Information Theory vs Filters

Intro

Lukáš Hozda

- Marketing at Braiins

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- Rust/Lisp programmer

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- Rust/Lisp programmer
- Bitcoin, Emacs, HTMX, Linux enthusiast
- Teaching Rust at MatFyz


BRAIINS
LET START = [
"BUILDING",
"BITCOIN",
"IN",
"RUST",
];
AUTHOR: LUKAS HOZDA
FOREWORD: DANIELA BROZZONI
Building bitcoin in Rust
Written by Lukáš Hozda
With contributors: Daniela Brozzoni, Luukas Pörtfors

Context

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- Focus today: mempool / relay-level filtering

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- Filtering is one of the main (technical) fault lines
  - Proponents of filtering want to filter arbitrary data embedding
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- Focus today: mempool / relay-level filtering
- `BIP-110` exists, but consensus-level filtering is out of scope today

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- By themselves, ordinals are about identification and tracking, not content

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- This is the part that usually triggers filtering debates

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- `Inscription` = what data is attached/associated
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- In practice, people usually discuss the combined ordinals+inscriptions ecosystem

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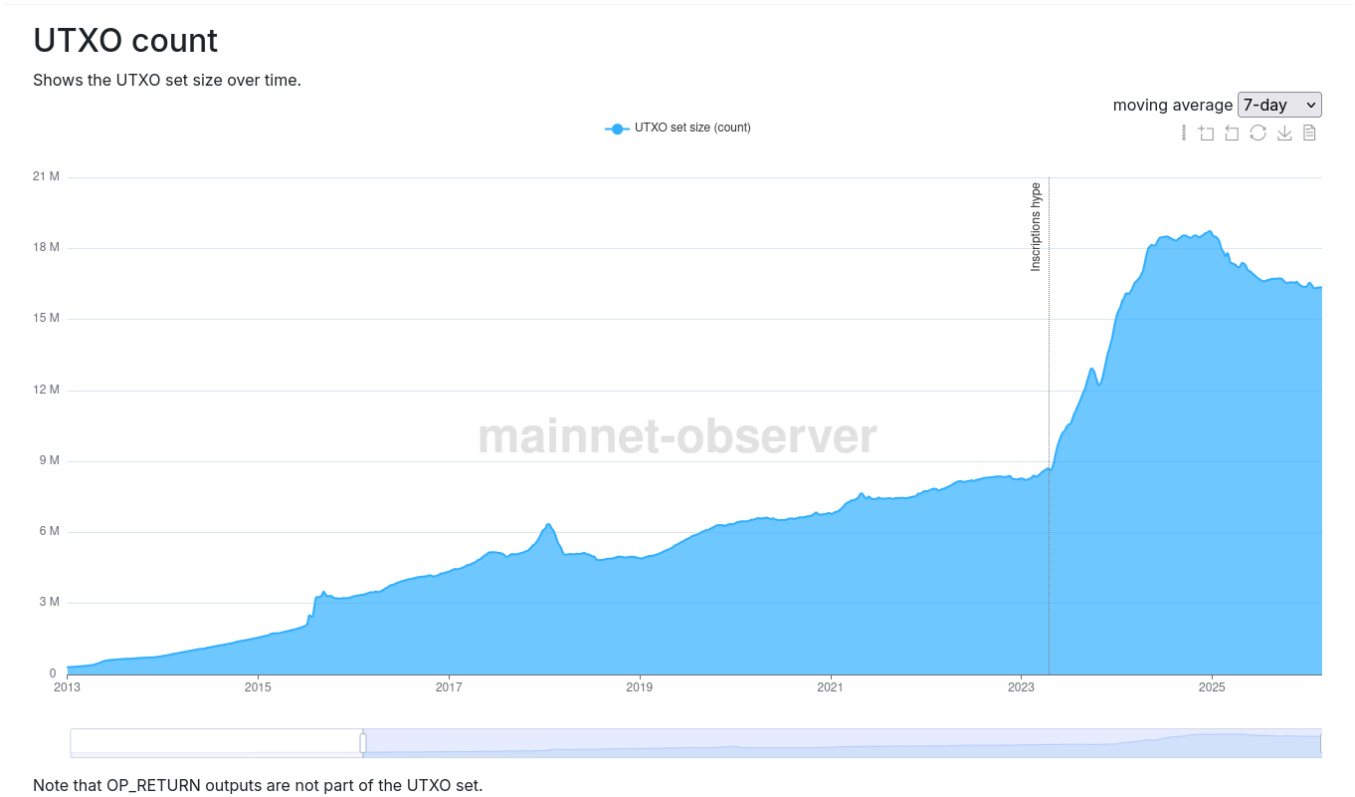
- One concern is competition for scarce blockspace (including witness-heavy payloads)
- Another concern is UTXO set growth from certain usage patterns
- These are different resource problems and should not be conflated

UTXO Set


UTXO count
Shows the UTXO set size over time.
moving average 7-day
UTXO set size (count)
21 M
18 M
15 M
12 M
9 M
6 M
3 M
0
Inscriptions hype
mainnet-observer
2013
2015
2017
2019
2021
2023
2025
Note that OP_RETURN outputs are not part of the UTXO set.

Chain Growth

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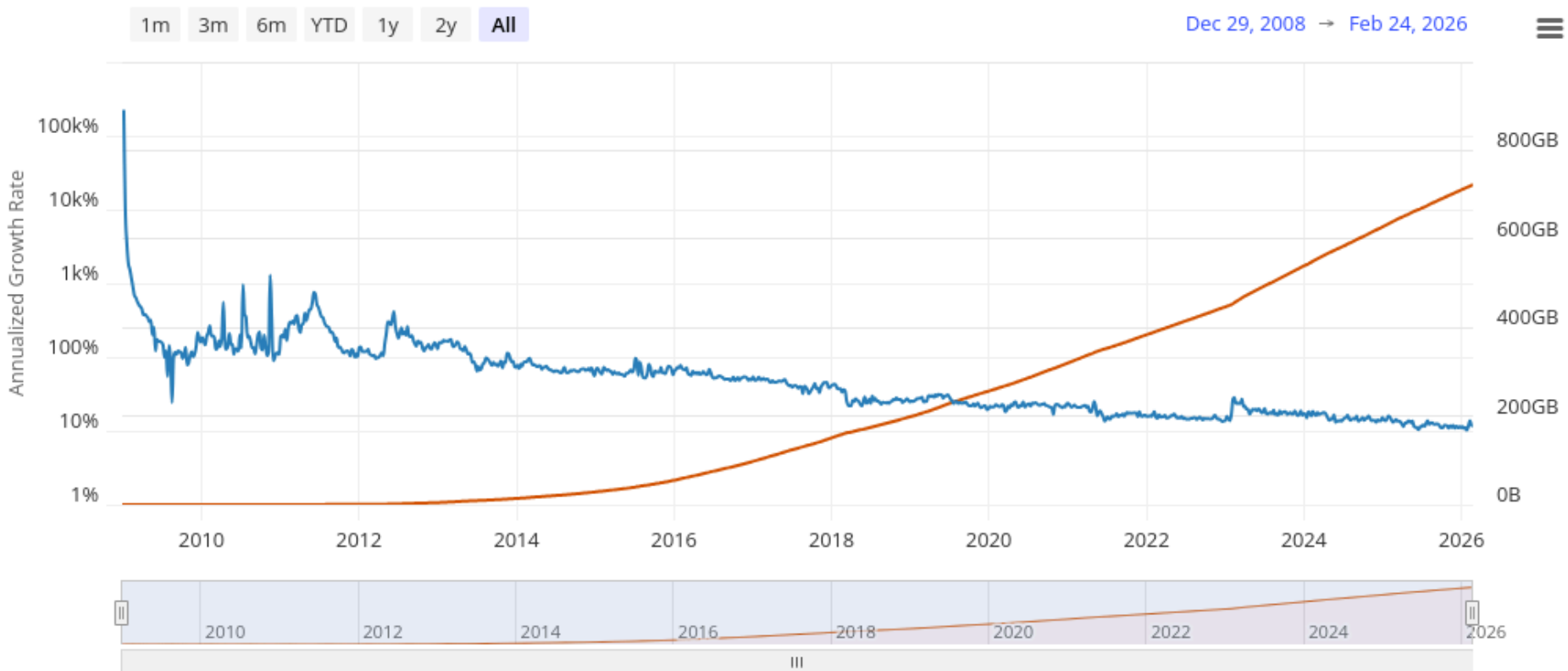
- Historical storage, bandwidth, and validation costs still accumulate
- UTXO set can shrink, the blockchain can’t


1m
3m
6m
YTD
1y
2y
All
Dec 29, 2008 → Feb 24, 2026
Annualized Growth Rate
100k%
10k%
1k%
100%
10%
1%
800GB
600GB
400GB
200GB
0B
2010
2012
2014
2016
2018
2020
2022
2024
2026

Network

Mempool

- There is no single global mempool

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- Miners build blocks from what they see and what pays

Gossip

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- Topology matters: peers, connectivity, implementation mix
- Small relay minorities can still create viable paths

BTC wire protocol

- The protocol through which nodes talk is pretty simple
- We can make a relay just by being able to process a few message types

Handshake

- `version`: announces protocol version, services, user agent, and chain height

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- `pong`: response to `ping`

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- `tx`: full transaction payload

Discovery

- `getaddr`: “send me peer addresses”

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- `getaddr`: “send me peer addresses”
- `addr`: list of peer addresses

Relay Flow

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- Node B decides what it wants
- Node B sends `getdata` for selected txs
- Node A sends `tx` with full bytes
- This reduces bandwidth compared to pushing full txs to everyone

Filtering

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- It cannot directly control the whole network topology
- The real question is network-wide effectiveness

Limits

Topology

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- More connectivity makes bypass easier
- Strong suppression needs near-universal adoption

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- They still propagate and still get mined
- Relay policy does not equal miner/pool inclusion policy
- Partial filtering is not network-wide suppression

Steganography

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- The receiver needs an extraction rule, but outsiders may only see an ordinary object
- The carrier still “works” for its normal purpose
- Steganography is about covert encoding, not encryption

Bitcoin

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- This gives adversaries room to encode side-information while staying consensus-valid
- Filters must infer intent from valid transactions

General Examples

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- Image pixels: least-significant bits can carry a hidden message with little visible change
- Text: whitespace, capitalization, or punctuation patterns can encode bits
- Network traffic: timing, padding, or packet ordering can carry side-information
- The same message can often move between multiple carriers

Rust example

- I have a tiny Rust example that hides a message in image pixel bytes (LSB)

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- I show it on a BMP photo
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- The decoder reads those low bits back in the agreed order

Encoding

```rust
fn put_bit(byte: &mut u8, bit: u8) {
    *byte = (*byte & !1) | (bit & 1);
}

for (i, bit) in bits.enumerate() {
    put_bit(&mut pixels[i], bit);
}
```

Decoding

```
let mut out = 0u8;
for (shift, b) in pixels[i..i + 8].iter().enumerate() {
    out |= (b & 1) << shift;
}
```

Original BMP

Encoded BMP

BTC Examples

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- Witness data payloads (the inscriptions case)
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- The same information can be moved between multiple valid representations

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- `OP_RETURN` and visible witness payloads are easy to identify
- Other encodings can be much less visible at policy level
- Example: data hidden in synthetic / fake public-key-like material or script patterns
- Filtering one encoding path can push usage into less transparent and more harmful ones

Asymmetry

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- Encoders have more degrees of freedom than filters
- This is a structural limit

Incentives

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- “Spam” definitions do not remove the limits above
- Filtering can push embedding into worse forms
- `OP_RETURN` is prunable; fake UTXO growth is worse
- Incentives and harm reduction matter more than prohibition

Miners

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- Their incentive is fee revenue and reliable block production
- They do not automatically share relay-policy filtering goals
- Even strong relay filtering can fail if mining incentives remain permissive

Rust

Rust at Braiins

- Rust across embedded systems

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- Rust in infrastructure components

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- Rust in high-level, low-latency network services

Async in Rust

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- Futures represent work that can make progress over time
- `.await` yields control while waiting for I/O
- This is a good fit when one process manages many peer connections

Tokio

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- Async tasks make large peer sets practical
- Rust gives memory safety under concurrency
- Metrics/logging compose well in the same process

Tokio

```
loop {
    tokio::select! {
        result = stream.read(&mut buf) => { /* parse */ }
        Some(msg) = outbound_rx.recv() => { /* send */ }
        _ = keepalive.tick() => { /* ping */ }
    }
}
```

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- Enums + `match` make protocol state handling readable and auditable
- Bounded channels make backpressure decisions explicit
- You can push performance without giving up memory safety

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- `tokio::select!` maps naturally to socket/read/write/keepalive loops
- `Arc<RwLock<...>>` is enough for shared relay state and metrics in a small tool
- `tracing` + Prometheus + Axum make observability cheap

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- Instrumentation is straightforward to wire into normal application code paths
- Exposing `/metrics` over Axum is simple and production-friendly
- Grafana integration is immediate; we do not need custom telemetry plumbing

Demo Tool

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- It observes relay, discovery, and transaction flow metrics
- The point is measurement and demonstration

Demo

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End

Q&A