Introduction to the CUDA Platform

CUDA Parallel Computing Platform

www.nvidia.com/getcuda

Programming Approaches

Libraries

"Drop-in" Acceleration

OpenACC Directives

Easily Accelerate Apps

Programming Languages

Maximum Flexibility

Development Environment

Nsight IDE
Linux, Mac and Windows
GPU Debugging and Profiling

CUDA-GDB debugger
NVIDIA Visual Profiler

Open Compiler Tool Chain

LLVM COMPILER INFRASTRUCTURE

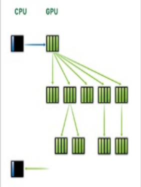
Enables compiling new languages to CUDA platform, and CUDA languages to other architectures

Hardware Capabilities

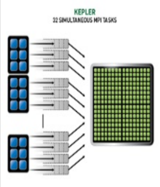
SMX

CONTROL LOGIC

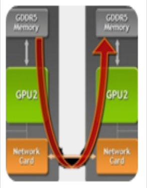
Dynamic Parallelism



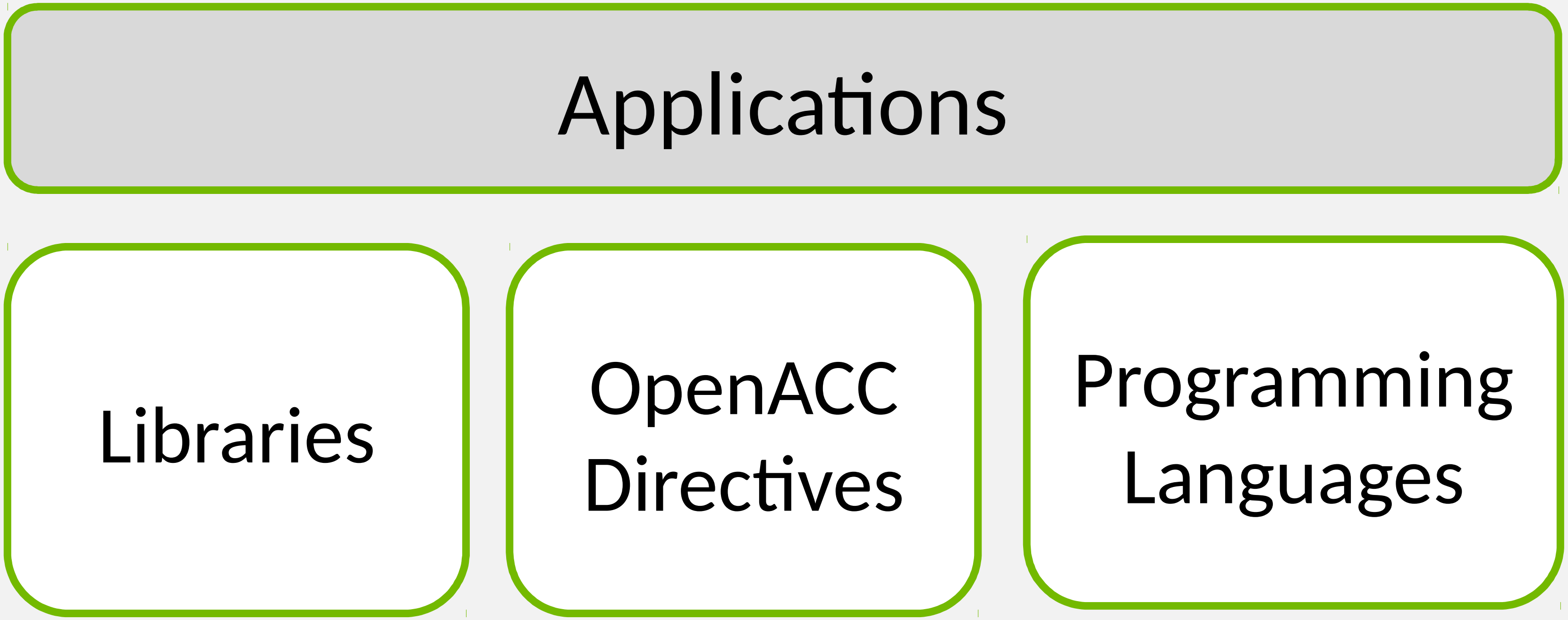
HyperQ



GPUDirect



3 Ways to Accelerate Applications



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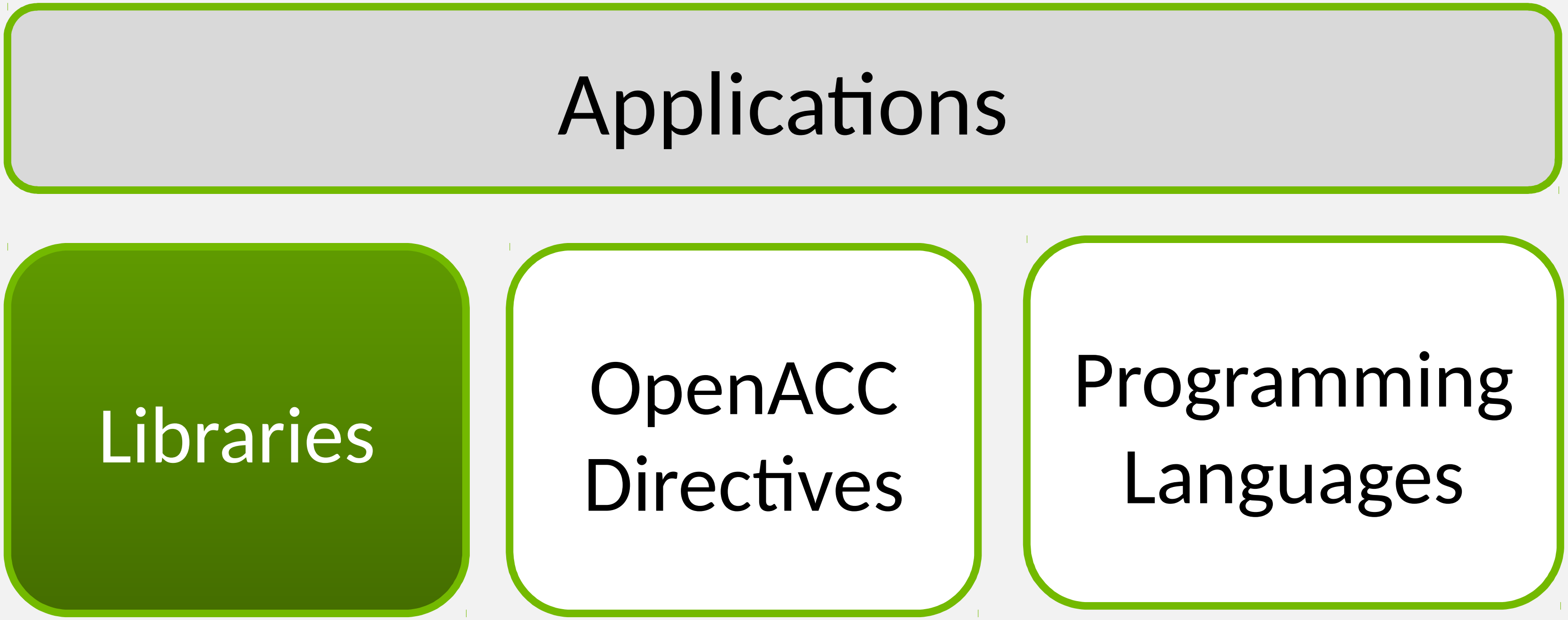

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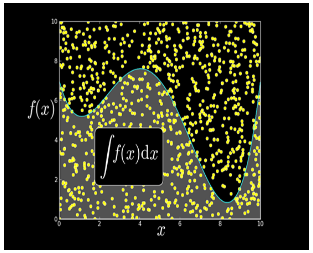
Libraries: Easy, High-Quality Acceleration

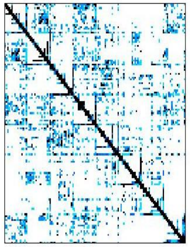
- **Ease of use:** Using libraries enables GPU acceleration without in-depth knowledge of GPU programming
- **“Drop-in”:** Many GPU-accelerated libraries follow standard APIs, thus enabling acceleration with minimal code changes
- **Quality:** Libraries offer high-quality implementations of functions encountered in a broad range of applications
- **Performance:** NVIDIA libraries are tuned by experts

Some GPU-accelerated Libraries

NVIDIA cuBLAS



NVIDIA cuRAND



NVIDIA cuSPARSE

NVIDIA NPP

GPU VSIPL

Vector Signal Image Processing

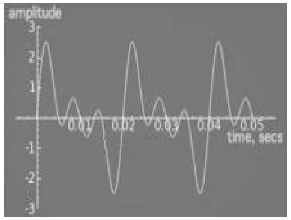
CULA | tools

GPU Accelerated Linear Algebra

MAGMA

Matrix Algebra on GPU and Multicore

open source initiative



NVIDIA cuFFT

ROGUE WAVE SOFTWARE

IMSL Library

ArrayFire Matrix Computations

CUSP

Sparse Linear Algebra

open source initiative

Thrust

C++ STL Features for CUDA

open source initiative

3 Steps to CUDA-accelerated application

- **Step 1:** Substitute library calls with equivalent CUDA library calls

```
saxpy ( … )          ►          cublasSaxpy ( … )
```

- **Step 2:** Manage data locality

  - with CUDA: `cudaMalloc(), cudaMemcpy(), etc.`
    - with CUBLAS: `cublasAlloc(), cublasSetVector(), etc.`

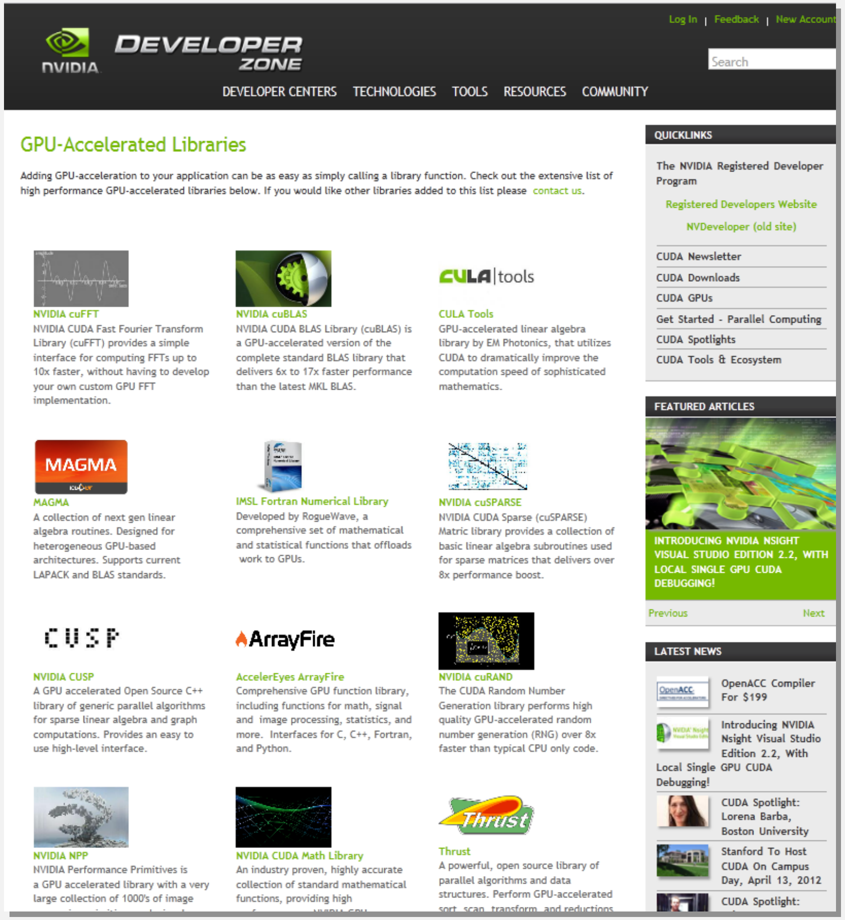
- **Step 3:** Rebuild and link the CUDA-accelerated library

```
nvcc myobj.o –l cublas
```

Explore the CUDA (Libraries) Ecosystem

- CUDA Tools and Ecosystem described in detail on NVIDIA Developer Zone:

  developer.nvidia.com/cuda-tools-ecosystem



GPU-Accelerated Libraries

Adding GPU-acceleration to your application can be as easy as simply calling a library function. Check out the extensive list of high performance GPU-accelerated libraries below. If you would like other libraries added to this list please contact us.

NVIDIA cuFFT
NVIDIA CUDA Fast Fourier Transform Library (cuFFT) provides a simple interface for computing FFTs up to 10x faster, without having to develop your own custom GPU FFT implementation.

NVIDIA cuBLAS
NVIDIA CUDA BLAS Library (cuBLAS) is a GPU-accelerated version of the complete standard BLAS library that delivers 6x to 17x faster performance than the latest MKL BLAS.

CULA Tools
GPU-accelerated linear algebra library by EM Photonics, that utilizes CUDA to dramatically improve the computation speed of sophisticated mathematics.

MAGMA
A collection of next gen linear algebra routines. Designed for heterogeneous GPU-based architectures. Supports current LAPACK and BLAS standards.

IMSL Fortran Numerical Library
Developed by RogueWave, a comprehensive set of mathematical and statistical functions that offloads work to GPUs.

NVIDIA cuSPARSE
NVIDIA CUDA Sparse (cuSPARSE) Matric library provides a collection of basic linear algebra subroutines used for sparse matrices that delivers over 8x performance boost.

NVIDIA CUSP
A GPU accelerated Open Source C++ library of generic parallel algorithms for sparse linear algebra and graph computations. Provides an easy to use high-level interface.

AccelerEyes ArrayFire
Comprehensive GPU function library, including functions for math, signal and image processing, statistics, and more. Interfaces for C, C++, Fortran, and Python.

NVIDIA cuRAND
The CUDA Random Number Generation library performs high quality GPU-accelerated random number generation (RNG) over 8x faster than typical CPU only code.

NVIDIA NPP
NVIDIA Performance Primitives is a GPU accelerated library with a very large collection of 1000's of image

NVIDIA CUDA Math Library
An industry proven, highly accurate collection of standard mathematical functions, providing high

Thrust
A powerful, open source library of parallel algorithms and data structures. Perform GPU-accelerated sort, scan, transform, and reductions

QUICKLINKS

The NVIDIA Registered Developer Program

Registered Developers Website

NVDeveloper (old site)

- CUDA Newsletter
- CUDA Downloads
- CUDA GPUs
- Get Started - Parallel Computing
- CUDA Spotlights
- CUDA Tools & Ecosystem

FEATURED ARTICLES

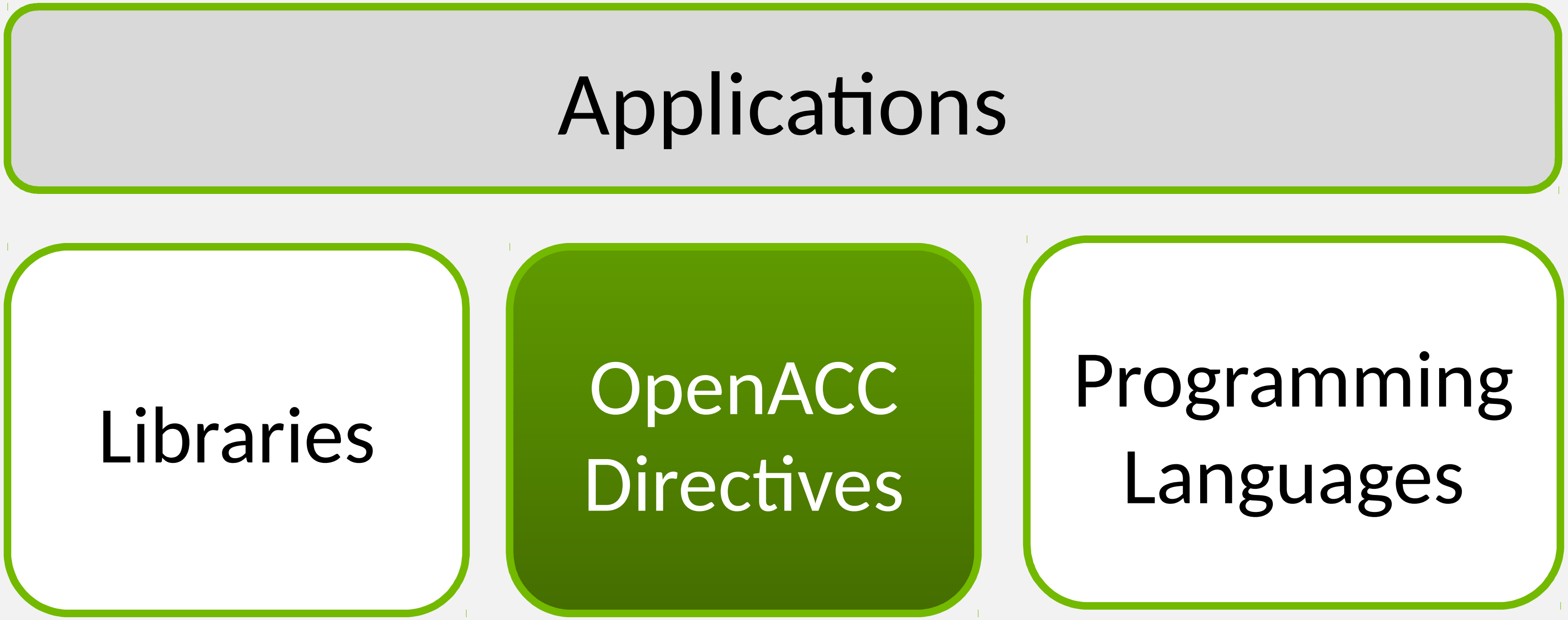
INTRODUCING NVIDIA NSIGHT VISUAL STUDIO EDITION 2.2, WITH LOCAL SINGLE GPU CUDA DEBUGGING!

Previous Next

LATEST NEWS

- OpenACC Compiler For $199
- Introducing NVIDIA Nsight Visual Studio Edition 2.2, With Local Single GPU CUDA Debugging!
- CUDA Spotlight: Lorena Barba, Boston University
- Stanford To Host CUDA On Campus Day, April 13, 2012
- CUDA Spotlight:

3 Ways to Accelerate Applications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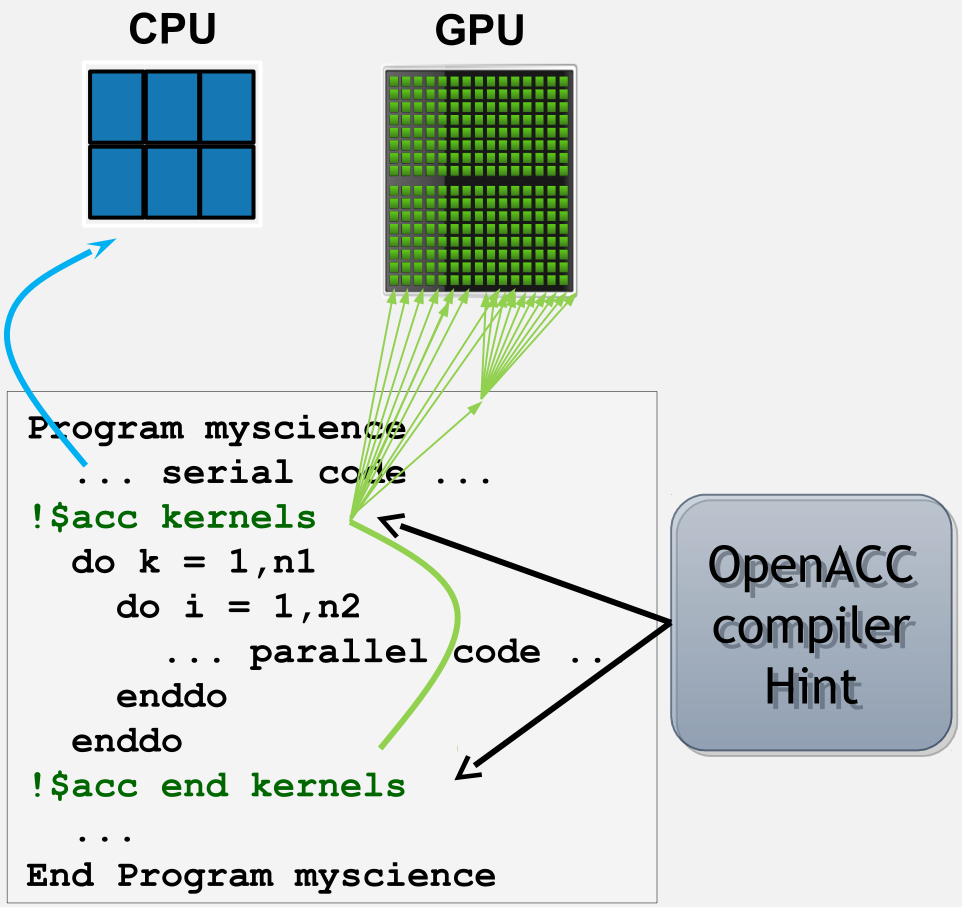


```
Program myscience
   ... serial code ...
!$acc kernels
   do k = 1,n1
      do i = 1,n2
         ... parallel code ..
      enddo
   enddo
!$acc end kernels
   ...
End Program myscience
```

Your original Fortran or C code

Simple Compiler hints

Compiler Parallelizes code

Works on many-core GPUs & multicore CPUs

OpenACC

The Standard for GPU Directives

- **Easy:** Directives are the easy path to accelerate compute intensive applications

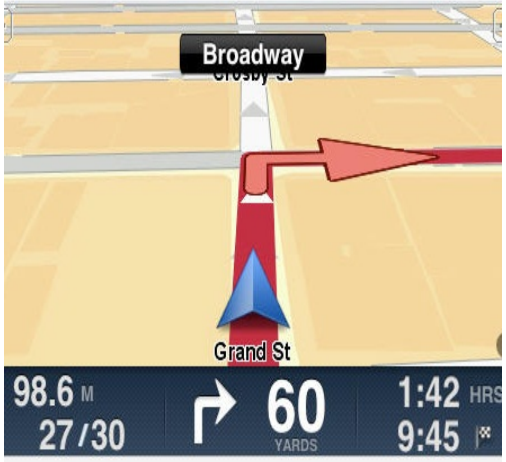
- **Open:** OpenACC is an open GPU directives standard, making GPU programming straightforward and portable across parallel and multi-core processors

- **Powerful:** GPU Directives allow complete access to the massive parallel power of a GPU

Directives: Easy & Powerful

Real-Time Object Detection

Global Manufacturer of Navigation Systems



5x in 40 Hours

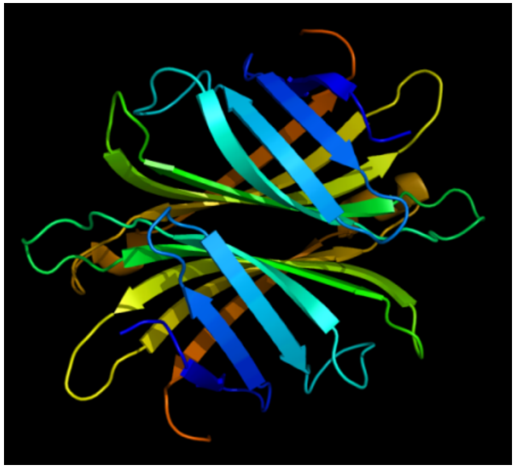
Valuation of Stock Portfolios using Monte Carlo

Global Technology Consulting Company

2x in 4 Hours

Interaction of Solvents and Biomolecules

University of Texas at San Antonio



5x in 8 Hours

> “Optimizing code with directives is quite easy, especially compared to CPU threads or writing CUDA kernels. The most important thing is avoiding restructuring of existing code for production applications.”

-- Developer at the Global Manufacturer of Navigation Systems

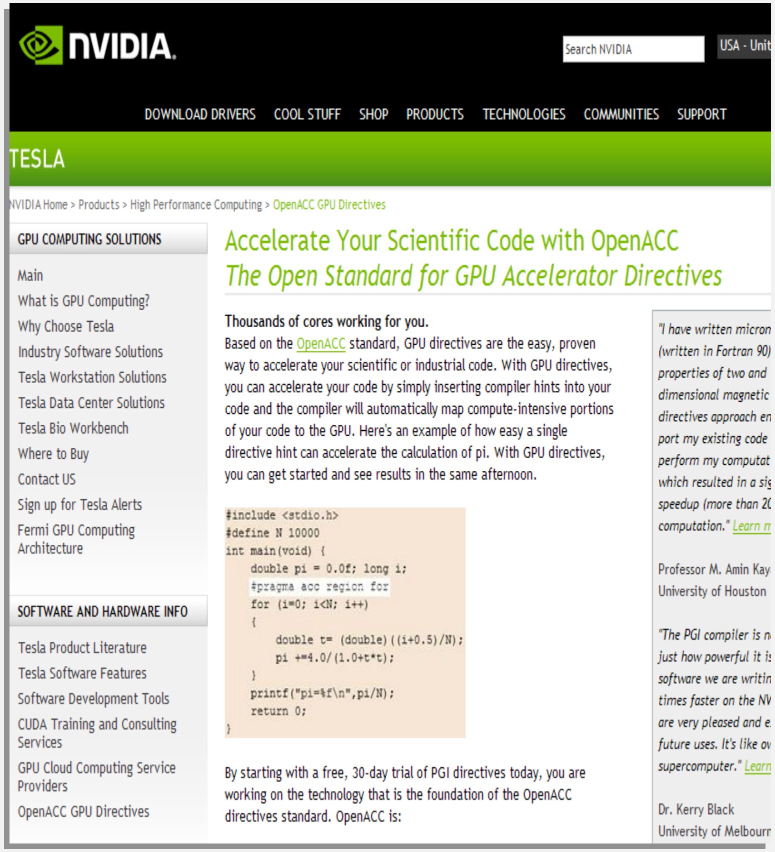
Start Now with OpenACC Directives

Sign up for a **free trial** of the directives compiler now!

Free trial license to PGI Accelerator

Tools for quick ramp

www.nvidia.com/gpudirectives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TESLA
NVIDIA Home > Products > High Performance Computing > OpenACC GPU Directives
GPU COMPUTING SOLUTIONS
Main
What is GPU Computing?
Why Choose Tesla
Industry Software Solutions
Tesla Workstation Solutions
Tesla Data Center Solutions
Tesla Bio Workbench
Where to Buy
Contact US
Sign up for Tesla Alerts
Fermi GPU Computing Architecture
SOFTWARE AND HARDWARE INFO
Tesla Product Literature
Tesla Software Features
Software Development Tools
CUDA Training and Consulting Services
GPU Cloud Computing Service Providers
OpenACC GPU Directives

Accelerate Your Scientific Code with OpenACC

The Open Standard for GPU Accelerator Directives

Thousands of cores working for you.

Based on the OpenACC standard, GPU directives are the easy, proven way to accelerate your scientific or industrial code. With GPU directives, you can accelerate your code by simply inserting compiler hints into your code and the compiler will automatically map compute-intensive portions of your code to the GPU. Here's an example of how easy a single directive hint can accelerate the calculation of pi. With GPU directives, you can get started and see results in the same afternoon.

```
#include <stdio.h>
#define N 10000
int main(void) {
    double pi = 0.0f; long i;
    #pragma acc region for
    for (i=0; i<N; i++)
    {
        double t= (double)((i+0.5)/N);
        pi +=4.0/(1.0+t*t);
    }
    printf("pi=%f\n",pi/N);
    return 0;
}
```

By starting with a free, 30-day trial of PGI directives today, you are working on the technology that is the foundation of the OpenACC directives standard. OpenACC is:

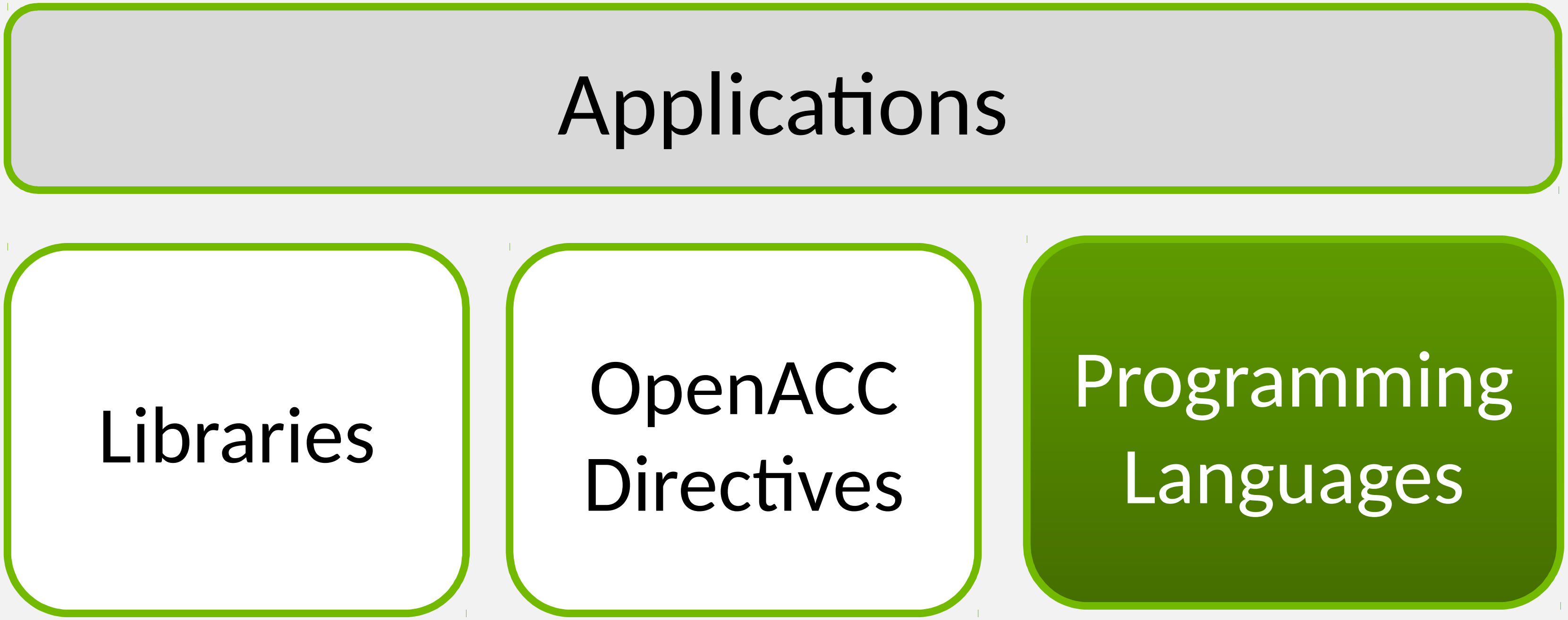
"I have written micron (written in Fortran 90) properties of two and dimensional magnetic directives approach en port my existing code perform my computat which resulted in a sig speedup (more than 20 computation." Learn m

Professor M. Amin Kay
University of Houston

"The PGI compiler is n just how powerful it is software we are writin times faster on the NV are very pleased and e future uses. It's like ov supercomputer." Learn

Dr. Kerry Black
University of Melbourn

3 Ways to Accelerate Applications



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GPU Programming Languages

Numerical analytics	MATLAB, Mathematica, LabVIEW
Fortran	OpenACC, CUDA Fortran
C	OpenACC, CUDA C
C++	Thrust, CUDA C++
Python	PyCUDA, Copperhead
F#	Alea.cuBase

Rapid Parallel C++ Development

- Resembles C++ STL
- High-level interface
  - Enhances developer productivity
  - Enables performance portability between GPUs and multicore CPUs
- Flexible
  - CUDA, OpenMP, and TBB backends
  - Extensible and customizable
  - Integrates with existing software
- Open source

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

// transfer data to device (GPU)
thrust::device_vector<int> d_vec = h_vec;

// sort data on 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());
```

http://developer.nvidia.com/thrust or http://thrust.googlecode.com

Learn More

These languages are supported on all CUDA-capable GPUs.

You might already have a CUDA-capable GPU in your laptop or desktop PC!

CUDA C/C++
http://developer.nvidia.com/cuda-toolkit

Thrust C++ Template Library
http://developer.nvidia.com/thrust

CUDA Fortran
http://developer.nvidia.com/cuda-toolkit

PyCUDA (Python)
http://mathema.tician.de/software/pycuda

GPU.NET
http://tidepowerd.com

MATLAB
http://www.mathworks.com/discovery/matlab-gpu.html

Mathematica
http://www.wolfram.com/mathematica/new-in-8/cuda-and-opencl-support/

Getting Started

- Download CUDA Toolkit & SDK: www.nvidia.com/getcuda

- Nsight IDE (Eclipse or Visual Studio): www.nvidia.com/nsight

- Programming Guide/Best Practices:
  - docs.nvidia.com

- Questions:
  - NVIDIA Developer forums: devtalk.nvidia.com
  - Search or ask on: www.stackoverflow.com/tags/cuda

- General: www.nvidia.com/cudazone