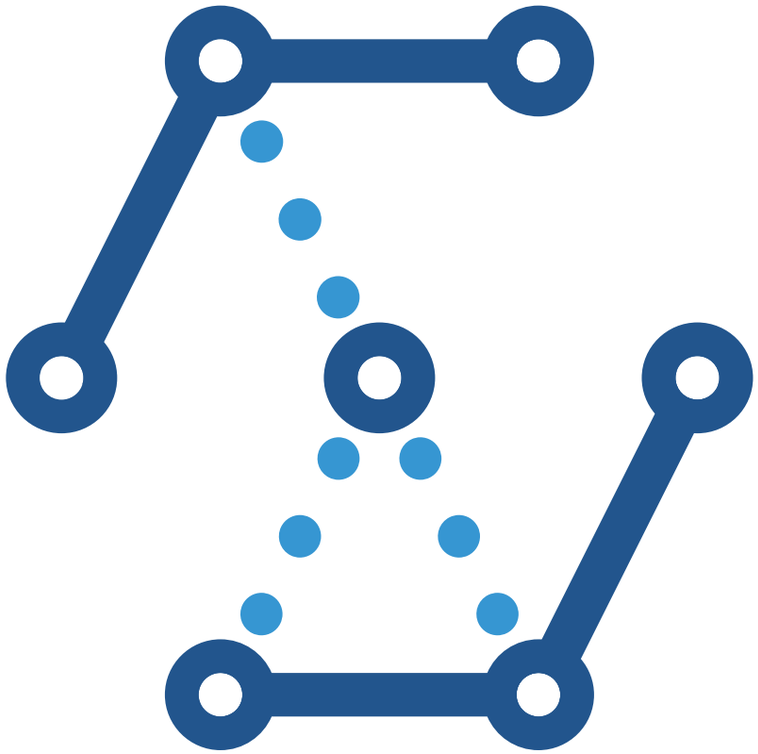


Talla

An Erlang implementation of Tor

Alexander Færøy

- Introduction.
- C.
- The architecture of Talla.
- Testing.
- Representation of the Tor network in Erlang.
- Questions.

Introduction

What is Talla?

- An attempt to build a robust implementation of a Tor relay daemon in Erlang.

- An opportunity for me to understand the inner workings of the Tor network better.

- A typical “evenings-only open source project” :-)

History

- Met Linus Nordberg from The Tor Project at the Erlang User Conference in 2015.

- Started development in August 2015.

- Very simple (read: messy) proof of concept up and running in December 2015.

- More sensible design work started in January 2016.

- Lasse Andersen joined in 2016.

- The official Tor in C.
- PurpleOnion in C#.
- GoTor in Google's Go language.
- Galois Inc's Haskell implementation.
- Orchid, tor-research-framework, and OnionCoffee in Java.
- node-Tor in JavaScript.
- Oppy, pycepa, and TorPylle in Python.
- Complete list on https://trac.torproject.org/projects/tor/wiki/doc/ListOfTorImplementations

Minimum Viable Product

- Due to Tor's end-to-end construction we really want to avoid implementing a Tor **client**.

- Primary priority: middle relay, secondary priority: exit nodes.

- Onion services.

- Use "as few" C dependencies as possible.

- Rewriting from scratch should always be an option.

Carefulness

- Running experimental Tor implementations on the "production network" would be irresponsible.
- Test networks.
- See email thread on tor-dev: https://lists.torproject.org/pipermail/tor-dev/2016-August/011300.html

Erlang

- Functional programming language designed by Ericsson in Sweden.
- Focus on concurrency via message passing.
- Extremely powerful when it comes to working with network protocols.
- Running on the BEAM virtual machine.

- Model your code using modules and functions.
- Model your complex stateful objects as processes.
- Use processes to handle ordering of events.
- Rich mocking possibilities in the language.
- Rich testing frameworks.

The Erlang mentality

- Program as if you are writing a domain specific operating system.

- Your “program” consists of multiple applications, which consists of multiple modules, which is running in the Erlang BEAM VM.

- Hot loading of modules and applications without restart.

Community

People who are interested in following the development of Talla should feel free to join **#talla** on **irc.baconsvin.org** or **6nbtgccn5nbcodn3.onion** with TLS on port **6697**.

C

- It is very hard to write complicated and safe C code.

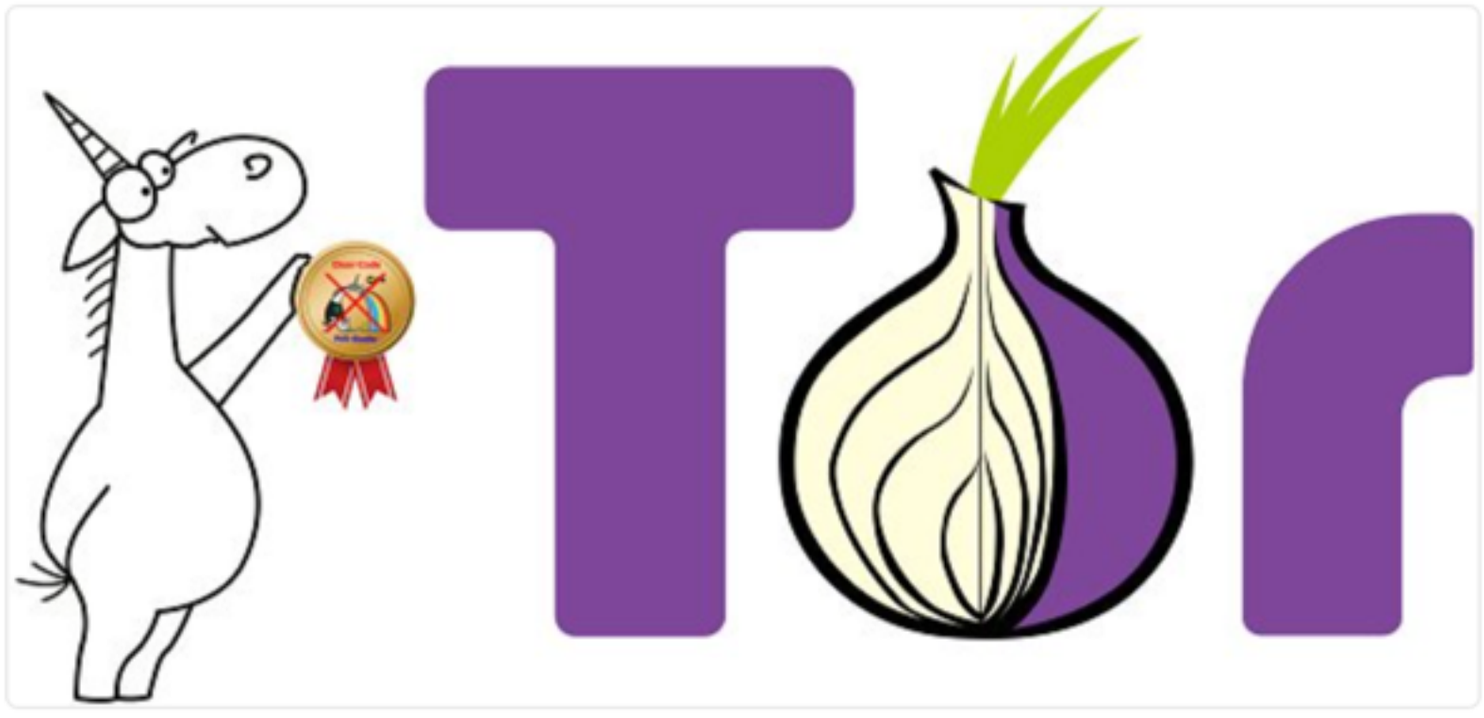
- The “Tor Daemon” that is in used today is written in C.

- The “Tor Daemon” is generally considered by security experts to be a very high quality C project.

Andrey Karpov
@Code_Analysis

Follow

#Tor #Tor2017 #InfoSec #torbrowser #TorProject #privacy #bugs PVS-Studio Team: No Bugs! viva64.com/en/b/0507/



6:30 PM - 12 May 2017

15 Retweets **38** Likes

3 15 38

“Special congratulations go to the Samba, tor, OpenPAM, and Ruby teams for being the first to reach Coverity Rung 3 certification.”

–2009 Coverity Scan Open Source Report

Tor and C

- Very high test coverage. “New features implies new tests” policy.
- Team rotation duties for things like Coverity issues.
- Fuzzing with and without Google’s oss-fuzz.
- Code review.
- Rust in Tor (work by Sebastian Hahn, Chelsea Komlo, and Isis Lovecruft).

Talla and C

- The BEAM VM have quite a lot of C code.
- We use libsodium for some cryptography.
- We use libcrypto from OpenSSL or LibreSSL, but do not use libssl.
- Some small C functions that was not exposed in Erlang.

The architecture of Talla

enacl

- Written by Jesper Louis Andersen.
- Used for its `/dev/urandom` interface.
- Used for x25519 Diffie-Hellman.
- Source code: https://github.com/jlouis/enacl

Ed25519

- Used for ed25519 signatures to the directory services.
- Multiple implementations of Ed25519 :-(
- We should probably switch to the Donna implementation instead.
- Major thanks to Yawning Angel from Tor.
- Source code: https://lab.baconsvin.org/talla/ed25519_ref10

Ed25519
(ref 10)

Luke

- Experimental Erlang NIF of the New Hope Post-Quantum cryptographic system.

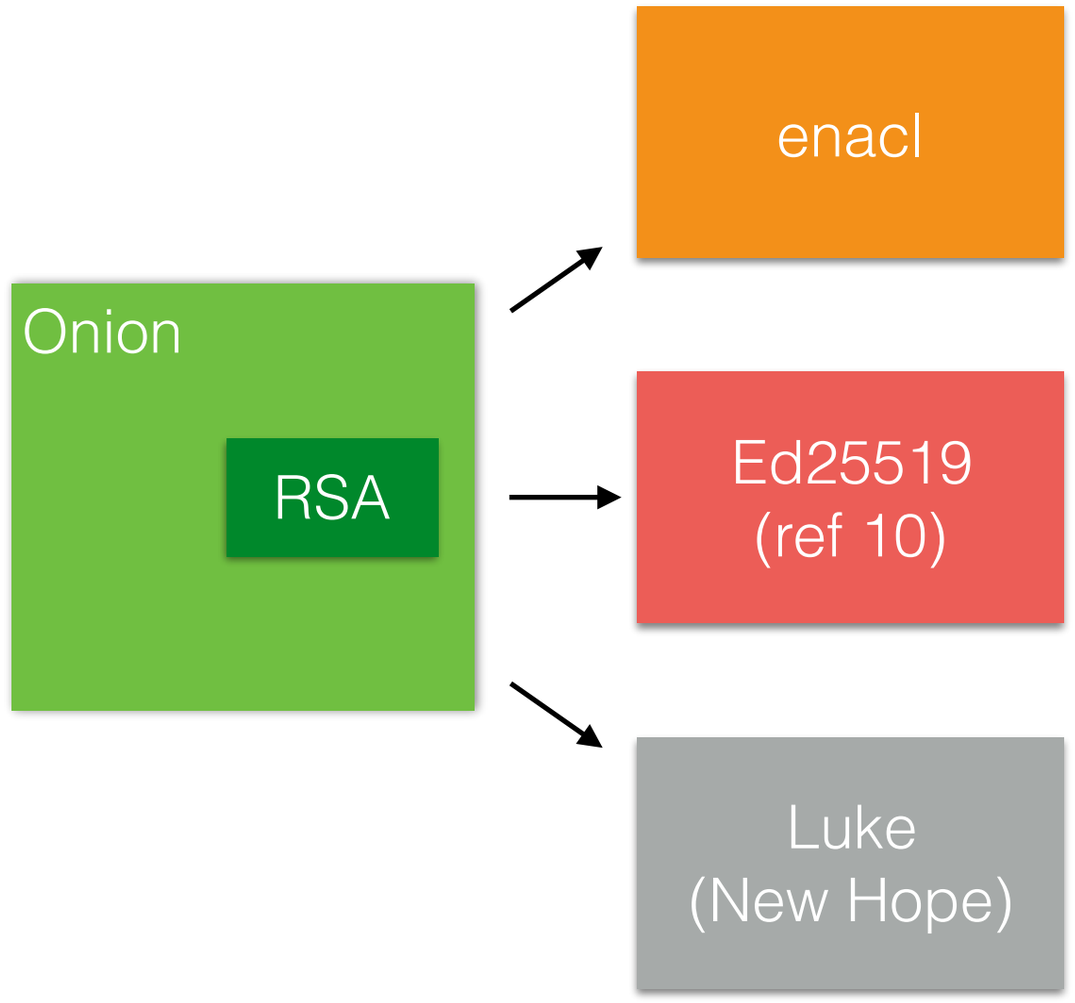
- Supports “normal” New Hope and Tor New Hope (Tor Proposal #270 by Isis Lovecruft and Peter Schwabe).

- Source code: https://lab.baconsvin.org/ahf/luke

Luke
(New Hope)

Onion

- Shared utilities needed for working with the Tor network.
- Small C function for generating an RSA key pair. Not needed for OTP 20.
- Well-tested code.
- Automated test execution.
- The most stable part of Talla right now :-)
- Source code: https://lab.baconsvin.org/talla/onion

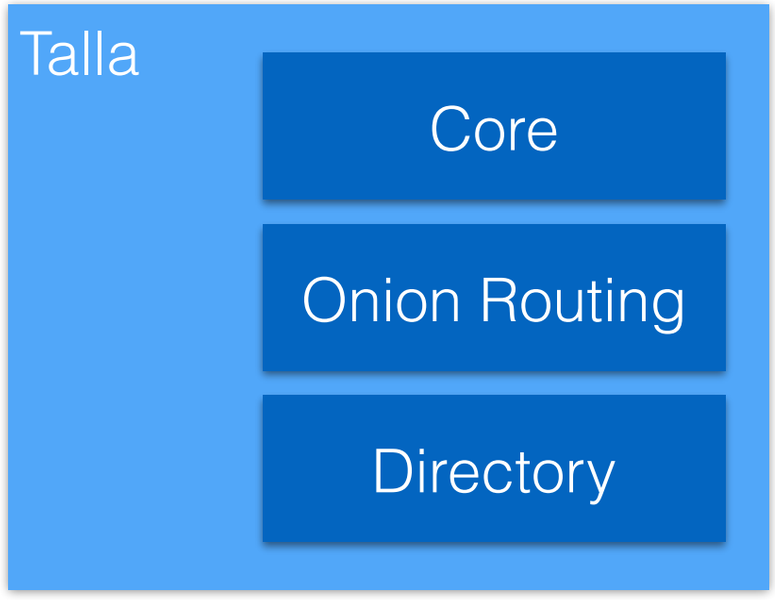


Talla

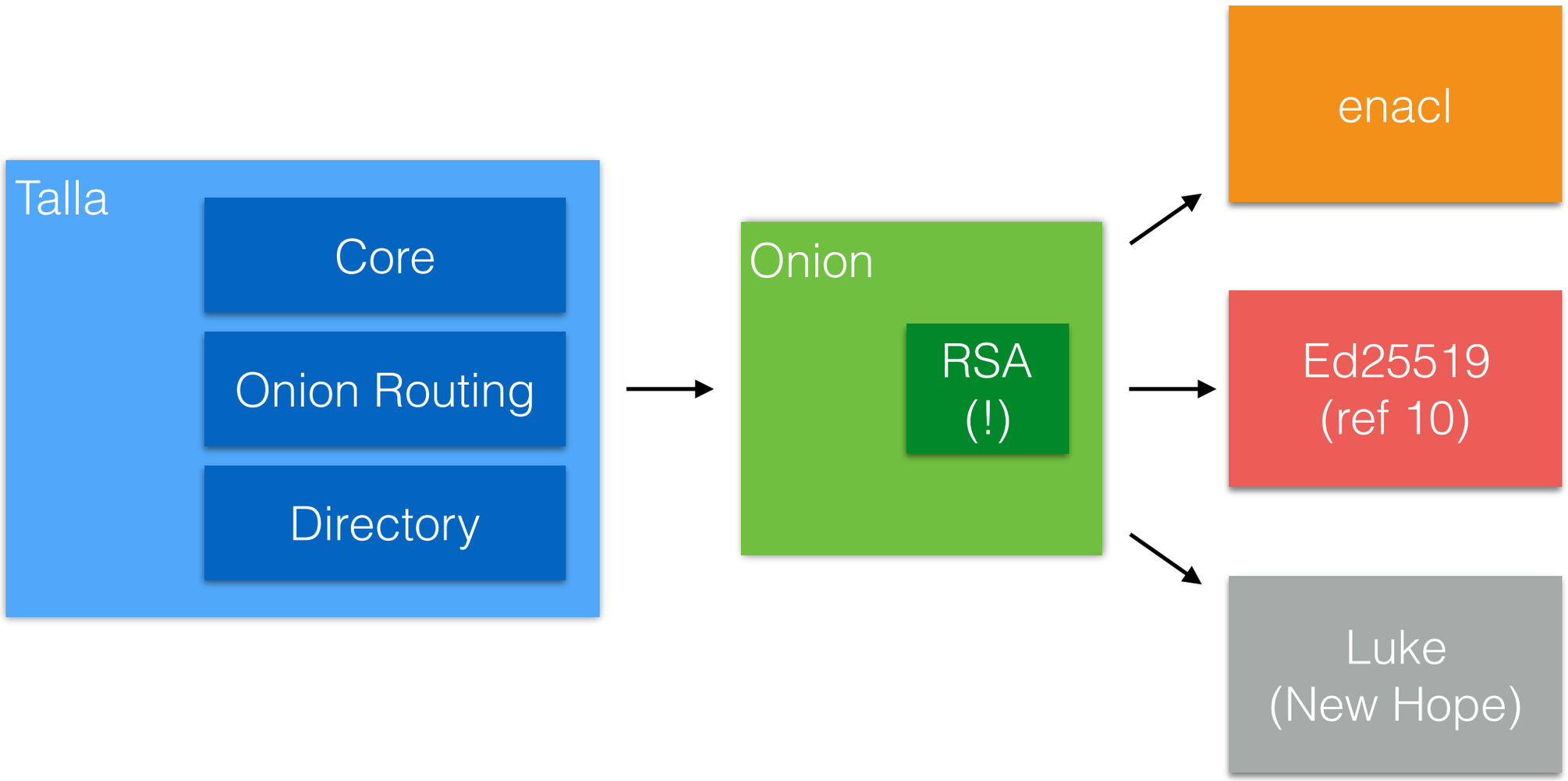
- Core application is for centralised services to the system.

- One application for Onion Routing.

- One application is for Directory service (announcement only as of 2016).



Applications and Libraries



Testing

Classical Unit Testing

```
hkdf_tor_test() ->
    %% Taken from test_crypto_hkdf_sha256() in tor/src/test/test_crypto.c.
    Salt   = <<"ntor-curve25519-sha256-1:key_extract">>,
    Expand = <<"ntor-curve25519-sha256-1:key_expand">>,
    [
        ?assertEqual(hkdf(<<"">>, Salt, Expand, 100),
                     base16_decode(["d3490ed48b12a48f9547861583573fe3f19aafe3f81dc7fc75",
                                    "eeed96d741b3290f941576c1f9f0b2d463d1ec7ab2c6bf71cd",
                                    "d7f826c6298c00dbfe6711635d7005f0269493edf6046cc7e7",
                                    "dcf6abe0d20c77cf363e8ffe358927817a3d3e73712cee28d8"])),
        ?assertEqual(hkdf(<<"Tor">>, Salt, Expand, 100),
                     base16_decode(["5521492a85139a8d9107a2d5c0d9c91610d0f95989975ebee6",
                                    "c02a4f8d622a6cfdf9b7c7edd3832e2760ded1eac309b76f8d",
                                    "66c4a3c4d6225429b3a016e3c3d45911152fc87bc2de9630c3",
                                    "961be9fdb9f93197ea8e5977180801926d3321fa21513e59ac"])),
        ?assertEqual(hkdf(<<"AN ALARMING ITEM TO FIND ON YOUR CREDIT-RATING STATEMENT”>>,
                     Salt, Expand, 100),
                     base16_decode(["a2aa9b50da7e481d30463adb8f233ff06e9571a0ca6ab6df0f",
                                    "b206fa34e5bc78d063fc291501beec53b36e5a0e434561200c",
                                    "5f8bd13e0f88b3459600b4dc21d69363e2895321c06184879d",
                                    "94b18f078411be70b767c7fc40679a9440a0c95ea83a23efbf"]))
    ].
```

```
hkdf_rfc5869_1_test() ->
    IKM  = base16_decode("0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b0b"),
    Salt = base16_decode("000102030405060708090a0b0c"),
    Info = base16_decode("f0f1f2f3f4f5f6f7f8f9"),
    L = 42,
    [
        ?assertEqual(hkdf(IKM, Salt, Info, L),
                     base16_decode(["3cb25f25faacd57a90434f64d0362f2a",
                                    "2d2d0a90cf1a5a4c5db02d56ecc4c5bf",
                                    "34007208d5b887185865"]))
    ].
```

Property based tests

- Generalise your tests into “properties”.
- Generators, shrinkers, and their relationship.
- We use the free and open source QuickCheck implementation named Proper. For more information see: http://proper.softlab.ntua.gr
- Mostly stateless testing right now.

```erlang
-module(onion_base64).

-export([encode/1, decode/1, valid/1]).

-spec encode(Data) -> Encoded
    when
        Data    :: binary(),
        Encoded :: binary().
encode(Data)-> …

-spec decode(Encoded) -> {ok, Decoded} | {error, Reason}
    when
        Encoded :: binary(),
        Decoded :: binary(),
        Reason  :: term().
decode(Encoded) -> …

-spec valid(Data) -> boolean()
    when
        Data :: binary().
valid(Data) -> …
```

```
prop_base64_iso() ->
    ?FORALL(Data, binary(),
        begin
            Encoded = onion_base64:encode(Data),
            true = onion_base64:valid(Encoded),
            {ok, Decoded} = onion_base64:decode(Encoded),
            Data =:= Decoded
        end).
```

```
$ rebar3 proper
===> Testing prop_base64:prop_base64_iso()
.............................
.............................
.............................
.........
OK: Passed 100 test(s).
```

```erlang
-module(onion_dh).

-export([keypair/0,
         shared_secret/2,
         is_degenerate/1,
         params/0]).

-define(G, 2).
-define(P, …).

keypair() -> …

shared_secret(SecretKey, PublicKey) -> …

is_degenerate(Value) -> …

params() -> [?P, ?G].
```

```
keypair() ->
    #{ secret := SecretKey,
       public := PublicKey } = onion_dh:keypair(),
    {SecretKey, PublicKey}.

prop_shared_secret() ->
    ?FORALL({{AS, AP}, {BS, BP}}, {keypair(), keypair()},
        begin
            {ok, SharedA} = onion_dh:shared_secret(AS, BP),
            {ok, SharedB} = onion_dh:shared_secret(BS, AP),
            SharedA =:= SharedB
        end).
```

```erlang
-module(onion_dh).

-export([keypair/0,
         is_degenerate/1,
         params/0]).

-define(G, 2).
-define(P, …).

keypair() -> …

is_degenerate(PublicKey) -> …

params() -> [?P, ?G].
```

```erlang
p() -> ?LET(L, onion_dh:params(), hd(L)).

g() -> ?LET(L, onion_dh:params(), lists:last(L)).

bad_public_key() ->
    ?LET(P, p(),
        ?LET(G, g(),
            begin
                oneof([
                    %% All negative numbers.
                    neg_integer(),

                    %% 0 and 1.
                    integer(0, 1),

                    %% The generator.
                    G,

                    %% P - 1 towards infinity.
                    integer(P - 1, inf)
                ])
            end)).

prop_degenerate() ->
    ?FORALL(BadPublicKey, bad_public_key(),
        onion_dh:is_degenerate(BadPublicKey)).

prop_public_key_not_degenerate() ->
    ?FORALL({_, P}, keypair(),
        not onion_dh:is_degenerate(P)).
```

Network testing

- We use Chutney for spawning an independent Tor network with C Tor directory authorities, middle relays, exit nodes, client nodes and Talla middle nodes.

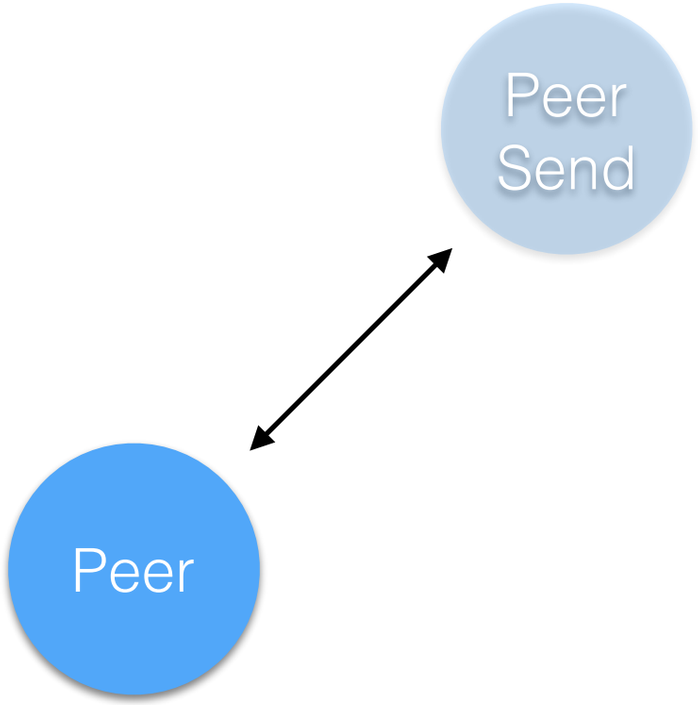
- Very easy way to catch “stupid” bugs while developing.

- Fast to setup, easy to use:

```
$ chutney configure misc/chutney/talla-mixed
$ chutney start misc/chutney/talla-mixed
$ chutney status misc/chutney/talla-mixed
$ chutney stop misc/chutney/talla-mixed
```

Internals of Talla

Peer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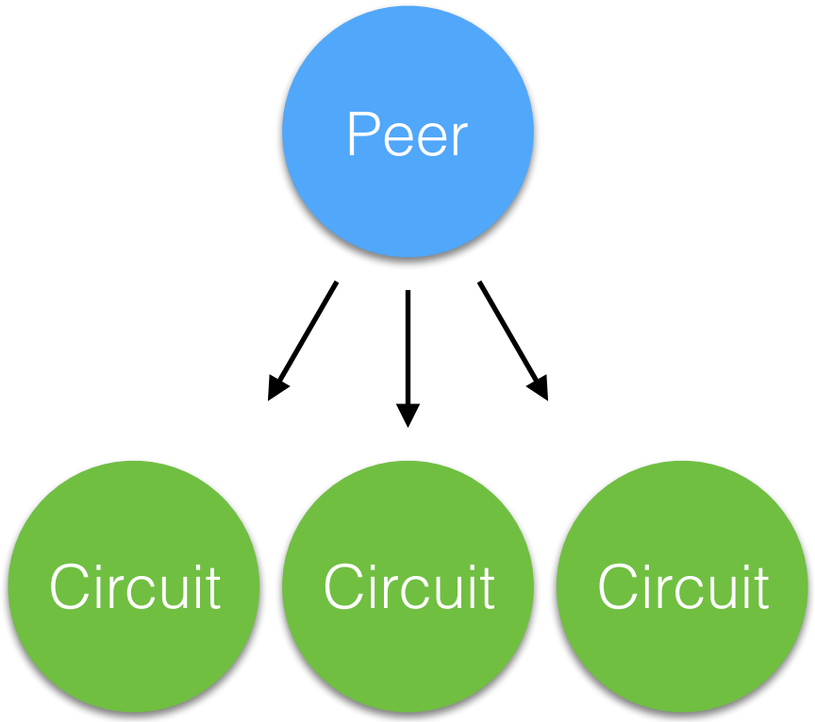
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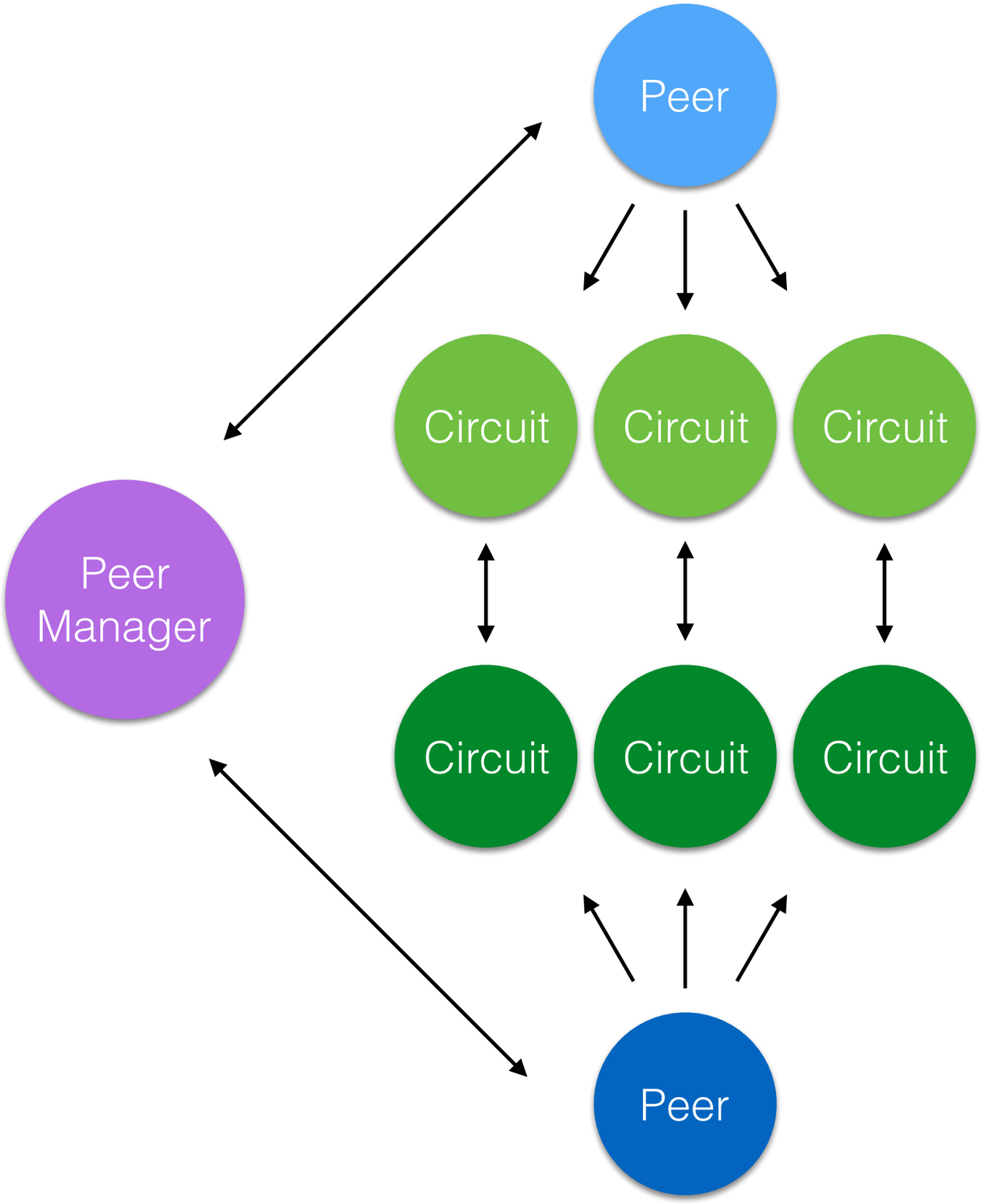
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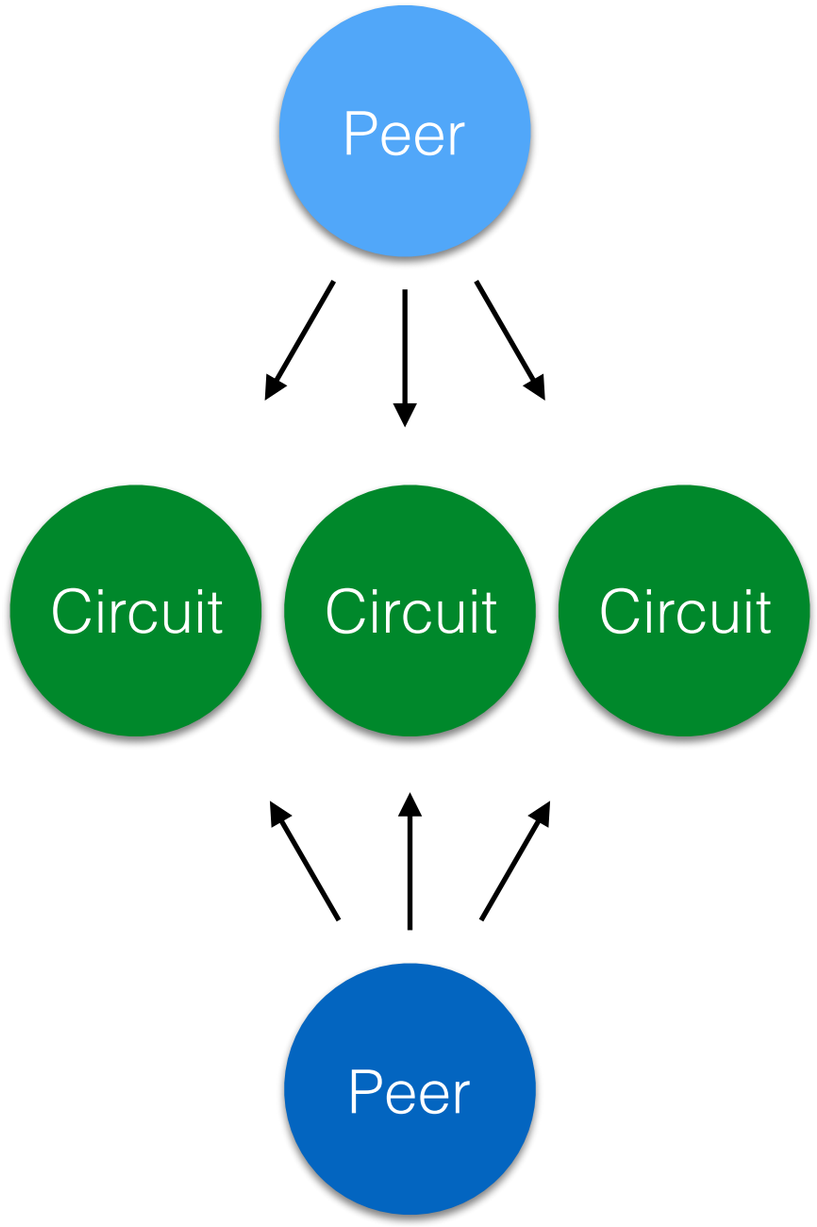
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Peer

Resources

- Tor specifications: gitweb.torproject.org/torspec.git - we are focused on tor-spec.txt and dir-spec.txt as of 2016.

- Ferd Hebert's Learn You Some Erlang for Great Good: learnyousomeerlang.com and erlang-in-anger.com

- The C Tor source code: https://gitweb.torproject.org/tor.git/

Source Code

The source code and issue tracker can be found at the Baconsvin Gitlab instance at

https://lab.baconsvin.org/talla

Conclusions

- Writing a **safe** Tor implementation from scratch using the specifications only is close to “impossible”.
- Great way of getting a much deeper understanding of how Tor works.
- Relaying traffic works; still missing code for handling onion services.
- Running on a small test network, but not on the production network yet.

Questions?

Come by the Baconsvin Village in
the Turing field if you want to talk
about Tor and Talla.

ahf@torproject.org

FDB1 6F45 A477 B314 E874 32EC 61A2 08E1 6E7C B435