



GTU CSE 344

System Programming Homework 5 Report

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# Run Commands:

make: to compile for executable MWCp

make clean: to clean object files and executables

./MWCp <buffer size> <numworkers> <source path> <destination path>

## OUTPUT EXAMPLES:

1->valgrind ./MWCp 10 10 ../testdir/src/libvterm ../tocopy:

```
Removed item from buffer: ../testdir/src/libvterm/t/41screen_unicode.test -> ../tocopy/t/41screen_unicode.test
Removed item from buffer: ../testdir/src/libvterm/t/90vttest_01-movement-4.test -> ../tocopy/t/90vttest_01-movement-4.test
Copied file: ../testdir/src/libvterm/t/17state_mouse.test -> ../tocopy/t/17state_mouse.test
Removed item from buffer: ../testdir/src/libvterm/t/16state_resize.test -> ../tocopy/t/16state_resize.test
Copied file: ../testdir/src/libvterm/t/45screen_protect.test -> ../tocopy/t/45screen_protect.test
Removed item from buffer: ../testdir/src/libvterm/t/20state_wrapping.test -> ../tocopy/t/20state_wrapping.test
Copied file: ../testdir/src/libvterm/t/90vttest_01-movement-4.test -> ../tocopy/t/90vttest_01-movement-4.test
Removed item from buffer: ../testdir/src/libvterm/t/03encoding_utf8.test -> ../tocopy/t/03encoding_utf8.test
Copied file: ../testdir/src/libvterm/src/evalfunc.c -> ../tocopy/src/evalfunc.c
Copied file: ../testdir/src/libvterm/t/41screen_unicode.test -> ../tocopy/t/41screen_unicode.test
Removed item from buffer: ../testdir/src/libvterm/t/30pen.test -> ../tocopy/t/30pen.test
Removed item from buffer: ../testdir/src/libvterm/tbl2inc_c.pl -> ../tocopy/tbl2inc_c.pl
Copied file: ../testdir/src/libvterm/t/12state_scroll.test -> ../tocopy/t/12state_scroll.test
Copied file: ../testdir/src/libvterm/t/40screen_ascii.test -> ../tocopy/t/40screen_ascii.test
Copied file: ../testdir/src/libvterm/t/03encoding_utf8.test -> ../tocopy/t/03encoding_utf8.test
Removed item from buffer: ../testdir/src/libvterm/t/44screen_pen.test -> ../tocopy/t/44screen_pen.test
Copied file: ../testdir/src/libvterm/t/30pen.test -> ../tocopy/t/30pen.test
Copied file: ../testdir/src/libvterm/t/44screen_pen.test -> ../tocopy/t/44screen_pen.test
Added item to buffer: ../testdir/src/libvterm/tbl2inc_c.pl -> ../tocopy/tbl2inc_c.pl
Added item to buffer: ../testdir/src/libvterm/.gitignore -> ../tocopy/.gitignore
Copied file: ../testdir/src/libvterm/tbl2inc_c.pl -> ../tocopy/tbl2inc_c.pl
Copied file: ../testdir/src/libvterm/t/16state_resize.test -> ../tocopy/t/16state_resize.test
Removed item from buffer: ../testdir/src/libvterm/.gitignore -> ../tocopy/.gitignore
Copied file: ../testdir/src/libvterm/t/20state_wrapping.test -> ../tocopy/t/20state_wrapping.test
Copied file: ../testdir/src/libvterm/.gitignore -> ../tocopy/.gitignore
Copied file: ../testdir/src/libvterm/src/MRT10.pdf -> ../tocopy/src/MRT10.pdf
Copied file: ../testdir/src/libvterm/src/isl1551098739430.pdf -> ../tocopy/src/isl1551098739430.pdf

-----STATISTICS-----
Consumers: 10 - Buffer Size: 10
Number of Regular Files: 194
Number of FIFO Files: 0
Number of Directories: 7
TOTAL BYTES COPIED: 25009680
TOTAL TIME: 00:00.521 (min:sec.milli)
==15025==
==15025== HEAP SUMMARY:
==15025==    in use at exit: 0 bytes in 0 blocks
==15025==   total heap usage: 53 allocs, 53 frees, 291,876 bytes allocated
==15025==
==15025== All heap blocks were freed -- no leaks are possible
==15025==
==15025== For lists of detected and suppressed errors, rerun with: -s
==15025== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
```

2->./MWCp 10 4 ../testdir/src/libvterm/src ../tocopy

```
Copied file: ../testdir/src/libvterm/src/if_mzsch.h -> ../tocopy/if_mzsch.h
Removed item from buffer: ../testdir/src/libvterm/src/bigvim.bat -> ../tocopy/bigvim.bat
Added item to buffer: ../testdir/src/libvterm/src/gvintutor -> ../tocopy/gvintutor
Copied file: ../testdir/src/libvterm/src/bigvim.bat -> ../tocopy/bigvim.bat
Removed item from buffer: ../testdir/src/libvterm/src/gui_athena.c -> ../tocopy/gui_athena.c
Added item to buffer: ../testdir/src/libvterm/src/if_ole.h -> ../tocopy/if_ole.h
Copied file: ../testdir/src/libvterm/src/fileio.c -> ../tocopy/fileio.c
Removed item from buffer: ../testdir/src/libvterm/src/evalfunc.c -> ../tocopy/evalfunc.c
Added item to buffer: ../testdir/src/libvterm/src/gui_xmebw.h -> ../tocopy/gui_xmebw.h
Copied file: ../testdir/src/libvterm/src/gui_athena.c -> ../tocopy/gui_athena.c
Removed item from buffer: ../testdir/src/libvterm/src/iscygpty.c -> ../tocopy/iscygpty.c
Added item to buffer: ../testdir/src/libvterm/src/insexpand.c -> ../tocopy/insexpand.c
Copied file: ../testdir/src/libvterm/src/iscygpty.c -> ../tocopy/iscygpty.c
Removed item from buffer: ../testdir/src/libvterm/src/gvim.exe.mnf -> ../tocopy/gvim.exe.mnf
Copied file: ../testdir/src/libvterm/src/gvim.exe.mnf -> ../tocopy/gvim.exe.mnf
Removed item from buffer: ../testdir/src/libvterm/src/json.c -> ../tocopy/json.c
Copied file: ../testdir/src/libvterm/src/json.c -> ../tocopy/json.c
Removed item from buffer: ../testdir/src/libvterm/src/pen.c -> ../tocopy/pen.c
Copied file: ../testdir/src/libvterm/src/pen.c -> ../tocopy/pen.c
Removed item from buffer: ../testdir/src/libvterm/src/mouse.c -> ../tocopy/mouse.c
Copied file: ../testdir/src/libvterm/src/mouse.c -> ../tocopy/mouse.c
Removed item from buffer: ../testdir/src/libvterm/src/create_cmdidxs.vim -> ../tocopy/create_cmdidxs.vim
Copied file: ../testdir/src/libvterm/src/evalfunc.c -> ../tocopy/evalfunc.c
Removed item from buffer: ../testdir/src/libvterm/src/if_ruby.c -> ../tocopy/if_ruby.c
Copied file: ../testdir/src/libvterm/src/create_cmdidxs.vim -> ../tocopy/create_cmdidxs.vim
Removed item from buffer: ../testdir/src/libvterm/src/gvintutor -> ../tocopy/gvintutor
Copied file: ../testdir/src/libvterm/src/gvintutor -> ../tocopy/gvintutor
Removed item from buffer: ../testdir/src/libvterm/src/if_ole.h -> ../tocopy/if_ole.h
Copied file: ../testdir/src/libvterm/src/if_ruby.c -> ../tocopy/if_ruby.c
Removed item from buffer: ../testdir/src/libvterm/src/gui_xmebw.h -> ../tocopy/gui_xmebw.h
Copied file: ../testdir/src/libvterm/src/gui_xmebw.h -> ../tocopy/gui_xmebw.h
Removed item from buffer: ../testdir/src/libvterm/src/insexpand.c -> ../tocopy/insexpand.c
Copied file: ../testdir/src/libvterm/src/if_ole.h -> ../tocopy/if_ole.h
Copied file: ../testdir/src/libvterm/src/insexpand.c -> ../tocopy/insexpand.c
Copied file: ../testdir/src/libvterm/src/MRT10.pdf -> ../tocopy/MRT10.pdf
Copied file: ../testdir/src/libvterm/src/isl1551098739430.pdf -> ../tocopy/isl1551098739430.pdf

-----STATISTICS-----
Consumers: 4 - Buffer Size: 10
Number of Regular Files: 140
Number of FIFO Files: 0
Number of Directories: 2
TOTAL BYTES COPIED: 24873082
TOTAL TIME: 00:00.038 (min:sec.milli)
```

## IMPORTANT NOTES:

I made some improvements over my last homework, even debug prints are different, unlike hw4; this time program ends when all files are completed without needing for SIGINT, My output screenshots were wrong even though code was working for homework 4, with homework 5 I was more careful about this. Homework 4 used condition variables but not barriers, with homework 5 I added barriers along with the existing condition variables to satisfy the needs of this homework.

3 → ./MWCp 10 10 ../testdir ../tocopy

```
Copied file: ../testdir/nsis/README.txt -> ../tocopy/nsis/README.txt
Copied file: ../testdir/.github/ISSUE_TEMPLATE/feature_request.md -> ../tocopy/.github/ISSUE_TEMPLATE/feature_request.md
Removed item from buffer: ../testdir/nsis/lang/danish.nsi -> ../tocopy/nsis/lang/danish.nsi
Added item to buffer: ../testdir/nsis/lang/simpchinese.nsi -> ../tocopy/nsis/lang/simpchinese.nsi
Added item to buffer: ../testdir/nsis/lang/dutch.nsi -> ../tocopy/nsis/lang/dutch.nsi
Copied file: ../testdir/nsis/gvim_version.nsh -> ../tocopy/nsis/gvim_version.nsh
Removed item from buffer: ../testdir/nsis/lang/dutch.nsi -> ../tocopy/nsis/lang/dutch.nsi
Removed item from buffer: ../testdir/nsis/lang/simpchinese.nsi -> ../tocopy/nsis/lang/simpchinese.nsi
Copied file: ../testdir/nsis/lang/danish.nsi -> ../tocopy/nsis/lang/danish.nsi
Removed item from buffer: ../testdir/nsis/lang/tradchinese.nsi -> ../tocopy/nsis/lang/tradchinese.nsi
Copied file: ../testdir/nsis/lang/dutch.nsi -> ../tocopy/nsis/lang/dutch.nsi
Added item to buffer: ../testdir/nsis/lang/german.nsi -> ../tocopy/nsis/lang/german.nsi
Copied file: ../testdir/nsis/gvim.nsi -> ../tocopy/nsis/gvim.nsi
Removed item from buffer: ../testdir/nsis/lang/italian.nsi -> ../tocopy/nsis/lang/italian.nsi
Copied file: ../testdir/nsis/lang/simpchinese.nsi -> ../tocopy/nsis/lang/simpchinese.nsi
Added item to buffer: ../testdir/nsis/lang/italian.nsi -> ../tocopy/nsis/lang/italian.nsi
Added item to buffer: ../testdir/nsis/lang/japanese.nsi -> ../tocopy/nsis/lang/japanese.nsi
Removed item from buffer: ../testdir/nsis/lang/japanese.nsi -> ../tocopy/nsis/lang/japanese.nsi
Added item to buffer: ../testdir/nsis/lang/english.nsi -> ../tocopy/nsis/lang/english.nsi
Copied file: ../testdir/.travis.yml -> ../tocopy/.travis.yml
Removed item from buffer: ../testdir/nsis/lang/english.nsi -> ../tocopy/nsis/lang/english.nsi
Copied file: ../testdir/nsis/lang/tradchinese.nsi -> ../tocopy/nsis/lang/tradchinese.nsi
Removed item from buffer: ../testdir/nsis/lang/german.nsi -> ../tocopy/nsis/lang/german.nsi
Added item to buffer: ../testdir/nsis/icons.zip -> ../tocopy/nsis/icons.zip
Copied file: ../testdir/nsis/lang/italian.nsi -> ../tocopy/nsis/lang/italian.nsi
Added item to buffer: ../testdir/appveyor.yml -> ../tocopy/appveyor.yml
Added item to buffer: ../testdir/.gitignore -> ../tocopy/.gitignore
Copied file: ../testdir/nsis/lang/japanese.nsi -> ../tocopy/nsis/lang/japanese.nsi
Removed item from buffer: ../testdir/.gitignore -> ../tocopy/.gitignore
Removed item from buffer: ../testdir/appveyor.yml -> ../tocopy/appveyor.yml
Copied file: ../testdir/nsis/lang/english.nsi -> ../tocopy/nsis/lang/english.nsi
Removed item from buffer: ../testdir/nsis/icons.zip -> ../tocopy/nsis/icons.zip
Copied file: ../testdir/nsis/lang/german.nsi -> ../tocopy/nsis/lang/german.nsi
Copied file: ../testdir/appveyor.yml -> ../tocopy/appveyor.yml
Copied file: ../testdir/.gitignore -> ../tocopy/.gitignore
Copied file: ../testdir/nsis/icons.zip -> ../tocopy/nsis/icons.zip

-----STATISTICS-----
Consumers: 10 - Buffer Size: 10
Number of Regular Files: 3116
Number of FIFO Files: 0
Number of Directories: 151
TOTAL BYTES COPIED: 73520554
TOTAL TIME: 00:00.092 (min:sec.milli)
```

# Pseudocodes:

## MAIN:

```
function main(argc, argv):
    record start time

    // Parse command line arguments
    args = parse_arguments(argc, argv)
    buffer_size = args.buffer_size
    worker_count = args.num_workers

    // Set up signal handler
    sa.sa_handler = handle_signal
    clear sa.sa_mask
    sa.sa_flags = 0
    set signal handler for SIGINT to sa

    // Initialize barrier and buffer
    initialize barrier with (args.num_workers + 1)
    initialize buffer with args.buffer_size

    // Allocate memory for worker threads
    allocate workers array of size args.num_workers
    if allocation fails:
        print error and clean up
        exit

    // Allocate memory for manager arguments
    allocate mgr_args
    if allocation fails:
        print error and clean up
        exit
    copy args.src_dir and args.dst_dir to mgr_args
    if allocation fails:
        print error and clean up
        exit

    // Create manager thread
    print "Creating manager thread..."
    if thread creation fails:
        print error and clean up
        exit

    // Create worker threads
    for each worker from 0 to args.num_workers - 1:
        print "Creating worker thread i..."
        if thread creation fails:
            print error, set terminate flag, and wait on barrier
            break

    // Wait for manager thread to finish
    wait for manager thread to join
```

```

// Signal workers to stop and wait for them to finish
buffer.stop = 1
broadcast condition to all waiting consumers

for each worker from 0 to args.num_workers - 1:
    wait for worker thread to join

// Destroy barrier and buffer, free allocated memory
destroy barrier
destroy buffer
free workers

// Record end time
calculate elapsed time in minutes, seconds, and milliseconds

// Print statistics
print statistics about consumers, buffer size, files processed, total bytes copied, and total time

return 0

```

## WORKER:

```

function worker(arg):
    buffer = cast arg to Buffer pointer

    loop forever:
        file = buffer_get(buffer)

        if terminate flag is set:
            exit thread

        copy file from file.src to file.dst

    wait on barrier
    exit thread

```

## MANAGER:

```

function manager_recursive(arg):
    args = cast arg to manager_args pointer
    src_dir = args.src_dir
    dst_dir = args.dst_dir

    open directory src_dir
    if directory cannot be opened:
        print error and clean up
        return NULL

    loop over each entry in the directory:
        if entry is "." or "..":
            continue

```

```

construct src_path from src_dir and entry name
construct dst_path from dst_dir and entry name

if entry is a directory:
    create directory dst_path with permissions 0755
    increment numDirectories
    allocate memory for new_args
    if allocation fails:
        print error and clean up
        return NULL
    copy src_path and dst_path to new_args
    call manager_recursive(new_args)

else if entry is a regular file:
    increment numRegularFiles
    create FilePair pair with src_path and dst_path
    put pair into buffer

close directory
free args.src_dir
free args.dst_dir
free arg
return NULL

```

## General Structure

1. **Headers and Macros:** The program includes necessary headers and defines a macro for the maximum path length.
2. **Global Variables:** Variables for tracking statistics, buffer, and worker threads are declared.
3. **Structures:**
  - **FilePair:** Stores source and destination paths.
  - **Arguments:** Holds program arguments.
  - **Buffer:** A circular buffer for storing **FilePair** items.
  - **manager\_args:** Holds source and destination directory paths for the manager thread.
4. **Functions:**
  - **init\_buffer( ):** Initializes the buffer.
  - **destroy\_buffer( ):** Cleans up the buffer.

- `buffer_put()`: Adds an item to the buffer.
  - `buffer_get()`: Removes an item from the buffer.
  - `parse_arguments()`: Parses command-line arguments.
  - `manager_recursive()`: Recursively scans directories, adding files to the buffer.
  - `copy_file()`: Copies a file from source to destination.
  - `worker()`: Worker thread function that processes files from the buffer.
  - `handle_signal()`: Signal handler for SIGINT to handle graceful termination.
5. **Main Function:** Sets up the environment, creates threads, and handles cleanup.

## Workflow

1. **Parse Arguments:** Command-line arguments are parsed to get buffer size, number of workers, source directory, and destination directory.
2. **Signal Handling:** A signal handler for SIGINT is set up to handle termination gracefully.
3. **Buffer Initialization:** The buffer is initialized with the specified size.
4. **Worker Threads Creation:** Worker threads are created to process files from the buffer.
5. **Manager Thread Creation:** A manager thread is created to recursively scan the source directory and add files to the buffer.
6. **Directory Scanning:** The manager thread scans the source directory recursively. For each file found, it adds a `FilePair` item to the buffer. For directories, it creates corresponding directories in the destination.
7. **File Processing:** Worker threads continuously fetch files from the buffer and copy them to the destination. They exit if the buffer is stopped and empty.
8. **Signal Handling:** If a SIGINT is received, the program sets a termination flag, stops the buffer, and prints statistics.
9. **Cleanup:** After the manager thread finishes, the buffer is stopped, worker threads are joined, and resources are cleaned up.
10. **Statistics:** The program prints statistics such as the number of files and directories processed, total bytes copied, and total execution time.