利用備份與投票技術實作雲端儲存之即時行為違反證明技術

Implementing Real-time POV for Cloud Storage by Replication and Voting

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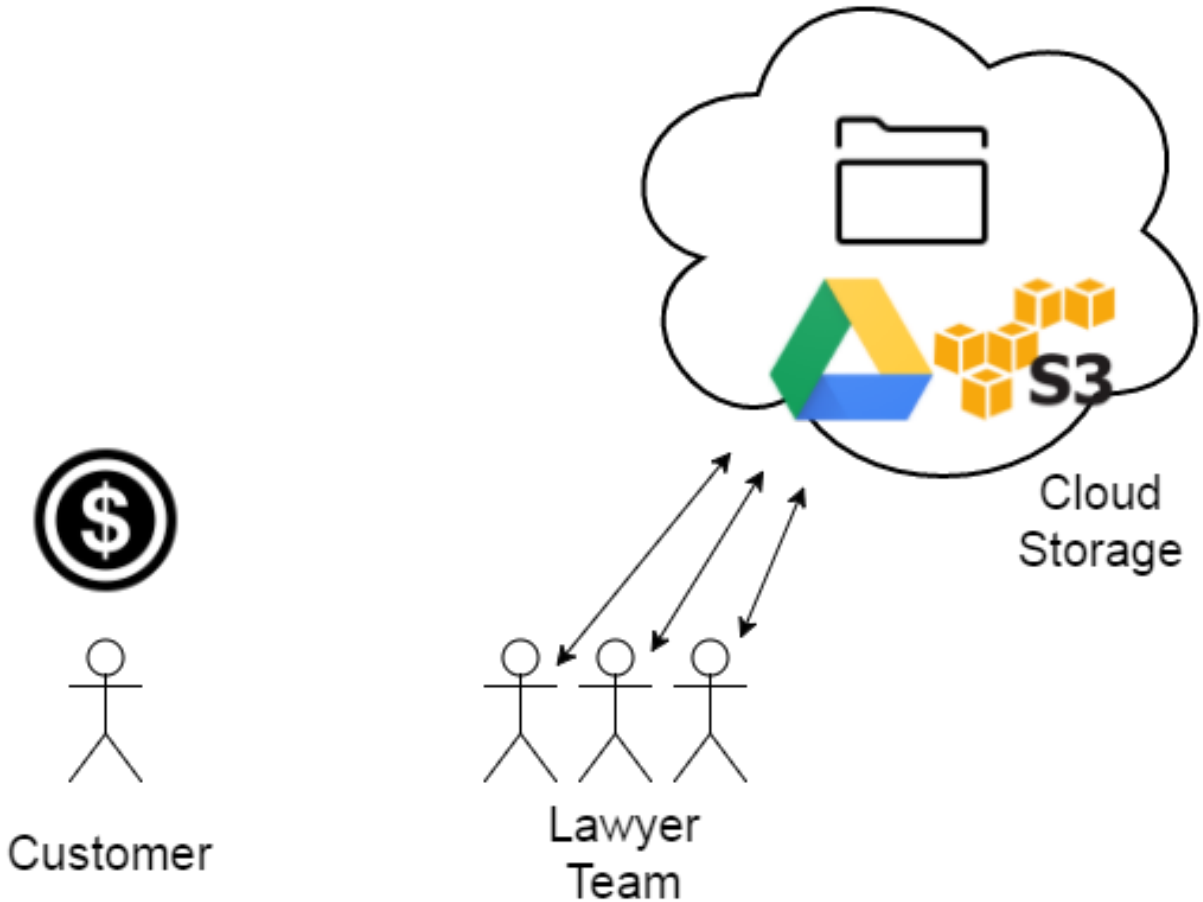
NTNU CSIE CCLAB

2016.07.13

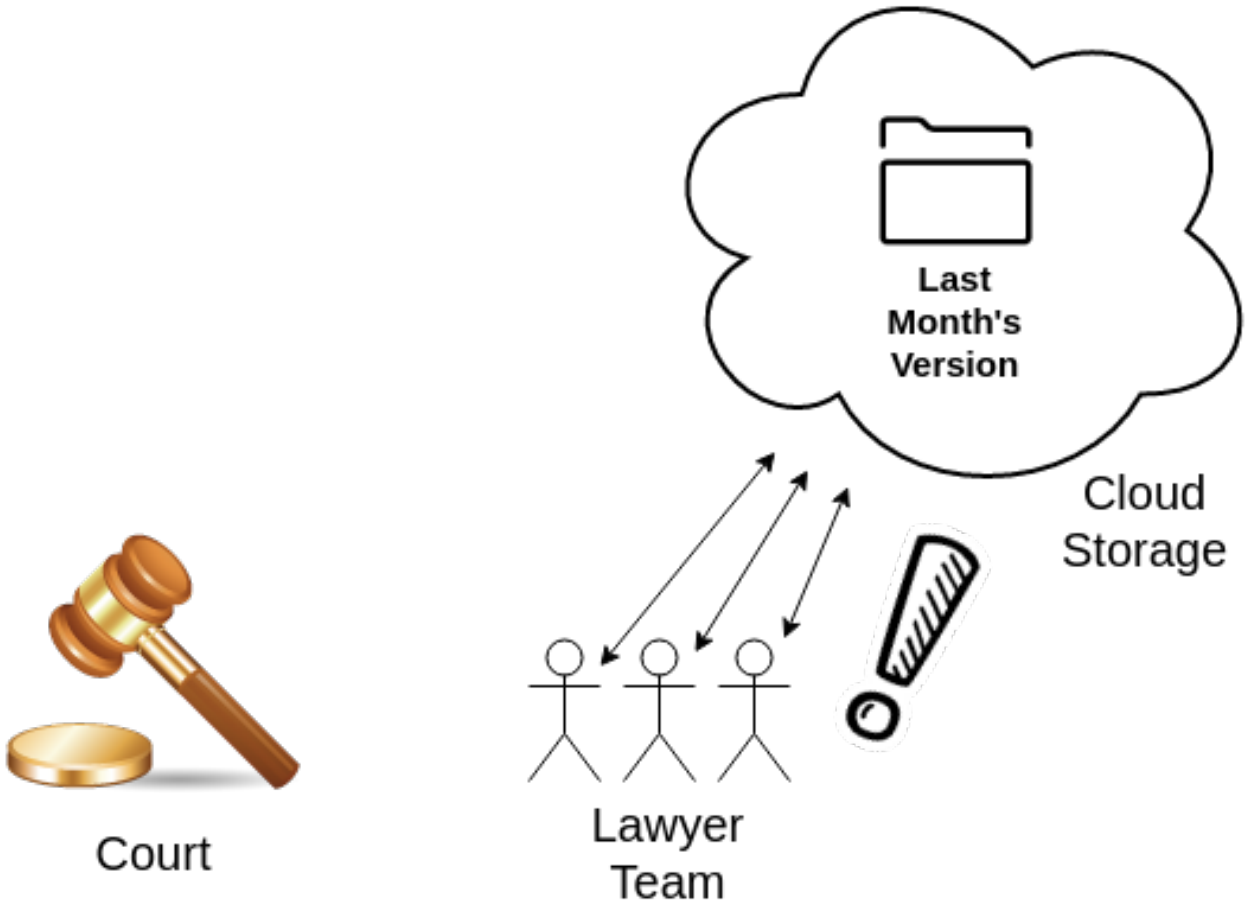
Outline

Scenario
Law Office



Scenario (CON'T)

What if...

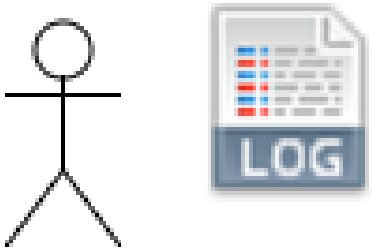


Service Provider's Rollback Attack

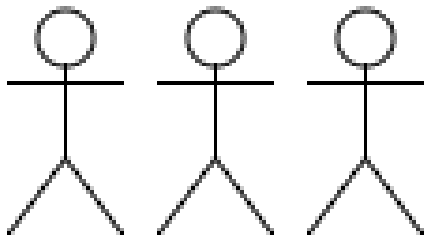
Scenario (CON'T)

No Error !

No Evidence ...

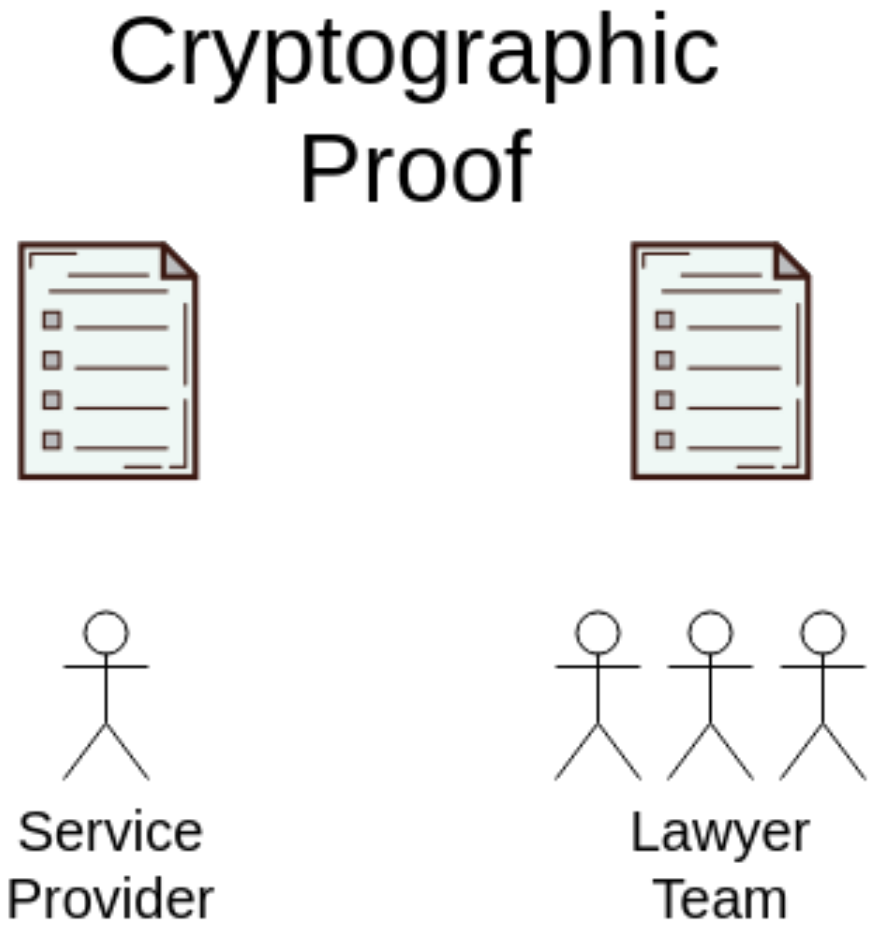


Service Provider



Lawyer Team

Scenario (CON'T)



Obtaining Mutual Non-repudiation

Previous Work

G.-H. Hwang, W.-S. Huang and J.-Z. Peng, "Real-time proof of violation for cloud storage," in Cloud Computing Technology and Science (CloudCom), 2014 IEEE 6th International Conference on, IEEE, 2014, pp. 394-399.

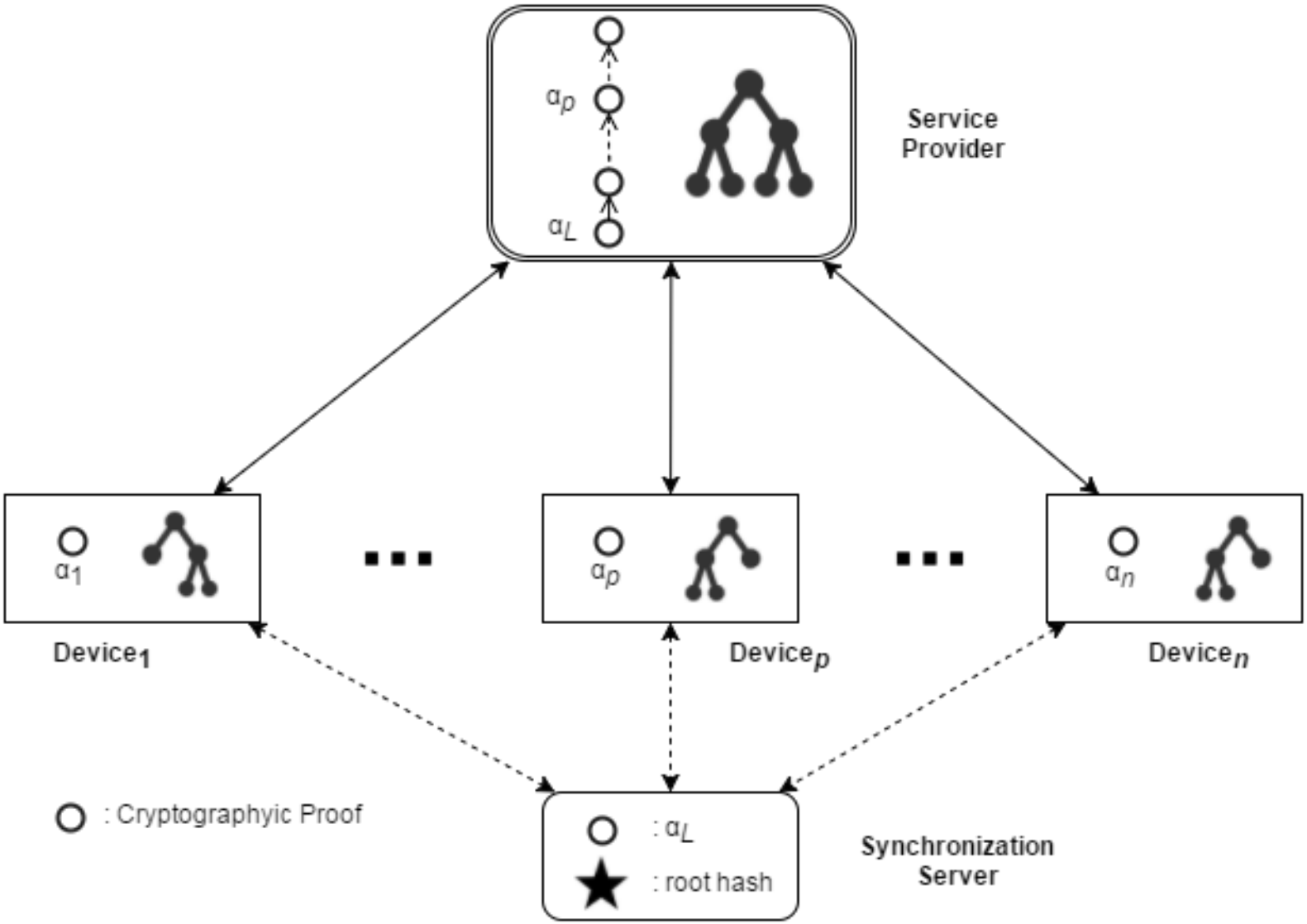
POV - Proof of Violation

定義以下三個 Tuples:

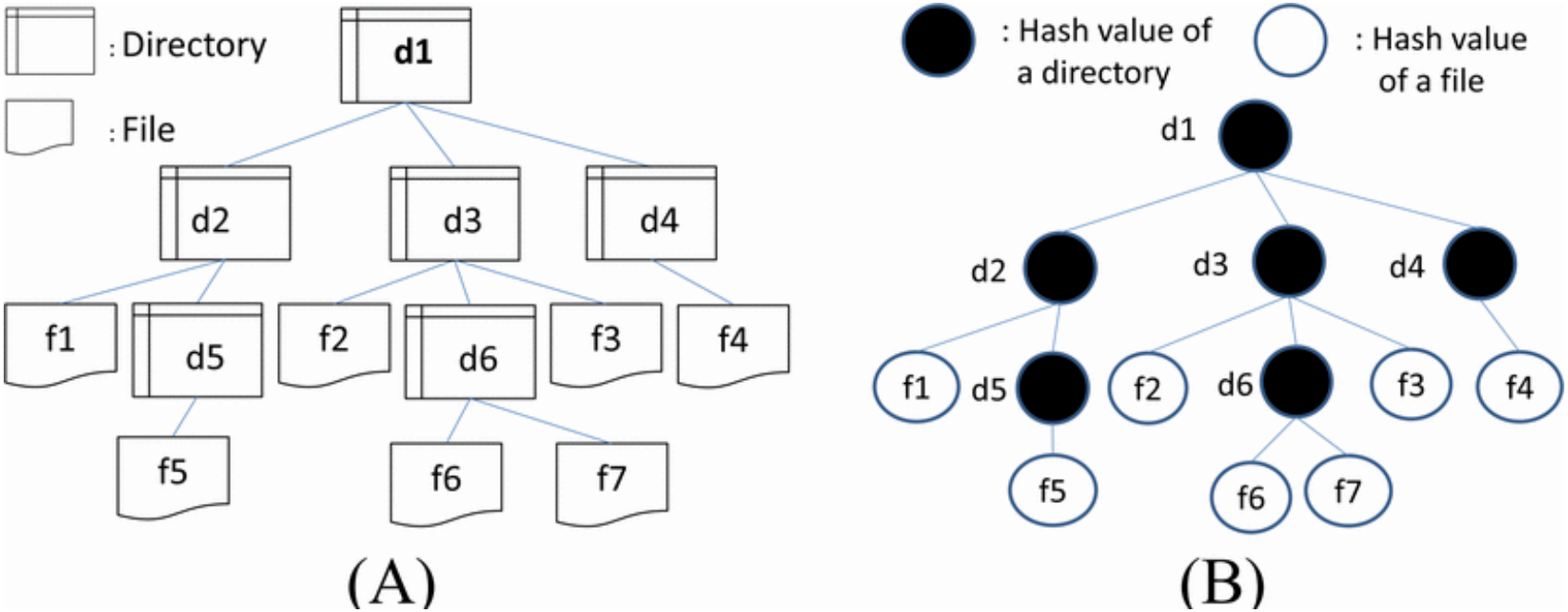
- Properties
  - Data Integrity
  - Write Serializability
  - Read Freshness
- A cryptographic accountability protocol (CAP)
  - 在 User 和 Service Provider 之間交換的訊息加上簽章,
    藉由此 Cryptographic Proof 讓雙方不可否認自己做過的事
- Auditing
  - 利用收集的 Cryptographic Proof 來證明是否違反 Properties

Real-time Proof of Violation for Cloud Storage

2014 IEEE 6th International Conference on Cloud Computing Technology and Science

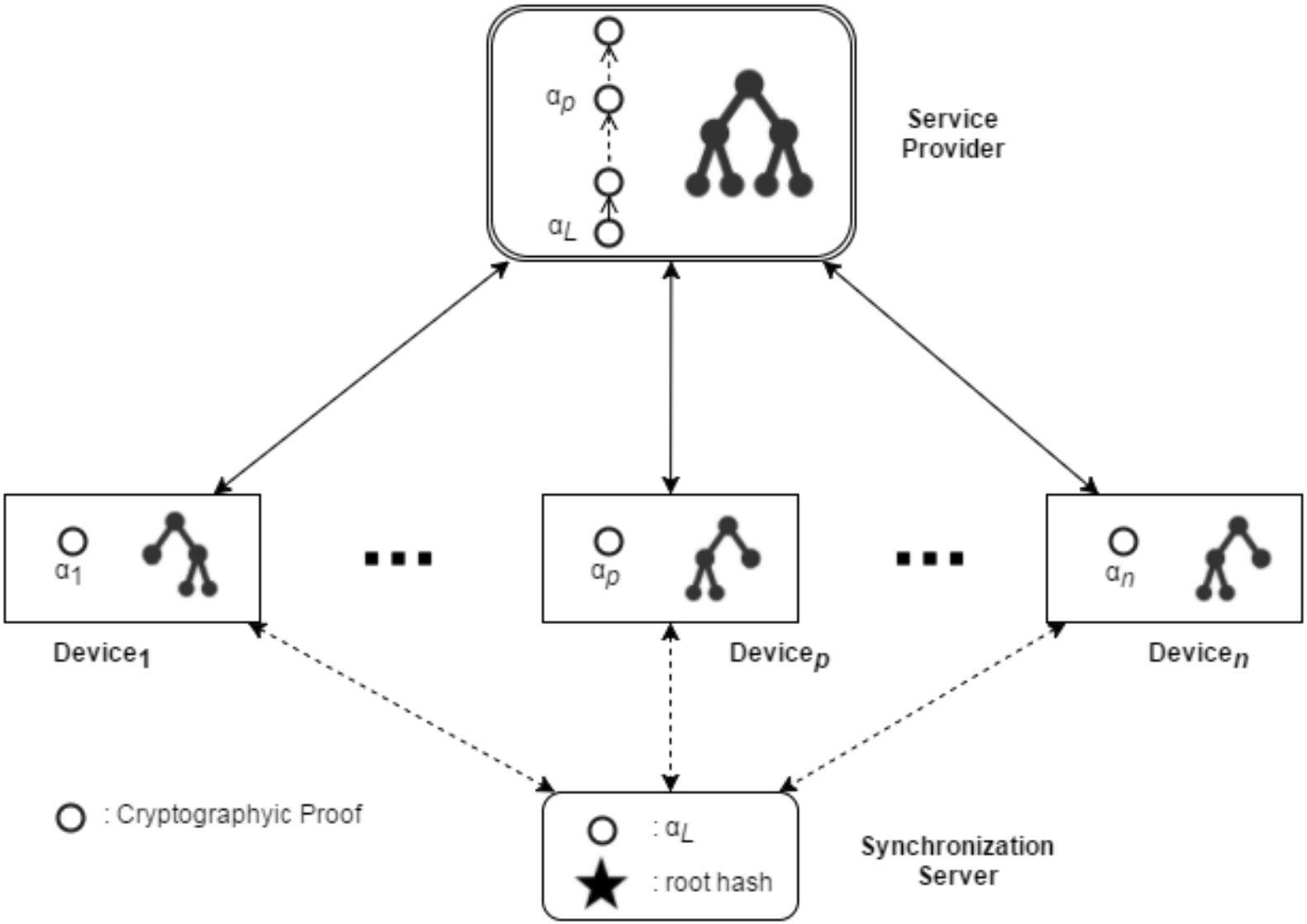


Merkle Tree


: Directory
: File
d1
d2
d3
d4
f1
d5
f2
d6
f3
f4
f5
f6
f7
(A)
: Hash value of a directory
: Hash value of a file
d1
d2
d3
d4
f1
d5
f2
d6
f3
f4
f5
f6
f7
(B)

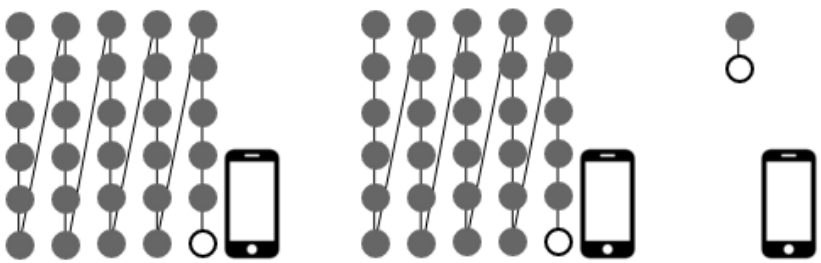
Real-time Proof of Violation for Cloud Storage

2014 IEEE 6th International Conference on Cloud Computing Technology and Science



Worst-case

若有個 device 很久沒有使用，下次要上傳下載檔案前需要花很長的時間將 merkle tree 更新到最新
累積的 hash chain 越長，使用者等待的時間越久

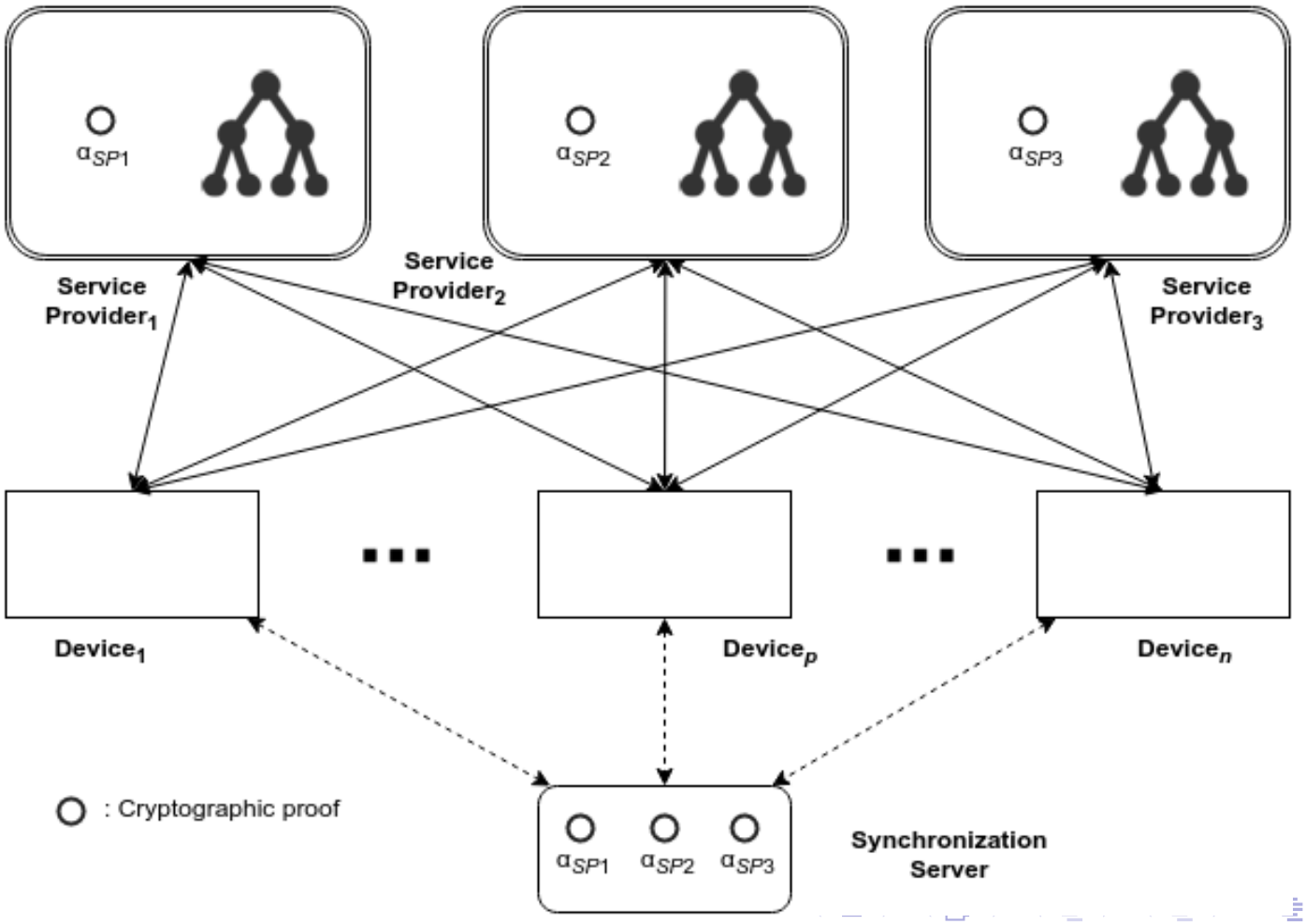


System Architecture

Assumption:

同時 k 個 server，同時回傳相同錯誤結果的機率 ≈ 0

Service Providers are Independent Cloud

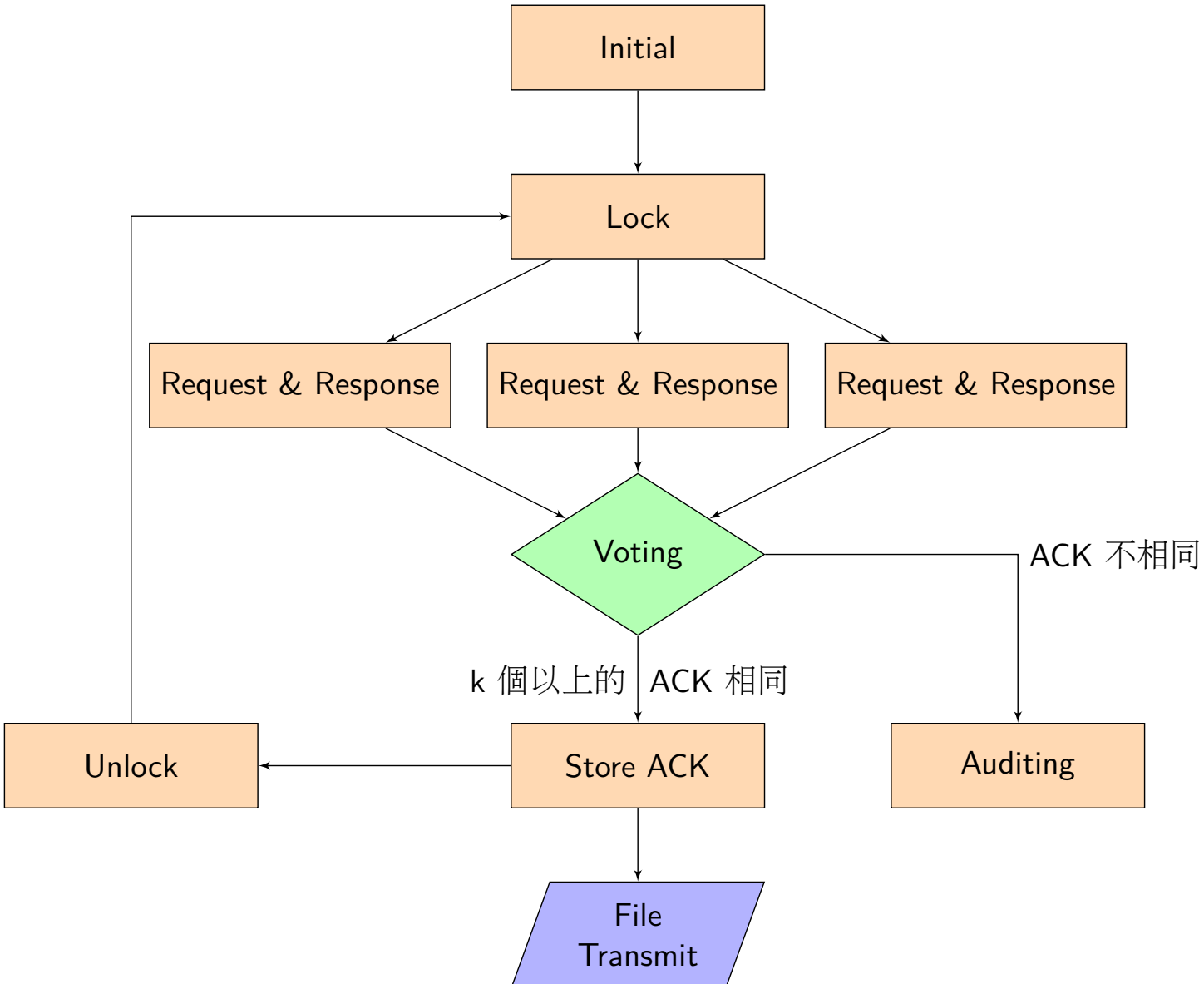


Comparison

- Pros
  1. Device 節省了儲存 Merkle tree 的空間
  2. Device 不需要計算新的 Roothash 將會節省時間
  3. 每一次更新資料都會即時的備份
  4. 不會有之前的 Worst-case

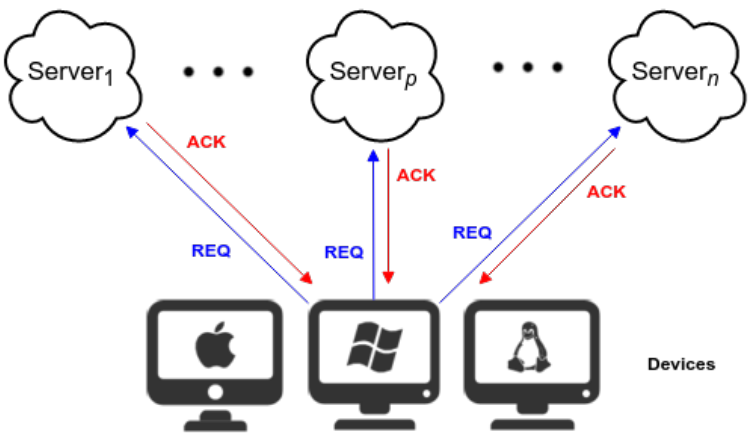
- Cons
  1. 需要傳送多份 Request, 處理多份 Response
  2. 需要使用較多的 Service Provider

System Flowchart



Download & Upload

Request & Response



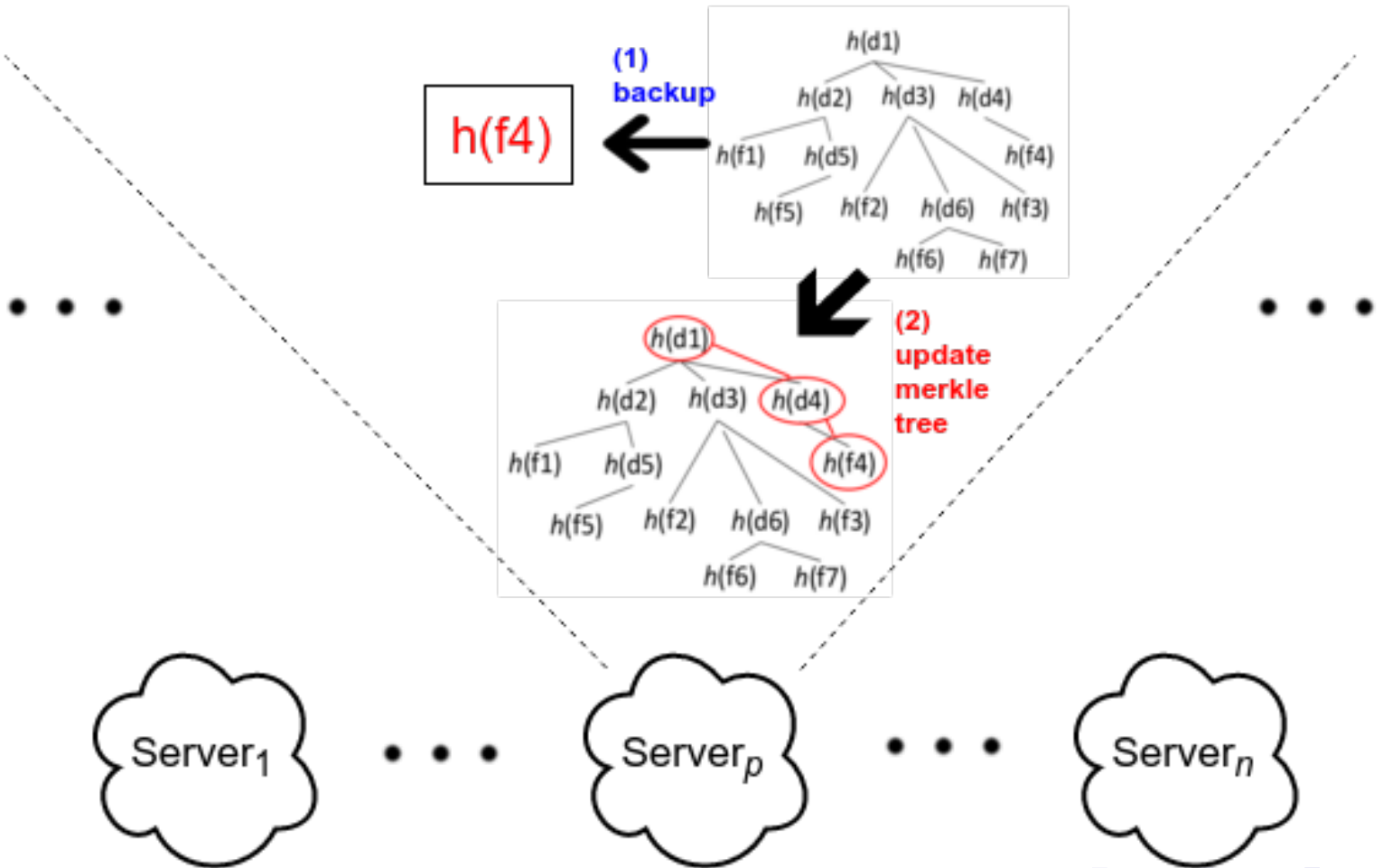
$$REQ = (OP,\ SN,\ [OP,\ SN]_{pri(D)})$$
$$OP = (TYPE,\ PATH,\ HASH)$$
$$SN = Sequence\ Number$$

$$ACK = (RESULT,\ REQ,\ [RESULT,\ REQ]_{pri(S)})$$
$$RESULT = (roothash,\ filehash)$$

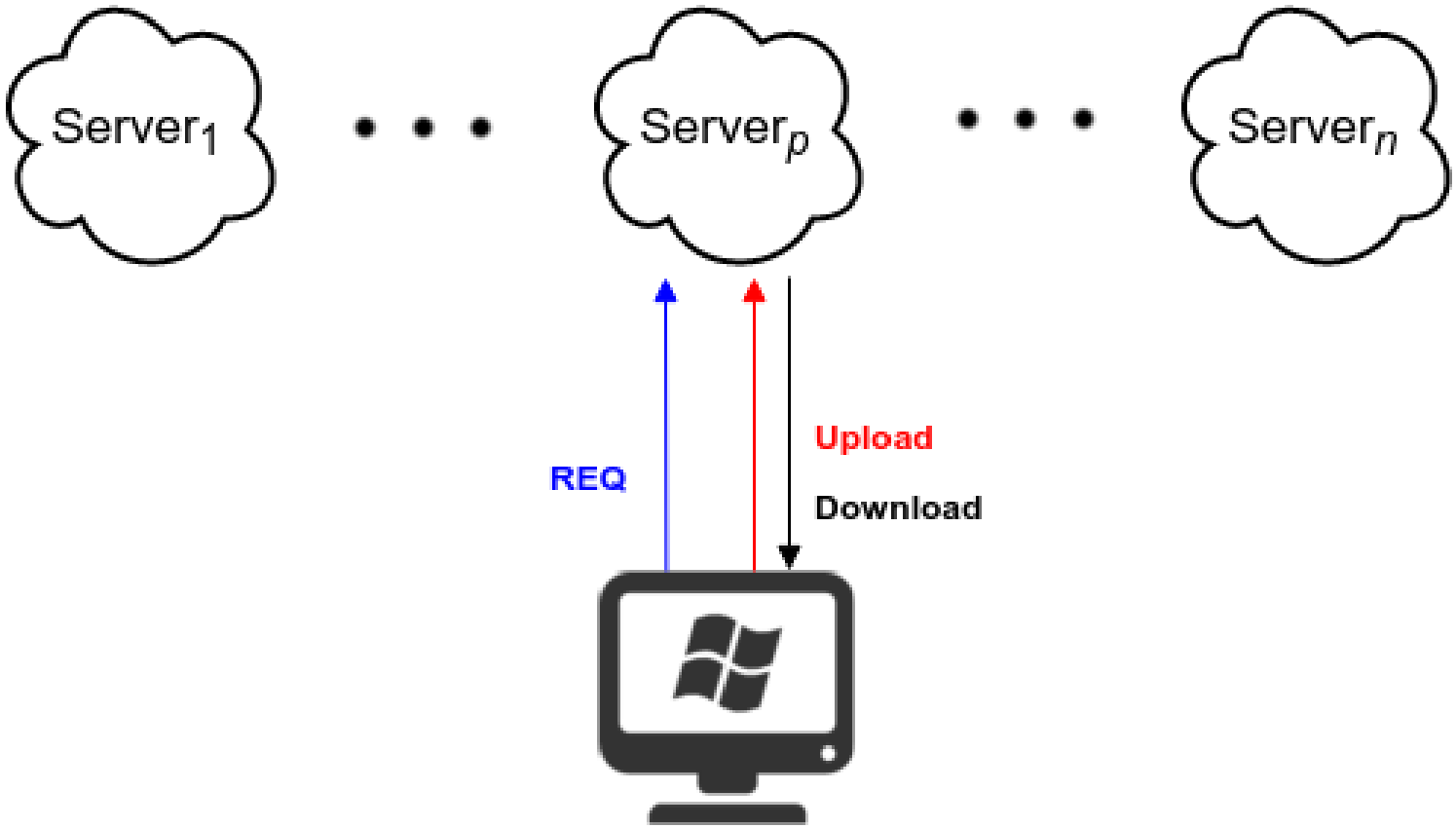
collect ACKs and voting

if Operation is UPLOAD

Servers Update Merkle tree



File Transmit



Audit

device request OP_i，收到回傳的 ACK_i
發現 $Server_p$ 的 ACK 有錯誤，因此向 $Server_p$ 稽核

device 向 $Server_p$ 索取 MT_{i-1}
(MT_{i-1} 為執行 OP_i 之前的 Merkle tree)

①② 兩點有一個出錯就能證明 $Server_p$ 出錯

[證明 i 之前的動作都沒問題]

① device 檢查 MT_{i-1} 的 roothash，應和 ACK_{i-1} 中紀錄的相同

[證明第 i 個動作沒問題]

② device 以 OP_i 中的 hash value 來更新 MT_{i-1}，
更新後的 roothash 應和 $Server_p$ 現在的 roothash 相同

Outline

Experimental Results

	Size	File	Directory
A	777 MB	48	6
B	145 MB	54198	188
C	5.95 GB	45089	1459

Table: GENERATE MERKLE TREE'S TIME (IN SEC.)

	Non Hashed	Pre Hashed	Merkle tree Size
A	9.406	0.003	5.4 KB
B	55.147	2.703	5.08 MB
C	339.181	0.334	4.37 MB

Table: SERIALIZE & DESERIALIZE MERKLE TREE OBJECT'S TIME (IN SEC.)

	Serialize	Deserialize
A	0.040	0.009
B	0.756	0.299
C	0.670	0.295

Outline

Experimental Results
Non POV

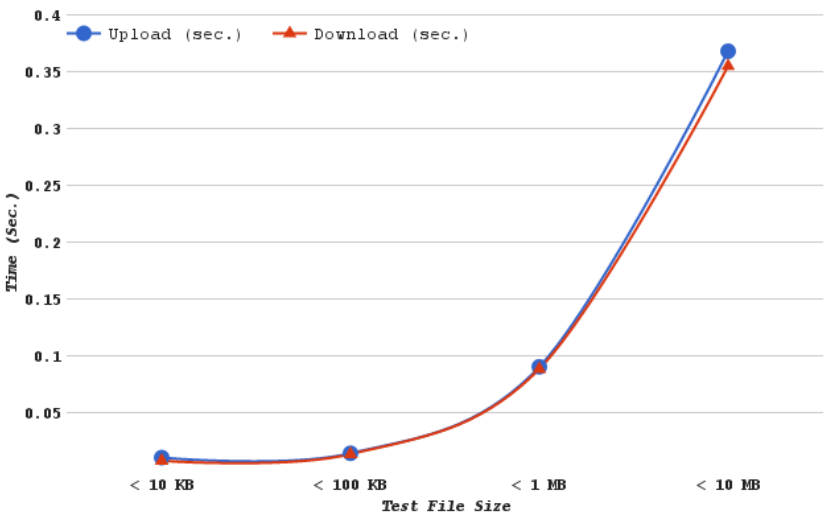
not in the same network segment: from lab to my home (16 hops.)

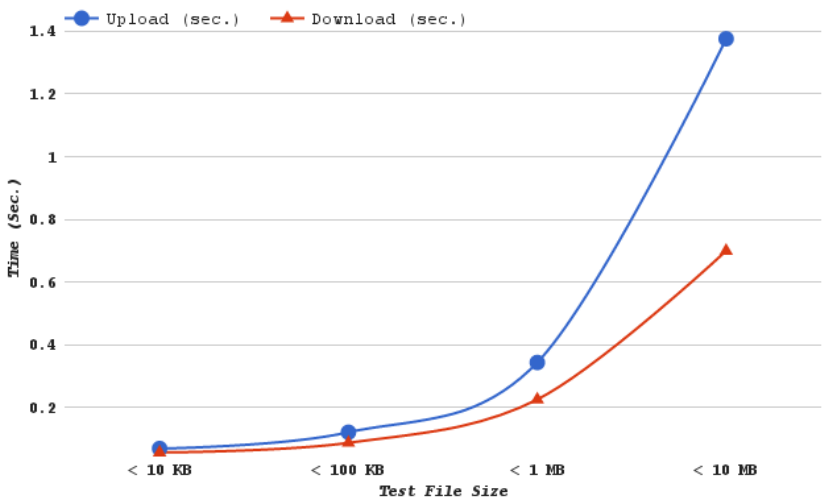
Table: The client device and SP are in the same network segment

	Upload (sec.)	Download (sec.)
<10 KB	0.010	0.007
<100 KB	0.014	0.013
<1 MB	0.090	0.088
<10 MB	0.367	0.354

Table: The client device and SP are not in the same network segment

	Upload (sec.)	Download (sec.)
<10 KB	0.069	0.056
<100 KB	0.121	0.087
<1 MB	0.343	0.225
<10 MB	1.675	0.699





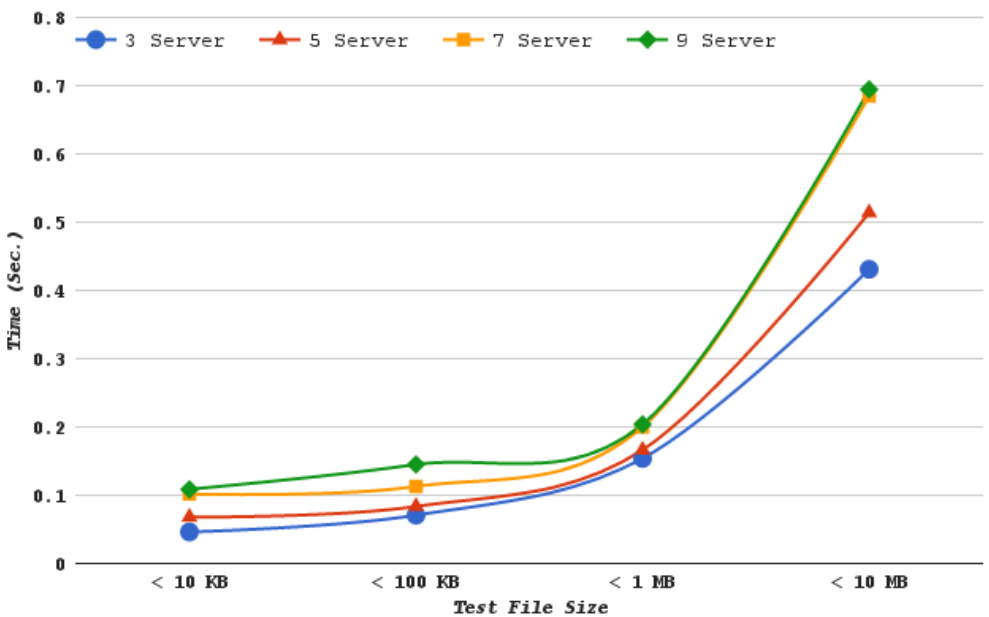
Outline

Experimental Results

The client device and SP are in the same network segment - My Method

Table: THE EXECUTION TIME OF UPLOAD OPERATIONS (IN SEC.) (Account C)

	3 Server	5 Server	7 Server	9 Server
<10 KB	0.046	0.067	0.101	0.108
<100 KB	0.070	0.083	0.112	0.145
<1 MB	0.153	0.166	0.200	0.203
<10 MB	0.430	0.513	0.684	0.694

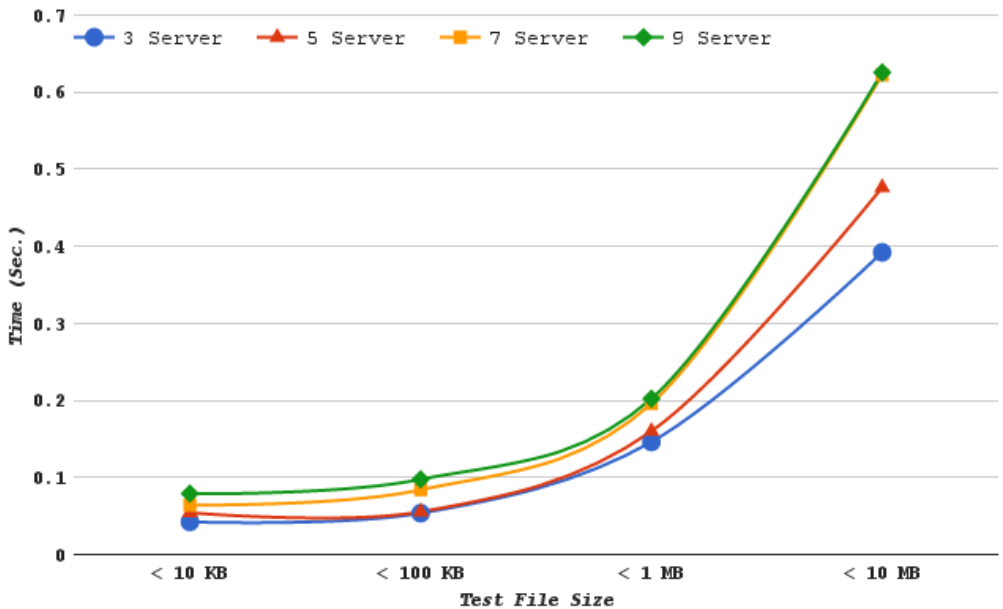


Experimental Results

The client device and SP are in the same network segment - My Method

Table: THE EXECUTION TIME OF DOWNLOAD OPERATIONS (IN SEC.) (Account C)

	3 Server	5 Server	7 Server	9 Server
<10 KB	0.042	0.054	0.064	0.078
<100 KB	0.053	0.055	0.083	0.097
<1 MB	0.146	0.159	0.195	0.202
<10 MB	0.392	0.476	0.622	0.625

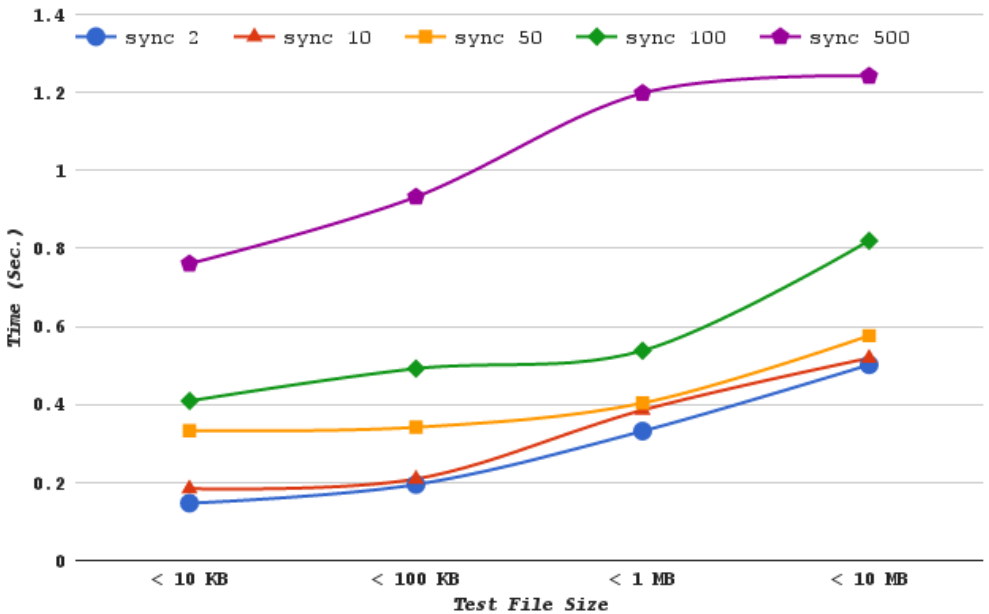


Experimental Results

The client device and SP are in the same network segment - 2014 Cloud Com

Table: THE EXECUTION TIME OF UPLOAD OPERATIONS (IN SEC.) (Account C)

	sync 2	sync 10	sync 50	sync 100	sync 500
<10 KB	0.146	0.184	0.332	0.409	0.760
<100 KB	0.194	0.209	0.341	0.491	0.932
<1 MB	0.331	0.385	0.403	0.537	1.198
<10 MB	0.501	0.518	0.576	0.819	1.242

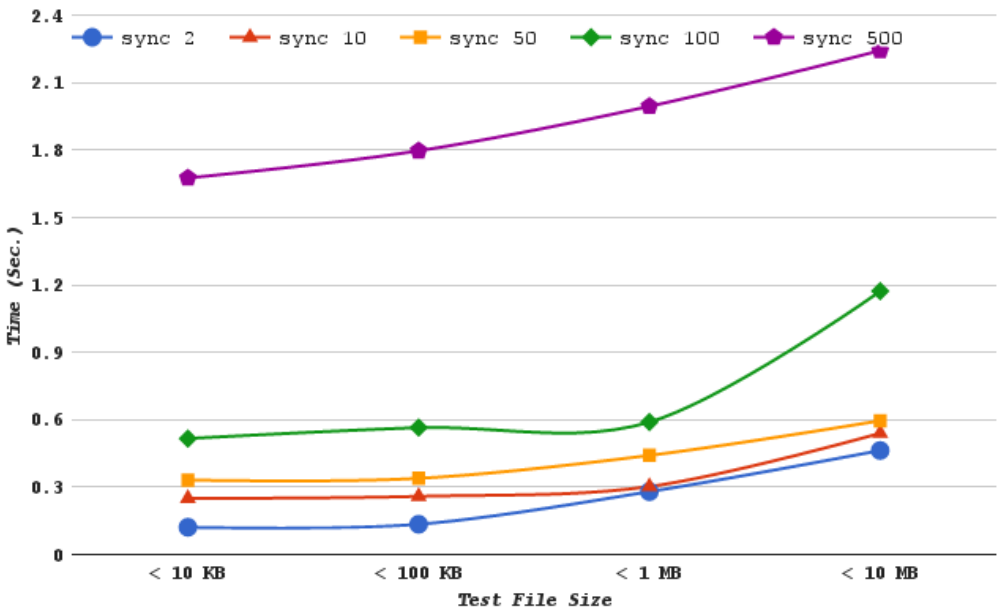


Experimental Results

The client device and SP are in the same network segment - 2014 Cloud Com

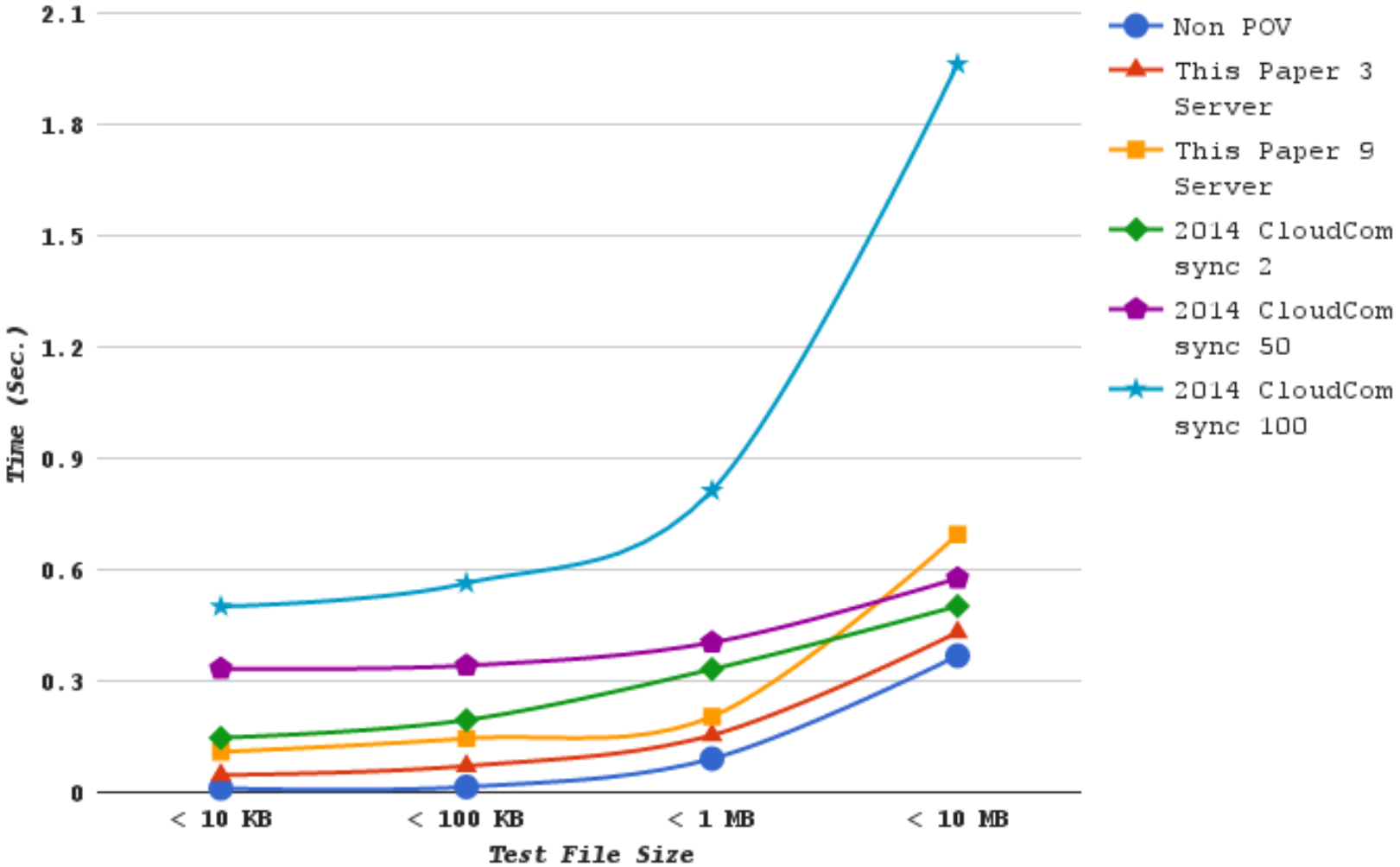
Table: THE EXECUTION TIME OF DOWNLOAD OPERATIONS (IN SEC.) (Account C)

	sync 2	sync 10	sync 50	sync 100	sync 500
<10 KB	0.121	0.249	0.331	0.515	1.675
<100 KB	0.134	0.258	0.338	0.564	1.796
<1 MB	0.279	0.302	0.440	0.588	1.994
<10 MB	0.462	0.539	0.595	1.171	2.241



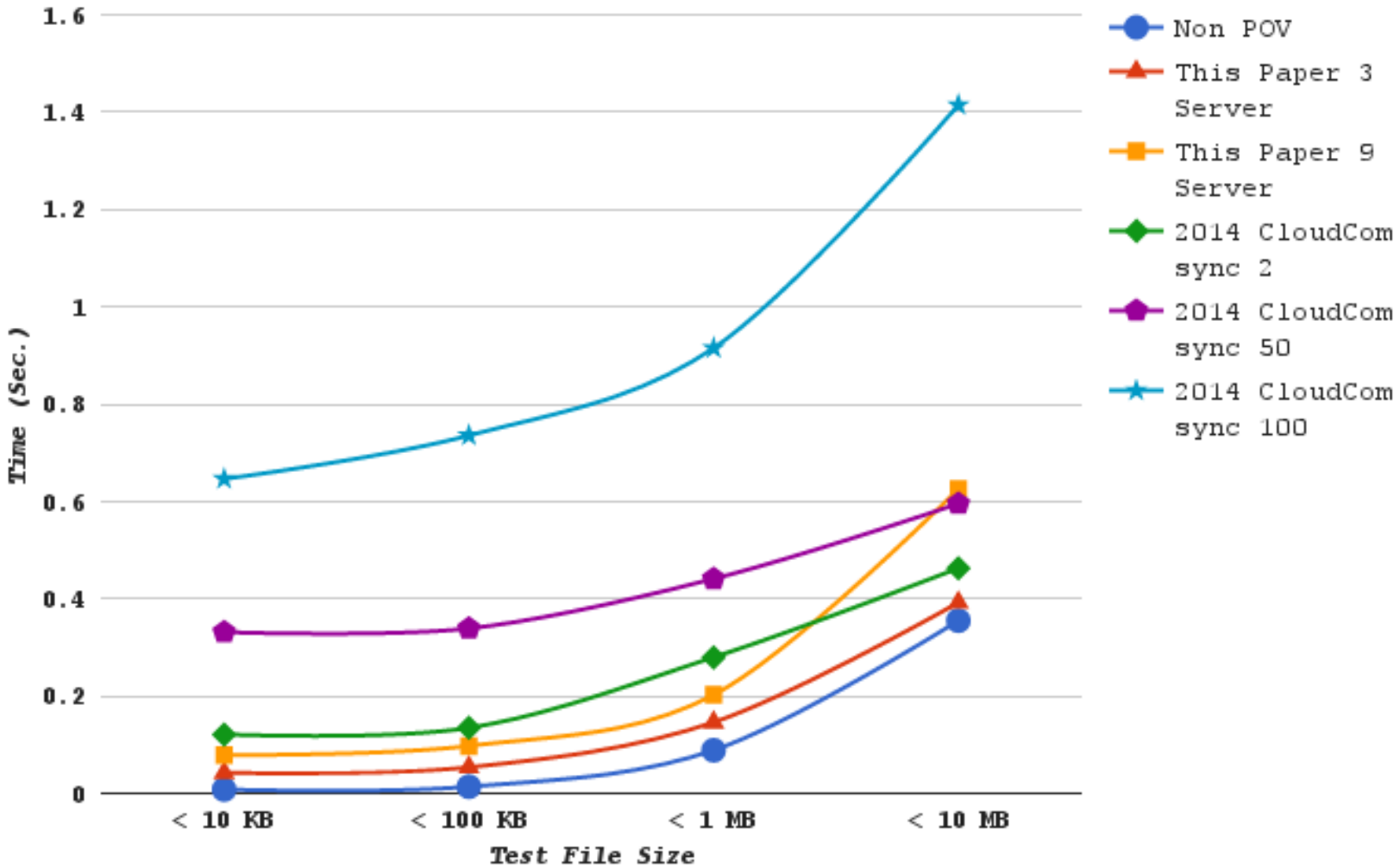
Experimental Results

The client device and SP are in the same network segment - UPLOAD operation



Experimental Results

The client device and SP are in the same network segment - DOWNLOAD operation



Experimental Results

The client device and SP are in the same network segment - UPLOAD Overhead

Table: My Method / Non POV (IN SEC.) (Account C)

	3 Server	5 Server	7 Server	9 Server
<10 KB	4.34	6.40	9.58	10.24
<100 KB	4.91	5.80	7.84	10.07
<1 MB	1.70	1.83	2.21	2.25
<10 MB	1.17	1.39	1.86	1.88

Table: 2014 Cloud Com / Non POV (IN SEC.) (Account C)

	sync 2	sync 10	sync 50	sync 100	sync 500
<10 KB	13.83	17.35	31.39	38.55	71.72
<100 KB	13.52	14.52	23.72	34.18	64.75
<1 MB	3.66	4.26	4.46	5.94	13.24
<10 MB	1.36	1.40	1.56	2.22	3.37

Avg: 3.97 times, Max: 6.99 times

Experimental Results

The client device and SP are in the same network segment - DOWNLOAD Overhead

Table: My Method / Non POV (IN SEC.) (Account C)

	3 Server	5 Server	7 Server	9 Server
<10 KB	5.39	6.91	8.20	10.05
<100 KB	3.91	4.04	6.13	7.12
<1 MB	1.64	1.80	2.21	2.28
<10 MB	1.10	1.34	1.75	1.76

Table: 2014 Cloud Com / Non POV (IN SEC.) (Account C)

	sync 2	sync 10	sync 50	sync 100	sync 500
<10 KB	15.45	31.84	42.23	119.48	532.25
<100 KB	9.82	18.89	24.74	70.34	307.57
<1 MB	3.15	3.41	4.97	13.26	48.48
<10 MB	1.30	1.52	1.67	3.51	12.28

Avg: 7.91 times, Max: 21.24 times

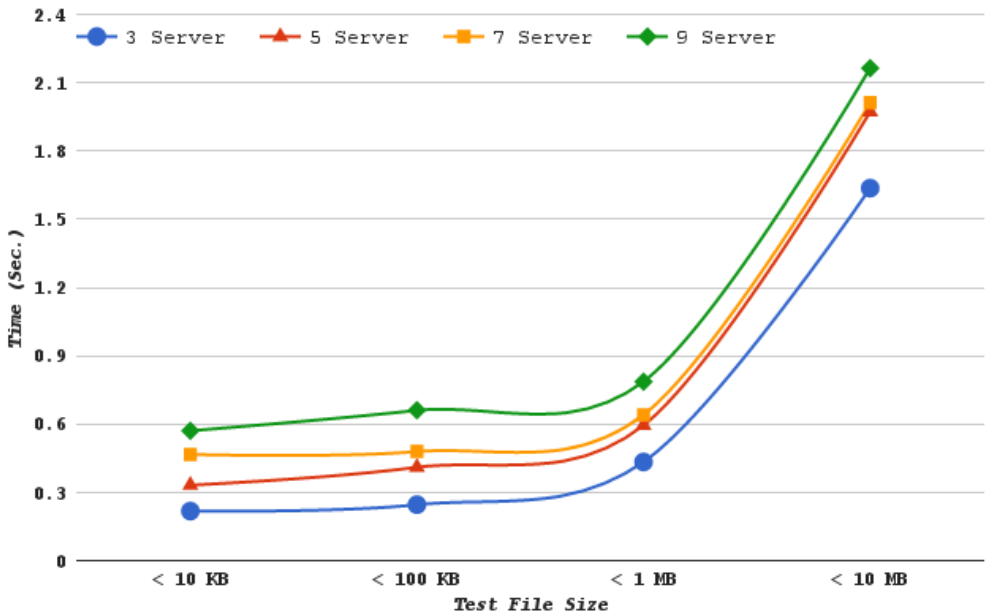
Outline

Experimental Results

The client device and SP are not in the same network segment - My Method

Table: THE EXECUTION TIME OF UPLOAD OPERATIONS (IN SEC.) (Account C)

	3 Server	5 Server	7 Server	9 Server
<10 KB	0.217	0.331	0.466	0.570
<100 KB	0.245	0.410	0.479	0.660
<1 MB	0.433	0.594	0.640	0.786
<10 MB	1.636	1.972	2.011	2.163

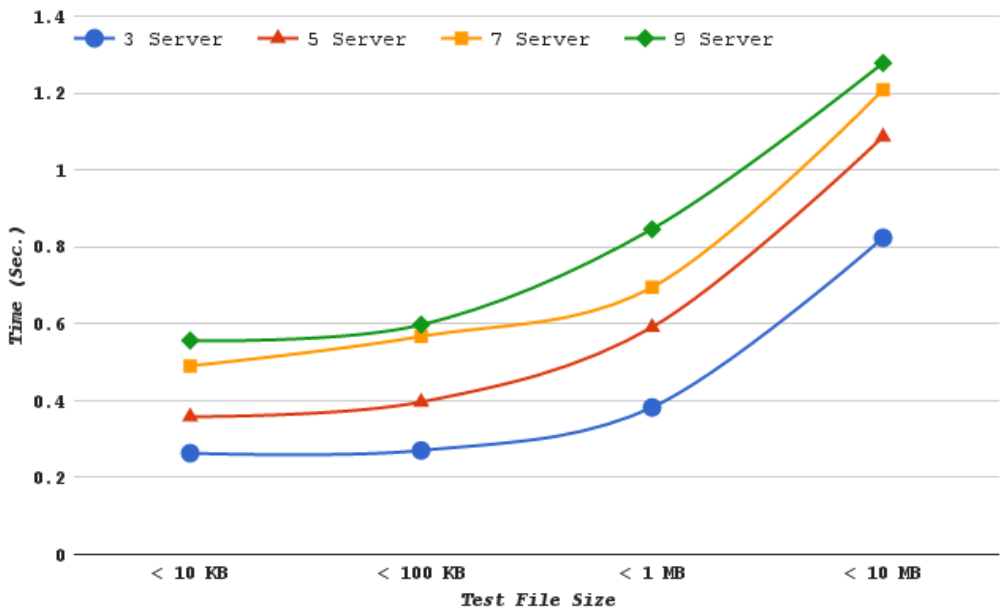


Experimental Results

The client device and SP are not in the same network segment - My Method

Table: THE EXECUTION TIME OF DOWNLOAD OPERATIONS (IN SEC.) (Account C)

	3 Server	5 Server	7 Server	9 Server
<10 KB	0.263	0.358	0.490	0.556
<100 KB	0.270	0.396	0.567	0.597
<1 MB	0.382	0.590	0.694	0.846
<10 MB	0.823	1.086	1.208	1.278

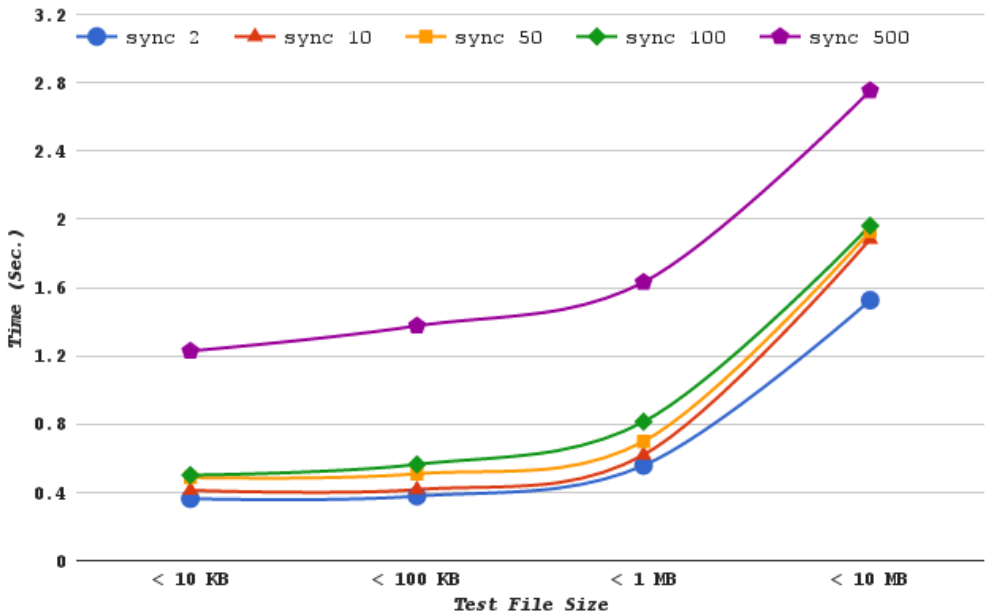


Experimental Results

The client device and SP are not in the same network segment - 2014 Cloud Com

Table: THE EXECUTION TIME OF UPLOAD OPERATIONS (IN SEC.) (Account C)

	sync 2	sync 10	sync 50	sync 100	sync 500
<10 KB	0.362	0.411	0.486	0.500	1.227
<100 KB	0.377	0.416	0.508	0.563	1.375
<1 MB	0.556	0.619	0.698	0.812	1.630
<10 MB	1.525	1.882	1.929	1.962	2.753

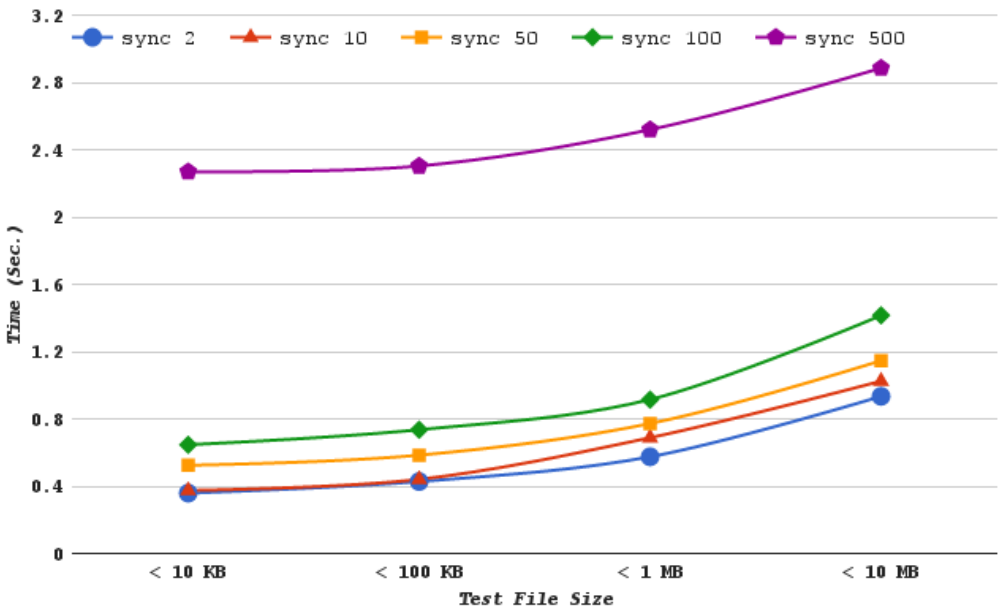


Experimental Results

The client device and SP are not in the same network segment - 2014 Cloud Com

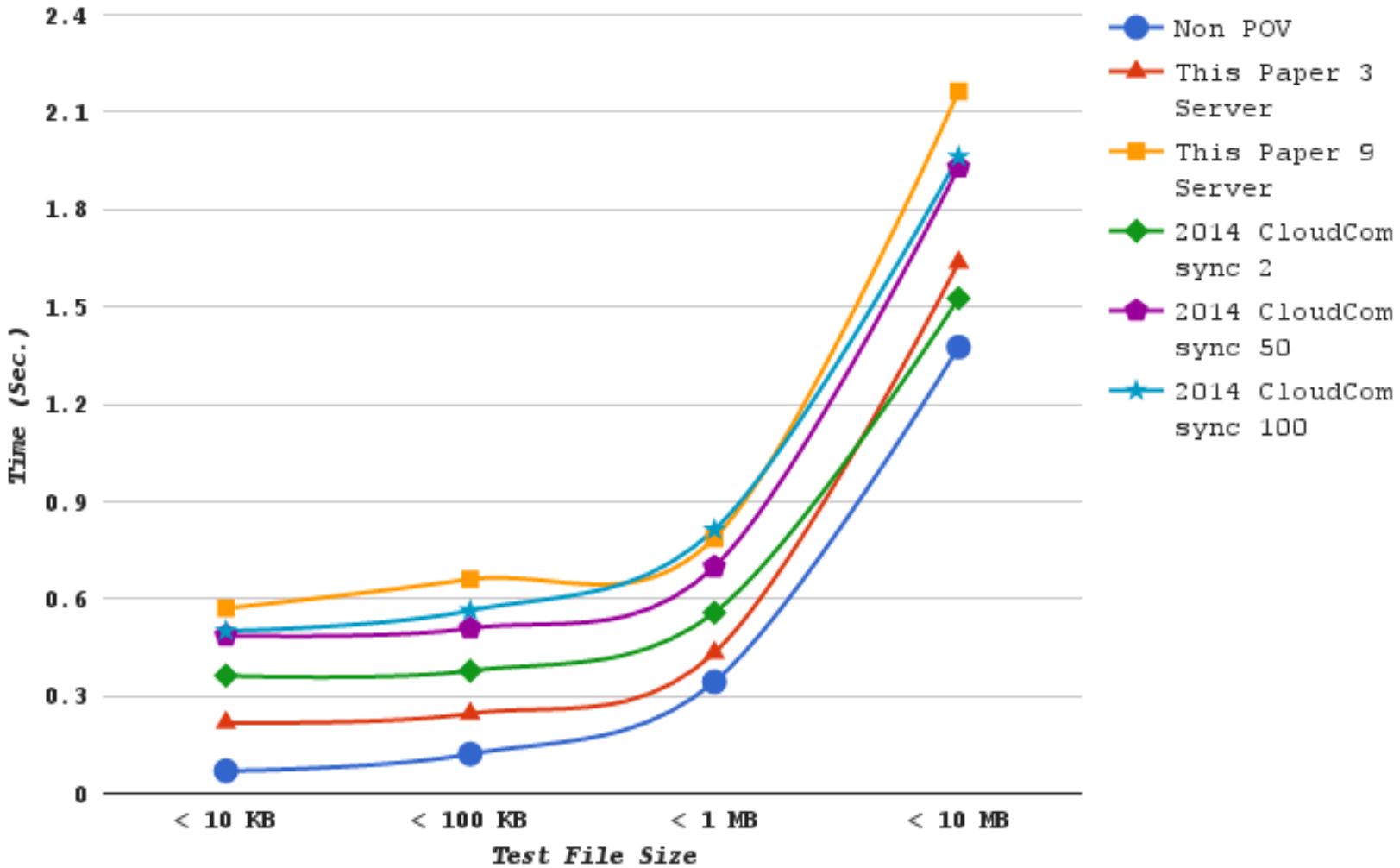
Table: THE EXECUTION TIME OF DOWNLOAD OPERATIONS (IN SEC.) (Account C)

	sync 2	sync 10	sync 50	sync 100	sync 500
<10 KB	0.388	0.374	0.524	0.646	2.269
<100 KB	0.427	0.440	0.584	0.735	2.302
<1 MB	0.574	0.687	0.772	0.914	2.519
<10 MB	0.933	1.024	1.145	1.414	2.884



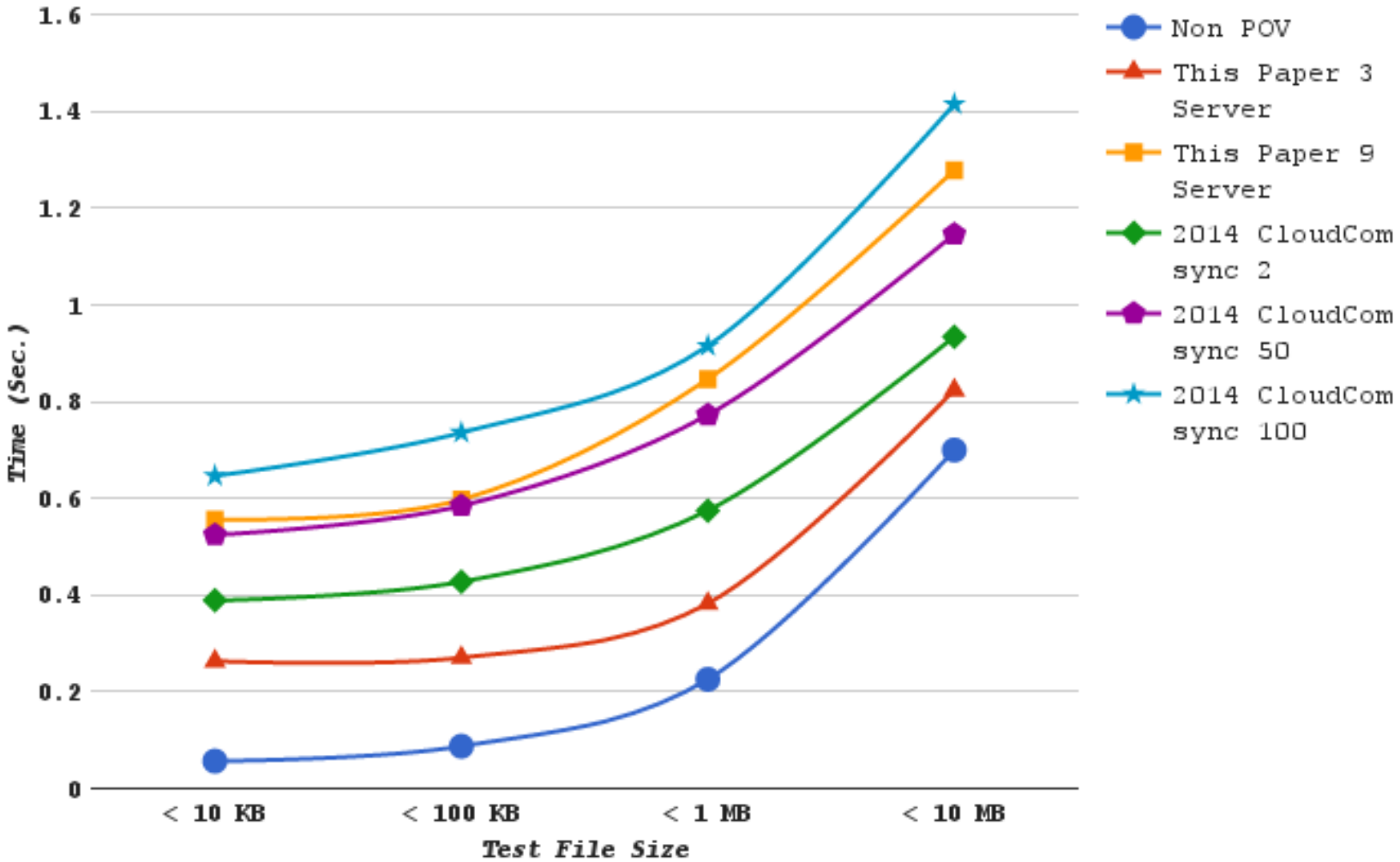
Experimental Results

The client device and SP are not in the same network segment - UPLOAD operation



Experimental Results

The client device and SP are not in the same network segment - DOWNLOAD operation



Experimental Results

The client device and SP are not in the same network segment - UPLOAD Overhead

Table: My Method / Non POV (IN SEC.) (Account C)

	3 Server	5 Server	7 Server	9 Server
<10 KB	3.14	4.78	6.73	8.23
<100 KB	2.02	3.38	3.95	5.45
<1 MB	1.26	1.73	1.86	2.28
<10 MB	1.18	1.43	1.46	1.57

Table: 2014 Cloud Com / Non POV (IN SEC.) (Account C)

	sync 2	sync 10	sync 50	sync 100	sync 500
<10 KB	5.23	5.94	7.02	7.22	17.72
<100 KB	3.11	3.43	4.20	4.65	11.35
<1 MB	1.62	1.80	2.03	2.36	4.74
<10 MB	1.10	1.36	1.40	1.42	2.00

Avg: 1.42 times, Max: 2.15 times

Experimental Results

The client device and SP are not in the same network segment - DOWNLOAD Overhead

Table: My Method / Non POV (IN SEC.) (Account C)

	3 Server	5 Server	7 Server	9 Server
<10 KB	4.65	6.32	8.65	9.82
<100 KB	3.09	4.53	6.49	6.83
<1 MB	1.69	2.62	3.07	3.75
<10 MB	1.17	1.55	1.72	1.82

Table: 2014 Cloud Com / Non POV (IN SEC.) (Account C)

	sync 2	sync 10	sync 50	sync 100	sync 500
<10 KB	6.86	6.60	9.25	11.41	40.07
<100 KB	4.89	5.04	6.68	8.41	26.36
<1 MB	2.54	3.04	3.42	4.05	11.16
<10 MB	1.33	1.46	1.63	2.02	4.12

Avg: 1.88 times, Max: 4.08 times

Conclusion

我們提出了一個應用於雲端儲存的 Real-time POV 技術，利用投票的方式快速檢查 Data Integrity，也即時的將資料備份到多個 Server 上。

實驗結果顯示，相較於之前的 Real-time POV 技術，平均能夠節省 8 倍的時間，Worst-case 時更能夠節省超過 20 倍的時間。

雲端儲存系統可以使用本論文提出的方法，提供雙方不可否認的保證於他們的服務層級協議 (Service Level Agreement) 中。

Future Work

1. 我們希望能將 FBHTree[1]套用到本論文的方法中，藉由實驗觀察能否增快 Merkle tree 在更新檔案時的速度。

2. 在本論文中使用同步伺服器來維護 Write Serializability，若有新的演算法能夠不需依賴同步伺服器又能維護 Write Serializability，將能讓我們的架構更加彈性且使用更少的硬體。

[1] G.-H. Hwang and H.-F. Chen, "Efficient Real-time Auditing and Proof of Violation for Cloud Storage Systems," in 9th IEEE International Conference on Cloud Computing, San Francisco, USA, 2016.

Thanks for Your Listening