Performance Measurement of Internet Service

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Abstract

This paper summarizes my papers and books, which reports on studies concerning the performance measurement of Internet services, particularly on mobile networks. In detail, Internet service quality measurements are grouped into two, the first is a measurement that aims to measure the provider's customer satisfaction, performed by the provider or by the user, and the second measurement goal is that the provider and/or by the vendor in relation to the quality assurance provided by the vendor to the provider. In detail, the first type of measurement uses a sampling technique and uses only one performance indicator, i.e. the data rate, otherwise, the second type performs the aggregate measurements with references to the signaling ladder diagram of the Internet services and measures many performance indicators.

1. Types of Quality of Experience and Quality of Service Measurement of Internet Service

Measurement of internet service quality is grouped into two, the first is a measurement that aims to measure the provider's customer satisfaction and the second measurement goal is that the provider and/or vendor is involved with the quality assurance provided by the vendor to the provider.

2. Quality Measurement of Internet Service for Customer Satisfaction

In relation to the customer satisfaction, internet service quality measurements are carried out in a sampling of customers of the providers, thus the measured is QoE (Quality of Experience) rather than QoS (Quality of Service). In this type of measurement, the measured parameter is the data rate. Unlike the QoE measurements of telephone and chat services, where the Quality of Experience is shown in the form of Mean Opinion Score (MOS), otherwise, the measurement of the mean data rate uses units of kbps or Mbps.

The application of statistical science should be accompanied by an in-depth understanding of the customer characteristics of the service provider, where the number of respondents interviewed is generally much more than the amount required for data processing.

For example, we only need data to be processed as many as 100 customers, then we should have 100 customers who meet all the criteria of the type of customer provider, assume that is that meet the criteria for comparison of female and male customers, e.g. 55% versus 45%, and also meet the customer age criteria, e.g. 60% of youth and 40% of established age, also meet the criteria of income level, e.g. 65% lower and 35% middle, and should meeting the criteria of call intensity, e.g. 75% rarely call and 25% more than three times a day.

There are two ways of reporting the measurement results of the data rate, first reporting the mean data rate with the standard deviation, and secondly reporting the minimum data rate reached by 90% of customers.

3. Quality Measurement of the Internet Services in Relation between Provider and Vendor or OTT Provider.

Measurements of network performance and quality of Internet services in relation to vendors should be done based on the aggregate data, not a sampling, and should refer to the Signaling Ladder Diagram of the Internet services. The problem faced by the provider is almost the

vendor's Signaling Ladder Diagram is not 100% the same as the Signaling Ladder Diagram compiled by International Standard ETSI and 3 GPP. Another problem is related to services provided by over-the-top providers that have no interconnection links with broadband providers, so that providers cannot ask for quality accountability to over-the-top providers.

Some important parameters on this type of measurement are:

- 1) Mean Data Rate or Minimum Data Rate
- 2) Internet Protocol Service non-accessibility
- 3) Internet Protocol Service Access Failure Ratio
- 4) Internet Protocol Service Access Time
- 5) Session Failure Ratio
- 6) Internet Protocol Setup times
- 7) Session times
- 8) Data Transfer Cut-off Ratio
- 9) Teardown Failure Ratio
- 10) Teardown Time

3.1. Measurement of Mean or Minimum Data Rate

Mean data rate parameter shows the value of the average speed of the data transmission, where average throughput values calculated from the start to build a data connection until the whole data is received successfully. Accompanying the mean data rate report, it is important to report also the standard deviation.

The minimum data rate parameter shows 90% of customers with the fastest data rate, which may also take a percentage larger or smaller than 90%.

Pre-condition for this parameter is UE has managed to attach, the connection has been active PDP context, as well as the service has been successfully carried out.

Abstract Equation of Internet Data rate:

$$Data\ rate(\frac{kbit}{s}) = \frac{User\ Data\ Transferred\ (kbit)}{t_{data\ transfer\ complete} - t_{start\ of\ data\ transfer}} \quad (1)$$

3.2. Measurement of Internet Service Non Accessibility

This parameter indicates the probability of the UE (User Equipment) can not establish a PDP context and can not access the internet access.

Pre condition for this parameter is that the UE has managed to make the process of attachment.

Abstract Equation of Internet Protocol Service Non-Accessibility:

$$Internet\ Service\ Non\ Accessibility(\%) = \frac{Unsuccessful\ Attempts\ to\ Reach\ the\ Point\ when\ contents\ is\ received}{All\ Attempts\ to\ reach\ the\ Point\ when\ contents\ is\ received} \times 100 \quad (2)$$

3.3. Measurement of Internet Service Access Failure Ratio

This parameter indicates the probability of an UE cannot successfully establish the TCP/IP connection to the server of the service.

Pre condition for this parameter is UE has managed to make the process of attachment and connection PDP context is active.

Abstract Equation of Internet Service Access Failure:

$$Internet\ Service\ Access\ Failure(\%) = \frac{Unsuccessful\ Attempts\ to\ established\ internet\ connection\ to\ the\ server}{All\ Attempts\ to\ established\ internet\ connection\ to\ the\ server} \times 100 \quad (3)$$

3.4. Measurement of Internet Service Access Time

This parameter represents the time required for the UE establish TCP/IP connection to the server from a service successfully.

Pre-condition for this parameter is UE has managed to attach and connection PDP context is active, so that the parameter can only be calculated on successful trials.

Abstract Equation of Internet Service Access Time:

$$Internet\ Service\ Access\ Time(second) = t_{Reception\ of\ the\ First\ of\ packet\ data} - t_{Service\ Request} \quad (4)$$

3.5. Measurement of Session Failure Ratio

This parameter shows the ratio of a successful session until the normal end of the service.

Pre condition for this parameter is UE has managed to attach and connection PDP context is active.

Abstract Equation of Session Failure Ratio:

$$\text{Session Failure ratio}(\%) = \frac{\text{Uncomplete Sessions}}{\text{Successful Started Sessions}} \times 100 \quad (5)$$

3.6. Measurement of Internet Protocol Setup times

This parameter represents the time required to access the full service, from establishing PDP context until receiving the first data packet.

Pre-condition for this parameter is UE has managed to make the process of attachment.

Abstract Equation of Internet Protocol Service Setup Time:

$$\text{Internet Service Setup Time(second)} = t_{\text{the Content had been sent or Received}} - t_{\text{the Connection had been Initiated}} \quad (6)$$

3.7. Measurement of Session times

This parameter shows the time required to process the data sessions to successfully complete.

Pre condition for this parameter is UE has managed to attach and connection PDP context is active.

Abstract Equation of Internet Protocol Service Setup Time:

$$\text{Session Time(second)} = t_{\text{the End of Session}} - t_{\text{Session Start}} \quad (7)$$

3.8. Measurement of Data Transfer Cut-off ratio

This parameter shows the ratio between the incomplete data transfer and data transfer begins with success.

Pre-condition for this parameter is UE has managed to attachment and connection PDP context is active.

Abstract Equation of Data Transfer Cut-off Ratio (%):

$$\text{Data Transfer Ratio}(\%) = \frac{\text{Incomplete Data Transfer}}{\text{Successful Sartetd Sessions}} \times 100 \quad (8)$$

3.9. Measurement of Teardown Failure Ratio (%)

Probability that the RTSP message (Real-Time Streaming Protocol message) or the "Teardown" message is sent from the UE to the server and there is no RTSP response "200 OK" is received from the EU server.

Abstract Equation of Teardown Failure Ratio (%):

$$\text{Teardown Failure Ratio}(\%) = \frac{\text{Number of Cases Without the 200 OK Response}}{\text{All Teardown Attempt by UE}} \times 100 \quad (9)$$

3.10. Measurement of Teardown Time

Duration of access to services measures from demand streaming or streaming requests on the portal to the reception of the first stream of data packets to the UE

Abstract Equation of Teardown Time:

$$\text{Teardown Time(second)} = t_{\text{Server Response to Teardown Message}} - t_{\text{UE Sending Teardown Message}} \quad (10)$$

$$\text{Teardown Times [s]} = t_{\text{server response to teardown message}} - t_{\text{UE sending teardown message}} \quad [2] \quad (25)$$

4. Signaling Ladder Diagram

The following is a list of Signaling Ladder Diagrams that are essential for measuring the quality of Internet services in an aggregate, most of which are referred to Internet Forum standards, and a small portion of Signaling Ladder Diagrams is referring to ETSI standards.

Table 1. Signaling Ladder Diagram of HTTP/Web Browsing Data Rate

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: Reception of the first data packet which contain the content.		HTTP OK 200	HTTP SERVER WEB	GATEWAY
		HTTP OK 200	GATEWAY	MS
		Ack	MS	GATEWAY
		HTTP Continue	HTTP SERVER WEB	MS
		Ack	MS	HTTP SERVER WEB
STOP: Reception of the last data packet which contain the content.		HTTP Continue	HTTP SERVER WEB	MS

The process of web browsing mean data rate measurement can be started from the reception of the first data packet containing content, marked by sending a "200 OK" signal from web server to Gateway until the reception of the last data packet containing content, marked by sending a "HTTP continue" signal from web server to MS.

Table 2. Signaling Ladder Diagram of Internet Service Non-Accessibility in 3G Network

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: ATD command.		Activate PDP Context	MS	SGSN
		Create PDP Context Request	SGSN	GGSN
		Create PDP Context Response	GGSN	SGSN
		Radio Access Bearer Assignment Request	3G RAN	SGSN
		Radio Bearer Setup	3G RAN	MS
		Radio Bearer Setup Complete	MS	3G RAN
		Radio Access Bearer Assignment Response	3G RAN	SGSN
		Update PDP Context Request	SGSN	GGSN
		Update PDP Context Response	GGSN	SGSN
		Activate PDP Context Accept	SGSN	MS
		Update PDP Context Request	SGSN	GGSN
		Update PDP Context Response	GGSN	SGSN
		Radio Access Bearer Modification	MS	3G RAN
		Radio Access Bearer Modification	3G RAN	MS
		Radio Access Bearer Modification	3G RAN	SGSN
		Radio Access Bearer Modification	SGSN	3G RAN
		Modify PDP Context Request	SGSN	MS
		Modify PDP Context Accept	MS	SGSN
		Invoke Trace	SGSN	3G RAN
		SYN	MS	GATEWAY
		SYN, ACK	GATEWAY	MS
		ACK	MS	GATEWAY
		HTTP GET	MS	GATEWAY
		DNS QUERY	GATEWAY	DNS SERVER
		DNS REPLY	DNS SERVER	GATEWAY

		SYN	GATEWAY	HTTP WEB SERVER
		SYN, ACK	HTTP WEB SERVER	GATEWAY
		ACK	GATEWAY	HTTP WEB SERVER
		HTTP GET	GATEWAY	HTTP WEB SERVER
		Ack	HTTP WEB SERVER	GATEWAY
		Ack	GATEWAY	MS
		HTTP OK 200	HTTP WEB SERVER	GATEWAY
STOP: Reception of the first data packet which contain the content.		HTTP OK 200	GATEWAY	MS

Table 3 Signaling Ladder Diagram of Internet Service Setup Time

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: the First [SYN] message sent		SYN	MS	GATEWAY
		SYN, ACK	GATEWAY	MS
		ACK	MS	GATEWAY
		HTTP GET	MS	GATEWAY
		DNS QUERY	GATEWAY	DNS SERVER
		DNS REPLY	DNS SERVER	GATEWAY
		SYN	GATEWAY	HTTP WEB SERVER
		SYN, ACK	POP3 SERVER	GATEWAY
		ACK	GATEWAY	HTTP WEB SERVER
		HTTP GET	GATEWAY	HTTP WEB SERVER
		Ack	HTTP WEB SERVER	GATEWAY
		Ack	GATEWAY	MS
		HTTP OK 200	HTTP WEB SERVER	GATEWAY
STOP: Reception of the first data packet which contain the content		HTTP OK 200	GATEWAY	MS

HTTP services setup time in 3G networks is measured beginning with the transmission of Synchronization signal by MS to Gateway, until the sending a HTTP 200 OK signal by Gateway to MS.

Table 4. Signaling Ladder Diagram of Internet Service Access Success Rate

Trigger Point	Log Ch	Signal Name	Outgoing Network Element	Incoming Network Element
START: the First [SYN] message sent		SYN	MS	GATEWAY
		SYN, ACK	GATEWAY	MS
		ACK	MS	GATEWAY

		HTTP GET	MS	GATEWAY
		DNS QUERY	GATEWAY	DNS SERVER
		DNS REPLY	DNS SERVER	GATEWAY
		SYN	GATEWAY	HTTP WEB SERVER
		SYN, ACK	POP3 SERVER	GATEWAY
		ACK	GATEWAY	HTTP WEB SERVER
		HTTP GET	GATEWAY	HTTP WEB SERVER
		Ack	HTTP WEB SERVER	GATEWAY
		Ack	GATEWAY	MS
		HTTP OK 200	HTTP WEB SERVER	GATEWAY
STOP: Reception of the first data packet which contain the content		HTTP OK 200	GATEWAY	MS

HTTP services success access rate in 3G networks, beginning with the transmission of Synchronization signal by MS to Gateway, until the sending a HTTP 200 OK signal by Gateway to MS.

Table 5. Signaling Ladder Diagram of FTP Download Service

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: ATD command		Activate PDP Context	MS	SGSN
		Create PDP Context Request	SGSN	GGSN
		Create PDP Context Response	GGSN	SGSN
		Radio Access Bearer Assignment Request	3G RAN	SGSN
		Radio Bearer Setup	3G RAN	MS
		Radio Bearer Setup Complete	MS	3G RAN
		Radio Access Bearer Assignment Response	3G RAN	SGSN
		Update PDP Context Request	SGSN	GGSN
		Update PDP Context Response	GGSN	SGSN
		Activate PDP Context Accept	SGSN	MS
		Update PDP Context Request	SGSN	GGSN
		Update PDP Context Response	GGSN	SGSN
		Radio Access Bearer Modification	MS	3G RAN
		Radio Access Bearer Modification	3G RAN	MS
		Radio Access Bearer Modification	3G RAN	SGSN
		Radio Access Bearer Modification	SGSN	3G RAN
		Modify PDP Context Request	SGSN	MS
		Modify PDP Context Accept	MS	SGSN
		Invoke Trace	SGSN	3G RAN
		SYN	MS	GATEWAY
		SYN, ACK	GATEWAY	MS
		ACK	MS	GATEWAY
		Connect	MS	GATEWAY

		DNS QUERY	GATEWAY	DNS SERVER
		DNS Response	DNS SERVER	GATEWAY
		SYN	GATEWAY	FTP SERVER
		SYN, ACK	FTP SERVER	GATEWAY
		ACK	GATEWAY	FTP SERVER
		Connect	GATEWAY	FTP SERVER
		Ack	FTP SERVER	MS
		FTP220	FTP SERVER	MS
		Ack	MS	FTP SERVER
		FTP331	FTP SERVER	MS
		Ack	MS	FTP SERVER
		Send username and password	MS	FTP SERVER
		Ack	FTP SERVER	MS
		FTP 230	FTP SERVER	MS
		Ack	MS	FTP SERVER
		FTP150	FTP SERVER	MS
		SYN	FTP SERVER	MS
		SYN, ACK	MS	FTP SERVER
		Ack	FTP SERVER	MS
		FTP200	FTP SERVER	MS
		Ack	MS	FTP SERVER
		LIST	MS	FTP SERVER
		Ack	FTP SERVER	MS
		FTP 226	MS	FTP SERVER
		Ack	FTP SERVER	MS
		FTP GET	MS	FTP SERVER
		Ack	FTP SERVER	MS
		RETR	MS	FTP SERVER
		Ack	FTP SERVER	MS
		FTP150	FTP SERVER	MS
		SYN	FTP SERVER	MS
		SYN, ACK	MS	FTP SERVER
		Ack	FTP SERVER	MS
STOP: Reception of the first data packet which contain the content.		FTP DATA	FTP SERVER	MS

The process of FTP download measurement can be started from the ATD Command, marked by sending an Activate PDP Context signal from MS to SGSN until the reception of the first data packet containing content, marked by sending a FTP Data signal from FTP server to MS.

The process of FTP download measurement can be started from the ATD Command, marked by sending an Activate PDP Context signal from MS to SGSN until the reception of the first

data packet containing content, marked by sending a FTP Data signal from FTP server to MS.

Table 6. Signaling Ladder Diagram of FTP Download

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: Reception of the first data packet which contain the content.		FTP DATA	FTP SERVER	MS
		Ack	MS	FTP SERVER
STOP: Reception of the last data packet which contain the content		FTP DATA + FIN	FTP SERVER	MS

The process of FTP download- mean data rate measurement can be started from the reception of the first data packet containing content, marked by sending a FTP Data signal from FTP server to MS until the reception of the last data packet containing content, marked by sending a FTP Data & FIN signal from FTP server to MS.

Table 7. Signaling Ladder Diagram of “Ping” on 3G Network

Trigger Point	Logical Channel	Signal Name	Abbreviation	Outgoing Network Element	Incoming Network Element
START: UE or MS sends the first "Activate PDP context Request" message (Layer 3).		Activate PDP Context	APC	MS	SGSN
		Create PDP Context Request	CPCReq	SGSN	GGSN
		Create PDP Context Response	CPCRes	GGSN	SGSN
		Radio Access Bearer Assignment Request	RABAReq	3G RAN	SGSN
		Radio Bearer Setup	RBS	3G RAN	MS
		Radio Bearer Setup Complete	RBSCom	MS	3G RAN
		Radio Access Bearer Assignment Response	RABARes	3G RAN	SGSN
		Update PDP Context Request	UPCReq	SGSN	GGSN
		Update PDP Context Response	UPCRes	GGSN	SGSN

STOP: UE or MS receives the "Activate PDP context Accept" message (Layer 3)		Activate PDP Context Accept	APCA	SGSN	MS
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The process of Ping - PDP CActFaiRat measurement can be started from by sending a Activate PDP Context signal from MS server to SGSN until sending a activate PDP Context Accept signal from SGSN to MS.

Table 8. Signaling Ladder Diagram of Ping Round Trip Time Measurement

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: ICMP echo request sent		Echo (ping) request	MS	GATEWAY
		DNS QUERY	GATEWAY	DNS SERVER
		DNS Response	DNS SERVER	GATEWAY
		Echo (ping) request	GATEWAY	SERVER
		Echo (ping) Reply	SERVER	GATEWAY
STOP: ICMP echo reply received by the sender		Echo (ping) Reply	GATEWAY	MS

The process of Ping – Round trip Time measurement can be started from by sending an Echo (ping) request signal from MS server to gateway until sending an Echo (ping) Reply signal from Gateway to MS.

Table 9. Signaling Ladder Diagram of Streaming Service on 3G Network

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: • WAP 1.x, WAP 2.x: WSP Disconnect; • WAP 2.x: TCP SYN towards streaming platform		SYN	MS	MEDIA SERVER
		SYN, ACK	MEDIA SERVER	MS
		ACK	MS	MEDIA SERVER
		RTSP : Setup	MS	MEDIA SERVER
		Ack	MEDIA SERVER	MS
		200 OK	MEDIA SERVER	MS

		Ack	MS	MEDIA SERVER
		Activate Secondary PDP Context	MS	SGSN
		Create PDP Context Request	SGSN	GGSN
		Create PDP Context Response	GGSN	SGSN
		Radio Access Bearer Assignment Request	3G RAN	SGSN
		Radio Bearer Setup	3G RAN	MS
		Radio Bearer Setup Complete	MS	3G RAN
		Radio Access Bearer Assignment Response	3G RAN	SGSN
		Update PDP Context Request	SGSN	GGSN
		Update PDP Context Response	GGSN	SGSN
		Activate Secondary PDP Context Accept	SGSN	MS
		RTSP : Play	MS	MEDIA SERVER
		Ack	MEDIA SERVER	MS
		200 OK	MEDIA SERVER	MS
		Ack	MS	MEDIA SERVER
STOP: Reception of first data packet.		IP/UDP/RTP	MEDIA SERVER	MS

The process of Streaming Service measurement can be started from by sending a synchronization signal from MS to Media Server until sending an IP/UDP/RTP signal from Media Server to MS.

Table 10. Signaling Ladder Diagram Streaming Reproduction

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: Streaming player signals the start of the stream reproduction		IP/UDP/RTP	MEDIA SERVER	MS
		IP/UDP/RTP	MEDIA SERVER	MS
		RTCP	MS	MEDIA SERVER
		RTSP : Teardown	MS	MEDIA SERVER
		Ack	MEDIA SERVER	MS
STOP: RTSP Teardown method sent by UE and reception of confirmation "RTSP 200 OK" from media server.		Ok 200	MEDIA SERVER	MS

The process of Streaming Reproduction measurement can be started from by sending an IP/UDP/RTP from Media server to MS until sending an OK 200 signal from Media Server to MS.

Table 11. Signaling Ladder Diagram of E-Mail Login (Upload)

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: TCP: First "SYN" sent by the client		SYN	MS	GATEWAY
		SYN, ACK	GATEWAY	MS
		ACK	MS	GATEWAY
		Connect	MS	GATEWAY
		DNS QUERY	GATEWAY	DNS SERVER
		DNS Response	DNS SERVER	GATEWAY
		SYN	GATEWAY	SMTP SERVER
		SYN, ACK	SMTP SERVER	GATEWAY
		ACK	GATEWAY	SMTP SERVER
		Ack	SMTP SERVER	MS
		220	SMTP SERVER	MS
		Ack	MS	SMTP SERVER
		EHLO	MS	SMTP SERVER
		Ack	SMTP SERVER	MS
		250 HELO, 8BITMIME, SIZE, DSN, AUTH	SMTP SERVER	MS
		Ack	MS	SMTP SERVER
		AUTH	MS	SMTP SERVER
		Ack	SMTP SERVER	MS
		334	SMTP SERVER	MS
		...authentication challenge	SMTP SERVER	MS
STOP: SMTP: Reply "235 Authentication successful" received by the client as an answer to the authentication request.		235 Authentication Successful	SMTP SERVER	MS

The process of E-mail login (upload) measurement can be started from by sending a synchronization signal from MS to Gateway until sending a 235 Authentication Successful signal from SMTP Server to MS.

Table 11. Signaling Ladder Diagram of E-Mail Login (Upload)

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: First TCP "SYN" sent by the client		SYN	MS	GATEWAY
		SYN, ACK	GATEWAY	MS
		ACK	MS	GATEWAY
		Connect	MS	GATEWAY
		DNS QUERY	GATEWAY	DNS SERVER
		DNS Response	DNS SERVER	GATEWAY
		SYN	GATEWAY	POP3 SERVER
		SYN, ACK	POP3 SERVER	GATEWAY
		ACK	GATEWAY	POP3 SERVER
		Connect	GATEWAY	POP3 SERVER
		Ack	POP3 SERVER	MS
		*OK	POP3 SERVER	MS
		Ack	MS	POP3 SERVER
		AUTH	MS	POP3 SERVER
		Ack	POP3 SERVER	MS
		*OK	POP3 SERVER	MS
		Ack	MS	POP3 SERVER
		AUTH	MS	POP3 SERVER
		Ack	POP3 SERVER	MS
		*OK message, 1500 octets	POP3 SERVER	MS
		Ack	MS	POP3 SERVER
		STAT	MS	POP3 SERVER
		Ack	MS	POP3 SERVER
		*OK 1 1500	MS	POP3 SERVER
		Ack	MS	POP3 SERVER
		LIST	MS	POP3 SERVER
		Ack	POP3 SERVER	MS
		*OK Scan list follows 1 1500 <CRLF>.<CRLF>	POP3 SERVER	MS
		Ack	MS	POP3 SERVER
		UIDL	MS	POP3 SERVER
		Ack	POP3 SERVER	MS
		*OK Scan list follows 1 12 <CRLF>.<CRLF>	POP3 SERVER	MS
		Ack	MS	POP3 SERVER
		RETR 1	MS	POP3 SERVER
		Ack	POP3 SERVER	MS
		*OK 1500 octets	POP3 SERVER	MS
STOP: Termination sequence <CRLF.CRLF> received by the client as an answer to the "RETR" command.		<CRLF>.<CRLF>	POP3 SERVER	MS

The process of E-mail download session measurement can be started from by sending a synchronization signal from MS to Gateway until sending a <CRLF>.<CRLF> signal from POP3 Server to MS.

Table 12. Signaling Ladder Diagram of E-Mail (Upload) Data Rate Measurement

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming Network Element
START: SMTP: "MAIL FROM" sent by the client		Mail from : (name@domain.com)	MS	SMTP SERVER
		Ack	MS	SMTP SERVER
		250 OK	SMTP SERVER	MS
		Ack	MS	SMTP SERVER
		RCPT TO	MS	SMTP SERVER
		Ack	SMTP SERVER	MS
		250 OK	SMTP SERVER	MS
		Ack	MS	SMTP SERVER
		DATA	MS	SMTP SERVER
		Ack	SMTP SERVER	MS
		354 Start mail input; end with <CRLF>.<CRLF>	SMTP SERVER	MS
		Ack	MS	SMTP SERVER
		Message	MS	SMTP SERVER
		Ack	SMTP SERVER	MS
STOP: SMTP: Reply "250 messages accepted" received by the client.		250 ok, message accepted	SMTP SERVER	MS

The process of E-mail (upload) mean data rate measurement can be started from by sending a Mail from: (name@domain.com) signal from MS to SMTP Server until sending the 250 OK, message accepted signal from SMTP Server to MS.

Table 13. Signaling Ladder Diagram of E-Mail (Download) Data Rate measurement

Trigger Point	Logical Channel	Signal Name	Outgoing Network Element	Incoming network Element
Start: POP3: "RETR" command sent by the client		RETR 1	MS	POP3 SERVER
		Ack	POP3 SERVER	MS
		*OK 1500 octets	POP3 SERVER	MS
STOP: POP3: Termination sequence		<CRLF>.<CRLF>	POP3 SERVER	MS

<CRLF.CRLF> received by the client.				
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The process of E-mail (Download) mean data rate measurement can be started from by sending a RETR 1 signal from MS to POP3 Server until sending a <CRLF>.<CRLF> signal from POP3 Server to MS.

Note

To the readers of this short paper, if you want to deepen the knowledge of this field, welcome to read the papers and books in the references.

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