Assignment - 2

Group Members

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What is GNU debugger (GDB)?

GNU Debugger, also called “gdb" is a command line debugger primarily used in UNIX systems to debug programs of many languages like C, C++, etc.

It was written by Richard Stallman in 1986 as a part of this GNU System, and since then it has been widely used as a go-to debugger till today.

It provides a lot of features to help debug a program, which includes monitoring and modifying the values of internal variables at run time, calling functions independent of the actual program behavior, and much more.

How to use GNU Debugger?

Part 0: Installing debugger

“sudo apt install gdb”

Part 1: Running the program using debugger

```
// Hello.c
#include <stdio.h>

int main(){
    int value = 3;
    for (int i = 0; i < 10; i++){
        if (i == value){
            printf("Target Reached, breaking...\n");
            break;
        }
        printf("Hello World\n");
    }
}
```

Generally, we do “gcc hello.c -o hello”

But to generate GDB accessible program, we will have to use “-g” flag

- “-g” flag is used to signal gcc to also generate a **symbol table** for gdb to read

So “gcc hello.c -o hello -g”

Now we just have to do “gdb hello” to start the debugger

Now we are inside gdb, to just run the program, we can do the following

1. “r” to run the program
2. “r 1 2” to pass command-line arguments to the program
3. “r < file1” to feed a file for writing the outputs

Part 2: Loading Symbol Table

1. Symbol table stores names of variables, functions and types defined within our program

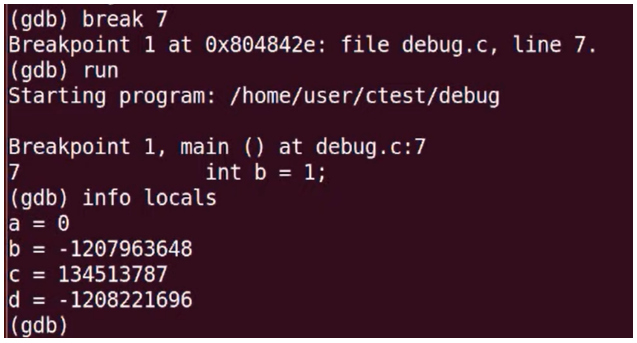
Part 3: Setting a Break Point

1. There are many ways to setup Break Points in the GNU GDB
2. Two majorly used ones include
   a. Setting a Break Point at the start of a function():

```
break /*{function name}*/
```

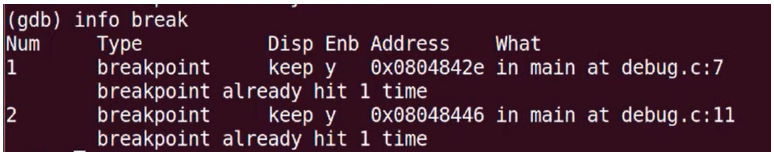
   b. Setting a Break Point at a specific line:

```
break /*{line number}*/
```



This command will add a break point at the line number we specify.
As soon as the execution reaches our line number, it will halt the execution process

3. After a Break Point is reached, we can view the state of every variable, function and the call stack up until that point.
4. The command “info locals” will show us the state of the local variables at out break point
5. The command “info break” will show us all the break points currently held within our program



6. The command “continue” will resume the execution which was previously halted after reaching a break point

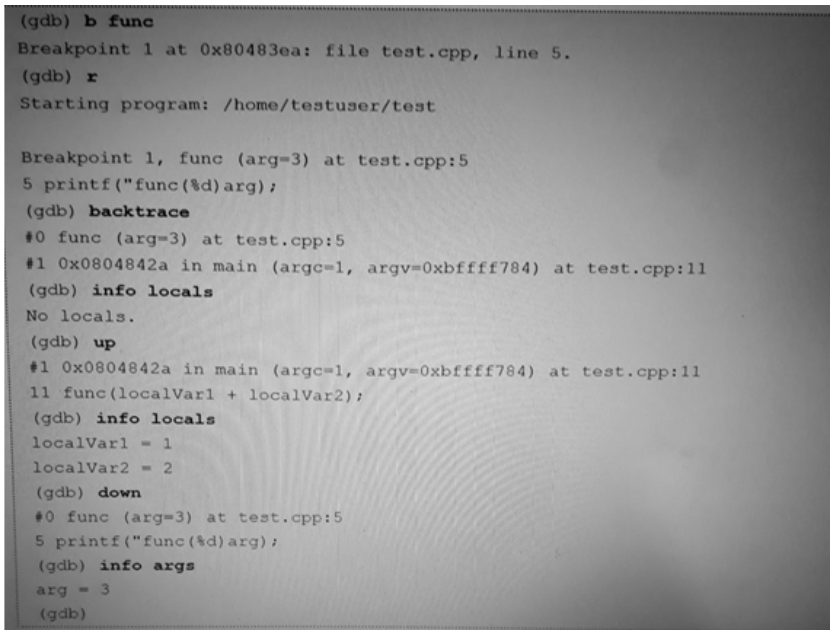
7. The command “delete /*{breakpoint number}*/ will delete a breakpoint

Part 4: Listing variables

- The **info locals** command displays the local variable values in the current frame. You can select frames using the **frame**, **up** and **down**
- Note that the **info locals** command does not display the information about the function arguments.
- Use the **info args** command to list function arguments.

We will run the program, set a breakpoint in **func()** and use the **info locals** command to display the local variables in **main()**:

```
#include <stdio.h>

void func(int arg)
{
    printf("func(%d)\n", arg);
}

int main(int argc, char *argv[])
{
    int localVar1 = 1, localVar2 = 2;
    func(localVar1 + localVar2);
    return 0;
}
```



Part 5: Printing content of an array

· Syntax:

set print array **on**

set print array **off**

show print array

· Modes:

on

GDB will display the values of arrays in a simple one-line format (e.g. $1 = {1, 2, 3}).

off

GDB will display the values of arrays using longer multi-line format.

- **Default mode:**

The default value for the **print array** setting is 'off'.

· Remarks:

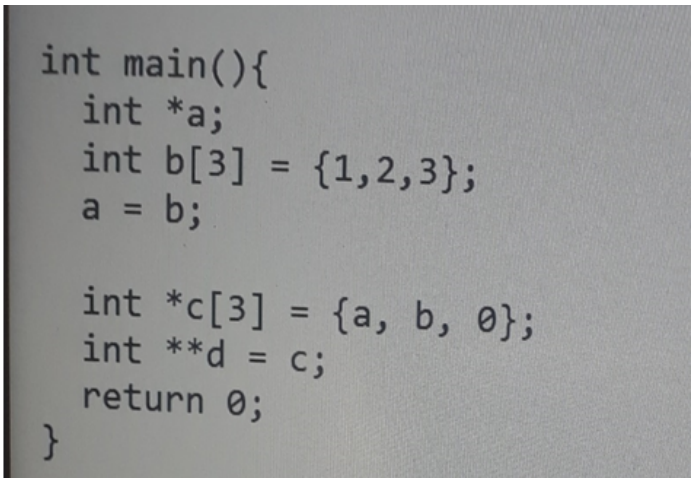
The **set print array** command can be used together with the **set print array-indexes** command to further customize the output of the array contents.

Examples:

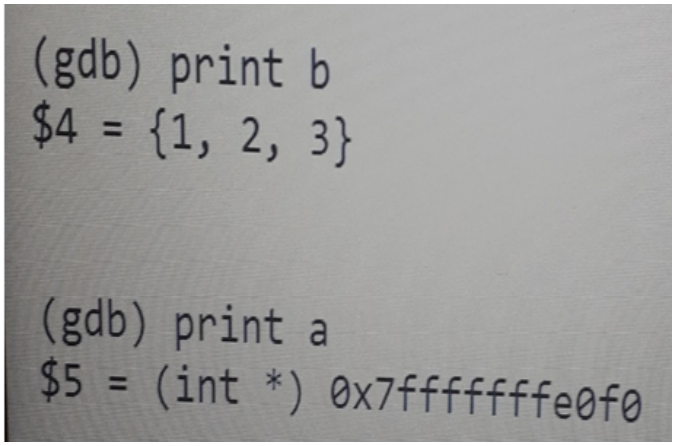
Below is a log of sample GDB session illustrating how **set print array** command affects the output of the **print** command:

```
(gdb) start
Temporary breakpoint 1 at 0x80483f3: file test.cpp, line 5.
Starting program: /home/bazis/test

Temporary breakpoint 1, main (argc=1, argv=0xbffff064) at test.cpp:5
5 int testArray[] = {1, 2, 3};
(gdb) next
6 return 0;
(gdb) print testArray
$1 = {1, 2, 3}
(gdb) show print array
Prettyprinting of arrays is off.
(gdb) set print array on
(gdb) print testArray
$2 = {1,
2,
3
```

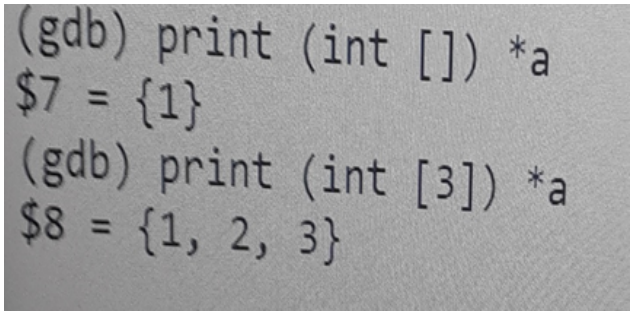
Example:



While debugging the above code if we do:



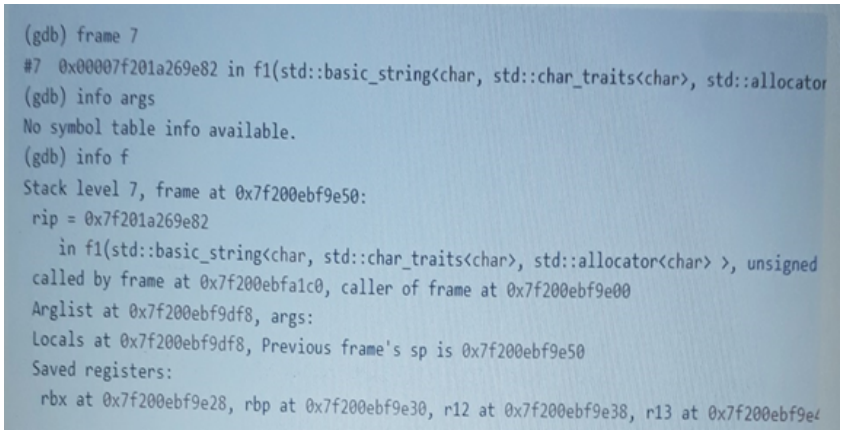
Both works but in order to print a as an array:



and when we specify the size it gets better.

Part 6: Printing Function Arguments

Inspecting a core dump and need to print function arguments values when only their types are known (no argument name symbols):



- Specifically, we need to know what's in the first argument (std::string) and in the last one (std::string*). The arglistand the *locals* in this frame both point to the same address.

- We have to look up the ABI for your platform and then use that to understand the argument-passing convention. This isn't always easy but it can be done. This will tell us how to find the arguments, whether they are in registers or memory; and then we can use casts to the appropriate types to print them.
- The casting may also be difficult if you don't have debuginfo. Though there is a trick: compile a dummy file with -gthat has the types you need and then symbol-file it into gdb to get access to the types. This of course has caveats; we have to use the correct compiler and library versions, correct compiler target and ABI-changing flags, etc.
- It's really much, much, much better to plan ahead and always have debug info somewhere.

Part 7: Next, Continue, Set commands

Next - Is used to step through code

- If the instruction is a single line of code it displays it
- If the line is a function call, it executes the entire function call in one step

There is a variation of the call next which is *nexti (ni).* According to the help pages of gdb below is it's functionality as compared to *next (n)*

next

> Step program, proceeding through subroutine calls.
> Usage: next [N]
> Unlike "step", if the current source line calls a subroutine,
> this command does not enter the subroutine, but instead steps over
> the call, in effect treating it as a single source line.

nexti

> Step one instruction, but proceed through subroutine calls.
> Usage: nexti [N]
> Argument N means step N times (or till program stops for another reason).

Below is an example demonstrating the use of *next*

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

void printString(string letters) {
  cout << "Printing the letters of string\n";
  for(auto letter :letters)
    cout << letter << ", ";
  cout << "\nEnd of string\n";
}


int main() {
  // a string variable
  string s = "Software engineering lab";

  // a function to print the string variable
  printString(s);
  return 0;
}
```

The output of this code is

```
riri@riri-VirtualBox:asgn 2$ ./next

Printing the letters of string
S, o, f, t, w, a, r, e,  , e, n, g, i, n, e, e, r, i, n, g,  , l, a, b,
End of string
riri@riri-VirtualBox:asgn 2$
```

For demonstration purposes, a break-point has been added at main and the program is then run.

```
riri@riri-VirtualBox:asgn 2$ gdb ./next -q
Reading symbols from ./next...
(gdb) break main
Breakpoint 1 at 0x13a5: file next.cpp, line 12.
(gdb) r
Starting program: /home/riri/Desktop/asgn 2/next

Breakpoint 1, main () at next.cpp:12
12      int main() {
(gdb) n
14              string s = "Software engineering lab";
(gdb) n
17              printString(s);
(gdb) n
Printing the letters of string
S, o, f, t, w, a, r, e,  , e, n, g, i, n, e, e, r, i, n, g,  , l, a, b,
End of string
18              return 0;
(gdb)
```

After a adding a break-point at main, we run and step through the code. It can be seen that when the code happens to be a single line, ***next*** simple displays the code. However when it hits the function call ***printString(s)***, it executes the entire function rather than stepping through it. The difference will be more visible after the demonstration of step 8.

Continue - is used to resume normal execution of a program until it ends, crashes or a break-point is encountered.

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

void printFirstFive(const array<int, 10>& numbers) {
  for(int i = 0 ; i < 5 ; i++) {
    cout << "numbers[" << i << "] : " << numbers[i] << '\n';
  }
}

void printRest(const array<int, 10>& numbers) {
  for(int i = 5 ; i < 10 ; i++) {
    cout << "numbers[" << i << "] : " << numbers[i] << '\n';
  }
}

int main() {
```

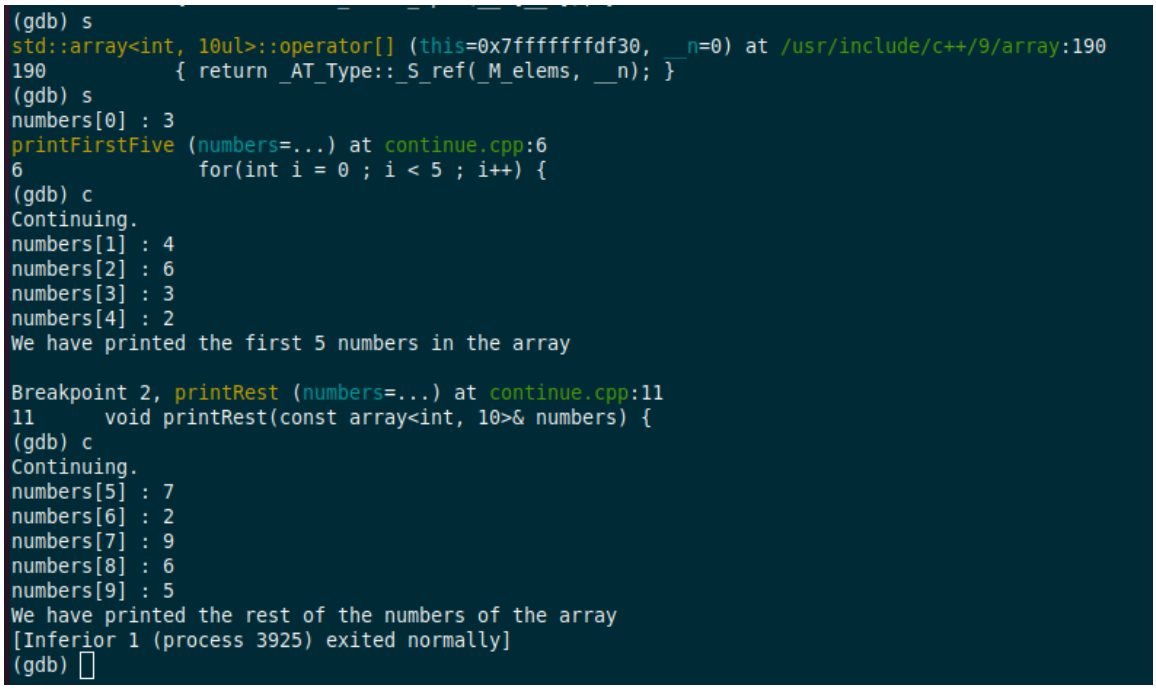
```
  array<int, 10> arr = {3, 4, 6, 3, 2, 7, 2, 9, 6, 5};
  printFirstFive(arr);

  cout << "We have printed the first 5 numbers in the array\n";

  printRest(arr);
  cout << "We have printed the rest of the numbers of the array\n";
  return 0;
}
```

Using the program above, we see that after stepping through the code line by line, we can choose to run it until one of the conditions to stop normal execution are met.

Break-points have been set at functions *main* and *printRest*

```
riri@riri-VirtualBox:asgn 2$ gdb ./continue -q
Reading symbols from ./continue...
(gdb) break main
Breakpoint 1 at 0x1307: file continue.cpp, line 17.
(gdb) break printRest
Breakpoint 2 at 0x1278: file continue.cpp, line 11.
(gdb) r
Starting program: /home/riri/Desktop/asgn 2/continue

Breakpoint 1, main () at continue.cpp:17
17      int main() {
(gdb) s
19              array<int, 10> arr = {3, 4, 6, 3, 2, 7, 2, 9, 6, 5};
(gdb) s
20              printFirstFive(arr);
(gdb) s
printFirstFive (numbers=...) at continue.cpp:5
5       void printFirstFive(const array<int, 10>& numbers) {
(gdb) s
6               for(int i = 0 ; i < 5 ; i++) {
(gdb) s
7                       cout << "numbers[" << i << "] : " << numbers[i] << '\n';
(gdb) s
std::array<int, 10ul>::operator[] (this=0x7fffffffdf20, __n=140737488347216)
    at /usr/include/c++/9/array:189
189           operator[](size_type __n) const noexcept
(gdb) s
190           { return _AT_Type::_S_ref(_M_elems, __n); }
(gdb) s
std::__array_traits<int, 10ul>::_S_ref (__t=..., __n=140737488347216)
    at /usr/include/c++/9/array:55
55            _S_ref(const _Type& __t, std::size_t __n) noexcept
(gdb) s
56            { return const_cast<_Tp&>(__t[__n]); }
(gdb) s
std::array<int, 10ul>::operator[] (this=0x7fffffffdf30, __n=0) at /usr/include/c++/9/array:190
190           { return _AT_Type::_S_ref(_M_elems, __n); }
(gdb) s
numbers[0] : 3
printFirstFive (numbers=...) at continue.cpp:6
6               for(int i = 0 ; i < 5 ; i++) {
(gdb)
```

After individually stepping through the code line by line, we get to printing the first number in the array which is 3. Following this I chose to resume normal execution rather than step through the code (Command : c).



The break-point at function *printRest* was met and normal execution stopped. Following this I again used continue to resume execution until termination of program.

Set - is used to set the value of a variable in the program during runtime

The value of the variable is not changed in the code but is rather used only for evaluation purposes during runtime.

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

int main() {
  int dividend = 84;
  int divisor = 2;

  if(divisor == 0)
    cout << "Division by 0 is not possible.\n";
  else if (divisor > dividend)
    cout << "Divisor " << divisor << " is greater then dividend " << dividend << ".\n";
  else
    cout << dividend << "/" << divisor << " = " << dividend/divisor <<'\n';


  return 0;
}
```

Using *set* to set values for divisor to check resilience of code.

```
riri@riri-VirtualBox:asgn 2$ gdb ./set -q
Reading symbols from ./set...
(gdb) break main
Breakpoint 1 at 0x11c9: file set.cpp, line 4.
(gdb) r
Starting program: /home/riri/Desktop/asgn 2/set

Breakpoint 1, main () at set.cpp:4
4       int main() {
(gdb) s
5               int dividend = 84;
(gdb) s
6               int divisor = 2;
(gdb) s
8               if(divisor == 0)
(gdb) s
10              else if (divisor > dividend)
(gdb) set divisor = 100
(gdb) s
11                      cout << "Divisor " << divisor << " is greater then dividend " << dividend << ".\n";
(gdb) s
Divisor 100 is greater then dividend 84.
16              return 0;
(gdb)
```

The condition divisor > dividend was evaluated at run-time by changing the runtime value of variable divisor.

```
(gdb) r
The program being debugged has been started already.
Start it from the beginning? (y or n) y
Starting program: /home/riri/Desktop/asgn 2/set

Breakpoint 1, main () at set.cpp:4
4       int main() {
(gdb) s
5               int dividend = 84;
(gdb) s
6               int divisor = 2;
(gdb) s
8               if(divisor == 0)
(gdb) set divisor = 0
(gdb) s
9                       cout << "Division by 0 is not possible.\n";
(gdb) s
Division by 0 is not possible.
16              return 0;
(gdb)
```

The condition divisor == 0 evaluated to true by setting the value of divisor variable t runtime.

Part 8: Single stepping into function

Single stepping into a function means to execute every line of the function body one by one rather than treating it as a single line and executing it's body in one go as done by *next.*

Variation *stepi* is also available

According to the help pages

stepi (si)

Step one instruction exactly.
Usage: stepi [N]
Argument N means step N times (or till program stops for another reason).

step (s)

Step program until it reaches a different source line.
Usage: step [N]
Argument N means step N times (or till program stops for another reason).

It's usage is shown in the demonstration of *continue* above in STEP 7

Part 9: Listing all breakpoints

info breaks is the command to list all break-points in the current file

Using the same example code as in Continue, break-points are added and then displayed. Two different ways of adding a break are used; one through using functionName and another by using filename:lineNumber.

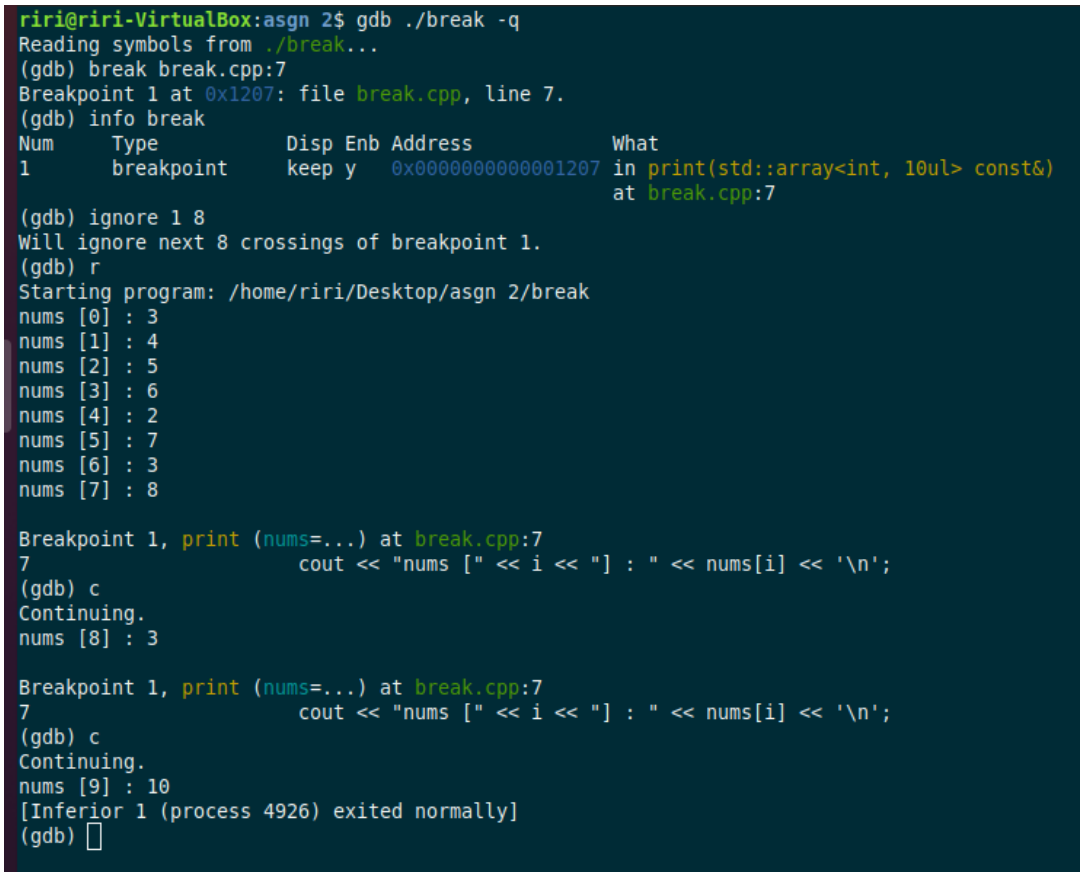
```
riri@riri-VirtualBox:asgn 2$ gdb ./continue -q
Reading symbols from ./continue...
(gdb) break main
Breakpoint 1 at 0x1307: file continue.cpp, line 17.
(gdb) break continue.cpp:11
Breakpoint 2 at 0x1278: file continue.cpp, line 11.
(gdb) info break
Num     Type           Disp Enb Address            What
1       breakpoint     keep y   0x0000000000001307 in main() at continue.cpp:17
2       breakpoint     keep y   0x0000000000001278 in printRest(std::array<int, 10ul> const&)
                                                   at continue.cpp:11
(gdb)
```

Part 10: Ignoring a breakpoint for N occurrence

ignore [breakpointnumber] [x] - ignores break-point numbered (this is done automatically by the system while setting a breakpoint) breakpointnumber until x hits are regsitered under it.

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

void print(const array<int, 10>& nums) {
  for(int i = 0 ; i < 10 ; i++) {
    cout << "nums [" << i << "] : " << nums[i] << '\n';
  }
}

int main() {
  array<int, 10> nums = {3, 4, 5, 6, 2, 7, 3, 8, 3, 10};
  print(nums);
  return 0;
}
```

Setting a break-point at line 7 and running the code



We can see that gdb ignored the first 8 hits of the breakpoint by not stopping normal execution. After the first 8 hits were ignored, it resumed normal function of break-point from iteration 8.

Part 11: Enable/disable a breakpoint

Let's say we run the following program using gdb:

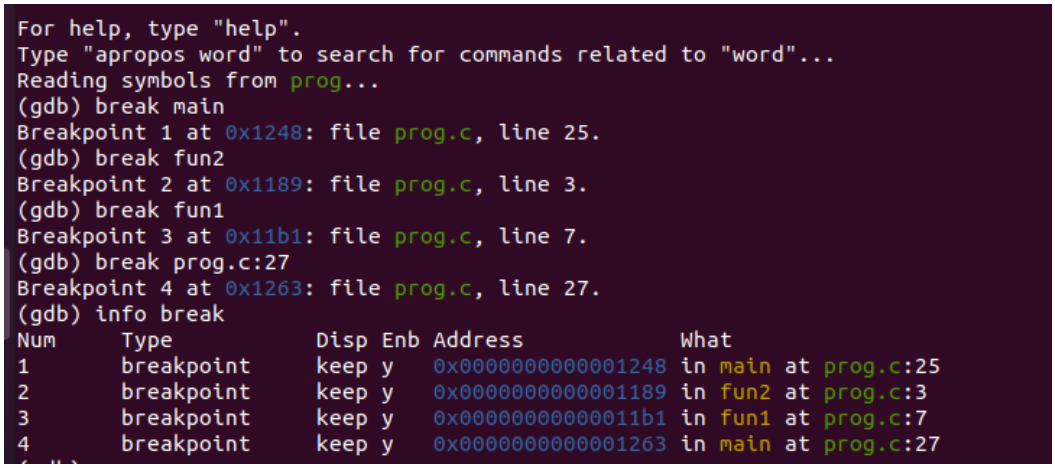
```
#include <stdio.h>
void fun2(int s)
{
    printf("The value you entered is : %d\n",s);
}
void fun1()
{
    int vari;
    printf("Enter any value of variable you want to print :");
    scanf("%d",&vari);
    fun2(vari);
}
int natural_no(int num)
{
    int i, sum = 0;
    // use for loop until the condition becomes false
    for (i = 1; i <= num; i++)
    {
        // adding the counter variable i to the sum value
```

```
        sum += i;
    }
    return sum;
}
int main()
{
    int num, total; // local variable
    printf("Enter a natural number : ");
    scanf("%d", &num); // take a natural number from the user
    total = natural_no(num);  // call the function
    printf("Sum of first %d natural numbers are : %d\n", num, total);
    fun1();
    return 0;
}
```

This is basically a simple program where the user can get the sum of all natural numbers from 1 to the number entered and through the other functions the user gets to see the number entered.

Now after going through Step -1 which says running a program through debugger ⇒

a. Introducing Breakpoints and **displaying break points** with command ⇒ `info break`



b. Now, here we are **Disabling the Breakpoint 1** ⇒ `disable 1`

```
(gdb) run
Starting program: /home/sayakrana/swe_lab/prog

Breakpoint 1, main () at prog.c:25
25      {
(gdb) disable 1
(gdb) info break
Num     Type           Disp Enb Address            What
1       breakpoint     keep n   0x0000555555555248 in main at prog.c:25
        breakpoint already hit 1 time
2       breakpoint     keep y   0x0000555555555189 in fun2 at prog.c:3
3       breakpoint     keep y   0x00005555555551b1 in fun1 at prog.c:7
4       breakpoint     keep y   0x0000555555555263 in main at prog.c:27
(gdb) run
The program being debugged has been started already.
Start it from the beginning? (y or n) y
Starting program: /home/sayakrana/swe_lab/prog

Breakpoint 4, main () at prog.c:27
27          printf("Enter a natural number : ");
(gdb)
```

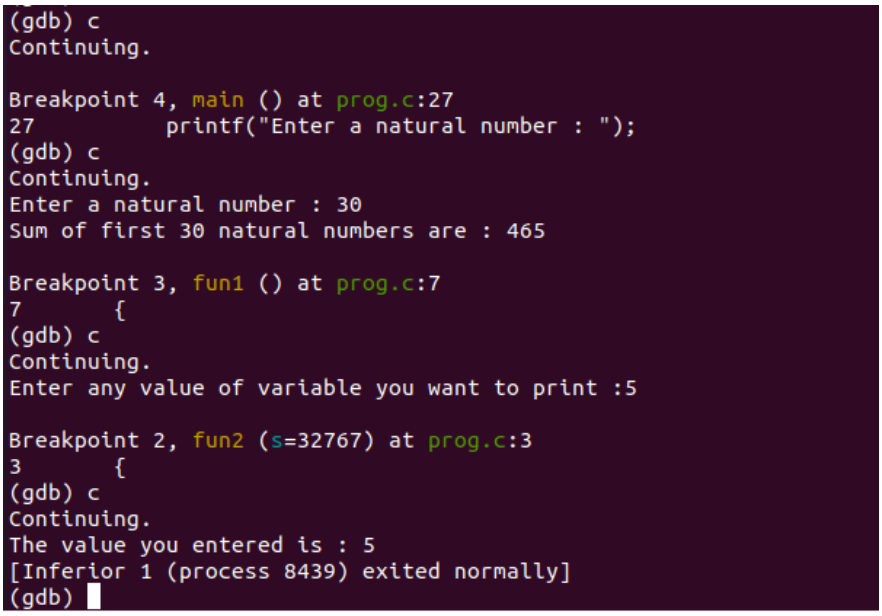
So, after disabling the breakpoint 1 when we do `info break` again we see ‘n’ under Enb which tells that breakpoint 1 is not enabled anymore. Also , again on running the program we see directly the program stops on Breakpoint 4 and not on Breakpoint 1.

c. Here we are **Enabling the Breakpoint 1** ⇒ `enable 1`

```
Breakpoint 4, main () at prog.c:27
27          printf("Enter a natural number : ");
(gdb) enable 1
(gdb) info break
Num     Type           Disp Enb Address            What
1       breakpoint     keep y   0x0000555555555248 in main at prog.c:25
2       breakpoint     keep y   0x0000555555555189 in fun2 at prog.c:3
3       breakpoint     keep y   0x00005555555551b1 in fun1 at prog.c:7
4       breakpoint     keep y   0x0000555555555263 in main at prog.c:27
        breakpoint already hit 1 time
(gdb) run
The program being debugged has been started already.
Start it from the beginning? (y or n) y
Starting program: /home/sayakrana/swe_lab/prog

Breakpoint 1, main () at prog.c:25
25      {
(gdb)
```

So, after enabling the breakpoint 1 when we do `info break` again we see ‘y’ under Enb which tells that breakpoint 1 is enabled. Also , again on running the program we see directly the program stops on Breakpoint 1.

d. Lastly, we are running the whole program by pressing `c` (continue) when we encounter the Breakpoints.



Part 12: Break condition and Command

Let's say we run the following program using gdb:

```
#include <stdio.h>
void display(int n)
{
    printf("Displaying the numbers from 1 to %d\n",n);
    int i;
    for(i = 1;i<=n;i++)
    {
        printf("%d ",i);
    }
}
int main()
{
    int num; // local variable
    printf("Enter number upto which you want to print: ");
    scanf("%d", &num); // take a natural number from the user
    display(num);
    return 0;
}
```

This is basically a simple program where the user enters a number and gets all the numbers from 1 to the number entered.

Now after going through Step -1 which says running a program through debugger ⇒

a. **Introducing breakpoint** in prog1.c at line 8 with condition if i%2 == 0 ⇒

```
break prog1.c:8 if i%2==0
```

```
(gdb) break prog1.c:8 if i%2==0
Breakpoint 1 at 0x11b7: file prog1.c, line 8.
(gdb) info break
Num     Type           Disp Enb Address            What
1       breakpoint     keep y   0x00000000000011b7 in display at prog1.c:8
        stop only if i%2==0
(gdb)
```

So, here what this command does is that it whenever it gets a multiple of 2 (say even number) it causes a break or pause in the execution of the program.

b. Running the program and pressing `c` (continue) till we get the output.

```
(gdb) run
Starting program: /home/sayakrana/swe_lab/prog1
Enter number upto which you want to print: 8
Displaying the numbers from 1 to 8

Breakpoint 1, display (n=8) at prog1.c:8
8               printf("%d ",i);
(gdb) print i
$1 = 2
(gdb) continue
Continuing.

Breakpoint 1, display (n=8) at prog1.c:8
8               printf("%d ",i);
(gdb) print i
$2 = 4
(gdb) continue
Continuing.

Breakpoint 1, display (n=8) at prog1.c:8
8               printf("%d ",i);
(gdb) print i
$3 = 6
(gdb) continue
Continuing.

Breakpoint 1, display (n=8) at prog1.c:8
8               printf("%d ",i);
(gdb) print i
$4 = 8
(gdb) continue
Continuing.
1 2 3 4 5 6 7 8 [Inferior 1 (process 3466) exited normally]
(gdb)
```

So, on pressing run we get the breakpoints whenever i gets value which is a multiple of 2.

Thus if n = 8, we get four breakpoints say at 2 , 4, 6 and 8.

On pressing `print i` and then `c` (continue) we can get to see the respective values of i too which are respectively 2,4,6 and 8 as specified already.

Part 13: Examining Stack Trace

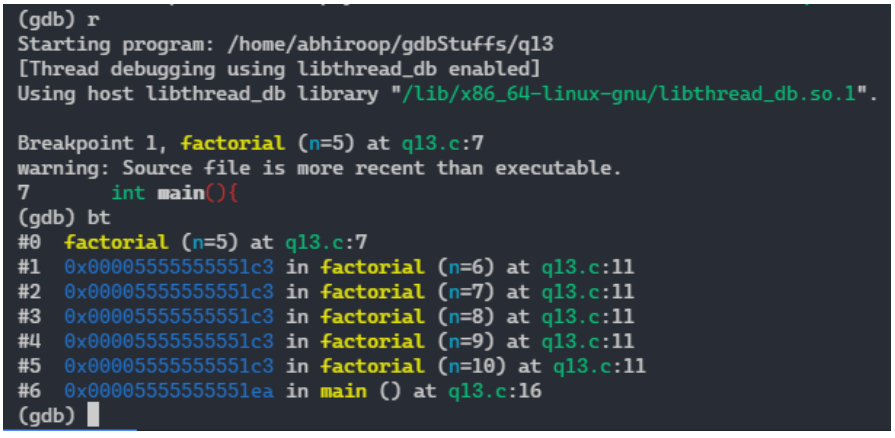
Let’s define a recursive function to see how the stack trace examination works in the gdb

```c
// filename: q13.c
#include <stdio.h>

long long factorial(int n){
    if (n == 1)
        return 1;
    if (n == 5)
        printf("n = 5 reached for debugger\n");
    if (n == 3)
        printf("n = 3 reached for debugger\n");

    return (long long)n * factorial(n - 1);
}

int main(){
    int value = 10;
    printf("factorial of %d is %lld\n", value, factorial(value));
    return 0;
}
```

This is a standard factorial recursive function which can overshoot for large value of n

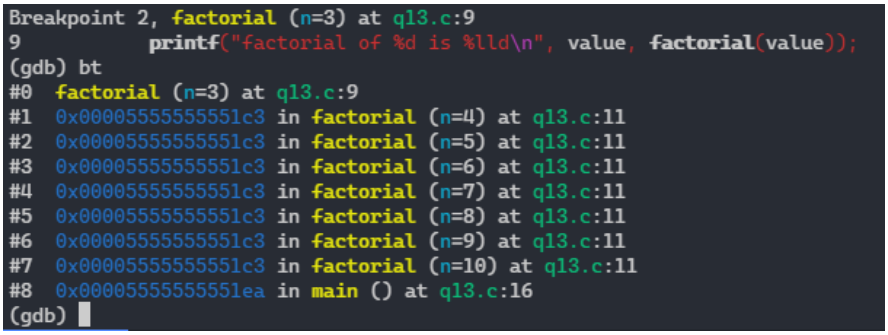
Let's compile and run it it with gdb

1. compile the program “gcc q13.c -o q13 -g”
2. run the program in gdb: “gdb q13”
3. add breakpoints to the line 7 and 9 (the printf’s in the factorial function): “b 7” and “b 9”
4. check if breakpoints are set or not: “info b”
5. run the program till a breakpoint occurs: “r”
    a. Now the program will stop at the first breakpoint (at line 7)
6. examine the stack trace: “bt”
    a. Output from my side:



    b. Here we can see the stack trace of the program in execution, the factorial function is called from main, then it is recursively called till the breakpoint at n = 5
7. continue till next breakpoint: “c”
    a. Now the program will stop again at breakpoint of line 9
8. examine the stack trace again: “bt”

a. output from my side:



b. Here we see that the previous stack trace grew from n = 5 to n = 3, as expected

9. continue till the next breakpoint (there aren't any so the program will complete executing) : "c"
10. exit from gdb: "q"

Part 14: Examining stack trace for multi-threaded program

consider the following simple program for this part

```
//filename q14.c
#include <stdlib.h>
#include <pthread.h>
#include <stdio.h>

#define NUM_THREADS 5

void *PrintHello(void *threadid) {
   long tid;
   tid = (long)threadid;
   printf("Hello World! Thread ID, %ld\n", tid);
   pthread_exit(NULL);
}

int main () {
   pthread_t threads[NUM_THREADS];
   int rc;
   int i;
   for( i = 0; i < NUM_THREADS; i++ ) {
      printf("main() : creating thread, %d\n", i);
      rc = pthread_create(&threads[i], NULL, PrintHello, (void *)i);
      if (rc) {
         printf("Error:unable to create thread, %d\n", rc);
         exit(-1);
      }
   }
   pthread_exit(NULL);
}
```

Here the main calls five threads and they print hello and exit

1. compile the program: "gcc -g q14.c -o q14"
2. open program in gdb: "gdb q14"
3. add a breakpoint where we can stop the processes: "b 10"
4. start the program: "r"
   a. we see the gdb notes that main() is creating threads

```
(gdb) r
Starting program: /home/abhiroop/gdbStuffs/q14
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".
main() : creating thread, 0
[New Thread 0x7ffff7d8f640 (LWP 2543)]
main() : creating thread, 1
[New Thread 0x7ffff758e640 (LWP 2544)]
[Switching to Thread 0x7ffff7d8f640 (LWP 2543)]

Thread 2 "q14" hit Breakpoint 1, PrintHello (threadid=0x0) at q14.c:10
warning: Source file is more recent than executable.
10          printf("Hello World! Thread ID, %ld\n", tid);
(gdb)
```

b. Now the program will stop when the threads are running

5. see the current thread: “thread”

```
(gdb) thread
[Current thread is 2 (Thread 0x7ffff7d8f640 (LWP 2543))]
(gdb)
```

6. see the back trace of the current thread: “bt”
   a. we see that the thread is not back tracing to main, it is back tracing to start_thread implemented in the OS itself

```
(gdb) bt
#0  PrintHello (threadid=0x0) at q14.c:10
#1  0x00007ffff7e2a927 in start_thread (arg=<optimized out>) at pthread_create.c:435
#2  0x00007ffff7eba9e4 in clone () at ../sysdeps/unix/sysv/linux/x86_64/clone.S:100
```

7. see the back trace of all the processes: “thread apply all bt”
   a. here we can see that thread 1 is from main making all the threads (was only able to make two threads before thread 2 stopped), and thread 3 has been made but hasn’t started to execute PrintHello() just yet

```
(gdb) thread apply all bt

Thread 3 (Thread 0x7ffff758e640 (LWP 2544) "q14"):
#0  clone () at ../sysdeps/unix/sysv/linux/x86_64/clone.S:83
#1  0x00007ffff7e2a6b0 in ?? () at pthread_create.c:321 from /lib/x86_64-linux-gnu/libc.so.6
#2  0x00007ffff758e640 in ?? ()
#3  0x0000000000000000 in ?? ()

Thread 2 (Thread 0x7ffff7d8f640 (LWP 2543) "q14"):
#0  PrintHello (threadid=0x0) at q14.c:10
#1  0x00007ffff7e2a927 in start_thread (arg=<optimized out>) at pthread_create.c:435
#2  0x00007ffff7eba9e4 in clone () at ../sysdeps/unix/sysv/linux/x86_64/clone.S:100

Thread 1 (Thread 0x7ffff7fbb5c0 (LWP 2539) "q14"):
#0  clone () at ../sysdeps/unix/sysv/linux/x86_64/clone.S:83
#1  0x00007ffff7ebb7a1 in __GI___clone_internal (cl_args=cl_args@entry=0x7fffffffdd50, func=func@entry=0x7fff
f7e2a6b0 <start_thread>, arg=arg@entry=0x7ffff758e640) at ../sysdeps/unix/sysv/linux/clone-internal.c:72
#2  0x00007ffff7e2a5b5 in create_thread (pd=pd@entry=0x7ffff758e640, attr=attr@entry=0x7fffffffde50, stopped_
start=stopped_start@entry=0x7fffffffde4e, stackaddr=stackaddr@entry=0x7ffff6d8e000, stacksize=<optimized out>
, thread_ran=thread_ran@entry=0x7fffffffde4f) at pthread_create.c:295
#3  0x00007ffff7e2b036 in __pthread_create_2_1 (newthread=<optimized out>, attr=<optimized out>, start_routin
e=<optimized out>, arg=<optimized out>) at pthread_create.c:799
#4  0x0000555555555252 in main () at q14.c:19
(gdb)
```

8. now you can exit or keep running the program till execution ends

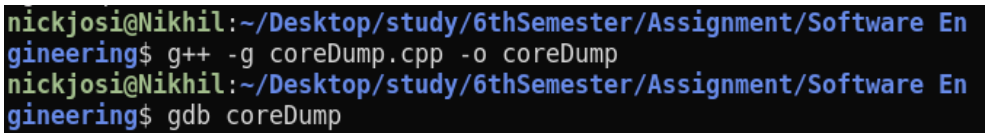
Part 15: Core file debugging

A “core dump” is a snapshot of memory at the instant the program crashed, typically saved in a file called “core”. GDB can read the core dump and give you the line number of the crash, the arguments that were passed, and more.

Let’s write a simple program to generate a core dump and debug it.

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

// function definition
int divide(int,int);

int main(){
    int x = 10 , y = 5;
    int xDivY = divide(x,y);
    cout << xDivY << "/n";

    x = 3; y = 0;
    // expecting error here !
    xDivY = divide(x,y);
    cout << xDivY << "/n";

    return 0;
}

// Takes two argument 'a' and 'b'
// Return 'a/b'
int divide(int a, int b){
    return a / b;
}
```

1. We will first compile this program using **g++** . Keep in mind to use **-g** option to debug with help of GDB. After that , we will load our executable file using gdb.



2. With **r** as the command, run the executable. Since there are not any breakpoints, it will run complete code.

   gdb is showing some information about core-dump. It is showing that our program has received the signal **Floating Point Error**. It is also showing **the line at which exception takes place. It is on line 19 , in function divide where arguments are a = 3 and b = 0 respectively**. It is also listing line number 19, **“return a/b”.**

3. We can print out context (code) where exception (/core dump) occur using ‘**l’** command.

```
(gdb) l
14
15          return 0;
16      }
17
18      int divide(int a, int b){
19          return a / b;
20      }
```

4. We can print the Stack trace using **“where”** command.

```
(gdb) where
#0  0x00005555555524e in divide (a=3, b=0)
    at coreDump.cpp:19
#1  0x0000555555555212 in main () at coreDump.cpp:12
```

This can be read as: The crash occurred in the function **divide** at **line 19** of coreDump.cpp. This, in turn, was called from the **function main at line 13** of coreDump.cpp.

5. We can use the **up** and the **down** command to move from the current level of stack trace up or down one level. Here, we are going from default level ‘0’ to one level up using **up**.

   We are also using **list** to list the code near to command from where the divide function is called.

```
(gdb) up
#1  0x0000555555555212 in main () at coreDump.cpp:12
12          xDivY = divide(x,y);
(gdb) list
7           int x = 10 , y = 5;
8           int xDivY = divide(x,y);
9           cout << xDivY << "/n";
10
11          x = 3; y = 0;
12          xDivY = divide(x,y);
13          cout << xDivY << "/n";
14
15          return 0;
16      }
```

6. We can print variable of current level of stack using **print** command.

```
(gdb) p x
$1 = 3
(gdb) p {x,y}
$2 = {3, 0}
```

Part 16. Debugging of an already running assignment.

When a program is not started as a process yet, we can attach it with gdb and then run it using **r** command.

> `gdb` *`program`*

But if the program is already running as a process then we have to perform following steps in order to attach gdb with it :

1. Find the process id (*pid*) with the help of **pidof** command:

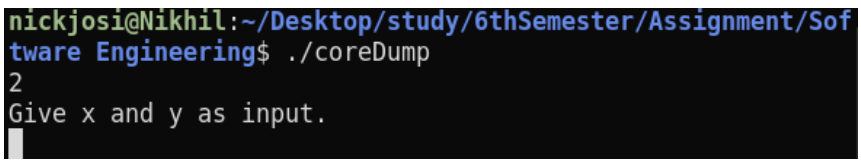
```
pidof program
# Replace program with a file name or path to the program.
```

2. Attach GDB to this process:

```
gdb program -p pid
# Replace program with a file name or path to the program, replace pid with an actual process id number from the ps output.
```

1. Code

2. Process start running



3. Finding Process id using **pidof** coreDump program runnning.

```
nickjosi@Nikhil:~/Desktop/study/6thSemester/Assignment/Sof
tware Engineering$ pidof coreDump
99427
```

4. Attaching gdb with program running with above mentioned process id.

```
nickjosi@Nikhil:~/Desktop/study/6thSemester/Assignment/Sof
tware Engineering$ sudo gdb "/home/nickjosi/Desktop/study/
6thSemester/Assignment/Software Engineering/coreDump" -p 9
9427
GNU gdb (Ubuntu 9.2-0ubuntu1~20.04.1) 9.2
Copyright (C) 2020 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org
/licenses/gpl.html>
This is free software: you are free to change and redistri
bute it.
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
```

5. Now we can do debugging in our normal manner.

Part 17: Watchpoint

Watchpoints are a special kind of breakpoint which is bound to a variable rather than line number

When the value of the variable being watched changes, the program is stopped

Consider a simple program

```
// filenaem: q17.c
#include <stdio.h>

int main(){
    for (int i = 0; i < 5; i++){
        if (i % 2 == 0)
            i++;
        printf("%d\n", i);
    }
    return 0;
}
```

Lets see the watch point in action

1. compile the code: “gcc -g q17.c -o q17"
2. open the program with gdb: “gdb q17”
3. add a breakpoint in main to stop the program just after the execution starts: “b main”
4. run the program to start execution of program: “r”
    a. The program will stop just after the start of execution

```
(gdb) r
Starting program: /home/abhiroop/gdbStuffs/q17
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib/x86_64-linux-gnu/libthread_db.so.1".

Breakpoint 1, main () at q17.c:4
4           for (int i = 0; i < 5; i++){
```

5. add a watchpoint to i: “watch i”
6. Now keep running the program with “c”, we observe that the program stops everytime i changes

```
(gdb) c
Continuing.

Hardware watchpoint 2: i

Old value = 0
New value = 1
main () at q17.c:7
7               printf("%d\n", i);
(gdb) c
Continuing.
1

Hardware watchpoint 2: i

Old value = 1
New value = 2
0x0000555555555189 in main () at q17.c:4
4           for (int i = 0; i < 5; i++){
(gdb) c
Continuing.

Hardware watchpoint 2: i

Old value = 2
New value = 3
main () at q17.c:7
7               printf("%d\n", i);
(gdb) c
Continuing.
3

Hardware watchpoint 2: i

Old value = 3
New value = 4
0x0000555555555189 in main () at q17.c:4
4           for (int i = 0; i < 5; i++){
(gdb) c
Continuing.

Hardware watchpoint 2: i

Old value = 4
New value = 5
main () at q17.c:7
7               printf("%d\n", i);
(gdb) c
Continuing.
5

Hardware watchpoint 2: i

Old value = 5
New value = 6
```