PUMIPic Parallel Unstructured Mesh Infrastructure for Particle-in-Cell

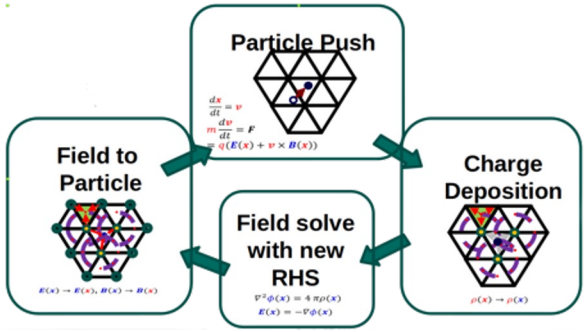
Parallel management of unstructured meshes with particles. Framework for GPU accelerated particle-in-cell applications using unstructured meshes.

Core functionality

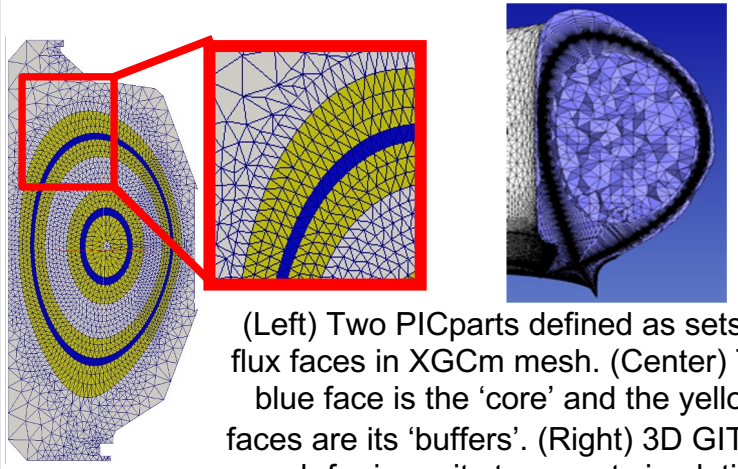
- Unstructured mesh-based approach
  - Particles accessed through mesh
  - Particle search through mesh adjacencies
  - Effective coupling to PDE solvers
  - Partitioning using bounding flux surfaces, graph, or geometric methods
  - PICpart: owned elements + copied elements from topologically or spatially neighboring processes
  - Stored on GPU using Omega_h library: *github.com/SNLComputation/omega_h*
- Particles
  - Supports multiple species
  - Particle storage choices: Sell-C-Sigma [Kreutzer 2014], COPA Cabana, and DPS.
  - DPS storage optimized for applications with tens of particles per mesh element.
- Parallel kernel launch function abstracts underlying particle and mesh storage
- Supports NVIDIA and AMD GPUs

Applications Supported

- GITRm: impurity transport
- XGCm: core+edge fusion plasma physics
- PolyMPO: GPU polygonal mesh-based material point operations
- Weak scaling on up to 24,000 GPUs of Summit with 1.15 trillion particles running push, particle-to-mesh, and mesh-to-particle operations with an XGCm tokamak mesh and domain decomposition



Stages of a PIC application supported by PUMIPic



(Left) Two PICparts defined as sets of flux faces in XGCm mesh. (Center) The blue face is the 'core' and the yellow faces are its 'buffers'. (Right) 3D GITRm mesh for impurity transport simulation.

Source Code: github.com/SCOREC/pumi-pic
Paper: scorec.rpi.edu/REPORTS/2020-2.pdf