Blockchain
& Distributed Internet Infrastructure

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Purpose of this Meeting

- Discuss blockchain-based and Distributed Internet Infrastructure concepts, state of the art, new ideas
  - Useful applications beyond financial sector?
  - Relationship to other efforts (ICN?)
  - Potential next steps

Agenda

1. **Overview of blockchain and related frameworks** -- Dirk
2. **Blockchain registries - the future of protocol operations** -- Alex
3. **Internet-wide Federation** -- Jeffrey
4. Discussion of potential next steps

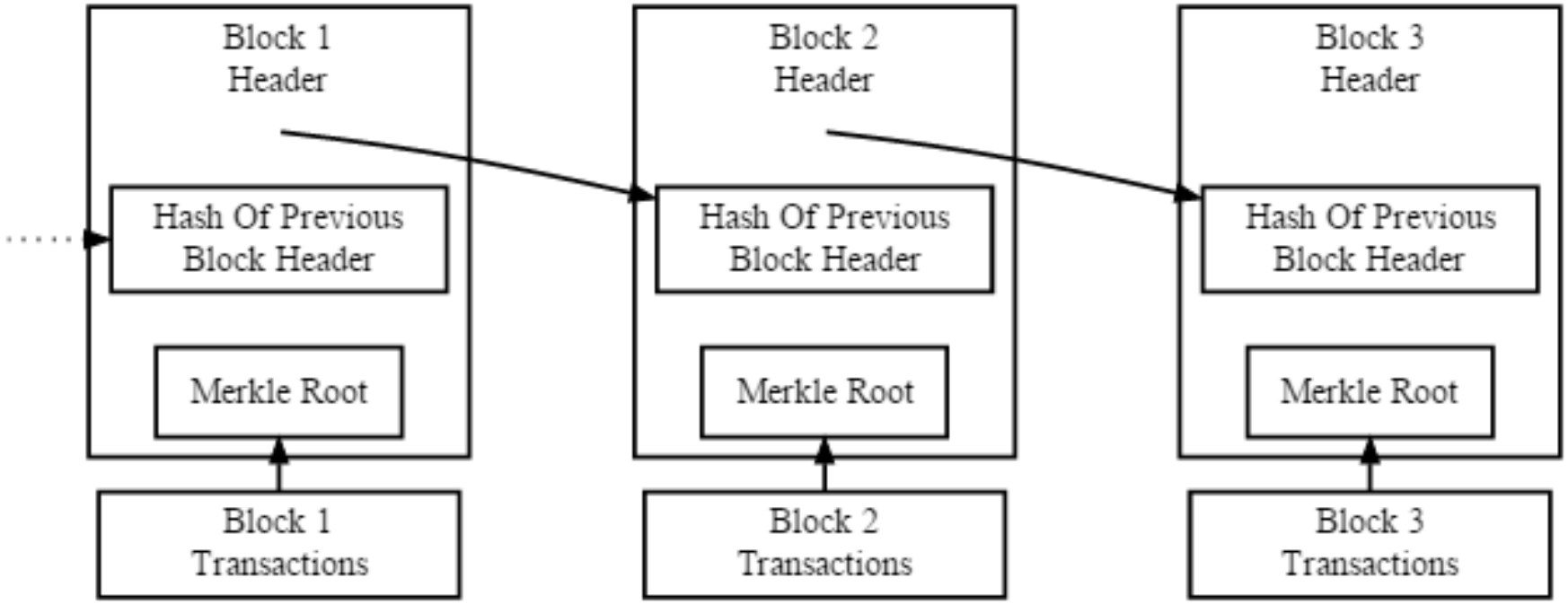
Bitcoin

- P2P payment network
- Transactions: broadcasting signed bitcoin transfer message
- Transactions are recorded in distributed and replicated public database: blockchain
- Blockchain groups transactions into blocks by timestamp
- Blockchain cryptographically protected
- Consensus algorithm based on proof-of-work
- Longest blockchain prevails
- Blockchain is distributed by P2P filetransfer

Interesting Properties

- No centralized coordination, no trusted parties
- Sufficiently robust against fraud (double-spending)
- Transaction irreversibility
- Some level of pseudonymity
- Blockchain can be generalized to other distributed ledger applications
  - Bitcoin: digital currency transfers
  - Other digital artifacts would work as well (names etc.)

Blockchain Illustrated

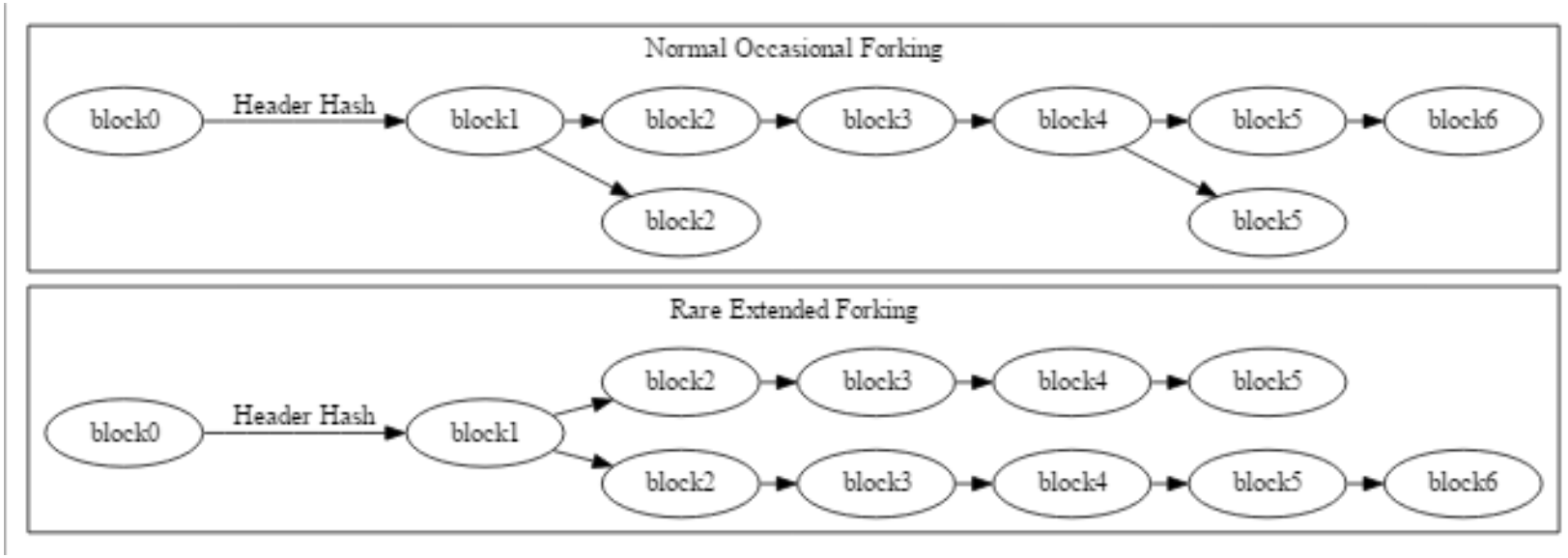


Simplified Bitcoin Block Chain

Proof of Work

- Blockchain is collaboratively maintained by peers on the network
- Each block to provide verifiable proof of work invested in its creation (here: finding a hash with certain properties)
- Blocks refering to previous blocks (chain)
- Chaining makes it impossible to modify transactions later

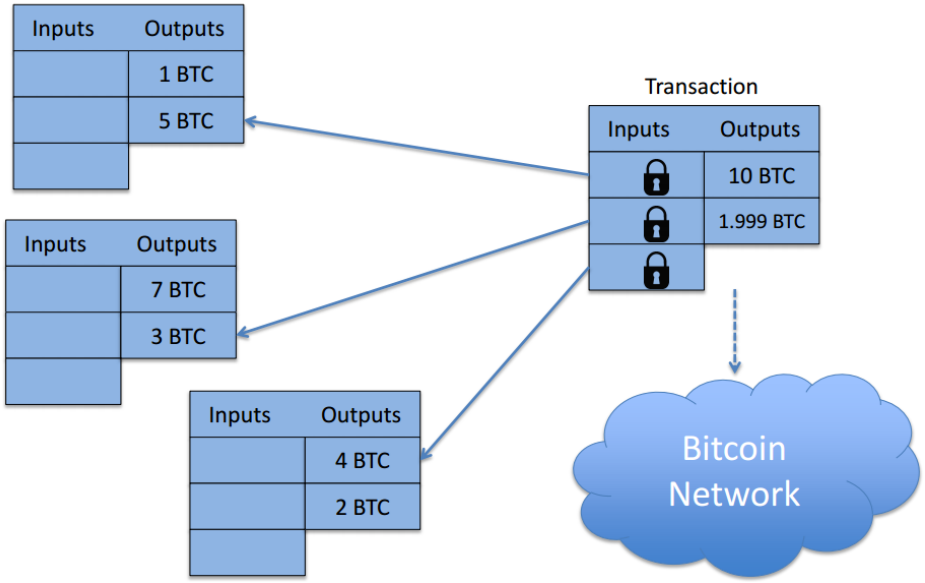
Consensus Protocol



- Blockchain can be modified concurrently
- Networks converges on longest chain (following the most difficult-to-recreate chain)
- Relatively robust against attacks (51% mining power required to attack blockchain)

Transactions

- Addresses: RIPEMD-160(SHA-256(PK))
  - Value is moved between addresses using transactions



- Verfication according to specified rules

Bitcoin Nodes

- Full nodes
  - Store entire blockchain (~15GB)
- Light nodes
  - Download block headers only
  - Verify proof of work on block headers
  - Download branches associated to a given transaction only

Bitcoin Merits

- Dentralized consensus based on proof-of-work concept
  - Implemented through blockchain
- Applicable to other applications that can benefit from a public, distributed ledger

- Caveats
  - Update & convergence times not really suitable for time-critical applications
  - Considerable cost for mining (i.e., for proof of work)

Alternative Blockchain Applications

- Namecoin
  - Decentralized name registration database
  - Map names to arbitrary identifiers (DNS names, Bitcoin IDs etc.)
  - *First-to-file paradigm* to avoid impersonation
- Other currencies
  - Colored coins (persistent attributes to Bitcoin units)
  - Metacoins (configurable state transitions)

Namecoin

- Can store data in blockchain database
- Records
  - Hierarchical names (keys)
  - Byte array values (520 max length)
- Potential applications
  - Identity systems
  - Notary systems
  - Decentralized name resolution („censorship-free DNS“)

.bit

- TLD outside DNS (independent of ICANN)
- Names resolved through Namecoin-enabled resolver (web-browser plugin or supporting DNS server)
- draft-grothoff-iesg-special-use-p2p-bit-00
- Differences to DNS
  - Domain names not delegated to an authority that can assign them – they are directly acquired by interested users
  - Namecoin blockchain is the complete domain database
  - Namecoin not limited to domain names – there are actually multiple namespaces in Namecoin
- Namecoin seems to be rarely used today

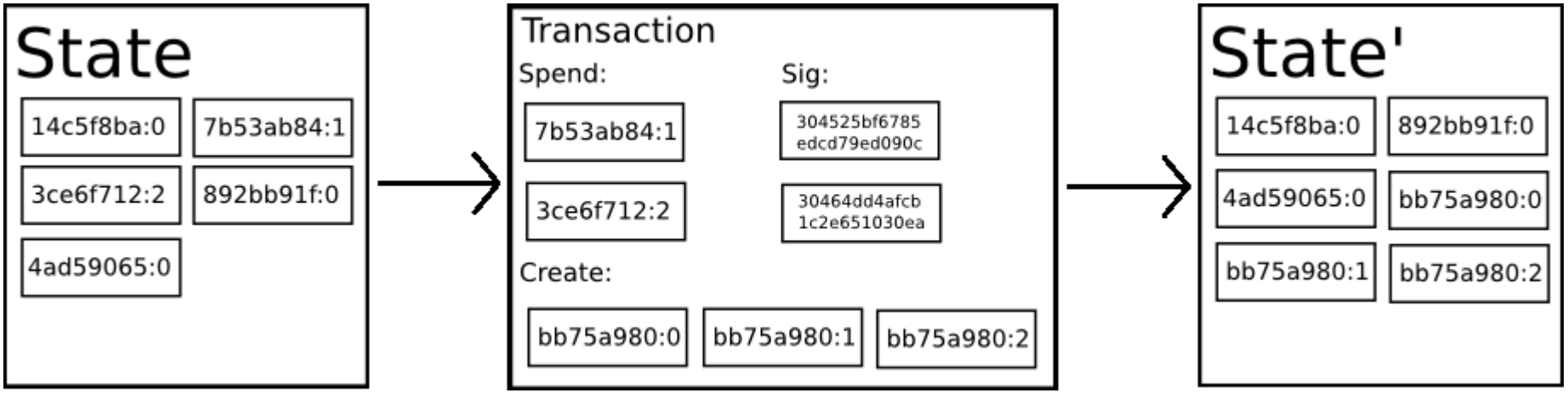
OneName

- Decentralized identity system

"u/username"


```
{
    "name": { "formatted": "John Smith" },
    "location": { "formatted": "New York, NY" },
    "website": "http://example.com",
    "github": { "username": "someuser" },
    "facebook": { "username": "someuser" },
    "twitter": { "username": "someuser" },
    "bitcoin": { "address": "1JwSSubhmg6iPtRjtyqhUYYH7bZg3Lfy1T" },
    "bitmessage": { "address": "BM-orkCbppXWSqPpAxnz6jnfTZ2djb5pJKDb" },
    "pgp": {
        "fingerprint": "D34987E8FAD4AE18C8680B4604DE396333BDC0E1",
        "url": "https://s3.amazonaws.com/97p/pubkey.txt"
    },
    "v": "0.2",
    "next": "i/username-1"
}
```

Generalizing State Transition / Validation



Ethereum

- Blockchain with Turing-complete programming language
- Smart contracts and decentralized applications
- Users can write arbitrary rules for ownership, transaction formats, and state transition functions
- Generalized platform for specific applications, e.g., Namecoin-like systems

Ethereum Applications

- Financial
  - Different ways of managing and entering into contracts using money
  - Sub-currencies, financial derivatitives, saving wallets etc.
- Other decentralized applications
  - Online voting, decentralized governance
- Decentralized File Storage
  - Storing file blocks as encrypted bloby in Merkle tree
  - Micropayments for storage and distribution services

Blockchain in OSS/Standards

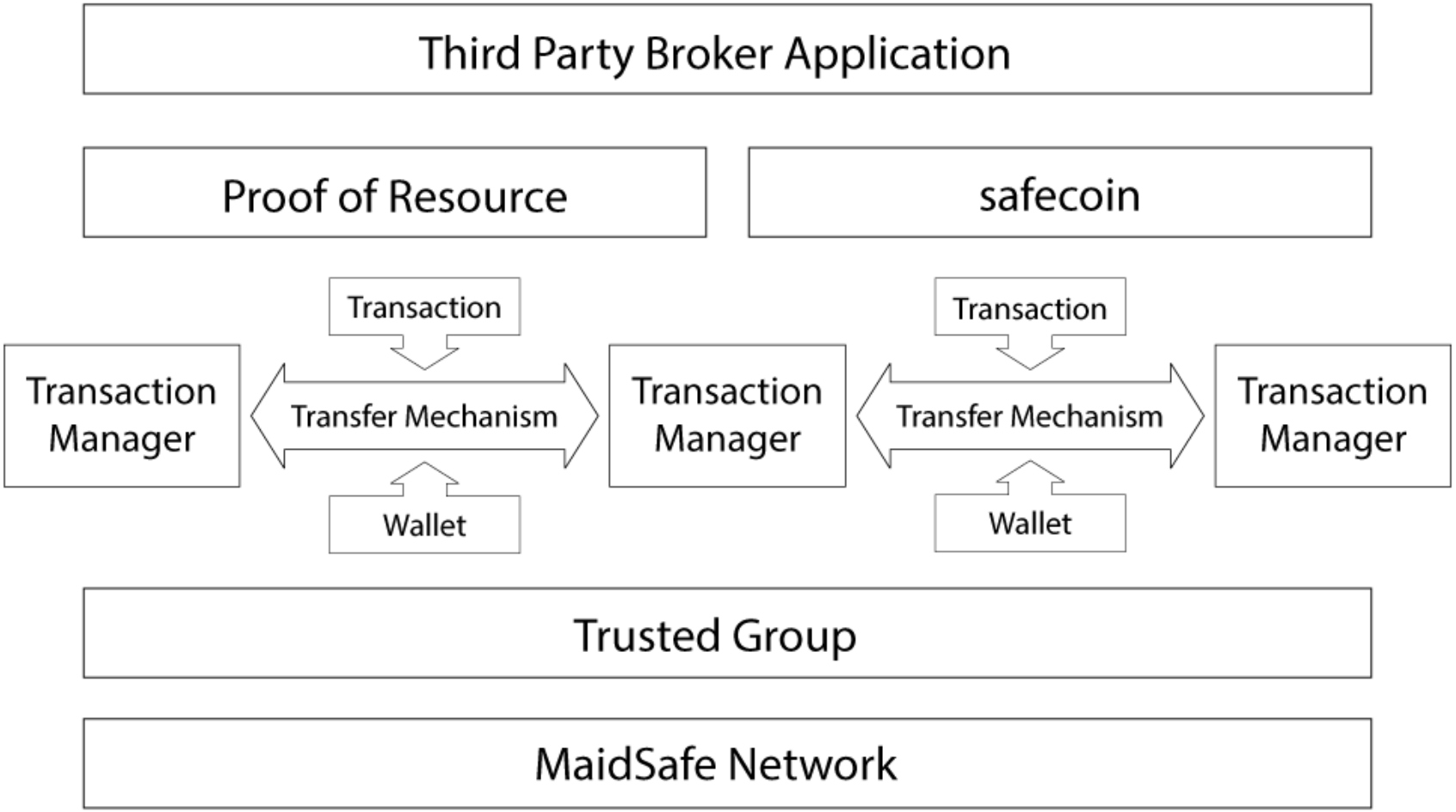
- Hyperledger Linux Foundation project
  - create an enterprise grade, **open source distributed ledger framework** and code base, upon which users can build and run robust, industry-specific applications, platforms and hardware systems to support business transactions
  - create an open source, technical community to benefit the ecosystem of HLP solution providers and users, focused on **blockchain and shared ledger use cases that will work across a variety of industry solutions**
  - promote participation of leading members of the ecosystem, including developers, service and solution providers and end users
  - host the infrastructure for HLP, establishing a neutral home for community infrastructure, meetings, events and collaborative discussions and providing structure around the business and technical governance of HLP

https://www.hyperledger.org/

Maidsafe

- P2P-like communication network based on blockchain
- Includes own Safecoin currency for incentivization (micropayments for resource usage) – built on top of bitcoin
- Network stores and replicates encrypted chunks of published data
- Chunk transport with caching support

MaidSafe Tech Stack

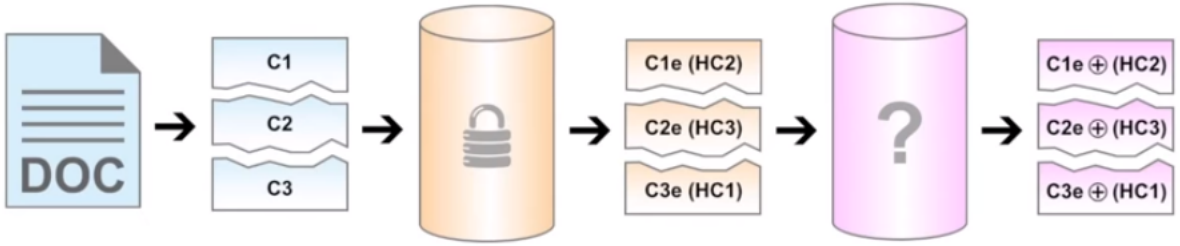


Maidsafe Implementations

- Distributed Transaction Manager (corresponding to Bitcoin‘s blockchain)
  - Stores users‘ account info
  - Not in a linked chain, but by other nodes that are (P2P-address-wise) close to user
- Proof-of-Resource
  - Validates users and their value to the network
  - Storage, computation and communication resources made available to network

MaidSafe Technologies

- Kademlia DHT
- UDP-based transport protocol



Data Map

Pre Encryption	Post Encryption
HC1	C1e ⊕ (HC2)
HC2	C2e ⊕ (HC3)
HC3	C3e ⊕ (HC1)

MaidSafe Assessment

- Many similarities to DHT-based ICN
  - E.g., Telecom Italia's Global Information Network (GIN)
  - Strangely, none of this seems to be considered in MaidSafe documents
- Documentation seems incomplete
  - Mostly on youTube...
  - Some skeptical reviews on the web
  - https://letstalkbitcoin.com/the-brokenness-of-maidsafe

Interplanetary Filesystem (IPFS)

- Hypermedia distribution protocol based on P2P file system
- Addressed by content and identities
- Aims at distributed application creation

IPFS: P2P distributed file system

- Seeks to connect all computing devices with the same system of files
- Analogy: a single BitTorrent swarm, exchanging objects within one Git repository
- Provides a high throughput content-addressed block storage model, with content-addressed hyperlinks
- Forms a generalized Merkle DAG, a data structure upon which one can build versioned file systems, blockchains, and even a Permanent Web
- Combines a distributed hashtable, an incentivized block exchange, and a “self-certifying namespace”
- No single point of failure, and nodes do not need to trust each other

IPFS (1)

- Identities
  - NodeIDs: public key hash
- DHT: S/Kademlia
  - Eliminates some attacks on Kademlia‘s routing system (among other properties)
- Transport
  - In principle agnostic to transport, but typically used with WebRTC DataChannels or uTP
  - Can add reliability service on top of chosen underlay
  - ICE for NAT traversal
  - Optional support for integrity and authenticity
  - Does not necessarily assume IP

IPFS (2)

- Routing in DHT, based on
  - Other peers‘ network addresses
  - Object names
- Block exchange
  - Like BitTorrent, but not exchange not limited to blocks in a torrent
  - Incentivizing cooperation (different strategies: tit-for-tat, currency-based etc.)
  - Per-node ledger for accounting transfers that is exchanged when nodes „connect“

IPFS (3)

- Object Merkle DAG
  - On top of DHT/block exchange
  - DAG links objects (based on their hash values)
  - Objects are immutable
  - Generalization of Git data structure
  - Similar to ICN manifests
- Special namespace for mutable objects
  - Signature verification with publisher/owner node‘s public key („self-certifying names“)
- Aliases for human-friendly names, URIs
- Different possible applications
  - Document publishing, cryptocurrency blockchains etc.

IPFS Advertized Use Cases

1. As a mounted global filesystem, under /ipfs and /ipns
2. As a mounted personal sync folder that automatically versions, publishes, and backs up any writes.
3. As an encrypted file or data sharing system
4. As a versioned package manager for all software
5. As the root filesystem of a Virtual Machine
6. As the boot filesystem of a VM (under a hypervisor)
7. As a database: applications can write directly to the Merkle DAG data model and get all the versioning, caching, and distribution IPFS provides
8. As a linked (and encrypted) communications platform
9. As an integrity checked CDN for large files (without SSL)
10. As an encrypted CDN
11. On webpages, as a web CDN
12. As a new Permanent Web where links do not die

IPFS Assessment

- „Marrying P2P and Github“
- Not directly an application of blockchain
- Seems to ignore existing work in ICN and P2P

Summary

- Blockchain: useful for decentralized recording of transactions – not only for crypto currency
- Consensus protocol does not lend itself to real-time applications
  - Takes some time until transaction can be considered accepted
- Hence: decentralized ledger
  - Registries, namespace management
  - Ethereum: generalized, programmable blockchain
  - Caveat: proof of work requires real work – cf. ressource consumption for bitcoin mining
- Related communication frameworks
  - Decentralized, censorship-free communication with crypto currency seem to be main drivers
  - Understanding merits and detailed security properties needs deeper analysis

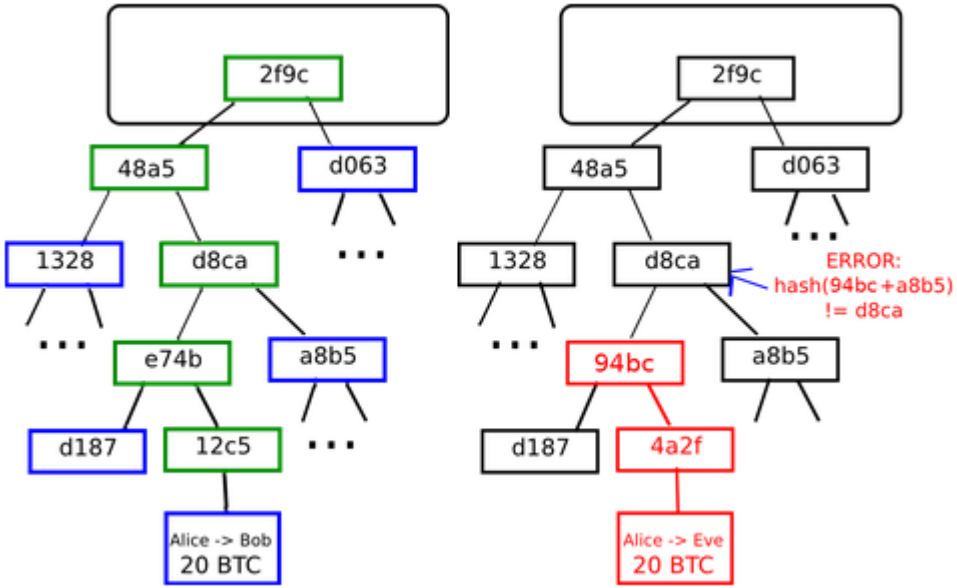
http://dirk-kutscher.info/misc/blockchain-resources/

Next

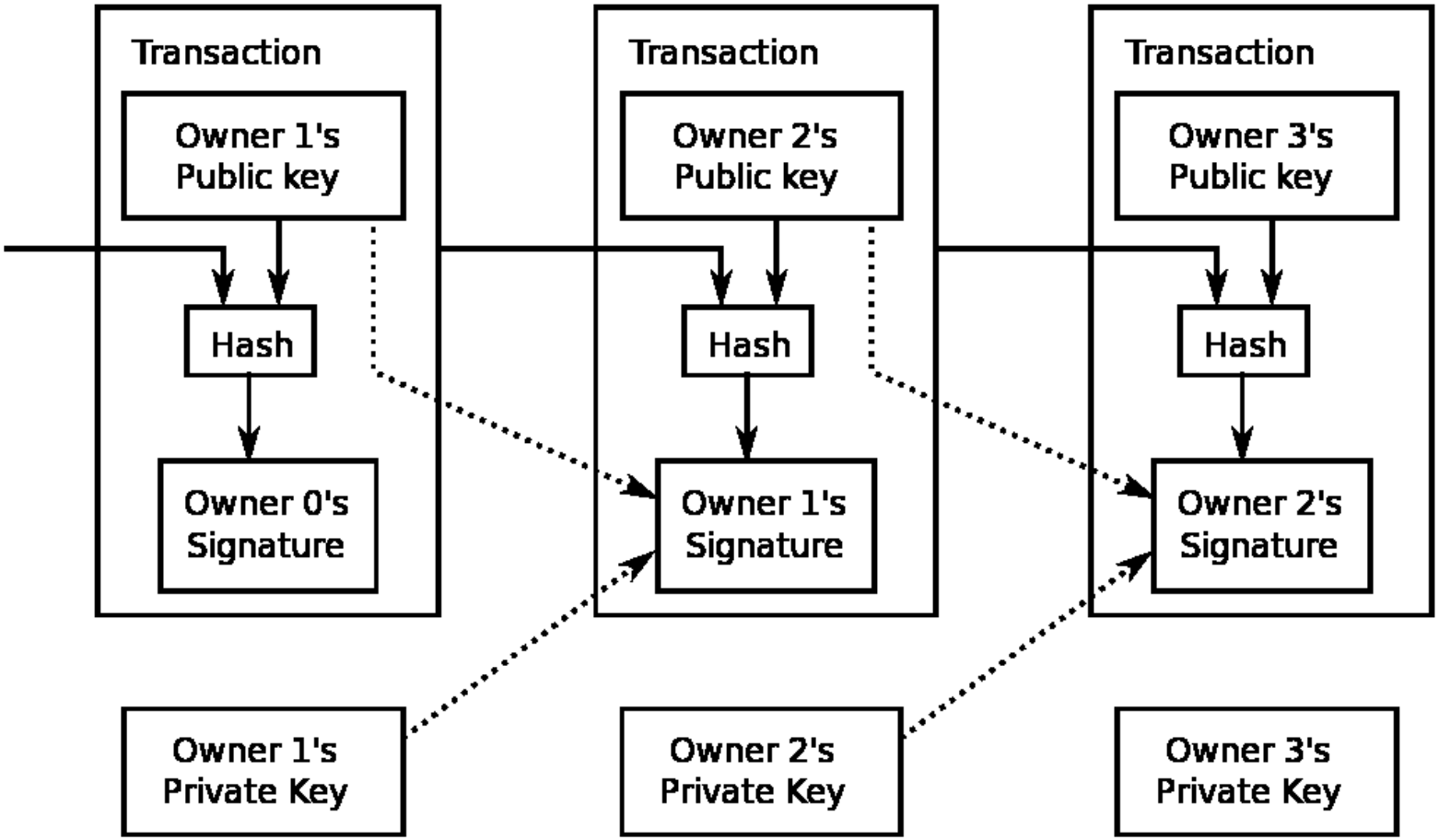
- **Blockchain registries - the future of protocol operations** -- Alex
- **Internet-wide Federation** -- Jeffrey

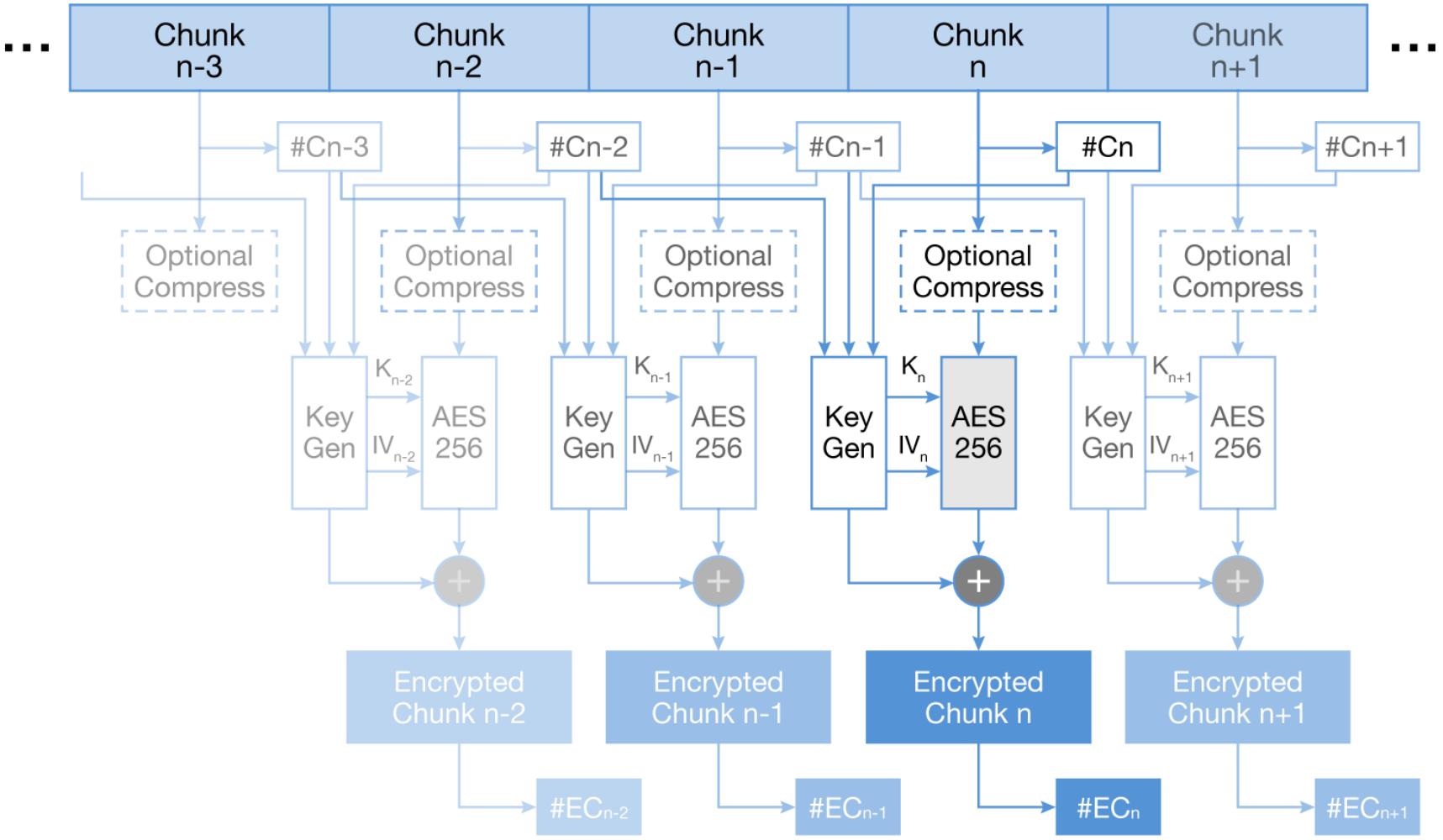
BACKUP

Transactions in a Block



Bitcoin Transfer




...
Chunk n-3
Chunk n-2
Chunk n-1
Chunk n
Chunk n+1
...
#Cn-3
#Cn-2
#Cn-1
#Cn
#Cn+1
Optional Compress
Optional Compress
Optional Compress
Optional Compress
Optional Compress
Key Gen
AES 256
K_{n-2}
IV_{n-2}
K_{n-1}
IV_{n-1}
K_n
IV_n
K_{n+1}
IV_{n+1}
Encrypted Chunk n-2
Encrypted Chunk n-1
Encrypted Chunk n
Encrypted Chunk n+1
$\#EC_{n-2}$
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