Open Compute Stack (OpenCS)
Overview

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DAE Tools Project,
http://www.daetools.com/opencs

What is OpenCS?

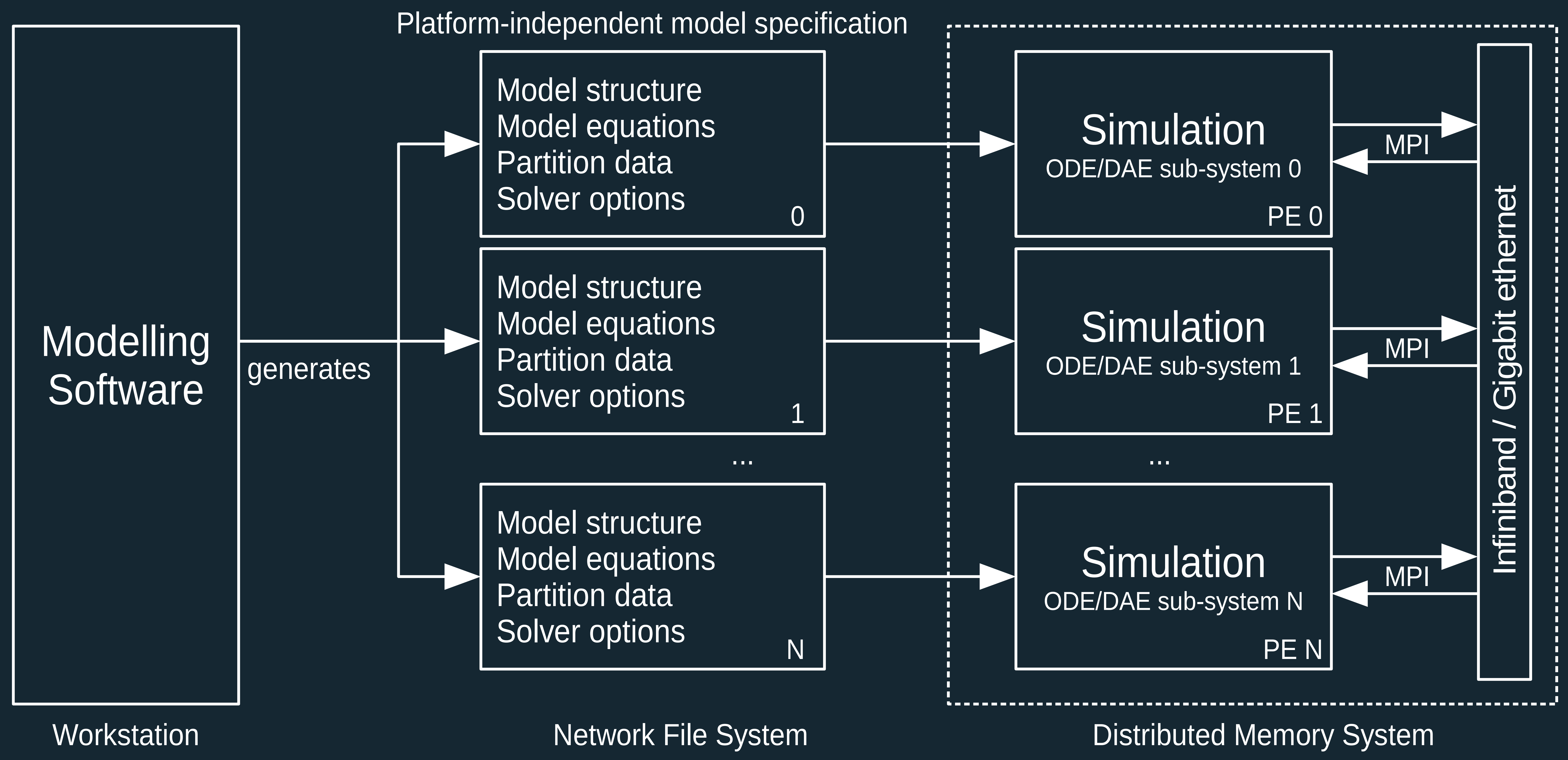
A framework for:

1. **Equation-based modelling**
   (large-scale ODE/DAE systems)
2. **Parallel evaluation of equations**
3. **Model exchange**
4. **Parallel simulation on:**
   – Shared memory systems
   – Distributed memory systems

Multi-domain applications

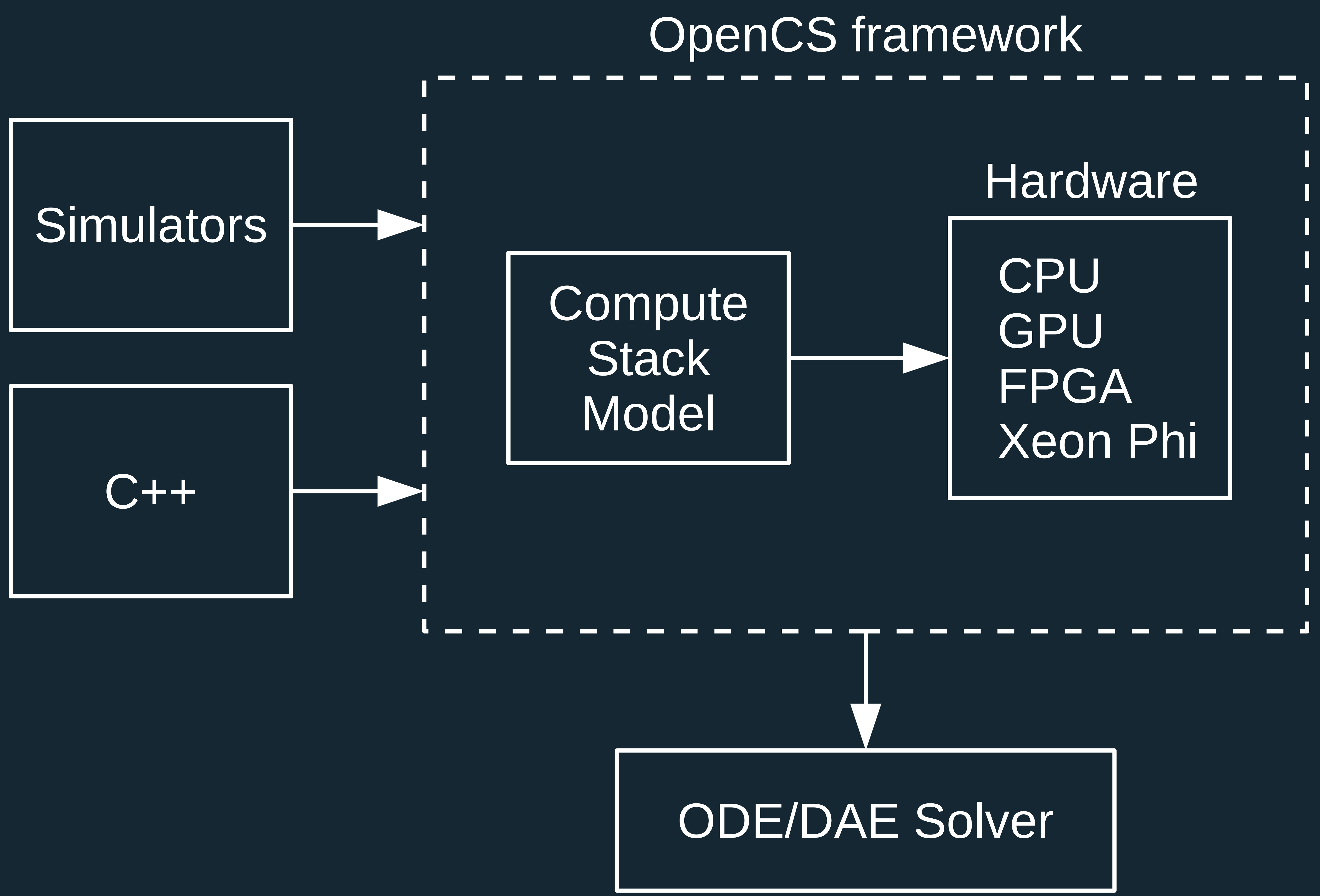
Free/Open source software

Cross-platform



Use case scenarios

1. **Development of large-scale models (C++)**
2. **Parallel evaluation of model equations**
3. **Universal parallel simulations on shared and distributed memory systems**
4. **Model export from 3rd-party simulators for:**
   - Model exchange
   - Benchmark between solvers and simulators
   - Benchmark between individual computing devices
   - Benchmark between HPC systems (i.e. hybrid CPU+GPU and CPU+FPGA clusters)



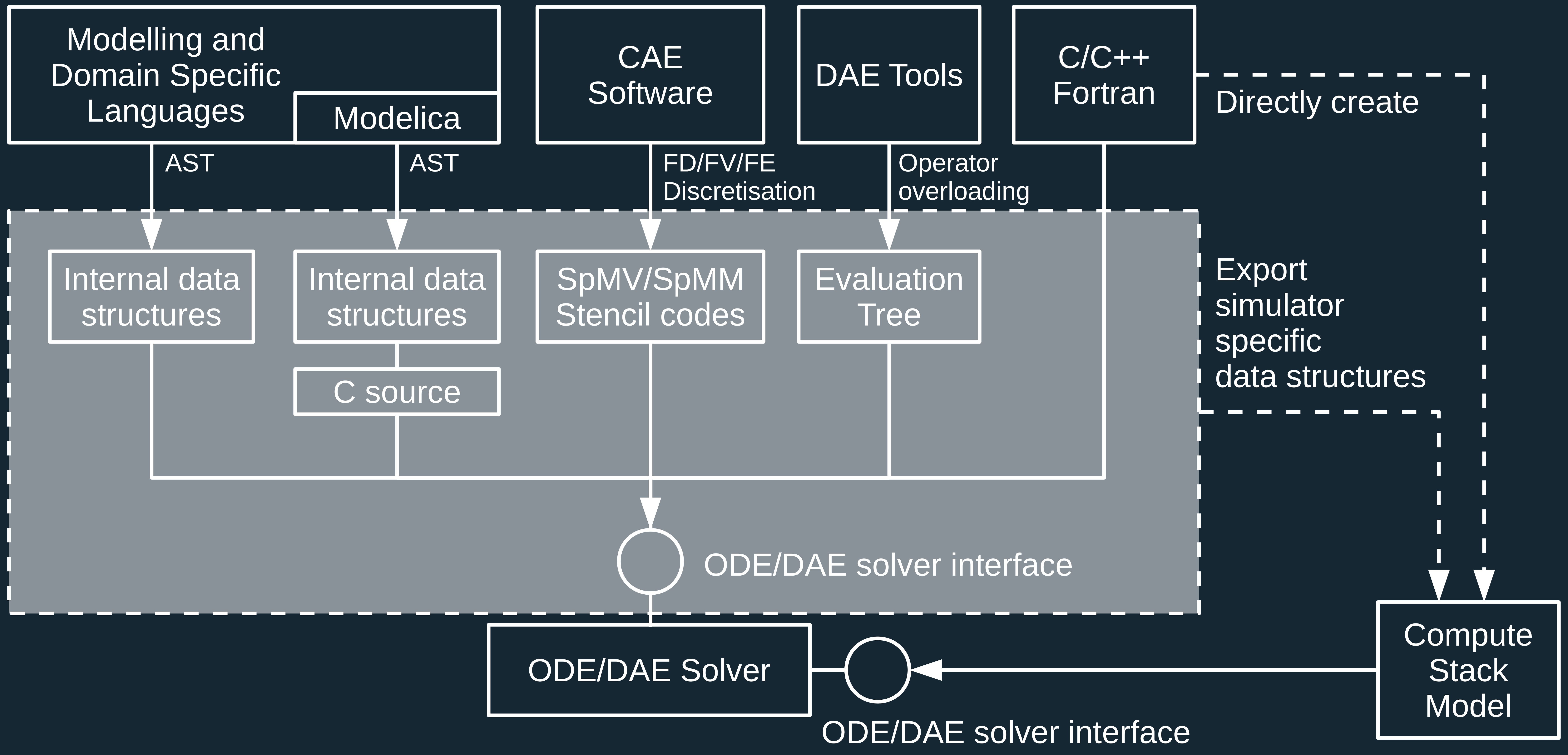
What can be done with OpenCS?

Model specification

- **Direct implementation** in C++
- **Export** from 3rd-party simulators

Model exchange

- **OpenCS models** stored as files in a **platform-independent binary format**
- **The OpenCS API:**
  - Loading the models into a host
  - Interface to ODE/DAE solvers (i.e. evaluation of equations)



What can be done with OpenCS?

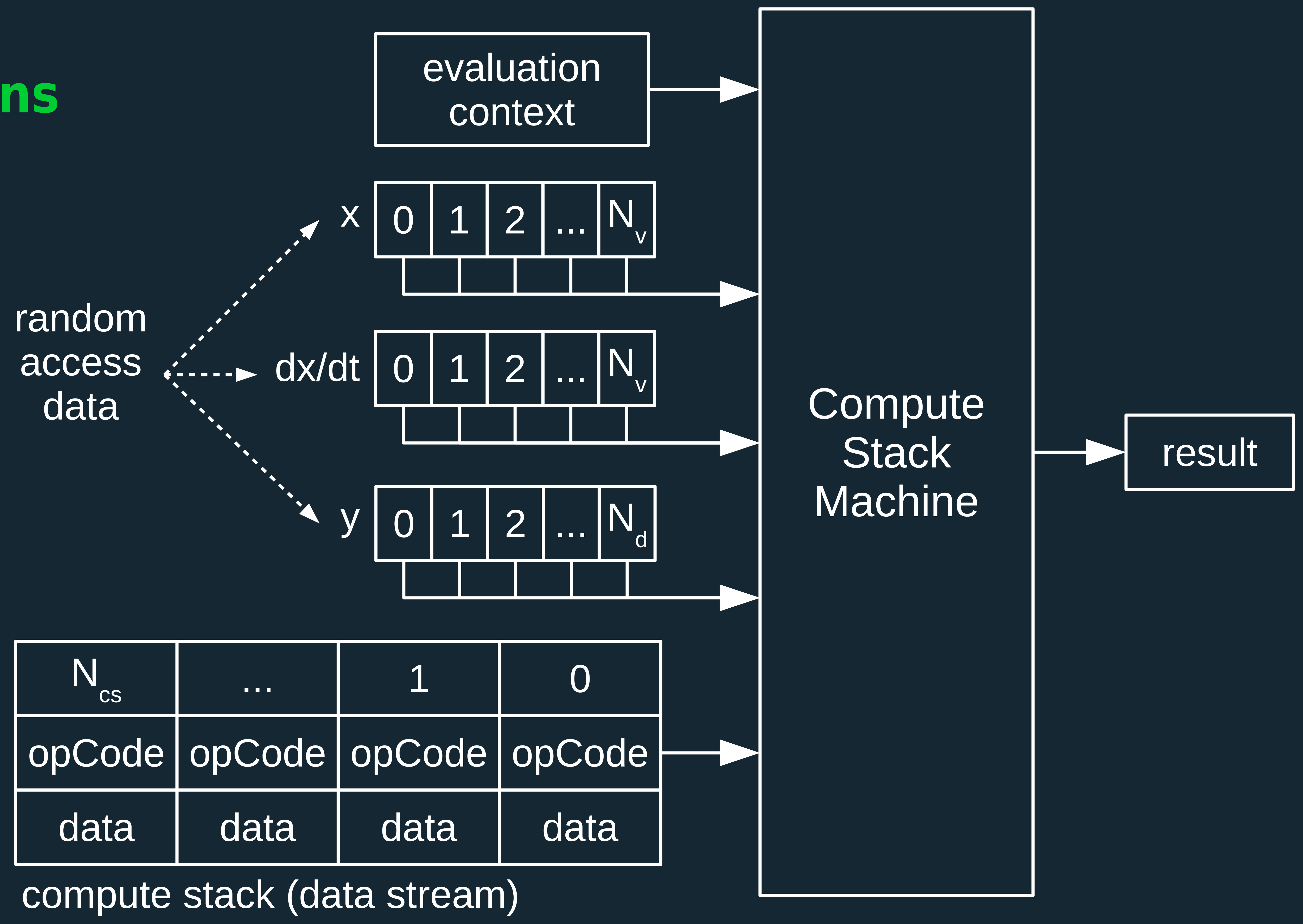
Platform-independent description of model equations

Reverse Polish (postfix) notation (Compute Stack)

Evaluation using a Compute Stack Machine

Advantages:

- Equations as an array of binary data
- Direct evaluation on all computing platforms
- Specialised hardware for evaluation (i.e. GPU, FPGA)
- No additional processing nor compilation steps

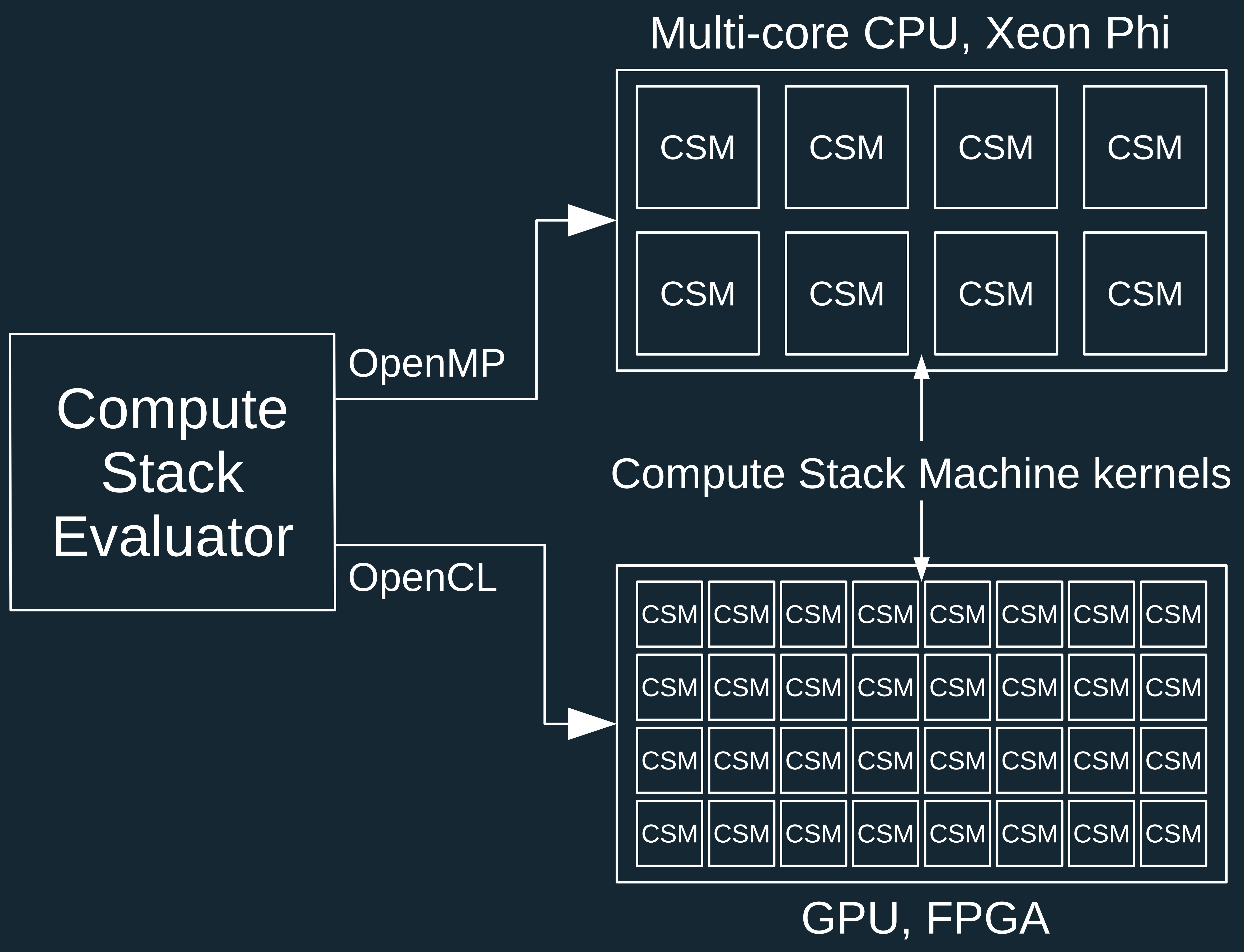


What can be done with OpenCS?

Parallel evaluation of model equations

Systems of equations evaluated using the Compute Stack Evaluator interface:

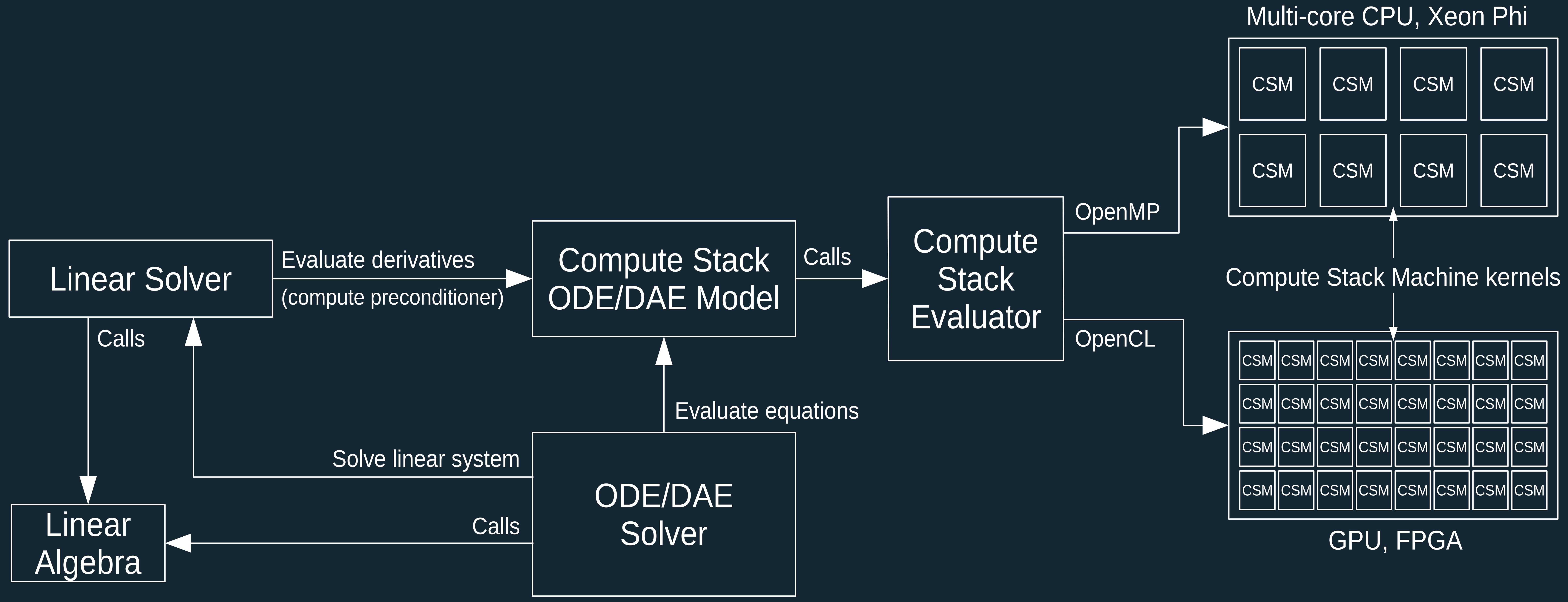
- **OpenMP** for **general purpose processors** (multi-core CPUs, Xeon Phi)
- **OpenCL** for:
  streaming processors (GPU, FPGA)
  heterogeneous systems (CPU+GPU/FPGA)



What can be done with OpenCS?

Parallel simulation on shared memory systems

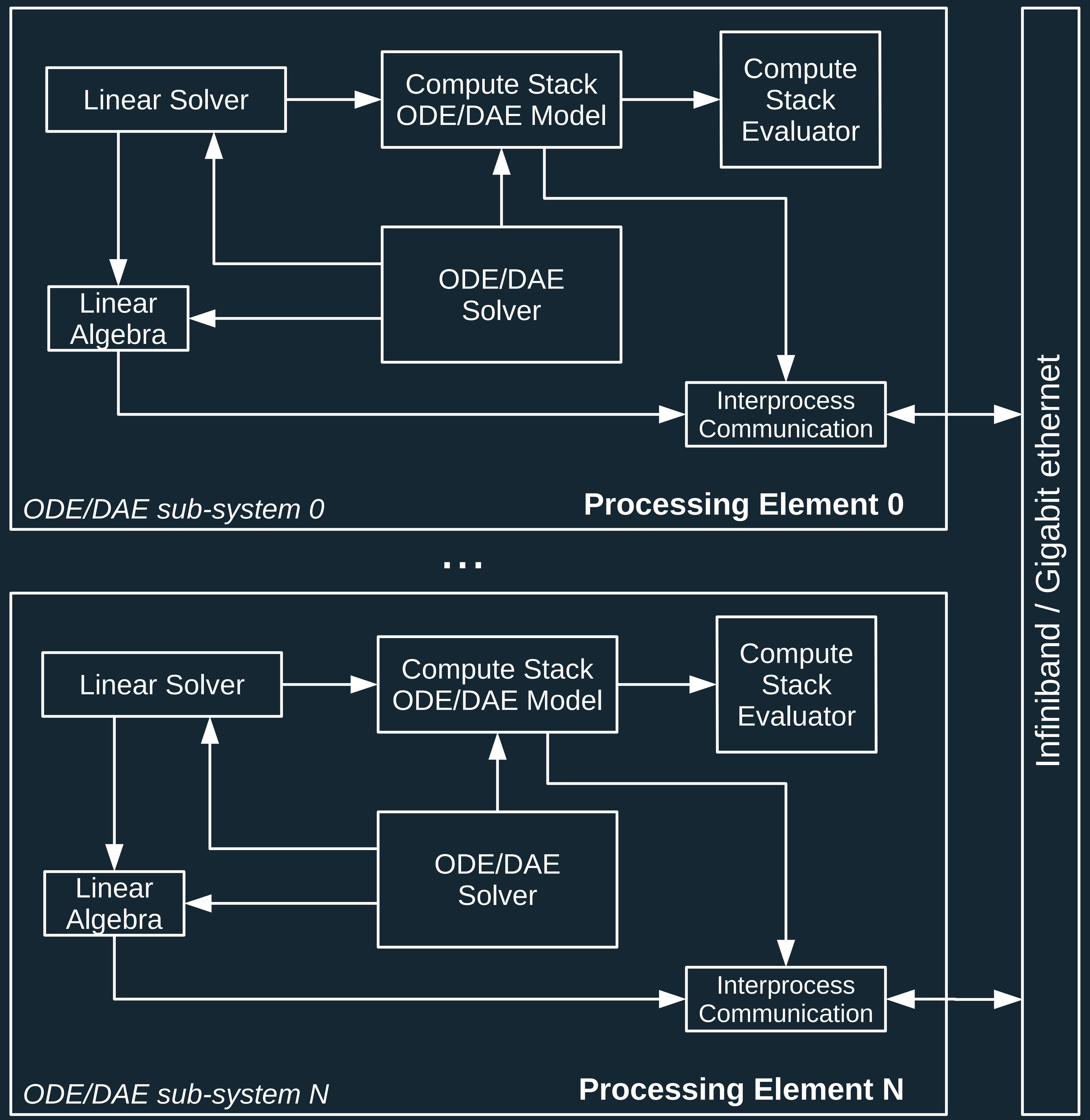
- **Single processing element**
- **Available computing hardware utilised for parallel evaluation of model equations:**
  - Multi-core CPU, Xeon Phi
  - GPU, FPGA
  - Heterogeneous systems
    i.e. CPU+GPU, CPU+FPGA



What can be done with OpenCS?

Parallel simulation on distributed memory systems

- **Multiple processing elements**
- **Software for simulation on shared memory systems as the main building block**
- **Partitioning using multiple balancing constraints**
- **Every processing element:**
  - Integrates one ODE/DAE sub-system in time
  - Performs an inter-process data exchange



OpenCS benefits

- A **single software** for numerical solution of **any ODE/DAE system** of **any size** on **all platforms**
- The model specification contains only the **low-level model description** (created from any software)
- The **model specification** stored as **files in a platform-independent binary format**
- **Model equations** specified in a **platform independent** way as **an array of binary data**
- Equations can be **evaluated on** virtually **all computing devices** (including heterogeneous systems)
- Switching to a different computing platform for evaluation of equations as an input parameter

The key OpenCS concepts

Compute Stack:	The Reverse Polish (postfix) notation expression stack to describe and store in computer memory equations of any type and any size
Compute Stack Machine:	A stack machine used to evaluate a single equation using LIFO queues
Compute Stack Evaluator:	An interface for parallel evaluation of systems of equations
Compute Stack Model:	Data structure that holds the low-level model specification
Compute Stack Differential Equations Model:	A common interface for ODE/DAE solvers for integration of ODE/DAE systems in time
Compute Stack Simulator:	Sequential/parallel simulator for general ODE/DAE systems
Compute Stack Model Builder:	A common interface for creation of ODE/DAE Compute Stack models