Adding Arti Backend(s) Support to the Gosling Library

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What is Gosling and What Does it Do?

- Rust library which provides peer-to-peer connectivity with the following features built-in:
  - End-to-End Encrypted
  - Anonymous
  - Hole Punching
  - Censorship Circumvention
  - Client Authentication
  - Optional Application-Specific Extensions
  - Metadata Resistance

How Does It Work?

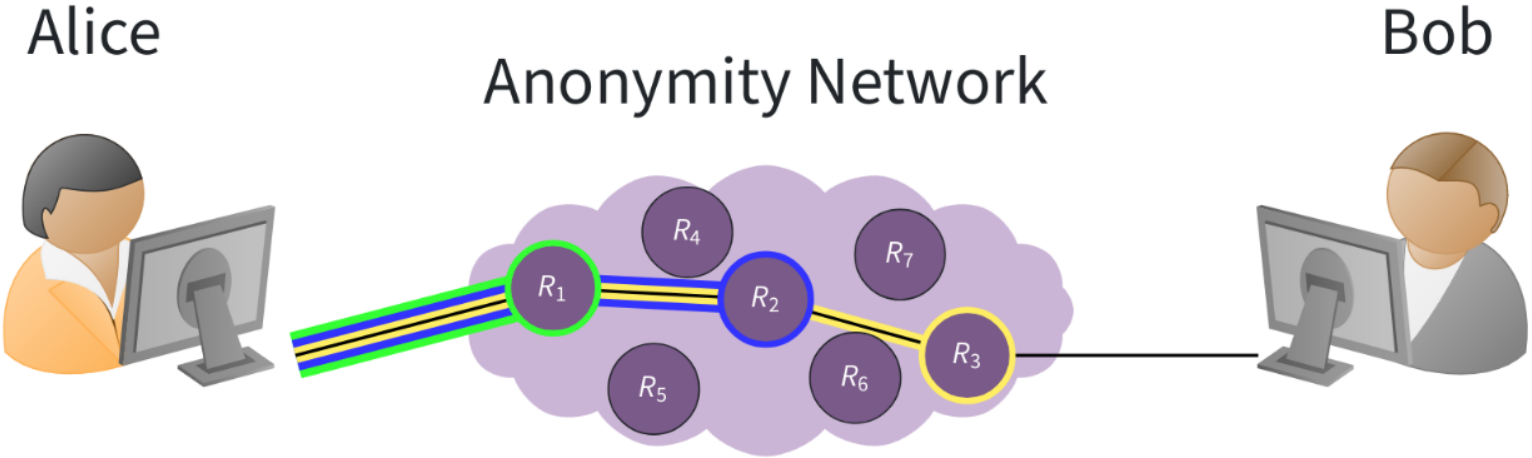
- Each user has a unique id like:
    - 6l62fw7tqctlu5fesdqukvpoxezkaxbzllrafa2ve6ewuhzphxczsjyd
- Users have only to share their id with other users, successfully complete a handshake, and they can connect to and send traffic to each other with all the afore-mentioned properties!

Right.. But How Does It Work?

- Built on Tor and Tor Onion Services

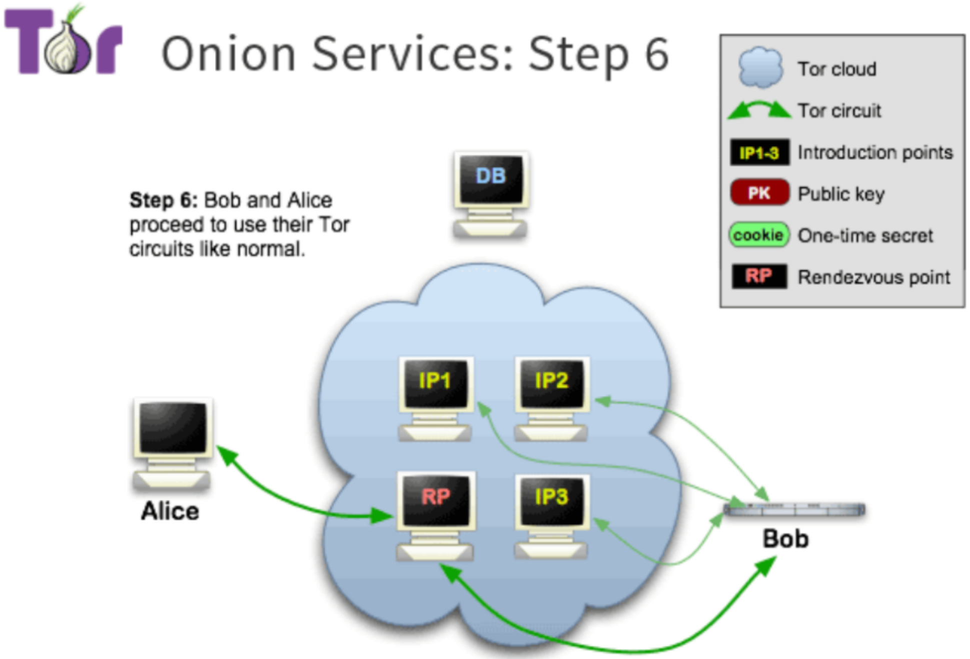
Tor

- Tor Network is a community of relay operators, each running tor aka little-t tor, c-tor, or the legacy tor daemon
- Users create circuits to their destination within the Tor Network:
  - 1st Hop - Guard Relay: knows IP address of user and guard relay
  - 2nd Hop - Middle Relay: knows the guard relay and the exit relay
  - 3rd Hop - Exit Relay: knows middle relay, final destination and contents of traffic



Onion Services

- Onion Service traffic never leaves the Tor Network
    - Onion Service defines a set of introduction points within the Tor Network
    - Onion Services registers these introduction points in a distributed database in the Tor Network
    - Client connects to one of these introduction points, and negotiates a rendezvous point on another relay
    - Client + Onion Service each create circuits to the rendezvous point and begin talking



How Does it Work (cont)

- Every user has an id, an onion-service id:
    - 6l62fw7tqctlu5fesdqukvpoxezkaxbzllrafa2ve6ewuhzphxczsjyd.onion
- This id serves dual purpose:
    - a destination (an Onion Service) for connecting peers
    - an identifier used for authenticating clients when connecting to other peers (Onion Services)
- Each peer hosts an Onion Service, which other peers may connect to

End-to-End Encrypted

- All communications between peers are end-to-end encrypted

Anonymous

- Peers do not need to know each other’s ‘real’ IP address to communicate

Hole Punching

- Peers do not need to have publicly accessible open ports for other peers to connect to them
- Peers only need to make outgoing connections

Censorship-Circumvention

- There is no centralised ‘registrar’ of Onion Services which can block a peer from receiving connections
- All peer-to-peer traffic stays within the Tor Network
- If you can connect to the Tor Network, then you have full access to other peers
- (Maybe a big ‘if’)

Censorship-Circumvention (cont)

- Suppose you are in a place which blocks Tor such as:
  - China, Iran, Russia
  - Schools, Universities, Libraries
  - Offices, Government Buildings
- We can use pluggable transports to circumvent the block!
- Pluggable transports disguise your traffic as something else
- For example:
  - Snowflake[1] disguises your traffic as WebRTC

[1] Snowflake: https://gitlab.torproject.org/tpo/anti-censorship/pluggable-transports/snowflake

Wait A Second...

- So you may be thinking something like: "Ok, so you have a library which routes your traffic through the Tor Network and inherits all its features. Good job, so what?"
- Bear with me

Authenticated

- Thanks to clever cryptography (*hand waving*), Onion Services are self-authenticating
- But clients are not, you do not need any authentication to connect to an Onion Service
- Clients do not have Onion Service Ids
- **Problem**: This is supposed to be a peer-to-peer system! How does an Onion Service verify connecting clients are who they say they are?

Authenticated (cont)

- If a user connects to your service, and claim they are the owner of onion service id `abcd...234.onion`, what they are *really* claiming is they control the *private* key which maps to the *public* key which is encoded in their onion service id.
- To verify the client is telling the truth, we ask them to sign a (carefully crafted) message[1] with their *private* key, and the onion service verifies the signature using the client's provided *public* key (derived from their claimed onion service id)

1. Gosling Protocol: https://gosling.technology/gosling-spec.xhtml

Optional Application-Specific Extensions

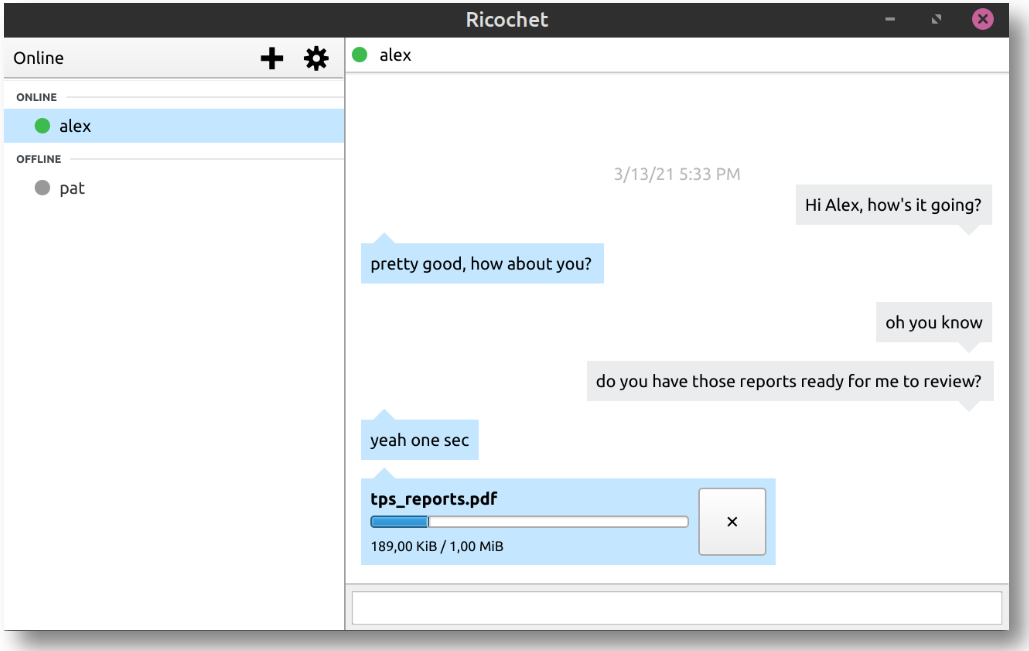
- Protocol has some flexiblity to allow for some additional application-specific authentication barriers or requirements such as:
    - Peer block/allow lists
    - Shared secrets/invite codes
    - Proof-of-Work/Stake schemes

Metadata-Resistance

- Communication contents are fully end-to-end encrypted, and stay entirely within the Tor Network
- Clients' real identities are unknown to each other
- No way to determine who peers have connected to; no way to generate a ‘social graph’ of peers
- Sounds great, so what's the problem?

Some History: Ricochet-Refresh

- Peer-to-peer instant messenger via tor onion services
- Anonymous chat + file transfer
- Similar peer (contact/friend) authentication mechanism as described previously
- At least one of the peers must be running an Onion Service for the other peer to connect to in-order to chat



3/13/21 5:33 PM

Hi Alex, how's it going?

pretty good, how about you?

oh you know

do you have those reports ready for me to review?

yeah one sec

tps_reports.pdf

189,00 KiB / 1,00 MiB

An Interesting Property of Onion Services

- Anyone (authenticated peer or not) can attempt to connect to your Onion Service and determine if it is currently online
- Therefore, a profile of the Onion Service's online/offline status can be built by repeatedly doing this
- Not really a big deal if your Onion Service is for a website or some other service that is meant to be always online
- *Kind* of a big deal when that Onion Service is running in a personal computing environment because PC online/offline status maps pretty closely to human user using/not using their computer

Whoops, Metadata Leak!

- Malicious 3rd parties can easily 'cyber-stalk' users by simply trying to connect to them
- Quite malicious 3rd parties could *also* discover your guard node by simultaneously knocking guard nodes offline and cyber-stalking users
- Quite malicious+capable 3rd parties could de-anonymise users if they can see who a guard node is connected to (using wiretaps for example, or running a malicious guard node and getting lucky)

What We Would Like

- Authenticated peers should be able to connect to and communicate with each other
- Unauthenticated peers should not be able to determine each others online/offline status
- Unauthenticated peers should be able to become Authenticated

- You can’t do all three at once

Gosling’s Solution

- Spread a peer’s Onion Service’s responsibility across more Onion Services:
    - One ‘identity’ service
    - N ‘endpoint’ services (one for each authenticated peer)
- Identity service acts as the gatekeeper for accepting new peers and distributing endpoint service credentials
- Endpoint services are where actual peer-to-peer communications happen

Implications and Trade-Offs

- The public identity service is not required for application functionality if you have collected enough peers
    - Identity services may be optionally disabled (depending on the application)
- Access by an authenticated peer may be revoked by simply no longer running their associated endpoint service
    - Endpoint services may *also* be optionally disabled if you want to appear offline even to your peers

Tor Integration in Gosling

- The **gosling** crate gets its Tor functionality from the **tor-interface** crate (which we also maintain)
- **tor-interface** defines a **TorProvider** trait which requires conforming implementations to implement a certain set of functions related to connecting to the Tor Network, creating and connecting to Onion Services, etc.
- Currently we have 2 complete **TorProvider** implementations:
  - **mock_tor_client**
  - **legacy_tor_client**

Tor Integration: mock_tor_client

- Minimal local and in-process **TorProvider** for testing
- Never reaches the Tor Network
- Internet access not required
- Invaluable for unit and fuzz testing the **gosling** protocol crate and any protocol which may use **gosling** at its foundation

Tor Integration: legacy_tor_client

- Launches and owns a local c-tor process
- Managed via the control port protocol
- Just a very standard Tor controller implementation which many other tor-using applications have had to implement for themselves

Arti

- Arti (A Rust Tor implementation) is an in-progress re-implementation of c-tor in Rust being developed by the Tor Project's Network Team.
- c-tor is currently in maintenance-mode, where possible no new functionality is being added
- Long-term goal to completely replace c-tor both in client software (such as Tor Browser, Onion Share, Ricochet-Refresh, cwtch, etc) and as network relays with Arti
- There are currently three ways to use Arti from client software:
    - The arti-client Rust crate (library)[1]
    - The Arti binary (c-tor's eventual replacement)[2]
    - TorVPN (Android app/service)[3]

1. arti-client: https://crates.io/crates/arti-client
2. arti: https://crates.io/crates/arti
3. TorVPN: https://gitlab.torproject.org/tpo/applications/vpn

Tor Integration: arti_client_tor_client

- Integrates the **arti-client** crate directly, in-process
- Not yet feature complete, currently missing:
    - Onion Service Client Authorisation
- **arti-client** *should* have all our required features in the 0.19.0 release next month
- We developed a few minor feature and bug-fix patches in the just released version 0.18.0
- We expect this portion to be initially complete by July, though there will likely be a long tail of bug-fixes as **arti-client** is likely to periodically break compatibility before 1.0

Tor Integration: arti_daemon_tor_client

- Will be similar to our current **legacy_tor_client TorProvider:**
  - Out-of-process Arti
  - Outgoing connections via local SOCKS5 proxy
  - Communications via new JSON-RPC[1] based RPC protocol[2]
- RPC system and first APIs are being developed now in **arti**, so we expect our implementation work to begin in June.

[1] json-rpc: https://www.jsonrpc.org/specification
[2] rpc: https://gitlab.torproject.org/tpo/core/arti/-/blob/main/doc/dev/notes/rpc-meta-draft.md

Tor Integration: tor_vpn_tor_client

- Arti-based VPN client for Android
- Still in early stages of development
- First public alpha is scheduled for Q4 of 2024
- Plan to begin working on this **TorProvider** backend Summer of 2024
- Expecting a lot of interesting Android-specific challenges

Why Are We Doing This Work?

- Improved privacy guarantees for Ricochet-Refresh
    - Ricochet-Refresh v4.0 will use Gosling
- Future-proofing Gosling
    - c-tor is going away in a few years
- Bring Ricochet-Refresh to mobile
    - TorVPN makes this a realistic possibility
- Make developing privacy-preserving peer-to-peer applications as easy as possible

Links

- Blueprint For Free Speech: **https://blueprintforfreespeech.net**
- Ricochet-Refresh
  - website: **https://ricochetrefresh.net**
  - github: **https://github.com/blueprint-freespeech/ricochet-refresh**
- Gosling
  - website: **https://gosling.technology/**
  - github: **https://github.com/blueprint-freespeech/gosling**