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Eastern Switzerland
University of Applied Sciences

Blockchain (BCh)

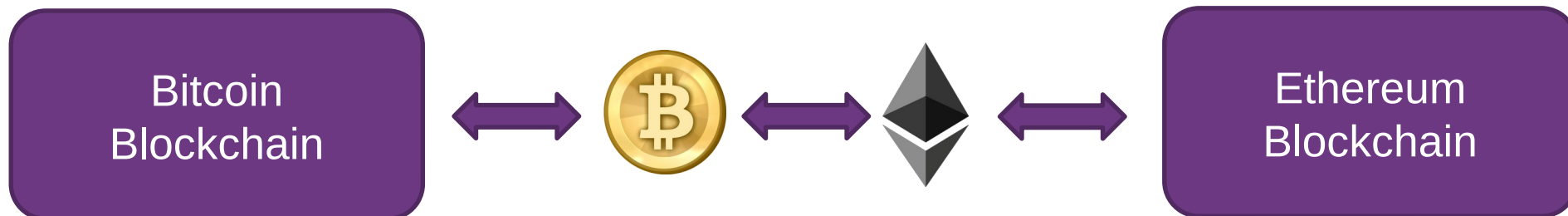
HTLCs, Cross-chain Atomic Swaps, Payment Channels

Thomas Bocek

19.11.2023

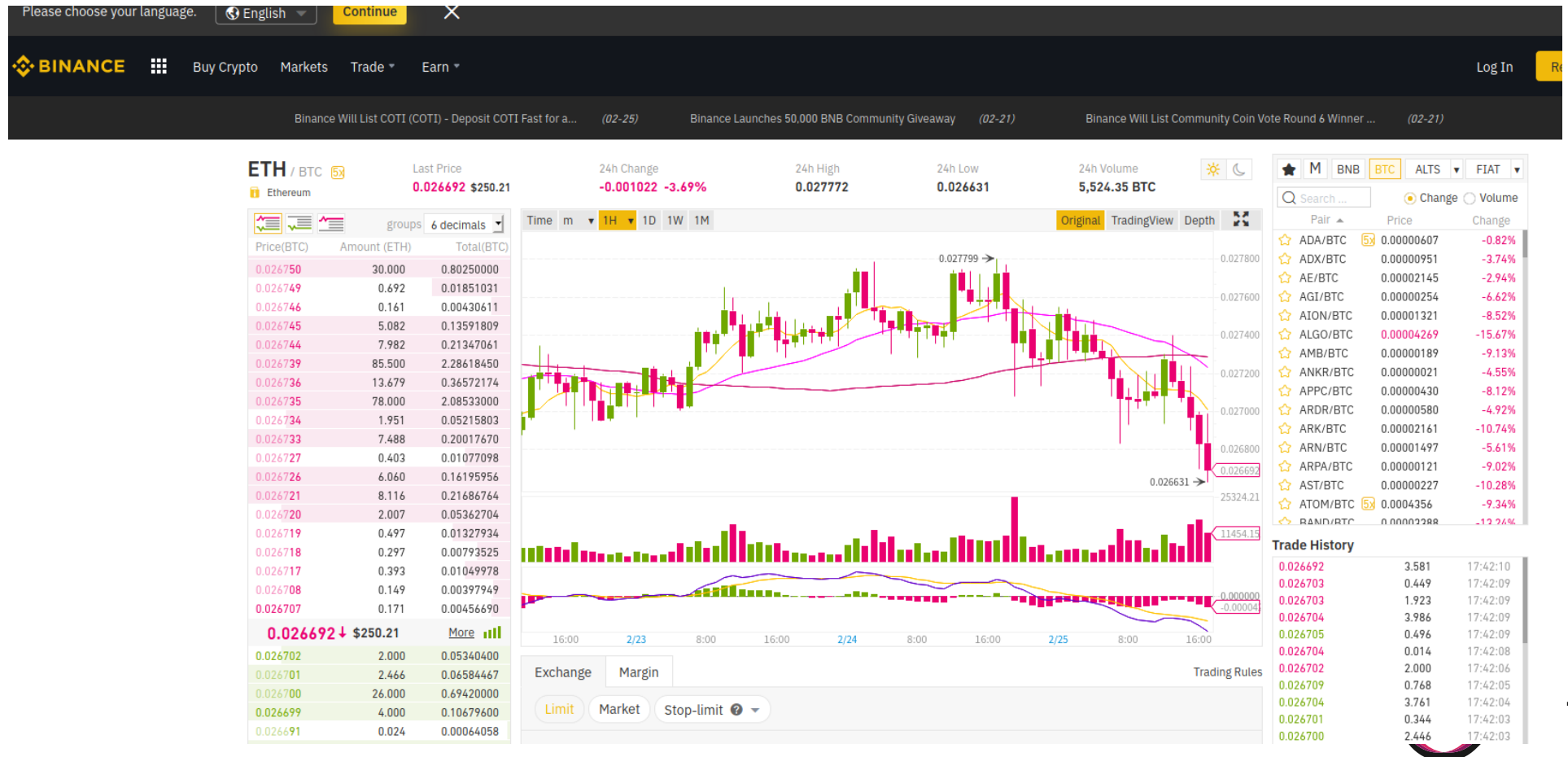
Cross-chain Atomic Swaps?

- A Showcase of **Cross-chain Atomic Swaps**
 - Either swap happens or becomes void



Why Cross-chain Atomic Swaps

- Use case: I want to exchange my 1 BTC to 37 ETH
- Obvious approach: use a centralized exchange, such as FTX, [Binance](#), [Bitstamp](#), or [Kraken](#)



Why Cross-chain Atomic Swaps

- There was also Mt.Gox, BTC-e, and FTX
- You loose control over your funds ([Mt. Gox](#))

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Bitcoin

This article is more than 5 years old

MtGox files for bankruptcy in Japan after collapse of bitcoin exchange

The bitcoin exchange has debts of £38m and assets of just £22.6m, it reported on Friday

Alex Hern
@alexhern
Fri 28 Feb 2014 13:30 GMT

f t e 70 39



▲ MtGox CEO Mark Karpeles bows in apology at a press conference at the Justice Ministry in Tokyo Friday night, Feb. 28, 2014. Photograph: I/AP

MtGox filed for bankruptcy protection in Tokyo on Friday, with the world's former biggest bitcoin exchange blaming "a weakness in our system" for its collapse.

Why the feds took down largest exchanges

Tracing Mt. Gox's stolen coins led feds to...
By Russell Brandom and Sarah Jeong | Jul 29, 2017, 10:00am E

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Illustration by Alex Castro / The Verge

This week, one of Bitcoin's largest and most notorious coin exchanges... law enforcement — and police and prosecutors are now beginning... Thursday, the Department of Justice unsealed an indictment against Alexander Vinnik — thought to be the operator, or one of the operators of Bitcoin exchange BTC-e — charging

ARCHIVE Published: January 17, 2019 12:21 PM UTC

Please Do Not Store Crypto on Any Exchange, Warns CEO of Major Crypto Exchange Kraken

Jesse Powell, the CEO of a major crypto exchange Kraken, warned users of digital assets to not store funds on trading platforms. The warning of Powell follows a high profile security breach suffered by Cryptopia, a New Zealand-based crypto exchange known for its listing of...

Author: Joseph Young @ianjosephyoung



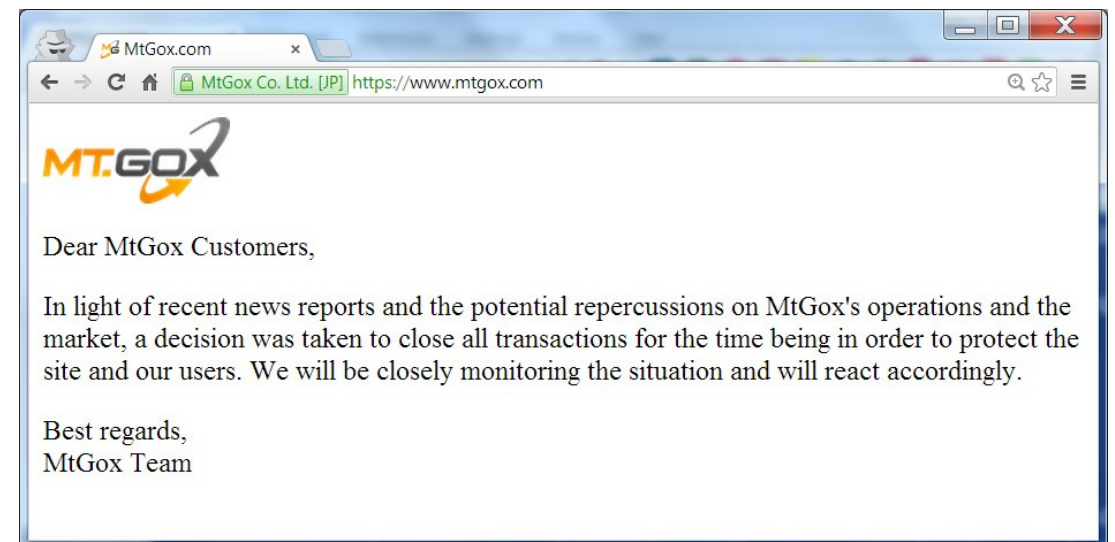
DON'T MISS:

- Crypto Trading Is the New Wall Street: Kraken Pro Trader
- Winklevoss Twins Foster Mainstream Adoption with Bitcoin Giveaway
- Crypto Mom Bemoans 'Regulatory Escape Room' Feel for Crypto
- Gemini Exchange Expands into Windy City to Capture Institutional Wave
- New York Kraken Ex-Employee Sues Crypto Exchange Over Failure to Pay \$900,000



Mt. Gox

- **Mt. Gox** (short for Magic: The Gathering Online Exchange)
 - July 2010 reused domain name, started Bitcoin trading platform
- April 2013, handled 70% of Bitcoin trades
- November 2013, users reported payout delays
 - Exchange rates different from other trading platforms
- 7. February 2014, suspended all BT withdrawals
 - “Bug in the Bitcoin system”: transaction malleability
- 20. February, suspended all withdrawals
- 24. February, all trading suspended, blank page
- 9. March 2014, filed for bankruptcy
 - 850k Bitcoins missing
- 16.11.2021: Mt. Gox rehabilitation plan is now 'final and binding' [[link](#)]
 - Compensate creditors, \$460 million at the time, repaying 150k BTC (from lost 850k BTC)



Why Cross-chain Atomic Swaps

- Exchanges caught trading against their customers - to boost their numbers

Rank 1

Website

Explorer (2 3 4 5)

Message Board

Source Code

Technical Documentation

Coin Mineable

Market Cap: \$171,765,938,910 USD / 18,236,850 BTC

Volume (24h): \$44,227,400,916 USD / 4,695,742 BTC

Charts Market Pairs Social Tools Historical Data Ratings

Bitcoin Market Pairs (Adjusted)

#	Source	Pair	Volume (24h)	Price	Volume (%)
1	BHEX	BTC/USDT	\$1,419,901,861	\$9,416.74	3.21%
2	EtherFlyer	BTC/USDT	\$1,333,576,662	\$9,569.26	3.02%
3	Coinsbit	BTC/USDT	\$1,332,527,140	\$9,416.74	3.01%
4	ChainX	BTC/KRW	\$1,319,100,615	\$9,361.61	2.98%
5	LBank	BTC/USDT	\$1,266,587,931	\$9,410.98	2.86%
6	BitForex	BTC/USDT	\$1,225,965,438	\$9,412.63	2.77%
7	Hotbit	BTC/USDT	\$1,076,692,891	\$9,413.41	2.43%
8	Bilaxy	BTC/USDT	\$987,764,643	\$9,409.37	2.23%
9	CoinBene	BTC/USDT	\$838,338,060	\$9,408.28	1.90%
10	Hubi	ETH/BTC	\$810,624,682	\$9,418.29	1.83%
11	Folgory	BTC/USDT	\$745,645,944	\$9,402.26	1.69%
12	BitMart	BTC/USDC	\$689,383,130	\$9,415.98	1.56%
13	BitForex	ETH/BTC	\$642,834,898	\$9,418.29	1.45%
14	PayBit	BTC/USD	\$632,525,870	\$9,385.98	1.43%

CoinBene Exchange

BTC/USDT Last Price: 3271.27 Change: -50.37 -1.52% High: 3699.50

Order Book

Price(USDT)	Quantity(BTC)	Total(BTC)
3999.00	0.0569	3.976
3464.40	0.1629	3.807
3400.00	0.6168	3.778
3388.60	0.5160	3.710
3323.52	0.4700	2.650
3317.29	0.3400	2.150
3316.48	0.4100	1.750
3315.44	0.5000	1.350
3306.72	0.3000	0.650
3304.95	0.3000	0.650
3296.17	0.2000	0.250
3287.10	0.0400	0.050
3287.04	0.0200	0.050
3274.33	0.0150	0.050

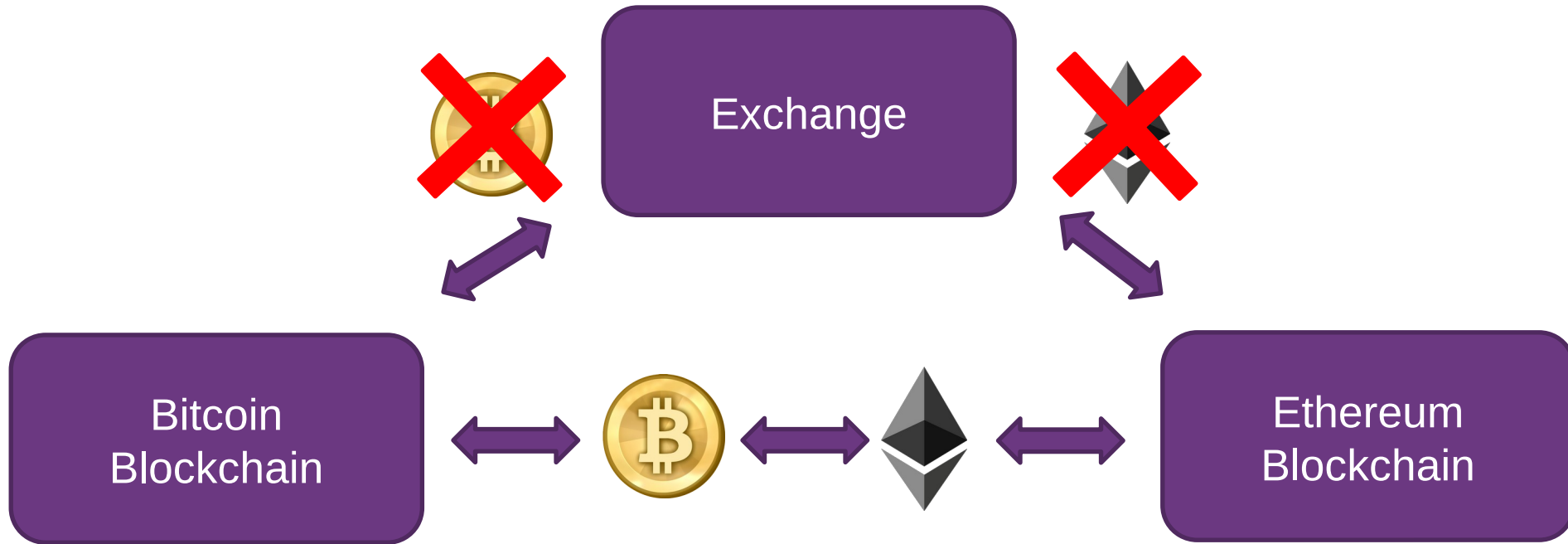
Market Trade

Price(USDT)	Quantity(BTC)	Date
3271.27		
3271.27		
3271.27		
3271.33	48.9	08:56:07
3271.33	43.4	08:56:07
3271.33	54.9	08:56:07
3271.33	48.9	08:56:07
3271.33	83.2	08:56:02
3271.33	73.4	08:56:02
3271.33	85.1	08:56:02
3271.33	75.4	08:56:02
3273.28	95.1	08:56:02
3273.28	84.0	08:56:02
3273.28	55.0	08:55:57
3273.28	25.2	08:55:57
3273.28	92.9	08:55:57
3273.36	58.1	08:55:57
3273.36	24.3	08:55:54
3273.36	10.1	08:55:54
3273.36	08.3	08:55:54
3273.36	96.7	08:55:54
3273.36	24.3	08:55:54
3273.36	10.2	08:55:54
3273.36	72.7	08:55:48
3273.99	64.9	08:55:48
3273.99	68.5	08:55:48
3273.99	61.1	08:55:48
3273.99	53.5	08:55:41
3271.38	47.3	08:55:41
3271.38	61.4	08:55:41
3271.38	54.5	08:55:41
3271.38	52.1	08:55:36
3271.38	35.5	08:55:36
3268.97		
3268.97		



Why Cross-chain Atomic Swaps

- With Atomic Swaps no trust in a centralized platform is needed: non-custodial



Hashed Time-Locked Contracts

- Building Blocks of Cross-chain Atomic Swaps
- Cryptographic hashing:
 - one-way function - computationally efficient in one way, computationally highly expensive the other way
 - deterministic – same input – same output
 - collision resistant – highly expensive to find two inputs that hash to the same output

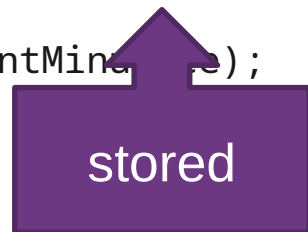
SHA256 Hash

Data:	<input type="text" value="aoeuaoeuao"/>
Hash:	<input type="text" value="8698bce64d5c921046ce61e7fd0f538ad44c8f5a44e0b7789daf660d653544d8"/>

Hashed Time-Locked Contracts

- Building block for cross-chain atomic swaps and payment channels
- Hash lock:
 - store hashed secret – publicly stored in a smart contract
 - unlock – only if secret is provided (publicly)

```
function redeem(bytes32 contractId, bytes32 secret) external {  
    require(contracts[contractId].sender != address(0), "contract needs to exist");  
    //encodePacked -> unpadded encoding  
    require(contracts[contractId].hashedSecret == sha256(abi.encodePacked(secret)), "hashlock hash does  
not match");  
    ...  
    c.receiver.transfer(amountMinimum);  
}
```



Hashed Time-Locked Contracts

- Building block for cross-chain atomic swaps and payment channels
- Hash time lock:
 - store hashed secret – publicly stored in a smart contract
 - unlock – only if secret is provided (publicly) before timeout

Or

- unlock – after timeout

```
function recover(bytes32 contractId) external {
```

```
    require(contracts[contractId].lockTime <= now, "refundable: timelock not yet passed");
```

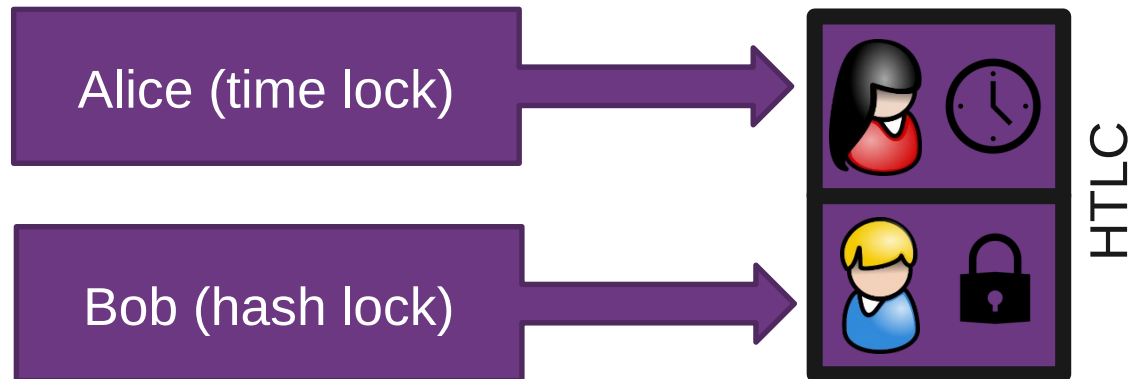
```
    c.sender.transfer(c.amount);
```

Hashed Time-Locked Contracts

- Building block for cross-chain atomic swaps and payment ch.
- Hash time lock:
 - store hashed secret – publicly stored in a smart contract
 - unlock – only if secret is provided (publicly) before timeout

Or

- unlock – after timeout



Hash time lock (HTLC)

```

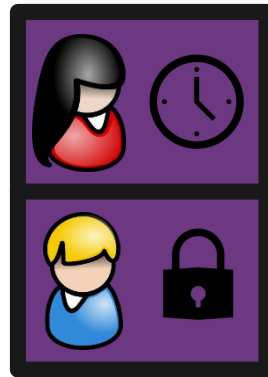
OP_IF
  OP_SIZE
  AddInt64(secretSize)
  OP_EQUALVERIFY
  OP_SHA256
  AddData(secretHash)
  OP_EQUALVERIFY)
  OP_DUP
  OP_HASH160
  AddData(pkhThem[:])
OP_ELSE
  AddInt64(locktime)
  OP_CHECKLOCKTIMEVERIFY
  OP_DROP
  OP_DUP
  OP_HASH160
  AddData(pkhMe[:])
OP_ENDIF
OP_EQUALVERIFY
OP_CHECKSIG
    
```

Annotations for the code block:

- A bracket on the left groups the entire code block under the label "Hash time lock (HTLC)".
- A bracket on the right groups the top half of the code (from `OP_IF` to `AddData(pkhThem[:])`) under the label "Hash lock to Bob".
- A bracket on the right groups the bottom half of the code (from `OP_ELSE` to `OP_CHECKSIG`) under the label "Time lock to Alice".

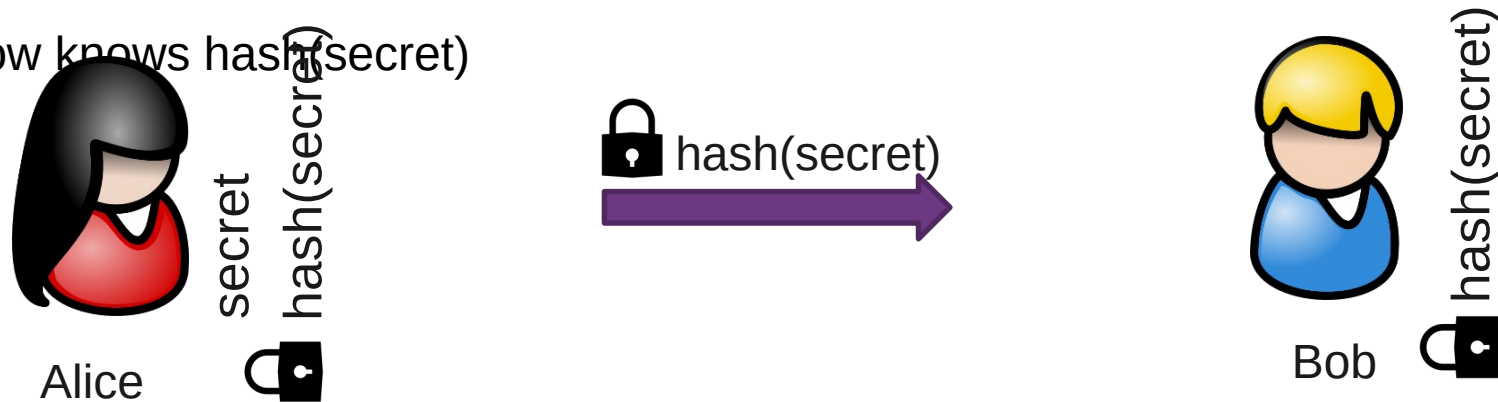
Hashed Time-Locked Contracts

- Now we are ready to do an atomic swap with Alice and Bob
 - 1 BTC for 37 ETH



Atomic Swaps

- Now we are ready to do an atomic swap with Alice and Bob with HTLC
 - Alice (initiator) creates “secret”, shares with Bob, hash(secret)
 - Bob now knows hash(secret)



Blockchain BTC

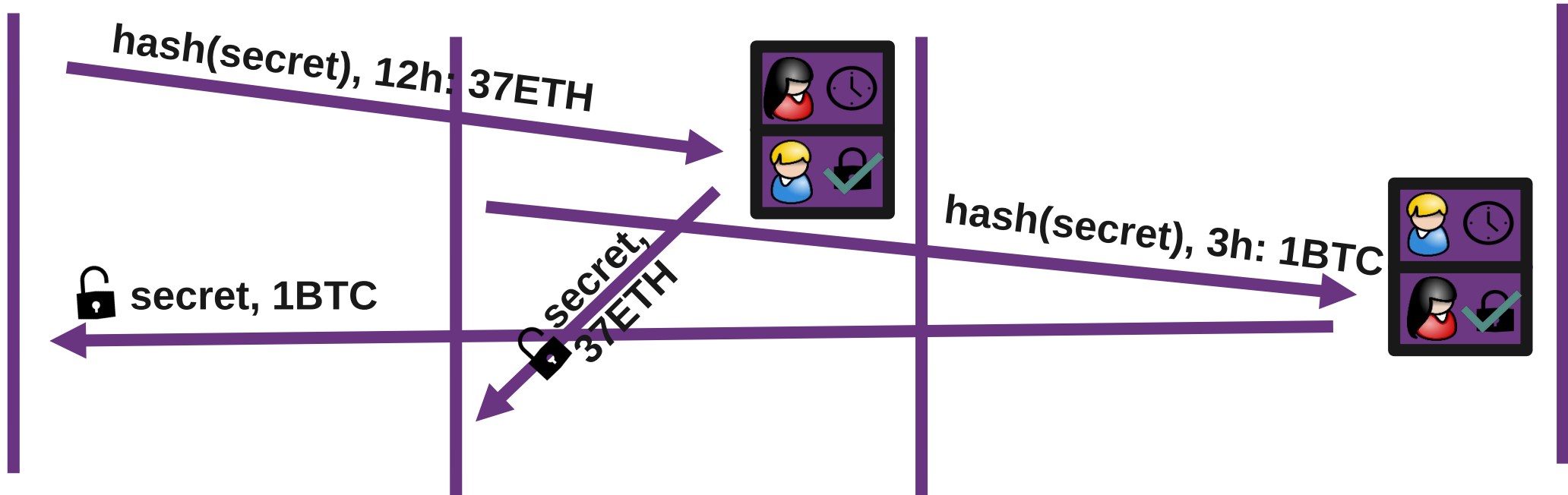
Blockchain ETH

Atomic Swaps - Alice reveals secret to redeem 1 BTC



Ethereum
Blockchain

Bitcoin
Blockchain

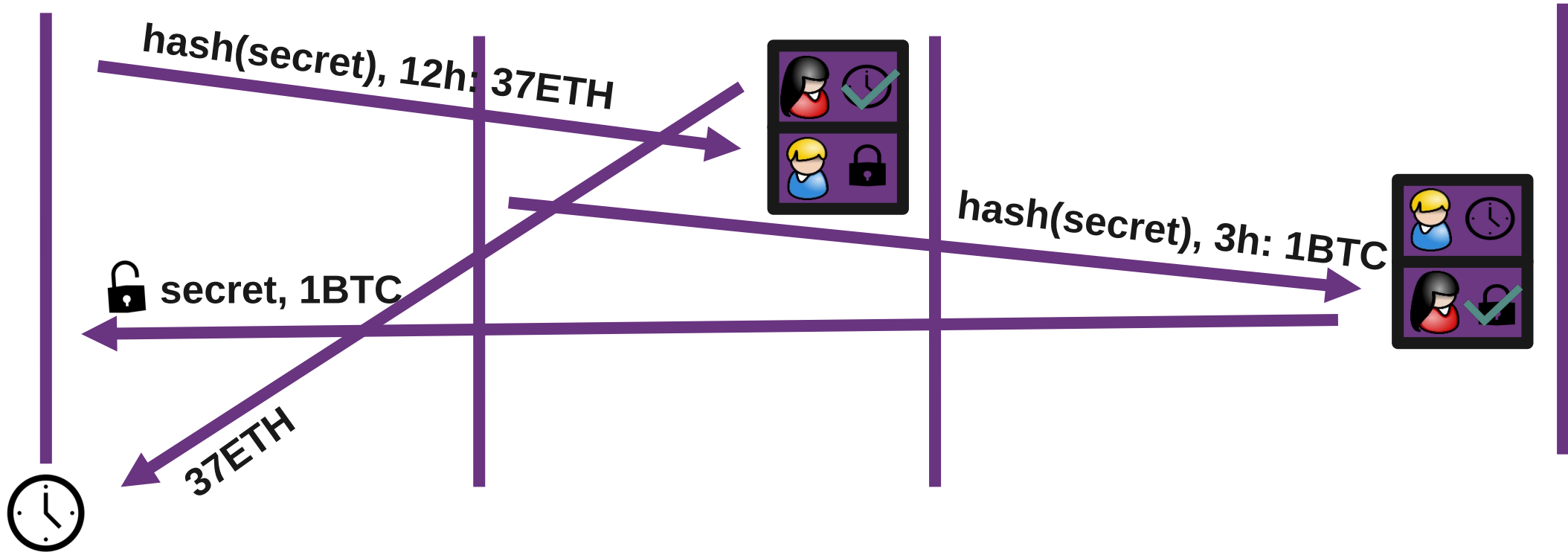


Atomic Swaps - Bob goes offline (worst case)



Ethereum Blockchain

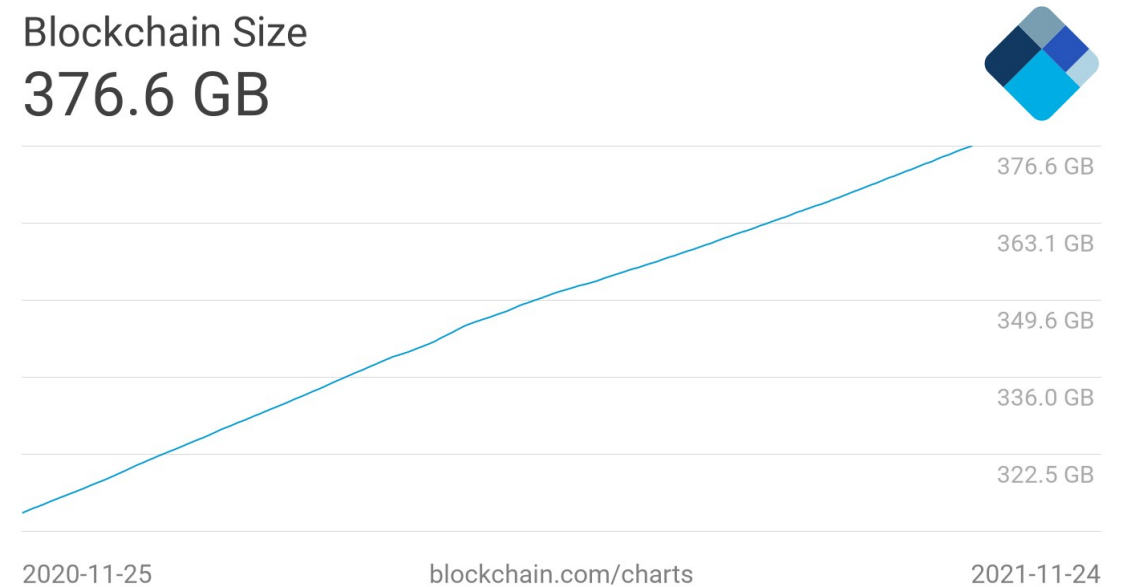
Bitcoin Blockchain



Scalability Solutions

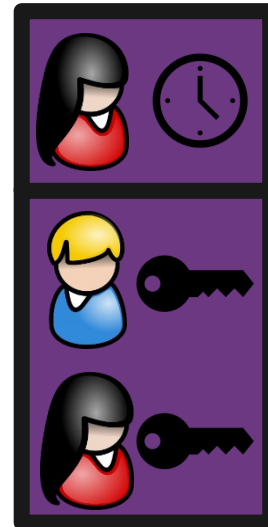
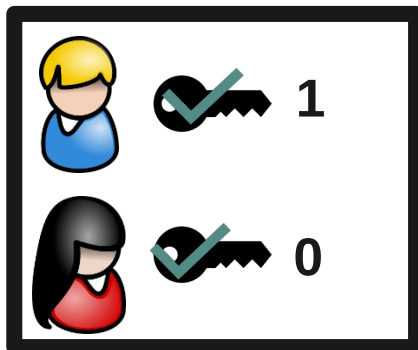
- Blockchains grow linearly
- Solutions
 - 1. First Layer Scalability Solutions (on-chain)
 - Sharding (distribute storage)
 - Improve protocol (SegWit, Taproot, Rollups)
 - 2. Second Layer Scalability Solutions (off-chain)
 - State Channels (payment channels)
 - Lightning Network
 - Sidechains / Blockchain Interoperability

Blockchain Size
376.6 GB

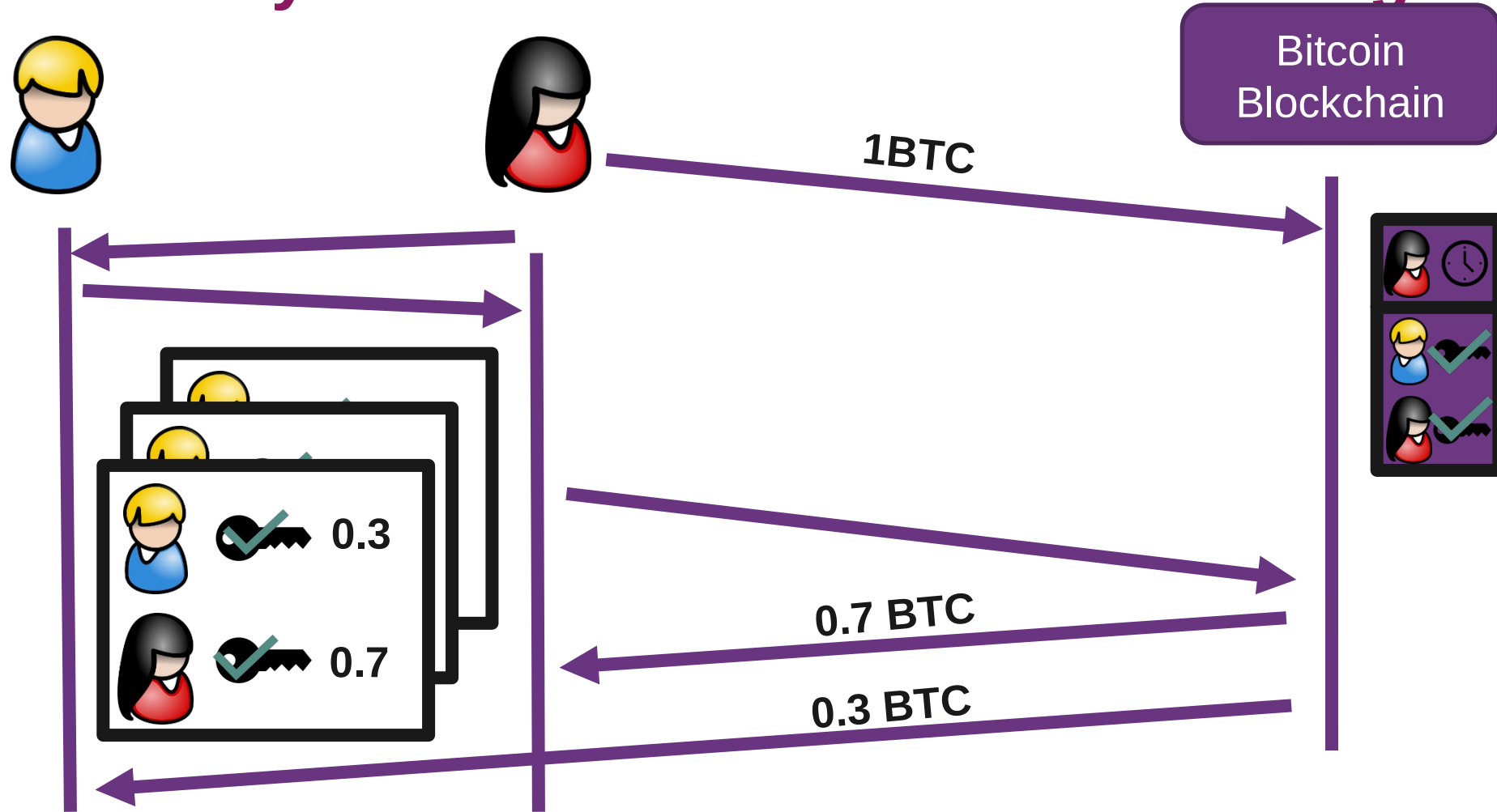


Direct Payment Channel with 2-of-2 Multisig Contracts

- Open a payment channel between Alice and Bob
 - 1 BTC of Alice to Locked Multisig
 - 2-of-2 multisig
 - Initial offchain TX
 - Bob does nothing

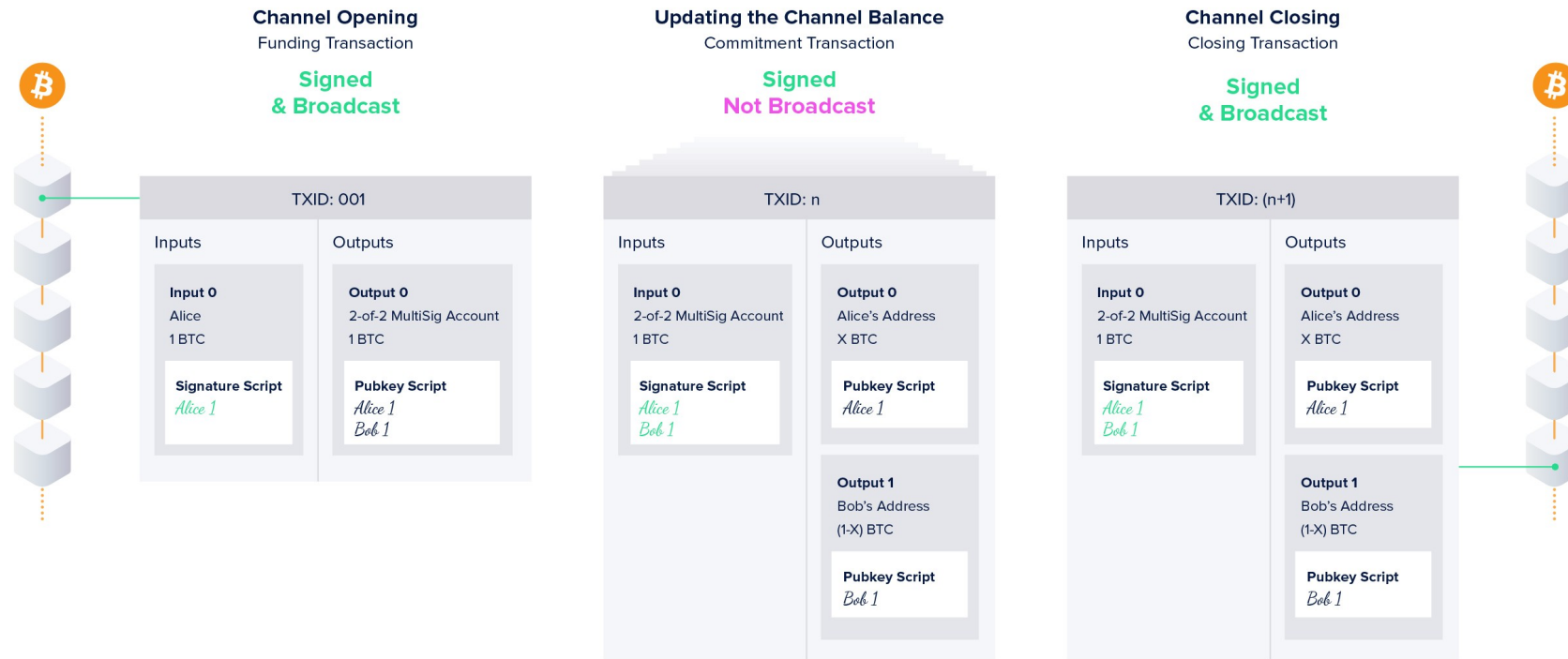


Direct Payment Channel with 2-of-2 Multisig Contracts



Other View on Direct Payment Channels

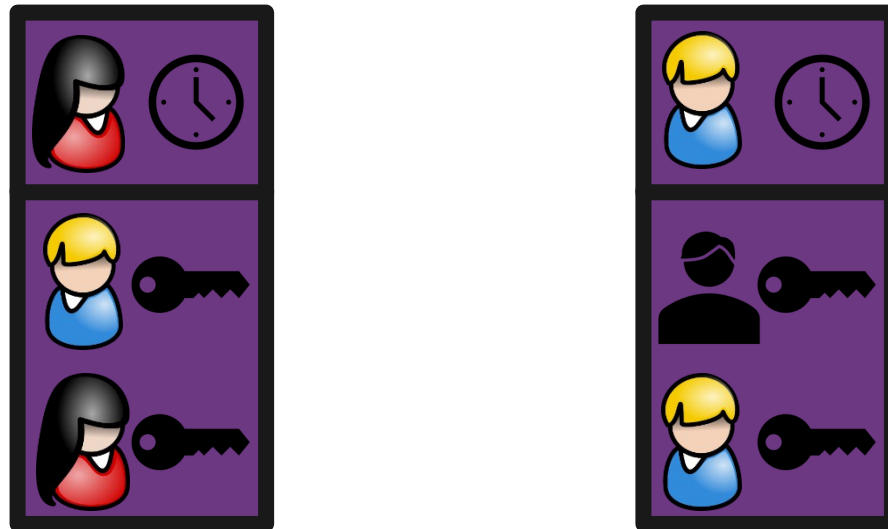
PAYMENT CHANNEL CONCEPT



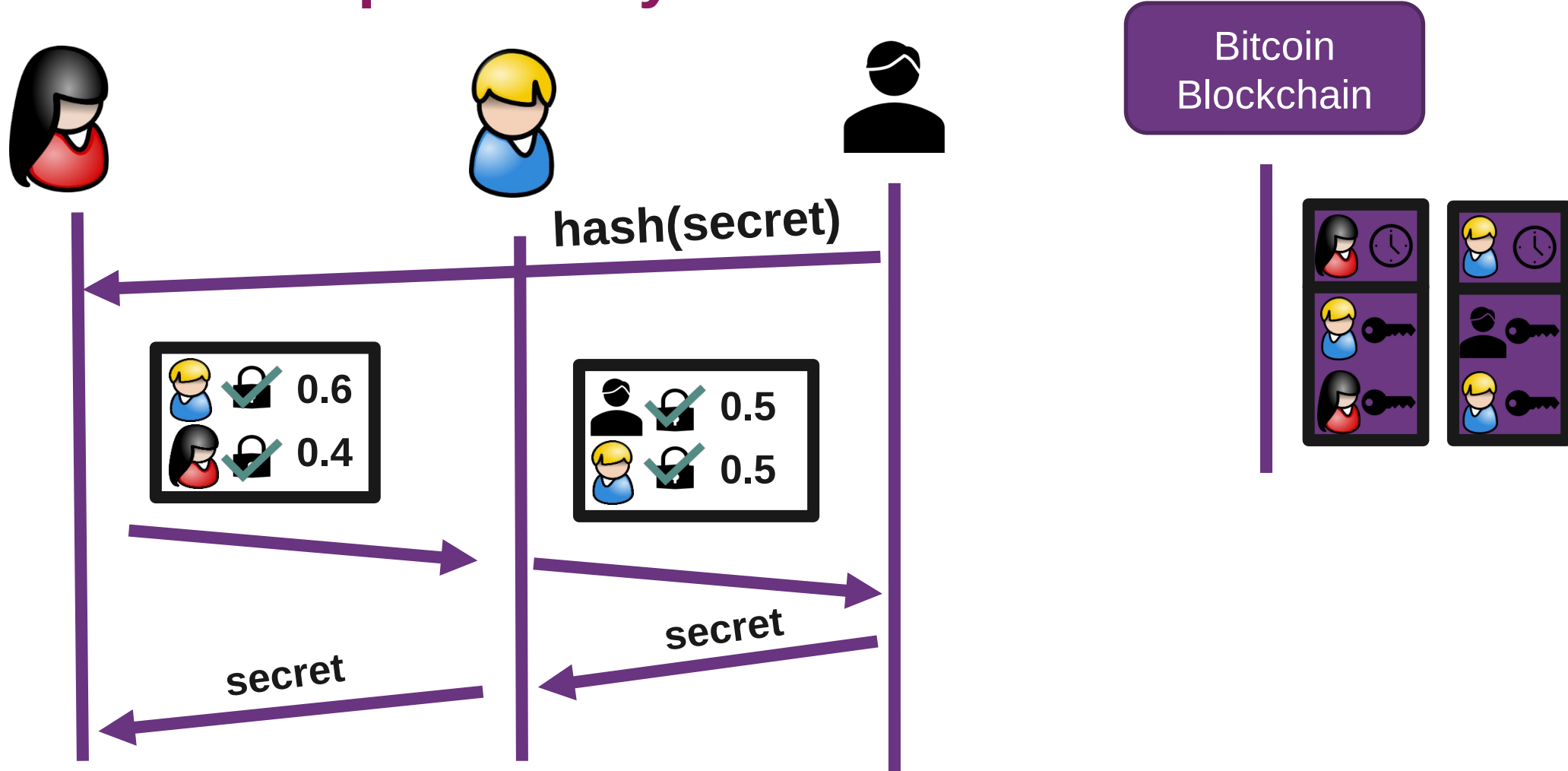
<https://academy.horizen.io/technology/expert/state-and-payment-channels/>

Indirect Payment Channel with HTLC

- Now we are ready to open a payment channel between Alice and Bob and Charlie
 - 1 BTC lockup, Alice – Bob, Bob – Charlie
 - Alice wants to send 0.5 BTC to Charlie (no direct channel)



Atomic Swaps – 2 Payment Channels with 1 BTC



Other View on Indirect Payment Channels

<https://medium.com/softblocks/lightning-network-in-depth-part-2-htlc-and-payment-routing-db46aea445a8>

