And Then There Were More:

Secure Communication for More Than Two Parties

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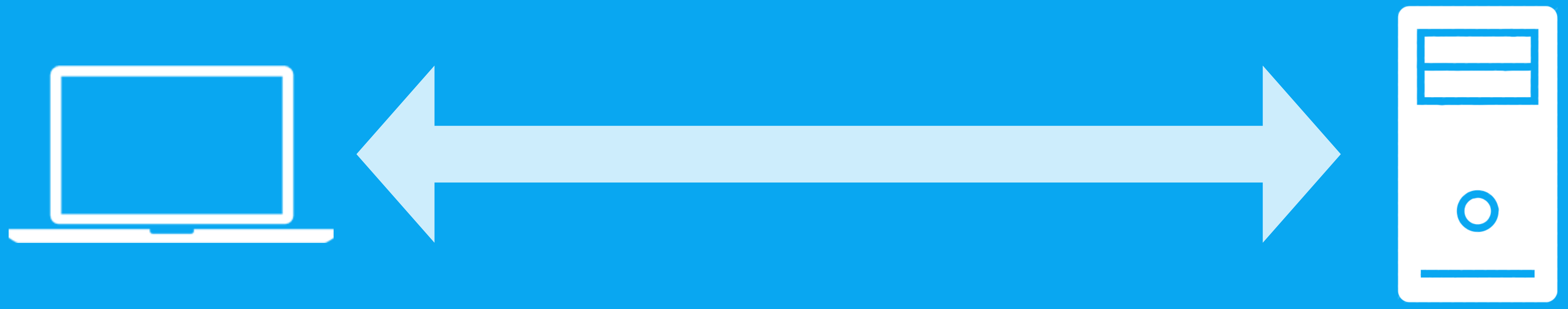
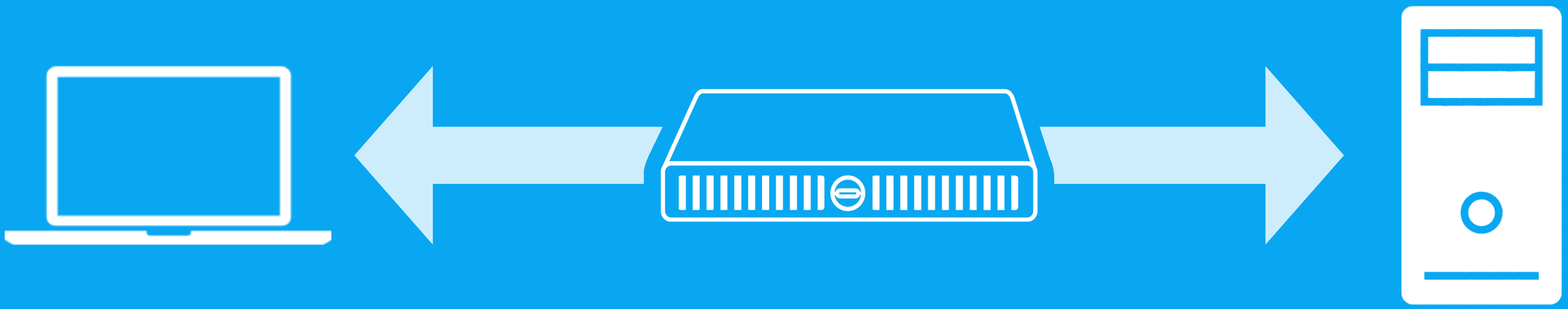


In most networks,

# middleboxes ≈ # routers



Web Cache
Compression Proxy
Intrusion Detection System

Virus Scanner
Parental Filter
Load Balancer

[Making Middleboxes Someone Else's Problem. *SIGCOMM '12*]

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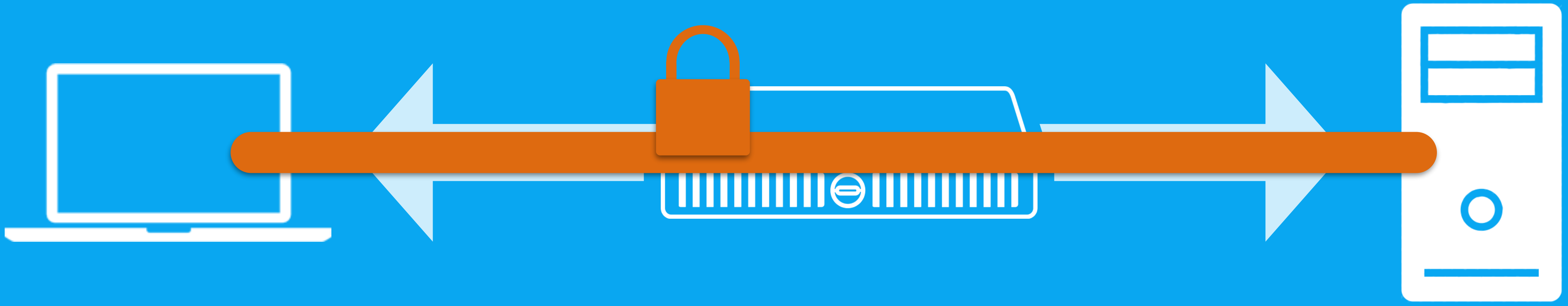
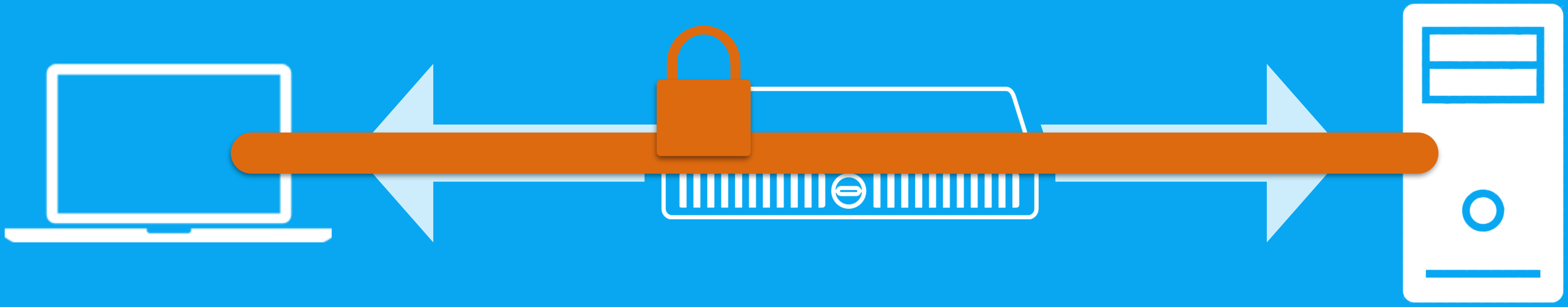
# middleboxes ≈ # routers



Encryption blinds middleboxes.



Encryption blinds middleboxes.

Goal: Encryption + Middleboxes

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1

Design Space

For secure, multi-entity communication protocols

2

mbTLS

A deployable protocol for outsourced middleboxes.

There’s a **big** design space for ***secure***, ***multi-entity*** *communication protocols*

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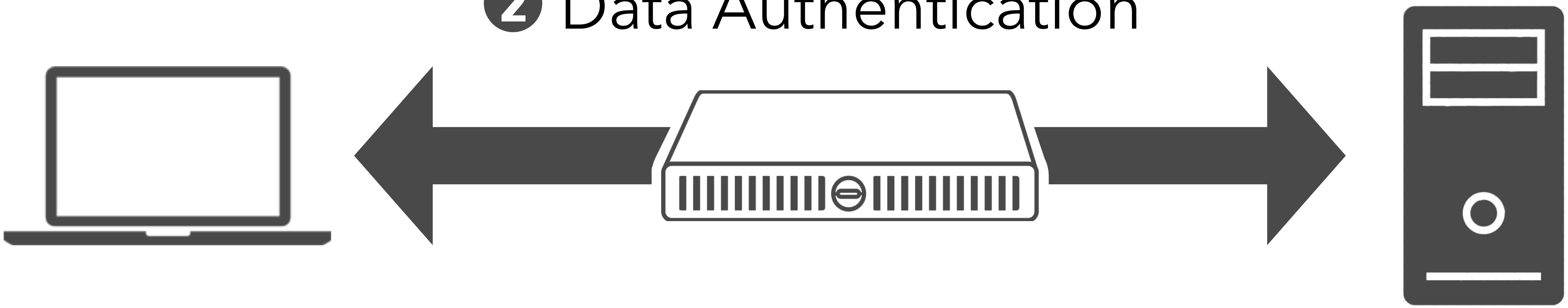
1. Extend TLS Security Properties
2. New Security Properties
3. Other Properties

① Extend TLS Security Properties

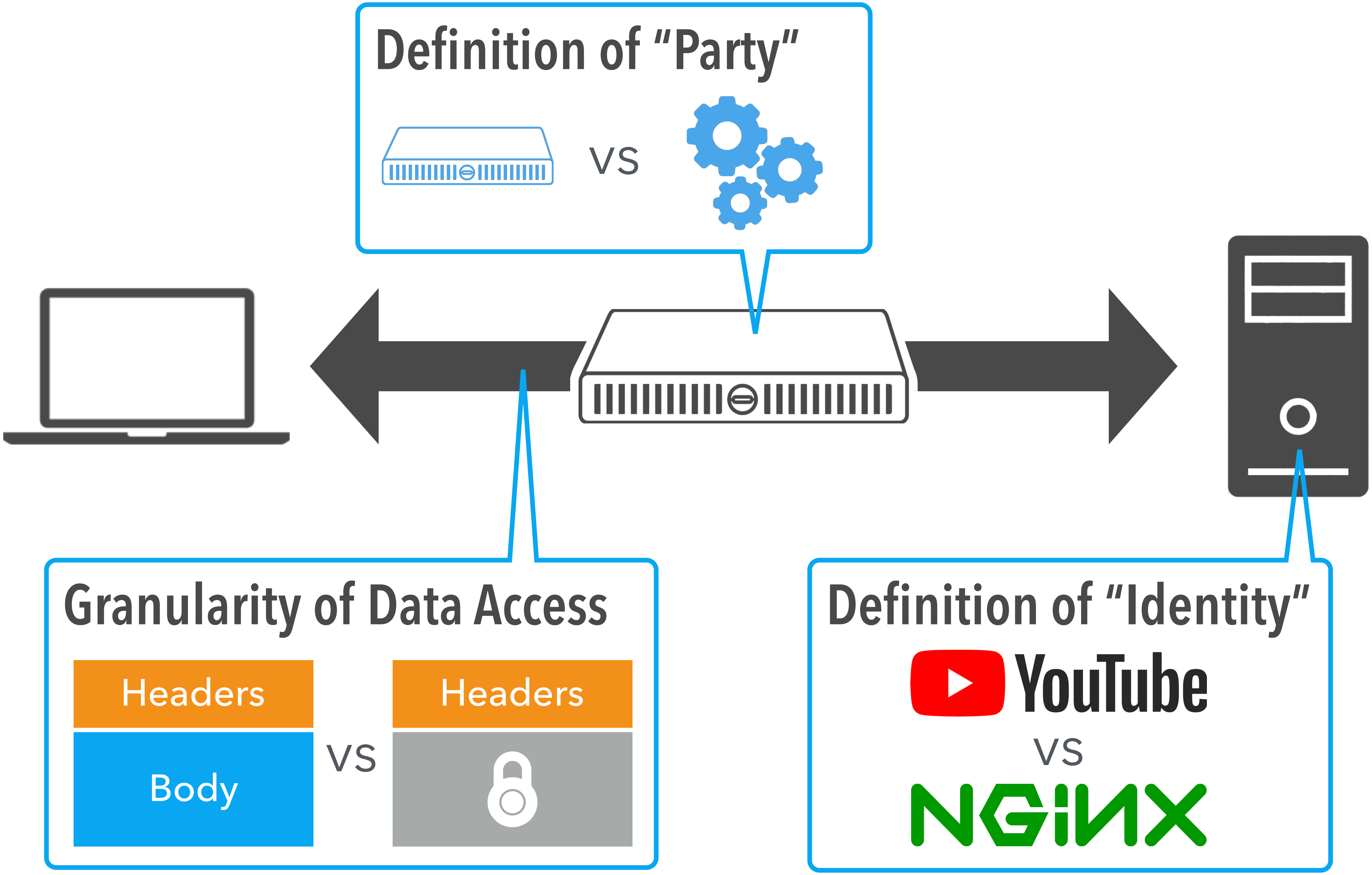


❶ Data Secrecy

❷ Data Authentication

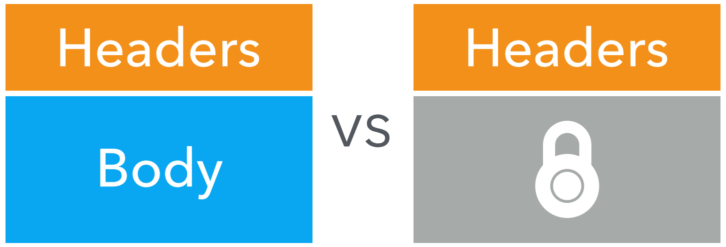
❸ Entity Authentication

① Extend TLS Security Properties

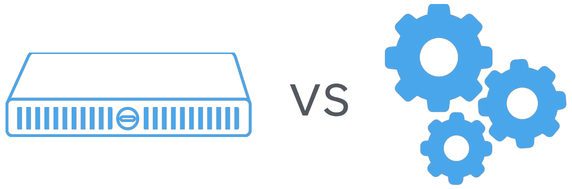


1 Extend TLS Security Properties

Granularity of Data Access



Definition of "Party"



Definition of "Identity"

YouTube

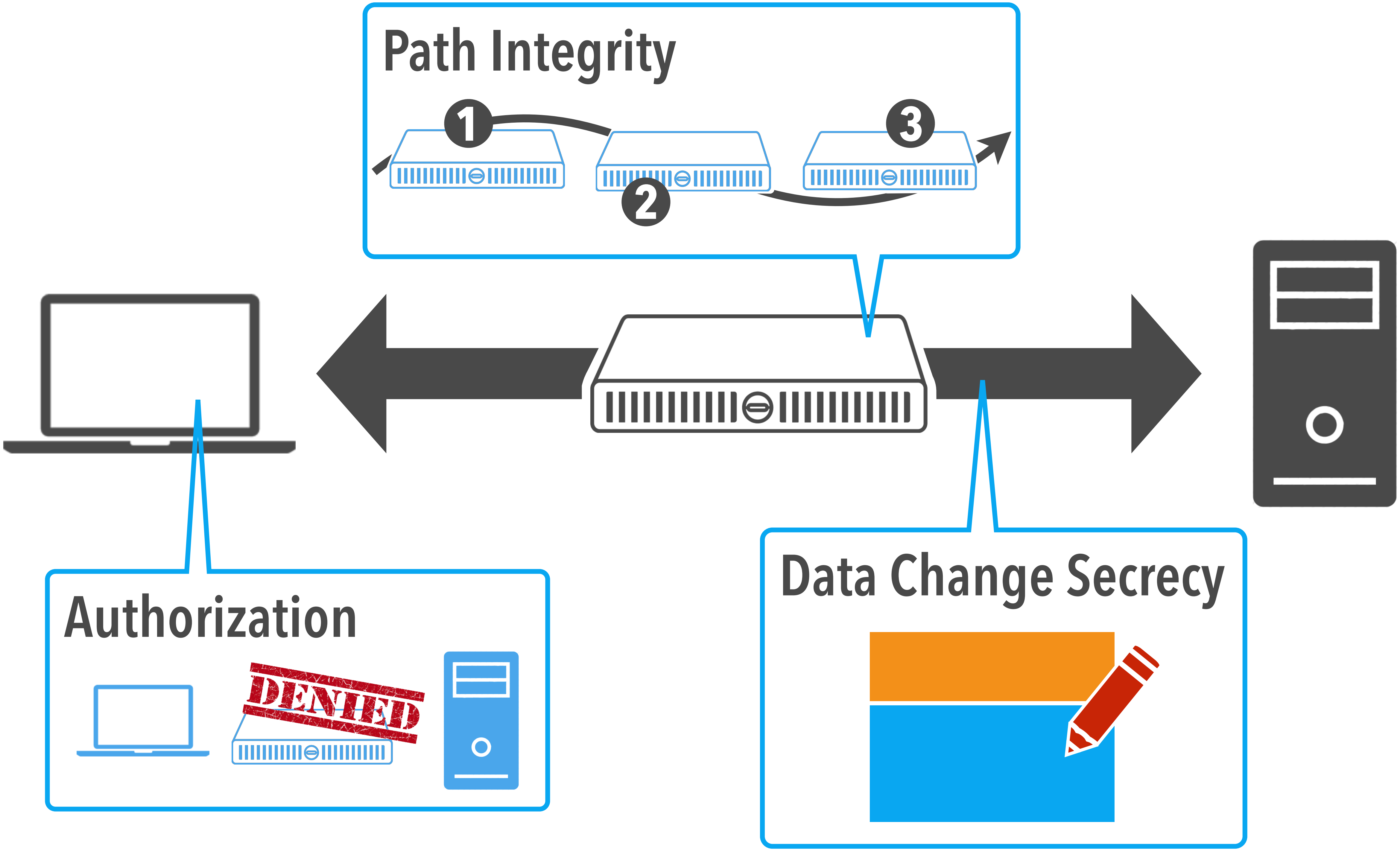
VS

NGINX

2 New Security Properties

3 Other Properties

2 New Security Properties



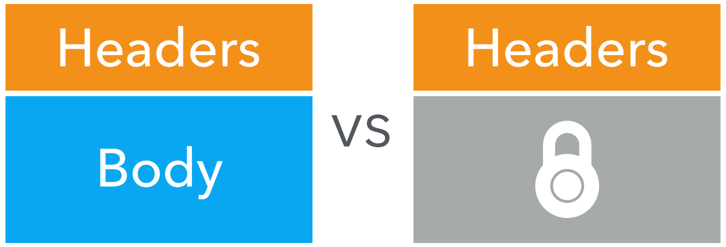
Path Integrity

Authorization

Data Change Secrecy

1 Extend TLS Security Properties

Granularity of Data Access



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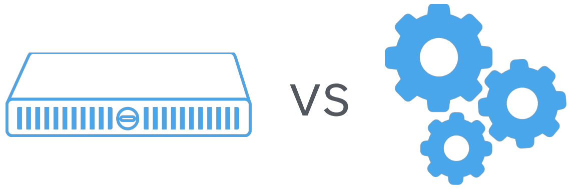

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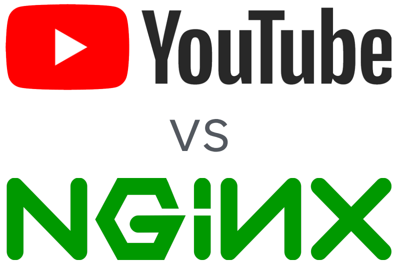
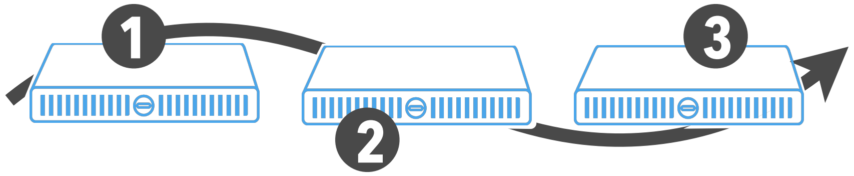


2 New Security Properties

Path Integrity



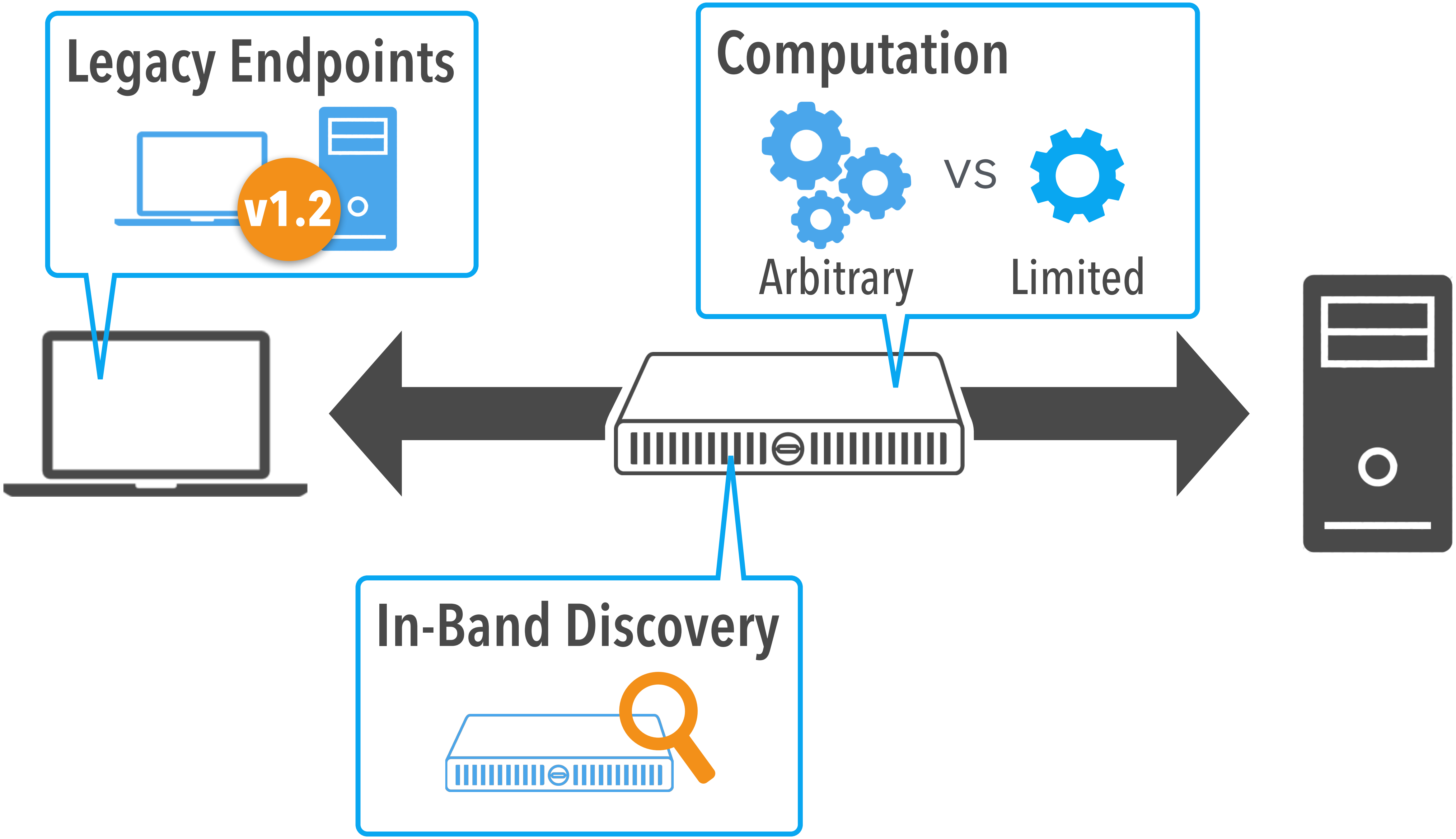
Data Change Secrecy

Authorization

3 Other Properties

3

Other Properties



Legacy Endpoints

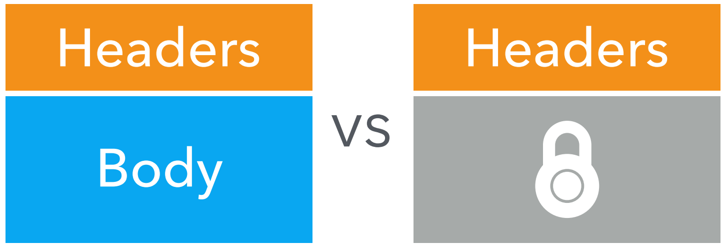
Computation

Arbitrary vs Limited

In-Band Discovery

1 Extend TLS Security Properties

Granularity of Data Access



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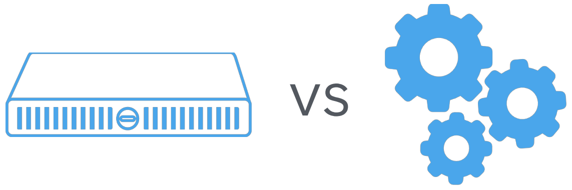

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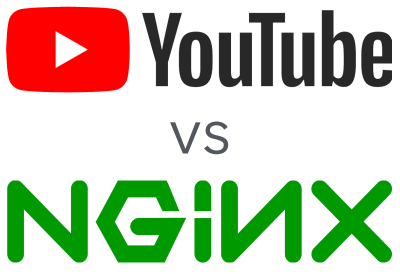

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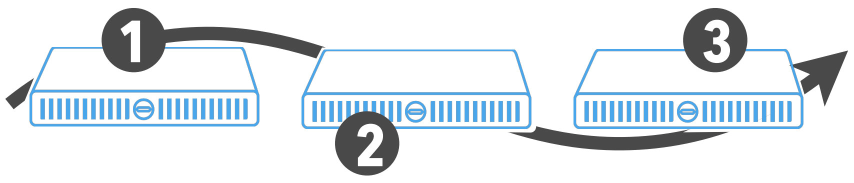

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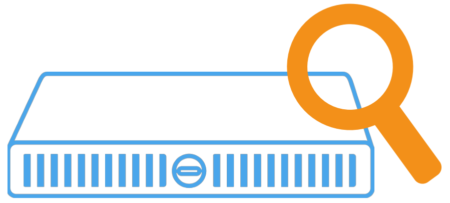
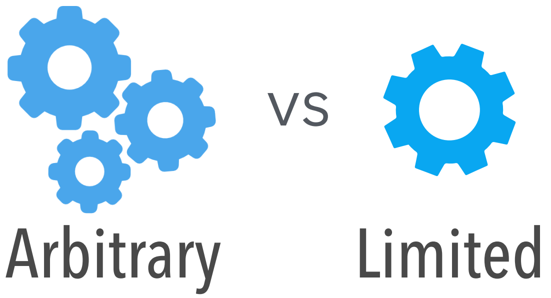


Computation



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Supporting one property often precludes another.

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TLS interception with custom root certificates

Supports

two legacy endpoints

Prevents

endpoint authentication (owner or code)

YouTube

vs

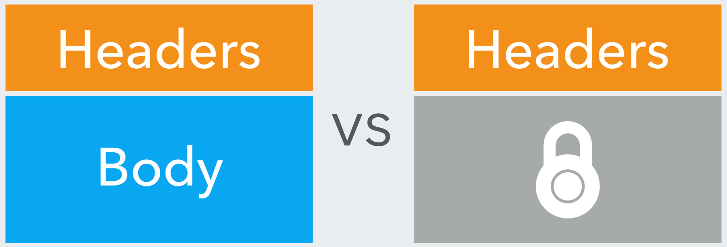
NGINX

Supporting one property often precludes another.

Multi-Context TLS (mcTLS) [SIGCOMM '15]

Supports

fine-grained data access



Prevents

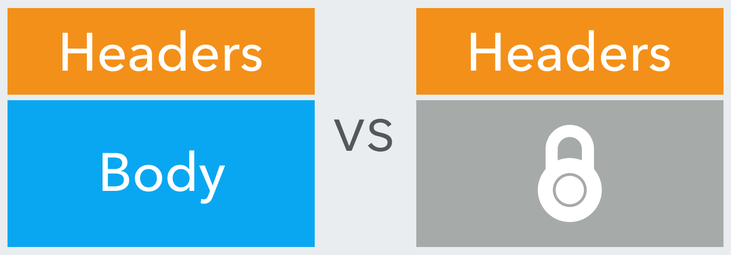
legacy support

Supporting one property often precludes another.

BlindBox [SIGCOMM '15]

Supports

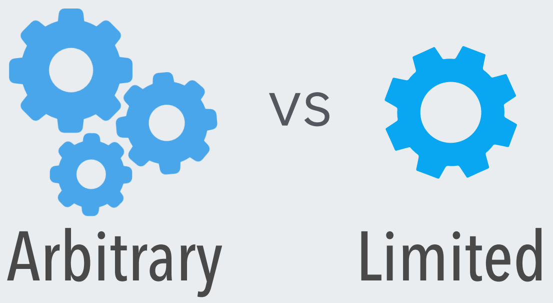
functional crypto
(minimal data access)



Headers
Body
vs
Headers

Prevents

arbitrary computation



Arbitrary
vs
Limited

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Goal: Encryption + Middleboxes

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mbTLS

A deployable protocol for outsourced middleboxes.

mbTLS targets two common-case, real-world needs

1. **Immediate deployability**
   Interoperate with one legacy endpoint

2. **Protection for outsourced middleboxes**
   Protect session data from middlebox infrastructure
   (in addition to traditional network attackers)

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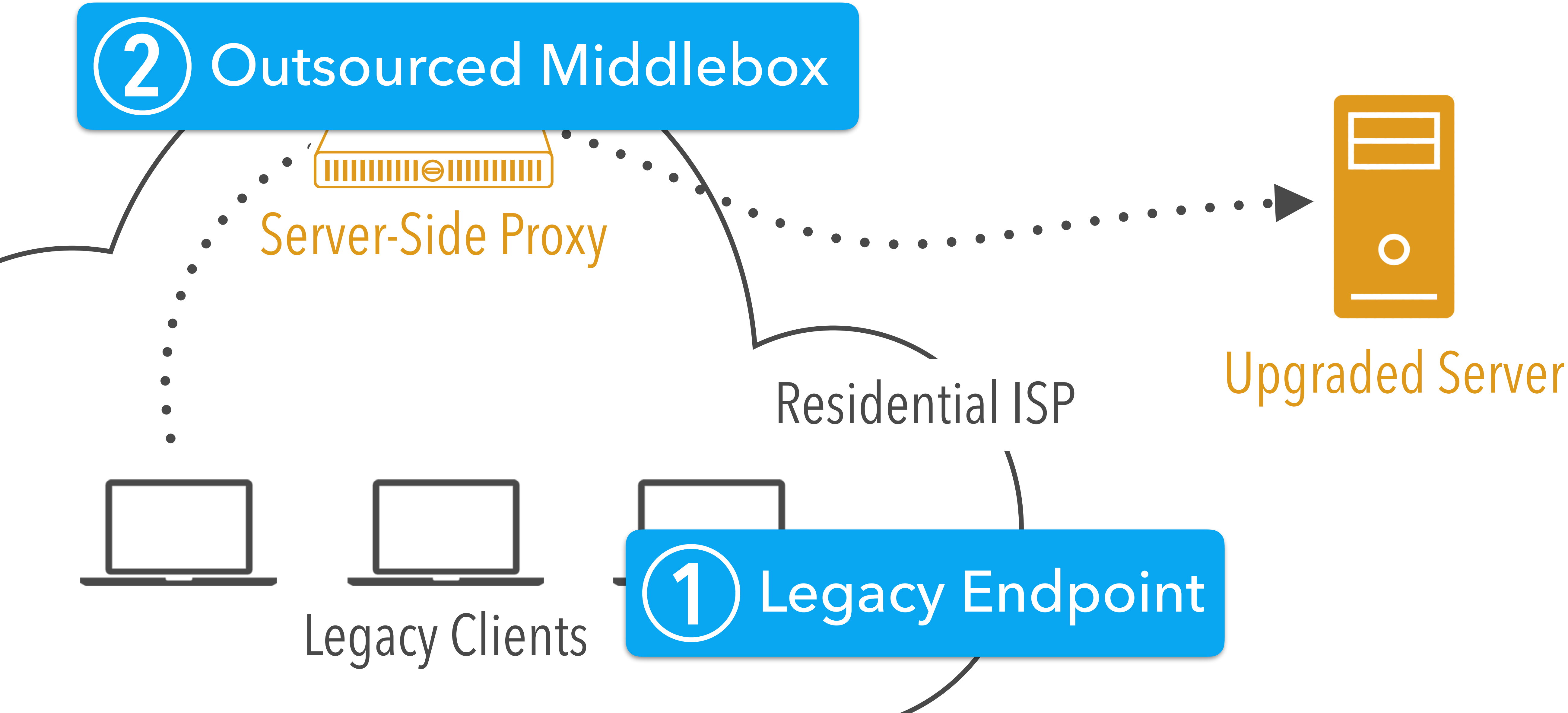

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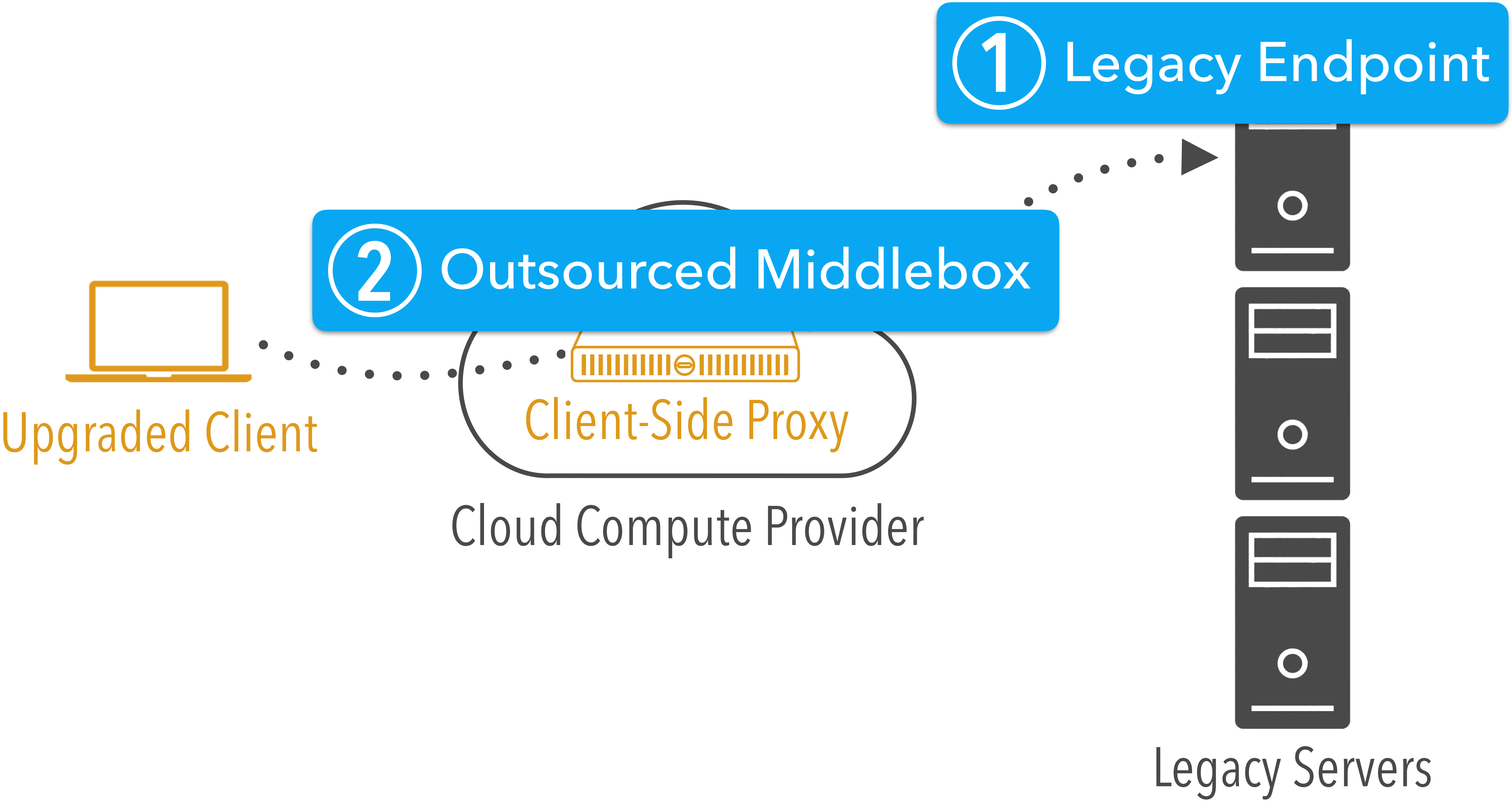

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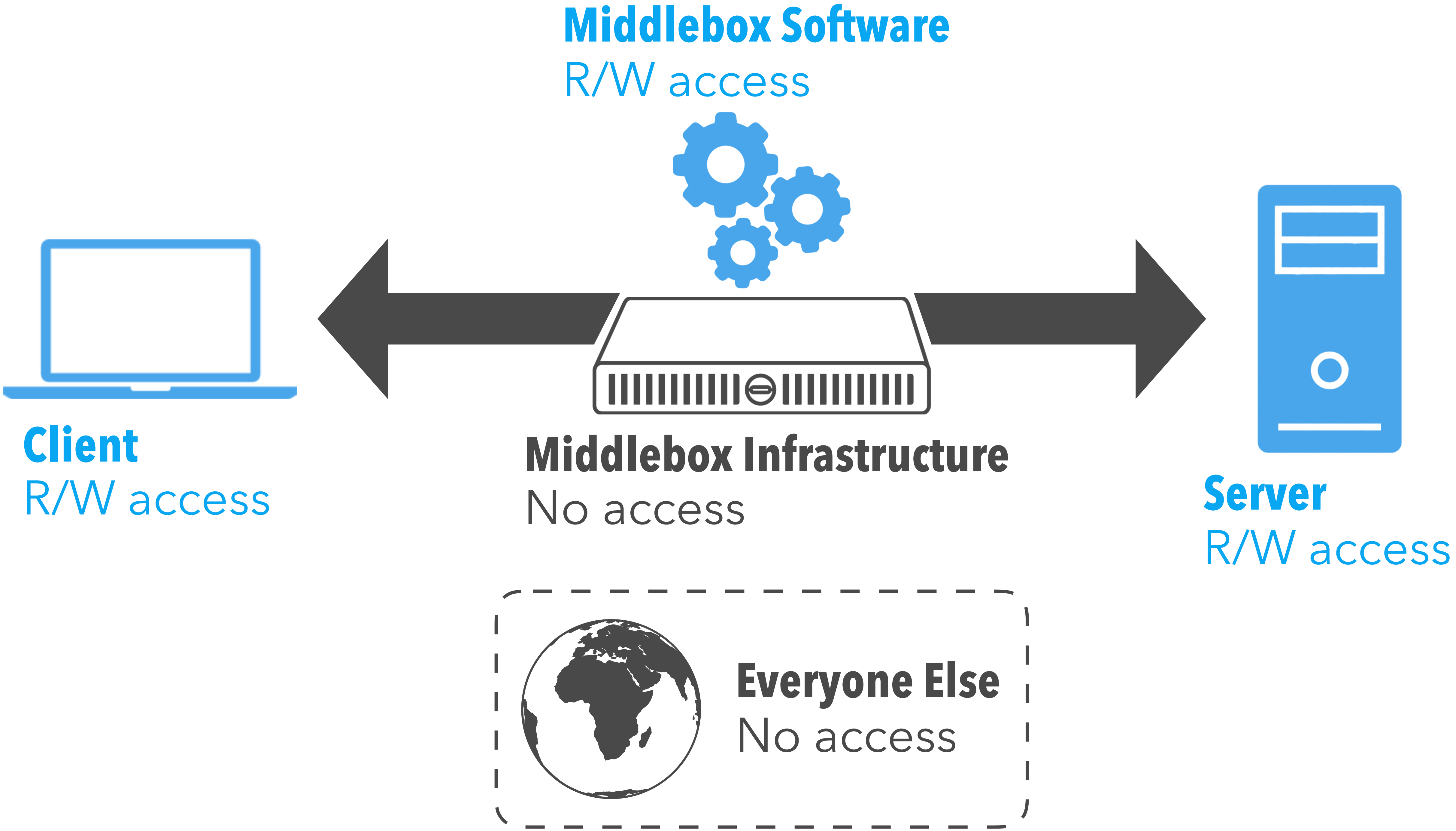
2 Protection for outsourced middleboxes

Protect session data from middlebox infrastructure

(in addition to traditional network attackers)



Middlebox Software
R/W access

Client
R/W access

Middlebox Infrastructure
No access

Server
R/W access

Everyone Else
No access

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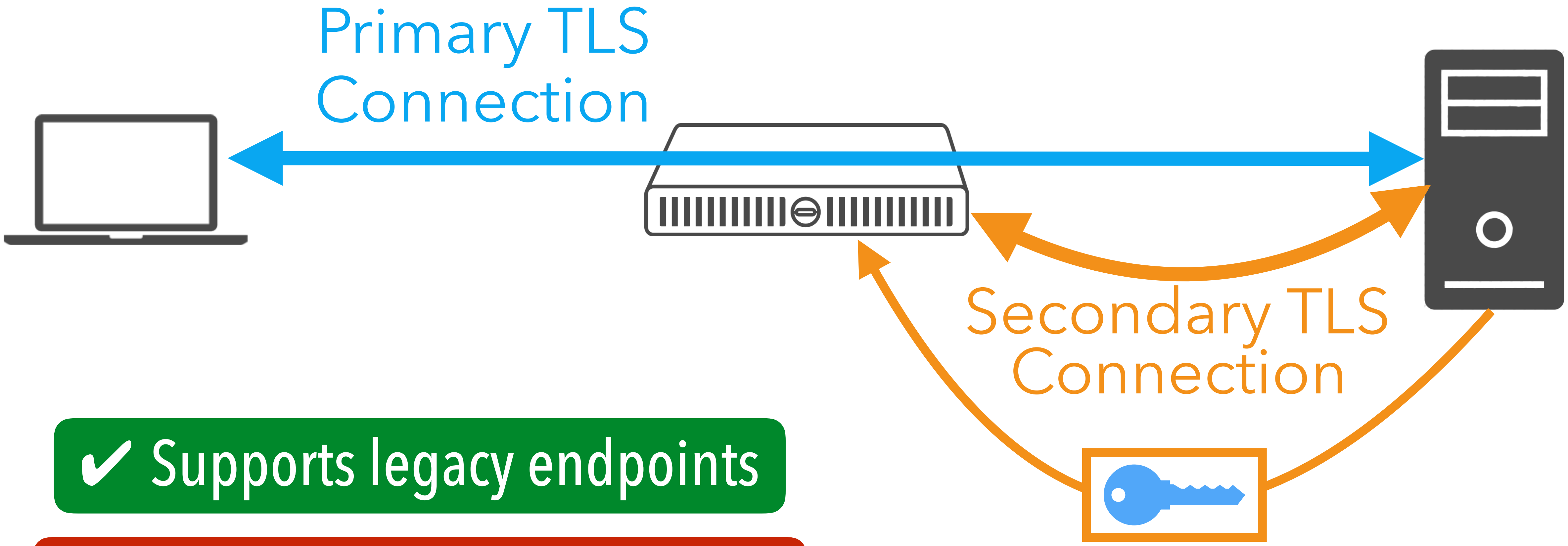
A first approach: pass primary session key over secondary TLS session



✔ Supports legacy endpoints

✗ Data and keys visible in RAM

An aside:

Intel SGX

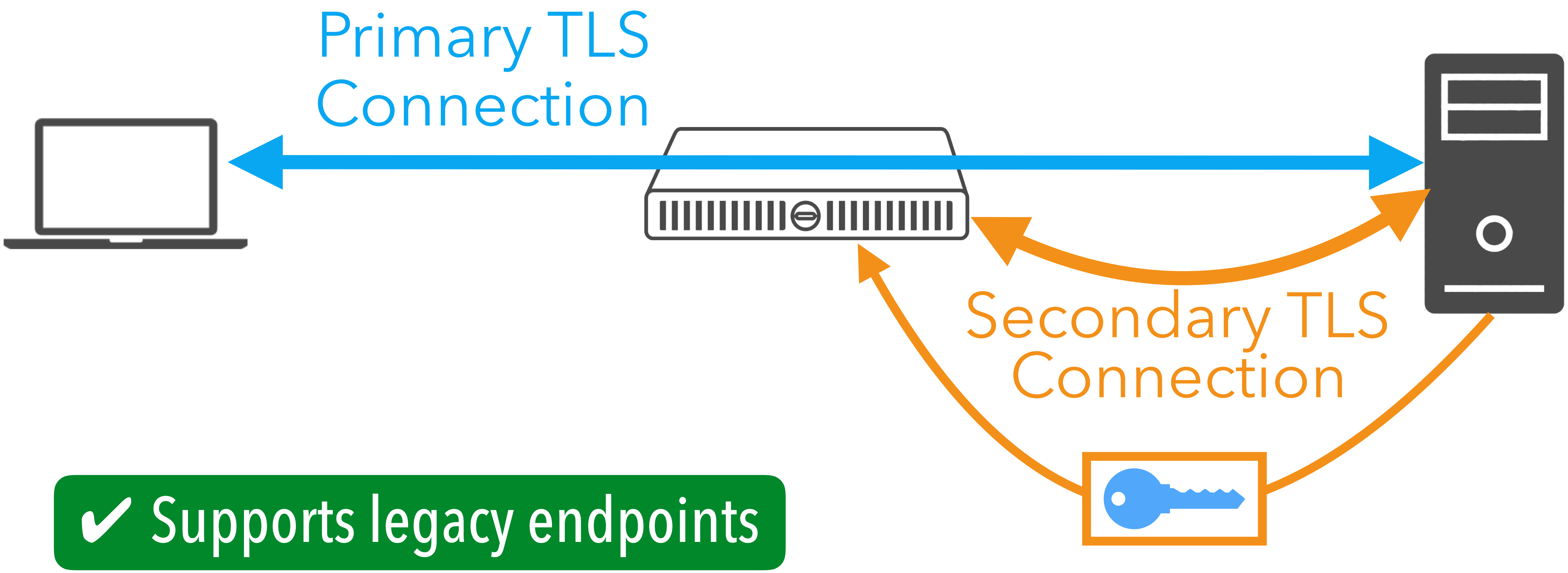
❶ **Secure Execution Environment**

Program code, data, and stack encrypted.

❷ **Remote Attestation**

Prove to remote party that ① is working.

A first approach: pass primary session key over secondary TLS session



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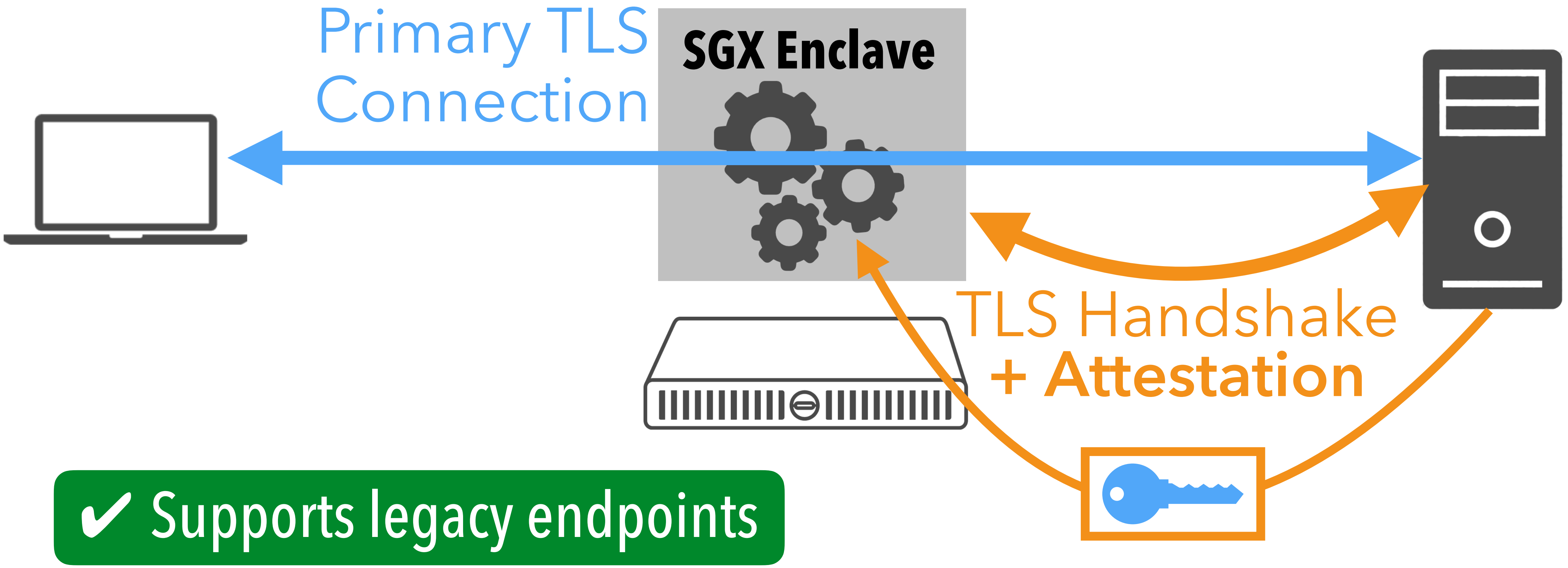
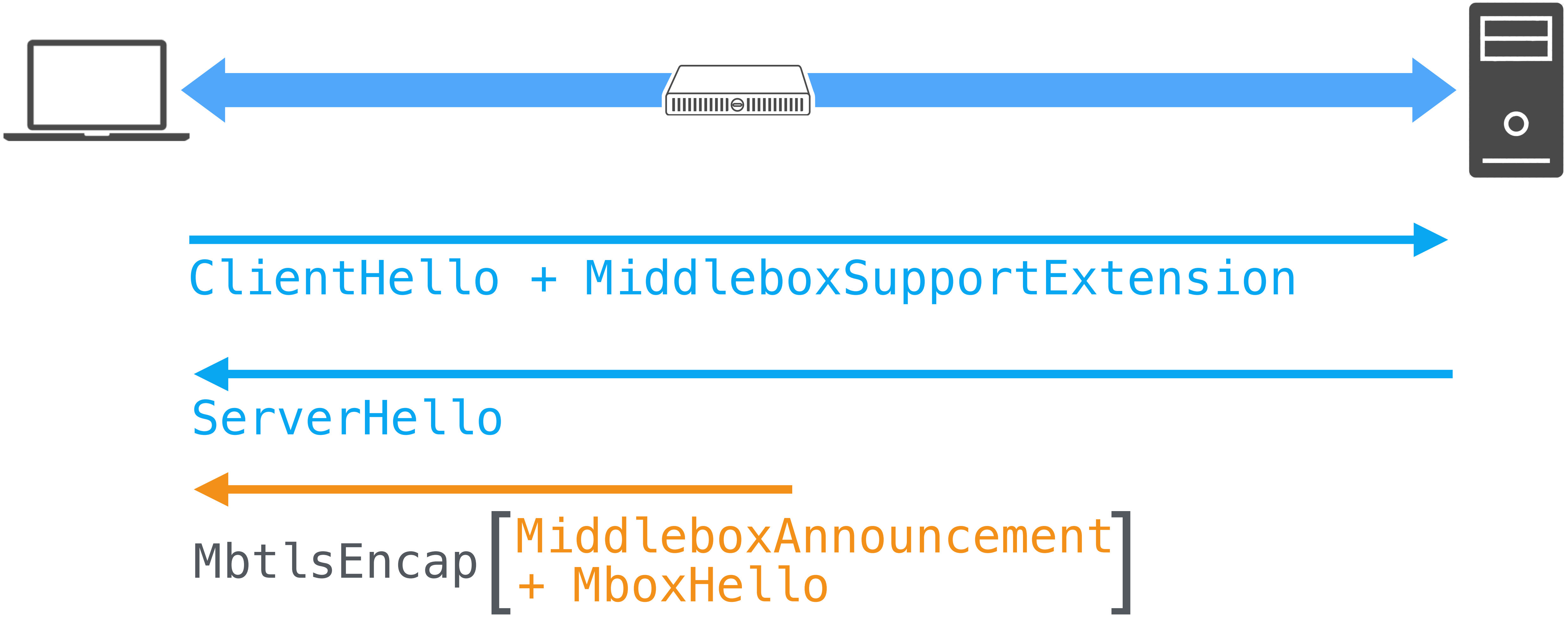
mbTLS protects session data and keys using SGX



✔ Supports legacy endpoints

✔ Data and keys encrypted in RAM

On-path middleboxes can be discovered "on-the-fly"

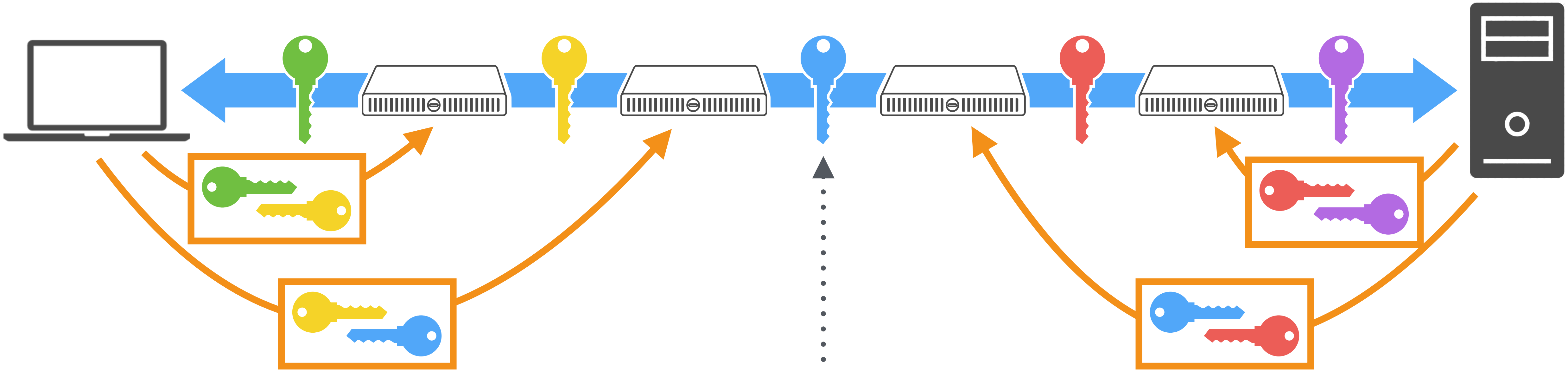


ClientHello + MiddleboxSupportExtension

ServerHello

MbtlsEncap[MiddleboxAnnouncement + MboxHello]

Per-hop keys provide path integrity and data change secrecy



Original session key "bridges" client- and server-side middleboxes.

Evaluation

1. **What overheads does mbTLS introduce?**

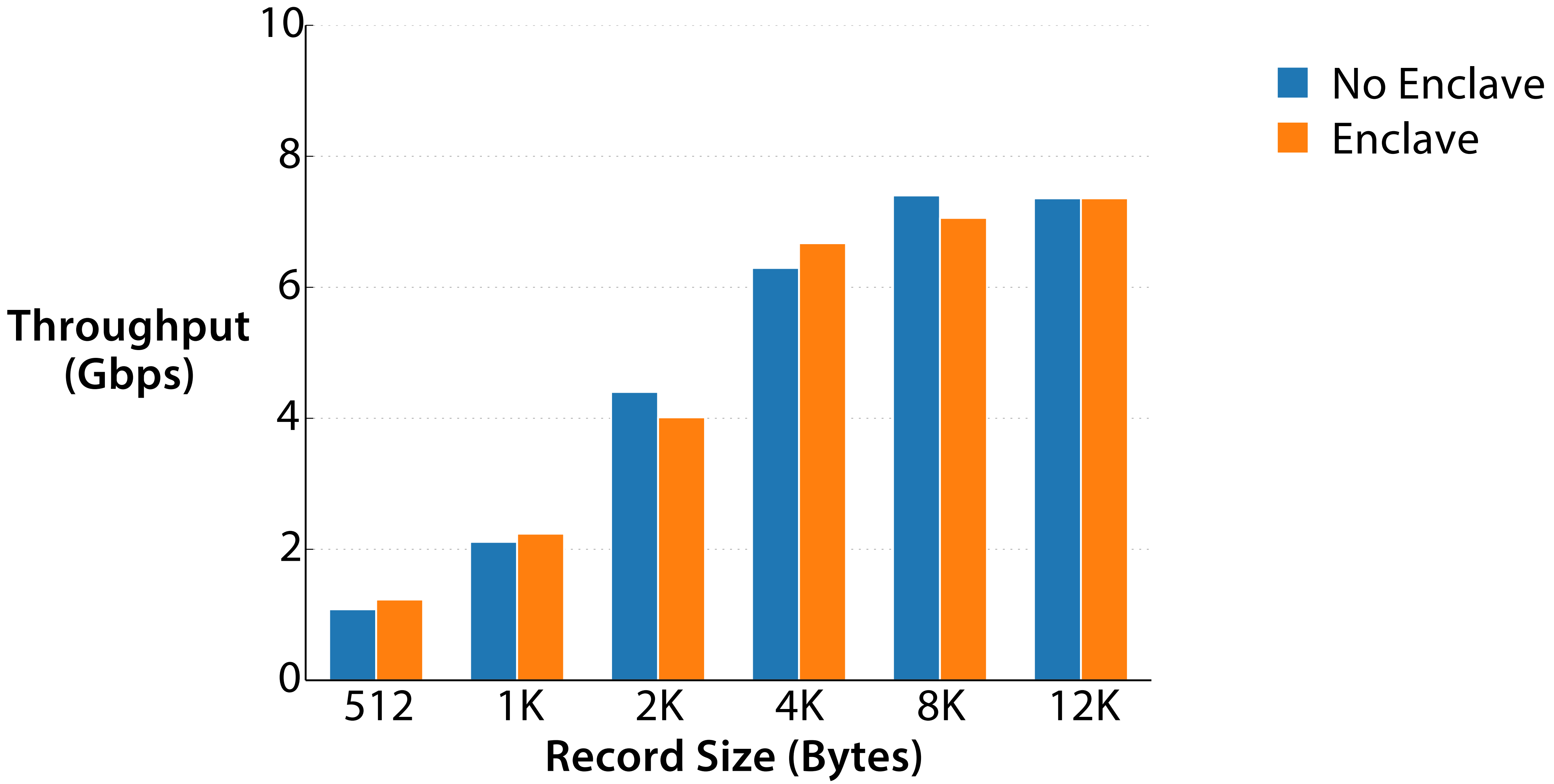
   From SGX?

   From crypto?

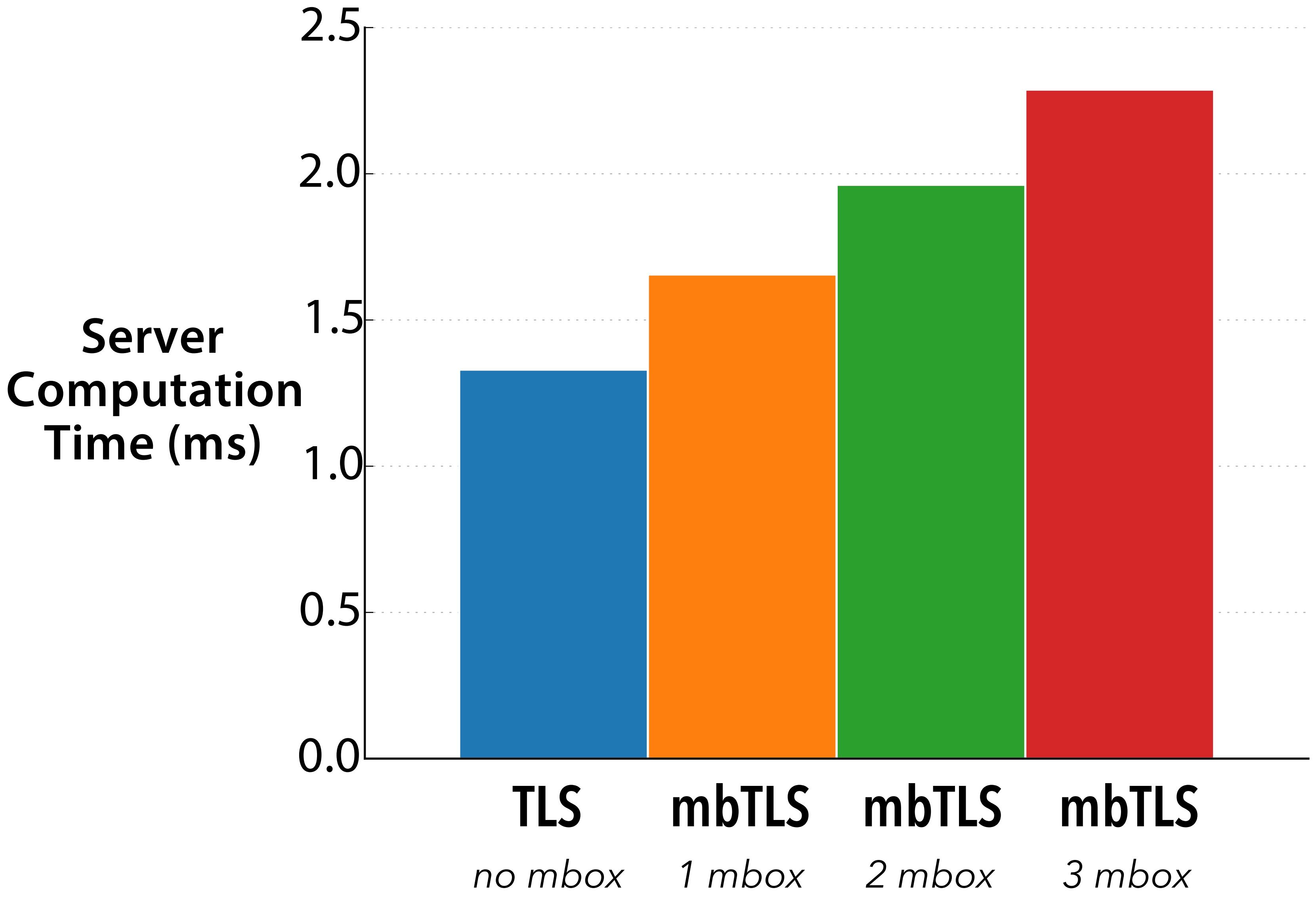
2. **Is mbTLS immediately deployable?**

   Will existing network devices drop mbTLS handshake messages?

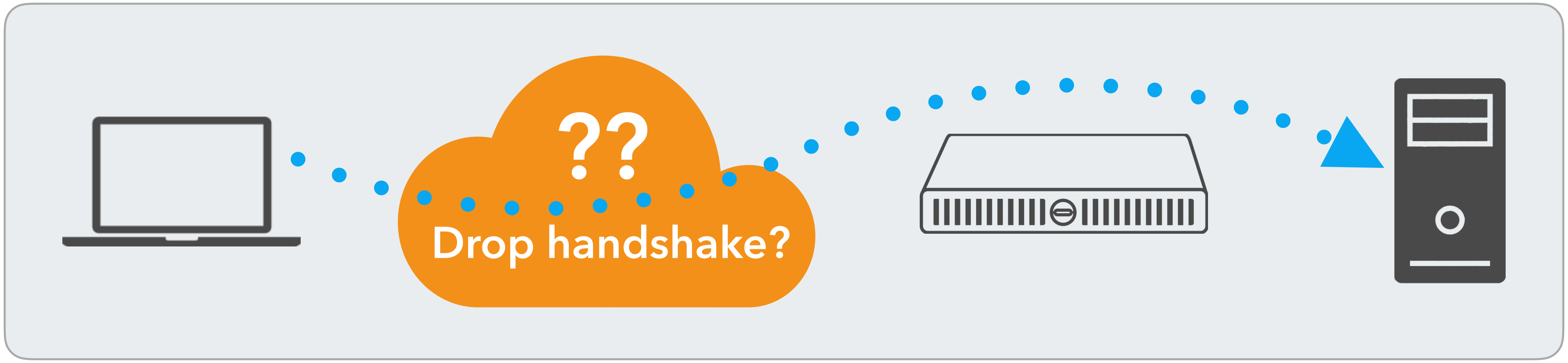
SGX doesn’t have much impact on I/O+compute-intensive workloads



mbTLS adds some handshake CPU overhead on the server



mbTLS' handshake protocol changes are deployable today



No handshakes were dropped.

6 enterprise networks

11 university networks

56 hosting networks

34 residential networks

35 colocation networks

19 data center networks

2 mobile networks

1 public network

77 unlabeled networks

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