

CERTIFICATE

P3 communications GmbH

Am Kraftversorgungsturm 3, D-52070 Aachen, Germany

hereby certifies that



vodafone

Vodafone Ghana

Vodafone Office, Takyi Plaza, Spintex Road, Accra

achieved **“Best in Test”** with a

Total Score of **399 of 1000**

in the **Mobile Benchmark Ghana 12/2017.**

(Score 270 of 400 in Telephony, Score 129 of 600 in Data Services)

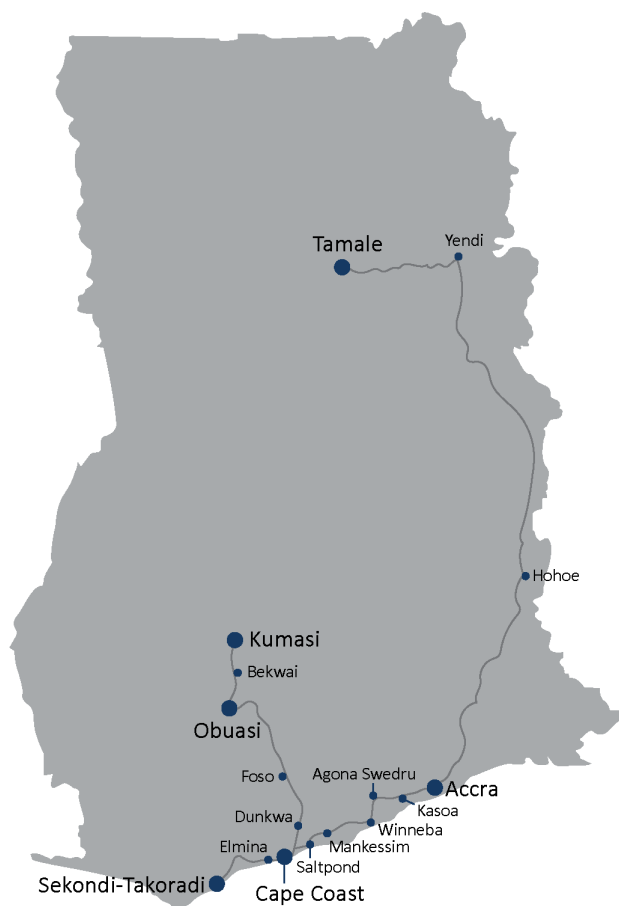


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*Head of Network Testing
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Measurement Setup

	Voice	Data
Device	Sony Xperia XZ cat9	Samsung Galaxy S7 cat9 Sony Xperia XZ cat9
Test Cases	Mobile-to-Mobile Side1 (4G preferred) to Side2 (4G preferred) Side1 (4G preferred) to Side2 (4G preferred) 115 sec call window 70 sec call duration 15 sec call setup timeout Multi-RAB traffic injection on both sides	Data 4G preferred CA HTTP DL datastream 7s HTTP UL datastream 7s HTTP 3MB DL fixed file transfer HTTP 1MB UL fixed file transfer Web Browsing - Kepler ETSI Ref. Page 10 Live web pages (50% http / 50% https) 4 YouTube HD video ~ 45s
Mobility and Route Types	100% Drivetest 52% in Cities, 18% in Towns and 30% on Roads	
Samples	~ 4100 per Operator	~ 1200 per Operator
Dates	12 measurement days 29.11.2017 – 15.12.2017	

Testing Route



Score Points and Breakdown

The following table indicates the score points achieved by the networks under test in the modules “Voice” and “Data Services” as well as the breakdown of achieved points in the geographical categories “Cities”, “Towns” and “Roads”.

Module	Infrastructure	Max.	Vodafone	Operator 2	Operator 3	Operator 4
Voice	Total	400	270	44	130	53
	Cities	240	71%	10%	32%	14%
	Towns	80	79%	12%	50%	12%
	Roads	80	46%	13%	16%	13%
Data	Total	600	129	279	90	71
	Cities	360	21%	57%	14%	14%
	Towns	120	31%	42%	19%	11%
	Roads	120	13%	19%	13%	7%
TOTAL		1.000	399	323	220	124

Shown voice, data and total scores are rounded

The following table indicates the achieved percentage of the maximum score in each of the different data services.

Data	Service Group	Max.	Vodafone	Operator 2	Operator 3	Operator 4
Cities	Web Browsing	108	8%	50%	10%	8%
	File Download	90	43%	59%	15%	18%
	File Upload	90	10%	71%	8%	7%
	YouTube	72	27%	49%	28%	25%
Towns	Web Browsing	36	9%	28%	10%	7%
	File Download	30	59%	49%	26%	8%
	File Upload	30	31%	54%	7%	7%
	YouTube	24	28%	39%	37%	24%
Roads	Web Browsing	36	9%	9%	7%	4%
	File Download	30	10%	16%	10%	6%
	File Upload	30	12%	19%	10%	6%
	YouTube	24	27%	35%	29%	16%

Voice KPI Overview

The following table indicates the achieved values of all networks under test in each of the relevant Voice Key Performance Indicators (KPIs) for the geographical categories “Cities”, “Towns” and “Roads”.

Voice M2M	KPI Name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
Cities	Qualifier	[%]	96,9	81,8	91,4	87,4
	Call Setup Time	[s]	5,2	9,3	6,0	6,4
	AVG Speech Quality	[MOS-LQO]	3,2	2,6	2,6	2,6
Towns	Qualifier	[%]	97,8	85,4	93,8	85,3
	Call Setup Time	[s]	4,6	7,8	5,5	6,2
	AVG Speech Quality	[MOS-LQO]	3,4	2,6	2,8	2,4
Roads	Qualifier	[%]	88,0	74,2	58,9	75,0
	Call Setup Time	[s]	5,4	7,3	5,7	6,3
	AVG Speech Quality	[MOS-LQO]	3,3	2,6	2,6	2,5

Data KPI Overview

The following table indicates the achieved values of all networks under test in each of the relevant Data Key Performance Indicators (KPIs) for the geographical categories “Cities”, “Towns” and “Roads”.

Data Cities	KPI Name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
HTTP Live Page DL	Qualifier	[%]	80,4	94,9	80,4	70,4
	Time to first Byte	[ms]	1.302	794	2.619	3.359
	KBytes first second	[KB]	150	247	196	142
HTTP Static Page DL	Qualifier	[%]	78,9	96,0	82,2	78,2
	AVG Session Time	[s]	5,4	3,5	5,6	5,6
HTTP file DL 3MB	Qualifier	[%]	96,4	97,7	87,9	90,9
	AVG Session Time	[s]	10,0	6,6	12,3	14,3
	90% faster than	[kbit/s]	1199	1790	1073	853
	10% faster than	[kbit/s]	8791	17559	9693	6916
HTTP file UL 1MB	Qualifier	[%]	87,1	98,3	80,5	78,5
	AVG Session Time	[s]	8,0	2,3	10,5	11,4
	90% faster than	[kbit/s]	630	2.448	513	468
	10% faster than	[kbit/s]	1.803	7.220	2.201	1.708
HTTP DL FDTT 7s	Qualifier	[%]	94,4	97,3	91,7	89,6
	AVG throughput	[kbit/s]	5825	14560	6495	4371
	90% faster than	[kbit/s]	1164	2000	1344	890
	10% faster than	[kbit/s]	12624	32947	12894	8998
HTTP UL FDTT 7s	Qualifier	[%]	79,9	97,7	74,2	74,2
	AVG throughput	[kbit/s]	1.475	11.294	1.382	1.022
	90% faster than	[kbit/s]	668	3387	490	492
	10% faster than	[kbit/s]	2282	18826	2820	2128
YouTube	Qualifier	[%]	79,0	91,4	82,0	68,4
	Start Time	[s]	5,4	3,5	6,0	6,4
	Playouts w/o interruptions	[%]	89,6	96,6	93,2	94,5
	AVG Resolution	[p]	927,9	1029,0	993,0	909,9

Data Towns	KPI Name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
HTTP Live Page DL	Qualifier	[%]	84,1	90,3	86,3	61,7
	Time to first Byte	[ms]	1.246	911	2.627	3.326
	KBytes first second	[KB]	154	243	200	140
HTTP Static Page DL	Qualifier	[%]	88,1	92,6	86,1	68,2
	AVG Session Time	[s]	5,3	3,7	5,5	5,5
HTTP file DL 3MB	Qualifier	[%]	98,3	95,2	90,7	77,4
	AVG Session Time	[s]	8,0	7,4	11,5	14,1
	90% faster than	[kbit/s]	1658	1281	1326	917
	10% faster than	[kbit/s]	9578	18251	8224	7600
HTTP file UL 1MB	Qualifier	[%]	93,0	96,8	78,1	71,8
	AVG Session Time	[s]	7,3	3,1	9,9	11,5
	90% faster than	[kbit/s]	753	1.300	519	473
	10% faster than	[kbit/s]	1.842	7.318	2.387	1.643
HTTP DL FDTT 7s	Qualifier	[%]	97,9	96,0	93,6	78,8
	AVG throughput	[kbit/s]	6265	15684	6885	4379
	90% faster than	[kbit/s]	1743	1183	1872	1009
	10% faster than	[kbit/s]	12454	38073	11965	9780
HTTP UL FDTT 7s	Qualifier	[%]	91,5	93,6	77,8	65,9
	AVG throughput	[kbit/s]	1.561	10.032	1.372	1.024
	90% faster than	[kbit/s]	784	1328	453	487
	10% faster than	[kbit/s]	2435	18941	2753	2095
YouTube	Qualifier	[%]	88,4	82,9	88,6	60,2
	Start Time	[s]	5,1	3,3	5,5	6,4
	Playouts w/o interruptions	[%]	93,7	97,5	96,9	85,5
	AVG Resolution	[p]	961,2	1044,1	1032,5	873,6

Data Roads	KPI Name	Unit	Vodafone	Operator 2	Operator 3	Operator 4
HTTP Live Page DL	Qualifier	[%]	51,0	54,4	42,2	20,9
	Time to first Byte	[ms]	1.344	1.574	2.702	3.768
	KBytes first second	[KB]	151	222	189	126
HTTP Static Page DL	Qualifier	[%]	50,7	56,2	42,5	23,8
	AVG Session Time	[s]	5,4	4,6	5,6	5,6
HTTP file DL 3MB	Qualifier	[%]	58,5	60,9	43,4	28,7
	AVG Session Time	[s]	10,6	8,7	10,5	17,0
	90% faster than	[kbit/s]	987	1435	1335	766
	10% faster than	[kbit/s]	8030	15141	9317	6663
HTTP file UL 1MB	Qualifier	[%]	54,0	58,6	40,9	20,0
	AVG Session Time	[s]	7,8	5,8	8,8	9,8
	90% faster than	[kbit/s]	664	759	538	592
	10% faster than	[kbit/s]	1.776	7.005	2.447	2.373
HTTP DL FDTT 7s	Qualifier	[%]	57,7	60,4	46,1	27,7
	AVG throughput	[kbit/s]	5644	10019	6122	3320
	90% faster than	[kbit/s]	944	2005	1578	707
	10% faster than	[kbit/s]	11117	21080	11302	7062
HTTP UL FDTT 7s	Qualifier	[%]	47,8%	52,6	36,7	20,9
	AVG throughput	[kbit/s]	1.531	5.633	1.704	1.119
	90% faster than	[kbit/s]	626	841	727	460
	10% faster than	[kbit/s]	2514	17243	2829	2477
YouTube	Qualifier	[%]	49,3	56,5	43,5	23,0
	Start Time	[s]	5,4	5,0	6,6	7,8
	Playouts w/o interruptions	[%]	91,2	95,4	92,9	77,4
	AVG Resolution	[p]	925.6	971.5	940.7	667.3