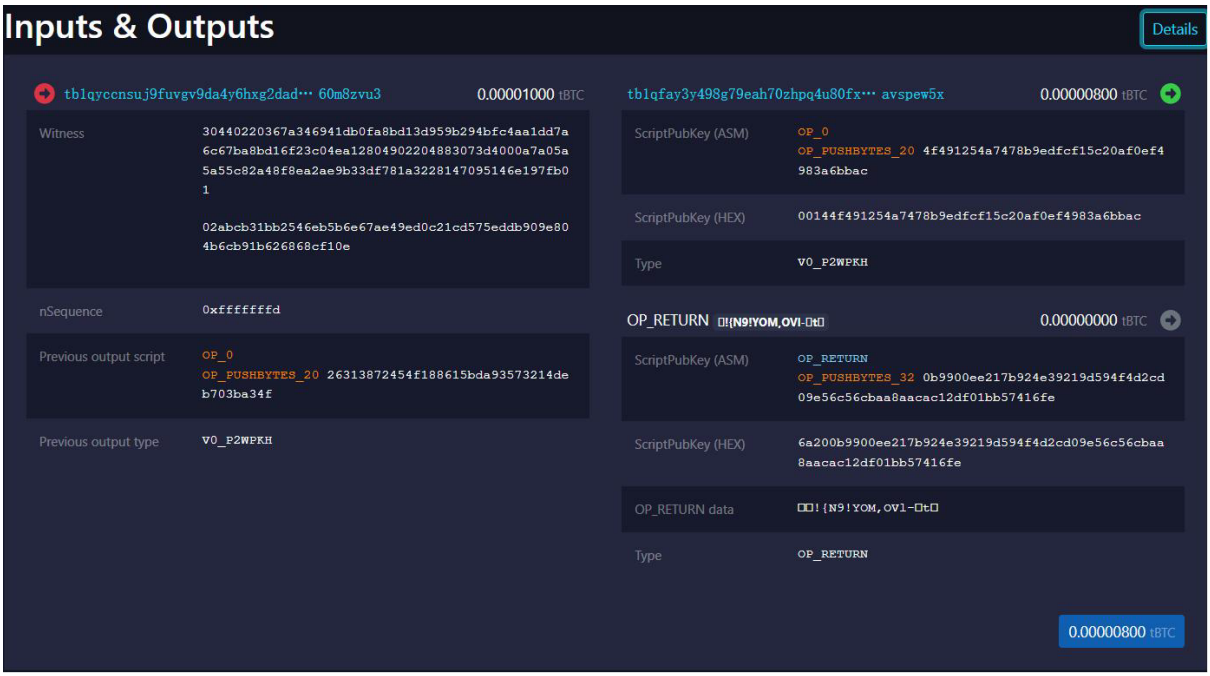
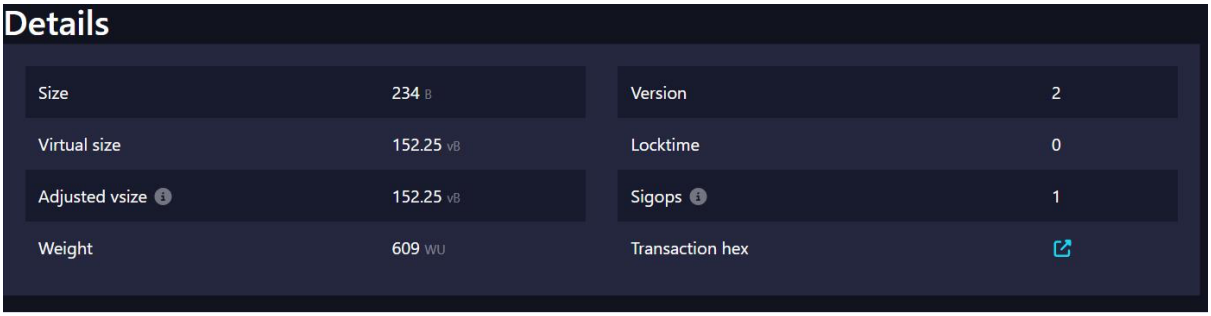
We conducted our experiments using the Bitcoin Testnet3 network (https://mempool.space/testnet/), with all tests performed on the mempool.space Bitcoin test network.





The experiment is divided into three main parts:

Part 1: Creating off-chain channels and simulating off-chain transactions. First, we initiated 20, 40, 60, 80, and 100 transactions within a single channel and measured the time taken to create each off-chain transaction. Then, we created 20, 40, 60, 80, and 100 off-chain channels, each with the same 20 transactions. We observed that the transaction creation time includes both the assertion and verification

phases. Additionally, we recorded the size (in bytes) of each transaction after attaching the assertion as an auxiliary field. From the results, we found that the time to create off-chain transactions remained almost constant, regardless of the total number of transactions in the channel. Similarly, the time for creating off-chain channels nearly unchanged as the number of channels increased.

The figure below displays an auxiliary field for the assertion following each transaction.

```
CT: 472 Bytes
0200000001b812b252c9b3c163b9dc67b67886312a8d61933b83cf4c2b48057c3a1524f79d0000000090473044022205c8095bdfce35160f25acfadf0ba52291c266f88219d7c154c4dde7aa24ff23302
20160273ee5f3ea5c2ad7f972f3ab3fff461050c4a3355d8cc701630d11ceab1a70147304402206d46d14ced9cf95b8409c757a50fa327bad9f166312d67bafd6e7c4796753e2b022046462da3a70ee1
0d758c26ed573e69fa76f5f4d8cc83405914d7de3025e9251701ffffffff023215000000000000e12102be06accf71eb1d24bc13693ecdbf672dae2a1627c26fcd7520643eebfffe6e54ac7c2102abcb
31bb2546eb5b6e67ae49ed0c21cd575eddb909e804b6cb91b626868cf10eac636352b275672102442e4c9a3a755c9b5d7508ec83e7f5219c9ca4421d4bb6c1523a0649a0294e29adaa20bf1d535d30eb
f4b7e639721faaa475ea6e5a884f646892910134 7e665b90fccdd88686763210 3ab13de07fd2f8d7e7ef772f08f144c7ec01d1c8efdbbf4e7b6dd2ae840d91cefadaa2088f78c1046639b63b4ed955562
e77f7f629cbaf4b1d4be2e2ced0b018d1e975a88676a6868510000000000000000226a2600b9900ee217b924e39219d594f4d2cd09e56c56cbaa8aacac12df01bb57416fe00000000
----------
CT spend: 306 Bytes
0200000001f428ce705bbf4f353d42cac9e8faa06a9d915b469f0352699b96da1ab73e7fb10000000090473044022052 6f2fa014b2122893bfa997f88614240d7f690077d42816738ba36add528b2502
201a6609f0633512b63790d9b0f6c7d77398859dc994555496a2923730d5ac6d2f0147304402203 50d0f271814ffb61b1d76e4f9d079d55296aecb32a73de78f27f40a9947e627022066c77a121b4dcd
6bb43c20ce1b0928edc383af36e1958fa01bb0d02f4c298fae01fffffffff037c11000000000000001976a9144f491254a7478b9edfcf15c20af0ef4983a6bbac88ac5203000000000000001976a914263138
72454f188615bda93573214deb703ba34f88ac0000000000000000226a2600b9900ee217b924e39219d594f4d2cd09e56c56cbaa8aacac12df01bb57416fe00000000
----------
CT_punish_l: 275 Bytes
0200000001f428ce705bbf4f353d42cac9e8faa06a9d915b469f0352699b96da1ab73e7fb10000000093016547304402204844eea5ba177f6af4fee4bf7142b94139c86f0610448d528006c3f94b7be9
bd02200a6490315fb0b57cf6d13d9700fd7b3dac7df8f80f4e2a0fe815f13b771f33ab0100473044022051442 19fac233b514e84451b4de7f8097add00c4b805416b1c79973ea19898800220705a29bb
ce1a0b3a983a693a5a884aca20972c059c09e11b5593917591663033 01ffffffff02ce1400000000000001976a9144f491254a7478b9edfcf15c20af0ef4983a6bbac88ac0000000000000000226a2600b
9900ee217b924e39219d594f4d2cd09e56c56cbaa8aacac12df01bb57416fe00000000
----------
CT_punish_r: 275 Bytes
0200000001f428ce705bbf4f353d42cac9e8faa06a9d915b469f0352699b96da1ab73e7fb10000000093012647304402202962baaf412ecf0cfdb32450c741fc98dc5c6ebd93ab7af30837bed1245d65
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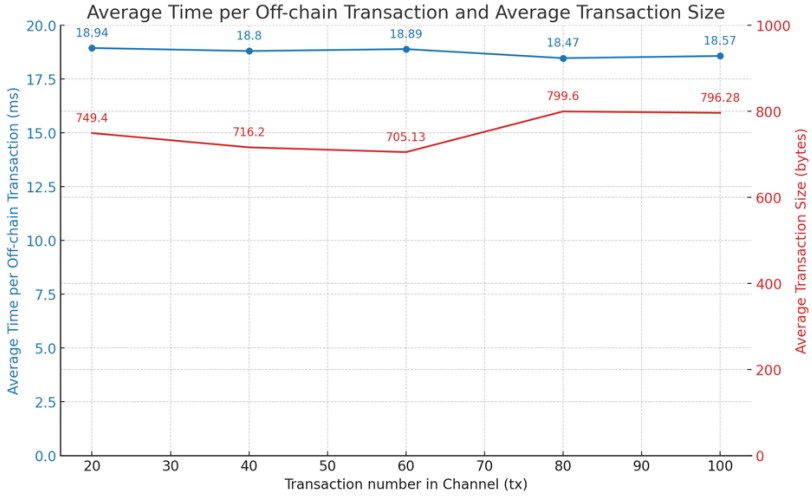
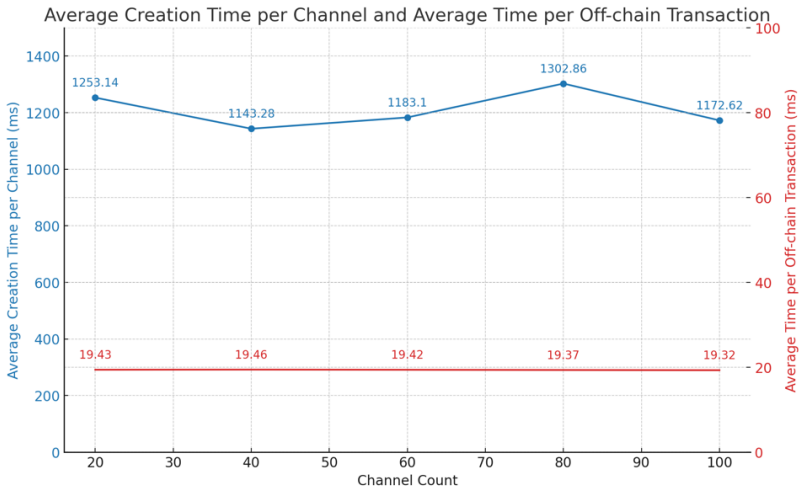
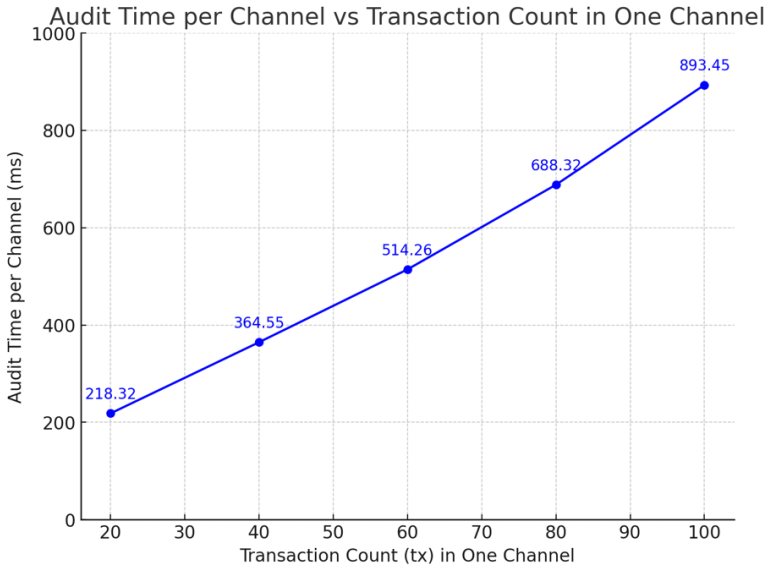




Part 2: Closing off-chain channels and simulating audit times for varying numbers of transactions. We evaluated the audit time for channels with 20, 40, 60, 80, and 100 off-chain transactions. The results showed that audit time increased linearly with the number of transactions.



Part 3: Details of transactions in the experiment

Below are excerpts of the transaction IDs from our experiment involving the creation of channels on the Bitcoin Testnet3 network (https://mempool.space/testnet/).

1	tx id:d16ed57d7af78d7e469ab30768d6d4848bd63ee702a7a24957f435d987d5056d
2	tx id:4288496ad69a1f7133e776113c8abd9243c87a16f60284c51c5395b67628701f
3	tx id:705632e7bf8b94f8229f7189f19401b9dff0cbfe21f0904e11705d93a66a3a78
4	tx id:d3cdfdadd44726fac64f4ef7e45291e0844abd694f16974155cc755af3af7907
5	tx id:4cfd44d2463e1df0188b7bbf2049b74a864f367f4c6890acff69c235ee51ee05
6	tx id:fcbd4675291b878fb46b560c25677fdbb8160809699bf234ab35ef716a7224af
7	tx id:94c2c53f3d5a2892b8474a7729e382a4af35d5fba515d715b502bd0b94ebd397
8	……

Tansaction ID	Input Address	Output Address	Transaction fee	Witness	Last output scripts	ScriptPubKey (ASM)	ScriptPubKey (HEX)	OP_RETURN	Transacti on broadcast time（s）
d16ed57d7af78d7e469ab30768d6d4848bd63ee702a7a24957f435d987d5056d	tb1qfay3y498g79eah70zhpq4u80fxp6dwavspew5x	tb1qyccnsuj9fuvgv9da4y6hxg2dadcrhg60m8zvu3	2990	304402202d9c383ba2aa755ea19fac381dc3d96ef78b3917ee8b75ee53330d1365eaf1bc0220294f76b096c1020bc851487bd698368647d689ceb0eb14e16ce5db63f019e27901 02be06accf71eb1d24bc13693ecdbf672dae2a1627c26fcd7520643eebfffe6e54	OP_PUSHBYTES_20 4f491254a7478b9edfcf15c20af0ef4983a6bbac	OP_PUSHBYTES_20 26313872454f188615bda93573214deb703ba34f	00142631387 2454f188615 bda93573214 deb703ba34f	0b9900ee217b924e39219d594f4d2cd09e56c56cbaa8aacac12df01bb57416fe	1.24
4288496ad69a1f7133e776113c8abd9243c87a16f60284c51c5395b67628701f	tb1qfay3y498g79eah70zhpq4u80fxp6dwavspew5x	tb1qyccnsuj9fuvgv9da4y6hxg2dadcrhg60m8zvu3	1054	304402200c3175bef9550a52f9653037349f11dfdb78422b3486f3cdb2da6ed223b9cfe902200d6716669ec163cbd52cb66cd19955e83733b4e84c640f48e090a5dacb85654101 02be06accf71eb1d24bc13693ecdbf672dae2a1627c26fcd7520643eebfffe6e54	OP_PUSHBYTES_20 4f491254a7478b9edfcf15c20af0ef4983a6bbac	OP_PUSHBYTES_20 26313872454f188615bda93573214deb703ba34f	00142631387 2454f188615 bda93573214 deb703ba34f	0b9900ee217b924e39219d594f4d2cd09e56c56cbaa8aacac12df01bb57416fe	1.13
705632e7bf8b94f8229f7189f19401b9dff0cbfe21f0904e11705d93a66a3a78	tb1qfay3y498g79eah70zhpq4u80fxp6dwavspew5x	tb1qyccnsuj9fuvgv9da4y6hxg2dadcrhg60m8zvu3	1990	304402202b3d06efa3ab50d940d859e35ec59dbdd56a7394ef862b5d9b7b38982d3abe54022026c89b62296875bdcd3627566cfa5cab393c0ff92b9d14eba48e6c81afc5c4120102 be06accf71eb1d24bc13693ecdbf672dae2a1627c26fcd7520643eebfffe6e54	OP_PUSHBYTES_20 4f491254a7478b9edfcf15c20af0ef4983a6bbac	OP_PUSHBYTES_20 26313872454f188615bda93573214deb703ba34f	00142631387 2454f188615 bda93573214 deb703ba34f	0b9900ee217b924e39219d594f4d2cd09e56c56cbaa8aacac12df01bb57416fe	1.17
d3cdfdadd44726fac64f4ef7e45291e0844abd694f16974155cc755af3af7907	tb1qyccnsuj9fuvgv9da4y6hxg2dadcrhg60m8zvu3	tb1qfay3y498g79eah70zhpq4u80fxp6dwavspew5x	200	3044022004b4256c513a8fd4d4cb9732a6151bc1478f9545888cabef7c6d6512f233c663022067cfcedfb43e680ce29c869b4bbe4003c0e44f215fc85303e8f14ae2e595153401 02abcb31bb2546eb5b6e67ae49ed0c21cd575eddb909e804b6cb91b626868cf10e	OP_PUSHBYTES_20 4f491254a7478b9edfcf15c20af0ef4983a6bbac	OP_PUSHBYTES_20 4f491254a7478b9edfcf15c20af0ef4983a6bbac	00144f491254a7478b9edfcf15c20af0ef4983a6bbac	0b9900ee217b924e39219d594f4d2cd09e56c56cbaa8aacac12df01bb57416fe	1.29
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