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Deliverable D5: Second Experts' Workshop Report APPENDIX A

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List of participant organisations:

Role	Participant name	Participant short name	Country
Tenderer	Hebrew University of Jerusalem	HUJI	Israel
Supporting partner	Alcatel Lucent Bell N.V.	ALB	Belgium
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This Appendix contains the first half of the slides presented as input to the second Expert Workshop in this study. Summaries of the material appear in the main report, which is Deliverable D5 of SMART 2012/0046. Both the report and this Appendix are public material.

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1. APPENDIX: SLIDES PRESENTED AT THE WORKSHOP

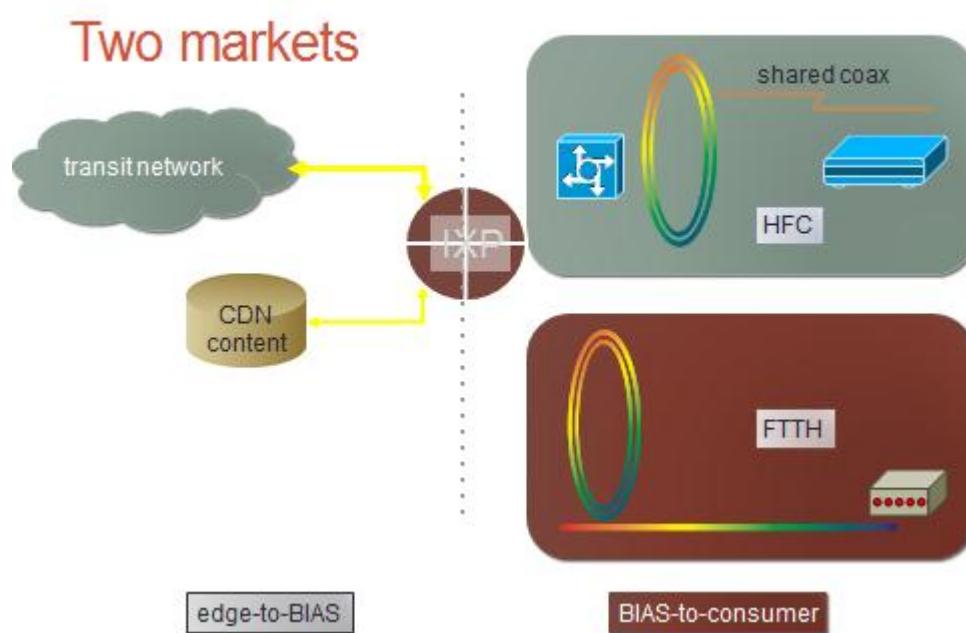
1.1 Prof. Henning Schulzrinne

01 May 2014

OPEN INTERNET

Henning Schulzrinne
FCC

01 May 2014



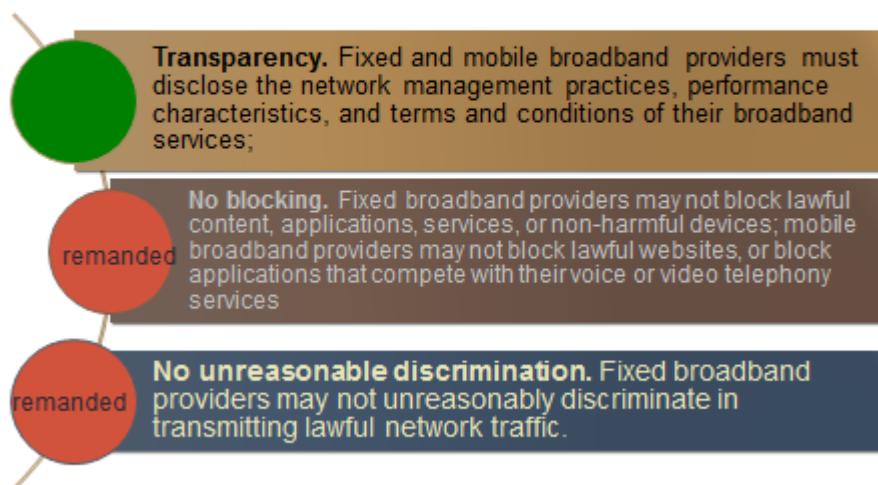
Ol May 2014

Shared resources

- QoS → generally, protect low-bandwidth, high-sensitivity flows against high-bandwidth, low-sensitivity flows
 - otherwise, reverts to TDM network (lose statistical multiplexing gain)
 - LB QoS: provide quality gain with minimal impact on HB services
- Thus, good for protecting
- QoS does not create capacity
 - thus, if video (40% of peak-hour usage) is prioritized, likely others suffer

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Open Internet R&O 2010 + DC Circuit



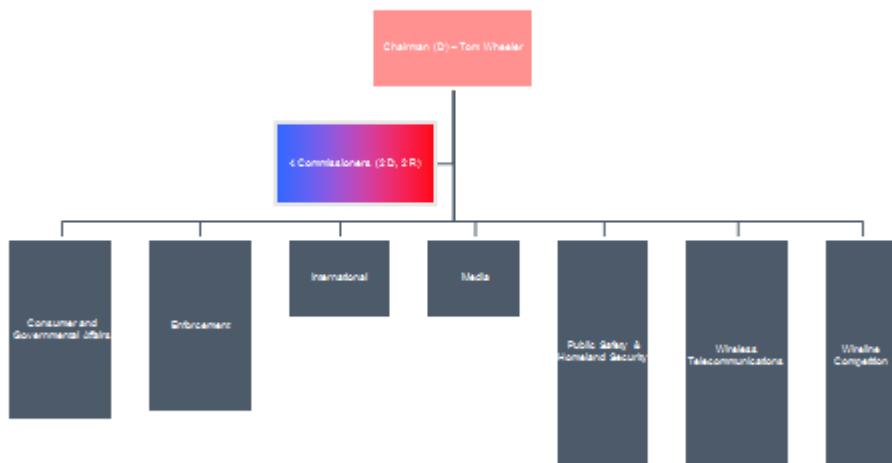
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Verizon holding

- **Upheld** Commission's authority to promulgate Open Internet rules under section 706
- **Upheld** transparency rule
- **Vacated and remanded** blocking and discrimination rules as impermissible common carriage regulation of an information service

01 May 2014

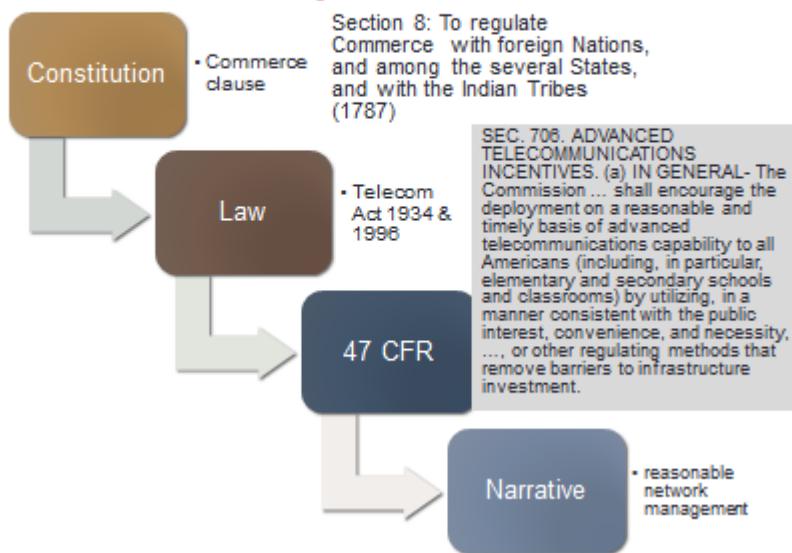
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- Independent federal agency
- About 1,700 employees

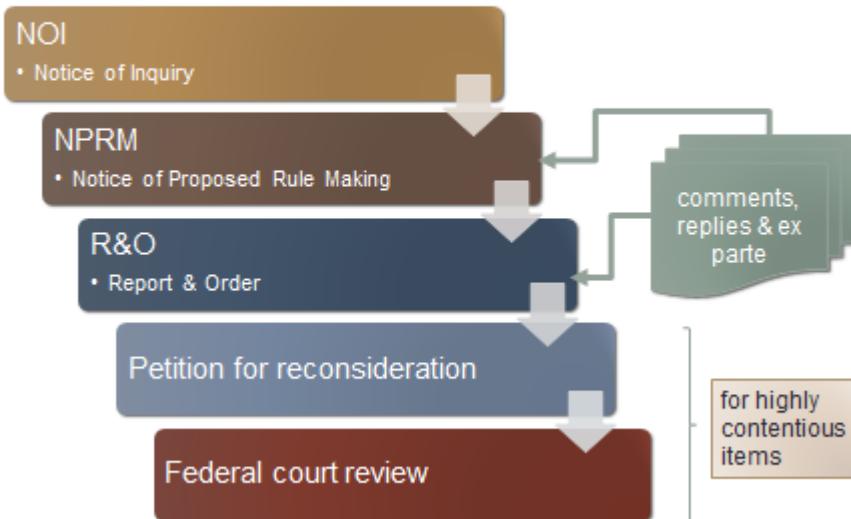
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The US hierarchy of laws



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Rule making process



OI May 2014

Section 706

- (a) The Commission and each State commission with regulatory jurisdiction over telecommunications services shall encourage the deployment on a reasonable and timely basis of advanced telecommunications capability to all Americans (including, in particular, elementary and secondary schools and classrooms) by utilizing, in a manner consistent with the public interest, convenience, and necessity, **price cap regulation, regulatory forbearance, measures that promote competition in the local telecommunications market, or other regulating methods that remove barriers to infrastructure investment.**
- (b) ... Commission shall determine whether advanced telecommunications capability is being deployed to all Americans in a reasonable and timely fashion. If the Commission's determination is negative, it shall take immediate action to accelerate deployment of such capability by removing barriers to infrastructure investment and by promoting competition in the telecommunications market.

OI May 2014

Title II, Section 201 & 202

- §201: "to establish physical connections with other carriers", "All charges, practices, classifications, and regulations for and in connection with such communication service, shall be *just and reasonable*, and any such charge, practice, classification, or regulation that is unjust or unreasonable is hereby declared to be unlawful"
- §202: It shall be unlawful for any common carrier to make any *unjust or unreasonable discrimination* in charges, practices, classifications, regulations, facilities, or services for or in connection with like communication service, directly or indirectly, by any means or device, or to make or give any undue or unreasonable preference or advantage to any particular person, class of persons, or locality, or to subject any particular person, class of persons, or locality to any undue or unreasonable prejudice or disadvantage.

OI May 2014

Title II Section 208 (Complaints)

- §208 (**Complaints to the Commission**): Any person, any body politic or municipal organization, or State commission, complaining of anything done or omitted to be done by any common carrier subject to this Act, in contravention of the provisions thereof, may apply to said Commission by petition which shall briefly state the facts, whereupon a statement of the complaint thus made shall be forwarded by the Commission to such common carrier, who shall be **called upon to satisfy the complaint** or to answer the same in writing within a reasonable time to be specified by the Commission.

OI May 2014

Title II Section 214

- §214: The Commission shall have power to issue such certificate as applied for, to refuse to issue it, or to issue it for a portion or portions of a line, or extension thereof, or **discontinuance, reduction, or impairment of service**, described in the application, or for the partial exercise only of such right or privilege, and may attach to the issuance of the certificate such terms and conditions as in its judgment the public convenience and necessity may require.

01 May 2014

Title II Section 202 (Privacy)

- (a) IN GENERAL.—Every telecommunications carrier has a duty to protect the confidentiality of proprietary information of, and relating to, other telecommunication carriers, equipment manufacturers, and customers, including telecommunication carriers reselling telecommunications services provided by a telecommunications carrier.
- (b) CONFIDENTIALITY OF CARRIER INFORMATION.—A telecommunications carrier that receives or obtains proprietary information from another carrier for purposes of providing any telecommunications service shall use such information only for such purpose, and shall not use such information for its own marketing efforts.
- PRIVACY REQUIREMENTS FOR TELECOMMUNICATIONS CARRIERS.—Except as required by law or with the approval of the customer, a telecommunications carrier that receives or obtains customer proprietary network information by virtue of its provision of a telecommunications service shall only use, disclose, or permit access to individually identifiable customer proprietary network information in its provision of (A) the telecommunications service from which such information is derived, or (B) services necessary to, or used in, the provision of such telecommunications service, including the publishing of directories.

01 May 2014

Title II Section 251

- (a) GENERAL DUTY OF TELECOMMUNICATIONS CARRIERS.—Each telecommunications carrier has the duty—
 - (1) to interconnect directly or indirectly with the facilities and equipment of other telecommunications carriers; and
 - (2) not to install network features, functions, or capabilities that do not comply with the guidelines and standards established pursuant to section 255 or 256.

OI May 2014

Section 706 authority

- **Section 706 is an independent grant of authority**
 - OI Order explicitly rejected Advanced Services Order language that 706 "does not constitute an independent grant of authority" → D.C. Circuit satisfied.
- **The Commission had rightly identified harms that fall within the scope of its authority under 706**
 - Virtuous circle (edge innovation drives consumer demand, which stimulates broadband investment, which leads to more edge innovation and investment) is a legitimate reason for promulgating OI rules.
 - Broadband providers have incentives and ability to discriminate against edge providers → prophylactic rules appropriate.

OI May 2014

DC Circuit: discrimination rule

- "Little hesitation" in concluding that nondiscrimination rule = common carriage regulation.
- The rule requires broadband providers to offer service to all edge providers → "by its very terms compels . . . providers to hold themselves out 'to serve the public indiscriminately,'" which is the essence of common carriage.
- Commission never argued that the "no unreasonable discrimination" standard differed from the general nondiscrimination standard that applies to common carriers.

OI May 2014

OI NPRM May 2014

- Seeks comments on applying Section 706 or Title II
- Ban paid prioritization outright?
- Initial comments until July 15, reply comments until September 10
- Includes a rebuttable presumption that exclusive contracts that prioritize service to broadband affiliates are unlawful
- Tentatively excludes peering and interconnection

OI May 2014

OI NPRM: transparency

- Enhance the transparency rules to provide increased and specific information about broadband providers' practices for edge providers, consumers.
- Asks whether broadband providers should be required to disclose specific network practices, performance characteristics (e.g., effective upload and download speeds, latency and packet loss) and/or terms and conditions of service to end users (e.g., data caps).
- Tentatively concludes that broadband providers should disclose "meaningful information" about the service, including (1) tailored disclosures to end users, (2) congestion that may adversely impact the experience of end users, including at interconnection points, and (3) information about new practices, like any paid prioritization, to the extent that it is otherwise permitted.

OI May 2014

OI NPRM: transparency

- Audience-specific disclosure
 - consumer “nutrition label”
 - include more than just intra-network performance
 - edge providers (CDN, transit providers)
 - performance
 - peering policy?
- Metrics
 - network performance: averages, variability
 - built-in measurements at finer geographic scale
 - bandwidth caps (and tools)
 - N-year cost

ExampleCom Ultra 15 Mbps Broadband Truth-in-Labeling	
Advertised Speed	15 Mbps downstream/2 Mbps upstream
Service Guarantees Services are measured from and to the border router.	
Minimum Speed at Border Router	8Mbps downstream, 2Mbps upstream
Avg. Reliability/Uptime	99%
Maximum Round-trip Latency (Delay) to Border Router	50ms
Service Guarantee Terms	Daily service credit upon request for any outages or extended periods of under-delivery of service
Price	\$44.99 monthly service \$79.99 monthly for the first six months on promotion
Service Limits (Limit all traffic management techniques)	<ul style="list-style-type: none"> ▪ Exceeding 10GB/Calendar week considered excessive use, subject to disconnect penalties, see http://www.examplecom.com/disconnectPenalties ▪ Traffic by heavy users in congested areas is artificially slowed, see http://www.examplecom.invalidShaping
Other Fees (ISPs cannot charge if not listed)	<ul style="list-style-type: none"> \$3 monthly modem rental fee \$10 early cancellation fee \$19 outlet installation \$130 early termination during promotion period \$50 service call fee unless \$3 monthly usage maintenance plan is in force Sales taxes and franchise fees, vary by location
Contract Term	All will, customer may cancel at anytime after first six months. During the first six months, a cancellation results in a \$100 fee.
Service Technology	DOCSIS 4.1 / 2.0 HFC
Legal and Privacy Policies	http://www.examplecom.com/legal

New America Foundation example

OI May 2014

OI NPRM: Rule proposals

- Prohibit blocking
- Non-blocking requires minimum level of service:
 1. “best effort”
 2. minimum quantitative performance
 3. “reasonable person” standard
- Applicability to mobile
 - 2010: web sites, voice & video telephony
 - expand to other competing applications?
- “Commercially reasonable” for discrimination

OI May 2014

OI NPRM: Enforcement

- Proposes the creation of an ombudsperson with significant enforcement authority to serve as a watchdog and advocate for start-ups, small businesses and consumers.
- Seeks comment on how to ensure that all parties, and especially small businesses and start-ups, have effective access to the Commission's dispute resolution and enforcement processes.
- Considers allowing anonymous reporting of violations to alleviate fears by start-ups of retribution from broadband providers.

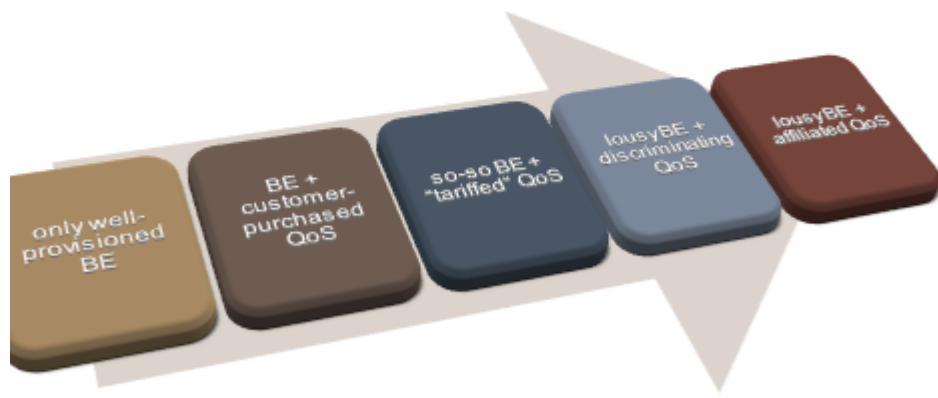
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What could “fast lane” mean?

- Separate mechanism from who pays
 - e.g., customer buys “commercial-grade” service (SLA)
 - edge provider pays
- Separate logical IP-based “pipe” to end user
 - e.g., U-Verse “cable TV” video delivery
 - may be faster than broadband Internet service
- Resource reservation
 - guaranteed bandwidth (e.g., similar to MPLS CIR)
- Scheduling or drop priority
 - priority packets get priority access to shared resources
- Impact on best-effort services
 - well-provisioned vs. artificial starvation

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Range of concerns



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Differentiation universe

Behavior	Content-neutral	By content type	By edge provider
Packet dropping, RST, delay		P2P	VoIP (non-US)
Limit flow bandwidth (e.g., 10 Mbps/flow)	TMo: reduce speed after cap		
Specialized service			BIAS or affiliated
Interconnection	refuse all peering		Cogent, Level3, Netflix
Bandwidth cap (e.g., 10 GB/month)		Satellite (count only video)	AT&T proposal
App restrictions		ISIS payment app bootloader	FaceTime

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The problem with analogies

- “Fast lane”
 - implicitly assumes that congestion is normal and unavoidable
 - confused with different consumer subscription levels
 - Google 5/1 service is “slow lane”
 - unclear whether impairment is
 - artificial → induce upgrade

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Specialized services

- R&O 2010: “services that share capacity with broadband Internet access service over providers’ last-mile facilities”
 - FCC OIAC report noted definitional difficulty
 - separate logical facilities?
 - cannot reach almost all IP addresses?
- EuP 2014: “an electronic communications service optimised for specific content, applications or services, or a combination thereof, provided over logically distinct capacity, relying on strict admission control, offering functionality requiring enhanced quality from end to end, and that is not marketed or usable as a substitute for internet access service.”

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Specialized services

- What's the difference to offering a "fast lane"?
- Definitional
 - only available to facilities-based provider (but not restricted)
 - doesn't provide access to whole Internet
 - would include CDN and Netflix deals
- Capacity impact
 - reduce investment into general-purpose Internet
 - or encourage benign neglect (middle mile, peering, ...) → US DSL
- Remedies
 - treat "specialized service" as catch-all non-BE service class subject to "commercially reasonable" restrictions

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Other issues

- Device attachment & software apps
 - Can a provider prevent use of software, such as tethering or video apps?
 - Alternate boot loader and OS versions?

NETWORK MEASUREMENTS

Henning Schulzrinne
FCC

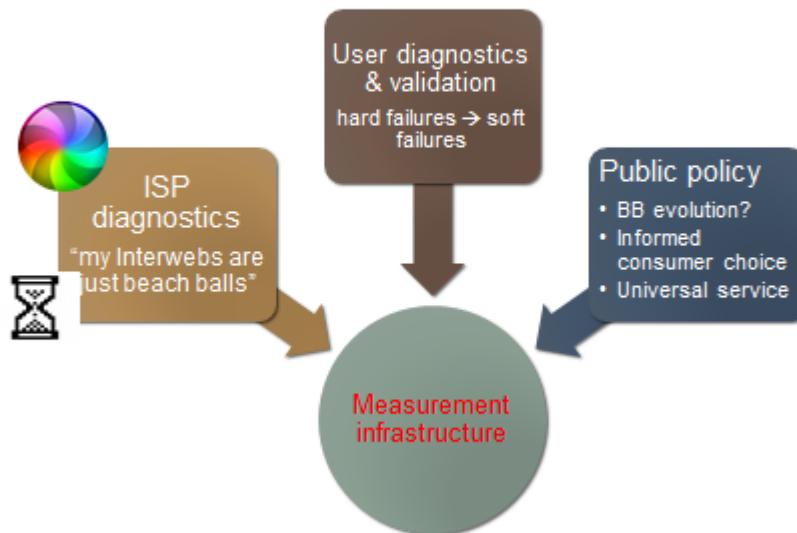
FCC measurement history

- FCC has acquired and analyze data on legacy PSTN
- More recent and evolving broadband interest
 - Section 706 of 1996 Telecommunications Act → annual report on availability of advanced telecommunications services to all Americans
 - Resulted in information on deployment of broadband technology ("Form 477")
 - but not its performance
 - FCC's National Broadband Plan – March 2010
 - Proposed performance measurements of broadband services delivered to consumer households
 - Work plan evolved from recommendations of National Broadband Plan

Consumers don't know

- FCC survey: 80% of consumers didn't know speed they purchased from their ISP
- 49% of consumer volunteers inaccurately reported their advertised broadband speed
- Sources of data found lacking
- → New approaches and tools for understanding consumer broadband needed

The role of network measurements



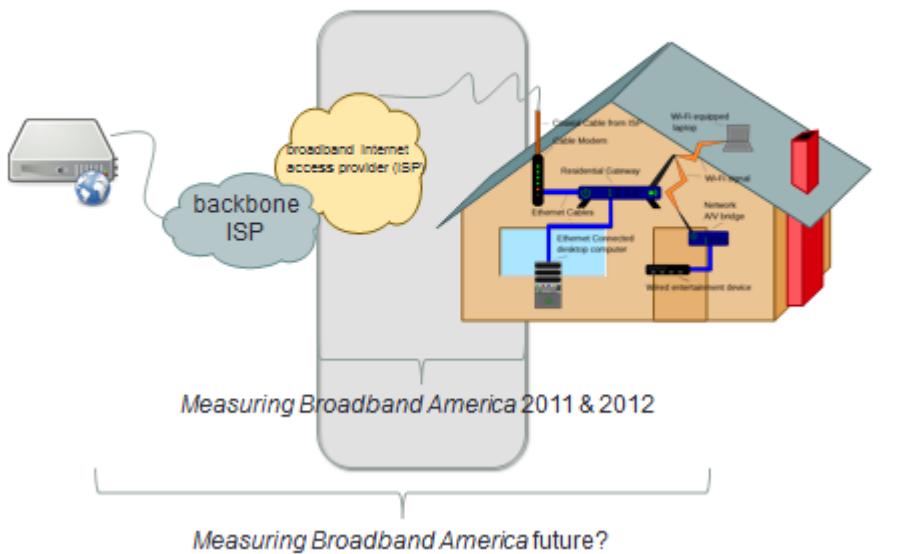
Principles

- The FCC Measuring Broadband America program is based on principles of openness, transparency and partnership with diverse stakeholders.
- We are committed to:
 - Ensuring that commonly accepted principles of *scientific research, good engineering practices, and transparency* guide the program;
 - Encouraging *collaboration* of industry, academia and government;
 - *Publishing the comprehensive technical methodology* used to collect the data, including the source code for the tests as open source;
 - *Releasing data* used to produce each report coincident with the report's release, and releasing all data for each collection cycle within one year of collection.

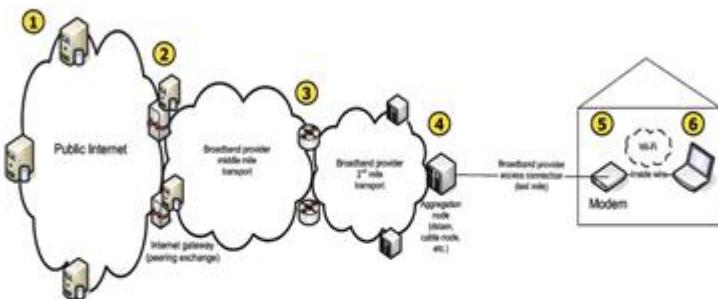
Fixed Testing Panel

- Panel of U.S. broadband subscribers drawn from pool of 145,000+ volunteers Goal of covering major ISPs in the 48 contiguous states across five broadband technologies: DSL, cable, fiber-to-the-home, fixed terrestrial wireless, and satellite
- Four Census Regions and split into speed ranges
- Whiteboxes distributions based on market share of participating ISPs
- Pre-collection "True-up" maintaining panel

Measurement architecture



Measurement Architecture



DEFINITIONS

- ① **Public Internet content:** public Internet content that is hosted by multiple service providers, content providers and other entities in a geographically diverse (worldwide) manner
- ② **Internet gateway:** closest peering point between broadband provider and public Internet for a given consumer connection
- ③ **Link between 2nd mile and middle miles:** broadband provider managed interconnection between middle and last mile
- ④ **Aggregation node:** first aggregation point for broadband provider (e.g. DSLAM, cable node, satellite, etc.)
- ⑤ **Modem:** Customer premise equipment (CPE) typically managed by a broadband provider as the last connection point to the managed network (e.g. DSL modem, cable modem, satellite modem, optical networking terminal (ONT), etc.)
- ⑥ **Consumer device:** consumer device connected to modem through internal wire or Wi-Fi (home networking), including hardware and software used to access the Internet and process content (customer-managed)

Figure 4: Year by Year Comparison of Panelist Population by Speed Tier—March 2011 and April 2012 Test Data

2011 Range	2012 Range									
	0-1	1-3	3-7	7-10	10-15	15-20	20-25	25-30	30-50	50+
0-1	37.50%	15.28%	16.67%	2.08%	15.28%	7.64%	2.78%	1.39%	0.00%	1.39%
1-3	3.61%	56.71%	17.64%	3.81%	7.82%	7.01%	1.40%	1.60%	0.40%	0.00%
3-7	2.80%	1.49%	63.72%	3.86%	11.31%	12.97%	1.14%	1.67%	0.88%	0.18%
7-10	1.27%	0.25%	3.82%	22.14%	58.02%	6.62%	2.29%	1.53%	3.82%	0.25%
10-15	1.27%	0.29%	2.61%	0.93%	30.80%	51.07%	3.42%	4.86%	4.05%	0.69%
15-20	0.92%	0.13%	1.45%	0.39%	5.91%	55.58%	6.44%	5.52%	21.29%	2.37%
20-25	1.13%	0.23%	1.13%	0.00%	2.48%	13.51%	44.59%	30.63%	4.05%	2.25%
25-30	0.35%	0.35%	1.05%	0.70%	2.81%	7.37%	4.91%	65.96%	13.33%	3.16%
30-50	2.02%	0.00%	0.00%	1.01%	2.02%	2.02%	1.01%	2.02%	74.75%	15.15%
50+	3.33%	0.00%	0.00%	0.00%	3.33%	6.67%	0.00%	10.00%	3.33%	73.33%

The MBA project - logistics

- Enlisted cooperation:
 - 13 ISPs covering 86% of US population
 - vendors, trade groups, universities and consumer groups
- Reached agreement reached on what to measure and how to measure it
- Enrolled roughly 9,000 consumers as participants
 - 6,800 (7,782) active during March 2011 (April 2012)
 - A total of 9,000 active over the data collection period

What is measured

Sustained Download	Burst Download
Sustained Upload	Burst Upload
Web Browsing Download	UDP Latency
UDP Packet Loss	Video Streaming Measure
VoIP Measure	DNS Resolution
DNS Failures	ICMP Latency
ICMP Packet Loss	Latency Under Load
Total Bytes Downloaded	Total Bytes Uploaded

Test Load Impact

Test	Target(s)	Duration	Total Est. Daily Volume
Web browsing	9 popular US websites	For: 30 seconds	80 MB
Video streaming ¹	1 off-net test node	Fixed 10 seconds at 768Kbps, 1.2Mbps, 2.2Mbps, 3.7Mbps	60 MB
	1 on-net test node	Fixed 10 seconds at 768Kbps, 1.2Mbps, 2.2Mbps, 3.7Mbps	60 MB
Voice over IP	1 on-net test node	Fixed 30 seconds at 64k	1 MB
	1 off-net test node	Fixed 30 seconds at 64k	1 MB
Download speed ^{2,3}	1 off-net test node	Fixed 30 seconds***	4.5 GB at 50Mbps
			1.72 GB at 20Mbps
	1 on-net test node	Fixed 30 seconds***	858 MB at 10Mbps
			357 MB at 5Mbps
Upload speed ^{4,5}	1 off-net test node	Fixed 30 seconds***	129 MB at 1.5Mbps
			17.4 MB at 2Mbps
	1 on-net test node	Fixed 30 seconds***	87 MB at 1Mbps
			44 MB at 0.5Mbps
UDP latency	1 off-net test node	Permanent	1 MB
	1 on-net test node	Permanent	1 MB
UDP packet loss	1 off-net test node	Permanent	N/A (seen above)
	1 on-net test node	Permanent	N/A (seen above)
DNS resolution	9 popular US websites	For: 3 seconds	0.3 MB
DNS failures	9 popular US websites	N/A (As DNS resolution)	
ICMP latency	1 off-net test node	For: 5 seconds	2MB
	1 on-net test node	For: 5 seconds	2MB
Latency under Load	1 off-net test node	For: 5 seconds	2MB
	1 on-net test node	N/A (As UDP latency)	0.1MB
UDP packet loss	1 off-net test node	N/A (As UDP latency)	0.1MB

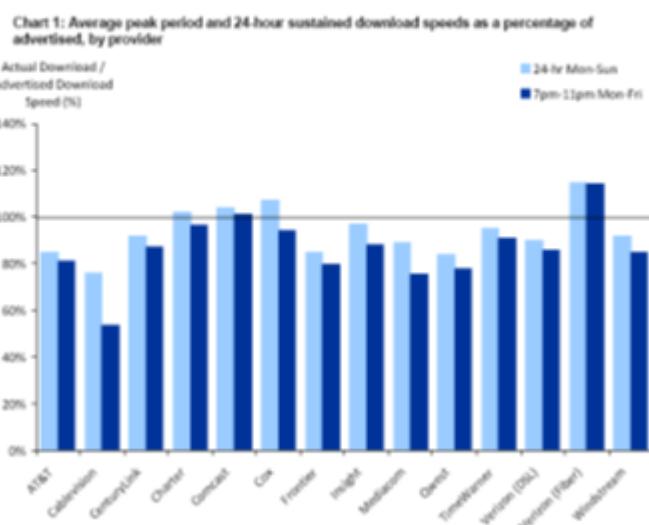
Test Load Impact

- Roughly twice every hour. Some tests report results once per hour.
- Download/upload daily volumes are estimates based upon likely line speeds. All tests operated at maximum line rate so actual consumption may vary.
- Tests run for a fixed duration of 30 seconds, with output the cumulative average transfer speed every 5 seconds (i.e., the first average is for seconds 0-5, the second is for 0-10, etc.)
- 60 seconds prior to and during testing, a 'threshold manager' service detects panelist actively using the Internet connection
- Traffic thresholds set to 64 kbps downstream and 32 kbps upstream.
- Statistics sampled and computed every 10 seconds and test delayed for a minute, retry process would continue for up to 5 times

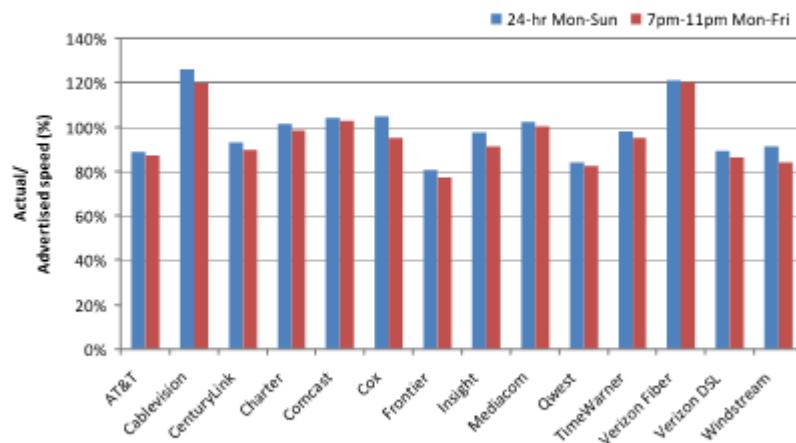
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15

2011: Most ISPs deliver close to advertised during peak hours

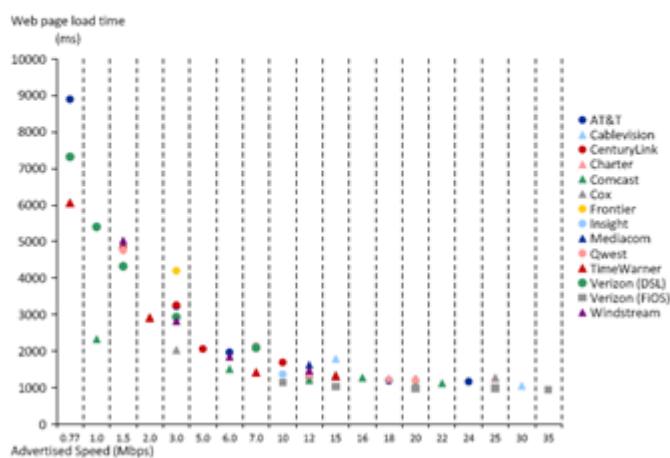


2012: You improve what you measure...



Web page downloading

Chart 10: Web loading time by advertised speed, by technology



Latency by technology

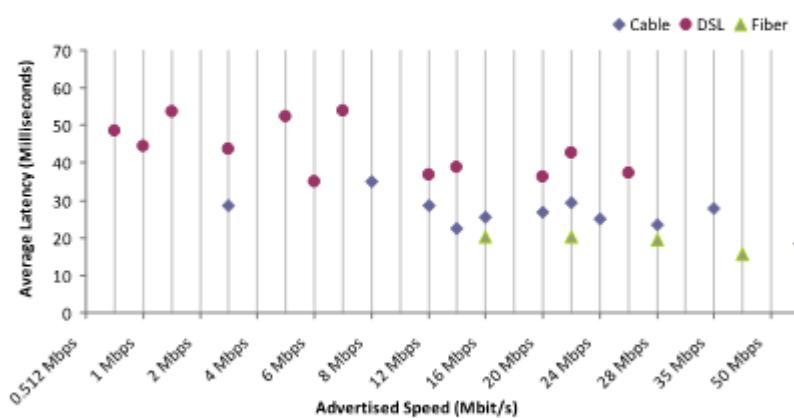
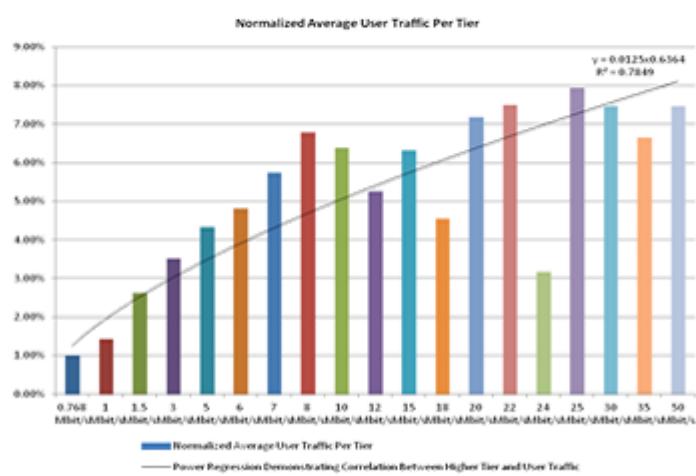
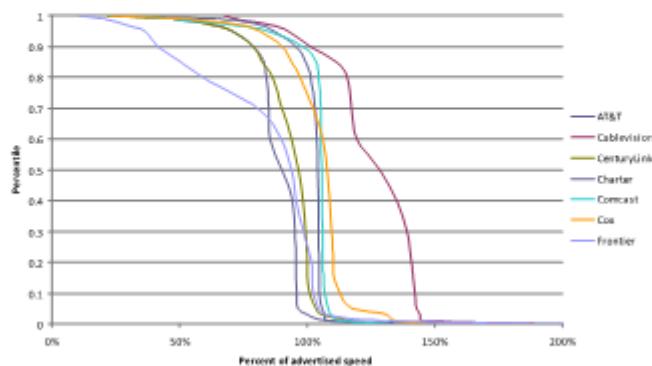


Chart 18: Normalized Average User Traffic—April 2012 Test Data

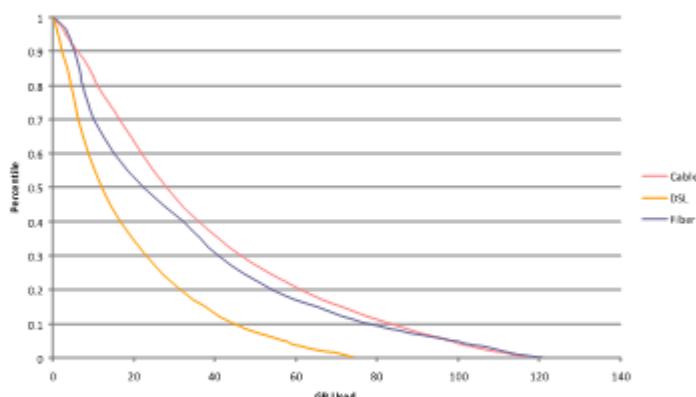


CDF of sustained download speed

Chart 15.1: Cumulative Distribution of Sustained Download Speeds as a Percentage of Advertised Speed, by Provider (7 Providers)—April 2012 Test Data



Data usage



The Internet is not a series of (fixed-width) tubes

- Some cable companies advertise burst speed
 - Quota based technique providing temporary speed increase of < 15 seconds
 - Also affected by other household activity
 - Can't be applied generally to DSL where sync rate often limiting factor
 - Marginal value to fiber where each subscriber has potentially available 37 Mb/s to 75 Mb/s provisioned bandwidth
 - → Links are no longer constant-size bit pipes
- Measured both burst and sustained speed



Measuring Broadband America Mobile

- Expanding the MBA program to mobile broadband networks by releasing the FCC Speed Test App for Android and iPhone
- We employ the same core principles:
 - open and transparent information about mobile broadband performance
 - encourage improvements in mobile broadband networks and drive competition and fact-based decision making

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Speed test apps

- Available to download from Google Play and Apple app store.
- Tests will run as requested by the user, and also automatically on a regularly-scheduled basis (Android only).
 - Measures speed, latency, and packet loss.
- The app is set with a default data limit of 100 MB per month. Users may increase or decrease this amount from within the app.

The screenshot shows the FCC Speed Test app interface. On the left, there's a sidebar with options like 'Mobile data usage report download', 'Select mobile reset', 'Enable device', and 'Enabling device'. The main screen has two tabs: 'Running Tests' (which shows 'Download: 8.64 Mbps', 'Upload: 3.95 Mbps', 'Latency: 61.41 ms', and 'Loss: 0 %') and 'Average Results' (which shows a graph of Mbps over time and a table of results). At the top, it says 'Data Used 27.86MB' and 'Mobile data cap: 100MB'.

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Performance History

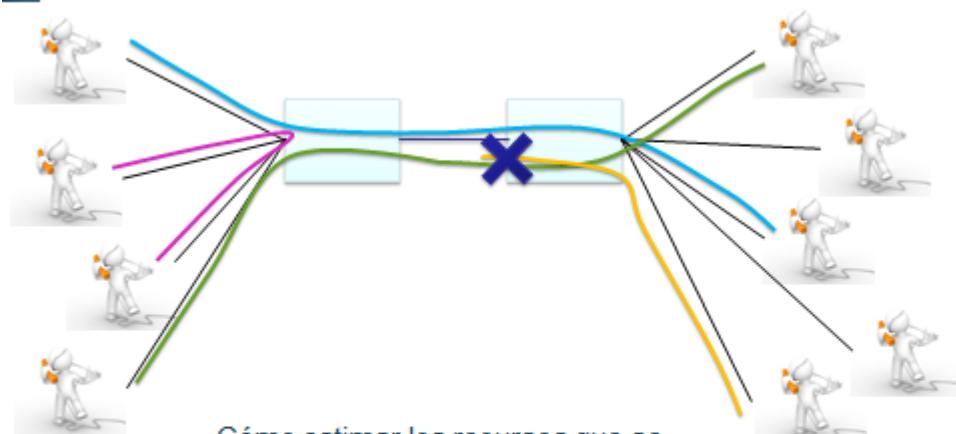
- Consumers can view performance history to see changes in their mobile broadband network performance over time.

The screenshot shows the 'Average Results' screen of the FCC Speed Test app. It features a large graph at the top showing 'Mbps' over time. Below the graph is a table of specific test results:

Date	Location	Mbps
10/10/2012	Washington, D.C.	6.11 Mbps
10/10/2012	Washington, D.C.	1.75 Mbps
10/10/2012	Washington, D.C.	1.53 Mbps
10/10/2012	Washington, D.C.	1.17 Mbps
10/10/2012	New York, NY	0.11 Mbps

1.2 Dr. Teresa Herrera Zamorana

02 El Problema...



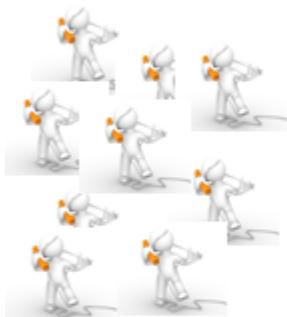
Cómo estimar los recursos que se necesitan para atender la demanda de los clientes, en una estructura de Red compleja

02 El Problema



01 La solución

Éste es un problema con dos poblaciones interaccionando entre sí



Un alto número de clientes que puede decidir utilizar su servicio en cualquier momento



Un alto número de elementos de Red que han de absorber esa demanda

Cómo resolvemos problemas

Warren Weaver

Artículo: "Science and Complexity" American Scientist, 36: 536-544 (1948)



Warren Weaver

Los científicos nos enfrentamos a tres tipos de problemas:

Problemas de Simplicidad

Pocas variables

Problemas de Complejidad Desorganizada

Billones de variables, casi independientes

Problemas de Complejidad Organizada

Nº intermedio de variables, con fuertes interacciones mutuas

Cómo resolvemos problemas

Problemas de Simplicidad

Fórmulas Analíticas

Problemas de Complejidad Desorganizada

Estadística: La ciencia de los valores medios

Problemas de Complejidad Organizada

???
Siglo XX: Teorías de Complejidad

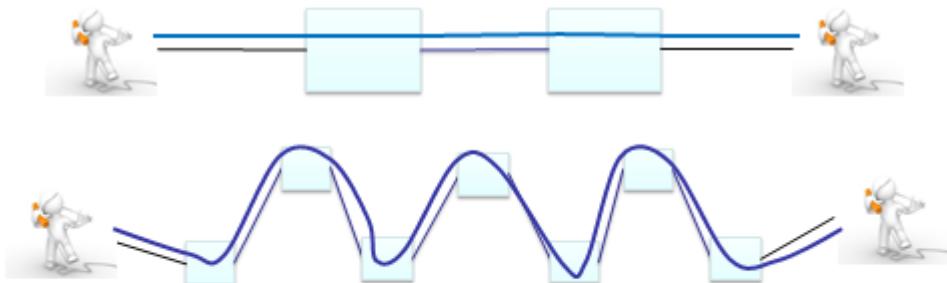
03

¿Cómo es el servicio?

1

La demanda es homogénea

Todos los clientes requieren de la Red el mismo servicio: Un canal de 4 KHz de ancho de banda, reservado de extremo a extremo para la comunicación, por toda su duración.



03 La Demanda: Distribución estadística

2

El tráfico de Voz obedece a una distribución de Poisson

$$P(x, \lambda) = \frac{\lambda^x e^{-\lambda}}{x!}$$

$P(x, \lambda)$ = probabilidad de que ocurran x éxitos, cuando el número promedio de ocurrencia de ellos es λ

λ = media o promedio de éxitos por unidad de tiempo, área o producto

x = variable que nos denota el número de éxitos que se desea que ocurra

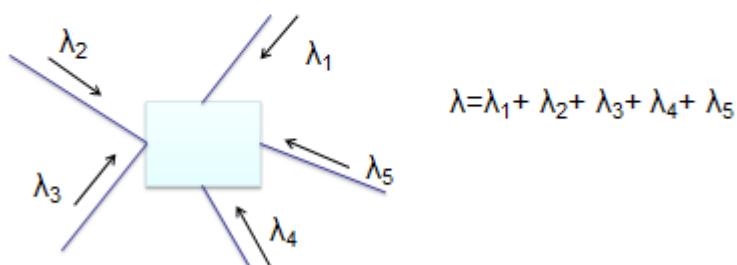
03

¿Son independientes las fuentes, y sus efectos?

4

La Red en conjunto es un sistema lineal.

La suma de procesos de Poisson independientes es también un proceso de Poisson cuyo parámetro es suma de los parámetros de las originales.



04

¿Y qué pasa en las Redes de Datos?

	Redes de Voz	Redes de Datos
1 La Demanda es homogénea		
2 La demanda obedece a una distribución de Poisson		
3 El sistema carece de memoria		
4 El sistema es lineal		

05

¿A qué nos enfrentamos?

- 1 La Demanda es heterogénea
- 2 No existe una distribución estadística universal que describa la demanda
- 3 El sistema tiene memoria
- 4 El sistema es altamente no lineal

El modelado de Redes y Servicios de Datos es un Problema de Complejidad Organizada



05

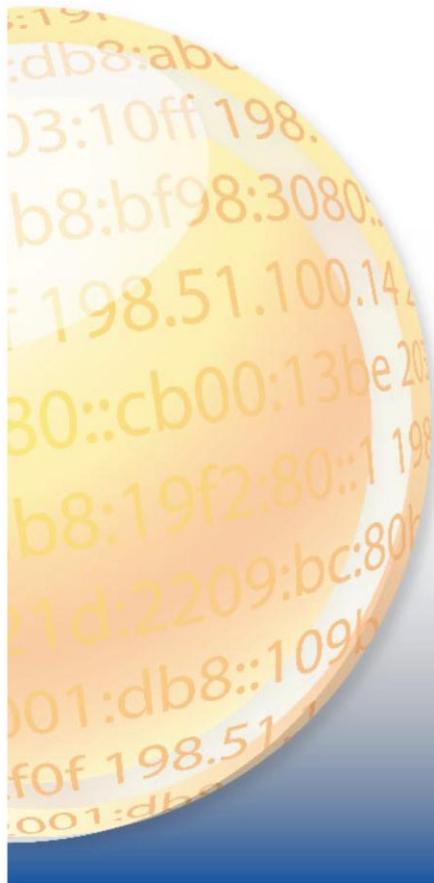
¿A qué nos enfrentamos?

- 1 La Demanda es heterogénea
- 2 No existe una distribución estadística universal que describa la demanda
- 3 El sistema tiene memoria
- 4 El sistema es altamente no lineal



El modelado de Redes
y Servicios de Datos
es un Problema de
Complejidad
Organizada

1.3 Dr. Bert Wijnen



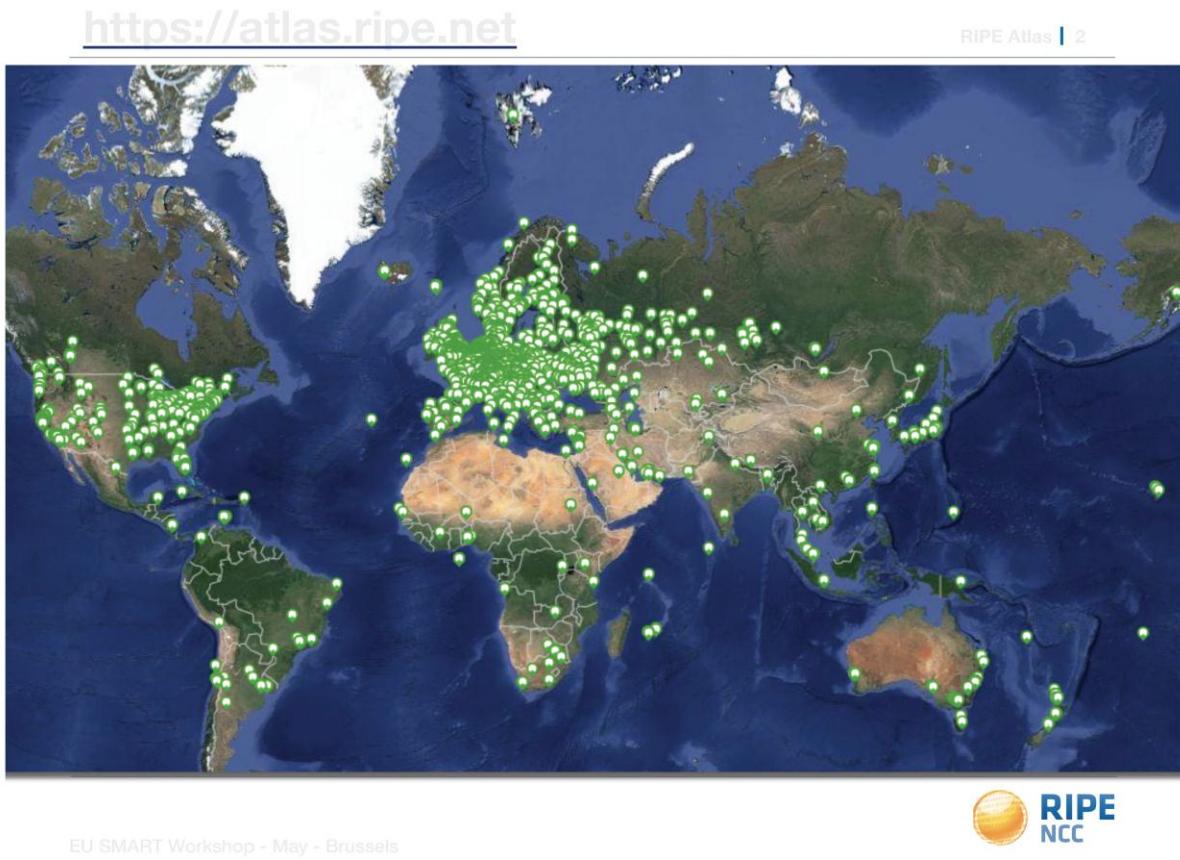
RIPE
NCC

RIPEstat, RIPE Atlas

Bert Wijnen
Science Division

EU SMART workshop, May 2014, Brussels

EU SMART Workshop - May 2014 - Brussels



Network Monitoring

RIPE Atlas | 3

- Network operators use tools for monitoring health of networks
 - Ex: Nagios & Icinga
- Tools can receive input from RIPE Atlas, via API
- Benefits:
 - Pings from 1,000 out of 5,000+ probes around the world
 - Looking at your network from the outside
 - Plug into your existing practices

Integration with Monitoring Systems

RIPE Atlas | 4

Three easy steps:

1. Create a RIPE Atlas ping measurement
2. Go to “Status Checks” URL
3. Add your alerts in Icinga or Nagios

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1. How to Schedule a Measurement

RIPE Atlas | 5

- General case - applicable for ping too!
- Log in to atlas.ripe.net
- Go to “My Atlas” and “Measurements”
- Choose “New Measurement” or “One-Off”
 - Most measurements are periodic & last a long time
 - Choose type, target, frequency, # of probes, region...
 - You will spend credits (next slides)
- More details: <https://atlas.ripe.net/doc/udm>
- Or use API: <https://atlas.ripe.net/docs/measurement-creation-api/>

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1.5 Credit System

RIPE Atlas | 6

- To perform measurements, you spend credits
 - Ping costs 10 credits, traceroute costs 20, etc.
- Credits ensure fairness and protect from overload
- By hosting a probe, you earn credits
- Extra credits can be earned by:
 - Being a RIPE NCC member
 - Hosting a RIPE Atlas anchor or probe
 - Sponsoring RIPE Atlas
- More details: <https://atlas.ripe.net/doc/credits>

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2. Creating Status Checks

RIPE Atlas | 7

- Status Checks work via RIPE Atlas [RESTful API](#)
 - https://atlas.ripe.net/api/v1/status-checks/MEASUREMENT_ID/
- You define the alert parameters:
 - Threshold for % of probes that successfully received reply
 - How many most recent measurements to base the status on
 - Maximum acceptable packet loss
- Documentation:
 - <https://atlas.ripe.net/docs/status-checks/>



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3. Icinga Examples

RIPE Atlas | 8

- Community of operators contributed configuration code!
 - Making use of the built-in “check_http” plugin
- GitHub examples:
 - https://github.com/RIPE-Atlas-Community/ripe-atlas-community-contrib/blob/master/scripts_for_nagios_icinga_alerts
- Post on Icinga blog:
 - <https://www.icinga.org/2014/03/05/monitoring-ripe-atlas-status-with-icinga-2/>



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Monitoring DNS

RIPE Atlas | 9

- “Old” DNSMON service migrated to RIPE Atlas
- RIPE Atlas anchors used as vantage points
 - instead of TTM boxes
- Currently monitoring small selection of zones
 - root name servers
 - 30 ccTLDs and few gTLDs
- New zones will be added next year
- Give us feedback about DNS alerts!
- https://labs.ripe.net/Members/fatemah_mafi/updated-dns-monitoring-service

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RIPE Atlas: April 2014

RIPE Atlas | 11

- 5,200+ active probes
- 7,000+ active users
- 52+ active RIPE Atlas anchors
- Four types of customised measurements available to probe hosts and RIPE NCC members:
Ping, Traceroute, DNS, SSL

Country	Probes
United States	855
Germany	819
Russian Federation	724
United Kingdom	604
Netherlands	458
France	398
Ukraine	364
Belgium	184
Italy	166
Czech Republic	161

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Measurement Devices

RIPE Atlas | 12

- v1 & v2: Lantronix XPort Pro
- v3: TP-Link TL-MR3020 powered from USB port
 - Does not work as a wireless router
 - Same functionality as the old probe!
- RIPE Atlas anchor: Soekris net6501-70



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RIPE Atlas Anchors

RIPE Atlas | 13

- Anchors: well-known targets and powerful probes
 - Regional baseline & “future history”
- Anchoring measurements
 - Measurements between anchors
 - 200 probes target each anchor with measurements
 - Each probe measures 4-5 anchors
- Vantage points for new DNSMON service
- Host are responsible for the hardware
- Benefits: <https://atlas.ripe.net/about/anchors/>



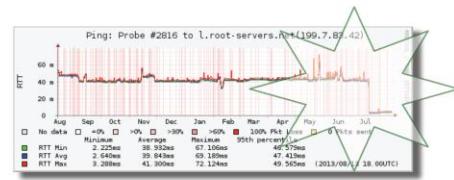
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Success Stories

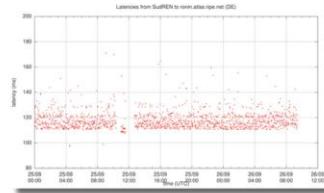
RIPE Atlas | 14

- IXP: Measuring the effect of installing L-root in Belgrade/SOX



- DNS: Looking for most popular instances of .FR anycast servers
- Events: Measuring Internet outage in Sudan

Name server instance	Nr. of probes connecting to instance	Percentage
dns.th2.nic.fr	173	36%
dns.fra.nic.fr	173	36%
dns.lon.nic.fr	47	10%
dns.lyr2.nic.fr	29	6%
dns.lyr1.nic.fr	25	5%
dns.bru.nic.fr	19	4%
dns.ix1.nic.fr	18	4%



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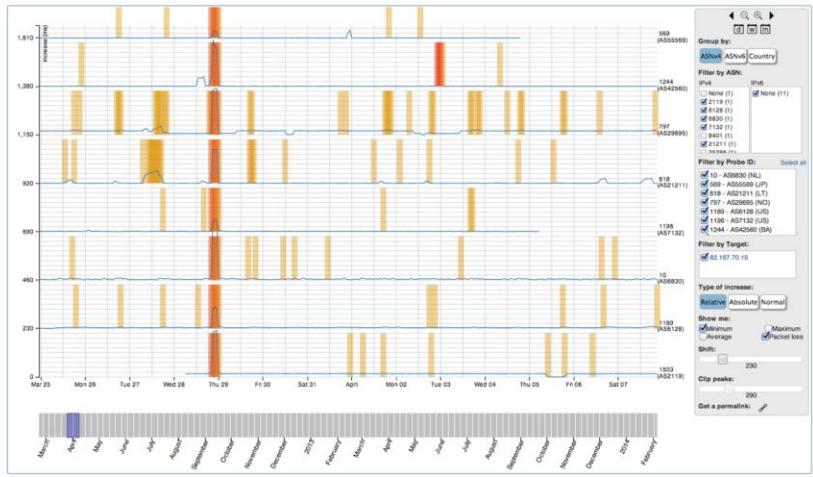


New Features

RIPE Atlas | 15

- Seismograph

- Multiple ping measurements in one view
- Stacked chart and interactive control panel



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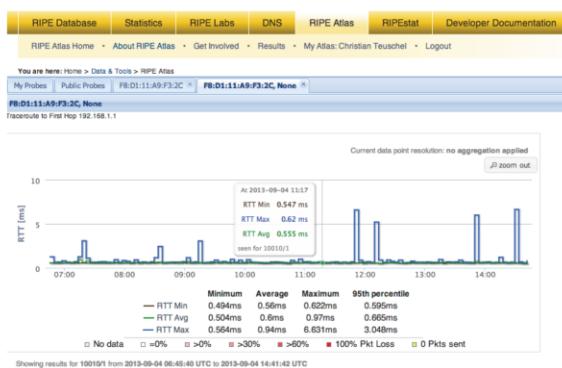


New Features

RIPE Atlas | 16

- Zoomable ping graph

- Replacing multiple RRDs graphs: zoom in/out in time in the same graph
- Easier visualisation of an event's details
- Selection of RTT class (max, min, average)



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Plans For The Future

RIPE Atlas | 17

- Tagging probes and measurements as “My Favourites” for easy viewing and selection
- More IPv6-related features
- Increasing probe distribution via RIR cooperation
- Tell us your feature requests:
 - <http://roadmap.ripe.net/ripe-atlas/>

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The RIPE Atlas Community GitHub

RIPE Atlas | 19

- If you are a **programmer**, contribute your code:
 - <https://github.com/RIPE-Atlas-Community/>
- If you are **researcher**, look & contribute here:
 - <https://github.com/RIPE-Atlas-Community/RIPE-Atlas-data-analysis>
- Measurements **source code** available:
 - https://labs.ripe.net/Members/philip_homburg/ripe-atlas-measurements-source-code



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Become an Ambassador

RIPE Atlas | 20

- If you want to...
 - Help distribute probes
 - Give workshops, tutorials and promote RIPE Atlas
- To become an ambassador:
 - email mcb@ripe.net and we'll ship you some probes
 - <https://atlas.ripe.net/go/ambassadors>
- Or consider becoming a sponsor:
 - <https://atlas.ripe.net/go/sponsors>



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RIPE Atlas 2013 Sponsors

RIPE Atlas | 21



Cable&Wireless
Worldwide



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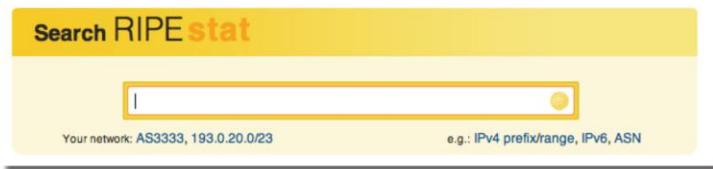


RIPEstat Introduction

RIPEstat | 23

<https://stat.ripe.net>

- RIPEstat is a “one-stop shop” for information about Internet number resources



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RIPEstat Data and Interfaces

RIPEstat | 24

- Search by:
 - IPv4 or IPv6 address/prefix
 - AS Number
 - Hostname
 - Country
 - Keywords (new)
- Data includes:
 - RIPE NCC: registration data and RIPE Database, routing (RIS), reverse DNS, RIPE Atlas measurements
 - External sources: IRR, RIRs, geolocation, blacklists, M-Lab network activity
- Web, widgets, data API, text service, mobile app

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RIPERstat Features

IP Address Introduction | 25

Other features:

- BGPlay2
- Abuse Finder
- Customisable “My Views”
- History view for RIPE NCC members
- Embed widgets on your site

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New Features

RIPERstat | 26

- Multiple widget and resource comparison
- In-widget comparison and monitoring
- Visualising bandwidth capacity and network activity using M-Lab data
- Main old RIS interfaces integrated into RIPERstat
- Tighter integration with RIPE Atlas
 - Zoomable ping graph, Seismograph
- Used extensively for Assisted Registry Checks by Registration Services and LIRs

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RIPEnstat - Data API

RIPEnstat | 27

- RESTful API
- Output: JSON, YAML

```

- data: {
    - first_seen: {
        origin: "39556",
        prefix: "2001:67c:b0::/48",
        time: "2009-12-11T16:00:00"
    },
    - last_seen: {
        origin: "5580",
        prefix: "2001:67c:b0::/48",
        time: "2014-05-14T16:00:00"
    },
    less_specifics: [ ],
    more_specifics: [ ],
    - origins: [
        - {
            origin: 5580,
            - route_objects: [
                "RIPE"
            ]
        }
    ],
    query_time: "2014-05-14T16:00:00",
    resource: "2001:67c:b0::/48",
}

```

- Documentation:
 - https://stat.ripe.net/docs/data_api.html

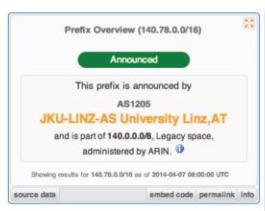
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RIPEnstat - Widget API

RIPEnstat | 28

- “Graphical UI for Data API”
- Build on web standards (HTML, CSS & Javascript)



- Documentation:
 - https://stat.ripe.net/docs/widget_api.html

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Questions & Feedback

RIPEstat | 29

- <https://stat.ripe.net/index/about-ripestat>
- Email:
 - stat@ripe.net
- RIPE Labs:
 - <https://labs.ripe.net/ripestat>

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Contact Us

RIPE Atlas | 30

- RIPE Atlas: <https://atlas.ripe.net>
- Apply for a probe: <https://atlas.ripe.net/apply>
- Apply for an anchor:
<https://atlas.ripe.net/anchors/apply/>
- Mailing list for active users: ripe-atlas@ripe.net
- Articles & updates on RIPE Labs:
<https://labs.ripe.net/atlas>
- Questions: atlas@ripe.net
- Twitter: @RIPE_Atlas and #RIPEAtlas

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1.4 Prof. Peter Heinzmann

cnlab Inputs to the Study on European Internet Traffic: Monitoring Tools and Analysis

Prof. Dr. P. Heinzmann
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Obere Bahnhofstrasse 32b, CH-8640 Rapperswil
peter.heinzman@cnlab.ch, Tel. +41 55 214 3330

07.06.2014

1

Deliverable D4: (Draft) Survey of Measurement and Monitoring

- What type of tools/measurements are supported?
- What is the deployment method?
 - Are end users opting to test?
 - Are researchers implementing passive monitoring?
- Metrics/data collected?
- Is the data open (to the public)?
 - Who has access to the data?
 - Who has access to which parts?
- What is the process for verification?
 - What are best practices for making data verifiable?
- Requirements for mobile networks
 - How do needs of mobile/wireless stretch our measurement and monitoring capabilities?

07.06.2014

2

SMART 2012/0046 Objectives

- analyze existing internet monitoring tools and methodologies
- provide concrete recommendations about the needs and the next steps that Europe should take in this area
 - identify new sources of information beyond the classic active and passive measurement tools
 - find or create new opportunities for data sharing to make it possible to manage Internet performance on a wider scale, while managing privacy concerns and exposures

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3



Information technology research - www.onlab.ch

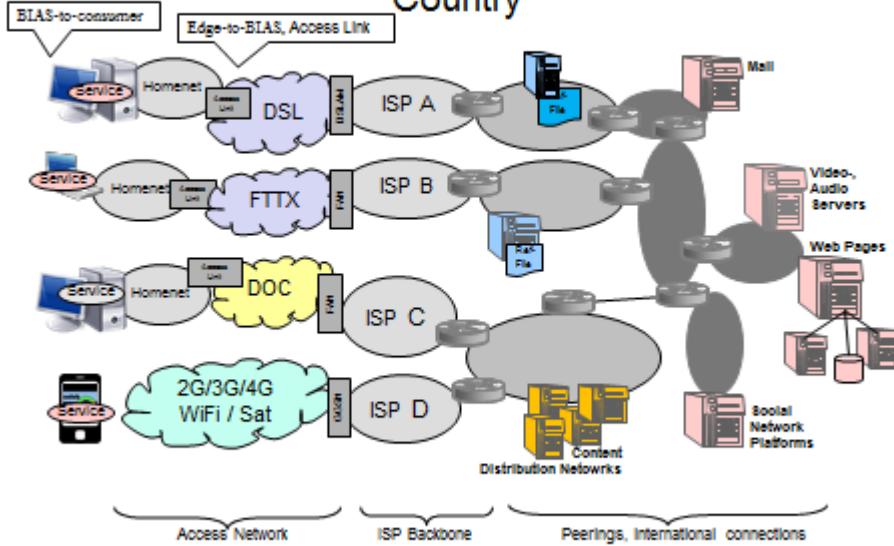
What type of
tools/measurements are
supported?

Internet Traffic vs. Internet Application
Responsiveness Monitoring

07.06.2014

4

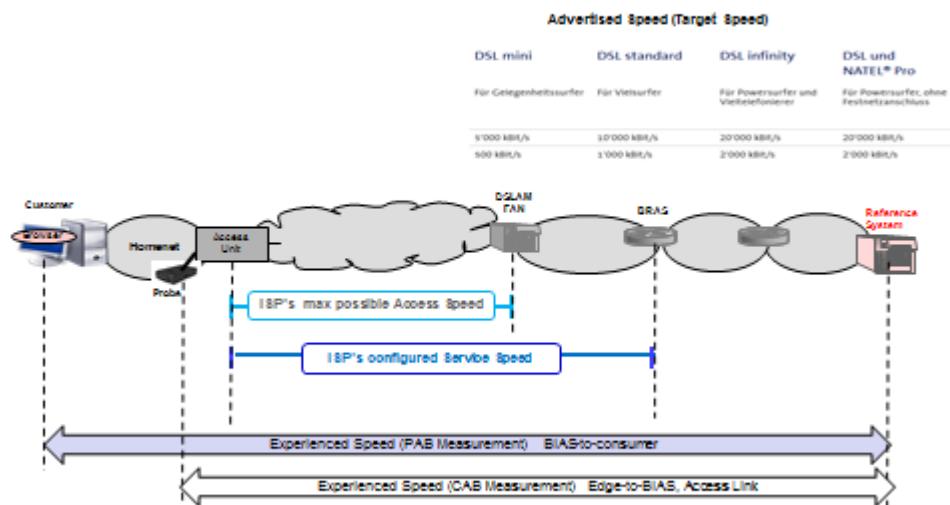
Performance Benchmarking Environment in a Given Country



07.06.2014

5

ISP's Definitions



07.06.2014

6

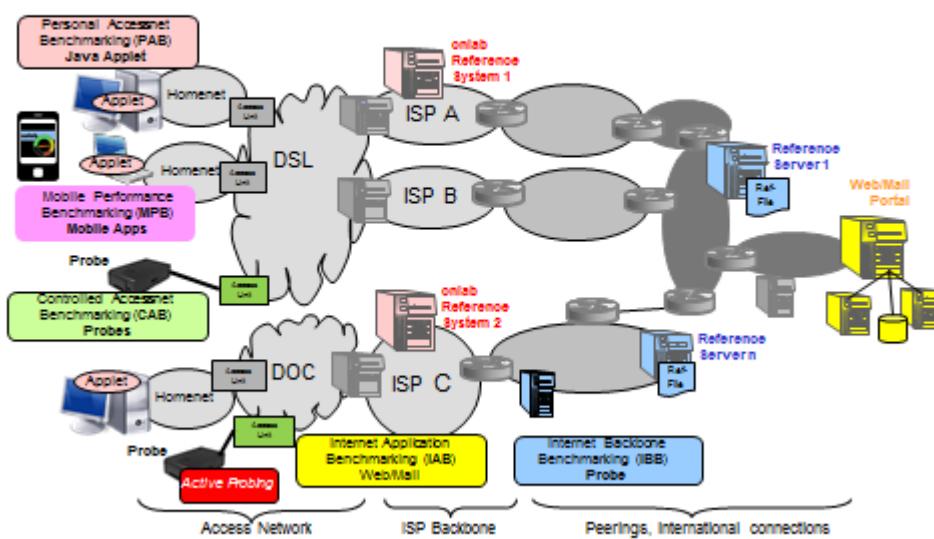
Performance Measurement Platforms Issues

- Type of Organisation
 - Academics (RIPE Atlas, ...)
 - Operators
 - Regulators (SamKnows, measurement broadband America)
 - Companies (Ookla, cnlab)
 - Open X (open street map)
 - Technical Focus
 - Access network (wireline, mobile, wifi, satellite)
 - Interconnection / Peering
 - Service responsiveness (Web, Mail, DNS)
 - Objective
 - QoS
 - Speed fulfillment of advertised speed (users, operators, regulators)
 - Service availability (response time measurements, DNS, Web Servers)
 - Web responsiveness
 - Net neutrality
 - Funding
 - State funding
 - Universities project funding
 - Commercial (licensees)

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7

Performance Benchmarking PAB/MPB, CAB, IBB, IAB (Web/Mail)



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8

cnlab Performance Benchmarking Services

- Personal Access network Benchmarking (PAB)
 - End users (testers) run test
- Controlled Access network Benchmarking (CAB)
 - Probes at residential sites run tests to reference systems and reference servers
- Internet Backbone Benchmarking (IBB)
 - Probes in the ISP backbone run tests to reference systems and reference servers
- Internet Application Benchmarking (IAB)
 - Web / Portal performance
 - Mail performance
- Mobile Performance Benchmarking (MPB)
 - iPhone Speedtest Application
 - Android Speedtest Application
 - Symbian Phones Speedtest Application
- Special services
 - Regulator requirements benchmarking (incl. satellite links)
 - network load testing
 - Debugging, Performance optimization

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9

Stakeholders

- Operators / carriers (cnlab licensees)
Engineering, Marketing, Customer Support
- Users (crowd)
- Regulators
- *Consumer organizations*
- *Media (cnlab clients)*
- *Companies (cnlab clients)*

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10

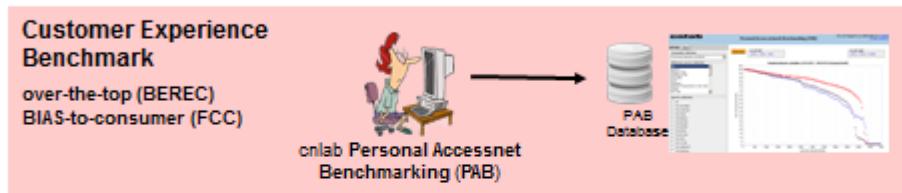
What is the deployment method?

Are end users opting to test?
Are researchers implementing passive monitoring?

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11

Accessnet Benchmarking



07.06.2014

12

Deployment Method: Media & Consumer Organizations

The screenshot shows a news article from SF 1 titled "Aktuelle Sendung vom 26.09.2006". The article discusses pharmaceutical prices, mentioning that in Switzerland, the price for a pill can be up to 50% higher than in Germany. It features a video thumbnail of a woman speaking and a red Formula 1 car with "Analos" branding.

SF SCHWEIZER FERNSEHEN

KASSENSTURZ
Aktuelle Sendung
Archiv

SERVICE
Tests
SMS Dienste
Vergleichsdienste
Beratungsstellen
Links
Literatur

KLARTEXT
Archiv
Doris Sloegl

ÜBER UNS
Geschichte
Galerie

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13

Deployment Method: ISP Marketing/Helpdesk

"Switzerland's number one in broadband Internet:
Fastest average download speed"
according to netindex.com, correct as of 20.03.2014.

Discover now >

How fast do you surf?
Do the speedtest >

Hobbit part 2 now On Demand
Find out more >

Customer satisfaction rate
More information >

MORE Mbit/s per CHF

Networkstatus >
Contact >

Topics
 ① Mobile Support: help topics
 ② Change Day - all information
 > All questions and answers

My UPC
 Your personal customer centre.
 • Order new products.
 • Check your bills
 • View unbilled costs
 • Update profile
 • Activate Replay
 My UPC login >

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14

cnlab Internet Performance Benchmarking Services History (1)

- 1995
 - developed at Computernetzwerklabor Technikum Rapperswil (P. Heinzmann)
- 1996
 - Directory of Internet Service Providers „www disp.ch“ (Th. Lüthi)
 - 24.4.1996 Ktip, Modem Dialup Tests (Th. Lüthi, Ch. Birchler)
- 2000
 - performance test probes: SW developed at cnlab (Th. Bruhin)
- 2001
 - Public Security Tester
- 2002
 - Independent PAB Speed Tester for ADSL sunsite.cnlab-switch.ch (Th. Bruhin)
 - 31.10.2002 InfoWeek, Die Kunst, den richtigen Provider zu finden
- 2003
 - 18.2.2003 Kassensturz, Lahmes ADSL: Swisscom verspricht Besserung
 - Saldo, Facts Reports

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15

cnlab Internet Performance Benchmarking Services History (2)

- 2004
 - 1.2.2004 Pctipp, Mehr Tempo
 - 2.3.2004 Kassensturz, Sicherheitslücken im Internet
 - 29.6. / 5.7.2004 Kassensturz, Internet: Testen Sie Ihren Provider
- 2005
 - 22.2.2005 Kassensturz, Internet: Provider im Geschwindigkeits-Test
 - IBB Probes
- 2006
 - 17.10.2006 Kassensturz, Surfgeschwindigkeit von turbo bis Schneckenpost
 - Integration in EU Project COST298
- 2007
 - IBB probes in backbones of all major Swiss ISPs and international probes in UPC backbone
 - PAB reference servers in 12 countries

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16

cnlab Internet Performance Benchmarking Services History (3)

- 2008
 - BAKOM/OFCOM Benchmarking «Grundversorgung»
- 2009
 - Skylogic Satellitenlink-Tests
- 2010
 - Mobile Performance Benchmarking (MPB) Anwendung für iPhone
 - Mobile Performance Benchmarking (MPB) Anwendung Android
- 2011
 - Mobile Performance Benchmarking (MPB) Anwendung Nokia
 - 1.3.2011 Smartphone Speedtest Ankündigung
 - 13.9.2011 Smartphone Speedtest Bericht
- 2012
 - Integration von Access Unit Daten (Account, Access Profiles)
 - Mobile Performance Benchmarking (MPB) LTE

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17

cnlab Internet Performance Benchmarking Services History (4)

- 2013
 - Saldo Mobile Performance Benchmarking (MPB) Report
- 2014
 - SRF Kassensturz [Datenraten-Anforderungen und –Erreichung](#)
 - TSR On en parle <http://www.rts.ch/la-1ere/programmes/on-en-parle/5793924-internet-haut-debit-vitesse-pas-garantie-07-05-2014.html>

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18

Metrics/data collected?

p. 5, QoS itself is not well defined

p. 29, Lack of standards

QoS (1): EC Directive and BEREC (ECC) Report

- 2002/22/EC Universal Service Directive (as amended by the 2009/136/EC Citizen's Rights Directive) contains some tools to empower consumers to make more informed decisions regarding their choice of ISP and subscription.
- CEPT, Electronic Communication Community (ECC), Report 195 on "Minimum Set of Quality of Service Parameters and Measurement Methods for Retail Internet Access Services", April 2013 by BEREC

QoS (2): Relevance of Technical parameters for the evaluation of typical IAS

Service/Application	Data transmission speed		Delay	Delay variation	Packet loss	Packet error
	Downstream	Upstream				
Browse (text)	++	-	++	-	+++	+++
Browse (media)	+++	-	++	+	+++	+++
Download file	+++	-	+	-	+++	+++
Transactions	-	-	++	-	+++	+++
Streaming media	+++	-	+	-	+	+
VoIP	+	+	+++	+++	+	+
Gaming	+	+	+++	++	+++	+++

- : not relevant

+: slightly relevant

++: relevant

+++: strongly relevant

QoS (2): Definitions of QoS parameters which could be considered for IAS

1. Parameters related to data transmission speed
2. Parameters related to service availability/unavailability
3. Parameters related to delay
4. Parameters related to delay variation
5. Parameters related to losing information/IP packets
6. Parameters related to errored IP packets
7. Parameters applicable to Internet access services that are accessed via a login process
8. Parameters related to access to DNS services
9. Parameters applicable for mobile Internet access services
10. Administrative / Non-technical parameters
11. Subjective evaluation

QoS (3): Recommended Minimum Set of Values and Measurement Units

No.	Parameter	Definition	Determinations of the values and measurement units
1.	Transmission speed	The data transmission rate that is achieved separately for downloading and uploading specified test files between a remote web site and a user's computer. (ETSI EG 202 057-04 clause 5.2)	Minimum and Average values Expressed in Mbit/s or kbit/s
2.	Delay	The delay is half the time in milliseconds that is needed for an ICMP Echo Request/Reply (Ping) to a valid IP address. (ETSI EG 202 057-04 clause 5.5)	Average value Expressed in ms
3.	Delay variation	For a given pair of IP packets, parameters represent the difference between the delay in one direction, measured for two consecutive packets. (As defined in ITU-T Recommendation Y.1540 clause 6.2.4 and with a calculation method being based on ITU-T Rec. Y.1541 Annex III)	Average value Expressed in ms.
4.	Packet loss ratio	The ratio of total lost IP packet outcomes to total transmitted IP packets in a population of interest. (ITU-T Rec. Y.1540 clause 6.4)	Average value Expressed in $\times 10^{-3}$
5.	Packet error ratio	The ratio of total errored IP packet outcomes to the total of successful IP packet transfer outcomes plus errored IP packet outcomes in a population of interest. (ITU-T Recommendation Y.1540 clause 6.3)	Average value Expressed in $\times 10^{-4}$

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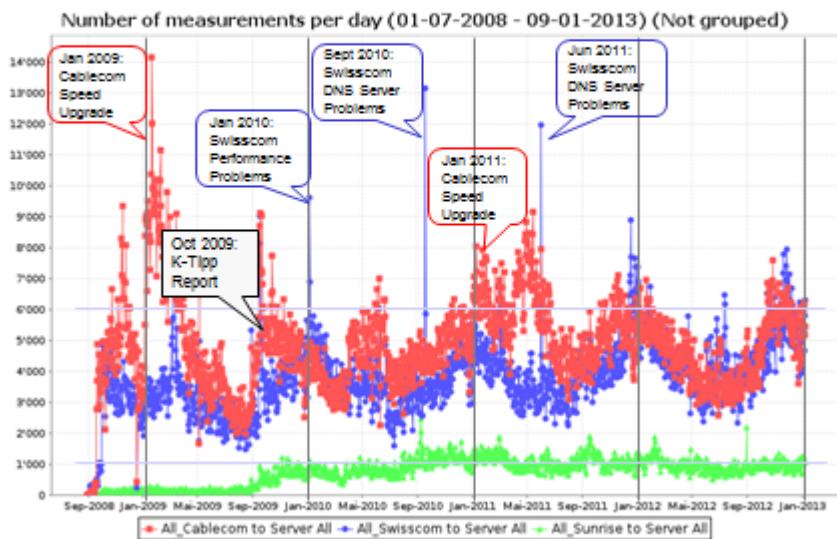
Is the data open (to the public)?

Who has access to the data?
Who has access to which parts?

07.06.2014

24

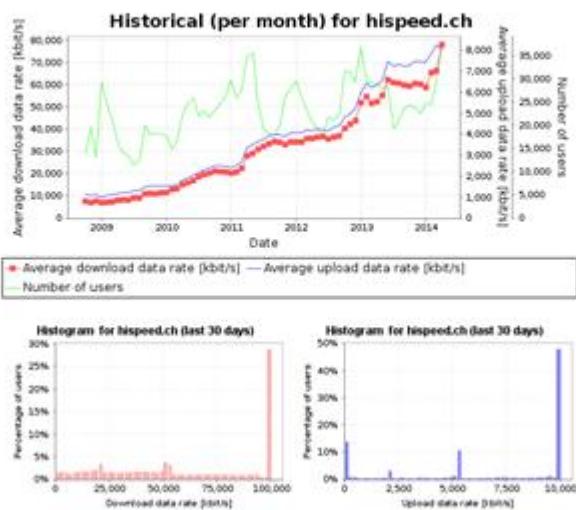
Number of Measurements per Day Cablecom, Swisscom, Sunrise



07.06.2014

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Public Statistics

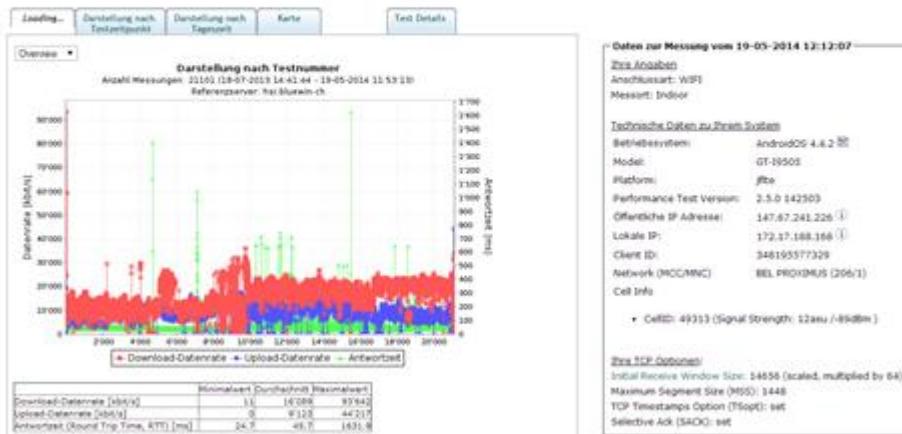


<https://www.cnlab.ch/speedtest/stats.jsp>

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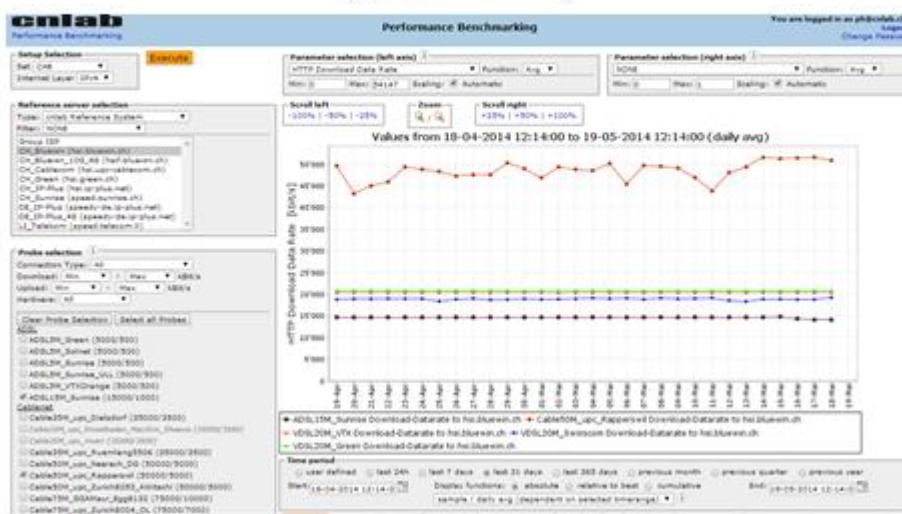
My own Results (MPB Examle)



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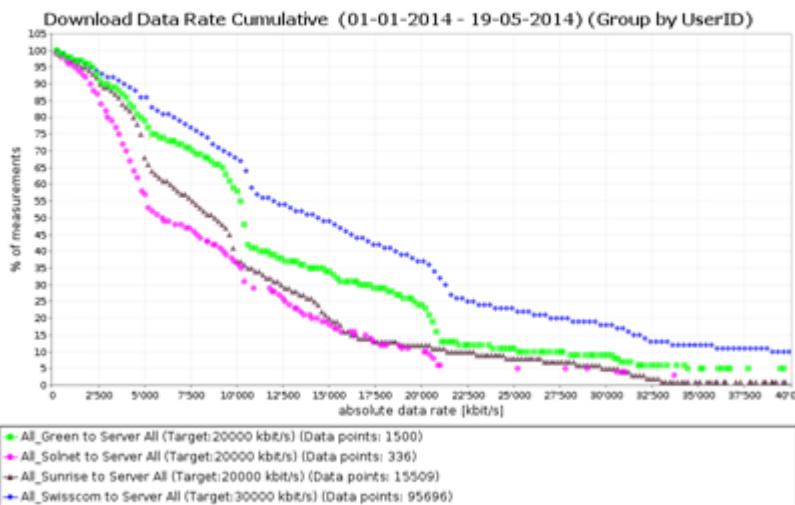
CAB Licensees Statistics (Probes)



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PAB Licensees Statistics (Crowd Measurements)



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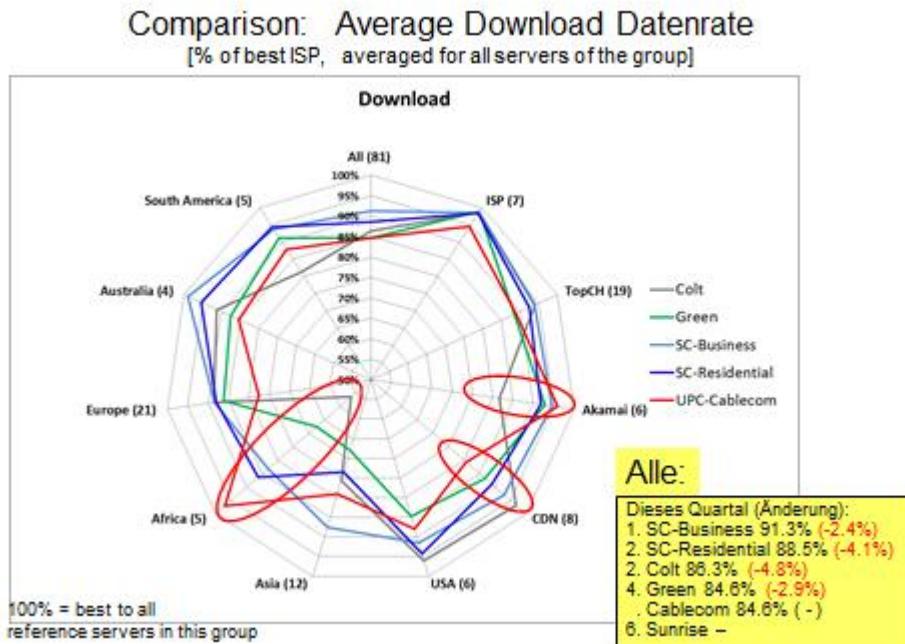
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What is the process for verification?

What are best practices for making data verifiable?

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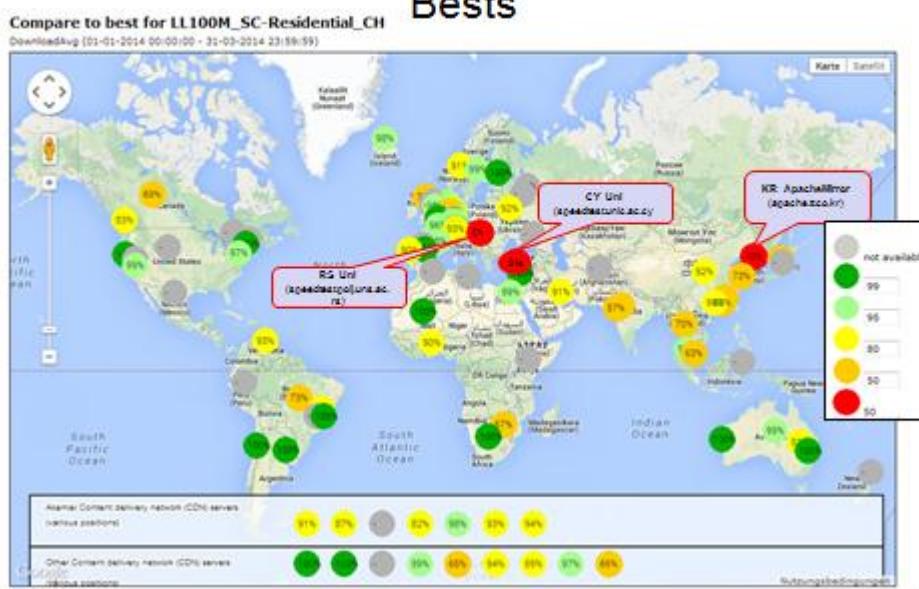
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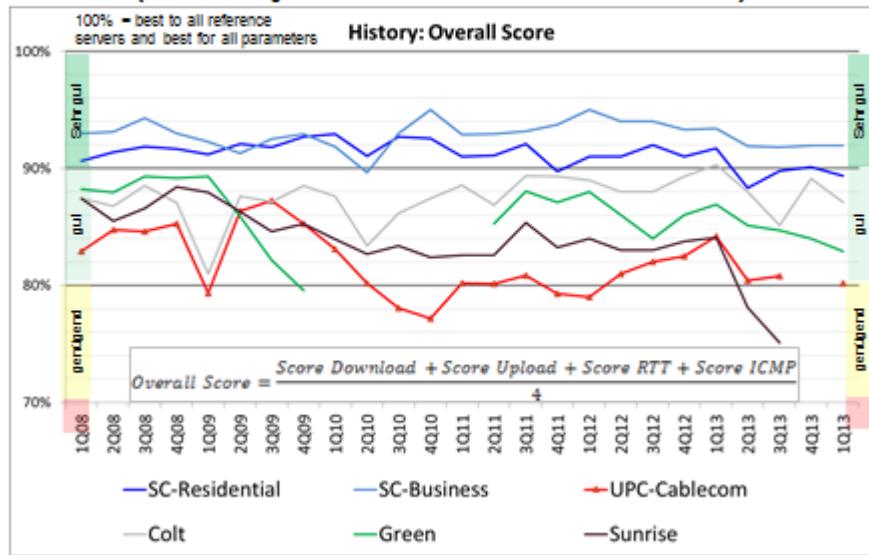
Comparison: Download Datarate Compared to Bests



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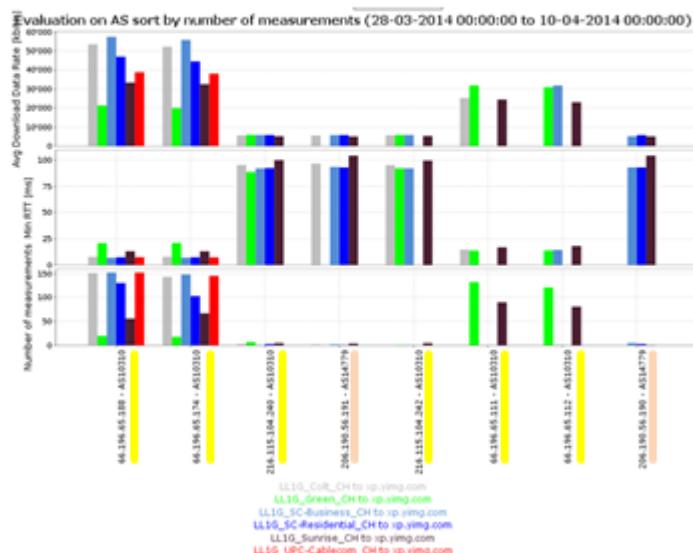
Comparison: Long Term Evolution (History 2008Q1 ... 2014Q1)



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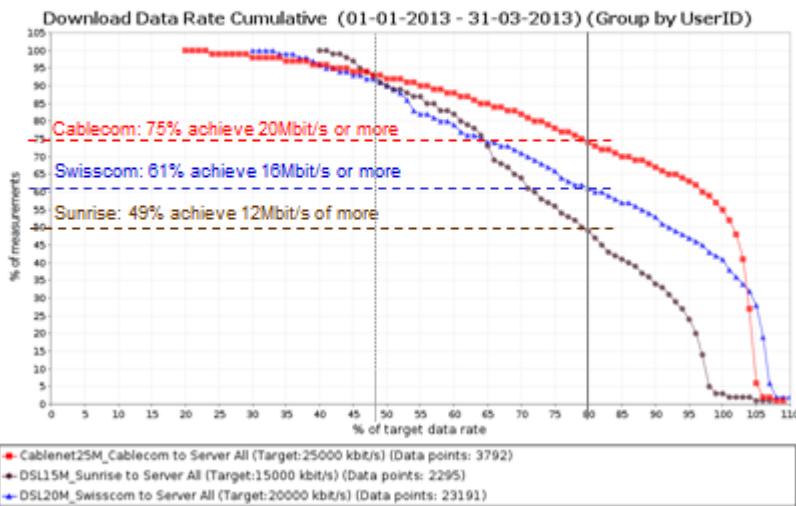
Comparison: CDN by ISP



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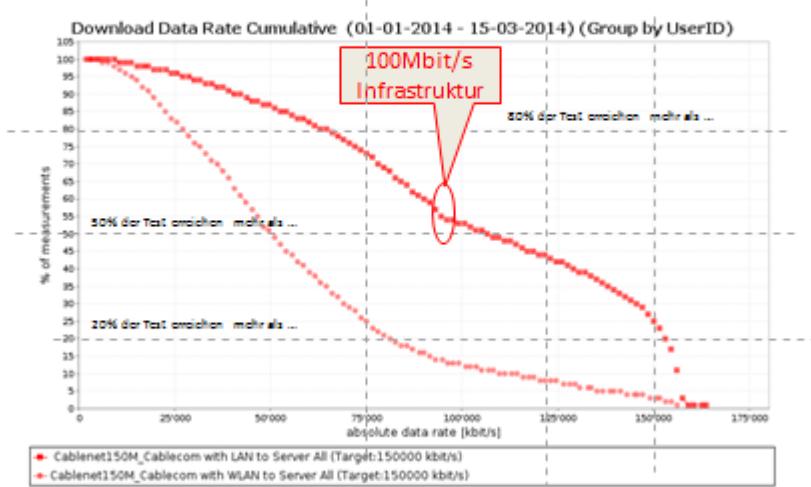
Analysis: Crowd Sourced Results: Experienced Speed / Advertised Speed (20Mbit/s)



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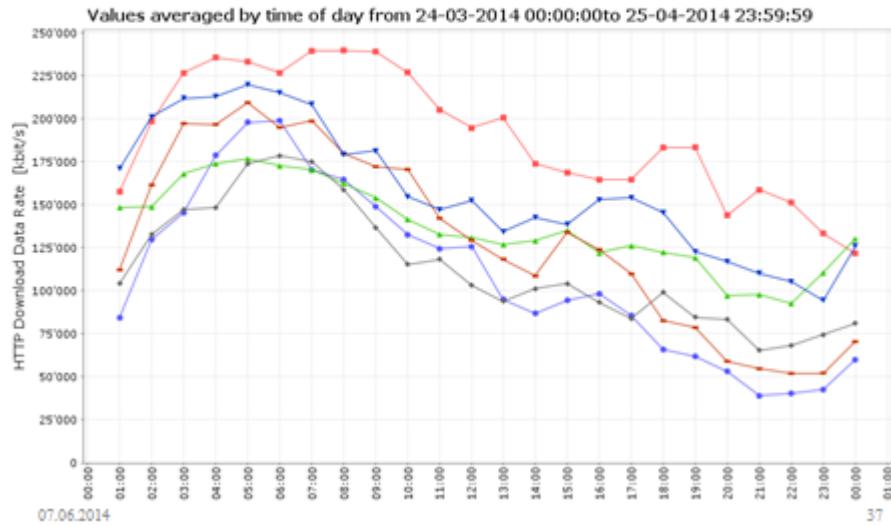
Analysis: PAB upc-cablecom 150M Download LAN vs. WLAN Access



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Analysis: CAB upc-cablecom Probes 250M Download by Time of Day



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Requirements for Mobile Networks

On the end device (browser-based, or Smartphone App)

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MPB Crowd Sourced Approach

- Up to 26'000 measurements per day

- Platforms



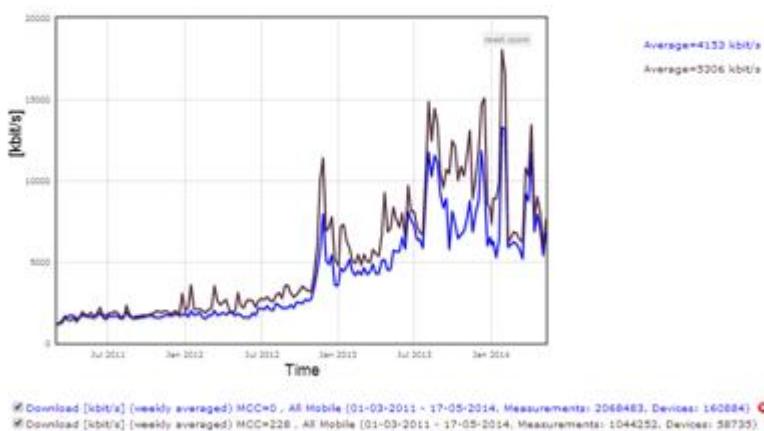
- Simple mode / expert mode app



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MPB Crowd Based Measurements



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Android Measurements (last 30 Days)



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cnlab MPB Apps Parameters (1)

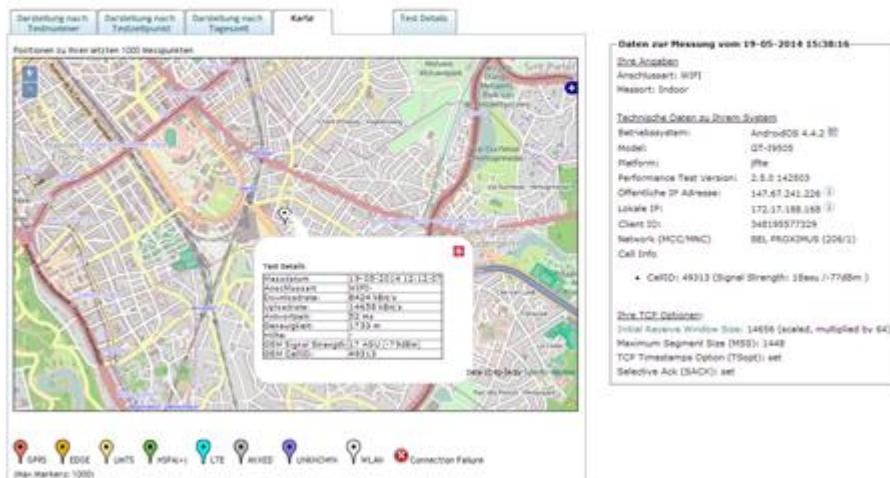
	iPhone	Android	Nokia
User Inputs	inhouse, outdoor, train, car, bus, other		
Performance			
Client Side	Download, Upload Data Rate, TCP Connect Time (min, 7sec avg, max, fastest second)		
Server Side	Download, Upload Data Rate, TCP Connect Time, Packet Loss, TCP Parameters (R_win, cwnd, ...)		
Location			
Logical (Operator)	Mobile Country Code (MCC), Mobile Network Code (MNC)		
Geographic	GPS, WLAN Cell Location, Mobile Cell Location		
Movement	Speed, Distance Travelled during Measurement		
RAN & Connection Parameters			
CellIDs	NA	EDGE CellID: 14783	CellID: 65626510
Received Signal Level (Signal Strength)	NA	Signal Strength: 13esu / -87dBm	Signal Strength: 100%
Connection Type	WWAN	Mobile (GPRS, EDGE)	GsmMode
		CDMA - 1xRTT, - EVDo rev. 0, - EVDo rev. A, - EVDo rev. A)	CdmaMode
		Mobile(UMTS)	
		Mobile(HSDPA)	WcdmaMode
		Mobile(HSPA)	
		LTE	-
	WLAN	WIFI WIMAX	WlanMode
		...	EthernetMode

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Compare with: <http://www.carrieriq.com/what-data-is-collected>

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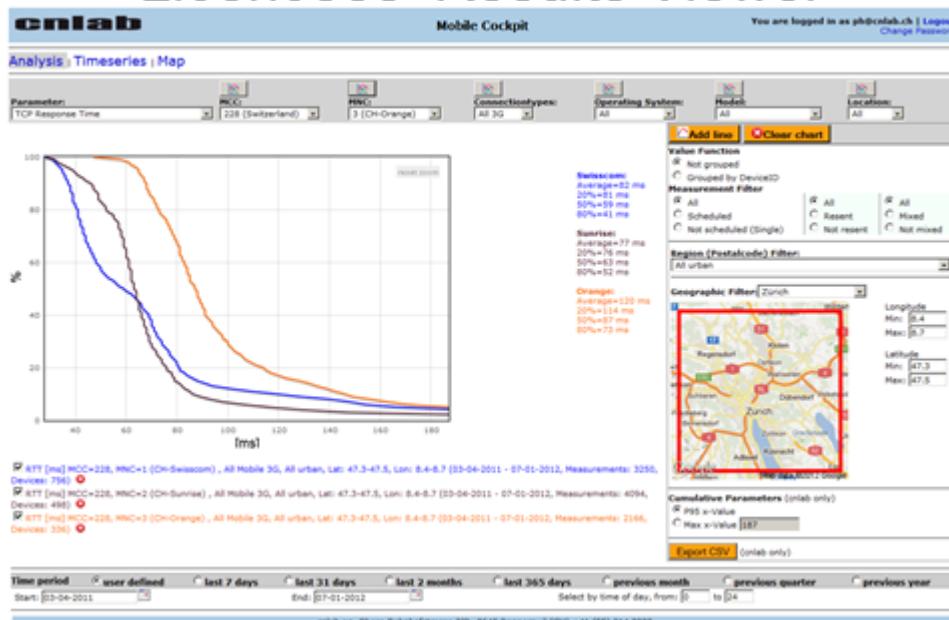
Crowd's Own Results Viewer



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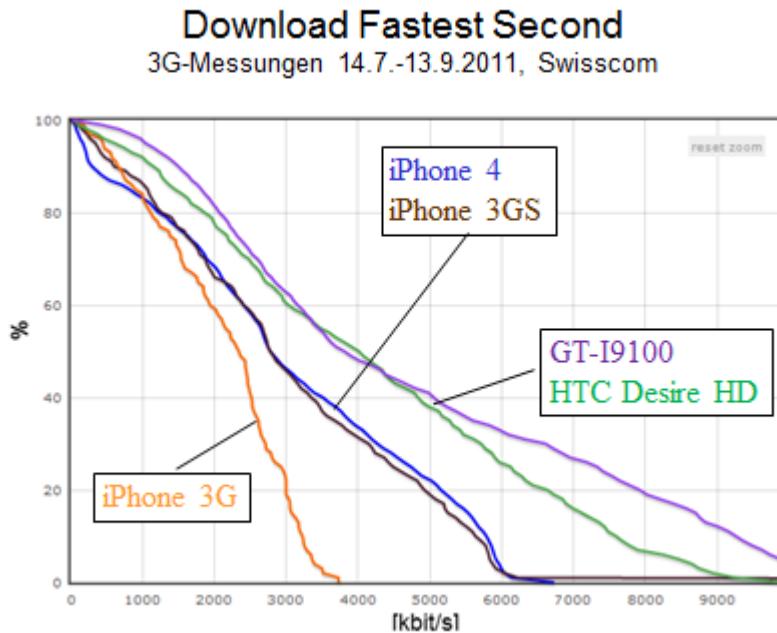
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Licencees' Results Viewer



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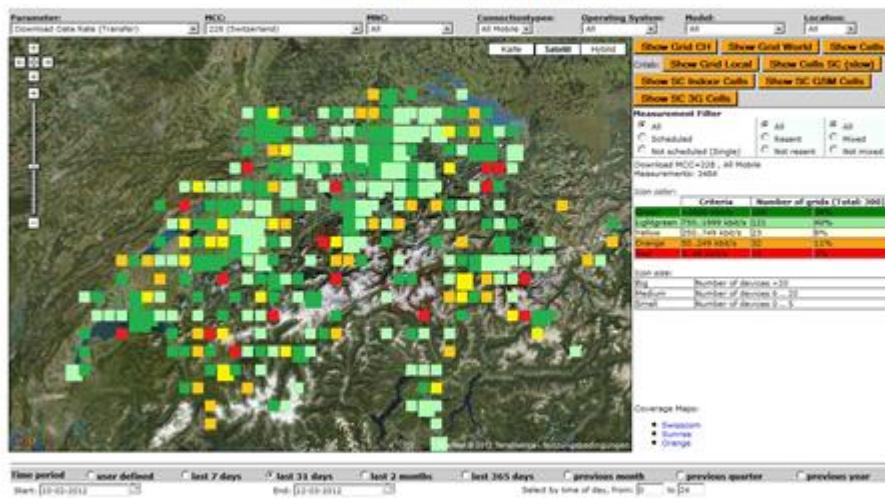
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Geographic Distribution Switzerland



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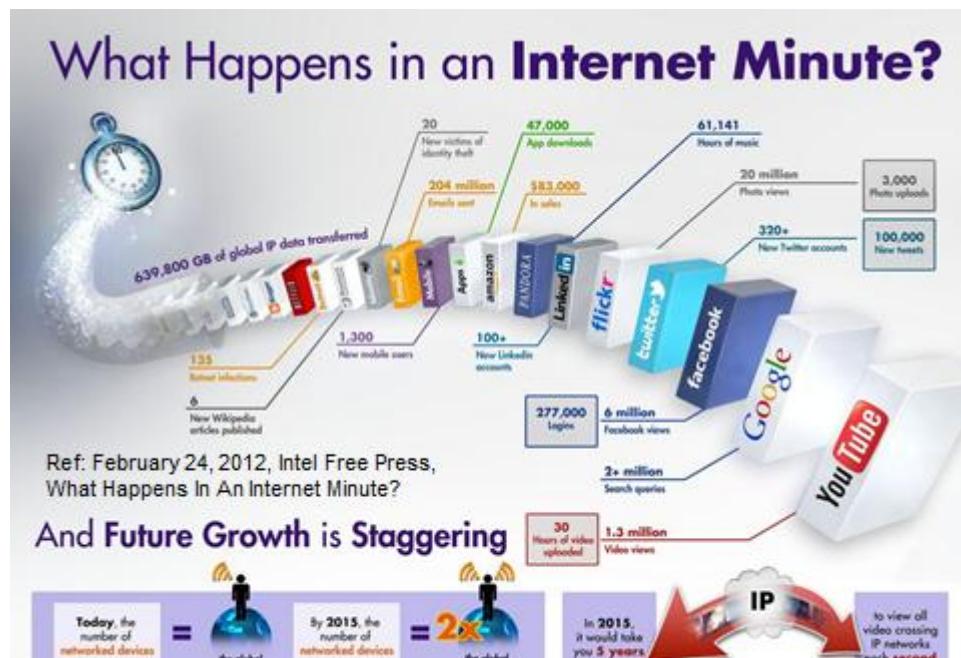
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Application Benchmarking

Per application measurement -- how to tell whether there's throttling, whether certain protocols aren't working and why, etc.? ("root cause analysis")

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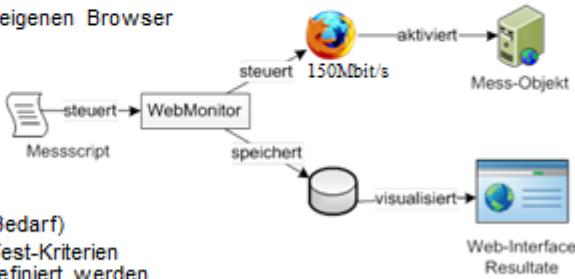


cnlab Webmonitor: Webmail Messsystem

Mittels eines in Java implementierten Testscripts wird ein Firefox-Browser ferngesteuert. Dabei können sämtliche Benutzer-Aktionen (Tastatureingaben, Mausklicks, usw.) simuliert werden.

Die Resultate der durchgeföhrten Aktionen werden in einer Datenbank gespeichert und können über ein Web-Interface visualisiert werden.

Jede Messung startet einen eigenen Browser mit gelöschttem Cache.



Aufgezeichnete Daten:

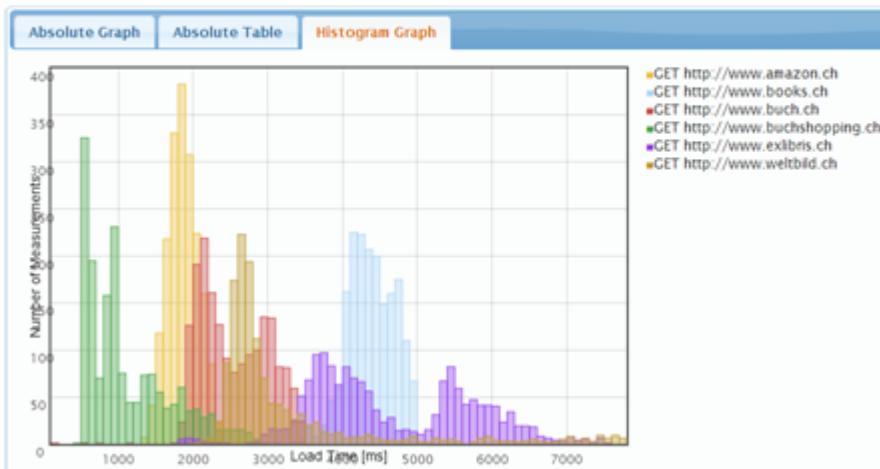
- Timing aller Requests
- Request- und Response-Header
- Abgerufene Inhalte (bei Bedarf)
- Für jede Aktion können Test-Kriterien (z.B. erwartete Inhalte) definiert werden.
- Im Fehlerfall wird ein Screenshot gespeichert

Beschreibung cnlab WebMonitor: <https://www.cnlab.ch/en/software/cnlab-webmonitor>

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Total Load Time Histogram



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Total Load Time Graph



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Conclusion, Next Steps, So What

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To understand «End-user Experience»

- Do comparative measurements and analysis
- Bottleneck moves from the access network
 - to the home network (wlan, pc, switches, nat, ...)
 - to servers
 - to backbones, and international connections
- Don't forget
 - Content Delivery Networks/Services (CDN)
 - The real customer problem: specifically used applications responsiveness

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Links

- <https://www.cnlab.ch/en/performance>
- Some Speedtest Servers
 - <http://speedy-de.ip-plus.net/speedtest/>
 - <http://speedy-ny.ip-plus.net/speedtest/>
 - <http://speedy-it.ip-plus.net/speedtest/>
 - <http://hsif.bluewin.ch>
- New interface:
<http://hsif.bluewin.ch/speedtestJavaV2/index.html>
- Mobile: <https://www.cnlab.ch/en/performance/mobile-network-wlan-speedtest-mobile-app>

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