# cuNumeric.jl : Automating Distributed Numerical Computing

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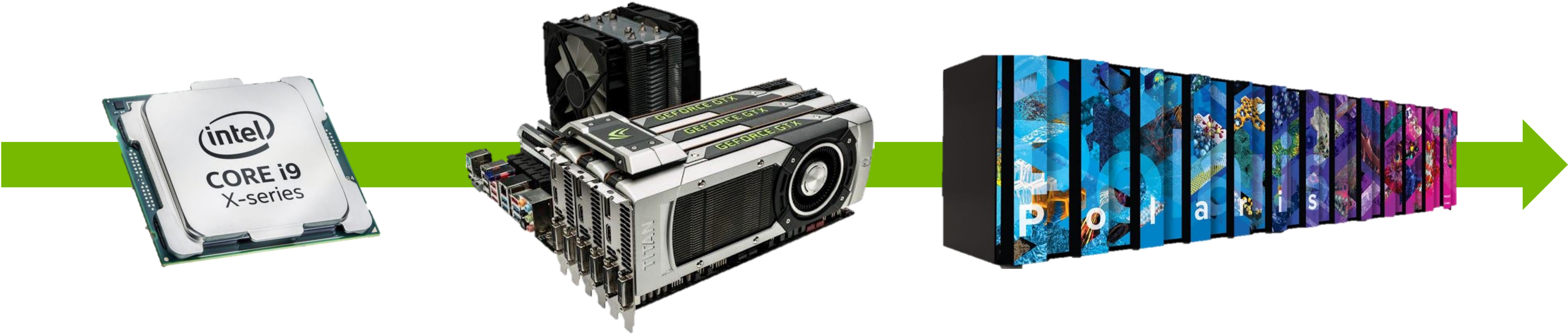
Julia for HPC BoF

# The Goal: Scale with Zero Code Changes

- “Easy” to implement the correct physics in a high-level language like Python, Julia, or MATLAB
- Time consuming to modify code to scale across multiple CPUs/GPUs
  - Need to learn and debug new technologies like MPI, CUDA etc.




**Code that runs on a single CPU core should also be able to run on multiple cores, multiple GPUs and across multiple nodes**

# Legate Enables Composable and Distributed Libraries

By providing data and task management abstractions, this enables the efficient implementation of complex library APIs.

NumPy · SciPy · pandas · scikit-learn · dmlc XGBoost · HDF · ...

Today's scope

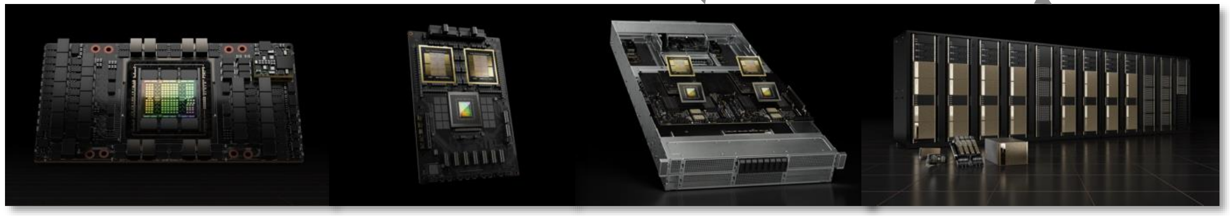
| cuPyNumeric | Legate Sparse | Legate Dataframe | Legate RAFT | Legate Boost | Legate IO |
|---|---|---|---|---|---|

**Legate Framework**

**Legate Core** - Productivity & Composability Layer

**Legion** - Implicit Parallelism Layer

**Realm** - Runtime for Scalable and Portable Execution

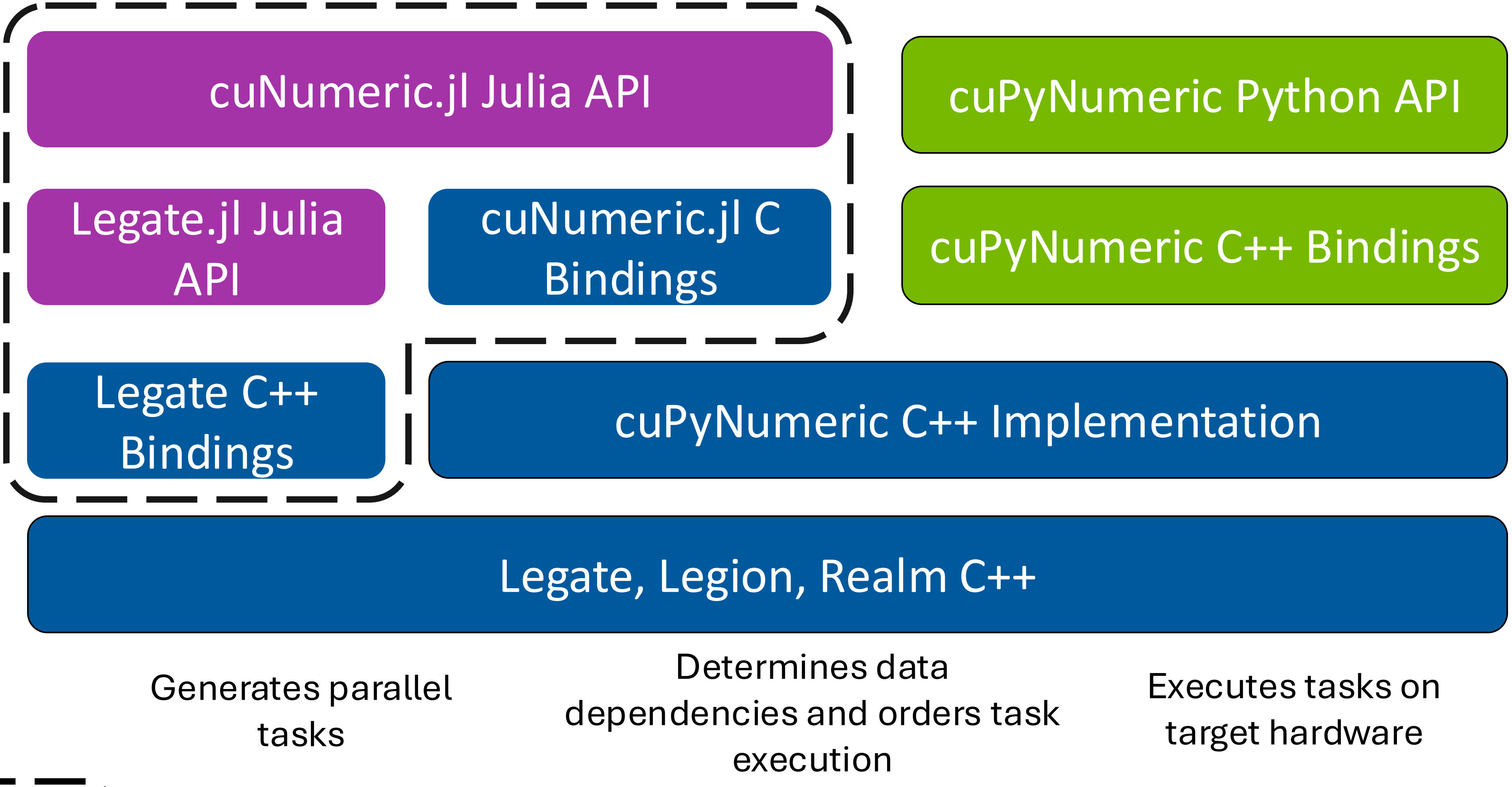


Single GPU · Mixed CPU/GPU · Single-Node Multi-GPU · Multi-Node Multi-GPU Cloud & Supercomputer

**Wouldn't this be great in Julia?**

https://developer.nvidia.com/legate
https://legion.stanford.edu/

# Software Stack



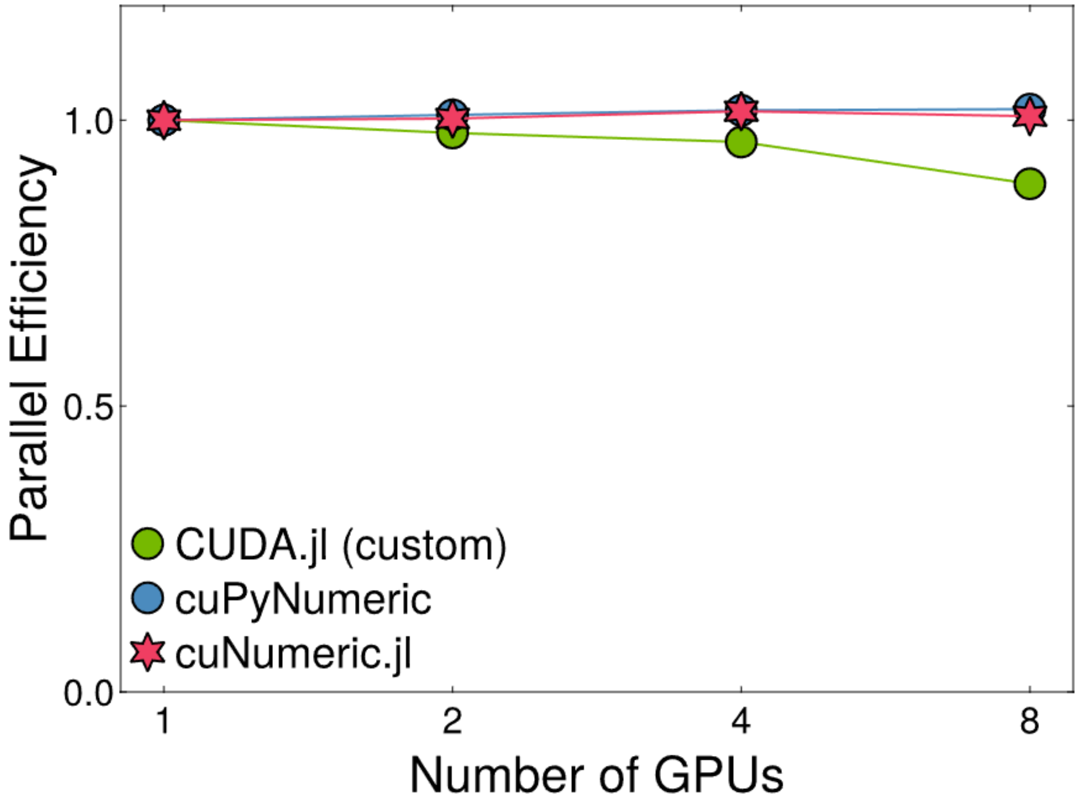

New Contributions

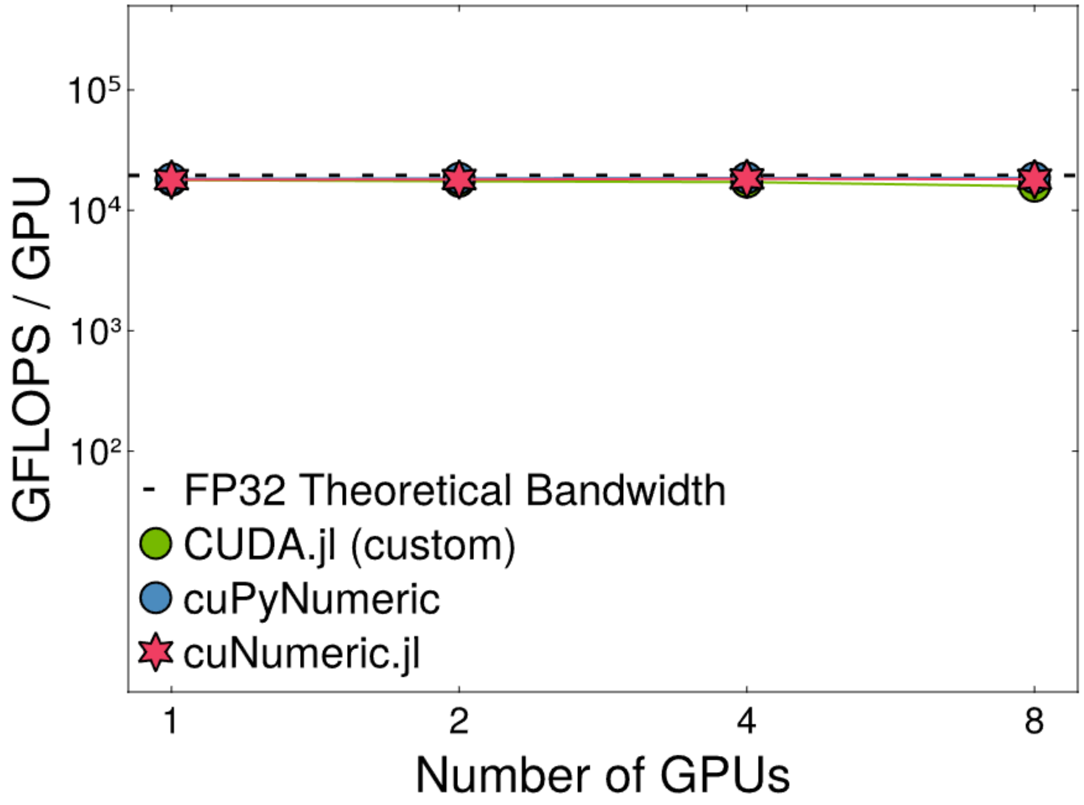
# Matrix Multiplication

## Syntax:

```
N = 10
A = cuNumeric.rand(Float32, N, N)
B = cuNumeric.rand(Float32, N, N)
C = cuNumeric.zeros(Float32, N, N)
mul!(C, A, B)
```

## Benchmark (8x A100):



# Running CUDA Kernels with cuNumeric.jl

```julia
using cuNumeric
using CUDA

function kernel_add(a, b, c, N)
    i = (blockIdx().x - 1i32) * blockDim().x + threadIdx().x
    if i <= N
        @inbounds c[i] = a[i] + b[i]
    end
    return nothing
end


N = 1024
threads = 256
blocks = cld(N, threads)

a = cuNumeric.full(N, 1.0f0)
b = cuNumeric.full(N, 2.0f0)
c = cuNumeric.ones(Float32, N)

task = cuNumeric.@cuda_task kernel_add(a, b, c, UInt32(1))

cuNumeric.@launch task=task threads=threads blocks=blocks \
                    inputs=(a, b) outputs=c scalars=UInt32(N)

```

CUDA.jl kernel

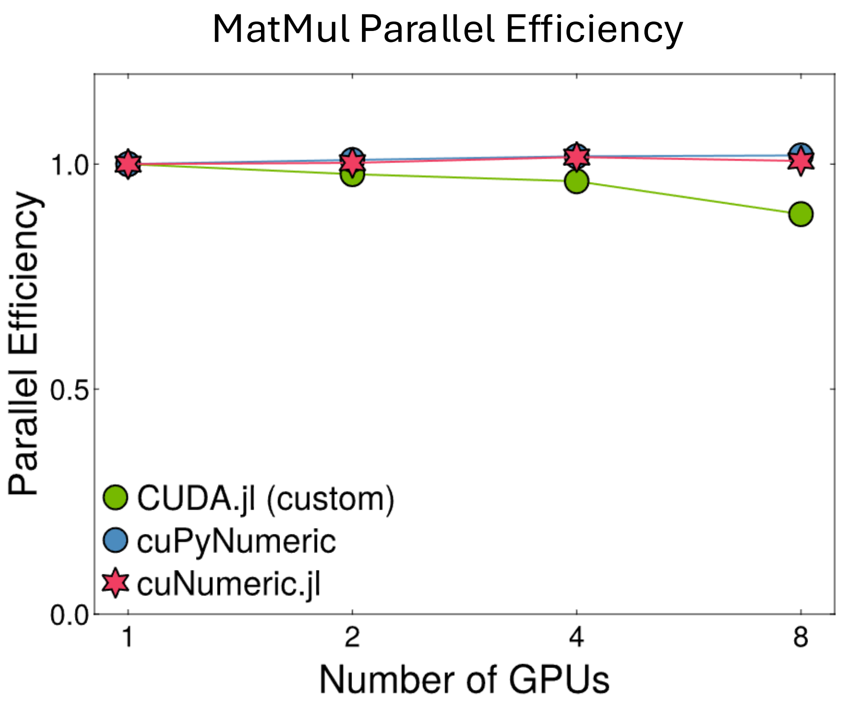
Initialize NDArrays

Compile

Launch

# Conclusions and Future Work

- Minimal code changes for scaling across large heterogeneous distributed systems
- Good weak scaling efficiency
- Ability to register custom CUDA kernels




**Disclaimers:**

1. Still in development, we will be releasing a public beta within the coming months

2. cuPyNumeric and Legate are currently in beta

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Check out our repo
https://github.com/JuliaLegate/cuNumeric.jl/

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