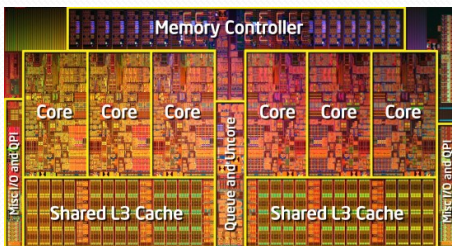# Parallel & Distributed Computing

- **Fact 1:** tomorrow **computing chips** *on your desktops and later on your gadgets* are current **computing clusters**

- **Fact 2: cluster nodes** are <u>already</u> **computing & mem chips**
  - several single/dual/quad threaded cores
  - shared data: at the cache and at the main memory
  - shared memory programming paradigm
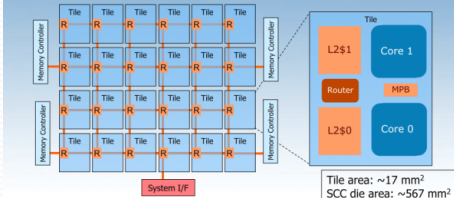 - increased #cores like those, 2x every 18 months, is sustainable **?**

Intel 6-core i7

A. Proença, J.L.Sobral, R. Ralha

Top Level Hardware Architecture
- 6x4 mesh 2 Pentium™ P54c cores per tile
- 256KB L2 Cache, 16KB shared MPB per tile
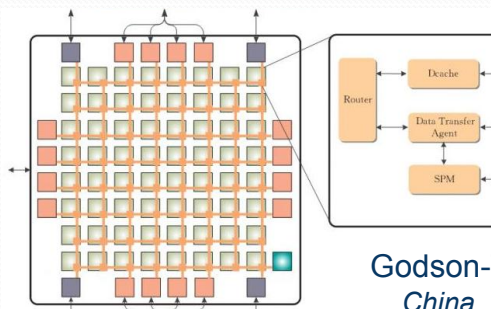- 4 iMCs, 16-64 GB total memory

Tile area: ~17 mm²
SCC die area: ~567 mm²

R = router, iMC = integrated Memory Controller, MPB = message passing buffer

Intel SSC
48-core

Programming
paradigm:
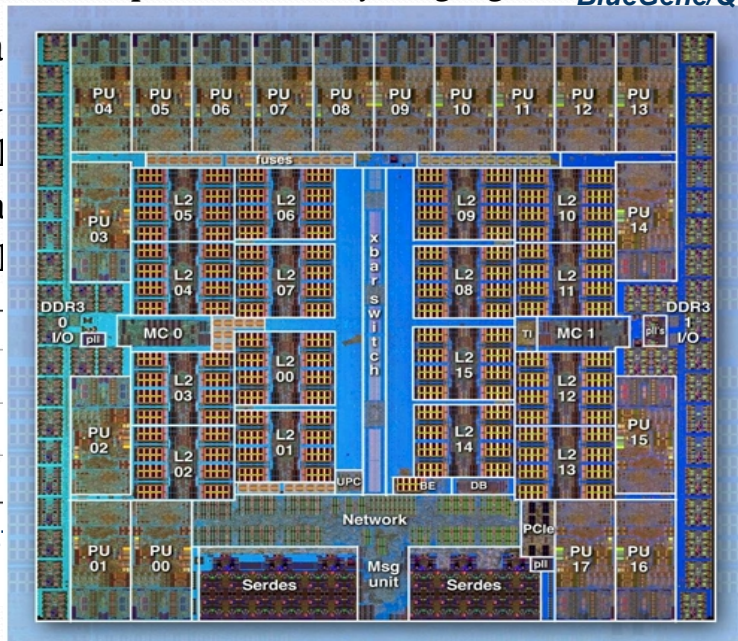**distributed-memory**

UMinho, Sept 2011

Parallel & Distributed Computing

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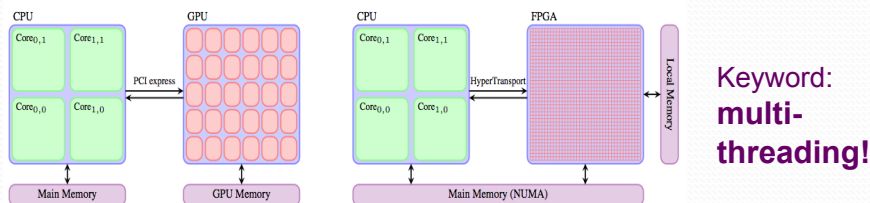**IBM BlueGene/Q**

Godson-
China
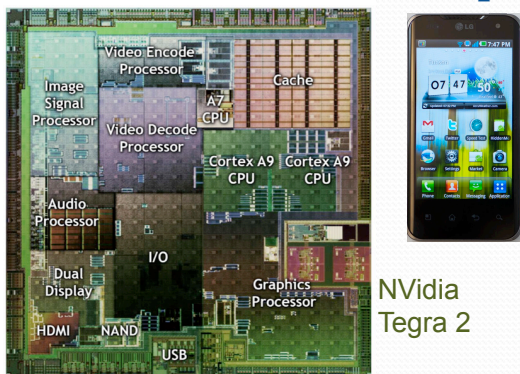
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Parallel & Distributed Computing

- **Fact 3:** computing systems are **no longer homogeneous** !
  - new computing units – gpGPU, FPGA – even mixed inside a chip

Keyword: **multi-threading!**

  - **examples:** the **LG smartphone**   & **#2,4,5 in Top500**

NVidia Tegra 2

| TOP 10 Systems - 06/2011	
1	K computer, SPARC64 VIIIfx 2.0GHz, Tofu interconnect
2	Tianhe-1A - NUDT TH MPP, X5670 2.93Ghz 6C, NVIDIA GPU, FT-1000 8C
3	Jaguar - Cray XT5-HE Opteron 6-core 2.6 GHz
4	Nebulae - Dawning TC3600 Blade, Intel X5650, NVidia Tesla C2050 GPU
5	TSUBAME 2.0 - HP ProLiant SL390s G7 Xeon 6C X5670, Nvidia GPU, Linux/Windows

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Parallel & Distributed Computing

- **Fact 4: performance portability** of software applications into these novel platforms require **total software re-design** !

- **Fact 5:** software companies and research centres look for — **and value!** — a novel generation of <u>software engineers</u> that can **efficiently** address these **new computing platforms** !
  - note 1: "**Voce SA**" ...
  - note 2: "**one man show**" is condemned to failure ...
  - note 3: bet on your personal training, **choose with passion** !

A. Proença, J.L.Sobral, R. Ralha

Parallel & Distributed Computing

- **What to expect?**
  - learn <u>today</u> with <u>tomorrow</u> platforms!
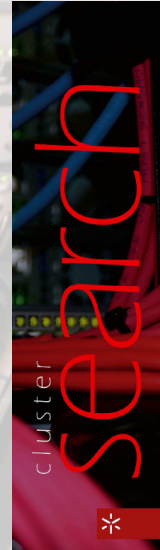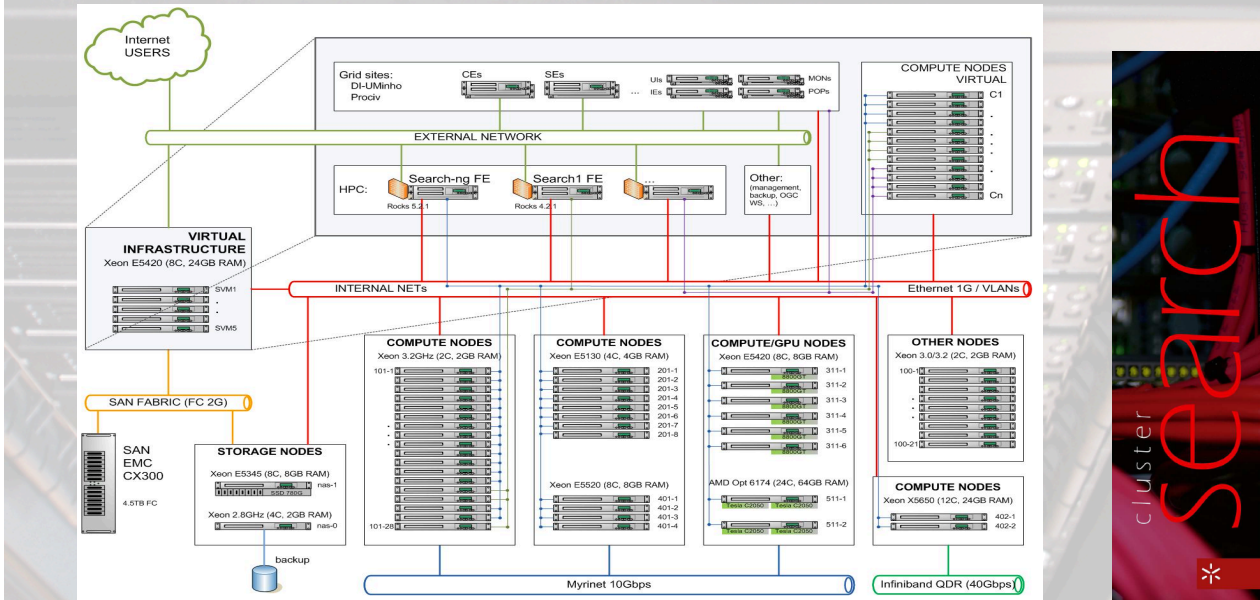
Parallel & Distributed Computing

- **What to expect?**
  - learn <u>today</u> with <u>tomorrow</u> platforms!
  - talks from industry and from researchers in Science & Eng, with pb's to solve & eventually proposals for dissertation
  - free attendance to international Workshop(s) in Portugal

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■ WACS – Winter Advanced Computing Seminars

The week of January 10th was the last one with classes for the doctoral students in Computer Science at the joint degree at Minho-Aveiro-Porto. Specially designed for PhD students in Computer Science and in Computational Sciences, this series of Winter Seminars - the WACS - received three faculty members from Texas that came to Braga to give talks on the science of programming.

Participants are already familiar with the high standards that these CoLab events have shown in the past: they came again from as far as the Algarve, but also from Lisbon, Aveiro, Guarda and Porto.

The addressed topics are no longer relevant only for a small community of CS researchers, since processor chips no longer contain a single CPU (or core) but instead are steadily growing to hundreds and thousands of cores, while current development tools are not yet able to produce efficient code for all platforms.

The talk on Monday, by Prof. Keshav Pingali (the Director of the Advanced Computing field in CoLab@Austin), showed that almost all scientific applications are based a small set of basic operations, from which it is possible to abstract rules and to bring reasoning to a higher level of abstraction when developing applications to take advantage of parallel platforms.

On Tuesday, Dr. Martin Burtscher showed that a GPU - that everyone

is now using as a vector co-processor to speed up their sc computations - can also be quite efficient to run non-regul plications. Results on a n-body simulation case showed that c GPU device can be faster than 16 of the fastest Intel Xeon c with 8 cores each. Dr. Martin also gave an extra talk to parallel puting students on a performance analy he developed, and is helping these stud install this tool in a cluster system and tar vantage of its outputs to improve the qua their code.

On Wednesday, Prof. Calvin Lin opened t sions with an introduction to the current opment in parallel languages that confc best of two competing worlds: a global v all data, and control on its locality to impro two speakers complemented this first s by showing how these new devices can ficiently programmed and how we should towards a real science of parallel program The audience followed all presentations w tive interventions, and dialogue was eas complished between each speaker and th ticipants. The coffee breaks were not long enough for all en from such active researchers.

As a closing remark, we believe that this type of events dc have a strong positive impact on the young generations.

■ WORKSHOP ON GPU PROGRAMMING FOR SCIENTIFIC APPLICATIONS

The *Workshop on GPU Programming for Scientific Applications* took place at the University of Coimbra, from 6th to the 8th July, in the framework of the UT Austin | Portugal Program.

During three days about 75 scientists of several areas learned how to develop high-performance applications using the latest GPUs in the market. This unique workshop counted with world-class experts: Jonathan Cohen from NVIDIA Inc., (UMinho) and Gabriel Falcão (DEEC/FCTUC). The challenge for the workshop was to implement the Floyd-Warshall algorithm that finds the shortest paths in a weighted graph. The contesters had to parallelize the algorithm and tune it to take the best performance out of the GPUs available. For the problem given, a quad-core i7 CPU would take over 6 minutes computing. Most participants improved the execution down to 80 seconds using a Tesla GPU. The winner got just 16 seconds with further optimizations.

Organized by the members of the CoLab of the University of Coimbra, the GPU workshop gathered almost 90 people in a unique atmosphere, and ended with a dinner by the river in a wonderful environment, where awards were presented to the winners of the competition: 1st place to Paulo Flores and Gil Lacerda, from IST Lisbon, 2nd place to Luís Ribeiro (DEEC/FCTUC) and 3rd place to José Rui Faustino and Micael Oliveira, Physics Department FCTUC.

Donal Fussel and Peter Ruymgaart from UT Austin and Martin Burtscher from Texas State University.

The workshop was divided in 3 morning presentations by our invited speakers and 3 practical workshops in the afternoon, where participants joined a programming competition. Attendees were divided into teams, supervised by Alcides Fonseca (DEI/FCTUC), Nuno Subtil (NVIDIA), João Barbosa

Jonathan Cohen, NVIDIA

Donald Fussel, UT Austin

Peter Ruymgaart, UT Austin

Parallel & Distribu

- **What to expect?**
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  - free attendance to international
  - free 5-week research internship
    in Austin, Texas (6 seats)

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■ Summer time news: Advanced Computing intern students at University of Texas at Austin

As it is becoming a tradition a group of Portuguese students from several universities around the country spent their summer working alongside with researchers at the University of Texas at Austin.

For six weeks, in July and August, eleven Portuguese students traveled to the capital of Texas, Austin, to spend their summer working with UT-Austin faculty and to integrate their research teams. As in previous years the spectrum of computer science fields that the students engaged in has wide ranging from **irregular application mapping to heterogeneous system, distributed computing platforms, data visualization and simulation to social and network information mapping and flow analysis.**

"This initiative contributes for the enrichment of those involved in a multitude of ways. Not only have I been learning and gaining a new perspective on several areas of Computer Science, I've also been applying what I was taught during the past few years in a real world scenario. This experience has been invaluable for me and, I'm sure, everyone involved…" stated David Neto from the University of Coimbra.

The advantages of the program and experience of working alongside top research team in several fields is one of the most common topic when talking with the students as referred by André Lourenço from the University of Coimbra: *"The internship enables students to interact closely with research teams working in state of the art topics of Computer Science… and learn from them."* Ricardo Alves from the University of Minho adds that the internships *"provides a bridge between Portuguese and UT-Austin research teams and transforms the student into a valuable asset for both…",* which is also a common filling among the students.

Nuno Silva and Ricardo Alves from the University of Minho, Ricardo Freitas and Tiago Henriques joined the High Performance Graphics and Parallels Systems group lead by Professor Donald Fussell. Nuno Silva focused is research on efficient

and physically based techniques to accurately represent the appearance of complex materials. *"Accurate appearance of materials such as cloth or leader still represents a major challenge in computers graphics today, specially is real-time is taken into account"*, Nuno stated.

Ricardo Alves dedicated is internship to mapping Barns-Hut irregular applications to heterogeneous platforms using the GAMA framework, still in development.

Ricardo Freitas and Tiago Henriques attempted to develop a program that simulates "drip painting", a form of abstract art in which point is dropped onto a canvas, using Lattice Boltzmann Model (LBM) as the fluid simulation technique.

Mónica Sofia and Tiago Gomes, from the U. of Coimbra and U. of Oporto respectively, joined Professor Keshav Pingali Distributed System group and worked closely with Dimitris Prountzos. Their project for the summer involved exploring new approaches to parallelize Lee's algorithm using Galois System.

André Costa (U.Minho) and André Lourenço (U.Coimbra) joined Vijay Garg distributed system group. André Costa worked in two projects, one to define new agreement policies for Accurate Byzantine Agreement and the other developing an efficient algorithm to decompose a finite state machine into smaller machines, which can ultimately be used to reduce the number of backups needed to support faults in distributed systems. While André Lourenço dedicated is internship to Faults Handling in Distributed Systems, more specifically on Fused Data Structures. *"I'm implementing two erasure correcting codes, raptor and turbo codes. Furthermore, I will be measuring the improvement they bring to the whole fusion fault handling system…"*he stated.

Professor Lili Qiu group welcomed David Neto and Carlos Mota, from the University of Coimbra into the research group. Under her tutoring David and Carlos develop information-gathering tools directed towards social networks in order to find and map traffic flow patterns of their users. To achieve their goal they exploited distributed crawling

Parallel & Distributed Computing

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  - free 5-week research intern in Austin, Texas (6 seats)

- **More information?**
  - check last year website
  - talk to previous students
  - come & try this course…
  - questions?

  A. Proença, J.L.Sobral, R. Ralha

Computação Paralela Distribuída
Mestrados em Informática e Eng.ª Informática
2010/2011
Docente responsável: A. Proença

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Avisos | Equipa docente | Objectivos | Resultados de Aprendizagem | Programa | Bibliografia | Sumários: SCD PAC PCP AMN PI | Avaliação

(Ano anterior: 2009/2010)

Ultima Modificação: 12 Abr 2011

departamento de informática

Avisos:

1. **Guião com o Projecto Integrado:** já se encontra disponível junto dos sumários de PI. *(12-Abr-11)*

2. **Estágios de investigação no Texas:** à semelhança do sucedido em anos anteriores, os alunos desta UCE terão a oportunidade de realizar um estágio de 5 a 6 semanas na Univ. Texas em Austin, mais concretamente trabalhando integrado em equipas

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Computação Paralela Distribuída (2010/11)

- **Objectivo:** formar profissionais competentes em
  - **Processadores: single-/multi-core, genéricos/especializados (CPU/GPU)**
  - **Sistemas: homogéneos/heterogéneos, multi-processador/cluster/grid**
  - **Programação paralela: linguagens, algoritmos, bibliotecas, depuração**
  - **Métodos numéricos em ciências/engª computacional** (Fís, Engª Mec, CGráf)

- **Vectores de formação**
  - **Sistemas de Computação e Desempenho**
  - **Paradigmas de Computação (Paralela / Distribuída)**
  - **Algoritmos e Métodos Numéricos**
  - **Planeamento e Administração de Clusters / Grid**

- **Formação complementar**
  - **Palestras: multidisciplinares e c/ investigadores convidados**
  - **Workshops: em temas avançados** (Intel, HP, IBM, NVidia)
  - **Estágios: em empresas/centros I&D no Texas** (c/ viagem+estadia)
  - **I&D: projectos nacionais/internacionais** (c/ bolsa de investigação)

- **Equipa docente**
  - **Do DInf (A.Proença / A.Pina / J.Sobral) e do DMatApl (R.Ralha)**
  - **Na GRID Ibérica e no acordo c/ UTexas em** *Advanced Computing*