

R E P O R T R O A D S

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TELEPHONY SERVICE

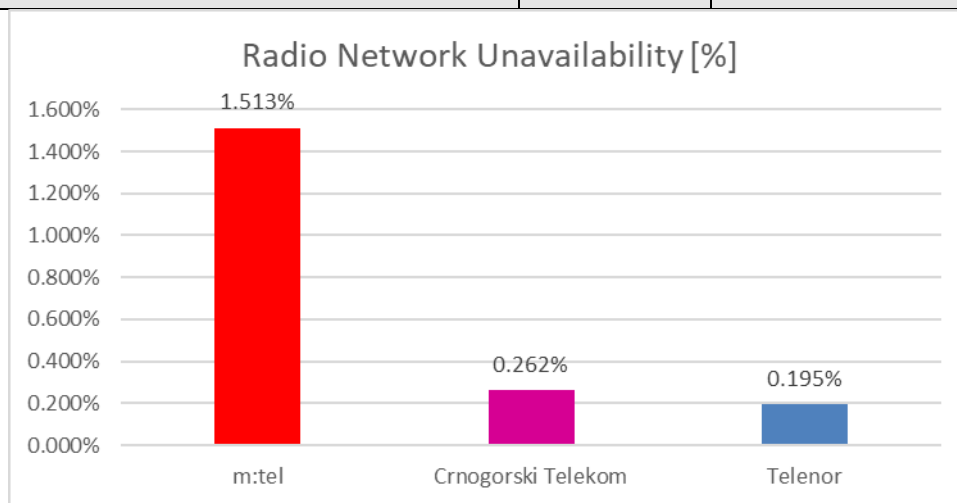
For telephony service 4 parameters have been measured: Radio Network Unavailability, Telephony Service Non-Accessibility, Telephony Setup Time and Telephony Cut-off Call.

Radio Network Unavailability [%] – probability that the end user has not been provided with mobile service.

number of failed attempts in setting up service i.e. in connecting to mobile network

$$\text{Radio Network Unavailability [\%]} = \frac{\text{number of failed attempts in setting up service i.e. in connecting to mobile network}}{\text{total number of attempts}} * 100$$

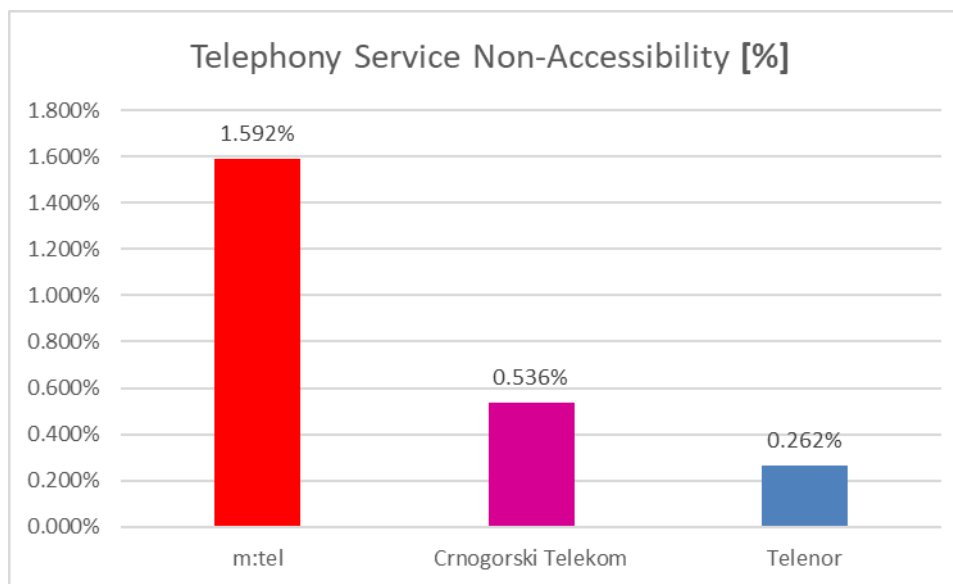
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1497	1518	1530
Unsuccessful	23	4	3
Total of samples	1520	1522	1533
Failure rate [%]	1,513	0,262	0,195
Interval of reliability of results [%] with confidence level of 99 %	0,83 – 2,52	0,04 – 0,83	0,02 – 0,71



Telephony Service Non-Accessibility [%] - probability that the end user cannot setup a call, although there is an indication on the mobile device that telephony service is accessible.

$$\text{Telephony Service Non-Accessibility [\%]} = \frac{\text{number of failed attempts to setup calls}}{\text{number of attempts in setting up calls}} * 100$$

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1421	1484	1517
Unsuccessful	23	8	4
Total of samples	1444	1492	1521
Failure rate [%]	1,592	0,536	0,262
Interval of reliability of results [%] with confidence level of 99 %	0,87 – 2,65	0,17 – 1,24	0,04 – 0,83

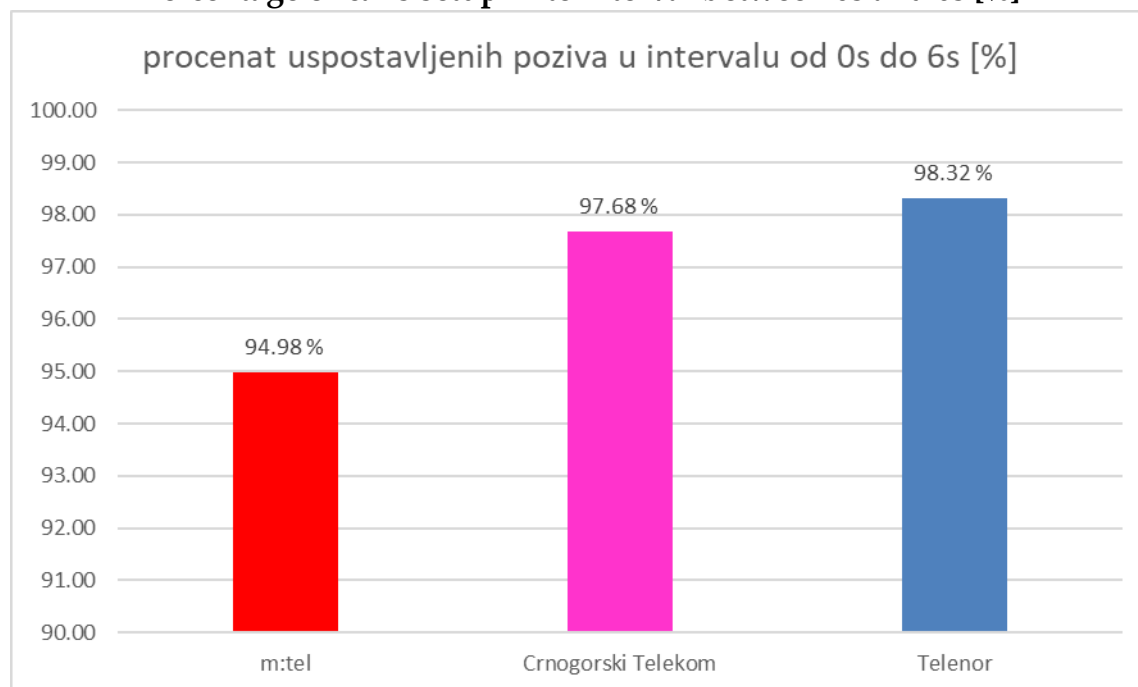


Telephony Setup Time [s] – time between sending the request to setup a call and receiving the signal for setting up the call.

$$\text{Telephony Setup Time [s]} = (\text{time needed for setting up a call} - \text{time for sending request to setup a call}) \text{ [s]}$$

Operator	m:tel	Crnogorski Telekom	Telenor
Telephony Setup Time in the interval between 0s and 6s	1210	1431	1468
Telephony Setup Time longer than 6s	64	34	25
Total of samples	1274	1465	1493
Rate of the calls setup in the interval between 0s and 6s [%]	94,98	97,679	98,325
Interval of reliability of results [%] with confidence level of 99 %	93,19 – 96,42	96,47 – 98,57	97,54 – 98,91

Percentage of calls setup in te interval between 0s and 6s [%]



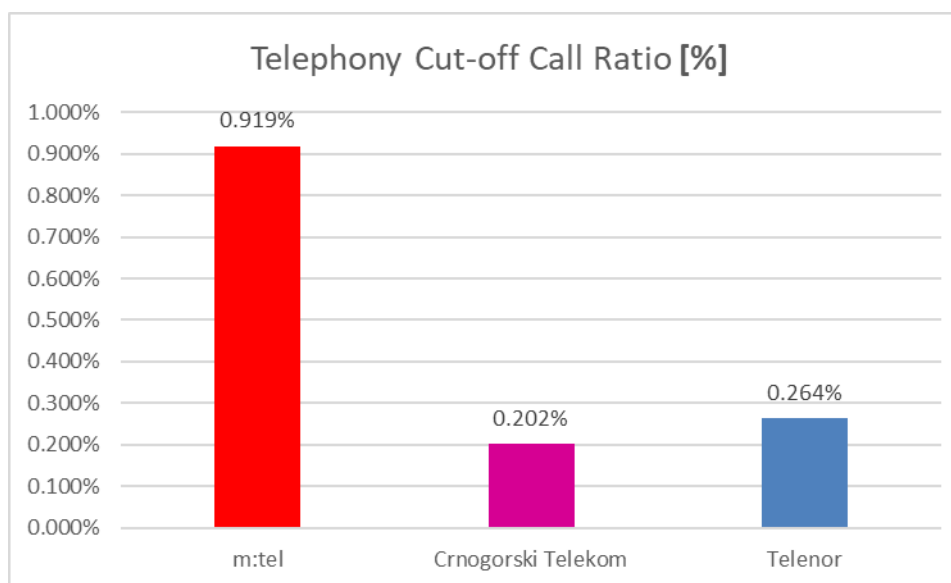
Telephony Cut-off Call [%] – probability that a successful attempt in setting up a call is cut-off, when the cut-off has not been initiated neither by the user who made a call and/nor by the user who received a call.

vjerovatnoća da se uspješan pokušaj ostvarivanja poziva prekine, a da prekid ne iniciraju korisnik pozivaoc i/ili pozvani korisnik.

number of calls unintentionally cut-off

$$\text{Telephony Cut-off Call Ratio [\%]} = \frac{\text{number of calls unintentionally cut-off}}{\text{number of calls setup successfully}} * 100$$

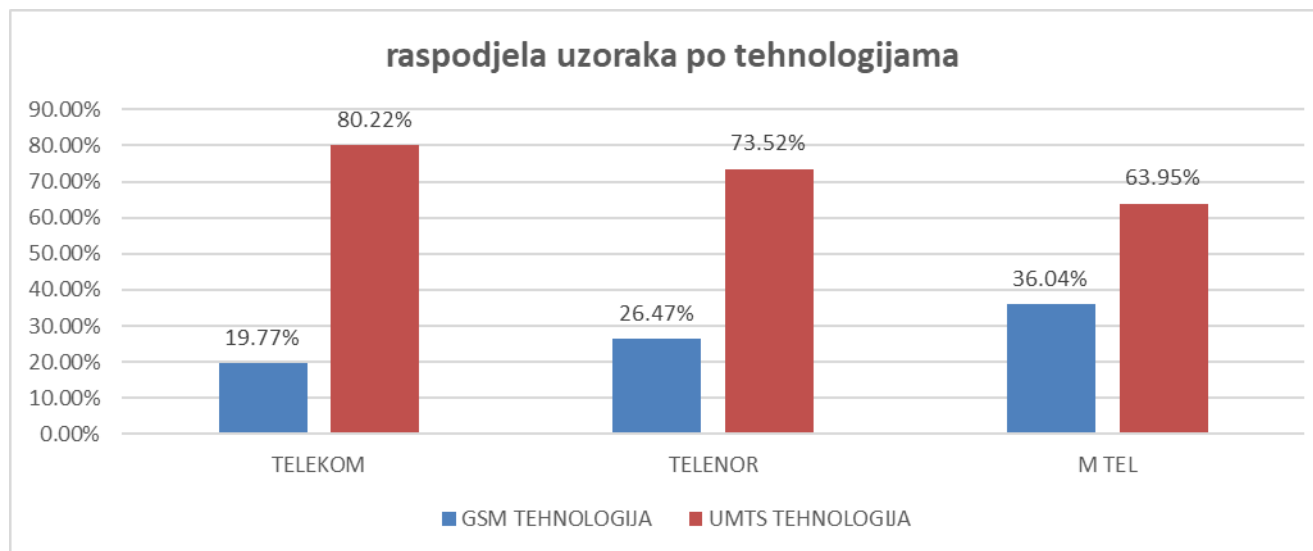
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1401	1479	1507
Unsuccessful	13	3	4
Total of samples	1414	1482	1511
Failure rate [%]	0,919	0,202	0,264
Interval of results reliability [%] with confidence level of 99 %	0,4 – 1,8	0,02 – 0,74	0,04 – 0,83



Figures showing technologies deployed in telephony service

OPERATOR	GSM TEHNOLOGY (%)	UMTS TEHNOLOGY (%)
Crnogorski Telekom	19,77	80,22
Telenor	26,47	73,52
m:tel	36,04	63,95

Scheme of samples according to technologies and operators



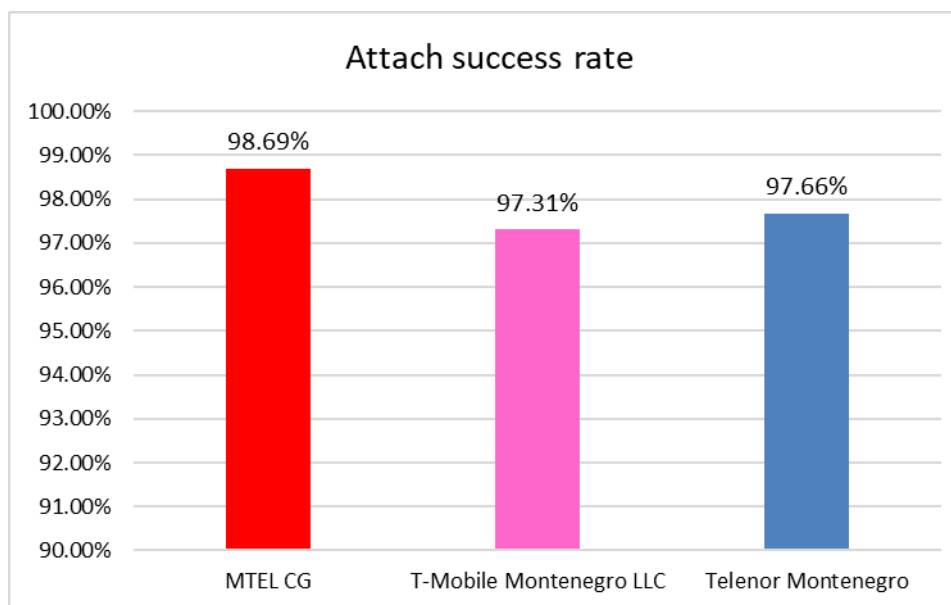
DATA SERVICE

For data service 12 parameters have been measured: Attach Success Ratio, PDP Context Activation Success Ratio, PDP Context Cut-off Ratio, EPS bearer allocation success ratio, FTP IP-Service Access Success Ratio, FTP {Download|Upload} Data Transfer Cut-off Ratio, HTTP browsing IP-Service Access Success Ratio, HTTP browsing Data Transfer Cut-off Ratio, FTP data rate download, FTP mean data rate download per session, FTP data rate upload, FTP mean data rate upload per session.

Attach Success Ratio [%] – probability that the user can be attached to the PS Network.

$$\text{Attach Success Ratio [\%]} = \frac{\text{number of successful attaches to the PS Network}}{\text{total number of attempts to attach to the PS Network}} * 100$$

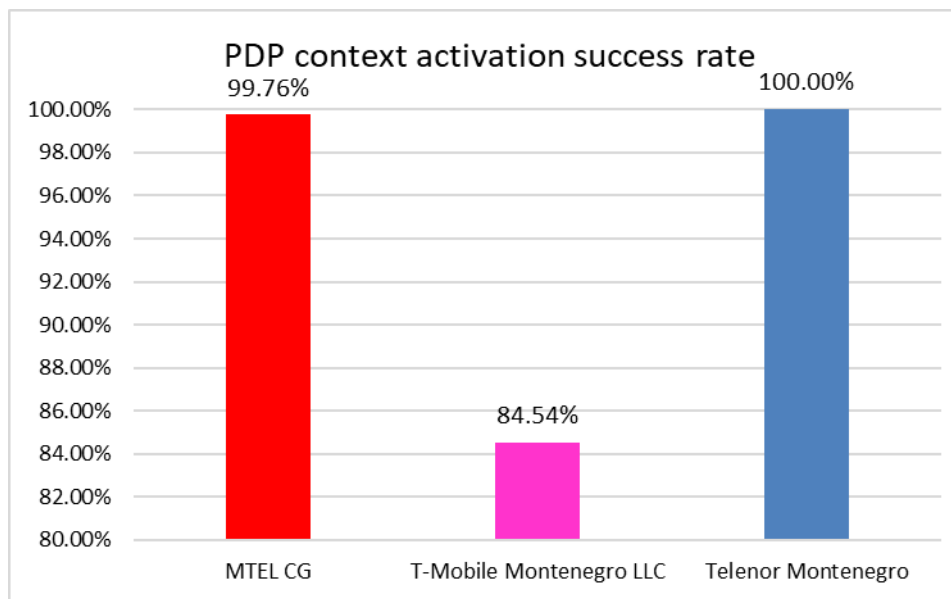
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1504	1519	1422
Unsuccessful	20	42	34
Total of samples	1524	1561	1456
Success rate [%]	98,69	97,31	97,66
Interval of reliability of results [%] with confidence level of 95 %	97,98-99,20	96,38-98,05	96,75-98,38



PDP Context Activation Success [%] - probability that the PDP (packet data protocol) context can be activated successfully. It refers to GSM and UMTS technologies.

$$\text{PDP Context Activation Success Ratio [\%]} = \frac{\text{number of successful activations of PDP contexts}}{\text{number of attempts to activate PDP contexts}} * 100$$

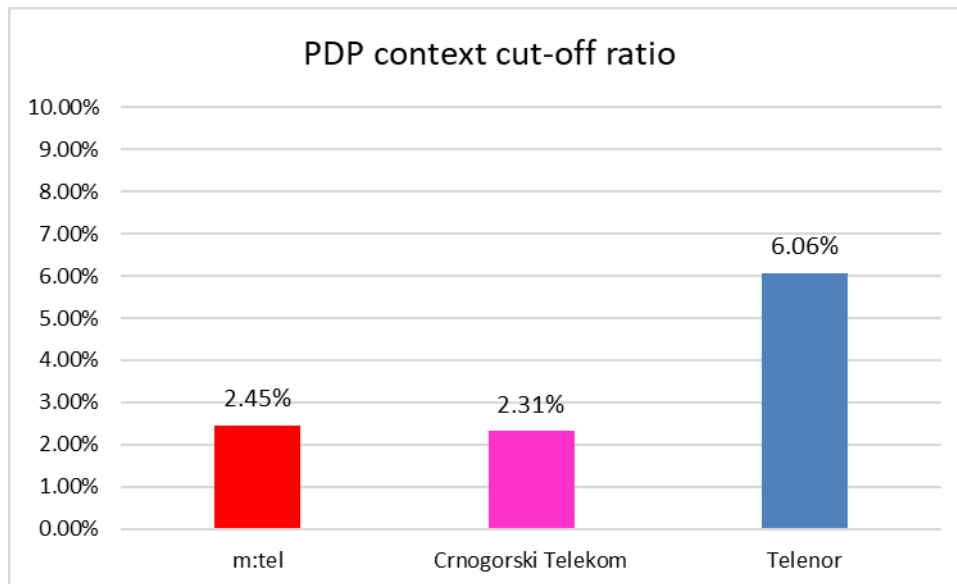
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	408	432	165
Unsuccessful	1	79	0
Total of samples	409	511	165
Success rate [%]	99,76	84,54	100,00
Interval of reliability of results [%] with confidence level of 95 %	98,65-99,99	81,11-87,57	97,79-100,00



PDP Context Cut-off [%] – probability that the PDP context is deactivated while the user hasn't started the procedure of deactivation. It refers to GSM and UMTS technologies.

$$\text{PDP Context Cut-off Ratio [\%]} = \frac{\text{number of cut-offs of PDP contexts}}{\text{number of PDP contexts successfully setup}} * 100$$

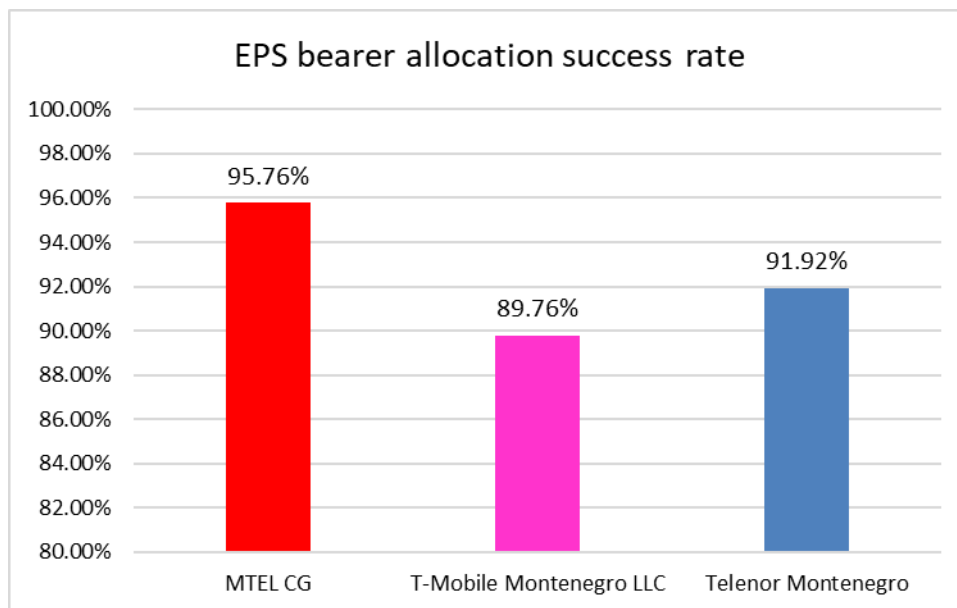
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	408	432	165
Unsuccessful	10	10	10
Failure rate [%]	2,45	2,31	6,06
Interval of reliability of results [%] with confidence level of 95 %	1,18-4,46	1,12-4,42	2,94-10,86



EPS bearer allocation success [%] – success in establishing default and dedicated EPS bearers. This parameter refers only to LTE technology.

$$\text{EPS bearer allocation success rate [\%]} = \frac{\text{number of successfully allocated EPS bearers}}{\text{number of attempts in allocation of EPS bearers}} * 100$$

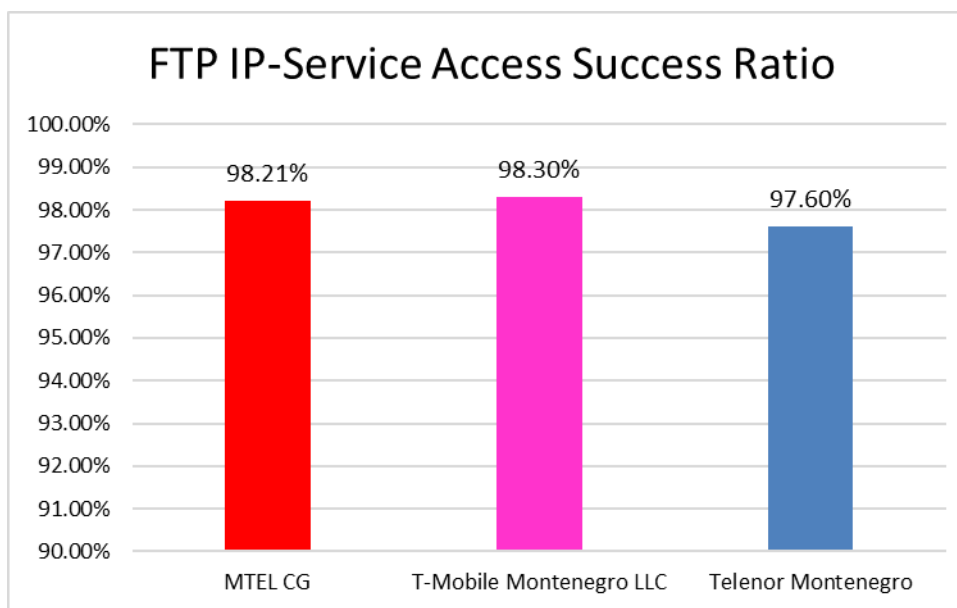
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1108	1105	1286
Unsuccessful	49	127	112
Total of samples	1157	1232	1398
Success rate [%]	95,76	89,76	91,92
Interval of reliability of results [%] with confidence level of 95 %	94,44-96,85	87,93-91,40	90,37-93,30



FTP IP- Service Access Success, Method B (Server connection setup success rate) [%] – probability that the user has successfully setup TCP/IP session with the server. It is measured jointly for upload and download.

$$\text{FTP IP-Service Access Success Ratio [\%]} = \frac{\text{number of sessions successfully setup}}{\text{number of attempts in setting up sessions}} * 100$$

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	2743	2783	2770
Unsuccessful	50	48	68
Total of samples	2793	2831	2838
Success rate [%]	98,21	98,30	97,60
Interval of reliability of results [%] with confidence level of 95 %	97,65-98,67	97,76-98,75	96,97-98,13

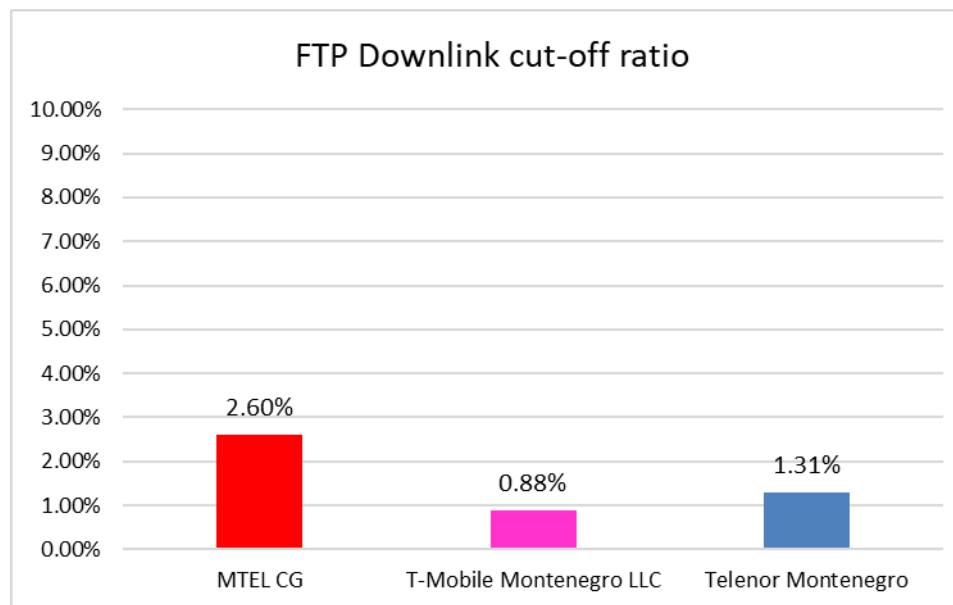


FTP {Download|Upload} Data Transfer Cut-off [%] – probability that downlink/uplink data transfer is cut-off without intention of the user to do so. Measuring the parameter starts with the first request for sending data, after the connection with the server has been established. Measuring the parameter is completed upon receiving the last data packet.

$$\text{FTP \{Download|Upload\} Data Transfer Cut-off Ratio [\%]} = \frac{\text{number of data transfers completed unsuccessfully}}{\text{number of data transfers successfully set-up}} * 100$$

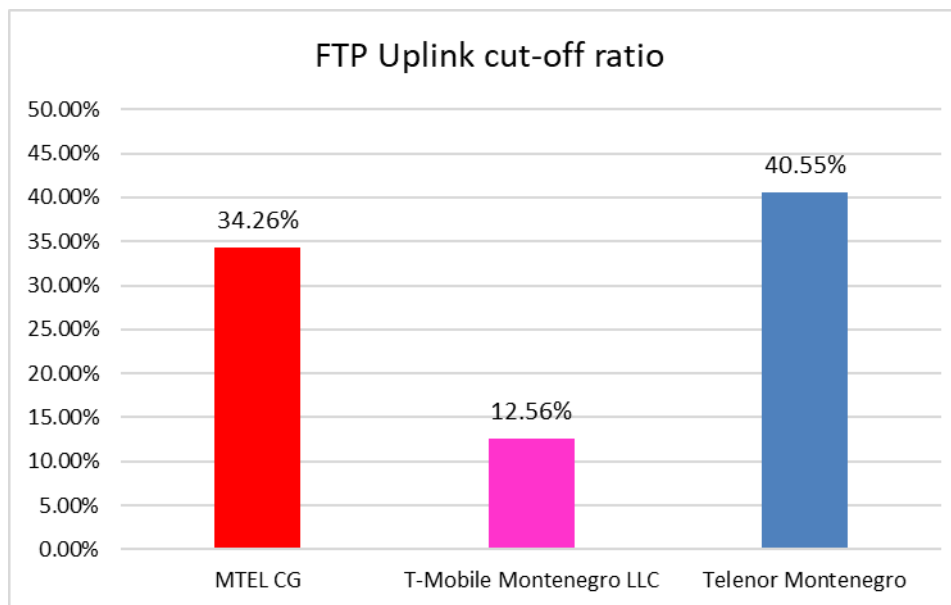
FTP Download:

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1308	1358	1378
Unsuccessful	34	12	18
Failure rate [%]	2,60	0,88	1,31
Interval of reliability of results [%] with confidence level of 95 %	1,81-3,61	0,46-1,54	0,78-2,06



FTP Upload:

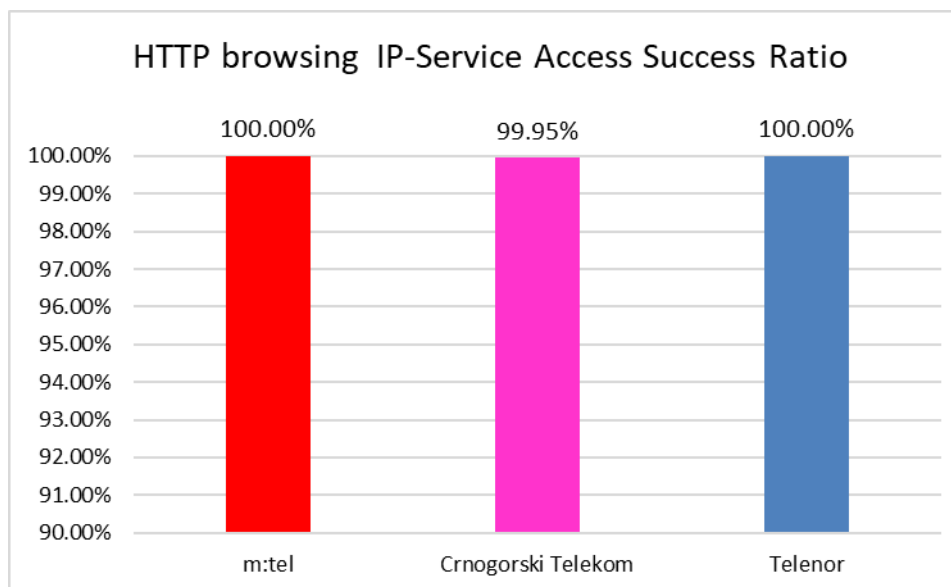
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	1433	1425	1391
Unsuccessful	491	179	564
Failure ratio [%]	34,26	12,56	40,55
Interval of reliability of results [%] with confidence level of 95 %	31,81-36,79	10,88-14,39	37,95-43,18



HTTP browsing IP-Service Access Success (Server connection setup success rate) [%] – probability that the user has successfully set up TCP/IP session with the server. It is measured jointly for upload and download.

$$\text{HTTP browsing IP-Service Access Success Ratio [\%]} = \frac{\text{number of sessions successfully setup}}{\text{number of attempts in setting up sessions}} * 100$$

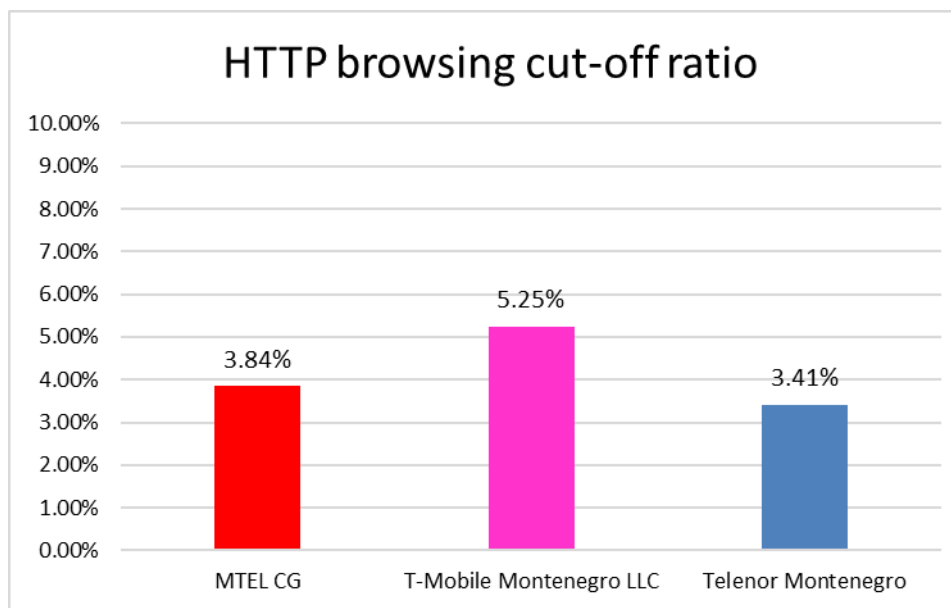
Operator	m:tel	Crnogorski Telekom	Telenor
Successful	2030	1982	2055
Unsuccessful	0	1	0
Total of samples	2030	1983	2055
Success rate [%]	100,00	99,95	100,00
Interval of reliability of results [%] with confidence level of 95 %	99,82-100	99,72-100	99,82-100



HTTP browsing Data Transfer Cut-off [%] – probability that data transfer is cut-off without intention of the user to do so. Measuring the parameter starts with the first request for sending data, after the connection with the server has been established. Measuring the parameter is completed upon receiving the last data packet.

$$\text{HTTP browsing Data Transfer Cut-off Ratio [\%]} = \frac{\text{number of data transfer unsuccessfully completed}}{\text{number of data transfer successfully commenced}} * 100$$

Operator	m:tel	Crnogorski Telekom	Telenor
Successful	2030	1982	2055
Unsuccessful	78	104	70
Failure ratio [%]	3,84	5,25	3,41
Interval of reliability of results [%] with confidence level of 95 %	3,05-4,77	4,31-6,32	2,66-4,28



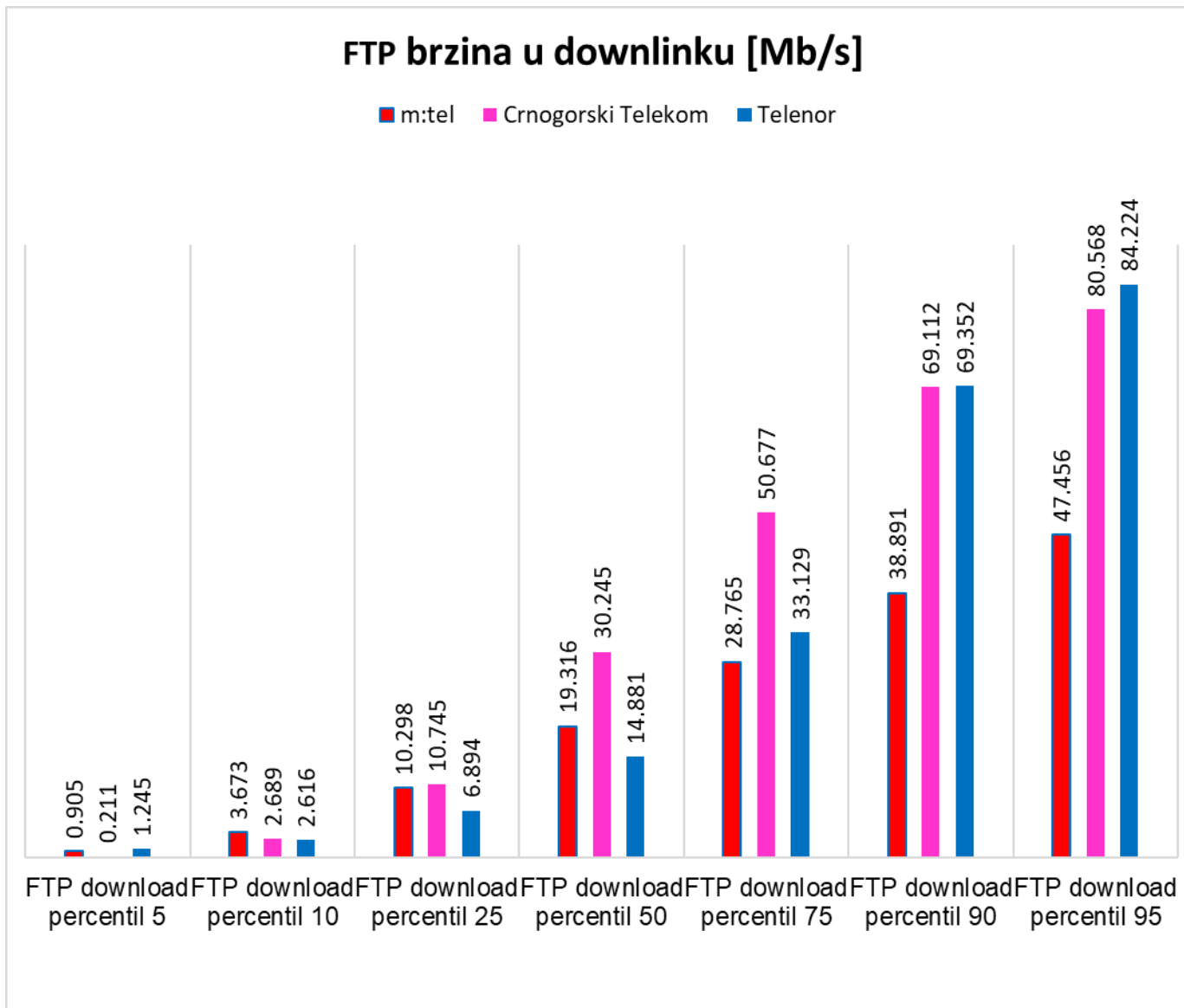
FTP data rate download [Mb/s] – speed of data transfer according to the sample measured within 1 second in the process of file transfer download.

Data given in percentiles*:

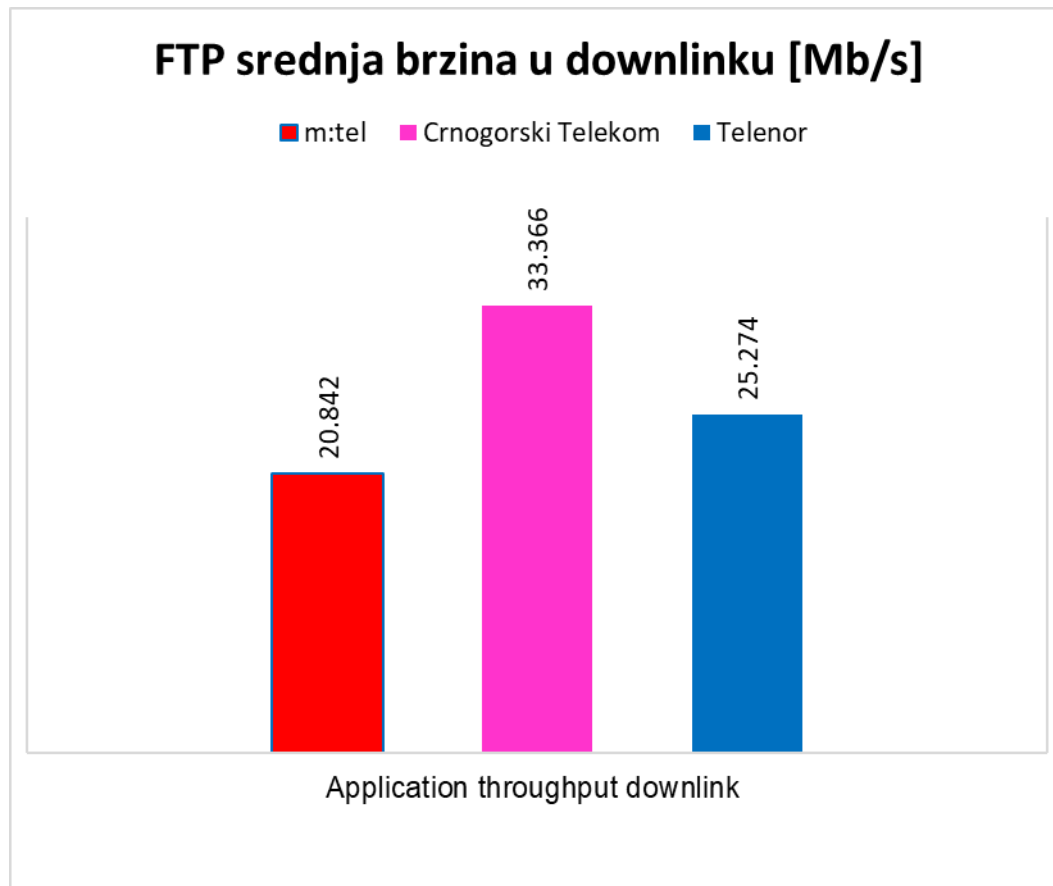
Operator	m:tel [Mb/s]	Crnogorski Telekom [Mb/s]	Telenor [Mb/s]
percentile 5	0.905	0.211	1.245
percentile 10	3.673	2.689	2.616
percentile 25	10.298	10.745	6.894
percentile 50	19.316	30.245	14.881
percentile 75	28.765	50.677	33.129
percentile 90	38.891	69.112	69.352
percentile 95	47.456	80.568	84.224
Total of samples	18822	19710	19865

	m:tel	Crnogorski Telekom	Telenor
Mean data rate [Mb/s]	20.842	33.366	25.274

* The term percentile 10 means that 10% of the samples have their values lower than or equal to the speed given in the Table (in Mb/s)



FTP data rate download [Mb/s]



FTP mean data rate download [Mb/s]

FTP mean data rate download per session [Mb/s] – mean speed of data transfer measured within one session i.e. of the test file download.

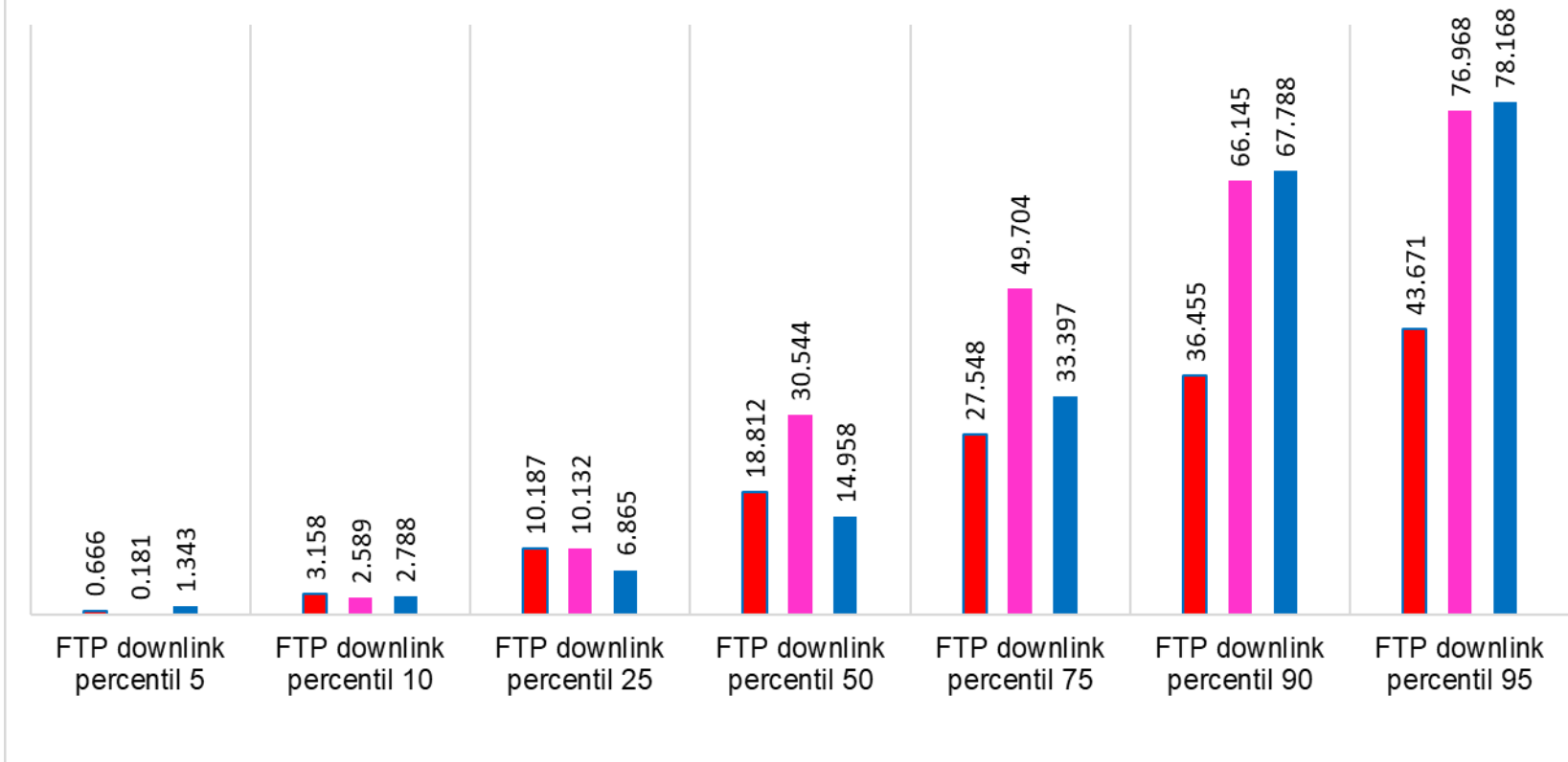
$$\text{FTP mean data rate download [Mb/s]} = \frac{\text{size of downloaded data (of the test file)}}{\text{(time of completion of the file download - time of commencement of the file download) [s]}}$$

Operator	m:tel [Mb/s]	Crnogorski Telekom [Mb/s]	Telenor [Mb/s]
percentile 5	0.666	0.181	1.343
percentile 10	3.158	2.589	2.788
percentile 25	10.187	10.132	6.865
percentile 50	18.812	30.544	14.958
percentile 75	27.548	49.704	33.397
percentile 90	36.455	66.145	67.788
percentile 95	43.671	76.968	78.168
Total of samples	1275	1325	1339

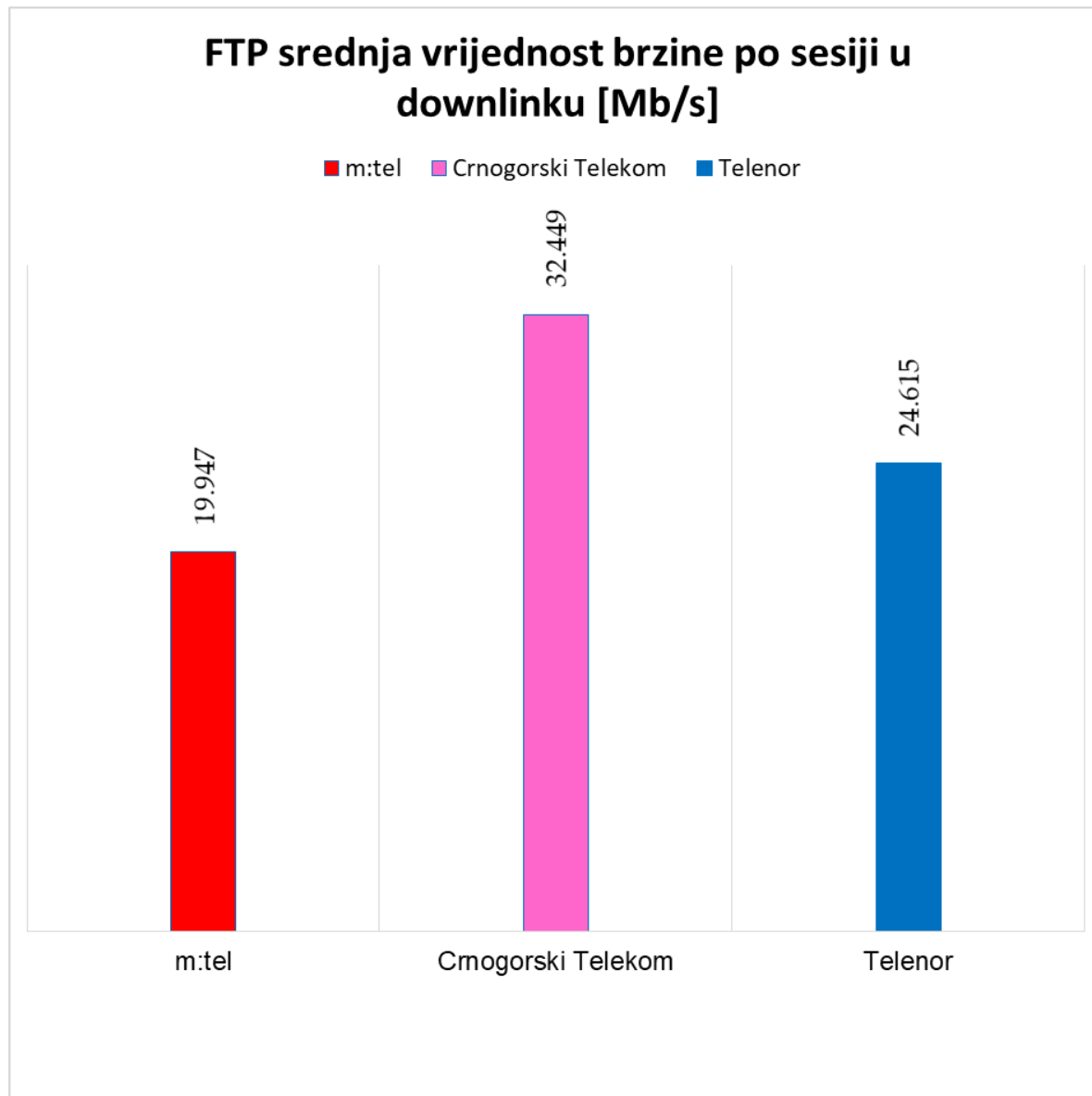
	m:tel	Crnogorski Telekom	Telenor
Mean data rate per session [Mb/s]	19.947	32.449	24.615

FTP srednja brzina u downlinku po sesiji [Mb/s]

m:tel Crnogorski Telekom Telenor



FTP mean data rate download per session [Mb/s]



FTP mean data rate download per session [Mb/s]

FTP data rate upload [Mb/s] – Speed of data transfer according to the sample measured within 1 second in the process of the file transfer upload.

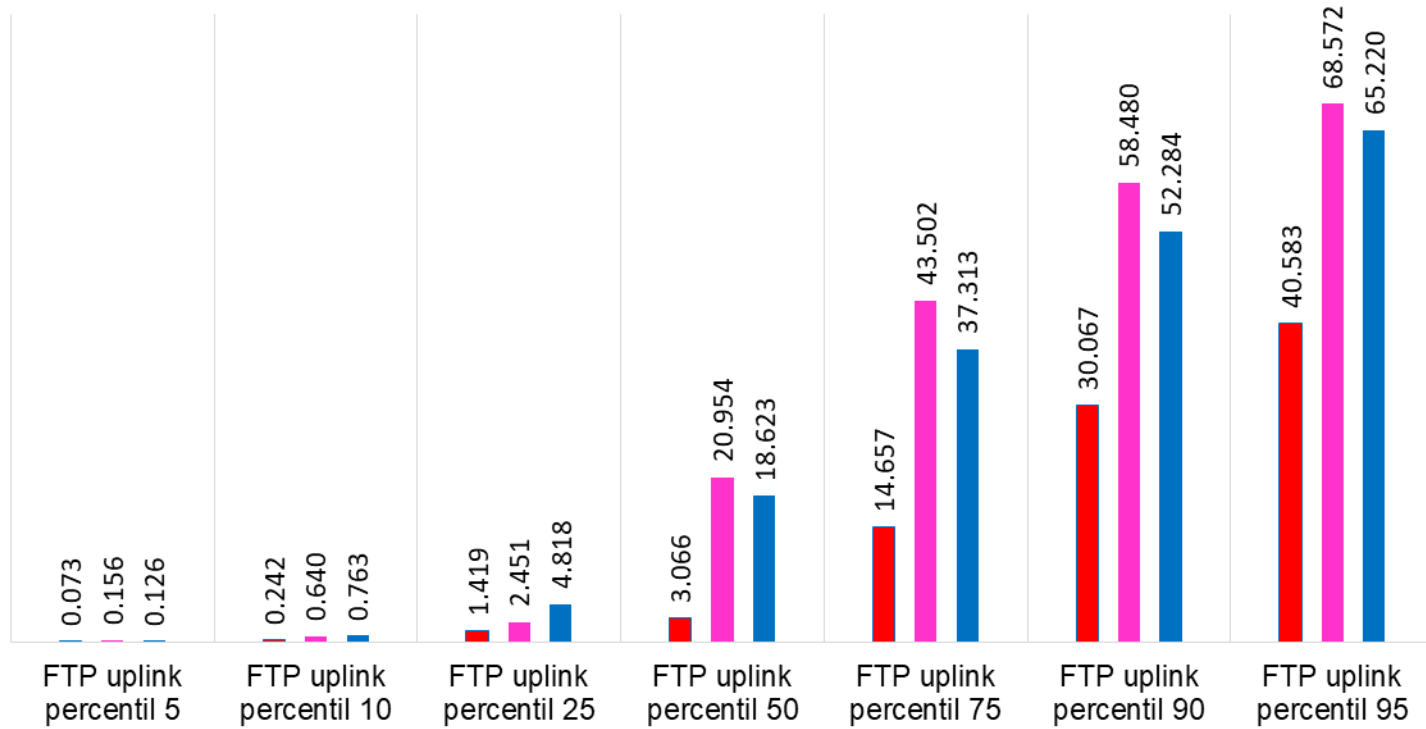
- Data given in percentiles:

Operator	m:tel [Mb/s]	Crnogorski Telekom [Mb/s]	Telenor [Mb/s]
percentile 5	0.073	0.156	0.126
percentile 10	0.242	0.640	0.763
percentile 25	1.419	2.451	4.818
percentile 50	3.066	20.954	18.623
percentile 75	14.657	43.502	37.313
percentile 90	30.067	58.480	52.284
percentile 95	40.583	68.572	65.220
Total of samples	10113	15745	8304

	m:tel	Crnogorski Telekom	Telenor
Mean data rate upload [Mb/s]	10.156	24.987	23.538

FTP brzina u uplinku [Mb/s]

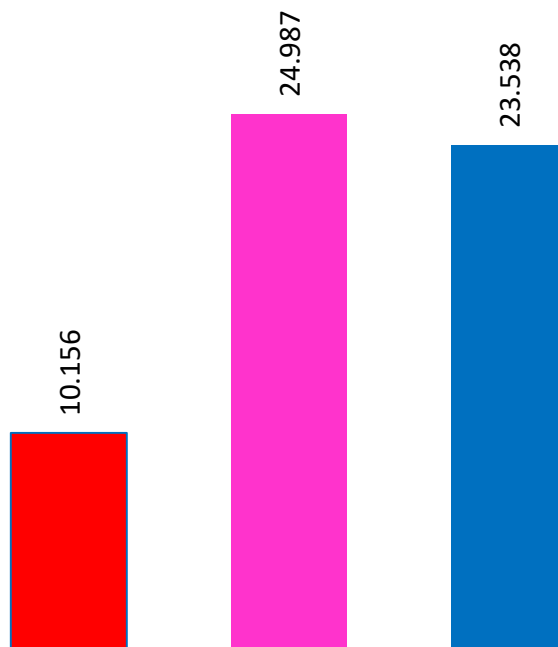
■ m:tel ■ Crnogorski Telekom ■ Telenor



FTP data rate upload [Mb/s]

FTP srednja brzina u uplinku [Mb/s]

■ m:tel ■ Crnogorski Telekom ■ Telenor



FTP mean data rate upload [Mb/s]

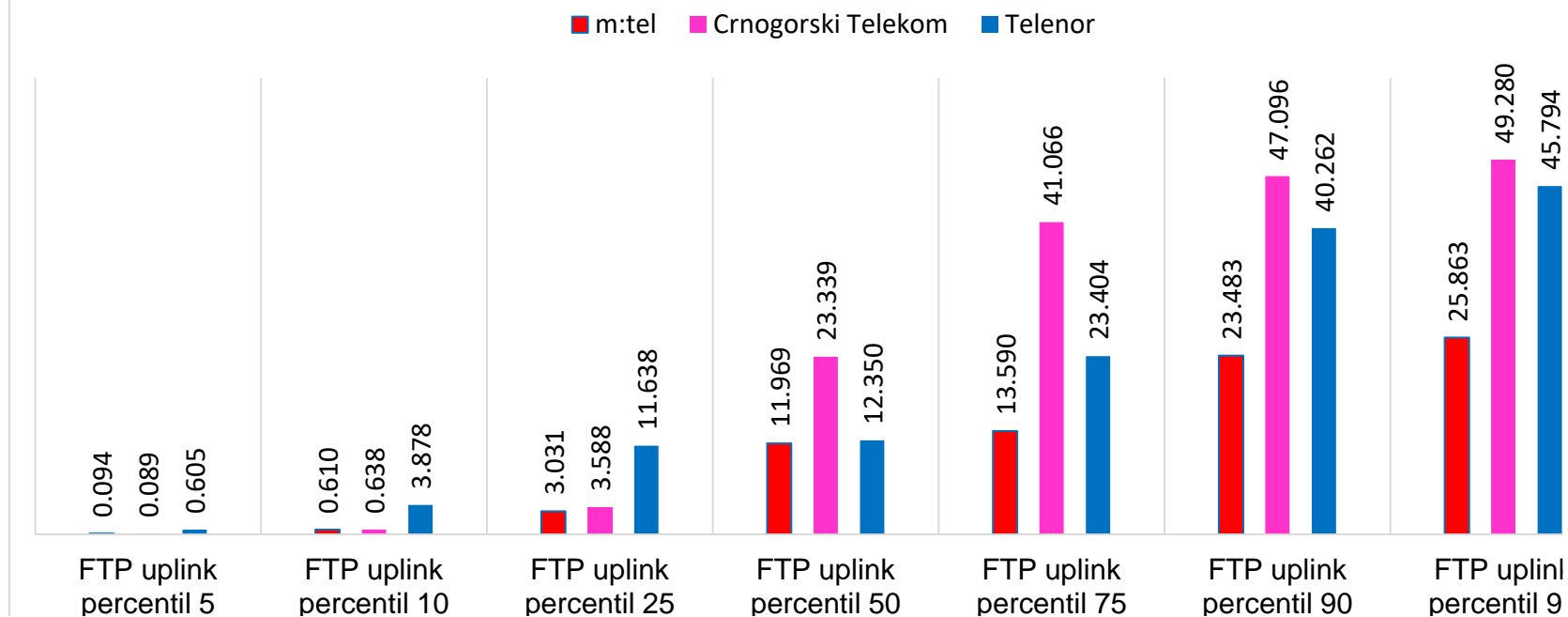
FTP mean data rate upload per session [Mb/s] –

$$\text{FTP Mean Data Rate upload [b/s]} = \frac{\text{size of uploaded data (of test file)}}{(\text{time of completion of the file upload} - \text{time of commencement of the file upload}) [\text{s}]}$$

Operator	m:tel [Mb/s]	Crnogorski Telekom [Mb/s]	Telenor [Mb/s]
percentile 5	0.094	0.089	0.605
percentile 10	0.610	0.638	3.878
percentile 25	3.031	3.588	11.638
percentile 50	11.969	23.339	12.350
percentile 75	13.590	41.066	23.404
percentile 90	23.483	47.096	40.262
percentile 95	25.863	49.280	45.794
Total of samples	1385	1396	1356

	m:tel	Crnogorski Telekom	Telenor
Mean data rate upload per session [Mb/s]	11.777	23.897	17.814

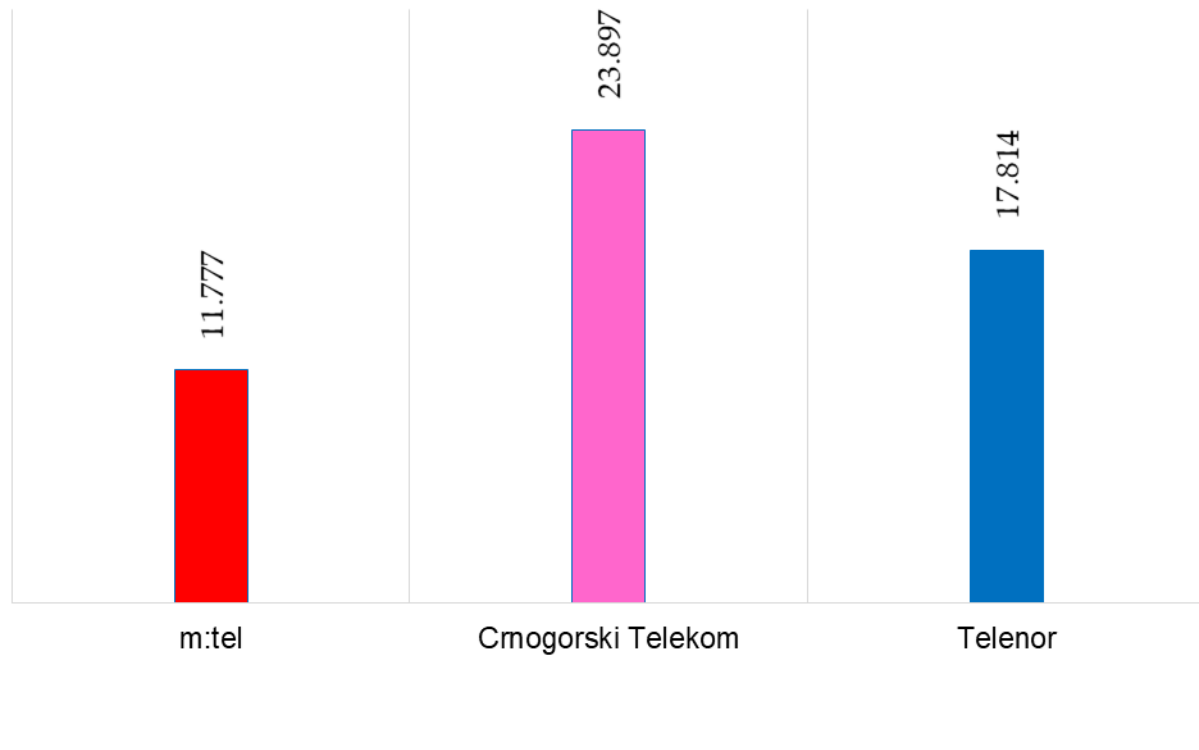
FTP srednja brzina u uplinku po sesiji [Mb/s]



FTP mean data rate upload per session [Mb/s]

Srednja vrijednost brzine po sesiji uplink [Mb/s]

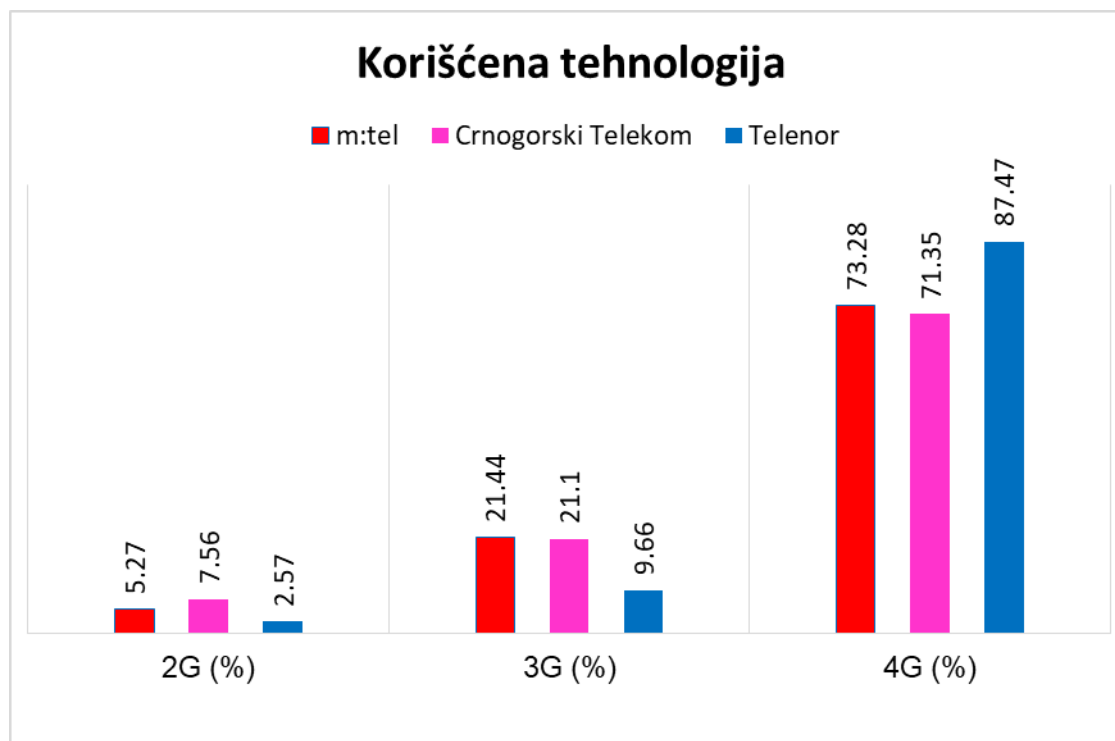
■ m:tel ■ Crnogorski Telekom ■ Telenor



FTP mean data rate upload per session [Mb/s]

Figures showing technologies deployed for data transfer.

Deployment of technology	m:tel	Crnogorski Telekom	Telenor
2G (%)	5.27	7.56	2.57
3G (%)	21.44	21.1	9.66
4G (%)	73.28	71.35	87.47



Deployment of technology