The Case for Content Search of VM Clouds

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Types of VM/Cloud Computing

<table>
<thead>
<tr>
<th>Local</th>
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Types of VM/Cloud Computing

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Managed execution (e.g. Amazon EC2)

cloud-cloud
Types of VM/Cloud Computing

Cloud

Execution

Local

Managed execution
(e.g. Amazon EC2)

Transient PC
(e.g. Internet Suspend/Resume)

Storage

Local

Cloud

cloud-cloud

cloud-local
Types of VM/Cloud Computing

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Types of VM/Cloud Computing

- **Local**
  - **Remote execution**
    - (e.g. Grid Computing)
  - **Classic PC**
    - (also laptops)

- **Cloud**
  - **Managed execution**
    - (e.g. Amazon EC2)
  - **Transient PC**
    - (e.g. Internet Suspend/Resume)
Types of VM/Cloud Computing

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- **Remote execution**: Remote execution allows users to run applications on remote servers. Examples include Grid Computing.
- **Managed execution**: Managed execution involves the use of cloud services like Amazon EC2 for running applications.
- **Classic PC**: Classic PC refers to traditional PCs, including laptops.
- **Transient PC**: Transient PC involves running applications on demand, with features like Internet Suspend/Resume.
Content is Important

• Specific versions of software
  • Tool chains, DLL's

• Proprietary Data

• Custom User Data

• Research Experiment Setups
Potential Applications

• Graphic Design – Copyright Infringement

• Corporate Policy – Software Updates, Licenses

• Software Development – Debugging
Search Requirements

• **Content-Based** Searching
  • Not meta-data alone

• **Domain-Dependent** Queries
  • Sensitive to type of data and search primitives

• **Iterative** Search Workflow
  • More than data mining
Discard-Based Search: Diamond
Discard-Based Search: Diamond

Diagram:
- User
- Diamond Client
- Searchlet
- Server
- Database

User sends a query to the Diamond Client, which then sends the query to the Searchlet. The Searchlet forwards the query to the servers, which then return results to the Diamond Client. The client returns the results to the user.
Discard-Based Search: Diamond
Discard-Based Search: Diamond

User

Diamond Client

Server

Server

Server

Returned Data
Discard-Based Search: Diamond

User

Diamond Client

Returned Results

Server

Returned Data

Server

Server

Database
Discard-Based Search: Diamond
Filters and Searchlets

- **Filter** – domain-specific executable code
  - Inherent parallelism
  - Temporal Locality enables just-in-time indexing

- **Searchlet** – Collection of parameterized filters

- Returned **Result** – Pass all filters in a searchlet
VM Growth

- Worldwide Pervasive VM Technology

- EC2, RC2, Eucalyptus, ISR, MokaFive...

- 1,000 Employees, 1,000 Daily Snapshots
VM Search Solved?

- VM's generally multi-gigabyte in size

- 1000's of VM's Implies Terabytes of Data

- **Key Insight**: VM's often contain *duplicate data*
  - Same OS, Same Software, Same Data
  - Search the same file *once*, not *thousands* of times
Importance of Deduplication: Files

Data from 78 NCSU VCL parcels based on Windows XP
Importance of Deduplication: Files

Data from 78 NCSU VCL parcels based on Windows XP
Importance of **Deduplication**: Bytes

Data from 78 NCSU VCL parcels based on Windows XP
Importance of Deduplication: Bytes

Data from 78 NCSU VCL parcels based on Windows XP
How to Deduplicate VM's?

- Virtual Machine Format Independent
- OS Independent
- File System Independent
Deduplication Solution: **Mirage**

- IBM Research Project
- Parses Virtual Disk Partitions
- Handles Multiple File Systems
  - Currently Tested: `ext2`, `ext3`, and `NTFS`
- Extracts and Deduplicates Files
Integrating **Diamond+Mirage**

- Data Source Abstraction
- Database with File-Level Semantics
- Scoping Mechanism
  - Limit to certain Files
  - Provides Access Control
Application: Image Search
Application: Source Code Search
Application: Vulnerability Search
Conclusion

- Content search of VM's has many applications
- Number of VM's growing
- Proposed Solution: Diamond+Mirage
  - Addresses unique search requirements
  - Addresses deduplication
Questions?
Privacy? Ethics? Legality?