Exercise 3.38.

Suppose that Peter, Paul, and Mary share a joint bank account that initially contains $100. Concurrently, Peter deposits $10, Paul withdraws $20, and Mary withdraws half the money in the account, by executing the following commands:

```
Peter:   (set! balance (+ balance 10))
Paul:    (set! balance (- balance 20))
Mary:    (set! balance (- balance (/ balance 2)))
```

a. List all the different possible values for `balance` after these three transactions have been completed, assuming that the banking system forces the three processes to run sequentially in some order.

b. What are some other values that could be produced if the system allows the processes to be interleaved? Draw timing diagrams like the one in figure 3.29 to explain how these values can occur.

Answer.

a. There are four possible values after these three processes been run sequentially in some order: 35, 40, 45 or 50.

b. Interleave only occurs when at least two people try to access the same account simultaneously. For otherwise these three transactions would occur sequentially, as subproblem a. addressed.

Transactions in which interleave involved can be roughly divided into three groups:

i. All three individuals tries to modify the joint account simultaneously.

ii. Two out of three people access the account simultaneously and finish their own transactions, then the third one make another transaction based on what updated by the second one.

iii. One of them changes `balance` first, then the rest of them make their modification on the account concurrently.

Even when all three people try to modify the joint account in the same time, there may still exists 3 kinds of processes dued to whose transaction finishes last. If the transaction of Peter finishes last, the final value of `balance` is $110, a particular instance of this kind of processes is given in figure 1. If however, the request of Paul is suffied after that of Peter's and Mary's, then the account would be left with $80. Figure 2 shows one of this kind of processes. Likewise, it is also possible that Mary's transaction is not processed until both of Peter's and Paul's finish, so the value of `balance` would be set to $50 in the end. Figure 3 presents an example of this case.

We see that in the second group, the requests of two individuals is pushed concurrently and the third one will not start to process until both of the former two requests suffice. This means that the final value of the account is determined by the last two transactions been handled.

If the request of Peter as well as that of Mary, is sended to the bank system simultaneously and, Peter's transaction completes right after Mary's. Paul however, accesses the account based on the information updated by Peter. This makes the account retain $90 after all the three transactions, as figure 4 shows. Similiarly, figure 5 through figure 9 show the timing diagrams for the rest cases in the

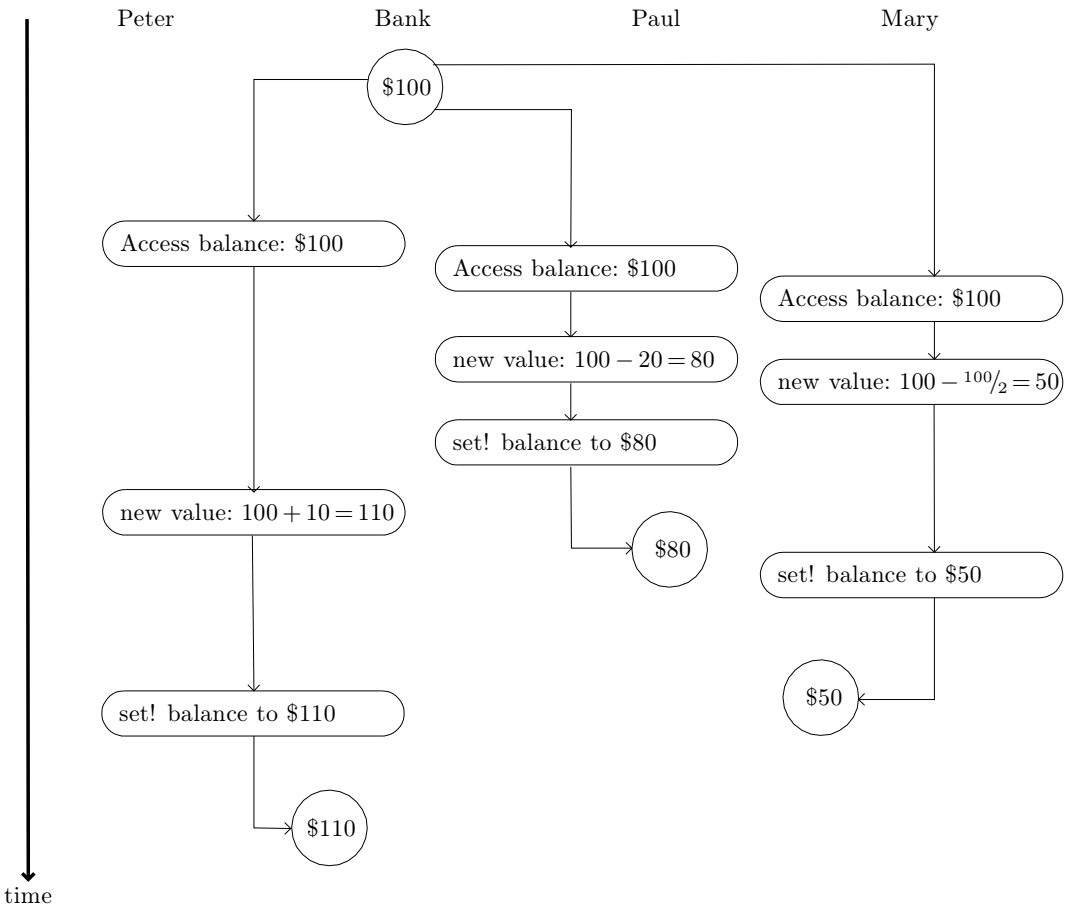

Figure 1. An instance of the case where all the three individuals tries to modify the joint account simultaneously and Peter's transaction finishes last.

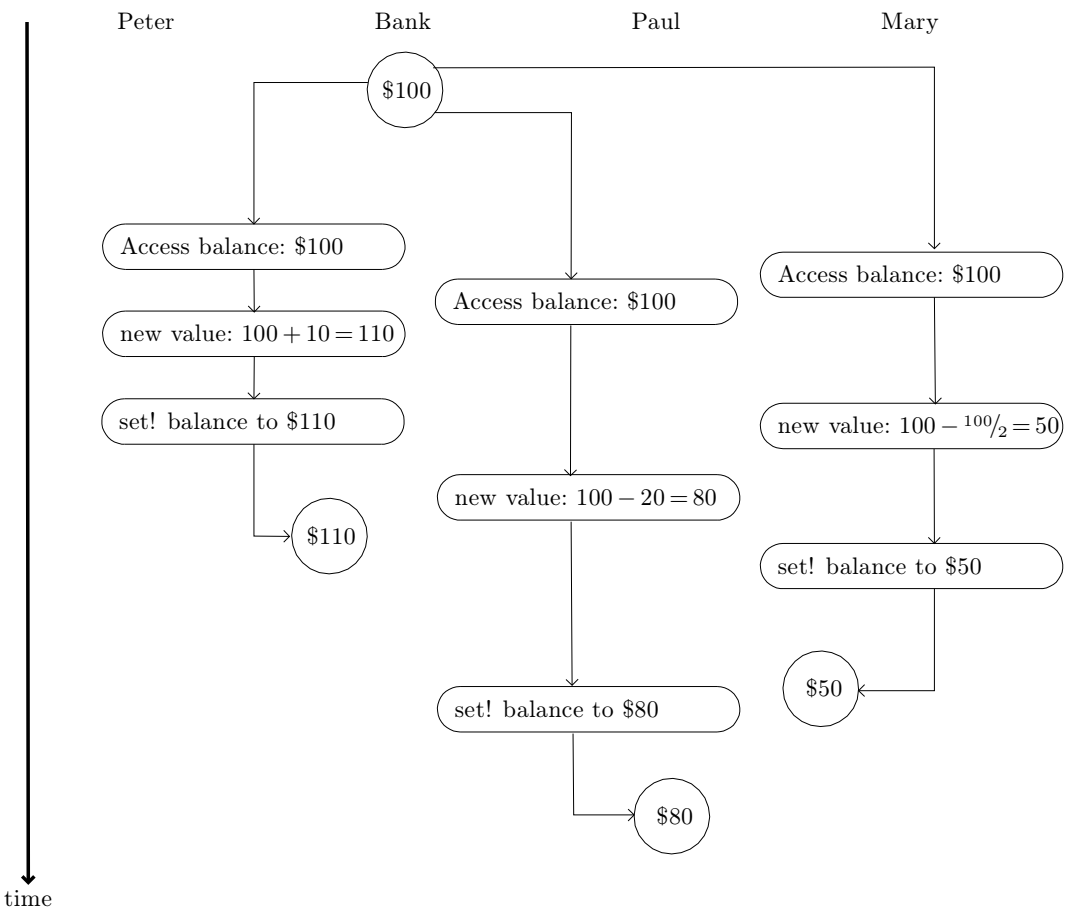

Figure 2. One of the cases where all the three individuals tries to modify the joint account simultaneously and Paul's request is suffied after Peter's and Mary's.

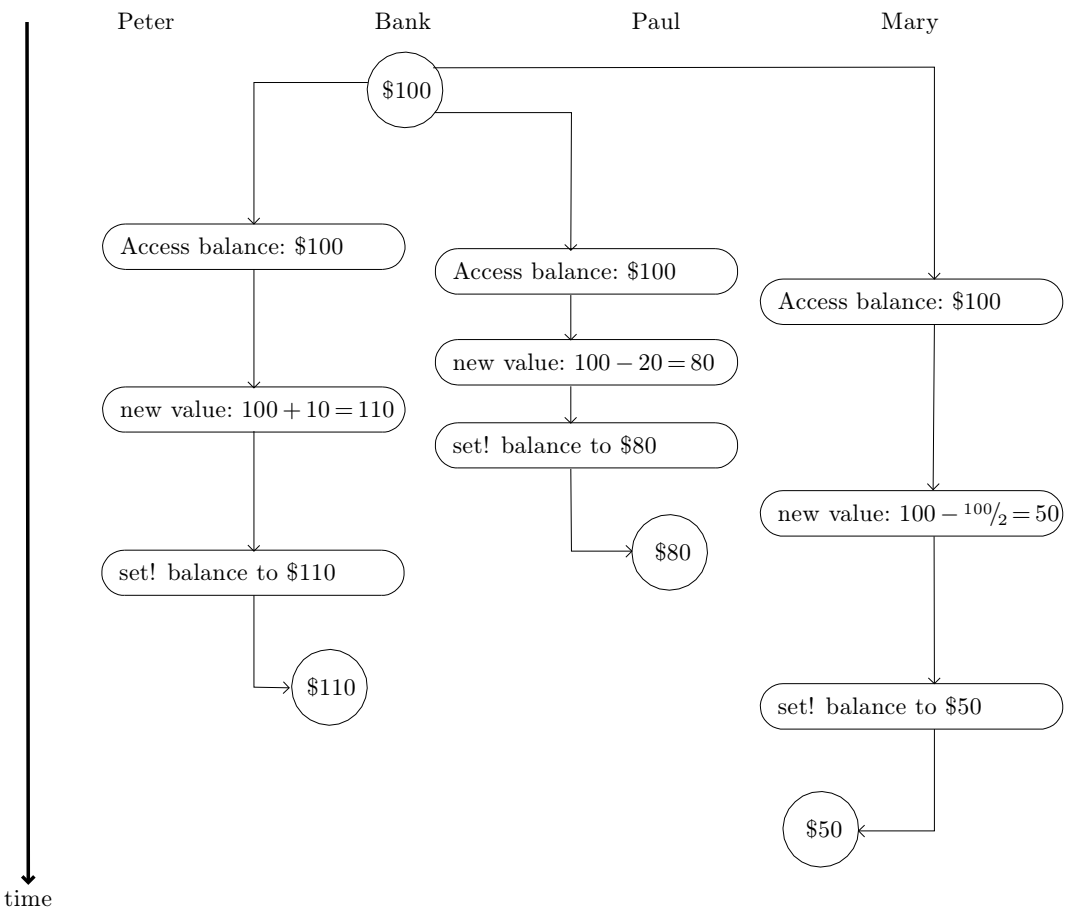

Figure 3. An example where all the three individuals tries to modify the joint account simultaneously and Mary's transaction is delayed behind that of Peter's and Mary's.

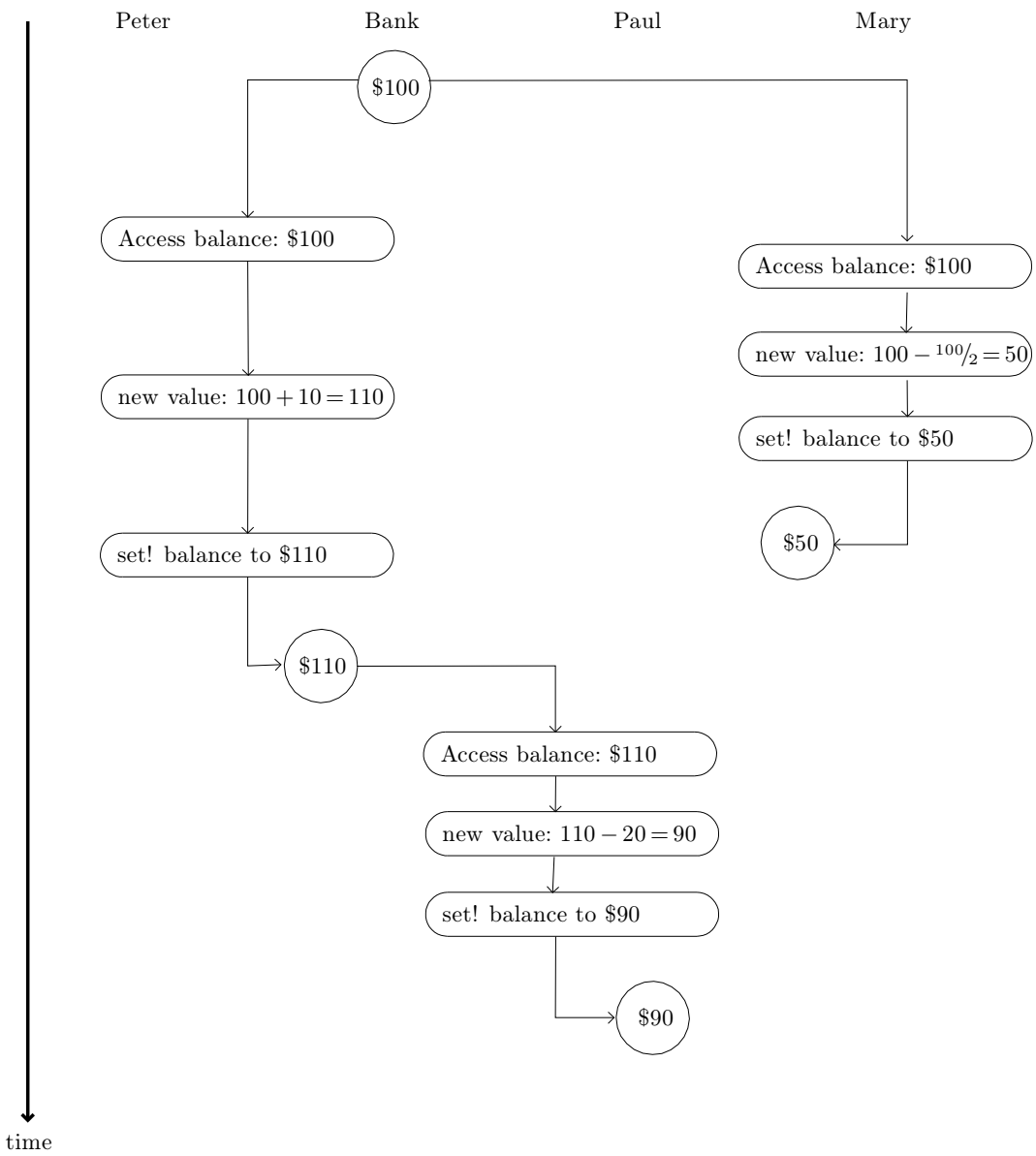

Figure 4. Paul accesses the joint account according to what updated by Peter.

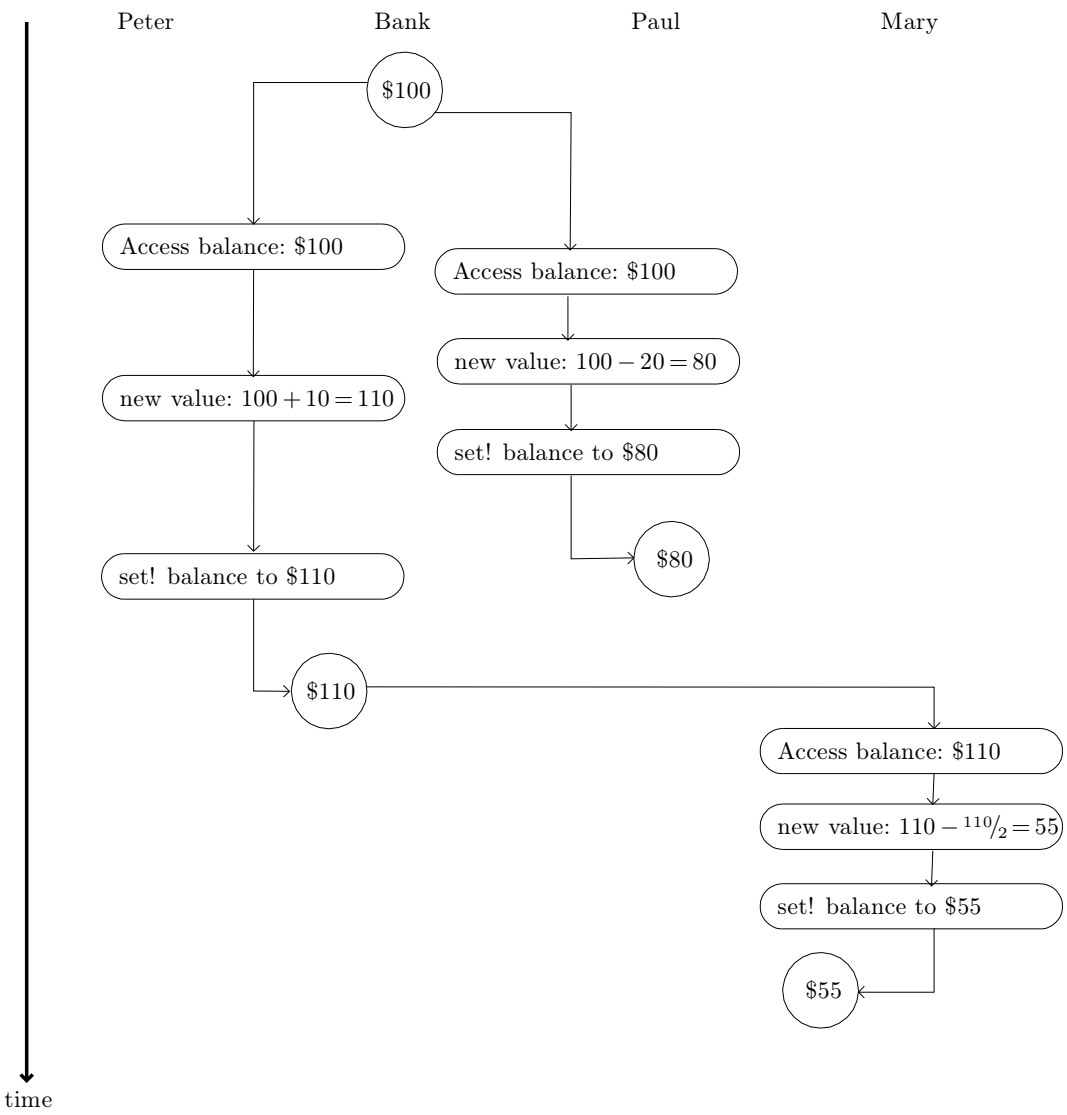

Figure 5. Mary accesses the joint account according to what updated by Peter.

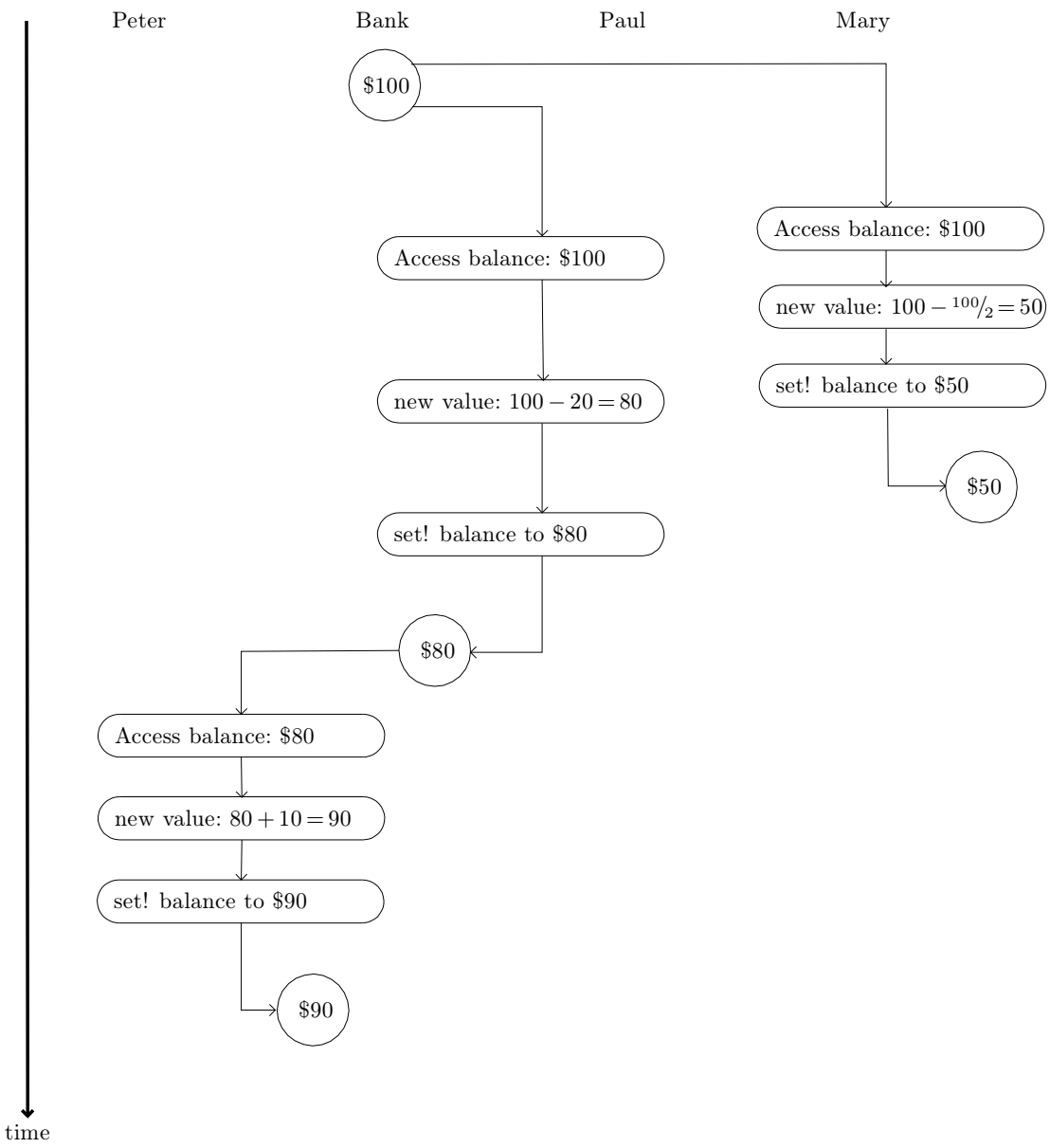

Figure 6. Peter accesses the joint account according to what updated by Paul.

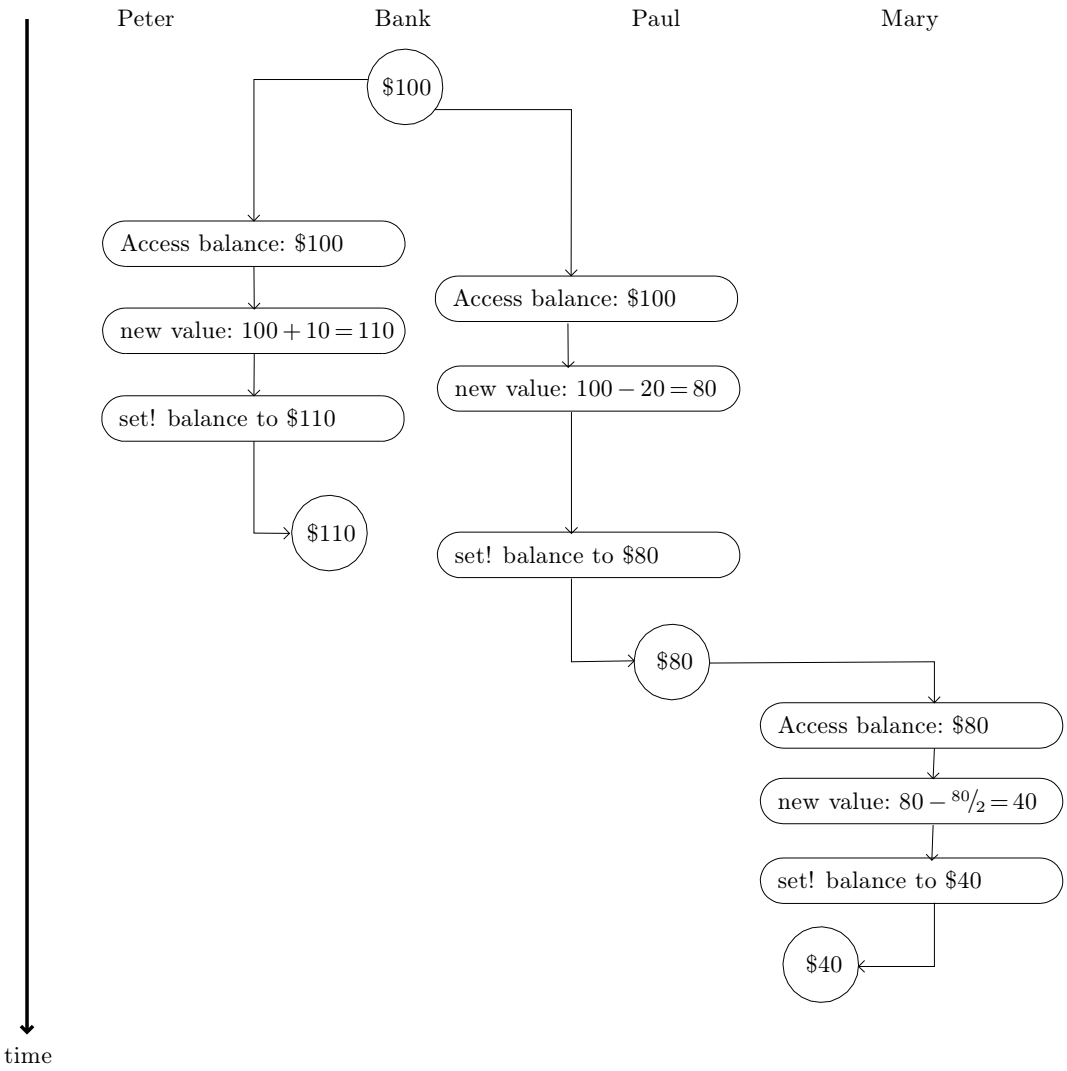

Figure 7. Paul accesses the joint account according to what updated by Mary.

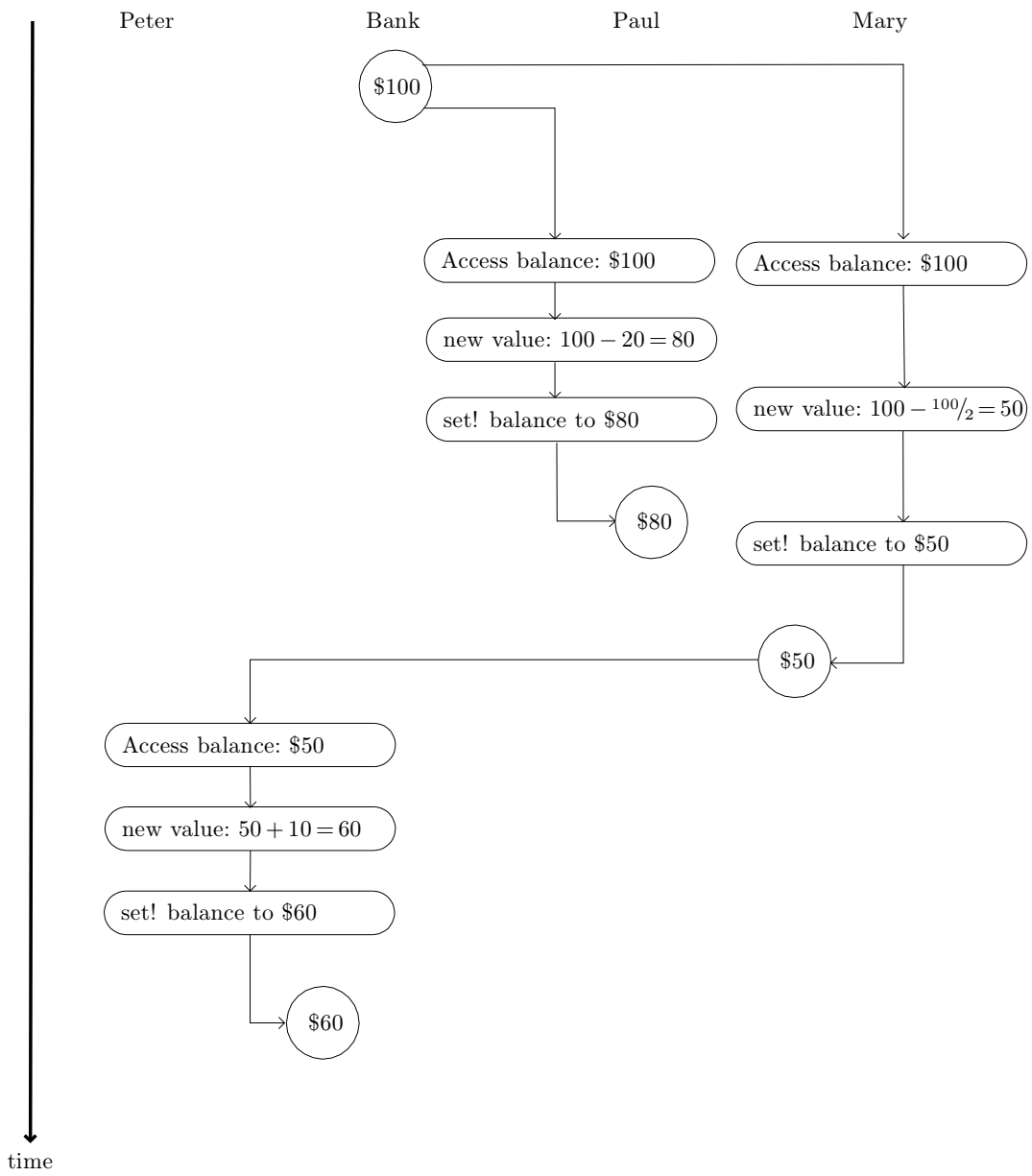

Figure 8. Peter accesses the joint account according to what updated by Mary.

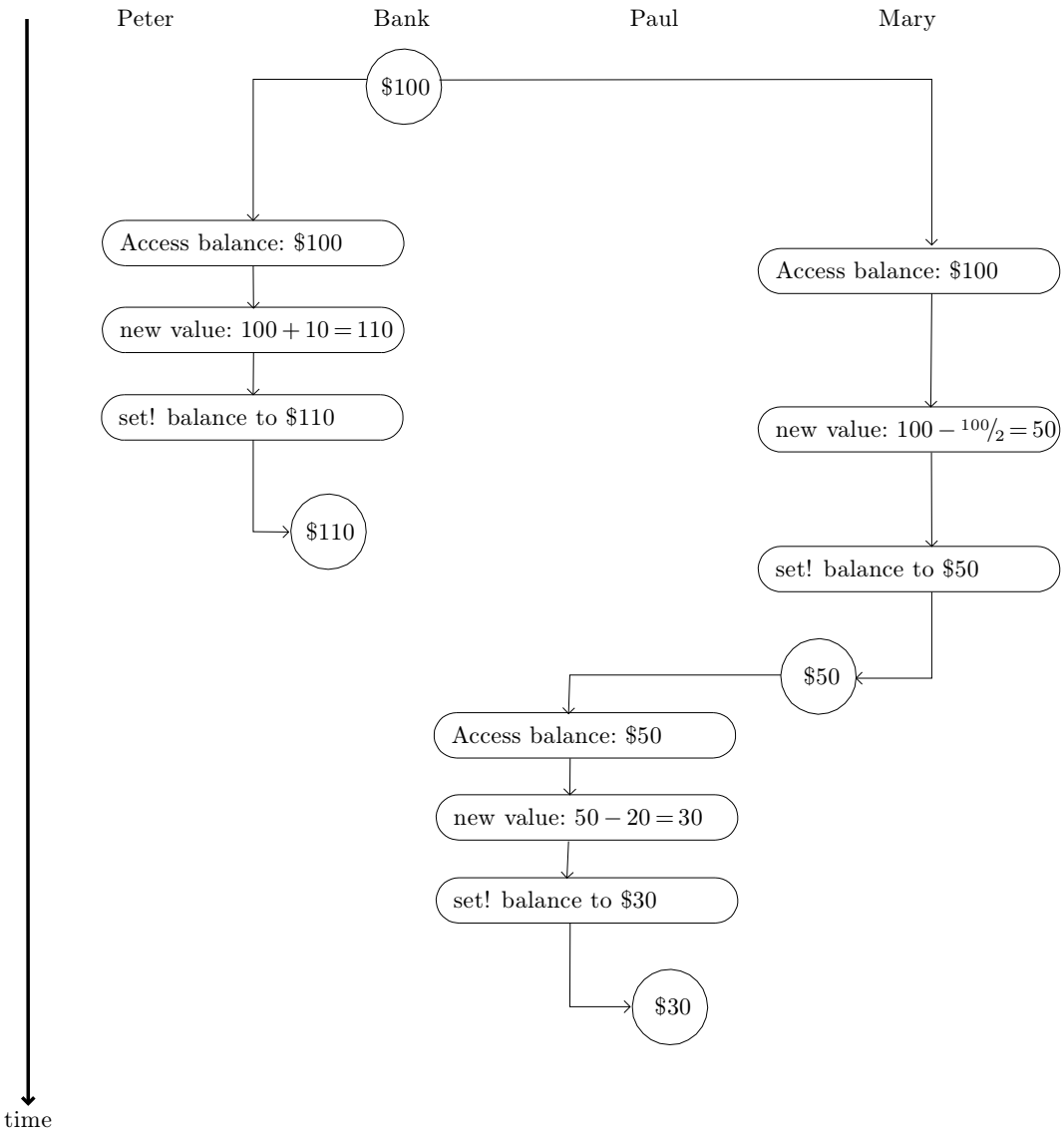

Figure 9. Mary accesses the joint account according to what updated by Paul.

second group of transactions.

Among the last group of transactions, where an individual changes `balance` first, then the rest of them make their modification on the account concurrently, the final value of the account is determined by the first one as well as the last one whose modification takes effect.

If the request of Peter is sufficed first and that of Paul happens in the last moment, the account will end up with a total amount of $90, as figure 10 shows. Likewise, figure 10 through figure 15 present

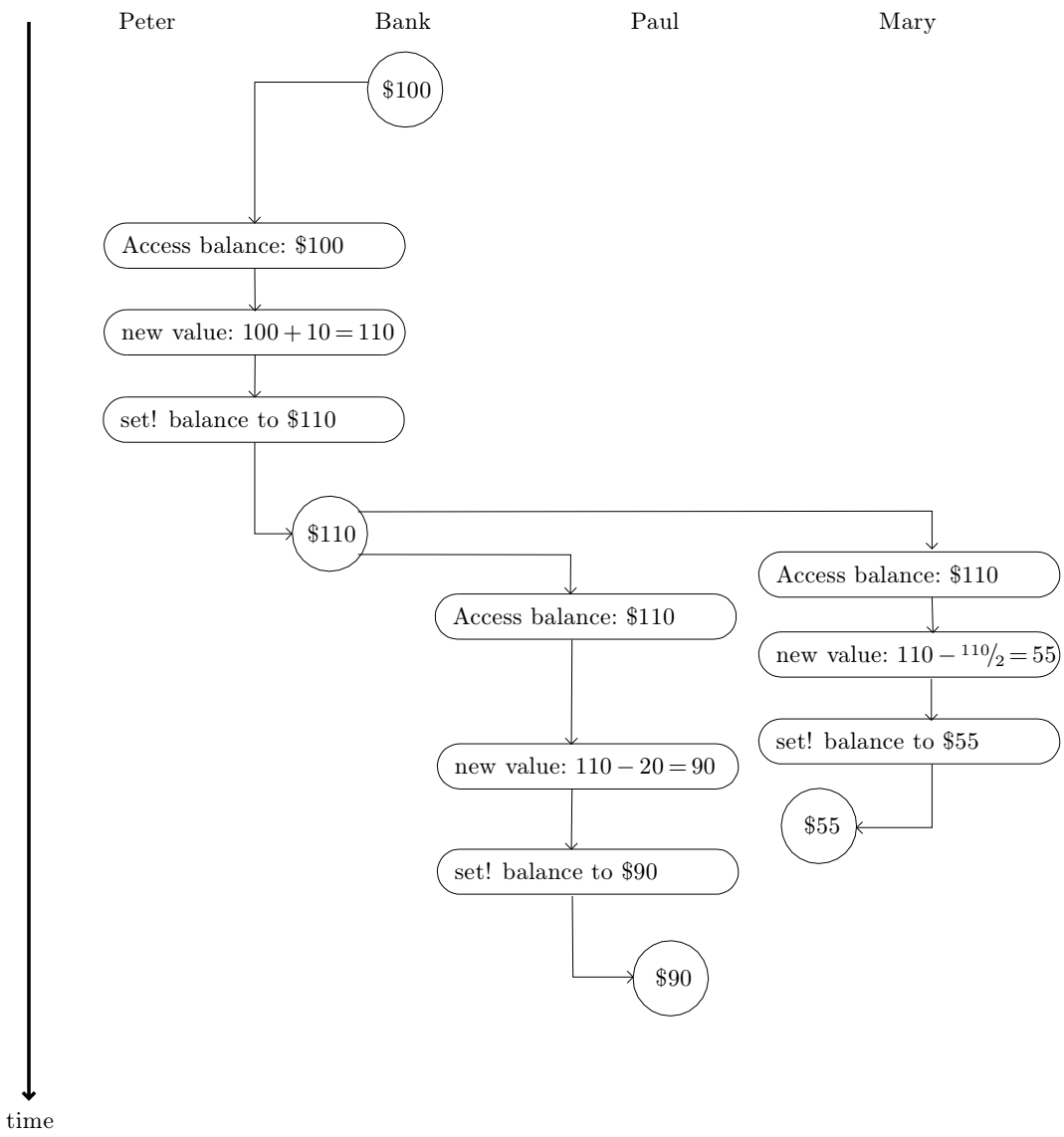

Figure 10. Peter's transaction accomplishes first and Paul's in the last turn.

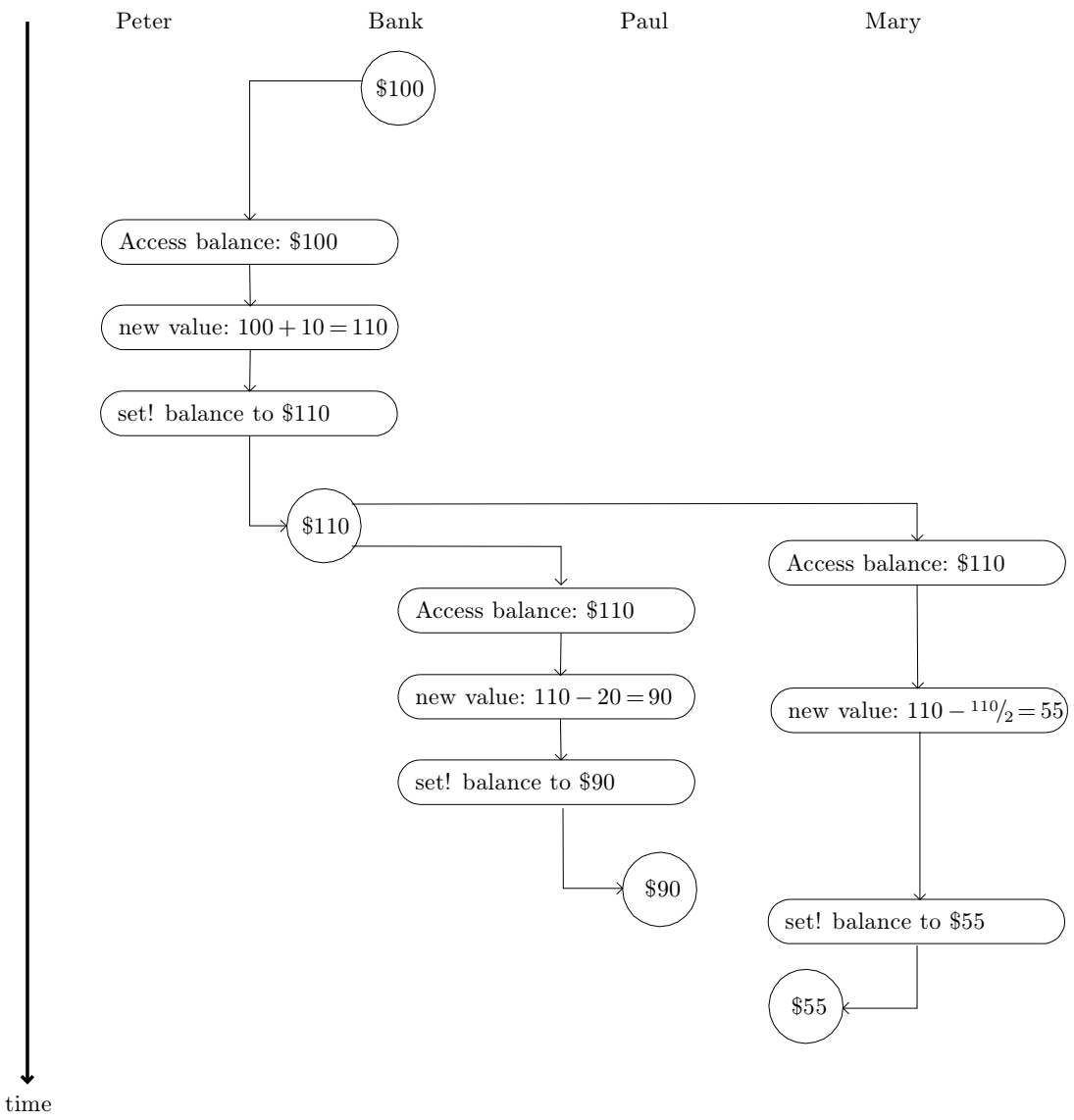

Figure 11. Peter's transaction accomplishes first and Mary's in the last turn.

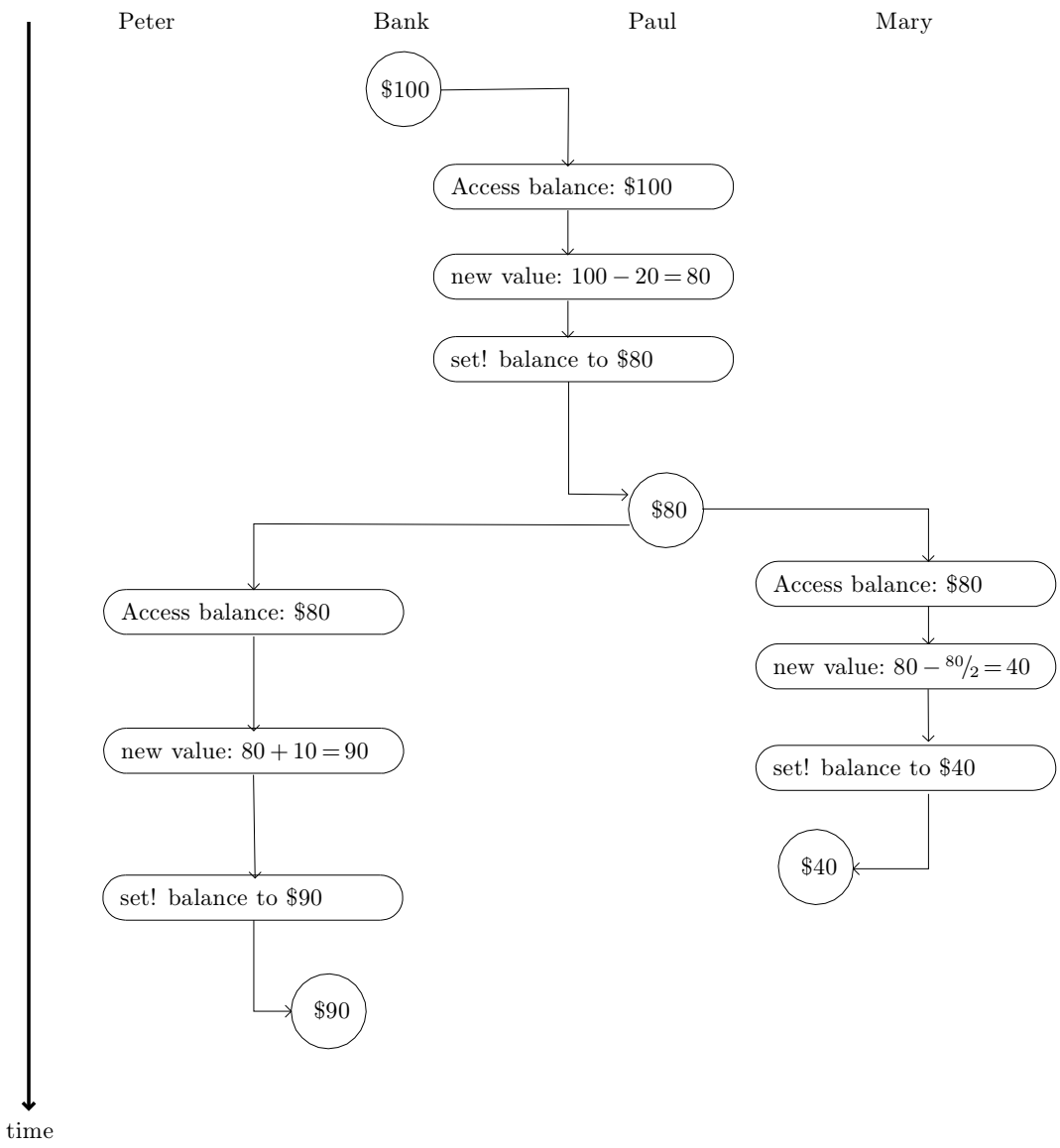

Figure 12. Paul's transaction accomplishes first and Peter's in the last turn.

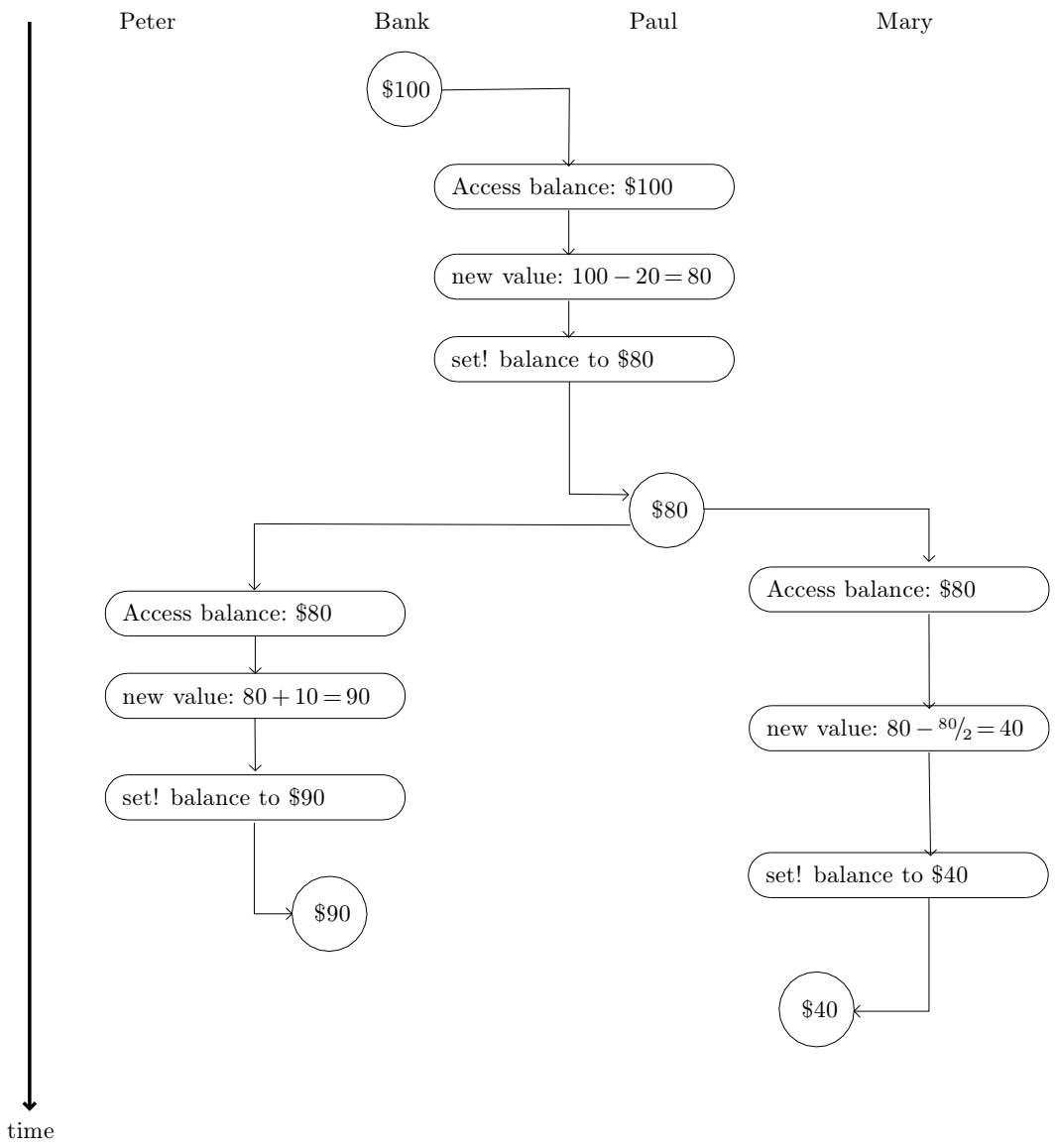

Figure 13. Paul's transaction accomplishes first and Mary's in the last turn.

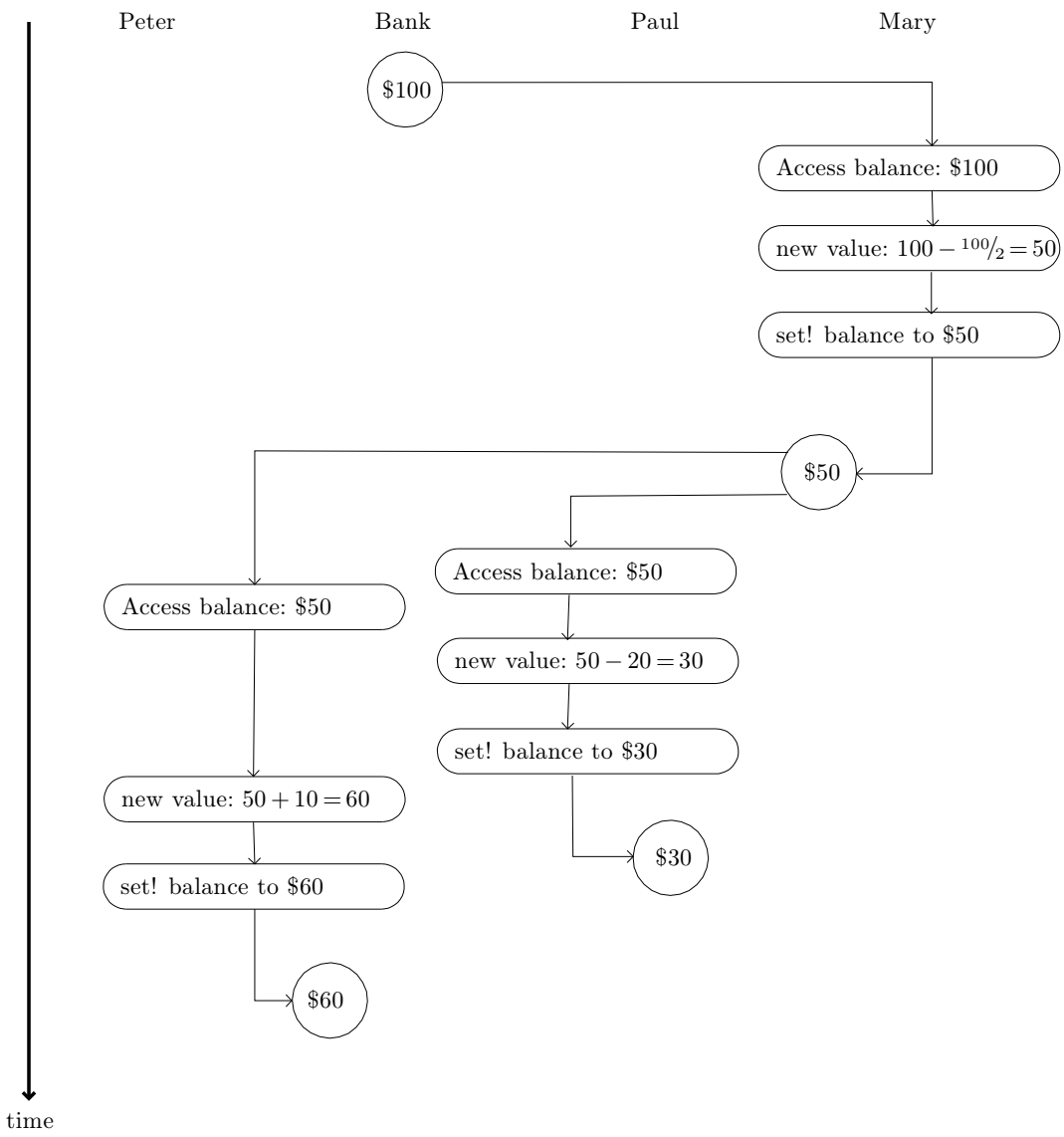

Figure 14. Mary's transaction accomplishes first and Peter's in the last turn.

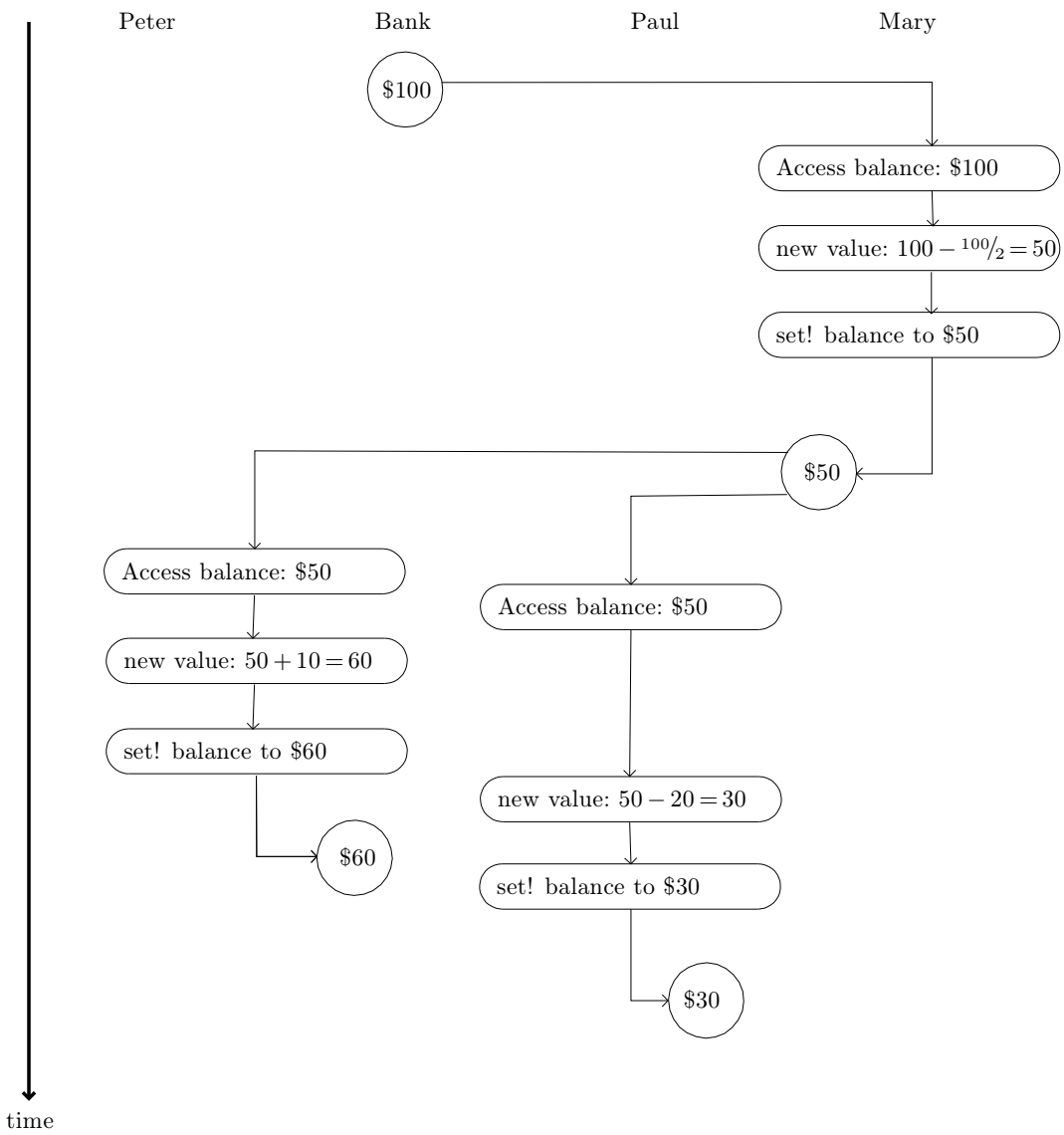

Figure 15. Mary's transaction accomplishes first and Paul's in the last turn.

the timing diagrams for the rest cases in the last group of transactions.