiler automatically performs behind the scenes for the programmer. Call-graph duplication enables offloading C++ code inside offload blocks without further changes to the code. (see example above). The Offload compiler separately compiles the code for the SPU and links it up with the PPU code (PPU code controls the SPU code, SPU code can reference data in host memory).

The key benefits of Call-Graph-Duplication are:

1. Reduces the amount of error-prone work required to move code onto an accelerator processor.
2. Allows programmers to keep their source code portable and easy-to-maintain.
3. Removes the requirement to hand-duplication functions for different processor cores and memory spaces.
4. Hides the complexity of offloading complex C++ to SPU

Consider a simple example:

```
int f(int* a, int* b) {
        return *a + *b;
}
```

Without call-graph-duplication, we would have to create 2 different versions of the function 'f' - for the PPU and one for the SPU . With call-graph-duplication, we only need one version of function 'f' and the compiler *automatically* generates the required SPU version. This leaves the code more maintainable, easier to read, and much easier to write. It is especially useful when offloading a lot of code onto SPU.

Call-graph duplication is also useful if we decide that (perhaps for performance reasons) we want to move the variable 'x' from shared memory to local memory. Without call-graph-duplication, this would involve changing the implementation of 'f', but with call-graph-duplication, the compiler works out that 'f' needs to be compiled with different access operations for 'x'.

Less code to write for the programmer

To illustrate how much less code there is to write using Offload™, this is how the programmer might have to write versions of function ‘f’ without call-graph-duplication:

```
int f(int* a, int* b) {
    return *a + *b;
}
int spu_f(int* a, int* b) {
    return *a + *b;
}
int spu_f_local_global (int* a, __ea int* b) {
    return *a + fetch_int (b);
}
int f_global_local(__ea int* a, int * b) {
    return fetch_int (a) + *b;
}
int f_global_global(int* a, int* b) {
    return fetch_int (a) + fetch_int (b);

}
```

Overloading for Performance

If automatic duplication doesn’t give you the performance you need, then you can manually override the default behaviour. For example, if you want to modify the ‘f’ function to use a different mechanism to read the pointer ‘a’ in the case where ‘a’ is in shared memory, you could write the following overloaded function:

```
__offload int f(int __outer * a, int* b) {
    return fetch_manual (a) + *b;
}
```

The Offload™ tool will choose to use this implementation of ‘f’ in the case where ‘a’ is an ‘outer’ (or shared memory) pointer, and use the normal implementation of ‘f’ when ‘a’ is a local pointer, or when called from PPU. This allows performance optimizers to write special high-performance versions of critical functions without having to modify the main source code, or lose source portability.

Core-Specific Optimizations

The Offload™ compiler implements optimizations for different types of cores. For example, casts from scalars to AltiVec vectors are performed using splat instructions.

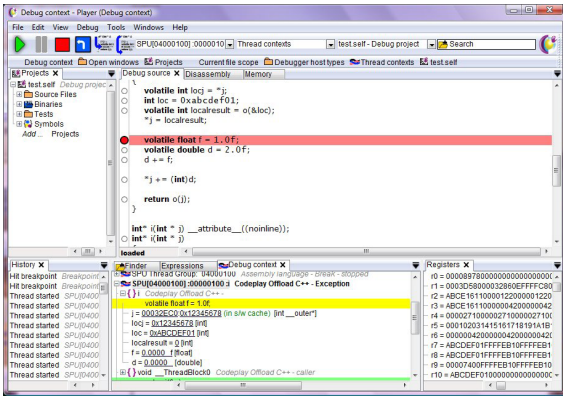
Sometimes there are more efficient intrinsics available than the corresponding GNU intrinsics and the Offload™ compiler can be configured to select these efficient instructions.

Useful Compiler Advice Messages

The Offload™ compiler implements various command line options to help programmers identify performance bottlenecks in offloaded code. For example, pointer variables initialized with data outside the offload block are expensive to dereference. The option -offloadwarnouterdeduction makes the compiler issue a warning so that the programmer can, if possible, move the initializer data inside the offload block and the pointer dereference operation then becomes fast.

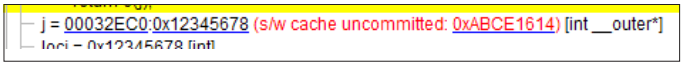
Debugging

The Offload™ compilers output C code which can be compiled with normal compilers (and possibly with different compilers for different processor cores) and debugged with normal debuggers. However, to debug everything together, and see the impact of the software cache, developers need to use Codeplay’s debugger, called Player.



Users can hover the mouse over a variable to see its value. Each processor core is shown as a normal thread with a normal call-stack. Everything behaves as users would expect for a single-core or normal multi-threaded processor, even though the system is working across PPU and SPU on the Cell processor.

The debugger handles code compiled with GCC and the standard DWARF debugger format, as well as code transformed with Codeplay’s Offload™ tool.
The debugger also shows the effect of the software cache, letting programmers see the effect of writing code that runs on multiple processors:



This is showing that a value (0xABCDE1614) has been written to the shared-memory pointer "j". The value is still in the software cache and not committed to shared memory, so shared memory still contains the value 0x12345678.

Availability

Offload™ can help you unlock the full power of the Cell Broadband Engine™ on whatever device it may be powering, without needing to increase your budget.

Offload™ is available for Cell Broadband Engine powered devices running under Linux, 2009. To find out more about Offload™ for The Cell Broadband Engine™ Linux and track its availability visit http://offload.codeplay.com

There are detailed walk-through examples showing the whole process of using Offload™ blocks step-by-step at http://offload.codeplay.com