



The ExaHyPE story & Profiling for ExaHyPE

Part I

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Introduction

Topics not covered by this presentation:

- ▶ Numerics deep dive (ADER-DG, Limiting, etc.)
- ▶ Performance analysis case studies and scaling graphs
- ▶ Demo session ;-(

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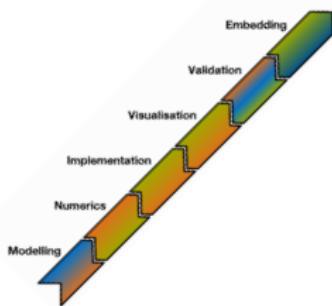
Topics covered by this presentation:

- ▶ Context and motivation behind the project
- ▶ Overview on key objectives of ExaHyPE
- ▶ Summary on techniques employed by the framework
- ▶ Current state and next steps on the agenda
- ▶ Profiling infrastructure for ExaHyPE

Context & Motivation

Important aspects in the context of Scientific Computing:

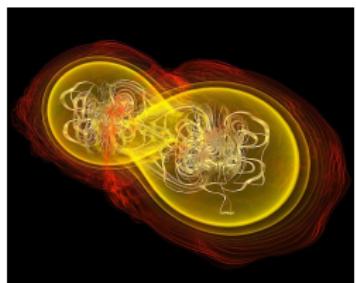
Simulation Pipeline



Exascale computing



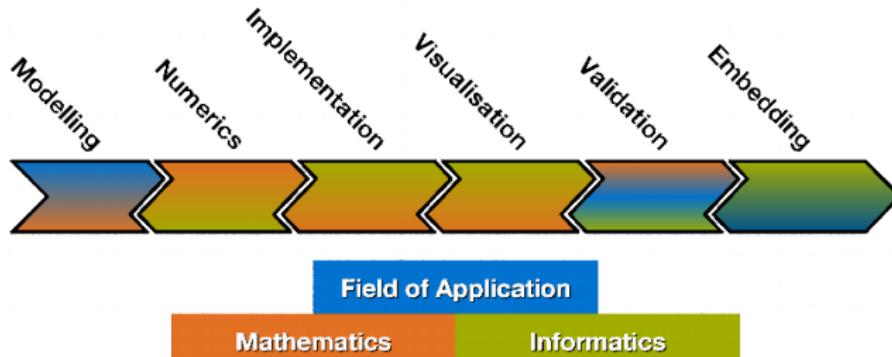
Hyperbolic PDEs



Simulation Pipeline

Observations from practice:

- ▶ All steps are repeated over and over again!
- ▶ Nobody can be an expert in everything!
- ▶ Why not focus on what you are best in and consider the other problems solved?



The Simulation Pipeline
via Hans-Joachim Bungartz: Modeling and Simulation (IN2010)

Exascale Computing

Major challenges

- ▶ Energy consumption
- ▶ Multi-level parallelism on hybrid architectures
- ▶ Fault tolerance and resilience
- ▶ Memory and bandwidth as bottleneck
- ▶ ...

Sunway TaihuLight, Wuxi, China
125 PFlop/s, 15.3 MW, 237M USD



An exascale system

Hyperbolic PDEs

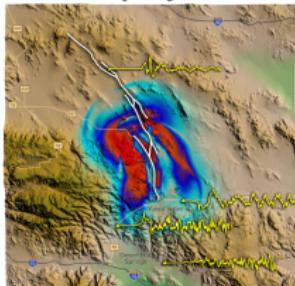
General form:

$$\frac{\partial}{\partial t} [\mathbf{u}]_v + \frac{\partial}{\partial x_d} [\mathbf{F}(\mathbf{u})]_{vd} = [\mathbf{s}(\mathbf{u})]_v,$$

where $v \in \{1, 2, \dots, V\}$ and $\mathbf{F} = [\mathbf{f}_1, \mathbf{f}_2, \dots, \mathbf{f}_D]$ and $\frac{\partial [\mathbf{f}_d]_i}{\partial x_j}$ has real eigenvalues for all $d \in \{1, 2, \dots, D\}$.

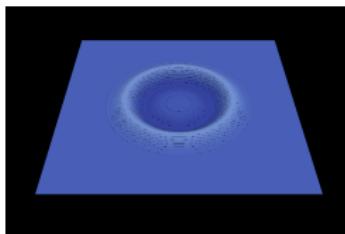
Areas of application:

Geophysics



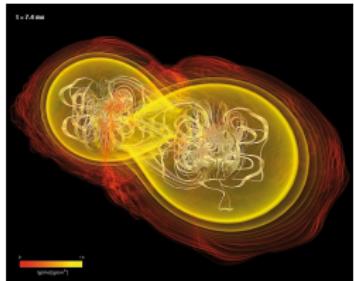
Simulation of ground shaking of the 1992 Landers Earthquake

Gas dynamics



Simulated pressure wave in a compressible gas

Astrophysics



Simulation of the merger of two magnetised neutron stars

Hyperbolic PDEs

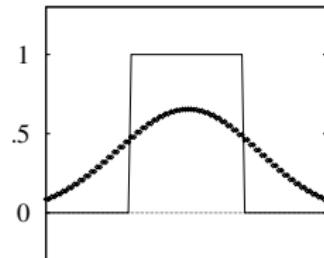
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Challenges:

- ▶ Long-term accuracy
- ▶ Stability at shocks
- ▶ Time step restrictions
(e.g. for stiff source terms)
- ▶ Arithmetic density and data locality



Hyperbolic PDEs

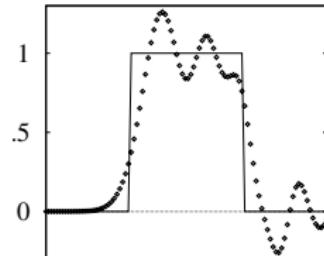
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What is Exahype



Approach



Exahype: Applications



Exahype: As a user



Exahype: Consortium



Exahype: Profiling motivation



Exahype: Profiling arch



Exahype: Profiling next steps