

## Scaling Definitions

### 1) Consensus (Old)

Define

$Z_M = 300000$  bytes ; Minimum penalty free zone.

$M_B$  = Block weight in bytes.

$M_L$  = The median over the last 100000 blocks of  $\max((\min(M_B, 1.7M_L), Z_M, M_L/1.7))$  ; recursive calculation for  $M_L$  with  $M_L$  starting at  $M_L$  of previous 100001 block (currently =  $Z_M$ ); Long term median

$M_L$  ; Dynamic penalty free zone.

$M_S$  = the median over the last 100 blocks of  $\max(M_B, M_L)$  ; Effective short term median.

$M_N = \min(M_S, 50M_L)$  ; Median for Penalty calculation.

$R_{Base}$  = Block Reward.

$0 < M_B \leq 2M_N$  ; Requirement for a valid block.

$B = M_B / M_N - 1$  where  $-1 < B \leq 1$

$P_B = R_{Base}B^2$  for  $B > 0$  ; Monero applies a penalty  $P_B$ , to increase the block weight by B;  $P_B = 0$  for  $B \leq 0$

## Scaling Definitions (17<sup>th</sup> December 2025 MRL meeting)

### 1) Consensus (New)

Define

$Z_M = 625000$  bytes ; Minimum penalty free zone.

$M_B$  = Block weight in bytes.

$M_L$  = The median over the last 100000 blocks of  $\max((\min(M_B, 1.2M_L), Z_M, M_L/1.2))$  ; recursive calculation for  $M_L$  with  $M_L$  starting at  $M_L$  of previous 100001 block (currently =  $Z_M$ ); Long term median

$M_L$  ; Dynamic penalty free zone.

$M_S$  = The median over the last 100 blocks of  $M_B$  ; Short Term Median.

$M_N = M_S \min(\max(M_S, M_L), 8M_L)$ ; Median for Penalty Calculation.

$R_{Base}$  = Block Reward.

$0 < M_B \leq 2M_N$  ; Requirement for valid block.

$B = M_B / M_N - 1$  where  $-1 < B \leq 1$

$P_B = R_{Base}B^2$  for  $B > 0$  ; Monero applies a penalty  $P_B$ , to increase the block weight by B;  $P_B = 0$  for  $B \leq 0$

### Changes

- 1) Maximum growth of  $M_S$  is reduced from  $50M_L$  to  $8M_L$
- 3) Rate of growth and decline of  $M_L$  is decreased from 1.7x to 1.2x
- 4)  $Z_M$  is increased from 300000 bytes to 625000 bytes
- 5) Definition change to reflect the code. Also  $M_N$  is added to the transitional consideration and  $M_{SW}$  removed  $M_{SW}$  is no longer relevant since the short term median is no longer used for the fee calculation.

## 2a) Minimum Fee For Node Relay (Old)

We add a, penalty attracting, transaction T with a size of  $T_T$  to a block of weight  $M_B$

Define

$T_R = 3000$  bytes ; Reference Transaction weight. Note:  $T_R$  must be greater than  $T_2$ .  $T_2$  equals the weight in bytes of a 2 input and 2 output transaction.

$$B_T = T_T / M_N$$

$P_{BT} = R_{Base}(B+B_T)^2 = R_{base}(B^2 + 2BB_T + B_T^2)$  ; The new penalty, where  $B + B_T > 0$

$P_T = P_{BT} - P_B = R_{Base}(2BB_T + B_T^2)$  ; Increase in penalty from adding transaction T

$F_T = R_{Base}(2BB_T + B_T^2)$  ; The additional fee required to overcome the increase in penalty  $P_T$

For the case  $B = 0$  this reduces to  $F_T = R_{Base}B_T^2$

$M_F = M_L$  ; Median for minimum fee calculation

To calculate the minimum fee we consider a transaction of weight  $T_R$  at the start of the penalty,  $B = 0$  with  $M_N = M_F$  95% of the fee required to pay the penalty incurred is the minimum fee.

$$B_{RL} = T_R / M_F ;$$

$F_R = R_{Base}B_{RL}^2$  ; Fee required to pay the penalty incurred

$f_R = R_{Base}B_{RL}/M_F$  ; Fee required to pay the penalty incurred per byte for a given  $M_F$

$f_i = 0.95f_R$  ; Minimum fee per byte

## 2a) Minimum Fee For Node Relay (New)

We add a, penalty attracting, transaction T with a size of  $T_T$  to a block of weight  $M_B$

Define

$T_R = 10000$  bytes ; Reference Transaction weight. Note:  $T_R$  must be greater than  $T_2$ .  $T_2$  equals the weight in bytes of a 2 input and 2 output transaction.

$$B_T = T_T / M_N$$

$P_{BT} = R_{Base}(B+B_T)^2 = R_{base}(B^2 + 2BB_T + B_T^2)$  ; The new penalty, where  $B + B_T > 0$

$P_T = P_{BT} - P_B = R_{Base}(2BB_T + B_T^2)$  ; Increase in penalty from adding transaction T

$F_T = R_{Base}(2BB_T + B_T^2)$  ; The additional fee required to overcome the increase in penalty  $P_T$

For the case  $B = 0$  this reduces to  $F_T = R_{Base}B_T^2$

$M_F = M_L$  ; Median for minimum fee calculation

To calculate the minimum fee we consider a transaction of weight  $T_R$  at the start of the penalty,  $B = 0$  with  $M_N = M_F$  100% of the fee required to pay the penalty incurred is the minimum fee.

$$B_{RL} = T_R / M_F ;$$

$F_{RL} = R_{Base}B_{RL}^2$  ; Fee required to pay the penalty incurred

$f_{RL} = R_{Base}B_{RL}/M_F$  ; Fee required to pay the penalty incurred per byte for a given  $M_F$

$f_{iL} = f_{RL}$  ; Minimum fee per byte

### Changes

- 1)  $T_R$  is increased from 3000 bytes to 10000 bytes. For clarity  $T_R$  is defined outside of consensus.
- 2) There is no reduction to 95% of the minimum fee. This is all now handled on the wallet side.

## 2b) Wallet Fees (Old)

For the calculation of wallet fees we assume that the next 10 blocks have no transactions, other than the coinbase transaction, the empty blocks, We then calculate  $M_{LW}$  and  $M_{SW}$  by following the calculation of  $M_L$  and  $M_S$  at this future point. We use the previous 99990 blocks and the future 10 empty blocks (100000 blocks) for  $M_L$  and the previous 90 blocks and future 10 blocks (100) blocks for  $M_S$ .

Define

$M_{BW} = M_B$  for the last 99990 blocks

$M_{BW} = 0$  for the future 10 blocks; A value of 0 bytes can be used for the empty blocks for the purposes of calculating  $M_{LW}$ .

$M_{LW}$  = The median over the last 99990 blocks and future 10 blocks (100000 blocks) of  $\max((\min(M_{BW}, 2M_L), Z_M, M_L/2))$ ; The current value of  $M_L$  from consensus is used; Effective long term median for wallet fees

$M_{LW}$  ; Penalty free zone for wallet fees

$M_{SW}$  = the median over the last 90 blocks and future 10 blocks (100 blocks) of  $\max(M_{BW}, M_{LW})$ ; Effective short term median for wallet fees

$M_{NW} = \min(M_{SW}, 50M_{LW})$

$M_{FW} = M_{LW}$  ; Median for wallet fee calculation

$B_{RLW} = T_R / M_{FW}$  ; Used for the low and normal fees

$B_R = T_R / Z_M$  ; Used for the medium and high fees

$F_L = R_{Base} B_{RLW}^2$  ; Low transaction fee for reference transaction

$f_L = R_{Base} B_{RLW} / M_{FW}$  ; Low transaction fee per byte for a given  $M_{FW}$

$f_N = 4f_L$  ; Normal transaction fee per byte for a given  $M_{FW}$

$f_M = 16 R_{Base} B_R / M_{FW}$  ; Medium Transaction fee per byte for a given  $M_{FW}$

$f_P = 2R_{Base} / M_{NW} = f_M M_{FW} / (8B_R M_{NW})$ ; Maximum Penalty ( $B=1$ ) Transaction fee per byte for a given  $M_{NW}$

$f_H = 4f_M \max(1, M_{FW} / (32B_R M_{NW}))$ ; High Transaction fee per byte

## 2b) Wallet Fees (New)

For the calculation of wallet fees we assume that the next 1000 blocks have no transactions, other than the coinbase transaction, the empty blocks, We then calculate  $M_{LW}$  by following the calculation of  $M_L$  at this future point. We use the previous 99000 blocks and the future 1000 empty blocks (100000 blocks) for  $M_L$ .

Define

$M_{BW} = M_B$  for the last 99000 blocks

$M_{BW} = 0$  for the future 1000 blocks; A value of 0 bytes can be used for the empty blocks for the purposes of calculating  $M_{LW}$ .

$M_{LW}$  = The median over the last 99000 blocks and future 1000 blocks (100000 blocks) of  $\max((\min(M_{BW}, 1.2M_L), Z_M, M_L/1.2))$ ; The current value of  $M_L$  from consensus is used; Effective long term median for wallet fees

$M_{LW}$  ; Penalty free zone for wallet fees

$M_{FW} = M_{LW}$  ; Median for wallet fee calculation

$B_{RLW} = T_R / M_{FW}$  ; Used for all fees

$B_R = T_R / Z_M$  ; Used for reference

$F_L = R_{Base} B_{RLW}^2$  ; Low (minimum scaling) transaction fee for reference transaction

$f_L = R_{Base} B_{RLW} / M_{FW}$  ; Low (minimum scaling) transaction fee per byte for a given  $M_{FW}$

$f_N = 4f_L$  ; Normal transaction fee per byte for a given  $M_{FW}$

$f_M = 16f_L$  ; Medium Transaction fee per byte for a given  $M_{FW}$

$f_{H64} = 64f_L$  ; 64x Transaction fee per byte for a given  $M_{FW}$

$f_{H256} = 256f_L$  256x Transaction fee per byte for a given  $M_{FW}$ . This is greater than or equal to Maximum Penalty ( $B=1$ ) for  $M_L < 1280000$  bytes.

### Changes

- 1) All fees including the high fee are now based upon  $M_{LW}$  with the ratio between fees constant for a given  $M_{LW}$ .
- 2) The grace period is increased to 1000 blocks.
- 3) 5 fee levels with at least a 4x factor between fees. Additional fee levels can be added if needed at 1024x, 4096x etc. for larger  $M_L$

### 3) Consensus Transitional considerations for Minimum penalty free zone, $Z_M$ , and Median calculations after the fork.

Define:

$Z_{MOld} = 300000$  bytes ( $Z_M$  before hard fork)

$M_{BOld}$  = Block Weight in bytes (before hard fork)

### 3) Consensus Transitional considerations for Minimum penalty free zone, $Z_M$ , and Median calculations after the fork.

Calculation of  $M_L$ ,  $M_S$ ,  $M_N$  and  $M_{LW}$  where blocks from a previous the Monero version are included in a calculation after the fork.  $M_B$  is modified as follows:

Define

$Z_M = 625000$  bytes

For blocks before the hard fork

$M_B = M_{BOld} (Z_M / Z_{MOld})$

The medians are then calculated normally.

#### 4) Wallet Fee Rounding

Wallet fees,  $f_N$ ,  $f_L$ ,  $f_M$ , and  $f_H$  are rounded up to the desired number of significant digits in the significant

##### Wallet Fee Rounding Examples

Two significant digits

27810	Rounded to : 28000
37.94	Rounded to : 38
0.5555	Rounded to : 0.56
0.002342	Rounded to : 0.0024

#### 4) Wallet Fee Rounding

Wallet fees,  $f_N$ ,  $f_L$ ,  $f_M$ ,  $f_H$ , and  $f_X$  are rounded to 2 significant digits in the significant

##### Wallet Fee Rounding Examples

Two significant digits

27810	Rounded to : 28000
37.94	Rounded to : 38
0.5555	Rounded to : 0.56
0.002342	Rounded to : 0.0023