OpenLI: What Network Operators Need to Know

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NZNOG 2019

Agenda

- What OpenLI is and what it is not
- Architectural Overview
- Example integration of OpenLI into a real network (Dave)
- Installing OpenLI packages for Debian / Ubuntu
- Configuring OpenLI
- Running the OpenLI services
- Checking that OpenLI is working
- Gotchas to be wary of when using OpenLI
- Installing and running OpenLI from source
- Installing and configuring DPDK
- Using DPDK with OpenLI
- Future development of OpenLI
- Q & A, discussions, etc.

What is OpenLI?

- Software that can help operators meet LI obligations
  - Written in NZ, specifically for TICSA
  - ETSI format is widely used elsewhere, though

openLI

What is OpenLI?

- Open source, licensed under GPLv3
  - Free, even for commercial use
  - Source code is available, modify as needed
  - Written in C
  - On GitHub

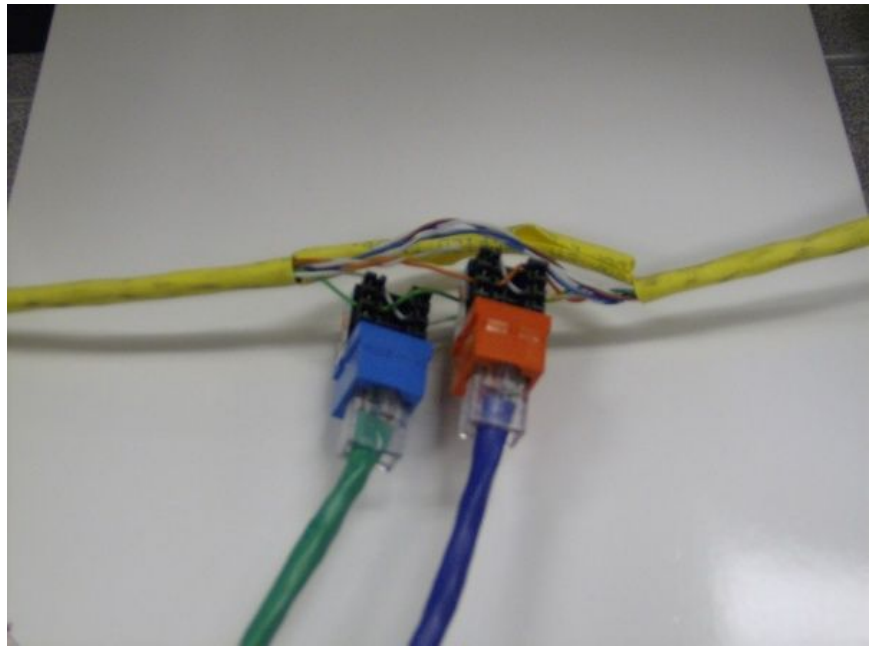
https://github.com/wanduow/openli

What is OpenLI?

- Designed to run on x86 Linux boxes
  - Install OpenLI boxes alongside your regular kit
  - Choose your own hardware
  - Affordable!

What is OpenLI?

- Entirely passive
  - Mirror interceptable traffic into OpenLI boxes
    - This is *your* responsibility!



What OpenLI is NOT

- An automatic solution to all your TICSA problems!
  - Some integration effort is required
  - Testing with NZP will still be necessary

What OpenLI is NOT

- Capable of configuring other devices in your network
  - You are in charge of mirroring traffic to OpenLI
  - Some mirrors may need to be dynamic
    - Only mirror traffic for intercept targets

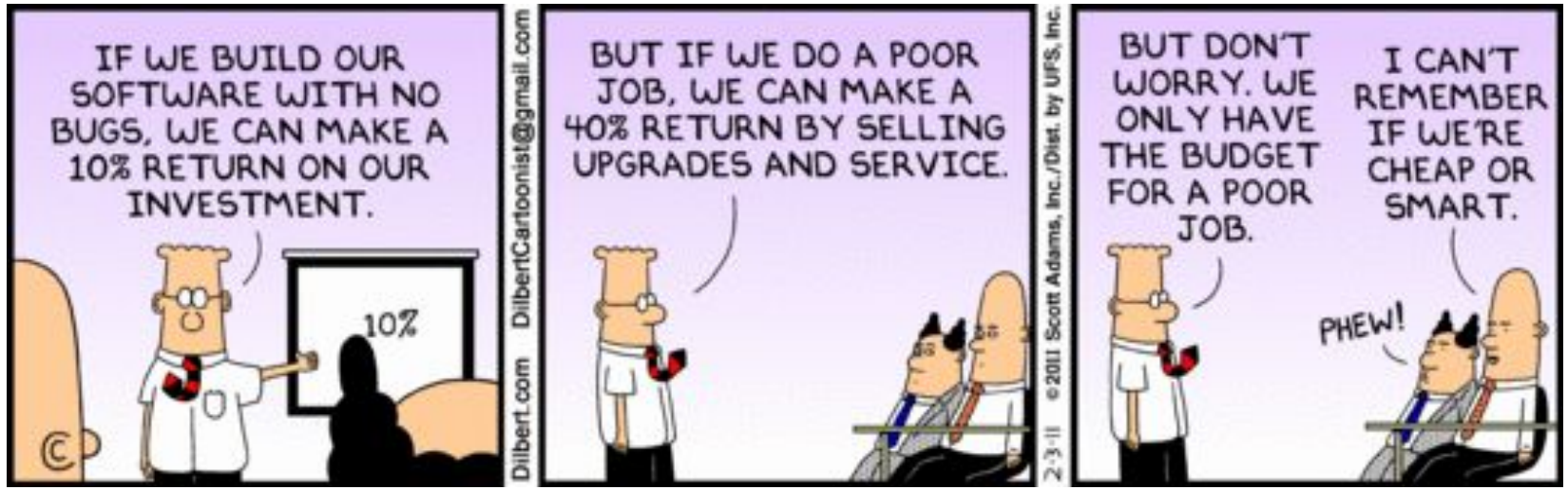
- Secure communication with the LEAs
  - An IPSec tunnel to NZ Police == your job

What OpenLI is NOT

- An opportunity to turn your LI into my problem
  - There's no 24/7 helpdesk for OpenLI
  - You need to be able to troubleshoot OpenLI
  - I'm happy to help out, but it will be "best-effort"
  - You get what you pay for

What OpenLI is NOT

- Perfect (yet?)
  - It's still early days
  - There will be bugs, incompatibilities, etc.
  - Be patient
  - Be nice to me and I'll be good to you ;)



Overview of the OpenLI Architecture

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Warrant

Config

OpenLI Provisioner

Forwarding Instructions

Intercept Instructions

OpenLI Mediator

OpenLI Collector

Packets

Interception Point

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OpenLI Mediator

OpenLI Collector

OpenLI Collector

Encoded Packets

Provisioner

- Centralised management of OpenLI components
  - Sole interface for interacting with OpenLI

- Low workload
  - Could run on a VM or alongside other services

- Currently configured by hand
  - Use signals to reload modified configuration

Mediator

- Forward encoded IRIs and CCs to LEAs
  - Only component that needs external access
  - All outgoing comms over an encrypted tunnel

- Connections to LEAs are always up and maintained
  - Keep alives (both TCP and application level)

- Multiple mediators are supported
  - Most deployments only need one

Collector

- Workhorse component
  - One per interception location (e.g. BNG)

- Mirror your interceptable traffic into collectors
  - Can read from multiple interfaces

- Internals are quite complex
  - A lot of parallelism going on
  - Session tracking for IP customers, VOIP calls
  - Spread workload to avoid bottlenecks

Collector

- Collector hardware
  - Each collector should be a dedicated x86 box
  - Linux (Debian recommended)
  - CPU: 8 virtual cores (more is definitely better)
  - RAM: at least 16 GB
  - NICs:
    - 10G DPDK-compatible card for IP intercept
    - 1 interface reserved for management
    - Additional 1G ports for RADIUS, SIP, RTP, etc.

Collector

- Dave's collector hardware: Lenovo x3550 M5

x3550 M5 Base Chassis 8x2.5(Standard)
Intel Xeon Processor E5-2609 v4 **8C** 1.7GHz 20MB Cache 1866MHz 85W (Standard)
16GB TruDDR4 Memory (2Rx4, 1.2V) PC4-19200 CL17 2400MHz LP RDIMM (Standard)
System x3550 M5 4x 2.5" HS HDD Kit (Standard)
ServeRAID M1215 SAS/SATA Controller(Standard)
System x3550 M5 PCIe Riser 1 (1x ML2 x16 CPU0)
Intel X710-DA2 ML2 2x10GbE SFP+ Adapter
System x 900W High Efficiency Platinum AC Power Supply
4 onboard GE NICs using Broadcom NetXtreme GE controllers.

Collector

- Traffic to mirror into a collector
  - IP customer traffic
    - Preferably just traffic for intercept targets!
  - RADIUS traffic for all customers at the location
    - Static IP assignment is a special case
  - SIP traffic for all VOIP customers
  - RTP traffic for all VOIP customers

Mirroring Options

- Buy a flow tap license from your BNG vendor
  - Easiest (?) but also most expensive

- Modify target's traffic flow using a RADIUS CoA (or similar)
  - Only do this for target IP traffic

- Customise your BNG in some other way

Hands On (optional)

- Virtual machines
  - openli-vm-blank-mediator
  - openli-vm-blank-collector
  - Login username: `openli` password: `tutorial`

- Dockerfiles
  - Download from https://bit.ly/2LS5WZD

Hands On (optional)

- VMs will require some network configuration
  - Two interfaces: one NAT, one “internal” network
  - Edit `/etc/network/interfaces`
    - First interface should be “auto <name> inet dhcp”
    - Second interface should be set to a static IP
    - Static IPs for both VMs should be on the same subnet
  - Restart networking
    - `sudo service networking restart`

Hands On (optional)

- Docker users
  - README should contain all the instructions you need...

OpenLI Packages

- Packaged for Debian / Ubuntu
  - Packages are “unofficial”, hosted by WAND and Bintray
  - Support stable / oldstable releases

- Highly recommended
  - Installing and updating will be much easier

OpenLI Packages

- Adding the WAND and OpenLI bintray repos to your apt sources

```
sudo apt-get install apt-transport-https curl

echo "deb https://dl.bintray.com/wand/general $(lsb_release -sc) \
  main" | sudo tee -a /etc/apt/sources.list.d/wand.list

echo "deb https://dl.bintray.com/wand/libtrace $(lsb_release -sc) \
  main" | sudo tee -a /etc/apt/sources.list.d/wand.list

echo "deb https://dl.bintray.com/wand/OpenLI $(lsb_release -sc) \
  main" | sudo tee -a /etc/apt/sources.list.d/wand.list

sudo curl https://packages.wand.net.nz/keyring.gpg -o \
  /etc/apt/trusted.gpg.d/wand.gpg

sudo apt-get update
```

OpenLI Packages

- Adding the WAND and OpenLI bintray repos to your apt sources

https://bit.ly/2RT1M97

OpenLI Packages

- Installing the provisioner

```
sudo apt-get install openli-provisioner
```

OpenLI Packages

- Installing the collector

```
sudo apt-get install openli-collector
```

OpenLI Packages

- Installing the mediator

```
sudo apt-get install openli-mediator
```

Configuring OpenLI

- Configuration files for OpenLI (packaged version)

```
/etc/openli/provisioner-config.yaml

/etc/openli/collector-config.yaml

/etc/openli/mediator-config.yaml
```

Configuring OpenLI

- Configuration format is YAML

```
# comments look like this
key: value

list_of_items:
 - listitem1
 - listitem2
 - listitem3

list_of_complex_items:
 - key_a: value_a_for_item1
   key_b: value_b_for_item1
   key_c: value_c_for_item1

 - key_a: value_a_for_item2
   key_b: value_b_for_item2
   key_c: value_c_for_item2
```

Configuring OpenLI

- Starting with the provisioner
  - `/etc/openli/provisioner-example.config`

https://bit.ly/2Pj4mA5

Configuring OpenLI

```
# Listen for incoming collectors on 10.0.0.1:9001
clientaddr: 10.0.0.1
clientport: 9001

# Listen for incoming mediators on 10.0.0.1:12001
mediationaddr: 10.0.0.1
mediationport: 12001
```

Configuring OpenLI

```
# List of SIP servers on our network
sipservers:
  - ip: 192.168.110.100
    port: 5060

# List of RADIUS servers on our network
# NOTE that we have an entry for both Auth and Accounting
radiusservers:
  - ip: 10.199.0.253
    port: 1812
  - ip: 10.199.0.253
    port: 1813
```

Configuring OpenLI

```
# List the set of law enforcement agencies
agencies:
 - agencyid: "Police"
   hi2address: 192.168.200.1
   hi2port: 35530
   hi3address: 192.168.200.1
   hi3port: 35531
   keepalivefreq: 300
   keepalivewait: 30
```

Configuring OpenLI

```
# List of active VOIP intercepts
voipintercepts:

  - liid: 1A23RD112
    authcountrycode: NZ
    deliverycountrycode: NZ
    mediator: 6001
    agencyid: "Police"
    siptargets:
      - username: 078384466
        realm: myisp.co.nz

      - username: xyzzy
```

Configuring OpenLI

```
# List of active IP intercepts
ipintercepts:

  # Target identified by username
  - liid: LP45NNST3
    authcountrycode: NZ
    deliverycountrycode: NZ
    mediator: 6001
    agencyid: "Police"

    user: "shanealcock"
    accesstype: "fiber"
```

Configuring OpenLI

```
# Target identified by static IP ranges(s)
- liid: XP45NN710T
  authcountrycode: NZ
  deliverycountrycode: NZ
  mediator: 6001
  agencyid: "Police"
  accesstype: "LAN"

  staticips:
    - iprange: "192.168.10.0/26"
      sessionid: 7
    - iprange: "2001:db8::/56"
      sessionid: 7
```

Configuring OpenLI

- Supported accesstype values (case insensitive)
  - Core types are defined by the ETSI spec

```
"dialup"
"adsl", "vdsl"
"cable"
"lan", "ethernet"
"wireless"
"fiber", "ufb"
"wimax"
"satellite"
"wireless-other"
```

Configuring OpenLI

- Let’s configure a “real” provisioner...

Configuring OpenLI

- Now let's move on to the mediator
  - `/etc/openli/mediator-example.config`

https://bit.ly/2ExtaTU

Configuring OpenLI

```
# Unique ID string for my network (16 chars max)
operatorid: WAND

# Set a unique ID for this mediator
mediatorid: 6001
```

Configuring OpenLI

```
# How to connect to the provisioner
provisioneraddr: 10.0.0.1
provisionerport: 12001

# Listen for collectors on 10.200.5.100:8888
listenaddr: 10.200.5.100
listenport: 8888
```

Configuring OpenLI

```
# Options for writing intercepts to pcap
# Hopefully you won't need to use this feature...

# Directory to store pcap files in
pcapdirectory: /traces/openlipcaps/

# Maximum duration of pcap file, in minutes
pcaprotatefreq: 30
```

Configuring OpenLI

- And we’re done with the mediator
  - Configure our “real” one...

Configuring OpenLI

- Finally, let's look at the collector config
  - `/etc/openli/collector-example.config`

https://bit.ly/2EtAv6U

Configuring OpenLI

```
# Connect to our provisioner
provisioneraddr: 10.0.0.1
provisionerport: 9001
```

Configuring OpenLI

```
# Unique ID string for my network (16 chars max)
operatorid: WAND

# Unique ID string for the location of my collector
# (16 chars max)
networkelementid: HLZ-BNG

# Unique ID string for this collector (optional)
# (8 chars max)
interceptpointid: col01
```

Configuring OpenLI

```
# Number of threads to use for sequence number tracking.
# You probably don't need to change this.
seqtrackerthreads: 1

# Number of threads to use to encode intercepted packets.
encoderthreads: 2

# Number of threads for forwarding records to mediators
# You probably don't need to change this.
forwardingthreads: 1
```

Configuring OpenLI

```
# List of interfaces to capture packets on
inputs:
 - uri: eth1
   threads: 2
 - uri: eth2
   threads: 4
```

Configuring OpenLI

- Configure our “real” collector and we’re ready to go!

Starting OpenLI services

- Assuming a packaged install, run one of:

```
sudo service openli-provisioner start                OR

sudo systemctl start openli-provisioner.service      OR

/etc/init.d/openli-provisioner start
```

- Repeat for the collector and mediator services

OpenLI services

- At this point, OpenLI is just like any other service

- Commands to interact with an OpenLI service
  - `start`
  - `stop`
  - `restart`
  - `reload`
  - `status`

OpenLI Logging

- Each component logs to `/var/log/openli/`
  - Docker users may want to restart rsyslogd

Starting OpenLI services

- Let’s try and turn it all on...

So Now What?

- How do we know if it is all working?
  - Libtrace is able to act as an ETSI LI client
  - Use `tracepktdump` as a pretend LEA

Testing with tracepktdump

- First, add your “test” agency to provisioner config

```
# List the set of law enforcement agencies
agencies:
 - agencyid: "Test"
   hi2address: 127.0.0.1
   hi2port: 44444
   hi3address: 127.0.0.1
   hi3port: 44445
   keepalivefreq: 300
   keepalivewait: 30
```

Testing with tracepktdump

- Next, create an intercept for your agency

```
# List of active IP intercepts
ipintercepts:

  # Target identified by static IP
  - liid: TEST01
    authcountrycode: NZ
    deliverycountrycode: NZ
    mediator: 6001
    agencyid: "Test"
    accesstype: "fiber"
    staticips:
       - iprange: X.X.X.X/32
         sessionid: 10
```

Testing with tracepktdump

- Tell the provisioner to reload its config
  - Mediator logs should mention the new agency
  - Collector logs should mention the new intercept

```
sudo service openli-provisioner reload
```

Testing with tracepktdump

- On the mediator, start `tracepktdump`
  - Use the IP + port from our agency configuration
  - Two instances, one per handover interface

```
sudo apt-get install libtrace4-tools

tracepktdump etsilive:127.0.0.1:44444

tracepktdump etsilive:127.0.0.1:44445
```

Testing with tracepktdump

- Generate some traffic on your capture interface
  - Make sure it belongs to the intercept target!

Testing with tracepktdump

```
Mon Dec 10 14:56:32 2018
 Capture: Packet Length: 170/170 Direction Value: -1
 ETSILI: pS-PDU:
 ETSILI:   PSHeader:
 ETSILI:     li-psDomainId: 0.4.0.2.2.5.1.17.0
 ETSILI:     lawfulInterceptionIdentifier: TEST01
 ETSILI:     authorizationCountryCode: NZ
 ETSILI:     communicationIdentifier:
 ETSILI:       networkIdentifier:
 ETSILI:         operatorIdentifier: Shane
 ETSILI:         networkElementIdentifier: intercept01
 ETSILI:       communicationIdentifier: 1322238349
 ETSILI:       deliveryCountryCode: NZ
 ETSILI:     sequenceNumber: 133518
 ETSILI:     microSecondTimeStamp:
 ETSILI:       seconds: 1544406992
 ETSILI:       microSeconds: 528115
 ETSILI:     timeStampQualifier: timeOfInterception
```

Testing with tracepktdump

```
Mon Dec 10 14:56:32 2018
 Capture: Packet Length: 170/170 Direction Value: -1
 ETSILI: pS-PDU:
 ETSILI:   PSHeader:
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Testing with tracepktdump

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 ETSILI:       seconds: 1544406992
 ETSILI:       microSeconds: 528115
 ETSILI:     timeStampQualifier: timeOfInterception
```

Testing with tracepktdump

```
ETSILI:   Payload:
ETSILI:     cCPayloadSequence:
ETSILI:       CCPayload:
ETSILI:         payloadDirection: toTarget
ETSILI:         cCContents:
ETSILI:           iPCC:
ETSILI:                 iPCCObjId: .5.3.10.2
ETSILI:                 iPCCContents:
ETSILI:               iPPackets: ...
IP: Header Len 20 Ver 4 DSCP 00 ECN 0 Total Length 52
IP: Id 46742 Fragoff 0 DONT_FRAG
IP: TTL 62 Proto 6 (tcp) Checksum 7463
IP: Source 17.253.67.204 Destination 10.0.0.1
TCP: Source 80 (http) Dest 51380
TCP: Seq 446314071
TCP: Ack 228132013
TCP: DOFF 8 Flags: FIN ACK Window 130
TCP: Checksum 19262 Urgent 0
...
```

Testing with tracepktdump

```
ETSILI:   Payload:
ETSILI:     cCPayloadSequence:
ETSILI:       CCPayload:
ETSILI:         payloadDirection: toTarget
ETSILI:         cCContents:
ETSILI:           iPCC:
ETSILI:                 iPCCObjId: .5.3.10.2
ETSILI:                 iPCCContents:
ETSILI:               iPPackets: ...
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TCP: Seq 446314071
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TCP: DOFF 8 Flags: FIN ACK Window 130
TCP: Checksum 19262 Urgent 0
...
```
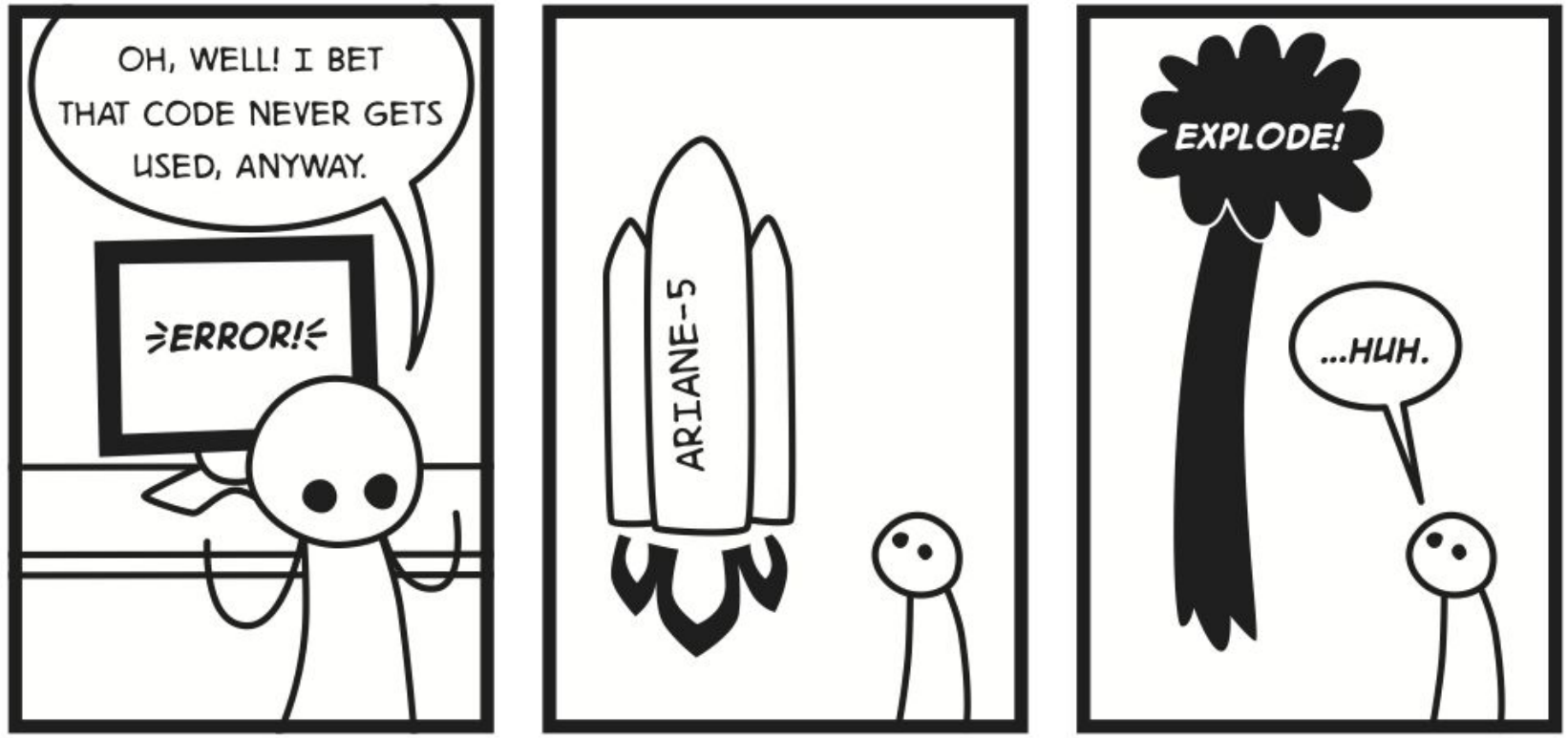

Testing with tracepktdump

- Try testing a “real” OpenLI deployment



Interfacing with Neil

- We think we're doing OK…

- Now try testing with someone else
  - Arrange some testing with Neil

Interfacing with Neil

- LIVE DEMO (maybe)!

Gotchas

- VOIP vendor eccentricities
  - Static “random” fields
  - Timestamps of 0
  - Non-incrementing sequence numbers

- Expect some teething problems, especially while OpenLI is new

Gotchas

- RADIUS
  - Don’t forget to include the port for the accounting packets!
  - Make sure all relevant RADIUS is mirrored to the collector

Gotchas

- IPSec
  - /24 vs /32
  - Firewalls

Building from Source

- Not recommended, but possible

- Install “standard” dependencies
  - libyaml
  - libosip2 (collector only)
  - uthash
  - libzmq
  - libJudy (collector & mediator)
  - libtcmalloc / libgoogle-perftools (collector only)
  - libpcap

- Install development versions of libraries

Building from Source

- Install developer tools
  - gcc
  - autoconf
  - automake
  - libtool
  - flex
  - bison

Building from Source

- Install “WAND-specific” dependencies
  - libwandio
    - https://research.wand.net.nz/software/libwandio.php
  - libwandder
    - https://github.com/wanduow/libwandder/releases
  - libtrace
    - https://research.wand.net.nz/software/libtrace.php

Acquiring OpenLI source code

- Clone the git repository
  - https://github.com/wanduow/openli.git

- Run `./bootstrap.sh` script inside openli directory

Acquiring OpenLI source code

- Download a source tarball
  - https://github.com/wanduow/openli/releases

- Extract the tarball

```
tar -xvzf openli-1.0.0.tar.gz
```

Building OpenLI source code

```
./configure   <options>
make
sudo make install
```

- configure options can include:
  - --disable-provisioner
  - --disable-collector
  - --disable-mediator

Running OpenLI source code

- Components are installed in `/usr/local/bin/`

- No init scripts are installed and no services registered
  - You can steal init scripts from `debian/`

Running OpenLI source code

```
[sudo] /usr/local/bin/openli-<component>
          -c <configfile>
        [ -d ]
        [ -p <pidfile> ]

-c <configfile> : use <configfile> as the
                  configuration file  (required!)
-d              : run component in the background
-p <pidfile>    : write PID into <pidfile>


NOTE: openli-collector will almost certainly require
root privileges, other components should be fine without.
```

DPDK

- Data Plane Development Kit
  - Originally developed by Intel for their NICs
  - Now more generalised

- Libraries + drivers for fast packet processing
  - Packets bypass kernel stack

- Enable 10Gb packet capture using commodity NICs

Why DPDK for OpenLI?

- UFB means customers have plenty of bandwidth
  - 1Gb plans are not uncommon

- Kernel packet capture is not reliable at high speed
  - Packet drops == undercollection

- Don’t forget you may have simultaneous intercepts!

Recommendations for DPDK

- Use DPDK for your customer IP traffic interface
  - RADIUS, SIP, RTP, etc. can all use kernel capture

- One 10Gb DPDK-capable card per collector
  - https://core.dpdk.org/supported/
  - Intel X520 or 82599 are good options

Configuring DPDK

- OpenLI source installs
  - https://github.com/wanduow/openli/blob/develop/doc/DPDKNotes.md
  - You'll need to rebuild libtrace
    - Add `--with-dpdk=yes` to `./configure`

Installing DPDK

- Packaged OpenLI installs
  - In theory, this should be easier
  - In practice, not so much :(

Installing DPDK

- Install the package for the igb_uio kernel module

```
sudo apt-get install dpdk dpdk-igb-uio-dkms
```

Running DPDK

- Run script to setup required environment variables

```
source /usr/share/dpdk/dpdk-sdk-env.sh
```

- Consider copying the contents of the script into `~/.profile`

Running DPDK

- Manually load the igb_uio module (!)

```
sudo modprobe uio

sudo insmod /var/lib/dkms/dpdk-igb-uio/ \
[dpdk version]/[kernel version]/x86_64/modules/igb_uio.ko
```

Running DPDK

- Run the DPDK configuration script

```
sudo -E /usr/share/dpdk/usertools/dpdk-setup.sh
```

OR

```
sudo -E /usr/share/dpdk/tools/dpdk-setup.sh
```

Running DPDK

- Setup hugepage mappings
  - Choose “Setup hugepage mappings for NUMA systems”
  - Enter ‘2048’ for each NUMA node that you are asked about

Running DPDK

- Bind an interface to DPDK
  - Choose “Bind Ethernet/Crypto device to IGB UIO module”
  - Enter PCI address of interface to bind
    - Use “`if=`” field to identify interface by name
    - PCI address will look like `0000:XX:00.X`

- `IMPORTANT:` once bound, the interface is no longer usable by the kernel
  - No more regular traffic
  - Don’t bind the interface you are using to reach the machine!

Using DPDK with OpenLI

- In your collector config...

```
# List of interfaces to capture packets on
inputs:
 - uri: eth1
   threads: 2

 - uri: dpdk:0000:42:00.1
   threads: 4
```

Future Development

- Provisioner configuration
  - Socket for pushing live intercept config
  - Expressed as a JSON object
  - Can integrate directly into existing web platforms

Future Development

- Internal communication security
  - Inter-component comms are unencrypted
  - You should keep these boxes isolated!
  - SSL, keys + certs, cert management
    - Leverage existing AMP experience

Future Development

- Disk backed buffering
  - Memory-backed for now, but limited capacity
  - Fall back to disk before memory gets full
  - Clear backlog when situation is resolved

Future Development

- Deal with bug reports and user feedback
  - Listen to the users :)

- Community building
  - Encourage others to become OpenLI experts
  - Invite new developers to work on the code base
  - Shared documentation covering common issues, use cases

Winding Up

- Questions
- Answers?
- Discussions
- Feature Requests / Ideas
- Problems
- Beers

Winding Up

Website: https://openli.nz

Code: https://github.com/wanduow/openli

Packages: https://www.bintray.com/wand/

Email me: shane.alcock@waikato.ac.nz

Workshop Resources:
https://wand.net.nz/~salcock/nznog19/openli-tutorial