

# RFC-004: SPKI Authorization Integration

**Status:** Implemented **Date:** January 2026 **Author:** Derrell Piper ddp@eludom.net **Implementation:** cert.scm, spki-cert.scm, spki-verify.scm

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## Abstract

This RFC specifies the SPKI/SDSI certificate system for Cyberspace, providing authorization without identity. Principals are identified by cryptographic keys, not names. Authorization flows through verifiable delegation chains.

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## Motivation

X.509 certificates bind names to keys. This requires: - Certificate authorities (trust hierarchies) - Global name registries (DNS) - Identity verification (bureaucracy)

SPKI inverts this model:

**Keys are principals. Authorization is local. Delegation is explicit.**

Benefits: - **No CA required** - Trust flows from keys you choose - **No global names** - Local namespaces, local meanings - **No identity** - Grant permissions to keys, not people - **Auditable** - S-expression format is human-readable

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## Specification

### Principals

A principal is an authorization endpoint. Two types:

**Key Principal** Direct identification by public key:

```
(define-record-type <key-principal>
  (make-key-principal public-key)
  key-principal?
  (public-key principal-public-key))
```

S-expression: bare bytes

```
#{32-byte-ed25519-public-key}
```

**Key Hash Principal** Identification by hash of public key:

```
(define-record-type <keyhash-principal>
  (make-keyhash-principal hash-alg hash)
  keyhash-principal?
  (hash-alg principal-hash-alg)
  (hash principal-hash))
```

S-expression:

```
(hash sha512 #{64-byte-hash})
```

## Authorization Tags

Tags define what permissions are granted:

```
(define-record-type <tag>
  (make-tag sexp)
  tag?
  (sexp tag-sexp))
```

Example tags:

```
;; Read access to library
(read (path /library/lamport-papers))

;; Agent spawning limit
(spawn-agent (max-count 5))

;; HTTP API access
(http-api (method POST) (path /deploy/*))

;; All permissions (wildcard)
(*)
```

## Validity Period

Optional time constraints:

```
(define-record-type <validity>
  (make-validity not-before not-after)
  validity?
  (not-before validity-not-before) ; ISO 8601 string
  (not-after validity-not-after)) ; ISO 8601 string
```

## Certificate Structure

```
(define-record-type <cert>
  (make-cert issuer subject tag validity propagate)
  cert?
  (issuer cert-issuer)           ; Principal granting permission
  (subject cert-subject)         ; Principal receiving permission
  (tag cert-tag)                 ; What is being granted
  (validity cert-validity)       ; When valid (optional)
  (propagate cert-propagate))    ; Can subject re-delegate?
```

S-expression format:

```
(cert
  (issuer #${alice-public-key})
  (subject #${bob-public-key})
  (tag (read (path /library/*)))
  (valid
    (not-before "2026-01-01")
    (not-after "2026-12-31"))
  (propagate))
```

## Signed Certificate

```
(define-record-type <signed-cert>
  (make-signed-cert cert signature)
  signed-cert?
  (cert signed-cert-cert)
  (signature signed-cert-signature))

(define-record-type <signature>
  (make-signature hash-alg cert-hash sig-bytes)
  signature?
  (hash-alg signature-hash-alg)
  (cert-hash signature-cert-hash)
  (sig-bytes signature-sig-bytes))
```

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## Operations

### Creating Certificates

```
(define cert
  (create-cert
    (make-key-principal alice-public)
    (make-key-principal bob-public)))
```

```
(make-tag '(read (path /library/*)))  
validity: (make-validity "2026-01-01" "2026-12-31")  
propagate: #t))
```

## Signing Certificates

```
(define signed-cert  
  (sign-cert cert alice-private))
```

Process: 1. Convert certificate to canonical S-expression  
2. Hash with SHA-512 3. Sign hash with Ed25519 4. Create  
signature record 5. Combine into signed certificate

## Verifying Certificates

```
(verify-signed-cert signed-cert alice-public)
```

Verification: 1. Recompute canonical S-expression 2. Hash  
with SHA-512 3. Compare with stored hash 4. Verify Ed25519  
signature

## Verifying Delegation Chains

```
(verify-chain root-key cert-list target-tag)
```

Chain verification ensures: 1. Each certificate is validly  
signed 2. Issuer of cert[n+1] matches subject of cert[n]  
3. Tags are properly delegated (each implies the next) 4.  
Propagation is allowed (except final cert) 5. Final tag  
implies target tag

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## CLI Tools

### spki-keygen

Generate Ed25519 keypair:

```
$ ./spki-keygen alice  
Generated keypair:  
  Public:  alice.public  
  Private: alice.private
```

### spki-cert

Create and sign certificate:

```
$ ./spki-cert \
  --issuer alice.private \
  --subject bob.public \
  --tag '(read (path /library/*))' \
  --propagate \
  --not-after "2026-12-31" \
  --output alice-to-bob.cert
```

### spki-verify

Verify certificate signature:

```
$ ./spki-verify alice.public alice-to-bob.cert
Certificate signature valid
```

### spki-show

Display certificate in human-readable form:

```
$ ./spki-show alice-to-bob.cert
Certificate:
  Issuer:  ed25519:cbc9b260da65f6a7...
  Subject: ed25519:a5f8c9e3d2b1f0e4...
  Tag:      (read (path /library/*))
  Valid:    until 2026-12-31
  Propagate: yes
```

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## Tag Semantics

### Tag Implication

Tag A implies Tag B if A grants at least all permissions of B.

```
(define (tag-implies tag1 tag2)
  (cond
    ((all-perms? tag1) #t)      ; (*) implies everything
    ((all-perms? tag2) #f)      ; Only (*) implies (*)
    (else (equal? tag1 tag2)))) ; Simple equality (extensible)
```

### Standard Tag Vocabulary

Tag	Meaning
(*)	All permissions
(read (path P))	Read access to path P
(write (path P))	Write access to path P
(spawn-agent (max-count N))	Spawn up to N agents
(http-api (method M) (path P))	HTTP API access
(seal-release)	Permission to create releases
(seal-publish (remote R))	Permission to publish to R

## Delegation Chains

### Example: Three-Level Delegation

Alice (root) → Bob (admin) → Carol (operator)

Certificates:

*;; Alice grants admin to Bob*

```
(cert
  (issuer #${alice-key})
  (subject #${bob-key})
  (tag (*))
  (propagate))
```

*;; Bob grants operator to Carol*

```
(cert
  (issuer #${bob-key})
  (subject #${carol-key})
  (tag (seal-publish (remote origin))))
```

Verification:

```
(verify-chain alice-public
  (list alice-to-bob bob-to-carol)
  (make-tag '(seal-publish (remote origin))))
;; => #t if Carol can publish
```

## Security Considerations

### Threat Model

- Trusted:** – Local key storage – Ed25519/SHA-512 (libsodium)
- Certificate chain construction

**Untrusted:** - Certificate sources - Network transport -  
Certificate claims (until verified)

### Attack Mitigations

Attack	Mitigation
Certificate forgery	Ed25519 signatures
Unauthorized delegation	Propagate flag
Expired permissions	Validity period checks
Over-delegation	Tag implication checking

### Key Management

- **Generation:** Use secure random (libsodium)
  - **Storage:** Private keys in protected files
  - **Backup:** Shamir secret sharing (see RFC-001)
  - **Rotation:** Issue new certs, revoke old
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## Integration Points

### Vault Authorization

```
(vault-init signing-key: alice-private)
(seal-release "1.0.0") ; Requires seal-release tag
```

### Audit Trail Attribution

```
(audit-append
 actor: bob-public
 action: '(seal-commit "abc123")
 authorization-chain: (list alice-to-bob-cert))
```

### Replication Access Control

```
(seal-publish "1.0.0"
 remote: "origin"
 authorization: bob-to-carol-cert)
```

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## SPKI vs X.509

Aspect	X.509	SPKI
Identity	Names (DN)	Keys
Trust	CA hierarchy	Local choice
Namespaces	Global (DNS)	Local
Revocation	CRL/OCSP	Validity periods
Format	ASN.1/DER	S-expressions
Readability	Requires tools	Human-readable
Delegation	Implicit (CA)	Explicit (propagate)

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## References

1. Ellison, C., et al. (1999). SPKI Certificate Theory. RFC 2693.
2. Ellison, C., et al. (1999). SPKI Requirements. RFC 2692.
3. Rivest, R., & Lampson, B. (1996). SDSI – A Simple Distributed Security Infrastructure.
4. Lampson, B. (1971). Protection.
5. RFC-006 – Vault System Architecture
6. RFC-018 – Sealed Archive Format (X25519/Ed25519 key compatibility)

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## Changelog

- **2026-01-06** – Initial specification

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**Implementation Status:** Complete **Test Status:** Passing (test-cert-minimal.scm) **CLI Tools:** spki-keygen, spki-cert, spki-verify, spki-show