



Arhitectura Sistemelor de Calcul – Curs 14



Computer Science
& Engineering
Department

Universitatea Politehnica Bucuresti
Facultatea de Automatica si Calculatoare

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Cuprins

2

- Top 500 Supercomputers (<http://www.top500.org>)
 - Prezentare generala
 - Benchmark – LINPACK(HPL)
- Top 10
 - Motivatie
 - Info – locatie/furnizor
 - Arhitectura
 - Performante LINPACK
 - OS & Software
 - Aplicatii
- Concluzii Top 500
- Cate ceva despre examen: mod de notare, etc...



www.top500.org

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- Proiect demarat in 1993 (Iunie 1993)
- Lista actualizata a celor mai puternice 500 de sisteme de calcul de **uz general**, disponibile **comercial** in lume si folosite la **aplicatii complexe**
- Statisticile referitoare la supercalculatoare sunt interesante pentru
 - Dezvoltatorii de sisteme (producatorii de HW & SW)
 - Utilizatori
 - Potentialii viitori utilizatori
- Se doreste cunoasterea
 - Numarului si locatiei sistemelor
 - Domeniilor de aplicatie ale sistemelor → facilitarea unor potentiale colaborari



www.top500.org

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- Lista este publicata de 2 ori pe an
- Benchmark – versiune paralela a Linpack – HPL (Jack Dongarra @ ICL, University of Tennessee)
 - <http://www.netlib.org/benchmark/hpl/>
 - Rezolvarea unui sistem dens de ecuatii liniare
 - Nu reflecta intr-un mod exhaustiv performanta intregului sistem!
 - Dimensiunea problemei poate fi modificata pentru a se potrivi cel mai bine pe arhitectura sistemului masurat
- A 40-a lista a fost publicata la SC12 (Supercomputing Conference – US)
- A 41-a va fi publicata la ISC13 (International Supercomputing Conference – Leipzig, Germania)



The LINPACK Benchmark

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- Linpack a fost ales pentru ca
 - Este extrem de raspandit si utilizat
 - Date si teste pentru acest program sunt disponibile pentru “toate” sistemele relevante din lume
- Benchmark-ul masoara cat de repede rezolva computer-ul un sistem dens de ecuatii liniare $A \cdot x = b$ de dimensiune $n \cdot n$
- Solutia se bazeaza pe metoda eliminarii Gaussiene, utilizand pivotarea partiala
- Conduce la $\frac{2}{3} \cdot n^3 + n^2$ operatii in virgula mobila $O(n^3)$
- Se exclude utilizarea metodelor optimizate de inmultire a matricelor de genul metodei lui Strassen $O(n^2)$
- In acest mod se vor genera milioane de operatii in virgula mobila pe secunda (Mflop/s)
- Rezolvarea sistemelor de ecuatii liniare este o problema intalnita **frecvent** in aproape orice aplicatie stiintifica sau inginereasca



The LINPACK Benchmark

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- Avantaje
 - Rpeak = performanta maxima teoretica de varf (in functie de CPU)
 - Linpack ofera ca rezultat un **singur** numar
 - Rmax = performanta maxima realizata
 - Usor de definit si usor de clasificat pe baza lui
 - Permite modificarea dimensiunii problemei – Jaguar 5.4×10^6
 - Ocupa sistemul testat cu un job de lunga durata
- Dezavantaje
 - Scoate in evidenta **doar** viteza “peak” si numarul de procesoare
 - **Nu** evidentiaza rata de transfer locala (bandwidth)
 - **Nu** evidentiaza reseaua de comutare
 - **Nu** testeaza mecanisme de tipul gather/scatter
- Un singur numar nu poate caracteriza performanta totala a unui sistem de calcul!



Cuprins

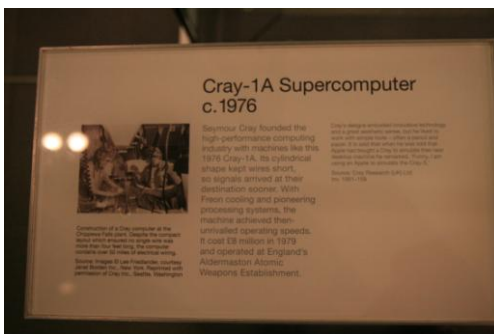
7

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Motivatie – HW Then & Now...

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Motivatie – Domenii de Aplicatie

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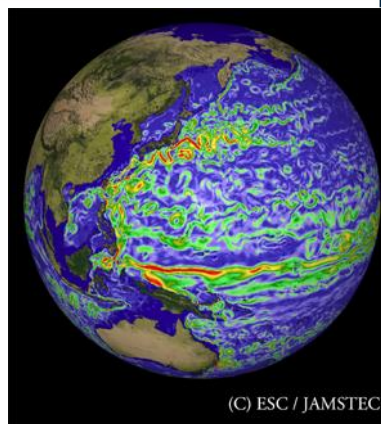
**(No) more
Kaboom...**



Motivatie – The Earth-Simulator

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- Simulari atmosferice pentru Agentia Aerospatiale a Japoniei
- Simulari oceanice pentru Centrul Japonez de Stiinte si Tehnologii Marine
- Simulari industriale
- **Simulari atomice pentru Insititutul Japonez de Cercetari Atomice**





NEC Earth-Simulator

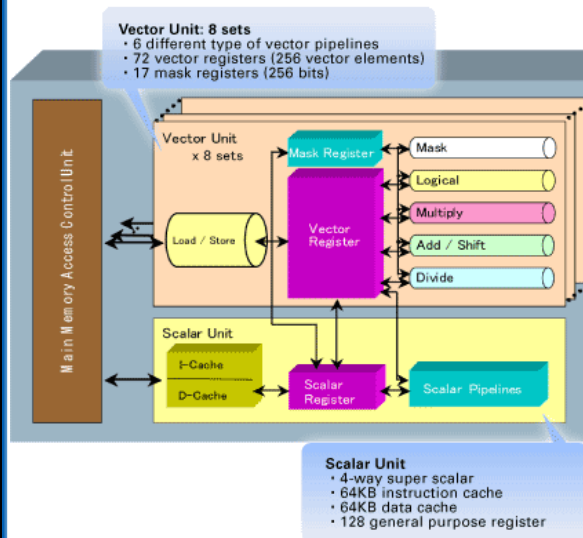
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- Site: The Earth Simulator Center
- Familia de sisteme: NEC Vector
- Model: SX6
- Procesor: NEC 1000MHz
- OS: Super-UX
- Arhitectura: MPP
- Aplicatii: studiul mediului
- Anul instalarii: 2002
- Numar de procesoare: 5120
- Rmax(TFlops): 35.86
- Rpeak(TFlops): 40.96
- Interconectare: Multi-stage crossbar
- No 1 intre 2002-2004



Procesoare Vectoriale SX6

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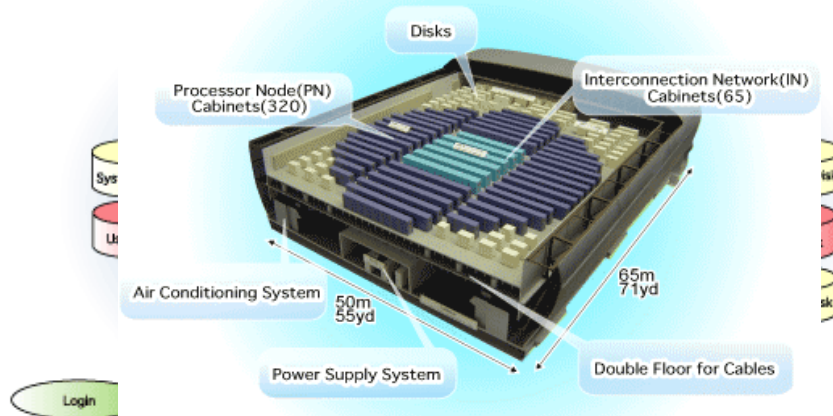


- Unitate Scalara (SU)
- Unitate Vectoriala (VU)
- Frecventa – 500 MHz
- SU – procesor super-scalar: 64Kb instr cache; 64Kb data cache; 128 registrii de uz general
- VU – 72 registrii vectoriali cu 256 elemente & 8 seturi de 6 benzi de asamblare pentru operatii logice si aritmetice
- Tehnologie de fabricatie: LSI, 0.15µm CMOS, 60 mil. tranzistori
- Consum 140 W



Arhitectura Earth-Simulator

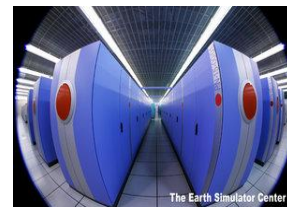
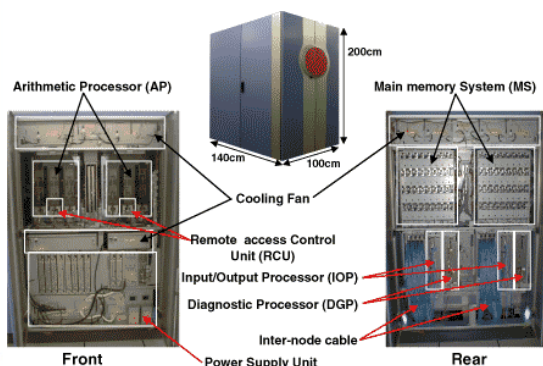
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Arhitectura Fizica Earth-Simulator

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- Fiecare 2 noduri sunt instalate într-un container (1x1.4x2m)
- Fiecare container consumă 20 KW → 8MW
- Memoria sistemului este de 10TB
- Spatiu de stocare pe disc 700 TB
- Stocare in masa pe banda 1.6 PB





Columbia – SGI Altix

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- Site: NASA/Ames Research Center/NAS
- Familia de sisteme: SGI® Altix™
- Model: SGI® Altix™ 3700, Voltaire Infiniband
- Procesoare: Intel IA-64 Itanium 2 1.5 GHz
- OS: SuSE Linux Enterprise Server 9
- Arhitectura: MPP
- Aplicatii: Cercetari aerospatiale
- Anul instalarii: 2004
- Numar de procesoare: 10240
- Rmax(TFlops): 51.870
- Rpeak(TFlops): 60.960
- Interconectare: Numalink/Infiniband



Columbia – Arhitectura

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- Botezat astfel în memoria echipajului de pe Columbia (1 februarie 2001)
- Utilizeaza 20 superclustere Altix™ din seria 3000
 - 8 SGI Altix 3700 si 12 Altix 3700 Bx2
 - 4 din Bx2-uri formeaza un 2048-PE (processor shared memory environment)
- Are 10.240 procesoare Intel Itanium 2 (1.5GHz, 6MB Cache)
- Pana la 24 TB de Global shared memory pe fiecare cluster

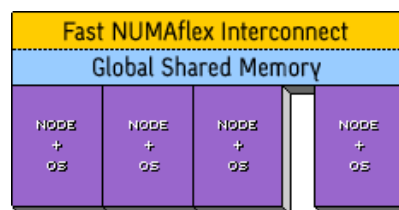




Columbia – Interconectare

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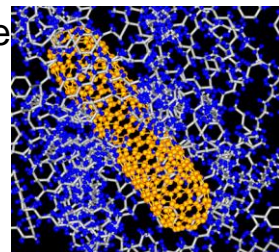
- Nodurile sunt conectate prin Voltaire InfiniBand si prin Ethernet de 1 si 10 Gb/s
- Columbia este conectat la un on-line RAID printr-o conexiune Fibre Channel → 440TB
- Conectarea procesoarelor prin SGI®NUMAlink™ → design modular
 - 2048 de procesoara folosesc NumaLink si pentru conectarea dintre noduri
 - Singura tehnologie care ofera global shared memory si intre noduri, nu doar in cadrul clusterului



Columbia – Software

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- OS: SGI ProPack 4 – bazat pe SUSE Linux
- Compilatoare Intel® Fortran/C/C++ & Gnu
- Fiecare nod de 512 procesoare ofera
 - Latență mică la accesul mem (<1 ms) → reduce overheadul in comunicare
 - Global shared mem de 1TB → procesele mari rămân rezidente
- Optim pentru aplicatii cu comunicare masiva intre procesoare
 - Simulări fizice in care domeniul este discretizat → CFD
 - Prognoza meteo & Nanotehnologii
 - N-Body simulations → Astrofizica

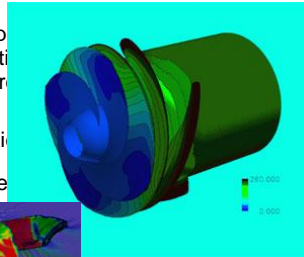




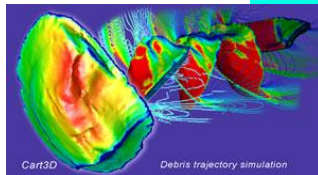
Columbia – Aplicatii

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- Cart3D:
 - O simulare utilizata pentru a prezice spuma desprinse in timpul ascensiunii
 - Culorile reprezinta presiunea

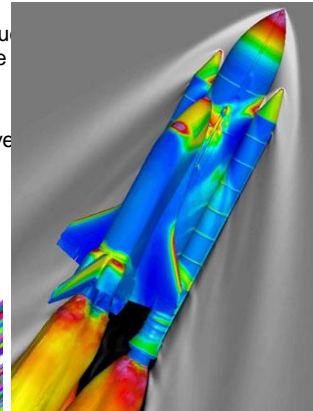
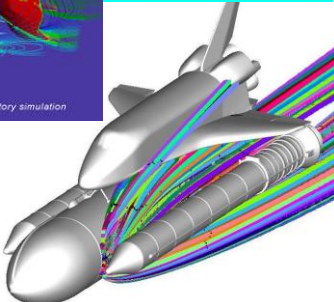


- Debris:
 - Codul calculeaza traiectoriile dezbrii in timpul ascensiunii
 - Ajuta la evaluarea pericolului



din jurul vehiculului

- Phantom:
 - Este un alt cod CF pentru reactie
 - Iata asadar presiunea in jurul principal al navetei



, nestationare in motoare cu
rului principal al navetei



MareNostrum JS20 Cluster

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- Site: Barcelona Supercomputing Center
- Familia de sisteme: IBM Cluster
- Model: BladeCenter JS20 Cluster
- Procesoare: PowerPC 970 2.3 GHz
- OS: SuSE Linux Enterprise Server 9
- Arhitectura: Cluster
- Aplicatii: Medicina
- Anul instalarii: 2006
- Numar de procesoare: 10240
- Rmax(TFlops): 62.630
- Rpeak(TFlops): 94.208
- Interconectare: Red Myrinet

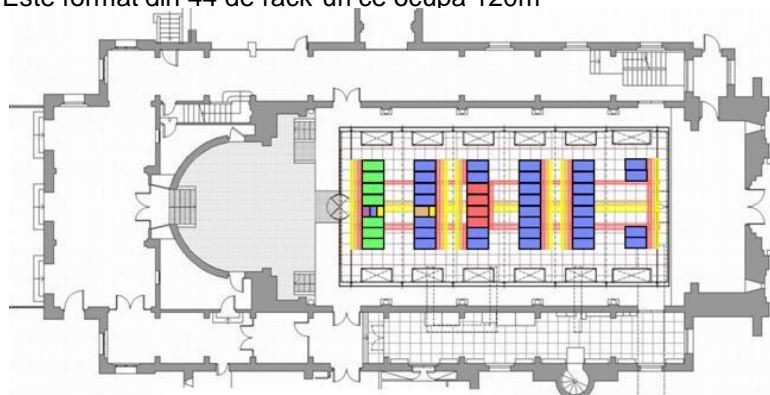




Arhitectura MareNostrum

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- Memorie totala 20TB
- Capacitate de stocare: 370TB
- Este format din 44 de rack-uri ce ocupa 120m²



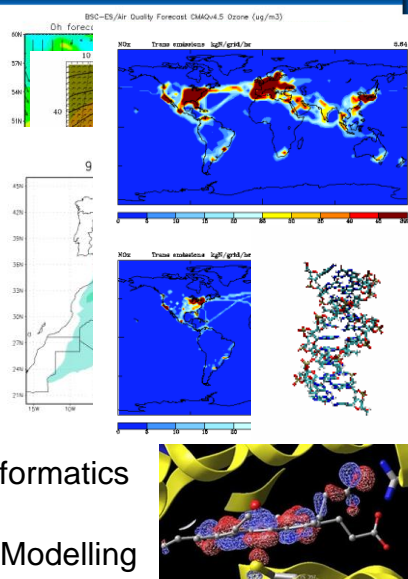
■ Blade centers ■ Storage servers ■ Gigabit switch
■ Myrinet racks ■ Operations rack ■ 10/100 switches



Aplicatii MareNostrum

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- Computational Sciences:
 - Computer Architecture
 - Performance Tools
 - Grid Computing & Clusters
- Earth Sciences
 - Air Quality
 - Meteorological Modelling
 - Mineral Dust
 - Climate Change
- Life Sciences
 - Molecular Modelling & Bioinformatics
 - Computational Genomics
 - Electronic & Atomic Protein Modelling

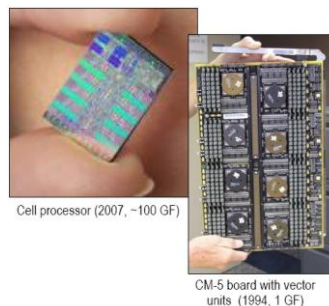




IBM RoadRunner

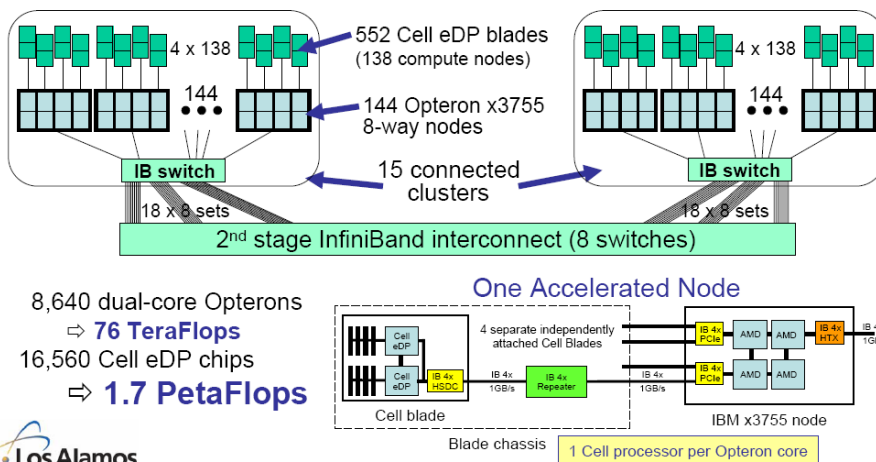
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- Site: DOE/NNSA/Los Alamos NL
- Familia de sisteme:
- Model: BladeCenter QS22 Cluster
- Procesoare: PowerXCell 8i 3.2 GHz
- OS: Linux
- Arhitectura: Cluster
- Memorie: 104TB
- Aplicatii: Cercetare
- Anul instalarii: 2008
- Numar de procesoare: 122.400
- Rmax(**PFlops**): 1,042 (NMax 2,25M)
- Rpeak(**PFlops**): 1,376
- Consum: 2345 KW
- Interconectarea: Voltaire Infiniband



Arhitectura RoadRunner

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Programare RoadRunner

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- **Computational Library (ALF w/ IBM)**

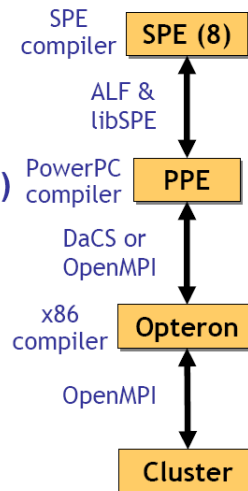
- Task & work block queuing & management
- Streaming & user-defined data partitioning
- Process management
- Error handling

- **Communication Library (DaCS w/ IBM)**

- Data movement & synchronization
- Process management & synchronization
- Topology description
- Error handling
- First implementation may leverage OpenMPI

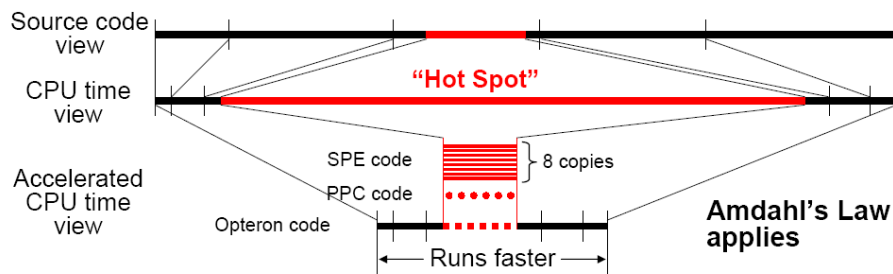
- **Longer term**

- ALF & DaCS support in tools
- ALF from Opteron \Rightarrow Cell directly
- Compilers supporting some of this



Programare Hibrida pe RoadRunner

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- **Hybrid programming will be a challenge!**

- No compiler switches to "just use the Cells"
- Not even a single compiler – 3 of them
- Code developer/architect must decompose application and create cooperative program pieces

Top 10


Rank	Site	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	DOE/SC/Oak Ridge National Laboratory United States	Titan - Cray XK7 , Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x Cray Inc.	560640	17590.0	27112.5	8209
2	DOE/NNSA/LLNL United States	Sequoia - BlueGene/Q, Power BQC 16C 1.60 GHz, Custom IBM	1572864	16324.8	20132.7	7890
3	RIKEN Advanced Institute for Computational Science (AICS) Japan	K computer , SPARC64 VIIIx 2.0GHz, Tofu interconnect Fujitsu	705024	10510.0	11280.4	12660
4	DOE/SC/Argonne National Laboratory United States	Mira - BlueGene/Q, Power BQC 16C 1.60GHz, Custom IBM	786432	8162.4	10066.3	3945
5	Forschungszentrum Juelich (FZJ) Germany	JUQUEEN - BlueGene/Q, Power BQC 16C 1.600GHz, Custom Interconnect IBM	393216	4141.2	5033.2	1970
6	Leibniz Rechenzentrum Germany	SuperMUC - iDataPlex DX360M4, Xeon E5-2680 8C 2.70GHz, Infiniband FDR IBM	147456	2897.0	3185.1	3423
7	Texas Advanced Computing Center/Univ. of Texas United States	Stampede - PowerEdge C8220, Xeon E5-2680 8C 2.700GHz, Infiniband FDR, Intel Xeon Phi Dell	204900	2660.3	3959.0	
8	National Supercomputing Center in Tianjin China	Tianhe-1A - NUDT YH MPP, Xeon X5670 6C 2.93 GHz, NVIDIA 2050 NUDT	186368	2566.0	4701.0	4040
9	CINECA Italy	Fermi - BlueGene/Q, Power BQC 16C 1.60GHz, Custom IBM	163840	1725.5	2097.2	822
10	IBM Development Engineering United States	DARPA Trial Subset - Power 775, POWER7 8C 3.836GHz, Custom Interconnect IBM	63360	1515.0	1944.4	3576



10 – DARPA Trial Subset

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- Site: IBM Development Engineering
- Familia de sisteme: Power 775
- Model: Power7
- Procesor: POWER7 8C 3.836GHz
- OS: Linux
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2012
- Numar de core-uri: 63.360
- Rmax(PFlops): 1,515
- Rpeak(PFlops): 1,944
- Consum: 3.576 KW
- Interconectare: Custom



PowerPC@ASC



9 – Fermi

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- Site: CINECA
- Familia de sisteme: 10 BGQ Power Frames
- Model: IBM-BG/Q
- Procesor: IBM PowerA2, 1.6 GHz
- OS: CNK/Linux
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2012
- Numar de core-uri: 163.840
- Rmax(PFlops): 1,726
- Rpeak(PFlops): 2,097
- Consum: 822 kW
- Interconectare: Custom 5D Torus – 11 Links



BG@uvt.ro



Arhitectura IBM BlueGene

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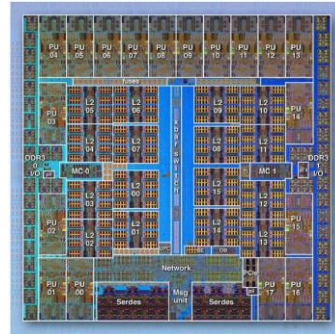
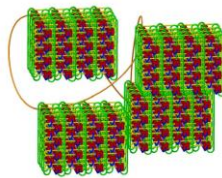
- Program initiat de IBM in 1999 pentru a construi “a petaflop scale machine”
- BlueGene/L – primul pas, bazat pe procesoare PowerPC
 - Spatiu de adresare mare
 - Compilatoare standard
 - Bazat pe middleware de “message passing” deja existent
 - A necesitat adaugiri semnificative fata de sistemul PowerPC standard
- Un nod computational = computer-on-a-chip – ASIC:
 - Procesoare IBM PowerPC
 - Memorie DRAM embedded
 - L1-3 cache embedded
 - Multiple module de interconectare folosind retele de comutare de mare viteza



Arhitectura IBM BlueGene (2)

31

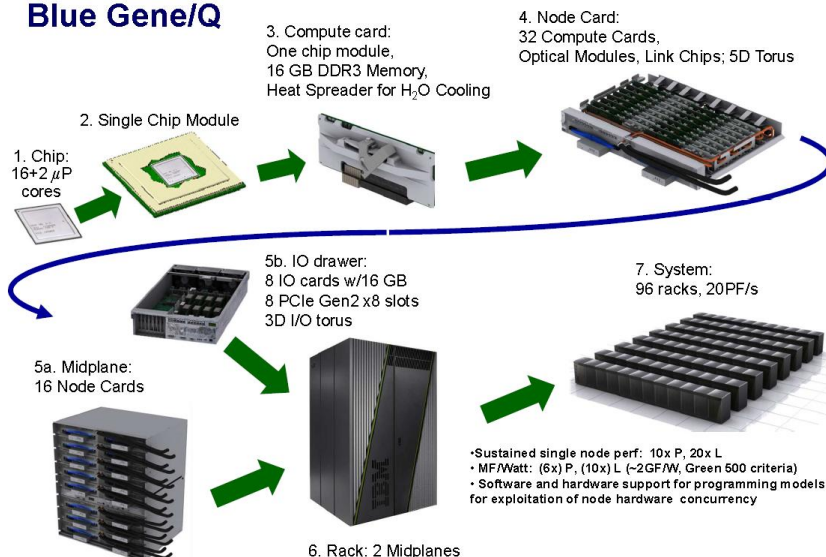
- **Memorie:** 1GB DDR RAM / core – 16GB pe nod
 - Doua controlere de memorie externa de tip DDR integrat on-chip la 1.33GHz
- **Procesor:**
 - 18 core at 1.6GHz: 16 computationale, unul pentru OS, unul de backup
 - 32MB DRAM L2 Cache: transactional memory & executie speculativa
 - Quad SIMD floating point unit
 - 45nm cu performanta maxima de 204.8 GFLOPS
 - Consuma 55W la 19.19mm si 1.47 B tranzistoare
- **Interconectare:**
 - Tor 5D cu un router pe nod cu 11 link-uri
 - Procesor I/O extern dedicat – 2GB/s
 - Core-urile legate printr-un crossbar
- **I/O extern:**
 - Noduri dedicate pentru I/O extern
 - Reteaua este de tip arborescent
- **OS**
 - CNK/Linux
- **Software**
 - MPI
 - OpenMP
 - Charm++
 - Global Arrays, Posix I/O



Arhitectura IBM BlueGene (3)

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Blue Gene/Q

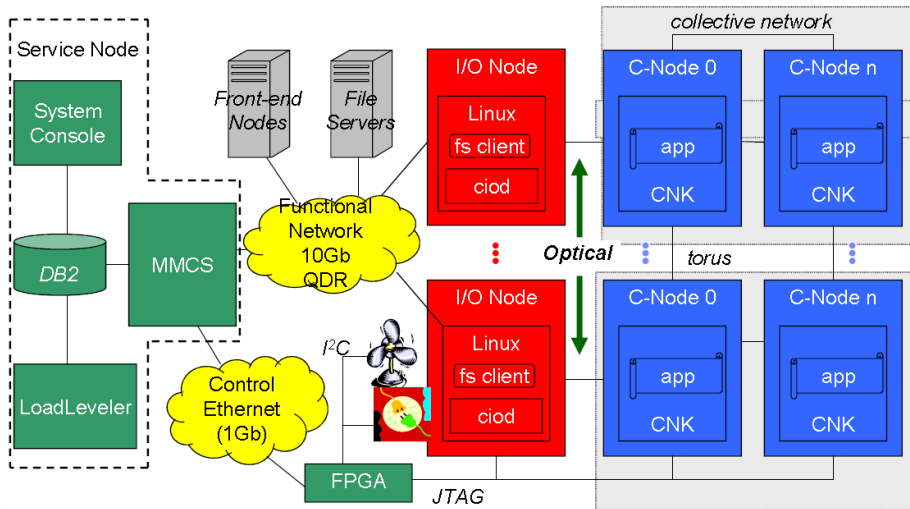


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Arhitectura IBM BlueGene (4)

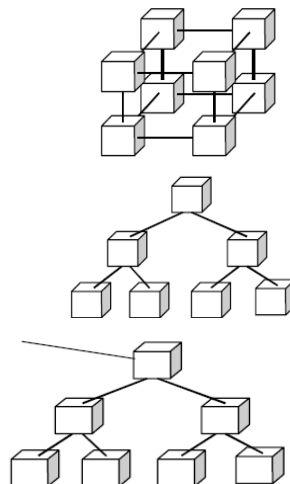
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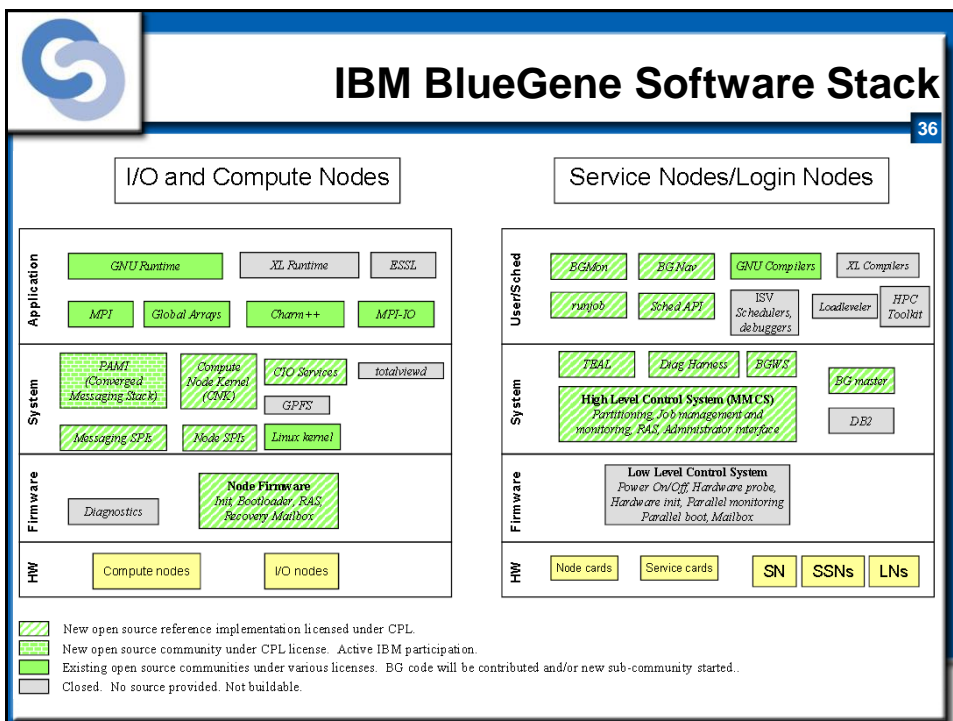
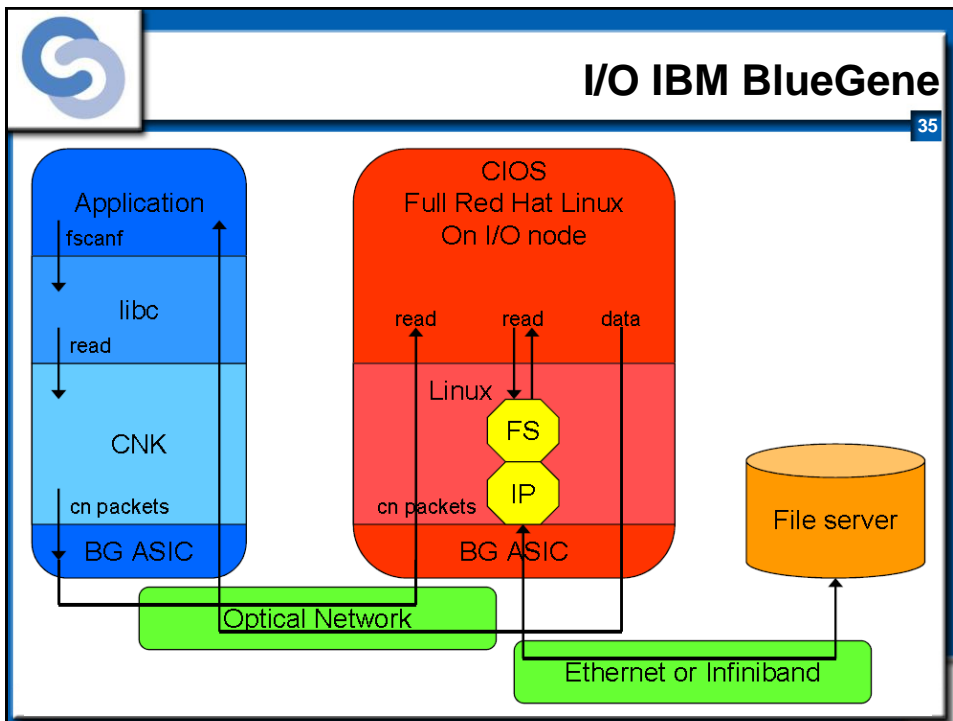


Retele de Comunicatie IBM BlueGene

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- Nodurile sunt atasate la 5 retele de comunicatie:
 - Retea toroidala 5D pentru comunicatii intre noduri
 - Retea colectiva de comunicatii
 - Retea globala de intreruperi si bariere
 - Pentru I/O – Gigabit Ethernet
 - Joint Test Access Group Gigabit Ethernet – pentru control si monitorizare

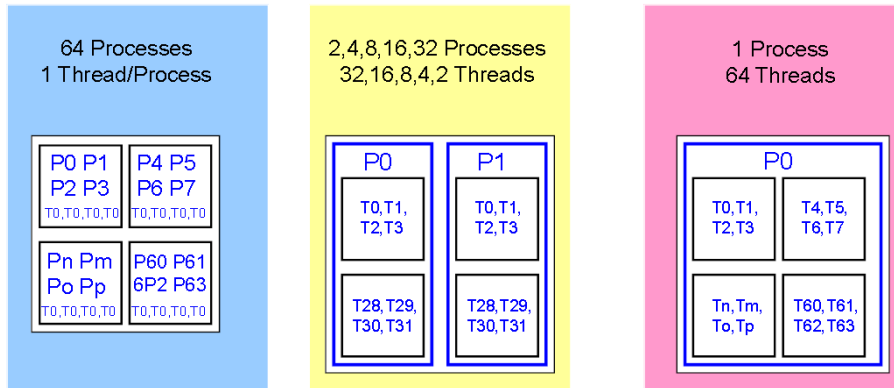






IBM BlueGene – Mod de executie

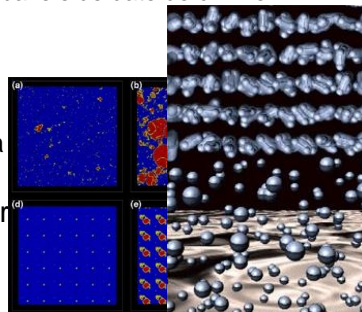
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Aplicatii IBM BlueGene

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- Favorizeaza aplicatii care utilizeaza comunicarea cu vecinii imediati
- BlueGene e dezvoltat pentru aplicatii cu volum mare de date
 - Analiza proteinelor
 - Interactiunea intre medicamente si proteine
 - Catalizarea enzimelor
 - Rafinarea structurilor moleculare
 - Identificarea parametrilor unor structuri folosite in recunoasterea "impaturirii" unor proteine
 - Identificarea parametrilor in structuri din bazele de date de chimie
 - Modelare si simulare
 - Data Mining
 - Fizica atomica: similar cu ASC Purple
 - Dinamica moleculara (inclusiv ab-initio)
 - Hidrodinamica steady state si turbulenta
 - Astrofizica
- Daca cercetarile vor avea succes se vor
 - Alzheimer
 - Fibroza cistica
 - Boala vacii nebune





8 – Tianhe-1A TH MPP

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- Site: National SuperComputer Center in Tianjin/NUDT
- Familia de sisteme: NUDT Cluster
- Model: NUDT YH MPP
- Procesor: Intel Xeon 5670 2.93Ghz 6C, NVIDIA GPU
- OS: Linux
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2010
- Numar de core-uri: 186.368
- Rmax(**PFlops**): 2,566 (NMax 3,6M)
- Rpeak(**PFlops**): 4,701
- Consum: 4040 KW
- Interconectare: Infiniband DDR 4x



Tianhe-1 – Caracteristici de Sistem

40

- Hybrid architecture with heterogeneous processors
 - 6144 Quadcore Intel Xeon CPUs and 5120 AMD GPUs
- Compute nodes
 - 2560 compute nodes totally with 32GB memory
- Operational node
 - 512 nodes with 2 Quadcore Xeon & 32GB memory
- Interconnection subsystem
 - Infiniband QDR: 40Gbps bandwidth & MPI latency 1.2us
- I/O storage subsystem:
 - Lustre parallel file system in 64 nodes and 1PB
- Compiling system
 - Supporting C/C++, Fortran77/90/95, Java, OpenMP and MPI
 - Providing a programming framework for hybrid architecture, which supports adaptive task partition and streaming data access

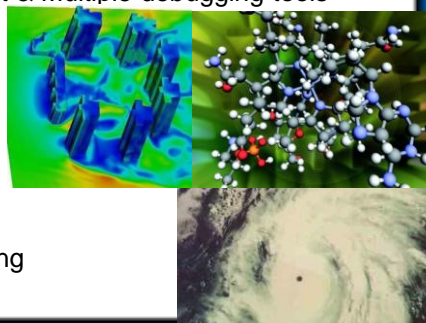




Tianhe-1 – Aplicatii

41

- Resource management subsystem:
 - Providing a uniform view of heterogeneous resources in the TH-1
 - Support multiple policies for task scheduling and resource allocation
 - Supporting multi-level Checkpoint/Restart
- Development kit for parallel programming:
 - Integrated Development Environment & Multiple debugging tools
- Applications:
 - Petroleum exploration
 - Biological medicine research
 - Simulation of large aircraft design
 - Remote sensing data processing
 - Data analyzing of financial engineering
 - Simulation of environment research



7 – Stampede

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- Site: Texas Advanced Computing Center/Univ. of Texas
- Familia de sisteme: Dell PowerEdge
- Model: PowerEdge C8220
- Procesor: Xeon E5-2680 8c 2.700 GHz, Xeon Phi
- OS: Linux (CentOS)
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2012
- Numar de core-uri: 204.900
- Rmax(PFlops): 2,660
- Rpeak(PFlops): 3,959
- Memorie: 205TB
- Interconectare: Infiniband FDR





6 – SuperMUC

43

- Site: Leibniz Rechenzentrum
- Familia de sisteme: iDataPlex
- Model: iDataPlex DX360M4
- Procesor: Xeon E5-2680 8C 2.70GHz
- OS: Linux
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2012
- Numar de core-uri: 147.456
- Rmax(PFlops): 2,897
- Rpeak(PFlops): 3,185
- Consum: 3.423 kW
- Interconectare: Infiniband FDR

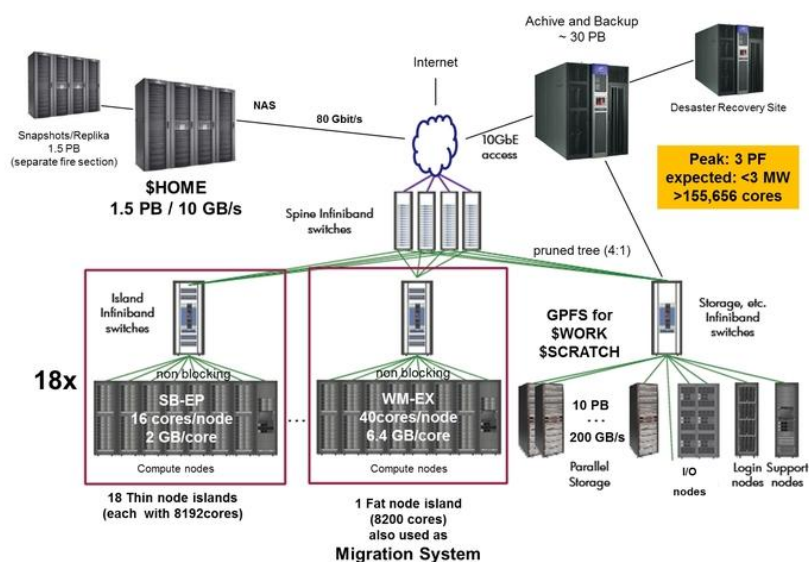


ASC@UPB: Alin Murarasu



SuperMUC – Arhitectura Sistemului

44





5 – JuQueen BlueGene/Q

45

- Site: Forschungszentrum Juelich (FZJ)
- Familia de sisteme: BGQ Power
- Model: IBM-BG/Q – 28 Frames
- Procesor: IBM PowerA2, 1.6 GHz
- OS: CNK/Linux
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2012
- Numar de core-uri: 393.216
- Rmax(PFlops): 4,141
- Rpeak(PFlops): 5,033
- Consum: 1.970 kW
- Interconectare: Custom



ASC@UPB: Monica Bugeanu & Alex Calatoiu



4 – Mira BlueGene/Q

46

- Site: DOE/SC/Argonne National Laboratory
- Familia de sisteme: BGQ Power
- Model: IBM-BG/Q – 48 Frames
- Procesor: IBM PowerA2, 1.6 GHz
- OS: CNK/Linux
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2012
- Numar de core-uri: 786.432
- Rmax(PFlops): 8,162
- Rpeak(PFlops): 10,066
- Consum: 3.945 kW
- Interconectare: Custom

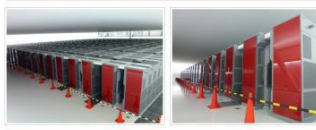
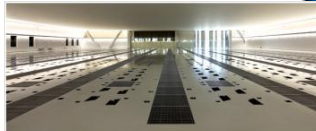




3 – K Computer

47

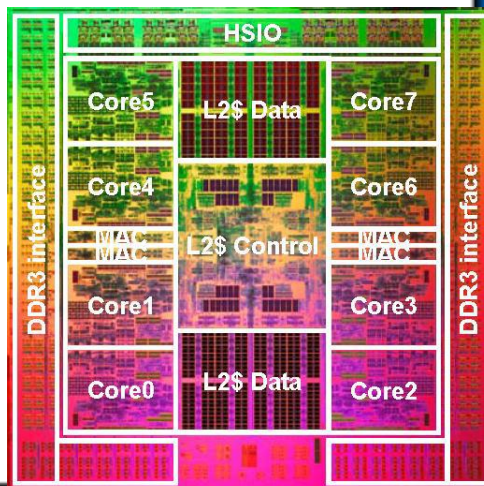
- Site: RIKEN Advanced Institute for Computational Science
- Familia de sisteme: Fujitsu – SPARC64 VIIIfx 2.0GHz
- Model: IBM-BG/Q – 48 Frames
- Procesor: SPARC64 VIIIfx 2.0GHz (8-core)
- OS: Linux
- Arhitectura: Cluster
- Aplicatii: Cercetare
- Anul instalarii: 2011
- Numar de core-uri: 705.024
- Rmax(PFlops): 10,510
- Rpeak(PFlops): 11,280
- Consum: 12.660 kW
- Interconectare: Custom – Tofu

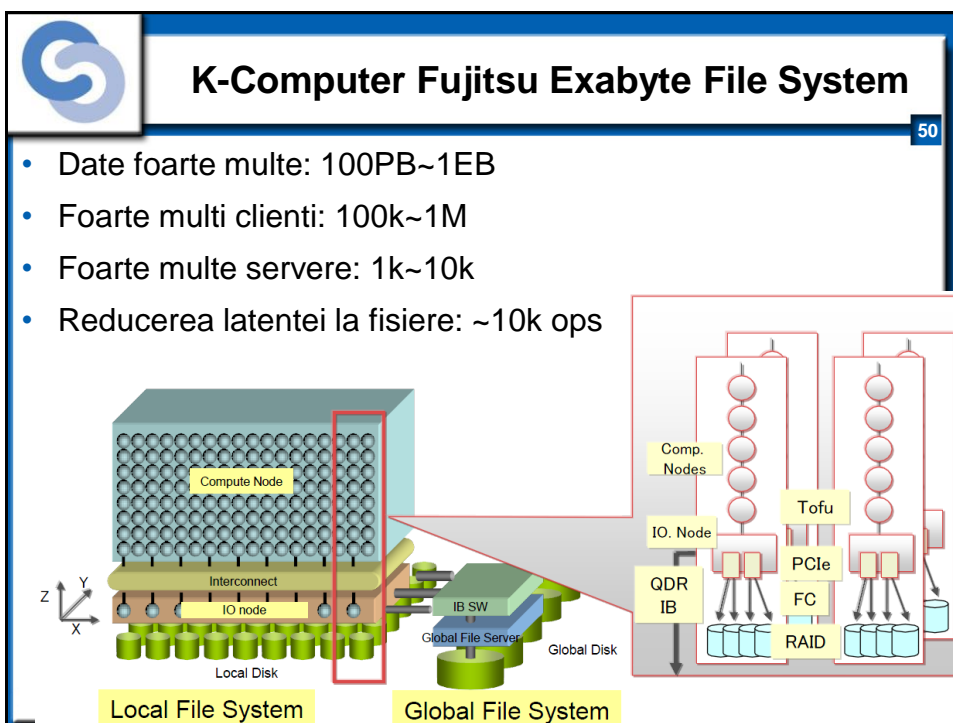
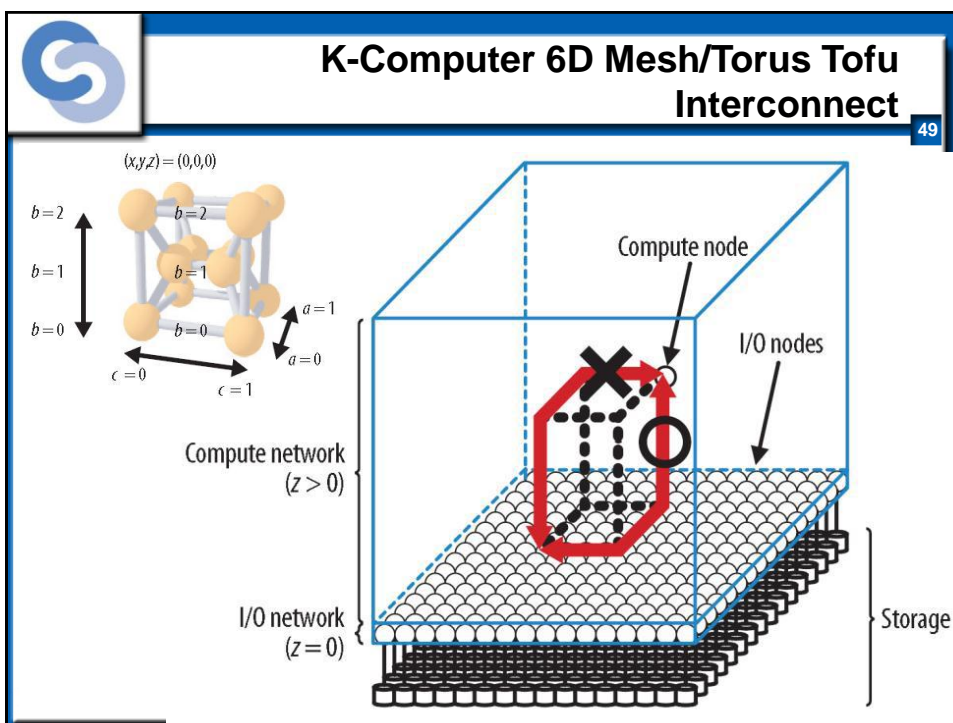


K Computer Processor

48

- 8 cores @ 2GHz – SoC design
- Embedded Memory Controller
- Shared 5M L2 Cache
- 45nm – 760M tranzistori
- 128GFlops (peak)
- 64GB/s transfer la memorie
- 58W si racire cu apa
- Set de registri mare
 - 192 registri int
 - 256 registri fp
- Unitati SIMD
- Software Managed Cache

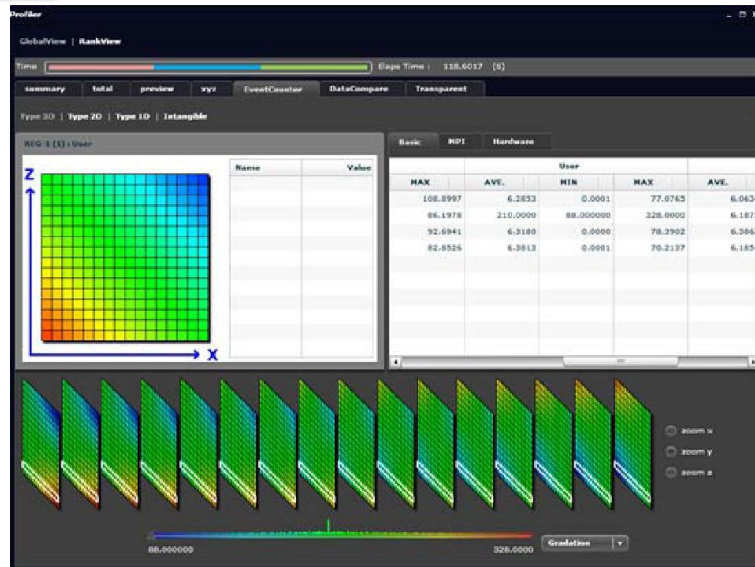






K-Computer Performance Tuning

51



2 – Sequoia BlueGene/Q

52

- Site: DOE/NNSA/LLNL
- Familia de sisteme: BGQ Power
- Model: IBM-BG/Q – 96 Frames
- Procesor: IBM PowerA2, 1.6 GHz
- OS: CNK/Linux
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2011
- Numar de core-uri: 1.572.864
- Rmax(PFlops): 16,324
- Rpeak(PFlops): 20,132
- Consum: 7.890 kW
- Interconectare: Custom





1 – Titan Cray XK7

53

- Site: DOE/SC/Oak Ridge National Laboratory
- Familia de sisteme: Cray XK7
- Procesoare: Opteron 6274 16C 2.200GHz, NVIDIA K20x
- OS: Cray Linux
- Arhitectura: MPP
- Aplicatii: Cercetare
- Anul instalarii: 2012
- Numar de procesoare: 560.640
- Memorie: 710.144 GB
- Rmax(**PFlops**): 17,590
- Rpeak(**PFlops**): 27,113
- Consum: 8.209 KW
- Interconectarea: Cray Gemini interconnect



Advancing the Era of Accelerated Computing

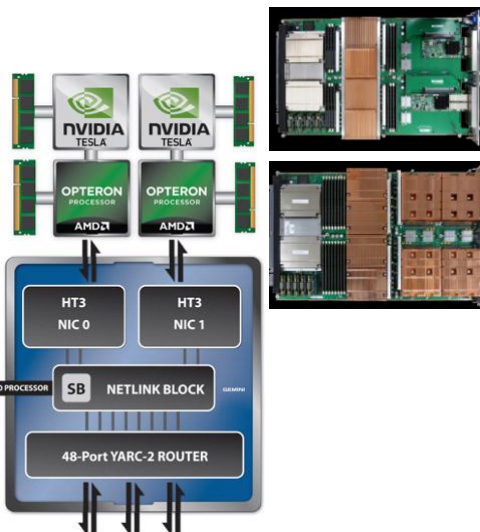
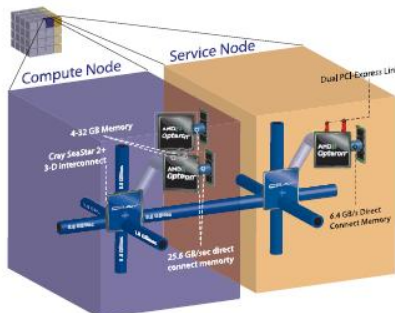


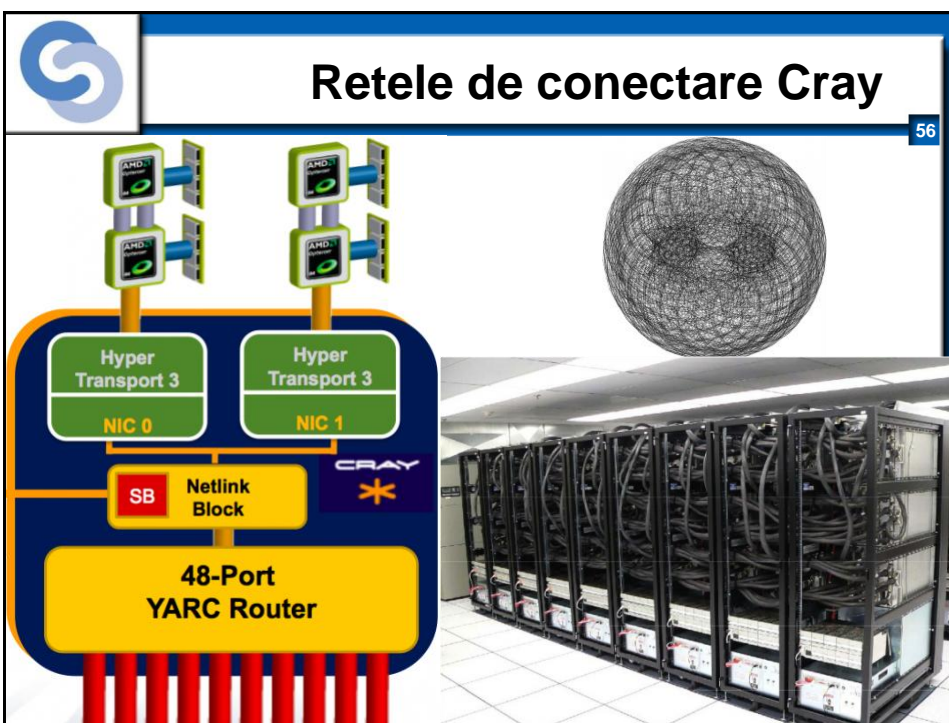
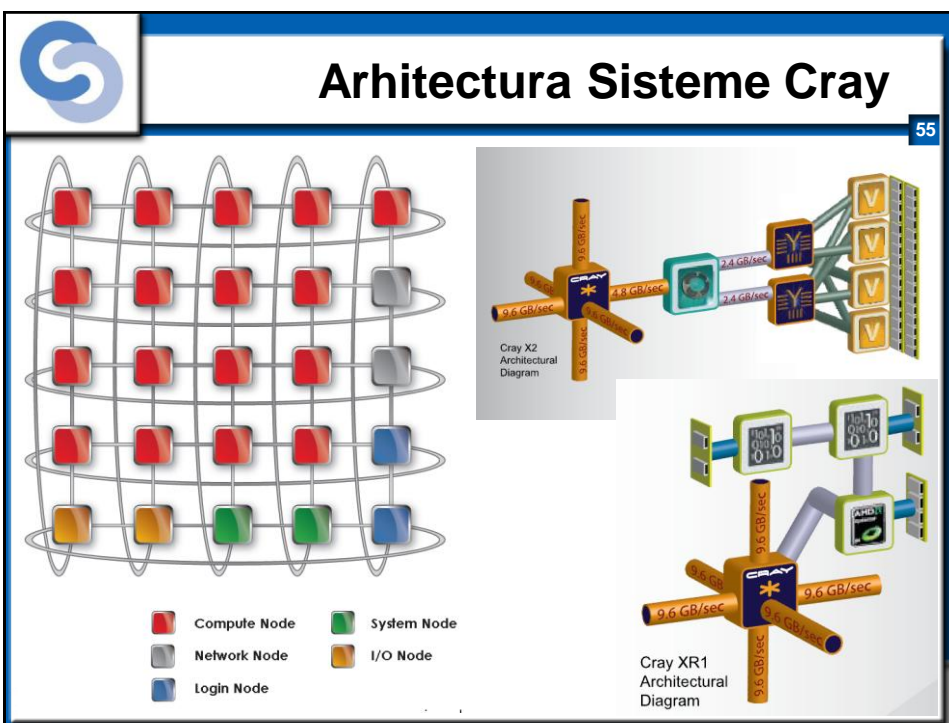
ENERGY Oak Ridge QLCF



Arhitectura Cray XK7

54





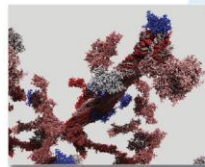
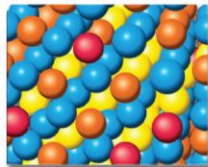


Titan - Aplicatii

57

WL-LSMS

Role of material disorder, statistics, and fluctuations in nanoscale materials and systems.



LAMMPS

A multiple capability molecular dynamics code.

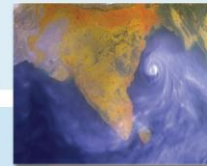


S3D

Combustion simulations to enable the next generation of diesel/bio fuels to burn more efficiently.

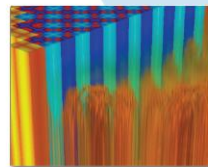
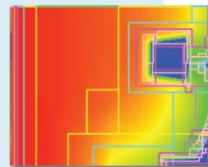
CAM-SE

Answers questions about specific climate change adaptation and mitigation scenarios.



NRDF

Radiation transport – important in astrophysics, laser fusion, combustion, atmospheric dynamics, and medical imaging – computed on AMR grids.



Denovo

High-fidelity radiation transport calculations that can be used in a variety of nuclear energy and technology applications.



Cuprins

58

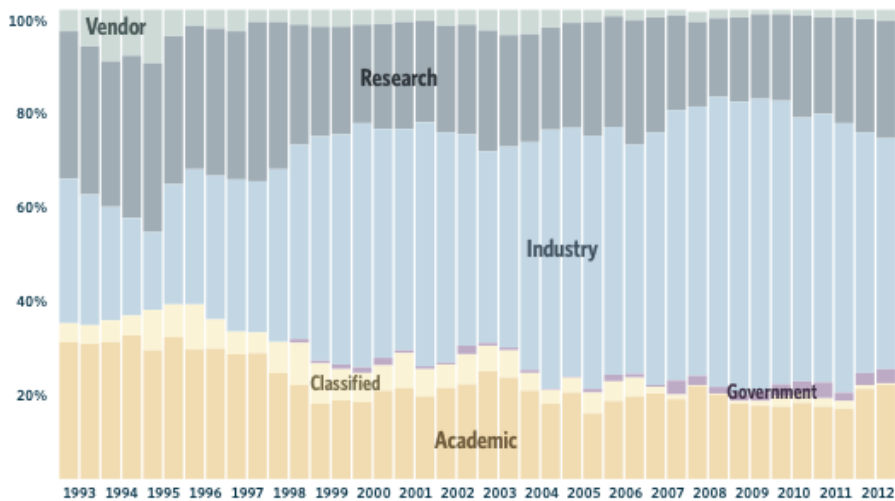
- Top 500 Supercomputers (<http://www.top500.org>)
 - Prezentare generala
 - Benchmark – LINPACK(HPL)
- Top 10
 - Info – locatie/furnizor
 - Arhitectura
 - Performante LINPACK
 - OS & Software
 - Aplicatii
- Concluzii Top 500
- Cate ceva despre examen: mod de notare, etc...



Clienti

59

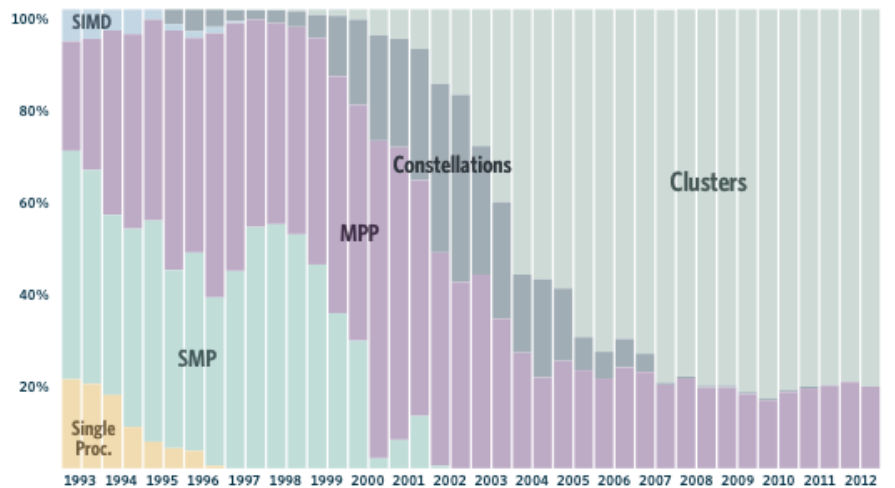
INSTALLATION TYPE



Architettura Sistemelor

60

ARCHITECTURES

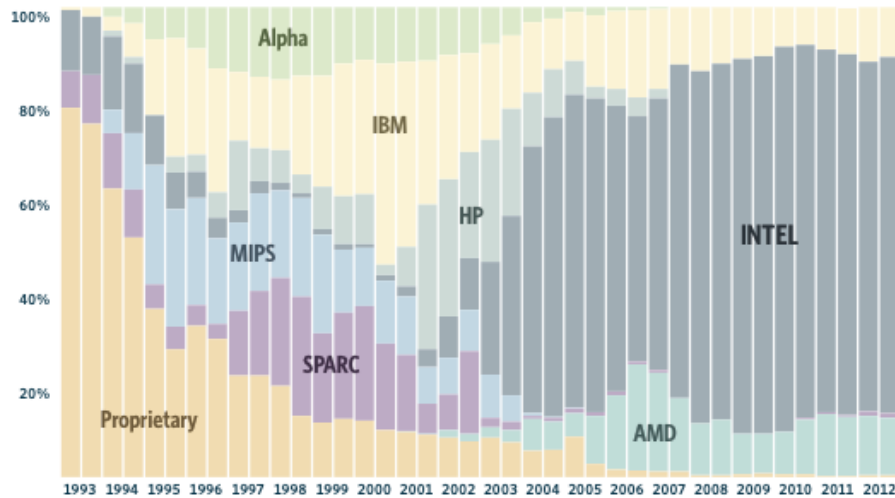




Tipuri de Procesoare

61

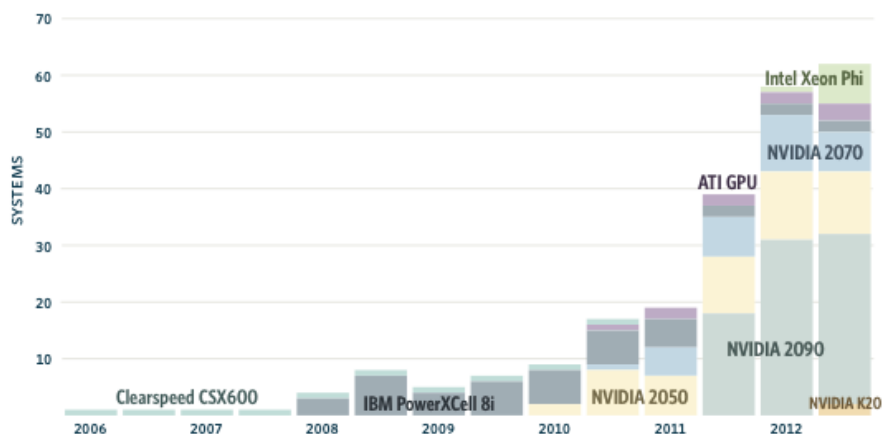
CHIP TECHNOLOGY

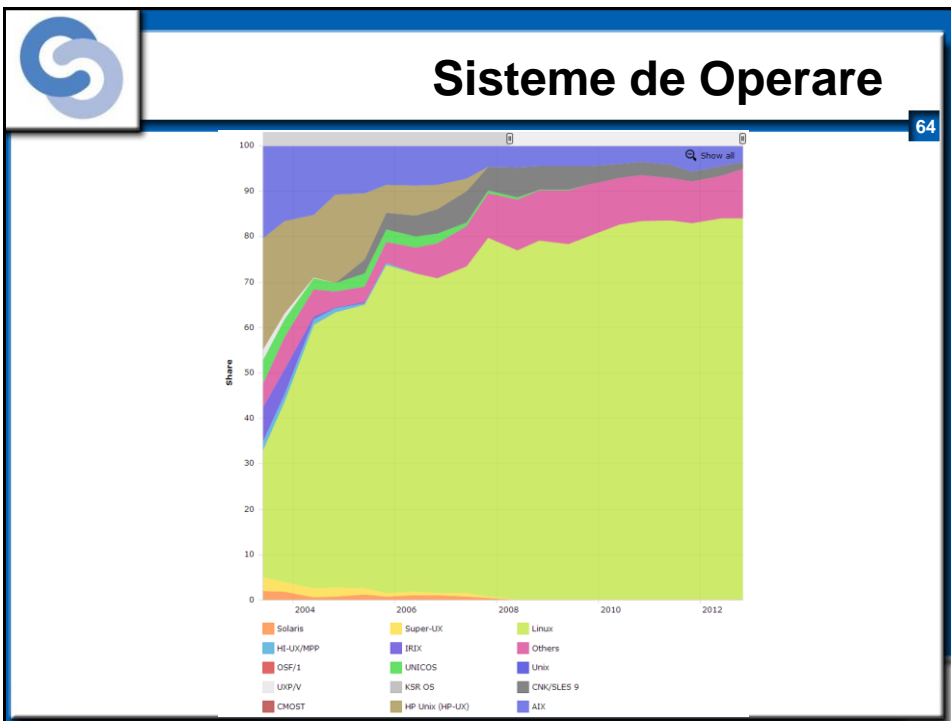
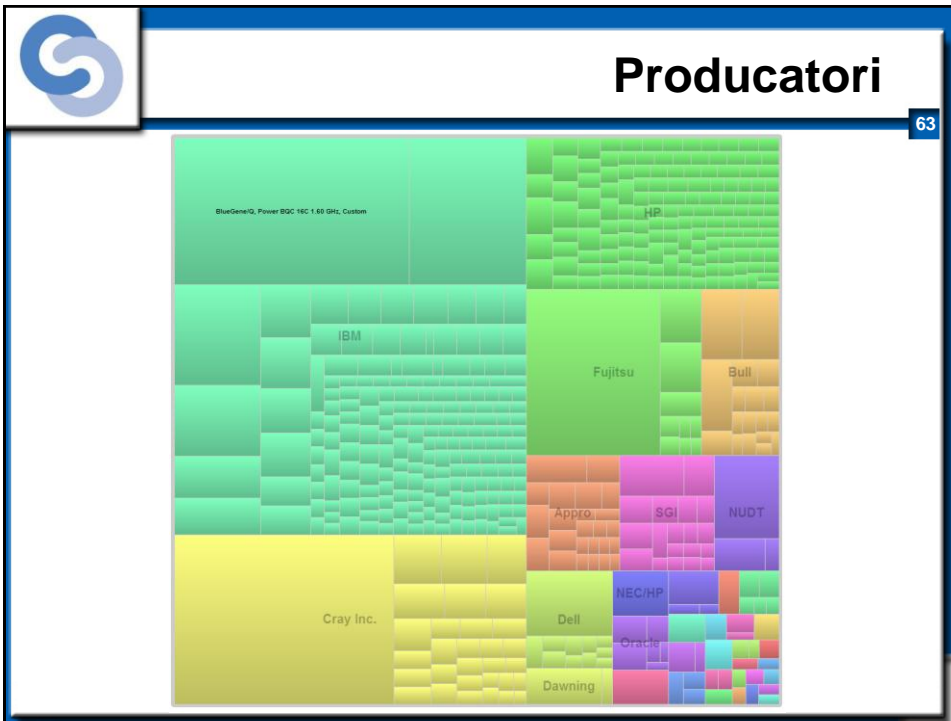


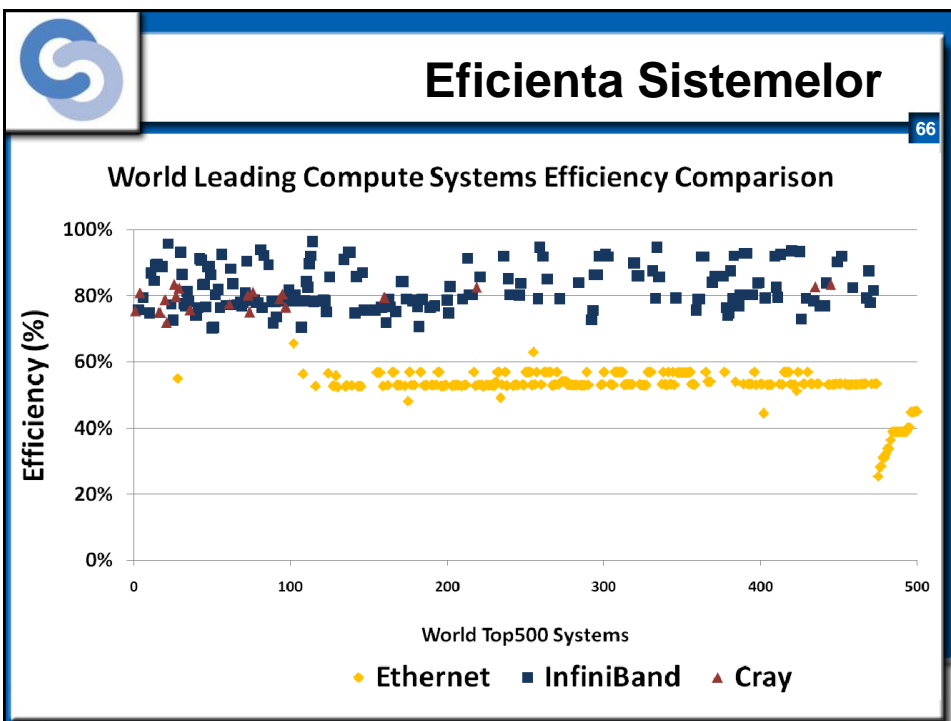
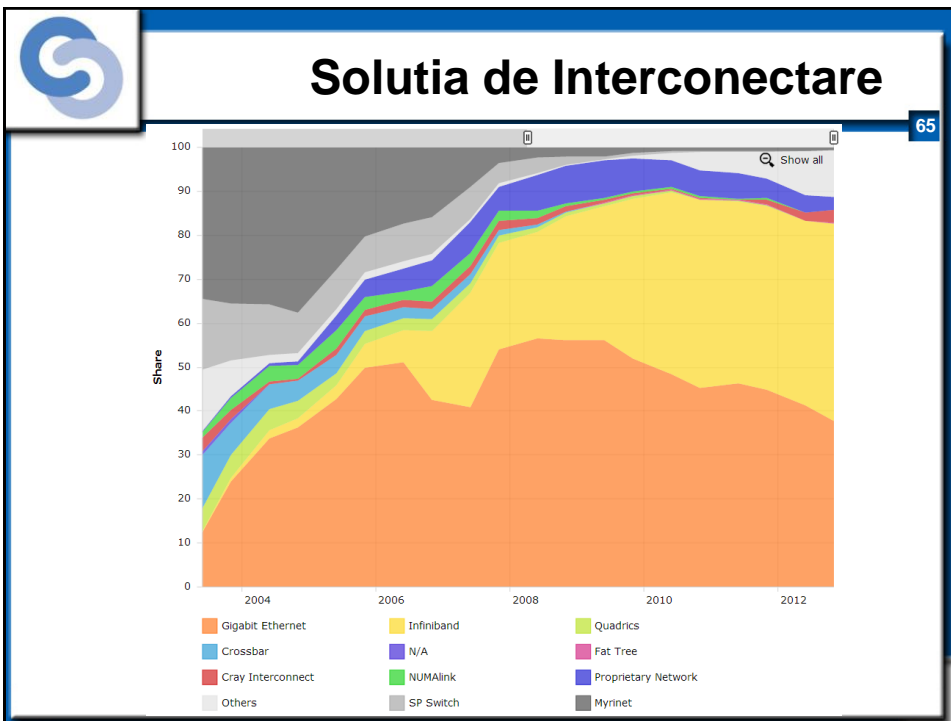
Acceleratoare / Coprocesoare

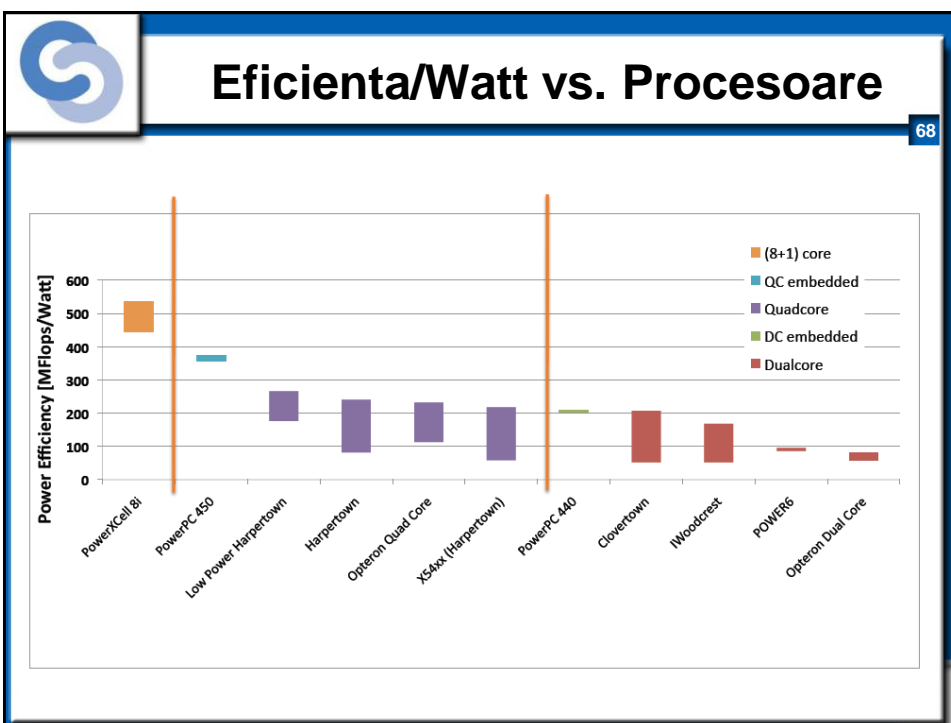
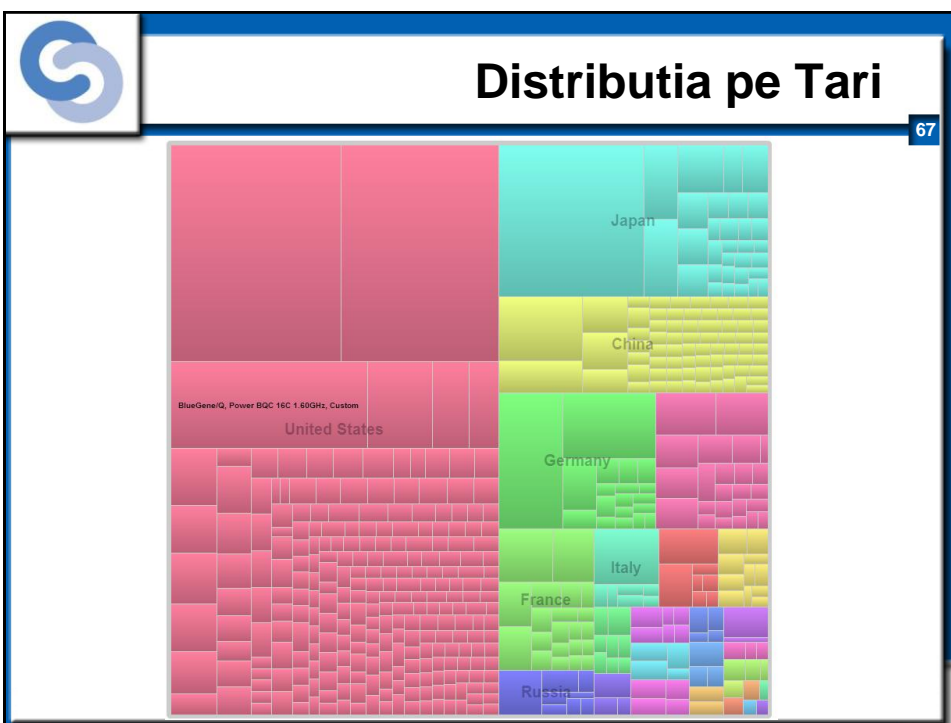
62

ACCELERATORS/CO-PROCESSORS





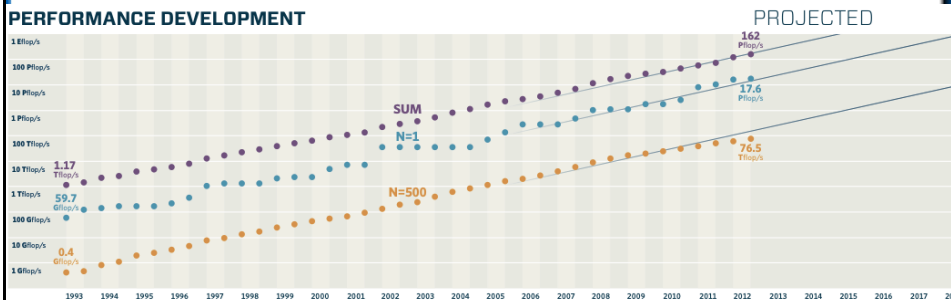






Proiectia Evolutiei Viitoare

69

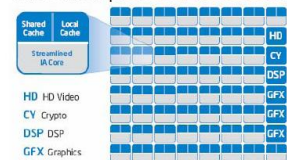


HW Trends

70

Industry presentations show changing trends in processors

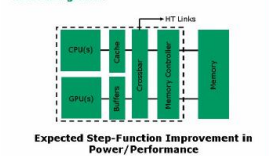
Intel's Microprocessor Research Lab



Intel's Visual Computing Group - Larabee



AMD Fusion
The Data Efficiency Benefits of Silicon-Level Integration



Unleashing the Processing Powerhouse



Los Alamos
NATIONAL LABORATORY
EST. 1943

Taken from publicly available information

Operated by Los Alamos National Security, LLC for NNSA

UNCLASSIFIED

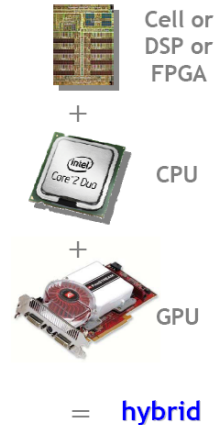
WEAPONS SCIENCE & ENGINEERING
CAPABILITY REVIEW
NNSA



Further Trends

71

- **New processors & accelerators:**
 - Multi-core to many-core: 8, 16, 32, ... 80, 128, 1000?
 - IBM Cell, AMD Fusion, Intel Polaris, NVidia G8800
 - Distributed memory & caches at core level
 - FPGAs, GPGPU, ClearSpeed CSX600, IBM Cell, XtremeData XD1000, Nvidia G80, AMD Stream Processor
- **Connection standards**
 - AMD Torrenza, Intel/IBM Geneseo, AMD HyperTransport Initiative
- **Programming**
 - IBM Roadrunner Cell libraries, RapidMind, Peakstream, Impulse C, Stanford's Sequoia, NVidia CUDA, ClearSpeed C, Mercury MFC, stream programming
- **Heterogeneous architectures**
 - Clusters of mixed node
 - Hybrid accelerated node (e.g. Roadrunner, ClearSpeed, FPGA)
 - Hybrid on the same bus (e.g. CPU+GPUs, Intel's Geneseo, AMD's Torrenza)
 - Within processor itself (e.g. Cell, AMD Fusion)



Cuprins

72

- Top 500 Supercomputers (<http://www.top500.org>)
 - Prezentare generala
 - Benchmark – LINPACK(HPL)
- Top 10
 - Motivatie
 - Info – locatie/furnizor
 - Arhitectura
 - Performante LINPACK
 - OS & Software
 - Aplicatii
- Concluzii Top 500
- Cate ceva despre examen: mod de notare, etc...



Examen la ASC

73

- Examenul consta din doua parti distincte
 - Partea de teorie – 50min:
 - Subiecte din temele prezentate la curs
 - Examenul de teorie poate fi sustinut si oral
 - Partea de probleme – 30min-45min:
 - Subiecte similare cu unele din problemele propuse ca teme de laborator
- **Nota finala** este calculata cu formula:
 - **Teorie Examen***0.40 + **Problema Examen***0.10 + **Laborator***0.50
- Punctajul fiecărei parti este in intervalul 0..10
- Intrarea in examen si promovarea **nu** poate avea loc decat daca nota finala de la laborator este **strict mai mare** ca 2.5
 - Restantierii din anii 4/5: **minim** o tema din 1 si 2 si una din 3 si 4 + minim 2.5 puncte
- Examen:
 - CA
 - CB – 01 & 02 Iunie 2013
 - CC



Bibliografie vs. Cursuri

74

- *Introduction to Parallel Computing: Design & Analysis of Algorithms*
 - Cursurile 6, 8, 11
- *The Sourcebook of Parallel Computing*
 - Cursurile 4, 13, 14
- *Computer Architecture: A Quantitative Approach*
 - Cursurile 3, 4, 7, 9, 10, 11
- *Introduction to Parallel Processing: Algorithms and Architectures*
 - Cursurile 6, 7, 8, 9, 10, 11
- *Techniques for Optimizing Applications: High Performance Computing:*
 - Cursul 4
- *Practical Computing on the Cell Broadband Engine*
 - Cursul 5
- www.top500.org, <http://www.netlib.org/benchmark/hpl/>,
<http://icl.cs.utk.edu/hpcc/>
 - Cursurile 13, 14
- *Structura si Arhitectura Sistemelor Numerice*
 - Cursurile 2, 3, 6, 7, 8, 9, 10, 11, 12



What Next?

75

- Q & A?
- Next time:
 - Exam...
 - Last but not least: va rugam ca completati feedback-ul!