PROTOKOLL v2

- PROTOKOLL v2
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    - conflict resolution
    - control protocol
    - transfer protocol
    - connection management
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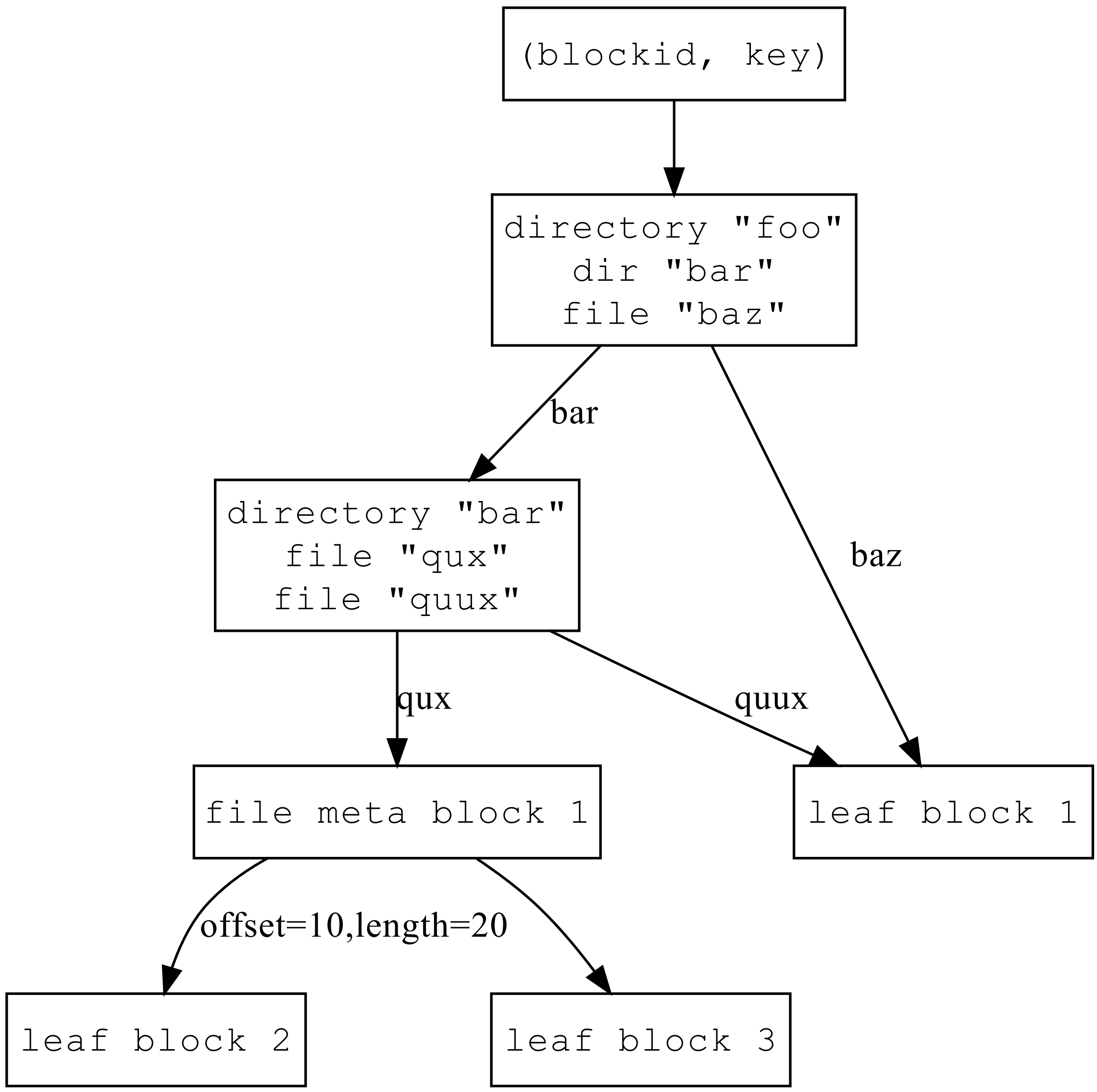
    - crypto
  - Filesystem Crypto
  - Transmission Crypto
  - Threat Model (v1)

- frontend
  - actual files / file tree
  - abstract, e.g.
    - FUSE (Filesystem in Userspace)
    - plain files
    - webdav / http api
    - samba/nfs
    - …
  - render the current tree state
  - propagate changes back, translating them into blockdb changes
- blockdb
  - independent storage of raw blocks
  - used to construct actual file-tree (frontend)
  - modified Merkle-Tree
  - abstract backend, e.g.
    - plain files
    - sqlite
    - …
  - invariants:
    - block identified by blockid, aka hash(block), thus is CoW

    - hash algorithm configurable but not compatible - if you wanna change it, you have to convert your entire db on every participant
    - variable block size, by default each file is one block and each dir is one block
    - blocks can be arbitrarily large
    - can store partial blocks! (e.g. incomplete/aborted transfers)
  - MAY use compression! lots of low hanging fruit here in terms of space savings!
  - different types of blocks:
    - leaf blocks
      - actual file contents
      - contain arbitrary payload data
    - file meta blocks
      - a list of blockrefs
      - the file is a concatenation of the blockref's payloads
      - cycles of file meta blocks not easily possible due to merkle tree structure
    - directory blocks
      - files / folders and one blockref each
      - metadata: Name, lastmodified, size
  - blockref = (blockid, key, hints)
    - NB changing the key of a blockref changes the plaintext
    - however modifications of the key (and the ciphertext if the cipher is CCA secure) produce random changes in plaintext
    - hints = Vec<(blockref, offset, length)>
      - "this block consists of these parts of other blocks"
      - prevent redownload of known subblocks
      - important when subdividing file blocks (e.g. change this part here in the middle: separate into 3 leaf blocks: first hints at beginning of original block, last at end, middle is new -> no redownload of first and last leaf block)
      - optional (can be empty or ignored), but can be used for optimizations
      - if set, it MUST be correct
      - correctness MUST be verified by blockid
      - MAY be used
      - SHOULD be forwarded
      - MAY be implemented for file meta blocks (2 PB file which gets changed often) and directory blocks (directory with 1e6 files)
      - SHOULD be implemented for leaf blocks
- random thought: zfs module possible; control front- and backend; use snapshots as blockdb

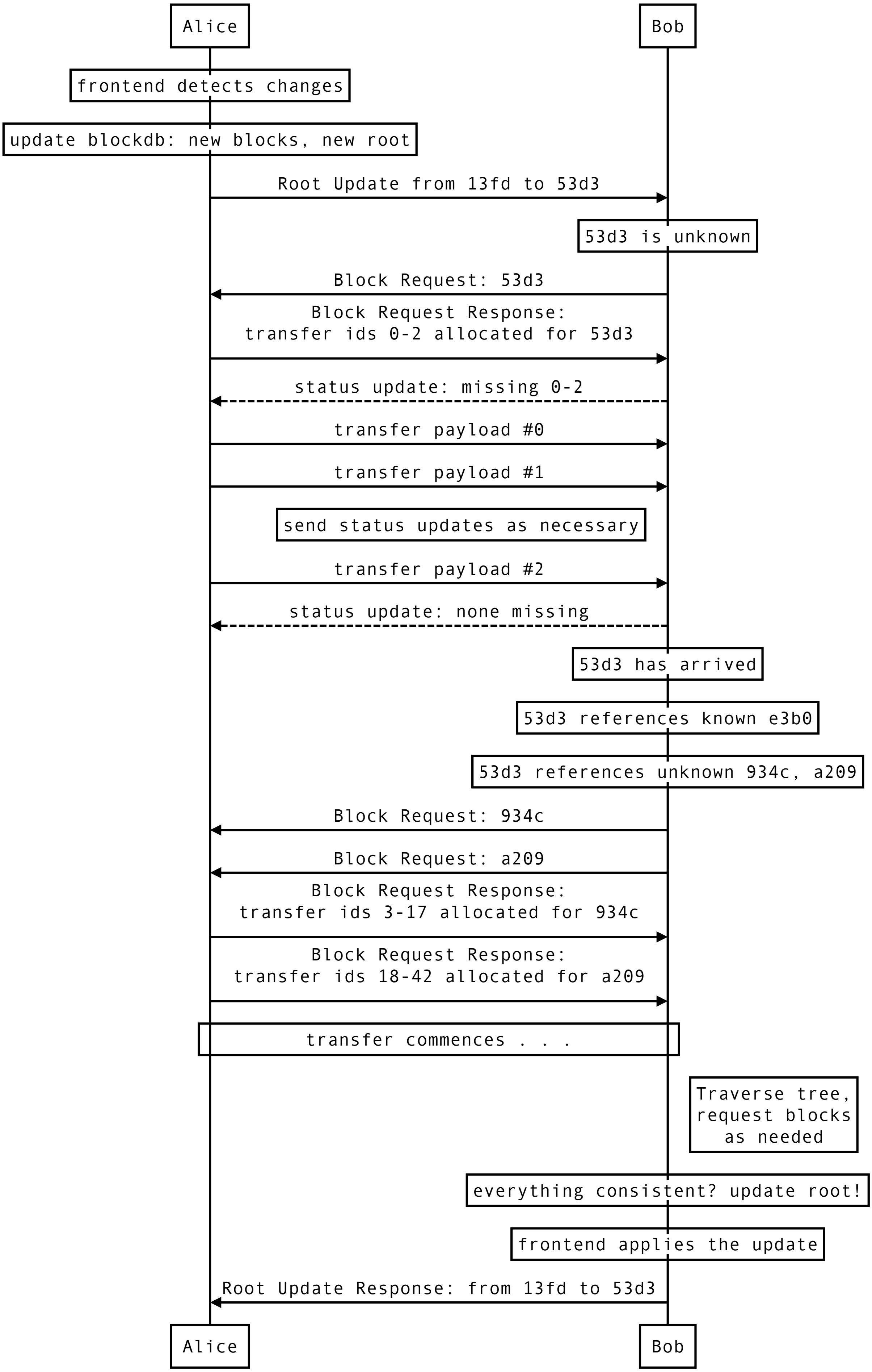
Example Merkle Tree (simplified)



bootstrap

folder always starts out empty; empty block hash is known, thus no bootstrap is required - everyone spontaneously starts out in the same state

basic protocol


Alice
Bob
frontend detects changes
update blockdb: new blocks, new root
Root Update from 13fd to 53d3
53d3 is unknown
Block Request: 53d3
Block Request Response:
transfer ids 0-2 allocated for 53d3
status update: missing 0-2
transfer payload #0
transfer payload #1
send status updates as necessary
transfer payload #2
status update: none missing
53d3 has arrived
53d3 references known e3b0
53d3 references unknown 934c, a209
Block Request: 934c
Block Request: a209
Block Request Response:
transfer ids 3-17 allocated for 934c
Block Request Response:
transfer ids 18-42 allocated for a209
transfer commences . . .
Traverse tree,
request blocks
as needed
everything consistent? update root!
frontend applies the update
Root Update Response: from 13fd to 53d3
Alice
Bob

conflict resolution

- block db: there are no conflicts
- root updates: longest chain wins, numerically lower hash to break ties
  - Simplification for implementation (server-client): Just use an RwLock on server, first come first serve
- bulk work done in the frontend
  - frontend has to aggregate its changes into “transactions” that atomically update the entire tree up to the root
  - frontend has to sort out “transaction aborts”, aka you made a new root but it was rejected
  - we basically have a 3way diff at this point
  - can auto-merge on directory level: simply take the most recent version of each file
  - can’t auto-merge files -> link both versions into the directory tree, just like dropbox

control protocol

- similar to simple TCP
  - Not often, not too relevant
  - open transfers can still produce enough traffic to fill pipe
  - TODO

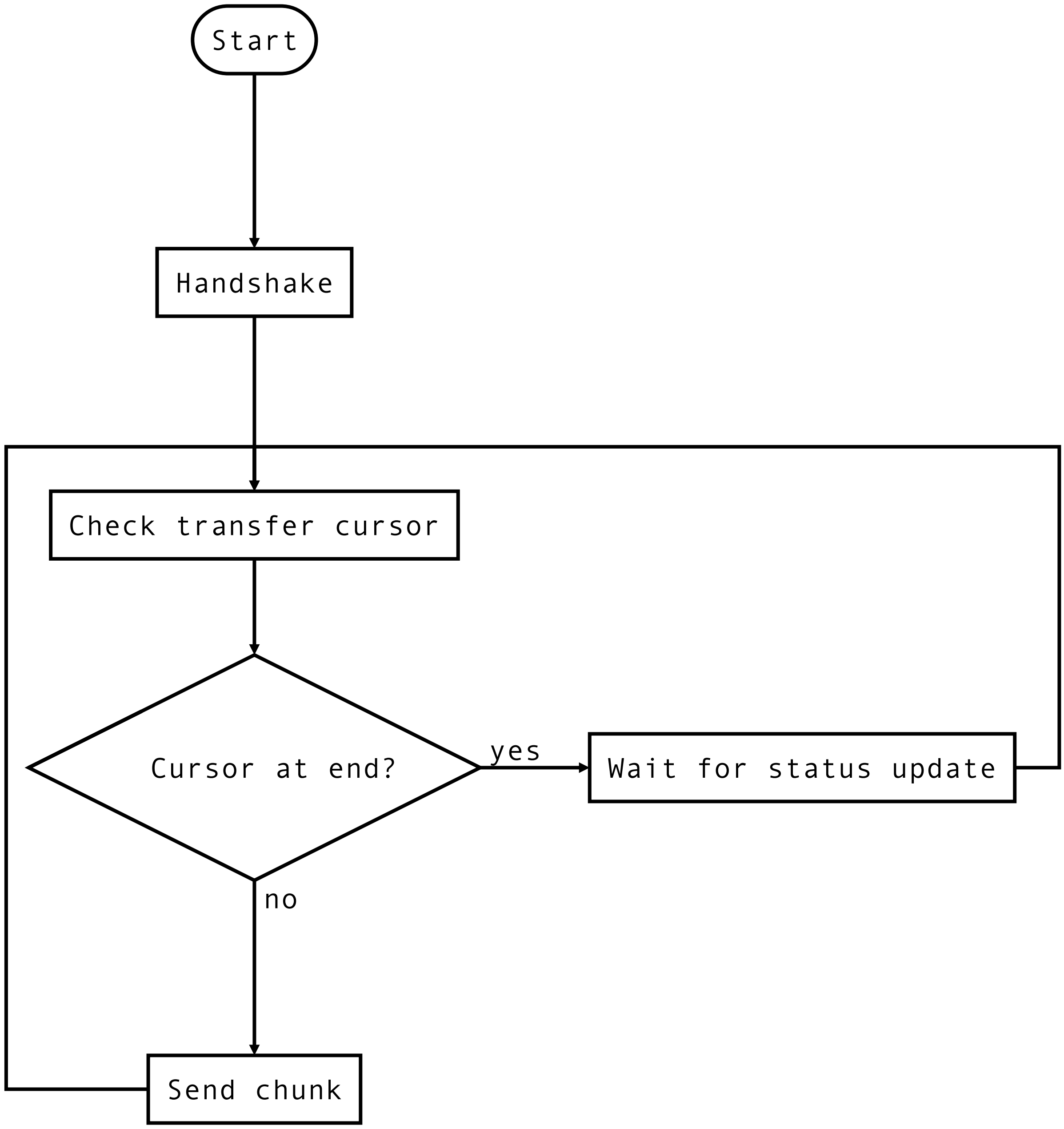
transfer protocol

basically PROTOKOLL v1 with a few changes:

- bidirectional (one channel instance in each direction)
- instead of one transfer we have
  - multiple
  - fixed-size
  - dynamically allocated
  - transfers
- global, incrementing ids
- to deal with unknown number of chunks, ids are varints
  - Variable receive windows, must be large enough to hold largest variant + largest possible control payload
- channel starts out idle
- receiver requests a block
- sender allocates a range of chunk ids for the block transfer
- keep sending until we sent it all, then connection is idle again
- naturally, any status report causes us to jump back and un-idle

- Control Payload
  - can open new transfers
- Data Payload
  - within a transfer

TODO: finish graph



connection management

- connection setup: simple handshake (TODO: really needed anymore?)
- connection teardown can happen at any time, just a handshake of fin packets

packet format

General:

```
flags {
    fin: bool,
    transfer payload: bool,
    transfer status: bool,

},
data
```

(compare exchange)

Root Update:

- AEAD

```
from blockid: [u8; N], // fixed length
to blockid: [u8; N], // fixed length
nonce: [u8; L], // fixed length
TODO
```

Root Update Response:

```
from blockid: [u8; N], // fixed length
to blockid: [u8; N], // fixed length
Ok / Nope
```

Block Request:

```
blockid: [u8; N] // fixed length
```

Block Request Response:

```
blockid: [u8; N] // fixed length
ids A to B reserved
```

Blocks:

TODO

crypto

- design goal: sophisticated/fancy crypto in later versions only
  - including fine grained multi user permissions

Filesystem Crypto

- v1: 1 folder/root = 1 user = 1 symmetric key, end of the story
- blockdb implicitly authenticated by blockid (Encrypt-then-MAC)

Transmission Crypto

- No Handshake
- blocks already encrypted
- control protocol mostly unencrypted
- Only Root Update encrypted, because it contains the key
  - AEAD
  - GCM with random nonce
  - nonce sent in same packet
- knowing a blockid entitles you to its contents
  - Guessing blockids not a problem, because attacker can't decrypt
- to support subslicing, each block is encrypted with a self-synchronizing stream cipher
- key of block = hash(plaintext) (possible attacks?)
  - same file will result in same blockref (with a random key it won't)
  - no duplicated data even if file exists multiple times

Threat Model (v1)

- attacker is not the user, i.e. does not know the secret master key
- attacker can eavesdrop on all network communications (Eve)
- attacker can send/modify network traffic arbitrarily (Mallory)
- confidentiality: encryption
  - block contents are encrypted (provably secure, todo verify)
  - transfers are transferring encrypted data
  - side channel: block lengths
  - side channel: block update frequency (roots/directory blocks trivially distinguishable)
  - root updates are AEAD'd under the master key
- authentication
  - block contents unforgeable, have to match the hash
  - merkle tree property: having a legit root confirms everything below
  - root updates being aead ensures roots are legit
  - real danger here: leaf block contents are completely arbitrary, you can serialize a root in there if you find a way to control the root ptr
- denial of service
  - trivial; withhold all traffic

- defending against attacker that can spoof/inject but not drop: future work, right now trivial by just sending FINs
- resource exhaustion
  - synflood -> TODO need smth like syncookies to mitigate
- Replay
  - irrelevant, known blocks discarded
  - can only result in DoS, which is possible anyway
  - TODO
- Spoofed attacker
  - probably irrelevant, same as replay
  - TODO
- Can we be used as DoS amplifier?
  - TODO
- ddos
  - transfers bound to handshake
- 1 user means "inside job" attacks (access someone else's private folder, resource exhaustion attacks after auth, etc) don't apply
- instead, each user has its own seperate storage (block db) on the server