MAX-PLANCK-INSTITUT
FÜR PLASMAPHYSIK

ETS (MUSCLE 3 implementation)

Meeting # 15 of the SC on the EUROfusion-IO development of IMAS 2024-03

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Building a new European Transport Simulator (ETS) using Persistent Actor Framework (PAF) based on MUSCLE3

- Background:
  - **New paradigm based on independent communicating programs**
    - **Each program can be serial, multi-threaded, MPI or hybrid**
  - **Fortran, C++ codes can be prepared as a subroutine receiving IDS inputs and returning IDS outputs that is “iWrap”ped**
    - **Each code (or actor) is linked to the muscle3 library**
  - **A YAML file then describes the data flow between the actors**
    - **Logic of the workflow resides in the YAML file supported by specialised actors**

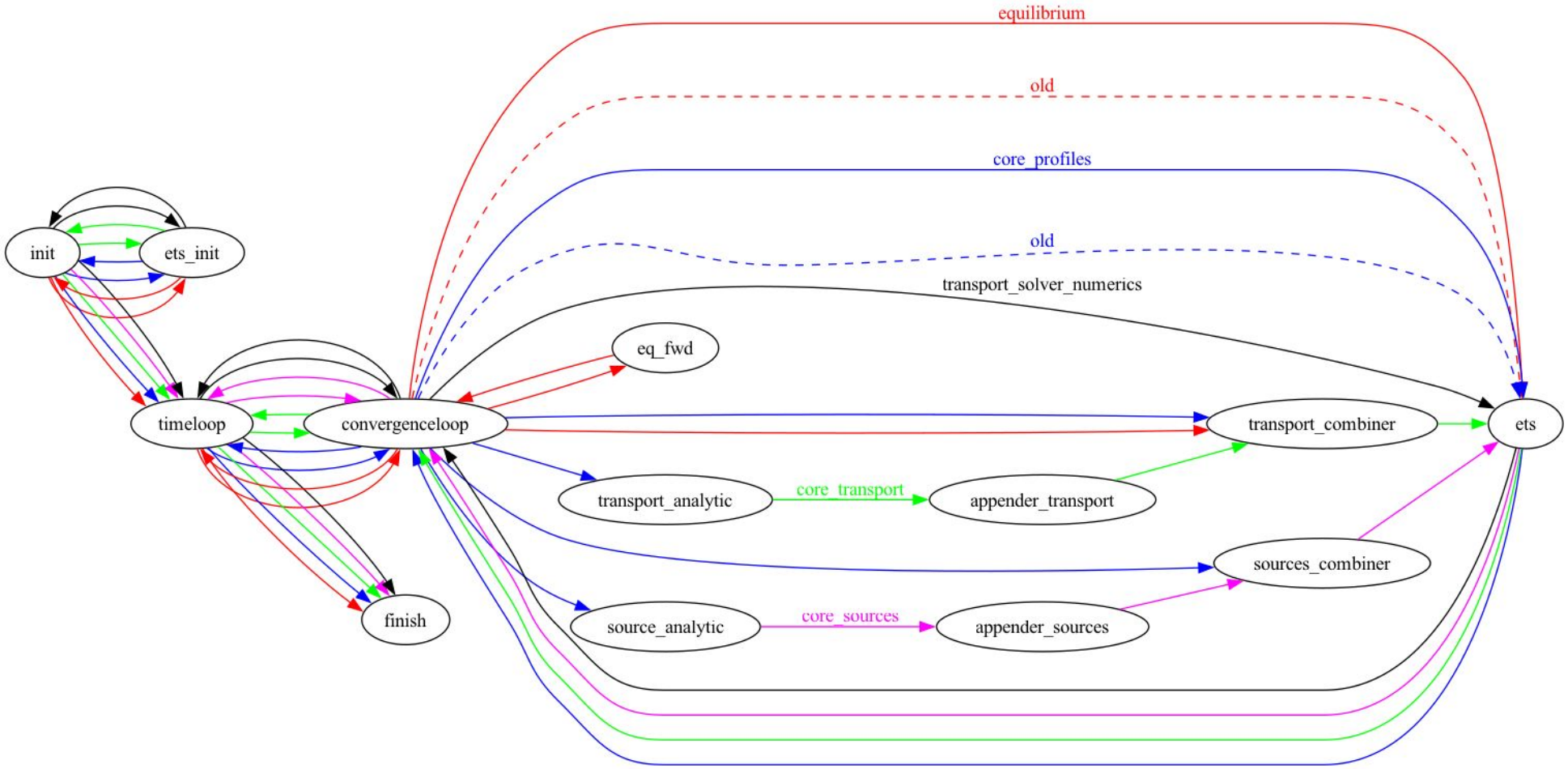
Simple version of the workflow

Simple version of the workflow that shows the key components

Uses

- Analytical sources
- Analytical transport
- Unchanging equilibrium

More complete version has the same basic logic, but a lot more actors



Most recent work

- UQ applied to ETS-PAF workflows

- Inclusion of the HCD workflow in an ETS-PAF workflow
  - Successful demonstration using ECRH
    - **Successful comparison between Gray and Torbeam**

- Inclusion of W in the simulation
  - Sources from ionization and recombination included to determine the charge state balance of each W charge state
  - Busy looking at the conservation of the summed over charge state W density

Actors in ETS6 (Kepler version, IMAS)

- **Equilibrium**: chease, helena, gkmhd, eqinput, database_equilibrium, database_plasma_boundary
- **Transport:** spitzer_resistivity, edwm, tglf, qlk, weiland, glf, bgb, mmm, nclass, neo, database_transport, analytical, neutral_transport, transport_combiner
- **Transport:** spitzer_resistivity, edwm, tglf, qlk, weiland, glf, bgb, mmm, nclass, neo, database_transport, analytical, neutral_transport, transport_combiner
- **Edge:** penn, cec, solpsz1
- **Solver:** transport_solver
- **Service:** ets_init, update_core_profiles, changeocc, empty_transport, empty_core_sources, empy_waves, empty_distribution_sources, empty_distributions, combine_core_profiles, database_profiles, update_numerics, check_convergence, fill summary

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ETSpy

- Object oriented ETS fully developed in Python and using iWrap actors.
  - **All actors using *iWrap* e.g. CHEASE, TCI suite, GRAY,…**
  - **Built to be agile and fast.**
  - ***Parameter* and *Plasma* bundle concepts inherited from ETS-Kepler → easy global data propagator between all actors.**
  - ***All workflow components* derive from same *abstract class* → trivial to integrate a new actor in the workflow**
    - **Each of the TCI transport modules took <5min to fully integrate in the workflow (ready to use).**
    - **HCD integration also trivial (granularity/modularity/clarity makes integration easy)**
- Development/benchmarking in parallel to ETS-PAF using progressively more physics.
  - ***Analytic, NCLASS, Bohm-GyroBohm, TGLF, GRAY.***
- Work is ongoing to consolidate/expand physics code and sub-workflows (HCD, MHD, fuelling) portfolio and collaboration with TSVV11/ITER already discussed.

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Some key needs

- A better model for encapsulation
  - The so far implemented “encapsulation” is *ad hoc* and implemented by the workflow designer
  - Will need something better when we incorporate the ETS workflow into the UQ workflow

- A faster serialization/deserialization method released (not just demonstrated)
  - 95.6% of the cpu time of the most expensive module (which accounted for 35.8% of the total time) was spent in serialization/deserialization

- A way for mapping requirements of the simulation (which actors, which options, …) onto the YMMSL files and the command line for running muscle3

Collaborations in place

- Collaboration between the various ETS developers
- Within TSVV11 (benchmarking, new physics)
- With ITER