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

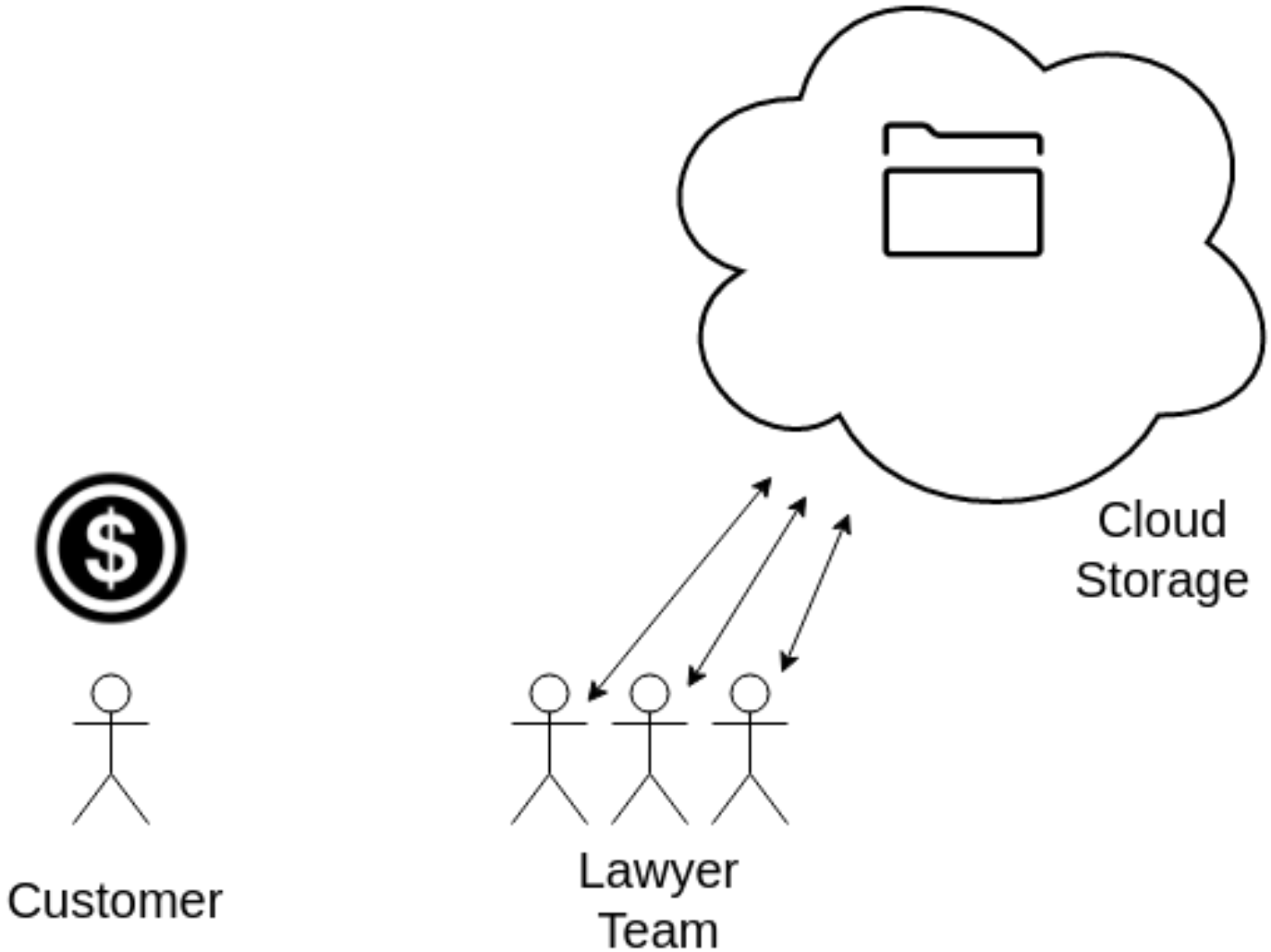
Advicer : Gwan-Hwan Hwang
Student : Wei-Chih Chien

NTNU CSIE CCLAB

2016.07

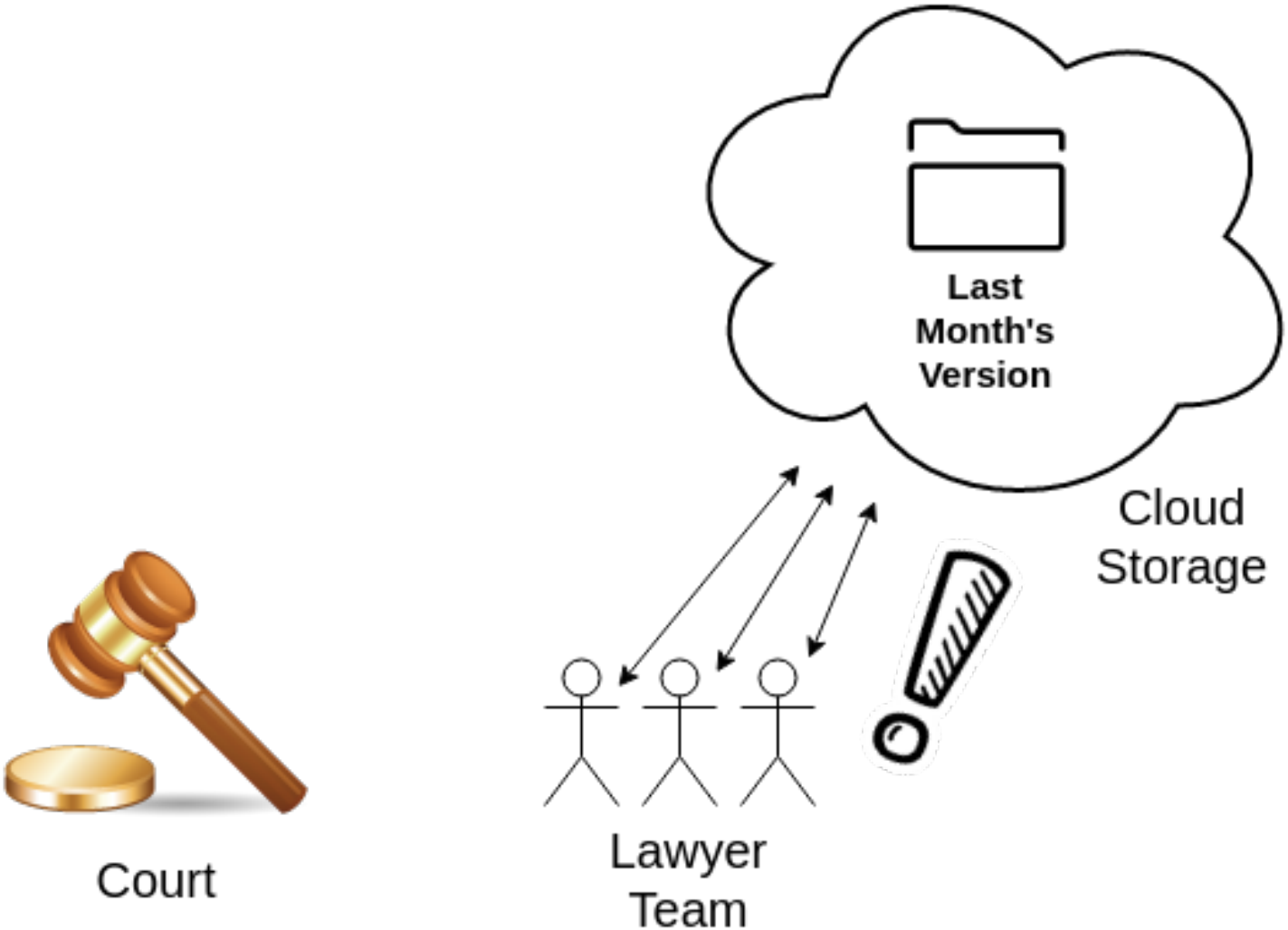
Outline

Scenario
Law Office



Scenario (CON'T)

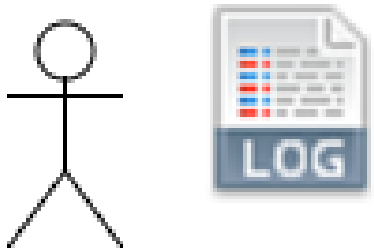
What if...



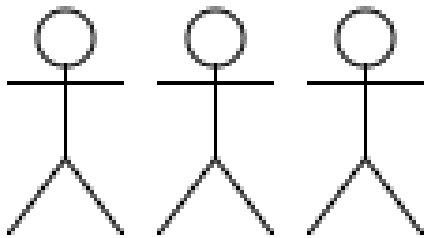
Scenario (CON'T)

No Error !

No Evidence ...



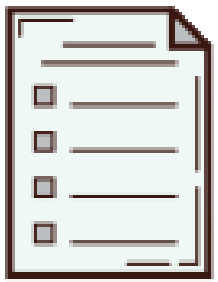
Service Provider

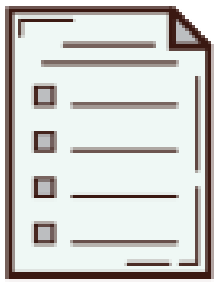


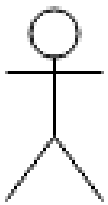
Lawyer Team

Scenario (CON'T)

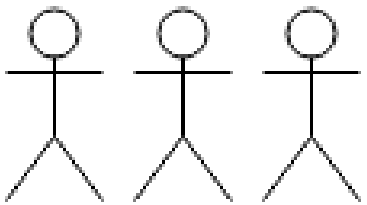
Cryptographic Proof







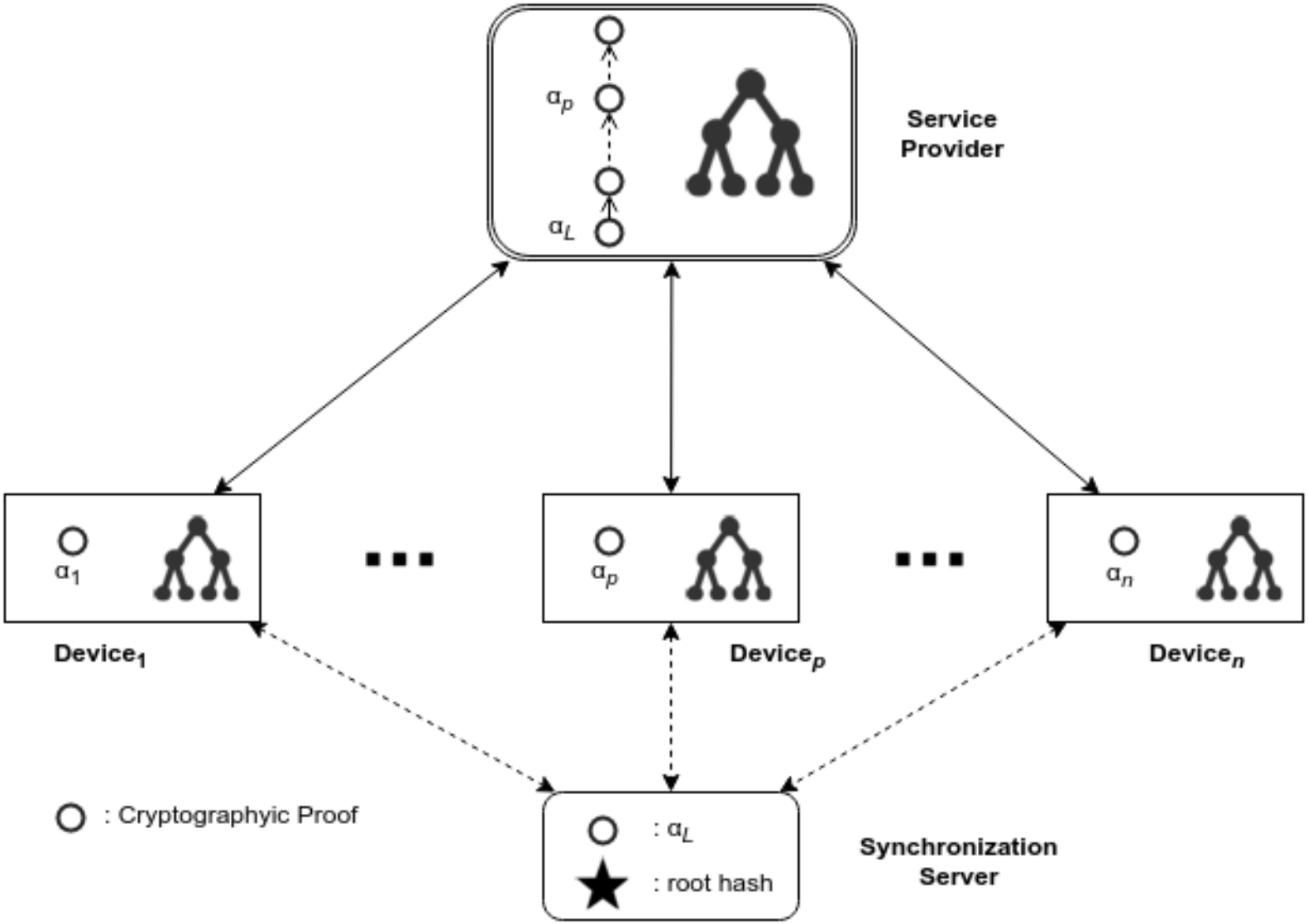
Service Provider



Lawyer Team

Instant Auditing of Cloud Storage Access by Cache Partial Merkle tree

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



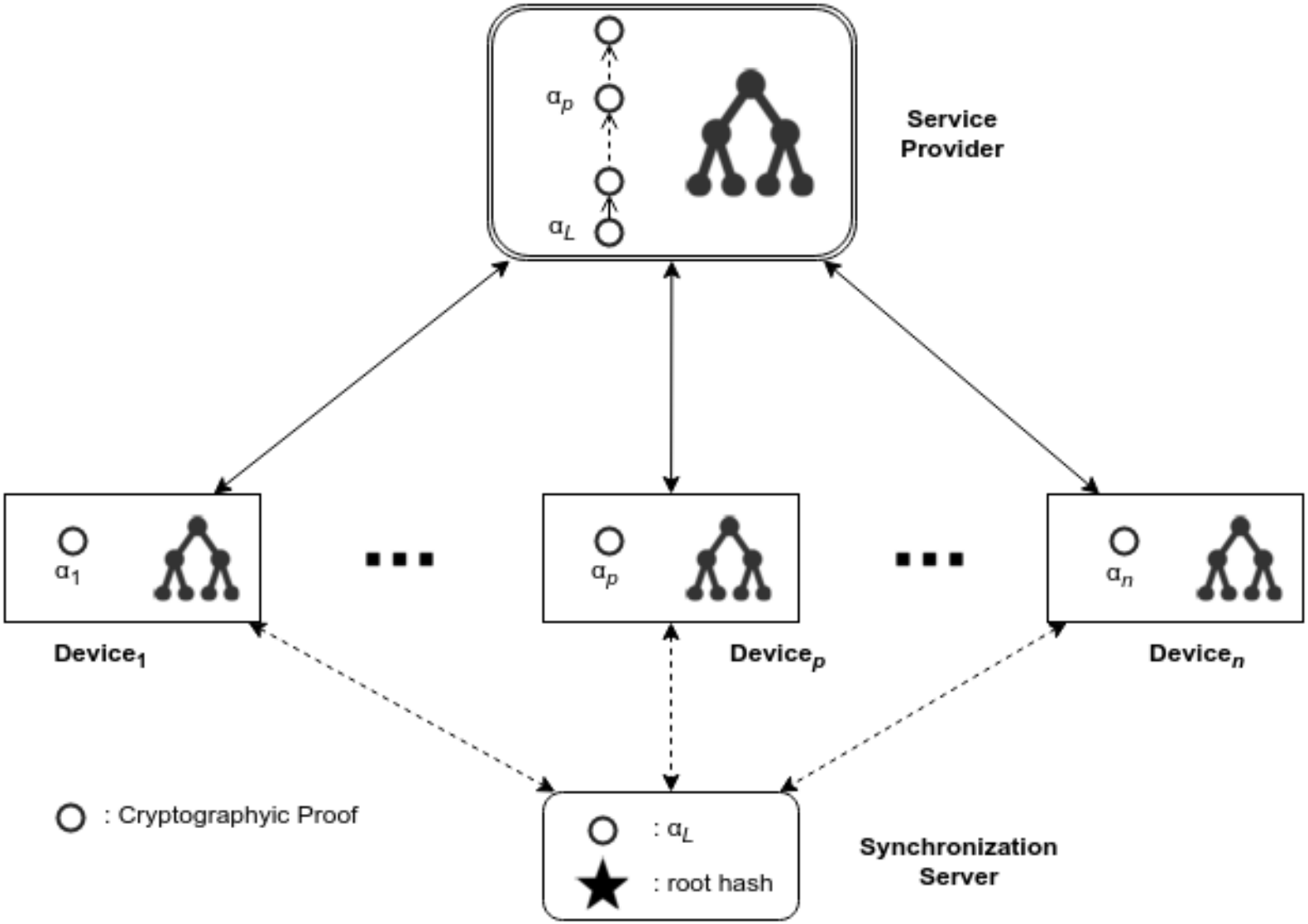
POV - Proof of Violation

定義以下三個 Tuples:

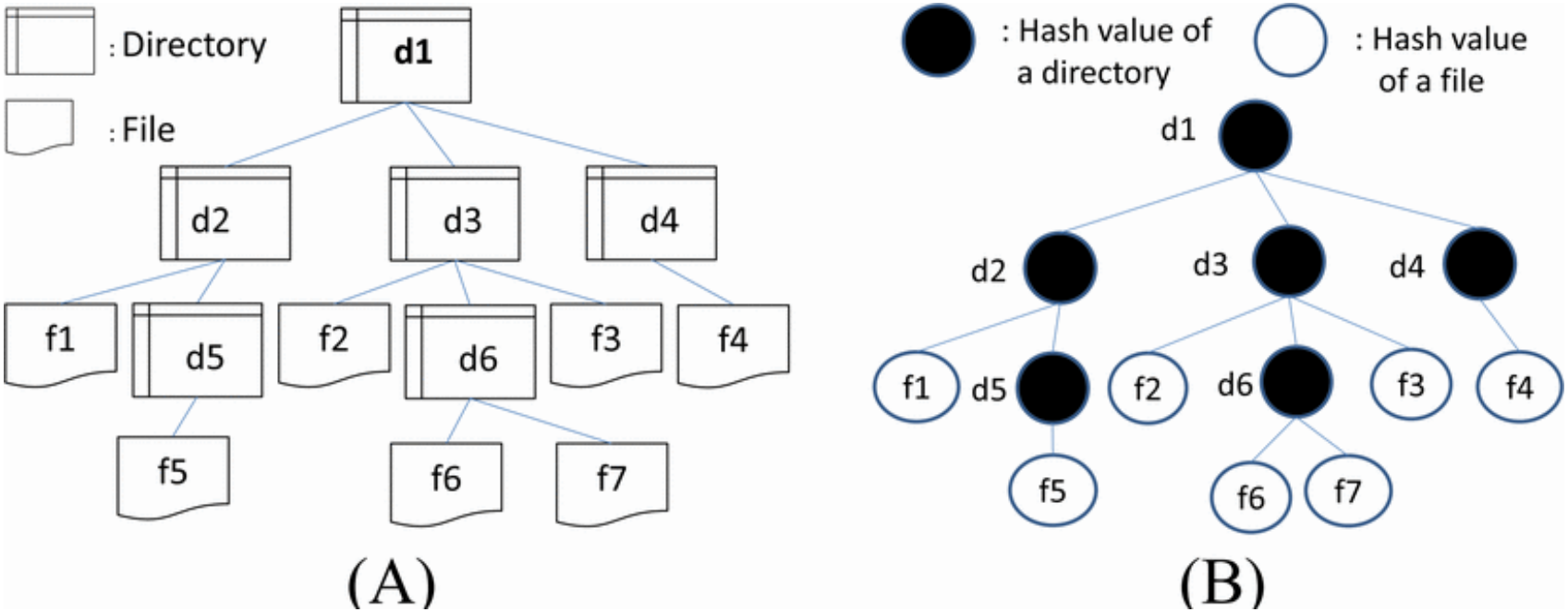
- Properties
  - Data Integrity
  - Write Serializability
  - Read Freshness
- Attestations
  - 在 User 和 Service Provider 之間的訊息加上簽章,
    藉由此密碼學的證據能讓雙方不可否認自己做過的事
- Auditing
  - 利用收集的 Attestations 來證明是否違反 Properties

Instant Auditing of Cloud Storage Access by Cache Partial Merkle tree

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

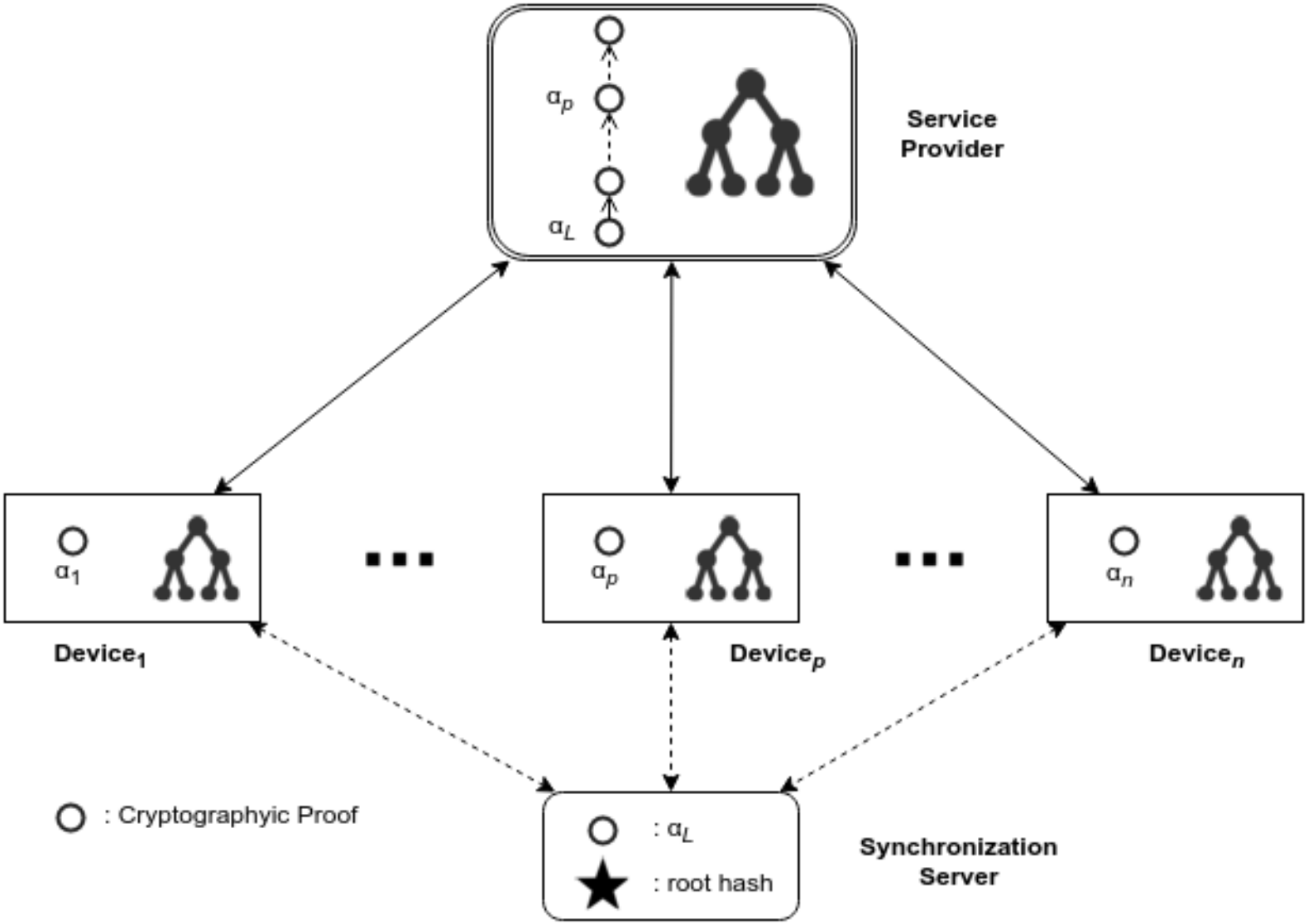


Merkle Tree


: 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)

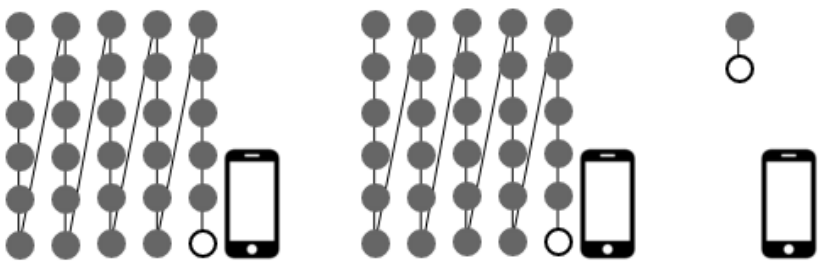
Instant Auditing of Cloud Storage Access by Cache Partial Merkle tree

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



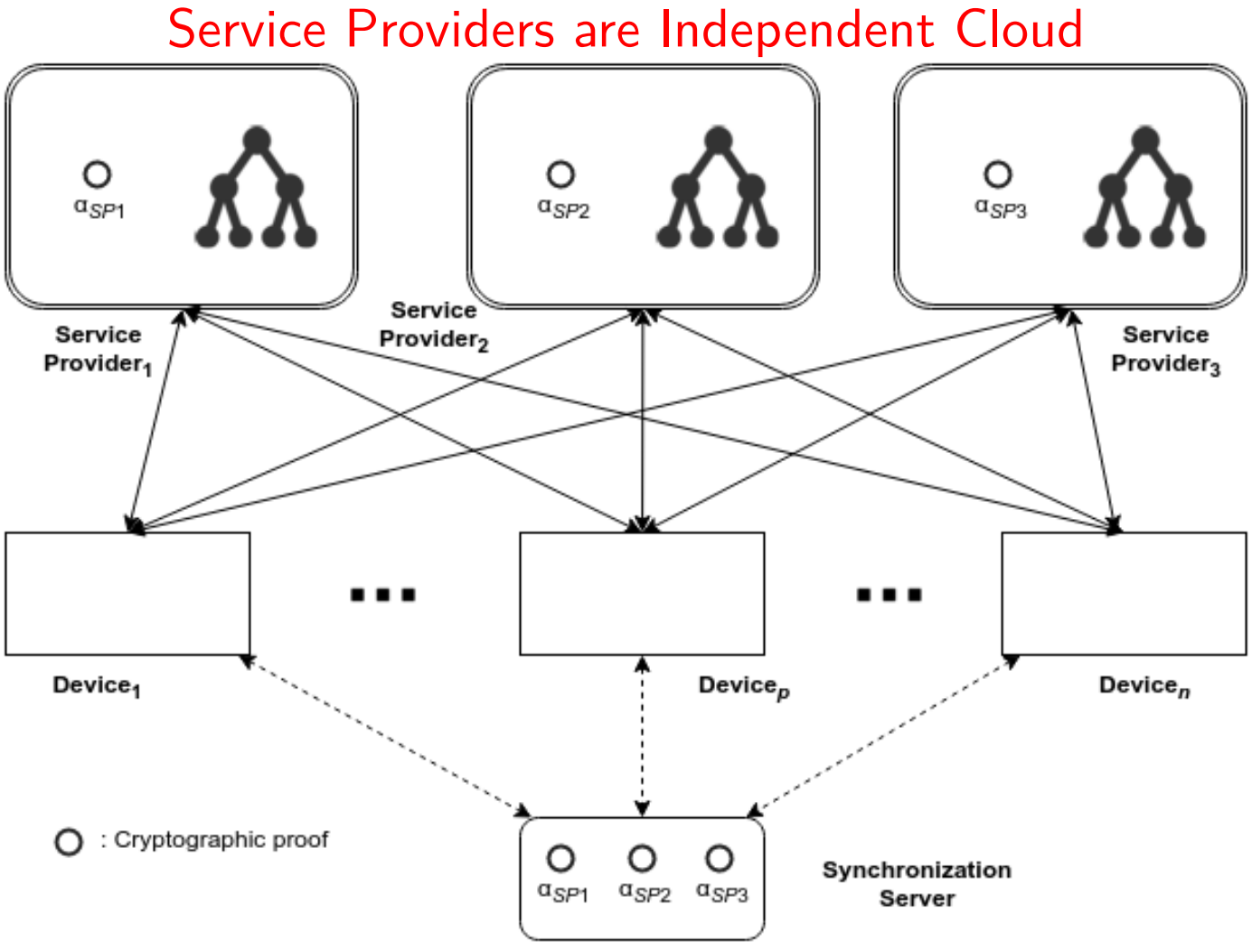
Worst-case

若有個 device 很久沒有使用
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: 同時有 k 個 server 回傳錯誤結果的機率 ≈ 0

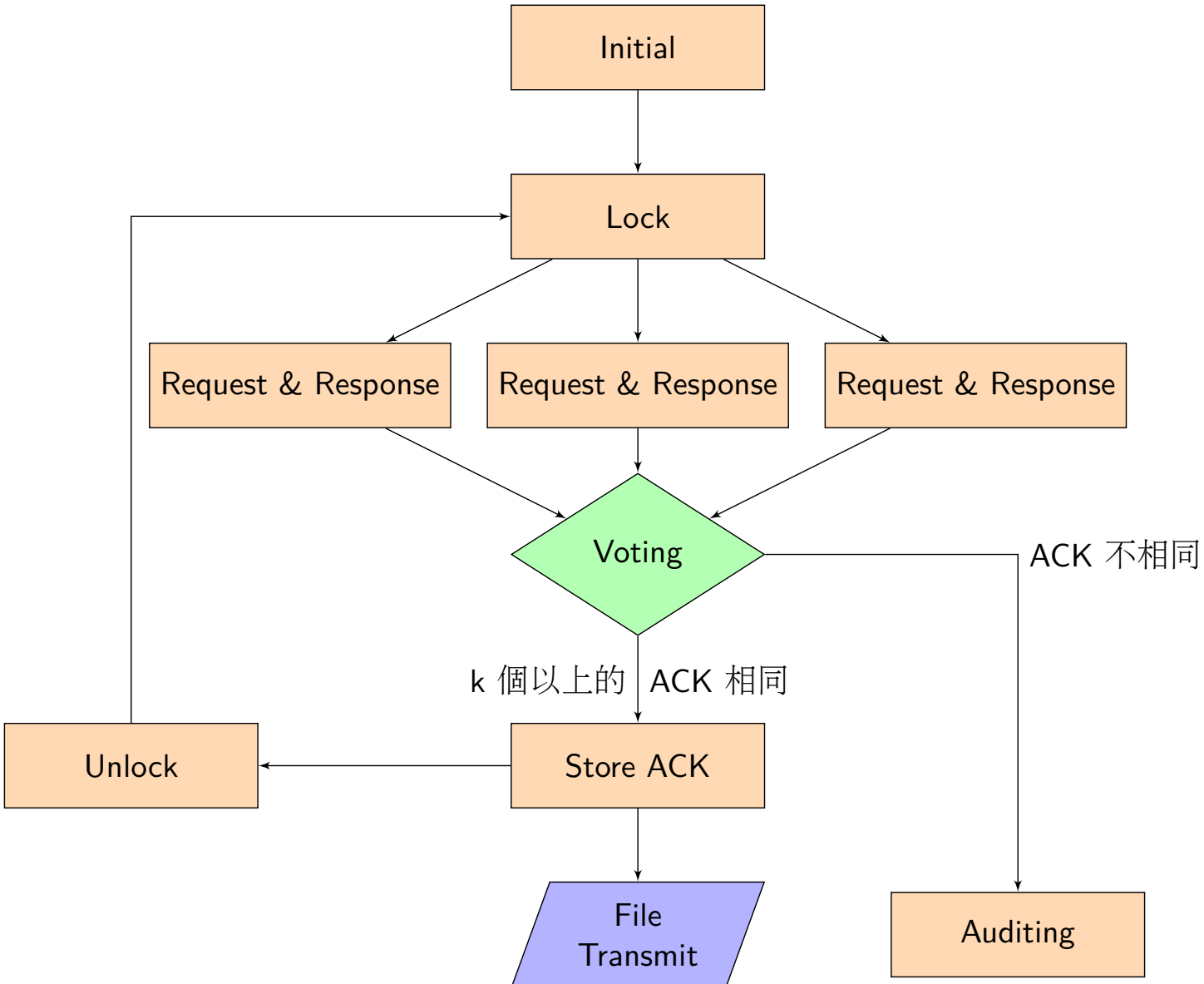


Comparison

- 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

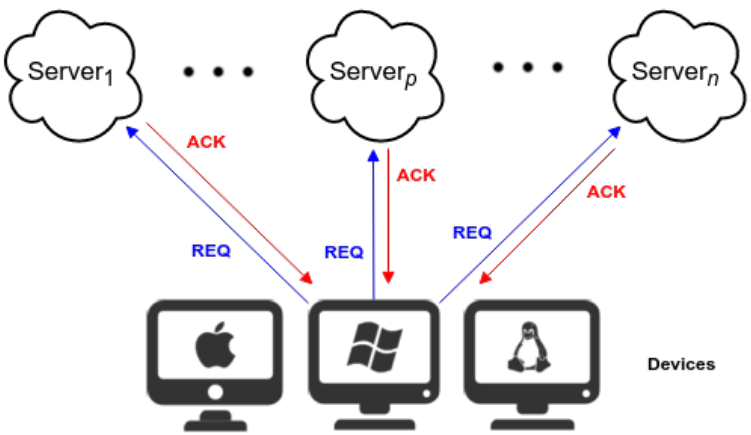
- Cons
  1. 需要傳送多份 Request, 處理多份 Response
  2. 需要使用較多的 Service Provider

Flowchart


Initial
Lock
Request & Response
Request & Response
Request & Response
Voting
ACK 不相同
k 個以上的
ACK 相同
Unlock
Store ACK
File Transmit
Auditing

Download & Upload

Request & Response



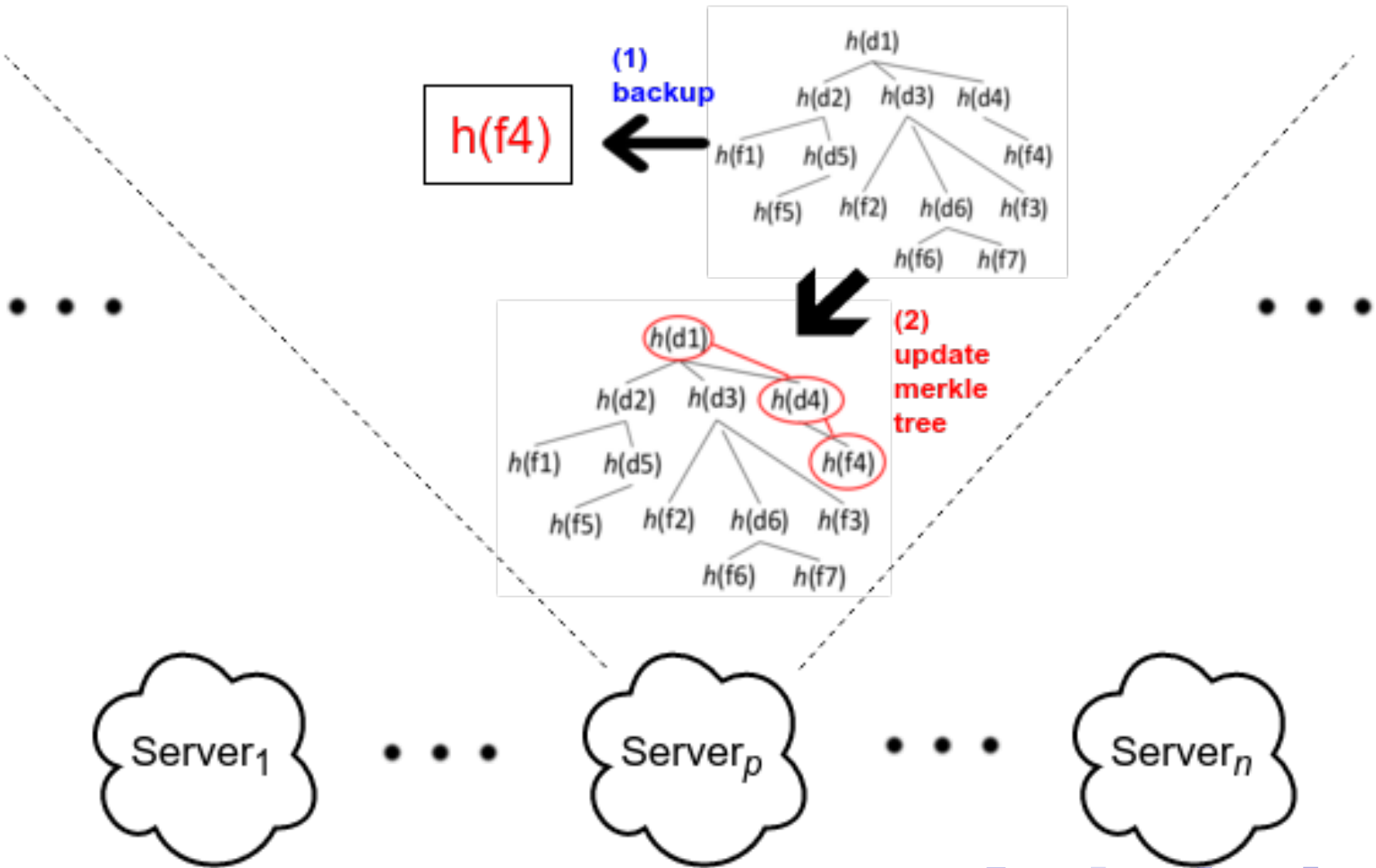
$$REQ = (OP,\ [OP]_{pri(D)})$$
$$OP = (TYPE,\ PATH,\ HASH,\ SN)$$
$$SN = \text{Sequence Number}$$

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

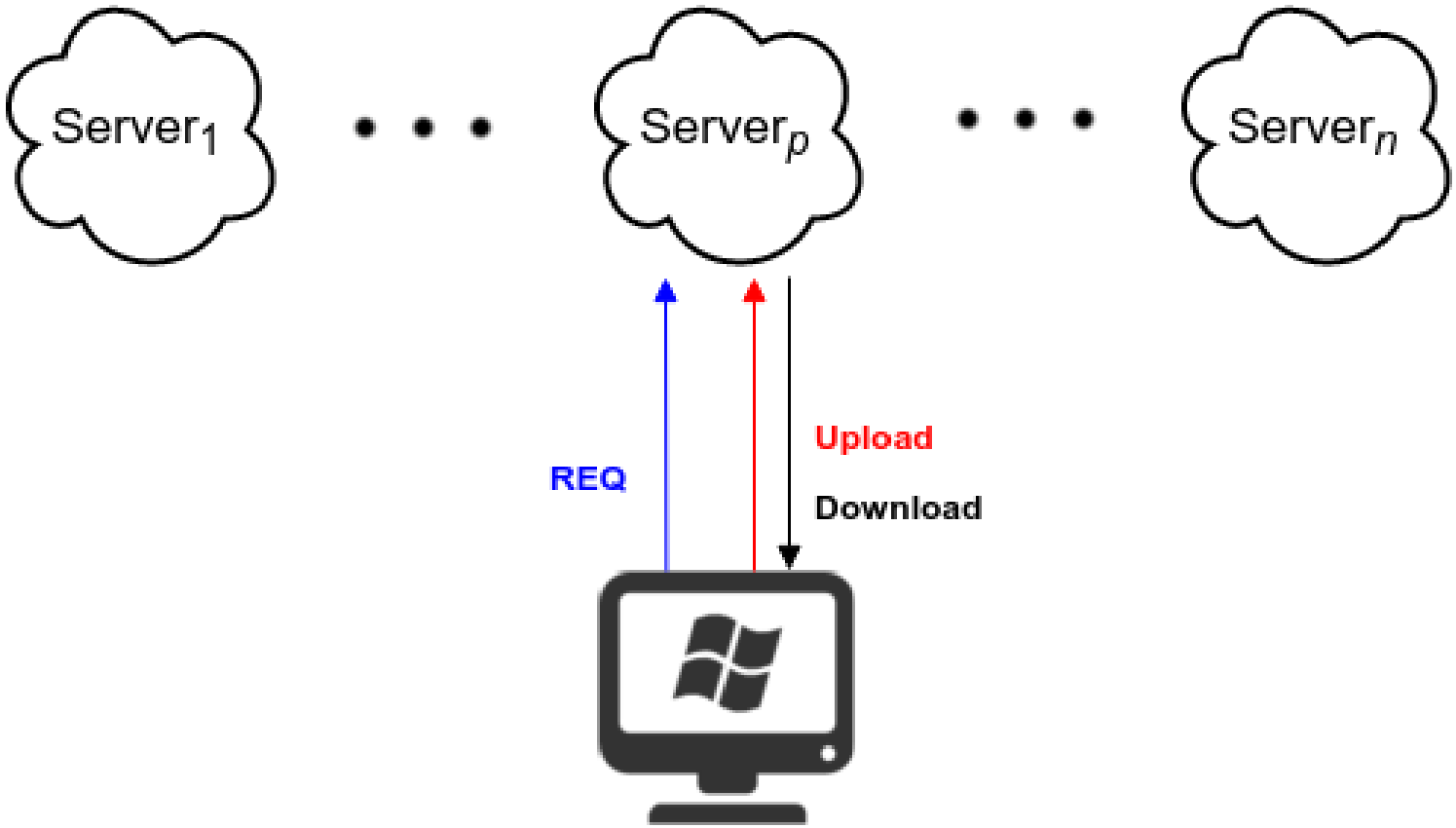
collect ACKs and voting

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

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	9.40653	0.00132	5.4 KB
B	55.14738	4.2467	5.08 MB
C	339.18192	0.3342	4.37 MB

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

	Serialize	Deserialize
A	0.04	0.009
B	0.756	0.299
C	0.67	0.295

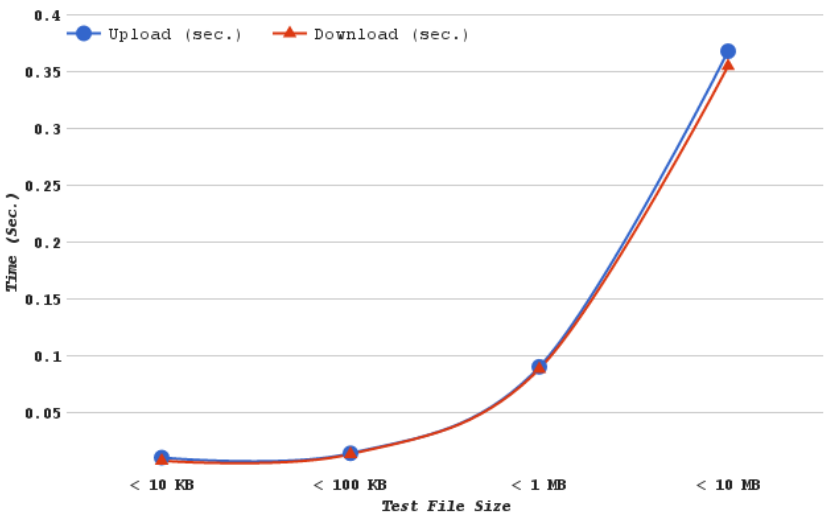
Experimental Results
Non POV

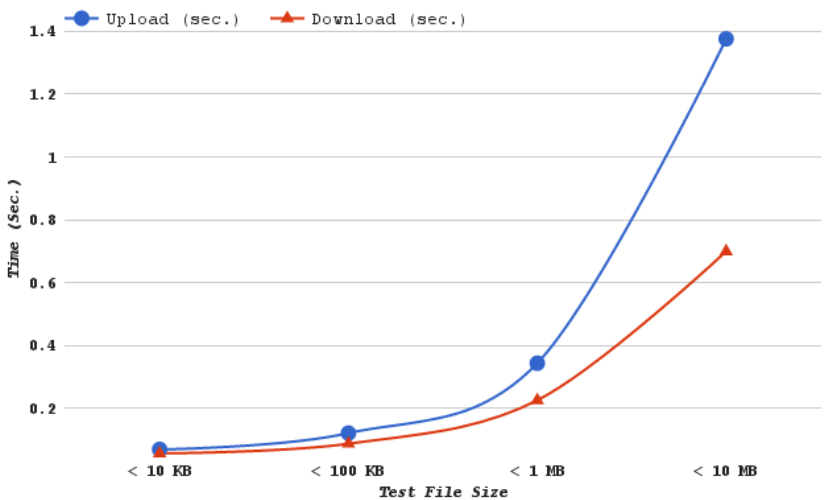
Table: The client device and SP are in the same network segment

	Upload (sec.)	Download (sec.)
<10 KB	0.010608	0.007845
<100 KB	0.014393	0.013691
<1 MB	0.090440	0.088570
<10 MB	0.367989	0.354916

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

	Upload (sec.)	Download (sec.)
<10 KB	0.069273	0.056629
<100 KB	0.121093	0.087351
<1 MB	0.343584	0.225566
<10 MB	1.675616	0.699524



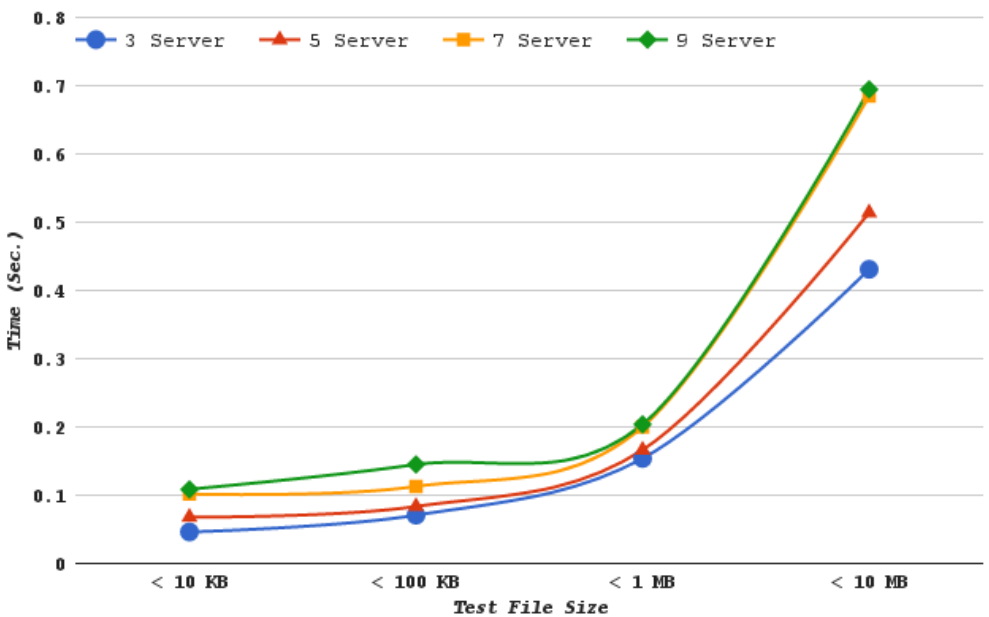


Experimental Results

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	0.046139	0.067923	0.101676	0.108696
<100 KB	0.070739	0.083563	0.112895	0.145049
<1 MB	0.153822	0.166289	0.200053	0.203870
<10 MB	0.430937	0.513879	0.684666	0.694259

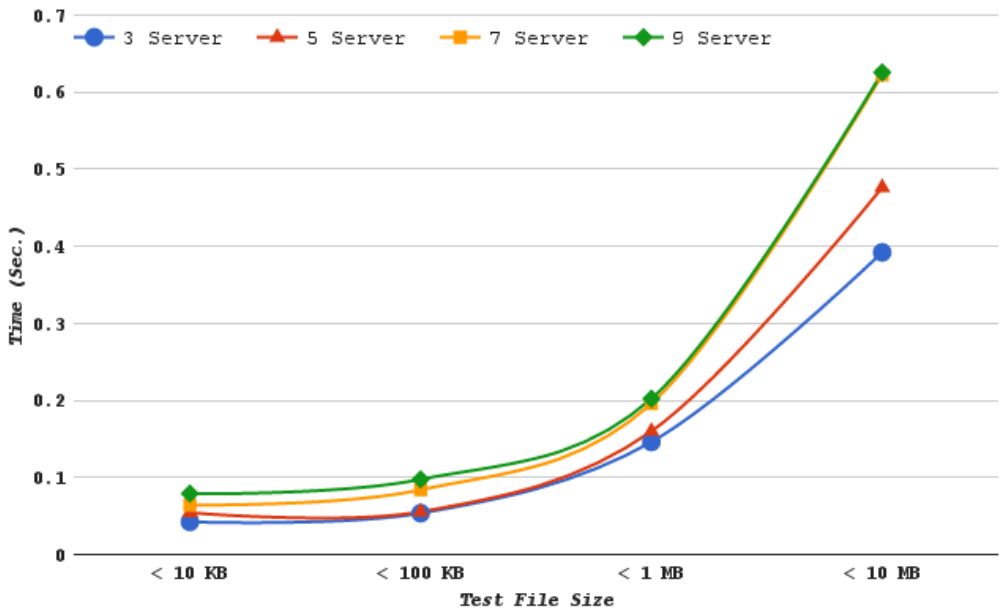


Experimental Results

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	0.042295	0.054263	0.064370	0.078872
<100 KB	0.053583	0.055442	0.083961	0.097507
<1 MB	0.146021	0.159869	0.195817	0.202213
<10 MB	0.392072	0.476251	0.622665	0.625499

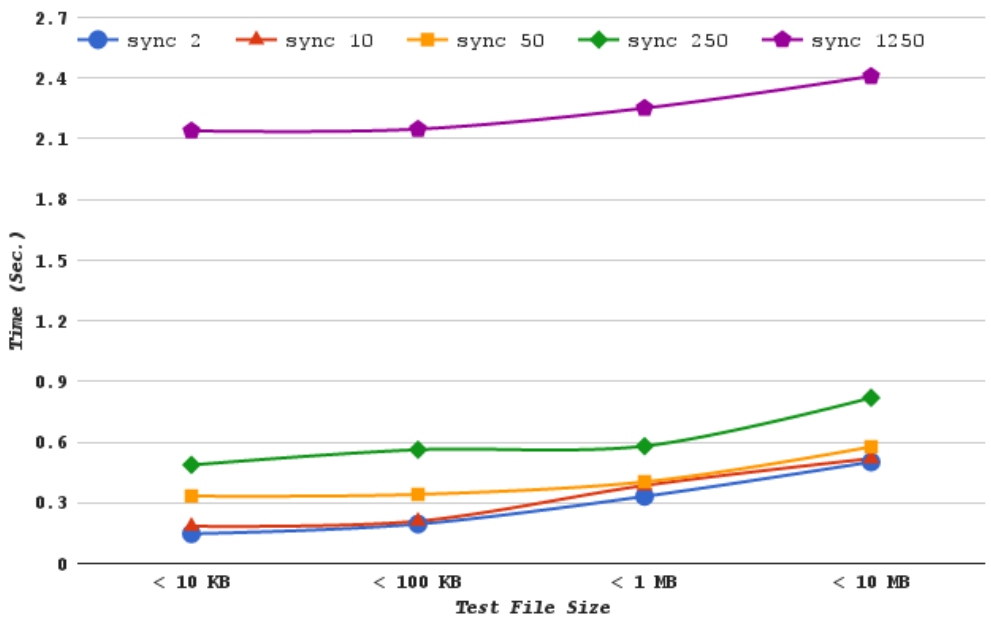


Experimental Results

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 250	sync 1250
<10 KB	0.146783	0.184138	0.332988	0.486858	2.139086
<100 KB	0.194642	0.209044	0.341408	0.562457	2.147664
<1 MB	0.331595	0.385494	0.403481	0.580193	2.251284
<10 MB	0.501692	0.518835	0.576403	0.819175	2.409135

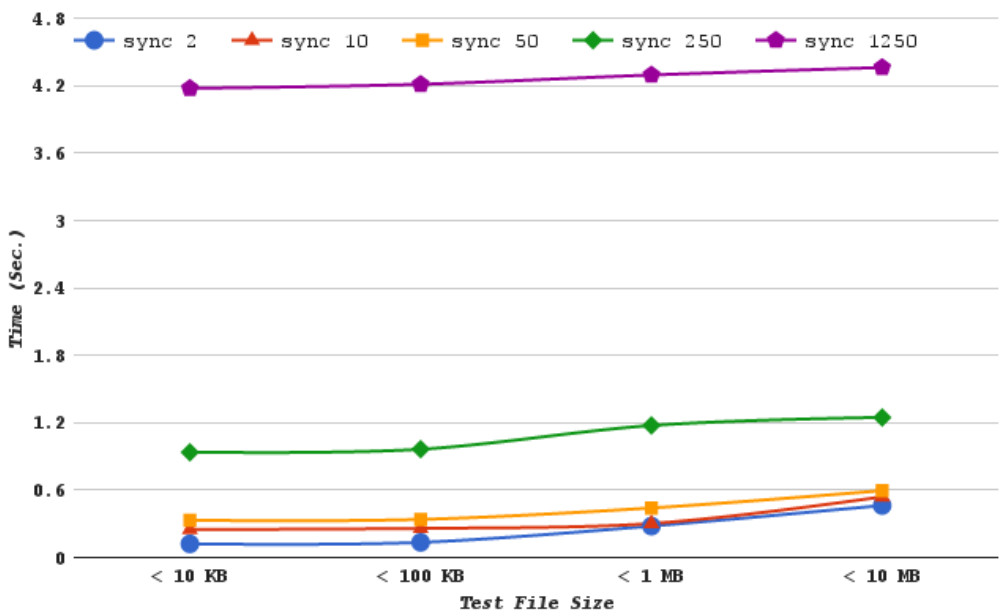


Experimental Results

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 250	sync 1250
<10 KB	0.121268	0.249803	0.331339	0.937337	4.175263
<100 KB	0.134563	0.258717	0.338794	0.963107	4.211038
<1 MB	0.279563	0.302230	0.440841	1.174882	4.294038
<10 MB	0.462677	0.539638	0.595140	1.247275	4.360539



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	0.035532	0.057315	0.091068	0.098088
<100 KB	0.056346	0.069170	0.098502	0.130656
<1 MB	0.063382	0.075848	0.109612	0.113430
<10 MB	0.062948	0.145890	0.316677	0.326270

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

	sync 2	sync 10	sync 50	sync 250	sync 1250
<10 KB	0.136175	0.173530	0.322380	0.476250	2.128478
<100 KB	0.180249	0.194651	0.327016	0.548064	2.133271
<1 MB	0.241154	0.295053	0.313041	0.489752	2.160844
<10 MB	0.133703	0.150846	0.208414	0.451186	2.041146

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	0.034450	0.046418	0.056526	0.071027
<100 KB	0.039892	0.041751	0.070270	0.083816
<1 MB	0.057451	0.071299	0.107247	0.113643
<10 MB	0.037156	0.121335	0.267749	0.270583

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

	sync 2	sync 10	sync 50	sync 250	sync 1250
<10 KB	0.113424	0.241959	0.323494	0.929492	4.167419
<100 KB	0.120872	0.245026	0.325103	0.949416	4.197347
<1 MB	0.190993	0.213660	0.352271	1.086312	4.205468
<10 MB	0.107761	0.184722	0.240224	0.892359	4.005623

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	4.349552	6.403042	9.584967	10.246768
<100 KB	4.914887	5.805870	7.843824	10.077857
<1 MB	1.700816	1.838656	2.211983	2.254196
<10 MB	1.171060	1.396453	1.860562	1.886630

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

	sync 2	sync 10	sync 50	sync 250	sync 1250
<10 KB	13.837201	17.358624	31.390677	45.895962	201.651193
<100 KB	13.523544	14.524231	23.720780	39.079062	149.217959
<1 MB	3.666447	4.262410	4.461293	6.415199	24.892477
<10 MB	1.363336	1.409920	1.566359	2.226087	6.546762

Avg: 6.61 times, Max: 19.67 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	5.391663	6.917309	8.205786	10.054378
<100 KB	3.913722	4.049482	6.132484	7.121880
<1 MB	1.648657	1.805003	2.210875	2.283095
<10 MB	1.104689	1.341869	1.754401	1.762387

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

	sync 2	sync 10	sync 50	sync 250	sync 1250
<10 KB	15.459033	31.844389	42.238325	119.489570	532.253193
<100 KB	9.828453	18.896670	24.745459	70.345135	307.573438
<1 MB	3.156419	3.412343	4.977329	13.265056	48.482022
<10 MB	1.303623	1.520467	1.676847	3.514280	12.286111

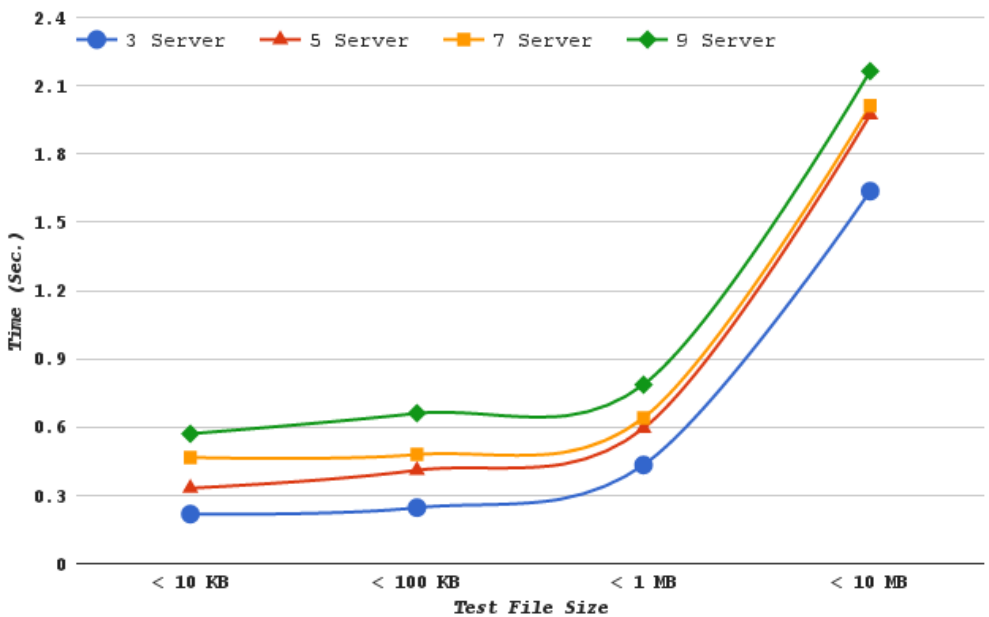
Avg: 15.41 times, Max: 52.93 times

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	0.217563	0.331341	0.466655	0.570460
<100 KB	0.245769	0.410174	0.479227	0.660178
<1 MB	0.433338	0.594532	0.640597	0.786688
<10 MB	1.636473	1.972134	2.011500	2.163858

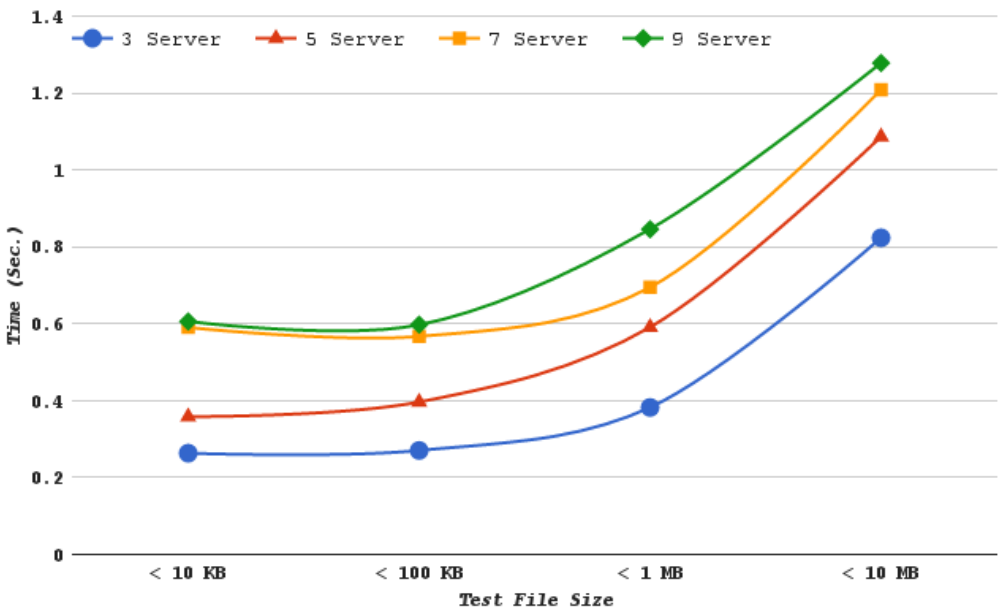


Experimental Results

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	0.263332	0.358435	0.590343	0.606110
<100 KB	0.270404	0.396497	0.567059	0.597088
<1 MB	0.382264	0.590987	0.694622	0.846141
<10 MB	0.823476	1.086515	1.208293	1.278169

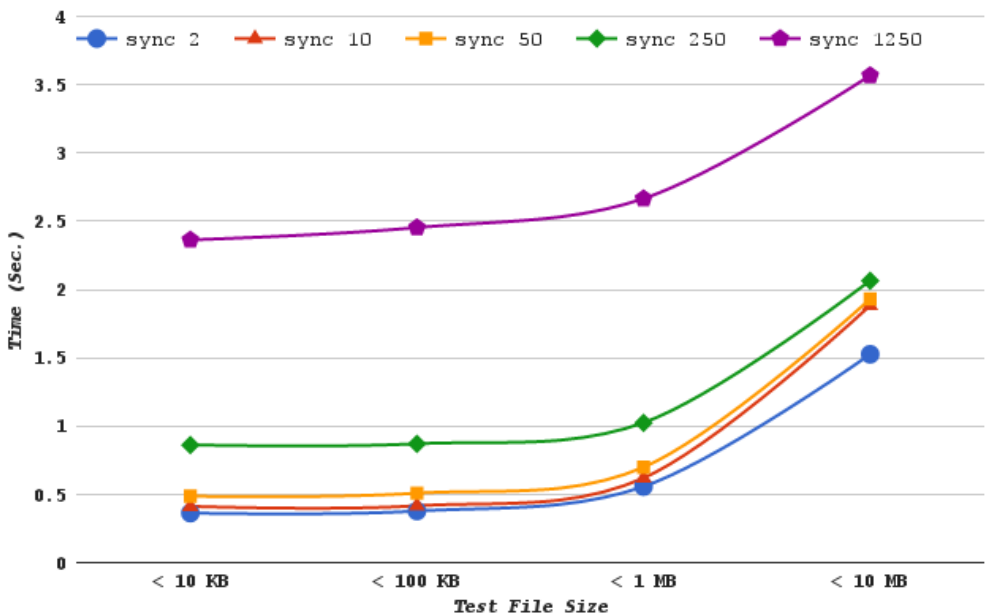


Experimental Results

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 250	sync 1250
<10 KB	0.362766	0.411929	0.486570	0.862048	2.363091
<100 KB	0.377788	0.416367	0.508769	0.870478	2.453335
<1 MB	0.556890	0.619318	0.698361	1.024154	2.665164
<10 MB	1.525459	1.882746	1.929606	2.064955	3.566919

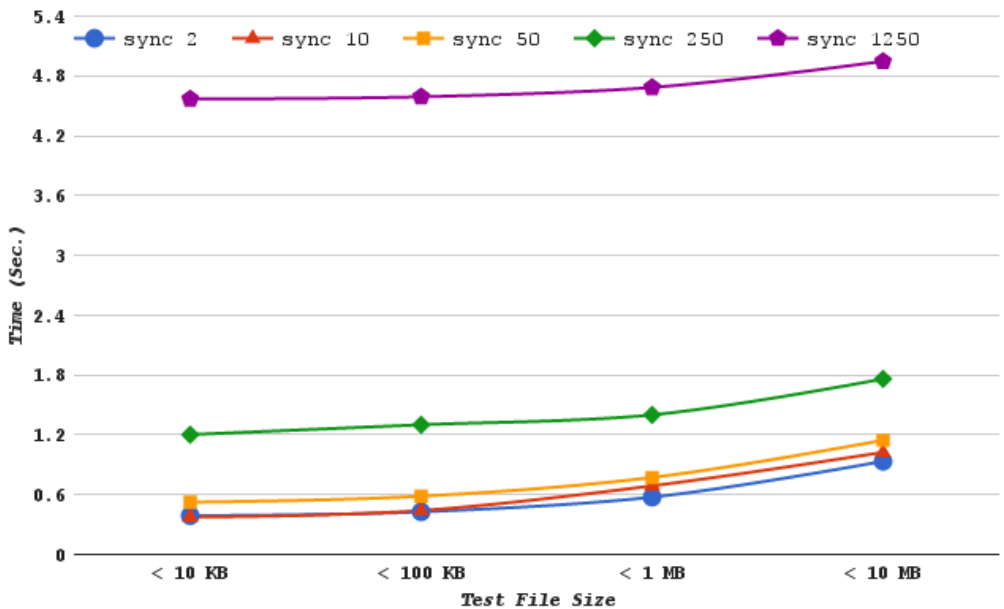


Experimental Results

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 250	sync 1250
<10 KB	0.388520	0.374224	0.524074	1.202312	4.569076
<100 KB	0.427226	0.440348	0.584122	1.300710	4.590791
<1 MB	0.574539	0.687956	0.772134	1.399860	4.684576
<10 MB	0.933868	1.024385	1.145598	1.759997	4.945930



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	0.148290	0.262068	0.397382	0.501187
<100 KB	0.124676	0.289081	0.358134	0.539085
<1 MB	0.089754	0.250948	0.297013	0.443104
<10 MB	0.260857	0.596518	0.635884	0.788242

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

	sync 2	sync 10	sync 50	sync 250	sync 1250
<10 KB	0.293493	0.342657	0.417297	0.792775	2.293818
<100 KB	0.256695	0.295274	0.387676	0.749385	2.332242
<1 MB	0.213306	0.275733	0.354776	0.680570	2.321579
<10 MB	0.149843	0.507130	0.553990	0.689340	2.191303

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	0.206703	0.301806	0.533714	0.549481
<100 KB	0.183053	0.309147	0.479708	0.509738
<1 MB	0.156698	0.365421	0.469057	0.620576
<10 MB	0.123952	0.386991	0.508769	0.578646

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

	sync 2	sync 10	sync 50	sync 250	sync 1250
<10 KB	0.331891	0.317594	0.467445	1.145683	4.512446
<100 KB	0.339875	0.352998	0.496772	1.213359	4.503441
<1 MB	0.348973	0.462390	0.546568	1.174294	4.459011
<10 MB	0.234344	0.324861	0.446074	1.060473	4.246406

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	3.140669	4.783127	6.736478	8.234973
<100 KB	2.029588	3.387261	3.957507	5.451819
<1 MB	1.261228	1.730382	1.864455	2.289650
<10 MB	1.189629	1.433637	1.462254	1.573011

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

	sync 2	sync 10	sync 50	sync 250	sync 1250
<10 KB	5.236767	5.946479	7.023971	12.444239	34.112817
<100 KB	3.119815	3.438406	4.201470	7.188500	20.259902
<1 MB	1.620825	1.802520	2.032574	2.980794	7.756942
<10 MB	1.108928	1.368657	1.402722	1.501113	2.592962

Avg: 2.01 times, Max: 4.14 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	4.650108	6.329503	10.424700	10.703127
<100 KB	3.095611	4.539142	6.491742	6.835527
<1 MB	1.694689	2.620022	3.079470	3.751199
<10 MB	1.177195	1.553220	1.727308	1.827199

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

	sync 2	sync 10	sync 50	sync 250	sync 1250
<10 KB	6.860769	6.608313	9.254478	21.231303	80.684047
<100 KB	4.890921	5.041151	6.687090	14.890653	52.555829
<1 MB	2.547104	3.049914	3.423100	6.205999	20.768135
<10 MB	1.335005	1.464403	1.637682	2.515992	7.070423

Avg: 2.93 times, Max: 7.53 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 7 倍以上的時間，
Worst-case 時更能夠節省高達將近 50 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 (SLA) 中

Future Work

1. 我們希望能將 FBH 樹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，
將將能讓我們的架構更加的彈性且使用更少的硬體。

Thanks for Your Listening