IETF 117
Crash Fault Tolerance,
Session Resumption,
Update On SATP Implementations

draft-hargreaves-satp-core-02
(draft-belchior-satp-gateway-recovery-00)

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On faults, crashes, and errors

• Gateways can enter a faulty state: and produce errors (alerts to the user) or fail (crashes)
• We need a logging and recovery procedure: crash recovery draft.
  • https://datatracker.ietf.org/doc/draft-belchior-satp-gateway-recovery/
  • https://github.com/CxSci/IETF-SATP/pull/9
• Log Storage (each gateway has one):
  – State DB (safety: correct operation, liveness)
  – Decentralized, public DB (safety: non-repudiation and decentralization, used for retrieving logs upon crash)
1 writeLogEntry <stage,step,process>
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2. `<1,1,init–TRANSFER–COMMENCE>`

3. `writeLogEntry <exec–TRANSFER–COMMENCE>`

4. `execute TRANSFER–COMMENCE`

5. `writeLogEntry <done–TRANSFER–COMMENCE>`

6. `writeLogEntry <ack–TRANSFER–COMMENCE>`
1 writeLogEntry <stage,step,process>
2 <1,1,init-TRANSFER-COMMENCE>
3 writeLogEntry <exec-TRANSFER-COMMENCE>
4 execute TRANSFER-COMMENCE
5 writeLogEntry <done-TRANSFER-COMMENCE>
6 writeLogEntry <ack-TRANSFER-COMMENCE>
7 [8] <1,2,init-TRANSFER-COMMENCE>
Handling crashes

• How do we handle crash faults?
  – Let us assume two scenarios: faults in a stage of the protocol that does not imply changes to the state of external systems (non-critical); and faults in a stage where one would have changes to external systems (critical)
  – Gateways assume to recover by itself (self-healing) or by employing a primary-backup service.
• We handle crashes depending on the scenario at hand; by keeping a write ahead log of operations, and by enforcing either a session resumption protocol, abort, or rollback.
• We need to define the state for recovering from crashes
Crash recovery state

- RECOVERY_STATE: Session ID, gateways, transfer context, stage, step, operation (init, exec, done, ack, fail), and rollback logic (needs to be implemented in a per-phase basis)
- Different parts of RECOVERY_STATE may be used for an abort vs rollback (example for abort and rollback, one should invalidate session ID; rollback logic only for rollback).
Non-critical crash

Stage 1

Unlocked (assigned)

1.1
Transfer Proposal Claims
G1 sends the signed Transfer Initialization Claim to G2

1.2
Transfer-Proposal Receipt
G2 accepts by signing Receipt containing hash of msg1.1

1.3
Transfer-Commence
Session open [Session_ID]

(Msg 1.1 & 1.2 may be multi-round)

Transfer Proposal Claims contains details of the asset transfer:
- Asset_ID in NW1
- Context_ID
- Address of Alice & Bob.
- Verified identities,
- etc. (lots)
How these are obtained and verified by G1 and G2 is out-of-scope for IETF SATP WG
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Session_ID is chosen by G1

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writeLogEntry<stage1,1.1,transfer-proposal-claims>

transfer-proposal-claims (1.1)

▲ Crash ▲

▲ Gets 503 or no answer ▲

alt
[retry until application timeout]
send Transfer-Proposal-Receipt (1.2)

[Failure]
record G1 has crashed, wait

alt
[waiting until max_timeout]
▲ recovers from crash

RECOVER
Critical crash

Asset on must be under the control of G1 before proceeding. G1 is now liable for asset.

G1 checks the status of asset.

G1 sends signed assertion (and metadata) of locked status of asset.

G2 locally logs the signed Lock Assertion and also broadcasts it to NW2.

G2 sends signed Receipt corresponding to the Lock-Assertion.

For evidence (cf. dispute resolution), G2 creates new asset assigned to G2 (to
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2.1B Status-check (locked?)

G1 checks the status of asset.

2.2 Lock-Assertion

G1 sends signed assertion (and metadata) of locked status of asset

2.3 Lock-Assertion Broadcast

G2 locally logs the signed Lock Assertion and also broadcasts it to NW2

2.4 Lock-Assertion-Receipt

G2 sends signed Receipt corresponding to the Lock-Assertion

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Example rollback logic for step Lock Assertion (2.2) - by G1

- **EFFECT TO BE ROLLED BACK**: X assets were locked/burned, we need to unlock it/mint it on the source chain

- **INPUT**: asset id and amount to unlock

- **OUTPUT**: success or fail (if fail requires manual intervention)

- **PROCEDURE**:
  - G1 create transaction tx unlocking X assets
  - G1 propagates transaction tx to source network and waits for confirmation
  - G1 logs confirmation on the decentralized log
Session Resumption Discussion

● Should session resumption be explicit or implicit?
  ○ We are considering it implicit but may define interface to do it explicitly

● Timeout on recover message. What happens if a gateway G1 crashes, it recovers, and when is sending a recover message, G2 crashes, i.e., problem of nested failures?
  ○ Possible solution: timestamp ordering, and rollbacks with lower timestamp have priority?
Rollback Discussion

- Burn-Mint is more secure than Lock-Unlock because of honeypots. What are the tradeoffs in terms of rollbacks for the two paradigms?
Error messages

Diagram:

- Client (Applic)
- Off-DLT
  - Resource
  - API Type-3
- DLT L1
- Gateway G1
  - API Type-1
- API Type-2
- Source gateway
- asset transfer
- DLT L2
- Gateway G2
  - API Type-2
  - Recipient gateway

success
Error messages

Source gateway

Recipient gateway

API Type-1

Gateway G1

API Type 2

API Type-1

Gateway G2

API Type 2

Success/ERROR

Off-DLT Resource

API Type-3

Asset transfer

Client (Applic)

V

DLT L1

DLT L2
Network NW1

(Alice) Orig
State Data DB1

G1 REST API

Network NW2

State Data DB2

{Bob) Benef

(All messages between G1 and G2 are using HTTPS POST/GET)

Stage 0

error 1

(1) Alice request cross-network transfer

G1 & G2 validate general network capabilities

G1 and G2 need to discover the technical capabilities of their respective network, including the types of asset supported.
Error 2

Network NW1

(Alice) Orig

State Data DB1

G1

G1 & G2 validate general network capabilities

Stage 0

error 2

(1) Alice request cross-network transfer

Network NW2

(G1 and G2 are using HTTPS POST/GET)

G2

State Data DB2

{Bob) Benef

G1 and G2 need to discover the technical capabilities of their respective network, including the types of asset supported.
(Alice) Orig

State Data DB1

G1

(All messages between G1 and G2 are using HTTPS POST/GET)

Network NW1

Stage 0

(1) Alice request cross-network transfer

error 3

Network NW2

G1 & G2 validate general network capabilities

G1 and G2 need to discover the technical capabilities of their respective network, including the types of asset supported.
The Error message is sent by a gateway to a gateway or a gateway to a client to indicate a message error.

- **error type** - Code list containing a code that identifies the error condition.
- **code** - Specification of the error, in coded form.

...
Error schema

• description - Description of the error found. The description is a standardized message that is used to provide information about an error that occurred during the processing of a message. The error description message provides information about the type of error, the location of the error, and other relevant details.

• proprietary - Specification of the error, in free format (specific to the party that generates the error, and it is not standardized). The error proprietary message can be used to provide additional details that are not available in the standard error messages.
A.3. Stage 2

Errors for messages 2.1 and 2.2

- [err_2.1] Badly formed message.
- [err_2.2] Incorrect parameter.
- [err_2.3] ACK mismatch.

Error reports for Messages 2.3.A and 2.3.B (Lock failed)

- [err_2.3.1] Asset already locked.
- [err_2.3.2] Insufficient funds to complete transaction.
- [err_2.3.3] Time-out on lock attempt.
- [err_2.3.4] Network consensus protocol error.

Error reports for Messages 2.3.A and 2.3.B (Read failed)

- [err_2.3.5] Gateway configuration error.
- [err_2.3.6] Insufficient read/write permission.

Error reports for Message 2.4 (Lock Assertion)

- [err_2.4.1] Badly formed message: badly formed Claim.
- [err_2.4.2] Badly formed message: bad signature.
- [err_2.4.3] Badly formed message: wrong transaction ID.
- [err_2.4.4] Badly formed message: Mismatch hash values.
- [err_2.4.5] Expired signing-key certificate.
- [err_2.4.6] Expired Claim.
Error schema

A.4. Stage 3

Error reports for Message 3.1 (Commit Prepare):

- [err_3.1.1] Badly formed message: wrong transaction ID.
- [err_3.1.2] Badly formed message: mismatch hash value.
- [err_3.1.3] Incorrect parameter.
- [err_3.1.4] Message out of sequence

Error reports for Message 3.2 (ACK-Prepare):

- [err_3.2.1] Badly formed message: wrong transaction ID.
- [err_3.2.2] Badly formed message: mismatch hash value.
- [err_3.2.3] Incorrect parameter.
- [err_3.2.4] Message out of sequence

Error reports for Message 3.3A and 3.3B (Create asset fail):

- [err_3.3.1] Asset already exist.
- [err_3.3.2] Insufficient funds to complete transaction.
- [err_3.3.3] Time-out for transaction finality.
- [err_3.3.4] Network consensus protocol error.
Update on open-source SATP implementations

- Stable SATP implementation, trusted, centralized node, with crash recovery (outdated):

- On-going implementation, relay, decentralized node (with Rama):
  https://github.com/outsidethecode/cacti/pull/1
Next steps

- Confirm error scope
- Define various errors across four stages of SATP
- Find a meaningful message for each error code
- Update/continue developing open-source implementations
Thank you and Q&A

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