AUP : Assignment - 9 [Multithreading]

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Q1

Write a program to take input from user for number of files to be scanned and word to be searched. Write a multi threaded program to search the files and return pattern if found.

Code

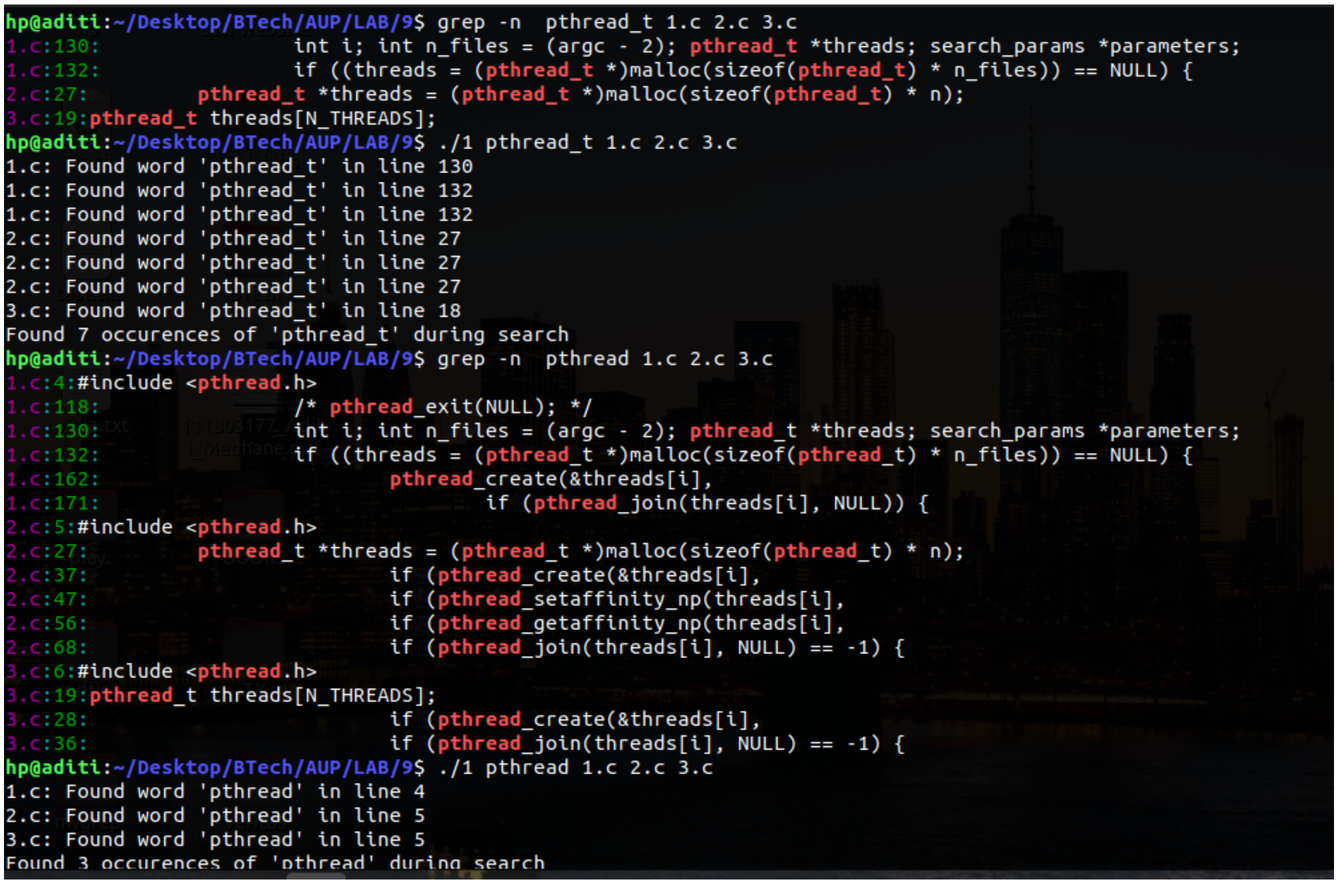
```c
#include <sys/types.h>
#include <unistd.h>
#include <fcntl.h>
#include <pthread.h>
#include <errno.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>


#define BUF_SIZE 1024
typedef struct {
        int fp;
        int offset;
        int chars_read;
        char buf[BUF_SIZE];
}read_buf;

void get_read_buf(read_buf *b, int fp) {
        b->fp = fp;
        b->offset = 0;
        b->chars_read = -1;
}

void destroy_read_buf(read_buf *b) {
        close(b->fp);
        b->offset = b->fp = 0;
        b->chars_read = -1;
}

int getchar_buffered(read_buf *b) {
        if (b->chars_read < 0 || b->offset == b->chars_read) {
                if ((b->chars_read = read(b->fp, b->buf, BUF_SIZE)) == -1) {
                        perror("read");
                        exit(errno);
                }

                if (!b->chars_read) {
                        // this is the end of file
                        return EOF;
                }

                // assert: buffer has nonzero number of bytes
                b->offset = 0;
        }

        return b->buf[++(b->offset)];
}

typedef struct {
        char *filepath;
        char *word;
        int count;
}search_params;


#define MAX_WORD 512
#define IN 101
#define OUT 102
void *search_word(void *arg) {
        search_params *sp;
        sp = (search_params *)arg;

        int c;
        int fp;
        read_buf rb;

        int lineno = 1;

        int state = OUT;
        char word[MAX_WORD + 1];
        int wordlen = 0;

        if ((fp = open(sp->filepath, O_RDONLY)) == -1) {
                perror("open");
                exit(errno);
        }

        get_read_buf(&rb, fp);

        while ((c = getchar_buffered(&rb)) != EOF) {
                if (c == '\n') {
                        lineno++;
                }

                if (state == OUT) {
                        if (isalpha(c) || c == '_') {
                                state = IN;
                                wordlen = 0;
                                word[wordlen++] = c;
                        }
                }
                else if (state == IN) {
                        if (!(isalpha(c) || (c == '_'))) {
                            word[wordlen] = '\0';
                            state = OUT;
                            wordlen = 0;
                            // printf("%s\n", word);
                            if (strcmp(word, sp->word) == 0) {
                                    // word found
                                    printf("%s: Found word '%s' in line %d\n",
                                        sp->filepath, sp->word, lineno);
                                    ++sp->count;
                            }
                        }
                        else {
                            word[wordlen++] = c;
                        }
                }
                else {
                    fprintf(stderr, "Invalid State\n");
                    exit(1);
                }
        }

        destroy_read_buf(&rb);

        // pthread_exit(NULL);
        return &(sp->count);
}

int main(int argc, char *argv[]) {

        // search word file1 file2 ..
        if (argc < 3) {
                fprintf(stderr, "usage: ./search <word> <file1> [<file2> ... <file-n>]\n");
                return EINVAL;
        }

        int i; int n_files = (argc - 2); pthread_t *threads; search_params *parameters;

        if ((threads = (pthread_t *)malloc(sizeof(pthread_t) * n_files)) == NULL) {
                fprintf(stderr, "malloc failed\n");
                return 1;
        }

        if ((parameters = (search_params *)malloc(sizeof(search_params) * n_files)) == NULL) {
                fprintf(stderr, "malloc failed\n");
                return 1;
        }

        for (i = 0; i < n_files; i++) {

            // add file path to parameters
            if ((parameters[i].filepath = (char *)malloc(sizeof(char) * (strlen(argv[2]) + 1))) == NULL) {
                    fprintf(stderr, "malloc failed\n");
                    return 1;
            }
            strcpy(parameters[i].filepath, argv[2 + i]);

            // add search pattern to parameters
            if ((parameters[i].word = (char *)malloc(sizeof(char) * (strlen(argv[1]) + 1))) == NULL) {
                    fprintf(stderr, "malloc failed\n");
                    return 1;
            }
            strcpy(parameters[i].word, argv[1]);

            // initialize count to 0
            parameters[i].count = 0;

            // dispatch thread for searching file
            pthread_create(&threads[i],
                           NULL,
                           search_word,
                           (void *)&parameters[i]);
        }

        int total_count = 0;

        for (i = 0; i < n_files; i++) {
                if (pthread_join(threads[i], NULL)) {
                        fprintf(stderr, "Unable to join thread\n");
                }
                free(parameters[i].word);
                free(parameters[i].filepath);

                total_count += parameters[i].count;
        }

        printf("Found %d occurences of '%s' during search\n", total_count, argv[1]);

        return 0;
}
```

Explanation

Search for word pthread_t & pthread in C source files

Note : grep -n option is used to verify line numbers and matching pattern lines

Output



```
hp@aditi:~/Desktop/BTech/AUP/LAB/9$ grep -n  pthread_t 1.c 2.c 3.c
1.c:130:                int i; int n_files = (argc - 2); pthread_t *threads; search_params *parameters;
1.c:132:                if ((threads = (pthread_t *)malloc(sizeof(pthread_t) * n_files)) == NULL) {
2.c:27:         pthread_t *threads = (pthread_t *)malloc(sizeof(pthread_t) * n);
3.c:19:pthread_t threads[N_THREADS];
hp@aditi:~/Desktop/BTech/AUP/LAB/9$ ./1 pthread_t 1.c 2.c 3.c
1.c: Found word 'pthread_t' in line 130
1.c: Found word 'pthread_t' in line 132
1.c: Found word 'pthread_t' in line 132
2.c: Found word 'pthread_t' in line 27
2.c: Found word 'pthread_t' in line 27
2.c: Found word 'pthread_t' in line 27
3.c: Found word 'pthread_t' in line 18
Found 7 occurences of 'pthread_t' during search
hp@aditi:~/Desktop/BTech/AUP/LAB/9$ grep -n  pthread 1.c 2.c 3.c
1.c:4:#include <pthread.h>
1.c:118:                /* pthread_exit(NULL); */
1.c:130:                int i; int n_files = (argc - 2); pthread_t *threads; search_params *parameters;
1.c:132:                if ((threads = (pthread_t *)malloc(sizeof(pthread_t) * n_files)) == NULL) {
1.c:162:                        pthread_create(&threads[i],
1.c:171:                                if (pthread_join(threads[i], NULL)) {
2.c:5:#include <pthread.h>
2.c:27:         pthread_t *threads = (pthread_t *)malloc(sizeof(pthread_t) * n);
2.c:37:                         if (pthread_create(&threads[i],
2.c:47:                         if (pthread_setaffinity_np(threads[i],
2.c:56:                         if (pthread_getaffinity_np(threads[i],
2.c:68:                         if (pthread_join(threads[i], NULL) == -1) {
3.c:6:#include <pthread.h>
3.c:19:pthread_t threads[N_THREADS];
3.c:28:                         if (pthread_create(&threads[i],
3.c:36:                         if (pthread_join(threads[i], NULL) == -1) {
hp@aditi:~/Desktop/BTech/AUP/LAB/9$ ./1 pthread 1.c 2.c 3.c
1.c: Found word 'pthread' in line 4
2.c: Found word 'pthread' in line 5
3.c: Found word 'pthread' in line 5
Found 3 occurences of 'pthread' during search
```

Figure 1: Output

Q2

Write a program to find number of CPUs, create that many threads and attach those threads to CPUs

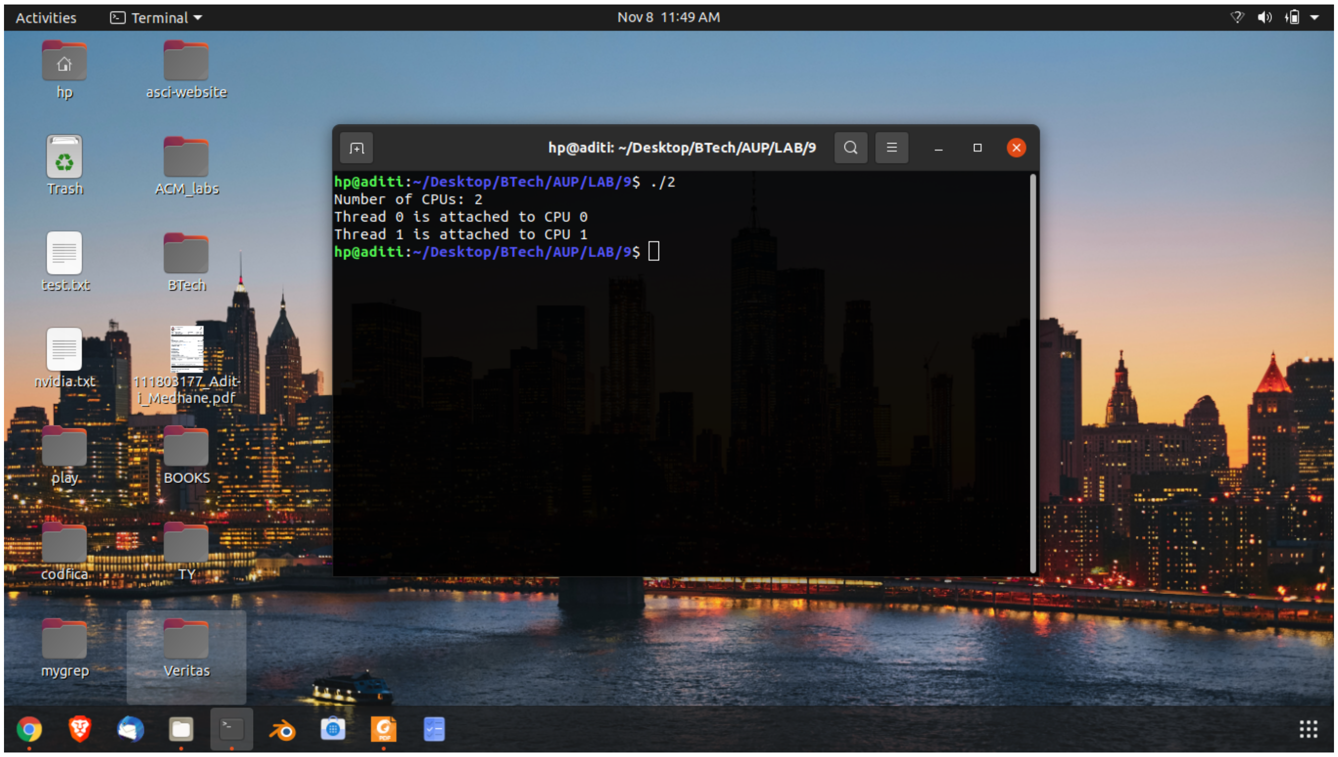
Code

```c
#define _GNU_SOURCE
#include <sched.h>
#include <sys/sysinfo.h>
#include <unistd.h>
#include <pthread.h>
#include <stdio.h>
#include <errno.h>
#include <stdlib.h>

void *busy_void(void *arg) {
        int count = 100000;
        while (count--);
        return NULL;
}

int main(void) {

        int n;

        if ((n = sysconf(_SC_NPROCESSORS_CONF)) == -1) {
                perror("sysconf");
                return errno;
        }

        printf("Number of CPUs: %d\n", n);

        pthread_t *threads = (pthread_t *)malloc(sizeof(pthread_t) * n);
        cpu_set_t *cpus = (cpu_set_t *)malloc(sizeof(cpu_set_t) * n);

        int i;
        for (i = 0; i < n; i++) {
                CPU_ZERO(&cpus[i]);
                CPU_SET(i, &cpus[i]);
        }

        for (i = 0; i < n; i++) {
                if (pthread_create(&threads[i],
                           NULL,
                               busy_void,
                           NULL) == -1) {
                        fprintf(stderr, "Unable to create thread\n");
                }
        }

        /* DANGER: non-POSIX code */
        for (i = 0; i < n; i++) {
                if (pthread_setaffinity_np(threads[i],
                                sizeof(cpu_set_t),
                                   &cpus[i]) == -1) {
                        fprintf(stderr, "Unable to set affinity\n");
                        return 1;
                }
        }

        for (i = 0; i < n; i++) {
                if (pthread_getaffinity_np(threads[i],
                                sizeof(cpu_set_t),
                                &cpus[i]) == -1) {
                        fprintf(stderr, "Unable to get affinity\n");
                        return 2;
                }
                printf("Thread %d is ", i);
                if (!CPU_ISSET(i, &cpus[i])) {
                        printf("not ");
                }
                printf("attached to CPU %d\n", i);

                if (pthread_join(threads[i], NULL) == -1) {
                        fprintf(stderr, "Unable to join with thread %lu\n", threads[i]);
                }
        }

        return 0;

}
```

Explanation

Code verifies that threads are running on CPUs which they are attached to.

Output



```
hp@aditi:~/Desktop/BTech/AUP/LAB/9$ ./2
Number of CPUs: 2
Thread 0 is attached to CPU 0
Thread 1 is attached to CPU 1
hp@aditi:~/Desktop/BTech/AUP/LAB/9$ 
```

Figure 2: Output

Q3

Write a short program that creates 5 threads which print a thread “id” that is passed to thread function by pointer.

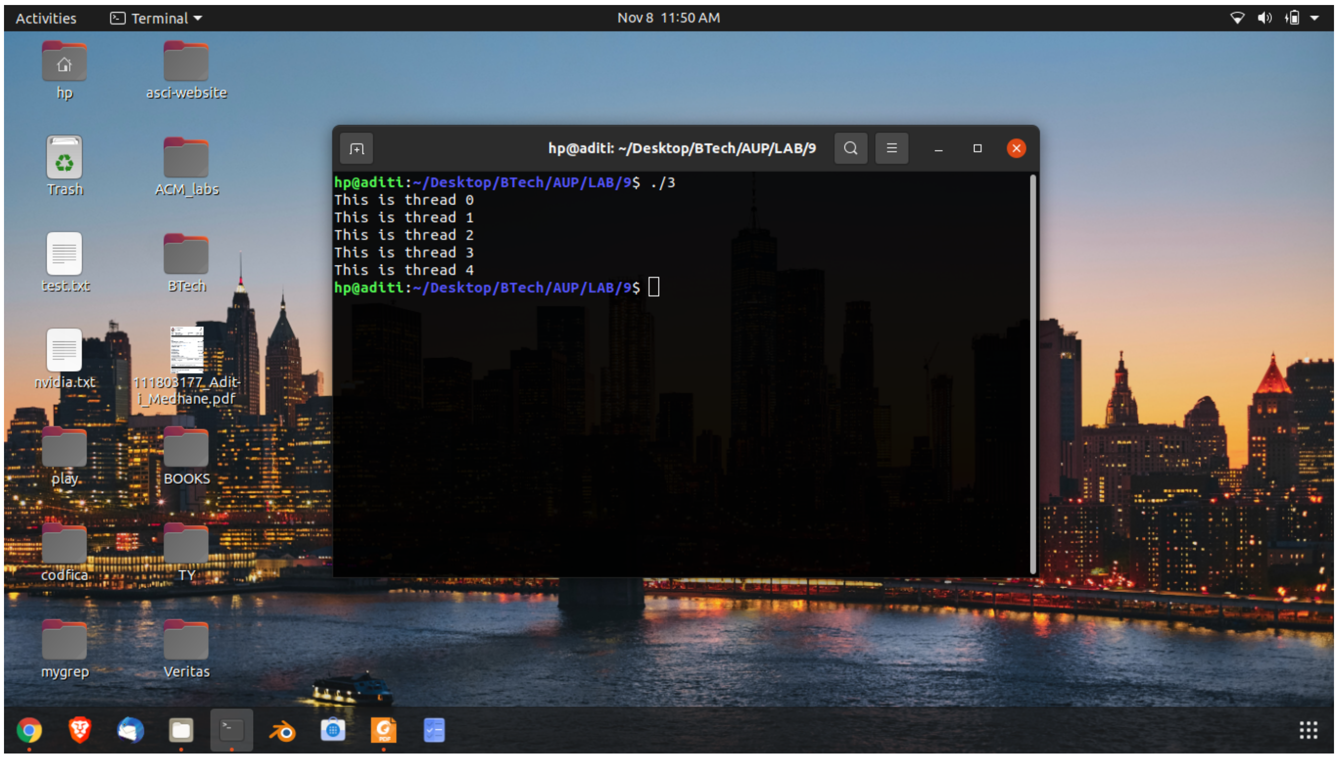
Code

```c
#define _GNU_SOURCE
#include <sched.h>
#include <sys/sysinfo.h>
#include <unistd.h>
#include <pthread.h>
#include <stdio.h>
#include <errno.h>
#include <stdlib.h>


void *busy_void(void *arg) {
        printf("This is thread %d\n", *((int *)arg));
        return NULL;
}

#define N_THREADS 5
static int thread_ids[N_THREADS];
pthread_t threads[N_THREADS];
int main(void) {

        int n, i;

        n = N_THREADS;

        for (i = 0; i < n; i++) {
                thread_ids[i] = i;
                if (pthread_create(&threads[i],
                           NULL,
                           busy_void,
                           &thread_ids[i]) == -1) {
                        fprintf(stderr, "Unable to create thread\n");
                }
        }
        for (i = 0; i < n; i++) {
                if (pthread_join(threads[i], NULL) == -1) {
                        fprintf(stderr, "Unable to join with thread %lu\n", threads[i]);
                }
        }


        return 0;

}
```

Explanation

Each thread prints it’s “thread id”. The pointer to the ID was passed to the thread.

Output



```
hp@aditi:~/Desktop/BTech/AUP/LAB/9$ ./3
This is thread 0
This is thread 1
This is thread 2
This is thread 3
This is thread 4
hp@aditi:~/Desktop/BTech/AUP/LAB/9$
```

Figure 3: Output