# Key Event Receipt Infrastructure
# KERI-2
# A Secure Identifier Overlay
# for the
# Internet


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version 2.30

https://github.com/SmithSamuelM/Papers

https://github.com/SmithSamuelM/Papers/blob/master/presentations/KERI2_Overview.web.pdf

https://github.com/SmithSamuelM/Papers/blob/master/whitepapers/KERI_WP_2.x.web.pdf

https://github.com/SmithSamuelM/keri

https://github.com/decentralized-identity/keri

# Background References

**Self-Certifying Identifiers:**

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# Human *Basis-of-Trust*

*"in person"*

*I can know you – therefore I can trust you*

*"on the internet"*

*I can't really know you – therefore I can't really trust you*

# Replace human *basis-of-trust* with cryptographic *root-of-trust.*

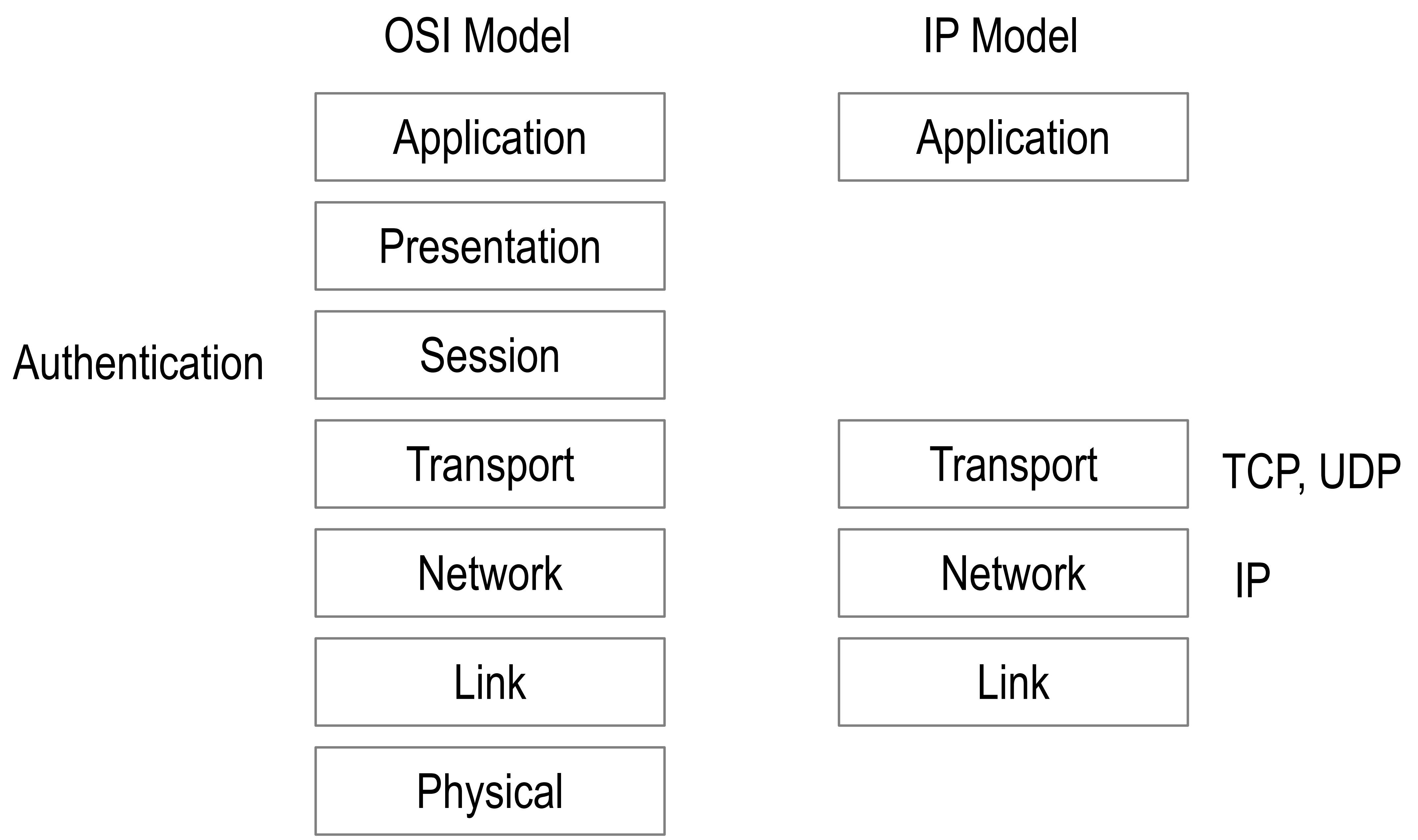
With verifiable digital signatures from asymmetric key crypto –
we may not trust in *"what"* was said, but we may trust in *"who"* said it.

We may *verify* that the *controller* of a private key, (*the who*), made a statement
but not the validity of the statement itself.

The *root-of-trust* is *consistent attribution* via verifiable integral non-repudiable statements

We may build trust over time  in *what* was said via histories
of verifiably attributable (to *whom*) consistent statements i.e. *reputation*.

# The Internet Protocol (IP) is *bro-ken* because it has no *security* layer.

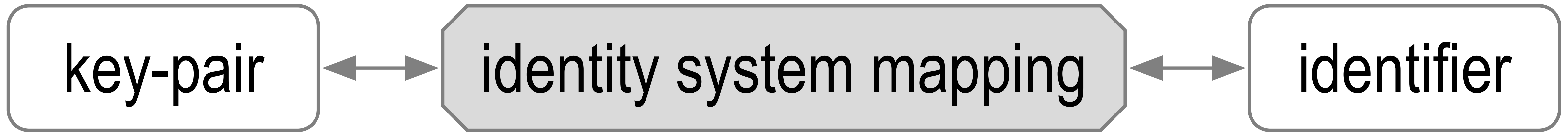



# Instead …

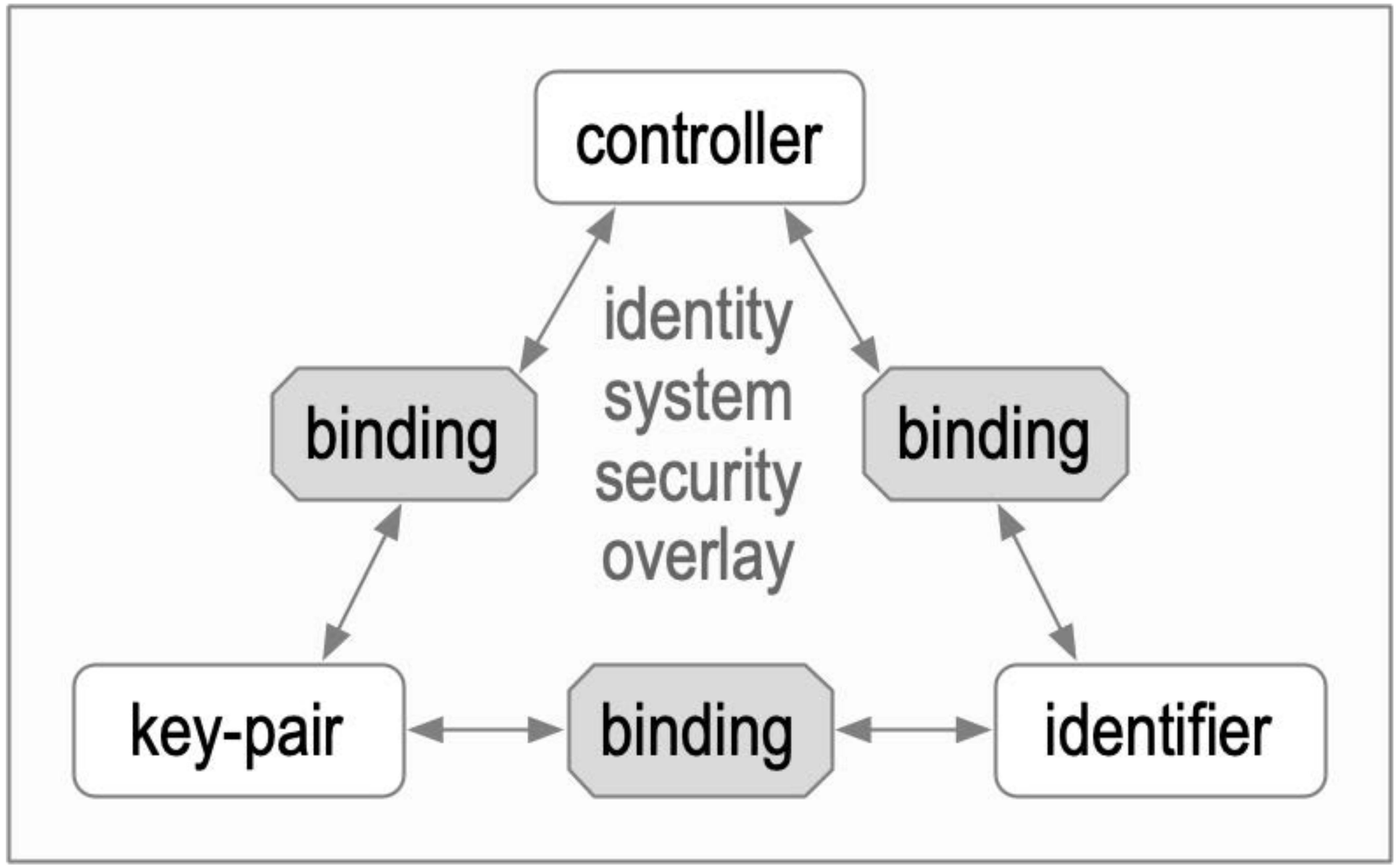
# We use *bolt-on* identity system security overlays. (DNS-CA … )

# Identity System Security Overlay

Establish authenticity of IP packet's message payload.



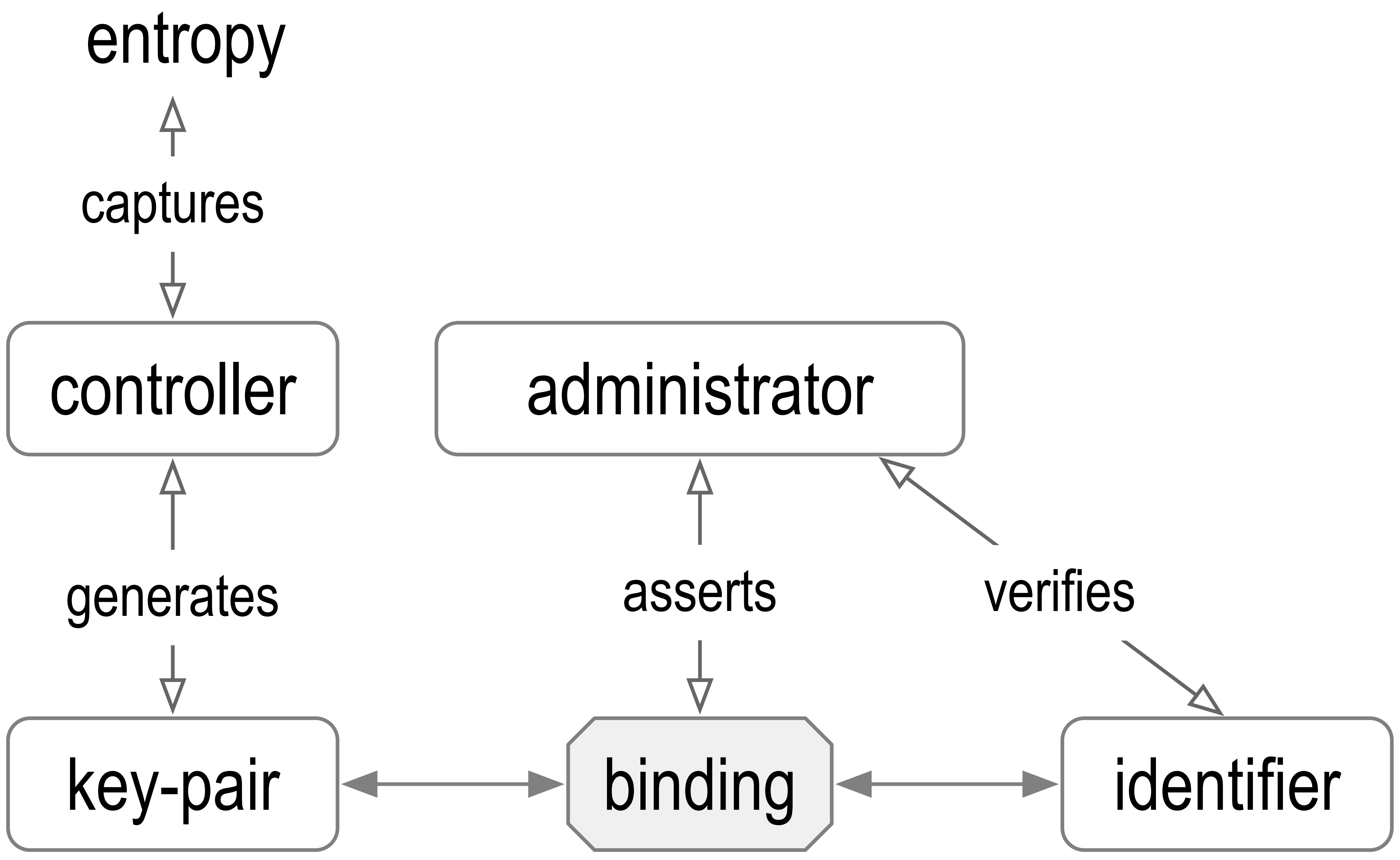




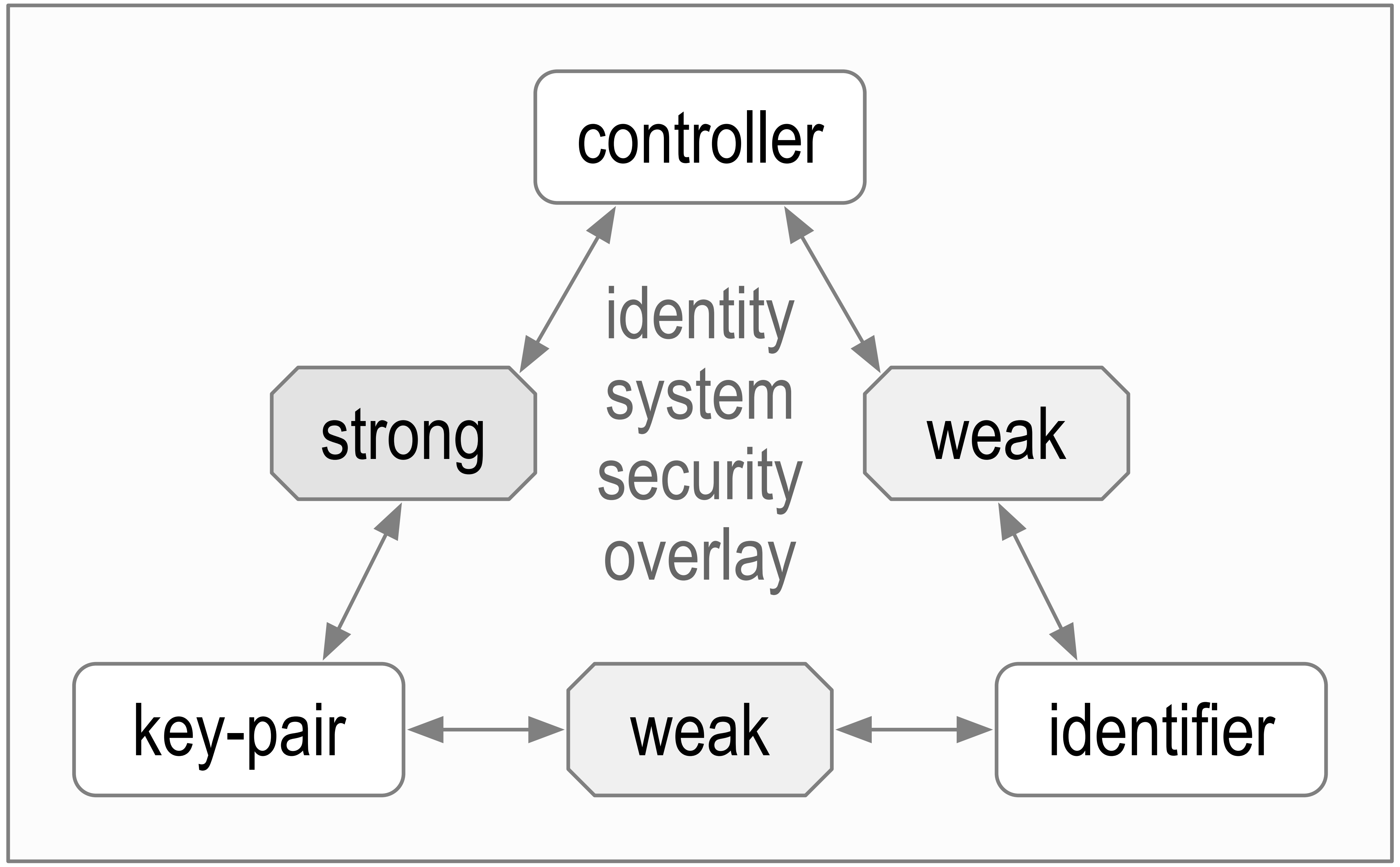

Identifier Issuance

The overlay's security is contingent on the mapping's security.

# Administrative Identifier Issuance and Binding




admin-certifying

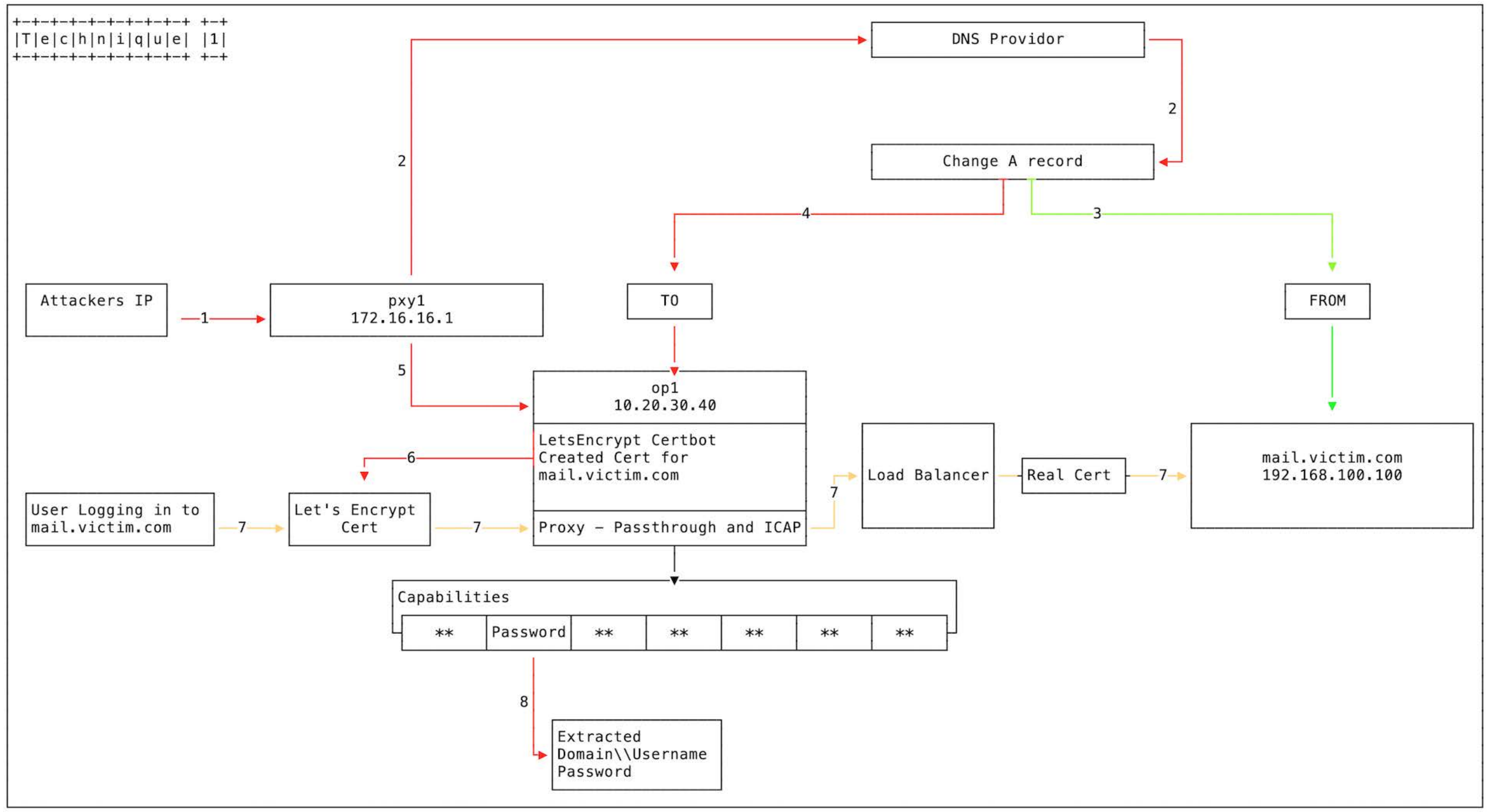


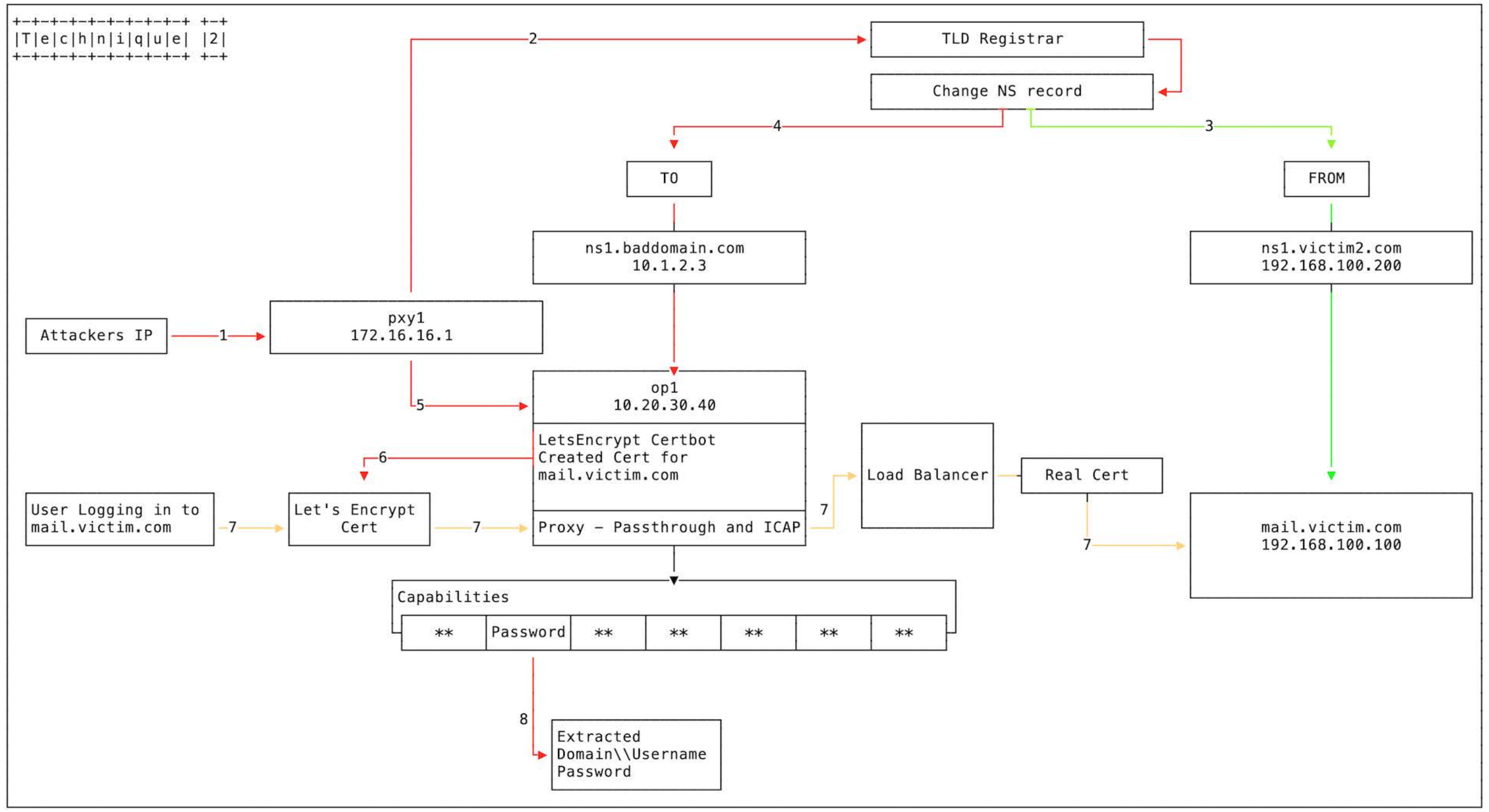

Admin-Certifying Identifier Issuance

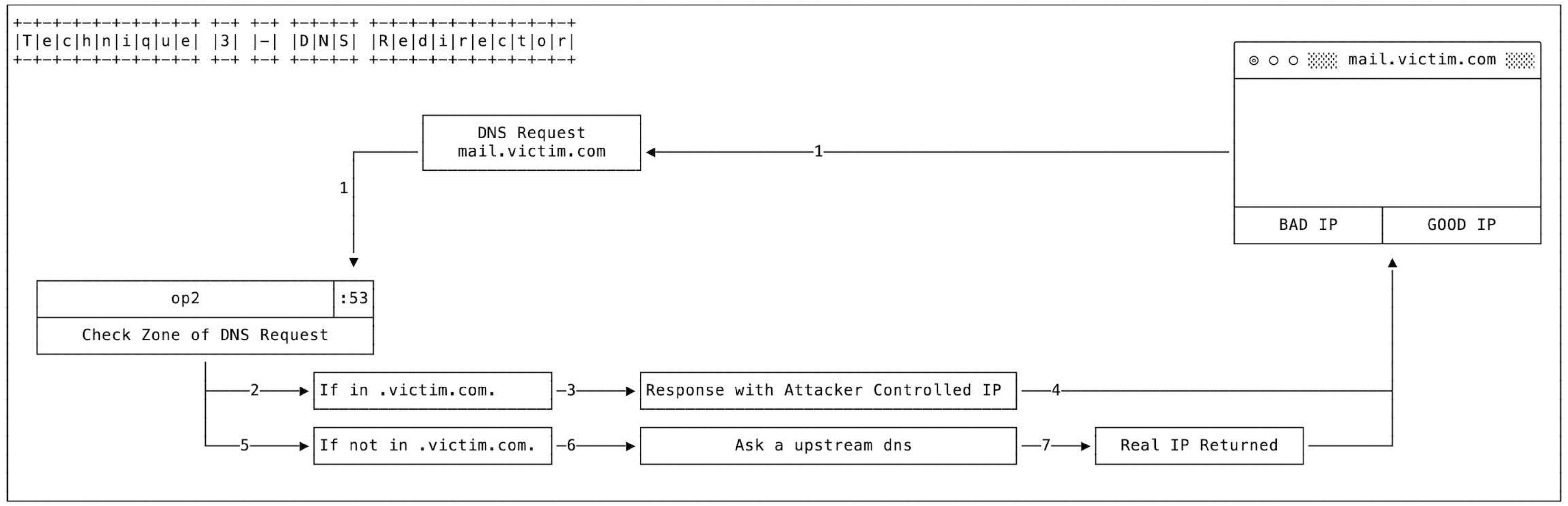
# DNS Hijacking

A DNS hijacking wave is targeting companies at an almost unprecedented scale. Clever trick allows attackers to obtain valid TLS certificate for hijacked domains.

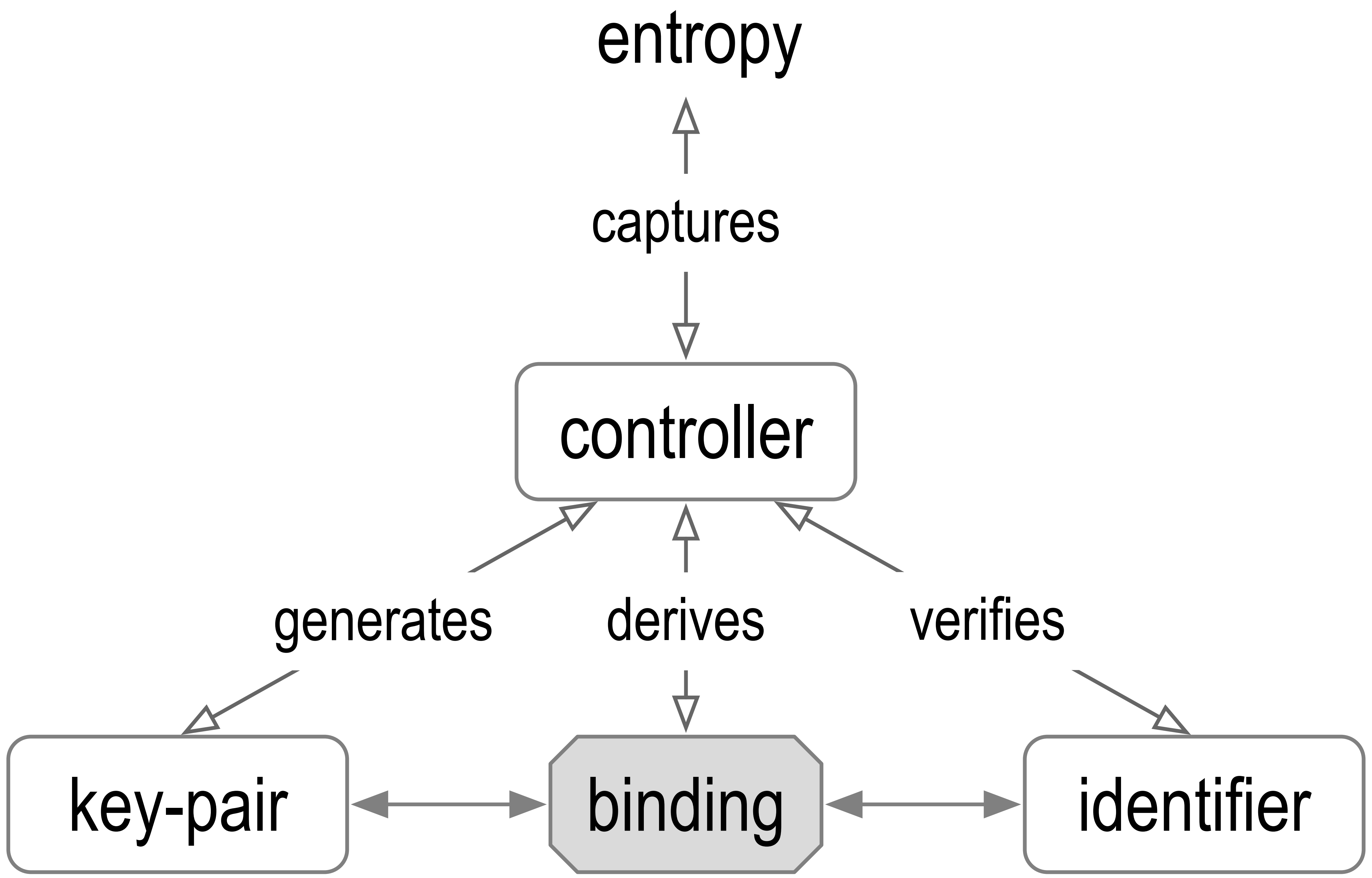
https://arstechnica.com/information-technology/2019/01/a-dns-hijacking-wave-is-targeting-companies-at-an-almost-unprecedented-scale/



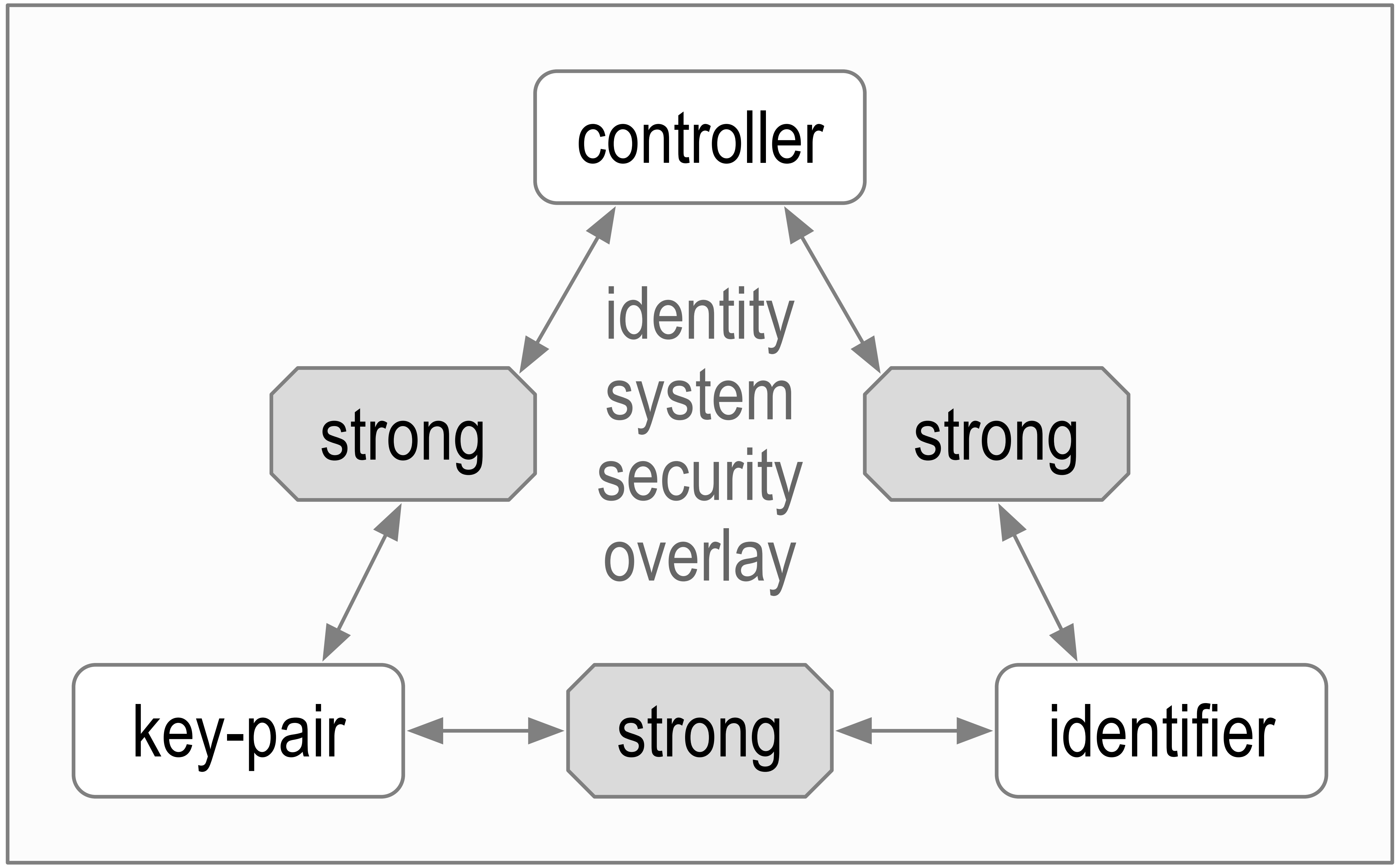



# Self-Certifying Identifier Issuance and Binding

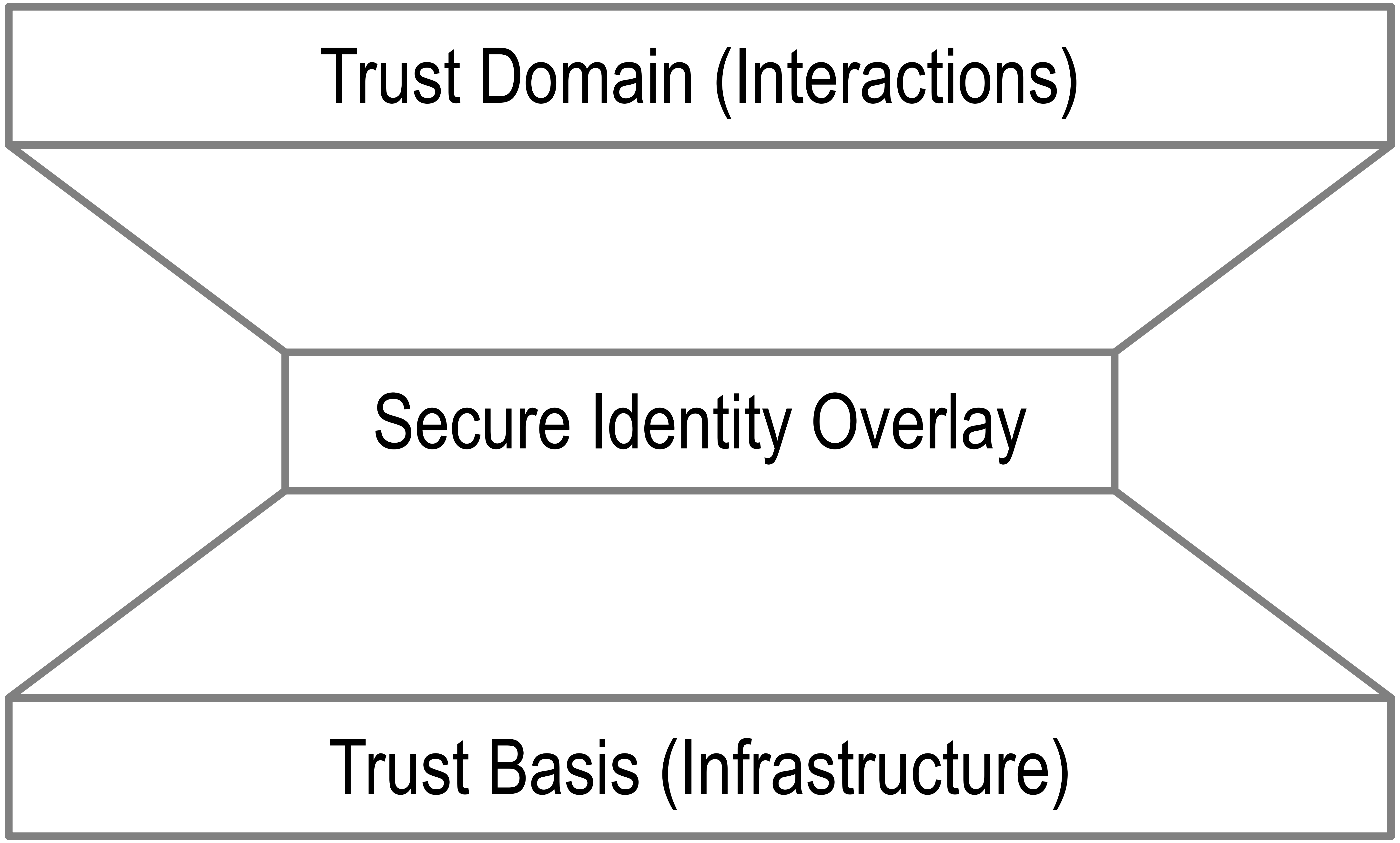



self-certifying

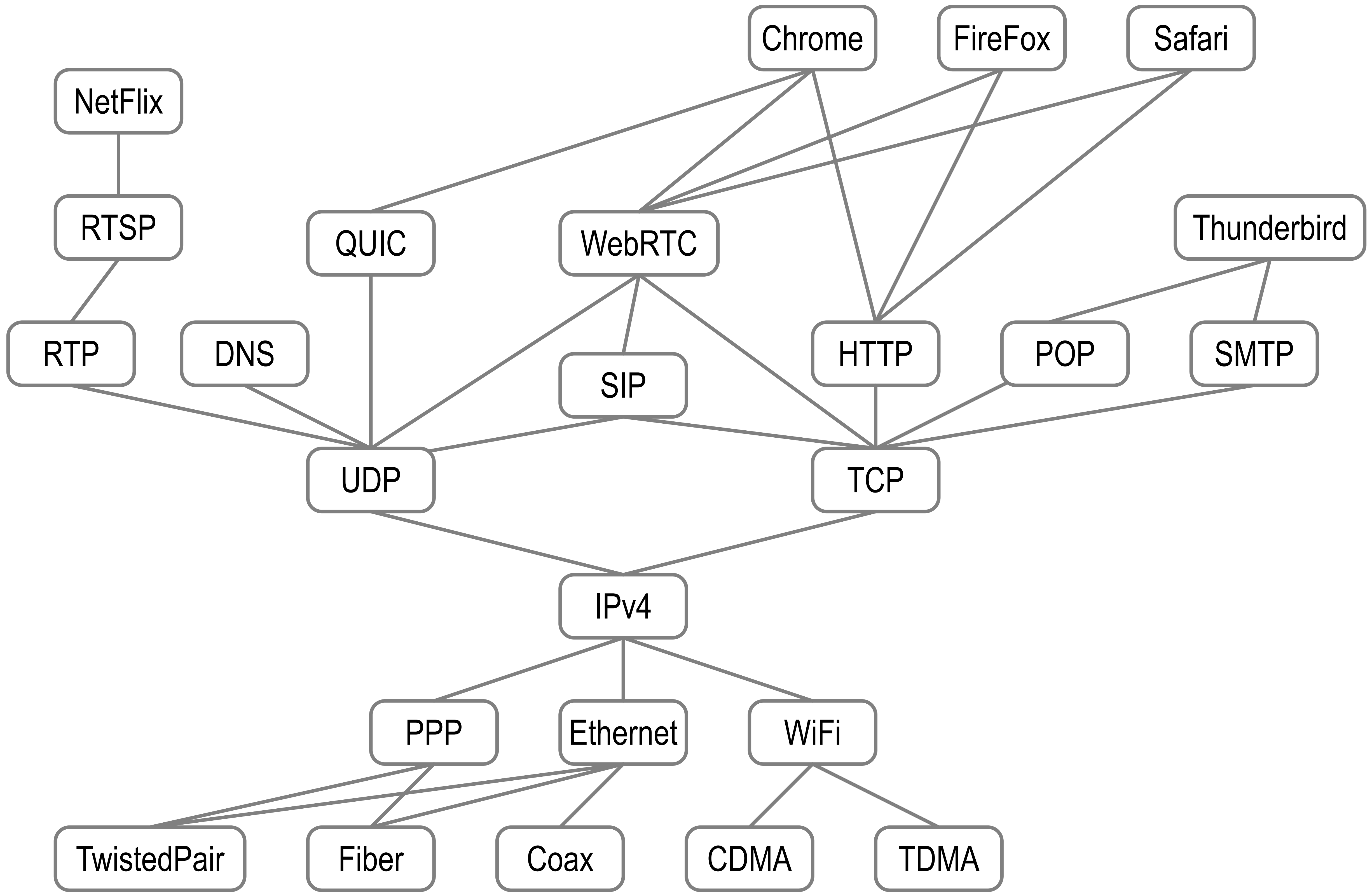


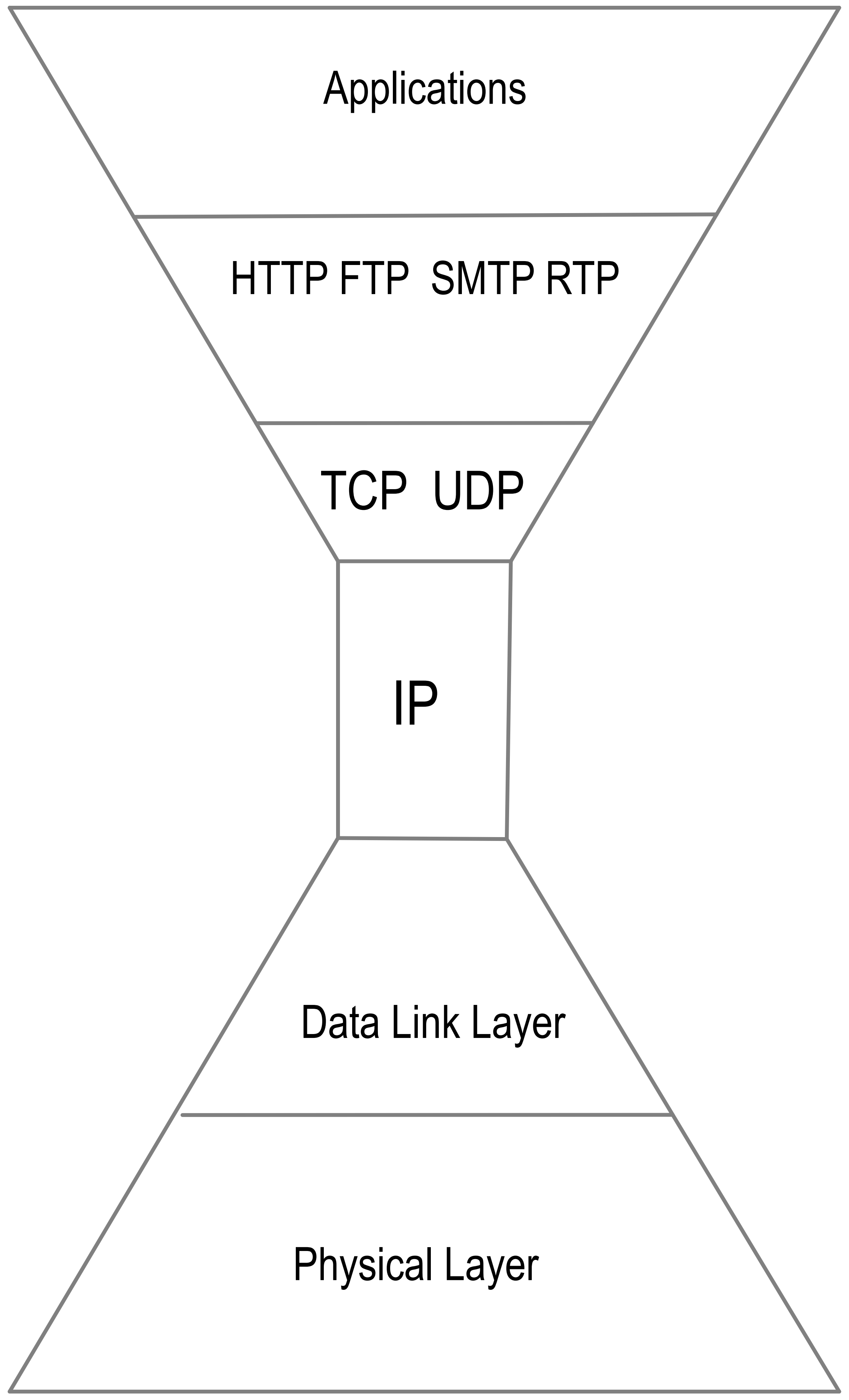

Self-Certifying Identifier Issuance

# Identity System Security Overlay

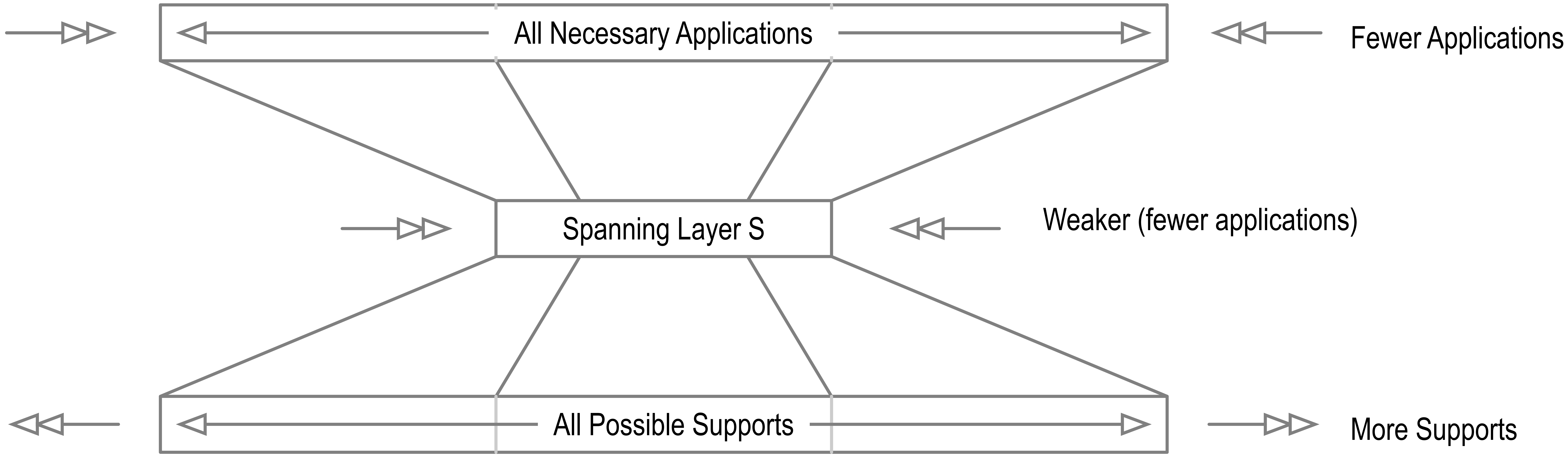


# Spanning Layer

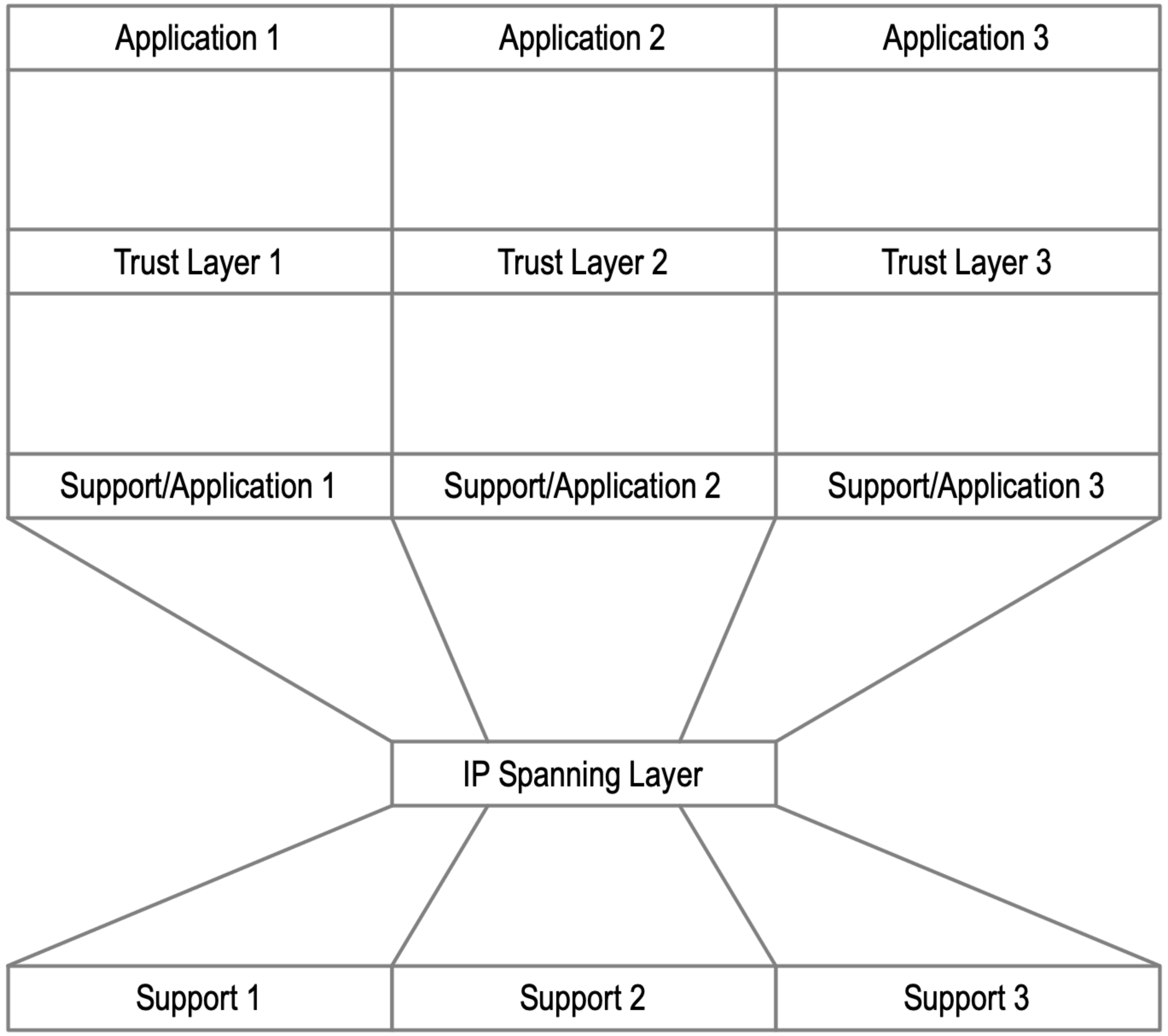


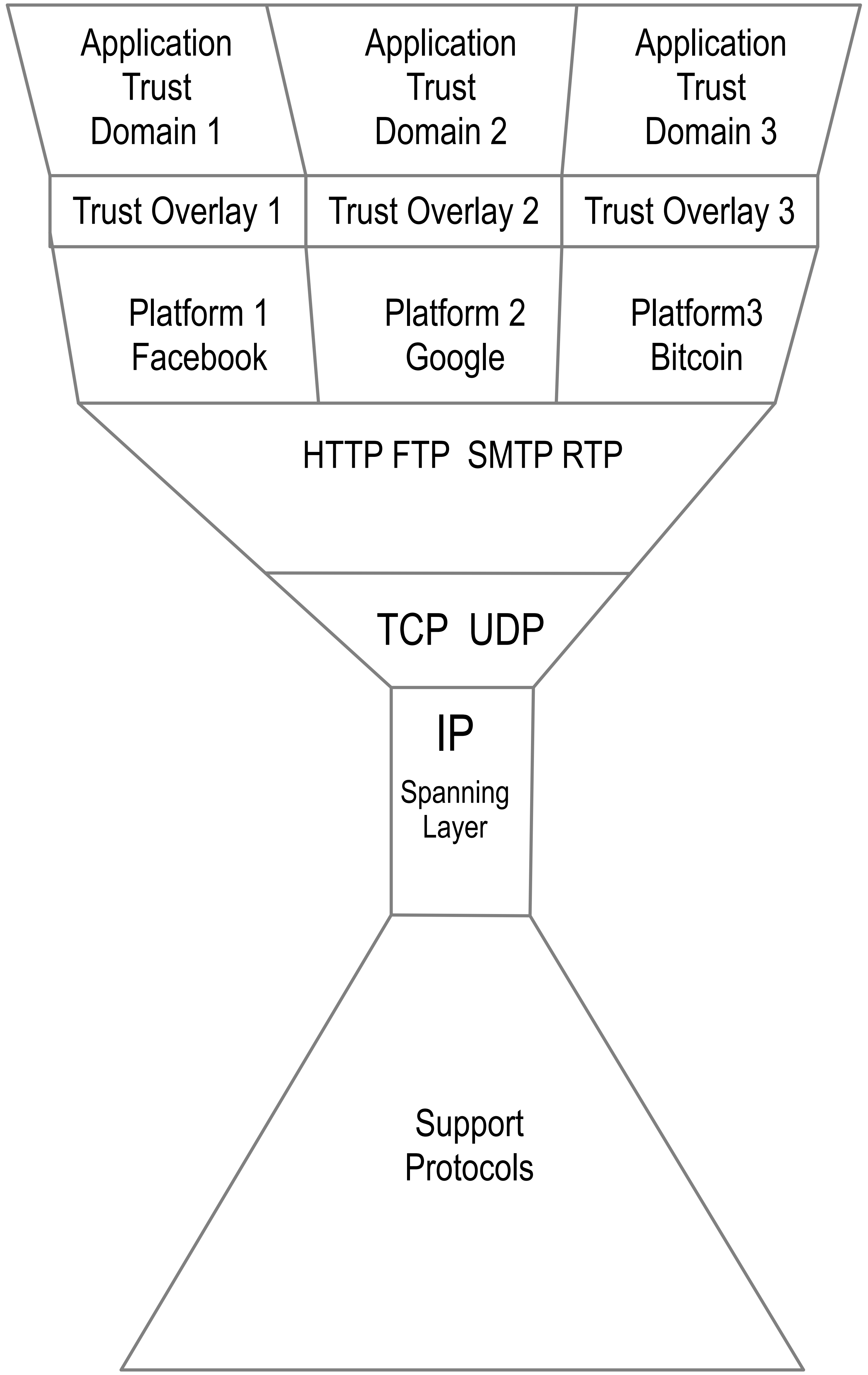
# Hourglass


All Necessary Applications
Fewer Applications
Spanning Layer S
Weaker (fewer applications)
All Possible Supports
More Supports

# Platform Locked Trust

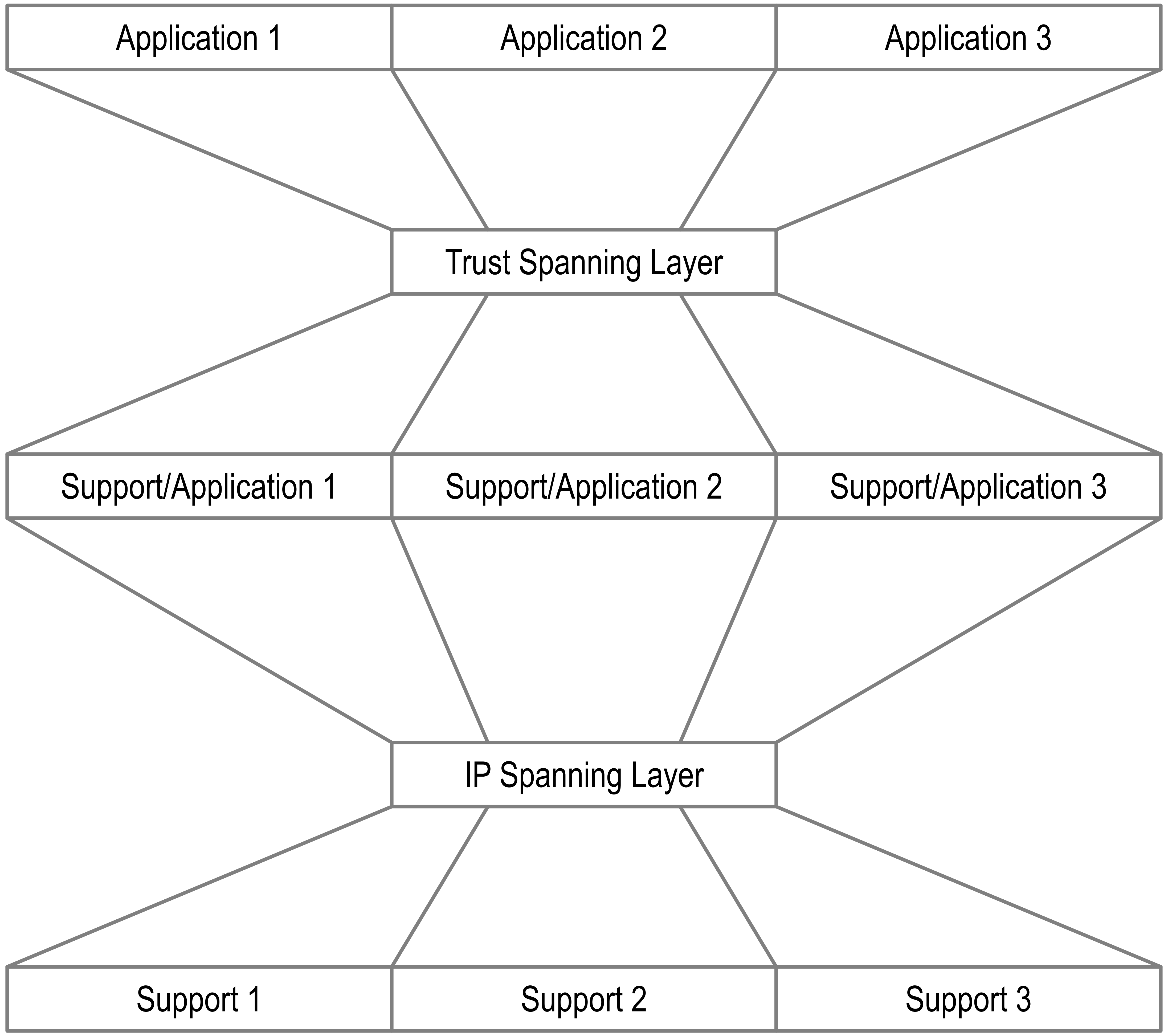


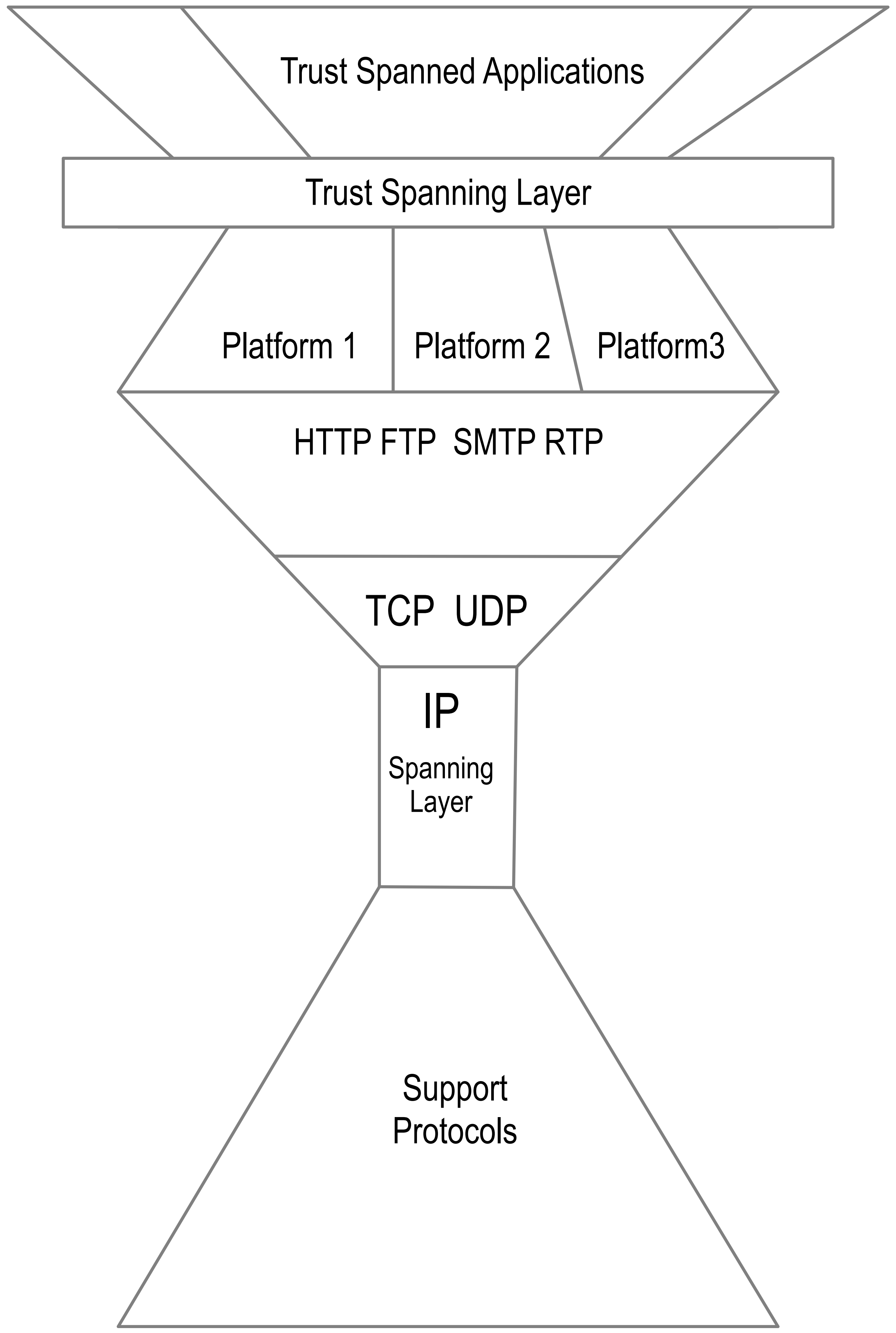

Platform Locked Trust



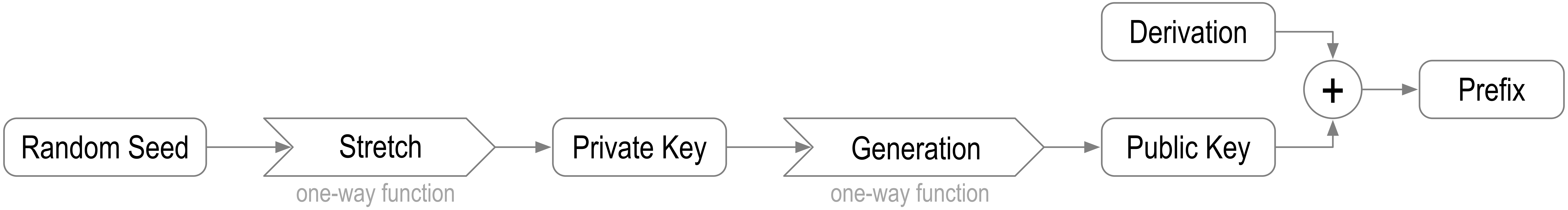

Each trust layer only spans platform specific applications
Bifurcates the internet trust map
No spanning trust layer

# Waist and Neck

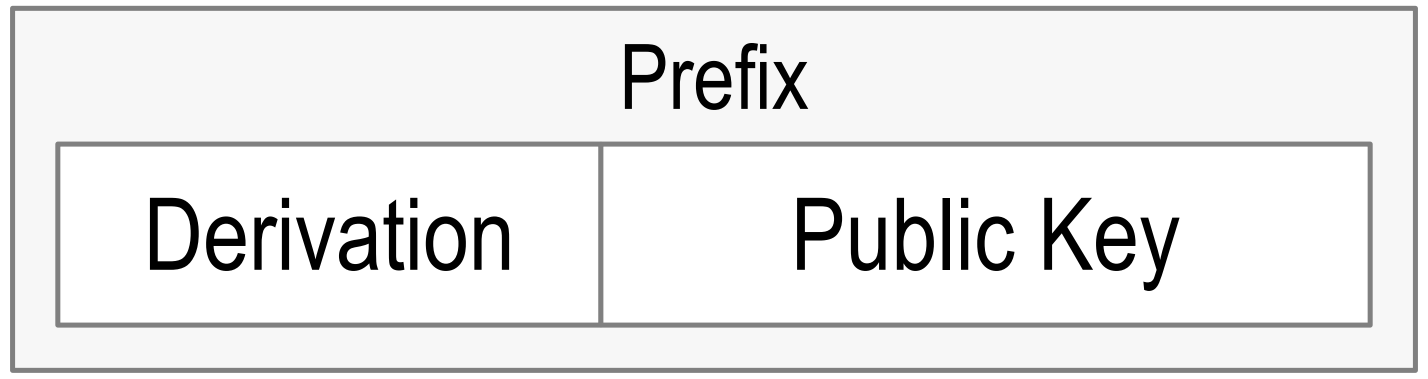


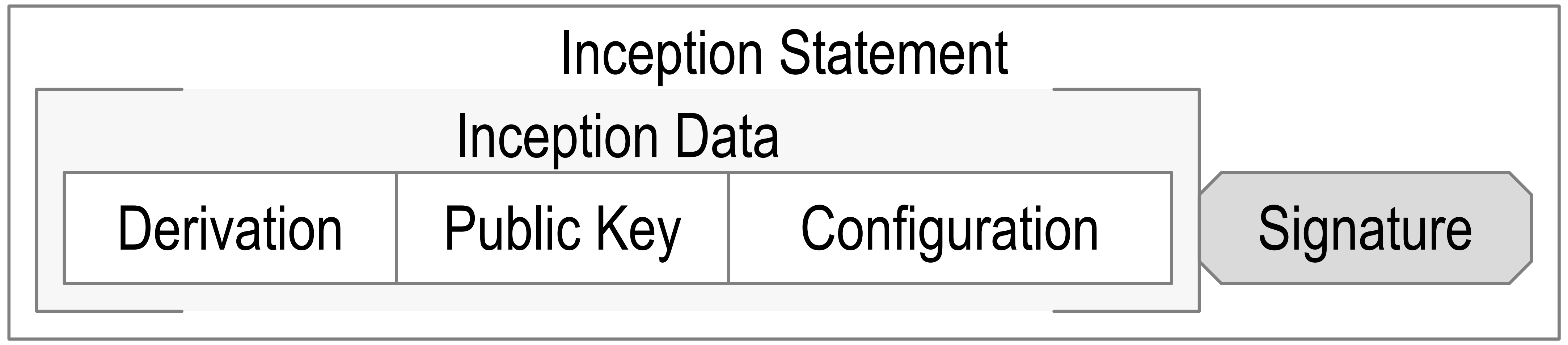
# Basic



Random Seed
Stretch
one-way function
Private Key
Generation
one-way function
Public Key
Derivation
+
Prefix

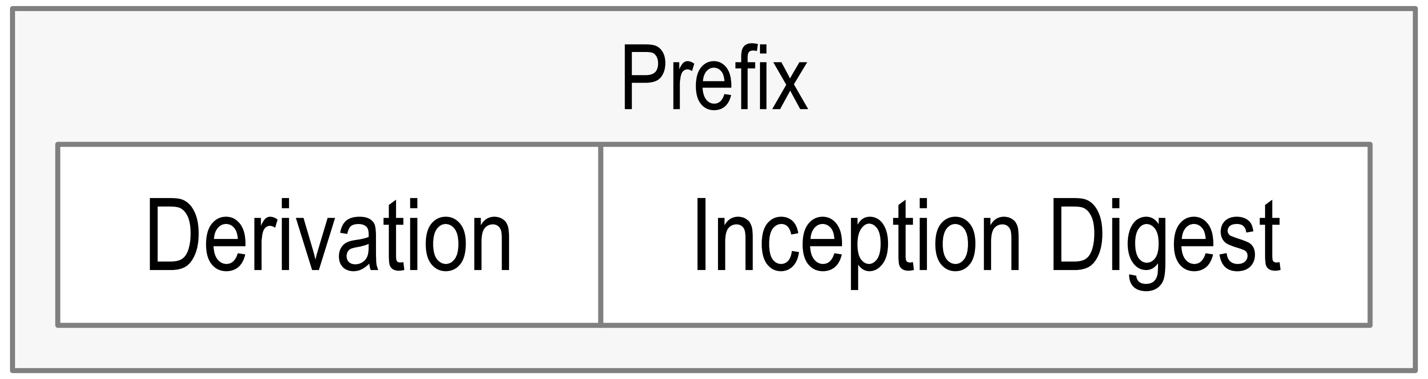



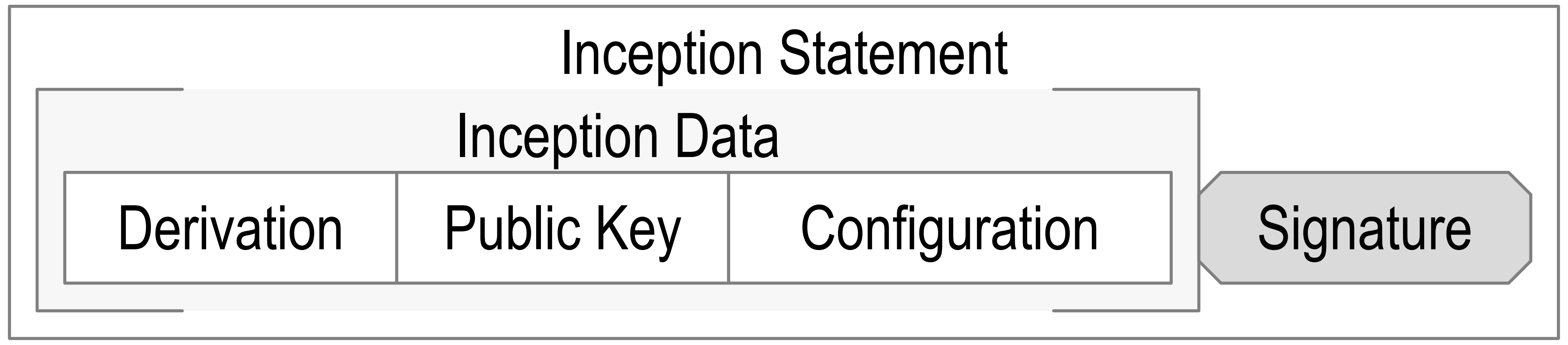
Prefix
Derivation
Public Key

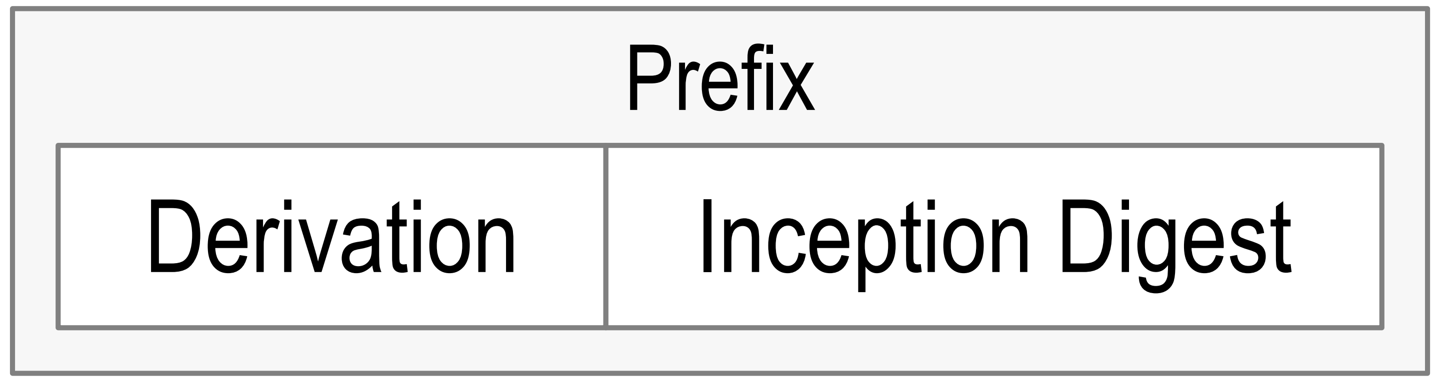
Inception Statement
Inception Data
Derivation
Public Key
Configuration
Signature

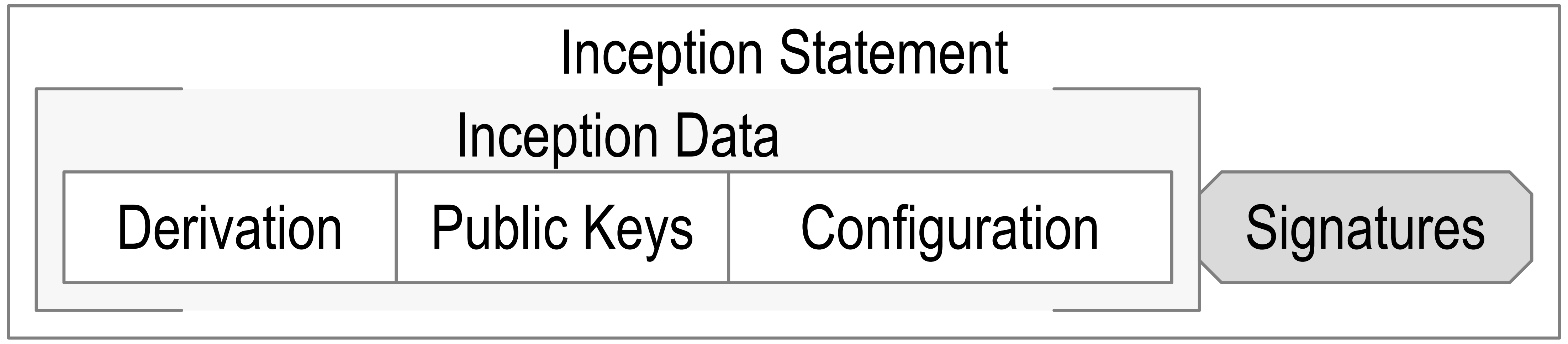
# Self-Addressing

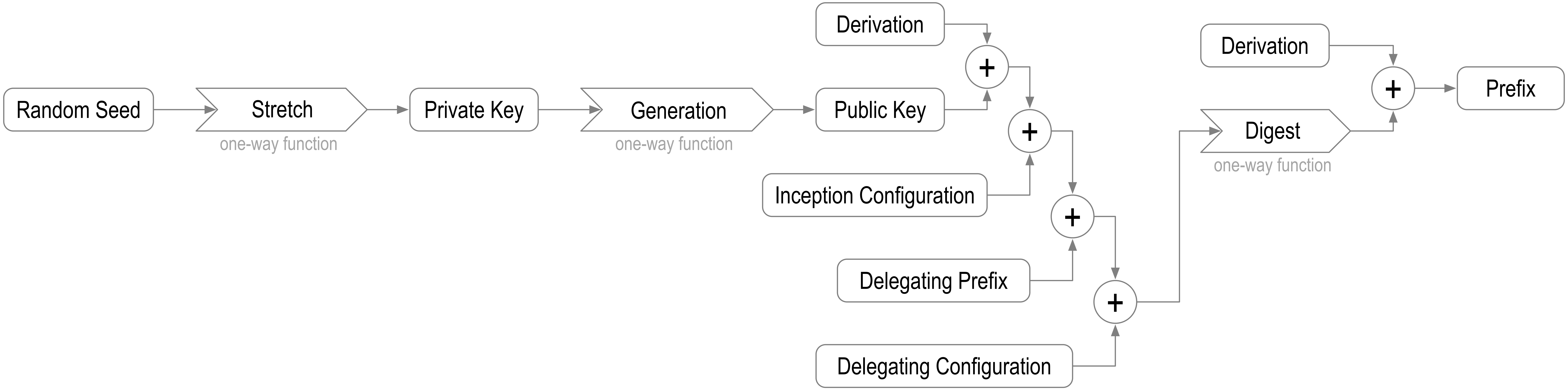



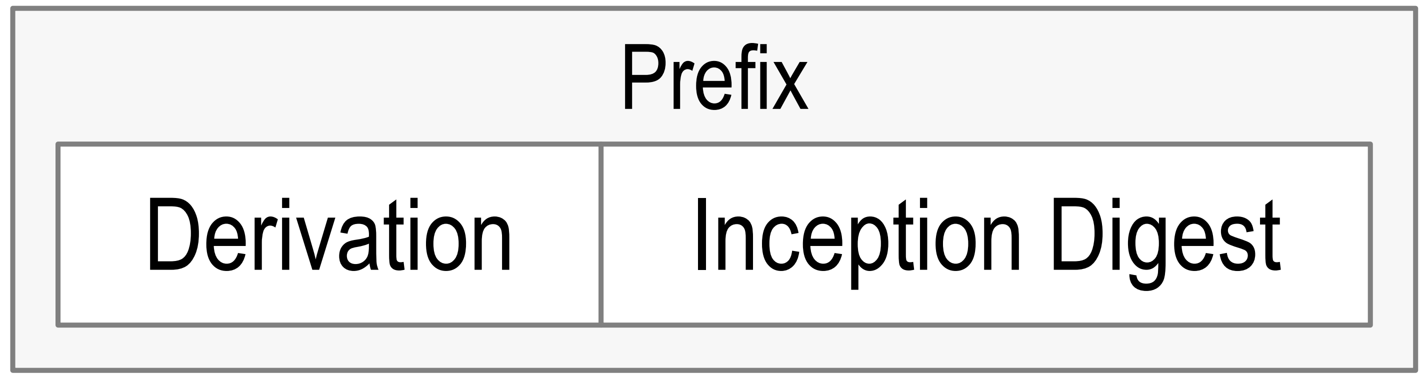
# Multi-Sig Self-Addressing

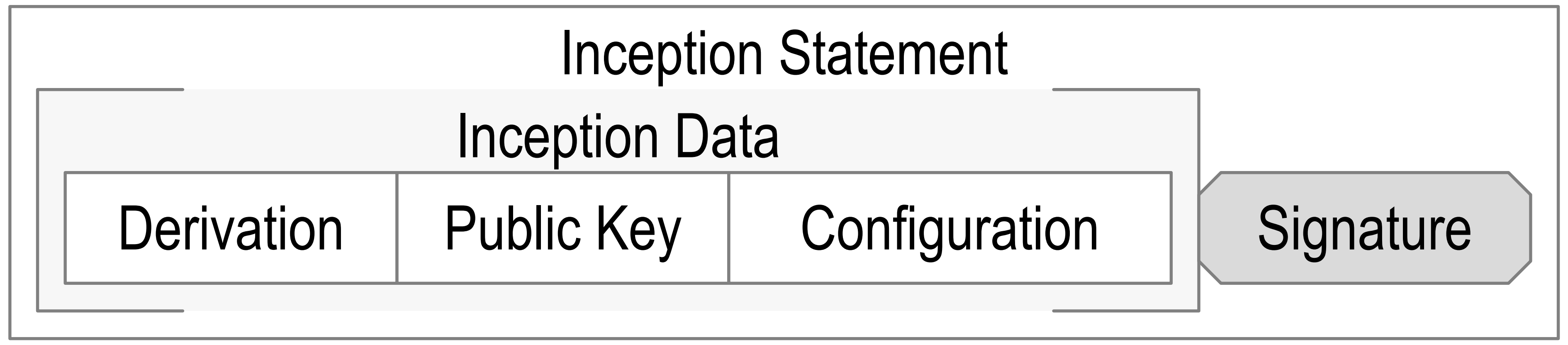



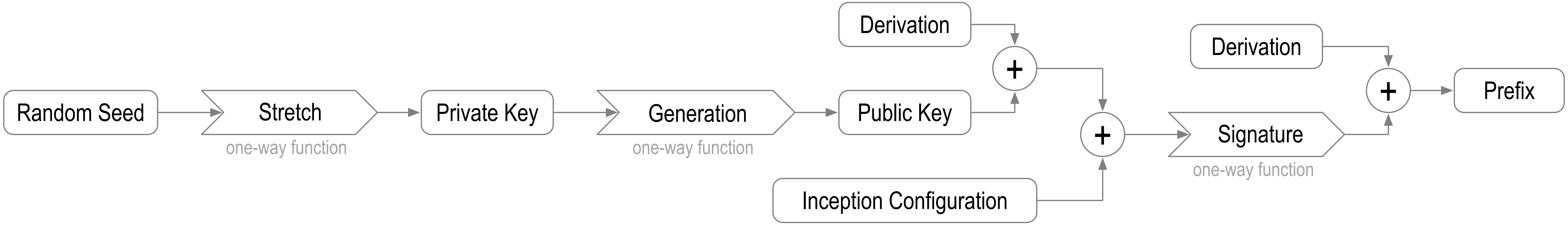
# Delegated Self-Addressing

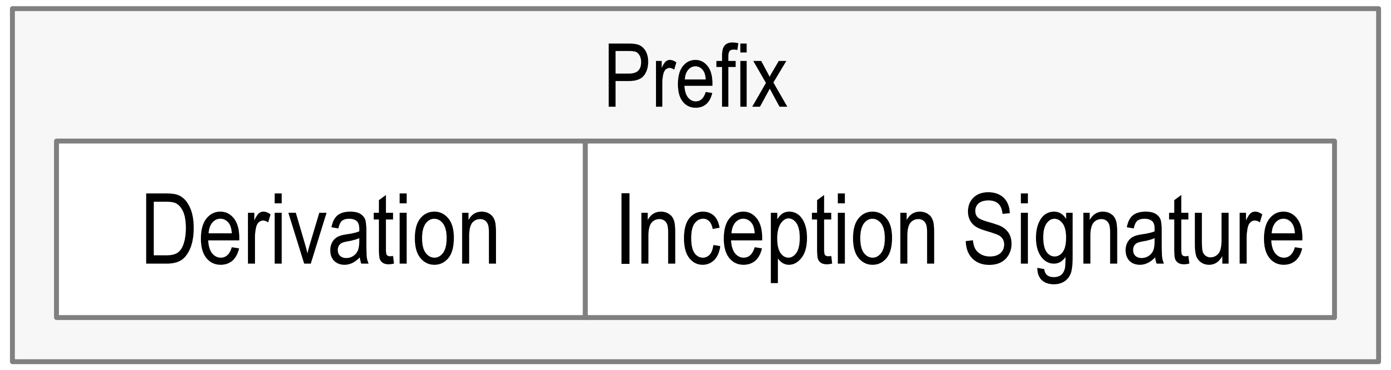


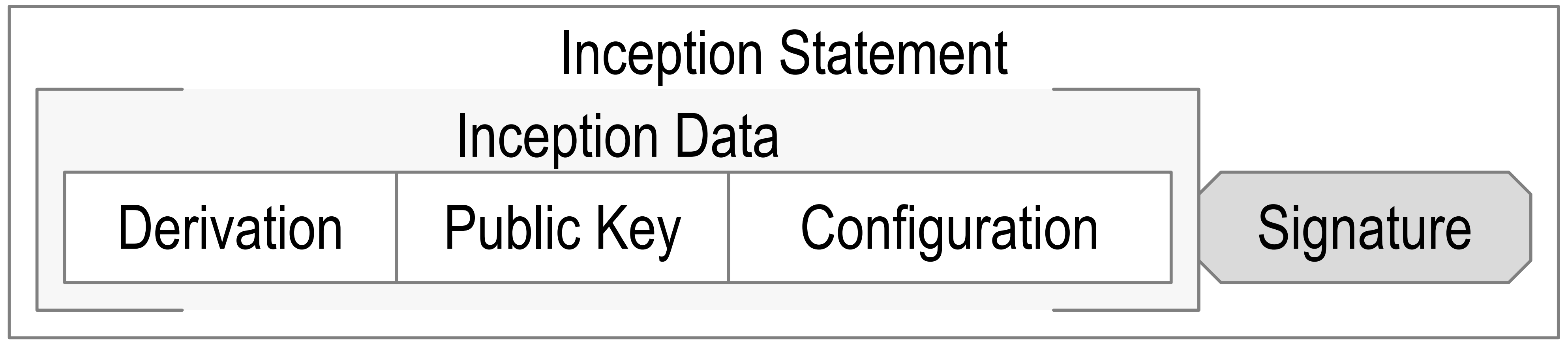



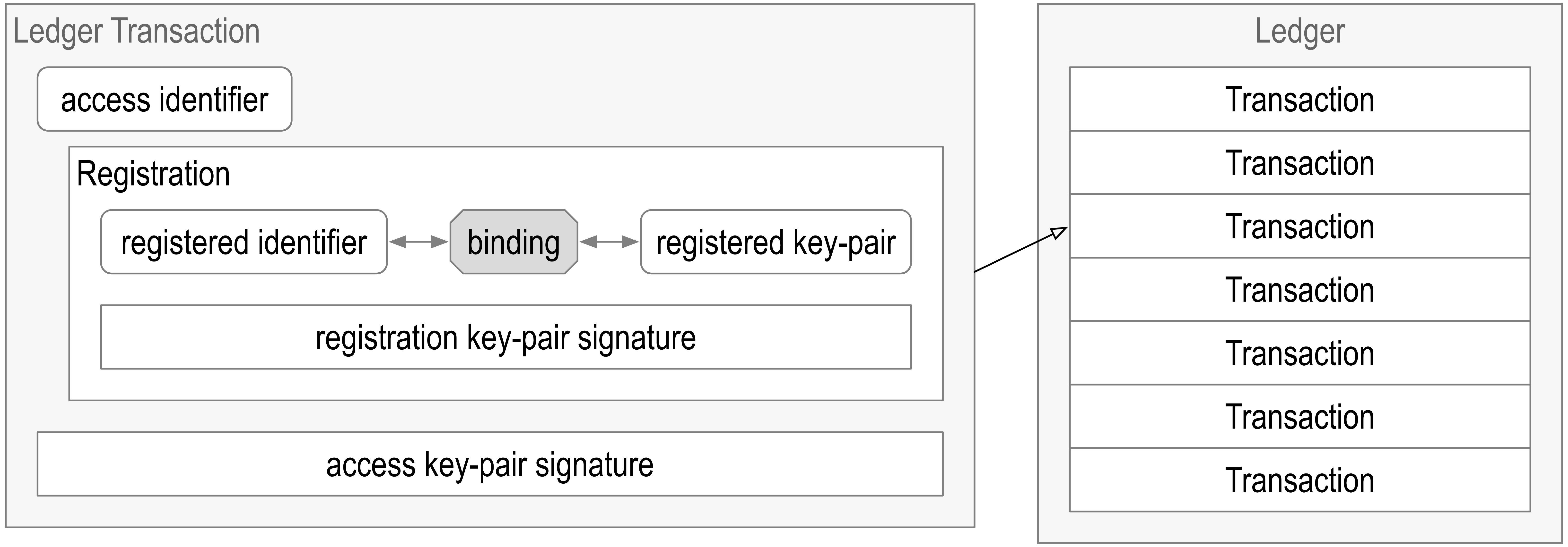
# Self-Signing

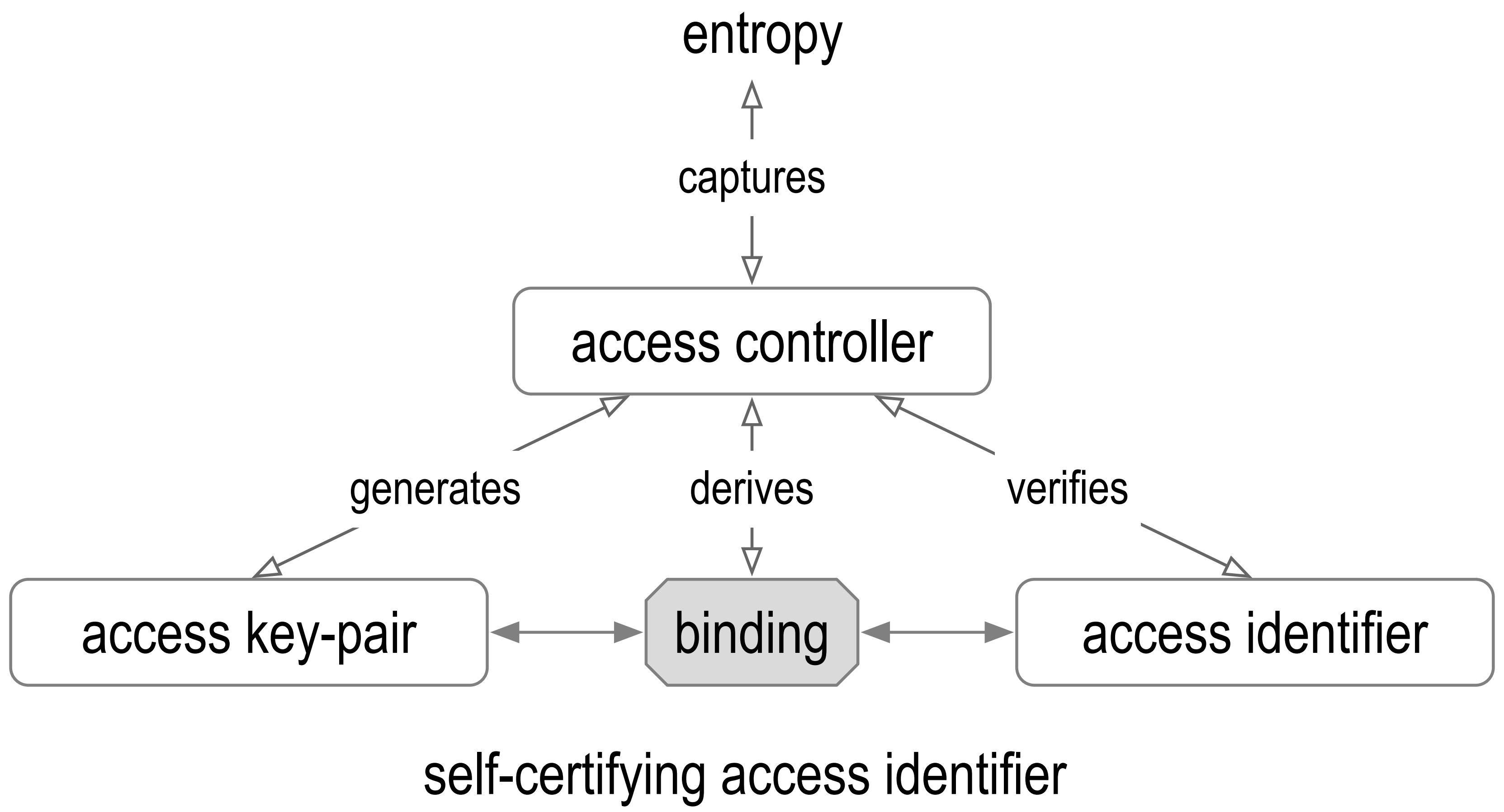


# Ledger Registration




Access identifier may have self-certifying primary root-of-trust
but registered identifier does not, even if its format appears self-certifying.

# Autonomic Identifier (AID) and Namespace (AN)

*auto nomos* = self rule

*autonomic* = self-governing, self-controlling, etc.

An *autonomic* namespace is

*self-certifying* and hence *self-administrating.*

ANs are *portable* = truly self-sovereign.

autonomic prefix = self-cert + UUID + URL = universal identifier

# Autonomic Identity System

*why*, *how* – *who* controls *what*, *when*, and *how*?

## Root-of-Trust

cryptographic autonomic identifier = *why*, *how*

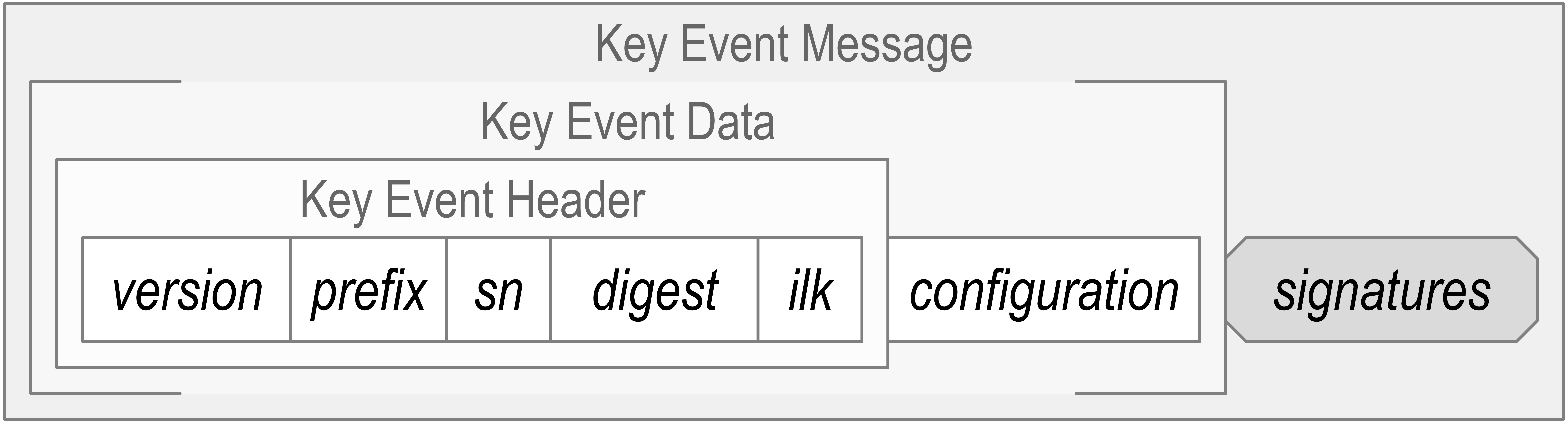
## Source-of-Truth

controller of the private key = *who*

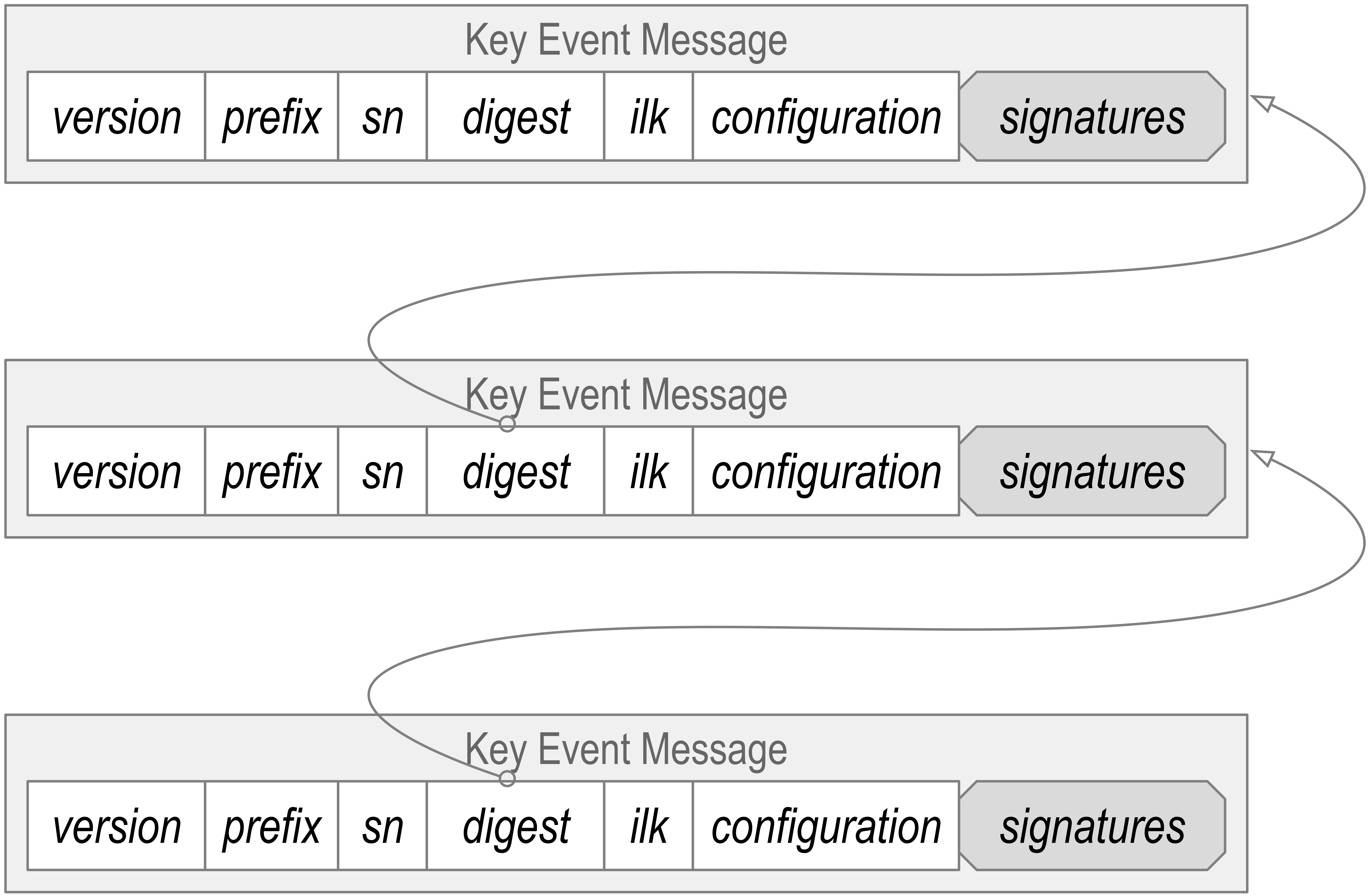
## Loci-of-Control

authoritative operation = *what*, *when*, *how*

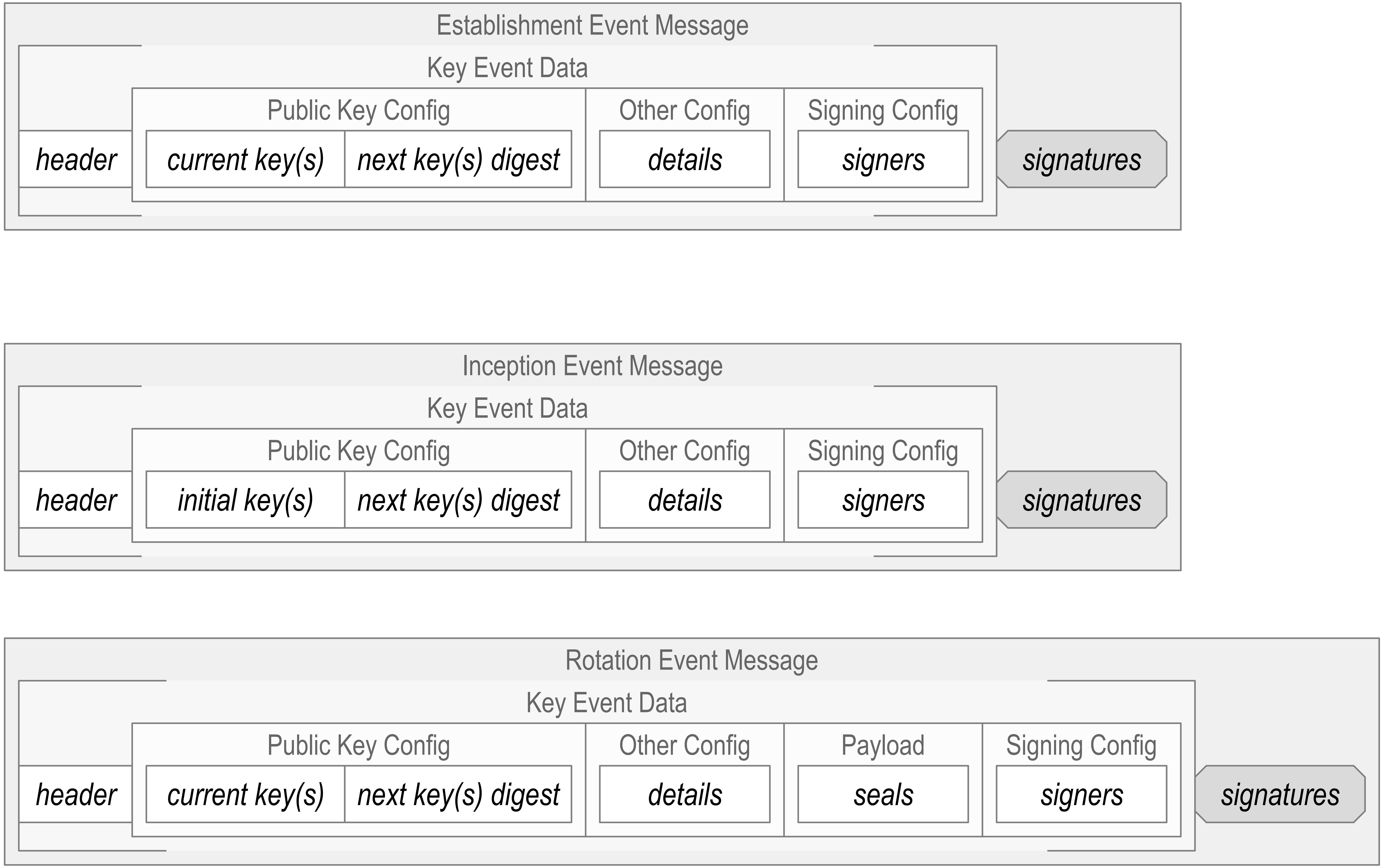
# Key Event Message

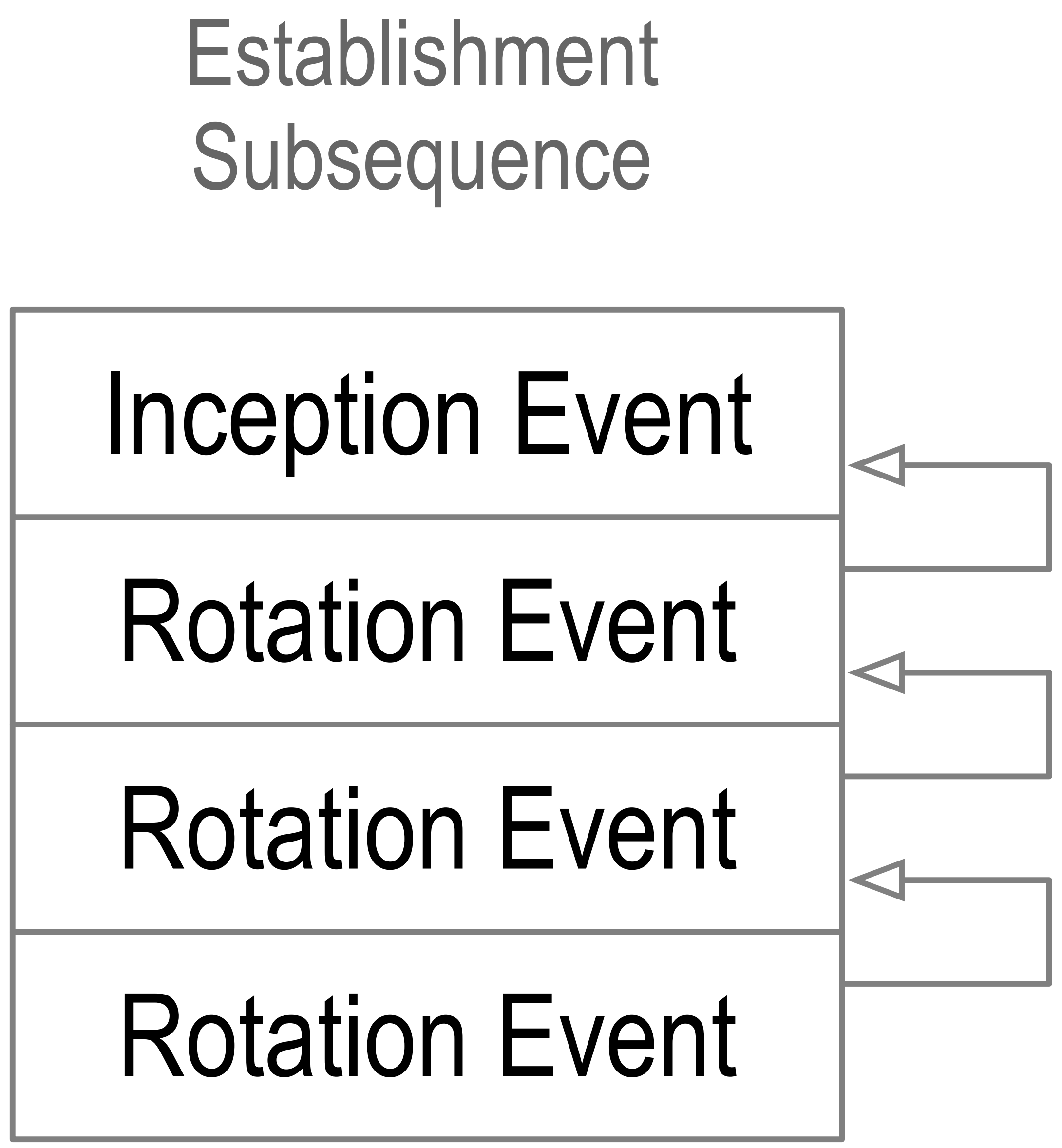



# Event Digest Chaining

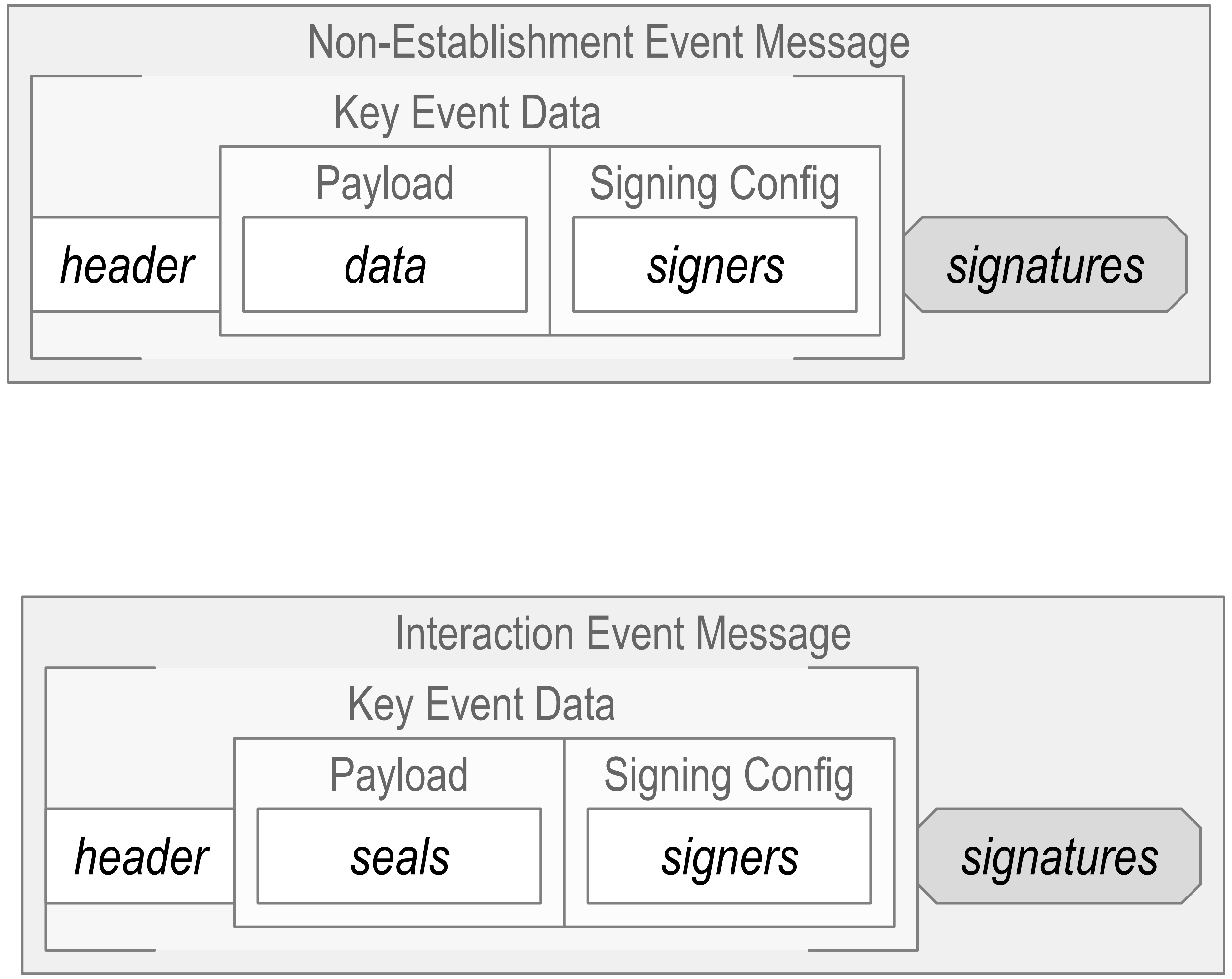


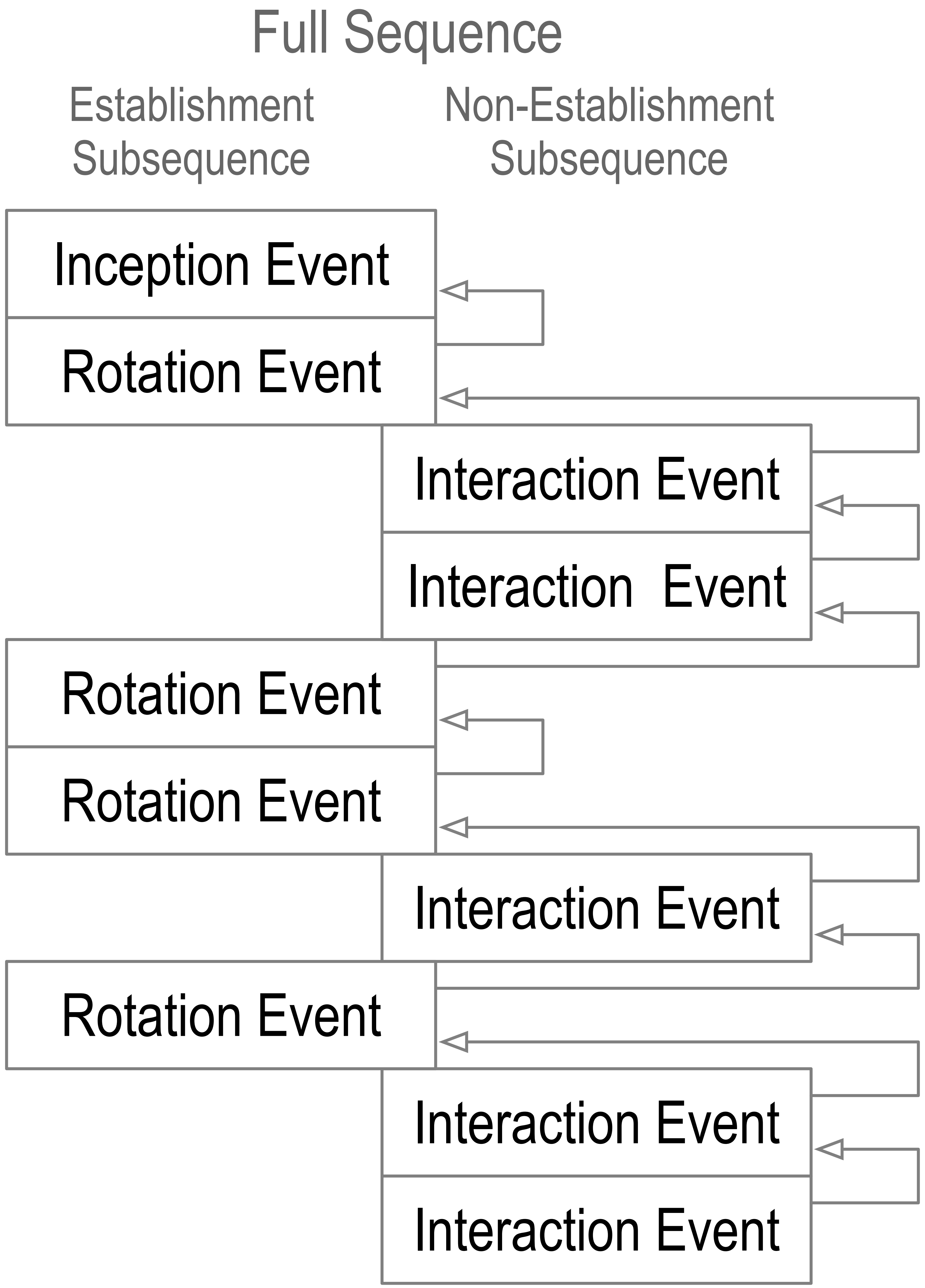
# Establishment Events



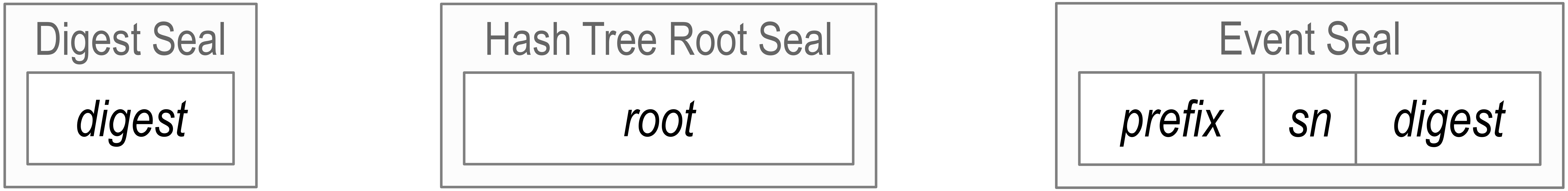
# Non-Establishment Events



# Seal (Anchor)

*seal* provides *evidence of authenticity*




A *seal* anchors arbitrary data to an event in the key event sequence thereby providing proof of control authority for that data at the location of the anchoring event.

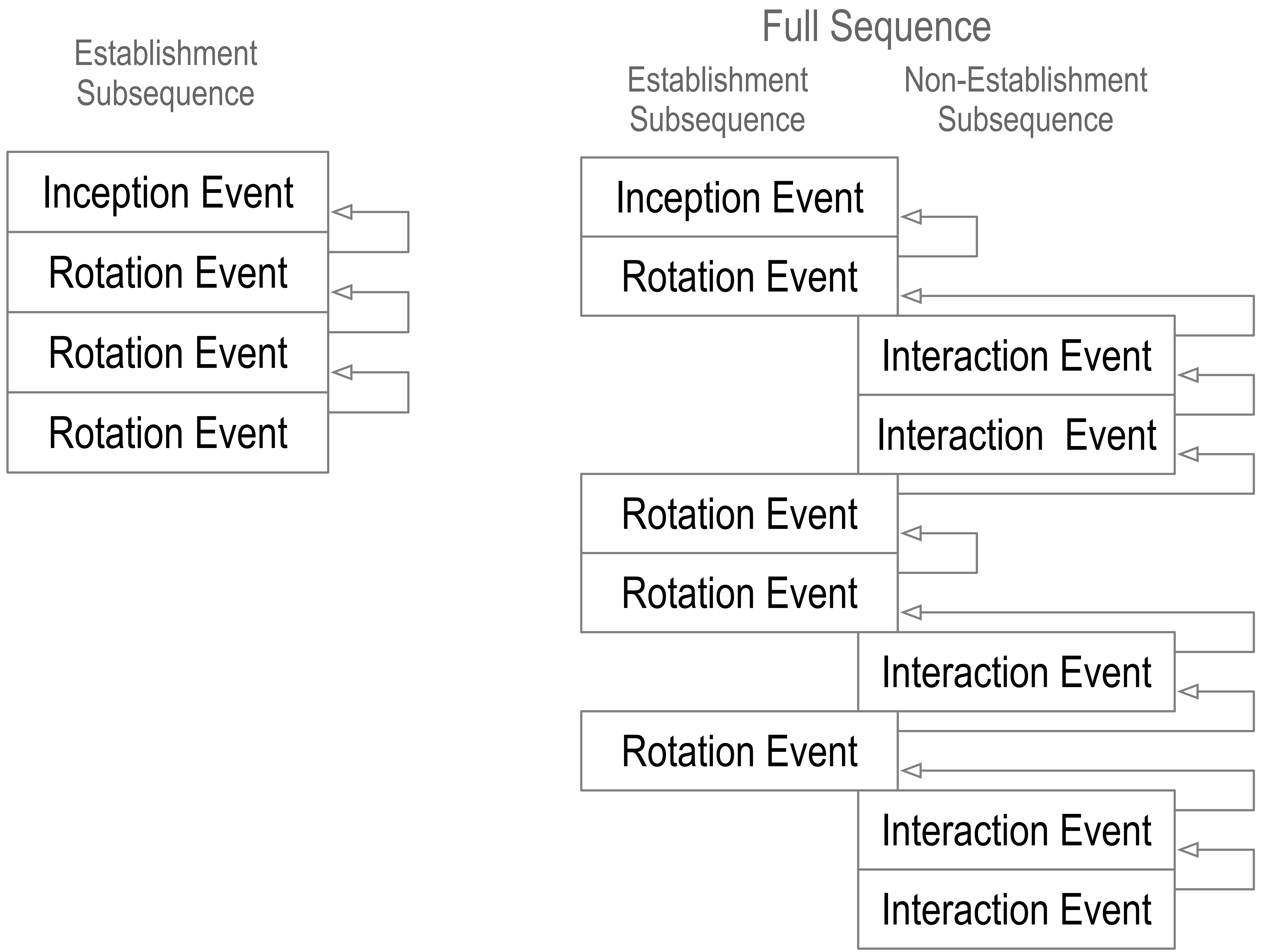
*Seals* make KERI both privacy preserving and *data semantic agnostic.*

*Context independent extensibility* via externally layered APIs for anchored data instead ofcontext dependent extensibility via internal linked data or tag registries.

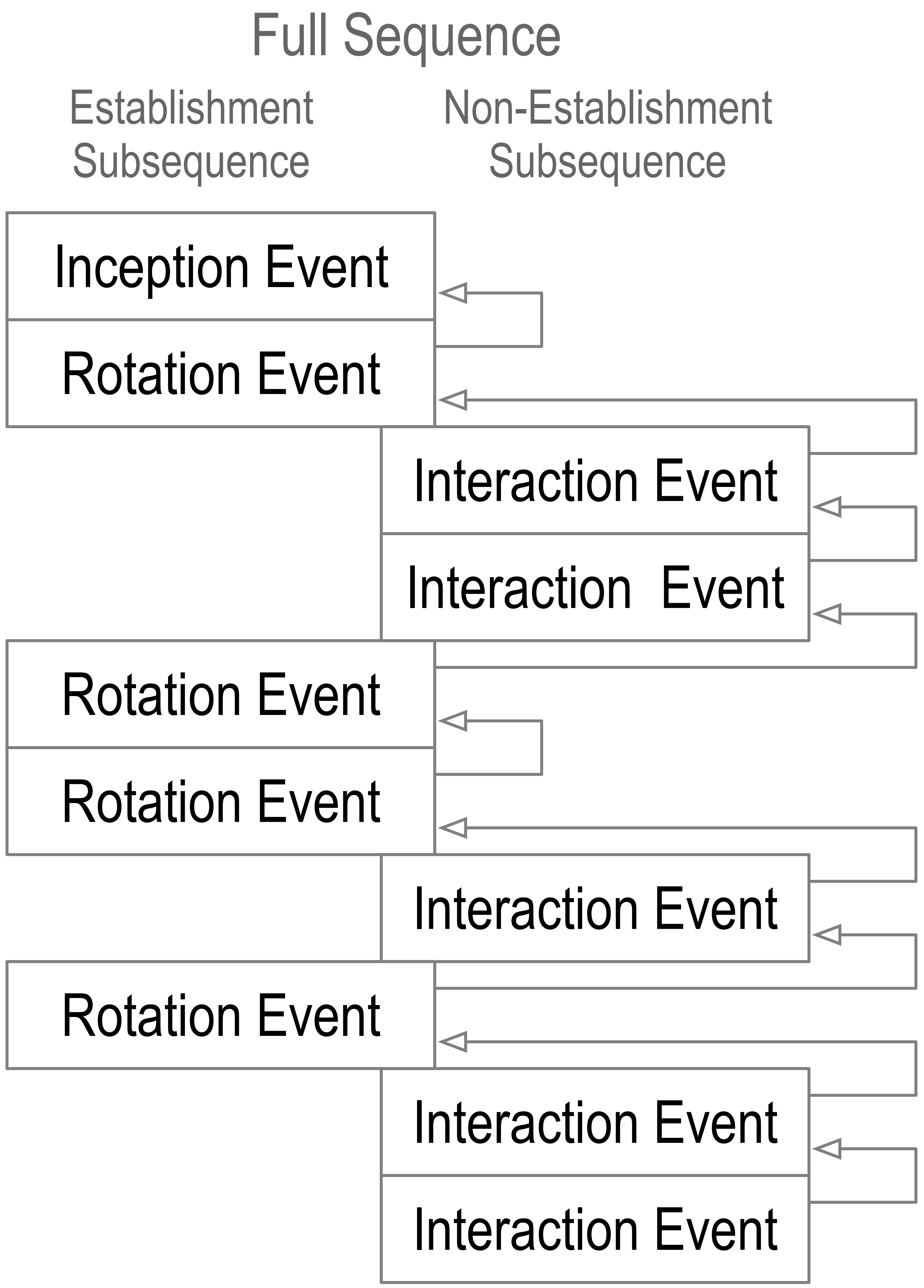
Interoperability is total w.r.t. establishment of control authority.

Minimally sufficient means.

# Event Sequencing



# Inconsistency and Duplicity




## Inconsistency vs. Duplicity

*inconsistency*: lacking agreement, as two or more things in relation to each other

*duplicity*: acting in two different ways to different people concerning the same matter

## Internal  vs. External Inconsistency

Internally inconsistent log = not verifiable.

Log verification from self-certifying root-of-trust protects against internal inconsistency.

Externally inconsistent log with a purported copy of log but both verifiable = duplicitous.

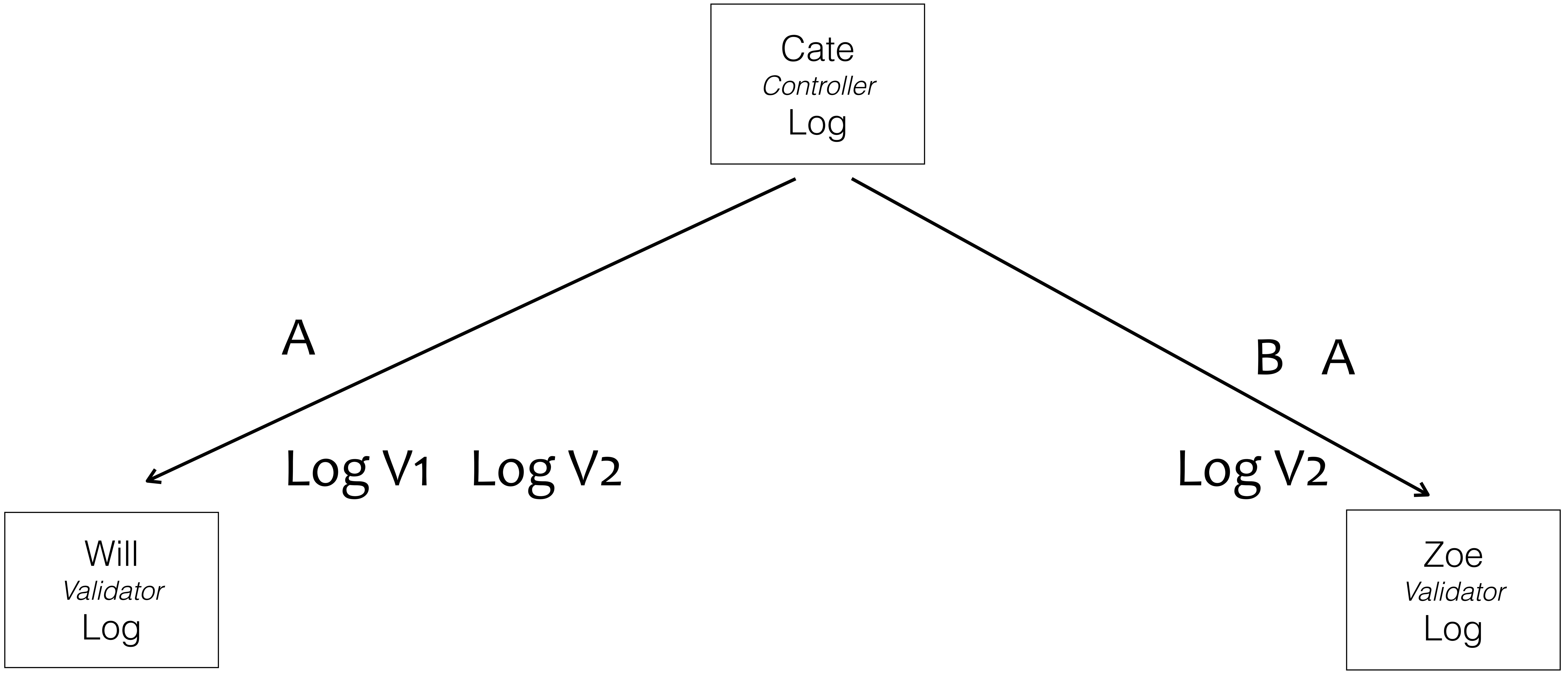
Duplicity detection protects against external inconsistency.

# Duplicity Game

Cate promises to provide a consistent pair-wise log.

*Local Consistency Guarantee*

*How may Cate be duplicitous and not get caught?*



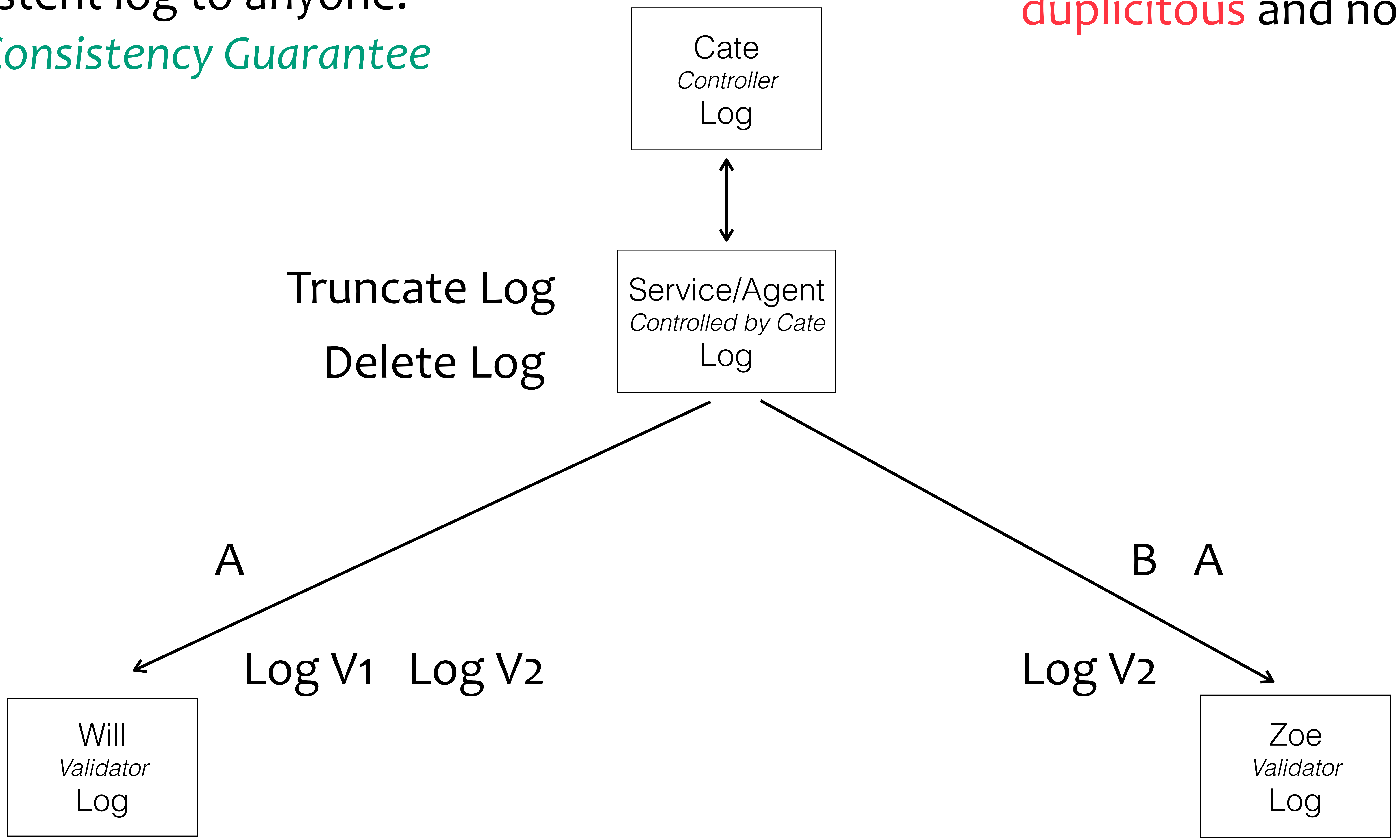

private (one-to-one) interactions

# Duplicity Game

Service promises to provide a consistent log to anyone.

*Local Consistency Guarantee*

How may Cate/Service/Agent be duplicitous and not get caught?




highly available, private (one-to-one) interactions

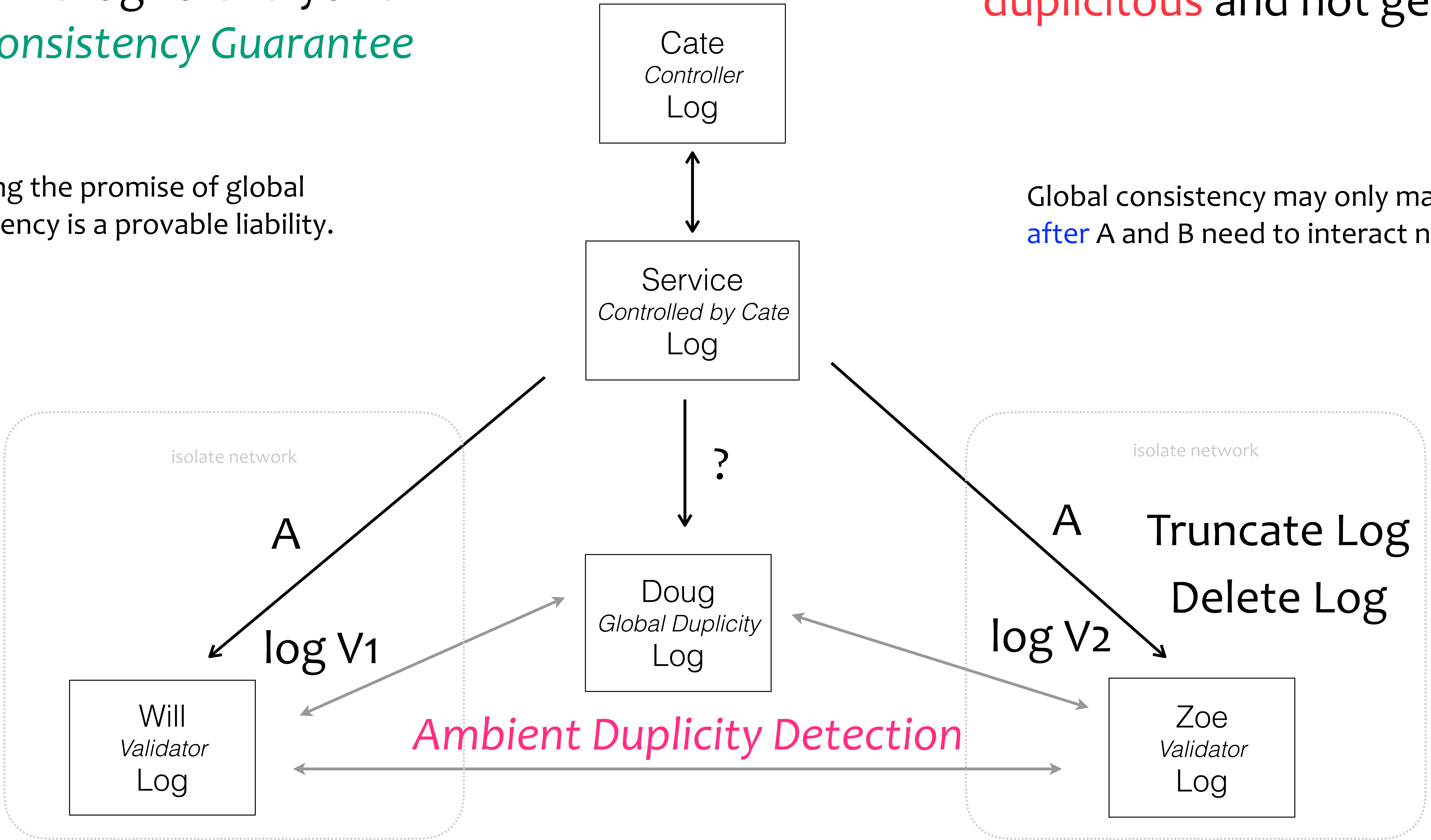
# Duplicity Game

Service promises to provide exact same log to everyone.
*Global Consistency Guarantee*

How may Cate and/or service be duplicitous and not get caught?

Breaking the promise of global consistency is a provable liability.

Global consistency may only matter after A and B need to interact not before.




global consistent, highly available, and public (one-to-any) interactions

# KEY Event Based Provenance of Identifiers

KERI enables cryptographic *proof-of-control-authority* (*provenance*) for each identifier.

A *proof* is in the form of an identifier's *key event receipt log* (KERL).

KERLs are *End Verifiable*:

End user alone may verify. Zero trust in intervening infrastructure.

KERLs may be *Ambient Verifiable*:

*Anyone* may verify *anylog*, *anywhere*, at *anytime*.

KERI = self-cert root-of-trust + certificate transparency + KA$^2$CE + recoverable + post-quantum.

# KERI for the DIDified

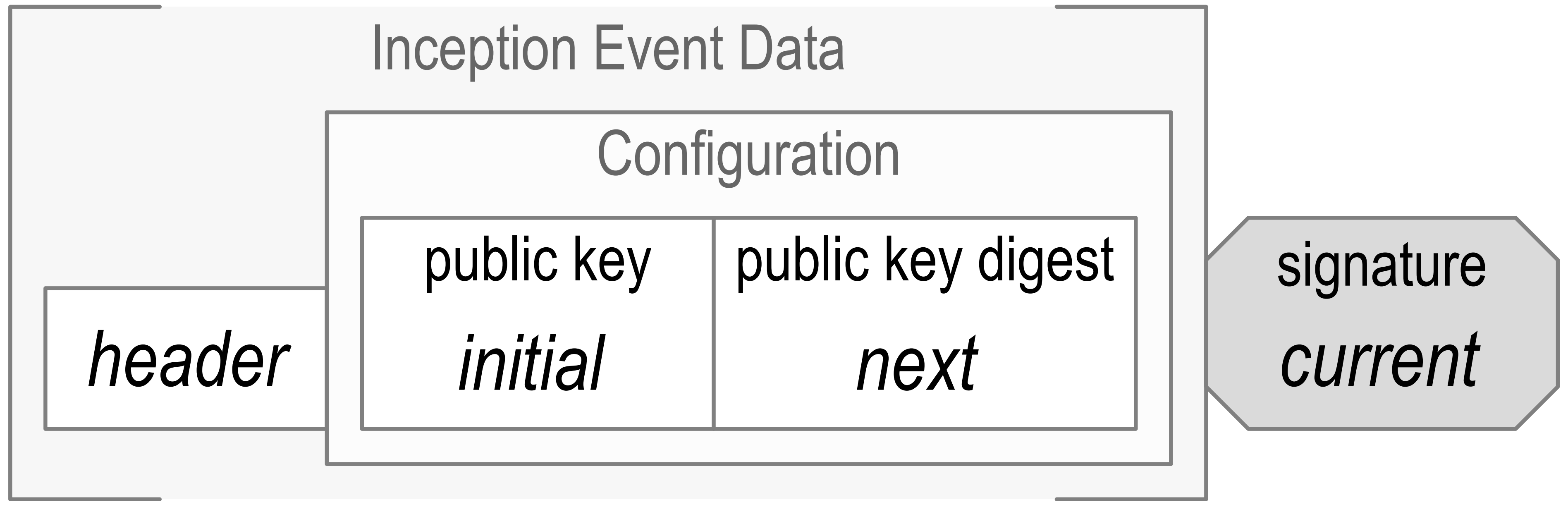
KERI non-transferable ephemeral with derivation prefix ~ did:key

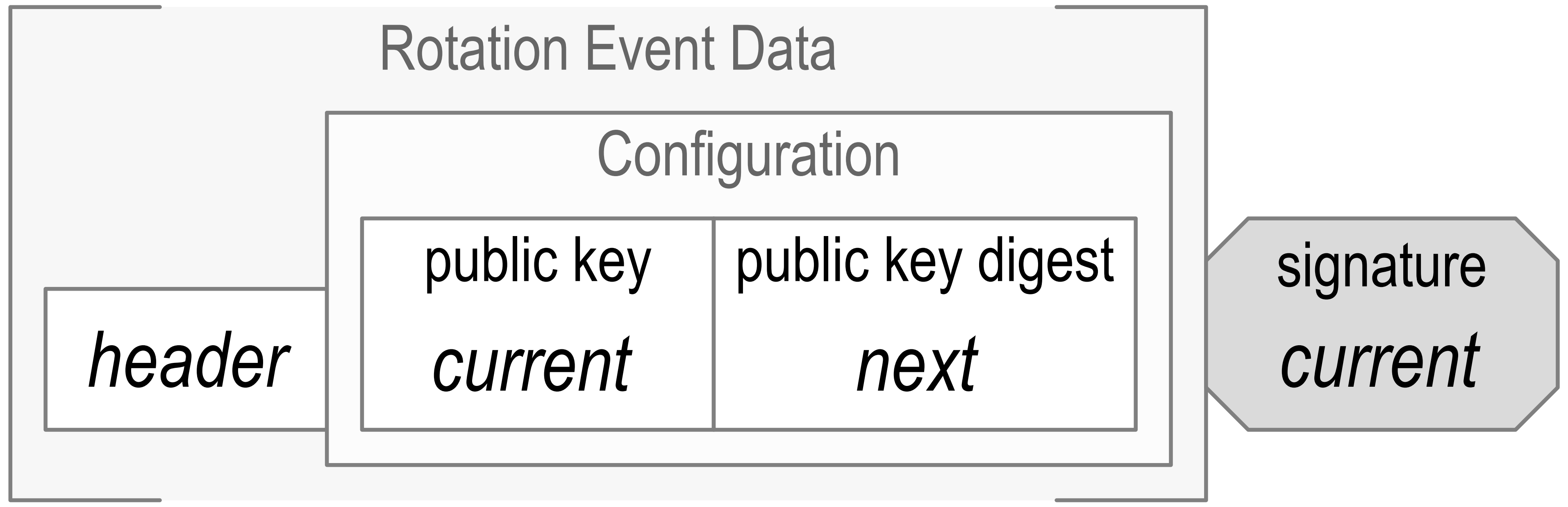
KERI private direct mode (one-to-one) ~ did:peer

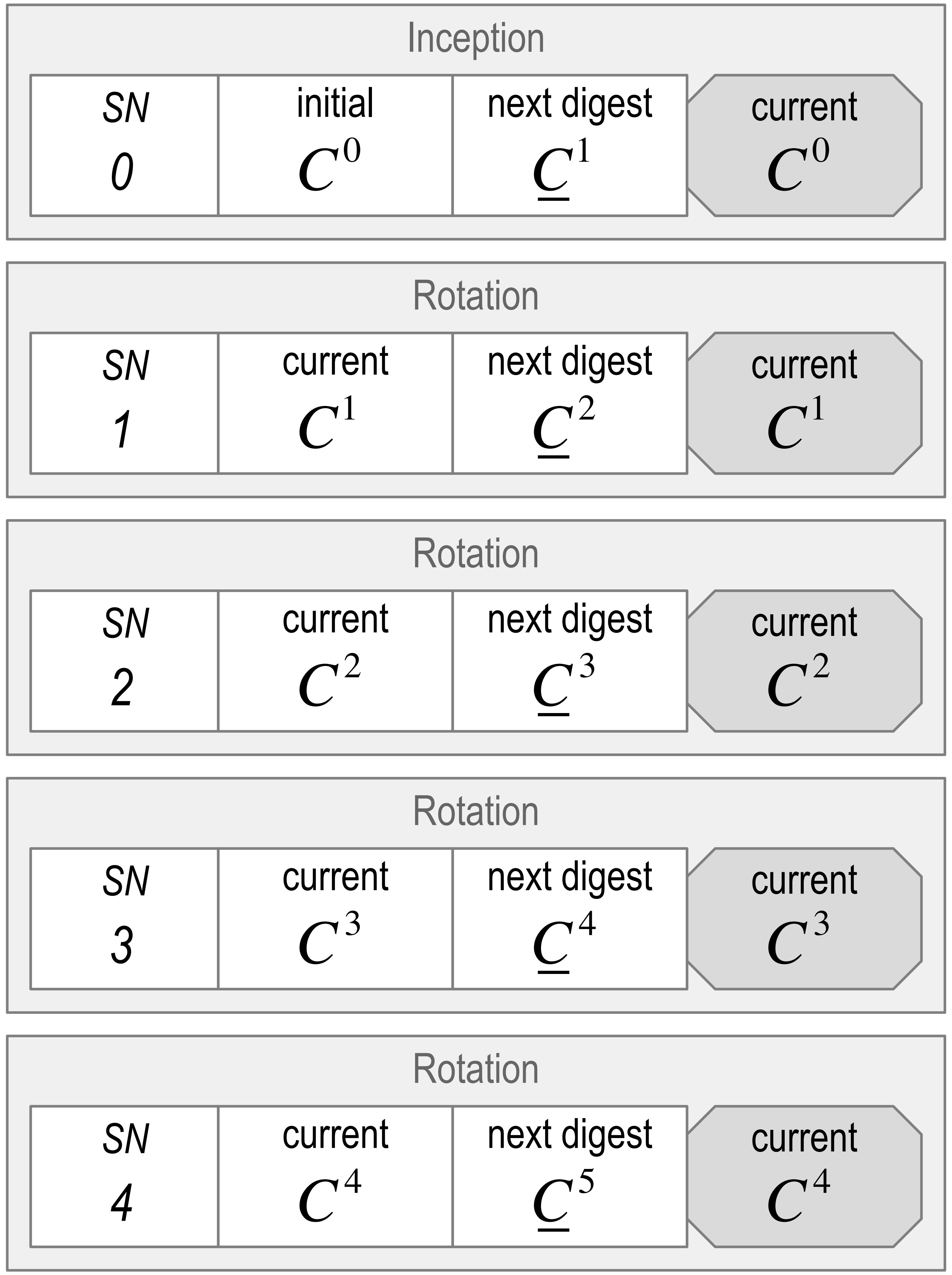
KERI public persistent  indirect mode (one-to-any)  ~ did:sov etc

KERI = did:uni (did:un)  (all of the above in one method)

# Pre-Rotation

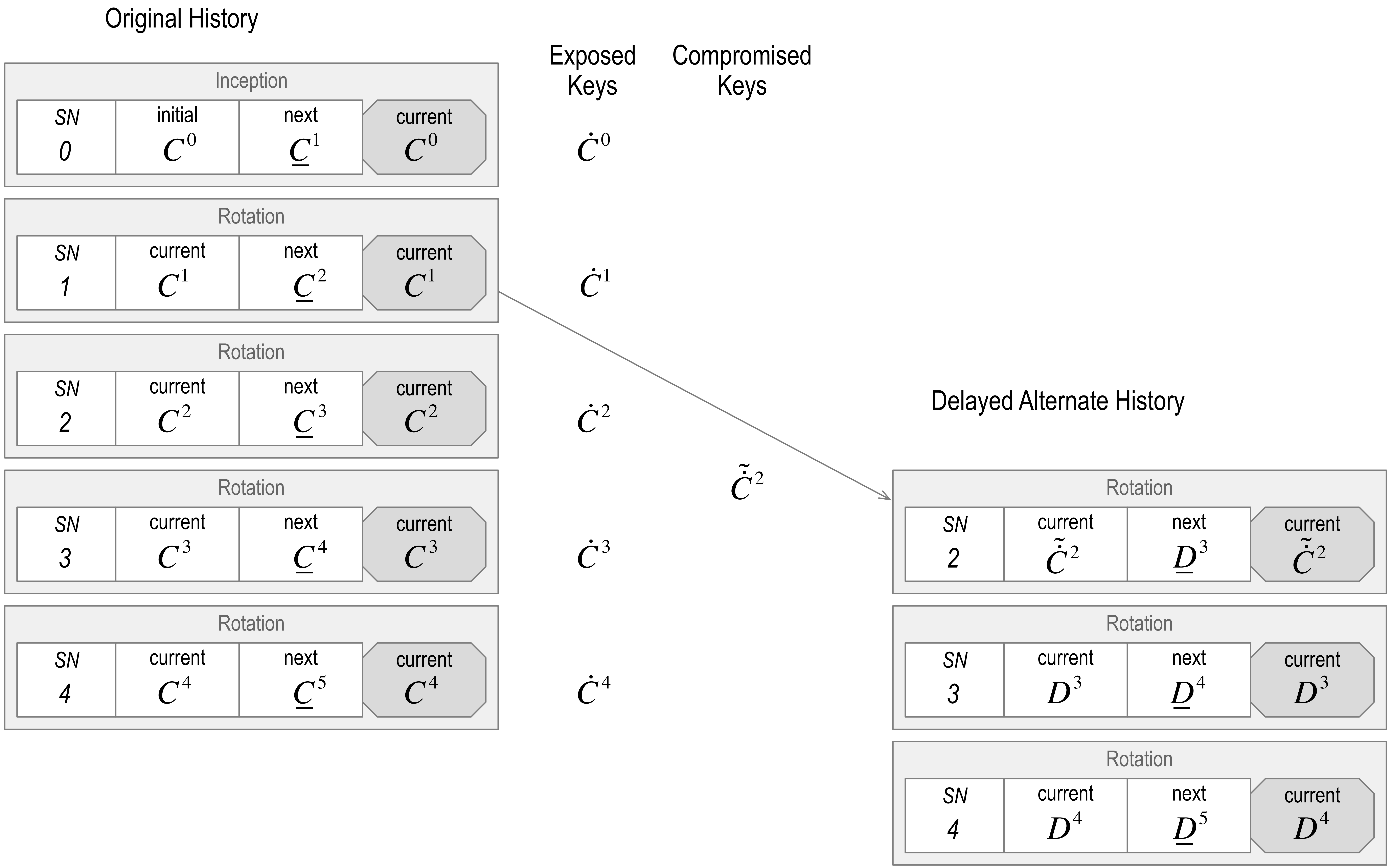


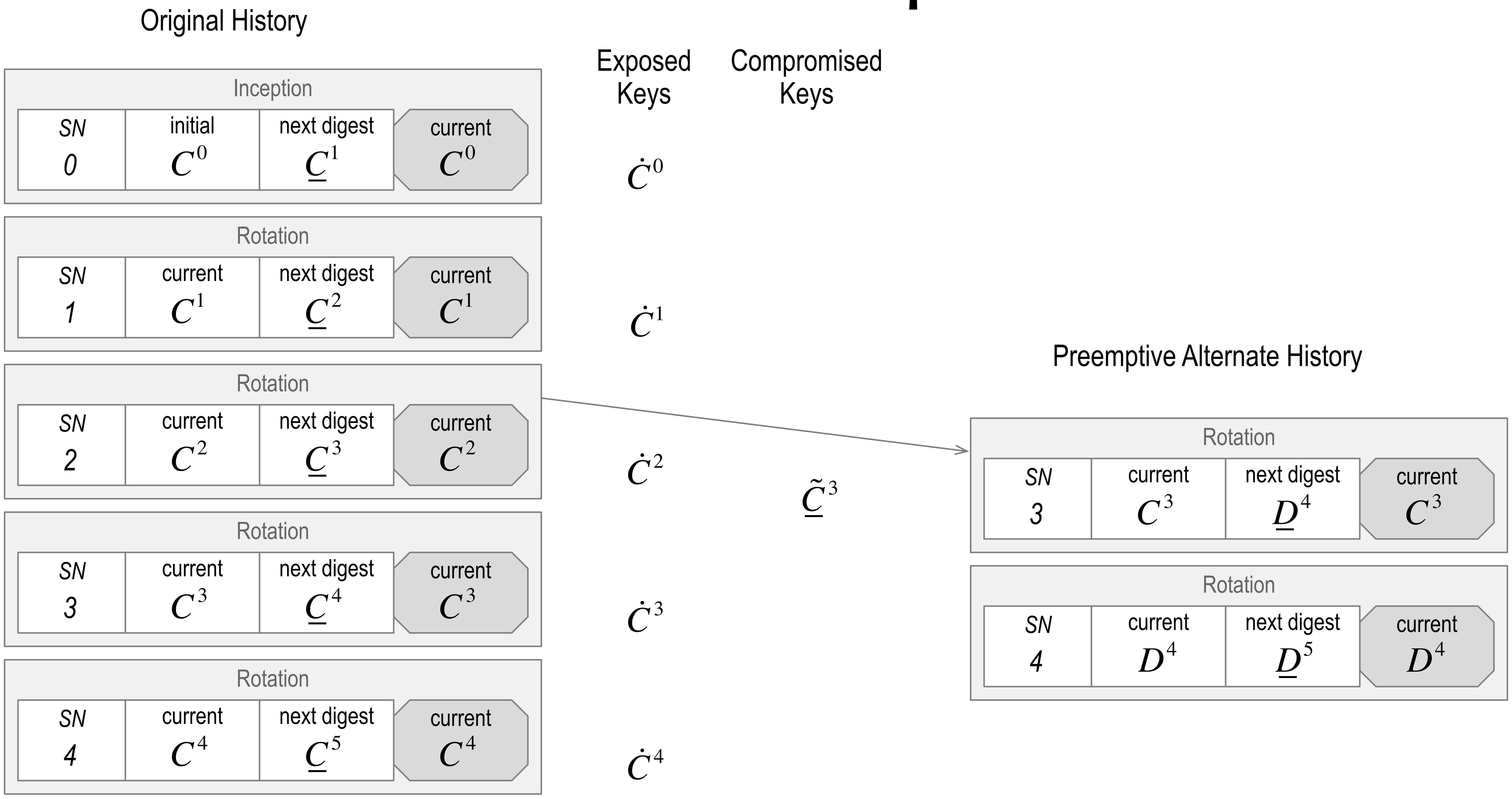

Digest of *next* key(s) makes pre-rotation post-quantum secure

# *Dead* Exploit



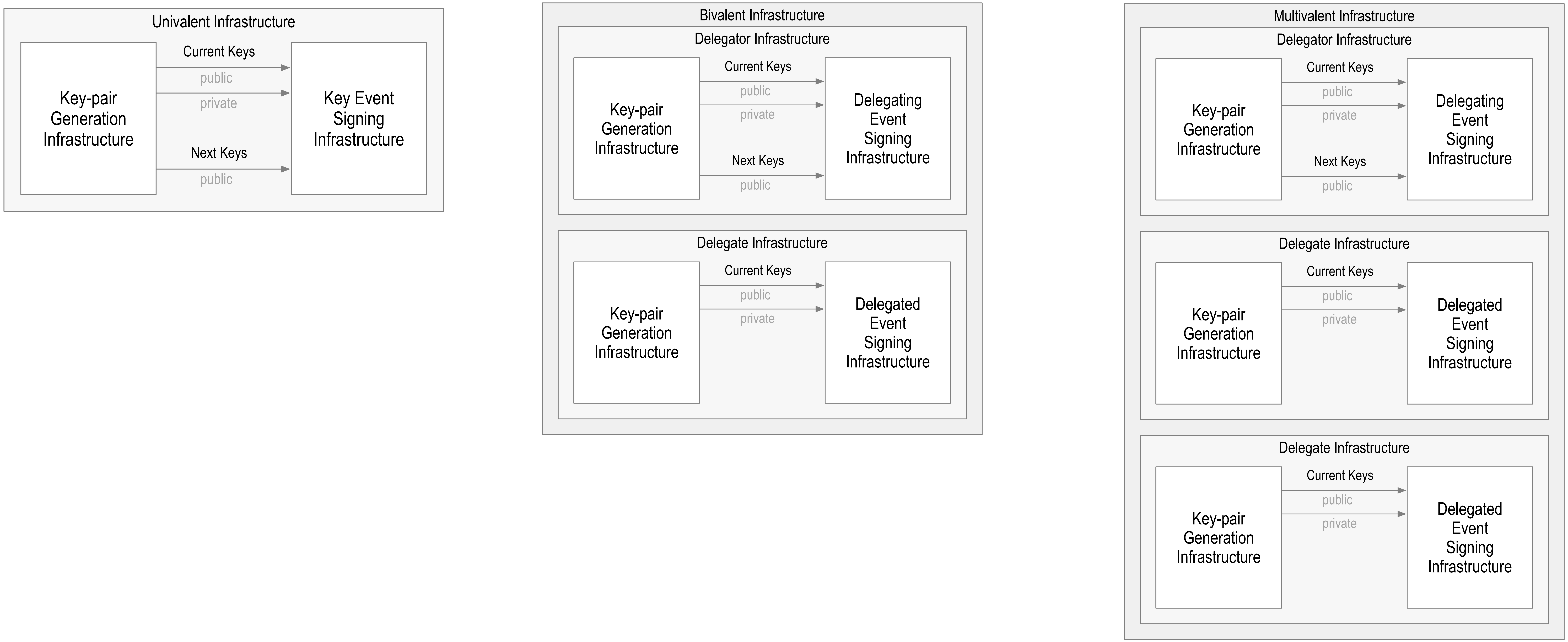

Any copy of original history protects against successful *dead* exploit

# *Live* Exploit

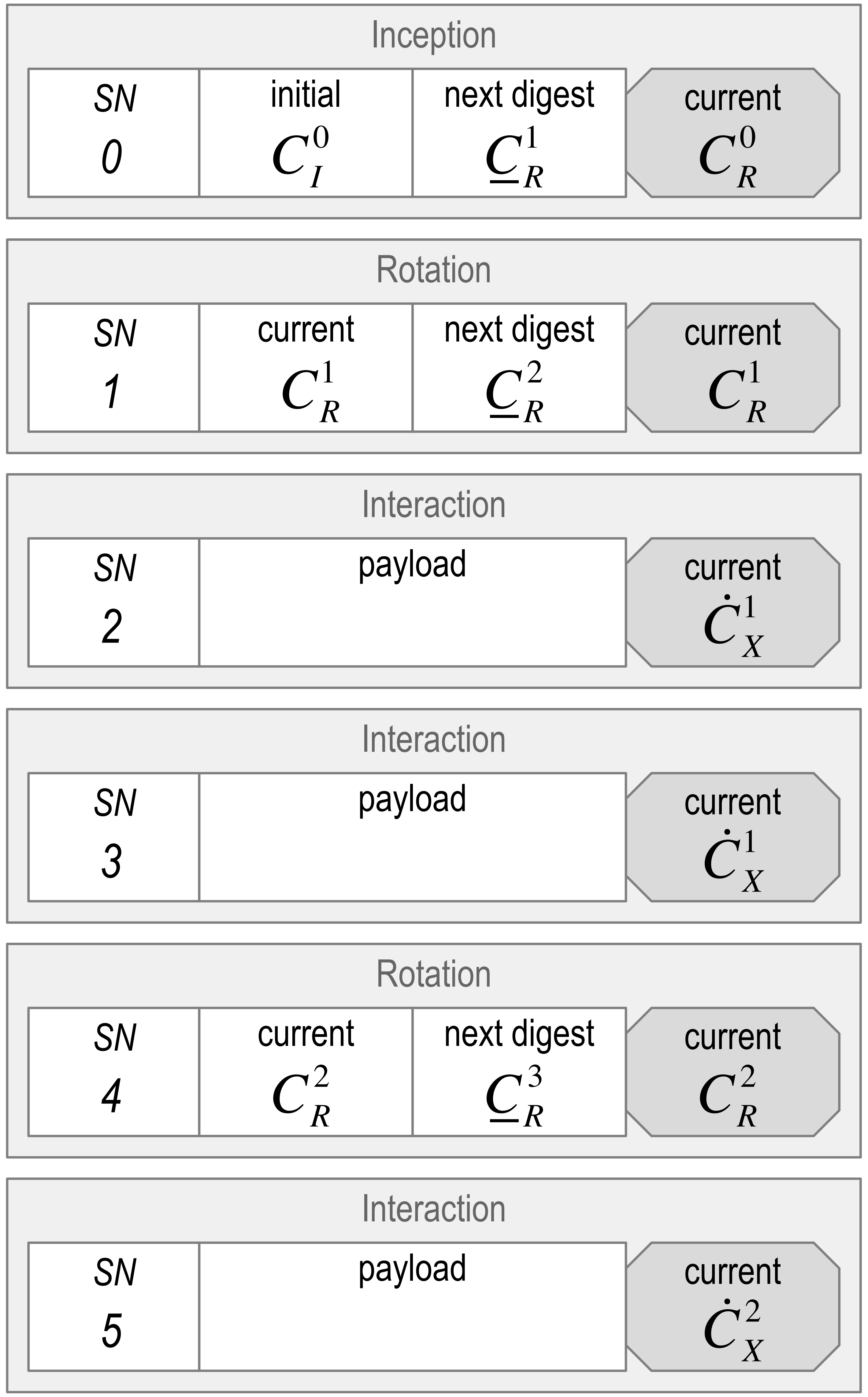


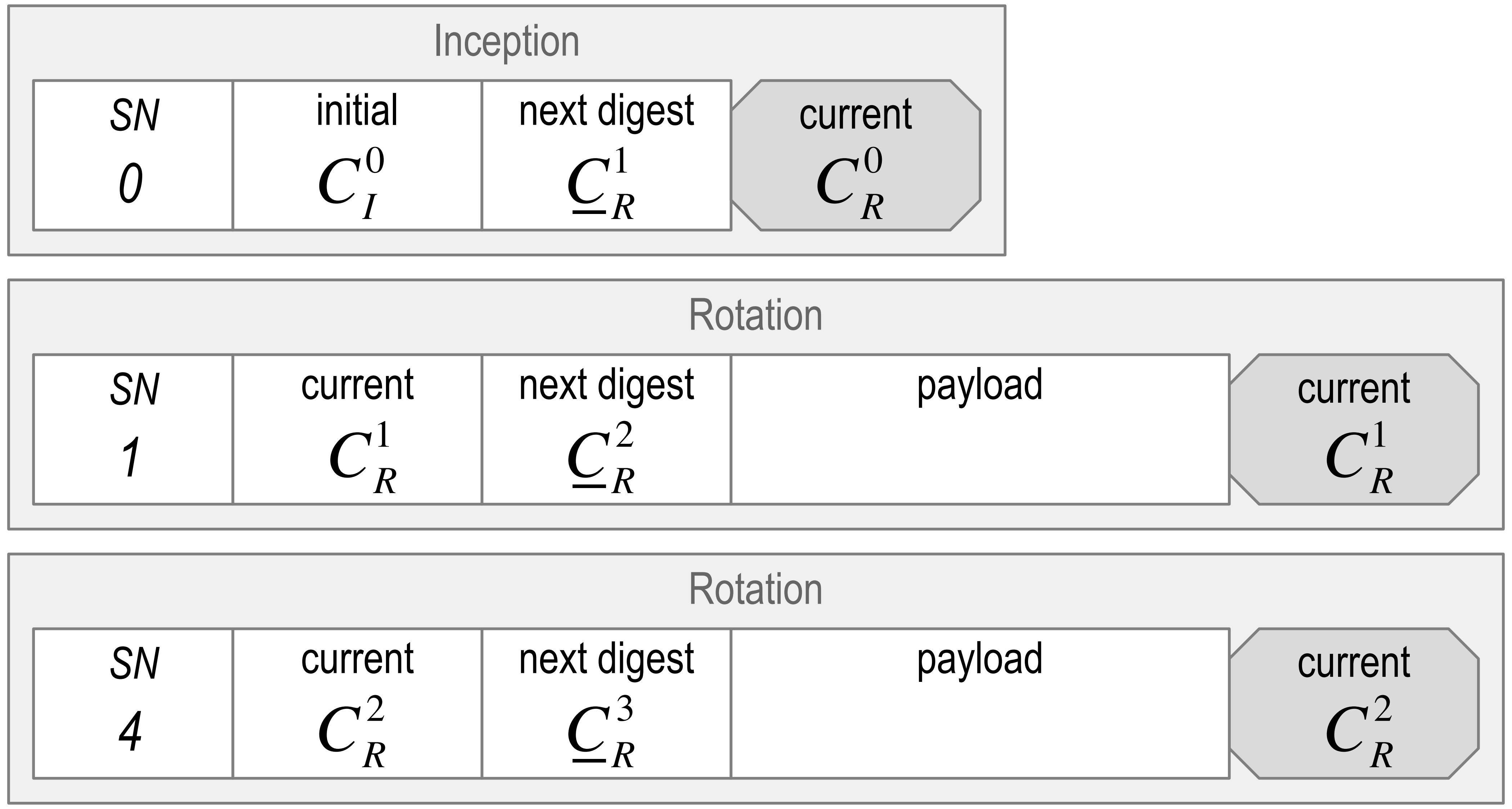

Difficulty of inverting *next* key(s) protects against successful *live* exploit

# Key Infrastructure Valence

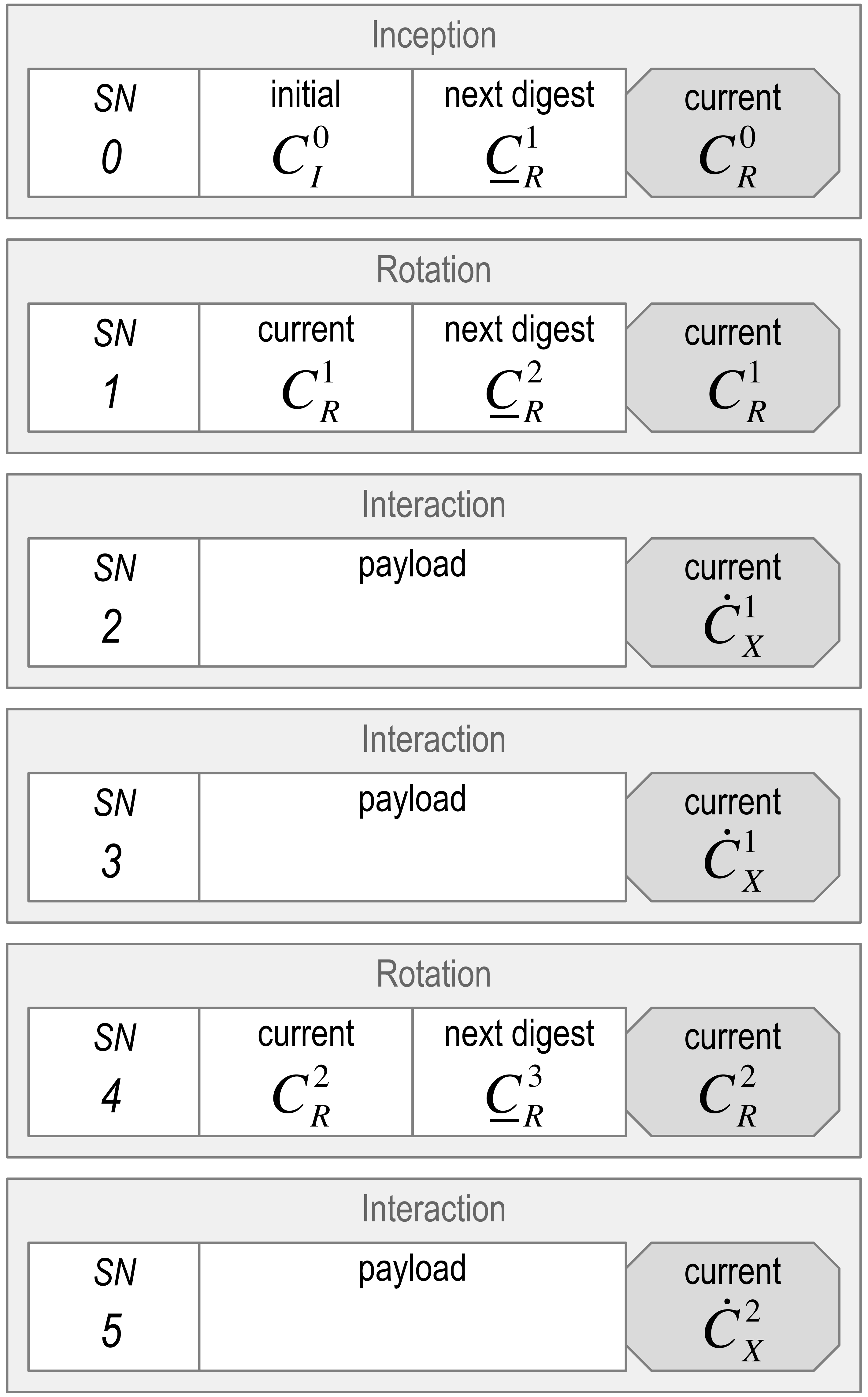


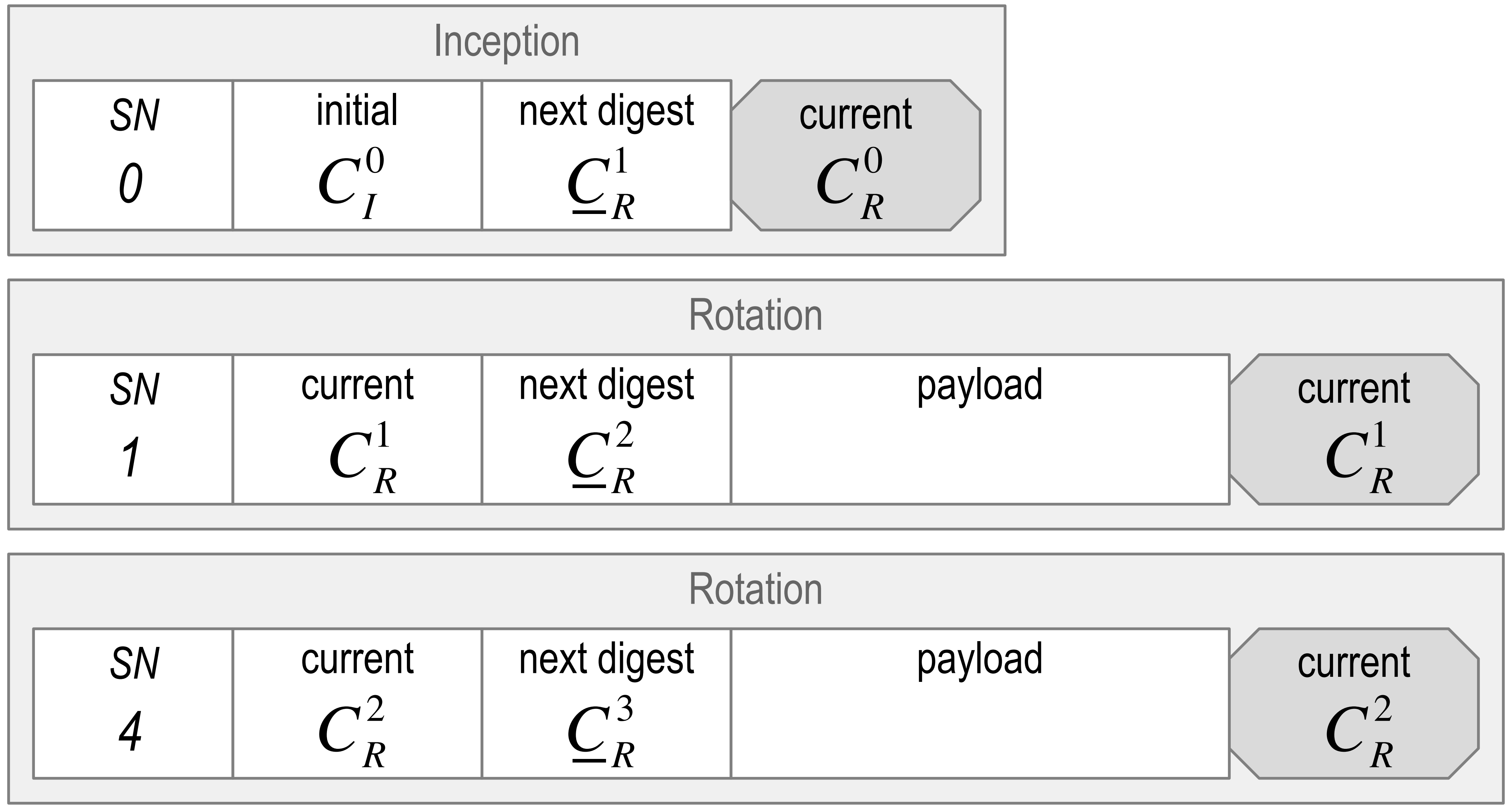
# Repurposed Keys



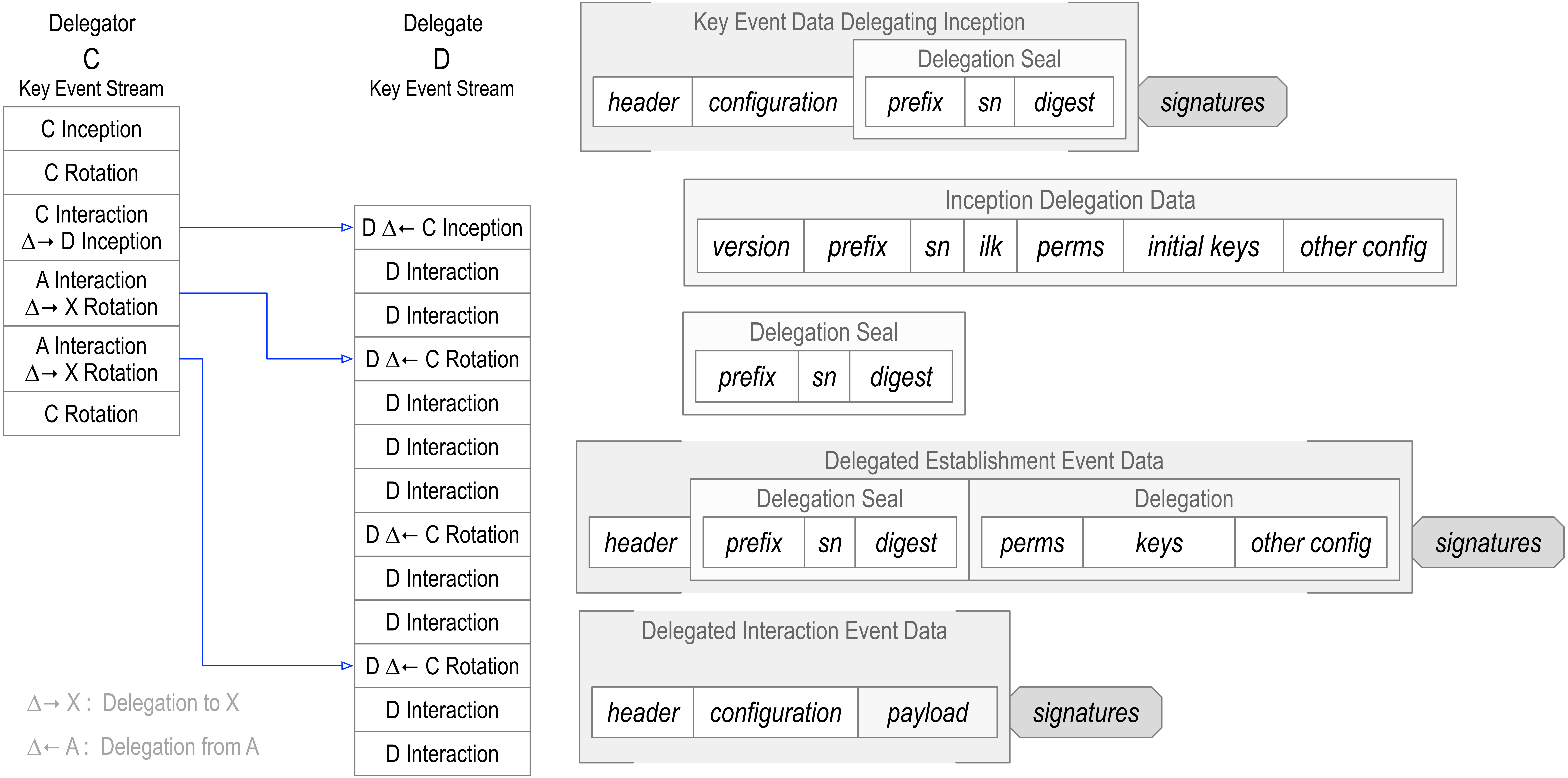



# Repurposed Keys

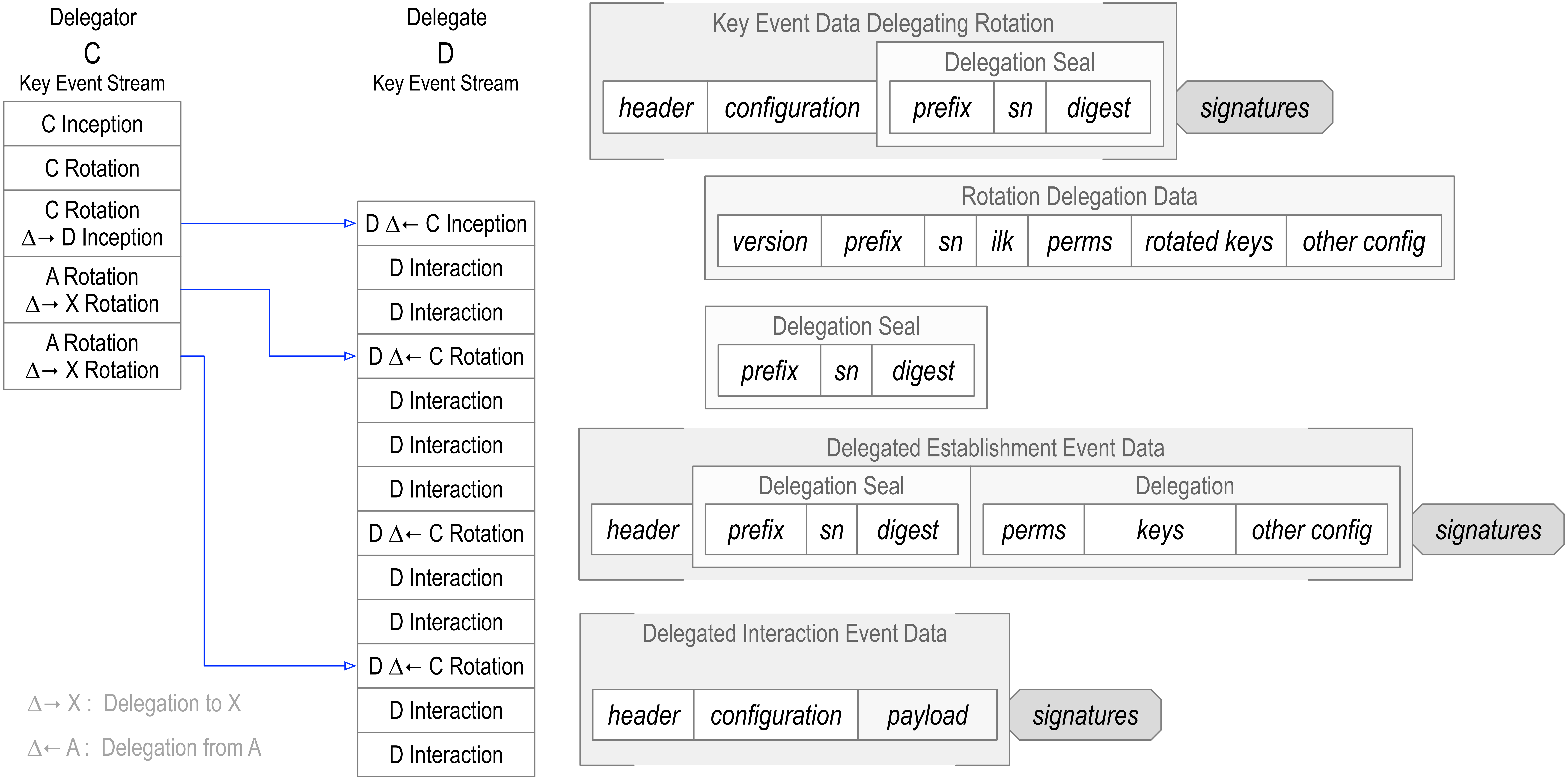


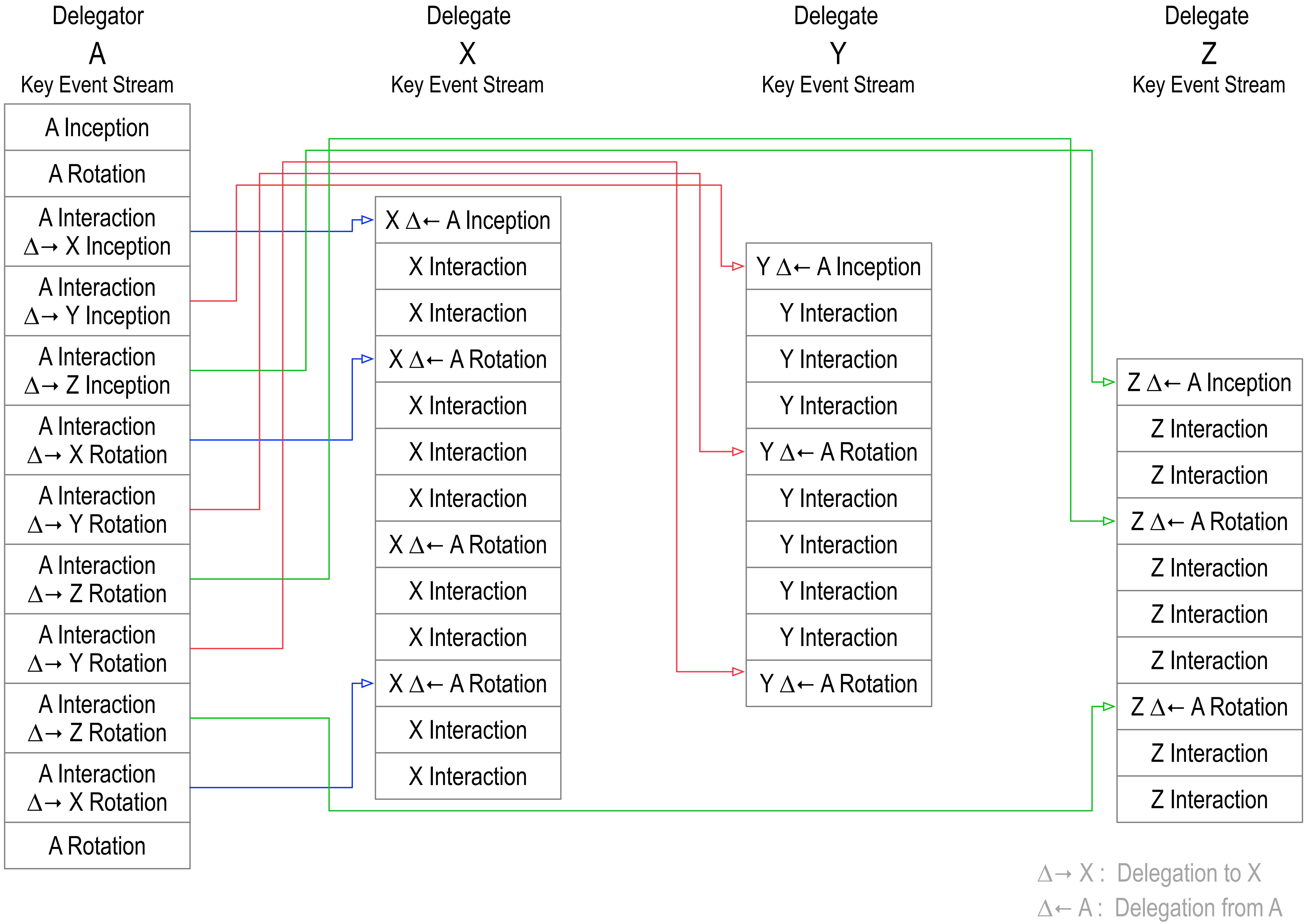
# Interaction Delegation



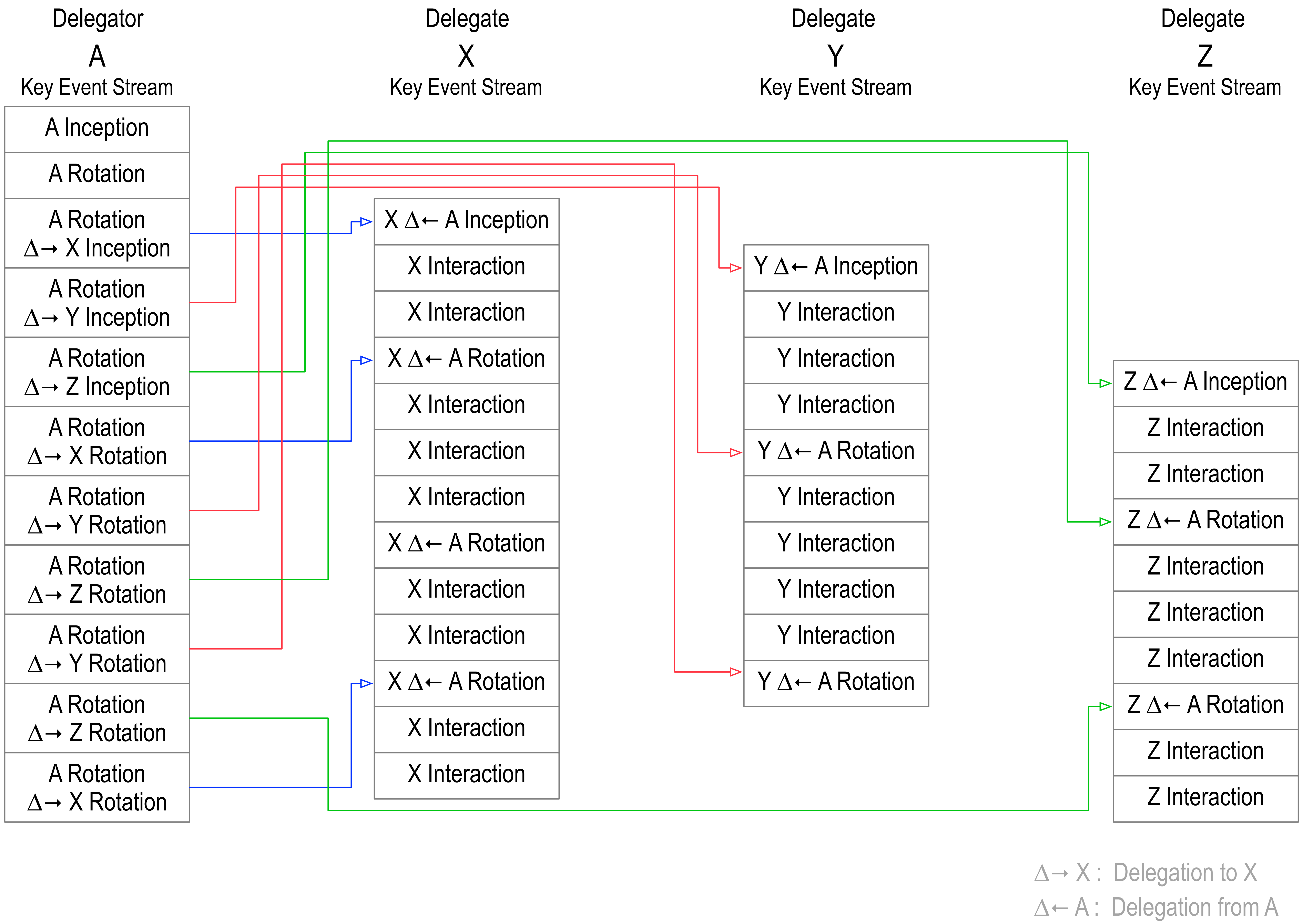
# Rotation Delegation



# Scaling Delegation via Interaction



# Scaling Delegation via Rotation

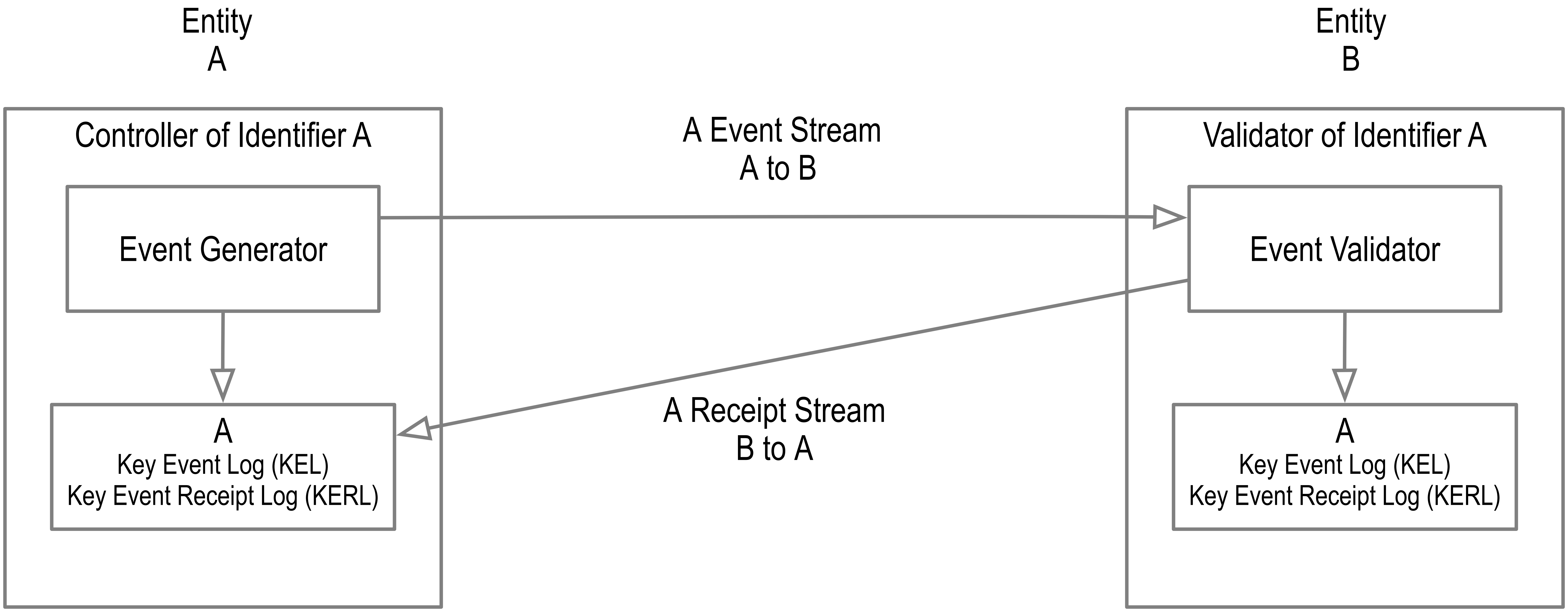


# Protocol Operational Modes

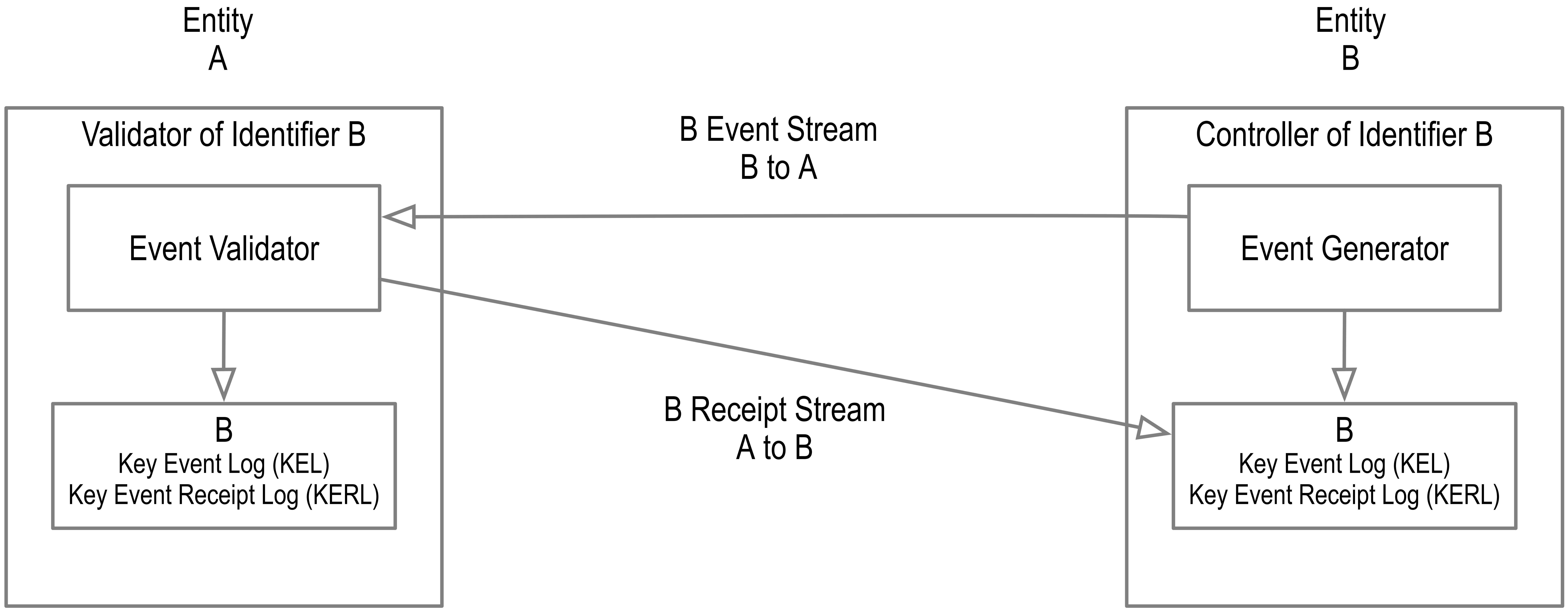
Direct Event Replay Mode  (one-to-one)

Indirect Event Replay Mode (one-to-any)

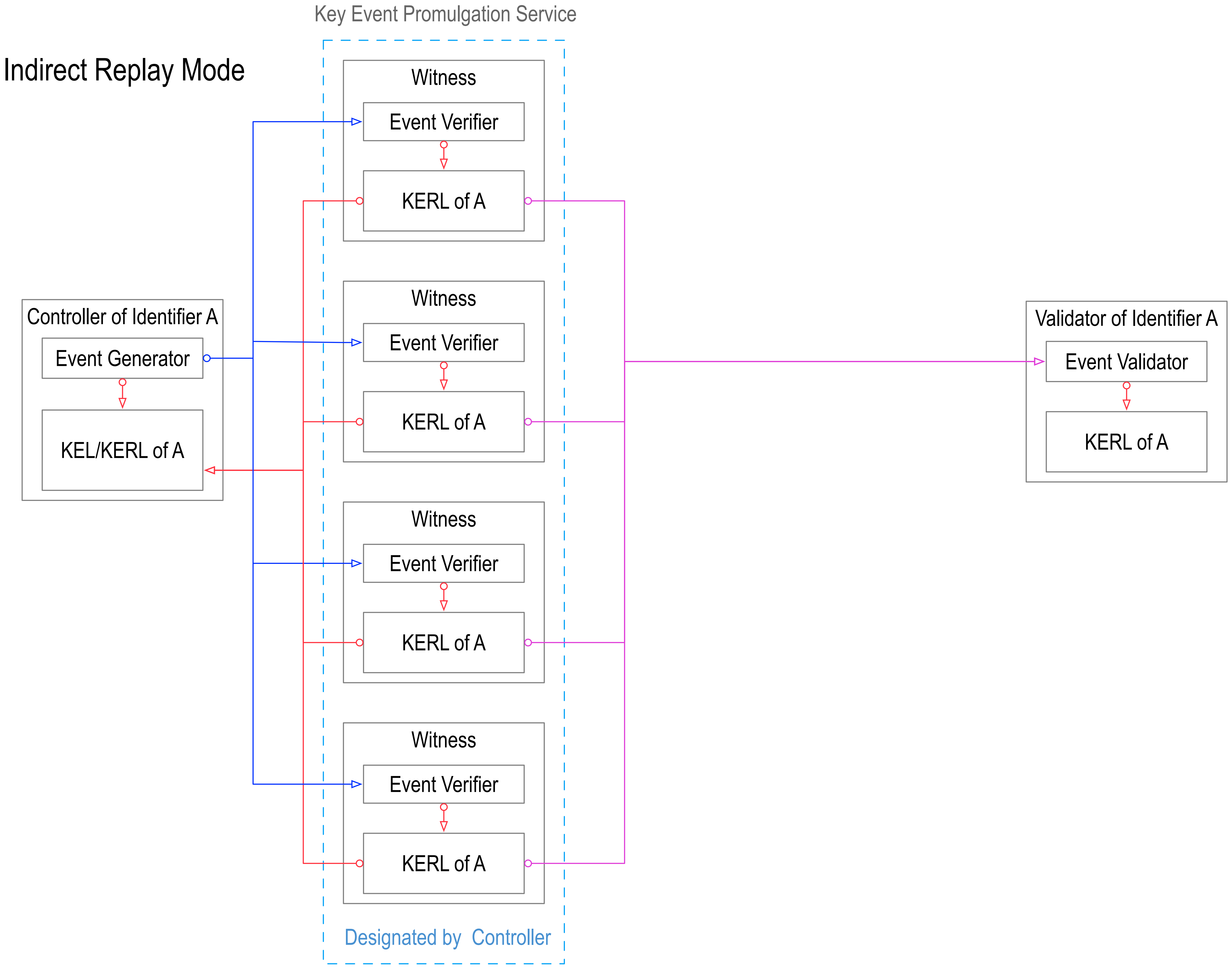
# Direct Mode: A to B



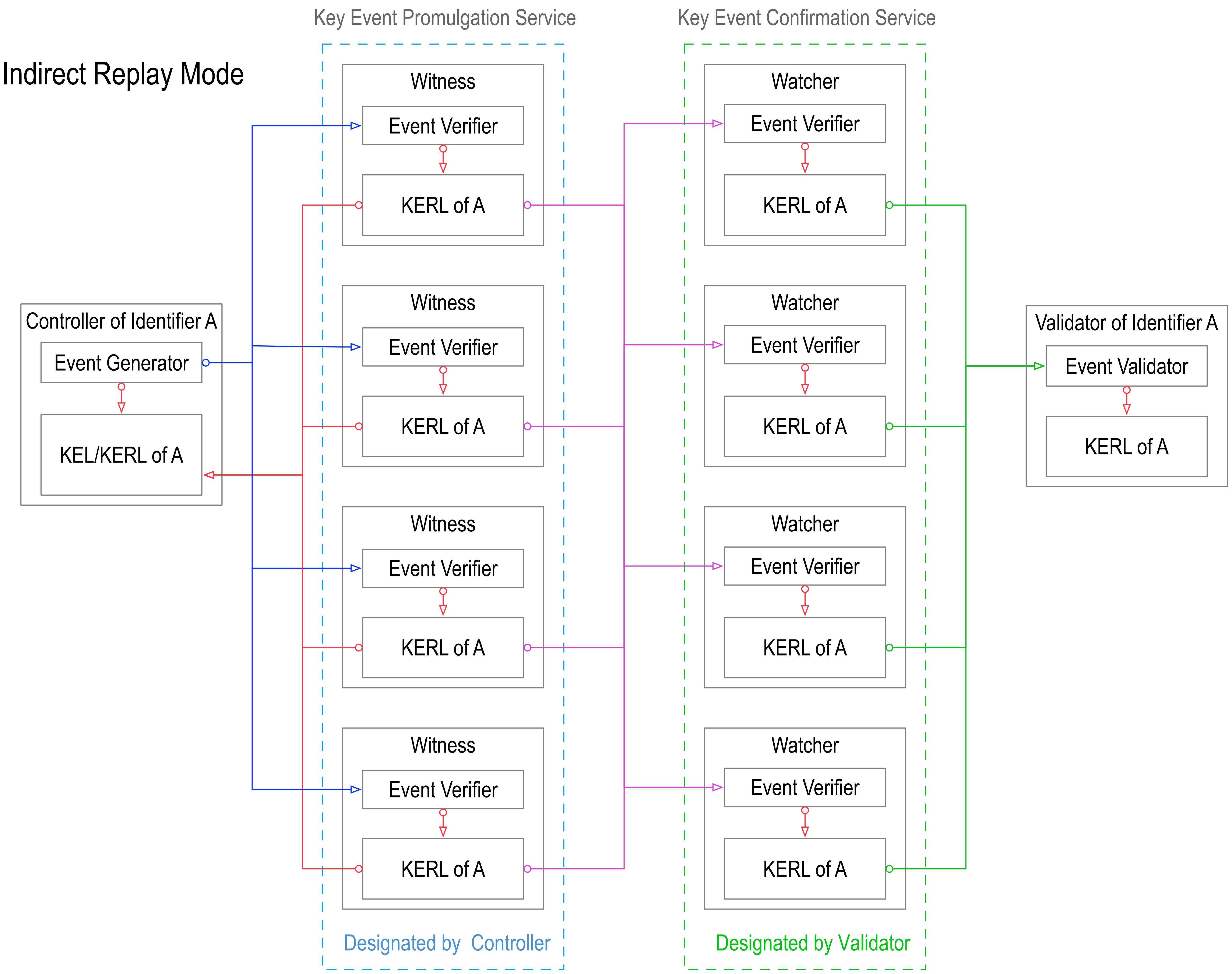
# Direct Mode: B to A



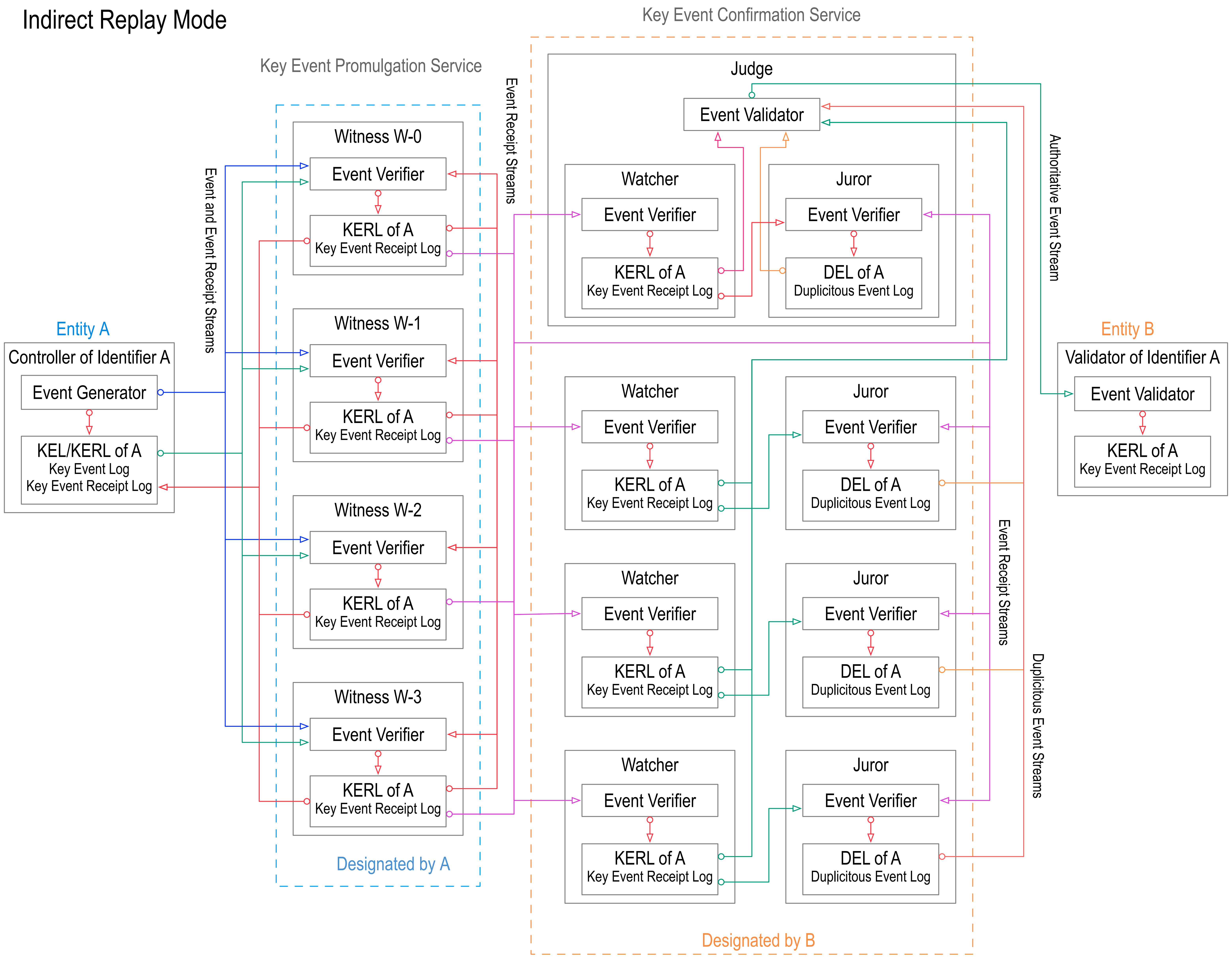
# Indirect Mode
# Promulgation Service



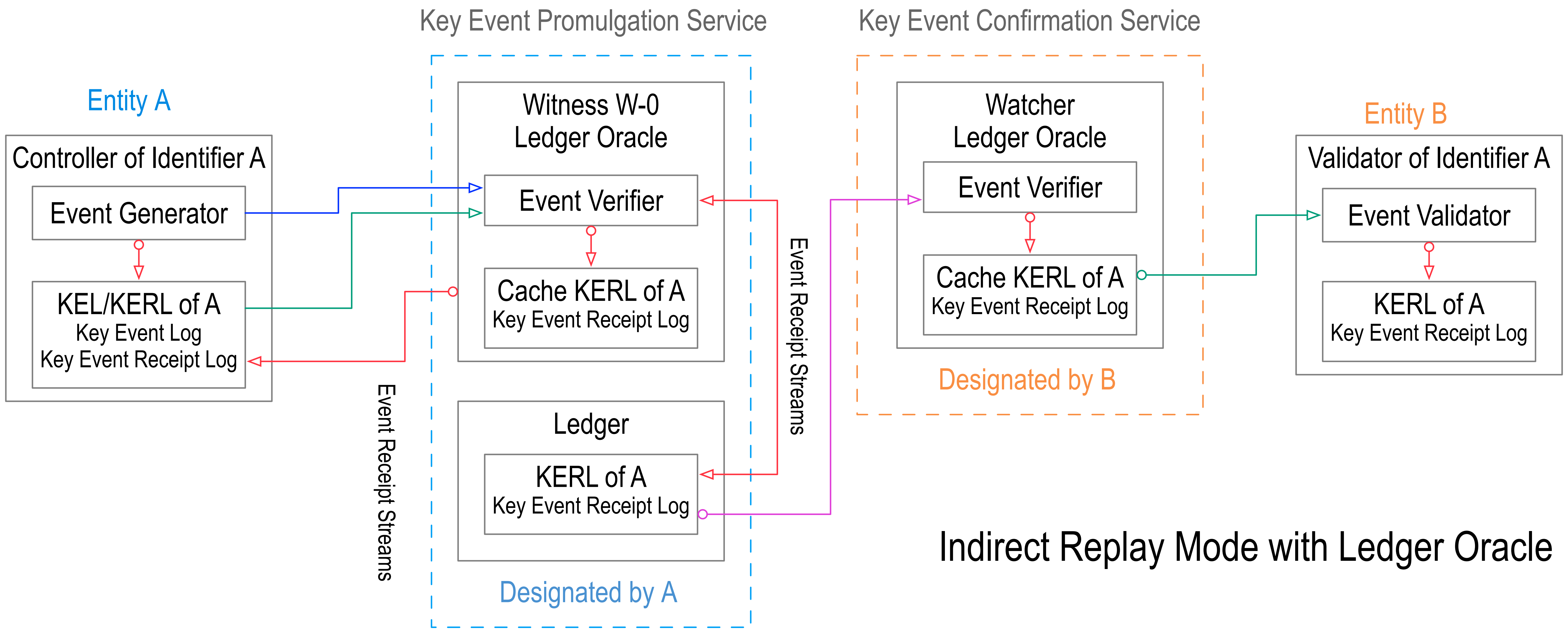
# Indirect Mode
# Promulgation and Confirmation Services



# Indirect Mode Full



# Indirect Mode with Ledger Oracles




Indirect Replay Mode with Ledger Oracle

# Separation of Control

Shared (permissioned) ledger = *shared control* over *shared data*.

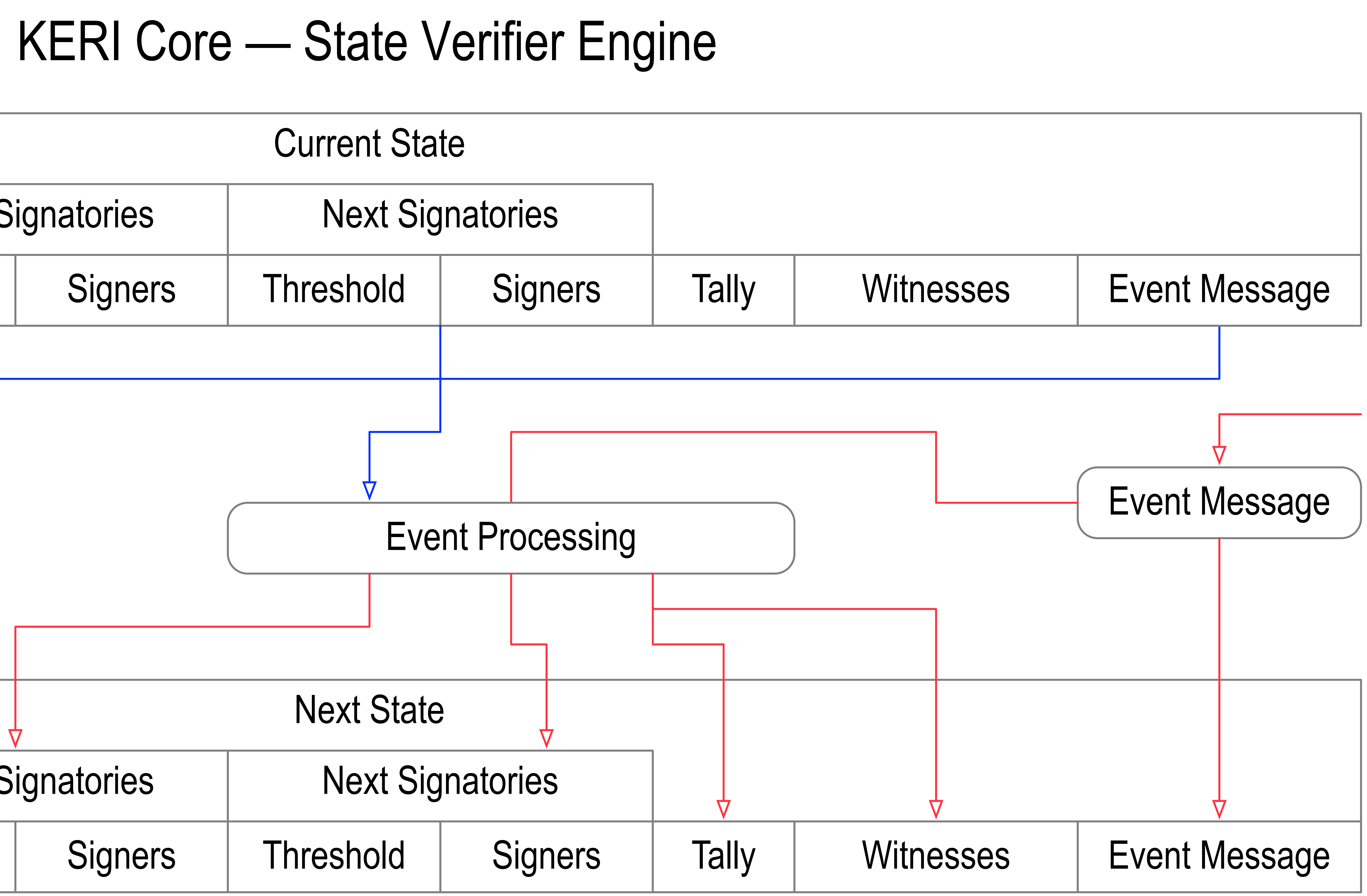
Shared *data* = *good*, shared *control* = *bad*.

Shared control between controller and validator may be problematic for governance, scalability, and performance.

KERI = *separated control* over *shared data*.

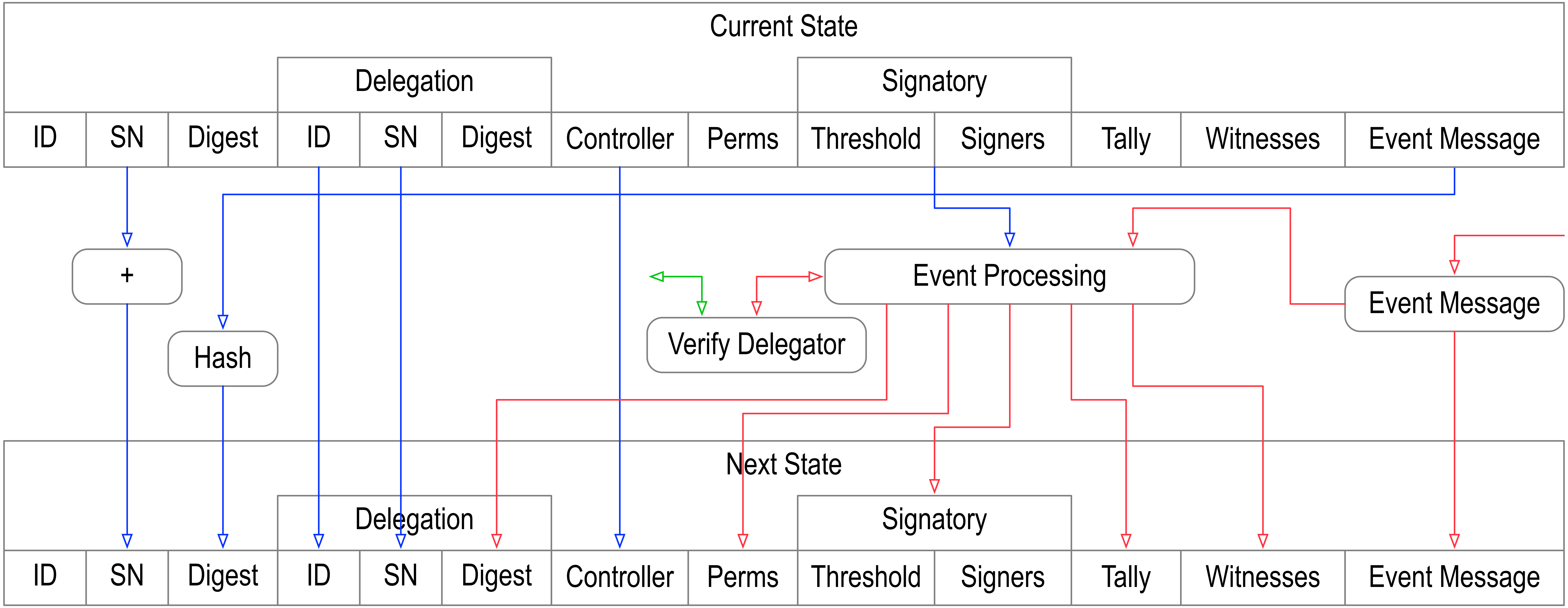
Separated control between controller and validator may provide better decentralization, more flexibility, better scalability, lower cost, higher performance, and more privacy at comparable security.

# State Verifier Engine

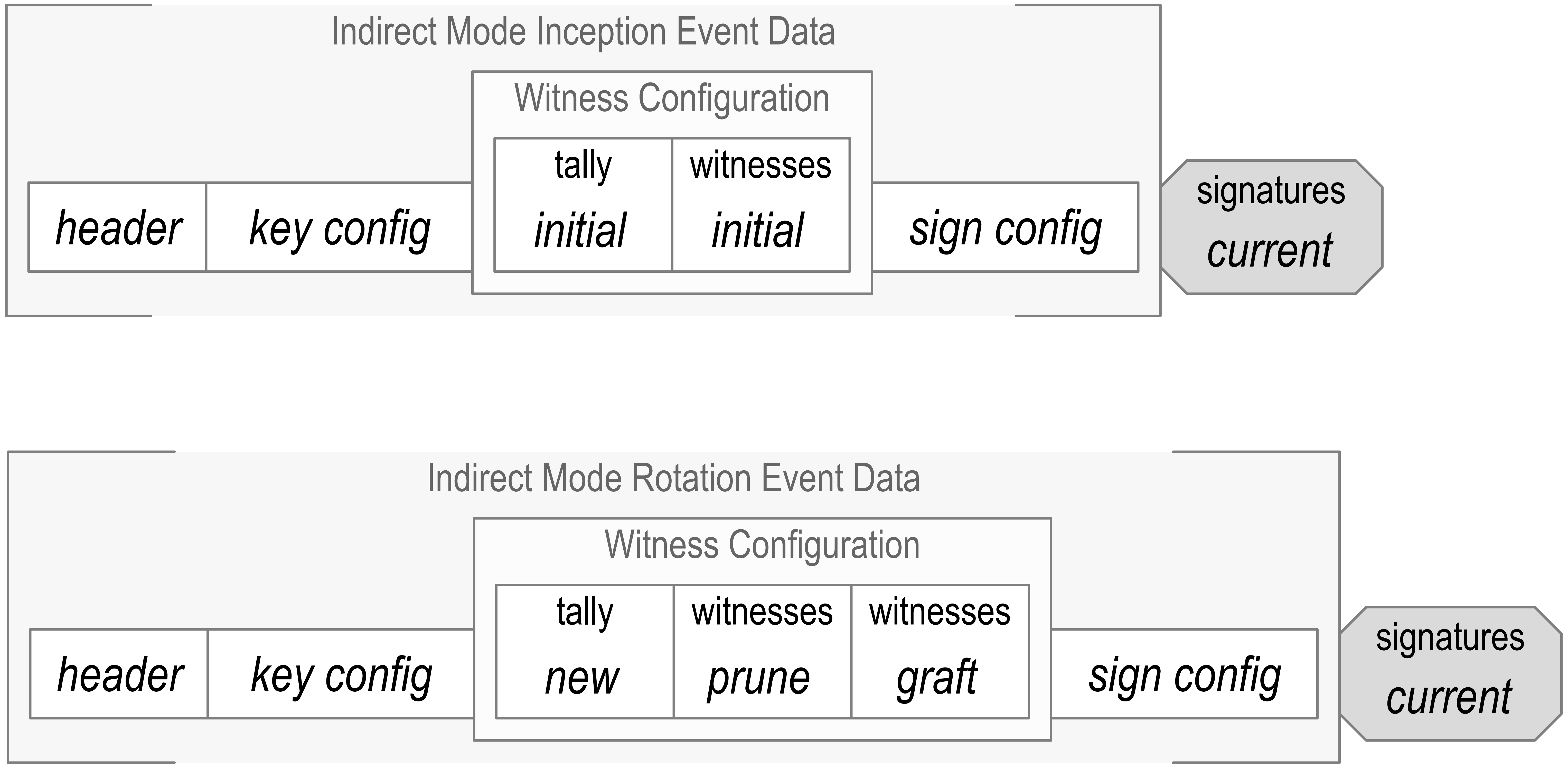


# Delegated State Verifier Engine

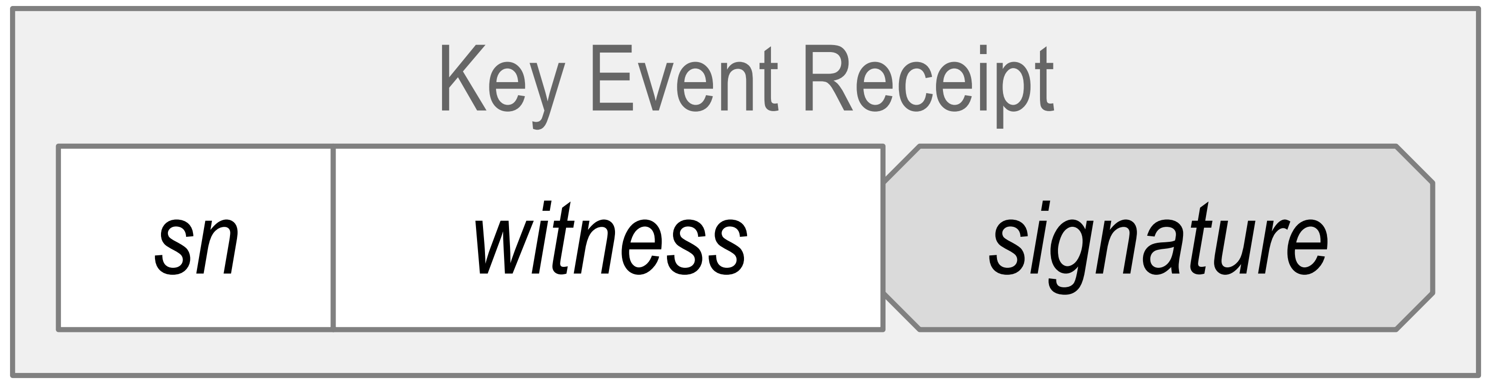
## KERI Delegated Core — State Verifier Engine



# Witness Designation



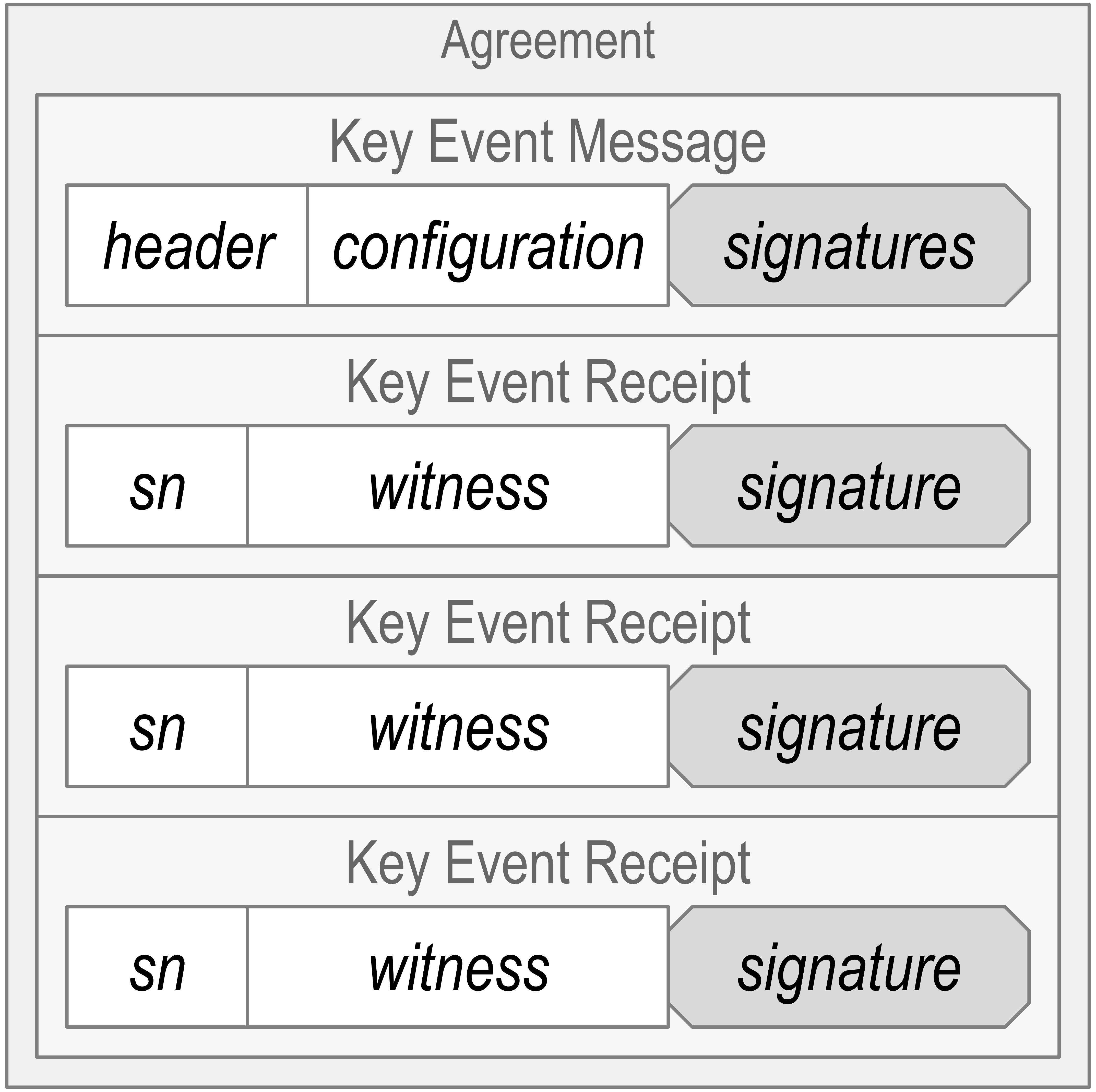
# Witnessed Key Event Receipt



(KA$^2$CE)

Keri’s Agreement Algorithm for Control Establishment

Produce Agreements with Guarantees



# Agreement Constraints

Proper Agreement

$$F+1$$

Sufficient Agreement

$$M > F$$

$$M \le N - F$$

$$F < M \le N - F$$

Intact Agreement

$$N \ge 2F+1$$

# One Agreement or None at All

$$\left|\overset{\frown}{N}\right| = N \qquad \left|\overset{\frown}{M}_1\right| = \left|\overset{\frown}{M}_2\right| = M$$

$$\left|\overset{\frown}{M}_1 \cup \overset{\frown}{M}_2\right| = \left|\overset{\frown}{N}\right| = N$$

$$\left|\overset{\frown}{M}_1\right| + \left|\overset{\frown}{M}_2\right| = \left|\overset{\frown}{M}_1 \cup \overset{\frown}{M}_2\right| + \left|\overset{\frown}{M}_1 \cap \overset{\frown}{M}_2\right|$$

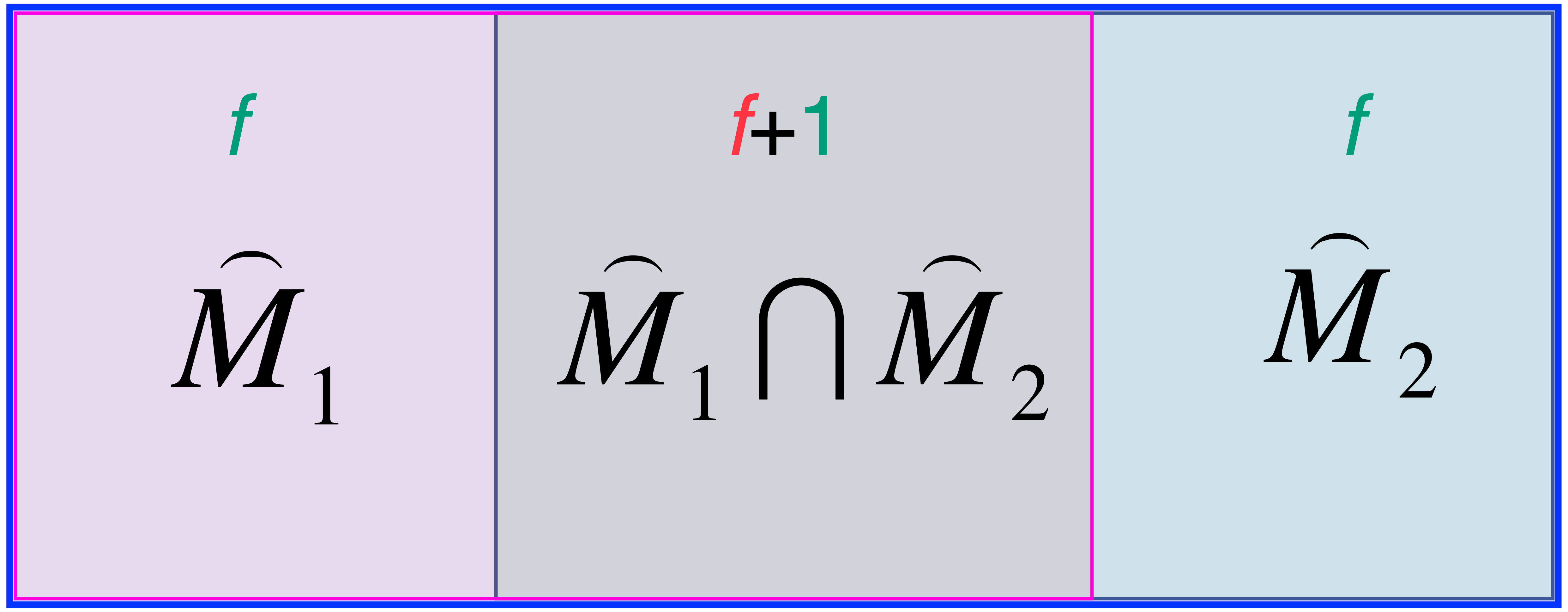
$$2M = N + F + 1$$

$$M \geq \left\lceil \frac{N+F+1}{2} \right\rceil$$

$$M \leq N - F$$

Overlapping Sets

$$\overset{\frown}{M}_1 \cup \overset{\frown}{M}_2 = \overset{\frown}{N}$$




One honest witness if:

$$\left|\overset{\frown}{M}_1 \cap \overset{\frown}{M}_2\right| \geq F + 1$$

Immune Agreement

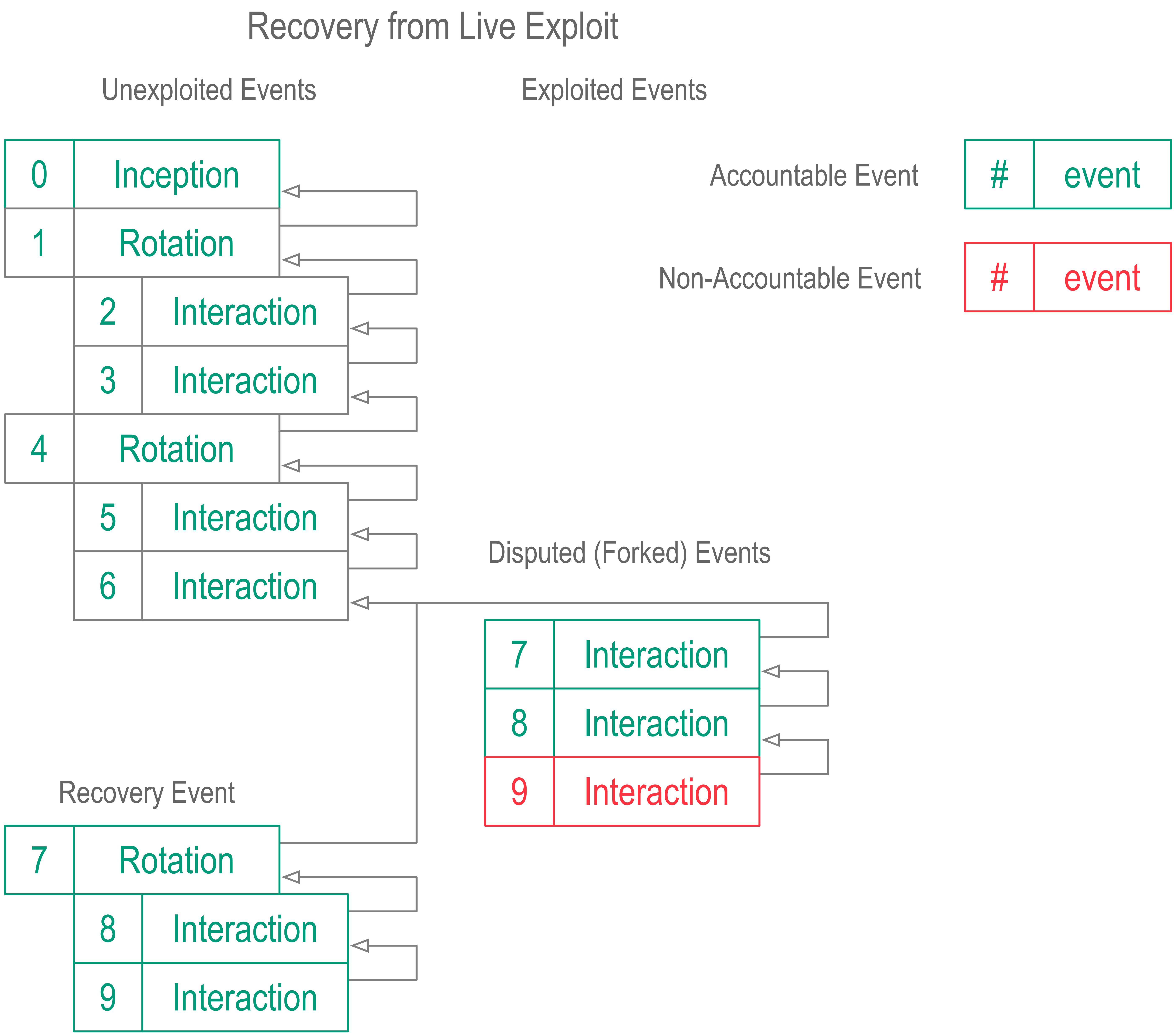
$$\frac{N+F+1}{2} \leq M \leq N - F$$

# Example Values

Immunity

| F | N | 3F+1 | $\left\lceil \frac{N+F+1}{2} \right\rceil$ | N-F | M |
|---|---|---|---|---|---|
| 1 | 4 | 4 | 3 | 3 | 3 |
| 1 | 5 | 4 | 4 | 4 | 4 |
| 1 | 6 | 4 | 4 | 5 | 4, 5 |
| 1 | 7 | 4 | 5 | 6 | 5, 6 |
| 1 | 8 | 4 | 5 | 7 | 5, 6, 7 |
| 1 | 9 | 4 | 6 | 8 | 6, 7, 8 |
| 2 | 7 | 7 | 5 | 5 | 5 |
| 2 | 8 | 7 | 6 | 6 | 6 |
| 2 | 9 | 7 | 6 | 7 | 6, 7 |
| 2 | 10 | 7 | 7 | 8 | 7, 8 |
| 2 | 11 | 7 | 7 | 9 | 7, 8, 9 |
| 2 | 12 | 7 | 8 | 10 | 8, 9, 10 |
| 3 | 10 | 10 | 7 | 7 | 7 |
| 3 | 11 | 10 | 8 | 8 | 8 |
| 3 | 12 | 10 | 8 | 9 | 8, 9 |
| 3 | 13 | 10 | 9 | 10 | 9, 10 |
| 3 | 14 | 10 | 9 | 11 | 9, 10, 11 |
| 3 | 15 | 10 | 10 | 12 | 10, 11, 12 |

# Recovery from Live Exploit



# Generic Event Formats

**Inception Event Data**

| Header | | | | Key Config | | | Witness Config | | Other Config | Sign Config | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| version | prefix | sn | ilk | threshold | public keys | threshold key digest | tally | witnesses | data | sign indices | signatures |
| `v1` | `C` | `0` | `icp` | *initial* | *initial* | *next* | *initial* | *initial* | *initial* | *initial* | *initial* |

**Rotation Event Data**

| Header | | | | | Key Config | | | Witness Config | | | Payload Config | Sign Config | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| version | prefix | sn | ilk | digest | threshold | public keys | threshold key digest | tally | witnesses | witnesses | payload | sign indices | signatures |
| `v1` | `C` | `1` | `rot` | *prev* | *current* | *current* | *next* | *new* | *prune* | *graft* | *details* | *current* | *current* |

**Interaction Event Data**

| Header | | | | | Payload Config | Sign Config | |
|---|---|---|---|---|---|---|---|
| version | prefix | sn | ilk | digest | payload | sign indices | signatures |
| `v1` | `C` | `2` | `icx` | *prev* | *details* | *current* | *current* |

# Generic Inception

$$\varepsilon_0^C = \left\langle v_0^C, C, t_0^C, \mathtt{icp}, K_0^C, \widehat{C}_0^C, \eta_0^C\left(\left\langle K_1^C, \widehat{C}_1^C \right\rangle\right), M_0^C, \widehat{W}_0^C, [data], \widehat{s}_0^C \right\rangle \widehat{\sigma}_0^C$$

$$\widehat{C}_0^C = \left[ C^0, \ldots, C^{L_0^C - 1} \right]_0^C$$

$$\widehat{C}_1^C = \left[ C^{r_1}, \ldots, C^{r_1 + L_1^C - 1} \right]_1^C$$

$$\widehat{W}_0^C = \left[ W_0^C, \ldots, W_{N_0^C - 1}^C \right]_0^C$$

$$\widehat{s}_0^C = \left[ s_0, \ldots, s_{S_0^C - 1} \right]_0^C$$

$$\widehat{\sigma}_0^C = \sigma_{C^{s_0}} \ldots \sigma_{C^{s_{S_0^C - 1}}}$$

# Generic Rotation

$$\varepsilon_k^C = \left\langle v_k^C, C, t_k^C, \eta_k^C\left(\varepsilon_{k-1}^C\right), \texttt{rot}, K_l^C, \widehat{C}_l^C, \eta_l^C\left(\left\langle K_{l+1}^C, \widehat{C}_{l+1}^C \right\rangle\right), M_l^C, \widehat{X}_l^C, \widehat{Y}_l^C, [seals], \widehat{s}_{kl}^C \right\rangle \widehat{\sigma}_{kl}^C$$

$$\widehat{C}_l^C = \left[ C^{r_l^C}, \ldots, C^{r_l^C + L_l^C - 1} \right]_l^C$$

$$\widehat{C}_{l+1}^C = \left[ C^{r_{l+1}^C}, \ldots, C^{r_{l+1}^C + L_{l+1}^C - 1} \right]_{l+1}^C$$

$$\widehat{X}_l^C = \left[ X_0^C, \ldots, X_{O_l^C - 1}^C \right]_l^C$$

$$\widehat{Y}_l^C = \left[ Y_0^C, \ldots, Y_{P_l^C - 1}^C \right]_l^C$$

$$\widehat{s}_{kl}^C = \left[ s_0, \ldots, s_{S_{kl}^C - 1} \right]_{kl}^C$$

$$\widehat{\sigma}_{kl}^C = \sigma_{C^{r_l^C + s_0}} \ldots \sigma_{C^{r_l^C + s_{S_{kl}^C - 1}}}$$

# Generic Interaction

$$\varepsilon_k^C = \left\langle v_k^C, C, t_k^C, \eta_k^C\left(\varepsilon_{k-1}^C\right), \texttt{ixn}, \left[seals\right], \widehat{s}_{kl}^C \right\rangle \widehat{\sigma}_{kl}^C$$

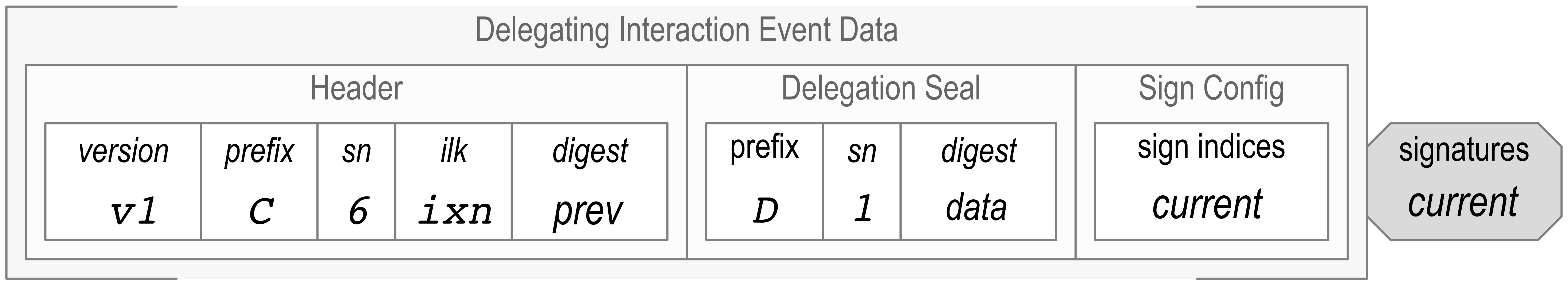
$$K_l^C$$

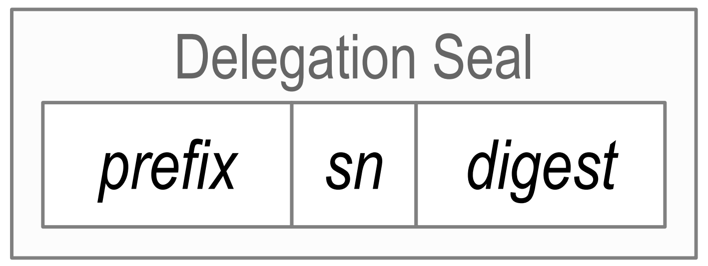
$$\widehat{C}_l^C = \left[ C^{r_l^C}, \ldots, C^{r_l^C + L_l^C - 1} \right]_l^C$$

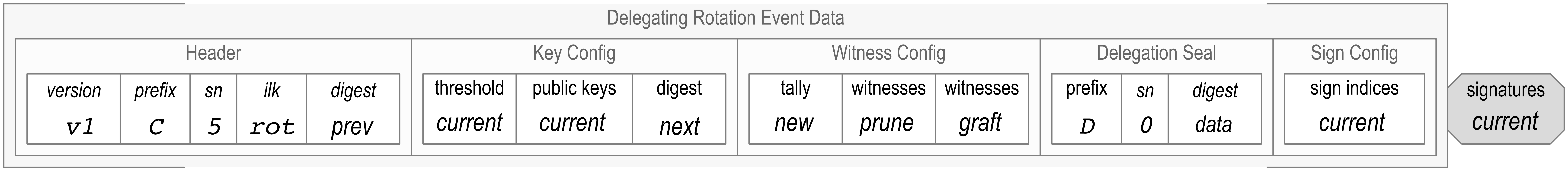
$$\widehat{s}_{kl}^C = \left[ s_0, \ldots, s_{S_{kl}^C - 1} \right]_{kl}^C$$

$$\widehat{\sigma}_{kl}^C = \sigma_{C^{r_l^C + s_0}} \ldots \sigma_{C^{r_l^C + s_{S_{kl}^C} - 1}}$$

# Generic Delegating Event Formats



# Generic Delegated Event Formats

**Inception Delegation Data**

| version | prefix | sn | ilk | initial threshold | initial keys | next digest | tally | initial witnesses | perms |
|---|---|---|---|---|---|---|---|---|---|

**Delegation Seal**

| prefix | sn | digest |
|---|---|---|

**Delegated Inception Event Data**

| Header | | | | Key Config | | | Witness Config | | Perms Config | Delegation Seal | | | Sign Config | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| version | prefix | sn | ilk | threshold | public keys | digest | tally | witnesses | perms | prefix | sn | digest | sign indices | signatures |
| `v1` | D | `0` | `dip` | initial | initial | next | initial | initial | data | `C` | 5 | prev 4 | initial | initial |

**Rotation Delegation Data**

| version | prefix | sn | ilk | digest | rotated threshold | rotated keys | next digest | tally | pruned witnesses | grafted witnesses | perms |
|---|---|---|---|---|---|---|---|---|---|---|---|

**Delegated Rotation Event Data**

| Header | | | | | Key Config | | | Witness Config | | | Perms Config | Delegation Seal | | | Sign Config | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| version | prefix | sn | ilk | digest | threshold | public keys | digest | tally | witnesses | witnesses | perms | prefix | sn | digest | sign indices | signatures |
| `v1` | D | `1` | `drt` | prev | current | current | next | new | prune | graft | data | `C` | 6 | prev 5 | current | current |

**Delegated Interaction Event Data**

| Header | | | | | Payload Config | Sign Config | |
|---|---|---|---|---|---|---|---|
| version | prefix | sn | ilk | digest | payload | sign indices | signatures |
| `v1` | D | 2 | `isn` | prev | details | current | current |

# Inception Delegation

$$\widehat{\Delta}_0^D = \left\{ D, t_0^D, \eta_k^C\left(\widehat{\delta}_0^D\right) \right\}$$

$$\widehat{\delta}_0^D = \left\langle v_0^D, D, t_0^D, \texttt{dip}, K_0^D, \widehat{D}_0^D, M_0^D, \widehat{W}_0^D, \left[perms\right] \right\rangle$$

$$\widehat{D}_0^D = \left[ D^0, \ldots, D^{L_0^D - 1} \right]_0^D$$

$$\widehat{W}_0^C = \left[ W_0^C, \ldots, W_{N_0^C - 1}^C \right]_0^C$$

$$\varepsilon_0^D = \left\langle v_0^D, D, t_0^D, \texttt{dip}, K_0^D, \widehat{D}_0^D, M_0^D, \widehat{W}_0^D, \left[perms\right], \widehat{\Delta}_k^C, \widehat{s}_0^D \right\rangle \widehat{\sigma}_0^D$$

$$\widehat{\Delta}_k^C = \left\{ C, t_k^C, \eta_0^D\left(\varepsilon_k^C\right) \right\}$$

$$\widehat{s}_0^D = \left[ s_0, \ldots, s_{S_0^D - 1} \right]_0^D$$

$$\widehat{\sigma}_0^D = \sigma_{D^{s_0}} \ldots \sigma_{D^{s_{S_0^D - 1}}}$$

# Rotation Delegation

$$\widehat{\Delta}_k^D = \left\{ D, t_k^D, \eta_k^C\left(\widehat{\delta}_k^D\right) \right\}$$

$$\widehat{\delta}_k^D = \left\langle v_k^D, D, t_k^D, \eta_k^D\left(\varepsilon_{k-1}^D\right), \texttt{drt}, K_l^D, \widehat{D}_l^D, M_l^D, \widehat{X}_l^D, \widehat{Y}_l^D, [perms] \right\rangle$$

$$\widehat{D}_l^D = \left[ D^{r_l^D}, \ldots, D^{r_l^D + L_l^D - 1} \right]_l^D$$

$$\widehat{X}_l^D = \left[ X_0^D, \ldots, X_{O_l^D - 1}^D \right]_l^D$$

$$\widehat{Y}_l^D = \left[ Y_0^D, \ldots, Y_{P_l^D - 1}^D \right]_l^D$$

$$\varepsilon_k^D = \left\langle v_k^D, D, t_k^D, \eta_k^D\left(\varepsilon_{k-1}^D\right), \texttt{drt}, K_l^D, \widehat{D}_l^D, M_l^D, \widehat{X}_l^D, \widehat{Y}_l^D, [perms], \widehat{\Delta}_k^C, \widehat{s}_{kl}^D \right\rangle \widehat{\sigma}_{kl}^D$$

$$\widehat{\Delta}_k^C = \left\{ C, t_k^C, \eta_k^D\left(\varepsilon_k^C\right) \right\}$$

$$\widehat{s}_{kl}^D = \left[ s_0, \ldots, s_{S_{kl}^D - 1} \right]_{kl}^D$$

$$\widehat{\sigma}_{kl} = \sigma_{C^{+r_l^D + s_0}} \ldots \sigma_{C^{r_l^D + s_{S_{kl}^D - 1}}}$$

# Delegated Interaction

$$\varepsilon_k^D = \left\langle \nu_k^D, D, t_k^D, \eta_k^D\left(\varepsilon_{k-1}^D\right), \mathtt{ixn}, [data], \widehat{s}_{kl}^D \right\rangle \widehat{\sigma}_{kl}^D$$

# Witness Rotations

$$\widehat{W}_0 = \left[ W_0 , W_1 , \cdots , W_{N-1} \right]$$

$$\widehat{W}_l = \left( \widehat{W}_{l-1} - \widehat{X}_l \right) \bigcap \widehat{Y}_l$$

$$\widehat{X}_l \subseteq \widehat{W}_{l-1} \quad \widehat{Y}_l \not\subset \widehat{W}_{l-1} \quad \widehat{X}_l \not\subset \widehat{W}_l$$

$$N_l = N_{l-1} - O_l + P_l$$

$$M_l \le N_l$$

$$\left| \widehat{X}_l \right| = O_l \quad \left| \widehat{Y}_l \right| = P_l \quad \left| \widehat{W}_l \right| = N_l$$

$$\widehat{U}_{l-1} \subseteq \widehat{W}_{l-1} \qquad \left| \widehat{U}_{l-1} \right| \ge M_{l-1}$$

$$\widehat{U}_l \subseteq \widehat{W}_l \qquad \left| \widehat{U}_l \right| \ge M_l$$

$$\left| \widehat{U}_{l-1} \bigcup \widehat{U}_l \right| \le M_{l-1} + M_l$$

# Complex Weighted Signing Thresholds

$$\widehat{C}_l = \left[ C_l^1, \ldots, C_l^{L_l} \right]_l$$

$$\widehat{K}_l = \left[ U_l^1, \ldots, U_l^{L_1} \right]_l$$

$$0 < U_l^j \le 1$$

$$\widehat{s}_k^l = \left[ s_0, \ldots, s_{S_k^l - 1} \right]_k^l$$

$$\bar{U}_l = \sum_{i=s_0}^{s_{S_k-1}} U_l^i \ge 1$$

$$\widehat{C} = \left[ C^1, C^2, C^3 \right]$$

$$U_l^j = {}^1\!/\!_{K_l}$$

$$\widehat{K} = \left[ \tfrac{1}{2}, \tfrac{1}{2}, \tfrac{1}{2} \right]$$

$$\widehat{K}_l = \left[ \tfrac{1}{2}, \tfrac{1}{2}, \tfrac{1}{4}, \tfrac{1}{4}, \tfrac{1}{4}, \tfrac{1}{4} \right]_l$$

$$\widehat{K}_l = \left[ \left[ \tfrac{1}{2}, \tfrac{1}{2}, \tfrac{1}{4}, \tfrac{1}{4}, \tfrac{1}{4}, \tfrac{1}{4} \right], \left[ \tfrac{1}{2}, \tfrac{1}{2}, \tfrac{1}{2}, \tfrac{1}{2} \right], \left[ 1, 1, 1, 1 \right] \right]$$

# BACKGROUND

# Derivation Code Tables

Length of crypt material determines number of pad characters. One character table for one pad char. Two character table for two pad char.

One Character KERI Base64 Prefix Derivation Code Selector

| Derivation Code | Prefix Description |
|---|---|
| 0 | Two character derivation code. Use two character table. |
| 1 | Four character derivation code. Use four character table. |
| 2 | Five character derivation code. Use five character table. |
| 3 | Six character derivation code. Use six character table. |
| 4 | Eight character derivation code. Use eight character table. |
| 5 | Nine character derivation code. Use nine character table. |
| 6 | Ten character derivation code. Use ten character table. |

One Character KERI Base64 Prefix Derivation Code

| Derivation Code | Prefix Description | Data Length Bytes | Pad Length | Derivation Code Length | Prefix Length Base64 | Prefix Length Bytes |
|---|---|---|---|---|---|---|
| A | Non-transferable prefix using Ed25519 public signing verification key. Basic derivation. | 32 | 1 | 1 | 44 | 33 |
| B | X25519 public encryption key. May be converted from Ed25519 public signing verification key. | 32 | 1 | 1 | 44 | 33 |
| C | Ed25519 public signing verification key. Basic derivation. | 32 | 1 | 1 | 44 | 33 |
| D | Blake3-256 Digest. Self-addressing derivation. | 32 | 1 | 1 | 44 | 33 |
| E | Blake2b-256 Digest. Self-addressing derivation. | 32 | 1 | 1 | 44 | 33 |
| F | Blake2s-256 Digest. Self-addressing derivation. | 32 | 1 | 1 | 44 | 33 |
| G | Non-transferable prefix using ECDSA secp256k1 public singing verification key. Basic derivation. | 32 | 1 | 1 | 44 | 33 |
| H | ECDSA secp256k1 public signing verification key. Basic derivation. | 32 | 1 | 1 | 44 | 33 |
| I | SHA3-256 Digest. Self-addressing derivation. | 32 | 1 | 1 | 44 | 33 |
| J | SHA2-256 Digest. Self-addressing derivation. | 32 | 1 | 1 | 44 | 33 |

Two Character KERI Base64 Prefix Derivation Code

| Derivation Code | Prefix Description | Data Length Bytes | Pad Length | Derivation Code Length | Prefix Length Base64 | Prefix Length Bytes |
|---|---|---|---|---|---|---|
| 0A | Ed25519 signature. Self-signing derivation. | 64 | 2 | 2 | 88 | 66 |
| 0B | ECDSA secp256k1 signature. Self-signing derivation. | 64 | 2 | 2 | 88 | 66 |
| 0C | Blake3-512 Digest. Self-addressing derivation. | 64 | 2 | 2 | 88 | 66 |
| 0D | SHA3-512 Digest. Self-addressing derivation. | 64 | 2 | 2 | 88 | 66 |
| 0E | Blake2b-512 Digest. Self-addressing derivation. | 64 | 2 | 2 | 88 | 66 |
| 0F | SHA2-512 Digest. Self-addressing derivation. | 64 | 2 | 2 | 88 | 66 |

# Base64

## Base64 Decode Binary from ASCII

Base64 Binary Decoding from ASCII

| ASCII Char | Base 64 Index Deci mal | Base64 Index Hex | Base64 Index 6 bit Binary | ASCII Char | Base 64 Index Deci mal | Base 64 Index Hex | Base64 Index 6 bit Binary | ASCII Char | Base 64 Index Deci mal | Base 64 Index Hex | Base64 Index 6 bit Binary | ASCII Char | Base 64 Index Deci mal | Base 64 Index Hex | Base64 Index 6 bit Binary |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 0 | 00 | 000000 | Q | 16 | 10 | 010000 | g | 32 | 20 | 100000 | w | 48 | 30 | 110000 |
| B | 1 | 01 | 000001 | R | 17 | 11 | 010001 | h | 33 | 21 | 100001 | x | 49 | 31 | 110001 |
| C | 2 | 02 | 000010 | S | 18 | 12 | 010010 | i | 34 | 22 | 100010 | y | 50 | 32 | 110010 |
| D | 3 | 03 | 000011 | T | 19 | 13 | 010011 | j | 35 | 23 | 100011 | z | 51 | 33 | 110011 |
| E | 4 | 04 | 000100 | U | 20 | 14 | 010100 | k | 36 | 24 | 100100 | 0 | 52 | 34 | 110100 |
| F | 5 | 05 | 000101 | V | 21 | 15 | 010101 | l | 37 | 25 | 100101 | 1 | 53 | 35 | 110101 |
| G | 6 | 06 | 000110 | W | 22 | 16 | 010110 | m | 38 | 26 | 100110 | 2 | 54 | 36 | 110110 |
| H | 7 | 07 | 000111 | X | 23 | 17 | 010111 | n | 39 | 27 | 100111 | 3 | 55 | 37 | 110111 |
| I | 8 | 08 | 001000 | Y | 24 | 18 | 011000 | o | 40 | 28 | 101000 | 4 | 56 | 38 | 111000 |
| J | 9 | 09 | 001001 | Z | 25 | 19 | 011001 | p | 41 | 29 | 101001 | 5 | 57 | 39 | 111001 |
| K | 10 | 0A | 001010 | a | 26 | 1A | 011010 | q | 42 | 2A | 101010 | 6 | 58 | 3A | 111010 |
| L | 11 | 0B | 001011 | b | 27 | 1B | 011011 | r | 43 | 2B | 101011 | 7 | 59 | 3B | 111011 |
| M | 12 | 0C | 001100 | c | 28 | 1C | 011100 | s | 44 | 2C | 101100 | 8 | 60 | 3C | 111100 |
| N | 13 | 0D | 001101 | d | 29 | 1D | 011101 | t | 45 | 2D | 101101 | 9 | 61 | 3D | 111101 |
| O | 14 | 0E | 001110 | e | 30 | 1E | 011110 | u | 46 | 2E | 101110 | - | 62 | 3E | 111110 |
| P | 15 | 0F | 001111 | f | 31 | 1F | 011111 | v | 47 | 2F | 101111 | _ | 63 | 3F | 111111 |

# Certificate Transparency Problem

"The solution the computer world has relied on for many years is to introduce into the system trusted third parties (CAs) that vouch for the binding between the domain name and the private key. The problem is that we've managed to bless several hundred of these supposedly trusted parties, any of which can vouch for any domain name. Every now and then, one of them gets it wrong, sometimes spectacularly."

Pinning inadequate
Notaries inadequate
DNSSec inadequate
All require trust in 3rd party compute infrastructure that is inherently vulnerable

Certificate Transparency: (related EFF SSL Observatory)
Public end-verifiable append-only event log with consistency and inclusion proofs
End-verifiable duplicity detection = Ambient verifiability of duplicity
Event log is third party infrastructure but zero trust because it is verifiable.
Sparse Merkle Trees for revocation of certificates

# Certificate Transparency Solution

Public end-verifiable append-only event log with consistency and inclusion proofs
End-verifiable duplicity detection = ambient verifiability of duplicity
Event log is third party infrastructure but it is not trusted because logs are verifiable.
Sparse Merkle trees for revocation of certificates
(related EFF SSL Observatory)

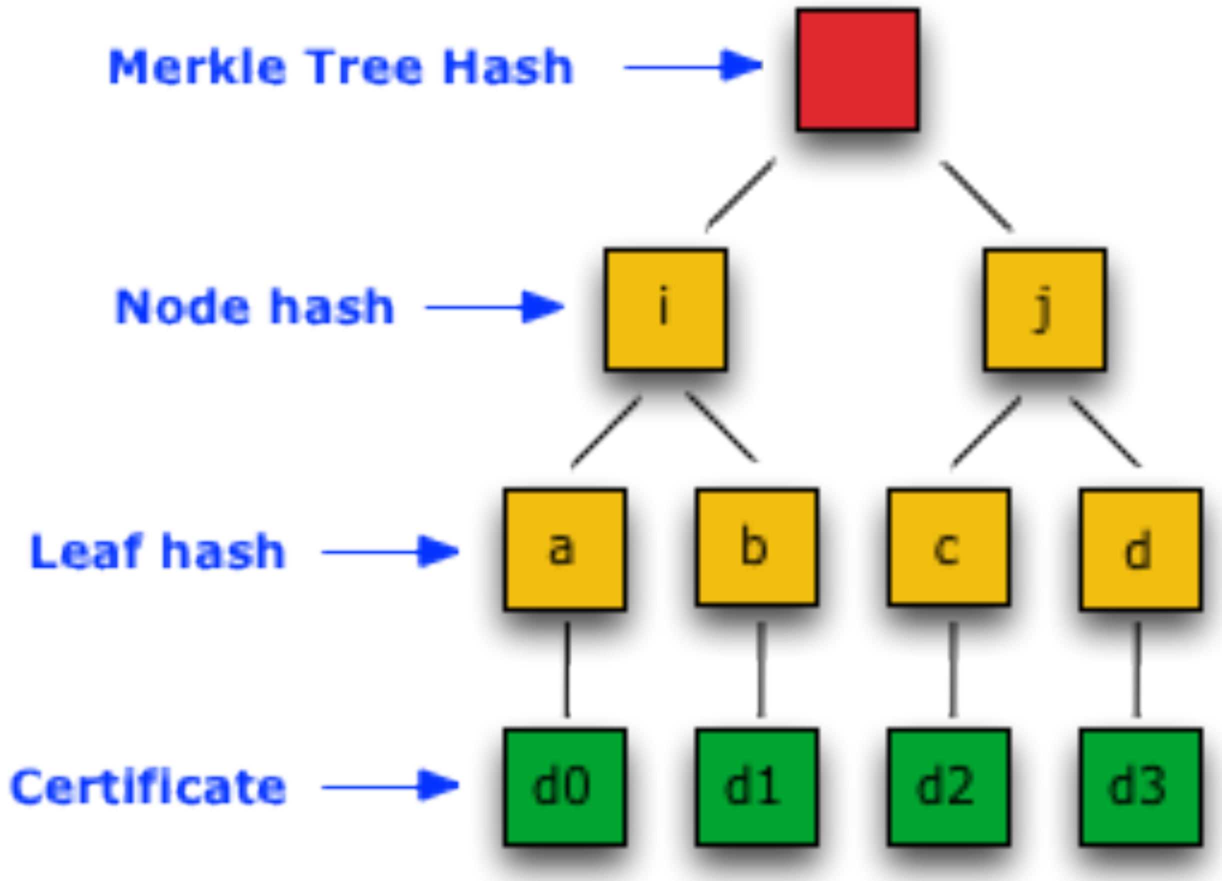



Figure 1

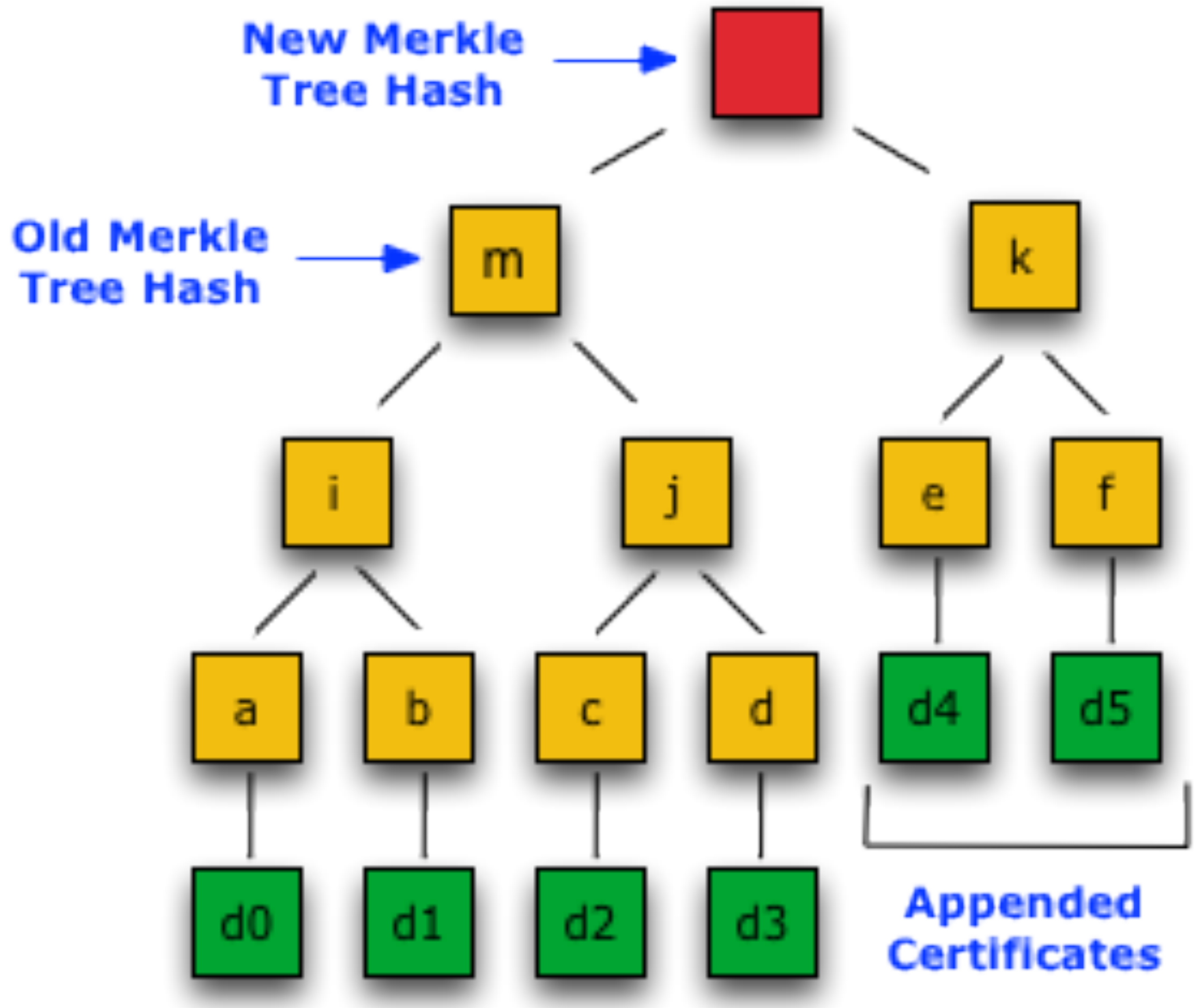



Figure 2

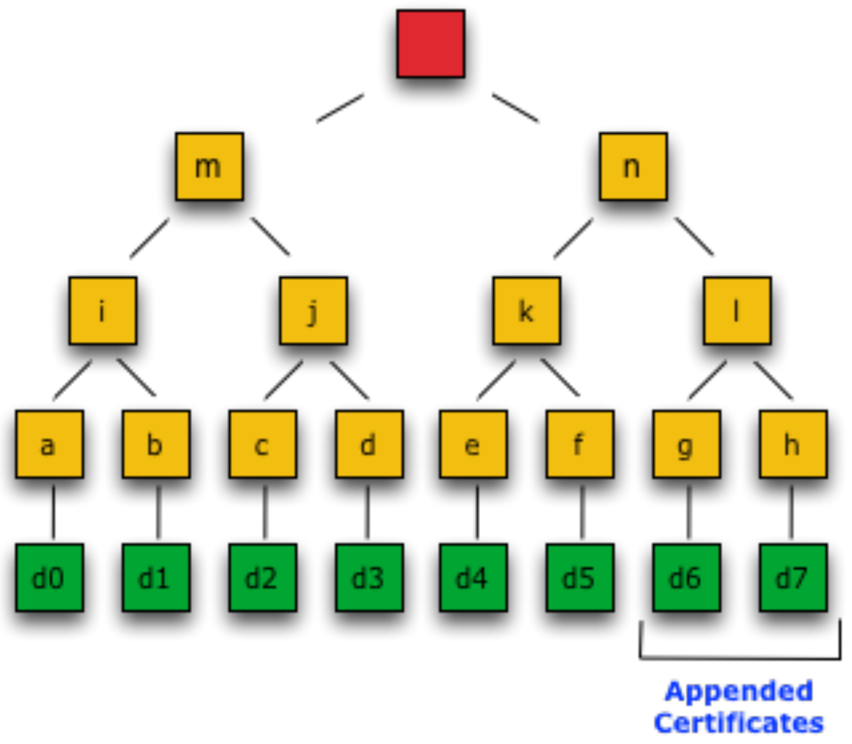



Figure 3

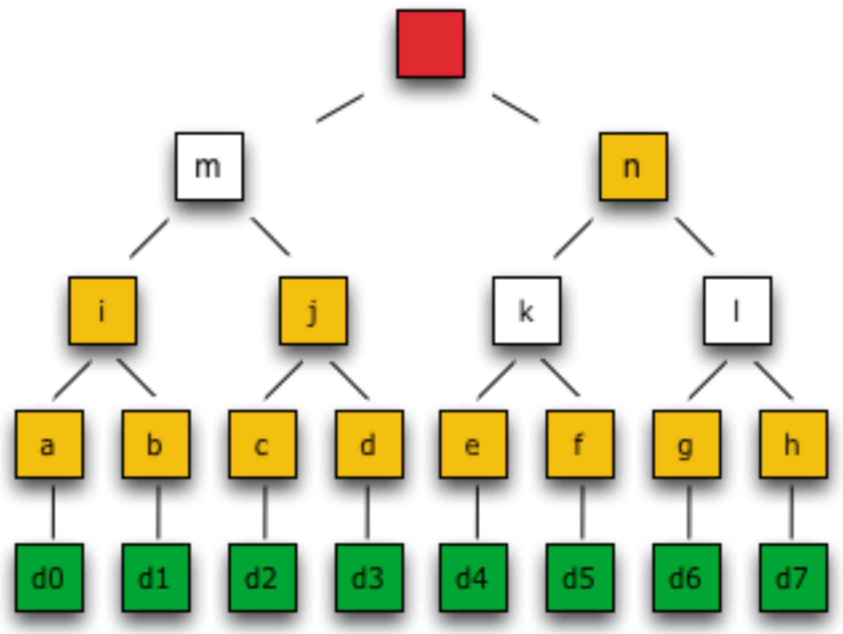


Figure 4