

## Demo:

100 users' authentication success messages on the server logs.

```
daisy@LAPTOP-488RQ82M:~/MutexMutualBank$ ./server
[12:11:06] Mutex Bank Server Starting...
[12:11:06] Shared memory initialized
[12:11:06] Listening on port 8888
[12:11:06] Waiting for clients...
[12:11:08] [AUTH] User user3 connected, account=3
[12:11:08] [AUTH] User user11 connected, account=11
[12:11:08] [AUTH] User user12 connected, account=12
[12:11:08] [AUTH] User user10 connected, account=10
[12:11:08] [AUTH] User user4 connected, account=4
[12:11:08] [AUTH] User user5 connected, account=5
[12:11:08] [AUTH] User user7 connected, account=7
[12:11:08] [AUTH] User user8 connected, account=8
[12:11:08] [AUTH] User user1 connected, account=1
[12:11:08] [AUTH] User user2 connected, account=2
[12:11:08] [AUTH] User user6 connected, account=6
[12:11:08] [AUTH] User user0 connected, account=0
[12:11:08] [AUTH] User user14 connected, account=14
[12:11:08] [AUTH] User user9 connected, account=9
[12:11:08] [AUTH] User user13 connected, account=13
[12:11:08] [AUTH] User user16 connected, account=16
[12:11:08] [AUTH] User user17 connected, account=17
[12:11:08] [AUTH] User user15 connected, account=15
[12:11:08] [AUTH] User user18 connected, account=18
[12:11:08] [AUTH] User user19 connected, account=19
[12:11:08] [AUTH] User user22 connected, account=22
[12:11:08] [AUTH] User user23 connected, account=23
[12:11:08] [AUTH] User user21 connected, account=21
[12:11:08] [AUTH] User user26 connected, account=26
[12:11:08] [AUTH] User user30 connected, account=30
[12:11:08] [AUTH] User user20 connected, account=20
[12:11:08] [AUTH] User user32 connected, account=32
[12:11:08] [AUTH] User user31 connected, account=31
[12:11:08] [AUTH] User user24 connected, account=24
[12:11:08] [AUTH] User user33 connected, account=33
[12:11:08] [AUTH] User user36 connected, account=36
[12:11:08] [AUTH] User user39 connected, account=39
[12:11:08] [AUTH] User user35 connected, account=35
[12:11:08] [AUTH] User user25 connected, account=25
[12:11:08] [AUTH] User user37 connected, account=37
[12:11:08] [AUTH] User user40 connected, account=40
[12:11:08] [AUTH] User user34 connected, account=34
[12:11:08] [AUTH] User user29 connected, account=29
[12:11:08] [AUTH] User user27 connected, account=27
[12:11:08] [AUTH] User user28 connected, account=28
[12:11:08] [AUTH] User user42 connected, account=42
[12:11:08] [AUTH] User user41 connected, account=41
[12:11:08] [AUTH] User user45 connected, account=45
[12:11:08] [AUTH] User user44 connected, account=44
[12:11:08] [AUTH] User user47 connected, account=47
[12:11:08] [AUTH] User user43 connected, account=43
[12:11:08] [AUTH] User user46 connected, account=46
[12:11:08] [AUTH] User user48 connected, account=48
[12:11:08] [AUTH] User user49 connected, account=49
[12:11:08] [AUTH] User user51 connected, account=51
[12:11:08] [AUTH] User user52 connected, account=52
[12:11:08] [AUTH] User user38 connected, account=38
[12:11:08] [AUTH] User user50 connected, account=50
[12:11:08] [AUTH] User user53 connected, account=53
[12:11:08] [AUTH] User user54 connected, account=54
[12:11:08] [AUTH] User user58 connected, account=58
[12:11:08] [AUTH] User user57 connected, account=57
[12:11:08] [AUTH] User user59 connected, account=59
[12:11:08] [AUTH] User user55 connected, account=55
[12:11:08] [AUTH] User user60 connected, account=60
[12:11:08] [AUTH] User user56 connected, account=56
[12:11:08] [AUTH] User user63 connected, account=63
[12:11:08] [AUTH] User user61 connected, account=61
[12:11:08] [AUTH] User user67 connected, account=67
[12:11:08] [AUTH] User user66 connected, account=66
[12:11:08] [AUTH] User user71 connected, account=71
[12:11:08] [AUTH] User user64 connected, account=64
[12:11:08] [AUTH] User user74 connected, account=74
[12:11:08] [AUTH] User user65 connected, account=65
[12:11:08] [AUTH] User user68 connected, account=68
[12:11:08] [AUTH] User user75 connected, account=75
[12:11:08] [AUTH] User user73 connected, account=73
[12:11:08] [AUTH] User user77 connected, account=77
[12:11:08] [AUTH] User user69 connected, account=69
[12:11:08] [AUTH] User user70 connected, account=70
[12:11:08] [AUTH] User user78 connected, account=78
[12:11:08] [AUTH] User user76 connected, account=76
[12:11:08] [AUTH] User user80 connected, account=80
[12:11:08] [AUTH] User user72 connected, account=72
[12:11:08] [AUTH] User user90 connected, account=90
[12:11:08] [AUTH] User user79 connected, account=79
[12:11:08] [AUTH] User user88 connected, account=88
[12:11:08] [AUTH] User user91 connected, account=91
[12:11:08] [AUTH] User user81 connected, account=81
[12:11:08] [AUTH] User user99 connected, account=99
[12:11:08] [AUTH] User user89 connected, account=89
[12:11:08] [AUTH] User user92 connected, account=92
[12:11:08] [AUTH] User user96 connected, account=96
[12:11:08] [AUTH] User user94 connected, account=94
[12:11:08] [AUTH] User user97 connected, account=97
[12:11:08] [AUTH] User user93 connected, account=93
[12:11:08] [AUTH] User user84 connected, account=84
[12:11:08] [AUTH] User user85 connected, account=85
[12:11:08] [AUTH] User user82 connected, account=82
[12:11:08] [AUTH] User user86 connected, account=86
[12:11:08] [AUTH] User user83 connected, account=83
[12:11:08] [AUTH] User user87 connected, account=87
[12:11:08] [AUTH] User user95 connected, account=95
[12:11:08] [AUTH] User user62 connected, account=62
[12:11:08] [AUTH] User user98 connected, account=98
^C
```

Each accounts' balance is shown on the server logs, assuming that the initial balance of each account is \$1000.

```
===== [Mutex Bank 帳戶餘額一覽] =====  
[Acc 00: $ 912] [Acc 01: $1015] [Acc 02: $1131] [Acc 03: $ 947]  
[Acc 04: $ 996] [Acc 05: $1025] [Acc 06: $1118] [Acc 07: $1093]  
[Acc 08: $ 993] [Acc 09: $1040] [Acc 10: $ 929] [Acc 11: $1058]  
[Acc 12: $ 909] [Acc 13: $ 990] [Acc 14: $ 906] [Acc 15: $ 919]  
[Acc 16: $ 980] [Acc 17: $1127] [Acc 18: $1009] [Acc 19: $ 920]  
[Acc 20: $ 971] [Acc 21: $ 997] [Acc 22: $ 962] [Acc 23: $ 964]  
[Acc 24: $ 919] [Acc 25: $1074] [Acc 26: $ 986] [Acc 27: $1094]  
[Acc 28: $1028] [Acc 29: $1022] [Acc 30: $ 980] [Acc 31: $1106]  
[Acc 32: $ 966] [Acc 33: $ 997] [Acc 34: $1079] [Acc 35: $1096]  
[Acc 36: $ 974] [Acc 37: $ 990] [Acc 38: $ 908] [Acc 39: $ 994]  
[Acc 40: $ 904] [Acc 41: $1080] [Acc 42: $1047] [Acc 43: $1023]  
[Acc 44: $ 948] [Acc 45: $1048] [Acc 46: $1002] [Acc 47: $ 953]  
[Acc 48: $1025] [Acc 49: $ 927] [Acc 50: $ 924] [Acc 51: $ 991]  
[Acc 52: $ 954] [Acc 53: $1051] [Acc 54: $ 999] [Acc 55: $ 995]  
[Acc 56: $1040] [Acc 57: $1154] [Acc 58: $1096] [Acc 59: $1106]  
[Acc 60: $ 918] [Acc 61: $1094] [Acc 62: $1059] [Acc 63: $ 928]  
[Acc 64: $ 983] [Acc 65: $1009] [Acc 66: $1058] [Acc 67: $1090]  
[Acc 68: $1086] [Acc 69: $ 919] [Acc 70: $ 941] [Acc 71: $ 979]  
[Acc 72: $ 957] [Acc 73: $ 939] [Acc 74: $ 993] [Acc 75: $ 975]  
[Acc 76: $ 943] [Acc 77: $ 981] [Acc 78: $ 938] [Acc 79: $1061]  
[Acc 80: $1116] [Acc 81: $ 965] [Acc 82: $ 946] [Acc 83: $ 942]  
[Acc 84: $ 927] [Acc 85: $1058] [Acc 86: $ 989] [Acc 87: $1069]  
[Acc 88: $1055] [Acc 89: $ 986] [Acc 90: $ 998] [Acc 91: $ 929]  
[Acc 92: $1083] [Acc 93: $1012] [Acc 94: $1001] [Acc 95: $ 900]  
[Acc 96: $ 974] [Acc 97: $ 985] [Acc 98: $ 932] [Acc 99: $ 904]
```

The statistical data on the server logs of the total assets in the Mutex Mutual Bank, the total transaction number, and the average latency in milliseconds.

 統計數據：  
1. 銀行總資產: \$100013  
2. 總交易筆數: 100 筆  
3. 平均延遲: 0.100 ms

The transaction content on the client logs.

[User 03] 轉帳成功！ Acc 03 -> Acc 59 (\$53)	[User 36] 轉帳成功！ Acc 36 -> Acc 66 (\$26)
[User 11] 存款成功！ Acc 11 (\$58)	[User 34] 存款成功！ Acc 34 (\$8)
[User 12] 轉帳成功！ Acc 12 -> Acc 31 (\$91)	[User 39] 轉帳成功！ Acc 39 -> Acc 73 (\$6)
[User 14] 提款成功！ Acc 14 (\$94)	[User 25] 存款成功！ Acc 25 (\$64)
[User 10] 提款成功！ Acc 10 (\$88)	[User 33] 提款成功！ Acc 33 (\$3)
[User 13] 轉帳成功！ Acc 13 -> Acc 93 (\$10)	[User 29] 轉帳成功！ Acc 29 -> Acc 17 (\$75)
[User 05] 轉帳成功！ Acc 05 -> Acc 18 (\$71)	[User 40] 轉帳成功！ Acc 40 -> Acc 05 (\$96)
[User 04] 提款成功！ Acc 04 (\$4)	[User 37] 轉帳成功！ Acc 37 -> Acc 25 (\$10)
[User 07] 存款成功！ Acc 07 (\$93)	[User 42] 存款成功！ Acc 42 (\$47)
[User 18] 轉帳成功！ Acc 18 -> Acc 57 (\$62)	[User 28] 轉帳成功！ Acc 28 -> Acc 54 (\$1)
[User 15] 提款成功！ Acc 15 (\$81)	[User 41] 存款成功！ Acc 41 (\$80)
[User 19] 提款成功！ Acc 19 (\$80)	[User 45] 轉帳成功！ Acc 45 -> Acc 32 (\$34)
[User 23] 提款成功！ Acc 23 (\$36)	[User 44] 轉帳成功！ Acc 44 -> Acc 80 (\$52)
[User 22] 提款成功！ Acc 22 (\$38)	[User 47] 轉帳成功！ Acc 47 -> Acc 06 (\$47)
[User 21] 轉帳成功！ Acc 21 -> Acc 94 (\$71)	[User 46] 存款成功！ Acc 46 (\$2)
[User 01] 提款成功！ Acc 01 (\$6)	[User 43] 存款成功！ Acc 43 (\$23)
[User 02] 存款成功！ Acc 02 (\$72)	[User 51] 轉帳成功！ Acc 51 -> Acc 29 (\$9)
[User 08] 提款成功！ Acc 08 (\$7)	[User 52] 提款成功！ Acc 52 (\$46)
[User 30] 提款成功！ Acc 30 (\$20)	[User 49] 提款成功！ Acc 49 (\$73)
[User 32] 轉帳成功！ Acc 32 -> Acc 21 (\$68)	[User 27] 存款成功！ Acc 27 (\$94)
[User 26] 提款成功！ Acc 26 (\$14)	[User 50] 提款成功！ Acc 50 (\$76)
[User 31] 存款成功！ Acc 31 (\$15)	[User 38] 提款成功！ Acc 38 (\$92)
[User 20] 轉帳成功！ Acc 20 -> Acc 28 (\$29)	[User 48] 存款成功！ Acc 48 (\$23)
[User 35] 存款成功！ Acc 35 (\$96)	[User 57] 存款成功！ Acc 57 (\$92)
[User 24] 轉帳成功！ Acc 24 -> Acc 53 (\$81)	[User 63] 轉帳成功！ Acc 63 -> Acc 59 (\$72)
[User 56] 存款成功！ Acc 56 (\$40)	[User 81] 提款成功！ Acc 81 (\$35)
[User 53] 提款成功！ Acc 53 (\$30)	[User 76] 提款成功！ Acc 76 (\$57)
[User 55] 提款成功！ Acc 55 (\$72)	[User 70] 轉帳成功！ Acc 70 -> Acc 02 (\$59)
[User 58] 存款成功！ Acc 58 (\$82)	[User 91] 轉帳成功！ Acc 91 -> Acc 34 (\$71)
[User 71] 轉帳成功！ Acc 71 -> Acc 01 (\$21)	[User 80] 存款成功！ Acc 80 (\$64)
[User 54] 提款成功！ Acc 54 (\$95)	[User 90] 轉帳成功！ Acc 90 -> Acc 48 (\$2)
[User 59] 轉帳成功！ Acc 59 -> Acc 93 (\$19)	[User 99] 提款成功！ Acc 99 (\$96)
[User 60] 轉帳成功！ Acc 60 -> Acc 45 (\$82)	[User 94] 提款成功！ Acc 94 (\$70)
[User 74] 轉帳成功！ Acc 74 -> Acc 79 (\$7)	[User 92] 存款成功！ Acc 92 (\$83)
[User 66] 存款成功！ Acc 66 (\$32)	[User 96] 轉帳成功！ Acc 96 -> Acc 61 (\$26)
[User 61] 存款成功！ Acc 61 (\$68)	[User 84] 提款成功！ Acc 84 (\$73)
[User 64] 轉帳成功！ Acc 64 -> Acc 10 (\$17)	[User 93] 提款成功！ Acc 93 (\$17)
[User 65] 存款成功！ Acc 65 (\$9)	[User 89] 轉帳成功！ Acc 89 -> Acc 58 (\$14)
[User 73] 轉帳成功！ Acc 73 -> Acc 55 (\$67)	[User 82] 提款成功！ Acc 82 (\$54)
[User 69] 提款成功！ Acc 69 (\$81)	[User 85] 存款成功！ Acc 85 (\$58)
[User 06] 存款成功！ Acc 06 (\$71)	[User 86] 提款成功！ Acc 86 (\$11)
[User 78] 提款成功！ Acc 78 (\$62)	[User 87] 存款成功！ Acc 87 (\$69)
[User 68] 存款成功！ Acc 68 (\$86)	[User 97] 提款成功！ Acc 97 (\$15)
[User 67] 存款成功！ Acc 67 (\$90)	[User 62] 存款成功！ Acc 62 (\$59)
[User 72] 提款成功！ Acc 72 (\$43)	[User 83] 提款成功！ Acc 83 (\$58)
[User 00] 轉帳成功！ Acc 00 -> Acc 29 (\$88)	[User 95] 提款成功！ Acc 95 (\$100)
[User 75] 轉帳成功！ Acc 75 -> Acc 98 (\$25)	[User 98] 轉帳成功！ Acc 98 -> Acc 54 (\$93)
[User 77] 提款成功！ Acc 77 (\$19)	[User 09] 存款成功！ Acc 09 (\$40)
[User 88] 存款成功！ Acc 88 (\$55)	[User 17] 存款成功！ Acc 17 (\$52)
[User 79] 存款成功！ Acc 79 (\$54)	[User 16] 提款成功！ Acc 16 (\$20)

The total transaction number, average latency, overall throughput (TPS), and total consume time show on the client logs.

```
===== [Client 統計] =====
總交易筆數: 100
平均延遲: 7.465 ms
整體 Throughput (TPS): 236.88 交易/秒
總耗時: 0.422 秒
=====
```

The transection log example.

```
[Thu Dec 25 13:18:57 2025] #39 Transfer: Acc 51 -> Acc 50 ($76)
[Thu Dec 25 13:18:57 2025] #40 Deposit: Acc 41 ($30)
[Thu Dec 25 13:18:57 2025] #41 Withdraw: Acc 49 ($96)
```

TCP Handshake Flood from clients.

793 31.36335...	127.0.0.1	127.0.0.1	TCP	74 59716 → 8888 [SYN] Seq=0 Win=65495 Len=0 MSS=65495 SACK PERM=1 TSval=323344261 TSecr=0 WS=128
794 31.36337...	127.0.0.1	127.0.0.1	TCP	74 8888 → 59716 [SYN, ACK] Seq=0 Ack=1 Win=65483 Len=0 MSS=65495 SACK PERM=1 TSval=323344261 TSecr=323344261 WS=128
795 31.36340...	127.0.0.1	127.0.0.1	TCP	66 59716 → 8888 [ACK] Seq=1 Ack=1 Win=65536 Len=0 TSval=323344261 TSecr=323344261
796 31.36341...	127.0.0.1	127.0.0.1	TCP	74 59718 → 8888 [SYN] Seq=0 Win=65495 Len=0 MSS=65495 SACK PERM=1 TSval=323344261 TSecr=0 WS=128
797 31.36347...	127.0.0.1	127.0.0.1	TCP	74 59720 → 8888 [SYN] Seq=0 Win=65495 Len=0 MSS=65495 SACK PERM=1 TSval=323344261 TSecr=0 WS=128
798 31.36355...	127.0.0.1	127.0.0.1	TCP	74 59724 → 8888 [SYN] Seq=0 Win=65495 Len=0 MSS=65495 SACK PERM=1 TSval=323344261 TSecr=0 WS=128
799 31.36357...	127.0.0.1	127.0.0.1	TCP	74 8888 → 59720 [SYN, ACK] Seq=0 Ack=1 Win=65483 Len=0 MSS=65495 SACK PERM=1 TSval=323344261 TSecr=323344261 WS=128
800 31.36359...	127.0.0.1	127.0.0.1	TCP	74 59728 → 8888 [SYN] Seq=0 Win=65495 Len=0 MSS=65495 SACK PERM=1 TSval=323344261 TSecr=0 WS=128

| Length | Checksum | Payload | packets

They are divided into three packets (you can observe 60552 -> 8888).

The three “Login content” 60552 -> 8888 packets sended by the client.

10.. 31.37035...	127.0.0.1	127.0.0.1	TCP	70 60552 → 8888 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=4 TSval=323344268 TSecr=323344268
10.. 31.37036...	127.0.0.1	127.0.0.1	TCP	66 8888 → 60552 [ACK] Seq=1 Ack=5 Win=65536 Len=0 TSval=323344268 TSecr=323344268
10.. 31.37038...	127.0.0.1	127.0.0.1	TCP	70 60552 → 8888 [PSH, ACK] Seq=5 Ack=1 Win=65536 Len=4 TSval=323344268 TSecr=323344268
10.. 31.37038...	127.0.0.1	127.0.0.1	TCP	66 8888 → 60552 [ACK] Seq=1 Ack=9 Win=65536 Len=0 TSval=323344268 TSecr=323344268
10.. 31.37039...	127.0.0.1	127.0.0.1	TCP	98 60552 → 8888 [PSH, ACK] Seq=9 Ack=1 Win=65536 Len=32 TSval=323344268 TSecr=323344268

Encrypted username and password of payload using AES.

```
Data (32 bytes)
Data: 356598f117abbd1e7b675da415a337626caca5092b364dc11f2c8473ef4f4db8
[Length: 32]
```

The three “transaction content” 59872 -> 8888 packets sended by the client.

18.. 31.56681...	127.0.0.1	127.0.0.1	TCP	70 59872 → 8888 [PSH, ACK] Seq=41 Ack=77 Win=65536 Len=4 TSval=323344464 TSecr=323344464
18.. 31.56686...	127.0.0.1	127.0.0.1	TCP	66 8888 → 59872 [ACK] Seq=77 Ack=45 Win=65536 Len=0 TSval=323344464 TSecr=323344464
18.. 31.56687...	127.0.0.1	127.0.0.1	TCP	70 59872 → 8888 [PSH, ACK] Seq=45 Ack=77 Win=65536 Len=4 TSval=323344464 TSecr=323344464
18.. 31.56688...	127.0.0.1	127.0.0.1	TCP	66 8888 → 59872 [ACK] Seq=77 Ack=49 Win=65536 Len=0 TSval=323344464 TSecr=323344464
18.. 31.56688...	127.0.0.1	127.0.0.1	TCP	82 59872 → 8888 [PSH, ACK] Seq=49 Ack=77 Win=65536 Len=16 TSval=323344464 TSecr=323344464

Encrypted src\_id, dst\_id, amount and op of payload using XOR.

```
Data (16 bytes)
Data:aaaaaaaa94aaaaaaaf8aaaaaaaaaaaaaaaa
[Length: 16]
```