Ahmad Adil 11/25/22
Computer Science 332: Operating Systems Laboratory
Professor Debnath

Information extracted from the original Code:

- Within the original code, there are two ATMs, however there are three processes being run. The important thing here is to make sure to avoid logical errors.
- Next, when money is deposited into the bank account by the dad process, it needs to be added to the New Balance.

Errors that resulted from the original source code:

```
SON_1 reads balance. Available Balance: 0
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 0
Number of attempts remaining: 15
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: -20
Number of attempts remaining:15
Dad writes new balance = 100
Dad will deposit 3 more time
SON_2 is requesting to view the balance.
SON_1 is requesting to view the balance.
```

- Negative balances are shown in New Balance and Available Balance. This is impossible since you cannot withdraw more money than you have.

```
SON_2 reads balance. Available Balance: 100
SON_1 reads balance. Available Balance: 100
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 80
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 80
Number of attempts remaining: 14
Number of attempts remaining:14
Dad is requesting to view the balance.
Dad reads balance = 80
```

- Within the figure above, when the SON_2 process withdrew 20, the New Balance became 80, however, when the SON_1 process withdrew the remaining 20, the New Balance stayed the same at 80, when it should have been 60.

Changes made to the original source code to resolve the errors:

```
/**
 * creating three semaphores for the three processes:
 * each for dad, son_1 and son_2
 */

int dad = semget(IPC_PRIVATE, 1,0666 | IPC_CREAT);
int son_1 = semget(IPC_PRIVATE, 1,0666 | IPC_CREAT);
int son_2 = semget(IPC_PRIVATE, 1,0666 | IPC_CREAT);

// Initalizing the semaphores
sem_create(dad,1);
sem_create(son_1,1);
sem_create(son_2, 1);

// Initalizing the file to have $100
fp1 = fopen("balance.txt", "w+");
bal1 = initBalance;
fprintf(fp1, "%d\n", bal1);
fclose(fp1);
```

- The code above is to ensure that no mistakes are made within the three processes and the two ATMs. A safeguard is created and initialized with three semaphores.

```
printf("SON_2 wants to withdraw money. ");
fseek(fp2,0L, 0);
if(bal2 >= WithdrawAmount)
    bal2 -= WithdrawAmount;

else
    printf("Insufficient Funds\n");
    fprintf(fp2,"%d\n", bal2);
    fclose(fp2);

printf("SON_2 withdrawed %d. New Balance: %d \n",WithdrawAmount, bal2);
```

- In order to ensure that there will be no negative balances, an if-else statement was put into place to decline the withdrawal and print an error if there are not sufficient funds in the account.

Dad Process:

```
for(i=1;i<=N; i++)
{
    // DAD process
    P(son_1);
    P(son_2);
    //Dad is requesting to get hold of an ATM.
    printf("Dad is requesting to view the balance.\n");
    //Dad successfully got hold of the ATM.
    fp1 = fopen("balance.txt", "r+");
    fscanf(fp1, "%d", &bal2);
    printf("Dad reads balance = %d \n", bal2);
    int r = rand()%5+1;
    printf("Dad needs %d sec to prepare money\n", r);
    //Dad Process is sleeping for r sec. You need to make sure that other processes can work in the mean time.
    sleep(r);

    fseek(fp1,0L,0); //Dad will now deposit the money. For this Dad will access the ATM again. And update the current balance.
    bal2 += DepositAmount;
    fprintf(fp1, "%d \n", bal2);
    fclose(fp1);
    printf("Dad writes new balance = %d \n", bal2);
    printf("Dad will deposit %d more time\n",N-i); //Dad depostited the money.
    sleep(rand()%10+1); /* Dad will wait some time for requesting to see balance again.*/
    V(son_1);
    V(son_2);
}
```

- In order to ensure that the deposited amount is added to the New Balance, the SON_1 and SON_2 processes are prevented from running while the Dad process is running.

Ahmad Adil
Computer Science 332: Operating Systems Laboratory
Professor Debnath

11/25/22

SON_1 Process:

```
// SON_1 Process
else
{
    P(dad);
    P(son_2);
    fp2 = fopen("balance.txt", "r+");//Son_1 reads the balance.
    fscanf(fp2,"%d", &bal2);
    printf("SON_1 reads balance. Available Balance: %d \n", bal2);
    printf("SON_1 wants to withdraw money. "); //And if balance is greater than Withdraw amount, then son can withdraw money.
    fseek(fp2,0L, 0);

    if(bal2 >= WithdrawAmount)
        bal2 -= WithdrawAmount;

    else
        printf("Insufficient Funds\n");
        fprintf(fp2,"%d\n", bal2);
        fclose(fp2);
        printf("SON_1 withdrawed %d. New Balance: %d \n",WithdrawAmount, bal2);

    fseek(fp3,0L, 0); //SON_1 will write the number of  attempt remaining in the attampt.txt file.
    N_Att -=1;
    fprintf(fp3, "%d\n", N_Att);
    fclose(fp3);
    printf("Number of attempts remaining:%d \n", N_Att);
    V(dad);
    V(son_2);
}

sleep(rand()%10+1); //SON_1 will wait some time before the next request.
```

SON_2 Process:

```
    // SON_2 Process
    else
    {
        P(dad);
        P(son_1);
        //Son_2 reads the balance.
        fp2 = fopen("balance.txt", "r+");
        fscanf(fp2,"%d", &bal2);
        printf("SON_2 reads balance. Available Balance: %d \n", bal2);
        //And if balance is greater than Withdraw amount, then son can withdraw money.
        printf("SON_2 wants to withdraw money. ");
        fseek(fp2,0L, 0);
        if(bal2 >= WithdrawAmount)
            bal2 -= WithdrawAmount;

        else
            printf("Insufficient Funds\n");
            fprintf(fp2,"%d\n", bal2);
            fclose(fp2);

        printf("SON_2 withdrawed %d. New Balance: %d \n",WithdrawAmount, bal2);
        fseek(fp3,0L, 0); //SON_2 will write the number of  attempt remaining in the attampt.txt file.
        N_Att -=1;
        fprintf(fp3, "%d\n", N_Att);
        fclose(fp3);
        printf("Number of attempts remaining: %d \n", N_Att);
        V(dad);
        V(son_1);
    }

    sleep(rand()%10+1);//SON_2 will wait some time before the next request.
}
```

Ahmad Adil 11/25/22
Computer Science 332: Operating Systems Laboratory
Professor Debnath

- In order to ensure that SON_1 and SON_2 processes can withdraw money properly, there cannot be another deposit or withdrawal on the second ATM, until the first withdrawal on the first ATM is finished. To achieve this, while the SON_1(SON_2) process is running, the dad and SON_2(SON_1) processes are prevented from running.

Ahmad Adil 11/25/22
Computer Science 332: Operating Systems Laboratory
Professor Debnath

Terminal Output:

```
adil@adil-VirtualBox:~/Documents/CSC332-hw/lab6$ ./bank
First Son's Pid: 3653
Dad's Pid: 3652
SON_1 is requesting to view the balance.
Dad is requesting to view the balance.
Attempt remaining: 20.
Dad reads balance = 0
Dad needs 2 sec to prepare money
Second Son's Pid: 3654
SON_2 is requesting to view the balance.
Attempt remaining: 20.
Dad writes new balance = 60
Dad will deposit 4 more time
SON_1 reads balance. Available Balance: 60
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 40
Number of attempts remaining:19
Dad is requesting to view the balance.
Dad reads balance = 40
Dad needs 4 sec to prepare money
Dad writes new balance = 100
Dad will deposit 3 more time
SON_2 reads balance. Available Balance: 100
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 80
Number of attempts remaining: 19
Dad is requesting to view the balance.
Dad reads balance = 80
Dad needs 3 sec to prepare money
SON_1 is requesting to view the balance.
Attempt remaining: 19.
Dad writes new balance = 140
Dad will deposit 2 more time
SON_2 is requesting to view the balance.
Attempt remaining: 19.
SON_1 reads balance. Available Balance: 140
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 120
Number of attempts remaining:18
Dad is requesting to view the balance.
Dad reads balance = 120
Dad needs 4 sec to prepare money
Dad writes new balance = 180
Dad will deposit 1 more time
SON_1 is requesting to view the balance.
Attempt remaining: 18.
SON_2 reads balance. Available Balance: 180
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 160
```

Ahmad Adil 11/25/22
Computer Science 332: Operating Systems Laboratory
Professor Debnath

```
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 140
Number of attempts remaining:17
Dad is requesting to view the balance.
Dad reads balance = 140
Dad needs 1 sec to prepare money
Dad writes new balance = 200
Dad will deposit 0 more time
SON_1 is requesting to view the balance.
Attempt remaining: 17.
SON_2 is requesting to view the balance.
Attempt remaining: 17.
SON_1 reads balance. Available Balance: 200
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 180
Number of attempts remaining:16
SON_2 reads balance. Available Balance: 180
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 160
Number of attempts remaining: 16
child(pid = 3652) exited with the status 0.
SON_1 is requesting to view the balance.
Attempt remaining: 16.
SON_1 reads balance. Available Balance: 160
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 140
Number of attempts remaining:15
SON_2 is requesting to view the balance.
Attempt remaining: 15.
SON_2 reads balance. Available Balance: 140
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 120
Number of attempts remaining: 14
SON_1 is requesting to view the balance.
Attempt remaining: 14.
SON_1 reads balance. Available Balance: 120
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 100
Number of attempts remaining:13
SON_2 is requesting to view the balance.
Attempt remaining: 13.
SON_2 reads balance. Available Balance: 100
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 80
Number of attempts remaining: 12
SON_2 is requesting to view the balance.
SON_1 is requesting to view the balance.
Attempt remaining: 12.
```

Ahmad Adil 11/25/22
Computer Science 332: Operating Systems Laboratory
Professor Debnath

```
Attempt remaining: 12.
SON_2 reads balance. Available Balance: 80
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 60
Number of attempts remaining: 11
SON_1 reads balance. Available Balance: 60
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 40
Number of attempts remaining:11
SON_2 is requesting to view the balance.
SON_1 is requesting to view the balance.
Attempt remaining: 11.
Attempt remaining: 11.
SON_1 reads balance. Available Balance: 40
SON_1 wants to withdraw money. SON_1 withdrawed 20. New Balance: 20
Number of attempts remaining:10
SON_2 reads balance. Available Balance: 20
SON_2 wants to withdraw money. SON_2 withdrawed 20. New Balance: 0
Number of attempts remaining: 10
SON_2 is requesting to view the balance.
Attempt remaining: 10.
SON_2 reads balance. Available Balance: 0
SON_2 wants to withdraw money. Insufficient Funds
SON_2 withdrawed 20. New Balance: 0
Number of attempts remaining: 9
SON_1 is requesting to view the balance.
Attempt remaining: 9.
SON_1 reads balance. Available Balance: 0
SON_1 wants to withdraw money. Insufficient Funds
SON_1 withdrawed 20. New Balance: 0
Number of attempts remaining:8
SON_2 is requesting to view the balance.
Attempt remaining: 8.
SON_2 reads balance. Available Balance: 0
SON_2 wants to withdraw money. Insufficient Funds
SON_2 withdrawed 20. New Balance: 0
Number of attempts remaining: 7
SON_1 is requesting to view the balance.
Attempt remaining: 7.
SON_1 reads balance. Available Balance: 0
SON_1 wants to withdraw money. Insufficient Funds
SON_1 withdrawed 20. New Balance: 0
Number of attempts remaining:6
SON_2 is requesting to view the balance.
Attempt remaining: 6.
```

Ahmad Adil 11/25/22
Computer Science 332: Operating Systems Laboratory
Professor Debnath

```
SON_2 reads balance. Available Balance: 0
SON_2 wants to withdraw money. Insufficient Funds
SON_2 withdrawed 20. New Balance: 0
Number of attempts remaining: 5
SON_1 is requesting to view the balance.
Attempt remaining: 5.
SON_1 reads balance. Available Balance: 0
SON_1 wants to withdraw money. Insufficient Funds
SON_1 withdrawed 20. New Balance: 0
Number of attempts remaining:4
SON_2 is requesting to view the balance.
Attempt remaining: 4.
SON_2 reads balance. Available Balance: 0
SON_2 wants to withdraw money. Insufficient Funds
SON_2 withdrawed 20. New Balance: 0
Number of attempts remaining: 3
SON_1 is requesting to view the balance.
Attempt remaining: 3.
SON_1 reads balance. Available Balance: 0
SON_1 wants to withdraw money. Insufficient Funds
SON_1 withdrawed 20. New Balance: 0
Number of attempts remaining:2
SON_2 is requesting to view the balance.
Attempt remaining: 2.
SON_2 reads balance. Available Balance: 0
SON_2 wants to withdraw money. Insufficient Funds
SON_2 withdrawed 20. New Balance: 0
Number of attempts remaining: 1
SON_1 is requesting to view the balance.
Attempt remaining: 1.
SON_1 reads balance. Available Balance: 0
SON_1 wants to withdraw money. Insufficient Funds
SON_1 withdrawed 20. New Balance: 0
Number of attempts remaining:0
SON_1 is requesting to view the balance.
Attempt remaining: 0.
SON_2 is requesting to view the balance.
Attempt remaining: 0.
child(pid = 3654) exited with the status 0.
child(pid = 3653) exited with the status 0.
adil@adil-VirtualBox:~/Documents/CSC332-hw/lab6$
```