IBLT and weak block propagation performance

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Invertible Bloom Lookup Tables (IBLT)

- Credit Gavin Andresen
- Based on the work of Michael T. Goodrich and Michael Mitzenmacher
- Allows efficient reconciliation of similar sets
- Great if block is similar to mempool
IBLT
IBLT parameters

- Number of hash functions?
- Value size, 8B? 64B? 128B?
  - Bigger values → More waste
  - Smaller values → More cell overhead
IBLT hash functions

![Bar chart showing the minimum IBLT size for different hash function counts. The chart indicates a significant drop in minimum size as the hash function count increases from 2 to 10.]
Value size, we like 64 bytes
Real data?

● Bitcoin-corpus covers 721 blocks from 4 nodes
● Average block size 381891
● Focus (randomly) on Australian node
● How small can we make the IBLT?
Result for Australia

Failure probability vs IBLT size

Corpus data Australia

IBLT size [bytes]

Failure probability

21kB (5.7%)  10kB (2.6%)
Scaling

• What happens when differences increase?
• Measure failure probability for increasing differences.
  – Select diffs randomly
  – Select IBLT size
  – Encode/decode many times to measure failure probability
Cost per diff

Failure probability vs Diff cost for 32-1024 diffs

- Sweet
- Expensive
- Cheapish
Example

- Assumptions
  - Diffs increase linearly with tx rate
  - Open question: How do differences change with transaction rate?
  - Block size increase linearly with tx rate
- Corpus average 6 diffs
- Increase tx rate by factor 10, 100 and 1000
- Target 5% failure probability
Example

5% failure probability target

<table>
<thead>
<tr>
<th>Estimated block size</th>
<th>Percentage of block size</th>
</tr>
</thead>
<tbody>
<tr>
<td>381891</td>
<td>0.021995805</td>
</tr>
<tr>
<td>3818910</td>
<td>0.015397064</td>
</tr>
<tr>
<td>38189100</td>
<td>0.010306606</td>
</tr>
<tr>
<td>381891000</td>
<td>0.008260996</td>
</tr>
</tbody>
</table>
So far we've...

- tested fixed sized IBLTs on bitcoin-corpus. **21KB** (5.7%).
- examined the scaling properties of IBLTs. **The bigger, the better.**
Bitcoin IBLT Protocol
Bitcoin IBLT Protocol

Transaction which occurs in block
Transaction which occurs in block

Node 1 remembers how different the incoming block was from its mempool (assuming it will be similar for peers)
Bitcoin IBLT Protocol
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Bitcoin IBLT Protocol
IBLT Protocol: Dynamic Sizing

• How do we choose IBLT size?
  – Mempools tend to be very similar.

• Assume receiver's mempool about as different from block as ours was.
  – Add some extra to cover differences...
Dynamic Estimate Extra Factors

- Fixed factor (e.g., assume an extra 2 txs to reconstruct)
- Variable factor (multiply total slices)
Dynamic Estimate Extra Factors

- Fixed factor (e.g., assume an extra 2 txs to reconstruct)
- Variable factor (multiply total slices)

![IBLT size heuristics graph](image-url)
Dynamic Estimate Extra Factors

- Fixed factor (eg. assume an extra 2 txs to reconstruct)
- Variable factor (multiply total slices)
Dynamic Estimate Extra Factors

• Fixed factor (eg. assume an extra 2 txs to reconstruct): +10 slices

• Variable factor (multiply total slices): x1.35
IBLT Corpus Performance

• Across our 825 MB corpus:
  – 20 MB transmitted (95% reconstructed)
  – 4% of blocks sent “raw”
Weak Blocks

aka. Near Blocks
Weak Blocks

- Miners broadcast “not quite good enough” blocks.
  - eg. within 20x required difficulty.
- Naturally ratelimited
- Offers (provable!) insight into miner mempools
- All blocks can be simply encoded in terms of previous weak blocks.
Weak Blocks
Weak Blocks

Simple 2-byte encoding:
18,1,3,8,12,-1,14,0,10,-1,20,11,13,4,19,9,-1,-1,
5,16,-1,2,7,-1,-1,-1,-1
<tx1><tx2><tx3><tx4><tx5>...<tx10>
Weak Blocks Simulation

• Take corpus, randomly generate weak block from (best paying) txs in mempool approximately every 30s.
• Assume these weak blocks instantly transmitted to other nodes.
• First node to see a block calculates encoding to other nodes vs. last known weak block (if any)
Weak Blocks Simulation

- Raw blocks: 825MB
- Strong blocks using 30-second weak blocks:
  - 35MB (+/- 3MB)
  - Total size increases to 1.51GB though!
Super Weak Blocks?

- If blocks are full, we want the first weak block as soon as possible.
Super Weak Blocks?

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- 16x super-weak first* blocks:
  - 27MB (+/- 1.7MB)
  - (Total size increases to 1.53GB)

*Handwave: define first!
Weak Blocks Simulation

- Note that we've seen that real blocks diverge much more than bitcoin-corpus peers!
  - Expect worse compression in practice.
IBLT + Weak Blocks?
IBLT + Weak Blocks?

- Raw blocks: 825 MB
IBLT + Weak Blocks?

- Raw blocks: 825 MB
- IBLT: 20 MB (95% recovery)
IBLT + Weak Blocks?

- Raw blocks: 825 MB
- IBLT: 20 MB (95% recovery)
- Weak blocks: 27 MB / 1530 MB total
IBLT + Weak Blocks?

- Raw blocks: 825 MB
- IBLT: 20 MB (95% recovery)
- Weak blocks: 27 MB / 1530 MB total
- Together: 15 MB (98%) / 233 MB (65%) total
  - Or 434 MB and 86% (fixed 133 buckets)
  - Or 804 MB and 96% (fixed 400 buckets)
Deployment

- New block transmission message:
  - [prev-weak-block][references][rawtxs][ibltseed][fee-hint][added-set][removed-set][iblt-size][iblt-buckets][ordering-info]
Deployment: Weak Blocks

- Start with weak block threshold 1/10000 difficulty
  - Rachet up to 1/20 as we see stronger weak blocks.
Future

- Canonical fee-per-byte ordering?
  - Much better for IBLT and weak block encoding.
- Coinbase encoding
  - Incentive to publish weak blocks (save 500 bytes)
- Block blast
  - Over half encodings give block < 3k.
- IBLT Mempool Sync
  - gmaxwell, may save ~70 bytes per tx per peer.
Questions?