	Principles	Policy	Management	Institutions
P				
R				
O				• Decision Rules
M	• External Accounts (BB) • Internal Accounts (NN)	• Automatic Adjustment • Active Adjustment (Fiscal, Monetary, Exchange, Wage) • Structural Reforms	• BBNN at the industry level • Automatic and Active Adjustment	• Product Markets • Financial System • Macro Prudential Regulation • Fiscal and Monetary Institutions
I	• Consistent Designed • Market Inefficiency		• Demand Institutionality	• Public Choice • Social Insurance • Unacceptable outcomes • Property Rights
S	• Social Aspirations • Political Aspirations • Standards of Living (SP)	• Message • Representation • Transparency • Accountability	• Political Influence • Community Reach • Corruption • **Commitment versus Involvement**	• Social & Personal needs • Political Voice & Representation • Justice & equality • Individual & Civil rights
E	• Environmental (EE) • Regeneration and Harvesting • Waste Generation and Recycling • Technology Improvement and Stocks	• Demand Control • Biased Technological Improvement • Biased Consumption Mixture • Market Interventions: Prices and Quotas	• Production Mix • Inputs Mix (Materials & Energy) • **Living at the Margin of the Unmeasurable**	• Regulation (Markets, Prices, Quotas) • International Coordination

Currency, CryptoCurrencies, and BitCoin

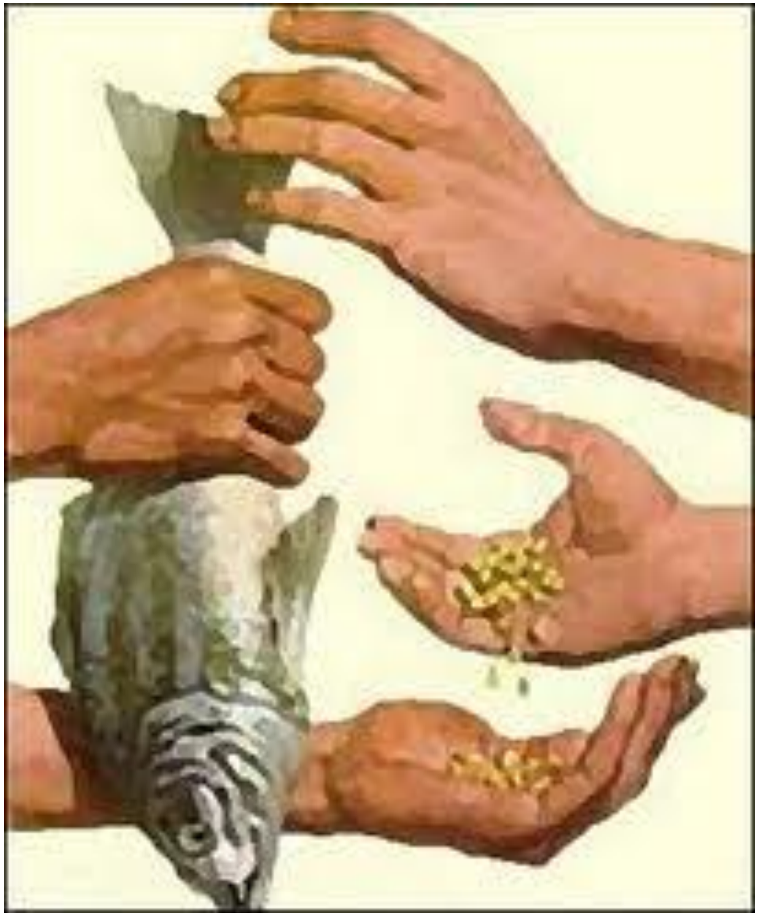
Physical Properties of Currency

Divisible	A currency must be divisible so that units of its value can be paid to match the value of your purchase.
Scarce	Money has to be sufficiently rare. If the medium of the currency is easily obtainable or reproducible, it will have little worth and be easily counterfeited.
Portable	For a currency to be convenient, it must be portable.
Uniform	Every unit of a currency must be equal in value. Diamonds are not fungible because there are other properties of a diamond that makes it worth more or less than any other diamond
Durable	Money must not have a property that allows it to decay over time. Any perishable items are a good example of this: Apples, Spices, Tea, Milk, etc.
Acceptable	Trusted and accepted by all

Currency

- Economic Properties
  - Store of value
    - Money must be able to be reliably saved, stored, and retrieved – and be predictably usable as a medium of exchange when it is retrieved.
    - The value must remain relatively stable over time.
  - Medium of exchange
    - Used to intermediate the exchange of goods and services.
    - For comparing the values of dissimilar objects.
    - Standard of deferred payment
      - Money is an accepted way to settle a debt.
      - When debts are denominated in money, the real value of debts may change due to inflation and deflation.
  - Unit of Account
    - A unit of account is a standard numerical monetary unit of measurement of the market value of goods, services, and other transactions.
      - Divisibility
      - Fungibility

Barter



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Goods *BECOME* Money

- Acceptable
- Durable
- Portable
- Scarce
- Divisible
- Recognizable

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Peacefully and voluntarily, markets choose money.

Gold Storage -> Paper Receipts

Gold	Claims

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England, 17th Century

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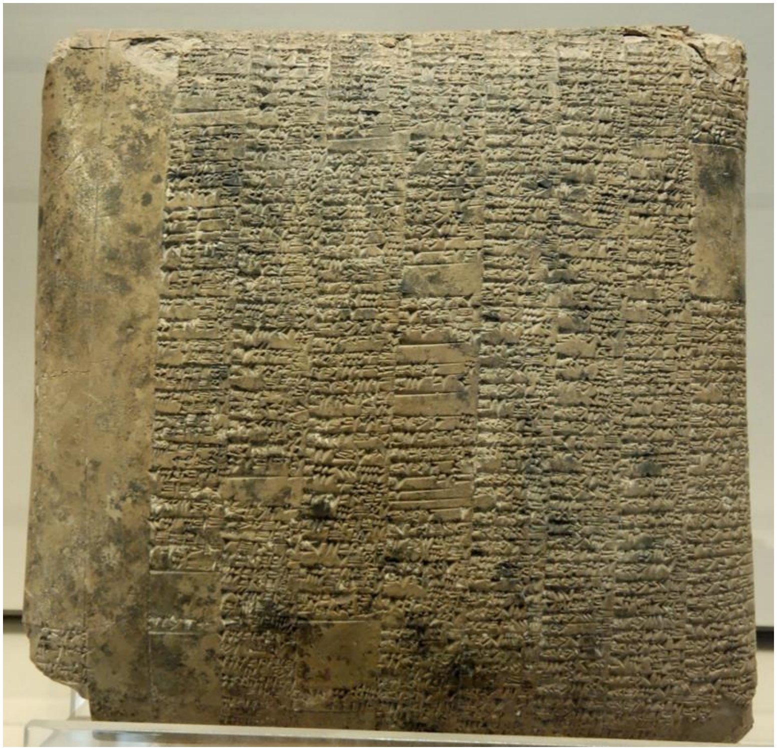
Payment System

- Infrastructure
  - Operational network
  - Clearing system
  - Governed by laws, rules and standards
  - Links bank accounts for monetary exchange
- Security
  - Identification
  - Verifiability
  - Reversibility
- Payments
  - Instead of physical cash uses other instruments
    - Traditional
      - Checks and Money orders
    - Newer
      - Debit card, credit card, electronic transfers, internet banking, e-commerce

Public Ledger

- A very easy way to have a clearing system: public ledger written in stone!
  - Every transaction is written in stone
  - Everybody can verify
  - Transactions are not reversible
  - Hard to commit fraud (need another stone)
- Bitcoin has the same features….



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What makes a good…

Currency?	Payment System?
Trust	Trust
No counterfeiting	Verification of ownership Verification of transaction
Anonymity	No Anonymity: Control Criminal Behavior
Clearing Automatic	Fast Low Transaction Cost
Managed by Central Bank to deal with demand shocks	No Monetary or Fiscal Policy tool
Denomination of Contracts	No Denomination
No issue with Liquidity	Exchange System to guarantee liquidity
Peer to Peer	Needs Clearing System

BitCoin

What is Bitcoin?

- A **peer-to-peer** internet currency that allows **decentralized** (verification) transfers of value between **individuals and businesses**.
  - **Bitcoin** is the system
  - **bitcoins** are the units

- In economic terms
  - An International Currency
  - An international clearing system
  - A payment system/network

Creating a currency from scratch

- Motivation
  - Distrust of financial institutions
  - Transaction costs
  - CB Manipulation
- Primary concerns
  - Transaction security
  - Double spends

Stripping down BitCoin

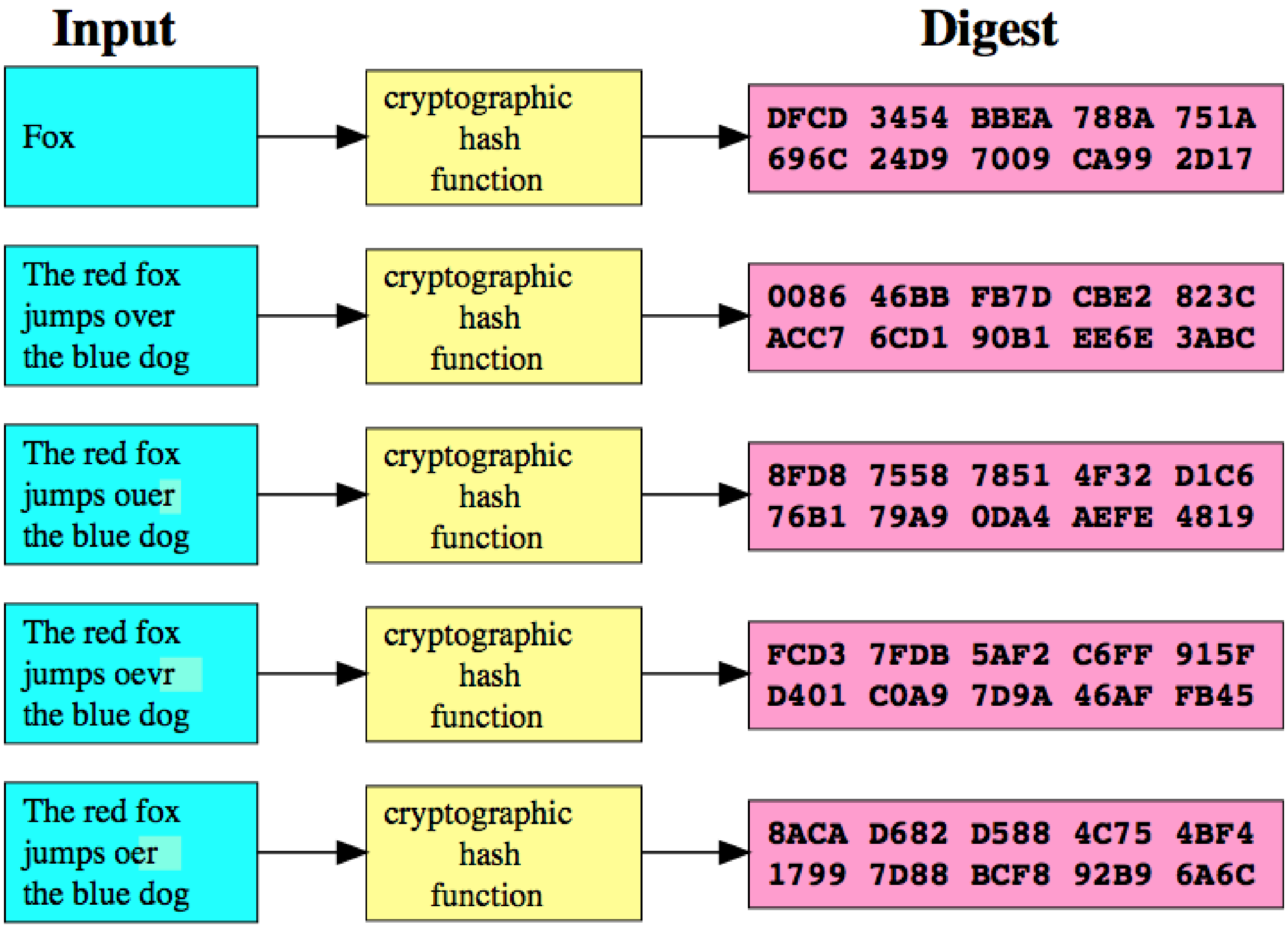
- How a macroeconomist thinks about the elements of BitCoin?

	How it is?	How it should be?
Documentation	Ledger	
Clearing Transactions	BlockChain	
Clearing House	Miners	
Currency of Transaction	BitCoin	
Currency	BitCoin	
Form of Transaction	P2P + Anonymous	

Transaction security

- Two levels of verification
  - Source is legitimate
  - Coins are legitimate
- Encryption
  - Public and private key verification ensures the legitimacy

TheoryCoin: (coins to ppl)
Encryption



Input

Digest

Fox → cryptographic hash function → DFCD 3454 BBEA 788A 751A 696C 24D9 7009 CA99 2D17

The red fox jumps over the blue dog → cryptographic hash function → 0086 46BB FB7D CBE2 823C ACC7 6CD1 90B1 EE6E 3ABC

The red fox jumps ouer the blue dog → cryptographic hash function → 8FD8 7558 7851 4F32 D1C6 76B1 79A9 0DA4 AEFE 4819

The red fox jumps oevr the blue dog → cryptographic hash function → FCD3 7FDB 5AF2 C6FF 915F D401 C0A9 7D9A 46AF FB45

The red fox jumps oer the blue dog → cryptographic hash function → 8ACA D682 D588 4C75 4BF4 1799 7D88 BCF8 92B9 6A6C

Double spends

- If the money is just digital codes, why not copy and paste to make more money?
  - Timestamps
    - Each transaction is packaged and publically recorded in the order it was carried out.
  - Hashes
    - The time-stamped group of transactions are given a unique algorithmically derived number
  - Block chain
    - Transactions are recorded in a community-built record of all transactions that acts as a proof-of-work.
    - Computers connected to the network accept the longest chain as accurate.

Digi-cash: Remittances

- **anonymous**
- **secure** (no double-spending)
- only **transfer** (no creation/storage)

...and **bankrupted** in 1999

The advent of Bitcoin

- 2009: **Bitcoin announced** by Satoshi Nakamoto
  - Pseudonym for person or group of person

- 2009-2011: slow start…

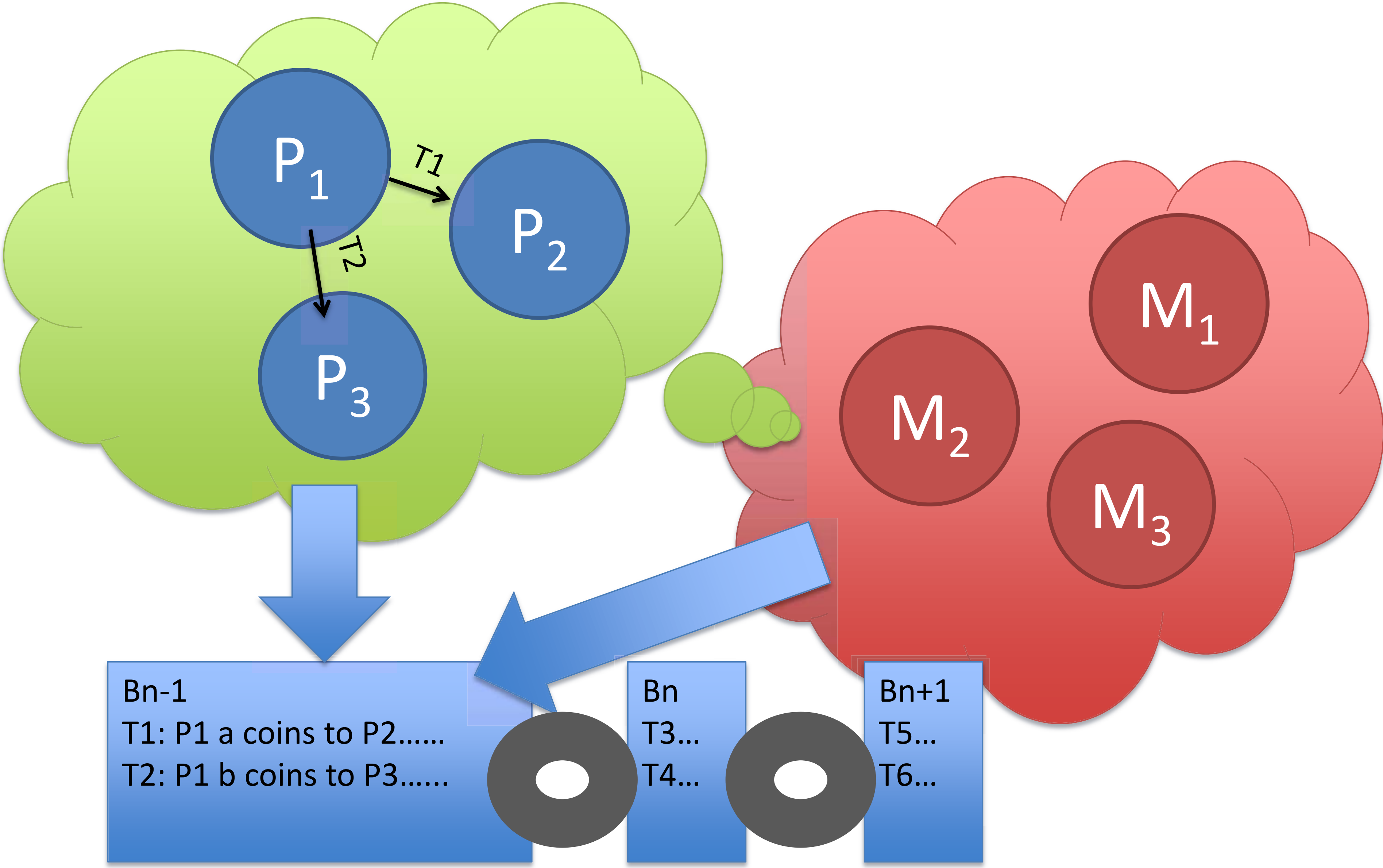
- 2011-2013: Silk Road and Dread Pirate Roberts

- End 2013: **Bitcoin price skyrockets**
  - and the world notices!

Elements of Bitcoin

- Individuals
  - Wallet (accounts)
  - Identity is anonymous
    - Private Key (sk)
    - Public Key (vk)
- Transactions
  - Peer-to-peer (descentralized)
  - Digital Signatures
  - Verification of “identity”
  - All transactions are public
- Transaction Block
  - List of transactions that are unrecorded
- Transaction Block Chain
  - List of transactions that have been recorded: Public Ledger
- Miners
  - Objective
    - Validate Transactions
      - Clearing house
    - Record transactions
      - Solve a complicated mathematical problem
      - Proof – of – work
  - Remuneration
    - When a block of transactions is recorded
    - Transaction fees

Elements of Bitcoin



Bn-1
T1: P1 a coins to P2……
T2: P1 b coins to P3……

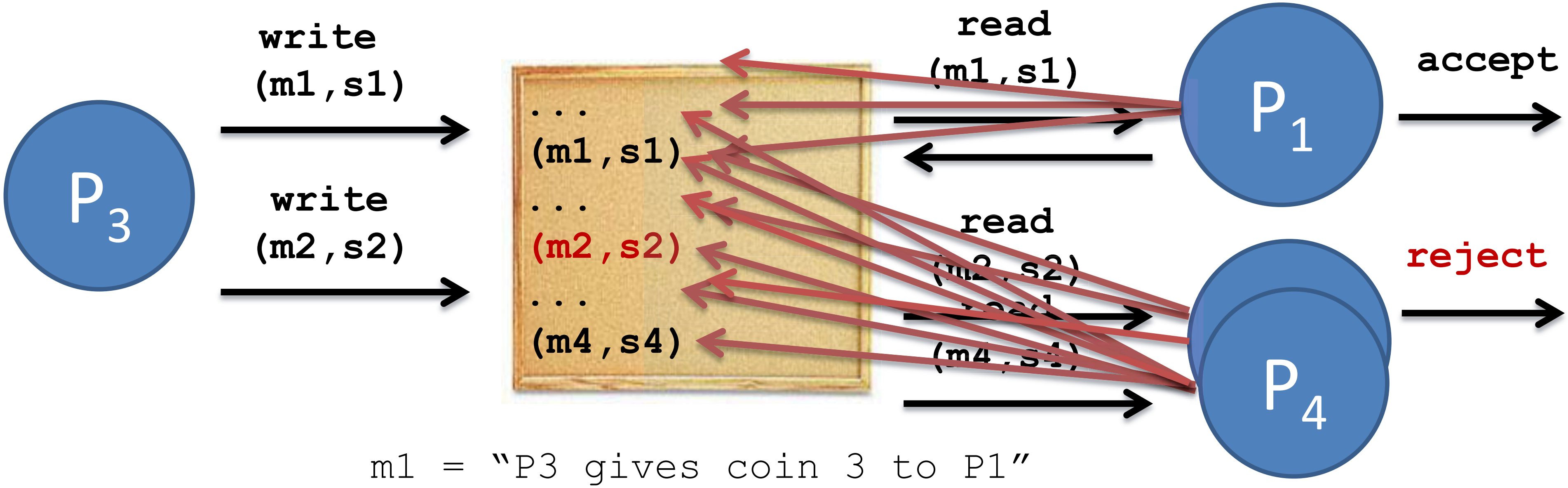
Bn
T3…
T4…

Bn+1
T5…
T6…

Miners

- Mining is the process of adding transaction records to Bitcoin's public ledger of past transactions.
  - This ledger of past transactions is called the block chain as it is a chain of blocks.
  - The block chain serves to confirm transactions to the rest of the network as having taken place.
  - Bitcoin nodes use the block chain to distinguish legitimate Bitcoin transactions from attempts to re-spend coins that have already been spent elsewhere.
- Mining is intentionally designed to be resource-intensive and difficult so that the number of blocks found each day by miners remains steady.
  - Individual blocks must contain a proof of work to be considered valid.
  - This proof of work is verified by other Bitcoin nodes each time they receive a block.
  - Bitcoin uses the hashcash proof-of-work function.
- The primary purpose of mining is to allow Bitcoin nodes to reach a secure, tamper-resistant consensus.

TheoryCoin: How to transfer money



write (m1,s1)

write (m2,s2)

...

(m1,s1)

...

(m2,s2)

...

(m4,s4)

read (m1,s1)

read (m2,s2)

(m4,s4)

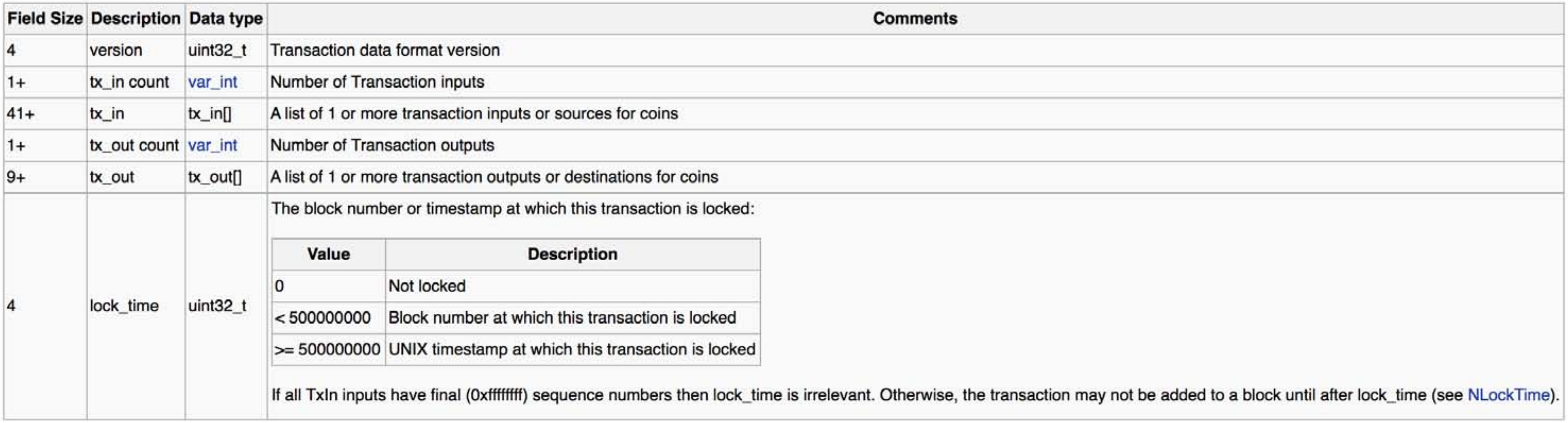
accept

reject

```
m1 = "P3 gives coin 3 to P1"
s1 = Sig(sk3,m1)

m2 = "P3 gives coin 3 to P2"
s2 = Sig(sk3,m2)
```

What info is in the transaction?



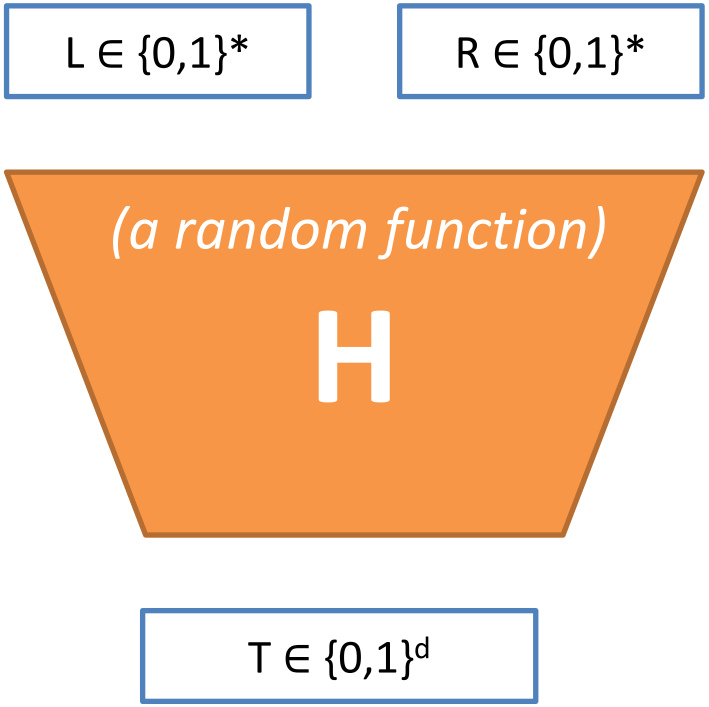
<table>
<tr><th>Field Size</th><th>Description</th><th>Data type</th><th>Comments</th></tr>
<tr><td>4</td><td>version</td><td>uint32_t</td><td>Transaction data format version</td></tr>
<tr><td>1+</td><td>tx_in count</td><td>var_int</td><td>Number of Transaction inputs</td></tr>
<tr><td>41+</td><td>tx_in</td><td>tx_in[]</td><td>A list of 1 or more transaction inputs or sources for coins</td></tr>
<tr><td>1+</td><td>tx_out count</td><td>var_int</td><td>Number of Transaction outputs</td></tr>
<tr><td>9+</td><td>tx_out</td><td>tx_out[]</td><td>A list of 1 or more transaction outputs or destinations for coins</td></tr>
<tr><td>4</td><td>lock_time</td><td>uint32_t</td><td>The block number or timestamp at which this transaction is locked:
<table>
<tr><th>Value</th><th>Description</th></tr>
<tr><td>0</td><td>Not locked</td></tr>
<tr><td>< 500000000</td><td>Block number at which this transaction is locked</td></tr>
<tr><td>>= 500000000</td><td>UNIX timestamp at which this transaction is locked</td></tr>
</table>
If all TxIn inputs have final (0xffffffff) sequence numbers then lock_time is irrelevant. Otherwise, the transaction may not be added to a block until after lock_time (see NLockTime).</td></tr>
</table>

TheoryCoin: Proof of Work

1. Everyone **tries to solve** a puzzle
2. The **first one** to solve the puzzle **gets 1 TC**
3. The solution of **puzzle *i*** **defines puzzle *i+1***

3			2	4			6	
	4						5	3
1	8	9	6	3	5	4		
				8		2		
		7	4	9	6	8		1
8	9	3	1	5		6		4
		1	9	2		5		
2			3			7	4	
9	6		5			3		2

TheoryCoin: Proof of Work

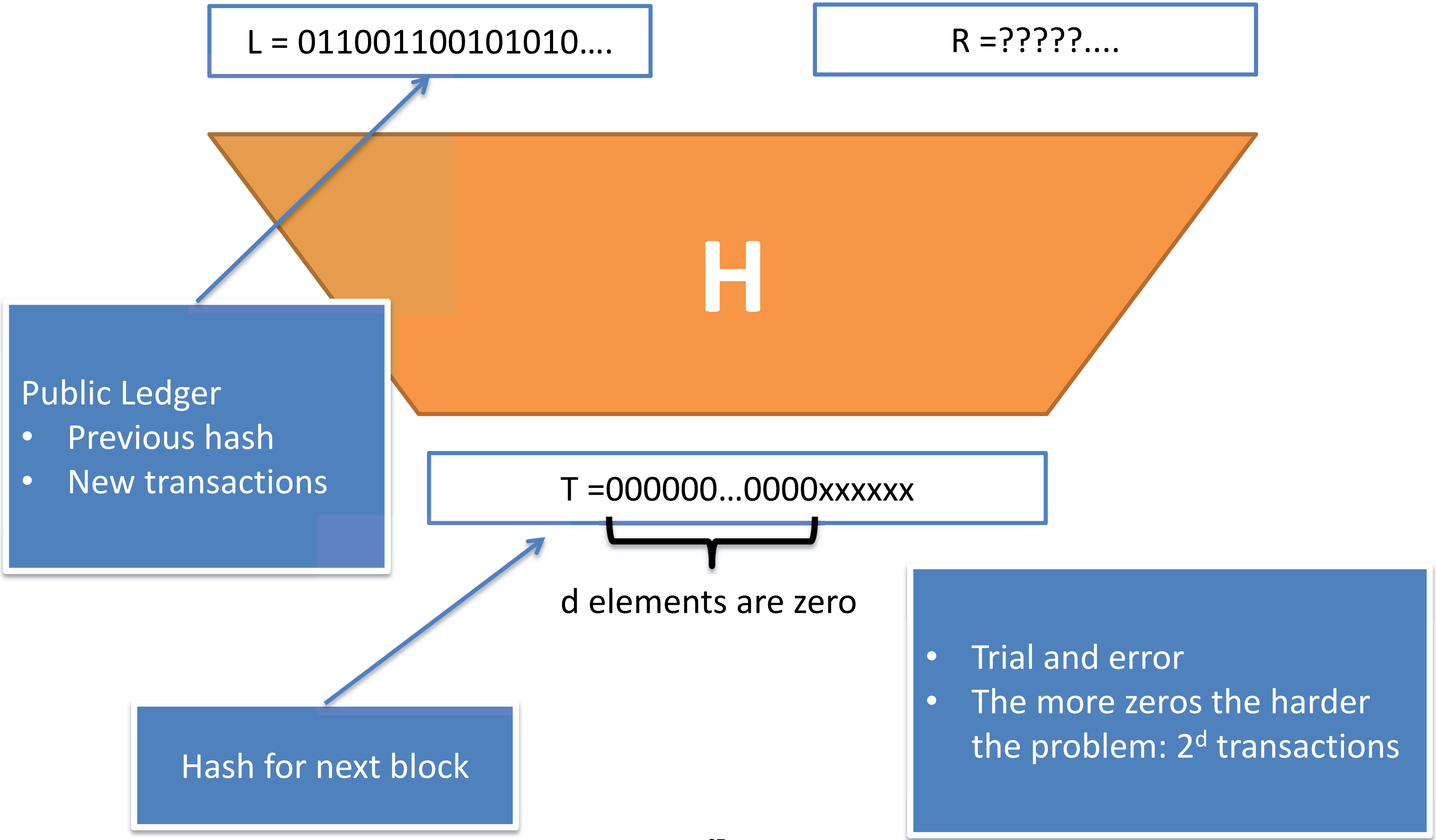


The puzzle:
given L, find R
such that $T=0^d$

```
SolvePuzzle(L){
  repeat{
    R = my_name || i++
    T = H(L,R)
  }while($T \neq 0^d$)
  return R
}
```

* *aka **Proof-of-Work***

TheoryCoin: Proof of Work



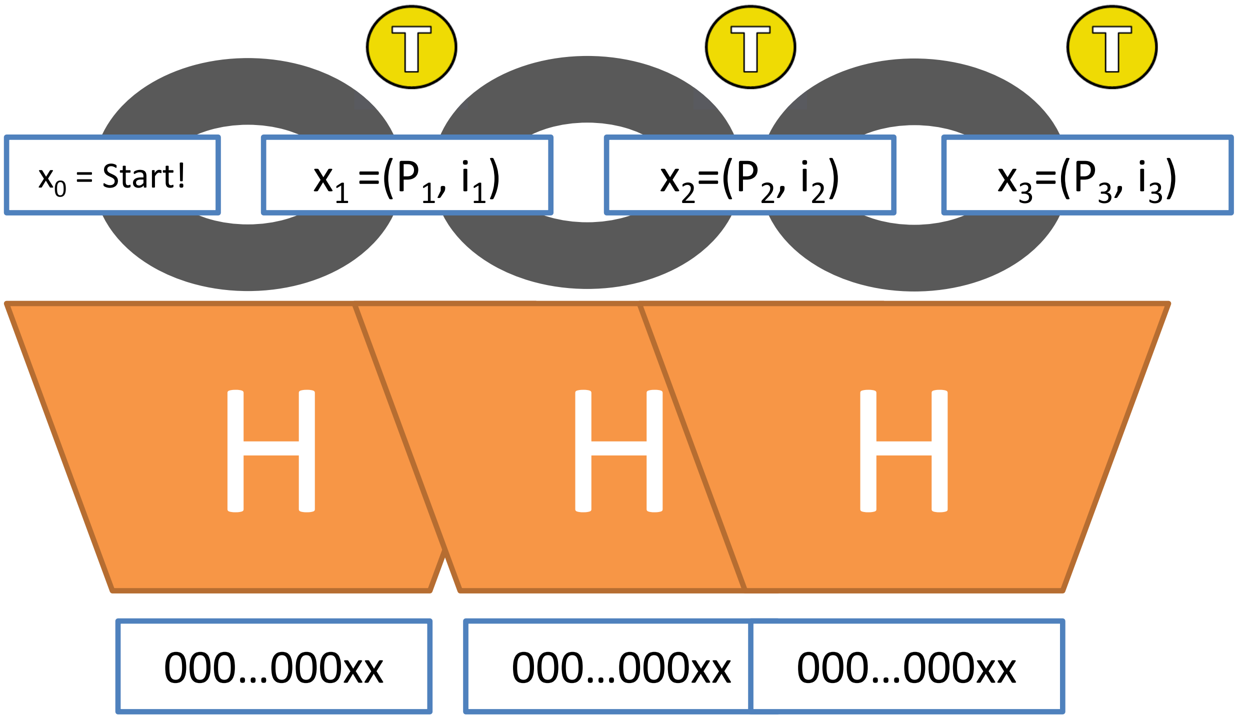
Public Ledger

- Previous hash
- New transactions

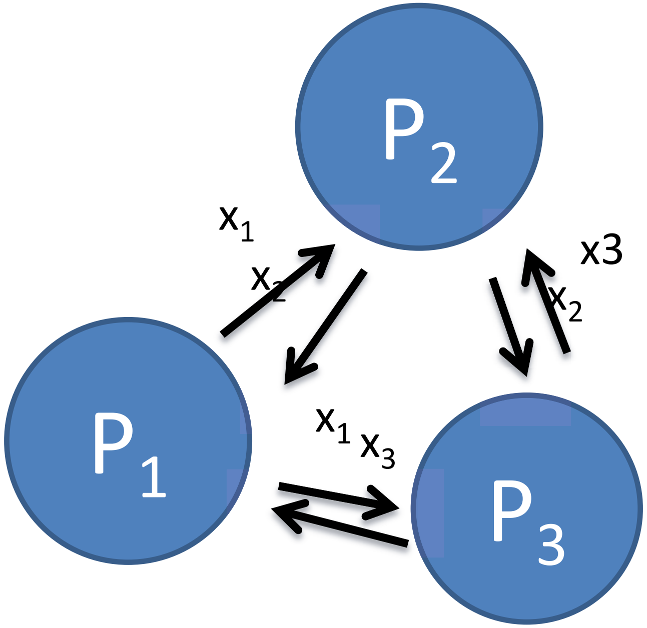
Hash for next block

- Trial and error
- The more zeros the harder the problem: 2^d transactions

TheoryCoin: (coins to ppl)
How to create money



```
SolvePuzzle(L){
   repeat{
      R = my_name || i++
      T = H(L,R)
   }while(T ≠ 0^d)
   return R
}
```



* *aka* ***the blockchain***

Problems

- Disclaimer: I am extremely affected by my research on law enforcement!
  - What is the purpose of the “coin”?
  - Why the remuneration to the miners is a tax on all holders, as opposed to a tax on each transaction?
  - Why the transactions need to be anonymous?
    - I understand confidentiality but anonymity?

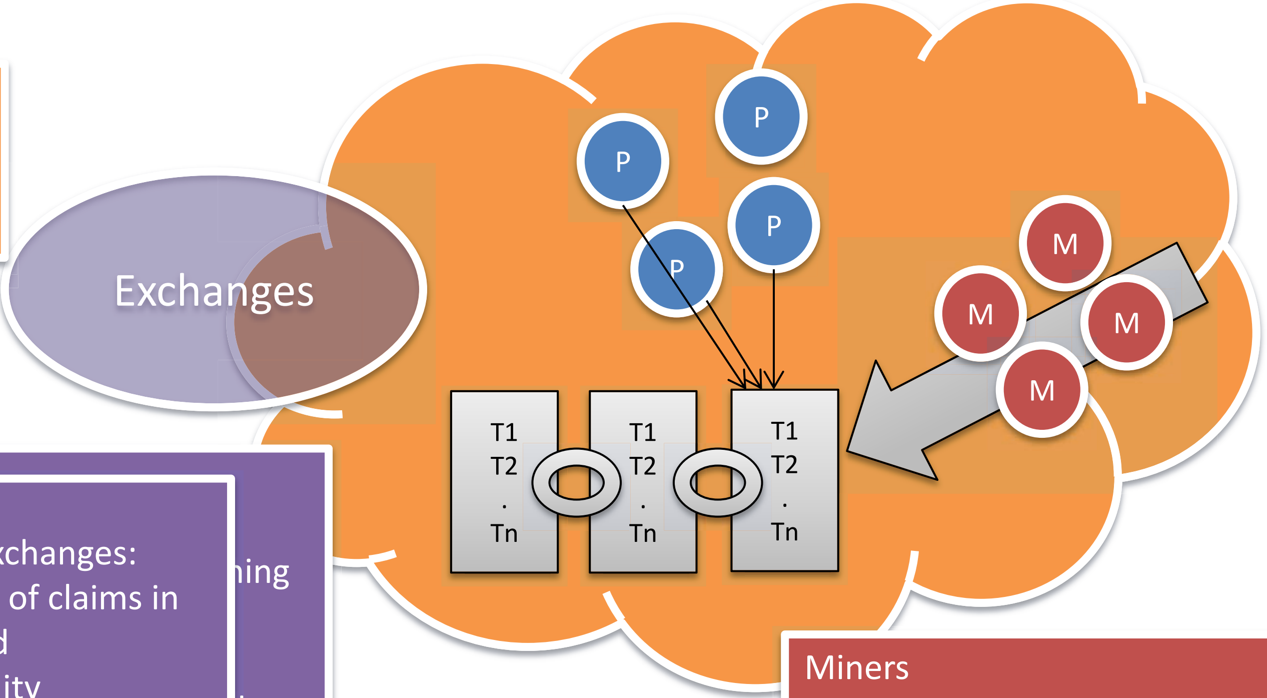
Anonymity

- Volume and Weight of Cash
  - – 1 Billion dollars in “new” 20 dollar bills
    - 50 million notes
    - Stack of 5km (3.11 miles)
    - Volume of 52 thousand litters (1.7 times a typical container)
    - Weights 50 tons
  - – In BitCoin?

Payment System with Fixed Exchange Rate: Dollars as Collateral

₿=$

One Bitcoin is a claim on one Dollar



Ex

hing

to

Objectives of exchanges:

- Guarantee value of claims in the Bitcoin world
- Guarantee liquidity
- Guarantee convertibility

  - Accounts might not need to be anonymous
- Remuneration
  - Transaction fee

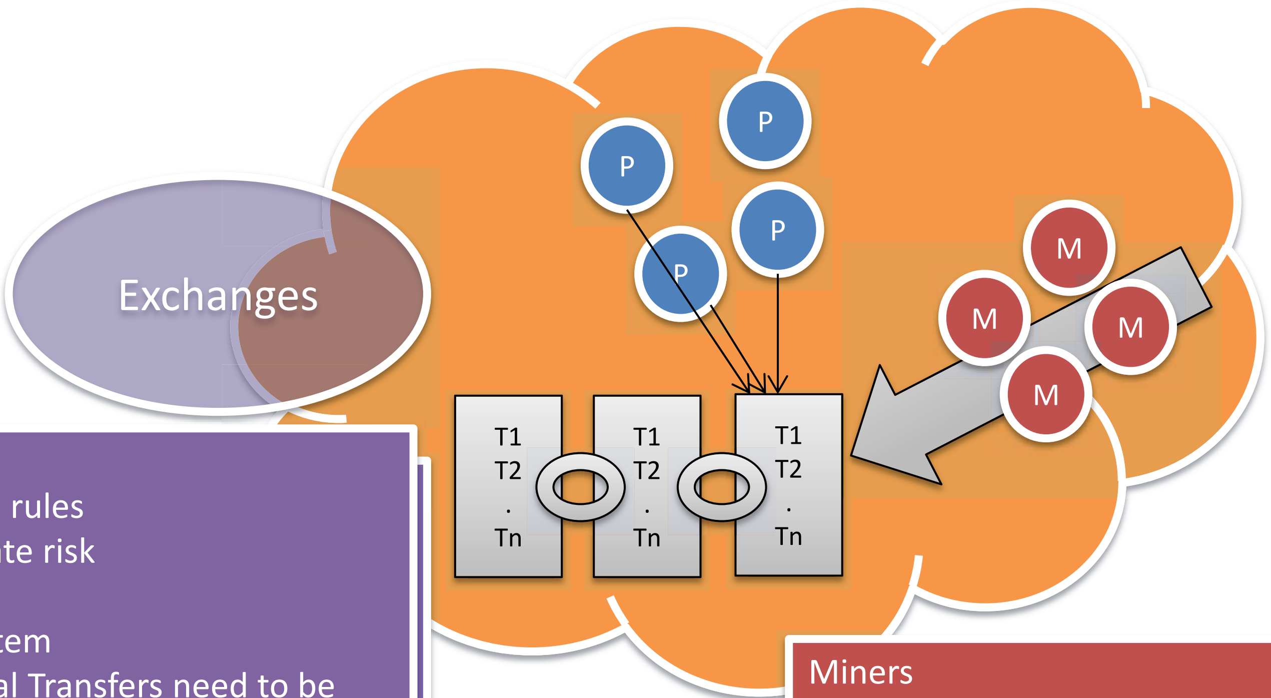
Miners

- Payment CANNOT be paid by creation of Bitcoins
- Remuneration exclusively based on transaction fees
  - Constant “fee” charged per block

Payment System with Flexible Exchange Rate: Dollars as Collateral

₿≠$

One Bitcoin is a NOT claim on a Dollar.



Exchanges

- Inflation Targeting rules
    - Exchange rate risk
    - CPI target
- Pure payment system
    - International Transfers need to be arranged in the formal Banking system
    - Accounts might not need to be anonymous
- Remuneration
    - Taxes on participants
    - Capitalization of central exchange

Miners

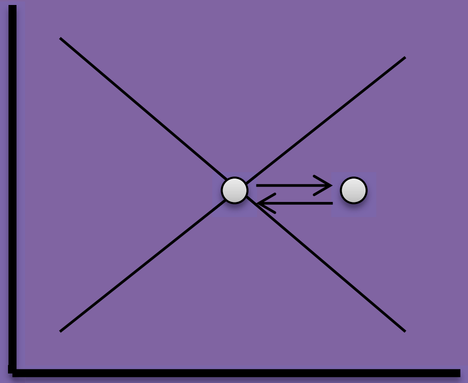
- Payment CANNOT be paid by creation of Bitcoins
- Remuneration exclusively based on transaction fees
    - Constant "fee" charged per block

Payment System with Flexible Exchange Rate: Dollars as Collateral

₿≠$

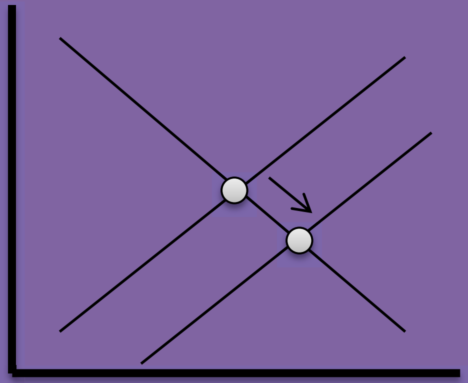
Exchanges

Demand Shock: BBNN



Active Monetary Policy requires a tightening after a boom and a loosening after a recession

Supply Shock: BBNN



Active Monetary Policy should validate the new equilibrium. No need to “fight” the economy

What are the problems?

- Money Management
  - Good monetary policy needs active management of the money supply
    - Shocks to the aggregate demand need to be accommodated
    - Shocks to the aggregate supply should not be accommodated
  - Bitcoin has a parsimonious printing
    - This means that the adjustment occurs through inflation and deflation
    - Asymmetry: Cost of lowering prices and wages is larger than the cost of increasing prices and wages
- Criminal behavior
  - Anonymity and confidentiality is good for small transactions
  - Verifiability and openness is good for financial transactions
- Lack of reversibility
  - Some transactions need to be reversed (flash crash, and human error)
- What is Bitcoin?
  - A decentralized clearing system
  - A decentralized system of payments
  - A decentralized currency

What I would do?

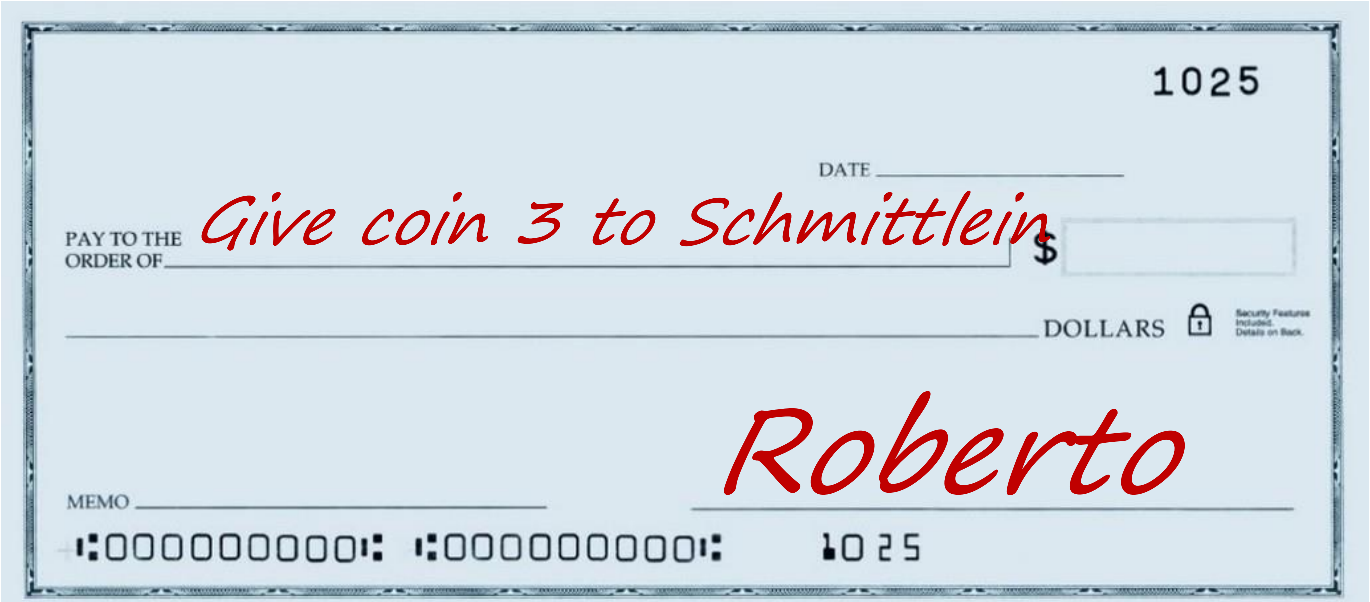
	How it is?	How it should be?	
Documentation	Ledger	Ledger	
Clearing Transactions	BlockChain	BlockChain	
Clearing House	Miners	Miners	Remuneration in fee-for-use not money creation
Currency of Transaction	BitCoin	BitCoin	Fixed to a single currency or a basket
Currency	BitCoin	Basket	
Form of Transaction	P2P + Anonymous	P2P	Confidential but NOT Anonymous

Technical Slides

TheoryCoin:
How to transfer money

(Digital) Signatures

- Only you can sign
- Everyone can verify
- You cannot deny



1025

DATE

PAY TO THE ORDER OF *Give coin 3 to Schmittlein* $

DOLLARS

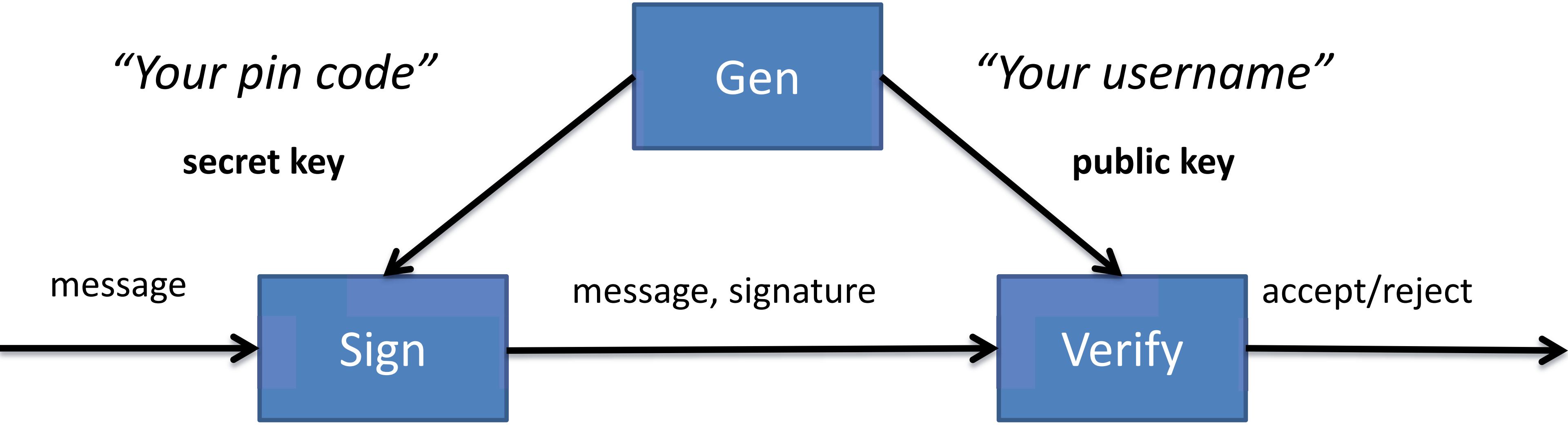
Security Features Included. Details on Back.

Roberto

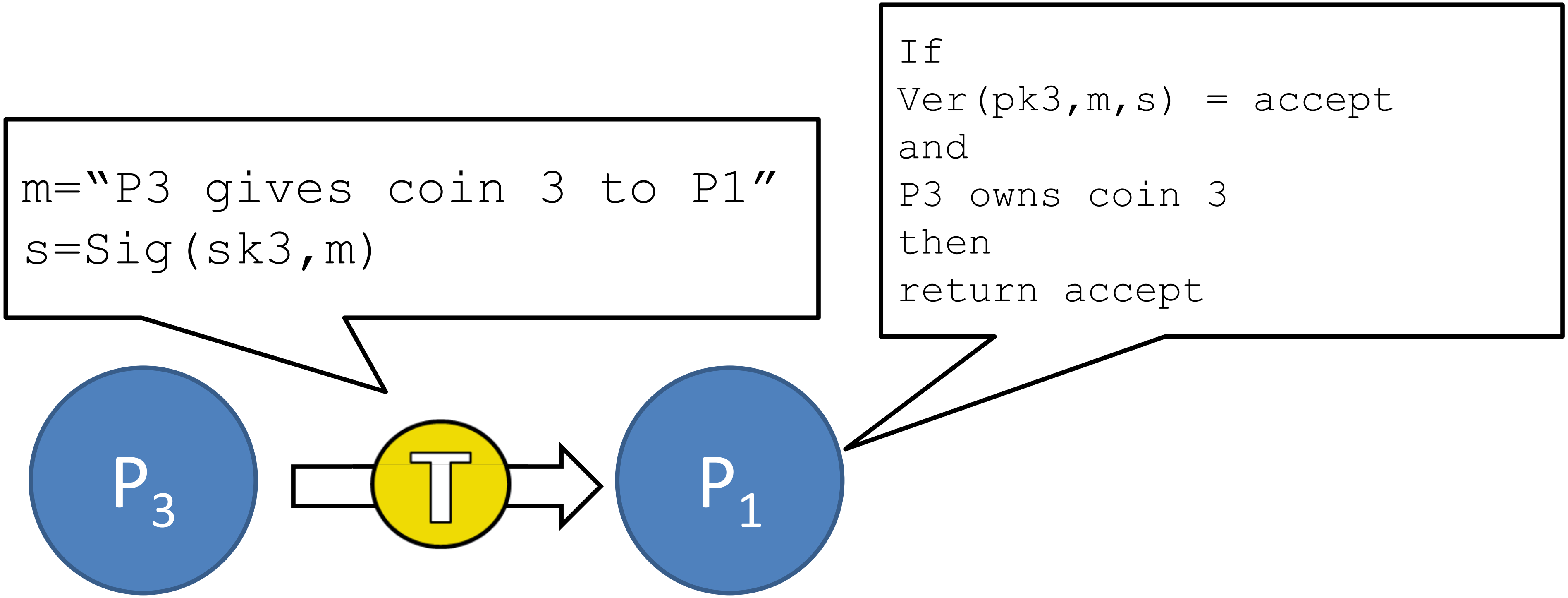
MEMO

⑆000000000⑆ ⑆000000000⑆ 1025

TheoryCoin: How to transfer money

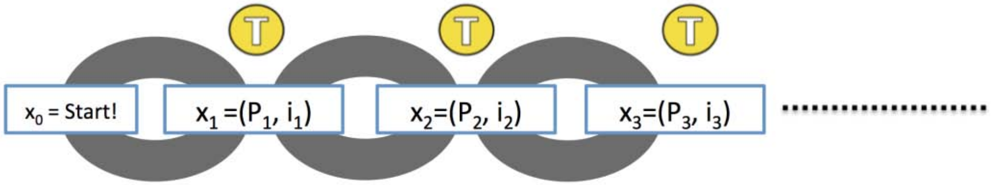


TheoryCoin:
How to transfer money

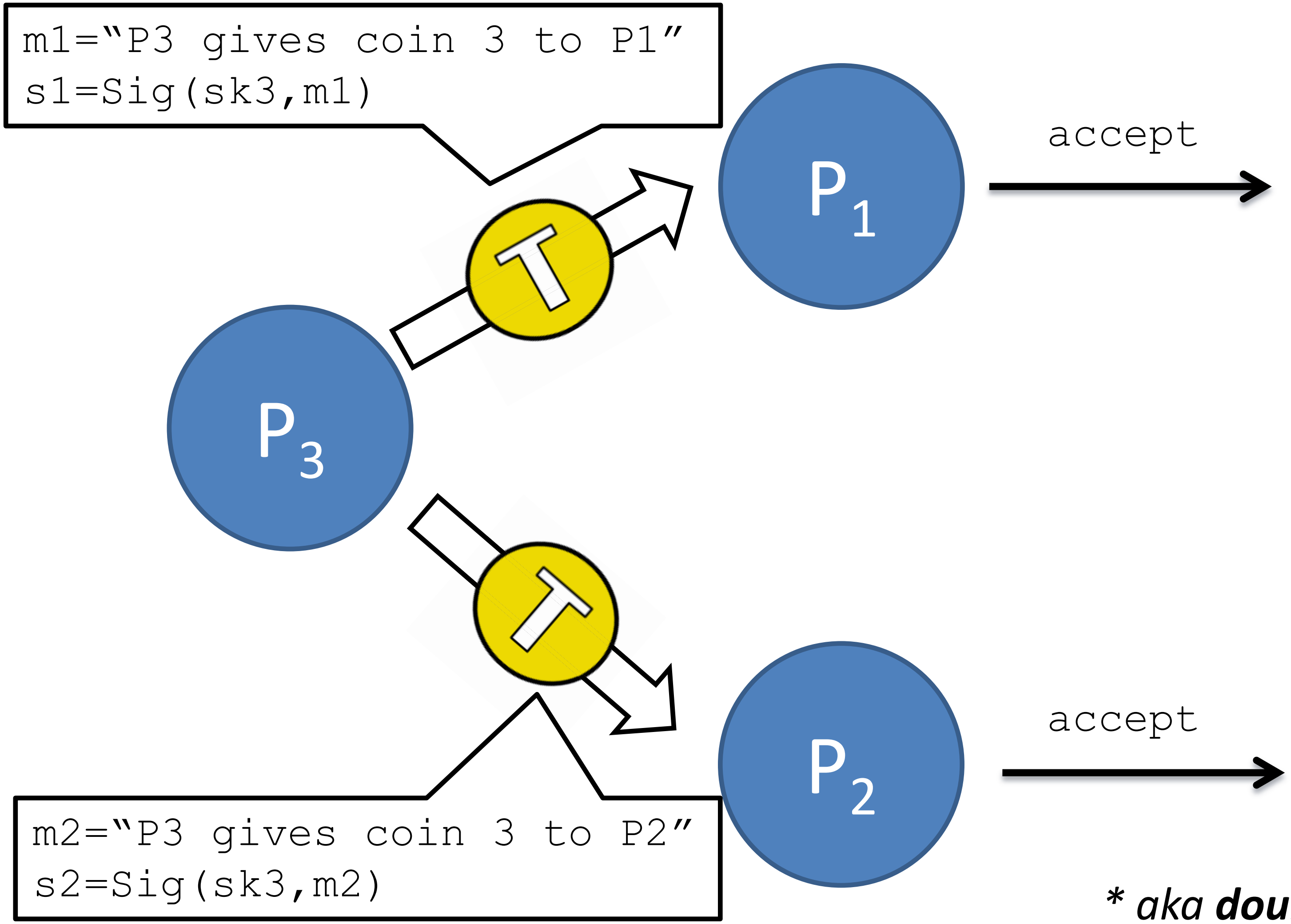


```
m="P3 gives coin 3 to P1"
s=Sig(sk3,m)
```

```
If
Ver(pk3,m,s) = accept
and
P3 owns coin 3
then
return accept
```



TheoryCoin:
How to transfer money



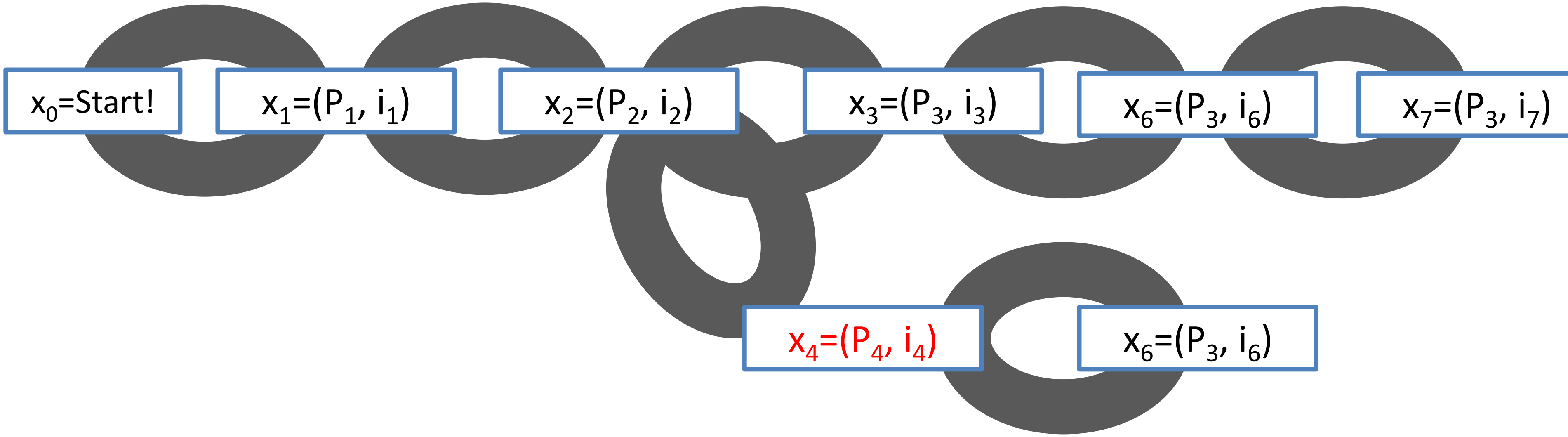
m1=“P3 gives coin 3 to P1”
s1=Sig(sk3,m1)

m2=“P3 gives coin 3 to P2”
s2=Sig(sk3,m2)

* *aka* ***double spending***

TheoryCoin:
How to create money

(Double Spending)



x_0=Start!

$x_1=(P_1, i_1)$

$x_2=(P_2, i_2)$

$x_3=(P_3, i_3)$

$x_6=(P_3, i_6)$

$x_7=(P_3, i_7)$

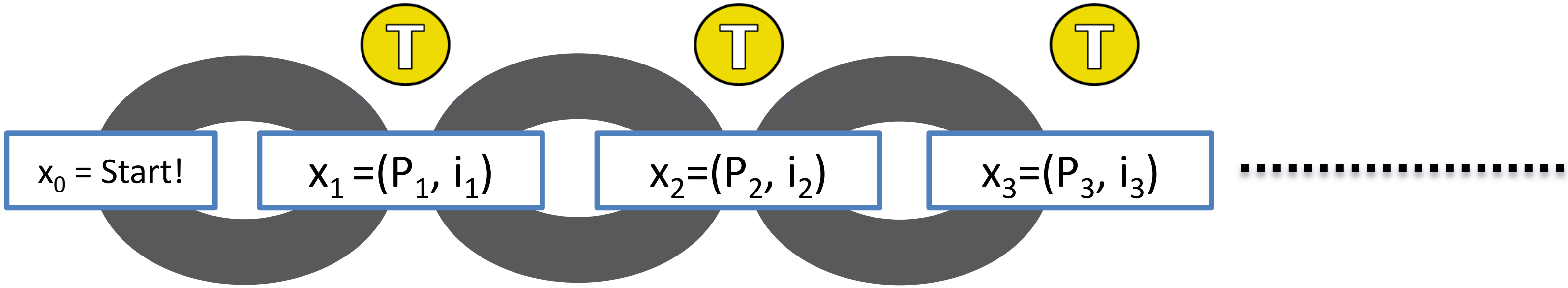
$x_4=(P_4, i_4)$

$x_6=(P_3, i_6)$

TheoryCoin:
How to store money

Main Idea:

Record **transfers** in the **blockchain**



x_0 = Start!

$x_1 = (P_1, i_1)$

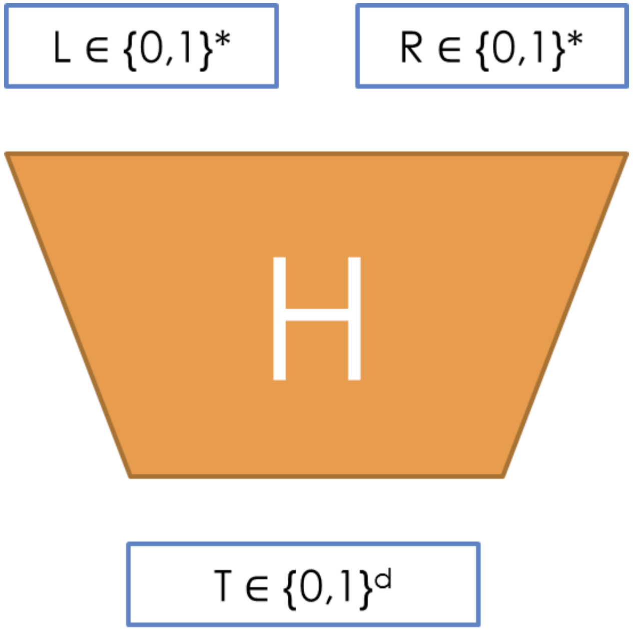
$x_2 = (P_2, i_2)$

$x_3 = (P_3, i_3)$

diff(T , ₿

How is money created in Bitcoin?

- New block **every ~10 mins**
  - **d** adjusted every ~2000 blocks
- H = **2-SHA2**
- Initial reward: **50 BTC**
  - Halved every ~4 years (now **25 BTC**)


$L \in \{0,1\}^*$
$R \in \{0,1\}^*$
H
$T \in \{0,1\}^d$