Programming Tools for Distributed and Parallel Systems (SPD)

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Value, period	6 credits, 2nd semester
Exam rules	lab project + written report + oral discussion (syllabus and project)
Pre-requisites	HPC; SPM is strongly suggested
Area	Computer Science
Course home page	hosted on https://didawiki.cli.di.unipi.it

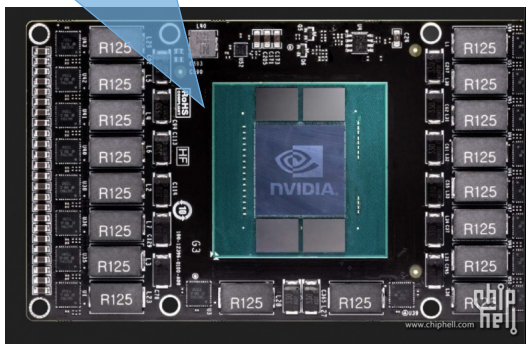
The course presents a selection of parallel and distributed programming languages and frameworks, covering parallelism exploitation at different scales.

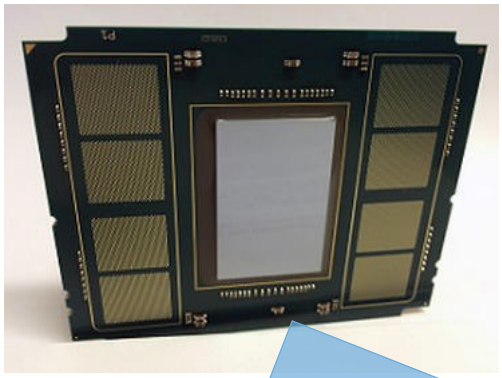
We address exploitation of parallelism via software at different architectural levels, targeting distributed systems, shared-memory/multicore CPUs and GPUs

The course relies on knowledge about parallel skeletons, their performance models and techniques to exploit them in the design and evaluation of parallel software.

A changing landscape where parallelism is pervasive

Nvidia Pascal GPU architecture
2560 shader cores on-chip





Intel's Xeon Phi Knight's Landing
72-cores with 4 HW threads/core

RISC-V FPGA CPUs up
to 1680 cores/board

Fujitsu K supercomputer
705000 SPARC VIIIfx cores
post-K supercomputer in 2021
will use custom ARMV8 CPUs

Home made cluster
of 120 Raspberry PI
(ARM 32 bit core)

Syllabus

Parallel tools & platforms for HPC and large scalable systems. Lessons + lab time

- MPI – Message Passing Interface standard
  - Message passing standard, linked library with support for multiple languages
- TBB – Intel Thread Building Blocks library
  - C++ template library for shared memory multi-thread programming
  - Multi core CPUs and multiprocessor systems
- OpenCL – High-level, portable standard to exploit many-core on-chip parallelism
  - Multithread, high-memory bandwidth algorithms with streaming/regular access patterns
  - Targets graphic units (GPUs), CPU vectorization, APUs, FPGA devices …
- Other frameworks
  - Change yearly and may be related to projects, examples are CUDA, BSP/Map&Reduce based frameworks (Spark / Graphx, Hama)
- Application examples for laboratory time (change from year to year):
  Data Mining, Deep Learning, Graph / Optimization Algorithms, Stream Data Processing

Some potential topics for Master Thesis or Research fellowships

- Clouds, Cloud-Federations and *Edge* / *Fog* computing:
  - Dynamical System Modeling, Resource Brokering, Scheduling Optimization strategies
    - Hierarchical and skeleton-based programming frameworks and performance models
    - Genetic programming, (mixed integer) linear programming, other optimization approaches to brokering and autonomic/adaptive resource management
    - Container-based and VM-based application composition, deployment and elastic scalability
    - High-performance implementation of authorization mechanisms for data security and privacy: Scalable policy evaluation and enforcing mechanisms at the hypervisor, cloud and/or federation manager levels as well as on edge devices
- Multicore CPU/GPU design and deployment on FPGA
- High-performance computing applications
  - HPC / distributed Data Mining, Stream Mining, Machine Learning, Deep Learning
  - Applications to HealthCare
  - Application of stream and Big-data Analysis for Clouds