Ice Cream Factory Problem

This program creates a simulation of an ice cream shop where multiple customers are entertained while preventing the race condition.

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1. Problem Description

The problem that our group has chosen is the traditional ice-cream factory problem, where there are multiple counters of the ice cream shop. At each counter, orders for the ice-creams will arrive which will be dealt with by adding different types of flavors and toppings to the order, as per requested by the customer. The ice-creams may have multiple flavors and toppings, which the customer will chose from the given menu. After the flavors are added, as per the customer's order, the ice-cream stock is updated, so that the shop may run smoothly. Once this is done, the ice-cream will be served. Our problem is to make a fully functioning and efficient ice-cream shop using the techniques taught to us throughout the duration of the course.

2. Concepts Covered

Throughout the Operating Systems course we have been made to understand the characteristics of different structures of the Operating Systems and identify the core functions of the Operating Systems. Moreover, to analyze and evaluate the algorithms of the core functions of the Operating Systems and explain the major performance issues with regard to the core functions. Which in turn helps us to demonstrate the knowledge in applying system software and tools available in modern operating systems. Some of the concepts that we have used are multi-threading, use of semaphores, and implementing system calls.

2.1. Multi-threading

Threads are often described as lightweight processes. They can work like two or more processes sharing the same address space i.e., they will work independently like processes but can share the same global variables. They are mostly used when two tasks can be done independently without depending much on each other. In our program we have used the threads to represent individual customers that will be coming to the ice-cream factory in order to buy our ice-cream.

2.2. Semaphores

A semaphore is a counter that can be used to synchronize multiple threads. Linux guarantees that checking or modifying the value of a semaphore can be done safely, without creating a race condition. Each semaphore has a counter value, which is a non-negative integer, in our case the semaphores are initialized with 1 so that the only one customer can access a counter each time to avoid overwriting an data.

A semaphore supports two basic operations:

- A wait operation decrements the value of the semaphore by 1. If the value is already zero, the operation blocks until the value of the semaphore becomes positive (due to the action of some other thread). When the semaphore's value becomes positive, it is decremented by 1 and the wait operation returns.
- A post operation increments the value of the semaphore by 1. If the semaphore was previously zero and other threads are blocked in a wait operation on that semaphore, one of those threads is unblocked and its wait operation completes (which brings the semaphore's value back to zero).

2.3. System Calls

A system call (also known as a syscall) is the programmatic mechanism for a computer application to request a service from the kernel of the operating system on which it is running. Most Unix-like systems handle system calls in kernel mode, which is achieved by switching the processor execution mode to a more privileged one. There is no need for a process context switch, though a privilege context switch does occur. Multiple threads can make system calls in a multi-threaded process. The handling of such calls is determined by the design of the operating system kernel and the application runtime environment. In our project the system call takes a parameter (i) and using that it determines which menu has to be printed, introductory menu, flavors menu, or toppings menu.

2.4. Starvation

When high priority processes continue to run while low priority processes are stalled for an extended period of time, this is known as starvation. A continual stream of higher-priority processes can prevent a low-priority activity from receiving the CPU in a densely loaded computer system. During famine, high-priority processes consume all available resources. In our program, the starvation would have occurred in the form of customers arriving first but being left to be served at the end. This has been addressed by ensuring that only five customers at a time are able to enter the factory, so that it is first come first serve.

3. Implementation

Our project has been made using the C language, and has been implemented on Linux using Ubuntu as the flavor. We have used multi-threading in order to represent the separate customers, and the semaphores ensure that each customer gets to access the counters separately so that the stock can be updated properly. Our system call consists of our showmenu(int i) function, which displays the menu on the kernel log, we have used dmesg() command to display the kernel log on the stdout.

3.1. System Call Implementation

3.1.1. Updating, upgrading and installing essential tools

```
maryam@maryam-VirtualBox:~$ sudo apt update && sudo apt upgrade -y
[sudo] password for maryam:
Hit:1 http://pk.archive.ubuntu.com/ubuntu bionic InRelease
Get:2 http://security.ubuntu.com/ubuntu bionic-security InRelease [88.7 kB]
Get:3 http://pk.archive.ubuntu.com/ubuntu bionic-updates InRelease [88.7 kB]
Get:4 http://security.ubuntu.com/ubuntu bionic-security/main amd64 DEP-11 Metadata [55.2 kB]
Get:5 http://pk.archive.ubuntu.com/ubuntu bionic-backports InRelease [74.6 kB]
Get:6 http://security.ubuntu.com/ubuntu bionic-security/universe amd64 DEP-11 Metadata [59.8 kB]
Get:7 http://pk.archive.ubuntu.com/ubuntu bionic-updates/main i386 Packages [1,474 kB]
Get:8 http://security.ubuntu.com/ubuntu bionic-security/multiverse amd64 DEP-11 Metadata [2,464 B
]
Get:9 http://pk.archive.ubuntu.com/ubuntu bionic-updates/main amd64 Packages [2,570 kB]
Get:10 http://pk.archive.ubuntu.com/ubuntu bionic-updates/main amd64 DEP-11 Metadata [297 kB]
Get:11 http://pk.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 Packages [1,810 kB]
Get:12 http://pk.archive.ubuntu.com/ubuntu bionic-updates/universe i386 Packages [1,607 kB]
Get:13 http://pk.archive.ubuntu.com/ubuntu bionic-updates/universe amd64 DEP-11 Metadata [301 kB]
Get:14 http://pk.archive.ubuntu.com/ubuntu bionic-updates/multiverse amd64 DEP-11 Metadata [2,468
 B]
Get:15 http://pk.archive.ubuntu.com/ubuntu bionic-backports/universe amd64 DEP-11 Metadata [9,268
 B]
Fetched 8,441 kB in 19s (437 kB/s)
Reading package lists... Done
Building dependency tree
Reading state information... Done
All packages are up to date.
Reading package lists... Done
Building dependency tree
Reading state information... Done
Calculating upgrade... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
maryam@maryam-VirtualBox:~$ sudo apt install build-essential libncurses-dev libssl-dev libelf-dev
 bison flex dwarves -y
Reading package lists... Done
Building dependency tree
Reading state information... Done
Note, selecting 'libncurses5-dev' instead of 'libncurses-dev'
bison is already the newest version (2:3.0.4.dfsg-1build1).
build-essential is already the newest version (12.4ubuntu1).
flex is already the newest version (2.6.4-6).
libelf-dev is already the newest version (0.170-0.4ubuntu0.1).
libncurses5-dev is already the newest version (6.1-1ubuntu1.18.04).
libssl-dev is already the newest version (1.1.1-1ubuntu2.1~18.04.17).
dwarves is already the newest version (1.21-0ubuntu1~18.04).
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
maryam@maryam-VirtualBox:~$
```

3.1.2. Cleaning the system

```
maryam@maryam-VirtualBox:~$ sudo apt clean && sudo apt autoremove -y
Reading package lists... Done
Building dependency tree
Reading state information... Done
0 upgraded, 0 newly installed, 0 to remove and 0 not upgraded.
```

3.1.3. Downloading and extracting new kernel files

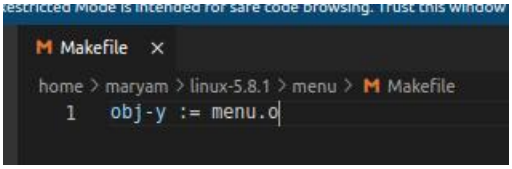
```
maryam@maryam-VirtualBox:~$ wget -P ~/ https://cdn.kernel.org/pub/linux/kernel/v5.x/linux-5.8.1.t
ar.xz
--2022-05-20 12:24:46--  https://cdn.kernel.org/pub/linux/kernel/v5.x/linux-5.8.1.tar.xz
Resolving cdn.kernel.org (cdn.kernel.org)... 151.101.193.176, 151.101.129.176, 151.101.65.176, ..
.
Connecting to cdn.kernel.org (cdn.kernel.org)|151.101.193.176|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 114458544 (109M) [application/x-xz]
Saving to: '/home/maryam/linux-5.8.1.tar.xz'

linux-5.8.1.tar.xz        55%[================>              ]  60.05M   569KB/s    eta 89s
```

3.1.4. Creating System Call file

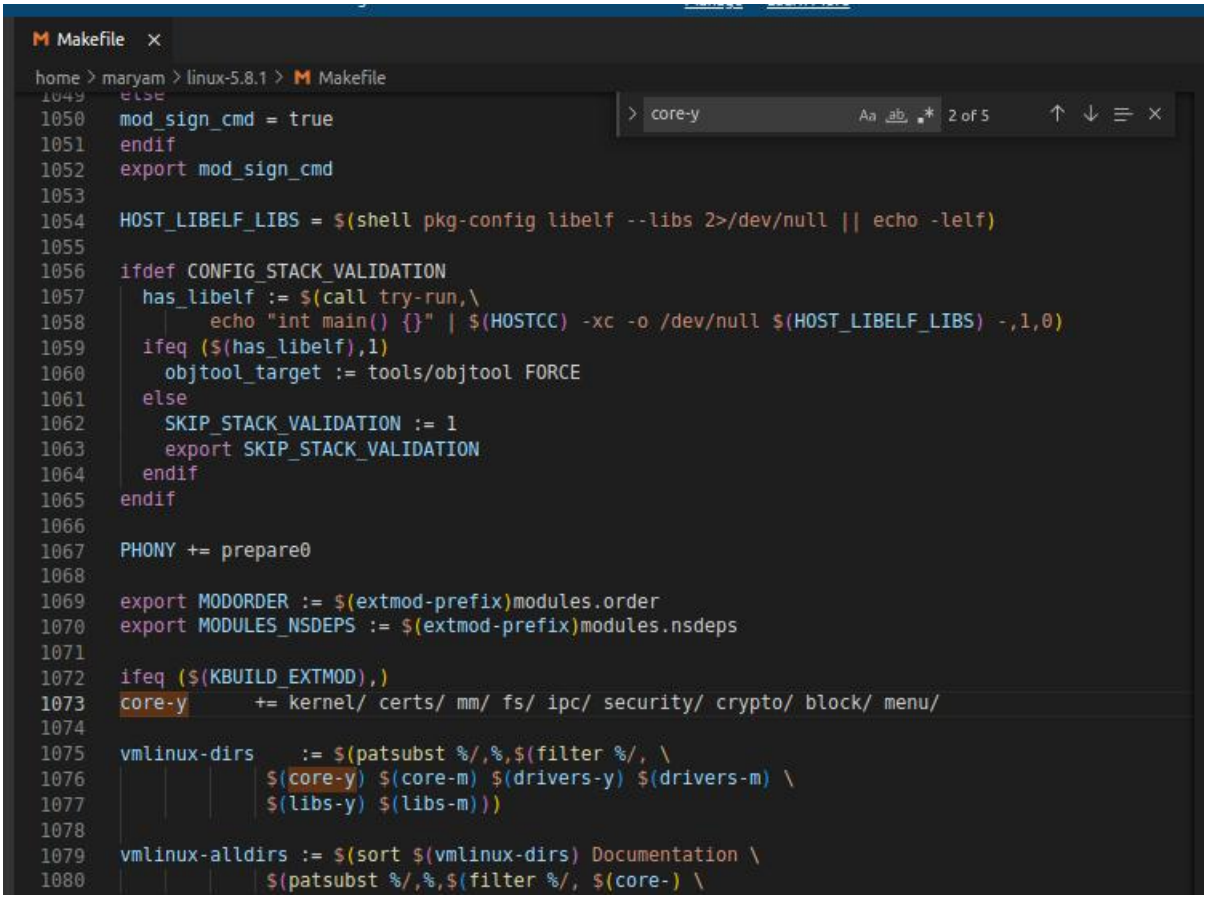
Open ▾ menu.c ~/linux-5.8.1/menu

```
#include <linux/kernel.h>
#include <linux/syscalls.h>

SYSCALL_DEFINE1(menu, int, i)

{
    switch (i)
        {
                case 1:
                        printk("\n\n\t\t\t**********WELCOME TO THE ICE CREAM FACTORY**********\n\n");
                    printk("\n\n\t\tWE HAVE 5 DIFFERENT EXCITING FLAVORS");
                    printk("\n\t\t\t1. VANILLA");
                    printk("\n\t\t\t2. CHOCOLATE");
                    printk("\n\t\t\t3. COOKIES N CREAM");
                    printk("\n\t\t\t4. CHOCOLATE MOUSSE ROYALE");
                    printk("\n\t\t\t5. COTTON CANDY");
                    printk("\n\n\n\t\tWE ALSO HAVE 3 DIFFERENT KINDS OF TOPPINGS");
                    printk("\n\t\t\t1. CHOPPED ALMONDS");
                    printk("\n\t\t\t2. RAINBOW SPRINKLES");
                    printk("\n\t\t\t3. CHOCOLATE CHIPS");
                    printk("\n\n\n\t\t\t\tYOU CAN HAVE ONE OF THESE OR ALL OF THESE");
                    printk("\n\n\t\t\t\tSO COME AND GRAB YOUR CUSTOM FAVORITE ICE CREAM");
                    printk("\n\n\t\t\tWE ONLY HAVE 10 TICKETS LEFT!");
                    printk("\n\t\t\tAND WE ONLY HAVE 10 REMAINING FLAVORS AND TOPPINGS");
                    printk("\n\n\t\t\tIF YOU WANT TO MISS THE ADVENTURE, PRESS 0");
                    break;
                case 2:
                        printk("Available Flavors: \n");
                        printk("1.      Vanilla\n");
                        printk("2.      Chocolate\n");
                        printk("3.      Cookies n Cream\n");
                        printk("4.      Chocolate Mousse Royale\n");
                        printk("5.      Cotton Candy\n");
                        break;
                case 3:
                        printk("Available Toppings: \n");
                        printk("1.      Chopped Almonds\n");
                        printk("2.      Rainbow Sprinkles\n");
                        printk("3.      Chocolate Chips\n");
                        break;
        }


    return 0;
}
```

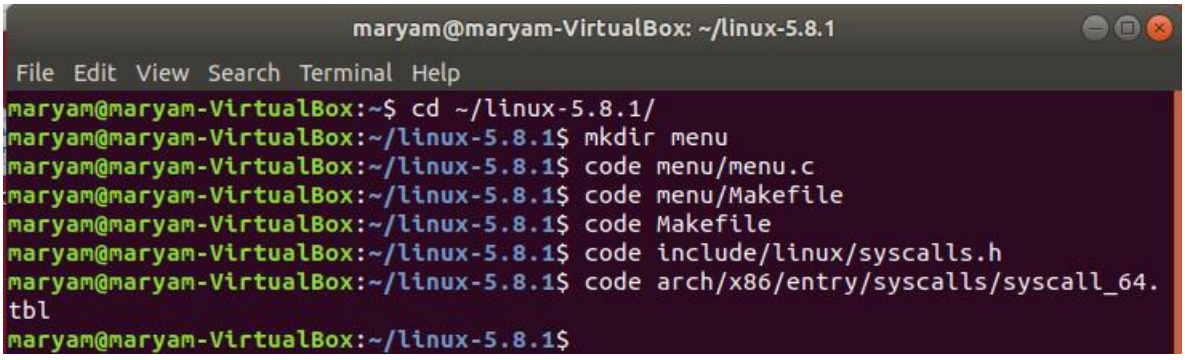
3.1.5. Creating Makefile for system call



3.1.6. Updating existing Makefile in new kernel



3.1.7. Updating syscalls.h and syscall_64.tbl



syscalls.h

home > maryam > linux-5.8.1 > include > linux > C syscalls.h

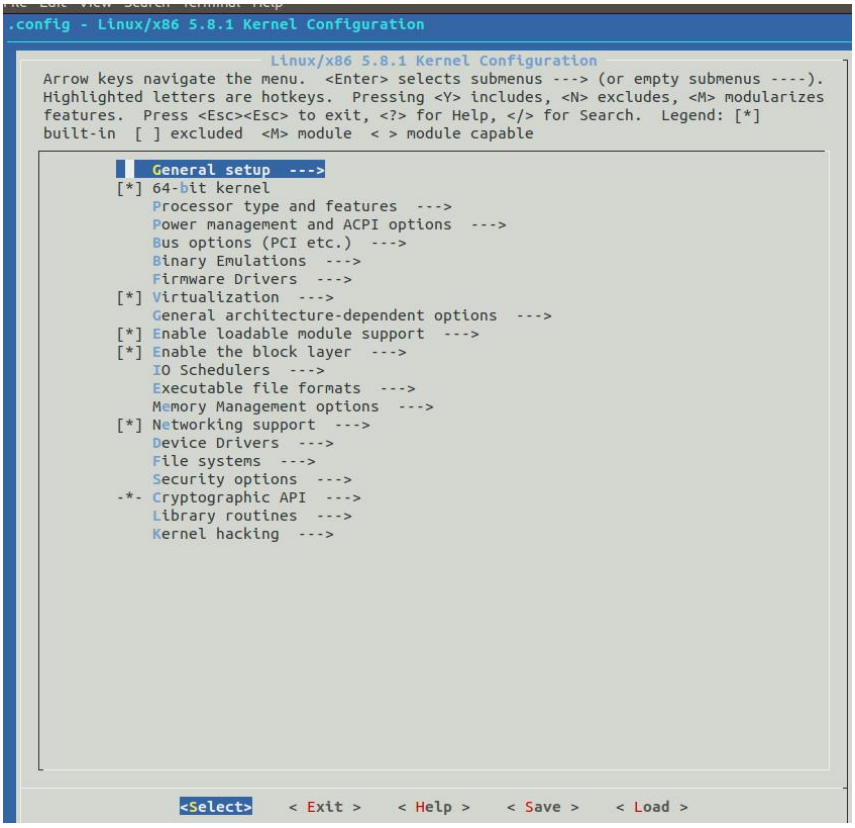
```
1413    long ksys_semget(key_t key, int nsems, int semflg);
1414    long ksys_old_semctl(int semid, int semnum, int cmd, unsigned long arg);
1415    long ksys_msgget(key_t key, int msgflg);
1416    long ksys_old_msgctl(int msqid, int cmd, struct msqid_ds __user *buf);
1417    long ksys_msgrcv(int msqid, struct msgbuf __user *msgp, size_t msgsz,
1418            long msgtyp, int msgflg);
1419    long ksys_msgsnd(int msqid, struct msgbuf __user *msgp, size_t msgsz,
1420            int msgflg);
1421    long ksys_shmget(key_t key, size_t size, int shmflg);
1422    long ksys_shmdt(char __user *shmaddr);
1423    long ksys_old_shmctl(int shmid, int cmd, struct shmid_ds __user *buf);
1424    long compat_ksys_semtimedop(int semid, struct sembuf __user *tsems,
1425                    unsigned int nsops,
1426                    const struct old_timespec32 __user *timeout);
1427    asmlinkage long sys_menu(int i);
1428    #endif
```

syscall_64.tbl

home > maryam > linux-5.8.1 > arch > x86 > entry > syscalls > syscall_64.tbl

```
351   427 common  io_uring_register   sys_io_uring_register
352   428 common  open_tree           sys_open_tree
353   429 common  move_mount          sys_move_mount
354   430 common  fsopen              sys_fsopen
355   431 common  fsconfig            sys_fsconfig
356   432 common  fsmount             sys_fsmount
357   433 common  fspick              sys_fspick
358   434 common  pidfd_open          sys_pidfd_open
359   435 common  clone3              sys_clone3
360   437 common  openat2             sys_openat2
361   438 common  pidfd_getfd         sys_pidfd_getfd
362   439 common  faccessat2          sys_faccessat2
363   440 common  menu                sys_menu
```

3.1.8. Making menuconfig



3.1.9. Running make -j4, make modules_install -j4 and make install -j4

```
maryam@maryam-VirtualBox:~/linux-5.8.1$ make menuconfig
  HOSTCC  scripts/basic/fixdep
  UPD     scripts/kconfig/mconf-cfg
  HOSTCC  scripts/kconfig/mconf.o
  HOSTCC  scripts/kconfig/lxdialog/checklist.o
  HOSTCC  scripts/kconfig/lxdialog/inputbox.o
  HOSTCC  scripts/kconfig/lxdialog/menubox.o
  HOSTCC  scripts/kconfig/lxdialog/textbox.o
  HOSTCC  scripts/kconfig/lxdialog/util.o
  HOSTCC  scripts/kconfig/lxdialog/yesno.o
  HOSTCC  scripts/kconfig/confdata.o
  HOSTCC  scripts/kconfig/expr.o
  LEX     scripts/kconfig/lexer.lex.c
  YACC    scripts/kconfig/parser.tab.[ch]
  HOSTCC  scripts/kconfig/lexer.lex.o
  HOSTCC  scripts/kconfig/parser.tab.o
  HOSTCC  scripts/kconfig/preprocess.o
  HOSTCC  scripts/kconfig/symbol.o
  HOSTCC  scripts/kconfig/util.o
  HOSTLD  scripts/kconfig/mconf
scripts/kconfig/mconf  Kconfig
#
# using defaults found in /boot/config-5.4.0-110-generic
#
/boot/config-5.4.0-110-generic:3816:warning: symbol value 'm' invalid for ISDN_CAPI
/boot/config-5.4.0-110-generic:8245:warning: symbol value 'm' invalid for ASHMEM
/boot/config-5.4.0-110-generic:9205:warning: symbol value 'm' invalid for ANDROID_BINDER_IPC
/boot/config-5.4.0-110-generic:9206:warning: symbol value 'm' invalid for ANDROID_BINDERFS
/boot/config-5.4.0-110-generic:9274:warning: symbol value 'm' invalid for INTERCONNECT


*** End of the configuration.
*** Execute 'make' to start the build or try 'make help'.

maryam@maryam-VirtualBox:~/linux-5.8.1$
```

```
maryam@maryam-VirtualBox:~/linux-5.8.1$ make -j4
  DESCEND  objtool
  CALL     scripts/atomic/check-atomics.sh
  CALL     scripts/checksyscalls.sh
  CHK      include/generated/compile.h
  CC       init/main.o
  CC       arch/x86/entry/vsyscall/vsyscall_64.o
  CC       kernel/sched/core.o
  CC       arch/x86/xen/enlighten.o
  AS       arch/x86/entry/vsyscall/vsyscall_emu_64.o
  AR       arch/x86/entry/vsyscall/built-in.a
  AS       arch/x86/entry/entry_64.o
  CC       arch/x86/xen/mmu.o
  AS       arch/x86/entry/thunk_64.o
  CC       init/do_mounts.o
  CC       arch/x86/entry/syscall_64.o
  CC       arch/x86/xen/time.o
  CC       arch/x86/entry/common.o
  CC       arch/x86/xen/grant-table.o
  CC       arch/x86/xen/suspend.o
  CC       init/do_mounts_initrd.o
  AS       arch/x86/entry/entry_64_compat.o
  CC       arch/x86/entry/syscall_32.o
  CC       arch/x86/xen/enlighten_hvm.o
  CC       init/do_mounts_md.o
  CC       arch/x86/entry/syscall_x32.o
  CC       arch/x86/xen/mmu_hvm.o
  CC       init/initramfs.o
  CC       kernel/sched/loadavg.o
  AR       arch/x86/entry/built-in.a
  CC       arch/x86/platform/pvh/enlighten.o
```

```
  CC      kernel/audit_fsnotify.o
  CC      kernel/audit_tree.o
  CC      kernel/kprobes.o
  CC      kernel/hung_task.o
  CC      kernel/watchdog.o
  CC      kernel/watchdog_hld.o
  CC      kernel/seccomp.o
  CC      kernel/relay.o
  CC      kernel/utsname_sysctl.o
  CC      kernel/delayacct.o
  CC      kernel/taskstats.o
  CC      kernel/tsacct.o
  CC      kernel/tracepoint.o
  CC      kernel/irq_work.o
  CC      kernel/static_call.o
  CC      kernel/static_call_inline.o
  CC      kernel/user-return-notifier.o
  CC      kernel/padata.o
  CC      kernel/crash_dump.o
  CC      kernel/jump_label.o
  CC      kernel/iomem.o
  CC      kernel/rseq.o
  CHK     kernel/kheaders_data.tar.xz
  GEN     kernel/kheaders_data.tar.xz
  AR      kernel/built-in.a
  CC [M]  kernel/kheaders.o
haryam@maryam-VirtualBox:~/linux-5.17.9$
```

```
maryam@maryam-VirtualBox:~/linux-5.17.9$ scripts/config --disable SYSTEM_TRUSTED_KEYS
maryam@maryam-VirtualBox:~/linux-5.17.9$ scripts/config --disable SYSTEM_REVOCATION_KEYS
maryam@maryam-VirtualBox:~/linux-5.17.9$ make -j4
Makefile:1830: target 'block' given more than once in the same rule
  SYNC    include/config/auto.conf.cmd
*
* Restart config...
*
*
* Certificates for signature checking
*
File name or PKCS#11 URI of module signing key (MODULE_SIG_KEY) [certs/signing_key.pem] certs/si
ning_key.pem
Type of module signing key to be generated
> 1. RSA (MODULE_SIG_KEY_TYPE_RSA)
  2. ECDSA (MODULE_SIG_KEY_TYPE_ECDSA)
choice[1-2?]: 1
Provide system-wide ring of trusted keys (SYSTEM_TRUSTED_KEYRING) [Y/?] y
  Additional X.509 keys for default system keyring (SYSTEM_TRUSTED_KEYS) [] (NEW)
  Reserve area for inserting a certificate without recompiling (SYSTEM_EXTRA_CERTIFICATE) [Y/n/?
 y
    Number of bytes to reserve for the extra certificate (SYSTEM_EXTRA_CERTIFICATE_SIZE) [4096]
096
  Provide a keyring to which extra trustable keys may be added (SECONDARY_TRUSTED_KEYRING) [Y/n/
] y
Provide system-wide ring of blacklisted keys (SYSTEM_BLACKLIST_KEYRING) [Y/n/?] y
  Hashes to be preloaded into the system blacklist keyring (SYSTEM_BLACKLIST_HASH_LIST) []
  Provide system-wide ring of revocation certificates (SYSTEM_REVOCATION_LIST) [Y/n/?] y
    X.509 certificates to be preloaded into the system blacklist keyring (SYSTEM_REVOCATION_KEYS
 [] (NEW)
Makefile:1830: target 'block' given more than once in the same rule
  DESCEND objtool
  DESCEND bpf/resolve_btfids
  CALL    scripts/atomic/check-atomics.sh
  CALL    scripts/checksyscalls.sh
  CHK     include/generated/compile.h
  HOSTCC  certs/extract-cert
  COPY    certs/x509.genkey
  CC      certs/common.o
  CC      certs/blacklist.o
  CC      mm/filemap.o
  CERT    certs/x509_revocation_list
  CC      certs/blacklist_nohashes.o
```

```
  LD [M]  sound/soc/intel/boards/snd-soc-sst-haswell.ko
  LD [M]  sound/soc/intel/boards/snd-soc-sst-glk-rt5682_max98357a.ko
  LD [M]  sound/soc/intel/common/snd-soc-acpi-intel-match.ko
  LD [M]  sound/soc/intel/common/snd-soc-sst-acpi.ko
  LD [M]  sound/soc/intel/common/snd-soc-sst-dsp.ko
  LD [M]  sound/soc/intel/common/snd-soc-sst-firmware.ko
  LD [M]  sound/soc/intel/common/snd-soc-sst-ipc.ko
  LD [M]  sound/soc/intel/haswell/snd-soc-sst-haswell-pcm.ko
  LD [M]  sound/soc/snd-soc-acpi.ko
  LD [M]  sound/soc/snd-soc-core.ko
  LD [M]  sound/soc/sof/intel/snd-sof-intel-byt.ko
  LD [M]  sound/soc/sof/intel/snd-sof-intel-hda-common.ko
  LD [M]  sound/soc/sof/intel/snd-sof-intel-hda.ko
  LD [M]  sound/soc/sof/intel/snd-sof-intel-ipc.ko
  LD [M]  sound/soc/sof/snd-sof-acpi.ko
  LD [M]  sound/soc/sof/snd-sof-pci.ko
  LD [M]  sound/soc/sof/snd-sof.ko
  LD [M]  sound/soc/sof/xtensa/snd-sof-xtensa-dsp.ko
  LD [M]  sound/soc/xilinx/snd-soc-xlnx-formatter-pcm.ko
  LD [M]  sound/soc/xilinx/snd-soc-xlnx-i2s.ko
  LD [M]  sound/soc/xilinx/snd-soc-xlnx-spdif.ko
  LD [M]  sound/soc/xtensa/snd-soc-xtfpga-i2s.ko
  LD [M]  sound/soc/zte/zx-tdm.ko
  LD [M]  sound/soundcore.ko
  LD [M]  sound/synth/emux/snd-emux-synth.ko
  LD [M]  sound/synth/snd-util-mem.ko
  LD [M]  sound/usb/6fire/snd-usb-6fire.ko
  LD [M]  sound/usb/bcd2000/snd-bcd2000.ko
  LD [M]  sound/usb/caiaq/snd-usb-caiaq.ko
  LD [M]  sound/usb/hiface/snd-usb-hiface.ko
  LD [M]  sound/usb/line6/snd-usb-line6.ko
  LD [M]  sound/usb/line6/snd-usb-pod.ko
  LD [M]  sound/usb/line6/snd-usb-podhd.ko
  LD [M]  sound/usb/line6/snd-usb-toneport.ko
  LD [M]  sound/usb/line6/snd-usb-variax.ko
  LD [M]  sound/usb/misc/snd-ua101.ko
  LD [M]  sound/usb/snd-usb-audio.ko
  LD [M]  sound/usb/snd-usbmidi-lib.ko
  LD [M]  sound/usb/usx2y/snd-usb-us122l.ko
  LD [M]  sound/usb/usx2y/snd-usb-usx2y.ko
  LD [M]  sound/x86/snd-hdmi-lpe-audio.ko
  LD [M]  sound/xen/snd_xen_front.ko
maryam@maryam-VirtualBox:~/linux-5.8.1$
```

```
maryam@maryam-VirtualBox:~/linux-5.8.1$ sudo make modules_install -j4
[sudo] password for maryam:
  INSTALL arch/x86/crypto/aegis128-aesni.ko
  INSTALL arch/x86/crypto/aesni-intel.ko
  INSTALL arch/x86/crypto/camellia-aesni-avx-x86_64.ko
  INSTALL arch/x86/crypto/blowfish-x86_64.ko
  INSTALL arch/x86/crypto/camellia-aesni-avx2.ko
  INSTALL arch/x86/crypto/camellia-x86_64.ko
  INSTALL arch/x86/crypto/cast6-avx-x86_64.ko
  INSTALL arch/x86/crypto/cast5-avx-x86_64.ko
  INSTALL arch/x86/crypto/chacha-x86_64.ko
  INSTALL arch/x86/crypto/crc32-pclmul.ko
  INSTALL arch/x86/crypto/crct10dif-pclmul.ko
  INSTALL arch/x86/crypto/des3_ede-x86_64.ko
  INSTALL arch/x86/crypto/glue_helper.ko
  INSTALL arch/x86/crypto/ghash-clmulni-intel.ko
  INSTALL arch/x86/crypto/nhpoly1305-avx2.ko
  INSTALL arch/x86/crypto/nhpoly1305-sse2.ko
  INSTALL arch/x86/crypto/serpent-avx-x86_64.ko
  INSTALL arch/x86/crypto/poly1305-x86_64.ko
  INSTALL arch/x86/crypto/serpent-avx2.ko
  INSTALL arch/x86/crypto/serpent-sse2-x86_64.ko
  INSTALL arch/x86/crypto/sha1-ssse3.ko
  INSTALL arch/x86/crypto/sha256-ssse3.ko
  INSTALL arch/x86/crypto/sha512-ssse3.ko
  INSTALL arch/x86/crypto/twofish-x86_64-3way.ko
  INSTALL arch/x86/crypto/twofish-avx-x86_64.ko
  INSTALL arch/x86/crypto/twofish-x86_64.ko
  INSTALL arch/x86/events/intel/intel-cstate.ko
  INSTALL arch/x86/events/rapl.ko
  INSTALL arch/x86/kernel/cpu/mce/mce-inject.ko
  INSTALL arch/x86/kernel/cpuid.ko
  INSTALL arch/x86/kernel/msr.ko
```

```
 INSTALL sound/soc/intel/boards/snd-soc-sst-cht-bsw-rt5672.ko
 INSTALL sound/soc/intel/boards/snd-soc-sst-glk-rt5682_max98357a.ko
 INSTALL sound/soc/intel/boards/snd-soc-sst-haswell.ko
 INSTALL sound/soc/intel/common/snd-soc-acpi-intel-match.ko
 INSTALL sound/soc/intel/common/snd-soc-sst-acpi.ko
 INSTALL sound/soc/intel/common/snd-soc-sst-dsp.ko
 INSTALL sound/soc/intel/common/snd-soc-sst-firmware.ko
 INSTALL sound/soc/intel/common/snd-soc-sst-ipc.ko
 INSTALL sound/soc/intel/haswell/snd-soc-sst-haswell-pcm.ko
 INSTALL sound/soc/snd-soc-acpi.ko
 INSTALL sound/soc/snd-soc-core.ko
 INSTALL sound/soc/sof/intel/snd-sof-intel-byt.ko
 INSTALL sound/soc/sof/intel/snd-sof-intel-hda-common.ko
 INSTALL sound/soc/sof/intel/snd-sof-intel-hda.ko
 INSTALL sound/soc/sof/intel/snd-sof-intel-ipc.ko
 INSTALL sound/soc/sof/snd-sof-acpi.ko
 INSTALL sound/soc/sof/snd-sof.ko
 INSTALL sound/soc/sof/snd-sof-pci.ko
 INSTALL sound/soc/sof/xtensa/snd-sof-xtensa-dsp.ko
 INSTALL sound/soc/xilinx/snd-soc-xlnx-formatter-pcm.ko
 INSTALL sound/soc/xilinx/snd-soc-xlnx-i2s.ko
 INSTALL sound/soc/xilinx/snd-soc-xlnx-spdif.ko
 INSTALL sound/soc/xtensa/snd-soc-xtfpga-i2s.ko
 INSTALL sound/soc/zte/zx-tdm.ko
 INSTALL sound/soundcore.ko
 INSTALL sound/synth/emux/snd-emux-synth.ko
 INSTALL sound/synth/snd-util-mem.ko
 INSTALL sound/usb/6fire/snd-usb-6fire.ko
 INSTALL sound/usb/bcd2000/snd-bcd2000.ko
 INSTALL sound/usb/caiaq/snd-usb-caiaq.ko
 INSTALL sound/usb/hiface/snd-usb-hiface.ko
 INSTALL sound/usb/line6/snd-usb-line6.ko
 INSTALL sound/usb/line6/snd-usb-pod.ko
 INSTALL sound/usb/line6/snd-usb-podhd.ko
 INSTALL sound/usb/line6/snd-usb-toneport.ko
 INSTALL sound/usb/line6/snd-usb-variax.ko
 INSTALL sound/usb/misc/snd-ua101.ko
 INSTALL sound/usb/snd-usb-audio.ko
 INSTALL sound/usb/snd-usbmidi-lib.ko
 INSTALL sound/usb/usx2y/snd-usb-us122l.ko
 INSTALL sound/usb/usx2y/snd-usb-usx2y.ko
 INSTALL sound/x86/snd-hdmi-lpe-audio.ko
 INSTALL sound/xen/snd_xen_front.ko
 DEPMOD  5.8.1
aryam@maryam-VirtualBox:~/linux-5.8.1$
```

```
maryam@maryam-VirtualBox:~/linux-5.8.1$ sudo make install -j4
sh ./arch/x86/boot/install.sh 5.8.1 arch/x86/boot/bzImage \
        System.map "/boot"
run-parts: executing /etc/kernel/postinst.d/apt-auto-removal 5.8.1 /boot/vmlinuz-5.8.1
run-parts: executing /etc/kernel/postinst.d/dkms 5.8.1 /boot/vmlinuz-5.8.1
 * dkms: running auto installation service for kernel 5.8.1
run-parts: executing /etc/kernel/postinst.d/initramfs-tools 5.8.1 /boot/vmlinuz-5.8.1
update-initramfs: Generating /boot/initrd.img-5.8.1
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 5.8.1 /boot/vmlinuz-5.8.1
run-parts: executing /etc/kernel/postinst.d/update-notifier 5.8.1 /boot/vmlinuz-5.8.1
run-parts: executing /etc/kernel/postinst.d/vboxadd 5.8.1 /boot/vmlinuz-5.8.1
VirtualBox Guest Additions: Building the modules for kernel 5.8.1.

VirtualBox Guest Additions: Look at /var/log/vboxadd-setup.log to find out what
went wrong
run-parts: executing /etc/kernel/postinst.d/xx-update-initrd-links 5.8.1 /boot/vmlinuz-5.8.1
I: /vmlinuz.old is now a symlink to boot/vmlinuz-5.4.0-110-generic
I: /initrd.img.old is now a symlink to boot/initrd.img-5.4.0-110-generic
I: /vmlinuz is now a symlink to boot/vmlinuz-5.8.1
I: /initrd.img is now a symlink to boot/initrd.img-5.8.1
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 5.8.1 /boot/vmlinuz-5.8.1
Sourcing file `/etc/default/grub'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-5.8.1
Found initrd image: /boot/initrd.img-5.8.1
Found linux image: /boot/vmlinuz-5.4.0-110-generic
Found initrd image: /boot/initrd.img-5.4.0-110-generic
Found linux image: /boot/vmlinuz-5.4.0-84-generic
Found initrd image: /boot/initrd.img-5.4.0-84-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
maryam@maryam-VirtualBox:~/linux-5.8.1$
```

3.1.10.Updating the kernel to the new version

```
maryam@maryam-VirtualBox:~/linux-5.8.1$ sudo update-grub
[sudo] password for maryam:
Sourcing file `/etc/default/grub'
Generating grub configuration file ...
Found linux image: /boot/vmlinuz-5.8.1
Found initrd image: /boot/initrd.img-5.8.1
Found linux image: /boot/vmlinuz-5.4.0-110-generic
Found initrd image: /boot/initrd.img-5.4.0-110-generic
Found linux image: /boot/vmlinuz-5.4.0-84-generic
Found initrd image: /boot/initrd.img-5.4.0-84-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
maryam@maryam-VirtualBox:~/linux-5.8.1$
```

4. Project Output

4.1. Introduction screen

```
maryam@maryam-VirtualBox: ~/Desktop
File  Edit  View  Search  Terminal  Help
                          **********WELCOME TO THE ICE CREAM FACTORY**********
[  718.542435]
                      WE HAVE 5 DIFFERENT EXCITING FLAVORS
[  718.542436]
                              1. VANILLA
[  718.542437]
                              2. CHOCOLATE
[  718.542438]
                              3. COOKIES N CREAM
[  718.542439]
                              4. CHOCOLATE MOUSSE ROYALE
[  718.542440]
                              5. COTTON CANDY
[  718.542441]

                      WE ALSO HAVE 3 DIFFERENT KINDS OF TOPPINGS
[  718.542442]
                              1. CHOPPED ALMONDS
[  718.542443]
                              2. RAINBOW SPRINKLES
[  718.542444]
                              3. CHOCOLATE CHIPS
[  718.542445]

                                    YOU CAN HAVE ONE OF THESE OR ALL OF THESE
[  718.542446]
                                    SO COME AND GRAB YOUR CUSTOM FAVORITE ICE CREAM
[  718.542447]
                              WE ONLY HAVE 30 TICKETS LEFT!
[  718.542448]
                              AND WE ONLY HAVE 30 REMAINING FLAVORS AND TOPPINGS
[  718.542449]
                              IF YOU WANT TO MISS THE ADVENTURE, PRESS 0

                      Enter your choice: 1
```

4.2. Number of Customers

```
File  Edit  View  Search  Terminal  Help

Enter Number Of Customers [ 30  Tickets Remaining ]: 2


Customer [ 2 ] Got Tickets.
Customer [ 1 ] Got Tickets.
```

4.3. Choice of flavors

```
Customer [ 2 ] entering the Flavor Counter
[  733.910878] Available Flavors:
[  733.910881] 1.       Vanilla
[  733.910882] 2.       Chocolate
[  733.910883] 3.       Cookies n Cream
[  733.910884] 4.       Chocolate Mousse Royale
[  733.910885] 5.       Cotton Candy
Enter the number of flavors you want to add [Max 5]: 2

Enter your desired flavor: 1
Customer [ 2 ] Got Vanilla Flavor.

Enter your desired flavor: 3
Customer [ 2 ] Got Cookies n Cream Flavor.

Customer [ 2 ] Got Flavour(s). Leaving Flavor Counter
```

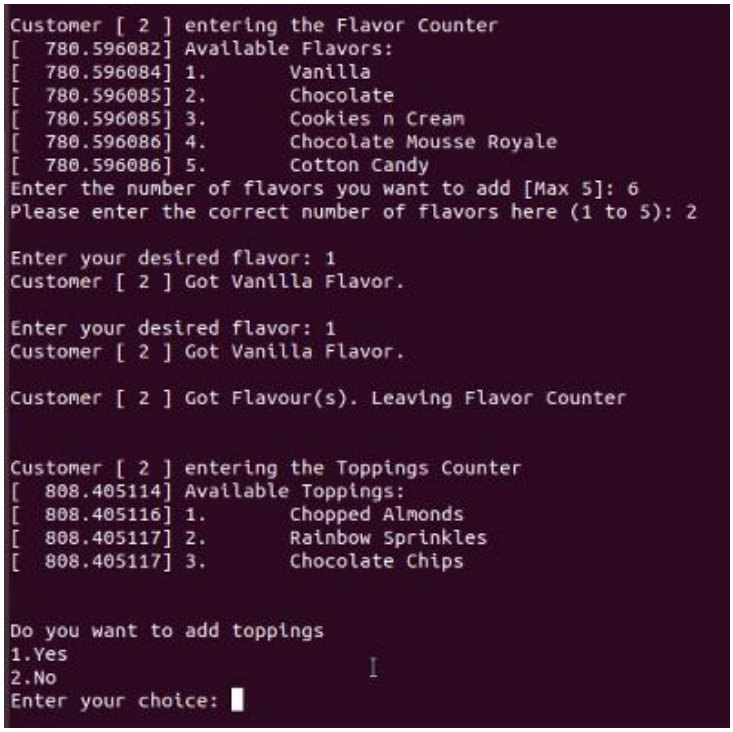
4.4. Limit on stock available

```
Customer [ 7 ] entering the Flavor Counter
[  495.605568] Available Flavors:
[  495.605570] 1.       Vanilla
[  495.605570] 2.       Chocolate
[  495.605571] 3.       Cookies n Cream
[  495.605571] 4.       Chocolate Mousse Royale
[  495.605572] 5.       Cotton Candy
Enter the number of flavors you want to add [Max 5]: 5

Enter your desired flavor: 1
Sorry Vanilla is finished,Please Select another flavor:
```

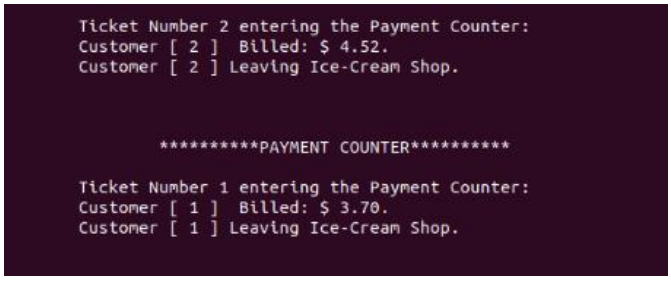
4.5. Choice of toppings

```
Customer [ 1 ] entering the Toppings Counter
[  767.504071] Available Toppings:
[  767.504074] 1.       Chopped Almonds
[  767.504075] 2.       Rainbow Sprinkles
[  767.504076] 3.       Chocolate Chips


Do you want to add toppings
1.Yes
2.No
Enter your choice: 1
Enter number of toppings you want to add [MAX 3]: 4
Please enter the correct number of flavors here (1 to 3): 1

Enter your desired Toppings: 1
Customer [ 1 ] Got Chopped Almonds Topping.
Customer [ 1 ] Leaving Topping Counter.
```

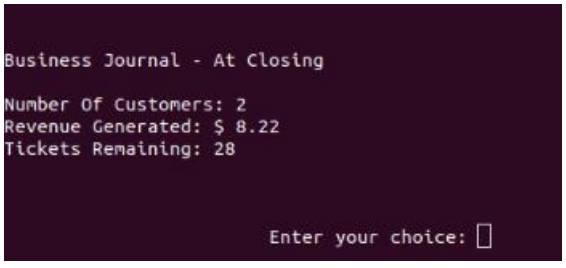
4.6. Continuation



4.7. Customers leaving



4.8. Ending Journal



4.9. Updated Counter