Extending the Anonymity of Zcash

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1. INTRODUCTION

Although Bitcoin [6] in its original whitepaper stated that it offers anonymous transactions, de-anonymization techniques have found otherwise [6] [1]. Therefore, alternative cryptocurrencies, like Dash [4] Monero [3] and Zcash [1], were developed to provide better privacy. As Edward Snowden stated “Zcash’s privacy tech makes it the most interesting Bitcoin alternative […] because the privacy properties of it are truly unique”. Zcash’s privacy is based on peer-reviewed cryptographic constructions, hence it is considered to provide the foundations for the best anonymity. However, even Zcash makes some privacy concessions. It does not protect users’ privacy in the presence of a global adversary who is able to observe the whole network, and hence correlate the parties exchanging money, by using their network addresses. The recent empirical analysis of Zcash [4] shows, that users often choose naive ways while performing the protocol operations, not realising that it degrades their anonymity.

In this talk, we will discuss an extension of Zcash using mix networks to enhance the privacy guarantees of users that choose to remain anonymous by tackling two major security challenges: one at the application layer of the scheme and one at its network layer.

2. ZCASH IN A NUTSHELL

Zcash offers two types of user addresses, the t-address, which is also used in Bitcoin, and the z-address, which has the purpose of hiding the identity of its owner. Zcash inherits Bitcoin’s functionality, in the sense that the sender may choose to perform a transparent transaction (t-to-t), in which both the spender and the recipient of the coins are identified by a t-address. However, transparent transactions enable tracking the whole transaction history of any given coin. In order to break the link between senders and recipients, Zcash enables a user to transact privately, either through a shielded transaction (t-to-z in which the recipient’s address remains hidden, a deshielded (z-to-t) one in which the sender’s address remains hidden; or a private (z-to-z) one, in which both of the addresses are unknown and the value of the spent coin remains secret.

Attacks on Zcash’s anonymity

Although applied to different layers, both of the attacks we describe below have a common goal: To correlate a t-to-z transaction with a z-to-t one, hence to identify the two end t-addresses that are involved in this sequence of transactions. The first attack, at the application layer, can be performed by anyone with access to the Zcash blockchain, whereas the second one, at the network layer, can be applied by a global passive adversary (GPA) who observes the whole Zcash P2P network.

Application Layer: In a t-to-z transaction, Zcash specifies that the sender must select two distinct destination z- addresses, like z1 and z2 in Figure 1, to give the incentive to the user to split the coin into two coins and avoid a withdrawal of the same value that was earlier deposited. However, as the analysis in [1] showed, most users send the entire coin value to z1 and 0 ZEC to z2, as shown in TX1 in Figure 1. This allows the adversary to correlate the transactions TX1 and TX2.

Network Layer: As recent revelations show, Bitcoin is under an extensive surveillance from the NSA, which monitors its blockchain and global traffic in order to identify users and their transactions. This shows that a GPA capable of observing the P2P network is not a theoretical bugbear, but a realistic danger. Therefore, it is crucial to secure the cryptocurrency at its network level and protect the privacy of the users. A GPA who is able to observe the Zcash network can easily discover the network addresses of users who broadcast, hence correlate their transactions [2]. This attack is applicable to most of the deployed cryptocurrencies. Tor [4] has been suggested as a possible defence, however, as...
shown in [2] it is not an ultimate solution since even a low-
resourced adversary can perform attacks. These not only
deanonimize the participants of the transaction but more
importantly allow the adversary to control which blockchain
state is visible to the users or which transactions are relayed
to them. Moreover, Tor is not resistant to a GPA, therefore
it is not suitable for our threat model.

3. MIXES FOR ANONYMITY

A mix network [3] is a sequence of cryptographic relays,
that hides network level metadata, by using end-to-end lay-
ered encryption and secret mixing of packets. The more
packets are mixed together, the better anonymity. There-
fore, traditional mix networks used long batching times and
cover traffic, thus significantly limiting their usage to only
high-latency communication. Recent research shows [7] that
it is possible to build low-latency mix networks by using tun-
able cover traffic and delays. In contrast to Tor, mix net-
woks protect the users` privacy even in the presence of a
GPA performing sophisticated traffic analysis. In this talk,
we want to discuss the idea of using mix networks as the
proxy between the users and the Zcash network. Imple-
menting a mix network over Zcash would ensure that users` trans-
actions remain anonymous even if the adversary is able
to observe the communication channel between the users` local
networks and the whole P2P network. Merging mix
networks with cryptocurrencies has a bilateral benefit. On
one hand, it allows for truly anonymous transactions. On
the other hand, it offers another use-case for mix networks,
thus increases their potential.

4. OUR SCHEME

In our proposal, we leverage a mix network as a proxy
channel between the users and the Zcash network. The mix
network would serve the two following roles:

Broadcast. It would be responsible for broadcasting all of
the users` transactions to the P2P network. The user encap-
sulates the transaction into the cryptographic packet format
and passes it to the first mix server. Thanks to that, only
the first server in the mix chain knows the network address
of the user and every other server learns only the address
of the previous and the next server. The last server in the
chain is responsible for broadcasting the decrypted trans-
action into the Zcash network. Hence, the network layer
attack is now impossible since the network address of the
user is only visible to the GPA in the user`s network and it
cannot be correlated with any transaction in the blockchain,
since the encryption of the packet hides its source, and the
broadcasting address belonging to the mix server.

Suggest coin splitting. We suggest using mix servers as
advisors who recommend to the users the optimal split of
their coins, hence help them protect themselves against ap-
plication layer attacks. Mix servers can aggregate infor-
mation about prior deposits into the pool and based on
this knowledge calculate the best strategy for splitting the
coins, which increases the anonymity set of the users. Such
blockchain analysis is very low-cost and can be performed by
modern personal computers. For example, Figure 4 shows
how Mix takes into consideration the transaction TX that
happened earlier by recommending to the user t1 to break
his coin X1 as X0 = X1 + X2.

5. DISCUSSION POINTS

The primary goal of this talk is to hear the community`s feedback and suggestions about the scheme, since such de-
sign raises many challenges, as well as to spur the discussion
regarding the anonymity of the cryptocurrencies. We intend
to debate the following points:

• Should the Zcash client enforce the users to transact ano-
mously by making the private transactions the only op-
tion, or should the choice remain? An interesting discus-
sion, as well, is whether and how we can give the users
the incentive to use the pool.

• In order to offer the anonymity properties, a mix network
uses additional delays, hence it would introduce additional
latency overhead for the transactions. In our opinion, a
thoroughly evaluated per hop delay does not significantly
increase the overall latency, hence does not degrade the
user experience.

• Some of the mix nodes can be malicious. One of the pos-
sible attacks that a corrupt mix can perform is a DoS at-
tack, in which the mix never transmits the received pack-
ets, hence decreases the system`s reliability. One possible
solution would be for the user to send the same packet
carrying a transaction to multiple mix cascades. More
importantly, the malicious mix servers cannot craft their
own transactions in order to steal users` money.

• In order to ensure that the shielded pool processes a large
enough number of transactions, hence guarantees anonymity,
and that the density of traffic in the mix net does not leak
any communication information, we have to use cover traf-
fic. The question of how much of such cover traffic is re-
quired opens up a new research challenge which we aim
to study.

• What are the requirements for such design in the opinion
of the research and developers communities.

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