BlueSky: A Cloud-Backed File System for the Enterprise

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Computing Services for the Enterprise

- Our work is focused primarily on small/medium-sized organizations
- These organizations run a number of computing services, such as e-mail and shared file systems
- Often brings significant cost:
  - Purchasing hardware
  - Operating hardware
  - Managing services
- Outsourcing these services to the cloud offers the possibility to lower costs

. . . Migrated to the Cloud

Some services are already migrating to the cloud. . .

Gmail™

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Network file systems have not yet migrated, but still have potential benefits:

- File system size entirely elastic: simpler provisioning
- Cloud provides durability for file system data
- Hardware reliability less important
- Integration with cloud backup

We build and analyze a prototype system, **BlueSky**, to investigate how to do so

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Spectrum of service models:

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In both cases:

- Infrastructure moved within network
- Reduce/eliminate need for hardware maintenance
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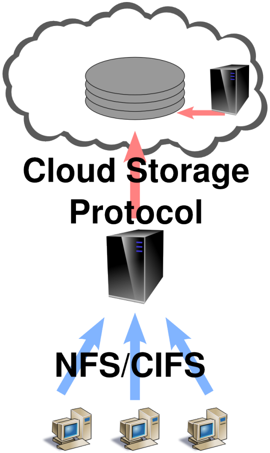
SaaS: Easy to set up
PaaS/IaaS: More choice among service providers, potentially lower cost

Challenges

Cloud storage (e.g., Amazon S3) acts much like another level in the storage hierarchy but brings new design constraints:

- New interface
  - Only supports writing complete objects
  - Does support random read access
- Performance
  - High latency from network round trips
  - Random access adds little penalty
- Security
  - Data privacy is a concern
- Cost
  - Cost is very explicit
  - Unlimited capacity, but need to delete to save money

BlueSky: Approach



- For ease of deployment, do not change software stack on clients
  - Clients simply pointed at a new server, continue to speak NFS/CIFS
- Deploy a local proxy to translate requests before sending to the cloud
  - Provides lower-latency responses to clients when possible by caching data
  - Implements write-back caching
  - Encrypts data before storage to cloud for confidentiality

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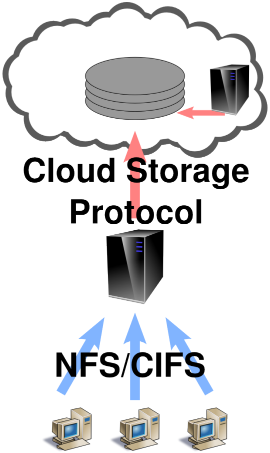
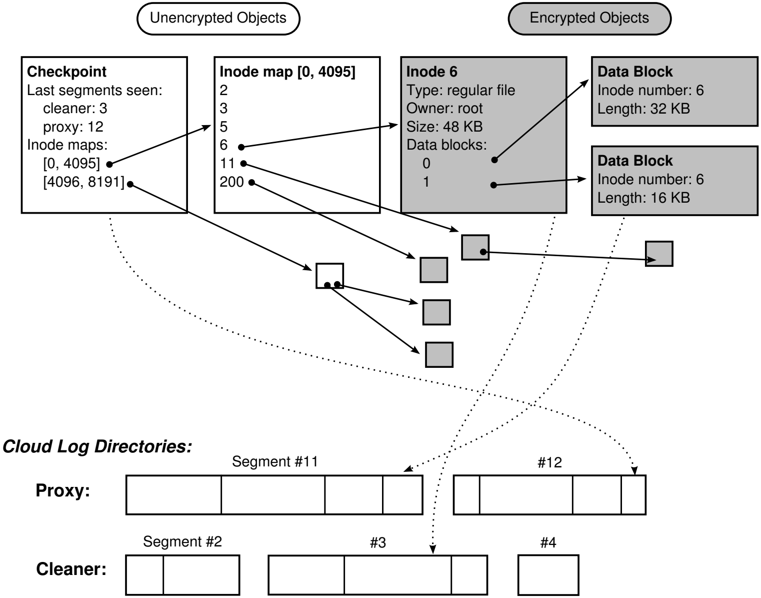
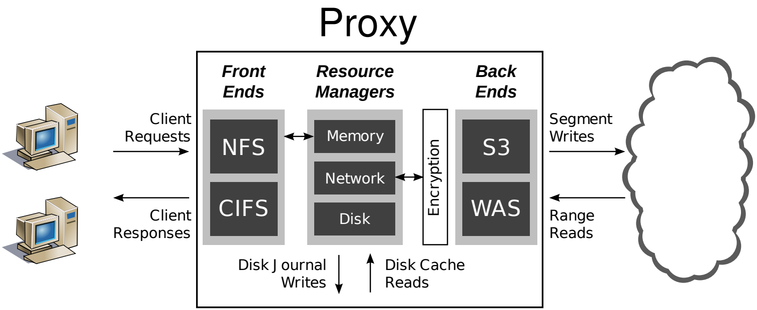


- BlueSky adopts a log-structured design
  - Each log segment uploaded all at once
  - Random access allowed for downloads
- Log cleaner can be run in the cloud (e.g., on Amazon EC2) for faster, cheaper access to storage
  - Log cleaner can run concurrently with active proxy
  - Cleaner not given full access to file system data

File System Design



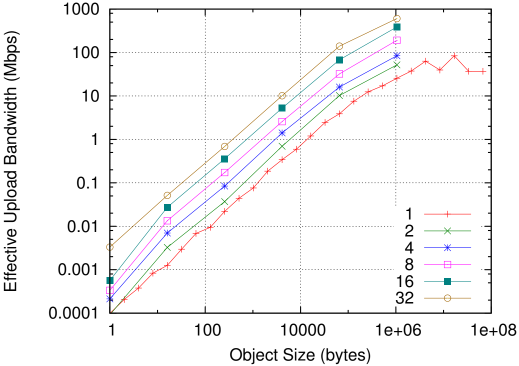
Architecture



- Proxy internally buffers updates briefly in memory
- File system updates are serialized and journaled to local disk
- File system is periodically checkpointed: log items are aggregated into segments and stored to cloud
- On cache miss, log items fetched back from cloud and stored on local disk

Cloud Storage Performance

- We are assuming that users will have fast connectivity to cloud providers (if not now, then in the near future)
- Latency is a fundamental problem (unless cloud data centers built near to customers)



- Network RTT: 30 ms to standard (US-East) S3 region, 12 ms to US-West region
- Proxy can fully utilize bandwidth to cloud
- Results argue for larger objects, parallel uploads

Application Performance

Simple benchmark: unpack Linux kernel sources, checksum kernel sources, compile a kernel

	Unpack	*Check*	*Compile*
	(write)	(read)	(R/W)
Local NFS server	10:50	0:26	4:23
NFS server in EC2			
BlueSky/S3-West			
warm proxy cache			
cold proxy cache			
full segment prefetch			
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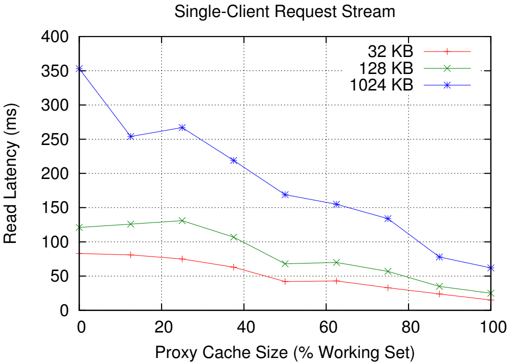
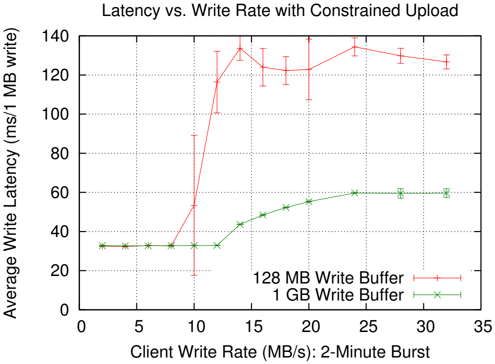
warm proxy	5:08	0:35	5:53
cold proxy cache		57:26	8:35
full segment prefetch		3:50	8:07

Read Performance Microbenchmark



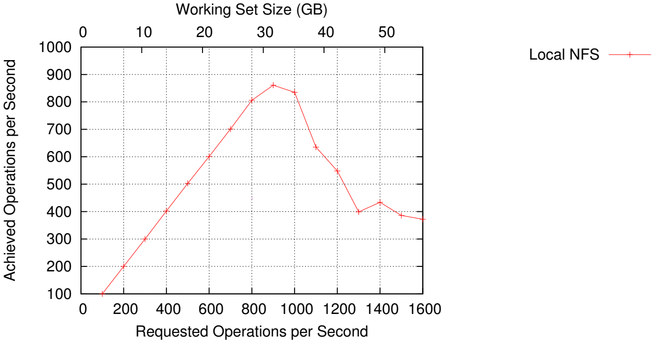
- Read performance depends on working set/cache size ratio
- At 100% hit rate, comparable to local NFS server
- Even at 50% hit rate, latency within about 2× to 3× of local case

Write Performance Microbenchmark



- Configure network to constrain bandwidth to cloud at 100 Mbps
- Write performance: similar to local disk, unless write rate exceeds cloud bandwidth and write-back cache fills

Aggregate Performance: SPECsfs2008



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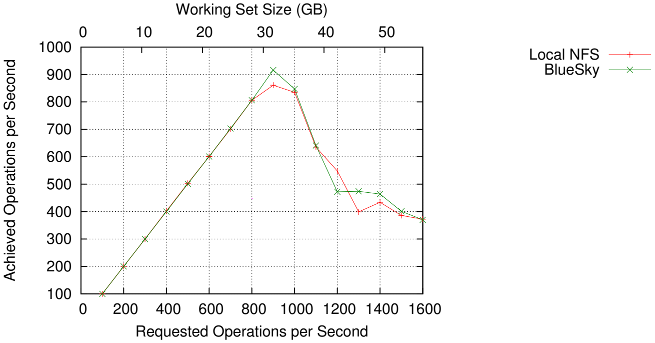

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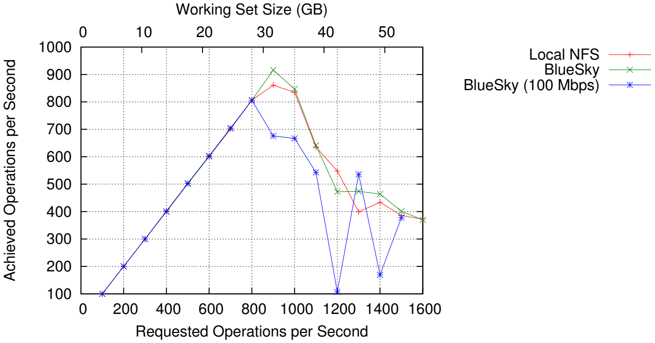

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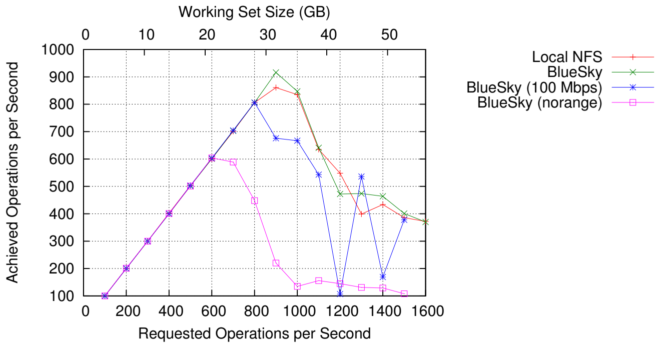

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- BlueSky is comparable to local NFS (as before, slight advantage on writes from log-structured design)
- Performance is less predictable with a constrained network link
- Fetching full segments is a big loss with mostly random access

Monetary Cost: SPECsfs2008

Normalized cost: cost per million SPECsfs operations
(for S3 prices: $0.12/GB download, $0.01/1000–10000 ops)

	Down	*Op*	*Total*	*(Up)*
Log-structured baseline	$0.18	$0.09	$0.27	$0.56
No aggregation	0.17	2.91	3.08	0.56
Full segment downloads	25.11	0.09	25.20	1.00

- Log-structured design minimizes cost for cloud storage operations
- Support for random access on reads (byte-range request) needed for low cost
- Storage cost also an important consideration, but less sensitive to system design

Conclusions

- BlueSky is a prototype file server backed by cloud storage
- Prototype supports multiple client protocols (NFS, CIFS) and storage backends (Amazon S3, Windows Azure)
- Allows clients to transparently move to cloud-backed storage
- Performance comparable to local storage when most access hits in cache
- Design is informed by cost models of current cloud providers