Lecture #25: Transaction Fees

COMS 4995-001:
The Science of Blockchains
URL: https://timroughgarden.org/s25/

Tim Roughgarden

Goals for Lecture #25

1. Block size and metering computation.
   - transactions fees most naturally priced “per-unit-size”
   - in a Turing-complete blockchain, how to measure “transaction complexity”?
2. Transaction fees and first-price auctions.
   - FPAs: users submit bids, do price discovery (Bitcoin, Ethereum 2015-21)
3. EIP-1559.
   - how Ethereum prices transactions (2021-now)
   - moves price discovery largely in-protocol, has deflationary side effects

Block Size

Limited capacity: a blockchain protocol can't process infinite txs/second.

- for a fixed block rate, maximum size of a block is finite

Block Size

Limited capacity: a blockchain protocol can't process infinite txs/second.

- for a fixed block rate, maximum size of a block is finite

Consequence: if demand for tx processing exceeds supply ➔ txs must compete for inclusion. (block proposer will have tough decisions to make)

Block Size

Limited capacity: a blockchain protocol can't process infinite txs/second.

- for a fixed block rate, maximum size of a block is finite

Consequence: if demand for tx processing exceeds supply ➔ txs must compete for inclusion. (block proposer will have tough decisions to make)

Question: what is the "size" of a block?

Block Size

Limited capacity: a blockchain protocol can't process infinite txs/second.

- for a fixed block rate, maximum size of a block is finite

Consequence: if demand for tx processing exceeds supply ➔ txs must compete for inclusion. (block proposer will have tough decisions to make)

Question: what is the "size" of a block?

First thought: size of block = number of txs in it.

Block Size

Limited capacity: a blockchain protocol can't process infinite txs/second.

- for a fixed block rate, maximum size of a block is finite

Consequence: if demand for tx processing exceeds supply ➔ txs must compete for inclusion. (block proposer will have tough decisions to make)

Question: what is the "size" of a block?

First thought: size of block = number of txs in it.

Issue: some txs "more complicated" than others.

Transaction Size

Idea: “tx size” ≈ amount of resources required to process it.

- size of block then sum of sizes of the txs in it

Transaction Size

Idea: “tx size” ≈ amount of resources required to process it.

- size of block then sum of sizes of the txs in it

Challenge: tx consumes multiple types of resources.

- network bandwidth, validator computation, storage

Transaction Size

Idea: “tx size” ≈ amount of resources required to process it.

- size of block then sum of sizes of the txs in it

Challenge: tx consumes multiple types of resources.

- network bandwidth, validator computation, storage

Further challenge: resource consumption may depend on specific client implementation and/or validator architecture.

Transaction Size

Idea: “tx size” ≈ amount of resources required to process it.

Challenges: tx consumes multiple types of resources; resource consumption may depend on implementation/architecture.

Bitcoin (pre-Segwit): tx size := description length (in bytes).

- typical tx size 250 bytes
- maximum block size = 1 MB ➔ 4000 tx/block (< 7 txs/sec)

Transaction Size

Idea: “tx size” ≈ amount of resources required to process it.

Challenges: tx consumes multiple types of resources; resource consumption may depend on implementation/architecture.

Bitcoin (pre-SegWit): tx size := description length (in bytes).

Bitcoin (post-SegWit): redefined “size” of a transaction to:

.25*(# of bytes used for witness data) + (# of additional bytes used)

– ➔ maximum block size now effectively 4MB (if entirely witness data)

Block 891332

00000000000000000017296d2ac7ffde35a988c17c6d8728a3ed0036853d796

Block was mined on 2025-04-07 07:01:06 GMT -4. It has 1 confirmation on the Bitcoin blockchain. There are 2800 transactions in block 891332.

PREVIOUS

DETAILS

HEIGHT	891332
STATUS	In best chain (1 confirmation)
TIMESTAMP	2025-04-07 07:01:06 GMT -4
SIZE	1617.481 KB
VIRTUAL SIZE	999 vKB
WEIGHT UNITS	3993.379 KWU
VERSION	0x23bdc000
MERKLE ROOT	1601e7d398911c9a6fa501e372fe84231acfbc5db9bf89aab5d43f8ad0b061ea
BITS	0x17025105
DIFFICULTY	121507793131898.06
NONCE	0x7951a124

Metering Computation in Ethereum

Metering Computation in Ethereum

Note: in a Turing-complete VM, even a “small” tx could run forever.

Metering Computation in Ethereum

Note: in a Turing-complete VM, even a “small” tx could run forever.

Solution: force user to prepay for computation, tx aborts and is rolled back if budget is exhausted. (important: txs are atomic)

Example: USDC Transfer

Transaction Hash:	0x3b9ada8e0cbf69fb4aff9f40e9946bf3d5585f47ed03b403fd50f570870be168
Status:	Success
Block:	21879725 5 Block Confirmations
Timestamp:	53 secs ago (Feb-19-2025 10:09:47 AM UTC)
Transaction Action:	Transfer 101.4 ($101.39) USDC To 0x618a16ED7d4C39EFB5A6342C3972c896757a1b79
Sponsored:	
From:	0xc4a3Dcd48118D77bE44E7853bd5938F7448c7bD7
Interacted With (To):	0xA0b86991c6218b36c1d19D4a2e9Eb0cE3606eB48 (Circle: USDC Token)
ERC-20 Tokens Transferred:	All Transfers Net Transfers From 0xc4a3Dcd4...7448c7bD7 To 0x618a16ED...6757a1b79 For 101.4 ($101.39) USDC (USDC)
Value:	0 ETH ($0.00)
Transaction Fee:	0.00008286227098344 ETH ($0.23)
Gas Price:	1.442086164 Gwei (0.000000001442086164 ETH)
Gas Limit & Usage by Txn:	94,566 | 57,460 (60.76%)
Gas Fees:	Base: 0.732318081 Gwei | Max: 1.6 Gwei | Max Priority: 0.709768083 Gwei
Burnt & Txn Savings Fees:	Burnt: 0.00004207899693426 ETH ($0.11) Txn Savings: 0.00000907372901656 ETH ($0.02)
Other Attributes:	Txn Type: 2 (EIP-1559) Nonce: 0 Position In Block: 165
Input Data:	Function: transfer(address to,uint256 value) MethodID: 0xa9059cbb [0]: 000000000000000000000000618a16ed7d4c39efb5a6342c3972c896757a1b79 [1]: 0000000000000000000000000000000000000000000000000000000060b3dc0

Metering Computation in Ethereum

Note: in a Turing-complete VM, even a “small” tx could run forever.

Solution: force user to prepay for computation, tx aborts and is rolled back if budget is exhausted. (important: txs are atomic)

Metering Computation in Ethereum

Note: in a Turing-complete VM, even a “small” tx could run forever.

Solution: force user to prepay for computation, tx aborts and is rolled back if budget is exhausted. (important: txs are atomic)

- associate an amount of “gas” with each EVM opcode
  - EVM opcodes = instruction set for VM code in Ethereum’s VM
  - add two numbers = 3 units of gas; evaluate SHA-256 = 30 units

Metering Computation in Ethereum

Note: in a Turing-complete VM, even a “small” tx could run forever.

Solution: force user to prepay for computation, tx aborts and is rolled back if budget is exhausted. (important: txs are atomic)

- associate an amount of “gas” with each EVM opcode
  - EVM opcodes = instruction set for VM code in Ethereum’s VM
  - add two numbers = 3 units of gas; evaluate SHA-256 = 30 units
- user prepays for gas

Metering Computation in Ethereum

Note: in a Turing-complete VM, even a “small” tx could run forever.

Solution: force user to prepay for computation, tx aborts and is rolled back if budget is exhausted. (important: txs are atomic)

- associate an amount of “gas” with each EVM opcode
  - EVM opcodes = instruction set for VM code in Ethereum’s VM
  - add two numbers = 3 units of gas; evaluate SHA-256 = 30 units
- user prepays for gas
- run out of gas mid-execution ➔ tx aborted and rolled back

Metering Computation in Ethereum

Note: in a Turing-complete VM, even a “small” tx could run forever.

Solution: force user to prepay for computation, tx aborts and is rolled back if budget is exhausted. (important: txs are atomic)

- associate an amount of “gas” with each EVM opcode
- user prepays for gas (recall “gas limit” and “gas price” fields)
- run out of gas mid-execution ➔ tx aborted and rolled back

Current block size: target = 18 million gas/block, max = 36 million.

  - typically a couple hundred txs/block (≈ 15 txs/sec)

Transaction Fees

- transaction fee = price paid (per unit “size”) for tx execution
  - generally priced (under the hood) in blockchain protocol’s native currency
  - potential source of validator rewards (in addition to block/staking rewards)

Transaction Fees

- transaction fee = price paid (per unit “size”) for tx execution
  - generally priced (under the hood) in blockchain protocol’s native currency
  - potential source of validator rewards (in addition to block/staking rewards)
- regime #1: abundant blockspace (supply > demand)
  - nominal tx fee generally sufficient (still want to deter spam)

Transaction Fees

- transaction fee = price paid (per unit “size”) for tx execution
  - generally priced (under the hood) in blockchain protocol’s native currency
  - potential source of validator rewards (in addition to block/staking rewards)
- regime #1: abundant blockspace (supply > demand)
  - nominal tx fee generally sufficient (still want to deter spam)
- regime #2: scarce blockspace (demand > supply)
  - have to choose, would like to include the “most valuable” txs

Transaction Fees

- transaction fee = price paid (per unit “size”) for tx execution
  - generally priced (under the hood) in blockchain protocol’s native currency
  - potential source of validator rewards (in addition to block/staking rewards)
- regime #1: abundant blockspace (supply > demand)
  - nominal tx fee generally sufficient (still want to deter spam)
- regime #2: scarce blockspace (demand > supply)
  - have to choose, would like to include the “most valuable” txs
  - “most valuable” = those willing to pay a suitable price (per unit “size”)
    - if don’t charge fees in-protocol, markets will arise out-of-protocol

Transaction Fees

- transaction fee = price paid (per unit "size") for tx execution
  - generally priced (under the hood) in blockchain protocol's native currency
  - potential source of validator rewards (in addition to block/staking rewards)
- regime #1: abundant blockspace (supply > demand)
  - nominal tx fee generally sufficient (still want to deter spam)
- regime #2: scarce blockspace (demand > supply)
  - have to choose, would like to include the "most valuable" txs
  - "most valuable" = those willing to pay a suitable price (per unit "size")
    - if don't charge fees in-protocol, markets will arise out-of-protocol
  - price could be set by protocol or by users themselves (or both)

First-Price Auctions (FPAs)

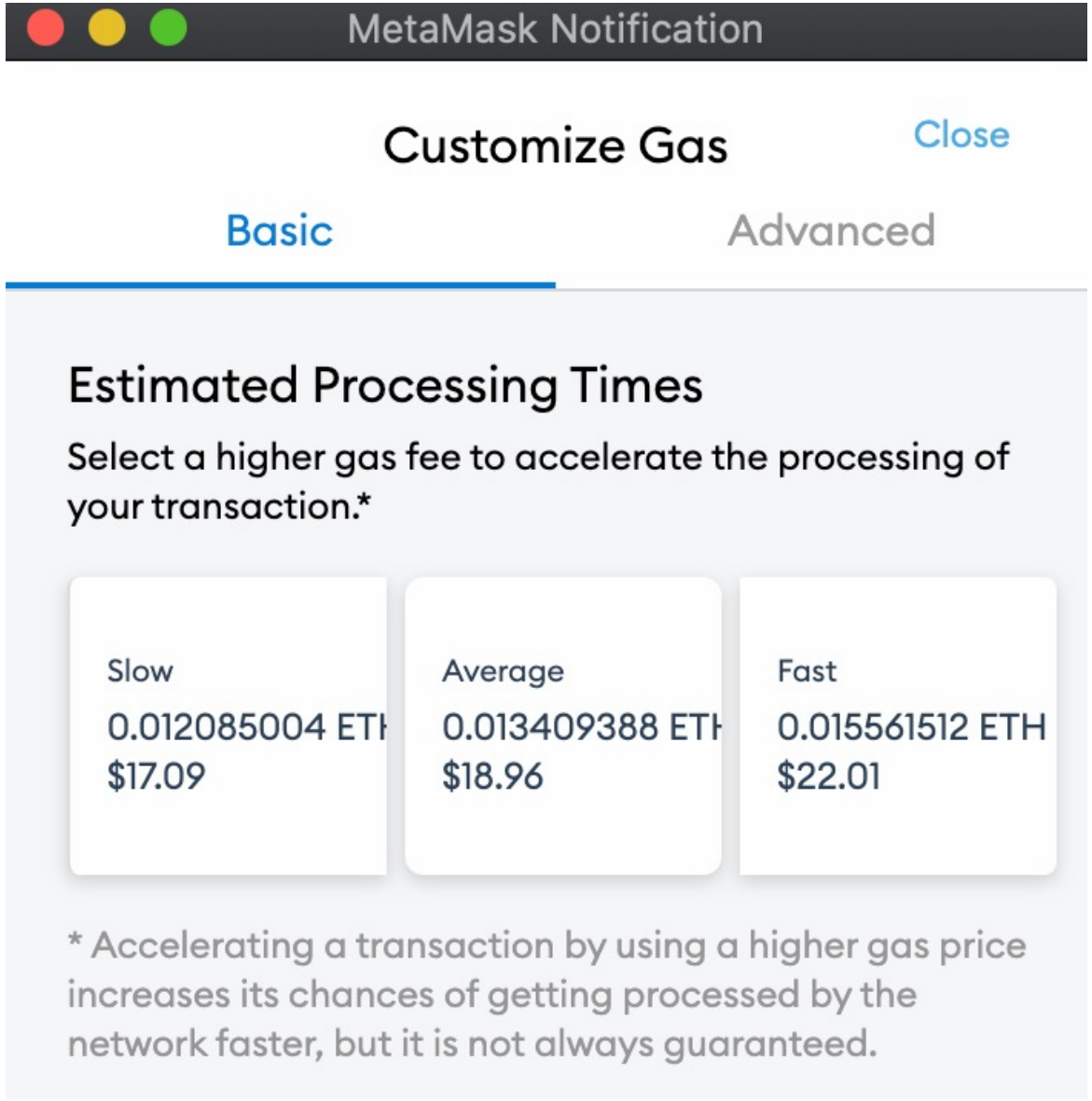
Idea: let “market do the work,” users/wallets to the price discovery.

First-Price Auctions (FPAs)

Idea: let “market do the work,” users/wallets to the price discovery.

First-price auction:

- each submitted tx includes a bid (per-unit “size”)
  - e.g., suggested by user’s wallet based on recently produced blocks



MetaMask, circa 2020-2021

First-Price Auctions (FPAs)

Idea: let “market do the work,” users/wallets to the price discovery.

First-price auction:

- each submitted tx includes a bid (per-unit “size”)
  - e.g., suggested by user’s wallet based on recently produced blocks
- on inclusion in a block, bid transferred to producer of that block
  - e.g., the leader of the current view
  - expect block producer to pack its block with the highest-bidding txs

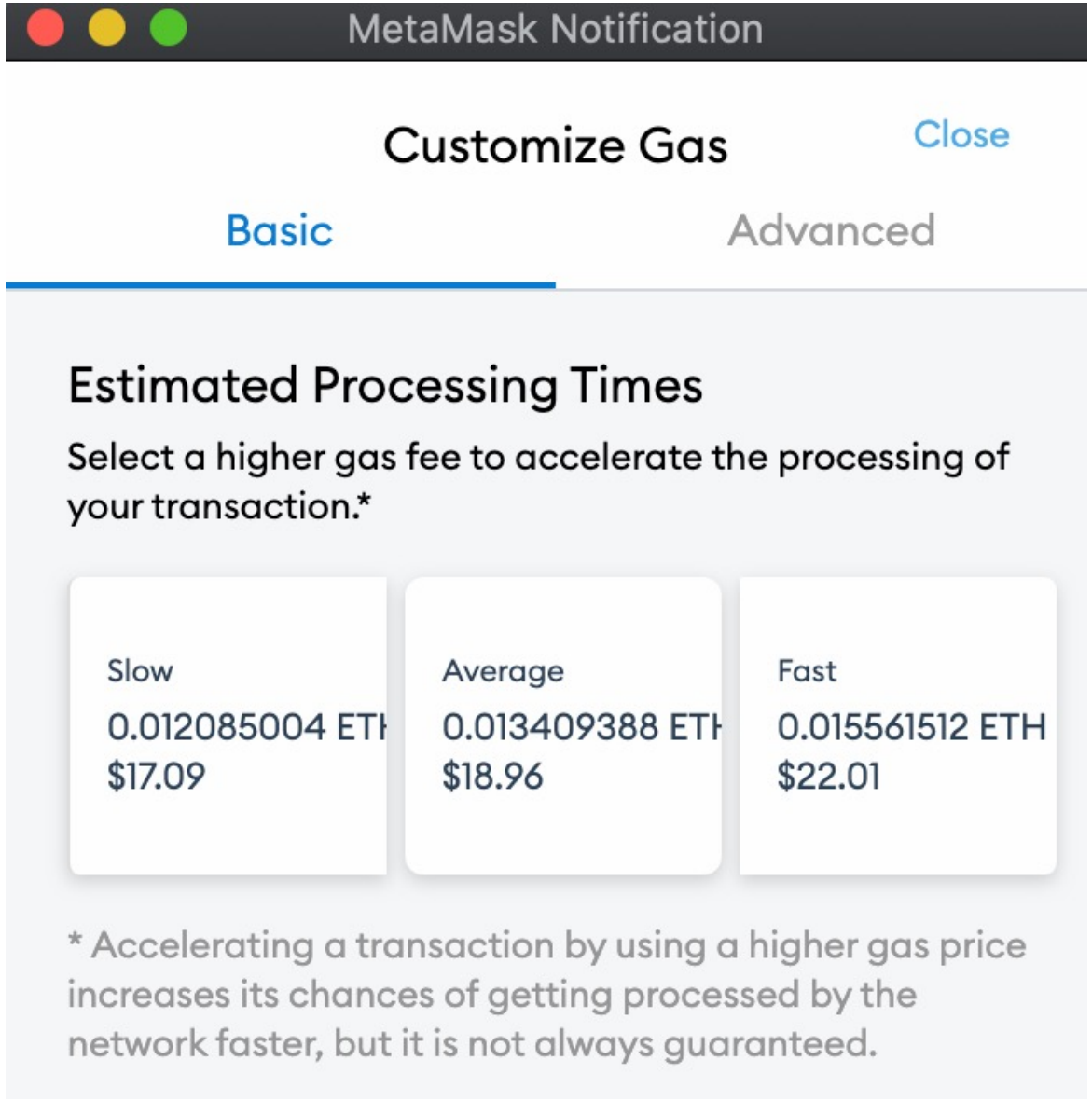
First-Price Auctions (FPAs)

Idea: let “market do the work,” users/wallets to the price discovery.

First-price auction:

- each submitted tx includes a bid (per-unit “size”)
  - e.g., suggested by user’s wallet based on recently produced blocks
- on inclusion in a block, bid transferred to producer of that block
  - e.g., the leader of the current view
  - expect block producer to pack its block with the highest-bidding txs

Issue with FPAs: tricky to figure out the best bid.



MetaMask, circa 2020-2021

First-Price Auctions (FPAs)

Idea: let “market do the work,” users/wallets to the price discovery.

First-price auction:

- each submitted tx includes a bid (per-unit “size”)
- on inclusion in a block, bid transferred to producer of that block

Issue with FPAs: tricky to figure out the best bid.

  – bid too high ➔ pay more than you needed to (in hindsight)

First-Price Auctions (FPAs)

Idea: let “market do the work,” users/wallets to the price discovery.

First-price auction:

- each submitted tx includes a bid (per-unit “size”)
- on inclusion in a block, bid transferred to producer of that block

Issue with FPAs: tricky to figure out the best bid.

  - bid too high ➔ pay more than you needed to (in hindsight)
  - bid too low ➔ excluded (even though you would have been willing to pay enough for inclusion)

EIP-1559

Key idea #1: each block has a “base fee” $r > 0$.

- minimum bid eligible for inclusion (OK to bid higher than r)

EIP-1559

Key idea #1: each block has a “base fee” $r > 0$.

- minimum bid eligible for inclusion (OK to bid higher than r)
- moves price discovery largely in-protocol (cf., FPAs)

Block	Slot	Age	Txn	Fee Recipient	Gas Used	Gas Limit	Base Fee	Reward	Burnt Fees (ETH)
22330775	11548010	14 secs ago	184	Titan Builder	14,024,967 (38.96%)	35,999,965	1.166 Gwei	0.01742 ETH	0.016360 (48.42%)
22330774	11548009	26 secs ago	228	Titan Builder	17,704,576 (49.23%)	35,964,845	1.168 Gwei	0.02039 ETH	0.020692 (50.36%)
22330773	11548008	38 secs ago	204	beaverbuild	20,131,027 (55.92%)	36,000,000	1.151 Gwei	0.01934 ETH	0.023184 (54.52%)
22330772	11548007	50 secs ago	173	beaverbuild	16,695,651 (46.38%)	36,000,000	1.162 Gwei	0.01824 ETH	0.019404 (51.53%)
22330771	11548006	1 min ago	324	Titan Builder	35,644,314 (99.01%)	36,000,000	1.035 Gwei	0.0492 ETH	0.036904 (42.86%)
22330770	11548005	1 min ago	115	quasarbuilder	7,545,978 (20.96%)	36,000,000	1.116 Gwei	0.00557 ETH	0.008424 (60.18%)
22330769	11548004	1 min ago	186	beaverbuild	17,009,799 (47.25%)	35,999,965	1.124 Gwei	0.04548 ETH	0.019121 (29.59%)
22330768	11548003	1 min ago	214	beaverbuild	21,519,909 (59.84%)	35,964,845	1.097 Gwei	0.04709 ETH	0.023610 (33.39%)
22330767	11548002	1 min ago	244	Titan Builder	21,948,869 (60.97%)	36,000,000	1.067 Gwei	0.01889 ETH	0.023438 (55.37%)
22330766	11548001	2 mins ago	146	beaverbuild	10,282,523 (28.56%)	36,000,000	1.128 Gwei	0.00775 ETH	0.011602 (59.95%)
22330765	11548000	2 mins ago	211	Titan Builder	22,679,059 (63.00%)	35,999,931	1.092 Gwei	0.01958 ETH	0.024784 (55.85%)
22330764	11547999	2 mins ago	315	Titan Builder	30,120,386 (83.75%)	35,964,811	1.007 Gwei	0.0271 ETH	0.030355 (52.82%)
22330763	11547998	2 mins ago	43	Lido: Execution Layer Rew...	2,326,986 (6.48%)	35,929,725	1.13 Gwei	0.00809 ETH	0.002631 (24.52%)
22330762	11547997	2 mins ago	274	Titan Builder	25,964,257 (72.19%)	35,964,845	1.071 Gwei	0.03609 ETH	0.027818 (43.53%)
22330761	11547996	3 mins ago	216	beaverbuild	24,057,554 (66.83%)	36,000,000	1.028 Gwei	0.04062 ETH	0.024735 (37.84%)
22330760	11547995	3 mins ago	165	Lido: Execution Layer Rew...	11,446,914 (31.80%)	36,000,000	1.077 Gwei	0.00408 ETH	0.012330 (75.12%)

EIP-1559

Key idea #1: each block has a “base fee” $r > 0$.

- minimum bid eligible for inclusion (OK to bid higher than r)
- moves price discovery largely in-protocol (cf., FPAs)

Note: can’t give base fee revenues to the block producer.

EIP-1559

Key idea #1: each block has a “base fee” $r > 0$.

- minimum bid eligible for inclusion (OK to bid higher than r)
- moves price discovery largely in-protocol (cf., FPAs)

Note: can’t give base fee revenues to the block producer.

- reason: collusion between users and block producer

EIP-1559

Key idea #1: each block has a "base fee" $r > 0$.

- minimum bid eligible for inclusion (OK to bid higher than r)
- moves price discovery largely in-protocol (cf., FPAs)

Note: can't give base fee revenues to the block producer.

- reason: collusion between users and block producer
  - either through off-chain agreement or facilitated via smart contracts
  - users bid r on-chain (for eligibility), submit off-chain bids to block producer
  - block producer includes highest-bidding txs, refunds (r-bid) off-chain
  - evades the base fee r, equivalent to an FPA!

EIP-1559

Key idea #1: each block has a "base fee" $r > 0$.

- minimum bid eligible for inclusion (OK to bid higher than r)
- moves price discovery largely in-protocol (cf., FPAs)

Note: can't give base fee revenues to the block producer.

- reason: collusion between users and block producer

Solution: burn the base fee revenue! (i.e., remove coins from circulation)

EIP-1559

Key idea #1: each block has a "base fee" $r > 0$.

- minimum bid eligible for inclusion (OK to bid higher than r)
- moves price discovery largely in-protocol (cf., FPAs)

Note: can't give base fee revenues to the block producer.

- reason: collusion between users and block producer

Solution: burn the base fee revenue! (i.e., remove coins from circulation)

- side effect: offsets staking rewards, decreases inflation rate

EIP-1559

Key idea #1: each block has a "base fee" r > 0.

- minimum bid eligible for inclusion (OK to bid higher than r)
- moves price discovery largely in-protocol (cf., FPAs)

Note: can't give base fee revenues to the block producer.

- reason: collusion between users and block producer

Solution: burn the base fee revenue! (i.e., remove coins from circulation)

- side effect: offsets staking rewards, decreases inflation rate
- any excess (bid – r) transferred to block producer

Block	Slot	Age	Txn	Fee Recipient	Gas Used	Gas Limit	Base Fee	Reward	Burnt Fees (ETH)
22330775	11548010	14 secs ago	184	Titan Builder	14,024,967 (38.96%)	35,999,965	1.166 Gwei	0.01742 ETH	0.016360 (48.42%)
22330774	11548009	26 secs ago	228	Titan Builder	17,704,576 (49.23%)	35,964,845	1.168 Gwei	0.02039 ETH	0.020692 (50.36%)
22330773	11548008	38 secs ago	204	beaverbuild	20,131,027 (55.92%)	36,000,000	1.151 Gwei	0.01934 ETH	0.023184 (54.52%)
22330772	11548007	50 secs ago	173	beaverbuild	16,695,651 (46.38%)	36,000,000	1.162 Gwei	0.01824 ETH	0.019404 (51.53%)
22330771	11548006	1 min ago	324	Titan Builder	35,644,314 (99.01%)	36,000,000	1.035 Gwei	0.0492 ETH	0.036904 (42.86%)
22330770	11548005	1 min ago	115	quasarbuilder	7,545,978 (20.96%)	36,000,000	1.116 Gwei	0.00557 ETH	0.008424 (60.18%)
22330769	11548004	1 min ago	186	beaverbuild	17,009,799 (47.25%)	35,999,965	1.124 Gwei	0.04548 ETH	0.019121 (29.59%)
22330768	11548003	1 min ago	214	beaverbuild	21,519,909 (59.84%)	35,964,845	1.097 Gwei	0.04709 ETH	0.023610 (33.39%)
22330767	11548002	1 min ago	244	Titan Builder	21,948,869 (60.97%)	36,000,000	1.067 Gwei	0.01889 ETH	0.023438 (55.37%)
22330766	11548001	2 mins ago	146	beaverbuild	10,282,523 (28.56%)	36,000,000	1.128 Gwei	0.00775 ETH	0.011602 (59.95%)
22330765	11548000	2 mins ago	211	Titan Builder	22,679,059 (63.00%)	35,999,931	1.092 Gwei	0.01958 ETH	0.024784 (55.85%)
22330764	11547999	2 mins ago	315	Titan Builder	30,120,386 (83.75%)	35,964,811	1.007 Gwei	0.0271 ETH	0.030355 (52.82%)
22330763	11547998	2 mins ago	43	Lido: Execution Layer Rew...	2,326,986 (6.48%)	35,929,725	1.13 Gwei	0.00809 ETH	0.002631 (24.52%)
22330762	11547997	2 mins ago	274	Titan Builder	25,964,257 (72.19%)	35,964,845	1.071 Gwei	0.03609 ETH	0.027818 (43.53%)
22330761	11547996	3 mins ago	216	beaverbuild	24,057,554 (66.83%)	36,000,000	1.028 Gwei	0.04062 ETH	0.024735 (37.84%)
22330760	11547995	3 mins ago	165	Lido: Execution Layer Rew...	11,446,914 (31.80%)	36,000,000	1.077 Gwei	0.00408 ETH	0.012330 (75.12%)

Example: USDC Transfer

Transaction Hash:	0x3b9ada8e0cbf69fb4aff9f40e9946bf3d5585f47ed03b403fd50f570870be168
Status:	Success
Block:	21879725 5 Block Confirmations
Timestamp:	53 secs ago (Feb-19-2025 10:09:47 AM UTC)
Transaction Action:	Transfer 101.4 ($101.39) USDC To 0x618a16ED7d4C39EFB5A6342C3972c896757a1b79
Sponsored:	
From:	0xc4a3Dcd48118D77bE44E7853bd5938F7448c7bD7
Interacted With (To):	0xA0b86991c6218b36c1d19D4a2e9Eb0cE3606eB48 (Circle: USDC Token)
ERC-20 Tokens Transferred:	All Transfers / Net Transfers From 0xc4a3Dcd4...7448c7bD7 To 0x618a16ED...6757a1b79 For 101.4 ($101.39) USDC (USDC)
Value:	0 ETH ($0.00)
Transaction Fee:	0.00008286227098344 ETH ($0.23)
Gas Price:	1.442086164 Gwei (0.000000001442086164 ETH)
Gas Limit & Usage by Txn:	94,566 | 57,460 (60.76%)
Gas Fees:	Base: 0.732318081 Gwei | Max: 1.6 Gwei | Max Priority: 0.709768083 Gwei
Burnt & Txn Savings Fees:	Burnt: 0.00004207899693426 ETH ($0.11) Txn Savings: 0.00000907372901656 ETH ($0.02)
Other Attributes:	Txn Type: 2 (EIP-1559) Nonce: 0 Position In Block: 165
Input Data:	Function: transfer(address to,uint256 value) MethodID: 0xa9059cbb [0]: 000000000000000000000000618a16ed7d4c39efb5a6342c3972c896757a1b79 [1]: 0000000000000000000000000000000000000000000000000000000060b3dc0

user/wallet specifies “tip/priority fee” and “fee cap”

EIP-1559

Key idea #1: each block has a "base fee" r > 0.

- minimum bid eligible for inclusion (OK to bid higher than r)

Note: can't give base fee revenues to the block producer.

- reason: collusion between users and block producer

Solution: burn the base fee revenue! (i.e., remove coins from circulation)

- side effect: offsets staking rewards, decreases inflation rate
- any excess (bid – r) transferred to block producer (BP)

EIP-1559

Key idea #1: each block has a "base fee" r > 0.

- minimum bid eligible for inclusion (OK to bid higher than r)

Note: can't give base fee revenues to the block producer.

- reason: collusion between users and block producer

Solution: burn the base fee revenue! (i.e., remove coins from circulation)

- side effect: offsets staking rewards, decreases inflation rate
- any excess (bid – r) transferred to block producer (BP)

Guarantee: user-BP collusion no longer an issue ("OCA-proof").

Setting the Base Fee

Question: how to set r?

Setting the Base Fee

Question: how to set r?

Ideal base fee: r = “market-clearing price.”

Setting the Base Fee

Question: how to set r?

Ideal base fee: r = “market-clearing price.”

- total size of txs willing to pay r (per-unit-size) exactly fills up block
  - 100% utilization, and used exactly by the most valuable txs

Setting the Base Fee

Question: how to set r?

Ideal base fee: r = “market-clearing price.”

- total size of txs willing to pay r (per-unit-size) exactly fills up block
  - 100% utilization, and used exactly by the most valuable txs

Issue: as demand varies over time, so does market-clearing price.

Setting the Base Fee

Question: how to set r?

Ideal base fee: r = “market-clearing price.”

- total size of txs willing to pay r (per-unit-size) exactly fills up block
  - 100% utilization, and used exactly by the most valuable txs

Issue: as demand varies over time, so does market-clearing price.

Solution: compute base fee via local search.

Setting the Base Fee

Question: how to set r?

Ideal base fee: r = “market-clearing price.”

- total size of txs willing to pay r (per-unit-size) exactly fills up block
  - 100% utilization, and used exactly by the most valuable txs

Issue: as demand varies over time, so does market-clearing price.

Solution: compute base fee via local search.

- total size of eligible txs > block size ➔ increase r
- total size of eligible txs < block size ➔ decrease r

Variable-Size Blocks

Idea: compute base fee via local search.

- increase/decrease r if size of eligible txs more than/less than block size

Variable-Size Blocks

Idea: compute base fee via local search.

- increase/decrease r if size of eligible txs more than/less than block size

Issue: excluded txs not recorded on-chain.

- can't differentiate r = market-clearing price vs. r = way too low

Variable-Size Blocks

Idea: compute base fee via local search.

- increase/decrease r if size of eligible txs more than/less than block size
- issue: can't differentiate r = market-clearing price vs. r = way too low

Key idea #2: allow variable-size blocks.

Variable-Size Blocks

Idea: compute base fee via local search.

- increase/decrease r if size of eligible txs more than/less than block size
- issue: can't differentiate r = market-clearing price vs. r = way too low

Key idea #2: allow variable-size blocks.

- set target block size = C (e.g., 18 million gas)

Variable-Size Blocks

Idea: compute base fee via local search.

- increase/decrease r if size of eligible txs more than/less than block size
- issue: can't differentiate r = market-clearing price vs. r = way too low

Key idea #2: allow variable-size blocks.

- set target block size = C (e.g., 18 million gas)
- allow blocks of size up to 2C (36 million gas)

Variable-Size Blocks

Idea: compute base fee via local search.

- increase/decrease r if size of eligible txs more than/less than block size
- issue: can't differentiate r = market-clearing price vs. r = way too low

Key idea #2: allow variable-size blocks.

- set target block size = C (e.g., 18 million gas)
- allow blocks of size up to 2C (36 million gas)
- whenever a block has size < C ➔ decrease r for next block
- whenever a block has size > C ➔ increase r for next block

Block	Slot	Age	Txn	Fee Recipient	Gas Used	Gas Limit	Base Fee	Reward	Burnt Fees (ETH)
22330775	11548010	14 secs ago	184	Titan Builder	14,024,967 (38.96%)	35,999,965	1.166 Gwei	0.01742 ETH	0.016360 (48.42%)
22330774	11548009	26 secs ago	228	Titan Builder	17,704,576 (49.23%)	35,964,845	1.168 Gwei	0.02039 ETH	0.020692 (50.36%)
22330773	11548008	38 secs ago	204	beaverbuild	20,131,027 (55.92%)	36,000,000	1.151 Gwei	0.01934 ETH	0.023184 (54.52%)
22330772	11548007	50 secs ago	173	beaverbuild	16,695,651 (46.38%)	36,000,000	1.162 Gwei	0.01824 ETH	0.019404 (51.53%)
22330771	11548006	1 min ago	324	Titan Builder	35,644,314 (99.01%)	36,000,000	1.035 Gwei	0.0492 ETH	0.036904 (42.86%)
22330770	11548005	1 min ago	115	quasarbuilder	7,545,978 (20.96%)	36,000,000	1.116 Gwei	0.00557 ETH	0.008424 (60.18%)
22330769	11548004	1 min ago	186	beaverbuild	17,009,799 (47.25%)	35,999,965	1.124 Gwei	0.04548 ETH	0.019121 (29.59%)
22330768	11548003	1 min ago	214	beaverbuild	21,519,909 (59.84%)	35,964,845	1.097 Gwei	0.04709 ETH	0.023610 (33.39%)
22330767	11548002	1 min ago	244	Titan Builder	21,948,869 (60.97%)	36,000,000	1.067 Gwei	0.01889 ETH	0.023438 (55.37%)
22330766	11548001	2 mins ago	146	beaverbuild	10,282,523 (28.56%)	36,000,000	1.128 Gwei	0.00775 ETH	0.011602 (59.95%)
22330765	11548000	2 mins ago	211	Titan Builder	22,679,059 (63.00%)	35,999,931	1.092 Gwei	0.01958 ETH	0.024784 (55.85%)
22330764	11547999	2 mins ago	315	Titan Builder	30,120,386 (83.75%)	35,964,811	1.007 Gwei	0.0271 ETH	0.030355 (52.82%)
22330763	11547998	2 mins ago	43	Lido: Execution Layer Rew...	2,326,986 (6.48%)	35,929,725	1.13 Gwei	0.00809 ETH	0.002631 (24.52%)
22330762	11547997	2 mins ago	274	Titan Builder	25,964,257 (72.19%)	35,964,845	1.071 Gwei	0.03609 ETH	0.027818 (43.53%)
22330761	11547996	3 mins ago	216	beaverbuild	24,057,554 (66.83%)	36,000,000	1.028 Gwei	0.04062 ETH	0.024735 (37.84%)
22330760	11547995	3 mins ago	165	Lido: Execution Layer Rew...	11,446,914 (31.80%)	36,000,000	1.077 Gwei	0.00408 ETH	0.012330 (75.12%)

Variable-Size Blocks

Idea: compute base fee via local search.

- increase/decrease r if size of eligible txs more than/less than block size
- issue: can't differentiate r = market-clearing price vs. r = way too low

Key idea #2: allow variable-size blocks.

- set target block size = C (e.g., 18 million gas)
- allow blocks of size up to 2C (36 million gas)
- whenever a block has size < C ➔ decrease r for next block
- whenever a block has size > C ➔ increase r for next block
  - in Ethereum, max increase/decrease = 12.5%

Does EIP-1559 Make Bidding Easy?

Recall issue with FPAs: tricky to figure out the best bid.

Does EIP-1559 Make Bidding Easy?

Recall issue with FPAs: tricky to figure out the best bid.

Defn: base fee r is *excessively low* if total size of eligible txs is > 2C.

Does EIP-1559 Make Bidding Easy?

Recall issue with FPAs: tricky to figure out the best bid.

Defn: base fee r is *excessively low* if total size of eligible txs is > 2C.

Guarantee: if r not excessively low, optimal for users to bid r.

- r acts like a “posted price” for blockspace, a la shopping on Amazon

Does EIP-1559 Make Bidding Easy?

Recall issue with FPAs: tricky to figure out the best bid.

Defn: base fee r is *excessively low* if total size of eligible txs is > 2C.

Guarantee: if r not excessively low, optimal for users to bid r.

- r acts like a “posted price” for blockspace, a la shopping on Amazon
- in practice, add nominal “tip” to strictly incentivize tx inclusion

Does EIP-1559 Make Bidding Easy?

Recall issue with FPAs: tricky to figure out the best bid.

Defn: base fee r is *excessively low* if total size of eligible txs is > 2C.

Guarantee: if r not excessively low, optimal for users to bid r.

- r acts like a "posted price" for blockspace, a la shopping on Amazon
- in practice, add nominal "tip" to strictly incentivize tx inclusion

- otherwise: EIP-1559 effectively reverts to an FPA
  - if need to compete with other eligible txs for inclusion, will bid above r

Does EIP-1559 Make Bidding Easy?

Recall issue with FPAs: tricky to figure out the best bid.

Defn: base fee r is *excessively low* if total size of eligible txs is > 2C.

Guarantee: if r not excessively low, optimal for users to bid r.

- r acts like a "posted price" for blockspace, a la shopping on Amazon
- in practice, add nominal "tip" to strictly incentivize tx inclusion

- otherwise: EIP-1559 effectively reverts to an FPA
  - if need to compete with other eligible txs for inclusion, will bid above r
  - e.g., if sudden demand spike (NFT drop) + base fee hasn't caught up yet