Usage of MGIS in Manta: a case of study

MFront User Meeting

06/11/2023

T. Helfer O. Jamond

CEA, DES, IRESNE, DEC, SESC, LMCP, CADARACHE, FRANCE

Outline

Introduction

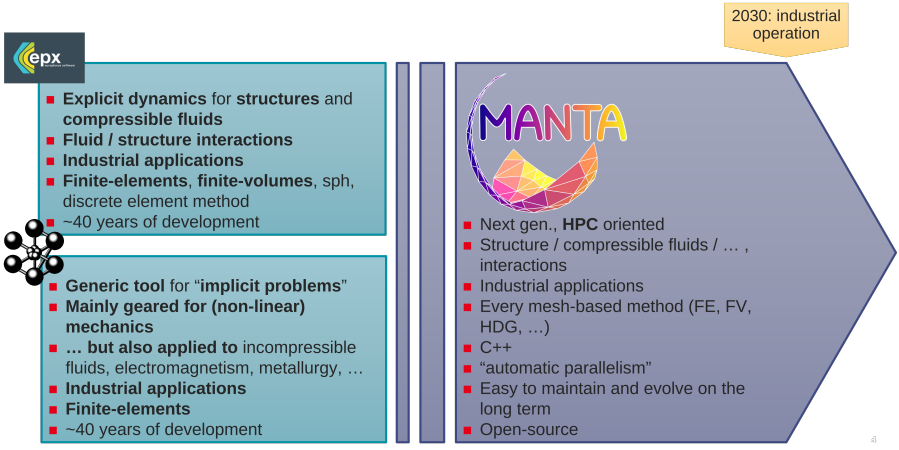
The need for code generation

Conclusions and perspectives

Addendum

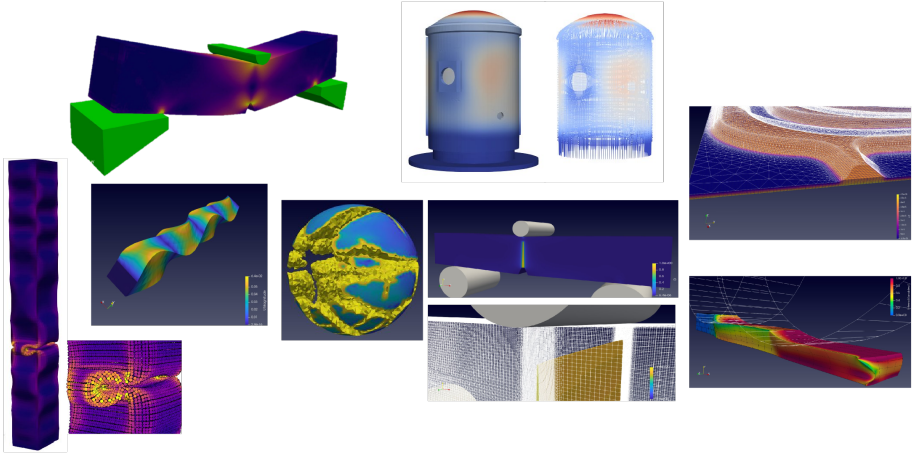
Introduction

About Manta

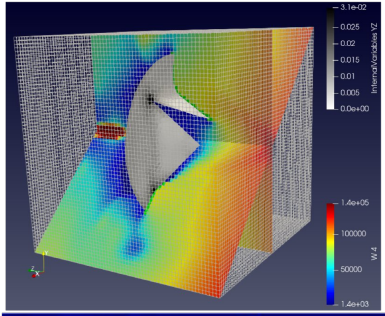


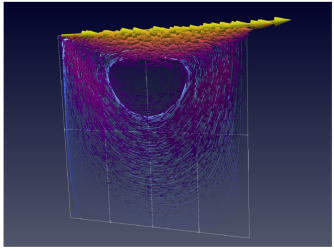
- `Manta` is a new solver developed at CEA.

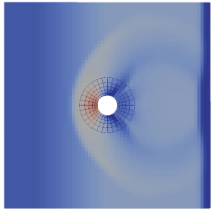
An overview of available functionalities

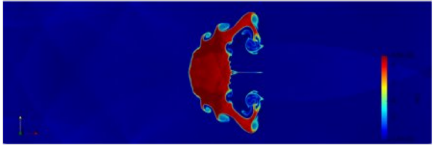


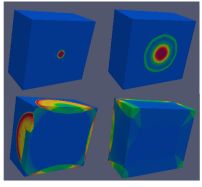
An overview of available functionalities - II

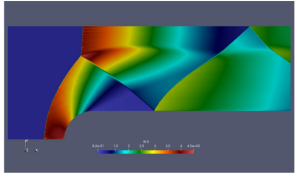












A first example in `python`

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ps.setModel(mechanics_model);
 ...
ps.addLoadingEvolution("ImposedDisplacementLoading", {0 : 0, 1 : 1e-2})
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s = Simulation(ps, [0, 0.2, 0.4, 0.6, 0.8, 1]))
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  - This abstract feature has a small impact on the performances on CPUs. On GPUs, this may be a completely different story.

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  - targets code coupling, thanks to the `ICoCo` standard.
  - aims at being simple to use, focused on the physics, documented, verified and stable in time.

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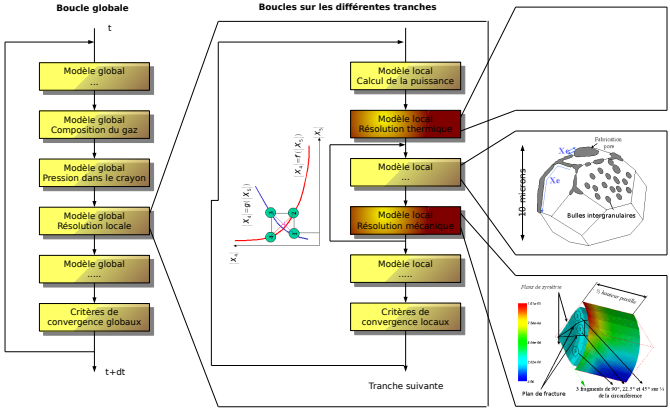
- Bricks may rely on external properties or behaviours to describe the structures or the materials.
  - In general, properties and behaviours are generated by `MFront`.
- Internally, bricks must participate to the dependency management algorithm and generate appropriate *formulations*.

Focus on a coupling scheme



- in `Manta`, the user will be able to build arbitrary complex coupling schemes, with accelerators, convergence criteria, etc..

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- Objects generated by plugins are totally equivalent to native objects.
- The `core` layer is used to create the plugins.
- Plugins are not covered by the stability guarantee of the end-user API.

The first example revisited

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- Explicit declaration of the coupling scheme.

Other commented examples

- Nonlinear heat transfer.
- Notched bar (ssna303).

The need for code generation

Toward code generation

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  - The plugins is 443 lines long (with comments), mostly for the brick which handles the dependency management algorithms and lot of internal details.
  - The physically relevant part is only 6% of the total number of lines.
  - The rest is only boilerplate.

A (imaginative)-example of an MFront-like input file

```
@DSL ModelBrick{
  location : "boundaries",
  method: "fem",
  jacobian: true
  configuration : current
};

@Unknown temperature T;
T.setGlossaryName("Temperature");

@MaterialProperty real h;
@ExternalStateVariable temperature T_inf;

@ShapeFunctions N;

@Integrator{
 // the integration point weight is automatically defined
 R = h * (T - T_inf) * N * w;
 dR_dT = h * N * N.transpose() * w;
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- This is the minimal information required to build the plugin in a MFront-like input file.

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  - That would be limited to FEM, what about HHO, FVM, VEM ?
  - Moreover, dR_dT could be computed by automatic differentiation.
  - This plugin shall be compiled Just-in-time to exploit the characteristics of the h and T_∞.

A (imaginative)-example of a mixed UFL/MFront-like input file

```
@DSL Formulation {configuration: current};

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- This may be the end of UFL as we know it

Conclusions and perspectives

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  - The tools developped will be designed to be usable by other solvers, just like `MFront` is.

Avalaible positions

- Two interships:
  - Implementation and verification of damage gradient models in Manta using the finite element method (FEM) and the Hybrid High Order method: application to PWR nuclear fuel element.
  - Development of new boundary conditions and verification of Manta for the simulation of nuclear fuel elements.
- Two PHD positions (october 2024):
  - Damage gradients models discretized by the Hybrid High Order method: adaptative mesh refinement and transition between damage and cracks.
    - with O. Fandeur, O. Jamond, S. Feld-Payet and J. Besson as supervisors.
  - JIT Automated generation of complex kernels for nonlinear multiphysics simulations.
    - with O. Jamond, B. Marchand and P. Kerfriden as supervisors.

Thanks for you attention ! Any questions?

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