Enhancing Applicability of Mix Networks

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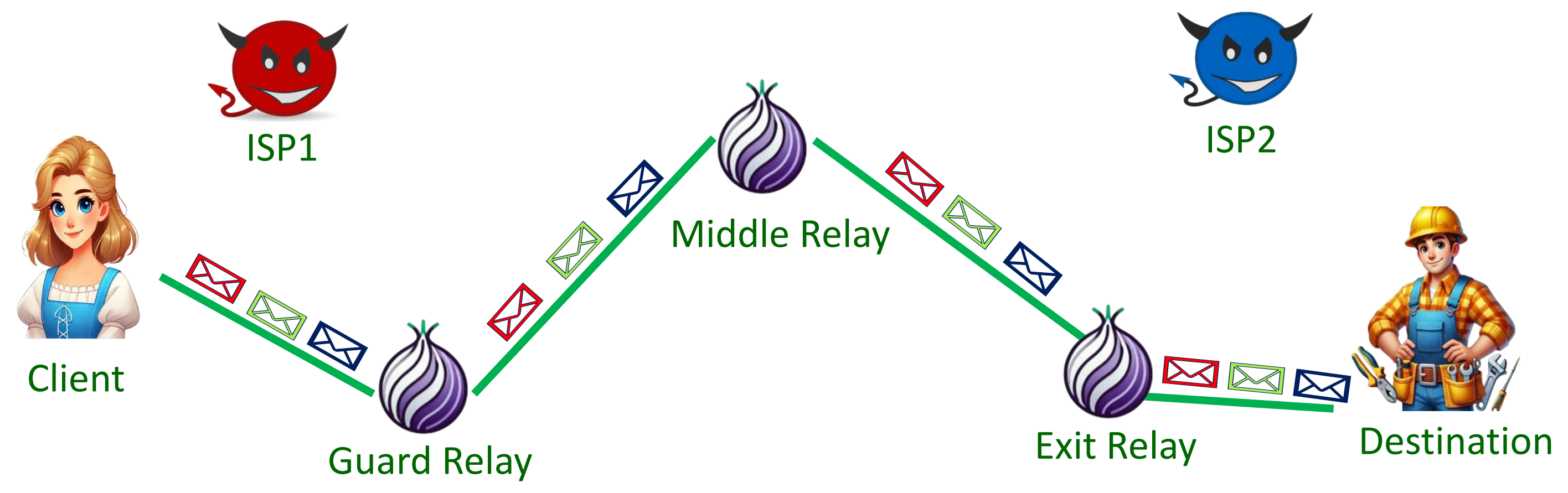
Backgrounds and Motivations

End users on the internet are not anonymized by default.

This poses serious privacy risk.

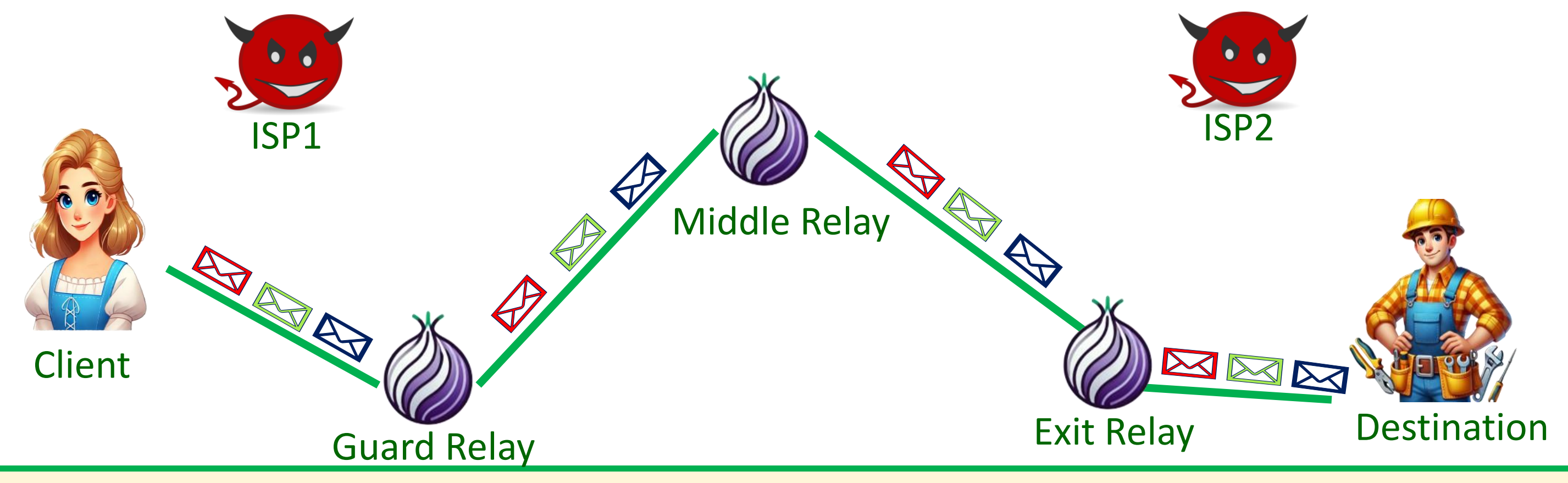
Tor Network



ISP: Internet Service Provider

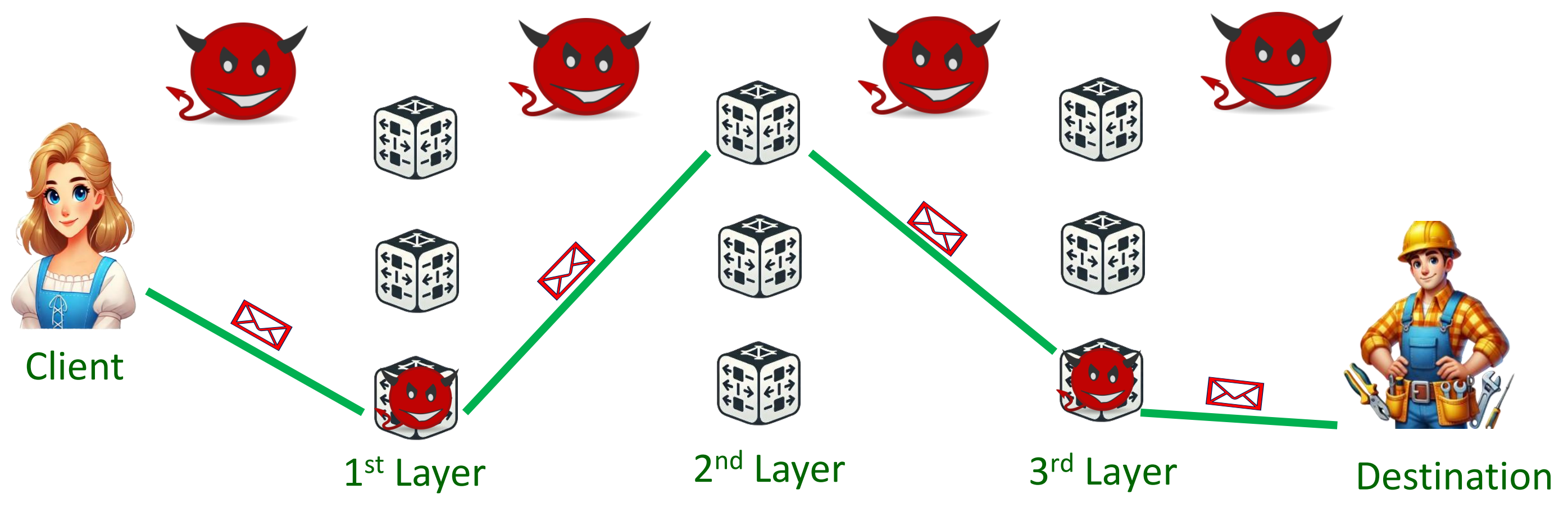
ISP1 does not collude with ISP2.

End-to-End Correlation Attacks



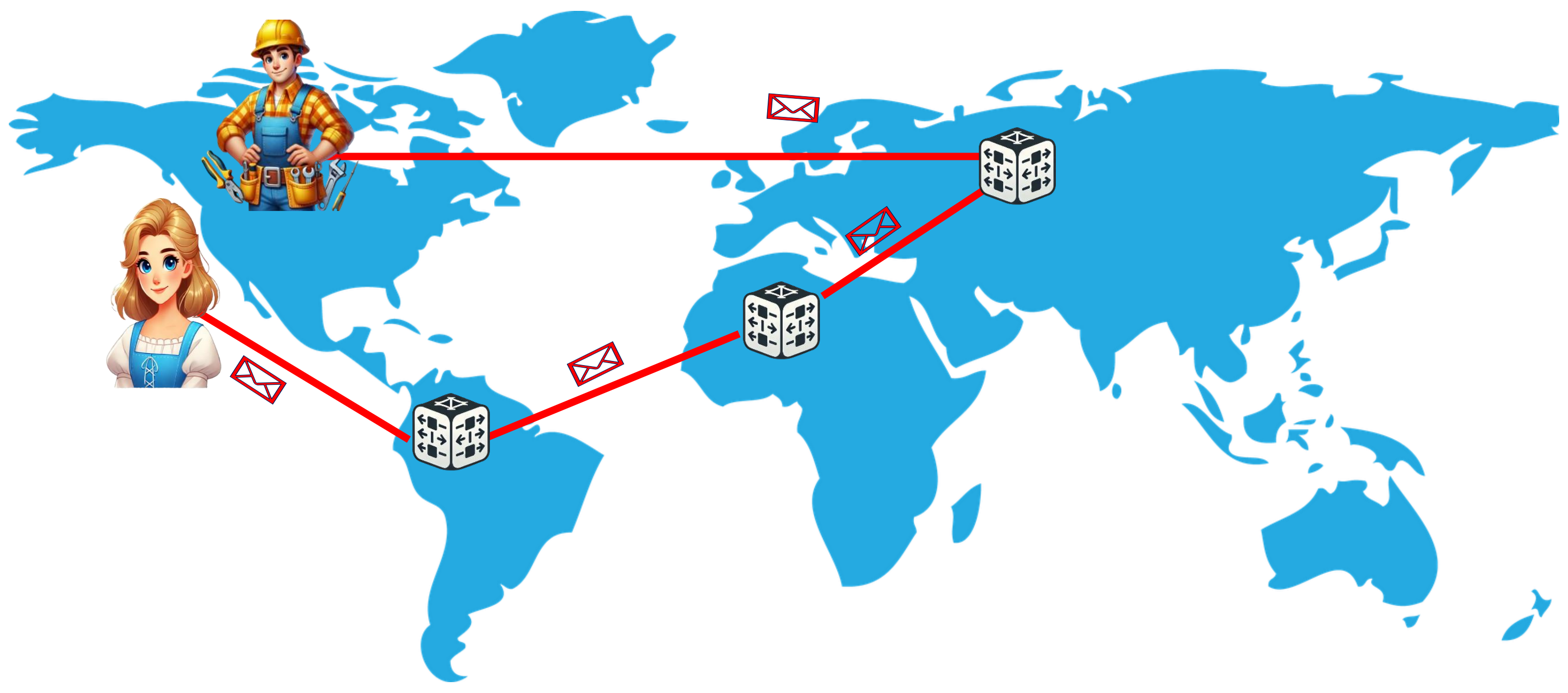
If ISP1 colludes with ISP2, they can deanonymize the client-destination connection.

Mix Networks (Mixnets)



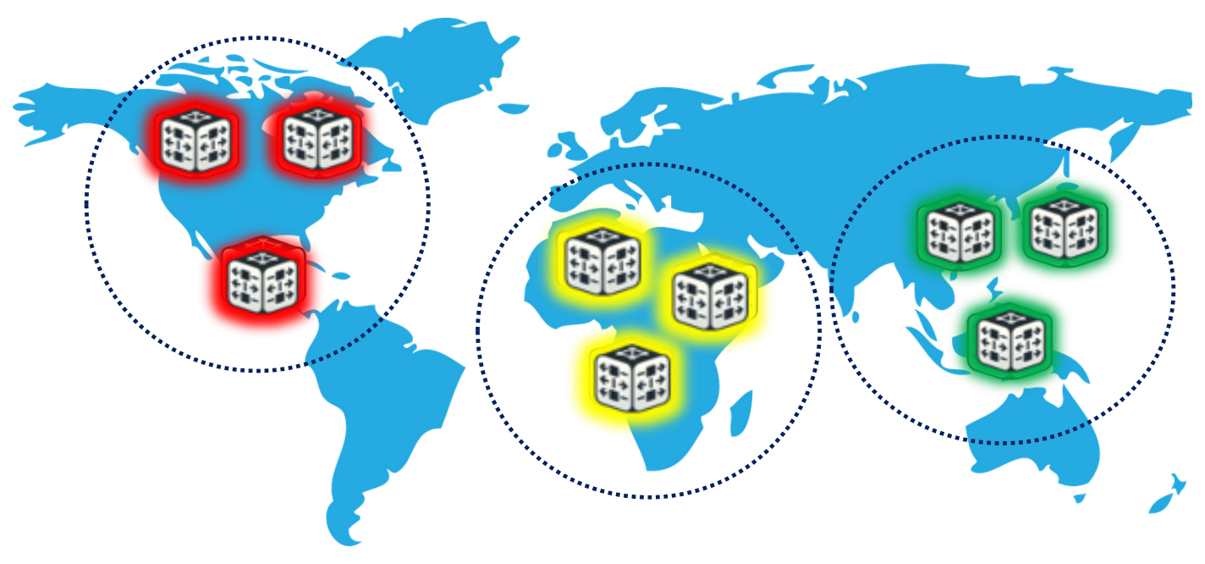
Mixnets provide strong anonymity by breaking the linkability of traffic flows.

High End-to-End Latency

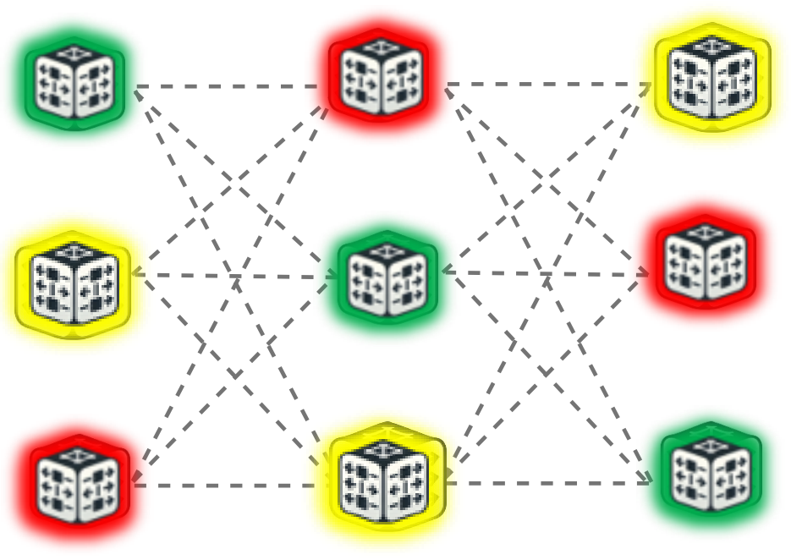


As a result of routing through intermediate nodes and mixing delays at each mixnode, the end-to-end latency is high.

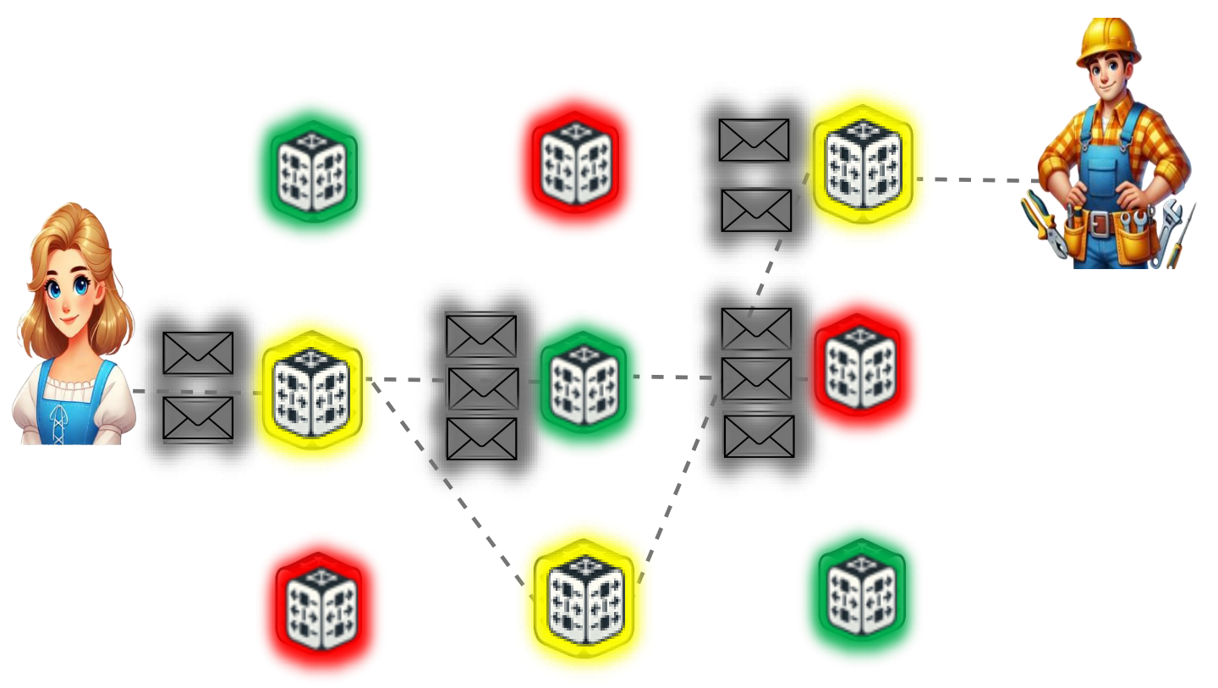
LARMix [1]



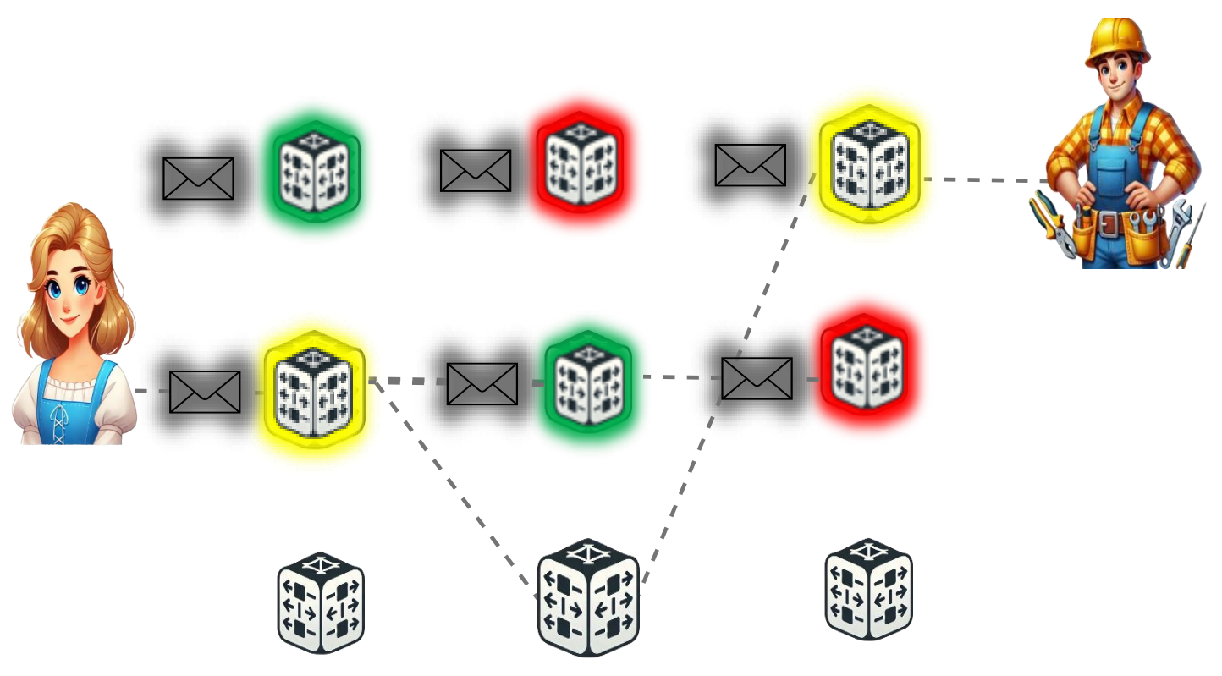
Clustering



Diversification

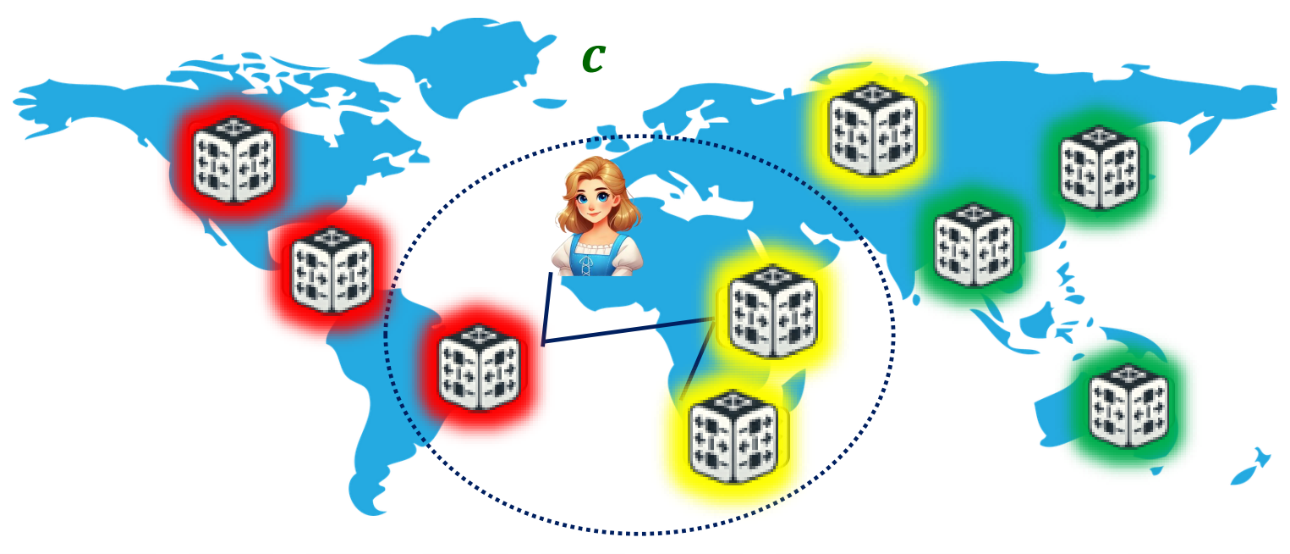


Low-latency routing

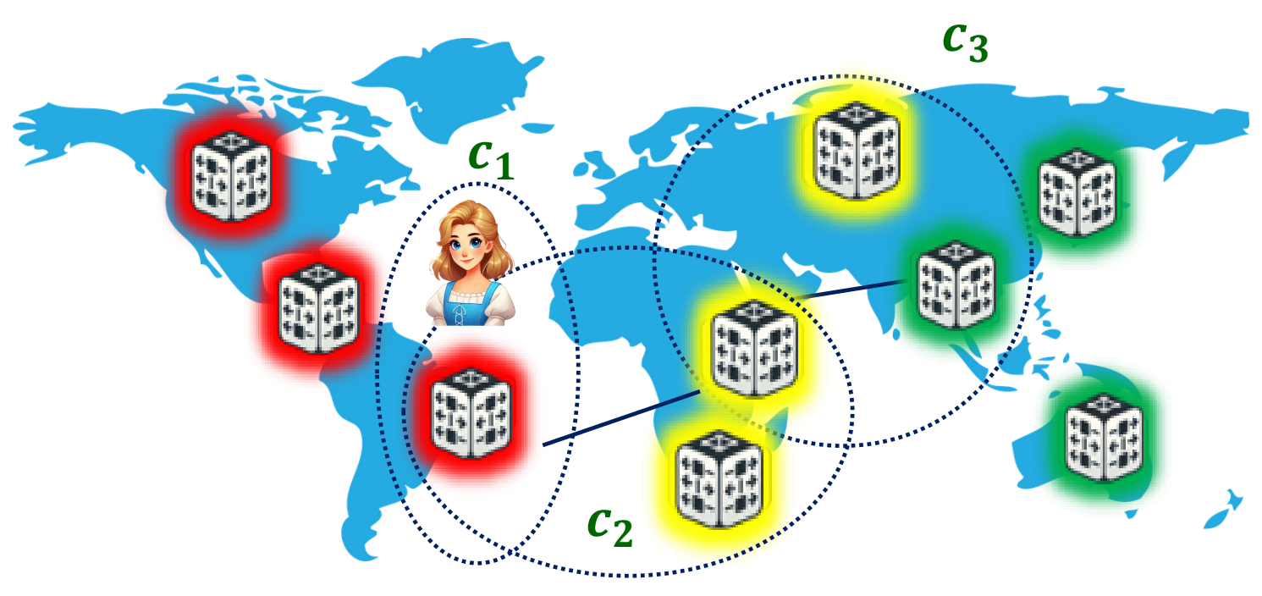


Load balancing

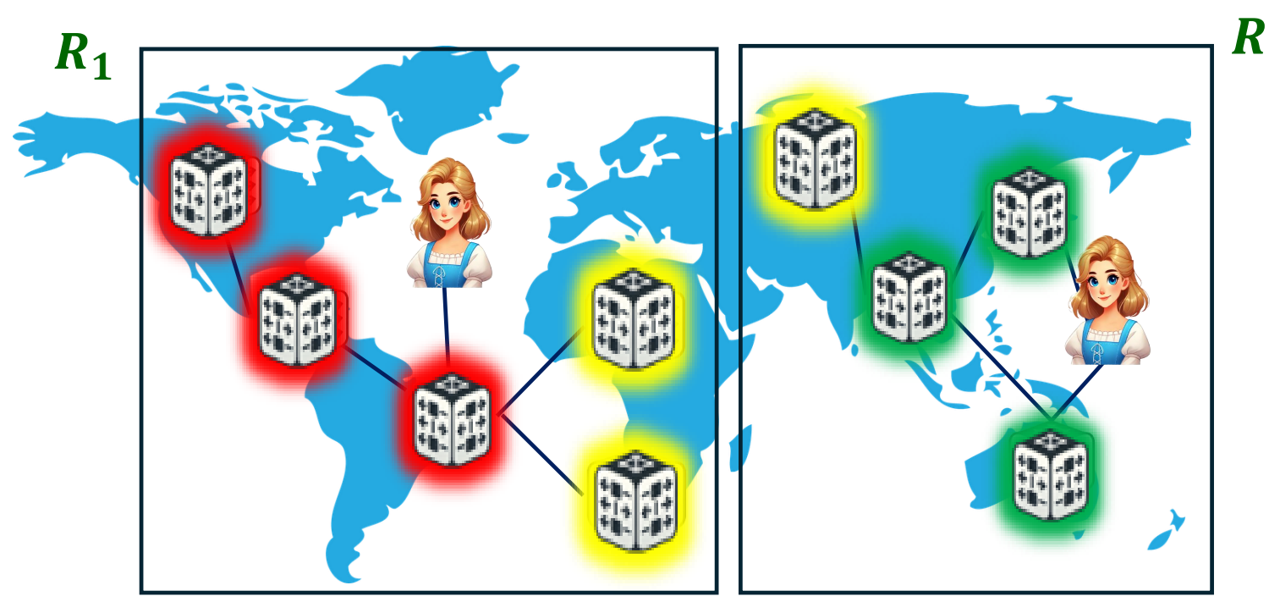
LAMP [2]



Single Circle (SC):
1- Super efficient approach
2- Moderate low-latency links



Multiple Circles (MC):
1- Efficient approach
2- Very low-latency links



Regional Mixnets (RM):
1- Efficient approach
2- Variant low-latency links

Results

Approach \ Metrics	Latency	Entropy	Gain	Complexity
Vanilla	153.4 ms	5.9 bits	38.5	t
LARMix [1]	68 ms	3.9 bits	57.35	13958t
Single Circle [2]	52 ms	4.2 bits	80.77	t
Multiple Circles [2]	20 ms	3.8 bits	190	56t
Regional Mixnet (EU) [2]	18 ms	3.75 bits	208.3	8t
Regional Mixnet (NA) [2]	46 ms	2.4 bits	52.2	t

Conclusions

Hiding who communicates with whom is **necessary** on the Internet.

Mixnets provide **high degree of anonymity** at the cost of **high latency**.

To reduce the high latency, we can use **LAMP** which improves the **performance** of mixnets by up to **87%**.

Acknowledgments
This work is supported by CyberSecurity Research Flanders.

References

[1]. M. Rahimi, P. Kumar & C. Diaz, “LARMix: Latency-Aware Routing in Mix Networks,” in NDSS 2024: 31st Symposium on Network and Distributed System Security, Internet Society.

[2]. M. Rahimi, P. Kumar & C. Diaz, “LAMP: Lightweight Approaches for Latency Minimization in Mixnets with Practical Deployment Considerations,” in NDSS 2025: 32nd Symposium on Network and Distributed System Security, Internet Society.