GigaDevice Semiconductor Inc.

Arm® Cortex®- M3/M4/M23/M33 32-bit MCU

Application Note
AN020

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1. Introduction

CmBacktrace (Cortex Microcontroller Backtrace) is an open source library that automatically tracks and locates error codes for ARM Cortex-M series MCUs, and automatically analyzes the causes of errors. The main features are as follows:

- Supported errors include:
  - Assert
  - Fault (Hard Fault, Memory Management Fault, Bus Fault, Usage Fault, Debug Fault)
- Failure reason Automatic diagnosis: When a failure occurs, the cause of the failure can be automatically analyzed, and the code location of the failure can be located, without the need to manually analyze the complicated fault registers; -Output the function call stack of the error site (need to cooperate with the addr2line tool for precise positioning), restore the field information when the error occurred, and locate the problem code location and logic more quickly and accurately. You can also use the library under normal conditions to get the current function call stack;
- Support bare metal and the following operating system platforms:
  - RT-Thread
  - UCOS
  - FreeRTOS (source code needs to be modified)
- According to the error scene status, output the corresponding thread stack or C main stack;
- The fault diagnosis information supports multiple languages (currently: Simplified Chinese, English);
- Adapt to Cortex-M0/M3/M4/M7 MCU;
- Support IAR, KEIL, GCC compiler;

This document describes how to port CmBacktrace to the GD32 project.

2. Porting CmBacktrace

2.1. Download CmBacktrace

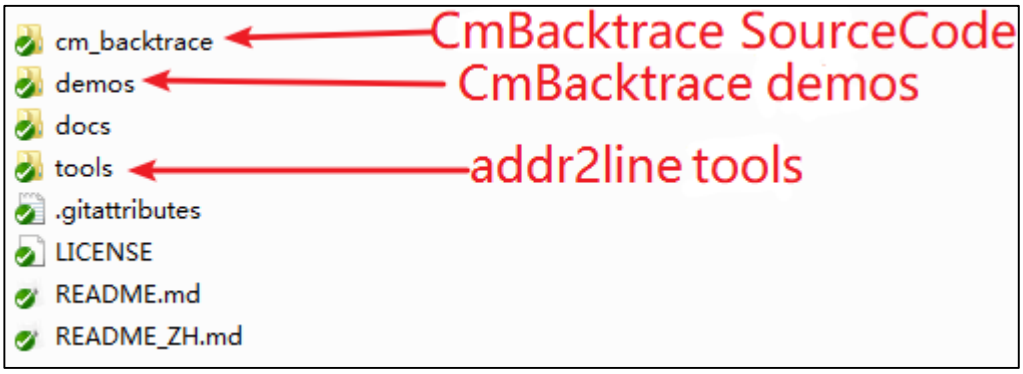
The CmBacktrace transplantation platform introduced in this document is the GD32E507Z-EVAL development board. The IDE platforms ported by CmBacktrace are KEIL5 and IAR.

CmBacktrace source code can be downloaded from https://github.com/armink/CmBacktrace. The currently tested CmBacktrace software version is 1.4.0, as shown in the figure below.

Figure2-1. Version information of CmBacktrace

```
/* library software version number */
#define CMB_SW_VERSION              "1.4.0"
```

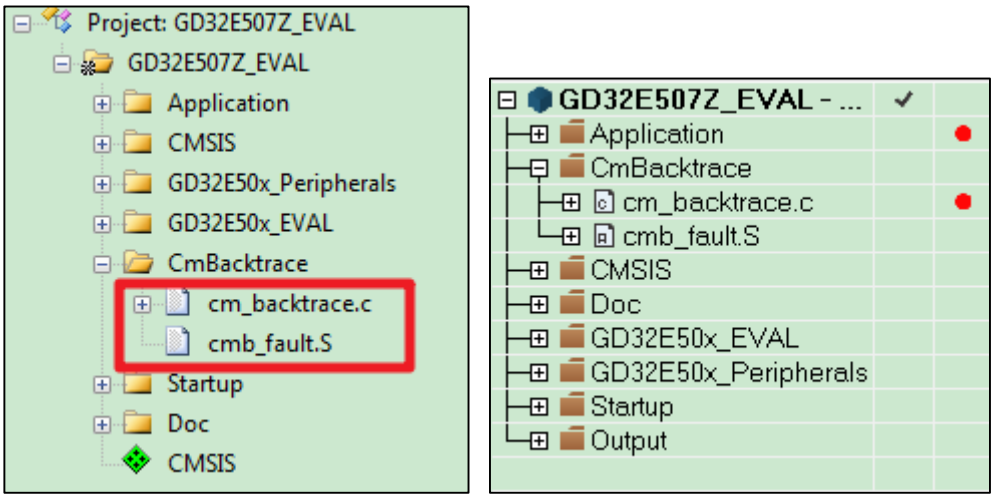
Figure 2-2. Flowchart of MPU



2.2. Add CmBacktrace source file

The migration method introduced in this article is based on the 01_GPIO_Running_LED project in GD32E507Z_EVAL_Demo_Suites. First, copy the CmBacktrace\cm_backtrace library file to the 01_GPIO_Running_LED file. Then open the project and add cm_backtrace.c and cmb_fault.S to the project.

Figure 2-3. Project configuration of Keil and IAR



Since cmb_fault.S will use HardFault_Handler, the original HardFault_Handler function should be commented.

Figure 2-4. Comment the original HardFault Handler function

```
/*!
    \brief      this function handles HardFault exception
    \param[in]  none
    \param[out] none
    \retval     none
*/
//void HardFault_Handler(void)
//{
//    /* if Hard Fault exception occurs, go to infinite loop */
//    while (1){
//    }
//}
```

2.3. Project configuration of different IDEs

CmBacktrace must be configured to support the C99 standard when using the KEIL5 compiler. The engineering configuration of Keil and IAR is shown in the figure below.

Figure 2-5. Project configuration of Keil

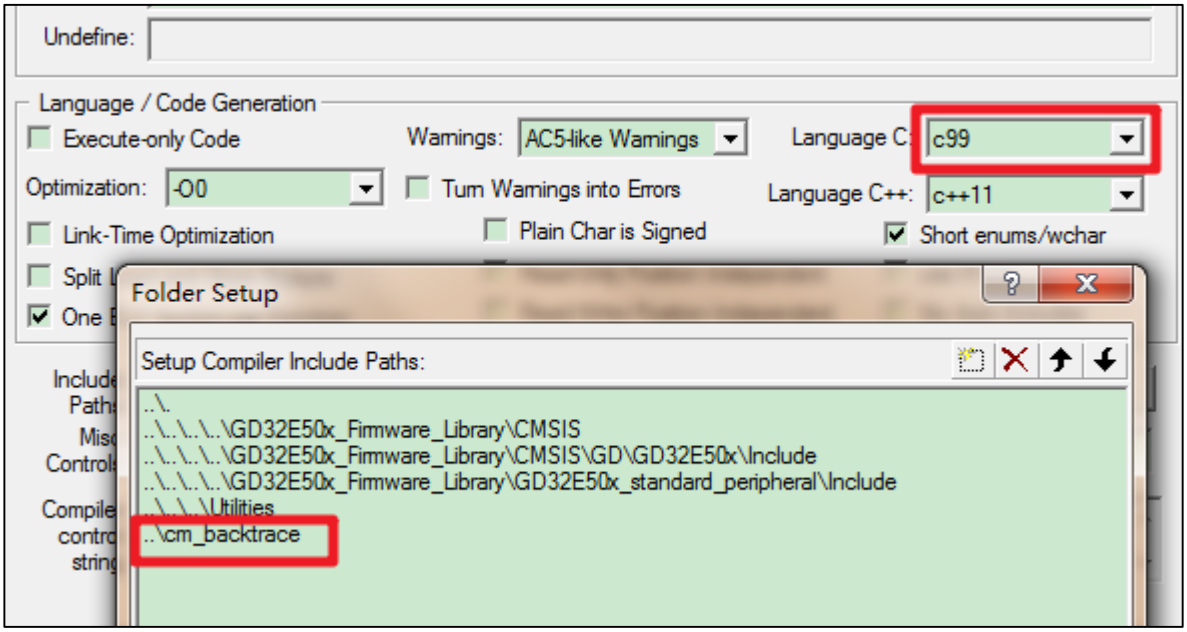
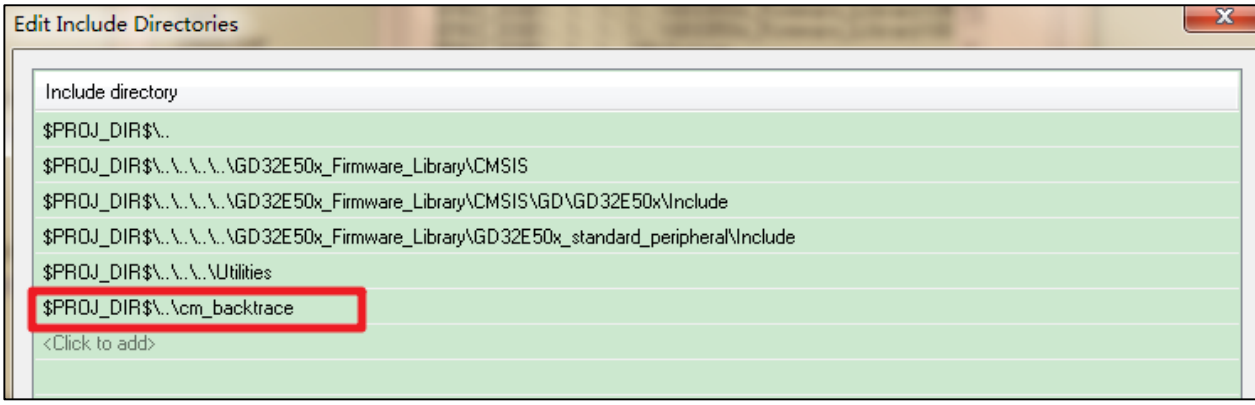


Figure 2-6. Project configuration of IAR



2.4. CmBacktrace parameter configuration

The configuration options for different platforms and scenarios are defined in cmb_def.h.

Table 2-1. Configuration of CmBacktrace parameter

Configuration Name	Function description	Note
cmb_println(...)	Error and diagnostic information output	Must be configured
CMB_USING_BARE_METAL_PLATFORM	Whether it is used on a bare metal platform	Define this macro if it is used
CMB_USING_OS_PLATFORM	Whether it is used on the operating system platform	Operating system and bare metal must choose one of two

Configuration Name	Function description	Note
CMB_OS_PLATFORM_TYPE	Operating System Platform	RTT/uCOS/FREERTOS
CMB_CPU_PLATFORM_TYPE	Operating System Platform	M0/M3/M4/M7/M33
CMB_USING_DUMP_STACK_INFO	Whether to use Dump stack function	Use to define this macro
CMB_PRINT_LANGUAGE	Language when outputting information	CHINESE/ENGLISH

The configuration in the CmBacktrace GD32E507Z project is shown in the figure below.

Figure 2-7. Configuration of cmb_def.h

```
#ifndef _CMB_CFG_H_
#define _CMB_CFG_H_

/* print line, must config by user */
#define cmb_println(...)                printf(__VA_ARGS__);printf("\r\n")
/* enable bare metal(no OS) platform */
#define CMB_USING_BARE_METAL_PLATFORM
/* cpu platform type, must config by user */
#define CMB_CPU_PLATFORM_TYPE           CMB_CPU_ARM_CORTEX_M33
/* enable dump stack information */
#define CMB_USING_DUMP_STACK_INFO
/* language of print information */
#define CMB_PRINT_LANGUAGE              CMB_PRINT_LANUUAGE_ENGLISH
#endif /* _CMB_CFG_H_ */
```

Redirection function

2.5. Others

The cmb_def.h in the original code uses the __CC_ARM macro to distinguish which IDE environment it is. For the ARM Compiler Version 6 compiler, the macro used is __ARMCC_VERSION, as shown in the figure below.

Figure 2-8. Conditional compilation of cmb_def.h

```
#if defined(__CC_ARM) || defined(__CLANG_ARM)
    /* C stack block name, default is STACK */
    #ifndef CMB_CSTACK_BLOCK_NAME
    #define CMB_CSTACK_BLOCK_NAME          STACK
    #endif
    /* code section name, default is ER_IROM1 */
    #ifndef CMB_CODE_SECTION_NAME
    #define CMB_CODE_SECTION_NAME          ER_IROM1
    #endif
#elif defined(__ICCARM__)
    /* C stack block name, default is 'CSTACK' */
    #ifndef CMB_CSTACK_BLOCK_NAME
    #define CMB_CSTACK_BLOCK_NAME          "CSTACK"
    #endif
    /* code section name, default is '.text' */
    #ifndef CMB_CODE_SECTION_NAME
    #define CMB_CODE_SECTION_NAME          ".text"
    #endif
#elif defined(__GNUC__)
```

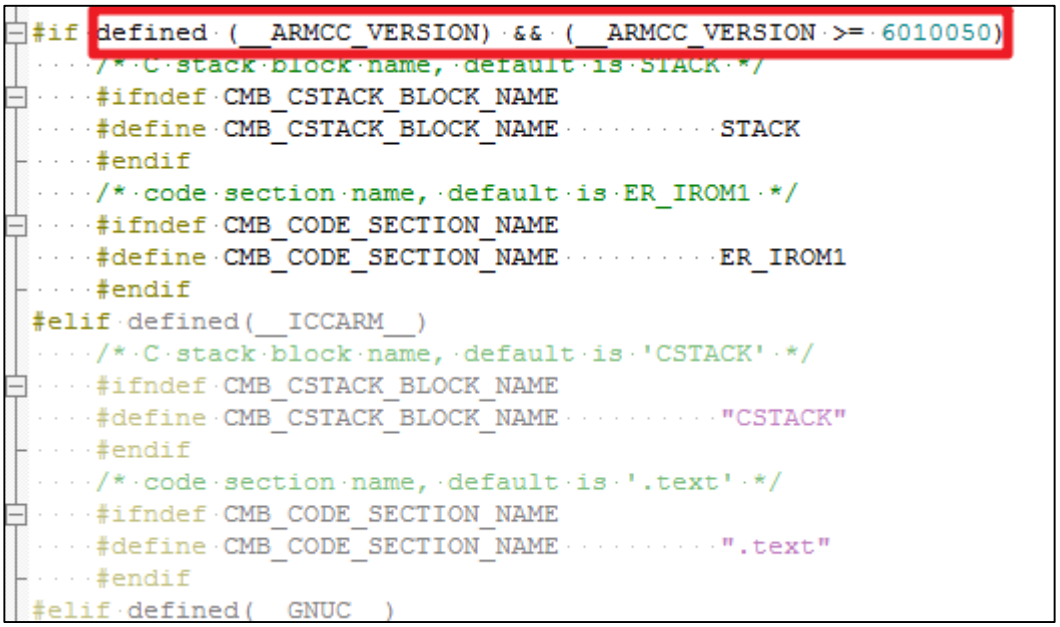
Figure 2-9. Explanation of ARM Compiler Version 6 on __ARMCC_VERSION

Table 9-21 Predefined macros

Name	Value	When defined
__arm__	-	Always defined for the ARM compiler, even when you specify the --thumb option. See also __ARMCC_VERSION.
__ARMCC_VERSION	ver	Always defined. It is a decimal number, and is guaranteed to increase between releases. The format is PVVbbbb where: ▪ P is the major version ▪ VV is the minor version ▪ bbbb is the build number.

Therefore, the ARM Compiler Version 6 compiler is used, some modifications should be made as follows.

Figure 2-10. Modification of compiler using ARM compiler version 6



```
#if defined (__ARMCC_VERSION) && (__ARMCC_VERSION >= 6010050)
    /* C stack block name, default is STACK */
    #ifndef CMB_CSTACK_BLOCK_NAME
    #define CMB_CSTACK_BLOCK_NAME          STACK
    #endif
    /* code section name, default is ER_IROM1 */
    #ifndef CMB_CODE_SECTION_NAME
    #define CMB_CODE_SECTION_NAME          ER_IROM1
    #endif
#elif defined(__ICCARM__)
    /* C stack block name, default is 'CSTACK' */
    #ifndef CMB_CSTACK_BLOCK_NAME
    #define CMB_CSTACK_BLOCK_NAME          "CSTACK"
    #endif
    /* code section name, default is '.text' */
    #ifndef CMB_CODE_SECTION_NAME
    #define CMB_CODE_SECTION_NAME          ".text"
    #endif
#elif defined(__GNUC__)
```

3. Functional test of CmBacktrace

This chapter introduces HardFault caused by misalignment and division by zero errors, which are captured by CmBacktrace and printed through the serial port, as shown below.

Table 3-1. fault_test_by_unalign

```
void fault_test_by_unalign(void) {
    volatile int * SCB_CCR = (volatile int *) 0xE000ED14; // SCB->CCR
    volatile int * p;
    volatile int value;

    *SCB_CCR |= (1 << 3); /* bit3: UNALIGN_TRP. */

    p = (int *) 0x00;
    value = *p;
    printf("addr:0x%02X value:0x%08X\r\n", (int) p, value);

    p = (int *) 0x04;
    value = *p;
    printf("addr:0x%02X value:0x%08X\r\n", (int) p, value);

    p = (int *) 0x03;
    value = *p;
    printf("addr:0x%02X value:0x%08X\r\n", (int) p, value);
}
```

Table 3-2. fault_test_by_div0

```
void fault_test_by_div0(void) {
    volatile int * SCB_CCR = (volatile int *) 0xE000ED14; // SCB->CCR
    int x, y, z;

    *SCB_CCR |= (1 << 4); /* bit4: DIV_0_TRP. */

    x = 10;
    y = 0;
    z = x / y;
    printf("z:%d\n", z);
}
```

According to the specific operating system of the computer, the addr2line.exe stored in the tools folder of CmBacktrace can be directly copied to C:\Windows, or the tools folder path of the CmBacktrace warehouse can be added to the environment variable path. This can ensure that the command line tool can use the addr2line command normally.

The fault_test_by_unalign error report generated under Keil and the result printed by

addr2line are as follows.

Figure 3-1. Fault_test_by_unalign error report generated under Keil

```
Firmware name: CmBacktrace, hardware version: V1.0.0, software version: V0.1.0
Fault on interrupt or bare metal(no OS) environment
===== Thread stack information =====
  addr: 20000928    data: 200000b4
  addr: 2000092c    data: 0800305d
  addr: 20000930    data: 0800304f
  addr: 20000934    data: 0000001c
  addr: 20000938    data: 08003034
  addr: 2000093c    data: 080001c1
  addr: 20000940    data: 00000003
  addr: 20000944    data: e000ed14
  addr: 20000948    data: 00000000
  addr: 2000094c    data: 08001af5
  addr: 20000950    data: 00000000
  addr: 20000954    data: 00000000
  addr: 20000958    data: 00000000
  addr: 2000095c    data: 00000000
  addr: 20000960    data: 00000000
  addr: 20000964    data: 00000000
  addr: 20000968    data: 00000000
  addr: 2000096c    data: 08000679
====================================
================== Registers information ====================
  R0 : 0000001c  R1 : 00000003  R2 : 00000007  R3 : 40013800
  R12: 00000001  LR : 08001811  PC : 080017c4  PSR: 29000000
=============================================================
Usage fault is caused by indicates that an unaligned access fault has taken place
Show more call stack info by run: addr2line -e CmBacktrace.axf -a -f 080017c4 08001810
080001c0 08001af4 08000678
```

Figure 3-2. According to the axf file generated by Keil, use the addr2line tool to obtain the function call stack information

```
_Suites\Projects\GPIO_Running_LED\MDK-ARM\output>addr2line -e Project.axf -a -f
080017c4 08001810 080001c0 08001af4 08000678
0x080017c4
fault_test_by_unalign
[redacted]GD32E50x_Demo_Suites\GD32E507Z_EVAL_Demo
_Suites\Projects\01_GPIO_Running_LED\MDK-ARM/../main.c:119
0x08001810
fputc
[redacted]GD32E50x_Demo_Suites\GD32E507Z_EVAL_Demo
_Suites\Projects\01_GPIO_Running_LED\MDK-ARM/../main.c:139
0x080001c0
Reset_Handler
[redacted]GD32E50x_Demo_Suites\GD32E507Z_EVAL_Demo
_Suites\Projects\01_GPIO_Running_LED\MDK-ARM/..\..\..\..\GD32E50x_Firmware_Libra
ry\CMSIS\GD\GD32E50x\Source\ARM\startup_gd32e50x_cl.s:185
0x08001af4
main
[redacted]GD32E50x_Demo_Suites\GD32E507Z_EVAL_Demo
_Suites\Projects\01_GPIO_Running_LED\MDK-ARM/../main.c:65
0x08000678
$d
??:?
```

The fault_test_by_unalign error report generated under IAR and the result printed by addr2line are as follows.

Figure 3-3. Fault_test_by_unalign error report generated under IAR

```
addr:0x00 value:0x20000A40
addr:0x04 value:0x08002E55

Firmware name: CmBacktrace, hardware version: V1.0.0, software version: V0.1.0
Fault on interrupt or bare metal(no OS) environment
===== Thread stack information =====
  addr: 20000a28    data: 08002e55
  addr: 20000a2c    data: 00000000
  addr: 20000a30    data: 00000000
  addr: 20000a34    data: 08002cb7
  addr: 20000a38    data: 00000000
  addr: 20000a3c    data: 08002ffb
====================================
================== Registers information ====================
  R0 : 0000001c  R1 : 00000003  R2 : 20000a24  R3 : 00000000
  R12: 00000008  LR : 08002d81  PC : 08002d5a  PSR: 09000000
=============================================================
Usage fault is caused by indicates that an unaligned access fault has taken place
Show more call stack info by run: addr2line -e CmBacktrace.out -a -f 08002d5a 08002d80
08002cb6 08002ffa
```

Figure 3-4. According to the axf file generated by IAR, use the addr2line tool to obtain the function call stack information

```
_Suites\Projects\GPIO_Running_LED\EWARM\GD32E50x\Exe>addr2line -e Project.out -a
 -f 08002d5a 08002d80 08002cb6 08002ffa
0x08002d5a
fault_test_by_unalign
[redacted]GD32E50x_Demo_Suites\GD32E507Z_EVAL_Demo
_Suites\Projects\GPIO_Running_LED/main.c:119
0x08002d80
fputc
[redacted]GD32E50x_Demo_Suites\GD32E507Z_EVAL_Demo
_Suites\Projects\GPIO_Running_LED/main.c:139
0x08002cb6
main
[redacted]GD32E50x_Demo_Suites\GD32E507Z_EVAL_Demo
_Suites\Projects\GPIO_Running_LED/main.c:65
0x08002ffa
_call_main
??:?
```

4. Revision history

Table 4-1. Revision history

Revision No.	Description	Date
1.0	Initial Release	Nov.30 2021

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