CSE 344 SYSTEM PROGRAMMING

HOMEWORK #4 REPORT

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26.05.2024

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Introduction

This report describes the implementation and experimentation of a directory copying utility called "MWCp" that copies files and subdirectories in parallel using a worker-manager approach to synchronize thread activity. The implementation uses POSIX and Standard C libraries to achieve the task.

Code Structure of Program and Pseudo Code

Code Structure

Description of the functions used:

-main (): Parses command line arguments, sets up signal handling, initializes threads, and prints statistics.

- handle_signal () : Handles SIGINT signal to clean up and exit.

- manager_thread () : Manages the directory copying process and signals completion.

- worker_thread () : Copies files as tasks are added to the buffer.

- copy_directory () : Recursively copies directories and adds file copy tasks to the buffer.

- copy_file () : Performs the actual file copy.

- cleanup_file_task () : Cleans up resources associated with a file task.

- remove_directory () : Removes a directory and its contents.

- print_statistics () : Prints the statistics of the copying process.

Pseudocode

1. **Initialize Program**

   - Parse command line arguments.

   - Set up signal handler for SIGINT.

   - Allocate memory for source and destination directories.

   - Clear destination directory.

   - Initialize statistics variables.

   - Record start time.

2. **Create Threads**
   - Create manager thread.
   - Create worker threads.

3. **Manager Thread Function**
   - **manager_thread**:
     - Copy directories recursively from source to destination.
     - Lock buffer mutex, set **done** flag, signal worker threads, unlock buffer mutex.

4. **Worker Thread Function**
   - **worker_thread**:
     - Loop:
       - Lock buffer mutex.
       - Wait if buffer is empty and not done.
       - Exit if buffer is empty and done.
       - Get task from buffer, signal buffer not full, unlock buffer mutex.
       - Copy file and clean up task.

5. **Copy Directory Function**
   - **copy_directory**:
     - Open source directory.
     - For each entry:
       - Skip **.** and **..**
       - Construct source and destination paths.
       - If directory:
         - Create destination directory, increment directory count, copy recursively.
       - Else:
         - Lock buffer mutex, wait if buffer full, create task, open files.

- On failure: print error, clean up, unlock mutex, continue.

- Add task to buffer, increment file count, signal buffer not empty, unlock mutex.

- Close source directory.

6. **Copy File Function**

- **copy_file**:

  - Read from source and write to destination in chunks.

  - Update total bytes copied.

  - Handle read/write errors.

  - Close files.

7. **Cleanup File Task Function**

- **cleanup_file_task**:

  - Free memory for file names.

8. **Remove Directory Function**

- **remove_directory**:

  - Open directory.

  - For each entry:

    - Skip **.** and **..**

    - Construct full path.

    - If directory, remove recursively; else, remove file.

  - Close and remove directory.

9. **Print Statistics Function**

- **print_statistics**:

  - Calculate and print elapsed time, number of files, directories, total bytes copied.

10. **Main Function**

- Parse arguments, set up signal handling, allocate memory, clear destination directory.

- Record start time.

- Create manager and worker threads, wait for completion.

- Record end time, print statistics, free memory, exit.

Makefile

The Makefile compiles the C code and provides targets for running the program and conducting tests.

```
2                                                                    >  diff
3     # Compiler
4     CC = gcc
5
6     # Compiler flags
7     CFLAGS = -Wall -pthread
8
9     # Source files
10    SRCS = MWCp.c
11
12    # Executable name
13    EXEC = MWCp
14
15    # Default target
16    all: $(EXEC)
17
18    # Build the executable
19    $(EXEC): $(SRCS)
20        $(CC) $(CFLAGS) -o $(EXEC) $(SRCS)
21
22    # Clean up the build files
23    clean:
24        rm -f $(EXEC) *.o
25        rm -rf ../tocopy/*
26
27    # Run the program with default parameters
28    run: $(EXEC)
29        ./$(EXEC) 10 4 ../testdir ../tocopy
30
31    # Run the tests
32    test1: clean $(EXEC)
33        valgrind --leak-check=full ./$(EXEC) 10 10 ../testdir/src/libvterm ../tocopy
34
35    test2: clean $(EXEC)
36        ./$(EXEC) 10 4 ../testdir/src/libvterm/src ../tocopy
37
38    test3: clean $(EXEC)
39        ./$(EXEC) 10 10 ../testdir ../tocopy
40
41    .PHONY: all clean run test1 test2 test3
42
```

- all: Compiles the code.

- clean : Cleans up build files and the destination directory.

- run : Runs the program with default parameters.

- test1, test2, test3 : Runs the program with different parameters for testing.

Experimentation

If there is no tocopy directory, program create a directory and copy the files.

```
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/hw4test/put_your_codes_here$ make run
./210104004298_main 10 4 ../testdir ../tocopy

---------------STATISTICS---------------
Consumers: 4 - Buffer Size: 10
Number of Regular Files: 3116
Number of FIFO Files: 0
Number of Directories: 151
TOTAL BYTES COPIED: 73520554
TOTAL TIME: 41.943 seconds
----------------------------------------
```

Test 1

Test1: valgrind ./MWCp 10 10 ../testdir/src/libvterm ../tocopy, #memory leak checking,
buffer size=10, number of workers=10, sourceFile, destinationFile

Before Test 1:

```
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ cd ..
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test$ cd tocopy/
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/tocopy$ ls
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/tocopy$
```

Before test 1 . "tocopy" directory is empty.

After Test 1:

```
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test$ cd put_your_codes_here/
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ make
gcc -Wall -pthread -o MWCp MWCp.c
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ make test1
rm -f MWCp *.o
rm -rf ../tocopy/*
gcc -Wall -pthread -o MWCp MWCp.c
valgrind --leak-check=full ./MWCp 10 10 ../testdir/src/libvterm ../tocopy
==115035== Memcheck, a memory error detector
==115035== Copyright (C) 2002-2017, and GNU GPL'd, by Julian Seward et al.
==115035== Using Valgrind-3.18.1 and LibVEX; rerun with -h for copyright info
==115035== Command: ./MWCp 10 10 ../testdir/src/libvterm ../tocopy
==115035==

---------------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: 5.691 seconds
-----------------------------------------
==115035==
==115035== HEAP SUMMARY:
==115035==     in use at exit: 0 bytes in 0 blocks
==115035==   total heap usage: 411 allocs, 411 frees, 312,656 bytes allocated
==115035==
==115035== All heap blocks were freed -- no leaks are possible
==115035==
==115035== For lists of detected and suppressed errors, rerun with: -s
==115035== ERROR SUMMARY: 0 errors from 0 contexts (suppressed: 0 from 0)
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$
```

```
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/tocopy$ ls
LICENSE  Makefile  README  bin  doc  include  src  t  tbl2inc_c.pl  vterm.pc.in
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/tocopy$
```


Ad	Değiştirme tarihi	Tür	Boyut
bin	26.05.2024 19:12	Dosya klasörü	
doc	26.05.2024 19:12	Dosya klasörü	
include	26.05.2024 19:12	Dosya klasörü	
src	26.05.2024 19:12	Dosya klasörü	
t	26.05.2024 19:12	Dosya klasörü	
.bzrignore	26.05.2024 19:12	BZRIGNORE Dosyası	1 KB
.gitignore	26.05.2024 19:12	Git Ignore Kaynak Do...	1 KB
vterm.pc.in	26.05.2024 19:12	IN Dosyası	1 KB
tbl2inc_c.pl	26.05.2024 19:12	Perl Kaynak Dosyası	1 KB
README	26.05.2024 19:12	Dosya	1 KB
LICENSE	26.05.2024 19:12	Dosya	2 KB
Makefile	26.05.2024 19:12	Dosya	4 KB

Test 2

Test2: ./MWCp 10 4 ../testdir/src/libvterm/src ../toCopy #buffer size=10, number of workers=4, sourceFile, destinationFile

Before Test2:

Tocopy directory is empty again.

After Test2:

```
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ make test2
rm -f MWCp *.o
rm -rf ../tocopy/*
gcc -Wall -pthread -o MWCp MWCp.c
./MWCp 10 4 ../testdir/src/libvterm/src ../tocopy

---------------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: 3.261 seconds
-----------------------------------------
```

Test 3

Test3: ./MWCp 10 10 ../testdir ../toCopy #buffer size=10, number of workers=10, sourceFile, destinationFile

Before Test 3:

Tocopy directory is empty again.

After Test 3:

```
-----------------------------------------
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ make test3
rm -f MWCp *.o
rm -rf ../tocopy/*
gcc -Wall -pthread -o MWCp MWCp.c
./MWCp 10 10 ../testdir ../tocopy

---------------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: 14.919 seconds
-----------------------------------------
```

Handling Invalid Commands

Some screenshoots of invalid commands examples:

```
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ ./MWCp 0 0 ../testdir ../tocopy
Buffer size and number of workers must be greater than 0
```

```
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ ./MWCp 1  a b 0 0 ../testdir
 ../tocopy
Usage: ./MWCp <buffer_size> <num_workers> <src_dir> <dest_dir>
```

```
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ ./MWCp 10 10 ../nofileeee ../tocopy
Failed to open source directory: No such file or directory

---------------STATISTICS----------------
Consumers: 10 - Buffer Size: 10
Number of Regular Files: 0
Number of FIFO Files: 0
Number of Directories: 0
TOTAL BYTES COPIED: 0
TOTAL TIME: 0.002 seconds
----------------------------------------
```

Handling SIGINT (Ctrl+C)

```
----------------------------------------
bktgncr@DESKTOP-AI758A5:/mnt/c/Users/HUAWEI/OneDrive/Masaüstü/system_hw4/hw4test/hw4test/put_your_codes_here$ ./MWCp 10 10 ../testdir ../tocopy
^C
 Process interrupted. Cleaning up and exiting...
```