

Project 4: Synchronization

CS 411

For this project, you'll implement *variations* of two of the classic synchronization problems: Dining Philosophers and The Sleeping Barber. You'll use Pthreads mutex and condition variables in your implementation of the Dining Philosophers problem and POSIX unnamed semaphores in your implementation of the Sleeping Barber problem. Your solutions will be thread-based.

You don't need your virtual machines for this project — you can use phoenix. You'll be using a new repository on GitHub to submit this project. See Canvas for the link to use to create your repository. Remember to create a new directory for your working files and the local copy of your repo. As a refresher, here's the basic sequence of git commands:

```
mkdir Project4
cd Project4
git init    # DON'T DO THIS IN YOUR HOME DIRECTORY!!!!!!
git remote add origin YOUR_GITHUB_REPO_URL
# add files
git add .
git commit -m "Initial commit."
git push -u origin master # Only for the very first push to the remote
git push # All pushes after the very first push

# If you're working on a system (phoenix, say) where you haven't used
# GitHub before, run these commands again:

# Let's start off by configuring your global git tooling. You'll only need
# to run the following commands once, unless your blow-up your VM and have
# to start over, or start working from another account. Use identity
# values that make sense for you _and_ that others will understand.

git config --global user.name "Your Name"
git config --global user.email Your.Name@mail.goucher.edu
git config --global push.default simple

# Rather than using geany, you could use emacs, gedit, or vi.

git config --global core.editor geany

# Okay, it can be pretty annoying to have to enter your GitHub credentials
# every single time you interact with your remote, so let's get some
# help. Run one of these two commands:

# 1) Cache credentials in memory for one hour (units are seconds). Adjust
```

```
# the timeout as you see fit.

git config --global credential.helper "cache --timeout=3600"

# 2) Store credentials unencrypted on disk permanently
#    Default storage file is ~/.git-credentials

git config --global credential.helper store

# If you're paranoid, to delete the credential cache before the timeout
# expires run

git credential-cache exit
```

References

The following are all available on, or linked to from, the course web site, and/or in the textbook:

1. Dining Philosophers Solution Using Monitors, Section 7.1.3 of the textbook. Note that this is a monitor-based solution, so it will require some modification — the addition of mutual exclusion for critical sections and the use of while loops with condition variables, rather than if statements. Also on the course web site.
2. *The Sleeping Barber Problem*. Includes a semaphore-based solution. On the course web site.
3. Pthreads Synchronization, Section 7.3 of the textbook for introductory material on Pthreads mutex and condition variables, and POSIX unnamed semaphores. Also see the documentation at the end of the course web site.
4. Projects 2 and 3 at the end of Chapter 7 for useful background information.
5. `semaphore.c` — A concise illustration of POSIX semaphore functions in Linux.
6. `producerConsumer.c` — An illustration of Pthreads operations in Linux, including thread creation, parameter passing, join, and mutex and condition variable operations.
7. `helloThreaded.c` — An illustration of how to manage a fair number of threads using a `pthread_t` array.

Code Structure for an Actor

This illustrates the basic structure of a philosopher, barber, customer, etc. thread that requests or performs some service at various intervals. Because this is an infinite loop, you'll need to terminate your programs by typing Ctrl-c.

```
/* Remember to include the Pthreads library when compiling:
 *
 * gcc -o foo foo.c -lpthread
 *
 * To run: ./foo
 */

/* Include files */
#include <stdio.h>
#include <pthread.h>
#include <unistd.h>
#include <stdlib.h>
#include <assert.h>

/* Function prototypes */
void delay(unsigned int *seed, unsigned int min, unsigned int max);
void *actor1(void *ptr);

/* Sleep a random amount of time between min and max seconds. */
void delay(unsigned int *seed, unsigned int min, unsigned int max)
{
    /* assert() terminates the program if its condition is false. */
    assert(min <= max);
    sleep((unsigned int) (min + (rand_r(seed) % (max - min + 1))));
}

void *actor1(void *ptr)
{
    long tid = (long) ptr;
    /* Each thread needs its own private seed for the pseudo-random
     * number generator.
     */
    unsigned int seed = tid;

    while (1)
    {
        /* Simulate action 1 by sleeping. */
        printf("Action 1\n");
        delay(&seed, 3, 8);

        /* Some synchronization here. */
    }
}
```

```

        /* Simulate action 2 by sleeping. */
        printf("Action 2\n");
        delay(&seed, 0, 10);

        /* More synchronization here. */

        /* etc. */
    }
}

int main()
{
    pthread_t actor;

    /* Use unbuffered output for output logging purposes. */
    setvbuf(stdout, (char *)NULL, _IONBF, 0);
    setvbuf(stderr, (char *)NULL, _IONBF, 0);

    pthread_create(&actor, NULL, actor1, (void *) 11);
    pthread_join(actor, NULL);
    return 0;
}

```

I/O Hints

In order to un-buffer I/O, put the following at the beginning of main():

```

/* Use unbuffered output for output logging purposes. */
setvbuf(stdout, (char *)NULL, _IONBF, 0);
setvbuf(stderr, (char *)NULL, _IONBF, 0);

```

You may find the following useful for timestamping your output:

```

/* Necessary include files */
#include <time.h>
#include <sys/time.h>
#include <string.h>

/* Function prototype */
void timestamp(char *msg);

/* Function */
void timestamp(char *msg)
{
    char buf[128];
    struct timeval tv;
    struct tm ltv;

    gettimeofday(&tv, NULL);

```

```

    localtime_r(&tv.tv_sec, &ltv);
    sprintf(buf, "%02d:%02d:%05.2f    ", ltv.tm_hour, ltv.tm_min,
            (double) (ltv.tm_sec + tv.tv_usec / 1.0E6));
    strncat(buf, msg, 128 - strlen(buf) - 1);
    printf("%s", buf);
}

/* Usage example */
foo(int tid)
{
    char msg[128];

    sprintf(msg, "Cust %d wants haircut\n", tid);
    timestamp(msg);
}

```

Dining Philosophers

Implement a mutex and condition variable-based solution to Dining Philosophers, based upon the monitor-based pseudo-code given in Section 5.8.2 of the textbook. Using a **turn** variable, ensure that starvation is avoided in your implementation, without unduly causing the other philosophers to go hungry. (I.e., if it's philosopher 3's turn and philosopher 3 is thinking, philosophers 2 and 4 shouldn't be prevented from eating.) Once the philosopher whose turn it is finally eats, it's the next philosopher's turn, where "next" is used in a circular way.

Because of the real possibility of spurious signal operations, ensure that your condition variable wait operations are "guarded" by while statements.

Here's how to implement the state enum in C:

```

/* enum state is a named enum.  It's wrapped in a typedef, creating a new
 * type named 'state'.
typedef enum state
    {
        THINKING,
        HUNGRY,
        EATING
    } state;

state philState[5];

int main()
{
    int i;

    for (i = 0; i < 5; i++)
        philState[i] = THINKING;

    return 0;
}

```

The Sleeping Barber

Implement a POSIX unnamed semaphores-based solution to The Sleeping Barber, using the pseudo-code in the *The Sleeping Barber Problem* reference document as a starting point. The town in which the barber cuts hair has one Very Important Person (VIP). When the VIP visits the barber, he gets preferential service — he doesn't preempt a customer receiving a haircut at the time he arrives, nor does he cause a fifth waiting customer to relinquish his seat, but he will always be the next customer to receive a haircut. The barber thread should contain logic and `printf()` statements to indicate when the barber has no customers and will therefore go to sleep. Finally, use a semaphore, controlled by the barber, to explicitly force a rendezvous between the barber and the customer/VIP receiving a haircut.

Assume that a customer's haircut takes one second, but that the VIP's haircut takes two seconds. The VIP needs a new haircut five seconds after the previous haircut. Ordinary customer i needs a new haircut $i + 2$ seconds after the previous visit to the barbershop.

To demonstrate your logic, run your program with two ordinary customers, demonstrating that the barber sleeps occasionally. Then, run your program with 10 ordinary customers, demonstrating that sometimes customers leave without getting a haircut, that the VIP receives priority treatment, and that the barber doesn't sleep when customers are waiting.

Project 4 Turn-in

By the project deadline, email to me the GitHub <https> URL of your project repository. Remember to document assistance you received from others. This can be done in the email you send me your repo URL, in your README.md file, or in comments at the very top of your source code files. This project will be assessed as follows:

- Dining Philosophers: 40%
- The Sleeping Barber: 40%
- Readability: 10%
- Verifiability: 10% (Your source code should contain a sufficient number of informative `printf()` calls so that I can understand what's happening as your program runs.)

Example Dining Philosophers Output

```
Phil 0 eating
Phil 1 now has priority
Phil 2 eating
Phil 3 hungry
Phil 4 hungry
Phil 1 hungry
Phil 4 eating
Phil 0 thinking
Phil 0 hungry
Phil 0 deferring to Phil 1
Phil 4 thinking
Phil 4 eating
```

Phil 1 eating
Phil 2 now has priority
Phil 2 thinking
Phil 2 hungry
Phil 3 deferring to Phil 2
Phil 4 thinking
Phil 0 eating
Phil 2 eating
Phil 3 now has priority
Phil 1 thinking
Phil 1 hungry
Phil 0 thinking
Phil 4 deferring to Phil 3
Phil 4 hungry
Phil 1 eating
Phil 3 eating
Phil 4 now has priority
Phil 2 thinking
Phil 4 eating
Phil 0 now has priority
Phil 3 thinking
Phil 3 hungry
Phil 0 hungry
Phil 2 hungry
Phil 2 eating
Phil 1 thinking
Phil 0 eating
Phil 1 now has priority
Phil 4 thinking
Phil 3 eating
Phil 2 thinking
Phil 2 eating
Phil 3 thinking
Phil 2 thinking
Phil 2 eating
Phil 2 thinking
Phil 2 eating
Phil 2 thinking
Phil 2 eating
Phil 1 hungry
Phil 4 hungry
Phil 3 hungry
Phil 3 eating
Phil 2 thinking
Phil 2 hungry
Phil 1 eating
Phil 2 now has priority
Phil 0 thinking

Phil 0 hungry
Phil 4 eating
Phil 3 thinking
Phil 4 thinking
Phil 0 eating
Phil 2 eating
Phil 3 now has priority
Phil 1 thinking
Phil 1 hungry
Phil 3 hungry
Phil 4 hungry
Phil 3 eating
Phil 4 now has priority
Phil 2 thinking
Phil 3 thinking
Phil 3 deferring to Phil 4
Phil 3 hungry
Phil 4 eating
Phil 0 now has priority
Phil 1 eating
Phil 0 thinking
Phil 0 hungry
Phil 2 hungry
Phil 2 eating
Phil 1 thinking
Phil 3 eating
Phil 0 eating
Phil 1 now has priority
Phil 4 thinking
Phil 4 hungry
Phil 2 thinking
Phil 3 thinking
Phil 3 eating
Phil 3 thinking
Phil 1 hungry
Phil 2 deferring to Phil 1
Phil 2 hungry
Phil 3 eating
Phil 1 eating
Phil 2 now has priority
Phil 0 thinking
Phil 0 hungry
Phil 0 eating
Phil 1 thinking
Phil 1 hungry
Phil 1 deferring to Phil 2
Phil 0 thinking
Phil 2 eating

Phil 3 now has priority
Phil 4 eating
Phil 3 thinking
Phil 0 hungry
Phil 3 hungry
Phil 1 eating
Phil 2 thinking
Phil 3 eating
Phil 4 now has priority
Phil 4 thinking
Phil 4 hungry
Phil 0 deferring to Phil 4
Phil 1 thinking
Phil 4 eating
Phil 0 now has priority
Phil 3 thinking
Phil 2 eating
Phil 2 thinking
Phil 1 deferring to Phil 0
Phil 1 hungry
Phil 2 eating
Phil 3 hungry
Phil 0 eating
Phil 1 now has priority
Phil 4 thinking
Phil 0 thinking
Phil 0 deferring to Phil 1
Phil 0 hungry
Phil 1 eating
Phil 2 now has priority
Phil 3 eating
Phil 2 thinking
Phil 0 eating
Phil 1 thinking
Phil 4 hungry
Phil 1 hungry
Phil 3 thinking
Phil 2 eating
Phil 3 now has priority
Phil 2 thinking
Phil 3 eating
Phil 4 now has priority
Phil 1 eating
Phil 0 thinking
Phil 1 thinking
Phil 2 hungry
Phil 2 eating
Phil 4 eating

Phil 0 now has priority
Phil 3 thinking
Phil 3 hungry
Phil 0 hungry
Phil 0 eating
Phil 1 now has priority
Phil 4 thinking
Phil 1 hungry
Phil 4 hungry
Phil 3 eating
Phil 2 thinking
Phil 2 deferring to Phil 1
Phil 2 hungry
Phil 3 thinking
Phil 4 eating
Phil 1 eating
Phil 2 now has priority
Phil 0 thinking
Phil 0 hungry
Phil 2 eating
Phil 3 now has priority
Phil 1 thinking
Phil 1 hungry
Phil 3 hungry
Phil 0 eating
Phil 4 thinking
Phil 4 hungry
Phil 4 deferring to Phil 3
Phil 0 thinking
Phil 1 eating
Phil 3 eating
Phil 4 now has priority
Phil 2 thinking
Phil 0 hungry
Phil 0 deferring to Phil 4
Phil 1 thinking
Phil 2 hungry
Phil 2 eating
Phil 4 eating
Phil 0 now has priority
Phil 3 thinking
Phil 3 hungry
Phil 2 thinking
Phil 1 deferring to Phil 0
Phil 1 hungry
Phil 2 eating
Phil 0 eating
Phil 1 now has priority

Phil 4 thinking
Phil 4 hungry

Example Sleeping Barber Output

Two Ordinary Customers

Notice that the barber occasionally sleeps and that neither of the ordinary customers leaves without getting a haircut.

```
15:09:09.38  VIP wants haircut
15:09:09.38  Cust 1 wants haircut
15:09:09.38  Cust 1 sits
15:09:09.38  Barber sleeping
15:09:09.38  Barber awake
15:09:09.38  Barber cuts VIP's hair
15:09:09.38  VIP gets haircut
15:09:09.38  Cust 0 wants haircut
15:09:09.38  Cust 0 sits
15:09:11.38  Barber cuts customer's hair
15:09:11.38  Cust 1 gets haircut
15:09:11.38  Cust 1 about town
15:09:12.38  Barber cuts customer's hair
15:09:12.38  VIP about town
15:09:12.38  Cust 0 gets haircut
15:09:13.38  Barber sleeping
15:09:13.38  Cust 0 about town
15:09:14.38  Cust 1 wants haircut
15:09:14.38  Cust 1 sits
15:09:14.38  Barber awake
15:09:14.38  Barber cuts customer's hair
15:09:14.38  Cust 1 gets haircut
15:09:15.38  Barber sleeping
15:09:15.38  Cust 1 about town
15:09:15.38  Cust 0 wants haircut
15:09:15.38  Cust 0 sits
15:09:15.38  Barber awake
15:09:15.38  Barber cuts customer's hair
15:09:15.38  Cust 0 gets haircut
15:09:16.38  Barber sleeping
15:09:16.38  Cust 0 about town
15:09:17.38  VIP wants haircut
15:09:17.38  Barber awake
15:09:17.38  Barber cuts VIP's hair
15:09:17.38  VIP gets haircut
15:09:18.38  Cust 1 wants haircut
15:09:18.38  Cust 1 sits
15:09:18.38  Cust 0 wants haircut
```

15:09:18.38 Cust 0 sits
15:09:19.38 Barber cuts customer's hair
15:09:19.38 Cust 1 gets haircut
15:09:19.38 Cust 1 about town
15:09:20.38 Barber cuts customer's hair
15:09:20.38 Cust 0 gets haircut
15:09:20.38 VIP about town
15:09:21.38 Barber sleeping
15:09:21.38 Cust 0 about town
15:09:22.38 Cust 1 wants haircut
15:09:22.38 Cust 1 sits
15:09:22.38 Barber awake
15:09:22.38 Barber cuts customer's hair
15:09:22.38 Cust 1 gets haircut
15:09:23.38 Barber sleeping
15:09:23.38 Cust 1 about town
15:09:23.38 Cust 0 wants haircut
15:09:23.38 Cust 0 sits
15:09:23.38 Barber awake
15:09:23.38 Barber cuts customer's hair
15:09:23.38 Cust 0 gets haircut
15:09:24.38 Barber sleeping
15:09:24.38 Cust 0 about town
15:09:25.38 VIP wants haircut
15:09:25.38 Barber awake
15:09:25.38 Barber cuts VIP's hair
15:09:25.38 VIP gets haircut
15:09:26.38 Cust 1 wants haircut
15:09:26.38 Cust 1 sits
15:09:26.38 Cust 0 wants haircut
15:09:26.38 Cust 0 sits
15:09:27.38 Barber cuts customer's hair
15:09:27.38 Cust 1 gets haircut
15:09:27.38 Cust 1 about town
15:09:28.38 Barber cuts customer's hair
15:09:28.38 VIP about town
15:09:28.38 Cust 0 gets haircut
15:09:29.38 Barber sleeping
15:09:29.38 Cust 0 about town
15:09:30.38 Cust 1 wants haircut
15:09:30.38 Cust 1 sits
15:09:30.38 Barber awake
15:09:30.38 Barber cuts customer's hair
15:09:30.38 Cust 1 gets haircut
15:09:31.38 Barber sleeping
15:09:31.38 Cust 1 about town
15:09:31.38 Cust 0 wants haircut
15:09:31.38 Cust 0 sits

15:09:31.38	Barber awake
15:09:31.38	Barber cuts customer's hair
15:09:31.38	Cust 0 gets haircut
15:09:32.38	Barber sleeping
15:09:32.38	Cust 0 about town
15:09:33.38	VIP wants haircut
15:09:33.38	Barber awake
15:09:33.38	Barber cuts VIP's hair
15:09:33.38	VIP gets haircut

Ten Ordinary Customers

Notice that the barber doesn't get to sleep and that some of the ordinary customers leave without getting a haircut.

15:16:11.82	Cust 1 wants haircut
15:16:11.82	Cust 1 sits
15:16:11.82	Cust 2 wants haircut
15:16:11.82	Cust 0 wants haircut
15:16:11.82	Cust 9 wants haircut
15:16:11.82	VIP wants haircut
15:16:11.82	Cust 3 wants haircut
15:16:11.82	Cust 2 sits
15:16:11.82	Cust 8 wants haircut
15:16:11.82	Cust 5 wants haircut
15:16:11.82	Cust 4 wants haircut
15:16:11.82	Cust 8 sits
15:16:11.82	Cust 0 sits
15:16:11.82	Cust 7 wants haircut
15:16:11.82	Cust 6 wants haircut
15:16:11.82	Cust 7 sits
15:16:11.82	Cust 9 leaves without haircut
15:16:11.82	Cust 9 about town
15:16:11.82	Cust 1 gets haircut
15:16:11.82	Barber cuts customer's hair
15:16:11.82	Cust 5 sits
15:16:11.82	Cust 4 leaves without haircut
15:16:11.82	Cust 4 about town
15:16:11.82	Cust 3 leaves without haircut
15:16:11.82	Cust 3 about town
15:16:11.82	Cust 6 leaves without haircut
15:16:11.82	Cust 6 about town
15:16:12.82	Barber cuts VIP's hair
15:16:12.82	VIP gets haircut
15:16:12.82	VIP about town
15:16:14.82	Barber cuts customer's hair
15:16:14.82	Cust 1 about town
15:16:14.82	Cust 2 gets haircut

15:16:15.82 Barber cuts customer's hair
15:16:15.82 Cust 8 gets haircut
15:16:15.82 Cust 2 about town
15:16:16.82 Cust 3 wants haircut
15:16:16.82 Cust 3 sits
15:16:16.82 Barber cuts customer's hair
15:16:16.82 Cust 0 gets haircut
15:16:16.82 Cust 0 about town
15:16:17.82 Cust 4 wants haircut
15:16:17.82 Cust 4 sits
15:16:17.82 VIP wants haircut
15:16:17.82 Cust 1 wants haircut
15:16:17.82 Cust 1 sits
15:16:17.82 Barber cuts VIP's hair
15:16:17.82 VIP gets haircut
15:16:17.82 VIP about town
15:16:18.82 Cust 0 wants haircut
15:16:18.82 Cust 0 leaves without haircut
15:16:18.82 Cust 0 about town
15:16:19.82 Cust 6 wants haircut
15:16:19.82 Cust 6 leaves without haircut
15:16:19.82 Cust 6 about town
15:16:19.82 Cust 2 wants haircut
15:16:19.82 Cust 2 leaves without haircut
15:16:19.82 Cust 2 about town
15:16:19.82 Barber cuts customer's hair
15:16:19.82 Cust 7 gets haircut
15:16:19.82 Cust 8 about town
15:16:20.82 Cust 0 wants haircut
15:16:20.82 Barber cuts customer's hair
15:16:20.82 Cust 0 sits
15:16:20.82 Cust 0 gets haircut
15:16:20.82 Cust 0 about town
15:16:21.82 Barber cuts customer's hair
15:16:21.82 Cust 3 gets haircut
15:16:21.82 Cust 3 about town
15:16:22.82 Cust 9 wants haircut
15:16:22.82 Cust 9 sits
15:16:22.82 VIP wants haircut
15:16:22.82 Cust 0 wants haircut
15:16:22.82 Cust 0 sits
15:16:22.82 Barber cuts VIP's hair
15:16:22.82 VIP gets haircut
15:16:22.82 Cust 7 about town
15:16:23.82 Cust 2 wants haircut
15:16:23.82 Cust 2 leaves without haircut
15:16:23.82 Cust 2 about town
15:16:24.82 Barber cuts customer's hair

15:16:24.82 Cust 4 gets haircut
15:16:24.82 Cust 4 about town
15:16:25.82 Barber cuts customer's hair
15:16:25.82 VIP about town
15:16:25.82 Cust 1 gets haircut
15:16:26.82 Cust 3 wants haircut
15:16:26.82 Cust 3 sits
15:16:26.82 Barber cuts customer's hair
15:16:26.82 Cust 1 about town
15:16:26.82 Cust 5 gets haircut
15:16:27.82 Cust 6 wants haircut
15:16:27.82 Cust 6 sits
15:16:27.82 Cust 2 wants haircut
15:16:27.82 Cust 2 sits
15:16:27.83 Barber cuts customer's hair
15:16:27.83 Cust 9 gets haircut
15:16:27.83 Cust 9 about town
15:16:28.83 Barber cuts customer's hair
15:16:28.83 Cust 0 gets haircut
15:16:28.83 Cust 0 about town
15:16:29.82 Cust 8 wants haircut
15:16:29.82 Cust 8 sits
15:16:29.83 Cust 1 wants haircut
15:16:29.83 Cust 1 sits
15:16:29.83 Barber cuts customer's hair
15:16:29.83 Cust 3 gets haircut
15:16:29.83 Cust 3 about town
15:16:30.82 Cust 4 wants haircut
15:16:30.82 Cust 4 sits
15:16:30.82 VIP wants haircut
15:16:30.83 Cust 0 wants haircut
15:16:30.83 Cust 0 leaves without haircut
15:16:30.83 Cust 0 about town
15:16:30.83 Barber cuts VIP's hair
15:16:30.83 VIP gets haircut
15:16:30.83 VIP about town
15:16:31.82 Cust 7 wants haircut
15:16:31.82 Cust 7 leaves without haircut
15:16:31.82 Cust 7 about town
15:16:32.83 Cust 0 wants haircut
15:16:32.83 Cust 0 leaves without haircut
15:16:32.83 Cust 0 about town
15:16:32.83 Barber cuts customer's hair
15:16:32.83 Cust 5 about town
15:16:32.83 Cust 6 gets haircut
15:16:33.83 Barber cuts customer's hair
15:16:33.83 Cust 6 about town
15:16:33.83 Cust 2 gets haircut

15:16:34.83 Cust 3 wants haircut
15:16:34.83 Cust 3 sits
15:16:34.83 Cust 0 wants haircut
15:16:34.83 Cust 0 sits
15:16:34.83 Barber cuts customer's hair
15:16:34.83 Cust 8 gets haircut
15:16:34.83 Cust 2 about town
15:16:35.83 VIP wants haircut
15:16:35.83 Barber cuts VIP's hair
15:16:35.83 VIP gets haircut
15:16:35.83 VIP about town
15:16:37.83 Barber cuts customer's hair
15:16:37.83 Cust 1 gets haircut
15:16:37.83 Cust 1 about town
15:16:38.83 Cust 9 wants haircut
15:16:38.83 Cust 9 sits
15:16:38.83 Cust 2 wants haircut
15:16:38.83 Cust 2 sits
15:16:38.83 Barber cuts customer's hair
15:16:38.83 Cust 4 gets haircut
15:16:38.83 Cust 4 about town
15:16:39.83 Cust 5 wants haircut
15:16:39.83 Cust 5 sits
15:16:39.83 Barber cuts customer's hair
15:16:39.83 Cust 3 gets haircut
15:16:39.83 Cust 3 about town
15:16:40.82 Cust 7 wants haircut
15:16:40.82 Cust 7 sits
15:16:40.83 VIP wants haircut
15:16:40.83 Cust 1 wants haircut
15:16:40.83 Cust 1 leaves without haircut
15:16:40.83 Cust 1 about town
15:16:40.83 Barber cuts VIP's hair
15:16:40.83 VIP gets haircut
15:16:40.83 VIP about town
15:16:41.83 Cust 6 wants haircut
15:16:41.83 Cust 6 leaves without haircut
15:16:41.83 Cust 6 about town
15:16:42.83 Cust 8 about town
15:16:42.83 Cust 0 gets haircut
15:16:42.83 Barber cuts customer's hair
15:16:43.83 Cust 1 wants haircut
15:16:43.83 Cust 1 sits
15:16:43.83 Barber cuts customer's hair
15:16:43.83 Cust 0 about town
15:16:43.83 Cust 9 gets haircut
15:16:44.83 Cust 4 wants haircut
15:16:44.83 Cust 4 sits

15:16:44.83 Cust 3 wants haircut
15:16:44.83 Cust 3 leaves without haircut
15:16:44.83 Cust 3 about town
15:16:44.83 Barber cuts customer's hair
15:16:44.83 Cust 9 about town
15:16:44.83 Cust 2 gets haircut
15:16:45.83 VIP wants haircut
15:16:45.83 Cust 0 wants haircut
15:16:45.83 Cust 0 sits
15:16:45.83 Barber cuts VIP's hair
15:16:45.83 VIP gets haircut
15:16:45.83 VIP about town
15:16:47.83 Barber cuts customer's hair
15:16:47.83 Cust 5 gets haircut
15:16:47.83 Cust 5 about town
15:16:48.83 Barber cuts customer's hair
15:16:48.83 Cust 7 gets haircut
15:16:48.83 Cust 2 about town
15:16:49.83 Cust 6 wants haircut
15:16:49.83 Cust 6 sits
15:16:49.83 Cust 3 wants haircut
15:16:49.83 Cust 3 sits
15:16:49.83 Barber cuts customer's hair
15:16:49.83 Cust 1 gets haircut
15:16:49.83 Cust 1 about town
15:16:50.83 VIP wants haircut
15:16:50.83 Barber cuts VIP's hair
15:16:50.83 VIP gets haircut
15:16:50.83 VIP about town
15:16:52.83 Cust 8 wants haircut
15:16:52.83 Cust 8 sits
15:16:52.83 Cust 2 wants haircut
15:16:52.83 Cust 2 leaves without haircut
15:16:52.83 Cust 2 about town
15:16:52.83 Cust 1 wants haircut
15:16:52.83 Cust 1 leaves without haircut
15:16:52.83 Cust 1 about town
15:16:52.83 Cust 4 gets haircut
15:16:52.83 Cust 4 about town
15:16:52.83 Barber cuts customer's hair
15:16:53.83 Barber cuts customer's hair
15:16:53.83 Cust 0 gets haircut
15:16:53.83 Cust 0 about town
15:16:54.83 Cust 5 wants haircut
15:16:54.83 Cust 5 sits
15:16:54.83 Barber cuts customer's hair
15:16:54.83 Cust 6 gets haircut
15:16:54.83 Cust 6 about town

15:16:55.83 Cust 9 wants haircut
15:16:55.83 Cust 9 sits
15:16:55.83 Cust 1 wants haircut
15:16:55.83 Cust 1 sits
15:16:55.83 VIP wants haircut
15:16:55.83 Cust 0 wants haircut
15:16:55.83 Cust 0 leaves without haircut
15:16:55.83 Cust 0 about town
15:16:55.83 Barber cuts VIP's hair
15:16:55.83 VIP gets haircut
15:16:55.83 VIP about town
15:16:56.83 Cust 2 wants haircut
15:16:56.83 Cust 2 leaves without haircut
15:16:56.83 Cust 2 about town
15:16:57.83 Cust 0 wants haircut
15:16:57.83 Cust 0 leaves without haircut
15:16:57.83 Cust 0 about town
15:16:57.83 Barber cuts customer's hair
15:16:57.83 Cust 3 gets haircut
15:16:57.83 Cust 3 about town
15:16:58.83 Cust 4 wants haircut
15:16:58.83 Cust 4 sits
15:16:58.83 Barber cuts customer's hair
15:16:58.83 Cust 8 gets haircut
15:16:58.83 Cust 8 about town
15:16:59.83 Cust 0 wants haircut
15:16:59.83 Cust 0 sits
15:16:59.83 Barber cuts customer's hair
15:16:59.83 Cust 5 gets haircut
15:16:59.83 Cust 5 about town
15:17:00.83 Cust 2 wants haircut
15:17:00.83 Cust 2 sits
15:17:00.83 VIP wants haircut
15:17:00.83 Barber cuts VIP's hair
15:17:00.83 VIP gets haircut
15:17:00.83 Cust 7 about town
15:17:02.83 Cust 6 wants haircut
15:17:02.83 Cust 6 leaves without haircut
15:17:02.83 Cust 6 about town
15:17:02.83 Cust 3 wants haircut
15:17:02.83 Cust 3 leaves without haircut
15:17:02.83 Cust 3 about town
15:17:02.83 Barber cuts customer's hair
15:17:02.83 VIP about town
15:17:02.83 Cust 9 gets haircut
15:17:03.83 Barber cuts customer's hair
15:17:03.83 Cust 1 gets haircut
15:17:03.83 Cust 1 about town

15:17:04.83 Barber cuts customer's hair
15:17:04.83 Cust 4 gets haircut
15:17:04.83 Cust 4 about town
15:17:05.83 Barber cuts customer's hair
15:17:05.83 Cust 0 gets haircut
15:17:05.83 Cust 0 about town
15:17:06.83 Cust 5 wants haircut
15:17:06.83 Cust 5 sits
15:17:06.83 Cust 1 wants haircut
15:17:06.83 Cust 1 sits
15:17:06.83 Barber cuts customer's hair
15:17:06.83 Cust 9 about town
15:17:06.83 Cust 2 gets haircut
15:17:07.83 Cust 3 wants haircut
15:17:07.83 Cust 3 sits
15:17:07.83 VIP wants haircut
15:17:07.83 Cust 0 wants haircut
15:17:07.83 Cust 0 sits
15:17:07.83 Barber cuts VIP's hair
15:17:07.83 VIP gets haircut
15:17:07.83 VIP about town
15:17:08.83 Cust 8 wants haircut
15:17:08.83 Cust 8 sits
15:17:09.83 Cust 7 wants haircut
15:17:09.83 Cust 7 leaves without haircut
15:17:09.83 Cust 7 about town
15:17:09.83 Barber cuts customer's hair
15:17:09.83 Cust 5 gets haircut
15:17:09.83 Cust 5 about town
15:17:10.83 Cust 6 wants haircut
15:17:10.83 Cust 6 sits
15:17:10.83 Cust 4 wants haircut
15:17:10.83 Cust 4 leaves without haircut
15:17:10.83 Cust 4 about town
15:17:10.83 Barber cuts customer's hair
15:17:10.83 Cust 1 gets haircut
15:17:10.83 Cust 1 about town
15:17:11.83 Barber cuts customer's hair
15:17:11.83 Cust 3 gets haircut
15:17:11.83 Cust 3 about town
15:17:12.83 VIP wants haircut
15:17:12.83 Barber cuts VIP's hair
15:17:12.83 VIP gets haircut
15:17:12.83 VIP about town
15:17:13.83 Cust 1 wants haircut
15:17:13.83 Cust 1 sits
15:17:14.83 Barber cuts customer's hair
15:17:14.83 Cust 0 gets haircut

15:17:14.83 Cust 0 about town
15:17:15.83 Barber cuts customer's hair
15:17:15.83 Cust 8 gets haircut
15:17:15.83 Cust 8 about town
15:17:16.83 Cust 4 wants haircut
15:17:16.83 Cust 4 sits
15:17:16.83 Cust 5 wants haircut
15:17:16.83 Cust 5 sits
15:17:16.83 Cust 3 wants haircut
15:17:16.83 Cust 3 sits
15:17:16.83 Cust 0 wants haircut
15:17:16.83 Cust 0 leaves without haircut
15:17:16.83 Cust 0 about town
15:17:16.83 Barber cuts customer's hair
15:17:16.83 Cust 6 gets haircut
15:17:16.83 Cust 6 about town
15:17:17.83 Cust 9 wants haircut
15:17:17.83 Cust 9 sits
15:17:17.83 VIP wants haircut
15:17:17.83 Barber cuts VIP's hair
15:17:17.83 VIP gets haircut
15:17:17.83 VIP about town
15:17:18.83 Cust 7 wants haircut
15:17:18.83 Cust 7 leaves without haircut
15:17:18.83 Cust 7 about town
15:17:18.83 Cust 0 wants haircut
15:17:18.83 Cust 0 leaves without haircut
15:17:18.83 Cust 0 about town
15:17:19.83 Barber cuts customer's hair
15:17:19.83 Cust 1 gets haircut
15:17:19.83 Cust 1 about town
15:17:20.83 Cust 0 wants haircut
15:17:20.83 Cust 0 sits
15:17:20.83 Barber cuts customer's hair
15:17:20.83 Cust 4 gets haircut
15:17:20.83 Cust 4 about town
15:17:21.84 Barber cuts customer's hair
15:17:21.84 Cust 5 gets haircut
15:17:21.84 Cust 5 about town
15:17:22.83 VIP wants haircut
15:17:22.83 Cust 1 wants haircut
15:17:22.83 Cust 1 sits
15:17:22.84 Barber cuts VIP's hair
15:17:22.84 VIP gets haircut
15:17:22.84 VIP about town
15:17:24.83 Cust 6 wants haircut
15:17:24.83 Cust 6 sits
15:17:24.84 Barber cuts customer's hair

15:17:24.84 Cust 3 gets haircut
15:17:24.84 Cust 3 about town
15:17:25.83 Cust 8 wants haircut
15:17:25.83 Cust 8 sits
15:17:25.84 Barber cuts customer's hair
15:17:25.84 Cust 9 gets haircut
15:17:25.84 Cust 9 about town
15:17:26.84 Cust 4 wants haircut
15:17:26.84 Cust 4 sits
15:17:26.84 Barber cuts customer's hair
15:17:26.84 Cust 0 gets haircut
15:17:26.84 Cust 0 about town
15:17:27.83 Cust 7 wants haircut
15:17:27.83 Cust 7 sits
15:17:27.84 VIP wants haircut
15:17:27.84 Barber cuts VIP's hair
15:17:27.84 VIP gets haircut
15:17:27.84 VIP about town
15:17:28.84 Cust 5 wants haircut
15:17:28.84 Cust 5 leaves without haircut
15:17:28.84 Cust 5 about town
15:17:28.84 Cust 0 wants haircut
15:17:28.84 Cust 0 leaves without haircut
15:17:28.84 Cust 0 about town
15:17:29.84 Cust 3 wants haircut
15:17:29.84 Cust 3 leaves without haircut
15:17:29.84 Cust 3 about town
15:17:29.84 Barber cuts customer's hair
15:17:29.84 Cust 1 gets haircut
15:17:29.84 Cust 1 about town
15:17:30.84 Cust 0 wants haircut
15:17:30.84 Cust 0 sits
15:17:30.84 Barber cuts customer's hair
15:17:30.84 Cust 6 gets haircut
15:17:30.84 Cust 6 about town
15:17:31.84 Barber cuts customer's hair
15:17:31.84 Cust 8 gets haircut
15:17:31.84 Cust 8 about town
15:17:32.84 VIP wants haircut
15:17:32.84 Cust 1 wants haircut
15:17:32.84 Cust 1 sits
15:17:32.84 Barber cuts VIP's hair
15:17:32.84 VIP gets haircut
15:17:32.84 VIP about town
15:17:34.84 Cust 3 wants haircut
15:17:34.84 Cust 3 sits
15:17:34.84 Barber cuts customer's hair
15:17:34.84 Cust 4 gets haircut

15:17:34.84 Cust 4 about town
15:17:35.84 Cust 5 wants haircut
15:17:35.84 Cust 5 sits
15:17:35.84 Barber cuts customer's hair
15:17:35.84 Cust 7 gets haircut
15:17:35.84 Cust 7 about town
15:17:36.84 Cust 9 wants haircut
15:17:36.84 Cust 9 sits
15:17:36.84 Barber cuts customer's hair
15:17:36.84 Cust 0 gets haircut
15:17:36.84 Cust 0 about town
15:17:37.84 VIP wants haircut
15:17:37.84 Barber cuts VIP's hair
15:17:37.84 VIP gets haircut
15:17:37.84 VIP about town
15:17:38.84 Cust 6 wants haircut
15:17:38.84 Cust 6 sits
15:17:38.84 Cust 0 wants haircut
15:17:38.84 Cust 0 leaves without haircut
15:17:38.84 Cust 0 about town
15:17:39.84 Barber cuts customer's hair
15:17:39.84 Cust 1 gets haircut
15:17:39.84 Cust 1 about town
15:17:40.84 Cust 4 wants haircut
15:17:40.84 Cust 4 sits
15:17:40.84 Cust 0 wants haircut
15:17:40.84 Cust 0 leaves without haircut
15:17:40.84 Cust 0 about town
15:17:40.84 Barber cuts customer's hair
15:17:40.84 Cust 3 gets haircut
15:17:40.84 Cust 3 about town
15:17:41.84 Cust 8 wants haircut
15:17:41.84 Cust 8 sits
15:17:41.84 Barber cuts customer's hair
15:17:41.84 Cust 5 gets haircut
15:17:41.84 Cust 5 about town
15:17:42.84 Cust 0 wants haircut
15:17:42.84 Cust 0 sits
15:17:42.84 VIP wants haircut
15:17:42.84 Cust 1 wants haircut
15:17:42.84 Cust 1 leaves without haircut
15:17:42.84 Cust 1 about town
15:17:42.84 Barber cuts VIP's hair
15:17:42.84 VIP gets haircut
15:17:42.84 Cust 2 about town
15:17:44.84 Cust 7 wants haircut
15:17:44.84 Cust 7 leaves without haircut
15:17:44.84 Cust 7 about town

15:17:44.84 Barber cuts customer's hair
15:17:44.84 VIP about town
15:17:44.84 Cust 9 gets haircut
15:17:45.84 Cust 3 wants haircut
15:17:45.84 Cust 3 sits
15:17:45.84 Cust 1 wants haircut
15:17:45.84 Cust 1 leaves without haircut
15:17:45.84 Cust 1 about town
15:17:45.84 Barber cuts customer's hair
15:17:45.84 Cust 9 about town
15:17:45.84 Cust 6 gets haircut
15:17:46.84 Cust 2 wants haircut
15:17:46.84 Cust 2 sits
15:17:46.84 Barber cuts customer's hair
15:17:46.84 Cust 4 gets haircut
15:17:46.84 Cust 6 about town
15:17:47.84 Barber cuts customer's hair
15:17:47.84 Cust 4 about town
15:17:47.84 Cust 8 gets haircut
15:17:48.84 Cust 1 wants haircut
15:17:48.84 Cust 1 sits
15:17:48.84 Cust 5 wants haircut
15:17:48.84 Cust 5 sits
15:17:48.84 Barber cuts customer's hair
15:17:48.84 Cust 8 about town
15:17:48.84 Cust 0 gets haircut