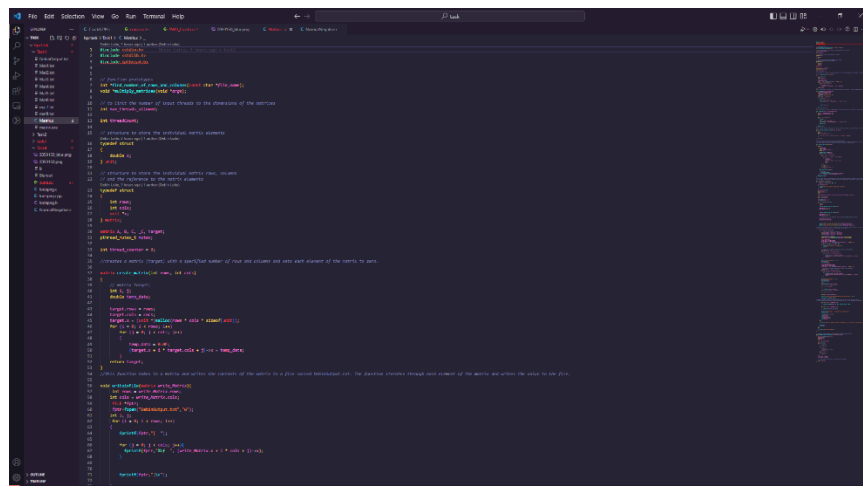


1. Matrix Multiplication (15% - 100 marks)

You will create a matrix multiplication program which uses multithreading, you will be taught two CPU multithreading concepts: POSIX threads and Open Multi-Processing (OpenMP). Matrices are often two-dimensional arrays varying in sizes (can also be 3D), for your application, you will only need to multiply two-dimensional ones. Your program will read in the matrix from a file (txt), store them appropriately using dynamic memory and multiply them by splitting the tasks across “n” threads (any number of threads via command line arguments). Each matrix will be in a separate file. You should also use command line arguments to allow the user to enter the which matrices need to be multiplied. The data files will be given to you however, you will need to initially identify the dimensions of the matrix to determine whether they can be multiplied. If the matrices cannot be multiplied, your program should notify the user. For example, if Matrix A is 3x3 and Matrix B is 2x2, you cannot multiply them. If Matrix A is 2x3 and Matrix B is 2x2, then this can be multiplied. You will need to research how to multiply matrices, this will also be covered in the lectures. The resulting matrix should be outputted to a file. It is up to you which multithreading library you use (Pthreads or OMP).

Code Screenshot and explanation



2059150_debin_luitel

```
#include <iostream>
#include <cmath>
using namespace std;

int main() {
    double width, height;
    cout << "Enter width and height: ";
    cin >> width >> height;
    double area = width * height;
    cout << "Area: " << area << endl;
    return 0;
}
```

The code is a simple C++ program that calculates the area of a rectangle. It uses the `cmath` library for the `sqrt` function, although it is not used in the provided code snippet. The program takes two inputs, `width` and `height`, and outputs the calculated area. The comments in Russian explain the steps: including headers, using namespace, declaring variables, getting input, calculating area, and outputting the result.

The image shows a C++ IDE with a file named `1.cpp`. The code implements a recursive function `sumSquare` to calculate the sum of squares of numbers from 1 to `n`.

```
#include <iostream>
using namespace std;

// Sum of squares of numbers from 1 to n
int sumSquare(int n)
{
    // Base case
    if (n == 1)
        return 1;

    // Recursive case
    return n * n + sumSquare(n - 1);
}

int main()
{
    int n;
    cout << "Enter a number: ";
    cin >> n;

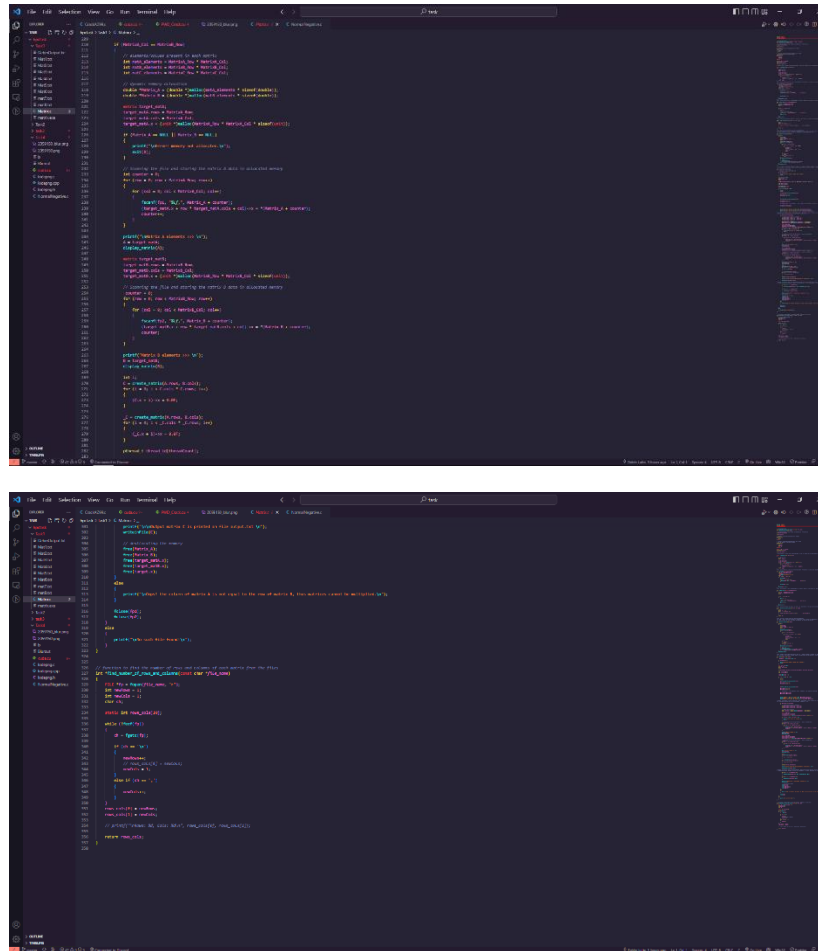
    // Call the function
    int result = sumSquare(n);

    // Print the result
    cout << "Sum of squares of numbers from 1 to " << n << " is: " << result << endl;

    return 0;
}
```

The IDE interface includes a menu bar (File, Edit, Selection, View, Go, Run, Terminal, Help), a toolbar, and a sidebar with a Project Explorer showing a folder named `1` containing `1.cpp` and `1.h`. The main editor area displays the code, and the right sidebar shows a Solution Explorer with a list of files.

[illegible]



Explanation in brief:

This code is used to multiply two matrices together using threads. It takes in two files containing the data for the two matrices and a number of threads as arguments. It then reads the two files, stores the data in two matrices, checks if the number of columns in MatrixA is equal to the number of rows in MatrixB, and if so, allocates memory for each of the two matrices and stores the data. It also creates a target matrix and stores the data from matrix A to it.

The code then passes the thread count to a function that creates "threadCount" number of threads and makes them run the "multiply_matrices" function. The "multiply_matrices" locks a mutex to check for an empty cell in the result matrix, assigns its coordinates to firstNum and secondNum, sets the cell to 1 and unlocks the mutex. It then calculates the value of the empty cell and sets the result to the same cell. Once all threads have completed, the code prints the output matrix C on a file, deallocates all the memory used, and closes the two files.

Task 2

2. Password cracking using multithreading (15% - 100 marks)

In this task, you will be asked to use the “crypt” library to decrypt a password using multithreading. You will be provided with two programs. The first program called “EncryptSHA512.c” allows you to encrypt a password. For this assessment, you will be required to decrypt a 4-character password consisting of 2 capital letters, and 2 numbers. The format of the password should be “LetterLetterNumberNumber.” For example, “HP93.” Once you have generated your password, this should then be entered into your program to decrypt the password. The method of input for the encrypted password is up to you. The second program is a skeleton code to crack the password on a single thread without any multithreading syntax. Your task is to use the pthread or omp library to split the workload over many threads and find the password. Once the password has been found, the program should finish meaning not all combinations of 2 letters and 2 numbers should be explored unless it's ZZ99 AND the last thread happens to finish last.

```

#include <stdio.h>
#include <string.h>
#include <crypt.h>
#include <unistd.h>

// Function to encrypt a password
char* encrypt_password(char* password, char* salt) {
    return crypt(password, salt);
}

// Main function
int main() {
    char password[100];
    char salt[100];

    printf("Enter password: ");
    fgets(password, sizeof(password), stdin);

    printf("Enter salt: ");
    fgets(salt, sizeof(salt), stdin);

    // Remove trailing newline characters
    password[strcspn(password, "\n")] = 0;
    salt[strcspn(salt, "\n")] = 0;

    char* encrypted_password = encrypt_password(password, salt);

    printf("Encrypted password: %s\n", encrypted_password);

    return 0;
}

```

```

#include <stdio.h>
#include <string.h>
#include <crypt.h>
#include <unistd.h>

// Function to decrypt a password
char* decrypt_password(char* encrypted_password, char* salt) {
    return crypt(encrypted_password, salt);
}

// Main function
int main() {
    char encrypted_password[100];
    char salt[100];

    printf("Enter encrypted password: ");
    fgets(encrypted_password, sizeof(encrypted_password), stdin);

    printf("Enter salt: ");
    fgets(salt, sizeof(salt), stdin);

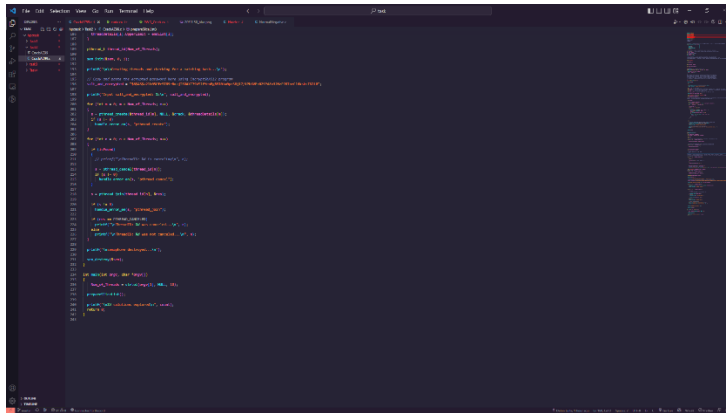
    // Remove trailing newline characters
    encrypted_password[strcspn(encrypted_password, "\n")] = 0;
    salt[strcspn(salt, "\n")] = 0;

    char* decrypted_password = decrypt_password(encrypted_password, salt);

    printf("Decrypted password: %s\n", decrypted_password);

    return 0;
}

```



Explanation in brief

This code sets up a multi-threaded program to search for a certain combination. The macro 'handle_error_en' is used to handle errors by setting the value of errno to a given value, printing a given message, and then exiting with a failure status. A struct threadInfo is used to store two variables, limit and Upperlimit, which will be used to store the range of characters from the given encrypted data that the thread will have to crack. A semaphore is used to allow multiple threads to use the same resources. A counter is used to track the number of combinations explored so far and a boolean is used to indicate if the password has been found.

The crack function will loop through characters from a given start limit to end limit, and then loop through letters A to Z and numbers 0 to 99 and check if the given encrypted string is the same as the one given. If it is, it prints the plaintext, encrypted string, and the count. If the required password is found, all other threads will be cancelled. The prepareSliceList function is used to prepare the slice list, which is used to divide the workload to the thread. It assigns a range of characters to each of multiple threads, based on the number of threads. The first thread is assigned the range of characters starting with 'A' (ASCII value 65) and the subsequent threads are assigned the range starting with the ending character of the previous thread, plus one. The ranges are printed to the console. The main function runs the prepareSliceList function and prints the total number of solutions explored.

Task 3

3. Password Cracking using CUDA (35% - 100 marks)

Using a similar concept as question 2, you will now crack passwords using CUDA. As a kernel function

cannot use the crypt library, you will be given an encryption function instead which will generate a password for you. Your program will take in an encrypted password and decrypt it using many threads on the GPU. CUDA allows multidimensional thread configurations so your kernel function (which runs on the GPU) will need to be modified according to how you call your function.

```

File Edit Selection View Go Run Terminal Help
task 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 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2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049 2050 2051 2052 2053 2054 2055 2056 2057 2058 2059 2060 2061 2062 2063 2064 2065 2066 2067 2068 2069 2070 2071 2072 2073 2074 2075 2076 2077 2078 2079 2080 2081 2082 2083 2084 2085 2086 2087 2088 2089 2090 2091 2092 2093 2094 2095 2096 2097 2098 2099 2100 2101 2102 2103 2104 2105 2106 2107 2108 2109 2110 2111 2112 2113 2114 2115 2116 2117 2118 2119 2120 2121 2122 2123 2124 2125 2126 2127 2128 2129 2130 2131 2132 2133 2134 2135 2136 2137 2138 2139 2140 2141 2142 2143 2144 2145 2146 2147 2148 2149 2150 2151 2152 2153 2154 2155 2156 2157 2158 2159 2160 2161 2162 2163 2164 2165 2166 2167 2168 2169 2170 2171 2172 2173 2174 2175 2176 2177 2178 2179 2180 2181 2182 2183 2184 2185 2186 2187 2188 2189 2190 2191 2192 2193 2194 2195 2196 2197 2198 2199 2200 2201 2202 2203 2204 2205 2206 2207 2208 2209 2210 2211 2212 2213 2214 2215 2216 2217 2218 2219 2220 2221 2222 2223 2224 2225 2226 2227 2228 2229 2230 2231 2232 2233 2234 2235 2236 2237 2238 2239 2240 2241 2242 2243 2244 2245 2246 2247 2248 2249 2250 2251 2252 2253 2254 2255 2256 2257 2258 2259 2260 2261 2262 2263 2264 2265 2266 2267 2268 2269 2270 2271 2272 2273 2274 2275 2276 2277 2278 2279 2280 2281 2282 2283 2284 2285 2286 2287 2288 2289 2290 2291 2292 2293 2294 2295 2296 2297 2298 2299 2300 2301 2302 2303 2304 2305 2306 2307 2308 2309 2310 2311 2312 2313 2314 2315 2316 2317 2318 2319 2320 2321 2322 2323 2324 2325 2326 2327 2328 2329 2330 2331 2332 2333 2334 2335 2336 2337 2338 2339 2340 2341 2342 2343 2344 2345 2346 2347 2348 2349 2350 2351 2352 2353 2354 2355 2356 2357 2358 2359 2360 2361 2362 2363 2364 2365 2366 2367 2368 2369 2370 2371 2372 2373 2374 2375 2376 2377 2378 2379 2380 2381 2382 2383 2384 2385 2386 2387 2388 2389 2390 2391 2392 2393 2394 2395 2396 2397 2398 2399 2400 2401 2402 2403 2404 2405 2406 2407 2408 2409 2410 2411 2412 2413 2414 2415 2416 2417 2418 2419 2420 2421 2422 2423 2424 2425 2426 2427 2428 2429 2430 2431 2432 2433 2434 2435 2436 2437 2438 2439 2440 2441 2442 2443 2444 2445 2446 2447 2448 2449 2450 2451 2452 2453 2454 2455 2456 2457 2458 2459 2460 2461 2462 2463 2464 2465 2466 2467 2468 2469 2470 2471 2472 2473 2474 2475 2476 2477 2478 2479 2480 2481 2482 2483 2484 2485 2486 2487 2488 2489 2490 2491 2492 2493 2494 2495 2496 2497 2498 2499 2500 2501 2502 2503 2504 2505 2506 2507 2508 2509 2510 2511 2512 2513 2514 2515 2516 2517 2518 2519 2520 2521 2522 2523 2524 2525 2526 2527 2528 2529 2530 2531 2532 2533 2534 2535 2536 2537 2538 2539 2540 2541 2542 2543 2544 2545 2546 2547 2548 2549 2550 2551 2552 2553 2554 2555 2556 2557 2558 2559 2560 2561 2562 2563 2564 2565 2566 2567 2568 2569 2570 2571 2572 2573 2574 2575 2576 2577 2578 2579 2580 2581 2582 2583 2584 2585 2586 2587 2588 2589 2590 2591 2592 2593 2594 2595 2596 2597 2598 2599 2600 2601 2602 2603 2604 2605 2606 2607 2608 2609 2610 2611 2612 2613 2614 2615 2616 2617 2618 2619 2620 2621 2622 2623 2624 2625 2626 2627 2628 2
```

Explanation in brief:

In this code, two arrays of characters are created on the CPU, one with the letters of the alphabet and one with the numbers 0-9. The CPU then copies these two arrays to the GPU using `cudaMemcpy`. The crack kernel is then launched with a grid of 26x26x1 blocks and a block of 10x10x1 threads. The kernel takes the `blockIdx` and `threadIdx` to generate a 4-character password, which is then encrypted into an 11-character password using the `__device__ CudaCrypt` function. The encrypted password is printed out and the kernel is synchronized. Finally, the GPU memory is freed and the program exits.

Task 4

4. Box Blur using CUDA (35% - 100 marks)

Your program will decode a PNG file into an array and apply the box blur filter. Blurring an image reduces noise by taking the average RGB values around a specific pixel and setting its RGB to the mean values you've just calculated. This smoothens the colour across a matrix of pixels. For this assessment, you will use a 3x3 matrix. For example, if you have a 5x5 image such as the following (be aware that the coordinate values will depend on how you format your 2D array):

0,4 1,4 2,4 3,4 4,4

0,3 1,3 2,3 3,3 4,3

0,2 1,2 2,2 3,2 4,2

0,1 1,1 2,1 3,1 4,1

0,0 1,0 2,0 3,0 4,0

The shaded region above represents the pixel we want to blur, in this case, we are focusing on pixel 1,2 (x,y) (Centre of the matrix). to apply the blur for this pixel, you would sum all the Red values from the surrounding coordinates including 1,2 (total of 9 R values) and find the average (divide by 9). This is now the new Red value for coordinate 1,2. You must then repeat this for Green and Blue values.

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This must be repeated throughout the image. If you are working on a pixel which is not fully surrounded by pixels (8 pixels), you must take the average of however many neighbouring pixels there are. Your task is to use CUDA to blur an image.

NOTE – this program should work with any amount of threads.

[illegible][illegible]

Explanation in brief:

The code above is used to blur an image stored in a file named 2059150.png. The code first reads the image file and stores it in a variable named image. The width and height of the image is then stored in the variables width and height.

It then creates two arrays, one to store the initial image in the host memory and one to store the processed image in the host memory.

The code then allocates device memory for the same two arrays and copies the initial image from the host memory to the device memory.

It then launches the box_blur kernel which performs a box blur on the image stored in the device memory. The blurred image is then stored back in the device memory.

Finally, the code copies the blurred image from the device memory to the host memory and then encodes the image and stores it in a new file named 2059150_blur.png. The code then prints the output file name and deallocates the device memory.

Input image



Output Image

