Interdisciplinary Research for Cloud Computing: Future and challenges

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- First Latin America University Member
- Goal: Evaluate and improve an open computing ecosystem
- Resources: Local OpenStack cloud with 6 nodes
  → up to 720 virtual machines
  → Joint laboratory at the campus
- Opportunities:
  → Coherence Accelerator Processor Interface (CAPI)
  → Fully programmable software stack. Open source firmware, switches, operating system
  → Full Debian Linux (little endian) distribution ported to POWER architecture

http://openpower.ic.unicamp.br

Example Project

```
int main()
{
    int b = 2;
    int a;
    for(a=-5000;a<-2;a=a >> 1)
    {
        b = b*a;
    }
    return b;
}
```

Intel x86 = POWER
Calculation of Virial Coefficients

- Physics Problem: Understanding macroscopic behavior of fluids from microscopic interactions.
- Approach: Assessment of convergence properties of virial expansion series.
- Physical system: Uhlenbeck-Ford model for which virial coefficients can be computed exactly.
- Computational approach:

  Order: \( n \) → Find all biconnected graphs with \( n \) vertices → Process all \( m \) graphs → Result: Coefficient \( B_n \) (single number)

- Problem:
  - Number of graphs grows exponentially with \( n \).
  - Calculation of \( B_{11} \) (largest known coefficient) required 1 week of processing on 120 CPU cores.
  - Coefficient \( B_{12} \) would require \( \sim 170 \) times longer (> 3 years!).
- Solutions:
  - Code optimization: \( B_{12} \) took 9 days in one core on a notebook
  - Better parallelization: \( B_{13} \) took 15 days in \( \sim 400 \) cores
  - \( B_{14} \) is 500x bigger \( \rightarrow \) GPU & Cloud
Imaging the earth’s interior

- Many human activities (engineering, natural resources, environment) rely on a correct understanding of the earth’s interior
- Efficient construction of subsurface images is of paramount importance
- Bag of tasks, small number of data transfers

Xeon E5-2630 2.6GHz
8 Semblances/Joule

Months

Verilog
78 Semblances/Joule

How good?

OpenCL
days/weeks

FPGA
118 Semblances/Joule

GPU

Improve imaging
OpenMP to the Cloud

• Using existing programming model: OpenMP
• Move tasks to the cloud for scalability

```c
#pragma omp parallel for
for (i = 0; i < MAX; i++)
    Compute(i);
```
WebLectures Project

• More than 1500 lectures recorded in video since 2009
  – No support for big videos on YouTube at that time
  – Local server, local infrastructure

• New opportunities on the cloud
  – Voice recognition
  – OCR
  – Automatic creation of cross-disciplines references
DoeNota Project:

- São Paulo state reimburses a small part of sales tax
  - Goal: increase the number of people that asks for receipts → increase tax payment
- Users can donate tax credits to charities
  - Charities must type the receipt parameters (40-60 characters per receipt)
- DoeNota is an App (iOS, Android and Microsoft)
  - Scans the receipt (picture)
  - Sends to our server (cloud)
  - Apply OCR
  - Donate to charity through the government site
  - 2683 receipts already processed (total value of R$165,694,64)
  - Migrated to cloud for scalability in less than a week
New Memory Technologies

• Non-volatile memory as main memory
• New opportunities for changing programming models
  – Data Persistence
  – Databases
• New security threats
  – Passwords will not be erased if left in memory
• New computer organization
  – Universal memory
Thank you!

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