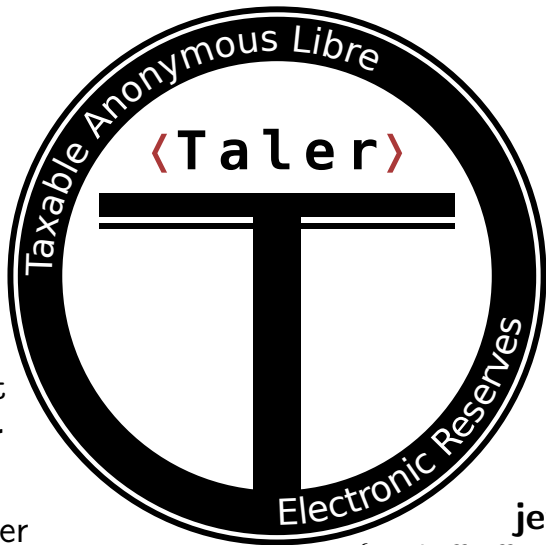


GNU



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jeff & sereni-t**

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A Social Problem

This was a question posed to RAND researchers in 1971:

“Suppose you were an advisor to the head of the KGB, the Soviet Secret Police. Suppose you are given the assignment of designing a system for the surveillance of all citizens and visitors within the boundaries of the USSR. The system is not to be too obtrusive or obvious. What would be your decision?”

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Mastercard/Visa are too transparent.

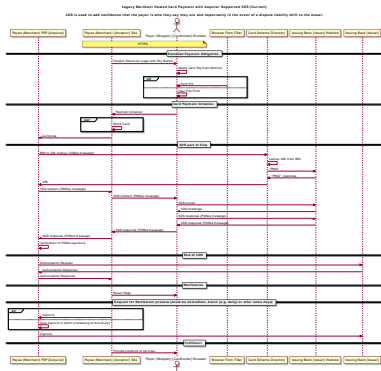
“I think one of the big things that we need to do, is we need to get a way from true-name payments on the Internet. The credit card payment system is one of the worst things that happened for the user, in terms of being able to divorce their access from their identity.”

—Edward Snowden, IETF 93 (2015)

The Bank's Problem

3D secure (“verified by visa”) is a nightmare:

- ▶ Complicated process
- ▶ Shifts liability to consumer
- ▶ Significant latency
- ▶ Can refuse valid requests
- ▶ Legal vendors excluded
- ▶ No privacy for buyers



Online credit card payments will be replaced, but with what?

The Bank's Problem

- ▶ Global tech companies push oligopolies
- ▶ Privacy and federated finance are at risk
- ▶ Economic sovereignty is in danger

The logo for PayPal, featuring the word "PayPal" in a blue, italicized sans-serif font with a trademark symbol.The logo for Alipay, consisting of the Chinese characters "支付宝" in blue and orange, with "Alipay.com" written below in orange.A yellow rectangular button with rounded corners. On the left is the Amazon logo (a lowercase 'a' with a smile). To its right is the text "Pay with Amazon". A mouse cursor is pointing at the bottom right corner of the button.The logo for Apple Pay, featuring the black Apple logo followed by the word "Pay" in a black sans-serif font.The logo for Samsung Pay, featuring the word "SAMSUNG" in white uppercase letters above the word "pay" in white lowercase letters, all inside a blue rounded square.The logo for Android Pay, featuring a green Android robot icon above the word "pay" in lowercase, all inside a white circle with a thin grey border.

The Distraction: Bitcoin

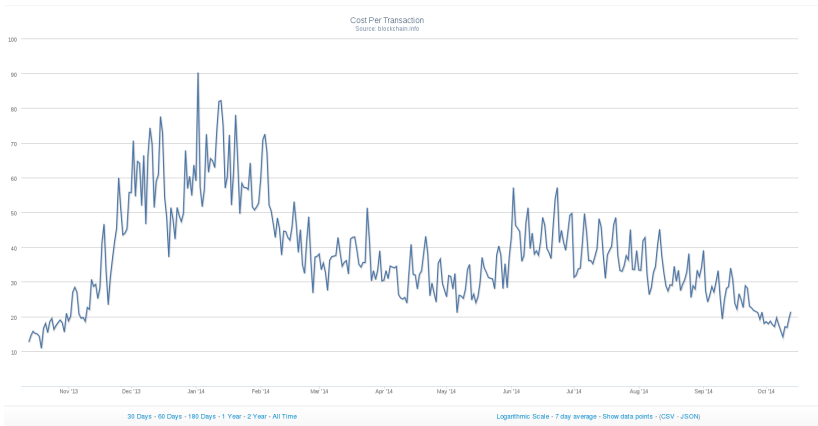
- ▶ Unregulated payment system and currency:
⇒ lack of regulation is a feature!
- ▶ Implemented in free software
- ▶ Decentralised peer-to-peer system

The Distraction: Bitcoin

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- ▶ Creative solution: tie initial accumulation to solving consensus

The Distraction: Bitcoin

- ▶ Unregulated payment system and currency:
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- ▶ Implemented in free software
- ▶ Decentralised peer-to-peer system
- ▶ Decentralised banking requires solving Byzantine consensus
- ▶ Creative solution: tie initial accumulation to solving consensus
 - ⇒ Proof-of-work advances ledger
 - ⇒ Very expensive banking



Current average transaction value: \approx 1000 USD



Cryptography is rather primitive:

All Bitcoin transactions are public and linkable!

⇒ no privacy guarantees

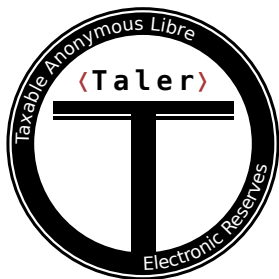
⇒ enhanced with “laundering” services

ZeroCoin, CryptoNote (Monero) and ZeroCash (ZCash) offer anonymity.

Do you want to have a libertarian economy?

Do you want to live under total surveillance?

Digital cash, made socially responsible.



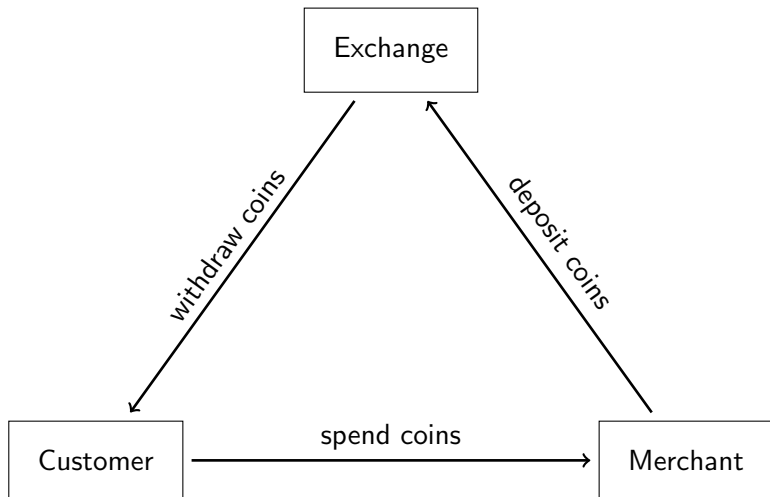
Privacy-Preserving, Practical, Taxable, Free Software, Efficient

What is Taler?

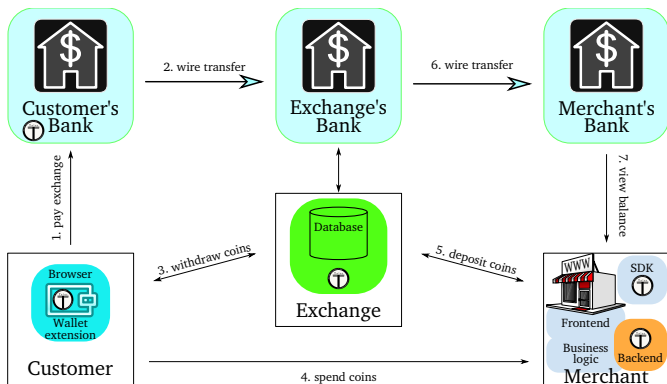
Taler is an electronic instant payment system.

- ▶ Uses electronic coins stored in **wallets** on customer's device
- ▶ Like **cash**
- ▶ Pay in **existing currencies** (i.e. EUR, USD, BTC), or use it to create new **regional currencies**

Taler Overview



Architecture of Taler



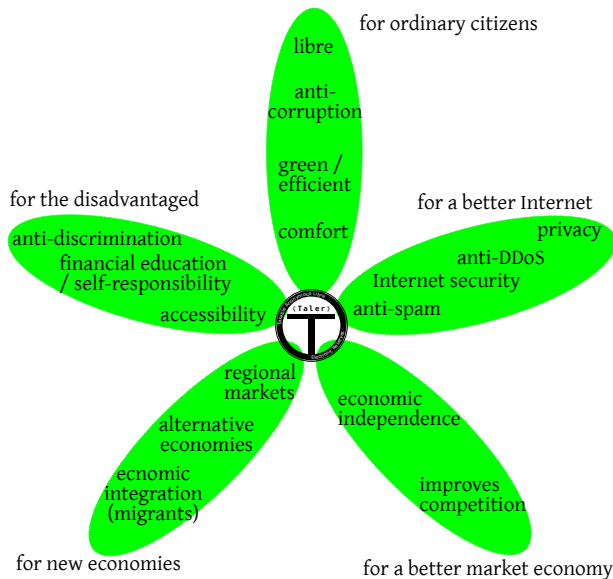
⇒ Convenient, taxable, privacy-enhancing, & resource friendly!

Usability of Taler

`https://demo.taler.net/`

1. Install Chrome extension.
2. Visit the `bank.demo.taler.net` to withdraw coins.
3. Visit the `shop.demo.taler.net` to spend coins.

Social Impact of Taler



Use Case: Journalism

Today:

- ▶ Corporate structure
- ▶ Advertising primary revenue
- ▶ Tracking readers critical for business success
- ▶ Journalism and marketing hard to distinguish

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With GNU Taler:

- ▶ One-click micropayments per article
- ▶ Hosting requires no expertise
- ▶ Reader-funded reporting separated from marketing
- ▶ Readers can remain anonymous

Use Cases: Refugee Camps

Today:

- ▶ Non-bankable
- ▶ Direct distribution of goods to population
- ▶ Limited economic activity in camps
- ▶ High level of economic dependence

Use Cases: Refugee Camps

Today:

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- ▶ High level of economic dependence

With GNU Taler:

- ▶ Local currency issued as basic income backed by aid
- ▶ Taxation possible based on economic status
- ▶ Local governance enabled by local taxes
- ▶ Increased economic independence and political participation

Use Case: Anti-Spam

Today, PGP provides authenticated encryption for e-mail:

- ▶ Free software
- ▶ Easy to use opportunistic encryption
- ▶ Available for Outlook, Android, Enigmail
- ▶ Spies & spam filters can no longer inspect content

Use Case: Anti-Spam

Today, p≡p provides authenticated encryption for e-mail:

- ▶ Free software
- ▶ Easy to use opportunistic encryption
- ▶ Available for Outlook, Android, Enigmail
- ▶ Spies & spam filters can no longer inspect content

With GNU Taler:

- ▶ Peer-to-peer payments via e-mail
- ▶ If unsolicited sender, hide messages from user & automatically request payment from sender
- ▶ Sender can attach payment to be moved to inbox
- ▶ Receiver may grant refund to sender

Taxability

We say Taler is taxable because:

- ▶ Merchant's income is visible from deposits.
- ▶ Hash of contract is part of deposit data.
- ▶ State can trace income and enforce taxation.

Taxability

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Limitations:

- ▶ withdraw loophole
- ▶ *sharing* coins among family and friends

How does it work?

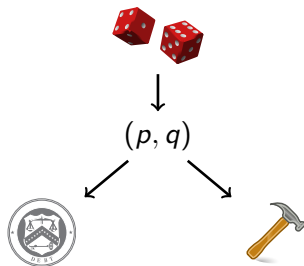
We use a few ancient constructions:

- ▶ Cryptographic hash function (1989)
- ▶ Blind signature (1983)
- ▶ Schnorr signature (1989)
- ▶ Diffie-Hellman key exchange (1976)
- ▶ Cut-and-choose zero-knowledge proof (1985)

But of course we use modern instantiations.

Exchange setup: Create a denomination key (RSA)

1. Pick random primes p, q .
2. Compute $n := pq$,
 $\phi(n) = (p - 1)(q - 1)$
3. Pick small $e < \phi(n)$ such that
 $d := e^{-1} \pmod{\phi(n)}$ exists.
4. Publish public key (e, n) .



Merchant: Create a signing key (EdDSA)

- ▶ pick random $m \pmod{o}$ as private key
- ▶ $M = mG$ public key



↓
 m

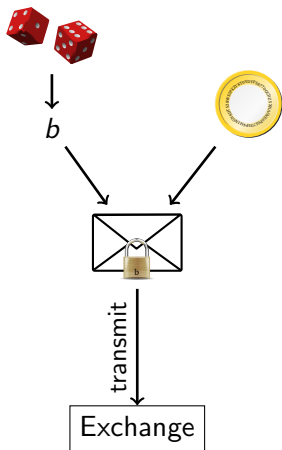
↓
 M

Capability: $m \Rightarrow$



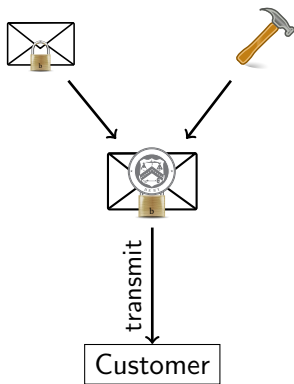
Customer: Blind planchet (RSA)

1. Obtain public key (e, n)
2. Compute $f := FDH(C)$, $f < n$.
3. Pick blinding factor $b \in \mathbb{Z}_n$
4. Transmit $f' := fb^e \pmod n$



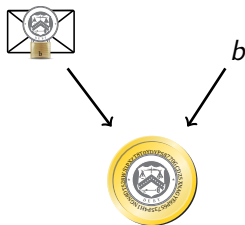
Exchange: Blind sign (RSA)

1. Receive f' .
2. Compute $s' := f'^d \pmod n$.
3. Send signature s' .

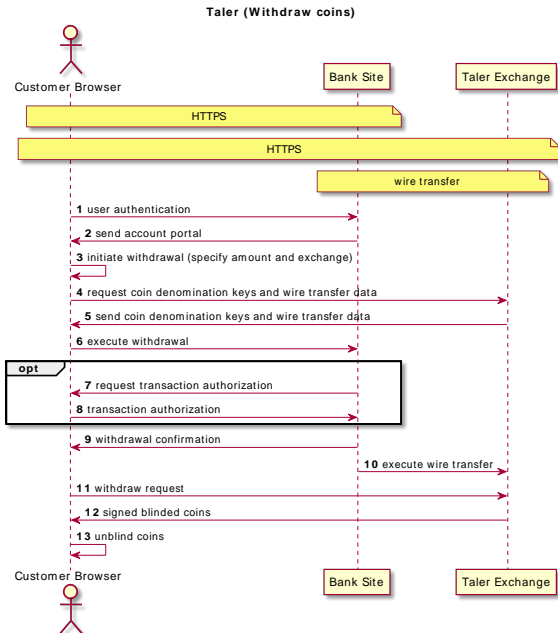


Customer: Unblind coin (RSA)

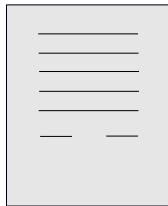
1. Receive s' .
2. Compute $s := s'b^{-1} \pmod n$



Withdrawing coins on the Web



Customer: Build shopping cart



transmit



Merchant

Merchant Integration: Wallet Detection

```
<script src="taler-wallet-lib.js"></script>
<script>
  taler.onPresent(() => {
    alert("Taler_wallet_is_installed");
  });
  taler.onAbsent(() => {
    alert("Taler_wallet_is_not_installed");
  });
</script>
```

Merchant Integration: Payment Request

```
HTTP/1.1 402 Payment Required
Content-Type: text/html; charset=UTF-8
X-Taler-Contract-Url: https://shop/generate-contract/42
```

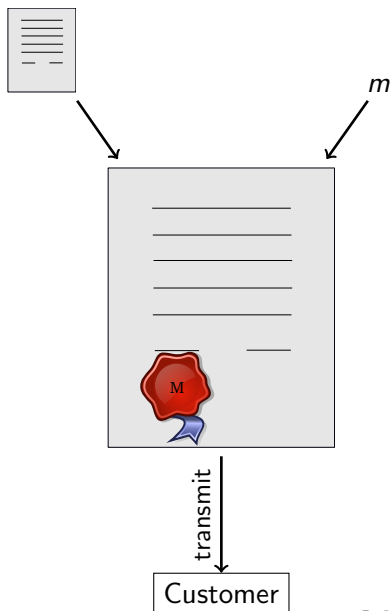
```
<!DOCTYPE html>
<html>
  <!-- fallback for browsers without the Taler extension -->
  You do not seem to have Taler installed, here are other
  payment options ...
</html>
```

Merchant Integration: Contract

```
{  
  "H_wire": "YTHOC4QBCQ10VDNTJNODCTTV2Z6JHT5NF43FORQHZ8JYB5NG4W4G...",  
  "amount": {"currency": "EUR", "fraction": 0, "value": 1},  
  "max_fee": {"currency": "EUR", "fraction": 100000, "value": 0},  
  "auditors": [{"auditor_pub": "42V6TH91Q83FB846DK1GW3JQ5E8DS273W4..."}],  
  "exchanges": [{"master_pub": "1T5FA8VQHMMKBHDMYPRZA2ZFK2S63AKFOY...",  
    "url": "https://exchange/"}],  
  "fulfillment_url": "https://shop/article/42?tid=249&time=14714744",  
  "merchant": {"address": "Mailbox_4242", "jurisdiction": "Jersey",  
    "name": "Shop_Inc."},  
  "merchant_pub": "Y1ZAR5346J3ZTEXJCHQY9NJN78EZ2HSKZK8MOMYTNRJG5N...",  
  "products": [{"  
    "description": "Essay: The_GNU_Project",  
    "price": {"currency": "EUR", "fraction": 0, "value": 1},  
    "product_id": 42, "quantity": 1}],  
  "pay_deadline": "/Date(1480119270)/",  
  "refund_deadline": "/Date(1471522470)/",  
  "timestamp": "/Date(1471479270)/",  
  "transaction_id": 249960194066269  
}
```

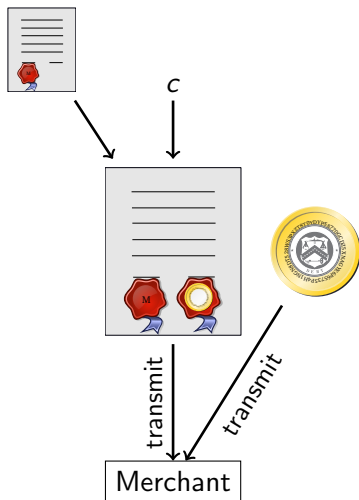
Merchant: Propose contract (EdDSA)

1. Complete proposal D .
2. Send $D, EdDSA_m(D)$



Customer: Spend coin (EdDSA)

1. Receive proposal D ,
 $EdDSA_m(D)$.
2. Send s , C , $EdDSA_c(D)$

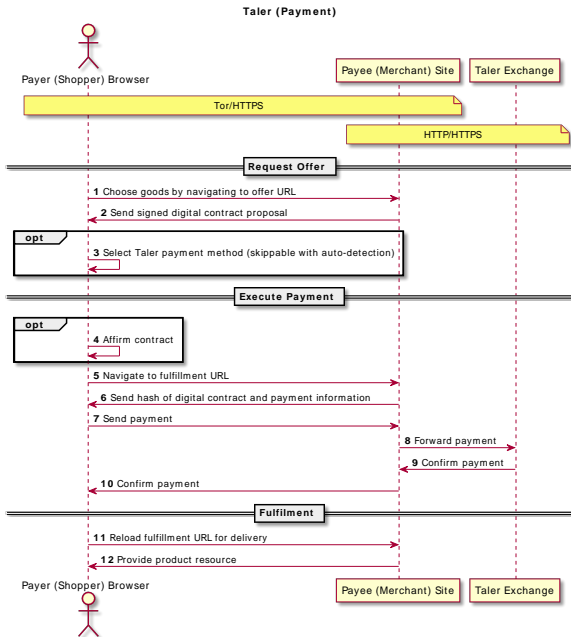


Merchant and Exchange: Verify coin (RSA)

$$s^e \stackrel{?}{\equiv} m \pmod{n}$$



Payment processing with Taler



Giving change

It would be inefficient to pay EUR 100 with 1 cent coins!

- ▶ Denomination key represents value of a coin.
- ▶ Exchange may offer various denominations for coins.
- ▶ Wallet may not have exact change!
- ▶ Usability requires ability to pay given sufficient total funds.

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- ▶ maintain unlinkability
- ▶ maintain taxability of transactions

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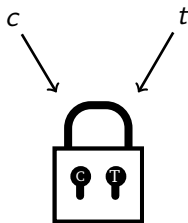
- ▶ maintain unlinkability
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Method:

- ▶ Contract can specify to only pay *partial value* of a coin.
- ▶ Exchange allows wallet to obtain *unlinkable change* for remaining coin value.

Diffie-Hellman (ECDH)

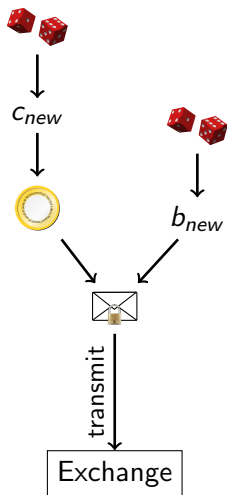
1. Create private keys $c, t \pmod{o}$
2. Define $C = cG$
3. Define $T = tG$
4. Compute DH
 $cT = c(tG) = t(cG) = tC$



Strawman solution

Given partially spent private coin key c_{old} :

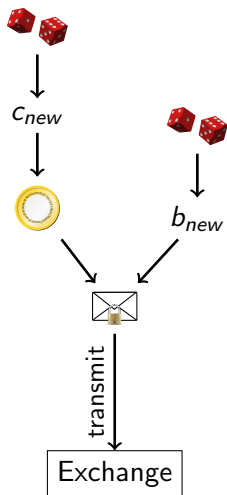
1. Pick random c_{new} mod o private key
 2. $C_{new} = c_{new}G$ public key
 3. Pick random b_{new}
 4. Compute $f_{new} := FDH(C_{new})$, $m < n$.
 5. Transmit $f'_{new} := f_{new}b_{new}^e \pmod n$
- ... and sign request for change with c_{old} .



Strawman solution

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 2. $C_{new} = c_{new}G$ public key
 3. Pick random b_{new}
 4. Compute $f_{new} := FDH(C_{new})$, $m < n$.
 5. Transmit $f'_{new} := f_{new}b_{new}^e$ mod n
- ... and sign request for change with c_{old} .

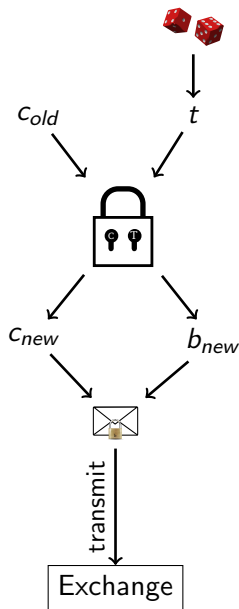


Problem: Owner of C_{new} may differ from owner of C_{old} !

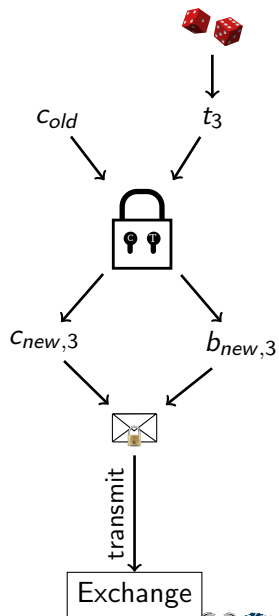
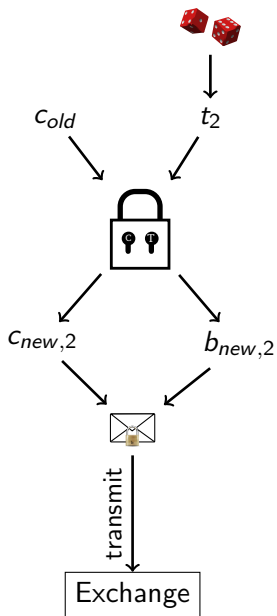
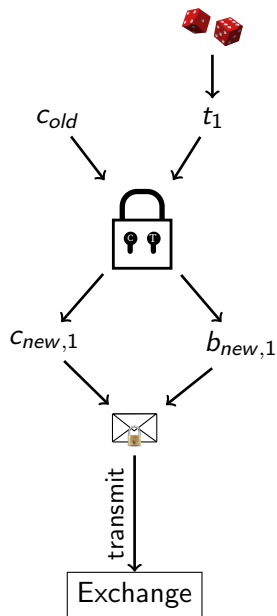
Customer: Transfer key setup (ECDH)

Given partially spent private coin key c_{old} :

1. Let $C_{old} := c_{old}G$ (as before)
2. Create random private transfer key $t \bmod o$
3. Compute $T := tG$
4. Compute $X := c_{old}(tG) = t(c_{old}G) = tC_{old}$
5. Derive c_{new} and b_{new} from X
6. Compute $C_{new} := c_{new}G$
7. Compute $f_{new} := FDH(C_{new})$
8. Transmit $f'_{new} := f_{new}b_{new}^e$



Cut-and-Choose



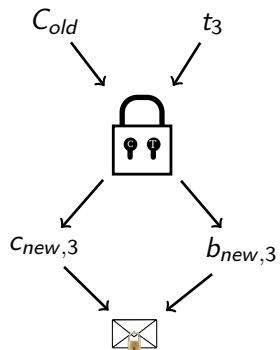
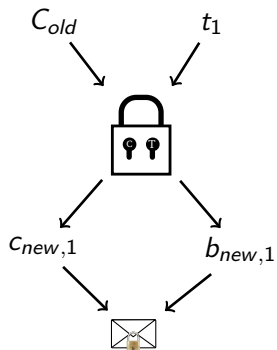
Exchange: Choose!

Exchange sends back random $\gamma \in \{1, 2, 3\}$ to the customer.

Customer: Reveal

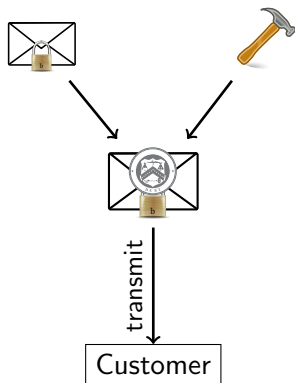
1. If $\gamma = 1$, send t_2, t_3 to exchange
2. If $\gamma = 2$, send t_1, t_3 to exchange
3. If $\gamma = 3$, send t_1, t_2 to exchange

Exchange: Verify ($\gamma = 2$)



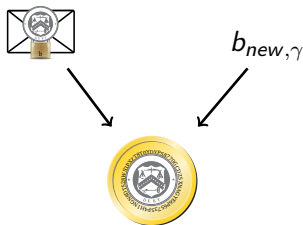
Exchange: Blind sign change (RSA)

1. Take $f'_{new,\gamma}$.
2. Compute $s' := f'^d_{new,\gamma} \pmod n$.
3. Send signature s' .



Customer: Unblind change (RSA)

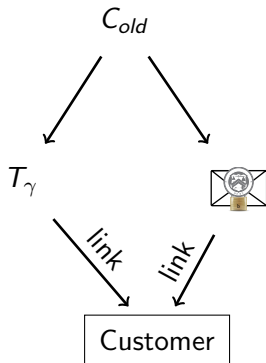
1. Receive s' .
2. Compute $s := s' b_{new,\gamma}^{-1} \pmod n$.



Exchange: Allow linking change

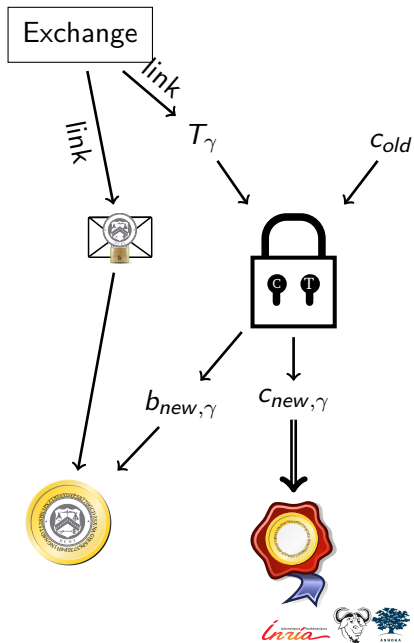
Given C_{old}

return $T_\gamma, s := s' b_{new,\gamma}^{-1} \bmod n.$



Customer: Link (threat!)

1. Have c_{old} .
2. Obtain T_γ, s from exchange
3. Compute $X_\gamma = c_{old} T_\gamma$
4. Derive $c_{new,\gamma}$ and $b_{new,\gamma}$ from X_γ
5. Unblind $s := s' b_{new,\gamma}^{-1} \pmod n$



Refresh protocol summary

- ▶ Customer asks exchange to convert old coin to new coin
- ▶ Protocol ensures new coins can be recovered from old coin
- ⇒ New coins are owned by the same entity!

Thus, the refresh protocol allows:

- ▶ To give unlinkable change.
- ▶ To give refunds to an anonymous customer.
- ▶ To expire old keys and migrate coins to new ones.
- ▶ To handle protocol aborts.

Transactions via refresh are equivalent to sharing a wallet.

Competitor comparison

	Cash	Bitcoin	Zerocoin	Creditcard	GNU Taler
Online	---	++	++	+	+++
Offline	+++	--	--	+	--
Trans. cost	+	----	----	-	++
Speed	+	----	----	o	++
Taxation	-	--	----	+++	+++
Payer-anon	++	o	++	----	+++
Payee-anon	++	o	++	----	----
Security	-	o	o	--	++
Conversion	+++	----	----	+++	+++
Libre	-	+++	+++	---	+++

How to support?

- ▶ Join: taler@gnu.org, #taler
- ▶ Coding & design: <https://gnunet.org/bugs/>
- ▶ Translation: https://git.taler.net/www.git/tree/locale/fr/LC_MESSAGES/messages.po
- ▶ Integration: <https://docs.taler.net/>
- ▶ Donations: <https://gnunet.org/ev>
- ▶ Funding: <https://taler.net/en/investors.html>

Conclusion

What can we do?

- ▶ Suffer mass-surveillance enabled by credit card oligopolies with high fees, and
- ▶ Engage in arms race with deliberately unregulatable blockchains, and
- ▶ Enjoy the “benefits” of cash



OR

- ▶ Establish free software alternative balancing social goals!

Do you have any questions?

References:

1. Christian Grothoff, Bart Polot and Carlo von Loesch. *The Internet is broken: Idealistic Ideas for Building a GNU Network*. **W3C/IAB Workshop on Strengthening the Internet Against Pervasive Monitoring (STRINT)**, 2014.
2. Jeffrey Burdges, Florian Dold, Christian Grothoff and Marcello Stanisci. *Enabling Secure Web Payments with GNU Taler*. **SPACE 2016**.
3. Florian Dold, Sree Harsha Totakura, Benedikt Müller, Jeffrey Burdges and Christian Grothoff. *Taler: Taxable Anonymous Libre Electronic Reserves*. Available upon request. 2016.
4. Eli Ben-Sasson, Alessandro Chiesa, Christina Garman, Matthew Green, Ian Miers, Eran Tromer and Madars Virza. *ZeroCash: Decentralized Anonymous Payments from Bitcoin*. **IEEE Symposium on Security & Privacy, 2016**.
5. David Chaum, Amos Fiat and Moni Naor. *Untraceable electronic cash*. **Proceedings on Advances in Cryptology, 1990**.
6. Phillip Rogaway. *The Moral Character of Cryptographic Work*. **Asiacrypt, 2015**.

Let money facilitate trade; but ensure capital serves society.