Large-Scale Measurement Platforms

cnds.eecs.jacobs-university.de/slides/2013-aims-large-scale-measurement-platforms.pdf

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Outline

- Introduction
- Survey on Large-scale Measurements
- Internals:
  - SamKnows Platform
  - RIPE Atlas Platform
- Standardardization Efforts

- Hands-on
  - OpenWrt-based Measurement Agent (MA)
  - RIPE RESTful API

Introduction

- Large-Scale Broadband Measurement Use Case [draft-linser-lmap-use-cases-02]
  - Internet Service Provider (ISP)
    - Identify, isolate and fix problems in the access network.
    - Evaluate the Quality of Experience (QoE) of the user.
    - Benchmark and look into competitor insights.
  - Consumers
    - Does the ISP service adhere to service level agreements (SLA)s?
    - Diagnose impaired components in the private network.
  - Regulators
    - Need datasets to compare multiple broadband providers: http://www.fcc.gov/measuring-broadband-america
    - Frame better policies to help regulate the broadband industry: http:/maps.ofcom.org.uk/broadband

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Survey | One-off measurements

- Early studies:
  - Inject packet trains to infer broadband link characteristics [Dischinger-IMC-2007].
- Software-based:
  - Speedtest.net, A flash tool to measure broadband throughput: http://www.speedtest.net. Demo
  - Glasnost, A Java-based applet that detects ISP-enforced traffic shaping [Dischinger-NSDI-2010]. Demo
  - Netalyzr, A Java-based applet that performs DNS, NAT, HTTP, IPv6-based tests [Kreibich-IMC-2010]. Demo
  - Fathom, A Firefox-extension to Netalyzr [Dhawan-IMC-2012].

Survey | Topology Discovery

- Traceroute-based
  - Cooperative Association for Internet Data Analysis (CAIDA) Archipelago (Ark) (or skitter): http://www.caida.org/projects/ark
  - RIPE Test Traffic Measurement (TTM): http://www.ripe.net/data-tools/stats/ttm/test-traffic-measurement-service
  - Dimes, A software agent that performs ping and traceroute measurements [Shavitt-CCR-2005].
  - National Laboratory for Applied Network Research (NLANR) Active Measurement Project (AMP): [Mcgregor-Commag-2000].
  - Rocketfuel, An ISP topology mapping engine [Spring-SIGCOMM-2002].
  - Scriptroute, remote measurement execution on Planetlab nodes [Spring-USITS-2003].
  - Network Cartographer (nec), uses traceroute web servers as proxies [Magoni-COMCOM-2005].

Discontinued

Survey | Topology Discovery

- Source-Routing-based
  - Atlas Project, source-routing IPv6 traceroute: [Waddington-CCR-2003]
  - Mercator, source-routing IPv4 traceroute and alias resolution: [Govindan-Infocom-2000].
- Backward-Probing-based
  - Doubletree, cooperative network topology discovery: [Donnet-SIGMETRICS-2005].

Survey | Topology Discovery

- Routing Registry Information
  - Regional Internet Registry (RIR) IP address blocks and AS number allocations are available via WHOIS [RFC 3912].
  - Internet Routing Registry (IRR) policies are also available via WHOIS.

- BGP Routing Information
  - Looking Glass and Route Servers: http://www.traceroute.org
  - University of Oregon's Route Views Project: http://www.routeviews.org
  - RIPE Routing Information Service (RIS): http://www.ripe.net/ris

Survey | Large-Scale Measurement Platforms

- Project BISmark: http://projectbismark.net
  - Led by Georgia Institute of Technology,
  - Study specific issues (e.g. bufferbloat) on a wider scale
- SamKnows: http://www.samknows.com
  - Over 40K probes deployed all over the world
  - Working in conjunction with Federal Communications Commission (FCC), European Commission (EC), Ofcom, *et al.*
- RIPE Atlas: http://atlas.ripe.net
  - Over 3300 probes deployed all over the world, over 1000 active measurements running concurrently

Survey | Large-Scale Measurement Facilitators

- Google's Measurement Lab (M-Lab): http://www.measurementlab.net
  - Open platform to deploy measurement tools. Tests measure against M-lab hosted servers.
  - Limited to active broadband measurements, open-source tools and open data mandate.
  - Avoid resource contention between experiments to avoid impact on accuracy.
  - Measurement data stored in Google Storage, retrievable via Google Query.

- PlanetLab: http://www.planet-lab.org
  - A global overlay testbed initiated by Princeton University, *et al.*
  - Provides access to real Internet path characteristics.
  - It's not a controlled environment. Results from experiments may not be repeatable.
  - Allocated slices are not isolated but shared amongst experiments.
  - Experiments on new network architectures, content distribution, measurements and monitoring.

Survey | Large-Scale Measurement Facilitators

- Emulab: http://www.emulab.net
  - A network testbed initiated by the University of Utah.
  - It's a controlled environment. Results from experiments are repeatable.
  - Flexibility to create network characteristics suited for the experiment.
  - Clear separation between the control plane and measurement plane.
  - Isolates experiments from one another.

- Federated Testbeds:
  - EmanicsLab: http://www.emanicslab.org
  - PlanetLab Japan: http://www.planet-lab.jp
  - Private PlanetLab Korea: http://www.planet-lab.kr
  - German Lab: http://www.german-lab.de

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RIPE Atlas | About

The Réseaux IP Européens Network Coordination Centre (RIPE NCC)

- independent
- not-for-profit membership organisation
- supports the Internet infrastructure through technical coordination in its service region

RIPE Atlas

- a global network of probes that measure Internet connectivity and reachability
- provides an unprecedented understanding of the state of the Internet in real time

RIPE Atlas | Overview

Numbers and Definitions

RIPE Atlas Probes

- Capabilities
- Deployment
- Anchor Probes

User-defined Measurements

- Measurement Types
- Credit System
- Accessing UDM Results
- Analysis and Use-cases

RIPEstat Hands-on

RIPE Academic Cooperation Initiative (RACI)

RIPE Atlas | Numbers

As of 2013-06-19

Registered users: 7351

Registered probes: 4782

Controllers: 16

Ongoing measurements: 1348

Number of IPv4 ASNs covered: 3.23% (1428 of 44243 ASNs)

Number of IPv6 ASNs covered: 5.88% (413 of 7025 ASNs)

Number of countries covered: 115

RIPE Atlas | Definitions

RIPE Atlas Probe:

a hardware device that runs measurements in the RIPE Atlas system

reports these measurements to the data collection component

probe
/prōb/

Noun
A blunt-ended surgical instrument used for exploring a wound or part of the body.

Verb
Physically explore or examine (something) with the hands or an instrument.

Synonyms
noun. investigation - inquiry - sound - examination
verb. explore - sound - search - investigate

RIPE Atlas Host:

someone who applies for a probe, connects it to the network and lets it run

RIPE Atlas Anchor Probe:

complements small probes at the network edge with bigger probes inside the network

RIPE Atlas User-defined Measurement (UDM):

allows hosts to to conduct measurements on their own network(s) using other probes within the RIPE Atlas network

RIPE Atlas | Probe Capabilities

Test its own network configuration

RTT measurements to the first and second hops

Current uptime, total uptime and uptime history

Ping and traceroute measurements to several root servers

Ping measurement to user-defined destinations

Traceroute measurement to user-defined destinations

DNS queries to root or user-defined DNS servers

SSL queries to user-defined destinations

Power and bandwidth consumption

RIPE Atlas | Probe Versions: 1, 2 and 3

V3

TP-Link TL-MR3020 powered from USB port (500mA)

32 MB RAM, 4MB flash built-in

4GB flash on USB stick

firmware is updated remotely

runs OpenWRT, 400 MHz MIPS CPU with MMU

Cannot be used as a wireless router

V1, V2

Convenient form-factor

Production discontinued

RIPE Atlas | Probe V2 "in action" at UTwente

RIPE Atlas | Anchor Probes

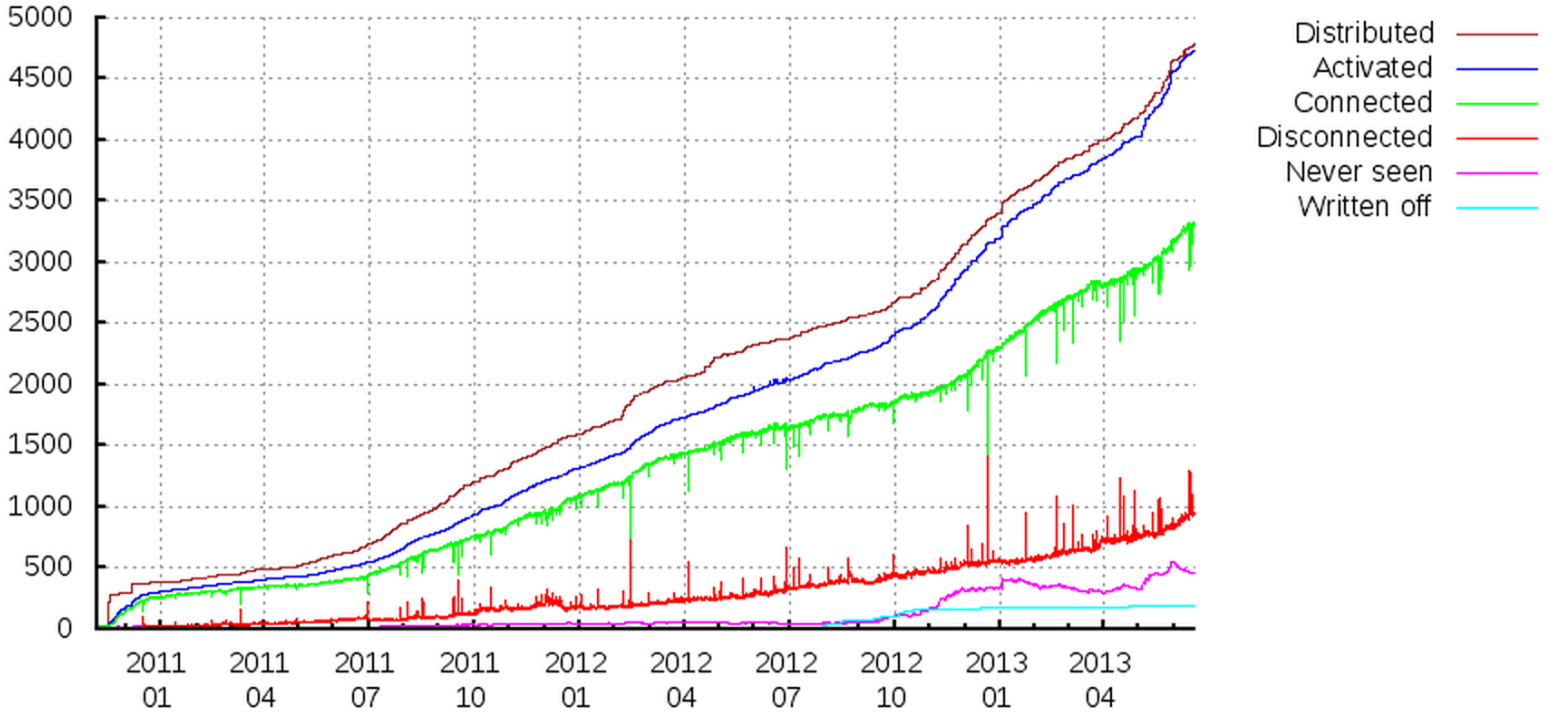
Anchors are well-known targets and powerful probes (aka jumbo probes)

- Probes from the inside vs probes at the edges
- Powerful: placed at hosts with sufficient bandwidth to support many incoming measurements
- Act as a fixed measurement target
- Perform baseline measurements to a number of regional or local targets that are relatively close
  - no need to trace the entire globe in order to identify problems in local connectivity
  - helps to understand disturbances in connectivity in areas served by anchors
- Will be available to all users for performing experiments

Currently in pilot phase, 16 anchors installed

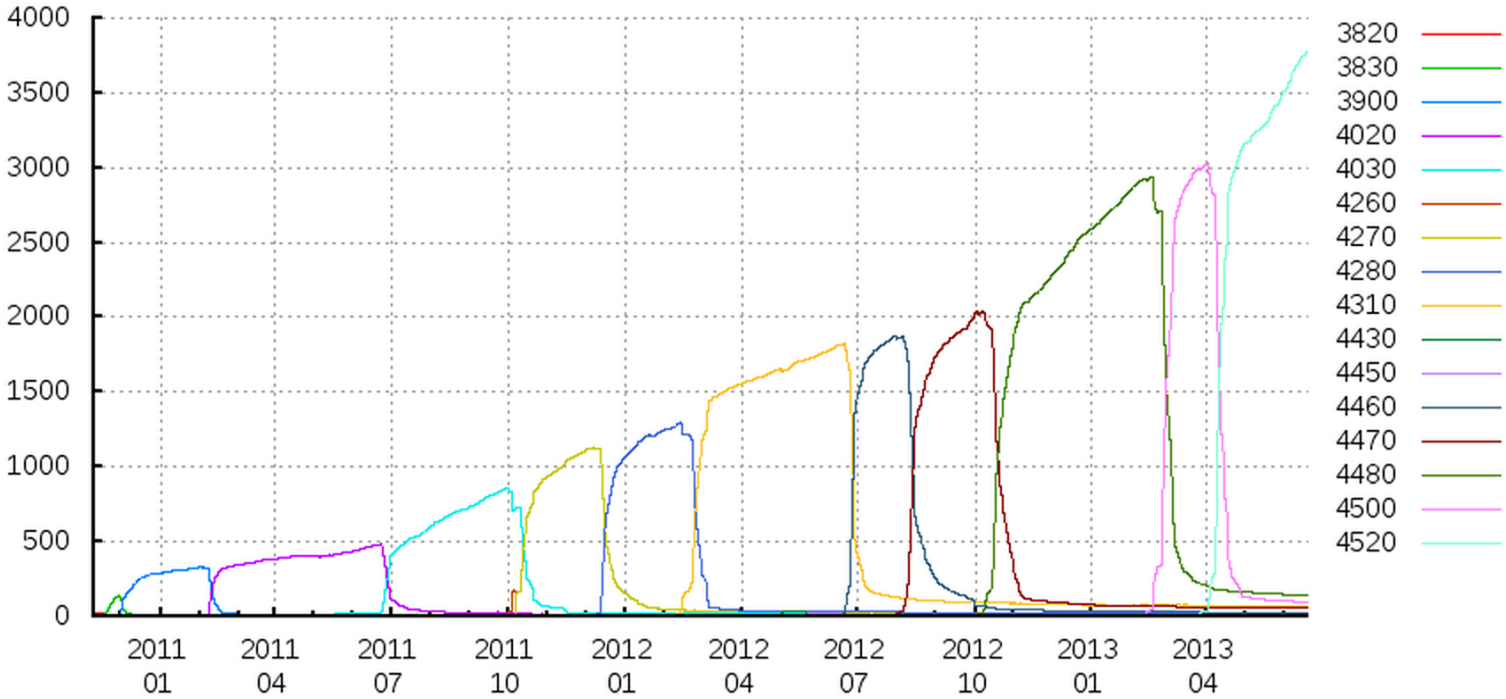
- Searching for partners

RIPE Atlas | Probe Deployment



https://atlas.ripe.net/results/graphs

RIPE Atlas | Probe Firmware



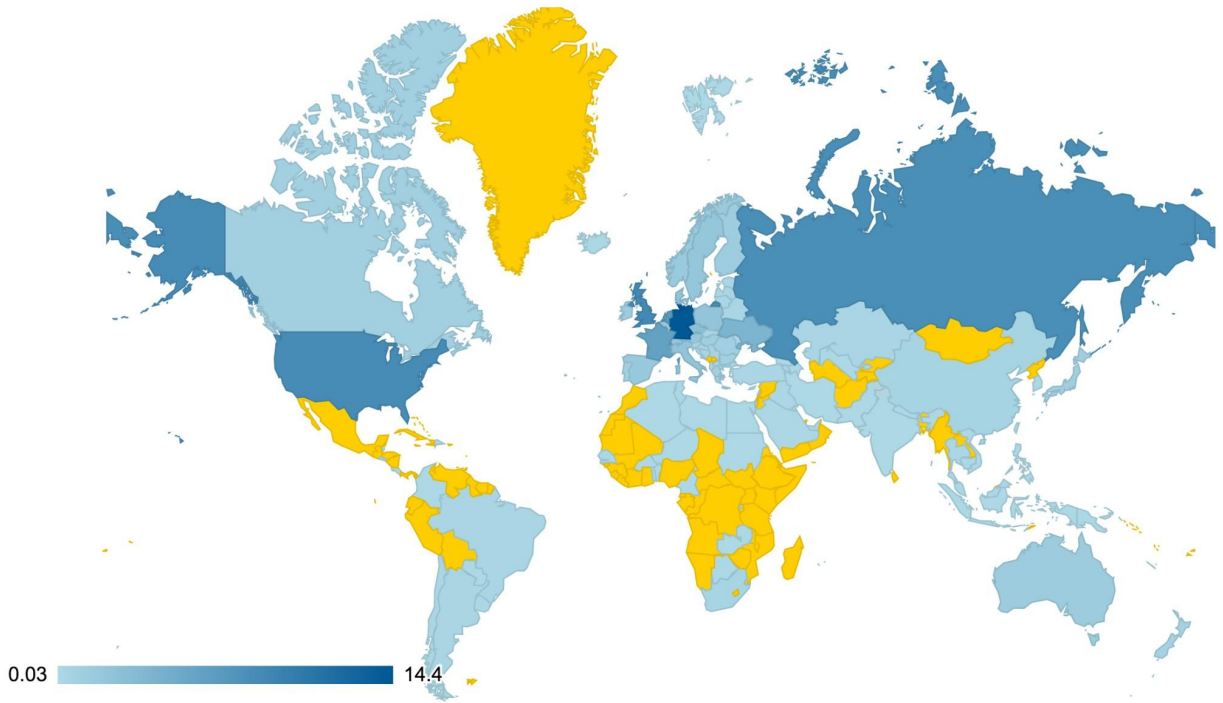
https://atlas.ripe.net/results/graphs

RIPE Atlas | World Coverage

https://atlas.ripe.net/results/maps

RIPE Atlas | Probes By Country

Country code	Number of up probes
DE	478
GB	294
US	288
RU	278
NL	230
FR	200
UA	130
CZ	97
PL	75
DK	74
IT	74
CH	66
SE	65
BE	64
AT	64
ES	57
NO	53
AU	47
FI	41
IE	40



https://atlas.ripe.net/results/graphs

RIPE Atlas | User-defined Measurements (UDMs): Types

Active measurements defined by users

Types of measurements

- DNS (v4, v6)
- ping (v4, v6)
- HTTP (v4, v6)
- SSL Cert (v4, v6)
- traceroute (v4, v6)

Public or private

Can be created only with sufficient credits (system warnings)

User-defined periodicity

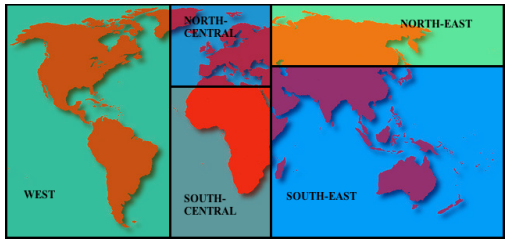
User-defined number of participating probes

Scheduling

Limits: max 100 simultaneous measurements, max 500 probes/measurement, max 270,000 credits/day

Measure from

- regions
- countries
- AS
- prefix
- probes
- existing UDM



Regions

RIPE Atlas | User-defined Measurements (UDMs): Credits

Credits (spend as much as you earn)

- Receive for probe uptimes (more probes - more credits)
- Spend to perform your own UDMs (more probes, higher frequency - more credits)
- Variable costs for different measurements
- Transaction history (downloadable)
- Advanced warnings
- Transfers to other users
- One can request more (via an e-mail... and a good reason)

RIPE Atlas | User-defined Measurements (UDMs)

As of 2013-06-19

Type of Measurement	Number of Static Measurements	Number of UDMs
Traceroute	26	130
SSLCert	2	18
Ping6	17	199
Ping	26	670
DNS6	66	7
HTTP6	1	4
DNS	84	36
Traceroute6	18	34
HTTP	1	2
SSLCert6	2	4

We will create some measurements in the "Hand-on" part of the tutorial

RIPE Atlas | Accessing UDMs

Access via

- web interface
- RESTful API: http://atlas.ripe.net/doc/rest
  - no registration necessary

JSON format

Available Methods

- Probes (GET)
- Measurements (GET, POST, DELETE)

Hands-on during demo session after the break

RIPE Atlas | Analyses and Use-cases

RIPE community: https://atlas.ripe.net/results/analyses

- De-bogonising 128.0.0.0/16
- Superstorm Sandy
- Comparing TCP and UDP Response Times of DNS Root Servers
- A Case Study of AAAA Filtering
- Using RIPE Atlas: A DENIC Case Study
- A Case Study of IPv6 /48 Filtering
- A Use Case for IPv6 Reachability Testing with RIPE Atlas
- RIPE Atlas & Anycast Instance Switches
- DNS Measurements with RIPE Atlas Data

Independent research:

- Traffic anomaly detection using a distributed measurement network:
  http://staff.science.uva.nl/~delaat/rp/2011-2012/p04/report.pdf
- Packet-pair technique for available bandwidth estimation in IPv6 network:
  http://arxiv.org/abs/1102.3533
- Discovering Path MTU black holes using RIPE Atlas:
  https://caldav.os3.nl/_media/2011-2012/students/maikel_de_boer/rp/de-boer_bosma-rp2_project_proposal.pdf

RIPE Atlas | Analyses and Use-cases: h.root-servers.net

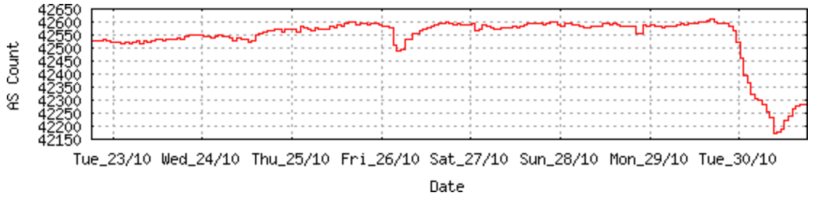
https://atlas.ripe.net/results/maps

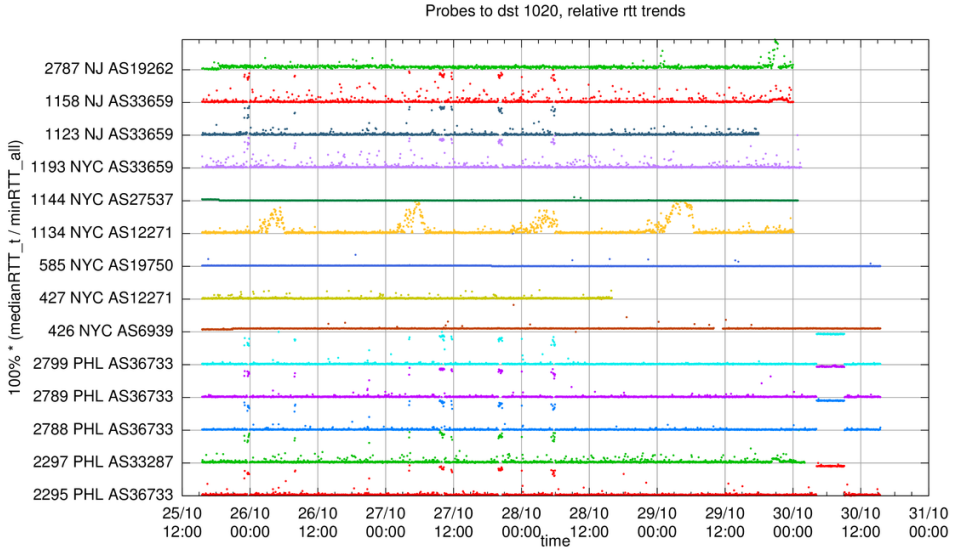
RIPE Atlas | Analyses and Use-cases: Hurricane Sandy (2012)

Affected area is key to communication channel (US - Europe)

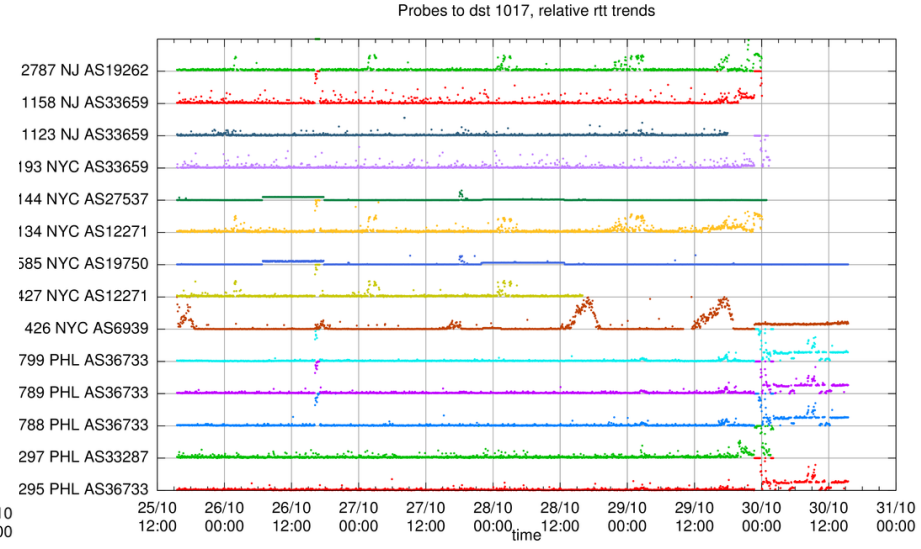
RIPE Atlas probe ID/location/ASN

400 ASes were taken dow





Measurements to a destination on the US West Coast

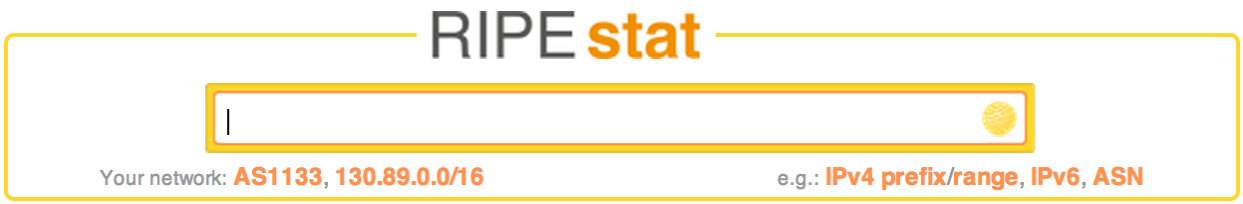


Measurements to a destination in Germany

https://labs.ripe.net/Members/emileaben/ripe-atlas-superstorm-sandy

RIPE Atlas | RIPE Stat: http://stat.ripe.net

Hands-on



RIPEstat API is available at: https://stat.ripe.net/docs/data_api
Maxmind GeoCity Light database is used for geolocation

RIPE Atlas | Roadmap and 2013 Outlook

Requested	Planned	In Progress	Delivered
Add NLNOG RING nodes as measurement targets	Sharing credit management with colleagues	Tools for interpreting results	Quick Look connectivity measurements
Automatic alarms	More visualisations for user-defined measurements	RIPE Atlas anchors pilot - phase two	Release measurement source code
Involve each probe in anchoring measurements		Improving back-end infrastructure	API keys
Replace unsuitable probes		List of available RIPE Atlas anchors	Improved credit model documentation and accounting
Vantage points dropping out of existing user-defined measurements			RIPE Atlas anchors as measurement targets
Share my probe with a custom-made group			Measurements on GitHub
Improve reporting when probe disconnects			One-off measurements
More controls for measurement distribution			Allowed creation of measurements using API
Credits APIs			Improved RIPE Atlas website
			Sharing probe management with colleagues
			Increase maximum number of probes and measurements

4000 additional probes in 2013
50 additional anchor probes in 2013
Tighter integration of UDM results into RIPEstat

Community contributions are welcome

https://github.com/RIPE-Atlas-Community

RIPE Atlas | RIPE Academic Cooperation Initiative - RACI

Started in 2013

Recommended topics, but not limited to:

- Network measurement and analysis
- IPv6 deployment
- BGP routing
- Network security
- Internet governance

Co-located with general RIPE meetings

Last: https://ripe66.ripe.net

Next: https://ripe67.ripe.net
Deadline: 29-09-2013
Application: 500 words

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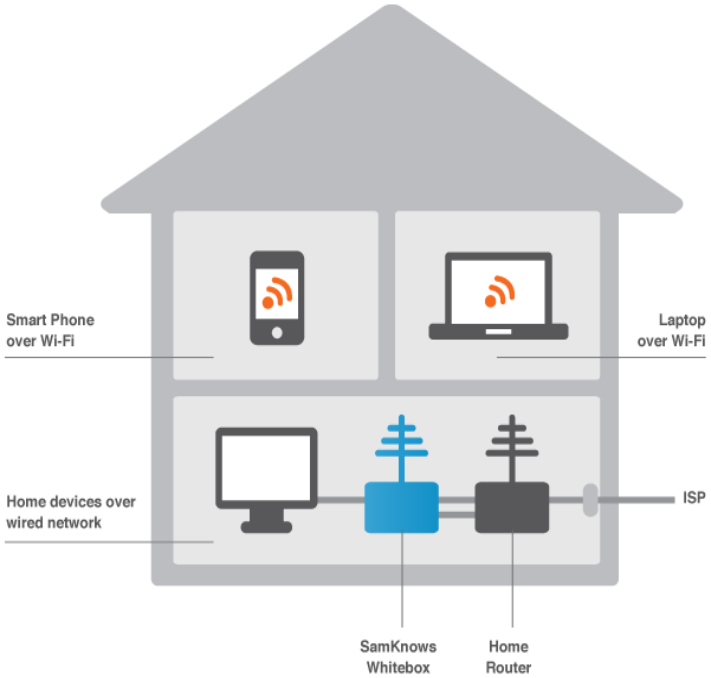
SamKnows Platform

- Collaboration:
  - 6 regulators and 12 ISP deployments:
    - Federal Communications Commission (FCC), United States
    - European Commission (EC), European Union
    - Canadian Radio-Television Commission (CRTC), Canada
    - Office of Communications (Ofcom), United Kingdom
    - Brazilian Agency of Telecommunications (Anatel), Brazil
    - Infocomm Development Authority of Singapore (IDA), Singapore
- Around 40K measurement probes deployed.
  http://www.ietf.org/proceedings/85/slides/slides-85-iesg-opsandtech-7.pdf

SamKnows Platform

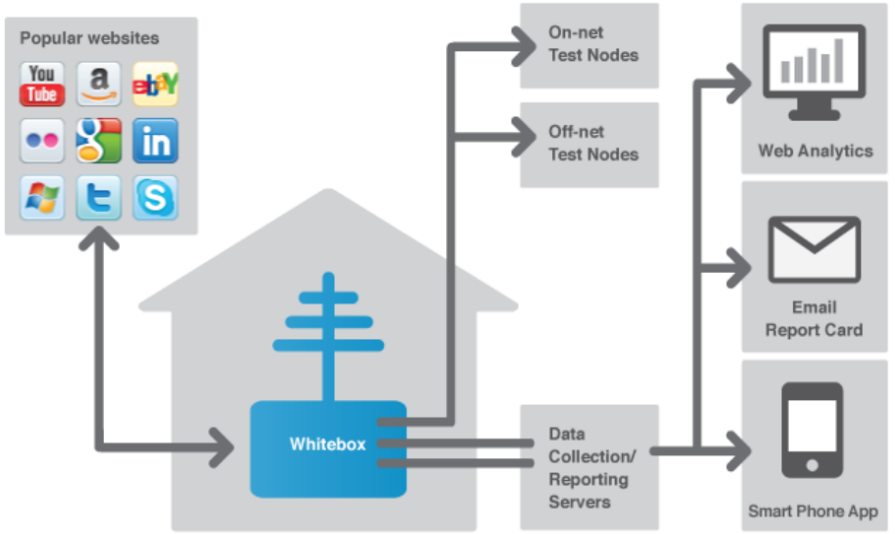
- Functionality
  - Works as a ethernet bridge.
  - The WiFi radio is only used to monitor cross-traffic.
  - Does not perform any passive measurement tests.
  - Active measurement tests run only in absence of cross-traffic.
  - Tests catered specifically to measure broadband performance.



http://www.samknows.com

SamKnows Platform

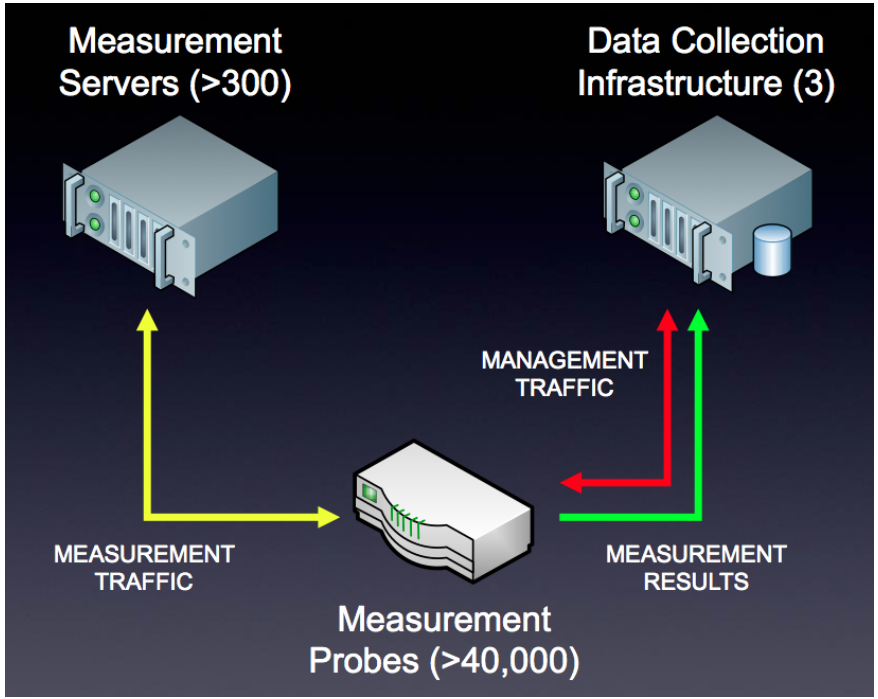
- Platform Overview
  - cron scripts schedule the measurement tests.
  - on-net nodes: measurement servers within ISP.
  - off-net nodes: measurement servers outside ISP.
  - ISPs signing code of conduct get anonymized and aggregated measurement result data.



http://www.samknows.com

SamKnows Platform

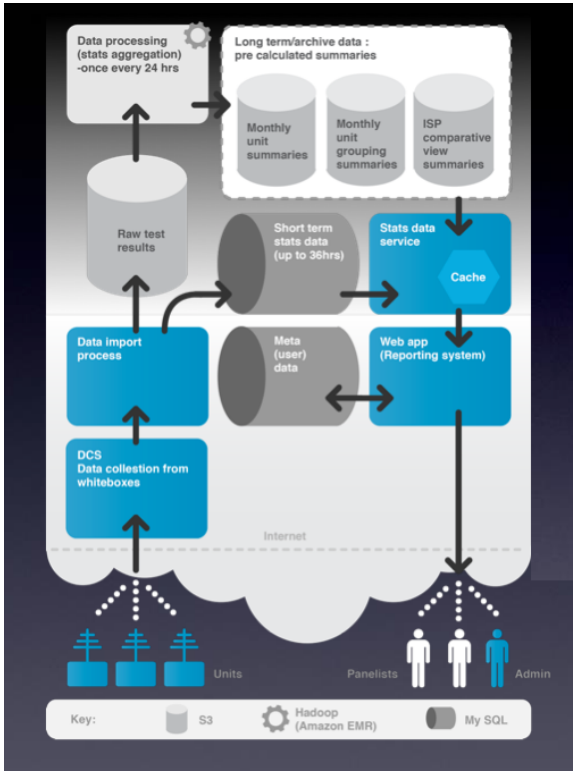
- Architecture
  - Measurement Probes
    - runs on TP-Link router hardware.
    - flashed with a custom snapshot of OpenWrt.
    - tests and schedules are remotely upgradeable.
  - Measurement Servers
    - dumb servers to test against with.
  - Data Collection Servers (DCS)
    - functions both as a controller and a collector.



http://www.ietf.org/proceedings/85/slides/slides-85-iesg-opsandtech-7.pdf

SamKnows Platform

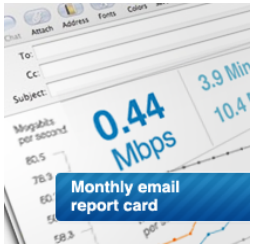
- Data Processing Backend
  - Raw measurement results are stored in Amazon S3.
  - Recent stats and metadata are stored in MySQL.
  - Hadoop jobs aggregate the data into monthly averages.
  - Service-tier validation with the ISP.
  - A web app generates a reporting web page with summary results.



http://www.ietf.org/proceedings/85/slides/slides-85-iesg-opsandtech-7.pdf

SamKnows Platform

- Reporting Suite
  - Web-based reporting system. Demo
    http://reporting.samknows.com
  - Monthly email report card. Demo
  - Smartphone app.



http://www.samknows.com

SamKnows Platform

- Measurement Probe (Whitebox): [Whitebox Briefing (Fixed) Whitepaper]
  - Firmware: http://files.samknows.com/~gpl
    - Custom snapshot on OpenWrt, remotely upgradeable by SamKnows.
    - No routing functionality.
  - Hardware Versions:
    - v1.0: TPLink SK-TL-WR741ND
    - v1.1: TPLink SK-TL-WR1043ND
  - Communications
    - Communication with DCS is server-side authenticated and encrypted over TLS.
    - Measurement tests and schedules are remotely upgradeable.

SamKnows Platform

- Measurement Servers (Test Nodes): [Test Node Briefing Whitepaper]
    - Test nodes are generic servers against which the probes perform measurements.
    - Test node locality to the customer is critical.
    - They do not store any measurement data.
    - Round trip time (RTT) checks help ensure the probe is measuring against the nearest test node.
    - Deployment of both on-net and off-net test-nodes.

SamKnows Platform

- Measurement Tests: [Test Suite Whitepaper]
  - Web browsing
    - Time taken to download the HTML and static assets. DNS resolution is accounted in the calculation.
    - Each test run tests against 10 common websites. Uses up to 8 concurrent TCP connections.
    - Supports HTTP persistent connections and cache-control.
    - Measures the time taken, number of bytes transferred, and the rate of transfer.
  - Speed test
    - Measures raw throughput and goodput via concurrent (3) HTTP GET and POST requests to a test-node.
    - TCP slow-start and congestion are avoided by performing a "warm up" test.
    - Content is download to /dev/null and uploaded from /dev/urandom.

SamKnows Platform

- Measurement Tests: [Test Suite Whitepaper]
  - Video streaming
    - TCP test using a proprietary client and server-side component.
    - Measures time taken to initial buffer (3s), total number of buffer underruns, total delay due to buffer underruns.
  - Voice over IP (VoIP)
    - UDP bidirectional test
    - Uses fixed-rate stream (64kbps), to measure jitter, throughput, delay and loss [RFC-5841].

SamKnows Platform

- Measurement Tests: [Test Suite Whitepaper]
  - UDP (and ICMP) latency and packet loss
    - Measures round-trip-time (RTT) to a test node using UDP (and ICMP) packets.
    - Treats a UDP (or ICMP) packet lost, if not received back within 3 seconds.
    - Records average RTT and total packet loss every hour.
  - Availability Test
    - Establishes a long-lived TCP connection to each test-node server (3).
    - If TCP connection cannot be established to all 3 simultaneously at anytime, Internet in availability is declared.

SamKnows Platform

- Measurement Tests: [Test Suite Whitepaper]
  - ICMP Latency under Load
    - Runs during the speed test.
    - Measures the RTT by sending ICMP packets to a test-node server.
  - DNS resolution
    - Measures the DNS resolution time of a list common websites.
    - Measures against the ISP's recursive resolver.

SamKnows Platform

- Measurement Tests: [Test Suite Whitepaper]
  - Peer-to-Peer
    - Performs bittorrent transfer of 10MB binary file.
    - Measures:
      - Average and peak throughput.
      - Number of connections established with peers.
      - Total number of pieces transferred.
      - Total number of TCP connections RST during the transfer.
    - Average throughput must match the downstream speed test. ISP is traffic shaping bittorrent otherwise.

SamKnows Platform

- Measurement Tests: [Test Suite Whitepaper]
  - FTP transfer
    - Uses a single TCP connection to measure the FTP transfer throughput to/from a test-node server.
  - Email relaying
    - Measures the time taken to send an email via the ISP's SMTP relay to a test-node email server.
    - Uses embedded timestamps in the email to compute the time taken.

SamKnows Platform

- Publications:
  - WTF? Locating Performance Problems in Home Networks [Sundaresan-TR-2013].
  - Web Performance Bottlenecks in Broadband Access Networks [Sundaresan-SIGMETRICS-2013].
  - Trying Broadband Characterization at Home [Sánchez-PAM-2013].
  - Revisiting Broadband Performance [Canadi-IMC-2012].
  - Measuring Home Broadband Performance [Sundaresan-CACM-2012].
  - Up, Down and Around the Stack: ISP characterization from Network Intensive Applications [Bischoff-WMUST-2012].
  - Crowdsourcing ISP characterization to the network edge [Bischoff-WMUST-2011].
  - Powerboost [Bauer-HomeNets-2011].
  - Helping Users Shop for ISPs with Internet Nutrition Labels [Sundaresan-HOMENETS-2011].
  - Broadband Internet Performance, A View from the Gateway [Sundaresan-SIGCOMM-2011].

SamKnows Platform

- Regulator Reports:
  - FCC: http://www.fcc.gov/measuring-broadband-america
  - Ofcom: http:/maps.ofcom.org.uk/broadband

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Standardization Efforts

- Large-Scale Measurement of Broadband Performance: Use Cases, Architecture and Performance Requirements: [draft-schulzrinne-lmap-requirements-00]

- Internet Architecture Board (IAB) Plenary on Challenges of Network Performance Measurements, IETF 85.

  - SamKnows platform by Sam Crawford: http://www.ietf.org/proceedings/85/slides/slides-85-iesg-opsandtech-7.pdf

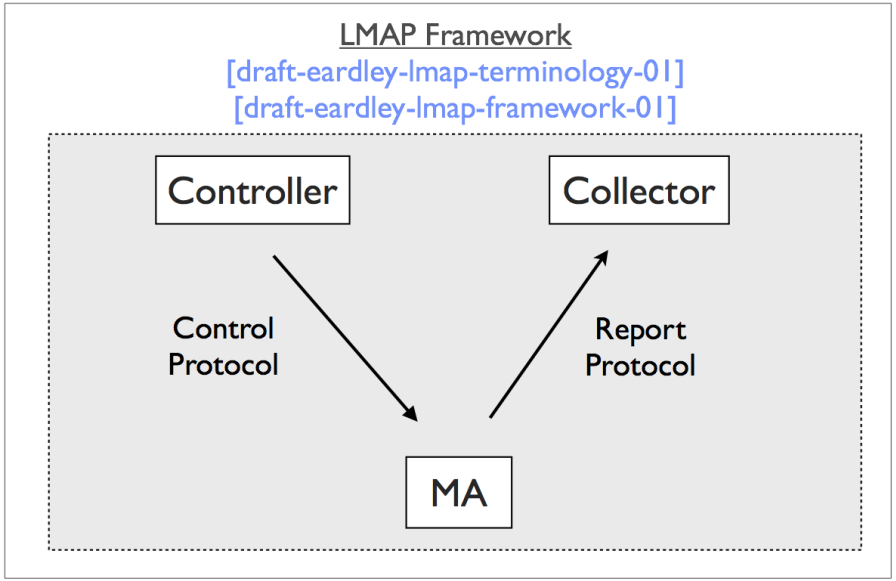
  - Large-Scale Internet measurements for data-driven public policy by FCC : http://www.ietf.org/proceedings/85/slides/slides-85-iesg-opsandtech-8.pdf

Standardization Efforts

- Large-Scale Measurement of Access Network Performance (LMAP) Bird of a Feather (BoF), IETF 86.
  - LMAP scope (Network Provider Perspective) [draft-boucadair-lmap-considerations-00]
  - LMAP and IP Performance Metrics (IPPM) dependencies and coordination
  - Control and Report protocol candidates:
    - NETCONF [draft-schoenw-lmap-netconf-00]
    - IPFIX [draft-bagnulo-lmap-ipfix-01]
    - ALTO [draft-seedorf-lmap-alto-00]
    - REST-based architectural style over HTTP
  - Data model candidates:
    - YANG [draft-schoenw-lmap-yang-00]

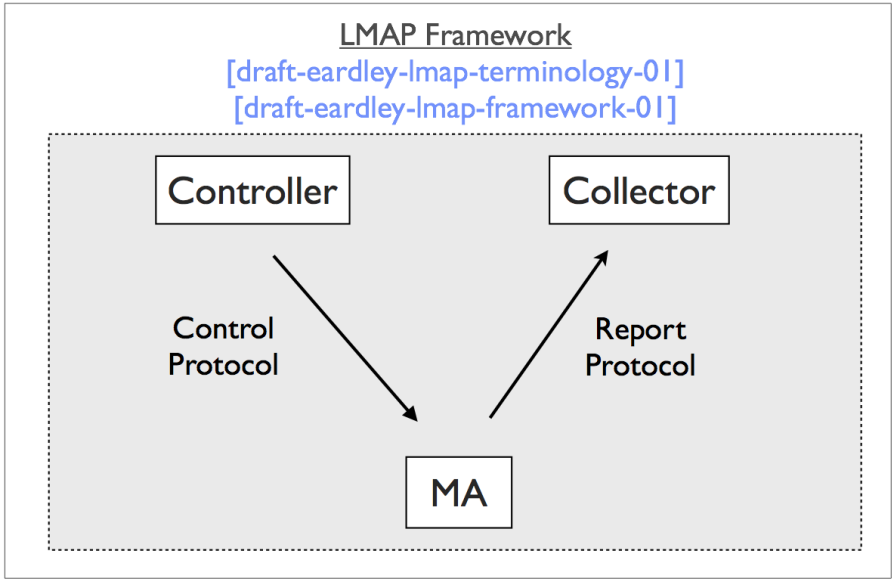
Standardization Efforts

- IETF LMAP Proposed Working Group
  - LMAP use cases
    [draft-linsner-lmap-use-cases-02]
  - LMAP terminology and framework
    [draft-eardley-lmap-terminology-01]
    [draft-eardley-lmap-framework-01]
  - LMAP charter approved by IESG for external review:
    http://datatracker.ietf.org/doc/charter-ietf-lmap



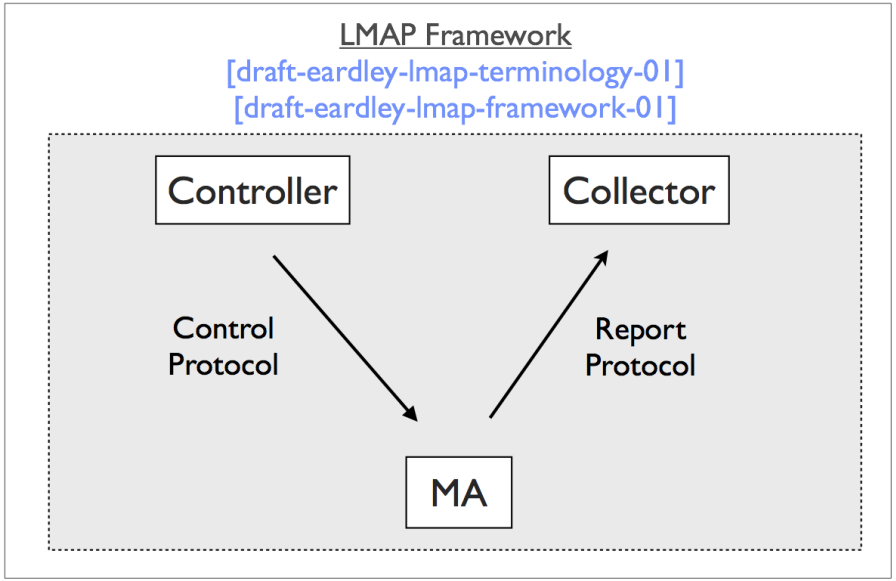
Standardization Efforts

- IETF LMAP Proposed Working Group
  - LMAP information model
    - Metric
    - Test Schedule
    - Test Report
  - LMAP control protocol and data model
  - LMAP report protocol and data model



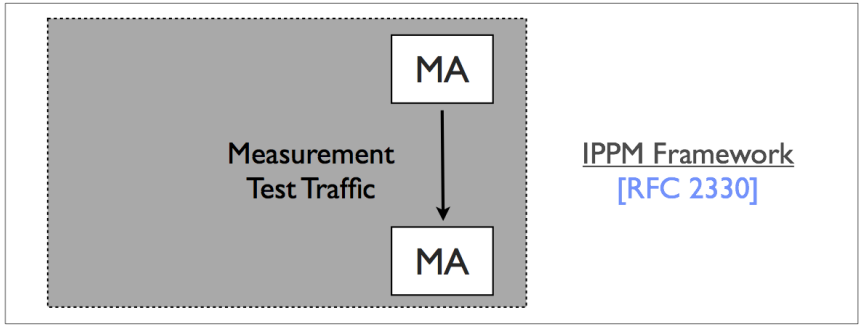
Standardization Efforts

- IETF LMAP Proposed Working Group
  - Scope
    - Isolated measurement systems (MS).
    - MS operated by a single organization.
    - MA interacts with only one controller.
    - MA can push results to multiple collectors.
    - Favour simple transport protocols.



Standardization Efforts

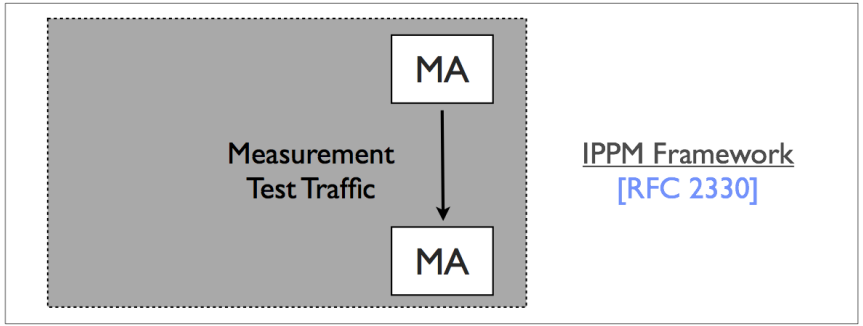
- IETF IPPM Working Group
  - Metrics:
    - Connectivity [RFC 2678]
    - One-way delay [RFC 2679]
    - One-way packet loss [RFC 2680]
    - Round-trip delay [RFC 2681]
    - IP packet delay variation (or jitter) [RFC 3393]
    - Packet reordering [RFC 4737]
    - Round-trip packet loss [RFC 6673]



  - Protocols:
    - One-way active measurement protocol (OWAMP) [RFC 4656]
    - Two-way active measurement protocol (TWAMP) [RFC 5357]
  - Information model and XML data model for traceroute measurements [RFC 5388]

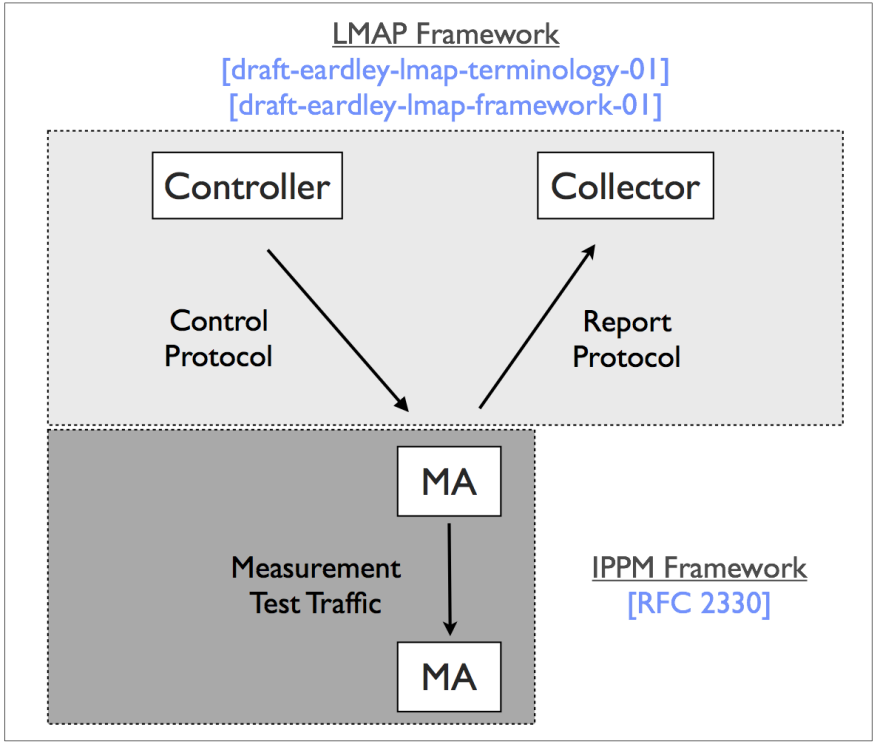
Standardization Efforts

- IETF IPPM Working Group
  - Charter Revision: http://datatracker.ietf.org/wg/ippm/charter
    - IPPM framework update [draft-morton-ippm-2330-update-01]
    - Using IPSEC to protect OWAMP and TWAMP [draft-bi-ippm-ipsec-00]
    - Model-based TCP bulk transfer capacity metrics: [draft-mathis-ippm-model-based-metrics-01]



Standardization Efforts

- IETF LMAP and IPPM Glue
  - A reference path and measurement points for LMAP:
    [draft-morton-ippm-lmap-path-01]
  - Registry for commonly-used metrics:
    [draft-bagnulo-ippm-new-registry-00]
    [draft-bagnulo-ippm-new-registry-independent-00]



Standardization Efforts

- IETF Metric Blocks for use with RTCP's Extended Report Framework (Xrblock) Working Group:
  - RTP Control Protocol (RTCP) provides feedback on the quality of the Real Time Protocol (RTP) data distribution [RFC 3550].
  - RTCP Extended Reports (RTCP XR) convey information beyond the defined reception report blocks [RFC 3611].
    - Packet-by-packet block types.
    - Reference time block types.
    - Metrics block types.
  - Xrblock evaluates proposals for new metric block type definitions.
    - Measurement identity reporting [RFC 6776].
    - Packet delay [RFC 6843].
    - Packet delay variation [RFC 6798].
    - Burst/Gap loss [RFC 6958].

Standardization Efforts

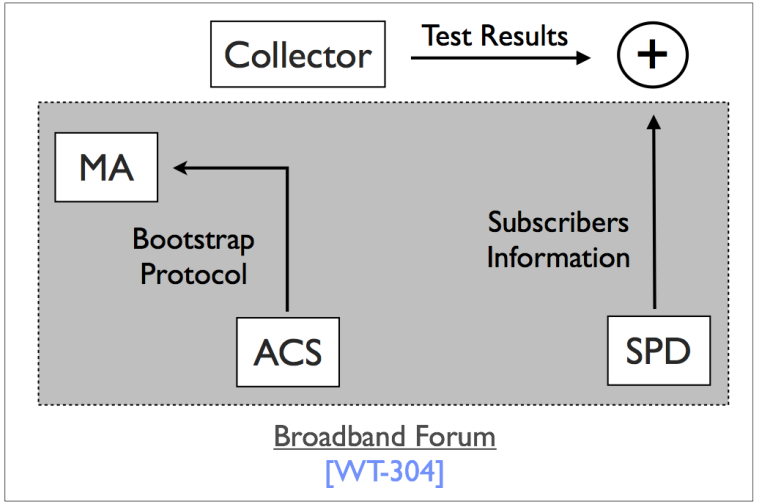
- Institute of Electrical and Electronics Engineers (IEEE)
  - Mobile Broadband Network Performance Measurements [P802.16.3].
    - End-to-end performance measurements.
    - Characterize mobile broadband networks from the user's vantage point.
- International Telecommunication Union - Telecommunication Standardization Sector (ITU-T)
  - Meet demands for a standardized methodology for measuring Internet access speeds.
  - ITU-T Joint Coordination Activity on Conformance and Interoperability Testing (JCA-CIT) [2013 - 2016]

Standardization Efforts

- Broadband Forum (BBF)
  - Enabling Network Throughput Performance Tests and Statistical Monitoring [TR-143].
    - Data-models to initiate performance throughput and latency tests.
    - Data-models to monitor the Customer Premises Equipment (CPE) using defined diagnostic mechanisms. [TR-069].
  - Broadband Access Service Attributes and Performance Metrics [WT-304].
    - Additional performance tests: loss, jitter, emulated streaming, browsing et al.
    - Additional capabilities:
      - Measure particular segments of the network.
      - Measure across multiple networks.
      - Scheduling tests.
      - Initiate on-demand triggering of tests.

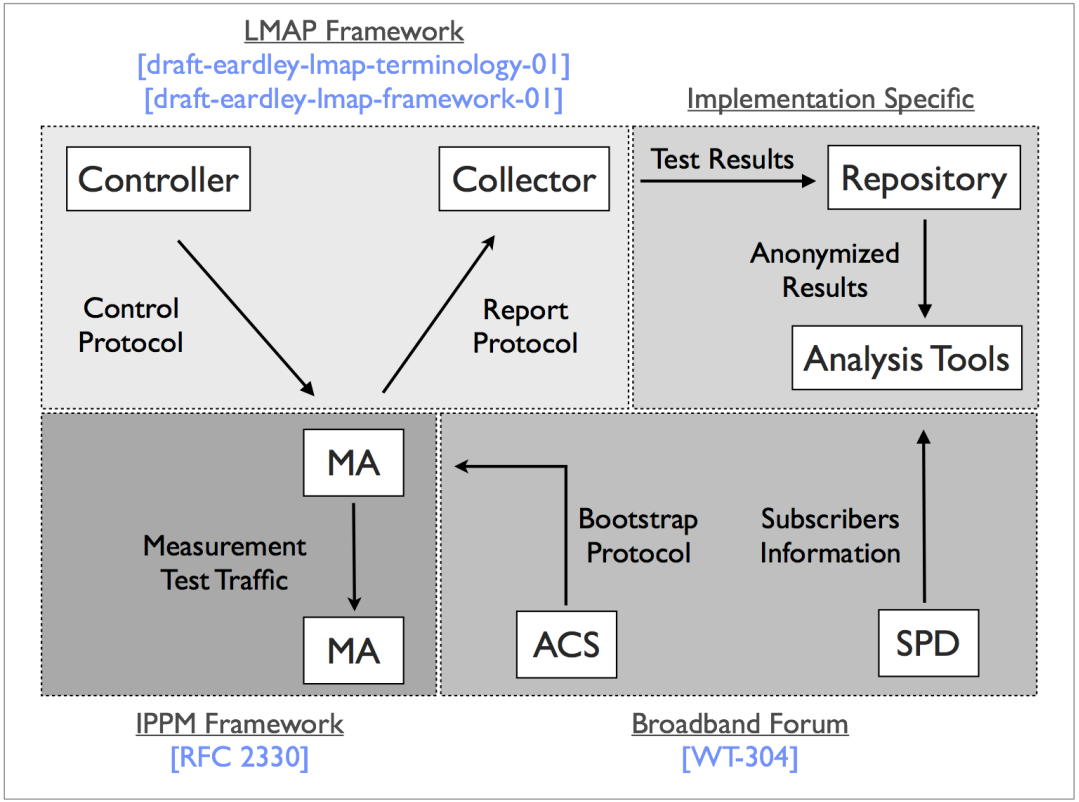
Standardization Efforts

- Broadband Forum (BBF)
  - Bootstrap the Measurement Agent (MA).
    - Using TR-069 (or DOCSIS).
  - Capability exchange between Controller and MA.
  - On-demand tests.
  - Splicing Subscriber Parameter Database (SPD) into results.
    - Collector splices the parameters into results (or)
    - MA reports the parameters to the Operational Support System (OSS) using TR-069.



Standardization Efforts

- Big Picture:
  - LMAP Framework
    - Information model
    - Data model
    - Control protocol
    - Report protocol
  - IPPM Framework
    - Measurement Metrics
  - Broadband Forum
    - Bootstrap protocol
    - Splicing SPD



Standardization Efforts

- Dissemination
  - A Framework for Large-Scale Measurements, July 2013 [Bagnulo-FNMS-2013].
  - Standardizing Large-Scale Measurement Platforms, April 2013 [Bagnulo-CCR-2013].
  - Large-Scale Broadband Measurement, RIPE 66, April 2013: https://ripe66.ripe.net/archives/video/1259

- Upcoming Events
  - IETF 87, Berlin, July 2013: http://www.ietf.org/meeting/87
  - NMRG Workshop at CNSM, Zurich, October 2013: http://www.cnsm-conf.org/2013/program.html
  - IETF 88, Vancouver, November 2013: http://www.ietf.org/meeting/88
  - Dagstuhl Workshop on Global Measurements Framework, Wadern, November 2013: http://www.dagstuhl.de/13472

Outline

- Introduction
- Survey on Large-scale Measurements
- Internals:
  - RIPE Atlas Platform
  - SamKnows Platform
- Standardization Efforts

- Hands-on
  - OpenWrt-based Measurement Agent (MA)
  - RIPE RESTful API

Hands-on | Exercise 1

- Virtualizing an OpenWrt-based CPE.
  http://cnds.eecs.jacobs-university.de/slides/2013-aims-virt-openwrt-cpe.pdf

  - Emulating a MIPS processor using qemu.
  - Virtualizing an OpenWrt distribution on the emulated MIPS processor.
  - Enabling external network access using VDE2.
  - Installing packages.
  - Securing remote access.

Hands-on | Exercise 2

- Experimenting with an LMAP testbed
  http://cnds.eecs.jacobs-university.de/slides/2013-aims-experimenting-lmap-testbed.pdf

  - Bootstrap the virtual CPE as a Measurement Agent (MA) with a Controller using a REST API
  - Install a measurement test.
  - Schedule the measurement test.
  - Push the measurement test results to a Collector using a REST API.
  - Read the measurement test result back using a REST API.

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Hands-on | Exercise 3

- RIPE Atlas
  http://cnds.eecs.jacobs-university.de/users/nmelnikov/aims2013-ripe-atlas.html
  - Accessing UDM results
    - via web interface
    - via command line interface
  - Accessing probes.
  - Introduction to the structure of different UDMs.
  - Creating UDMs.
  - Using d3.js for cross-platform visualization.

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