Neptune

A Domain Specific Language for Deploying HPC Software on Cloud Platforms

Chris Bunch Navraj Chohan Chandra Krintz
Khawaja Shams

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Cloud Computing

- Three tiers of abstraction:
- Infrastructure: Scalable hardware
- Platform: Scalable APIs
- Software: Scalable application

HPC in the Cloud

- Hard to automatically configure and deploy libraries
  - Especially for the average scientist
    - Even harder for those w/o grid experience
- Hard to get high performance on opaque cloud
- Wide range of APIs for similar services (e.g., compute, storage)

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Introducing Neptune

- A Domain Specific Language that facilitates HPC configuration and deployment
- Serves High Throughput Computing (HTC) as well as Many Task Computing (MTC)
- Part language component, part runtime component

Design

- Language - Consists of metaprogramming extensions to Ruby
- Runtime - Operates at cloud platform layer
  - Can control VMs as well as applications
- Can act standalone or as a library to existing Ruby programs

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Syntax

```
neptune :type => “service-type”,
        :option1 => “setting-1”,
        :option2 => “setting-2”
```

Semantics

- Options are unique per job
  - Not all jobs are equal
- Uses Ruby's dynamic typing so option and setting types can be dynamic
- Extensible - add your own job types / options / settings

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Semantics

- Neptune jobs return a hashmap
  - :result is either :success or :failure
  - Additional parameters are job-specific
- Customizable per job

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Design

- Need something more than XML
  - Need to control the execution
- Allows for integration with Rails
- Code is reusable across job types
  - e.g., job input / output / ACLs

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To Run a Job:

- Minimum set of requirements for jobs:
  - Acquire resources
  - Run job
  - Get output
- Leverage AppScale cloud platform

AppScale

- Open source implementation of the Google App Engine APIs

- Can deploy to Amazon EC2 or Eucalyptus
- Standard three tier deployment model:

- Load balancer ↔ app server ↔ database

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AppScale Tools

- Modified the command line tools
- Added support for placement strategies
  - e.g., hot spares for HPC computation
- Added hybrid cloud support
  - Can run in Amazon EC2 and Eucalyptus simultaneously

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AppController

- A special daemon on all systems that configures necessary services
- Now acts as part of Neptune's runtime component
- Can receive Neptune jobs
- Acquires nodes from infrastructure, configures, and deploys as needed

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Virtual Machine Reuse

- Machines are charged by the hour - so keep them for an hour in case users need them later
- Scheduling policies - hill climbing algorithm used based on execution time or total cost
- Relies on user to specify how many nodes the code can run over

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Message Passing Interface (MPI)

- Many implementations exist - we use a commonly used version (C/C++)
- Data is shared via NFS
- User specifies how many nodes are needed, and processors are to be used, and where their code is located

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An Example

```
neptune :type => :mpi,

        :nodes_to_use => 64,

:code => “/code/NQueens”,

:output => “/results/nqueens.txt”,

:storage => “s3”
```

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X10

- IBM's effort at simplifying parallel computing
- Java-like syntax, no pointers needed
- Can use Java backend or MPI backend via C++
- Thus, same parameters as MPI jobs

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- Popularized by Google in 2004
- Neptune supports both ‘flavors’:
  - Regular: Write Java Mapper and Reducer, specify a single JAR for execution and main class
  - Streaming: Write code in any language, specify location of Map and Reduce files

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Stochastic Simulation Algorithms

- Computational scientists do large numbers of Monte Carlo simulations
- Embarassingly parallel
- Two types of simulations (DFSP and dwSSA) supported by Neptune
- User specifies how many nodes and how many simulations to run

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An Example

```
path = “/racelab/dfsp-run-#{rand}”

neptune :type => “dfsp”,

        :output => path,

        :simulations => 1_000_000


result = neptune :type => “output”,

        :output => path

puts “DFSP result is #{result[:stdout]}”
```

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Storage Backends

- Can store to any database AppScale uses

- Can also store to Amazon S3
  - Or anything that uses the same APIs
  - e.g., Eucalyptus Walrus, Google Storage

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Not Just for HPC

- Can be used to scale AppScale itself
- Specify which component to add and how many
- Can specify resources across clouds
- e.g., ten database nodes, five in each of two clouds

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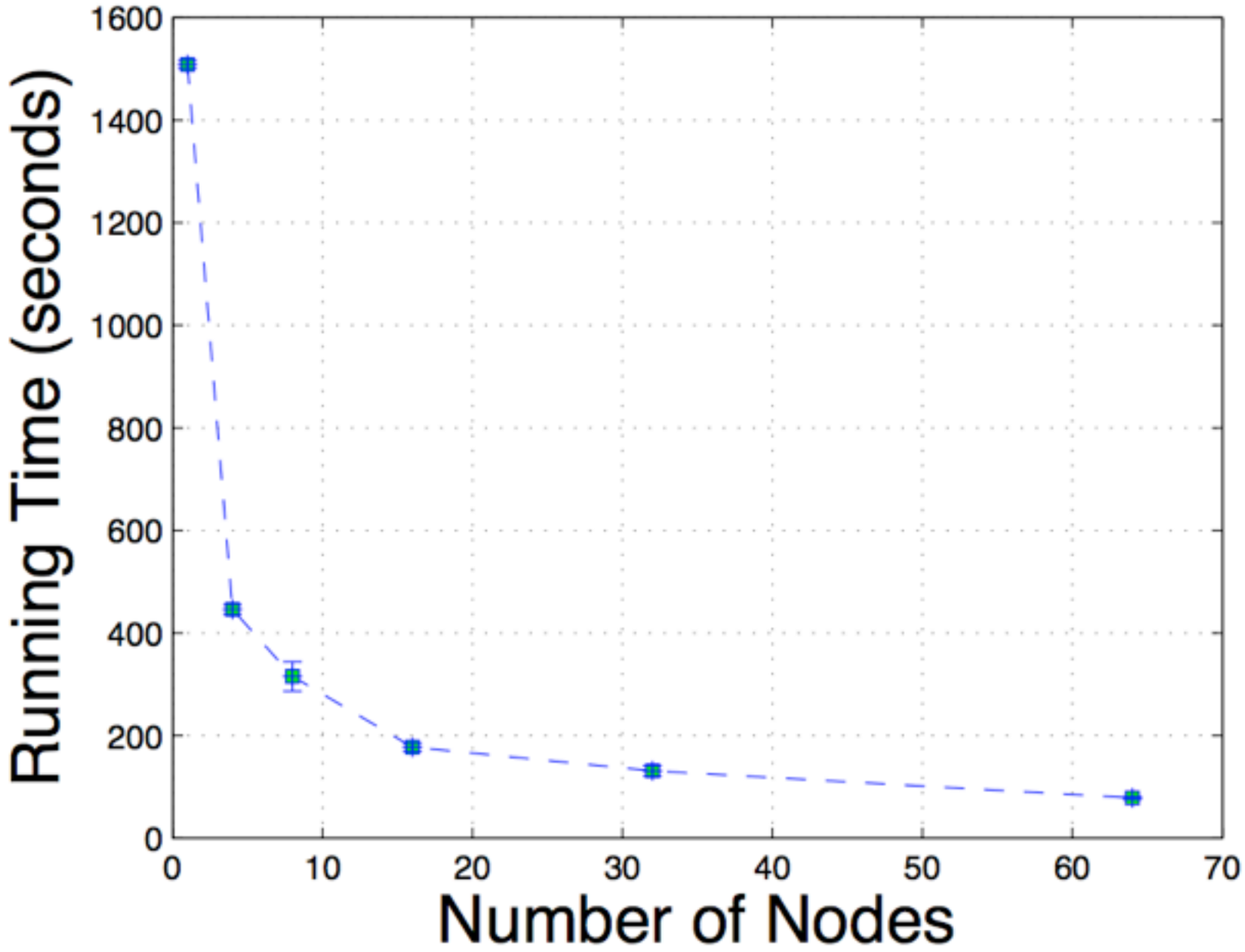
Limitations

- Not amenable to codes that require hard-coded IP addresses or other identifiers
- Not amenable for codes that require closed source software to run
  - Is ok if the software is only needed for compilation or linking

Evaluation

- Physical hardware:
  - Intel Xeon, 8 cores, 16GB of memory
- Virtual machines:
  - 1 virtual core, 1GB of memory
- MapReduce Java WordCount: 2.5GB input file containing Shakespeare 500 times

Java WordCount



VM Reuse

# Type of Job	Cost with VM Reuse	Cost without VM Reuse
NQueens(MPI)	$12.92	$64.60
NQueens(X10)	$13.01	$64.60
MapReduce	$13.01	$64.18
DFSP	$35.70	$78.63
dwSSA	$12.84	$64.18
Total	$87.48	$336.19

Wrapping it Up

- Thanks to the AppScale team, especially co-lead Navraj Chohan and advisor Chandra Krintz
- Currently Neptune is at version 0.1.1, with added support for UPC, Erlang, Go and R
- gem install neptune
- Visit us at http://neptune-lang.org

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