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REVIEW PAPER

Analysis of Bitcoin Improvement Proposals for Block Size Increase

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Abstract. This paper will discuss the issues, hurdles and concerns regarding the maximum one megabyte block size limit currently imposed for Bitcoin and whether an increase to the block size is needed or required. This paper will also analyze both arguments for and against the block size and compare that to each of the current Bitcoin Improvement Proposals (BIP). It is the conclusion of this paper that the block size should increase as long as the arguments against an increase are addressed and the best BIP(s) that supports this conclusion is an amalgamation of BIP 102 and BIP 103.

KEY WORDS

1. Blockchain. 2. Block size. 3. BIPs. 4. Hard fork.

1. Introduction

For the past year, arguments have been had over the current 1 MB limit per block on the Bitcoin network. Many do not see this size being large enough to accommodate all users. This paper will discuss the issues, hurdles and concerns regarding the maximum one megabyte block size and whether an increase to the block size is required. This paper will discuss the current size issues and projected date of the 1 MB limit, then will discuss transactions capacity and fees, followed by a magnitude of a hard fork. It will then breakdown the arguments for and against the block size increase and then will go into detail about BIPs 101, 102, 103, 105 and 106. The information included in this paper will result in a conclusion of which BIP will meet the immediate and long term concerns to raise the Bitcoin block size limit.

2. Blockchain Present State

Size—Satoshi Nakomoto, the founder and creator of Bitcoin, initially released Bitcoin without an explicit block size limit. However, due to other coding there was an effective limit of 32 MB per block put in place. In September 2010, the Bitcoin source code changed to reject blocks larger than 1 MB, but without commenting and stating a true reason why.[1] Some argue that this was a temporary measure put in place to stop malfeasance in the form of initially creating a large block chain that would discourage new users in the beginning stages of Bitcoin.[2]

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Blockchain.info gathers data and information from the Bitcoin blockchain into helpful charts for the analysis of the Bitcoin community. In one such chart, as shown in Fig. 1 the data can be compiled to see a running average over the past two years.[3]

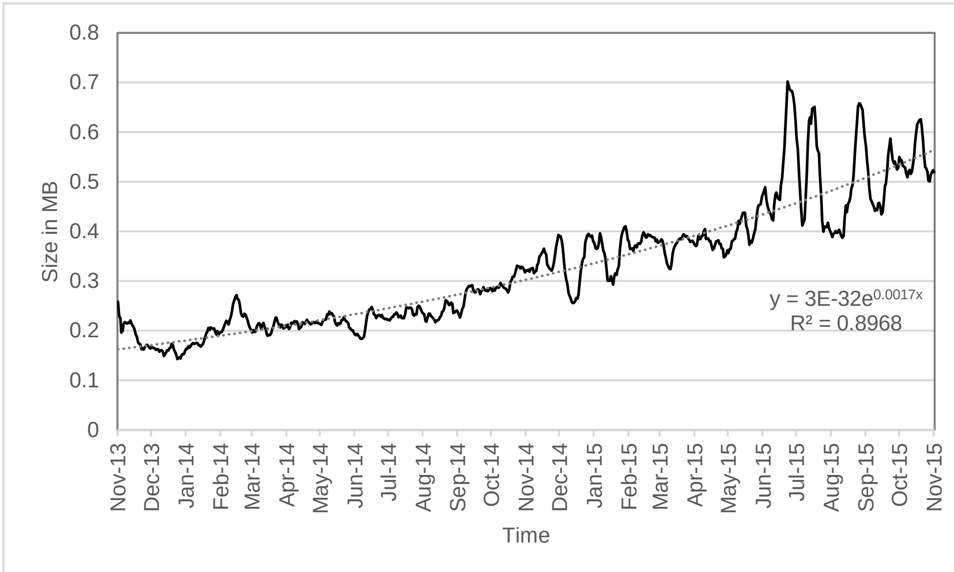

Fig. 1. Daily block size average since November 2013 with best trendline and equation.

By using trend line analysis we can find a best fit, which establishes the equation

$$y = 0.1622e^{0.0017x} \tag{1}$$

as a best fit with an R^2 of 0.8968. By using this equation, we can estimate when the block size current limit of 1 MB will be reached. This gives us an answer of 1070 days, or 26 October 2016. Mind you, this is the daily average, so odds are prior to October we will be seeing delays of transactions at peak hours due to hitting the size limit on several consecutive blocks. Also, during "bubble" periods, the average daily block size has hit 0.7 MB, with several blocks hitting the cap of 1 MB. Based on these facts and growth, there is enough reason to increase the block size sooner rather than later.

Transactions and Fees—The current maximum transactions per second (tps) can be calculated by taking the current maximum of 1,000,000 bytes divided by the number of seconds between blocks (600 seconds) and then by the average transaction size of (250 bytes/transaction) or 6.6 tps.[4] Knowing the maximum, the next item to check is what the current utilization is. As shown in Fig. 2, it is hovering right below 2 transactions per second.

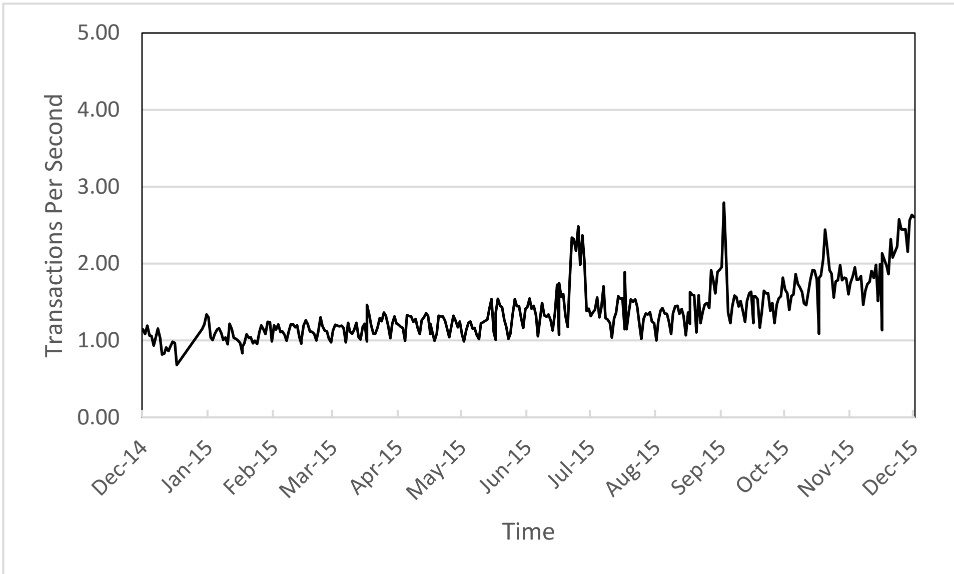

Fig. 2. Transactions per second averaged per day for the previous year.

At this rate, the theoretical maximum will not likely be hit any time soon. The discrepancy between the size limitation and the transactions per second limitation, is that many transactions are above 250 bytes. In fact, one transaction took up an entire block at 999,657 bytes.[5] This was identified as a block that attempted to clean up a bunch of spam created by others; but one can see how an occasional large transaction can quickly turn the 6.6 tps limit to a more realistic 4 tps with an average of 400 to 500 bytes.As part of the transactions, fees are given by the users to the miners to prioritize and reward the miners for their work. "A miner is free to choose which, if any, transactions they include in a block as long the transactions are valid and don't make the block too big."[6] Transactions are allowed to be free, but are limited to only 15,000 bytes per minute to prevent malicious flooding of transactions.[7] A typical transaction fee is .0001 BTC, or currently 0.04 USD to send any amount of bitcoins. As shown in Fig. 3 miners receive nearly $10,000 USD a day due to daily transaction fees. However, this pales in comparison to the average 3,600 bitcoins that are made available daily to miners as a reward for solving the latest proof of work. Its current value is nearly $1.3M per day. The general idea of Bitcoin's future as a currency is for the transaction fees to outperform the bitcoin rewards allowing for the continual incentive to perpetuate the network. The date at which the transaction fees should surpass the bitcoin rewards is still up for debate and a topic for another paper.

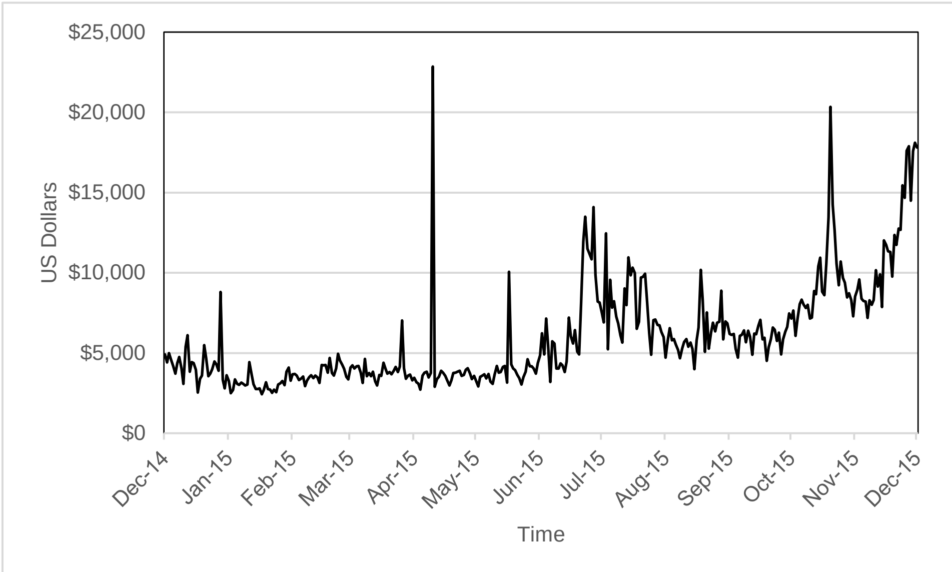

Fig. 3. Total Transactions Fees in USD per Day over previous year.

Hard Fork—One issue that may not be understood well is "why is this a big deal?" This issue deals with the fact the code for the maximum block size is hard written as shown below:

```
static const unsigned int MAX_BLOCK_SIZE = 1000000; 8
```

Since it is an unsigned integer, it has a theoretical upper limit of 4 GiB due to the unsigned portion making the first bit count towards the upper limit, instead of allowing for negative numbers. It is also a hard coded integer that is publically available throughout the source code and referenced a few times. So in affect, a quick change would be to just increase the number. However, unless every single other node and miner updates to the newest code, the first block that is higher than the current 1 MB limit will only be processed on new ones and not on the old ones. This is because of the code below:

```
if (::GetSerializeSize(tx, SER_NETWORK, PROTOCOL_VERSION) >
   MAX_BLOCK_SIZE)
   return state.DoS(100, false, REJECT_INVALID, "bad-txns-
       oversize"); 9
```

This essentially checks to see if the block being processed is larger than the maximum size. If it is, it rejects as invalid with the code "bad-txns-oversize." So if half the nodes and miners are operating off a new higher standard at 4 MB and the other half at the current 1 MB limit, then the network will likely run into issues with double spending. For example, one could spend bitcoins using a greater than 1 MB block and then double spend the same coins again in the next block if it is below 1 MB.[10] The reason is due to the second ledger not acknowledging the block with the output transaction from the first ledger, thus the second ledger still believes you have the amount of bitcoins assigned to your private key.

3. The Cases for an Increase

There are many arguments for the increase of the size of blocks for Bitcoin, however, this paper will tackle three of the more prevalent arguments. This includes that the transaction capacity is limited and not capable of handling the number of transactions of some of its competitors, total collection of transactions fees will increase with the size of the block and that any change to the block size is only to the code and will not cause immediate impact. Other arguments include block size is self-correcting by appropriate orphaning of blocks, not constraining legitimate transactions, and increasing the adoption of Bitcoin.

Transaction Capacity—The current theoretical maximum transactions per second capability of the Bitcoin network is approximately 6.6 transactions per second (tps). Without an increase in the size of the blocks, this metric will not increase. When this capacity is reached, users will either experience extended delays in the processing of their transactions or have to pay exorbitant fees thus making it impractical for all but the richest.[11] One of the core principles of Bitcoin is that bitcoin should be accessible by everyone. By not taking the appropriate actions to increase the block size limit, the everyday person will not be able to afford to use bitcoin. Another reason why the block size should increase is the possibility for overloading the memory pool of nodes. Since all transactions not included in a block are stored in memory, the number of transactions not included in blocks will continue to grow as we get closer to the limit. This will negatively impact nodes with less memory causing network performance degradation. To combat this other users will increase their transaction fees, which instead of helping the situation makes the lower priority transactions continue to fill up.[12] The transaction capacity also is very low compared to other global currency exchanges, such as Paypal, which had a transactions per second of 112 in 2013.[13] As many key players and users of Bitcoin want Bitcoin to be competitive globally see the 6.6 tps as a very low number that needs to improve, otherwise it will never be as big as Paypal or Visa.

Transaction Fees—Transaction fees as noted above are rewards from individuals to incentivize the inclusion of their transaction in the latest block. By increasing the size of blocks, the general idea is it will allow for more transactions, thus more transaction fees. The current maximum transactions in a block is about 2,500. By doubling the block size one allows for double the amount of fees. Which is fairly obvious as better in any scenario, with the exception where the Fee/Tx decreases by more than half.

Block size in Code Only—One of the key points of the individuals arguing for a block size increase is that this is currently only a discussion about changing the Bitcoin core code to allow for a higher size block. If the code is suddenly changed to allow for a 20 MB hard limit, that doesn't mean we will immediately see 20 MB blocks. A rapid increase may in fact have detrimental effects to the Bitcoin network. However, an appropriately timed increase can be offset by Moore's Law, where the cost of storage and bandwidth is no longer as much of a concern as it may be at this point in time. The general idea is that growth will continue to be incremental with spikes of rapid interest and the change will not affect the network.

4. The Cases against an Increase

As many arguments there are for increasing the block size, there are that many against an increase. The primary arguments against an increase are the economic change to the block size will impact transaction fees, the size increase will decrease nodes causing other negative actions and this change will divide the community and create a hard fork that may cause unknown damages. Other arguments against the block size change include technical issues with implementing a change and a perspective change of what Bitcoin is all about.

Transaction Fees—Transaction fees are both an argument for and against an increase in a block size. By increasing the size of blocks, there may be an economic incentive to decrease each individual transaction fee. This may seem counterintuitive, but if a Bitcoin user knows the average block size is 1 MB with a maximum of 2 MB, he can lower his individual transaction fee because he knows it will eventually be included. If everyone else decides to do the same, we may run into situations where the total transactions are higher, but the transaction fees are lower.[14] The unfortunate side of this argument is that it can't really be tested until implementation. There are also possibilities where the transaction fees could be increased or the free transaction limiting rate be decreased.

[15]*Fewer Nodes*—Another argument against increasing the block size is the cost associated with running a full node. A full node is one in which contains the entire block chain for users and miners to reference. As the block size increases, so does the size of the block chain, thus causing issues and expenses for those running full nodes. These include bandwidth, storage and operational costs. Bitcoin.org states that a full node can see above 200 GB upload per month and total current storage above 35 GB.[16] If these costs increase, the number of available nodes may decrease; and they have as shown in Fig. 4. There have been a decrease of nearly 27% over the past year.[17] The consequence of fewer nodes is that more people will be depending upon the accurate reporting of information from fewer and fewer individuals. As this number decreases users become “vulnerable to fraud in the form of double-spending or monetary inflation.”[18]

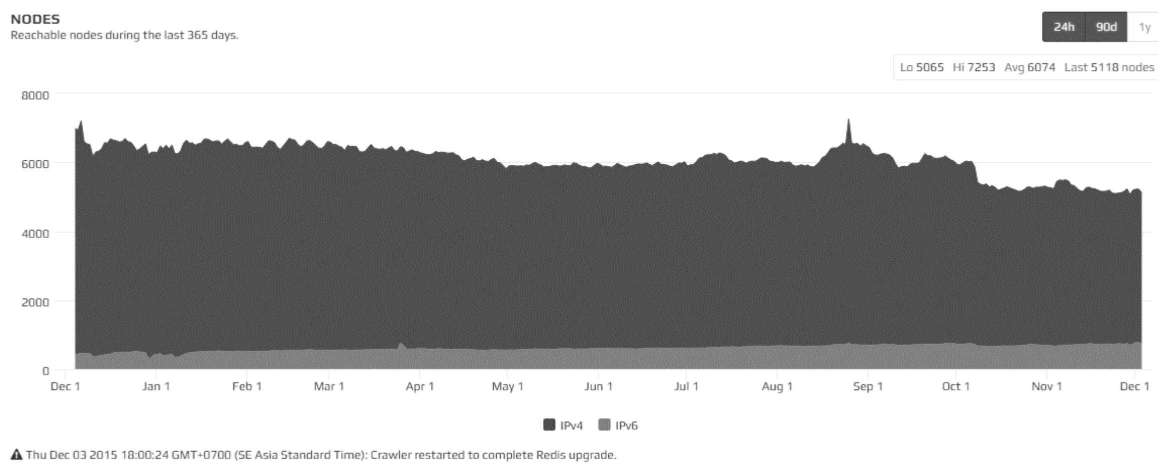

Fig. 4. Total nodes reachable during the previous year. Includes number of IPV4 and IPV6 nodes.

Irreversible—One of the strongest arguments is the irreversibility in conducting a hard fork. Any hard fork is going to cause schisms in the community and will be just as difficult to reverse or change should the path going forward. A strong majority consensus is warranted for a change of this nature and without it the consequences could mean loss of faith in Bitcoin. Some techniques to receive a strong consensus is to have miners vote on it. This is done by using a special signature transaction bit to vote upon successful proof of work. The downside to this, is only the miners really have a say in how this will be implemented. The users while being vocal and can move their bitcoins from certain exchanges and mining pools, won’t really have a vote in this change. The other difficulty with the irreversibility is that any damage done, may not be undone. When dealing with a market cap of nearly $6 Billion, a lot of money is at stake. If a decision ends up causing undue harm to the network, or causes the complete loss of faith in Bitcoin it will cause irreparable harm to many individuals.

Case Conclusion—After analyzing arguments for and against increasing the block size, there is sufficient evidence to suggest a block size increase is warranted; if not required. However, since there is time available to come up with a good solution, a solution should be posited that addresses the issues of fewer nodes, achieves a strong consensus and plans for the future of Bitcoin through and increase in transaction capacity and transaction fees.

5. Analysis of Current Bitcoin Improvement Proposals

As of the writing of this paper, there are five Bitcoin Improvement Proposal (BIP) that propose potential solutions to the block size problem. BIPs are intended “to be the primary mechanism for proposing new features.”[19] By analyzing each in comparison to the core arguments for and against a block size increase we may be able to determine the best current course of action for Bitcoin (assuming 1 or more is a suitable solution). There are many other proposals that have been drafted in articles and forums, but the official channel for change is done through the BIP process and will be the focus for this analysis.

BIP 101 – Increase maximum block size—BIP 101 was written and drafted by the Chief Scientist of the Bitcoin Foundation and core developer for the Bitcoin core code for several years, Gavin Andresen.[20] He has provided the second most commits to the Bitcoin Core Github repository,[21] which is an indicator that Mr. Andresen may know what he is proposing.
The general proposal of BIP 101 is to replace the current 1 MB maximum block size with an immediate 8 MB maximum and then have it grow over time at a predictable rate. The rate is a doubling every 2 years until year 2036 and stopping at 8,192,000,000 bytes (8.2 GB). The 20 year forecast is based upon long-term growth trends and a prediction that exponential growth cannot maintain course forever.[22]

BIP 101 already has a strong consensus achieved within the community. Eight CEOs of Bitcoin companies have all signed off on supporting BIP 101.[23] Also written into BIP 101 is how consensus will be achieved and that is by having 75% of the previous 1000 blocks voting for or against BIP 101. The code also allows for a two week grace period to allow for organizations to switch over to the new fork.[24]

Since nodes have already been decreasing, the rapid increase will likely cause the nodes to decrease quicker with this proposal. The reason for this is the potential misuse of block sizes and that the storage and bandwidth requirements will increase. Andresen believes that the decrease in “nodes on the network is largely due to the availability of… lightweight wallet software” and the moving away from desktop computer as the primary wallet.[25] If we assume the average capacity of every block is 25% of the maximum and the growth according to BIP 101, we can see that in Table 1. Blockchain Increase with BIP 101,**Error! Reference source not found.** we may have a blockchain that is larger than most current commercial hard disks in less than 10 years.

Table 1. Blockchain Increase with BIP 101

Year	Block Size	Blockchain
2015	1 MB	50 GB
2016	8 MB	155 GB
2018	16 MB	470 GB
2020	32 MB	1.10 TB
2022	64 MB	2.36 TB
2024	128 MB	4.89 TB
2026	256 MB	9.93 TB

The strongest argument against BIP 101 is why implement a change that attempts to predict the future. Jeff Garzik, author of BIP 102 has stated “don’t plan decades into the future and assume we know what 10+ year future will look like. Pick a short term plan that ensures system will not collapse or overly-centralize.”[26] BIP 101 addresses this by allowing for the possibility to be reduced with miner consensus as a soft fork.[27] BIP 101, however, does not address issues with transaction fees and largely assumes this will be taken care of by the market.

BIP 102 – Block size increase to 2MB—BIP 102 is authored by Jeff Garzik. Garzik is described as a futurist and has worked on the Red Hat Linux kernel as a primary software engineer. BIP 102's proposal is a stop gap measure. Its intent is to create a hard fork changing the current limit of 1 MB to 2 MB.[28]

BIP 102 solves the immediate need to increase the network to a limit that may not be reached for several years. Bitcoin has existed for nearly 7 years and has only just recently been hitting the 1 MB limit. By only making a minimal change to the code structure as shown below

```
// 1MB blocks until 11 Nov 2015, then 2MB
return (nBlockTimestamp < MEG_FORK_TIME ? 1000*1000 : 2*1000*1000);
```
[29]

BIP 102 solves the issue of any technical issues, as it is pretty straight forward change. The change involves returning either 1 million or 2 million as the number of bytes each block size maximum can be depending upon the time of the fork. The intent of this one time change is to buy time to find a more suitable long term solution. If Equation 1 is used to find the date for the new 2 MB limit, we find that it only buys an extra 400 days. This means the 2 MB limit would likely be reached at the end of 2017. BIP 101 on the other hand would already be preparing to double to a 16 MB limit at that time.

BIP 102 also has a similar voting mechanism as BIP 101 requiring 75% of the previous 1,000 blocks to signal their support for this BIP. This means consensus will need to be reached for implementation. Compared to BIP 101 there has not been as much vocal support for BIP 102, but most see the logic in the compromise BIP 102 is attempting to accomplish.

BIP 103 – Block size following technological growth—BIP 103, drafted by Peter Wuille, is an attempt to only increase the block size in close step to technological growth. BIP 103 would increase the maximum block size by 4.4% every 97 days, or 17.7% every year (Wuille 2015). Wuille instead of tying the growth to disk space, believes the true limiting factor is bandwidth. So using the average growth rate of bandwidth over the past few years came to the number of 17.7% growth.

BIP 103 will provide a slow steady growth of the block size over time. BIP 102 and 101 both attempt to make the block size change next year, while BIP 103 is slated to start in January 2017 in order to "provide ample time to minimize the risk of a hard fork" (Wuille 2015). As previously discussed, the Bitcoin network will be oversaturated in October of 2016, causing issues for two to three months before this change would be implemented.

Transaction fees aren't immediately addressed, but by conducting the change slowly over time the community can watch for issues with transaction fees given to miners and adjust as required. A bonus for BIP 103, like BIP 102, is that the code is very easy to understand and valid. Wuille even states it is "very simple to implement, needs little context, is efficient, and is trivially reviewable."[30]

BIP 103 has no built in consensus voting by the miners, unlike BIP 102 and 101, but rather decides everyone should have a say in how the network should be run and a consensus should be reached. By putting a January 2017 start date, there should be sufficient time to come to a consensus for a hard fork. Also, if the rate limiting factor is too fast, it can be reduced even further in what some call a soft fork.

BIP 105 – Consensus based Block size retargeting algorithm—BIP 105 is a consensus based block size that can increase or decrease depending upon market conditions. This retargeting algorithm is done every 2016 blocks, or 2 weeks and will increase or decrease by no more than 10%. In addition, BIP 105 introduces a floor for the maximum of 1 MB and a ceiling of 8 MB.[31]

BIP 105 introduces another feature in that voting to increase requires the miners to meet a harder proof of work, if they decide to vote for an increase. This feature is intended to add a cost to miners that may wish to increase the block size for nefarious purposes. As stated in a review of several proposals, BIP 105 "force[s] the mining community to collude on any attempted changes."[32] The reason is why would only one miner try and increase it, since it makes it difficult for him to meet the harder requirement than other miners.

BIP 105 does not currently have any code associated with it, as far as I could identify and so would take more time to implement than others who have code associated with them. BIP 105 also does not tackle the near immediacy of a block increase. It changes the code to allow for the change, but does nothing for the current state. Although once implemented an immediate 10% increase could be established by the miners, which would take 9 months to surpass that amount under BIP 103.

BIP 106 – Dynamically Controlled Bitcoin Block Size Max Cap—BIP 106 is one of the more complicated proposals to Bitcoin for the maximum block size. For starters, it includes two separate proposals for how the block size will be dynamic. The first is to factor in only the previous block size calculations. The second is to also use the transaction fees collected by miners.[33]

BIP 106 makes a lot of sense in that the block size will double or half depending upon how full blocks are in any given time. For example, if for a period of 2000 blocks more than 50% of blocks were filled to 90% capacity, the block size would double. If 90% were less than 50%, than it would half the current block size. Otherwise the block size would stay the same. This is helpful for the network because the maximum won't outpace the growth of the network, while at the same time if Bitcoin is being underutilized, then it can decrease in kind. It is also very difficult to game the dynamisms of the changes due to having to artificially increase the size of so many blocks, for so long.

BIP 106's second proposal is more interesting because it is one of the first to address the concerns of transaction fees. The general principle is if in the last 4016 blocks there was both an increase in size, and transaction fees from the first 2000 to the second 2000 blocks, then there will be an increase according to the formula below.

```
MaxBlockSize = TotalBlockSizeInLastDifficulty * MaxBlockSize /
   TotalBlockSizeInLastButOneDifficulty
```
[34]

So if we take an example where the total block size is 1,606.4 MB for the first 2008 blocks, and 1,807.2 MB, then the resulting block size will be 1.13 MB, due to a 12.5% increase. As shown in Table 2. Table Breakdown of when a change would occur according to BIP 106**Error! Reference source not found.**, changes would only go up or down if both the transaction fees and block size increase or decrease in kind.

Table 2. Table Breakdown of when a change would occur according to BIP 106

Total Transaction Fee Period 2 Compared to Period 1	Total Block Size Period 2 Compared to Period 1	Max Block Size
Higher	Higher	Increase
Higher	Lower	No Change
Lower	Lower	Decrease
Lower	Higher	No Change

While both proposals are interesting, they both are too dynamic to be counted on. We would see wild changes nearly every two weeks and that alone may bring quite a bit of chaos along with it. BIP 106 also does not have a technical implementation, and even requires a few rounds of efficiency improvement on the pseudocode. It is even lacking a chart showing if implemented what the maximum block size would be retroactively. So that is included in Fig. 5Fig. 5 using data tabulated in Appendix Table 3. As shown the maximum block size would fluctuate nearly every difficulty period.

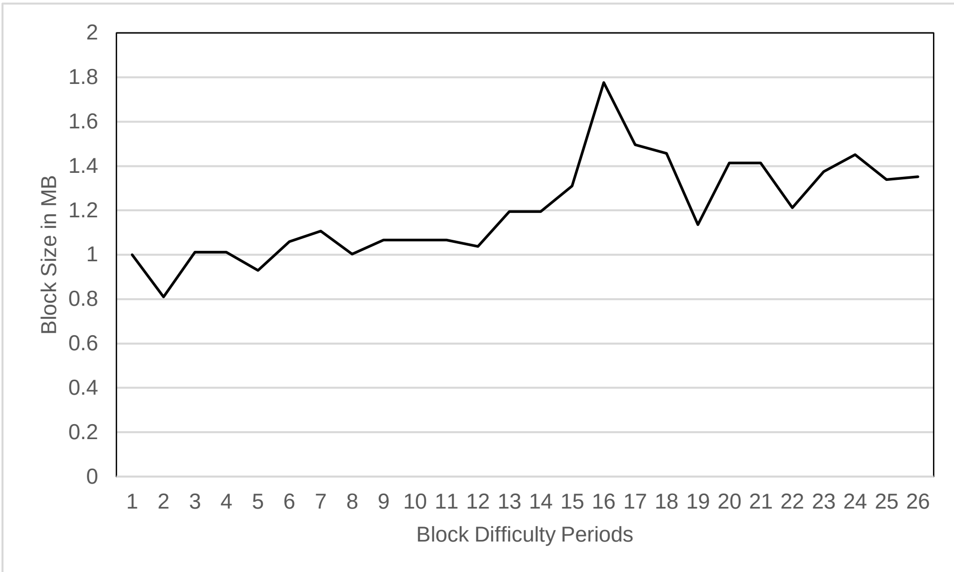

Fig. 5. Max block size if BIP 106 was implemented 1 year ago.

These things make it too early for implementation and more of a novel idea to include transaction fees as a way to assist in the maximum block size equation.

6. Conclusion

As noted, all five Bitcoin Improvement Proposals bring a possible solution to the current block size. Some are immediate, others prepare the network for the inevitability. BIP 101 solves the immediate concern of meeting the demands of the network in the near term, while also allowing for a capacity that would bring it on par with companies such as Visa in transactions per second. BIP 102 is a stop gap short term increase to allow for more time for analysis. BIP 103 slows the growth to match that of technology to mitigate concerns with the decrease in nodes. BIP 105 brings a miner consensus based approach to increase with both a floor and ceiling for the maximum block size, while also instituting a penalty to increase. Last, BIP 106 attempts to dynamically adjust the maximum block size based upon previous block and transaction fee trends.

Of these 5 proposals, I believe none address both the immediate concerns to increase the maximum block size, while alleviating all concerns of the Bitcoin community. For that reason, I can see why this issue is so divisive amongst all the players. I, however, believe the closest would be to utilize BIP 102's immediate increase to 2 MB, followed by BIP 103's slow steady growth. This solution would solve all immediate concerns of network viability, allow for growth in the future without another hard fork, allow for the monitoring of transaction fees and likely not cause a strong decrease in nodes due to the technological growth limiting factor.

Appendix A

Table 3. Table of Changes over previous year to calculate Max Block Size per BIP 106

Difficulty Period	Total Transaction Fees	Total of Daily Average Block Size	Adjusted Max Block Size
1	181.3709349	4.945453302	1
2	180.6077587	4.006115102	0.810060243
3	231.1600338	5.00026577	1.011083406
4	186.9045097	5.040671854	No Change
5	180.6633272	4.631629047	0.929035535
6	202.7325682	5.279324728	1.058953604
7	205.5579352	5.517347911	1.106697496
8	203.5623601	5.003216204	1.003570363
9	226.5182994	5.319883558	1.067089099
10	214.5820126	5.389605472	No Change
11	297.6110234	5.255994929	No Change
12	209.5312212	5.11148711	1.037750654
13	256.8339396	5.884128769	1.194614864
14	262.9682218	5.885503934	1.194894055
15	281.3552851	6.452774021	1.310063063
16	467.9619541	8.749284843	1.776308122
17	412.8094036	7.370539011	1.496390682
18	386.1752359	7.175471409	1.456787426
19	329.9730265	5.591468278	1.135197984
20	389.4921737	6.961132045	1.413271555
21	379.147374	7.773588284	No Change
22	347.5412529	6.667687015	1.21221398
23	373.580989	7.558436981	1.374156129
24	438.3119069	7.981501757	1.451071112
25	369.0487043	7.365595775	1.339096774
26	382.3180495	7.431415936	1.35106316

Acknowledgement

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Notes and References

[1] Scalability FAQ. (n.d.). Retrieved November 23, 2015, from BitcoinWiki: https://en.bitcoin.it/wiki/Scalability_FAQ

[2] Sterry, D. R. (2015). Arguments in the Bitcoin Block Size Debate. Retrieved from https://www.zapchain.com/a/l/arguments-in-the-bitcoin-block-size-debate/qL5rsZnHmO

[3] Blockchain.info. (2015, November 21). *Bitcoin Average Block Size*. Retrieved from https://blockchain.info/charts/avg-block-size

[4] Scalability FAQ. (n.d.). Retrieved November 23, 2015, from BitcoinWiki: https://en.bitcoin.it/wiki/Scalability_FAQ

[5] Blockchain.info. (2015, November 23). *Bitcoin Number Of transactions Per Day*. Retrieved from https://blockchain.info/charts/n-transactions

[6] Sterry, D. R. (2015). *Arguments in the Bitcoin Block Size Debate*. Retrieved from https://www.zapchain.com/a/l/arguments-in-the-bitcoin-block-size-debate/qL5rsZnHmO

[7] Transaction Fees. (2015). Retrieved from BitcoinWiki: https://en.bitcoin.it/wiki/Transaction_fees

[8] Bitcoin. (n.d.). Bitcoin Core commit c322652. Retrieved November 23, 2015, from https://github.com/bitcoin/bitcoin/blob/master/src/main.cpp. File: src/consensus/consensus.h, line 10

[9] Bitcoin. (n.d.). Bitcoin Core commit c322652. Retrieved November 23, 2015, from https://github.com/bitcoin/bitcoin/blob/master/src/main.cpp. File: src/main.cpp, line 729-730)

[10] Bustiloos, M. (2015, August 25). *Inside the Fight Over Bitcoin's Future*. Retrieved from The New Yorker: http://www.newyorker.com/business/currency/inside-the-fight-over-bitcoins-future

[11] Bitcoin Stackexchange. (2015). *What are the arguments for and against the increase of the block size limit?* Retrieved from http://bitcoin.stackexchange.com/questions/36085/what-are-the-arguments-for-and-against-the-increase-of-the-block-size-limit

[12] This may be partially offset by the priority of transactions being higher the longer they are held in memory.

[13] Paypal. (2014, December 26). Retrieved from Paypal: https://web.archive.org/web/20141226073503/https://www.paypal-media.com/about

[14] Streng, M. (2015, August 17). *Let's examine the actual arguments for and against a block size increase*. Retrieved from https://ihb.io/2015-08-17/news/block-size-increase-22737

[15] BitNodes. (2015). *365 Charts*. Retrieved from Bitnodes: https://bitnodes.21.co/dashboard/?days=365

[16] Bitcoin.org. (n.d.). *Running a Full Node - Bitcoin*. Retrieved November 2015, from https://bitcoin.org/en/full-node#minimum-requirements

[17] BitNodes. (2015). *365 Charts*. Retrieved from Bitnodes: https://bitnodes.21.co/dashboard/?days=365

[18] Sterry, D. R. (2015). *Arguments in the Bitcoin Block Size Debate*. Retrieved from https://www.zapchain.com/a/l/arguments-in-the-bitcoin-block-size-debate/qL5rsZnHmO

[19] Maxwell, G. (2011, August 19). *BIP Purpose and Guidelines*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0001.mediawiki

[20] Bitcoin Foundation. (2015). *Transparency | Bitcoin*. Retrieved from https://bitcoinfoundation.org/transparency/

[21] Bitcoin.org. (n.d.). *Development - Bitcoin*. Retrieved from https://bitcoin.org/en/development

[22] Andresen, G. (2015, June 22). *Increase maximum block size*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0101.mediawiki

[23] Pair, S., Smith, P., Allaire, J., Neville, S., Cole, S., Cascarilla, C., . . . Belshe, M. (2015, August 24). *Industry Block Size Letter All Signed.* Retrieved from https://blog.blockchain.com/wp-content/uploads/2015/08/Industry-Block-Size-letter-All-Signed.pdf

[24] Andresen, G. (2015, June 22). *Increase maximum block size*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0101.mediawiki

[25] Andresen, G. (2015, June 22). *Increase maximum block size*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0101.mediawiki

[26] Garzik, J. (n.d.). *8 Major Players Support BIP 101*. Retrieved December 2015, from Reddit.com: https://www.reddit.com/r/Bitcoin/comments/3i7mtz/8_major_players_support_bip_101/cue0cz6

[27] Andresen, G. (2015, June 22). *Increase maximum block size*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0101.mediawiki

[28] Garzik, J. (2015, June 23). *Block size increase to 2MB*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0102.mediawiki

[29]Garzik, J. (2015, June 23). *Increase Block Size Limit to 2 MB on Nov 11, 2015*. Retrieved from Github: https://github.com/jgarzik/bitcoin/commit/985418ef0f02d37485700c31b216eb13af6de9d7. File: src/consensus/Consensus.h, line 14-16

[30] Wuille, P. (2015, July 21). *Block size following technological growth*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0103.mediawiki

[31] BtcDrak. (2015, August 21). *Consensus based block size retargeting algorithm*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0105.mediawiki

[32] Torpey, K. (2015, September 9). *6 Proposals for Increasing the Bitcoin Block Size Limit*. Retrieved from CoinGecko: https://www.coingecko.com/buzz/6-proposals-increasing-bitcoin-block-size-limit?locale=en

[33] Chakraborty, U. (2015, August 24). *Dynamically Controlled Bitcoin Block Size Max Cap*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0106.mediawiki

[34] Chakraborty, U. (2015, August 24). *Dynamically Controlled Bitcoin Block Size Max Cap*. Retrieved from https://github.com/bitcoin/bips/blob/master/bip-0106.mediawiki