Learn how to build secure infrastructure with these three tricks!

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Lord make me secure
...but not yet

Security Landscape

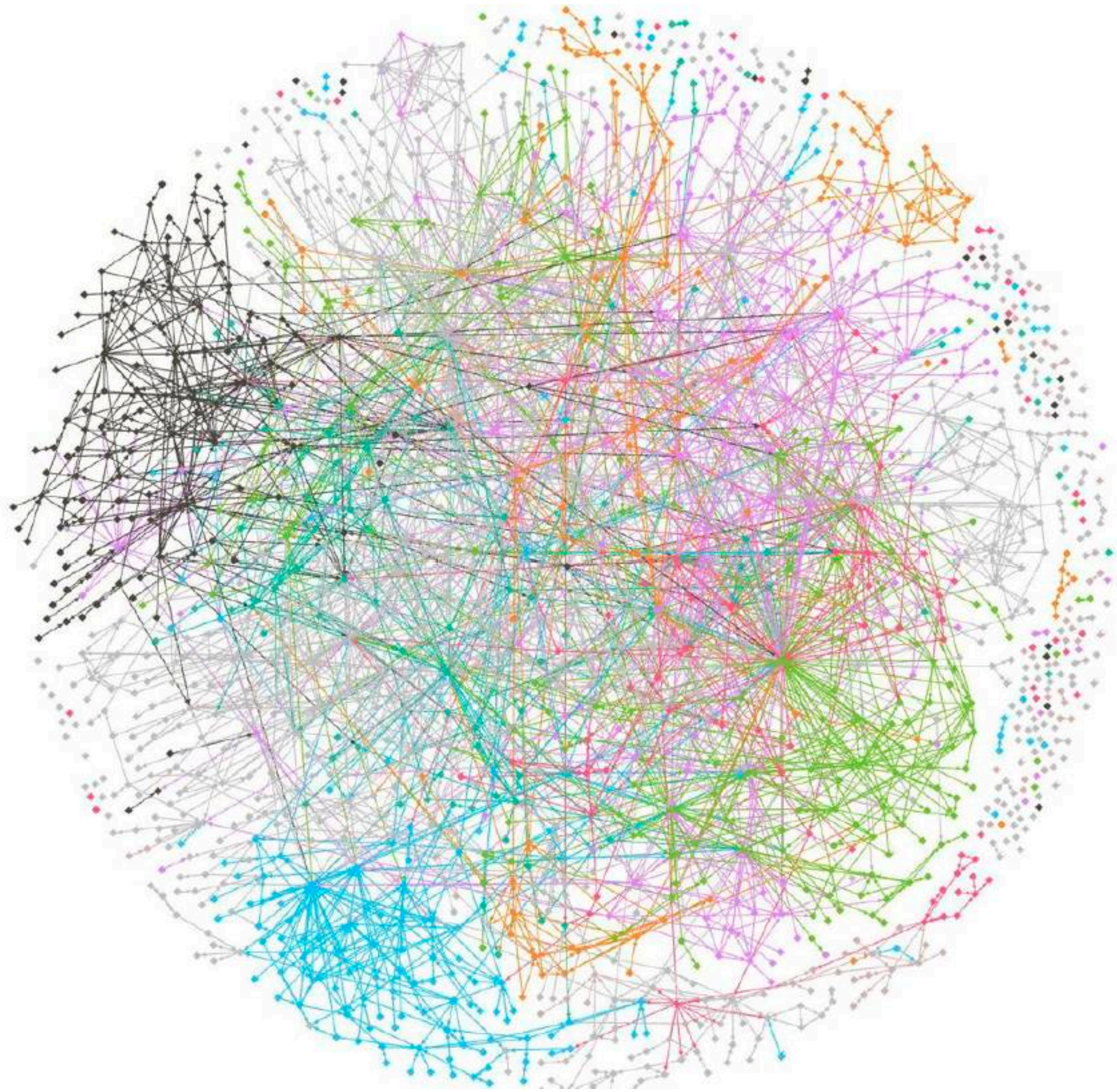
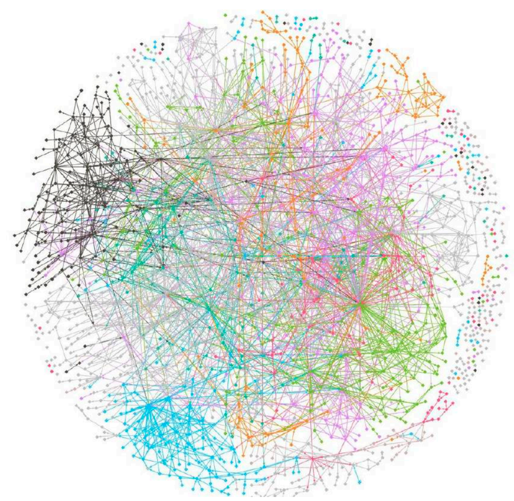


Image credits: Monzo & Istio

Security Landscape



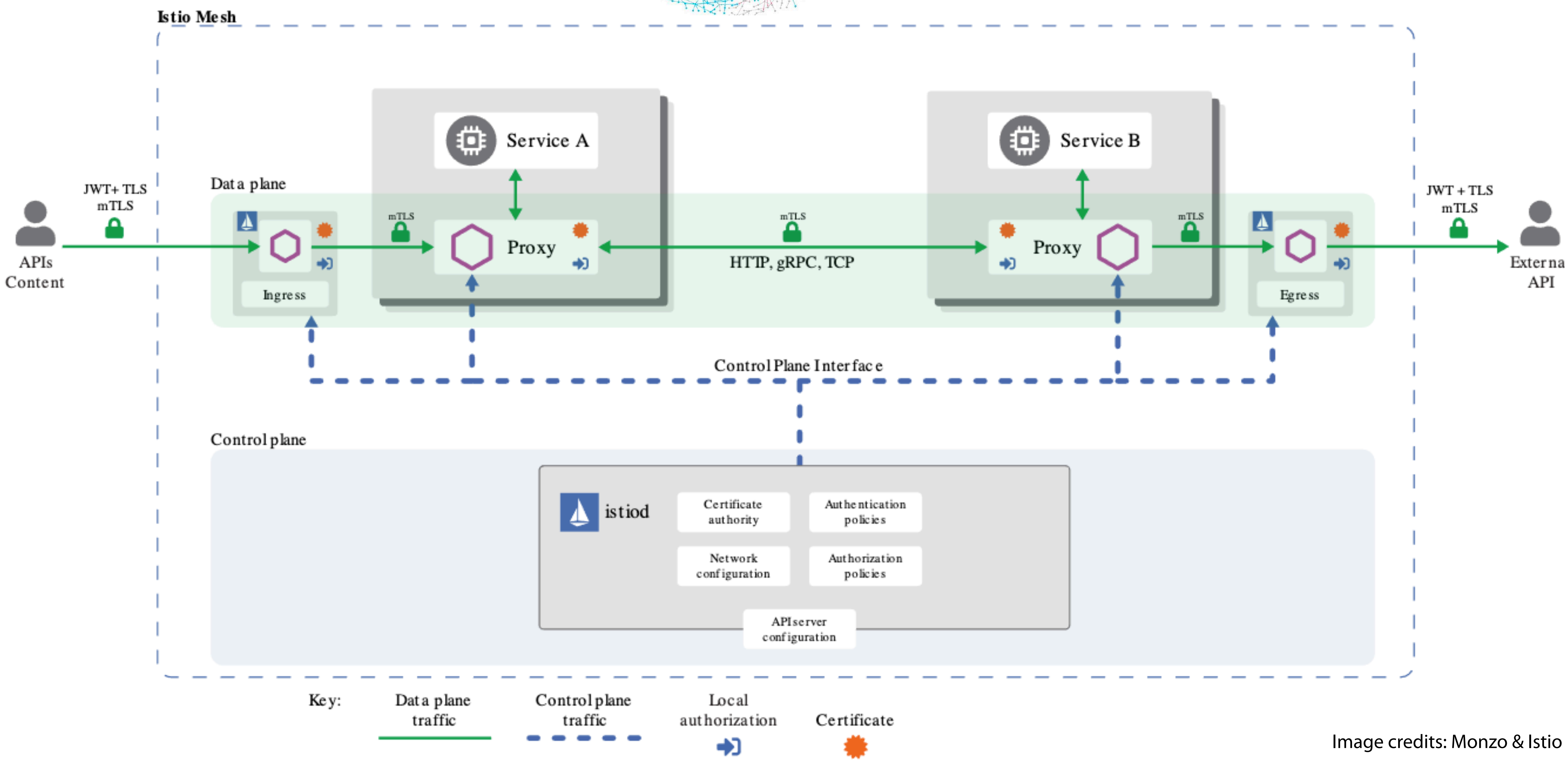


Image credits: Monzo & Istio

Edge Cloud Architecture

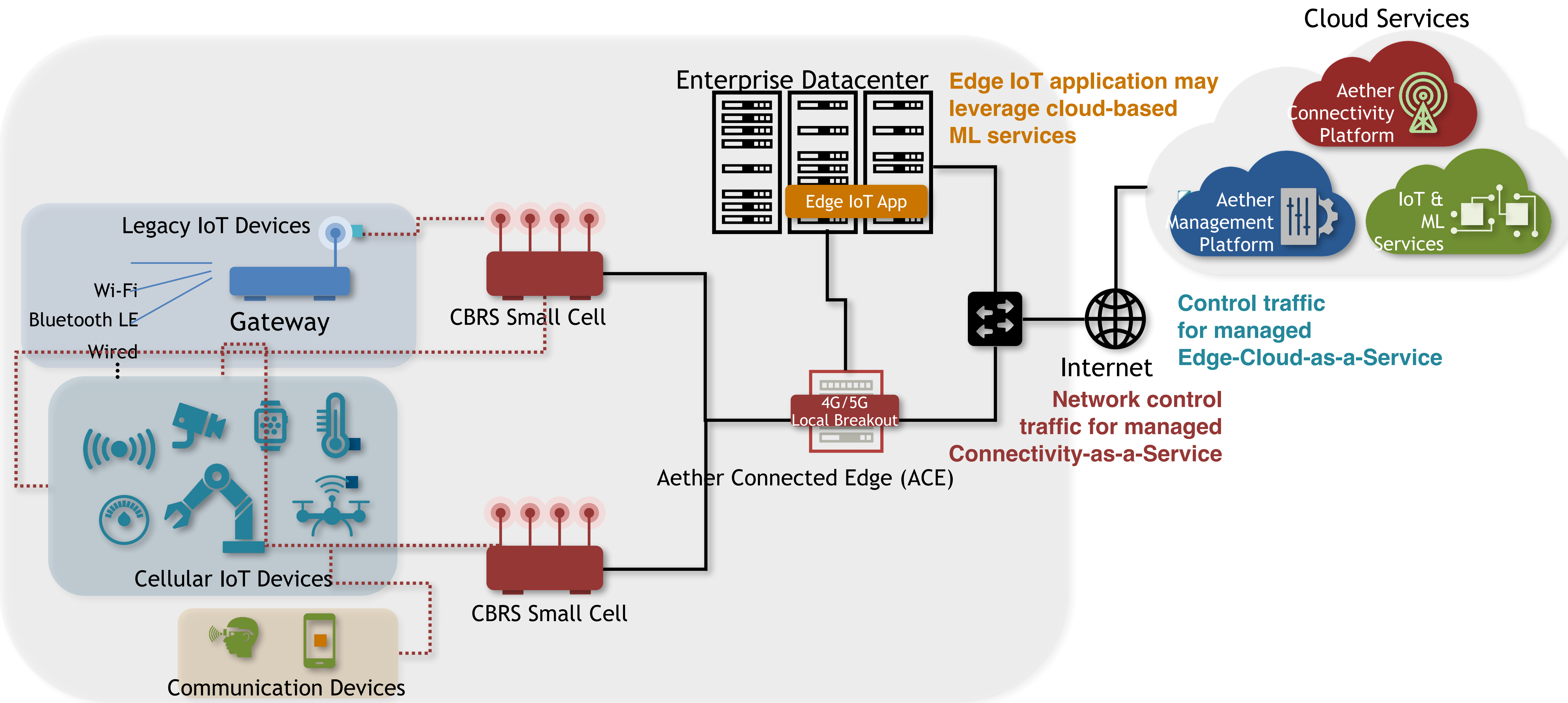


Image credit: ONF

Three Tricks

Verified Network Devices

Three Tricks

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Proof-Carrying Authorization

Three Tricks

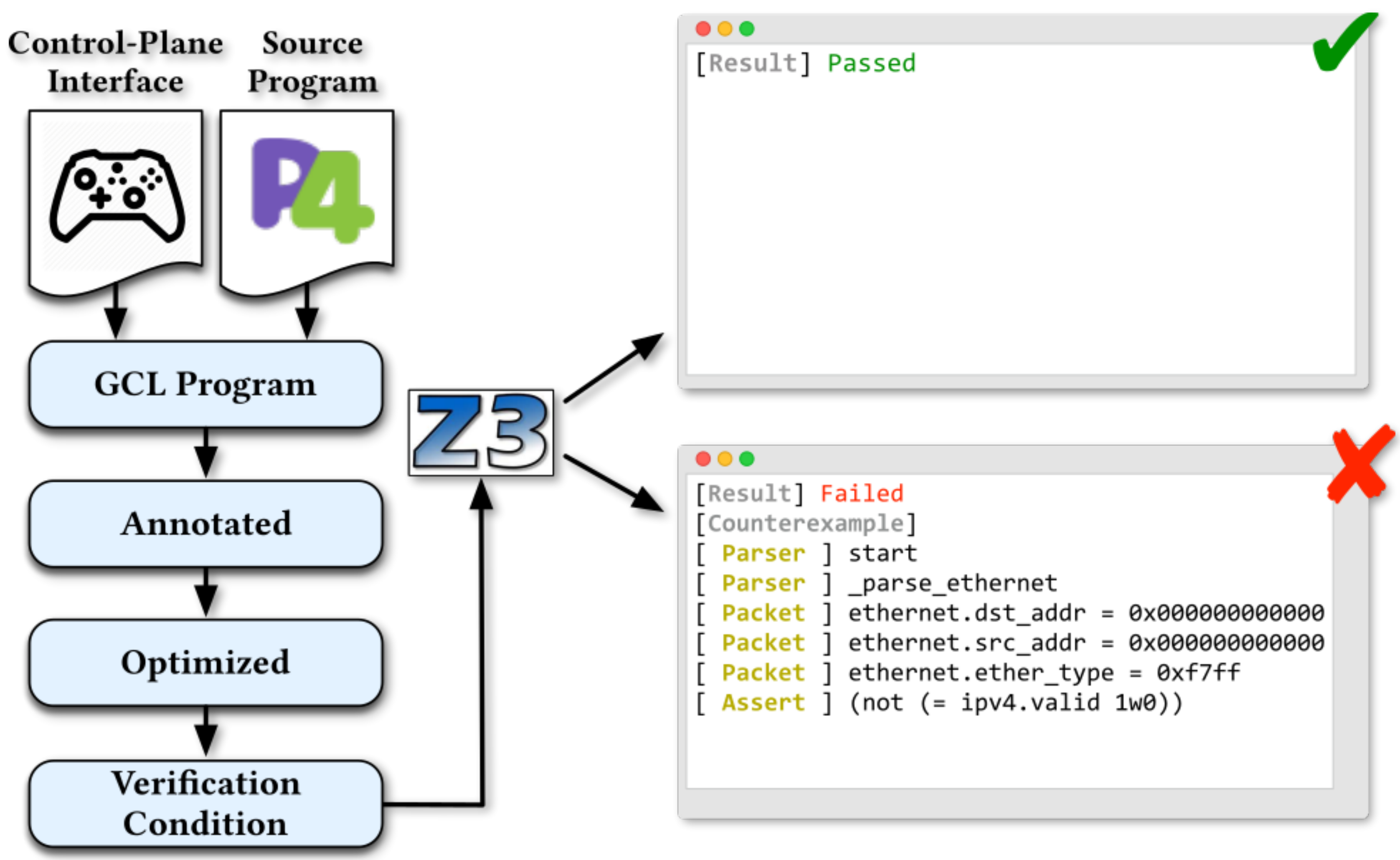
Verified Network Devices

Proof-Carrying Authorization

Timing-Safe Information Flow

Verified Data Planes [SIGCOMM '18]

Goal: automatically verify behavioral properties for network devices



Credits: Bill Hallahan, Robert Soulé, many colleagues at Barefoot

Formal Foundations for P4 [POPL '21]

$\langle C, \Delta, \sigma, \epsilon, exp \rangle \Downarrow \langle \sigma', val \rangle$	Expression evaluation
$\langle C, x, \overline{val : x} \rangle \Downarrow_{match} x(\overline{exp})$	Match-action evaluation
$\langle C, \Delta, \sigma, \epsilon, stmt \rangle \Downarrow \langle \sigma', \epsilon', sig \rangle$	Statement evaluation
$\langle C, \Delta, \sigma, \epsilon, decl \rangle \Downarrow \langle \Delta', \sigma', \epsilon', sig \rangle$	Declaration evaluation

Petr4: Formal Foundations for P4 Data Planes

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P4 is a domain-specific language for specifying the behavior of packet-processing systems. It is based on an elegant design with high-level abstractions, such as parsers and match-action pipelines, which can be compiled to efficient implementations in hardware or software. Unfortunately, like many industrial languages, P4 lacks a formal foundation. The P4 specification is a 160-page document with a mixture of informal prose, graphical diagrams, and pseudocode. The reference compiler is complex, running to over 40KLoC of C++ code. Clearly neither of these artifacts is suitable for formal reasoning.

This paper presents a new framework, called Petr4, that puts P4 on a solid foundation. Petr4 uses standard elements of the semantics engineering toolkit, namely type systems and operational semantics, to build a compositional semantics that assigns an unambiguous meaning to every P4 program. Petr4 is implemented as an OCaml prototype that has been validated against a suite of over 750 tests from the reference

HyperFlow [CCS '18]

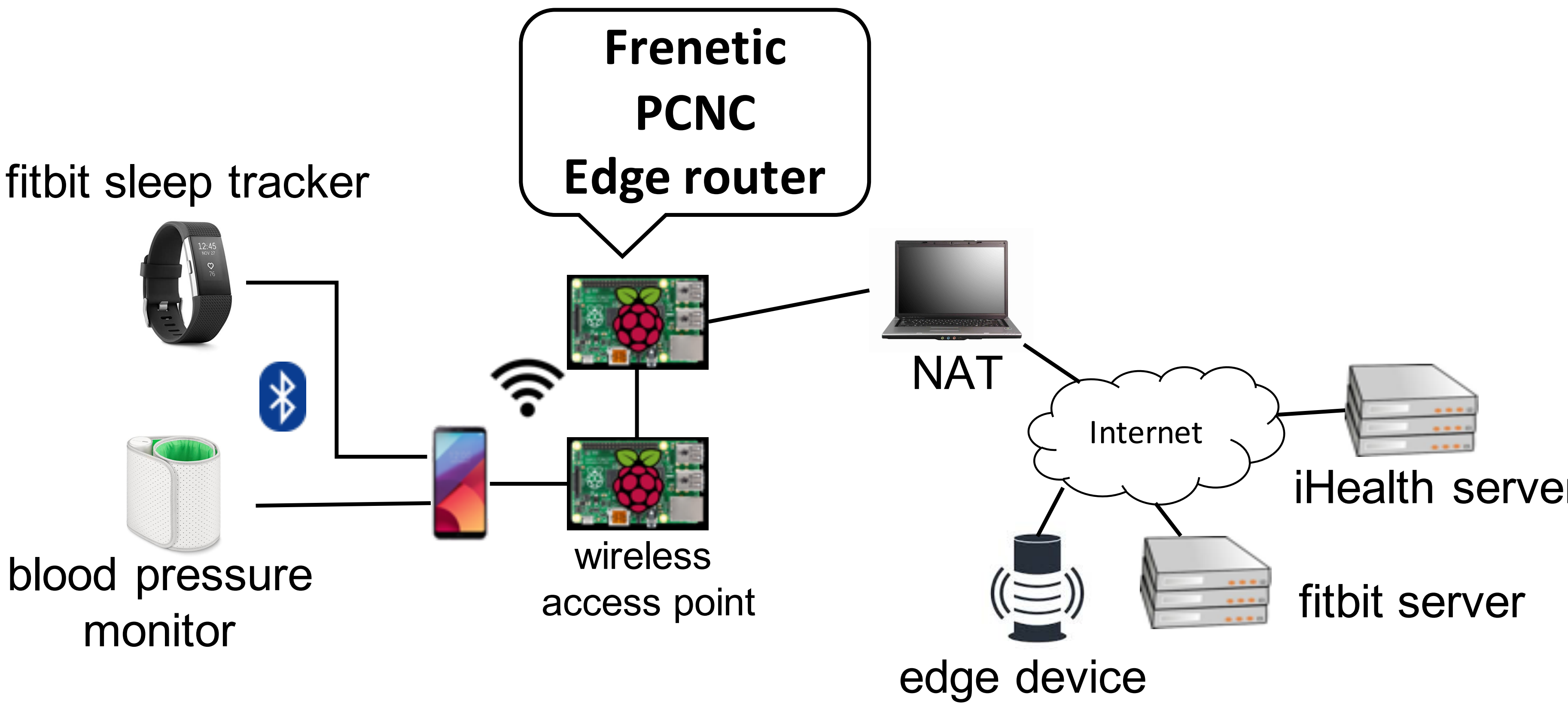
Goal: timing-safe information flow security with expressive policies and strong assurance

Software	• **DIFC policies: confidentiality, integrity** ➙ Mutually distrusting yet communicating parties
ISA	• **New HW-SW contract for timing-safe IFC** ➙ Encode expressive security policies in hardware
MicroArch	• **Tagged architecture for enforcement** ➙ Remove timing channels
HDL	• **Secure HDL for information flow security** ➙ Timing-sensitive non-interference

Credits: Ed Suh and Andrew Myers

Proof-Carrying Network Code [CCS ’19]

Goal: specify and enforce fine-grained network policies with distributed authorization



$$
\begin{array}{lcl}
F, G, H & ::= & f(t, \ldots) \\
& | & \mathrm{true} \\
& | & \mathrm{false} \\
& | & F \; \mathit{Says} \; F \\
& | & X \\
& | & F \wedge F \\
& | & F \vee F \\
& | & F \Rightarrow F \\
& | & \forall X.F \\
& | & \exists X.F
\end{array}
$$

Credits: Christian Skalka, David Darais, **Minseok Kwon**

Takeaways…

Verified Network Devices

Proof-Carrying Authorization

Timing-Safe Information Flow