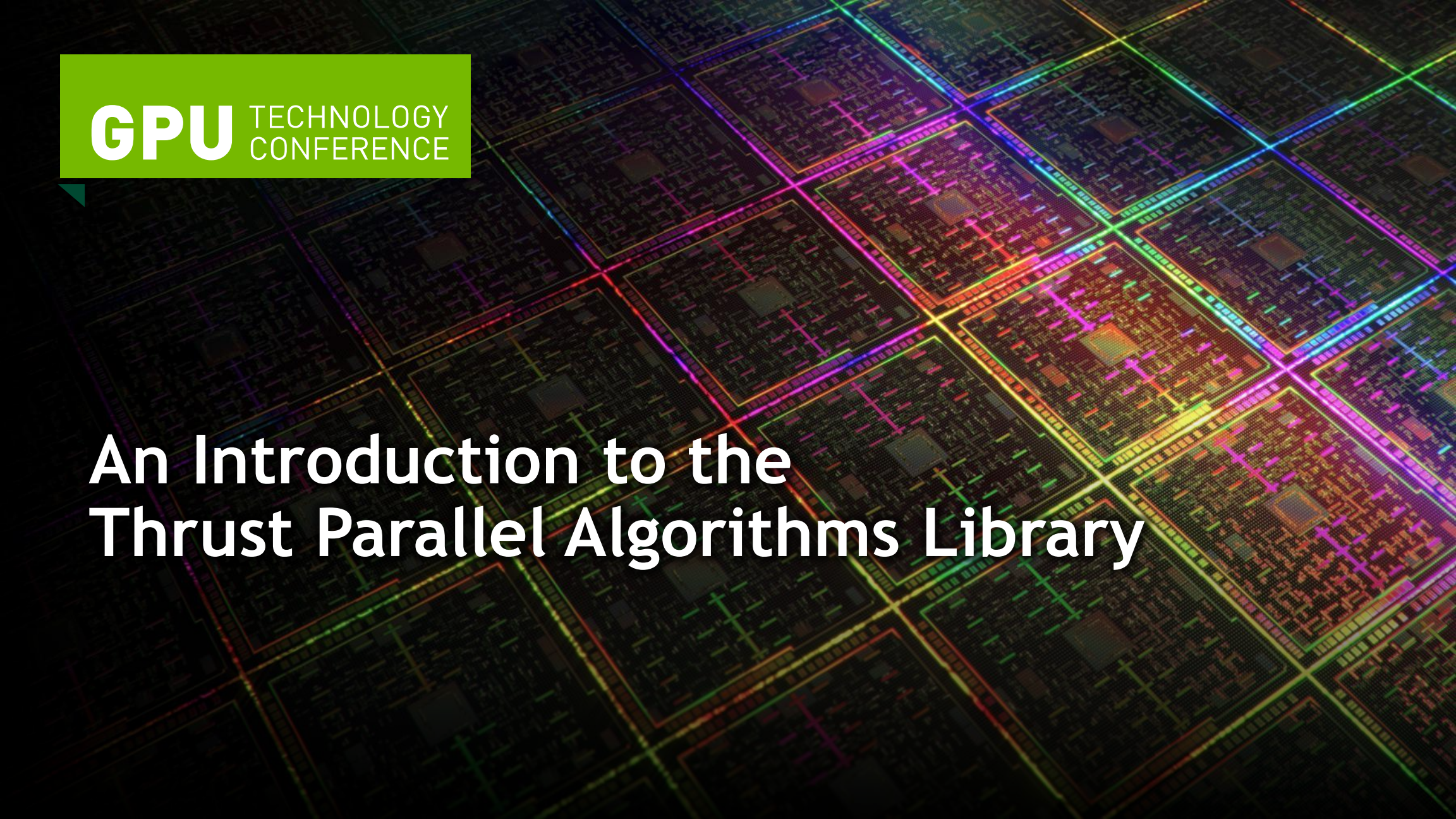
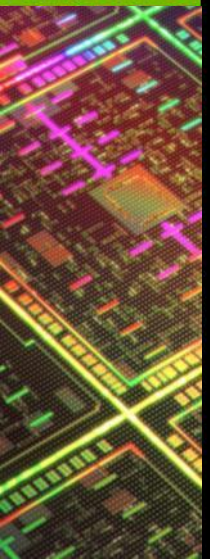
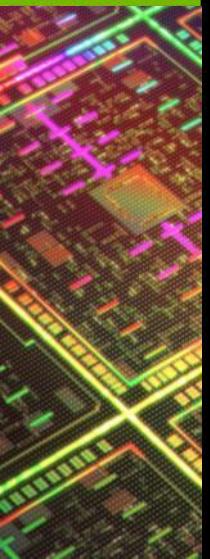


An Introduction to the Thrust Parallel Algorithms Library



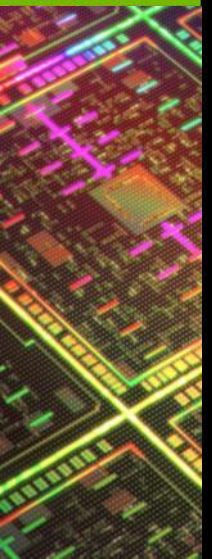
What is Thrust?

- High-Level Parallel Algorithms Library
- Parallel Analog of the C++ Standard Template Library (STL)
- Performance-Portable Abstraction Layer
- Productive way to program CUDA



Example

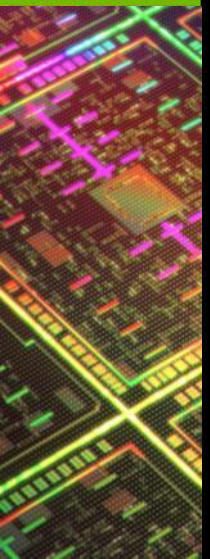
```
#include <thrust/host_vector.h>
#include <thrust/device_vector.h>
#include <thrust/sort.h>
#include <cstdlib>

int main(void)
{
    // generate 32M random numbers on the host
    thrust::host_vector<int> h_vec(32 << 20);
    thrust::generate(h_vec.begin(), h_vec.end(), rand);

    // transfer data to the device
    thrust::device_vector<int> d_vec = h_vec;

    // sort data on the device
    thrust::sort(d_vec.begin(), d_vec.end());

    // transfer data back to host
    thrust::copy(d_vec.begin(), d_vec.end(), h_vec.begin());

    return 0;
}
```



Easy to Use

- Distributed with CUDA Toolkit
- Header-only library
- Architecture agnostic
- Just compile and run!

```
$ nvcc -O2 -arch=sm_20 program.cu -o program
```



Why should I use Thrust?

Productivity

- Containers
  - `host_vector`
  - `device_vector`
- Memory Mangement
  - Allocation
  - Transfers
- Algorithm Selection
  - Location is implicit

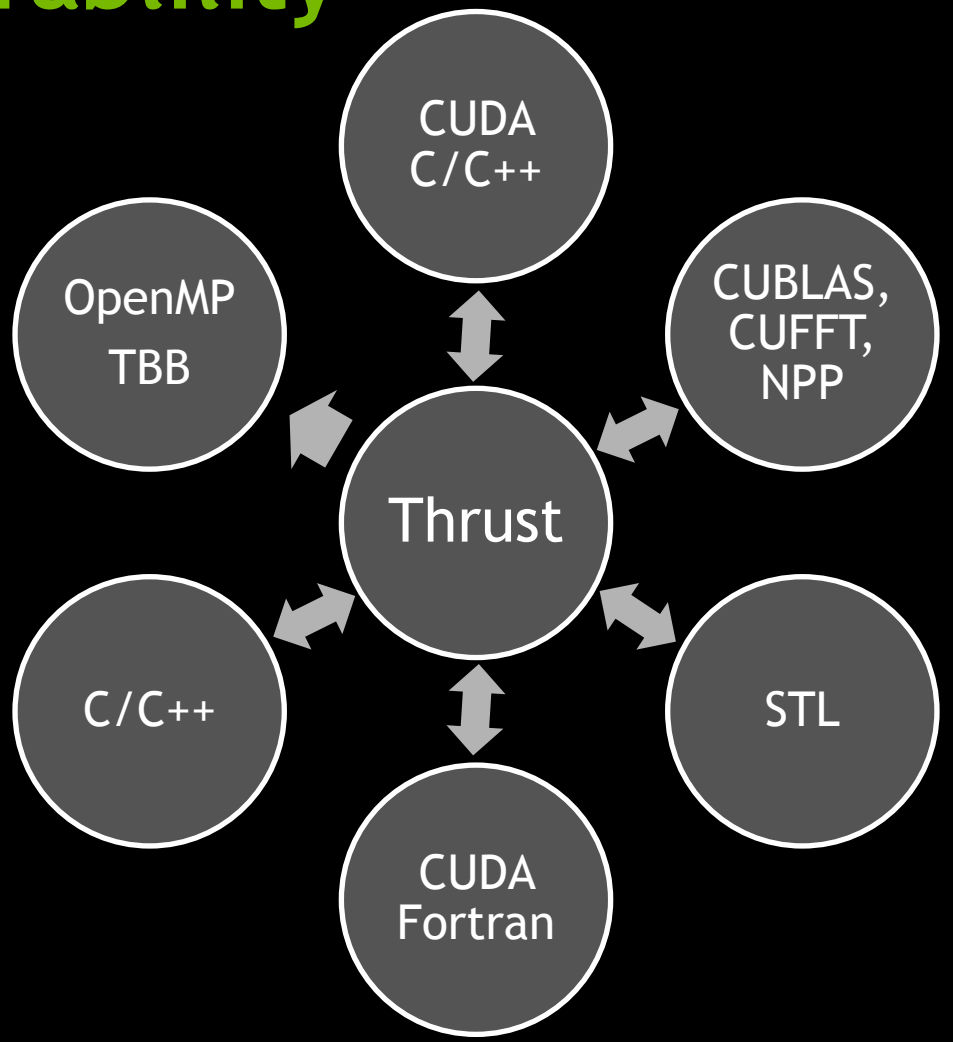
```
// allocate host vector with two elements
thrust::host_vector<int> h_vec(2);

// copy host data to device memory
thrust::device_vector<int> d_vec = h_vec;

// write device values from the host
d_vec[0] = 27;
d_vec[1] = 13;

// read device values from the host
int sum = d_vec[0] + d_vec[1];

// invoke algorithm on device
thrust::sort(d_vec.begin(), d_vec.end());

// memory automatically released
```

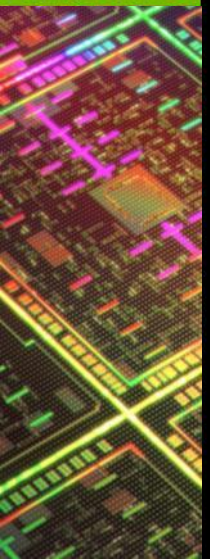
Productivity

- Large set of algorithms
  - ~75 functions
  - ~125 variations
- Flexible
  - User-defined types
  - User-defined operators

Algorithm	Description
`reduce`	Sum of a sequence
`find`	First position of a value in a sequence
`mismatch`	First position where two sequences differ
`inner_product`	Dot product of two sequences
`equal`	Whether two sequences are equal
`min_element`	Position of the smallest value
`count`	Number of instances of a value
`is_sorted`	Whether sequence is in sorted order
`transform_reduce`	Sum of transformed sequence

Interoperablility





Portability

- Support for CUDA, TBB and OpenMP
  - Just recompile!

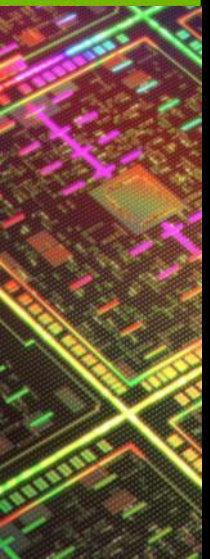
```
nvcc -DTHRUST_DEVICE_SYSTEM=THRUST_HOST_SYSTEM_OMP
```

NVIDA GeForce GTX 580

```
$ time ./monte_carlo
pi is approximately 3.14159

real    0m6.190s
user    0m6.052s
sys 0m0.116s
```

Intel Core i7 2600K

```
$ time ./monte_carlo
pi is approximately 3.14159

real    1m26.217s
user    11m28.383s
sys 0m0.020s
```



Backend System Options

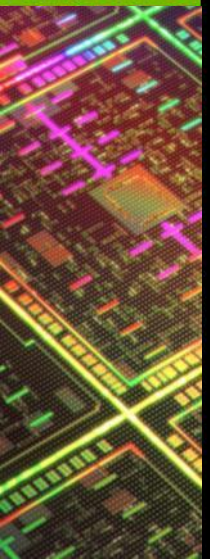
Host Systems
THRUST_HOST_SYSTEM_CPP
THRUST_HOST_SYSTEM_OMP
THRUST_HOST_SYSTEM_TBB

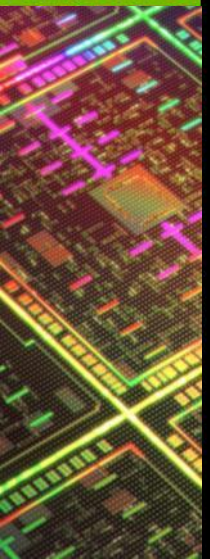
Device Systems
THRUST_DEVICE_SYSTEM_CUDA
THRUST_DEVICE_SYSTEM_OMP
THRUST_DEVICE_SYSTEM_TBB

Multiple Backend Systems

- Mix different backends freely within the same app

```
thrust::omp::vector<float> my_omp_vec(100);
thrust::cuda::vector<float> my_cuda_vec(100);

...

// reduce in parallel on the CPU
thrust::reduce(my_omp_vec.begin(), my_omp_vec.end());

// sort in parallel on the GPU
thrust::sort(my_cuda_vec.begin(), my_cuda_vec.end());
```





Thrust_sort

- Open exercises/cuda/thrust_sort/kernel.cu
- Code should build without modification
- What is performance of GPU versus CPU code?

Potential Workflow

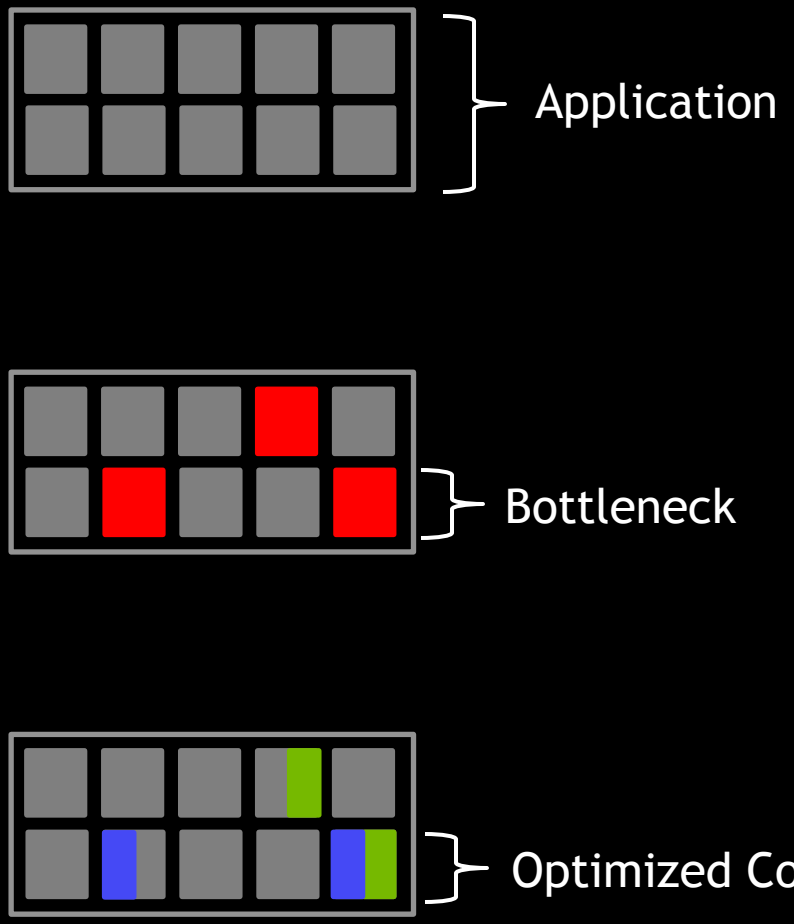
Thrust Implementation

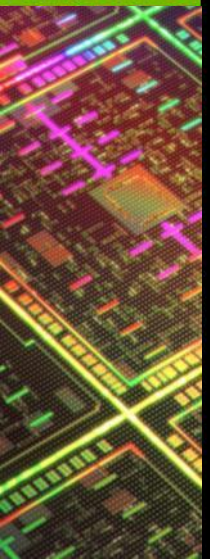
↓

Profile Application

↓

Specialize Components





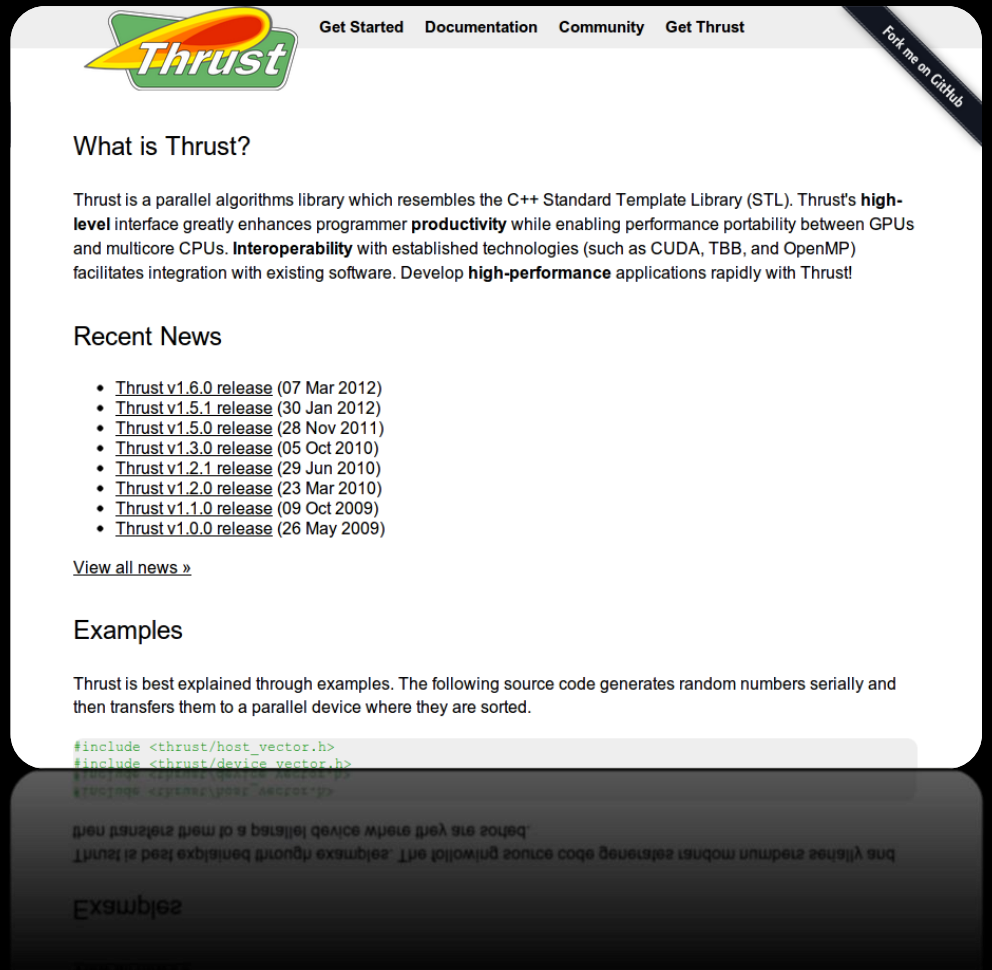
Robustness

- Reliable
  - Supports all CUDA-capable GPUs
- Well-tested
  - ~850 unit tests run daily
- Robust
  - Handles many pathological use cases

Openness

- Open Source Software
  - Apache License
  - Hosted on GitHub
- Welcome to
  - Suggestions
  - Criticism
  - Bug Reports
  - Contributions

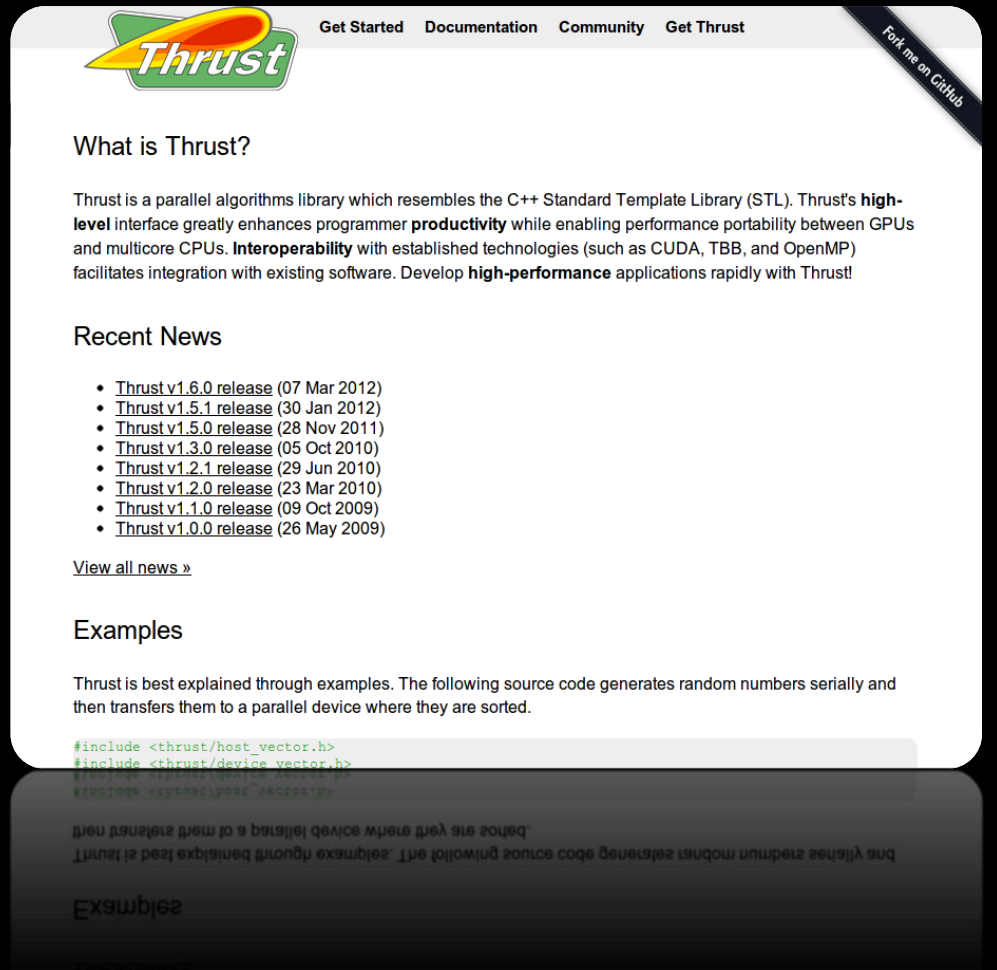
thrust.github.com



Resources

- Documentation
- Examples
- Mailing List
- Webinars
- Publications

thrust.github.com



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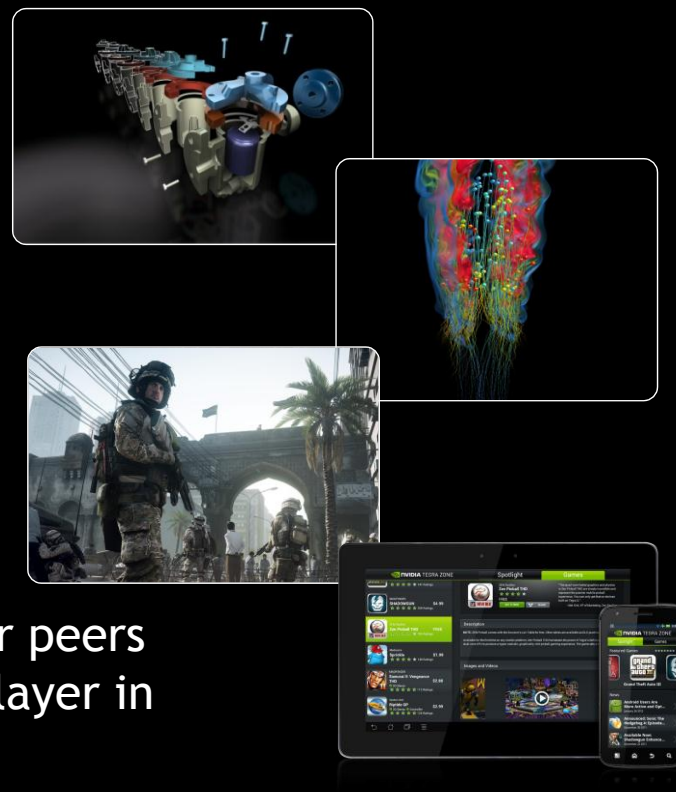

Ways to participate

- Submit a Research Poster – share your work and gain exposure as a thought leader
- Register – learn from the experts and network with your peers
- Exhibit/Sponsor – promote your organization as a key player in the GPU ecosystem

Visit www.gputechconf.com