Making use of Double Hashing for Privacy

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IPFS þing
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Work from the libp2p privacy discussion group

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- Erik Daniel - TU Berlin
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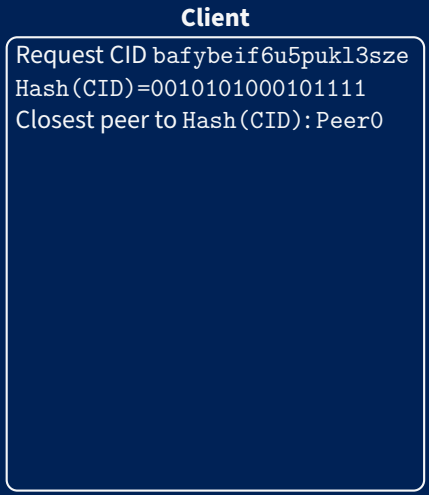
Double Hashing in IPFS

Hash() $\rightarrow$ 00100111011001001110001 10

CID $\rightarrow$ bafybeiaqr6csdcnxrkpx23oithpjt

Hash(CID) $\rightarrow$ 111010000011001011110101

IPFS content lookup (simplified)



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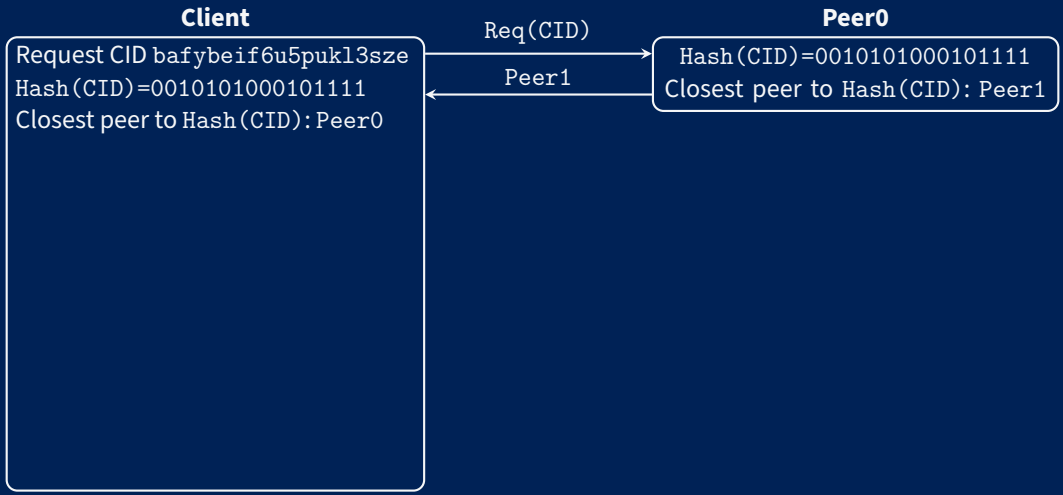

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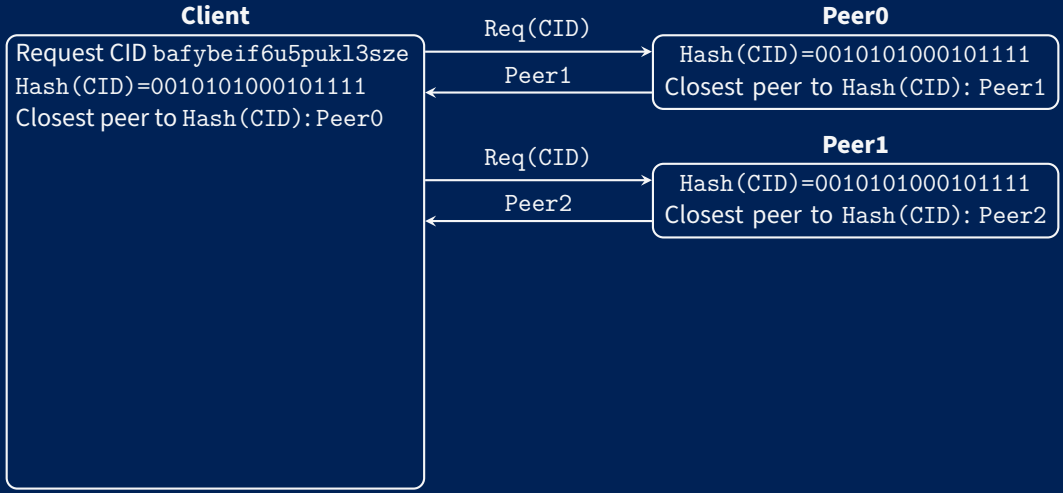

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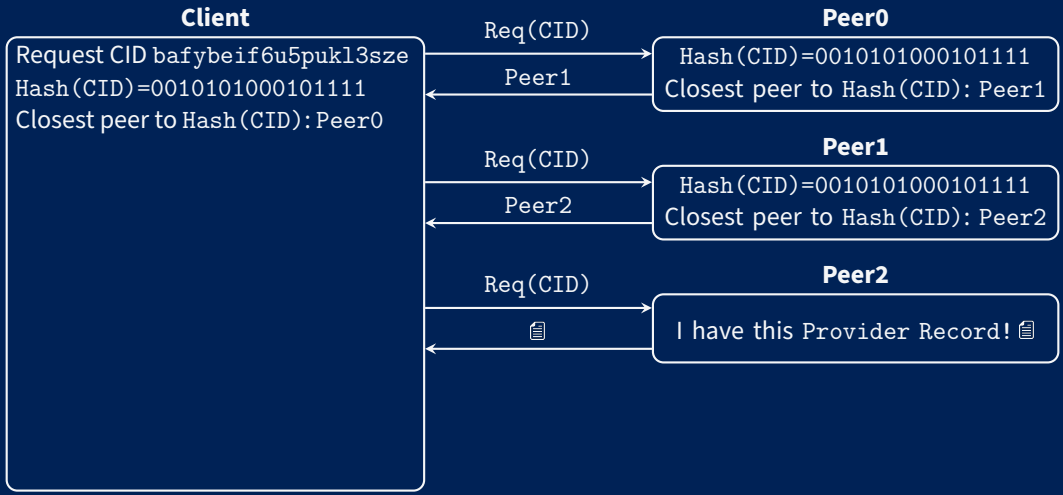

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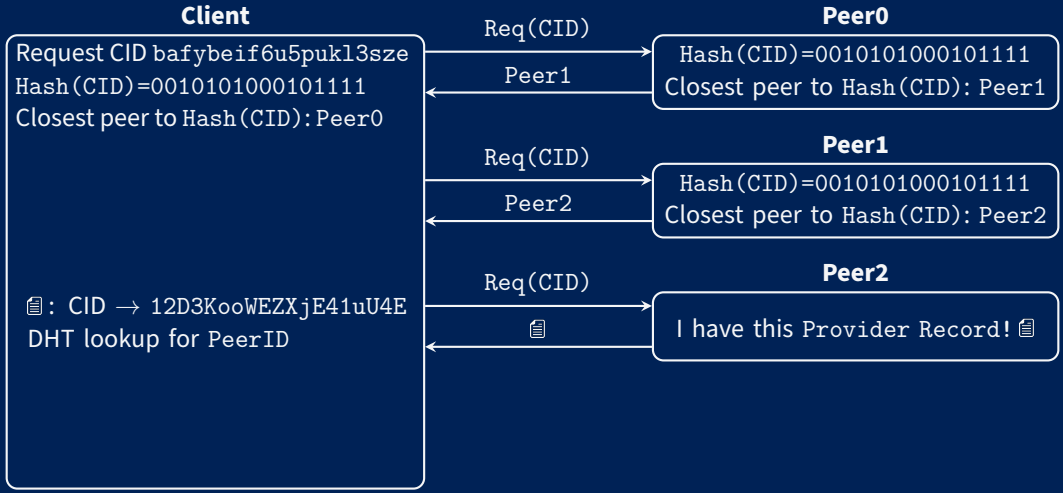

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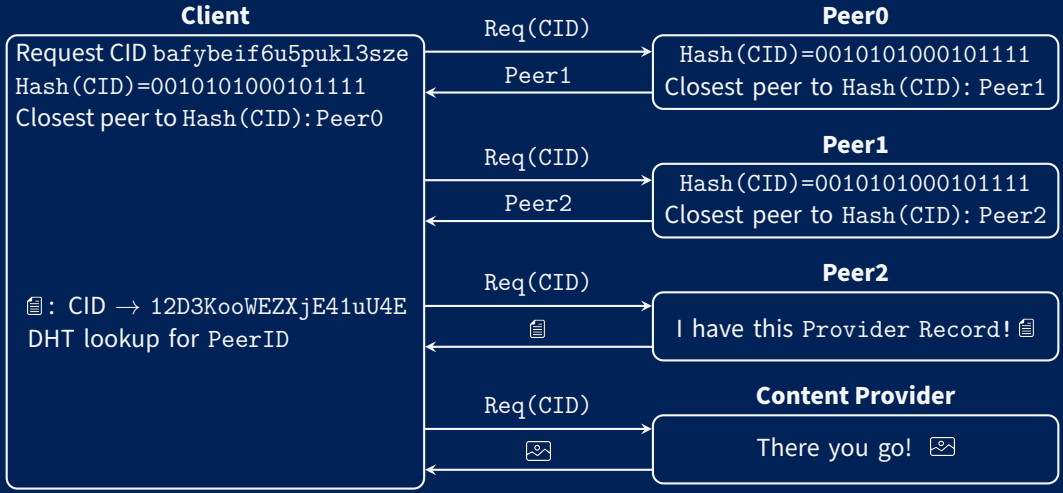
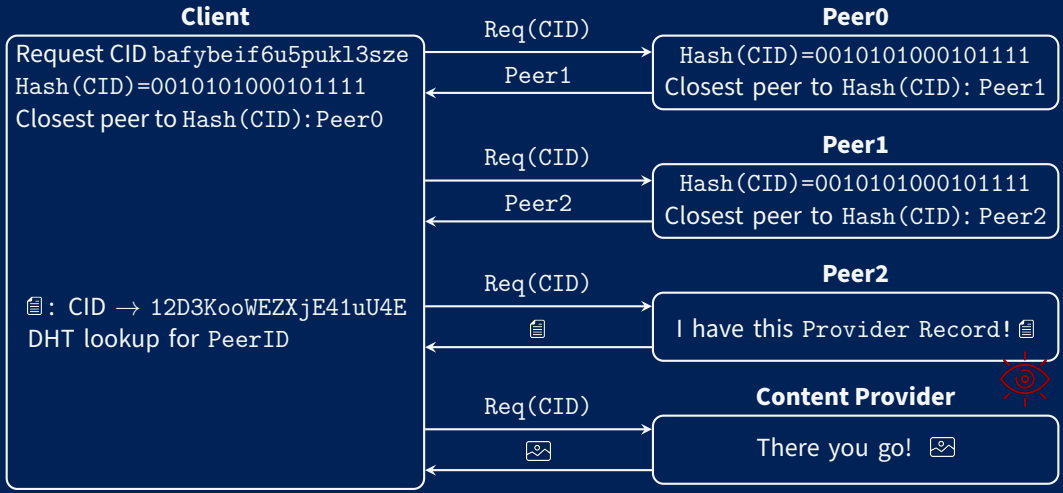


Who can see my requests?



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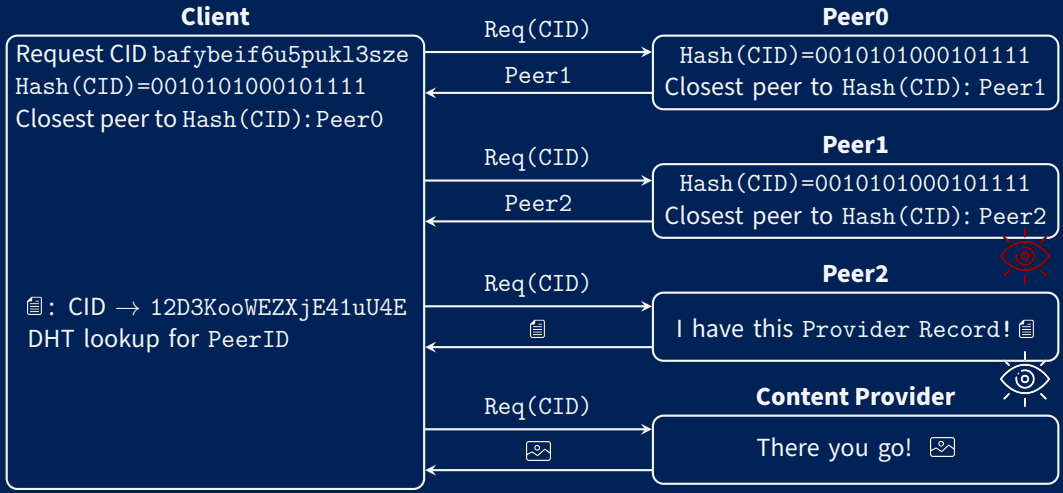

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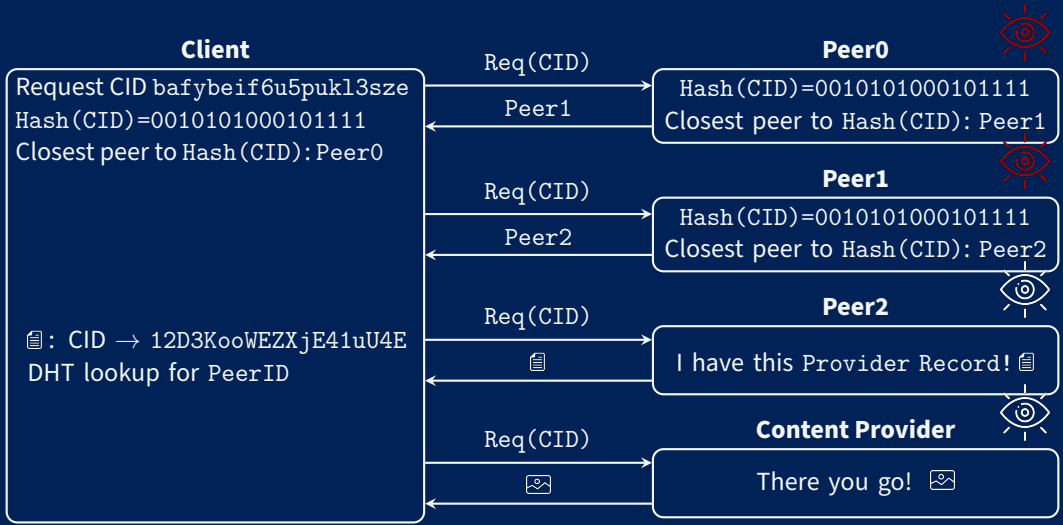

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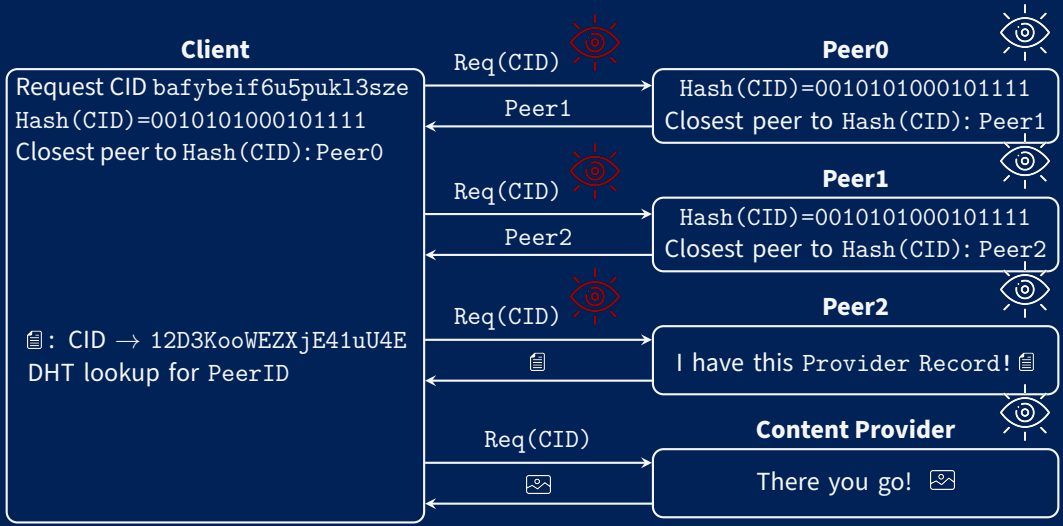


Problem definition

We want to improve *Client Privacy* in the DHT. We want to hide Content Requests from the DHT nodes and passive observers.

We do not address:

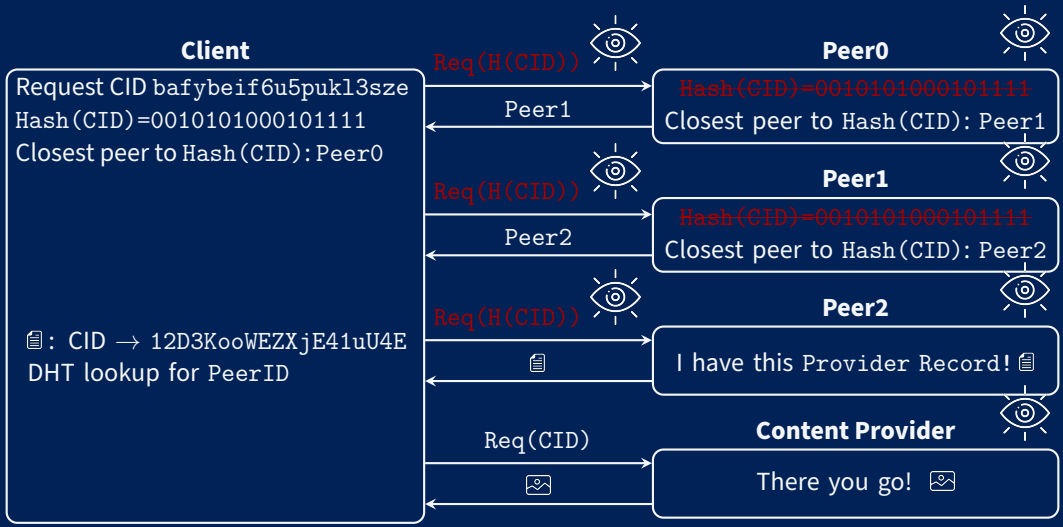
- Content Provider Privacy
- Bitswap Privacy
- Client Privacy from the Content Provider
- Client Privacy from the Gateways

Prefix lookup

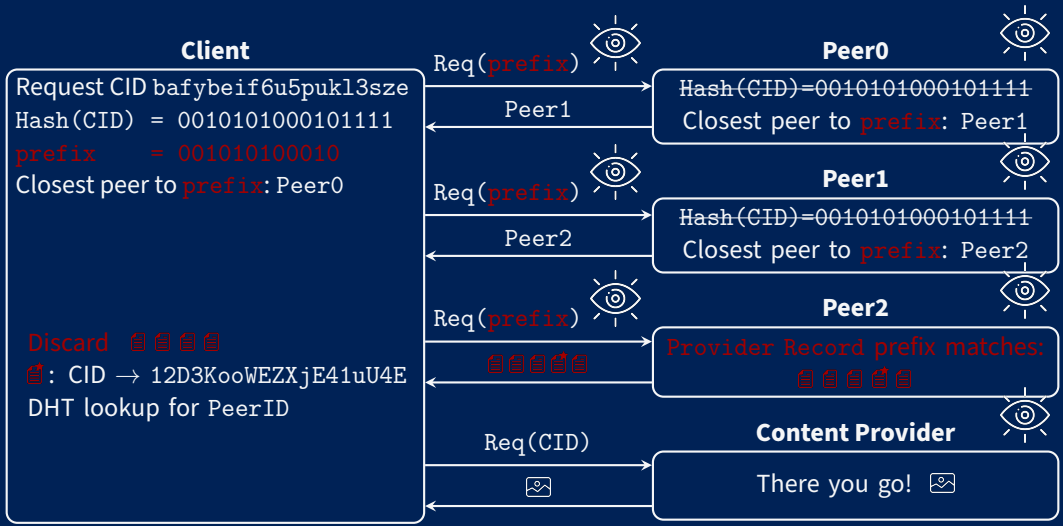
We want to request a prefix of the content to hide the exact CID. But:

- `Hash(bafybeif6u5pukl3szе)` $\neq$ `Hash(bafybeif6u5puk)`
- Request cannot be routed in the DHT $\rightarrow$ the content cannot be accessed
- We want to request a prefix of `Hash(bafybeif6u5pukl3szе)`
- DHT Routing process has to be adapted

First change: Request Hash(CID)

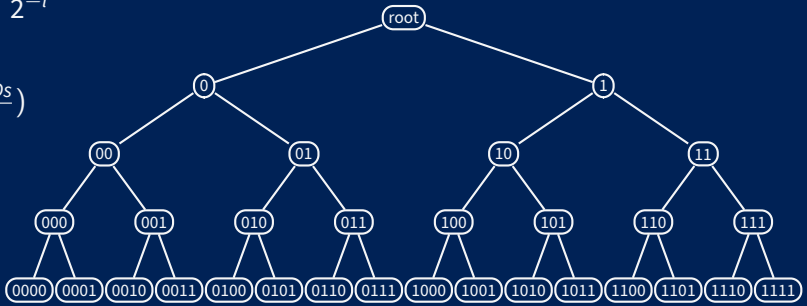


Second change: Request a prefix of Hash(CID)



Prefix Length Selection

- Prefix Length: l
- `k-anonymity`: The requested Provider Record can not be distinguished from at least $k - 1$ other Provider Records
- $k = \#CIDs \times 2^{-l}$
- $\frac{\#CIDs}{k} = 2^l$
- $l = log_2(\frac{\#CIDs}{k})$



Privacy gains

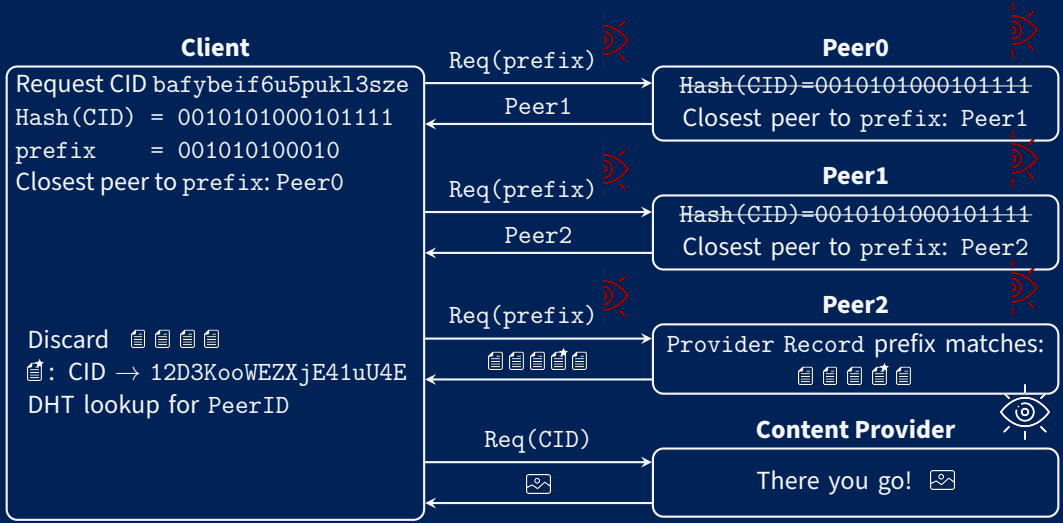
`k-anonymity` and plausible deniability from:

- DHT routing nodes
- DHT node storing the Provider Record
- Passive observers

But:

- No `l-diversity` nor `t-closeness`
- Network overhead: transmit *k* Provider Records instead of 1
- It is easy for observers to replay the same prefix request, and resolve all Provider Records matching this prefix

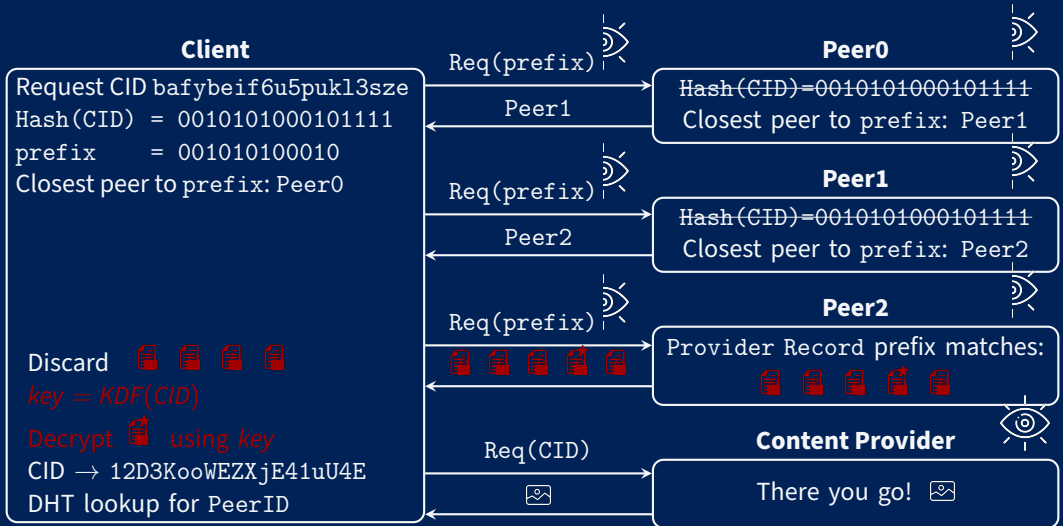
Privacy gains



Provider Records Encryption

- Provider Records encrypted before pinning
- Symmetric encrypted e.g `AES-256`
- $key = KDF(CID)$
- Having access to `Hash(CID)` is not enough to read the Provider Record
- Only nodes knowing the CID can read the Provider Record

Provider Records Encryption

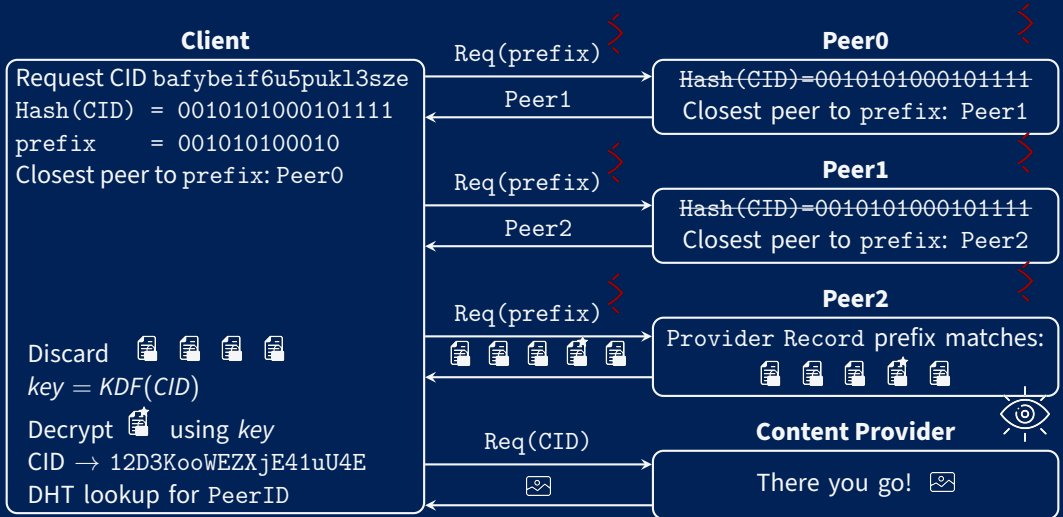


Privacy Gains

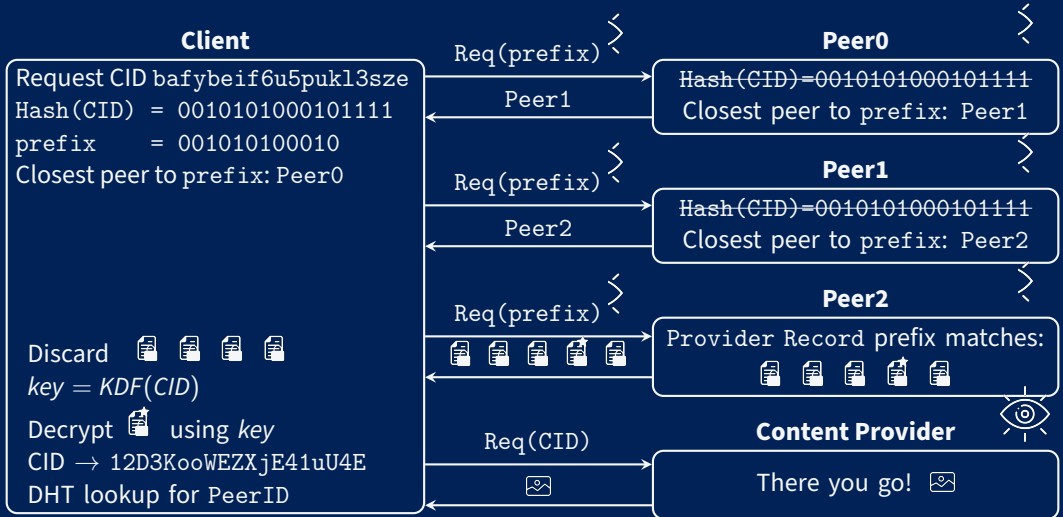
- Observers can only decrypt the Provider Records of which they know the CID
- DHT nodes storing the Provider Records don’t know the accessed Provider Record
- Bonus: The Content Provider gains privacy from the DHT nodes storing the Provider Record

- Downside: The client has to perform one decryption operation

Privacy Gains



Privacy Gains



Conclusion

- We can significantly improve privacy in the DHT!
- DHT servers don’t need to hash the CID for every request
- Network overhead: sending *k* Provider Records instead of 1
- Computation overhead: one symmetric decryption for the Provider Record
- Require to modify the server code and republish all Provider Records
- Illusion of privacy