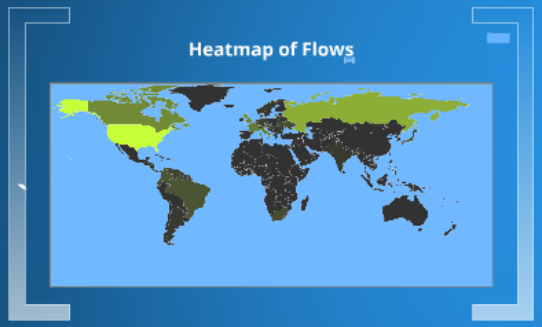
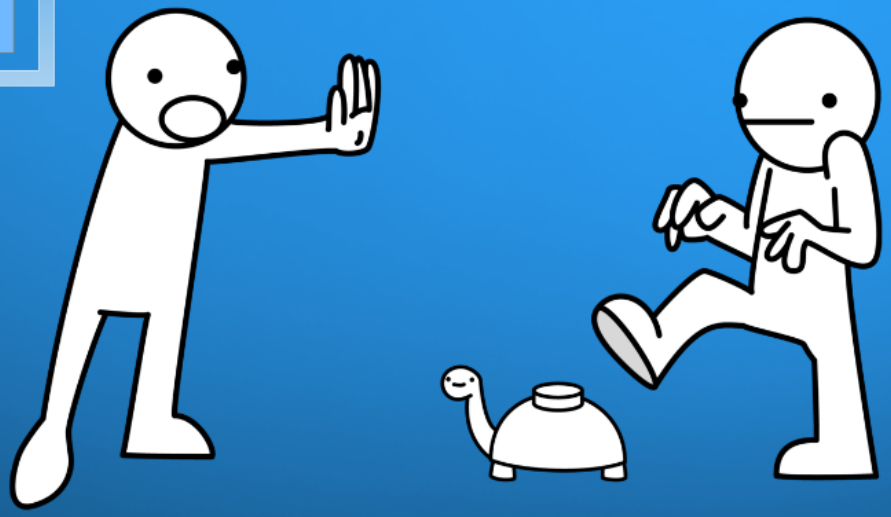
An Exploration of Network Flows for Geolocation and Traffic Visualization to aid in Cyber Defense



By Sean Pennefather



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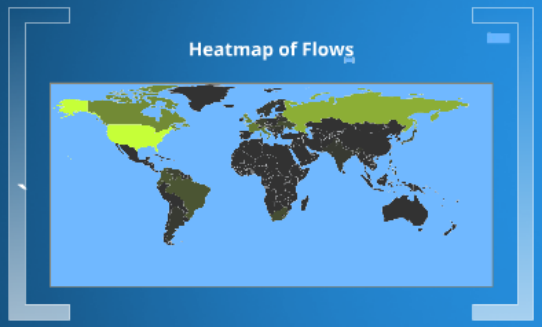

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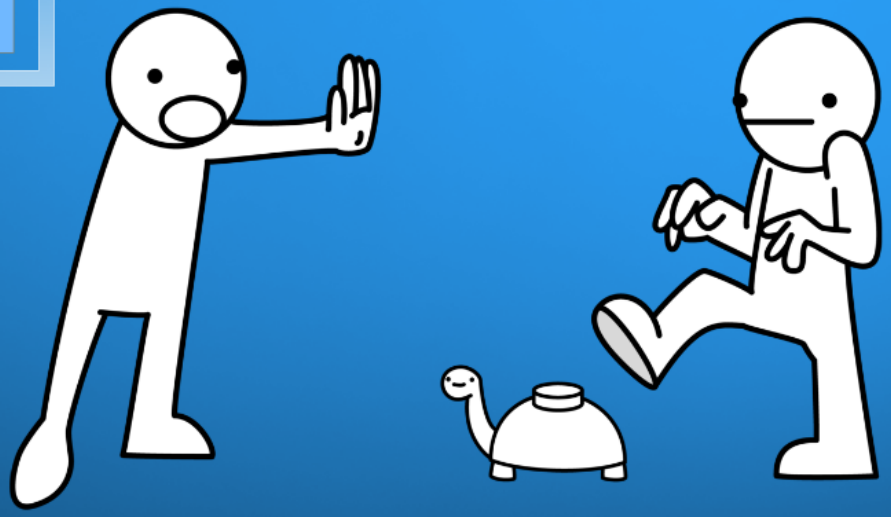


Research Goals

- An investigation of protocols used to export raw flows.
- Investigation into using raw flows for geolocation and data visualization.
- Investigation into the feasibility of a real-time Geolocation system using network flows to aid in cyber defense.

Approach

- Develop a prototype system capable of collecting and processing raw flows.
  - Process exported flows.
  - Perform geolocation on destination IPs.
  - Render heatmaps for collected flow characteristics.
  - Replay geolocated traffic.
  - Produce a sample monthly report on traffic statistics.

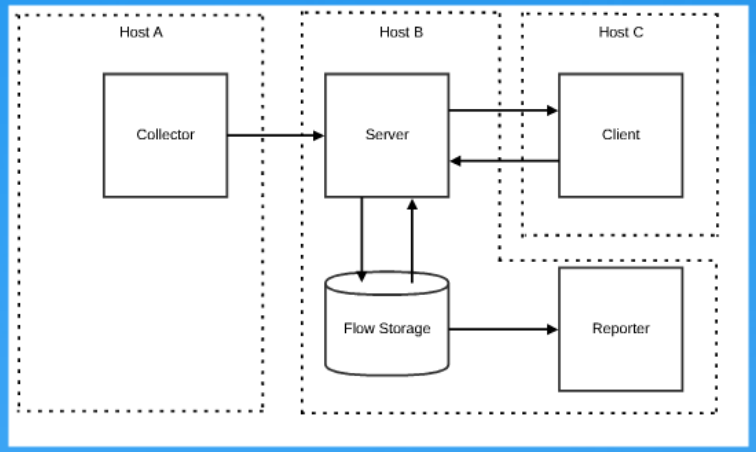
So.. Network Flows

- What are they?
  - A way of representing a stream of unidirectional packets as a single entity.
- The good
  - Less data (less memory and processing needs)
- The bad
  - Less data (less resolution of traffic)
- NetFlow v5, v9
- IPFIX

Scope

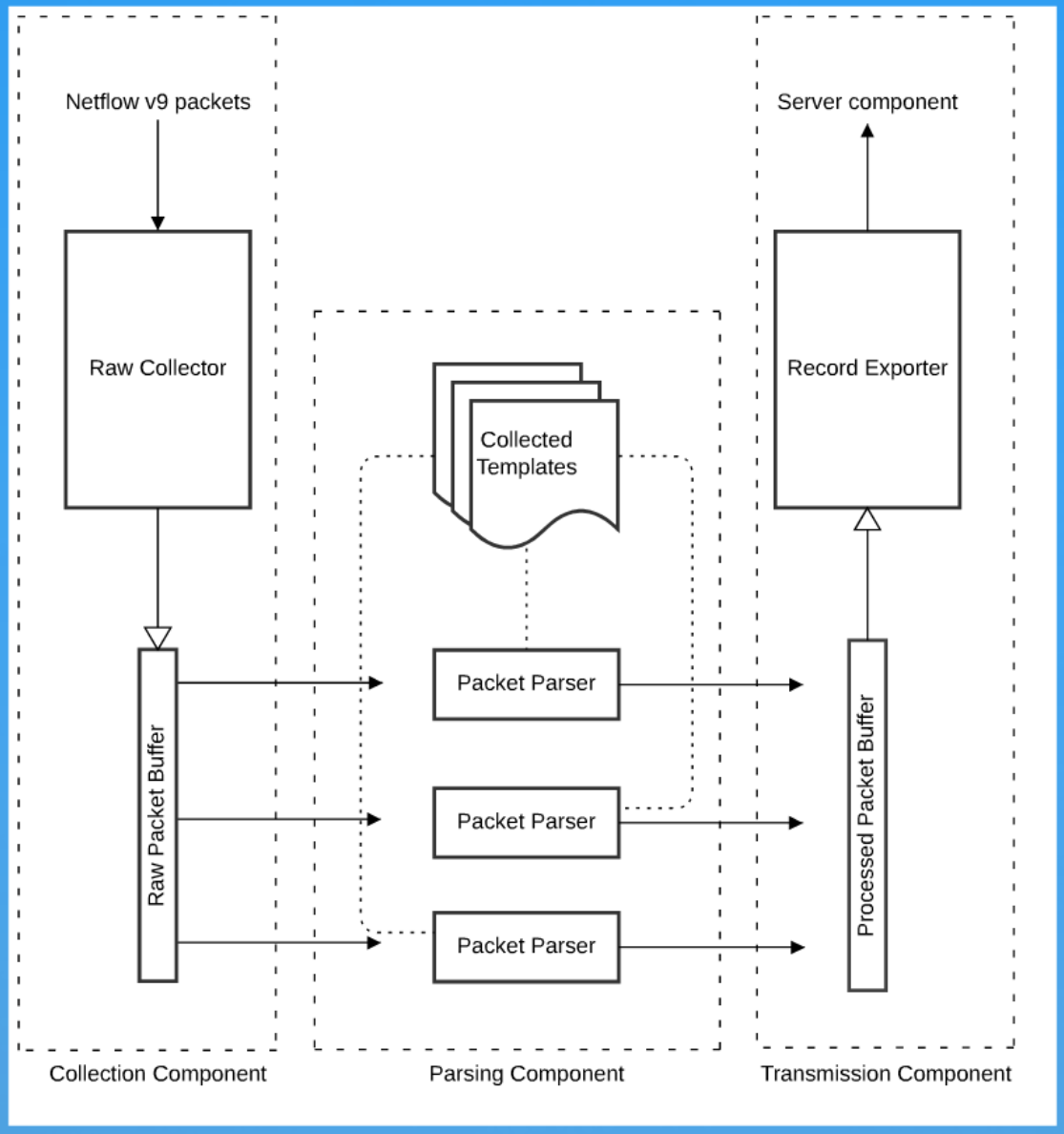
- Implemented to accept NetFlow version 9.
- IPv4 only
- Ignoring options templates and records
- Host based only
- Report is only a sample to show what can be done
- Not overly concerned with memory impact of system.

System Overview



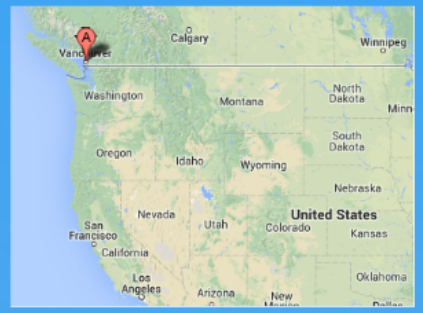
- Four components:
  - Collector: Collects and parses raw flow packets
  - Server: Geolocates IPs, stores records, grunt work
  - Client: User interface of system, renders maps
  - Reporter: Generates a sample report

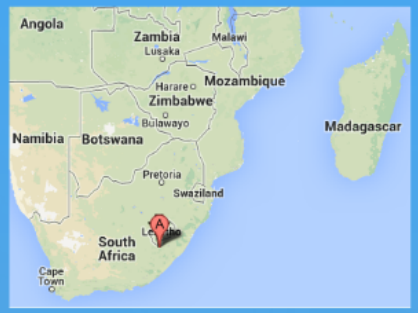
Collector



Geolocation Testing

Google Maps





System

System Timings

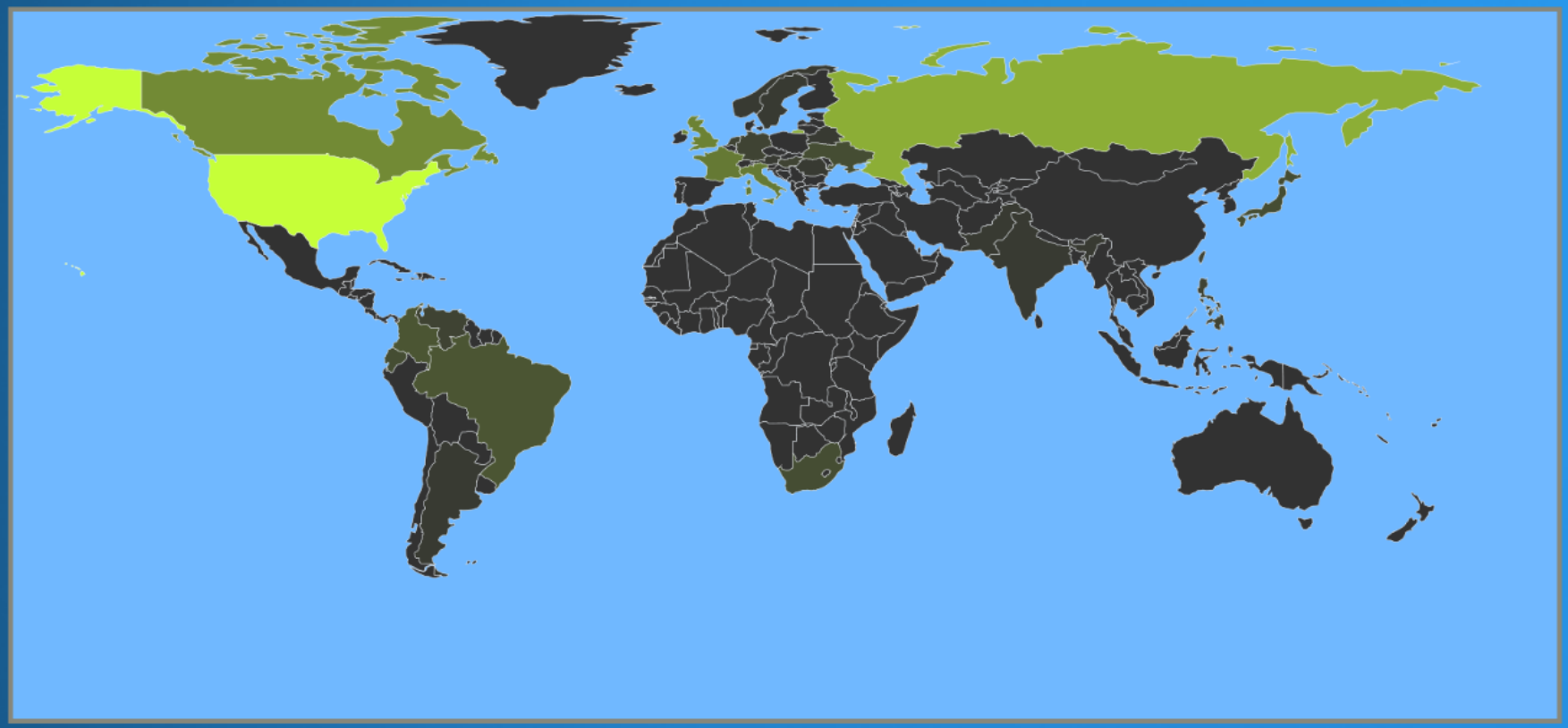
Table 5.3: Sample recorded results of time taken to process a network flow

Test No.	Time Packet Received	Time First Record Sent	Duration [s]
1	1381000626.1056400	1381000626.1600400	0.0543940
2	1381001156.9537300	1381001157.0111500	0.0574150
3	1381001211.8136500	1381001211.8485900	0.0349381
4	1381001301.8416500	1381001301.8949600	0.0533080
5	1381001356.3536600	1381001356.4073800	0.0537219
6	1381001536.2776300	1381001536.3262600	0.0486290
7	1381001686.5536400	1381001686.6038200	0.0501890
8	1381001771.8176900	1381001771.8710300	0.0533390
9	1381001866.4496300	1381001866.4996200	0.0499859
10	1381001921.6336400	1381001921.6834500	0.0498040

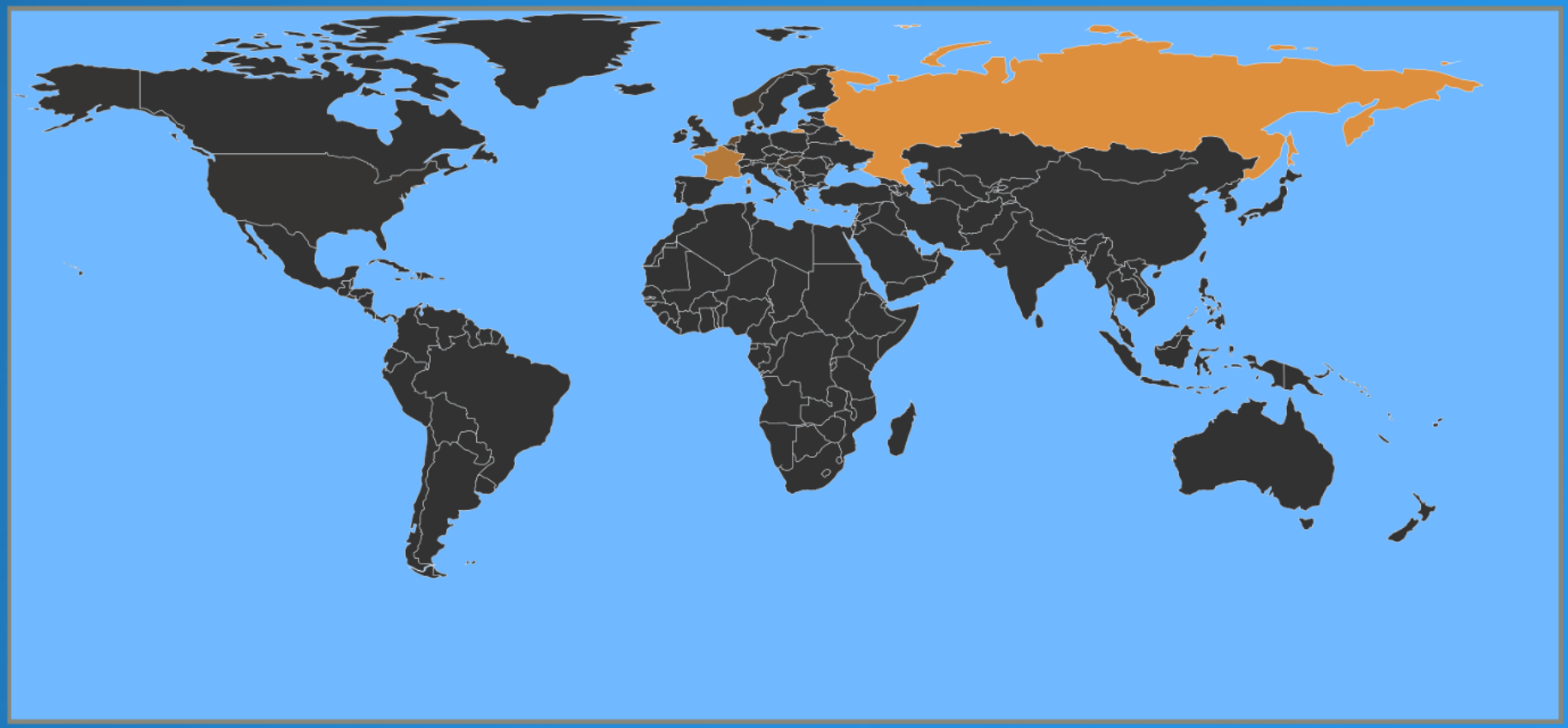
Next, a System Demonstration

Realtime Map

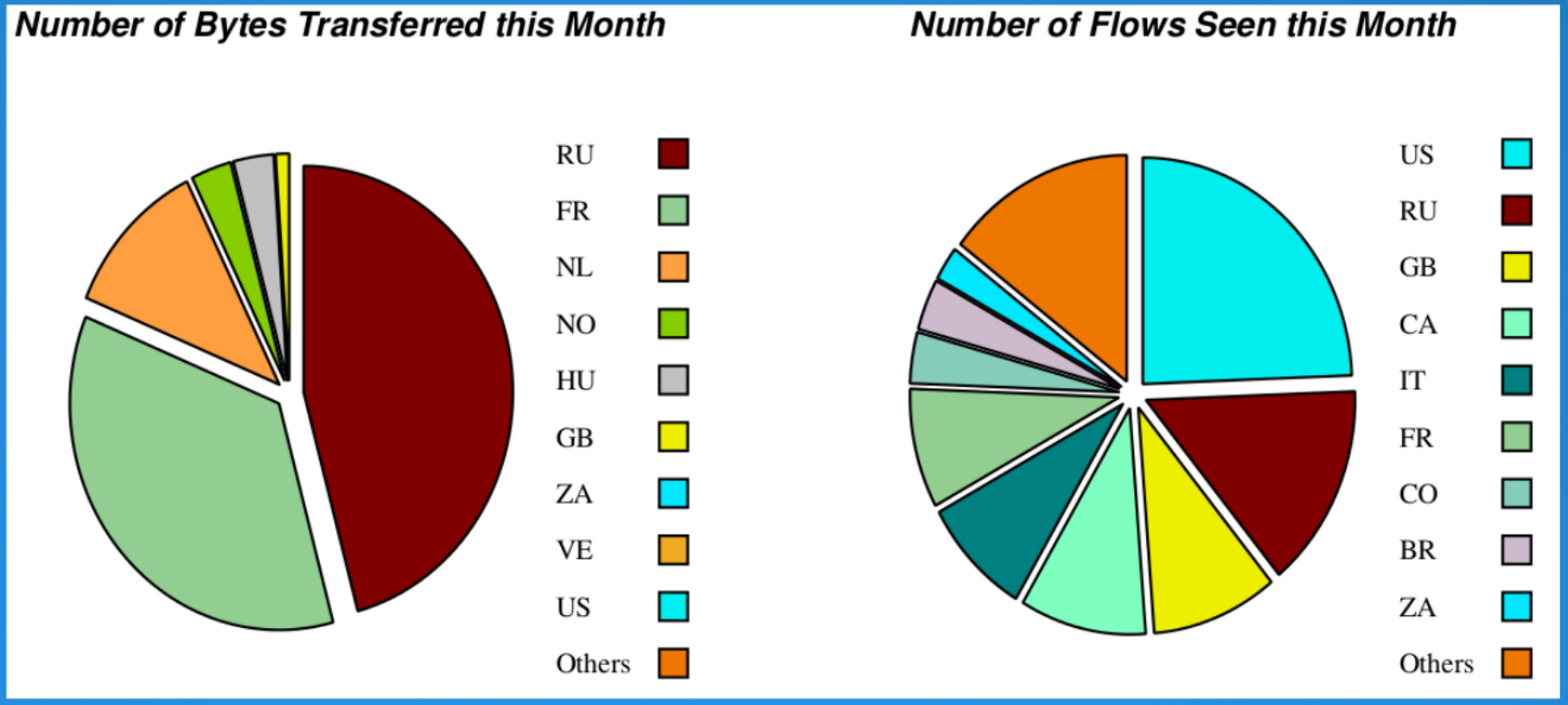
Heatmap of Flows



Heatmap of Bytes



Or another way to look at it...



Conclusions

- Was able to successfully produce a prototype system capable of meeting the defined goals.
  - Geolocation and heatmaps proved successful.
  - Sample report would need improving on...
- Real-time is feasible but requires the collector maintain flow state.

Future Work

- Expand the current system
  - IPv6
  - Better reporting tools
  - IPFIX
- Crteate a better software based flow export system.
  - Handle packet timings correctly
  - Allow for characteristic specification
  - Allow IPFIX export
  - Allows users to define their own characteristics to export.

Questions?