Workshop

14.01.2023

everscale-network

TL Language

```
// builtins
int ? = Int;
long ? = Long;
string ? = String;
bytes data:string = Bytes;
true = True;
boolTrue = Bool;
boolFalse = Bool;

vector {t:Type} # [ t ] = Vector t;

---types---

myConstructor firstField:int secondField:int = MyClass;

firstConstructor someField:Bool = MyEnum;
secondConstructor fields:vector fields:int = MyEnum;

---functions---

doSomething params:MyClass = MyEnum;
```

TL Scheme

```
int ? = Int;
string ? = String;
bytes data:string = Bytes;

int256 8*[ int ] = Int256;

pub.ed25519 key:int256 = PublicKey;
pub.aes key:int256 = PublicKey;
pub.overlay name:bytes = PublicKey;
```

Code

```
#[derive(TlWrite, TlRead)]
#[tl(boxed)]
pub enum PublicKey {
    #[tl(id = "pub.ed25519")]
    Ed25519 { key: [u8; 32] },
    #[tl(id = "pub.aes")]
    Aes { key: [u8; 32] },
    #[tl(id = "pub.overlay")]
    Overlay { name: Vec<u8> },
}
```

TL Encoding

Type	Pseudocode
`()`	`[]`
`i32`,`u32`,`i64`,`u64`	`little_endian(x)`
`true`	`[0xb5, 0x75, 0x72, 0x99]`
`false`	`[0x37, 0x97, 0x79, 0xbc]`
`[u8; N], N % 4 ≡ 0`)	`[…x]`
`Vec<u8>, len < 254`)	`[len as u8, …x, …padding_to_4(len)]`
`Vec<u8>, len ≥ 254`)	`[254, …little_endian(x)[0…=2], …x, …padding_to_4(len)]`
`Vec<T>`	`[…little_endian(len as u32), …map(…x, tl_repr)]`
`(T0, … , Tn)`	`[…tl_repr(T0), … , …tl_repr(Tn)]`
`Option<T>`	`{ Some(x) ⇒ tl_repr(x), None ⇒ [] }`
`enum { T0, …, Tn }`	`{ T0(x) ⇒ […id(T0), …tl_repr(x)], …, Tn(x) ⇒ […id(Tn), …tl_repr(x)] }`

ADNL address

```
pub.ed25519 key:int256 = PublicKey;
pub.aes key:int256 = PublicKey;
pub.overlay name:bytes = PublicKey;
```

```
use everscale_crypto::ed25519;
use everscale_network::adnl;

let secret_key = ed25519::SecretKey::generate(&mut rand::thread_rng());
let public_key = ed25519::PublicKey::public_key(&secret_key);

let peer_id_full = adnl::NodeIdFull::new(public_key);
let peer_id: adnl::NodeIdShort = peer_id_full.compute_short_id();
```

$$peer\_id = hash(tl\_repr(public\_key)$$

ADNL peer

```
struct Peer {
    /// Remote peer public key.
    id: adnl::NodeIdFull,
    /// IPv4 address.
    addr: SocketAddrV4,

    /// Channel key pair to encrypt messages from our side.
    channel_key: ed25519::KeyPair,

    /// Packets receiver state.
    receiver_state: PeerState,
    /// Packets sender state.
    sender_state: PeerState,
}

struct PeerState {
    /// Packet deduplication slots.
    packet_history: PacketHistory,
    /// Remote init date.
    reinit_date: u32,
}
```

ADNL transport

Handshake packet

$$header\_len\_orig_{handshake} = 96\ bytes$$
$$header\_len\_ever_{handshake} = 100\ bytes$$

ADNL transport

Handshake encryption

```rust
pub fn build_handshake_packet(peer_id_full: &NodeIdFull, payload: &[u8]) -> Vec<u8> {
    // Generate temp key (ed25519) and shared secret (x25519)
    let temp_private_key = ed25519::SecretKey::generate(&mut rand::thread_rng());
    let temp_private_key = ed25519::ExpandedSecretKey::from(&temp_private_key);
    let temp_public_key = ed25519::PublicKey::from(&temp_private_key);
    let shared_secret = temp_private_key.compute_shared_secret(peer_id_full.public_key());

    let checksum = Sha256::digest(payload);

    let aes_key_bytes: [u8; 32] = ...; // shared_secret[0..16] + checksum[16..32]
    let aes_ctr_bytes: [u8; 16] = ...; // checksum[0..4] + shared_secret[20..32]

    let mut result = Vec::new(); // encode header and payload
    result.extend_from_slice(peer_id_full.compute_short_id().as_slice());
    result.extend_from_slice(temp_public_key.as_bytes());
    result.extend_from_slice(checksum.as_slice());
    result.extend_from_slice(payload);

    Aes256Ctr::new(aes_key_bytes, aes_ctr_bytes).apply_keystream(96..); // encrypt payload
    result // done
}
```

ADNL transport

Channel packet

$$header\_len\_orig_{channel} = 64\ bytes$$
$$header\_len\_ever_{channel} = 68\ bytes$$

ADNL transport

Packet payload

```rust
struct Payload {
    /// Random bytes.
    rand1: Vec<u8>,

    /// Sender public key
    from: Option<PublicKey>,
    /// One or many messages.
    messages: Vec<Message>,
    /// Sender socket address.
    address: AddressList,
    /// Packet sequence number (sender side).
    seqno: u64,
    /// Known sequence number (receiver side).
    confirm_seqno: u64,
    /// Initialization dates.
    reinit_dates: Option<ReinitDates>,
    /// Optional signature.
    signature: Option<[u8; 64]>,

    /// Random bytes.
    rand2: Vec<u8>,
}
```

```rust
struct ReinitDates {
    /// Sender initialization time.
    local: u32,
    /// Receiver initialization time.
    target: u32,
}
```

Summary:

- Sender `NodeIdFull` / `NodeIdShort`
- Seqno (new / known)
- Timestamps (new / known)
- Signature
- One or many messages

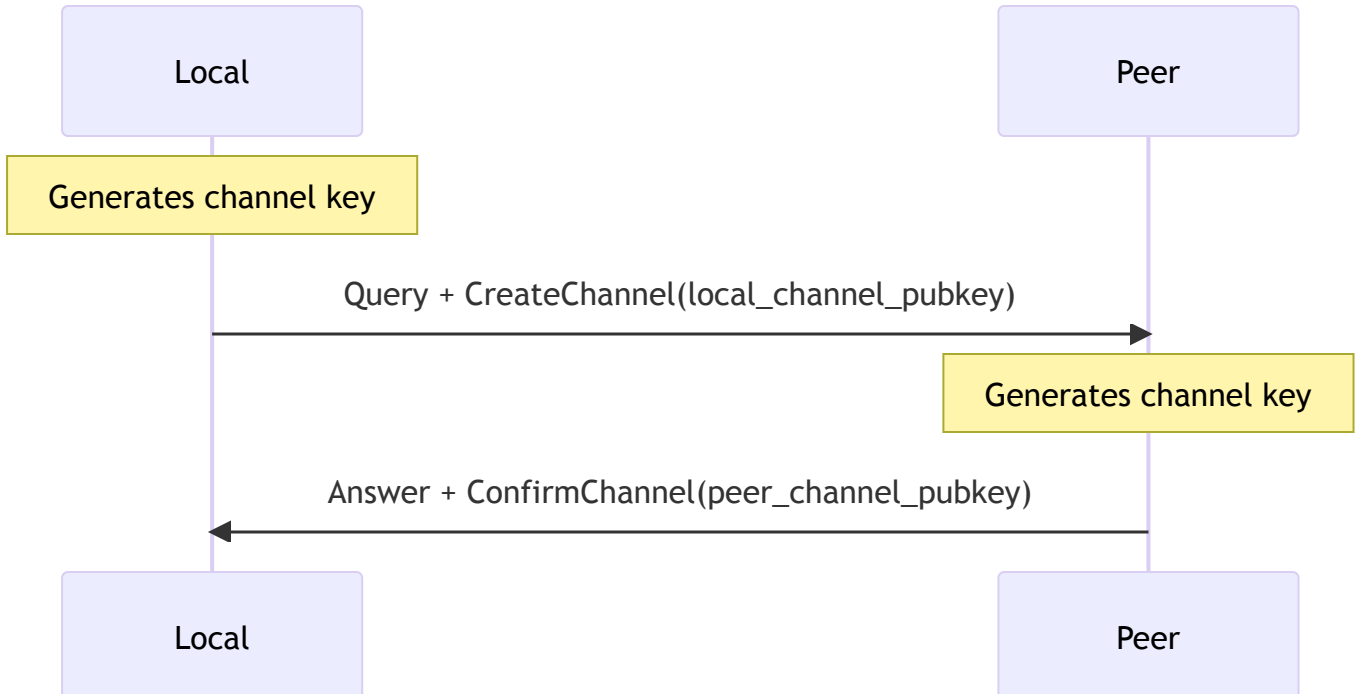
ADNL transport

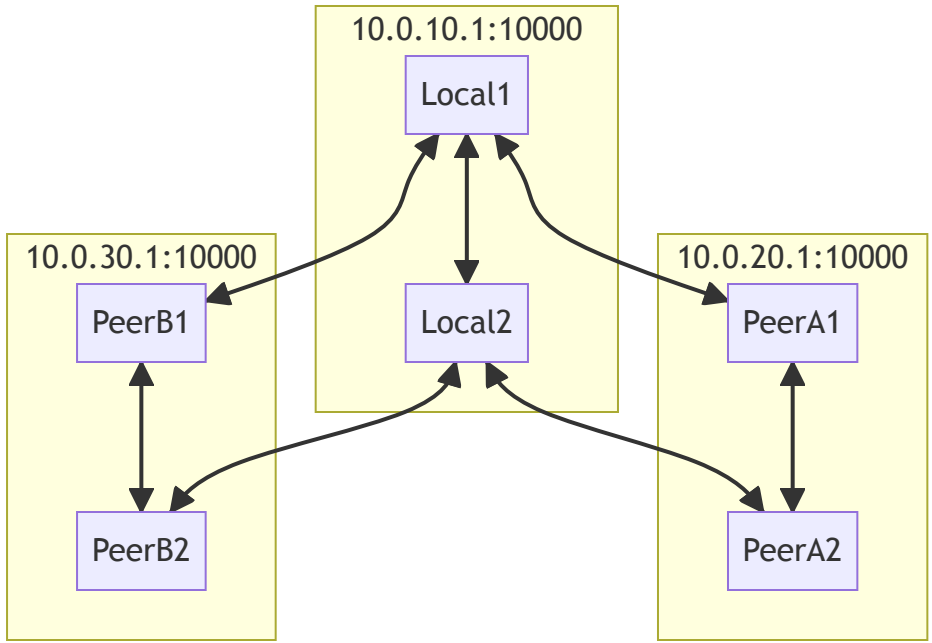
Message types

```
enum Message {
    #[tl(id = "adnl.message.createChannel")]
    CreateChannel { key: [u8; 32], date: u32 }, // ask other peer to create channel

    #[tl(id = "adnl.message.confirmChannel")]
    ConfirmChannel { key: [u8; 32], peer_key: [u8; 32], date: u32 }, // confirm the requested channel

    #[tl(id = "adnl.message.query")]
    Query { query_id: [u8; 32], query: Vec<u8> }, // message to be answered

    #[tl(id = "adnl.message.answer")]
    Answer { query_id: [u8; 32], Vec<u8> }, // answer to the query

    #[tl(id = "adnl.message.custom")]
    Custom { data: Vec<u8> }, // unidirectional message

    #[tl(id = "adnl.message.part")]
    Part { hash: [u8; 32], total_size: u32, offset: u32, data: Vec<u8> }, // part of some bigger message

    #[tl(id = "adnl.message.nop")]
    Nop, // does nothing (but resets reinit dates)
}
```

ADNL transport

Channel creation





- Public key
- Socket address

DHT

Buckets

```
struct Buckets {
  /// Short key id of the local ADNL node.
  local_id: NodeIdShort,
  /// DHT nodes, distributed by affinity.
  buckets: [HashMap<NodeIdShort, DhtPeer>; 256],
}
```

Storage

```
type Storage = HashMap<KeyHash, Value>;
type KeyHash = [u8; 32];
```

Proto

```
struct DhtPeer {
    id: PublicKey, // ADNL node public key
    address: AddressList, // one or multiple addresses
    version: u32, // init timestamp
    signature: [u8; 64],
}
```

```
struct Value {
    key: KeyDescription, // full key info
    value: Vec<u8>, // arbitrary data
    ttl: u32, // value expiration timestamp
    signature: [u8; 64],
}
```

DHT

Key

```
struct KeyDescription {
    key: Key, // key info
    id: PublicKey, // signer key (`PublicKey::Ed25519` or `PublicKey::Overlay`)
    update_rule: UpdateRule, // verification behavior
    signature: [u8; 64],
}

struct Key {
    id: [u8; 32], // either `NodeIdShort` or overlay id (see UpdateRule)
    name: Vec<u8>, // key name ('address', 'nodes')
    idx: u32, // key index
}

enum UpdateRule {
    #[tl(id = "dht.updateRule.signature")]
    Signature, // generic case for owned values.
    #[tl(id = "dht.updateRule.overlayNodes")]
    OverlayNodes, // special case for overlay nodes.
    #[tl(id = "dht.updateRule.anybody")]
    Anybody, // anybody can store unsigned value with this rule.
}
```

DHT

`Signature` flow:

- Sign basic key info (`Key`)
- Sign key description (`KeyDescription`)
- Store value locally (`hash(Key)`)
- Call `dht.store` for some known DHT nodes
- Optionally fetch value from the network

```rust
#[derive(TlWrite, TlRead)]
#[tl(boxed, id = 0x11223344)]
struct MyCustomData {
    counter: u32,
}

let some_key: adnl::Key = ...;
let stored: bool = dht
    .entry(some_key.id(), "some_value")
    .with_data(MyCustomData { counter: 0 })
    .with_ttl(3600)
    .sign_and_store(some_key)?
    .then_check(|_, MyCustomData { counter }| {
        Ok(counter == 0)
    })
    .await?;
```

DHT

`OverlayNodes` flow:

- Verify overlay node info (reinit dates, signature, etc.)
- Merge this overlay node with known overlay nodes

  > - Signature is empty
  > - Key id is overlay id
  > - Public key is `PublicKey::Overlay`

- Call `dht.store` for some known DHT nodes (they will try to merge new nodes)
- Optionally fetch value from the network

DHT

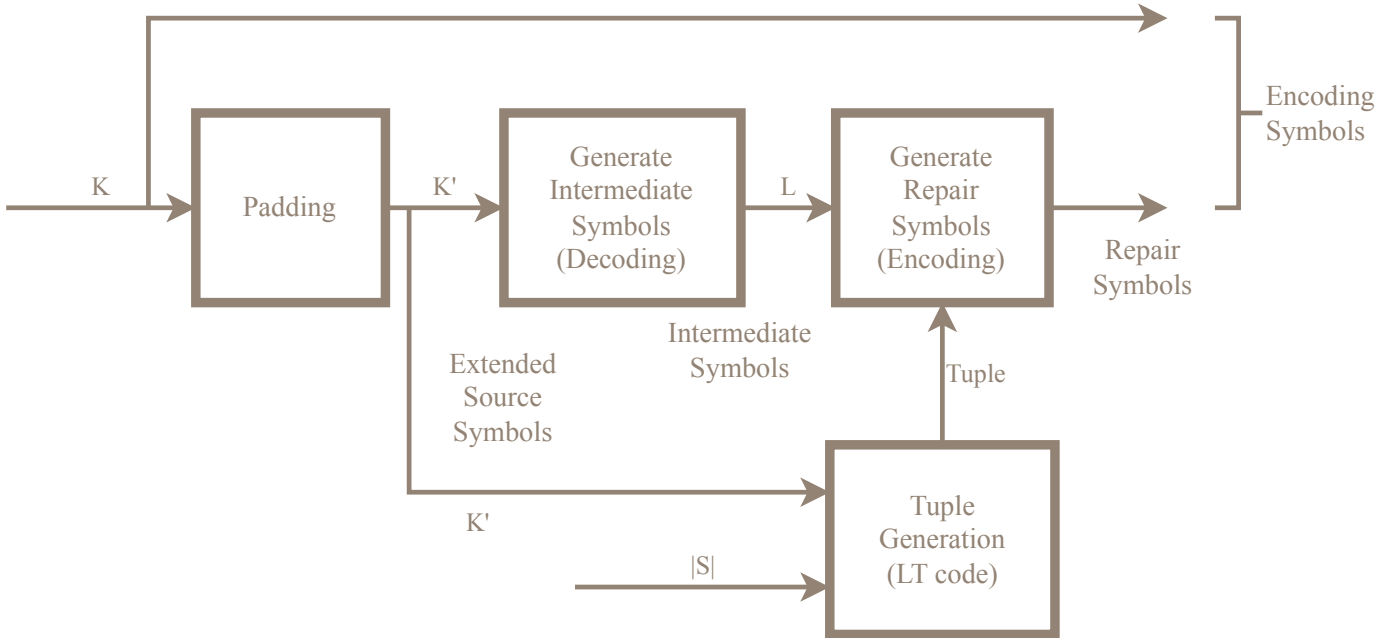
Methods

```
dht.ping random_id:long = dht.Pong;                // simple ping
dht.store value:dht.value = dht.Stored;           // store value
dht.findNode key:int256 k:int = dht.Nodes;        // find k DHT nodes for some affinity
dht.findValue key:int256 k:int = dht.ValueResult; // find value (or receive some other nodes)
dht.getSignedAddressList = dht.Node;              // get signed DHT node info from the specified node

dht.query node:dht.node = True; // <- optional prefix to store local node while executing the query
```

Bootstrap

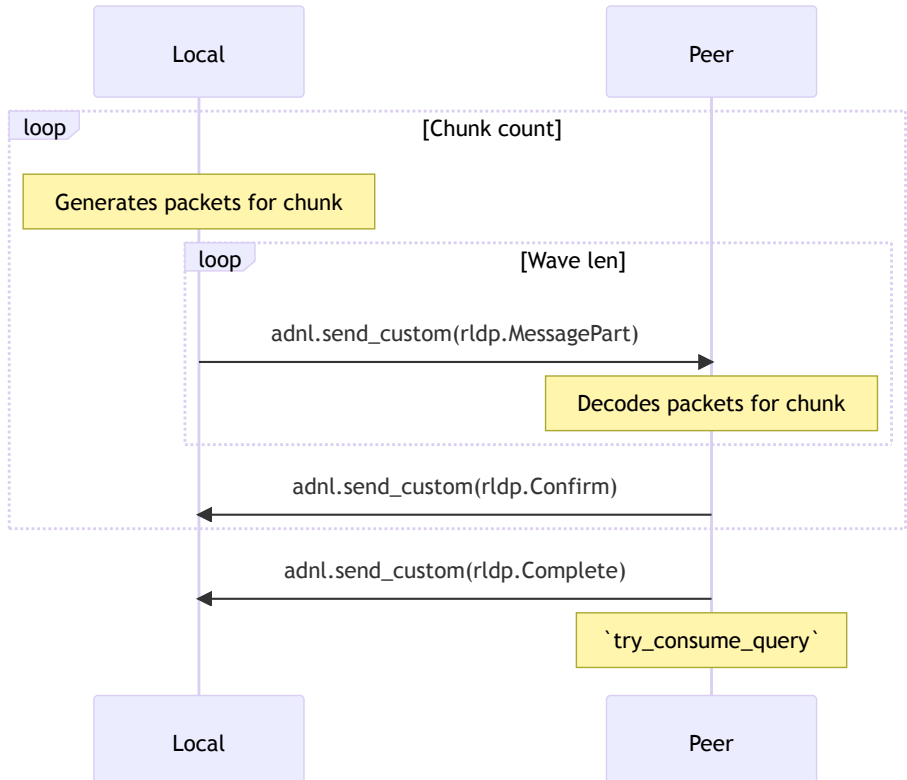
- Add static nodes from global config
- For each static node call `dht.findNode(local_id, k)`
- Store all valid unique DHT nodes

RLDP
RaptorQ



`everscale-raptorq` - https://crates.io/crates/everscale-raptorq

RLDP


Local
Peer
loop
[Chunk count]
Generates packets for chunk
loop
[Wave len]
adnl.send_custom(rldp.MessagePart)
Decodes packets for chunk
adnl.send_custom(rldp.Confirm)
adnl.send_custom(rldp.Complete)
`try_consume_query`
Local
Peer

Overlays

Public

- Nodes are stored in DHT
- Anyone can add itself to the list
- Id derived from workchain and zerostate file hash

> For each workchain

Private

- Nodes are stored somewhere else

  (e.g. validator set in bc config)
- The set of nodes is known in advance
- Id derived from params and known node ids

> For each catchain session

Overlays

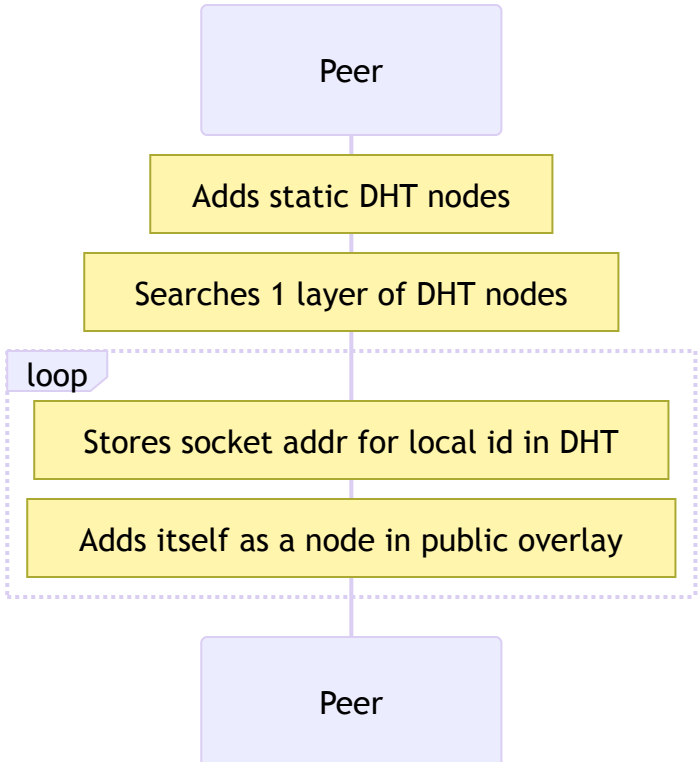
Operations:

- Exchange random peers with the specified peer
- Send broadcast
  - Simple broadcast
  - FEC broadcast (if data size > 768 bytes)
- ADNL query to the specified peer (with `OverlayQuery` prefix)
- RLDP query to the specified peer (with `OverlayQuery` prefix)

```
#[tl(boxed, id = "overlay.query")]
struct OverlayQuery {
    overlay_id: [u8; 32],
}
```

Overlays

Public peer lifecycle



Overlays

Node RPC

```
tonNode.getNextBlockDescription prev_block:tonNode.blockIdExt = tonNode.BlockDescription;
tonNode.prepareBlockProof block:tonNode.blockIdExt allow_partial:Bool = tonNode.PreparedProof;
tonNode.prepareKeyBlockProof block:tonNode.blockIdExt allow_partial:Bool = tonNode.PreparedProof;
tonNode.prepareBlock block:tonNode.blockIdExt = tonNode.Prepared;
tonNode.preparePersistentState block:tonNode.blockIdExt masterchain_block:tonNode.blockIdExt = tonNode.PreparedState;
tonNode.prepareZeroState block:tonNode.blockIdExt = tonNode.PreparedState;
tonNode.getNextKeyBlockIds block:tonNode.blockIdExt max_size:int = tonNode.KeyBlocks;
tonNode.downloadNextBlockFull prev_block:tonNode.blockIdExt = tonNode.DataFull;
tonNode.downloadBlockFull block:tonNode.blockIdExt = tonNode.DataFull;
tonNode.downloadBlock block:tonNode.blockIdExt = tonNode.Data;
tonNode.downloadPersistentStateSlice block:tonNode.blockIdExt masterchain_block:tonNode.blockIdExt offset:long max_size
  = tonNode.Data;
tonNode.downloadZeroState block:tonNode.blockIdExt = tonNode.Data;
tonNode.downloadBlockProof block:tonNode.blockIdExt = tonNode.Data;
tonNode.downloadKeyBlockProof block:tonNode.blockIdExt = tonNode.Data;
tonNode.downloadBlockProofLink block:tonNode.blockIdExt = tonNode.Data;
tonNode.downloadKeyBlockProofLink block:tonNode.blockIdExt = tonNode.Data;
tonNode.getArchiveInfo masterchain_seqno:int = tonNode.ArchiveInfo;
tonNode.getArchiveSlice archive_id:long offset:long max_size:int = tonNode.Data;

tonNode.getCapabilities = tonNode.Capabilities;
```

Overlays

Broadcast

```
tonNode.blockSignature who:int256 signature:bytes = tonNode.BlockSignature;
tonNode.externalMessage data:bytes = tonNode.ExternalMessage;

tonNode.blockBroadcast
    id:tonNode.blockIdExt
    catchain_seqno:int
    validator_set_hash:int
    signatures:vector signatures:tonNode.blockSignature
    proof:bytes
    data:bytes
  = tonNode.Broadcast;
tonNode.externalMessageBroadcast message:tonNode.externalMessage = tonNode.Broadcast;
```

Usage

- `ton-indexer` - "light-node" core
  - `ton-kafka-producer` - transactions streamer
  - `ever-wallet-api` - self-hosted wallet management service
  - `octusbridge-relay` - Octus Bridge relay node that validates transfers across multiple blockchains
  - `everscan-indexer` - indexer for https://everscan.io
- `stever-node-tools` - all-in-one node management tool
- `everscale-monitoring` - network state monitoring, https://monitoring.ever.rs