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The MyClerk Protocol: Tiered Security Communication for Distributed Family Systems
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Abstract

This document specifies the MyClerk Protocol, a tiered-security communication protocol designed for distributed family orchestration systems. The protocol provides six security tiers ranging from 1-byte minimal overhead for tunneled messages to 144-byte full security for critical operations. It supports multiple transport mechanisms including NATS, Matrix, WebSocket, and direct TCP, while maintaining end-to-end encryption using ChaCha20-Poly1305 and X25519 key exchange.

The protocol is transport-agnostic, federation-capable, and optimized for environments ranging from resource-constrained IoT devices to full-featured desktop clients.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

Modern families operate across multiple locations and devices: a primary home with network-attached storage, a vacation house with a mini-PC, grandparents with a Raspberry Pi, and mobile devices requiring access while traveling. The MyClerk Protocol addresses the communication requirements of such distributed family systems.

Traditional protocols impose significant overhead that becomes problematic for constrained channels. The MyClerk Protocol introduces tiered security levels, allowing applications to select appropriate overhead based on the security requirements of each operation.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

1.2. Terminology

Node A device participating in a MyClerk deployment, such as a server, desktop client, mobile device, or IoT device.

Core Node A node classified as stable and reliable, expected to maintain high availability (>95% uptime over 30 days).

Bonus Node A node with variable availability, used opportunistically for additional redundancy.

Family A group of users and nodes sharing a common trust domain and cryptographic key hierarchy.

Federation The interconnection of multiple families for resource sharing or communication.

Tier A security level (0-5) determining the header structure and cryptographic protections applied to a message.

Session A stateful connection between two endpoints with established cryptographic keys.

2. Protocol Overview

The MyClerk Protocol is a binary protocol using MessagePack [RFC8949] for payload encoding. It defines six security tiers with increasing header sizes and cryptographic protections.

2.1. Design Goals

1. *Tiered Security:* 1-144 bytes overhead depending on security requirements.

2. *Transport Agnostic:* Operates over NATS, Matrix, WebSocket, TCP, or other transports.

3. *Federation Ready:* Supports multi-server, multi-family deployments.

4. *Future Proof:* Extensible operations and feature negotiation.

2.2. Security Tiers Overview

Tier	Header Size	Encryption	Authentication	Use Case
0	1 byte	None (tunneled)	None	Inside secure session
1	4 bytes	None	None	Fire-and-forget commands
2	6 bytes	Optional	CRC-16	Home automation
3	12 bytes	ChaCha20-Poly1305	HMAC-32	Conversational
4	42 bytes	ChaCha20-Poly1305	HMAC-64	Key exchange
5	58+ bytes	ChaCha20-Poly1305	HMAC-256 + Poly1305	Maximum security

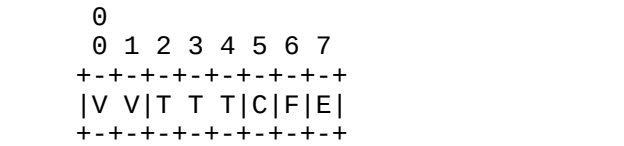
Table 1: Security Tier Summary

3. Message Format

All messages consist of a header, optional payload, and optional trailer. The header format varies by security tier.

3.1. Common Header Fields

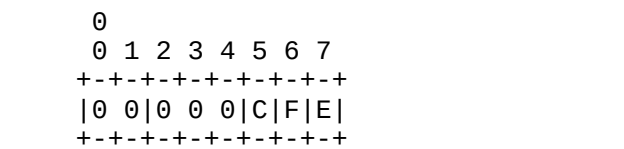
The first byte (Flags) is present in all tiers and has the following structure:



V: Protocol Version (2 bits) - Currently 0
T: Security Tier (3 bits) - Values 0-5
C: Compressed (1 bit) - Payload is compressed
F: Fragmented (1 bit) - Message is fragmented
E: Encrypted (1 bit) - Payload is encrypted

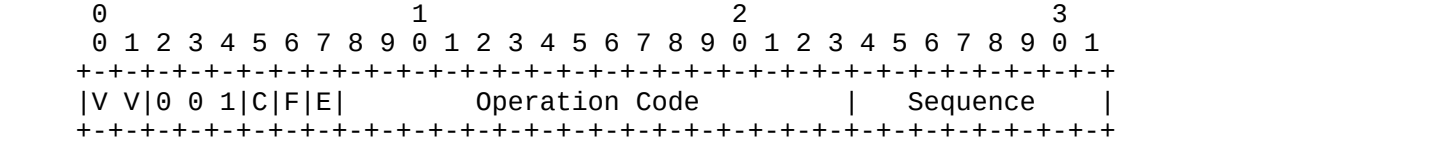
3.2. Tier 0 Header (1 byte)

Tier 0 is used for messages tunneled inside an already-secure session. It provides minimal overhead.



Tier 0 messages MUST only be sent within an established Tier 3+ session. Implementations receiving a Tier 0 message outside of a secure session MUST discard it.

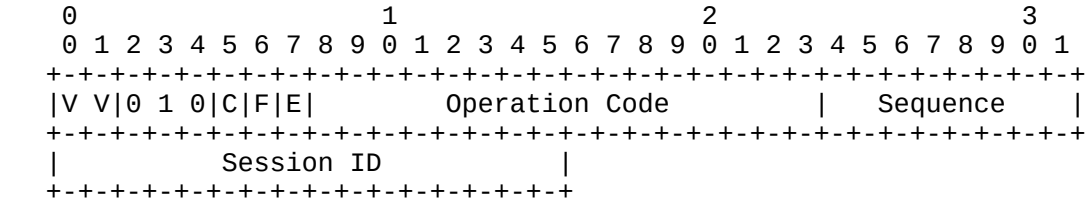
3.3. Tier 1 Header (4 bytes)



Operation Code (16 bits) Identifies the operation. See Section 6.

Sequence (8 bits) Message sequence number, wrapping at 255.

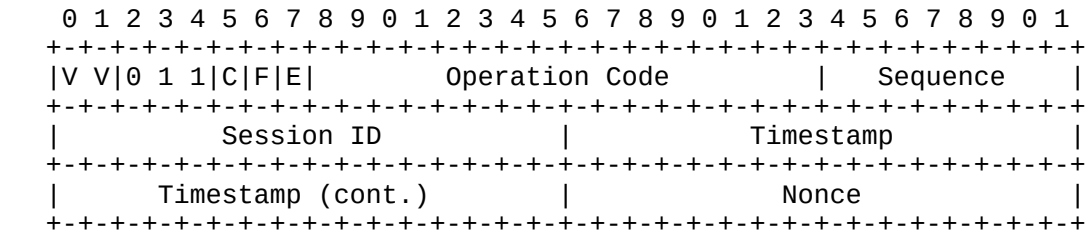
3.4. Tier 2 Header (6 bytes)



Session ID (16 bits) Identifies the session context for this message.

Tier 2 messages SHOULD include a CRC-16 trailer for error detection.

3.5. Tier 3 Header (12 bytes)

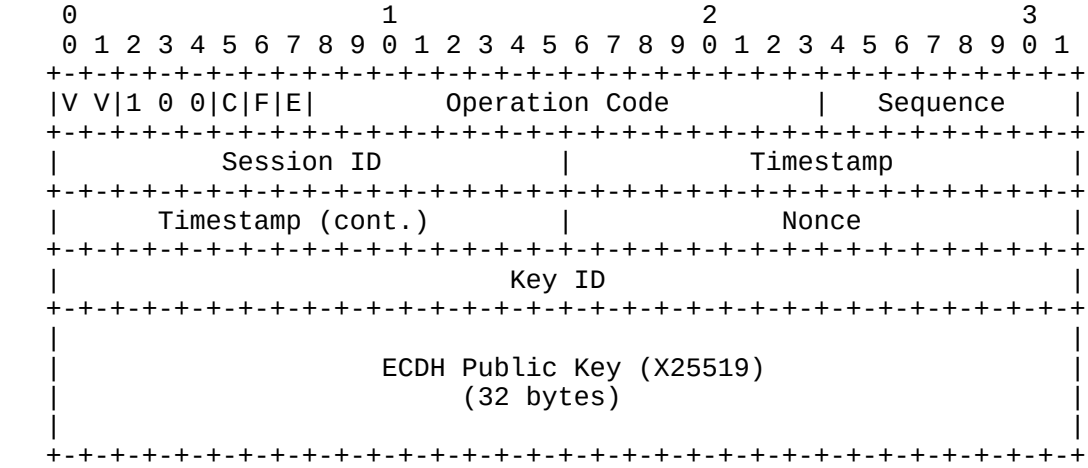


Timestamp (32 bits) Unix timestamp in seconds. Used for replay protection.

Nonce (16 bits) Random nonce component. Combined with timestamp and counter to form the full 96-bit nonce for ChaCha20-Poly1305.

Tier 3 messages with the E flag set MUST be encrypted using ChaCha20-Poly1305 as specified in [RFC8439].

3.6. Tier 4 Header (42 bytes)

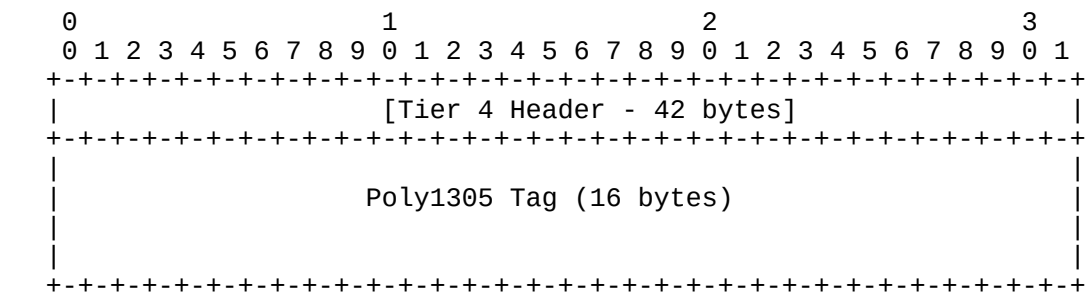


Key ID (32 bits) Identifier for the key being used or negotiated.

ECDH Public Key (256 bits) X25519 public key as specified in [RFC7748].

3.7. Tier 5 Header (58 bytes)

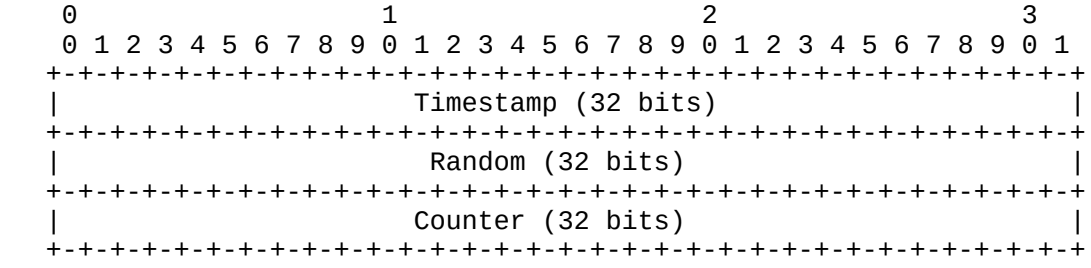
Tier 5 extends Tier 4 with a full Poly1305 authentication tag in the header:



Tier 5 messages MUST include a full HMAC-SHA256 (32 bytes) in the trailer, providing dual authentication: Poly1305 for AEAD integrity and HMAC-SHA256 for post-quantum resistance.

4. Nonce Construction

ChaCha20-Poly1305 requires a 96-bit (12-byte) nonce that MUST NOT be reused with the same key. The MyClerk Protocol constructs nonces as follows:



Timestamp (32 bits) Unix epoch seconds. Provides cross-session replay protection.

Random (32 bits) Cryptographically random value generated per session using a CSPRNG. Provides 2^32 possible values per second.

Counter (32 bits) Per-message counter starting at 0, incremented for each message. Allows 2^32 messages per session.

All fields are encoded in big-endian byte order.

This construction provides a collision probability of less than 2^-80 per year at 1 million operations per second, assuming proper CSPRNG implementation.

5. Key Derivation

Session keys are derived using HKDF as specified in [RFC5869] with SHA-256 as the hash function.

5.1. ECDH Key Exchange

For Tier 4+ sessions:

```
shared_secret = X25519(local_private_key, remote_public_key)

session_key = HKDF-SHA256(
    IKM  = shared_secret,
    salt = nonce_initiator || nonce_responder,
    info = "myclerk-session-v0",
    L    = 32
)
```

5.2. Key Rotation

Keys MUST be rotated after any of the following conditions:

* 2^32 messages sent (nonce exhaustion)

* 24 hours elapsed (time-based)

* Explicit KEY_ROTATE operation received

Rotated keys are derived as:

```
new_key = HKDF-SHA256(
    IKM  = current_key,
    salt = "rotate",
    info = rotation_counter (4 bytes, big-endian),
    L    = 32
)
```

6. Protocol Operations

Operations are identified by a 16-bit operation code. The operation space is divided into ranges:

Range	Category
0x0000-0x00FF	Core Operations (Session, Key Management)
0x0100-0x01FF	Standard Operations (Device, Identity, Messaging)
0x0200-0x02FF	Resource Sharing
0x0300-0x03FF	Federation
0x0400-0x04FF	Billing and Economics
0x0500-0x05FF	Virtual File System (VFS)
0xF000-0xFFFE	Vendor Extensions
0xFFFF	Reserved

Table 2: Operation Code Ranges

6.1. Core Operations (0x0000-0x00FF)

6.1.1. Session Management (0x0000-0x000F)

Code	Name	Description
0x0000	NOP	No operation
0x0001	KEEPALIVE	Session keepalive
0x0002	KEEPALIVE_ACK	Keepalive acknowledgment
0x0003	SESSION_INIT	Initialize session
0x0004	SESSION_ACK	Session acknowledgment
0x0005	SESSION_CLOSE	Close session
0x0006	SESSION_CLOSE_ACK	Close acknowledgment
0x0007	SESSION_RESUME	Resume session with ticket
0x0008	SESSION_RESUMED	Session resumed

Table 3: Session Management Operations

6.1.2. Key Management (0x0010-0x001F)

Code	Name	Description
0x0010	KEY_EXCHANGE_INIT	Initiate key exchange
0x0011	KEY_EXCHANGE_RESPONSE	Key exchange response
0x0012	KEY_EXCHANGE_COMPLETE	Key exchange complete
0x0016	SESSION_ROTATE	Rotate session key
0x0017	SESSION_REVOKE	Revoke session key

Table 4: Key Management Operations

7. Payload Formats

Payloads are encoded using MessagePack (a subset of CBOR). This section defines payload structures using CDDL [RFC8610].

7.1. SESSION_INIT Payload

```
session-init = {
    nonce: bstr .size 8,
    timestamp: uint,
    ? capabilities: [* capability],
    ? device-id: bstr .size 16,
}

capability = &(
    compression-lz4: 0,
    compression-zstd: 1,
    encryption-chacha20: 2,
    encryption-aes256gcm: 3,
    fragmentation: 4,
    streaming: 5,
    federation: 6,
    vfs: 8,
)
```

7.2. SESSION_ACK Payload

```
session-ack = {
    session-id: uint .size 2,
    nonce: bstr .size 8,
    selected-tier: uint .le 5,
    ? selected-capabilities: [* capability],
}
```

7.3. SESSION_RESUME Payload

```
session-resume = {
    old-session-id: uint .size 2,
    ticket: bstr .size 64,
}

; Ticket structure (encrypted with server key, AES-256-GCM):
; - session-key: 32 bytes
; - device-id: 16 bytes
; - issued-at: 4 bytes (Unix timestamp)
; - expires-at: 4 bytes (Unix timestamp)
; - ticket-nonce: 8 bytes
```

8. Tier Compatibility

When endpoints support different maximum tiers, they MUST negotiate to the highest common tier. The server MUST respond with the minimum of its supported tier and the client’s requested tier.

Servers MAY enforce minimum tier requirements for specific operations. If a client requests an operation at an insufficient tier, the server MUST respond with error code 0x12 (FORBIDDEN) and include the required tier in the error payload.

8.1. Minimum Tier Requirements

The following operations have minimum tier requirements:

Operation Category	Minimum Tier
Lock/Unlock (physical access)	3
Key Exchange	4
Federation Operations	4
Emergency Operations	3

Table 5: Minimum Tier Requirements

9. Error Handling

Error codes are 8-bit values organized into ranges:

Range	Category
0x00-0x0F	Success
0x10-0x1F	Client Errors
0x20-0x2F	Server Errors
0x30-0x3F	Federation Errors
0xF0-0xFF	Reserved

Table 6: Error Codes

9.1. Specific Error Codes

0x00 OK Operation completed successfully.

0x10 BAD_REQUEST Malformed message or invalid parameters.

0x11 UNAUTHORIZED Authentication required or failed.

0x12 FORBIDDEN Insufficient permissions or tier.

0x13 NOT_FOUND Requested resource does not exist.

0x17 INVALID_SESSION Session expired or invalid.

0x20 INTERNAL_ERROR Server encountered an unexpected error.

0x21 SERVICE_UNAVAILABLE Service temporarily unavailable.

0x22 TIMEOUT Operation timed out.

10. Security Considerations

10.1. Nonce Reuse

Reusing a nonce with the same key in ChaCha20-Poly1305 completely compromises the confidentiality and authenticity of all messages encrypted with that key-nonce pair. Implementations MUST ensure nonces are never reused by:

* Using cryptographically random values for the Random field
* Maintaining a monotonic counter per session
* Rotating keys before counter exhaustion

10.2. Replay Protection

Tier 3+ messages include timestamps for replay protection. Implementations SHOULD reject messages with timestamps more than 5 minutes in the past or future. Session resumption tickets include a nonce that MUST be tracked to prevent replay attacks.

10.3. Tier Downgrade Attacks

An attacker might attempt to force communication at a lower tier. Servers MUST enforce minimum tier requirements for sensitive operations. Clients SHOULD warn users when connecting at a lower tier than expected.

10.4. Key Compromise

If a session key is compromised, an attacker can decrypt all messages in that session. The 24-hour automatic key rotation limits the window of exposure. For forward secrecy, implementations SHOULD use ephemeral ECDH keys for each session.

10.5. Post-Quantum Considerations

The X25519 key exchange is not quantum-resistant. Tier 5 includes an additional HMAC-SHA256 trailer that provides some protection against future quantum attacks on Poly1305. Implementations concerned about long-term confidentiality SHOULD use Tier 5 for sensitive data.

11. IANA Considerations

This document has no IANA actions.

If this protocol were to be standardized, IANA would be requested to create a registry for MyClerk Protocol operation codes with the ranges defined in Section 6.

12. References

12.1. Normative References

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Acknowledgements

This specification is part of the MyClerk project, a privacy-first family orchestration platform currently in development. For more information, visit https://myclerk.eu.

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