ParaTools

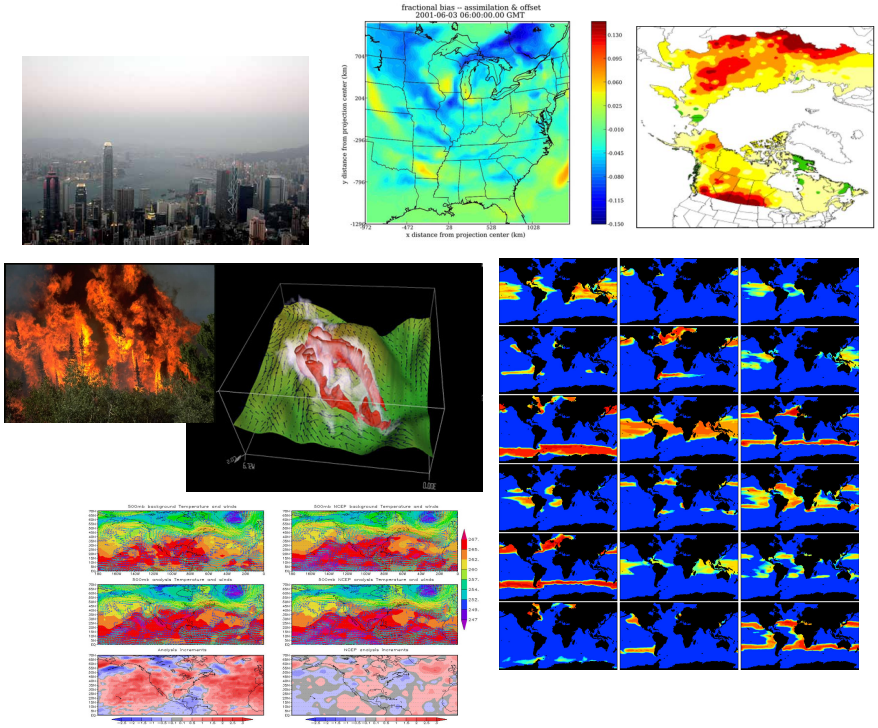
Kppa

The Kinetic PreProcessor Accelerated

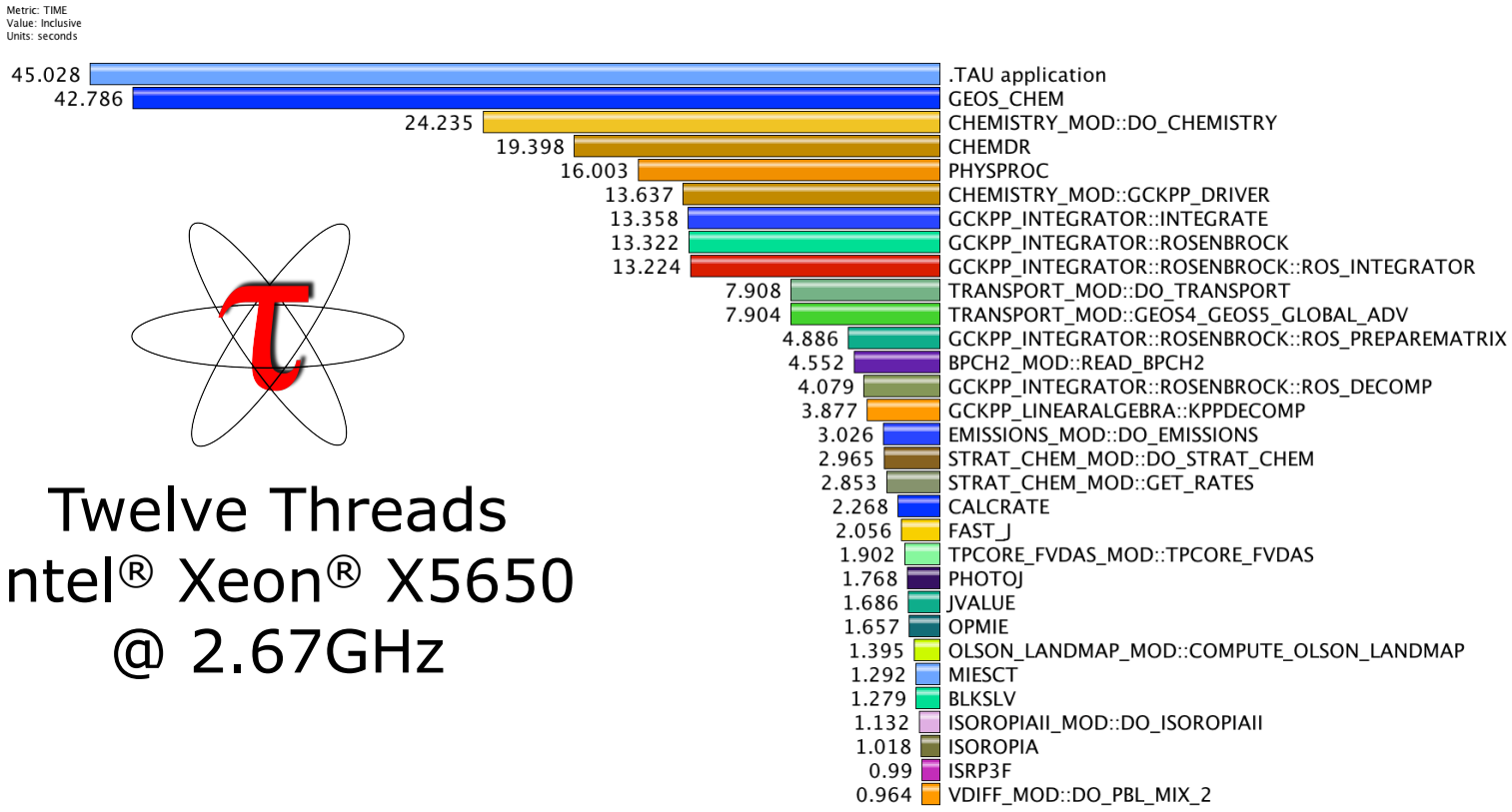
November 15, 2012

Chemical Kinetic Simulation

- Pyrolysis and Combustion
- Air and Water Quality
- Climate Change
- Wildfires, Volcanic Eruptions
- Plastics Devolatilzation
- Microorganism Growth
- Cell Biology



Solving Coupled Stiff ODE Systems is Expensive



Twelve Threads
Intel® Xeon® X5650
@ 2.67GHz

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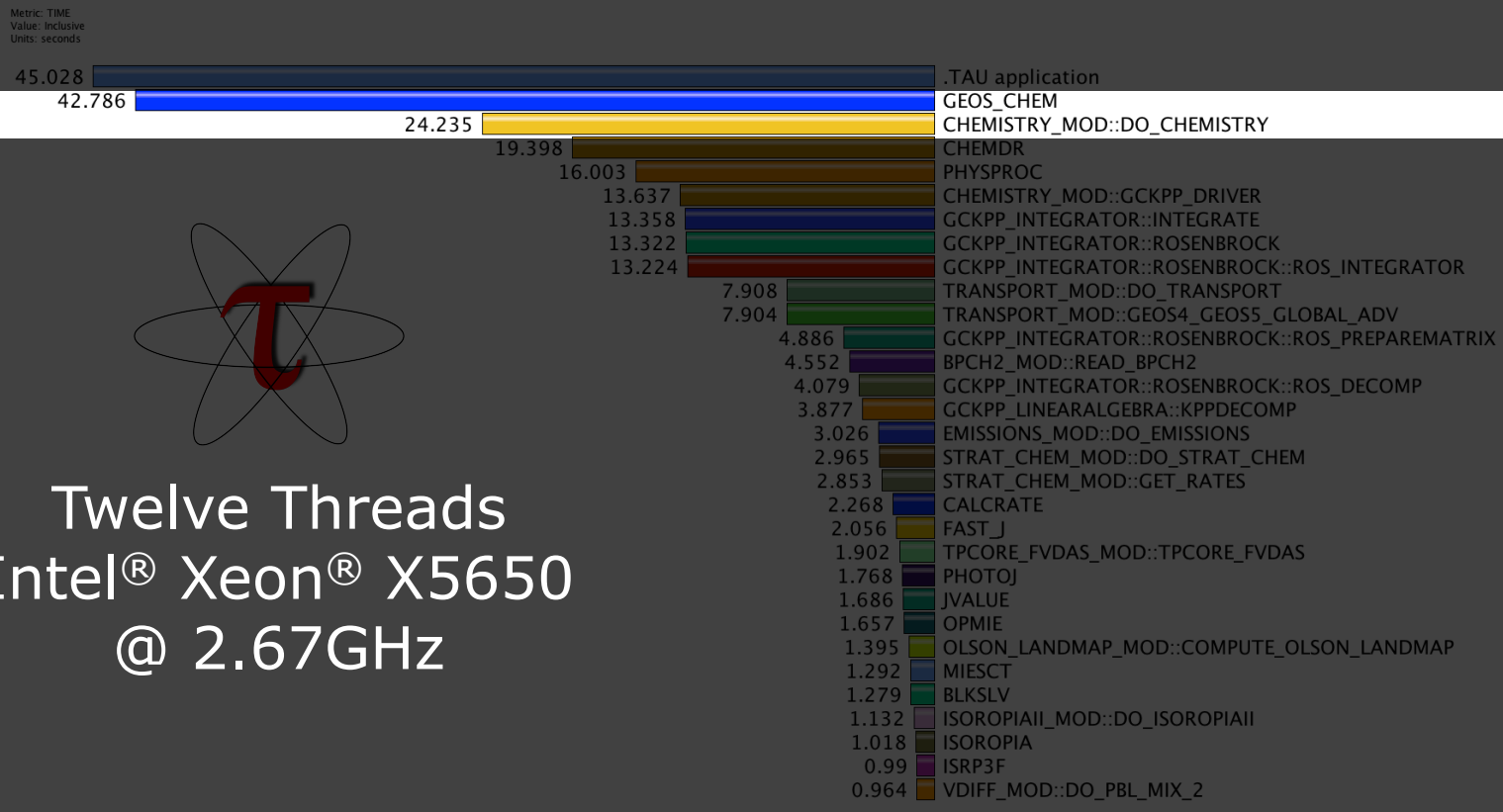

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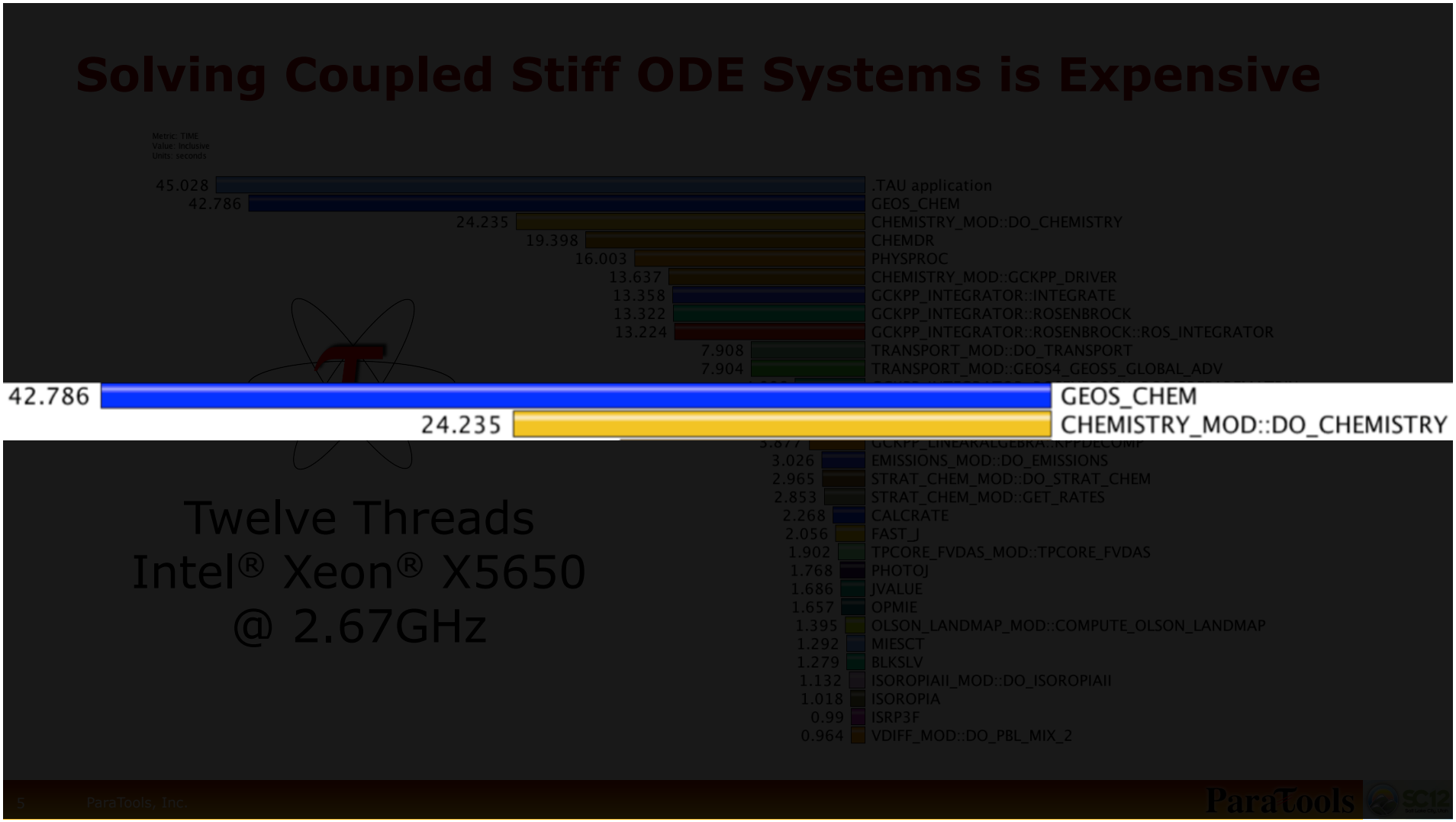

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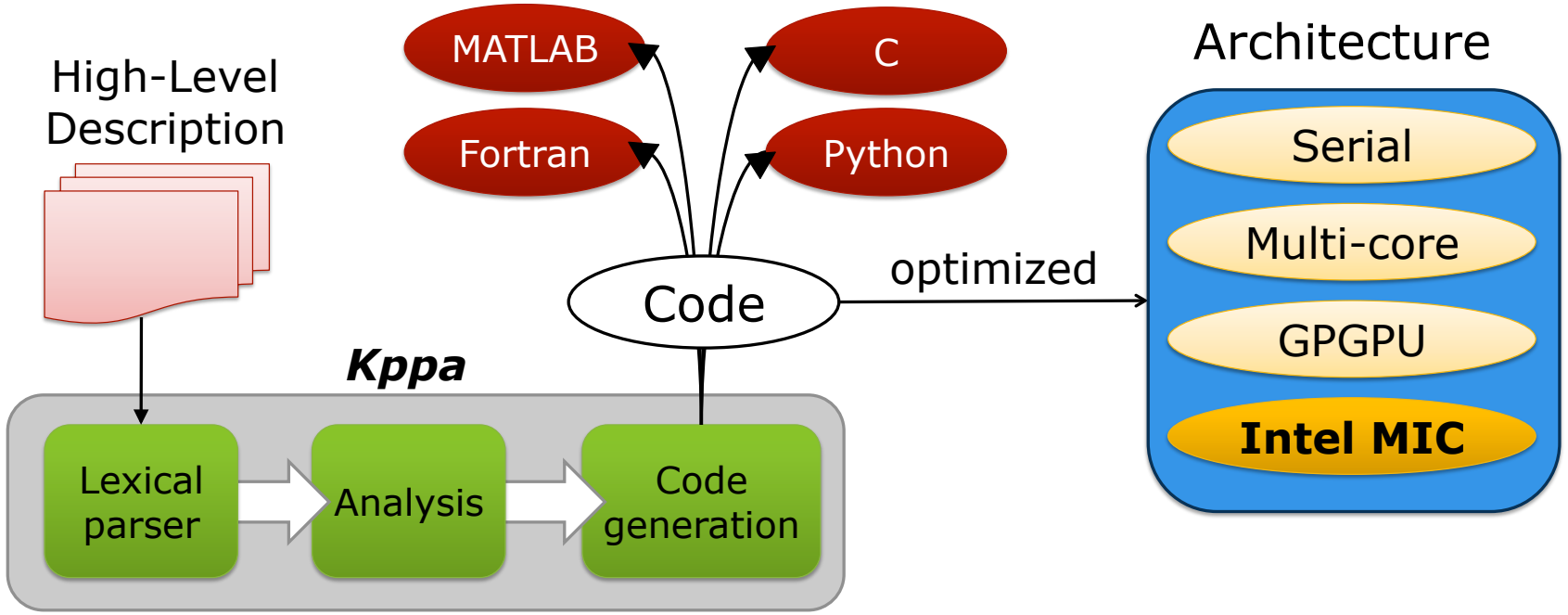
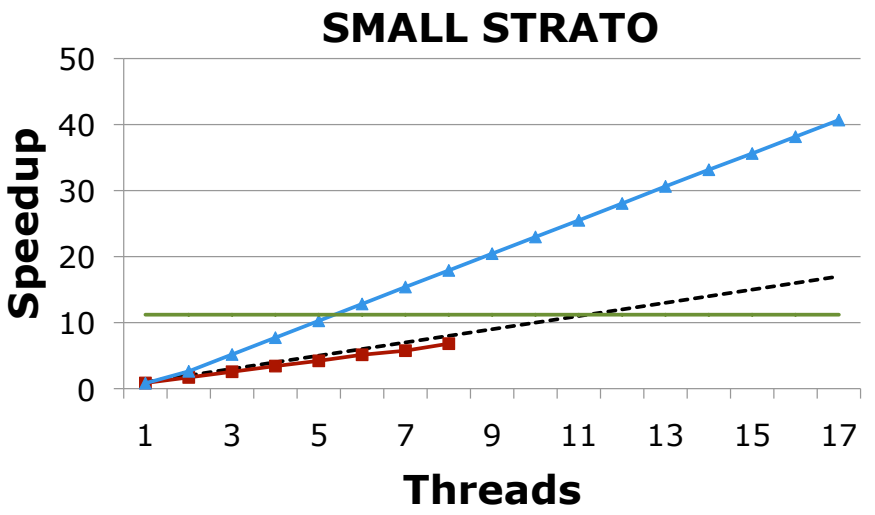
Kppa: The Kinetic PreProcessor Accelerated



Kppa-generated can be 40x faster than hand-tuned

- Reorder chemical species to **minimize fill-in**
- Reorder concentration data to **maximize vectorization**
- Reorder grid cells to **reduce excessive iteration**



Meta-programming for Automatic Code Generation

```
<%
d_Decomp.begin()

piv = lang.Variable('piv', REAL,
                    'Row element divided by diagonal')
piv.declare()
%>
    ${size_t} idx = blockDim.x*blockIdx.x+threadIdx.x;
    if(idx < ${ncells32}) {
        ${A} += idx;
<%
lang.upindent()
for i in xrange(1, nvar):
    for j in xrange(crow[i], diag[i]):
        c = icol[j]
        d = diag[c]
        piv.assign(A[j*ncells32] / A[d*ncells32])
        A[j*ncells32].assign(piv)
...
%>
    }
<% d_Decomp.end() %>
```

C/C++/CUDA, Fortran

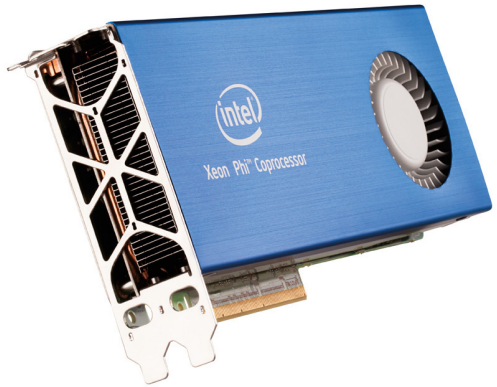
```
A[334] = t1;
A[337] = -A[272]*t1 + A[337];
A[338] = -A[273]*t1 + A[338];
A[339] = -A[274]*t1 + A[339];
A[340] = -A[275]*t1 + A[340];
t2 = A[335]/A[329];
A[335] = t2;
A[337] = -A[330]*t2 + A[337];
A[338] = -A[331]*t2 + A[338];
A[339] = -A[332]*t2 + A[339];
A[340] = -A[333]*t2 + A[340];
t3 = A[341]/A[59];
```

Kppa's Architecture Parameterization

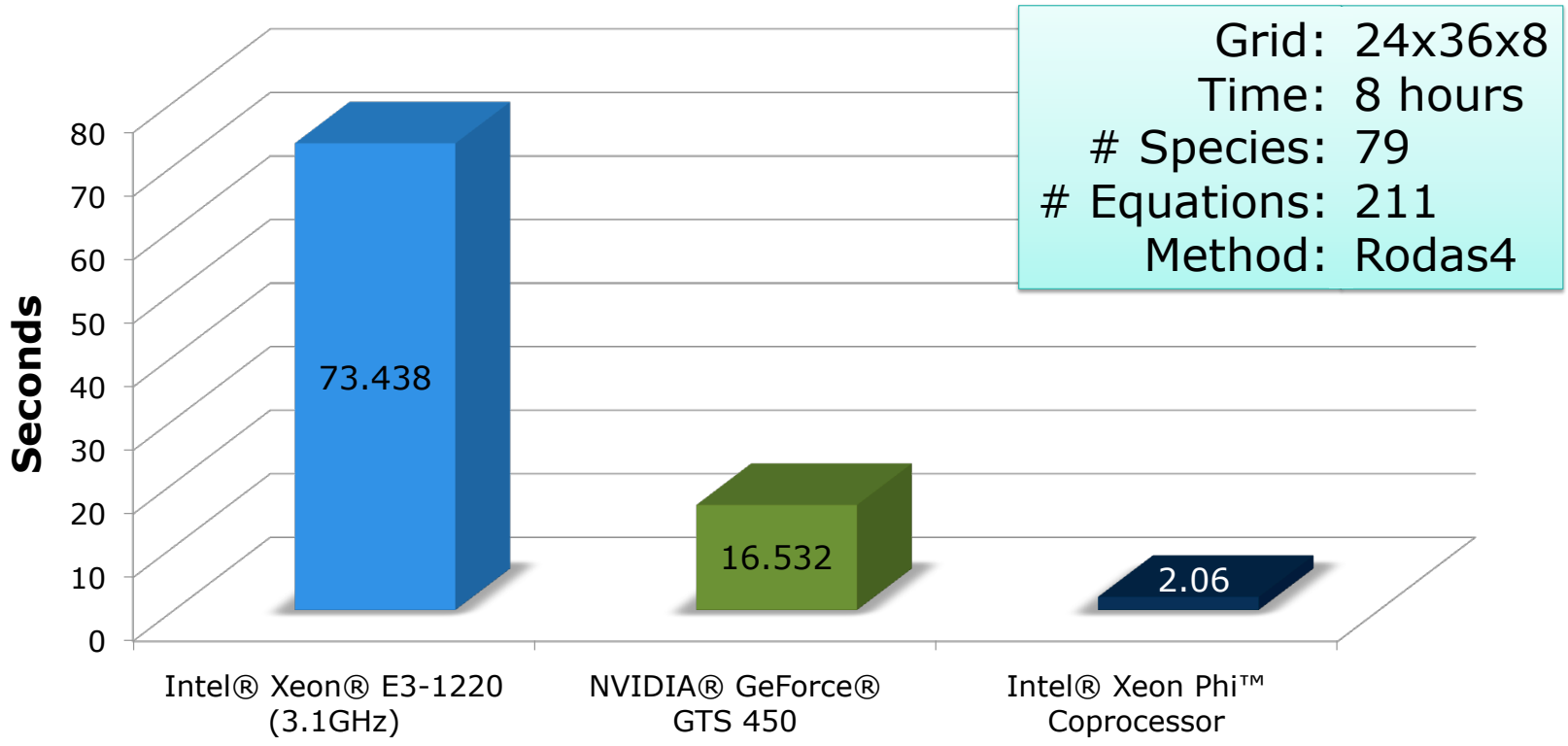
	CPU	GPU	Intel® MIC	CBEA
Instruction Cardinality	1	32	16	4
Integrator Cardinality	1	∞	16	4
Scratch Size	N/A	16 KB	N/A	256 KB

Just had to parameterize the new architecture in Kppa and generate an OpenMP code

Targeting the Intel® Xeon® Phi™ coprocessor was easy!



Kppa-generated SAPRC Kernel: 35.6x Speedup



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Download Kppa from
www.paratools.com/kppa


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