THE NABLA LANGUAGE
&
THE NABLAB ENVIRONMENT

Jean-Sylvain Camier, Marie-Pierre Oudot, Benoît Lelandais, Benoît Combemale

ECLIPSE SCIENCE WORKING GROUP - 12/11/2017

THE TEAM

Jean-Sylvain Camier (JSC)

Lawrence Livermore National Laboratory (LLNL)
Nabla project leader and main contributor
HPC expert

Marie-Pierre Oudot (MPO) & Benoît Lelandais (BL)

French Alternative Energies and Atomic Energy Commission (CEA)
Software engineering, Eclipse EMF experts

Benoît Combemale (BC)

University of Toulouse
Researcher in the software engineering domain mainly in modeling languages and tools

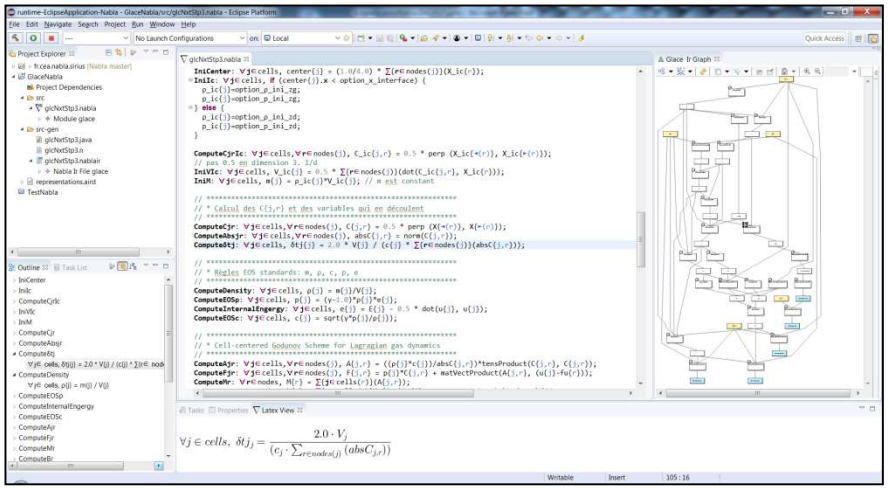
PROJECT ARCHITECTURE

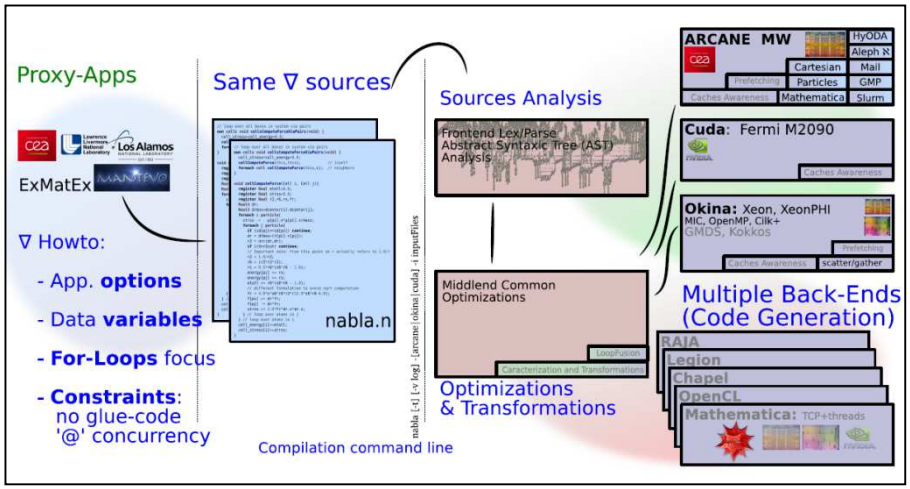
Nablab Environment

Technologies : Eclipse EMF, Xtext, Sirius
Contributors : MPO, BL, BC

Nabla Language

Technologies : Flex, Bison, C++
Contributors : JSC, BL



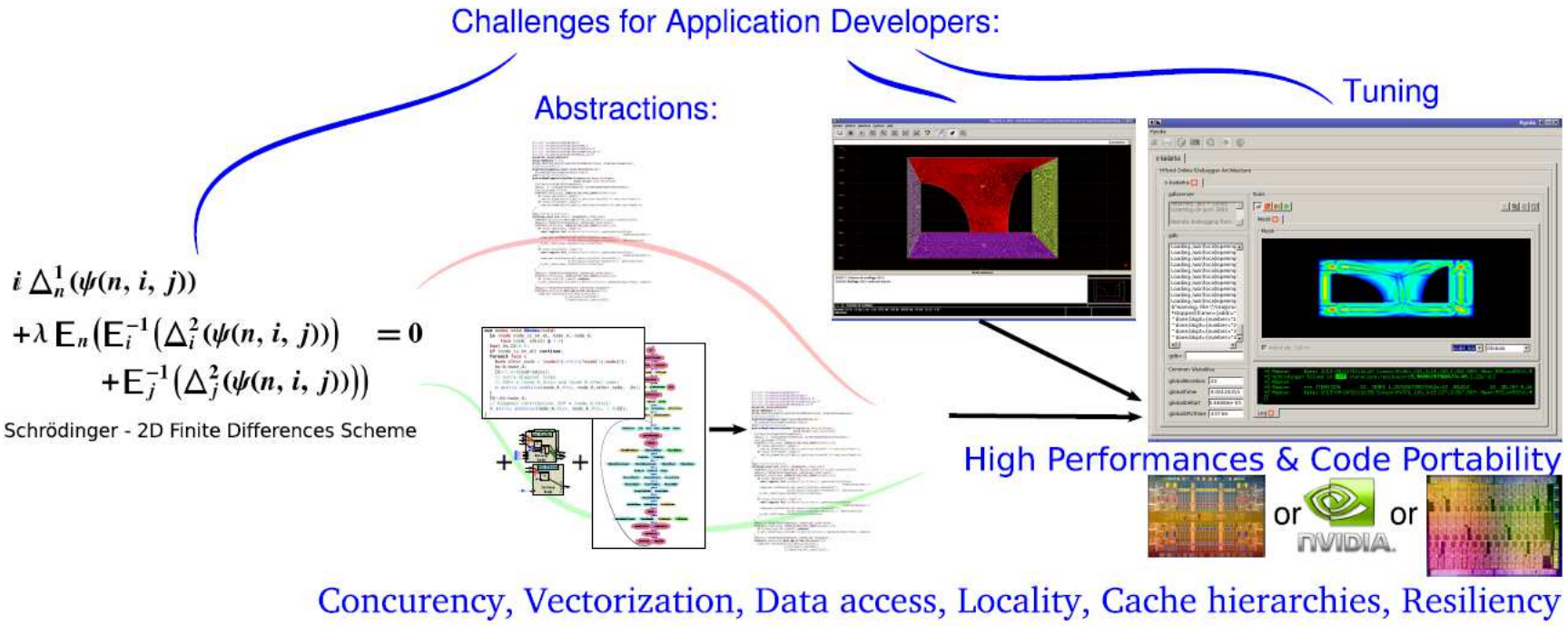


Nabla text files (.n)

THE ∇ LANGUAGE

www.nabla-lang.org

CHALLENGES AND OBJECTIVES



Objectives & Roadmap since 2009

Performances: Instantiate the right programming model for different SW/HW stacks

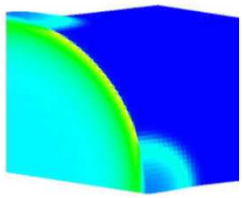
Portability: Provide portable scientific applications across architectures

Programmability: Attractive approach for tomorrow's SW engineers

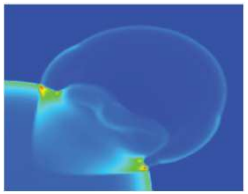
Interoperability: Allow modularity with legacy codes

MAIN PROXY APPLICATIONS PORTED TO ∇

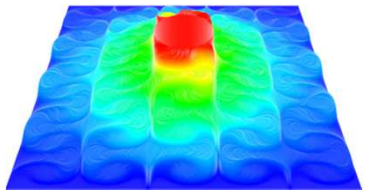
Numerical Methods	Application	# of ∇ lines
Explicite Unstructured	LULESH 1.0 (LLNL)	1030
Explicite Structured	HYDRO (CEA)	757
Implicite	M-NL-DDFV (CEA) Schrödinger (CEA)	2304 375
Monte-Carlo	MCTB (CEA)	828
Dynamique Molecular	CoMD (LANL) MiniMD (SNL)	293 474
SPH	SPH (CEA)	2500



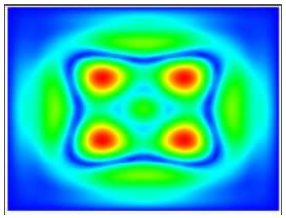
Lulesh



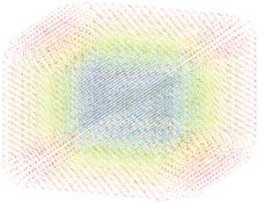
Hydro



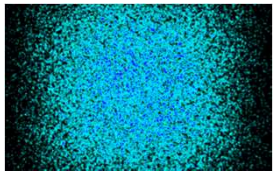
MNLDDFV



Schrödinger



CoMD



SPH

SYNTAX

Options and global variables

```
options{
 ℝ option_δt_fixed   =-1e-7;
 ℝ option_δt_initial = 1e-7;
 ℝ option_δt_courant = 1e+20;
 ℝ option_δt_hydro   = 1e+20;
};

nodes{
  ℝ³ ∂x,∂∂x;  // Velocity, acceleration
  ℝ³ nForce; // Force
  ℝ nMass;   // Mass
};

cells{
  ℝ p,e,q;     // pressure, energy, viscosity
  ℝ v,calc_volume,vdov; // volumes
  ℝ delv,volo; // rel. & ref. volumes
  ℝ arealg;    // characteristic length
  ℝ³ ε;        // terms of deviatoric strain
  ℝ ql,qq;     // artificial viscosity terms
  ℝ³ cForce[nodes];
};

global{
  ℝ δt_courant; // Courant time constraint
  ℝ δt_hydro;   // Hydro time constraint
};
```

Jobs

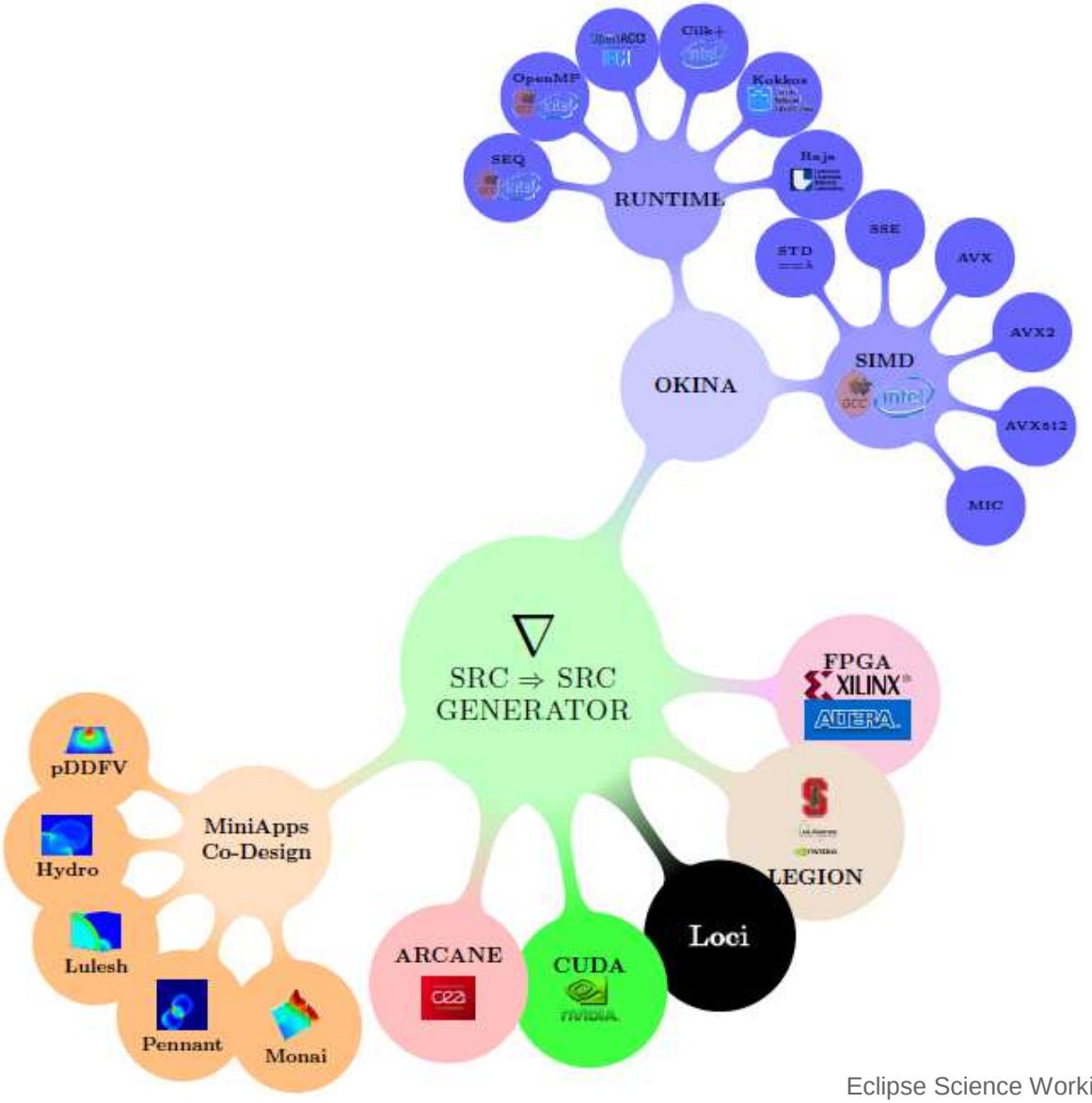
Data-parallelism is implicitly expressed via jobs items

```
∀ cells hydroConstraintForElems @ 12.2{
  ℝ arg_max_hydro=δt_cell_hydro = +∞;
  ℝ δdv = fabs(vdov[m]);
  ℝ δdvov = option_dvovmax/δdve;
  ℝ δhdr = min(arg_max_hydro,δdvov);
  δt_cell_hydro=(vdov!=0.0)?δhdr;
}

∀ cells δt_courant <?= δt_cell_courant @ 12.11;
∀ cells δt_hydro   <?= δt_cell_hydro   @ 12.22;
```

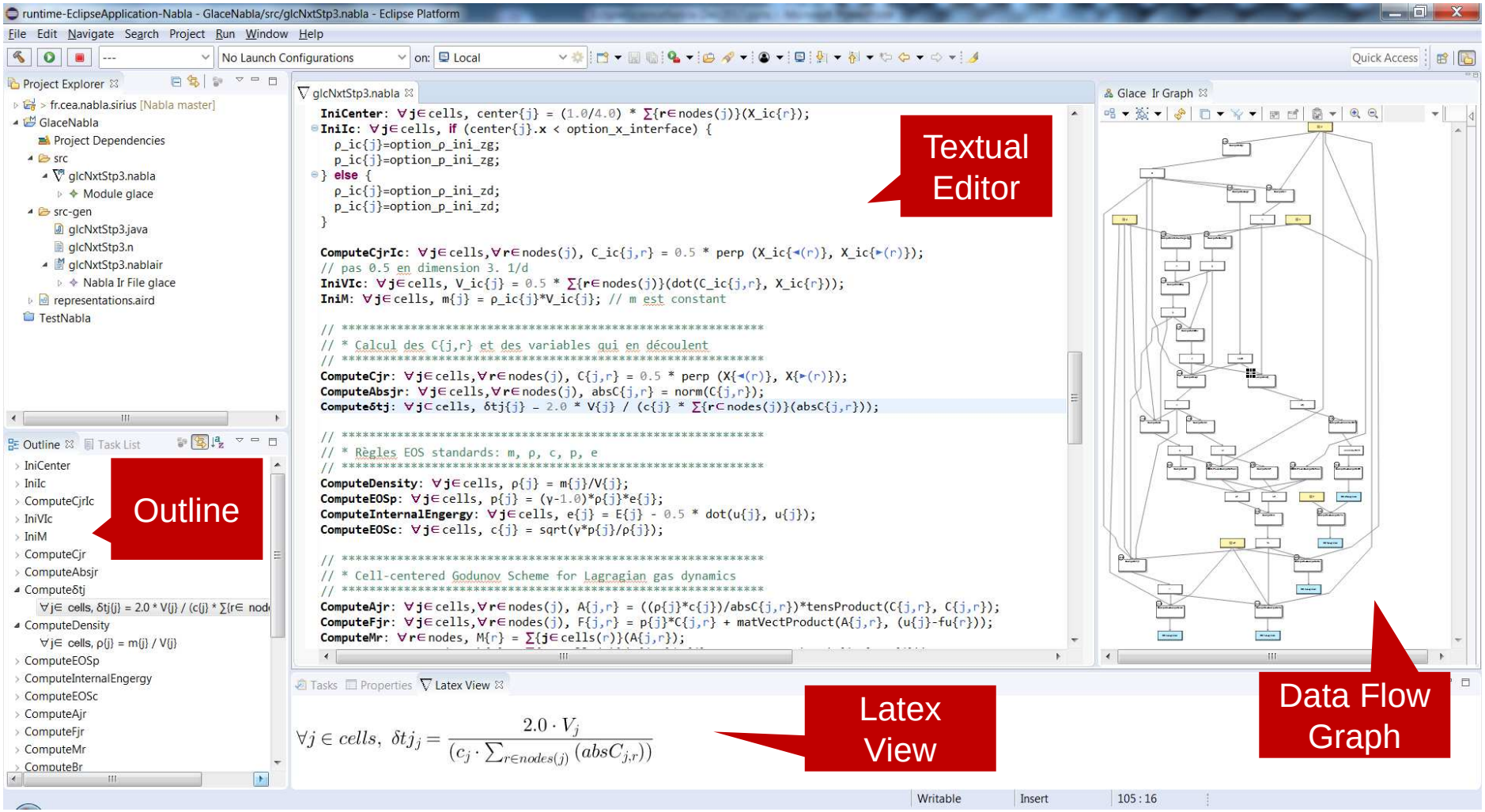
Jobs parallelism is explicitly declared via Hierarchical Logical Time (HLT)

MULTIPLE BACKENDS



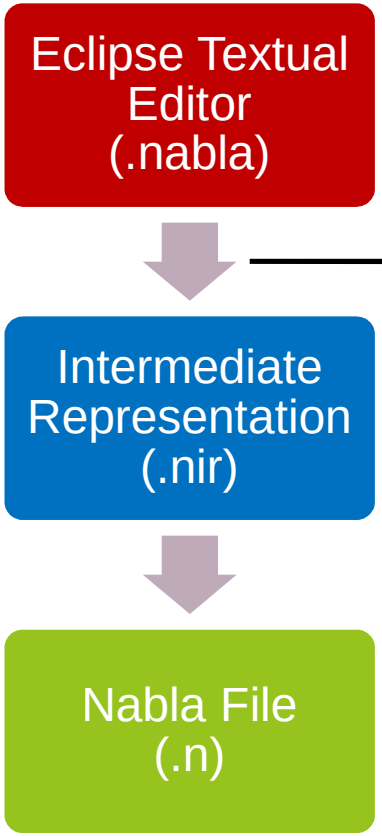
THE NABLAB ENVIRONMENT

NABLAB ECLIPSE ENVIRONMENT



NABLAB COMPILATION CHAIN

EMF TRANSFORMATION AND GENERATION




```
ComputeDt: ∀n∈ℕ,
δt^{n=0}=option_δt_ini; ,
δt^{n+1}=option_δt_cfl*min{j∈cells}(δtj{j});
```

Construction of a Data Flow Graph
to compute '@' statements

Modular compilation chain
Reference model to verify, validate, integrate tools…

```
ComputeDtInit @ -34.0  {
    δt = option_δt_ini;
}

∀ cells min3db5d2 <?= δtj @ 5.1;

ComputeDt @ 5.2  {
    δt_n_plus_1 = option_δt_cfl * min3db5d2;
}
```

QUESTIONS

- Needs: integrate tools to give support to SW engineers from development to execution:
  - Debugging facilities (variables inspection, step by step execution)
    ⇨ GEMOC Studio ?
  - Visualization (plot display, 3D visualization)
    ⇨ ICE ?

- Could people be interested in contributing in Nablab development around the IR ?
  - Implementing their own DSL above the IR ?
  - Providing their own backend for Nabla Compiler ?
  - Integrating new tools in Nablab ?

- Could people be interested in following the Nablab development in order to use it later ?
  - To take advantage of Nabla performance ?
  - To raise abstraction level of algorithms ?

Commissariat à l'énergie atomique et aux énergies alternatives
Centre DAM-Île de France – Bruyères Le Châtel
91297 Arpajon Cedex

Etablissement public à caractère industriel et commercial | RCS Paris B 775 685 019