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A soft implementation for interrupting GPU kernels

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LEADERS IN IDEAS AND SOLUTIONS

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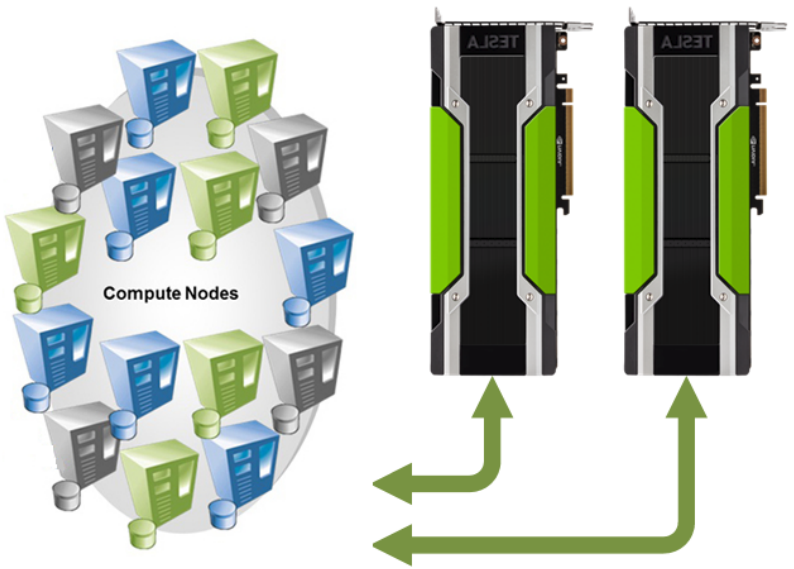
Checkpoint/Restart with GPUs



- GPUs run asynchronously
- Synchronize with the GPU
- Wait until GPU finishes
- **PROBLEM: Cannot interrupt GPU**

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Checkpoint/Restart Libraries

- 2002. BLCR – No Support for GPUs
- 2009. CheCUDA – Compatible with BLCR
- 2011. NVCR – Similar to CheCUDA
- 2011. FTI – No support for GPUs

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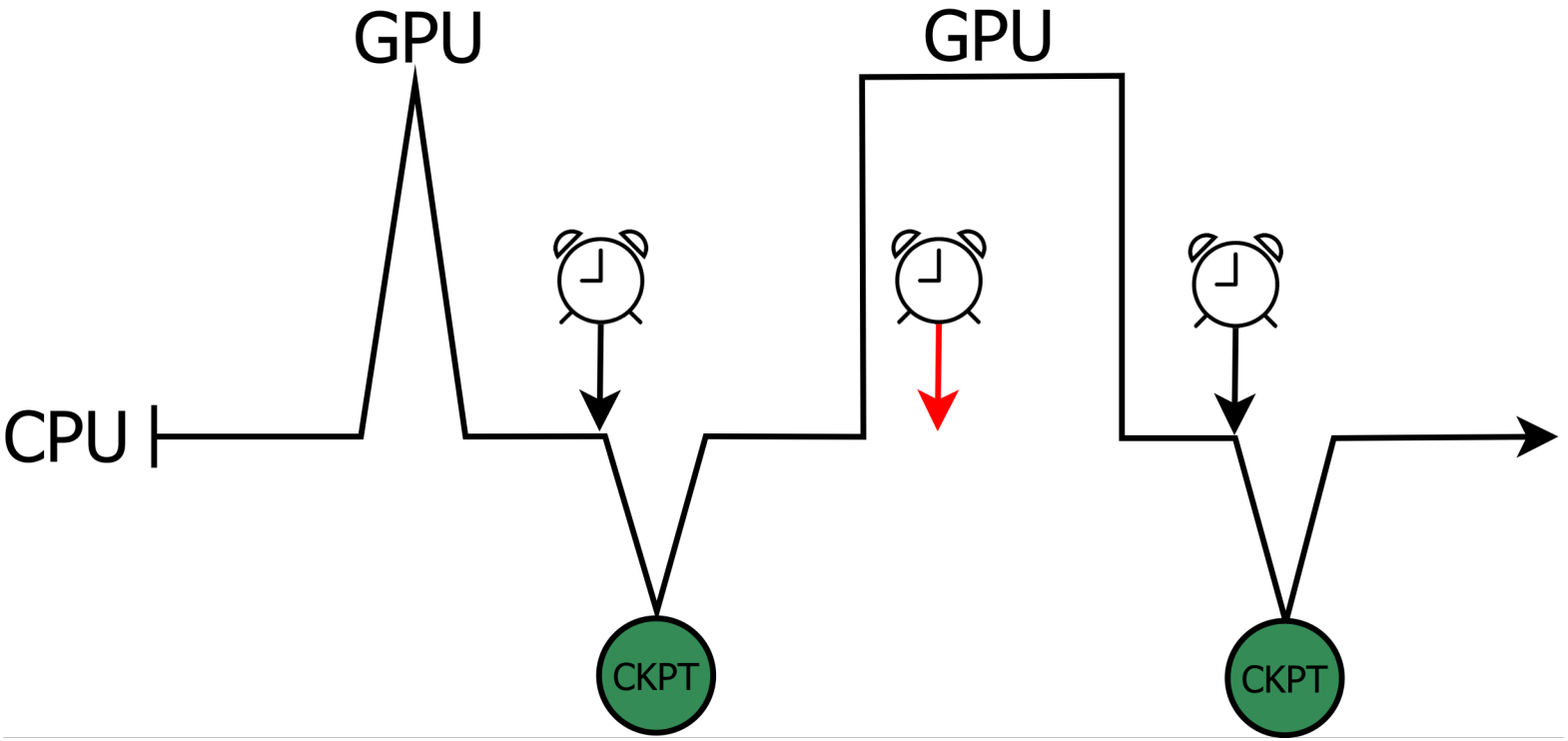
Checkpoint/Restart with GPU



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Possible Approaches?

- Manually Rewrite kernels
  - Can be tricky
- Automated approach?
  - No interrupt
  - What memory to transfer?

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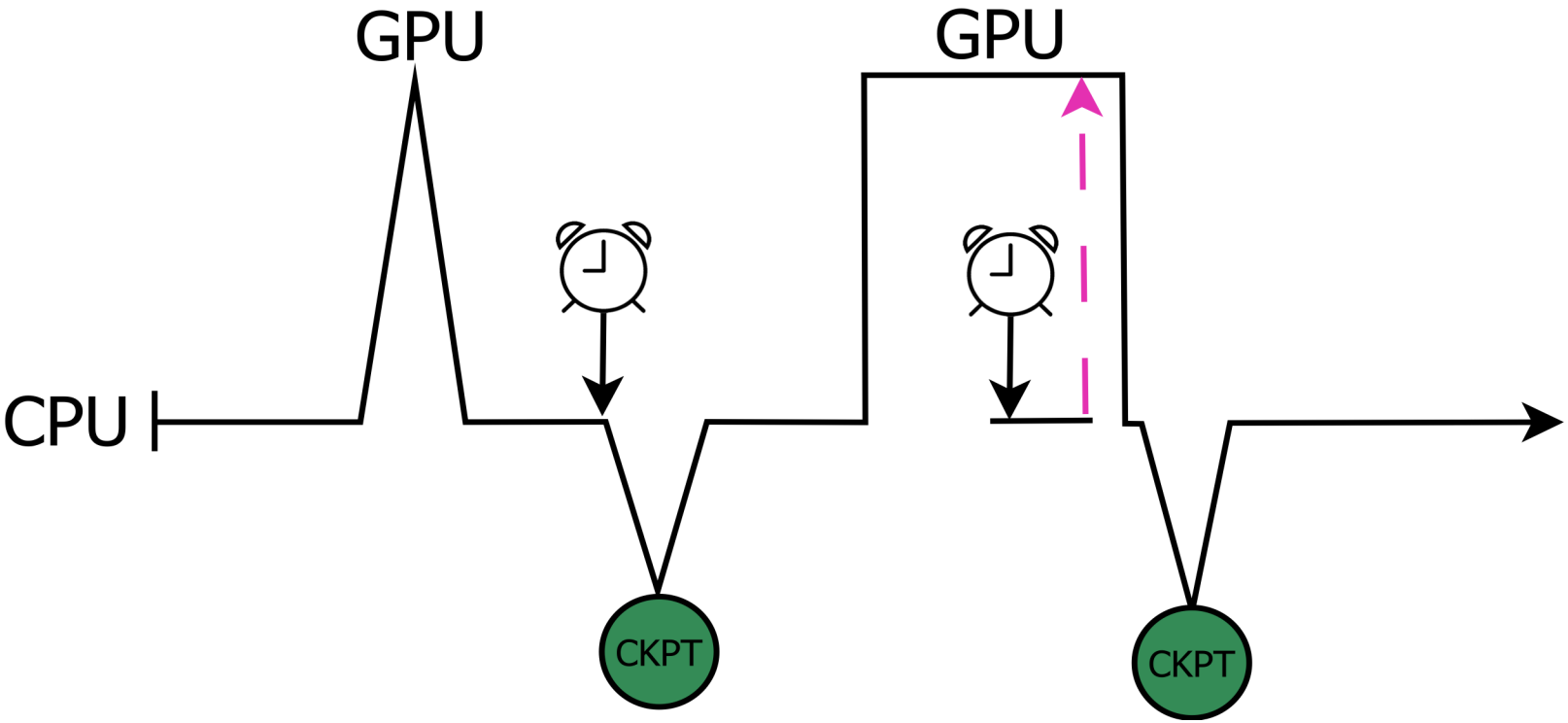
Solution: Soft Interrupt



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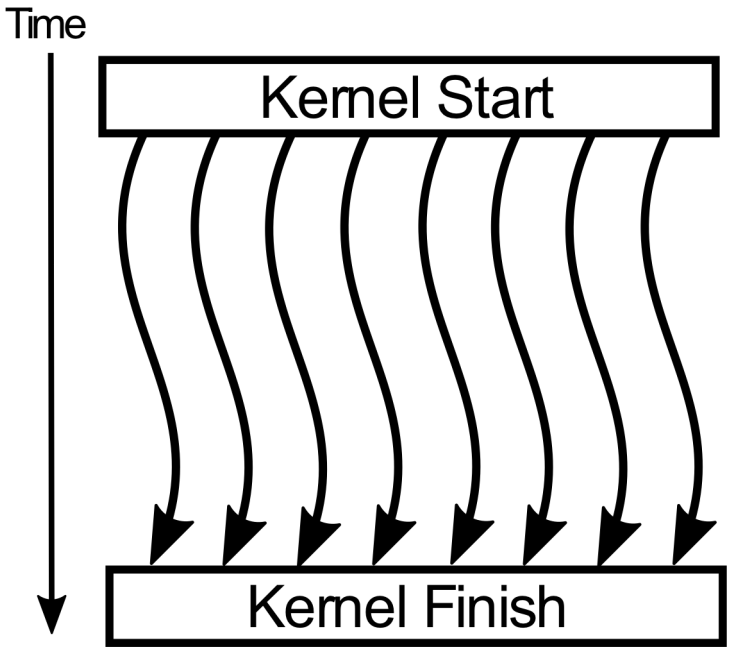
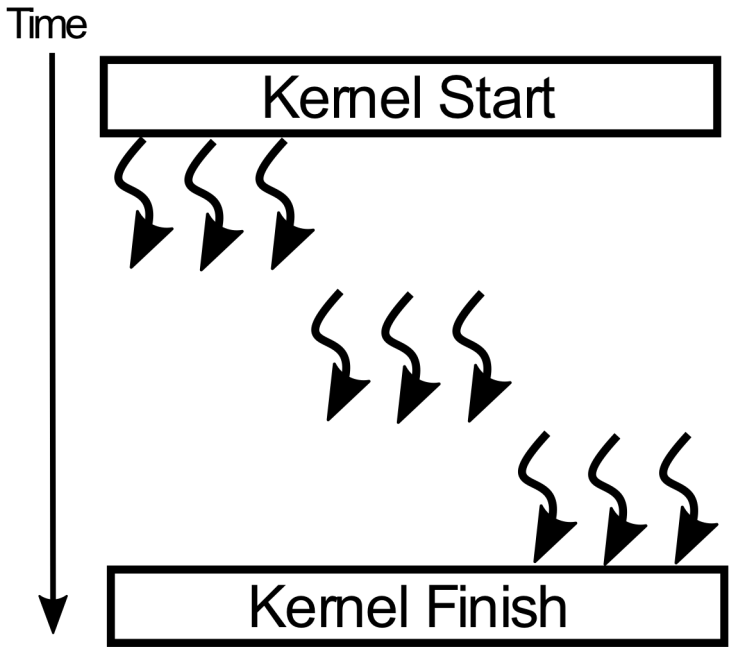
Key Idea

Conceptually



Reality



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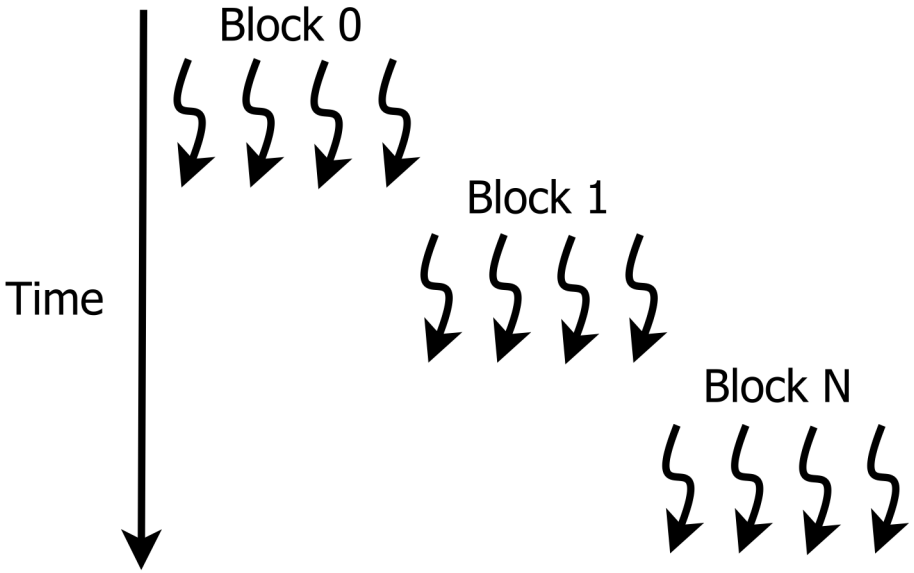
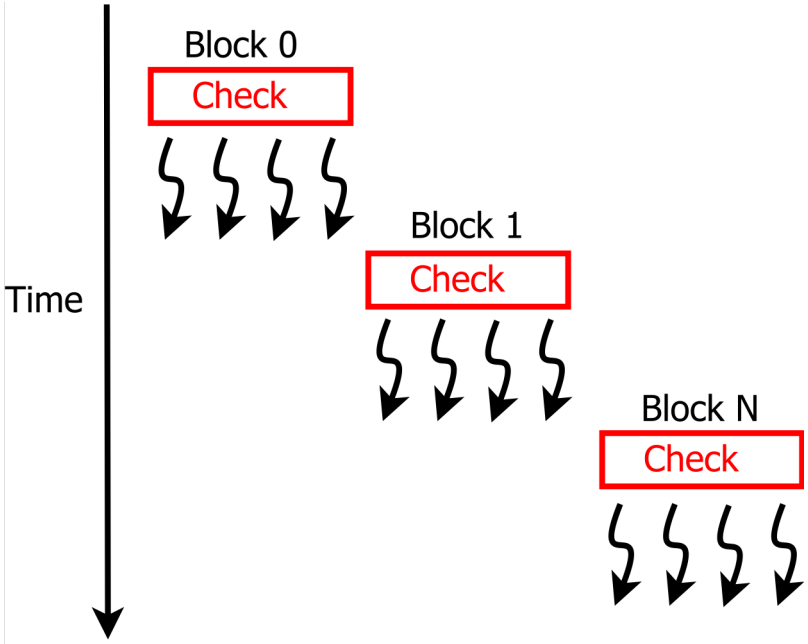
Key Idea

CUDA model



Checks can be inserted



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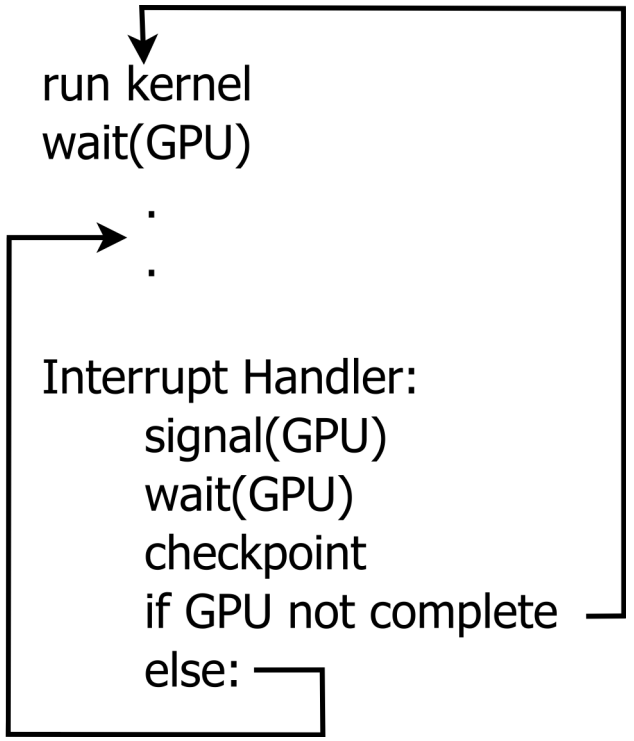
Idea of Soft Interrupt

- GPU

```
do{
    If  time to return
    execute
}while(work)
```

- Host



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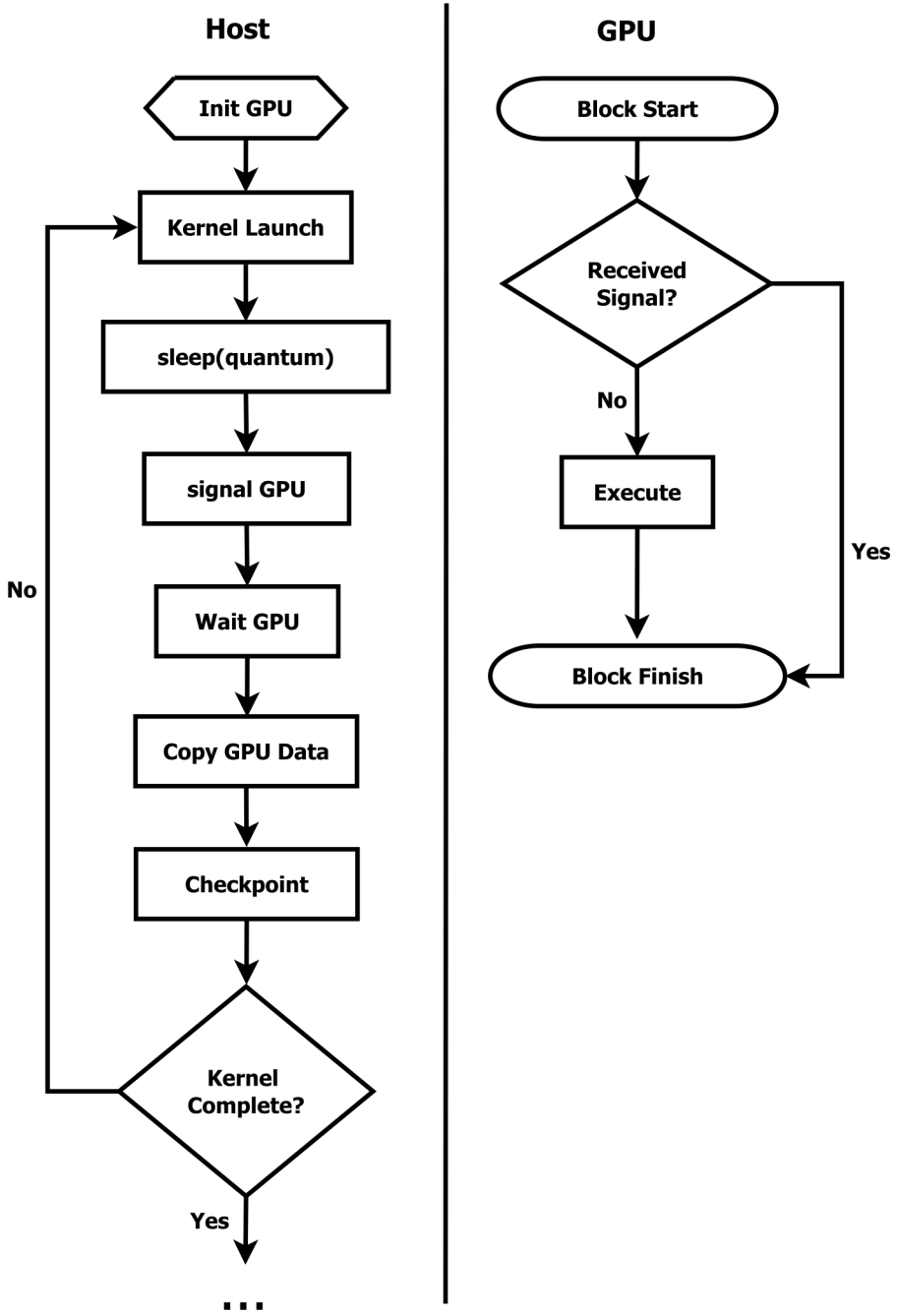
Checkpoint/Restart Extension

- Kernel executes in loop
- Thread groups check for permission to continue



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Checkpoint/Restart Extension

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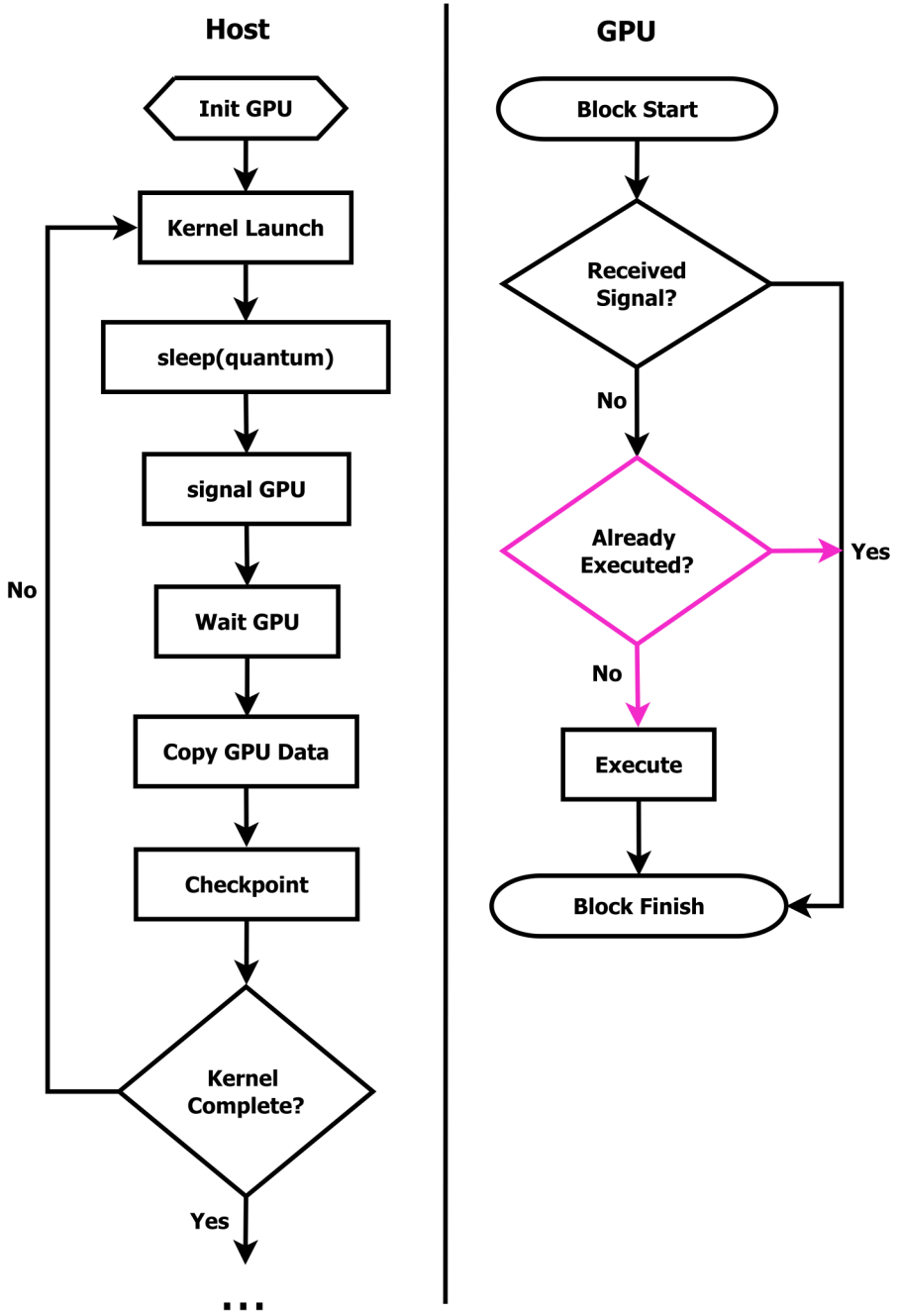

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A library to automate this

- Concise API
  - 3 Macros
    - Re-write kernel definition
    - Re-write kernel launch
    - Insert check in kernel
  - 2 Wrappers
    - Keep track of allocations on GPU
    - Keep track of frees on GPU

https://bitbucket.org/maxbaird/cuda_backup/

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Sources of Overhead

- Conditional checks in each thread
- Soft interrupts of a kernel
- Memory transfers

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Kernel for Evaluating Overhead

```
__global__ void
kernel(unsigned long long n, unsigned long long
*res)
{
 unsigned long long x=0;
 for (unsigned long long i=0 ; i<n; i++){
      x++;
 }
 *res = x ;
}
```

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Experiment Environment

CPU	AMD Opteron 6376
GPU	Nvidia Titan-XP
CPU Memory	512 GB
GPU Memory	12 GB
Driver Version	384.81
CUDA Version	9.0
PCIe	x16
Operating System	Scientific Linux Release 7.4

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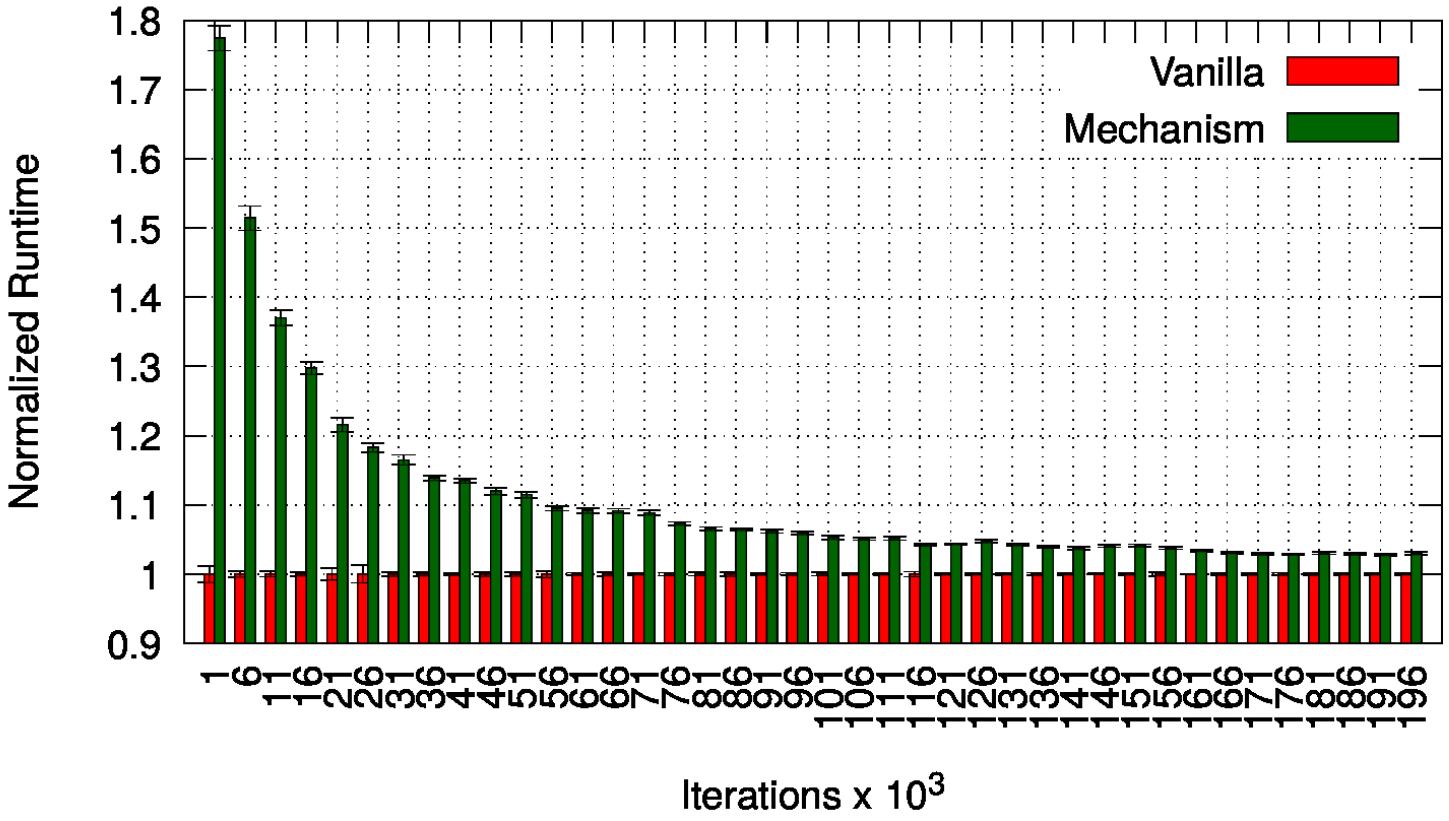
Overhead of Conditional Check

kernel config <<<60, 1024>>>



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Overhead of Conditional Check

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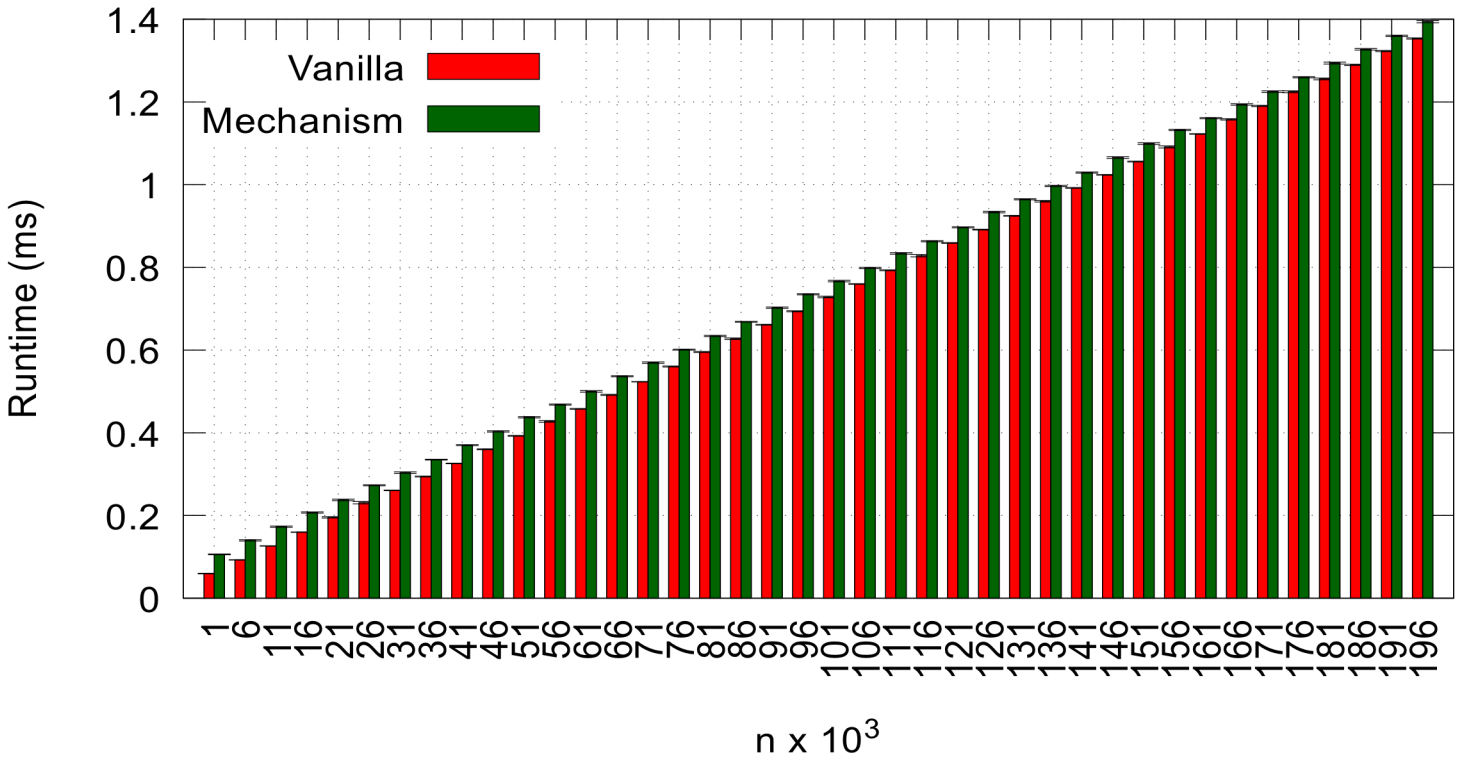

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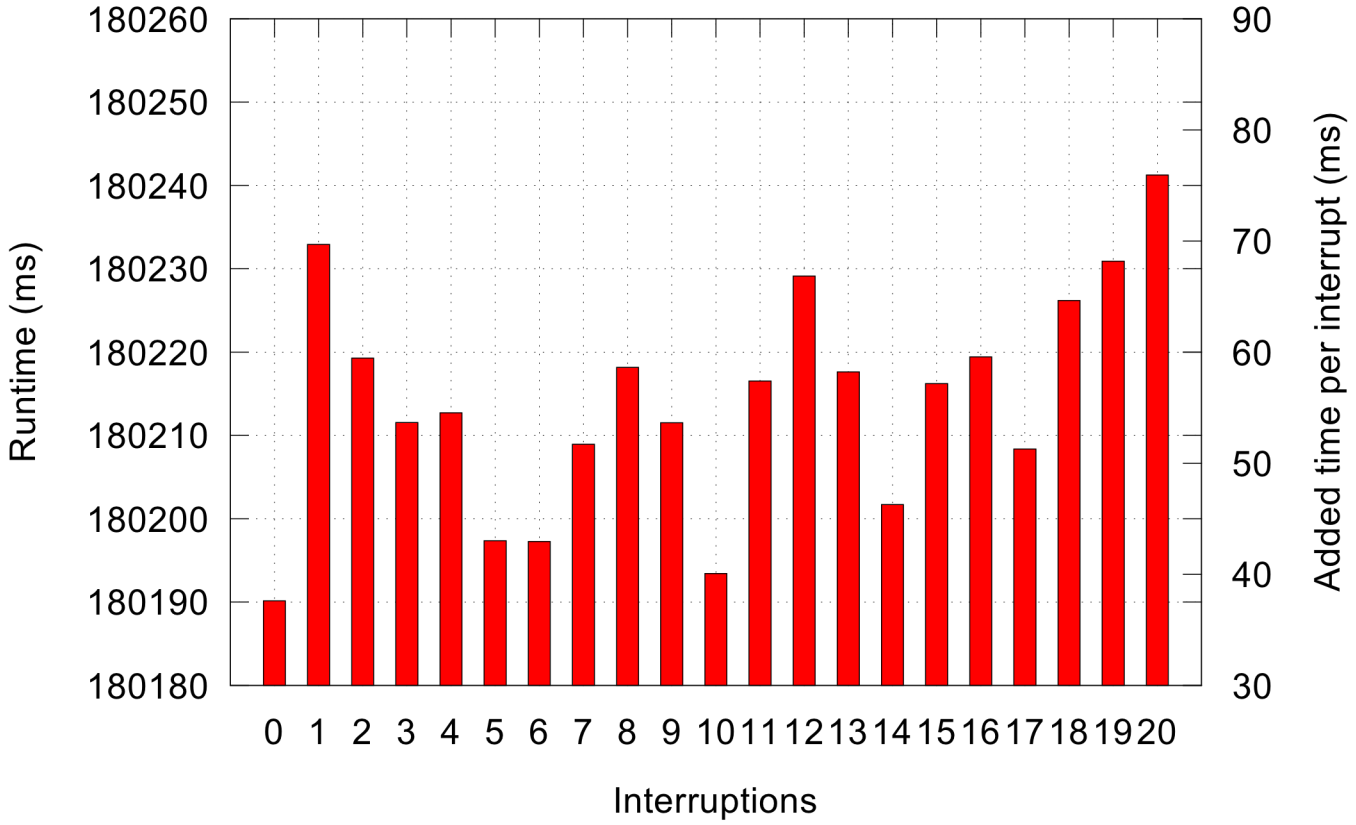
Overhead of Soft Interrupt

kernel config <<<1320, 1024>>> iterations = 1.6 x 10^9



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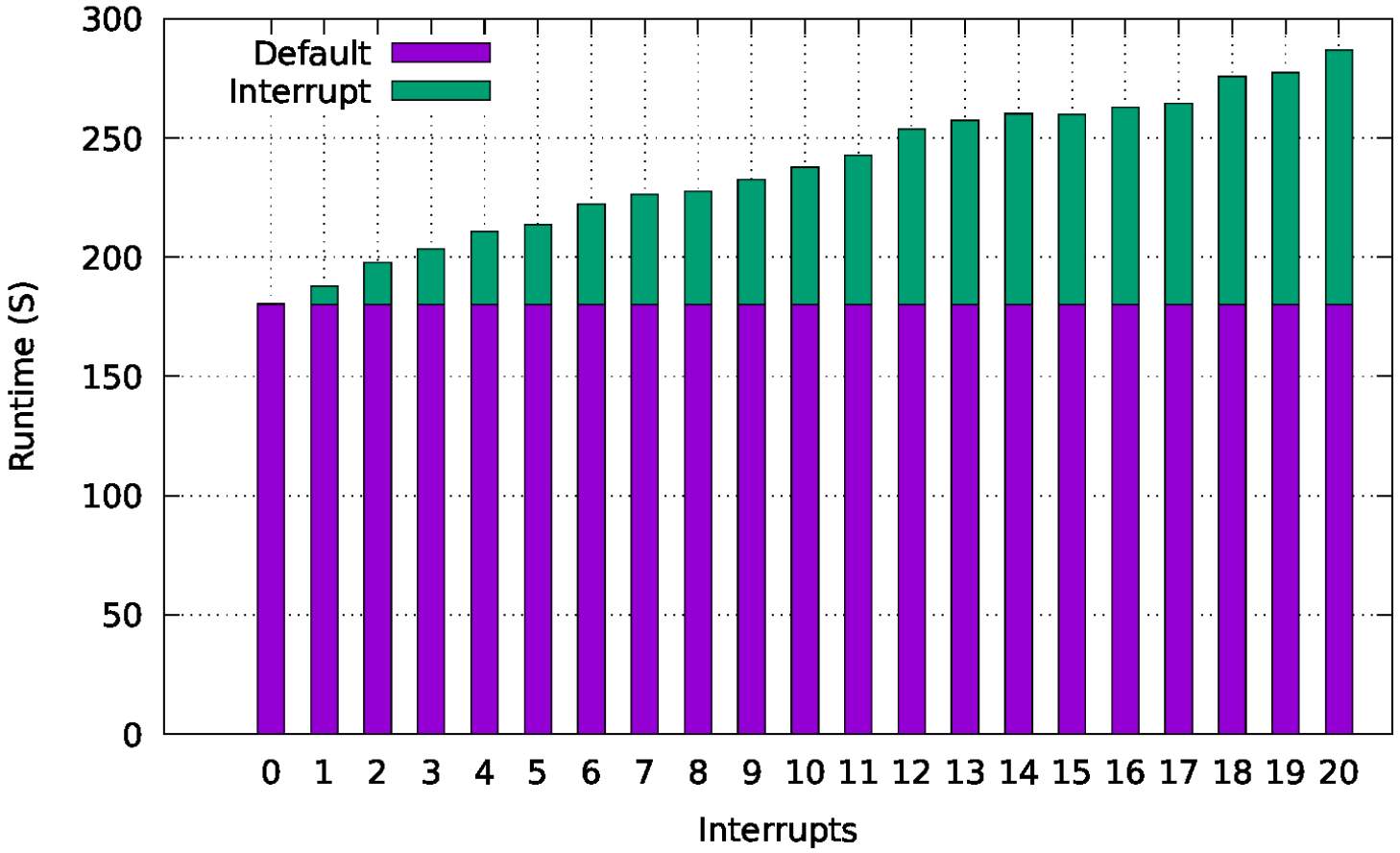
Memory Transfers

98.3% (11.9GB) allocated GPU memory, kernel config <<<1320, 1024>>>
iterations = 1.6×10^9



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Achievements/Conclusions

- Negligible overhead for the kernel
- Very simple to mechanically transform kernels
- Potential limitations
  - Global synchronization
    - Should be broken into sepaparte kernels
  - Small kernel launch configurations
    - Don’t occur in practice with long running kernels

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Future Work

- Integrating with the fault tolerance library FTI from BSC
- Leverage the existing MPI and cluster support of FTI
- Compiler integration

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Questions?