Children's Bible Coloring Book of PoC || GTFO
Issue 0x02, an Epistle to the 30th CCC Congress in Hamburg

Composed by the Rt. Revd. Pastor Manul Laphroaig to put pwnage before politics.
pastor@phrack.org

December 28, 2013

1 Call to Worship

Please join me in reading this third issue of the International Journal of Proof of Concept or Get the Fuck Out, a friendly little collection of articles for ladies and gentlemen of distinguished ability and taste in the field of software exploitation and the worship of weird machines. If you are missing the first two issues, we the editors suggest pirating them from the usual locations, or on paper from a neighbor who picked up a copy of the first in Vegas or the second in São Paulo.

This edition is written to the fine neighbors of the Chaos Computer Club in honor of their thirtieth congress, to be held this December in Hamburg. As in prior issues, you'll find plenty of pwnage, some neighborly preaching, and no politics.

In Section 2, Pastor Laphroaig preaches that in the tradition of Noah and of Howard Hughes, we should build our own fucking birdfeeders.

Brother Myron Aub takes a break from his evangelical promotion of Graphitics to teach us a little about the PGP Message format in Section 3. It turns out that RFC 4880 gives him just enough room to encode an LZ-compression quine within a message, and the PGP interpreter is just "smart"[1] enough to keep decoding it 'till the cows come home. Perhaps other weird machines remain to be found?

Natalie Silvanovich shares in Section 4 her techniques for reliably dropping shellcode into the Tamagotchi's 6502 controller from malicious plugin cartridges. Her exploit requires a number of nifty tricks, not least of which is that the some bits of the program counter are ignored in this architecture, so her victim executes the right code from the wrong address! It is feared that this technology might be used

[1]Because things marketed as "smart" usually aren't, at least not for the buyer's benefit. Truly, the world does occasionally need reminding that stupid is as stupid does.

by the Royal Canadian Mounted Police to fuel a Cyber War of 1812 against the State of New Hampshire and the People's Republic of Vermont. Both American and Canadian neighbors can rest assured that this one would have the same winner as the original, Non-Cyber War of 1812.

Travis Goodspeed shares a grab-bag of tricks for exploiting microcontrollers in Section 5. Learn how to combine a Write and a Checksum primitive with weirder properties of Flash memory into a bitwise Read primitive when exploiting microcontrollers, how to NOP-out instructions without erasing Flash pages, and how to use bootloader ROMs for a return-to-libc attack.

Bx Shapiro had a nifty article in PoC||GTFO 0:5 in which she showed out to return from ELF to libc. That article ended with a challenge to our readers, asking you fine folks to figure out how in living hell parameters could be passed to the function beging called. In Section 6, she rises to her own challenge, showing you how to call putchar() from an ELF Weird Machine without having any of your own native code.

Dave Weinstein in Section 7 explains why `POKE 62975, 0` will brick a Trash 80 Model 100 until that poor machine is put out its misery by a cold reset. Feel free to try it out in your emulator and consider that many Automatic Exploit Generators aren't very good at predicting the effects of a write-once-anywhere vuln.

Ange Albertini explains the internal organization of this issue's PDF in Section 8. Curious readers might want to run `qemu-system-i386 -fda pocorgtfo02.pdf` in order to experience all the neighborliness that this issue has to offer.

In PoC||GTFO 01:02, Dan Kaminsky shared with us a 4-line RNG for Javascript, challenging our readers to exploit it. It had no whitening, no scrambling, and no other defenses, so any weakness in the principle ought to have been exploitable. In proper PoC||GTFO fashion, Joernchen demonstrates such a vulnerability in Section 9, by observing that some versions of Firefox bias toward producing bytes of low Hamming weight.

Section 10 contains Ben Nagy's latest masterpiece, sure to get you, dear reader, on all sorts of watchlists. We half-heartedly apologize in advance to any of our readers at spooky agencies who have to explain having this magazine to their employers.

Finally, in Section 11, we do what churches are best at and pass the collection plate. Please consider giving alms of 0day and PoC to those who are poor in spirit.

Artwork in this issue was created by Ra of Tama-Zone, Stefan Bauwens, and others. The painting featured in the museum on page 31 is in remembrance of the one first drawn by Mirromaru in red creeper cards at the 29th Congress, then quickly censored due to controversy.

— — — —

We the editors are aware that some of the illustrations might be offensive to our more sensitive readers, either for reasons of vulgarity or blasphemy. In both cases, we rely on the Bill Hicks Defense.

"Buddy, we're Christians, and we don't like what you said."

"So forgive me!"

4Kx8 Static Memories

MB-1 Mk-8 board, 1 usec 2102 or eq.
PC Board. . $22 Kit $100

MB-2 Altair 8800 or IMSAI compatible switched address and wait cycles.
PC Board. . $25 Kit (1 usec) . . $112
Kit (91L02A or 21L02-1) $132

MB-4 Improved MB-2 designed for 8K "piggy-back" without cutting traces.
PC Board. . . . . $ 30
Kit 4K 0.5 usec $137
Kit 8K 0.5 usec $209

MB-3 1702A's EROMs, Altair 8800 & Imsai 8080 compatible switched address & wait cycles. 2K may be expanded to 4K. Kit less Proms . $ 65
2K kit . . $145 4K kit $225

I/O Boards

I/O-1 8 bit parallel input & output ports, common address decoding jumper selected, Altair 8800 plug compatible.
Kit . . . . . $42 PC Board only. . $25

I/O-2 I/O for 8800, 2 ports committed, pads of 3 more, other pads for EROMs UART, etc.
Kit . . . $47.50 PC Board only. . $25

Misc.
Altair compatible mother board
15 sockets 11"x11½" $40
Altair extender board. . . . . $ 8
100 pin WW sockets .125"
centers . . . . $ 6

2102's	1usec	0.65usec	0.5usec
ea.	$ 1.95	$ 2.25	$ 2.50
32	$59.00	$68.00	$76.00

1702A*	$10.00	8223	$3.00
2101	$ 4.50	MM5320	$5.95
2111-1	$ 4.50	8212	$5.00
2111-1	$ 4.50	8131	$2.80
91L02A	$ 2.55	MM5262	$2.00
32 ea.	$ 2.40	1103	$1.25
Programming send Hex List			$5.00
AY5-1013 Uart			$8.00

All kits by Solid State Music
Please send for complete list of products and ICs.

MIKOS
419 Portofino Dr.
San Carlos, Calif. 94070

Check or money order only. Calif. residents 6% tax. All orders postpaid in US. All devices tested prior to sale. Money back 30 day Guarantee. $10 min. order. Prices subject to change without notice.

2 A Parable on the Importance of Tools; or, Build your own fucking birdfeeder.

an epistle from the Rt. Rvd. Pastor Manul Laphroaig,
for the Beloved Congregation of the First United Church of the Weird Machines

Grace and Peace to you!

Once there was a wine-maker named Noah, the sort of fella you'd be happy to share a beer with. He made damned good wine, but one day he started building a boat.

"Why are you building that?" they'd ask, "Are the voices in your head telling you that it's gonna rain?"

"Nope," he'd say, "Just toolin' around."

They showed him yacht catalogs and boating magazines. "Look, man, you can just buy one at the store."

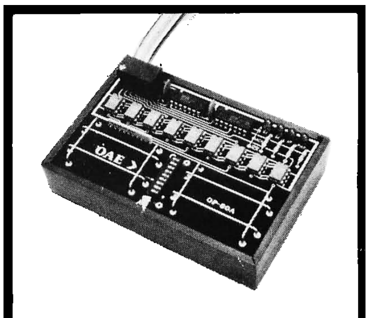
"Haven't got the money," he'd say and then get back to building the frame or bending boards for the hull.

"Well, you could afford to rent a boat for the weekend."

Now Noah was a patient guy, but everyone has his limit. "I'm building my own fucking birdfeed," he'd say, "because they've got wood at the store."

And there was a fella named Howard Hughes, a crazy old millionaire. Back in the thirties, he built his own air force to film a movie about the first World War, so during the forties, when Roosevelt needed an air force of his own, he bought Howie's.

Howie Hughes built other birdfeeders. He made the H4 Hercules, the world's largest airplane and a damned big boat, out of wood. It was five stories tall with a hundred meter wingspan. First flying in 1947, nothing approaching its size was seen for another forty years.



Pictured above is the new OP-80A High Speed Paper Tape Reader from OAE. This unit has no moving parts, will read punched tape as fast as you can pull it through (0-5,000 c.p.s.), and costs **only $74.50 KIT, $95.00 ASSEMBLED & TESTED.** It includes a precision optical sensor array, high speed data buffers, and all required handshake logic to interface with any uP parallel I/O port.

To order, send check or money order (include $2.50 shipping/handling) to Oliver Audio Engineering, 7330 Laurel Canyon Blvd., No. Hollywood, CA 91605, or call our 24 hr. M/C-B/A order line: (213) 874-6463.

During the cold war, when the CIA wanted to recover a sunken Soviet submarine, K-129, they called ol' Howie up. "Howie," they said, "We've gotta keep this real quiet. Don't tell anyone."

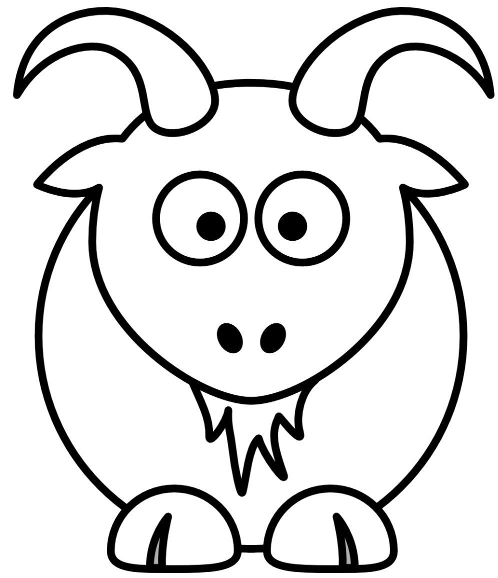
So the next day, Howard Hughes held a press conference! "There are giant blobs of copper on the ocean floor," he lied, "and I'm building a big-ass boat with a big-ass crane to pick them up and drop them on the deck. It'll be so efficient that I'll put the other copper mines out of business."

So while folks were scrambling to invest in his copper company and divest from the real ones, Howie built the Hughes Glomar Explorer. True to his word it was a big-ass boat with a big-ass crane, but instead of picking up copper blobs it lifted that submarine off the ocean floor and dropped it on the deck.

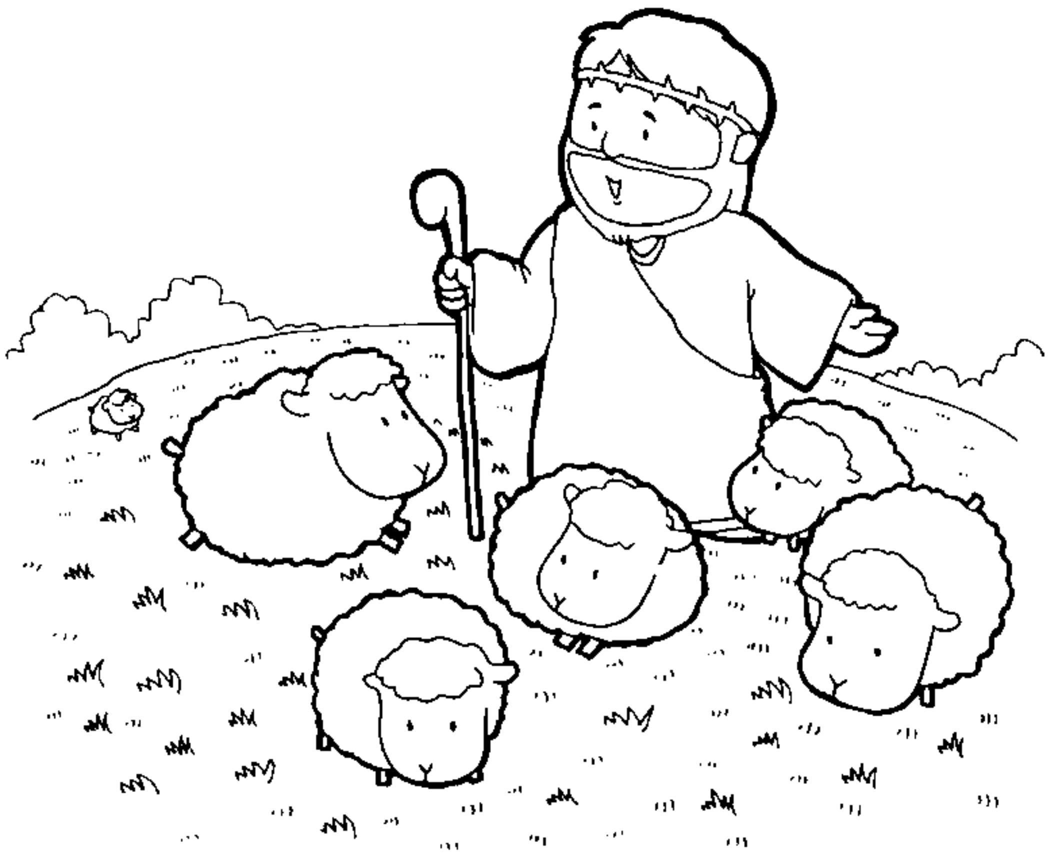
How could he do these things? Because he built his own fucking birdfeeders, that's how.

So when you're tooling around with a from-scratch tool, your own hex editor or interactive disassembler, and your neighbors tell you to use 010 or to use IDA or to use this or use that, do what Noah and Howie would do. Look 'em in the eye and say,

"I'm building my own fucking birdfeeder."



Pastor Laphroaig tells us that when the streams of our computation are unclear,
it's often because the SEO Experts are enjoying their goats upstream.



Pastor Laphroaig says to the SEO Experts,
"Not with my flock!"

3 A PGP Matryoshka Doll

by Brother Myron Aub

Take out your favourite matryoshka doll, neighbour. Now piece by piece, open it until you can open it no longer. Every piece is smaller and closer to the end of the experience, and then—it stops: you can open the smallest piece no more.

But beware, neighbour! Not all matryoshka dolls behave like this. Some matryoshka craftsneighbours are tempted by the devil's lures. They see no farther than the devil's unholy promises of extensibility and compactness when they craft a matryoshka doll that can compress a larger one to fit within it! And our good neighbour Phil Zimmerman fell prey to this lure when designing the PGP doll format.[2]

When you want to send a message, you must first stuff it into a literal doll. You can then enclose that in an encrypted doll, a signed doll, or a compressed doll. How do you assemble these together? However you please! You can put your literal doll inside a signed doll inside an encrypted doll inside a compressed doll. Naturally, ciphertext compresses poorly, so this would be a stupid way to nest a PGP matryoshka doll. Normally you put your literal doll inside a signed doll inside a compressed doll inside an encrypted doll, but you can do it stupidly if you like.

And how do you open a PGP matryoshka doll? Since the sender could have assembled it however they pleased, you must be ready for anything. If you see an encrypted doll, you decrypt it and open the enclosed smaller doll. If you see a signed doll, you verify its signature—throwing it away if it fails to verify—and open the enclosed smaller doll. If you see a literal doll, you're done and you read the message.

But what if you get a compressed doll? You decompress it—and hope there are no vulnerabilities in your system's zlib—but unless some idiot tried to compress ciphertext, the enclosed doll will be *bigger* than the doll you just opened.

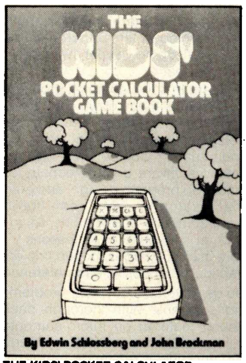
'Surely,' you say, 'if someone assembled a PGP doll for me, it must have a literal doll buried inside it!' But no, my poor, naïve neighbour! There is no rule that all PGP dolls be assembled like that. With the help of our neighbourly neighbour Russ Cox,[3] and with a dab of holy water to dispel the devil's temptations to misuse this black magic, we can craft a voodoo PGP doll from a quine, a self-reproducing program written in the *Lempel-Ziv compression language*, that bites any who naïvely try to open it up.

Our neighbour Tavis Ormandy discovered similar unholiness in IPsec.[4] What other matryoshka dolls can you turn into voodoo dolls, good neighbour?

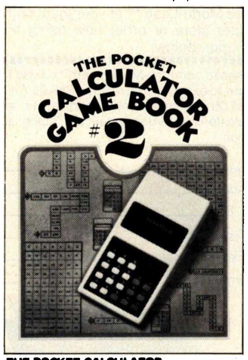
IT ALL ADDS UP TO EDUCATIONAL

FUN

The creators of the original *Pocket Calculator Game Book* now present two fun-filled new game books for use with that incredible machine that has found a place in almost every home


THE KIDS' POCKET CALCULATOR GAME BOOK
By Edwin Schlossberg and John Brockman

THE KIDS' POCKET CALCULATOR GAME BOOK
by Edwin Schlossberg and John Brockman
A quick trip through elementary mathematics—fun and games with real purpose. The first book of its kind for kids from kindergarten through college. Illustrated with line drawings and cartoons
$6.95 hardcover $3.95 paperbound



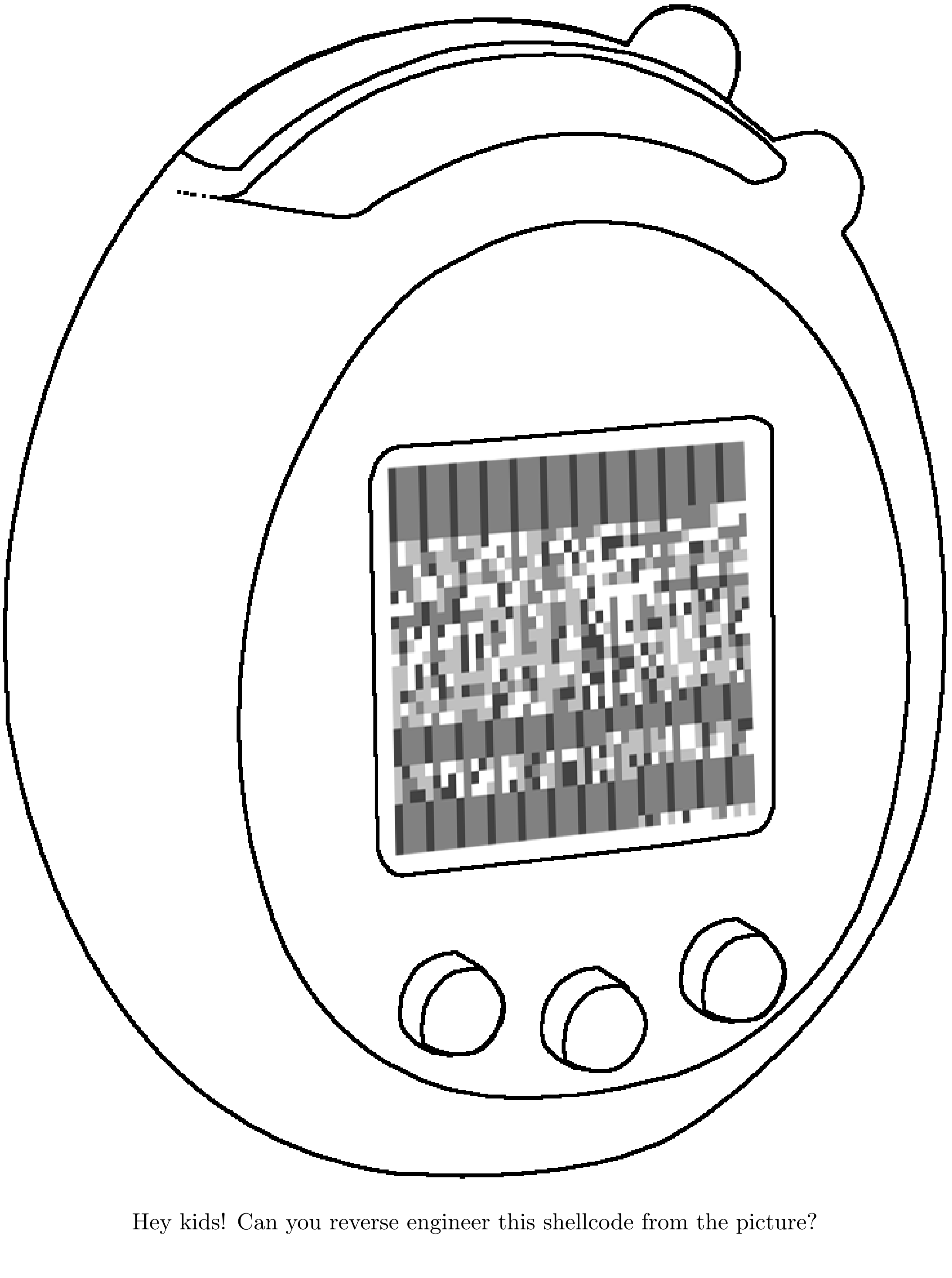
THE POCKET CALCULATOR GAME BOOK #2
by Edwin Schlossberg and John Brockman
Even more popular in approach than its famous predecessor, this book is simpler, more accessible, and its games are more mathematically basic. Illustrated with line drawings and cartoons.
$6.95 hardcover $3.95 paperbound

WILLIAM MORROW

[2]RFC 4880, 'OpenPGP Message Format'

[3]Russ Cox, 'Zip Files All the Way Down', 2010-03-18

[4]Tavis Ormandy, 'BSD derived RFC 3173 IPcomp encapsulation will expand arbitrarily nested payload', CVE-2011-1547, posted to full-disclosure 2011-04-01



Hey kids! Can you reverse engineer this shellcode from the picture?

4 Reliable Code Execution on a Tamagotchi

by Natalie Silvanovich

Tamagotchis are an excellent target for reverse engineering for a number of reasons: They have a limited number of inputs and outputs, they run on a poorly documented 6502 microcontroller and they're, well, Tamagotchis. Recently, I discovered a technique for reliably executing foreign code on a Tamagotchi.

Let's begin at the beginning. Modern Tamagotchis run on a GeneralPlus GPLB52X LCD controller, a lightweight 6502 controller that uses an internal mask ROM for all code and some data. This means that exploitation is necessary to free the Tamagotchi from the shackles of its read-only code. Also, in the absence of any debug outputs, code execution provides valuable insight into the internals of the Tamagotchi and its MCU.

There are four inputs into a Tamagotchi that can be manipulated by the user. (1) The buttons, (2) the EEPROM that saves the Tamagotchi state across resets, (3) the IR interface and (4) certain accessories containing external SPI memory called figures. Attempts to find useful bugs in the EEPROM and IR interface were unsuccessful, so I moved onto the figures. Eventually I found an exploitable bug in how the Tamagotchi processes figure data.

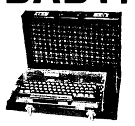
When attached to a Tamagotchi, figures add extra functionality, such as games or items. So attaching a figure might allow your Tamagotchi to play shuffleboard, purchase a vacuum cleaner or attend 30c3. The bug I found was in the processing of game data. Game logic is not actually included in the figure data; rather, the figure provides an index to the game logic in the Tamagotchi's mask ROM.[5] Changing this index causes some very strange behavior. If the index is an expected value, from 0 to about 0x20, a game will be played as expected, but for higher indexes, the device will freeze, requiring a reset. Even stranger, if the index is very high (0xD8 or higher), the Tamagotchi jumps to a different, valid screen, such as feeding the Tamagotchi or giving it a bath, and the Tamagotchi functions normally afterwards. This made me suspect that the game index was used as an index into a jump table and that freezing was due to jumping to an invalid location.

With no way to gain additional information about the cause of the behavior, and about 200 possible vulnerabilities, it made sense to to fill up as much memory as possible up with a NOP sled, try all possible indexes, and hope that one caused a jump to the right location. Unfortunately, the only memory controllable by the figure is the LCD RAM, so I filled that with NOPs and shellcode. (The screen data starts at 0x1C80 in the figure memory, and maps to 0x1000 in the Tamagotchi memory, for people trying this at home.) After several tries and some fiddling the shellcode, index 0xD4 lead to very unreliable code execution. This code execution allowed me to perform a complete ROM dump of the Tamagotchi, which in turn led to the ability to better analyze the bug.

NOT A KIT! BURNED IN

BABY!

FULLY TESTED



Complete System in a case!

KEYBOARD: 62 key upper & lower case + Greek;

TAPE INTERFACE: High speed, 1200 Baud! Cassette, programs included;

VIDEO INTERFACE: E.I.A. Compatible;

MICROPROCESSOR: 6502 based system!

MEMORY: 2K or 4K byte RAM minimum system monitor + 3K ROM sockets;

2K $850.00

S.T.M. SYSTEMS INC.
P.O. Box 248
Mont Vernon, N.H. 03057

4K $1000.00

The following code contains the vulnerability. Please note that the current state (current_state_22) is set from the game index without validation.

```
seg004:4E2E         LDA     byte_1A4
seg004:4E31         BEQ     loc_44E39
seg004:4E33         LDA     gameindex2
seg004:4E36         JMP     loc_44E3C
seg004:4E39         LDA     gameindex1
seg004:4E3C         CLC
seg004:4E3D         ADC     #$27 ;
seg004:4E3F         STA     current_state_22
seg004:4E41         JMP     locret_44E4C
```

[5]The important index is located at address 0x18 in figure memory.

The main Tamagotchi execution loop checks the state based on a timer interrupt, then makes a state transition if the state has changed. The state transition is as follows.

```
ROM:EFE8                LDX     current_state_22
ROM:EFEA                LDA     $F00E,X
ROM:EFED                STA     change_page
ROM:EFF0                STA     current_page
ROM:EFF2                BEQ     loc_F001
ROM:EFF4                LDA     #0
ROM:EFF6                STA     off_34
ROM:EFF8                LDA     #$40 ; '@'
ROM:EFFA                STA     off_34+1
ROM:EFFC                LDA     current_state_22
ROM:EFFE                JMP     (off_34)
```

In essence, the Tamagotchi looks up the page of the state in a table at 0xF00E, then jumps to address 0x4000 in that page. Looking at this code, it is clear why my first exploit was unreliable. 0xD4 + 0xF00E + 0x27 is 0xF109, which resolves to a value of 0x3c. Since the Tamagotchi only has 19 pages, this is an invalid page number. Testing what would happen if the MCU was provided an invalid page, addresses 0x4000 and up resolved to 0xFF.

This means that there are two possibilities of how this exploit works. Either the memory addresses are floating and sometimes end up with values that, when executed, send the instruction pointer to the LCD RAM, or the undefined instruction 0xFF, when executed, puts the instruction pointer into the right place, sometimes. Barring bizarreness beyond my wildest imagination, neither of these possibilities would allow for the exploit to be made more reliable though manipulation of the figure data.

Instead, I looked for a better index to use, which turned out to be 0xCD. 0xCD + 0xF00E + 0x27 is 0xF102, which maps to part of the LCD segment table, which has a value of 4. Jumping to 0x4000 in page 4 immediately indexes into another page table.

CANADIANS!

Eliminate the Customs Hassles. Save Money and get Canadian Warranties on IMSAI and S-100 compatible products.

IMSAI 8080	KIT	$ 838.00
	ASS.	$1163.00

(Can. Duty & Fed. Tax Included).

AUTHORIZED DEALER

Send $1.00 for complete IMSAI Catalog.

We will develop complete application systems.

Contact us for further information.

Rotundra Cybernetics

Box 1448, Calgary, Alta. T2P 2H9

Phone (403) 283-8076

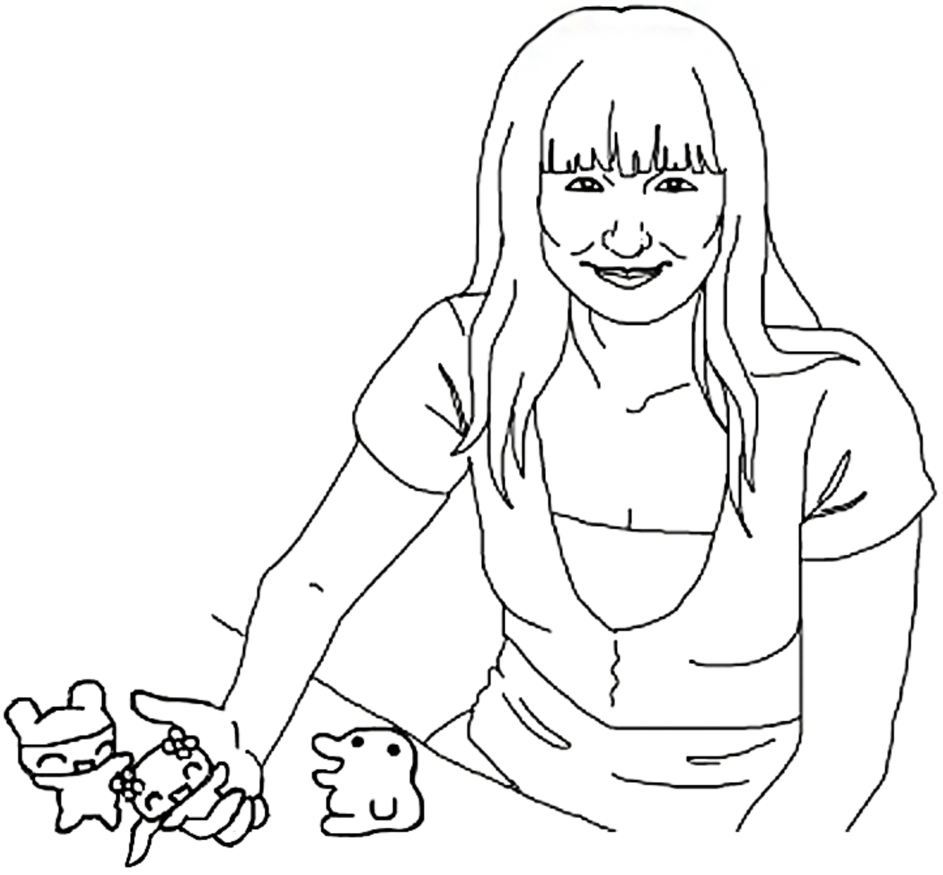
```
seg004:4000                 LDA     #$D
seg004:4002                 STA     $34
seg004:4004                 LDA     #$40 ; '@'
seg004:4006                 STA     $35
seg004:4008                 LDA     $22
seg004:400A                 JMP     jump_into_table_D27F
```

This index is also out of range, and indexes into a code section:

```
seg004:41F5                 INC     $11E
```

Interpreted as a pointer, however, this value is 0x1EEE. The LCD RAM range is from 0x1000 to 0x1200, but fortunately, bits 2-7 of the upper byte of addresses in the 0x1000-0x2000 range are ignored, so reading 0x1EEE returns the value at 0x10EE. This means that playing a game with the index of 0xCD will execute code in the LCD RAM every time!

While reading POC||GTFO obligates you to share a copy with a neighbour, trying this on your own Tamagotchi is only strongly recommended. Further instructions can be found by unzipping the PDF of this issue.



“The ancient teachers of this science promised impossibilities and performed nothing. The modern masters promise very little; they know that metals cannot be transmuted and that the elixir of life is a chimera but these philosophers, whose hands seem only made to dabble in dirt, and their eyes to pore over the microscope or crucible, have indeed performed miracles. They penetrate into the recesses of nature and show how she works in her hiding-places. They ascend into the heavens; they have discovered how the blood circulates, and the nature of the air we breathe. They have acquired new and almost unlimited powers; they can command the thunders of heaven, mimic the earthquake, and even mock the invisible world with its own shadows.” – Shelley 3:16

5 Some Shellcode Tips for MSP430 and Related MCUs

by Travis Goodspeed

Howdy y'all,

I'm writing this to introduce you as an exploiter of desktops and servers to some of the tricks that I've used in writing shellcode for microcontrollers, with examples from the MSP430 in particular. You can try most of these examples on a GoodFET or Facedancer board, and many of them are portable to other embedded targets, such as AVR or the lower-end ARM devices.

5.1 Flash Patching is Weird

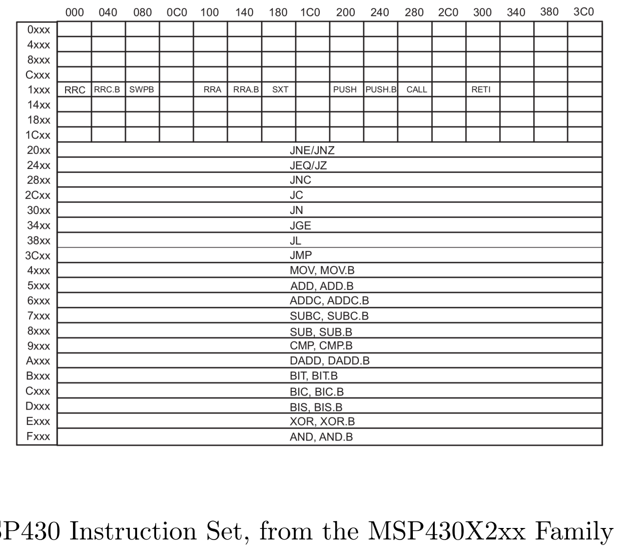
In Unix and Windows, you are used to processes operating within virtual memory. On a microcontroller, they often run directly in physical memory, so the rules are rather different. It helps to take the German approach, learning all of the rules to get away with things that ought to be illegal.

The first difference you'll run into on the MSP430 is that code runs in-place from Flash memory. Flash has some very different rules from RAM, because it's a different technology and a proper programmer knows better than to rely on layers of abstraction.

- Flash is erased to ones as segments or globally, never as bytes or words.
- Flash writes *clear* bits at word granularity, but can't set them.
- Flash writes require a safety password to be written into a register.

Thus, to do a normal write to Flash, an MCU programmer is taught to first disable the Flash write protection and configure the right special-function registers, then erase the entire page, then rewrite the entire page. Many programmers never bother, opting for an external memory chip or relying on battery-backed RAM.

To make smaller changes, there's another option. After disabling Flash, a neighbor could clear individual bits rather than rewriting the entire page. This is handy for regular developers to do what's called EEPROM Emulation, which emulates memory that can be written bytewise, but it's also damned useful when patching code in-place.



	000	040	080	0C0	100	140	180	1C0	200	240	280	2C0	300	340	380	3C0
0xxx																
4xxx																
8xxx																
Cxxx																
1xxx	RRC	RRC.B	SWPB		RRA	RRA.B	SXT		PUSH	PUSH.B	CALL		RETI			
14xx																
18xx																
1Cxx																
20xx	JNE/JNZ															
24xx	JEQ/JZ															
28xx	JNC															
2Cxx	JC															
30xx	JN															
34xx	JGE															
38xx	JL															
3Cxx	JMP															
4xxx	MOV, MOV.B															
5xxx	ADD, ADD.B															
6xxx	ADDC, ADDC.B															
7xxx	SUBC, SUBC.B															
8xxx	SUB, SUB.B															
9xxx	CMP, CMP.B															
Axxx	DADD, DADD.B															
Bxxx	BIT, BIT.B															
Cxxx	BIC, BIC.B															
Dxxx	BIS, BIS.B															
Exxx	XOR, XOR.B															
Fxxx	AND, AND.B															

Figure 1: MSP430 Instruction Set, from the MSP430X2xx Family User's Guide

For example, Figures 1 and 2 show that 0x3Cxx is an unconditional Jump while 0x38xx is a conditional Jump if Less Than instruction. If we overwrite a JMP instruction with 0x3BFF, it will have the effect of bitwise ANDing that instruction with 0x3BFF, changing the 3C opcode to a 38 while retaining the jump offset.

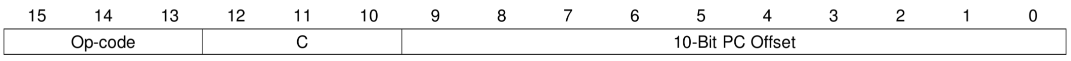


Figure 2: MSP430 Jump Instructions, from the MSP430X2xx Family User's Guide

Since MSP430 instructions are 16-bit word aligned, the 10-bit PC offset is multiplied by two and then added to the program counter. 0x3FFF is an unconditional jump backward by one word, or an unconditional infinite while loop. If you zero-out the offset by overwriting the instruction with 0x3C00, you can turn any jump instruction into a NOP.

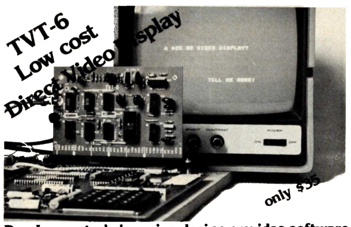
When attacking a poorly protected bootloader, you might find yourself with the ability to write and to checksum, but not to read. If you can write without erasing, then writing all 1's with a single 0 will change the checksum if and only if that bit previously was a 1. Repeating for each bit of Flash is slow, but it might get you a firmware dump.

5.2 Efficient Shellcode

Quite often, the first thing you'll do with shellcode is to dump out the state of the microcontroller being attacked. It's worth studying ways to make that code in as few bytes as possible, as a microcontroller generally processes very small packets and you won't have room for anything fancy.

To quickly dump memory on an architecture that you don't know very well, it helps to have simple code that already has its environment configured. The code should be completely oblivious to timing, and it should access as few structures as possible. It should also be portable, requiring neither knowledge of its position in memory nor knowledge of the specifics of the rest of the device motherboard at compile time.

My solution is to blink the LEDs, half with a clock and half with data, to dump all of the memory to an SPI sniffer. The LEDs that light up with consistent brightness are the clock, while those that sporadically become very bright or very dim are the data. Tapping one of each with my handy Saleae Logic analyzer gives me a firmware dump.



Don Lancaster's ingenius design provides software controllable options including:

- **Scrolling** • **Full performance cursor**
- **Over 2K on-screen characters with only 3MHz bandwidth**
- **Variety of line/character formats including 16/32, 16/64 .... even 32/64**
- **User selectable line lengths**

TELL ME MORE! ( ) Send instruction manual for the TVT-6 Kit with full operational details. $1 enclosed.

( ) SEND FREE CATALOG

Name: ____________

Address: ____________

PAiA ELECTRONICS, INC. City: ________ State: ______ Zip: ____

DEPT. 10–B, 1020 W. WILSHIRE BLVD., OKLAHOMA CITY, OK 73116

5.3 Mask ROMs have Useful Gadgets

In my WOOT '09 paper with Aurélien Francillon, we toyed around with using the MSP430's BSL (BootStrap Loader) ROM to aid in exploiting an unknown executable.[6] That paper concerns exploiting firmware without having a copy, but I'll recount one of its tricks here.

The MSP430 BSL has two entry points. The first is the Hard Entry Point, whose address is always stored at 0x0C00. By twiddling the reset and test pins with proper timing, the chip will boot from this address instead of from the RESET handler in the interrupt table.

The second entry point is called the Soft Entry Point, and it is rather poorly documented. The original idea was that a program could return into the bootloader ROM by branching to the address stored at 0x0C02, with some of the initialization routines skipped. One of these routines is the instruction that initializes the register holding password protection, so by setting or clearing a bit in that register, the calling application can enable or disable password checking.

While the soft entry point is sometimes useful to an MSP430 developer, it's damned useful for an attacker. On an MSP430F1612, my favorite shellcode for dumping firmware is a bit like the following, which assembles to just six bytes of memory.

```
mov #0xFFFF, r11     ;; Disable BSL password protection.
br &0x0c02           ;; Branch to the BSL Soft Entry Point
```

[6]Half-Blind Attacks: Mask ROM Bootloaders are Dangerous, WOOT 2011, Goodspeed and Francillon

5.4 Unused RAM is Not Erased at Reboot

In larger machines, memory which is not used by a process is not mapped into that process's virtual memory. In microcontrollers, it is still accessible, since the code is running with physical rather than virtual memory. Rather than reset every RAM word during a reboot, most microcontrollers simply leave it alone and let the program take care of clearing its values.

Now an MSP430 application is compiled with a view of memory that it sparingly uses. GCC, for example, will allocate code (.text) into Flash from the lowest Flash address in its linker script.

RAM is only used by the compiler for data, never for code, unless the linker script is carefully and intentionally hand-crafted. It is divided into two segments by the linker, .data and .bss. The .data region is initialized by copying the data over from Flash, while the .bss region is initialized to zero through a simple while() loop. This provides us with two nifty tricks.

The first trick is that, given a poor POKE gadget, we can slowly place a large chunk of shellcode into upper regions of RAM. For example, an MSP430F2618 has enough RAM to fit the GoodFET firmware, so a device using that chip could have the GoodFET firmware itself act as second-stage shellcode! Smaller chips, such as the MSP430F2274, could have a Flash driver loaded into unused RAM, with third-stage shellcode written into unused Flash.

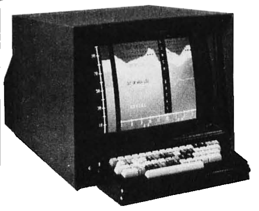
5.5 Where Flash is Protected, RAM is Not

Recalling that unused RAM is never cleared by an application, let's abuse that behavior in a second way.

Back in 2010, Texas Instruments released their ZStack implementation of Zigbee for use with the Smart Energy Profile. I found that the random number generator was crap, and they patched that bug. So how was little ol' me supposed to get more Zigbee Smart Energy Profile keys without a Certicom license?

The remaining vulnerability was a combination of the BSL ROM with the ZStack firmware. ZStack relied upon the BSL ROM and the JTAG fuses to prevent keys and firmware from being read out of the device, but the BSL ROM was only intended to keep *code* from being read out of the device. A second bug in that Zigbee stack was that keys were stored in the .data segment instead of the .text segment, so the firmware would copy the key from Flash into RAM during startup.

As a quick recap, the bootloader requires a password to run most commands, but some are unprotected. Among them are the ones to supply a password and the Mass Erase command, which wipes all of Flash and resets the password, which is stored in Flash, to 32 bytes of 0xFF.



UNBELIEVABLE!!!!!
The Intecolor® 8001 Kit
A Complete 8 COLOR Intelligent CRT Terminal Kit
$1,395

"Complete" Means
- 8080 CPU • 25 Line x 80 Character/Line • 4Kx8 RAM / PROM Software
- Sockets for UV Erasable PROM • 19" Shadow Mask Color CR Tube
- RS232 I/O • Sockets for 64 Special Graphics • Selectable Baud Rates to 9600 Baud • Single Package • 8 Color Monitor • ASCII Set
- Keyboard • Bell • Manual

And you also get the Intecolor® 8001 9 Sector Convergence System for ease of set up (3-5 minutes) and stability.

Additional Options Available:
- Roll • Additional RAM to 32K • 48 Line x 80 Characters/Line • Light Pen
- Limited Graphics Mode • Background Color • Special Graphics Characters
- Games

ISC WILL MAKE A BELIEVER OUT OF YOU.

PE 276

Send me______ (no.) Intecolor® 8001 kits at $1,395 plus $15.00 shipping charges each.
Enclosed is my ☐ cashier's check, ☐ money order, ☐ personal check*
☐ $350 deposit/kit for C.O.D. shipment for $__________
NAME________________________
ADDRESS________________________
CITY____________ STATE______ ZIP________

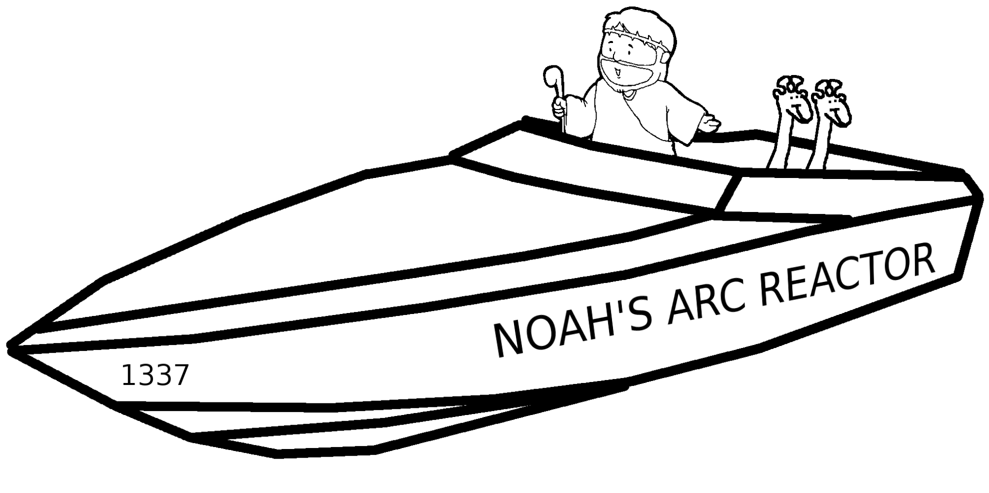
*Allow 8 weeks clearance on personal checks.
Delivery 30-60 days ARO

Intelligent Systems Corp.® 4376 Ridge Gate Drive, Duluth, Georgia 30136
Telephone (404) 449-5961

So to get keys out of locked ZStack devices, I just needed to use the serial bootloader, first sending the command to Mass Erase and then–without losing power–to supply a password of all 0xFF and then to dump all of RAM to disk. A little bit of RAM is overwritten by the BSL's call stack, but only the lowest 32 bytes. Everything else is saved.

— — — —

I hope you find these tricks to be handy. If you'd like to hear more, buy me a nice India Pale Ale.
— Travis



Who would remember Noah if he had just bought a boat from the store?
Build your own fucking birdfeeder.

6 Calling putchar() from an ELF Weird Machine.

by Rebecca .Bx Shapiro

Pastor's Exordium.[7] *Behold the daily miracle of the loader: it takes stored dumb bytes and makes them into a new process or splices them into a running one. The Pharisees may dismiss it as mere engineering, but verily I tell you, long after their textbooks are forgotten the loader and its Phrack exegesis will shine on, for there is more wisdom gathered in its metadata structures than can be found in a dozen OS textbooks.*

Yet there is more! The binary metadata structures consumed by the loader are actually a program *for the loader. A weird machine devotee will readily recognize that these data drive all the actions behind the loader's miracle; they can be thought of as executable bytecode for the loader, which can be thought of as a virtual machine. And just as assembly with all its glorious* `mov`*s,* `add`*s, and* `call`*s is encoded in opcodes and offsets, ABI metadata entries are encoded in types and addends, except that they are split into symbols and relocation structures, residing in different sections of the binary but cross-referenced by their entry numbers in the respective sections.*

In this follow-up to earlier work, Bx shares more nifty tricks of programming the ELF loader with relocation and symbol data as weird assembly. This work is as advanced as it is neighborly, so please read her articles from WOOT 2013 and POC‖GTFO 00:05 to learn how to build a Turing-complete virtual machine out of an ELF loader and how to extend that VM to call native code. In this sermon, Bx shows us how to make system calls from ELF relocation and symbol data; full shellcode is left as an exercise to the faithful! –PML

— — — —

Welcome back, friends. In the first edition of POC‖GTFO, I demonstrated how we can craft ELF relocation metadata to instruct the loader to make libc calls. The method I demonstrated was fairly limited and lacked the ability to do useful things such as control the arguments passed to the called function. Thus I ended the article with an unsolved challenge: *How can metadata control the arguments passed to the metadata-initiated function call?*

In this sermon, I will partially answer that challenge by demonstrating how to control a call to `putchar()` using relocation metadata.

```
PUTCHAR(3)          bx's Programmer's Manual           PUTCHAR(3)

SYNOPSIS
       #include <stdio.h>

       int putchar(int c);

DESCRIPTION
       putchar(c) writes the character c, cast to an unsigned char, to stdout.

RETURN VALUE
       putchar() returns  the character written as an unsigned char cast to
       an int or EOF on error.

       puts() and fputs() return a nonnegative number on success, or EOF on error.
```

One may ask "why focus on `putchar()`?" The answer is simple. Because `putchar()` is required in order to implement a full, honest-to-manul brainfuck-to-ELF metadata compiler. You may have noticed that `putchar()` requires only a single (byte-long) argument and have thought to yourself "I only have control over one argument!? How will that help me take over the world?" Don't worry your pretty little

[7]How is a sermon like a binary file? Both have prescribed parts that follow each other in a conventional order, but may be skipped or used creatively by an extra neighborly preacher. Convention is there to help, but it's the result that matters. So just think of *exordium* as the ELF/ABI header or vice versa and bear with the Preacher as you bear with your binary toolchain! *–PML*

nose off. I will provide insight on how you can control not one, not two, but three (ish) arguments to a function call!

Instead of asking how one can control the first argument to a function call, one should really be asking how can we be the last to set the RDI register (the first argument to a function as heralded by the System V amd64 ABI gospel 3:2:3, aka amd64 calling convention[8]) before our metadata-driven libc function is called.

It turns out that the loader generally processes each relocation entry within a single function, although there are a few exceptions to this rule. This means that, generally speaking, the arguments that are in place during any metadata-driven function call are the arguments that were passed to the currently executing function processing the relocation entries. An exception to this "rule" occurs when relocation entries of type R_X86_64_COPY are processed. These types of relocation entries cause the loader to make a call to memcpy(), thus changing the values of RDI, RSI, RDX, which by convention hold the first three arguments to a function call, and in the case of a call to memcpy(void *dest, const void *src, size_t n) hold dest, src, and size, respectively.

Now imagine that the dynamic loader has been processing our relocation entries and now the next dynamic symbol, pointed to by the next relocation entry r0 to be processed, looks like this:

```
s0 = {..., st_value = &putchar, st_size = 0x0}
```

(Note: We have already shown how to calculate the address of libc functions in past work and will not cover how to do that in this sermon. See our WOOT article and POC||GTFO 00:05 for a thorough explanation.)

The following three relocation entries (represented here as C structs, but of course encoded in a .rel section) will make a call to putchar(), to print the character of our choice:

```
r0 = {r_offset=<&r2->r_addend>, r_symbol=0, r_type=R_X86_64_64,
      r_addend=0x0}
r1 = {r_offset=<char to print>, r_symbol=0, r_type=R_X86_64_COPY,
      r_addend=0x0}
r2 = {r_offset=&r2, r_symbol=0, r_type=R_X86_64_IRELATIVE,
      r_addend=<&putchar (filled in by r0)>}
```

The purpose of r0 is to write the address of putchar() into r2's addend. The purpose of r1 is to setup RDI (the first argument) for r2's function call. When it is processed, memcpy() is called with the following arguments: memcpy(<char to print>, &putchar, 0). More generally, the call to memcpy() looks like: memcpy(r1->r_offset, s0->st_value, s0->st_size).

After r1 is processed, 0 byes are copied from &putchar to <char to print>[9], and RDI=<char to print>, RSI=&putchar, and RDX=0. r2, of type R_X86_64_IRELATIVE, instructs the loader to treat its addend as a function pointer, making a call to it(!). How's that for a relocation-based weird assembly instruction? But, one problem: relocation entries of type IRELATIVE do not support functions that require arguments (meaning that there is no conventional way to pass them). Still, the actual function doesn't care and will happily reach for its arguments in RDI etc.—and, luckily, we were able to set up the arguments via our relocation-entry crafted call to memcpy() via r1! Hence r2 will cause the loader to call putchar(), which will consult RDI to determine what character to print to stdout.

You may see the potential downfalls of manufacturing a call to memcpy() in order to put arguments in place for the following library call. For example, if the third argument is not zero, you need to start worrying about your first two arguments pointing to read/writable memory. However, it may be comforting to know that the value returned by the function call is written into a spot of your choosing (in r2->r_offset).

If you would like to further your studies of metadata-driven library calls, please refer to the **elf-bf-tools** repository on github.[10] May the Great Manul keep and protect you from the Weird Machine. And let us say, amen.

[8]http://www.x86-64.org/documentation/abi.pdf, pages 17-21, Fig. 3.4—and don't ask us in what world RDI, RSI, RDX might stand for A, B, C or suchlike. This program may be brought to you by the register RDI anyhow, but let's just say if the Manul meets the amd64 Big Bird there might be feathers flying.

[9]Note, memcpy would treat it as a destination pointer, but luckily nothing gets copied here, and memcpy implementation isn't paranoid about checking its arguments, since a bad pointer would trap anyway.

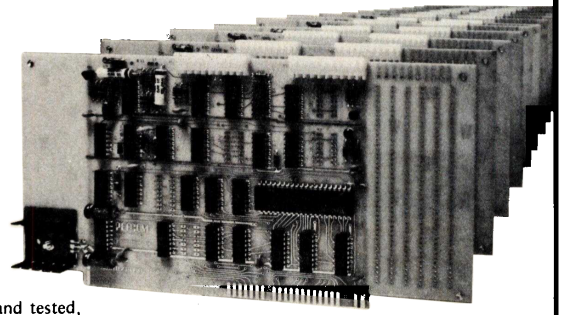
[10]See syscall/putchar in https://github.com/bx/elf-bf-tools .

MULTIPLE DATA RATE INTERFACING FOR YOUR CASSETTE AND RS-232 TERMINAL

the CI-812

The Only S-100 Interface You May Ever Need

On one card, you get dependable "KC-standard"/biphase encoded cassette interfacing at 30, 60, 120, or 240 bytes per second, and full-duplex RS-232 data exchange at 300- to 9600-baud. Kit, including instruction manual, only $89.95*.



PERCOM

PERCOM DATA COMPANY, INC.
4021 WINDSOR • GARLAND, TEXAS 75042
(214) 276-1968

*Assembled and tested, $119.95. Add 5% for shipping. Texas residents add 5% sales tax. BAC/MC available.

PerCom *'peripherals for personal computing'*

```
446 case R_X86_64_IRELATIVE:
447  value = map->l_addr + reloc->r_addend;
448  value = ((Elf64_Addr (*) (void)) value) ();
449  *reloc_addr = value;
450  break;
```

```
429case R_X86_64_COPY:
430  if (sym == NULL)
431    /* This can happen in trace mode if an object could not be (gdb)
432       found.  */
433    break;
434  memcpy (reloc_addr_arg, (void *) value,
435  MIN (sym->st_size, refsym->st_size));
436  if (__builtin_expect (sym->st_size > refsym->st_size, 0)
437      || (__builtin_expect (sym->st_size < refsym->st_size, 0)
438  && GLRO(dl_verbose)))
439    {
  440      fmt = ``\
  441%s: Symbol `%s' has different size in shared object, consider re-linking\n'';
(gdb)
  442      goto print_err;
  443    }
444  break;
445#  endif
```

```
--------------
Breakpoint 6, elf_machine_rela (sym=0x601030, reloc_addr_arg=0x601241, version=<optimized out>,
    reloc=0x601318, map=0x555555773228) at ../sysdeps/x86_64/dl-machine.h:434
    434  memcpy (reloc_addr_arg, (void *) value,
(gdb) print/x *reloc
$6 = {r_offset = 0x601241, r_info = 0x5, r_addend = 0x0}
(gdb) print refsym->st_size
$7 = 0
(gdb) print sym->st_size
$8 = 0
(gdb)
(gdb) print/x reloc_addr_arg
$9 = 0x601241
(gdb) x/gx reloc_addr_arg
    0x601241:0x0000000060103800
(gdb) x/gx value
```

```
    0x7ffff7ce1184:0x011d8b48f8894153
(gdb) print/x $rsi
$5 = 0x7ffff7ce1184
(gdb) print $rdx
$10 = 0

(after memcpy)
(gdb) x/gx 0x601241
    0x601241:0x0000000060103800
(gdb) print/x $rdi
$14 = 0x601241
(gdb) c
Continuing.

Breakpoint 5, elf_machine_rela (sym=0x601030, reloc_addr_arg=0x6012e8, version=<optimized out>,
    reloc=0x601330, map=0x555555773228) at ../sysdeps/x86_64/dl-machine.h:448
    448  value = ((Elf64_Addr (*) (void)) value) ();
(gdb) print/x $rdi
$15 = 0x601241
(gdb) print/x value
$16 = 0x7ffff7ce1184
(gdb) x/10i value
    0x7ffff7ce1184:push   %rbx
    0x7ffff7ce1185:mov    %edi,%r8d
    0x7ffff7ce1188:mov    0x313c01(%rip),%rbx        # 0x7ffff7ff4d90
    0x7ffff7ce118f:mov    (%rbx),%eax
    0x7ffff7ce1191:test   $0x80,%ah
    0x7ffff7ce1194:jne    0x7ffff7ce11ea
    0x7ffff7ce1196:mov    %fs:0x10,%r9
    0x7ffff7ce119f:mov    0x88(%rbx),%rdx
    0x7ffff7ce11a6:cmp    0x8(%rdx),%r9
    0x7ffff7ce11aa:je     0x7ffff7ce11df
(gdb) print/x $rsi
$4 = 0x7ffff7ce1184
```

P.C. cards made simple — with COPYDAT!

1. Prepare the 1X artwork, using an opaque layout aid such as Chartpak, Bishop Graphics, or other similar product.
2. Make a negative: Place the artwork face down, cover with the negative material colored film side up (we recommend Scotchcal products), and expose with the Copydat. Typical exposure time is 1.5 minutes.
3. Develop the negative in developer provided with negative material.
4. Attach negative to pre-sensitized face of copper board. Place board and negative face down on Copydat. Expose. Typical exposure time: 30 seconds.
5. Save the negative for reuse, and develop the board in the developer provided.
6. Etch the board.
7. As a finishing touch, tin the board to avoid oxidation of the copper and to improve solderability.

Result: a custom, high quality, single-sided P.C. board.

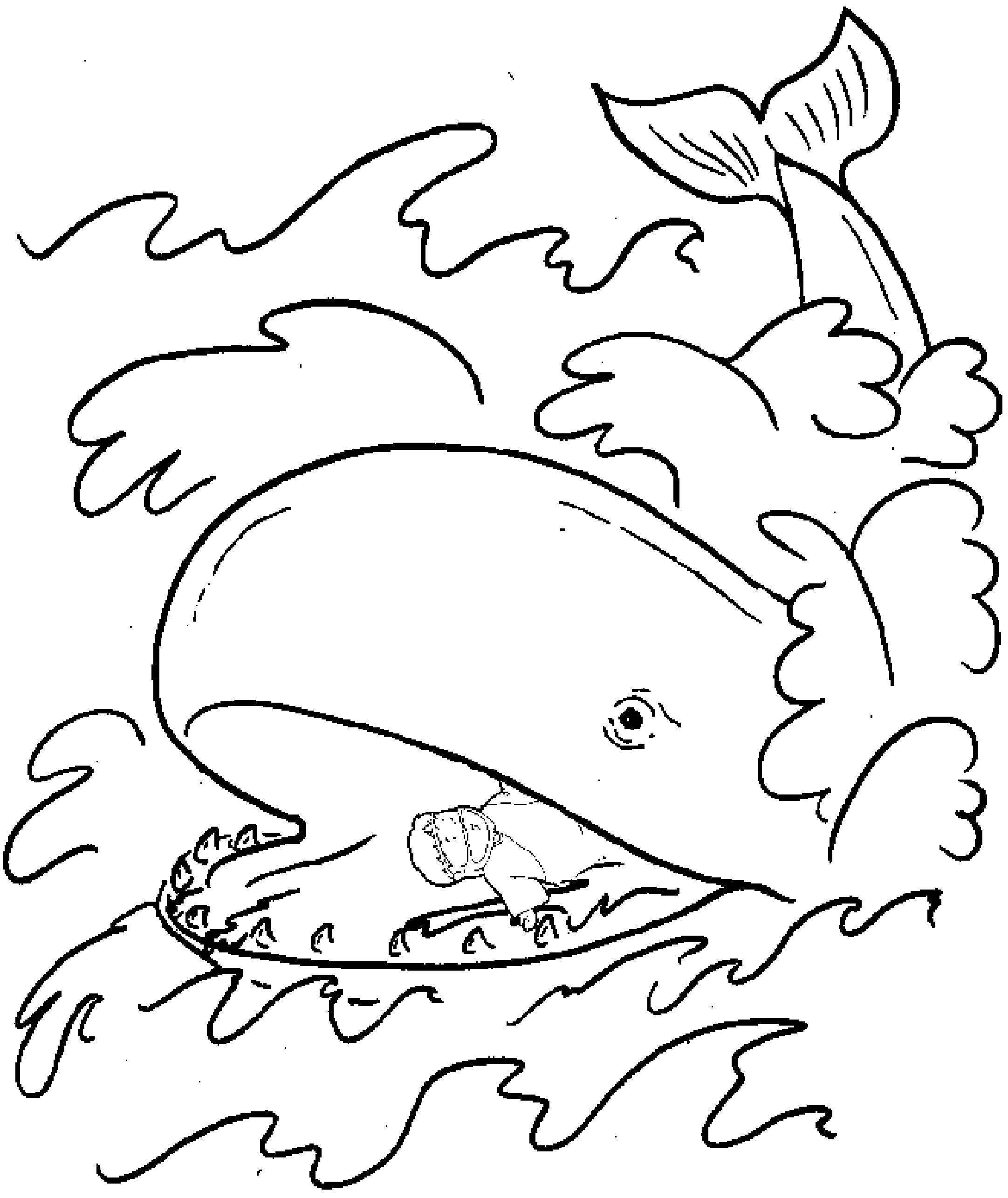
With careful alignment, you can make doublesided boards too!

Alternatively, buy high-quality hardware assemblers from us — and these are predrilled as well (and feature plated-through holes):

P.S. The Copydat does a lot more than make high-quality P.C. boards. It makes superior blueline, blackline, sepia, and other diazo process copies, and you can make pressure-sensitive labels with it and even instrument front panels from pre-sensitized metal plates ! !

from $149.95 (B size prints)

CELDAT Design Assoc.
P.O. Box 752
Amherst, N.H. 03031



Just as Jonah was told to preach in Nineveh,
Pastor Laphroaig was once called to preach to the harlots and tax collectors at RSA.
Asked about the experience, he said that, like Jonah,
he'd rather be thrown overboard than go back.

7 POKE of Death for the TRS 80 Model 100

by Dave Weinstein

In his Epistle on the Divinity of Languages, PoC||GTFO 01:07, Pastor Manul Laphroig wrote of the merits of PEEK and POKE in teaching the youth of a previous generation how to fiddle with hardware in ways the hardware did not want to be fiddled.

And so I offer to you a short example of the wonders of POKE as applied to interrupt handlers.

In 1983, Radio Shack introduced the Model 100, a copy of the Kyocera Kyotronic 85. With its 40 character wide 8-line screen, built-in 300 baud modem, and up to 32k of RAM, it was a state of the art laptop, capable of generating endless questions from passengers and crew on any flight.

In high memory, there is a vector at 0xF5FF, which allows a program to hook the keyboard/clock interrupt. Every 4 ms or so, the timer interrupt fires, and the keyboard is polled. By default, the vector is a simple RET NOP NOP.

As it happens, the very next vector in high memory is a JMP to handle the low-power situation and shut the computer down.

```
0xf5ff          0xc9  (RET)
0xf600          0x00  (NOP)
0xf601          0x00  (NOP)
0xf602          0xc3  (JMP 0x1451)
0xf603          0x31
0xf604          0x14
```

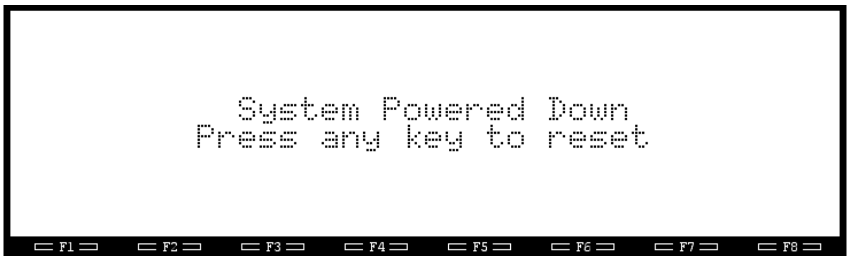
The function at 0x1431 will turn the computer off, as the code flows to the actual shutdown sequence at 0x1451:

```
0x1451          di
0x1452          in 0xba
0x1454          ori 0x10
0x1456          out 0xba
0x1458          hlt
```

Should we replace the RET at 0xF5FF (62975) with a NOP, the Model 100 will power down every time the timer interrupt fires. The only way to restore functionality is to do a cold restart of the machine, which, if I recall correctly, in this case requires removing the batteries, unplugging the machine, and disabling the internal NiCad battery. All of the contents would be lost. For those who do not know what has been done, the computer shows every sign of having simply died.

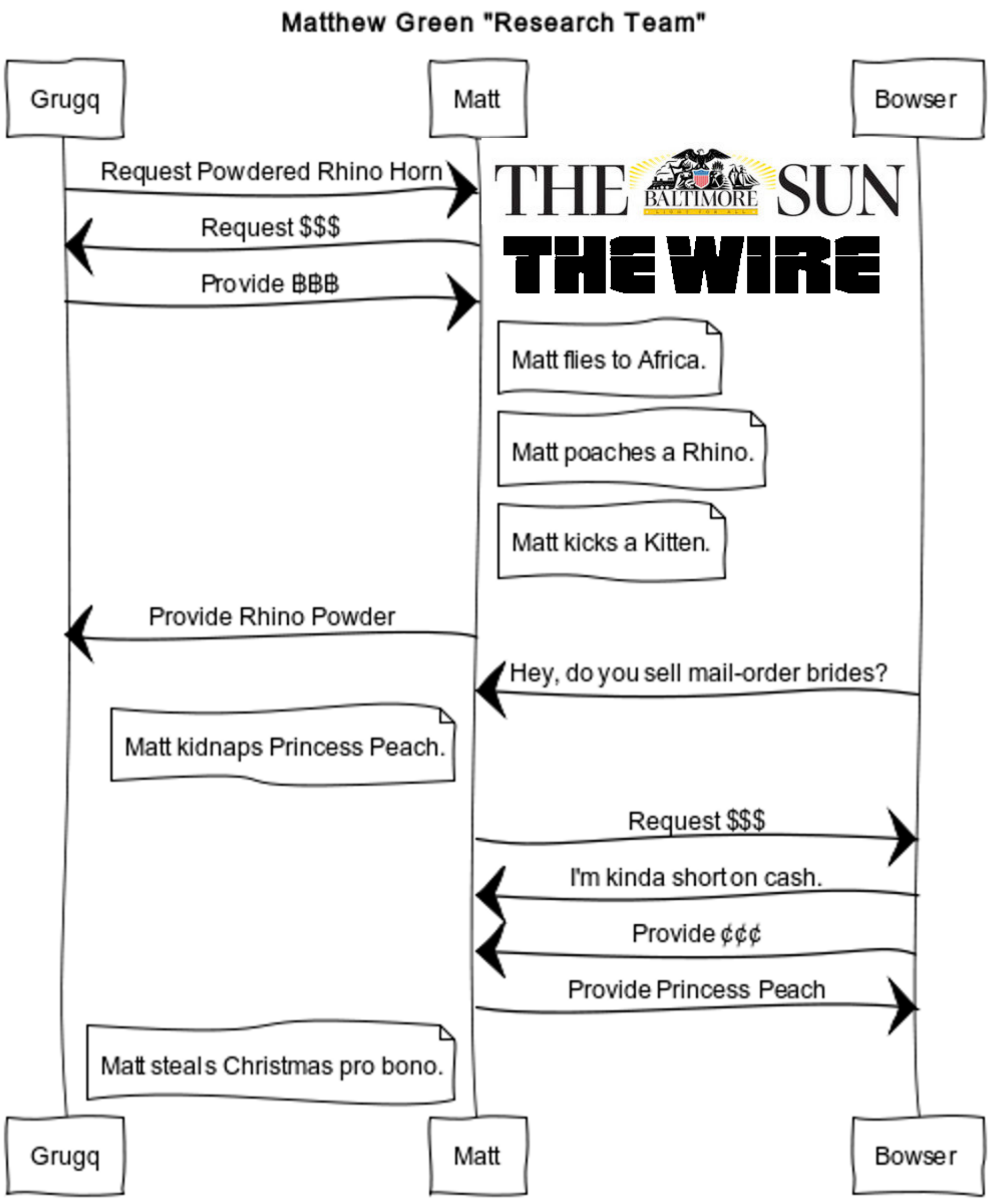
POKE 62975, 0

The only way to prevent it is to prevent access to the BASIC interpreter. Which is possible, but is a discussion for another time.



```
  System Powered Down
Press any key to reset
```

Figure 3: POKE 62975, 0



Pastor Laphroaig tells us that the news is stranger than fiction, because unlike the news, fiction requires an element of truth.

8 This OS is also a PDF

by Ange Albertini

A careful reader may have noticed that a bootable OS image was hidden in the last issue of PoC || GTFO, as one of the files in its dual PDF/ZIP structure (if you haven't, download and extract it now!). This time, though, let's hide it in plain sight. You will find by running 'qemu-system-i386 -fda pocorgtfo02.pdf' that the PDF file you are reading is also a bootable disk image.

8.1 Requirements

To combine two file types, we first need to list the requirements of each format and then produce a single file that meets both sets of requirements with no conflicts.

What makes a bootable disk image? An X86 machine begins booting by copying the first 512 byte sector, the Master Boot Record, into RAM and executing it. The requirements for a functional MBR are simple:

- 16 bit x86 code starts at offset `00`.
- It will be executing at the `0000:7c00` address in RAM.
- It must be 512 bytes long, ending with the signature `55,AA`
- Labels and primary partition tables are optional, but can go within this sector.
- It must contain code that finds and loads into RAM the code for the next boot stage (such as an OS loader).

PDF files are a mixture of text and binary fragments, which are parsed from the start of the file and delimited by words and newlines. The requirements for a valid PDF are also simple and surprisingly flexible:

- It is initially parsed as text.
- The signature "%%PDF-" must be present within the first 1024 bytes. It can be present there twice or more.
- Comment lines begin with '%', which is `25` in hex.
- Binary characters other than CRLF are acceptable in a comment.
- "Multi-line" binary objects or simply larger objects can also be stored in object streams, which are declared like this:

```
<obj number> <revision> obj
<<>>
stream
<stream content>
endstream
endobj
```

8.2 Strategy

In most cases, we can freely prepend anything at the start of the file as long as the above requirements are fulfilled. Luckily, the % comment character is `0x25`, which encodes nicely as an x86 **and** instruction. Thus, the head of the file can be `25FFFF: and ax, 0xffff`, which also starts a PDF comment. We can then add a jump into the next part of the code, which will be stored in a dummy object stream below, and then finish our first line. Adding a PDF signature will prevent any potential problem in case the stream object is too long: it can then contain anything, of any length, as long as it doesn't contain the 'endstream' keyword.

```
; this will encode as '%\xff\xff\xeb\x21', a comment line
and ax, -1
jmp start

%PDF-1.5

999 0 obj
<<>>
stream

code:
...

; put the 55AA signature at the end of the 512 block
times 200h - 2 - ($ - $$) db 0cch
    db 55h, 0aah

endstream
endobj
```

8.3 An Unexpected Challenge

This was almost too easy, but there is a caveat to keep in mind. I'll mention it here to save you the headache when reproducing these results.

This new challenge emerged as I was testing the bootable PDF files with different PDF readers. Since we pre-pend our MBR without altering the contents of the original document, the original's cross-reference table XREF is no longer in sync with the actual file offsets. Technically, this makes the XREF tables corrupted.

Corrupted XREFs are so common that they are usually transparently recovered by all PDF readers, even picky ones such as PDF.JS. However, your pdflatex **may** generate a document based on the optimized PDF 1.5 specification, where the XREF is stored not in cleartext as in PDF 1.4, but rather as a separate, compressed object. This configuration choice is made for the user by the TeX distribution, so even a freshly updated pdflatex install may generate PDF 1.4 documents.

Even when compressed, corrupted XREFs are recovered by some readers, such as GS and Sumatra. Unfortunately, Foxit, Adobe, Firefox, Chrome, and Poppler-based readers—such as Evince and Okular—would reject such a document. Although rejecting corrupted documents out of hand is the best strategy, even Pastor Laphroaig would be pretty pissed if folks couldn't read his epistles because of this.

A simple and elegant workaround that achieves 100% reader compatibility with our MBR PDF is to make sure that, even if your pdflatex distribution generates a 1.5 format document, it doesn't compress the XREF. This is easily done by adding the following command to your LaTeX source.

```
\pdfobjcompresslevel=0
```

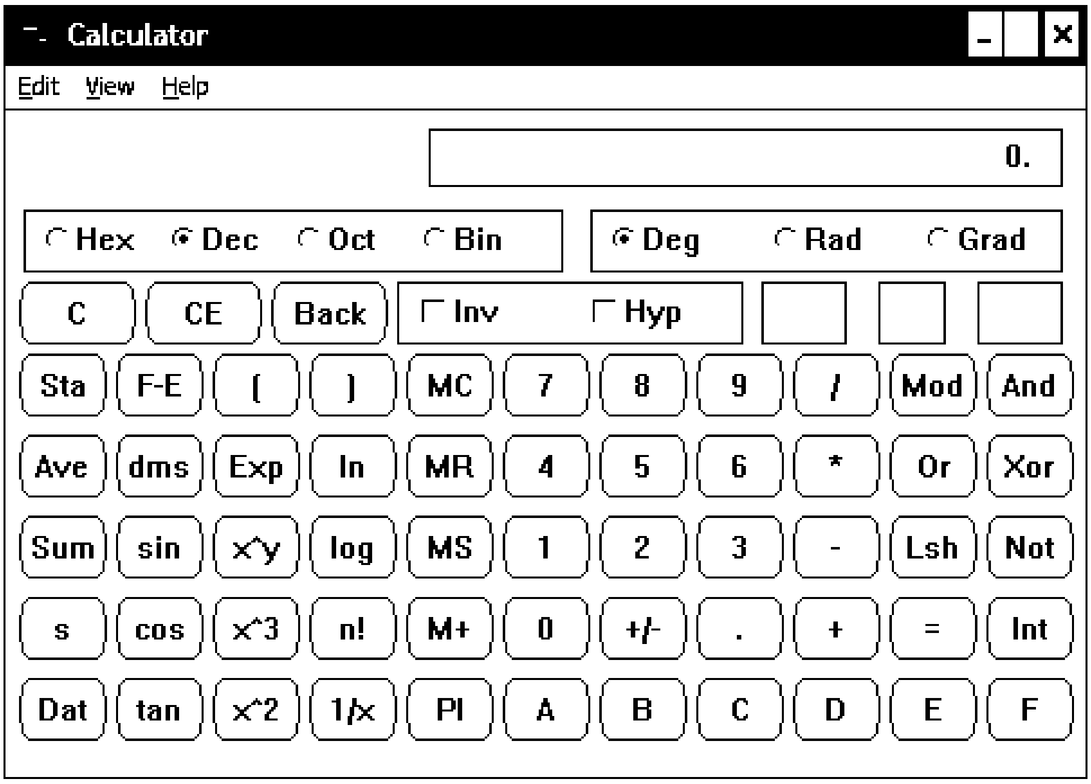
This command will cause pdflatex to store non-objects uncompressed while still taking advantage of other 1.5 features such as reducing document bloat. I should add that, although the fix looks trivial, finding the real cause and the most elegant solution was a challenge.

— — — —

Enjoy booting this PDF, and be sure to share copies—both electronic and paper—so that your neighbors can enjoy it as well!

```
00000000  25 ff ff e9 fc 00 0a 25  50 44 46 2d 31 2e 35 0a  |%......%PDF-1.5.|
00000010  39 39 39 39 20 30 20 6f  62 6a 0a 3c 3c 3e 3e 0a  |9999 0 obj.<<>>.|
00000020  73 74 72 65 61 6d 0a 0a  50 6f 43 20 6f 72 20 47  |stream..PoC or G|
00000030  54 46 4f 20 49 73 73 75  65 20 30 78 30 32 0a 0d  |TFO Issue 0x02..|
00000040  62 79 20 52 74 2e 20 52  76 64 2e 20 50 61 73 74  |by Rt. Rvd. Past|
00000050  6f 72 20 4d 61 6e 75 6c  20 4c 61 70 68 72 6f 61  |or Manul Laphroa|
00000060  69 67 20 61 6e 64 20 46  72 69 65 6e 64 73 0a 0a  |ig and Friends..|
00000070  0d 00 59 6f 75 20 68 61  76 65 20 62 65 65 6e 20  |..You have been |
00000080  65 61 74 65 6e 20 62 79  20 61 20 67 72 75 65 2e  |eaten by a grue.|
00000090  20 20 53 6f 72 72 79 2e  0a 0d 54 72 79 20 74 68  |  Sorry...Try th|
000000a0  69 73 3a 20 71 65 6d 75  2d 73 79 73 74 65 6d 2d  |is: qemu-system-|
000000b0  69 33 38 36 20 2d 66 64  61 20 70 6f 63 6f 72 67  |i386 -fda pocorg|
000000c0  74 66 6f 30 32 2e 70 64  66 0a 0d 00 31 29 20 52  |tfo02.pdf...1) R|
000000d0  65 61 64 69 6e 67 20 6b  65 72 6e 65 6c 20 66 72  |eading kernel fr|
000000e0  6f 6d 20 64 69 73 6b 2e  0a 0d 00 32 29 20 45 78  |om disk....2) Ex|
000000f0  65 63 75 74 69 6e 67 20  6b 65 72 6e 65 6c 2e 0a  |ecuting kernel..|
00000100  0d 00 be 27 7c e8 3e 00  31 c0 8e d8 30 d2 cd 13  |...'|.>.1...0...|
00000110  0f 82 97 00 be cc 7c e8  2c 00 b8 e0 07 8e c0 31  |......|.,......1|
00000120  db b8 10 02 b5 00 b1 02  b6 00 b2 00 cd 13 72 7b  |..............r{|
00000130  b8 00 7e 89 c6 e8 38 00  be eb 7c e8 08 00 ea 00  |..~...8...|.....|
00000140  00 e0 07 e8 65 00 ac 3c  00 74 06 b4 0e cd 10 eb  |....e..<.t......|
00000150  f5 c3 89 c3 c1 e8 0c e8  39 00 89 d8 c1 e8 08 e8  |........9.......|
00000160  31 00 89 d8 c1 e8 04 e8  29 00 89 d8 e8 24 00 c3  |1.......)....$..|
00000170  31 c9 ad e8 dc ff e8 2c  00 83 c1 02 81 f9 00 02  |1......,........|
00000180  75 f0 c3 30 31 32 33 34  35 36 37 38 39 41 42 43  |u..0123456789ABC|
00000190  44 45 46 50 56 83 e0 0f  05 83 7d 89 c6 ac b4 0e  |DEFPV.....}.....|
000001a0  cd 10 5e 58 c3 b8 20 0e  cd 10 c3 be 72 7c e8 95  |..^X.. .....r|..|
000001b0  ff eb fe ea 00 00 ff ff  cc cc cc cc cc cc cc cc  |................|
000001c0  cc cc cc cc cc cc cc cc  cc cc cc cc cc cc cc cc  |................|
000001d0  cc cc cc cc cc cc cc cc  cc cc cc cc cc cc cc cc  |................|
000001e0  cc cc cc cc cc cc cc cc  cc cc cc cc cc cc cc cc  |................|
000001f0  cc cc cc cc cc cc cc cc  cc cc cc cc cc cc 55 aa  |..............U.|
```

Hey kids! Can you color the bytes of this MBR to indicate what's going on?


Calculator
Edit View Help
0.
C CE Back
Inv Hyp
Sta F-E ( ) MC 7 8 9 / Mod And
Ave dms Exp ln MR 4 5 6 * Or Xor
Sum sin x^y log MS 1 2 3 - Lsh Not
s cos x^3 n! M+ 0 +/- . + = Int
Dat tan x^2 1/x PI A B C D E F

Hex [✓ Dec] Oct Bin

[✓ Deg] Rad Grad

CALC.EXE||GTFO

9 A Vulnerability in Reduced Dakarand from PoC||GTFO 01:02

by joernchen of Phenoelit

I'm not a math guy, so this is a poor man's RNG analysis. Try it yourself at home!

9.1 Introduction

In PoC||GTFO 01:02, Dan Kaminsky proposed the following code for use as a Random Number Generator, arguing that the phase difference between a fast clock and a slow clock is sufficient to produce random bits in a high level language. This is a reduced version of his Dakarand program, with the intent of the reduction being that if there is any vulnerability within the code, that vuln ought to be exploitable.

```
// These functions form an RNG.
function millis()          {return Date.now();}
function flip_coin()
  {n=0; then = millis()+1; while(millis()<=then) {n=!n;} return n;}
function get_fair_bit()
  {while(1) {a=flip_coin(); if(a!=flip_coin()) {return(a);}}}
function get_random_byte()
  {n=0; bits=8; while(bits--){n<<=1; n|=get_fair_bit();} return n;}

// Use it like this.
report_console = function() {while(1){console.log(get_random_byte());}}
report_console();
```

Actually the above code boils down to the function flip_coin, which takes a boolean value n=0 and continuously flips it until the next millisecond. The outcome of this repeated flipping shall be a random bit. We neglect the get_fair_bit function mostly in this analysis, as it just slows down the process and adds almost no additional entropy. For gathering random bits we are just left with the clock ticking for us.

9.2 A Naive Analysis

In order to analyze the output of the RNG we need some of its output, so I simply put up a small HTML piece which would pull out 100.000 random bytes out of the above RNG and log it to the HTML document. Then a severe 90-minute DoS on my Firefox 24 happened, after which I managed to copy and paste one hundred thousand uint8_t results into a text file.

After messing with several tools like ministat, sort and uniq I could show with the following ruby script that this RNG (on my machine) has a strong bias towards bytes with low hamming weights:

```
#!/usr/bin/env ruby

f=File.open(ARGV[0])

h = Hash.new
f.each_line do |m|
  n = m.to_i
  if h[n].nil?
    h[n]=1
  else
    h[n] = h[n]+1
  end
end

t = h.sort_by do |k,v| v end
```

CAPTAIN VIDEO

Ideal for communicating with your microprocessor!

RS-232 interface x 32 characters $400
TV/TTY kbd./display (16 lines x 64 characters) $500
Keyboard/CRT Monitor (24 lines x 80 characters) $700

ORDER FORM

Ship To________

Subtotal $____
Calif. residents add sales tax: ____
Please find a check enclosed in the amount of total order: $____

Bill my BankAmericard. exp.
Mastercharge: exp.
My signature as purchaser: date

MICON INDUSTRIES
Micon Industries
252 Oak Street
Oakland, CA 94607
(415) 763-6033

```
t.each do |a|
  puts "Num:\t#{a[0]}"+
       "\tCount:\t#{a[1]}"+
       "\tWeight:\t#{a[0].to_s(2).split("").reject{|j|j=="0"}.count}"
end
```

The shortened output of this script on the 100k 8bit numbers is as follows. Note that the heavy hamming weights, like `11111111` are least common and the light hamming weights, like `00000000` are most common.

Value	Count	Weight
255	22	8
254	23	7
251	28	7
253	29	7
127	32	7
239	34	7
191	34	7
223	36	7
247	37	7
...	...	...
132	1173	2
64	1821	1
32	1881	1
16	1922	1
1	1934	1
8	2000	1
4	2042	1
2	2133	1
128	2145	1
0	3918	0

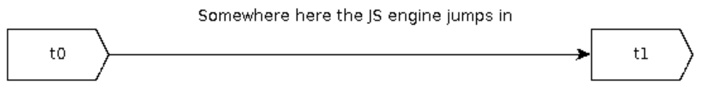
The table lists the Number which is the output of the RNG along with this number's hamming weight as well as the count of this number in total within the 100.000 random bytes. For a random distribution of all possible bytes we could expect roughly a count of 390 for each byte. But as we see, the number 0 with the hamming weight 0 peaks out with a count of 3918, whereas 255 with the hamming weight of 8 is generated 22 times by the RNG. That's not fair!

9.3 My fair bit is not fair!

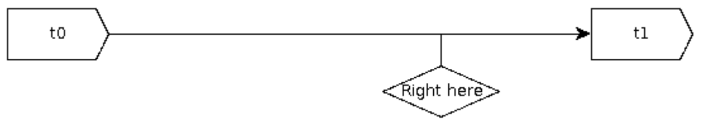
Real statistical analysis of an RNG is hard, and I will not attempt it here. Still, looking at a few simple distributions might give us a hint (alas, only a hint) of what might behind the unfairness.

First, a short recap on how this RNG works:

We've got a 1 millisecond timeslot from t0 to t1, where at t1 the flip_coin method will stop. The first call to get_random_byte can happen anywhere between t0 and t1:



Let's say it is here:



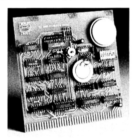
Now the algorithm happily flips the bit until t1 and hands over the result of this flipping as a random bit (note that we're omitting get_fair_bit here).

What is a

CLOCALPEEP?

Another name for the **CCB-II**, which is:

- a clock
  hour, minute, second
- a calendar
  day, day of week, month, year
- an audio alarm



All on one board for your

TRS-80 Model II

It includes a pacemaker battery which will give over 8 years of continuous timekeeping.

From the folks who brought you the best CP/M® for the Model II.

$175 plus shipping

Prepaid, COD, Mastercharge or Visa orders accepted. California residents add 6% sales tax.

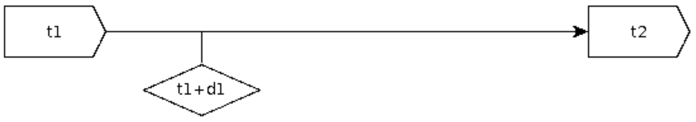
TRS-80 is a trademark of Tandy Corp.
CP/M is a registered trademark of Digital Research Inc.

PICKLES & TROUT

PICKLES & TROUT
P.O. BOX 1206, GOLETA, CA 93116, (805) 967-9563

Warning: Installation requires opening the Model II, which may void its warranty. We suggest that you wait until the warranty period has expired before installing the CCB-II.

Although we cannot predict the output of a single run of flip_coin, things get a bit more predictable when we make a lot of consecutive calls to flip_coin. Let's say we need the time d to process and store the result of flip_coin. So the next time we flip_coin we are at t1 + d1:



Now the RNG flips the coin until t2 in order to give us a random bit. As we are calling the RNG more than twice in a row, the next flip_coin is at t2+d2, and so on.

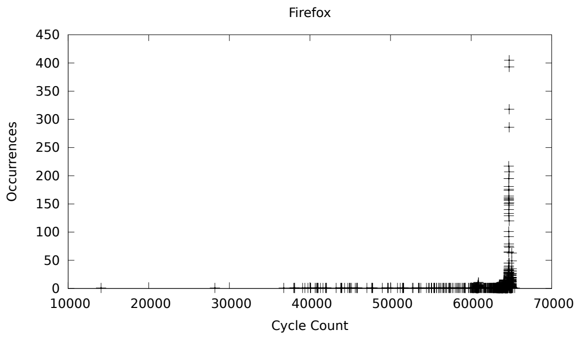
The randomness and fairness of the RNG's random bit depends on how fairly and randomly we get odd and even values of d, since that the same amount of flips yields the same bit as we have a static start value of 0/false.[11] So it makes sense to look at the distribution of d. To visualize this and to compare it with another browser I came up with this slight modification of the RNG that counts the flips and records them right inside the HTML page:

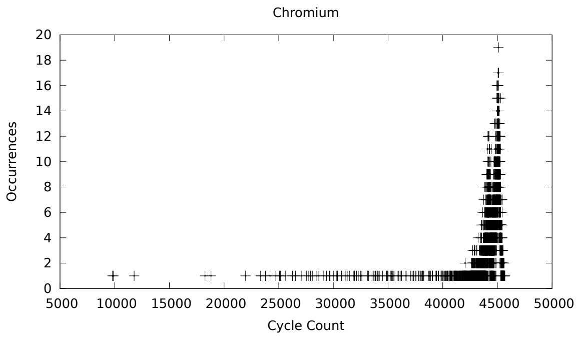
```
function flip_coin()
{i=0;n=0; then=millis()+1; while(millis()<=then) {n=!n;i++} return [n,i];}

function get_fair_bit()
{while(1) {a=flip_coin(); if(a[0]!=flip_coin()[0]) {return(a);}}}

function doit(){
  var i = 10000;
  while(i--){
    var d = document.getElementById(''target'');
    var content = document.createTextNode( get_fair_bit().toString() + ''\n'');
    d.appendChild(content);
  }
}
```

Loading the page in Chromium and Firefox and throwing them into gnuplot, we get:





We can see that the graph for Chromium has a lot more variance in the number of coin flip within a millisecond than that for Firefox. Although, strictly speaking, it might still be possible to get good randomness with poor variance if the few frequent values were to alternate just so due to some underlying scheduling magic, it seems reasonable to expect that the same magic would also increase the variance in the flip numbers.

We can also see, with the help of simple UNIX tools, that Chromium counts do not peak out to a certain value, unlike those of Firefox:

[11]The second coin flip in get_fair_bit complicates it a bit, but it cannot substantially improve the RNG's entropy if it lacks in the first place.

```
$ sort iter_Firefox|uniq -c|sort -n
...
    176 64683
    181 64671
    195 64673
    195 64684
    207 64717
    217 64672
    286 64718
    318 64721
    393 64719
    405 64720
```

vs.

```
$ sort iter_Chromium|uniq -c|sort -n
...
     15 45147
     15 45282
     16 44947
     16 45004
     16 45010
     16 45076
     16 45086
     17 45059
     17 45107
     19 45092
```

9.4 Closing words

In conclusion we see that in Firefox under stress Dan's RNG appears to fail at exactly the point he wanted to use as the main source of randomness. The tiny clock differentials used to gather the entropy are not given often enough in Firefox. There is still much room to stress this RNG implementation. Bonus rounds would include figuring exactly what the significant difference between the Firefox and Chromium JavaScript runtime is that causes this malfunction on Firefox. Also attacks on other JavaScript runtimes would be interesting to see. It might even be the case that this implementation has different results under different conditions with respect to CPU load.

A broader question occurs: The Dakarand RNG relies on what could be called a "code clock." It may be that in many kinds of environments stressed code clocks tend to go into phase with one another. *Driven by stress to seek comfort in each other's rhythms, their chance encounters may grow into something more close and intimate, grinding into periodic patterns. Which, of course, is bad for randomness. Can we learn to tell such environments from others, where periodization with stress doesn't happen?* –PML

MODEL CC-7 SPECIFICATIONS:

A. Recording Mode: Tape saturation binary. This is not an FSK or Home type recorder. **No voice capability. No Modem. (NRZ)**

B. Two channels (1) Clock, (2) Data. OR, Two data channels providing four (4) tracks on the cassette. **Can also be used for Bi-Phase, Manchester codes etc.**

C. Inputs: Two (2). Will accept TTY, TTL or RS 232 digital.

D. Outputs: Two (2). Board changeable from RS 232 to TTY or TTL digital.

E. Runs at 2400 baud or less. Synchronous or **Asynchronous. Runs at 4800 baud or less. Synchronous or Asynchronous. Runs at 3.1"/sec. Speed regulation $\pm$ .5%**

F. Compatability: Will interface any computer or terminal with a serial I/O. (Altair, Sphere, M6800, PDP8, LSI 11, IMSAI, etc.

G. Other Data: (110-220 V), (50-60 Hz); 3 Watts total; UL listed 955D; three wire line cord; on/off switch; audio, meter and light operation monitors. Remote control of motor optional. Four foot, seven conductor remoting cable provided. Uses high grade audio cassettes.

H. Warrantee: 90 days. All units tested at 300 and 2400 baud before shipment. Test cassette with 8080 software program included. This cassette was recorded and played back during quality control.

ALSO AVAILABLE: MODEL CC-7A with variable speed motor. Uses electronic speed control at 4"/sec. or less. **Regulation $\pm$ .2%**
Runs at 4800 baud Synchronous or Asynchronous without external circuitry.
Recommended for quantity users who exchange tapes. Comes with speed adjusting tape to set exact speed.

DIGITAL DATA RECORDER $149.95
FOR COMPUTER or TELETYPE USE
Any baud rate up to 4800

Uses the industry standard tape saturation method to beat all FSK systems ten to one. No modems or FSK decoders required. Loads 8K of memory in 17 seconds. This recorder, using high grade audio cassettes, enables you to back up your computer by loading and dumping programs and data fast as you go, thus enabling you to get by with less memory. Can be software controlled.

Model CC7 . . . $149.95
Model CC7A . . . $169.95

NATIONAL multiplex
CORPORATION

NEW – 8080 I/O BOARD with ROM.
Permanent Relief from "Bootstrap Chafing"

This is our new "turnkey" board. Turn on your Altair or Imsai and go (No Bootstrapping). Controls one terminal (CRT or TTY) and one or two cassettes with all programs in ROM. Enables you to turn on and just type in what you want done. Loads, Dumps, Examines, Modifies from the keyboard in Hex. Loads Octal. For the cassettes, it is a fully software controlled Load and Dump at the touch of a key. Even loads MITS Basic. Ends "Bootstrap Chafe" forever. Uses 512 bytes of ROM, one UART for the terminal and one USART for the Cassettes. Our orders are backing up on this one. No. 2SIO (R)

Kit form $140. – Fully assembled and tested $170.00

Send Two Dollars for Cassette Operating and Maintenance Manual with Schematics and Software control data for 8080 and 6800. Includes Manual on I/O board above. Postpaid

Master Charge & BankAmericard accepted.

On orders for Recorders and Kits please add $2.00 for Shipping & Handling.
(N.J. Residents add 5% Sales Tax)

3474 Rand Avenue, Box 288
South Plainfield, New Jersey 07080
(201) 561-3600

This page intentionally left blank.
Draw your own damned picture.

10 Juggernauty

by Ben Nagy

‘Twas UMBRA, and the STUNT WORMS
Did ZARF and CIMBRI in the SUEDE:
All GUPY were the PUZZLECUBES,
And the DIRESCALLOP AQUACADE.
“Beware the JUGGERNAUT, my son!
The RONIN bytes, the IMSI catch!
Beware the TUSKATTIRE, and shun
EGOTISTICAL GIRAFFE!”

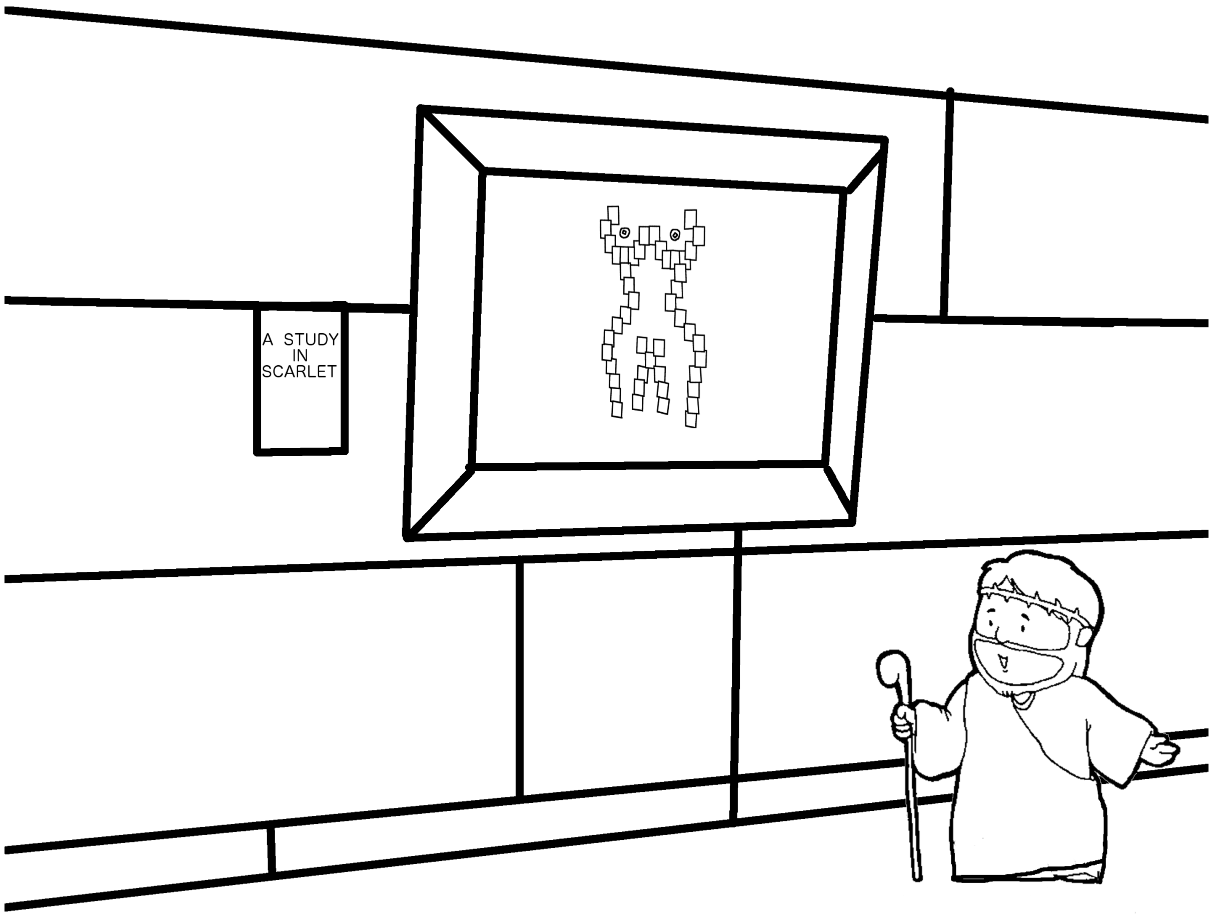
He brought his FERRET CANNON forth:
yet SKOPE he not the RUTLEY spoor —
So browsed he to an onion,
And surfed awhile in Tor.

And, as in BOOTY Tor he surfed,
The JUGGERNAUT, with eyes of FLAME,
Leapt from the EVOLVED MUTANT BROTH,
with DISHFIRE as it came!

One, two! One, two! And through and through
The FERRET CANNON’s furred attack!
He left it dead, and with its LED
He rode his QUICK ANT back.

“And, has thou slain the JUGGERNAUT?
Come to my arms, my DANGERMOUSE!
OLYMPIC day! MESSIAH! MORAY!”
He TALKQUICK in his joy.

‘Twas UMBRA, and the STUNT WORMS
Did ZARF and CIMBRI in the SUEDE;
All GUPY were the PUZZLECUBES,
And the DIRESCALLOP AQUACADE.



"He that is without sin among you,
let him first cast a stone at her."

11 A Call for PoC

by Rt. Revd. Pastor Manul Laphroaig

We stand, sit, or simply relax and chill on the shoulders of the giants, *Phrack* and *Uninformed.* They pushed the state-of-the-art forward mightily with awesome, deep papers and at times even with poetry to match. And when a single step carries you forward by a measure of academic years, it's OK to move slowly.

But for the rest of us dwarves, running around or lounging on those broad shoulders can be so much fun! A hot PoC is fun to toss to a neighbor, and who knows what some neighbor will cook up with it for the shared roast of the vuln-beast? A neighbor might think, "my PoC is unexploitable" or "it is too simple," but verily I tell you, one neighbor's PoC is the missing cog for another neighbor's 0day. How much PoC is hoarded and lies idle while its matching piece of PoC wastes away in another hoard? Let's find out!

11.1 Author guidelines

Do this: Write an email telling our editors how to do reproduce *ONE* clever, technical trick from your research.

Like an email, keep it short. Like an email, you should assume that we already know more than a bit about hacking, and that we'll be insulted or—WORSE!—that we'll be bored if you include a long tutorial where a quick reminder would do. Don't try to make it thorough or broad.

Do pick one quick, clever low-level trick and explain it in a few pages. Teach me how to implement Dakarand in a 512-byte boot sector; teach me how to compose shellcode in Korean characters; or, teach me how to patch Natalie's Tamagotchi shellcode with nothing but `MSPAINT.EXE`. Don't tell me that it's possible; rather, teach me how to do it myself with the absolute minimum of formality and bullshit.

Like an email, I expect informal (or faux-biblical) language and hand-sketched diagrams. Write it in a single sitting, and leave any editing for our poor bastard of an editor to apply to later drafts. Send this to pastor@phrack.org and hope that the neighborly Phrack folks—praise be to them!—aren't man-in-the-middling our submission process.

11.2 Other Departments

Editor at Large	Rt. Revd. Pastor M.L.
Dept. of Bringing APT Home	Cultural attaché of the 41st Directorate
Dept. of Funky File Formats	Ange Albertini
Dept. of Fail	FX of Phenoelit
Ethics Board	The Grugq
Dept. of Busting BS	pipacs
Poet Laureate	Ben Nagy
Dept. of Drama	Xbf
Dept. of PHY	Michael Ossmann