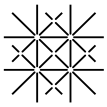

University of Basel

A Feed Bundle Protocol for Scuttlebutt

Bachelor Thesis

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2017-054-370

02.07.2020

Acknowledgments

I would like to thank Prof. Dr. Christian Tschudin for giving me the opportunity to work with him on this thesis. He has supported me during the entire process of planning and developing this thesis and has given me valuable and constructive suggestions and guidance, especially in light of this unique COVID-crisis time. In addition, I would like to thank Christopher Scherb and Claudio Marxer for supporting my work with essential feedback. Finally, I want to express my gratitude to my whole family and friends for supporting me in so many ways during the creation of this thesis.

Abstract

Aspiring new technologies emerge every day, one of which is Secure Scuttlebutt (SSB). Secure Scuttlebutt is a peer-to-peer communication protocol based on ID-centric append-only logs (Tarr et al. [2]).[1] The aim of this thesis is to take the mechanics from Secure Scuttlebutt and bring them to a more commercial environment by introducing new intermediary service providers (ISP) which offer connectivity to servers. Having a contract with such an ISP makes the initial onboarding much easier than in SBB.
By splitting up the ID-centric feeds into feed pairs for every connection, information on the specific dialogs gets bundled and stored independently. Since this is the smallest abstraction, it allows an additional form of bundling by multiplexing log entries together into larger feeds. Therefore the challenge of the immense replication work done by SSB is approached differently.

[1] Quelle

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1 Introduction

The world is constantly changing and so is the internet. At this very moment, a revolution in networking research is taking shape. This movement is leading away from well-known, proven practices and measurements of the centralized web and strives for novelty: distribution. The direction is away from centralised servers and classical routing and moving towards routing into a new peer-to-peer-driven, distributed and decentralized web. Secure Scuttlebutt is exactly one of these new platforms/apps/developments, which captivate with refreshingly different approaches to solving common networking problems. Yet they are still in development and have a future that is anything but sure.

1.1 Secure Scuttlebutt

Scuttlebutt (SSB), invented and created by Dominic Tarr in 2014[2], is a gossip peer-to-peer communication protocol (Tarr et al. [2]). The term scuttlebutt is slang for "water-cooler" gossip used by sailors and boatsmen. Coincidentally his motivation to develop such a protocol was an unreliable internet connection on his sailboat and the result was his own offline-friendly secure gossip protocol for social networking. [3]

Differing from other technologies, Secure Scuttlebutt does not offer a self-explanatory out of the box onboarding principle. In other software, the user typically receives suggestions (e.g. Instagram) or connectivity and management are built into the software (e.g. default gateway DHCP). In SSB, the user has to connect manually to a ub via an invite code, which they must obtain on a channel other than SSB.[4]

1.2 Motivation

However, it is problematic for new users to connect to the SSB world, hence a very interesting and promising problem to solve has presented itself. SSB is a promising, inovative new

[2] Initial commit github
[3] P2P-Event Basel
[4] Invide Code - https://ssbc.github.io/scuttlebutt-protocol-guide/

technologie that has a great deal of potential. At the moment, it is still in an experimental state and used primarily in pilot projects where the technology is connected to existing domains (social network, git, databases etc.)[5] I would like to explore its potential in a more commercial manner and environment.

1.3 Goal

This thesis explores the role of intermediary "connectivity providers" which sell connectivity e.g. to Google or Facebook, through a prototype implementation of a Feed Bundling Protocol. It is based on SSB but also differs in many concepts. Introducing these intermediary participants, where you are connected on start up, will make the onboarding easier, since they will hold all information to create new connections. In plain English: *It's a guy who knows another guy who can help.* With "feed pairs", which are described later in this thesis, the ID-centric information gathering into one single feed from SSB is split into parts. This results in less data in each dialog of two participants and allows bundling.

1.4 Outline

First a more detailed description of SSB, with focus on the concepts and problems connected to the Feed Bundling Protocol, will be given. Then the newly created and adapted concepts, as well as the architectural idea of the FBP with respect to SSB, will be presented. Subesequently I will take a closer look at the implemented code and how it is solved. This evaluation covers previously solved issues, as well as newly generated problems with the approach to these strategies and how they might possibly be solved. Finally, I will present a conclusion and highlight future challenges that discovered during the process.

[5] Quelle

2
Related Work

In this chapter we will see some of the key features which were taken account of to realise the feed bundle protocol. Befor taking a closer at the baseline for the protocol, which consists of parts from the Secure Scuttlebutt technologie and the Remote Procedure Call Protocol, we jump shortly into the blockchain and its properties, since by this very moment, everybody who reads this thesis will heard about.

2.1 Blockchain

The blockchain is well known as the foundation of the bitcoin. It has received an extensive attention in the recent years.
footnoteQuelle Zheng Xie etc 5 But what is the thing that makes the blockchain so impressiv and desired? The blockchain is often described as an immutable ledger which allows transactions to take place in a decentralised manner.
footnoteQuelle Zheng Xie etc 6 Exactly these key properties we also find in Secure Scuttlebutt.

2.2 Secure Scuttlebutt

Having the blockchain as a foundation and rather well know by the broad mass for an append-only log makes the jump into the the universe of Secure Scuttlebutt much easier. Secure Scuttlebutt (SSB) is a novel peer-to-peer event-sharing protocol and architecture for social apps.
footnoteTschudin Paper Aim of this section is to give a very high level overview about SSB, its ideas and properties, since the they are not quiet easy to understand.

2.2.1 Append-Only Log

2.2.2 Onboarding

2.3 Remote Procedure Call

Remote procedure calls, as the name implicates, are based on procedure calls but extended to provide for transfer of control and data across a communication network. There are two participants in the simplest manner, caller and callee. The caller wants to invoke a procedure with given parameters. The callee is the instance, which actually proceeds with the data and returns the result of that specific request. If an RPC is invoked, the the caller's environement is supended, all the information needed for the call transmitted through the network and received by the callee, where the actual procedure is executed with these exact parameters. The benefit of such an RPC-protocol is that the interfaces are designed in a way, that third parties only write the procedures and call exactly these procedures in the callers environement.Birrell and Nelson [1] This leads to a very promissing way to have a basic version of such an RPC-protocol for this thesis. Since it allows to invoke in the callers environement but are atually performend by a callee which returns the result back to the caller.Birrell and Nelson [1]

3
Concepts and Architecture

As described in the chapter Related Work, SSB is an ID-centric single feed driven environment, where onboarding is challenging. This prerequisite changes from the beginning. The basic idea of the Feed Bundle Protocol is to split up this ID-centric environment into replicated feed pairs, where two participants hold at least one of such a pair. This pair contains the whole dialog between two identities which have a contract with each other. Similar to the tin can phone from your childhood where you had two cans connected for every friend you want to communicate with. By introducing intermediary service providers, the onboarding happens at contract signing. Clients will have to possibility to connect to new servers via this ISP and create for each server a new feed pair, which is replicated over this very ISP. Since this approach means an enormous amount of feed replications between ISP and server, these feeds get bundled again.

3.1 Tin Can Analogy

This announced system seems very hard to understand but we can simplifiy it. Look at it as a tin can phone from your childhood where on either side you have two cans, strapped together for every friend you want to communicate with. You start with one corded phone to your best friend, the one you trust the most. In one you talk and the can 'saves' everything you say to it, from the other can you can only hear things from your friend, it also saves everything said from your friend. Let's already label them in general as the You-Friend can and Friend-You can. On the other side your friend has the same but can only hear things out You-Friend can and can only talk into the Friend-You can. This is one replicated feed pair, having both cans on both side.

Having this, the dialog needs a way or language to express expectations or requests from either side to communicate with each other, where you can declare what you want from your friend. Leading to the simplified RPC protocol.

After a while it gets boring only talking to this one friend. Luckily, your friend is the coolest kid in school and knows everyone and even tells you about everyone he knows. Then you

ask your friend if he could introduce you to his other friends, since you are tired of only talking to your friend. This introduction process is real, human social behavior, not face to face, but via tin can phone.

After your friend has introduced you to one of his other friends and this other friend descides to be friends with you, you and your new friend start to build a new tin can phone, with the You-Other and Other-You tins. But because you are too far away from each other, you cannot just have a cord from one to the other, so your best friend allows you to route the cord through his house. This corresponds to the replication of the feeds over an intermediary connectivity provider.

But there is another problem: you are not the only one. After a while, your best friend has so many connections running through his house from all his friends who want to talk to their other friends, that here is an enormous number of strings going to that other friend. Your friend descides to combine all these strings into one and send all messages through this one, single bundled connection with the information into which tin can it comes at the end. He multiplexes. Given that little story, we can derive concepts and architecture for the tin can phones of the future.

3.2 Contracts

Given that little story, we see the foundation of the friendship. The friendship between you and your best friend and the friendship between your best friend and his other friend. By the same token, it is the business contracts between the nodes that provide the foundation for the entire connectivity, protocol and bundling. These contracts are to most important building block of the whole thesis since the define the behaviour of the replicated feed pairs, onboarding mechanics and bundling.

3.2.1 Contract Values

To build the tin can phone, three basic identifiers are needed. First of all you have to trust each other. This corresponds to the whole legal contract between the two parties. Next you need to know your names to label the phone, so you know who you are talking to. These are the public keys.

Since everybody in your house can use the tin phone, you also need some sort of code so that your friend knows that it is you who is sending the message and not your mother. These are the private keys. Having tha,t you need your two tin cans and two wires. One can stands for one feed and the wire for the replication. But if you do not know your friend's address, you do not know where to put that wire, so you need that as well.
The address, as the name is well chosen, refers to the IP-address. Last but not least, to distinguish all the cans, you label them accordingly.

Therefore a contract consists of actual public key, actual private key, actual feed ID and the peers public key, feed ID and location. Since a contract has been established, we need to know what happens in the tin cans and the wire. This leads to the replicated feeds. *Picture of identities with contract*

3.3 Replicated Feeds

The following sentences can be exctracted from the Scuttlebutt Protocol Guide: "A feed is a signed append-only sequence of messages. Each identity has exactly one feed."[6] and "Messages from feeds 3 hops out are replicated to help keep them available for others."[7] - So what do these properties mean?

What can be derived from this information? Signing ensures that you can trust that this message was created by one specific identity. More specific, the encryption of plain text with the sender's private key to a cipher text. The crypto text can be deciphered with the sender's public key. Therefore this means intergrity is given. Append-only means this sequence can not be forged. So there is no possible way to modify or delete any entries that were appended at any time.[8] This append-only property is realized with a macheanism which references the previously generated message.[9] The mentioned ID-centric architecture means exactly one identity (key) is mapped to exactly one feed, where every single bit of information you created or used in the SSB universe is stored.
There is a lot more going on in the SSB feed and protocol, but an adapted simplified version with three fields*(Figure link and siplify even more)* is more than sufficient for this thesis.
These properties underline the trust by guaranteeing completeness and validity of the information read in a feed. But we can see the sticking point in the replication of ID-centric feeds. Since the replication of the SSB protocol always replicates the whole feed with all information to all peers three hops away of a single identity, there is a load on the wire for big feeds. This causes latency and long scuttling time (feed update).[10] By splitting the feeds into smaller ones and having the effective communication between two parties bundled in the feed pairs mentioned previously, we try to bypass this bottleneck. As a result, we have a diagram like this: For the sake of clarity, only the situation between the client and the ISP is shown.
The replicator or the replication process has it first appearance. As a concept, there is some sort of replicator instance or procedure that replicates the feeds to the corresponding address or location. But let's have a closer look at the implementation part.
Having this setup, the next step is to have a possibility to communicate, so the client can request information from the ISP's real database.

[6] https://scuttlebot.io/more/protocols/secure-scuttlebutt.html
[7] https://scuttlebot.io/more/protocols/secure-scuttlebutt.html
[8] Feeds - https://ssbc.github.io/scuttlebutt-protocol-guide/
[9] Feeds - https://ssbc.github.io/scuttlebutt-protocol-guide/
[10] Quelle

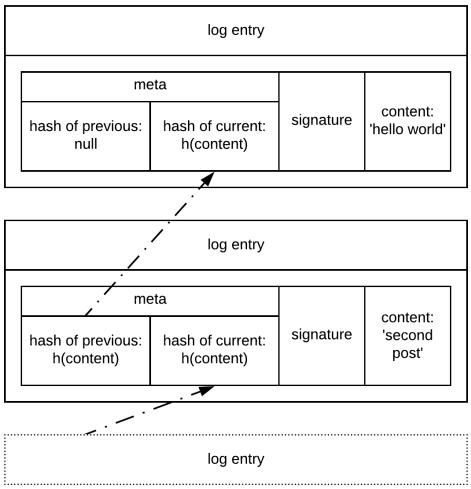


Figure 3.1: A schematic simplified feed. The meta data ensures the append only property, whereas the signature realises signing. Content is the actual data which is stored in the feed.

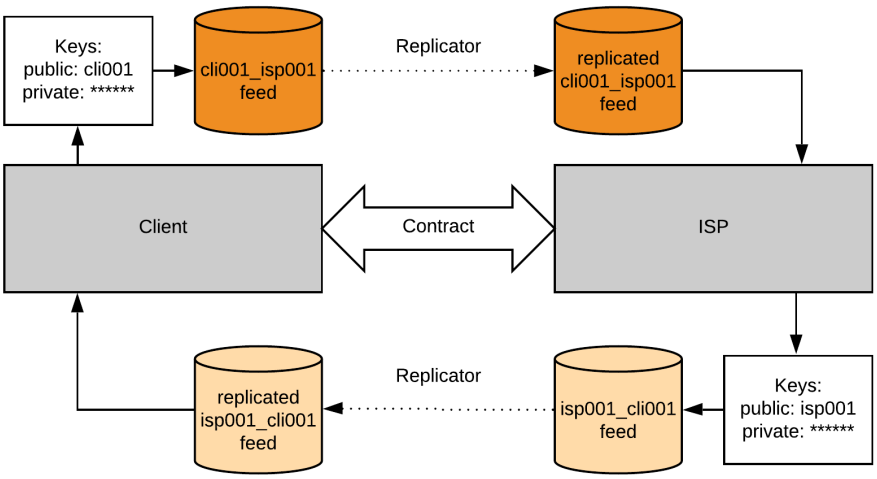


Figure 3.2: Full contract between client and ISP with feeds as it is the same for the server and the ISP as shown.

3.4 Remote Procedure Call

As explained in the section Related Work, Remote Procedure Calls are a useful paradigm for providing communication across a network between programs (Birrell and Nelson [1]). This faces many challenges, but these are not particularly relevant to this stage in the development of the Feed Bundle Protocol. Therfore the RPC used in this section is a very simplified version.

The Idea is to have a caller, in our case the client and a callee, the ISP or server. Having this kind of request–response protocol, an RPC-request is initiated by the caller, which sends a

request to a callee to execute a specified procedure with given attributes. Where as sending is not the appropriate terminology for an environement with the replicated feeds. The RPC-request gets written in the Caller-Callee feed, which is replicated to the callee. When the replication is complete, the callee gets notfied on the feed change and can read the request. After proceeding the request the result gets written in the Callee-Caller feed and the caller can use the result as needed. In our case these specified procedures are called services. By only having one such service e.g. the echo-service, which just echoes the attributes back to the caller, it is ensured the RPC-protocol works as defined. The introducing and detrucing mechanics, described in the next section, can also be summarized in such services, where the caller makes an RPC-request to the for example introduce-service with the necessary parameters.

3.5 Introducing and Detrucing

3.5.1 Introducing

Recapping the tin can phone story: The idea of introducing is to get in touch with a new friend, to whom your best friend introduces you. You and your new friend create a new tin can phone. Since the cord is only long enough to reach your best friend, he connects you to your newly acquired friend. Therefore, the general idea of introducing in context of the feed bundling protocol, is onboarding to a new server over your ISP.

This approach differs from the common publish and subscribe (pub-sub) architecture. Where the server has no choice to decline a client in the pub-sub model, this is the foundation of the introduce-detruce model, by simulating real, human behaviour.

A more detailed description: A client writes an RPC-request for the introduce service of his ISP in the Client-ISP feed. This request needs an attribute which specifies the server which the client wants to be intrduced to. The ISP invokes the introduce service with this given parameter, which now makes an RPC-request with information about the client and the fact that it wants to introduce itself to the server. By writing in the ISP-Server feed, the server detects the change and has the choice to either accept or decline the introduce inquiry. If the Server accepts the introduction, it will directly create the Server-Client feed which is replicated to the ISP. Afterwards, it sends a confirmation or acceptance back to the ISP to fullfill the request. Additionally to just the statement that the client was accepted the whole contract information for the client is given by server to ensure the feeds are labled correctly and the ISP knows where to replicate the new feeds gereated by server and client to. Or the server declines the introducing approach, so the result is rejection followed by no or some sort of empty contract.

Either way the ISP gets the result and fullfills the initial RPC request with this result. The client now gets his result. Depending to the state of acceptance or rejection it builds the Client-Server feed, replicated to the ISP, in accordance with the contract and finally the connection is successfully established. Now if the client wants to use a service from server it only writes the request in the corresponding feed and the procedure is the same as described in the RPC Section, whereas the feed is just forwarded over the ISP.

An important distinction: only the client can introduce itself. The server has no knowledge

of clients and also no way to acquire knowledge of clients, so only the client can ask the server for a contract.

3.5.2 Detrucing

Detrucing as a newly invented word in this thesis, since normally after you introduced yourself to a person there is no way to make this unhappened. It acts the same as an unfollow in a pub-sub domain or as terminating the contract. But contrary, to the introduce both parts of the contract can detruce.
Either the client or the server can send an RPC-request to the ISP service to detruce, which is propagated to the opposite end descibed above in the Introducing section and results in the terminaton of the whole contract. The result of this action is deleting keys and feeds. There is no way to decline a detruce service request.
An important note: after detrucing from either side, the client can yet again introduce itself to the server and the server has again the possibility to accept or decline the introduction.
A new diagram of the network can be derived using these descriptions.

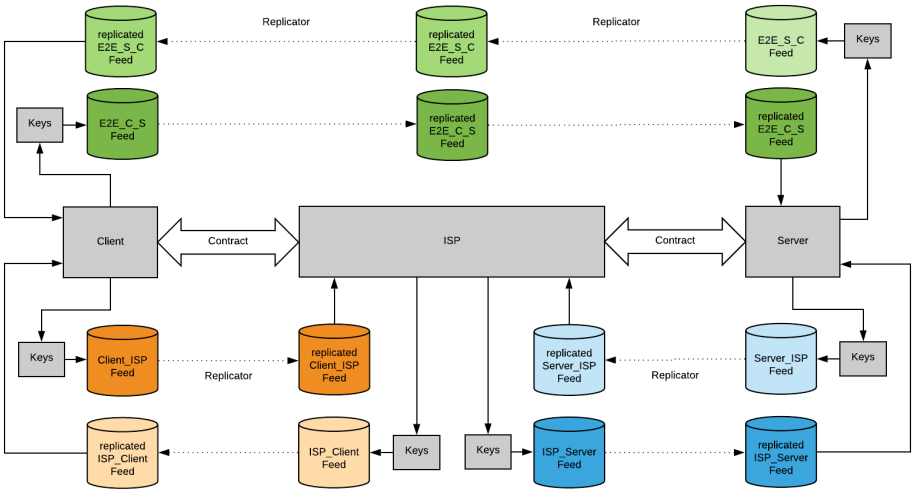


Figure 3.3: State after accepted introduce-request from Client to Server. Clearly seen the green End-to-End feed-pair is replicated over the mediating ISP.

3.6 Bundling

Taking again a look at the real-world problem, the ISP will have a random number of clients, many of whom want to communicate with the same server. Instead of repeating each End-to-End feed-pair over the ISP to the server, the new requests will be sent through a single feed pair between the ISP and the server. This should reduce the amount of replication work enormously.

3.6.1 Adapted Introducing and Detrucing

The introducing and detrucing idea remains the same, whereas the replication process is different. After a server accepts a client, the server generates the entire feed pair: Client-Server and Server-Client feed. But instead of replicating to the ISP, nothing happens. To close the introduce request, the server sends the contract to the ISP and the ISP generates the feed there, which holds data from the server to the client: the Server-Client feed. It is the same feed as in the server but it is not replicated over the general replication instance from server to ISP but replicated from ISP to client. Finally the client receives the result and generates the feed which contains the data from the client to the server: the Client-Server feed. This feed is also replicated the normal way to the ISP. So, the feed pair for client-server communication is normally replicated between client and ISP, whereas between ISP and server a new way of replication is given.

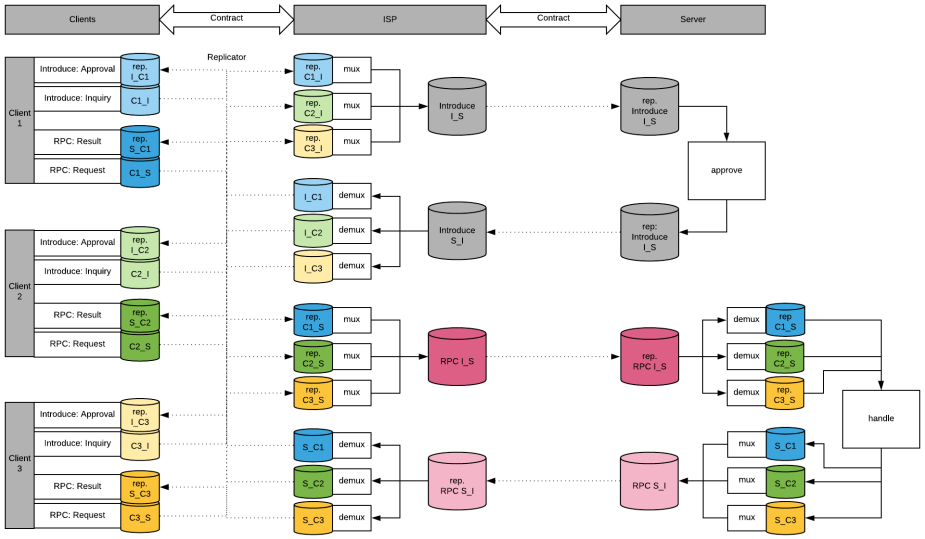


Figure 3.4: multiplexing

3.6.2 Multiplexing and Demultiplexing

As far as the communication between a client and a server is concerend, requests from the client are transferred the same way as before to the ISP. Instead of just forwarding the updated feed, by replicating to the server, the ISP detects new log entries and multiplexes

these into a new log entry. More specifically, the ISP generates a log entry signed by itself, where the content of it is the whole log entry signed by the client. This log entry is written to the ISP-Server feed and replicated. The server detects the change on the ISP-Server feed and takes this log entry. The multiplexed log entry, which belongs into a client-server feed is extracted and appended to the Client-Server feed. This step is called demultiplexing. At this point the situation is the same as before. A change in the Client-Server feed is given and the request is executed. The result is written to the Server-Client feed and not replicated again over the ISP to the client directly. From there the whole story is repeated. The log entry is multiplexed in the Server-ISP feed again, when it arrives at the ISP it is demultiplexed and appended to the Server-Client feed. From there it is replicated to the client and the client receives its result for the request.
Schema von log entry in log entry

3.7 Outlook

Having all these concepts and architecture, we see the whole process is simplified on a single central ISP. In the real world this is not the case, but as proof of concept it is more than sufficient. In the next steps, the system must be expanded by splitting this same internet service provider into a network of internet connectivity providers, which act as an effective connectivity stations. An additional architecture must be found where clients and servers can connect to these connectivity nodes. Adding more ISPs necessarily means that more internet service provider companies will be needed. The dynamic of contracts between ISPs will be explored, but more in the Future Work section.

4
Implementation

In this chapter will be discussed, how a prototype implementation could be realised by applying the above outlined concepts and architectures. This implementation or better said pseudo code shall give a high level overview what can be derived from the concept into the software, by discussing the key elements. All these descriptions are so far known 'best practice', but do not tackle all software-architectural concerns of the FBP as long as the concept and consense is not violated.

4.1 Contracts

Implementing the contracts is a rather easy task on a prototype implementation than it would be for a real world application. As mentioned it consists of the knowledge about each other and where they are located.

Client-Contract	value	ISP-contract	value
actual public key:	cli001	actual public key:	isp001
actual private key:	******	actual private key:	******
Client-ISP feed ID:	cli001_isp001	ISP-Client feed ID:	isp001_cli001
ISP public key	isp001	Client public key:	cli001
ISP-Client feed ID	isp001_cli001	Client-ISP feed ID:	cli001_isp001
ISP location:	131.152.158.21:5000	Client location:	131.152.211.12:5000

In this table we can see a basic contract with all the information needed. This contract can still be broken down even more, since the feed-IDs are just appended public keys. Here a first abstraction to the real world application is made, the public and private keys would most likely be some 256-bits long integer key pairs for example Curve25519[11]. This would result in a 64 digit long hexadecimal representation. The terms here act as simplification and easier distinguishable keys. Having this setup with a for exapmle Curve25519 key pair it is best practice to store them in a secrets or key file. So the most basic contract can look

[11] Quelle

like this:

Client-Contract	value	ISP-contract	value
key file:	cli001.key	key file:	isp001.key
ISP public key	isp001	Client public key:	cli001
ISP location:	./isp001/	Client location:	./cli001/

This even more simplified base, which runs on a localhost over the filesystem, can be stored in some file and build the rest of the contract by the programm. Then these contracts need to be stored somewhere in the software, but can be freely chosen.

4.1.1 ISP-Server Contract

remove

Contract between Client and ISP			
ISP-contract	value	Server-Contract	value
actual public key:	isp001	actual public key:	ser001
actual private key:	******	actual private key:	******
actual feed ID:	isp001_ser001	actual feed ID:	ser001_isp001
Server public key:	ser001	ISP public key:	isp001
Server feed ID:	ser001_isp001	ISP feed ID:	isp001_ser001

4.2 Replicated Feeds

This implementation was developped by Prof. Dr. Christian Tschudin. It is a very simplified version of an append-only log in the .pcap format, generated from a Curve25519 key pair. Every log entry is signed by some private key, which leads to integrity but not security. The whole security part was left out during this thesis.

4.2.1 Structure

The Feed is a list of log entries. Each log entry consists of three main parts: meta data, the signature and the content. The meta holds information about the current log entry such as the feed-ID of its feed, its sequence number, which is the internal possition in the feed of the log entry, a hash reference to the log entry before, its own hash value of the content for the next log entry to reference to. Next is the signature which signs the meta data. The content part is what is actually put into the log entry.
Since all the information is stored in the cbor2[12] format and and held in a pcap file, the result is a binary array which holda important properties usful for the bundling. Either a

[12] Quelle

new log entry can be written with a key or an existing log entry can be appended to the binary array without validation. This mechanism is a key feature for the bundling aspect. *BILD*

4.2.2 Replication

The replication mechanism gets invoked after each write operation to a feed. Generally speaking, this could be realised easily with TCP or UDP in a real network. In this basic implementation replicates feeds in the filesystem this was solved by just copy the feed to the corresponding folder given in the contract.

4.3 RPC

Having the contract and replicated feeds, the type of RPC-protocol plays its turn. To communicate between two participants four general methodes are needed as listed below. By having a simple serialisable datastructure for requests and results, they can be easily encorperated in the feeds. Requests call services which use the given attributes and produce a result, this connects to the given idea of the original RPC-protocol by Birrell and Nelson [1].

4.4 Datastructure

A suiting datastructure or format is a dictionary or a JSON-String, having keys that reference a field, as well as being serialisable. In this structure an ID has to be given to distinguish repeted reqests as well as map the results to their request, a type has to be set to distinguish request and result, further the service to be called is needed as well as the attributes or the result of the call. This results in a minimal set of keys for request and result:
{'ID':0, 'type':'request', 'service':'echo', 'attributes':['An echo']}
{'ID':0, 'type':'result', 'result':'An echo'}
Having the ID as identifier, caller can look up the request made and map the result to the call.

4.5 Services

Services are the procedures called by the caller and executed by the callee. In the feed bundle protocol there are some key services which have to be considered:

- echo - Tt just returns the given attributes.
- get_service_catalog - The caller needs a list of all services the caller has available.
- introduce - This service passes a request to the server specified in the attributes and introduces the caller(client) to it and sign a contract.

- detruce - This closes an alread established contract and ereases all information built on it.
- get_servers - To call the introduce service a server is needed. Since the caller has no knowledge about servers, this is essential.

4.6 API

As disclaimer, these API methods correspond only to the logical aspect of the pseudo code. There are many ways to implement them in differing software-architecturial styles, the implementation only shows what is minimally needed and executed.

4.6.1 Send Request

pseudo method

The send_request method needs to have knowledge about the to invoke service and the attributes for that, as well as a destination. Since already described it is not e sending in the old-fashined way, the destination correspons to the Caller-Callee feed where the caller is the source and the Callee is the destination. Given these parameters, a request can be formed and written to the destination feed, whereas the feed has to be replicated afterwards.

4.6.2 Read Request

pseudo method

This method needs to follow on a feed change. This can be realised either by a global polling mechanism which invokes the read_request method or directly in the method by listening to a feed. It takes the request, extracts its contents and invokes the specified service and waits for its result. Afterwards either returns the result or passes it directly to send_result method.

4.6.3 Send Result

pseudo method

This method is very similar to the send_request method. It takes old executed request to have information about the ID, formes the result and writes it to the Callee-Caller feed.

4.6.4 Read Result

pseudo method

Again this method needs also to follow on a feed change, takes the result and closes the request. Since the send_request method quiet some time elapsed, so there is a threading issue. Will the send_request method be blocking or not? This depends on overlay of FBP and cannot be decided in general although it is blocking in the implementation of Birrell and Nelson [1]. Therefore it needs to be remarked but not considered at this API level.

4.7 Bundling

Leading to the bundling key element, the other components were laied out and specificaly designed for this. There can be made two approaches on the bundling, whereas one consists of a single feed-pair between ISP and the server, where all the communication happens. Or we distinguish two feed-pairs where one acts only for request from the ISP to the server and the other only for multiplexed client requests. In this section the first one approach is discussed, since they differ not that much.

4.7.1 Introducing and Detrucing

As seen in the RPC implementation, a client calls the introduce-service with the server it wants to be introduced to. At this point the ISP holds a request from the client. The ISP does an RPC-request by itself to the server as followed:
Client request: {'ID':0, 'type':'request', 'service':'introduce', 'attributes':'ser001'}
ISP request: {'ID':0, 'client_request_ID':0, 'type':'request', 'service':'introduce', 'attributes':'public_key':'cli001'}

In this request, everything is given the server needs to know. After creating the entire feed-pair and setting up the contract, the result is returned to the ISP.
{'ID':0, 'client_request_ID':0, 'type':'result', 'result':
{'public_key':'ser001', 'client_server_feed_ID':'cli001_ser001', 'server_client_feed_ID':'ser001_cli001'}
}
With these informations, the ISP can build the Server-Client feed and replicate it, since the location of the client is already known. Afterwards the client gets its result on the initial introduce-request an can build the Client-Server feed and also replicate this to the ISP.
{'ID':0, 'type':'result', 'result':
{'public_key':'ser001', 'client_server_feed_ID':'cli001_ser001', 'server_client_feed_ID':'ser001_cli001'}
}
This implementation corresponds to a client, ISP and server, which do not know how each other names the feeds, as well as over which public key the connection will be handled, this lays the base for several ISP nodes dicussed in the future work.

4.7.2 Multiplexing

Having now an introduced client we need to have a look at the communication between it and the server. As already mentioned, there is no direct feed replication between the client and the server over the ISP. Instead the requests are taken from the Client-Server feed at the ISP put in the ISP-Server feed and then again taken from this same feed in the representation of the Client-Server feed at the server.
For this a new type is accepted, as well as a new field is added in the RPC-datastructure: the mux-type and the meta-field. Here an abstraction of the structure of a 'mux-request':
{'ID':1, 'type':'mux', 'meta':
{'feed_ID':'cli001_ser001'},'request':
{'ID':1, 'type':'request', 'service':'echo', 'attributes':'hello server'}
}

The mux type ensures that the log entry is not designd for the read_result method of the RPC and in the meta field, all information additionally needed by the server are given. A server reading this, knows in which feed the request belongs writes it into this feed and from there performs the requested service. The result is as followed written in the Server-ISP feed:
{'ID':1, 'type':'mux', 'meta':
{'feed_ID':'ser001_cli001'},'result':
{'ID':1, 'type':'result', 'result':'hello server'}
}
Again the meta data describes how to handle this specific mux-result in the ISP.
If we approach the problem like this, one particular inconsitency occurs. When writing in feeds with this approach the signing process is violated and the integrity broken. Hence the replicated feed offers a solution for this. Instead of extracting the request to and then rewrite it, the whole log entry is put as the value of the key request or result and at demultiplexing state bytewise appended to the corresponding feed. *Picture* Clearly seen is the full log entry w of the Client-Server feed. By putting w directly in the log entry v of the ISP-Server feed no information gets lost or changed. This ensures integrity and replicates the feed exactly as is it is bytewies over the ISP to the server.

5 Evaluation

Evaluating a system, which takes baby steps into a completely new environement, was quiet challenging. Since most of the work was to come up with the concepts and architecture, the implementation is a little bit chaotic and often not best practice oriented as in the Implementation chapter. Nevertheless, the code has been tested and important conclusions were drawn.

5.1 Testing Environment

As seen in the implementation part, the client can call services via requests from the ISP as well as from the server after introducing itself to it. Given this, the main testing aspect was to see that ISP and servers can keep up with the work load and distribute the results back to its origin. The test was as followed:
First the implementation was tested manually by testing each functionality by its own. Second came the automated thest. At the beginning there were three nodes involved, one client, one ISP and one server. After initialising all nodes the client went into a loop, where it first introduced itself to the server. The server automatically accepted this request and the feed-pair was created. After this, a random number was created between 5 and 20, which were the amount of service requests sent to this now connected server. To mimic a human interaction at first delays between the 1.0 and 4.0 seconds, randomly distributed with one decimal place, were implemented between the RPC-requests. This was the basic evaluation on functionality, performance, reliability and correctness.
Unfortunately after about 50 requests, either ISP or the server had an exception on the cbor2 library[13]. Something with the bytestream seemed to be broken. Any other solution than just ignoring this exception and leave this specific log entry hanging could not be found. This resulted in open, unresolved request which the client waited for.
In a next step, after ignoring inconsitencies in the log entries, the system was tested to its limits, by having delays lowest at 0.1, adding more and more clients and up to a thousand iterations per client. Where at the last test with a delay of 0.1 seconds, 5 clients and a

[13] Quelle

combined thousand requests per client, my personal machine nearly broke down. The tests lead to interesting results.

5.2 Results

5.2.1 Functionality

The functionallity was tested manually on different Linux distributions[14][15][16] where as on Windwos and Mac OS heavy problems occured. The filesystem poller (Watchdog[17]) could not detect any changes on feeds, even they were made. As far as concerned and tested on Linux distributions the functionallity is complete, the whole process of requesting services from the ISP as well as introducing to diffrent servers is given and works as intended. But only if the user follows strictly through the documentation how the system must be used. The user experiance is rather not intuitive and false use can lead the system to corrupt. This is founded in the very early stage of the project, by iterating over it these issues can be found and eliminated.

5.2.2 Performance

The performance begins with an astonishing speed with nearly no latency between request and response and collapses over time. This fact was already know at the implementation point. To distinguish already handled and completed requests, the system cycles through the whole feed, every time a change is detected. This problem can be solved by indexing the feed and saving the position, where everything already has been done. This factor has been left out intentionally to concentrate on the underlying concepts and architecture in the big picture.

5.2.3 Reliability and Correctness

As already teased in the section Testing Environement, some *undefined* or *undiscovered* fault between this implementation and the cbor2 library caused to ignore requests. Having this information, the tradeoff between the reliability and correctness of the feed bundle protocol lay on the hand. Having the underlaying simplified RPC protocol, the fact that request do not get a response violates the consensus if it is not exactly specified. All these findings generalise one big problem.

5.2.4 General Collaboration of Components

Again having this completly new technology, developed in just a few months, having the main focus on the general aspects results in a patchwork of diffrent libraries, common technologies and new technologies which are not coordinated on each other. To generally improve the

[14] Ubuntu - 18.04.4 LTS, Python 3.6.9
[15] Ubuntu - 19.10, Python 3.7.5
[16] Arch - 5.7.6, Python 3.8.3
[17] Quelle

very broadly open architecture and concepts need to be thighted with more rules and less freedom resulting in a more specific implementation where the components optimally are written to function well with each other. As claimed in the thesis, splitting the ID-centric feeds from Secure Scuttlebutt into feed-pairs which are bundled by the Feed Bundle Protocol should reduce load on the wire can not be judged already. The Feed Bundle Protocol is in a too early state with not enough backbone in its implementation. Where as the claimed easier onboarding is definately given. After establishing a contract with an ISP on start-up of the software the client is directly connected to this ISP and indirectly connected to the servers the ISP holds contracts with.

6
Conclusion and Future Work

6.1 Conclusion

The goal of this project was to introduce new intermediary service providers and replace the ID-centric append-only log from Secure Scuttlebutt Protocol with a feed-pairs, which hold information of the dialog of two identities in the Feed Bundle Protocol. This extension or modification allows a much easier onboarding experience, since the client is indirectly connected to all the ISP's servers after signing a contract with an ISP. With the new introduce-detruce architecture, clients can connect and diconnect to new servers in a simple manner. Within this process new feed pairs are created, which bundle all the information for that specific connection. To ease the load on the wire and the process of replicating every feed through the ISP directly to the server, requests are multiplexed into a single feed pair between the ISP and the Server. If this approach is more promissing than the ID-centric architecture of Secure Scuttlebutt can not yet be decided. Since this system is so new an has been developed completely "out of the blue", there are many ways to improve it, one of which is to use the feeds properties primarily to define the state of doneness inside a feed and its single log entries. There are still many avenues to be explored and important key features to be added to in order to generate relieable Client-ISP-Server Network, some of which are discussed within the next section.

6.2 Future Work

Apart from improving the general system, we have only examined the connection between a single ISP with a single connectivity node with a random number of clients and servers connected. In the real world, however, this is not the case. There are many ISPs on the market which have connectivity stations all over their respective countries. Therefore internet service providers (ISPs) and internet connectivity providers (ICPs) can be separated. Contracts between two ISPs would also be conceivable. In the process of creating the simplified version of the feed bundle protocol, we always kept the big picture in the foreground and decisions were made keeping this in mind. Also a way to combine log entries in the bundling process has to be considered for effectivly reducing the replication work.

6.3 Combination of Log Entries

Seen in the concept and the implementation, only a single new log entry is multiplexed into the ISP-server feed pair, resulting in a replication after each request. A diffrent approach can be made. We combine log entries in the multiplexing system. Meaning, instead of only one, a defined number of new log entries or log entries generated over an elapsed time will be multiplexed to the server. This gives room for more efficient replication, since the whole feed gets replicated to the peer every time. Deriving from this the multiplexing feed pair can be splited up into arbitrary many sub feed pairs, linked to the priority of the request.

6.4 ISPs and ICPs

As mentioned previously, the ISP was always a single node, with contracts to clients and servers. However, we could also look at the ISP as a company with a network of ICPs where the physical connection between the servers and clients takes place. In simple terms, the client and server were indirectly 'connected' through the ISP. The initial mind map drawn to lay out the concept of this thesis was a peer-to-peer Internet Connectivity Provider (ICP) network where the ISP-Company distributes the feeds internally between the ICPs. Applied real life, there is a contract with the ISP, e.g. Swisscom, and this same ISP has connectivity provider stations or nodes which form a network of ICPs. This means that a client has a connection to ICP342 of Swisscom and the server has a contract with ICP903. But both have a contract with Swisscom, which provides internal replication and bundling of feed-pairs to pass information from ICP342 to ICP903. In light of this fact, a new challenge emerges.

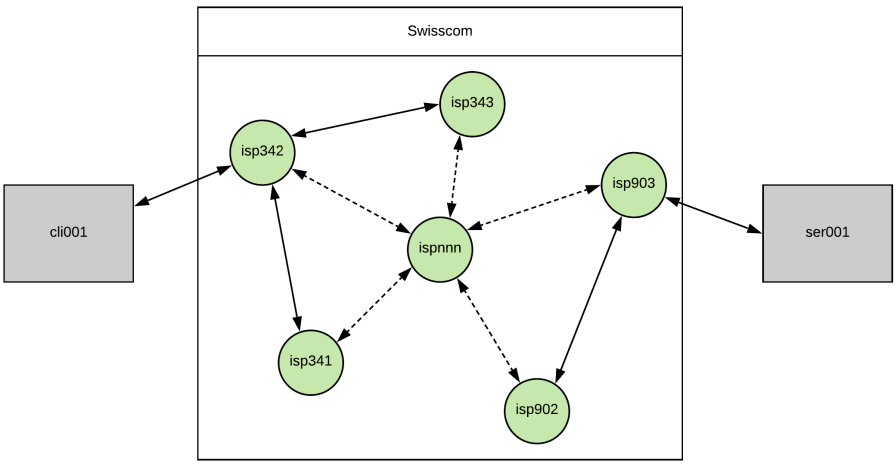


Figure 6.1: A simplified contract network.

How are the feeds replicated? How will an introduce-request happen? Can a client have several ICPs connected. Either with the same approach as is currently the case, where every ICP node stores a replication of each feed-pair which it routes to the next node, or only by appending the multiplexed log entries to the ICP-ICP feed-pair or even a hybrid solution is considered. Additionally, terminating a contract with one ICP should be possible for a

client to change the connectivity provider, for example when traveling from Basel to Zurich. New algorithms need to be developed tho handle exactly such use cases.

6.5 Contracts between ISPs

Yet again, we can take this distribution to the next level where ISPs have contracts with other ISPs. This provides a way to bypass the current requirement that each ISP, which wants to offer every server in the FBP-universe, must have a contract with each server. This has a very special impact on the system however, since new contracts are generated, when the business aspect has not yet been defined.

7 Body of the Thesis

This is the body of the thesis.

7.1 Structure

7.1.1 Sub-Section

7.1.1.1 Sub-Sub-Section

Paragraph

Even Sub-Paragraph This is the body text. Make sure that when you reference anything you use labels and references. When you refer to anything, you normally capitalise the type of object you reference to, e.g. Section 7.1 instead of section 7.1. You may also just use the `cref` command and it will generate the label, e.g., for Section 7.1, we did not specify the word "Section".
Hint: Try to structure your labels as it is done with `sec:my-label` and `fig:machine`, etc.

7.2 Equations

A Turing Machine is a 7-Tuple:

$$M = \langle Q, \Gamma, b, \Sigma, \delta, q_0, F \rangle \tag{7.1}$$

A Turing Machine is a 7-Tuple even if defined in the text, as in $M = \langle Q, \Gamma, b, \Sigma, \delta, q_0, F \rangle$.

7.3 Tables

Some tables can also be used as shown in Table 7.1[18]. Remember that tables might be positioned elsewhere in the document. You can force positioning by putting a `ht!` in the definition.

[18] Table captions are normally above the table.

Table 7.1: Frequency of Paper Citations. By the way: Make sure to put the label always after the caption, otherwise LaTeX might reference wrongly!

Title	f	Comments
The chemical basis of morphogenesis	7327	
On computable numbers, with an application to the ...	6347	Turing Machine
Computing machinery and intelligence	6130	

7.4 Figures

Figures are nice to show concepts visually. For organising well your thesis, put all figures in the Figures folder. Figure 7.1 shows how to insert an image into your document. Figure 7.2 references a figure with multiple sub-figures.

Missing: Description figure.

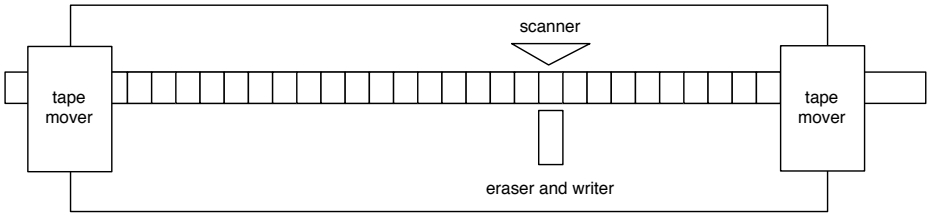
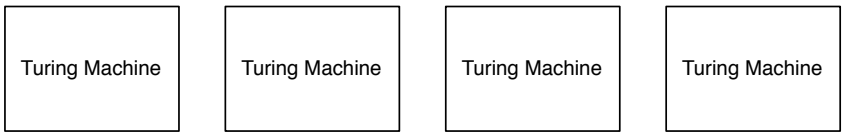


Figure 7.1: A Turing machine.



(a) Turing Machine 1 (b) Turing Machine 2 (c) Turing Machine 3 (d) Turing Machine 4

Figure 7.2: Plots of four Turing machines

7.5 Packages

These packages might be helpful for writing your thesis:

`caption` to adjust the look of your captions

`glossaries` for creating glossaries (also list of symbols)

`makeidx` for indexes and the back of your document

`algorithm, algorithmicx, algpseudocode` for adding algorithms to your document

8 Conclusion

This is a short conclusion on the thesis template documentation. If you have any comments or suggestions for improving the template, if you find any bugs or problems, please contact me.

Good luck with your thesis!

Bibliography

[1] Andrew D Birrell and Bruce Jay Nelson. Implementing remote procedure calls. *ACM Transactions on Computer Systems (TOCS)*, 2(1):39–59, 1984.

[2] Dominic Tarr, Erick Lavoie, Aljoscha Meyer, and Christian Tschudin. Secure scuttlebutt: An identity-centric protocol for subjective and decentralized applications. In *Proceedings of the 6th ACM Conference on Information-Centric Networking*, pages 1–11, 2019.

A

Appendix

Declaration on Scientific Integrity
Erklärung zur wissenschaftlichen Redlichkeit

includes Declaration on Plagiarism and Fraud
beinhaltet Erklärung zu Plagiat und Betrug

Author — Autor
Jannik Jaberg

Matriculation number — Matrikelnummer
2017-054-370

Title of work — Titel der Arbeit
A Feed Bundle Protocol for Scuttlebutt

Type of work — Typ der Arbeit
Bachelor Thesis

Declaration — Erklärung
I hereby declare that this submission is my own work and that I have fully acknowledged the assistance received in completing this work and that it contains no material that has not been formally acknowledged. I have mentioned all source materials used and have cited these in accordance with recognised scientific rules.

Hiermit erkläre ich, dass mir bei der Abfassung dieser Arbeit nur die darin angegebene Hilfe zuteil wurde und dass ich sie nur mit den in der Arbeit angegebenen Hilfsmitteln verfasst habe. Ich habe sämtliche verwendeten Quellen erwähnt und gemäss anerkannten wissenschaftlichen Regeln zitiert.

Basel, 02.07.2020

Signature — Unterschrift