Batman

1-Overall organization and functions:

The project is divided into 3 main classes which are : Main , Bat , Monitor

1. Bat class : a class which works like the bat which holds the type of the bat (north , east , …) in integer values (north : 0 , east : 1 , south : 2 , west : 3) and holding an id which indicates it's index in the input

```
#ifndef BAT_H
#define BAT_H


class Bat
{
    public:
        Bat();
        virtual ~Bat();

        void set_type(int t){
            type = t;
        }

        int get_type(){
            return type;
        }

        void set_id(int t){
            id = t;
        }

        int get_id(){
            return id;
        }

    protected:

    private:

    int type;
    int id;
};

#endif // BAT_H

```

2. Main class : a class which do most of the work. It starts with initializing a lot of locks and conditions which will be mentioned later , it also take in the input and make a loop for each character and build a bat for each character using the bat class and then in starts a thread which calls a method called deal_with_bat which determine the type of the bat and check some conditions which will be mentioned later and then call another method called apply_queue which start to call arrive , cross , leave by turn and also will be mentioned later. We can divide the class as follow :

```cpp
#include <iostream>
#include <thread>
#include <queue>
#include <pthread.h>

#include "Bat.h"
#include "Monitor.h"

using namespace std;

string input;

int north_counter= 0;
int east_counter= 0;
int south_counter= 0;
int west_counter= 0;

bool north_signal_flag = false;
bool east_signal_flag = false;
bool south_signal_flag = false;
bool west_signal_flag = false;

pthread_mutex_t north_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t east_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t south_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t west_queue_lock = PTHREAD_MUTEX_INITIALIZER;

pthread_mutex_t apply_north_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t apply_east_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t apply_south_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t apply_west_queue_lock = PTHREAD_MUTEX_INITIALIZER;

pthread_mutex_t apply_waiting_north_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t apply_waiting_east_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t apply_waiting_south_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t apply_waiting_west_queue_lock = PTHREAD_MUTEX_INITIALIZER;

pthread_mutex_t flag_north_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t flag_east_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t flag_south_queue_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t flag_west_queue_lock = PTHREAD_MUTEX_INITIALIZER;

pthread_mutex_t arrive_lock = PTHREAD_MUTEX_INITIALIZER;
pthread_mutex_t leave_lock = PTHREAD_MUTEX_INITIALIZER;

pthread_cond_t north_queue_can_arrive_cond = PTHREAD_COND_INITIALIZER;
pthread_cond_t east_queue_can_arrive_cond = PTHREAD_COND_INITIALIZER;
pthread_cond_t south_queue_can_arrive_cond = PTHREAD_COND_INITIALIZER;
pthread_cond_t west_queue_can_arrive_cond = PTHREAD_COND_INITIALIZER;

Monitor m;

void deal_with_bat(Bat b);
void apply_queue(Bat b);

int main(){

    pthread_mutex_init( &north_queue_lock, NULL);
    pthread_mutex_init( &east_queue_lock, NULL);
    pthread_mutex_init( &south_queue_lock, NULL);
    pthread_mutex_init( &west_queue_lock, NULL);

    pthread_mutex_init( &apply_north_queue_lock, NULL);
    pthread_mutex_init( &apply_east_queue_lock, NULL);
    pthread_mutex_init( &apply_south_queue_lock, NULL);
    pthread_mutex_init( &apply_west_queue_lock, NULL);

    pthread_mutex_init( &apply_waiting_north_queue_lock, NULL);
    pthread_mutex_init( &apply_waiting_east_queue_lock, NULL);
    pthread_mutex_init( &apply_waiting_south_queue_lock, NULL);
    pthread_mutex_init( &apply_waiting_west_queue_lock, NULL);

    pthread_mutex_init( &flag_north_queue_lock, NULL);
    pthread_mutex_init( &flag_east_queue_lock, NULL);
    pthread_mutex_init( &flag_south_queue_lock, NULL);
    pthread_mutex_init( &flag_west_queue_lock, NULL);

    pthread_mutex_init( &arrive_lock, NULL);
    pthread_mutex_init( &leave_lock, NULL);

    pthread_cond_init( &north_queue_can_arrive_cond, NULL);
    pthread_cond_init( &east_queue_can_arrive_cond, NULL);
    pthread_cond_init( &south_queue_can_arrive_cond, NULL);
    pthread_cond_init( &west_queue_can_arrive_cond, NULL);

    cin >> input;

    thread my_threads[input.size()];

```

```
    for(int i = 0 ; i < input.size() ; i++){
        Bat b;

        if(input[i] == 'n'){
            b.set_type(0);
        }else if(input[i] == 'e'){
            b.set_type(1);
        }else if(input[i] == 's'){
            b.set_type(2);
        }else if(input[i] == 'w'){
            b.set_type(3);
        }

        b.set_id(i);

        my_threads[i] = thread(deal_with_bat ,b);
    }

    for(int i = 0 ; i < input.size() ; i++){
        my_threads[i].join();
    }

    return 0;
}

void deal_with_bat(Bat b){
    if(b.get_type() == 0){
        pthread_mutex_lock(&north_queue_lock);
        if(north_counter == 0){
            north_counter++;
            pthread_mutex_unlock(&north_queue_lock);
            apply_queue(b);
        }else{
            north_counter++;
            pthread_mutex_unlock(&north_queue_lock);
            pthread_mutex_lock(&apply_waiting_north_queue_lock);
            if(north_signal_flag == false){
                pthread_cond_wait(&north_queue_can_arrive_cond , &apply_north_queue_lock );
            }
            pthread_mutex_lock(&flag_north_queue_lock);
            north_signal_flag = false;
            pthread_mutex_unlock(&flag_north_queue_lock);
            pthread_mutex_unlock(&apply_waiting_north_queue_lock);
            apply_queue(b);
        }
    }else{
        pthread_mutex_lock(&west_queue_lock);
        if(west_counter == 0){
            west_counter++;
            pthread_mutex_unlock(&west_queue_lock);
            apply_queue(b);
        }else{
            west_counter++;
            pthread_mutex_unlock(&west_queue_lock);
            pthread_mutex_lock(&apply_waiting_west_queue_lock);
            if(south_signal_flag == false){
                pthread_cond_wait(&west_queue_can_arrive_cond , &apply_west_queue_lock );
            }
            pthread_mutex_lock(&flag_west_queue_lock);
            west_signal_flag = false;
            pthread_mutex_unlock(&flag_west_queue_lock);
            pthread_mutex_unlock(&apply_waiting_west_queue_lock);
            apply_queue(b);
            }
    }
}

void apply_queue(Bat b){
    pthread_mutex_lock(&arrive_lock);
    m.arrive(b);
    pthread_mutex_unlock(&arrive_lock);
    m.check();
    m.cross(b);
    pthread_mutex_lock(&leave_lock);
    m.leave(b);
    pthread_mutex_unlock(&leave_lock);
    }else if(b.get_type() == 1){
        pthread_mutex_lock(&east_queue_lock);
        east_counter--;
        pthread_mutex_unlock(&east_queue_lock);
        pthread_cond_signal(&east_queue_can_arrive_cond);
    }else{
        pthread_mutex_lock(&west_queue_lock);
        west_counter--;
        pthread_mutex_unlock(&west_queue_lock);
        pthread_cond_signal(&west_queue_can_arrive_cond);
        pthread_mutex_lock(&flag_west_queue_lock);
        west_signal_flag = true;
        pthread_mutex_unlock(&flag_west_queue_lock);
    }
}
```

- Locks : 6 families were used as the follow
    1. north_queue_lock : used to make sure that only one thread is checking the value of the north counter and changing it
    2. apply_north_queue_lock : used with the waiting condition
    3. apply_waiting_north_queue_lock : used in the waiting case where there is another bat from the same member in the monitor so all other bats will wait and only one will receive the signal to go
    4. flag_north_queue_lock : used to make sure only one thread is checking the flag value and changing it.
    5. arrive_lock : used to make sure that only one thread is applying arrive mode now
    6. leave_lock : used to make sure that only one thread is applying leave now
       "The last 2 locks are only used to sync the printing to avoid a print of something like : BAT BAT 2 from North arrives at crossing 3 from East arrives at crossing"
- Conditions : 1 family was used as follow
    1. north_queue_can_arrive_cond : used to signal that a thread of a family has left the crossing and another one can come in the crossing
       "The bat is only allowed to be in after a member has finished the leave method and this can be modified only by changing the signal place"
- Counters : 1 family is used as follow
    1. north_counter : used to know the number of waiting threads from the same family
- Flags : 1 family is used as follow
    1. north_signal_flag : used to solve a problem which occurs. The problems was as follow processor starts with thread A so it goes in to arrive then the processor switches to thread B from the same family so it checks the counter and in founds it should wait but before applying the wait on signal the processor switches again to A and finishes it so it signals a signal but B wasn't yet waiting on it so it was lost and when the processor switches back to B it was like a deadlock case
- deal_with_bat method : this method is used to make sure that is only one member of the family is in the monitor. It works at first by determining the type of the bat then it locks the counter (for mutual exe) and checks it then unlock it and here it can find that there is no any member from the family in the monitor so it can call apply_queue method which pushes it to the monitor or it can find that it should wait so it locks the waiting and wait on the signal after checking that there was no lost signals and then it lock the flag and changes it and unlock them all and go to apply_queue method
- apply_queue method: this method is working like the navigation for the threads in the monitor which starts with locking the arrive the call arrive then unlock it and then it checks for deadlocks by calling check then cross and then locks the leave and leave and then unlock it after that it locks the counter change it then unlock it

finally it signal that any waiting on can move on and set the flag to true to make sure it isn’t lost

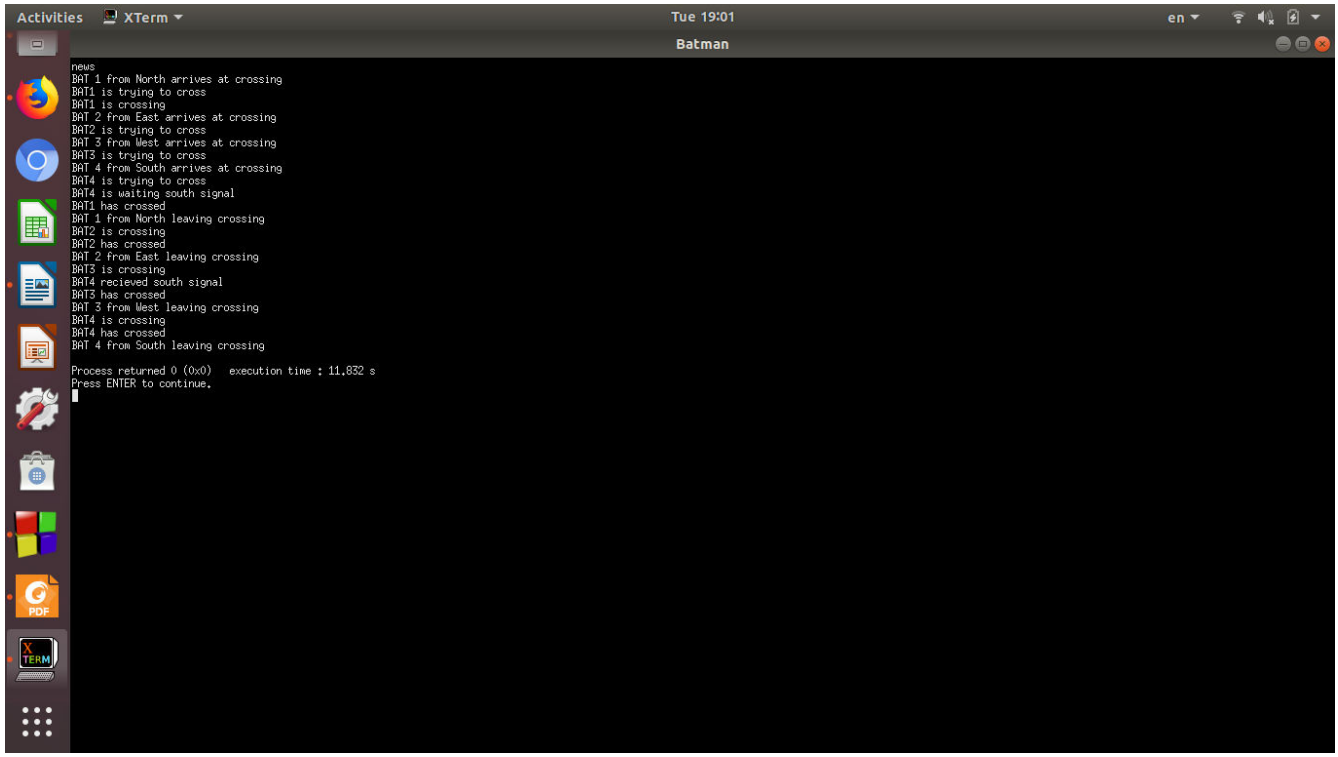
4. Monitor class : this class is very simple as we are sure that we have max of 4 threads from different families at a time so it has 4 objects of bats one for each family and another 4 flags to indicate if there is a member of the family in the monitor or not and 4 signals for the right condition and a print lock and a cross lock we can divide It as follow:

```
#ifndef MONITOR_H
#define MONITOR_H

#include <iostream>
#include <chrono>
#include <thread>

using namespace std;

#include "Bat.h"

class Monitor
{
    public:
        Monitor(){
            pthread_mutex_init( &north_lock, NULL);
            pthread_mutex_init( &east_lock, NULL);
            pthread_mutex_init( &south_lock, NULL);
            pthread_mutex_init( &west_lock, NULL);

                    pthread_mutex_unlock(&print_lock);
                    pthread_mutex_unlock(&cross_lock);
                }else{
                    pthread_mutex_lock(&print_lock);
                    cout << "BAT" << b.get_id() + 1 << " is trying to cross" << endl;
                    pthread_mutex_unlock(&print_lock);
                    pthread_mutex_lock(&cross_lock);
                    if(west_flag == true){
                        pthread_mutex_unlock(&cross_lock);
                        pthread_mutex_lock(&print_lock);
                        cout << "BAT" << b.get_id() + 1 << " is trying to cross" << endl;
                        pthread_mutex_unlock(&print_lock);
                        pthread_mutex_lock(&print_lock);
                        cout << "BAT" << b.get_id() + 1 << " is waiting north signal" << endl;
                        pthread_mutex_unlock(&print_lock);
                        pthread_cond_wait(&north_cross_cond , &north_lock);
                        pthread_mutex_lock(&print_lock);
                        cout << "BAT" << b.get_id() + 1 << " recieved north signal" << endl;
                        pthread_mutex_lock(&print_lock);
                        cout << "BAT" << b.get_id() + 1 << " is crossing" << endl;
                        pthread_mutex_unlock(&print_lock);
                        east_flag = false;
                        std::this_thread::sleep_for (std::chrono::seconds(1));
                        pthread_mutex_lock(&print_lock);
                        cout << "BAT" << b.get_id() + 1 << " has crossed" << endl;
                        pthread_mutex_unlock(&print_lock);
                    pthread_mutex_lock(&print_lock);
                    cout << "BAT" << b.get_id() + 1 << " is waiting west signal" << endl;
                    pthread_mutex_unlock(&print_lock);
                    pthread_cond_wait(&west_cross_cond , &west_lock);
                pthread_cond_signal(&east_cross_cond);
        void check(){
            if(north_flag == true && east_flag == true && south_flag == true && west_flag == true){
                pthread_mutex_lock(&print_lock);
                cout << "DEADLOCK: BAT jam detected, signalling North to go" << endl;
                pthread_mutex_unlock(&print_lock);
                pthread_cond_signal(&north_cross_cond);
            }
        }

    protected:

    private:

    pthread_mutex_t north_lock = PTHREAD_MUTEX_INITIALIZER;
    pthread_mutex_t east_lock = PTHREAD_MUTEX_INITIALIZER;
    pthread_mutex_t south_lock = PTHREAD_MUTEX_INITIALIZER;
    pthread_mutex_t west_lock = PTHREAD_MUTEX_INITIALIZER;

    pthread_mutex_t cross_lock = PTHREAD_MUTEX_INITIALIZER;
    pthread_mutex_t print_lock = PTHREAD_MUTEX_INITIALIZER;
```

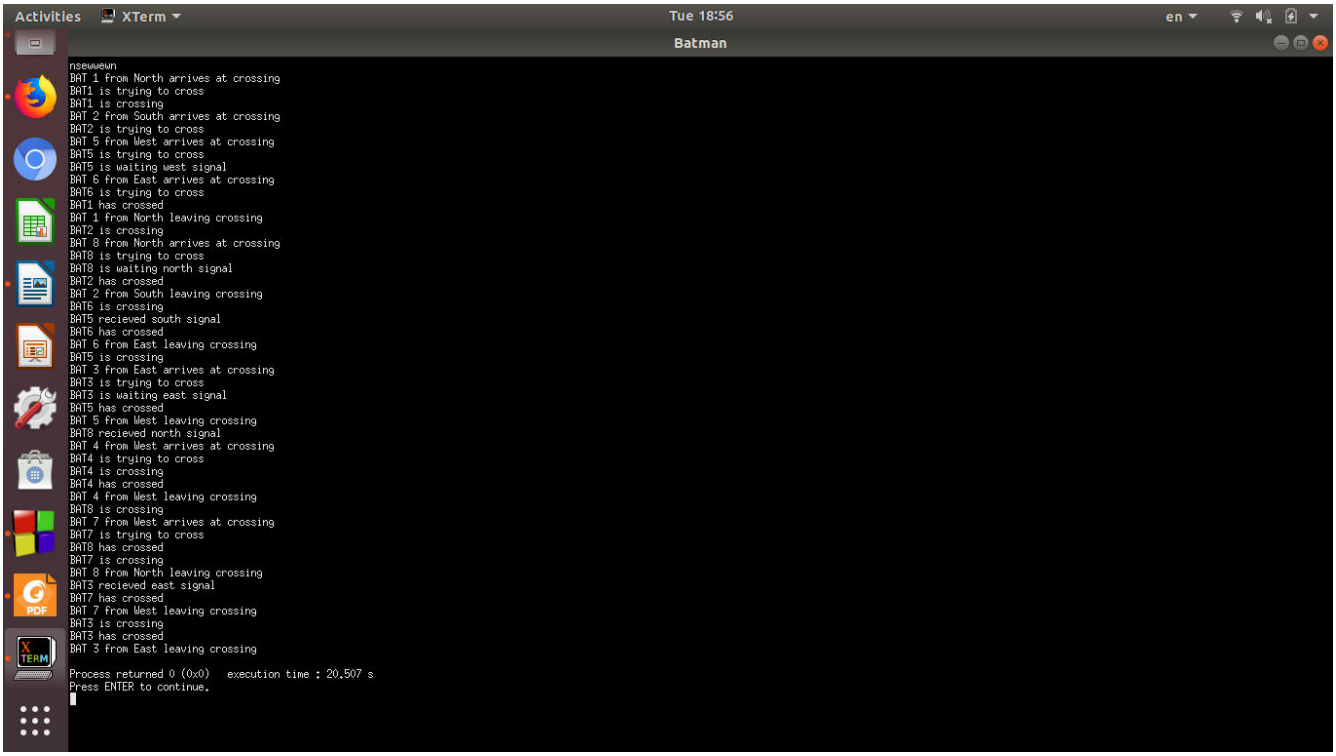
- arrive method : this method print the statement and then set the object to the new one and sets it’s flag
- cross method : this method checks if the flag of the right bat is true and if so it let the right bat to cross then it crosses but if it was false it crosses if the cross is free
- leave method : this method print the statement and then set the flag to false and signals the left to pass
- check method : this method checks the 4 flags after every arrive and if they were all true then a deadlock occur

1-Sample runs and screen shots:

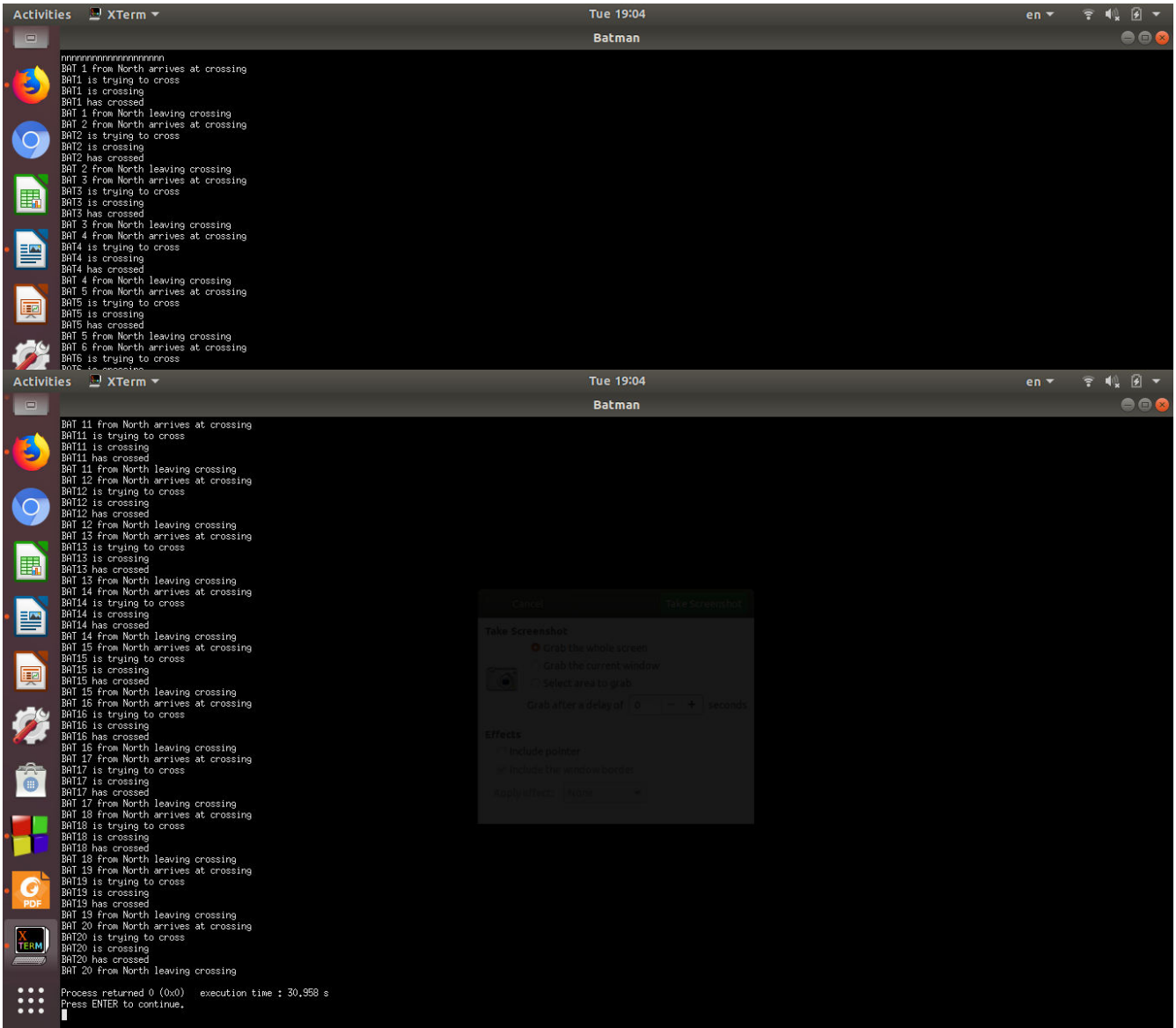
1-



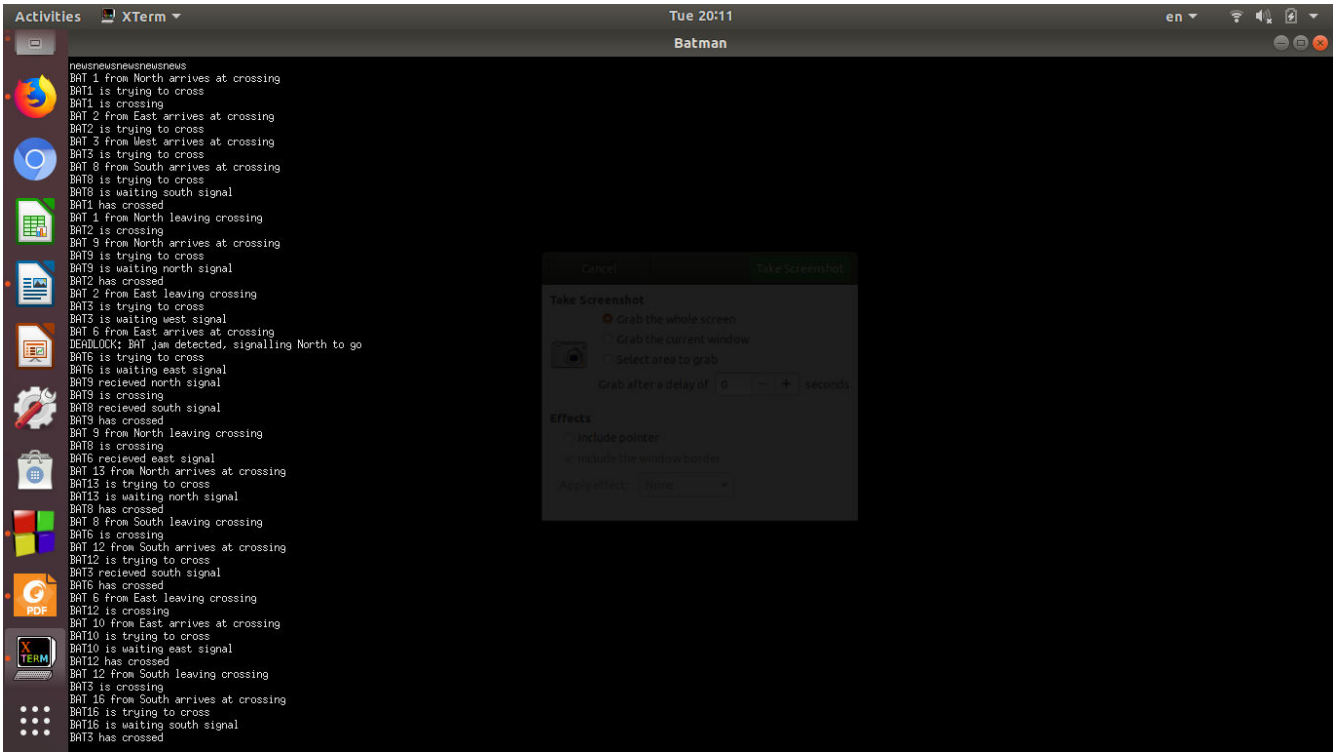
2-

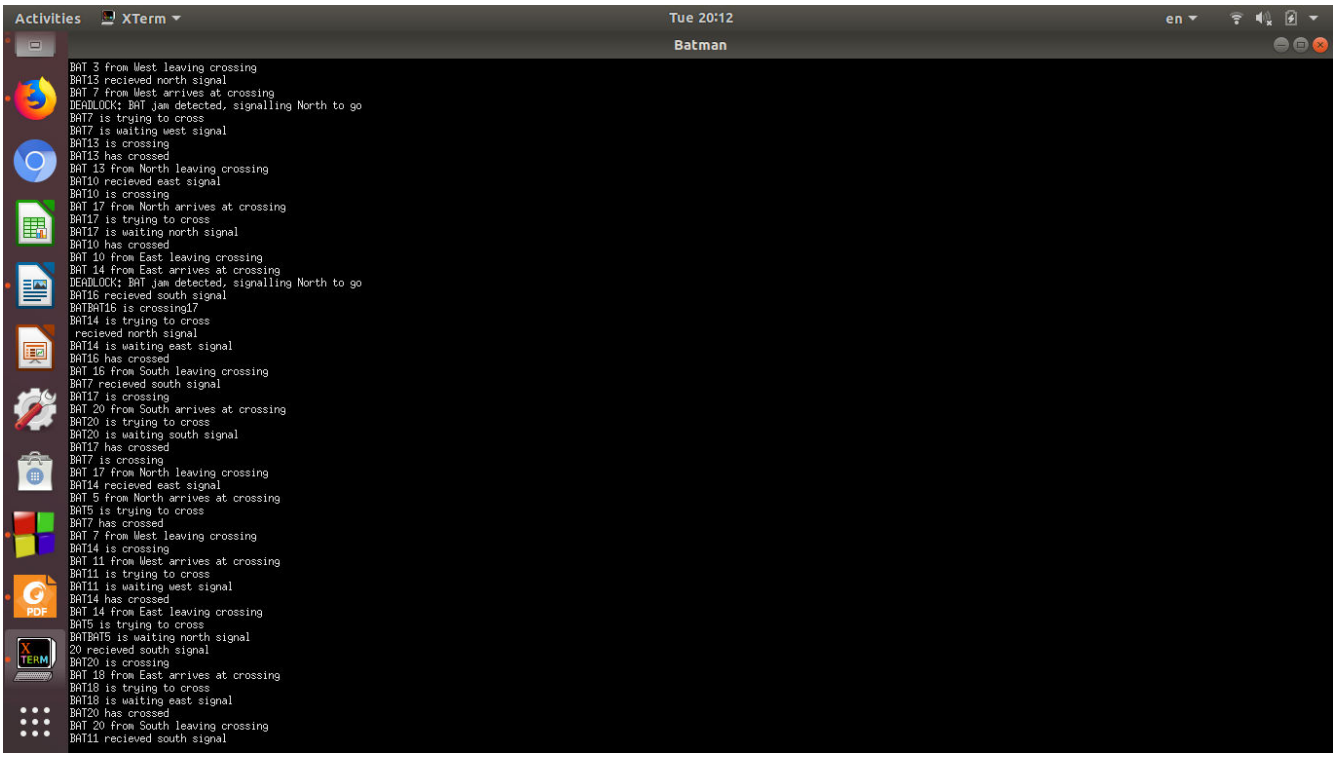

Activities
XTerm
Tue 18:56
en
Batman
nsewwewn
BAT 1 from North arrives at crossing
BAT1 is trying to cross
BAT1 is crossing
BAT 2 from South arrives at crossing
BAT2 is trying to cross
BAT 5 from West arrives at crossing
BAT5 is trying to cross
BAT5 is waiting west signal
BAT 6 from East arrives at crossing
BAT6 is trying to cross
BAT1 has crossed
BAT 1 from North leaving crossing
BAT2 is crossing
BAT 8 from North arrives at crossing
BAT8 is trying to cross
BAT8 is waiting north signal
BAT2 has crossed
BAT 2 from South leaving crossing
BAT6 is crossing
BAT5 recieved south signal
BAT6 has crossed
BAT 6 from East leaving crossing
BAT5 is crossing
BAT 3 from East arrives at crossing
BAT3 is trying to cross
BAT3 is waiting east signal
BAT5 has crossed
BAT 5 from West leaving crossing
BAT8 recieved north signal
BAT 4 from West arrives at crossing
BAT4 is trying to cross
BAT4 is crossing
BAT4 has crossed
BAT 4 from West leaving crossing
BAT8 is crossing
BAT 7 from West arrives at crossing
BAT7 is trying to cross
BAT8 has crossed
BAT7 is crossing
BAT 8 from North leaving crossing
BAT3 recieved east signal
BAT7 has crossed
BAT 7 from West leaving crossing
BAT3 is crossing
BAT3 has crossed
BAT 3 from East leaving crossing
Process returned 0 (0x0) execution time : 20.507 s
Press ENTER to continue.

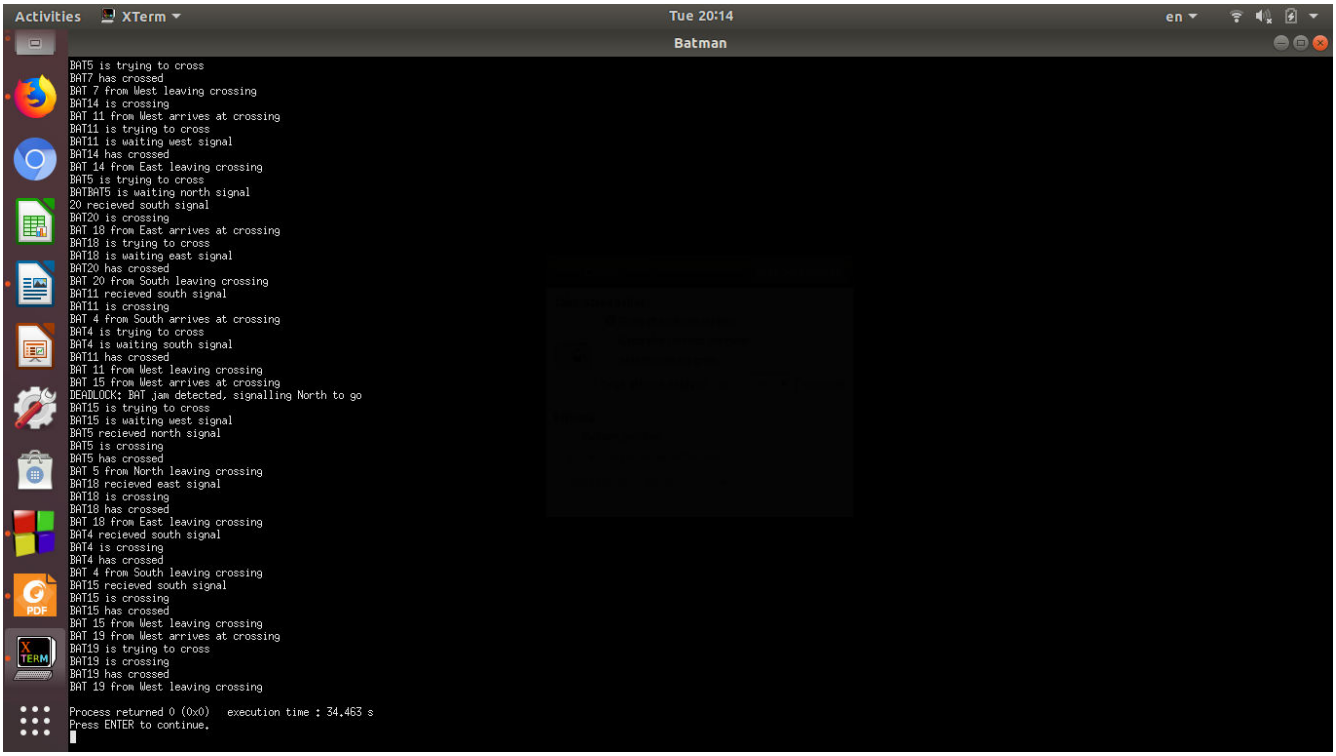
3-


Activities
XTerm
Tue 19:04
en
Batman
nnnnnnnnnnnnnnnnnnn
BAT 1 from North arrives at crossing
BAT1 is trying to cross
BAT1 is crossing
BAT1 has crossed
BAT 1 from North leaving crossing
BAT 2 from North arrives at crossing
BAT2 is trying to cross
BAT2 is crossing
BAT2 has crossed
BAT 2 from North leaving crossing
BAT 3 from North arrives at crossing
BAT3 is trying to cross
BAT3 is crossing
BAT3 has crossed
BAT 3 from North leaving crossing
BAT 4 from North arrives at crossing
BAT4 is trying to cross
BAT4 is crossing
BAT4 has crossed
BAT 4 from North leaving crossing
BAT 5 from North arrives at crossing
BAT5 is trying to cross
BAT5 is crossing
BAT5 has crossed
BAT 5 from North leaving crossing
BAT 6 from North arrives at crossing
BAT6 is trying to cross
Activities
XTerm
Tue 19:04
en
Batman
BAT 11 from North arrives at crossing
BAT11 is trying to cross
BAT11 is crossing
BAT11 has crossed
BAT 11 from North leaving crossing
BAT 12 from North arrives at crossing
BAT12 is trying to cross
BAT12 is crossing
BAT12 has crossed
BAT 12 from North leaving crossing
BAT 13 from North arrives at crossing
BAT13 is trying to cross
BAT13 is crossing
BAT13 has crossed
BAT 13 from North leaving crossing
BAT 14 from North arrives at crossing
BAT14 is trying to cross
BAT14 is crossing
BAT14 has crossed
BAT 14 from North leaving crossing
BAT 15 from North arrives at crossing
BAT15 is trying to cross
BAT15 is crossing
BAT15 has crossed
BAT 15 from North leaving crossing
BAT 16 from North arrives at crossing
BAT16 is trying to cross
BAT16 is crossing
BAT16 has crossed
BAT 16 from North leaving crossing
BAT 17 from North arrives at crossing
BAT17 is trying to cross
BAT17 is crossing
BAT17 has crossed
BAT 17 from North leaving crossing
BAT 18 from North arrives at crossing
BAT18 is trying to cross
BAT18 is crossing
BAT18 has crossed
BAT 18 from North leaving crossing
BAT 19 from North arrives at crossing
BAT19 is trying to cross
BAT19 is crossing
BAT19 has crossed
BAT 19 from North leaving crossing
BAT 20 from North arrives at crossing
BAT20 is trying to cross
BAT20 is crossing
BAT20 has crossed
BAT 20 from North leaving crossing
Process returned 0 (0x0) execution time : 30.958 s
Press ENTER to continue.

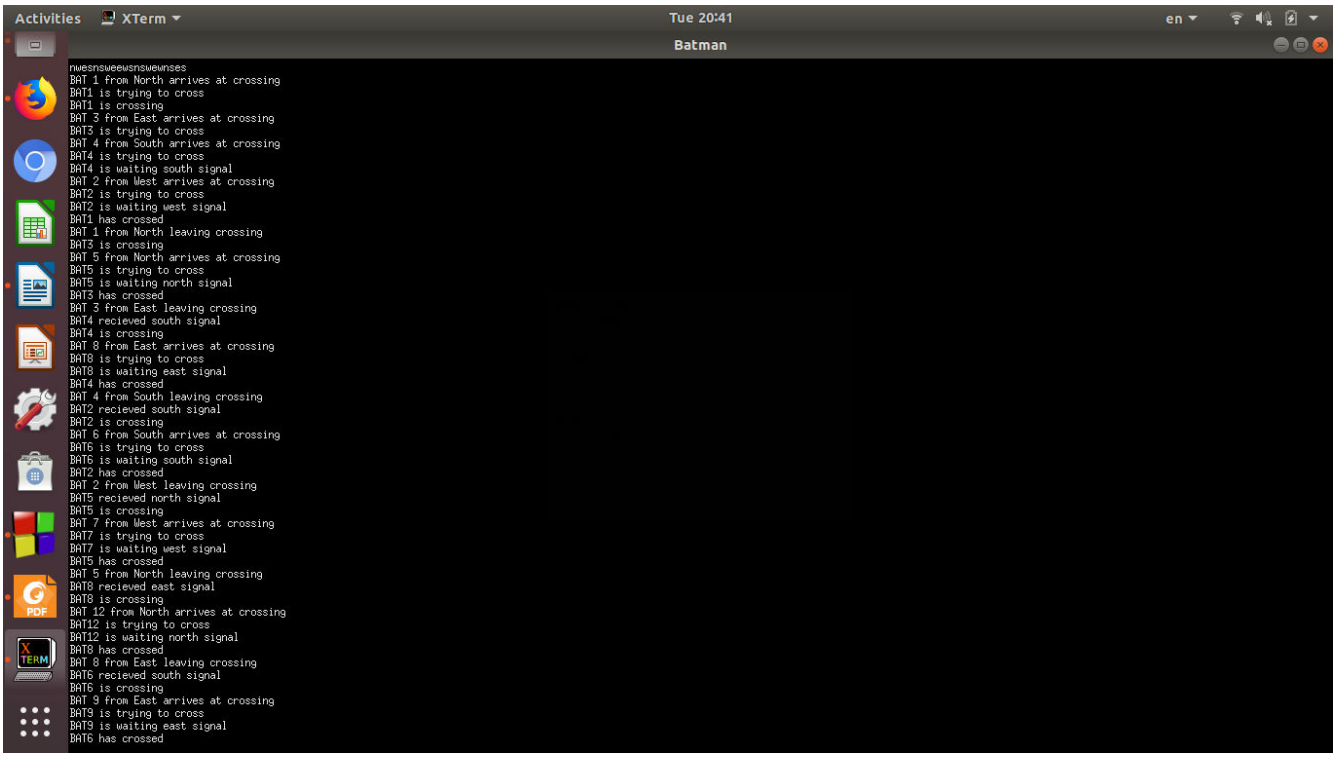
4-

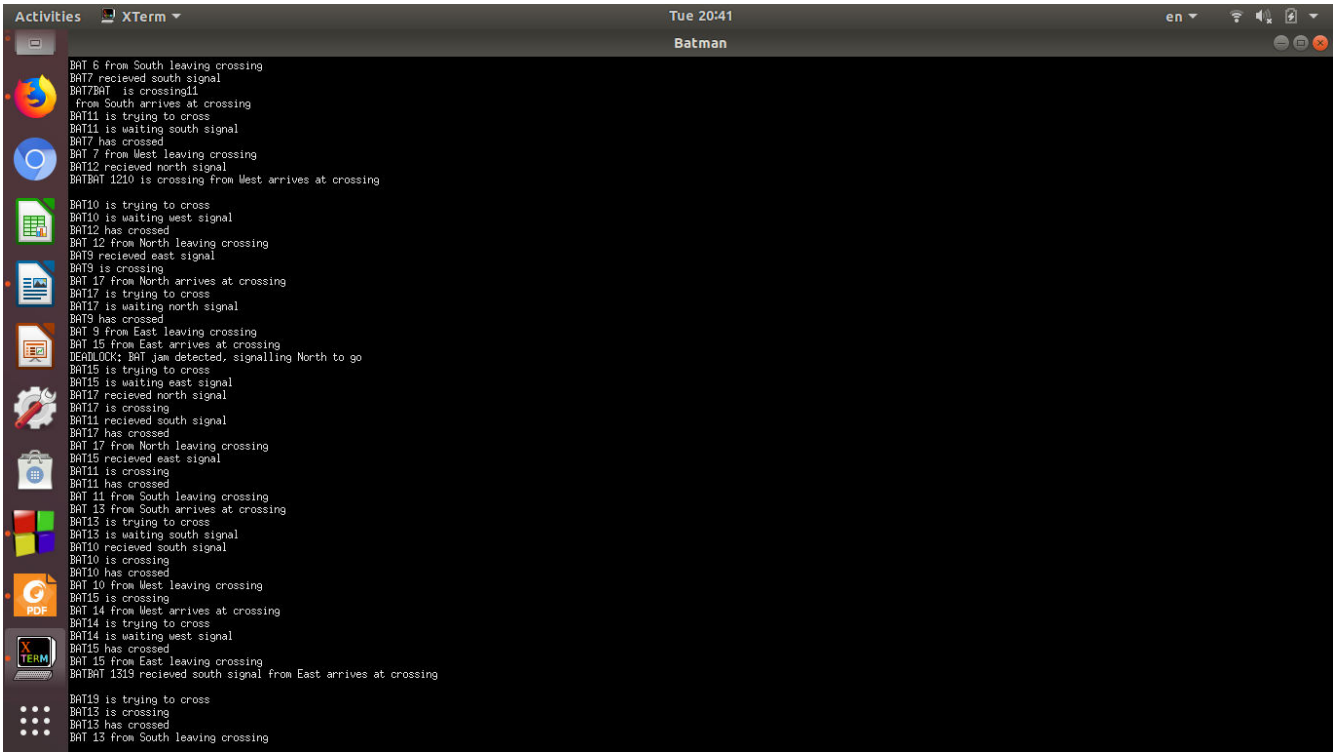

Activities
XTerm
Tue 20:11
en
Batman
newsnewsnewsnewsnews
BAT 1 from North arrives at crossing
BAT1 is trying to cross
BAT1 is crossing
BAT 2 from East arrives at crossing
BAT2 is trying to cross
BAT 3 from West arrives at crossing
BAT3 is trying to cross
BAT 8 from South arrives at crossing
BAT8 is trying to cross
BAT8 is waiting south signal
BAT1 has crossed
BAT 1 from North leaving crossing
BAT2 is crossing
BAT 9 from North arrives at crossing
BAT9 is trying to cross
BAT9 is waiting north signal
BAT2 has crossed
BAT 2 from East leaving crossing
BAT3 is trying to cross
BAT3 is waiting west signal
BAT 6 from East arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT6 is trying to cross
BAT6 is waiting east signal
BAT9 recieved north signal
BAT9 is crossing
BAT8 recieved south signal
BAT9 has crossed
BAT 9 from North leaving crossing
BAT8 is crossing
BAT6 recieved east signal
BAT 13 from North arrives at crossing
BAT13 is trying to cross
BAT13 is waiting north signal
BAT8 has crossed
BAT 8 from South leaving crossing
BAT6 is crossing
BAT 12 from South arrives at crossing
BAT12 is trying to cross
BAT3 recieved south signal
BAT6 has crossed
BAT 6 from East leaving crossing
BAT12 is crossing
BAT 10 from East arrives at crossing
BAT10 is trying to cross
BAT10 is waiting east signal
BAT12 has crossed
BAT 12 from South leaving crossing
BAT3 is crossing
BAT 16 from South arrives at crossing
BAT16 is trying to cross
BAT16 is waiting south signal
BAT3 has crossed

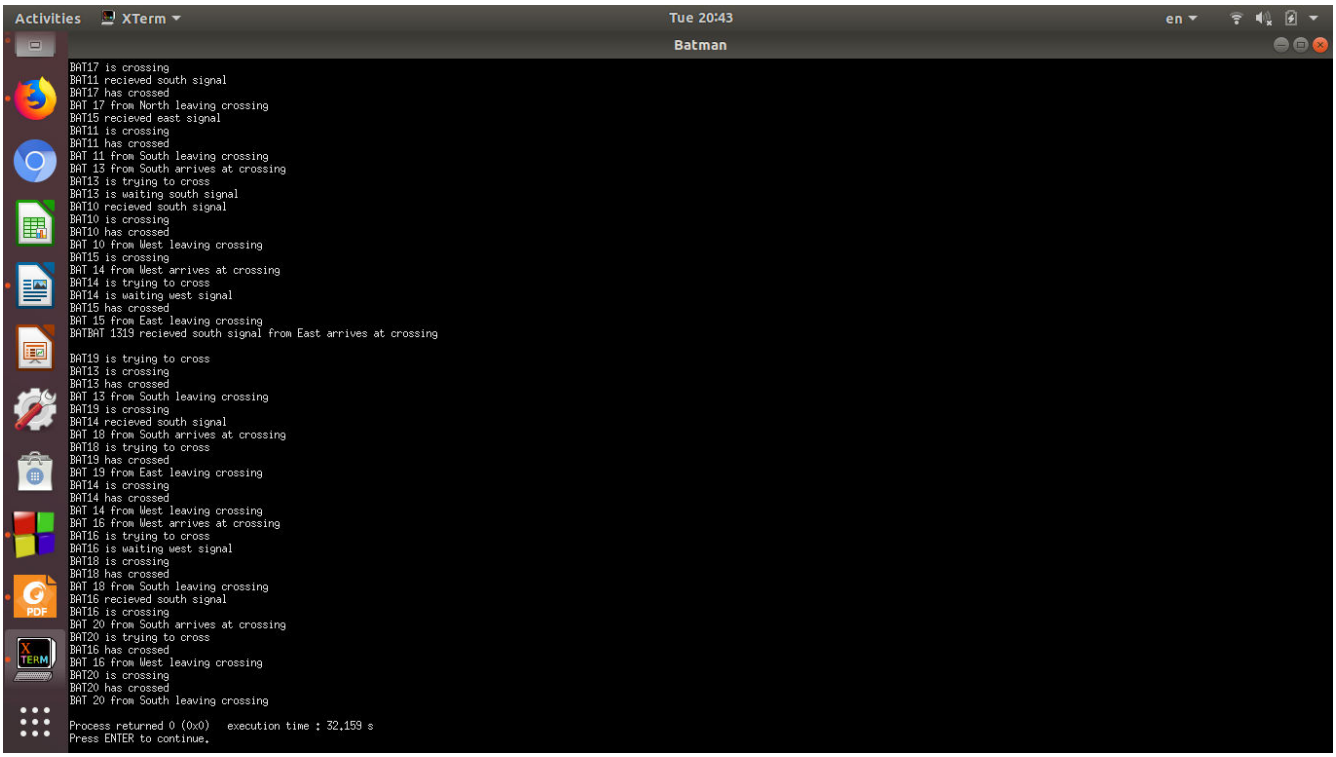

Activities
XTerm
Tue 20:12
en
Batman
BAT 3 from West leaving crossing
BAT13 recieved north signal
BAT 7 from West arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT7 is trying to cross
BAT7 is waiting west signal
BAT13 is crossing
BAT13 has crossed
BAT 13 from North leaving crossing
BAT10 recieved east signal
BAT10 is crossing
BAT 17 from North arrives at crossing
BAT17 is trying to cross
BAT17 is waiting north signal
BAT10 has crossed
BAT 10 from East leaving crossing
BAT 14 from East arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT16 recieved south signal
BATBAT16 is crossing17
BAT14 is trying to cross
recieved north signal
BAT14 is waiting east signal
BAT16 has crossed
BAT 16 from South leaving crossing
BAT7 recieved south signal
BAT17 is crossing
BAT 20 from South arrives at crossing
BAT20 is trying to cross
BAT20 is waiting south signal
BAT17 has crossed
BAT7 is crossing
BAT 17 from North leaving crossing
BAT14 recieved east signal
BAT 5 from North arrives at crossing
BAT5 is trying to cross
BAT7 has crossed
BAT 7 from West leaving crossing
BAT14 is crossing
BAT 11 from West arrives at crossing
BAT11 is trying to cross
BAT11 is waiting west signal
BAT14 has crossed
BAT 14 from East leaving crossing
BAT5 is trying to cross
BATBAT5 is waiting north signal
20 recieved south signal
BAT20 is crossing
BAT 18 from East arrives at crossing
BAT18 is trying to cross
BAT18 is waiting east signal
BAT20 has crossed
BAT 20 from South leaving crossing
BAT11 recieved south signal


Activities
XTerm
Tue 20:14
en
Batman
BAT5 is trying to cross
BAT7 has crossed
BAT 7 from West leaving crossing
BAT14 is crossing
BAT 11 from West arrives at crossing
BAT11 is trying to cross
BAT11 is waiting west signal
BAT14 has crossed
BAT 14 from East leaving crossing
BAT5 is trying to cross
BATBAT5 is waiting north signal
20 recieved south signal
BAT20 is crossing
BAT 18 from East arrives at crossing
BAT18 is trying to cross
BAT18 is waiting east signal
BAT20 has crossed
BAT 20 from South leaving crossing
BAT11 recieved south signal
BAT11 is crossing
BAT 4 from South arrives at crossing
BAT4 is trying to cross
BAT4 is waiting south signal
BAT11 has crossed
BAT 11 from West leaving crossing
BAT 15 from West arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT15 is trying to cross
BAT15 is waiting west signal
BAT5 recieved north signal
BAT5 is crossing
BAT5 has crossed
BAT 5 from North leaving crossing
BAT18 recieved east signal
BAT18 is crossing
BAT18 has crossed
BAT 18 from East leaving crossing
BAT4 recieved south signal
BAT4 is crossing
BAT4 has crossed
BAT 4 from South leaving crossing
BAT15 recieved south signal
BAT15 is crossing
BAT15 has crossed
BAT 15 from West leaving crossing
BAT 19 from West arrives at crossing
BAT19 is trying to cross
BAT19 is crossing
BAT19 has crossed
BAT 19 from West leaving crossing
Process returned 0 (0x0) execution time : 34.463 s
Press ENTER to continue.

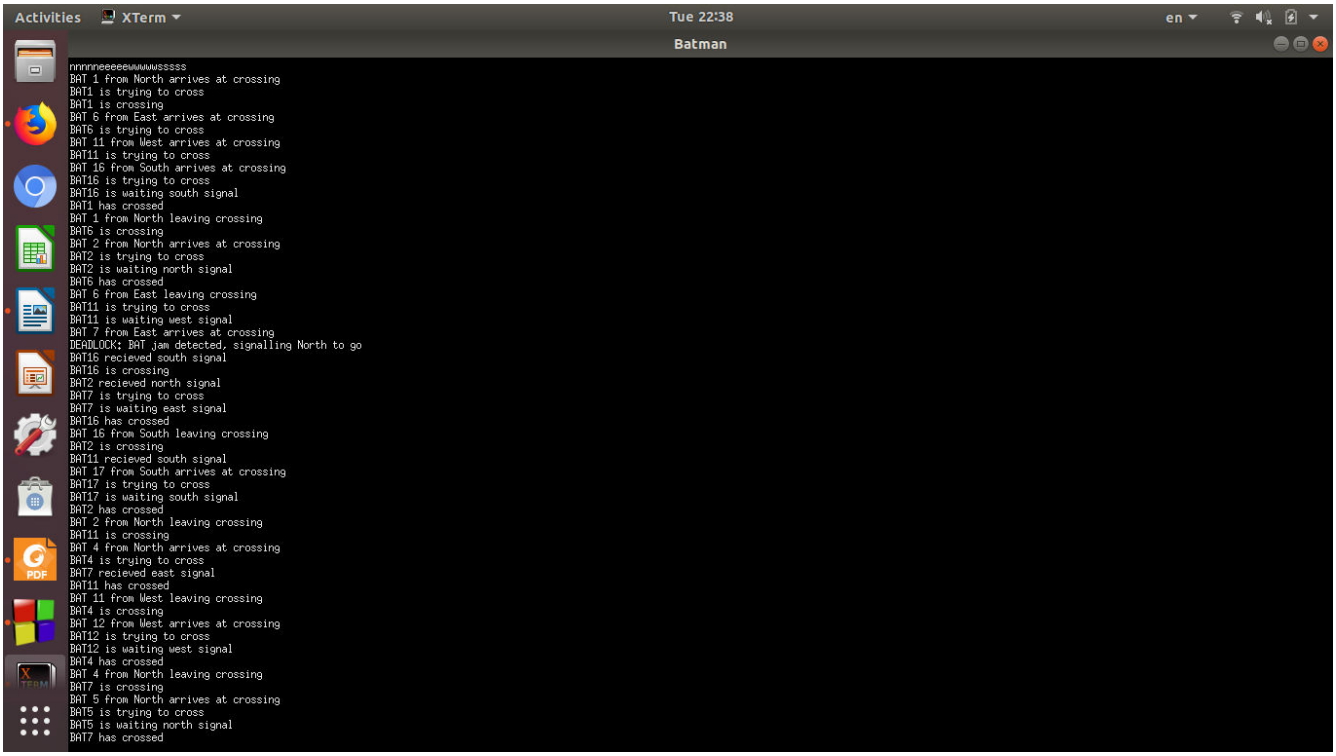
5-

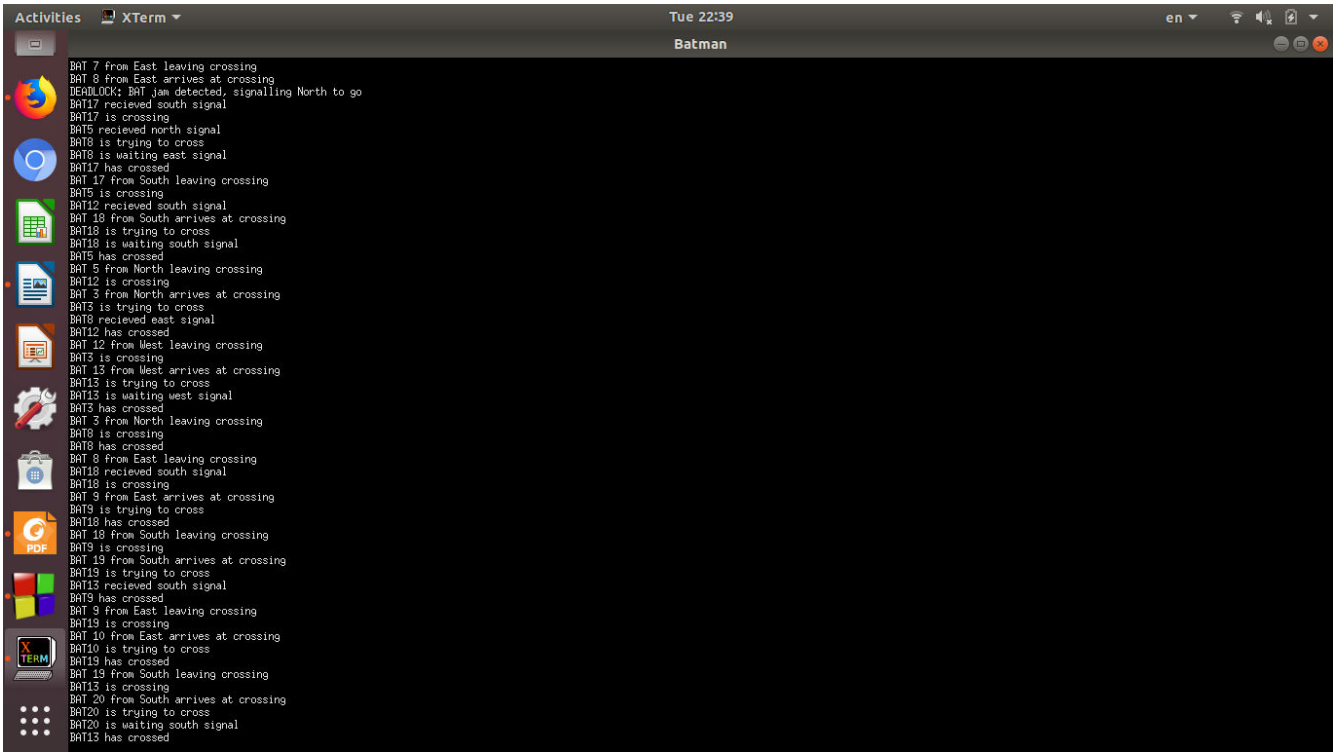

Activities
XTerm
Tue 20:41
en
Batman
nwesnsweewsnswewnses
BAT 1 from North arrives at crossing
BAT1 is trying to cross
BAT1 is crossing
BAT 3 from East arrives at crossing
BAT3 is trying to cross
BAT 4 from South arrives at crossing
BAT4 is trying to cross
BAT4 is waiting south signal
BAT 2 from West arrives at crossing
BAT2 is trying to cross
BAT2 is waiting west signal
BAT1 has crossed
BAT 1 from North leaving crossing
BAT3 is crossing
BAT 5 from North arrives at crossing
BAT5 is trying to cross
BAT5 is waiting north signal
BAT3 has crossed
BAT 3 from East leaving crossing
BAT4 recieved south signal
BAT4 is crossing
BAT 8 from East arrives at crossing
BAT8 is trying to cross
BAT8 is waiting east signal
BAT4 has crossed
BAT 4 from South leaving crossing
BAT2 recieved south signal
BAT2 is crossing
BAT 6 from South arrives at crossing
BAT6 is trying to cross
BAT6 is waiting south signal
BAT2 has crossed
BAT 2 from West leaving crossing
BAT5 recieved north signal
BAT5 is crossing
BAT 7 from West arrives at crossing
BAT7 is trying to cross
BAT7 is waiting west signal
BAT5 has crossed
BAT 5 from North leaving crossing
BAT8 recieved east signal
BAT8 is crossing
BAT 12 from North arrives at crossing
BAT12 is trying to cross
BAT12 is waiting north signal
BAT8 has crossed
BAT 8 from East leaving crossing
BAT6 recieved south signal
BAT6 is crossing
BAT 9 from East arrives at crossing
BAT9 is trying to cross
BAT9 is waiting east signal
BAT6 has crossed

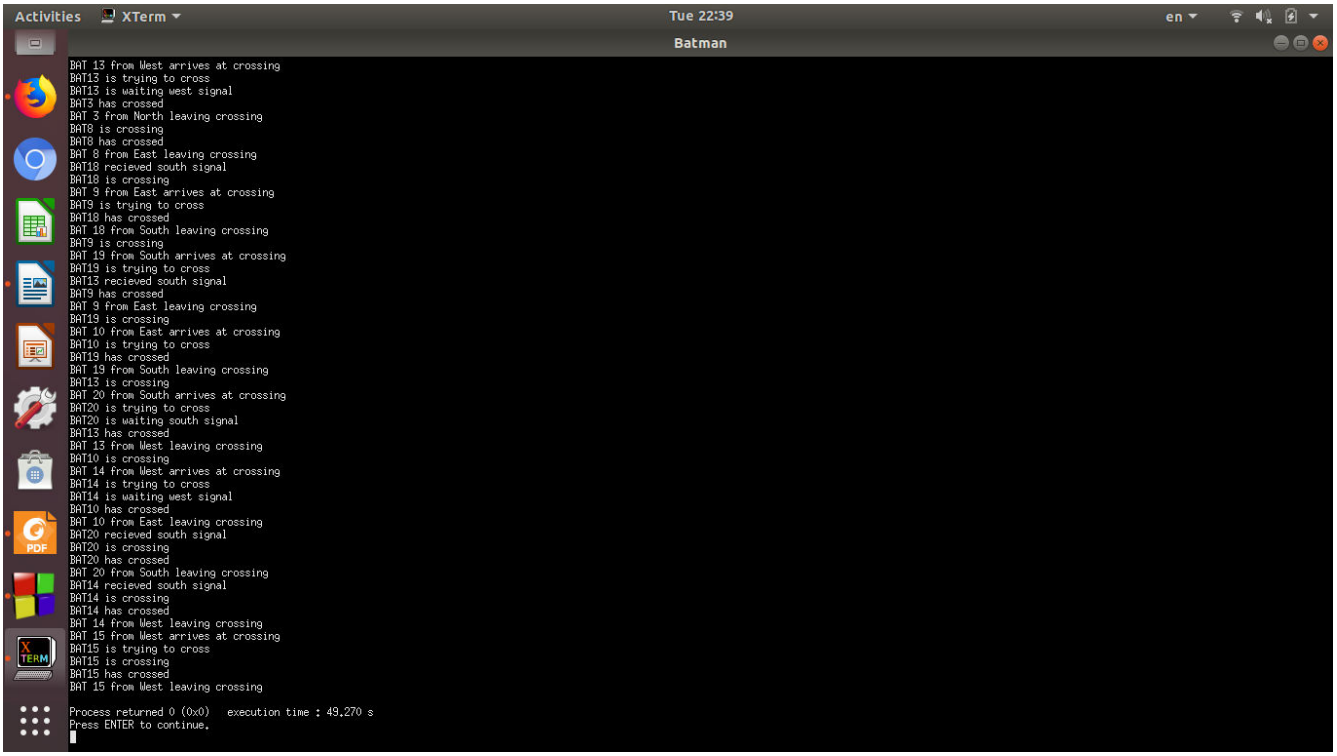

Activities
XTerm
Tue 20:41
en
Batman
BAT 6 from South leaving crossing
BAT7 recieved south signal
BAT7BAT is crossing11
 from South arrives at crossing
BAT11 is trying to cross
BAT11 is waiting south signal
BAT7 has crossed
BAT 7 from West leaving crossing
BAT12 recieved north signal
BATBAT 1210 is crossing from West arrives at crossing
BAT10 is trying to cross
BAT10 is waiting west signal
BAT12 has crossed
BAT 12 from North leaving crossing
BAT9 recieved east signal
BAT9 is crossing
BAT 17 from North arrives at crossing
BAT17 is trying to cross
BAT17 is waiting north signal
BAT9 has crossed
BAT 9 from East leaving crossing
BAT 15 from East arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT15 is trying to cross
BAT15 is waiting east signal
BAT17 recieved north signal
BAT17 is crossing
BAT11 recieved south signal
BAT17 has crossed
BAT 17 from North leaving crossing
BAT15 recieved east signal
BAT11 is crossing
BAT11 has crossed
BAT 11 from South leaving crossing
BAT 13 from South arrives at crossing
BAT13 is trying to cross
BAT13 is waiting south signal
BAT10 recieved south signal
BAT10 is crossing
BAT10 has crossed
BAT 10 from West leaving crossing
BAT15 is crossing
BAT 14 from West arrives at crossing
BAT14 is trying to cross
BAT14 is waiting west signal
BAT15 has crossed
BAT 15 from East leaving crossing
BATBAT 1319 recieved south signal from East arrives at crossing
BAT19 is trying to cross
BAT13 is crossing
BAT13 has crossed
BAT 13 from South leaving crossing


Activities
XTerm
Tue 20:43
en
Batman
BAT17 is crossing
BAT11 recieved south signal
BAT17 has crossed
BAT 17 from North leaving crossing
BAT15 recieved east signal
BAT11 is crossing
BAT11 has crossed
BAT 11 from South leaving crossing
BAT 13 from South arrives at crossing
BAT13 is trying to cross
BAT13 is waiting south signal
BAT10 recieved south signal
BAT10 is crossing
BAT10 has crossed
BAT 10 from West leaving crossing
BAT15 is crossing
BAT 14 from West arrives at crossing
BAT14 is trying to cross
BAT14 is waiting west signal
BAT15 has crossed
BAT 15 from East leaving crossing
BATBAT 1319 recieved south signal from East arrives at crossing
BAT19 is trying to cross
BAT13 is crossing
BAT13 has crossed
BAT 13 from South leaving crossing
BAT19 is crossing
BAT14 recieved south signal
BAT 18 from South arrives at crossing
BAT18 is trying to cross
BAT19 has crossed
BAT 19 from East leaving crossing
BAT14 is crossing
BAT14 has crossed
BAT 14 from West leaving crossing
BAT 16 from West arrives at crossing
BAT16 is trying to cross
BAT16 is waiting west signal
BAT18 is crossing
BAT18 has crossed
BAT 18 from South leaving crossing
BAT16 recieved south signal
BAT16 is crossing
BAT 20 from South arrives at crossing
BAT20 is trying to cross
BAT16 has crossed
BAT 16 from West leaving crossing
BAT20 is crossing
BAT20 has crossed
BAT 20 from South leaving crossing
Process returned 0 (0x0)   execution time : 32.159 s
Press ENTER to continue.

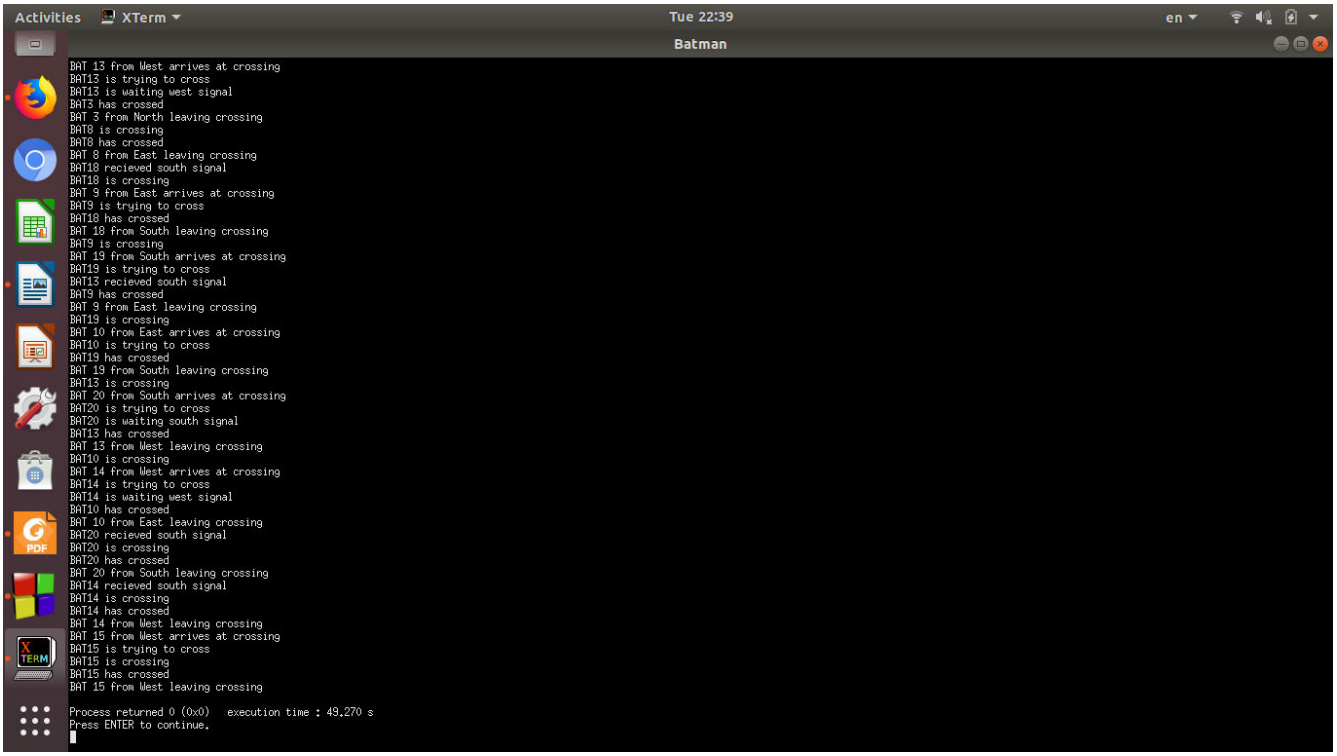
6-

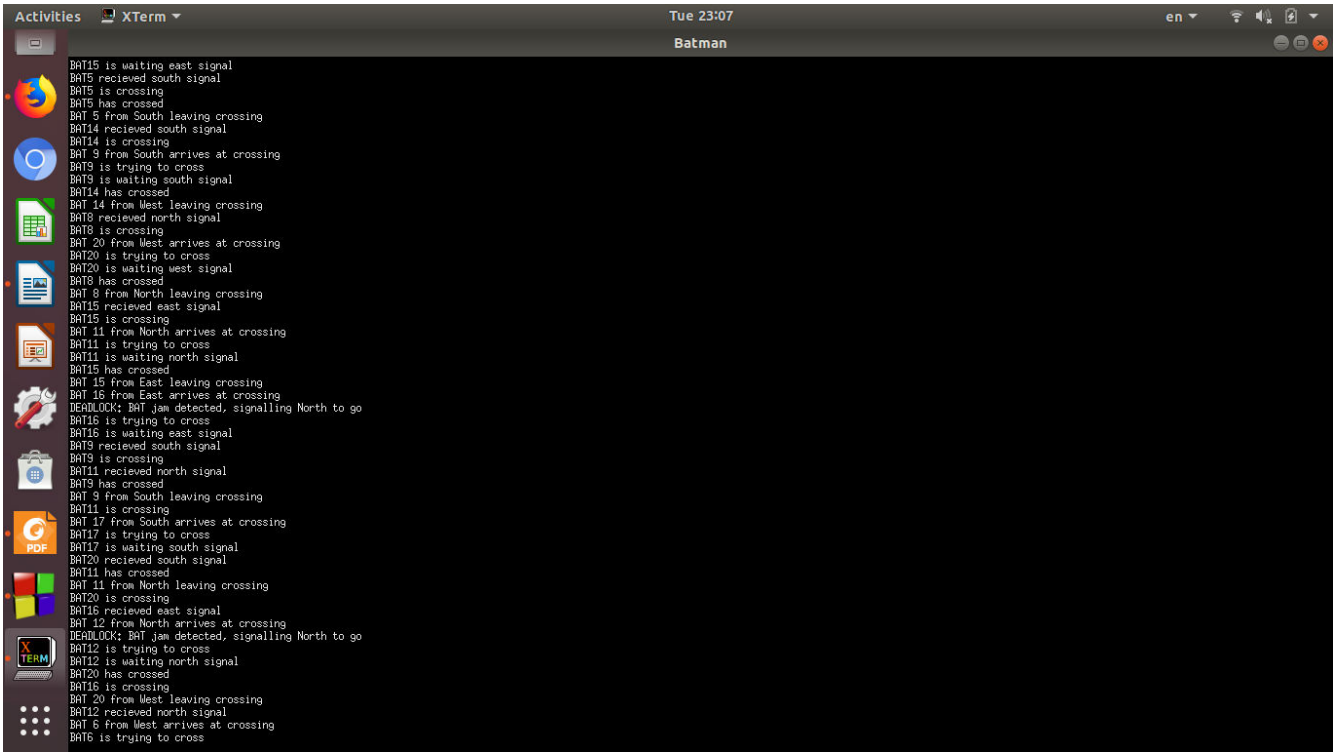

Activities
XTerm
Tue 22:38
en
Batman
nnnnneeeeeewwwwwssssss
BAT 1 from North arrives at crossing
BAT1 is trying to cross
BAT1 is crossing
BAT 6 from East arrives at crossing
BAT6 is trying to cross
BAT 11 from West arrives at crossing
BAT11 is trying to cross
BAT 16 from South arrives at crossing
BAT16 is trying to cross
BAT16 is waiting south signal
BAT1 has crossed
BAT 1 from North leaving crossing
BAT6 is crossing
BAT 2 from North arrives at crossing
BAT2 is trying to cross
BAT2 is waiting north signal
BAT6 has crossed
BAT 6 from East leaving crossing
BAT11 is trying to cross
BAT11 is waiting west signal
BAT 7 from East arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT16 recieved south signal
BAT16 is crossing
BAT2 recieved north signal
BAT7 is trying to cross
BAT7 is waiting east signal
BAT16 has crossed
BAT 16 from South leaving crossing
BAT2 is crossing
BAT11 recieved south signal
BAT 17 from South arrives at crossing
BAT17 is trying to cross
BAT17 is waiting south signal
BAT2 has crossed
BAT 2 from North leaving crossing
BAT11 is crossing
BAT 4 from North arrives at crossing
BAT4 is trying to cross
BAT7 recieved east signal
BAT11 has crossed
BAT 11 from West leaving crossing
BAT4 is crossing
BAT 12 from West arrives at crossing
BAT12 is trying to cross
BAT12 is waiting west signal
BAT4 has crossed
BAT 4 from North leaving crossing
BAT7 is crossing
BAT 5 from North arrives at crossing
BAT5 is trying to cross
BAT5 is waiting north signal
BAT7 has crossed

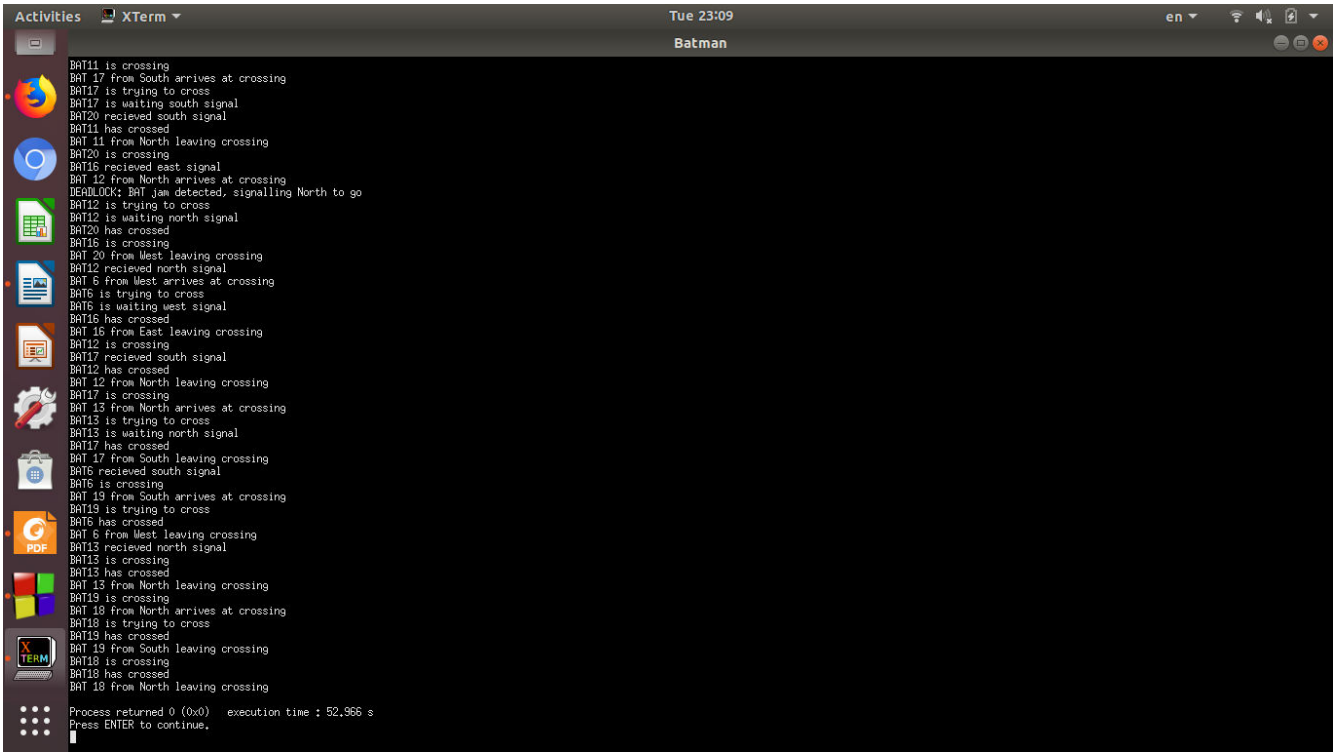

Activities
XTerm
Tue 22:39
en
Batman
BAT 7 from East leaving crossing
BAT 8 from East arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT17 recieved south signal
BAT17 is crossing
BAT5 recieved north signal
BAT8 is trying to cross
BAT8 is waiting east signal
BAT17 has crossed
BAT 17 from South leaving crossing
BAT5 is crossing
BAT12 recieved south signal
BAT 18 from South arrives at crossing
BAT18 is trying to cross
BAT18 is waiting south signal
BAT5 has crossed
BAT 5 from North leaving crossing
BAT12 is crossing
BAT 3 from North arrives at crossing
BAT3 is trying to cross
BAT8 recieved east signal
BAT12 has crossed
BAT 12 from West leaving crossing
BAT3 is crossing
BAT 13 from West arrives at crossing
BAT13 is trying to cross
BAT13 is waiting west signal
BAT3 has crossed
BAT 3 from North leaving crossing
BAT8 is crossing
BAT8 has crossed
BAT 8 from East leaving crossing
BAT18 recieved south signal
BAT18 is crossing
BAT 9 from East arrives at crossing
BAT9 is trying to cross
BAT18 has crossed
BAT 18 from South leaving crossing
BAT9 is crossing
BAT 19 from South arrives at crossing
BAT19 is trying to cross
BAT13 recieved south signal
BAT9 has crossed
BAT 9 from East leaving crossing
BAT19 is crossing
BAT 10 from East arrives at crossing
BAT10 is trying to cross
BAT19 has crossed
BAT 19 from South leaving crossing
BAT13 is crossing
BAT 20 from South arrives at crossing
BAT20 is trying to cross
BAT20 is waiting south signal
BAT13 has crossed


Activities
XTerm
Tue 22:39
en
Batman
BAT 13 from West arrives at crossing
BAT13 is trying to cross
BAT13 is waiting west signal
BAT3 has crossed
BAT 3 from North leaving crossing
BAT8 is crossing
BAT8 has crossed
BAT 8 from East leaving crossing
BAT18 recieved south signal
BAT18 is crossing
BAT 9 from East arrives at crossing
BAT9 is trying to cross
BAT18 has crossed
BAT 18 from South leaving crossing
BAT9 is crossing
BAT 19 from South arrives at crossing
BAT19 is trying to cross
BAT13 recieved south signal
BAT9 has crossed
BAT 9 from East leaving crossing
BAT19 is crossing
BAT 10 from East arrives at crossing
BAT10 is trying to cross
BAT19 has crossed
BAT 19 from South leaving crossing
BAT13 is crossing
BAT 20 from South arrives at crossing
BAT20 is trying to cross
BAT20 is waiting south signal
BAT13 has crossed
BAT 13 from West leaving crossing
BAT10 is crossing
BAT 14 from West arrives at crossing
BAT14 is trying to cross
BAT14 is waiting west signal
BAT10 has crossed
BAT 10 from East leaving crossing
BAT20 recieved south signal
BAT20 is crossing
BAT20 has crossed
BAT 20 from South leaving crossing
BAT14 recieved south signal
BAT14 is crossing
BAT14 has crossed
BAT 14 from West leaving crossing
BAT 15 from West arrives at crossing
BAT15 is trying to cross
BAT15 is crossing
BAT15 has crossed
BAT 15 from West leaving crossing
Process returned 0 (0x0) execution time : 49.270 s
Press ENTER to continue.

7-


Activities
XTerm
Tue 22:39
en
Batman
BAT 13 from West arrives at crossing
BAT13 is trying to cross
BAT13 is waiting west signal
BAT3 has crossed
BAT 3 from North leaving crossing
BAT8 is crossing
BAT8 has crossed
BAT 8 from East leaving crossing
BAT18 recieved south signal
BAT18 is crossing
BAT 9 from East arrives at crossing
BAT9 is trying to cross
BAT18 has crossed
BAT 18 from South leaving crossing
BAT9 is crossing
BAT 19 from South arrives at crossing
BAT19 is trying to cross
BAT13 recieved south signal
BAT9 has crossed
BAT 9 from East leaving crossing
BAT19 is crossing
BAT 10 from East arrives at crossing
BAT10 is trying to cross
BAT19 has crossed
BAT 19 from South leaving crossing
BAT13 is crossing
BAT 20 from South arrives at crossing
BAT20 is trying to cross
BAT20 is waiting south signal
BAT13 has crossed
BAT 13 from West leaving crossing
BAT10 is crossing
BAT 14 from West arrives at crossing
BAT14 is trying to cross
BAT14 is waiting west signal
BAT10 has crossed
BAT 10 from East leaving crossing
BAT20 recieved south signal
BAT20 is crossing
BAT20 has crossed
BAT 20 from South leaving crossing
BAT14 recieved south signal
BAT14 is crossing
BAT14 has crossed
BAT 14 from West leaving crossing
BAT 15 from West arrives at crossing
BAT15 is trying to cross
BAT15 is crossing
BAT15 has crossed
BAT 15 from West leaving crossing
Process returned 0 (0x0) execution time : 49.270 s
Press ENTER to continue.


Activities
XTerm
Tue 23:07
en
Batman
BAT15 is waiting east signal
BAT5 recieved south signal
BAT5 is crossing
BAT5 has crossed
BAT 5 from South leaving crossing
BAT14 recieved south signal
BAT14 is crossing
BAT 9 from South arrives at crossing
BAT9 is trying to cross
BAT9 is waiting south signal
BAT14 has crossed
BAT 14 from West leaving crossing
BAT8 recieved north signal
BAT8 is crossing
BAT 20 from West arrives at crossing
BAT20 is trying to cross
BAT20 is waiting west signal
BAT8 has crossed
BAT 8 from North leaving crossing
BAT15 recieved east signal
BAT15 is crossing
BAT 11 from North arrives at crossing
BAT11 is trying to cross
BAT11 is waiting north signal
BAT15 has crossed
BAT 15 from East leaving crossing
BAT 16 from East arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT16 is trying to cross
BAT16 is waiting east signal
BAT9 recieved south signal
BAT9 is crossing
BAT11 recieved north signal
BAT9 has crossed
BAT 9 from South leaving crossing
BAT11 is crossing
BAT 17 from South arrives at crossing
BAT17 is trying to cross
BAT17 is waiting south signal
BAT20 recieved south signal
BAT11 has crossed
BAT 11 from North leaving crossing
BAT20 is crossing
BAT16 recieved east signal
BAT 12 from North arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT12 is trying to cross
BAT12 is waiting north signal
BAT20 has crossed
BAT16 is crossing
BAT 20 from West leaving crossing
BAT12 recieved north signal
BAT 6 from West arrives at crossing
BAT6 is trying to cross


Activities
XTerm
Tue 23:09
en
Batman
BAT11 is crossing
BAT 17 from South arrives at crossing
BAT17 is trying to cross
BAT17 is waiting south signal
BAT20 recieved south signal
BAT11 has crossed
BAT 11 from North leaving crossing
BAT20 is crossing
BAT16 recieved east signal
BAT 12 from North arrives at crossing
DEADLOCK: BAT jam detected, signalling North to go
BAT12 is trying to cross
BAT12 is waiting north signal
BAT20 has crossed
BAT16 is crossing
BAT 20 from West leaving crossing
BAT12 recieved north signal
BAT 6 from West arrives at crossing
BAT6 is trying to cross
BAT6 is waiting west signal
BAT16 has crossed
BAT 16 from East leaving crossing
BAT12 is crossing
BAT17 recieved south signal
BAT12 has crossed
BAT 12 from North leaving crossing
BAT17 is crossing
BAT 13 from North arrives at crossing
BAT13 is trying to cross
BAT13 is waiting north signal
BAT17 has crossed
BAT 17 from South leaving crossing
BAT6 recieved south signal
BAT6 is crossing
BAT 19 from South arrives at crossing
BAT19 is trying to cross
BAT6 has crossed
BAT 6 from West leaving crossing
BAT13 recieved north signal
BAT13 is crossing
BAT13 has crossed
BAT 13 from North leaving crossing
BAT19 is crossing
BAT 18 from North arrives at crossing
BAT18 is trying to cross
BAT19 has crossed
BAT 19 from South leaving crossing
BAT18 is crossing
BAT18 has crossed
BAT 18 from North leaving crossing
Process returned 0 (0x0) execution time : 52.966 s
Press ENTER to continue.

“There is an interfering in a few printing lines in the screen shots which can be solved by applying a screen lock for all cout instructions (solved in code and from screen shot 6)”
“Check method is called after each arrive so in the steps the thread arrive then the deadlock is detected then the thread check it’s right and wait on signal and I think this happen due to unlock is slowing it a bit”
“The received signal is late a bit but it works right”
“A thread may receive a signal but another cross may happen first but this doesn’t lead to starvation as it will cross after that cross”

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