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Leveraging Locality of Reference for Certificate Revocation

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Seven Challenges Facing Certificate Revocation

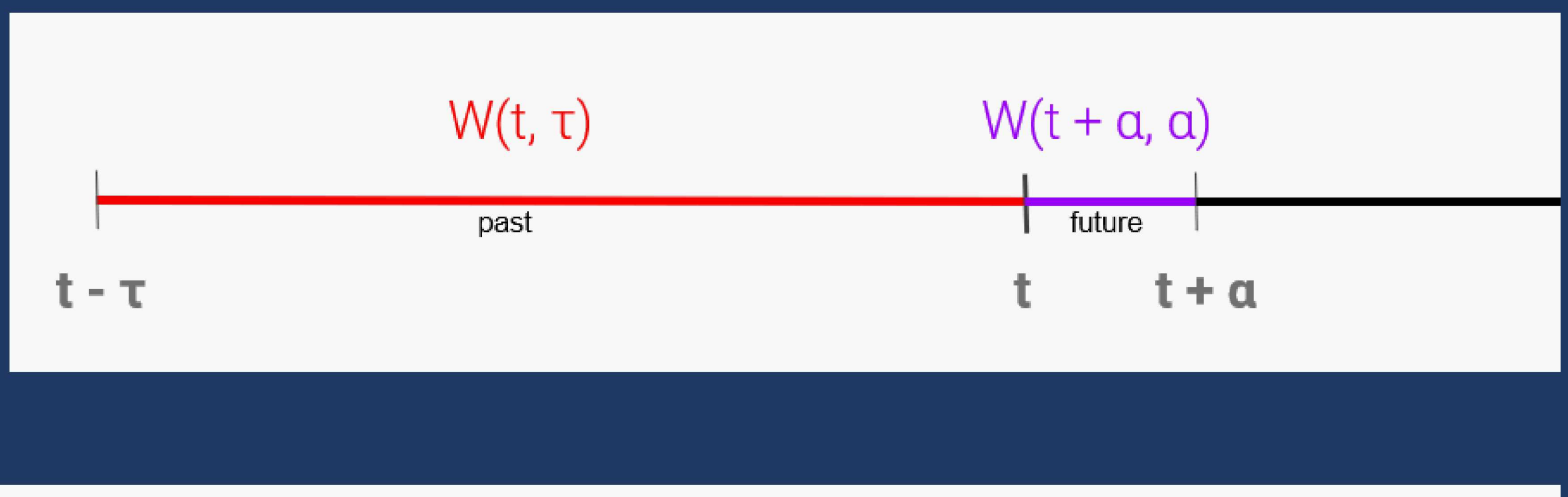
1. Effectiveness during an Active Attack
2. Client Bandwidth Costs
3. Future Bandwidth Costs due to Certificate Growth
4. Mass Revocation Event Scalability
5. Revocation Timeliness
6. Exposure of Client Traffic Patterns
7. Deployment Requirements and Incentives

We designed a new revocation strategy to address the seven challenges

Certificate Revocation Table (CRT)

Certificate Working Set – Recent certificates used by an organization

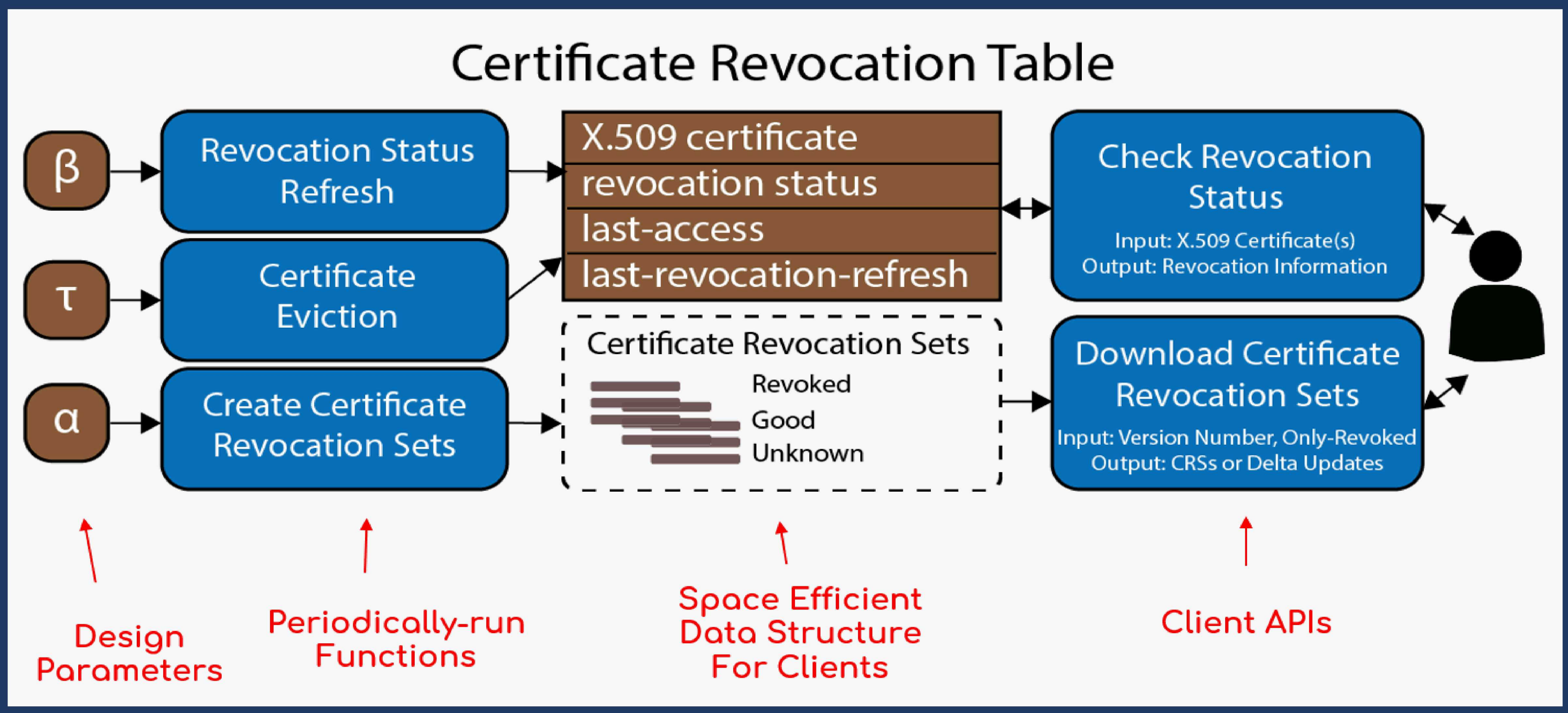
Hypothesis: majority of certificates accessed in near future W(t + α, α) will reuse certificates seen in the recent past W(t, τ), if α is small.



- The CRT contains an organization's certificate working set (both revoked and non-revoked)
- Periodically the CRT will refresh status information, evict unused certificates, and create a data structure for clients
- Clients can download a local copy of the CRT to check revocation status

Design Strengths:

- Design parameters (τ, β, α) give flexibility to support different types of organizations and clients
- Incentive Alignment: network administrators assume control, responsibility, and cost burdens while local users receive the benefits


Certificate Revocation Table
β
τ
α
Revocation Status Refresh
Certificate Eviction
Create Certificate Revocation Sets
X.509 certificate
revocation status
last-access
last-revocation-refresh
Certificate Revocation Sets
Revoked
Good
Unknown
Check Revocation Status
Input: X.509 Certificate(s)
Output: Revocation Information
Download Certificate Revocation Sets
Input: Version Number, Only-Revoked
Output: CRSs or Delta Updates
Design Parameters
Periodically-run Functions
Space Efficient Data Structure For Clients
Client APIs

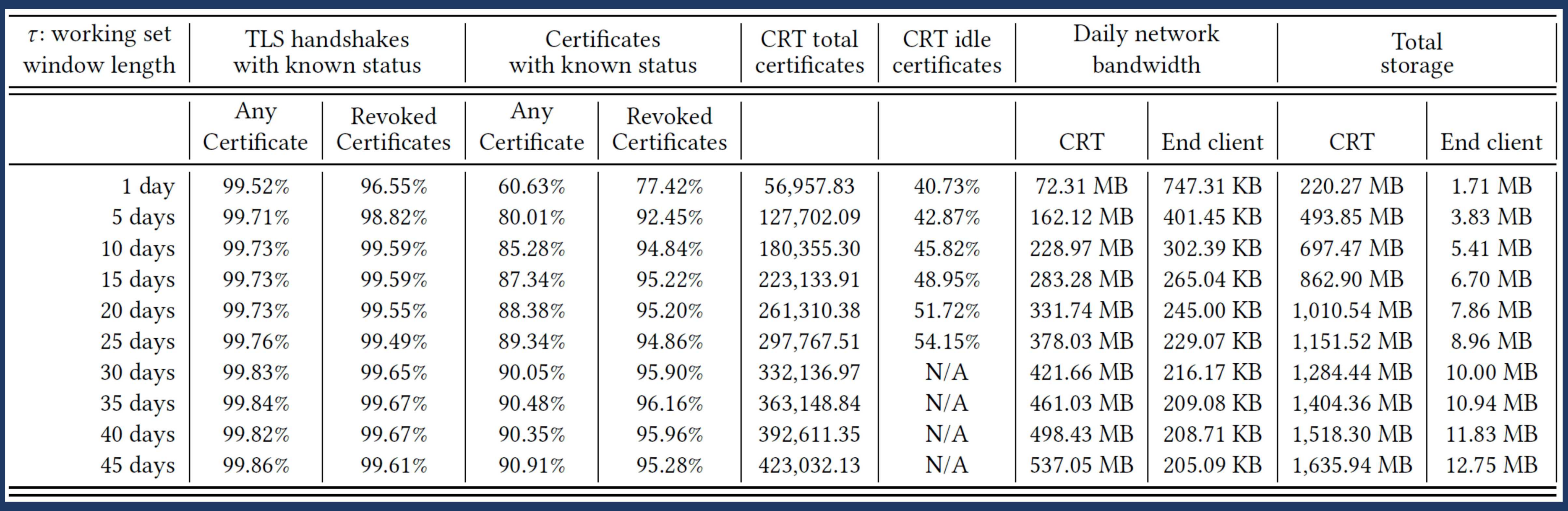
Measurement Study

Analyze TLS logs at BYU for April-June 2018

- 33,000+ students
- 4,144,404,123 TLS handshakes
- 112 revoked certificates in 228,427 handshakes (0.005%)

Simulated impact of CRT

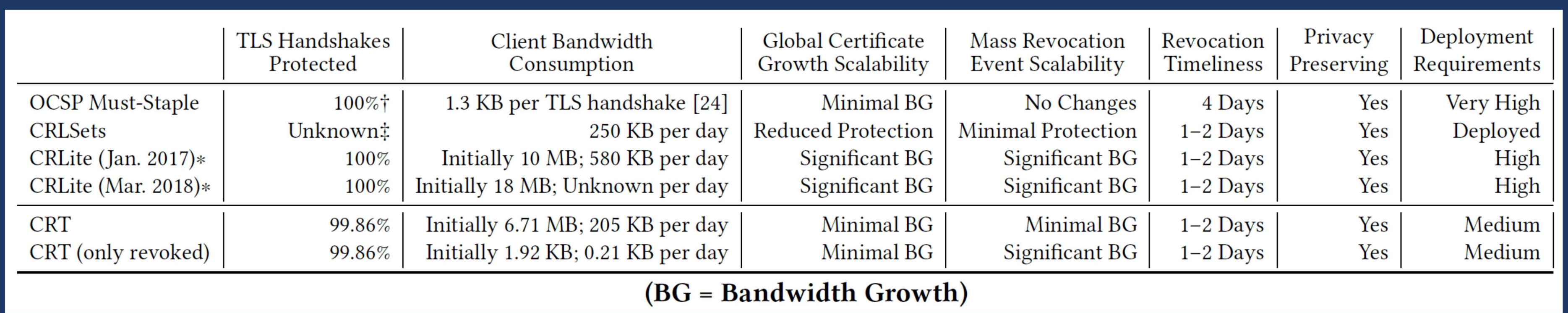
- 99%+ of handshakes had cached revocation information
- Decreasing bandwidth as window size increases
- Small fraction of overall certificate space



τ: working set window length	TLS handshakes with known status		Certificates with known status		CRT total certificates	CRT idle certificates	Daily network bandwidth		Total storage	
	Any Certificate	Revoked Certificates	Any Certificate	Revoked Certificates			CRT	End client	CRT	End client
1 day	99.52%	96.55%	60.63%	77.42%	56,957.83	40.73%	72.31 MB	747.31 KB	220.27 MB	1.71 MB
5 days	99.71%	98.82%	80.01%	92.45%	127,702.09	42.87%	162.12 MB	401.45 KB	493.85 MB	3.83 MB
10 days	99.73%	99.59%	85.28%	94.84%	180,355.30	45.82%	228.97 MB	302.39 KB	697.47 MB	5.41 MB
15 days	99.73%	99.59%	87.34%	95.22%	223,133.91	48.95%	283.28 MB	265.04 KB	862.90 MB	6.70 MB
20 days	99.73%	99.55%	88.38%	95.20%	261,310.38	51.72%	331.74 MB	245.00 KB	1,010.54 MB	7.86 MB
25 days	99.76%	99.49%	89.34%	94.86%	297,767.51	54.15%	378.03 MB	229.07 KB	1,151.52 MB	8.96 MB
30 days	99.83%	99.65%	90.05%	95.90%	332,136.97	N/A	421.66 MB	216.17 KB	1,284.44 MB	10.00 MB
35 days	99.84%	99.67%	90.48%	96.16%	363,148.84	N/A	461.03 MB	209.08 KB	1,404.36 MB	10.94 MB
40 days	99.82%	99.67%	90.35%	95.96%	392,611.35	N/A	498.43 MB	208.71 KB	1,518.30 MB	11.83 MB
45 days	99.86%	99.61%	90.91%	95.28%	423,032.13	N/A	537.05 MB	205.09 KB	1,635.94 MB	12.75 MB

Comparison to Other Strategies

Certificate Revocation Table is competitive with or exceeds alternative strategies for each of the seven challenges facing certificate revocation.



	TLS Handshakes Protected	Client Bandwidth Consumption	Global Certificate Growth Scalability	Mass Revocation Event Scalability	Revocation Timeliness	Privacy Preserving	Deployment Requirements
OCSP Must-Staple	100%†	1.3 KB per TLS handshake [24]	Minimal BG	No Changes	4 Days	Yes	Very High
CRLSets	Unknown‡	250 KB per day	Reduced Protection	Minimal Protection	1–2 Days	Yes	Deployed
CRLite (Jan. 2017)*	100%	Initially 10 MB; 580 KB per day	Significant BG	Significant BG	1–2 Days	Yes	High
CRLite (Mar. 2018)*	100%	Initially 18 MB; Unknown per day	Significant BG	Significant BG	1–2 Days	Yes	High
CRT	99.86%	Initially 6.71 MB; 205 KB per day	Minimal BG	Minimal BG	1–2 Days	Yes	Medium
CRT (only revoked)	99.86%	Initially 1.92 KB; 0.21 KB per day	Minimal BG	Significant BG	1–2 Days	Yes	Medium

(BG = Bandwidth Growth)

- Lowest deployment requirements with:
  - Over 99% of TLS handshakes had revocation information cached on clients
  - Revocation timeliness of 1-2 days
  - Low client bandwidth - the only-revoked option requires just 200 bytes per day, which is three orders of magnitude smaller than other strategies

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