Proof of Service: Trust-free OCS for Decentralized Cellular Networks

Milind Kumar V
UIUC, Banyan Intelligence

Team

Pramod Viswanath

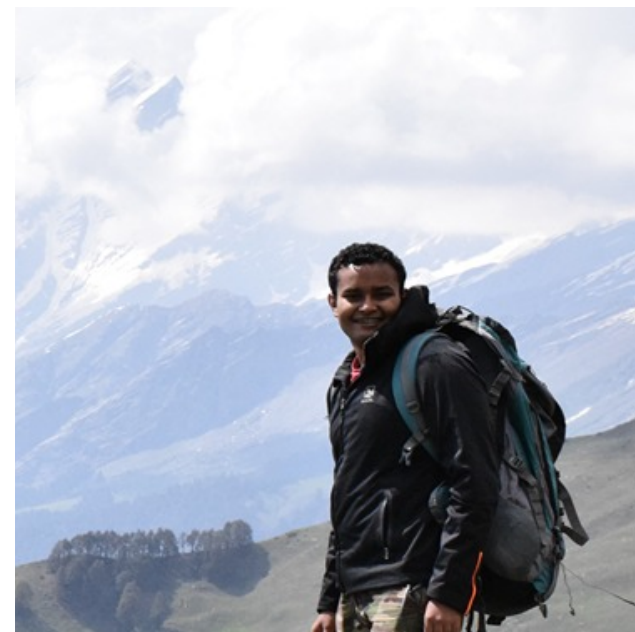**Himanshu Tyagi**

Sachin Katti

SVR Anand

Serhat Arslan

Milind Kumar V

Rajat Chopra

Ranvir Rana
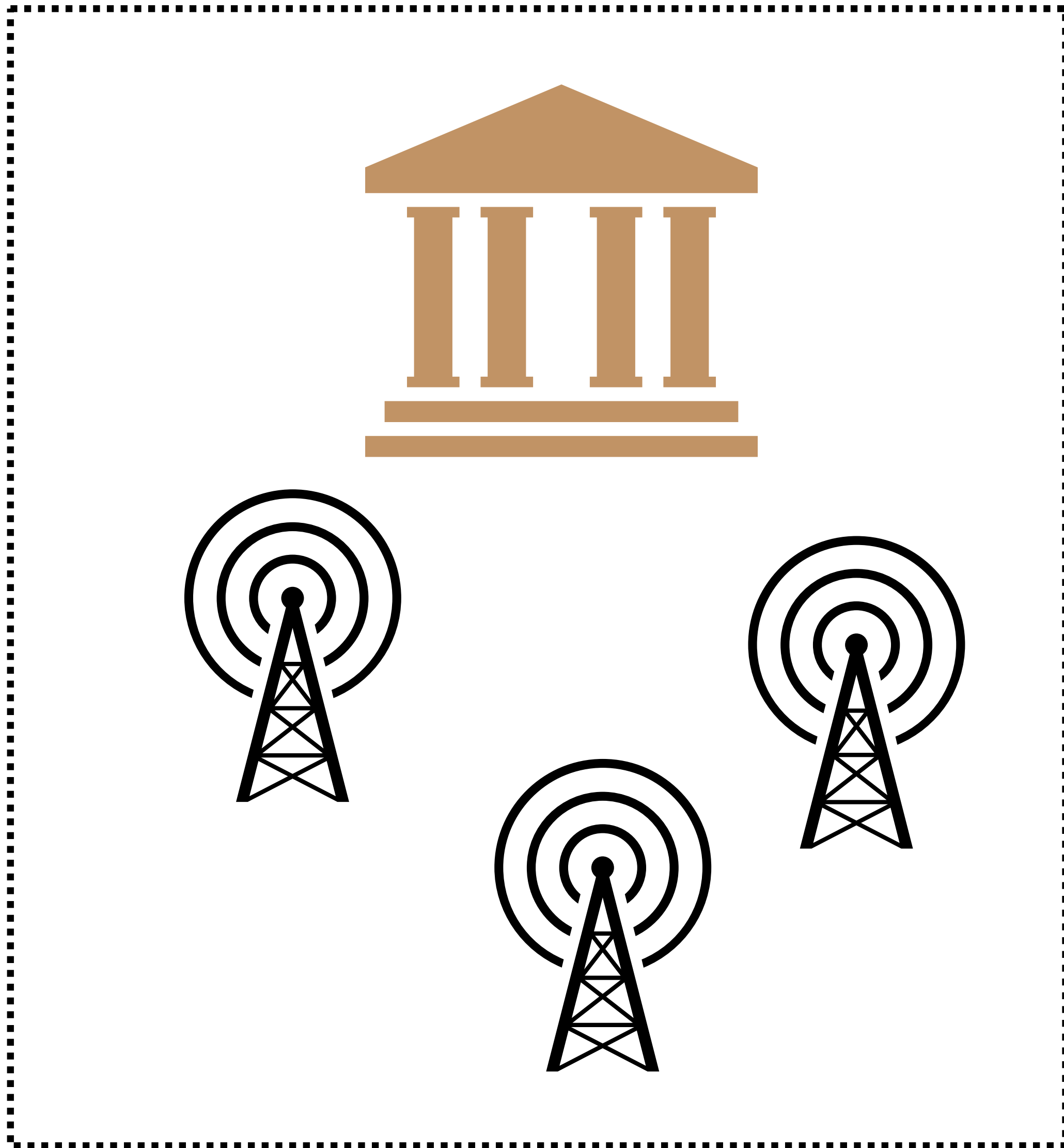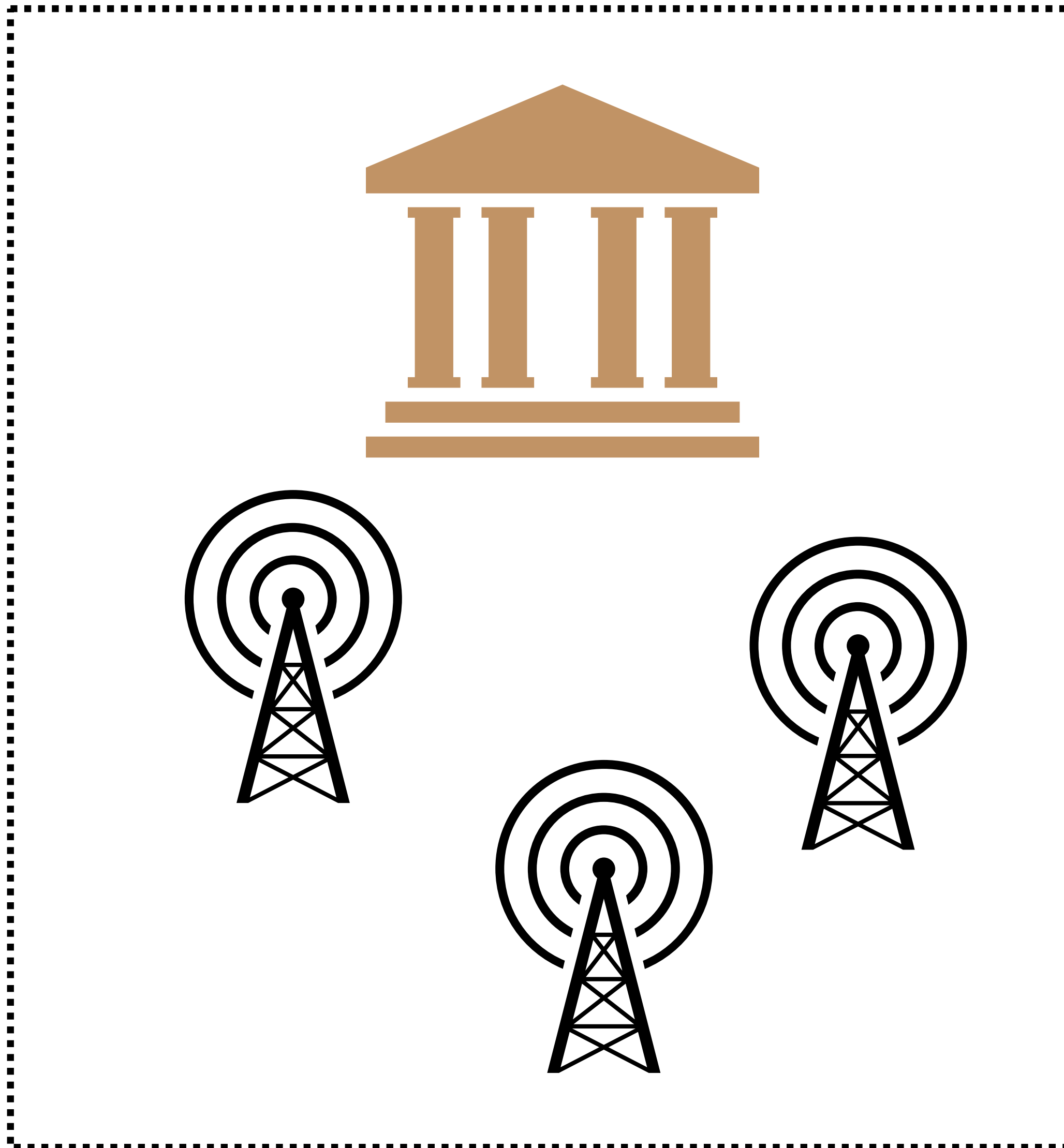
Peiyao Sheng

Arun Babu

Overview

- Decentralized networks

  - What?

  - Why?

  - How?

- Proof of Service

  - What?

  - Blockchain primitives

  - Current system

  - Future work

Well, what are decentralized networks?
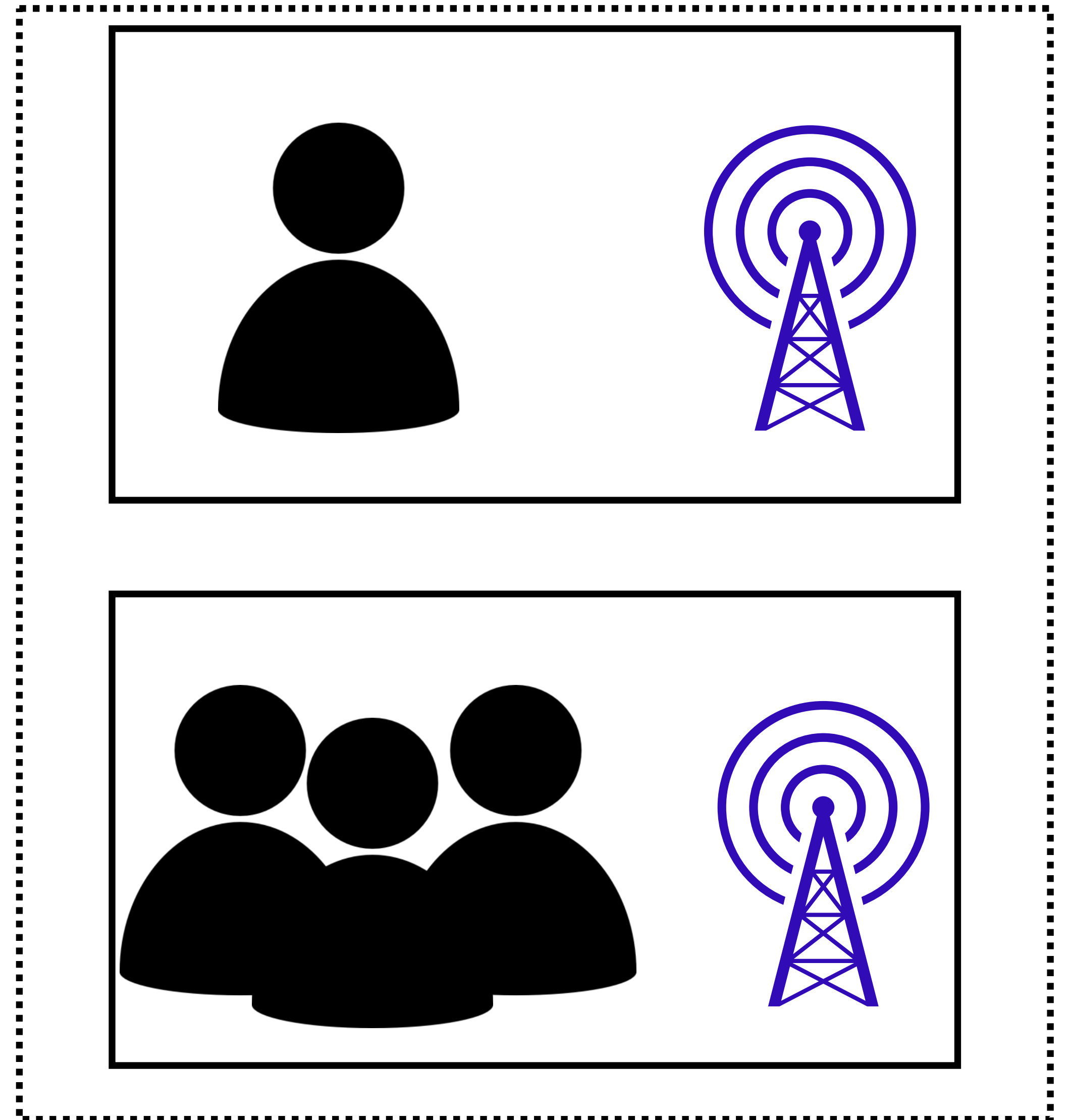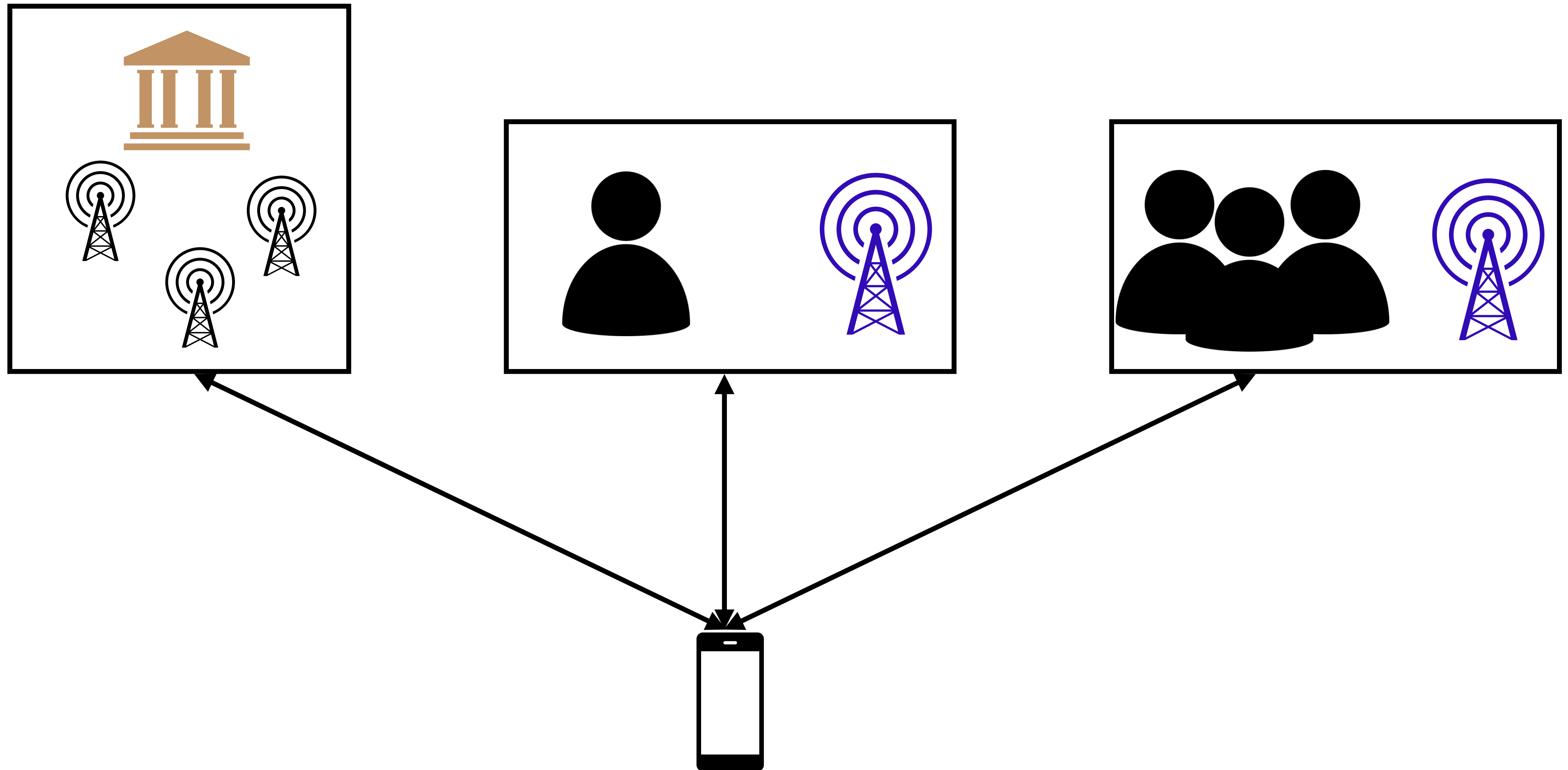
The traditional model with few carriers

Distributed ownership: anyone can provide service
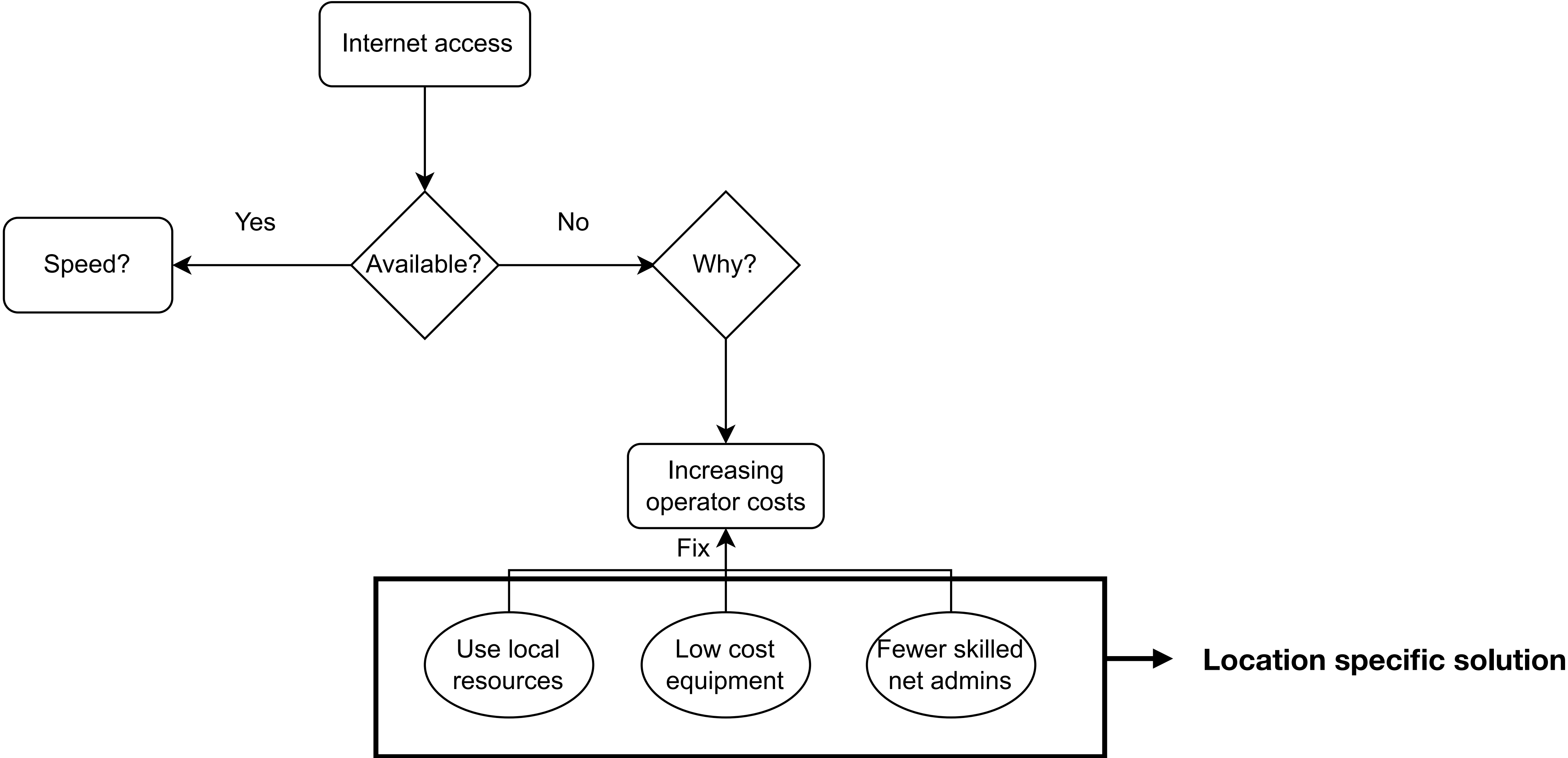
Permissionless access: anyone can receive service

Community cellular networks were the precursors to decentralized networks

Scaling community cellular networks: CCM

Scaling Community Cellular Networks
with CommunityCellularManager

Shaddi Hasan, *UC Berkeley;* Mary Claire Barela, *University of the Philippines, Diliman;*
Matthew Johnson, *University of Washington;* Eric Brewer, *UC Berkeley;*
Kurtis Heimerl, *University of Washington*

https://www.usenix.org/conference/nsdi19/presentation/hasan

This paper is included in the Proceedings of the
16th USENIX Symposium on Networked Systems
Design and Implementation (NSDI '19).

February 26–28, 2019 • Boston, MA, USA

ISBN 978-1-931971-49-2

Open access to the Proceedings of the
16th USENIX Symposium on Networked Systems
Design and Implementation (NSDI '19)
is sponsored by

NetApp

Globe

- Spectrum

- Phone numbers

- Deployment

**University of
the Philippines**

- Deployment

- Support

This is still a top down approach!

Scaling Community Cellular Networks
with CommunityCellularManager

Shaddi Hasan, *UC Berkeley*; Mary Claire Barela, *University of the Philippines, Diliman*;
Matthew Johnson, *University of Washington*; Eric Brewer, *UC Berkeley*;
Kurtis Heimerl, *University of Washington*

https://www.usenix.org/conference/nsdi19/presentation/hasan

This paper is included in the Proceedings of the
16th USENIX Symposium on Networked Systems
Design and Implementation (NSDI '19).

February 26–28, 2019 • Boston, MA, USA

ISBN 978-1-931971-49-2

Open access to the Proceedings of the
16th USENIX Symposium on Networked Systems
Design and Implementation (NSDI '19)
is sponsored by

Globe ↔ **University of the Philippines**

- Spectrum

- Phone numbers

- Deployment

- Deployment

- Support

Decentralized networks are more successful when built bottom up!

Decentralized networks are more successful when built bottom up!

Decentralized networks are more successful when built bottom up!

Decentralized networks are more successful when built bottom up!

Decentralization lowers the costs of setting up networks

Effective Transmission Distance of 5G vs. 4G Spectrum

5G — **Effective Range** 1,000 ft. (0.19 miles)*

4G — **Effective Range** 50,000 ft (9.47 miles)*

5G — **5G** in the United States leverages millimeter wave (mmWave) technology, allowing for much faster transmission but at much shortage distances.

4G — Most **4G** traffic operates on 700 MHz spectrum, giving long-range and building-penetrating capabilities to transmitted signals.

Devices Supported Per Square Mile

4G 6,500 DEVICES

5G 1 MILLION DEVICES

*Range can be degraded by buildings, weather and other environment aspects.

GOVERNING.COM

Trust-free billing and accounting are vital to decentralization

Anybody can serve

Anybody can receive service

Trust-free billing and accounting are vital to decentralization
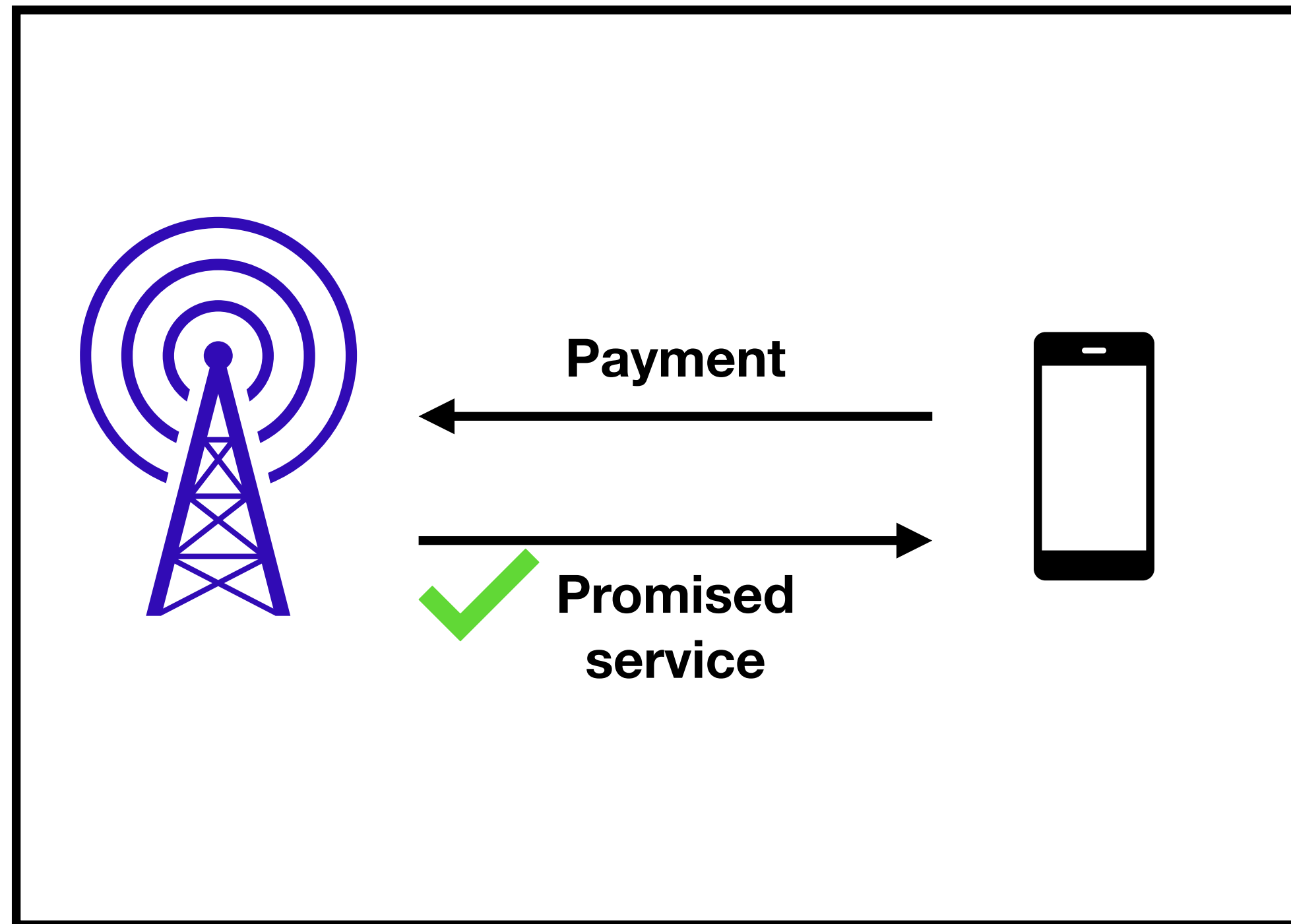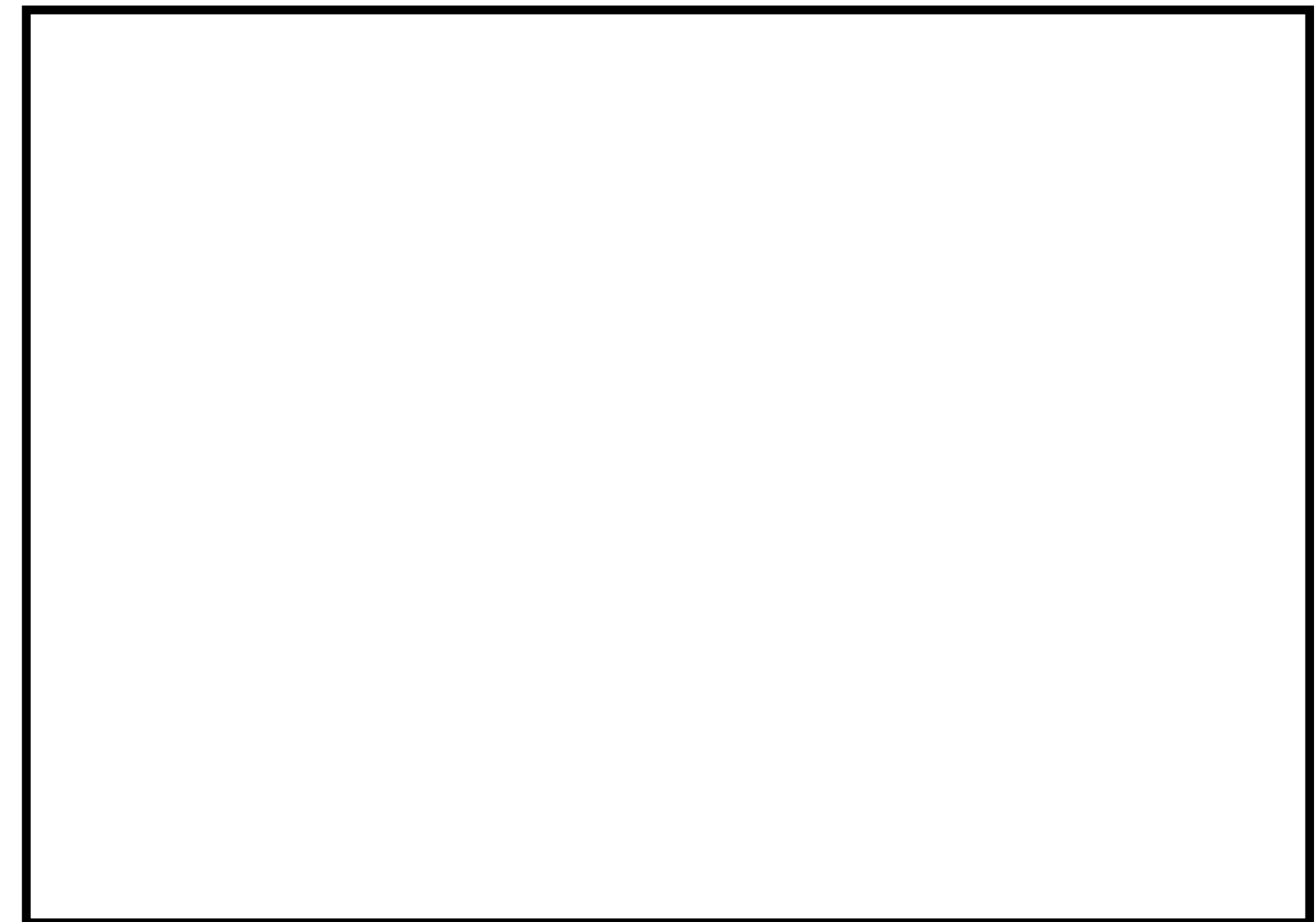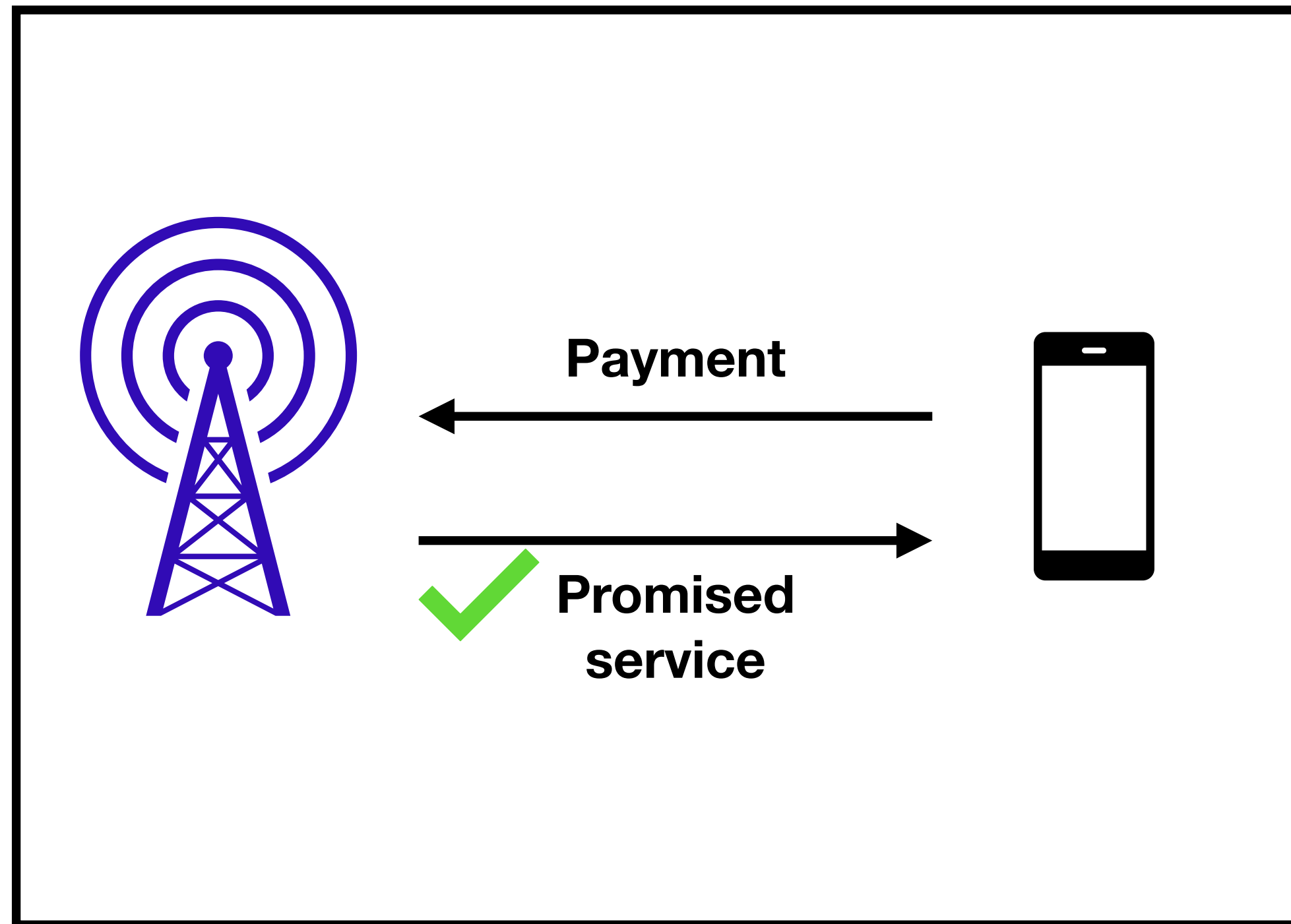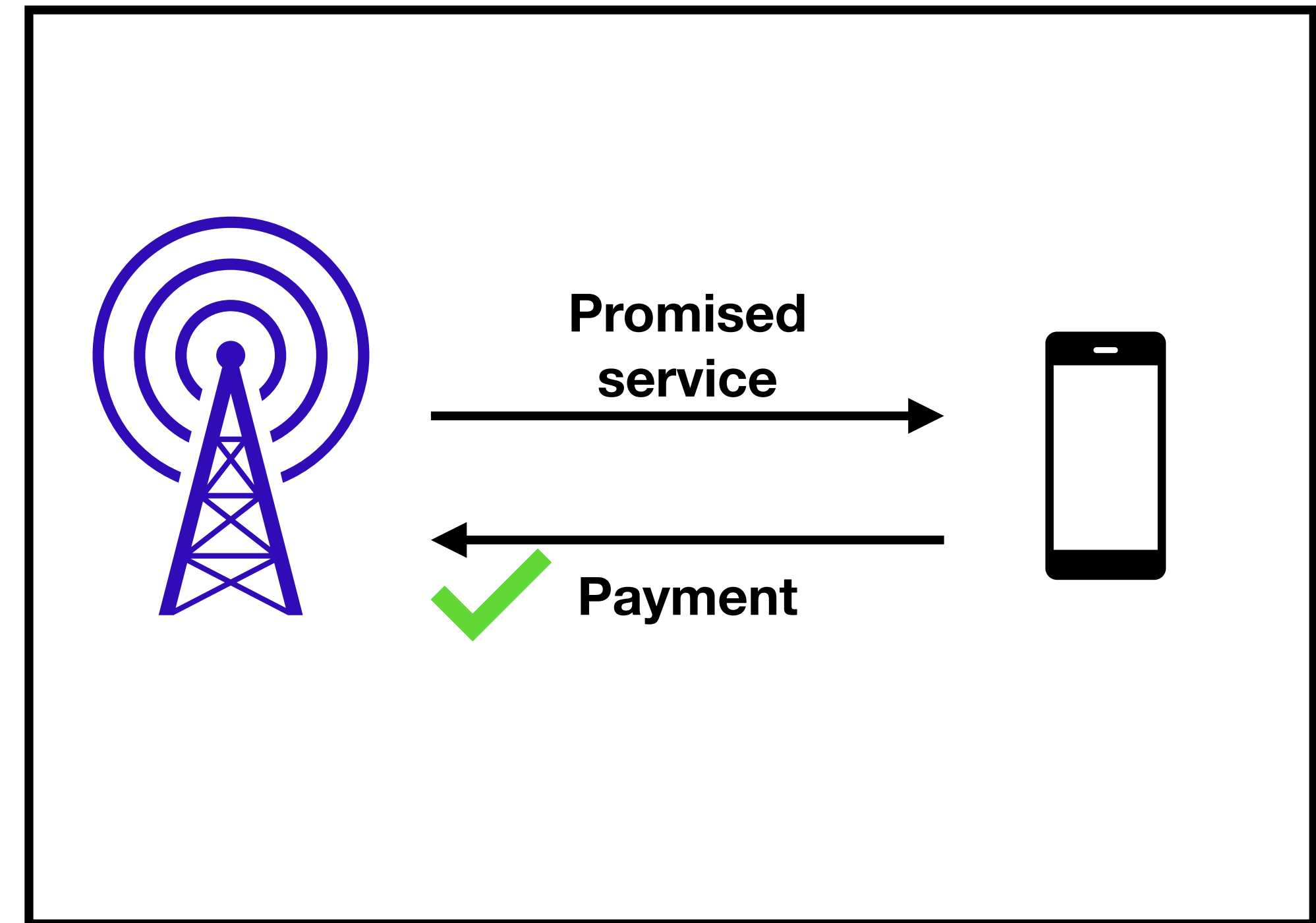
Anybody can serve

Payment

✓ Promised service
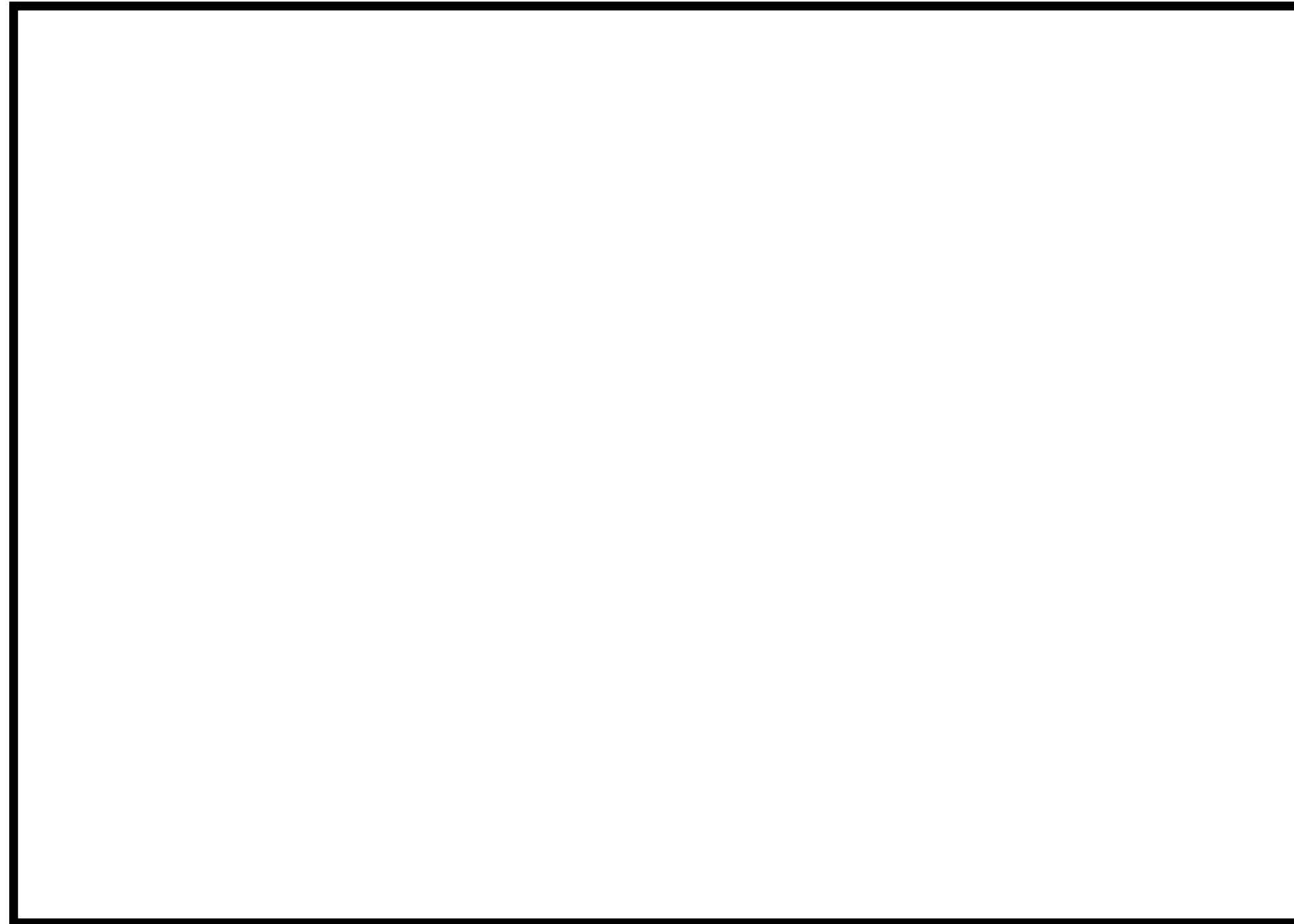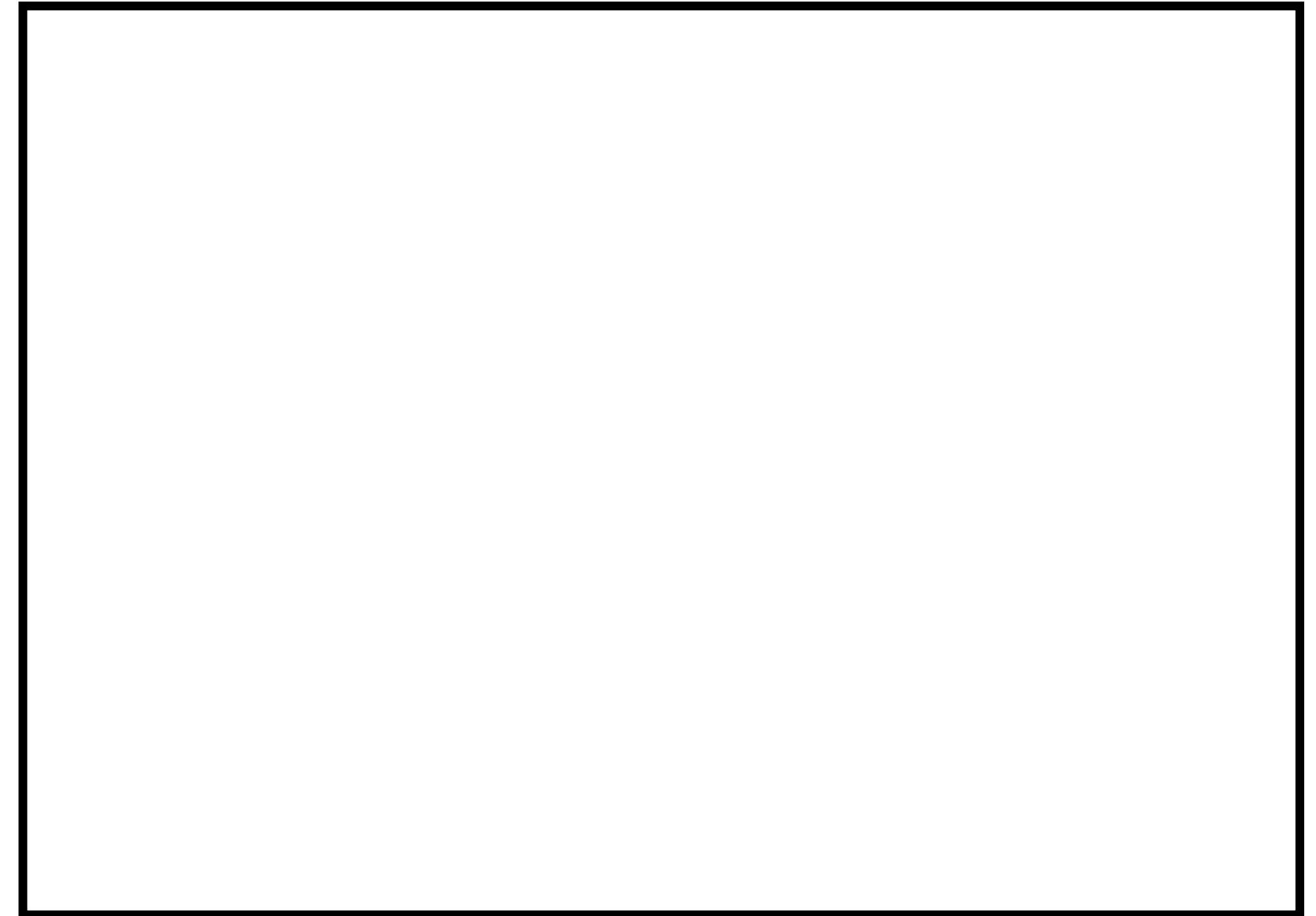
Anybody can receive service

Trust-free billing and accounting are vital to decentralization

Anybody can serve

**Anybody can receive service**

A truly decentralized network must rely on a technological solution for billing and accounting

- Design must ensure trustworthy service and reliable performance

- Design must make adversarial behavior unprofitable

A truly decentralized network must rely on a technological solution for billing and accounting

- Design must ensure trustworthy service and reliable performance

- Design must make adversarial behavior unprofitable

Proof of Service: ensuring trustworthy service and reliable performance
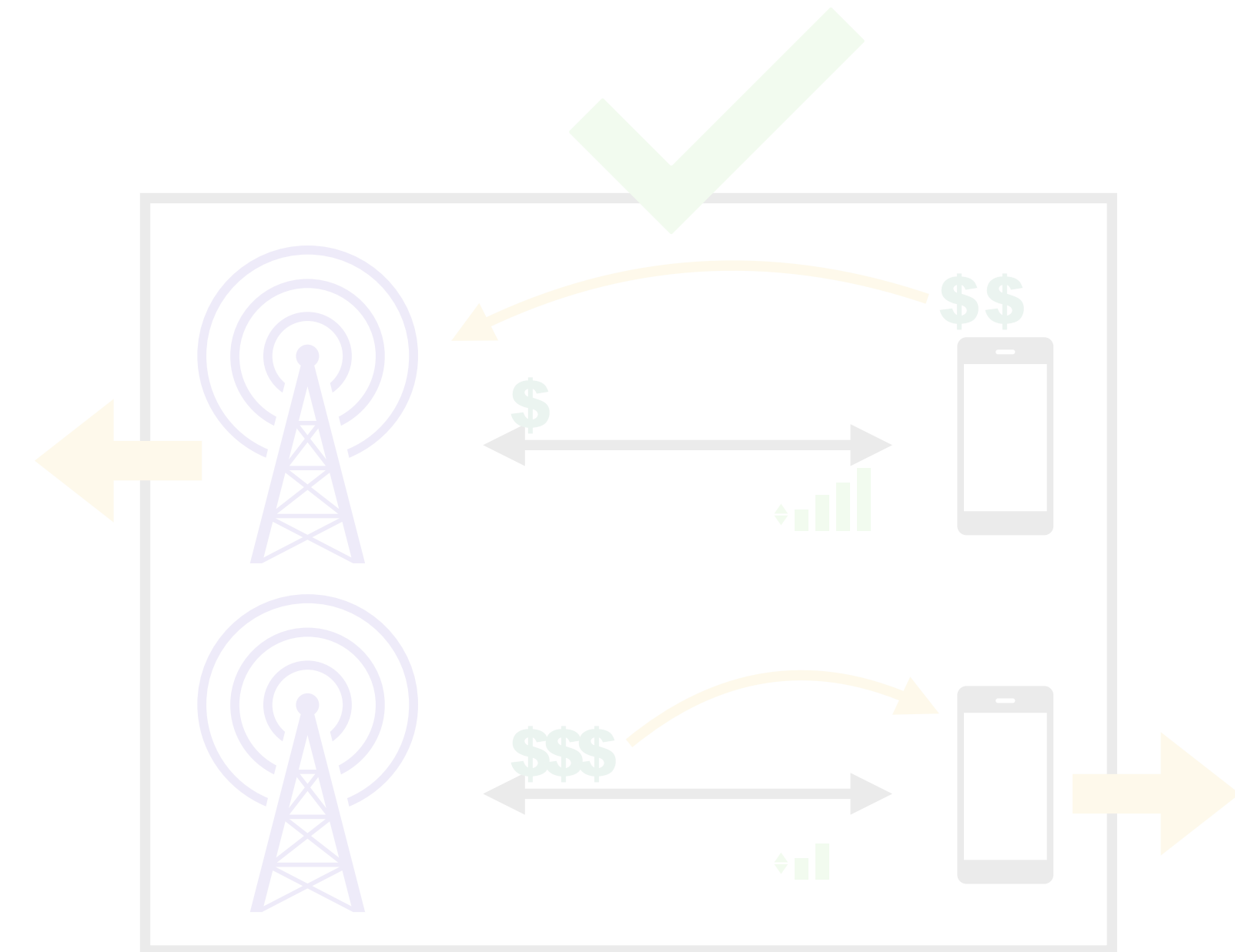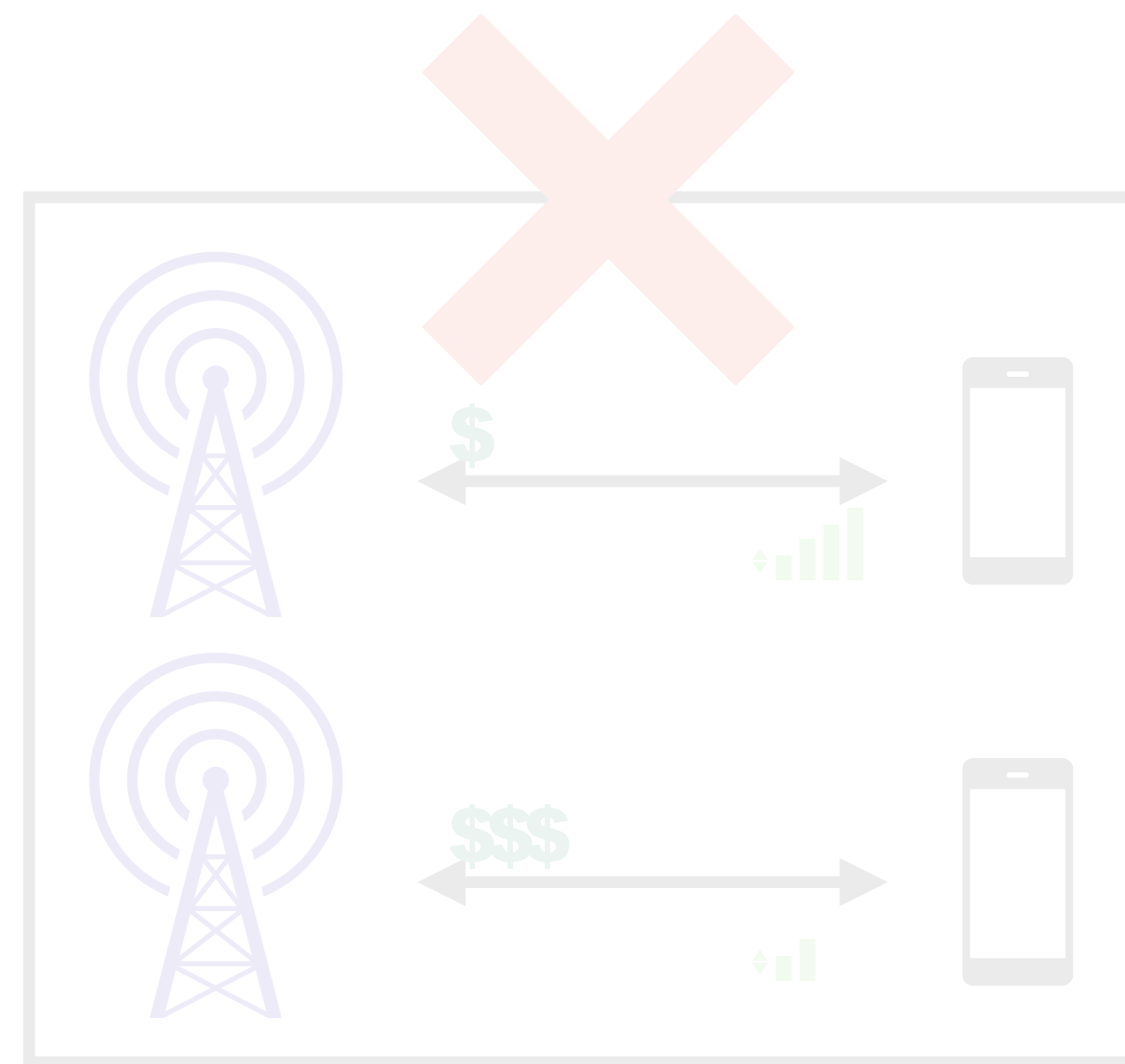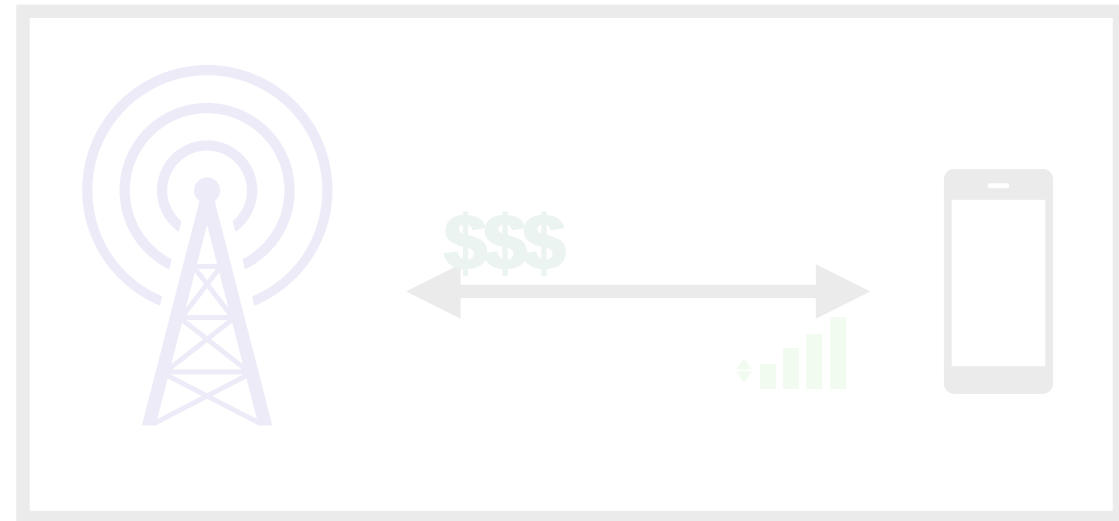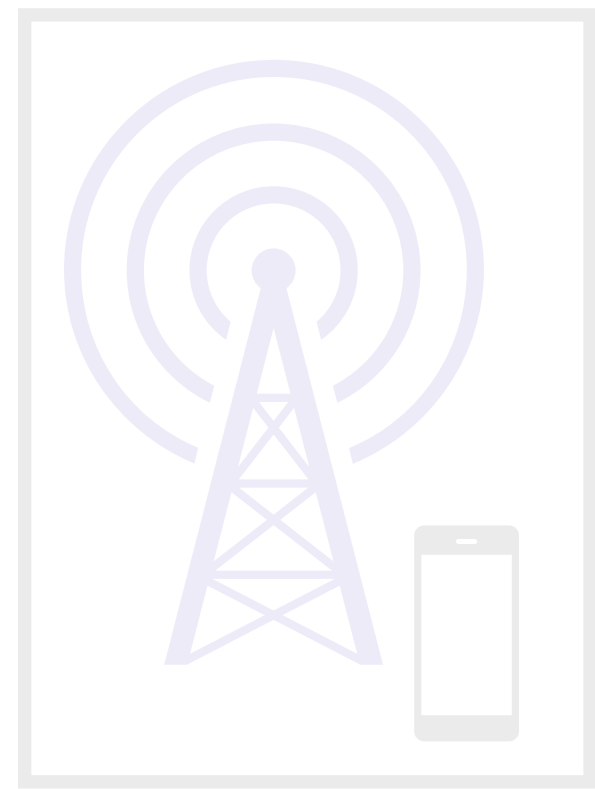
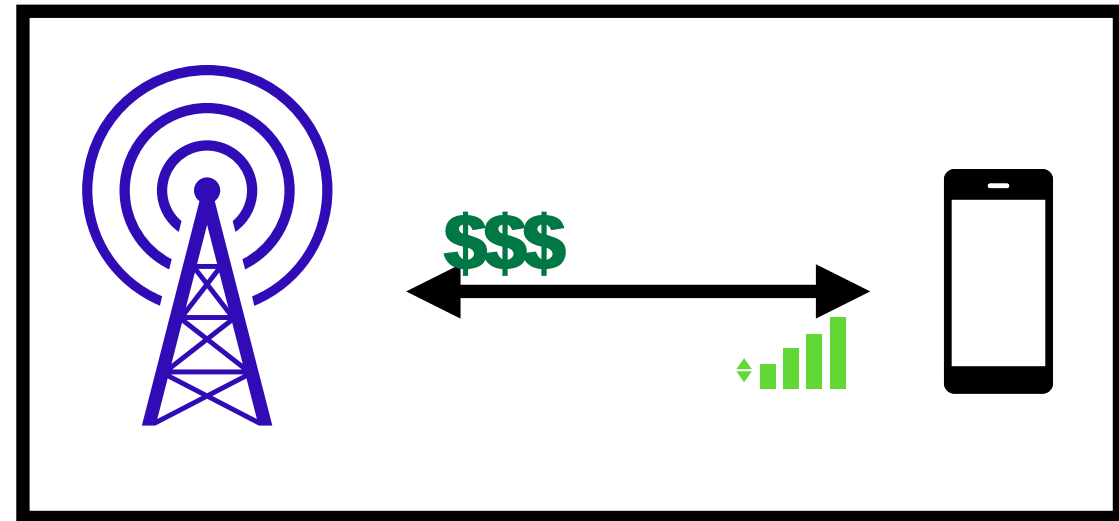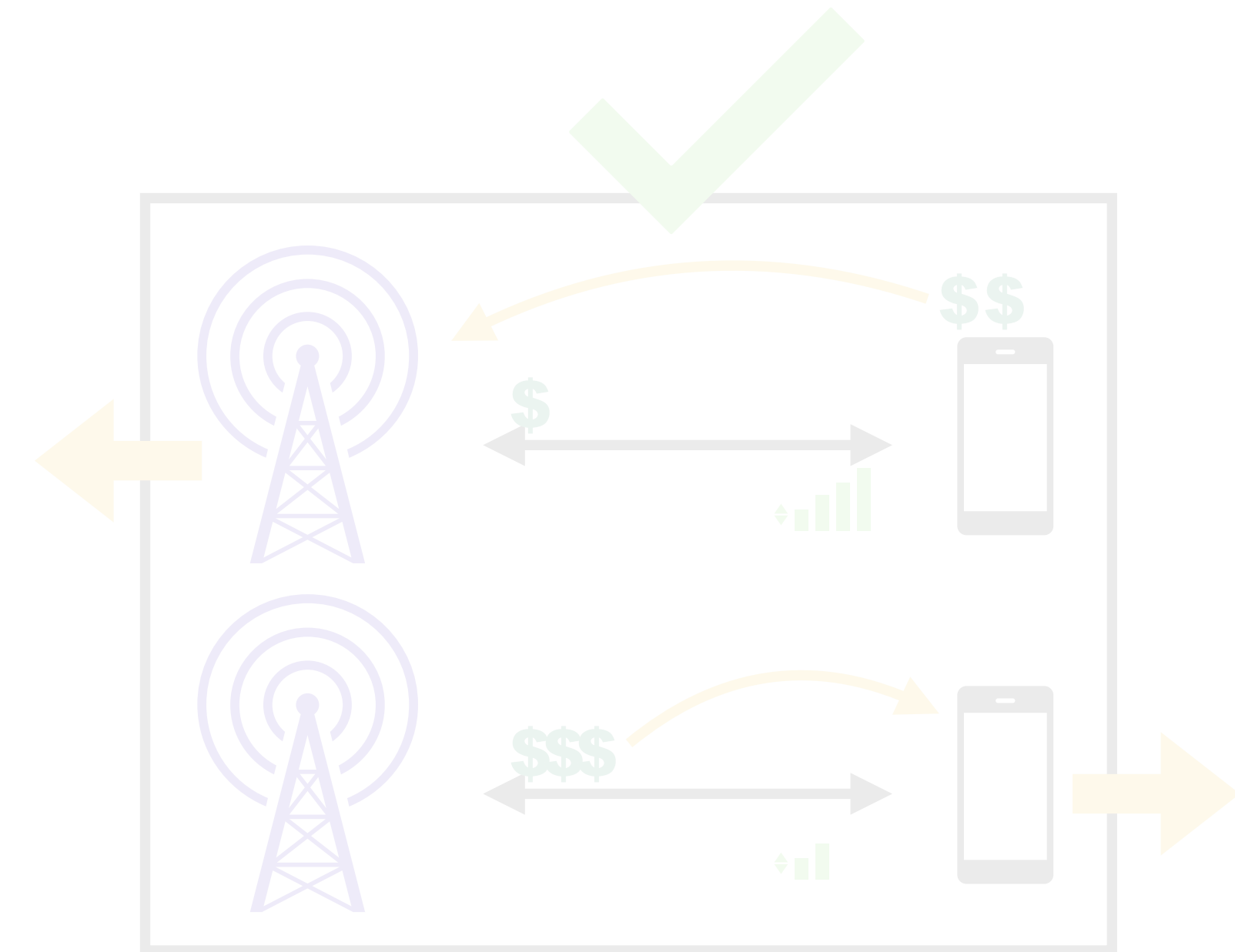# Proof of Service: ensuring trustworthy service and reliable performance
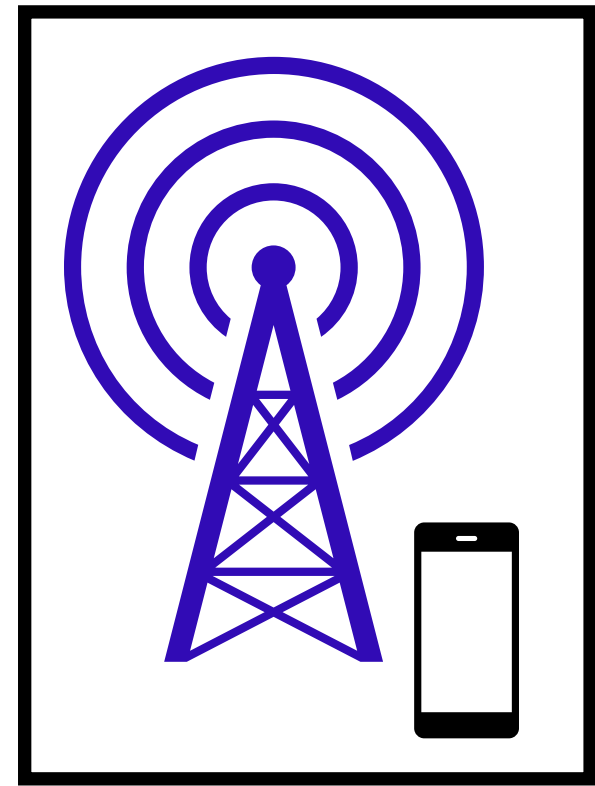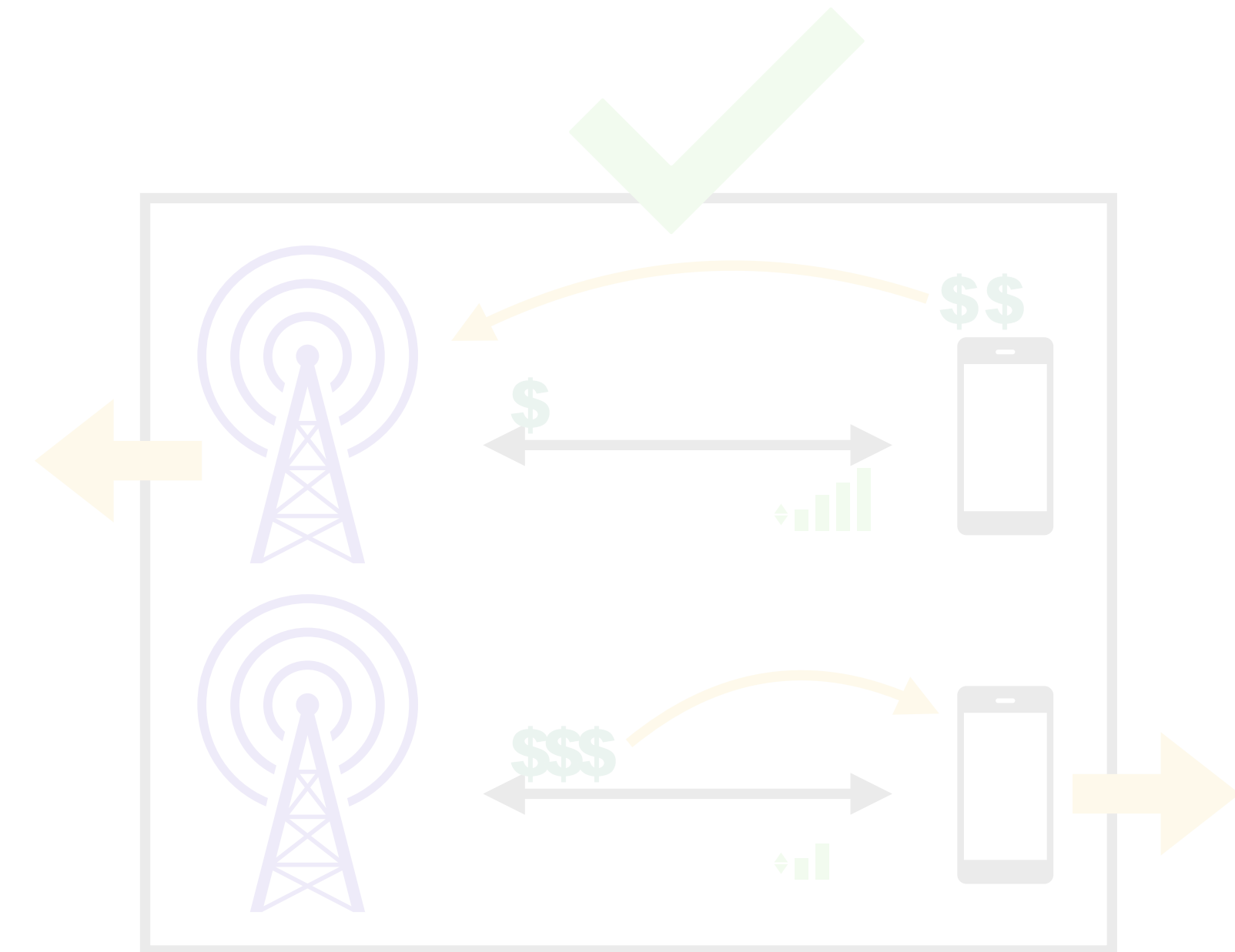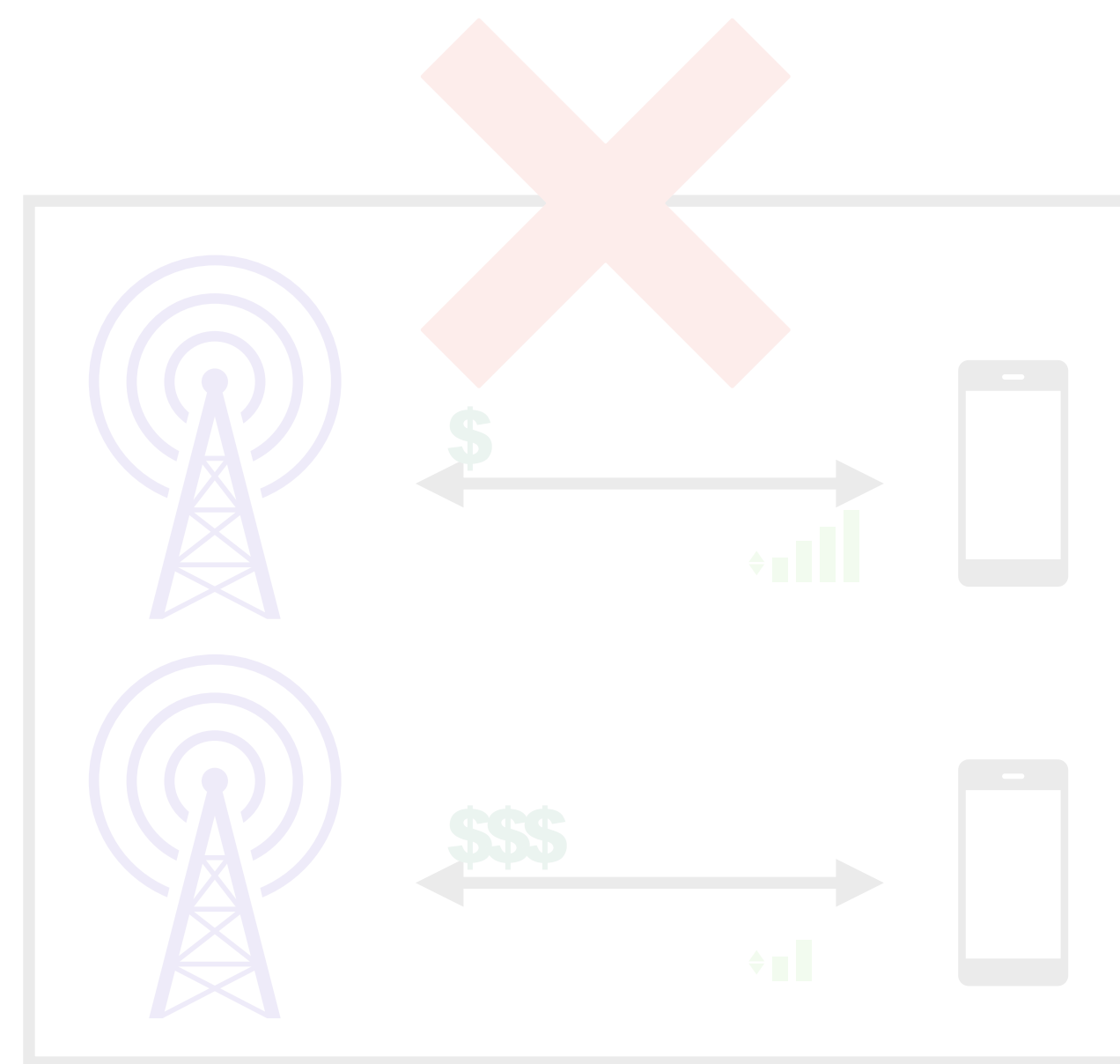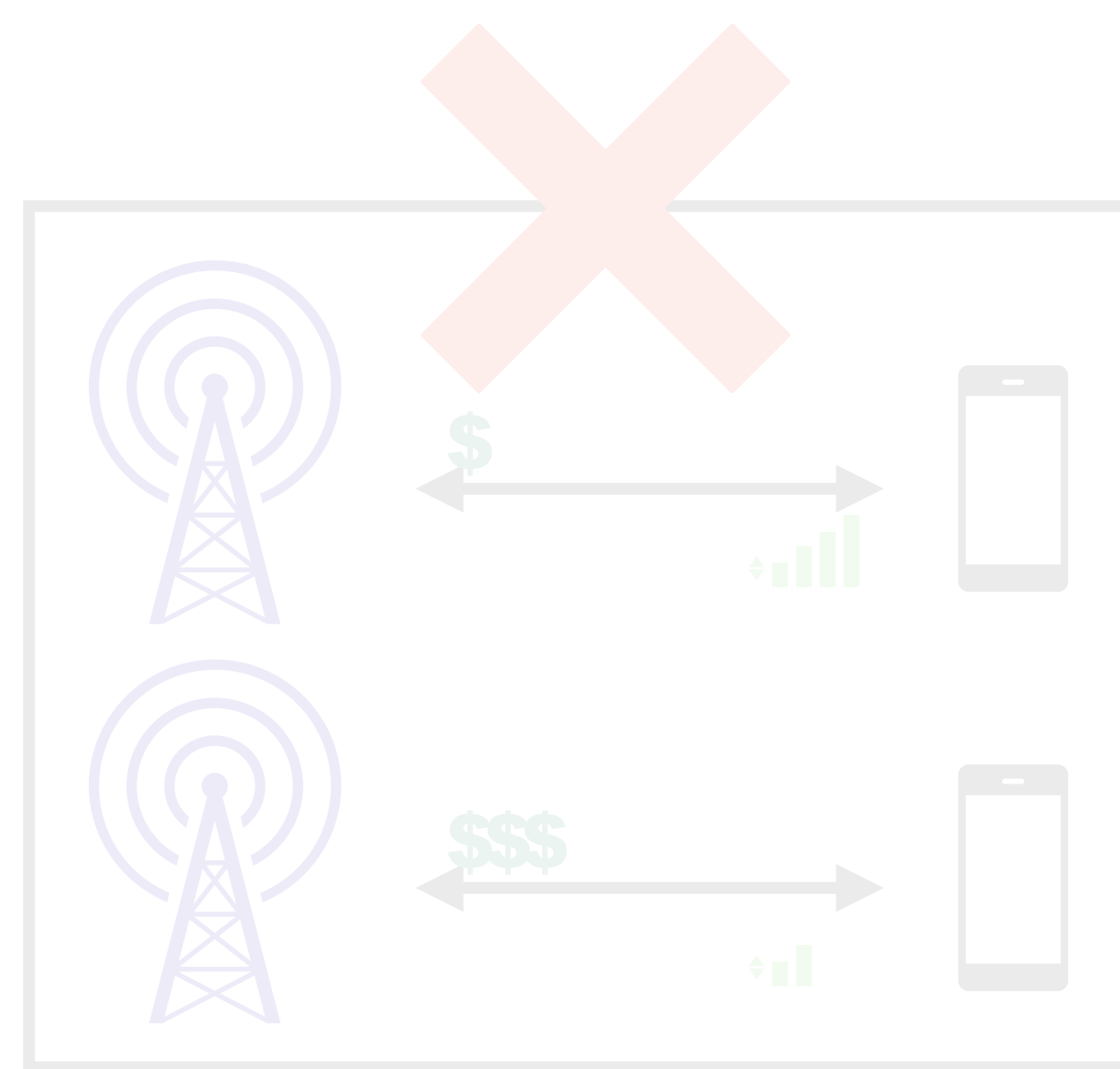

Flexible Stack

Proof of Service: ensuring trustworthy service and reliable performance
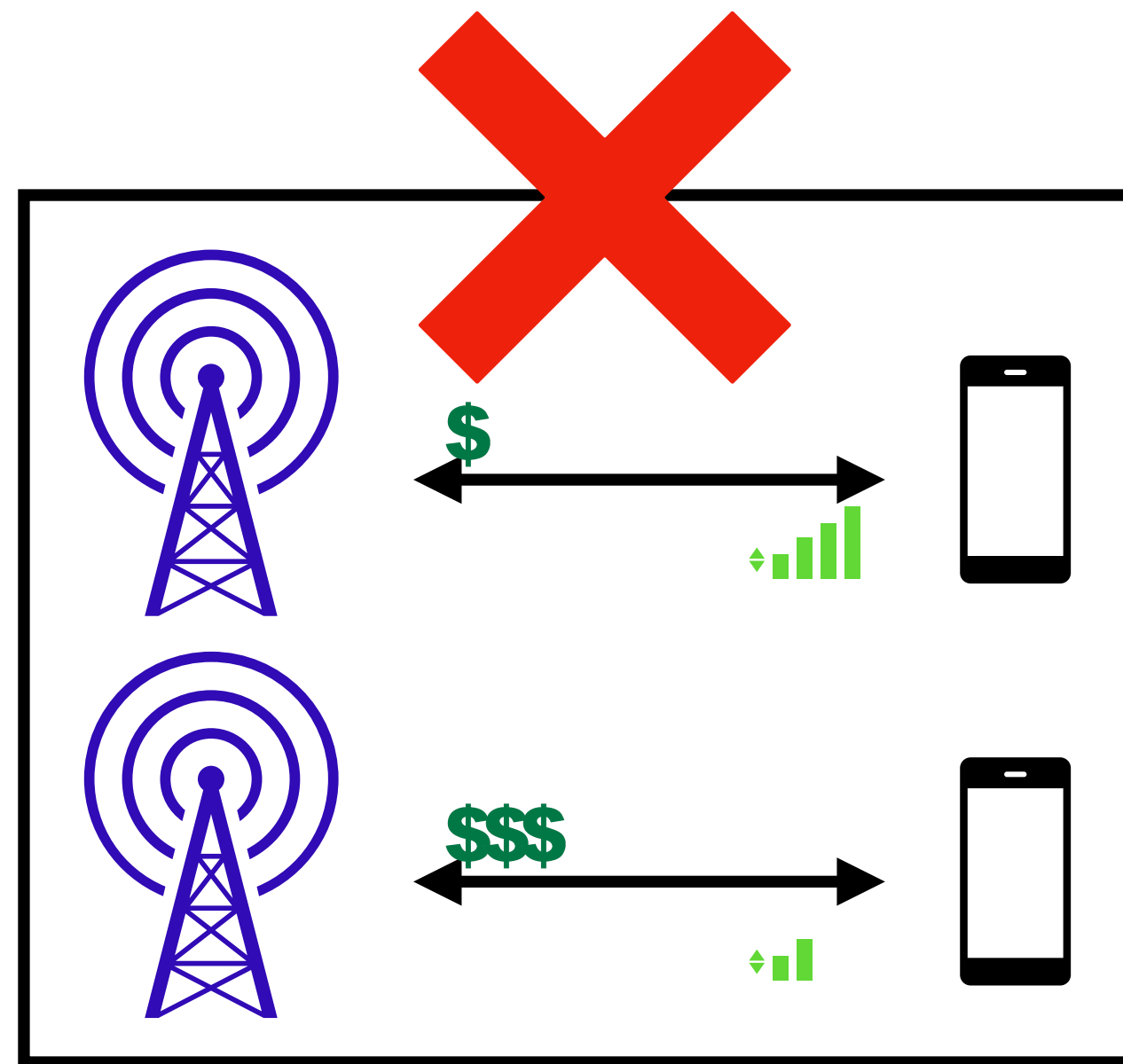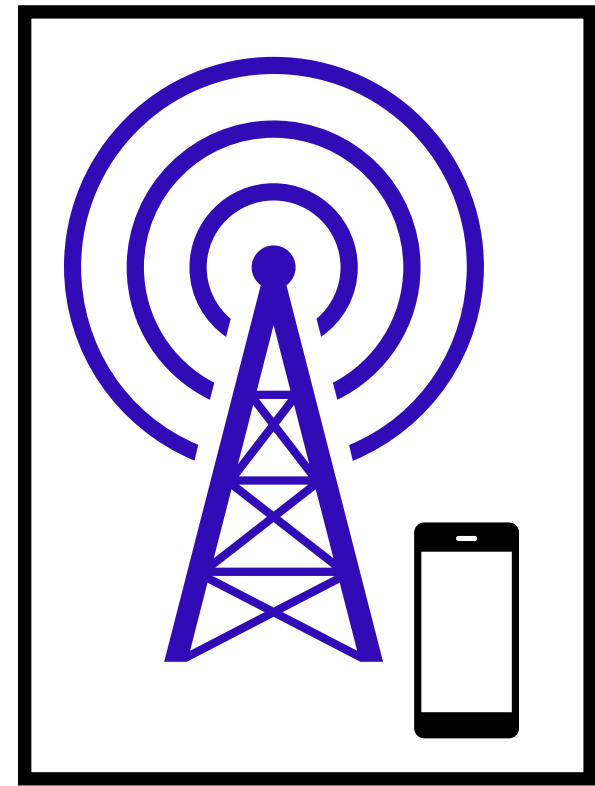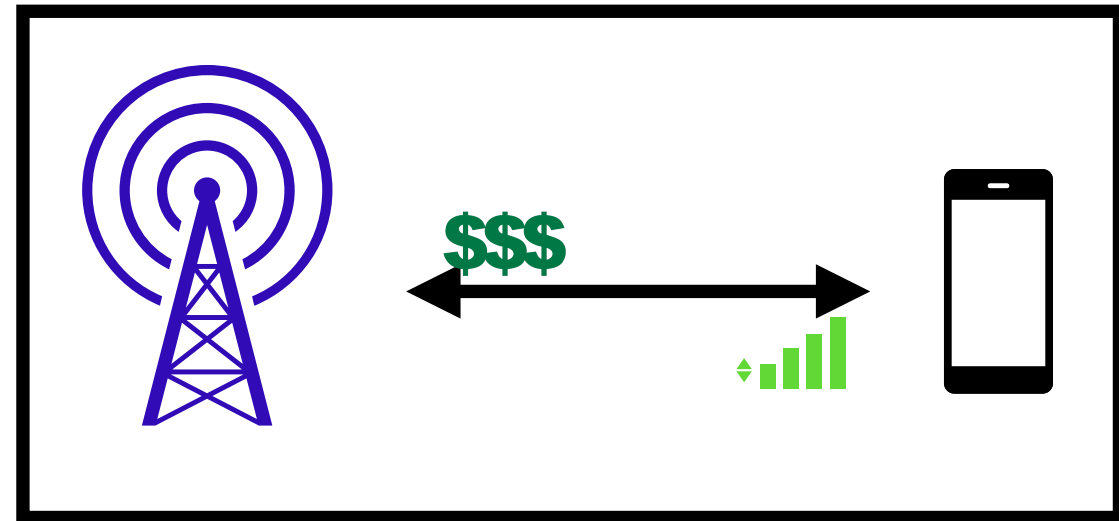

Flexible Stack

Payment ≡ Service

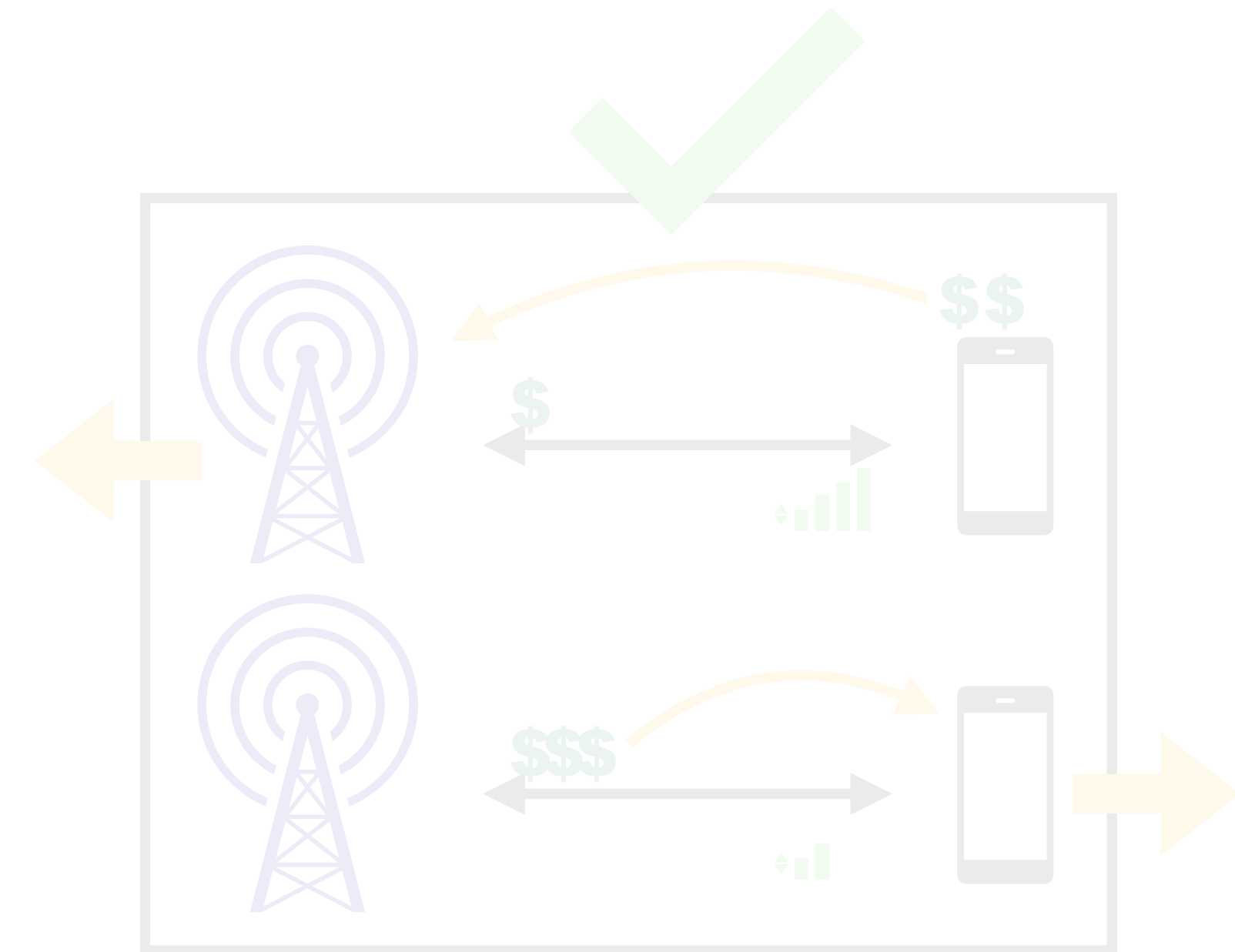# Proof of Service: ensuring trustworthy service and reliable performance

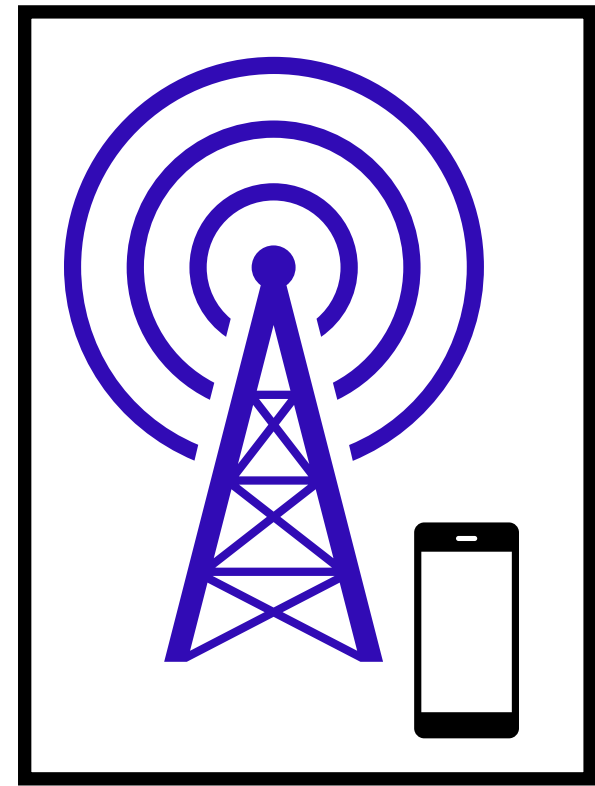**Flexible Stack**
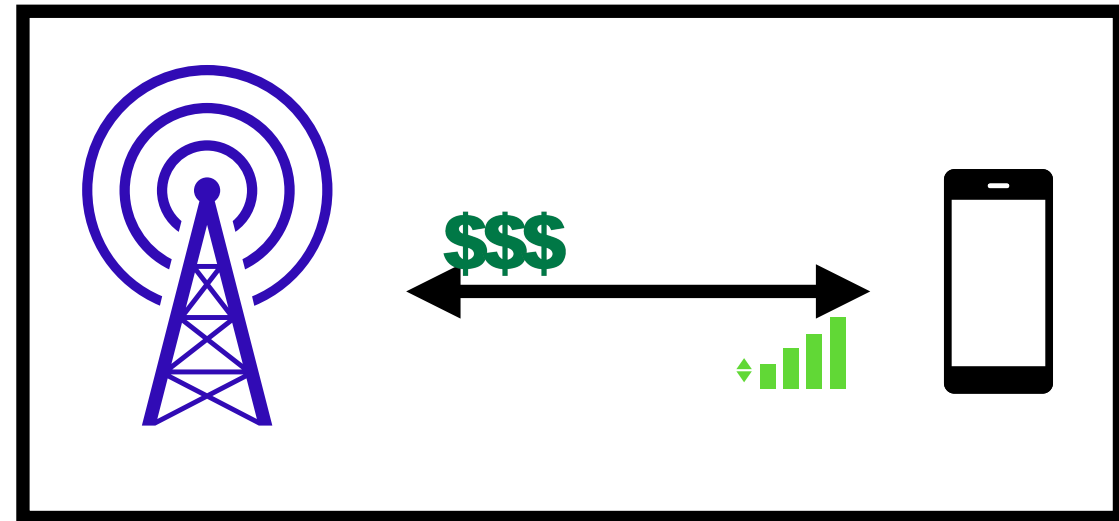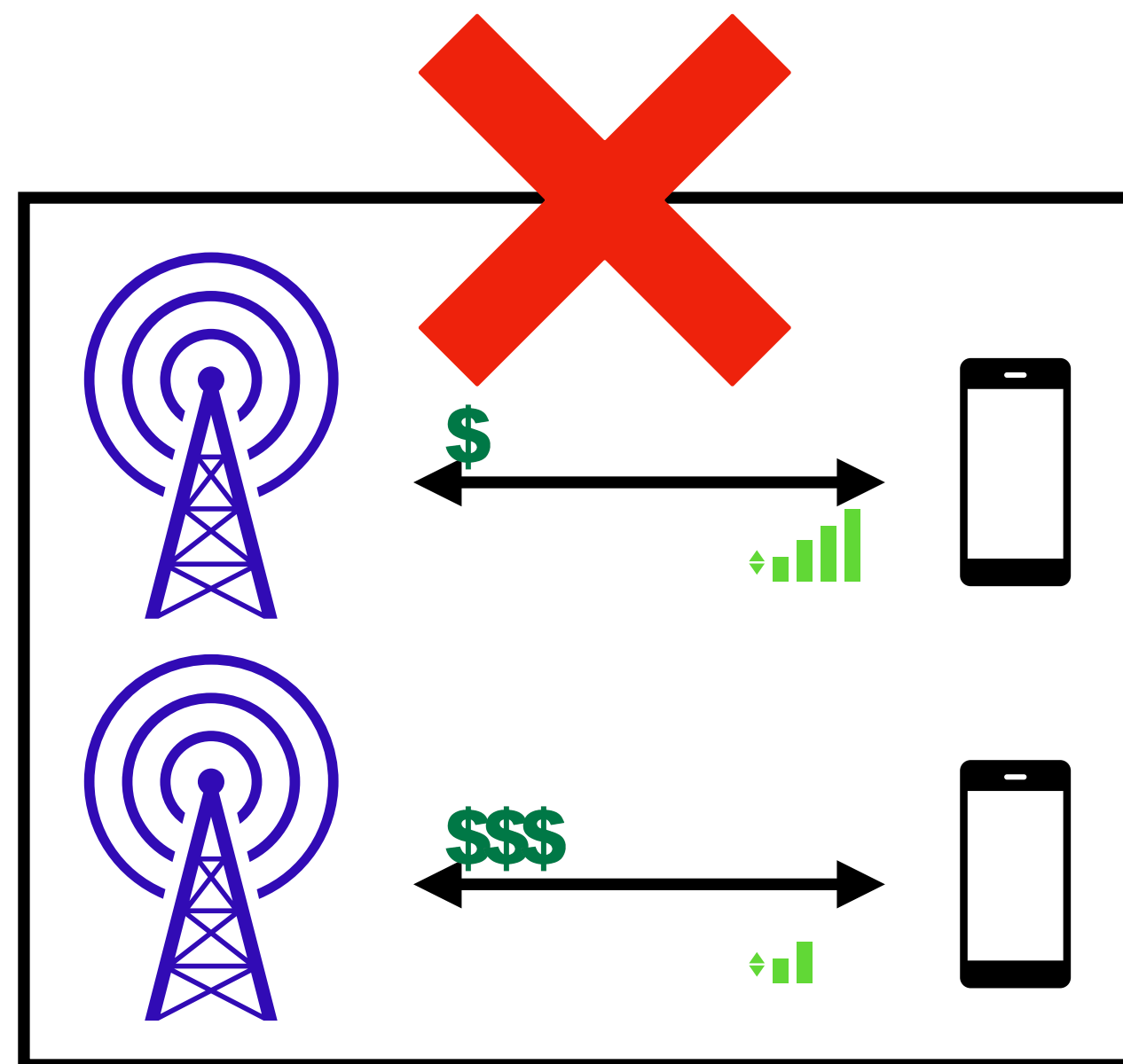
Payment ≡ Service

Infrequent disputes

Proof of Service: ensuring trustworthy service and reliable performance

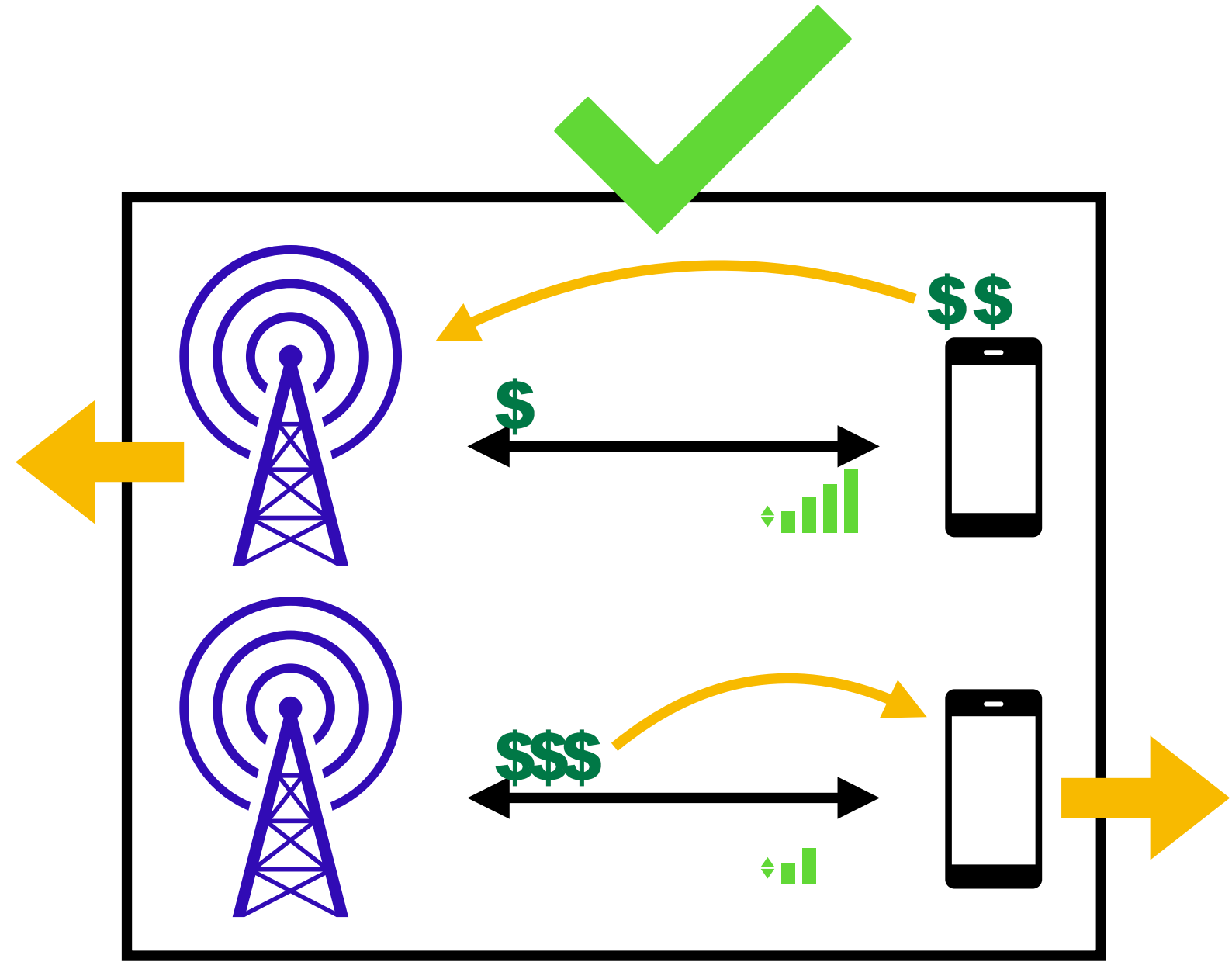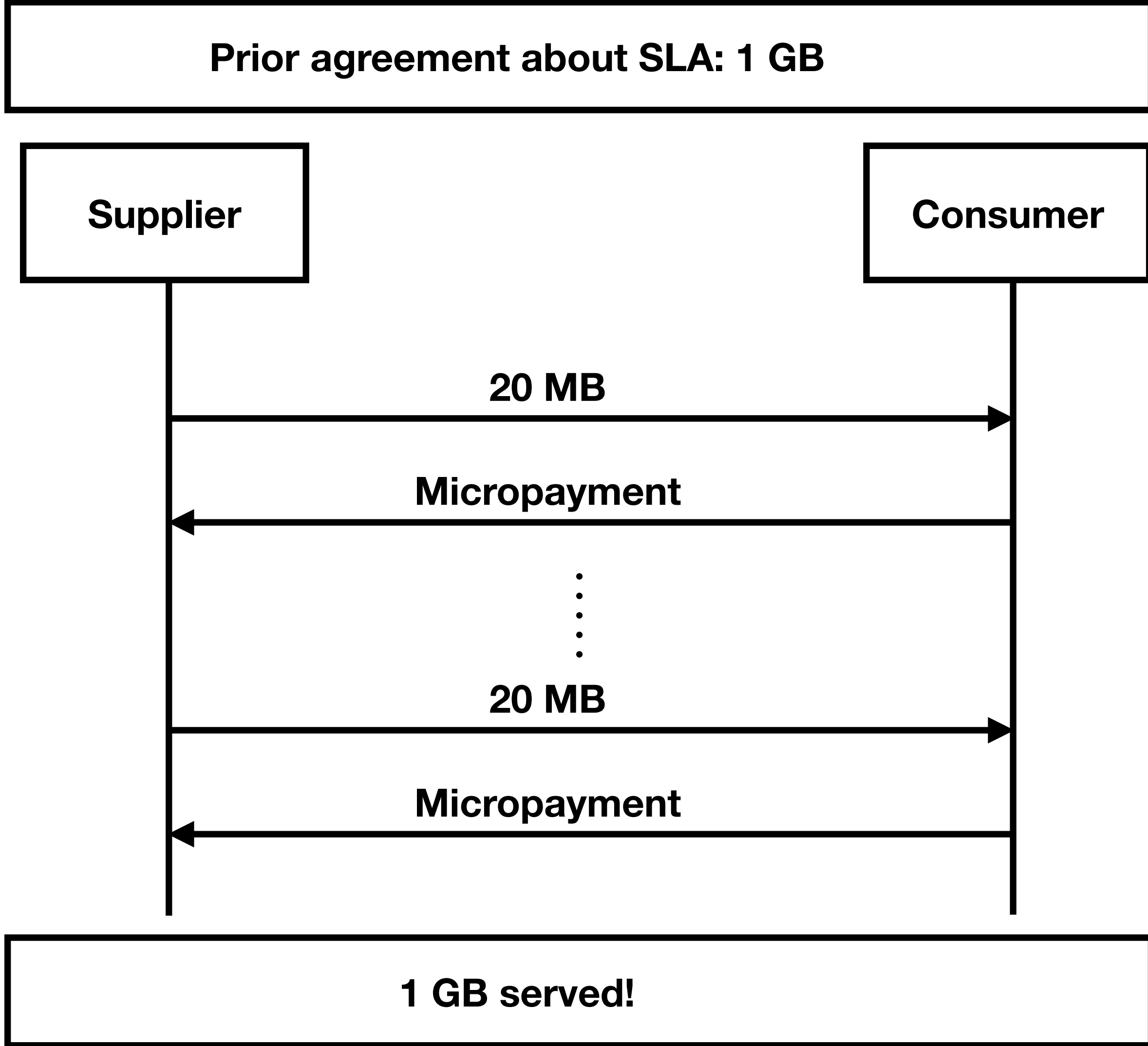**Flexible Stack**

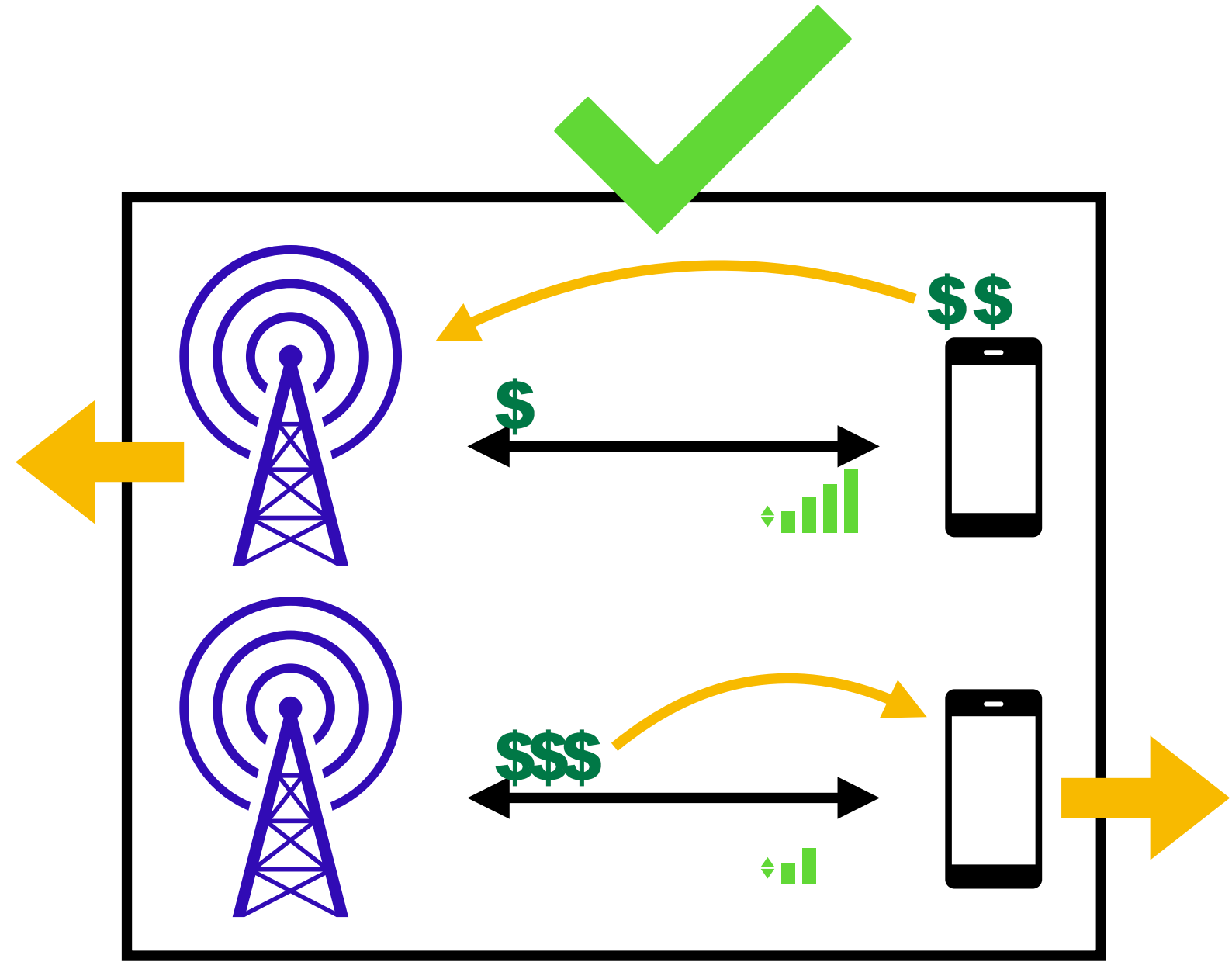**Payment ≡ Service**
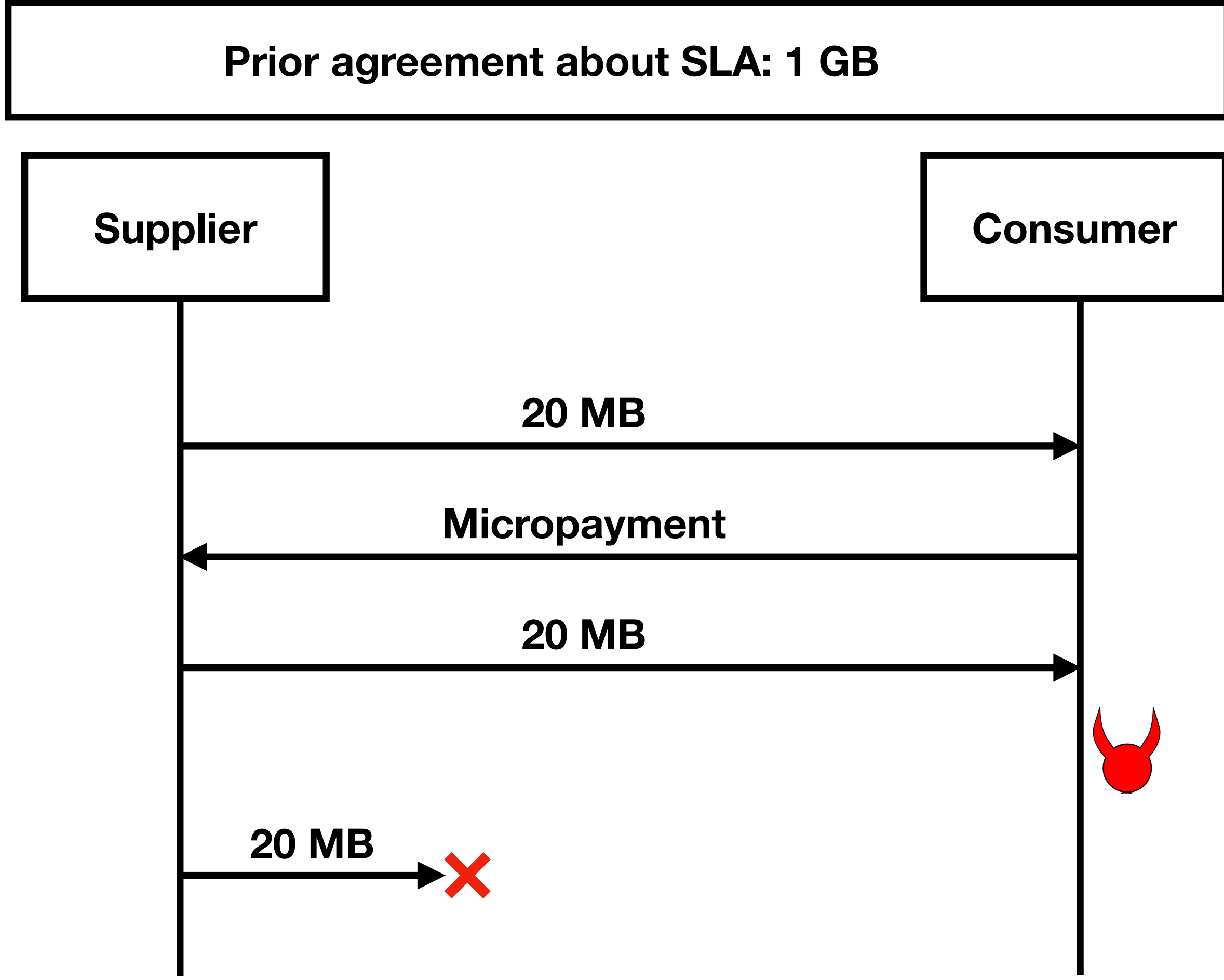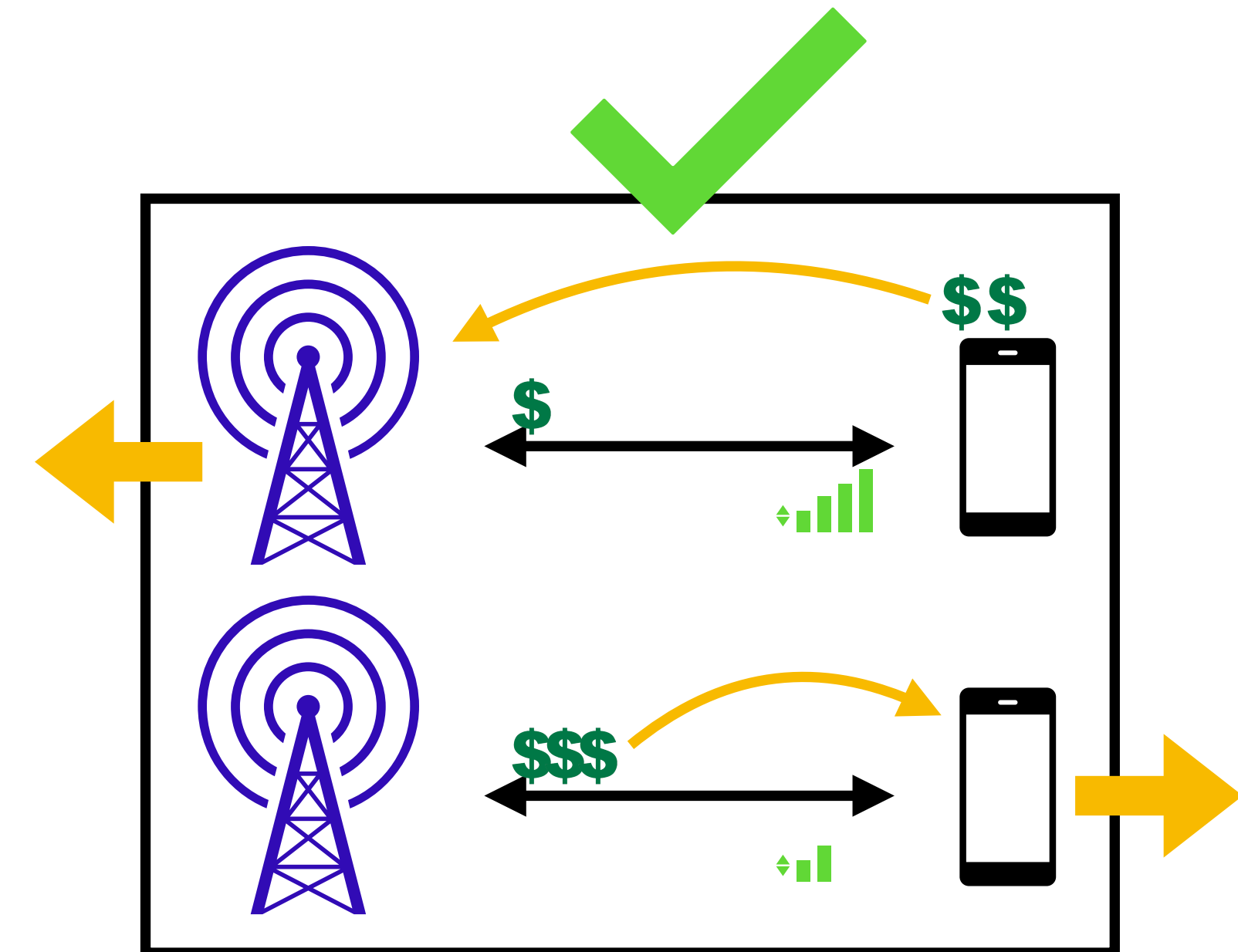
Infrequent disputes
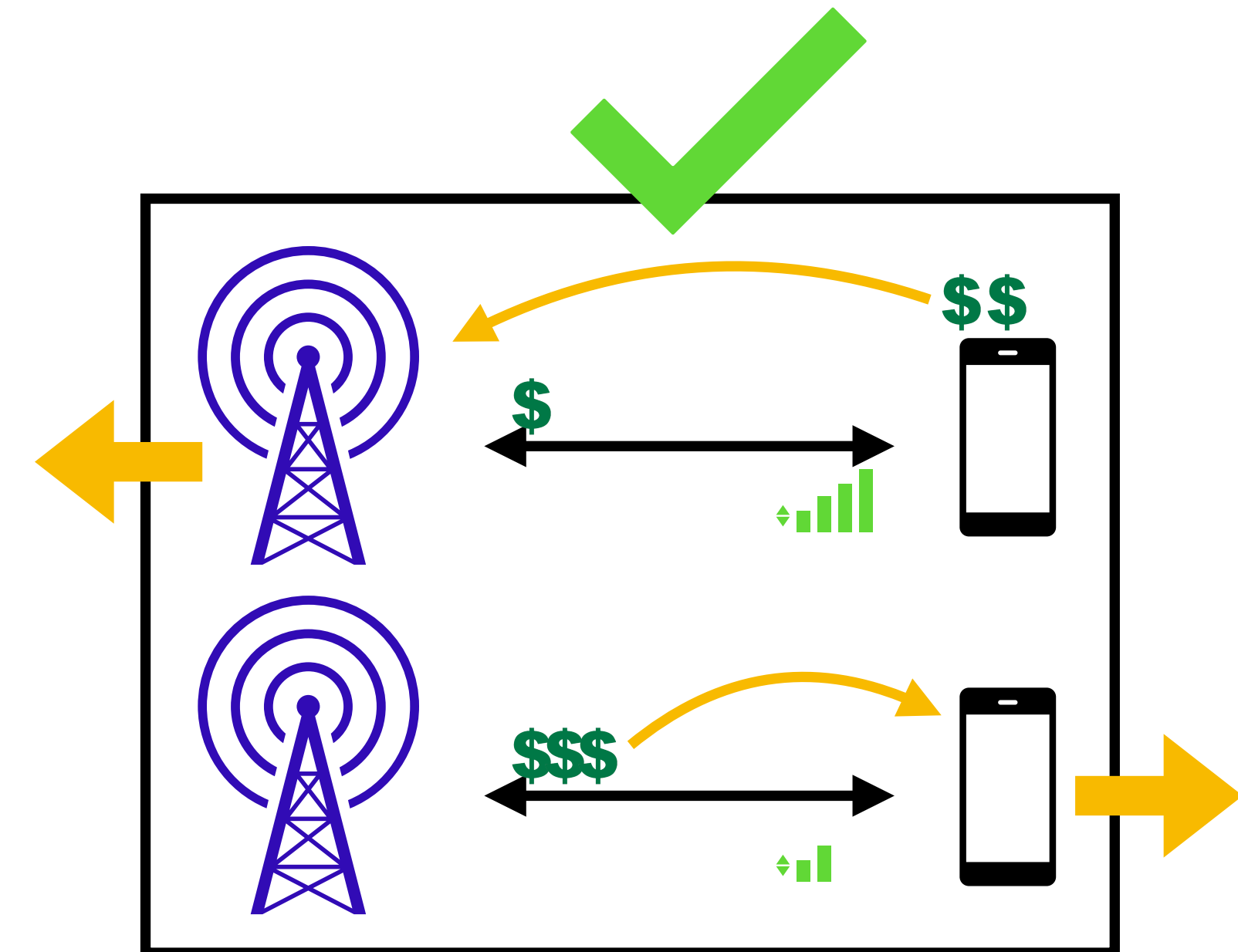
Speedy response to disputes
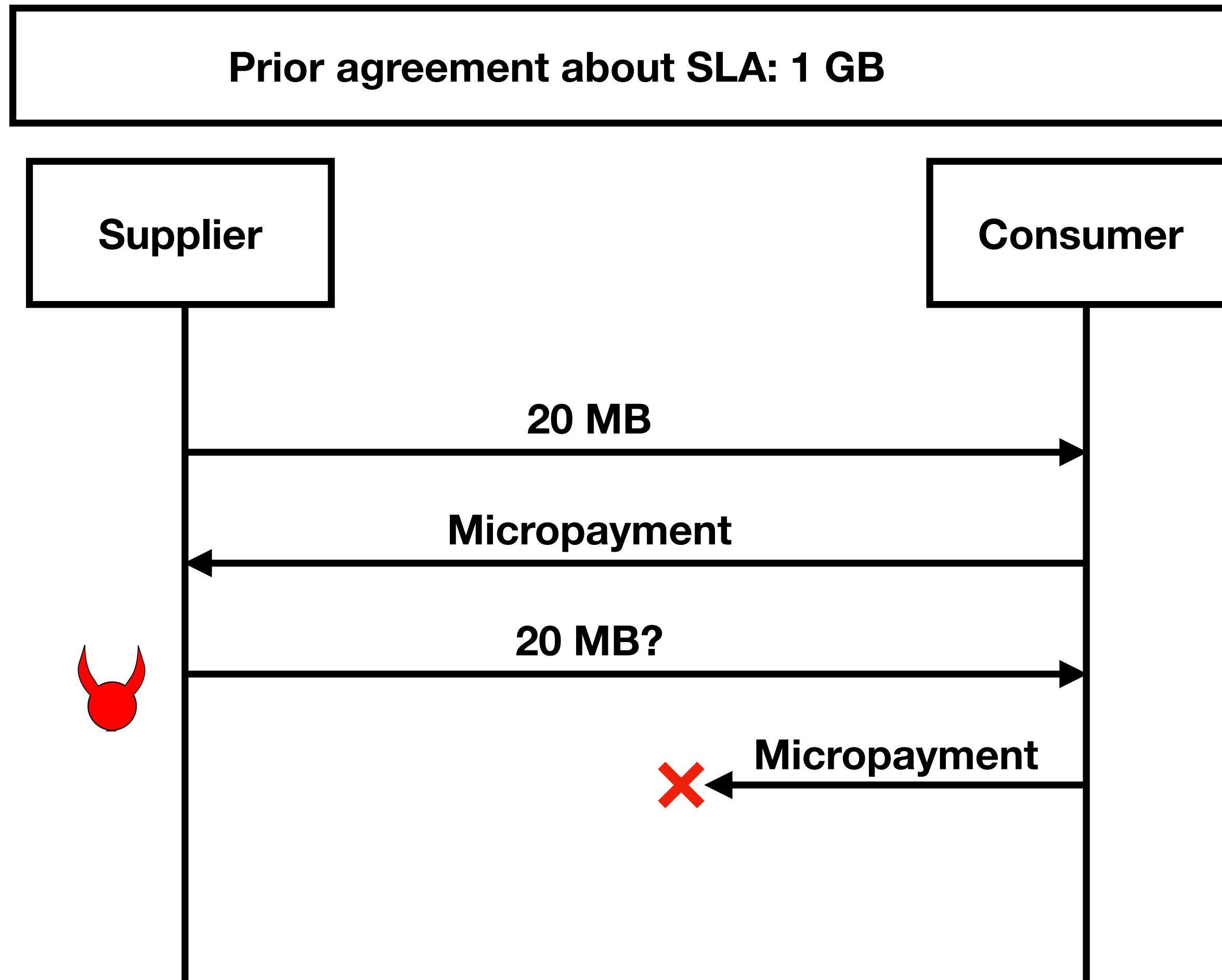
Incremental SLAs ensure the system is trust-free

Incremental SLAs ensure the system is trust-free

Prior agreement about SLA: 1 GB

Supplier	Consumer

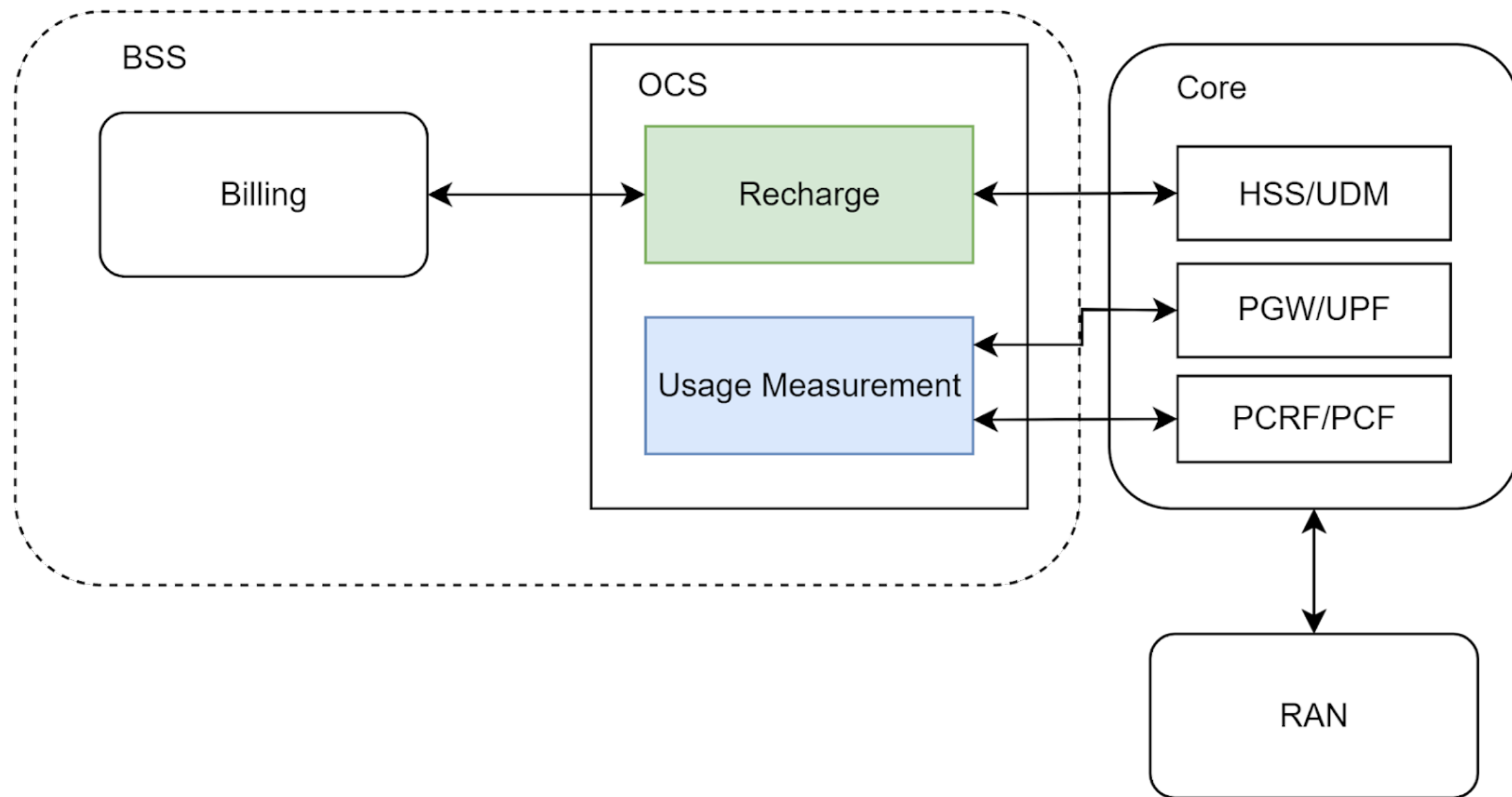20 MB

Micropayment

20 MB

20 MB

Incremental SLAs ensure the system is trust-free

Proof of Service refactors the OCS

Traditional Centralized Carrier
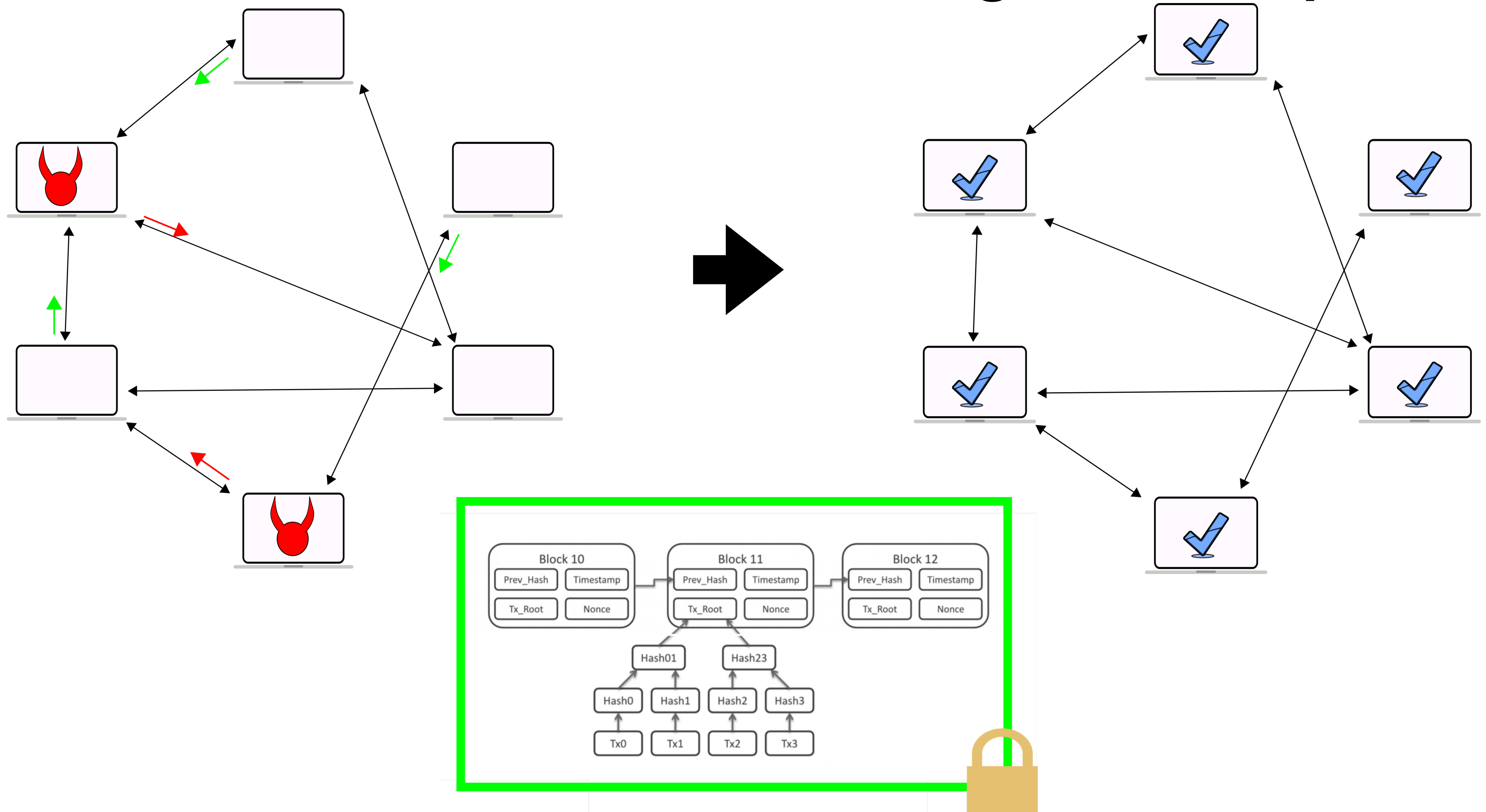
Proof of Service refactors the OCS

Upfront payment!

Traditional Centralized Carrier

BSS
- Billing

OCS
- Recharge
- Usage Measurement

Core
- HSS/UDM
- PGW/UPF
- PCRF/PCF

RAN

Proof of Service refactors the OCS

Traditional Centralized Carrier

Upfront payment!

BSS
- Billing

OCS
- Recharge
- Usage Measurement

Core
- HSS/UDM
- PGW/UPF
- PCRF/PCF

RAN

Trustfree Transaction Layer for NH

BSS

Smart Contract
- Escrow (Recharge)

HSS/UDM

State Channel
- Usage Measurement

Verification by Home Network (optional)

PGW/UPF

PCRF/PCF

RAN telemetry (optional)

RAN

Necessary primitives: a quick detour!

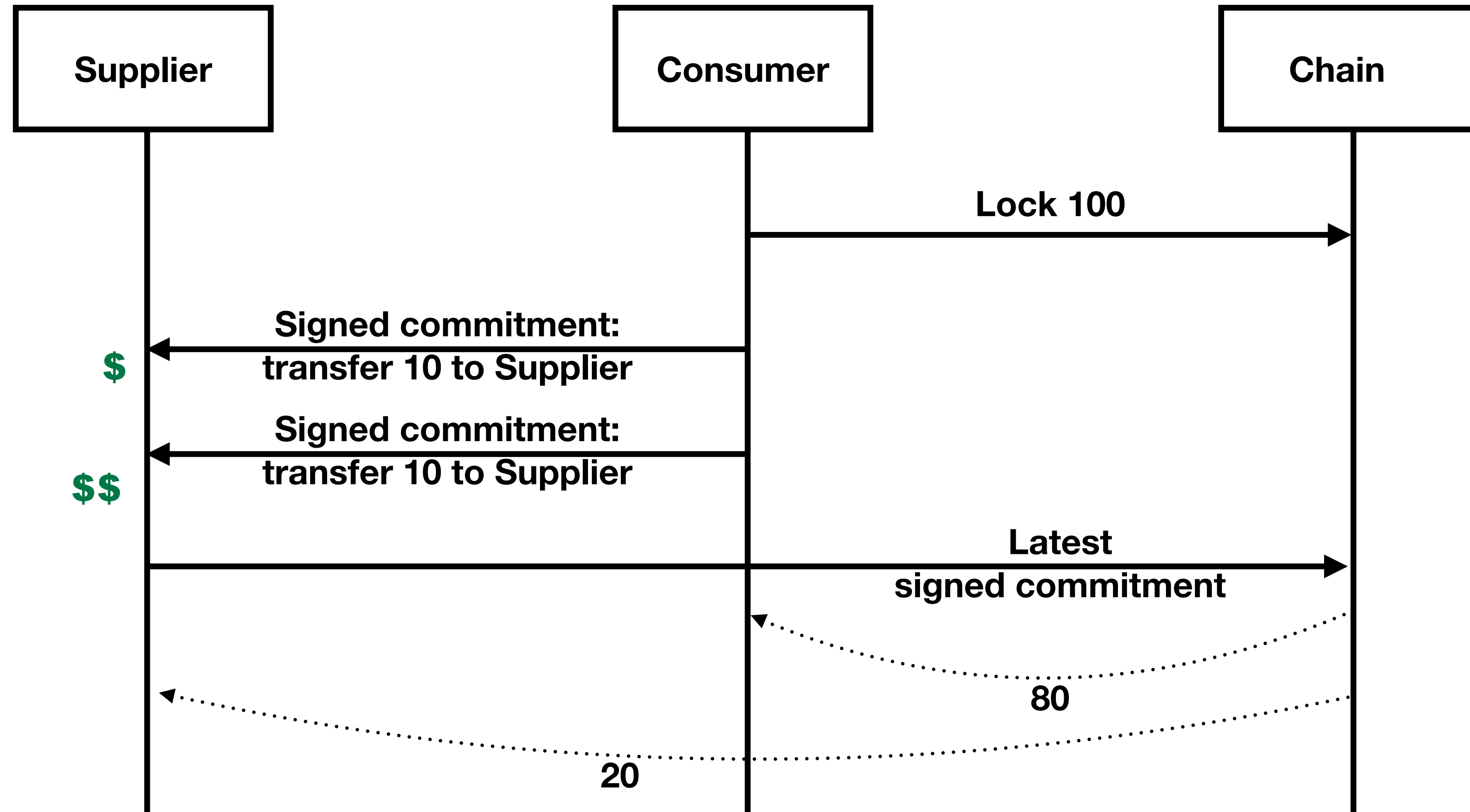# A blockchain is a decentralized digital trust platform

Smart contracts act as the escrow

- Code enforcing transaction when conditions are met
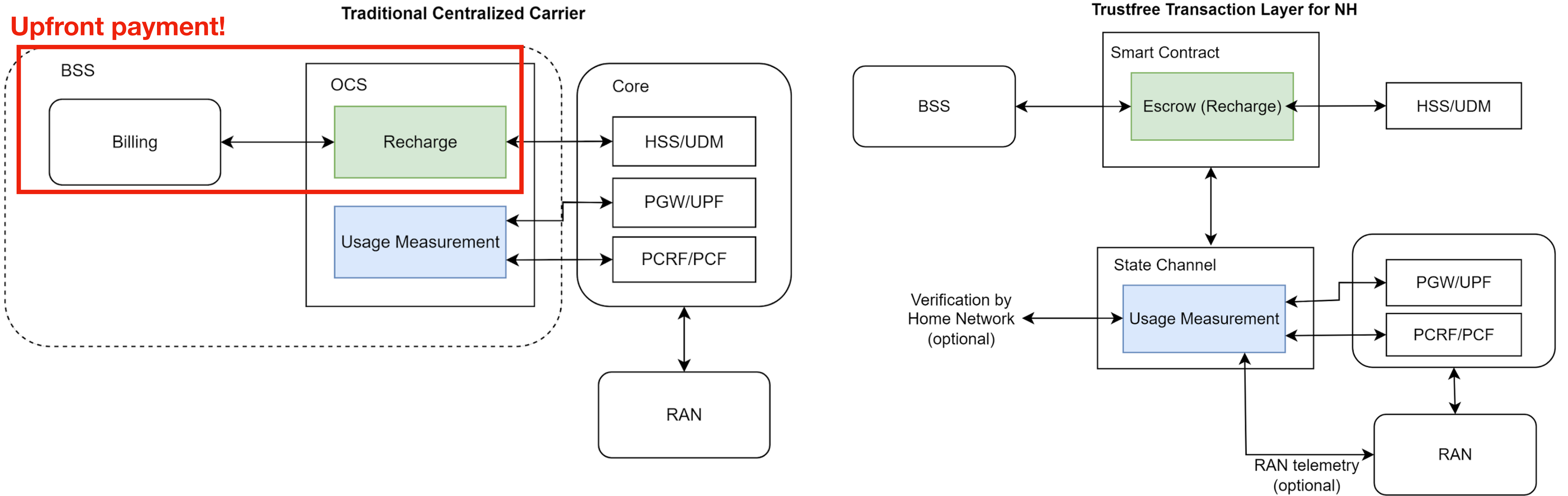
- Deployed on chain

- Code is law

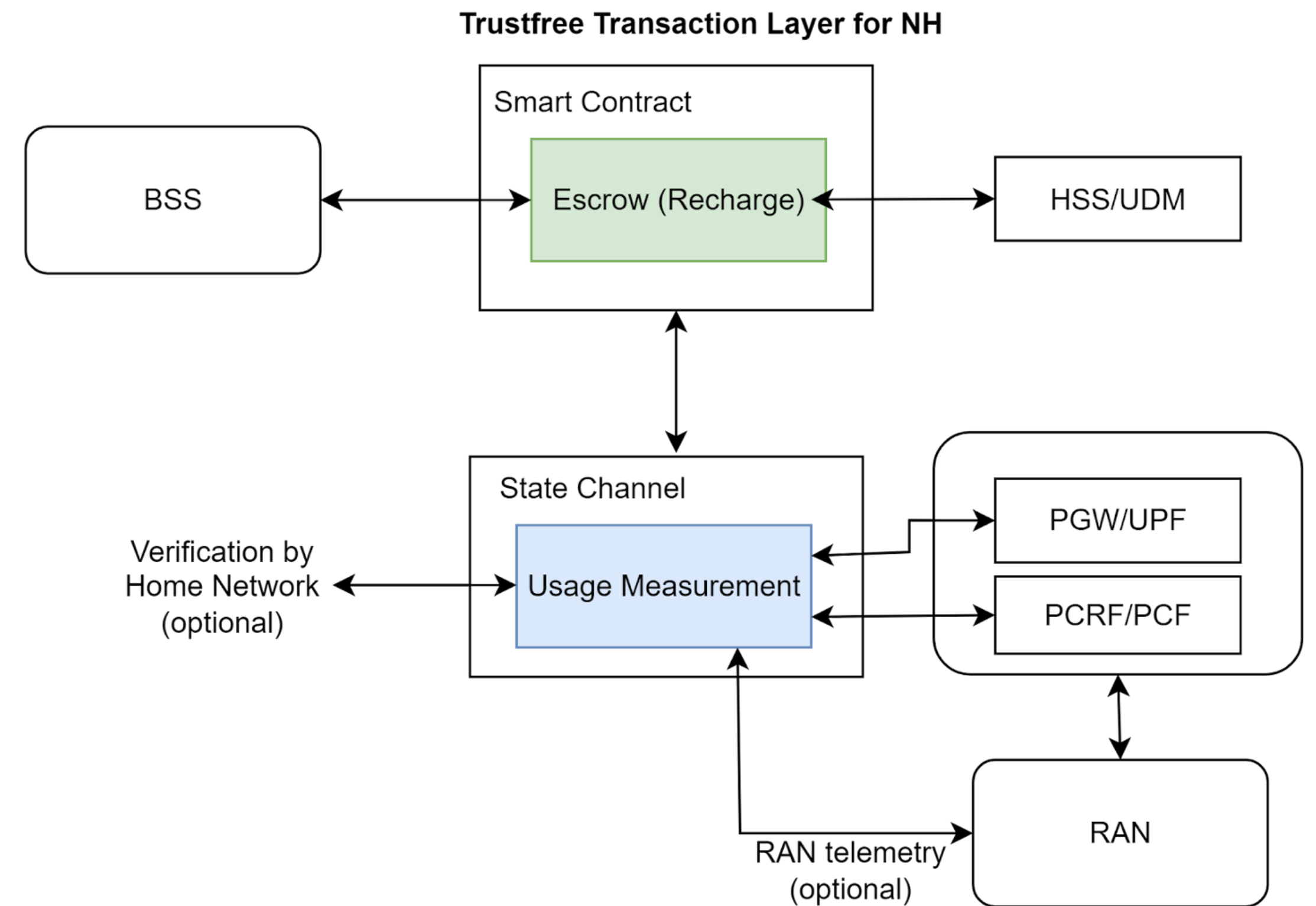# State channels enable high throughput transactions

- Transaction fee ❌

- Faster
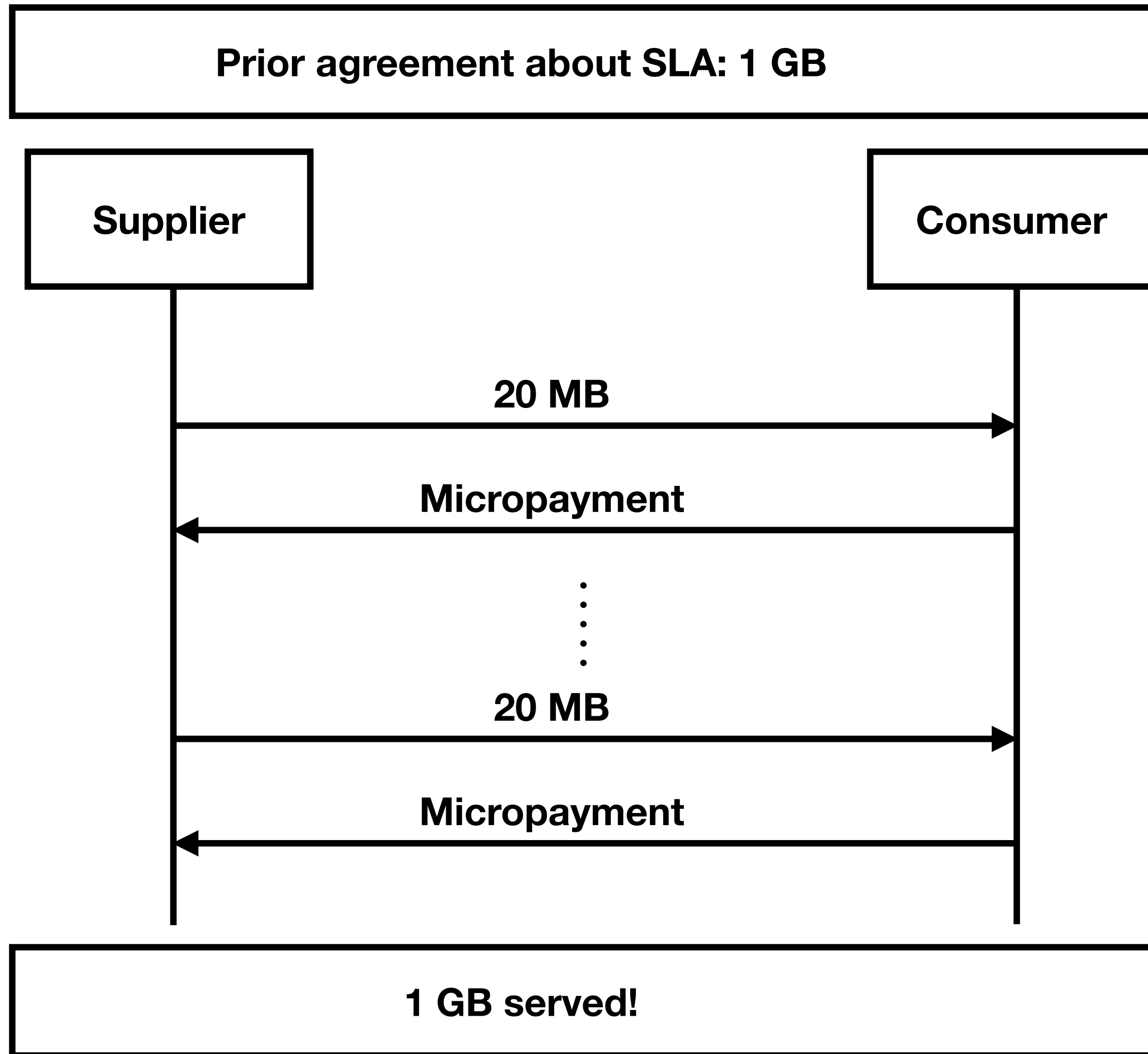
Supplier

Consumer

Chain

Lock 100

Signed commitment: transfer 10 to Supplier

$

Signed commitment: transfer 10 to Supplier

$$

Latest signed commitment

80

20

Back to the OCS!

Proof of Service refactors the OCS

Traditional Centralized Carrier

Upfront payment!

BSS
- Billing

OCS
- Recharge
- Usage Measurement

Core
- HSS/UDM
- PGW/UPF
- PCRF/PCF

RAN

Trustfree Transaction Layer for NH

BSS

Smart Contract
- Escrow (Recharge)

HSS/UDM

State Channel
- Usage Measurement

Verification by Home Network (optional)

PGW/UPF

PCRF/PCF

RAN telemetry (optional)

RAN

Proof of Service refactors the OCS

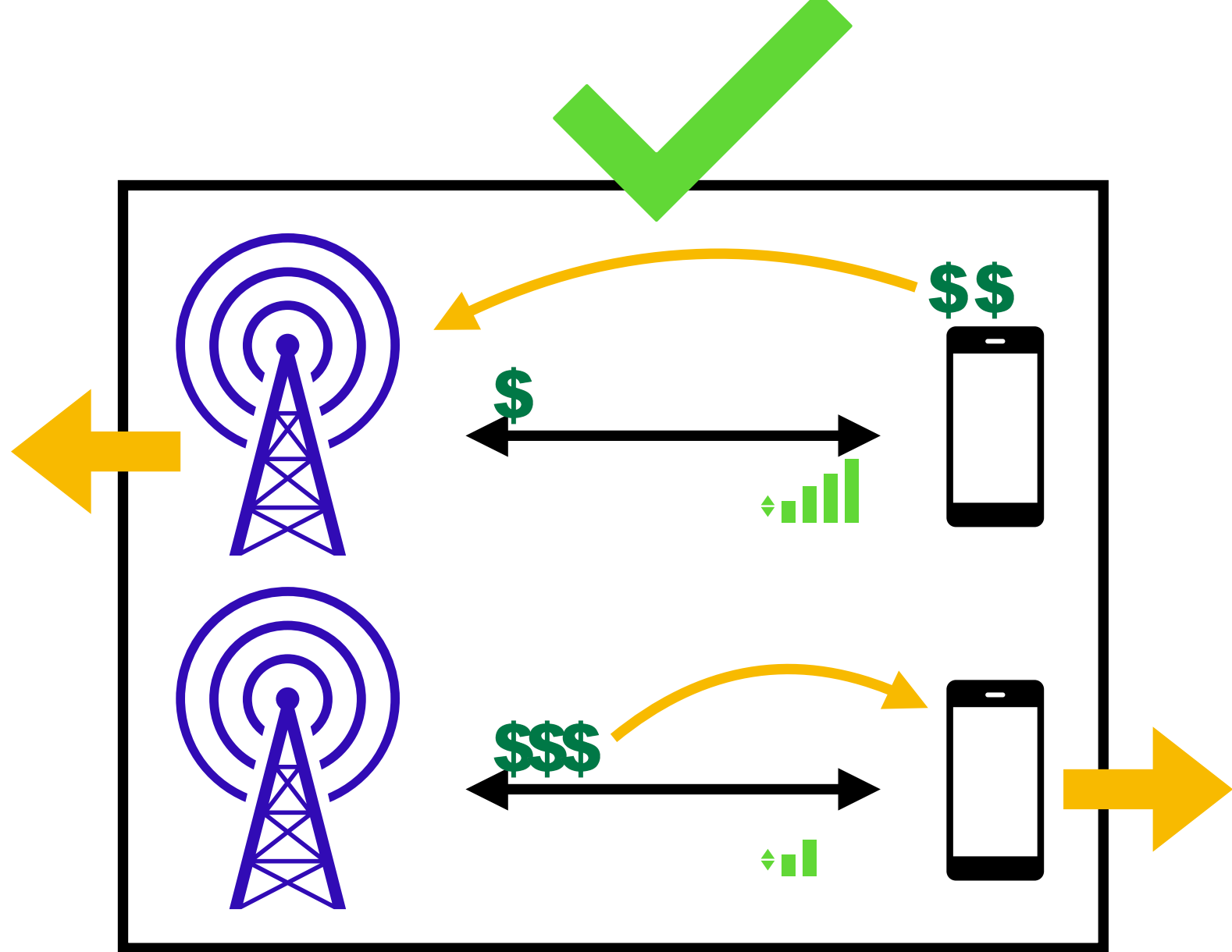# Proof of Service refactors the OCS to make billing and accounting trust-free
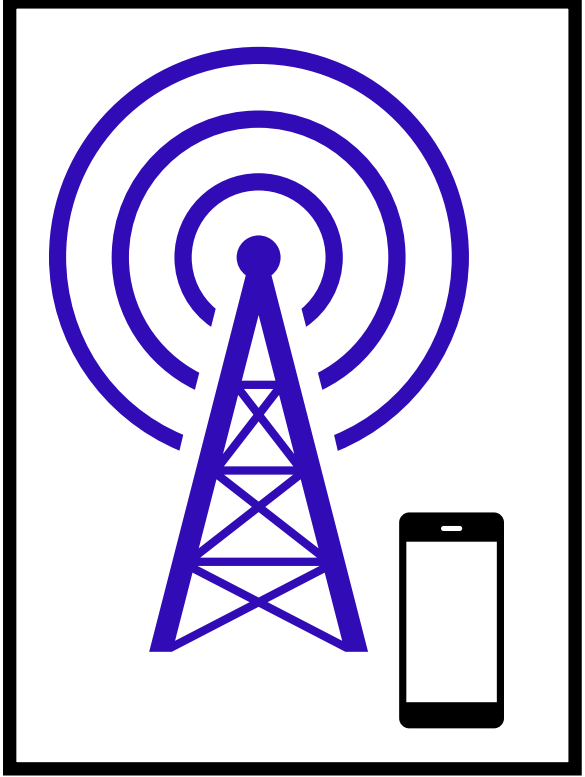
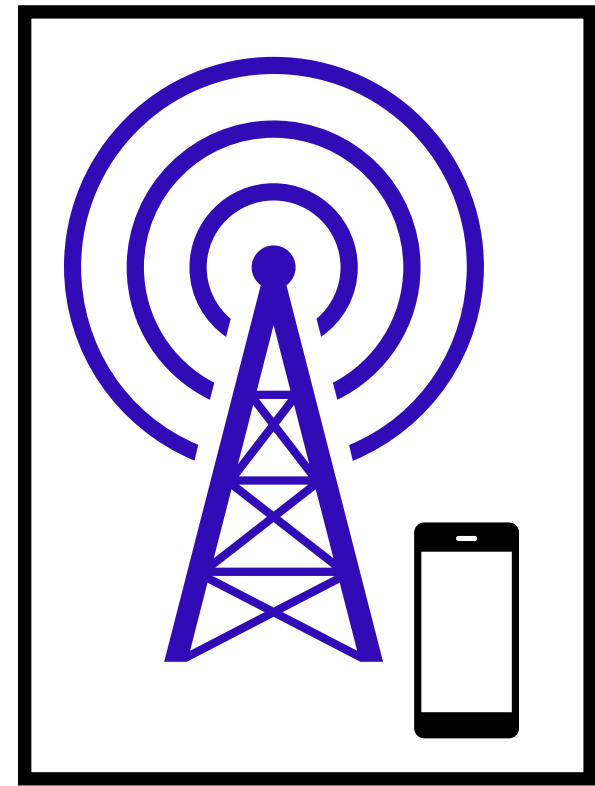**Flexible Stack**
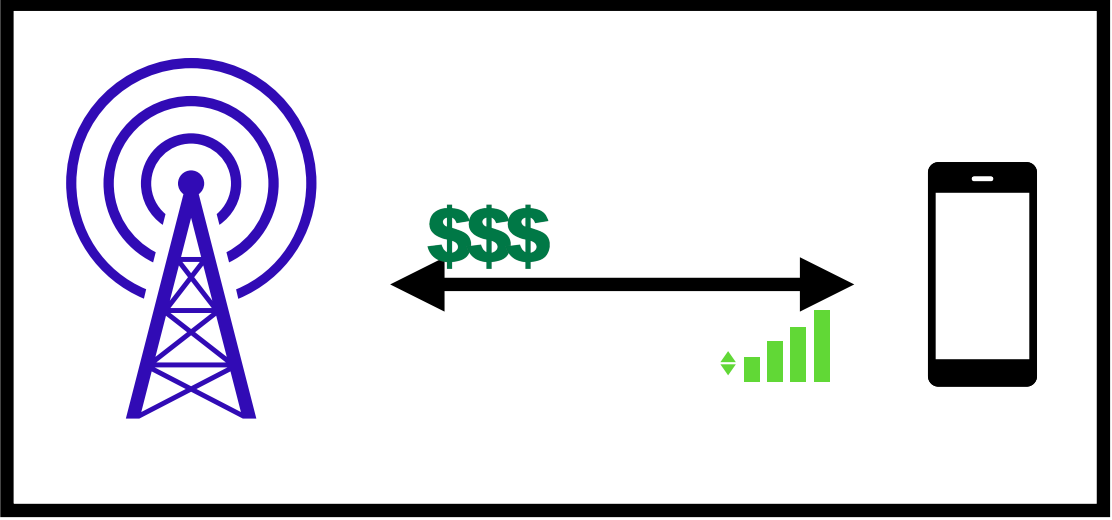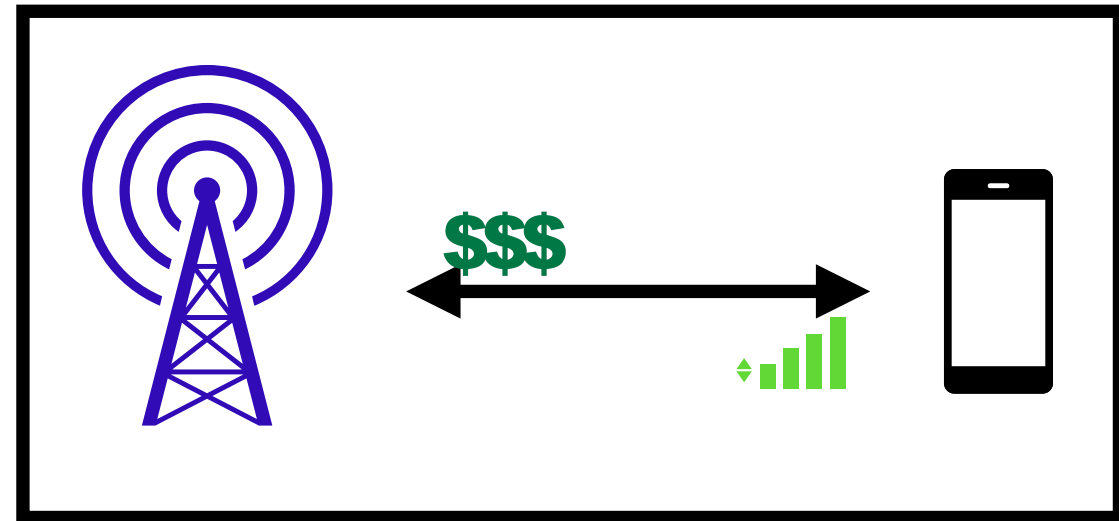
Payment ≡ Service
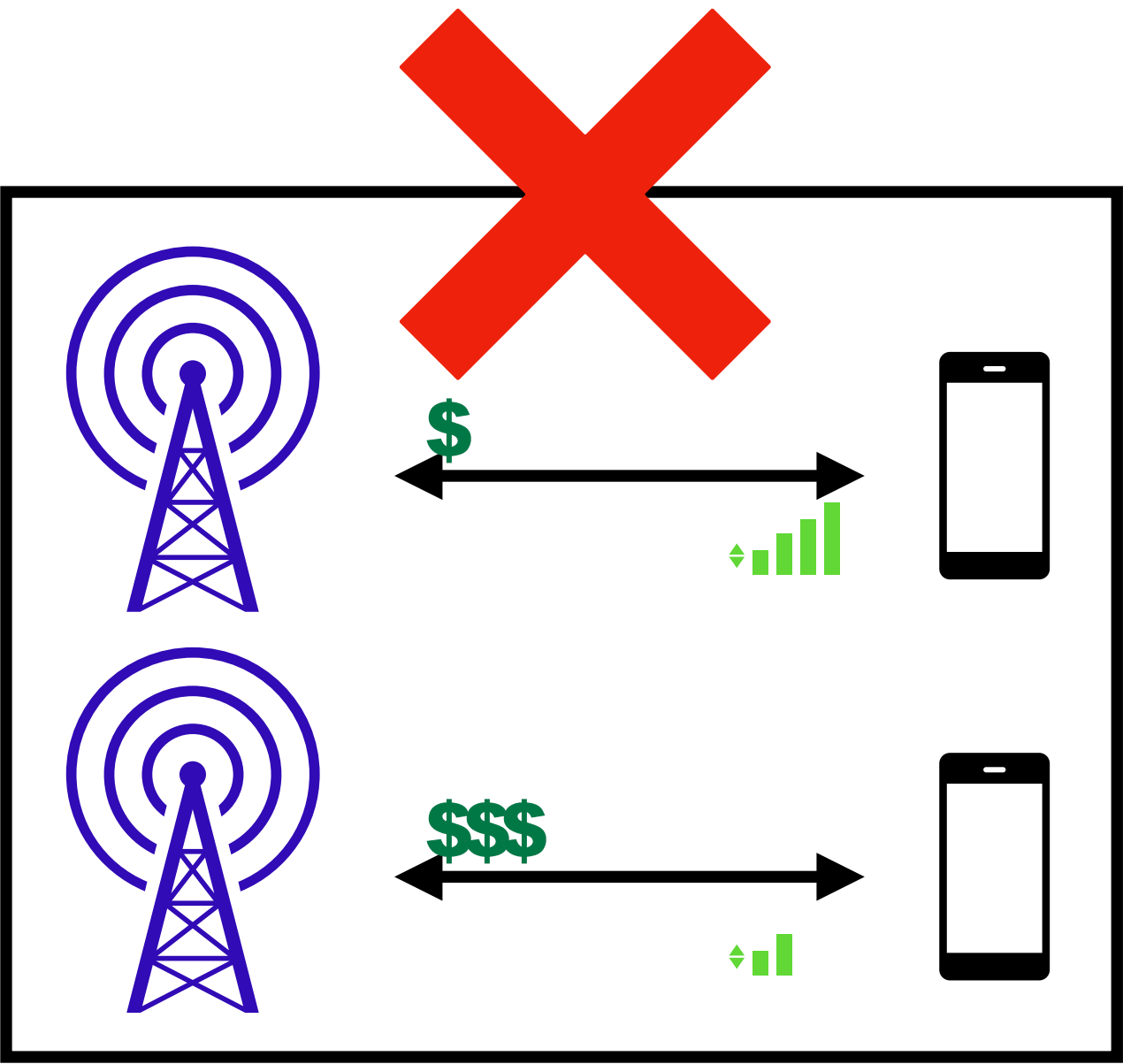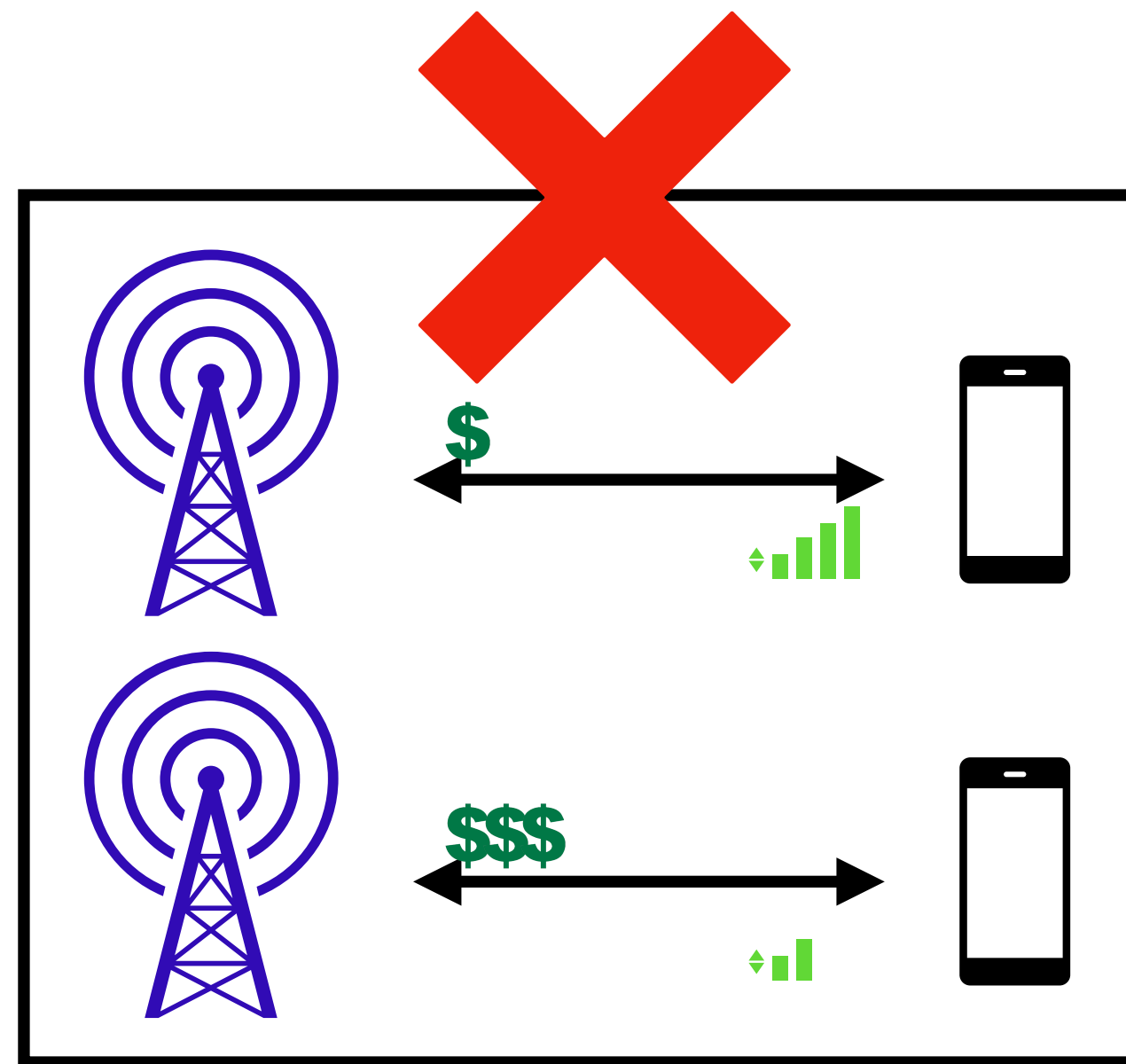
Infrequent disputes

Speedy response to disputes

Proof of Service: ensuring trustworthy service and reliable performance

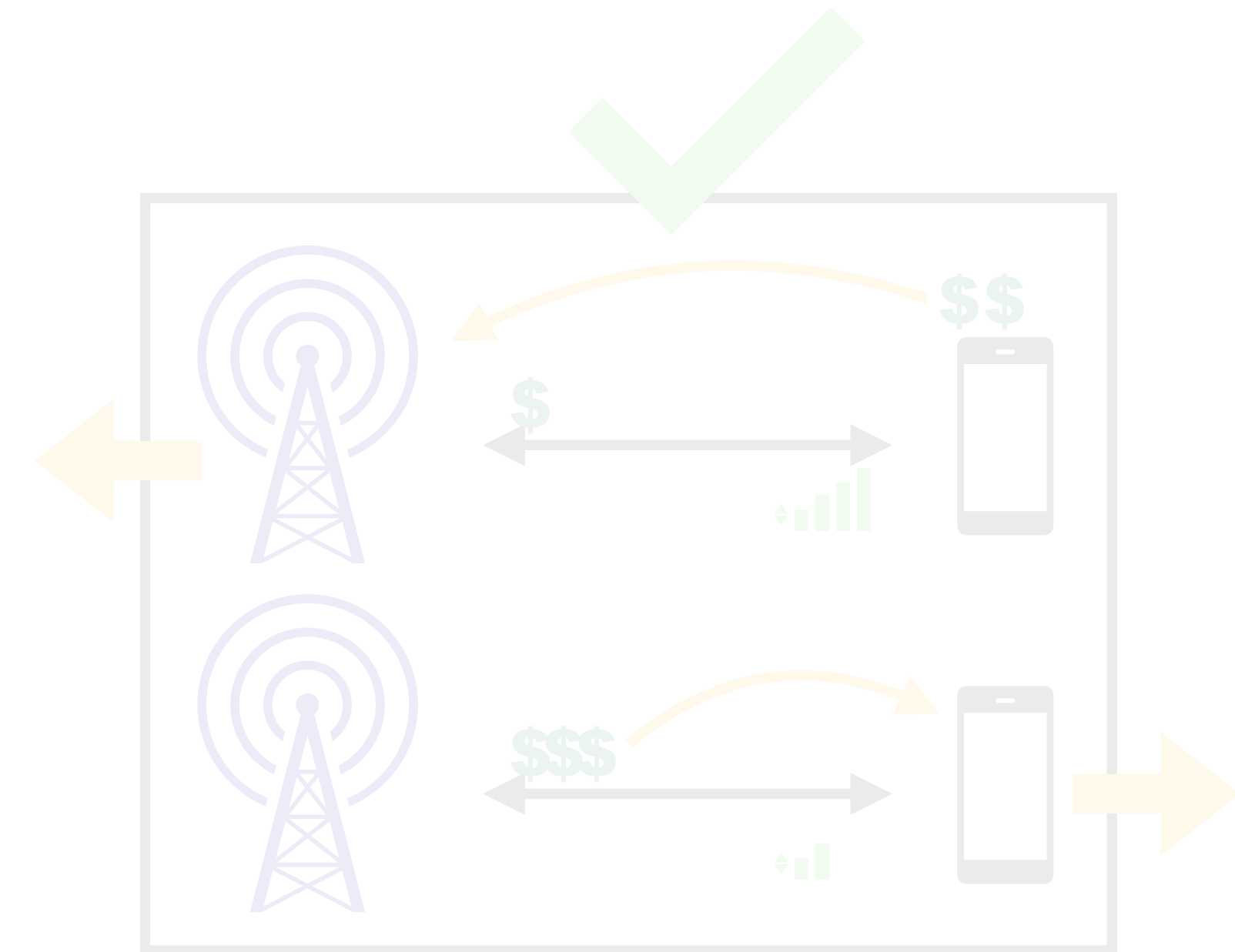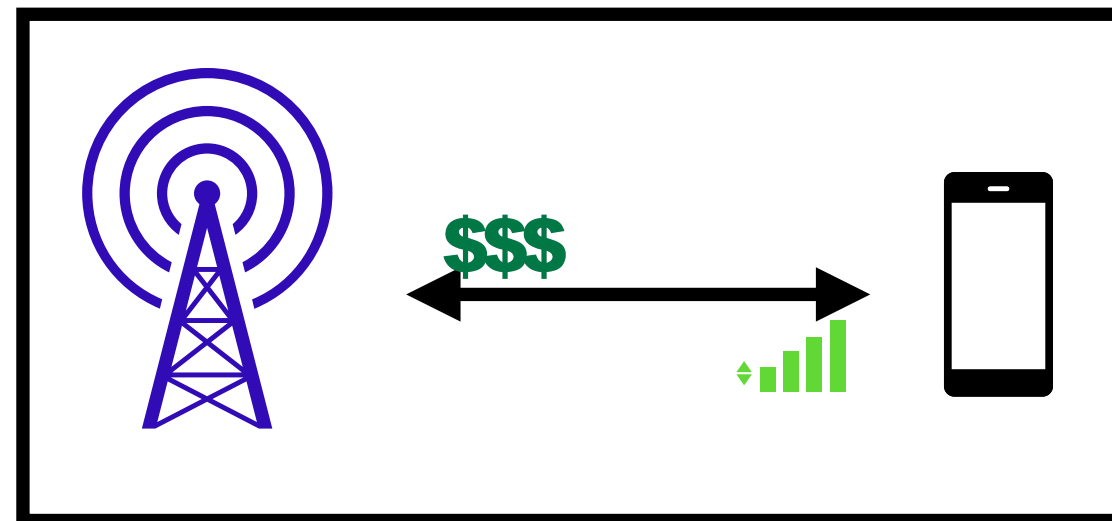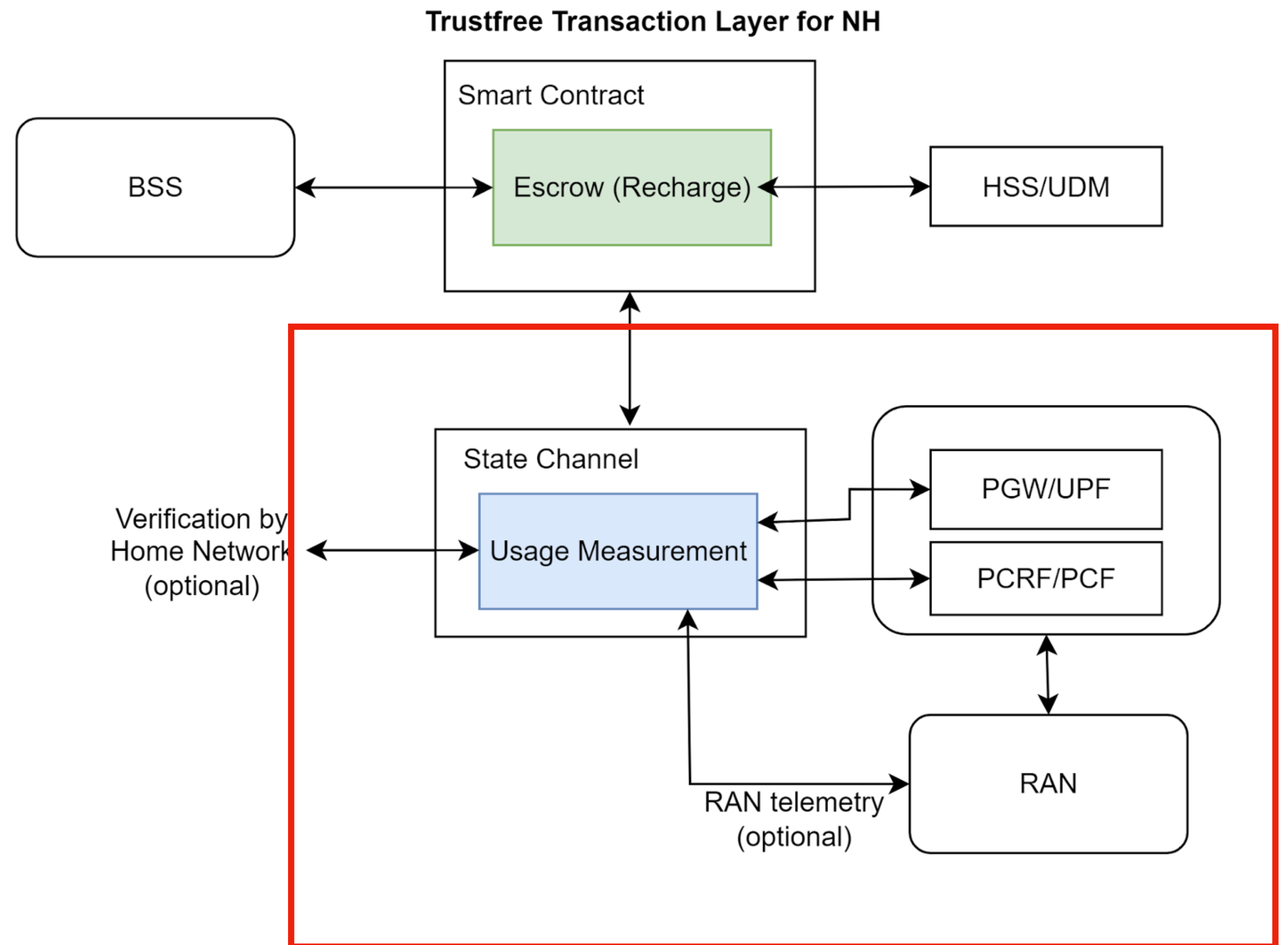**Flexible Stack**

Payment ≡ Service

Infrequent disputes

Speedy response to disputes
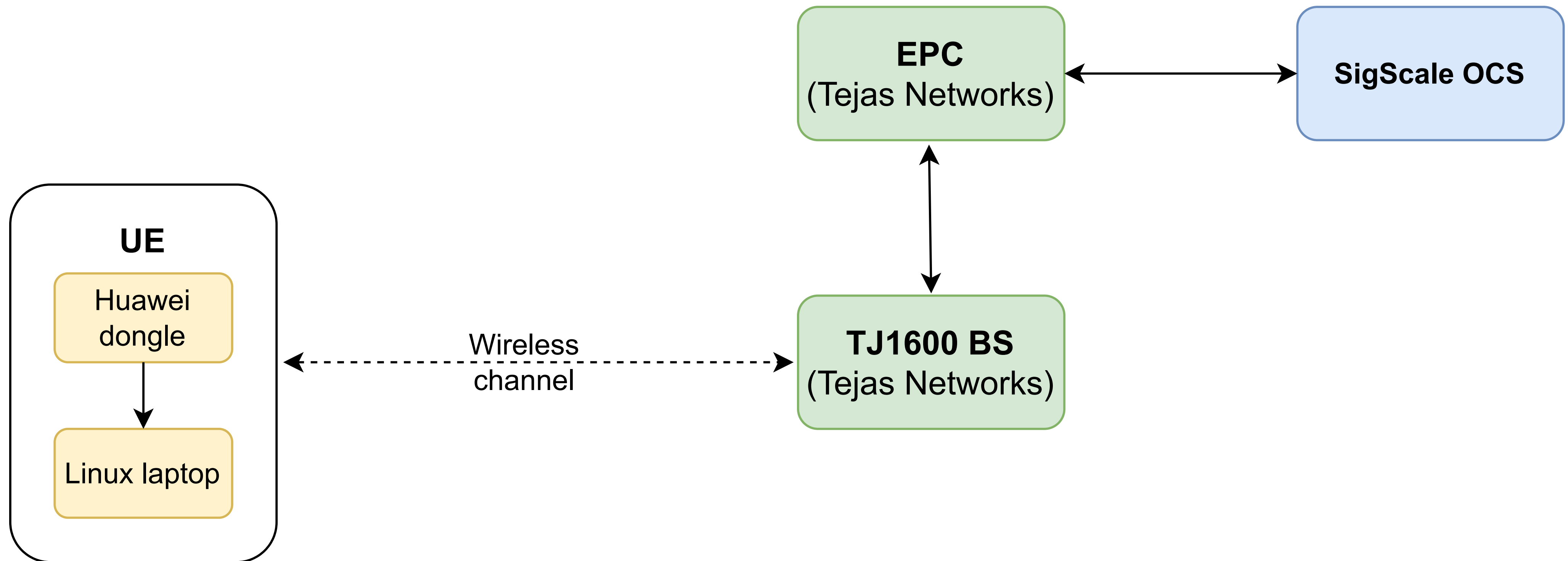
Two sided measurements make incremental SLAs possible

Payment ≡ Service

Trustfree Transaction Layer for NH

Smart Contract

BSS

Escrow (Recharge)

HSS/UDM

State Channel

Verification by Home Network (optional)

Usage Measurement

PGW/UPF

PCRF/PCF
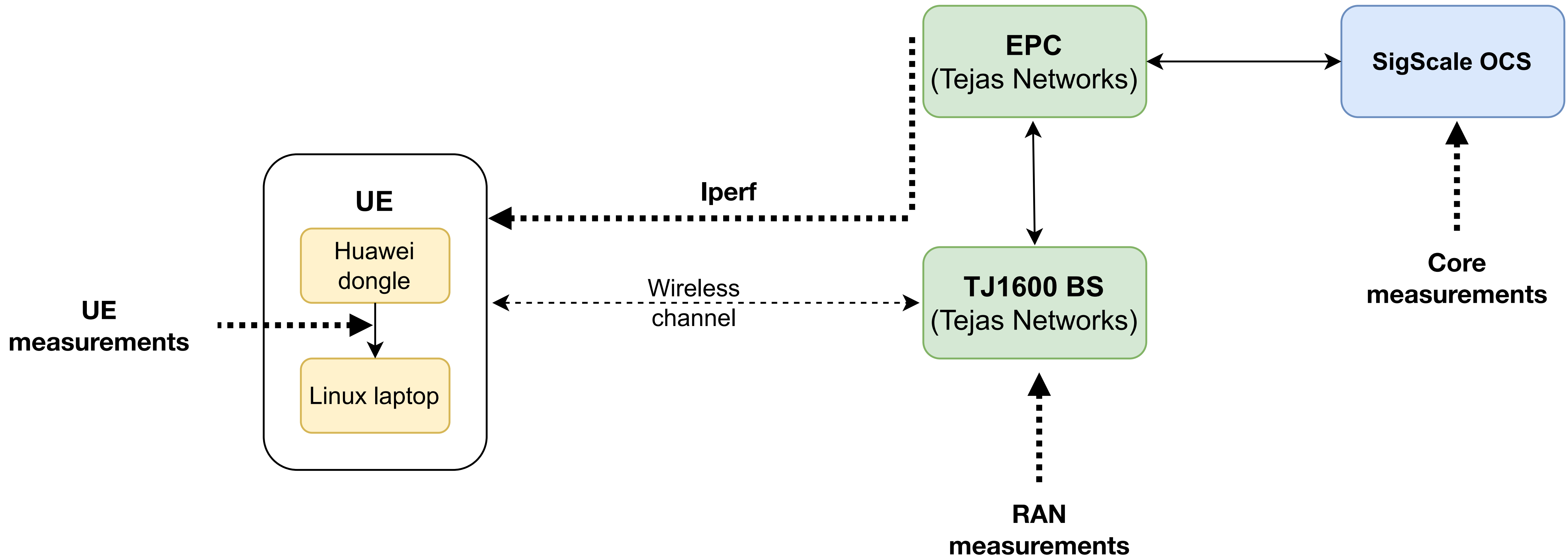
RAN telemetry (optional)

RAN

Two sided measurements: challenges

- Reconciling measurements
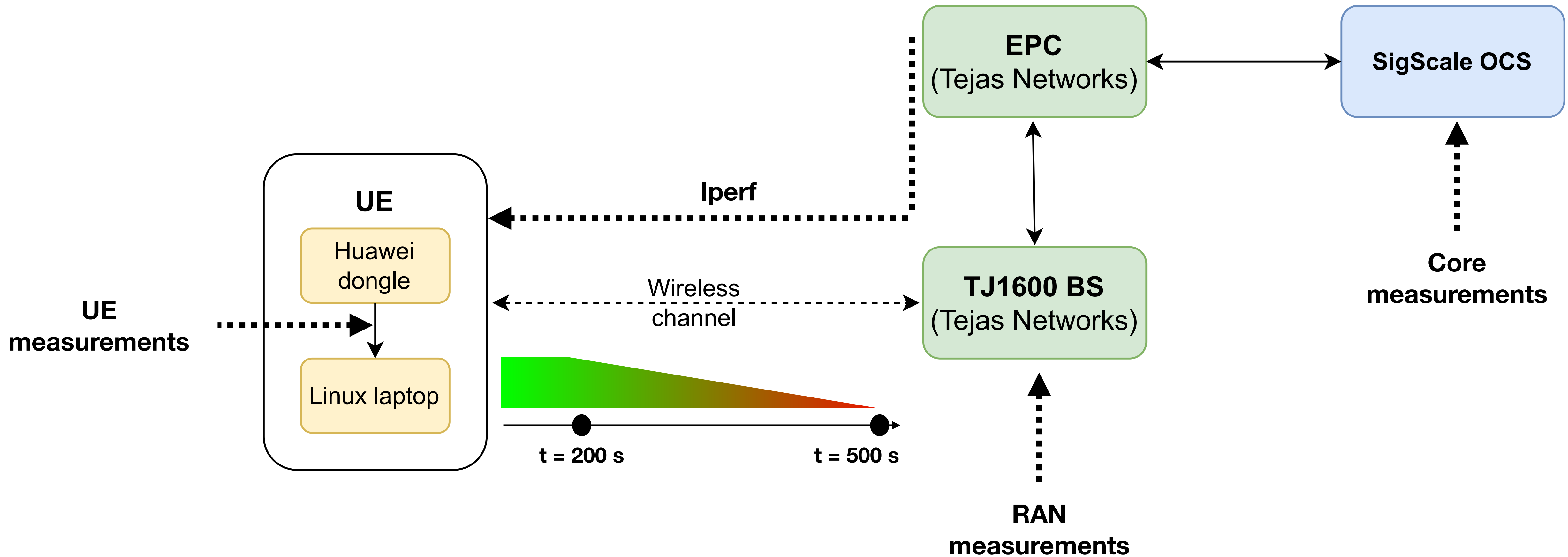
- Non-intrusive

- Variety

- Overhead

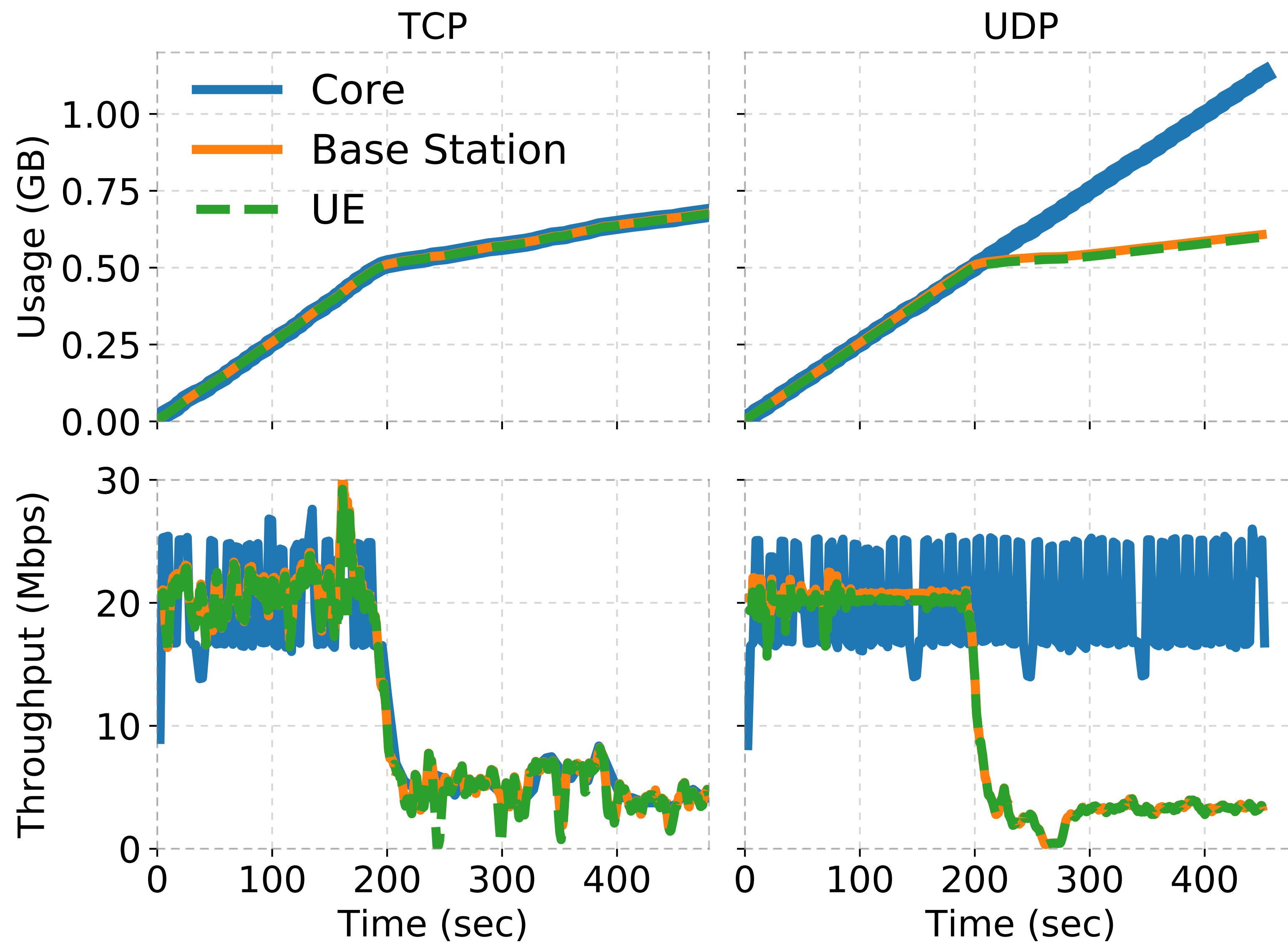# Two sided measurements: experimental setup

Two sided measurements: experimental setup

Two sided measurements: experimental setup
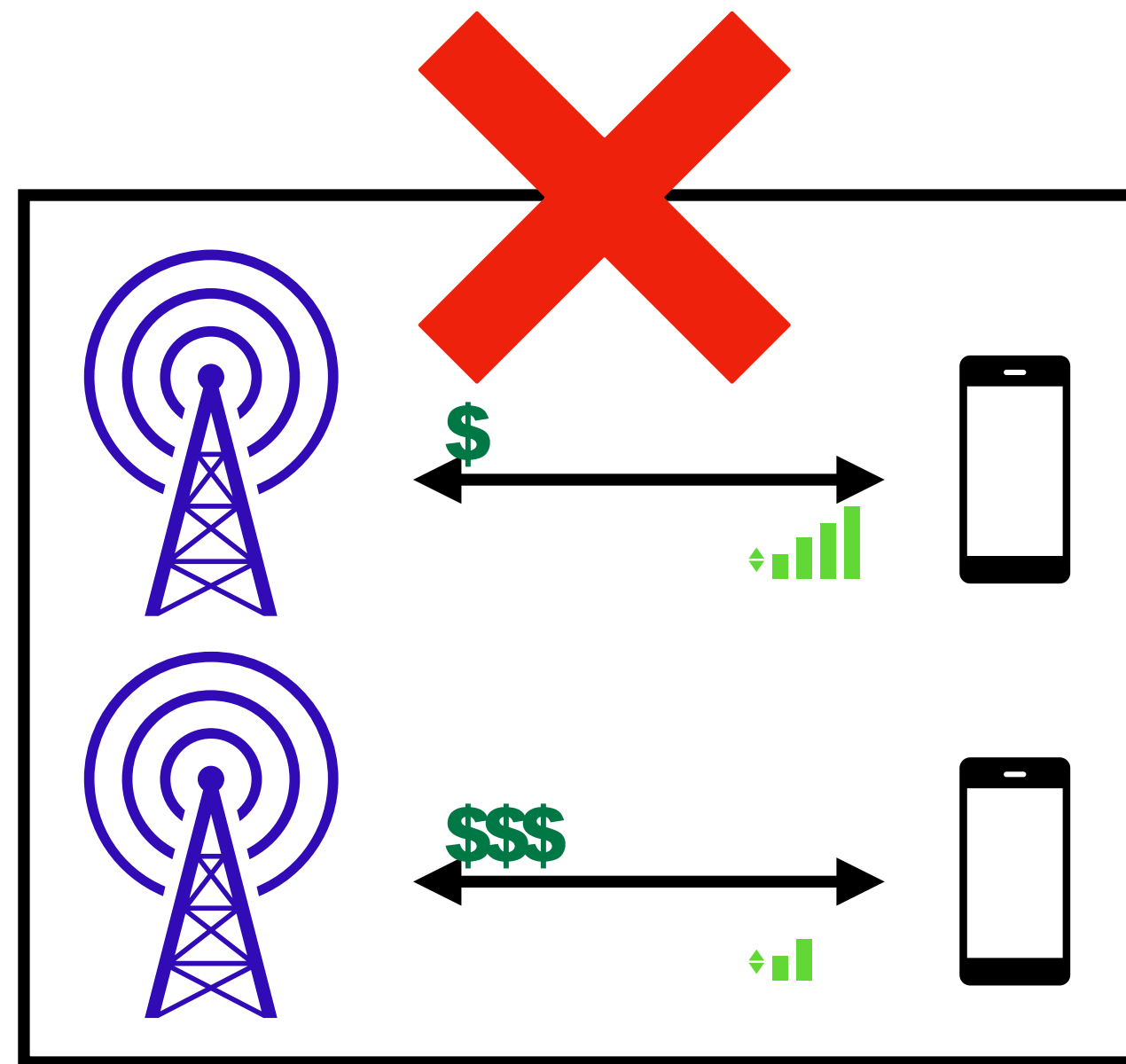
Two sided measurements: results
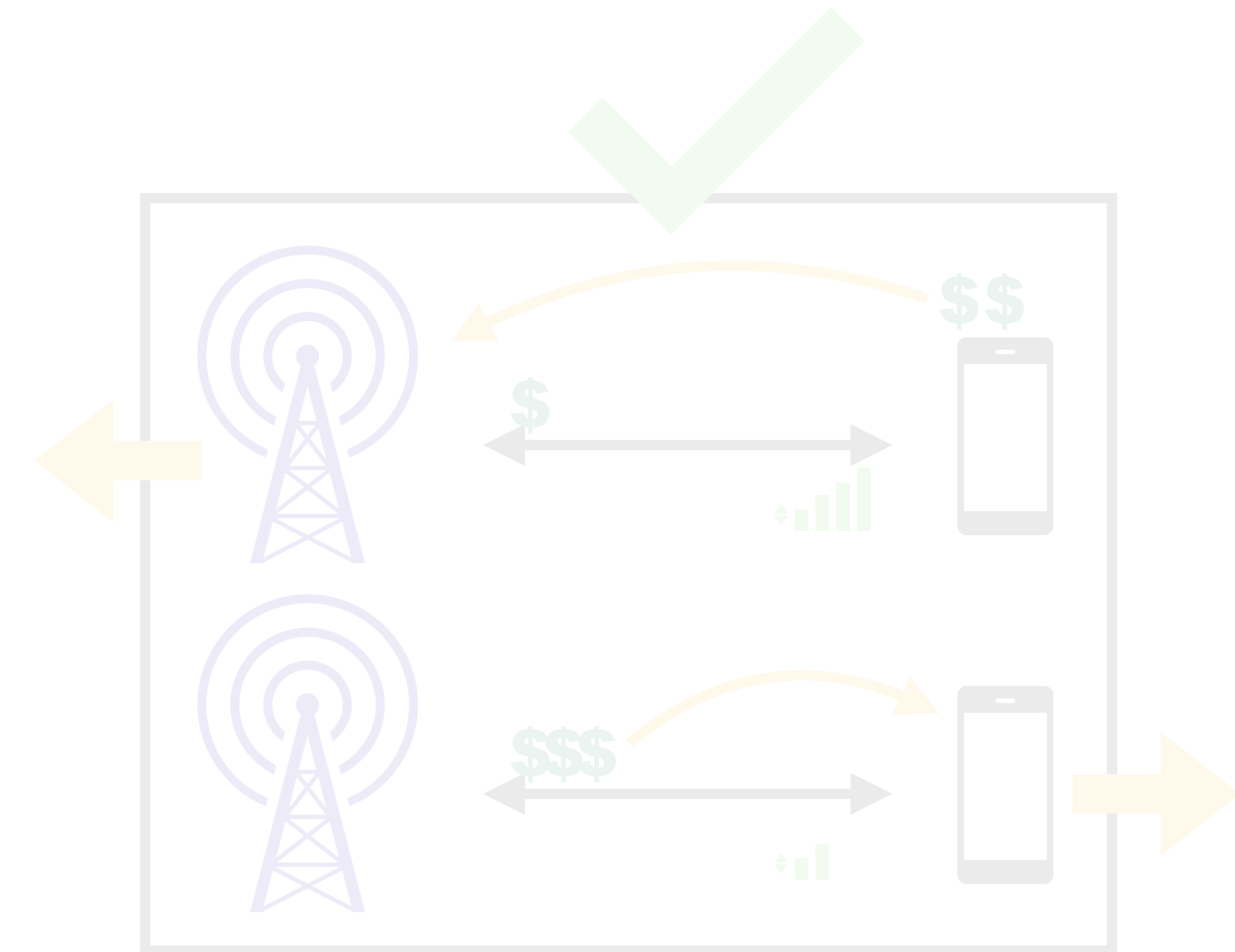
Magma for a flexible stack
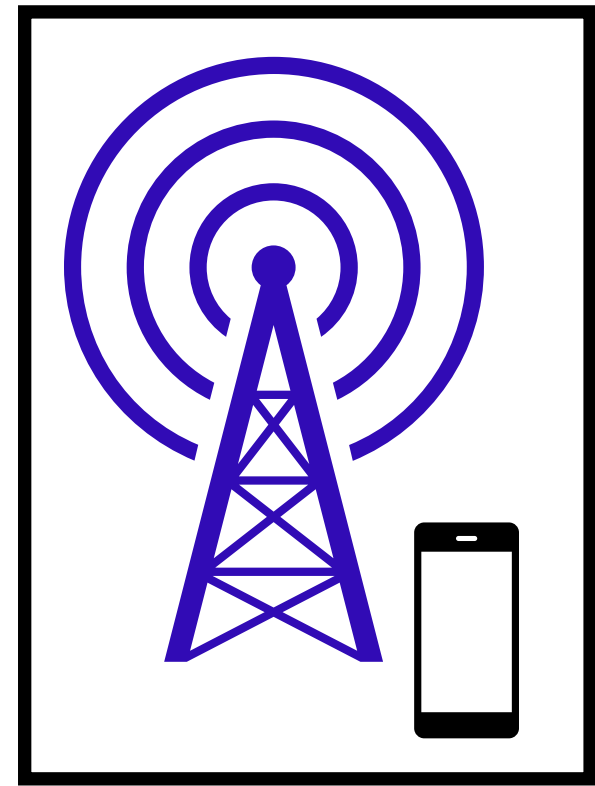

Flexible Stack
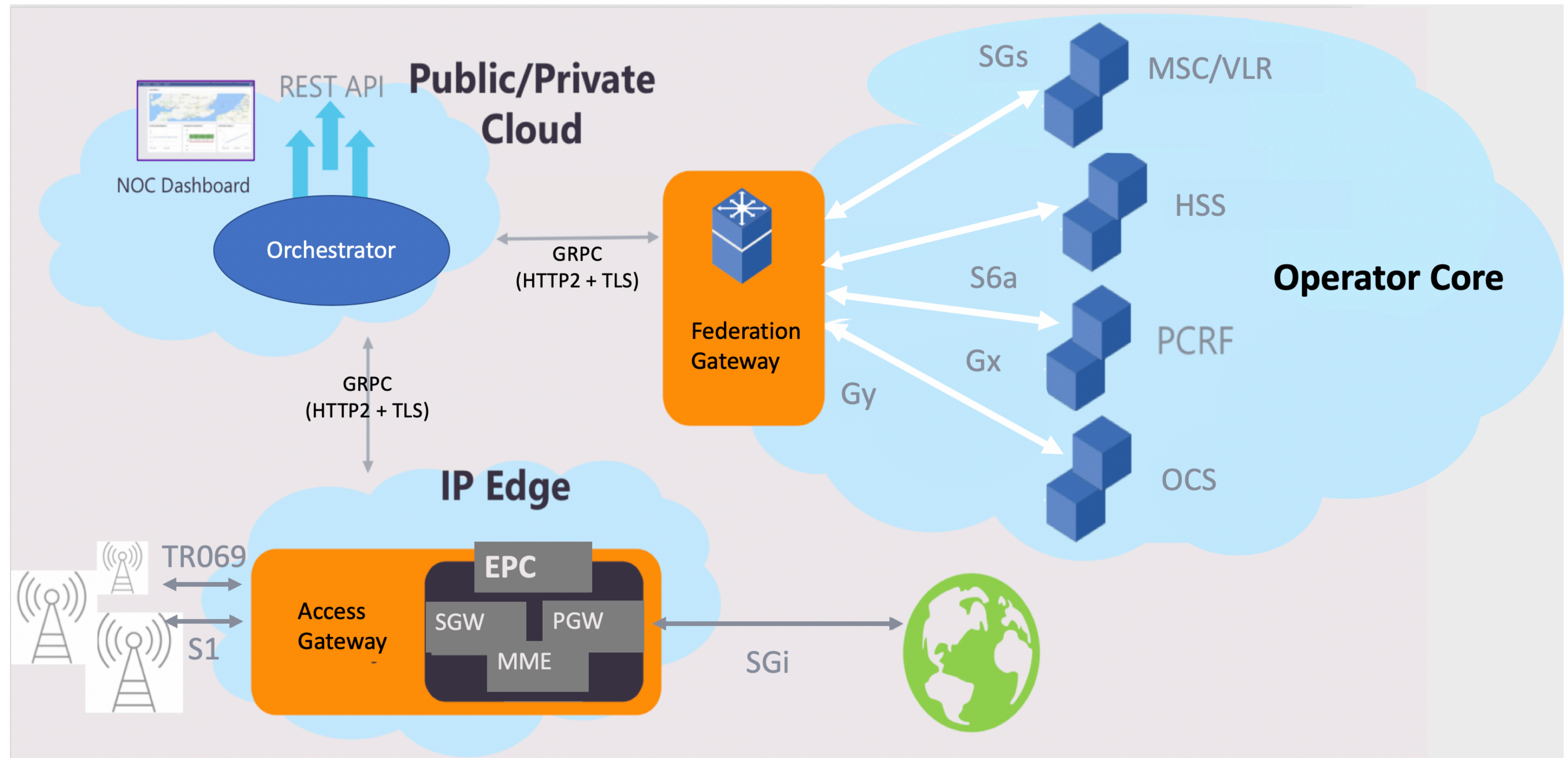
Payment ≡ Service

Infrequent disputes
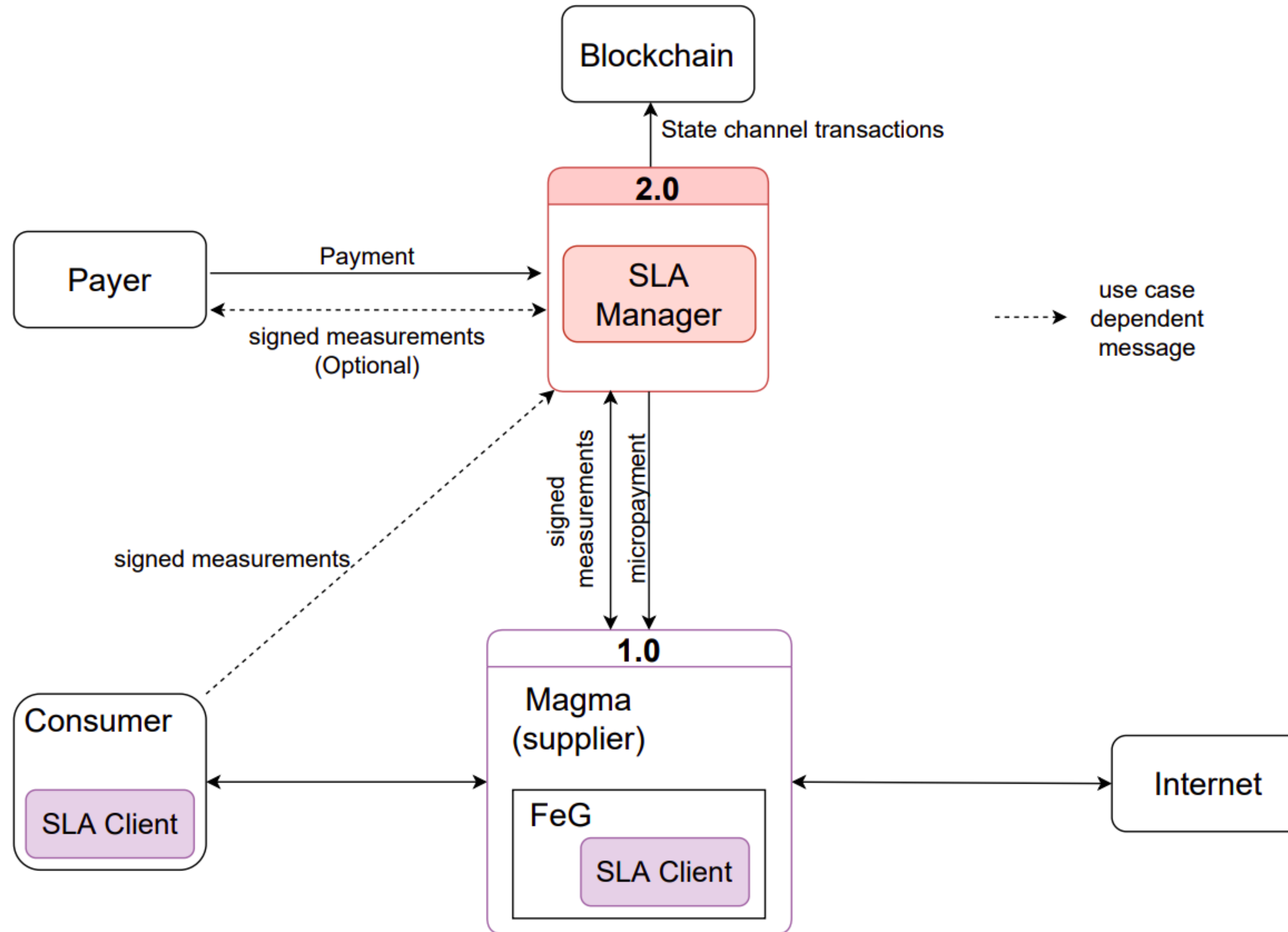
Speedy response to disputes
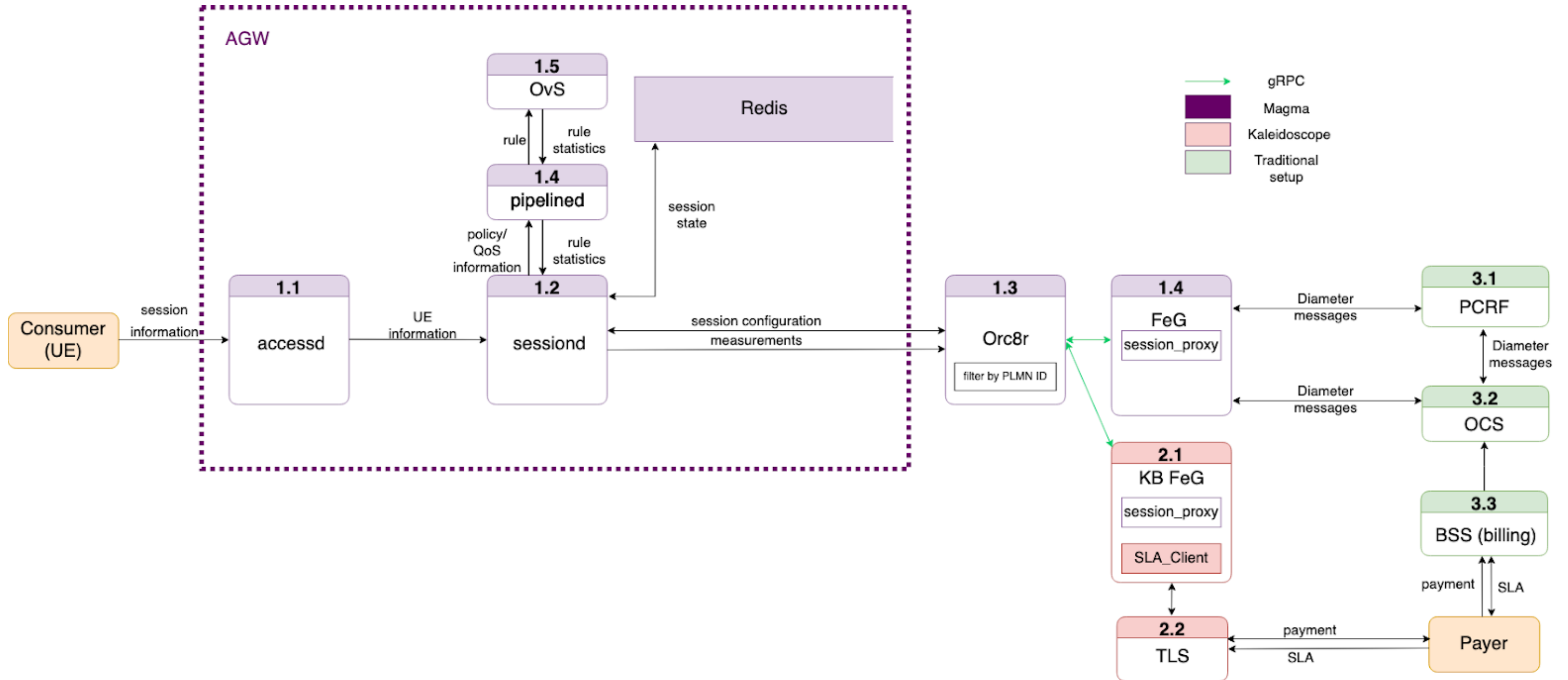
Magma for a flexible stack

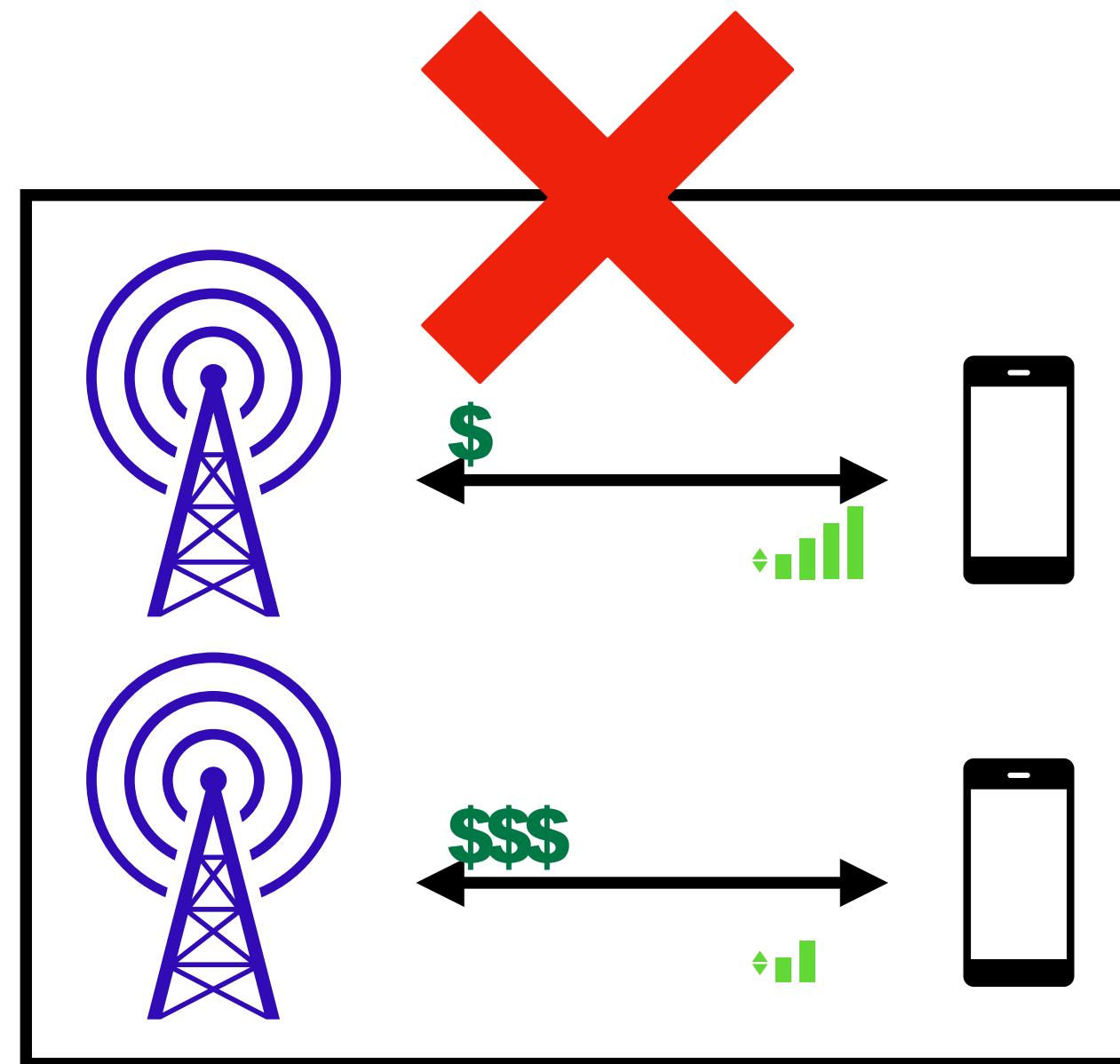**Flexible Stack**

System building

Proof of Service under the hood

Some questions

Decentralization- yes, but at what price?

1. Protocol performance

1. Performance
2. Power usage
3. Non-intrusive telemetry

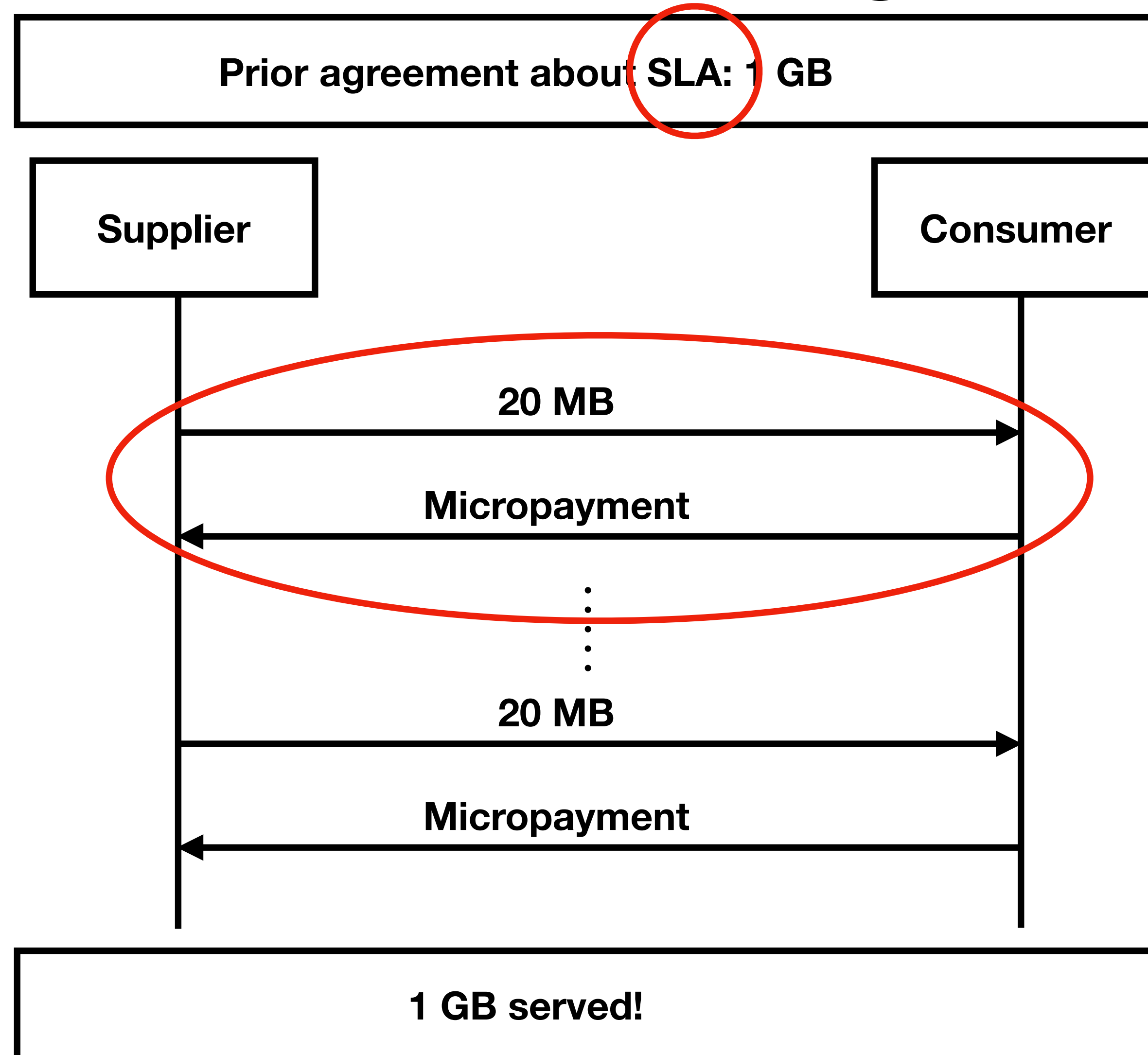1. Performance
2. Telemetry
3. Robustness
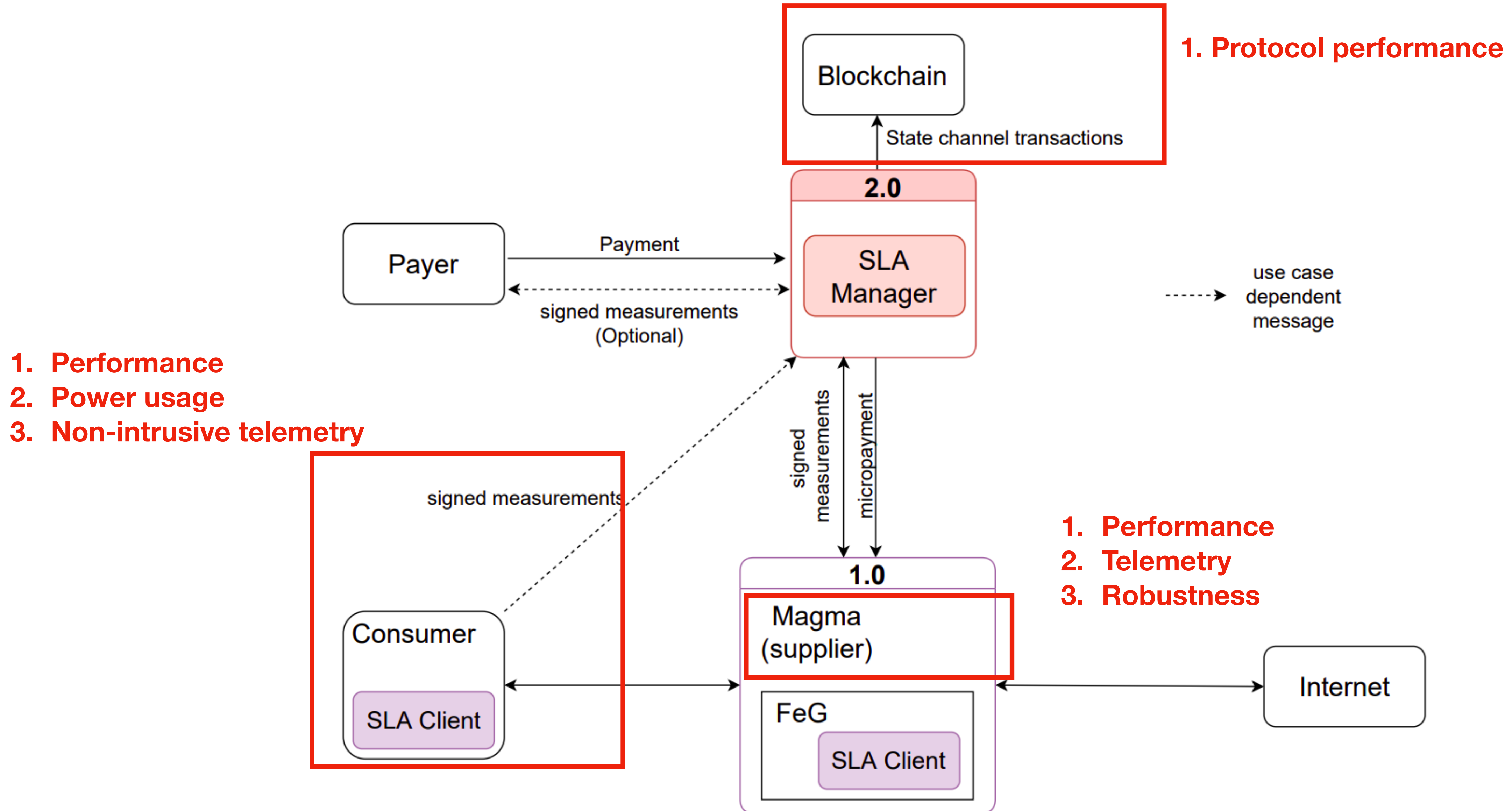
Reducing dispute frequency through better measurements

Infrequent disputes

Incentivising participation through better pricing and SLA design

Thank you!