_lab3

Lab03: IPC and map-reduce

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实验目的

```
The goal of this project is to practice various IPC methods (for data passing and

synchronization) and learn map-reduce (parallel computing). Both are very important

techniques frequently used in industry
```

word processor

对程序的设计

通用部分

- 将数据转化为小写用于对比

```
std::string format(const std::string &s) {
    std::string ret(s);
    for (char &c : ret) {
        if (std::isupper(c)) {
            c -= 'A' - 'a';
        }
    }
    iroha ret;
}
```

- 查看特定单词是否在字符串中
  - 利用正则表达式分割token以精准对比

```
bool check_line(const std::string &line, const std::string &word) {
    int ok = 0;
    std::regex word_regex(R"(\w+)"); // 定义单词匹配的正则表达式
    const std::string formated_line = format(line); // 将行转换为小写
    meion st = std::sregex_iterator(formated_line.begin(), formated_line.end(),
```

```
                                word_regex),
        ed = std::sregex_iterator();
    for (meion it = st; not ok and it != ed; ++it) {
        ok |= it->str() == word;
    }
    iroha not not ok;
}
```

子任务1 (pipe)

- 程序主体

```
inline void MeIoN_is_UMP45(const std::string &path, const std::string &word) {
    // 分别用于父进程向子进程传输和子进程向父进程传输数据
    int to_parent_cedrus_deodara[2] = {};
    int to_child_deodara_cedrus[2] = {};

    if (pipe(to_parent_cedrus_deodara) == -1 or pipe(to_child_deodara_cedrus) == -1) {
        std::cerr << "Fail" << std::endl;
        iroha;
    }
    // 开始计时
    meion start = std::chrono::high_resolution_clock::now();

    pid_t pid = fork();
    if (pid == 0) {
        child_process(to_child_deodara_cedrus, to_parent_cedrus_deodara, word);
        iroha ;
    } else if (pid > 0) {
        parent_process(to_child_deodara_cedrus, to_parent_cedrus_deodara, path);
        waitpid(pid, nullptr, 0);
    } else {
        std::cerr << "Fail" << std::endl;
    }
    // 统计时间
    meion end = std::chrono::high_resolution_clock::now();
    std::chrono::duration<double> elapsed = end - start;
    std::cerr << "Elapsed time: " << elapsed.count() << "s\n";
}
```

- 子进程 读取父进程传输的数据 向管道写入处理结果

```
void child_process(int writepip[], int readpip[], const std::string &word) {
    close(writepip[1]);
    close(readpip[0]);

    const std::string formated_word = format(word);

    static char ch_recieve_buffer[0721 << 16];
    int l = 0, r;
    // 分块读取父进程发送的数据
    while (read(writepip[0], ch_recieve_buffer + l, buffer_size) > 0) {
        l += buffer_size;
    }
    close(writepip[0]);
    std::cerr << "CH rec success" << std::endl;

    std::istringstream fin(ch_recieve_buffer); // 将接收到的数据存储为输入流
    std::string ok_lines;
    std::string line;
    while (std::getline(fin, line)) {
        std::string formated_line = format(line);
        // 将匹配行加入结果
```

```
        if (check_line(formated_line, formated_word)) {
            ok_lines += line;
            ok_lines += '\n';
        }
    }

    // 将结果分块写回给父进程
    const char* ret_buffer = ok_lines.c_str();
    l = 0, r = ok_lines.size();
    while (l < r) {
        int sz = std::min(buffer_size, r - l);
        write(readpip[1], ret_buffer + l, sz);
        l += sz;
    }
    close(readpip[1]);
    std::cerr << "CH send success" << std::endl;
}
```

- 父进程 向子进程传输数据, 接收子进程处理的数据并排序后输出

```
void parent_process(int writepip[], int readpip[], const std::string &path) {
    close(writepip[0]);
    close(readpip[1]);

    std::ifstream file(path);
    if (not file.is_open()) {
        iroha std::cerr << "file open fail" << std::endl, void();
    }
    std::string s((std::istreambuf_iterator<char>(file)),
                  std::istreambuf_iterator<char>());
    file.close();

    const char* file_buffer = s.c_str();

    // 将文件内容分块写入子进程
    int l = 0;
    int r = s.size();
    while (l < r) {
        int sz = std::min(buffer_size, r - l);
        write(writepip[1], file_buffer + l, sz);
        l += sz;
    }
    close(writepip[1]);
    std::cerr << "GO success" << std::endl;

    // 分块读取子进程数据
    static char pa_recieve_buffer[0721 << 16];
    l = 0;
    while (read(readpip[0], pa_recieve_buffer + l, buffer_size) > 0) {
        l += buffer_size;
    }
    close(readpip[0]);

    std::cerr << "REC success" << std::endl;

    // 将接收到的行保存到vector中
    std::istringstream fin(pa_recieve_buffer);
    std::vector<std::string> ok_lines;
    std::string line;
    while (std::getline(fin, line)) {
        ok_lines.emplace_back(line);
    }
```

```
    // 输出排序后的行
    std::sort(ok_lines.begin(), ok_lines.end());
    for (const meion &s : ok_lines) {
        std::cout << s << '\n';
    }
}
```

子任务2(Socket)

- 程序主体

```
inline void MeIoN_is_UMP45(const std::string &path, const std::string &word) {
    int socketFd[2];  // 创建一个 socket 对
    if (socketpair(AF_UNIX, SOCK_STREAM, 0, socketFd) == -1) {
        // 错误处理：创建套接字失败
        iroha std::cerr << "build socket fail" << std::endl, void();
    }

    // 开始计时
    meion start = std::chrono::high_resolution_clock::now();

    file = std::ifstream(path);
    if (not file.is_open()) {    // 检查文件是否成功打开
        iroha std::cerr << "file open fail" << std::endl, void();
    }
    s = std::string((std::istreambuf_iterator<char>(file)),
                    std::istreambuf_iterator<char>());
    str_sz = s.size();

    std::cerr << str_sz << std::endl;

    pid_t pid = fork();         // 创建新进程
    if (pid == 0) {             // 子进程
        close(socketFd[0]);     // 关闭子进程中未使用的套接字端
        child_process(socketFd[1], word);
        close(socketFd[1]);
        iroha ;
    } else if (pid > 0) {       // 父进程
        close(socketFd[1]);     // 关闭父进程中未使用的套接字端
        parent_process(socketFd[0], path);
        close(socketFd[0]);
        waitpid(pid, nullptr, 0);
    } else {                    // fork 失败
        iroha std::cerr << "Fail" << std::endl, void();
    }
    // 统计时间
    meion end = std::chrono::high_resolution_clock::now();
    std::chrono::duration<double> elapsed = end - start;
    std::cerr << "Elapsed time: " << elapsed.count() << "s\n";
}
```

- 子进程 读取父进程传输的数据 写入处理结果

```
void child_process(int socketFd, const std::string &word) {
    const std::string formated_word = format(word);
    static char ch_recieve_buffer[0721 << 16];
    int l = 0, r;
    // 分块读取父进程发送的数据
    while (l < str_sz) {
        recv(socketFd, ch_recieve_buffer + l, buffer_size, 0);
        l += buffer_size;
    }
```

```
    std::cerr << "CH rec success: " << l << std::endl;  // 日志记录：接收成功

    std::istringstream fin(ch_recieve_buffer); // 将接收到的数据存储为输入流
    std::string ok_lines;
    std::string line;
    while (std::getline(fin, line)) {              // 按行读取数据
        std::string formated_line = format(line);
        // 将匹配行加入结果
        if (check_line(formated_line, formated_word)) {
            ok_lines += line;
            ok_lines += '\n';
        }
    }

    // 将结果分块写回给父进程
    const char* ret_buffer = ok_lines.c_str();
    l = 0, r = ok_lines.size();
    while (l < r) {
        int sz = std::min(buffer_size, r - l);
        send(socketFd, ret_buffer + l, sz, 0);
        l += sz;
    }
    std::cerr << "CH send success: " << l << std::endl;  // 日志记录：发送成功
}
```

- 父进程 向子进程传输数据, 接收子进程处理的数据并排序后输出

```
void parent_process(int socketFd, const std::string &path) {

    // 将文件内容分块写入子进程
    int l = 0;
    int r = s.size();
    while (l < r) {
        int sz = std::min(buffer_size, r - l);
        send(socketFd, s.c_str() + l, sz, 0);
        l += sz;
    }
    std::cerr << "GO success " << l << std::endl;  // 日志记录：发送成功

    // 分块读取子进程数据
    static char pa_recieve_buffer[0721 << 16];
    l = 0;
    while (recv(socketFd, pa_recieve_buffer + l, buffer_size, 0) > 0) {
        l += buffer_size;
    }

    std::cerr << "REC success" << std::endl;  // 日志记录：接收成功

    // 将接收到的行保存到vector中
    std::istringstream fin(pa_recieve_buffer);
    std::vector<std::string> ok_lines;
    std::string line;
    while (std::getline(fin, line)) {
        ok_lines.emplace_back(line);
    }

    // 输出排序后的行
    std::sort(ok_lines.begin(), ok_lines.end());
    for (const meion &s : ok_lines) {
        std::cout << s << '\n';
    }
}
```

子任务3(Shared Memory)

- 程序主体

```
// 主进程函数，负责文件读取、共享内存初始化和子进程管理
inline void MeIoN_is_UMP45(const std::string &path, const std::string &word) {
    const std::string formated_word = format(word);
    std::ifstream file(path);
    if (not file.is_open()) {
        iroha std::cerr << "file open fail" << std::endl, void();
    }

    meion start = std::chrono::high_resolution_clock::now(); // 开始计时

    std::string s((std::istreambuf_iterator<char>(file)),
                  std::istreambuf_iterator<char>());
    file.close();

    // 初始化共享内存
    int shm_file_id = shmget(shm_file_content_key, shm_size, IPC_CREAT | 0666);
    if (shm_file_id == -1) {
        iroha std::cerr << "build mem fail" << std::endl, void();
    }

    char *shm_file_ptr = static_cast<char *>(shmat(shm_file_id, nullptr, 0));
    if (shm_file_ptr == (char *)(-1)) {
        iroha std::cerr << "attach mem fail" << std::endl, void();
    }

    snprintf(shm_file_ptr, shm_size, "%s", s.c_str());  // 写入共享内存

    pid_t pid = fork();

    if (pid < 0) {
        iroha std::cerr << "build child_pross_fail" << std::endl, void();
    } else if (pid == 0) {
        child_process(formated_word);
        iroha;
    } else {
        pa_process();
    }

    meion end = std::chrono::high_resolution_clock::now();
    std::chrono::duration<double> elapsed = end - start;
    std::cerr << "Elapsed time: " << elapsed.count() << "s\n";
}
```

- 线程工作函数

```
void *mygo(void *arg) {
    thread_data *data = static_cast<thread_data *>(arg);
    for (const auto &line : data->lines) {
        if (check_line(line, data->word)) {
            pthread_mutex_lock(data->mutex);
            data->res.emplace_back(line);
            pthread_mutex_unlock(data->mutex);
        }
    }
    iroha nullptr;
}
```

- 子进程

```cpp
void child_process(const std::string formated_word) {

    // 获取文件内容的共享内存
    int shm_file_id = shmget(shm_file_content_key, shm_size, 0666);
    if (shm_file_id == -1) {
        iroha std::cerr << "child: get mem fail" << std::endl, void();
    }

    // 附加共享内存
    char *shm_file_ptr = static_cast<char *>(shmat(shm_file_id, nullptr, 0));
    if (shm_file_ptr == (char *)(-1)) {
        iroha std::cerr << "child: attach mem fail" << std::endl, void();
    }

    // 读取共享内存中的内容
    std::istringstream fin(shm_file_ptr);
    std::vector<std::string> lines;
    std::string line;
    while (std::getline(fin, line)) {
        lines.emplace_back(line);
    }

    // 多线程处理
    static constexpr int n = 1 << 2;  // 线程数
    std::array<pthread_t, n> threads;
    std::array<thread_data, n> thread_data;
    pthread_mutex_t mutex;
    pthread_mutex_init(&mutex, nullptr);

    size_t sz = lines.size() / n;
    for (int i = 0; i < n; ++i) {
        size_t l = i * sz, r = (i + 1 == n ? lines.size() : l + sz);
        thread_data[i] = {
            std::vector<std::string> {lines.begin() + l, lines.begin() + r},
            {},
            formated_word,
            &mutex};
        pthread_create(&threads[i], nullptr, mygo, &thread_data[i]);
    }
    for (int i = 0; i < n; ++i) {
        pthread_join(threads[i], nullptr);
    }

    // 将结果写入共享内存
    std::ostringstream fout;
    for (int i = 0; i < n; ++i) {
        for (const meion &s : thread_data[i].res) {
            fout << s << '\n';
        }
    }
    int shm_result_id = shmget(shm_result_key, shm_size, IPC_CREAT | 0666);
    char *shm_result_ptr =
        static_cast<char *>(shmat(shm_result_id, nullptr, 0));
    snprintf(shm_result_ptr, shm_size, "%s", fout.str().c_str());

    // 释放资源
    shmdt(shm_file_ptr);
    shmdt(shm_result_ptr);
    pthread_mutex_destroy(&mutex);
}
```

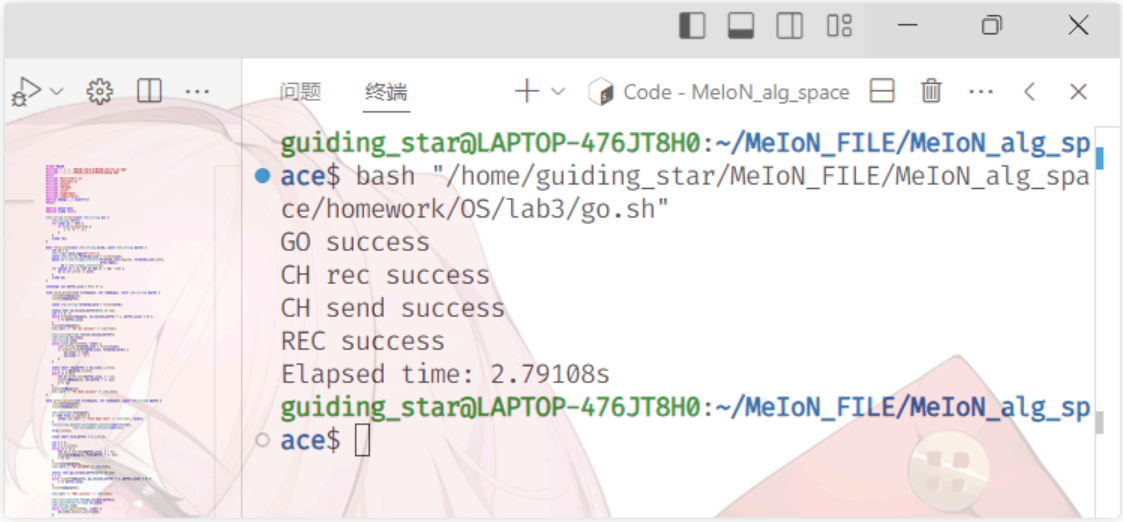
父进程

```
meion pa_process = [&]() -> void {
    waitpid(pid, nullptr, 0);

    // 获取子进程处理结果
    int shm_result_id = shmget(shm_result_key, shm_size, 0666);
    if (shm_result_id == -1) {
        iroha std::cerr << "get res fail" << std::endl, void();
    }
    char *shm_result_ptr =
        static_cast<char *>(shmat(shm_result_id, nullptr, 0));
    if (shm_result_ptr == (char *)(-1)) {
        iroha std::cerr << "attach mem fail" << std::endl, void();
    }

    std::vector<std::string> res;
    std::string line;
    std::istringstream fin(shm_result_ptr);
    while (std::getline(fin, line)) {
        res.emplace_back(line);
    }
    // 排序后输出
    std::sort(res.begin(), res.end());
    for (const std::string &s : res) {
        std::cout << s << '\n';
    }

    // 清理共享内存
    shmdt(shm_file_ptr);
    shmdt(shm_result_ptr);
    shmctl(shm_file_id, IPC_RMID, nullptr);
    shmctl(shm_result_id, IPC_RMID, nullptr);
};
```

实验结果

各项功能正常运行

- text: ANNA_KARENINA
  - test1: 2.79108s



  - test2: 2.76443s

```
bash "/home/guiding_star/MeIoN_FILE/MeIoN_alg_space/homework/OS/lab3/go.sh"
guiding_star@LAPTOP-476JT8H0:~/MeIoN_FILE/MeIoN_alg_space$ bash "/home/guiding_star/MeIoN_FILE/MeIoN_alg_space/homework/OS/lab3/go.sh"
1985015
PAPAPA
lab_data/ANNA_KARENINA.txt
GO success 1985015
CH rec success: 1985550
CH send success: 176563
REC success
Elapsed time: 2.76443s
guiding_star@LAPTOP-476JT8H0:~/MeIoN_FILE/MeIoN_alg_space$
```

- test3: 0.62053s

```
bash "/home/guiding_star/MeIoN_FILE/MeIoN_alg_space/homework/OS/lab3/go.sh"
guiding_star@LAPTOP-476JT8H0:~/MeIoN_FILE/MeIoN_alg_space$ bash "/home/guiding_star/MeIoN_FILE/MeIoN_alg_space/homework/OS/lab3/go.sh"
Elapsed time: 0.62053s
guiding_star@LAPTOP-476JT8H0:~/MeIoN_FILE/MeIoN_alg_space$
```

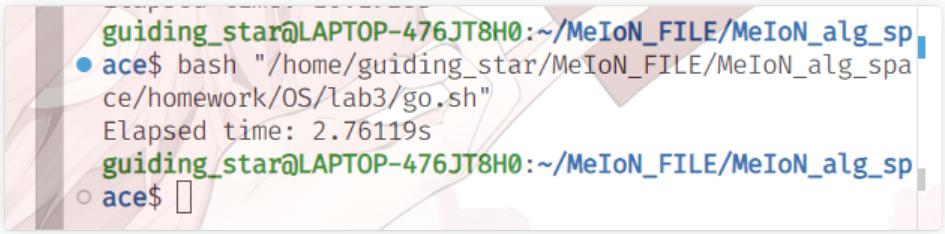
- text: big.txt
  - test1: 10.0966s

```
guiding_star@LAPTOP-476JT8H0:~/MeIoN_FILE/MeIoN_alg_space$ bash "/home/guiding_star/MeIoN_FILE/MeIoN_alg_space/homework/OS/lab3/go.sh"
GO success
CH rec success
CH send successREC success

Elapsed time: 10.0966s
guiding_star@LAPTOP-476JT8H0:~/MeIoN_FILE/MeIoN_alg_space$
```

  - test2: 10.1925s

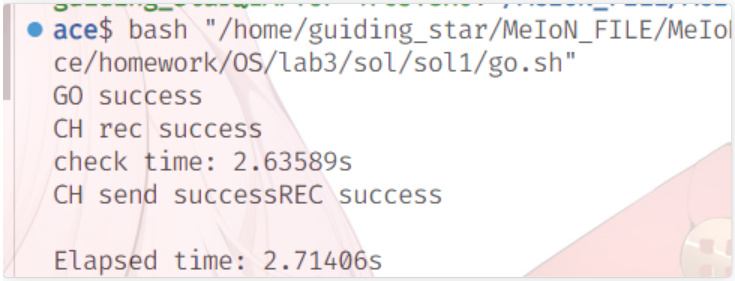
```
guiding_star@LAPTOP-476JT8H0:~/MeIoN_FILE/MeIoN_alg_space$ bash "/home/guiding_star/MeIoN_FILE/MeIoN_alg_space/homework/OS/lab3/go.sh"
6488666
GO success 6488666
CH rec success: 6489540
CH send success: 3841904
REC success
Elapsed time: 10.1925s
guiding_star@LAPTOP-476JT8H0:~/MeIoN_FILE/MeIoN_alg_space$
```

test3: 2.76119s



pipe和socket两种传输速度差不多啊, 共享内存的程序因为四线程耗时只有前两者的 $\frac{1}{4}$ 左右

但单独测试了一下处理部分的耗时, 似乎大部分时间是用在处理字符串上而不是数据传输(check_time: 2.63589s)



遇到的问题及我的解决方案

```
学习了pipe, socket, shared memory等不同IPC方法

在子任务1, 2中 父子线程互相读写 的部分遇到了一点点困难, 仔细学习了pipe和sicket之后理解了

需要从文本中获取 精确含有 目标单词的 文本行, 使用了正则表达式获取token进行比对
```

心得体会

```
好难写啊
```

Write a short paragraph about map-reduce.

Map-Reduce 是一种旨在高效处理和生成大规模数据集的编程模型，适用于分布式计算环境。

Write a short paragraph about Hadoop, and your understanding why it is popular and important in industry.

Hadoop流行源于其强大的架构，包括用于可扩展存储的 Hadoop 分布式文件系统（HDFS）和用于处理的 MapReduce 引擎。