RisingSTARS, RISE International Network for Solutions Technologies and Applications of Real-time Systems

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Extend **parallel programming** frameworks for the development and execution of advanced and large-scale **Cyber-Physical Systems** with **High-Performance** and **Real-Time** requirements

The Need of New Generation Parallel Programming Models

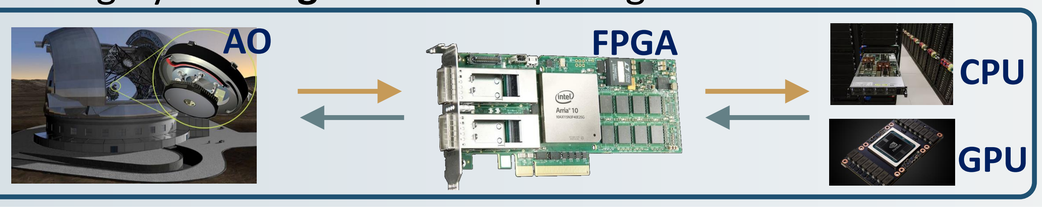
- ✓ **Parallel and heterogeneous computing** is key to cope with high-performance and real-time requirements of new Cyber-Physical Systems
- ✓ **Productivity** as a goal, including **programmability**, **portability**, **performance** and **scalability**

Parallel programming models are crucial for the development of Cyber-Physical Systems

- ✓ De facto standard in **HPC** systems
- ✓ **High-level** (easy to use) abstraction
- ✓ Supported by many **chip/compiler vendors**
- ✓ Supports **task** and **data parallelism**
- ✓ Support for **heterogeneous computing** by expressing host and device parallelism

Objective: Converging HPC and Real-Time

Highly **heterogeneous** computing solutions needed



What

#1 Enable a versatile and efficient **data acquisition** platform based on **FPGA**

#2 Expose **data acquisition/transfer** mechanisms in the **programming model**

#3 Introduce **real-time** oriented features in the **programming model**

How

- ✓ Enables the **timing characterization** of the parallel execution [1]
- ✓ Tasking model matches **real-time** systems [2]

#1 **Interoperability** between parallel programming models (OpenMP, CUDA, etc.) [3]

#2 Expose **memory model** for host to/from accelerator data transfers

#3 Expose tasks **execution model** for scheduling: *periodicity, preemption, migration, allocation* [4]

[1] Serrano, et al. "**An Analysis of Lazy and Eager Limited Preemption Approaches under DAG-based Global Fixed Priority Scheduling.**",ISORC 2017.

[2] Serrano, et al. "**Towards an OpenMP Specification for Critical Real-Time Systems.**",IWOMP 2018,

[3] Yu, et al., "**OpenMP to CUDA Graphs: a Compiler-based Transformation to Enhance the Programmability of NVIDIA devices**", SCOPES 2020.

[4] Royuela, et al., "**The Cooperative Parallel: A Discussion about run-time schedulers for nested parallelism**", IWOMP 2019.

Use Cases: Adaptive Optics and beyond

Adaptive Optics for Extremely Large Telescope (AO)

Characterization of the atmospheric turbulence and mirrors corrections within 1ms and a maximum jitter of 100µs (or less)

Square Kilometer Array (SKA)

Regular monitoring of neutron stars by tracking the radio pulses arrival time with a 1ms period and with few tens of ns of accuracy over long periods

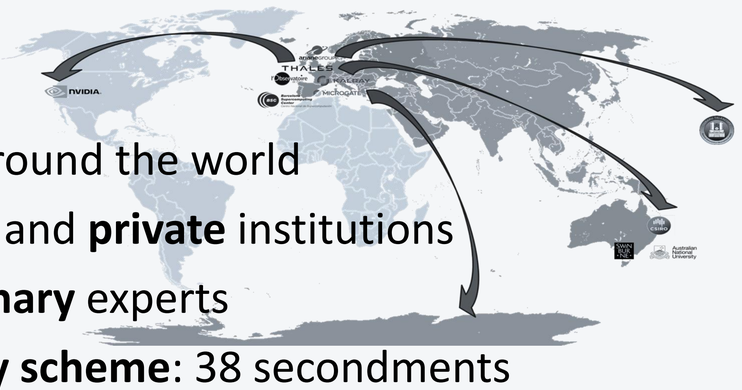
Adaptive Beamforming (Critical Real-Time Embedded Systems - CRTES)

Combine signals from multiple sensors focusing on one direction for applications such as seismology or radio astronomy

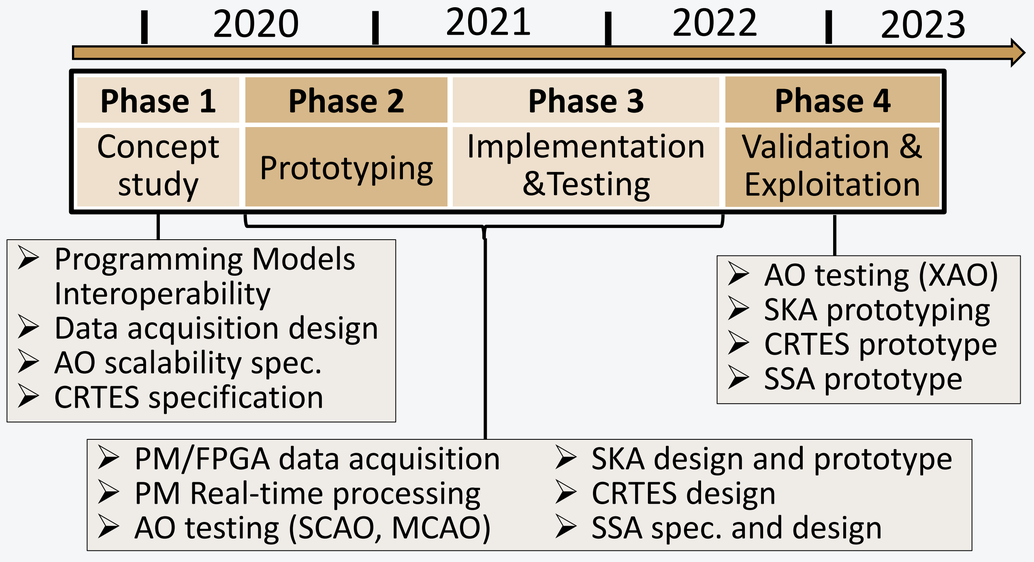
Antarctica Observing Station (Space Situational Awareness - SSA)

Real-time assimilation of data at the Antarctica station to assess the risk of collision of a satellite in operation with space debris

Consortium and Roadmap



- **11 partners** around the world
- **Leader public** and **private** institutions
- **Multi-disciplinary** experts
- **Large mobility scheme**: 38 secondments



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