Privacy-Sensitive VM Retrospection

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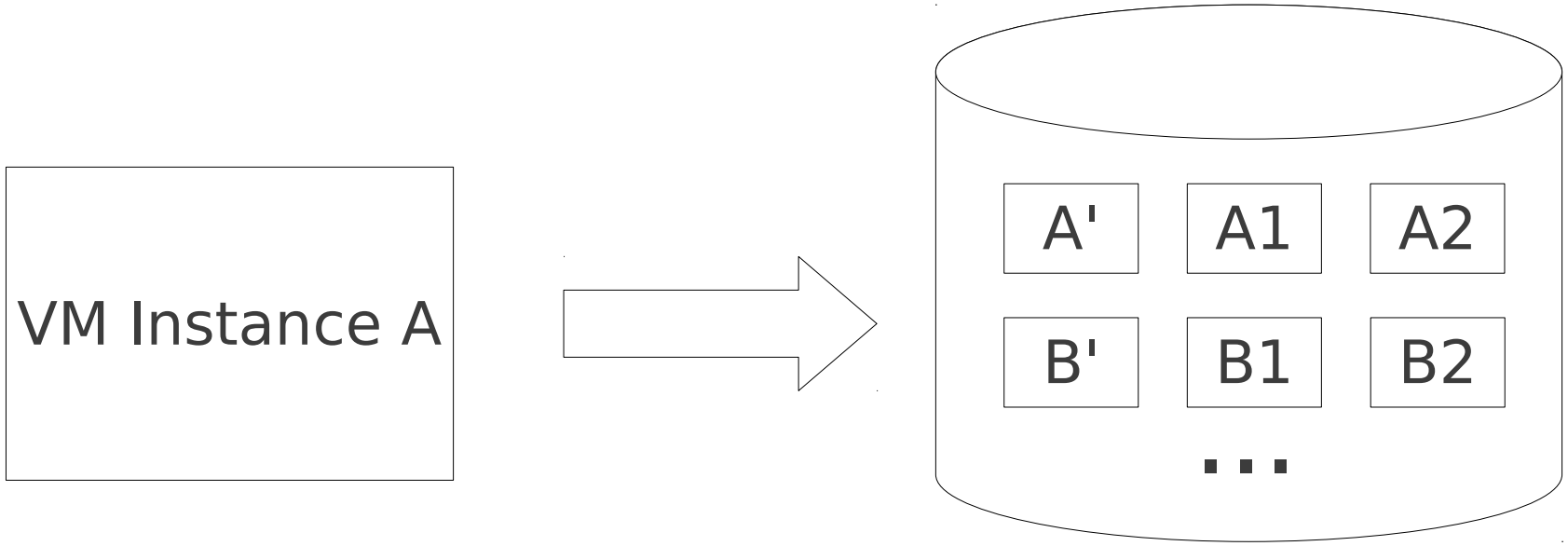
Introspection vs Retrospection

- Examine active state of VM during execution
- Examine historical state of VMs and their snapshots



Examine live logs

Examine all historic logs A*

Change: Shift in Thinking

- Traditionally a VM == executable content
- VM Image Libraries break this paradigm
- Think of VMs as big data
- What can we do with them?

Change: Shift in Thinking

- Traditionally a VM == executable content
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Apple's Time Machine over all VM instances including their complete snapshotted history

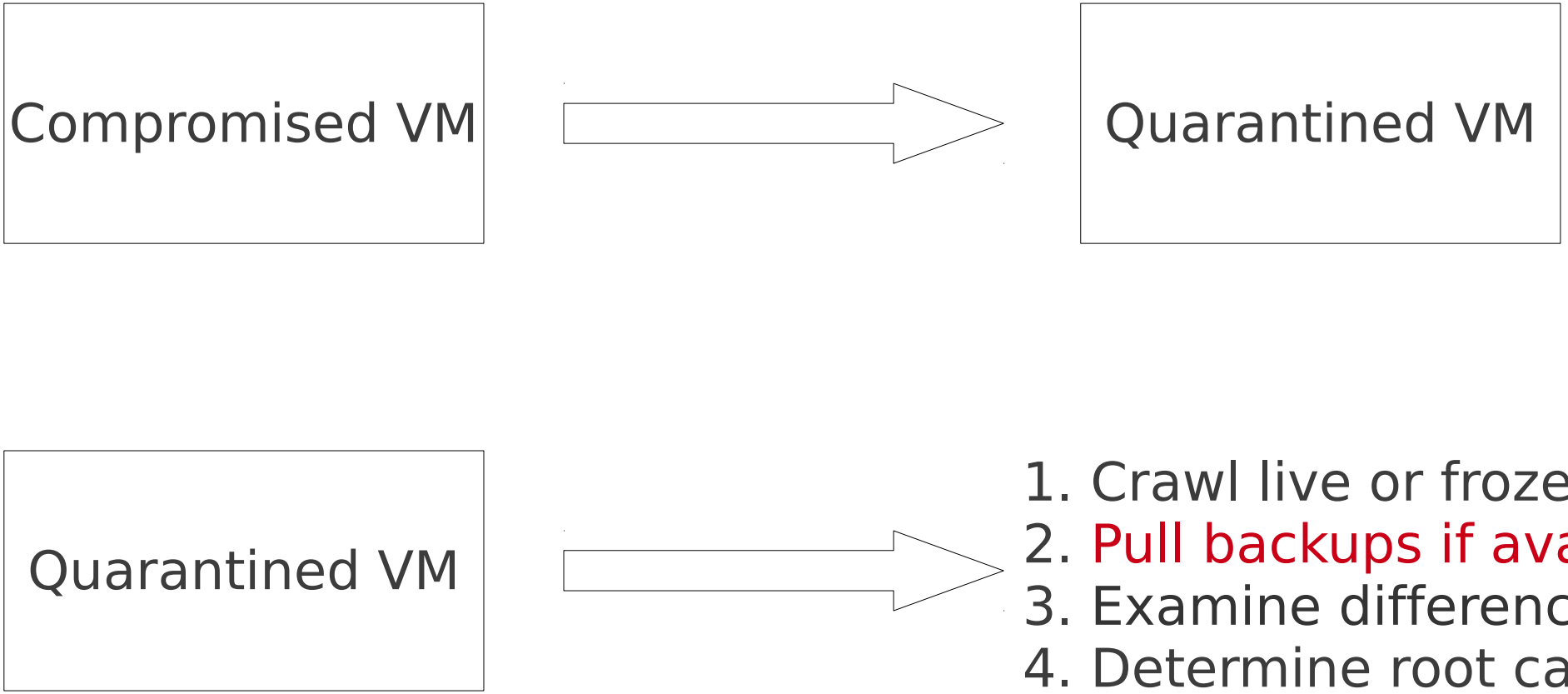
Retrospection

- Deep search over historical VM data
  - Snapshots, Virtual Disks, ...
- Help with:
  - Debugging and troubleshooting
  - Legal establishment of data/code provenance
  - Malware tracking
  - License violations

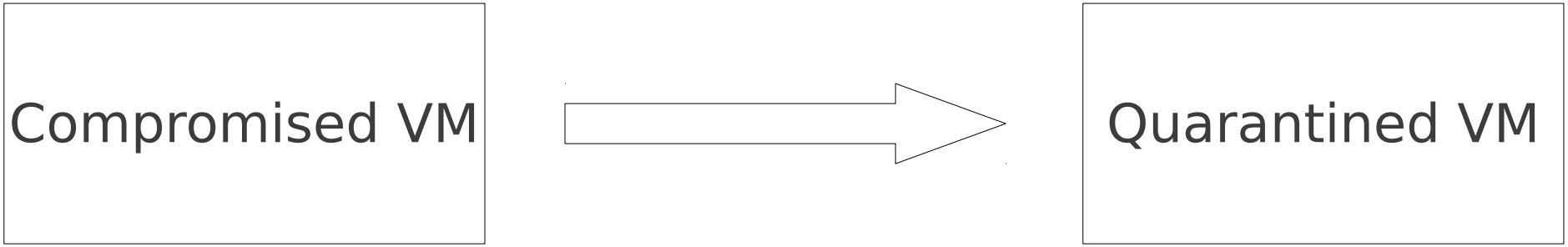
Deep Search?

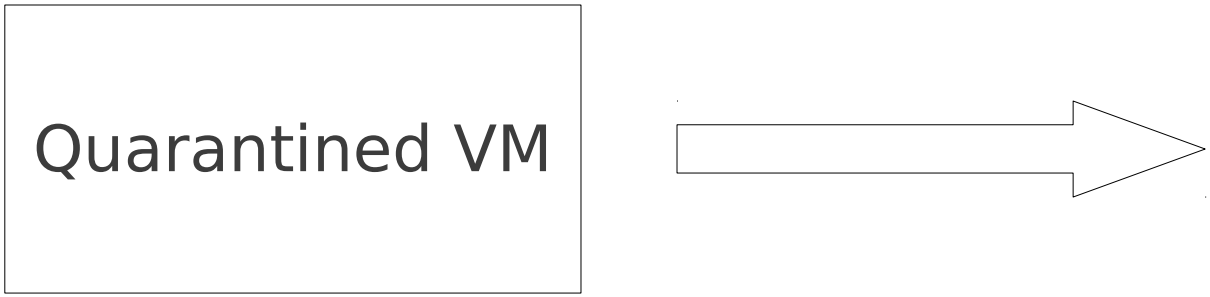
- Search content of files
  - Pictures, Documents, Binary files
- Enable proprietary plugins
  - Adobe, MS Office, Norton, SW Discovery Tools
- While respecting privacy...

Example: Forensics - Before



Example: Forensics - After





1. Crawl live or frozen logs
2. Retrospect entire history
3. Examine differences
4. Determine root causes
5. Redeploy

Example: Forensics - After

Compromised VM → Quarantined VM

Unified interface for searching historic state:
uncover suspicious log entries, infected binaries, etc. at once

Quarantined VM →

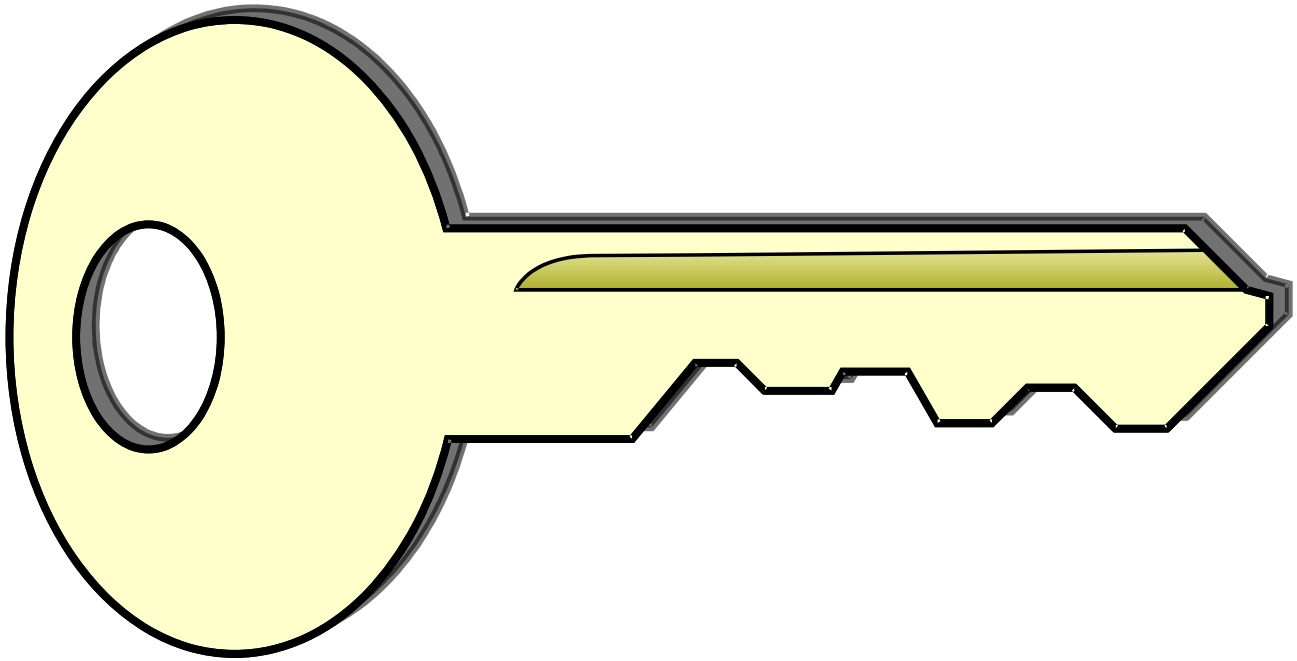
1. Crawl live or frozen logs
2. Retrospect entire history
3. Examine differences
4. Determine root causes
5. Redeploy

Example: Copyright

- Examine a set of instances
- Retrospect to find history of transforms
- Provide evidence in court
- Multiple companies with similar cloud infrastructures supporting retrospection could perform the same queries

Privacy via Cryptography

- Complete trust, if encrypted keys shared
- Some trust, key escrow service
- No trust, no external search infrastructure
- Per-file, per-directory, per-partition



Design Principles

1) Support on-demand queries, scoped to a minimal set of data.

2) Control of retrospection policy resides with VM owners, not cloud operators.

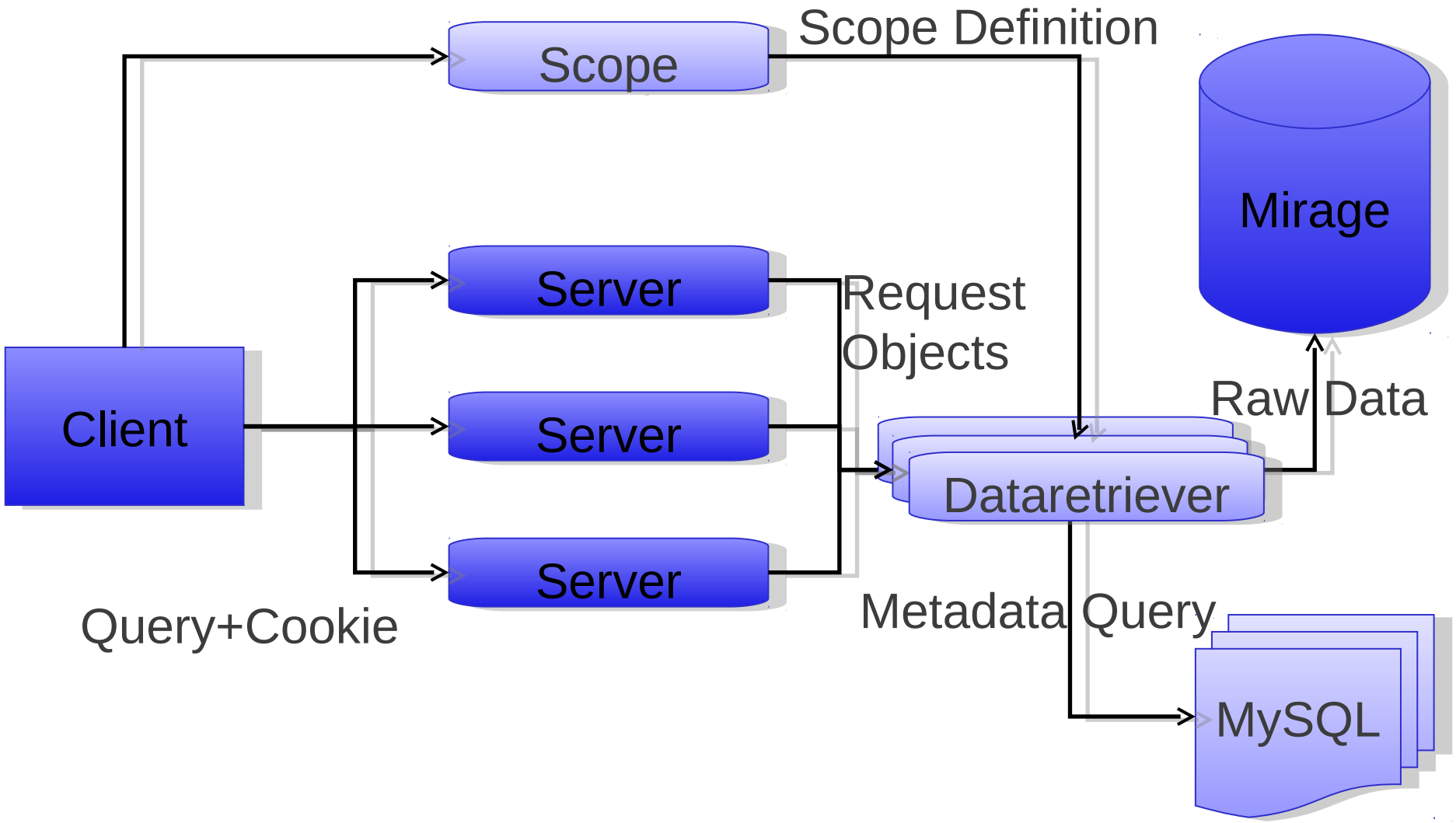
3) Place as few constraints as possible on the generality of search computations.

Retrospection

- VMs become big data
- New opportunities with deep search over historical VM data
- Retrospection is the unifying mechanism for examining historical VM data
- Nanuk – Our implementation

Questions?

Nanuk


Scope
Scope Definition
Mirage
Server
Request
Objects
Client
Server
Raw Data
Dataretriever
Server
Metadata Query
Query+Cookie
MySQL

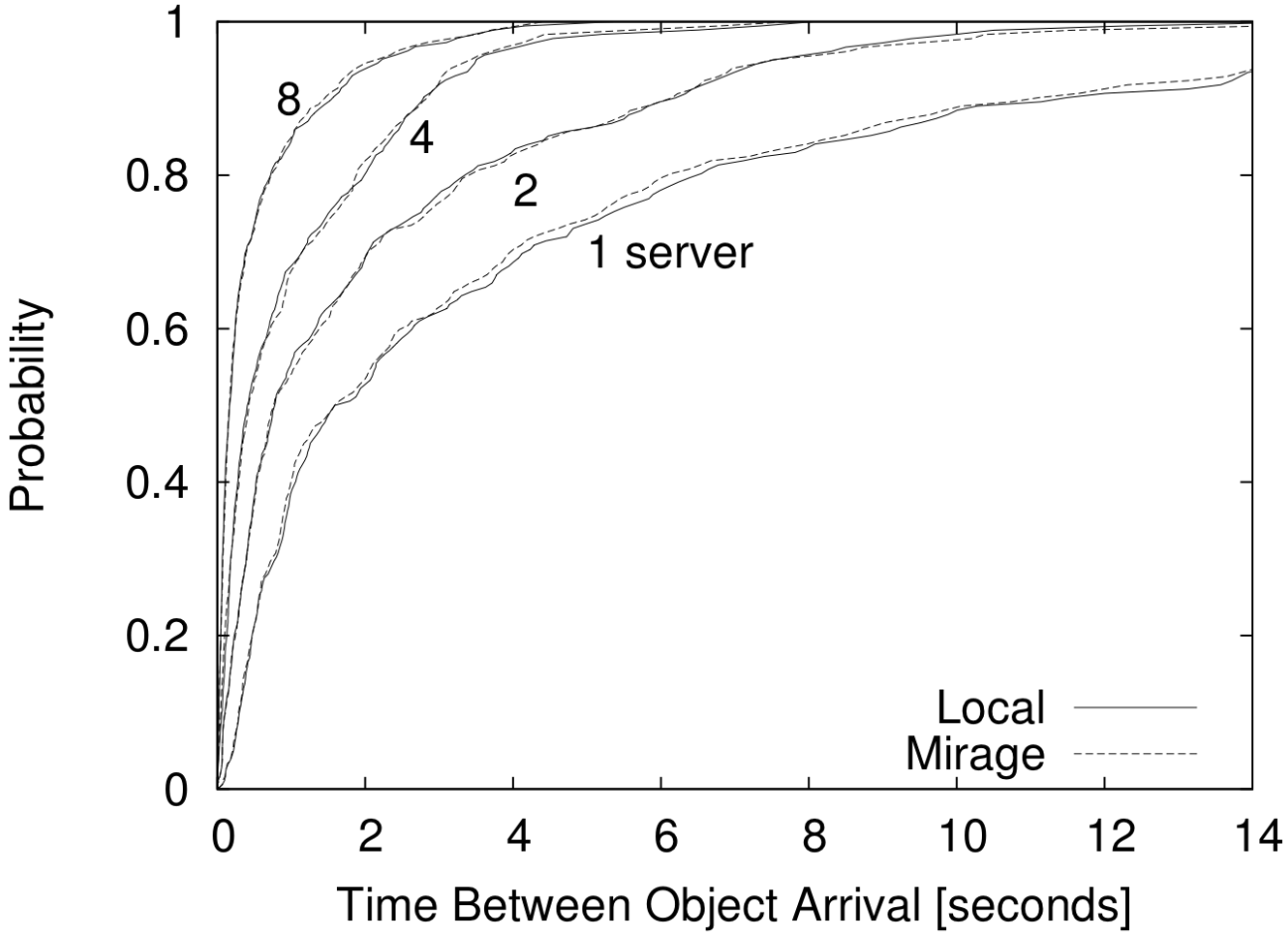
IBM Research Mirage

- Virtual Image Library
- File-level deduplication
  - Files are referenced by SHA-1
- Reads VM Image partitions and file systems

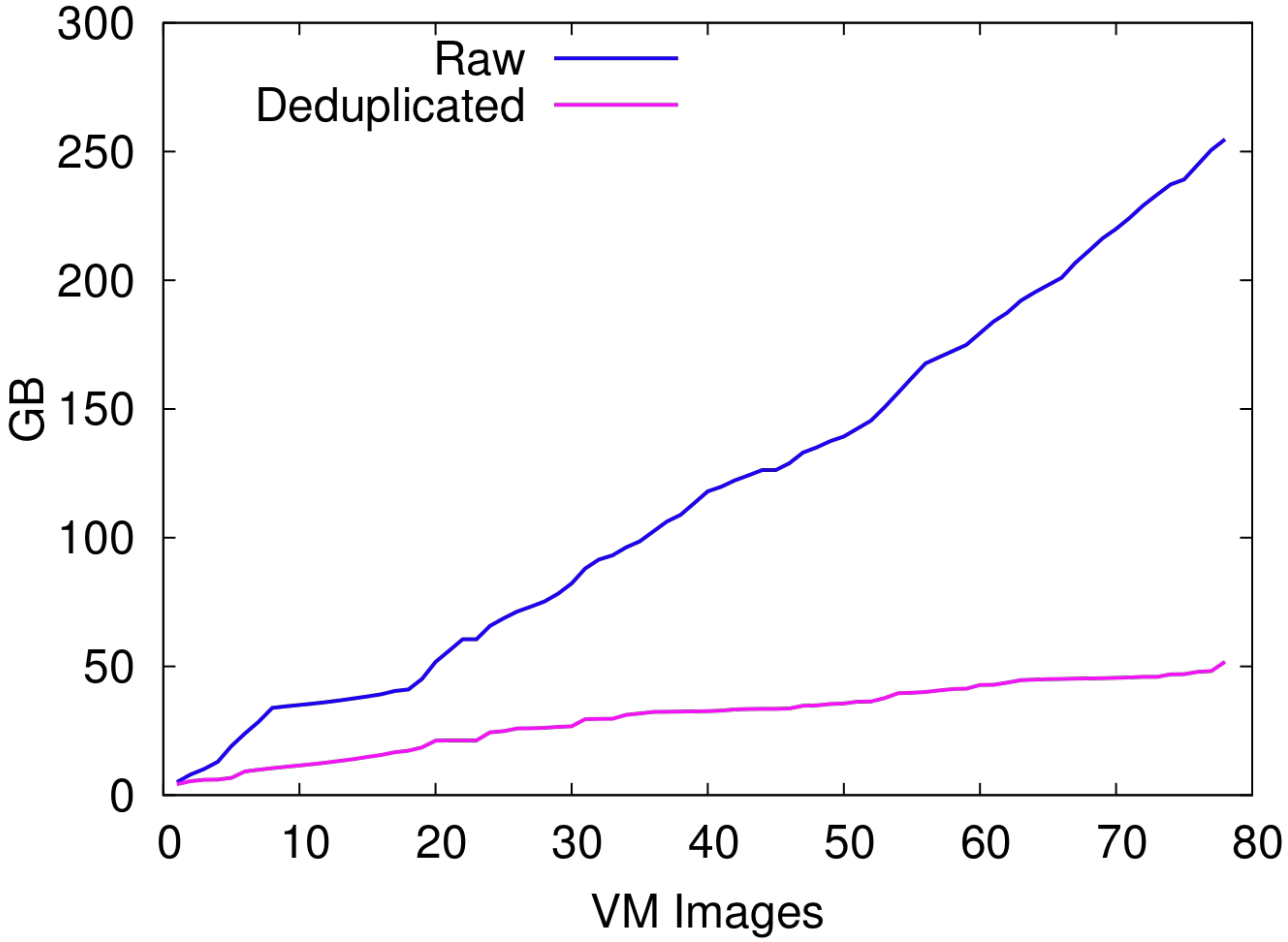
OpenDiamond Platform

- Distributed, interactive, unindexed search
- Focuses on the principle of early discard
- Enables arbitrary search queries
  - Arbitrary x86 binary code as query primitives

Achievable Efficient Retrospection



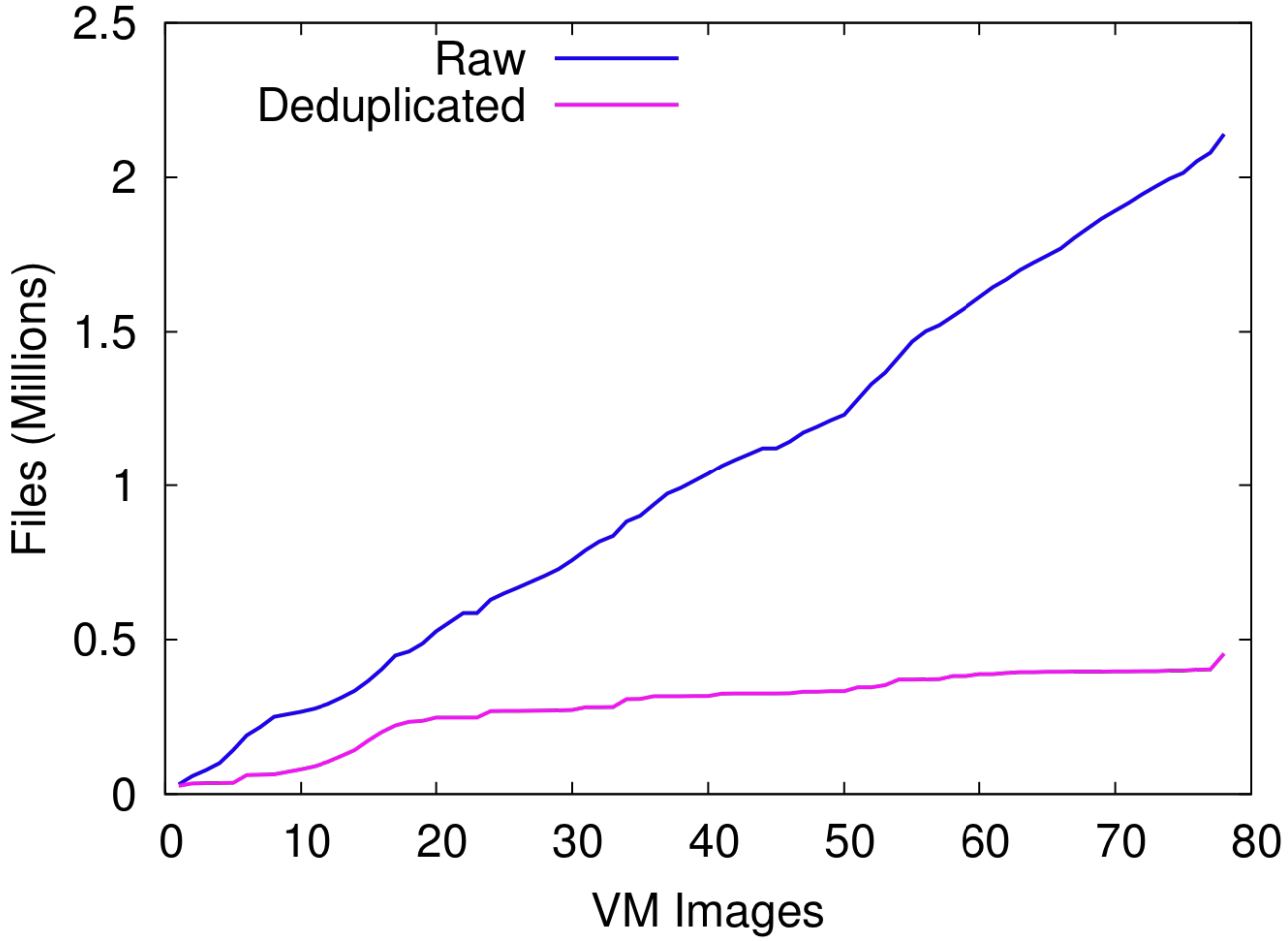
Effect of Deduplication - Bytes



Reduce Storage Space

Data from 78 NCSU VCL
VM Images based on Windows XP

Effect of Deduplication - Files



Reduce Search Time

Data from 78 NCSU VCL
VM Images based on Windows XP