

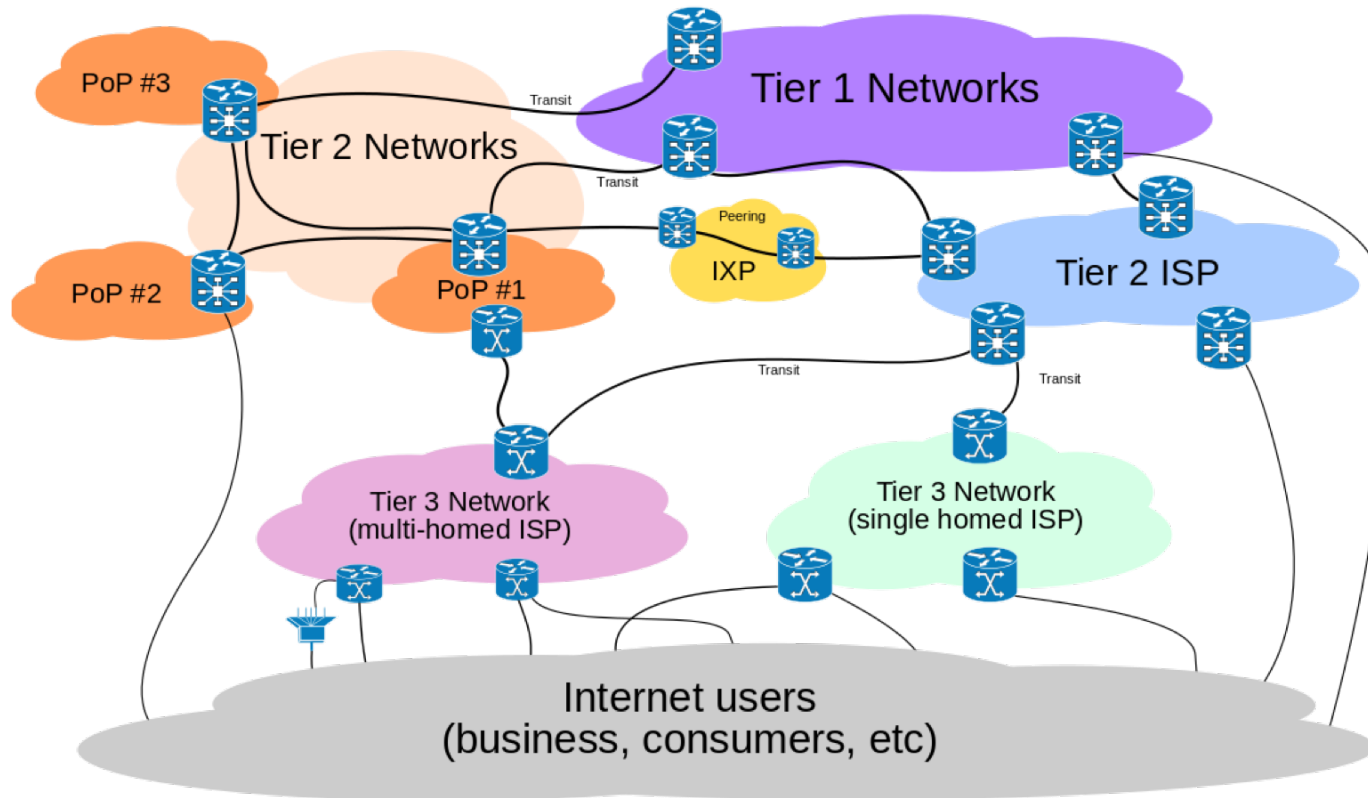
The real-time Internet routing observatory

Alessandro Improta

APNIC BoF - Data gathering and analysis

February 26th, 2018

Our research interest: the Internet AS-level ecosystem

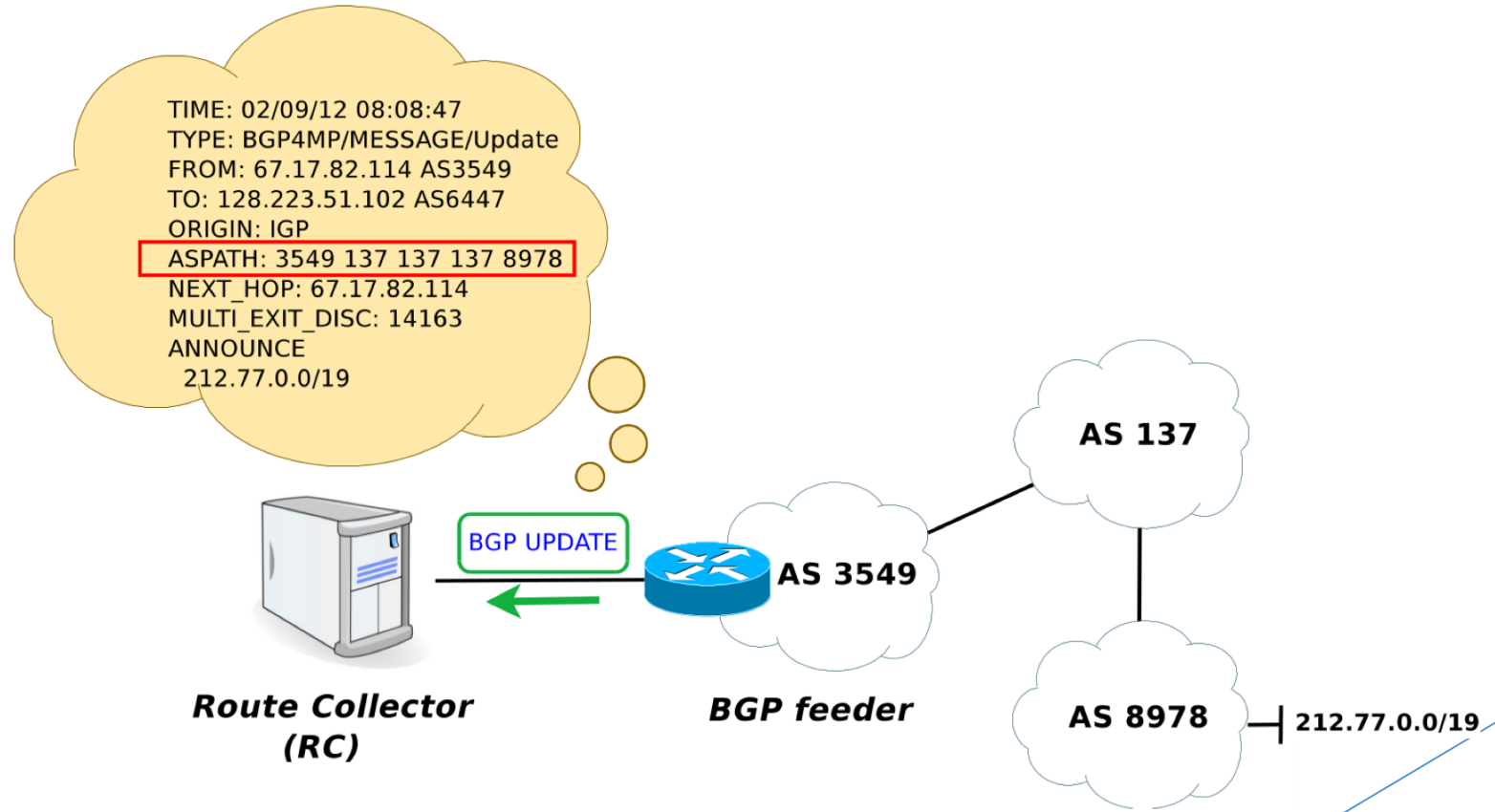


Why is it important?

- ▶ To identify Internet topological properties and drawbacks
- ▶ To build realistic network topology generators for simulations
- ▶ To evaluate the effectiveness of new protocols

Classic BGP route collector concept

Route collectors are devices which collect BGP routing data from co-operating ASes (feeders)



Route collectors collect routing information and not user traffic



BGP route collector projects



University of Oregon Route Views Project

Route Views was originally conceived as a tool for Internet operators to obtain real-time information about the global routing system from the perspectives of several different backbones and locations around the Internet. It collects BGP packets since 1997, in MRT format since 1997

<http://www.routeviews.org>



RIPE NCC Routing Information Service (RIS)

The RIPE NCC collects and stores Internet routing data from several locations around the globe, using RIS. It collects BGP packets in MRT format since 1999

<https://www.ripe.net/analyse/internet-measurements/routing-information-service-ris>



Packet Clearing House (PCH)

PCH is the international organization responsible for providing operational support and security to critical Internet infrastructure, including Internet exchange points and the core of the domain name system. It operates route collectors at more than 100 IXPs around the world and its data is made available in MRT format since 2011

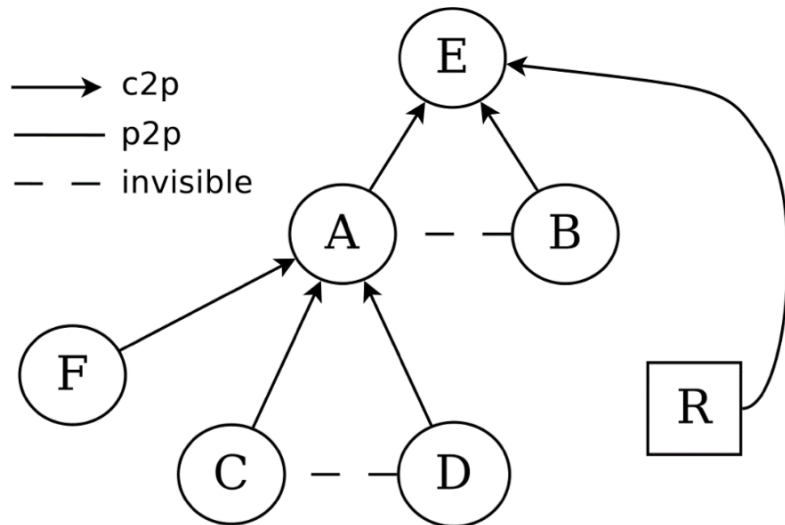
<https://www.pch.net/resources/Raw Routing Data>

Beware of data completeness!

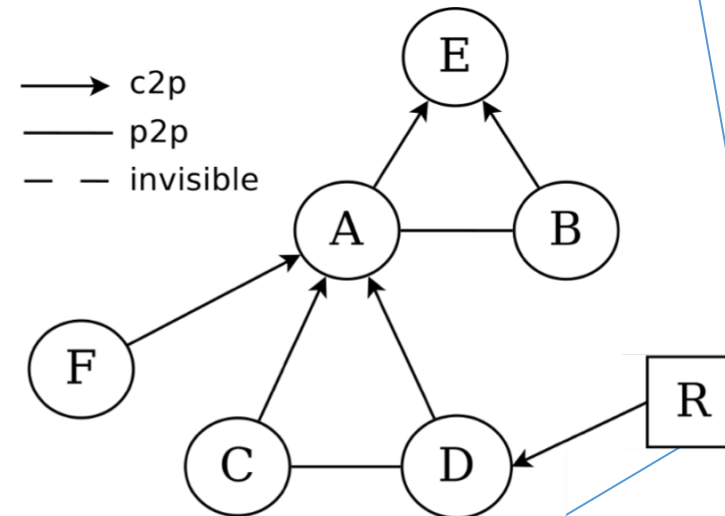
Feeders connected to Route Views, RIS and/or PCH (February 22nd, 2018)

- ▶ 1178 ASes announcing v4 data, 729 announcing v6 data
- ▶ 228 ASes share full v4 routing table, 184 their full v6 routing table

A view from the top



A view from the bottom



Most of p2p connectivity (IXPs) is currently invisible to route collectors



Isolario project

Objective: push more ASes to join

- ▶ The more the ASes, the more the completeness of public BGP data



Isolario - The Book of Islands

"[...] where we discuss about all islands of the world, with their ancient and modern names, histories, tales and way of living..."

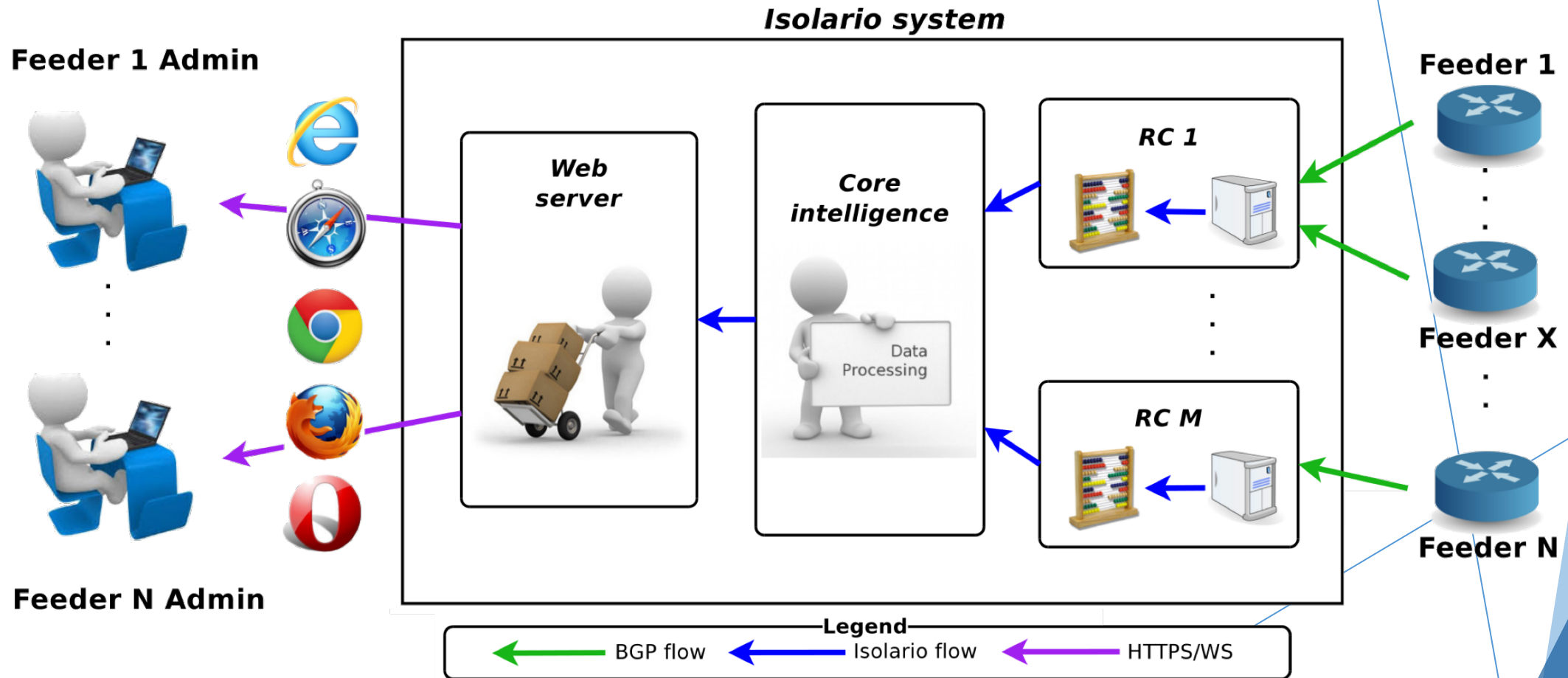
Benedetto Bordone (Italian cartographer)

Approach: Do-ut-des

- ▶ Participants open at least one v4/v6 BGP session with Isolario providing their full routing table
- ▶ In change, Isolario offers real-time applications based on the aggregation of every routing information collected

Isolario real-time system overview

Incoming BGP flows are used as real-time streams for services dedicated to participants



Results are provided to users via WebSockets (RFC 6455)

Isolario free services for feeders

Every feeder has free access to a set of services tailored to monitor and analyse BGP data coming into Isolario system

Real-time monitoring services



BGP Flow viewer



Routing table viewer



Subnet reachability



Website reachability

Diagnostic services



Alerting system



Daily reports

Historic monitoring services (work in progress)



Routing table viewer



Subnet reachability

Please, feel free to try isolario.it !

Username: *guest*
Password: *guest*



BGP Flow Viewer (BFV)

BFV allows to monitor BGP packets announced by a feeder to Isolario

My Feeders

Average AS PATH Length: 6.076

LAST MAX

IP: 186.209.240.0/20
 AS PATH: 2597 137 174 1239 7738 8167 53062 53062 53062 53062 53062 53062
 Length: 16

LAST MIN

IP: 91.212.208.0/24
 AS PATH: 2597 3356 43061 49407
 Length: 4

Prefix	AS path	Timestamp
+ 202.70.64.0/21	2597 3356 9498 23752	2014-11-25 13:22:06
+ 202.70.88.0/21	2597 3356 9498 23752	2014-11-25 13:22:06
+ 202.41.92.0/24	2597 3356 6453 4755 2697	2014-11-25 13:22:07
+ 202.141.142.0/24	2597 3356 6453 4755 2697	2014-11-25 13:22:07
+ 193.34.164.0/23	2597 3356 3216 41826	2014-11-25 13:22:07
2597 3356 3549 21219 39728 39728 39728 397...	2597:101 2597:111 2597:666 2597:1000	
2597 3356 3549 21219 39728 39728 39728 397...	2597:101 2597:111 2597:666 2597:1000	
2597 3356 3549 21219 39728 39728 39728 397...	2597:101 2597:111 2597:666 2597:1000	
2597 3356 3549 21219 39728 39728 39728 397...	2597:101 2597:111 2597:666 2597:1000	
2597 3356 15412 15412 15412 15412 9304 23752	2597:101 2597:111 2597:666 2597:1000	
2597 3356 15412 15412 15412 15412 9304 23752	2597:101 2597:111 2597:666 2597:1000	
2597 6939 16604 16604 54821	2597:101 2597:113 2597:666	
2597 3356 3257 14743 14743 11054	2597:101 2597:111 2597:666 2597:1000	
2597 137 174 4637 1221 45510	2597:666 AT 45510 202.93.100.150	

A/W Events

Announcements (95.2%) Withdrawals (4.8%)

Events evolution (last 30s)

Announcements Withdrawals Packets

Statistics are computed on packets received from the moment the user started BFV





Subnet Reachability (SR)

SR allows to understand how Isolario feeders are reaching subnets of interest

Neighbor AS Dependency
Top ten Neighbor ASes

AS	Percentage of IP space
AS 137	72.727
AS 197440	9.09
AS 20836	4.545
AS 3356	4.545
AS 12779	4.545
AS 16004	4.545
AS 12637	0
AS 12874	0

Remote Feeders Reachability of 192.12.192.0/23

100% Feeder able to reach the whole space (100.0%)
0% Feeder unable to reach the whole space (0.0%)

Average AS-distance from remote feeders
1.954

Communities distribution
Top ten communities

Community	Percentage of IP space affected
137-1000	40.909
137-3025	40.909
137-6882	40.909
12637-65010	18.181
12637-65099	18.181
12637-65016	9.09
12637-65012	9.09
20912-65016	9.09
2957-90	4.545
3356-100	4.545

AS Dependency
Top ten ASes

AS	Percentage of IP space
AS 137	72.727
AS 12637	18.181
AS 6882	18.181
AS 25309	9.09
AS 197835	9.09
AS 16004	9.09
AS 20912	9.09
AS 197440	9.09
AS 24796	9.09
AS 3356	4.545

BGPlay has been integrated thanks to the collaboration of Massimo Candela (RIPE NCC)
<http://bgplay.massimocandela.com>





Alerting system

The alerting system allows to receive notifications as soon as any user-configured alarm is triggered

Alerting Management | Notifications | Current configured alerts

Create new alert (Tip: often the elements of the interface displayed below have an help text that will be shown simply by leaving the mouse on the element itself.)

General Alert Options

Available feeder IPs

- 127.254.0.1 (ASN 65001)
- 127.254.0.10 (ASN 65010)
- 127.254.0.11 (ASN 65011)
- 127.254.0.13 (ASN 65013)
- 127.254.0.19 (ASN 65019)
- 127.254.0.2 (ASN 65002)
- 127.254.0.20 (ASN 65020)
- 127.254.0.21 (ASN 65021)
- 127.254.0.22 (ASN 65022)
-

Alert Type

- BGP attributes
- Flap Detector
- Session Watchdog
- Hijack
- Reachability

Action upon event

Email s

POST HTTP(s)

Save Alert

BGP attributes

Prefix

Prefix Subnet

Community

Prefix Related

AS path end

AS path substring

AS path begin

AS path exact

Origin

Aggregator

You can specify one or more BGP attribute types on which the monitoring will run. Multiple types can be combined by means of *and/or* operators and round brackets. For each attribute type you can insert one or more values that the attribute should match. The system will report any BGP_UPDATE message advertised by one of the selected feeder IPs matching the inserted attributes.

EXAMPLE

Current BGP attribute types selected

Triggers available:

BGP attributes
Flap events

Prefix reachability
BGP Session down

Hijack attempts
Route changes



Daily reports

Summaries about inter-domain routing status as perceived by the Isolario:

- ▶ Feeder reports about the evolution of the feeder routing
- ▶ AS reports about the reachability of the network of the feeder AS

1 General statistics

Analysis start date: *Thursday 21 May 2015 at 00:00:00*
 Analysis end date: *Thursday 21 May 2015 at 23:59:59*

Number of non overlapping IPv4 space covered¹: *2739704260 (98.581001 %)*
 The remaining 1.418999 % is covered by a default route

Packets received: *227490*
 Feeder status at end date: *up*
 Downs experienced since start date: *0*

2 Route statistics

Subnets: *532099*
 Unstable subnets: *57727 (10.848 %)*
 Stable subnets: *474372 (89.151001 %)*

Number of reserved subnets: *1* – see Sect. 2.4 for further details

Geolocated subnets²: *475610 (89.383003 %)*

5 AS statistics

ASes seen: *50241*
 Private ASes: *34 (0.067 %)*
 Public ASes: *50207 (99.931999 %)*

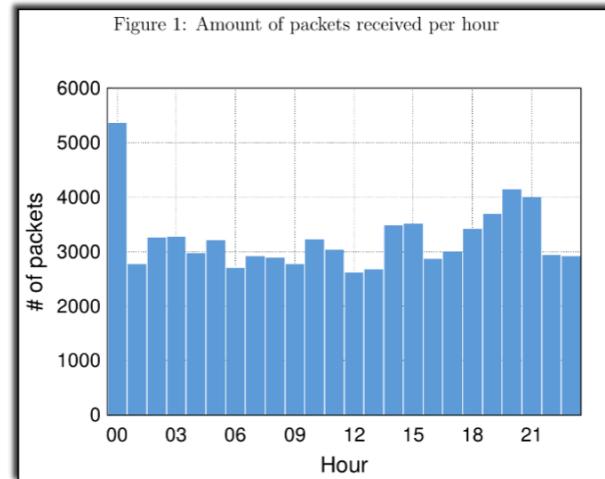
Public ASes on 16 bits: *42864 (85.316002 %)*
 Public ASes on 32 bits: *7343 (14.615 %)*
 Number of public ASes at start date: *50089*
 Number of public ASes at end date: *50142*
 Difference: *+53 ASes (+0.105 %)*

7 My subnet statistics

Total number of subnets perceived as proprietary: *1*

Subnet
192.65.131.0/24

Number of events related to proprietary subnets: *0*
 Number of announcements related to proprietary subnets: *0*
 Number of withdrawals related to proprietary subnets: *0*



How to use Isolario?

Real-time services

Let me check what's going on...

- ▶ How is my RIB(s) evolving?
- ▶ How is my reachability affected?

Alerting system

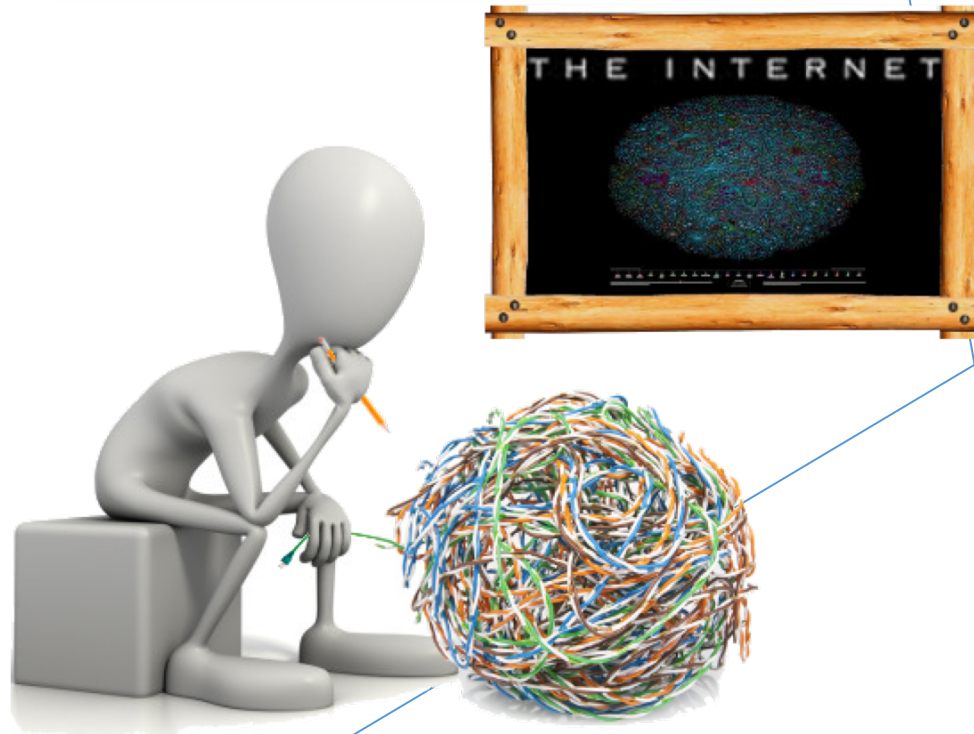
Some particular routing event is on NOW!

- ▶ Check real-time services!
- ▶ Do something! (if needed)

Daily reports

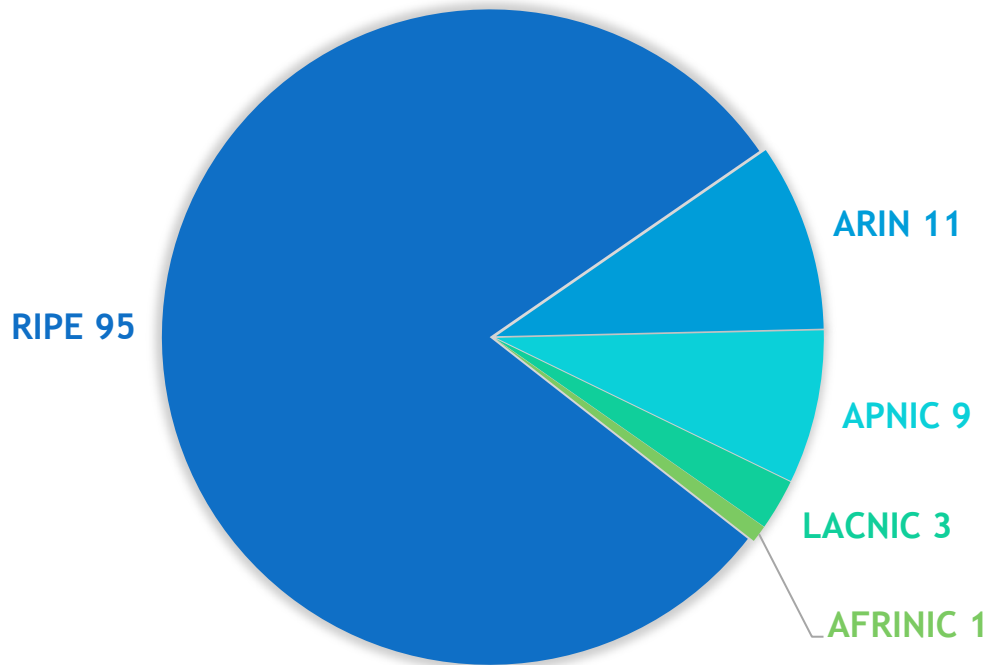
Was my routing ok yesterday?

- ▶ Check historic services (soon)!
- ▶ Do something! (if needed)



Isolario numbers (Feb 22nd, 2018)

FEEDER ASes GEOLOCATION



Number of full routing tables:

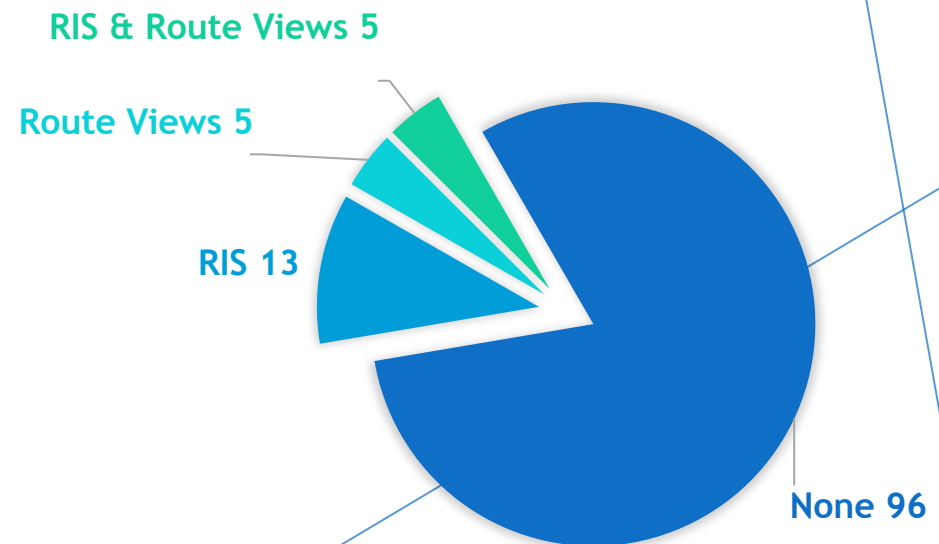
- ▶ IPv4: 95 from 65 different ASes
- ▶ IPv6: 102 from 64 different ASes

Number of ASes participating: 119

Number of sessions configured: 329

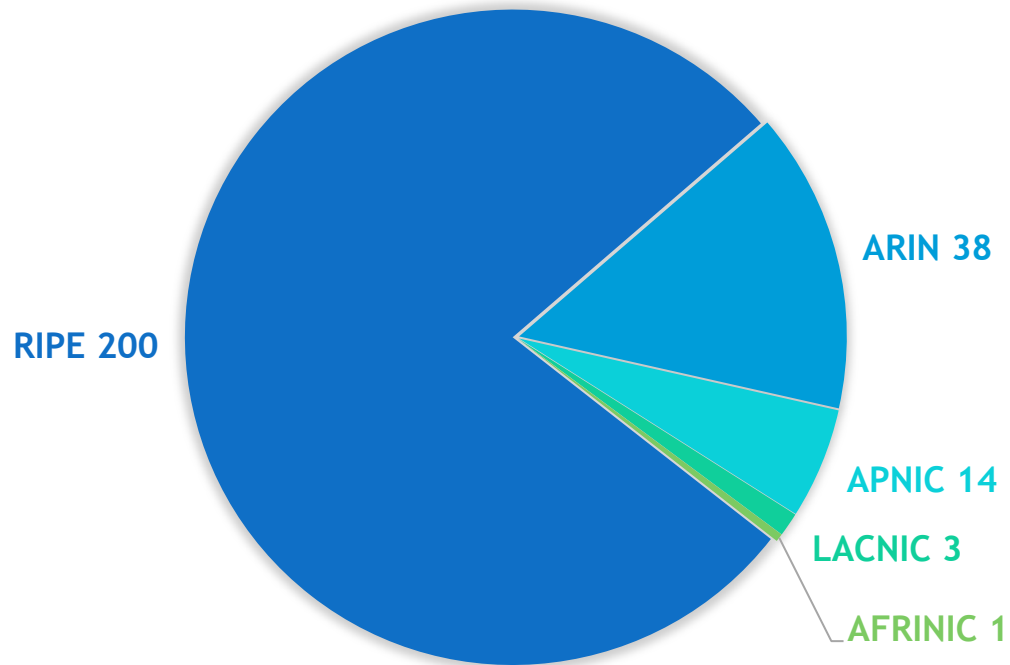
- ▶ IPv4: 167 from 106 different ASes
- ▶ IPv6: 162 from 94 different ASes

ASes CONNECTED TO OTHER COLLECTORS



Isolario numbers with ADDPATH - RFC 7911 (Feb 22nd, 2018)

FEEDER ASES GEOLOCATION



Number of ADDPATH ASes participating: 10

Number of feeder ASes: 256 (+137 ASes)

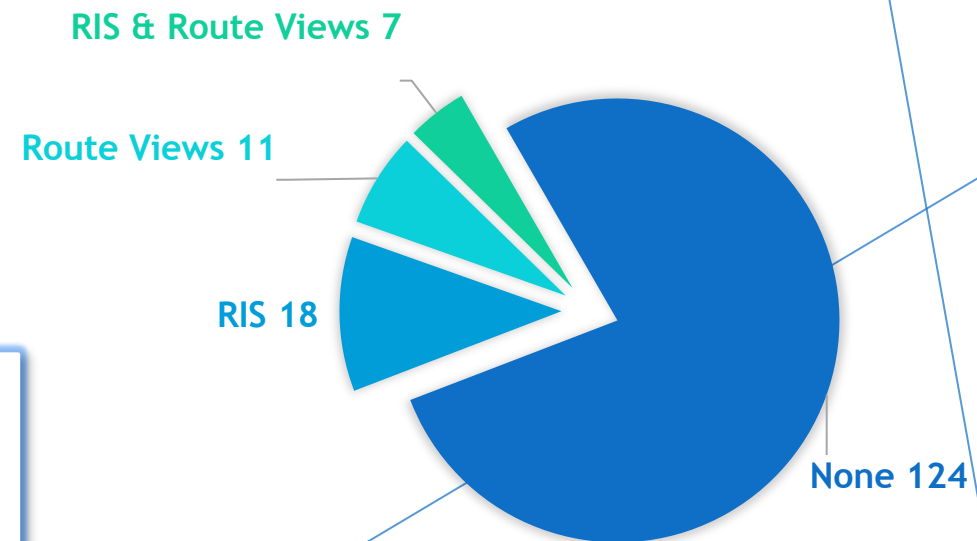
Number of sessions configured: 25

- ▶ IPv4: 14 from 9 different ASes
- ▶ IPv6: 11 from 7 different ASes

Number of full routing tables:

- ▶ IPv4: 192 (+97) from 128 (+63) different ASes
- ▶ IPv6: 209 (+107) from 128 (+64) different ASes

ASES CONNECTED TO OTHER COLLECTORS



What do we provide to the community?

MRT data

- ▶ RIB feeder snapshots every 2 hours
- ▶ UPDATE collections every 5 minutes
 - * same format as RIPE RIS and Route Views (RFC 6396, ADDPATH RFC 8050)
 - ** used in Hurricane Electric BGP Toolkit (<https://bgp.he.net>)

Periodic analyses

- ▶ AS characteristics
- ▶ Feeder contribution
- ▶ Total coverage of route collectors

Open source software

- ▶ Interactive Collecting Engine (ICE)
- ▶ MRT Data Reader



What's next?

New services

- ▶ Bogon real-time recognition
- ▶ Real-time looking glass
- ▶ Route collector on BMP (RFC 7854)

Our future research directions

- ▶ Real-time routing anomaly detection (e.g. prefix hijack)
- ▶ Pattern recognition in BGP attributes
- ▶ Country-focused special analyses (e.g. Internet shutdown recognition)
- ▶ Feeder data hygiene techniques



Thank you for your attention



Join us and help us to unveil the Internet AS-level structure!

To participate, contact us at:

info@isolario.it



Questions?

alessandro.improta@iit.cnr.it

info@isolario.it