

S402 Payment Verification Flow Comparison (Sequence Diagrams)

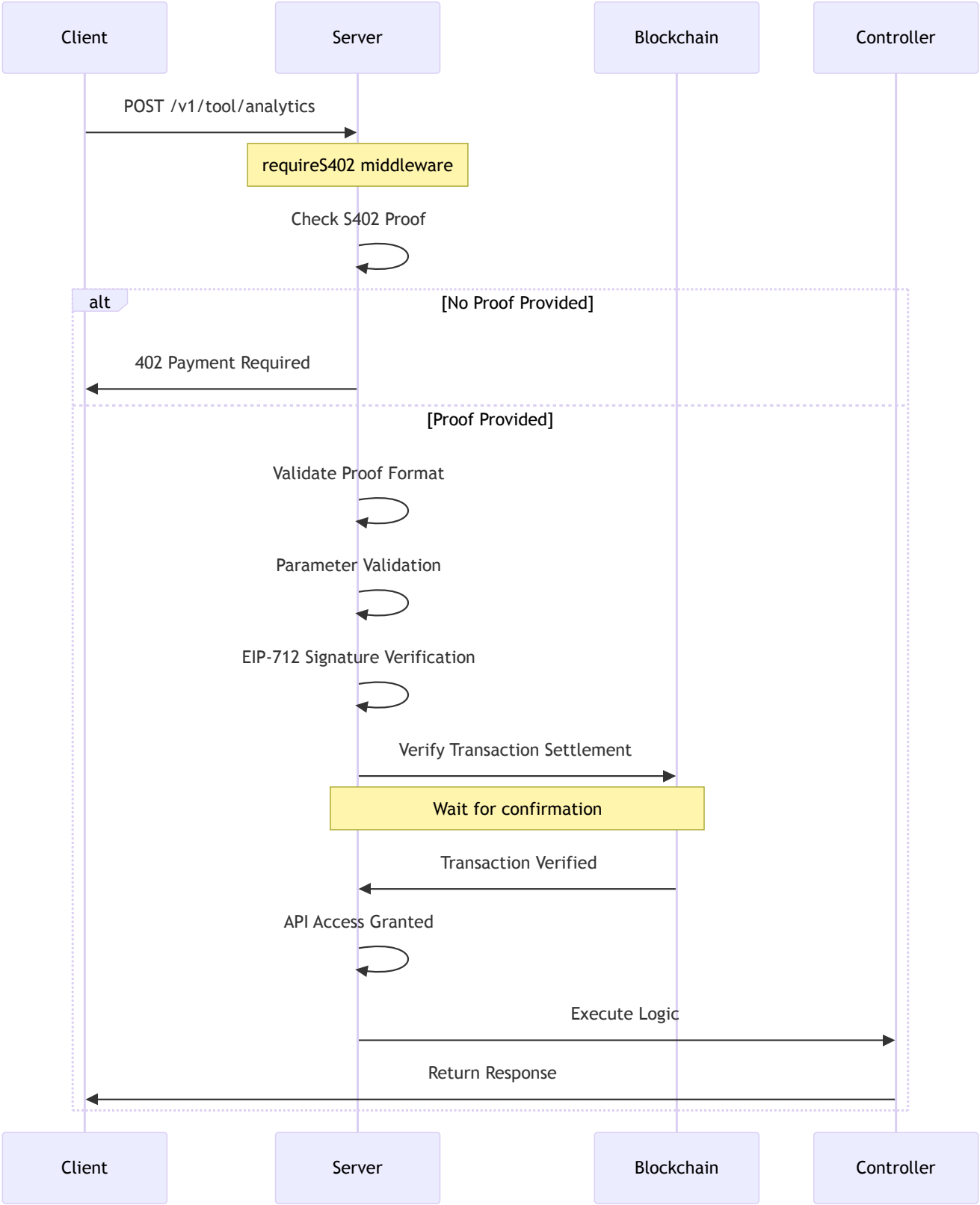
This document compares two execution flows for S402 payment verification using sequence diagrams: synchronous verification and asynchronous verification.

Route Definition Comparison

```
// Synchronous verification route
router.post("/v1/tool/example-async", requireS402Async("tool.example"), toolController.

// Asynchronous verification route
router.get("/v1/tool/analytics", requireS402("tool.analytics"), toolController.analytic
```

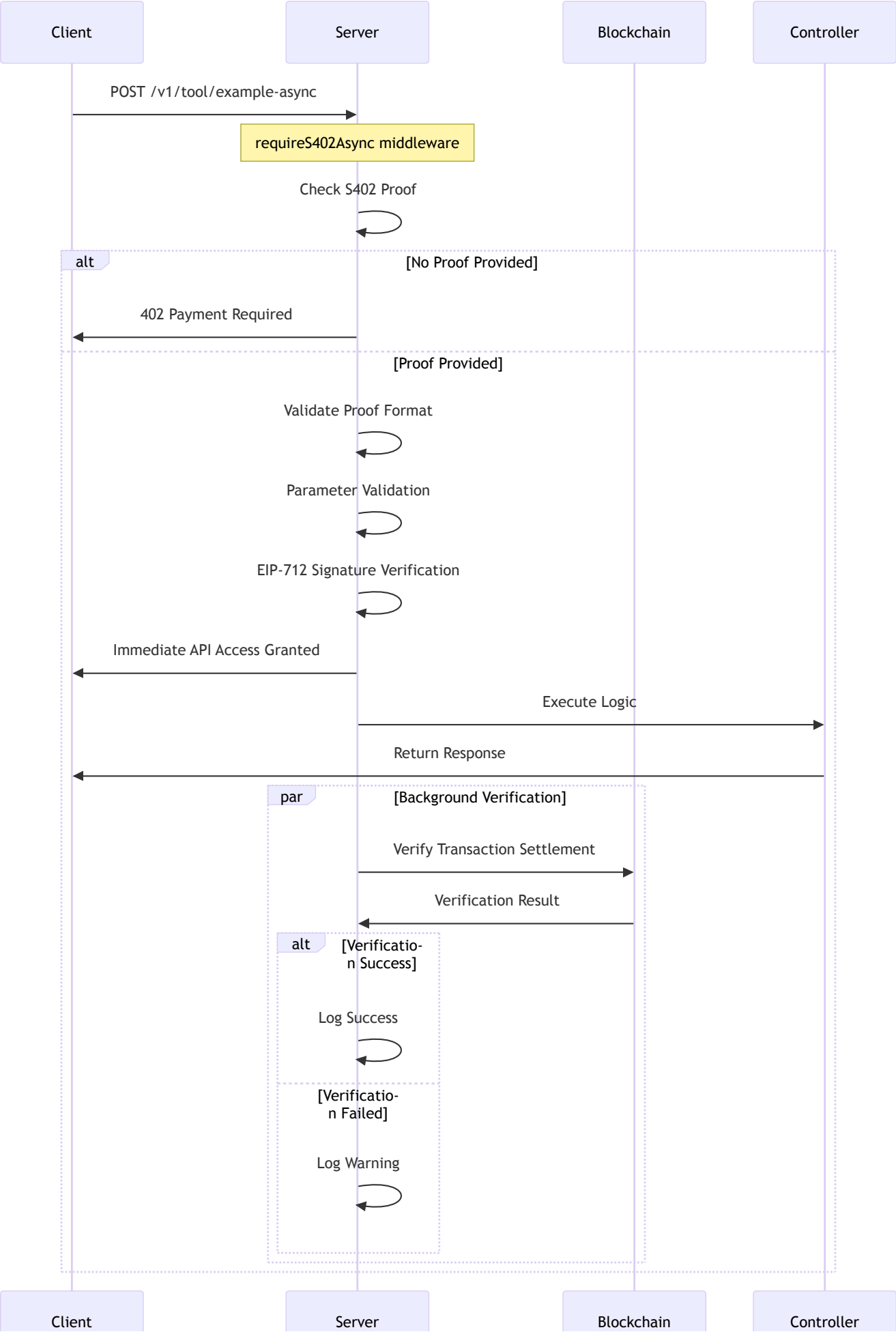
Synchronous Verification Flow (requireS402)



Synchronous Verification Characteristics

- **Blocking Verification:** Waits for complete blockchain transaction confirmation before proceeding
- **Strong Consistency:** Ensures payment is fully confirmed on-chain before granting access
- **Response Delay:** Requires waiting for blockchain confirmation, longer response time
- **High Security:** Full verification before service provision

Asynchronous Verification Flow (requireS402Async)



Asynchronous Verification Characteristics

- **Non-blocking Verification:** Grants access immediately after signature verification, blockchain verification runs in background
- **Eventual Consistency:** Allows API access before blockchain confirmation completes
- **Fast Response:** No need to wait for blockchain confirmation, better user experience
- **Controlled Risk:** Relies on EIP-712 signature verification as primary security mechanism

Core Differences Comparison

Feature	Synchronous Verification (requireS402)	Asynchronous Verification (requireS402Async)
Verification Timing	Waits for complete verification during request processing	Responds immediately after signature verification
Blockchain Confirmation	Waits for confirmation completion	Background asynchronous verification
Response Time	Longer (waiting for blockchain)	Shorter (signature verification only)
Consistency Guarantee	Strong consistency	Eventual consistency
Security Level	Highest (dual verification)	High (signature verification primary)
Use Cases	High-value/sensitive operations	Regular API calls

Technical Implementation Differences

Synchronous Verification Key Code

```
// Wait for blockchain verification to complete
const verification = await verifyTransactionSettlement(proof.txHash!, proof.payment);
if (!verification.verified) {
    throw new Error(`Transaction verification failed: ${verification.error}`);
}
```

Asynchronous Verification Key Code

```
// Return immediately, verify in background
const verificationPromise = verifyTransactionSettlement(proof.txHash!, proof.payment);
return {
    // ... other fields
    verifiedAsync: true,
    verificationPromise // For background processing
};
```

Usage Recommendations

- **Synchronous Verification:** Suitable for financial transactions, sensitive data access, and scenarios requiring highest security guarantees
- **Asynchronous Verification:** Suitable for regular API calls, user experience-first scenarios, providing sufficient security through signature verification

Both verification methods offer robust payment verification mechanisms, with the choice depending on specific business scenario requirements for security and performance.