



Introduction to SCION

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November 29, 2021

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Abstract

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Chapter 1

Introduction

Today's world is not only unimaginable without technology, it is also growing ever more connected. From our basic utilities, to public transport, our personal devices right down to light bulbs, everything is connected to the internet. Since its inception in the 1970s the internet has permeated through all aspects of our lives and thus is an indispensable part of what makes our modern and connected society and industries possible. One could go as far as to say that the internet has become the backbone of our modern society. However with the ever greater scale of this global network, it has become brittle. A chain of well publicised outages demonstrates this clearly. The outage at Facebook on **TODO** is only the most recent which springs to mind.

When the internet and its core protocols were designed nobody could imagine the eventual scale it would reach, also solving the technical challenge of connecting computers over long distances reliably took precedence over matters like security and efficiency. In fact getting it to work at all was seen as a major achievement. By the early 1990s the internet as we know it today had come together. Since then it has evolved little and if so reluctantly. As a consequence today's protocols are no longer up to the task of managing the scale and complexity of the internet, nor navigating the modern threat landscape.

In this paper we give an introduction to *scalability, control, and isolation on next-generation networks* also known as *SCION*. A project which aims to provide a clean slate reengineering of the core internet infrastructure, in order to solve some of the most pressing concerns which plague the modern global internet.

This paper will outline inherent shortcomings of the current internet architecture and examine how SCION proposes to solve said challenges. We will explore the concepts contained in the proposed solution as well, as comparing SCION to the existing protocol.

The core protocols and services which make our modern connected world tick may be narrowed down to the following:

1. Internet Protocol (IP): Provides addressing of devices.
2. Border Gateway Protocol (BGP): Provides forwarding and path discovery between networks.
3. Domain Name System (DNS): Provides resolution between domain names and IP addresses.
4. Public Key Infrastructure (PKI): Provides cryptographic binding between names and entities.

Of course there are many more technologies involved in getting information from point A to point B, but these are the ones that make the global portion of the internet work. Any disruptions to these services, can cause major outages and other problems for large parts of the global internet. These protocols and services have only evolved little, which on one hand is a testament to the relative foresight and design rigour applied by their creators, on the other hand are they no longer up to task of managing today's scale and complexity of the global internet and the modern threat landscape. This becomes evident by the comparatively low availability of the internet. XY calculates the availability of the internet at 99.9 %. Which might seem high at first, but actually amounts to an average downtime of xx seconds per day. This is shockingly low compared to other infrastructure systems like the plain old telephone system, with an availability of 99.9999 %.

The possible reasons why parts of the global internet or individual resources may be unreachable are manifold however here are some major ones:

- Denial of service attacks
- Disruptions in DNS
- BGP route hijacking
- BGP route misconfiguration
- Physical route failures

The compromise or corruption of certificate authority and with it the compromise of the roots of trust which they provide do not directly impact the availability of the internet, however it has adverse effects on qualities, and needs mentioning in this context as well.

Chapter 2

Problem Analysis

2.1 The Global Interne

Many protocols and technologies are involved in transporting information from point A to point B in a computer network. However, the core protocols and services which make our modern connected world tick and thus constitute what we will call the global internet, may be narrowed down to the following:

- Internet Protocol (IP): Provides adressng of devices.
- Border Gateway Protocol (BGP): Provides forwarding and path discovery between networks.
- Domain Name System (DNS): Provides resolution between domain names and ip addresses.
- Public Key Infrastructure (PKI): Provides cryptographic binding between names and entities.

2.2 Quality Metrics

Now that we know what set of technologies we include in the discussion, it must also be definded what measures of quality we are concerned with and what the expectations are regarding these quality measures. Here again there are plenty of metrics to choos from. First and foremost we want to have availability - if a resource is unreachable, all bets are off. As a benchmark point for availablity in a vital cummunications system we might look at the *plain old telephon systems* (POTS). Its availablilty is generally estimated to be around 99.999 % NEEDS REF.

If a resource is available we want to be able to trust that resource. Trust is hard, manly because trust is a social and political concept which can be only conveyed by techonological means, not generated by them. We expect that if any entity is reveiled to be untrustworthy or becomes compromised, we can revoke our trust quickly. We also expect that we can choos whom to trust with any out of scale reprecussions The current solution to the trust problem is subject of the browser PKI and BGP Sec.

Once trust is established we would like to ensure that communictain can not be altered between two or more mutually trested parties. This adds the requirement of data integrity. The current state of the global internet also suggest it would be wise to take scalability and efficiency into account as well. Adding and removing entities should be preferably low

cost, quick, disruption free and error free. The same must be true for connection between entities.

The possible reasons why the above qualities may be degraded are manyfold, but here are the ones that are at play on a global scale:

2.3 Shortcomings of the Current Internet Infrastructure

There are many factors that can degrade the service quality we expect from our internet connections, however the following are the main issues which can and do affect the global internet on a daily basis.

- (Distributed) Denial of Service Attacks (DOS)
- Disruptions or poisoning of DNS
- BGP route misconfiguration or hijack
- Physical route failures
- Compromise or corruption of trust roots

Any disruptions or attacks on BGP, DNS or the PKI can cause major degradation of service quality for large parts of the global internet. These protocols and services have only evolved little, which on one hand is a testament to the relative foresight and design rigour applied by their creators, on the other hand are they no longer up to task of managing today's scale and complexity of the global internet and the modern threat landscape. This becomes evident by the comparatively low availability of the internet. XY calculates the availability of the internet to around 99.9 %. This might seem high at first glance, however this amounts to around xy seconds per day. Of course DOS attacks and physical failures in the carrier medium are most obvious causes for outages. However, these tend to be often localized to one or just a few sites, only occasionally causing world wide effects. In contrast, attacks on or misconfigurations in BGP often have wide ranging consequences and can take large swaths of the internet down. Even short lived problems like temporary dead routes or loops during route convergence often affect thousands of users.

Managing trust is notoriously difficult. There have been multiple attempts to implement certificate revocation in the past and all of them failed. The natural thing to do may be to then drastically shrink the pool of trust roots one relies upon. However doing this is almost impossible task. For once, the sheer number of available trust roots is immense. Firefox for example, at the time of writing, ships with 131 CA certificates including NEEDS REF. Assessing them all reliably and continuously is a task. Furthermore, removing a trust root may render a large number of resources on the internet untrusted and thus inaccessible. This also illustrates that the current trust model does not scale.

Finally the question of scalability and efficiency must be addressed. The most glaring issue at the time is the exhaustion of IPv4 address space. IPv6 is a valiant effort to relieve this problem, which until now has not come to fruition. This fact alone demonstrates how slowly core internet technologies evolve. Adding a new AS to the global internet not only requires each resource in that AS to be addressable by IP address it also requires that the new location of the AS be propagated through the whole network to all the routers and to be added to their routing tables. As XY demonstrates route convergence in BGP can take up to XY seconds after a change, so changing, adding or removing routes is slow. Further is the process error prone, as demonstrated by numerous BGP misconfiguration

related outages. Prominent cases of BGP route hijacking further makes its lack of proper security clear.

By now the need for a profound change should have become evident. The current internet architecture does not or only partially provide the qualities its current scale and the surrounding threat landscape demand. Attempts to resolve these issues by evolution through grafting on solutions by protocol extensions or replacing current individual technologies have largely failed, as the current adoption of IPv6 and DNS Sec clearly demonstrate. Although technologies like TLS and DNS Sec have seen partial success, they still suffer from lack of unsolved issues outside their problem scope. From this it follows that a wholistic solution - revolution instead of evolution - is needed. SCION endeavours to deliver this whole cloth reengineering.

Chapter 3

Results

3.1 Separation of Data and Control Plane

3.2 Control Plane

3.2.1 Path Discovery by Beacons

3.3 Data Plane

3.3.1 Path Assembly

3.3.2 Data Forwarding

3.4 Trust Management

3.5 SCION Adoption

Chapter 4

Indicies

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