

Лекция 2

Инструменты отладки:

- `cuda-gdb`
- Data Display Debugger (ddd)
- Nsight Eclipse Plugins
- Nsight Visual Studio Code Edition

```
> ~Lecture3/Lab3-gdb> g++ lab3a.cpp -g3 -o lab3a  
> ~Lecture3/Lab3-gdb> gdb lab3a
```

```
(gdb) list main
```

```
.....  
36         gettimeofday(&t, NULL);  
37         Start =(double)t.tv_sec*1000000.0 +  
         (double)t.tv_usec;  
38         hTest(N,a,b);  
39         gettimeofday(&t, NULL);  
40         Finish =(double)t.tv_sec*1000000.0 +  
         (double)t.tv_usec;
```

```
.....  
(gdb) b 38
```

```
Breakpoint 1 at 0x400865: file lab3a.cpp, line 38.
```

(gdb) **run 256**

Starting program: ~/Lecture3/Lab3-gdb/lab3a 16

(gdb) **step**

hTest (N=16, a=0x613e70, b=0x613ec0) at lab3a.cpp:7

```
7         for(int i=0; i<N;i++)
```

(gdb) list hTest

```
1         #include <malloc.h>
```

```
2         #include <stdio.h>
```

```
3         #include <stdlib.h>
```

```
4         #include <sys/time.h>
```

```
5
```

```
6         void hTest(int N, int* a, int* b){
```

```
7             for(int i=0; i<N;i++)
```

```
8                 a[i]+=b[i];
```

```
9             }
```

```
(gdb) info args
```

```
N = 16
```

```
a = 0x613e70
```

```
b = 0x613ec0
```

```
(gdb) info locals
```

```
i = 0
```

```
(gdb) next 8
```

```
7         for(int i=0; i<N;i++)
```

```
(gdb) info locals
```

```
i = 3
```

```
(gdb) print b[2]
```

```
$1 = 5
```

```
(gdb) print a[2]
```

```
$2 = 9
```

```
gdb) break 8 if i==12
```

```
Breakpoint 3 at 0x400705: file lab3a.cpp, line 8.
```

```
(gdb) c
```

```
Continuing.
```

```
Breakpoint 3, hTest (N=16, a=0x613e70, b=0x613ec0) at  
lab3a.cpp:8
```

```
8          a[i]+=b[i];
```

```
(gdb) info locals
```

```
i = 12
```

```
(gdb) finish
```

```
Run till exit from #0 hTest (N=16, a=0x613e70,  
b=0x613ec0) at lab3a.cpp:8
```

```
main (argc=2, argv=0x7fffffffdd9b8) at lab3a.cpp:39
```

```
39      gettimeofday(&t, NULL);
```

(gdb) **x/16d b**

0x613ec0:	1	3	5	7
0x613ed0:	9	11	13	15
0x613ee0:	17	19	21	23
0x613ef0:	25	27	29	31

(gdb) **x/16d a**

0x613e70:	1	5	9	13
0x613e80:	17	21	25	29
0x613e90:	33	37	41	45
0x613ea0:	49	53	57	61

(gdb) **print a[2]-b[2]**

\$16 = 4

(gdb) **c**

Continuing.

Elapsed time: 9.57138e+06 ms

0	1	1
1	5	3
2	9	5
3	13	7
4	17	9
5	21	11

..... • •

13	53	27
14	57	29
15	61	31

[Inferior 1 (process 4272) exited normally]

(gdb) **quit**

Отладка многопоточных программ

```
~/Lecture3/Lab3-gdb> gdb lab3b
```

```
(gdb) list hTest
```

```
16 void* hTest(void* arg) {  
17     struct targ* s arg=(struct targ*)arg;  
18     int length=s arg->length;  
19     int offset=s_arg->num_thread*length;  
20     int i;  
21     for(i=0;i<length;i++)  
22         a[i+offset]+=/*1000*sin((double)*/b[i+offset];  
23     return NULL;  
25 }
```

```
(gdb) break lab3b.cpp:22
```

```
Breakpoint 1 at 0x40083f: file lab3b.cpp, line 22.
```



```
(gdb) run 4 16
```

```
Starting program: ../Lecture3/Lab3-gdb/lab3b 4 16
```

```
[Thread debugging using libthread_db enabled]
```

```
Using host libthread_db library
```

```
"/lib64/libthread_db.so.1".
```

```
[New Thread 0x7ffff6ed1700 (LWP 10741)]
```

```
[New Thread 0x7ffff66d0700 (LWP 10742)]
```

```
[New Thread 0x7ffff5ecf700 (LWP 10743)]
```

```
[Switching to Thread 0x7ffff6ed1700 (LWP 10741)]
```

```
Thread 2 "lab3b" hit Breakpoint 1, hTest (arg=0x614e70)  
at lab3b.cpp:22
```

```
22          a[i+offset]+=/*1000*sin((double)*/b[i+offset];
```

(gdb) **info threads**

	Id	Target Id	Frame
1	Thread 0x7ffff7fc0740	(LWP 10737) "lab3b"	clone ()
at	../sysdeps/unix/sysv/linux/x86_64/clone.S:78		
* 2	Thread 0x7ffff6ed1700	(LWP 10741) "lab3b"	hTest
	(arg=0x614e70) at lab3b.cpp:22		
3	Thread 0x7ffff66d0700	(LWP 10742) "lab3b"	hTest
	(arg=0x614e7c) at lab3b.cpp:22		
4	Thread 0x7ffff5ecf700	(LWP 10743) "lab3b"	clone ()
at	../sysdeps/unix/sysv/linux/x86_64/clone.S:78		

```
(gdb) print offset
```

```
$1 = 0
```

```
(gdb) thread 3
```

```
[Switching to thread 3 (Thread 0x7ffff66d0700 (LWP  
10742))]
```

```
#0  hTest (arg=0x614e7c) at lab3b.cpp:22
```

```
22
```

```
a[i+offset] += /*1000*sin((double)*/b[i+offset];
```

```
(gdb) print offset
```

```
$2 = 4
```

```
(gdb) break 22 thread 3
```

Note: breakpoint 1 (all threads) also set at pc
0x40083f.

Breakpoint 2 at 0x40083f: file lab3b.cpp, line 22.

```
(gdb) info breakpoints
```

Num	Type	Disp	Enb	Address	What
1	breakpoint	keep y		0x0000000000040083f	in hTest(void*) at lab3b.cpp:22
					breakpoint already hit 1 time
2	breakpoint	keep y		0x0000000000040083f	in hTest(void*) at lab3b.cpp:22 thread 3
					stop only in thread 3

```
(gdb) delete 1
```

```
(gdb) x/16d a
```

0x614ee0:	0	2	4	6
0x614ef0:	8	10	12	14
0x614f00:	16	18	20	22
0x614f10:	24	26	28	30

```
(gdb) continue
```

```
Continuing.
```

```
Thread 3 "lab3b" hit Breakpoint 2, hTest (arg=0x614e7c)
at lab3b.cpp:22
```

```
22          a[i+offset]+=/*1000*sin((double)*/b[i+offset];
```

```
(gdb) c
```

```
.....
(gdb) x/16d a
```

0x614ee0:	1	2	4	6
0x614ef0:	17	21	12	14
0x614f00:	33	37	20	22
0x614f10:	49	53	28	30

(gdb) **c**

Continuing.

[Thread 0x7ffff5ecf700 (LWP 10743) exited]

[Thread 0x7ffff66d0700 (LWP 10742) exited]

Thread-specific breakpoint 2 deleted - thread 3 no longer in the thread list.

[Thread 0x7ffff56ce700 (LWP 11167) exited]

[Thread 0x7ffff6ed1700 (LWP 10741) exited]

Elapsed time: 2.22941e+06 ms

0	1	1
---	---	---

1	3	5
---	---	---

2	5	9
---	---	---

.....

14	29	57
----	----	----

15	31	61
----	----	----

[Inferior 1 (process 10737) exited normally]

```
(gdb) print a[1]
```

```
..... •
```

```
(gdb) info locals
```

```
..... •
```

```
(gdb) info args
```

```
arg = 0x614e7c
```

```
(gdb) print ((struct targ*)arg)->length
```

```
$1 = 4
```


Отладка программ, выполняемых на GPU

<https://docs.nvidia.com/cuda/archive/11.2.0/cuda-gdb/index.html>

```
> nvcc -g -G ...
```

```
~/Workshop/VSC> cuda-gdb lab3c
```

```
(cuda-gdb) list main
```

```
23     __global__ void gSum(int* a, int *b){  
24         int i=threadIdx.x+blockIdx.x*blockDim.x;  
25         a[i]+=b[i];  
26     }
```

```
27
```

```
28     int main(){  
29         int N=VECTOR_LENGTH;  
30         int *a, *b;  
31         int *a_h;  
32
```

```
(cuda-gdb) break 25
```

```
Breakpoint 1 at 0x403fdd: file lab3c.cu, line 26.
```

```
(cuda-gdb) run
```

(cuda-gdb) **info cuda threads**

BlockIdx	ThreadIdx	To	BlockIdx	ThreadIdx	Count	VirtualPC
						Filename Line
Kernel 0						
*	(0,0,0)	(0,0,0)	(0,0,0)	(3,0,0)	4	
0x00007fffe525c3e0						
					9	.../Lecture3/Lab3-cuda-gdb/lab3c.cu
	(1,0,0)	(0,0,0)	(3,0,0)	(3,0,0)	12	
0x00007fffe525c2b0						
					8	.../Lecture3/Lab3-cuda-gdb/lab3c.cu

```
cuda-gdb) cuda block 2 thread 3
```

```
[Switching focus to CUDA kernel 0, grid 1, block  
(2,0,0), thread (3,0,0), device 0, sm 2, warp 0, lane 3]
```

```
8          b[i]=2*i+1;
```

```
(cuda-gdb) print i
```

```
$2 = 11
```

```
(cuda-gdb) n
```

```
9          }
```

```
(cuda-gdb) x/16d b
```

```
0x7fffecc00200: 1          3          5          7
```

```
0x7fffecc00210: 0          0          0          0
```

```
0x7fffecc00220: 0          0          0          0
```

```
0x7fffecc00230: 0          0          0          0
```

```
malkov@192:~> ssh cyber.sibsutis.ru
```

```
malkov@linux-47dw: ~/WORKSHOP/PGP-2023> cuda-gdb lab3c
```

```
(cuda-gdb) break 8
```

```
Breakpoint 1 at 0x403851: file lab3c.cu, line 8.
```

```
(cuda-gdb) run
```

```
Starting program: /home/malkov/WORKSHOP/PGP-2023/lab3c
```

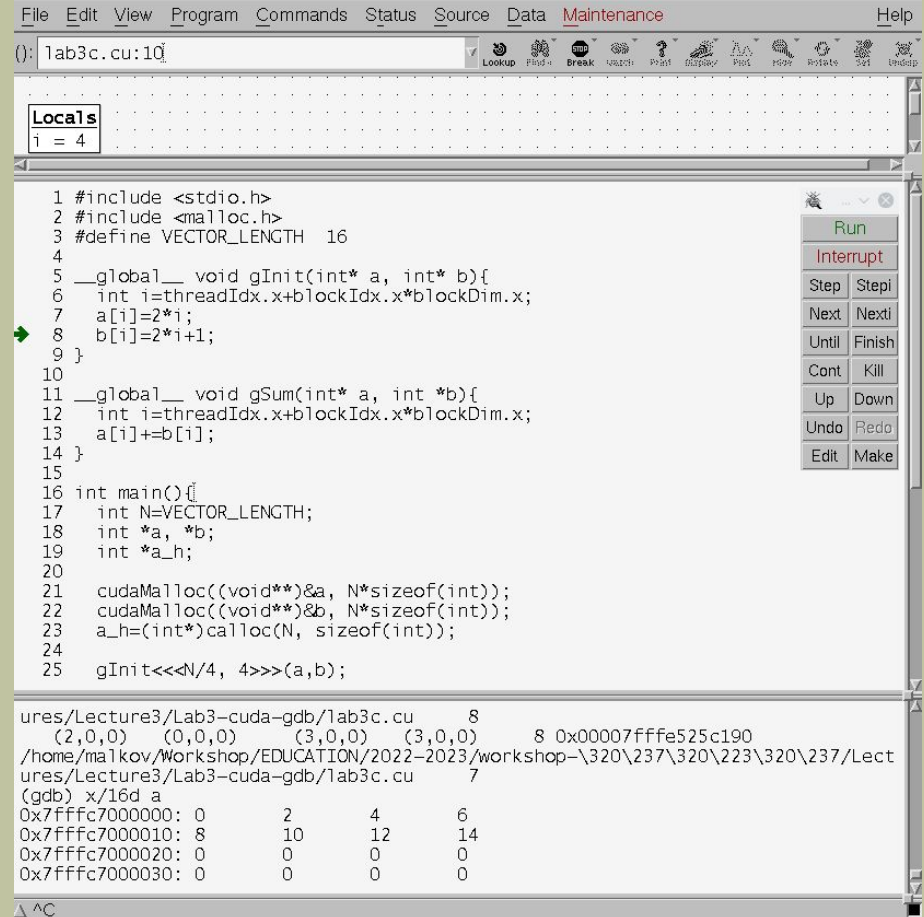
```
.....  
[Switching focus to CUDA kernel 0, grid 1, block  
(0,0,0), thread (0,0,0), device 0, sm 0, warp 0, lane 0]  
Thread 1 "lab3c" hit Breakpoint 1,  
gInit<<<(4,1,1),(4,1,1)>>> (a=0x7fffe6800000,  
b=0x7fffe6800200) at lab3c.cu:8  
8           b[i]=2*i+1;
```

Data Display Debugger (ddd)

```
.../Lecture3/  
Lab3-cuda-gdb>  
ddd cuda-gdb lab3c
```

```
malkov@192:~> ssh  
cyber.sibsutis.ru -X
```

```
malkov@linux-47dw:  
~/WORKSHOP/PGP-2023>  
ddd cuda-gdb lab3c
```



The screenshot shows the Data Display Debugger (ddd) interface. The top menu bar includes File, Edit, View, Program, Commands, Status, Source, Data, Maintenance, and Help. The toolbar contains icons for various debugging actions like LookUp, Find, Break, Watch, Print, Display, Step, Next, Run, Interrupt, and Undo. The main window displays the source code of a CUDA program (lab3c.cu) with line numbers 1 through 25. A green arrow points to line 8, indicating the current execution point. The code defines a vector length, initializes arrays, and performs a summation. The bottom panel shows the memory dump for variable 'a' at address 0x7fffc7000000, displaying a 4x4 grid of values.

```
1 #include <stdio.h>  
2 #include <malloc.h>  
3 #define VECTOR_LENGTH 16  
4  
5 __global__ void gInit(int* a, int* b){  
6     int i=threadIdx.x+blockIdx.x*blockDim.x;  
7     a[i]=2*i;  
8     b[i]=2*i+1;  
9 }  
10  
11 __global__ void gSum(int* a, int* b){  
12     int i=threadIdx.x+blockIdx.x*blockDim.x;  
13     a[i]+=b[i];  
14 }  
15  
16 int main(){  
17     int N=VECTOR_LENGTH;  
18     int *a, *b;  
19     int *a_h;  
20  
21     cudaMalloc((void**)&a, N*sizeof(int));  
22     cudaMalloc((void**)&b, N*sizeof(int));  
23     a_h=(int*)calloc(N, sizeof(int));  
24  
25     gInit<<<N/4, 4>>>>(a,b);
```

Memory dump for variable 'a' (gdb) x/16d a:

Address	Value	Address	Value
0x7fffc7000000: 0	2	4	6
0x7fffc7000010: 8	10	12	14
0x7fffc7000020: 0	0	0	0
0x7fffc7000030: 0	0	0	0

Nsight Eclipse Plugins

The screenshot displays the Nsight Eclipse IDE interface for debugging a CUDA application. The main components are:

- Project Explorer:** Shows the project structure for 'lab3 [C/C++ Application]'. It includes a 'gSum' target on a NVIDIA GeForce RTX 2060. The 'All Kernel Threads' section shows a hierarchy of threads and blocks, with the current thread being 'Thread #5 [lab3] 11138 [core: 4] (Suspended : Container)'.
- Source Code Editor:** Displays the file 'vector_types.h'. The code defines a vector length and implements a global sum function. The current execution point is at line 13, where the operation `a[i] += b[i];` is being performed.
- Variable Window:** Shows the state of variables. The variable 'b' is of type '@generic int [16]' and contains the values {1, 3, 5, 7, 9, 11, 13, 15, 17, 19, ...}. Its details are shown below the table.
- Console:** Displays the execution log, including thread creation messages and a breakpoint hit notification for Thread 1 at line 13.

Variable Window Details:

Name	Type	T(0.0,0)B(0.0,0)
a	@generic int * @int [16]	0x7ffff7000000
b	@generic int [16]	1 (Decimal)

Details for variable b:

Details: {1, 3, 5, 7, 9, 11, 13, 15, 17, 19, ...}
Default: 0x7ffff7000200
Decimal: 140736532054528
Hex: 0x7ffff7000200
Binary: 111111111111111110001110000000000000
Octal: 0377770700001000

Console Output:

```
lab3 [C/C++ Application] ./usr/local/cuda-11.2/bin/cuda-gdb (8.3.1)
[New Thread 0x7ffff36ef700 (LWP 11136)]
[New Thread 0x7ffff2eee700 (LWP 11137)]
[New Thread 0x7ffff238a700 (LWP 11138)]

Thread 1 "lab3" hit Breakpoint 1, gSum<<<(4,1,1),(4,1,1)>>> (a=0x7ffff7000000, b=0x7ffff7000200) at ../lab3-e.cu:13
13     a[i] += b[i];
    n
    n
14 }
```