High-Resolution Metrics

Simone Mainardi, PhD
mainardi@ntop.org

Emanuele Faranda
faranda@ntop.org

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"Tell me how you measure me, and I will tell you how I will behave."

— Eliyahu M. Goldratt

Agenda

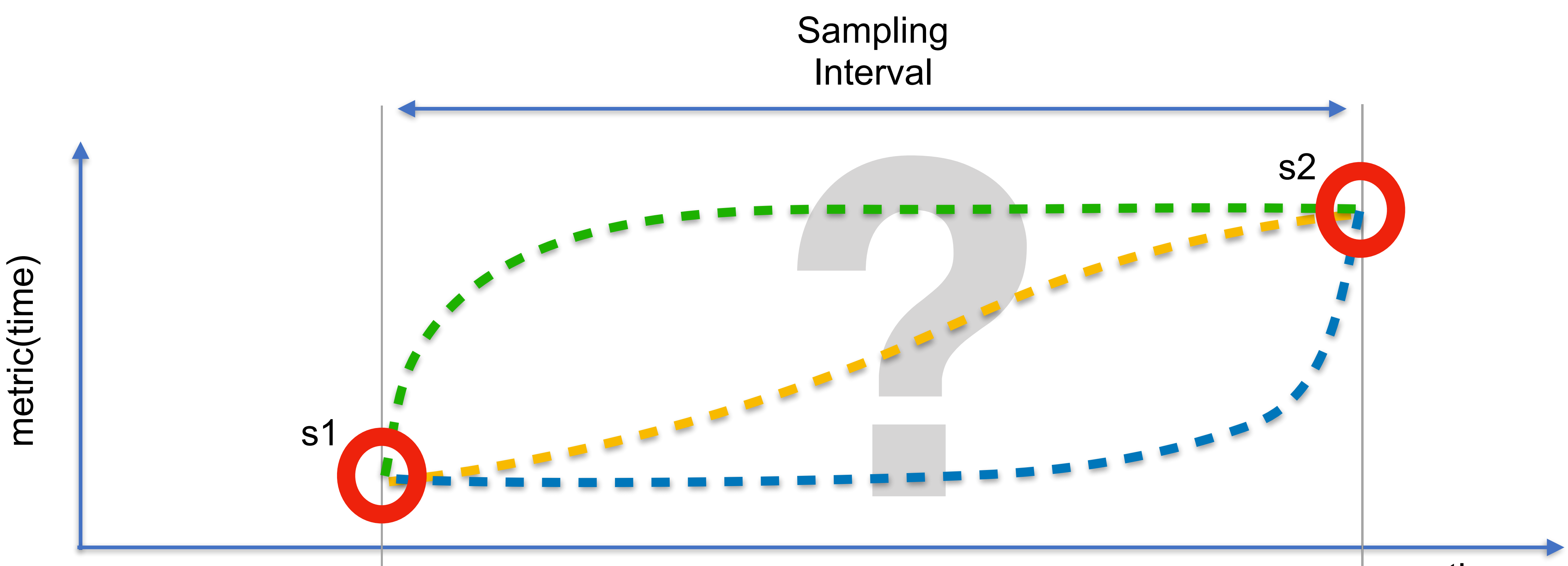
- Network visibility - state-of-the-art and benefits of high-resolution metrics
- High-Resolution metrics in ntopng: from RRD to InfluxDB

Network Visibility

- In general, network visibility is provided by means of metrics
  - bytes, packets, applications (e.g, YouTube, FaceBook), …
- Metrics are **sampled** at **discrete time** intervals — the shorter the interval, the higher the **resolution**

Inter-Interval Blindness

- Nothing is known on the metric evolution between consecutive samples
- Being able to increase the resolution reduces the unknowns



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Let’s See an Example

- 10 GB traffic transferred
  - Free link
  - Fully-utilized link
- Client and server connected to a GbE switch
- iperf for the transfer (https://github.com/esnet/iperf)
- monitoring with ntopng (https://github.com/ntop/ntopng)
  - 5-min vs 10-sec traffic samples

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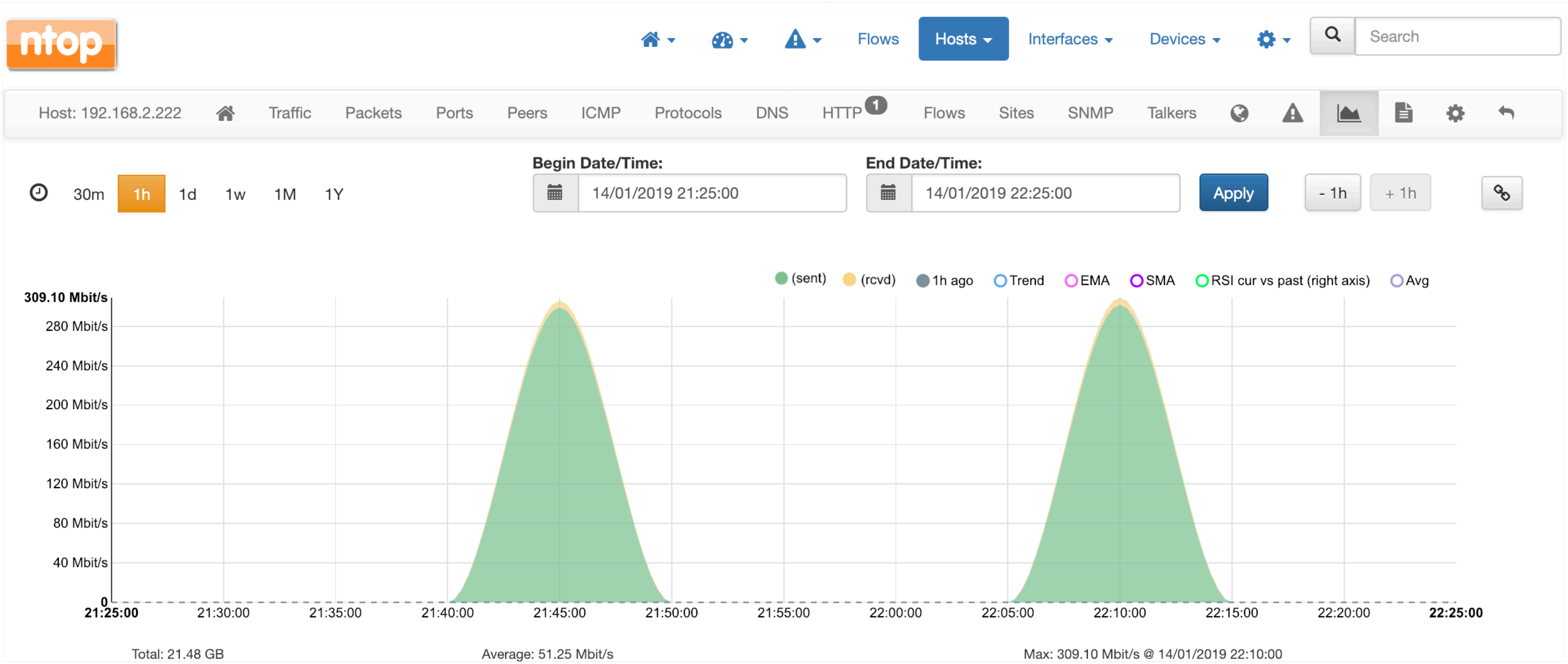
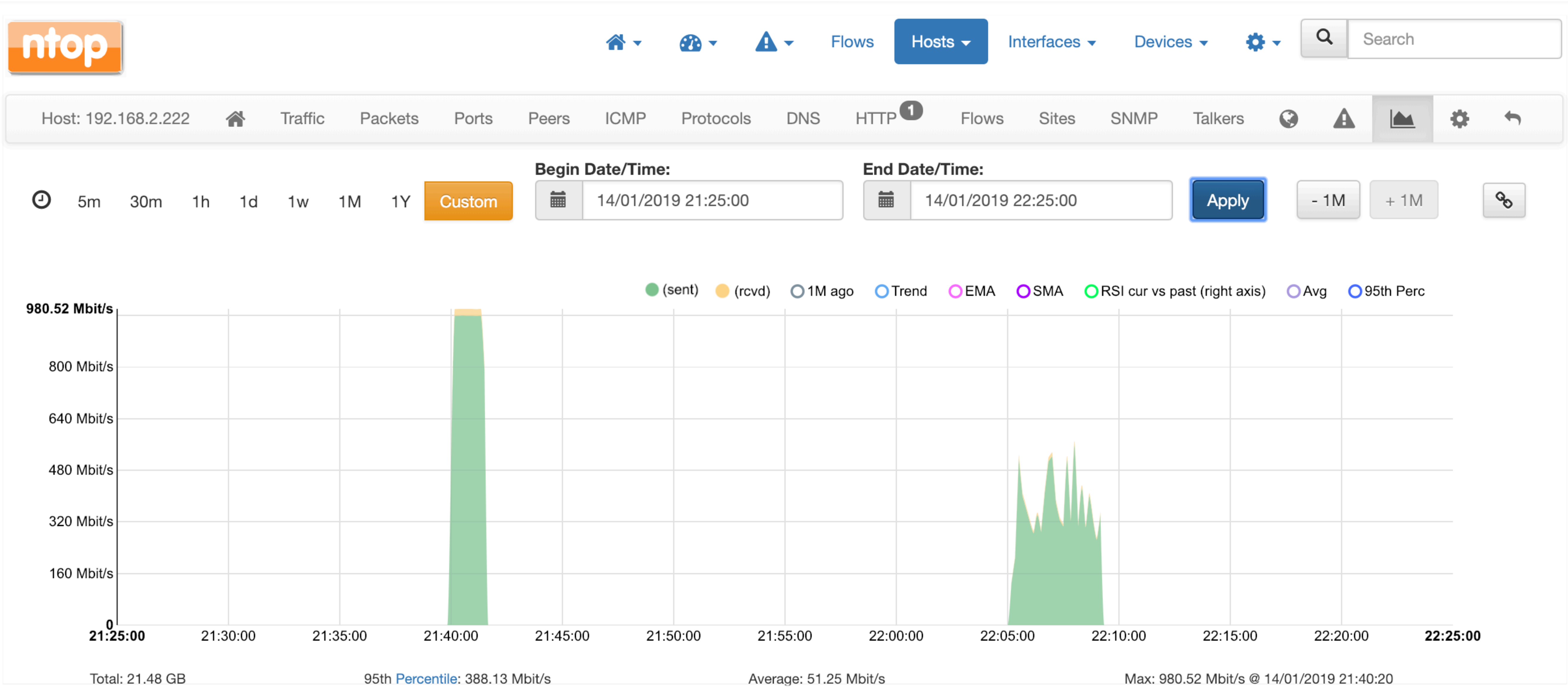
Free vs Fully-Utilized Link: 5-min Samples




```
client: simone@192.168.2.222:~$ iperf -c develv5 -p 8082 -i 1 -t 9999 -n 10240M
server: simone@192.168.2.225:~$ iperf -s -p 8082 -i 1 -t 99999
```

Free vs Fully-Utilized Link: 10-sec Samples




```
client: simone@192.168.2.222:~$ iperf -c develv5 -p 8082 -i 1 -t 9999 -n 10240M
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```

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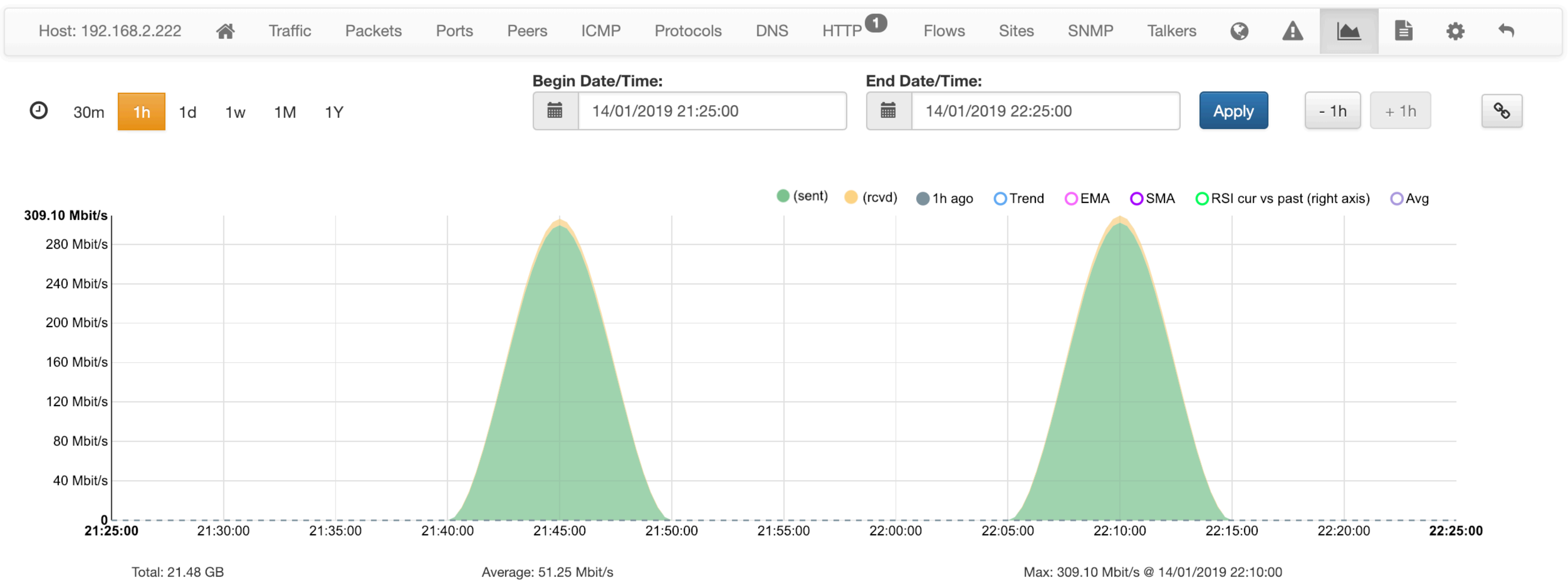
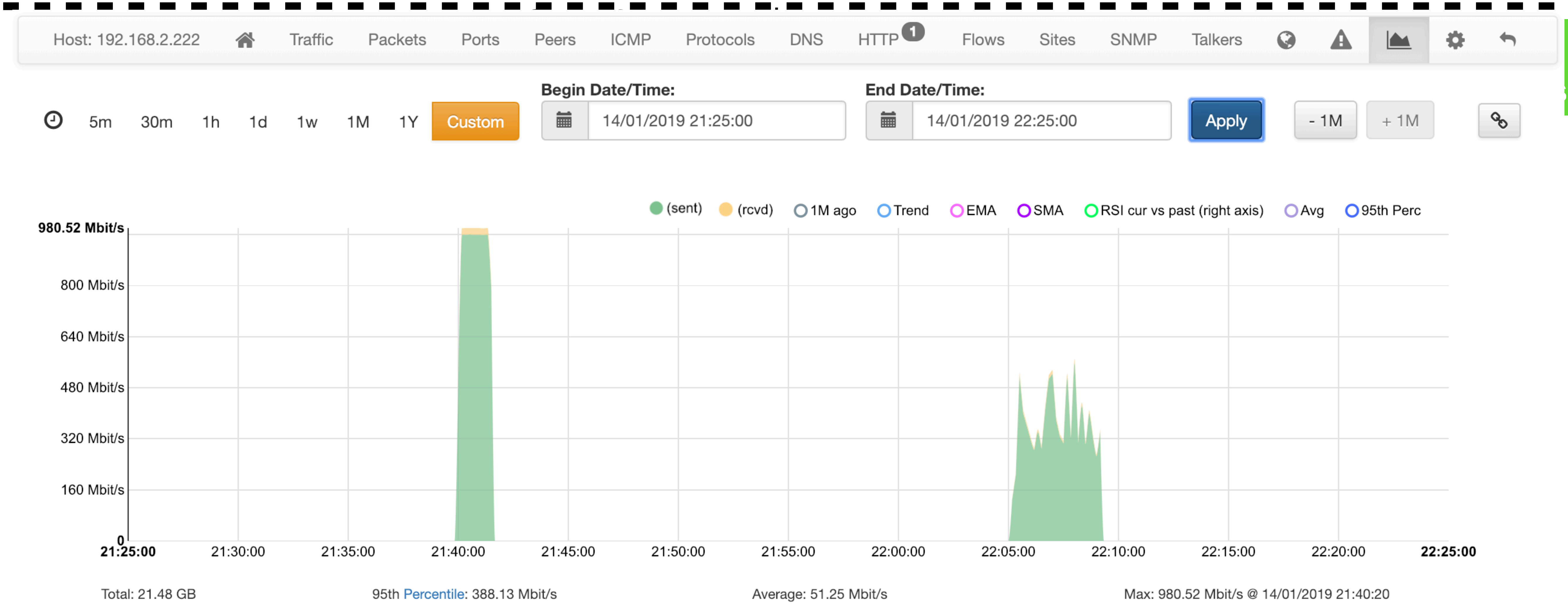


Host: 192.168.2.222
Traffic
Packets
Ports
Peers
ICMP
Protocols
DNS
HTTP 1
Flows
Sites
SNMP
Talkers
30m
1h
1d
1w
1M
1Y
Begin Date/Time:
14/01/2019 21:25:00
End Date/Time:
14/01/2019 22:25:00
Apply
- 1h
+ 1h
(sent)
(rcvd)
1h ago
Trend
EMA
SMA
RSI cur vs past (right axis)
Avg
309.10 Mbit/s
280 Mbit/s
240 Mbit/s
200 Mbit/s
160 Mbit/s
120 Mbit/s
80 Mbit/s
40 Mbit/s
0
21:25:00
21:30:00
21:35:00
21:40:00
21:45:00
21:50:00
21:55:00
22:00:00
22:05:00
22:10:00
22:15:00
22:20:00
22:25:00
Total: 21.48 GB
Average: 51.25 Mbit/s
Max: 309.10 Mbit/s @ 14/01/2019 22:10:00



Host: 192.168.2.222
Traffic
Packets
Ports
Peers
ICMP
Protocols
DNS
HTTP 1
Flows
Sites
SNMP
Talkers
5m
30m
1h
1d
1w
1M
1Y
Custom
Begin Date/Time:
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14/01/2019 22:25:00
Apply
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Trend
EMA
SMA
RSI cur vs past (right axis)
Avg
95th Perc
980.52 Mbit/s
800 Mbit/s
640 Mbit/s
480 Mbit/s
320 Mbit/s
160 Mbit/s
0
21:25:00
21:30:00
21:35:00
21:40:00
21:45:00
21:50:00
21:55:00
22:00:00
22:05:00
22:10:00
22:15:00
22:20:00
22:25:00
Total: 21.48 GB
95th Percentile: 388.13 Mbit/s
Average: 51.25 Mbit/s
Max: 980.52 Mbit/s @ 14/01/2019 21:40:20

Why Care? Throughput

- Some applications expect the network to provide them a minimum throughput
  - VoIP
  - Realtime Video
- Failing to meet such requirements could cause intermittent user experience and application performance degradation
- 10-sec throughput **!=** 5-min throughput

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Why Care? Burstiness

- Detect bursty traffic
- Bursts can cause network buffers to overflow
  - Packet drops while having a low average link utilization
- Cause network equipment further down the line to deliver packets at odd intervals, determining latency and jitter issues
- 10-sec samples can highlight bursts averaged out when using 5-min samples

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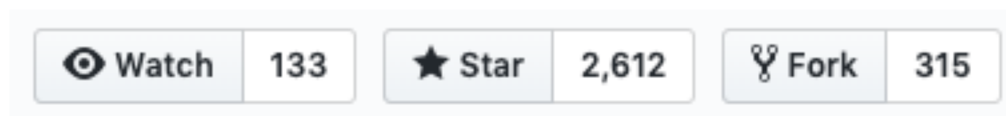
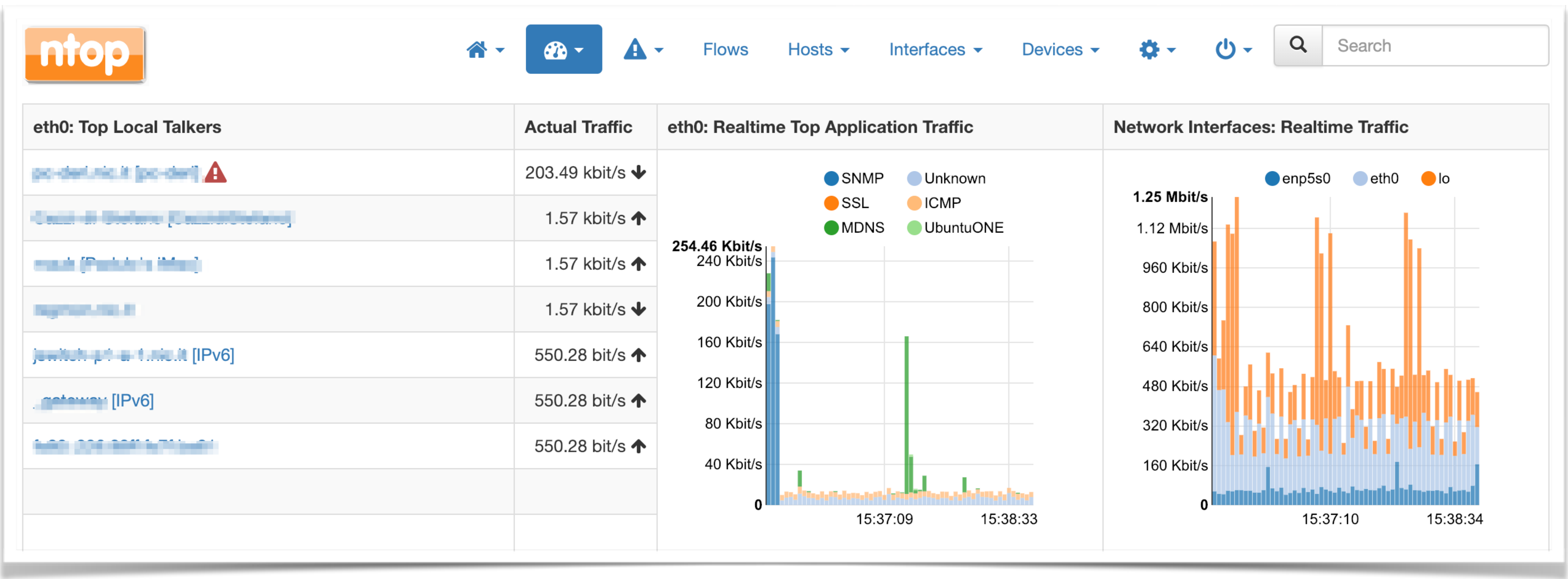
High Resolution Metrics: The Recipe

- **ntopng** to generate metrics up to a packet-by-packet resolution
- **InfluxDB** to retain sub-minute samples

Monitoring Tool: ntopng

- opensource web-based network monitoring tool
- https://github.com/ntop/ntopng





Sub-Min Samples with ntopng

- ntopng architecture
  - Packet capture thread
  - Periodic activities
- Originally based on RRDs, ntopng has been extended to produce 10-second samples, e.g., bytes(t), bytes(t+10), bytes(t+20), …
- Samples are temporary stored and periodically POST-ed to InfluxDB

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From RRD to InfluxDB

InfluxDB Integration Goals

- Overcome the RRD write speed limitations to avoid losing data when dealing with high number of hosts
- Increase the timeseries resolution
- Extract insights from data via built-in functions (e.g. topk, rolling average)
- Use ntopng as a data source and visualize data on Grafana

History of InfluxDB Integration

- ntopng 3.4
  - Export to InfluxDB of common timeseries (beta)
- ntopng 3.6
  - Full timeseries export to InfluxDB
  - Possibility to use RRD or InfluxDB
- ntopng 3.8:
  - Support for authentication
  - Handle slow and aborted queries

The Need for an Abstraction Layer

- Keeping the existing RRD data for users who do not need InfluxDB
- Provide InfluxDB as a beta for users willing to help with testing while keeping RRD functional
- RRD is a lighter dependency than InfluxDB as it is just a C library

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RRD and InfluxDB: Two Different Worlds

RRD

- Data structure is defined during RRD creation
- The tags must be encoded in the RRD path
- Downsamples the points during writes
- Returns data with the appropriate resolution

InfluxDB

- Data structure is dynamic and no definition is needed
- Tags and metrics are logically split by design
- Downsamples the points in query phase
- Resolutions must be handled explicitly

The Timeseries Framework

- A schema, defining the metric type and attributes
- The ts_utils.lua module which implements the timeseries API
- InfluxDB and RRD drivers which implement the functionalities

https://www.ntop.org/guides/ntopng/api/timeseries/intro.html

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Schema Examples

https://github.com/ntop/ntopng/tree/dev/scripts/lua/modules/timeseries/schemas

```
schema = ts_utils.newSchema("iface:traffic", {step=1, rrd_fname="bytes"})
schema:addTag("ifid")
schema:addMetric("bytes")
```

```
schema = ts_utils.newSchema("host:ndpi", {step=300})
schema:addTag("ifid")
schema:addTag("host")
schema:addTag("protocol")
schema:addMetric("bytes_sent")
schema:addMetric("bytes_rcvd")
```

Schemas in Practice

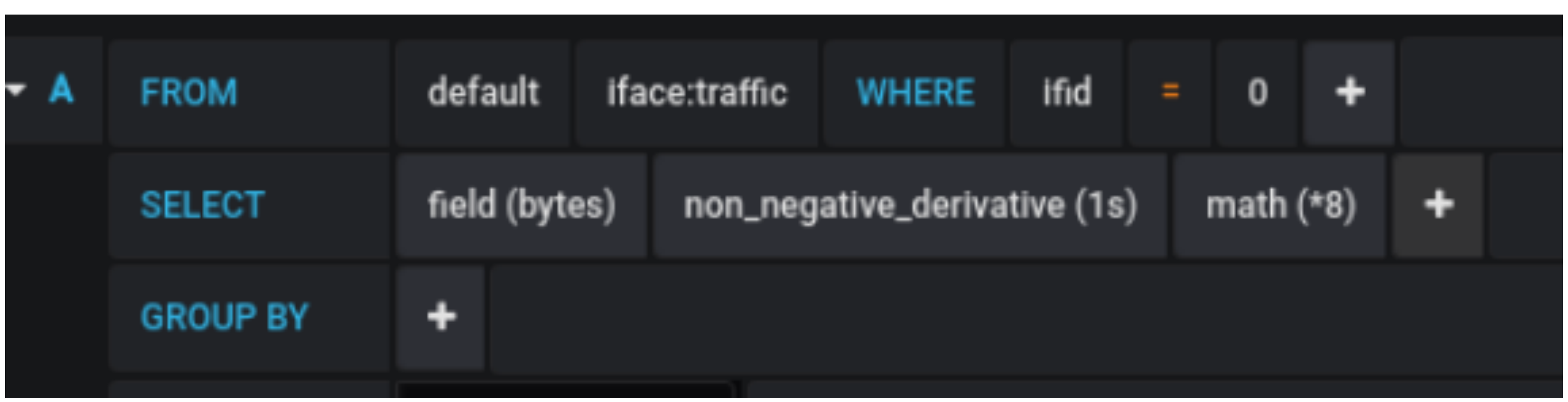
InfluxDB

```
name: iface:traffic
time                bytes  ifid
----                -----  ----
1550742429000000000 184824 1
1550742430000000000 185006 1
1550742431000000000 185185 1
1550742432000000000 185245 1
1550742433000000000 185364 1
```

RRD

```
filename = "/var/lib/ntopng/0/rrd/bytes.rrd"
rrd_version = "0003"
step = 1
last_update = 1556919319
header_size = 1000
ds[num].index = 0
ds[num].type = "DERIVE"
ds[num].minimal_heartbeat = 2
```

InfluxDB visualization in Grafana



InfluxDB or RRD? [1/2]

- RRD advantages:
  - Runs within ntopng itself, no additional services needed
  - It's usually faster for the extraction of raw data (e.g. to produce charts)
  - Can be suitable to be installed in a SBC computer (e.g. raspberry) with low cpu power
- However:
  - With >1k hosts it can become a bottleneck, especially with slow storage

InfluxDB or RRD? [2/2]

- InfluxDB advantages:
  - Can be installed in a separate host, with almost 0% cpu and disk impact on the ntopng host
  - It's **much faster** than RRD for writing timeseries
  - High resolution timeseries, 10s versus 5 minutes of RRD
- However:
  - Query performance degrades after a lot of points are stored (we have a fix for this)

Disk Requirements

- Testing environment:
  - ntopng 3.8
  - L7 Application timeseries enabled

- RRD:
  - 500 KB / Local Host (RRD preallocates the necessary disk space)

- InfluxDB:
  - 450 KB / Local Host / Day (10s resolution)
  - 75 KB / Local Host / Day (60s resolution)

https://www.ntop.org/ntopng/ntopng-disk-requirements-for-timeseries-and-flows/

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Improvement in InfluxDB Support

- The latest development version of ntopng introduces substantial improvements:
  - The ntopng charts loading time is drastically reduced by aggregating data via the InfluxDB Continuous Queries
  - The CPU usage and the network load on the ntopng host is reduced by using batched queries to populate the time series menu

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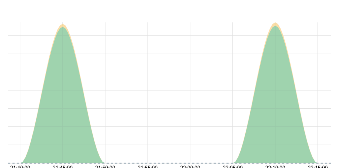
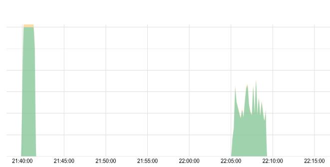
The Future

- InfluxDB will be the base for the future time series developments in ntopng
- Exporting new high resolution metrics to detect anomalies on network traffic and generate alerts
- Improve the time series correlation with historical flows and alerts

Fork me on GitHub

Take-Home

- High-resolution metrics can unveil traffic patterns hidden at lower-resolutions
- Effective solution for high-resolution network monitoring involves ntopng (monitoring / visualization / analysis) + InfluxDB (storage)
- mainardi@ntop.org, faranda@ntop.org

Slow Charts while using InfluxDB [1/2]

- The problem:
  - During page load, ntopng needs to know if a particular timeseries should be shown
  - To do this, ntopng performs an "exists" query on InfluxDB for every possible timeseries (~30 queries = ~30 HTTP connections)
- The solution:
  - ntopng 3.9 now batches most queries, page load performance increased

Slow Charts while using InfluxDB [2/2]

- The problem:
  - When the visualized chart range is wide, InfluxDB has to process a huge number of data points (depending on the timeseries resolution)
  - ntopng performs complex operations (derivatives, subqueries) which are not optimized in InfluxDB
- The solution:
  - ntopng 3.9 creates Continuos Queries to aggregate the data, reducing the data cardinality

Pitfalls in Continuos Queries Integration

- A CQ must be created for every timeseries schema
- CQ are bound to the current time and cannot be triggered on past data
- CQ creation fails if a tag on a schema is changed after a CQ was already created for it
- CQ can lose the last point of the current interval, so the CQ must be run again for the past interval