ETH zürich

SCION™
ELEVATING SECURE COMMUNICATION

REACHING ESCAPE VELOCITY

SCION DAY 2024

Adrian Perrig
ETH Zurich, Network Security Group

Benefits of a SCION Connection

Security: Authenticated control plane and resilience against path hijacks.

Stability: Native multipath capability at the network level with rapid path failover ensures high stability despite link failures at the physical layer

Control: Path-awareness for end hosts enables application-specific path control and optimization

E.g., possibility for traffic geofencing determined by the sender

Protection: Hidden paths and sender-based path selection increase protection against DDoS attacks.

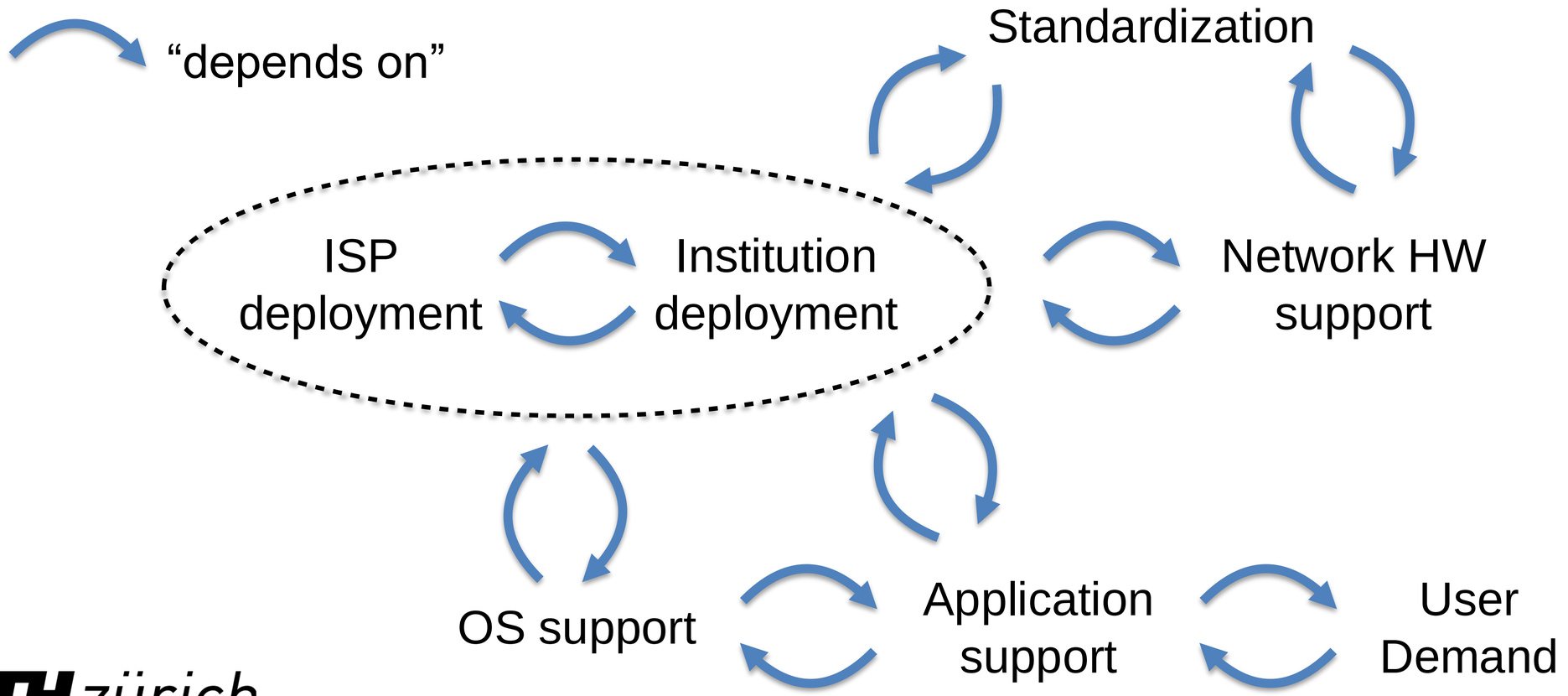
Performance: SCION applications can select the best paths based on latency, bandwidth, loss, or jitter.

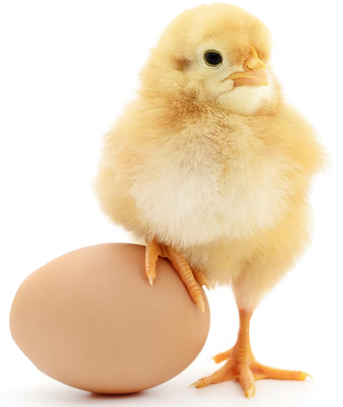
ETH zürich

SCION

Deployment Challenge: Dependency Loops

- Disruptive technology: potential risk for incumbents
- Several circular dependencies complicate deployment





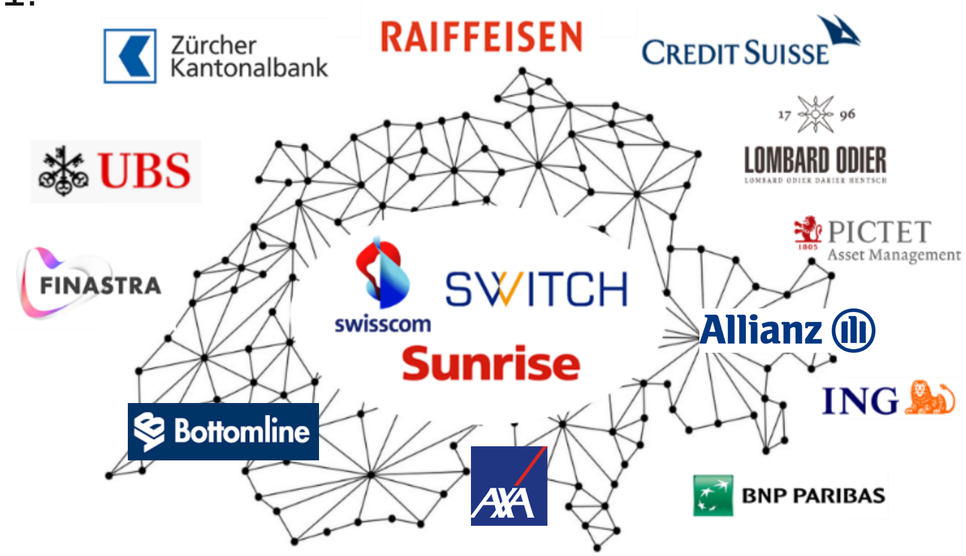
Secure Swiss Finance Network (SSFN)

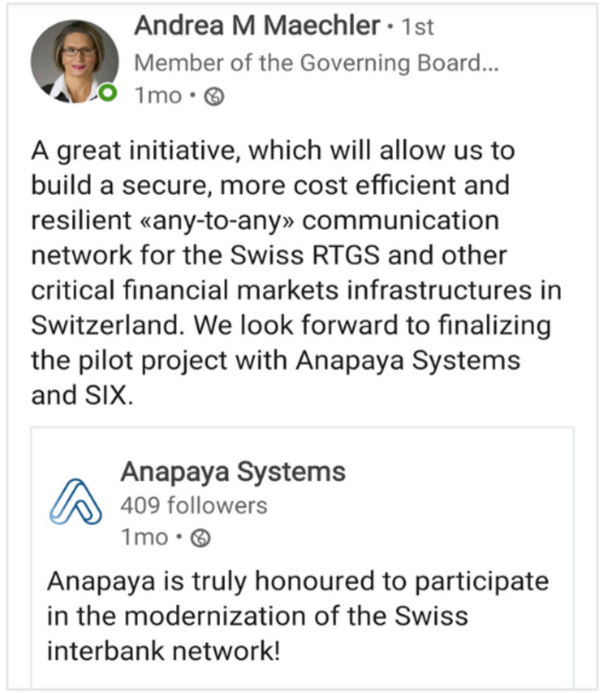
The Swiss Interbanking Clearing system in numbers:

- 321 participants, including 280 banks, 14 insurance companies and 12 securities firms
- 2.9 million transaction representing 178 billion CHF per day

SSFN: Secure Swiss Finance Network

The new secure, reliable, community-based and sovereign network announced in July 2021:





Logos are illustrative

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

SIX

SCION Production Network

- **Not an overlay!**
  BGP-free global communication
  - Fault independent from BGP protocol
- Deployment with international ISPs
  - First **global public secure** communication network
- Construction of SCION network backbone at select locations to bootstrap adoption

ANAPAYA cyberlink colt

interCloud BT telindus

SWITCH axpo swisscom

swissix SWISS INTERNET EXCHANGE LG U+ vtx

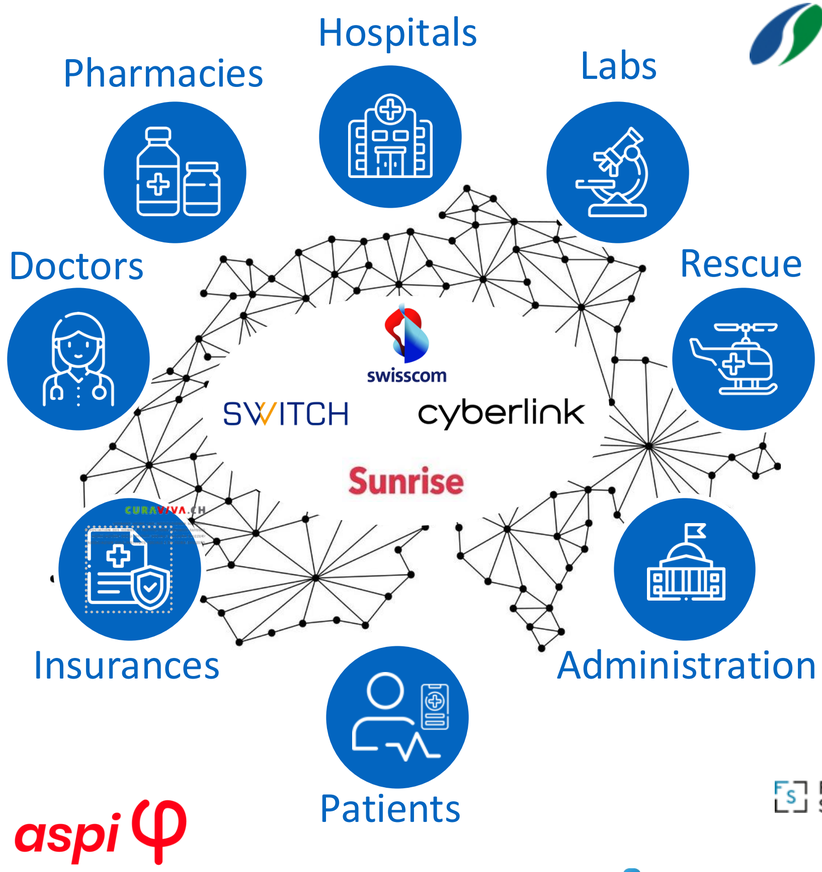
Sunrise GÉANT KREONET

ETH zürich SCION

Secure Swiss Healthcare Network (SSHN)

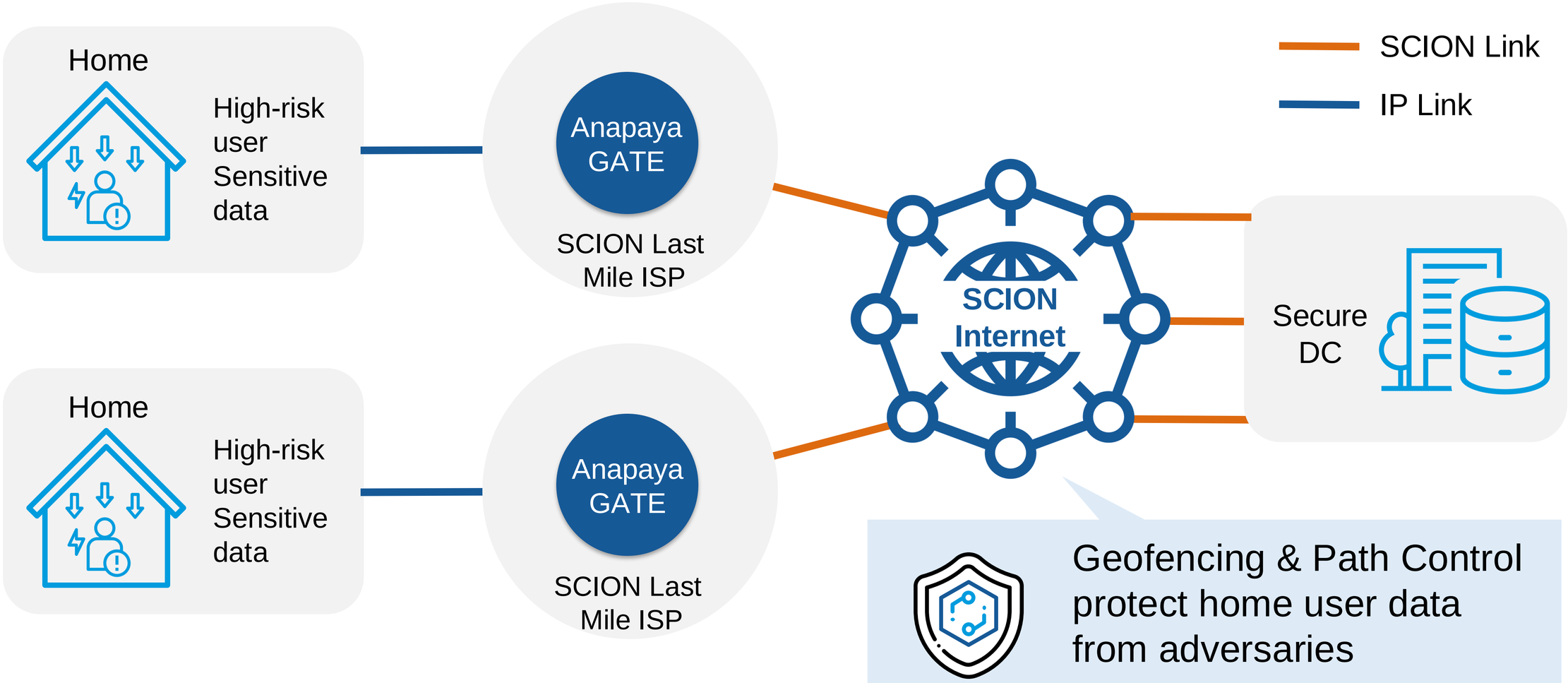
The HIN Trust Circle (HIN Vertrauensraum):

- Interconnecting **hundreds of hospitals** and **tens of thousands of doctors**
- Healthcare is **highly dependent on communication** between multiple parties
- Connectivity could be **life-saving**



Anapaya GATE Approach Against DDoS

Seamless secure SCION for remote users



ANAPAYA

SCION

Growing SCION Ecosystem

PRINCETON UNIVERSITY
SIDN
ETH zürich
UFMS
고려대학교 KOREA UNIVERSITY
NUS National University of Singapore
OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG
CYBEXER TECHNOLOGIES
CSCS Centro Svizzero di Calcolo Scientifico Swiss National Supercomputing Centre
KAIST
KiSTi www.kisti.re.kr
UNIVERSITY of VIRGINIA
DEMOKRITOS
BT
proximus telindus
interCloud
swisscom
Sunrise
DIGITAL REALTY
axpo
swissix SWISS INTERNET EXCHANGE
LG U+
vtx
cyberlink
GÉANT
KREONET
Switch
colt
ETH zürich

ANAPAYA
infoGuard SWISS CYBER SECURITY
Extreme™
INFOSEC GLOBAL
Startups
HIN
eraneos
securosys
libC TECHNOLOGIES

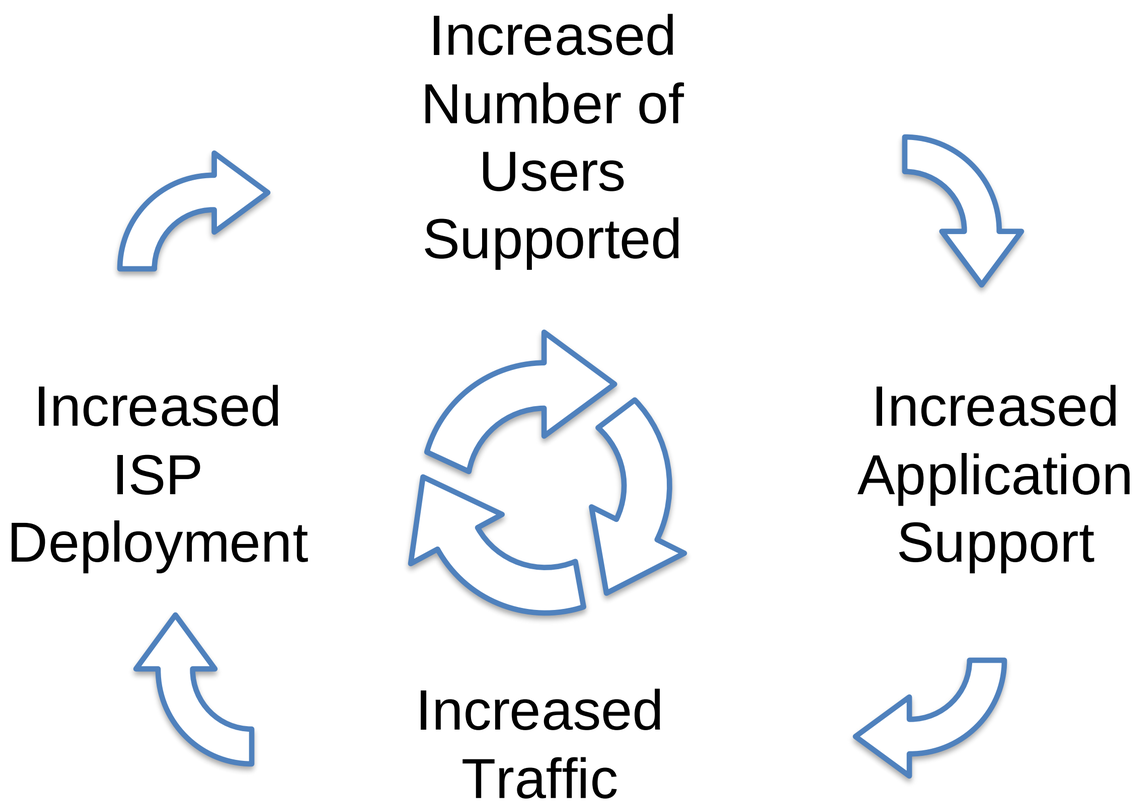
RAIFFEISEN
SIX
Zürcher Kantonalbank
UBS
armasuisse
aws
Sui

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Federal Department of Foreign Affairs FDFA

SCHWEIZERISCHE NATIONALBANK
BANQUE NATIONALE SUISSE
BANCA NAZIONALE SVIZZERA
BANCA NAZIUNALA SVIZRA
SWISS NATIONAL BANK

Virtuous Cycle: Proposal to Reach Escape Velocity

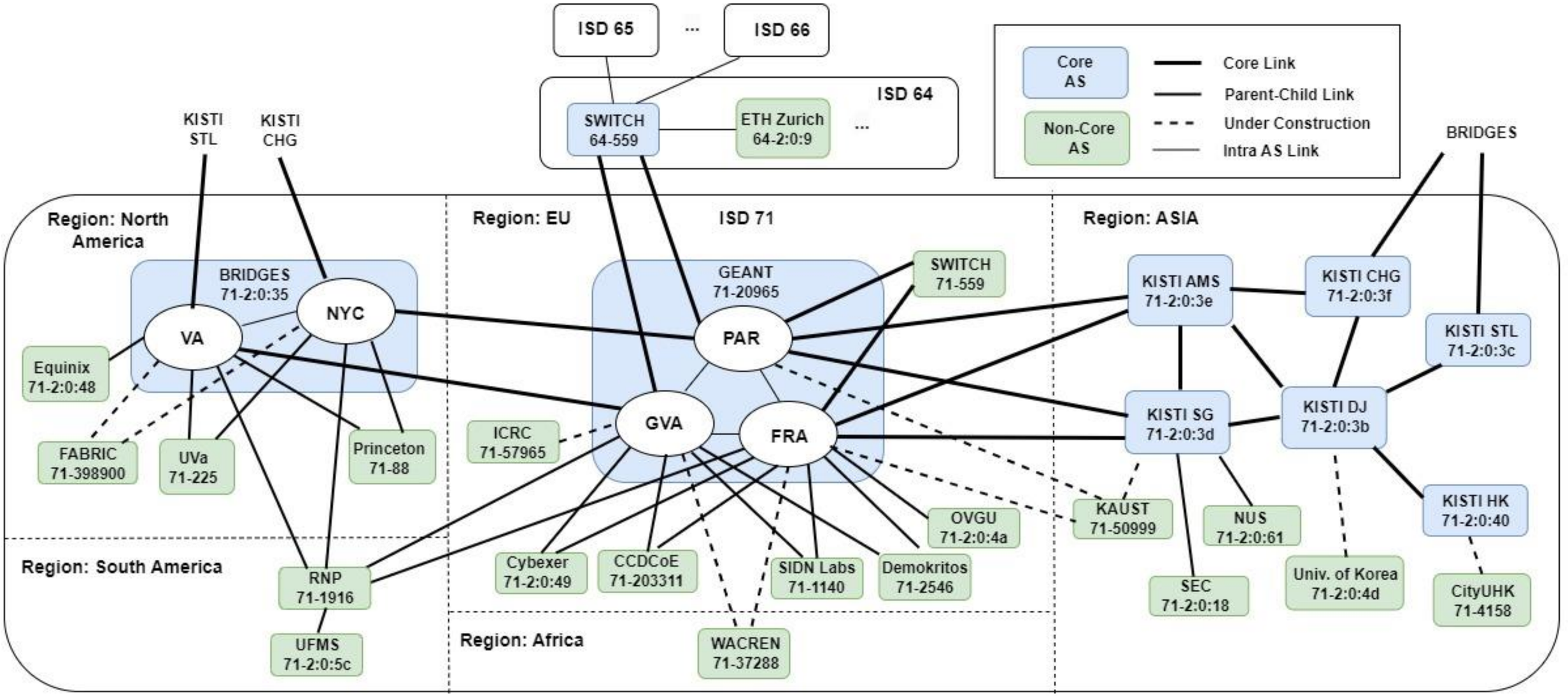
- Observation: adoption fuels more adoption



Research and Education Network: Priming the Virtuous Cycle

- With the initial SCION research and education network, around 1/4 million users now have native SCION connectivity
- Initial institutions: BRIDGES/GMU/Internet2, CityU HK, Demokritos, ETH, GEANT, KAUST, KISTI, Korea University, NUS, OvGU Magdeburg, Princeton, SEC, SIDN, SWITCH, UFMS, U of Virginia, WACREN, …
- Applications with 4% user base at Universities will see 10’000 users with native SCION access
- Once applications deploy, traffic increases, setting the cycle in motion …

SCION Research and Education Network



ETH zürich

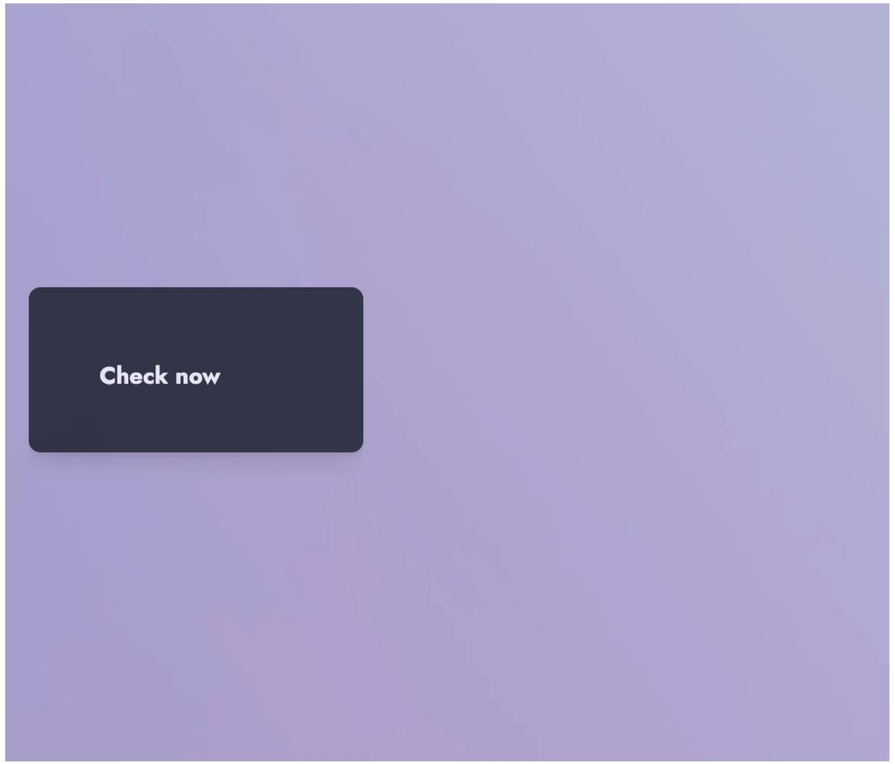
SCION

Simplify Native SCION Usage

- Bootstrapper infrastructure provides SCION configuration information to local applications, avoiding user configuration
- End host software facilitates building of native SCION applications
  - Simplest way is to use JPAN library with Java
  - Several SCION libraries for Golang
  - Many projects offering SCION support, listed on the “Awesome SCION” page: https://github.com/scionproto/awesome-scion

Testing SCION Connectivity

- https://scion-architecture.net/apps/



01

Discover if you have SCION connectivity

If you're connected to a network that provides native SCION connectivity to the SCION commercial network, then you can send a SCION packet to any destination in that network in a "BGP-free" manner, i.e., **without relying on the BGP protocol**!

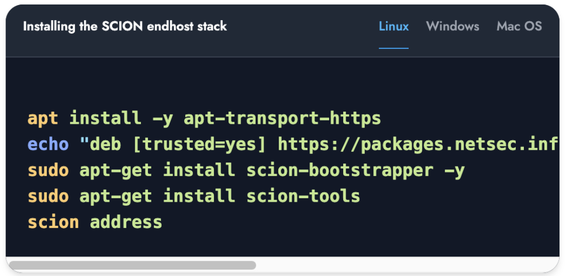
Thus, the commercial SCION network is **not an overlay** and operates independently from today's Internet. Therefore, at the very least, making use of both SCION and IPv4/6 enables more resilient end-to-end connectivity.

As SCION provides in most cases many different forwarding paths (in many cases over 100 different path choices!), the odds are high that one of the SCION paths provides improved communication quality (in terms of latency, jitter, loss, bandwidth, MTU, or CO2, just to mention some options) over the single Internet path.

You can check for connectivity by using the connectivity checker on this page.

Examples on how to use SCION

- https://scion-architecture.net/apps/



03

How to set up SCION on your host

SCION requires a set of components to be installed on your end-host system to be able to use the network.

The **Bootstrapping Service** uses hints, such as DHCP options, to find where your AS' infrastructure is located, and exposes this information to the Daemon.

The **SCION Daemon** takes care of communicating with the control plane, for instance to fetch paths to a specific destination. Applications that use SCION typically communicate with the daemon for that purpose.

The **SCION Dispatcher** responds to SCMP Echo and Traceroutes requests.

A tool has been created which sets up all the components necessary on your system, please refer to the installation commands for your OS.

If you got stuck in the set up process, please let us know where you are stuck via our **Slack channel**

04

Sending your first SCION packet

It's time to test your setup! Let's start with the universal test for network connectivity, sending a ping packet.

ETH zürich

SCION

SCION Ping and Path Fetcher

- `scion ping 71-2:0:5c,127.0.0.1`

```
inf-isec-core-vpn-1-b-03:mac_bin adrianperrig$ ./scion ping 71-2:0:5c,127.0.0.1
Resolved local address:
  129.132.227.235
Using path:
  Hops: [64-2:0:9 1>5 64-559 30>5 71-20965 141>1 71-2:0:5c] MTU: 8952 NextHop: 192.168.53.20:30042

PING 71-2:0:5c,127.0.0.1:0 pld=0B scion_pkt=156B
152 bytes from 71-2:0:5c,127.0.0.1: scmp_seq=0 time=490.439ms
152 bytes from 71-2:0:5c,127.0.0.1: scmp_seq=1 time=482.032ms
152 bytes from 71-2:0:5c,127.0.0.1: scmp_seq=2 time=481.426ms
152 bytes from 71-2:0:5c,127.0.0.1: scmp_seq=3 time=482.486ms
152 bytes from 71-2:0:5c,127.0.0.1: scmp_seq=4 time=484.741ms
152 bytes from 71-2:0:5c,127.0.0.1: scmp_seq=5 time=481.425ms
152 bytes from 71-2:0:5c,127.0.0.1: scmp_seq=6 time=481.876ms
152 bytes from 71-2:0:5c,127.0.0.1: scmp_seq=7 time=482.231ms
```

- `scion showpaths 71-2:0:5c`

```
inf-isec-core-vpn-1-b-03:mac_bin adrianperrig$ ./scion showpaths 64-2:0:c
Available paths to 64-2:0:c
3 Hops:
[0] Hops: [64-2:0:9 1>5 64-559 11>1 64-2:0:c] MTU: 8972 NextHop: 192.168.53.20:30042 Status: alive LocalIP: 129.132.227.235
[1] Hops: [64-2:0:9 1>5 64-559 12>2 64-2:0:c] MTU: 8972 NextHop: 192.168.53.20:30042 Status: alive LocalIP: 129.132.227.235
[2] Hops: [64-2:0:9 2>6 64-559 11>1 64-2:0:c] MTU: 1472 NextHop: 192.168.53.35:30042 Status: alive LocalIP: 129.132.227.235
[3] Hops: [64-2:0:9 2>6 64-559 12>2 64-2:0:c] MTU: 1472 NextHop: 192.168.53.35:30042 Status: alive LocalIP: 129.132.227.235
inf-isec-core-vpn-1-b-03:mac_bin adrianperrig$ ./scion showpaths 71-2:0:5c
Available paths to 71-2:0:5c
4 Hops:
[0] Hops: [64-2:0:9 1>5 64-559 29>6 71-20965 141>1 71-2:0:5c] MTU: 8952 NextHop: 192.168.53.20:30042 Status: timeout LocalIP: 129.132.227.235
[1] Hops: [64-2:0:9 1>5 64-559 29>6 71-20965 142>2 71-2:0:5c] MTU: 8952 NextHop: 192.168.53.20:30042 Status: timeout LocalIP: 129.132.227.235
[2] Hops: [64-2:0:9 1>5 64-559 30>5 71-20965 141>1 71-2:0:5c] MTU: 8952 NextHop: 192.168.53.20:30042 Status: timeout LocalIP: 129.132.227.235
[3] Hops: [64-2:0:9 1>5 64-559 30>5 71-20965 142>2 71-2:0:5c] MTU: 8952 NextHop: 192.168.53.20:30042 Status: timeout LocalIP: 129.132.227.235
[4] Hops: [64-2:0:9 2>6 64-559 29>6 71-20965 141>1 71-2:0:5c] MTU: 1472 NextHop: 192.168.53.35:30042 Status: timeout LocalIP: 129.132.227.235
[5] Hops: [64-2:0:9 2>6 64-559 29>6 71-20965 142>2 71-2:0:5c] MTU: 1472 NextHop: 192.168.53.35:30042 Status: timeout LocalIP: 129.132.227.235
[6] Hops: [64-2:0:9 2>6 64-559 30>5 71-20965 141>1 71-2:0:5c] MTU: 1472 NextHop: 192.168.53.35:30042 Status: timeout LocalIP: 129.132.227.235
[7] Hops: [64-2:0:9 2>6 64-559 30>5 71-20965 142>2 71-2:0:5c] MTU: 1472 NextHop: 192.168.53.35:30042 Status: timeout LocalIP: 129.132.227.235
```

Packet Inspector

- https://scionpacketinspector.netsec.ethz.ch

Live SCION packet analyzer

Send SCION traffic to 64-2:0:9,[129.132.175.104] and inspect the received SCION packet below.

Live SCION traffic

```
        .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
    Source: Cisco_e3:fb:41 (04:c5:a4:e3:fb:41)
        Address: Cisco_e3:fb:41 (04:c5:a4:e3:fb:41)
        .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
        .... ...0 .... .... .... .... = IG bit: Individual address (unicast)
    Type: IPv4 (0x0800)
Internet Protocol Version 4, Src: 129.132.227.231, Dst: 129.132.175.104
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
    Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
        0000 00.. = Differentiated Services Codepoint: Default (0)
        .... ..00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
    Total Length: 87
    Identification: 0x9d82 (40322)
    Flags: 0x00
        0... .... = Reserved bit: Not set
        .0.. .... = Don't fragment: Not set
        ..0. .... = More fragments: Not set
    ...0 0000 0000 0000 = Fragment Offset: 0
    Time to Live: 60
    Protocol: UDP (17)
    Header Checksum: 0x4abb [validation disabled]
    [Header checksum status: Unverified]
    Source Address: 129.132.227.231
    Destination Address: 129.132.175.104
User Datagram Protocol, Src Port: 61559, Dst Port: 30041
    Source Port: 61559
    Destination Port: 30041
    Length: 67
    Checksum: 0x243d [unverified]
    [Checksum Status: Unverified]
    [Stream index: 0]
    [Timestamps]
        [Time since first frame: 0.000000000 seconds]
        [Time since previous frame: 0.000000000 seconds]
    UDP payload (59 bytes)
SCION Protocol, Src: 64-2:0:9,[129.132.227.231], Dst: 64-2:0:9,[129.132.175.104]
    0000 .... .... .... .... .... .... .... = Version: 0
    .... 0000 0000 .... .... .... .... .... = Traffic Class: 0x00
    .... .... .... 0000 0000 0000 0000 0001 = FlowID: 0x00001
    Next Header: UDP (17)
    Header Length: 36 bytes (9)
    Payload Length: 23 bytes
    Path Type: Empty (0)
    0000 .... = Destination Type: IPv4 (0x0)
    .... 0000 = Source Type: IPv4 (0x0)
    Reserved: 0x0000
    Destination ISD: 64
    Destination AS: 2:0:9
    Source ISD: 64
```

```
    Source Host: 129.132.227.231
SCION User Datagram Protocol, Src Port: 61559, Dst Port: 30041
    Source Port: 61559
    Destination Port: 30041
    Length: 31
    Checksum: 0x0000 [unverified]

0000  56 6f 6b 6e 00 26 04 c5 a4 e3 fb 41 08 00 45 00   Vokn.&.....A..E.
0010  00 57 9d 82 00 00 3c 11 4a bb 81 84 e3 e7 81 84   .W....<.J.......
0020  af 68 f0 77 75 59 00 43 24 3d 00 00 00 01 11 09   .h.wuY.C$=......
0030  00 17 00 00 00 00 00 40 00 02 00 00 00 09 00 40   .......@.......@
0040  00 02 00 00 00 09 81 84 af 68 81 84 e3 e7 f0 77   .........h.....w
0050  75 59 00 1f 00 00 53 43 49 4f 4e 20 77 61 73 20   uY....SCION was
0060  68 65 72 65 21                                    here!
```

ETH zürich

SCION

Sending a Packet to Packet Inspector

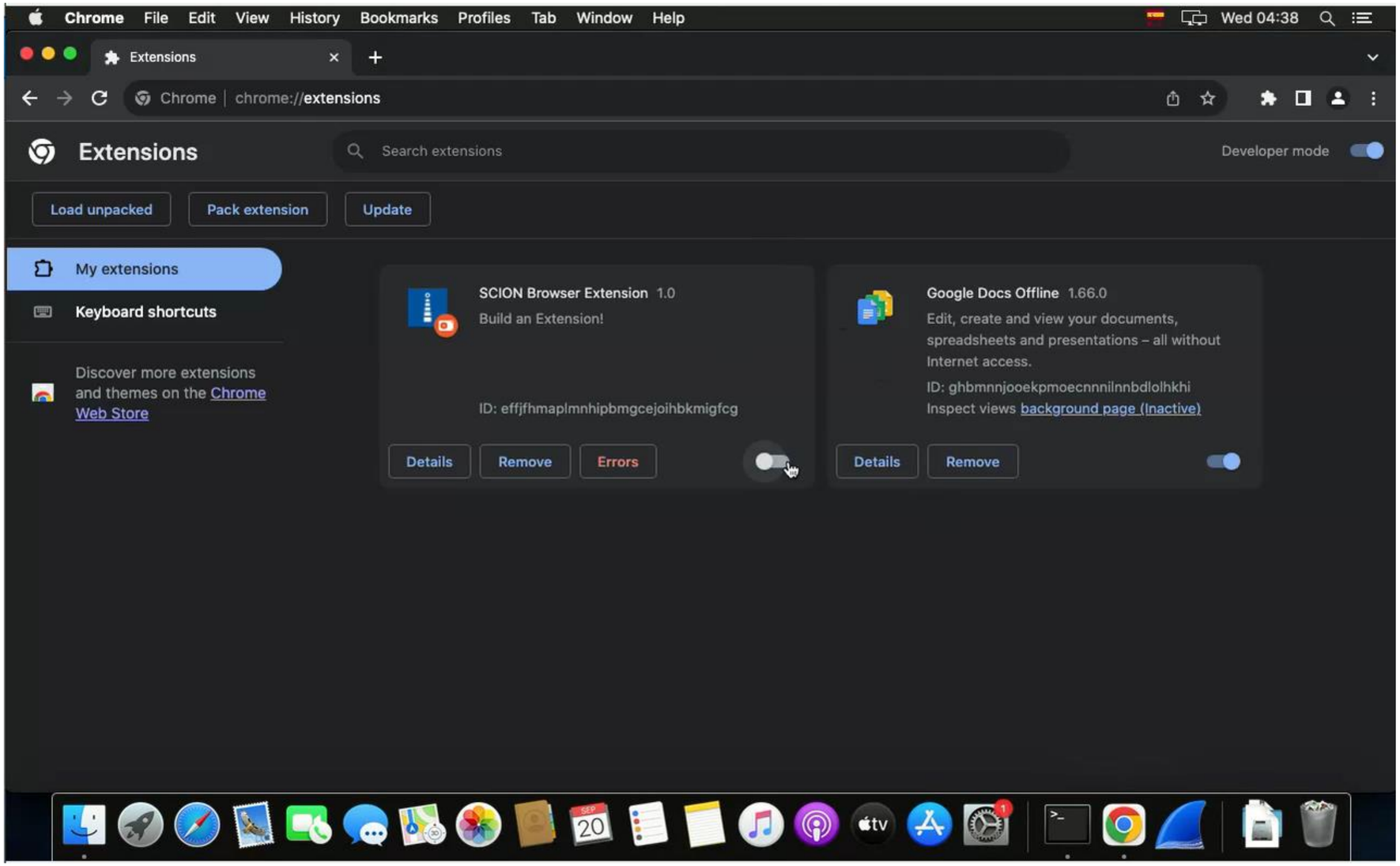
- `git clone https://github.com/netsec-ethz/scion-java-packet-example`
- `cd scion-java-packet-example`
- `mvn clean package -Pcreate-executable-example`
- `java -jar target/scion-packet-example-0.1.4-SNAPSHOT-executable.jar`

- To change the message in the body of the packet, you can adjust the message in this file: scion-java-packet-example/src/main/java/org/scion/demo/ScionPacketExample.java

SCION Integration

- Collaboration with Brave browser team to build native SCION communication into browser
- Without OS support, SCION-enabled browser can directly fetch web pages over the SCION network if host is within SCION-enabled network
- Compelling advantages
  - Download speed optimization
  - Specific optimizations possible: low carbon footprint paths, low delay, high bandwidth, low jitter, low loss, …
- 60M enabled devices would help spur SCION adoption

chrome Demo



ETH zürich

SCION

Is IPv6 Working?

IPv6

kame.net

The KAME project

1998.4 - 2006.3

Use IPv6 HTTP and you will watch the dancing kame

The KAME project was a joint effort of six companies in Japan to provide a free stack of IPv6, IPsec, and Mobile IPv6 for BSD variants.

Our products are available in:

- FreeBSD 4.0 and beyond
- OpenBSD 2.7 and beyond
- NetBSD 1.5 and beyond
- BSD/OS 4.2 and beyond

The project officially concluded in March 2006 (see press release from the WIDE project). Almost all of our implemented code has been merged to FreeBSD and NetBSD. The historical archive of the KAME repository is available at github.

Google

[Top] [Old info]

IPv4

The KAME project

1998.4 - 2006.3

Dancing kame by atelier momonga

The KAME project

kame.net/kame-mosaic.html

This is a MOSAIC version.
If you migrate to IPv6 HTTP, you'll be able to view the NON-MOSAIC DANCING KAME!

ETH zürich

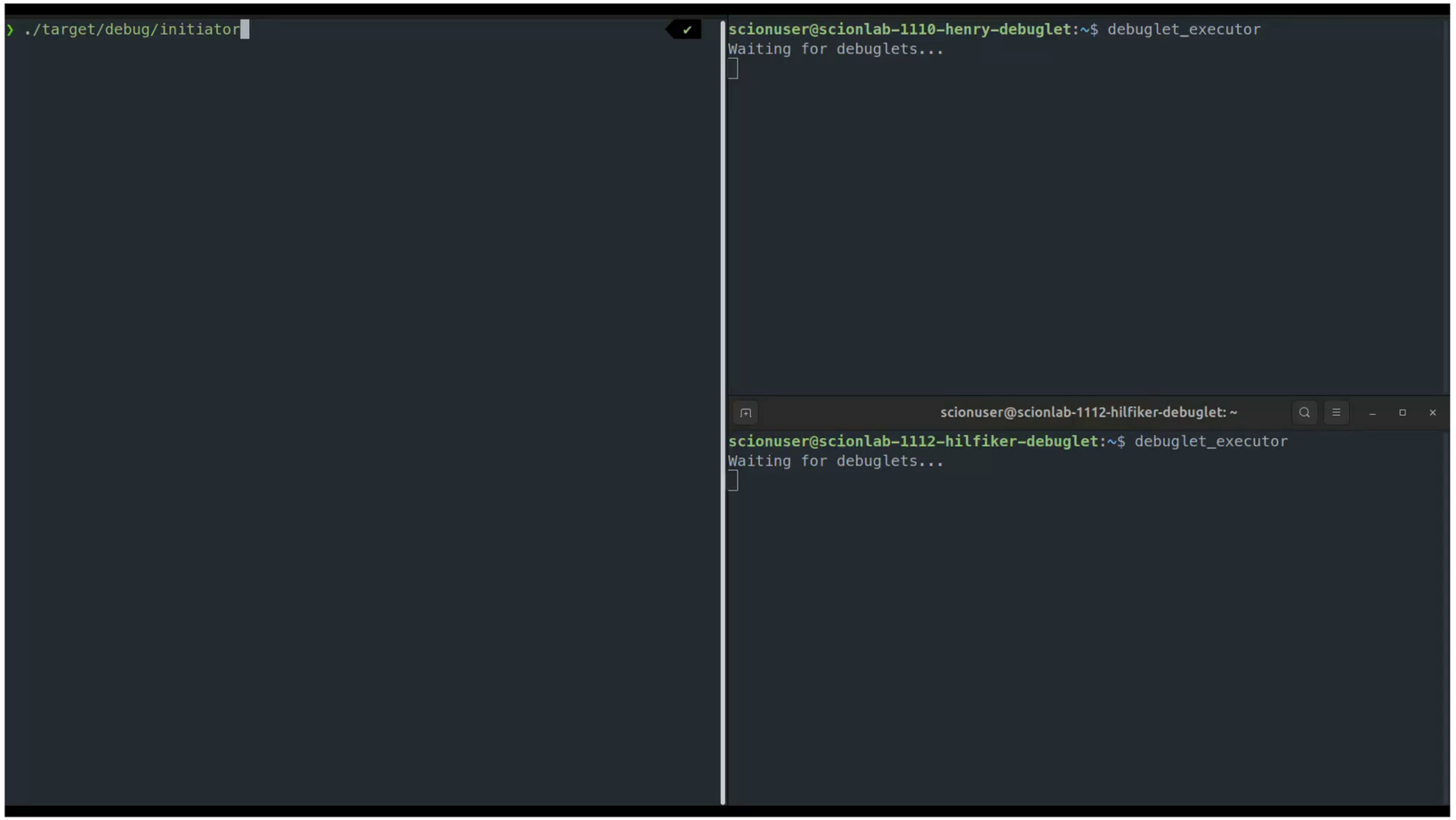
SCION

Dancing Gazelle: Is SCION Working?

- http://gazelle.scionapps.com

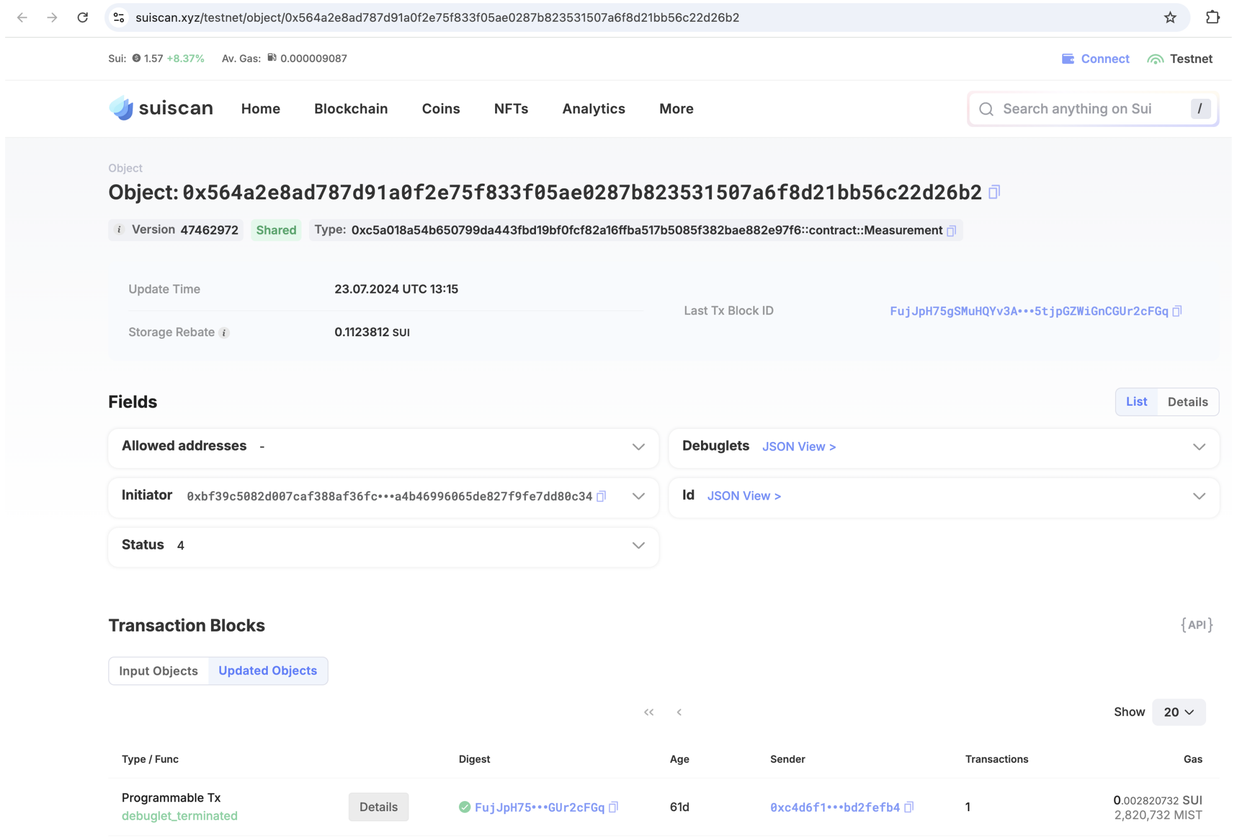
Next-generation Debugging: Debuglet

Debuglet enables running small pieces of code on servers distributed across the Internet



Debuglet Uses Sui Blockchain

- Debuglet code executions are paid with Sui, prevents DoS and incentivizes setup of Debuglet servers
- Sui smart contracts can be used to achieve verifiable execution



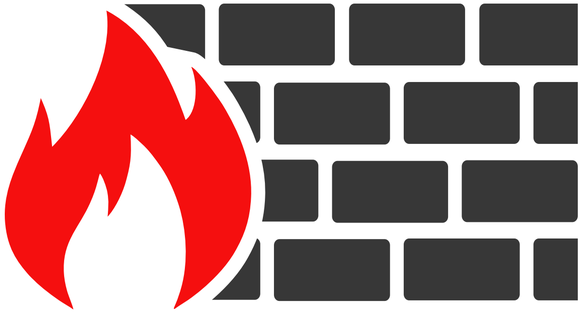
ETH zürich

Sui

SCION

Applications

- **Hercules** file transfer app greatly improves performance
  - Leverages full path control and enables multipathing over SCION
  - Avoids head-of-line blocking in TCP-based solutions
  - Improved congestion control and acknowledgment scheme
  - Efficient implementation bypassing OS network stack
  - Gartner et al., Hercules: High-Speed Bulk-Transfer over SCION, IFIP Networking 2023

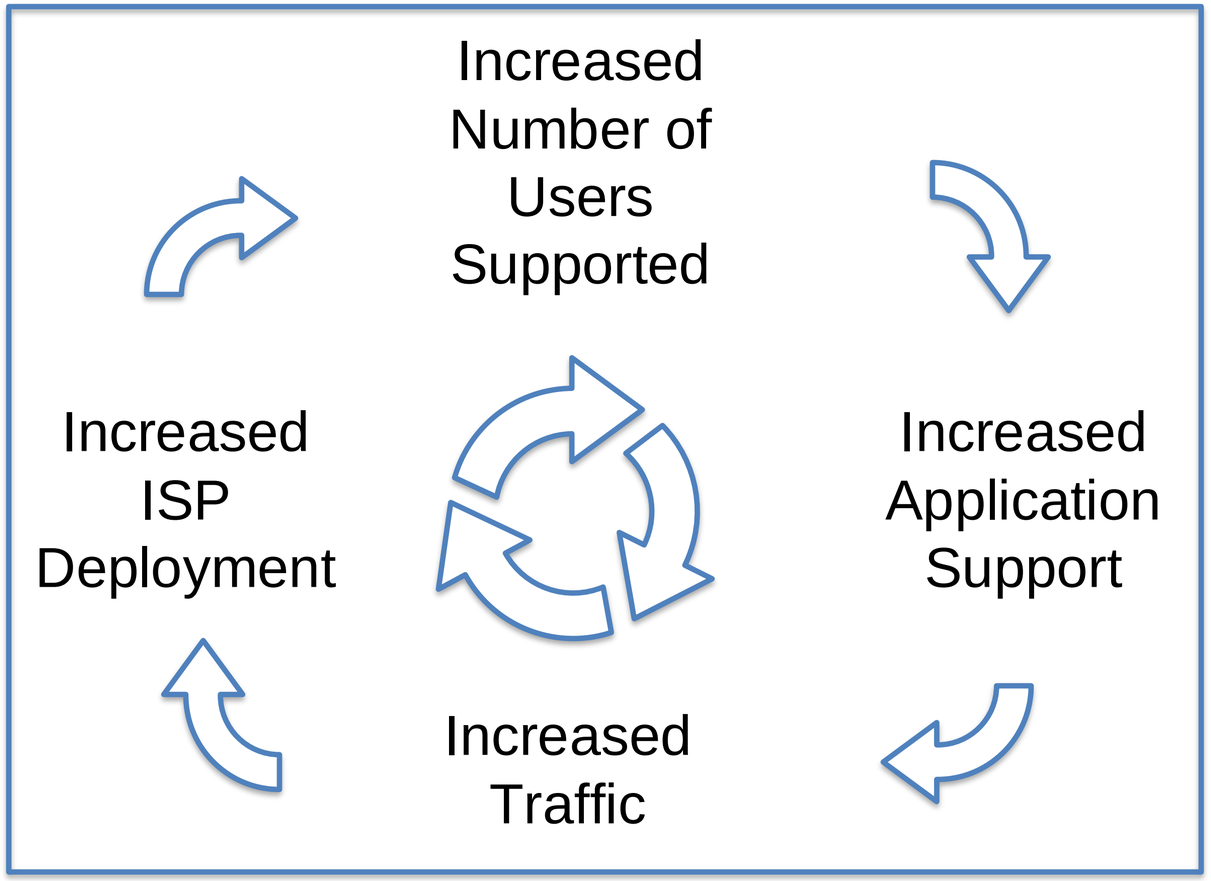


- **LightningFilter**
  - Enables strong source authentication of every data packet
  - Supports high-speed transmission rates
  - Avoids high cost of traditional IP firewalls

Virtuous Cycle: Reaching Escape Velocity

Necessary ingredients

- ISP: setup of client bootstrapping infrastructure
- Easy-to-use application libraries
  - Happy eyeballs: IPv4 / IPv6 / SCION
  - MPQUIC: IPv4 / IPv6 / SCION
- Applications that start using SCION next to IPv4/IPv6



Conclusion

- SCION can provide an advantage over IPv4 / IPv6: availability, latency, bw …
- Competition fuels adoption
- Virtuous cycle will bring SCION to reach escape velocity and enable a secure global Internet before the end of this decade