
# Programming Model INTERoperability ToWards Exascale

## FETHPC 1-2014 – HPC Core Technologies, Programming Environments and Algorithms for Extreme Parallelism and Extreme Data Applications

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# Background

- **Exascale architectures will rely on extreme-scale parallelism exposed in multiple layers of hardware**
  - nodes, cores, hardware threads, SIMD lanes, …
- **No sign of "silver bullet" programming model (API) to address all these layers within timeframe of first Exascale systems**
- **Thus applications requiring Exascale performance must use multiple APIs in single program**
  - Significant expansions of current hybrid programming (e.g. MPI and OpenMP)

# Background, continued

- **Problems using different APIs in same 'layer'**
  - E.g. program using OpenMP threads not easily able to exploit library w/ POSIX threads
  - Hybrid codes typically scale modestly due to simplified interaction necessitated by approach to interoperability
- **Interoperability between APIs is very important**
  - and already becoming a bottleneck
- **To advance necessitates changes/ improvements to both**
  - API specification
  - Implementation (especially runtimes)

# Objectives

- **INTERTWinE will address interoperability issues for key APIs**
  - **MPI** – distributed-memory model, dominant and ubiquitous
  - **GASPI** – PGAS model focused on asynchronous, one--sided communications
  - **OpenMP** – widely used API for shared-memory parallelism
  - **OmpSs** – model that efficiently runs sequential applications in data-flow execution paradigm on distributed systems
  - **StarPU** – task scheduler for distributed, heterogeneous (accelerator) systems
  - **PARSEC** – scheduler for execution of micro-tasks on distributed-memory systems

# Approach

- **Interoperability focused on nine key API combinations, identified from strategically important applications/ benchmarks**
  - BSC Application Repository – mixed collection of applications
  - CombBLAS – linear-algebra
  - iPIC3D – particle-in-cell plasma simulation
  - Ludwig – Lattice Boltzmann CDF
  - PLASMA and DPLASMA – linear-algebra
  - Tau – computational fluid dynamics

**—following co-design methodology**

- Interoperability work driven by needs of applications: interoperability outputs validated within applications

# Project Resources

- **Time-line and effort**
  - 3-year project, October 2015—September 2018
  - 473 person-months
- **Nine partners**
  - EPCC, University of Edinburgh, UK – Lead
  - Barcelona Supercomputing Centre, Spain
  - Kungliga Tekniska Hoegskolan (KTH), Sweden
  - Inria, France
  - Fraunhofer, Germany
  - Deutsches Zentrum für Luft und Raumfahrt, Germany
  - TS-SFR Solutions for Research, Germany
  - Universitat Jaume I de Castellon, Spain
  - University of Manchester, UK

# Technical Work Packages

- **Programming model interoperability**
  - requirements analysis, API extensions, standardisation efforts, best-practice guides, training
- **Resource management and runtime interoperability**
  - resource management API for shared memory runtime, directory/cache API for distributed memory runtimes, reference implementations
- **Applications and kernels**
  - porting to API combinations, requirements, evaluation
- **Training courses and workshops vital to enabling software developers and API implementers**

# Progress so far

- Refined ambition plans for the project
- Established working relationships with MPI, OpenMP and GASPI standards bodies
- Started the programme of training courses and best practice guides
- Prototype resource management and directory/cache APIs and implementations of these
- Completed initial requirements analysis from applications and kernels
- Built repository of applications and kernels, with benchmark datasets and testing framework.

# Collaborations and external activities

- Runtime implementations and benchmark suite to be publically available (e.g. via PRACE system, PRACE Code Vault)
- Running training courses in collaboration with PATCs
- International collaboration through standards bodies and their working groups (MPI, GASPI, OpenMP) and close connection with Jack Dongarra's group at Oak Ridge via PARSEC/PLASMA/DPLASMA
- Would like to initiate an international Interoperability Forum (e.g. with a representative from each API standards body or equivalent)
- Will be running joint Applications Workshop with EPiGRAM – other projects would be welcome to join in.
- Aim to contribute to the SRA

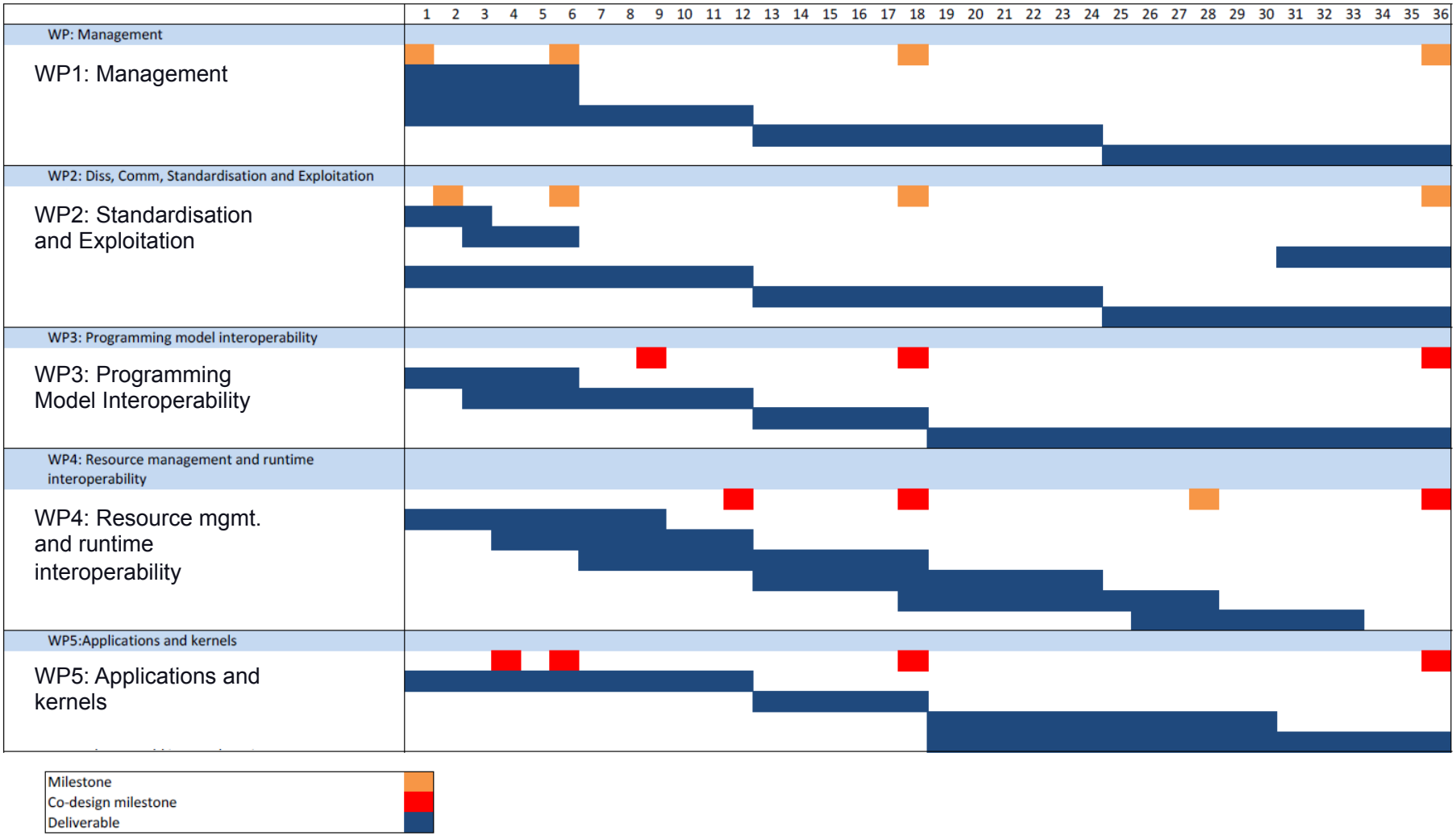
# Contact and further information

**http://www.intertwine-project.eu/**

**info@intertwine-project.eu**

# Extra Slides

# Work Plan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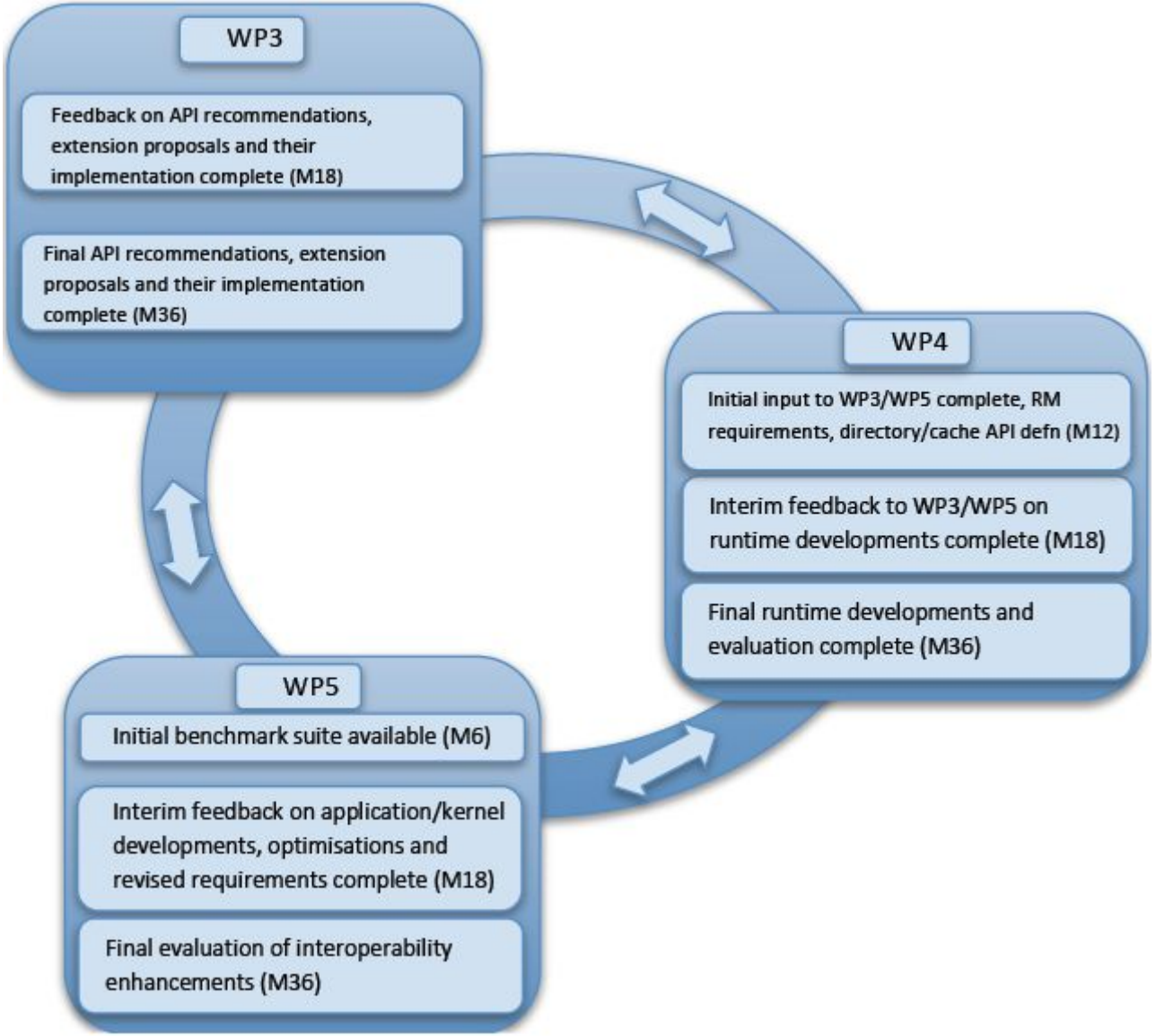
WP: Management
WP1: Management
WP2: Diss, Comm, Standardisation and Exploitation
WP2: Standardisation and Exploitation
WP3: Programming model interoperability
WP3: Programming Model Interoperability
WP4: Resource management and runtime interoperability
WP4: Resource mgmt. and runtime interoperability
WP5:Applications and kernels
WP5: Applications and kernels
Milestone
Co-design milestone
Deliverable

# Co-design Methodology



# Exploitation Targets and Intended Impact

- **Exploitations**
  - Focus on enabling end users to exploit next-gen. HPC systems
  - Engage HPC centres to ensure project outputs readily available
  - Inform funding strategies and Exascale community
- **Expected Impact**
  - Contribute to realisation of ETP4HPC Strategic Research Agenda
  - Impact on standards bodies and relevant international programs
  - Strengthen competitiveness and growth of companies, innovating to meet needs of Europe and global markets