Parallel Computing Workshop

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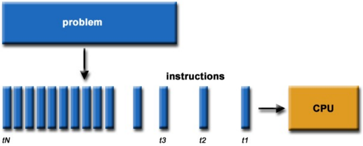
University of Nebraska Lincoln

26 Feb 2015

What is parallel computing?

Serial Computing



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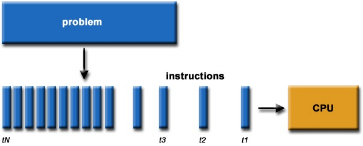
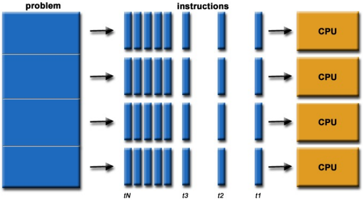


Parallel Computing



What is parallel computing?

Major Uses

- Solve many small problems at the same time.

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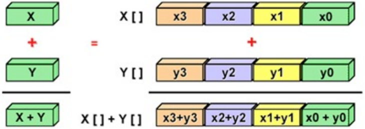

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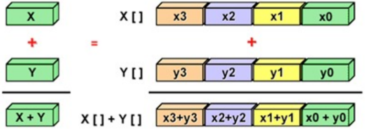

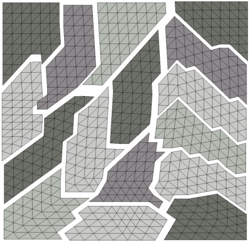

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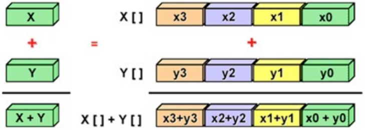
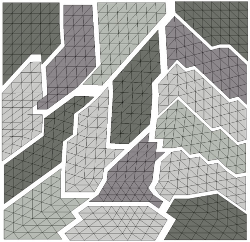
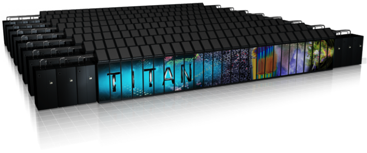




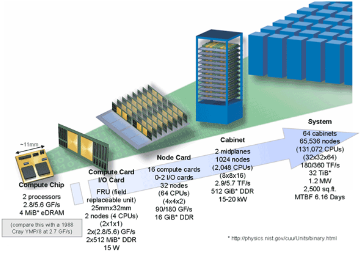
- Repeated associative binary operations (addition, multiplication, maximization)
- Matrix-vector multiplication

Supercomputers

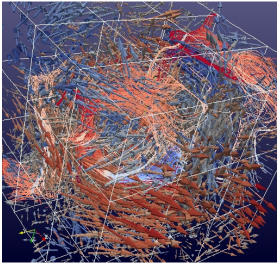


Titan

Blue Gene



Processors Assembly



Simulations

Why do parallel computing?

Good Reasons

- Massive speed up.
- Massive increase in problem size.
- Concurrency (the universe is inherently parallel in space)

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- E.g., do you have even one parameter in your problem?

How do you access parallel resources?

Parallel Machines

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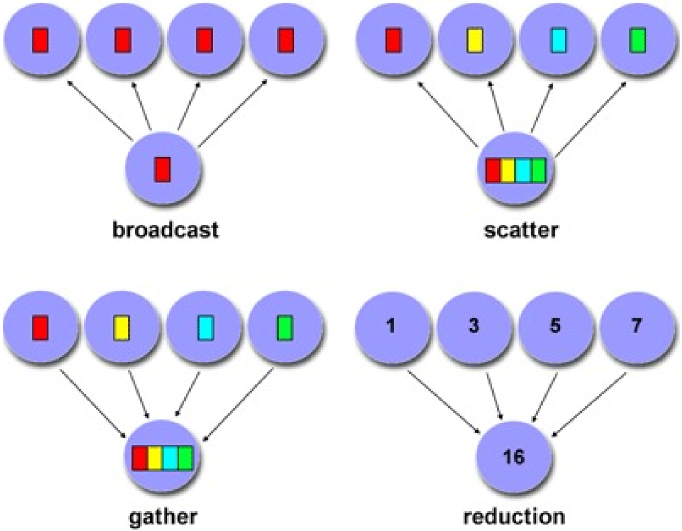
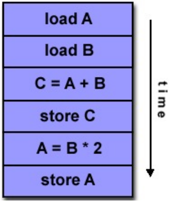
- Open Science Grid

How does it work?



How does it work?

Serial Logic



load A

load B

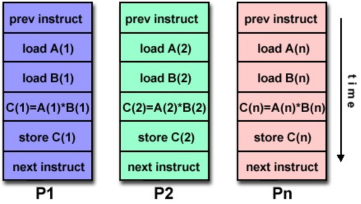
C = A + B

store C

A = B * 2

store A

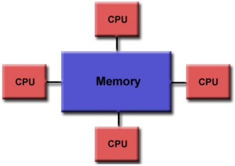
Parallel Logic



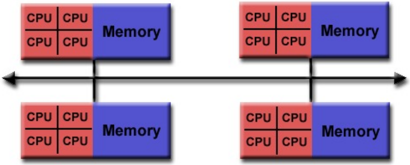
P1	P2	Pn
prev instruct	prev instruct	prev instruct
load A(1)	load A(2)	load A(n)
load B(1)	load B(2)	load B(n)
C(1)=A(1)*B(1)	C(2)=A(2)*B(2)	C(n)=A(n)*B(n)
store C(1)	store C(2)	store C(n)
next instruct	next instruct	next instruct

Memory

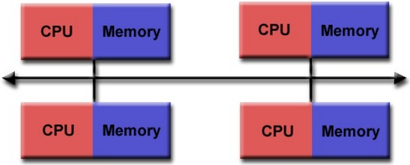
Shared Memory



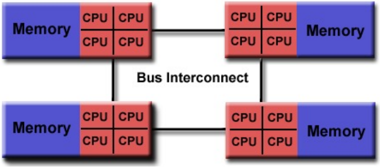
Hybrid Memory



Distributed Memory



Non-Uniform Memory



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What do you need?

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Other notes

- Vendors: MPI, Intel MPI, Scali MP
- Matlab parallel programming

A basic MPI program

```
program who_am_I
  use mpi
  implicit none
  integer :: nb_procs,rank,code

  call MPI_INIT(code)
  call MPI_COMM_SIZE(MPI_COMM_WORLD ,nb_procs,code)
  call MPI_COMM_RANK(MPI_COMM_WORLD ,rank,code)

  print *,'I am the process ',rank,' of ',nb_procs

  call MPI_FINALIZE (code)
end program who_am_I
```

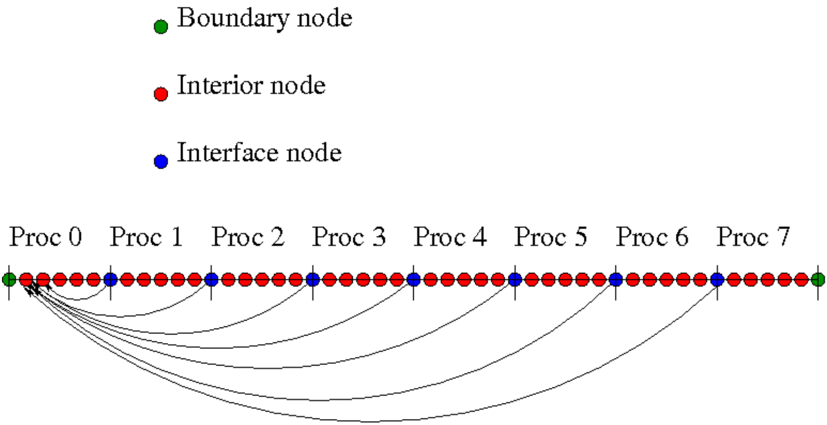
Communications

```
program point_to_point
use mpi
implicit none

integer, dimension( MPI_STATUS_SIZE ) :: status
integer, parameter  :: tag=100
integer  :: rank,value,code

call MPI_INIT(code)
call MPI_COMM_RANK (MPI_COMM_WORLD ,rank,code)

if (rank == 2) then
  value=1000
  call MPI_SEND(value,1,MPI_INTEGER,5,tag,MPI_COMM_WORLD,code)
elseif (rank == 5) then
  call MPI_RECV(value,1,MPI_INTEGER,2,tag,MPI_COMM_WORLD,status,code)
  print *,'I, process 5, have received value ',value,'&
           from process 2'
end if

call MPI_FINALIZE (code)

end program point_to_point
```

Communications

```
> mpiexec -n 7 point_to_point
I, process 5 , have received value 1000 from process 2
```

Communication Overhead

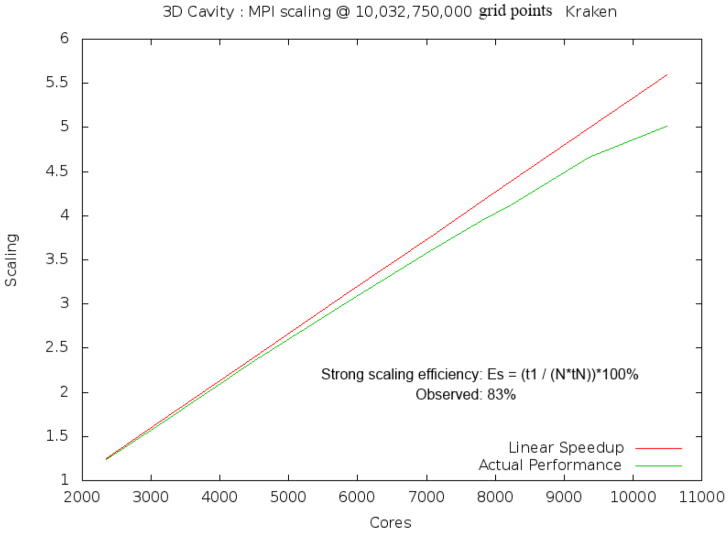


● Boundary node

● Interior node

● Interface node

Scaling Tests



Resources

- “Introduction to Parallel Computing”, Blaise Barney
  `https://computing.llnl.gov/tutorials/parallel_comp`
- “A Parallel Multigrid Tutorial”, Jim Jones
  `https://computing.llnl.gov/casc/linear_solvers/present.html`
- “Introduction to Parallel Computing, Design and Analysis of Algorithms”, Vipin Kumar, Ananth Grama, Anshul Gupta, George Karypis
- IDRIS tutorial with great coding examples:
  `http://www.idris.fr/data/cours/parallel/openmp/`

Thank you, and have fun!