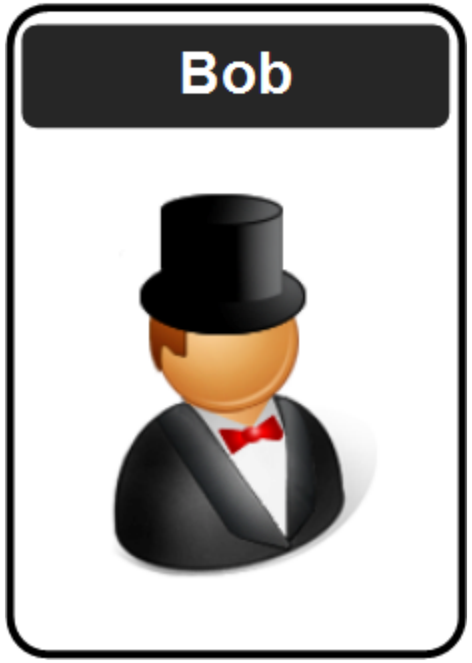


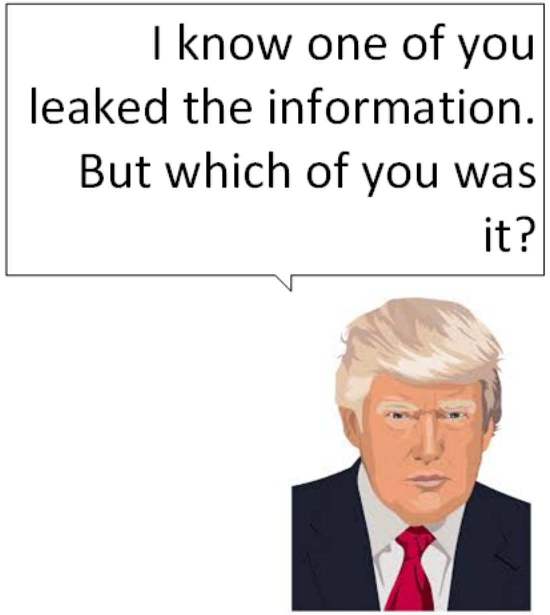
Python and Crypto:
Ring Signatures

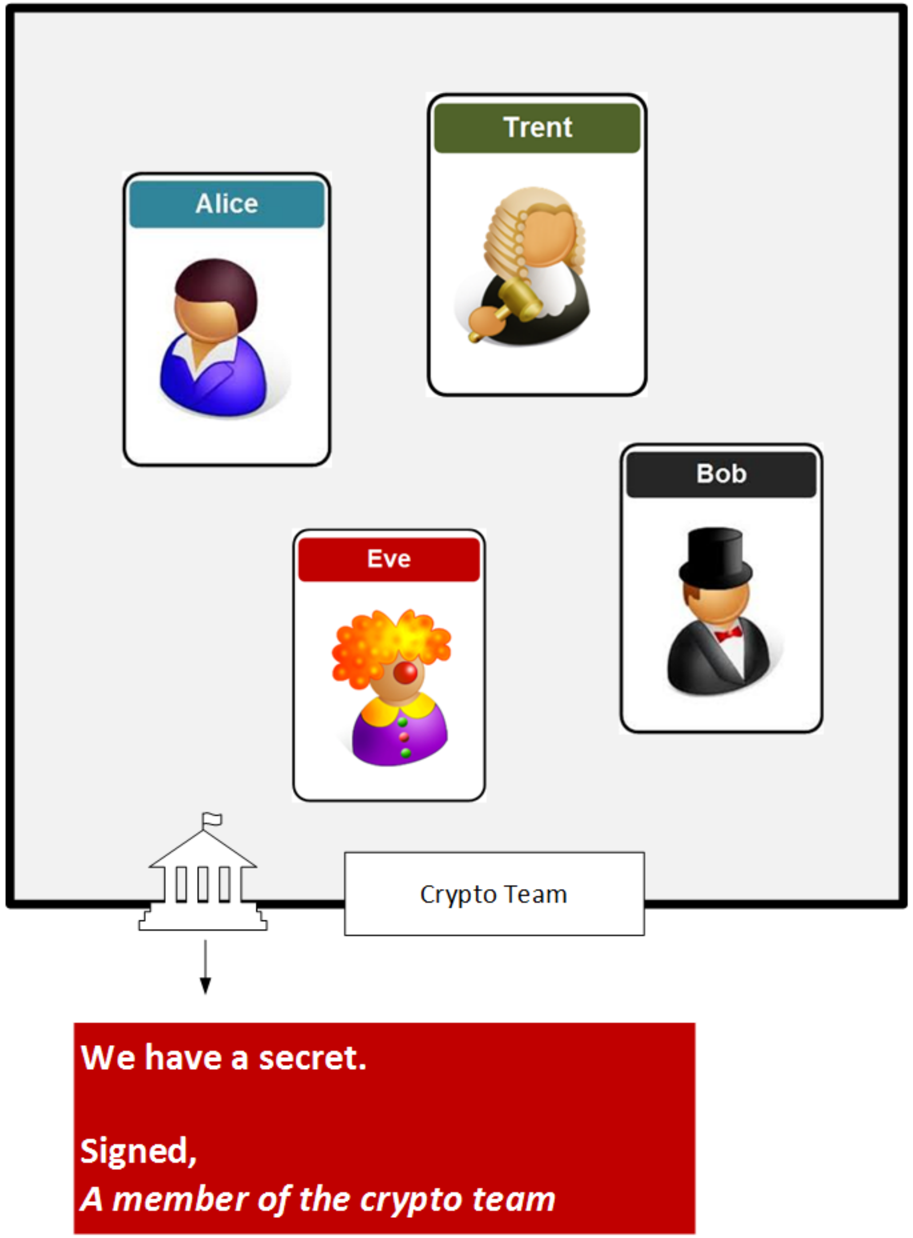
Prof Bill Buchanan OBE, The Cyber Academy

http://asecuritysite.com

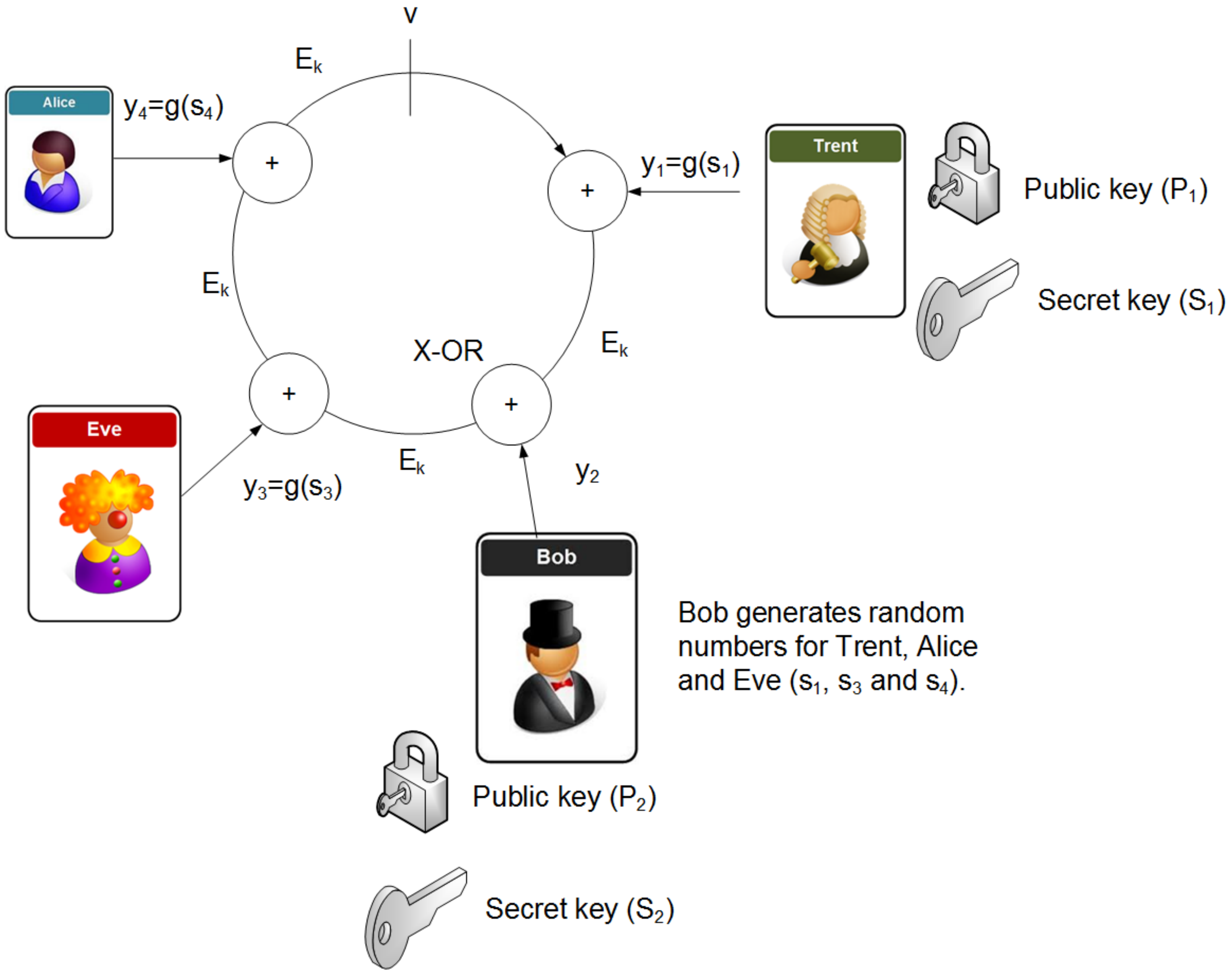
CYBER ACADEMY

Ring Signatures





Generating Signature



Bob generates random numbers for Trent, Alice and Eve (s_1, s_3 and s_4).

Generating Signature

Original seed generated: u

E_k = Hash(Message)

$v = E_k(u)$

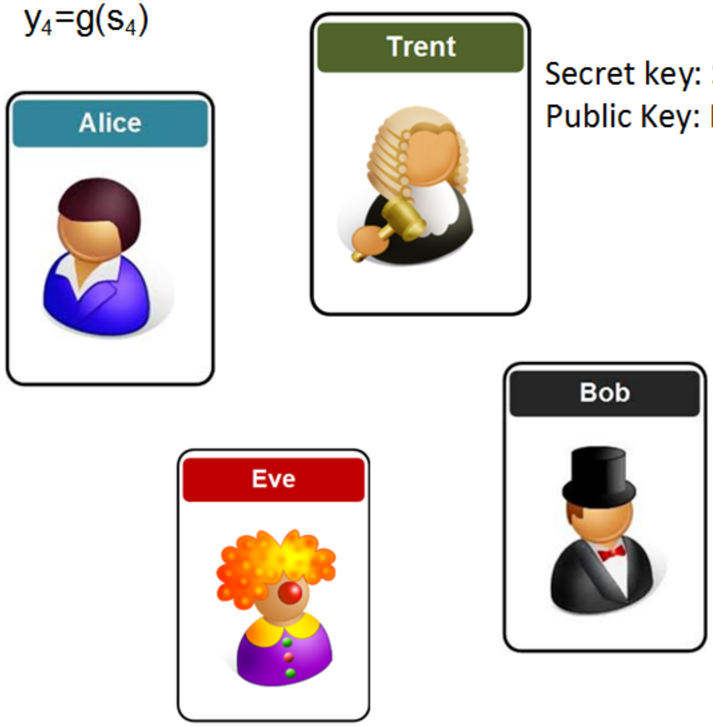
$v = E_k(s_1^{P1} \oplus v)$ — Fake secret key for Trent (s_1)

$v = E_k(s_3^{P3} \oplus v)$ — Fake secret key for Eve (s_3)

$v = E_k(s_4^{P4} \oplus v)$ — Fake secret key for Alice (s_4)

$y_1 = g(s_1)$

$y_4 = g(s_4)$



Secret key: S_1
Public Key: P_1

Secret key: S_2 (d)
Public Key: P_2 (e)

$y_3 = g(s_3)$

Bob now adds:

$v = E_k(u \oplus v)^d$

All the operations are conducted with (mod N_i)

Bob sends: {Message, v, P_1, P_2 ... P_r, s_1, s_2, ... s_r}

Verifying The Signature

Original seed generated: u

E_k = Hash(Message)

$v = E_k(u)$

$v = E_k(s_1^{p1} \oplus v)$ —— Fake secret key for Trent (s_1)

$v = E_k(s_3^{p3} \oplus v)$ —— Fake secret key for Trent (s_3)

$v = E_k(s_4^{p4} \oplus v)$ —— Fake secret key for Trent (s_4)

Bob now adds:

$v = E_k(u \oplus v)^d$

All the operations are conducted with (mod N_i)

E_k = Hash(Message)

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$v = E_k(s_4^{p4} \oplus v)$ —— Fake secret key for Trent (s_4)

$v = E_k\{(u \oplus v))^d\}^e$ -> u

Verifying The Signature

Original seed generated: u

E_k = Hash(Message)

$v = E_k(u)$

$v = E_k(s_1^{p1} \oplus v)$ — Fake secret key for Trent (s_1)

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Bob now adds:

$v = E_k(u \oplus v)^d$

All the operations are conducted with (mod N_i)


```
def sign(self, m, z):
    self.permut(m)
    s = [None] * self.n
    u = random.randint(0, self.q)
    c = v = self.E(u)
    for i in (range(z+1, self.n) + range(z)):
        s[i] = random.randint(0, self.q)
        e = self.g(s[i], self.k[i].e, self.k[i].n)
        v = self.E(v^e)
        if (i+1) % self.n == 0:
            c = v
    s[z] = self.g(v^u, self.k[z].d, self.k[z].n)
    return [c] + s

def verify(self, m, X):
    self.permut(m)
    def _f(i):
        return self.g(X[i+1], self.k[i].e, self.k[i].n)
    y = map(_f, range(len(X)-1))
    def _g(x, i):
        return self.E(x^y[i])
    r = reduce(_g, range(self.n), X[0])
    return r == X[0]
```

```
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    self.permut(m)
    s = [None] * self.n
    u = random.randint(0, self.q)
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        v = self.E(v^e)
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    s[z] = self.g(v^u, self.k[z].d, self.k[z].n)
    return [c] + s

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```

E_k = Hash(Message)

$v = E_k(u)$

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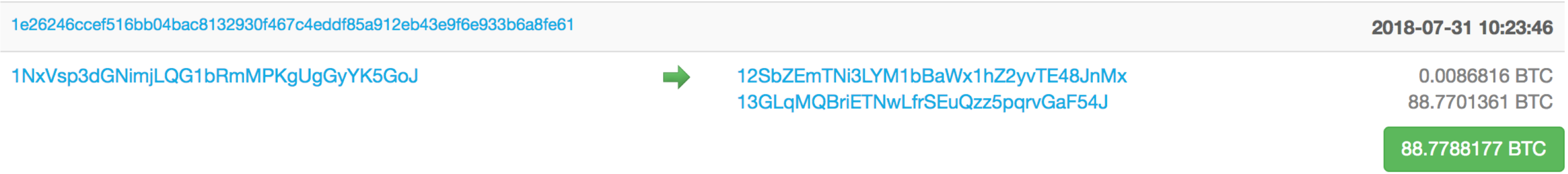
$v = E_k(s_3^{p3} \oplus v)$ — Fake secret key for Trent (s_3)

$v = E_k(s_4^{p4} \oplus v)$ — Fake secret key for Trent (s_4)

$v = E_k\{(u \oplus v))^d\}^e$ -> u

So what?

The major problem with the Bitcoin network, is that the amount of a transaction and the sender and receive of the funds are not private, and someone who knows someone's address can trace their transactions. This is the case because the blockchain needs to check that the sender has enough funds to pay the recipient. Thus many cryptocurrencies are looking for ways of anonymising the transaction.



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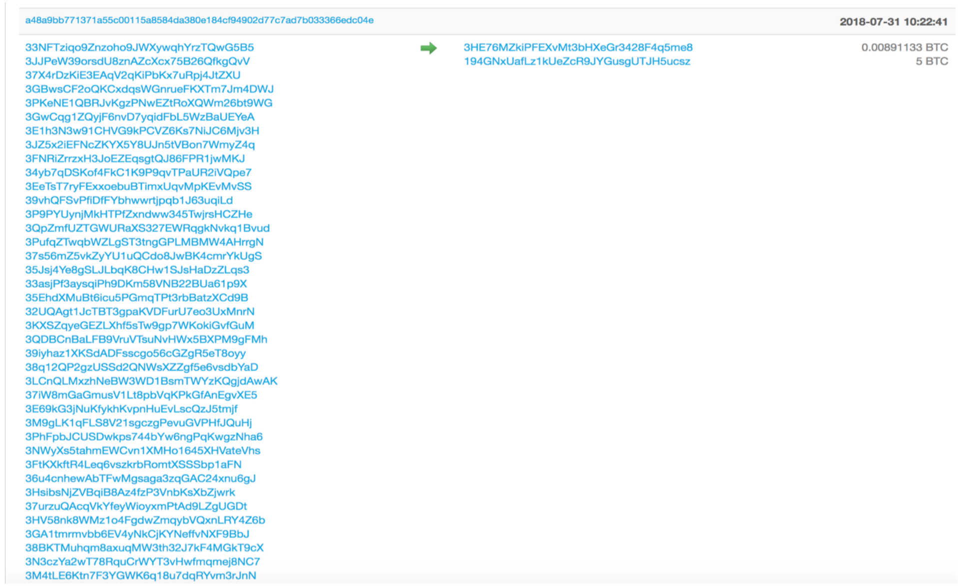


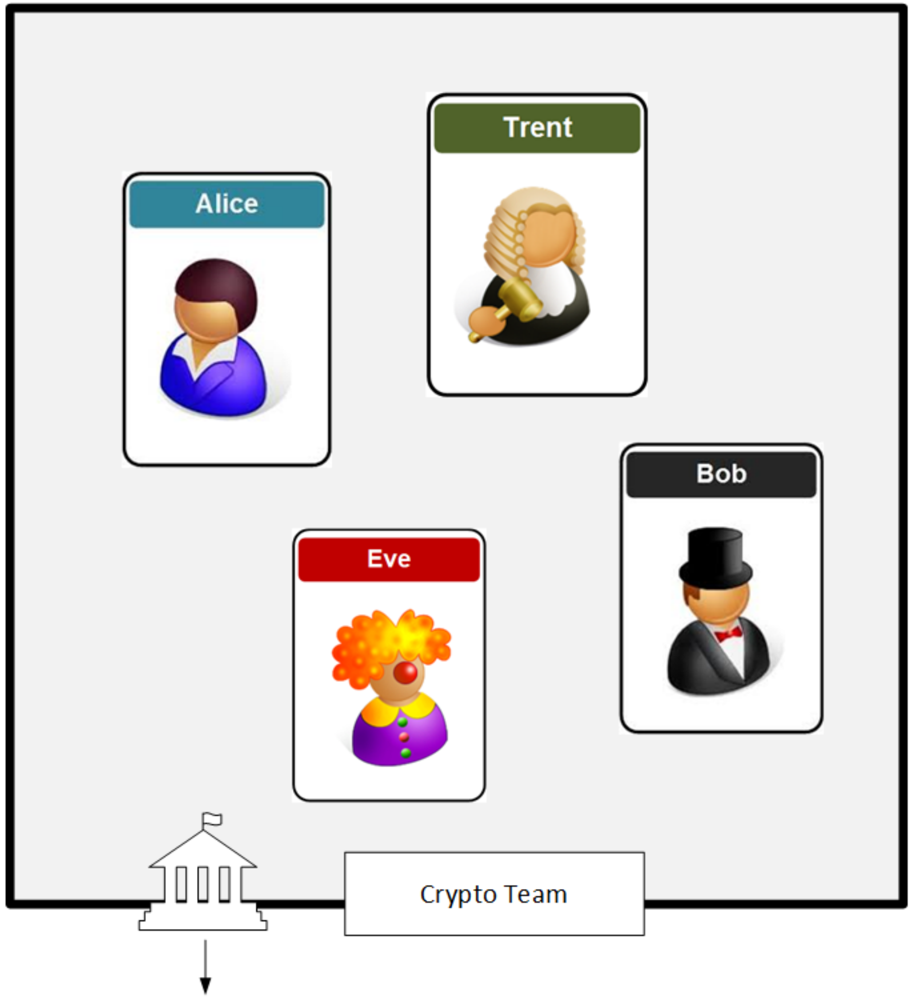
So what?

MONERO

- The method proposed by Rivest et al uses RSA is not efficient for modern systems.
- Thus Greg Maxwell's defined an elliptic curve methods as a new way of creating the ring signature: the Borromean ring signature [paper].
- The cryptocurrency Monero adopted the method for anonymising transactions.
- Since migrated to a new method: Multi-layered Linkable Spontaneous Anonymous Group signature. This method hides the transaction amount and the identity of the payer and recipient [paper]. It is now known as RingCT (Ring Confidential Transactions), and was rolled-out in January 2017 and mandatory for all transactions from September 2017.

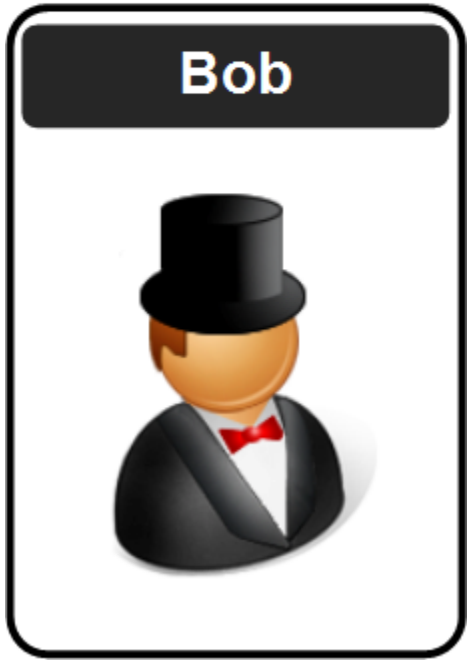
Ring Signatures

I know one of you leaked the information. But which of you was it?



We have a secret.

Signed,
A member of the crypto team



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