CSE 344
SYSTEMS PROGRAMMING

MIDTERM PROJECT

REPORT

ÖMER ÇEVİK
161044004

1. **Program Flow**

In that part, program starts with one **supplier**, N **cooks** and M **students** processes. First of all in the main function **SIGINT** signal is handled for all processes. Four semaphores are created by **sem_init()**. In the main, all arguments of program are taken and saved. Three shared memories are used to provide data sharing between processes: kitchen, counter and tables. Synchronization between processes is applied by only semaphores. Using **fork()** syscall, created all necessary processes.

In **supplier()**, in the beginning of work supplier reads the input file which contains 0-1-2 that represents the soup-course-desert randomly but same sized. I wrote a function to create that kind of input file which is in the code and commented line (*createRandomInputFile()*). After the read operation, supplier creates a loop until all soup-course-desert foods are going to the kitchen. The kitchen is a shared memory and soup-course-desert foods are written and read into it. But while doing that operations cook processes are running. For each iteration of supplier creates its own critical section and doesn't let the cook work with kitchen. While doing that, it prints the necessary printing informations to console and completes its work correctly with exit.

In **cook()**, in the beginning of work cooks create an infinite loop and wait the students and supplier with different semaphores. Then reads the kitchen shared memory and writes to counter shared memory randomly. After all printing informations which are necessary then exits the critical section and posts the supplier and student semaphores. That loop is continues until all kitchen foods are read. After all it prints the good bye message and exits.
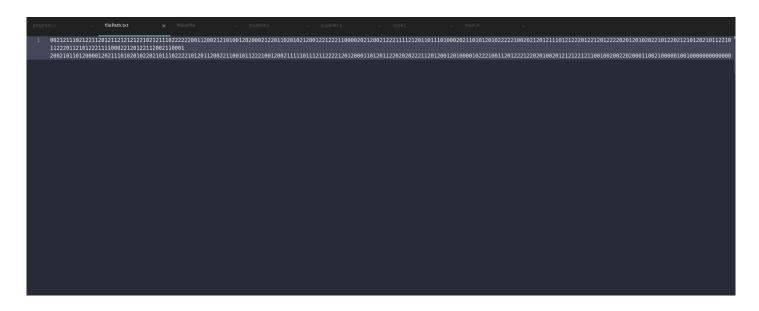
In **student()**, in the beginning of work students creates a loop and waits the cooks to get its foods. The loop's condition is how many times a student will go to counter that is given by program runner as L. A student reads the counter shared memory and tables shared memory to checks if each of foods are ready to eat and if there is any table exist. If soup-course-desert each of them are ready and table is exist then goes and eats. After all, it posts to cook that it can continue to service. While doing all these, it prints the necessary informations. In the end, it prints the good bye message and exits.

While programming, the deadlock between cooks and students made some problems. In normally I was thinking to solve all the program with three semaphores. But communication between students and cooks with one semaphore was not enough. So I had to create another semaphore for communication.

Makefile:

```makefile
CC = gcc
CFLAGS = -c
VALG = valgrind -v
SHD = -lrt -lpthread

all:main run

main: program.o supplier.o cook.o student.o shdmem.o fileOperations.o
	$(CC) program.o supplier.o cook.o student.o shdmem.o fileOperations.o -o program $(SHD)

program.o: program.c
	$(CC) $(CFLAGS) program.c

supplier.o: supplier.c
	$(CC) $(CFLAGS) supplier.c

cook.o: cook.c
	$(CC) $(CFLAGS) cook.c

student.o: student.c
	$(CC) $(CFLAGS) student.c

shdmem.o: shdmem.c
	$(CC) $(CFLAGS) shdmem.c

fileOperations.o: fileOperations.c
	$(CC) $(CFLAGS) fileOperations.c

run:
	./program -N 3 -M 12 -T 5 -S 4 -L 13 -F filePath.txt

v:main runv

runv:
	$(VALG) ./program -N 3 -M 12 -T 5 -S 4 -L 13 -F filePath.txt

clean:
	rm -rf *o program
```

filePath.txt:

```
0021211102122112012112121212212102121110222220011200212101001202000212201102010212001221222110000202120021222111121201110111010002011010120102022210002021201211101212201221201222202012010202210122021210120210112210
1122201121012221111000221201221120021100010
20021011012000012021110102010202021011102220210120011200221100101122210012002111110111211222212012000110120112202020202211201200120100001022210011201222122020100201212122121100100200220200011002100000100100000000000000
```

Console:

```
omer@omer:~/Desktop/Midterm/Midterm$ make
gcc -c program.c
gcc -c supplier.c
gcc -c cook.c
gcc -c student.c
gcc -c shdmem.c
gcc -c fileOperations.c
gcc program.o supplier.o cook.o student.o shdmem.o fileOperations.o -o program -lrt -lpthread
./program -N 3 -M 12 -T 5 -S 4 -L 13 -F filePath.txt
NMTSLK : 3 12 5 4 13 313
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 0 is going to the counter to deliver soup - counter items P:0,C:0,D:0=0
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:1,C:0,D:0=1
Cook 0 placed soup on the counter - counter items P:1,C:0,D:0=1
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 0 is going to the counter (round 1) - # of students at counter: 1 and counter items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:1,C:0,D:0=1
Cook 1 placed soup on the counter - counter items P:2,C:0,D:0=2
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Student 1 is going to the counter (round 1) - # of students at counter: 1 and counter items P:2,C:0,D:0=2
Cook 2 is going to the counter to deliver desert - counter items P:2,C:0,D:0=2
Cook 2 placed desert on the counter - counter items P:2,C:0,D:1=3
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 2 is going to the counter (round 1) - # of students at counter: 1 and counter items P:2,C:0,D:1=3
Cook 0 is going to the counter to deliver course - counter items P:2,C:0,D:1=3
Cook 0 placed course on the counter - counter items P:2,C:1,D:1=4
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Student 3 is going to the counter (round 1) - # of students at counter: 1 and counter items P:2,C:1,D:1=4
Student 3 got food and is going to get a table (round 1) - # of empty tables: 5
Student 3 sat at table 4 to eat (round 1) - empty tables:4
Student 3 left table 4 to eat again (round 1) - empty tables:4
Cook 1 is going to the counter to deliver desert - counter items P:1,C:0,D:0=1
Cook 1 placed desert on the counter - counter items P:1,C:0,D:1=2
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 4 is going to the counter (round 1) - # of students at counter: 1 and counter items P:1,C:0,D:1=2
Cook 2 is going to the counter to deliver course - counter items P:1,C:0,D:1=2
Cook 2 placed course on the counter - counter items P:1,C:1,D:1=3
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 5 is going to the counter (round 1) - # of students at counter: 1 and counter items P:1,C:1,D:1=3
Student 5 got food and is going to get a table (round 1) - # of empty tables: 5
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Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
Student 9 is going to the counter (round 4) - # of students at counter: 1 and counter items P:0,C:8,D:11=19
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:0,C:8,D:11=19
Cook 1 placed soup on the counter - counter items P:1,C:8,D:11=20
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
Student 10 is going to the counter (round 2) - # of students at counter: 1 and counter items P:1,C:8,D:11=20
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 10 got food and is going to get a table (round 2) - # of empty tables: 5
Student 10 sat at table 4 to eat (round 2) - empty tables:4
Student 10 left table 4 to eat again (round 2) - empty tables:4
Cook 2 is going to the counter to deliver course - counter items P:0,C:7,D:10=17
Cook 2 placed course on the counter - counter items P:0,C:8,D:10=18
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Cook 0 is going to the counter to deliver course - counter items P:0,C:8,D:10=18
Cook 0 placed course on the counter - counter items P:0,C:9,D:10=19
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:0,C:9,D:10=19
Cook 1 placed soup on the counter - counter items P:1,C:9,D:10=20
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
Student 1 is going to the counter (round 4) - # of students at counter: 1 and counter items P:1,C:9,D:10=20
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Student 1 got food and is going to get a table (round 4) - # of empty tables: 5
Student 1 sat at table 4 to eat (round 4) - empty tables:4
Student 1 left table 4 to eat again (round 4) - empty tables:4
Cook 2 is going to the counter to deliver desert - counter items P:0,C:8,D:9=17
Cook 2 placed desert on the counter - counter items P:0,C:8,D:10=18
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 0 is going to the counter to deliver soup - counter items P:0,C:8,D:10=18
Cook 0 placed soup on the counter - counter items P:1,C:8,D:10=19
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
Student 3 is going to the counter (round 3) - # of students at counter: 1 and counter items P:1,C:8,D:10=19
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 3 got food and is going to get a table (round 3) - # of empty tables: 5
Student 3 sat at table 4 to eat (round 3) - empty tables:4
Student 3 left table 4 to eat again (round 3) - empty tables:4
Cook 1 is going to the counter to deliver course - counter items P:0,C:7,D:9=16
Cook 1 placed course on the counter - counter items P:0,C:8,D:9=17
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Student 4 is going to the counter (round 3) - # of students at counter: 1 and counter items P:0,C:8,D:9=17
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 2 is going to the counter to deliver soup - counter items P:0,C:8,D:9=17
Cook 2 placed soup on the counter - counter items P:1,C:8,D:9=18
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
Student 5 is going to the counter (round 3) - # of students at counter: 1 and counter items P:1,C:8,D:9=18
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The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Cook 2 is going to the counter to deliver course - counter items P:0,C:10,D:12=22
Cook 2 placed course on the counter - counter items P:0,C:11,D:12=23
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Cook 0 is going to the counter to deliver course - counter items P:0,C:11,D:12=23
Cook 0 placed course on the counter - counter items P:0,C:12,D:12=24
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Student 2 is going to the counter (round 5) - # of students at counter: 1 and counter items P:0,C:12,D:12=24
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:0,C:12,D:12=24
Cook 1 placed soup on the counter - counter items P:1,C:12,D:12=25
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
Student 3 is going to the counter (round 5) - # of students at counter: 1 and counter items P:1,C:12,D:12=25
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 3 got food and is going to get a table (round 5) - # of empty tables: 5
Student 3 sat at table 4 to eat (round 5) - empty tables:4
Student 3 left table 4 to eat again (round 5) - empty tables:4
Cook 2 is going to the counter to deliver course - counter items P:0,C:11,D:11=22
Cook 2 placed course on the counter - counter items P:0,C:12,D:11=23
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Cook 0 is going to the counter to deliver desert - counter items P:0,C:12,D:11=23
Cook 0 placed desert on the counter - counter items P:0,C:12,D:12=24
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
Student 5 is going to the counter (round 8) - # of students at counter: 1 and counter items P:0,C:12,D:12=24
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:1,D:0=1
Cook 1 is going to the counter to deliver course - counter items P:0,C:12,D:12=24
Cook 1 placed course on the counter - counter items P:0,C:13,D:12=25
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Cook 2 is going to the counter to deliver desert - counter items P:0,C:13,D:12=25
Cook 2 placed desert on the counter - counter items P:0,C:13,D:13=26
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Cook 0 is going to the counter to deliver desert - counter items P:0,C:13,D:13=26
Cook 0 placed desert on the counter - counter items P:0,C:13,D:14=27
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:1=1
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Cook 1 is going to the counter to deliver desert - counter items P:0,C:13,D:14=27
Cook 1 placed desert on the counter - counter items P:0,C:13,D:15=28
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
Student 9 is going to the counter (round 7) - # of students at counter: 1 and counter items P:0,C:13,D:15=28
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 2 is going to the counter to deliver soup - counter items P:0,C:13,D:15=28
Cook 2 placed soup on the counter - counter items P:1,C:13,D:15=29
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Student 1 got food and is going to get a table (round 6) - # of empty tables: 5
Student 1 sat at table 4 to eat (round 6) - empty tables:4
Student 1 left table 4 to eat again (round 6) - empty tables:4
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Cook 1 is going to the counter to deliver course - counter items P:0,C:19,D:25=44
Cook 1 placed course on the counter - counter items P:0,C:20,D:25=45
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Cook 2 is going to the counter to deliver desert - counter items P:0,C:20,D:25=45
Cook 2 placed desert on the counter - counter items P:0,C:20,D:26=46
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 0 is going to the counter to deliver soup - counter items P:0,C:20,D:26=46
Cook 0 placed soup on the counter - counter items P:1,C:20,D:26=47
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 4 got food and is going to get a table (round 6) - # of empty tables: 5
Student 4 sat at table 4 to eat (round 6) - empty tables:4
Student 4 left table 4 to eat again (round 6) - empty tables:4
Cook 1 is going to the counter to deliver soup - counter items P:0,C:19,D:25=44
Cook 1 placed soup on the counter - counter items P:1,C:19,D:25=45
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Student 5 got food and is going to get a table (round 10) - # of empty tables: 5
Student 5 sat at table 4 to eat (round 10) - empty tables:4
Student 5 left table 4 to eat again (round 10) - empty tables:4
Cook 2 is going to the counter to deliver desert - counter items P:0,C:18,D:24=42
Cook 2 placed desert on the counter - counter items P:0,C:18,D:25=43
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
Student 6 is going to the counter (round 6) - # of students at counter: 1 and counter items P:0,C:18,D:25=43
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:1,D:0=1
Cook 2 is going to the counter to deliver course - counter items P:0,C:18,D:25=43
Cook 2 placed course on the counter - counter items P:0,C:19,D:25=44
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Student 7 is going to the counter (round 7) - # of students at counter: 1 and counter items P:0,C:19,D:25=44
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:0,C:19,D:25=44
Cook 1 placed soup on the counter - counter items P:1,C:19,D:25=45
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:1,C:0,D:0=1
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 8 got food and is going to get a table (round 6) - # of empty tables: 5
Student 8 sat at table 4 to eat (round 6) - empty tables:4
Student 8 left table 4 to eat again (round 6) - empty tables:4
Cook 0 is going to the counter to deliver course - counter items P:0,C:18,D:24=42
Cook 0 placed course on the counter - counter items P:0,C:19,D:24=43
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
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The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Cook 0 is going to the counter to deliver course - counter items P:0,C:27,D:24=51
Cook 0 placed course on the counter - counter items P:0,C:28,D:24=52
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
Student 1 is going to the counter (round 12) - # of students at counter: 1 and counter items P:0,C:28,D:24=52
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Cook 2 is going to the counter to deliver desert - counter items P:0,C:28,D:24=52
Cook 2 placed desert on the counter - counter items P:0,C:28,D:25=53
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:0,C:28,D:25=53
Cook 1 placed soup on the counter - counter items P:1,C:28,D:25=54
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
Student 3 got food and is going to get a table (round 10) - # of empty tables: 5
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 3 sat at table 4 to eat (round 10) - empty tables:4
Student 3 left table 4 to eat again (round 10) - empty tables:4
Cook 0 is going to the counter to deliver course - counter items P:0,C:27,D:24=51
Cook 0 placed course on the counter - counter items P:0,C:28,D:24=52
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver desert: kitchen items P:0,C:0,D:0=0
The supplier delivered desert - after delivery: kitchen items P:0,C:0,D:1=1
Cook 2 is going to the counter to deliver desert - counter items P:0,C:28,D:24=52
Cook 2 placed desert on the counter - counter items P:0,C:28,D:25=53
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:0,C:28,D:25=53
Cook 1 placed soup on the counter - counter items P:1,C:28,D:25=54
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 7 got food and is going to get a table (round 9) - # of empty tables: 5
Student 7 sat at table 4 to eat (round 9) - empty tables:4
Student 7 left table 4 to eat again (round 9) - empty tables:4
Cook 0 is going to the counter to deliver soup - counter items P:0,C:27,D:24=51
Cook 0 placed soup on the counter - counter items P:1,C:27,D:24=52
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 8 got food and is going to get a table (round 9) - # of empty tables: 5
Student 8 sat at table 4 to eat (round 9) - empty tables:4
Student 8 left table 4 to eat again (round 9) - empty tables:4
Cook 2 is going to the counter to deliver soup - counter items P:0,C:26,D:23=49
Cook 2 placed soup on the counter - counter items P:1,C:26,D:23=50
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 9 got food and is going to get a table (round 7) - # of empty tables: 5
Student 9 sat at table 4 to eat (round 7) - empty tables:4
Student 9 left table 4 to eat again (round 7) - empty tables:4
Cook 1 is going to the counter to deliver course - counter items P:0,C:25,D:22=47
```

```
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 2 sat at table 4 to eat (round 12) - empty tables:4
Student 2 left table 4 to eat again (round 12) - empty tables:4
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:0,C:14,D:16=30
Cook 1 placed soup on the counter - counter items P:1,C:14,D:16=31
Student 3 got food and is going to get a table (round 13) - # of empty tables: 5
Student 3 sat at table 4 to eat (round 13) - empty tables:4
Student 3 left table 4 to eat again (round 13) - empty tables:4
Student 3 is done eating L=13 times - going home - GOODBYE!!!
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Cook 2 is going to the counter to deliver course - counter items P:0,C:13,D:15=28
Cook 2 placed course on the counter - counter items P:0,C:14,D:15=29
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 0 is going to the counter to deliver soup - counter items P:0,C:14,D:15=29
Cook 0 placed soup on the counter - counter items P:1,C:14,D:15=30
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Student 6 is going to the counter (round 9) - # of students at counter: 1 and counter items P:1,C:14,D:15=30
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 6 got food and is going to get a table (round 9) - # of empty tables: 5
Student 6 sat at table 4 to eat (round 9) - empty tables:4
Student 6 left table 4 to eat again (round 9) - empty tables:4
Cook 1 is going to the counter to deliver soup - counter items P:0,C:13,D:14=27
Cook 1 placed soup on the counter - counter items P:1,C:13,D:14=28
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver course: kitchen items P:0,C:0,D:0=0
The supplier delivered course - after delivery: kitchen items P:0,C:1,D:0=1
Student 8 got food and is going to get a table (round 12) - # of empty tables: 5
Student 8 sat at table 4 to eat (round 12) - empty tables:4
Student 8 left table 4 to eat again (round 12) - empty tables:4
Cook 2 is going to the counter to deliver course - counter items P:0,C:12,D:13=25
Cook 2 placed course on the counter - counter items P:0,C:13,D:13=26
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
Cook 0 is going to the counter to deliver soup - counter items P:0,C:13,D:13=26
Cook 0 placed soup on the counter - counter items P:1,C:13,D:13=27
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
Student 10 is going to the counter (round 13) - # of students at counter: 1 and counter items P:1,C:13,D:13=27
Student 10 got food and is going to get a table (round 13) - # of empty tables: 5
Student 10 sat at table 4 to eat (round 13) - empty tables:4
Student 10 left table 4 to eat again (round 13) - empty tables:4
Student 10 is done eating L=13 times - going home - GOODBYE!!!
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 1 is going to the counter to deliver soup - counter items P:0,C:12,D:12=24
Cook 1 placed soup on the counter - counter items P:1,C:12,D:12=25
Student 11 is going to the counter (round 11) - # of students at counter: 1 and counter items P:1,C:12,D:12=25
Student 11 got food and is going to get a table (round 11) - # of empty tables: 5
Student 11 sat at table 4 to eat (round 11) - empty tables:4
```

Make:

```
Student 9 is done eating L=13 times - going home - GOODBYE!!!
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 2 is going to the counter to deliver soup - counter items P:0,C:5,D:5=10
Cook 2 placed soup on the counter - counter items P:1,C:5,D:5=11
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Student 11 is going to the counter (round 12) - # of students at counter: 1 and counter items P:1,C:5,D:5=11
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 11 got food and is going to get a table (round 12) - # of empty tables: 5
Student 11 sat at table 4 to eat (round 12) - empty tables:4
Student 11 left table 4 to eat again (round 12) - empty tables:4
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:1,C:0,D:0=1
Cook 0 is going to the counter to deliver soup - counter items P:0,C:4,D:4=8
Cook 0 placed soup on the counter - counter items P:1,C:4,D:4=9
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Student 6 is going to the counter (round 11) - # of students at counter: 1 and counter items P:1,C:4,D:4=9
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 6 got food and is going to get a table (round 11) - # of empty tables: 5
Student 6 sat at table 4 to eat (round 11) - empty tables:4
Student 6 left table 4 to eat again (round 11) - empty tables:4
Cook 1 is going to the counter to deliver soup - counter items P:0,C:3,D:3=6
Cook 1 placed soup on the counter - counter items P:1,C:3,D:3=7
Cook 1 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
Student 11 is going to the counter (round 13) - # of students at counter: 1 and counter items P:1,C:3,D:3=7
Student 11 got food and is going to get a table (round 13) - # of empty tables: 5
Student 11 sat at table 4 to eat (round 13) - empty tables:4
Student 11 left table 4 to eat again (round 13) - empty tables:4
Student 11 is done eating L=13 times - going home - GOODBYE!!!
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Cook 2 is going to the counter to deliver soup - counter items P:0,C:2,D:2=4
Cook 2 placed soup on the counter - counter items P:1,C:2,D:2=5
Cook 2 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
The supplier is going to the kitchen to deliver soup: kitchen items P:0,C:0,D:0=0
Student 6 is going to the counter (round 12) - # of students at counter: 1 and counter items P:1,C:2,D:2=5
The supplier delivered soup - after delivery: kitchen items P:1,C:0,D:0=1
Student 6 got food and is going to get a table (round 12) - # of empty tables: 5
Student 6 sat at table 4 to eat (round 12) - empty tables:4
Student 6 left table 4 to eat again (round 12) - empty tables:4
Cook 0 is going to the counter to deliver soup - counter items P:0,C:1,D:1=2
Cook 0 placed soup on the counter - counter items P:1,C:1,D:1=3
Cook 0 is going to the kitchen to wait for/get a plate - kitchen items P:0,C:0,D:0=0
Student 6 is going to the counter (round 13) - # of students at counter: 1 and counter items P:1,C:1,D:1=3
Cook 1 finished serving - items at kitchen: 0 - going home - GOODBYE!!!
Student 6 got food and is going to get a table (round 13) - # of empty tables: 5
Student 6 sat at table 4 to eat (round 13) - empty tables:4
Student 6 left table 4 to eat again (round 13) - empty tables:4
Student 6 is done eating L=13 times - going home - GOODBYE!!!
The supplier finished supplying - GOODBYE!
Cook 2 finished serving - items at kitchen: 0 - going home - GOODBYE!!!
Cook 0 finished serving - items at kitchen: 0 - going home - GOODBYE!!!
omer@omer:~/Desktop/Midterm/Midterm$ _
```

Make with Valgrind:

```
omer@omer:~/Desktop/Midterm/Midterm$ make v
gcc -c program.c
gcc -c supplier.c
gcc -c cook.c
gcc -c student.c
gcc -c shdmem.c
gcc -c fileOperations.c
gcc program.o supplier.o cook.o student.o shdmem.o fileOperations.o -o program -lrt -lpthread
valgrind -v ./program -N 3 -M 12 -T 5 -S 4 -L 13 -F filePath.txt
==16135== Memcheck, a memory error detector
==16135== Copyright (C) 2002-2017, and GNU GPL'd, by Julian Seward et al.
==16135== Using Valgrind-3.15.0-608cb11914-20190413 and LibVEX; rerun with -h for copyright info
==16135== Command: ./program -N 3 -M 12 -T 5 -S 4 -L 13 -F filePath.txt
==16135==
--16135-- Valgrind options:
--16135--    -v
--16135-- Contents of /proc/version:
--16135--   Linux version 5.4.0-29-generic (buildd@lgw01-amd64-035) (gcc version 9.3.0 (Ubuntu 9.3.0-10ubuntu2)) #33-Ubuntu SMP Wed Apr 29 14:32:27 UTC 2020
--16135--
--16135-- Arch and hwcaps: AMD64, LittleEndian, amd64-cx16-lzcnt-rdtscp-sse3-ssse3-avx-avx2-bmi-f16c-rdrand
--16135-- Page sizes: currently 4096, max supported 4096
--16135-- Valgrind library directory: /usr/lib/x86_64-linux-gnu/valgrind
--16135-- Reading syms from /home/omer/Desktop/Midterm/Midterm/program
--16135-- Reading syms from /lib/x86_64-linux-gnu/ld-2.31.so
--16135--   Considering /lib/x86_64-linux-gnu/ld-2.31.so ..
--16135--    .. CRC mismatch (computed 387b17ea wanted d28cf5ef)
--16135--   Considering /lib/x86_64-linux-gnu/ld-2.31.so ..
--16135--    .. CRC mismatch (computed 387b17ea wanted d28cf5ef)
--16135--   Considering /usr/lib/debug/lib/x86_64-linux-gnu/ld-2.31.so ..
--16135--    .. CRC is valid
--16135-- Reading syms from /usr/lib/x86_64-linux-gnu/valgrind/memcheck-amd64-linux
--16135--    object doesn't have a symbol table
--16135--    object doesn't have a dynamic symbol table
--16135-- Scheduler: using generic scheduler lock implementation.
--16135-- Reading suppressions file: /usr/lib/x86_64-linux-gnu/valgrind/default.supp
==16135== embedded gdbserver: reading from /tmp/vgdb-pipe-from-vgdb-to-16135-by-omer-on-???
==16135== embedded gdbserver: writing to   /tmp/vgdb-pipe-to-vgdb-from-16135-by-omer-on-???
==16135== embedded gdbserver: shared mem   /tmp/vgdb-pipe-shared-mem-vgdb-16135-by-omer-on-???
==16135==
==16135== TO CONTROL THIS PROCESS USING vgdb (which you probably
==16135== don't want to do, unless you know exactly what you're doing,
==16135== or are doing some strange experiment):
==16135==   /usr/lib/x86_64-linux-gnu/valgrind/../../bin/vgdb --pid=16135 ...command...
==16135==
==16135== TO DEBUG THIS PROCESS USING GDB: start GDB like this
==16135==   /path/to/gdb ./program
==16135== and then give GDB the following command
==16135==   target remote | /usr/lib/x86_64-linux-gnu/valgrind/../../bin/vgdb --pid=16135
==16135== --pid is optional if only one valgrind process is running
==16135==
--16135-- REDIR: 0x4022d80 (ld-linux-x86-64.so.2:strlen) redirected to 0x580c9ce2 (???)
--16135-- REDIR: 0x4022b50 (ld-linux-x86-64.so.2:index) redirected to 0x580c9cfc (???)
--16135-- Reading syms from /usr/lib/x86_64-linux-gnu/valgrind/vgpreload_core-amd64-linux.so
--16135--    object doesn't have a symbol table
--16135-- Reading syms from /usr/lib/x86_64-linux-gnu/valgrind/vgpreload_memcheck-amd64-linux.so
```

```
==16145==
==16145== All heap blocks were freed -- no leaks are possible
==16145==
==16145== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
--16149-- REDIR: 0x4935850 (libc.so.6:free) redirected to 0x483c9d0 (free)
==16141==
==16148==
==16148== HEAP SUMMARY:
==16148==     in use at exit: 0 bytes in 0 blocks
==16148==   total heap usage: 1 allocs, 1 frees, 1,024 bytes allocated
==16148==
==16148== All heap blocks were freed -- no leaks are possible
==16148==
==16141== HEAP SUMMARY:
==16141==     in use at exit: 0 bytes in 0 blocks
==16141==   total heap usage: 1 allocs, 1 frees, 1,024 bytes allocated
==16141==
==16148== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
==16141== All heap blocks were freed -- no leaks are possible
==16141=
==16141== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
==16151==
==16151== HEAP SUMMARY:
==16151==     in use at exit: 0 bytes in 0 blocks
==16151==   total heap usage: 1 allocs, 1 frees, 1,024 bytes allocated
==16151==
==16151== All heap blocks were freed -- no leaks are possible
==16151==
==16151== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
==16149==
==16149== HEAP SUMMARY:
==16149==     in use at exit: 0 bytes in 0 blocks
==16149==   total heap usage: 1 allocs, 1 frees, 1,024 bytes allocated
==16149==
==16149== All heap blocks were freed -- no leaks are possible
==16149==
==16149== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
==16152==
==16152== HEAP SUMMARY:
==16152==     in use at exit: 0 bytes in 0 blocks
==16152==   total heap usage: 1 allocs, 1 frees, 1,024 bytes allocated
==16152==
==16152== All heap blocks were freed -- no leaks are possible
==16152==
==16152== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
==16135==
==16135== HEAP SUMMARY:
==16135==     in use at exit: 0 bytes in 0 blocks
==16135==   total heap usage: 3 allocs, 3 frees, 3,364 bytes allocated
==16135==
==16135== All heap blocks were freed -- no leaks are possible
==16135==
==16135== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
omer@omer:~/Desktop/Midterm/Midterm$ _
```

Zombie Detection with ps -A:

```
13482 ?        00:00:06 kworker/0:0-events
13582 ?        00:00:00 mount.ntfs
13681 ?        00:00:01 kworker/2:2-events
13843 ?        00:00:00 kworker/2:0-mm_percpu_wq
13844 ?        00:00:01 kworker/3:2-events
13850 ?        00:00:02 kworker/u8:10-i915
13894 ?        00:00:00 irq/128-mei_me
13900 ?        00:00:02 kworker/1:3-events
13918 ?        00:00:00 kworker/1:5-events
14004 ?        00:00:00 fwupd
14221 ?        00:09:51 firefox
14274 ?        00:01:07 Web Content
14330 ?        00:00:21 WebExtensions
14396 ?        00:01:07 sublime_text
14435 ?        00:00:03 plugin_host
14482 ?        00:00:00 Web Content
14727 ?        00:00:12 nautilus
14760 ?        00:00:00 oosplash
14776 ?        00:02:08 soffice.bin
14803 ?        00:00:00 kworker/3:2H-kblockd
15193 ?        00:00:01 kworker/u8:1-i915
15212 ?        00:00:02 kworker/0:1-events
15236 ?        00:00:00 kworker/3:0-rcu_gp
15275 ?        00:00:06 evince
15281 ?        00:00:00 evinced
15418 ?        00:00:00 kworker/u8:0-events_unbound
15605 ?        00:00:00 kworker/u8:2-i915
15695 ?        00:00:00 kworker/0:2-events
15767 ?        00:00:00 kworker/2:1-events
15768 ?        00:00:00 kworker/1:0-mm_percpu_wq
15771 ?        00:00:00 kworker/3:1-events
15773 ?        00:00:00 kworker/0:3-events
15780 ?        00:00:00 kworker/1:1-events
15784 ?        00:00:00 kworker/3:3-mm_percpu_wq
15814 ?        00:00:39 shotwell
16025 ?        00:00:00 tracker-store
16076 pts/0    00:00:00 ps
omer@omer:~/Desktop/Midterm/Midterm$ _
```

Notes:

- Program compiles perfectly.
- Program runs perfectly.
- No deadlock, no crash.
- Only POSIX unnamed semaphores and shared memories are used.
- Synchronization between processes is provided by only semaphores.
- Graph plots are not implemented.
- In the end, kitchen items : 0.
- In the end, counter items : 0.
- In the end, all students ate L times.