Lending Smart Contract 2-of-3 Multi-Signature Facility

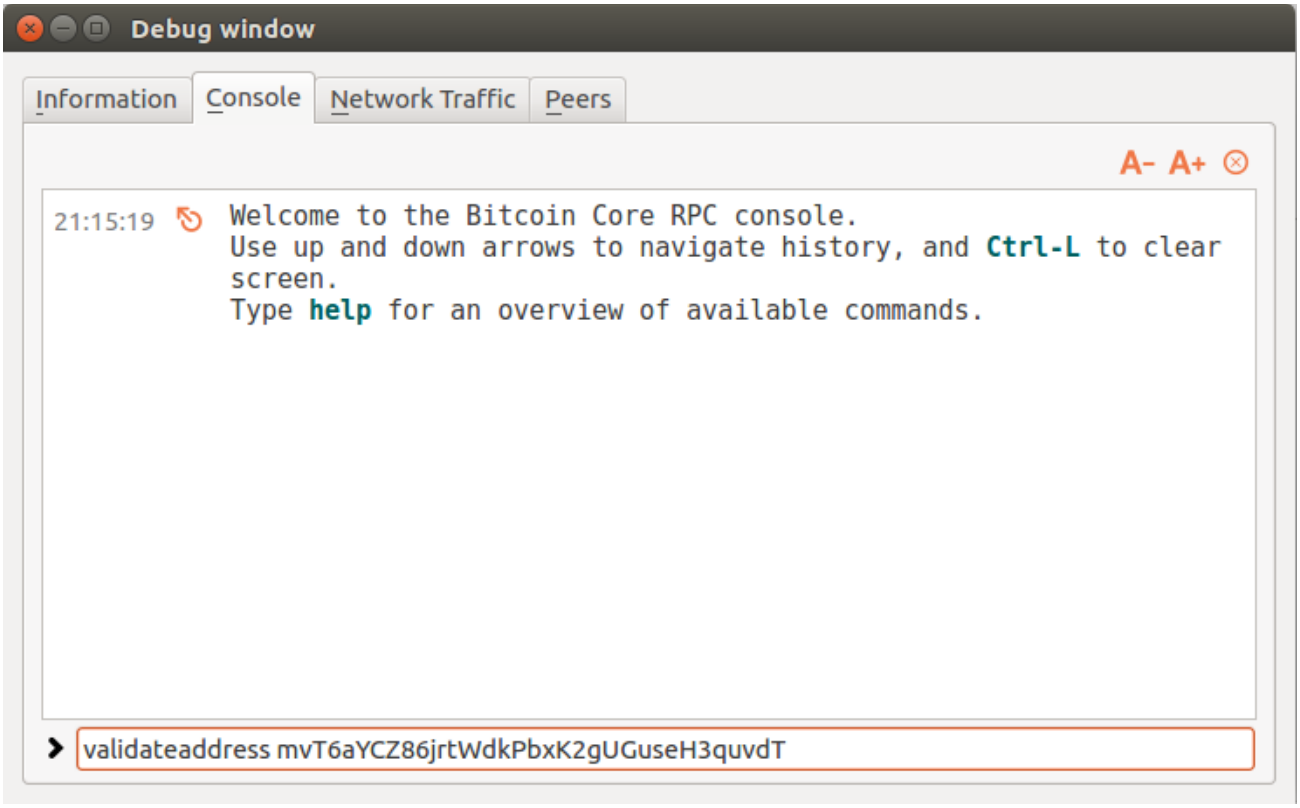
by Douglas Bebber - 01 December 2016

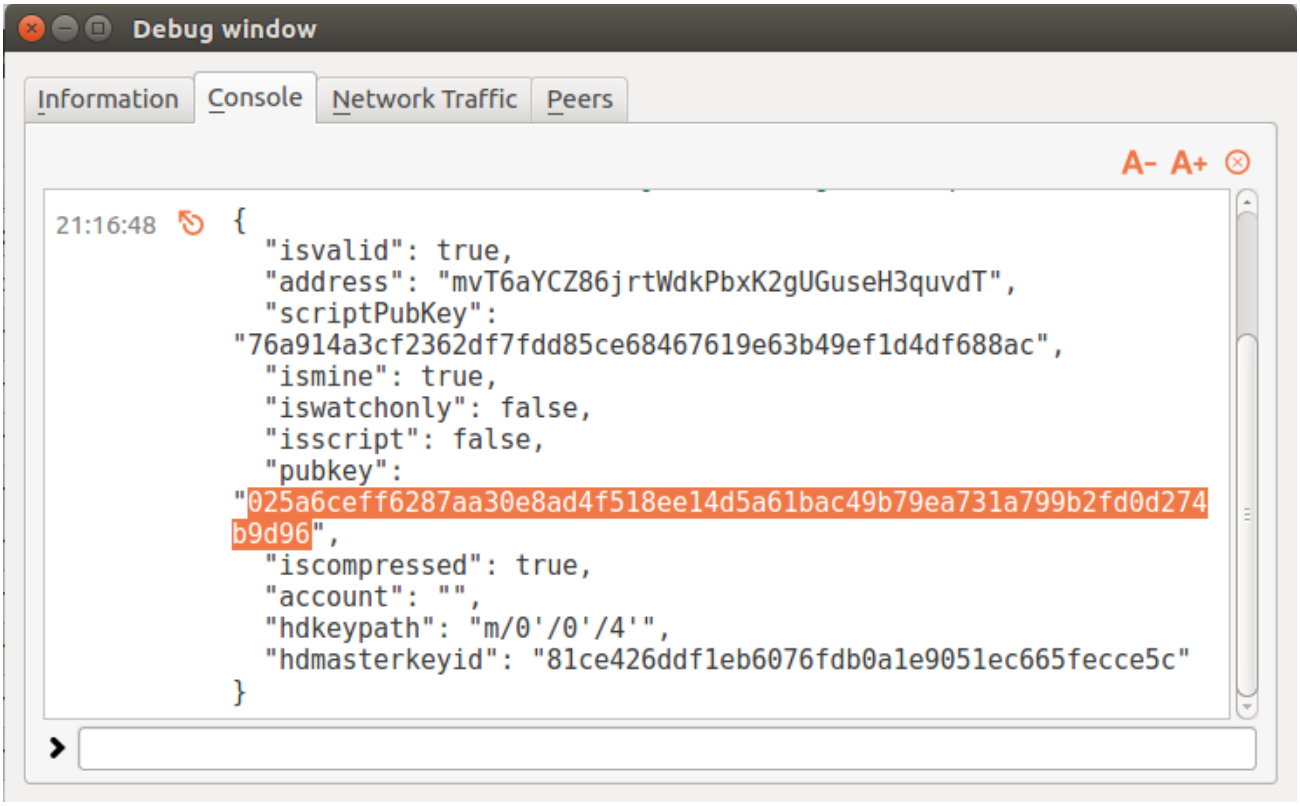
(Many of the steps outlined here will be automated in the background in the software therefore users will not be burdened with a complex user experience. The steps are illustrated here with the bitcoin-qt software simply to illustrate the necessary steps in a comprehensive manner so that readers can follow along.)

All parties to the smart contract need to provide a bitcoin public key for the 2-of-3 multi-signature facility. To obtain a public key for this purpose, each party should generate a new bitcoin address in their wallet. Then issue the **validateaddress** command to obtain their public key.

For example, we will demonstrate this process for the borrower. The borrower creates a new bitcoin address: *mvT6aYCZ86jrtWdkPbxK2gUGuseH3quvdT*

*Now the borrower goes to the **Debug window** in the bitcoin-qt application and issues the validateaddress command as shown below:*





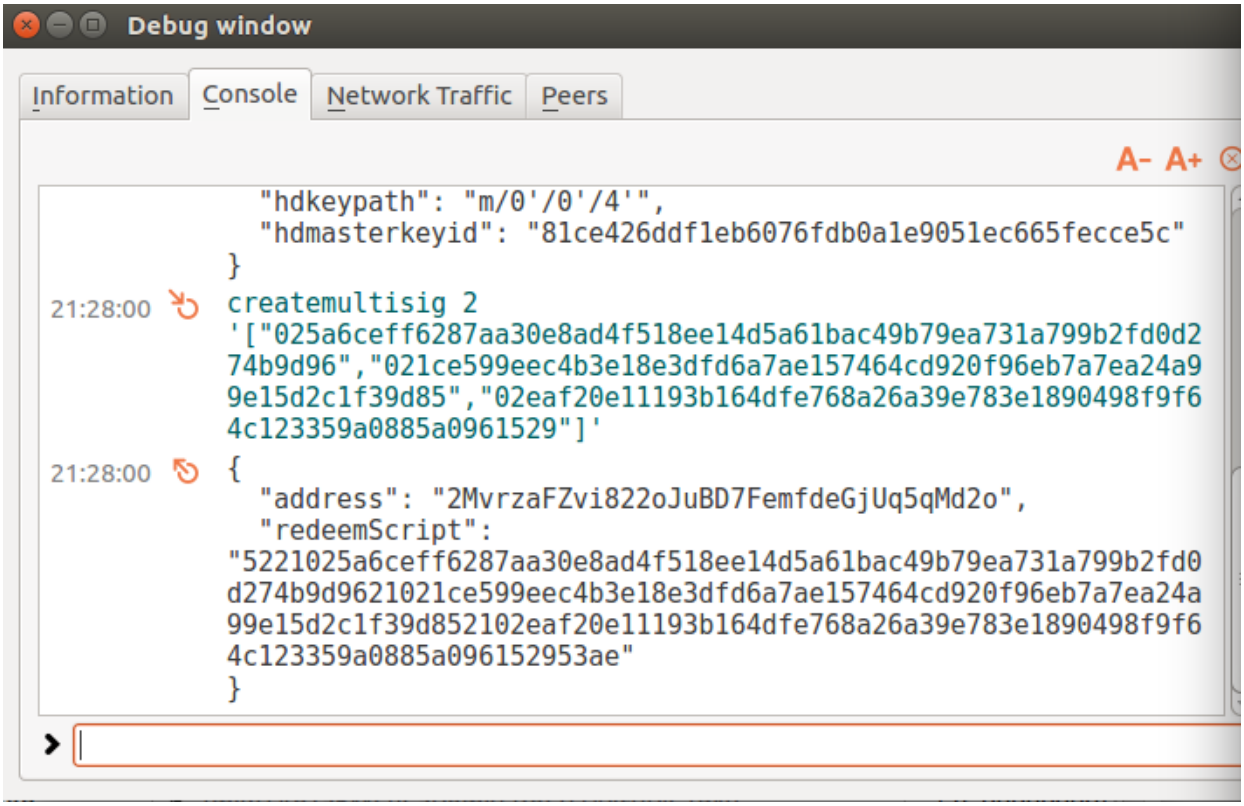
Borrower pub key: *025a6ceff6287aa30e8ad4f518ee14d5a61bac49b79ea731a799b2fd0d274b9d96*
Lender pub key:021ce599eec4b3e18e3dfd6a7ae157464cd920f96eb7a7ea24a99e15d2c1f39d85
Arbiter pub key:02eaf20e11193b164dfe768a26a39e783e1890498f9f64c123359a0885a0961529

The borrower and lender need to provide their public keys to the Arbiter software agent to create the lending smart contract.

The Arbiter software agent will then create the 2-of-3 multi-signature bitcoin address to secure the borrowers collateral deposit. The Arbiter software agent does this using the **createmultisig** command. The parameters to the createmultisig command are the number of key signatures necessary to spend the multi-sig funds (2), and the 3 public keys designated as the set of which two are necessary to unlock the funds i.e., 2-of-3. Here is the command:

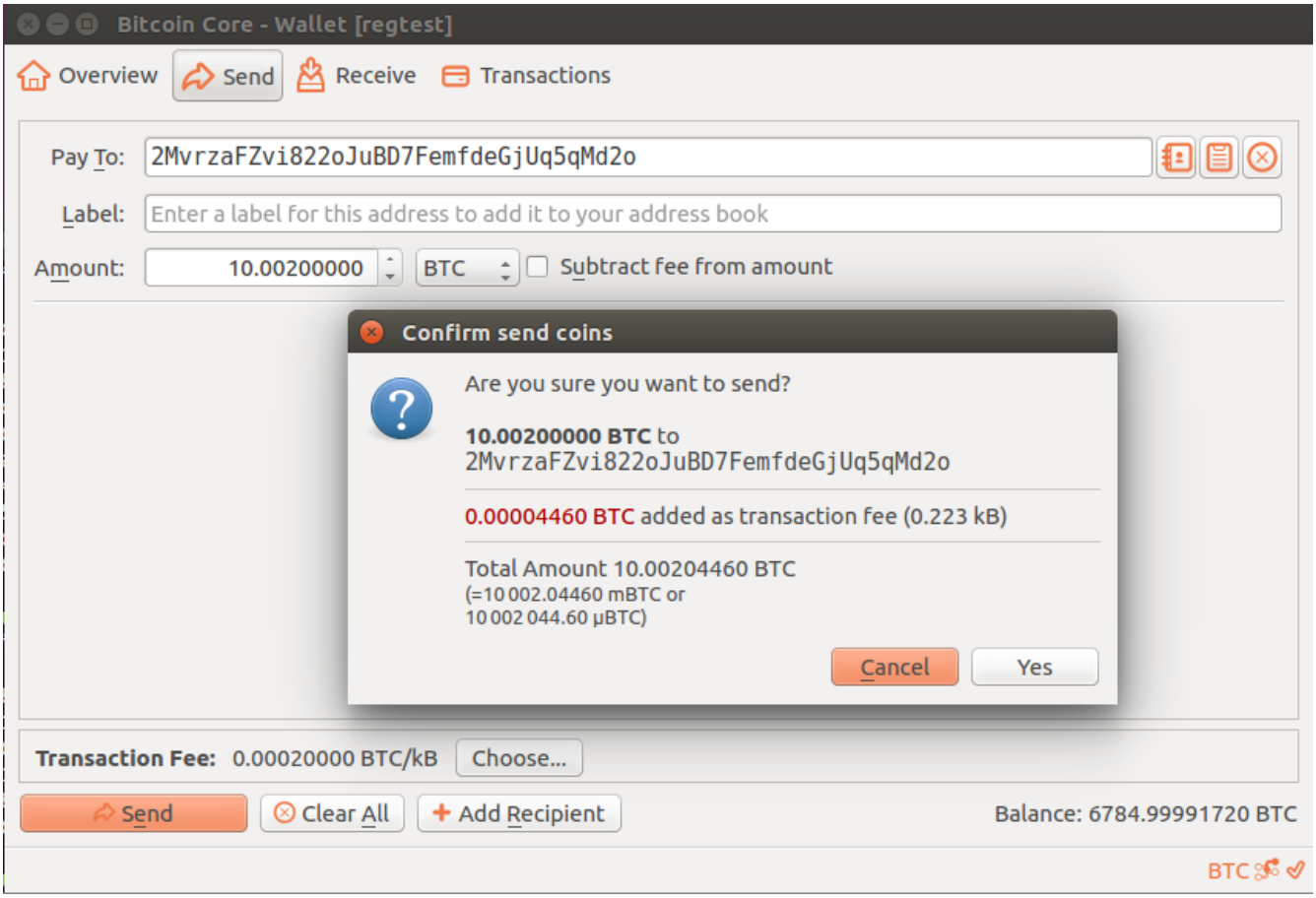
> *createmultisig 2*
> *'["025a6ceff6287aa30e8ad4f518ee14d5a61bac49b79ea731a799b2fd0d274b9d96","021ce599eec4b3e18e3dfd6a7ae157464cd920f96eb7a7ea24a99e15d2c1f39d85","02eaf20e11193b164dfe768a26a39e783e1890498f9f64c123359a0885a0961529"]'*

Here is the output from the bitcoin-qt Debug window:

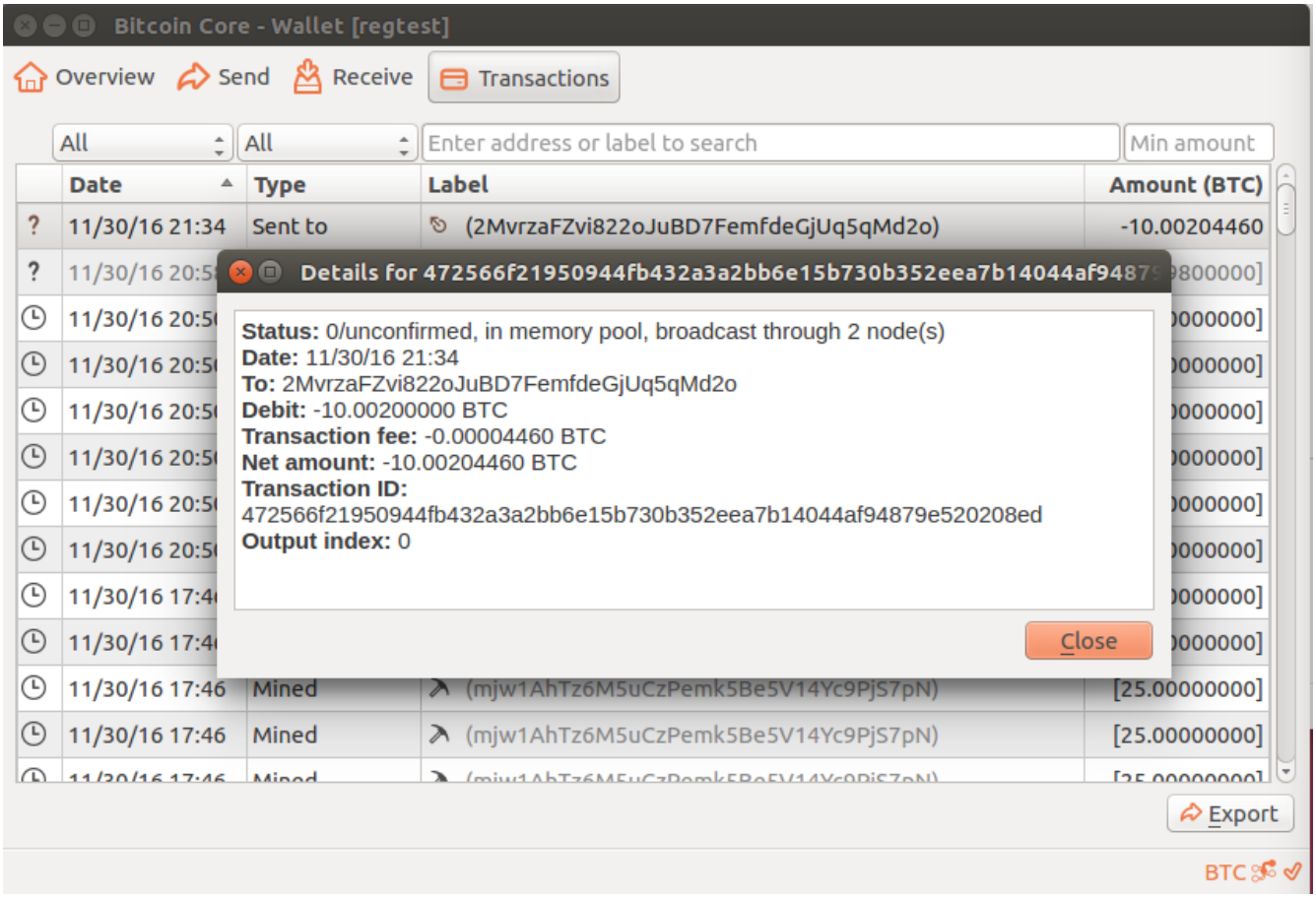


Now the borrower can send his collateral to the multi-signature address: *2MvrzaFZvi822oJuBD7FemfdeGjUq5qMd2o*

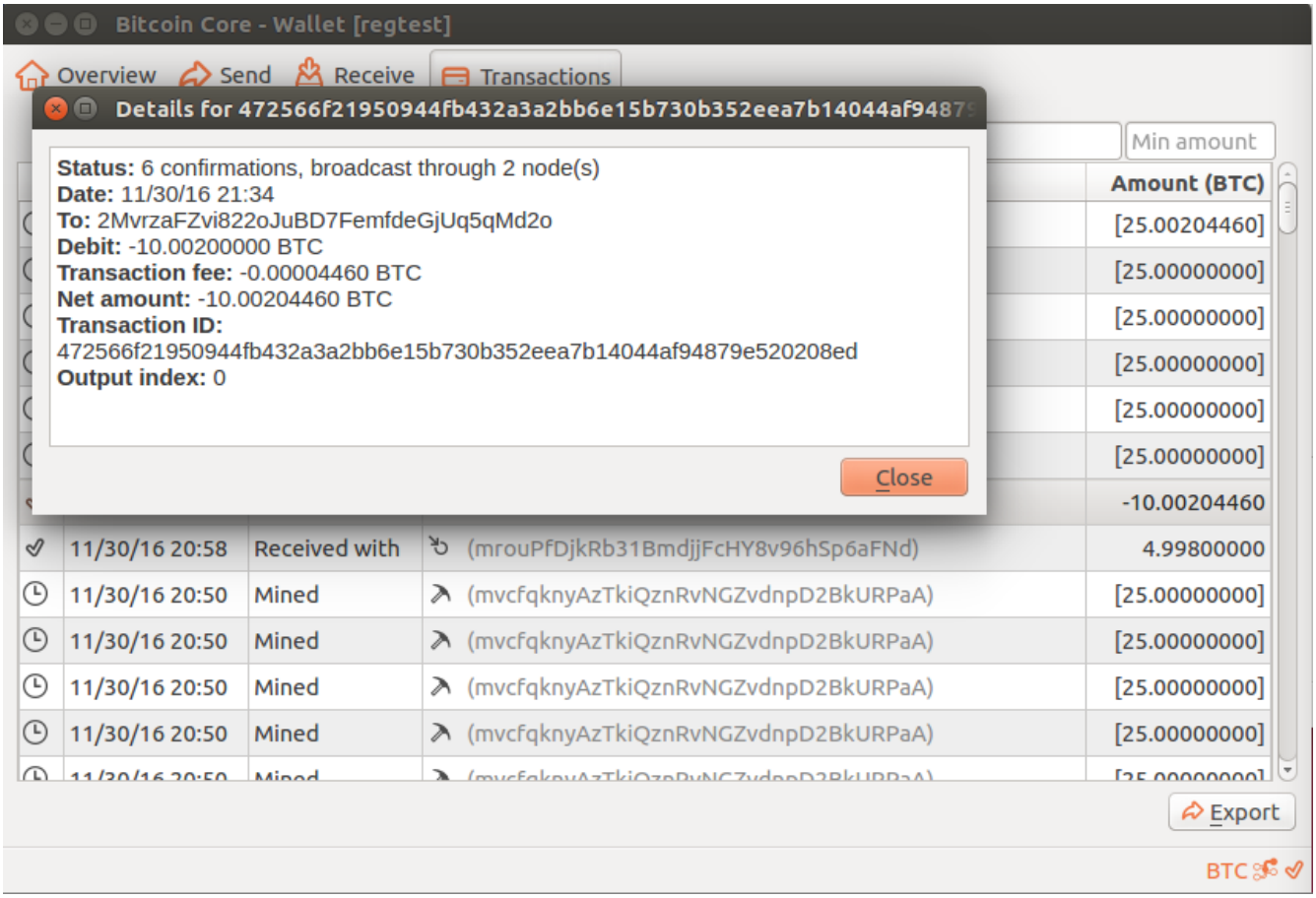
For example, lets have the borrower deposit 10.002 BTC as collateral into the lending smart contract multi-signature address:



Once sent here is a screenshot of the transaction:

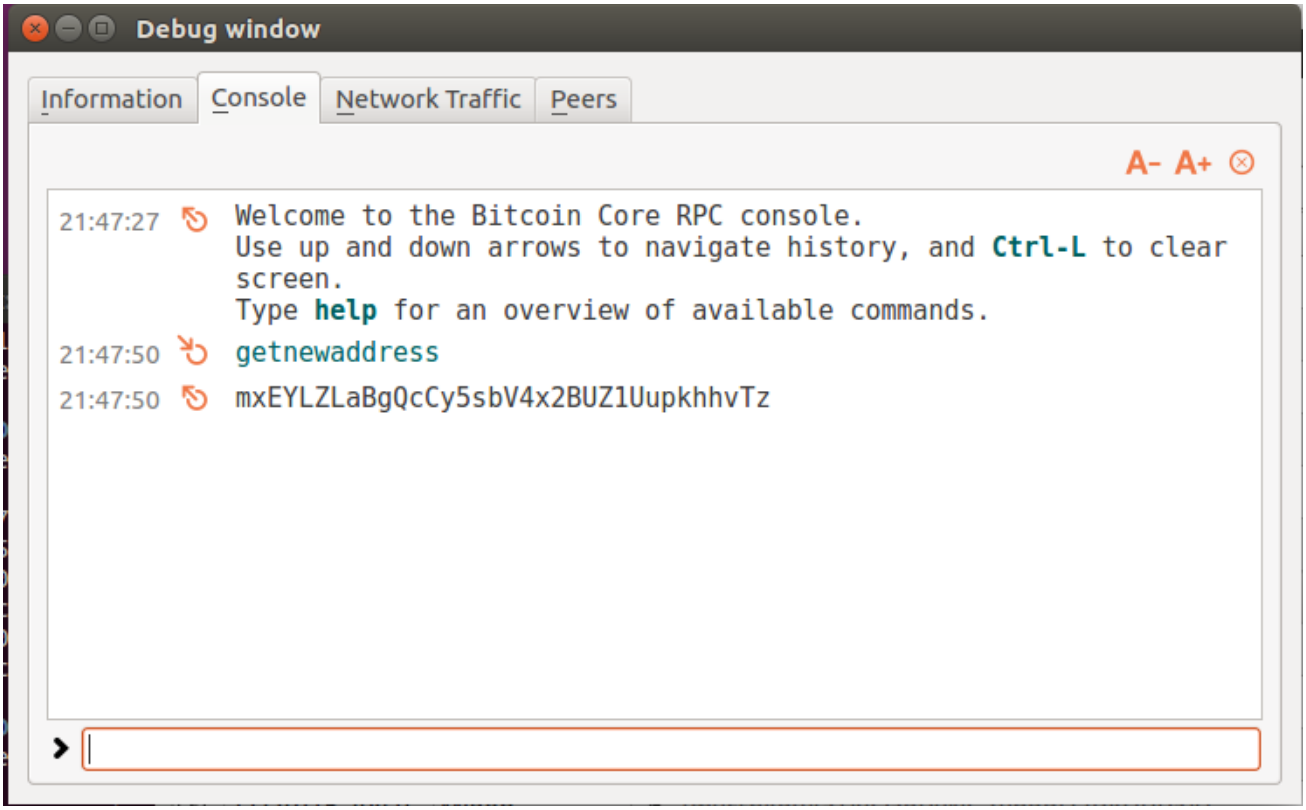


Once this transaction has confirmations all parties can be assured that the collateral is safely secured for purposes of the smart contract (see figure below).



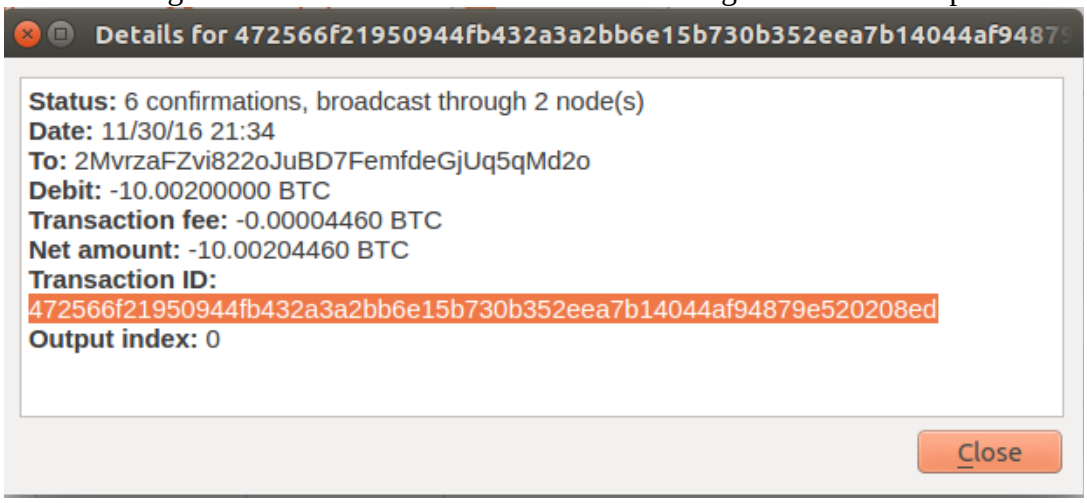
Now when the loan is complete, the collateral needs to be returned to a provided bitcoin address. If the borrower defaults, the collateral will be sent to an address of the lender. If the borrower does not default and executes the contract according to the terms, the collateral will be sent to a bitcoin address of the borrower. Basically what follows is a single set of coded commands the only variables are the address to where the collateral is sent and the two keys used to sign the collateral flow transaction.

For example purposes, let’s say everything went according to plan and the borrower is getting his collateral back. In this case the borrower provides a new bitcoin address to receive his collateral. The borrower creates a new address to receive his collateral:



Collateral return address: mxEYLZLaBgQcCy5sbV4x2BUZ1UupkhhvTz

The Arbiter software agent obtains the **Transaction ID** for the original collateral deposit transaction:



The Arbiter software agent then inspects the raw transaction for that Transaction ID using the command:

getrawtransaction 472566f21950944fb432a3a2bb6e15b730b352eea7b14044af94879e520208ed 1

The output of the command from the bitcoin-qt Debug window below:

21:57:51
OBJ
getrawtransaction
472566f21950944fb432a3a2bb6e15b730b352eea7b14044af94879e520208ed 1

21:57:51
OBJ
{
  "hex":
"01000000012ce2ad70273e0b71f84b366e488b60e5e68ac6f1f5e96356392a207107460aae0000
00006a47304402202b489936a4b65e162c9436fb7c08ec59455dacb414474d9ba88bcf3817fc871
502204fc5897a6c20f10d001928a404309b265d44a3889756abef01c03b25527d838b01210268d
b342e58791865b46e6d56d297829d10363a17b37203e5c67d3272d49e67b8feffffff0240d79d3b0
000000017a91427ac277c9a87be168956edeaf7f9c5609b6a5b9787fcb9ff94000000001976a9140
d395c69e138b015dee0d833cd83a06f6c1b82ae88acec000000",
  "txid": "472566f21950944fb432a3a2bb6e15b730b352eea7b14044af94879e520208ed",
  "hash": "472566f21950944fb432a3a2bb6e15b730b352eea7b14044af94879e520208ed",
  "size": 223,
  "vsize": 223,
  "version": 1,
  "locktime": 236,
  "vin": [
    {
      "txid": "ae0a460771202a395663e9f5f1c68ae6e5608b486e364bf8710b3e2770ade22c",
      "vout": 0,
      "scriptSig": {
        "asm":
"304402202b489936a4b65e162c9436fb7c08ec59455dacb414474d9ba88bcf3817fc871502204f
c5897a6c20f10d001928a404309b265d44a3889756abef01c03b25527d838b[ALL]
0268db342e58791865b46e6d56d297829d10363a17b37203e5c67d3272d49e67b8",
        "hex":
"47304402202b489936a4b65e162c9436fb7c08ec59455dacb414474d9ba88bcf3817fc87150220
4fc5897a6c20f10d001928a404309b265d44a3889756abef01c03b25527d838b01210268db342e
58791865b46e6d56d297829d10363a17b37203e5c67d3272d49e67b8"
      },
      "sequence": 4294967294
    }
  ],
  "vout": [
    {
      "value": 10.00200000,
      "n": 0,
      "scriptPubKey": {
        "asm": "OP_HASH160 27ac277c9a87be168956edeaf7f9c5609b6a5b97 OP_EQUAL",
        "hex": "a91427ac277c9a87be168956edeaf7f9c5609b6a5b9787",
        "reqSigs": 1,
        "type": "scripthash",
        "addresses": [

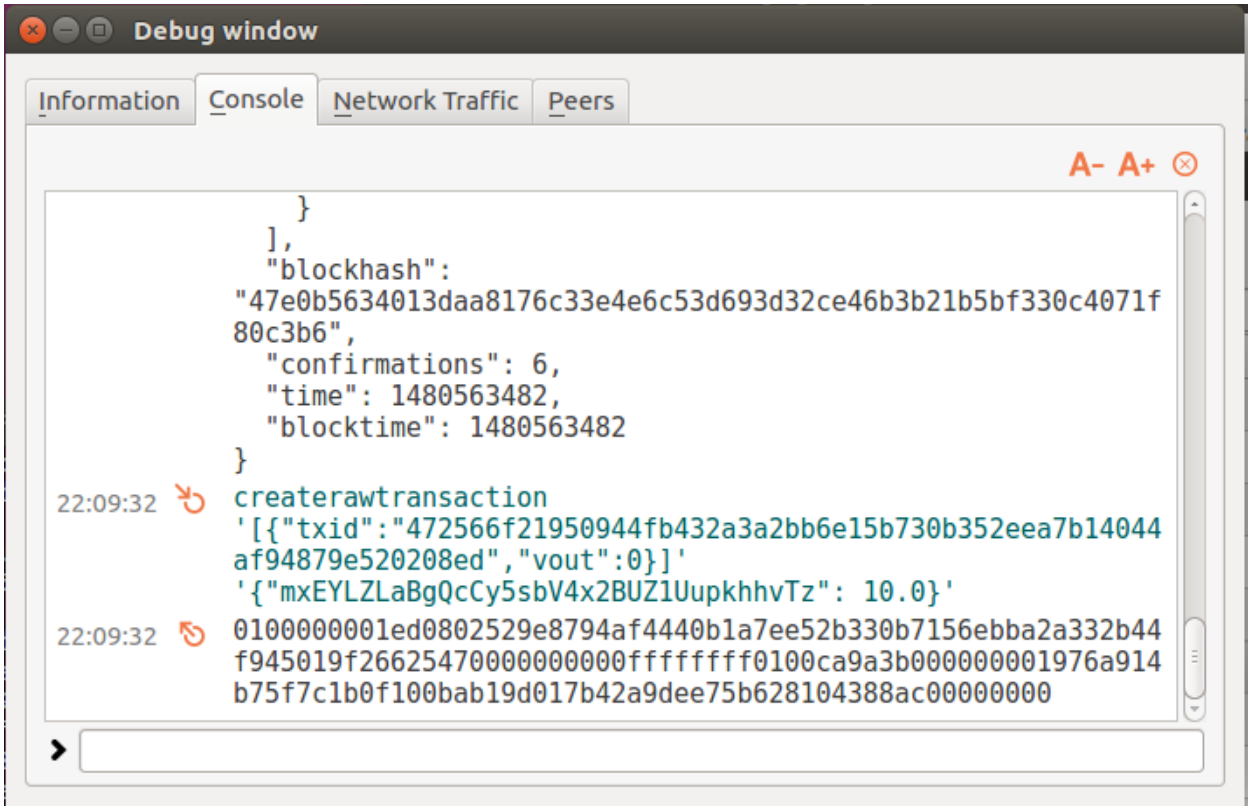
"2MvrzaFZvi822oJuBD7FemfdeGjUq5qMd2o"
]
}
},
{
"value": 24.99787260,
"n": 1,
"scriptPubKey": {
"asm": "OP_DUP OP_HASH160 0d395c69e138b015dee0d833cd83a06f6c1b82ae OP_EQUALVERIFY OP_CHECKSIG",
"hex": "76a9140d395c69e138b015dee0d833cd83a06f6c1b82ae88ac",
"reqSigs": 1,
"type": "pubkeyhash",
"addresses": [
"mgiso4PnWZKutCBk5BSXTMKqCAMdAP14rX"
]
}
}
],
"blockhash": "47e0b5634013daa8176c33e4e6c53d693d32ce46b3b21b5bf330c4071f80c3b6",
"confirmations": 6,
"time": 1480563482,
"blocktime": 1480563482
}

The key information necessary for the next command is highlighted in yellow above. Basically, this means we need to direct the appropriate output of that transaction as an input for the multi-sig spend transaction.

The Arbiter software agent then issues a **createrawtransaction** command to create the transaction to return the collateral to the borrower:

*createrawtransaction '[{"txid":"472566f21950944fb432a3a2bb6e15b730b352eea7b14044af94879e520208ed","vout":0}]' '{"*mxEYLZLaBgQcCy5sbV4x2BUZ1UupkhhvTz*": 10.0}'*

From the bitcoin-qt Debug window:



The transaction to return the collateral to the borrower has been created. Now what's left is for the Arbiter software agent and the borrower need to sign (authorize) the transaction.

First we will have the Aribter software agent sign the transaction:

signrawtransaction
0100000001ed0802529e8794af4440b1a7ee52b330b7156ebba2a332b44f945019f26625470000000000ffffffff0100ca9a3b000000001976a914b75f7c1b0f100bab19d017b42a9dee75b628104388ac00000000
'[{"txid":"472566f21950944fb432a3a2bb6e15b730b352eea7b14044af94879e520208ed","vout":0,"scriptPubKey":"a91427ac277c9a87be168956edeaf7f9c5609b6a5b9787","redeemScript":"5221025a6ceff6287aa30e8ad4f518ee14d5a61bac49b79ea731a799b2fd0d274b9d9621021ce599eec4b3e18e3dfd6a7ae157464cd920f96eb7a7ea24a99e15d2c1f39d852102eaf20e11193b164dfe768a26a39e783e1890498f9f64c123359a0885a096152953ae"}]'
'["cQxaGc6iCHDm4pqm1isdZvXGT8fezFHTnTErqgeTEKMVmR5EtvjQ"]'

bitcoin-qt Debug window output:

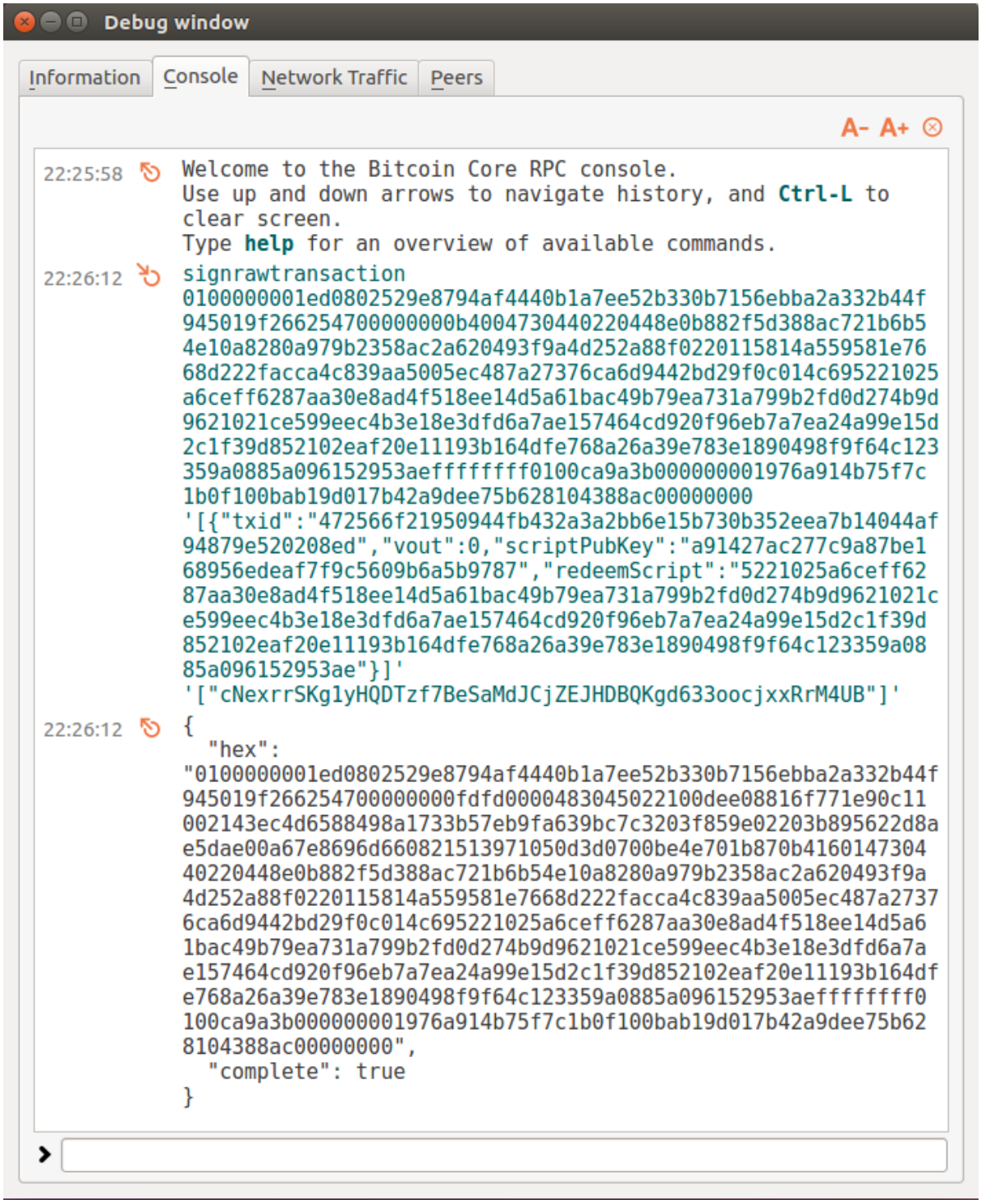
22:19:19
OBJ
{
"hex":
"0100000001ed0802529e8794af4440b1a7ee52b330b7156ebba2a332b44f945019f26625470000000000b4004730440220448e0b882f5d388ac721b6b54e10a8280a979b2358ac2a620493f9a4d252a88f0220115814a559581e7668d222facca4c839aa5005ec487a27376ca6d9442bd29f0c014c695

221025a6ceff6287aa30e8ad4f518ee14d5a61bac49b79ea731a799b2fd0d274b9d9621021ce599eec4b3e18e3dfd6a7ae157464cd920f96eb7a7ea24a99e15d2c1f39d852102eaf20e11193b164dfe768a26a39e783e1890498f9f64c123359a0885a096152953aeffffffff0100ca9a3b000000001976a914b75f7c1b0f100bab19d017b42a9dee75b628104388ac00000000",
"complete": false,
"errors": [
{
"txid": "472566f21950944fb432a3a2bb6e15b730b352eea7b14044af94879e520208ed",
"vout": 0,
"scriptSig": "004730440220448e0b882f5d388ac721b6b54e10a8280a979b2358ac2a620493f9a4d252a88f0220115814a559581e7668d222facca4c839aa5005ec487a27376ca6d9442bd29f0c014c695221025a6ceff6287aa30e8ad4f518ee14d5a61bac49b79ea731a799b2fd0d274b9d9621021ce599eec4b3e18e3dfd6a7ae157464cd920f96eb7a7ea24a99e15d2c1f39d852102eaf20e11193b164dfe768a26a39e783e1890498f9f64c123359a0885a096152953ae",
"sequence": 4294967295,
"error": "Operation not valid with the current stack size"
}
]
}

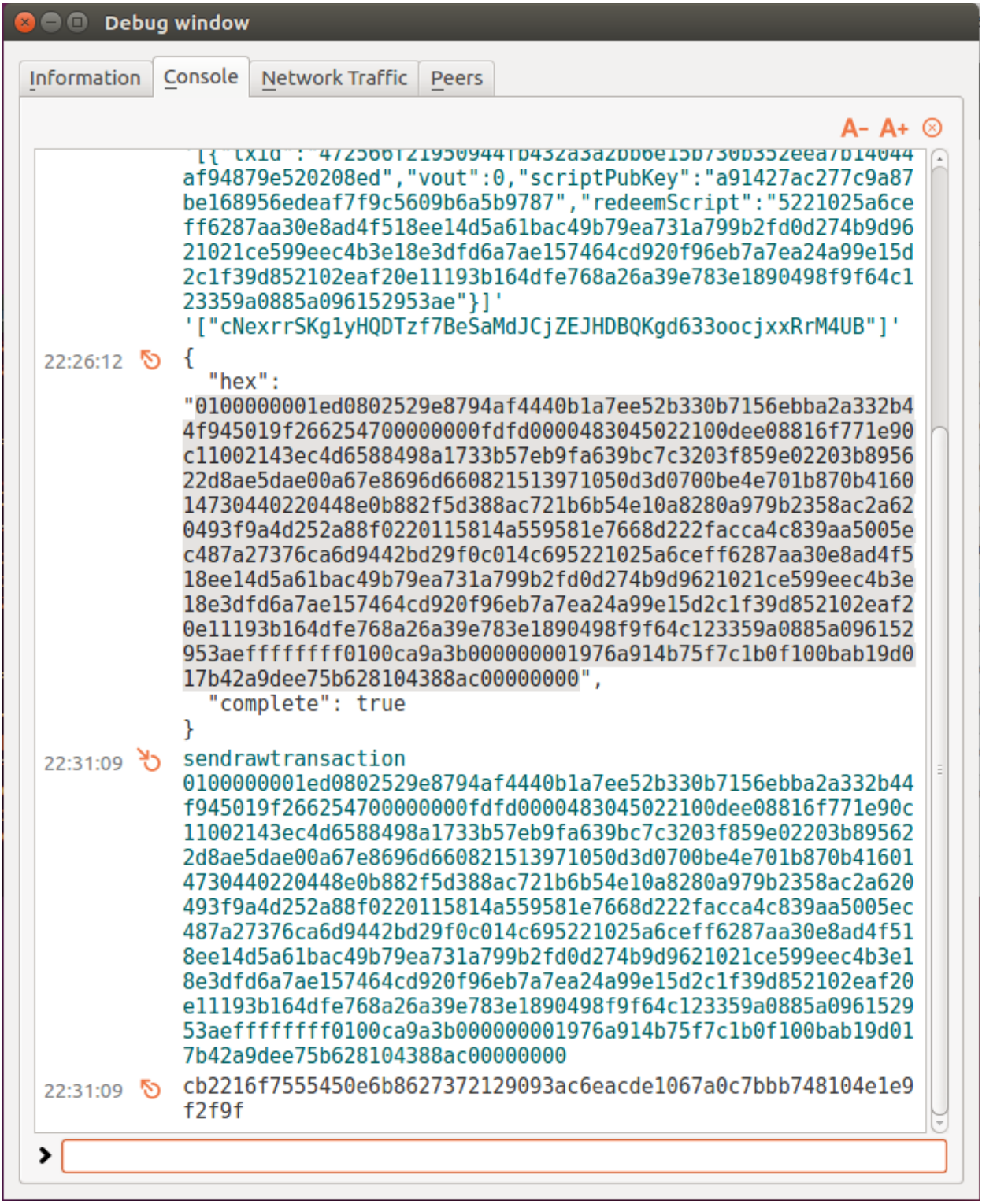
Now, the borrower needs to sign the partially signed raw transaction (highlighted in yellow above):

signrawtransaction 0100000001ed0802529e8794af4440b1a7ee52b330b7156ebba2a332b44f945019f266254700000000b4004730440220448e0b882f5d388ac721b6b54e10a8280a979b2358ac2a620493f9a4d252a88f0220115814a559581e7668d222facca4c839aa5005ec487a27376ca6d9442bd29f0c014c695221025a6ceff6287aa30e8ad4f518ee14d5a61bac49b79ea731a799b2fd0d274b9d9621021ce599eec4b3e18e3dfd6a7ae157464cd920f96eb7a7ea24a99e15d2c1f39d852102eaf20e11193b164dfe768a26a39e783e1890498f9f64c123359a0885a096152953aeffffffff0100ca9a3b000000001976a914b75f7c1b0f100bab19d017b42a9dee75b628104388ac00000000 '[{"txid":"472566f21950944fb432a3a2bb6e15b730b352eea7b14044af94879e520208ed","vout":0,"scriptPubKey":"a91427ac277c9a87be168956edeaf7f9c5609b6a5b9787","redeemScript":"5221025a6ceff6287aa30e8ad4f518ee14d5a61bac49b79ea731a799b2fd0d274b9d9621021ce599eec4b3e18e3dfd6a7ae157464cd920f96eb7a7ea24a99e15d2c1f39d852102eaf20e11193b164dfe768a26a39e783e1890498f9f64c123359a0885a096152953ae"}]' '["cNexrrSKg1yHQDTzf7BeSaMdJCjZEJHDBQKgd633oocjxxRrM4UB"]'

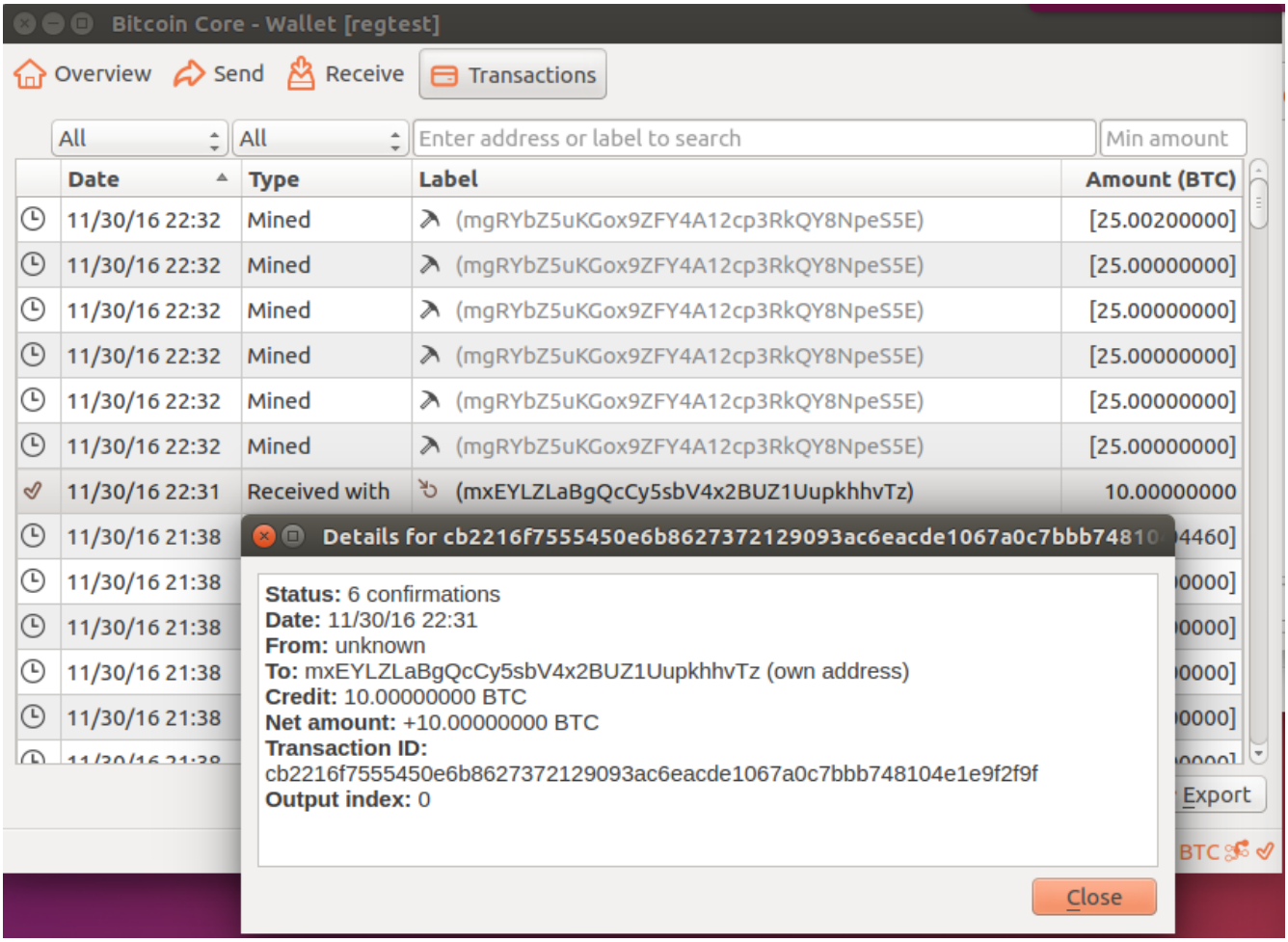
bitcoin-qt Debug window output:



The last thing to do is to send (or broadcast) the signed transaction out to the bitcoin network using the **sendrawtransaction** command:



We see the borrower has received his collateral and the 2-of-3 multi-signature facility of the lending smart contract is now completed.



High-level Summary:

- All parties supply a public key for the 2-of-3 multi-signature facility
- The Arbiter uses those public keys to create a multi-signature address that collateral can be deposited to
- The borrower deposits collateral into the multi-signature addresses
- Collateral is returned to the borrower or released to the lender based on whether the contract was successfully executed or breached. This is governed by the Arbiter software agent via the collateral flow transaction authorized through the signing of the collateral flow transaction by the corresponding private keys of the initially provided public keys.
- The successfully signed collateral flow transaction is then broadcasted to the Bitcoin network to release the collateral from the multi-signature facility