



Windows HPC Server 2008

Parallel Computing @Microsoft

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Challenges?



Free Lunch Is Over For Traditional Software



Free Lunch
for traditional software

Operations per second for serial code



3 GHz
2 Cores

3 GHz
4 Cores

3 GHz
8 Cores

Additional operations per second if code can take advantage of concurrency



No Free Lunch for traditional software
(Without highly concurrent software it won't get any faster!)

- Scaling distributed systems is hard
- Data sets are increasing
- Programming models are complex



We need simpler programming models



$\sin x$	$\cos x$	$\tan x$	$\ln x$	x^a	$(0, +\infty)$	$\sinh x$	$\cosh x$	x	$\arcsinh x$
$\sin x$	$\cos x$	$\tan x$	$\log x$	x^a	$(0, +\infty)$	$\cosh x$	$\tanh x$	R	$1 - x^2$
$\sinh x$	$\cosh x$	$\tanh x$	$\ln x$	x^a	$(0, +\infty)$	$\sinh x$	$\cosh x$	R	$\arcsinh x$
$\frac{1}{\cos x}$	$\frac{1}{\sinh x}$	$\frac{1}{x^a}$	$\frac{1}{x}$	x^{a-1}	$(0, +\infty)$	$\tanh x$	$\coth x$	R	$\frac{1}{1-x^2}$

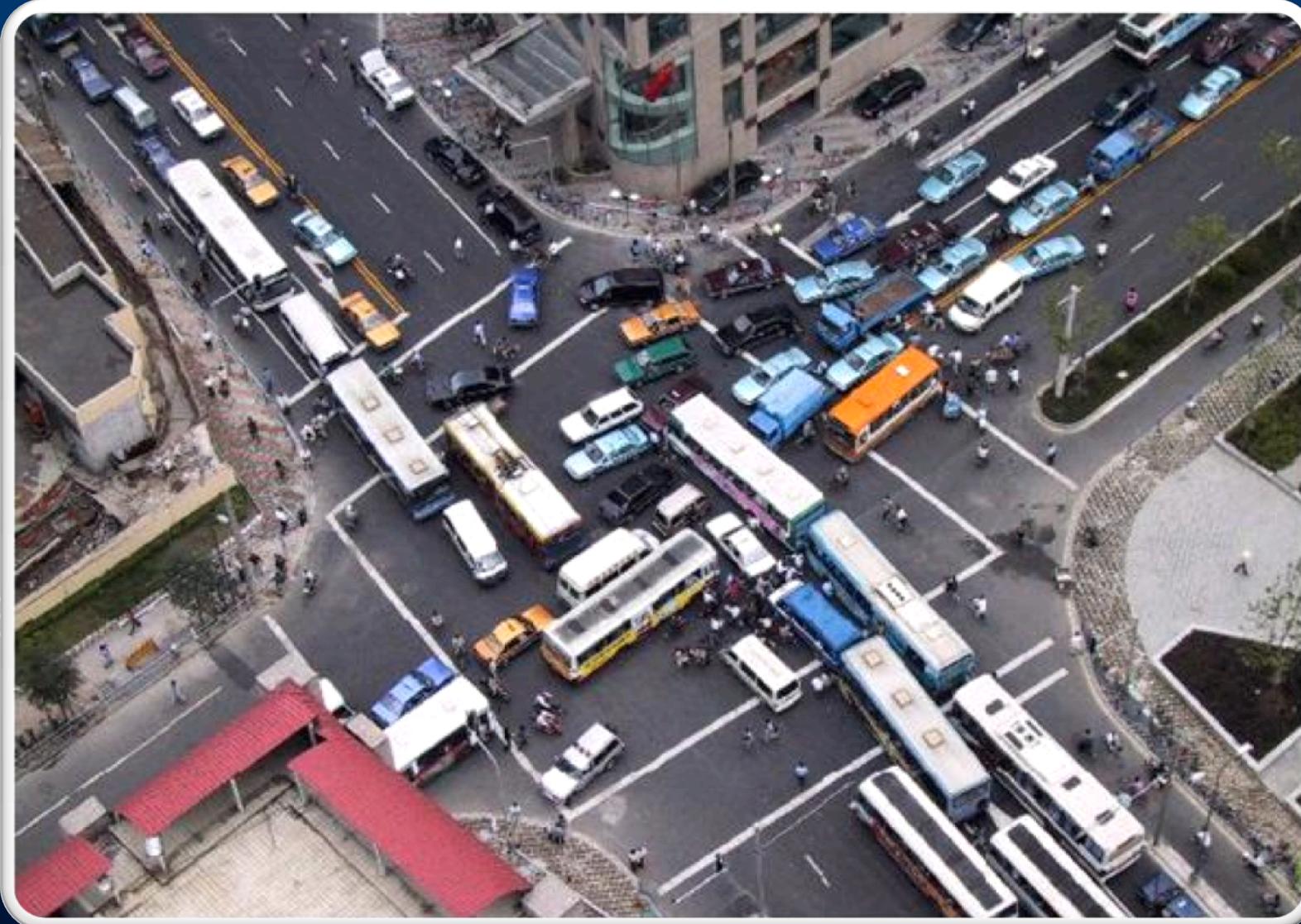
Geometricky význam derivace
 Tj. lokální a geometrický význam derivace je prvního pořadí funkce $y = f(x)$ v nějaké veličině, která je jednotkou změny pro $x \in (x_0, x_0 + h)$, tj. prvního pořadí funkce $f'(x_0) = \lim_{h \rightarrow 0} \frac{f(x_0 + h) - f(x_0)}{h}$ je skutečná různice veličiny y v čase $x - x_0$.
 Pokud $f'(x_0) > 0$ je první pořadí funkce $y = f(x)$ v nějaké veličině, která je jednotkou změny pro $x \in (x_0, x_0 + h)$, tedy $f'(x_0) > 0$, tj. první pořadí funkce $f'(x_0) < 0$ je první pořadí funkce $y = f(x)$ v nějaké veličině, která je jednotkou změny pro $x \in (x_0, x_0 - h)$.
 Nechť $s = s(t)$ je skutečná různice funkce $s = s(t)$ v čase $t - t_0$. Nechť všechny funkce $s = s(t)$ mají v čase t_0 první pořadí funkce $s'(t_0) > 0$. Nechť všechny funkce $s = s(t)$ mají v čase t_0 první pořadí funkce $s'(t_0) < 0$.
 Nechť $s = s(t)$ je skutečná různice funkce $s = s(t)$ v čase $t - t_0$. Nechť všechny funkce $s = s(t)$ mají v čase t_0 první pořadí funkce $s'(t_0) > 0$. Nechť všechny funkce $s = s(t)$ mají v čase t_0 první pořadí funkce $s'(t_0) < 0$.



I'm convinced... now what?

Windows HPC Server 2008

- Now what?
- Bus stops



Example: “Race Car Drivers”

```
IEnumerable<RaceCarDriver> drivers = ...;  
var results = new List<RaceCarDriver>();  
foreach(var driver in drivers)  
{  
    if (driver.Name == queryName &&  
        driver.Wins.Count >= queryWinCount)  
    {  
        results.Add(driver);  
    }  
}  
results.Sort((b1, b2) =>  
    b1.Age.CompareTo(b2.Age));
```

Manual Parallel Solution

```
IF<T> drivers = ...;
var<T> carDriver = new CarDriver();
var<ProcessorCount> processorCount;
var<ProcessorCount> maxParallelism;
var<T> enumerator;
try {
    using (var<T> parallel = new ParallelProcessorCollection<T>(processorCount))
        parallel.ForEach<T>(drivers, (driver, index) => {
            var<T> result = carDriver.Process(driver);
            if (result != null)
                parallel.Decrement<T>(ref index);
            else
                break;
        });
    done.Set();
}
finally { if (enumerator is IDisposable) ((IDisposable)enumerator).Dispose(); }
```

Synchronization Knowledge

Inefficient locking

Lack of foreach simplicity

Manual aggregation

Tricks

Heavy synchronization

Non-parallel sort

LINQ Solution

```
var results = from driver in drivers .AsParallel()
               where driver.Name == queryName &&
                     driver.Wins.Count >= queryWinCount
               orderby driver.Age ascending
               select driver;
```

Example 2: MPI “Hello World”

```
#include <stdio.h>
#include <mpi.h>

int main (int argc, char *argv[])
{
    int rank, size,
        MPI_Init (&argc, &argv);
    MPI_Comm_rank (MPI_COMM_WORLD, &rank);
    MPI_Comm_size (MPI_COMM_WORLD, &size);
    printf( "Hello world from process %d of %d\n", rank, size );
    MPI_Finalize();
    return 0;
}
```

Example 2: MPI “Hello World”

```
using System;
using MPI;

class MPIHello
{
    static void Main(string[] args)
    {
        using (new MPI.Environment(ref args))
        {
            int rank = MPI.Communicator.world.Rank;
            int worldSize = MPI.Communicator.world.Size;

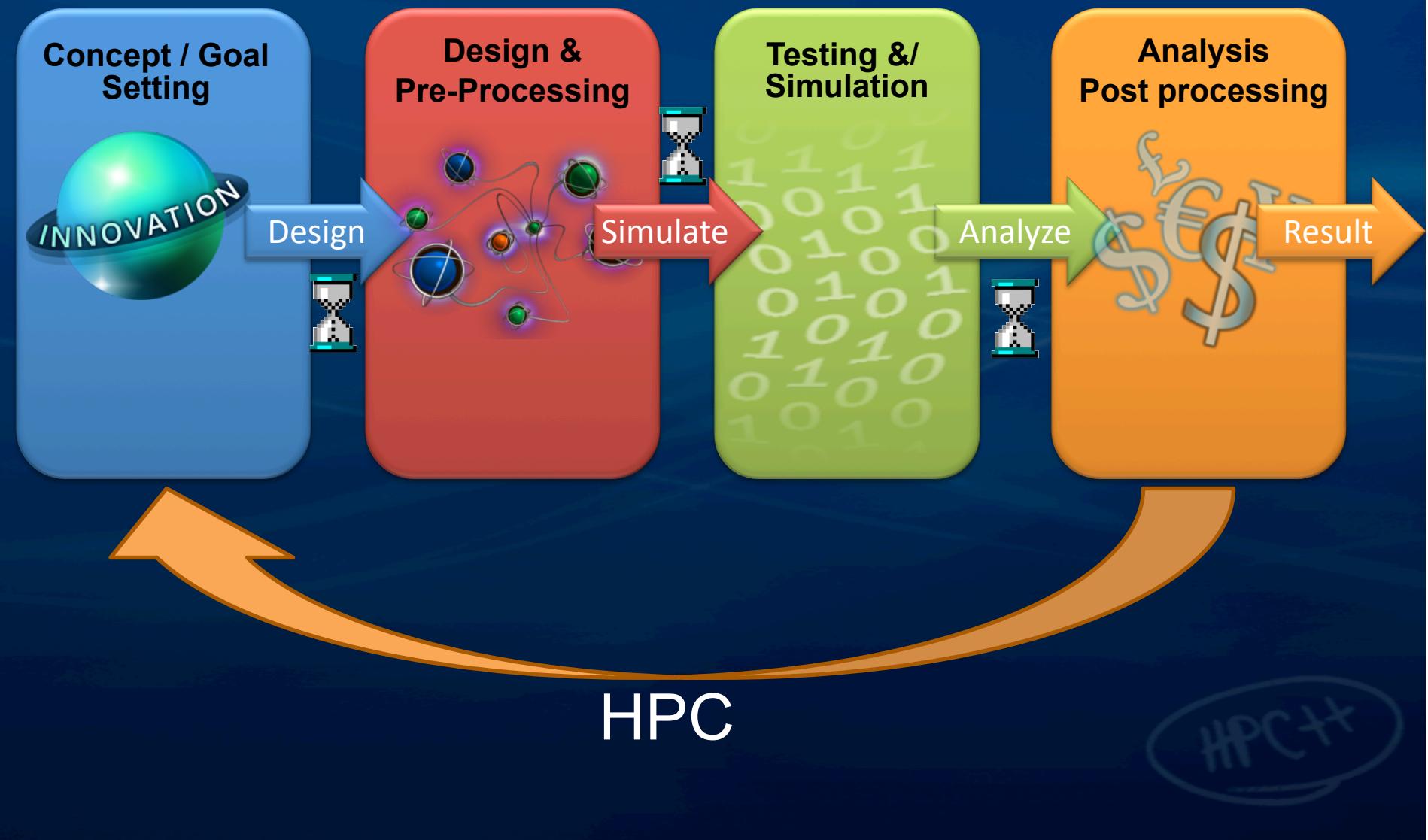
            Console.WriteLine("Hello World from process"
                + rank + " of " + size);
        }
    }
}
```

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What is HPC?

HPC is computing infrastructure to accelerate innovation



Today's HPC Environment



Corporate infrastructure



Information workers



Mainstream technologies



Clusters/
supercomputers



High speed
networking



Storage



Scientists



Engineers



Financial
analysts



Compilers



Specialized
languages



Debuggers

High Productivity Computing



Combined infrastructure

HPC and IT data centers
merge, streamlined
cluster management



Integrated desktop and HPC environment

Users with broad access to
multiple cores and servers



Unified development environment

Simplified parallel
development



Windows HPC Server 2008



- Complete, integrated platform for computational clustering
- Built on top the proven Windows Server 2008 platform
- Integrated development environment

Windows Server Operating System

- Secure, Reliable, Tested
- Support for high performance hardware (x64, high-speed interconnects)

HPC Pack

- Job Scheduler
- Resource Manager
- Cluster Management
- Message Passing Interface

Microsoft Windows HPC Server 2008

- Integrated Solution out-of-the-box
- Leverages investment in Windows administration and tools
- Makes cluster operation easy and secure as a single system



Windows HPC Server 2008



- **Simple to setup and manage**
 - Simplify system and application deployment
 - Base images, patches, drivers, applications
- **Focus on ease of management**
 - Comprehensive diagnostics , troubleshooting and monitoring
 - Familiar, flexible and “pivotal” management interface
 - Equivalent command line support for unattended management
- **Increased Scale**
 - Scale deployment, administration, infrastructure
 - Cluster usage reporting
- **Better integration**
 - Patch Management
 - System Center Operations Management
 - PowerShell
 - Windows 2008 high Availability Services



Visual Studio 2010

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Tools/Programming Models/Runtimes

Tools

Parallel Debugger Tool Windows Visual Studio IDE Profiler Concurrency Analysis

Programming Models

Parallel LINQ

Task Parallel Library

.NET Framework 4

ThreadPool

Task Scheduler

Resource Manager

Data Structures

Parallel Pattern Library

Agents Library

Visual C++ 10

Task Scheduler

Resource Manager

Operating System

Threads Windows

UMS Threads

Key:

Managed

Native

Tooling

Developer Accessibility



Make it easier to express and manage the correctness, efficiency and maintainability of parallelism on Microsoft platforms for developers of all skill levels

Enable developers to express parallelism easily and focus on the problem to be solved

Improve the efficiency and scalability of parallel applications

Simplify the process of designing and testing parallel applications



**Microsoft's
vision for HPC**

Microsoft's Vision for HPC



"Provide the platform, tools and broad ecosystem to reduce the complexity of HPC by making parallelism more accessible to address future computational needs."

Reduced Complexity

Ease deployment for larger scale clusters

Simplify management for clusters of all scale

Integrate with existing infrastructure

Mainstream HPC

Address needs of traditional supercomputing

Address emerging cross-industry computation trends

Enable non-technical users to harness the power of HPC

Broad Ecosystem

Increase number of parallel applications and codes

Offer choice of parallel development tools, languages and libraries

Drive larger universe of end-users, developers, and system administrators

Democratize!



Parallel Computing for the Masses



Additional Information



- Microsoft HPC Web site
 - <http://www.microsoft.com/hpc>
- Parallelism at Microsoft
 - <http://msdn.microsoft.com/concurrency>
- Visual Studio 2010 Release Candidate
 - <http://msdn.microsoft.com/visualstudio>
- Windows HPC TechCenter
 - <http://technet.microsoft.com/en-us/hpc/default.aspx>
- HPC on MSDN
 - <http://code.msdn.microsoft.com/hpc>
- To join Microsoft's HPC Newsletter
 - hpcnews@microsoft.com



Questions



- To join Microsoft's HPC Newsletter
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Your potential. Our passion.™

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