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

Samuel M. Smith Ph.D.
sam@prosapien.com
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# Background References


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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.*

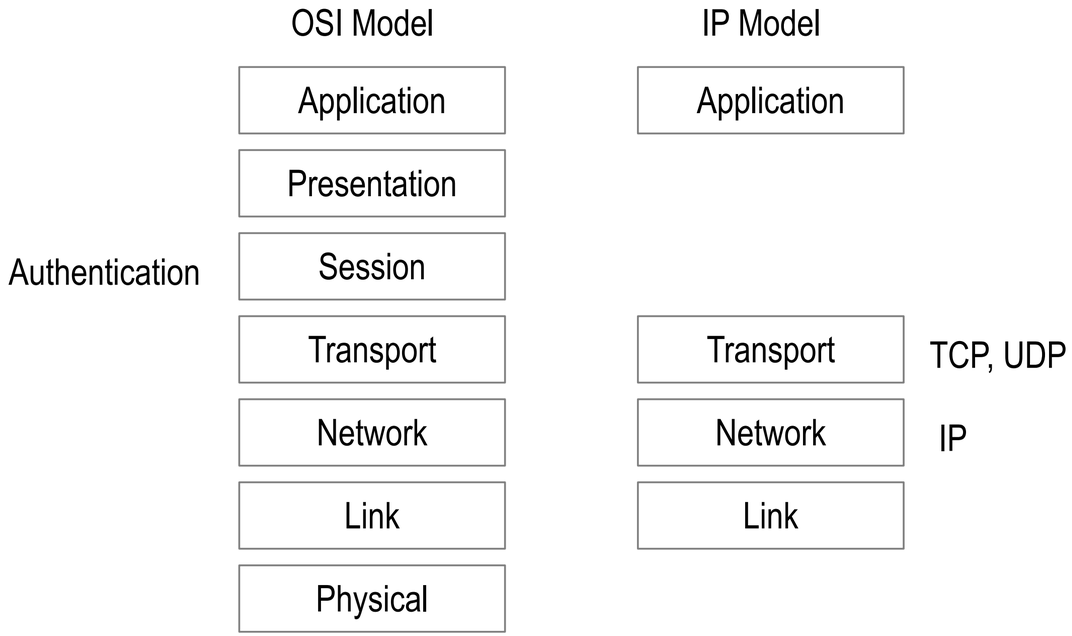
With verifiable digital signatures from asymmetric key crypto –
we may not trust in "*what*" was said, but we may trust in "*who*" said it.

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.

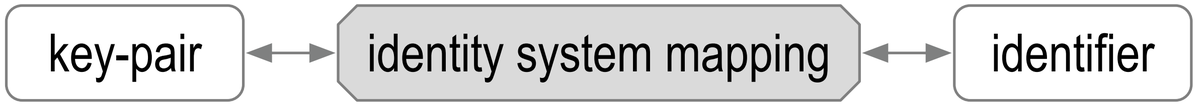


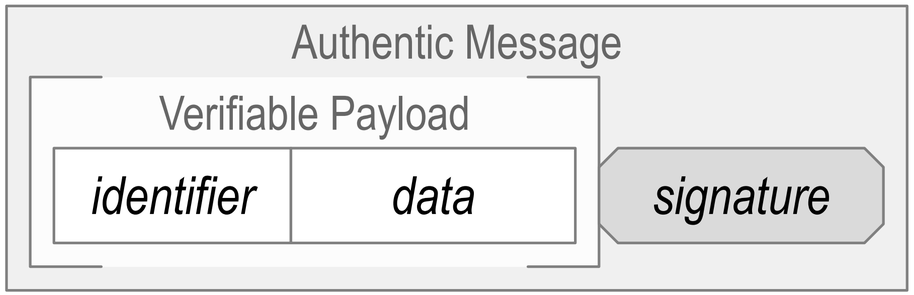

Instead …

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

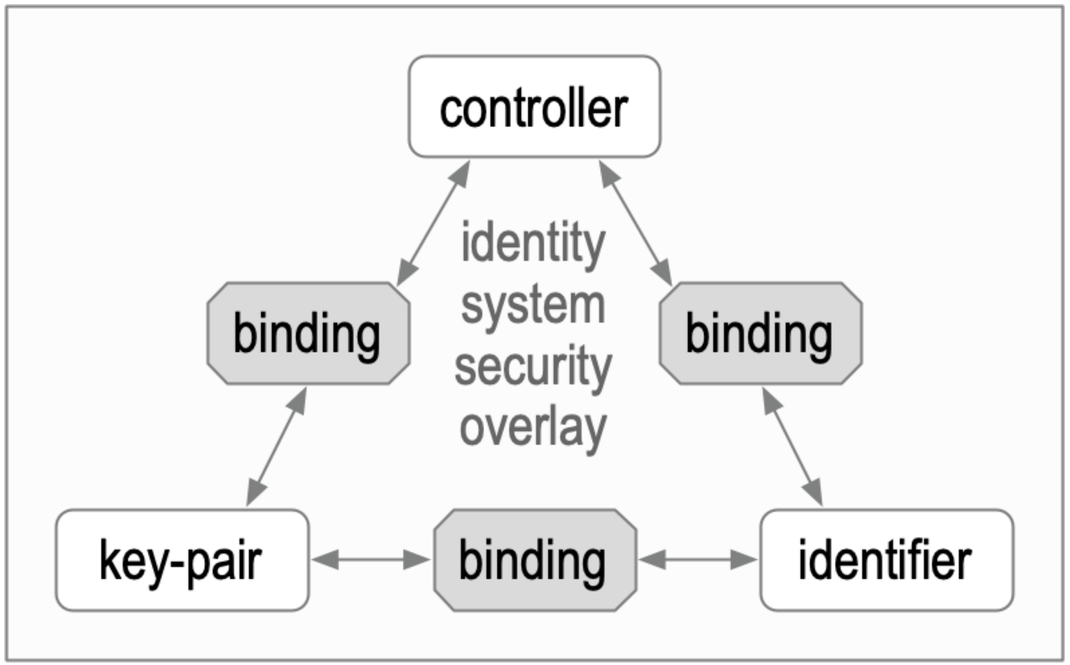
# Identity System Security Overlay

Establish authenticity of IP packet's message payload.



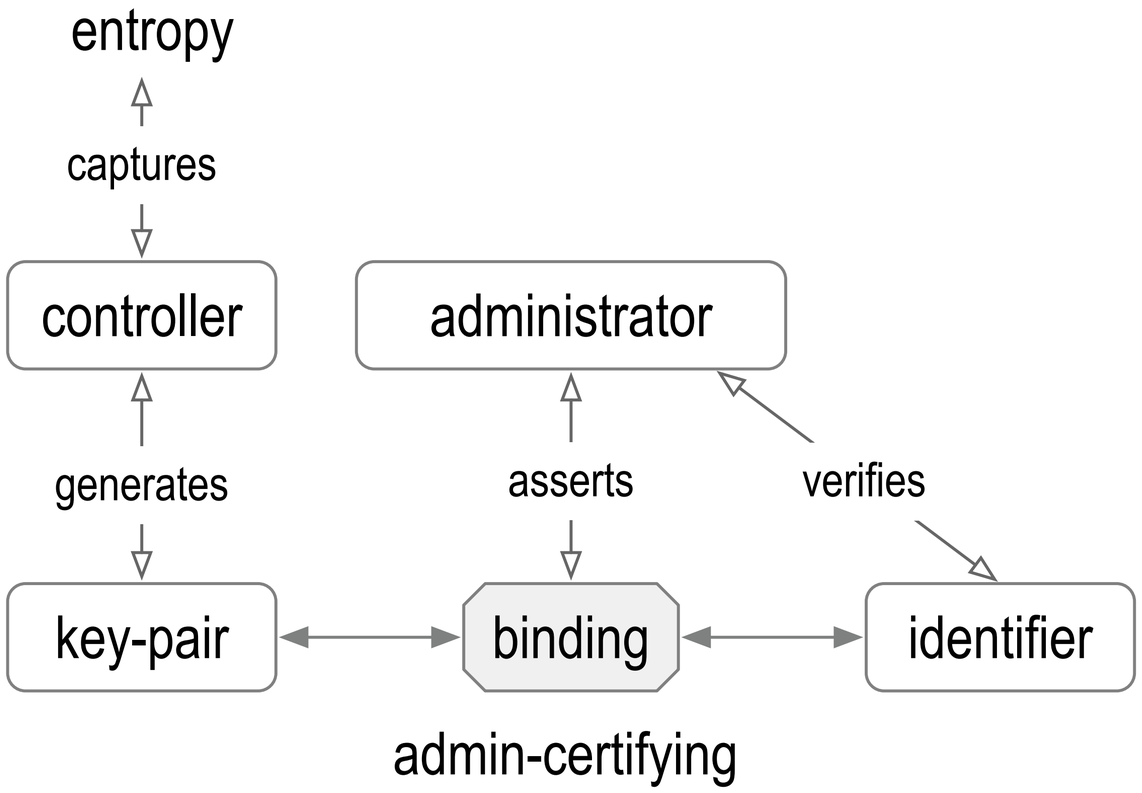



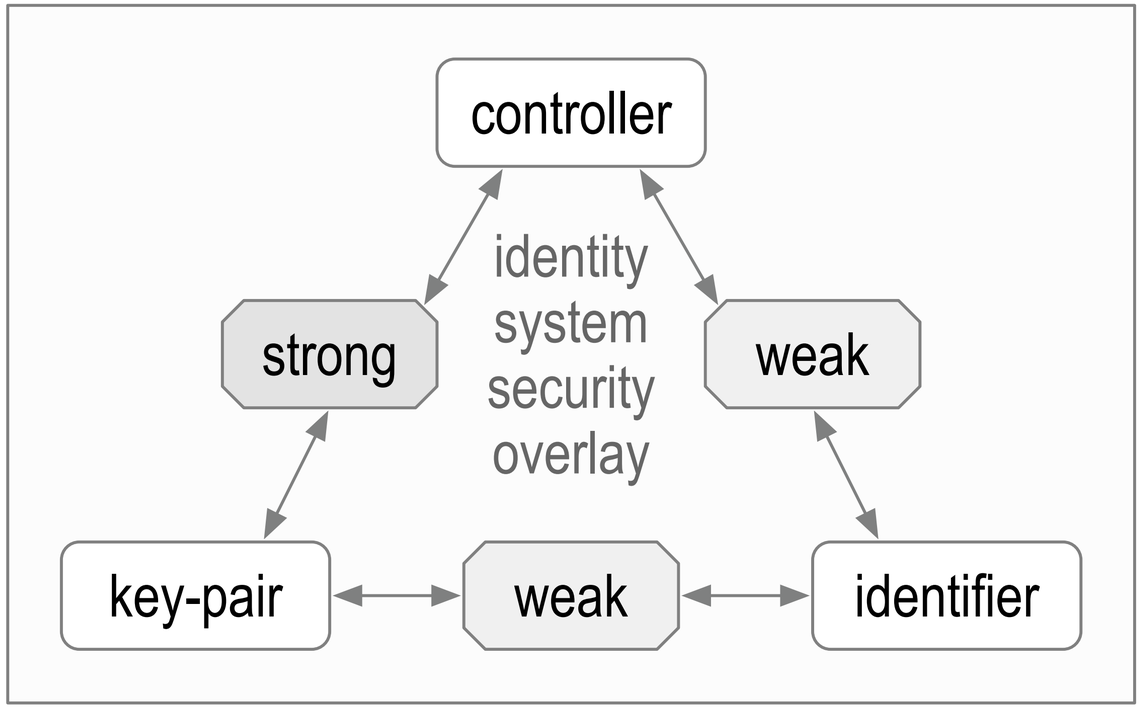

The overlay's security is contingent on the mapping's security.




Identifier Issuance

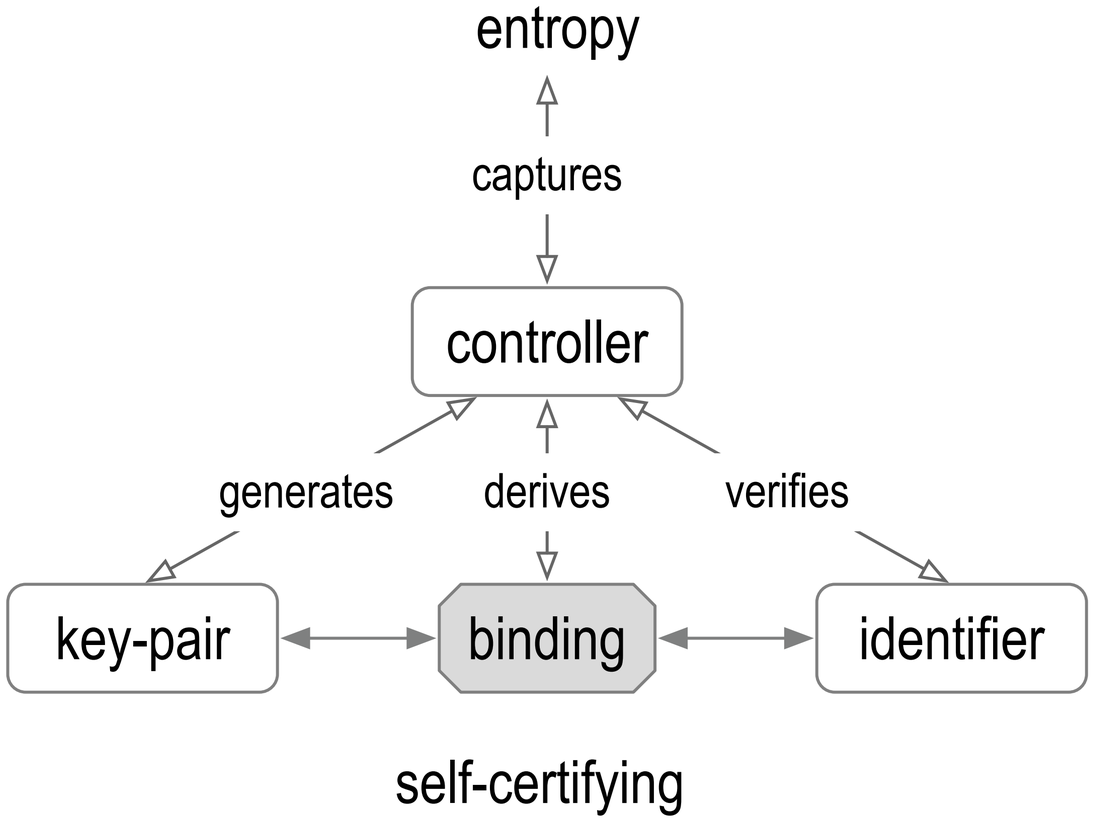
# Administrative Identifier Issuance and Binding

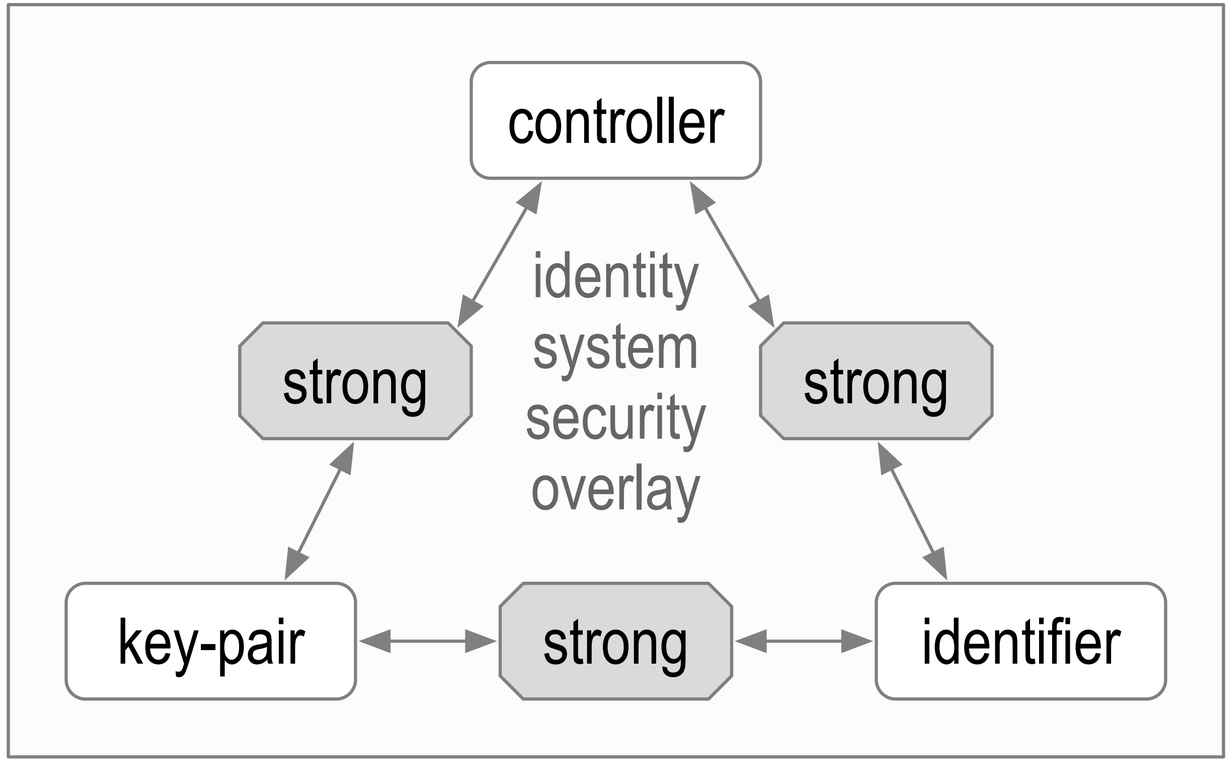



Admin-Certifying Identifier Issuance

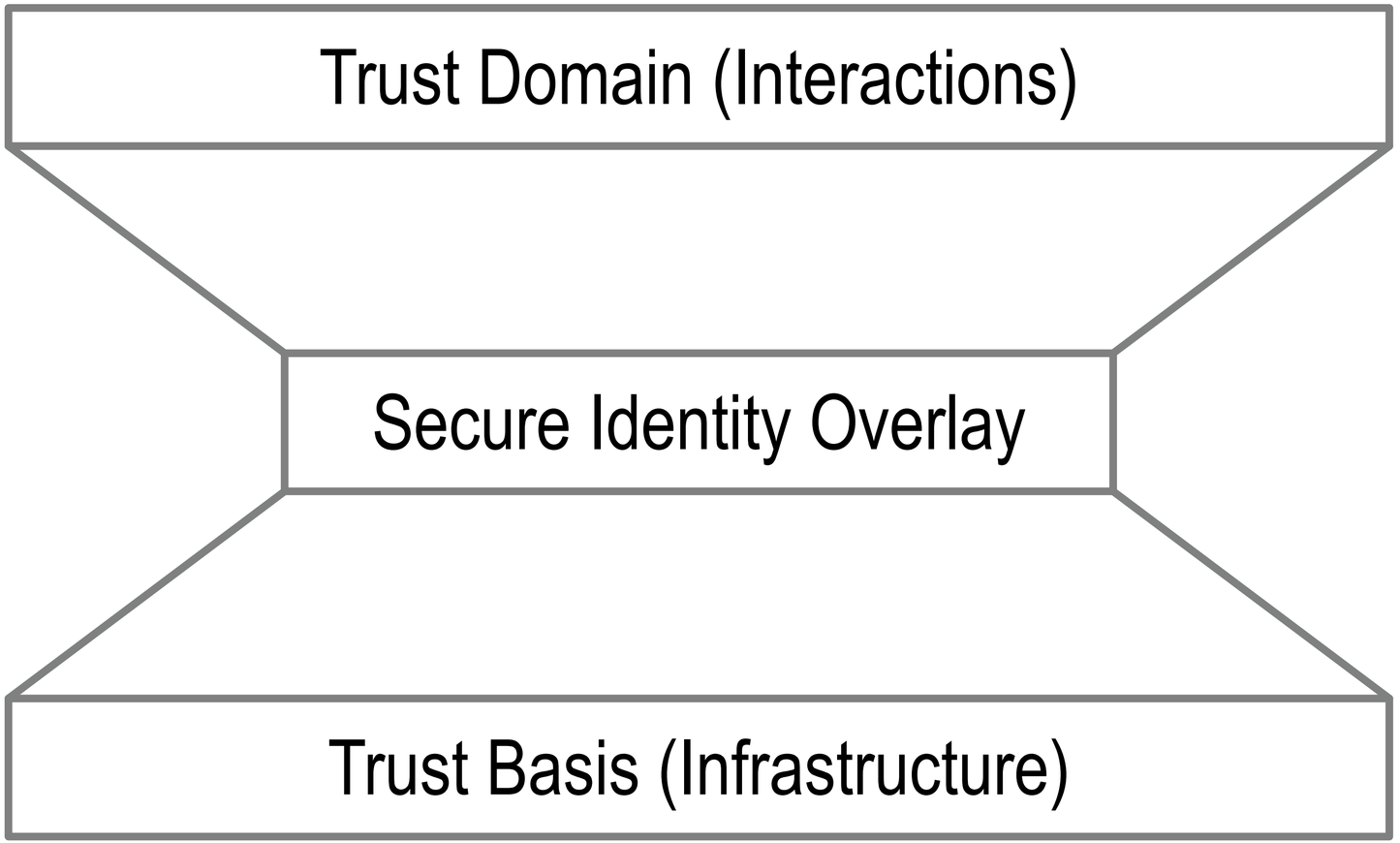
# Self-Certifying Identifier Issuance and Binding



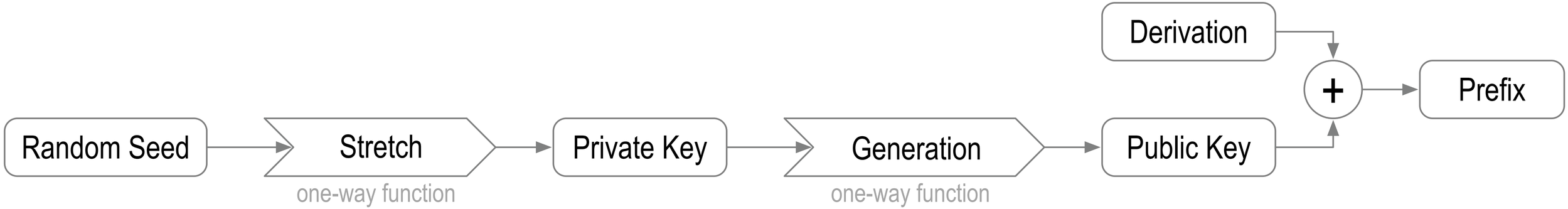



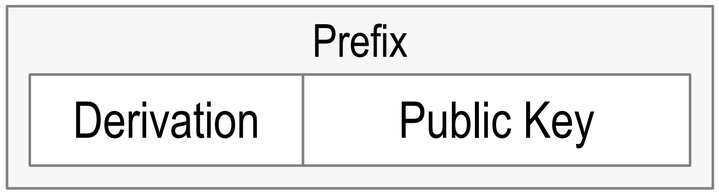

Self-Certifying Identifier Issuance

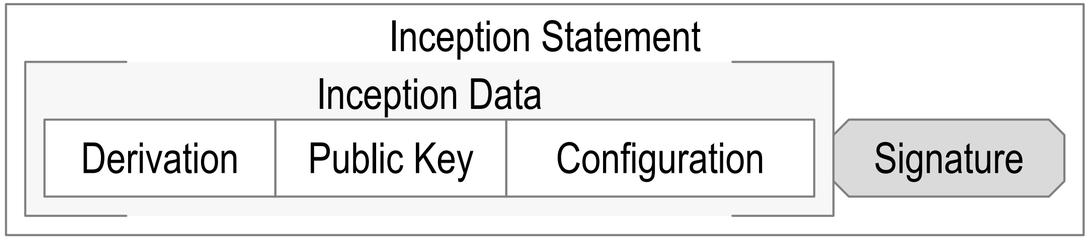
# Identity System Security Overlay



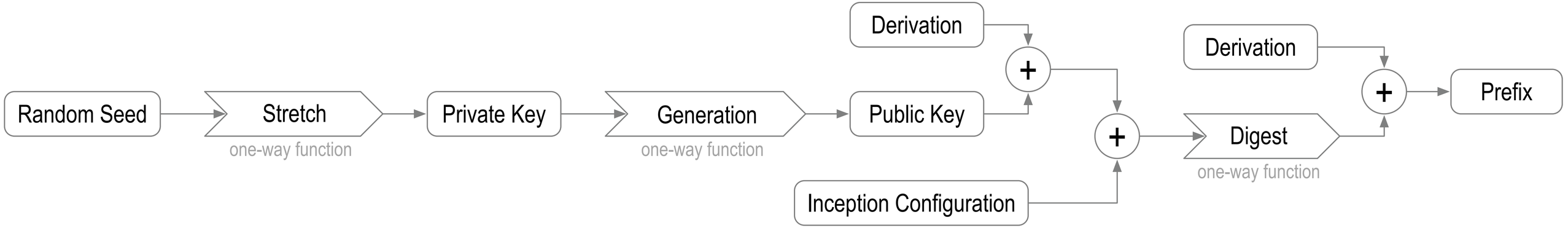
# Basic

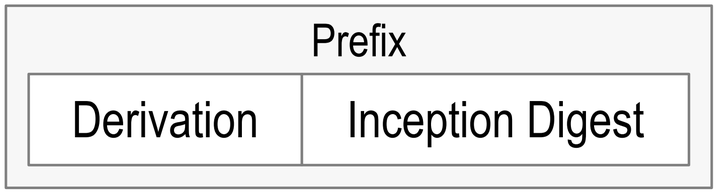

Derivation
+
Prefix
Random Seed
Stretch
one-way function
Private Key
Generation
one-way function
Public Key

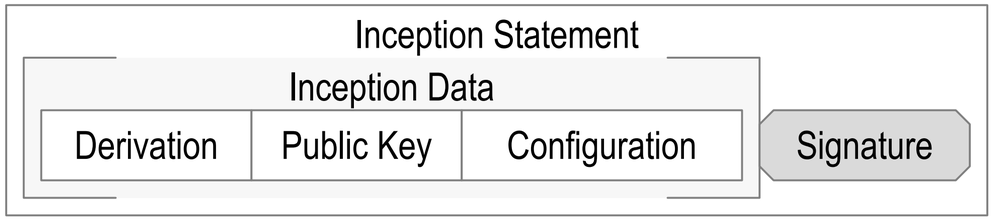

Prefix
Derivation
Public Key


Inception Statement
Inception Data
Derivation
Public Key
Configuration
Signature

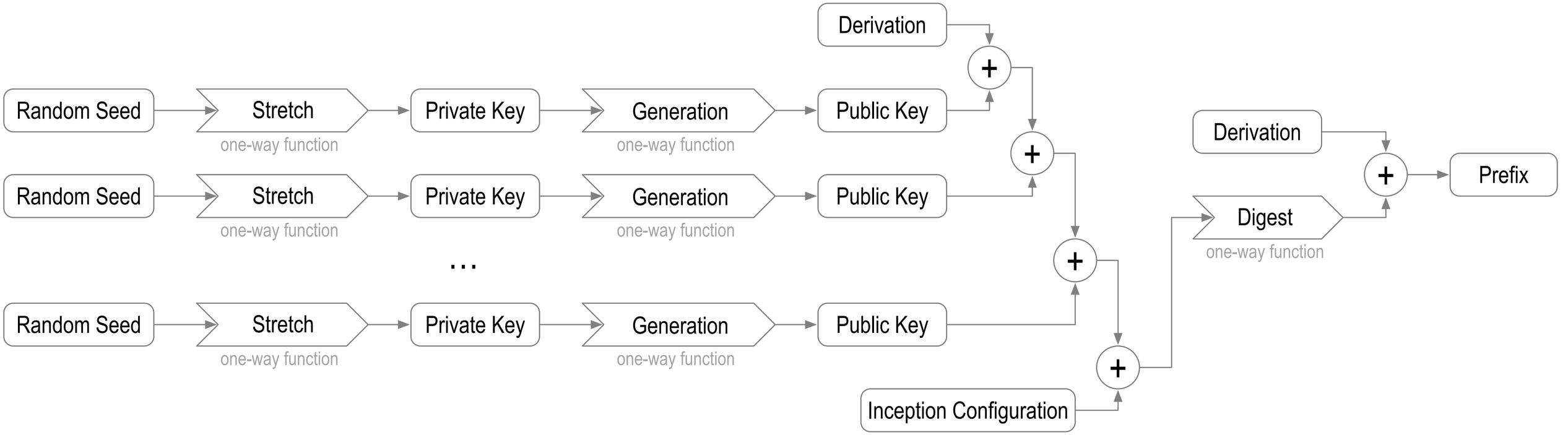
# Self-Addressing

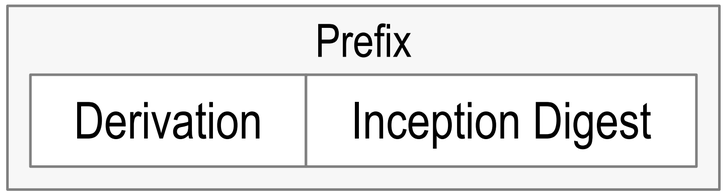


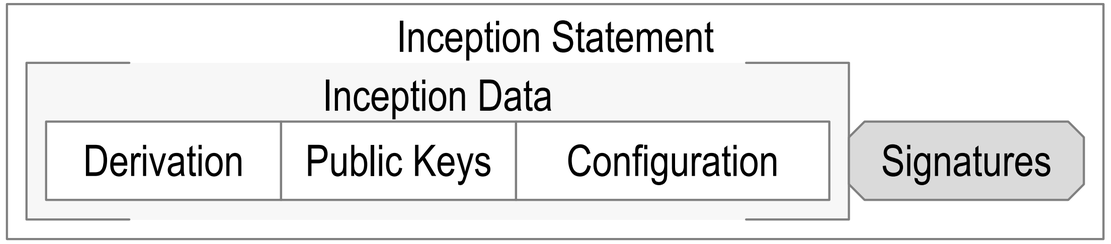



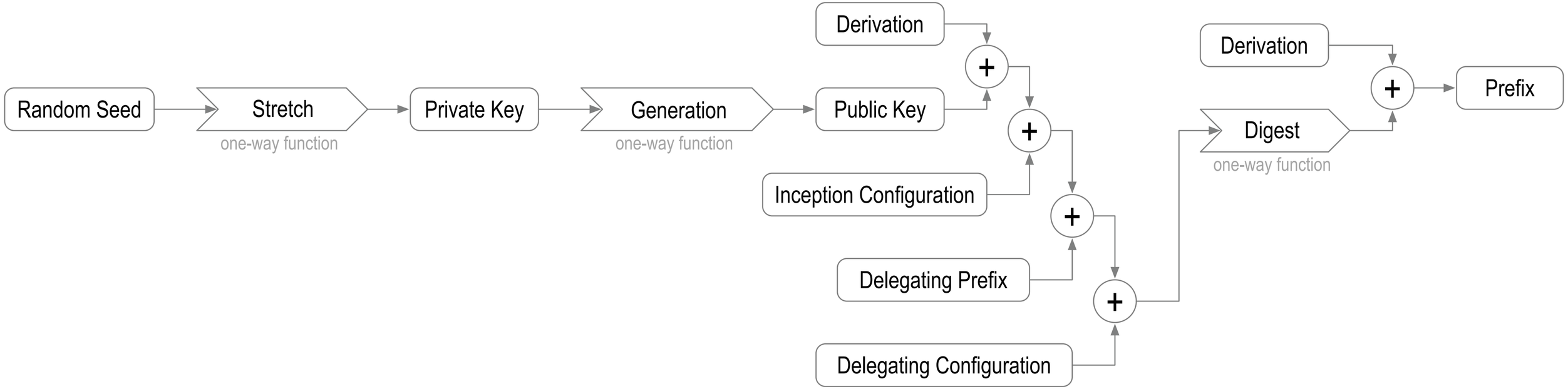
# Multi-Sig Self-Addressing

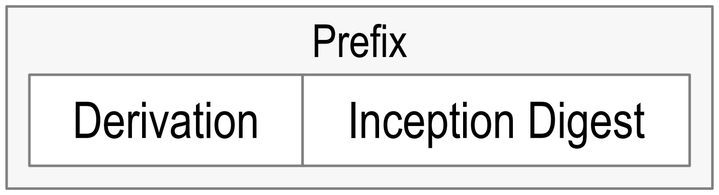


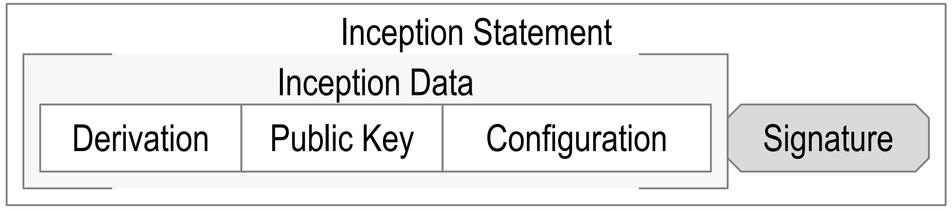



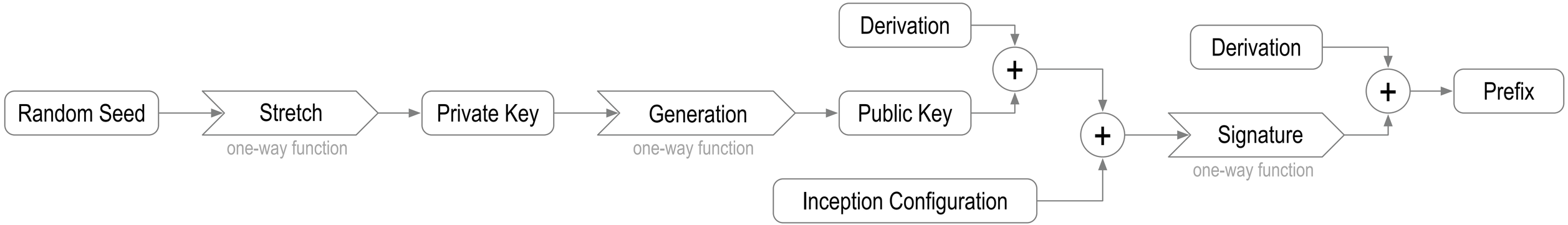
# Delegated Self-Addressing

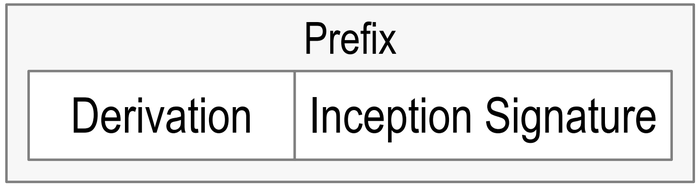


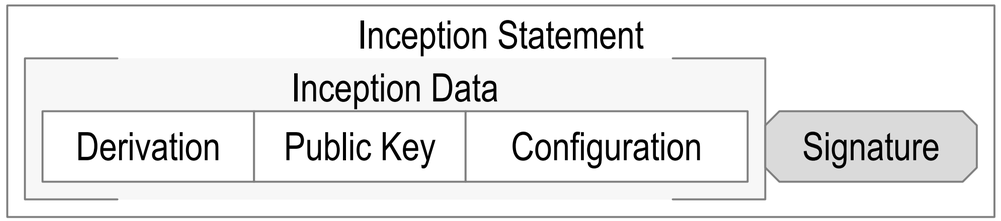



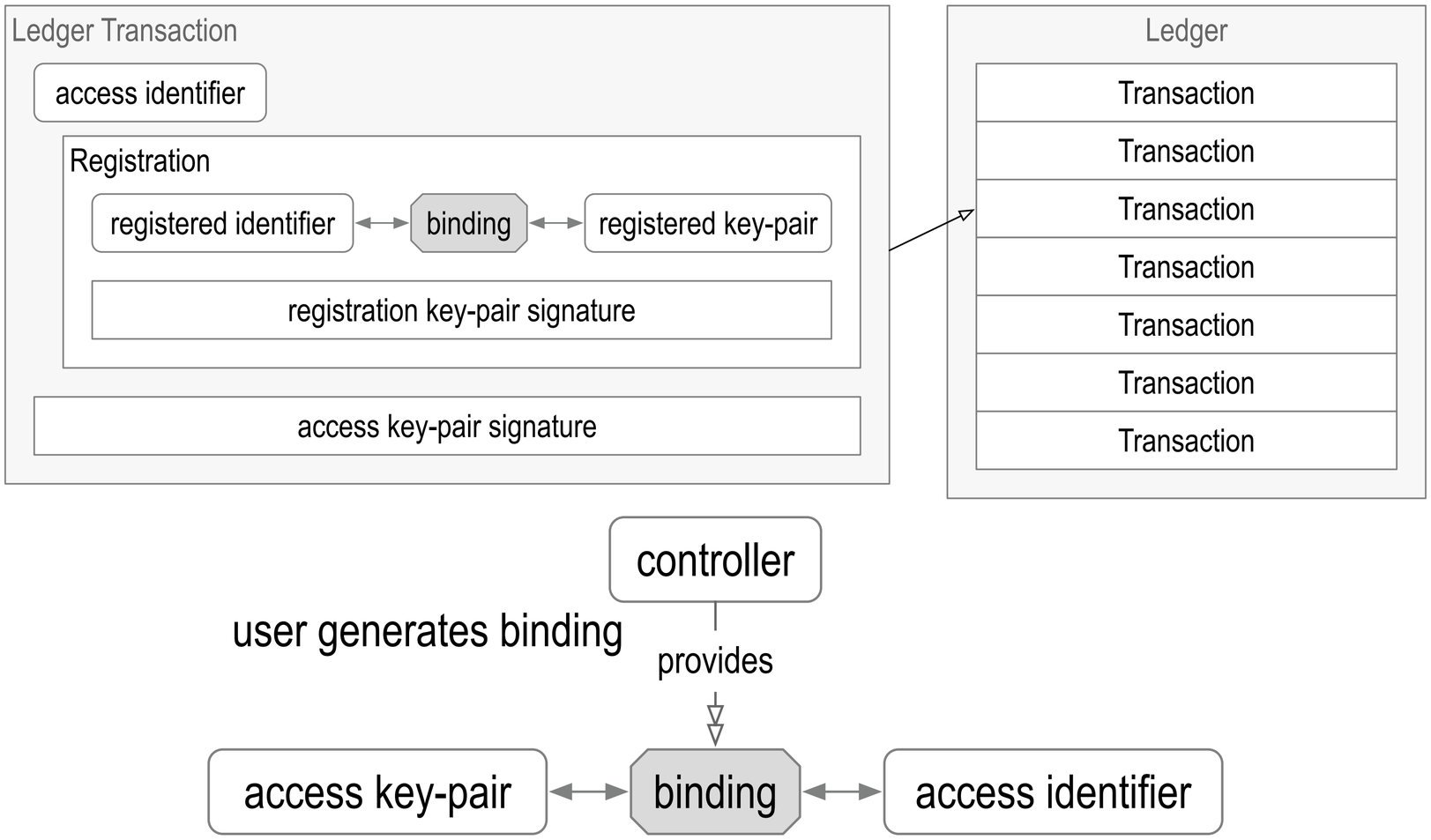
# Self-Signing



# 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*

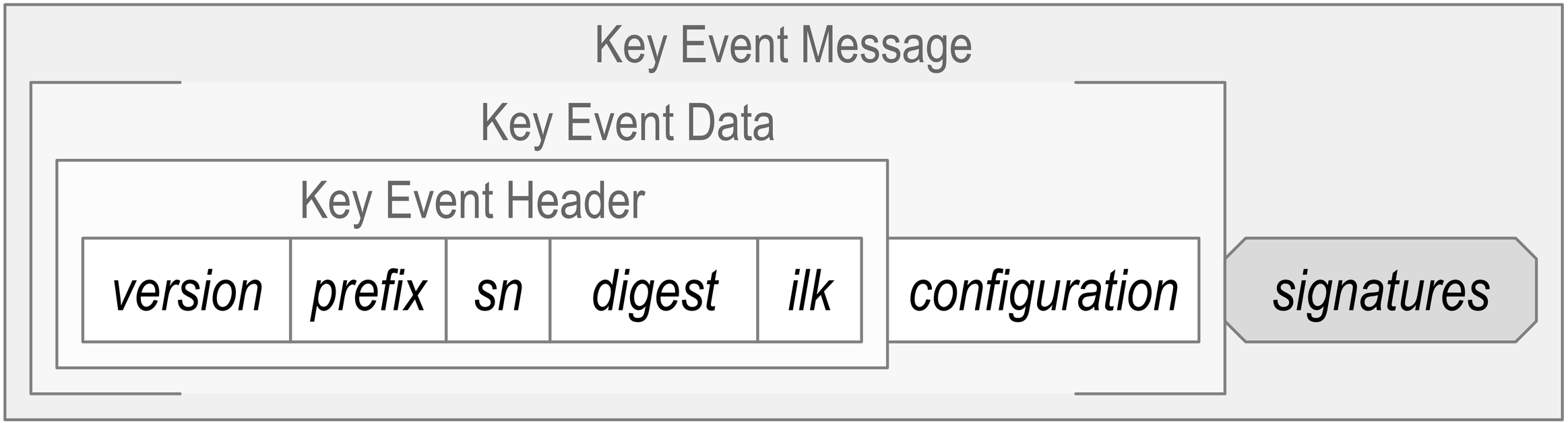
## Source-of-Truth

controller of the private key = *who*

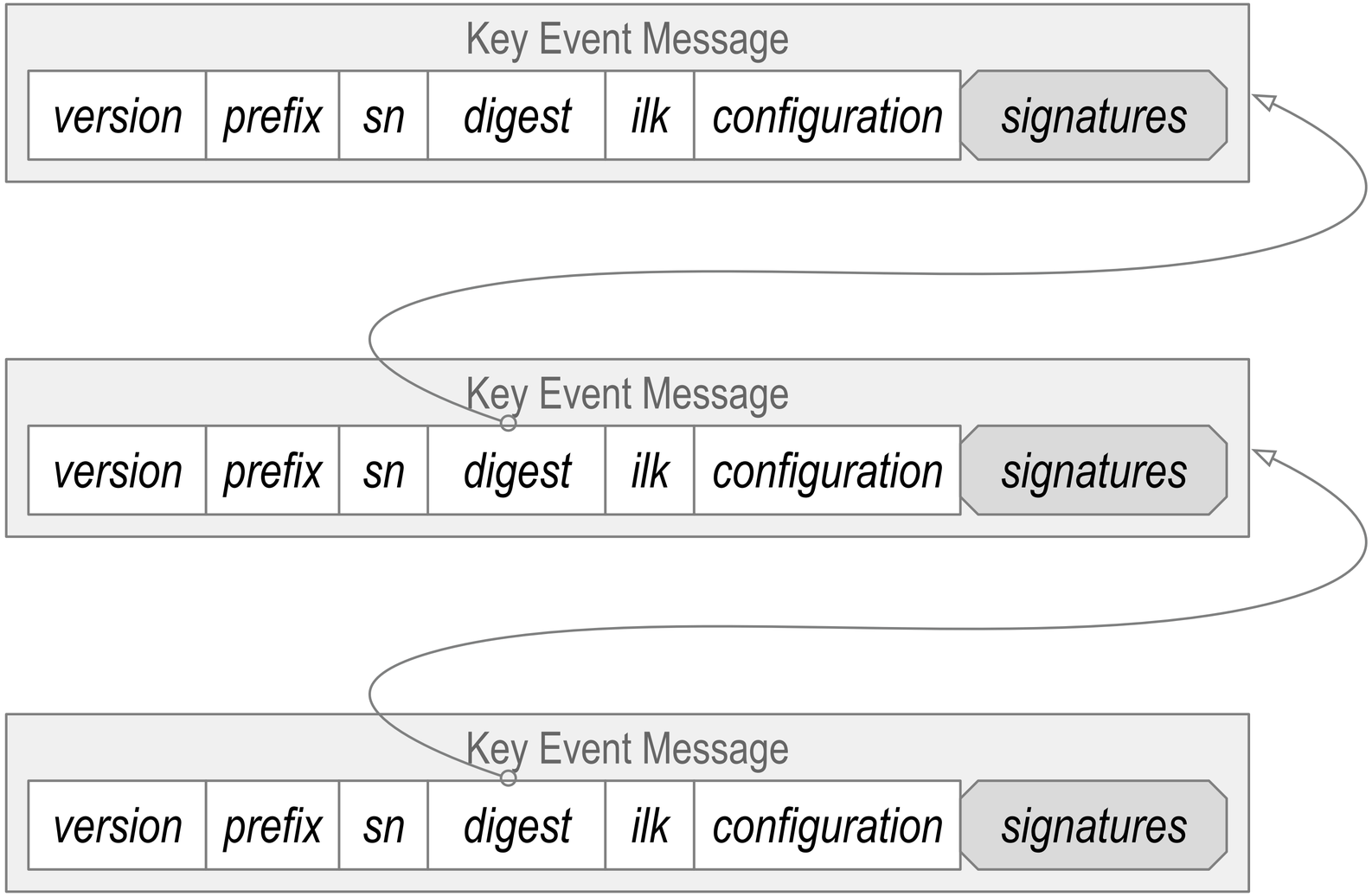
## Loci-of-Control

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

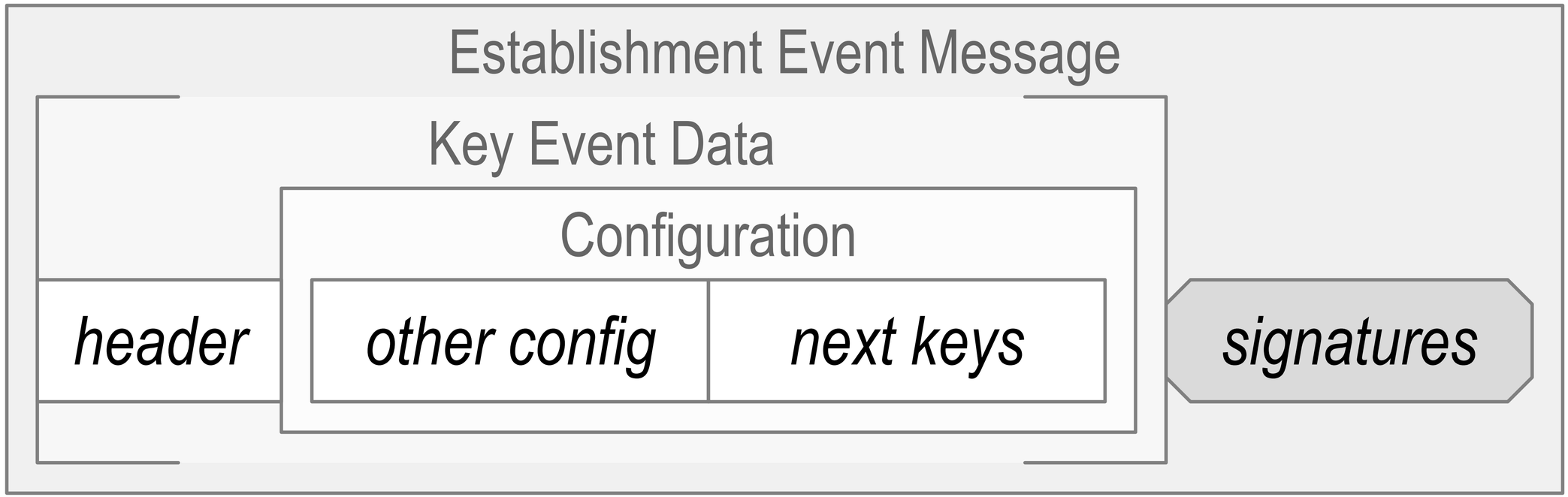
# Key Event Message




# Event Digest Chaining



# Establishment Event

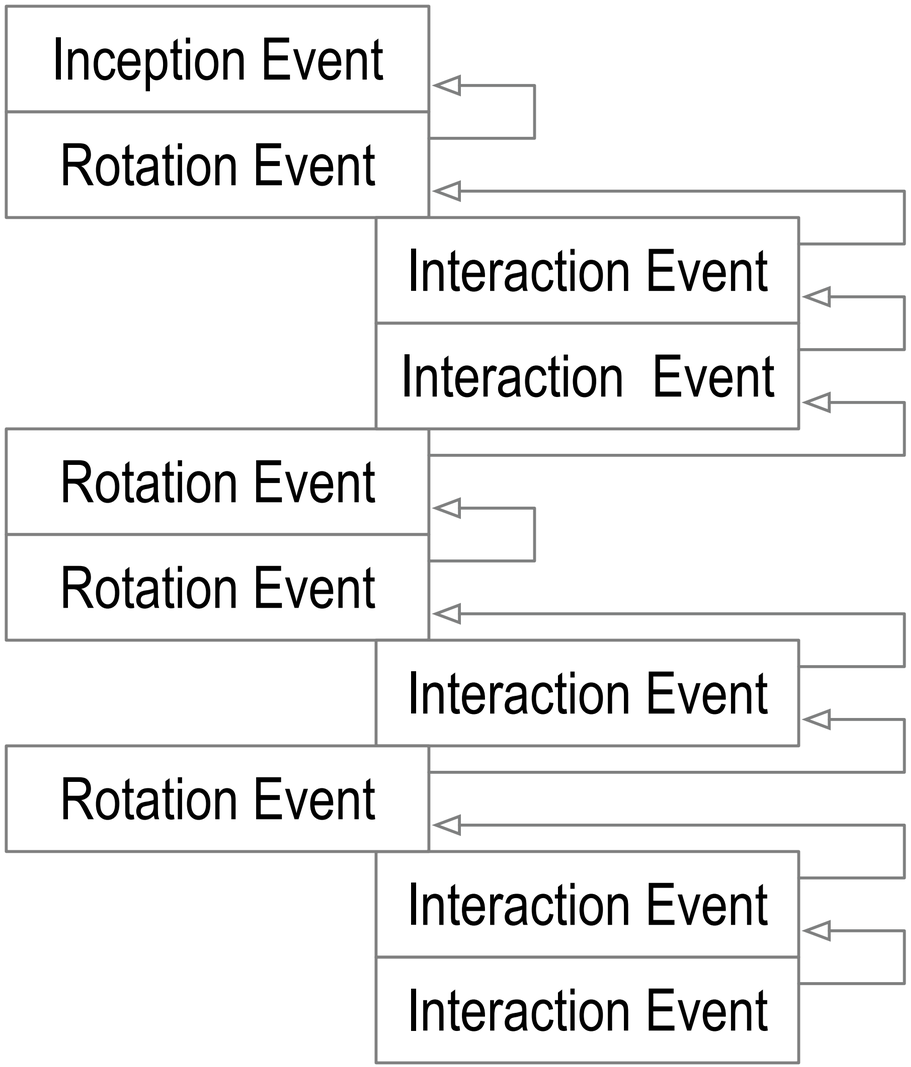


# Event Sequencing

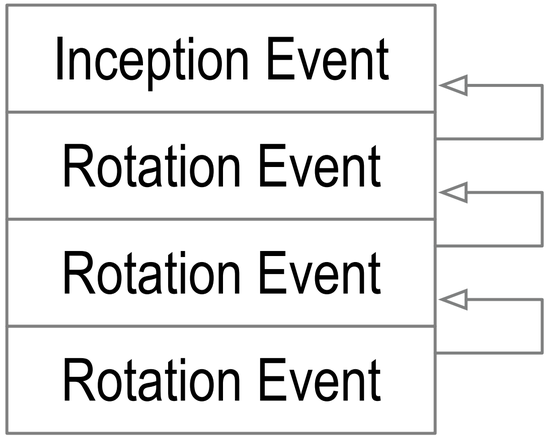
Full Sequence

Establishment Subsequence

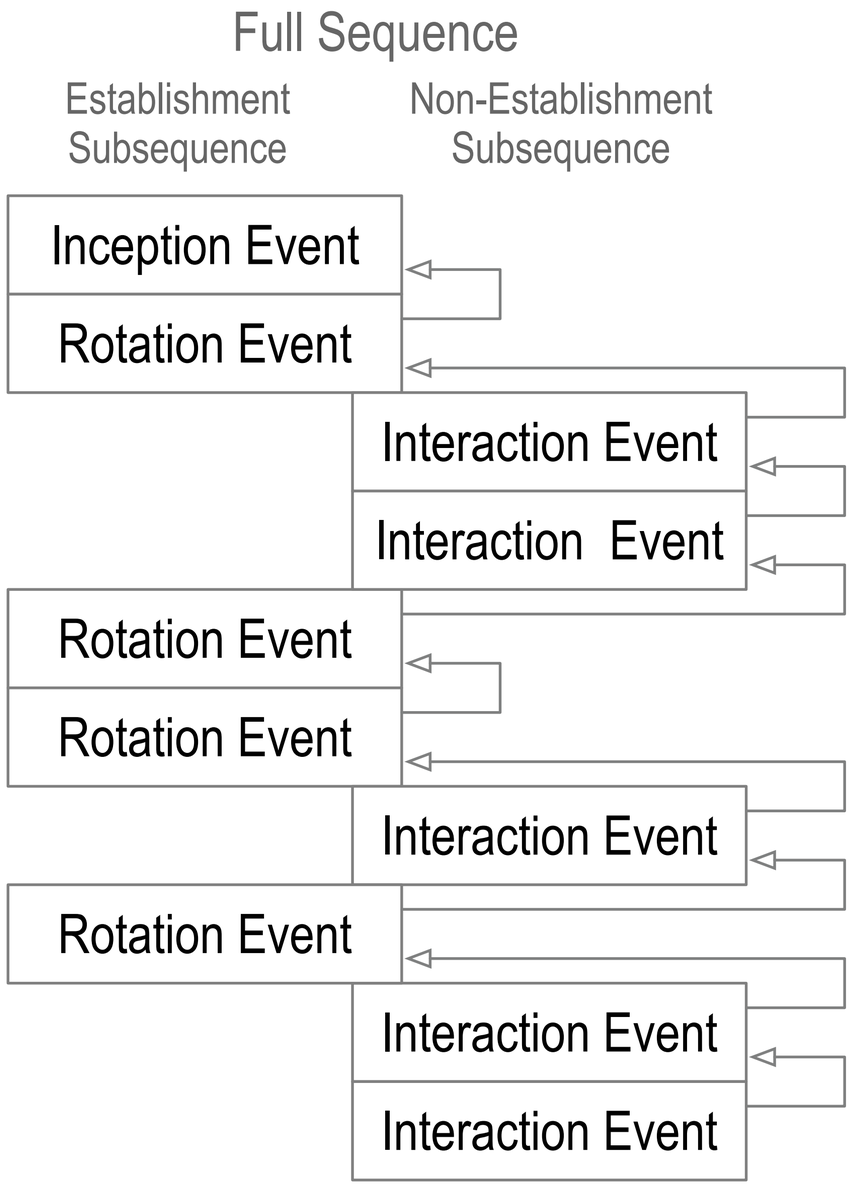
Non-Establishment Subsequence




Establishment Subsequence



# 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.

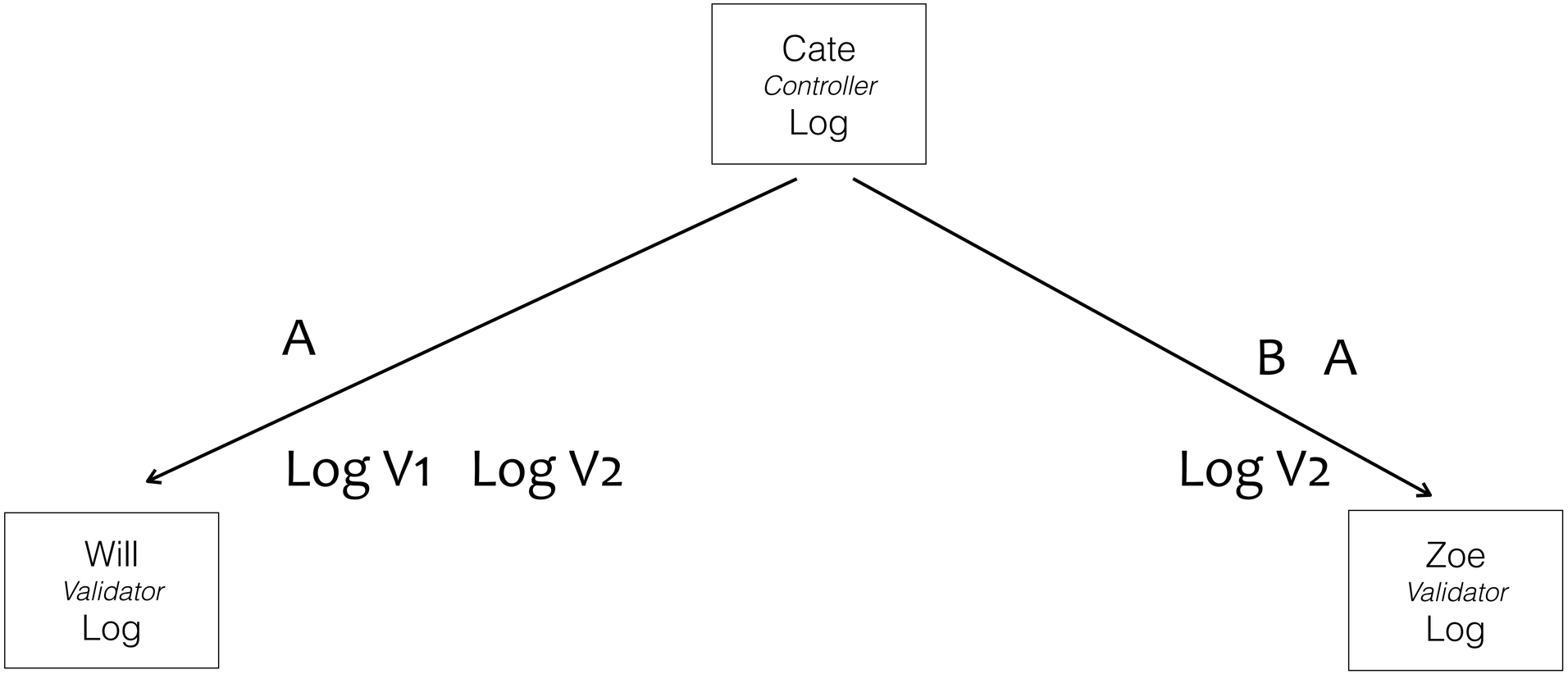
Duplicity detection protects against external inconsistency.

# Duplicity Game

Cate promises to provide a consistent pair-wise log.

*Local Consistency Guarantee*

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



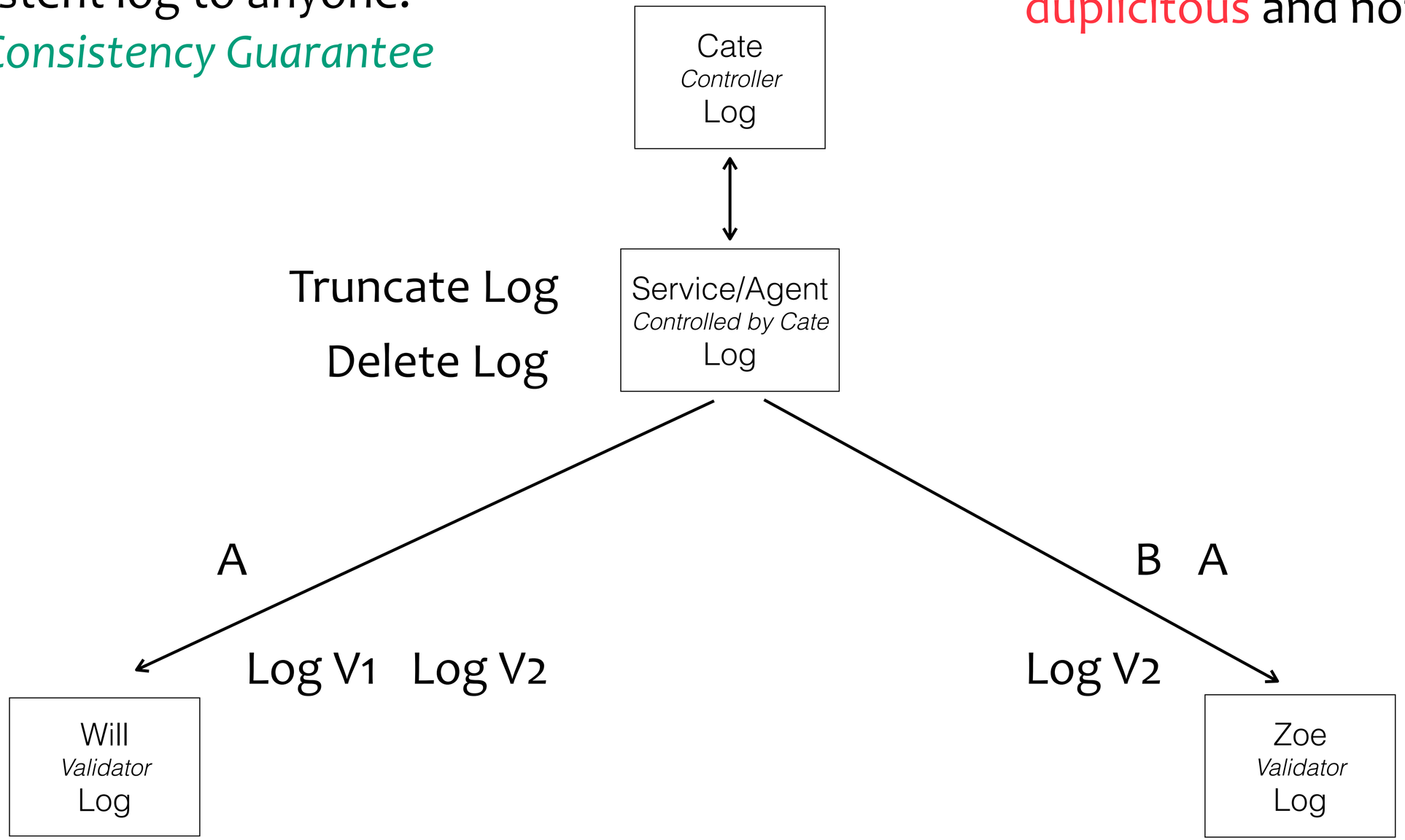

private (one-to-one) interactions

# 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

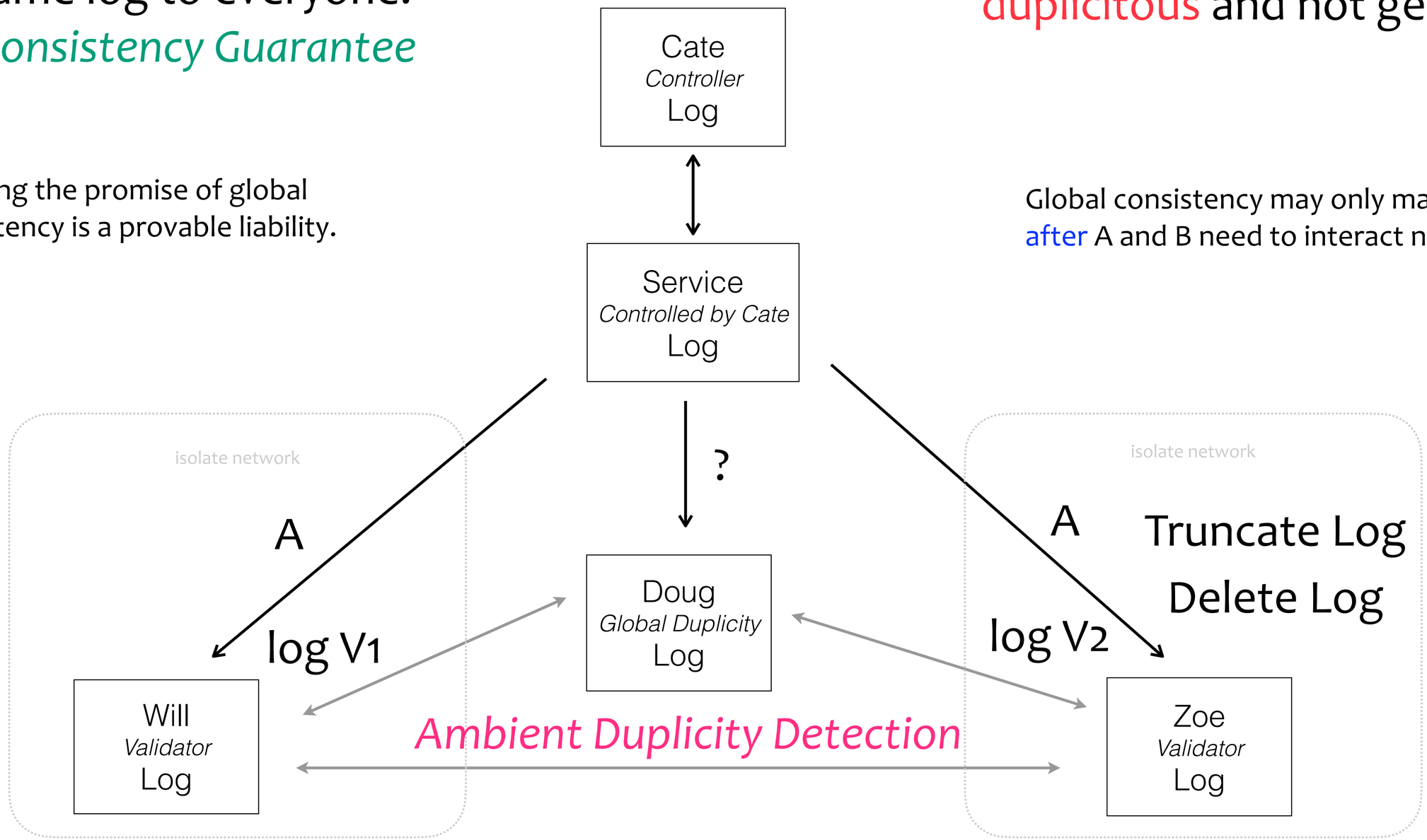
Service promises to provide exact same log to everyone.

*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*:

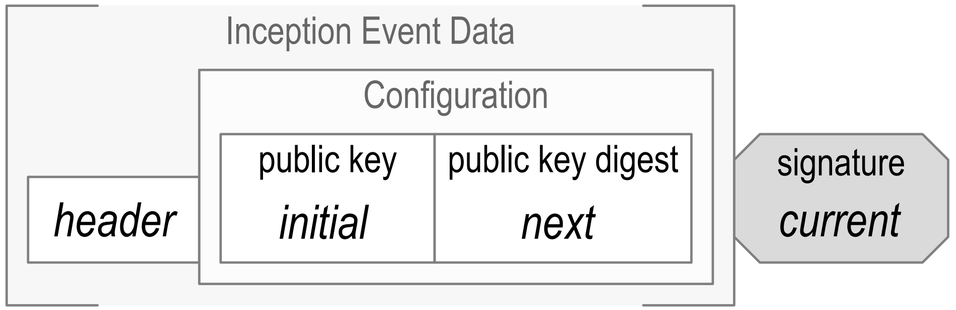
End user alone may verify. Zero trust in intervening infrastructure.

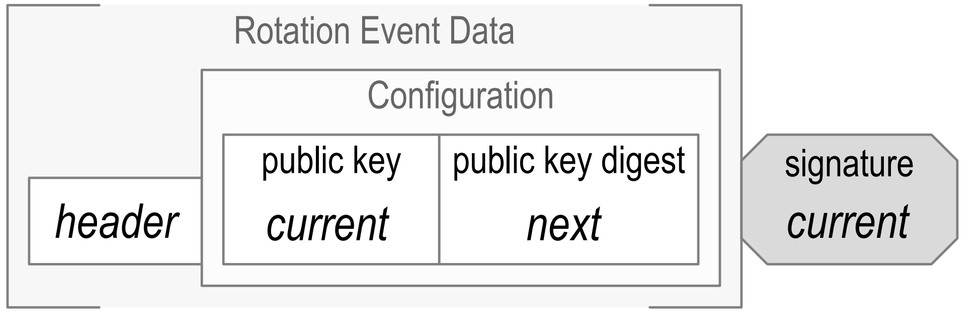
KERLs may be *Ambient Verifiable*:

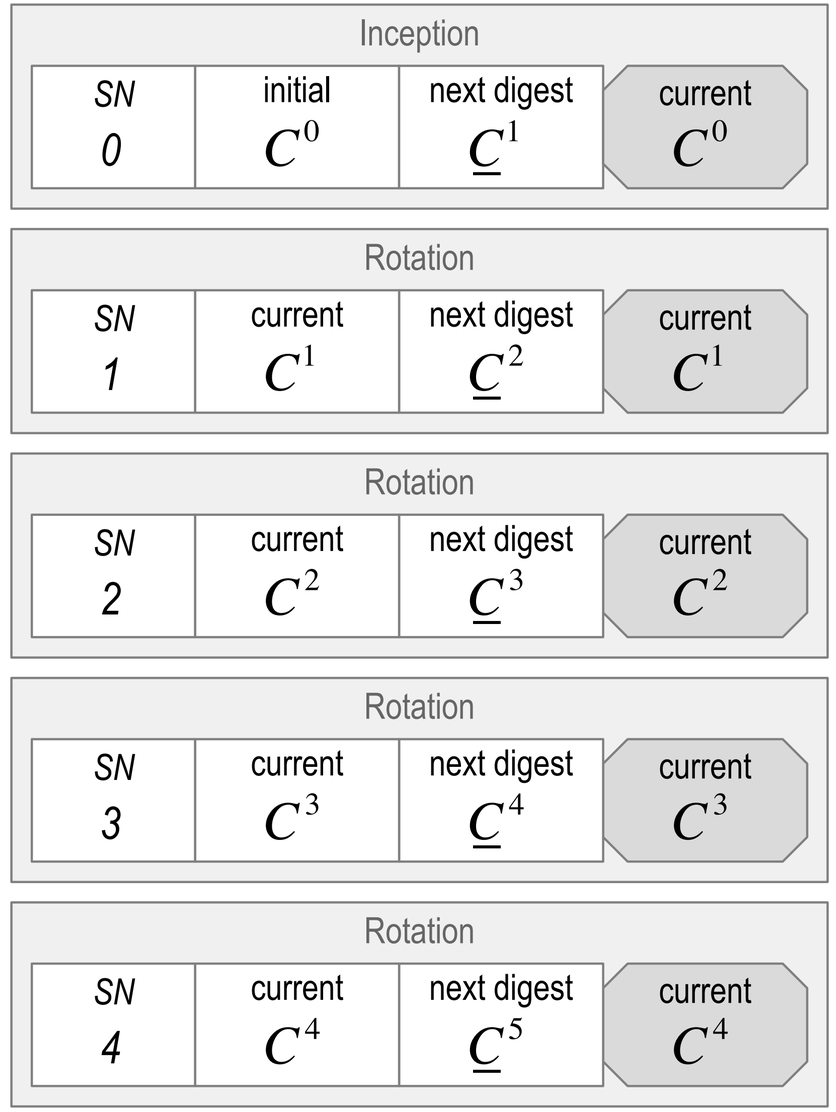
*Anyone* may verify *anylog*, *anywhere*, at *anytime*.

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

# Pre-Rotation

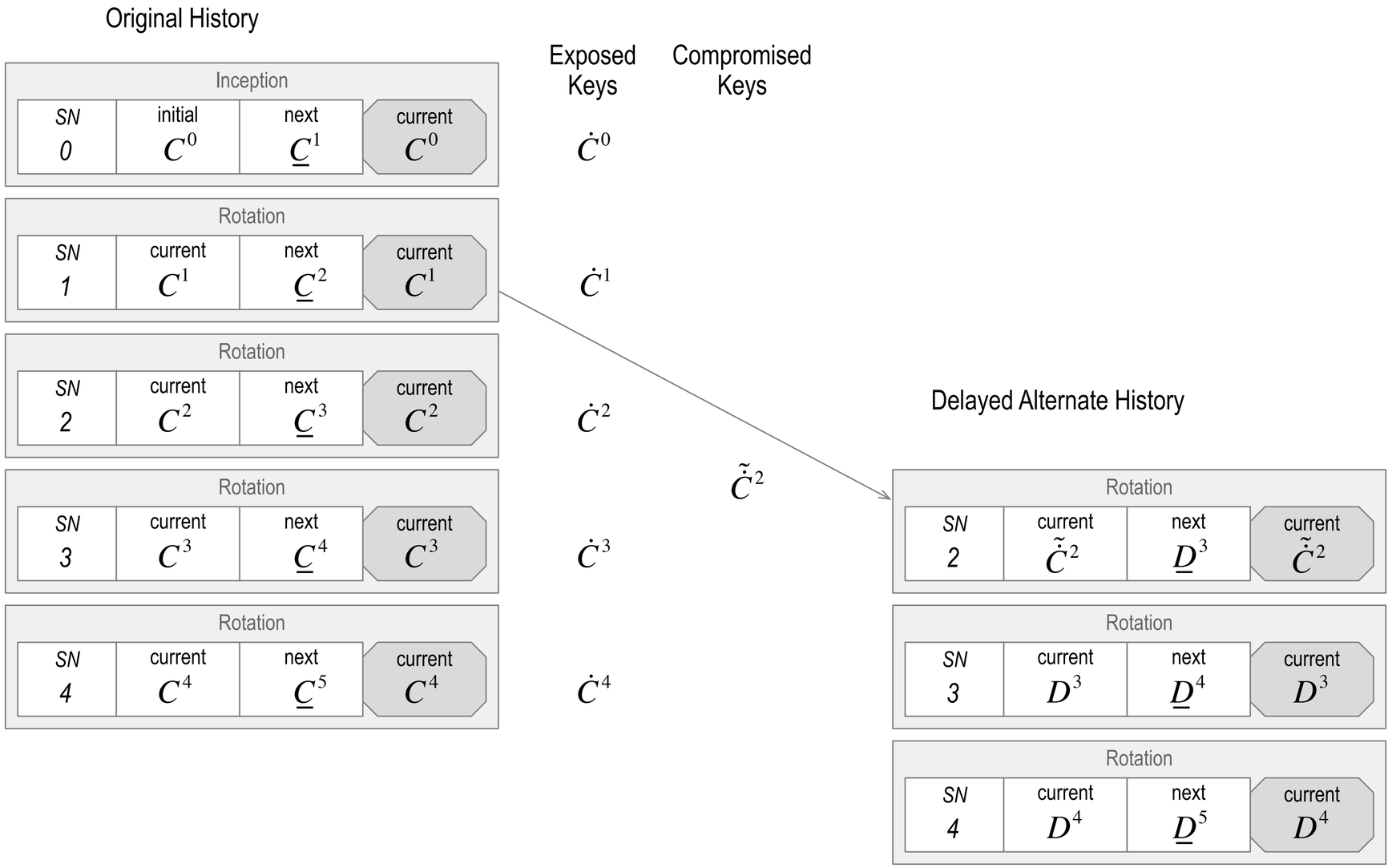


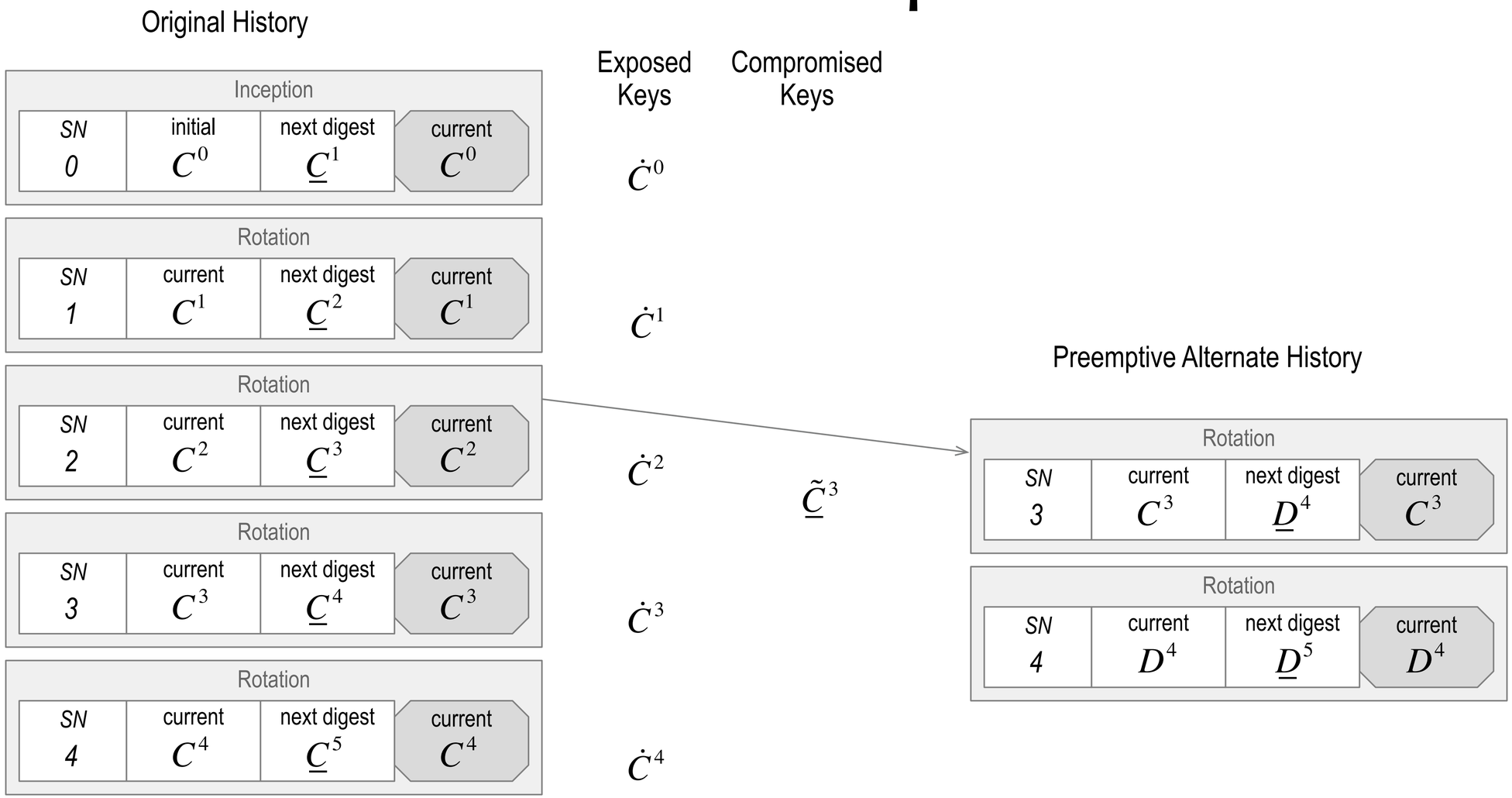

Digest of *next* key(s) makes pre-rotation post-quantum secure

# *Dead* Exploit



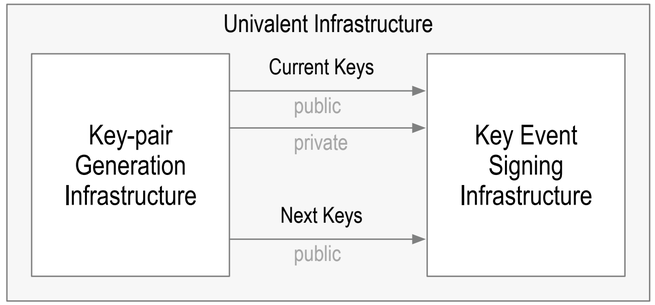

Any copy of original history protects against successful *dead* exploit

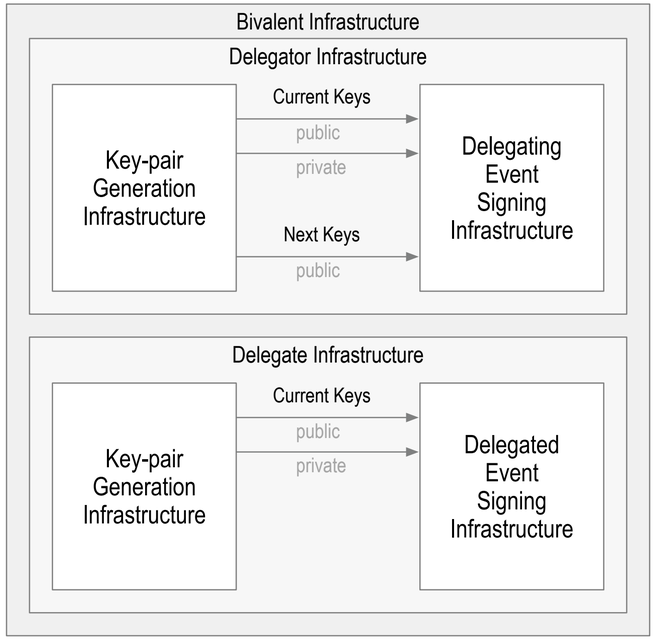
# *Live* Exploit

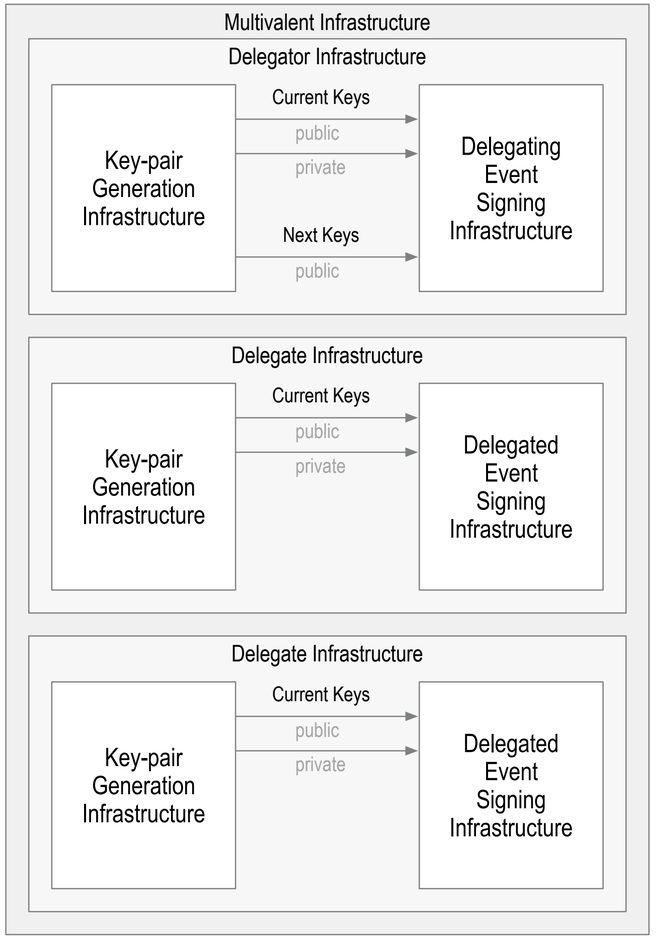



Difficulty of inverting *next* key(s) protects against successful *live* exploit

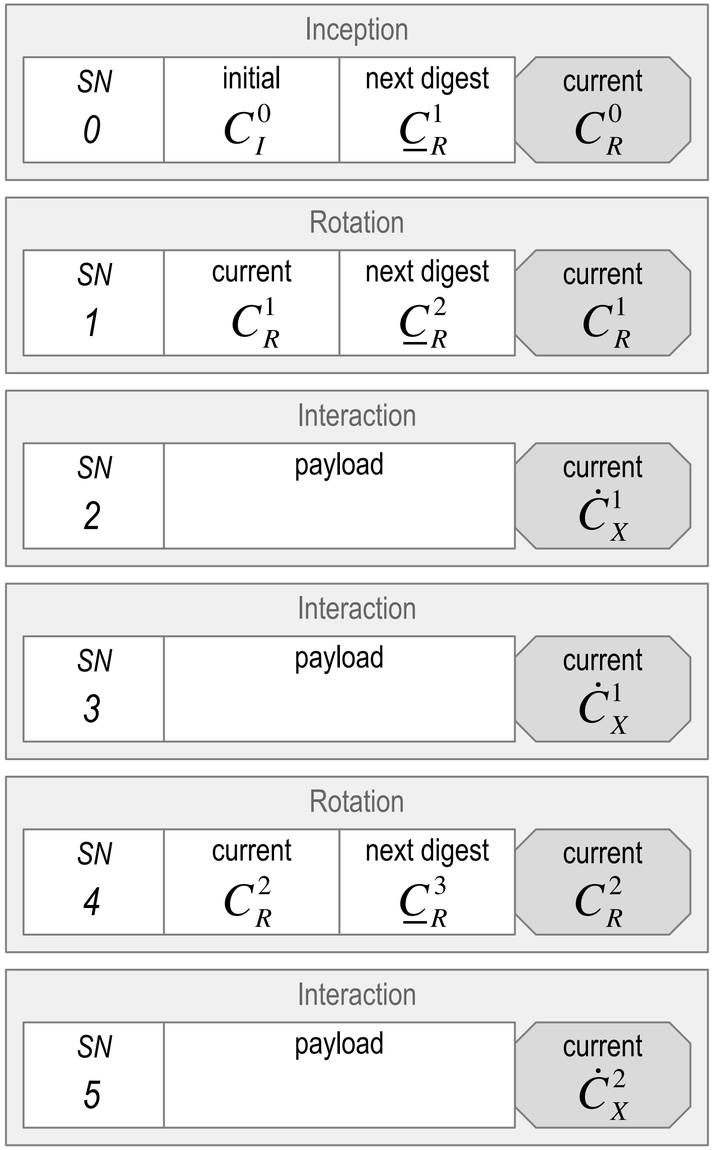
# Key Infrastructure Valence

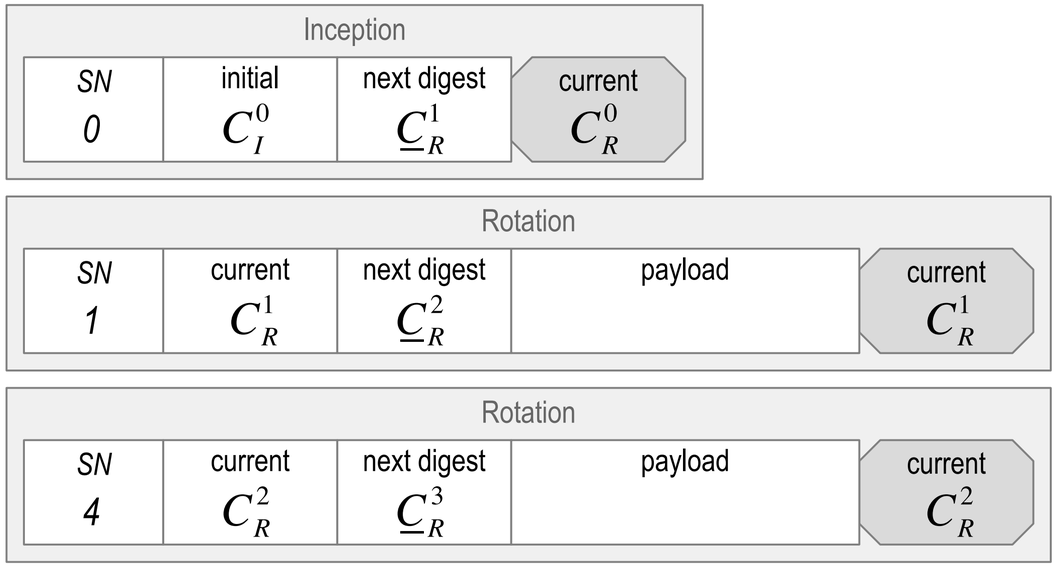


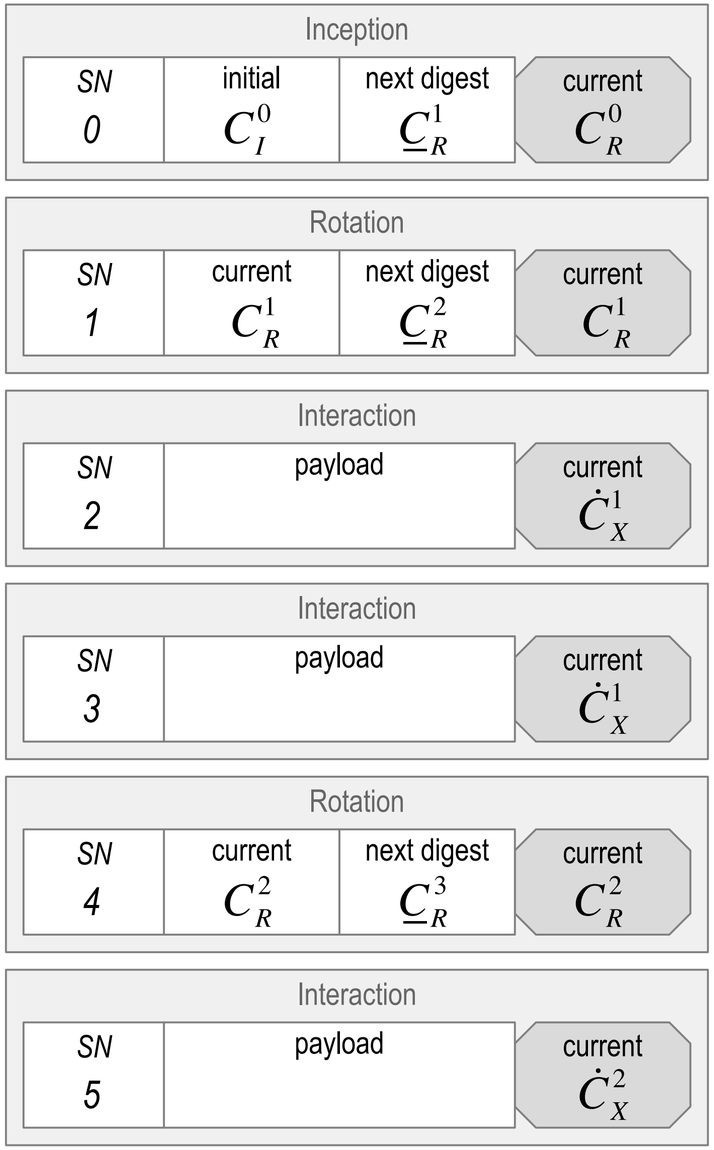



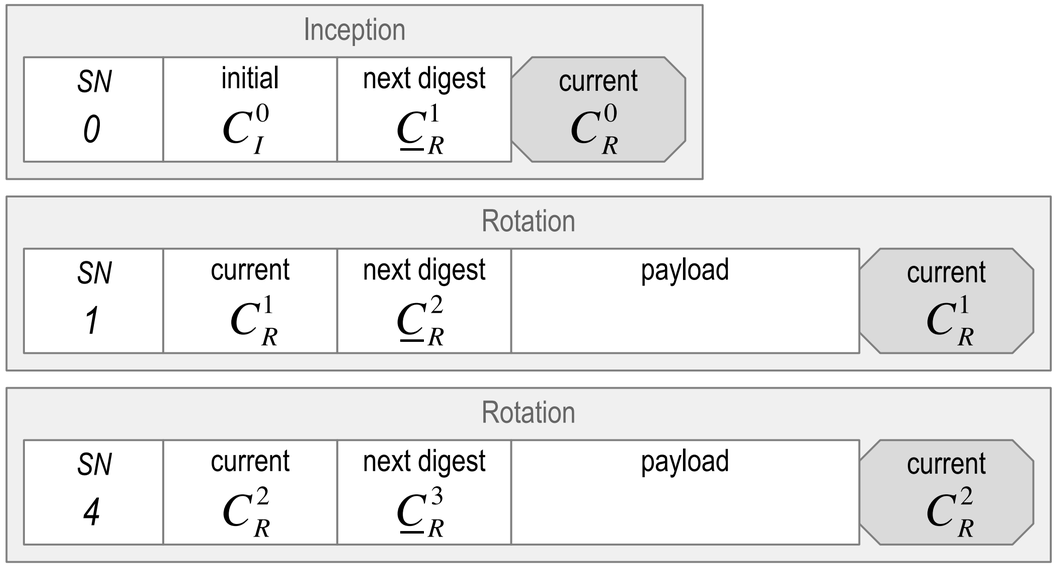
# *Repurposed Keys*



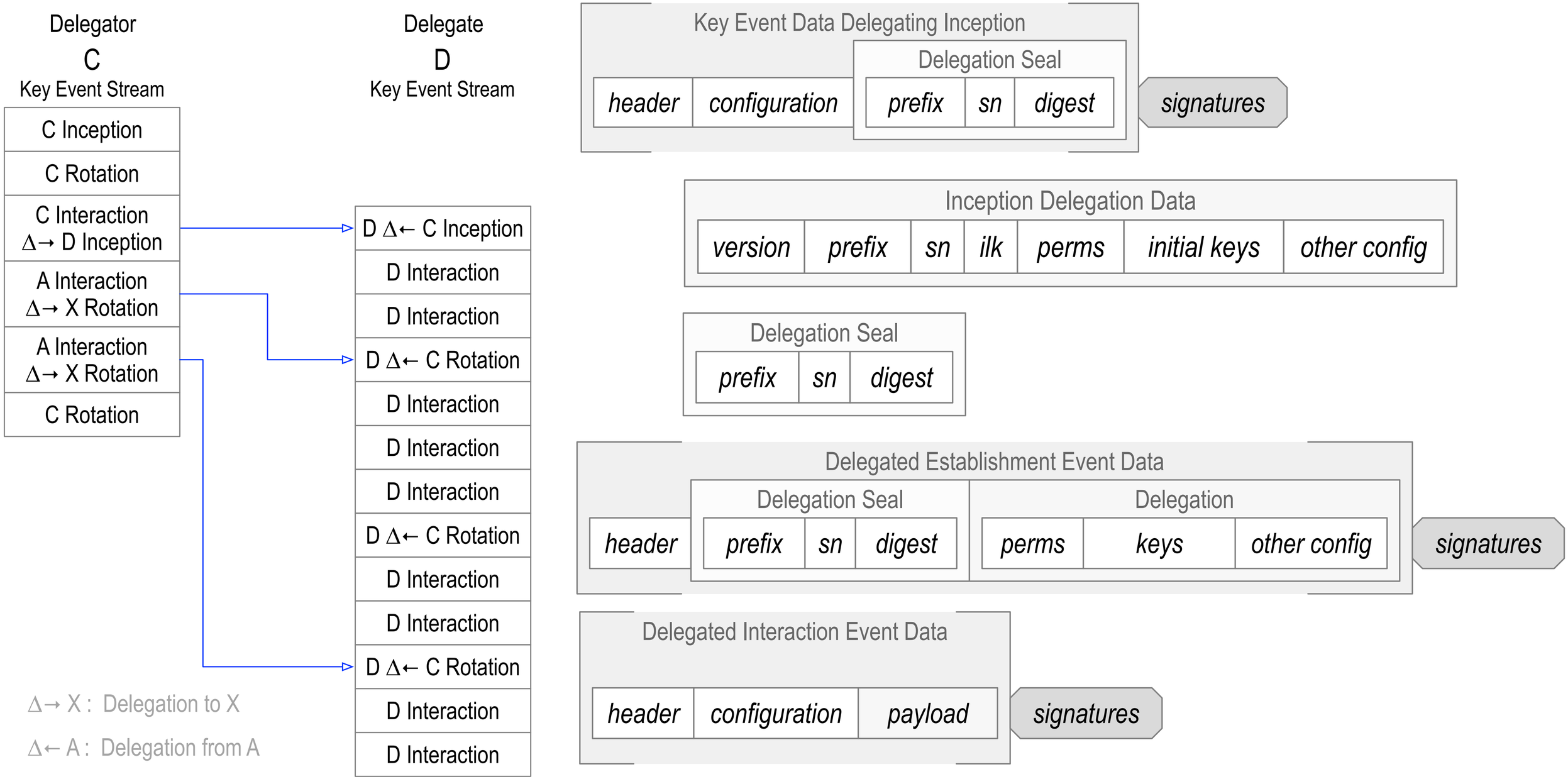



# *Repurposed Keys*

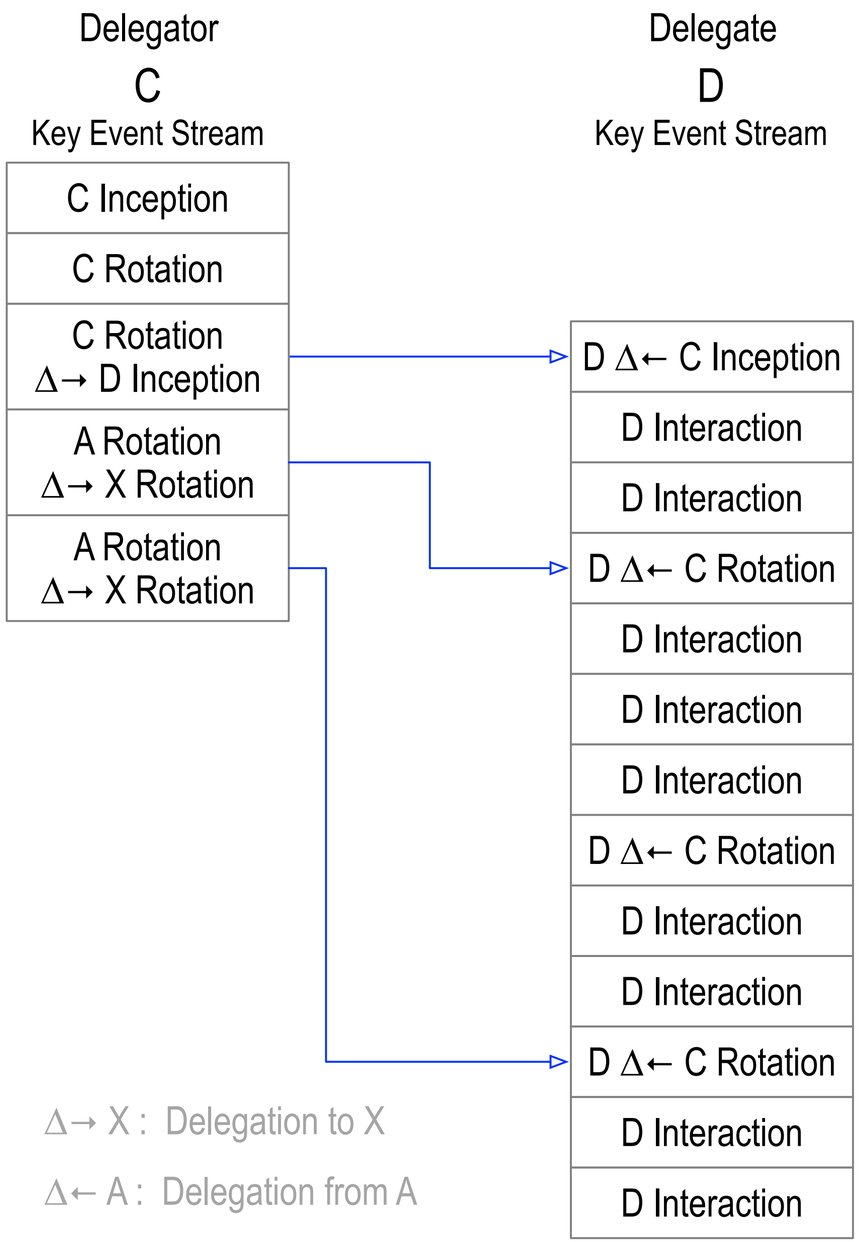


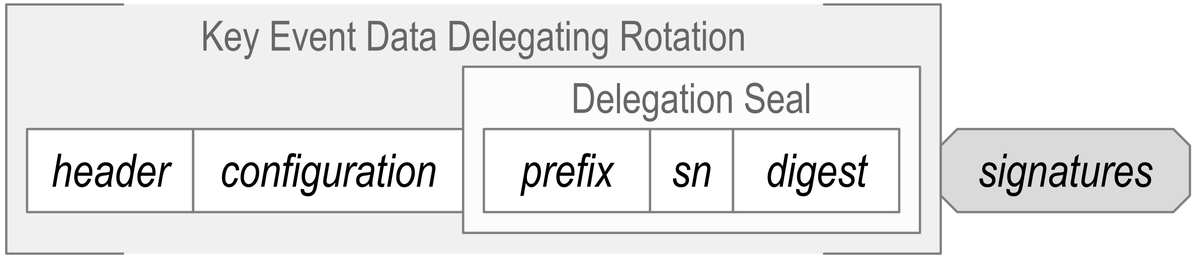



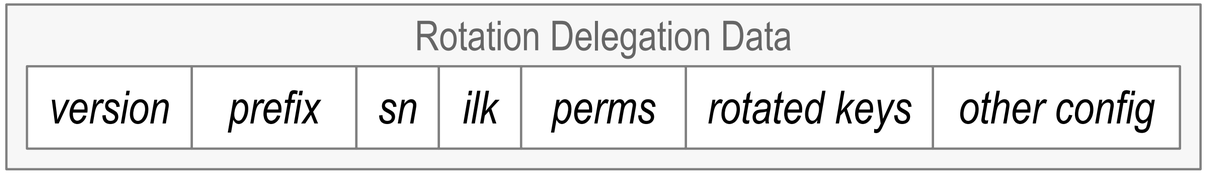
# Interaction Delegation

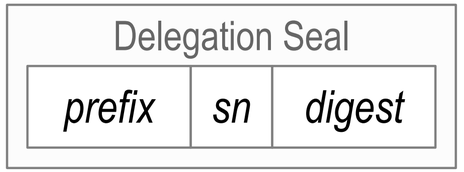


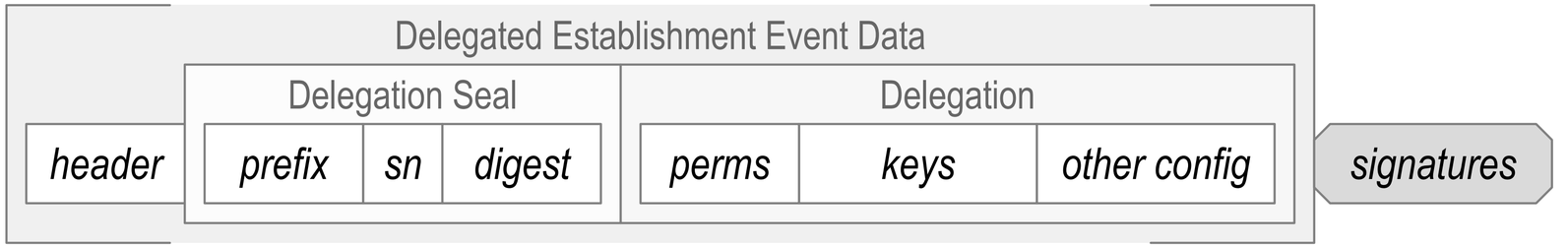
# Rotation Delegation

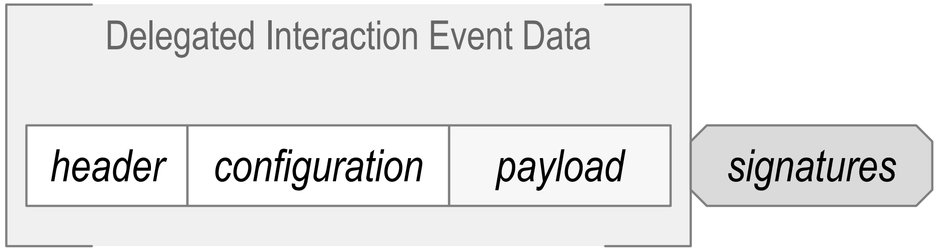


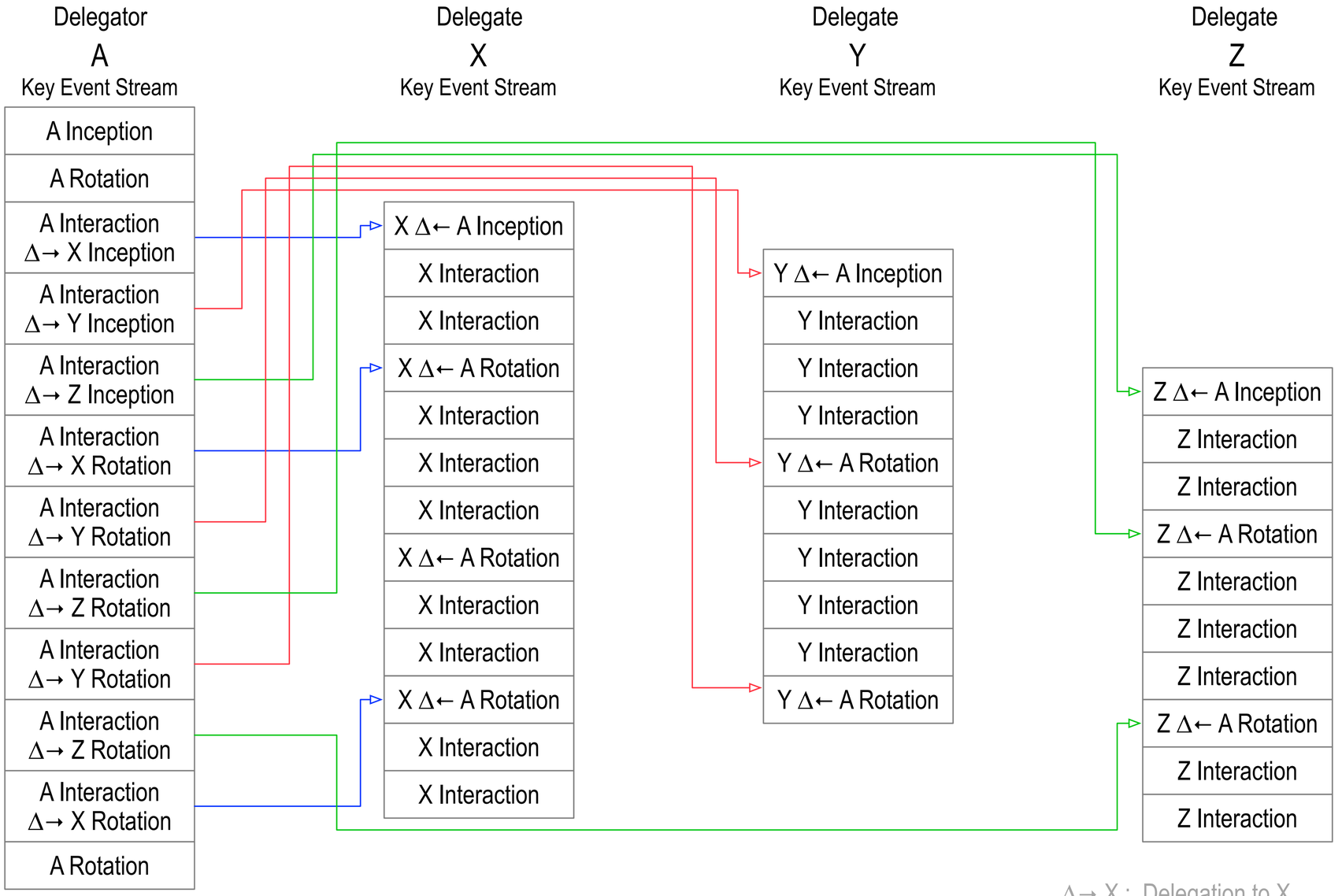



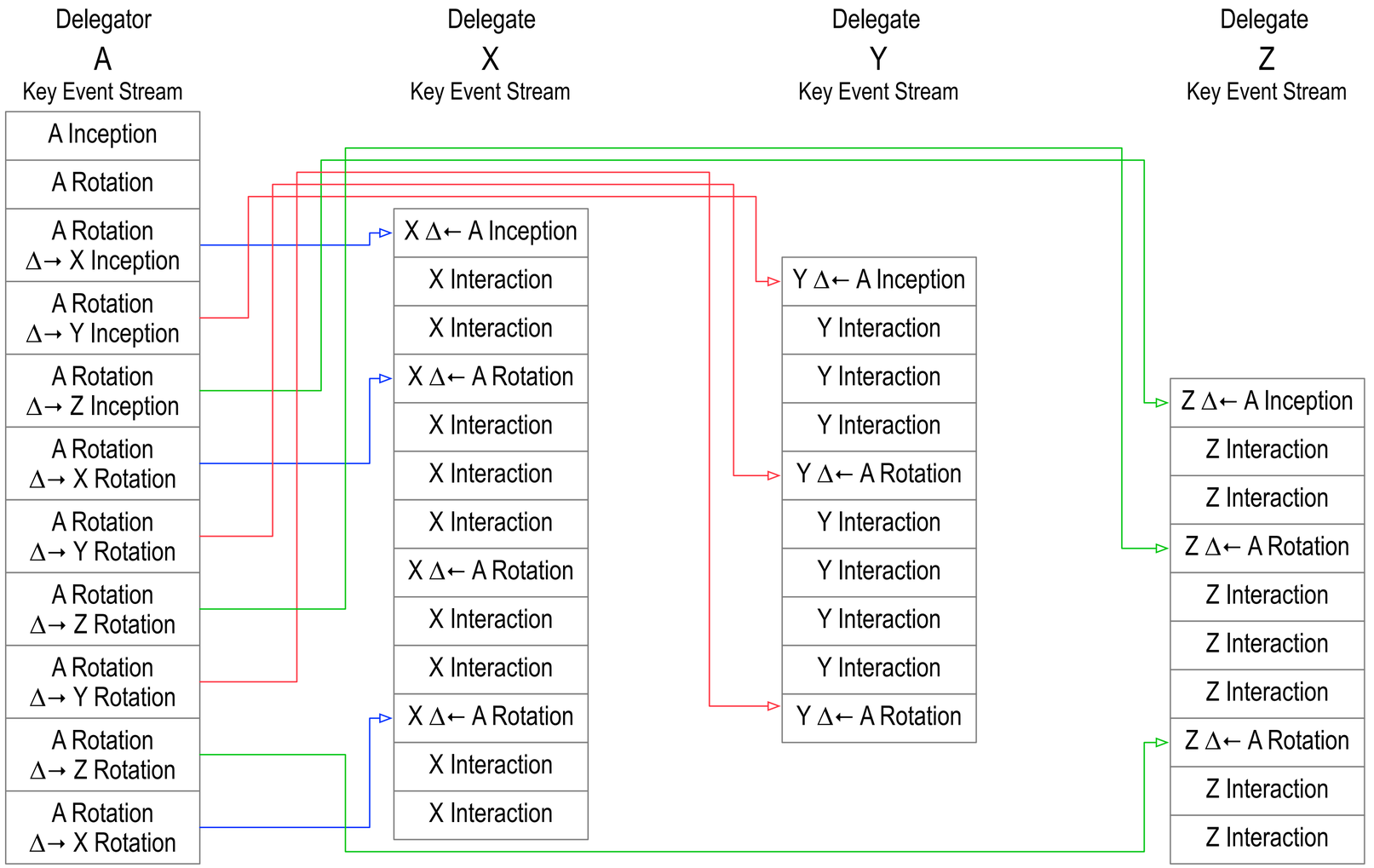



# Scaling Delegation via Interaction



# Scaling Delegation via Rotation




Δ→ X : Delegation to X

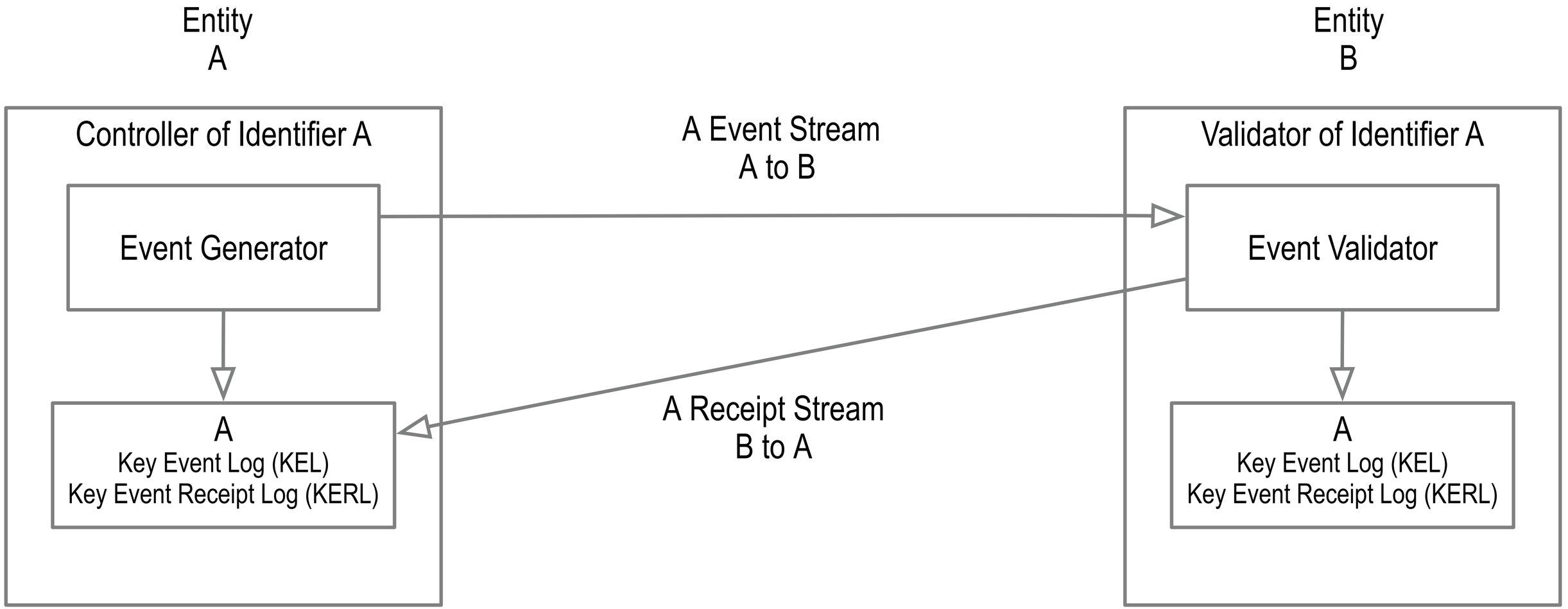
Δ← A : Delegation from A

# Protocol Operational Modes

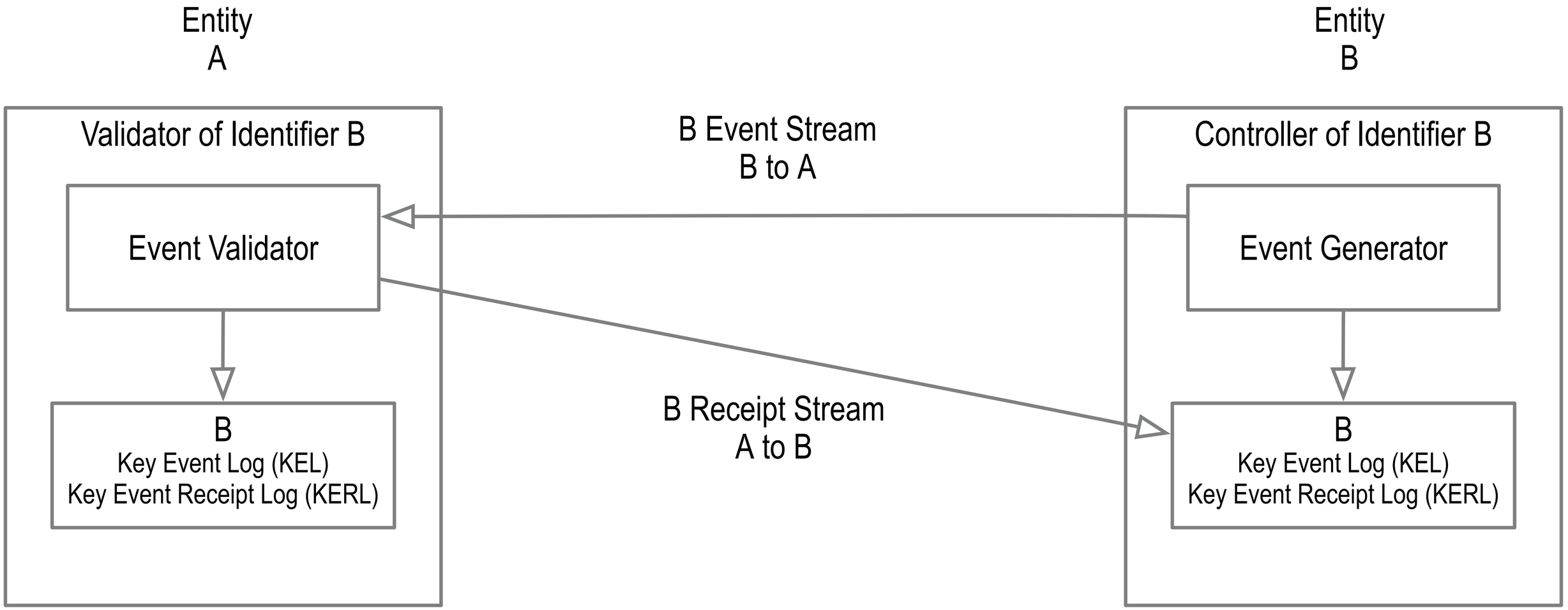
Direct Event Replay Mode  (one-to-one)

Indirect Event Replay Mode (one-to-any)

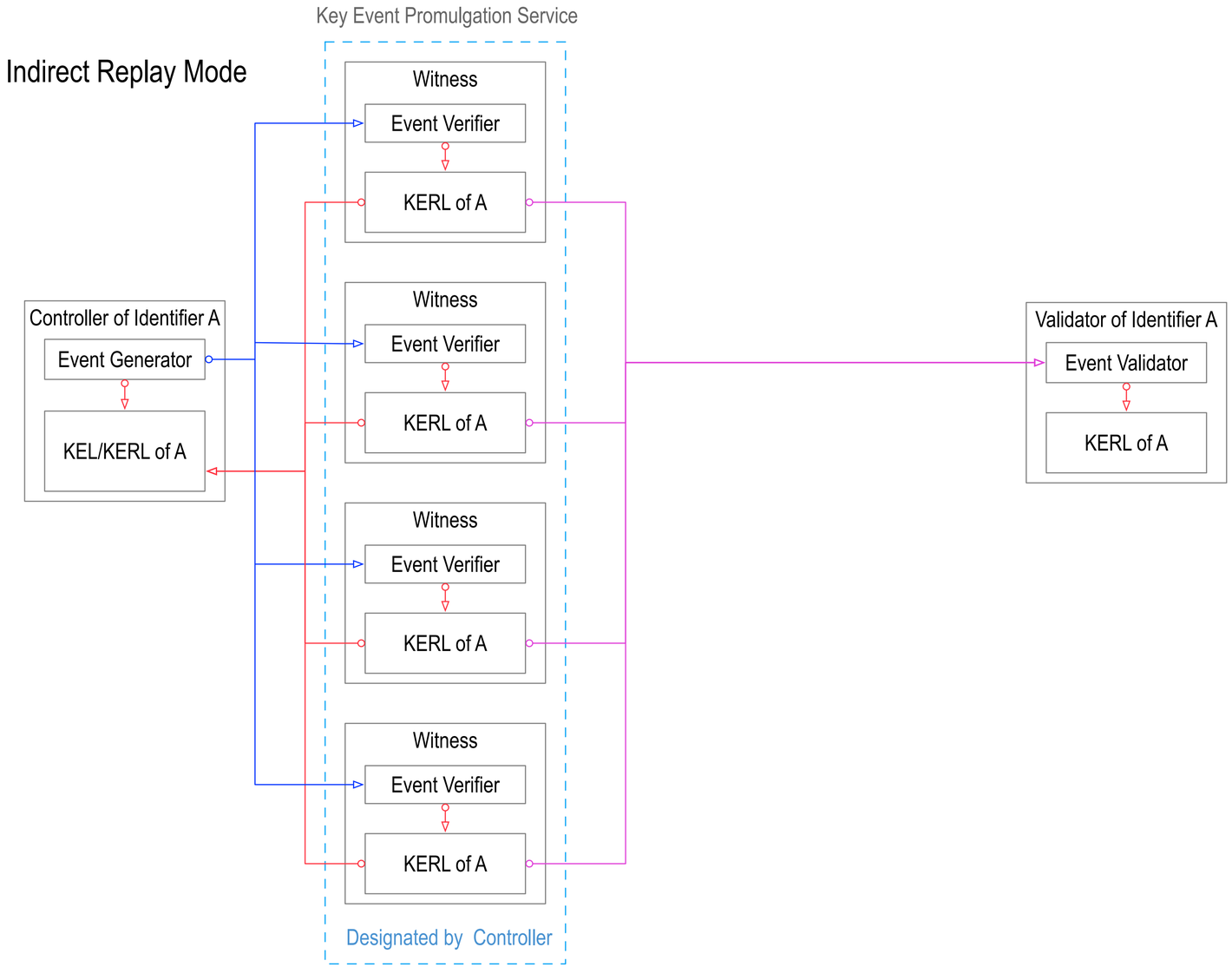
# Direct Mode: A to B



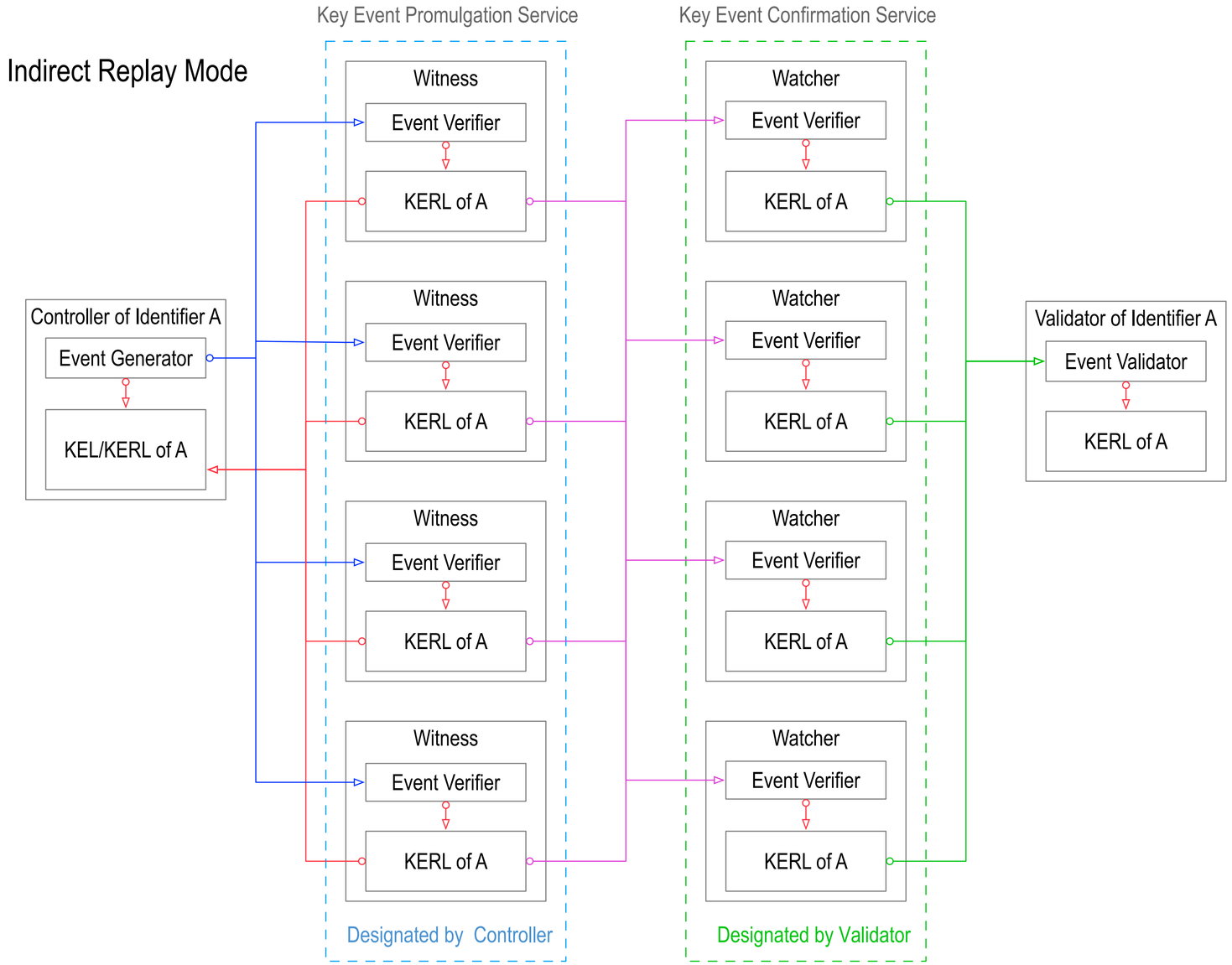
# Direct Mode: B to A



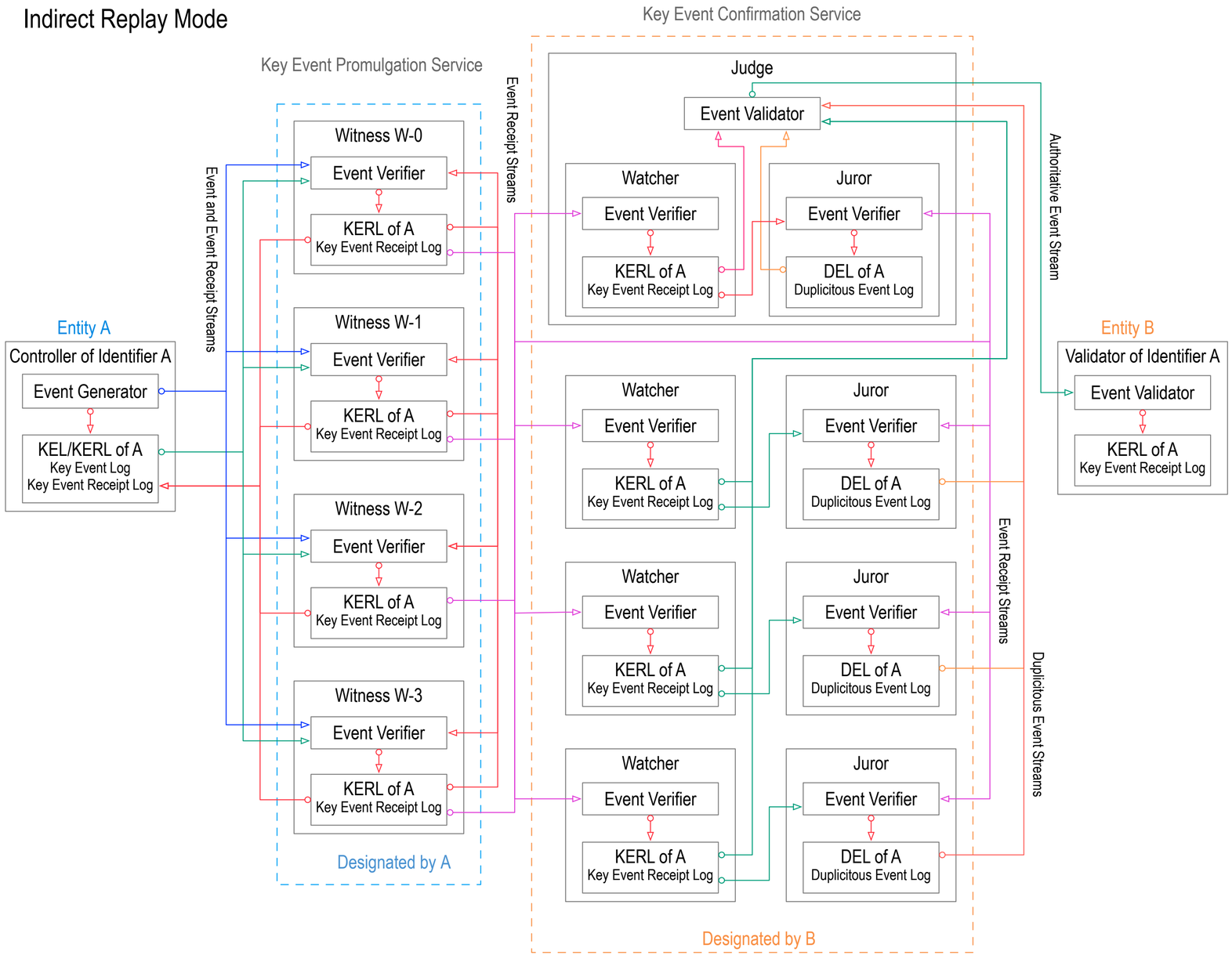
# Indirect Mode Promulgation Service



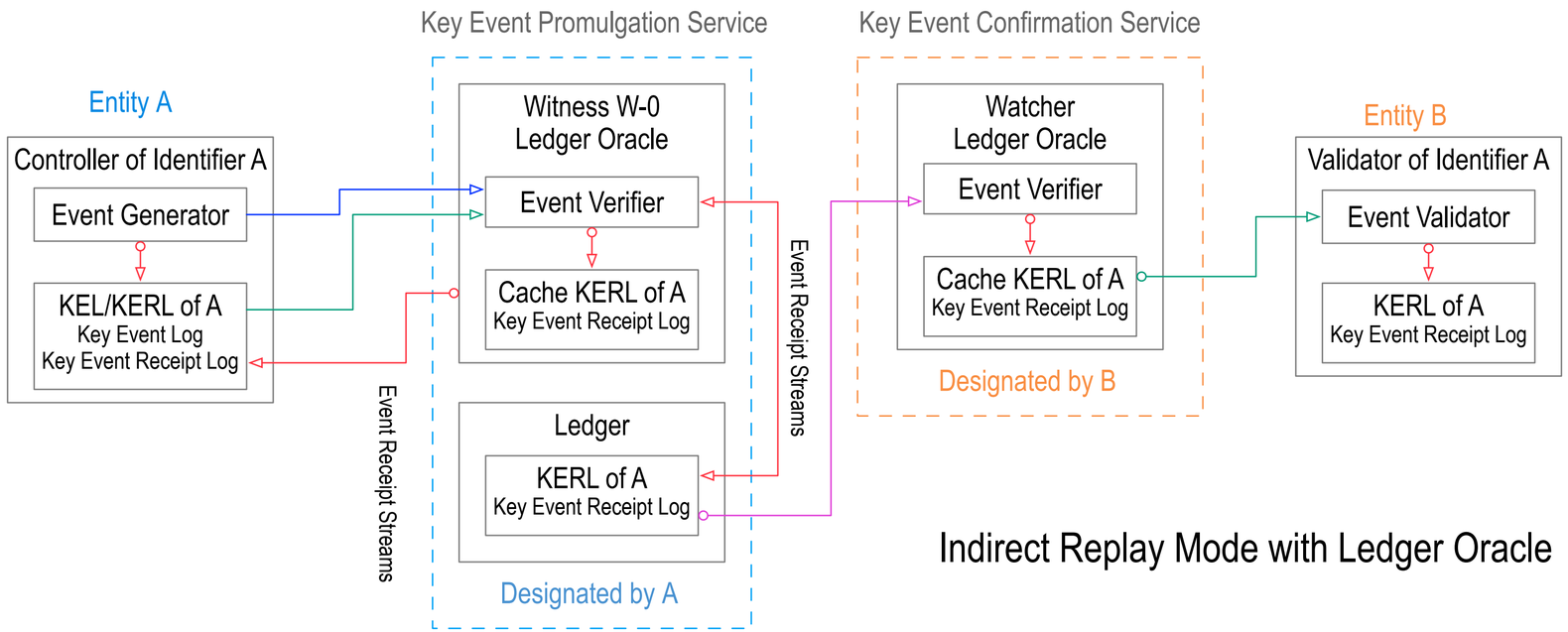
# Indirect Mode
# Promulgation and Confirmation Services



# 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*.

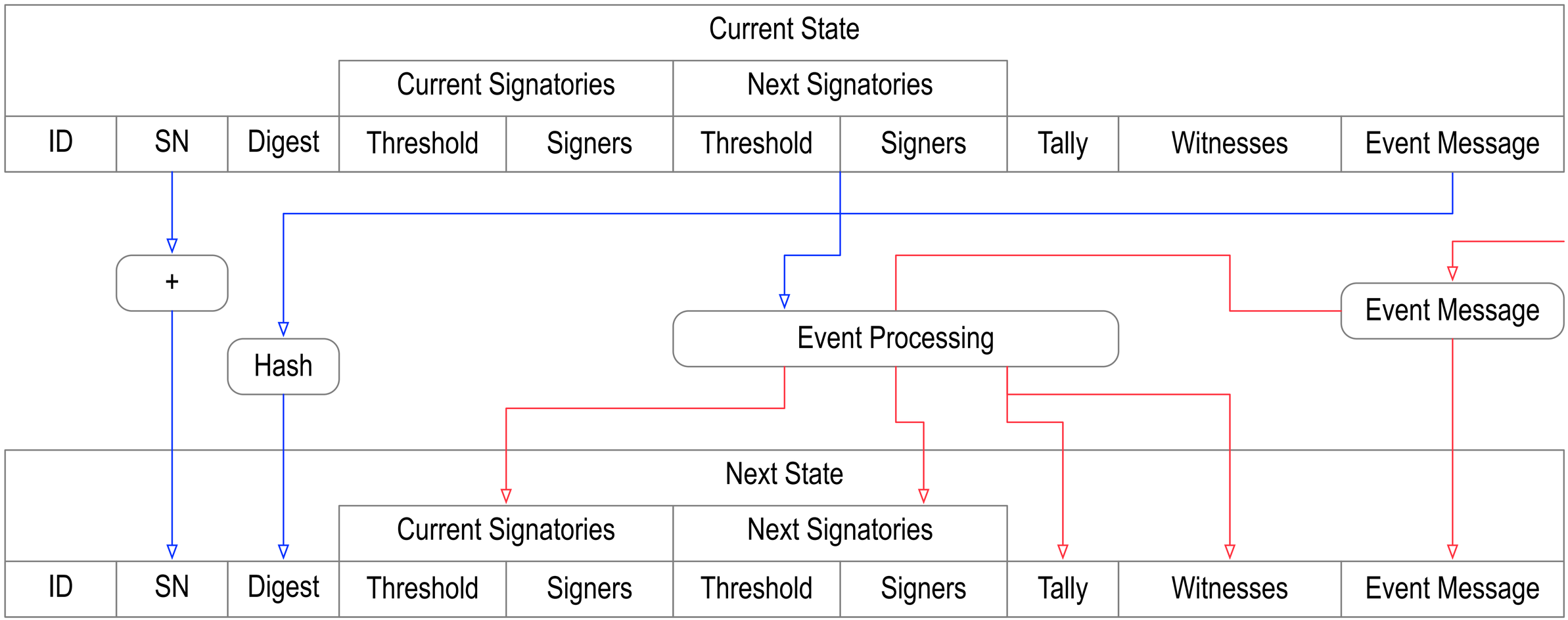
Shared *data* = *good*, shared *control* = *bad*.

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

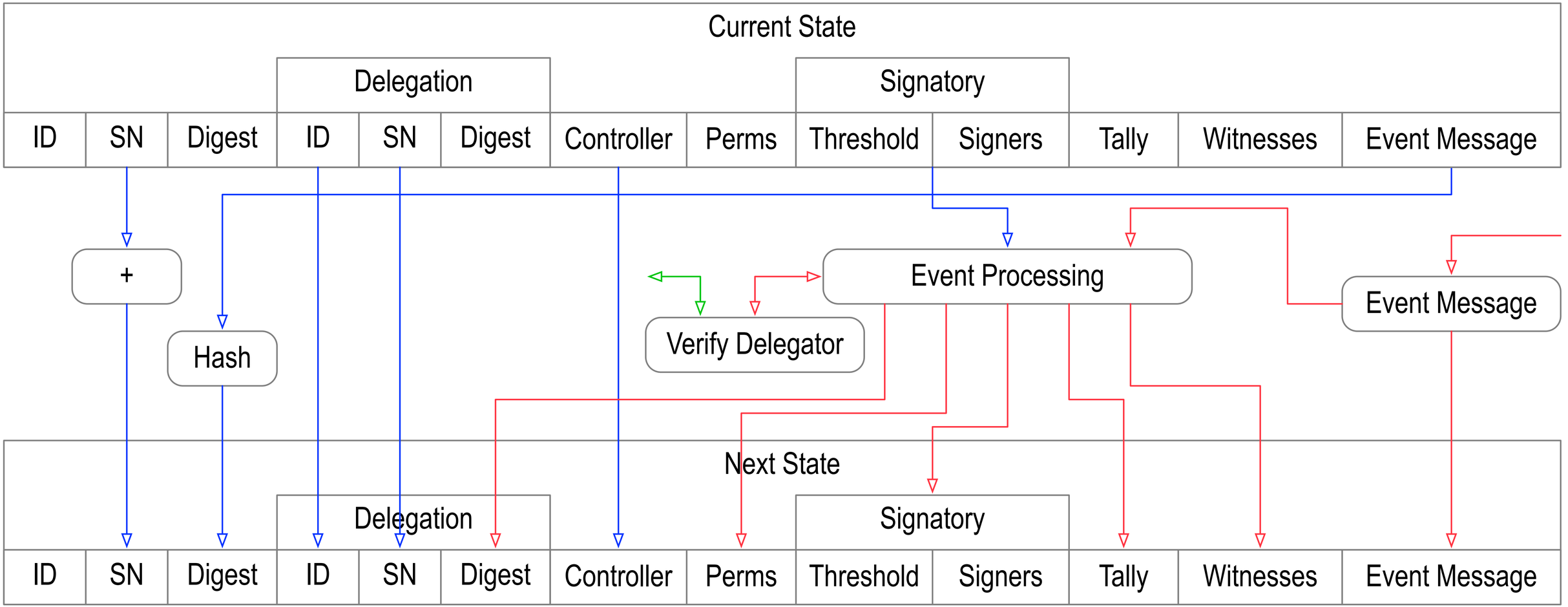
KERI = *separated control* over *shared data*.

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

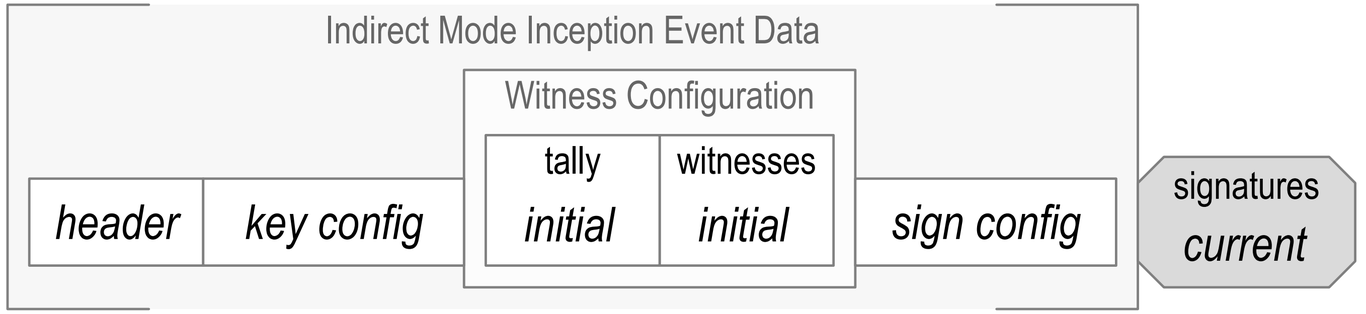
# State Verifier Engine

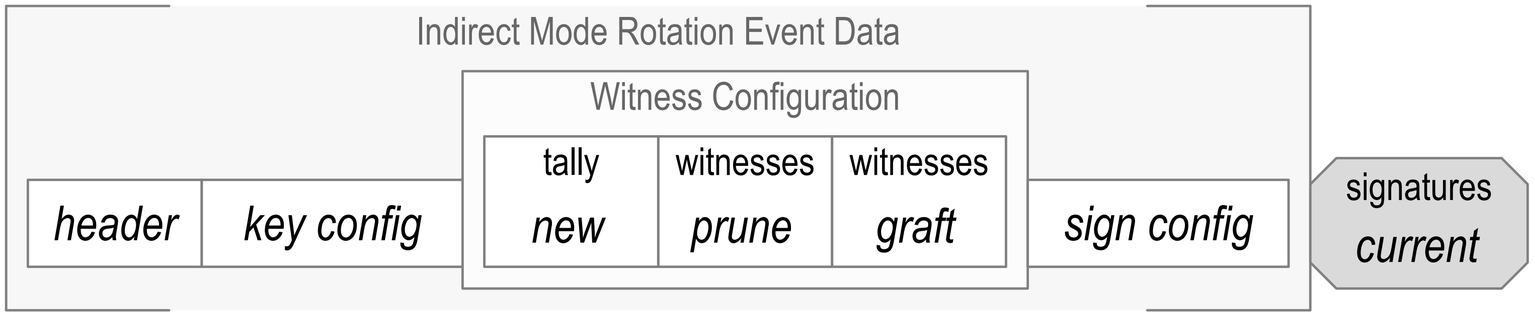


# Delegated State Verifier Engine

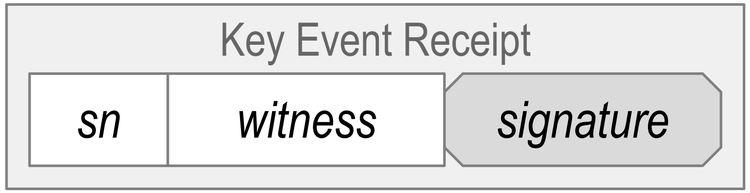


# Witness Designation



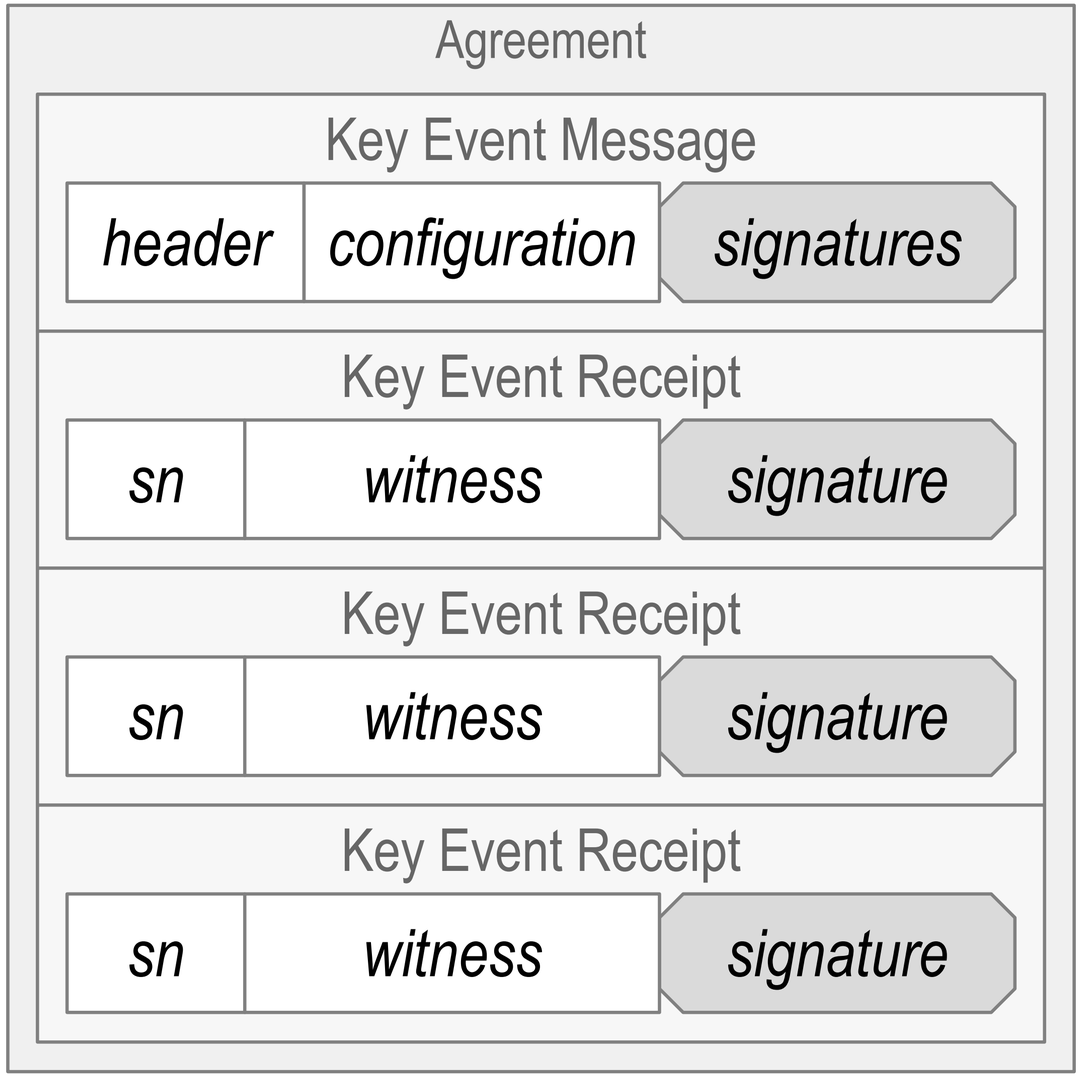



# Witnessed Key Event Receipt



# (KA²CE)
# Keri's Agreement Algorithm for Control Establishment

Produce Agreements with Guarantees



# Agreement Constraints

Proper Agreement

$$F+1$$

Sufficient Agreement

$$M > F$$

$$M \leq N - F$$

$$F < M \leq N - F$$

Intact Agreement

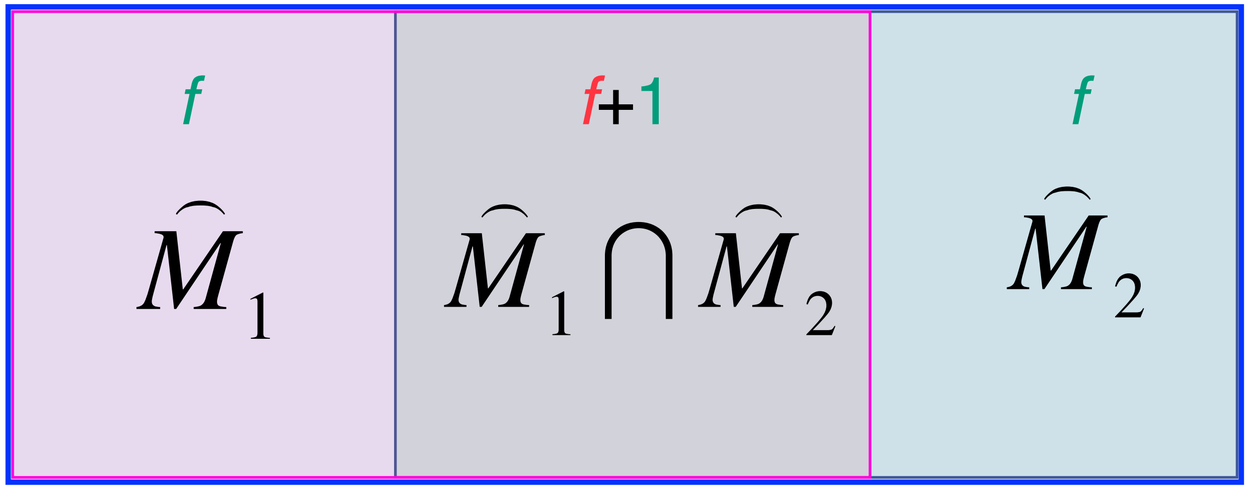
$$N \geq 2F+1$$

# One Agreement or None at All

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

Overlapping Sets

$$\widehat{M}_1 \bigcup \widehat{M}_2 = \widehat{N}$$




One honest witness if:

$$\left|\widehat{M}_1 \bigcap \widehat{M}_2\right| \geq F+1$$

$$\left|\widehat{M}_1 \bigcup \widehat{M}_2\right| = \left|\widehat{N}\right| = N$$

$$\left|\widehat{M}_1\right| + \left|\widehat{M}_2\right| = \left|\widehat{M}_1 \bigcup \widehat{M}_2\right| + \left|\widehat{M}_1 \bigcap \widehat{M}_2\right|$$

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

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

$$M \leq N - F$$

Immune Agreement

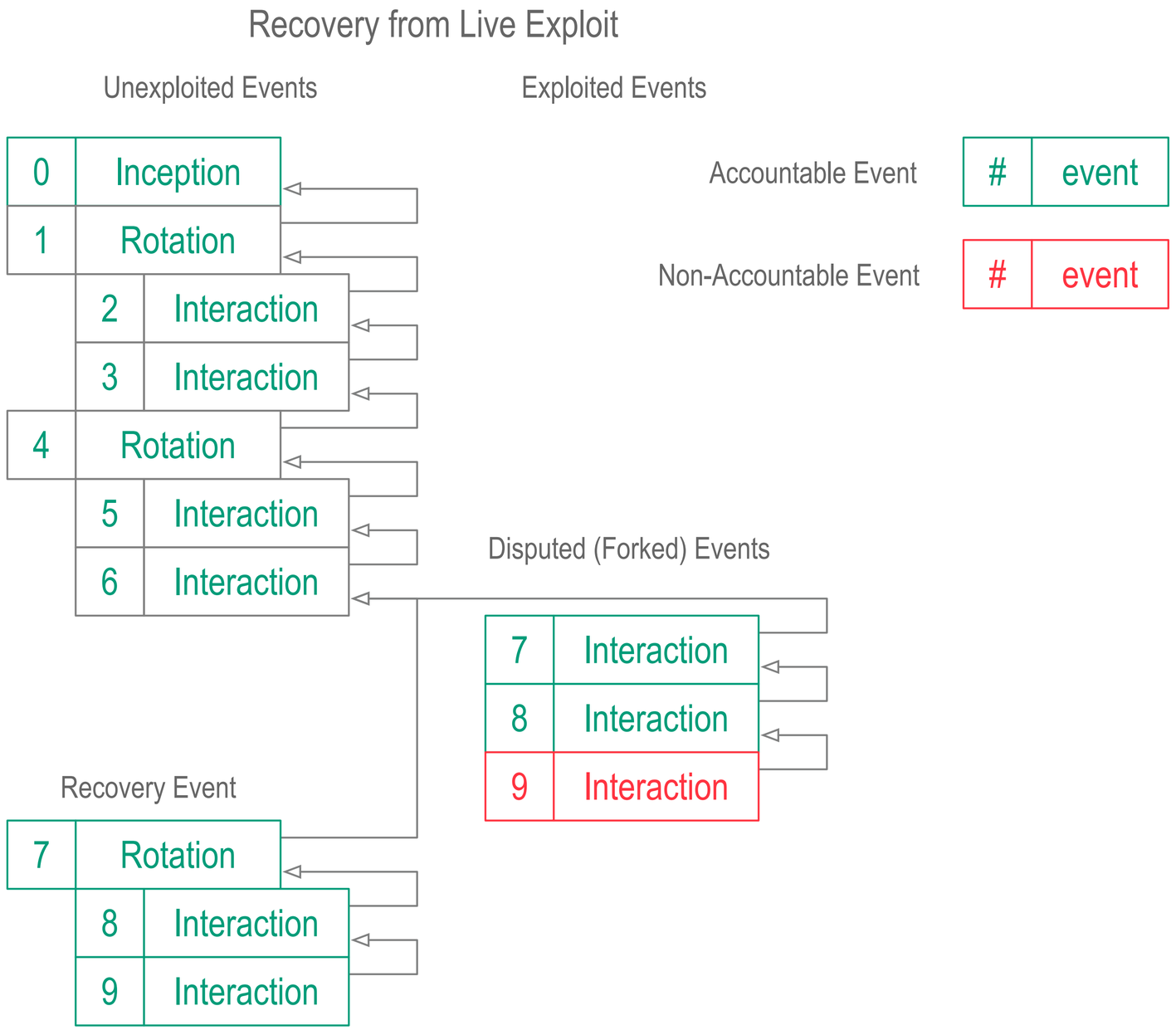
$$\frac{N+F+1}{2} \leq M \leq N - F$$

# Example Values

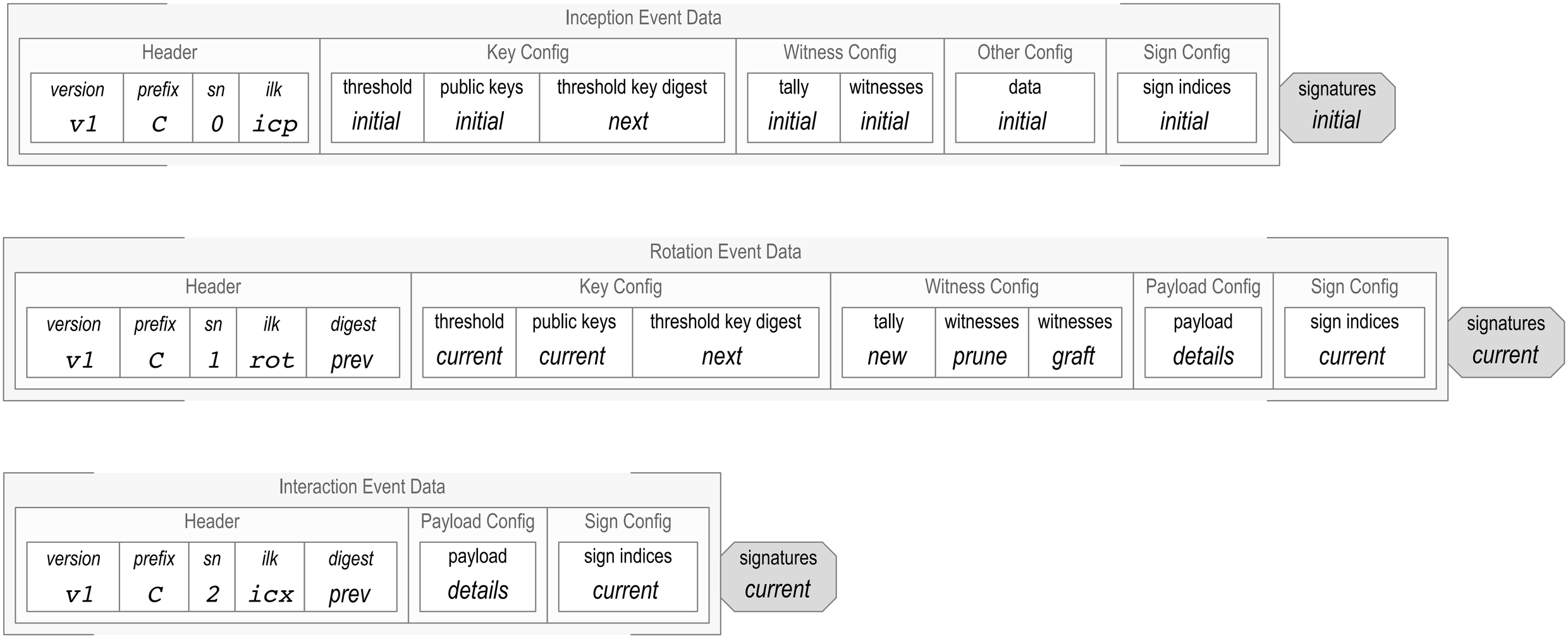
Immunity

| 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



# Generic Inception

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

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

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

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

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

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

# Generic Rotation

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

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

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

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

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

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

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

# Inception Delegation

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

$$\widehat{\delta}_0^D = \left\langle \nu_0^D, D, t_0^D, \texttt{dip}, perms, K_0^D, \widehat{D}_0^D, M_0^D, \widehat{W}_0^D \right\rangle$$

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

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

$$\varepsilon_0^D = \left\langle \nu_0^D, D, t_0^D, \texttt{dip}, perms, K_0^D, \widehat{D}_0^D, M_0^D, \widehat{W}_0^D, \widehat{\Delta}_k^C, \widehat{s}_0^D \right\rangle \widehat{\sigma}_0^D$$

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

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

$$\widehat{\sigma}_0^D = \sigma_{D^{s0}} \ldots \sigma_{D^{s S_0^D - 1}}$$

# Rotation Delegation

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

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

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

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

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

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

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

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

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

# Generic Interaction

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

$$K_l^C$$

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

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

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

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

# Witness Rotations

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

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

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

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

$$M_l \leq N_l$$

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

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

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

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

# Complex Weighted Signing Thresholds

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

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

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

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

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

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

$$U_l^j = 1 / K_l$$

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

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

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

# 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

| Derivation Code | Prefix Description |
|---|---|
| _ | Skip. Start code with next character. |
| - | |
| 0 | Two character derivation code. Use next character from two character table. |
| 1 | Four character derivation code. Use next three characters from four character table. |
| 2 | Five character derivation code. Use next four characters from five character table. |
| 3 | Six character derivation code. Use next five characters from six character table. |
| 4 | Eight character derivation code. Use next seven characters from eight character table. |
| 5 | Nine character derivation code. Use next eight characters from nine character table. |
| 6 | Ten character derivation code. Use next nine characters from ten character table. |

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 |

One Character KERI Base64 Prefix Derivation Code-1

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

# Base64

Base64 to ASCII

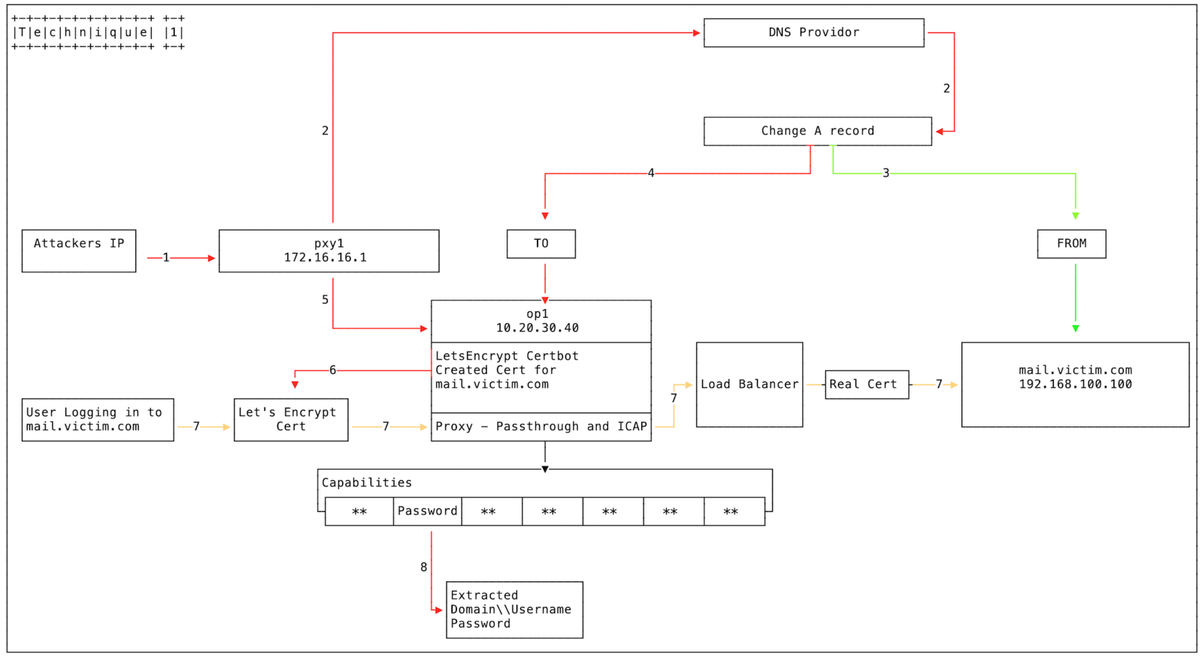
| Base64 Index | ASCII Char | ASCII Decimal | ASCII Hex | ASCII Binary |
|---|---|---|---|---|
| **0** | A | 65 | 41 | 01000001 |
| **1** | B | 66 | 42 | 01000010 |
| **2** | C | 67 | 43 | 01000011 |
| **3** | D | 68 | 44 | 01000100 |
| **4** | E | 69 | 45 | 01000101 |
| **5** | F | 70 | 46 | 01000110 |
| **6** | G | 71 | 47 | 01000111 |
| **7** | H | 72 | 48 | 01001000 |
| **8** | I | 73 | 49 | 01001001 |
| **9** | J | 74 | 4A | 01001010 |
| **10** | K | 75 | 4B | 01001011 |
| **11** | L | 76 | 4C | 01001100 |
| **12** | M | 77 | 4D | 01001101 |
| **13** | N | 78 | 4E | 01001110 |
| **14** | O | 79 | 4F | 01001111 |
| **15** | P | 80 | 50 | 01010000 |
| **16** | Q | 81 | 51 | 01010001 |
| **17** | R | 82 | 52 | 01010010 |
| **18** | S | 83 | 53 | 01010011 |
| **19** | T | 84 | 54 | 01010100 |
| **20** | U | 85 | 55 | 01010101 |
| **21** | V | 86 | 56 | 01010110 |
| **22** | W | 87 | 57 | 01010111 |
| **23** | X | 88 | 58 | 01011000 |
| **24** | Y | 89 | 59 | 01011001 |
| **25** | Z | 90 | 5A | 01011010 |
| **26** | a | 97 | 61 | 01100001 |
| **27** | b | 98 | 62 | 01100010 |
| **28** | c | 99 | 63 | 01100011 |
| **29** | d | 100 | 64 | 01100100 |
| **30** | e | 101 | 65 | 01100101 |
| **31** | f | 102 | 66 | 01100110 |
| **32** | g | 103 | 67 | 01100111 |
| **33** | h | 104 | 68 | 01101000 |
| **34** | i | 105 | 69 | 01101001 |
| **35** | j | 106 | 6A | 01101010 |
| **36** | k | 107 | 6B | 01101011 |
| **37** | l | 108 | 6C | 01101100 |
| **38** | m | 109 | 6D | 01101101 |
| **39** | n | 110 | 6E | 01101110 |
| **40** | o | 111 | 6F | 01101111 |
| **41** | p | 112 | 70 | 01110000 |
| **42** | q | 113 | 71 | 01110001 |
| **43** | r | 114 | 72 | 01110010 |
| **44** | s | 115 | 73 | 01110011 |
| **45** | t | 116 | 74 | 01110100 |
| **46** | u | 117 | 75 | 01110101 |
| **47** | v | 118 | 76 | 01110110 |
| **48** | w | 119 | 77 | 01110111 |

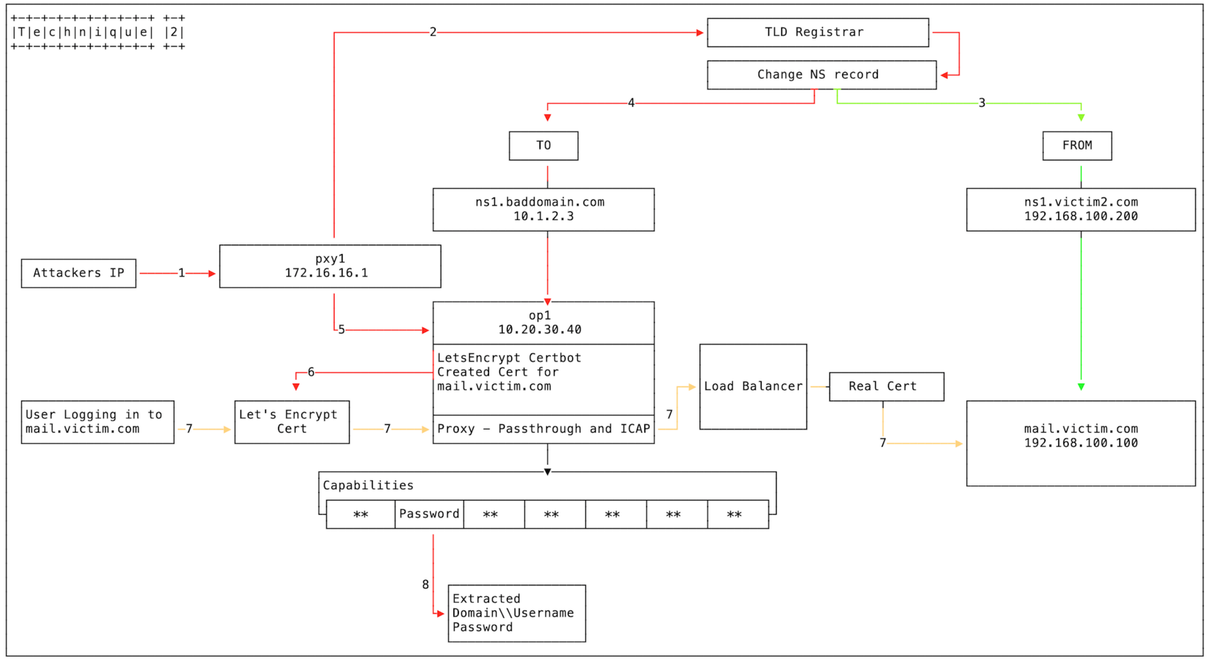
Base64 to ASCII

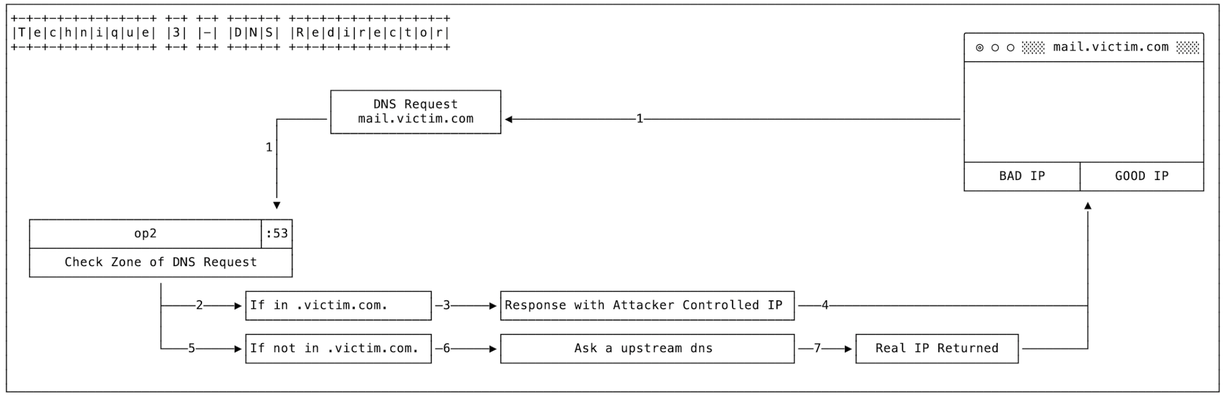
# DNS Hijacking

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

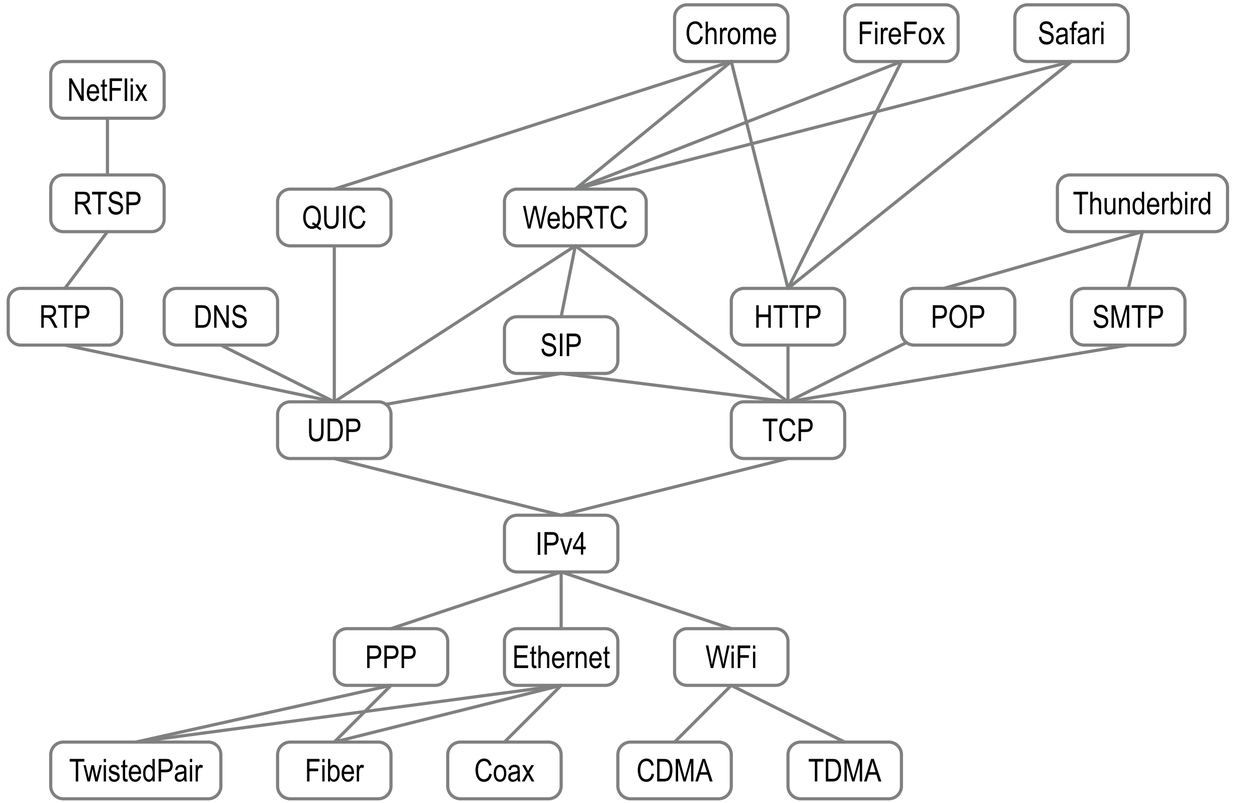
https://arstechnica.com/information-technology/2019/01/a-dns-hijacking-wave-is-targeting-companies-at-an-almost-unprecedented-scale/

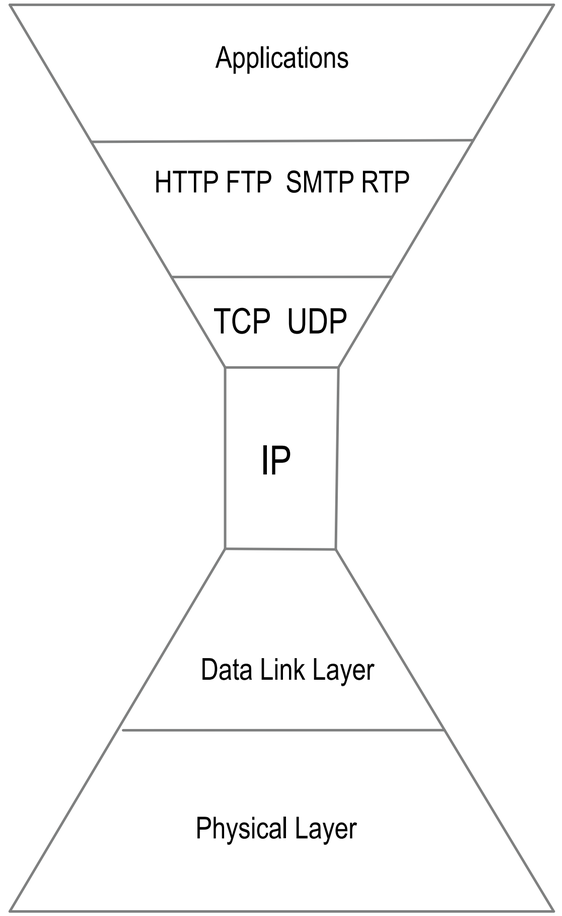


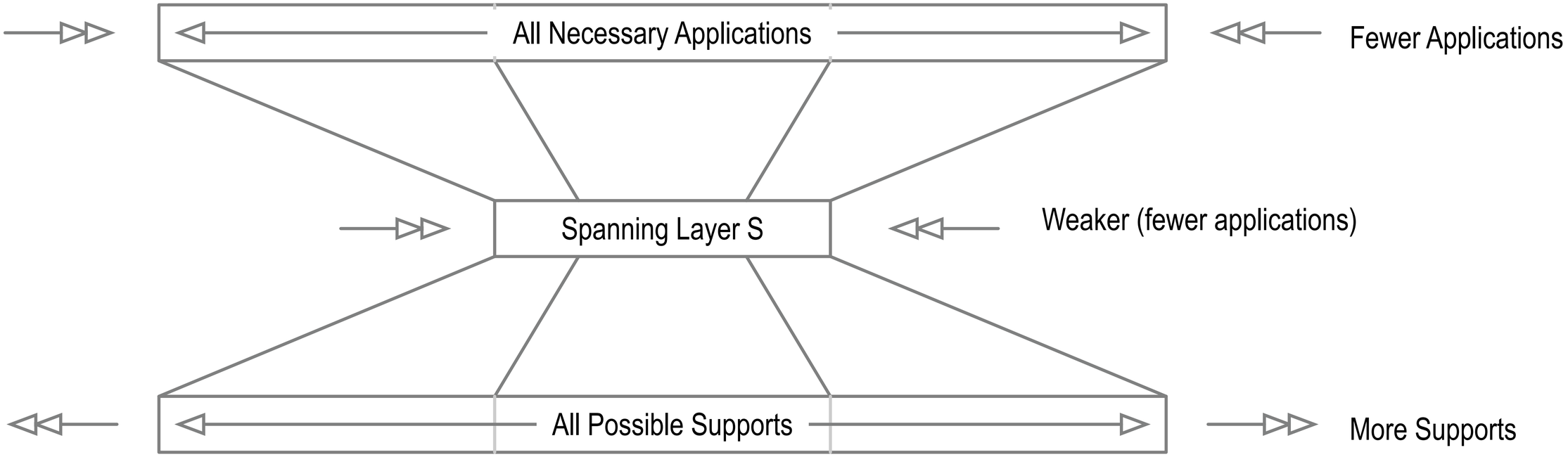



# Spanning Layer

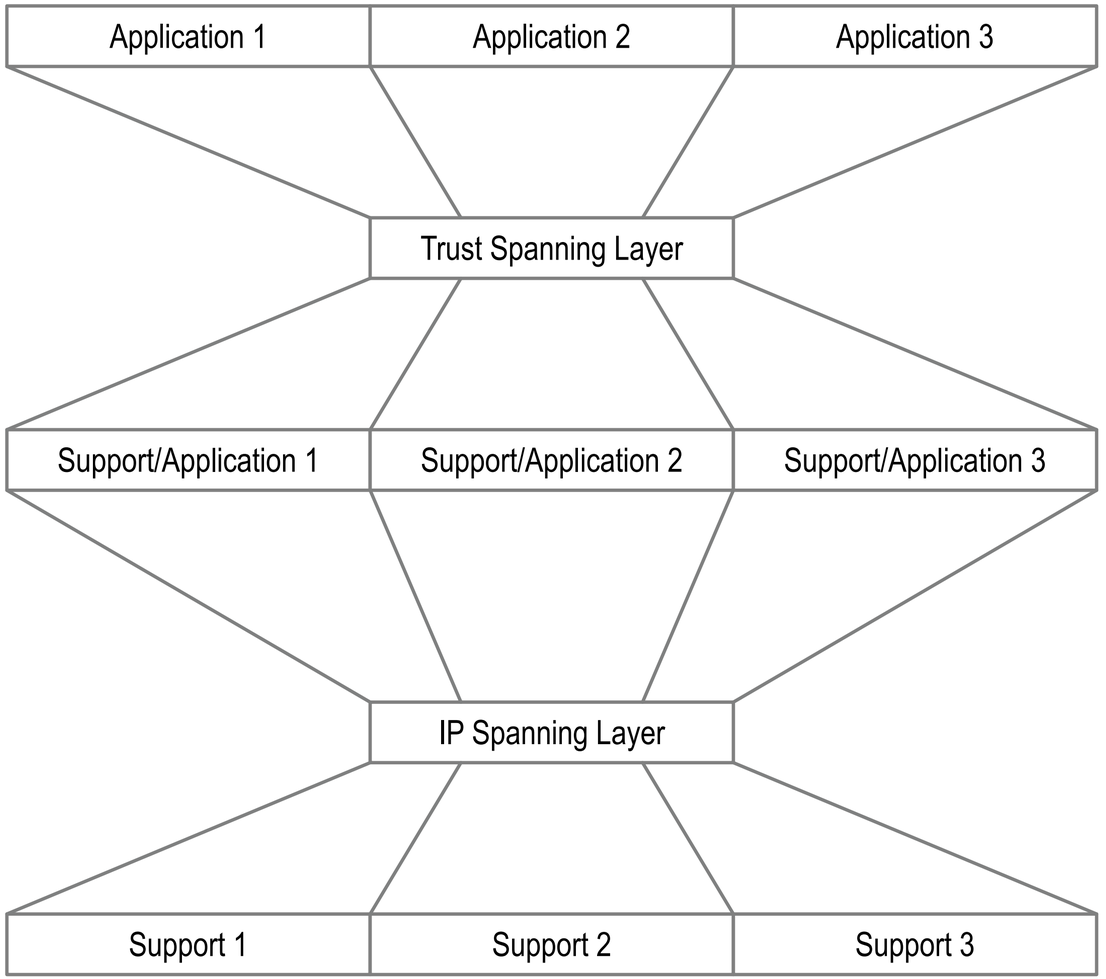


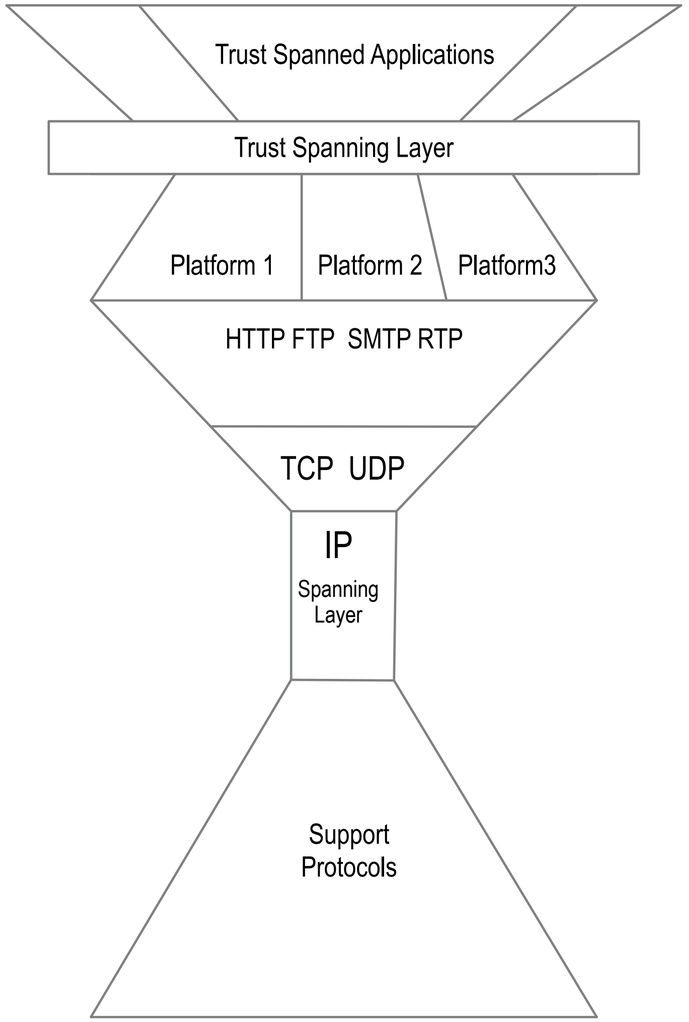



# Hourglass


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

# Waist and Neck



# 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)

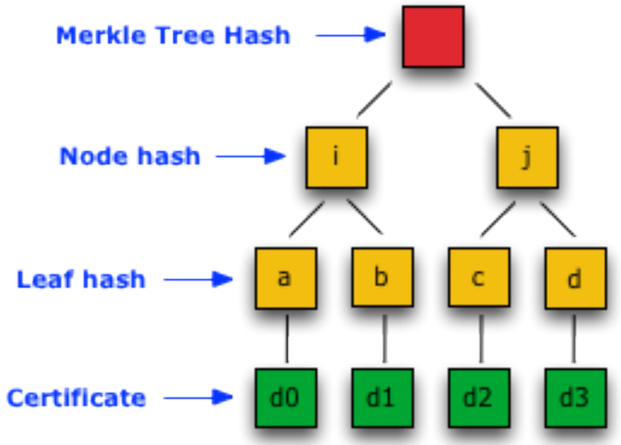



Figure 1

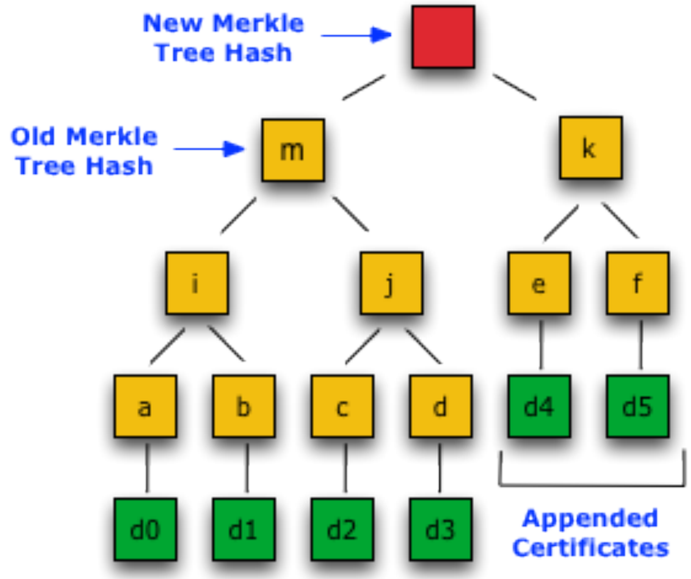



Figure 2

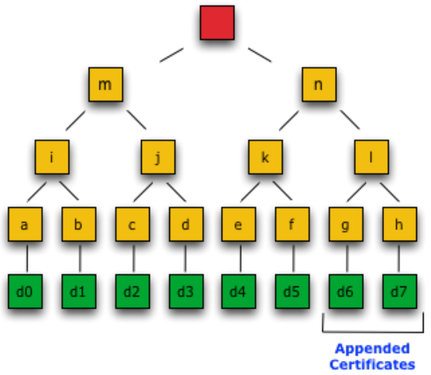



Figure 3

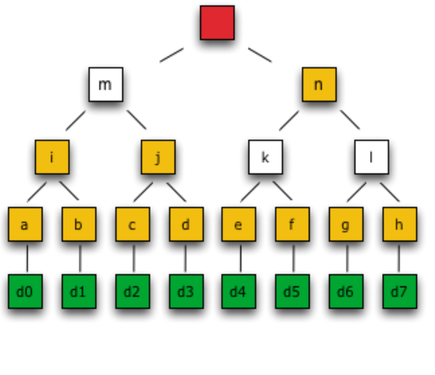



Figure 4