6 GIOVEDI’ TEMATICI SULLA (NOSTRA) CHIMICA
MAGGIO > DICEMBRE 2018
AULA AVOGADRO
DIPARTIMENTO DI CHIMICA
UNIVERSITÀ DI TORINO

Da HPC a BigData al Deep Learning
L’EVOLUZIONE DELLE PIATTAFORME E DEI SISTEMI AD ALTE PRESTAZIONI

America Has a Monopoly Problem—and It’s Huge

The Nobel Prize winner argues that an economy dominated by large corporations has failed the many and enriched the few.

By Joseph E. Stiglitz
OCTOBER 23, 2017
Big data is like teenage sex: everyone talks about it, nobody really knows how to do it, everyone thinks everyone else is doing it, so everyone claims they are doing it ...
Number of applications using a given programming paradigm in the set of 30 candidate exascale applications of the USA DoE Exascale Computing Project (ECP).
Programming model: stencil
(locally synchronous data parallelism)

\[ \text{Cell}_{(x,y)}^{T+1} = P_1 \text{Cell}_{(x,y-1)}^{T} + P_2 \text{Cell}_{(x-1,y)}^{T} + P_3 \text{Cell}_{(x+1,y)}^{T} + P_4 \text{Cell}_{(x,y+1)}^{T} \]
HPC is mostly batch

- Long runs
  - CPU intensive, mostly
- Long round-trip time
- Man-in-the-loop not admitted
- Streaming not usual
- Virtualization complex
  - Need to bypass kernel space for I/O and network, e.g. libverb, MVAPICH, ...
OCCAM: Open Computing Cluster for Advanced data Manipulation

- The “Bando Grandi Infrastrutture” Compagnia di San Paolo foundation
  - Call open Fall 2014, Total budget: 5M€
  - Infrastructure only, no personnel cost whatsoever
  - Total cost of ownership typically include costs that do not fit, e.g. electricity, maintenance, security, cleaning, licences, …

- Facts
  - 16 departments
  - 1056 cores HT, 24K CUDA cores
  - 1PB archive, 320TB scratch
  - ~30 TFLOPS (linpack)
OCCAM performance
Weak scaling on HPL standard benchmark

![Graph showing weak scaling performance for OCCAM.]
C3S, the new usage model
GITLAB-based Docker Orchestrator for HPC

Docker images

Light nodes

FAT nodes

GPU nodes
Examples of a Specialised Island: GITLAB-based Docker Orchestrator for HPC

“The most damaging phrase in the language is l’oma semper fait parei” (we've always done it this way!)

The grandma of Cobol

Grace Hopper

From Wikipedia, the free encyclopedia

Grace Brewster Murray Hopper (née Murray; December 9, 1906 – January 1, 1992) was an American computer scientist and United States Navy rear admiral.[1] One of the first programmers of the Harvard Mark I computer, she was a pioneer of computer programming who invented one of the first compiler related tools. She popularized the idea of machine-independent programming languages, which led to the development of COBOL, an early high-level programming language still in use today.

Hopper was accepted to enlist in the Navy during World War II but was rejected because she was 34 years old. She joined the Navy Reserves. Hopper began her computing career in 1944 when she worked on the Harvard Mark II team led by Howard H. Aiken. In 1949, she joined the Eckert–Mauchly Computer Corporation team that developed the UNIVAC I computer. At Eckert–Mauchly she began developing the compiler that a programming language based on English was possible. Her compiler converted machine code understood by computers. By 1952, Hopper had finished her program linker (a compiler), which was written for the A-O System.[2][3][4][5]

Mauchly chose Hopper to lead their department for automatic programming, and she led the first compiled languages like FLOW-MATIC. In 1959, she participated in the CODASYL consulted Hopper to guide them in creating a machine-independent programming language, DBOL language, which was inspired by her idea of a language being based on English words. She left the Naval Reserve, but in 1967, the Navy recalled her to active duty. She retired from the Navy and found work as a consultant for the Digital Equipment Corporation, sharing her computing accomplishments and her naval rank, she was sometimes referred to as "Amazing Grace".[6][7] The Heigh Burke-class guided-missile destroyer USS Hopper was named for her, as was the Cray supercomputer at NERSC.[8] During her lifetime, Hopper was awarded 40 honorary degrees from
“La mathématique est l’art de donner le même nom à des choses différentes”

– Henry Poincaré
From HPC to BigData to Deep Learning

- **HPC**
  - Send/recv, batch, CPU intensive
  - Programmer should have the direct knowledge of all processes and all communications

- **Exascale HPC**
  - Data movements rather than compute power
  - Beyond locally synchronous data parallelism? Tasks?

- **BigData (more abstract)**
  - Mostly streams & I/O: intensive, interactive
  - Virtualised, cloud stack, Platform/Service-as-a-Service, service composition
  - O(n) algorithms - no more!

- **Machine & Deep Learning Deep Learning (much more abstract)**
  - Naturally asynchronous, permissive, low precision
  - Both batch (training) and stream (inference)
Personal and group funding perspective

- ParaPhrase (EC-STREP, 7th FP): Parallel Patterns for Adaptive Heterogeneous Multicore Systems (2011, 42 months, total cost 4.2M €).
- REPARA (EC-STREP, 7th FP): Reengineering and Enabling Performance And poweR of Applications (2013, 36 months, total cost 3.5M €).
- DIMA-HUB (EU I4MS): Regional Digital Manufacturing Innovation Hub (2016, 6 months).
- cHiPSet (EC-COST Action IC1406): High-Performance Modelling and Simulation for Big Data Applications (2015, 48 months, total cost 500K).
- OptiBike (EU I4MS): Robust Lightweight Composite Bicycle design and optimization, an experiment of EU i4MS Fortissimo2 project (2017, 24 months, total cost 230K €).
- HPC4AI (Regione Piemonte, INFRA_P): Turin’s centre in High-Performance Computing for Artificial Intelligence (2018, 24 months, total cost 4.5M €).
- PDEvolve Deep Learning + HPC (ICT-11-b - deadline 14 Nov 2018)
The new Turing GPU

2500€

**NVIDIA TESLA T4 SPECIFICATIONS**

**Performance**
- **TURING TENSOR CORES**
  - 320
- **MAGMA CLEAR CORES**
  - 2,560
- **SINGLE PRECISION PERFORMANCE (FP32)**
  - 8.1 TFLOPS
- **MIXED PRECISION (FP16/FP32)**
  - 65 TFLOPS
- **INT8 PRECISION**
  - 130 INT8 TOPS
- **INT4 PRECISION**
  - 260 INT4 TOPS

**Interconnect**
- **SQU**
  - x16 PCIe

**Memory**
- **CAPACITY**
  - 16 GB HBM2
- **BANDWIDTH**
  - 320+ GB/s

**Power**
- 70 watts

![Image of Turing GPU specifications]
The new Turing GPU
2500€

CONCURRENT EXECUTION

Per 100 FP instructions, average 36 INT PIPE instructions (ie add, select, fp min/max, compare etc)

Figure 4. Turing TU102/TU104/TU106 Streaming Multiprocessor (SM)
From FP32 to FP16 to INT8, as well as INT4
Facts

- INFRA-P call Nov. 2017
- Ranked 1st on ~30 submitted projects
- Kick-off mid apr 2018
- 4.5M€ funding
- 2 partners
- 8 associated partners
- Coord. M. Aldinucci
- Many industrial stakeholders
Federated Architecture based on the GARR cloud (i.e. Openstack version maintained by GARR+Canonical)
Spin-off project: Management of Federated Marketplace by way of Distributed Ledgers

Legal entities

Projects

hpc4ai free coins

Researchers

Marketplace services & datasets

hpc4ai blockchain

cryptocurrency exchanger

C3S PdF SmartData HPC

hpc4ai coins

Projects

Data Centers

BlueReply CSP AizoOn

CSP FCA Leonardo

Intesa SanPaolo Reale Mutua

Legal entities

hpc4ai free coins

Researchers

Marketplace services & datasets

cryptocurrency exchanger

C3S PdF SmartData HPC

hpc4ai blockchain
HPC4AI: one-stop-shop for BDA and AI

- Provide AI+HPDA on-demand to end-user with different needs
  - Moulded as a cloud stack of abstractions
  - Based on GARR cloud federation: PaaS and SaaS

- Horizontal and a vertical exploitation strategy
  - Vertical. Domain expert start from top of the stack with a rapid prototyping; solution is refined/tuned moving to the next level down
  - Horizontal. Marketplace solutions at each levels of the stack; marketplace and federated approach cross-fertilise

- Competence booster (researchers, students, practitioners)
  - Crucial to boost regional industrial competitiveness - SME especially
GARR Cloud Federation (OpenStack)
<table>
<thead>
<tr>
<th>Users</th>
<th>Kind of service</th>
<th>Services</th>
<th>Artifacts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domain experts with no skills</strong> on ML and BDA.</td>
<td><strong>Service-as-a-Service (SaaS)</strong></td>
<td>SaaS for ML and BDA designed within HPC4AI partners</td>
<td>Market place for ML and BDA services: Dashboards, trained models in several domains (NLP, Vision, …)</td>
</tr>
<tr>
<td><strong>Domain experts skilled</strong> on ML and BDA. <strong>Not expert in parallel computing.</strong></td>
<td><strong>Platform-as-a-Service (PaaS)</strong></td>
<td>PaaS solutions for ML and BDA directly designed within HPC4AI or companion projects</td>
<td>Market place of VMs and Platforms realising software stacks for ML and BDA. Solutions for data ingestion, data lake, etc.</td>
</tr>
<tr>
<td>New networks or pipelines; training set required.</td>
<td></td>
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</tr>
<tr>
<td>Researchers, cloud engineering, ML and BDA framework designers, cloud engineers, stack and automation designers.</td>
<td><strong>1) Infrastructure-as-a-Service (IaaS)</strong></td>
<td>1) GARR/other cloud able to support federation</td>
<td>1) Openstack, docker, VM, object storage, file storage, kubernetes, etc.</td>
</tr>
<tr>
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<td><strong>2) Metal-as-a-Service (IaaS)</strong></td>
<td>2) Job scheduler for HPC resources</td>
<td>2) Alternative cloud, job queue, Big Data Stack (Spark, …).</td>
</tr>
<tr>
<td></td>
<td><strong>Hardware</strong></td>
<td><strong>Bare Metal</strong></td>
<td>Multicore, GPU, storage, network, switch, UPS, cooling, etc.</td>
</tr>
</tbody>
</table>
Everything-as-a-Service by way of a Declarative Modelling Approach

- Federation are managed through automated tools (juju) on a declarative modelling approach
  - Describe the structure and constraints of the cloud system components at each level of abstraction
  - An automation tool generates a deployment plan consisting of the steps required to achieve the requested configuration, transforming the state of the system until it satisfies all constraints.

- Benefits
  - Portability: models are described in a declarative fashion, abstracting from the specifics of a cloud provider and hence they can be ported to different platforms
  - Consistency: both physical and virtual infrastructures can be modelled, as well as the relationships between infrastructure, network, and application components
  - Automation: mapping a model onto infrastructure and cloud-specific deployment operations is a responsibility of the orchestrator rather than of a system administrator
Example PaaS on Bare Metal: Kubernetes-as-a-service

Example PaaS on VMs: BigData-as-a-service

Follow-up project (EU I4MS Fortissimo2 – 230K€)
OptiBike experiment on C3S/HPC4AI

- OptiBike: Robust Lightweight Composite Bicycle design and optimization
- Noesis solution, Belgium (coord), IDEC, Spain, University of Torino (Alpha, ICxT and C3S/HPC4AI), Italy, Arctur, Slovenia
Follow-up project (2018_ICT-11-a EU IA, 13M€)
DeepHealth: Deep-Learning and HPC to Boost Biomedical Applications for Health

- 18 Partners: Everis, Siveco, Wings, Philips, SIVECO, IBM, Thales, CEA, Treelogic, EPFL, UPV, UNITO, UNIMORE, ...
- Design and develop:
  - European Library for Distributed Deep Learning for health
  - AI-on-demand cloud platforms (HPC4AI, ...)

Use cases and data sets:
- UC1: Migraine and seizure prediction
- UC2: Colon pathology
- UC3: Brain scans
- UC4: Chest scans
- UC5: Deep image annotation
- UC6: Prostate tumor diagnosis
- UC7: Depression
- UC8: Lymphoma
- UC9: Alzheimer
- UC10: Ultrasound
- UC11: Urology
- UC12: Skin cancer
- UC13: Epileptic seizures
- UC14: Neurodegenerative disease

Platforms:
- PF1: Open Innovation Platform
- PF2: MasterDHH
- PF3: ExpressDHH
- PF4: PAM
- PF5: Open DeepHealth
- PF6: Digital pathology
- PF7: Monitory

Software:
- Machine Learning: UPV, CEA, EPI, THALES, UNITO
- Deep Learning: WINGS, EPI, THALES, UNITO
- Concurrent Programming: BSC, UNITO, FISABIO
- Heterogeneous HPC: BSC, UNITO, FISABIO, EPFL
- GDPR and Confidentiality: UNITO, PHILIPS, CR54
- Computer Vision: UNISO, PHILIPS

HPC infrastructure:
- Operating System: BSC, UPV, EPI, UNISO
- HPC architectures: BSC, UPV, EPI, UNISO
- HPC communications: BSC, UPV, EPI, UNISO
- HPC maintenance: BSC, UPV, EPI, UNISO
- Multi-GPUs servers: BSC, UPV, EPI, UNISO
- Multi-cores: BSC, UPV, EPI, UNISO
- PCIE boards: BSC, UPV, EPI, UNISO
- Cloud, IOT, Data Analytics: BSC, UPV, EPI, UNISO
- Security (access & service): BSC, UPV, EPI, UNISO
- Validation processes and integration: BSC, UPV, EPI, UNISO

Industrial product development: EVERIS – PHILIPS, CEA – THALES
Project management: EVERIS – PHILIPS – EPFL – WINGS
Risk management: EVERIS – PHILIPS – EPFL – WINGS
Impact management: EVERIS – BSC

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La strategia cloud delineata da AGID prevede un percorso di
qualificazione per i soggetti pubblici e privati che intendono fornire
infrastrutture e servizi Cloud alla Pubblica amministrazione,
affinché queste ultime possano adottare servizi e infrastrutture di
cloud computing omogenei, che rispettino elevati standard di
sicurezza, efficienza ed affidabilità, in linea con le previsioni delle
circolari AGID n.2 e n. 3 del 9 aprile 2018.

AGID ha tracciato le caratteristiche organizzative, di sicurezza, di
performance e scalabilità, interoperabilità, portabilità e conformità
legislativa a cui dovranno uniformarsi rispettivamente:

- I fornitori di servizi Cloud della PA, servizi Saas (software as a
  service), servizi IaaS (Infrastructure as a service) e Paas
  (Platform as a service).
- I fornitori di infrastrutture cloud della PA: Cloud service
  provider, Cloud SPC Lotto 1, Poli strategici nazionali.

I provider che risponderanno ai requisiti di qualità fissati potranno
così entrare nel Marketplace Cloud della PA, attualmente in corso
di implementazione. Su questa piattaforma tutte le pubbliche
amministrazioni avranno la possibilità di acquistare infrastrutture e
servizi cloud qualificati.

A partire dal 20 novembre 2018 le PA potranno acquisire
esclusivamente infrastrutture e soluzioni presenti nel Marketplace
Cloud.

Apprefondimenti

Informazioni sulla strategia del cloud pubblico su Cloud Italia.
**HPC4AI - evento di presentazione**

by Università di Torino, Politecnico di Torino

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<tr>
<td>Fri 30 November 2018</td>
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<td>09:00 – 13:00 CET</td>
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**Description**

Presentazione del centro federato UNITO-POLITO High-Performance Computing for Artificial Intelligence (HPC4AI)

**Agenda**

- 09.30-09.45 Saluti istituzionali: interventi da Regione e Università
- 09.45-11.00 HPC4AI e i suoi obiettivi
- 11.00-11.30 Pausa caffè
- 11.30-13.00 HPC4AI incontra le aziende - tavola rotonda
- 13.00-14.30 Light lunch

**Location**

Collegio Carlo Alberto
Piazza Arbarello 8
Torino

[View Map](http://www.hpc4ai.it)