SVM API

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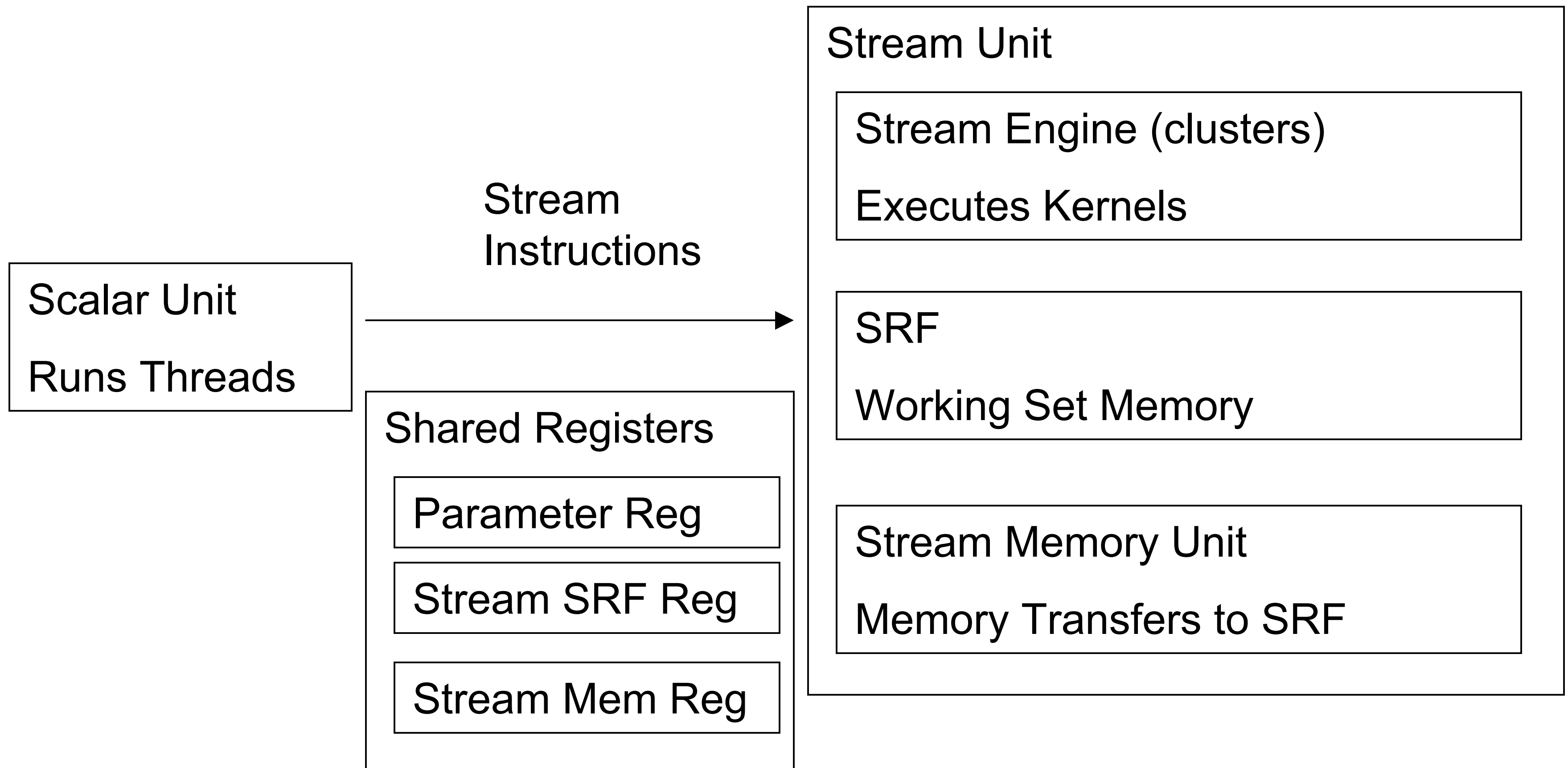
Modifications of the meeting in Blue

Single Node Big Picture



SVM Programs

Control Thread

C thread with

- Special Registers
- Special Functions
- Call Stream Instructions on Stream Unit

Kernel Foobar

Kernel Foo

Similar to KernelC with cluster abstraction

Deals with 1D streams

Control Thread – Special Functions

1. Creating Parallel Control Threads

   When multiple nodes are working on a subset of the problem doing reductions across these nodes

```
mythreadID = SpawnParallelCThreads(8);
```

Here if the control thread was running on node x, copies of the control thread have been created on nodes x+1 to x+7 each returning their thread ID

Control Thread – Stream Instructions

- The Control Thread launches Stream Instructions executed on Stream Unit (StreamLoad, StreamStore, KernelStart, …)
- It needs to specify the dependencies of these instructions on each other
- It also needs to synchronize on the completion of these operations (ex: expecting a reduction value)

Control Thread – Stream Instructions

- Each Stream Instruction launched returns a fence ID.
- The dependencies between Stream Instructions are specified with a list of fence ID (which need to complete before it can be executed)
- The Control Thread can query (non-blocking) or sync (blocking) on these fences too.

```
fence[87] = StreamLoad (StreamMemRegA, StreamSRFRegA, Fence[86],
   Fence[85]);
fence[88] = KernelStart (KernelPtrFoo, StreamSRFRegA, StreamSRFRegB,
   fence[87]);

if (query(fence[87])
   // Stream Load has completed already

synch(fence[88]); // Will only return once KernelStart has completed
```

Control Thread – Shared Registers

- The Shared Registers are used to specify arguments being reused by stream instructions (closer to machine working)
- Ex: Stream Memory Register describes how a stream is laid out in main memory, used by Streamloads and Streamstores

Control Thread – Stream Memory Register

```
#define STREAM_MEM_RF 32 // could be a SVM parameter, not really critical

#define STRIDED_STREAM 0
#define INDEXED_STREAM 1

struct StreamMemReg {
   int stream_access_mode; // STIDED_STREAM or INDEXED_STREAM
   int stream_stride_or_index; // the stride or which stream is indexed
   int stream_ptr;  // address at which the stream access is to start.
   int stream_record_size;  // Size in Words of records
   int stream_length;      // Number of records
};

StreamMemReg StreamMemRF[STREAM_MEM_RF];
```

- StreamLoads and StreamStore refer to a stream described in the StreamMem Register file

Control Thread – Stream SRF Register

```
#define STREAM_SRF_RF 32 // could be a SVM parameter, not really critical

struct StreamSRFReg {
    int stream_ptr;          // address at which the stream starts in SRF.
    int stream_record_size; // Size in Words of records
    int stream_length;      // Number of records
};

StreamReg StreamSRF_RF[STREAM_SRF_RF];
```

- Used By StreamLoads, StreamStore and KernelStart to tell location of stream IOs of kernel.

Control Thread – Kernel Parameter Register

```
#define KERNEL_PARAM_RF 32 // could be a SVM parameter, not really critical

int KernelParamRf[KERNEL_PARAM_RF];
```

- This is where the scalar (non-stream) kernel parameters are passed.
- Also where the reductions are written by the stream unit and read by the control thread

Control Thread - Reductions

```
#define REDUCTION_ADD_INT 0;
#define REDUCTION_ADD_FP 1;
…

LocalReduction = KernelParamRf[11];

GlobalReduction = Reduce(REDUCTION_ADD_INT, localReduction);
```

- Doing reduction across multiple nodes (control threads).
- Leave some room for faster machine specific implementation of reduction
- Leave choice for communication pattern (radix of three)
- MODIFICATION: non-blocking reduction and reductions that return the value to a specific control thread only

Stream Instructions – StreamLoad

```
Fence[87] = StreamLoad (StreamMemRegA, StreamSRFRegA, Fence[86],
    Fence[85]);
```

- Arguments:
  - Stream MEM Register Index
  - Stream SRF Register Index
  - List of fence IDs which need to complete before it can execute
- Possible Dependencies
  - StreamStore, wait for SRF Space to be freed
  - KernelStart, Stream is being consume to free SRF space
- MODIFICATION: Specify the number of dependencies as an argument, for all stream instructions

Stream Instructions – StreamStore

```
Fence[87] = StreamStore (StreamMemRegA, StreamSRFRegA, Fence[86]);
```

- Arguments:
  - Stream MEM Register Index
  - Stream SRF Register Index
  - List of fence IDs which need to complete before it can execute
- Possible Dependencies
  - KernelStart, Stream is being produced

Stream Instructions - KernelLoad

```
Fence[87] = KernelLoad (KernelStartMEMAdd, KernelStartKMEMAdd, length,
   Fence[85]);
```

- Arguments:
  - Kernel Start address in memory
  - Kernel Start address in the kernel memory
  - Kernel length
  - List of fence IDs which need to complete before it can execute
- Possible Dependencies
  - KernelStart, some kernel code won't be needed, liberating some space in kernel memory
- MODIFICATION: no KernelLoad needed, just call the kernel

Stream Instructions - KernelStart

```
Fence[87] = KernelStart (KernelStartKMEMAdd, KernelParamStartIndex,
    StreamSRFRegA, StreamSRFRegB, StreamSRFRegC, Fence[85], Fence[86]);
```

- Arguments:
  - Kernel Start address in the kernel memory
  - The index of the first argument in the parameter register (they are contiguous, wraparound)
  - List of Indices in the Stream SRF register for the stream Inputs and Outputs
  - List of fence IDs which need to complete before it can execute
- Possible Dependencies
  - StreamLoad loading input stream
  - StreamStore, KernelStart liberating SRF space that will be required by output stream.

Stream Instructions – StreamBarrier

```
Fence[87] = StreamBarrier ();
```

- All the previous instructions have to be completed before the next one can start.

SVM Kernels

- General C,
  - For, while, if –else
- Section before and after the stream element loop unlike Brook which only has the main loop
  - To handle corner cases like starting and stop special cases.

SVM Kernels –Stream IO

- Like KernelC, use the C++ syntax to get the next element from the stream and output the next element.
- Also use the conditional input and output stream construct.
  - Because the number of clusters is not defined, the order is not guaranteed when using conditional streams

SVM Kernels - Stencils

- Stencils are regular accesses within a stream which can be propagated through the inter-cluster communication switch
- SVM kernel supports only 1D streams.
- Within a 1D stream, can access relative elements anywhere:

```
Int prev;

Prev << StreamA[INSTANCE-1]
```

- INSTANCE gives which element of the stream you are at.
- Makes C-syntax happier than negative indices

SVM Kernels – Test Conditions

- Test Conditions:
  - Input Stream: End of Stream (EOS)
  - Output Stream: Full
- The end of stream is used to loop on an input stream until it is empty.
- The full output stream could for kernels with undefined number of outputs to suspend and restore.

SVM Kernels – Suspend and Restore

- Basically supported explicitly in a kernel
  - The kernel has an extra input stream to restore state
  - An extra output stream to save state
  - Within the kernel it can test to see if the kernel is full (maybe more flexibility would be useful, like number of words left)
  - The kernel would have an argument to know if it needs to restore
- The details need to be worked out, does the stream instructions need to be resend, or does the barrier has a special state for suspend
- Also what happens for Software pipelined kernels which need the stream data

Multinode Issues - Naming

- Global address space
  - Physical : Node + Offset
  - Virtual: specify where within the address the node number is inserted (not as flexible as segments) elements can be dispersed every power of 2 across nodes
- Implementation detail: For each stream in memory, specify where the node id is insered in the virtual address

Multinode Issues - Coherence

- Basically all the coherence has to be explicit:
  - You could get coherence across everything with an expensive operation: MemFlush
- Can specify higher levels of tolerance through typedefs in the Control thread:

Multinode Issues – Stream Communications

- Desirable to send stream from one SRF to another without going to memory: SSS supports this?
- More Stream Instructions like StreamSend, StreamReceive
- Use MPI-like protocol

Multinode Issues - Synchronization

- Pthread would be great to use, as a framework, but the primitives are limited:
  - Mutex
  - Conditional Variables
- UPC … Parallel C looks more suited to us.