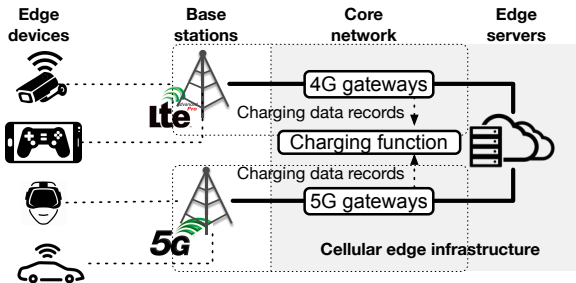


# Bridging the Data Charging Gap in the Cellular Edge

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## Intelligent cellular edge

- Low-latency service anywhere, anytime
- Powered by 4G/5G cellular networks
- Active standardization and early adoption



## Charging gap: what & why

**The cellular traffic is not free!**

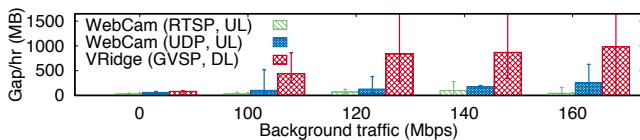
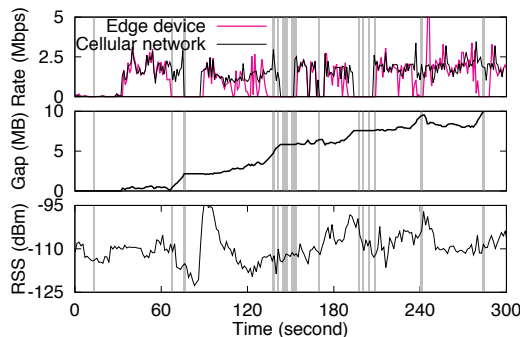
- Edge app pays 4G/5G operator by data usage

**Data charging gap (thus over-/under-billing):**

The operator and edge app vendor may not agree on how much data should be paid

### Causes of the gap

- **Data loss** by intermittent wireless, mobility, congestions, SLA violation, and many more.



- **Selfish charging claims** by 4G/5G operator (over-billing) or edge app vendor (under-billing)

**The charging gap can be amplified in the edge**

- UDP-based delay-sensitive edge traffic is vulnerable to the data loss
- Heavy data usage in some edge applications

## Our solution: TLC

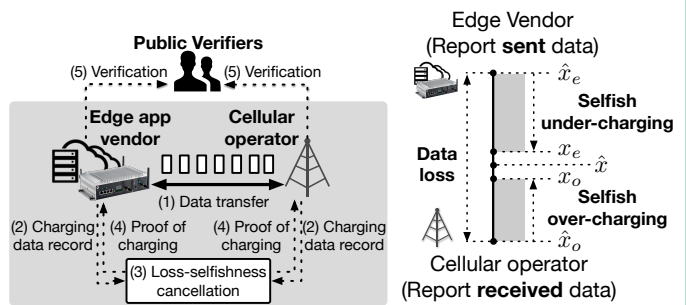
### Trusted, Loss-tolerant Charging

Let the edge app vendor and 4G/5G operator **negotiate** the charging data volume

- Rather than today's operator-centric charging
- **Loss-selfishness cancellation:** Game-theoretical approach to let selfishness and loss-induced gaps cancel out each other
- **Proof-of-Charging (PoC)** is constructed and digitally signed for mutual trust

Three provable properties

- ✓ **Correctness:** Always-bounded charging gap, and no gap if edge and operator are rational
- ✓ **Latency friendliness:** No blocking of delay-sensitive edge traffic
- ✓ **Public verifiability:** Any independent 3<sup>rd</sup> party (e.g., FCC or court) can verify the charging



## How well TLC performs

Compared with the legacy 4G/5G

- ✓ **Gap reduction:** 80.2% in WebCam, 87.5% in edge-based VR, and 47.06% in online gaming
- ✓ **Marginal overhead:** Negligible extra data latency and signaling message overhead
- ✓ **Scalability:** A single HP Z840 workstation (public verifier) can verify 230K PoCs/hour.

