PIQ: Persistent Interactive Queries for Network Security Analytics

ACM SDN-NFV Security '19, March 27th 2019

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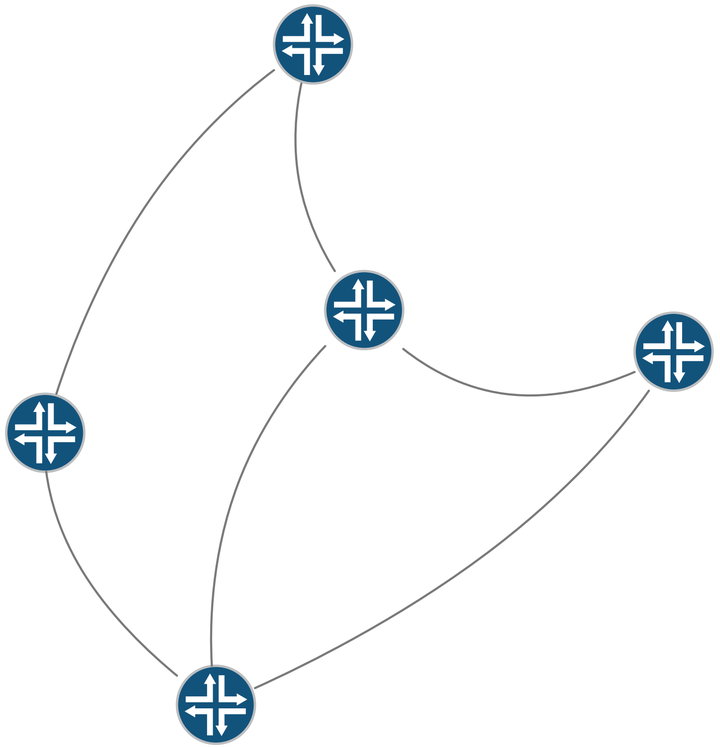
Penn

Network Monitoring is important

- Security issues
- Performance issues
- Equipment failure
- Misconfiguration

Today’s networks are larger and more complex than ever before



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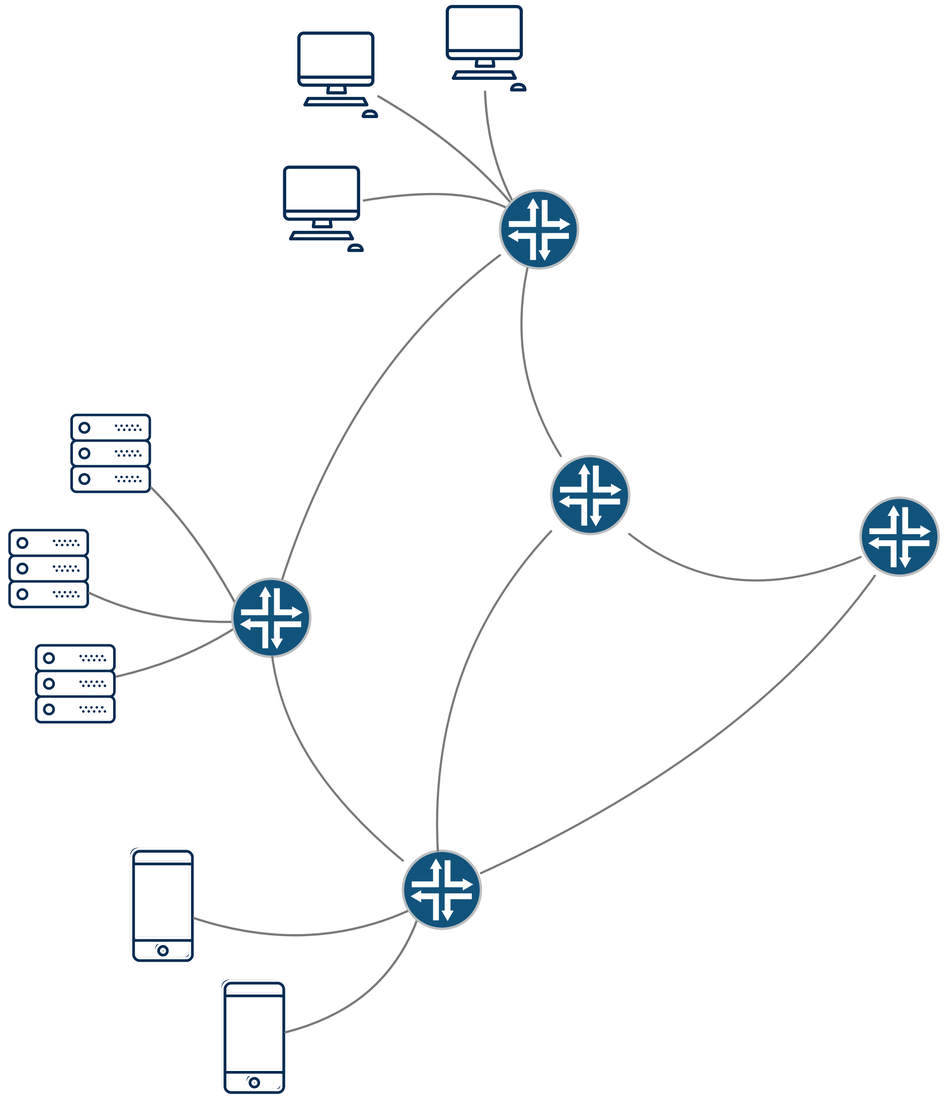

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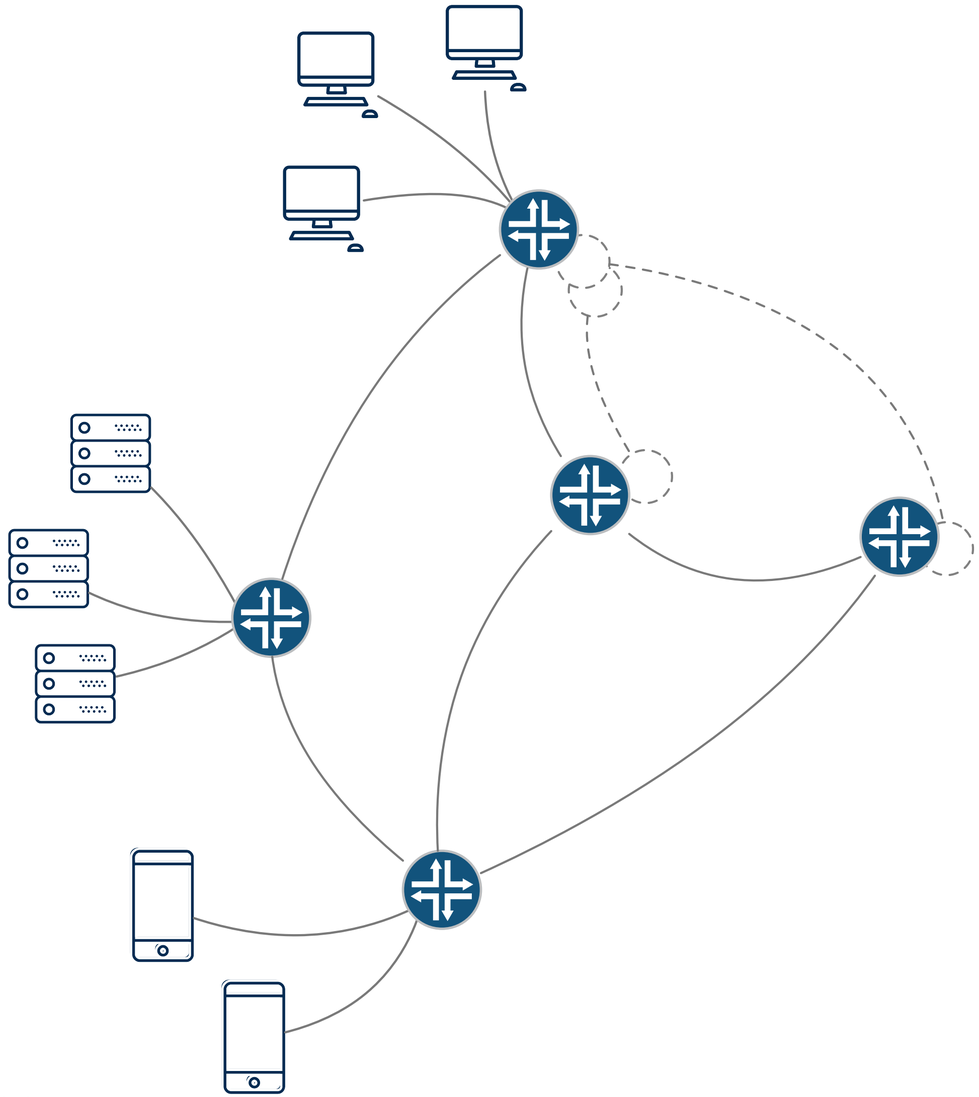

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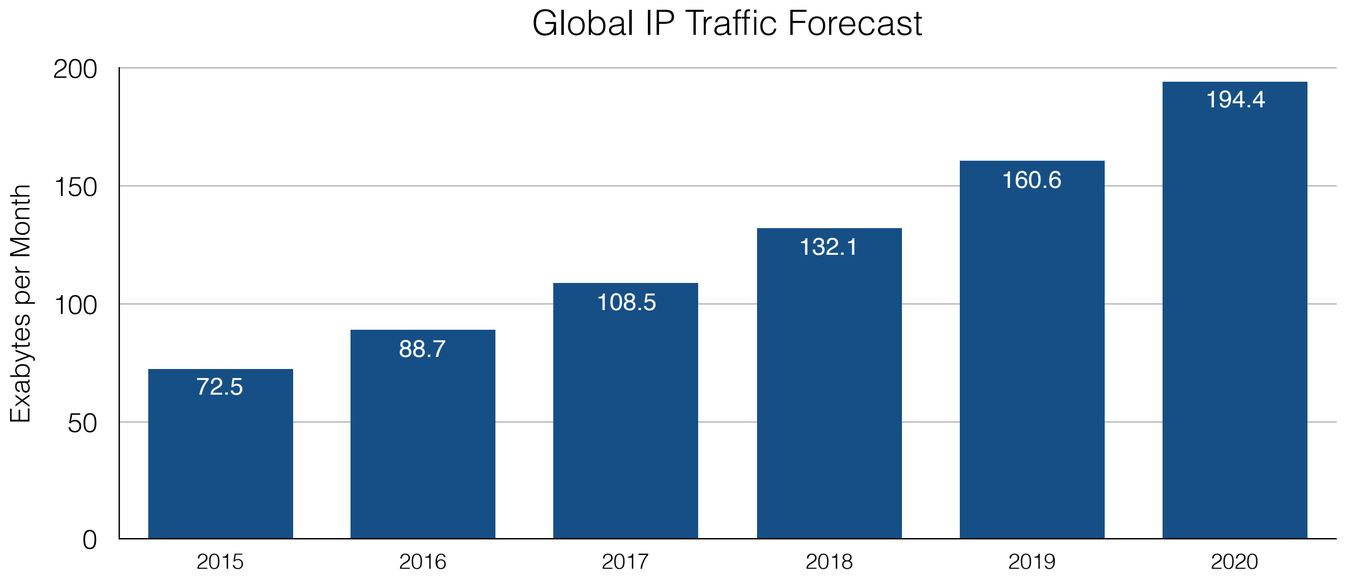
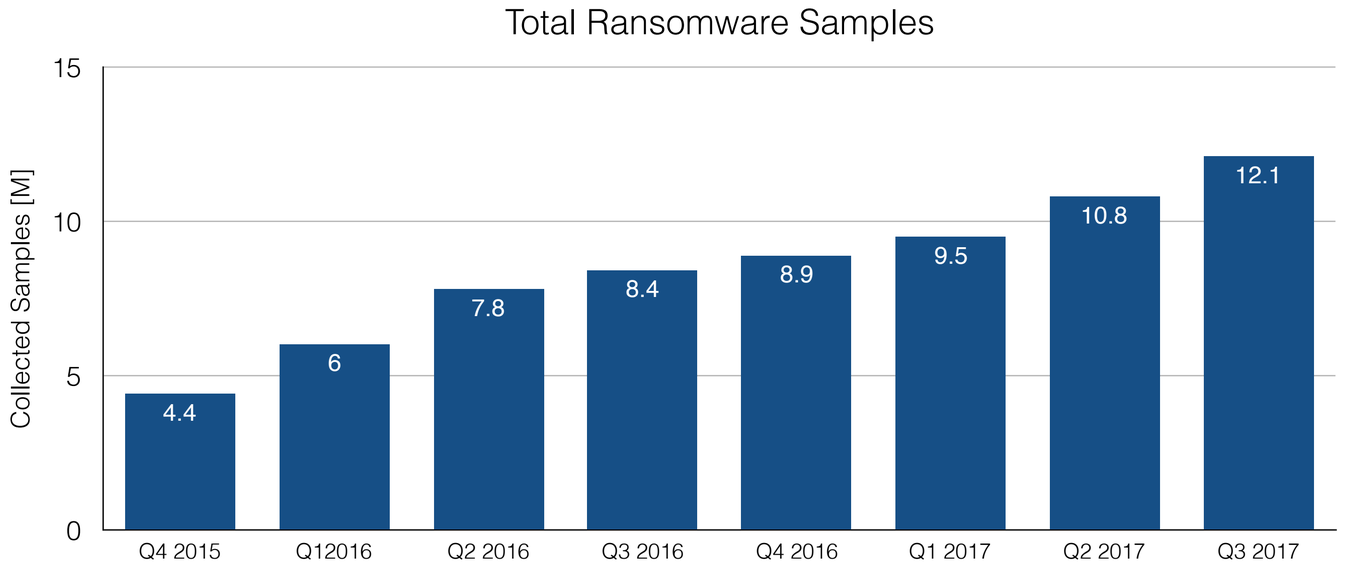


[Cisco Visual Networking Index 2017]

Network Threats grow rapidly



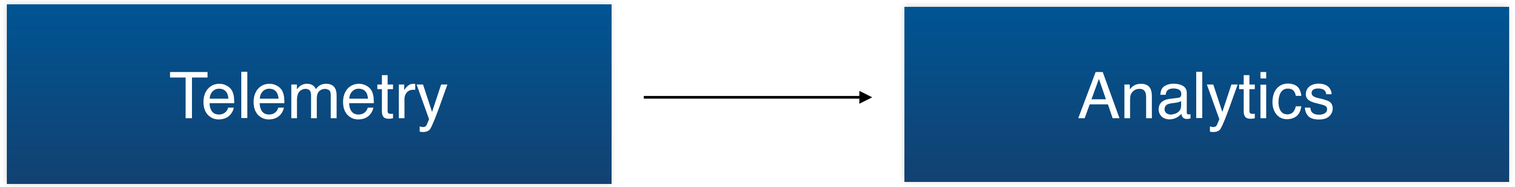
[McAfee Labs Thread Report Dec. 2017]

Passive Monitoring

Passive Monitoring

Telemetry

Passive Monitoring



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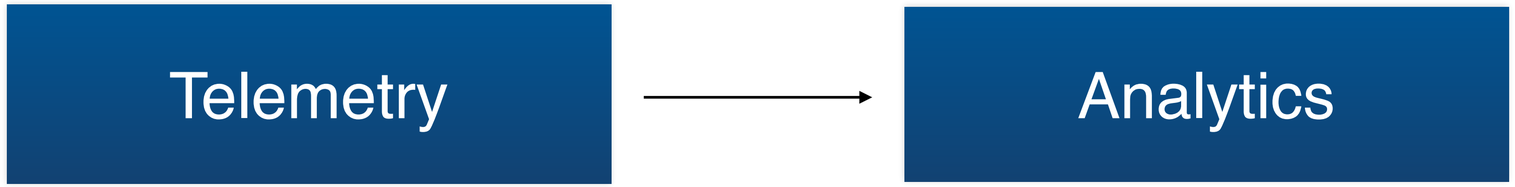

[UnivMon, SIGCOMM ’16]
[Marple, SIGCOMM ’17]
[*Flow, ATC ’18]

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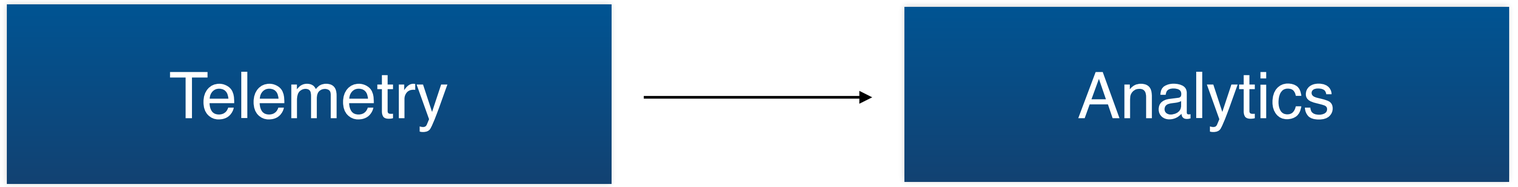
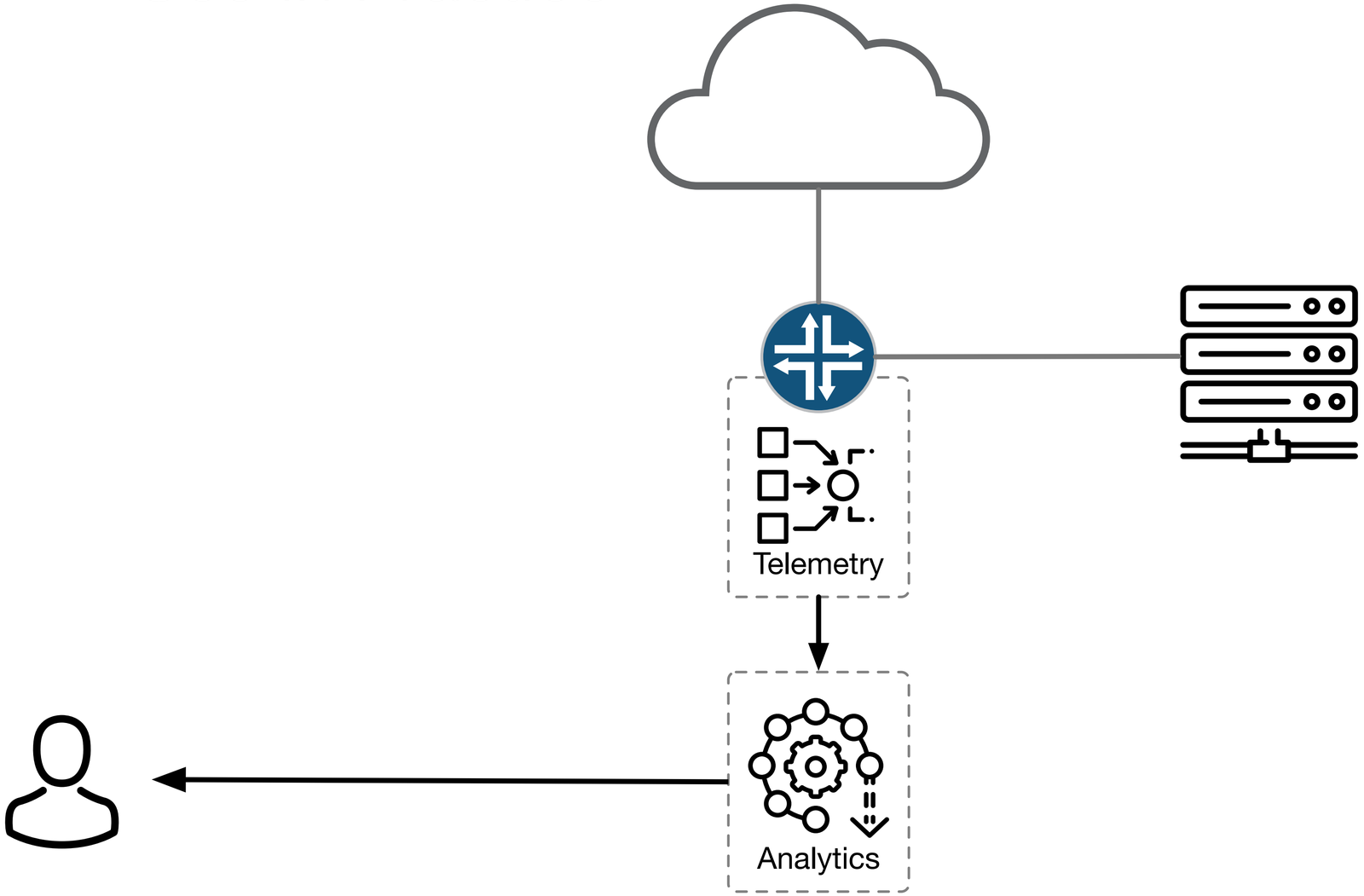


[UnivMon, SIGCOMM ’16]
[Marple, SIGCOMM ’17]
[*Flow, ATC ’18]

[NetQRE, SIGCOMM ’17]
[Jetstream, HotCloud '18]
[Sonata, SIGCOMM ’18]

Use in Practice



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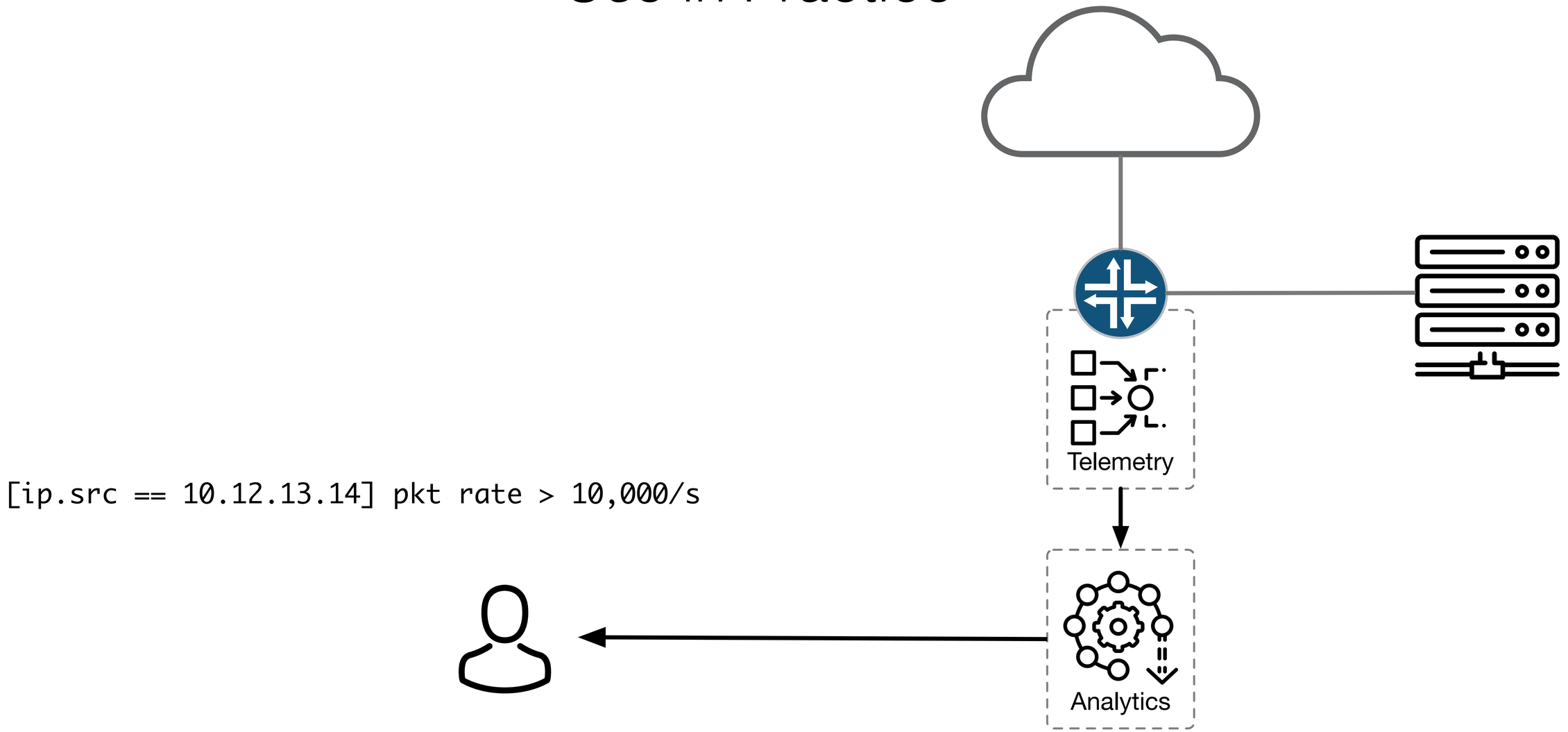

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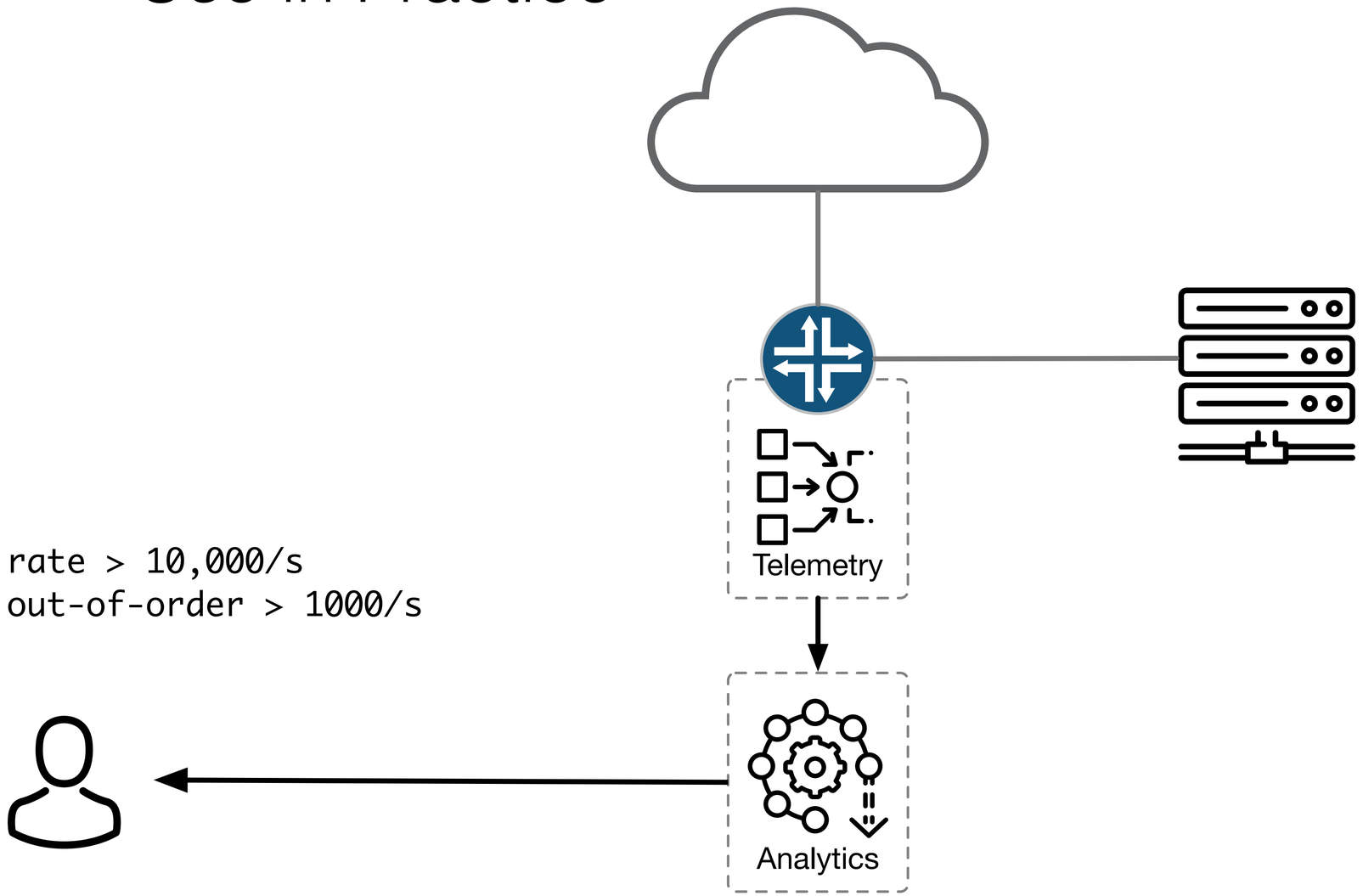

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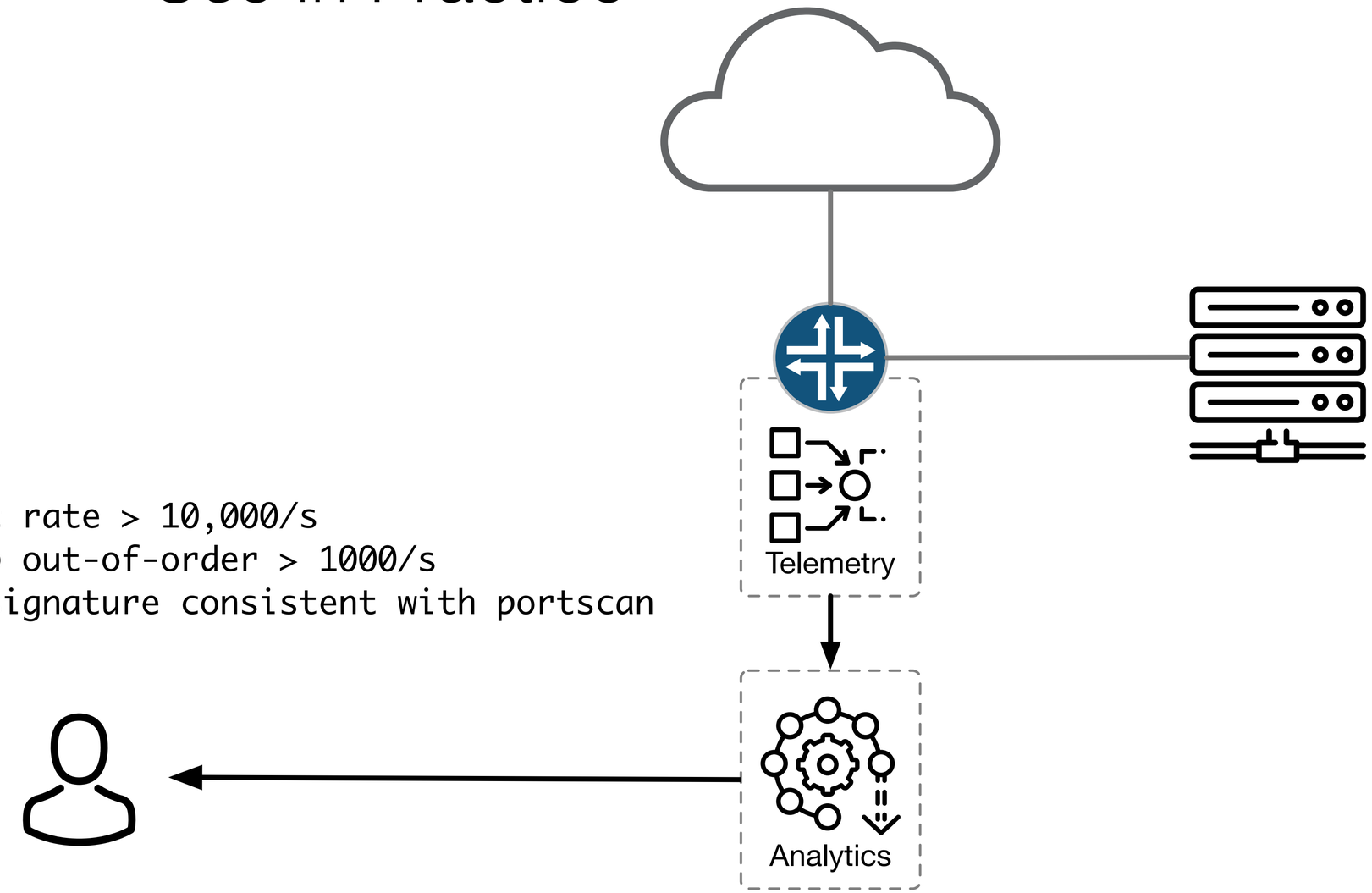

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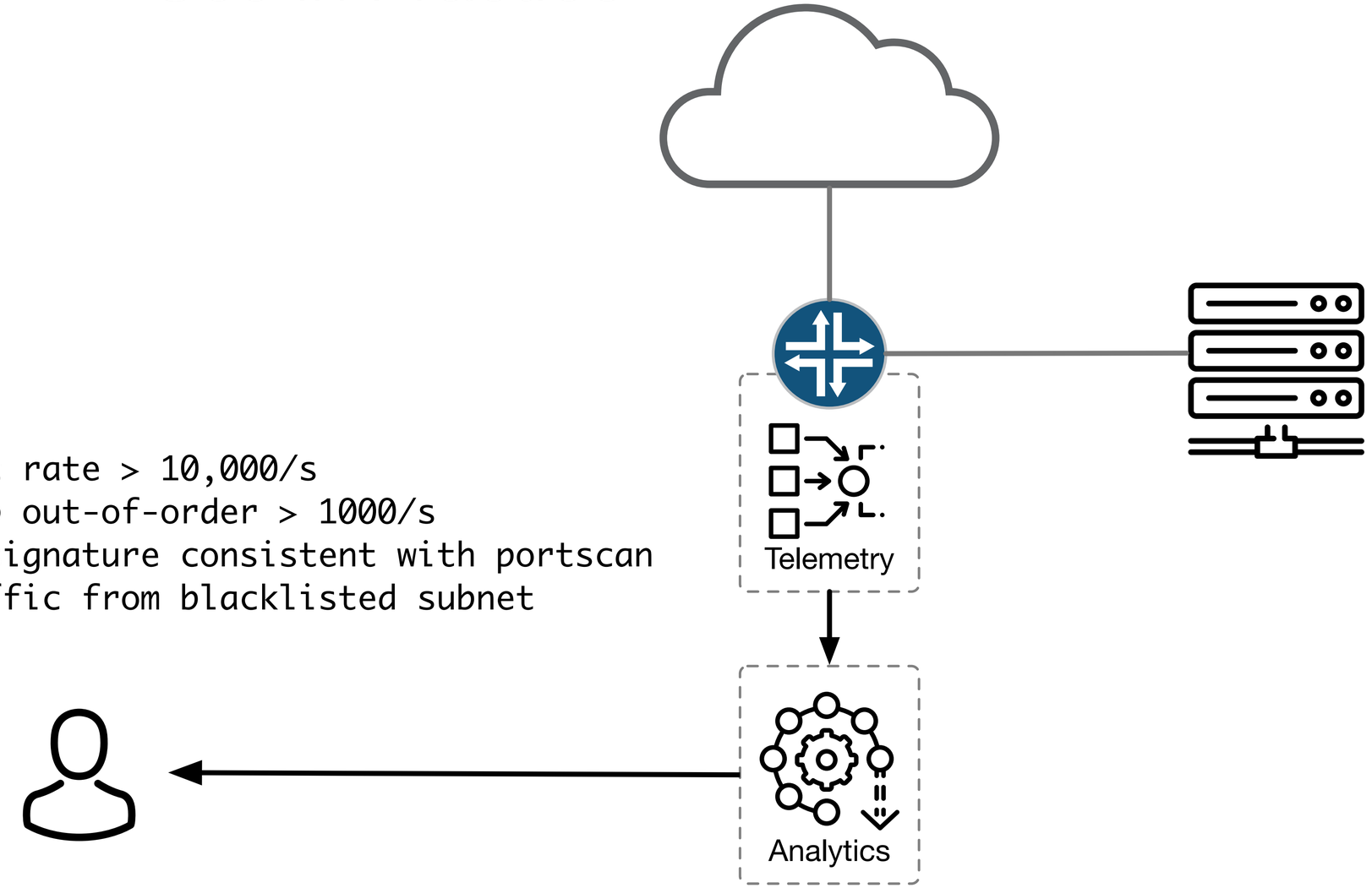

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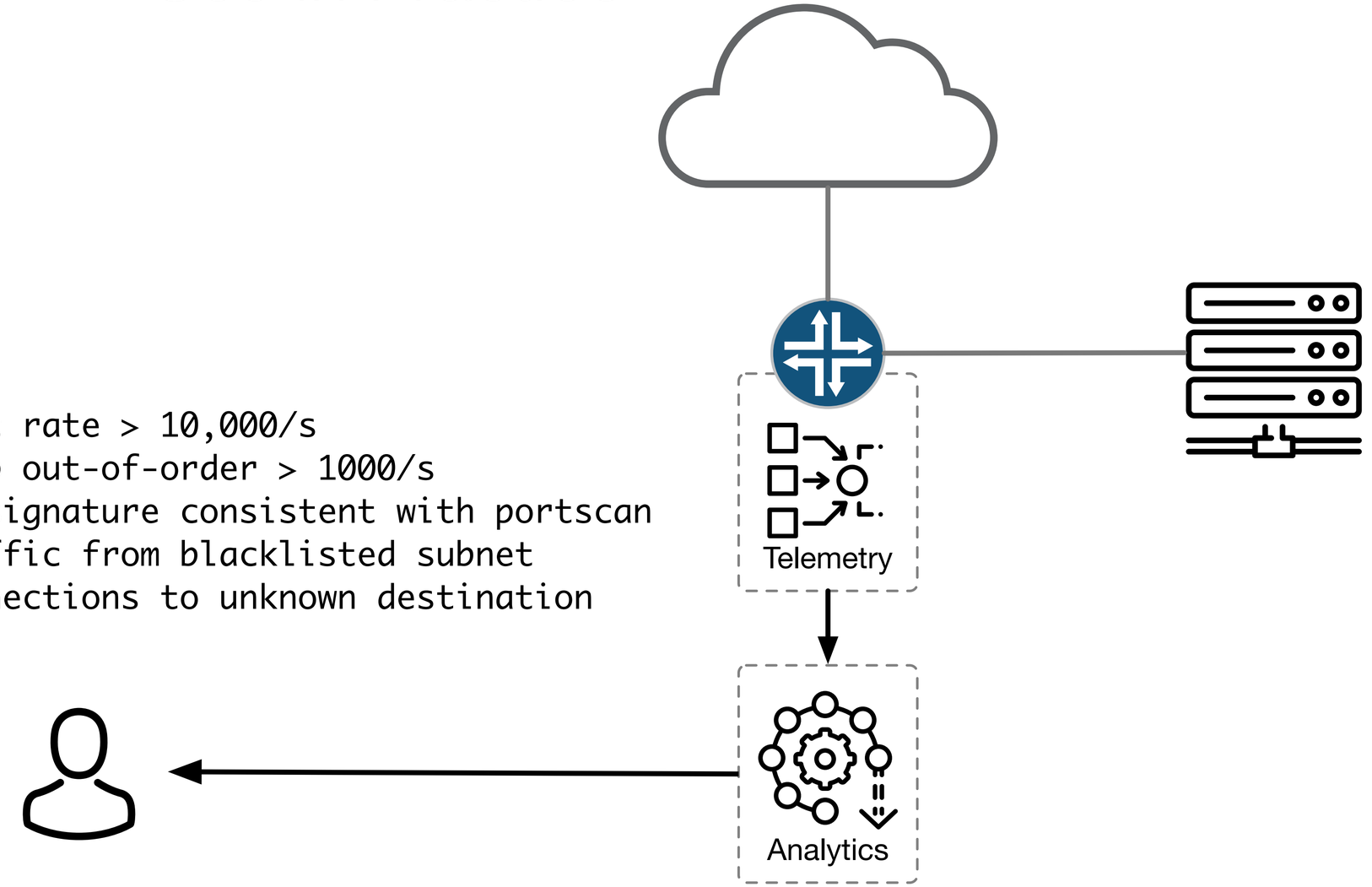

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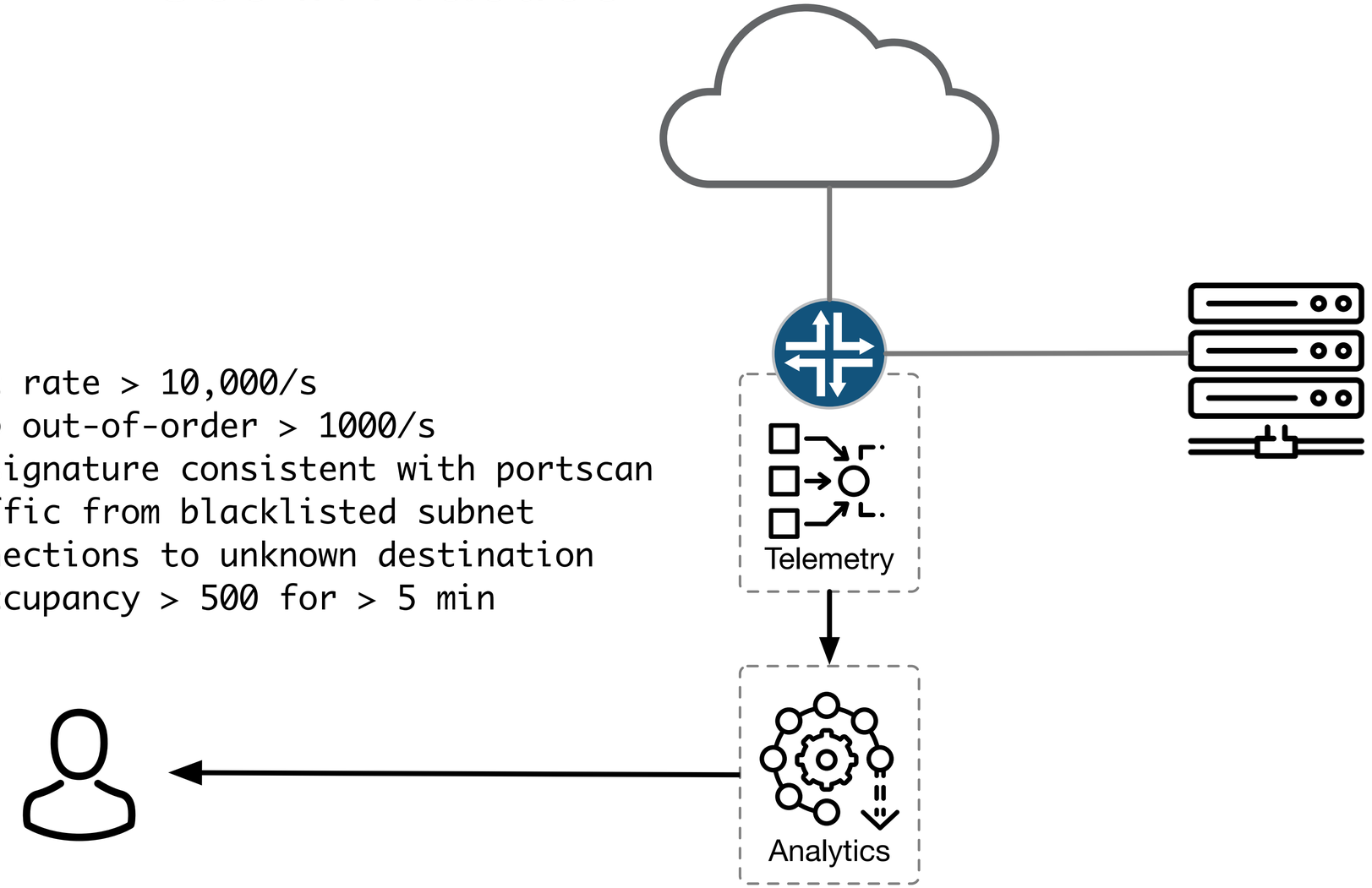

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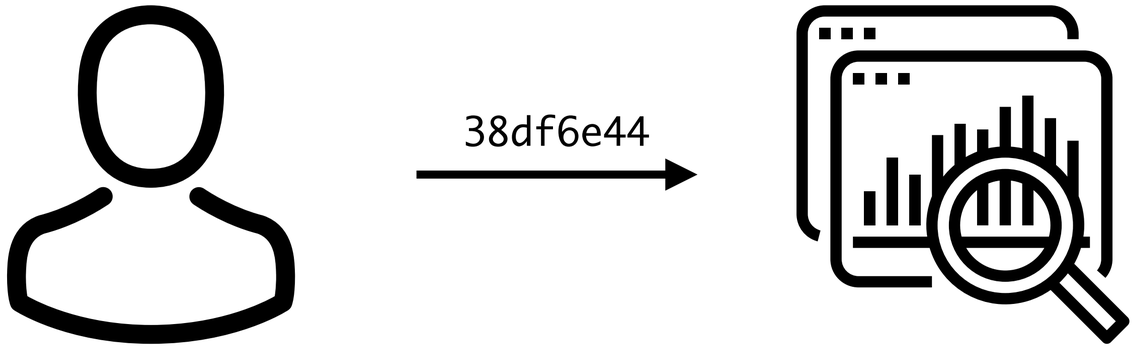
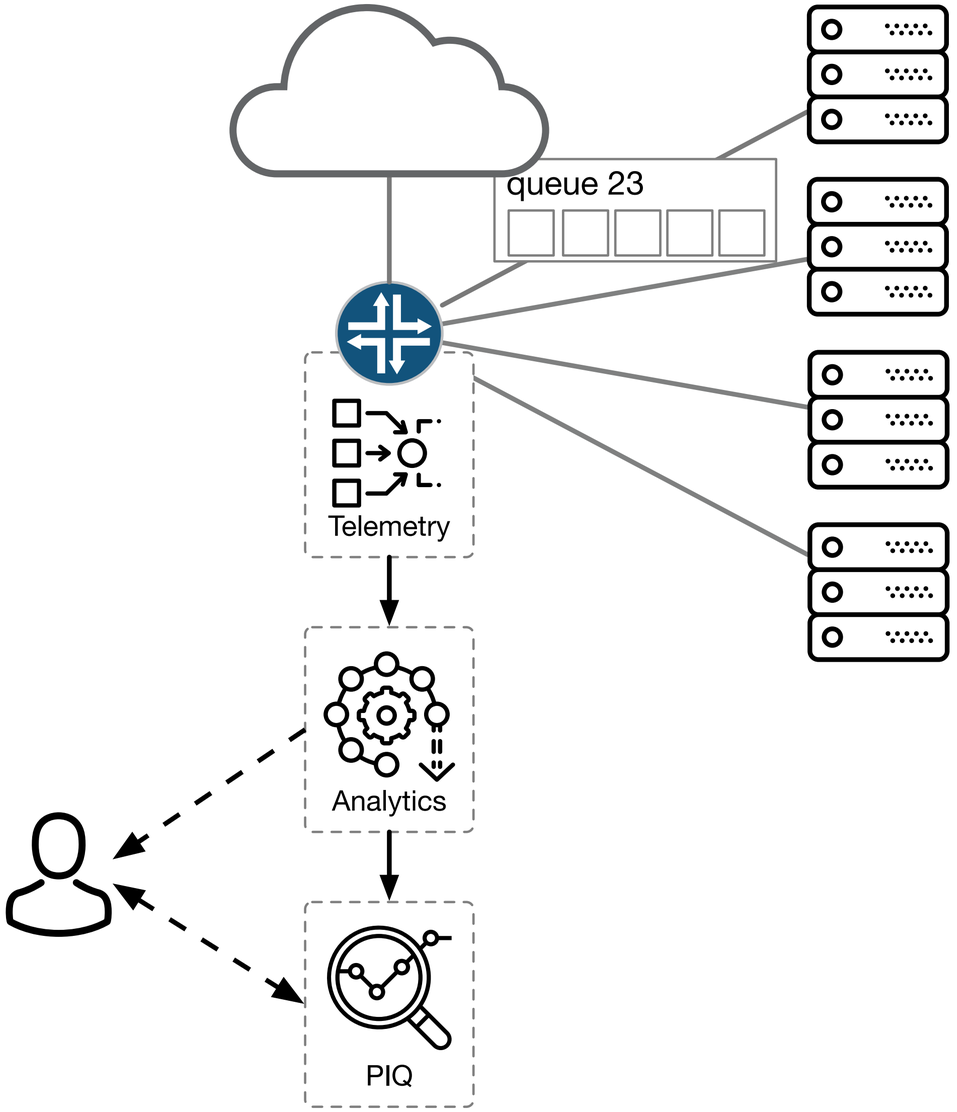


Retrospective Network Queries



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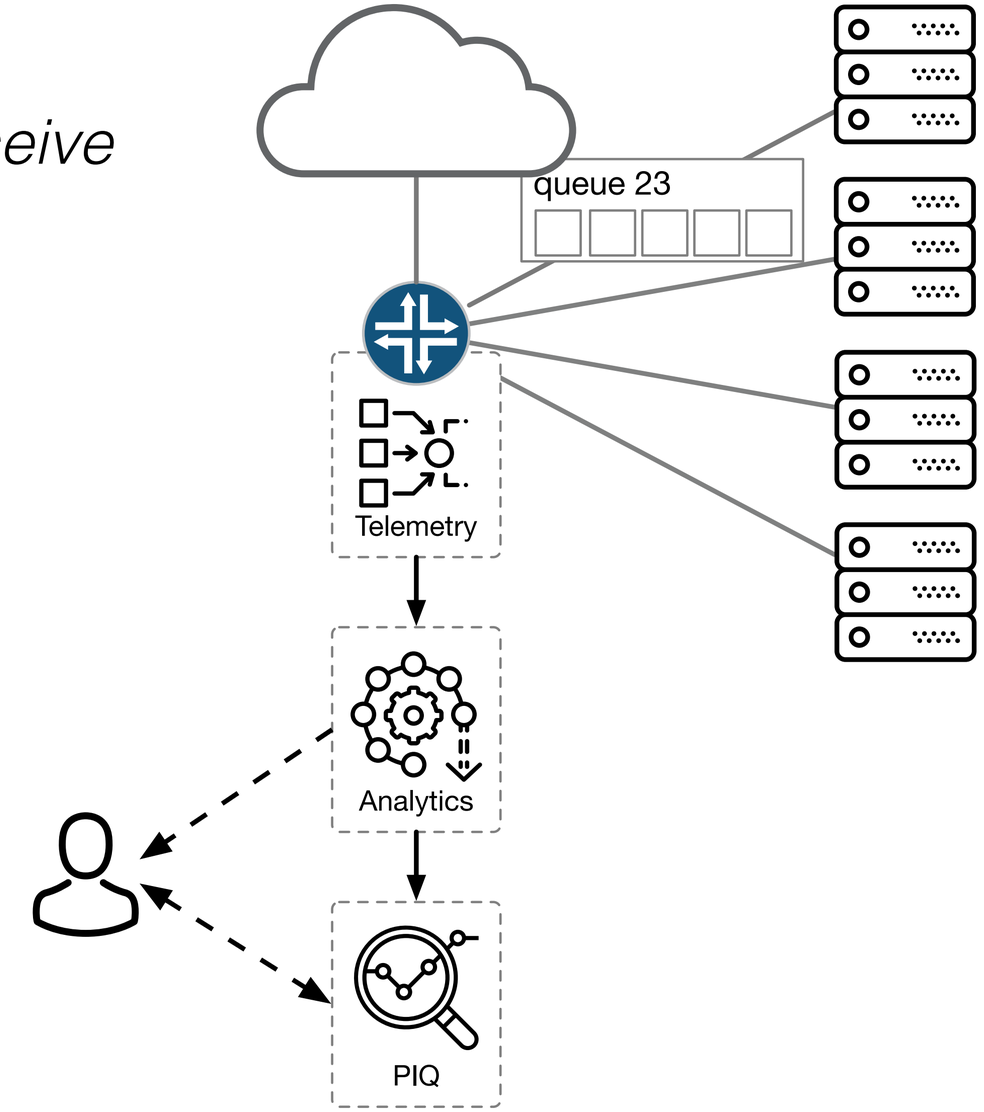
Is there a configuration problem or do we ‘just’ receive more than usual traffic?



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- “show me sample 38df6e44”
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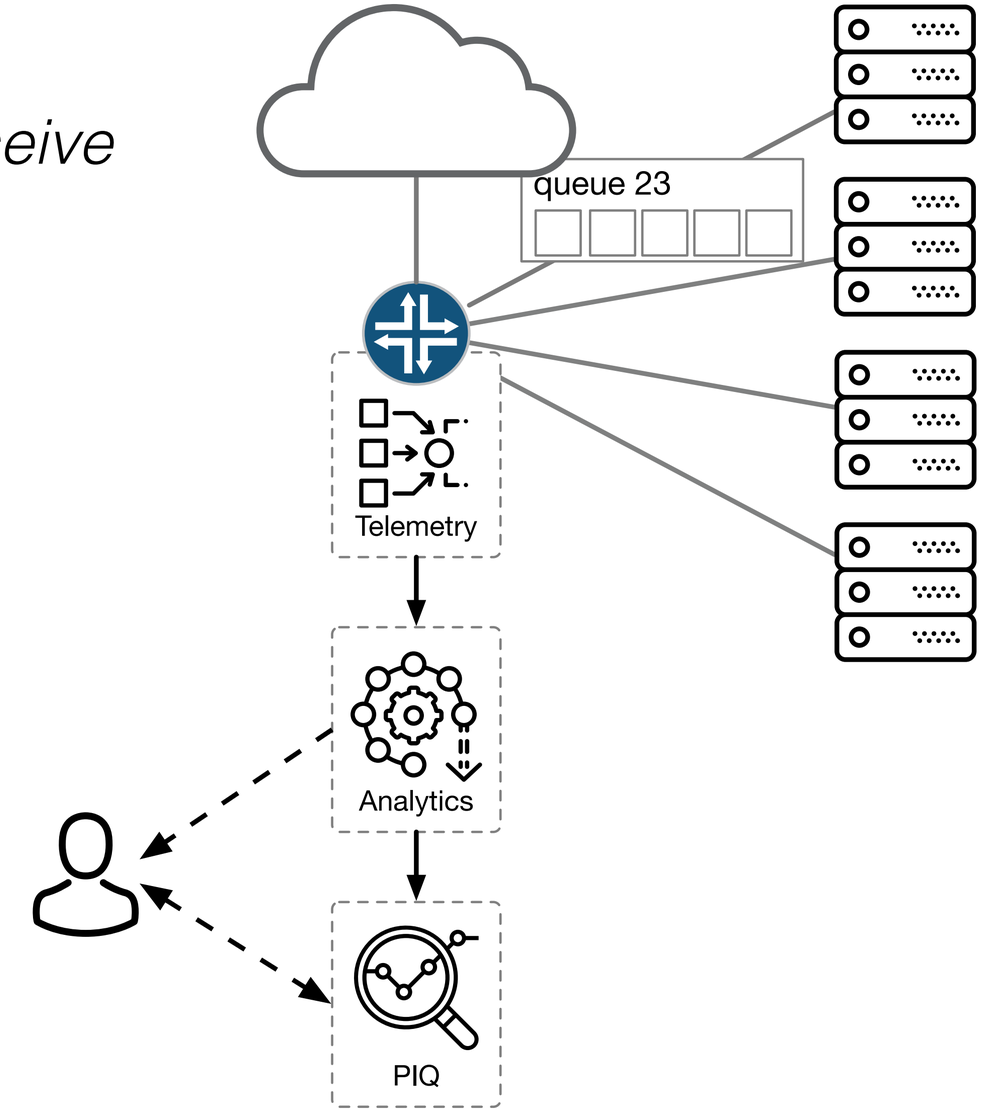

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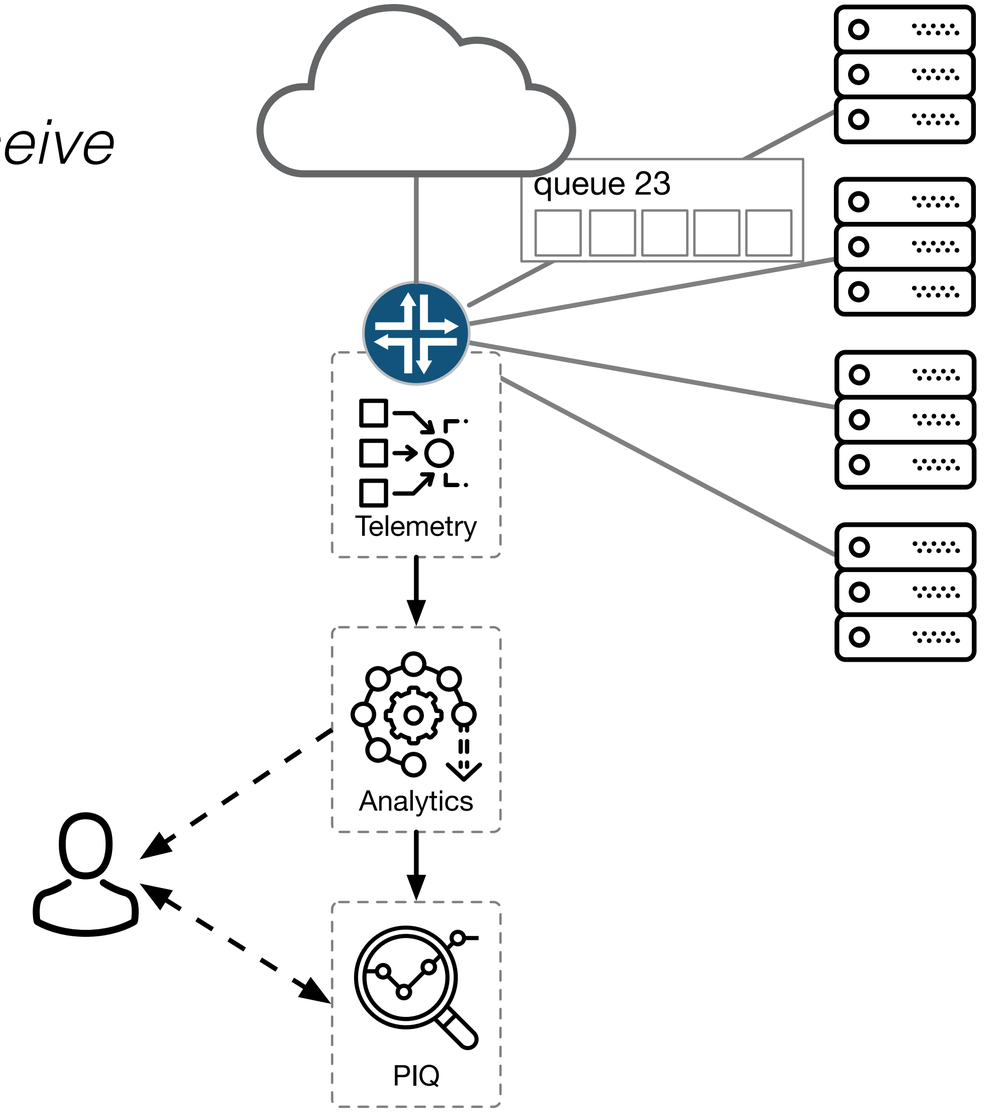

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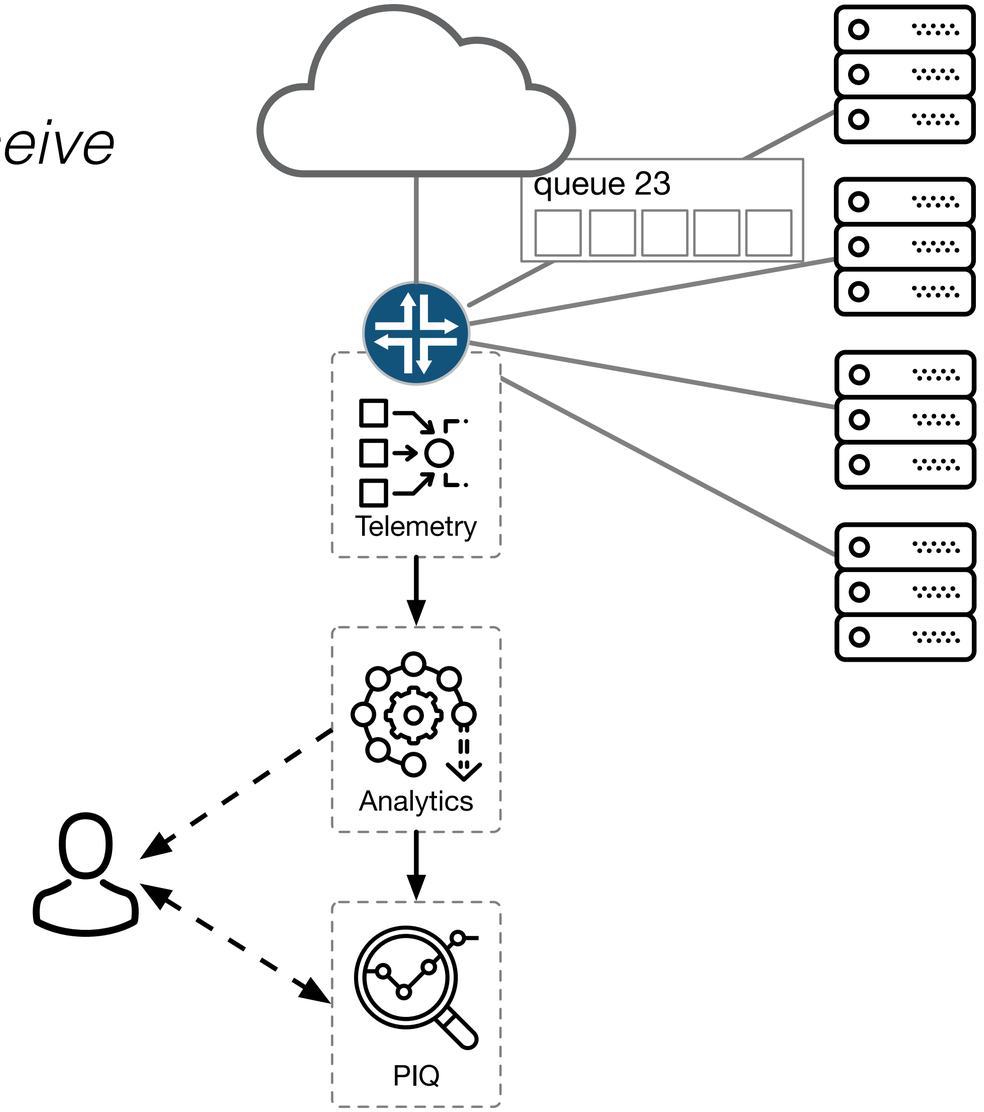
  - queues 24, 25, and 26



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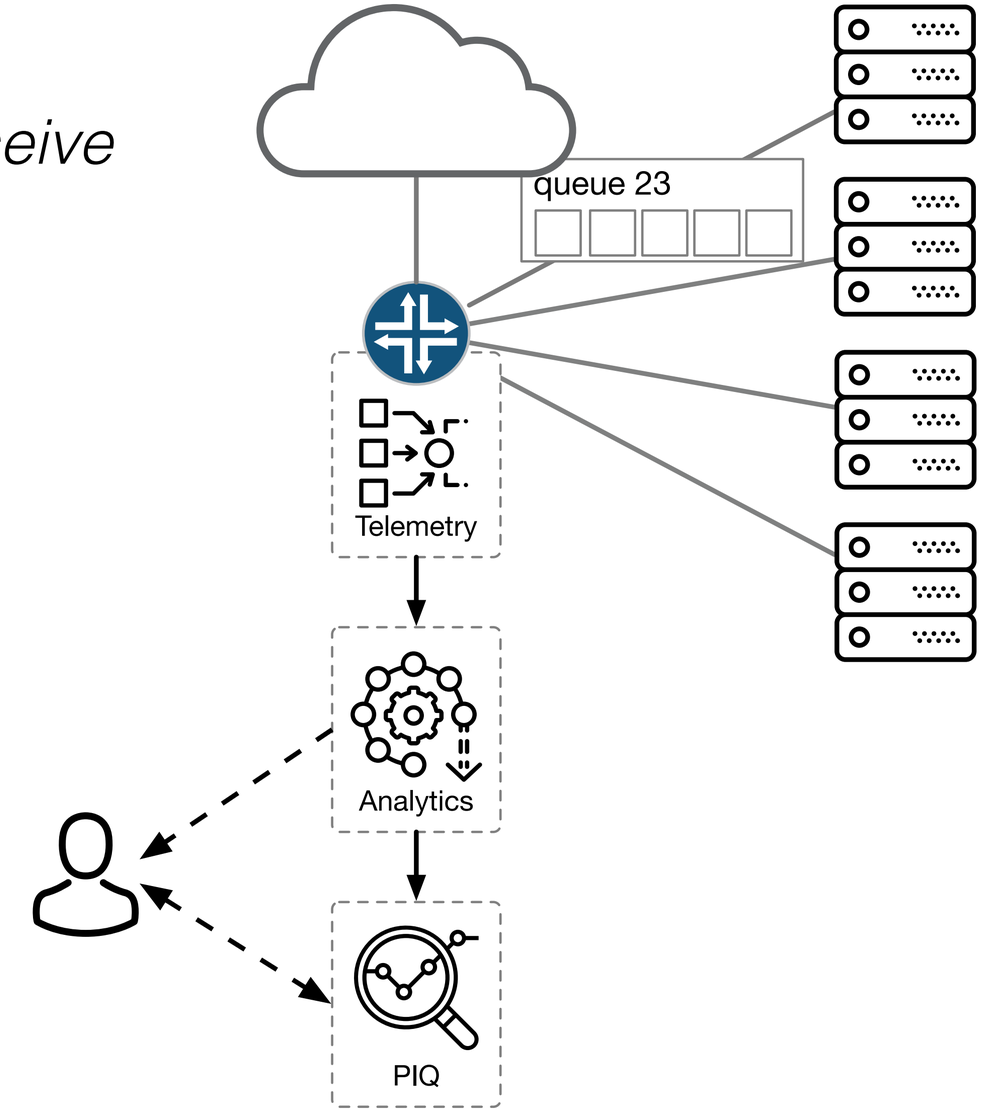

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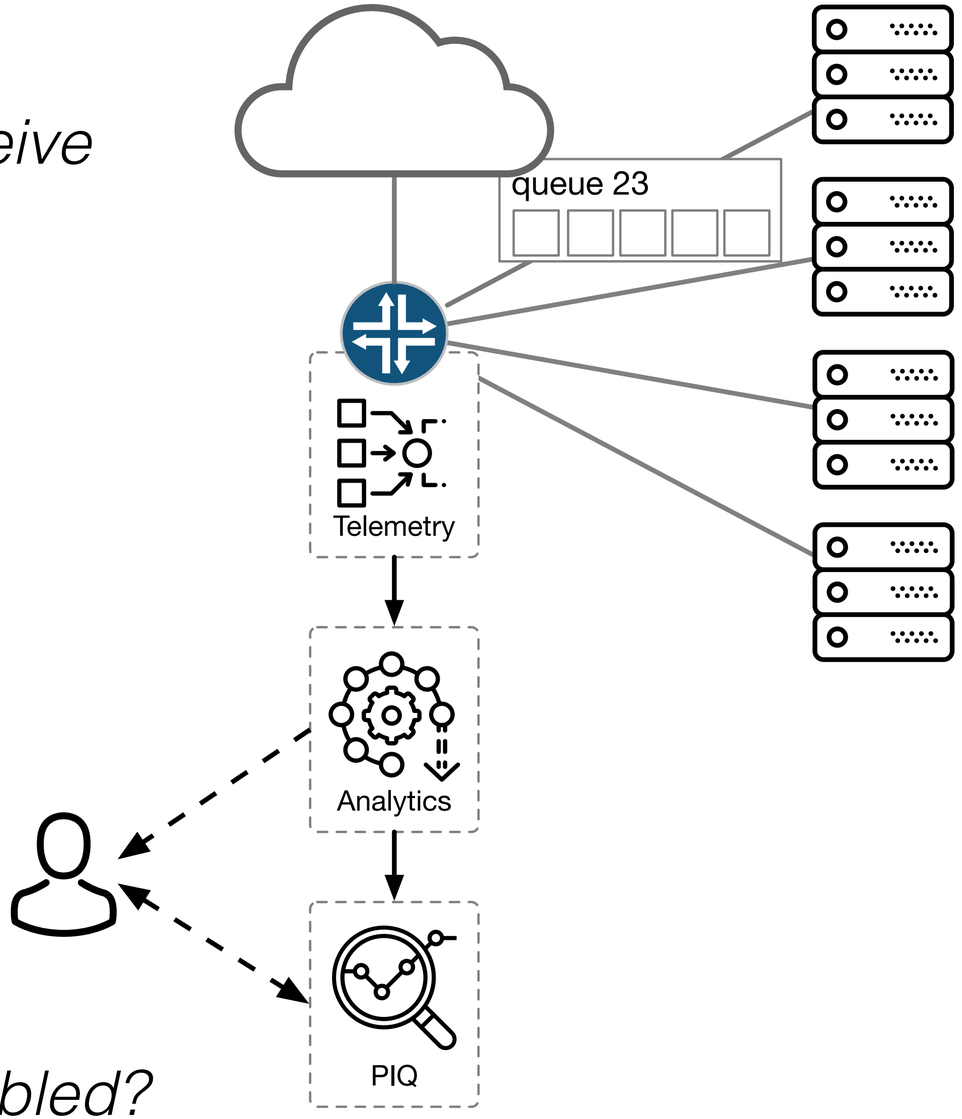


Problem with Hashing? Other queues in group disabled?

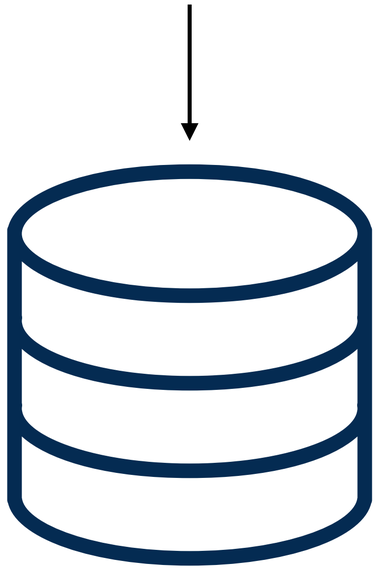
Retrospective Network Queries

Persistent

Interactive Queries

Retrospective Network Queries

Persistent

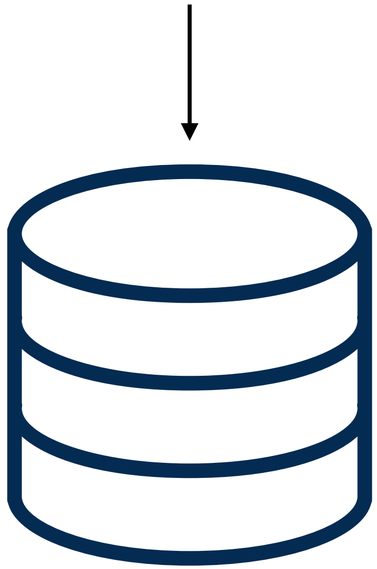


Database

Interactive Queries

Retrospective Network Queries

Persistent



Database

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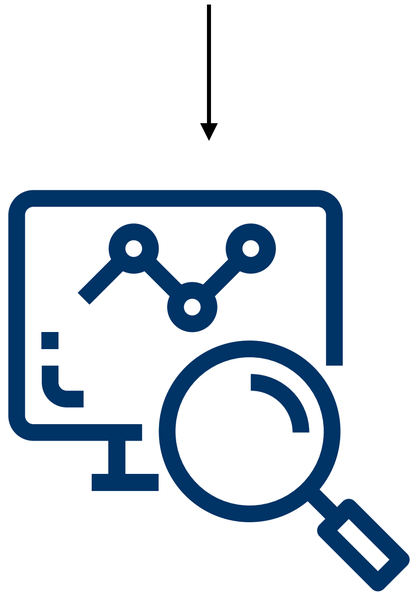

Query Interface

Retrospective Network Queries

1. Storing Network Records
2. Injecting Records into a Database
3. Querying the Database

Grouped Packet Vectors

[Sonchack et.al. *Flow, USENIX ATC 2019]

- per-packet header fields
- meta data: *e.g.*, queue depth, ingress/egress timestamps

aggregation keys

packet features

aggregated features

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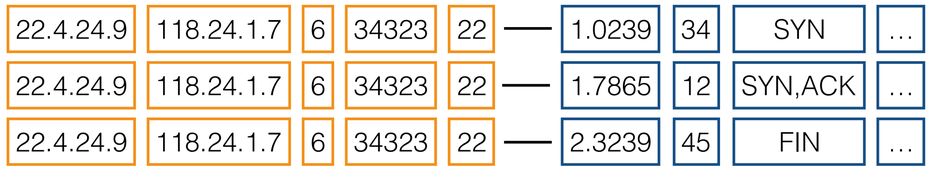

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Packet Records

22.4.24.9	118.24.1.7	6	34323	22	1.0239	34	SYN	…
22.4.24.9	118.24.1.7	6	34323	22	1.7865	12	SYN,ACK	…
22.4.24.9	118.24.1.7	6	34323	22	2.3239	45	FIN	…

aggregation keys

packet features

aggregated features

Flow Records

22.4.24.9	118.24.1.7	6	34323	22	1.0239	1.1000	3	91

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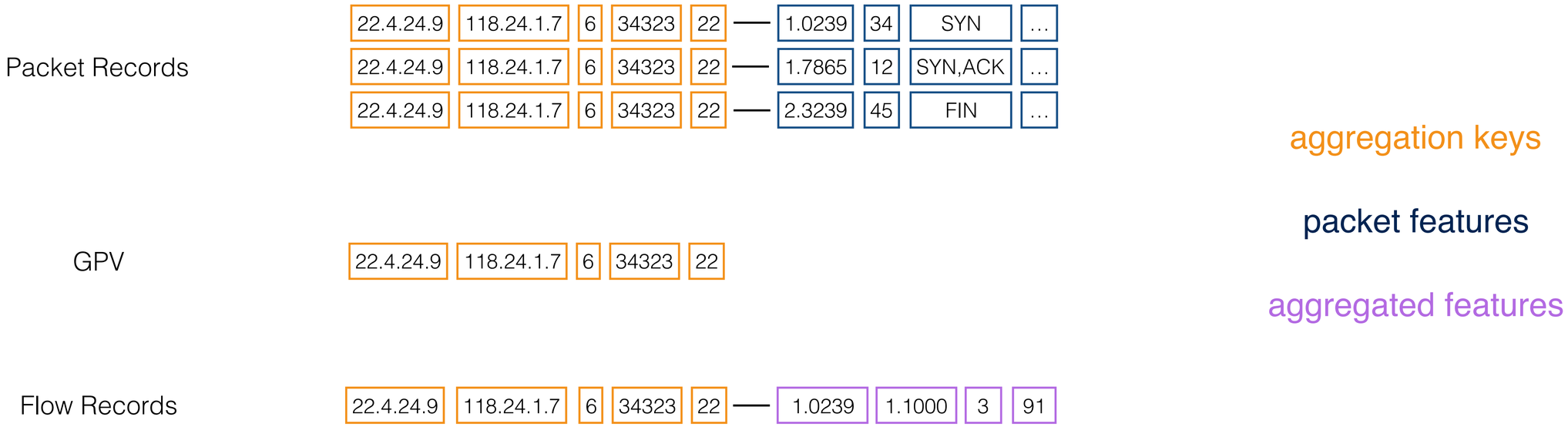

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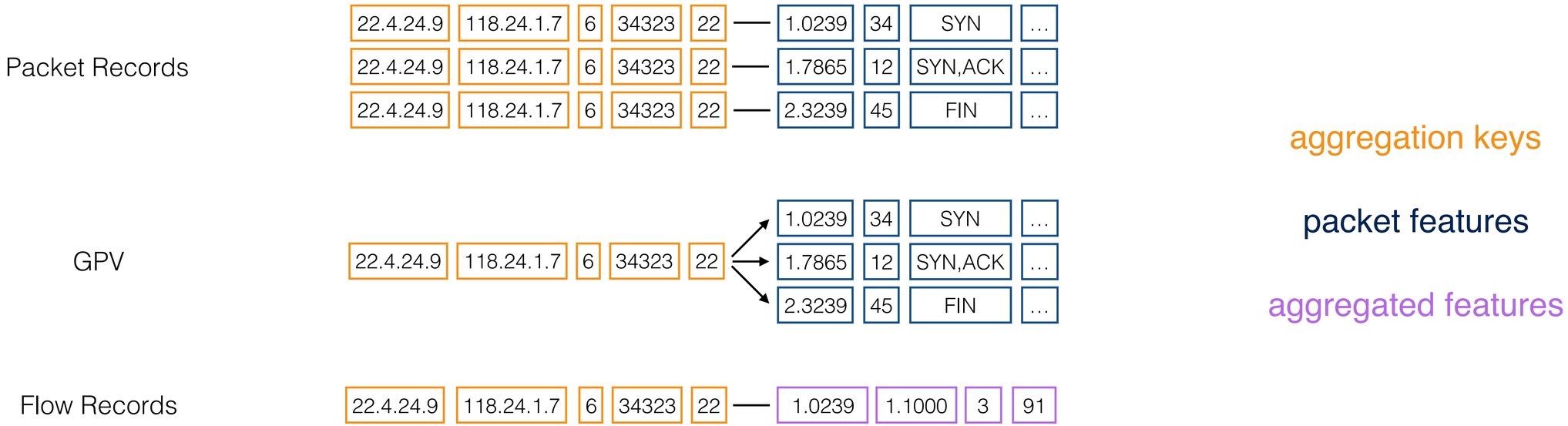

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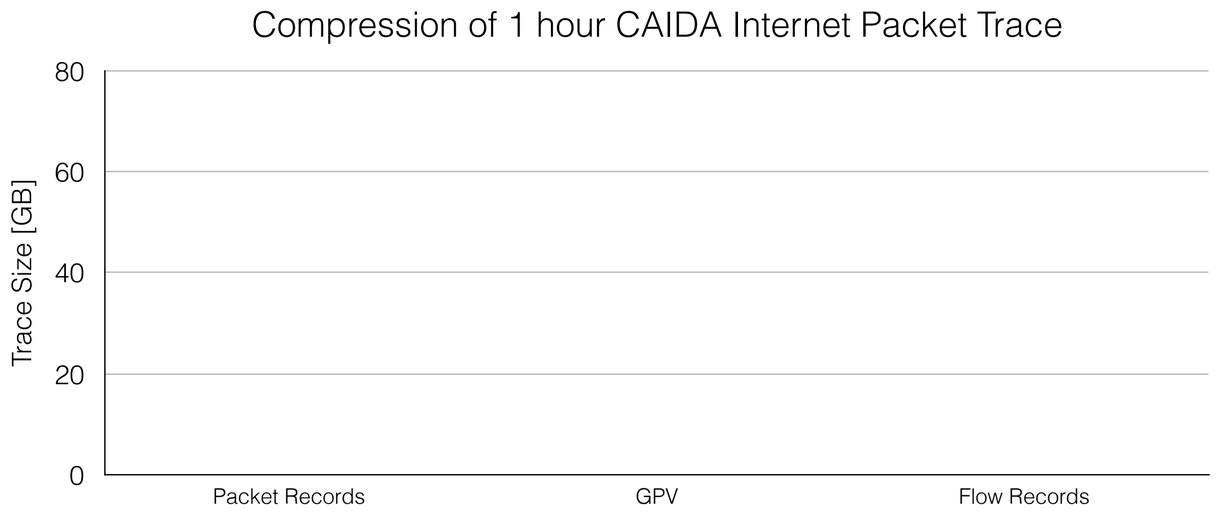

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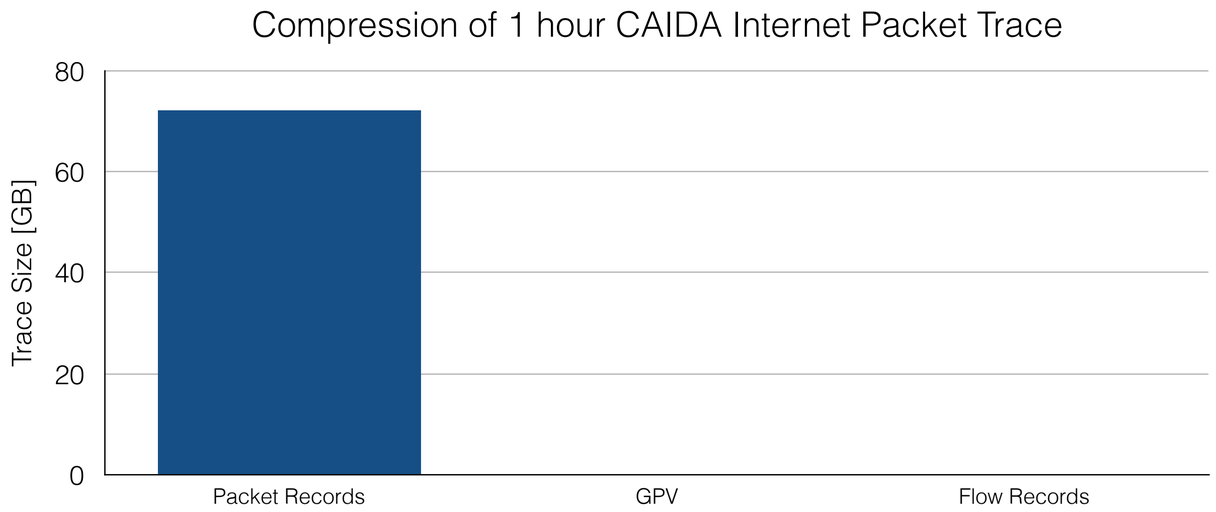

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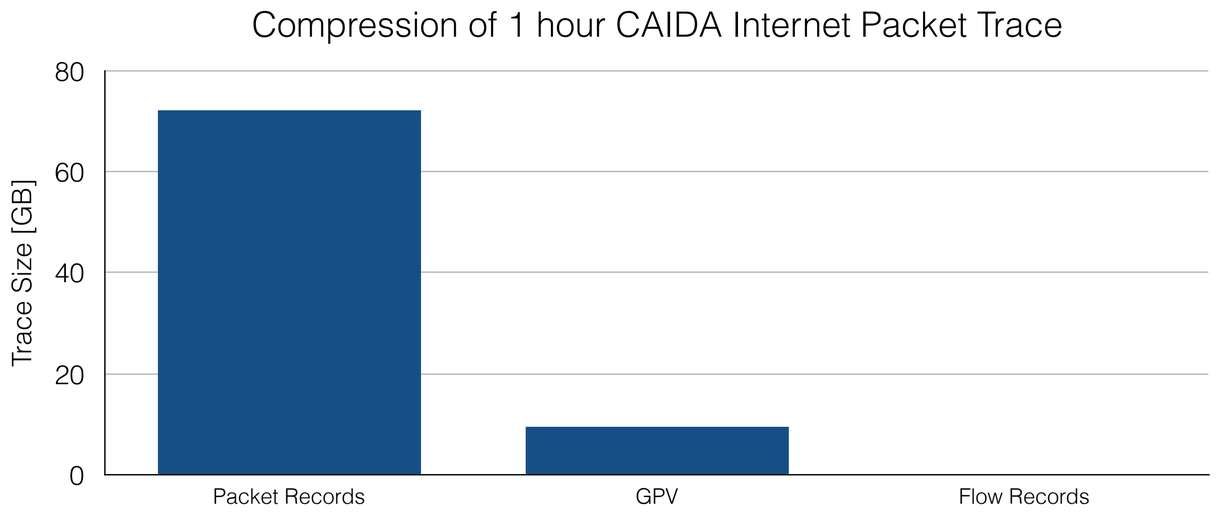

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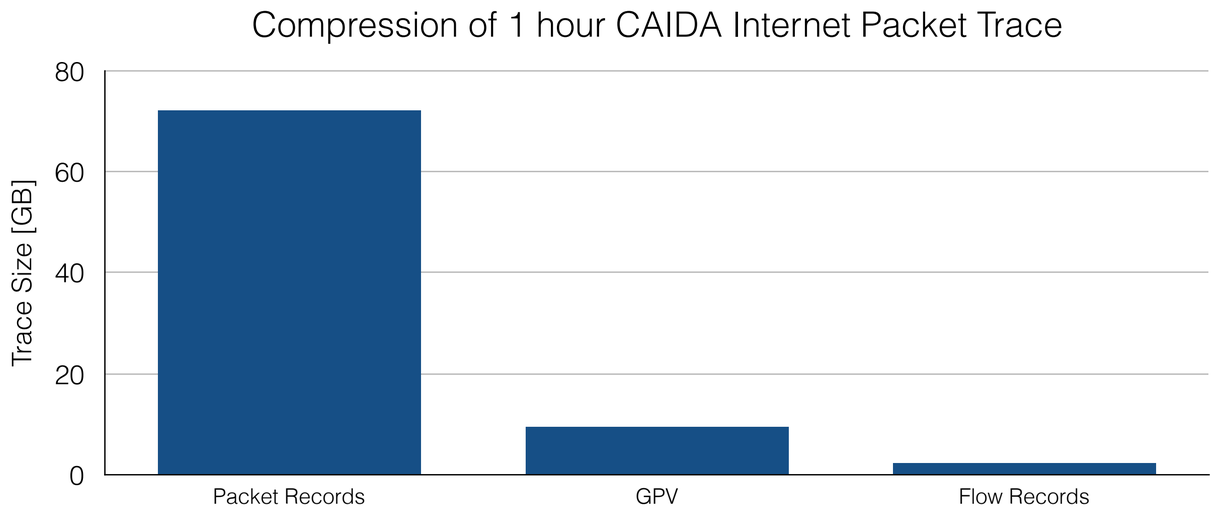


Database Models

Database Models

Relational

Database Models

Relational

NoSQL

Database Models

Relational

NoSQL

Time-Series

Database Models

Relational

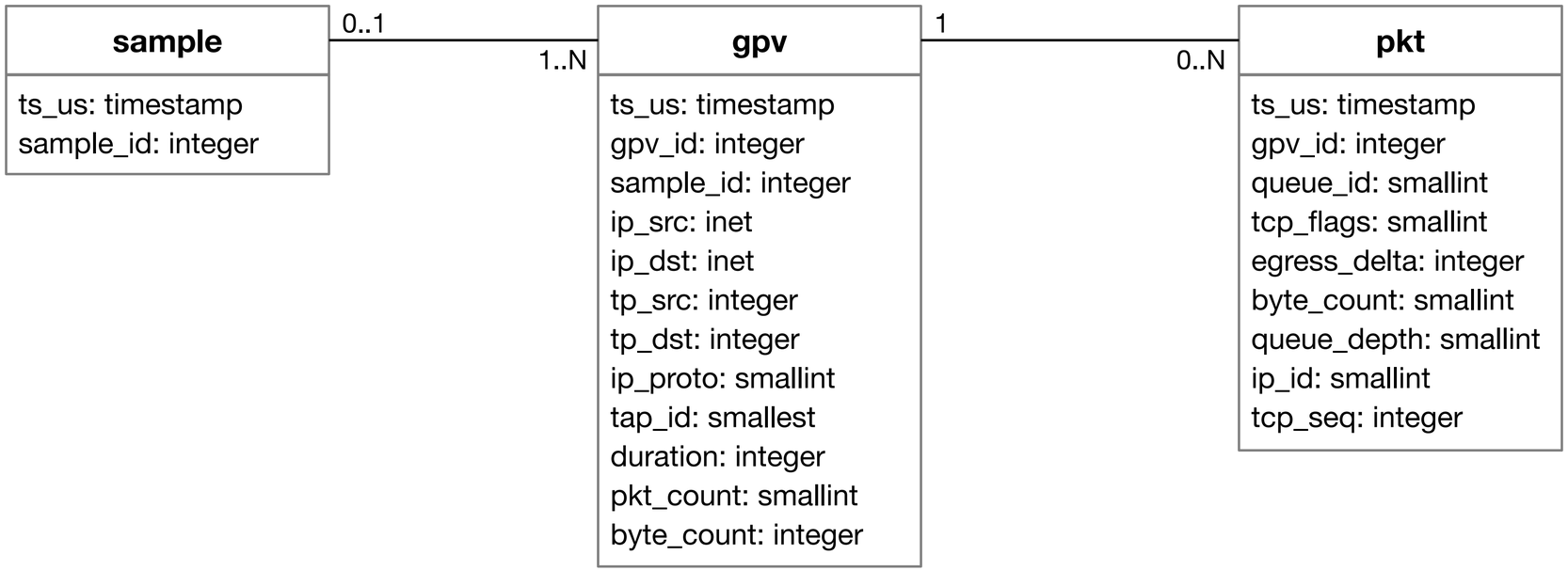
NoSQL

Time-Series

- optimized for time-series data
  - append-heavy workloads
  - grouping functionality based on time
  - timestamps as primary keys for data
  - relational or NoSQL

Storing Network Records

Storing Network Records



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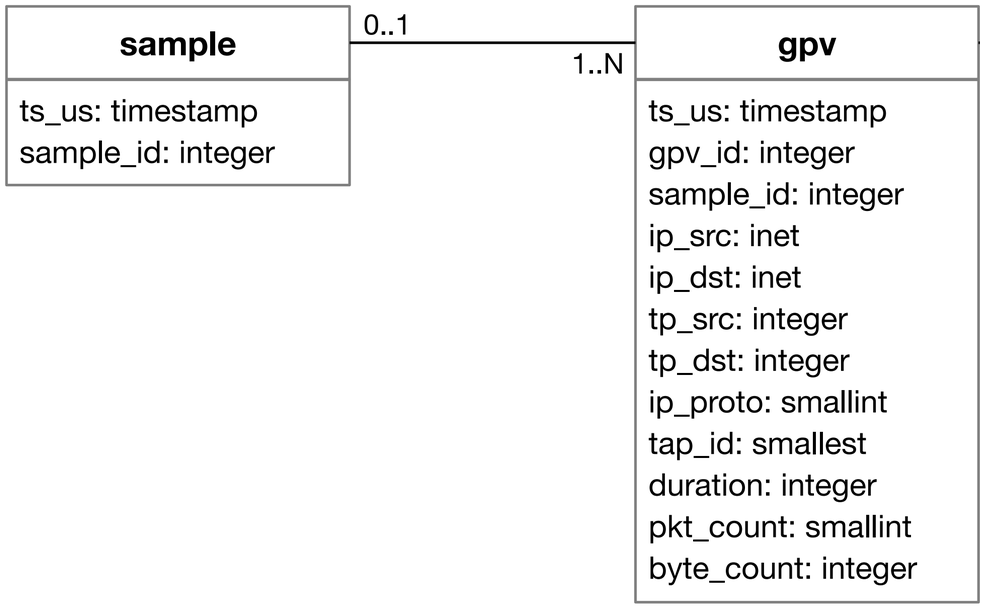

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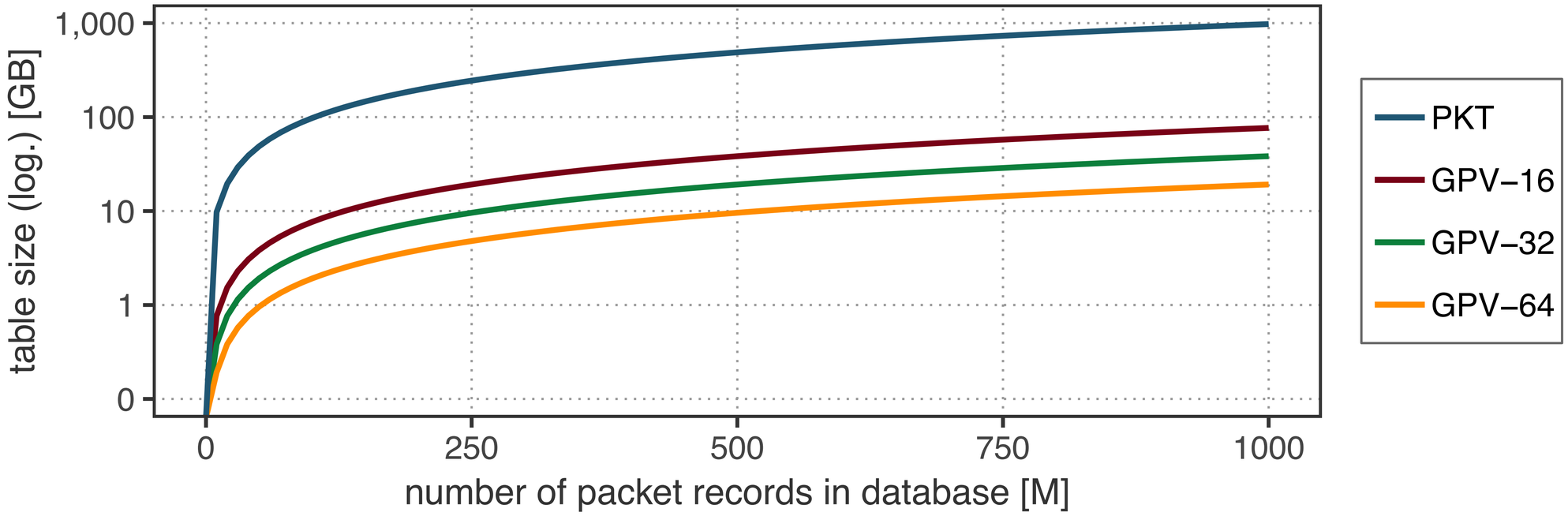

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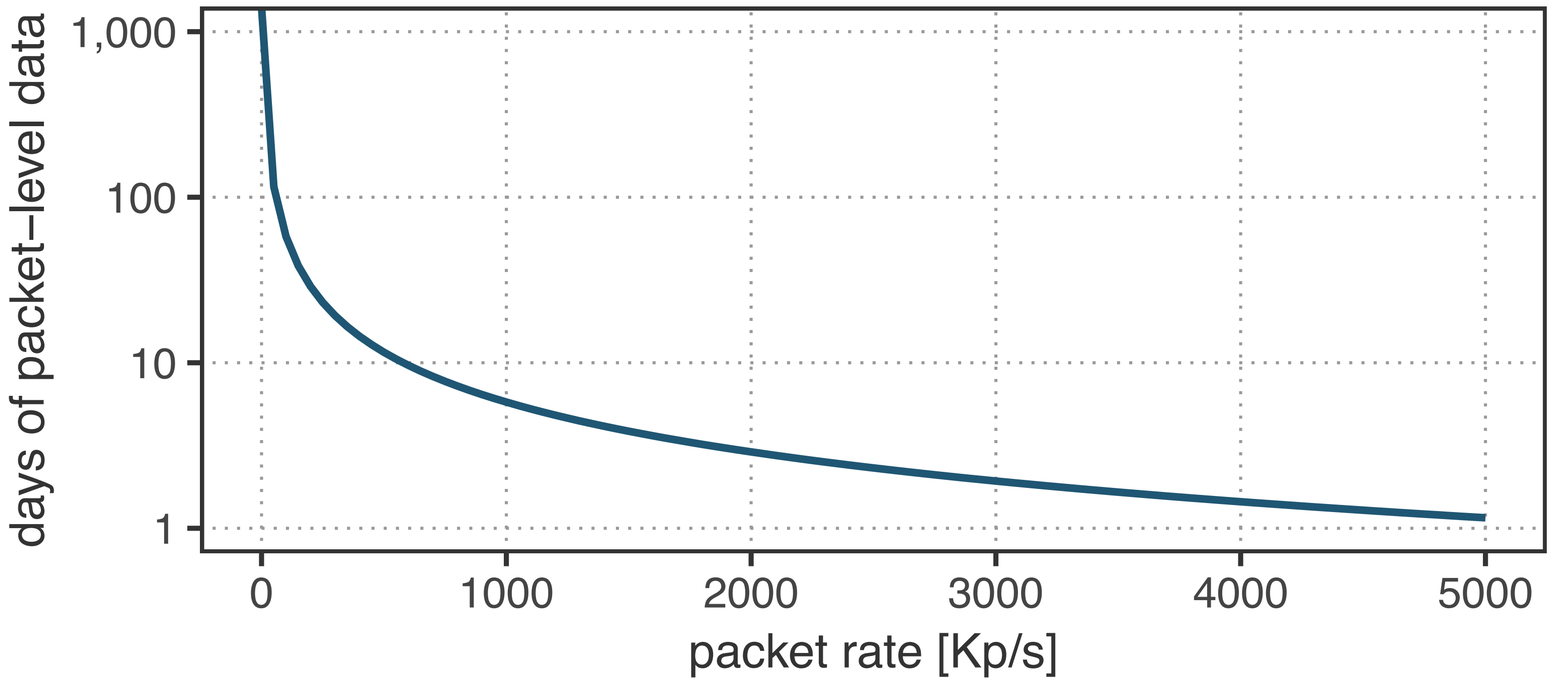

Injecting Network Records

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INSERT INTO packets VALUES
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 ‘123.213.123.4’, ‘213.11.23.23’, …)
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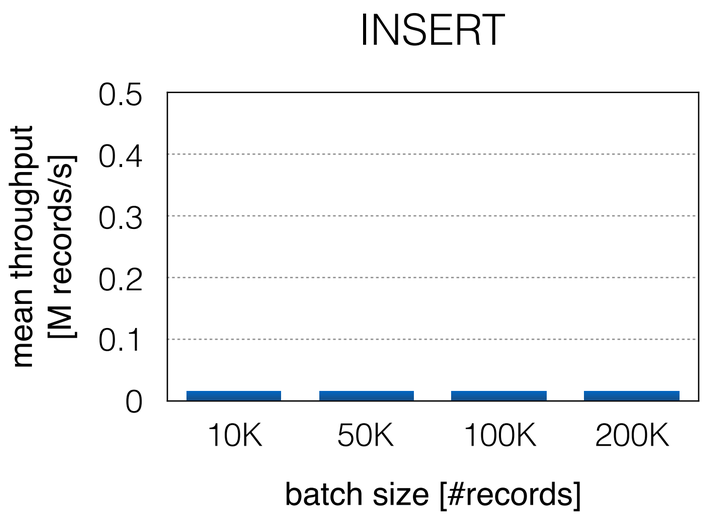

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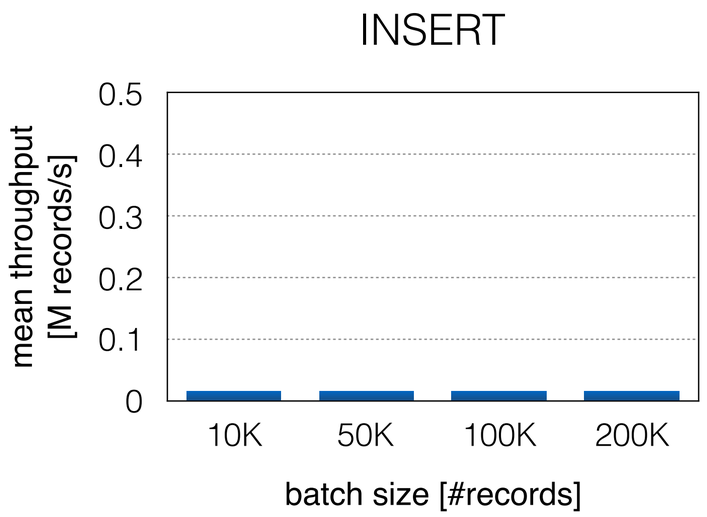


```
1  auto buf = new char[h_len + 10000
2     * rec_len + t_len];
3
4  // 10000 times
5  pkt.write_to_pg_buf(buf, offset);
6
7  pg_conn.copy(“pkt”, buf, sizeof(buf));
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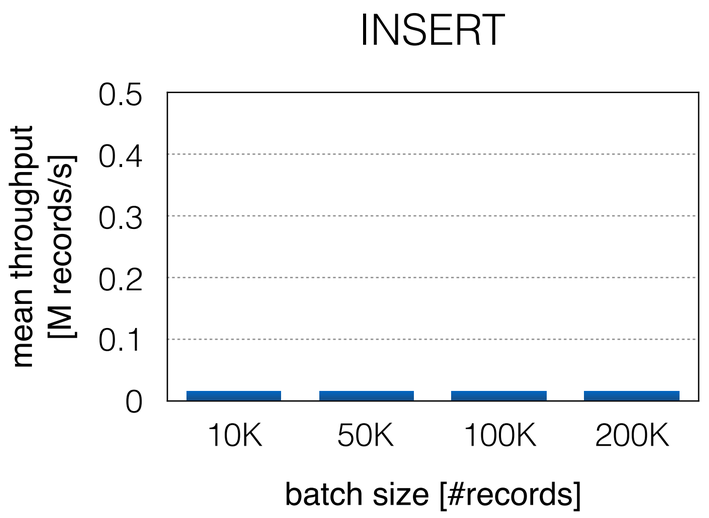
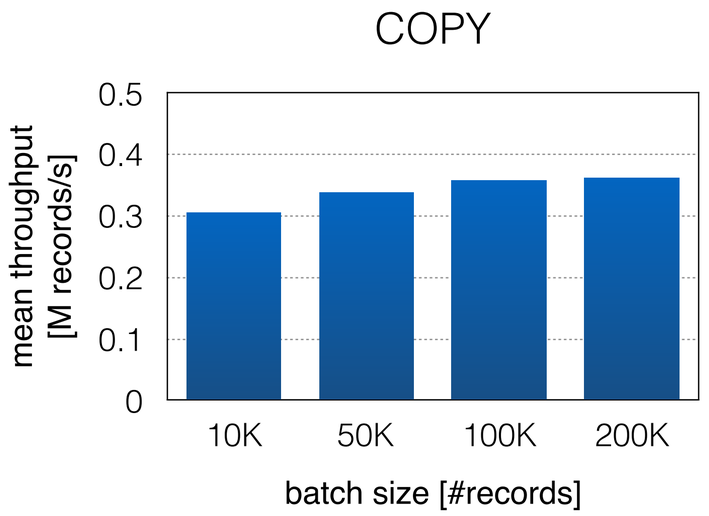
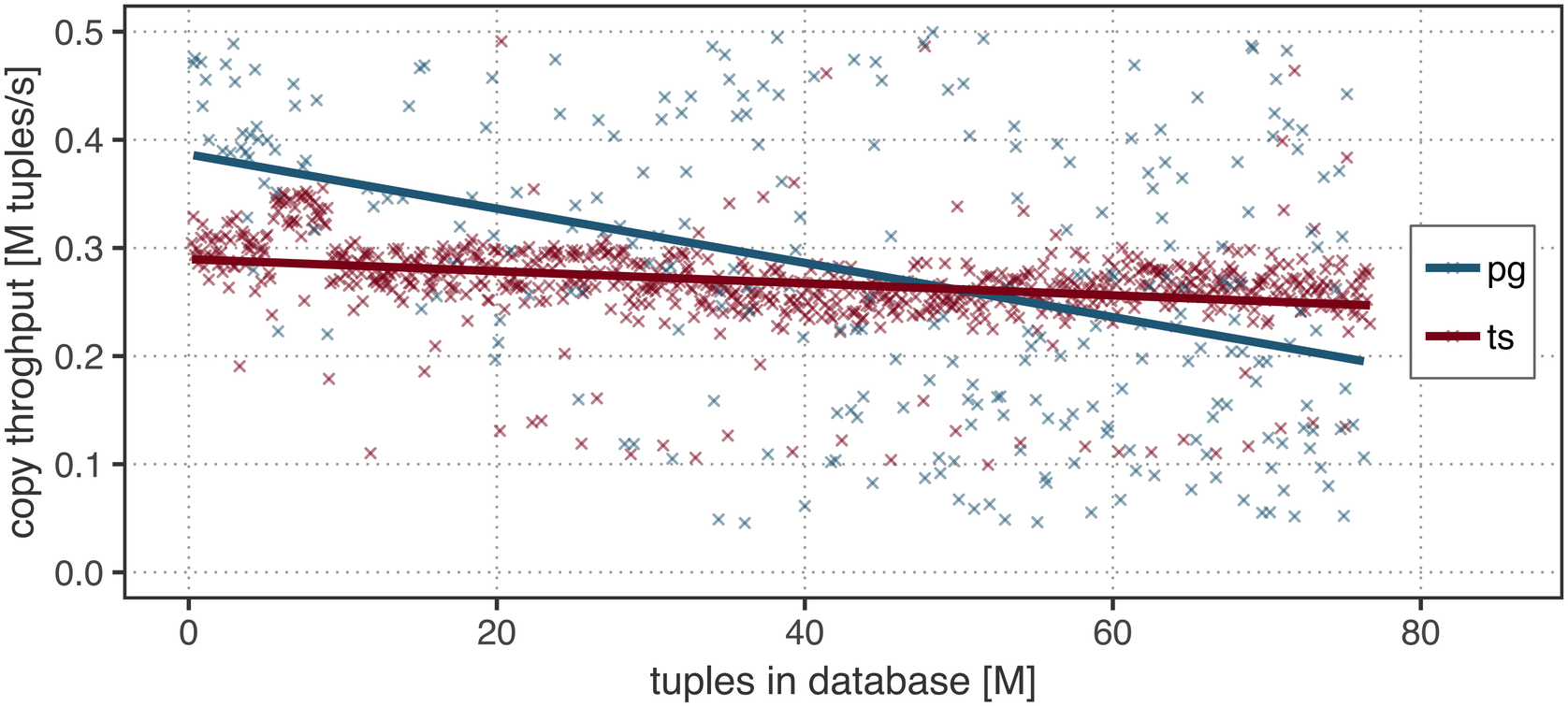




Injecting Network Records



Querying Network Records

Querying Network Records

```
SELECT time_bucket('1 seconds', ts_us) AS interval, SUM(pkt_count), SUM(byte_count)
  FROM gpv GROUP BY interval ORDER BY interval ASC
```

Querying Network Records

```
SELECT time_bucket('1 seconds', ts_us) AS interval, SUM(pkt_count), SUM(byte_count)
  FROM gpv GROUP BY interval ORDER BY interval ASC
```

```
SELECT * FROM (gpv RIGHT JOIN pkt ON gpv.gpv_id = pkt.gpv_id)
  WHERE gpv.ip_src << inet '60.70.0.0/16'
```

Querying Network Records

Querying Network Records

```
SELECT DISTINCT gpv.ip_src, gpv.ip_dst, gpv.ip_proto, gpv.tp_src, gpv.tp_dst
  FROM (gpv RIGHT JOIN pkt ON gpv.gpv_id = pkt.gpv_id)
  WHERE pkt.ingress_ts >= '2018-02-19 12:59:11.595’
    AND pkt.ingress_ts < '2018-02-19 12:59:11.600'
    AND pkt.queue_id = ’23’
```

Querying Network Records

```
SELECT DISTINCT gpv.ip_src, gpv.ip_dst, gpv.ip_proto, gpv.tp_src, gpv.tp_dst
  FROM (gpv RIGHT JOIN pkt ON gpv.gpv_id = pkt.gpv_id)
  WHERE pkt.ingress_ts >= '2018-02-19 12:59:11.595’
    AND pkt.ingress_ts < '2018-02-19 12:59:11.600'
    AND pkt.queue_id = ’23’
```

```
SELECT pkt.queue_id, COUNT(pkt.queue_id)
  FROM (gpv RIGHT JOIN pkt ON gpv.gpv_id = pkt.gpv_id)
  WHERE gpv.ip_dst << inet ’53.231/16'
    AND pkt.queue_id IN (23,24,25,26)
  GROUP BY pkt.queue_id;
```

Conclusion

Conclusion

identify the need for retrospective network analytics

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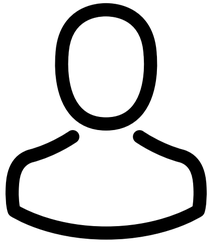
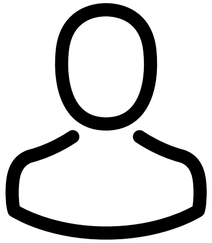


show using example queries how retrospective analytics can be used to get better insight into what happened in the network

Conclusion

identify the need for retrospective network analytics



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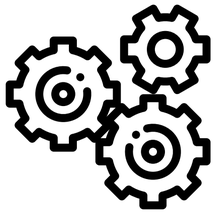

implement a prototype application demonstrating technical feasibility

Q&A / Discussion

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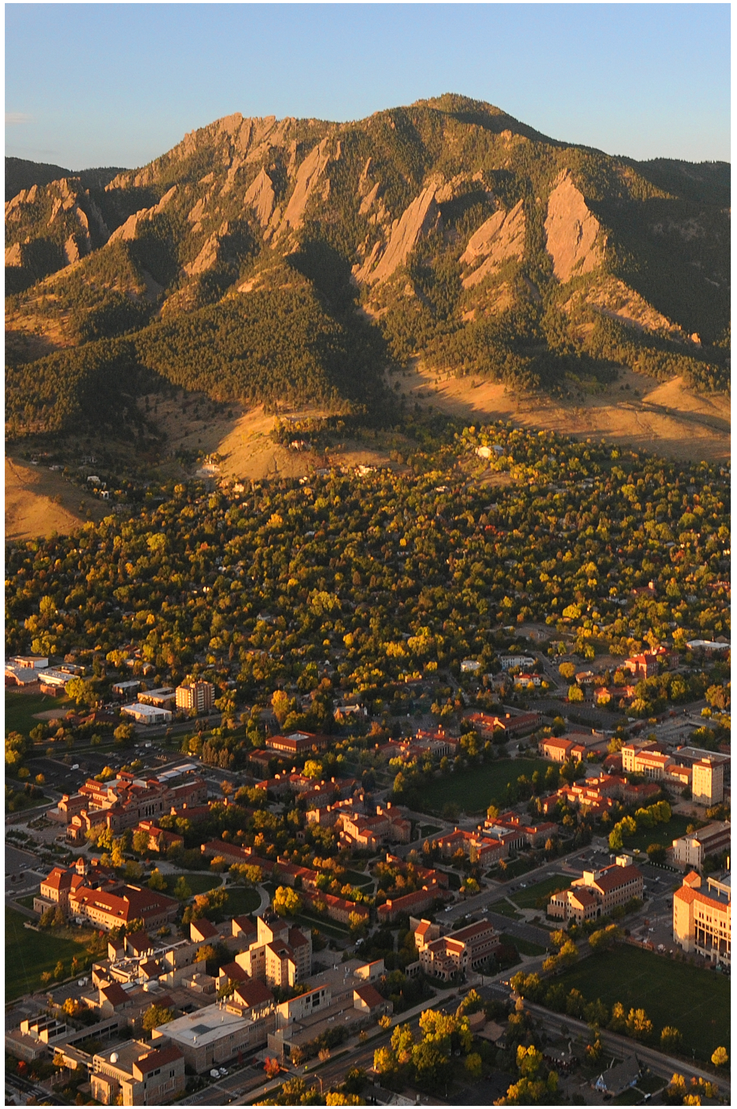
University of Colorado **Boulder**



BACKUP SLIDES

Example SQL Queries

Example SQL Queries

```
SELECT ip_src, SUM(pkt_count)
  FROM gpv WHERE ip_src << inet ’60.70.0.0/16’
    AND gpv.ts_us > now() - interval '1 hours’
  GROUP BY ip_src
```