Nebulas: Using Distributed Voluntary Resources to Build Clouds

Abhishek Chandra and Jon Weissman
Department of Computer Science
University of Minnesota
Clouds

- Cloud: Hides details of actual service deployment from users
Current Cloud Model

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Current Cloud Model

- Largely centralized (or small degree of distribution)
- Pay-as-you-go model
- Strong guarantees

Question: Are there services that do not need/fit this cloud model?
Class 1: “Experimental” Services

- Experimental deployment for:
  - Debugging, viability, requirement estimation
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Diagram:
- ACM
- USENIX
- SOSP 07
- USENIX 09
- OSDI 08
- SOSP 2009
- Stack of papers
Class 2: Dispersed-Data-Intensive Services

- Data is geographically distributed
  - Costly, inefficient to move to central location
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Class 3: Shared “Public” Services

- Personal application offered as free service
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Common Service Characteristics

- Elastic resource consumption
  - Scale up/down based on demand
- Geographical data/user distribution
  - Execution dependent on location of data/user
- Low/no cost
  - Do not want to pay for resources
- Weak performance/robustness requirements
  - Some failures may be ok
Cloud

- Cloud: Hides details of actual service deployment from users
Nebula

- Decentralized, less-managed cloud
  - Dispersed storage/compute resources
  - No/low user cost

Users
Building Nebulas

- **Idea:** Use distributed voluntary resources
  - Resources donated by end-users
  - ala @home, P2P systems
Why Voluntary Resources?

- **Scalability**: Large number of resources available
  - SETI@Home: Over 2.2 million computers contributing ~510 TFlops of compute power
  - Kazaa: Over 3.5 million users

- **Low cost**:
  - Minimal deployment, management costs
  - [Kondo09]: 2 orders of magnitude difference in EC2 vs. SETI@home resources/$

- **Dispersion**: Geographically distributed
  - Users can be located worldwide
How is Nebula different from @home?

- Cloud-oriented services impose new requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Nebula</th>
<th>@home</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collective performance</td>
<td>High</td>
<td>None</td>
</tr>
<tr>
<td>Locality/Context-awareness</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Statefulness</td>
<td>High/medium</td>
<td>Low</td>
</tr>
</tbody>
</table>
Challenges

- Heterogeneity
  - Different nodes have different CPU speeds, network bandwidth, loads

- Resource dispersion
  - Data sources and compute resources may be widely distributed

- Unreliability
  - Node/link failures, high churn
Handling Heterogeneity

- Heterogeneity-aware resource selection and allocation
  - Allows better collective performance
- Trivedi et al. [IJHPCA06]: Fit tasks to node capability

Heterogeneity-aware allocation reduces execution time
Handling Data Dependence

- Find compute nodes and data sources with high accessibility to each other
- Kim et al. [UM-TR08]: Use passive accessibility estimation

Data accessibility-based selection improves download time
Handling Failures

- Replication, state-maintenance
- Sonnek et al. [TPDS07]: Reliability-aware dynamic replication

Dynamic replication improves performance, reliability
Other Issues/Challenges

- Incentivizing Nebulas
  - Market economy, bartering, auctions
  - How to prevent cheating/freeloading?
- Deployment tools/APIs/client support
  - Virtualization, Middleware?
- Privacy/security issues
  - How to secure systems and applications?
  - We think: Nebulas not suitable for privacy-sensitive services
Summary

- Current Cloud models:
  - Well-provisioned, well-managed, centralized
- Some service classes:
  - Need loose performance, low/no cost, distributed data-intensive
- Nebula: Distributed, less-managed clouds
  - Use voluntary resources