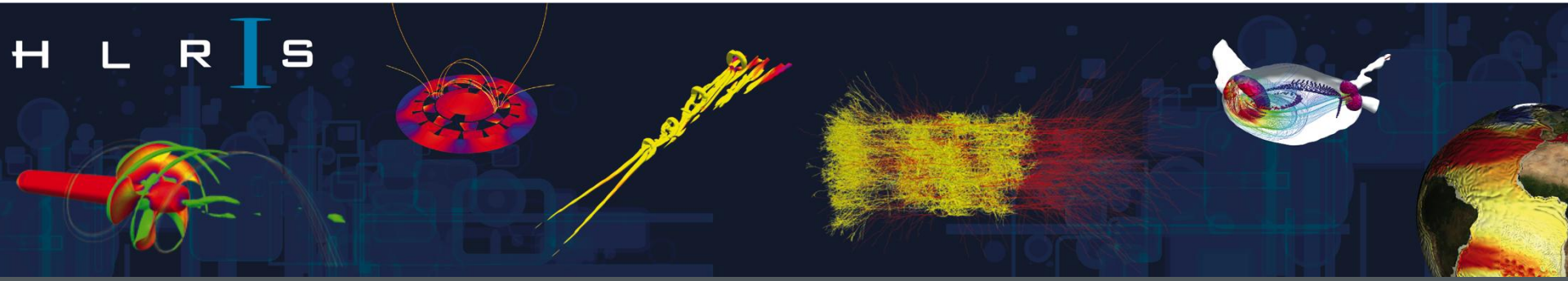
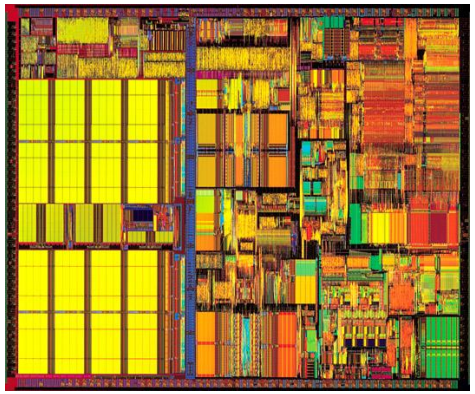
Overview on HPC research activities@HLRS

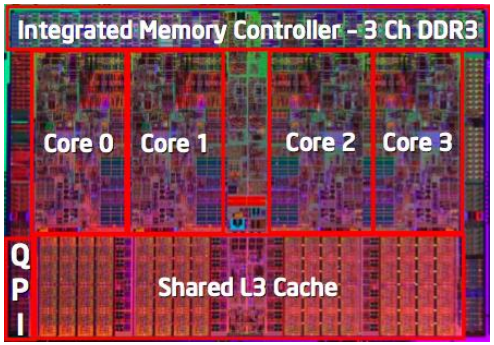
Dr.-Ing. Stefan Wesner
Managing Director, HLRS



High Performance Computing is at cross-roads

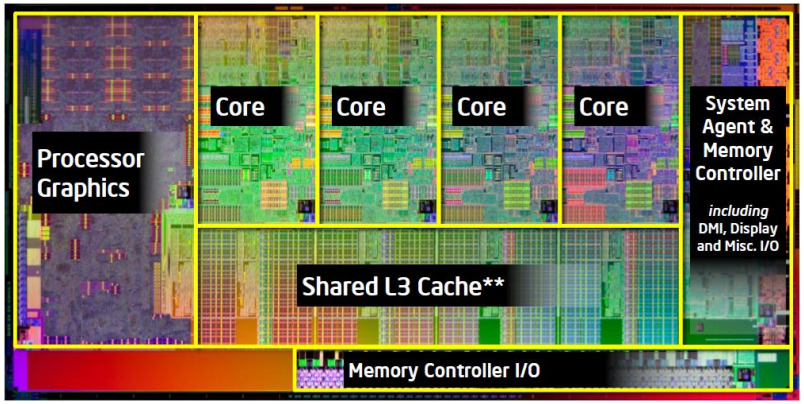
Intel Pentium III
1999

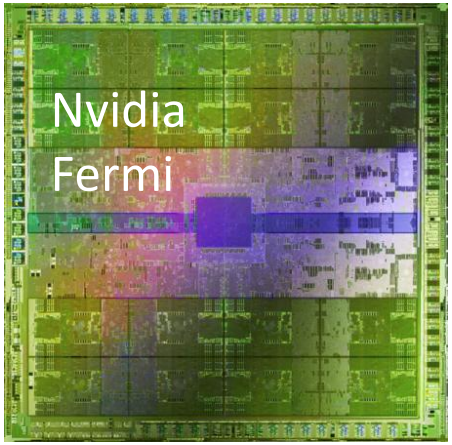


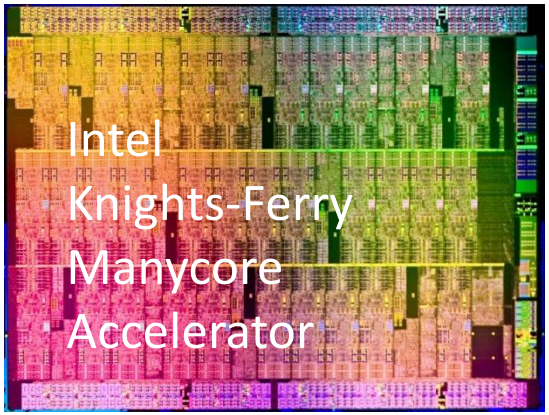


Intel
Nehalem
2008

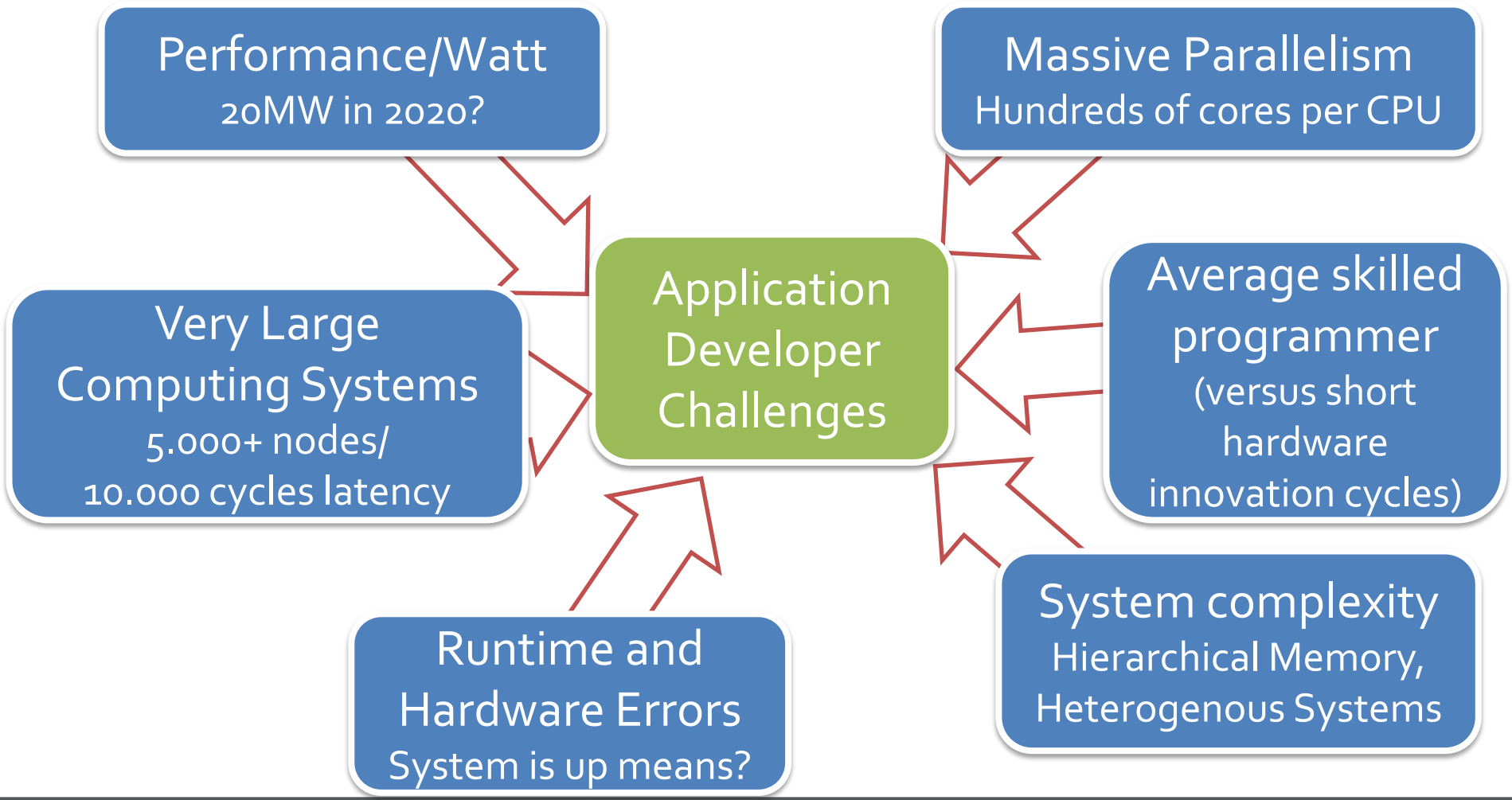
AMD Llano APU 2011







Focus on ~~Exascale~~ High Performance Computing

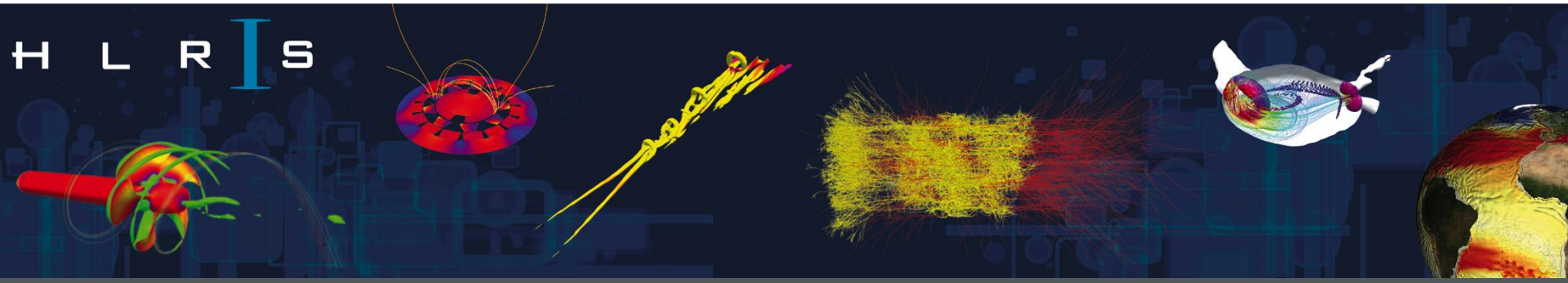


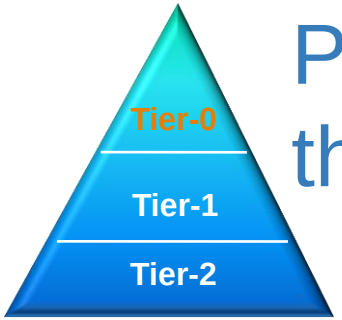
EXASCALE COMPUTING ACTIVITIES

Partnership for Advanced Computing in Europe (PRACE) 1IP/2IP

Collaborative **R**esearch into **E**xascale **S**ystemware, **T**ools and **A**pplications

Towards EXascale ApplicatTions (TEXT)





PRACE is building the top of the pyramid...

First production system available:
1 Petaflop/s IBM BlueGene/P (**JUGENE**) at GCS (Gauss Centre for Supercomputing) partner FZJ (Forschungszentrum Jülich)

Italy and Spain expect to deploy their own Tier-0 systems from 2012.

Second production system available: Bull Bullx **CURIE** at GENCI partner CEA. Full capacity of **1.8 Petaflop/s** reached by late 2011.

Fourth production system available by mi 2012: **3 Petaflop/s** IBM (**SuperMUC**) at GCS partner LRZ (Leibniz-Rechenzentrum).

Third production system available by the end of 2011: **1 Petaflop/s** Cray (**HERMIT**) at GCS partner HLRS (High Performance Computing Center Stuttgart). Upgrade to **4-5 Petaflop/s** planned in 2013.

The CRESTA Project

- Three year EU-funded collaborative project, 13 partners, €12 million costs, €8.5 million funding
  - Collaborative Research into Exascale Systemware, Tools and Applications
  - Project coordinator: EPCC at The University of Edinburgh
- CRESTA has a very strong focus on exascale software challenges
- Uses a co-design model of applications with exascale potential interacting with systemware and tools activities
- The hardware partner is Cray
- Applications represent broad spectrum from science and engineering
- CRESTA will compare and contrast incremental and disruptive solutions to Exascale challenges

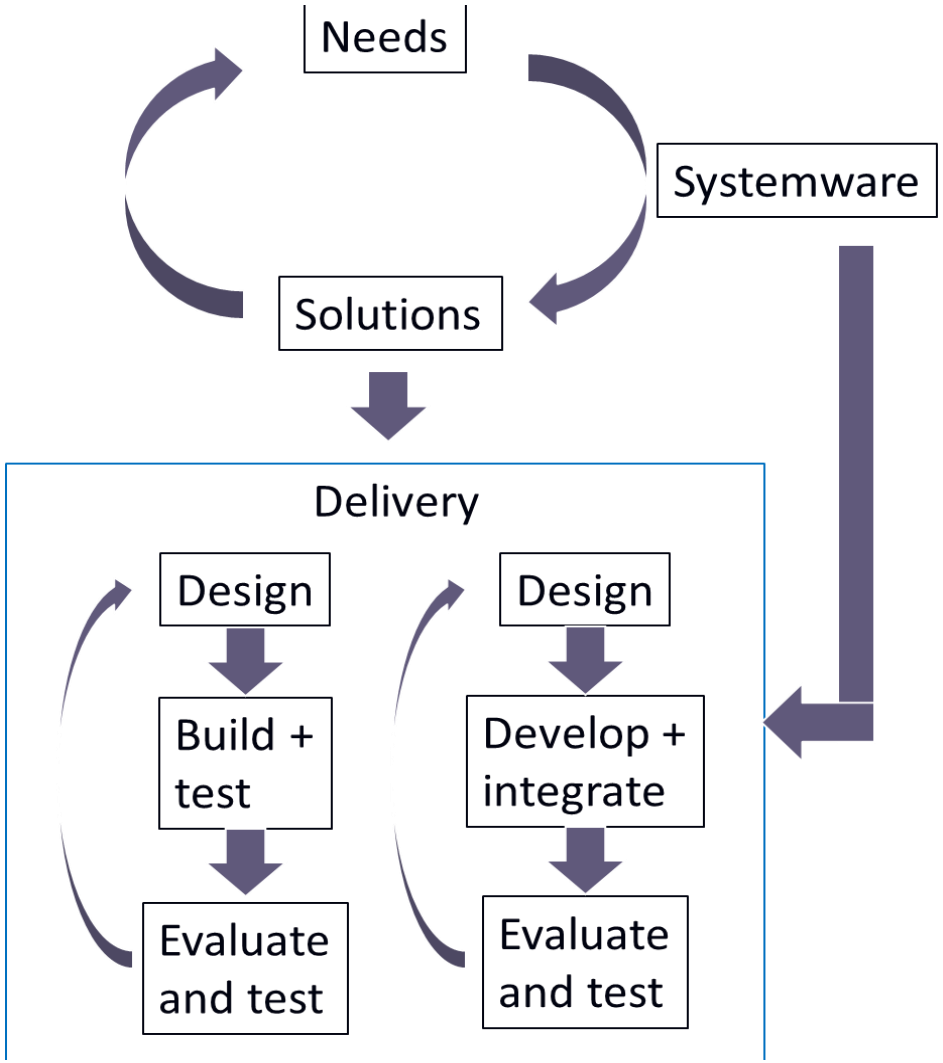
Consortium & Applications

- Leading European HPC centres
  - EPCC, HLRS, CSC, PDC
- A world leading vendor
  - Cray
- World leading tools providers
- Exascale application owners and specialists
  - ABO, JYU, UCL, ECMWF, ECP, DLR

Application	Grand challenge	Partner responsible
GROMACS	Biomolecular systems	KTH (Sweden)
ELMFIRE	Fusion energy	ABO (Finland)
HemeLB	Virtual Physiological Human	UCL (UK)
IFS	Numerical weather prediction	ECMWF (International)
OpenFOAM	Engineering	EPCC / HLRS / ECP
Nek5000	Engineering	KTH (Sweden)

CRESTA key principle

- Some problems at exascale require incremental solutions
- Some problems at exascale require a disruptive approach
- CRESTA will compare and contrast different approaches
- This is particularly true for applications which are at the limit of scaling today
- What we learn at the exascale will help codes scale at the peta- and tera-scales.



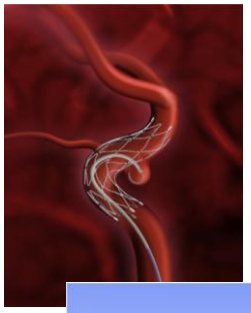
TEXT Project 1/3

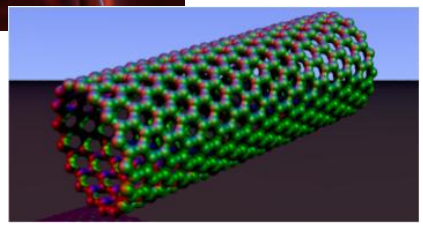
- Towards EXascale ApplicatTions (TEXT)
- EU-funded CP & CSA in FP7-Infrastructures-2010-2
- 9 Partners:
  4 HPC Centers, 4 Universities, 1 Industrial)
- Centered around StarSS programming model by BSC:

```
#pragma css task input(v1, v2, len) output(v3)
void vadd (float *v1, float *v2, float *v3, int len)
{ ... }
```

- **Project Aim**: To apply the StarSS at various HPC Centers, various real-world applications and extend and optimize the compiler in the process.

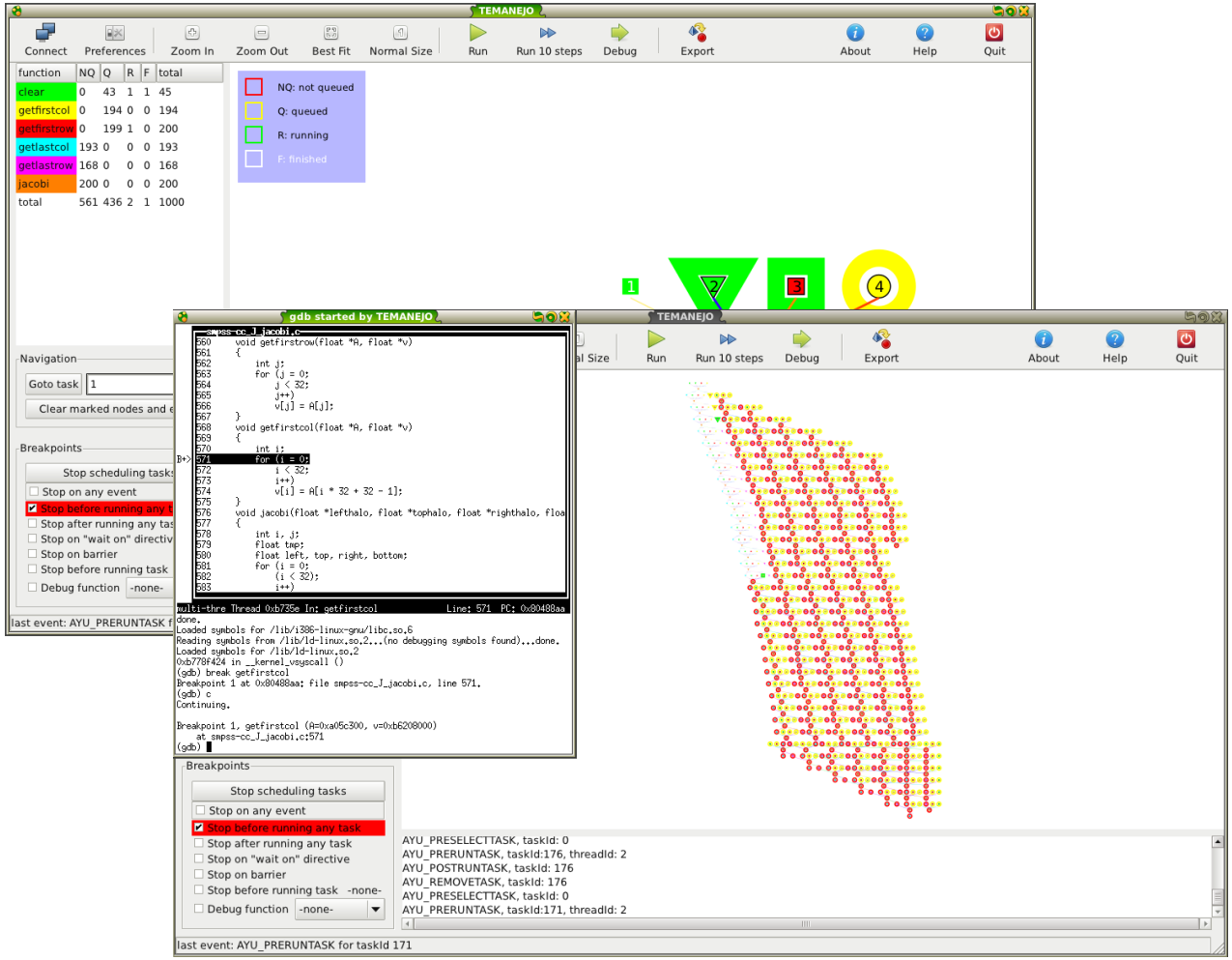
TEXT Project 2/3





- Parallelization using SmpSS on the:
  - BEST / LBC Lattice Boltzmann codes
    Jose Gracia
  - LS1-Mardyn MD code
    Christoph Niethammer
- Develop a small testsuite to find implementation bugs and tools capabilities (valgrind-like errors)
- Develop debugger & techniques of threaded debugging

TEXT Project 3/3



Ease thread programming with graphical debugger…

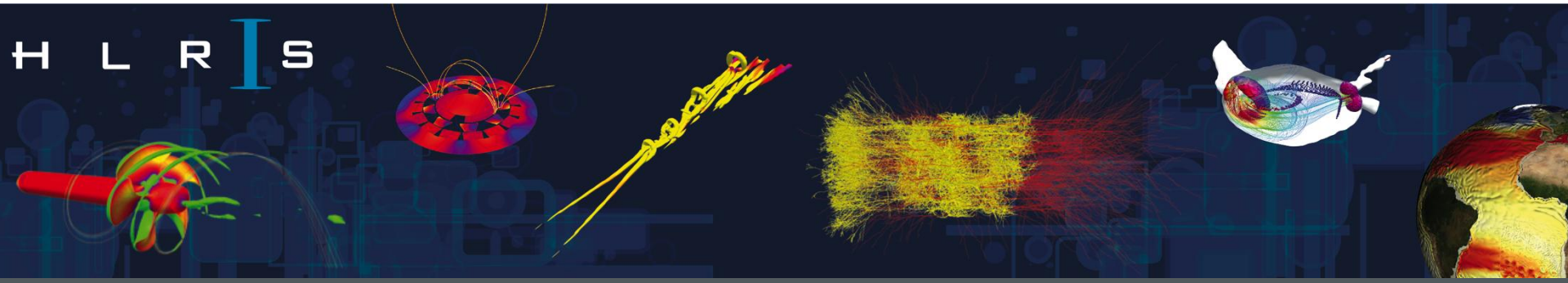
Contact: Steffen Brinkmann

INDUSTRY DRIVEN RESEARCH

H4H - Hybrid Parallel Programming to Optimise HPC Applications on Heterogeneous Architectures

ECOUSS – Effiziente und offene Compiler Umgebung für Semantisch annotierte parallele Simulationen

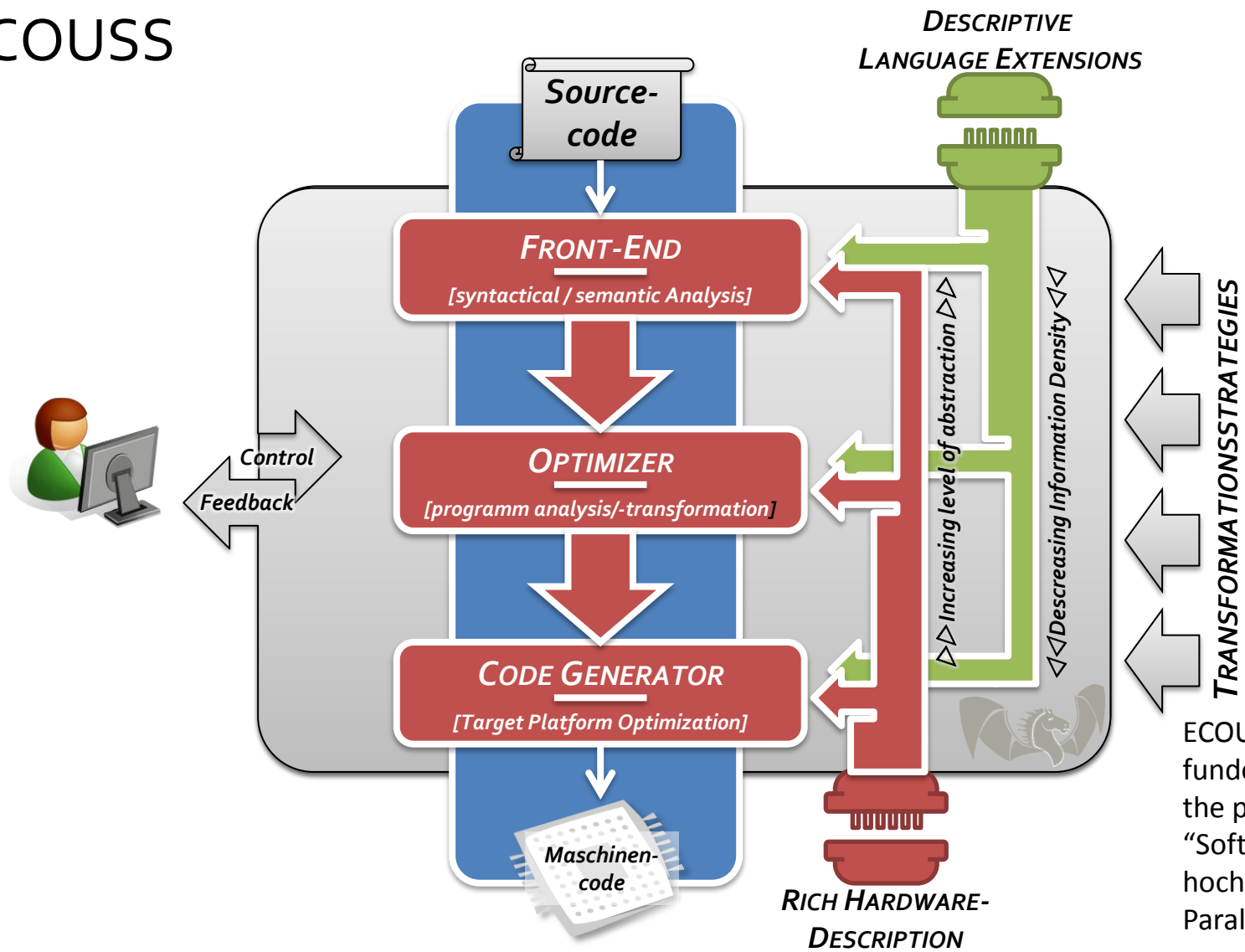
TIMACS – Tools for Intelligent Management of Very Large Computing Systems



Hybrid Parallel Programming to Optimise HPC Applications on Heterogeneous Architectures

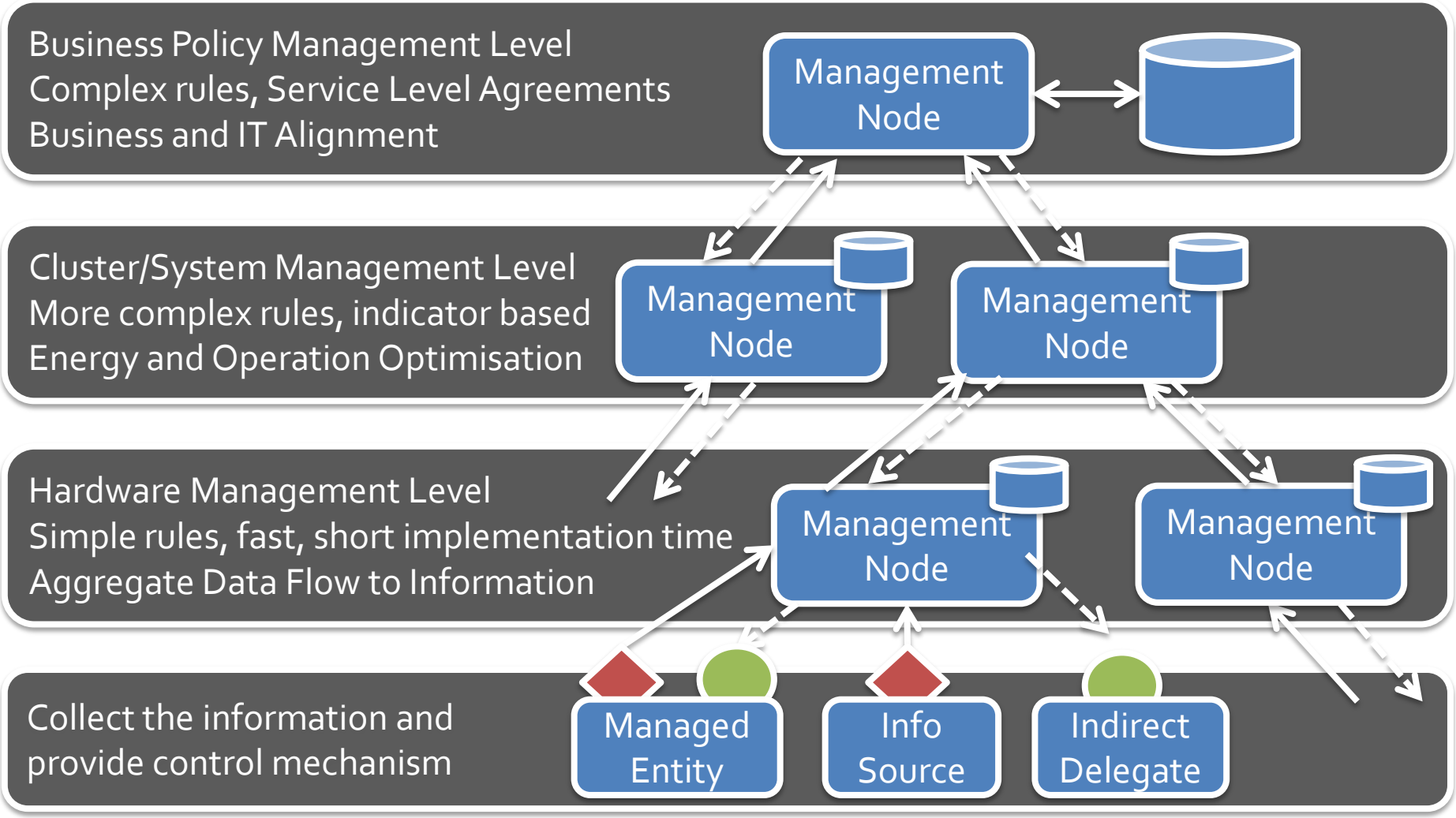
- Objectives
  - Evolve hybrid parallel programming models and associated support.
  - Develop smart translation facilities to port performance-critical code from CPU to GPU.
  - Extend performance analysis tools to accelerator-based architectures.
  - Develop an optimized software stack for heterogeneous execution platforms.
- Unique selling points
  - Enable HPC application developers to easily and fully exploit the power of heterogeneous architectures.
  - Validated with industrial applications in various domains (video, oil & gas …).
  - A comprehensive, innovative, and integrated set of programming models, methods, and tools to harness accelerator-based architectures.

ECOUSS



ECOUSS is a BMBF funded project under the programm "Software für hochskalierbare Parallelrechner"

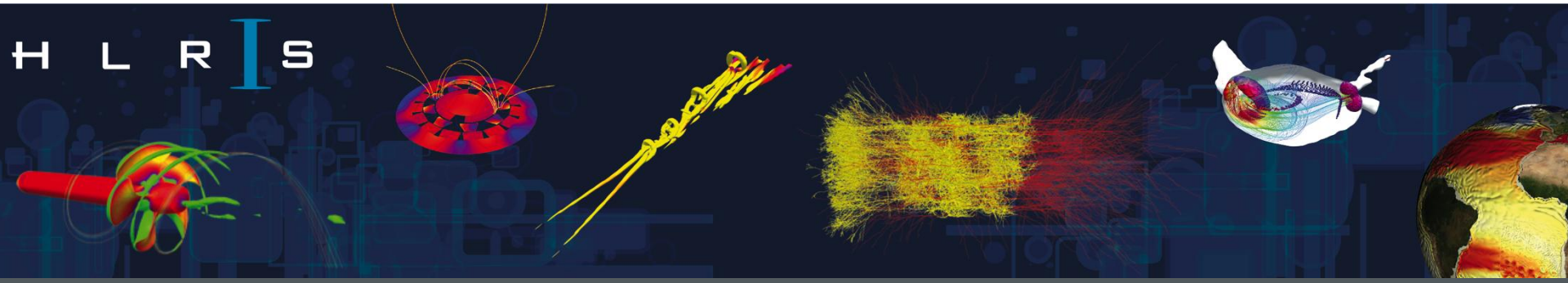
Tools for Intelligent Management of Very Large Computing Systems



LONG TERM RESEARCH ACTIVITIES

Service Oriented Operating Systems- S(o)OS

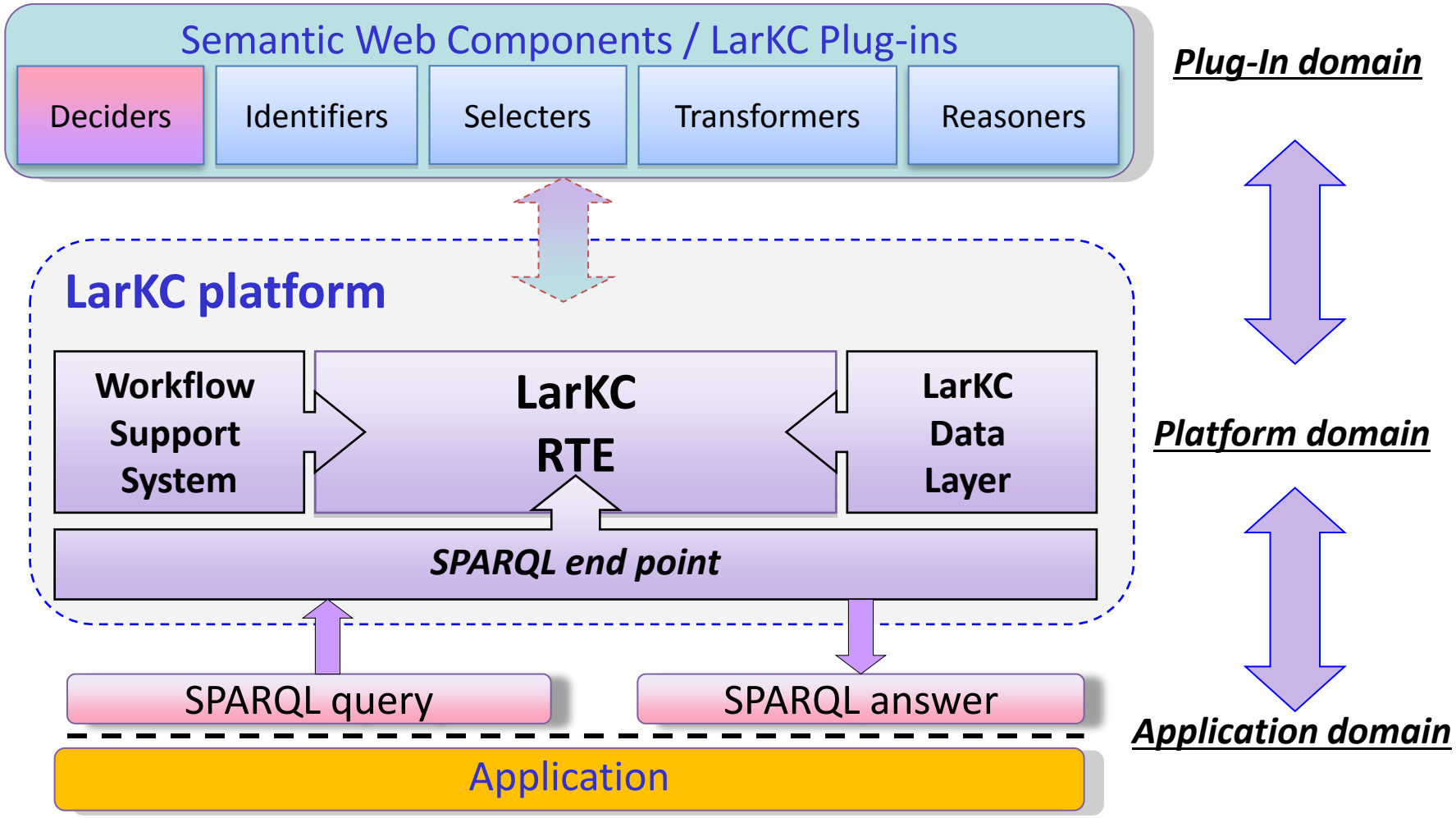
The Large Knowledge Collider - LarKC



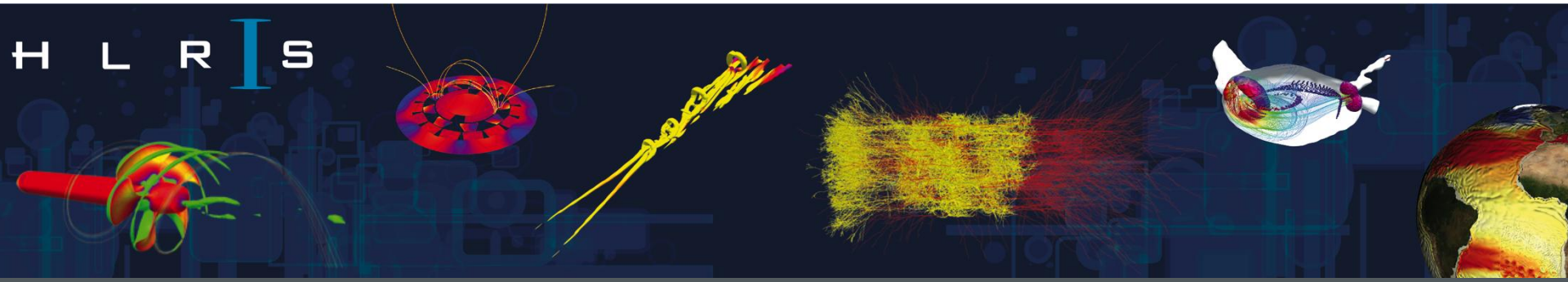
Service Oriented Operating System

- More long term oriented Execution Management can go on task level within an application
- Very challenging in terms of cost of dynamicity on that level
- Requires exploiting heuristics and potentially new types of hardware (e.g. transactional memory)
- Currently investigated in FET Project S(o)OS
- Clearly Long Term Vision

The LarKC platform – Very new user communities



Conclusions

- HLRS is involved in a wide range of different HPC research activities
  - Look ahead projects(exascale/2020)
  - Address "parallel divide" in short term
  - Address "parallel divide" in the very long term
- Software solutions are a much more challenging problem than infrastructure
- Research activities cannot be focused on Exascale only
  - There are a couple of problem to be solved before 2020
  - Industry oriented research demands for solutions and not only for proof of concepts
- New application domains ask for completely new solutions

ANY QUESTIONS?