Design:

Semaphores:

tellerSem:

Initial Value: 0

Purpose: Used by Teller to signal Customer it is available.

officerSem:

Initial Value: 0

Purpose: Used by Loan Officer to signal Customer it is available.

readySem:

Initial Value: 0

Purpose: Used by Customer to signal Teller that tellerSem was acknowledged.
Creates instance of synchronization between specific Customer and
Teller.

readyOSem:

Initial Value: 0

Purpose: Used by Customer to signal Loan Officer that officerSem was
acknowledged. Creates instance of synchronization between specific
Customer and Loan Officer.

editIDSem:

Initial Value: 1

Purpose: Universal mutex lock of shared variables used by all instances.

registeredCID:

Initial Value: 0

Purpose: Used by Customer to signal Bank Teller that Customer ID was recorded
in the shared variable.

gotCID:

Initial Value: 0

Purpose: Used by Bank Teller to signal Customer that Customer ID was recorded
at a local level within the Bank Teller thread.

registeredTID:

Initial Value: 0

Purpose: Used by Bank Teller to signal Customer that Teller ID was recorded
in the shared variable.

gotTID:

Initial Value: 0

Purpose: Used by Customer to signal Bank Teller that Teller ID was recorded at a
local level within the Customer thread.

registeredOID:

> *Initial Value: 0*
>
> *Purpose: Used by Loan Officer to signal Customer that Officer ID was recorded in the shared variable.*

gotOID:

> *Initial Value: 0*
>
> *Purpose: Used by Customer to signal Loan Officer that Officer ID was recorded at a local level within the Customer thread.*

registeredOCID:

> *Initial Value: 0*
>
> *Purpose: Used by Customer to signal Loan Officer that Customer ID was recorded in the shared variable.*

gotOCID:

> *Initial Value: 0*
>
> *Purpose: Used by Loan Officer to signal Customer that Customer ID was recorded at a local level within the Loan Officer thread.*

registeredDetails:

> *Initial Value: 0*
>
> *Purpose: Used by Customer to signal Bank Teller/Loan Officer that transaction details have been recorded in the shared variable.*

gotDetails:

> *Initial Value: 0*
>
> *Purpose: Used by Bank Teller/Loan Officer to signal Customer that Customer transaction amount, balance, and transaction type was recorded at a local level within the Bank Teller/Loan Officer thread.*

Pseudocode:

```
Semaphore tellerSem = 0;
Semaphore officerSem = 0;
Semaphore readySem = 0;
Semaphore readyOSem = 0;
Semaphore editIDSem = 1;
Semaphore registeredCID = 0;
Semaphore gotCID = 0;
Semaphore registeredTID = 0;
Semaphore gotTID = 0;
Semaphore registeredOID = 0;
Semaphore gotOID = 0;
Semaphore registeredOCID = 0;
Semaphore gotOCID = 0;
Semaphore registeredDetails = 0;
Semaphore gotDetails = 0;

void Customer_Deposit()
- and - void Customer_Withdrawal()
- and - void Customer_Loan()
{

        while (numVisit < 3)
        {

                wait(tellerSem);
                signal(readySem);
                wait(editIDSem);
                LocalCIDtoSharedCID();
                signal(registeredCID);
                wait(gotCID);
                wait(registeredTID);
                SharedTIDtoLocalTID();
                signal(gotTID)
                LocalDetailstoSharedDetails();
                signal(registeredDetails);
                wait(gotDetails)
                SharedBalancetoLocalBalance();
                signal(editIDSem);

        }
}
```

```
void Teller_Deposit()
- and - void Teller_Withdrawal()

{

        while (true)

        {

                signal(tellerSem);
                wait(readySem);
                wait(registeredCID);
                SharedCIDtoLocalCID();
                signal(gotCID);
                LocalTIDtoSharedTID();
                signal(registeredTID);
                wait(gotTID);
                wait(registeredDetails);
                SharedDetailstoLocalDetails();
                if(localIsDeposit)
                {
                        LocalBalancePlusLocalDeposit();
                        LocalBalancetoSharedBalance();
                }
                else
                {
                        LocalBalanceMinusLocalWithdrawal();
                        LocalBalancetoSharedBalance();

                }
                signal(gotDetails);

        }

}
```

```
void Loan()

{

        while (true)

        {

                signal(officerSem);
                wait(readyOSem);
                wait(registeredOCID);
                SharedCIDtoLocalCID();
                signal(gotOCID)
                LocalOIDtoSharedOID();
                signal(registeredOID);
                wait(gotOID);
                wait(registeredDetails);
                SharedDetailstoLocalDetails();
                AddLocalLoantoLocalBalance();
                LocalBalancetoSharedBalance();
                signal(gotDetails);

        }

}
```

Example Run:

Raw Output:	*Organized Output:*
Customer 0 created	Teller 0 created
Customer 2 created	Teller 1 created
Customer 1 created	Loan Officer 0 created
Customer 3 created	
Customer 4 created	Customer 0 created
Teller 0 created	Teller 0 begins serving customer 0
Teller 1 created	Customer 0 requests of teller 0 to make
Loan Officer 0 created	a deposit of $300
Teller 0 begins serving customer 0	Teller 0 processes the deposit of $300
Customer 0 requests of teller 0 to make	for customer 0
a deposit of $300	Customer 0 gets receipt from teller 0
Teller 0 processes the deposit of $300	Teller 0 begins serving customer 0
for customer 0	Customer 0 requests of teller 0 to make
Customer 0 gets receipt from teller 0	a deposit of $300
Teller 0 begins serving customer 1	Teller 0 processes the deposit of $300
Customer 1 requests of teller 0 to make	for customer 0
a deposit of $400	Customer 0 gets receipt from teller 0
Teller 0 processes the deposit of $400	Loan Officer 0 begins serving customer 0
for customer 1	Customer 0 requests of loan officer 0 to
Customer 1 gets receipt from teller 0	apply for a loan of $200
Teller 0 begins serving customer 0	Loan Officer 0 approves loan for
Customer 0 requests of teller 0 to make	customer 0
a deposit of $300	Customer 0 gets loan from loan officer 0
Teller 0 processes the deposit of $300	Customer 0 departs the bank
for customer 0	Customer 0 is joined by main
Customer 0 gets receipt from teller 0	
Teller 0 begins serving customer 1	
Customer 1 requests of teller 0 to make	Customer 1 created
a withdrawal of $100	Teller 0 begins serving customer 1
Teller 0 processes the withdrawal of	Customer 1 requests of teller 0 to make
$100 for customer 1	a deposit of $400
Customer 1 gets cash and receipt from	Teller 0 processes the deposit of $400
teller 0	for customer 1
Teller 0 begins serving customer 1	Customer 1 gets receipt from teller 0
Customer 1 requests of teller 0 to make	Teller 0 begins serving customer 1
a deposit of $100	Customer 1 requests of teller 0 to make
Teller 0 processes the deposit of $100	a withdrawal of $100
for customer 1	Teller 0 processes the withdrawal of
Customer 1 gets receipt from teller 0	$100 for customer 1
Customer 1 departs the bank	Customer 1 gets cash and receipt from
Loan Officer 0 begins serving customer 3	teller 0
Customer 3 requests of loan officer 0 to	Teller 0 begins serving customer 1
apply for a loan of $300	Customer 1 requests of teller 0 to make
Loan Officer 0 approves loan for	a deposit of $100
customer 3	Teller 0 processes the deposit of $100
Customer 3 gets loan from loan officer 0	for customer 1
Loan Officer 0 begins serving customer 2	Customer 1 gets receipt from teller 0
	Customer 1 departs the bank

Customer 2 requests of loan officer 0 to
apply for a loan of $100
Loan Officer 0 approves loan for
customer 2
Customer 2 gets loan from loan officer 0
Teller 1 begins serving customer 2
Customer 2 requests of teller 1 to make
a withdrawal of $100
Teller 1 processes the withdrawal of
$100 for customer 2
Customer 2 gets cash and receipt from
teller 1
Loan Officer 0 begins serving customer 4
Customer 4 requests of loan officer 0 to
apply for a loan of $100
Loan Officer 0 approves loan for
customer 4
Customer 4 gets loan from loan officer 0
Teller 0 begins serving customer 2
Customer 2 requests of teller 0 to make
a withdrawal of $100
Teller 0 processes the withdrawal of
$100 for customer 2
Customer 2 gets cash and receipt from
teller 0
Customer 2 departs the bank
Loan Officer 0 begins serving customer 0
Customer 0 requests of loan officer 0 to
apply for a loan of $200
Loan Officer 0 approves loan for
customer 0
Customer 0 gets loan from loan officer 0
Teller 1 begins serving customer 4
Customer 0 departs the bank
Customer 4 requests of teller 1 to make
a withdrawal of $300
Customer 0 is joined by main
Teller 1 processes the withdrawal of
$300 for customer 4
Customer 1 is joined by main
Customer 2 is joined by main
Customer 4 gets cash and receipt from
teller 1
Loan Officer 0 begins serving customer 3
Customer 3 requests of loan officer 0 to
apply for a loan of $300
Loan Officer 0 approves loan for
customer 3
Customer 3 gets loan from loan officer 0
Teller 0 begins serving customer 4
Customer 4 requests of teller 0 to make
a withdrawal of $100
Teller 0 processes the withdrawal of
$100 for customer 4

Customer 1 is joined by main

Customer 2 created
Loan Officer 0 begins serving customer 2
Customer 2 requests of loan officer 0 to
apply for a loan of $100
Loan Officer 0 approves loan for
customer 2
Customer 2 gets loan from loan officer 0
Teller 1 begins serving customer 2
Customer 2 requests of teller 1 to make
a withdrawal of $100
Teller 1 processes the withdrawal of
$100 for customer 2
Customer 2 gets cash and receipt from
teller 1
Teller 0 begins serving customer 2
Customer 2 requests of teller 0 to make
a withdrawal of $100
Teller 0 processes the withdrawal of
$100 for customer 2
Customer 2 gets cash and receipt from
teller 0
Customer 2 departs the bank
Customer 2 is joined by main

Customer 3 created
Loan Officer 0 begins serving customer 3
Customer 3 requests of loan officer 0 to
apply for a loan of $300
Loan Officer 0 approves loan for
customer 3
Customer 3 gets loan from loan officer 0
Loan Officer 0 begins serving customer 3
Customer 3 requests of loan officer 0 to
apply for a loan of $300
Loan Officer 0 approves loan for
customer 3
Customer 3 gets loan from loan officer 0
Teller 1 begins serving customer 3
Customer 3 requests of teller 1 to make
a withdrawal of $400
Teller 1 processes the withdrawal of
$400 for customer 3
Customer 3 gets cash and receipt from
teller 1
Customer 3 departs the bank
Customer 3 is joined by main

Customer 4 created
Loan Officer 0 begins serving customer 4
Customer 4 requests of loan officer 0 to
apply for a loan of $100

Customer 4 gets cash and receipt from teller 0
Customer 4 departs the bank
Teller 1 begins serving customer 3
Customer 3 requests of teller 1 to make a withdrawal of $400
Teller 1 processes the withdrawal of $400 for customer 3
Customer 3 gets cash and receipt from teller 1
Customer 3 departs the bank
Customer 3 is joined by main
Customer 4 is joined by main
Teller 0 is joined by main
Teller 1 is joined by main
Loan Officer 0 is joined by main

                    Bank Simulation Summary

                    Ending balance   Loan
Amount

Customer 0   1600   200
Customer 1   1400   0
Customer 2   800   100
Customer 3   600   600
Customer 4   600   100

Totals   5000   1000

Loan Officer 0 approves loan for customer 4
Customer 4 gets loan from loan officer 0
Teller 1 begins serving customer 4
Customer 4 requests of teller 1 to make a withdrawal of $300
Teller 1 processes the withdrawal of $300 for customer 4
Customer 4 gets cash and receipt from teller 1
Teller 0 begins serving customer 4
Customer 4 requests of teller 0 to make a withdrawal of $100
Teller 0 processes the withdrawal of $100 for customer 4
Customer 4 gets cash and receipt from teller 0
Customer 4 departs the bank
Customer 4 is joined by main

Teller 0 is joined by main
Teller 1 is joined by main
Loan Officer 0 is joined by main

                    Bank Simulation Summary

                    Ending balance   Loan
Amount

Customer 0   1600   200
Customer 1   1400   0
Customer 2   800   100
Customer 3   600   600
Customer 4   600   100

Totals   5000   1000