Classbench-ng: recasting Classbench after a decade of network evolution

Gianni Antichi

gianni.antichi@cl.cam.ac.uk

http://www.cl.cam.ac.uk/~ga288/

Packet Classification is the fine art of:

Matching header fields of incoming packets against a set of rules and performing the corresponding **action**

Packet Classification is the fine art of:

Matching header fields of incoming packets against a set of rules and performing the corresponding **action**

- packet forwarding

Packet Classification is the fine art of:

Matching header fields of incoming packets against a set of rules and performing the corresponding **action**

- packet forwarding
- application of security policies

Packet Classification is the fine art of:

Matching header fields of incoming packets against a set of rules and performing the corresponding **action**

- packet forwarding
- application of security policies
- application-specific processing

Packet Classification is the fine art of:

Matching header fields of incoming packets against a set of rules and performing the corresponding **action**

- packet forwarding
- application of security policies
- application-specific processing
- application of QoS guarantees

Is the packet classification mechanic still a problem in 2017?

Is the packet classification mechanic still a problem in 2017?

- Increasing transfer rate => **faster** classification

Is the packet classification mechanic still a problem in 2017?

- Increasing transfer rate => **faster** classification
- Increasing number of rules => **larger** data structures

Is the packet classification mechanic still a problem in 2017?

- Increasing transfer rate => **faster** classification
- Increasing number of rules => **larger** data structures
- Growing adoption of IPv6 => **longer** IP prefixes

Is the packet classification mechanic still a problem in 2017?

- Increasing transfer rate => **faster** classification
- Increasing number of rules => **larger** data structures
- Growing adoption of IPv6 => **longer** IP prefixes
- Adoption of OpenFlow/SDN => **more** header fields

Is the packet classification mechanic still a pr 2017?

- Increasing transfer rate => **fa**
- Increasing number of r structures
- Growing adoptio IP prefixes
- Adoption o > **more** header fields

NEW CHALLENGES FOR HW DESIGNERS

lot of research effort in the past identified better packet classification techniques leveraging the **characteristics of real rule sets** for faster searches.

lot of research effort in the past identified better packet classification techniques leveraging the **characteristics of real rule sets** for faster searches.

the capacity and efficiency of Ternary Content Addressable Memories (TCAMs) are also subject to the **characteristics of rule sets**.

lot of research effort in the past identified better packet classification techniques leveraging the **characteristics of real rule sets** for faster searches.

the capacity and efficiency of Ternary Content Addressable Memories (TCAMs) are also subject to the **characteristics of rule sets**.

new algorithms needs to be **benchmarked**

…characteristics of real rule sets….

Dear DC/network/cloud operator, can you please send me a snapshot of your forwarding tables so I can use them?

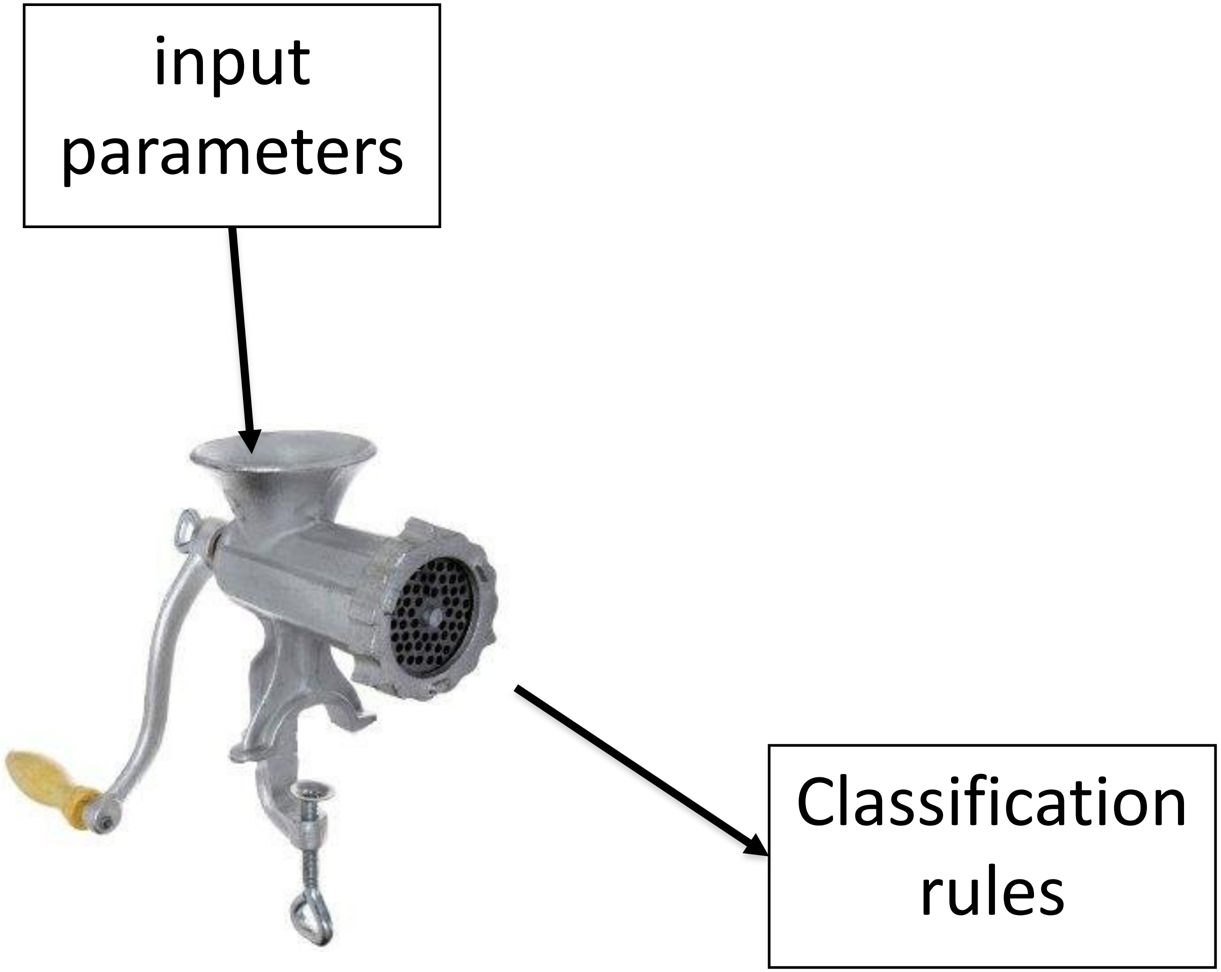
Not sure it is going to be so easy….

Not sure it is going to be so easy….

OR

Create a tool for automatic **generation of synthetic rule sets** with the same characteristic of real ones.

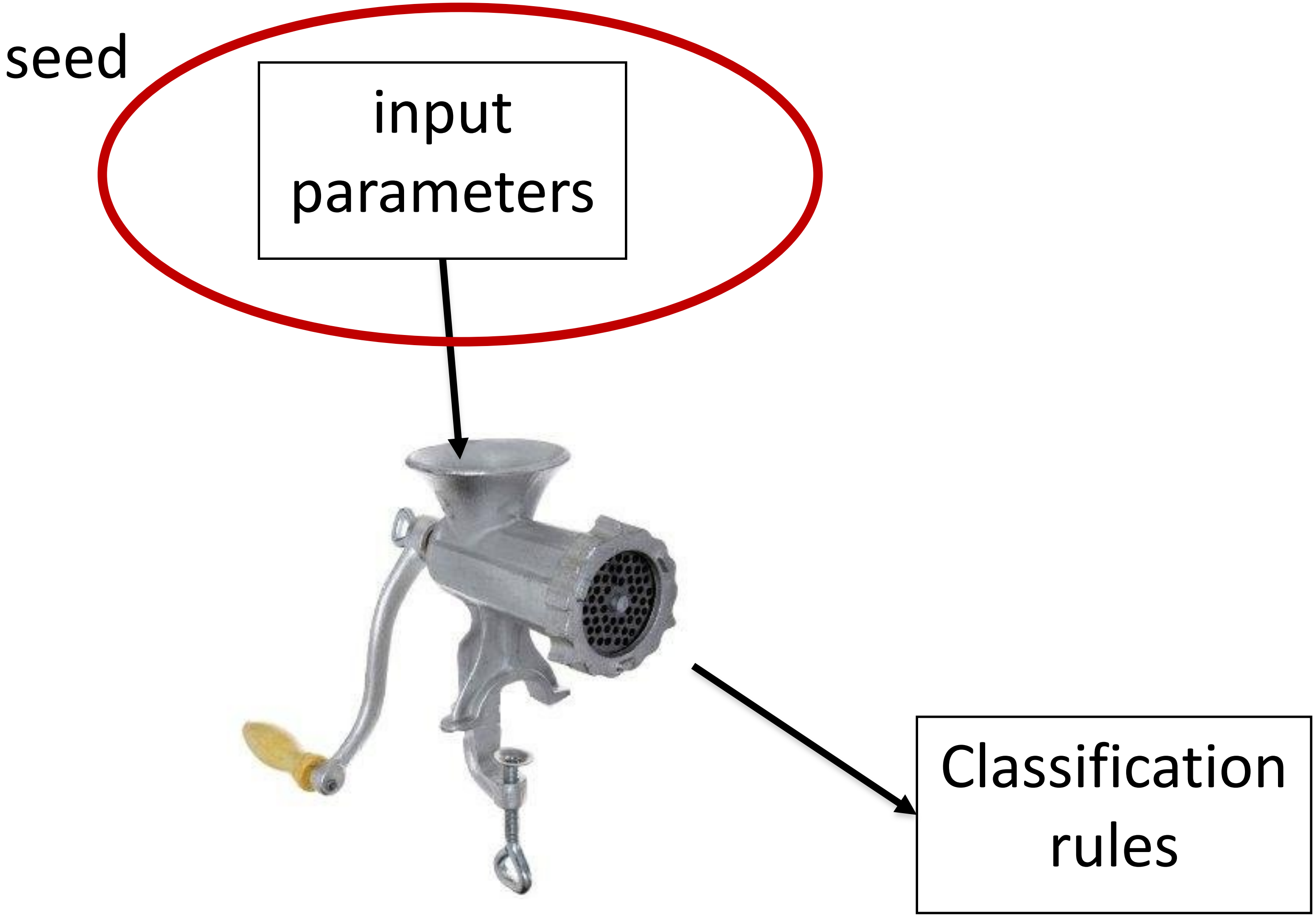
In a nutshell….



input parameters

Classification rules

In a nutshell….



seed

input parameters

Classification rules

Available tools use as an input either statistic distributions of real sets [1] or user-defined characteristics [2]

[1] ClassBench: A Packet Classification Benchmark, D. E. Taylor and J. S. Turner. In Transactions on Networking, 15(3). ACM/IEEE, 2007.

[2] FRuG: A benchmark for packet forwarding in future networks, T. Ganegedara, W. Jiang, and V. K. Prasanna. In IPCCC. IEEE, 2010.

Available tools use as an input either statistic distributions of real sets [1] or user-defined characteristics [2]

[1] is good if we are seeking for an output as close as possible to a real set, but can become **easily obsolete** if the seeds are not updated accordingly.

[1] ClassBench: A Packet Classification Benchmark, D. E. Taylor and J. S. Turner. In Transactions on Networking, 15(3). ACM/IEEE, 2007.

[2] FRuG: A benchmark for packet forwarding in future networks, T. Ganegedara, W. Jiang, and V. K. Prasanna. In IPCCC. IEEE, 2010.

Available tools use as an input either statistic distributions of real sets [1] or user-defined characteristics [2]

[1] is good if we are seeking for an output as close as possible to a real set, but can become **easily obsolete** if the seeds are not updated accordingly.

[2] is more flexible in the long term, but does not guarantee output characteristics similar to real sets

[1] ClassBench: A Packet Classification Benchmark, D. E. Taylor and J. S. Turner. In Transactions on Networking, 15(3). ACM/IEEE, 2007.

[2] FRuG: A benchmark for packet forwarding in future networks, T. Ganegedara, W. Jiang, and V. K. Prasanna. In IPCCC. IEEE, 2010.

What we want is the best of both worlds:

What we want is the best of both worlds:

- **Fidelity**

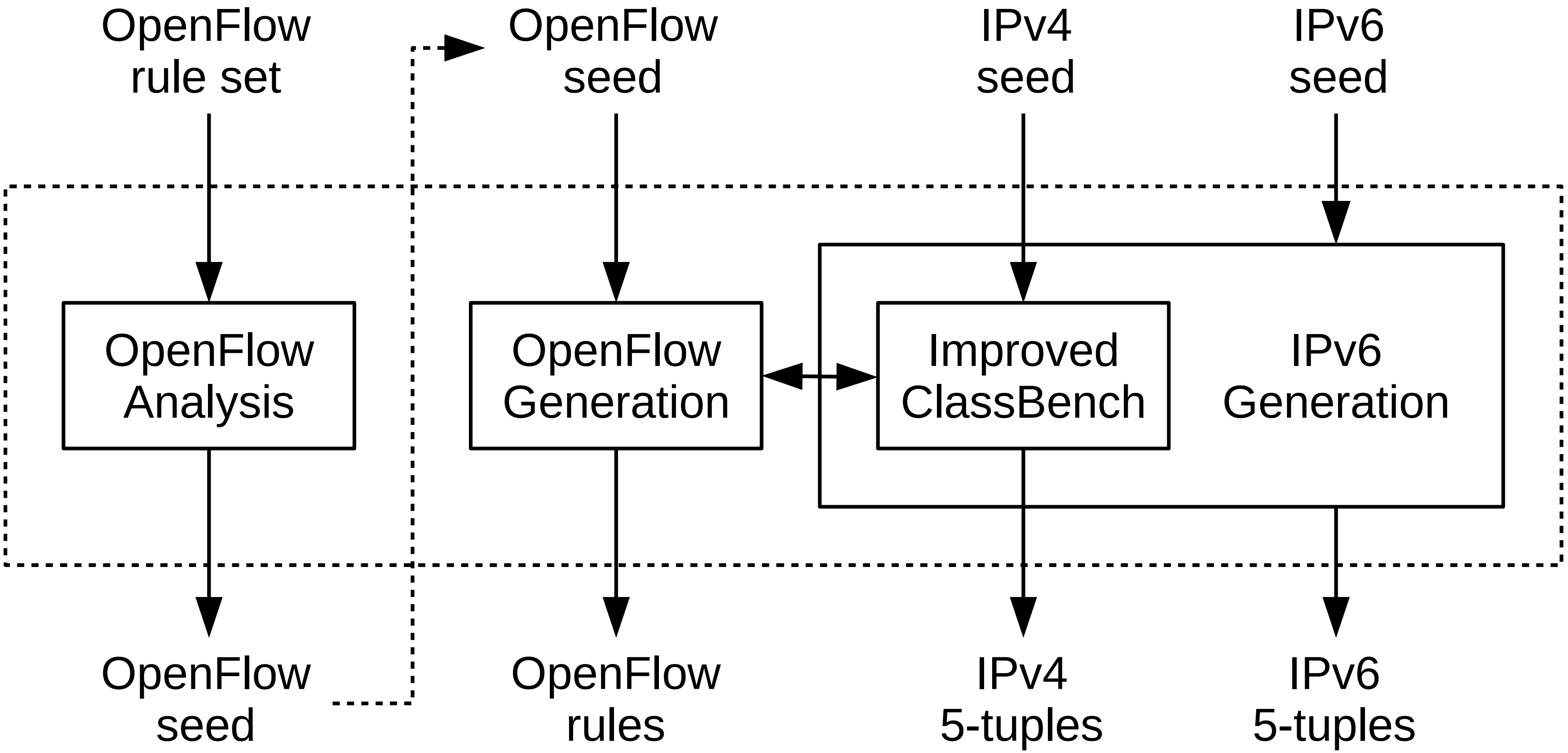
What we want is the best of both worlds:

- **Fidelity**
- **Longevity**

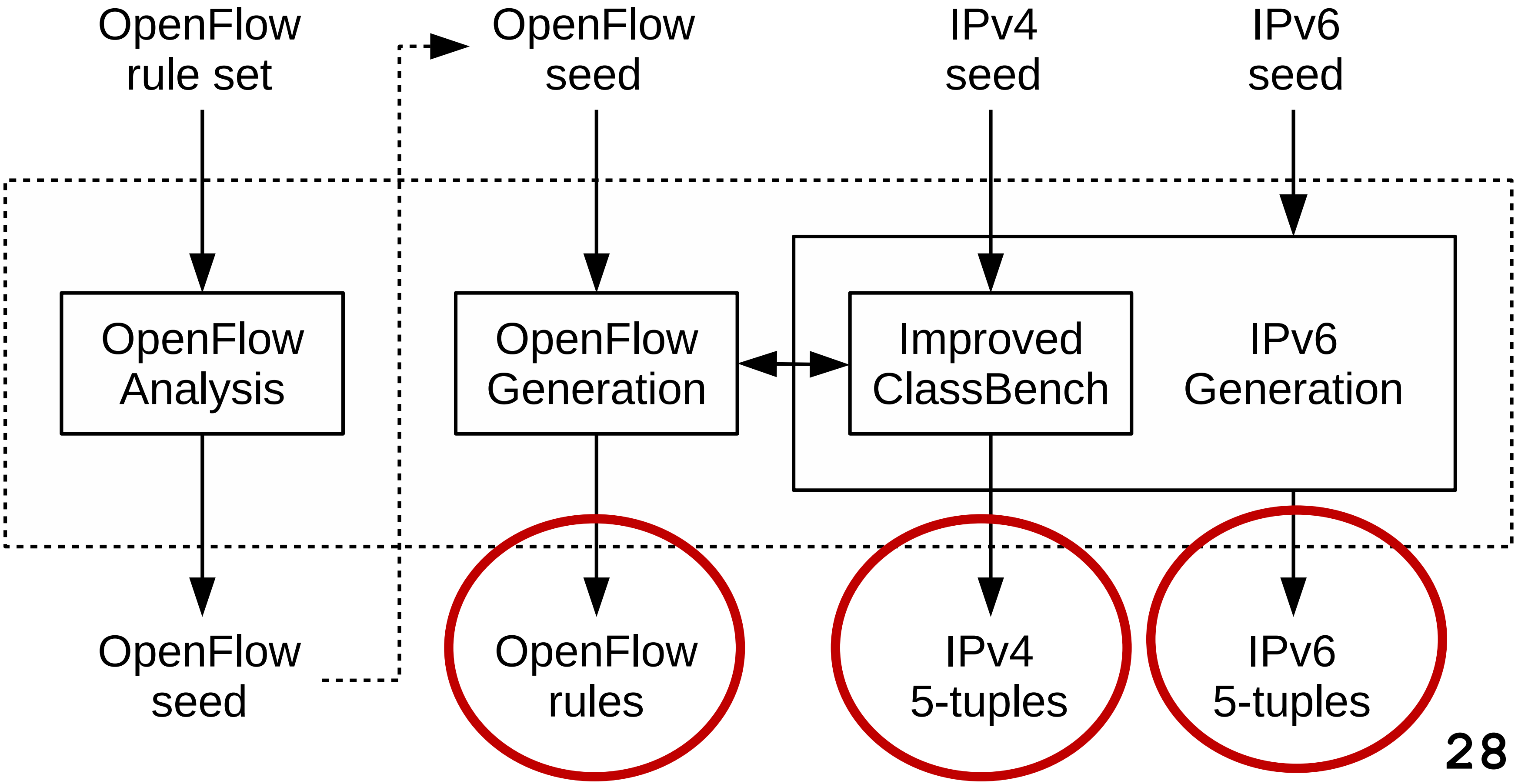
What we want is the best of both worlds:

- **Fidelity**
- **Longevity**

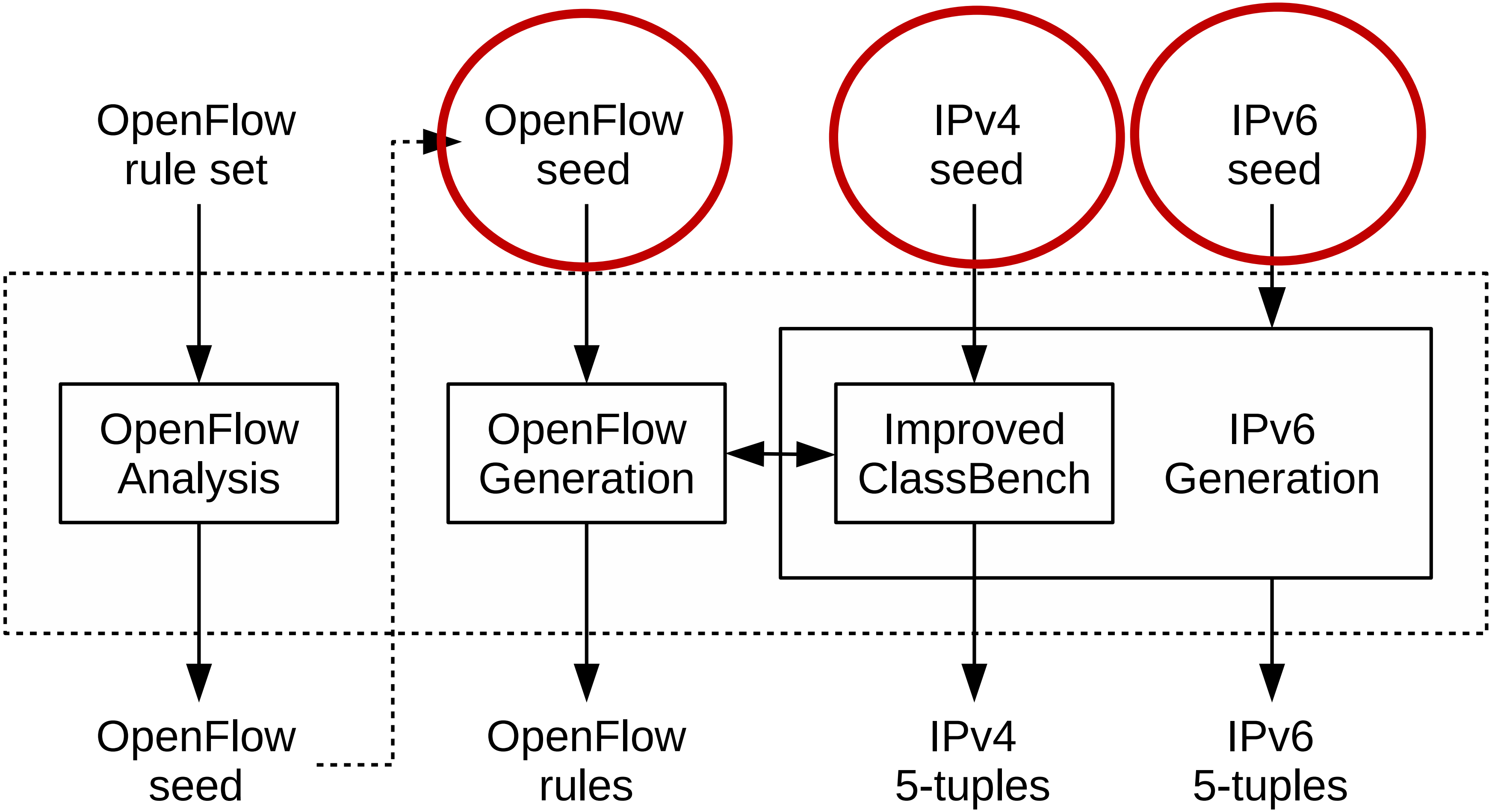
Classbench-ng is the tool for you!!!


OpenFlow rule set
OpenFlow seed
IPv4 seed
IPv6 seed
OpenFlow Analysis
OpenFlow Generation
Improved ClassBench
IPv6 Generation
OpenFlow seed
OpenFlow rules
IPv4 5-tuples
IPv6 5-tuples

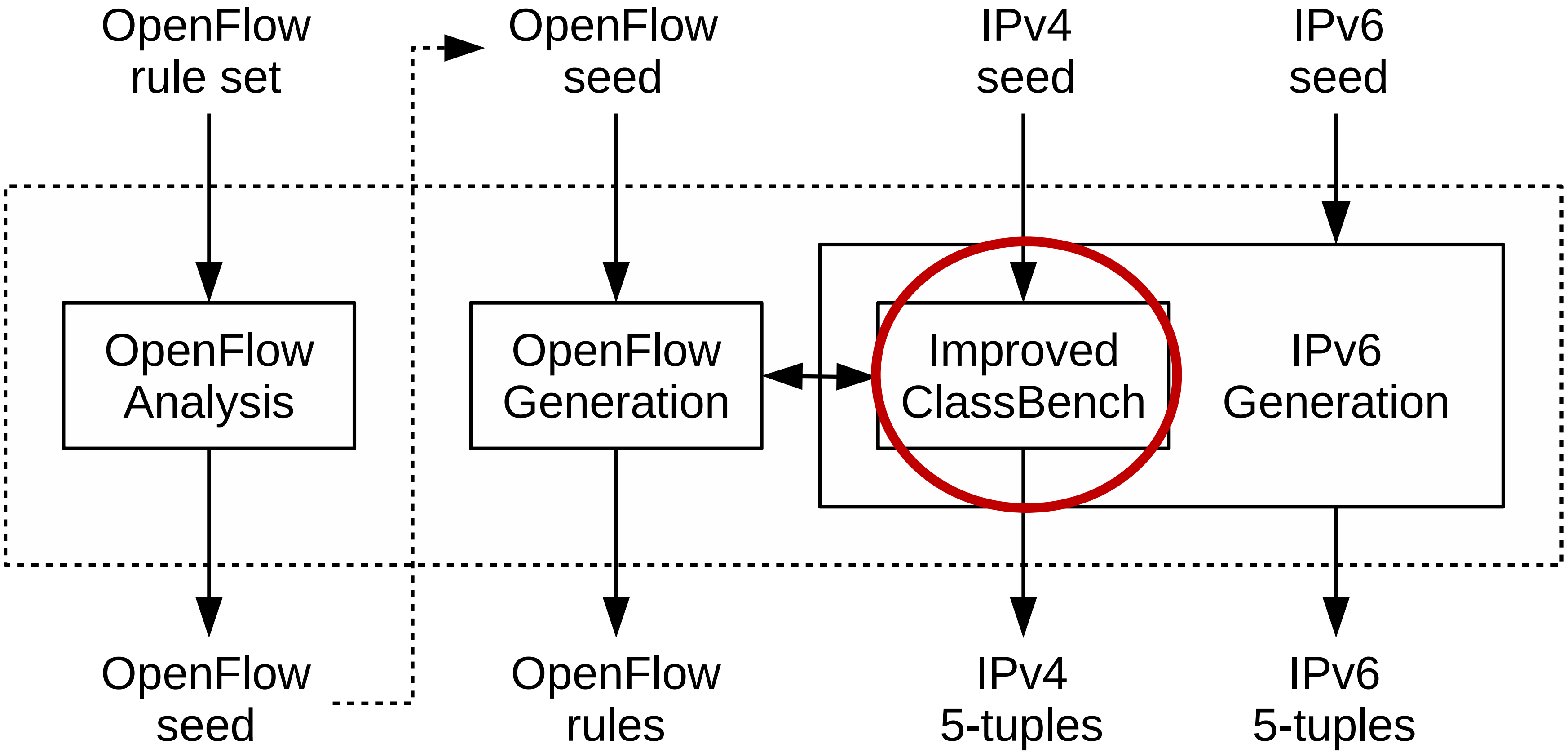
In constrast to Classbench, Classbench-ng can successfully generate IPv4, IPv6 and OpenFlow rules.



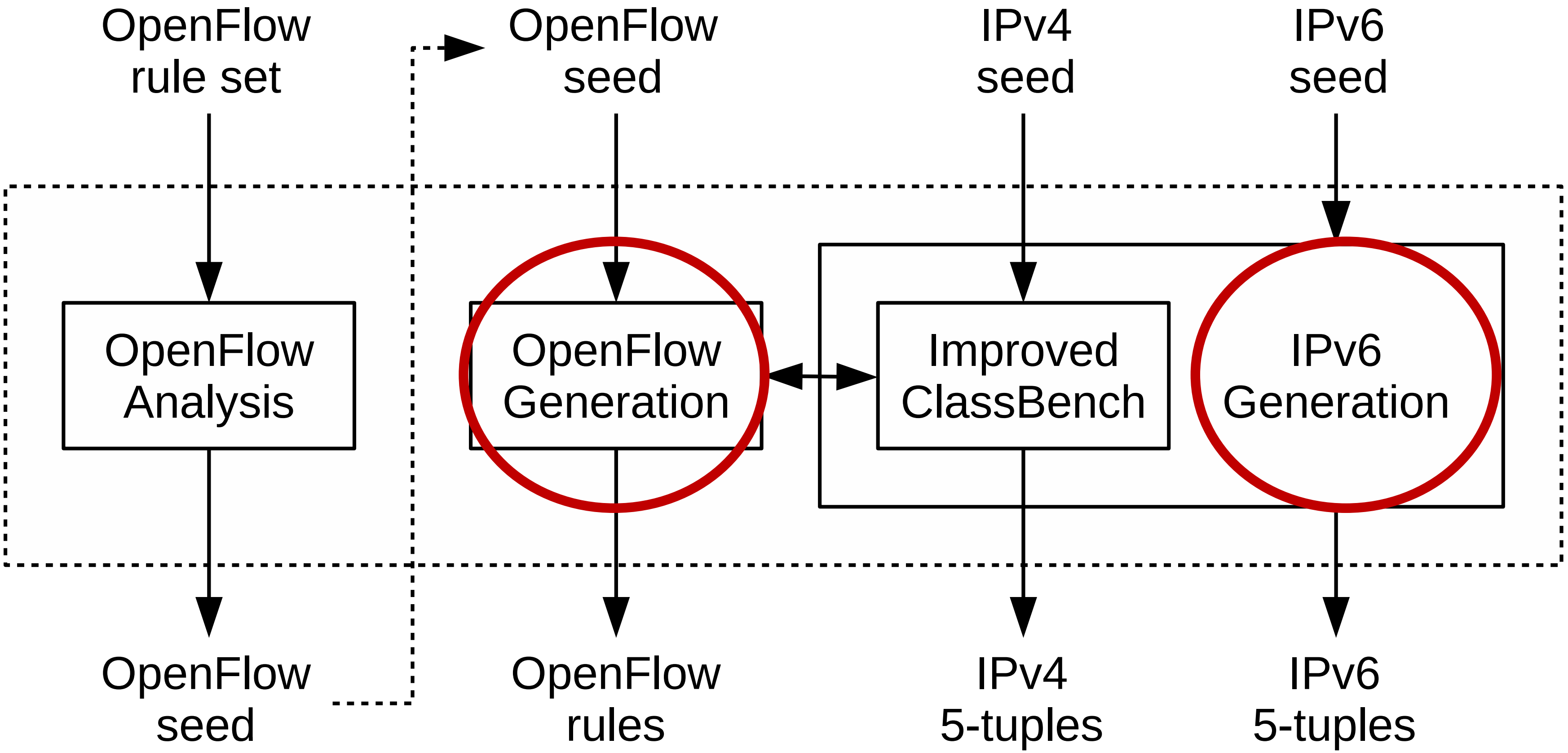
Classbench-ng, as Classbench, relies on seeds as input for the rule generation



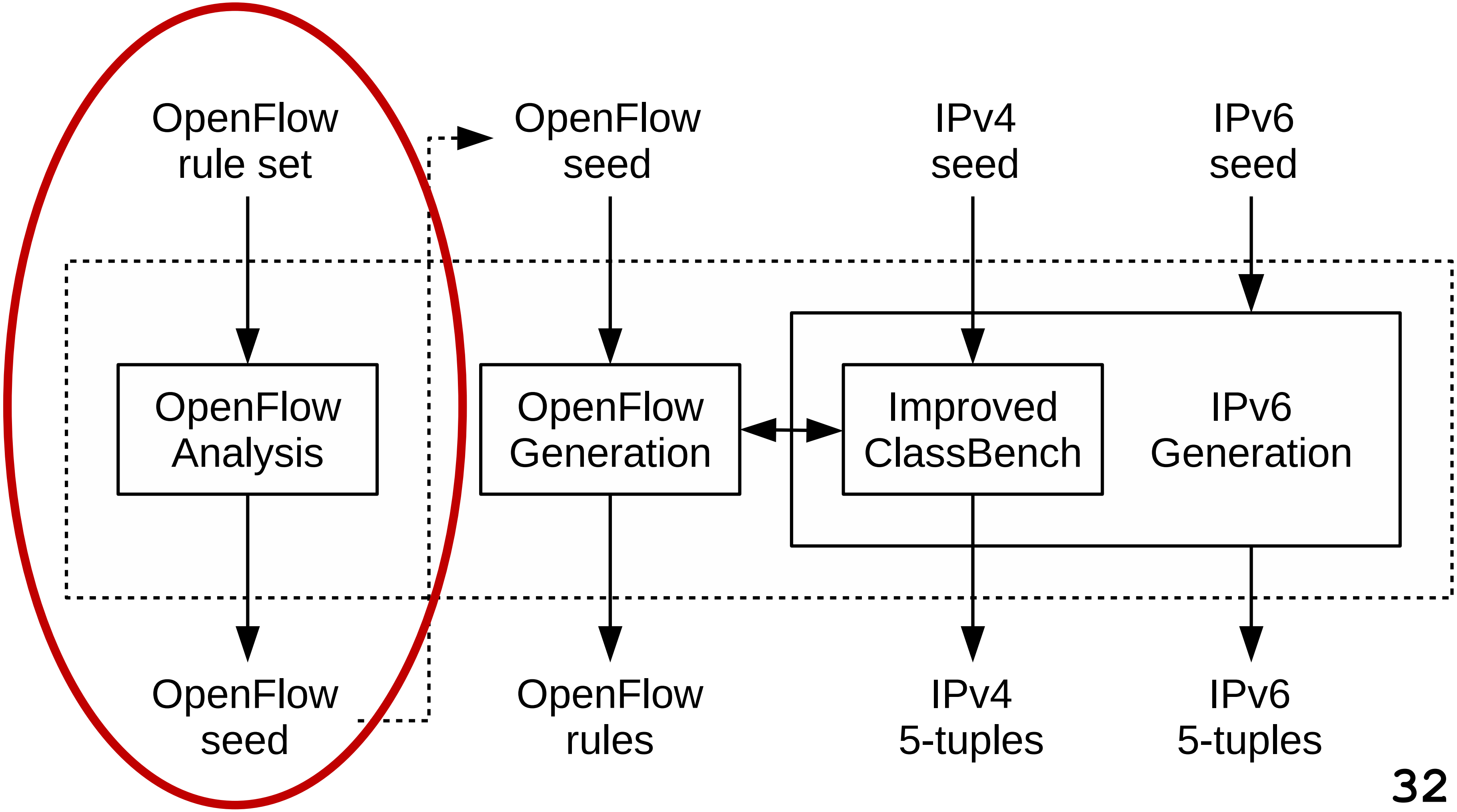
Classbench-ng is based on Classbench, but improves its IPv4 generation fidelity



Classbench-ng provides modules for IPv6 and OpenFlow rules generation



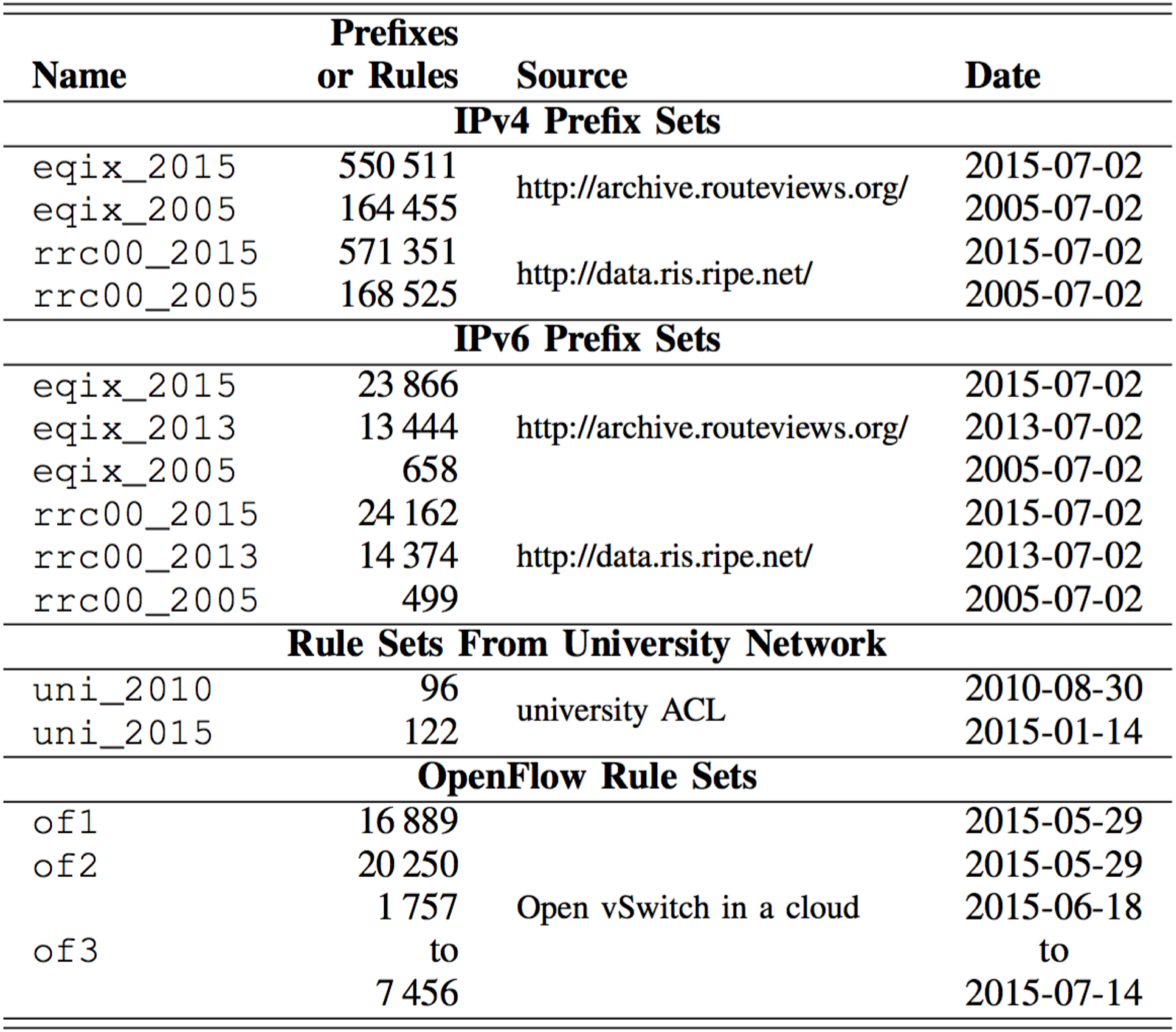
Classbench-ng includes an analysis module, which is able to extract seeds from input rule sets.



The main idea behind **Classbench-ng** is to create a repository where researchers can upload just the **seeds** of the rule sets they might have/use.

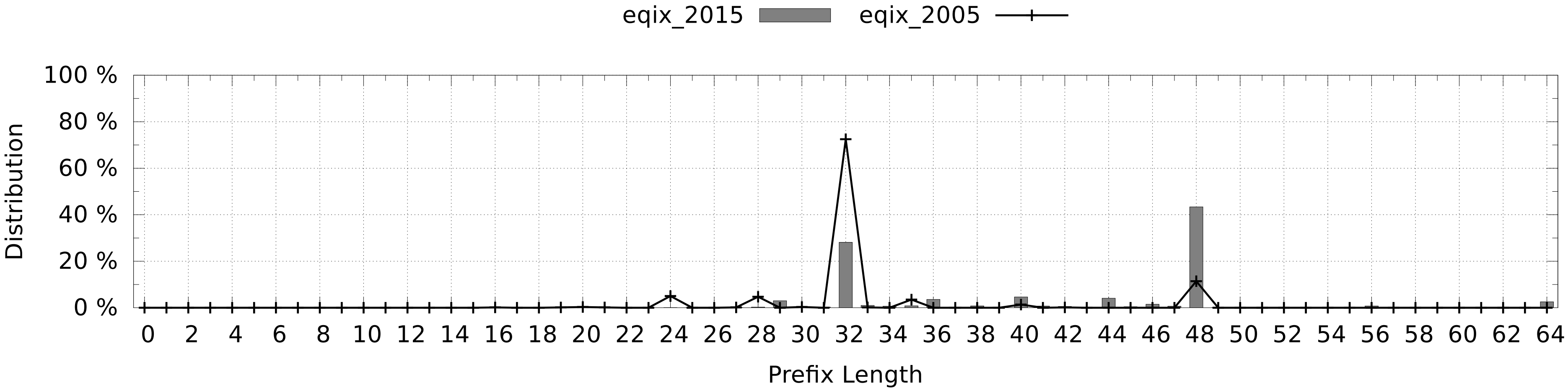
This will foster **reproduciability,** but also will help reseachers that do not have access to real rule sets to create synthetic ones.

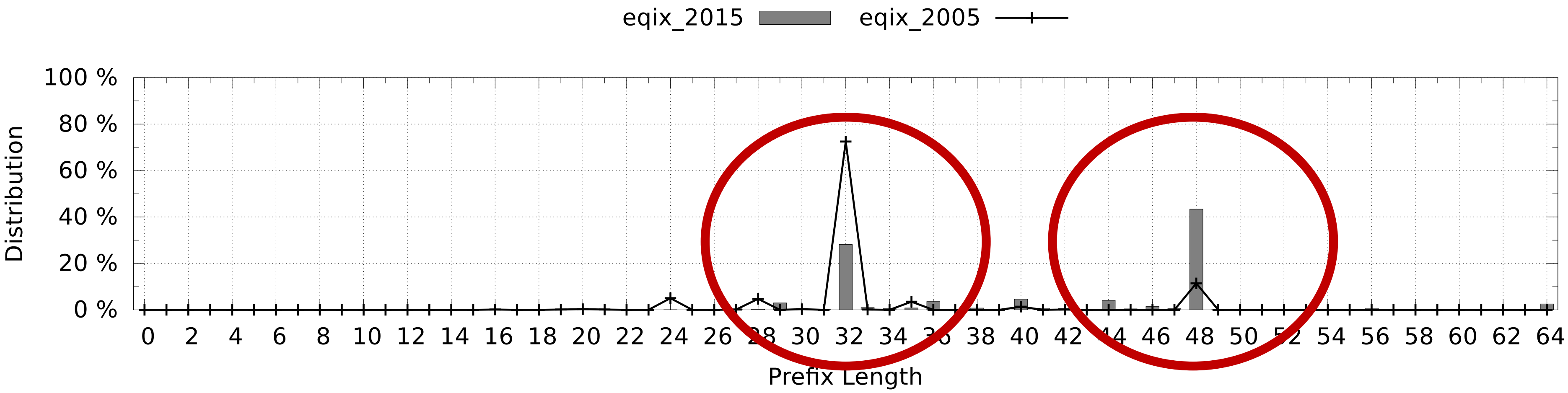
To start with, Classbench-ng **already provide** some initial seeds, created after we analysed the following rule sets:



Name	Prefixes or Rules	Source	Date
IPv4 Prefix Sets			
eqix_2015	550 511	http://archive.routeviews.org/	2015-07-02
eqix_2005	164 455		2005-07-02
rrc00_2015	571 351	http://data.ris.ripe.net/	2015-07-02
rrc00_2005	168 525		2005-07-02
IPv6 Prefix Sets			
eqix_2015	23 866	http://archive.routeviews.org/	2015-07-02
eqix_2013	13 444		2013-07-02
eqix_2005	658		2005-07-02
rrc00_2015	24 162	http://data.ris.ripe.net/	2015-07-02
rrc00_2013	14 374		2013-07-02
rrc00_2005	499		2005-07-02
Rule Sets From University Network			
uni_2010	96	university ACL	2010-08-30
uni_2015	122		2015-01-14
OpenFlow Rule Sets			
of1	16 889	Open vSwitch in a cloud	2015-05-29
of2	20 250		2015-05-29
of3	1 757 to 7 456		2015-06-18 to 2015-07-14

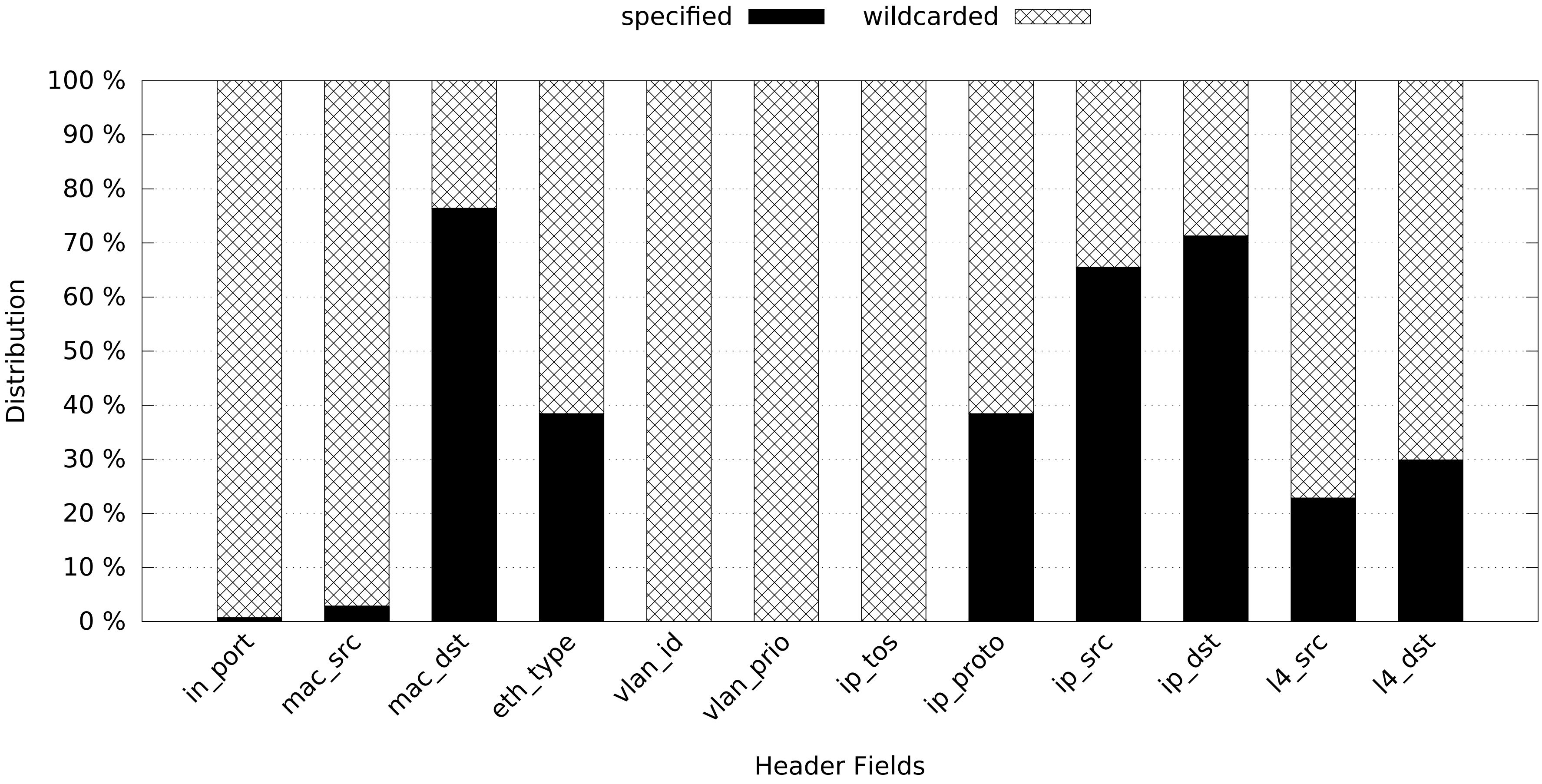
some of the results from our analysis of **IPv6** datasets


eqix_2015
eqix_2005
100 %
80 %
60 %
40 %
20 %
0 %
Distribution
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52
54
56
58
60
62
64
Prefix Length



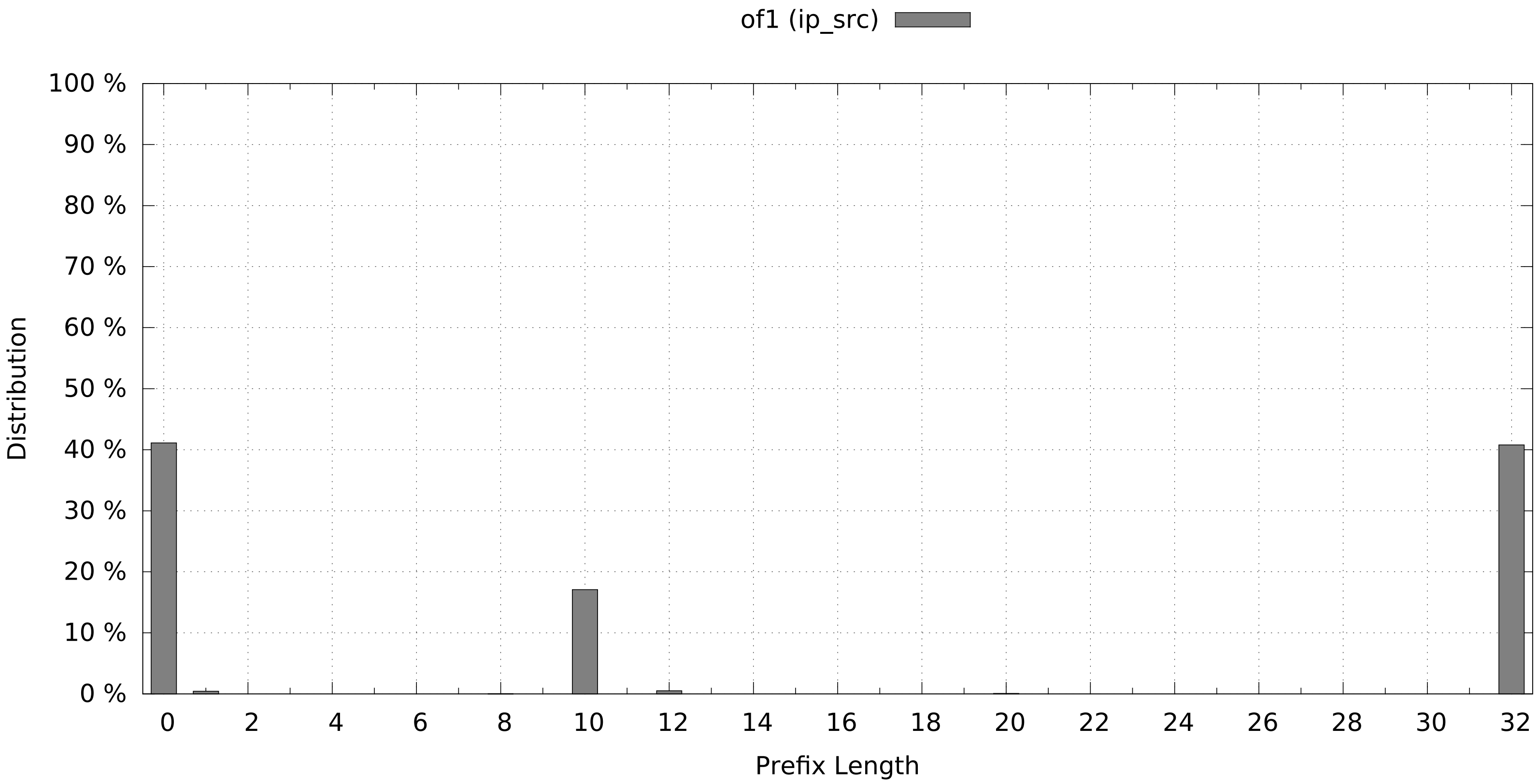
- 36 times more prefixes after 10 years of evolution

- the most common prefix length shifted from 32 (RIRs/ISPs) to 48 (end users/organizations) some of the results from our analysis of OF rules deployed in a cloud datacenter

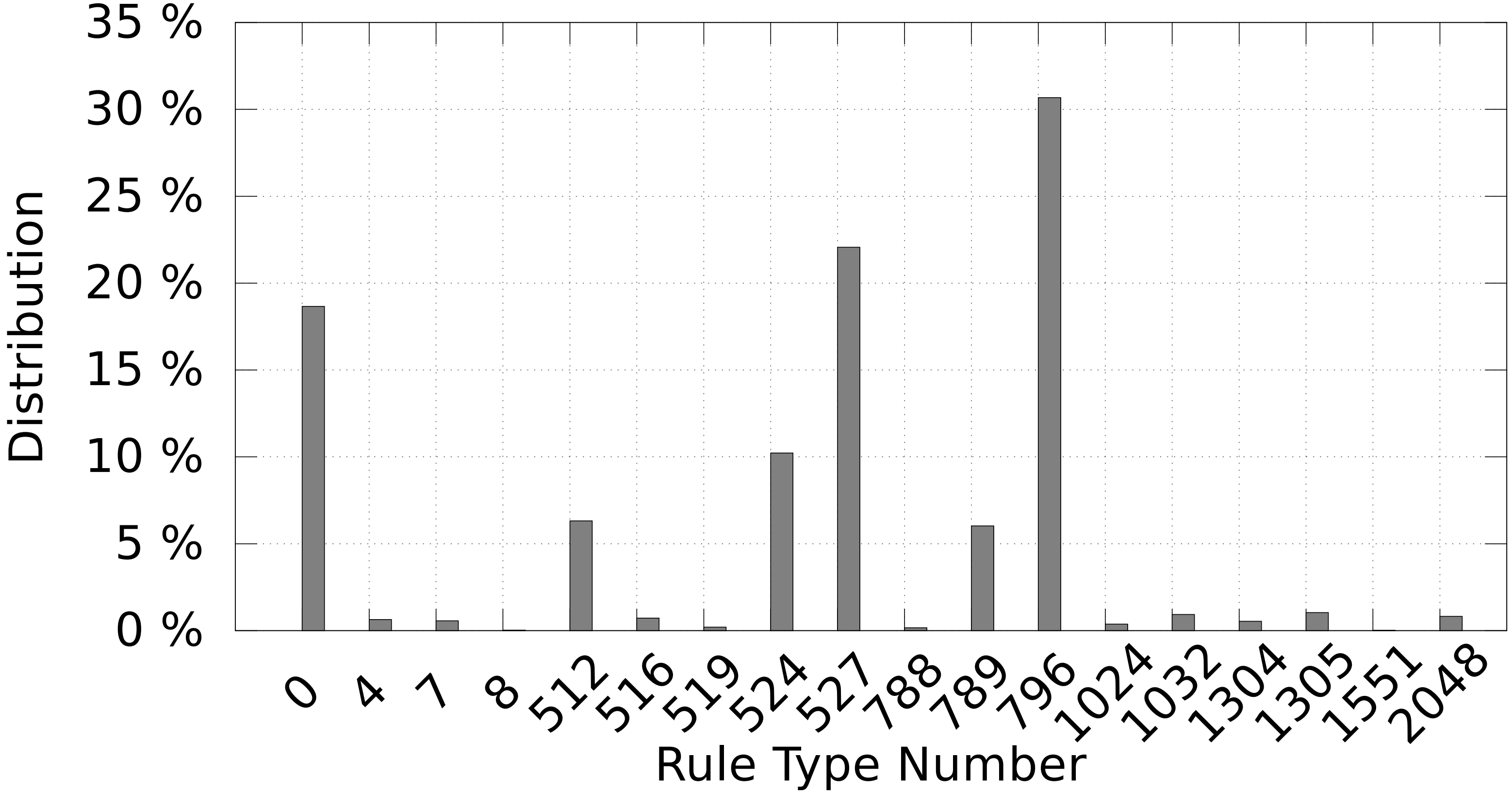


Destination MAC based forwarding.

Not much interest on the application side: l4 ports and protocols are specified less then 30% of the times.



Forwarding is based on either the exact destination or in a big subnet.



Rule type is a template that indicate which header fields are specified.

rule type number 796 refers to rules where **mac dst**, **eth type**, **ip proto**, **ip src**, and **ip dst** present specified values

Evaluation of generation fidelity is based on the Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\bar{y} - y_i)^2}$$

Evaluation of generation fidelity is based on the Root Mean Square Error (RMSE)

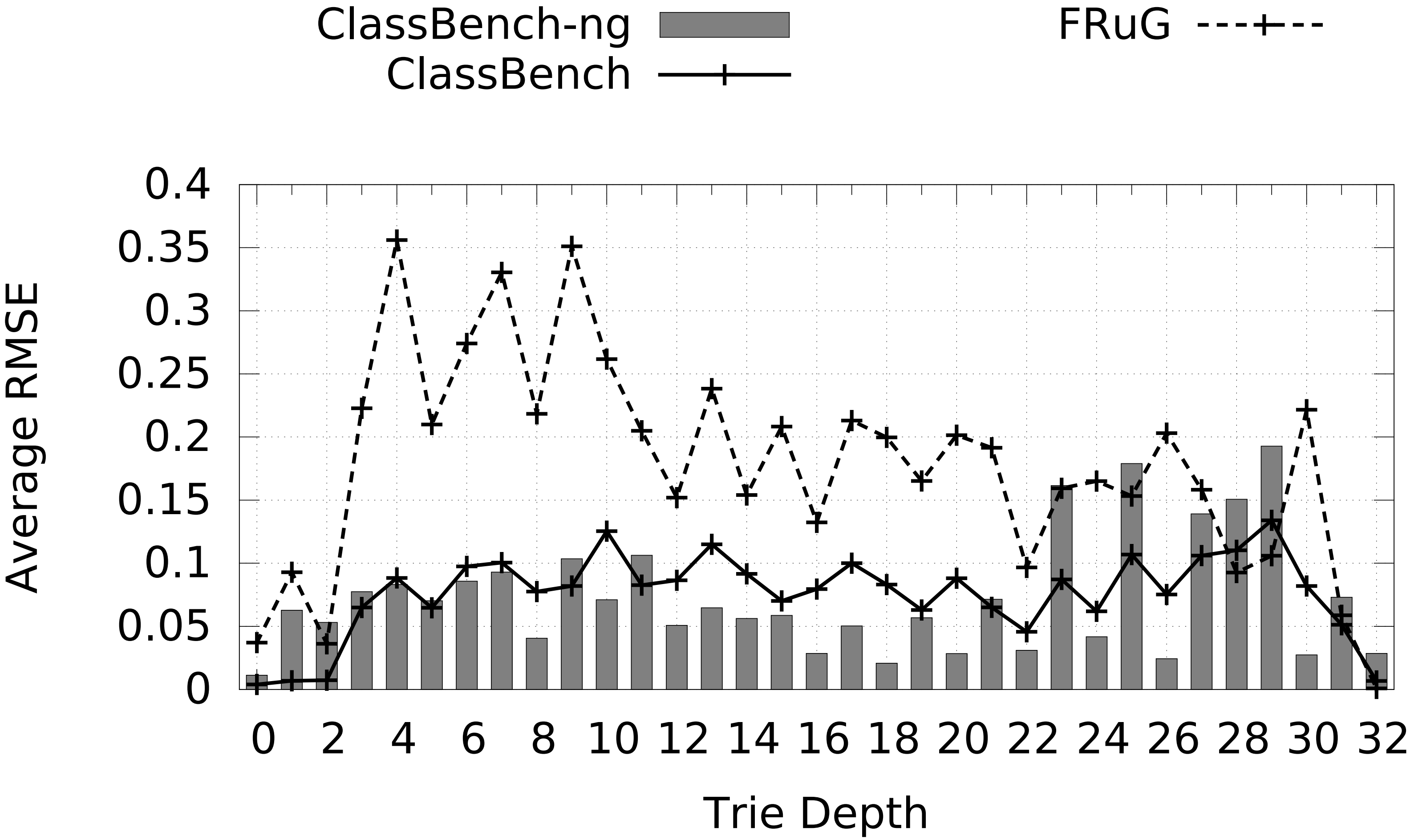
$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\bar{y} - y_i)^2}$$

Target Value

Evaluation of generation fidelity is based on the Root Mean Square Error (RMSE)

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(\bar{y} - y_i)^2}$$

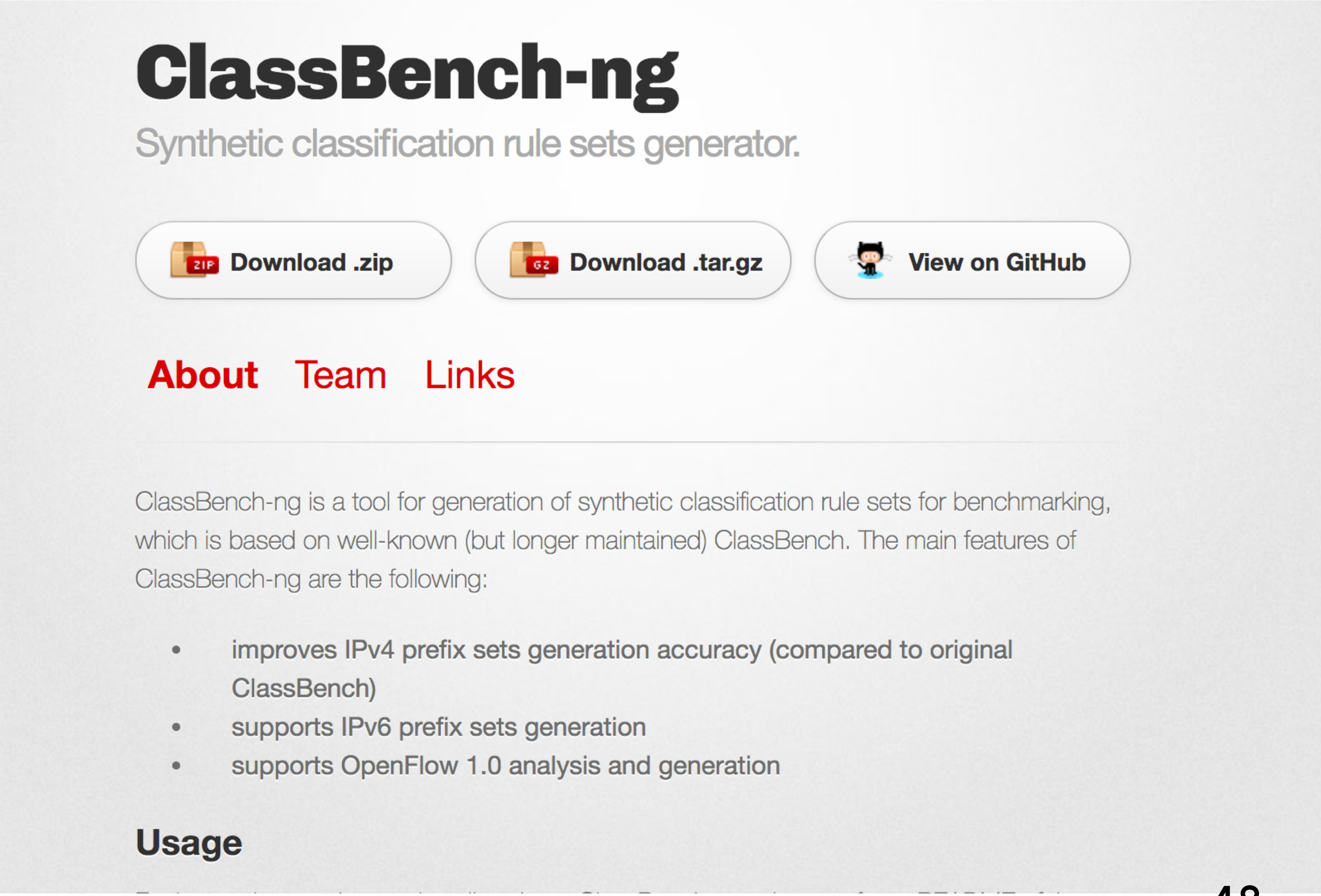
Generated Value


ClassBench-ng
ClassBench
FRuG
Average RMSE
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Trie Depth

The beta-version of the code is released OpenSource.

We invite everyone from the community to contribute with new seeds taken from different scenarios

https://classbench-ng.github.io/



ClassBench-ng

Synthetic classification rule sets generator.

ClassBench-ng is a tool for generation of synthetic classification rule sets for benchmarking, which is based on well-known (but longer maintained) ClassBench. The main features of ClassBench-ng are the following:

- improves IPv4 prefix sets generation accuracy (compared to original ClassBench)
- supports IPv6 prefix sets generation
- supports OpenFlow 1.0 analysis and generation

Usage

Thank you.