HOW TO RUN THE PROGRAM

Video Description - https://drive.google.com/file/d/1Fp-wRUSnynjQuuTh3lxJ5HuhsUXNTeS_/view?usp=sharing

- Save the file on your system as project1.erl

- Latest Version of Erlang/OTP 25.1 is recommended.

- Run the erl command on your system to ensure it is installed correctly.

- Move to the directory where the program is saved.

- Open two different terminals on your system[For Distributed System Execution on a single system] or a single terminal on two different systems[For Distributed System Implementation across devices].
  *Note: Both designs have been implemented and tested with screenshots attached for the implementation.

-
For Master Terminal:	**erl -sname master -setcookie uflorida**
For Worker Terminal:	**erl -sname worker -setcookie uflorida**

- In both the terminals run the command **c(project1).**

- Note: This step is only for distributed system implementation across devices

For Master Terminal	**net_adm:ping('worker@DESKTOP-KHTE3K0').**	Expected Output: pang
For Worker Terminal	**net_adm:ping('master@DESKTOP-QSBT3FN').**	Expected Output: pong

  *Note: DESKTOP-KHTE3K0 and DESKTOP-QSBT3FN are the address of the two systems for setting up a connection between the two devices. Both the systems had Windows Operating System installed. Additionally, both devices need to be connected to the same hotspot.

- In the master terminal run the command **project1:start_master('worker@DESKTOP-KHTE3K0',4).**
  *Note : project1:start_master('Worker Address', Number of Leading Zeroes).

- In worker terminal run the command **project1:start_worker('master@DESKTOP-KHTE3K0').**
  *Note : project1:start_worker('Master Address'). Therefore, All the Master Address be same.

- The master side gives output **Worker with <Process_ID> Found Coin "UFID+Random_String" "Hashed_Output"**
  *Note: **Different Process ID's** for different actors running parallel as proof of parallelization.

- The worker side gives output.
  Starting work for Master_Node <Master_Node_ID>
  *Note: Same Master ID for all Actors as they are called upon by the same master.
  Code Time in microseconds
  Ratio

Sample Output
Number of Workers = 10, Work Units to find coins = 10, Number of Zeroes = 4

Master Terminal

```
PS C:\Users\Shivam\Desktop\DOSP> erl -sname master -setcookie uflorida
Eshell V13.0.4  (abort with ^G)
(master@DESKTOP-KHTE3K0)1> c(project1).
{ok,project1}
(master@DESKTOP-KHTE3K0)2> project1:start_master('worker@DESKTOP-KHTE3K0',4).
ok
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.104.0>      Found Coin "shivamgupta1jPJCSP+gqFYlEQ=="
"0000b2e8c8d4e087925b2e2eee9058790afe6cc47e39fac4e8cbb2e6bc73c056"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.97.0>      Found Coin "shivamgupta1EWQX/EAQCkMHtg=="
"000098cd8d0bd55027e3d4da0575f51b6ef6ab86dd0c65c53deb92134dca4258"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.96.0>      Found Coin "shivamgupta1UAWAgOFIQpxzhA=="
"0000d7cf23b5292d1ffc3db9b5c2fe524913816bd9298cf0d36256779cae9d3c"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.104.0>      Found Coin "shivamgupta1NYoI5ftwMmkM5Q=="
"000096956a76e875e8647f2bf9d504c35259a6e5fe12a7184b69925e101763ac"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>      Found Coin "shivamgupta1s5Q40mne2H4EJg=="
"0000e696fa201c0951c69e381793dd36d79ceada16b7b2b7314fe1d6ea8977e5"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.104.0>      Found Coin "shivamgupta1C/s7Larhduyqig=="
"00004c609eff52d4508eca029b7697e850d3760f1855c7333b36f125e79a94f1"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.100.0>      Found Coin "shivamgupta1z2EVAk6wxia0kw=="
"0000f8a3e17f995bd680a32c7fab4307a90542adb984af90de5702d00af5227b"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.97.0>      Found Coin "shivamgupta1GGlnOrn5HU12Gw=="
"0000509f05166f47fb823022f749cacf93e164289fad9af06e8a6bc85d03c1a1"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.98.0>      Found Coin "shivamgupta1Y+9rGMx4p9leuw=="
"0000377ebb91ebeec549b496781d409b71194df0cae4dafb92f00ff3df5135a7"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.96.0>      Found Coin "shivamgupta1uYPqNBqjjTZZPQ=="
"00002a9d7c4a8f66b5543ea32b37bce55e1498b50fd85933843dc1deee6f1653"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.97.0>      Found Coin "shivamgupta1MBsGrnaOvBYk6w=="
"0000c643f12ec890253fcc5570a8edc9edb35d7fe194296bd8894501d342fd91"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>      Found Coin "shivamgupta19zYIJDw2HVVHkg=="
"00005bf85a3e9f2369e7783dfae941da99f29ec19ad78e7acbaeb0e5d9832589"
```

Worker Terminal

PS C:\Users\Shivam\Desktop\DOSP> erl -sname worker -setcookie uflorida

Eshell V13.0.4 (abort with ^G)

(worker@DESKTOP-KHTE3K0)1> c(project1).

{ok,project1}

(worker@DESKTOP-KHTE3K0)2> project1:start_worker('master@DESKTOP-KHTE3K0').

Starting work for Master_Node <13326.92.0>Starting work for Master_Node <13326.92.0>ok

Starting work for Master_Node <13326.92.0>Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> Code time=107422000 (18224000) microseconds

(worker@DESKTOP-KHTE3K0)3> Ratio [CPU Time:Real Time]= 5.894534679543459(worker@DESKTOP-KHTE3K0)3>

Code Time: Code time=107422000 (18224000) microseconds

Ratio: Ratio [CPU Time:Real Time]= 5.894534679543459

Screenshot

DISTRIBUTED IMPLEMENTATION

Number of Workers = 10, Work Units to find coins = 10, Number of Zeroes = 4

Working Instructions detailed in How to run program section.

net_adm module in Erlang is used for various Erlang net administration routines. This module contains various network utility functions.

net_adm:ping('shivam@DESKTOP-KHTE3K0').
Master **shivam@DESKTOP-KHTE3K0** a **Dell Inspiron 15 Intel Core i7 8th Gen**

```
{ok,master}
(caroline@DESKTOP-QSBT3FN)2> net_adm:ping('shivam@DESKTOP-KHTE3K0').
pong
(caroline@DESKTOP-QSBT3FN)3> project1:start_master('shivam@DESKTOP-KHTE3K0',4).
true
(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3
FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> Coin Found (carol
ine@DESKTOP-QSBT3FN)4> "shivamgupta17mr5vUCHZ1fu"(caroline@DESKTOP-QSBT3FN)4> "00008534d6ddef11bd515b2cd9eeb07de2835b7bcc1ebb5bf66b831b23658eeb"
(caroline@DESKTOP-QSBT3FN)4>  (caroline@DESKTOP-QSBT3FN)4> Actor PID = <13270.108.0>(caroline@DESKTOP-QSBT3FN)4>
(caroline@DESKTOP-QSBT3FN)4> Coin Found (caroline@DESKTOP-QSBT3FN)4> "shivamgupta1/SES5LX3VL99"(caroline@DESKTOP-QSBT3FN)4> "0000fdb121b440b7b5e
eba3ddd6c72cf684f4d9c36ea4edde84cdbc745d240cf"(caroline@DESKTOP-QSBT3FN)4>  (caroline@DESKTOP-QSBT3FN)4> Actor PID = <13270.105.0>(caroline@DESKTOP-QSBT3FN)4>
(caroline@DESKTOP-QSBT3FN)4> Coin Found (caroline@DESKTOP-QSBT3FN)4> "shivamgupta1+BQpYJMzzmGP"(caroline@DESKTOP-QSBT3FN)4> "0000683ca988750e2af
3f36ca78baa27b4c7ea56a95777b950b48c4461e03591"(caroline@DESKTOP-QSBT3FN)4>  (caroline@DESKTOP-QSBT3FN)4> Actor PID = <13270.102.0>(caroline@DESKTOP-QSBT3FN)4>
(caroline@DESKTOP-QSBT3FN)4> Coin Found (caroline@DESKTOP-QSBT3FN)4> "shivamgupta1hdXKBZPiC9Vr"(caroline@DESKTOP-QSBT3FN)4> "0000eb966ea4f734e46
45d7d2affb17e6931eec4e55c78df12c14e55d5f391d8"(caroline@DESKTOP-QSBT3FN)4>  (caroline@DESKTOP-QSBT3FN)4> Actor PID = <13270.100.0>(caroline@DESKTOP-QSBT3FN)4>
```

net_adm:ping('caroline@DESKTOP-QSBT3FN').
Worker **caroline@DESKTOP-QSBT3FN** a **Dell G5 Intel Core i7 10th Gen**

```
{ok,master}
(shivam@DESKTOP-KHTE3K0)2> net_adm:ping('caroline@DESKTOP-QSBT3FN').
pang
(shivam@DESKTOP-KHTE3K0) project1:start_worker('caroline@DESKTOP-QSBT3FN').
Master finished 'caroline@DESKTOP-QSBT3FN' 4
Code time= 7422000 (18224000) microseconds
Ratio [CPU Time:Real Time]= 5.894534679543459
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
```

<u>README REQUIREMENTS AND ANALYSIS</u>

- Size of the work unit that you determined results in the best performance for your implementation and an explanation of how you determined it. The size of the work unit refers to the number of sub-problems that a worker gets in a single request from the boss.
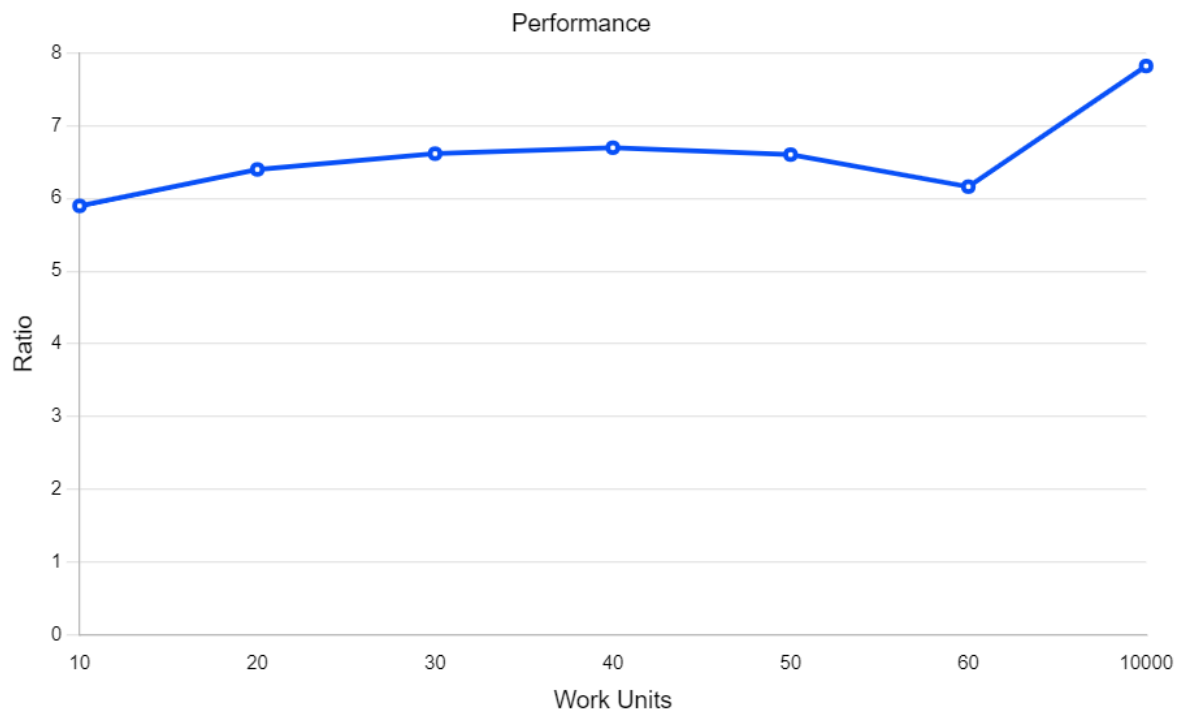
  The program ran for several combinations. Number of Workers = 10000, Work Units to find coins = 10, Number of Zeroes = 4
  The ratio came out 7.819331681052901
  This results in the best performance.

  Number of Workers = 10000, Work Units to find coins = X-Axis, Number of Zeroes = 4, Ratio = Y-Axis

  Computation of other results

Screenshots of the executions to compute the graph.


```erlang
64        U2 = Time2 * 1000,
65        io:format(
66            "Code time=~p (~p) microseconds~n",
67            [U1, U2]
68        ),
69        io:format("Ratio [CPU Time:Real Time]= ~p",[U1/U2]).
70
71    wunit(0, _, _) ->
72        stopped;
73    wunit(N, Master_Node, NumZ) ->
74        V = "Worker",
75        bitcoin_miner(Master_Node, NumZ, V),
76        wunit(N - 1, Master_Node, NumZ).
77
```

PROBLEMS OUTPUT DEBUG CONSOLE **TERMINAL**

```
 "shivamgupta1dPQzl3uPm1bIPA=="   "0000198b84fa816414f8774590d385a8b5de202870
ccb16d716280203f046399"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.98.0>        Found Coin
 "shivamgupta1LCsRMRZInJlDjg=="   "00001d0cddfce63048365f1c734780d1b54f7ba03f
1e0c122f826e6e7a122370"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>       Found Coin
 "shivamgupta19ZVxgXSOAnl0UQ=="   "000032ce989b05138ae9ab2f11906446fa1161f3e9
57680699f963f05554a5be"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>       Found Coin
 "shivamgupta1fNLIUdK5S8oiSQ=="   "0000d442b005f84fd6162facb022d7823a47ba97e8
02e8374c79ed04d85cba94"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>       Found Coin
 "shivamgupta1QgyKNW3+3j7PQA=="   "0000c94295ab34fd3dc540d6058565a811836736f2
ed8af76455a6263297e4c6"
(master@DESKTOP-KHTE3K0)3> []
```

```
Starting work for Master_Node <13326.92.0>ok
Starting work for Master_Node <13326.92.0>Starting work for Master_Node <13326.9
2.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker
@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KH
TE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> St
arting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work
 for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master
_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <1332
6.92.0>(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-K
HTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKT
OP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@D
ESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> Code t
ime=262015000 (40957000) microseconds
(worker@DESKTOP-KHTE3K0)3> Ratio [CPU Time:Real Time]= 6.397319139585419(worker@
DESKTOP-KHTE3K0)3> []
```



```erlang
84            {From, Msg, Input} ->
85                if
86                    Msg == startwork ->
87                        io:fwrite("Starting work for Master_Node ~p",[From]),
88
89                        %Assignment of Work Units
90                        wunit(30, Master_Node, Input),
91                        io:fwrite("."),
92                        Val = persistent_term:get(t),
93                        persistent_term:put(t, Val - 1);
94                    % From ! {self(), donework};
```

PROBLEMS OUTPUT DEBUG CONSOLE **TERMINAL**

```
 "shivamgupta1dPQzl3uPm1bIPA=="   "0000198b84fa816414f8774590d385a8b5de202870
ccb16d716280203f046399"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.98.0>        Found Coin
 "shivamgupta1LCsRMRZInJlDjg=="   "00001d0cddfce63048365f1c734780d1b54f7ba03f
1e0c122f826e6e7a122370"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>       Found Coin
 "shivamgupta19ZVxgXSOAnl0UQ=="   "000032ce989b05138ae9ab2f11906446fa1161f3e9
57680699f963f05554a5be"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>       Found Coin
 "shivamgupta1fNLIUdK5S8oiSQ=="   "0000d442b005f84fd6162facb022d7823a47ba97e8
02e8374c79ed04d85cba94"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>       Found Coin
 "shivamgupta1QgyKNW3+3j7PQA=="   "0000c94295ab34fd3dc540d6058565a811836736f2
ed8af76455a6263297e4c6"
(master@DESKTOP-KHTE3K0)3> []
```

```
Starting work for Master_Node <13326.92.0>ok
Starting work for Master_Node <13326.92.0>Starting work for Master_Node <13326.9
2.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker
@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KH
TE3K0)3> Starting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> St
arting work for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work
 for Master_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master
_Node <13326.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <1332
6.92.0>(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-K
HTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKT
OP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@D
ESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> Code t
ime=262015000 (40957000) microseconds
(worker@DESKTOP-KHTE3K0)3> Ratio [CPU Time:Real Time]= 6.397319139585419(worker@
DESKTOP-KHTE3K0)3> []
```

project1.erl

```erlang
87                io:fwrite("Starting work for Master_Node ~p",[From]),
88
89                %Assignment of Work Units
90                wunit(30, Master_Node, Input),
91                io:fwrite("."),
92                Val = persistent_term:get(t),
93                persistent_term:put(t, Val - 1);
94            % From ! {self(), donework};
95            true ->
96                ok
97        end;
```

TERMINAL

```
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.94.0>        Found Coin
 "shivamgupta10t/gLRtf31S3dw=="  "0000ab2c896cd439f12e2433ed5ac13938f2bb1d14
c2c5f55ea374040b6fa50f"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1cC53ea0+SkhplA=="  "0000d17d37ce7f79946b8333ece87d428f3b468b37
165dcf66b201231259132a"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.94.0>        Found Coin
 "shivamgupta1/fUHW+RcM5BeYA=="  "00006bb9ecfd8688e534d6a73f7175e527e9905ada
1aea8f8daed693c5b2fb7a"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.97.0>        Found Coin
 "shivamgupta1ZCJY1P4Y3XNt3w=="  "000058f7f466355e38a1faa613a496e87e62d7981c
6e1aa3a37da31d0906fd54"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.97.0>        Found Coin
 "shivamgupta1TskstlLUMSjmSg=="  "000050bab8a952c860fe80cbc58821a5cece0c619e
c79bc23a44b83ef0e24d3e"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.94.0>        Found Coin
 "shivamgupta179/vVo+Y6xUHYA=="  "000059f81e736ece62f3018b74e5c0d058dec2182b
e79151e66c73aaff8c63b6"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1uKAHU5A0UP/ryw=="  "0000c185af5be079815e0ad8fe6bce66884018b47d
ca356734642f0df36fc65d"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.97.0>        Found Coin
 "shivamgupta1Xd6IjsEQ+3jSDg=="  "00009d8fbf70b0b1ad61dc697063a9e404e18eea7f
da43d66c1e25c1dbdffc91"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.97.0>        Found Coin
 "shivamgupta14A+N3iJDKuVcg=="  "0000f8d827c34d749d84aa1900d297d405963da708
01ddd0f0e7312a8e4be0fa"
(master@DESKTOP-KHTE3K0)3> []
```

```
PS C:\Users\Shivam\Desktop\DOSP> erl -sname worker -setcookie uflorida
Eshell V13.0.4  (abort with ^G)
(worker@DESKTOP-KHTE3K0)1> c(project1).
{ok,project1}
(worker@DESKTOP-KHTE3K0)2> project1:start_worker('master@DESKTOP-KHTE3K0').
ok
(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DES
KTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K
0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starti
ng work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for
 Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Nod
e <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92
.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@
DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHT
E3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> .(w
orker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3>
 .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K
0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KH
TE3K0)3> .(worker@DESKTOP-KHTE3K0)3> Code time=381687000 (57701000) microseconds
(worker@DESKTOP-KHTE3K0)3> Ratio [CPU Time:Real Time]= 6.614911353356094(worker@
DESKTOP-KHTE3K0)3>
```

project1.erl

```erlang
87                io:fwrite("Starting work for Master_Node ~p",[From]),
88
89                %Assignment of Work Units
90                wunit(40, Master_Node, Input),
91                io:fwrite("."),
92                Val = persistent_term:get(t),
93                persistent_term:put(t, Val - 1);
94            % From ! {self(), donework};
95            true ->
96                ok
97        end;
```

TERMINAL

```
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.94.0>        Found Coin
 "shivamgupta1z1Sj0D7tVNw+Xg=="  "000068ccd66025302145de4067eea0449f0c43880d
dd7b9816d85f70700ed49a"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.96.0>        Found Coin
 "shivamgupta1yWoo/q/ZQSBC3w=="  "00007644adb5658ef66bba90114e9634ac99c20829
a5333899d4151691437441"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1YyokC0QzsEl/Pg=="  "00006733105f8de986337cd1140957c3cf7e7f5512
a12b573a67512a40049901"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1tdr0YG8pdIquGQ=="  "0000254bdceb1f01e1a70c03d7041db970f7b2bf0a
5215946432bfe9eaf253d8"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1yxZKkJXX3NLn9A=="  "0000b14d45bf3b16f7307ab0ae22465304c6918b33
3692e2c19ce69e04a228f5"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1ZxoDJZJPR+q8ag=="  "00001314216fe3c49391856b55ec1c08212eae355c
5cd00aebbdd2044732edb7"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1EMiWmZSlg4CDdQ=="  "000013057ff49ed9f3544fcc605115318e209184f7
0aa408766514c13c8ef37c"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1MENl8cNUH1GmvA=="  "000077e7194ef77771f665da82261ab13541fd785f
6ccec821f75bb9e314248f"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1TzA/ijAf9QF/SQ=="  "0000f02a6c202e0b8a045dac5fa5d3ab03cce141f6
6044151b14088e70f33afb"
(master@DESKTOP-KHTE3K0)3> []
```

```
Eshell V13.0.4  (abort with ^G)
(worker@DESKTOP-KHTE3K0)1> c(project1).
{ok,project1}
(worker@DESKTOP-KHTE3K0)2> project1:start_worker('master@DESKTOP-KHTE3K0').
ok
(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DES
KTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K
0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starti
ng work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for
 Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Nod
e <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92
.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@
DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHT
E3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> .(w
orker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3>
 .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K
0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KH
TE3K0)3> .(worker@DESKTOP-KHTE3K0)3> Code time=564750000 (84804000) microseconds
(worker@DESKTOP-KHTE3K0)3> Ratio [CPU Time:Real Time]= 6.659473609735895(worker
@DESKTOP-KHTE3K0)3>
```

Ln 90, Col 28   Spaces: 4   UTF-8   CRLF   Erlang

Top editor:

```erlang
87                io:fwrite("Starting work for Master_Node ~p",[From]),
88
89                %Assignment of Work Units
90                wunit(50, Master_Node, Input),
91                io:fwrite("."),
92                Val = persistent_term:get(t),
93                persistent_term:put(t, Val - 1);
94            % From ! {self(), donework};
95            true ->
96                ok
97        end;
```

Top-left terminal:

```
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1uUxMYxfTKy2U5w=="  "0000a1a2f8b57022a1d0431ff6b623209609f3bdc9
3e7706c1d63c1ac5f44c38"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1e13Qki54niQ3ZQ=="  "00009ae5dbe7154f0630c47b276d3e2aac5c9bf785
376d09641b9afe48052a09"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1TMKaG2yKUaPu0g=="  "00003fae5c0979e6c2de3e6a11a54861226488c11f
b5f6de22fa989b61bf7455"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1p5pOxjpSvot4vg=="  "0000760795d9950d2398f8fb0c6857862620667da3
2ae720637aab68970c817f"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1/QZhf/jf7sPiAw=="  "000079c57b49dbe171d61910c472b3c353b86403b5
c1b0c28ad19631309f82ff"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1qLRtF/1z3xI6RQ=="  "000079699dca311d4af4799e9a7beed1a27eba72e9
f512b07193f1d7d1eeb0d7"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1EuwQZ8PonnvBfg=="  "0000661fcffa20579a536a32ab59a7f65a50d5d69d
33104cfb584429fc3b45ad"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta1Qf/0tQzON+dHOg=="  "00002ffa3fbd0a2b9a43847c7ff0f9edee45c68d3b
a5526e3cc7bbb143a6db67"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.101.0>        Found Coin
 "shivamgupta13YRK7xqVJtzMxw=="  "00003eb8edd3d79fa7a0cb340686f9348731664858
ba258c6743a63635e5f3ba"
(master@DESKTOP-KHTE3K0)3> []
```

Top-right terminal:

```
PS C:\Users\Shivam\Desktop\DOSP> erl -sname worker -setcookie uflorida
Eshell V13.0.4  (abort with ^G)
(worker@DESKTOP-KHTE3K0)1> c(project1).
{ok,project1}
(worker@DESKTOP-KHTE3K0)2> project1:start_worker('master@DESKTOP-KHTE3K0').
ok
(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DES
KTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K
0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starti
ng work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for
 Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Nod
e <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92
.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@
DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHT
E3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> .(w
orker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3>
 .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K
0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KH
TE3K0)3> .(worker@DESKTOP-KHTE3K0)3> Code time=742141000 (112396000) microsecond
s
(worker@DESKTOP-KHTE3K0)3> Ratio [CPU Time:Real Time]= 6.602912915050358(worker@
DESKTOP-KHTE3K0)3>
```

Status bar: Ln 90, Col 50   Spaces: 4   UTF-8   CRLF   Erlang

Bottom editor:

```erlang
87                io:fwrite("Starting work for Master_Node ~p",[From]),
88
89                %Assignment of Work Units
90                wunit(60, Master_Node, Input),
91                io:fwrite("."),
92                Val = persistent_term:get(t),
93                persistent_term:put(t, Val - 1);
94            % From ! {self(), donework};
95            true ->
96                ok
97        end;
```

Bottom-left terminal:

```
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1X87cKOqIihrVzQ=="  "00007081d881212c6281b79a50a5133a56e63432c4
48e544a1cd4c323ada169b"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1Jis6+0CUHuPLlw=="  "0000e1a69d22ae1779839a68c3615f7c01af23ace9
34f862969b81c5da135ef0"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1qH7hWIe8/NX8Lw=="  "00007bd5812d6ca9d5940e5a52c6502847a5bfa4ad
ed031a1550f40851d87594"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1EmPhsscG0efxcg=="  "000080d2d48aed3457e5e655a20e16357decd6ff03
5841f9e640cbfcbe11eed1"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta14mNm05Z9L7IDng=="  "0000be3f308af8cdb48f694a4cd8c71861c03b588f
8983d256d0594668e56863"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1SNK4GttGsGh3gg=="  "000086da79034c732ace6c617768514d025a24d79d
d429a1ee8dd383d592a4fe"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1c+F16ioKRetvIQ=="  "00007fbcb0eeffe63dd81fb773960bf845b594558e
14ba0b5266d6aa55859a48"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1/Qj+p8p5cVg4GA=="  "0000a40d64e2c914546c029c9b276b7a6e4003914b
9e5702da36c37a84745a59"
(master@DESKTOP-KHTE3K0)3> "Worker" with ID <13270.93.0>        Found Coin
 "shivamgupta1N9KXrigQJxgNzA=="  "0000731479d4c66b75405cfab6a8b70ec73f45c415
d97e7681e53cbaff9f692e"
(master@DESKTOP-KHTE3K0)3> []
```

Bottom-right terminal:

```
PS C:\Users\Shivam\Desktop\DOSP> erl -sname worker -setcookie uflorida
Eshell V13.0.4  (abort with ^G)
(worker@DESKTOP-KHTE3K0)1> c(project1).
{ok,project1}
(worker@DESKTOP-KHTE3K0)2> project1:start_worker('master@DESKTOP-KHTE3K0').
ok
(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DES
KTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K
0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starti
ng work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for
 Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Nod
e <13270.92.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92
.0>(worker@DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@
DESKTOP-KHTE3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHT
E3K0)3> Starting work for Master_Node <13270.92.0>(worker@DESKTOP-KHTE3K0)3> .(w
orker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K0)3>
 .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KHTE3K
0)3> .(worker@DESKTOP-KHTE3K0)3> .(worker@DESKTOP-KH
TE3K0)3> .(worker@DESKTOP-KHTE3K0)3> Code time=788906000 (128058000) microsecond
s
(worker@DESKTOP-KHTE3K0)3> Ratio [CPU Time:Real Time]= 6.160536631838698(worker@
DESKTOP-KHTE3K0)3>
```

Status bar: Ln 90, Col 28   Spaces: 4   UTF-8   CRLF   Erlang

- The result of running your program for input 4.

Number of Workers = 10, Work Units to find coins = 10, Number of Zeroes = 4
Code Time: Code time=107422000 (18224000) microseconds
Ratio: Ratio [CPU Time:Real Time]= 5.894534679543459

- The running time for the above is reported by time for the above and report the time. The ratio of CPU time to REAL TIME tells you how many cores were effectively used in the computation. If you are close to 1 you have almost no parallelism (points will be subtracted).

Number of Workers = 10, Work Units to find coins = 10, Number of Zeroes = 4
Code Time: Code time=107422000 (18224000) microseconds
Ratio: Ratio [CPU Time:Real Time]= 5.894534679543459

- The coin with the most 0s you managed to find.
  7 Leading Zeroes

  "shivamgupta1rD1XkCc59aww
  0000000801def69122a2b446fd9e6ed039b04453815c76cff280f8be56a2659f"Code
  time=2587891000 (325699563) microseconds

```
"shivamgupta1rD1XkCc59aww    0000000801def69122a2b446fd9e6ed039b04453815c76cff280f8be56a2659f"Code time=2587891000
ok
3>
```

Xorbin Verification for 7 leading zeroes.

- The largest number of working machines you were able to run your code with.

  The program was implemented on **2 systems** as detailed in the Distributed Implementation section between the two partners i.e. Caroline Fedele and Shivam Gupta.

```
{ok,master}
(caroline@DESKTOP-QSBT3FN)2> net_adm:ping('shivam@DESKTOP-KHTE3K0').
pong
(caroline@DESKTOP-QSBT3FN)3> project1:start_master('shivam@DESKTOP-KHTE3K0',4).
true
(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3
FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> 4(caroline@DESKTOP-QSBT3FN)4> Coin Found (carol
ine@DESKTOP-QSBT3FN)4> "shivamgupta17mr5vUCHZ1fu"(caroline@DESKTOP-QSBT3FN)4> (caroline@DESKTOP-QSBT3FN)4> "00008534d6ddef11bd515b2cd9eeb07de2835b7bcc1ebb5bf66b831b23658eeb"
(caroline@DESKTOP-QSBT3FN)4>  (caroline@DESKTOP-QSBT3FN)4> Actor PID = <13270.108.0>(caroline@DESKTOP-QSBT3FN)4>
(caroline@DESKTOP-QSBT3FN)4> Coin Found (caroline@DESKTOP-QSBT3FN)4> "shivamgupta1/SES5LX3VL99"(caroline@DESKTOP-QSBT3FN)4> (caroline@DESKTOP-QSBT3FN)4> "0000fdb121b440b7b5e
eba3ddd6c72cf684f4d9c36ea4edde84cdbc745d240cf"(caroline@DESKTOP-QSBT3FN)4>  (caroline@DESKTOP-QSBT3FN)4> Actor PID = <13270.105.0>(caroline@DESKTOP-QSBT3FN)4>
(caroline@DESKTOP-QSBT3FN)4> Coin Found (caroline@DESKTOP-QSBT3FN)4> "shivamgupta1+BQpYJMzzmGP"(caroline@DESKTOP-QSBT3FN)4> (caroline@DESKTOP-QSBT3FN)4> "0000683ca988750e2af
3f36ca78baa27b4c7ea56a95777b950b48c4461e03591"(caroline@DESKTOP-QSBT3FN)4>  (caroline@DESKTOP-QSBT3FN)4> Actor PID = <13270.102.0>(caroline@DESKTOP-QSBT3FN)4>
(caroline@DESKTOP-QSBT3FN)4> Coin Found (caroline@DESKTOP-QSBT3FN)4> "shivamgupta1hdXKBZPiC9Vr"(caroline@DESKTOP-QSBT3FN)4> (caroline@DESKTOP-QSBT3FN)4> "0000eb966ea4f734e46
45d7d2affb17e6931eec4e55c78df12c14e55d5f391d8"(caroline@DESKTOP-QSBT3FN)4>  (caroline@DESKTOP-QSBT3FN)4> Actor PID = <13270.100.0>(caroline@DESKTOP-QSBT3FN)4>
```

```
{ok,master}
(shivam@DESKTOP-KHTE3K0)2> net_adm:ping('caroline@DESKTOP-QSBT3FN').
pang
(shivam@DESKTOP-KHTE3K0) project1:start_worker('caroline@DESKTOP-QSBT3FN').
Master finished 'caroline@DESKTOP-OSBT3FN' 4
Code time= 7422000 (18224000) microseconds
Ratio [CPU Time:Real Time]= 5.894534679543459
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
(shivam@DESKTOP-KHTE3K0)4> Actor Work finished for 'caroline@DESKTOP-QSBT3FN' 4
```