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

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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.*

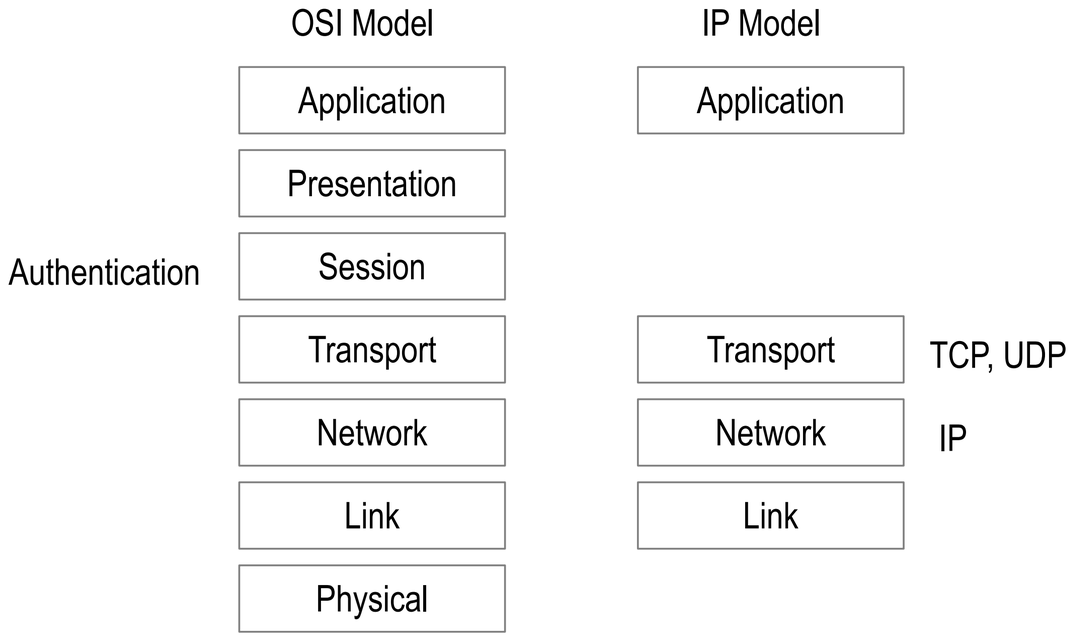
With verifiable digital signatures from asymmetric key crypto –
we may not trust in "*what*" was said, but we may trust in "*who*" said it.

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.

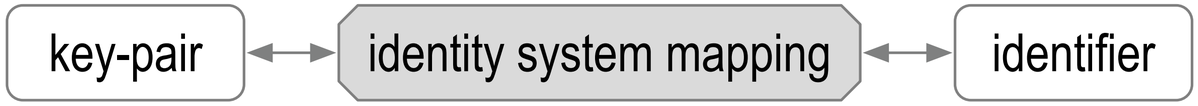


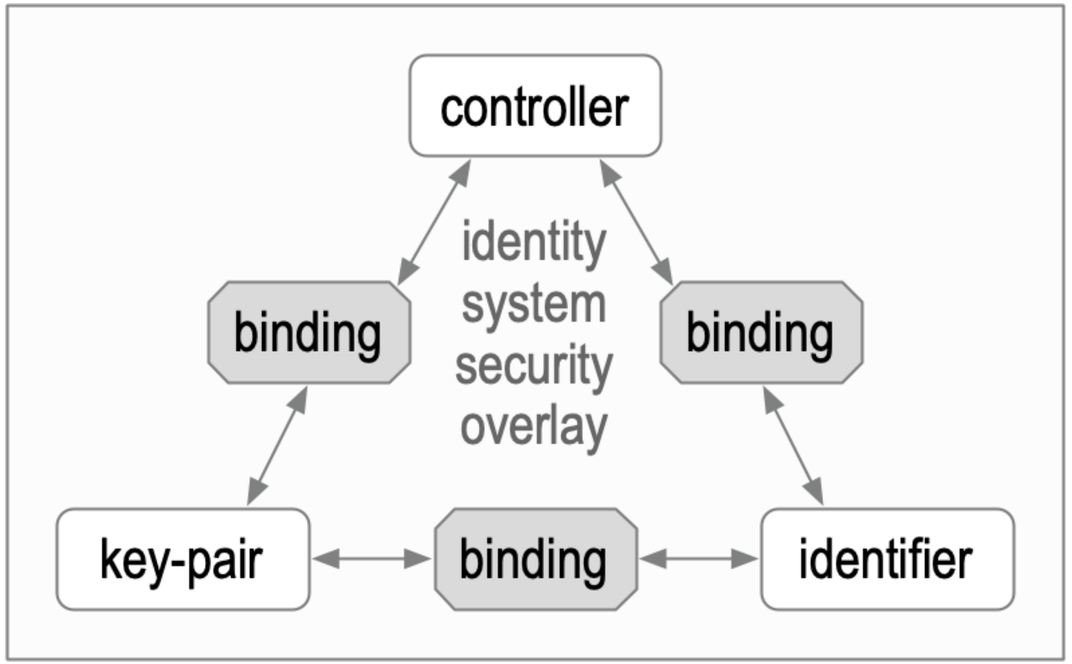
Instead …

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

Identity System Security Overlay

Establish authenticity of IP packet's message payload.

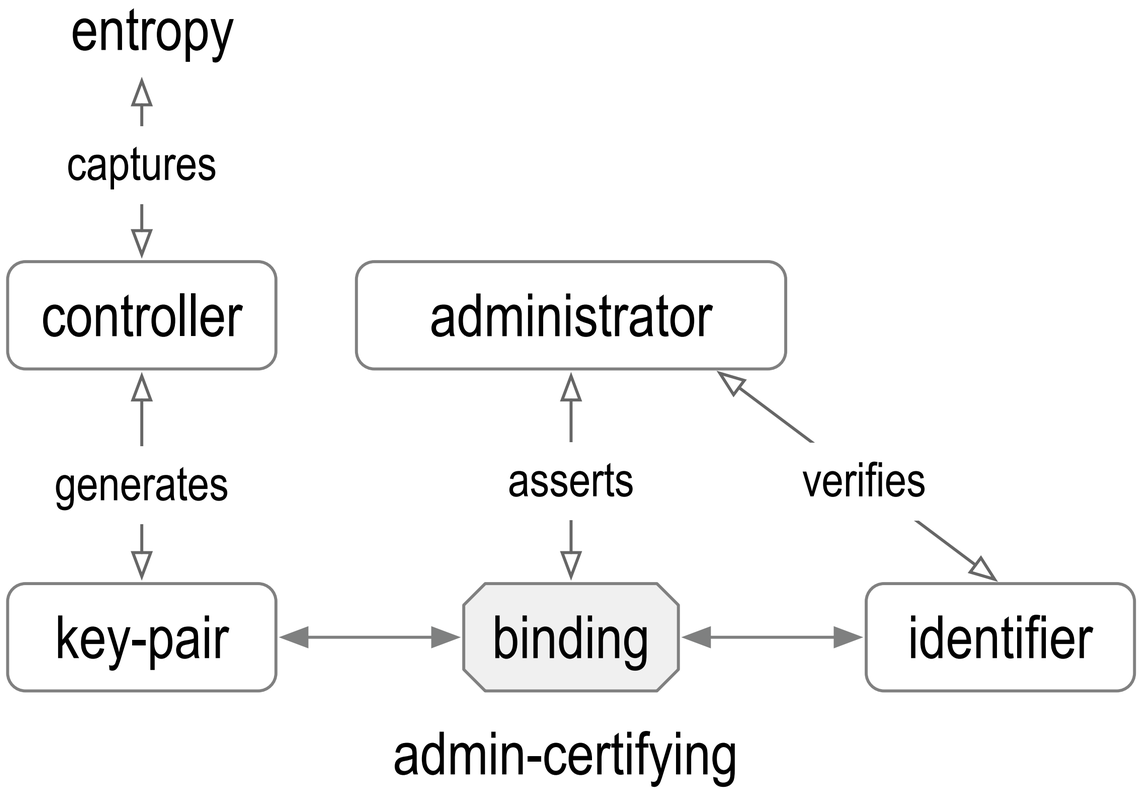


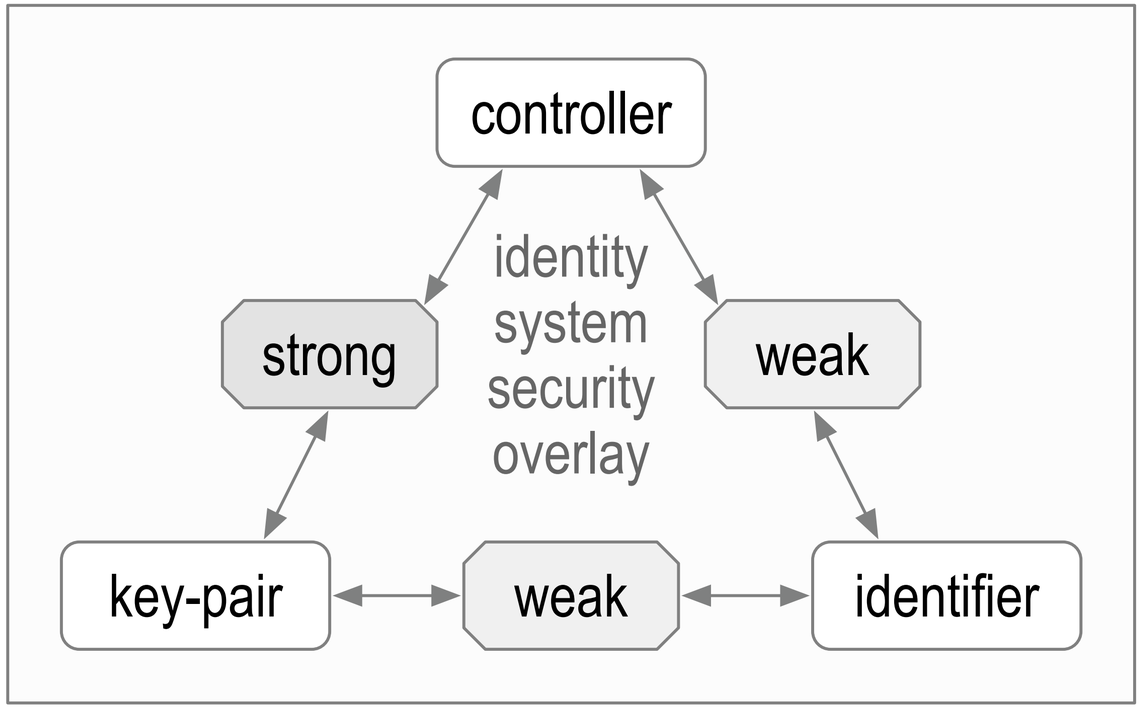


Identifier Issuance

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

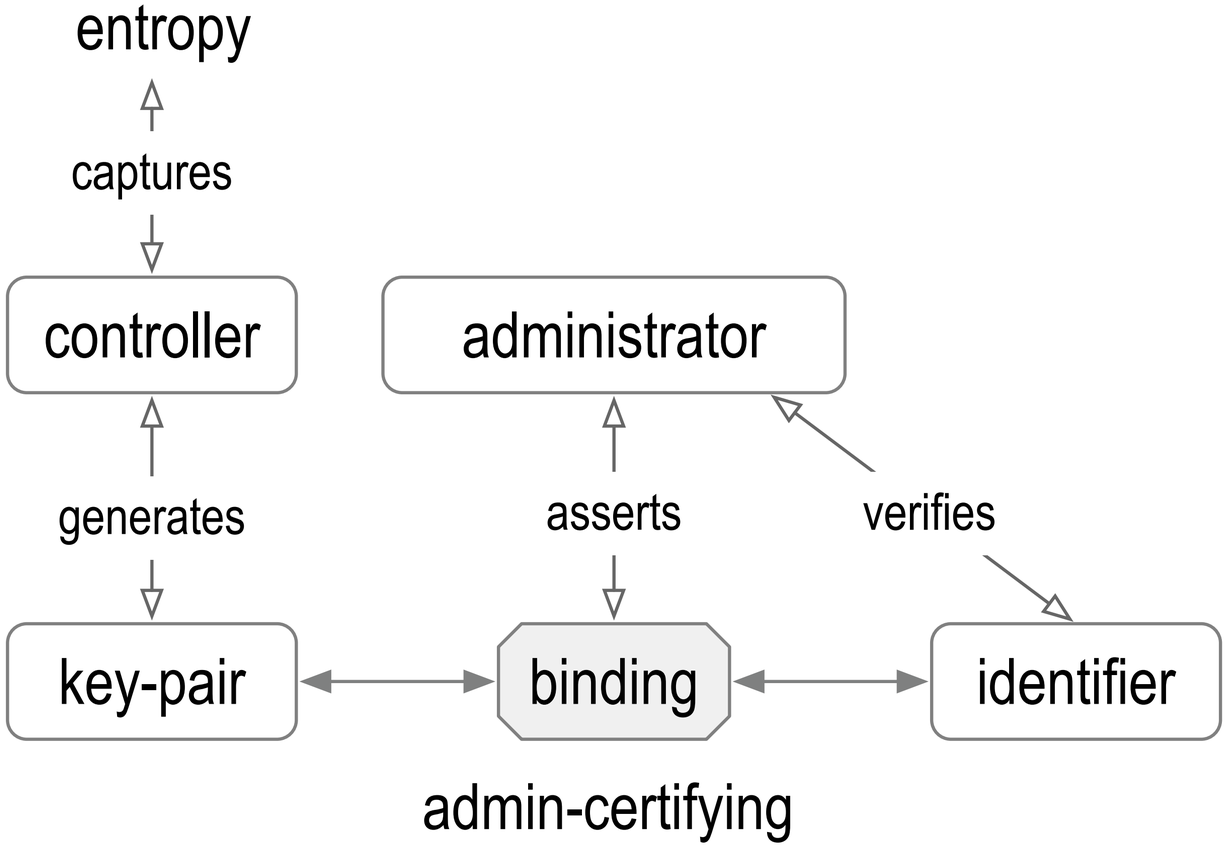
Administrative Identifier Issuance and Binding

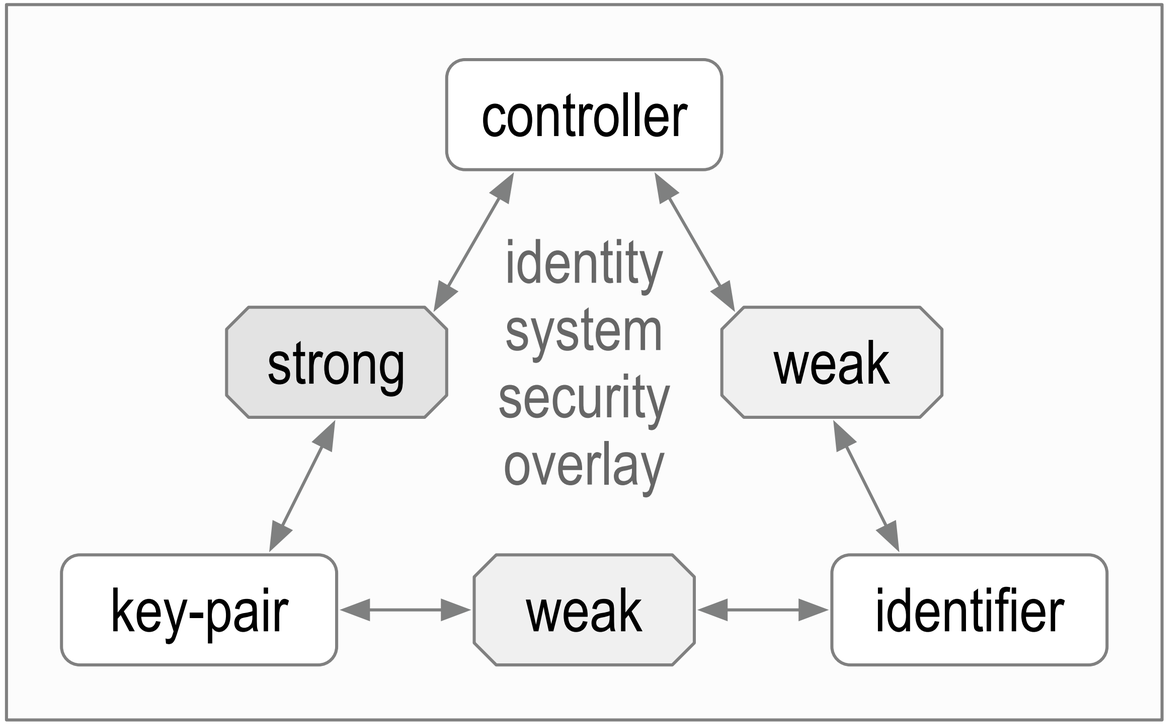




Admin-Certifying Identifier Issuance

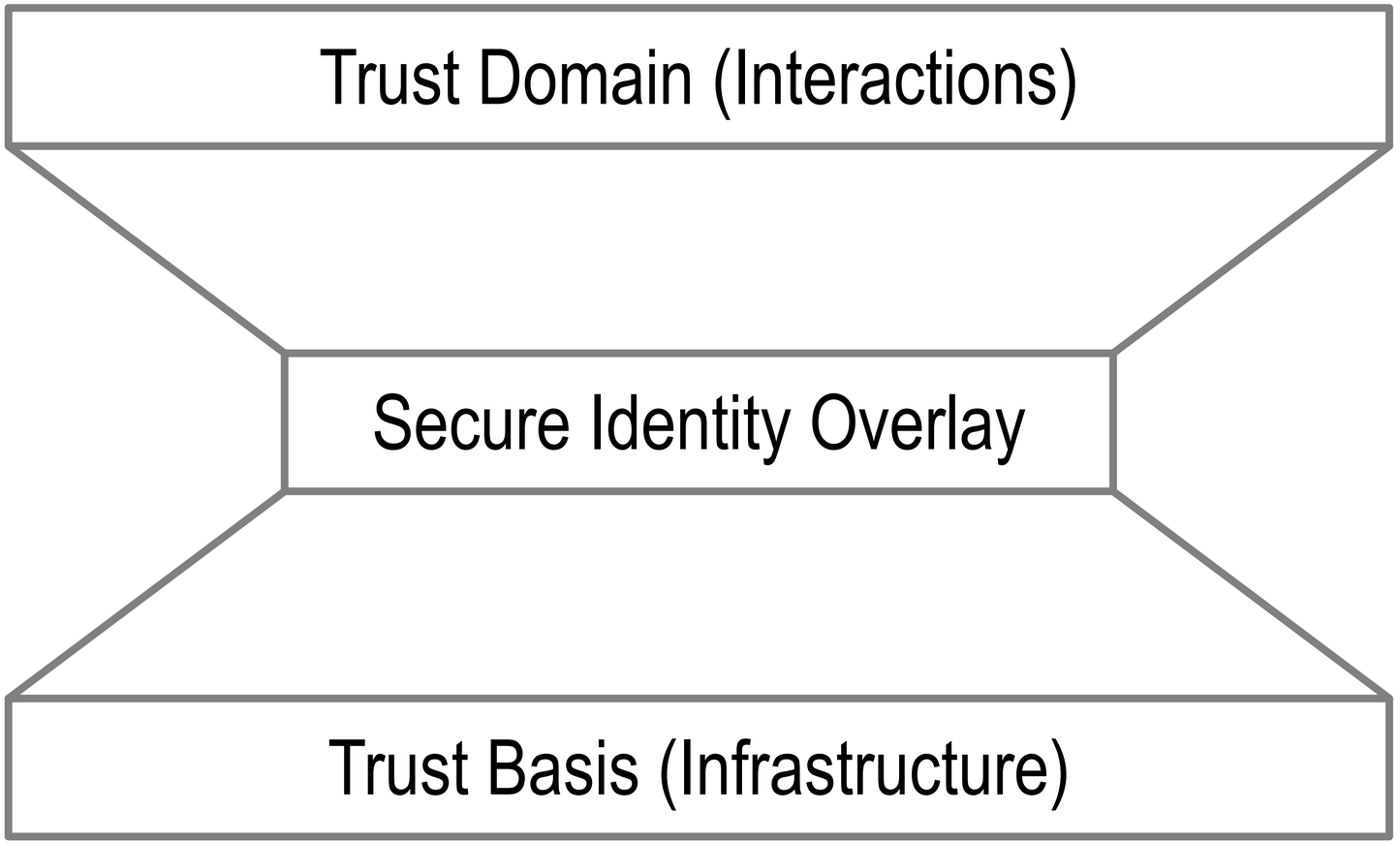
Self-Certifying Identifier Issuance and Binding



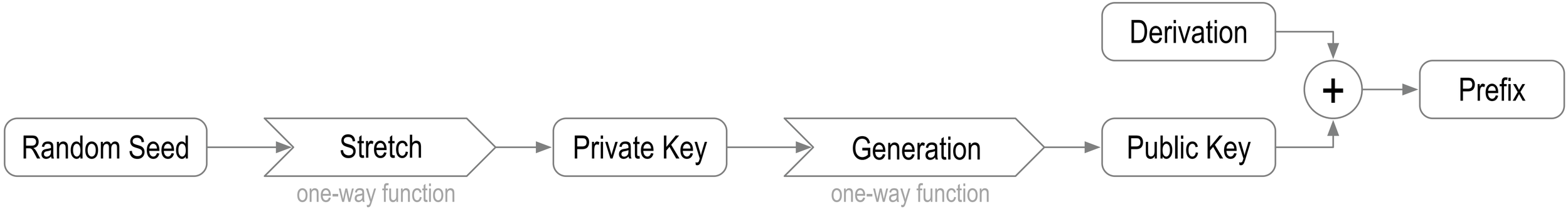


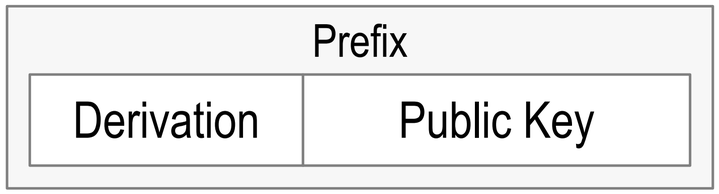
Admin-Certifying Identifier Issuance

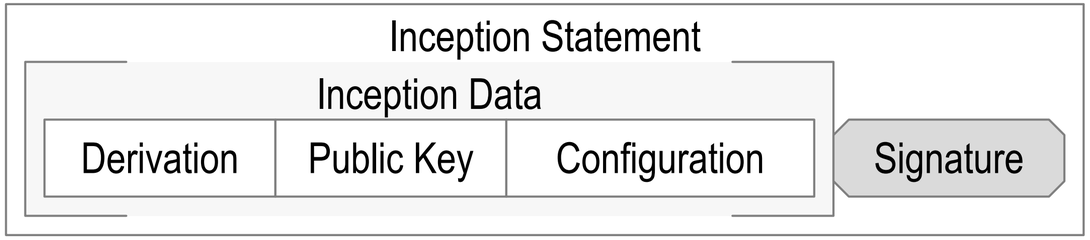
Identity System Security Overlay



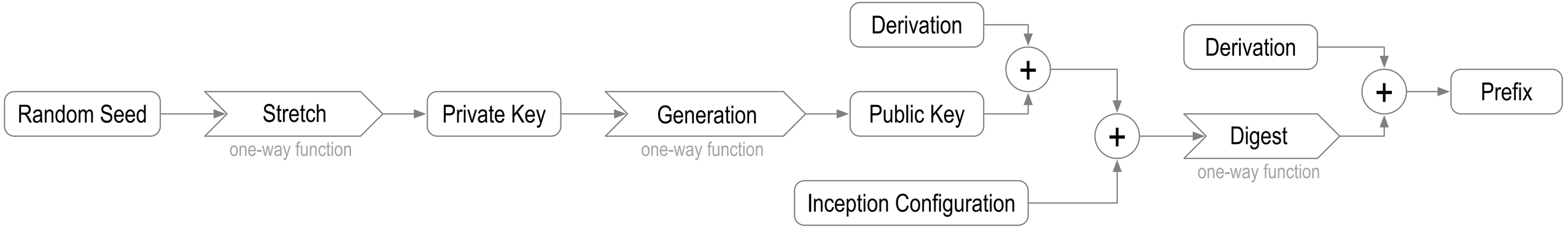
Basic

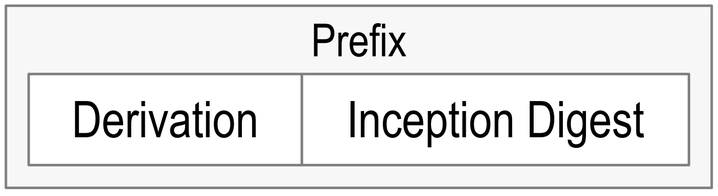

Derivation
+
Prefix
Random Seed
Stretch
one-way function
Private Key
Generation
one-way function
Public Key

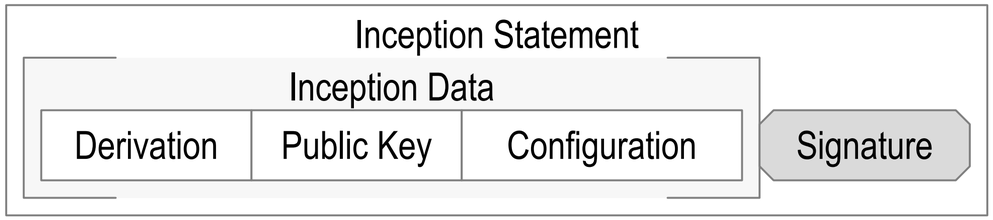

Prefix
Derivation
Public Key


Inception Statement
Inception Data
Derivation
Public Key
Configuration
Signature

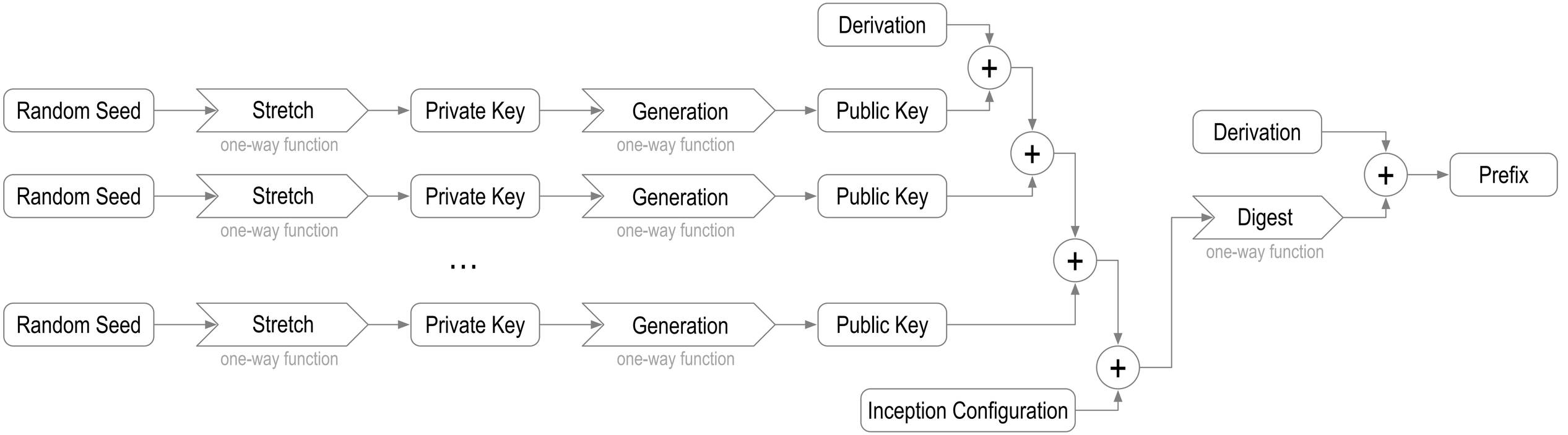
Self-Addressing

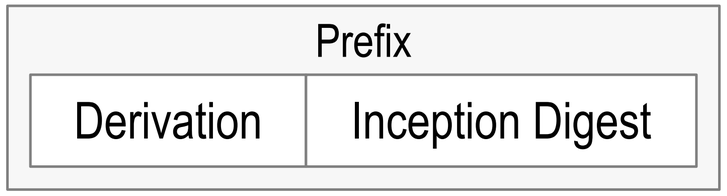


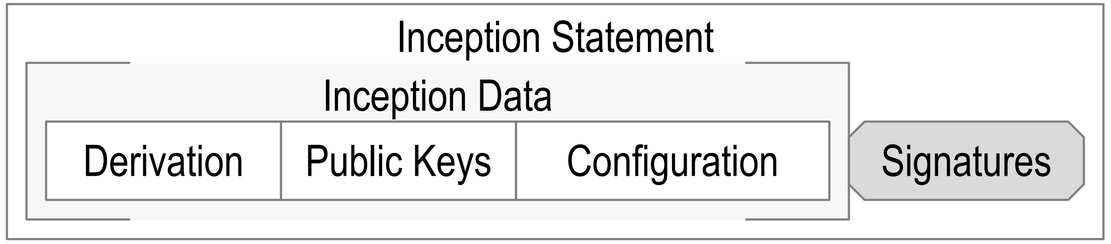




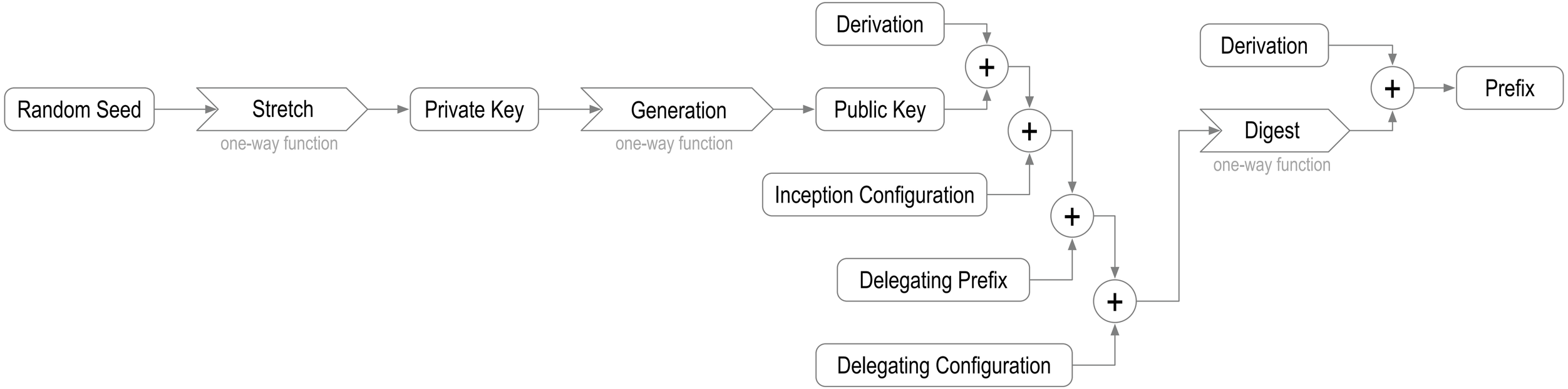
Multi-Sig Self-Addressing

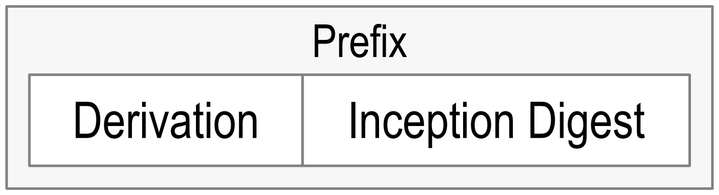


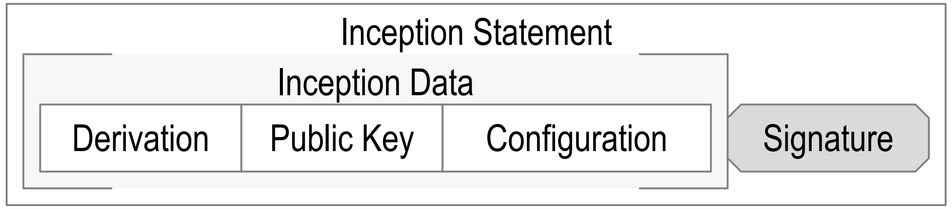




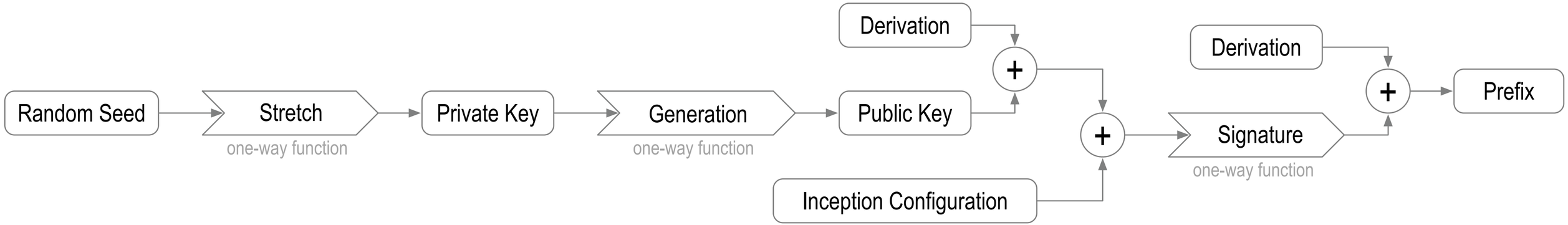
Delegated Self-Addressing

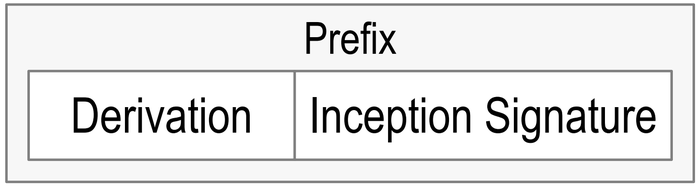


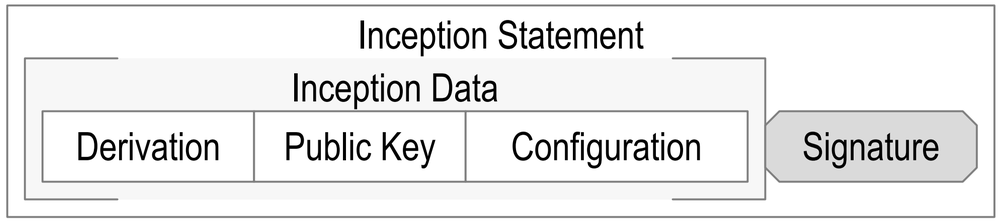




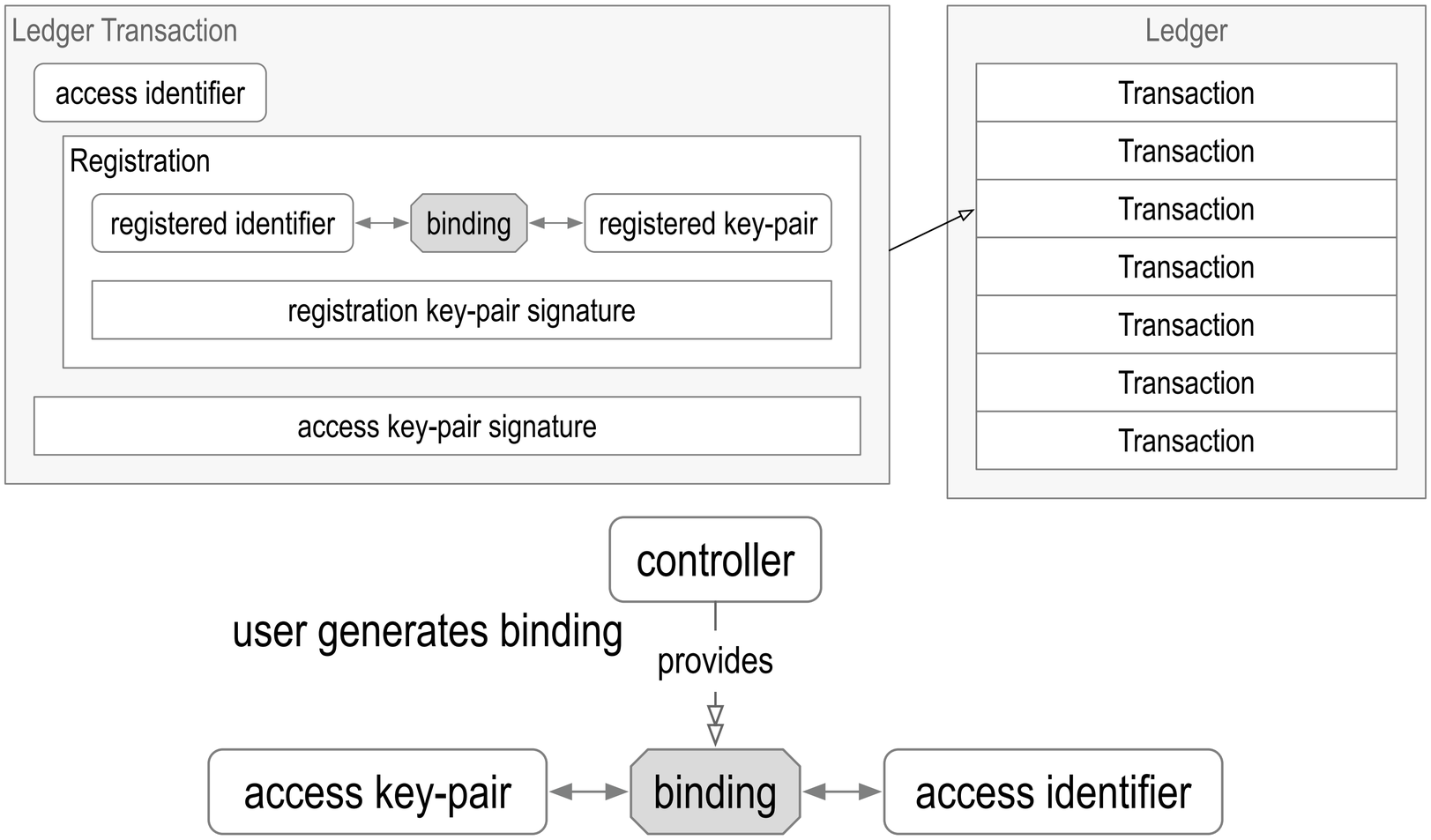
Self-Signing







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*

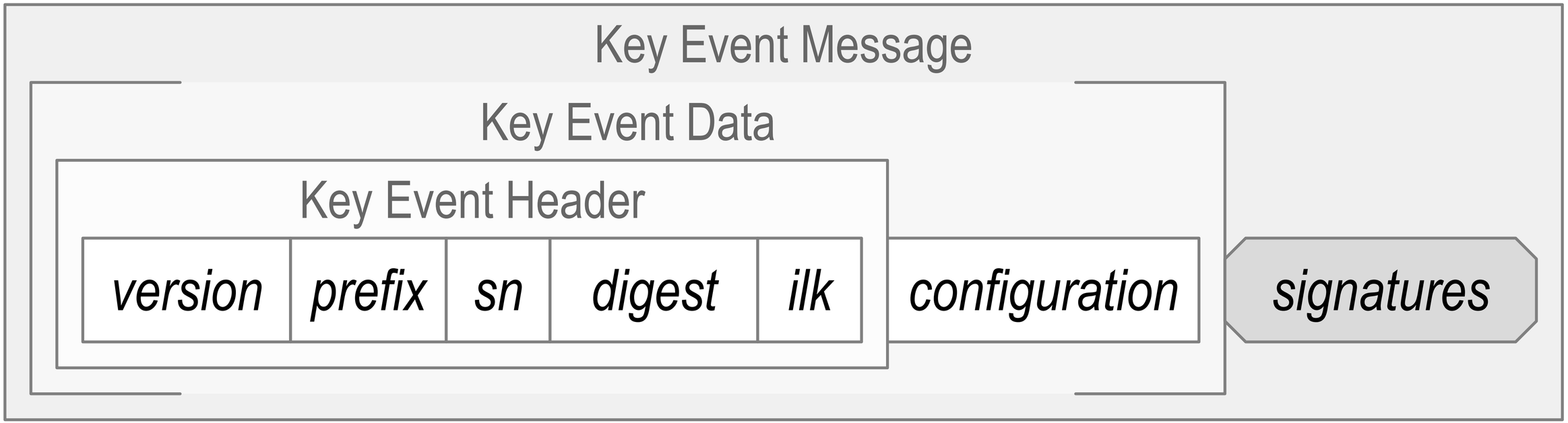
Source-of-Truth

controller of the private key = *who*

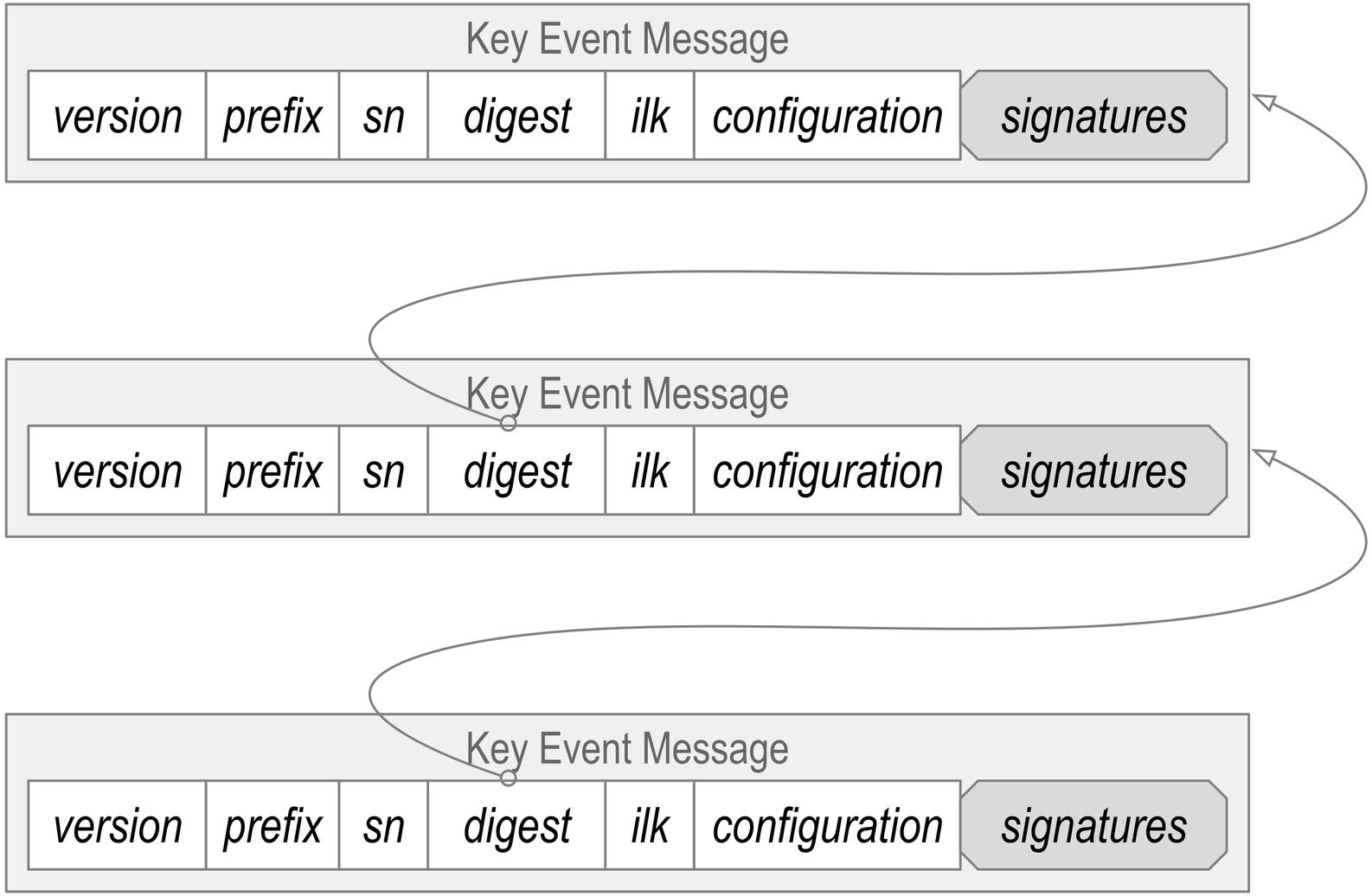
Loci-of-Control

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

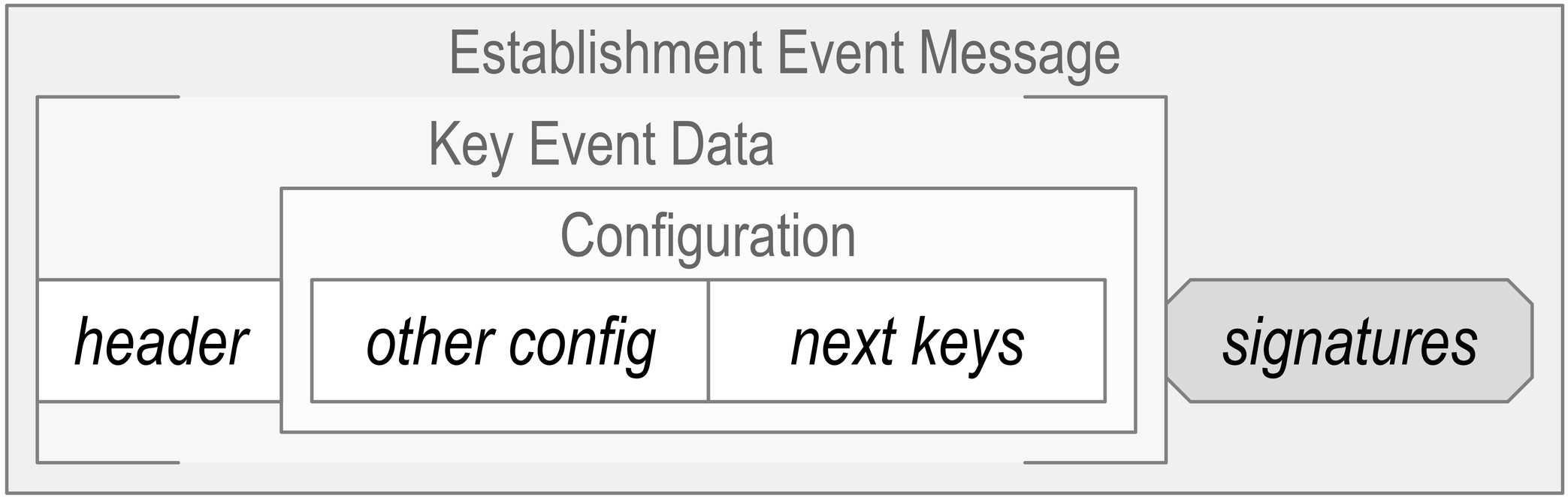
Key Event Message



Event Digest Chaining



Establishment Event

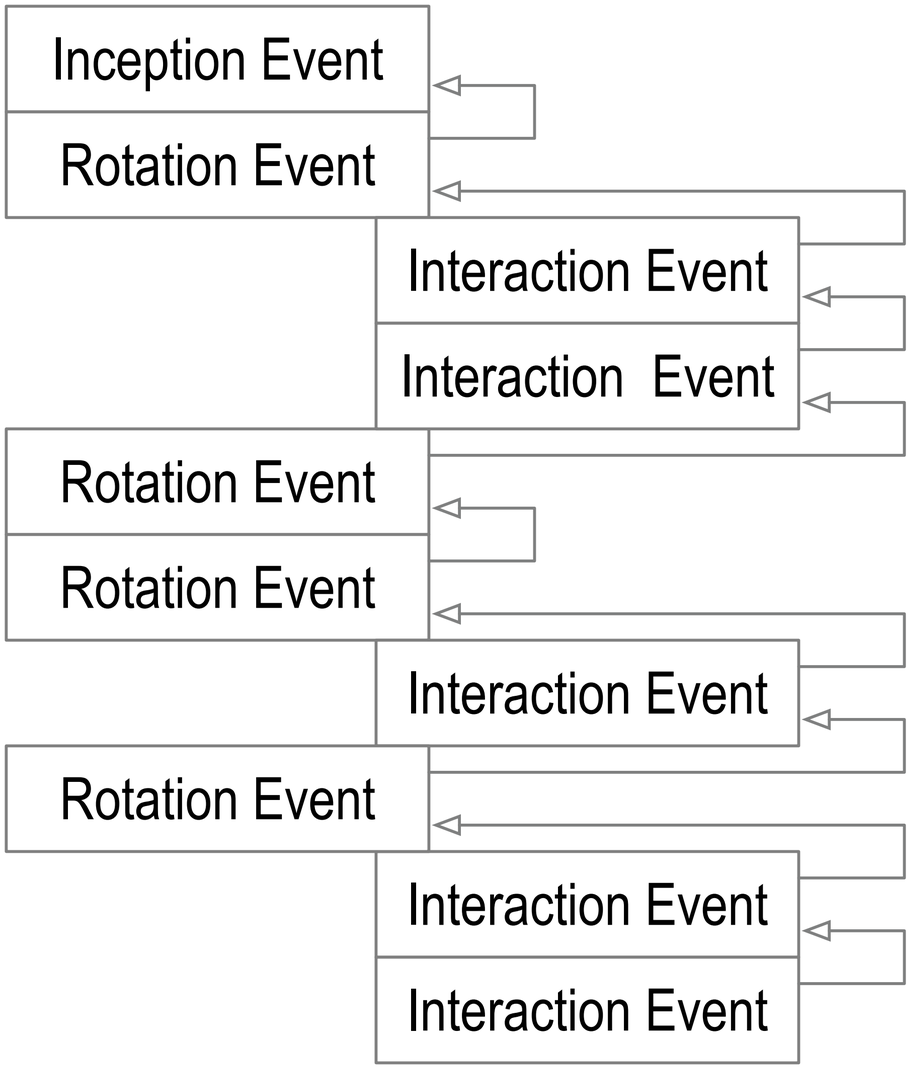


Event Sequencing

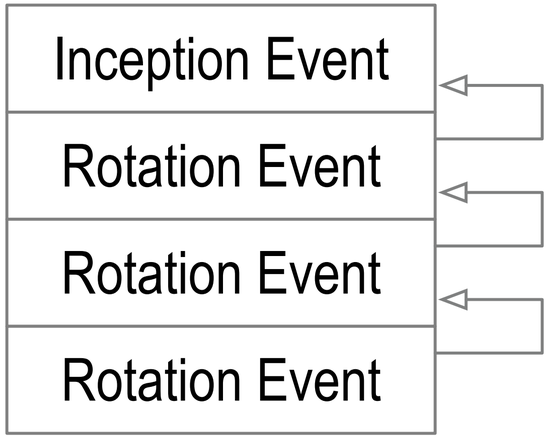
Full Sequence

Establishment Subsequence

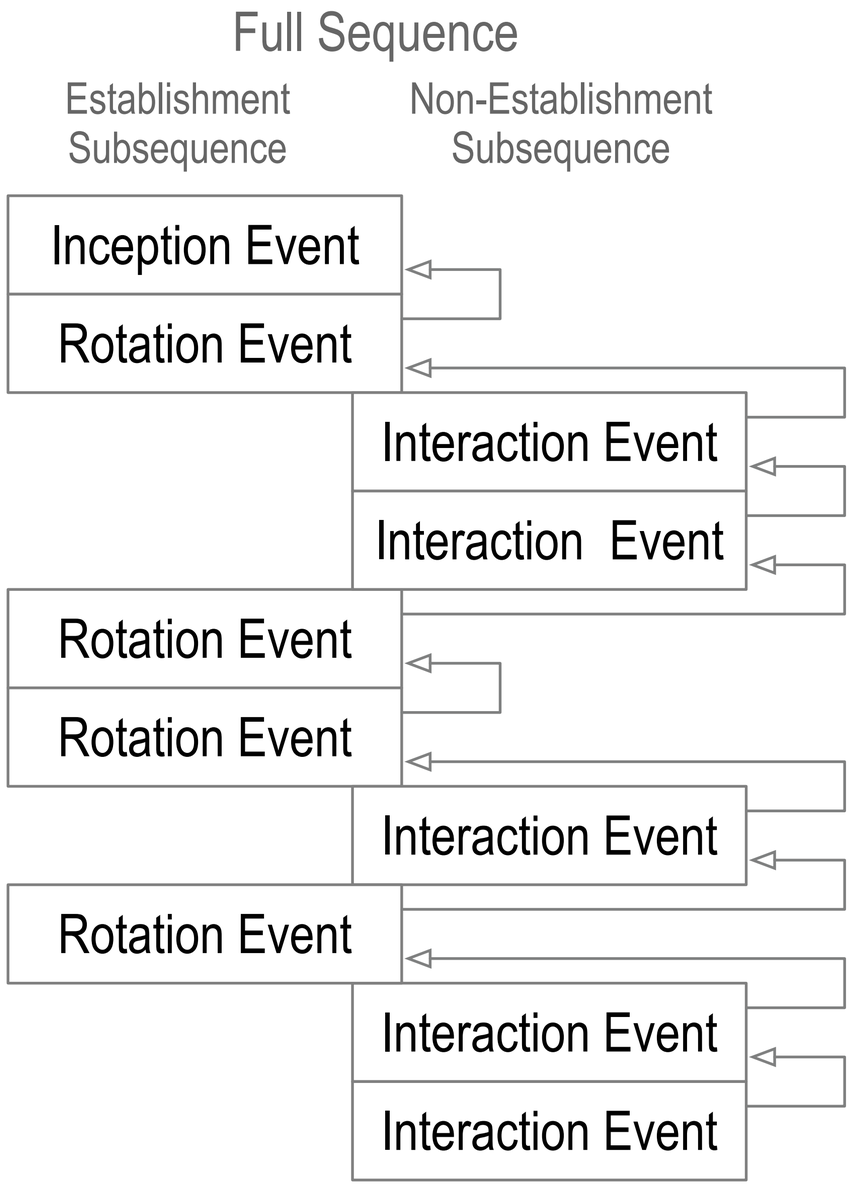
Non-Establishment Subsequence



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.

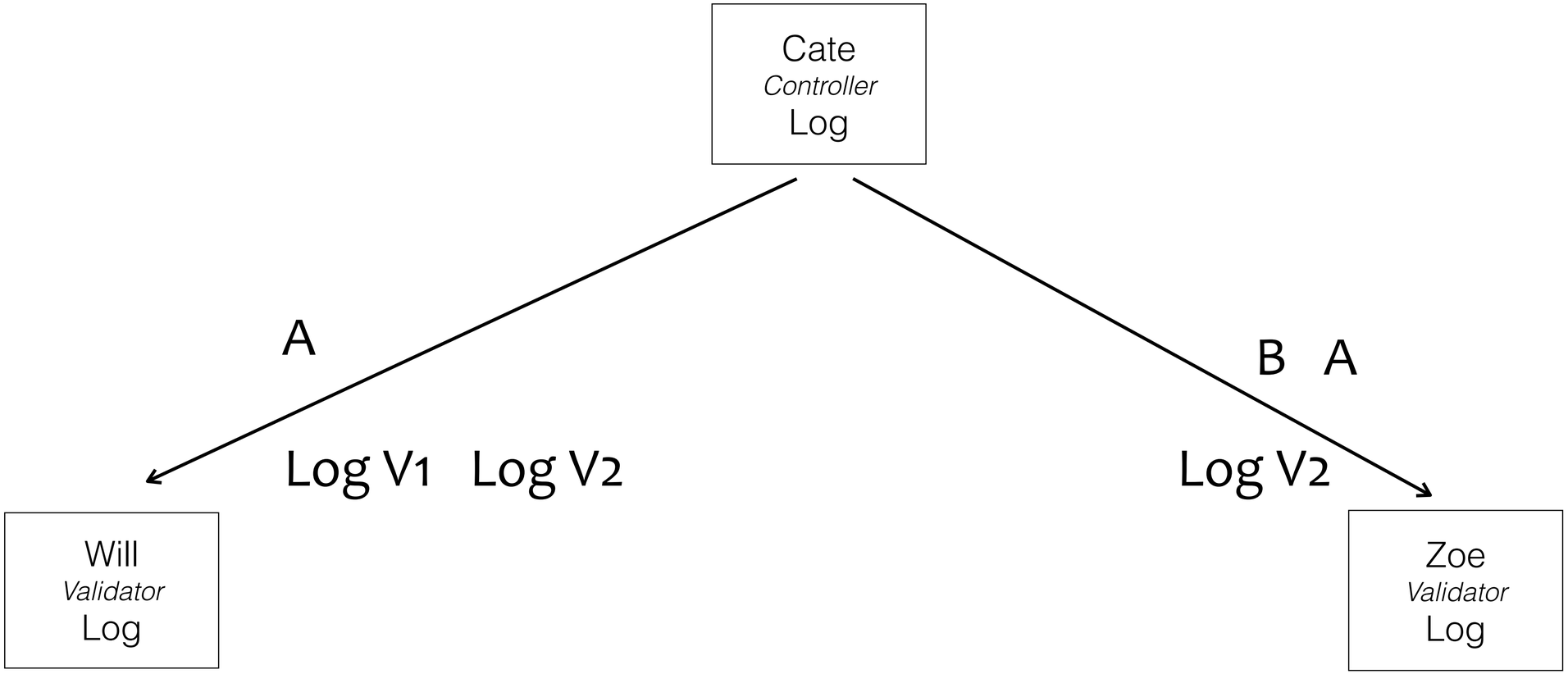
Duplicity detection protects against external inconsistency.

Duplicity Game

Cate promises to provide a consistent pair-wise log.

Local Consistency Guarantee

How may Cate be duplicitous and not get caught?



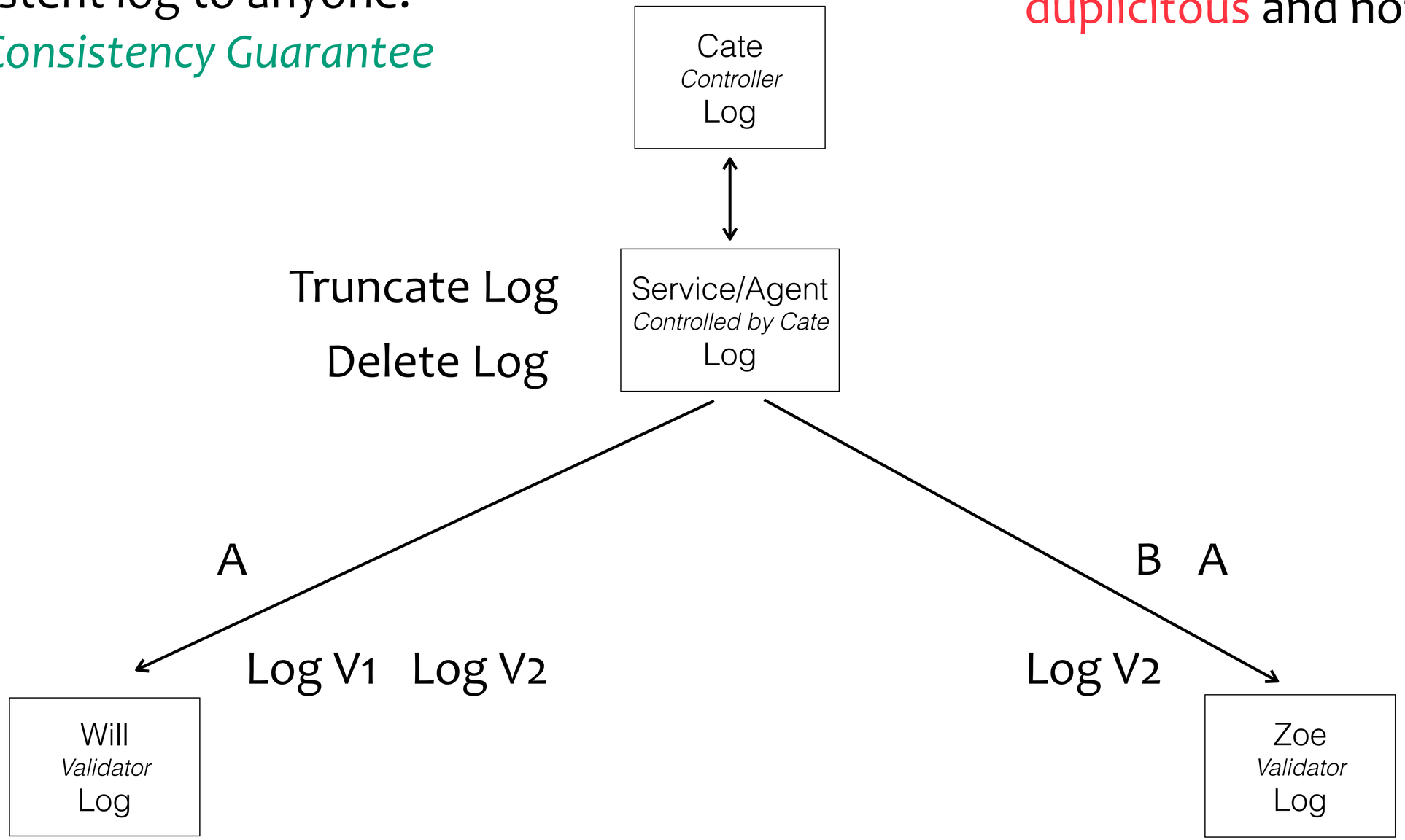
private (one-to-one) interactions

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

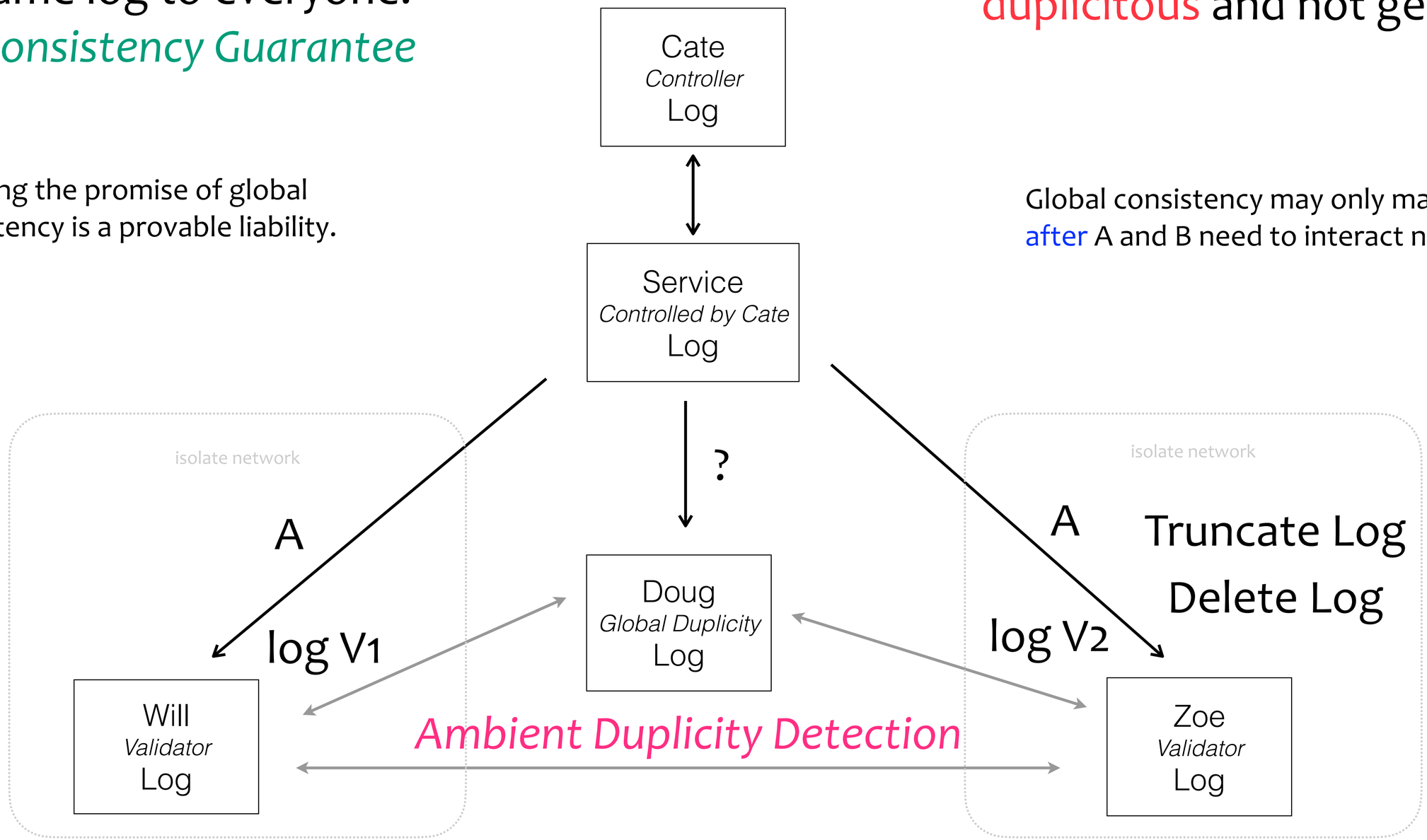
Service promises to provide exact same log to everyone.

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*:

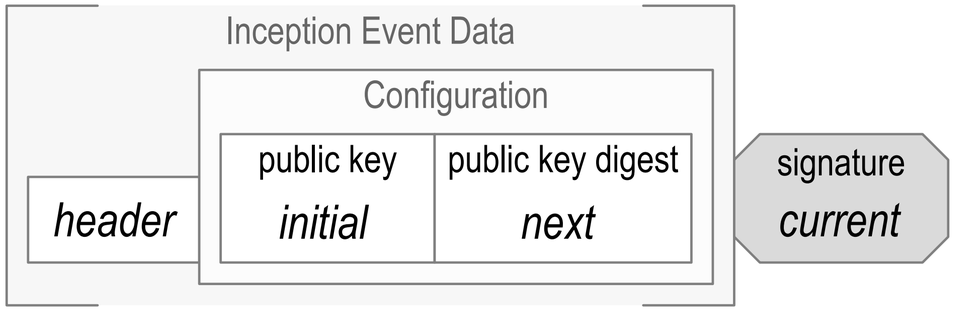
End user alone may verify. Zero trust in intervening infrastructure.

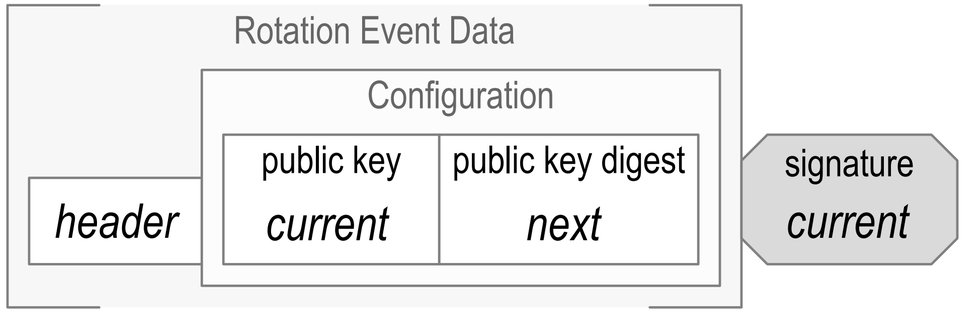
KERLs may be *Ambient Verifiable*:

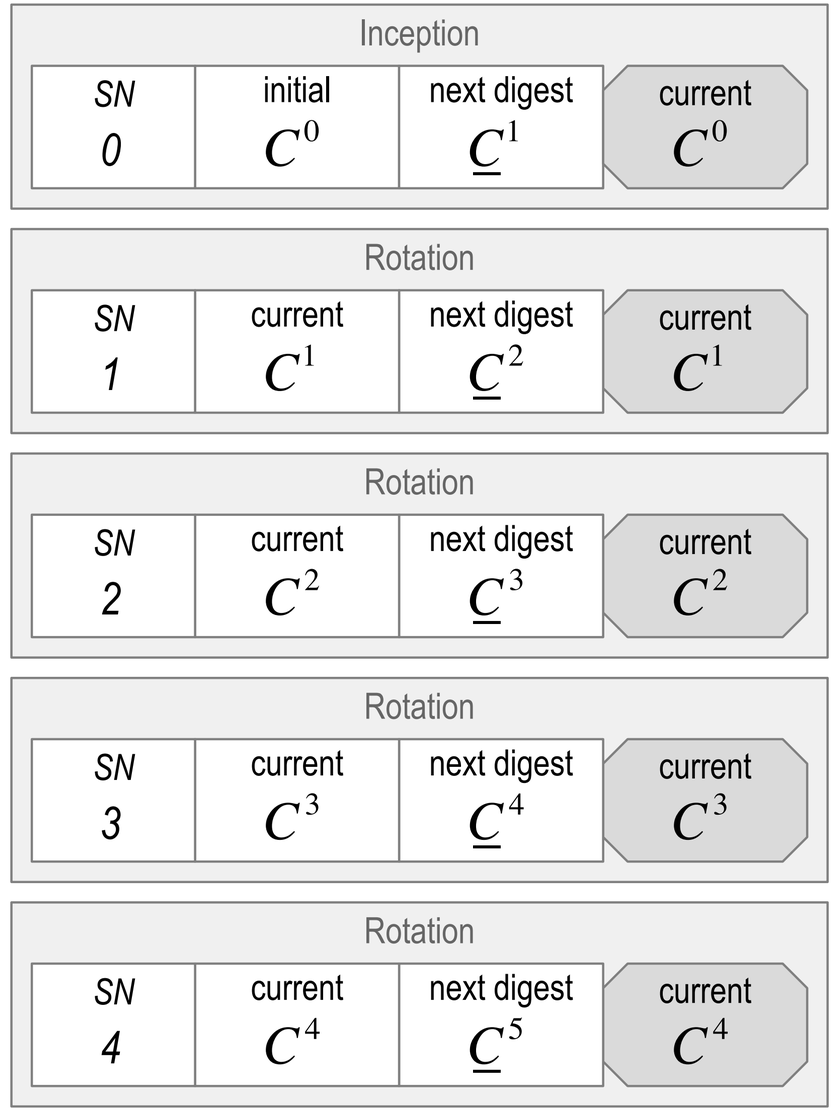
Anyone may verify *anylog*, *anywhere*, at *anytime*.

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

Pre-Rotation

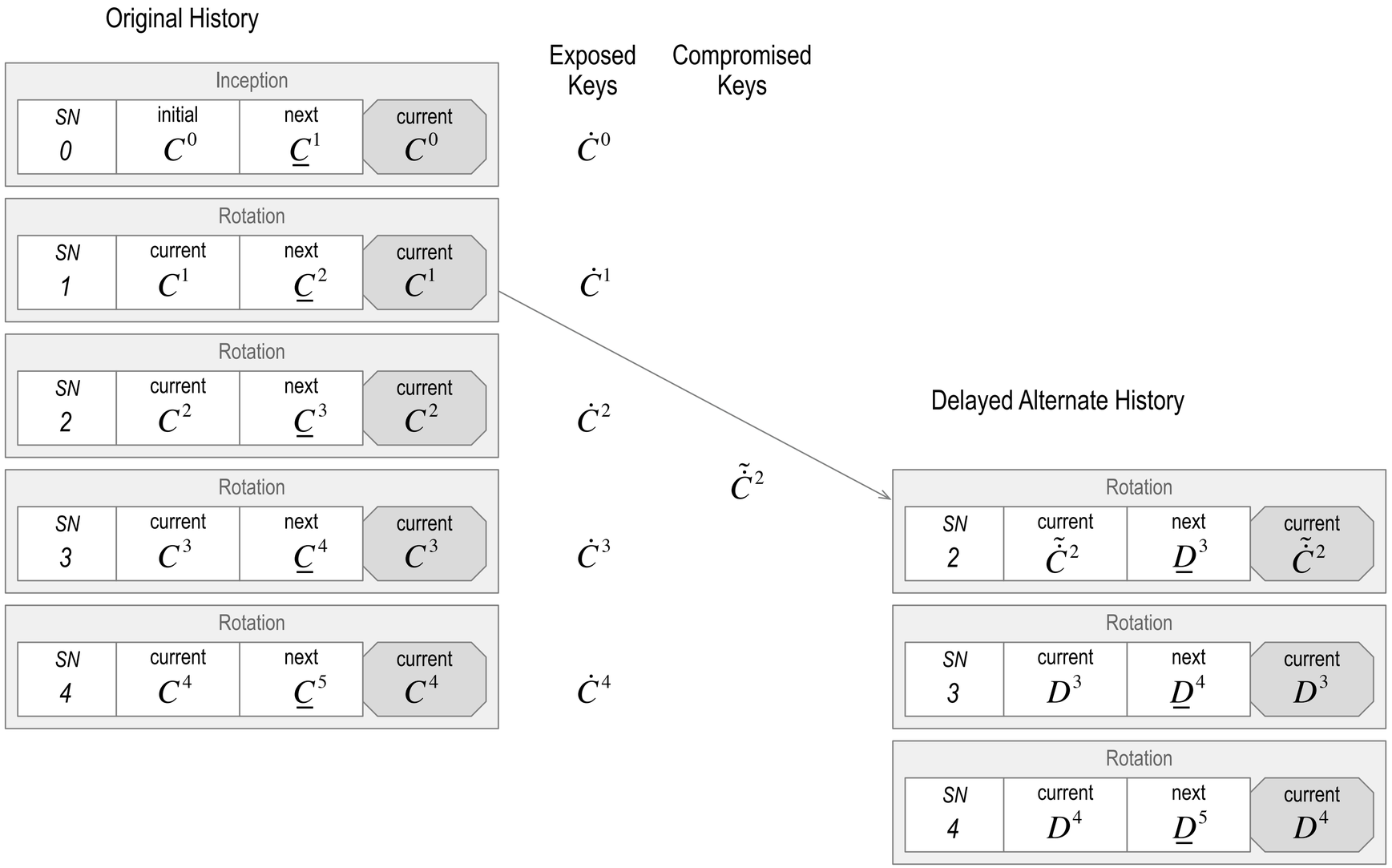






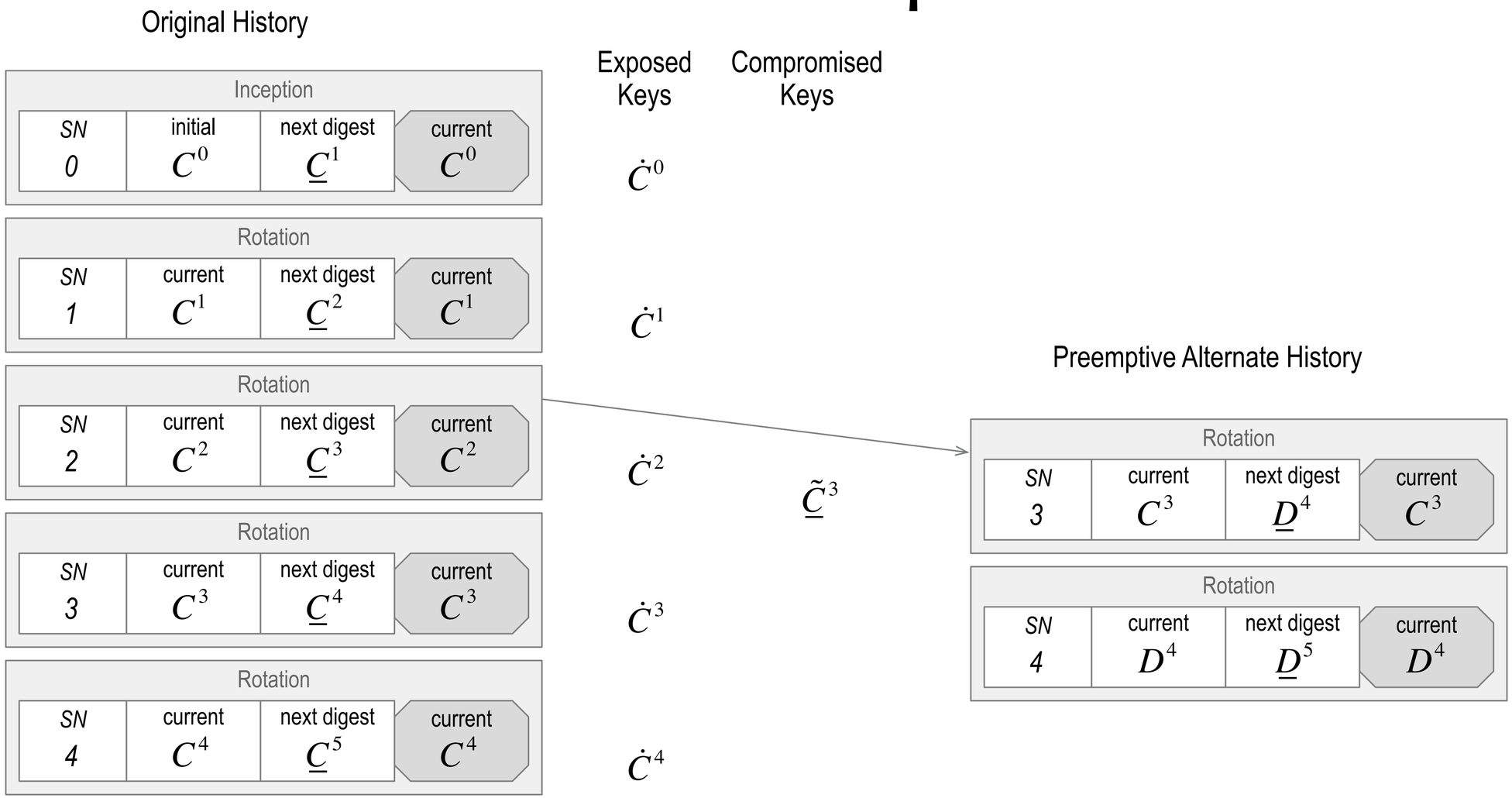
Digest of *next* key(s) makes pre-rotation post-quantum secure

Dead Exploit



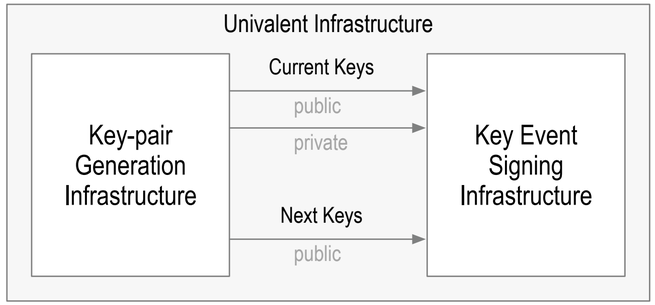
Any copy of original history protects against successful *dead* exploit

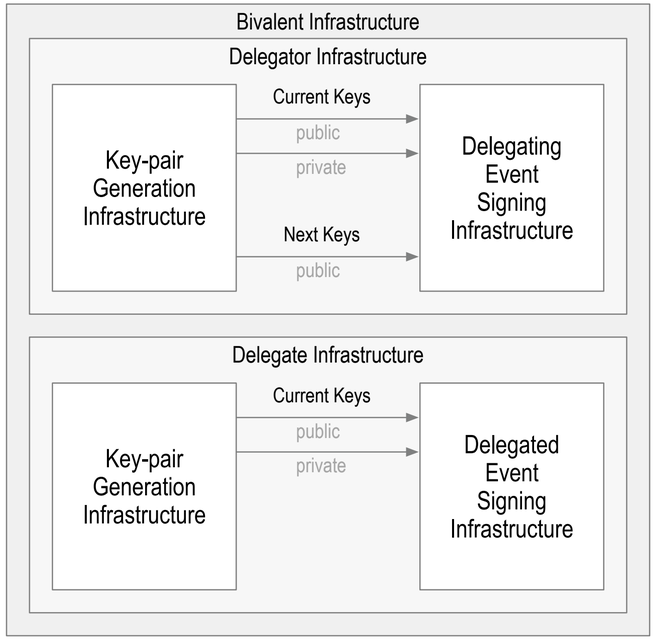
Live Exploit

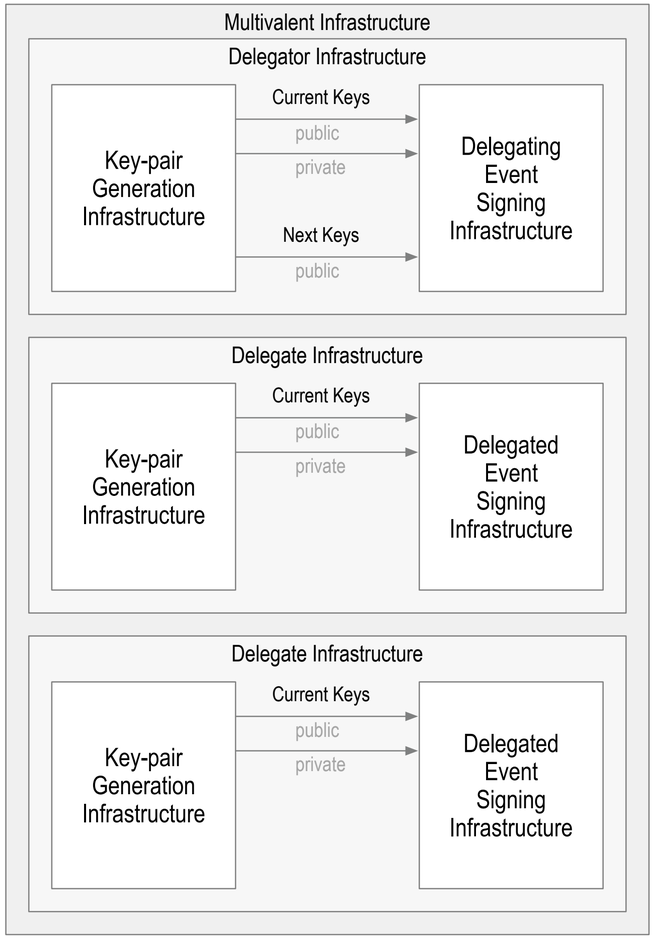


Difficulty of inverting *next* key(s) protects against successful *live* exploit

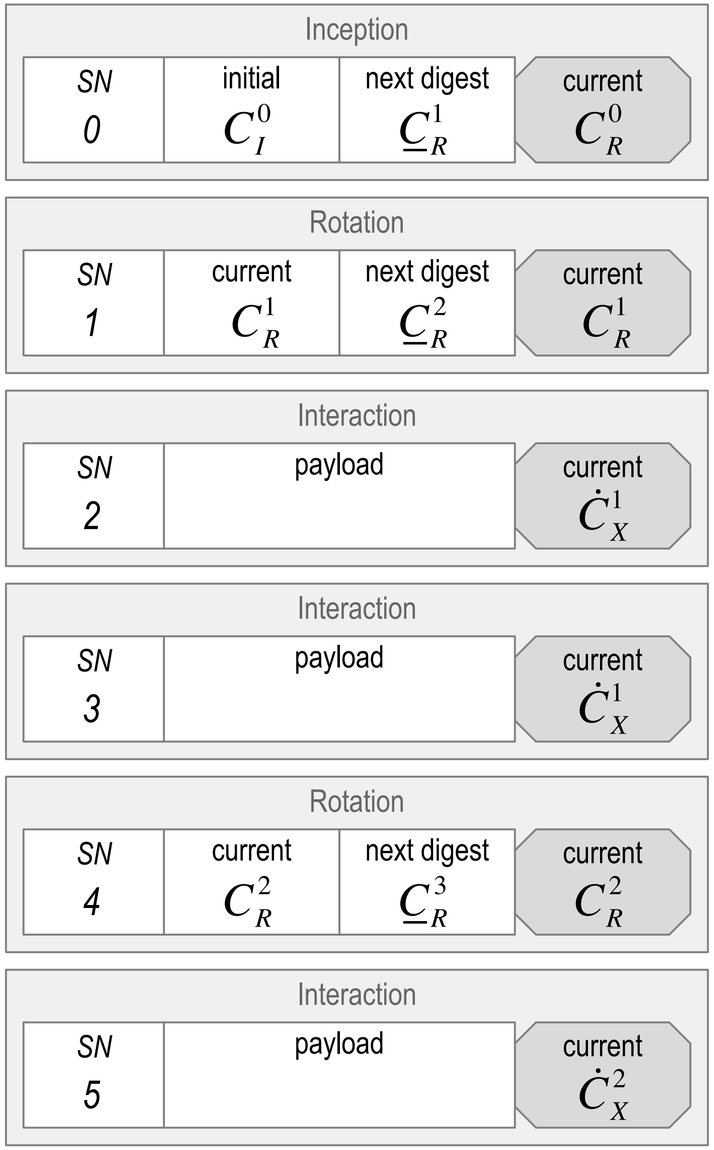
Key Infrastructure Valence

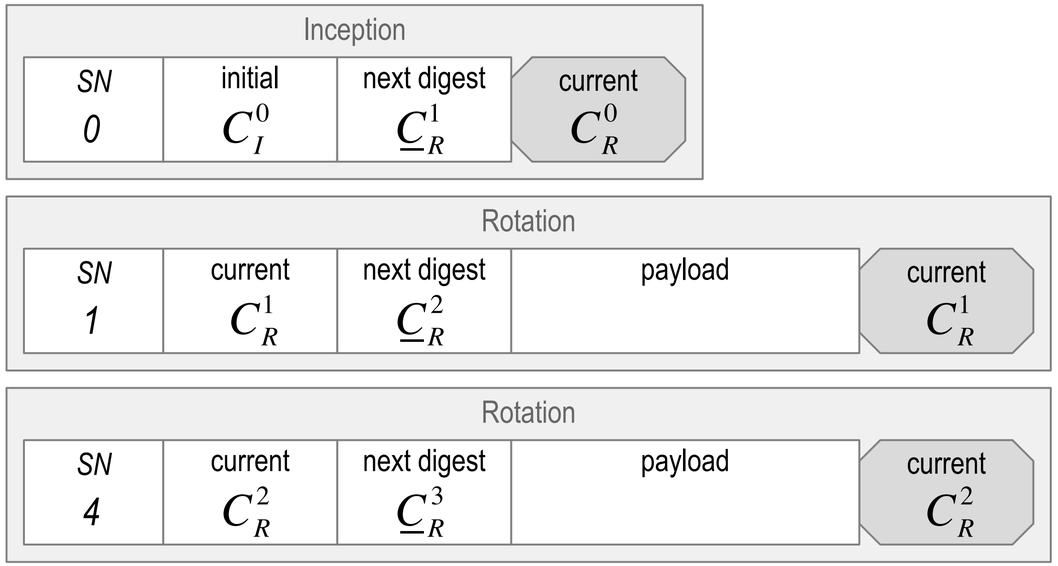




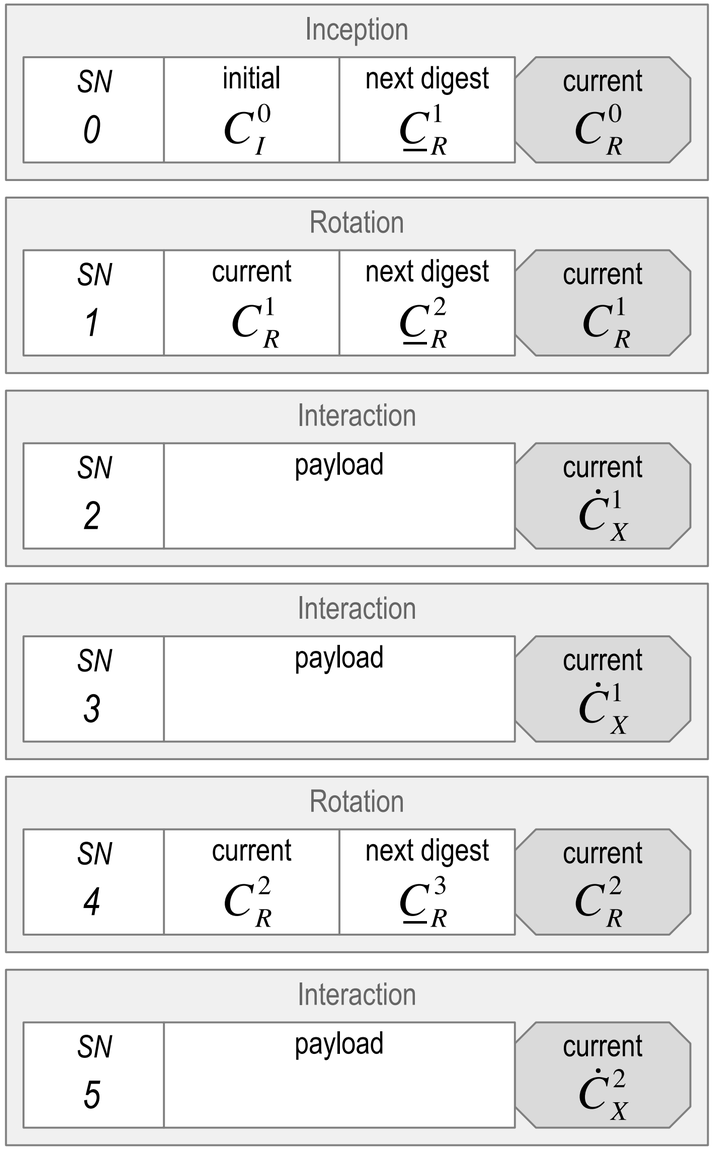


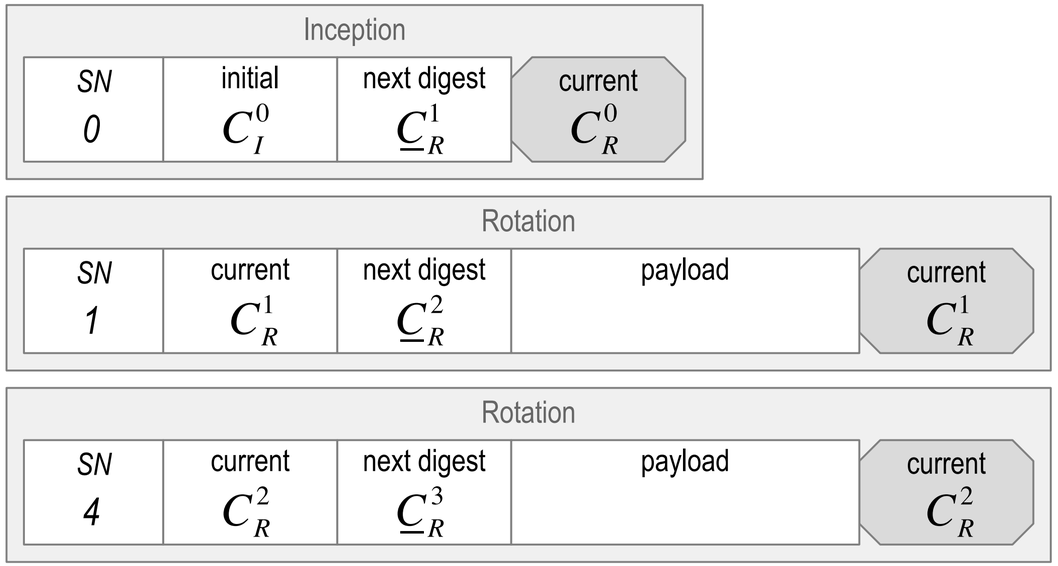
Repurposed Keys



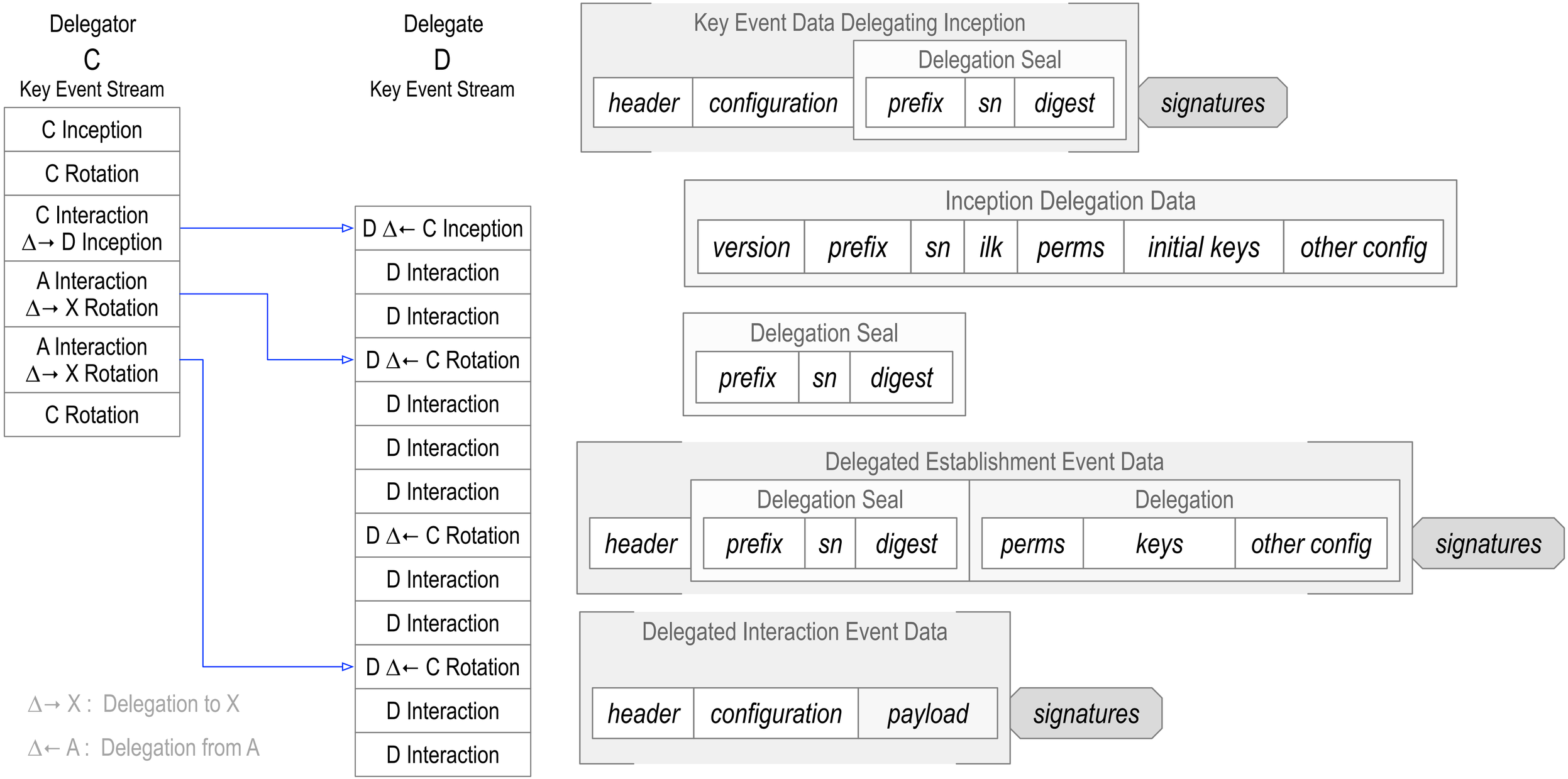


Repurposed Keys

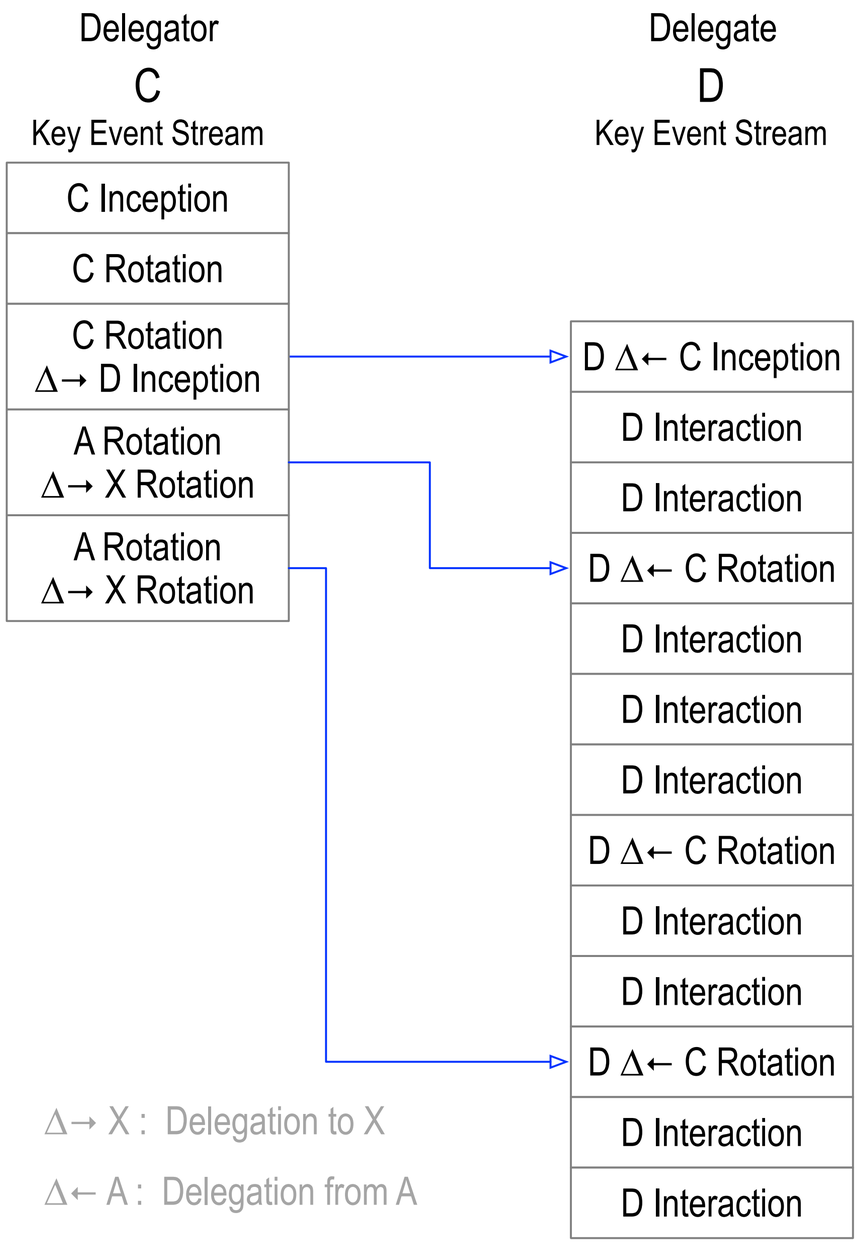


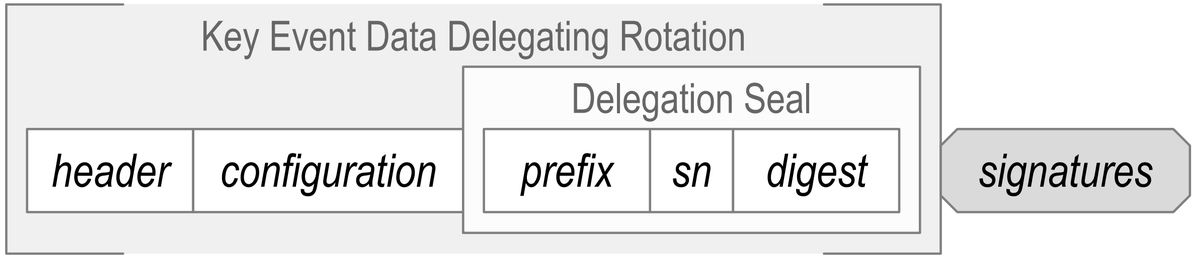


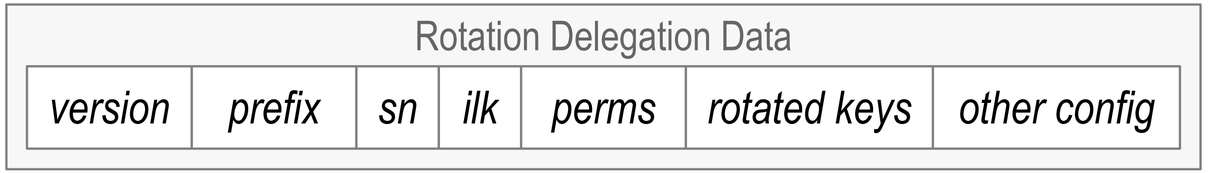
Interaction Delegation

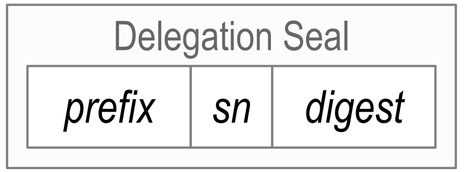


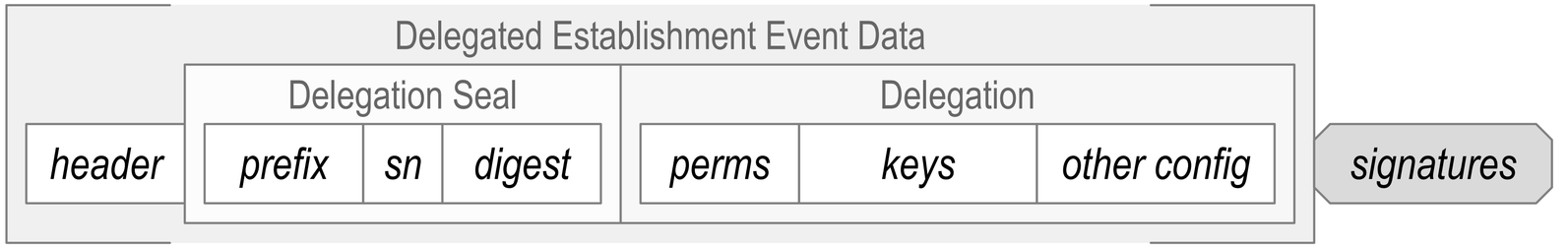
Rotation Delegation

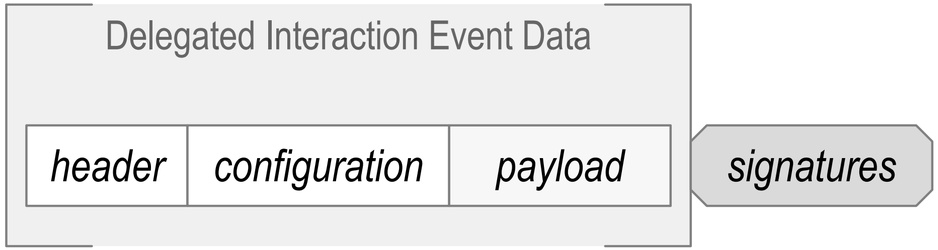




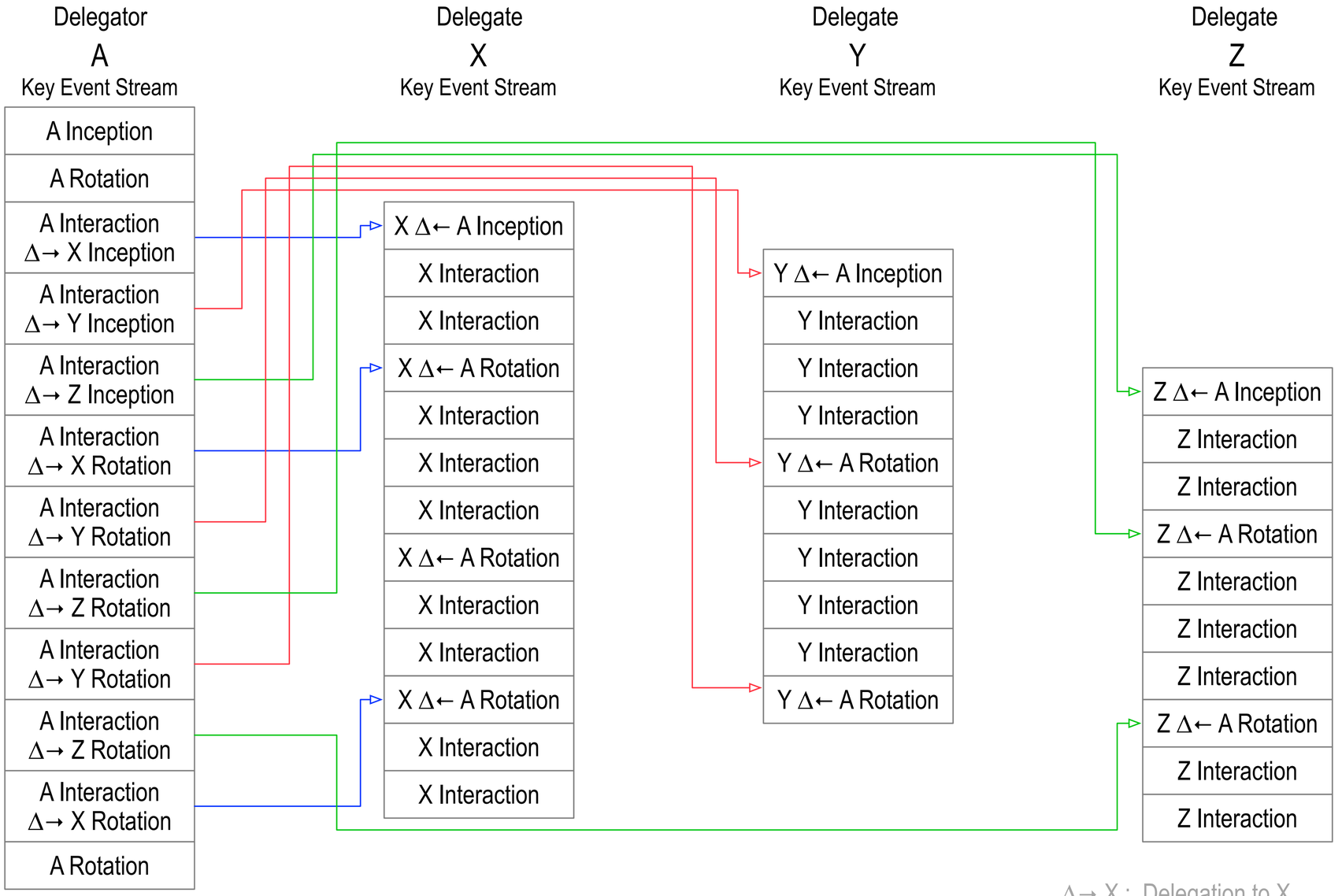




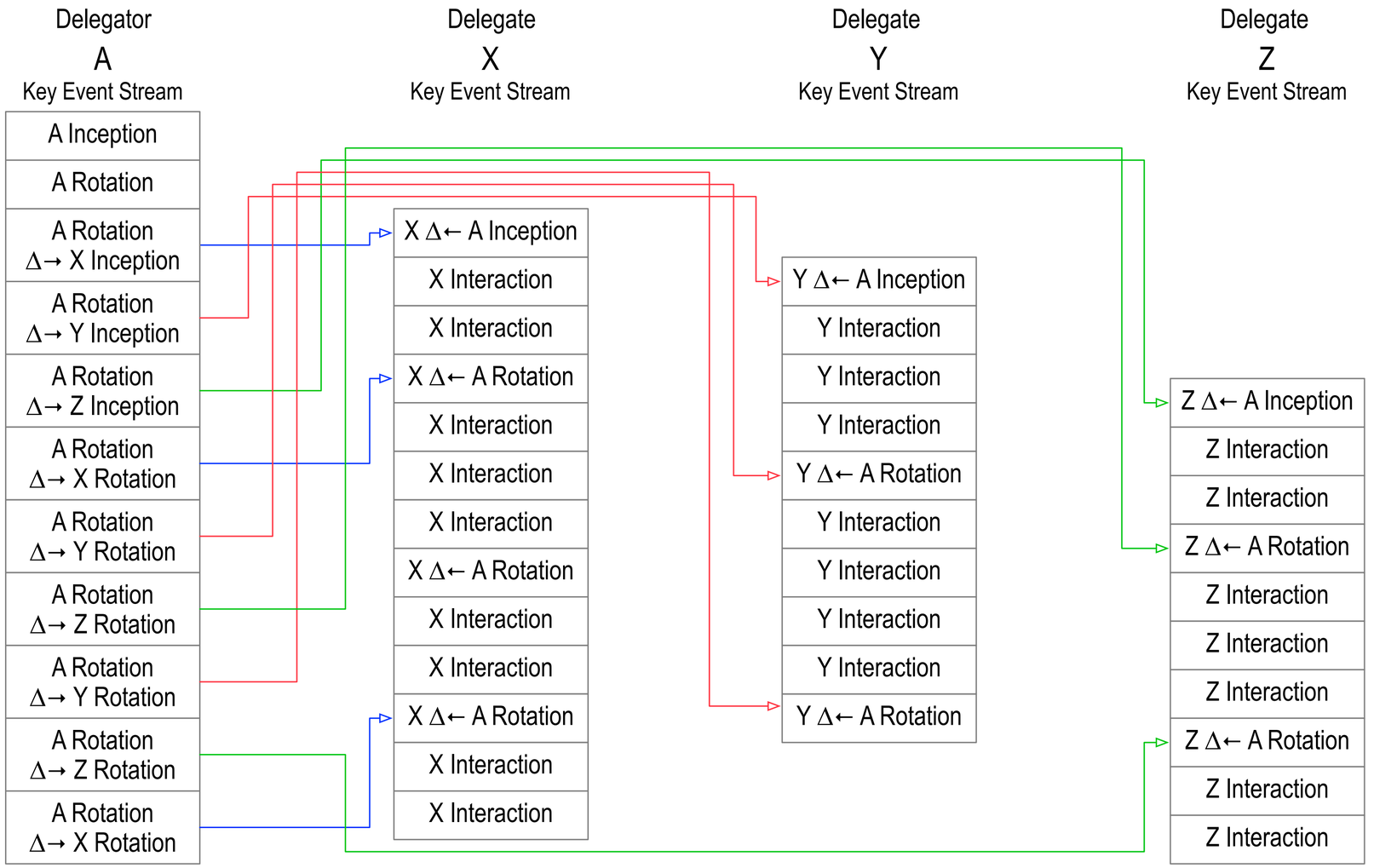




Scaling Delegation via Interaction



Scaling Delegation via Rotation



Δ→ X : Delegation to X

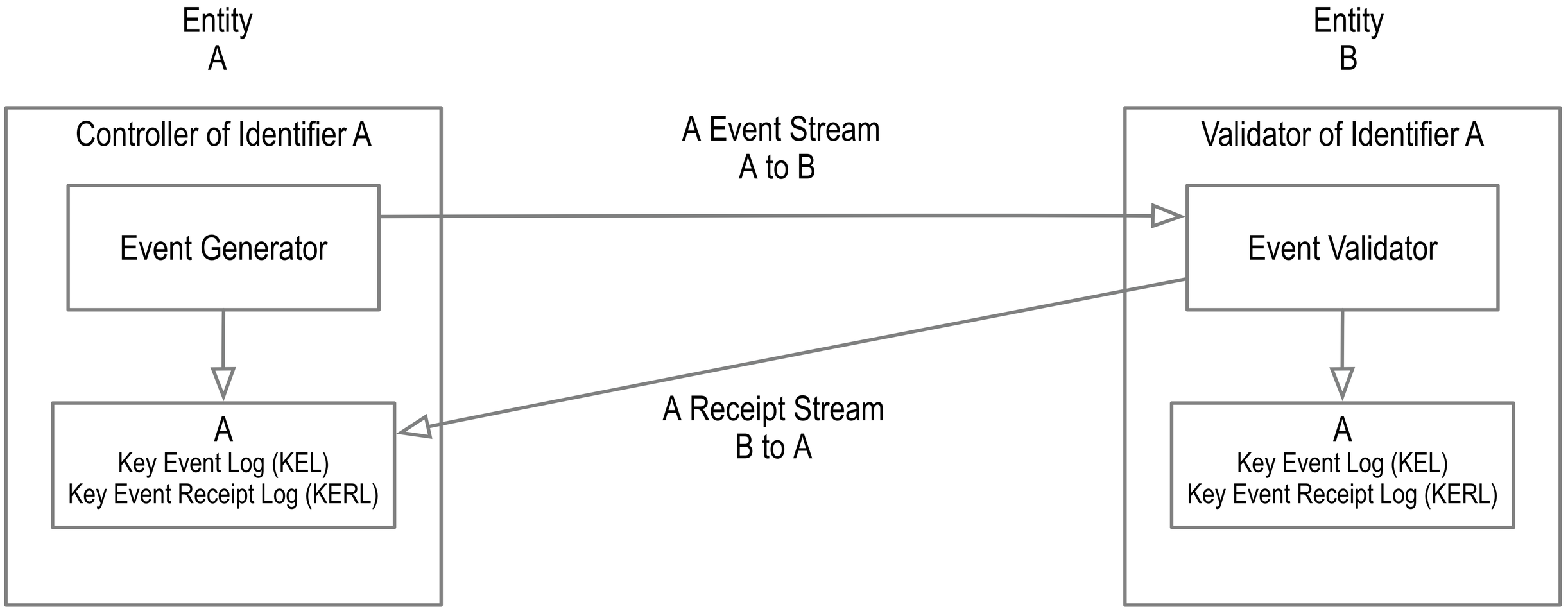
Δ← A : Delegation from A

Protocol Operational Modes

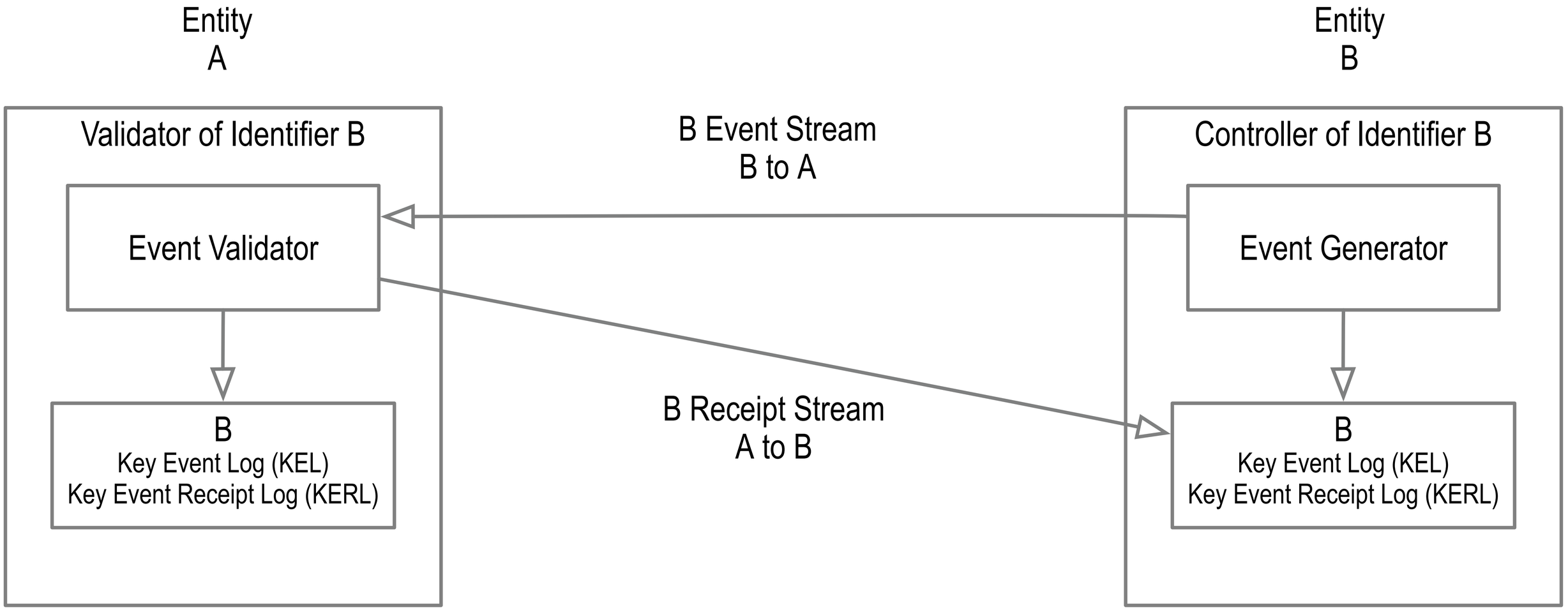
Direct Event Replay Mode (one-to-one)

Indirect Event Replay Mode (one-to-any)

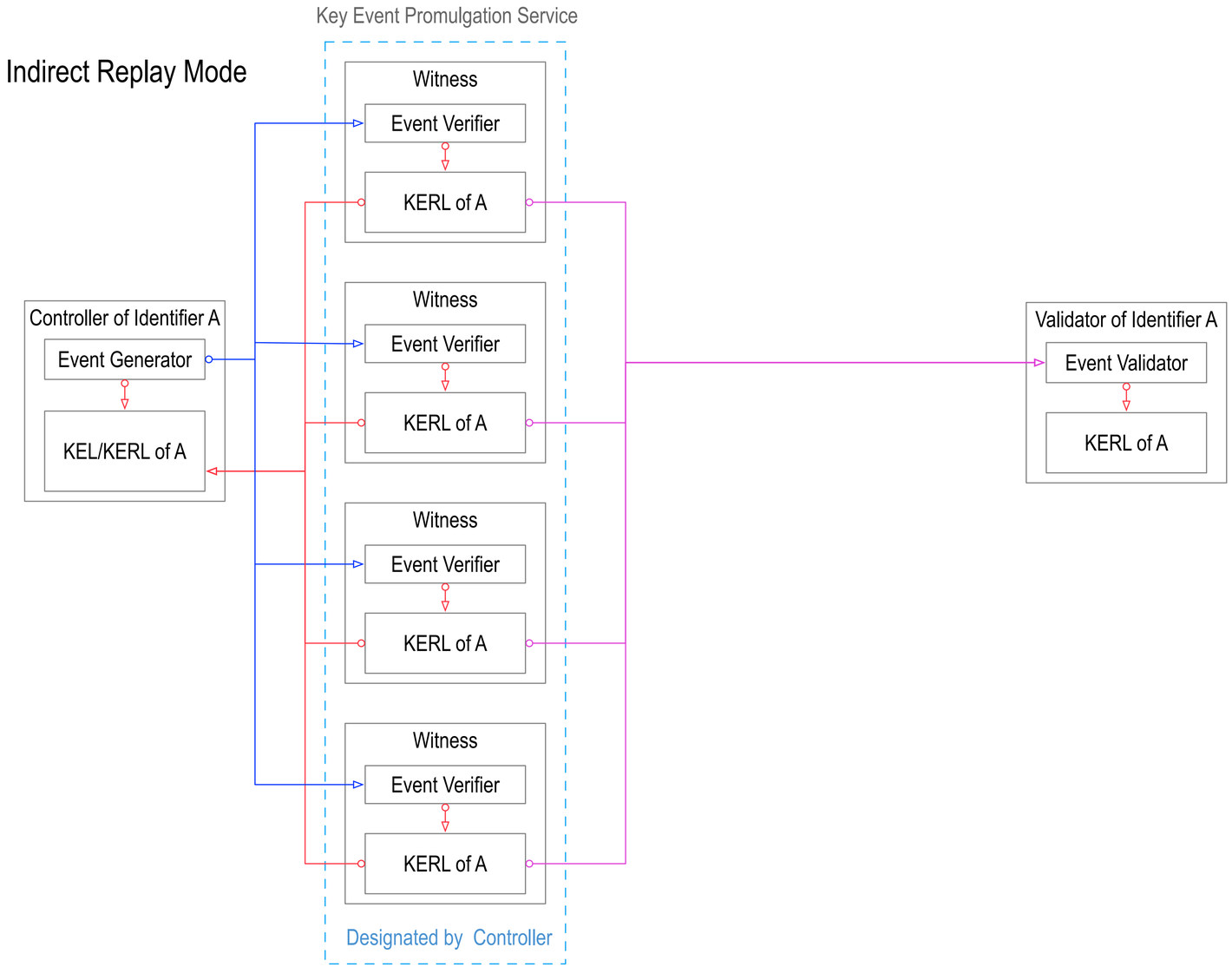
Direct Mode: A to B



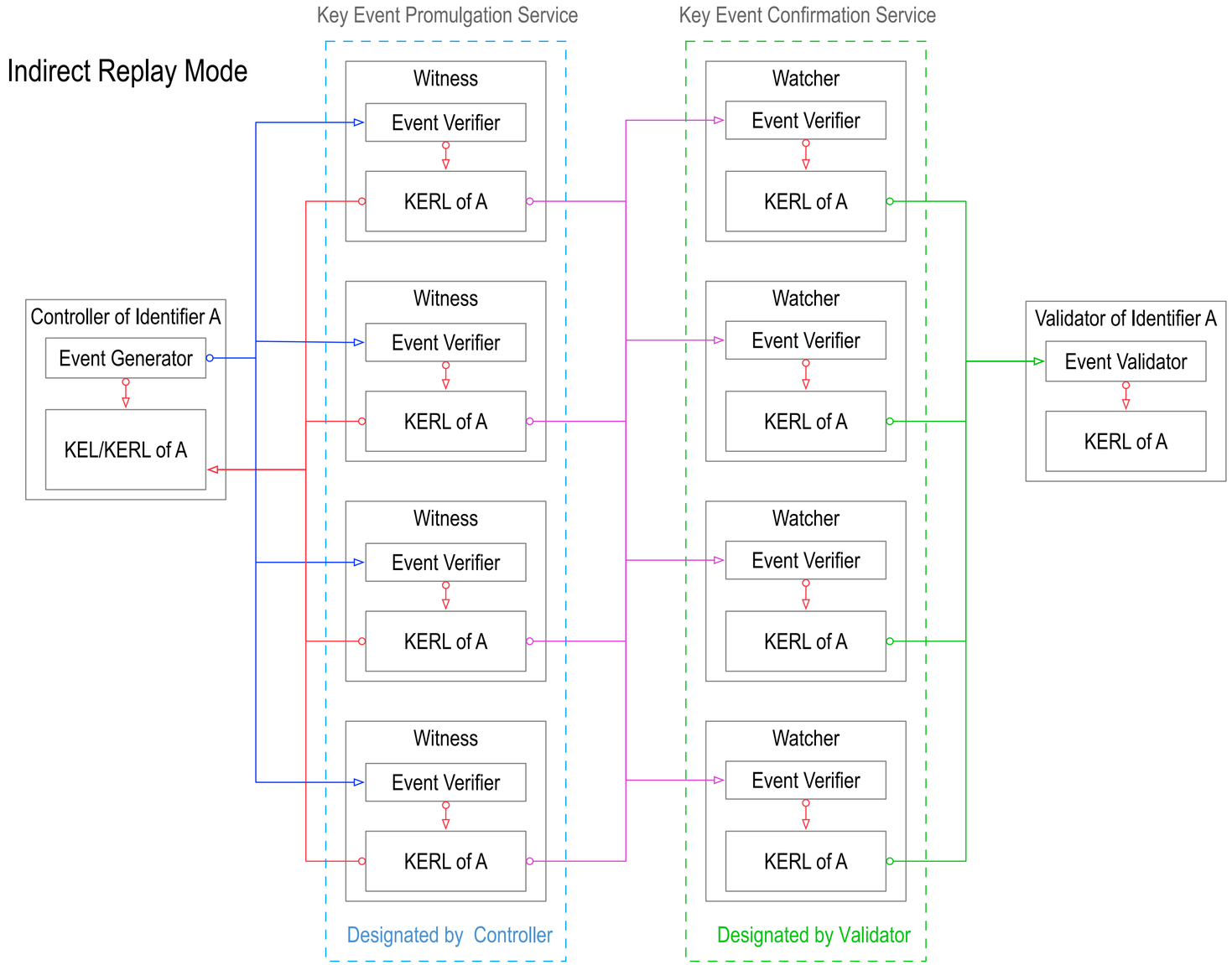
Direct Mode: B to A



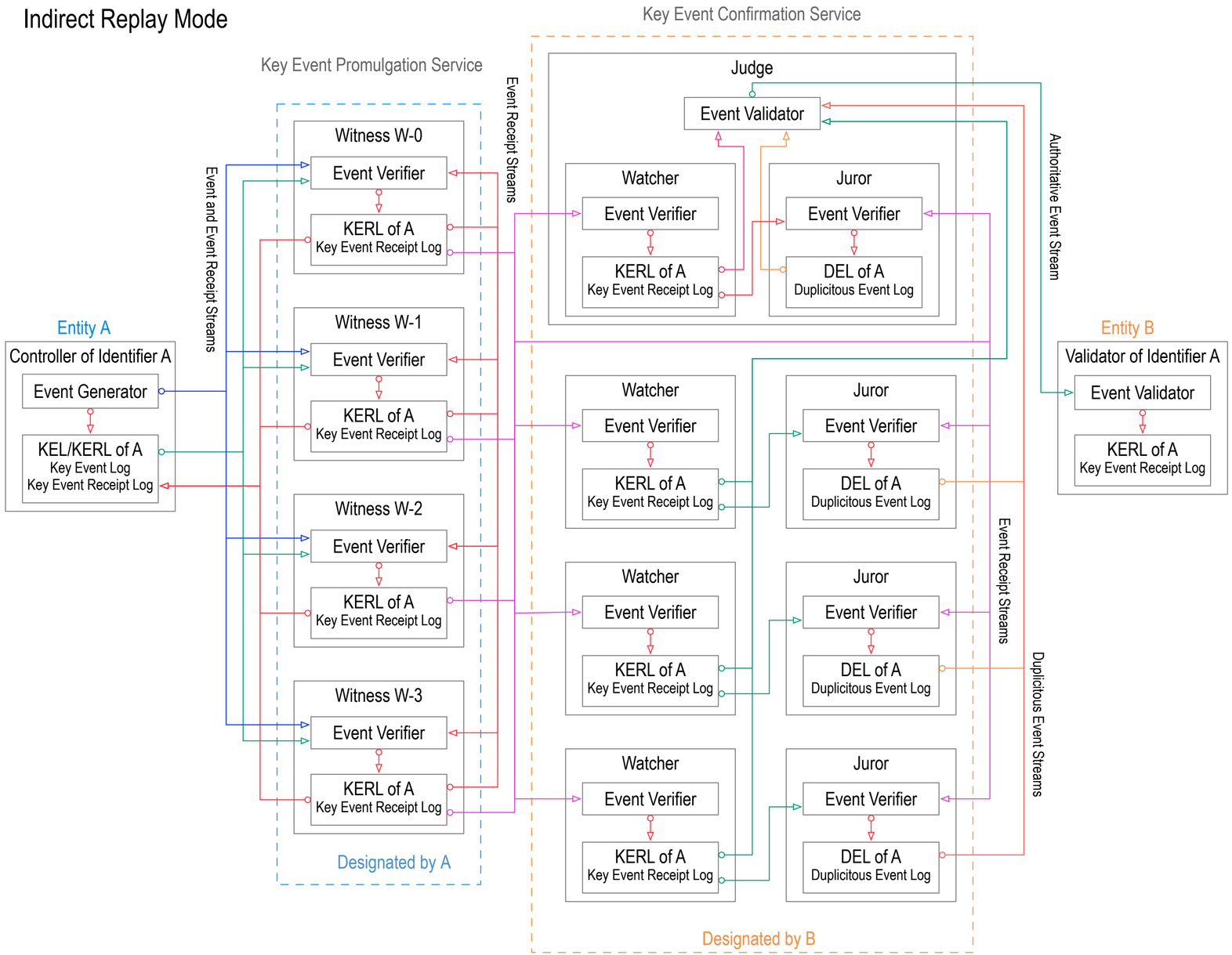
Indirect Mode Promulgation Service



Indirect Mode
Promulgation and Confirmation Services



Indirect Mode Full



Separation of Control

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

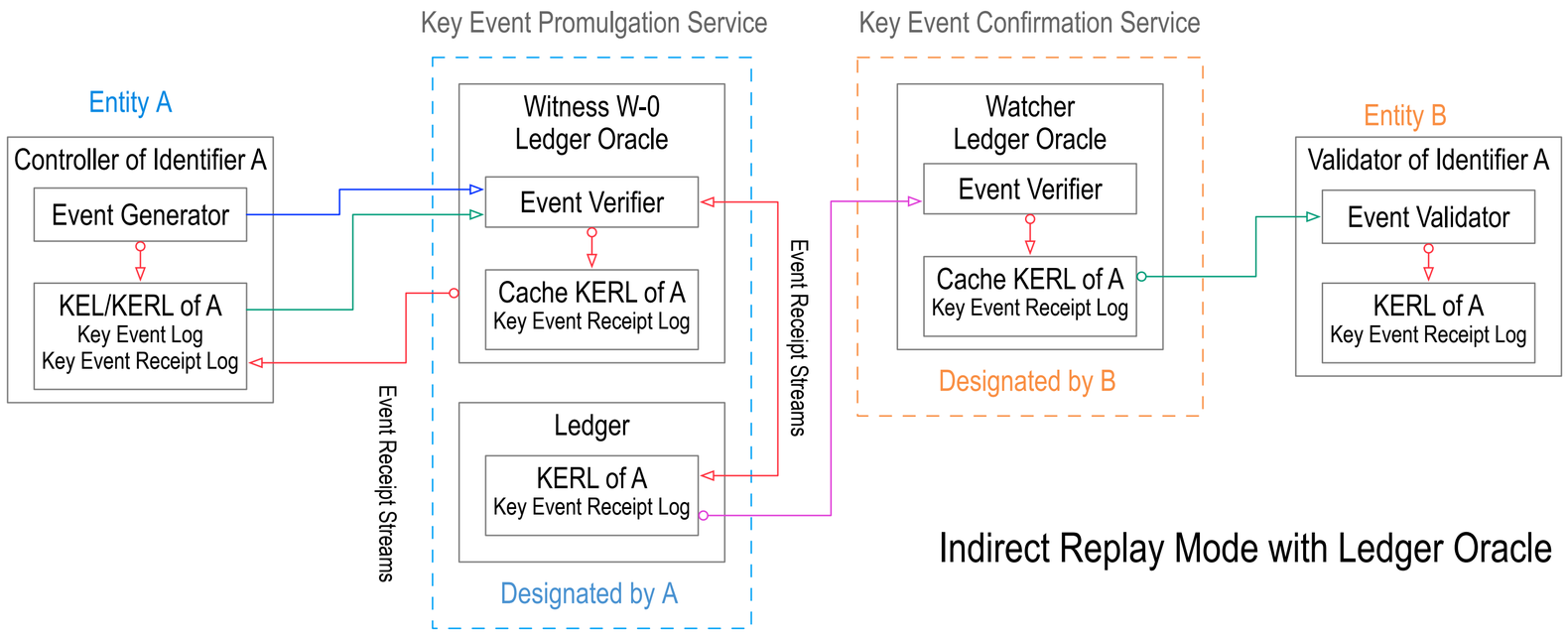
Shared *data* = *good*, shared *control* = *bad*.

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

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

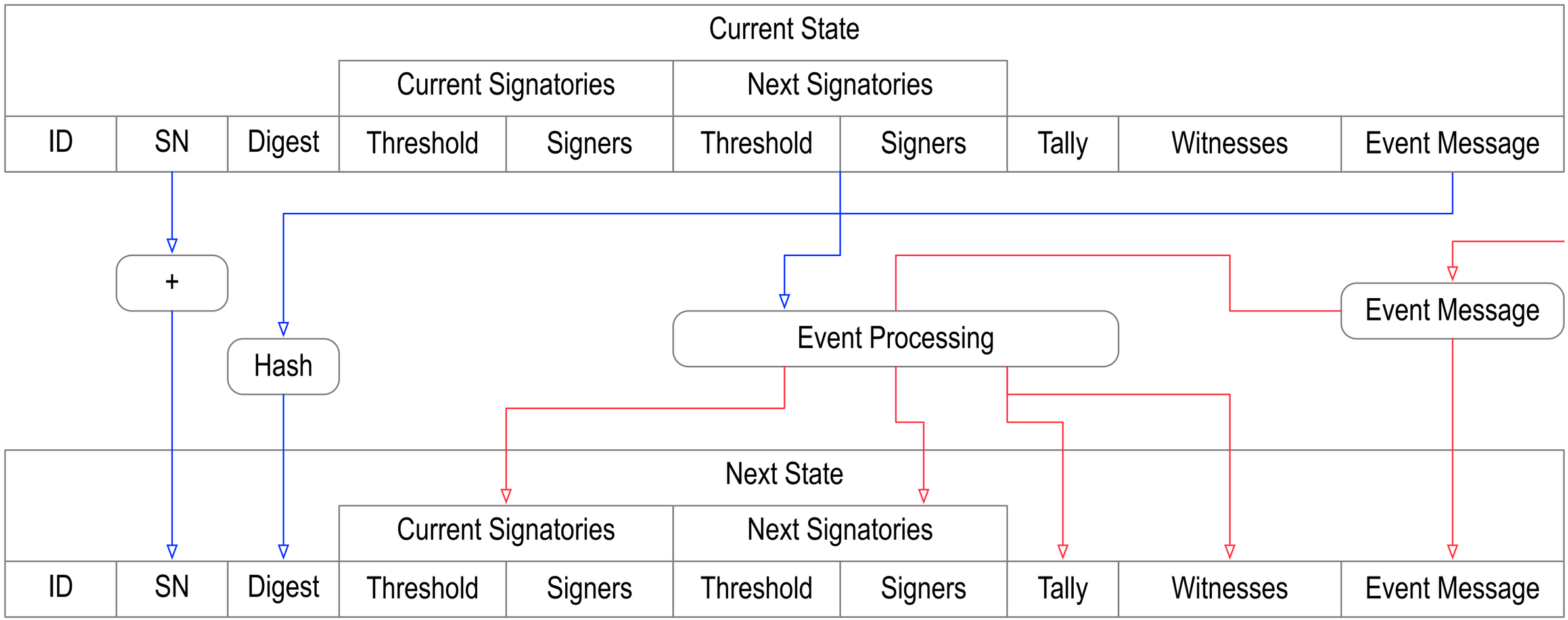
Separated control between controller and validator may provide better decentralization, more flexibility, better scalability, lower cost, higher performance, and more privacy at comparable security.

Indirect Mode with Ledger Oracles

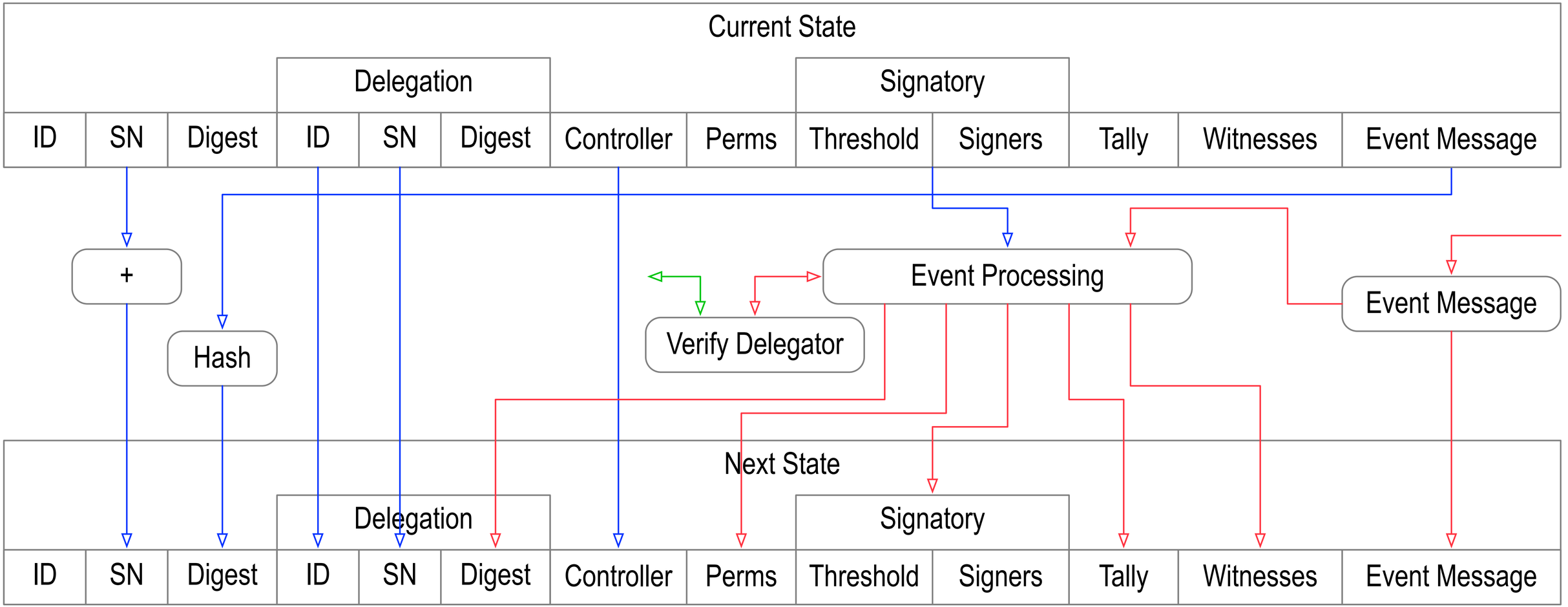


Indirect Replay Mode with Ledger Oracle

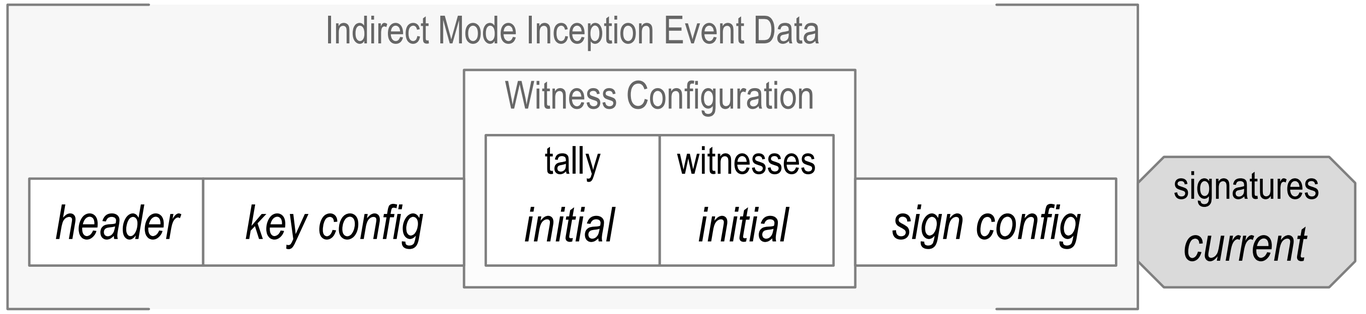
State Verifier Engine

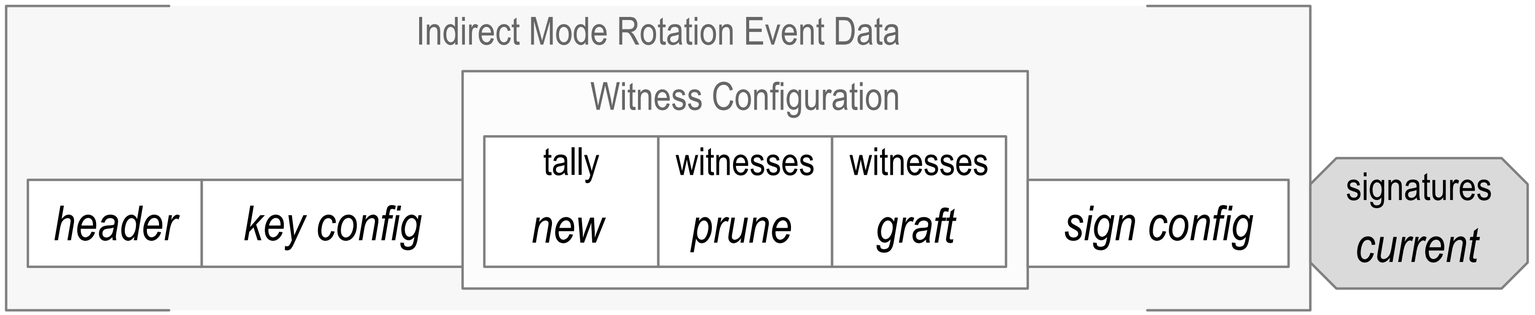


Delegated State Verifier Engine

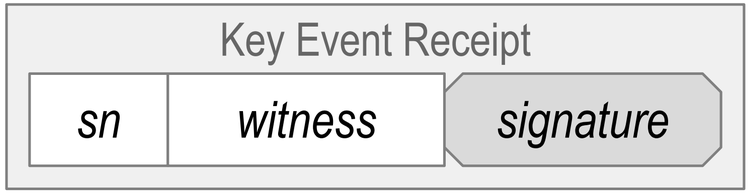


Witness Designation



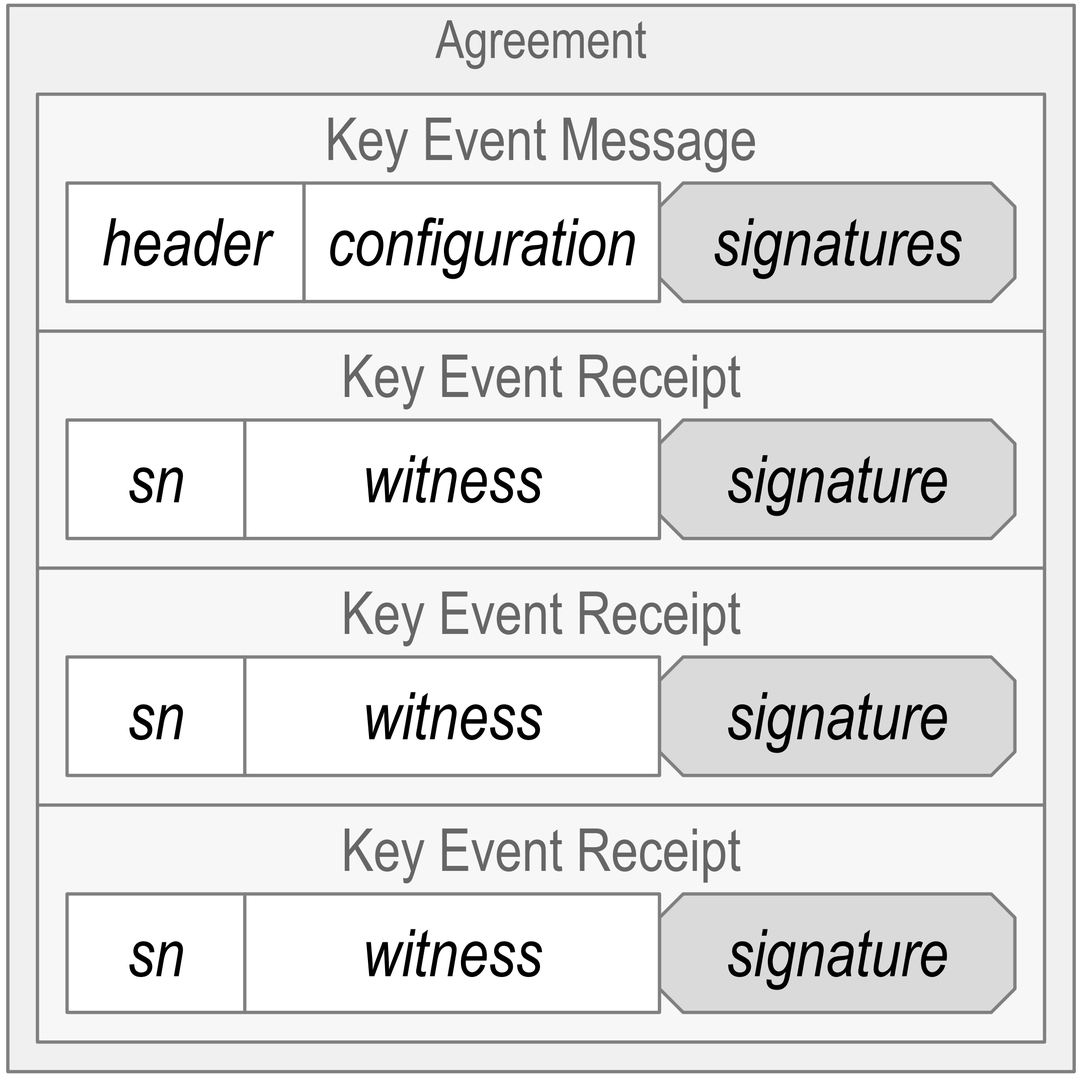


Witnessed Key Event Receipt



(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

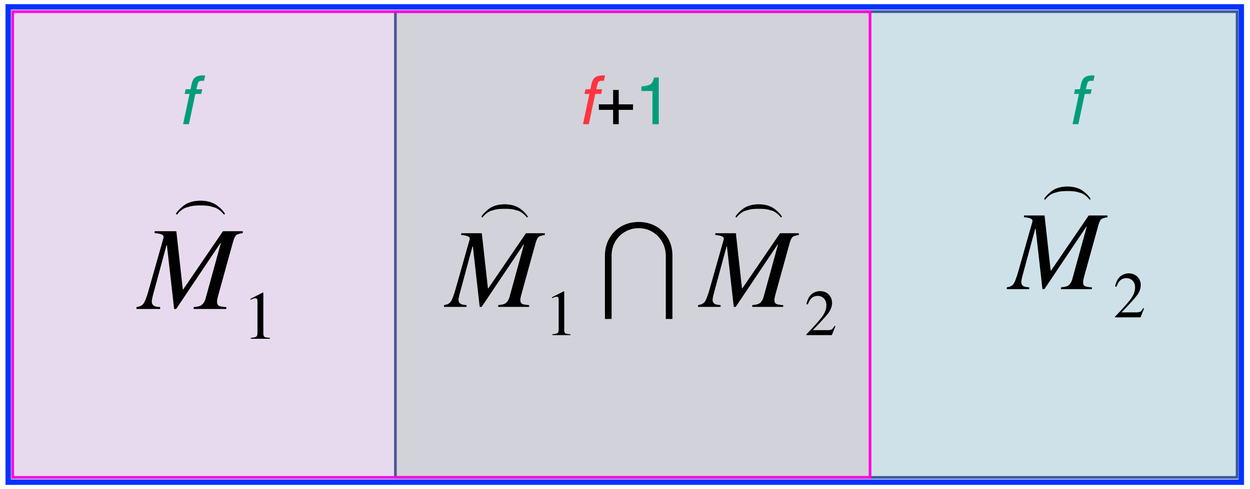
$$N \geq 2F+1$$

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

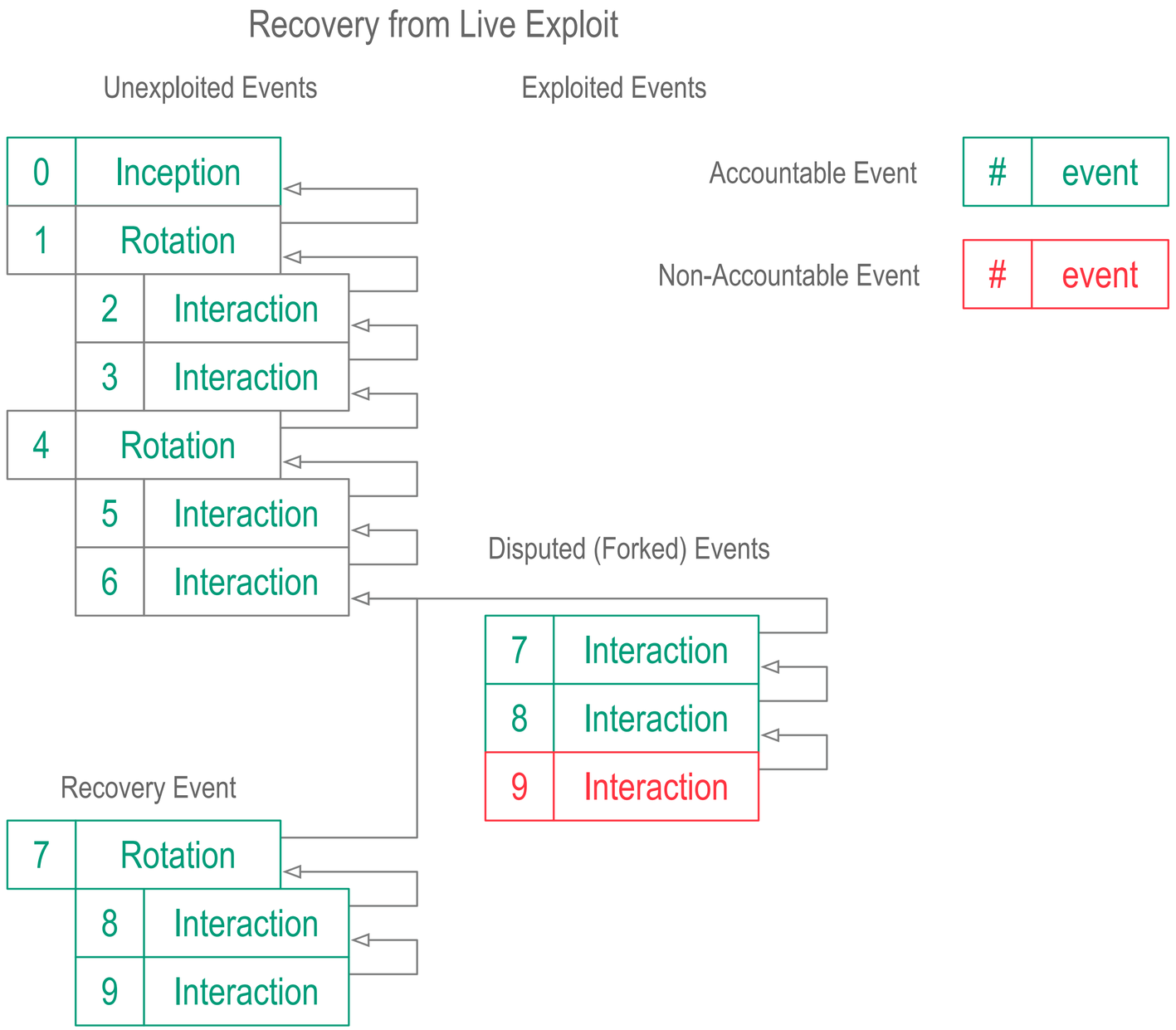
$$\frac{N+F+1}{2} \leq M \leq N - F$$

Example Values

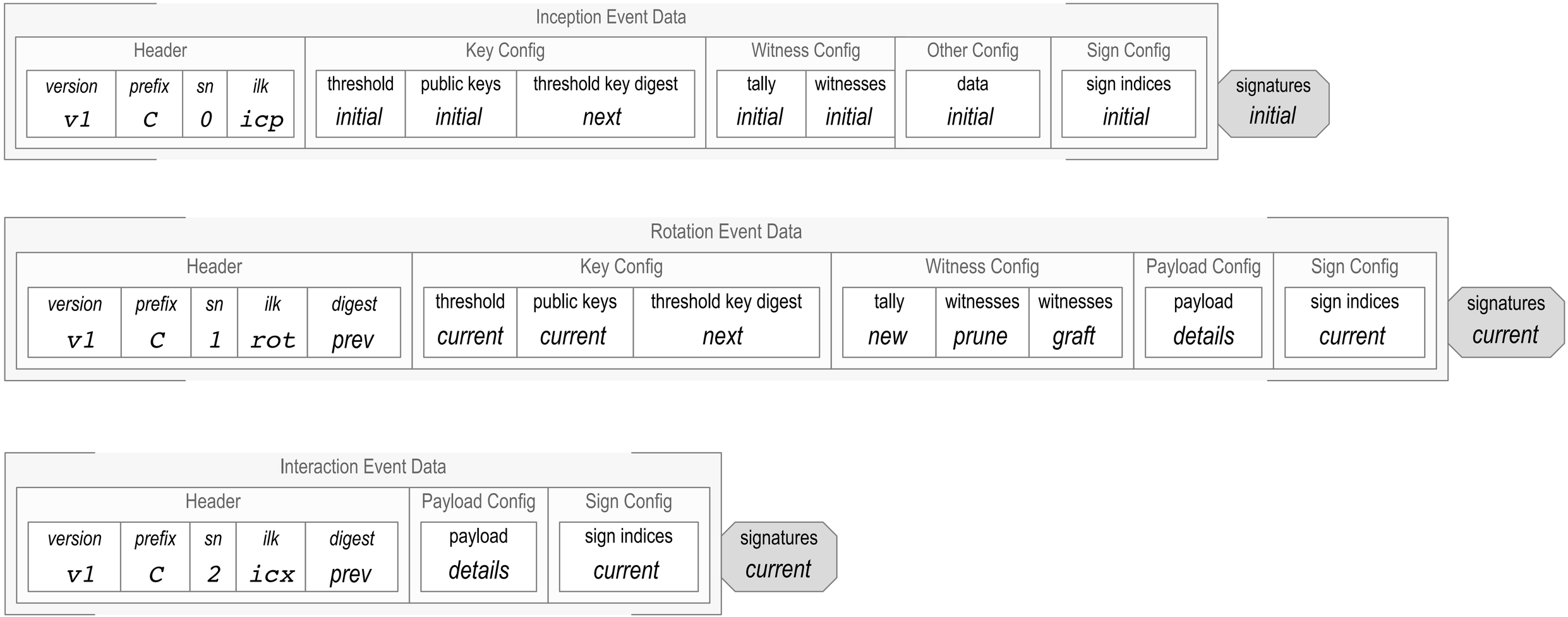
Immunity

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

$$\varepsilon_0^C = \left\langle \nu_0^C, C, t_0^C, \texttt{icp}, K_0^C, \widehat{C}_0^C, \eta_0^C\left(\left\langle K_1^C, \widehat{C}_1^C \right\rangle\right), M_0^C, \widehat{W}_0^C, \{data\}, \widehat{s}_0^C \right\rangle \widehat{\sigma}_0^C$$

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

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

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

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

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

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.

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
J	Blake3-256 Digest. Self-addressing delegated derivation.	32	1	1	44	33
K	SHA3-256 Digest. Self-addressing delegated derivation.	32	1	1	44	33
L	Blake2b-256 Digest. Self-addressing delegated derivation.	32	1	1	44	33
M	Blake2s-256 Digest. Self-addressing delegated derivation.	32	1	1	44	33
N	SHA2-256 Digest. Self-addressing derivation.	32	1	1	44	33

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.

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	Blake2s-512 Digest. Self-addressing derivation.	64	2	2	88	66
0G	SHA2-512 Digest. Self-addressing derivation.	64	2	2	88	66
0H	Blake3-512 Digest. Self-addressing delegated derivation.	64	2	2	88	66
0I	SHA3-512 Digest. Self-addressing delegated derivation.	64	2	2	88	66
0J	Blake2b-512 Digest. Self-addressing delegated derivation.	64	2	2	88	66
0K	Blake2s-512 Digest. Self-addressing delegated derivation.	64	2	2	88	66
0L	SHA2-512 Digest. Self-addressing derivation.	64	2	2	88	66

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.

Derivation Code	Prefix Description	Data Length Bytes	Pad Length	Derivation Code Length	Prefix Length Base64	Prefix Length Bytes
_	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.					
7						
8						
9						
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
J	Blake3-256 Digest. Self-addressing delegated derivation.	32	1	1	44	33
K	SHA3-256 Digest. Self-addressing delegated derivation.	32	1	1	44	33
L	Blake2b-256 Digest. Self-addressing delegated derivation.	32	1	1	44	33
M	Blake2s-256 Digest. Self-addressing delegated derivation.	32	1	1	44	33
N	SHA2-256 Digest. Self-addressing derivation.	32	1	1	44	33
O						
P						
Q						
R						
S						
T						
U						
V						
W						
X						
Y						
Z						
a						
b						
c						
d						
e						
f						
g						
h						
i						
j						
k						
l						
m						
n						
o						
p						
q						
r						
s						
t						
u						
v						
w						
x						
y						
z						

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
0_						
0-						
00						
01						
02						
03						
04						
05						
06						
07						
08						
09						
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	Blake2s-512 Digest. Self-addressing derivation.	64	2	2	88	66
0G	SHA2-512 Digest. Self-addressing derivation.	64	2	2	88	66
0H	Blake3-512 Digest. Self-addressing delegated derivation.	64	2	2	88	66
0I	SHA3-512 Digest. Self-addressing delegated derivation.	64	2	2	88	66
0J	Blake2b-512 Digest. Self-addressing delegated derivation.	64	2	2	88	66
0K	Blake2s-512 Digest. Self-addressing delegated derivation.	64	2	2	88	66
0L	SHA2-512 Digest. Self-addressing derivation.	64	2	2	88	66
0M						
0N						
0O						
0P						
0Q						
0R						
0S						
0T						
0U						
0V						
0W						
0X						
0Y						
0Z						
0a						
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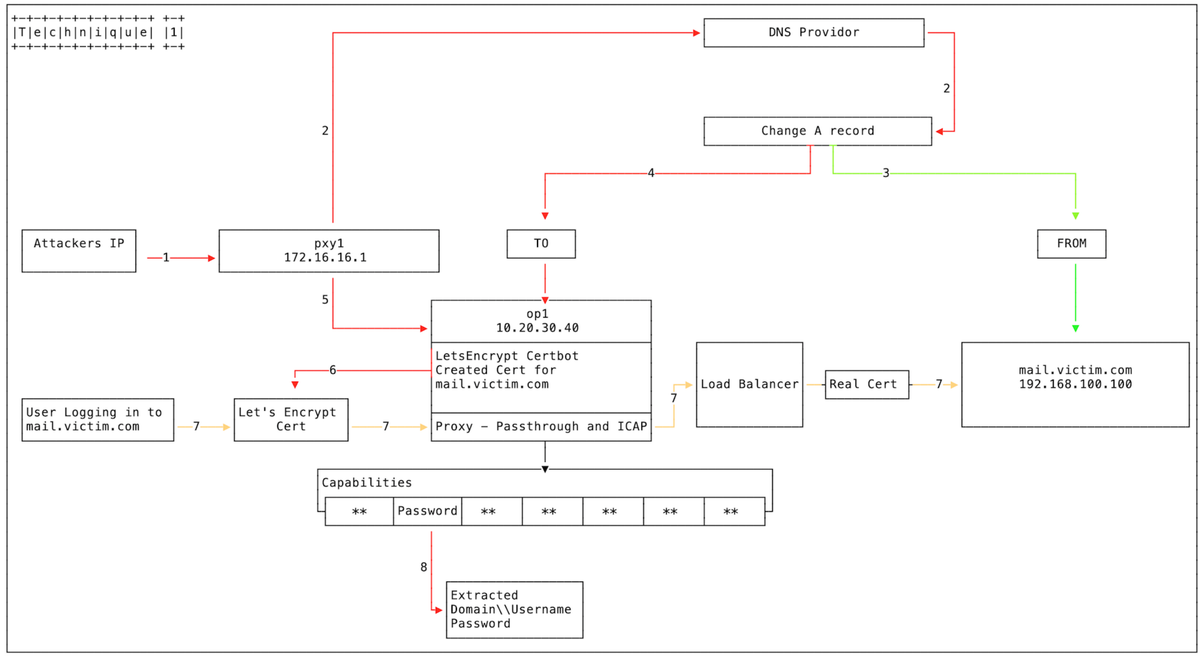
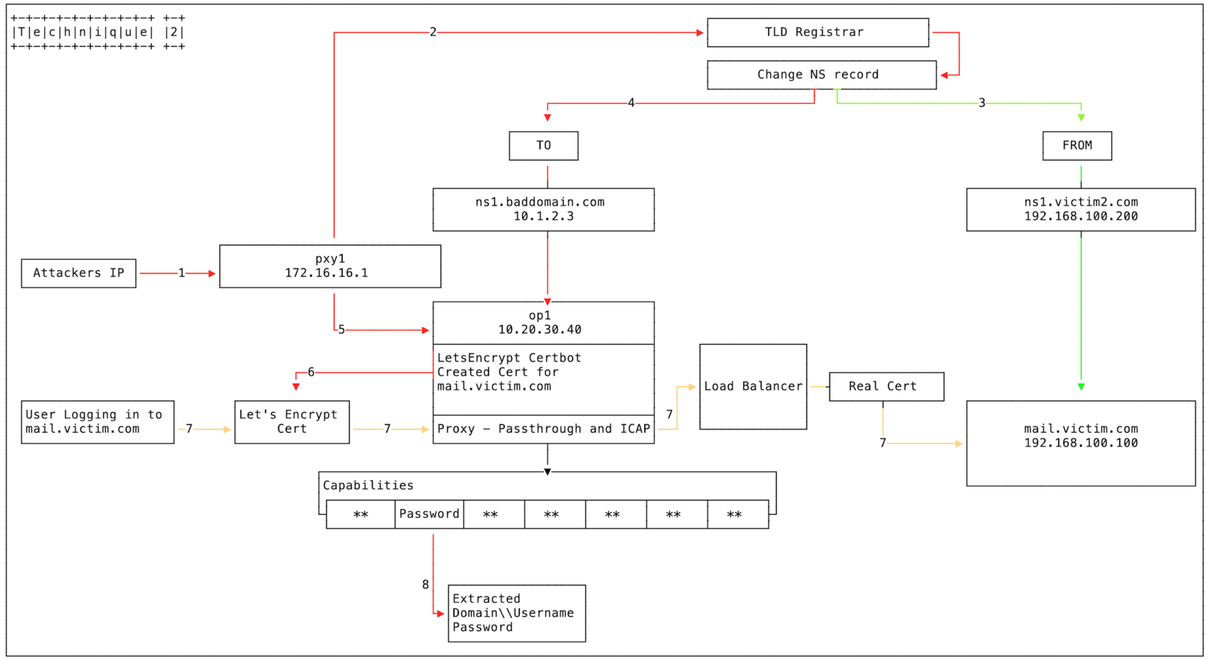
0j						
0k						
0l						
0m						
0n						
0o						
0p						
0q						
0r						
0s						
0t						
0u						
0v						
0w						
0x						
0y						
0z						

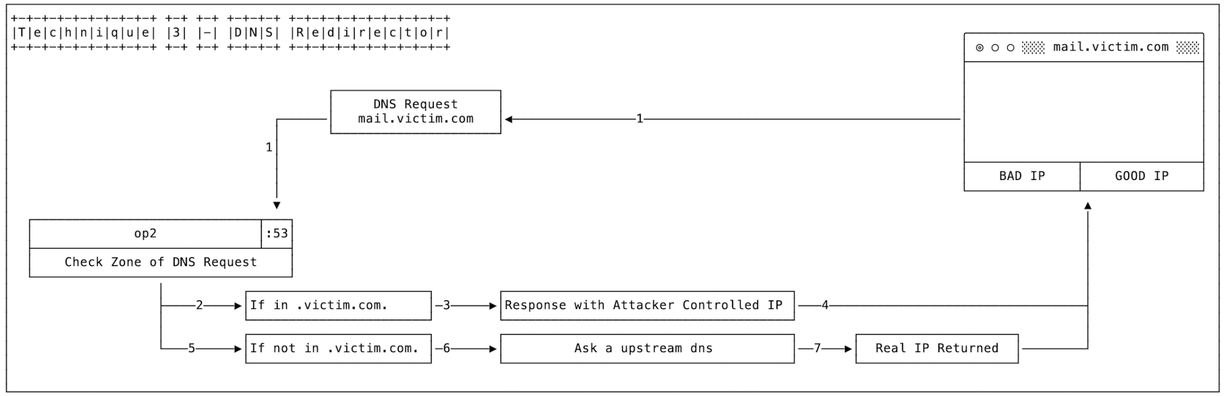
DNS Hijacking

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

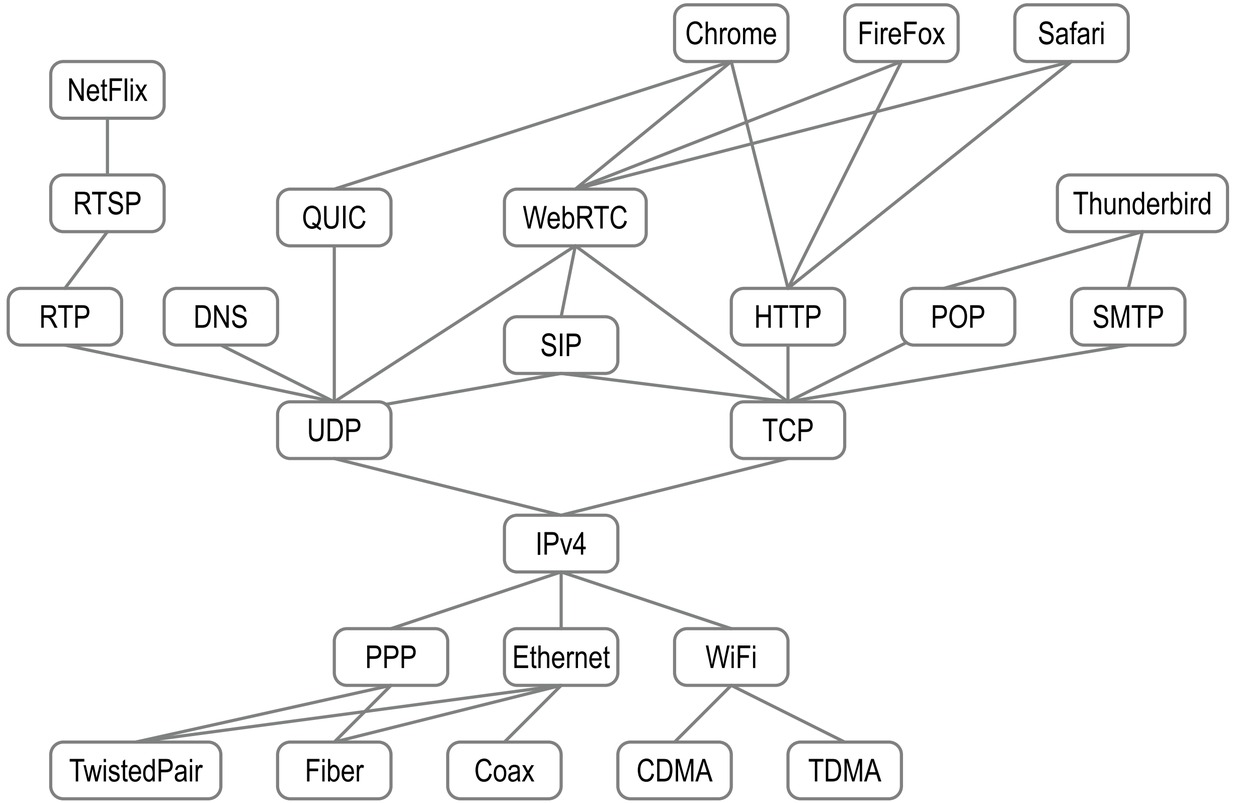
https://arstechnica.com/information-technology/2019/01/a-dns-hijacking-wave-is-targeting-companies-at-an-almost-unprecedented-scale/

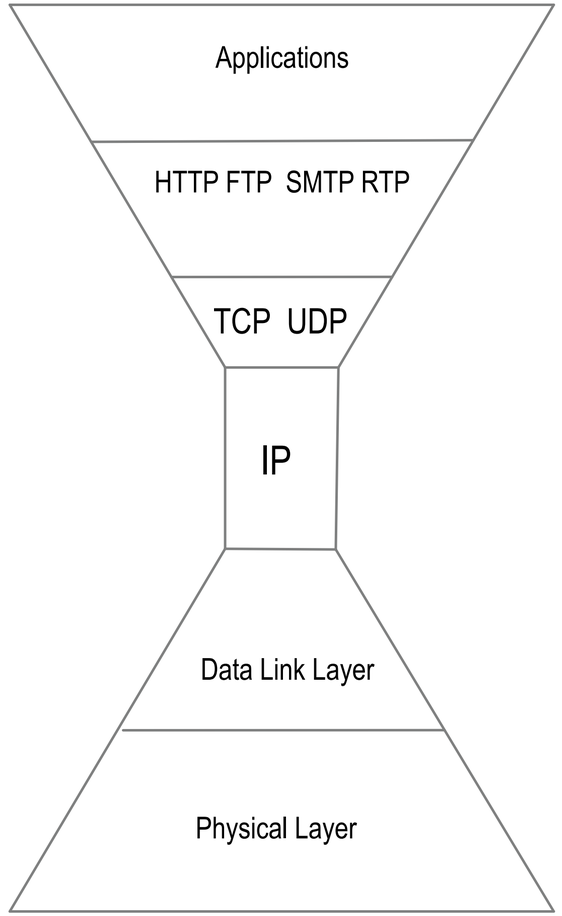




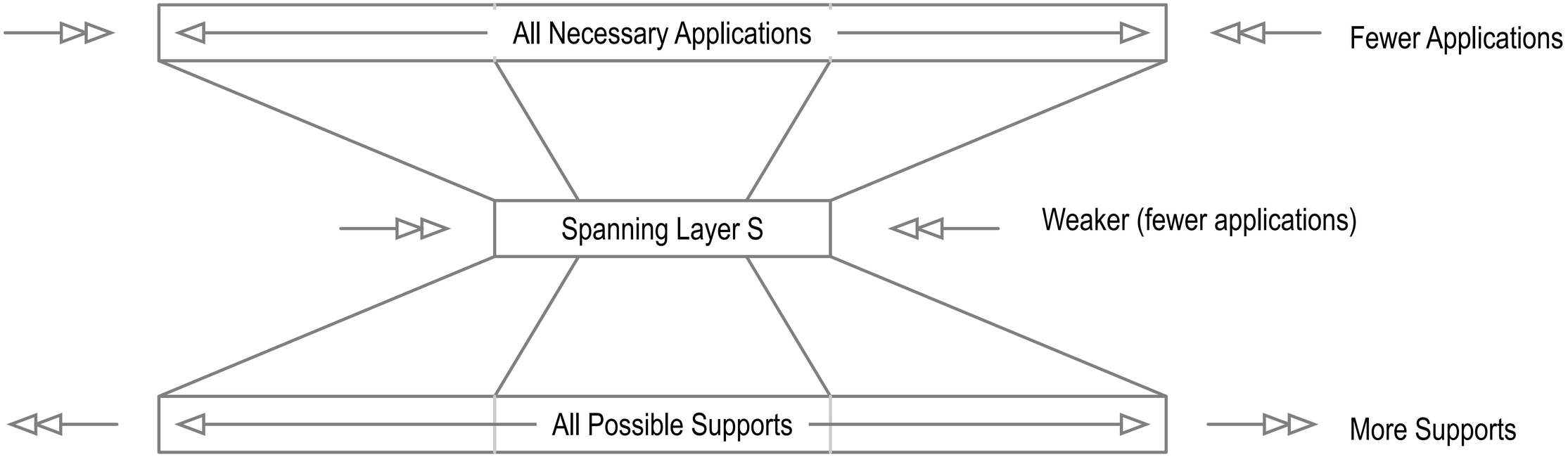


Spanning Layer

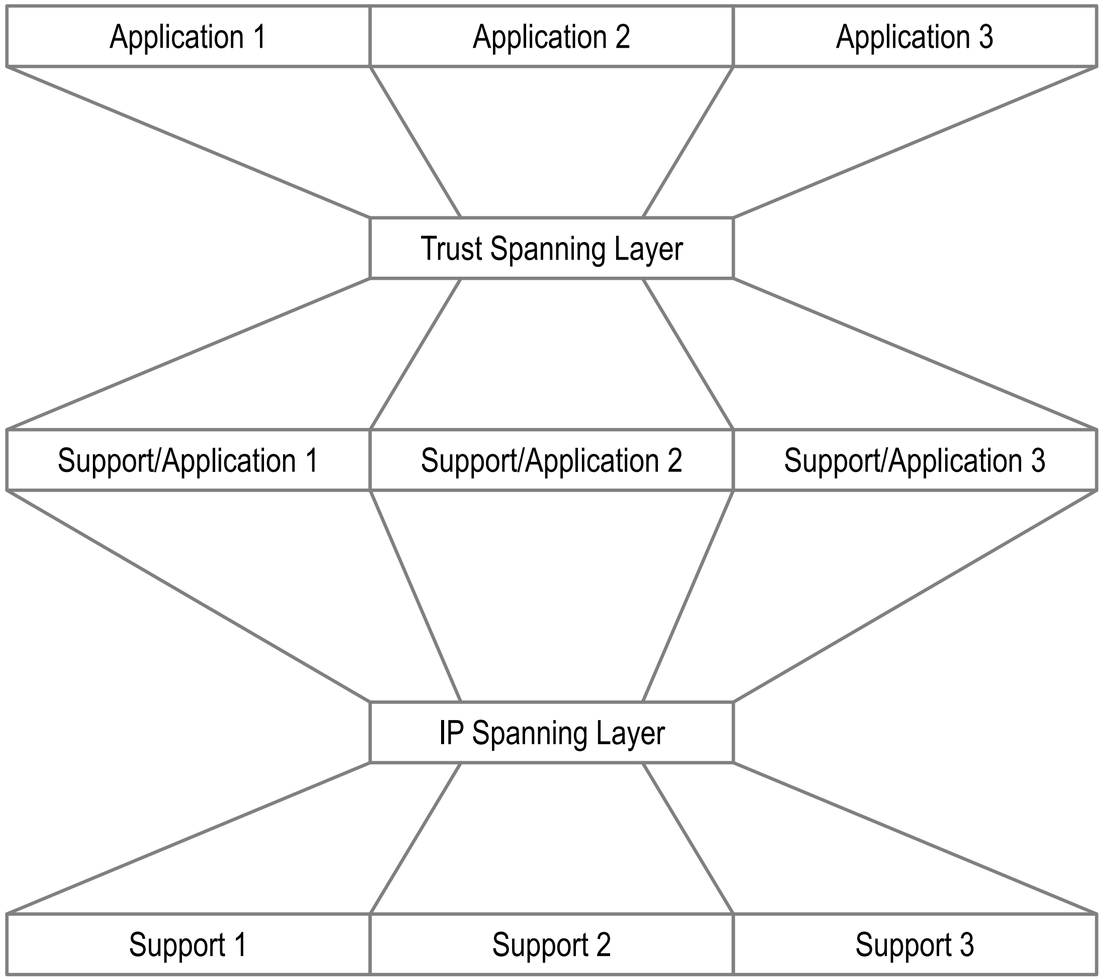


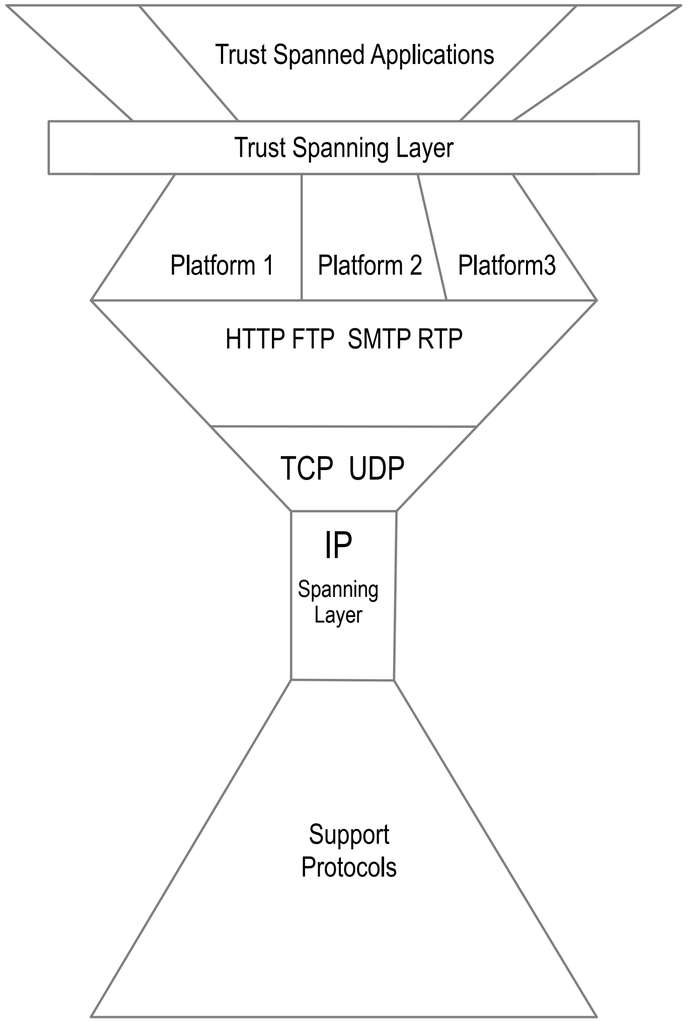


Hourglass


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)

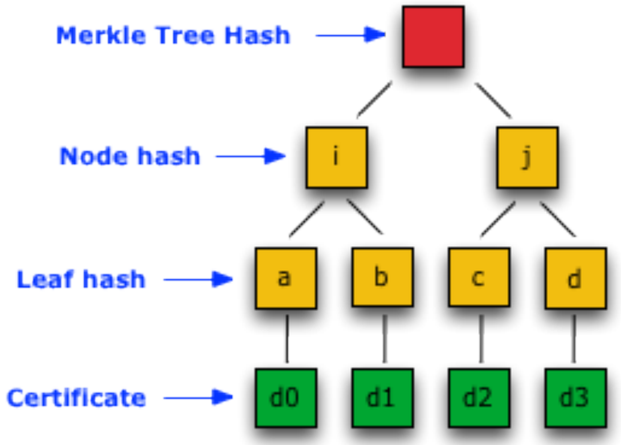


Figure 1

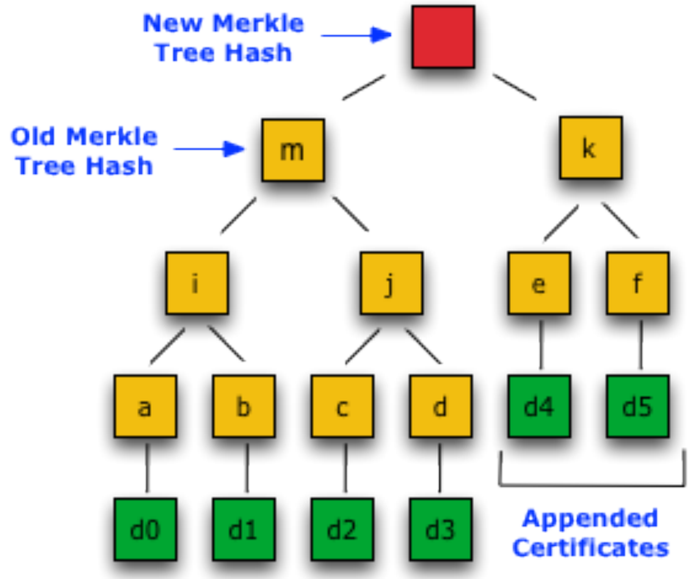


Figure 2

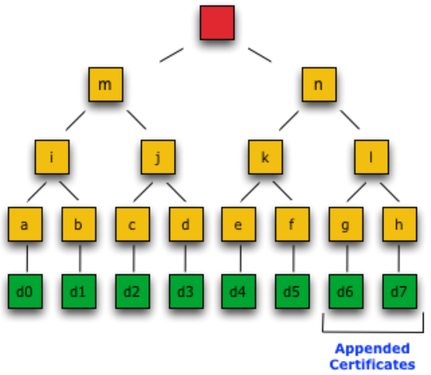


Figure 3

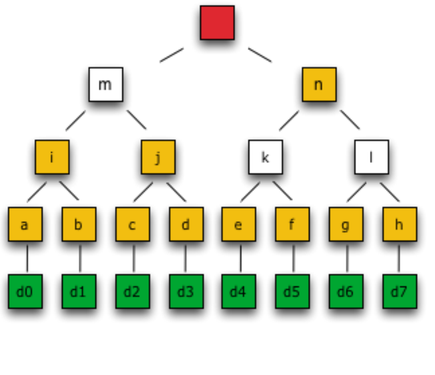


Figure 4

IETF/TCG Alternative Standards Stack

Interoperable Remote Device Configuration Attestation

“Remote ATtestation proceduresS (RATS) WG,” IETF,

https://datatracker.ietf.org/wg/rats/about/

Working Group, R. A. T. S., “Network Device Attestation Workflow,” IETF Internet-Draft, 2019/12/03

https://tools.ietf.org/html/draft-fedorkow-rats-network-device-attestation-01

Interoperable Authentic Device Configuration Attestations

CBOR/JSON CWT JWT FIDO

Source-of-Truth

The Controller is the source-of-truth for control over the Identifier

Only the the controller my make verifiably authoritative control statements:

- Sequencing (of authoritative statements)
- Dependency (of authoritative statements)

Authoritative Statements:

- Transfer of control (non-revokable)
- Delegation of control (revokable)
- Authorizations:
  - Additional roots-of-trust and sources-of-truth

Loci-of-Control

Who controls What

Control over Identifier

Control over Support Infrastructure

Control over Operations on Identifier

AUTONOMIC IDENTIFIER (AID)

auto nomos self rule (autonomic, autonomous)

Self-Governing, Self-Sovereign, Self-Controlling

Self-Authorizing, Self-Certifying

Self-Managing, Self-Administering

AUTONOMIC NAMESPACE (AN)

Prefixed with AID

Extensible

Cryptographically Verifiable Identifier Derivation

“BEST” DECENTRALIZED SECURITY

End Verifiability

Ambient Verifiability = Anyone can verify

End Verifiability + Immutable Log = Duplicity Detection = Consistent Attribution

Ambient Verifiability + Ambient Immutable Logs = Ambient Duplicity Detection

EXPLOIT MANAGEMENT

Control exploit always eventually exhibits as duplicitous behavior:

i.e. inconsistent control statements

Exploit detection and containment via duplicity detection

Scalable performant duplicity detection via immutable logs of control statements

Control exploit potential mitigated via best practices for key management

KEY MANAGEMENT

Rotation = Revoke and Replace = Full Transfer of Control

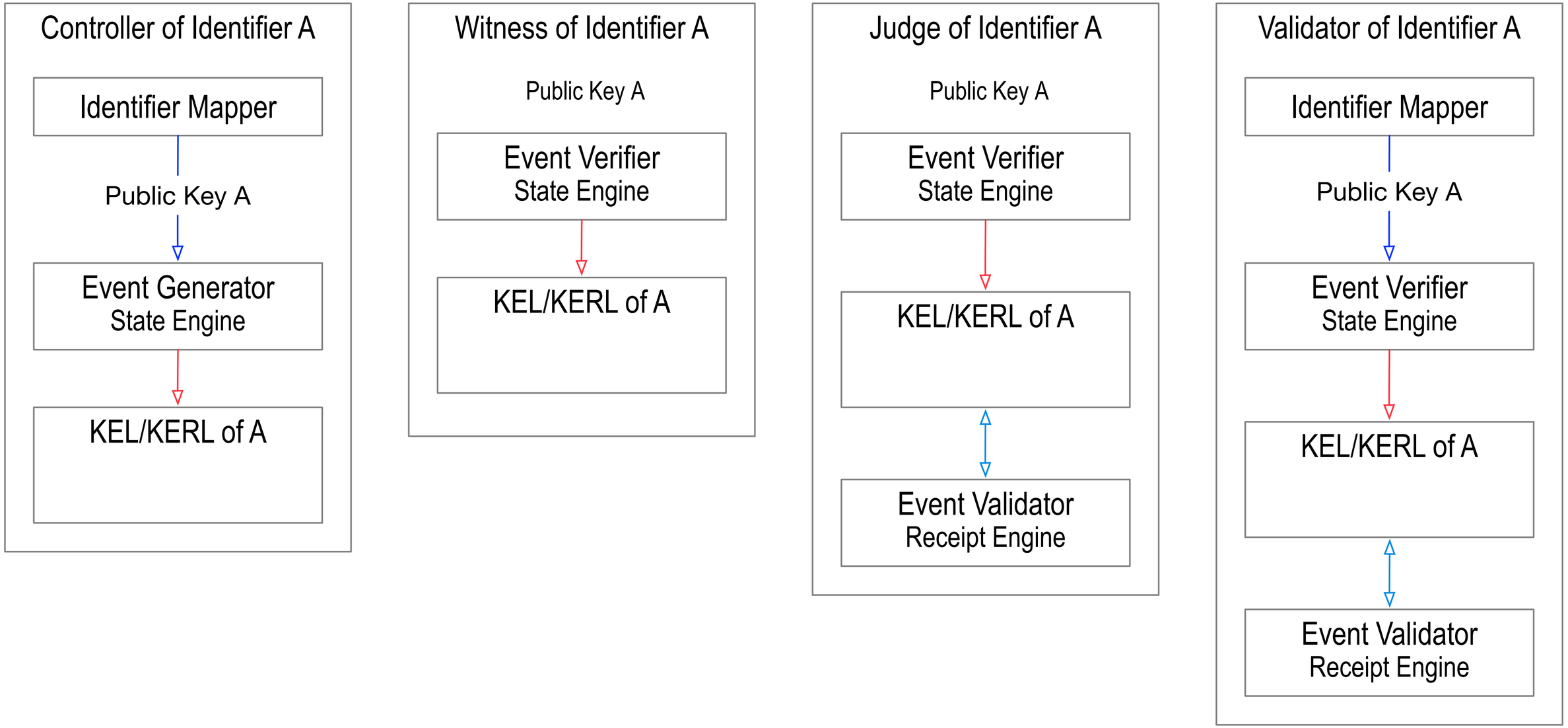
Reproduction = Creation, Derivation

Recovery

BEST PRACTICE

One-use = One-time, One-place, One-way

Offline Components



KERI Nomenclature

self-certifying identifier: includes public key

digital signature: unique non-repudiable (cypher suite known)

digest: collision resistant hash of content

signed digest: commitment to content

controller: controlling entity of identifier

message: serialized data structure

event: actionable message

key event: key management operation

More KERI Nomenclature

inception event: unique self-signed event that creates identifier and controlling key(s)

rotation event: self-signed uniquely ordered event from a sequence that changes the set of controlling keys

verifier: cryptographically verifies signature(s) on an event message.

witness: entity that may receive, verify, and store key events for an identifier. Each witness controls its own identifier used to sign key event messages, *controller* is a special case of witness.

receipt: event message or reference with one or more witness signatures

Even More KERI Nomenclature

key event log: ordered record of all self-signed key event messages

key event receipt log: ordered record of all key event receipts for a given set of witnesses

validator: determines current authoritative key set for identifier from at least one key event (receipt) log.

judge: determines current authoritative key set for identifier from the key event receipt logs from a set of witnesses.

pre-rotation: commitment to next rotated key set in previous rotation or inception event