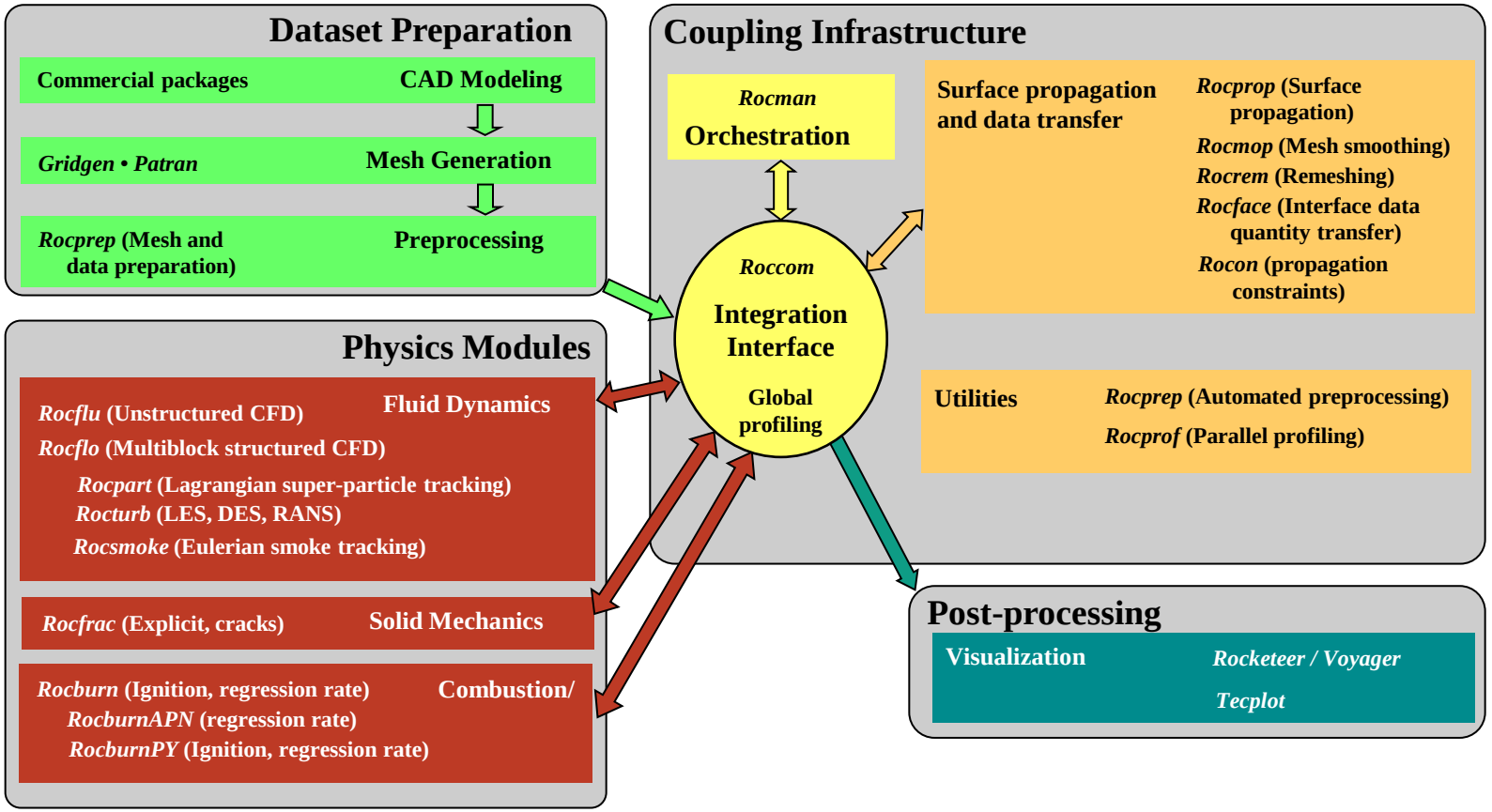
Section 3
Rocstar Multiphysics

Rocstar Simulation Suite Architecture



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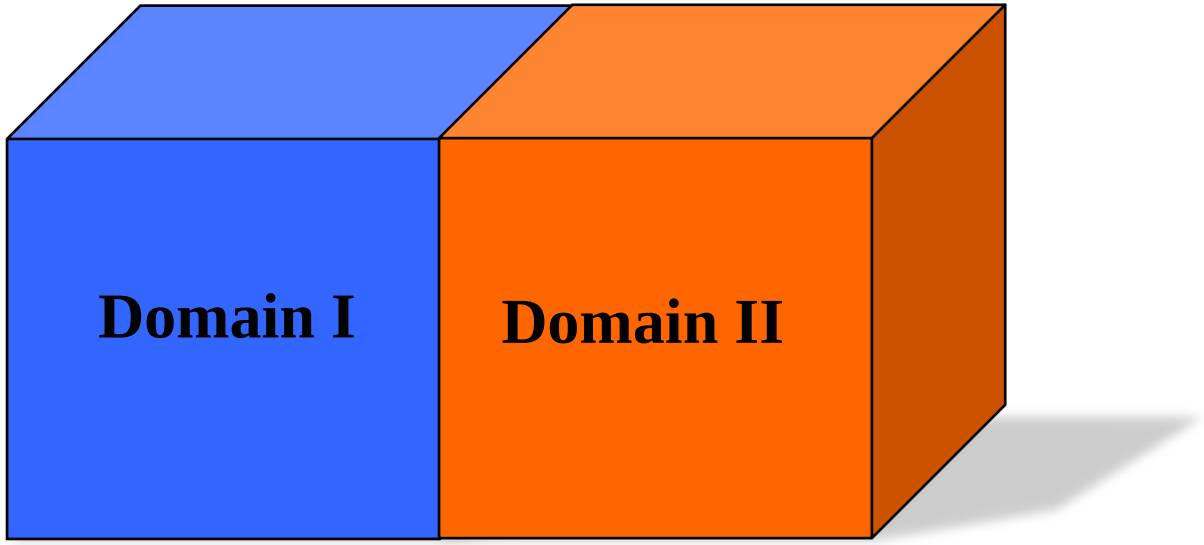

Two or more 3D physical domains abut at a common interface.

- The domains do not overlap
- The geometry of the interface is a 2D surface in space
- The domains may move/deform but they do not come apart

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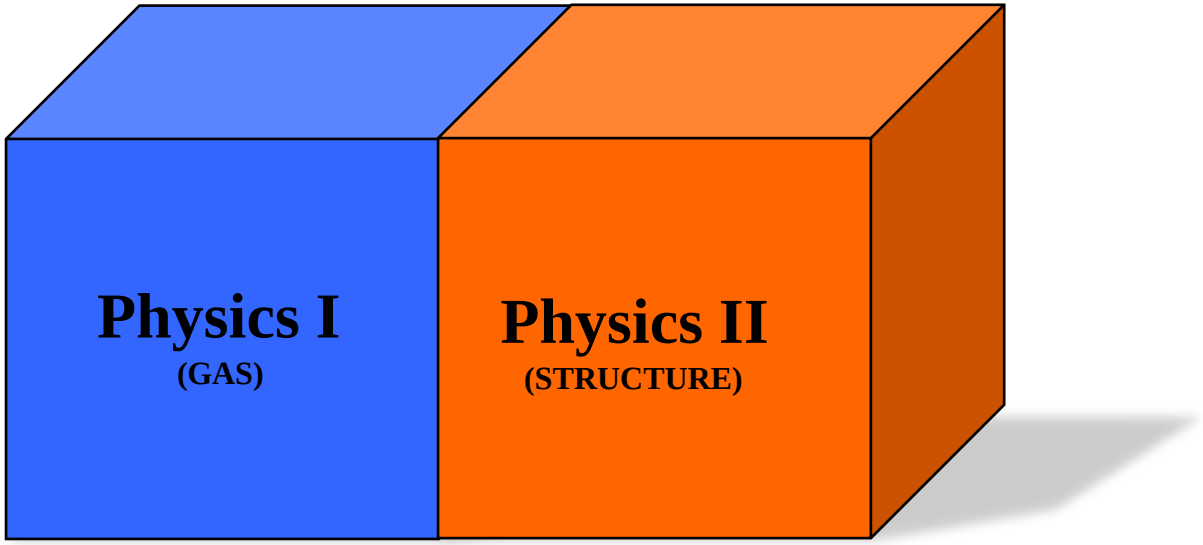

The two domains have differing physical character and interact at the interface.

- Mass, momentum, energy and charge are conserved in the interactions across the interface
- Some physical quantities of interest "jump" at the interface (e.g. density).

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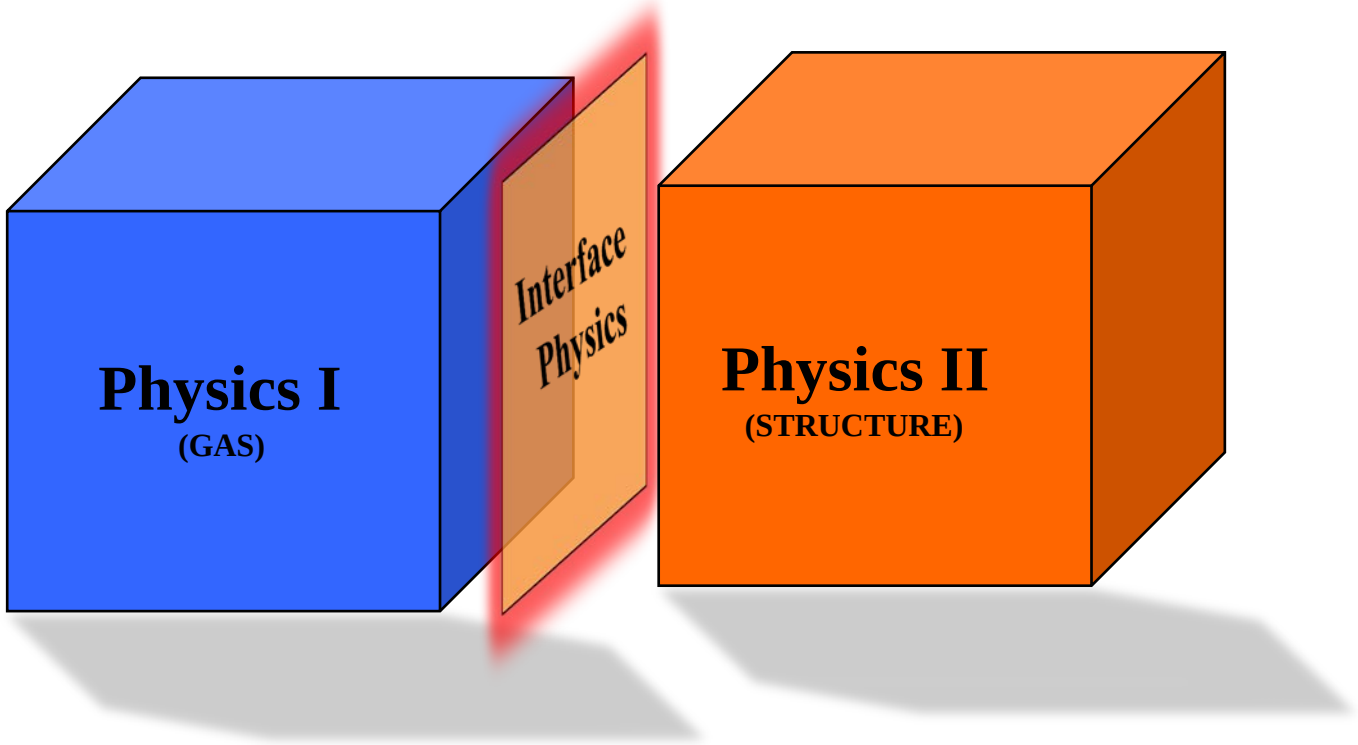

The interface may have physics of its own.

- The interface could be reactive with a combustion or other chemical process
- The interface could propagate or move due to some process
- Goal: Simulate two or more physical domains which interact across a moving, reacting interface

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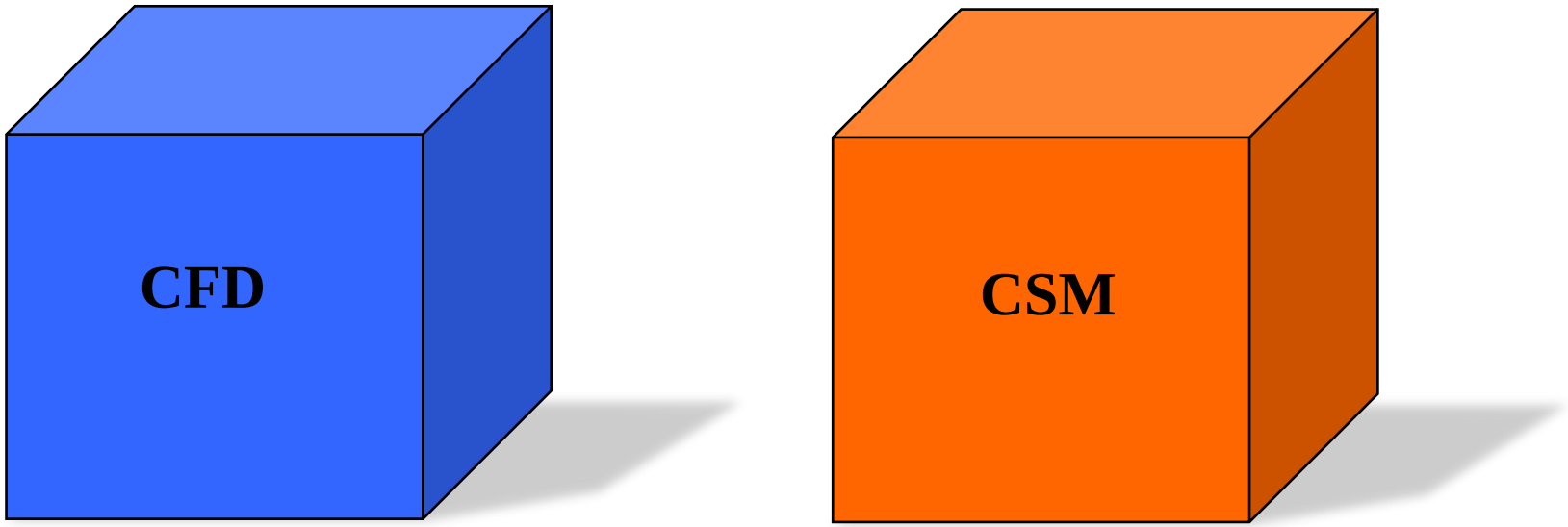

Each domain is simulated numerically by methods observing the respective physics.

- *Rocstar* implements a partitioned approach wherein each domain is simulated by a dedicated solver
- *Rocstar* solvers are independently developed and can stand alone as simulation applications in their own regard
- Rocstar uses staggered stepping (i.e. stepping is centrally synchronized)

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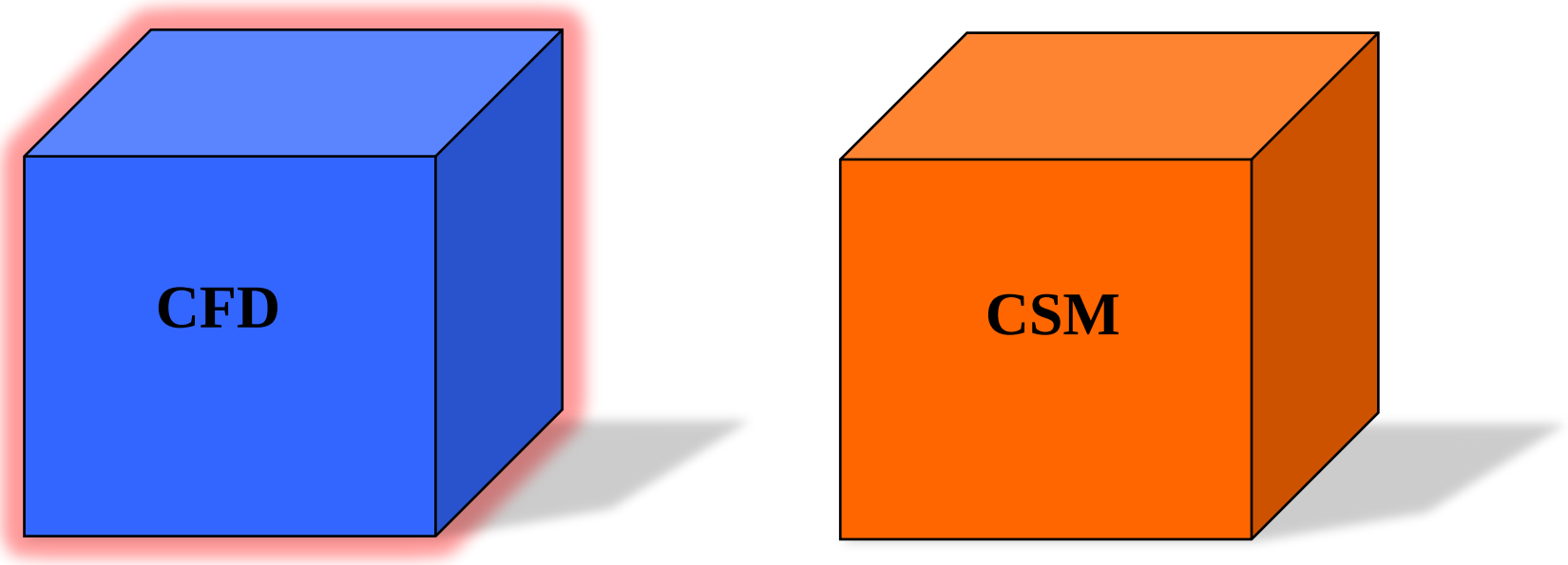
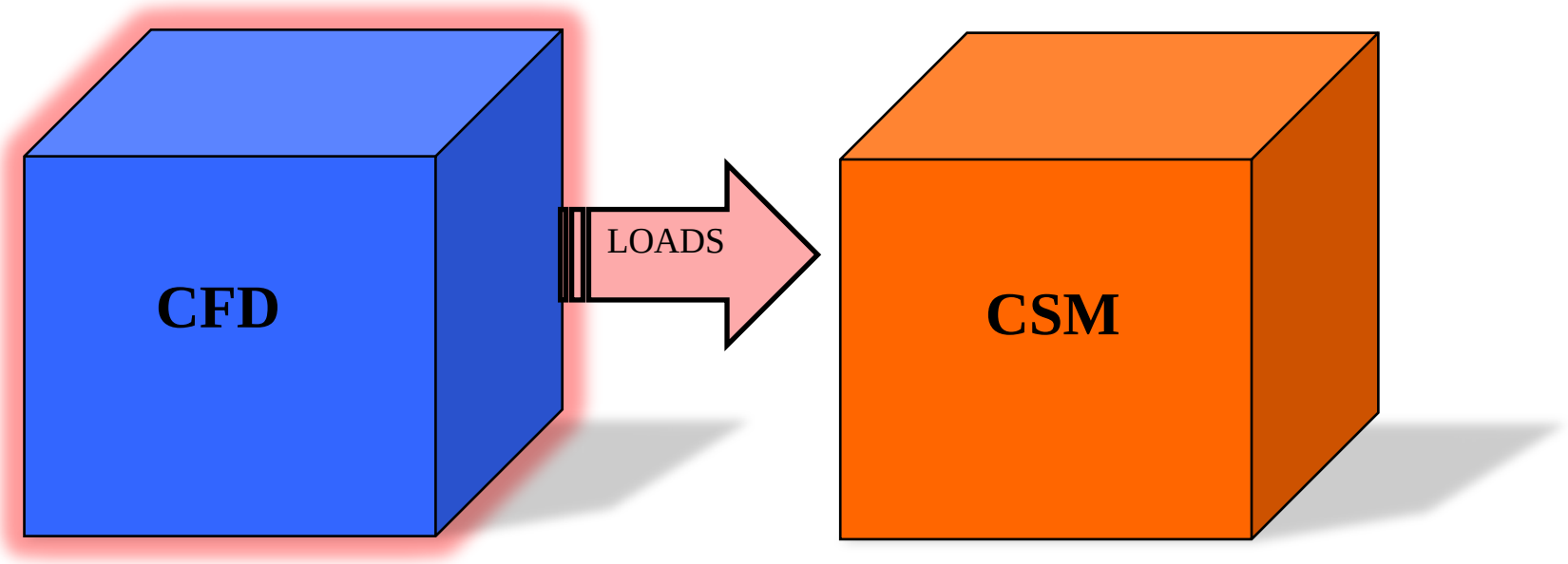


Partitioned and staggered: stepping and interactions are centrally synchronized

- Fluids domain steps and calculates pressure loads the interface

Rocstar Multiphysics



Partitioned and staggered: stepping and interactions are centrally synchronized

- Fluids domain steps and calculates pressure loads on the interface
- The loads are then passed to the structures domain

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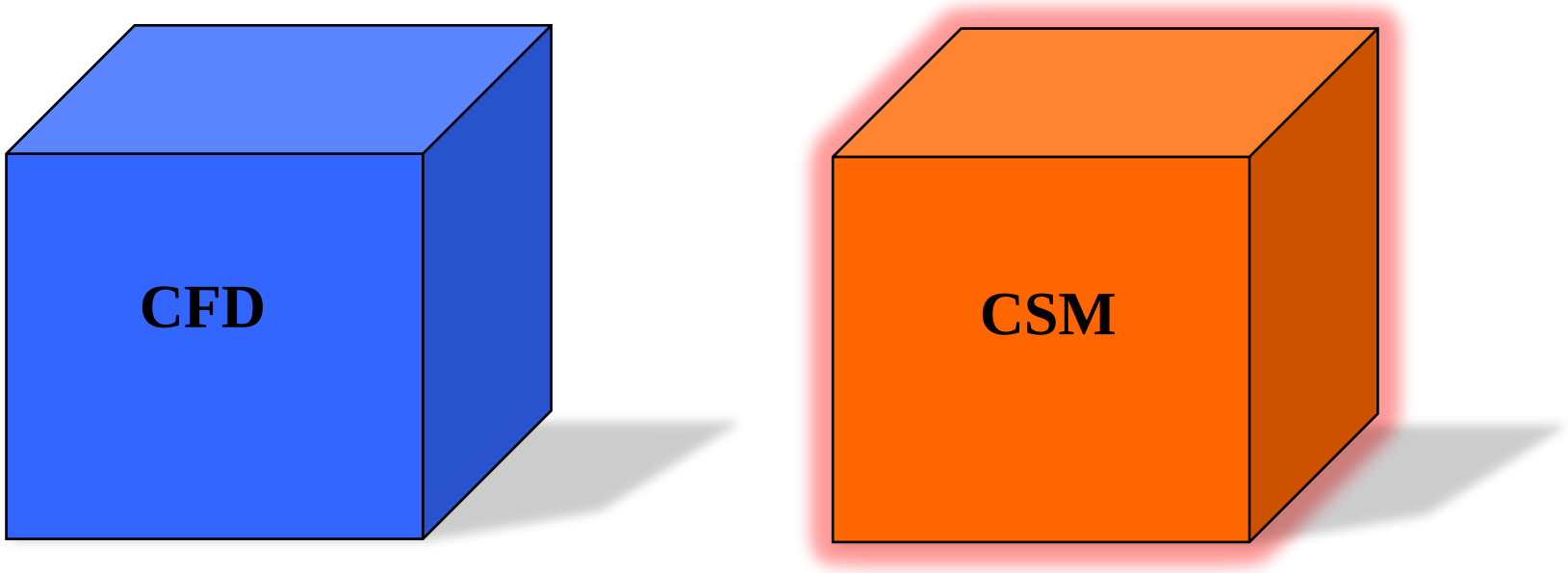

Partitioned and staggered: stepping and interactions are centrally synchronized

- The structures domain steps and calculates the deformation and interface velocities

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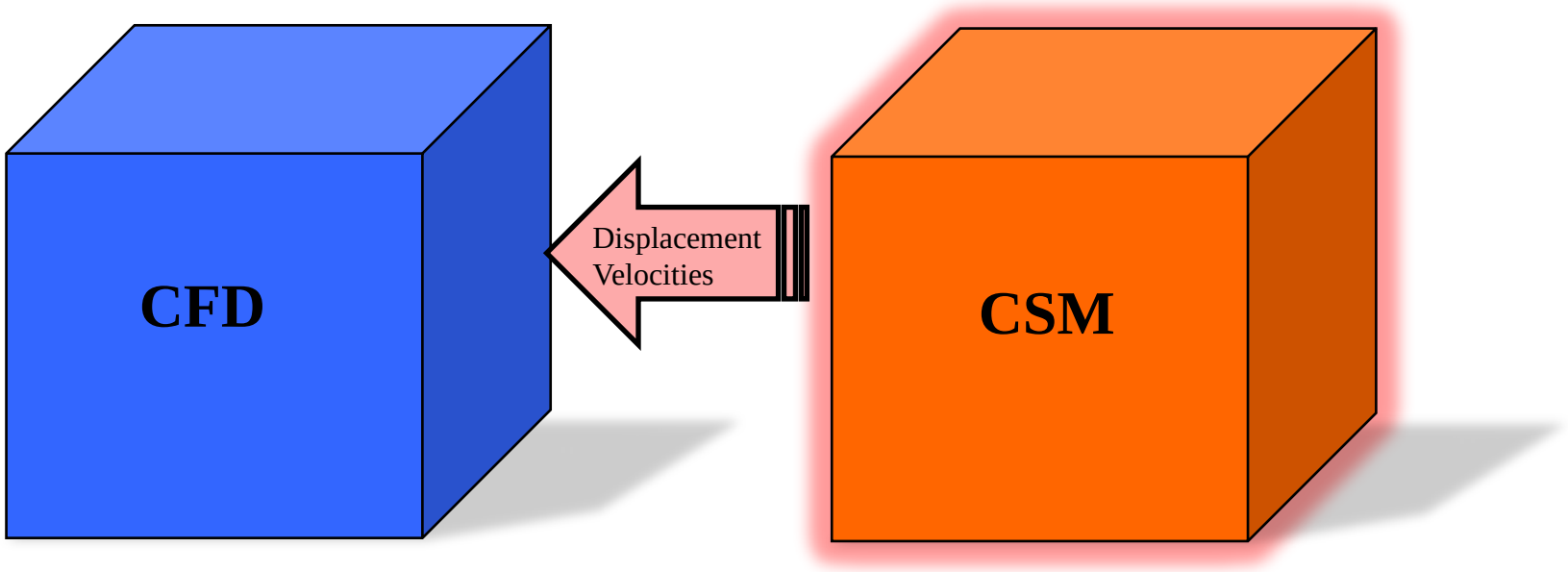

Partitioned and staggered: stepping and interactions are centrally synchronized

- The structures domain steps and calculates the deformation and interface velocities
- Interface motion sent to fluids domain

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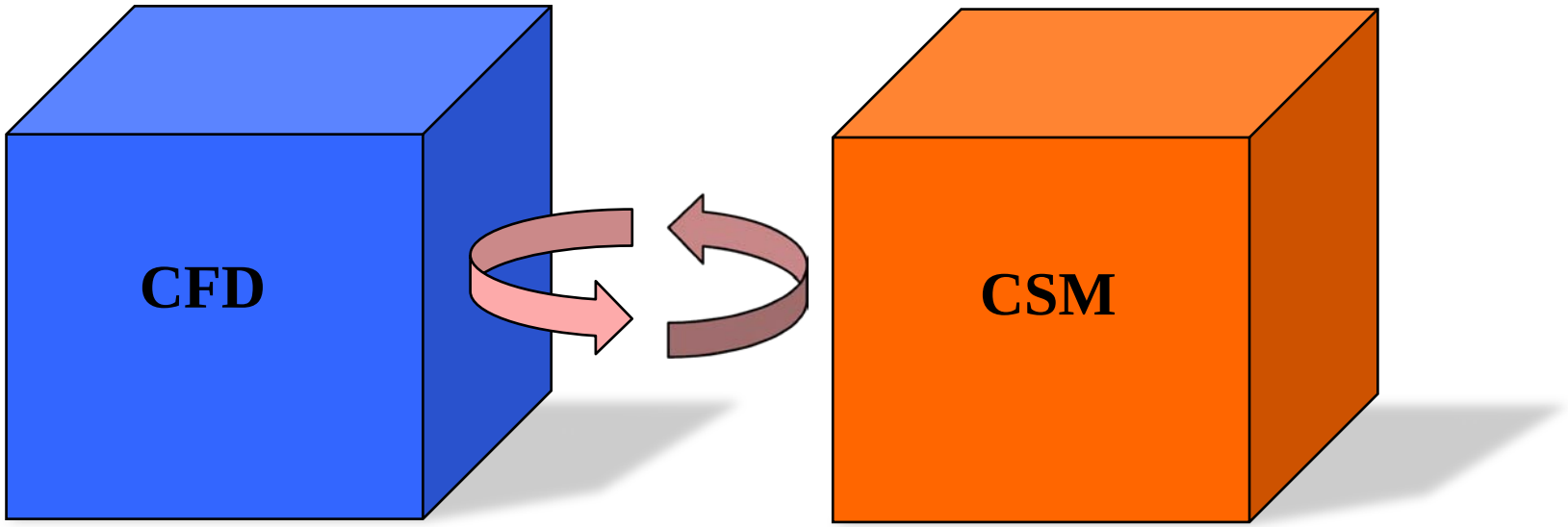

Partitioned and staggered: stepping and interactions are centrally synchronized

- The process is repeated to step the simulation through time

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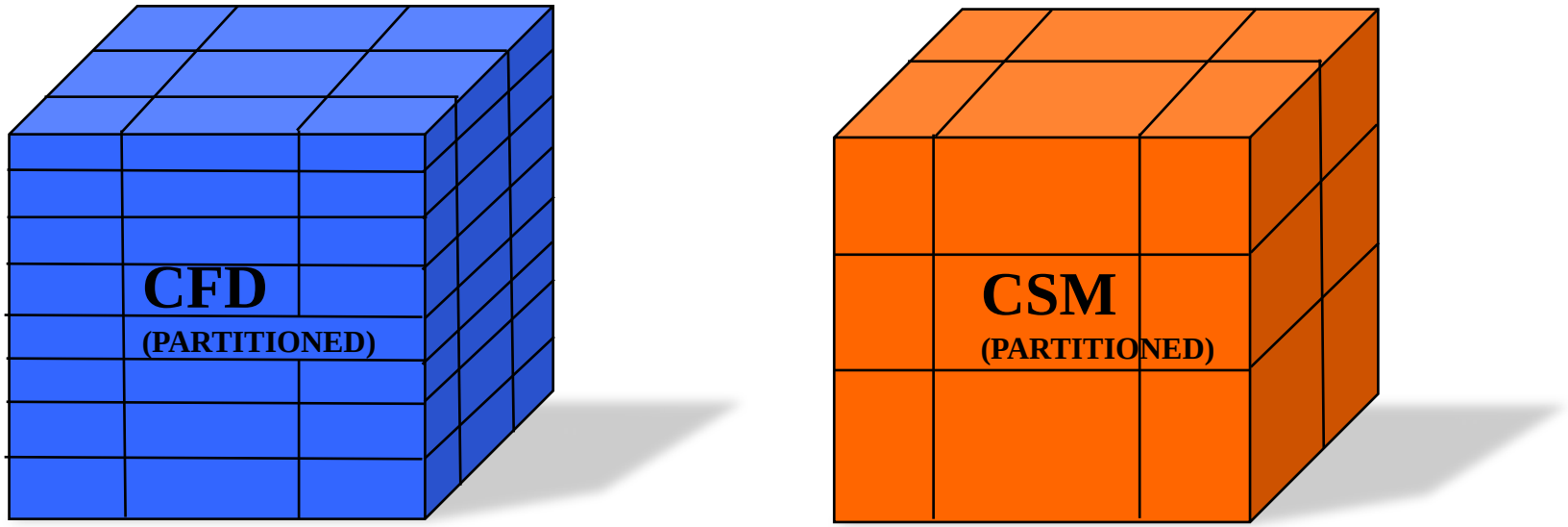

Each domain is decomposed into partitions to be distributed among processors.

- *Rocstar's* solvers implement their own parallelism and partitioning
- In general, the partitioning is disparate across the domains
- In this example, 72 fluid partitions + 18 structures partitions implies 72 physical processors

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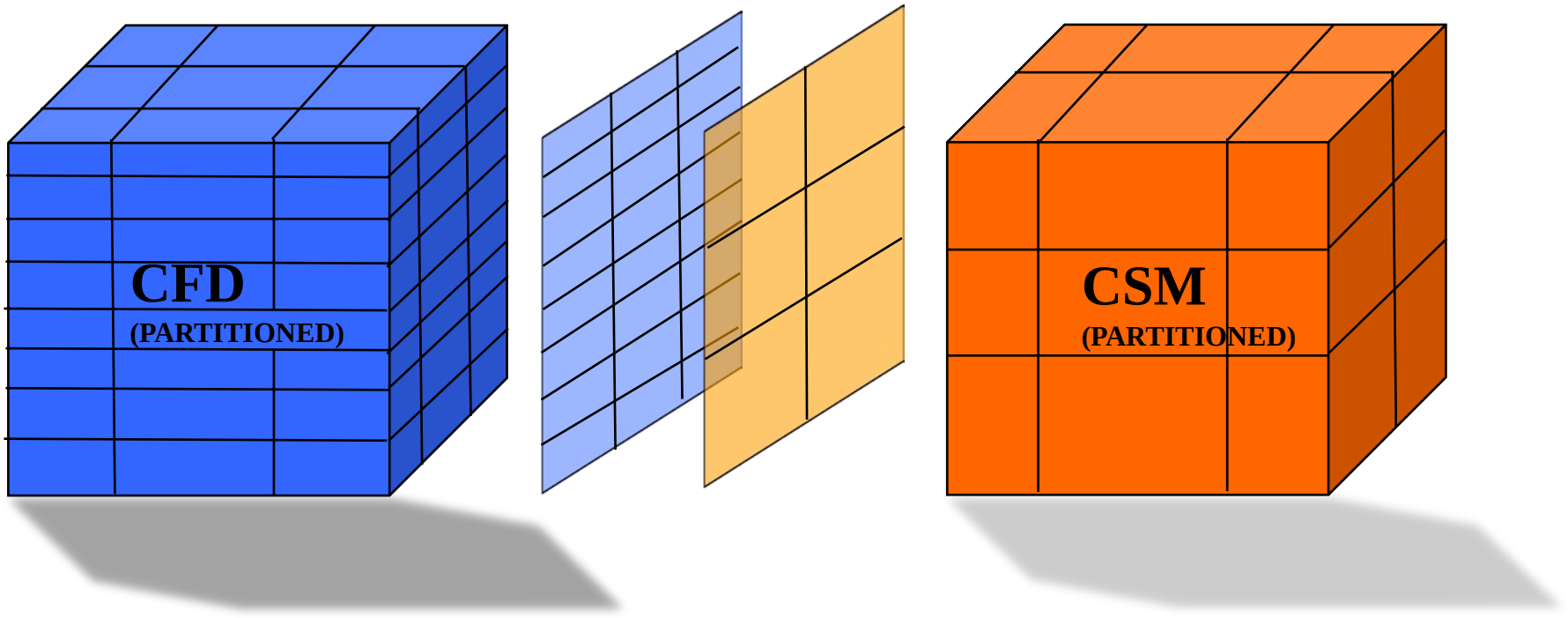

The domains and shared interface are discretized by each solver application.

- *Rocstar's* solvers each have their own mesh (i.e. non-conformal between interface discretizations).
- Each solver marches through time according to the domain-specific physics (i.e. time steps are disparate).
- Getting the interface data transfer right is essential for accuracy and stability of the simulation.

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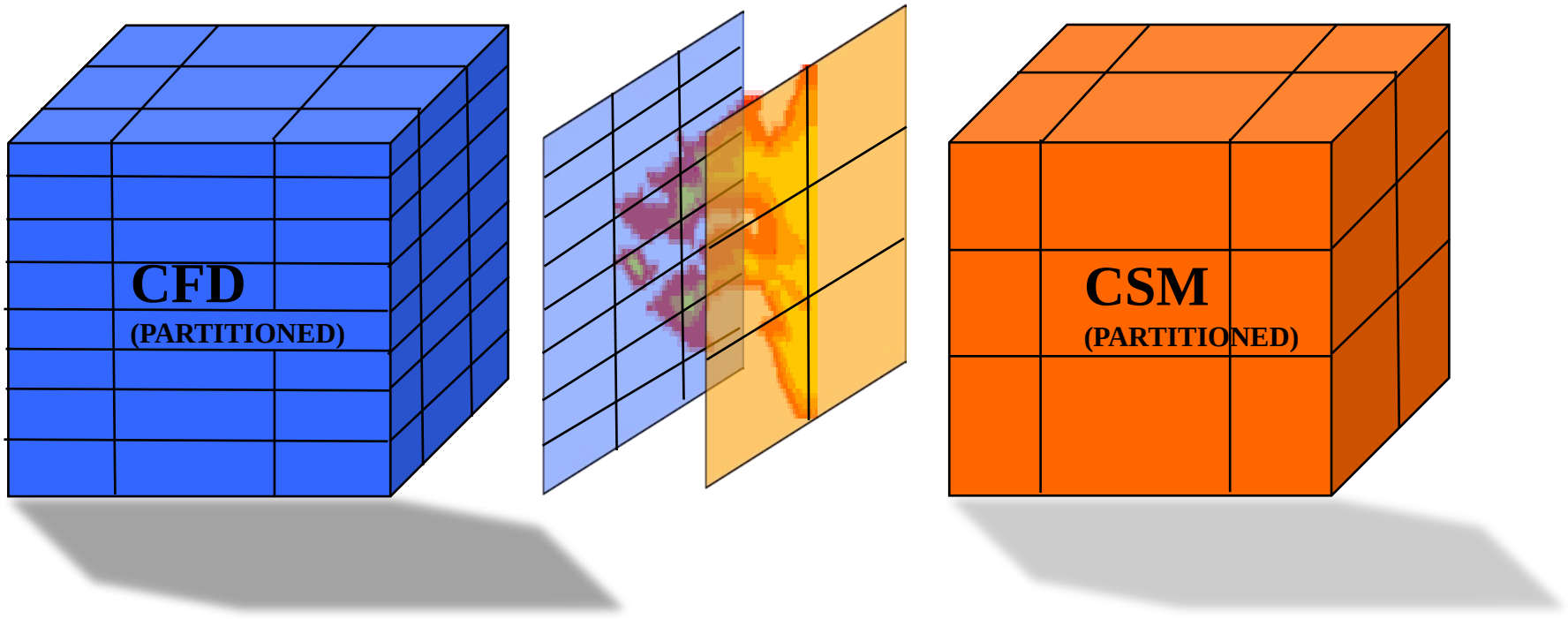
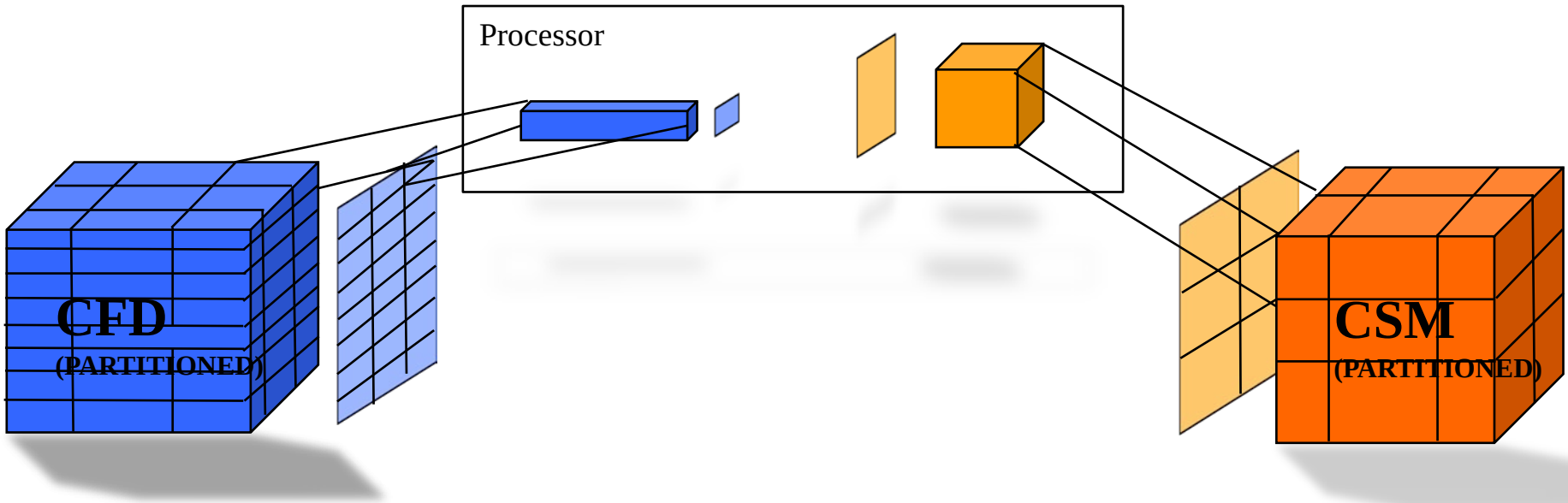


The interface is reactive. It catches on fire, injects materials, and propagates (burns).

- Combustion depends on solutions and geometry of other domains
- Both geometries change drastically (propellant burns away completely!)

Rocstar Multiphysics



Each computer processor has one or more partitions of one or more solver's domain.

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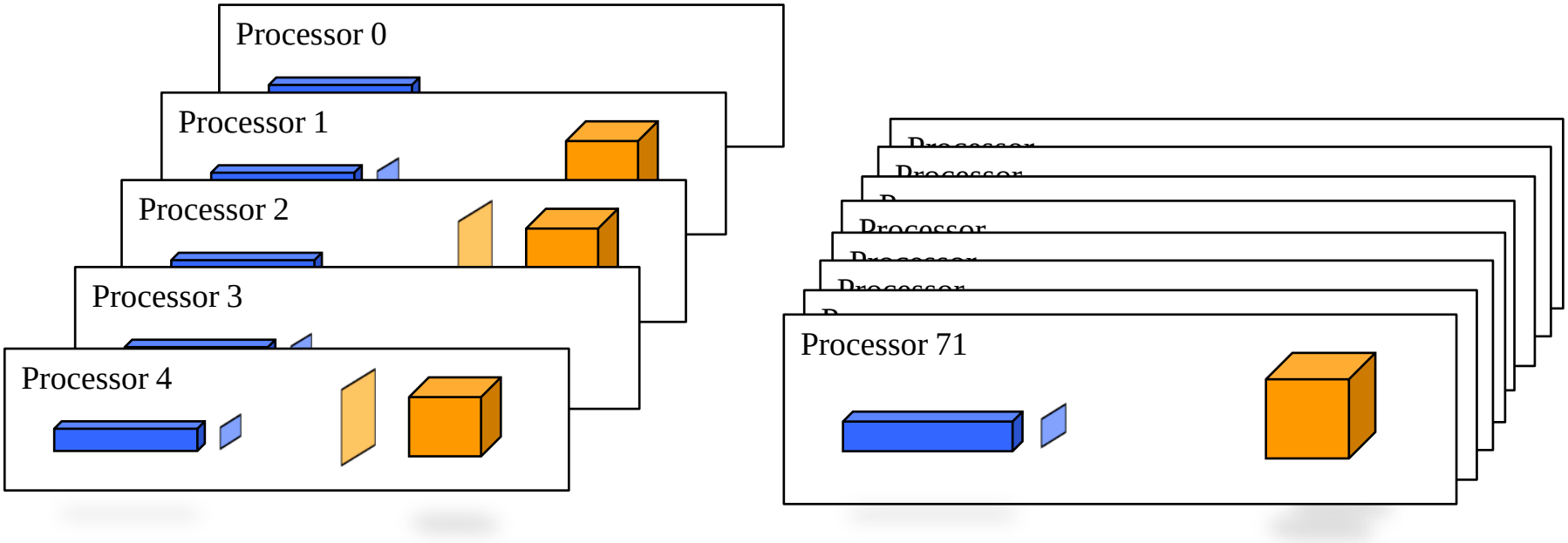

Each computer processor has one or more partitions of one or more solver's domain.

- The geometry and data of each domain is spread out among all the processors in the simulation.
- Not all processors have a piece of all domains
- Not all processors have interface data

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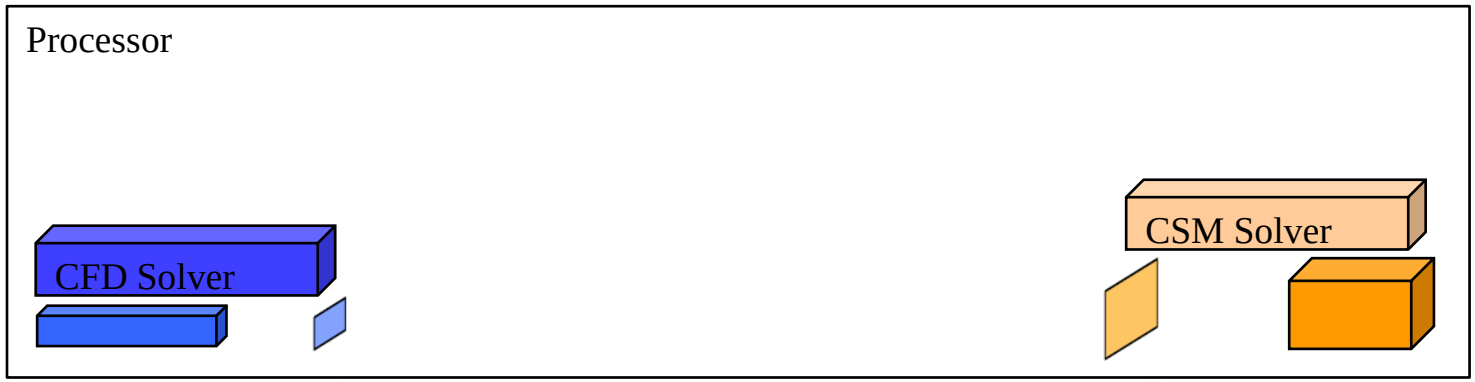

A simulation processor may have an instance of each solver, its domain, and interface.

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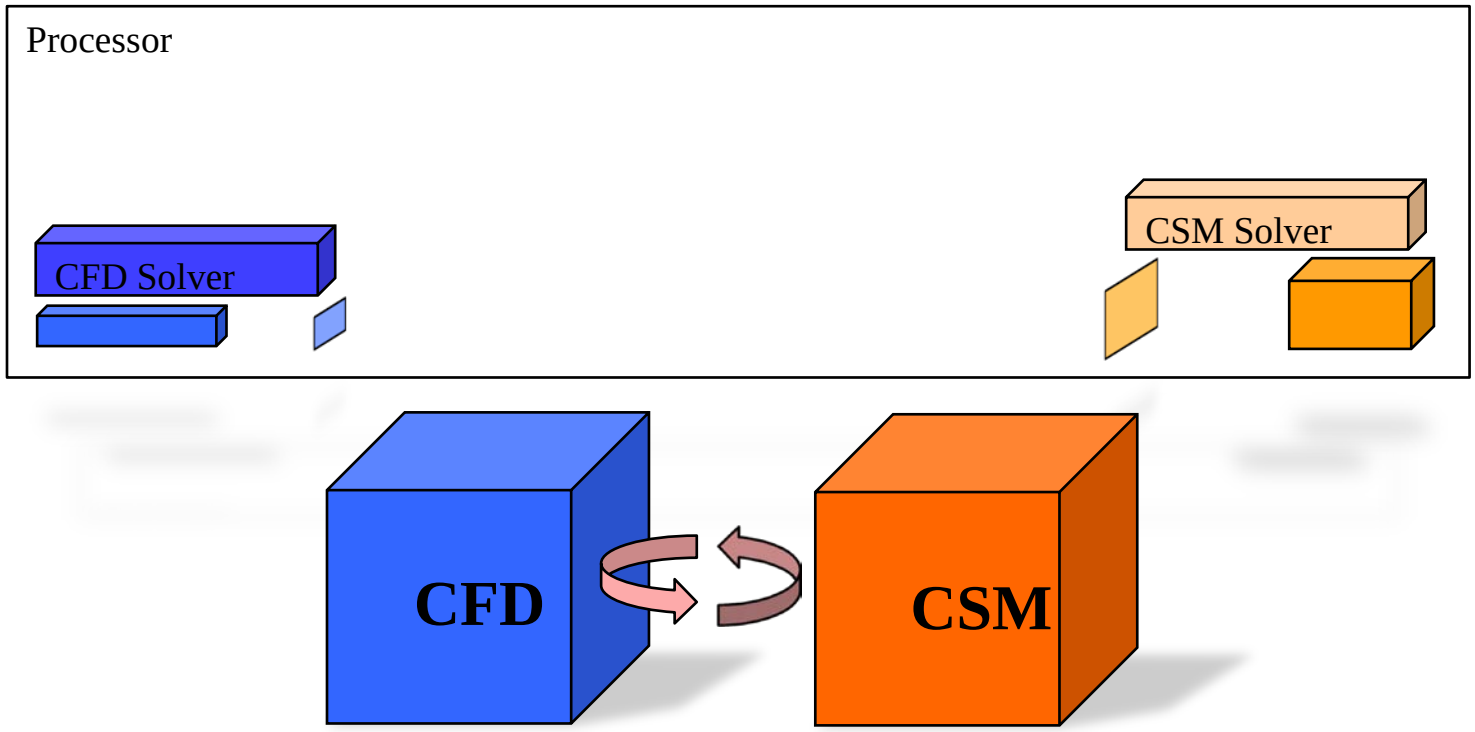

There must be a control flow manager for synchronous stepping, to handle some jump conditions, unit conversions.

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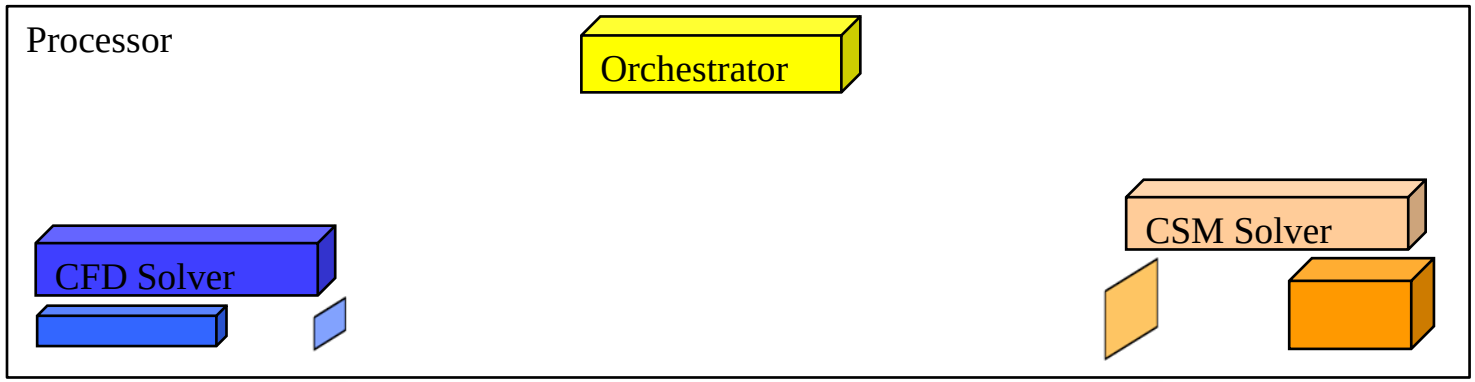

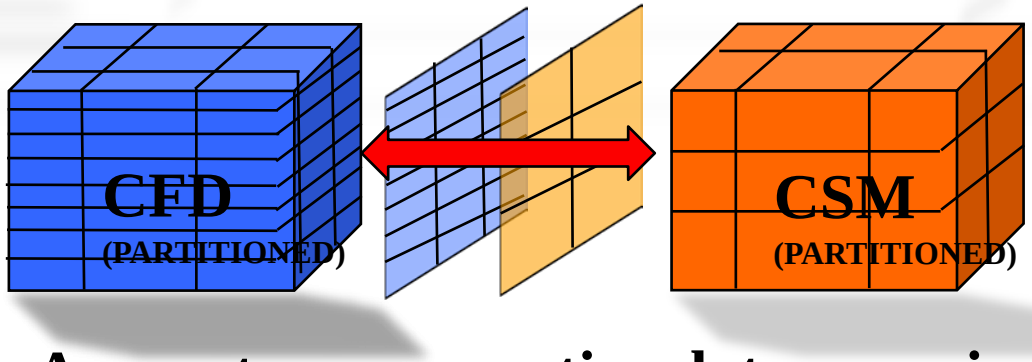

Accurate, conservative data mapping across the interface and processor-geometry mapping is required.

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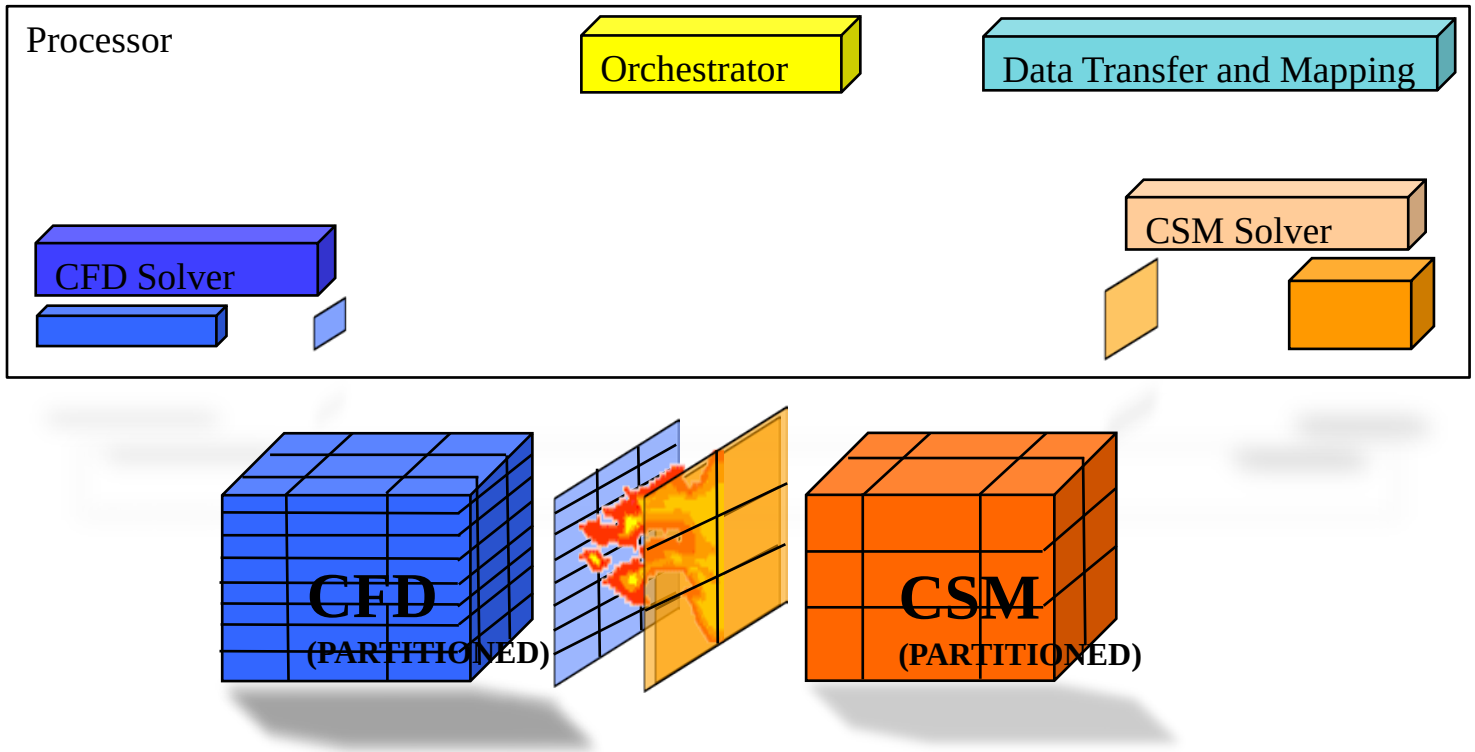

To handle the burning, we need a combustion solver capable of operating on geometry and data from other solvers and their domains.

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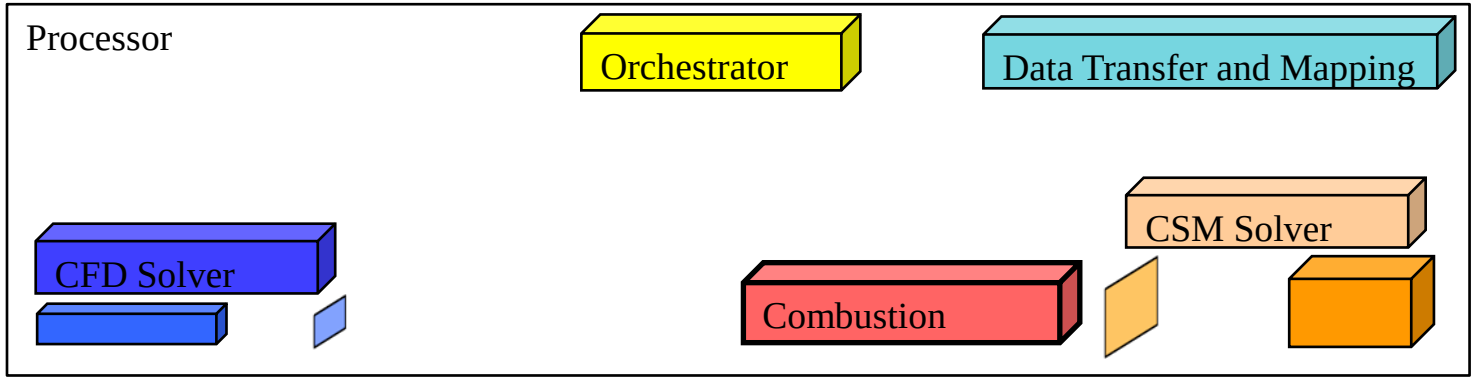

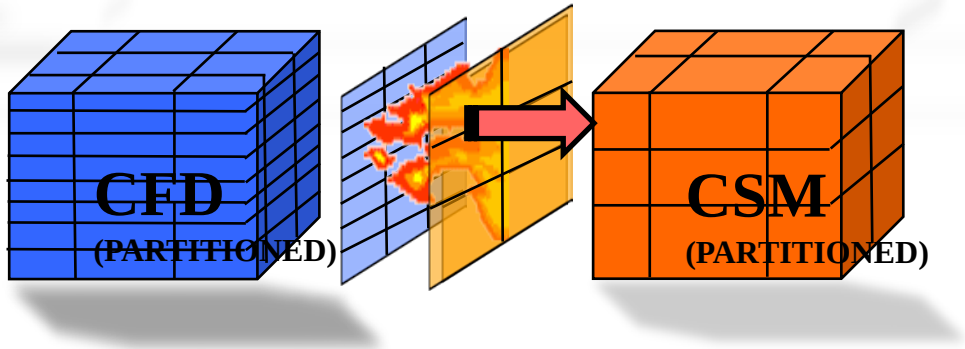

We need sophisticated surface propagation capabilities to handle the interface motion due to burning.

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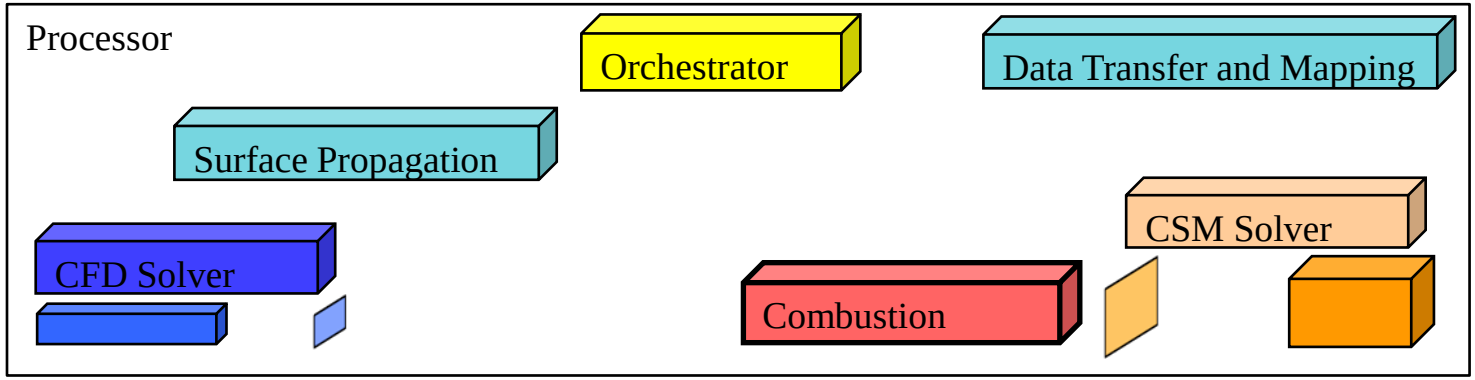

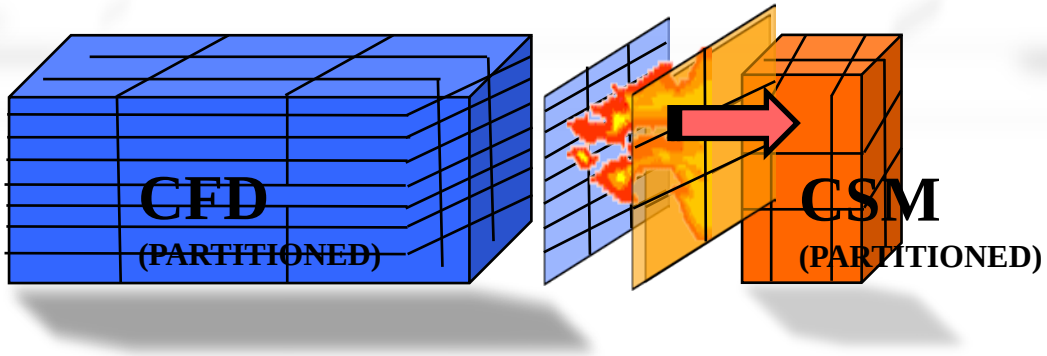

Mesh modification will be required for handling the extreme changes in geometry due to burning and deformations.

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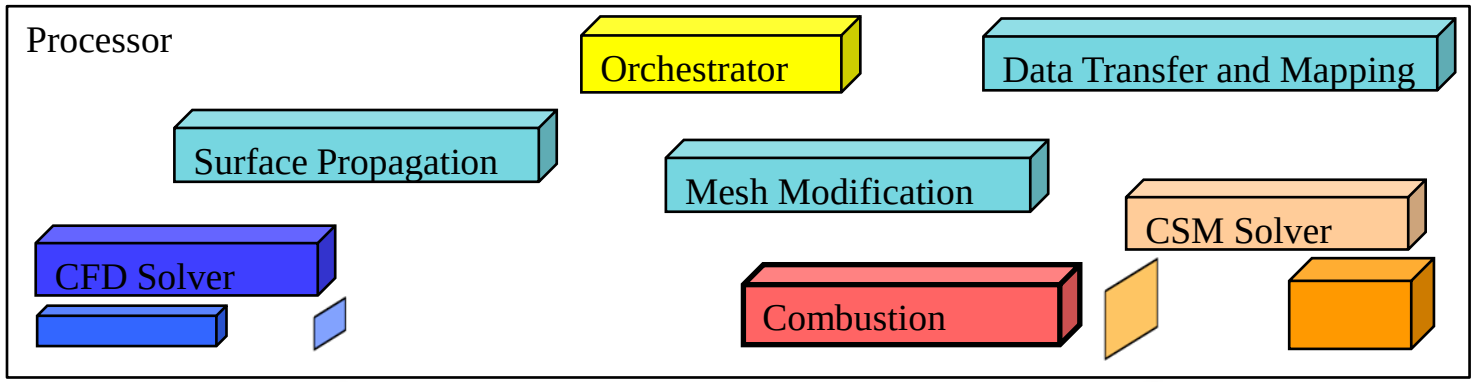
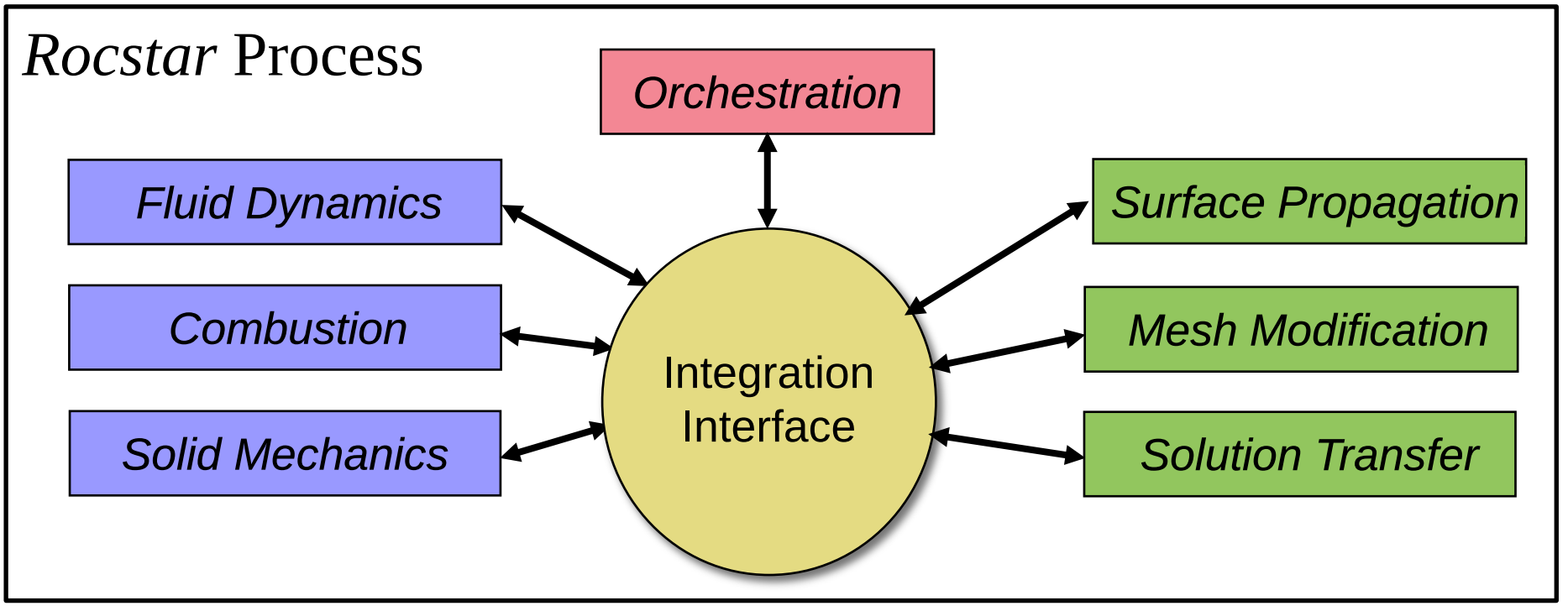


Finally, all the pieces have to interact in an efficient manner, sharing data, methods, and working together to simulate the complete system.

Rocstar Multiphysics



The integration interface provides the mechanisms by which applications can publish and access methods and data. This is the "glue" of the *Rocstar* multiphysics simulation.

Rocstar Simulation Suite Architecture