U.S. Army Research, Development and Engineering Command

Brown Deer Technology

High Performance Java

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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Schedule

- Introduction
- Context
- Java
- Aparapi
- Conclusion
- Questions

Software Goals:

Introduction

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- Compatibility

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- Compatibility
- Reliability

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- Compatibility
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- Fault-Tolerance

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- Compatibility
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- Security

Software Goals:

- Compatibility
- Reliability
- Fault-Tolerance
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- Reusability

Software Goals:

- Compatibility
- Reliability
- Fault-Tolerance
- Security
- Reusability
- Usability

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"For over a decade prophets have voiced the contention that the organization of a single computer has reached its limits and that truly significant advances can be made only by interconnection of a multiplicity of computers." - Gene Amdahl

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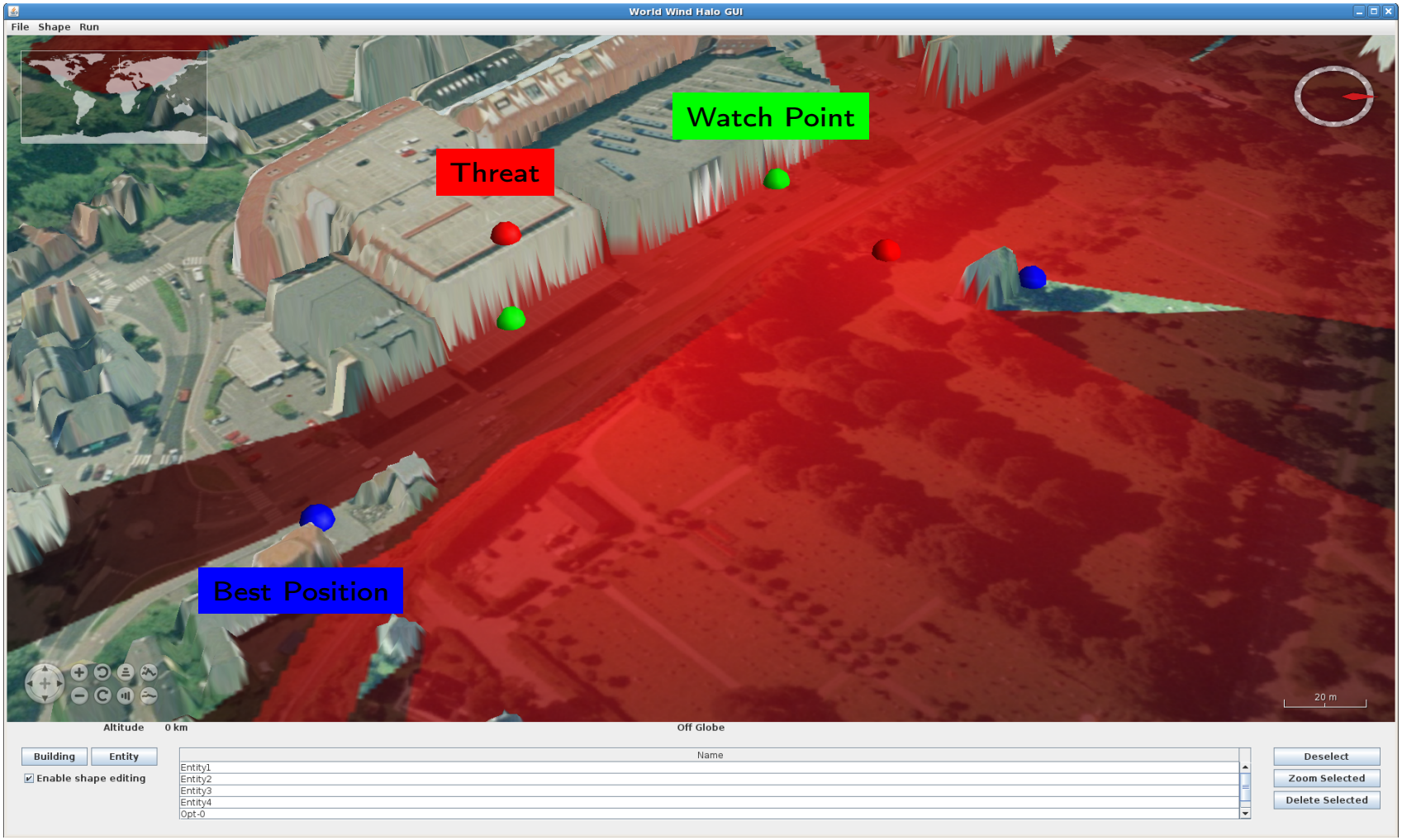
"We stand at the threshold of a many core world. The hardware community is ready to cross this threshold. The parallel software community is not." - Tim Mattson

Context


World Wind Halo GUI
File Shape Run
Watch Point
Threat
Best Position
20 m
Altitude 0 km
Off Globe
Building
Entity
Enable shape editing
Name
Entity1
Entity2
Entity3
Entity4
Opt-0
Deselect
Zoom Selected
Delete Selected

Java Threading

- Thread
  - Java 5
  - 1 Runnable Task
- ThreadPoolExecutor
  - Java 5
  - 1 Concurrent Queue

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- Thread
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  - 1 Runnable Task
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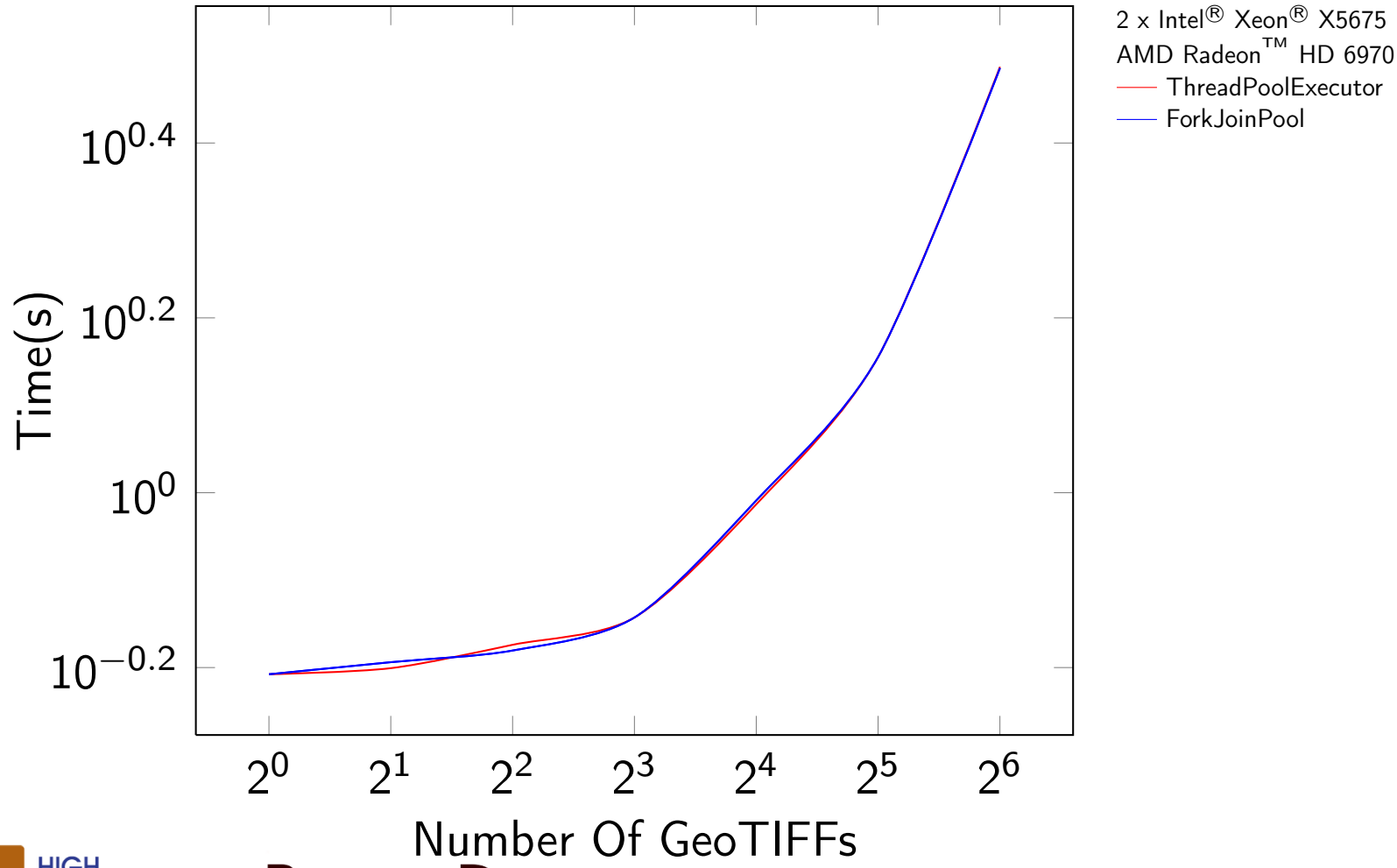
  - 1 Concurrent Queue
- ForkJoinPool
  - Java 7
  - N Concurrent Queues
  - Work-Stealing

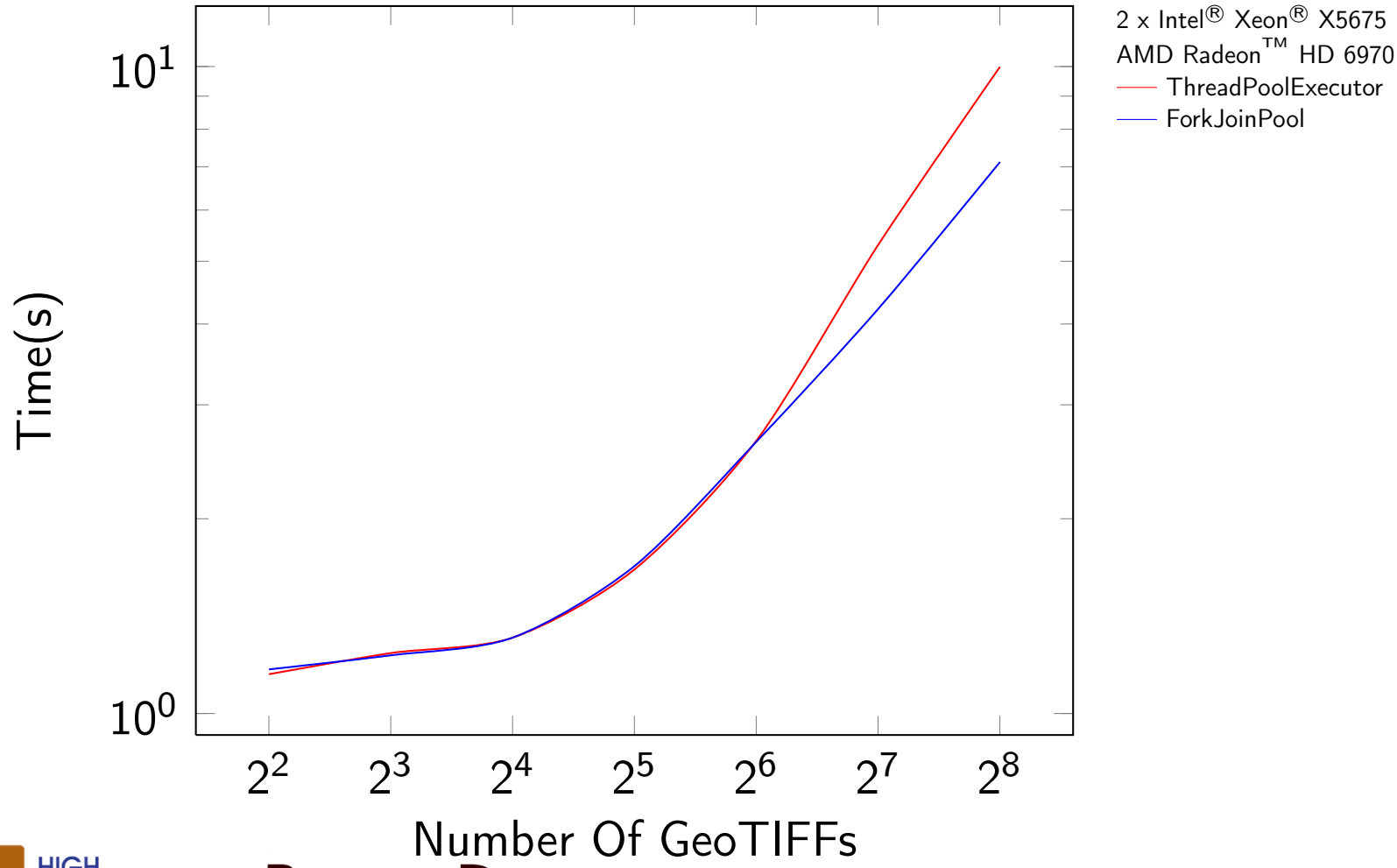
Java Benchmarks

- Load A Set Of GeoTIFFs Into A Usable Data Format
- NASA WorldWind Java Data Formats:
  - ElevationModel
  - SurfaceImage
- Performance Comparison Between ThreadPoolExecutor And ForkJoinPool

Execution Time For Loading A GeoTIFF Multiple Times



Execution Time For Loading Multiple GeoTIFFs Multiple Times



HIGH PERFORMANCE TECHNOLOGIES GROUP

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Hardware

- Central Processing Units (CPUs)
- Graphics Processing Units (GPUs)
- Field-Programmable Gate Arrays (FPGAs)
- Digital Signal Processors (DSPs)
- Microcontrollers

Java Libraries

- JCuda
- jocl.org JOCL
- JogAmp.org JOCL
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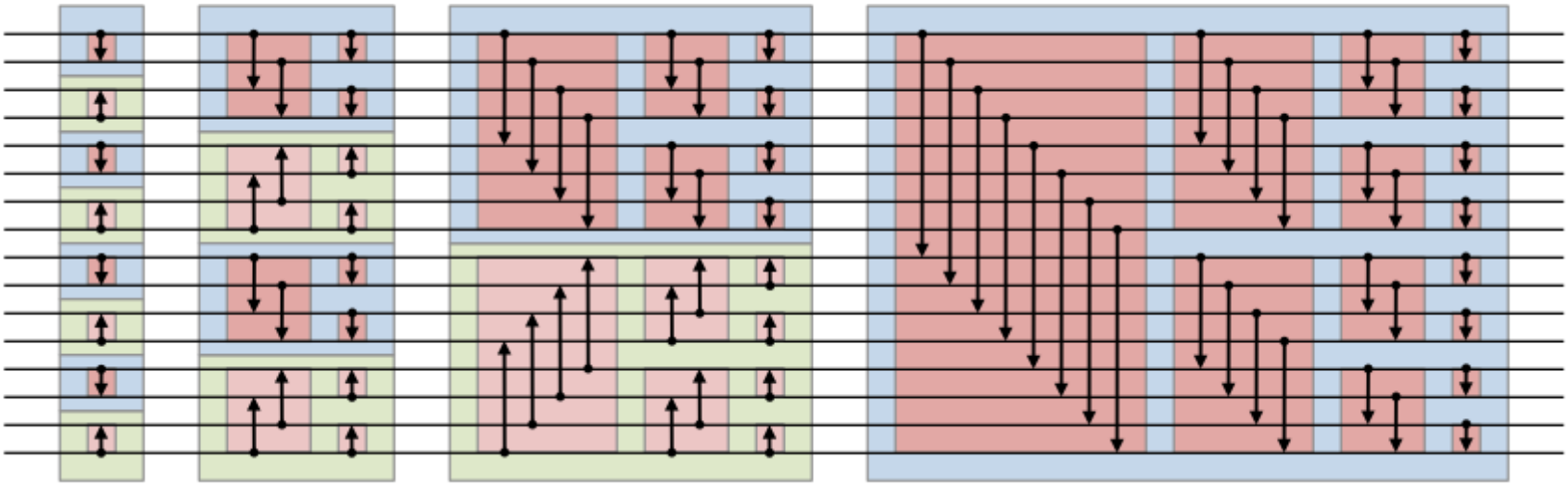
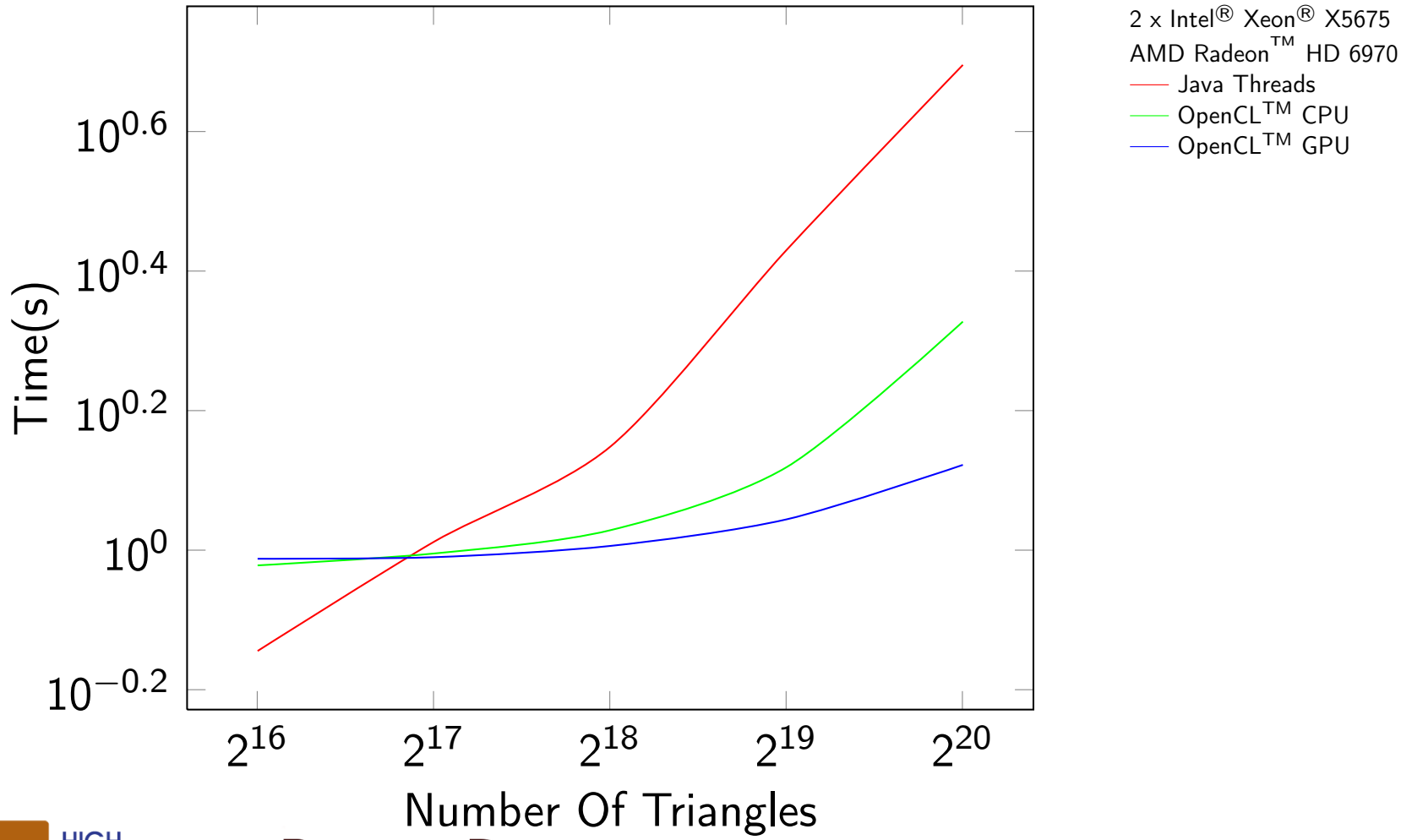
Preparation Kernels

- Bounding Box Construction
  - $O(1)$ Parallel Time
- Bitonic Sort
  - $O(log^2(n))$ Parallel Time



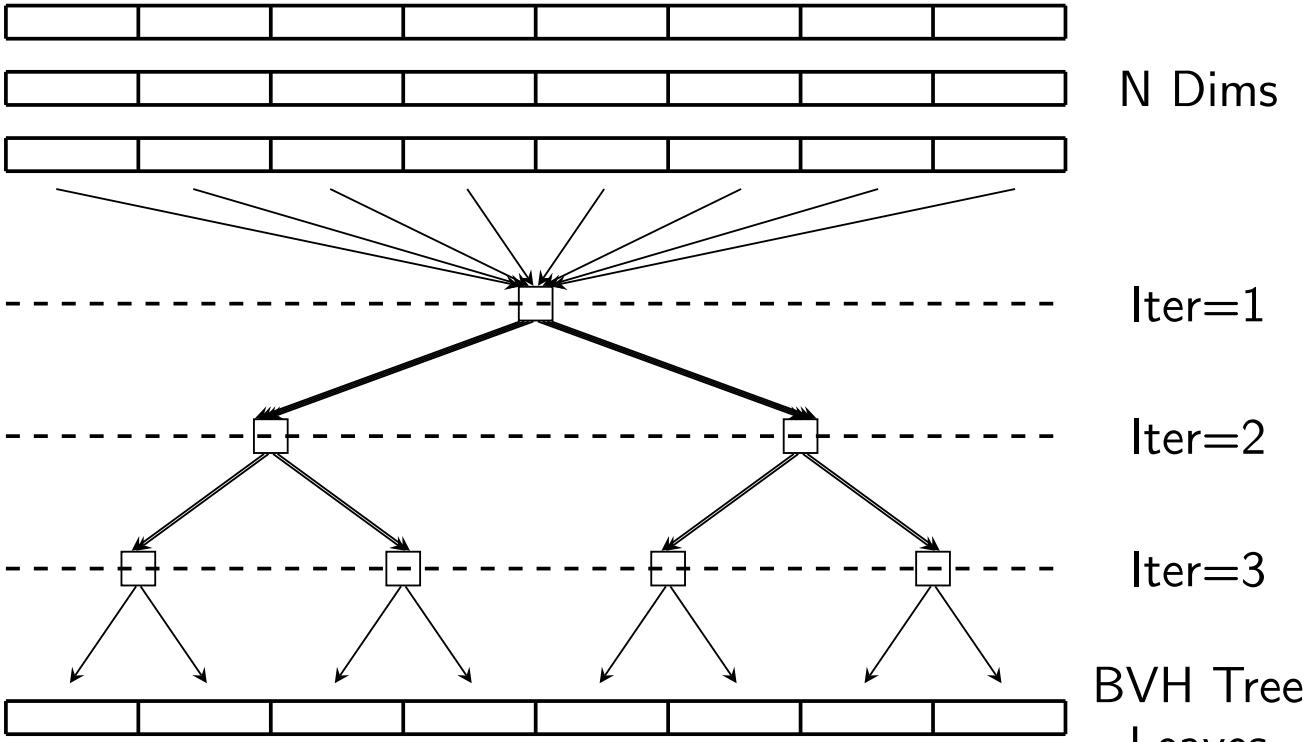
http://upload.wikimedia.org/wikipedia/en/b/bd/BitonicSort1.svg

Preparation Kernels Execution Time



BVH Tree Construction Kernel

- BVH Tree Construction
  - $O(log(n))$ Parallel Time
  - $O(2^{Iteration})$ Parallel Execution Units



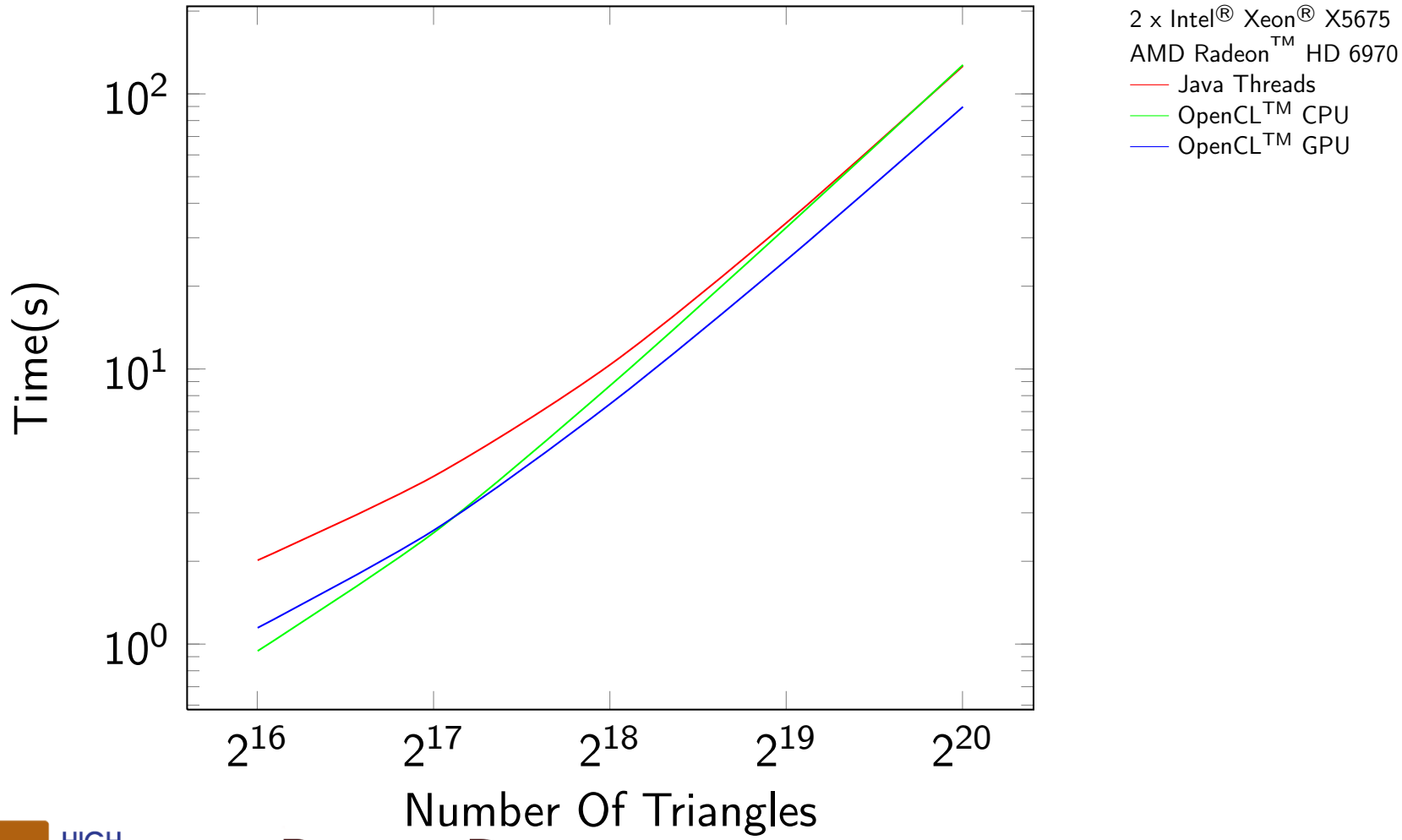
BVH Tree Construction Kernel Algorithm

```
 1: procedure BuildBVHTree
 2:     SetUpInitialNode
 3:     while NotFullySplit do
 4:         for all NodesWhichExist do
 5:             for all Dimension ∈ Dimensions do
 6:                 ChooseBestSplit
 7:             end for
 8:             SplitNode
 9:             SetupNodeForDataParallelPortion
10:             for all Dimension ∈ Dimensions do
11:                 if DimensionWasNotSplitDimension then
12:                     for all Indexes ∈ SortedIndexes do
13:                         CalculateNewPosition
14:                         Reorder
15:                     end for
16:                 end if
```

BVH Tree Construction Kernel Algorithm


```
17:                 end for
18:             end for
19:         end while
20:         for all Node ∈ Nodes do
21:             CalculateAxisAlignedBoundingBoxes
22:         end for
23:         for Values ∈ Sorted do
24:             SetToSortedIndexInFirstDimension
25:         end for
26: end procedure
```

BVH Tree Construction Kernel Execution Time



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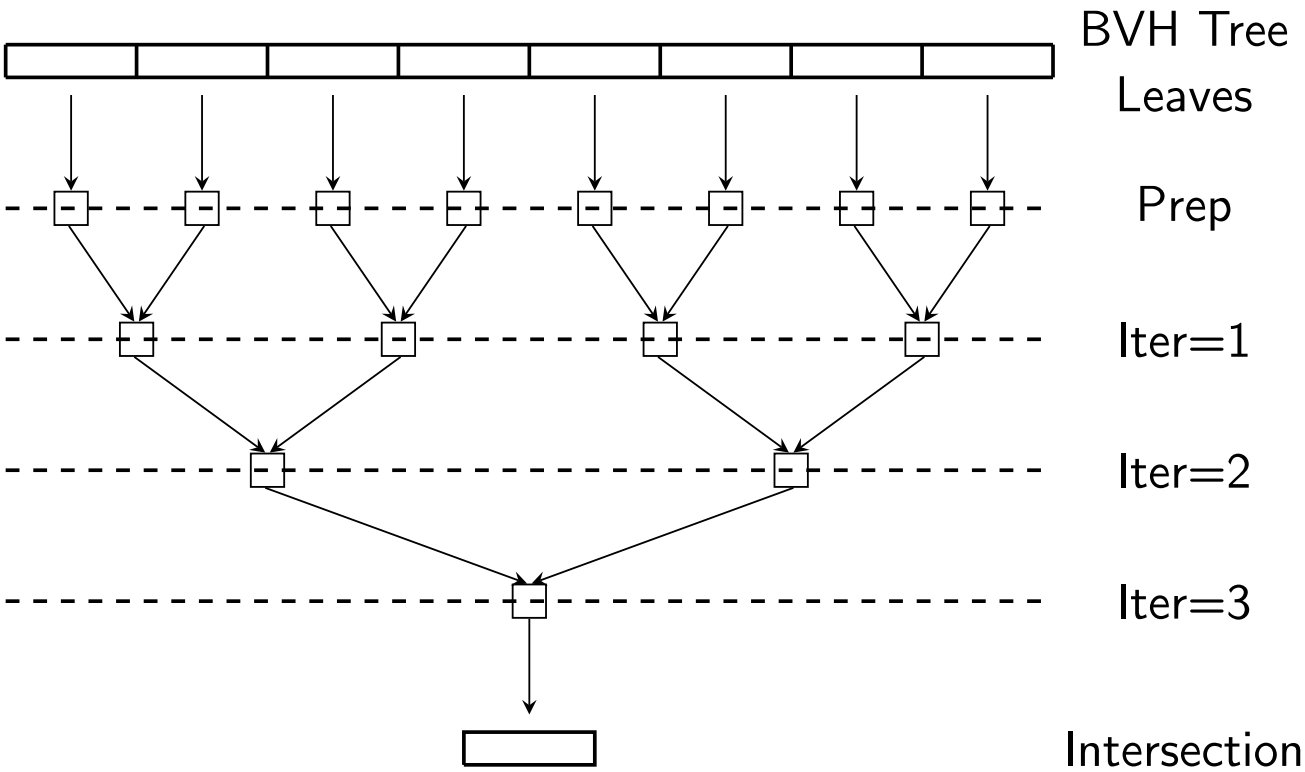
Intersection Kernel

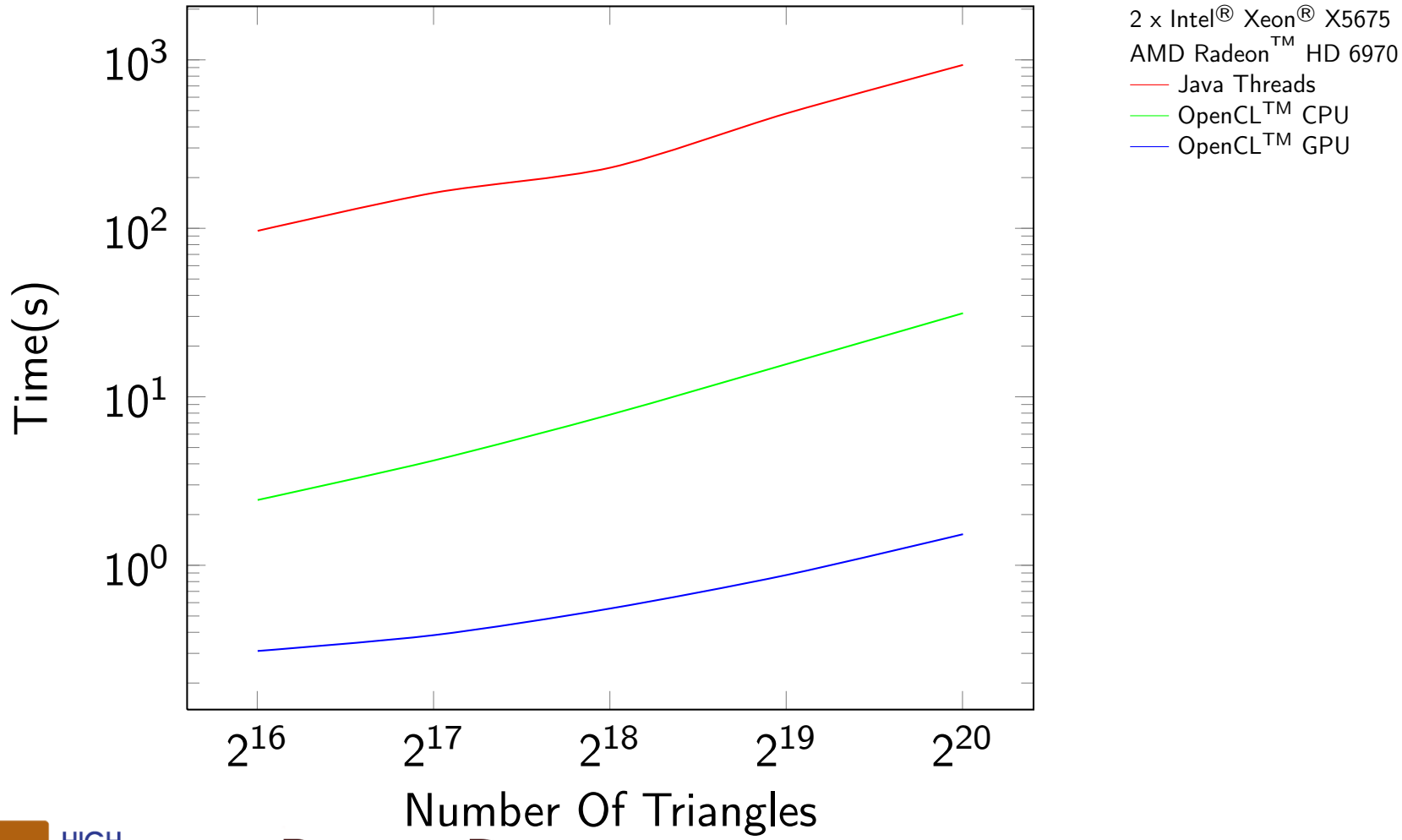
- Intersection Kernel
  - $O(log(n))$ Parallel Time
  - $O(2^{Iterations-Iteration})$ Parallel Execution Units



Intersection Kernel Algorithm


```
1:  procedure IntersectBVHTree
2:      for all Ray ∈ Rays do in Parallel
3:          for all Node ∈ LeafNodes do in Parallel
4:              if RayHitsBoundingBox then
5:                  FindClosestStructureHit
6:              end if
7:          end for
8:          FindClosestNodeHit
9:      end for
10: end procedure
```

Intersection Kernel Execution Time



Conclusion

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- Java 7 ForkJoinPool Should Be Utilized Where It Is More Efficient

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    - Higher Performance
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- Aparapi
  - Pros:
    - Higher Performance
    - Utilize Additional Resources
  - Cons:
    - Limited Usability

Questions?