AUDIT REPORT

P3 communications GmbH

Am Kraftversorgungsturm 3, D-52070 Aachen, Germany

Has been tasked by

TDC Group, Sletvej 30 10-184, 8310 Tranbjerg J, Denmark

to independently audit the

performance of its voice and data services on smartphones

in comparison to other GSM/UMTS/LTE mobile radio networks in metropolitan and rural areas of the islands Zealand, Lolland and Falster in Denmark.

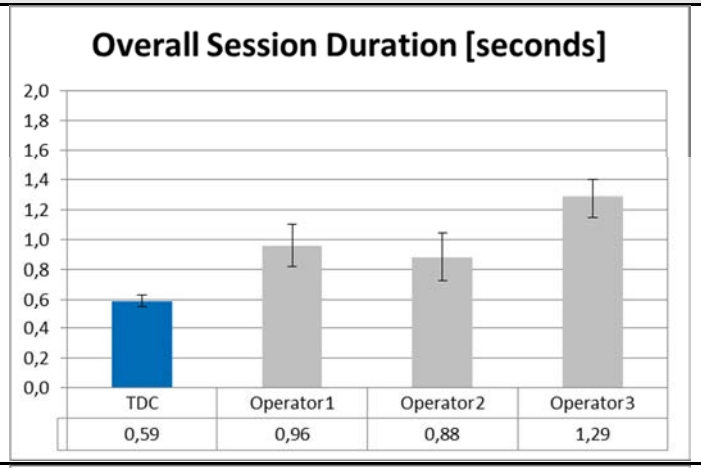
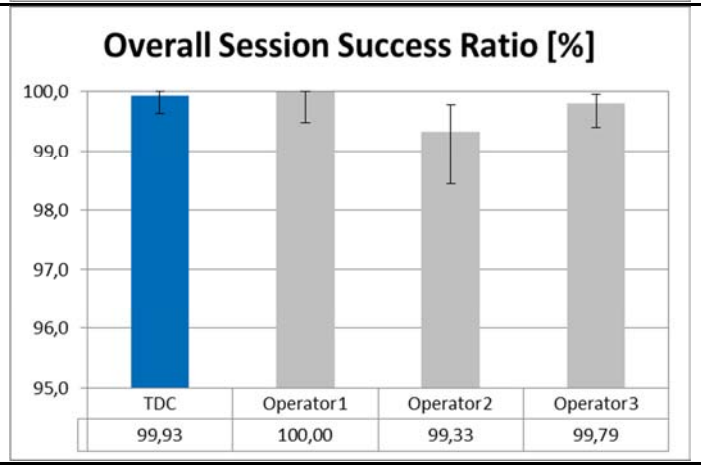
The audit was done as an independent performance benchmark performed by P3 communications between December 12th and December 18th, 2014 in Copenhagen and 10 further cities and towns as well as on connection roads. Measurements have been executed as drive tests outdoors using a Samsung Galaxy S4 LTE+ Smartphone (150 Mbit/s Download / 50 Mbit/s Upload). All data measurements have been performed in LTE/3G/2G mode (LTE preferred). Voice measurements have been done in LTE preferred mode on one side and 3G preferred mode on other side, while call origin has been alternated.

The following pages provide a comparative overview about the performance results observed for the different tested service types. Unless otherwise stated the shown bar graphs present the average value of the respective KPI and the error bars indicate the 95% confidence interval.

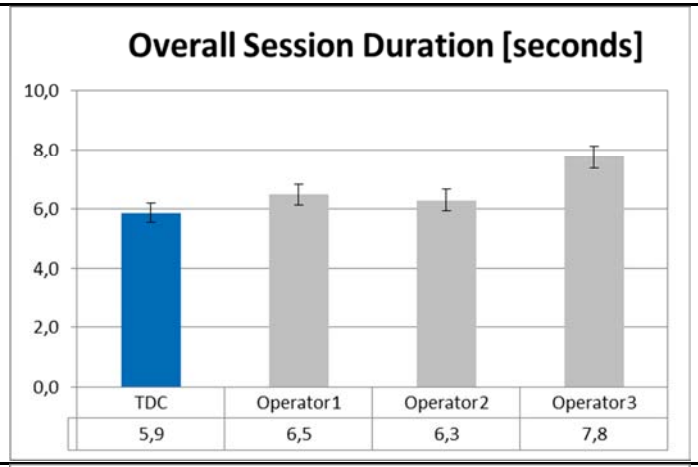
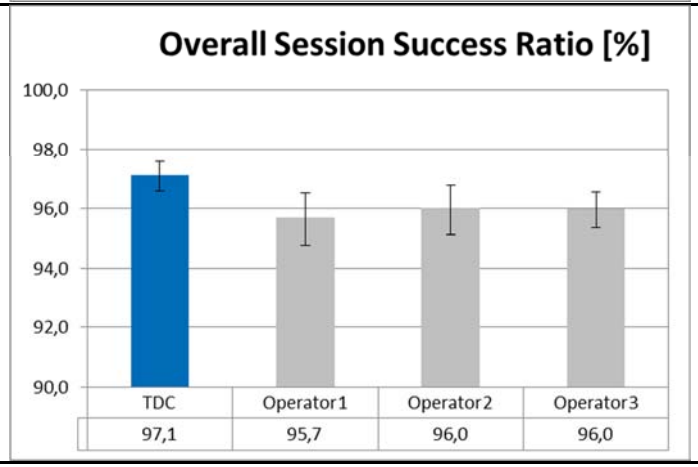
Smartphone Voice – mobile-to-mobile communication
Smartphone Data – HTTP Web Browsing, HTTP File Transfer and YouTube Video

Maziar Kianzad
Head of International Benchmarking

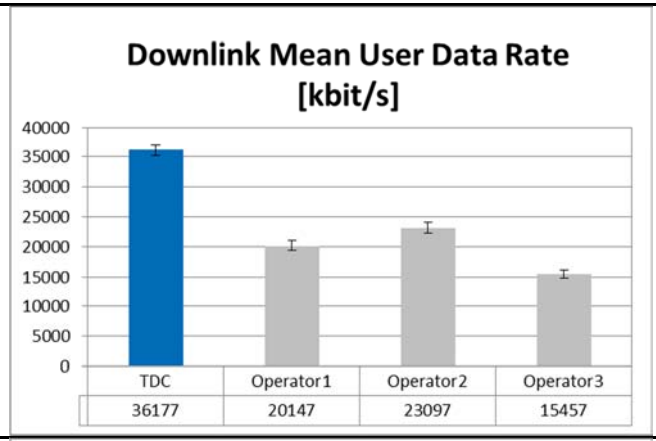
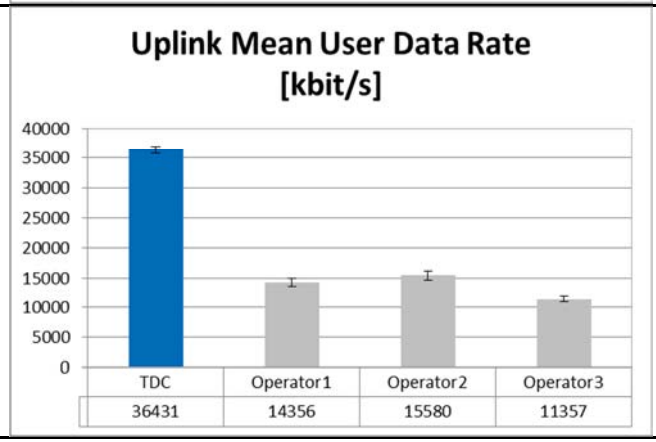
Audit Result Summary

Smartphone Data Service			
Service Type	**Requirement**	**KPI Name and Description**	**Result**
Smartphone Data – Static Web Browsing ‚Kepler' reference page	In order to offer a good HTTP Static Web Browsing service the content must be transferred quickly and reliably. Further the content must not be compressed in a way that lossy compression affects the user perception.	Static Web Page Session Time including DNS resolution time, IP Service Access Time and Transfer Time.	
		Static Web Page Session Success Ratio including DNS Resolution Success, IP Service Access Success.	

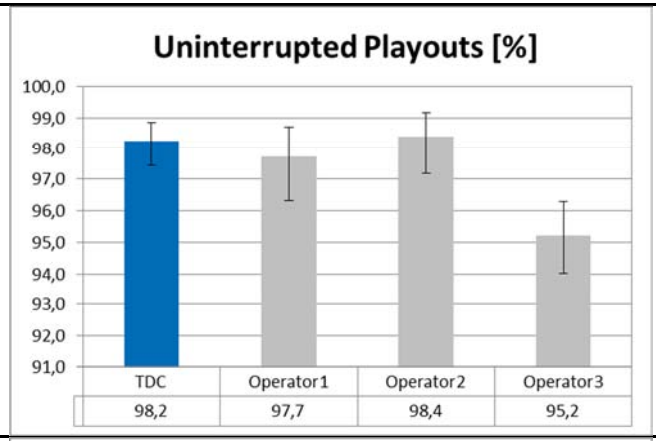
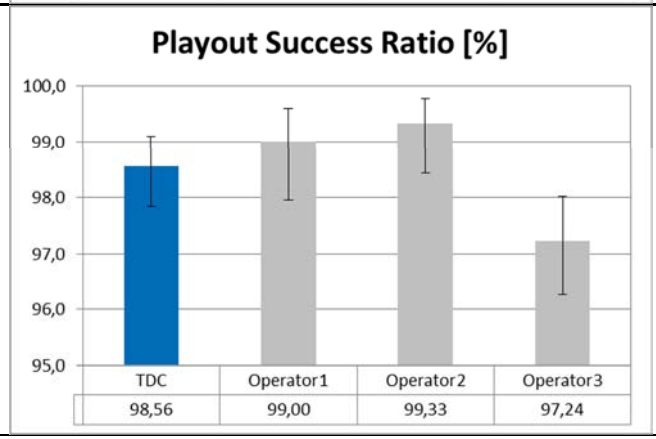
Audit Result Summary

Smartphone Data – Live Web Browsing. 3 Top live web pages in Denmark have been measured: **m.ekstrabladet.dk** **m.youtube.com** **en.m.wikipedia.org**	In order to offer a good HTTP Live Web Browsing service the content of 3 Top Live pages must be transferred quickly and reliably. Further the content must not be compressed in a way that lossy compression affects the user perception.	Live Web Page Session Time including DNS Resolution Time, IP Service Access Time and Transfer Time.	
		Live Web Page Session Success Ratio including DNS Resolution Success, IP Service Access Success and Transfer Success.	

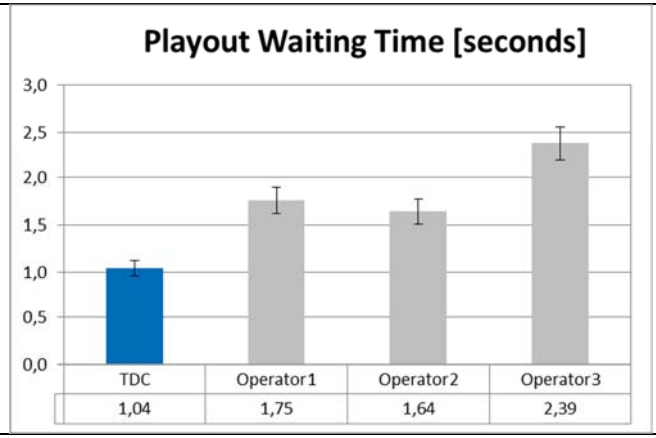
Audit Result Summary

Smartphone Data - Data Transfer in uplink and downlink direction	In order to offer a good HTTP Data Transfer downlink or uplink service the uncompressible content must be transferred quickly and reliably.	Average Mean User Data Rate based on a 10 second HTTP file download. An infinite file is downloaded for 10 seconds. The transferred amount of data is divided by 10 seconds to calculate the mean user data rate.		Better
		Average Mean User Data Rate based on a 10 second HTTP file upload. An infinite file is uploaded for 10 seconds. The transferred amount of data is divided by 10 seconds to calculate the mean user data rate.		Better

Audit Result Summary

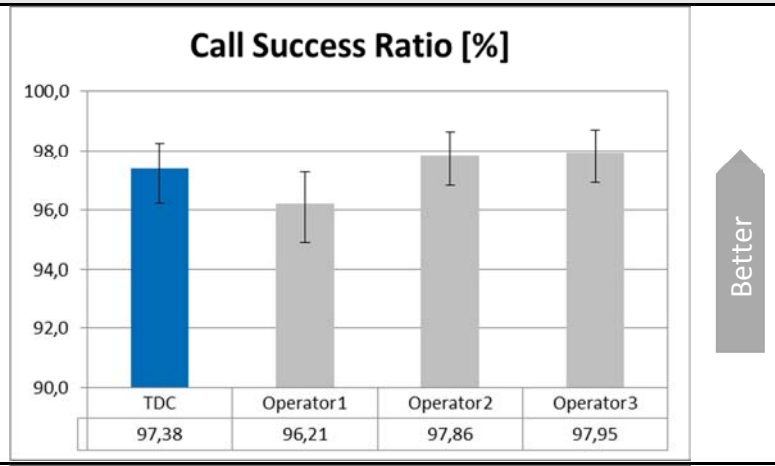
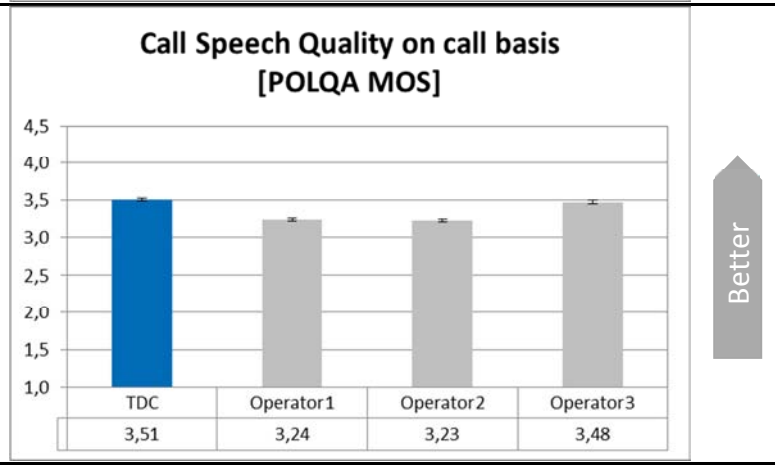
Smartphone Data - YouTube Video HD	In order to provide a good quality regarding the YouTube service, a smooth Playout of the reference video without any interruptions is required.	Percentage of uninterrupted Playouts without any interruptions. This KPI aims at fixed line YouTube Experience without any interruptions.		Better
	In order to provide a good quality regarding the YouTube service, a smooth Playout of the reference video without major interruptions is required.	Percentage of successful downloads including minor interruptions. Single interruptions up to 8 seconds and a total interruption length of 15 seconds are accepted.		Better

Audit Result Summary

	In order to offer a good quality regarding the YouTube service a short waiting time before the video starts playing is required.	The Playout Waiting Time includes video Catalogue Service Access and Download time, video IP Service Access and video buffering time.		Better

Audit Result Summary

<table>
<tr><th colspan="4">LTE/3G preferred Smartphone Voice Service</th></tr>
<tr><th>Service Type</th><th>Requirement</th><th>KPI Name and Description</th><th>Result</th></tr>
<tr><td rowspan="2">Voice mobile-to-mobile service measured with two independent devices and systems at different locations. One party was set to LTE preferred, the other to 3G preferred mode.</td><td>In order to offer a good Voice Service a network has to provide reliable service access and stable voice calls.

Call Success Ratio values around 97% indicate a sufficient, values around 98% a good and values around 99% an excellent quality.</td><td>The Call Success Ratio includes the Call Setup Success Ratio and the composite Dropped Call Ratio.</td><td> 
</td></tr>
<tr><td>In order to offer a good Voice Service a network has to provide reasonable speech quality. Offered speech codecs, share of low and empty speech samples and general network performance impact the mean speech quality score.</td><td>Average Speech Quality on Call Basis is adapted from POLQA wideband evaluation. Each recorded speech sample is compared with a German wideband reference sample. The POLQA algorithm determines a value between 1.0 and 4.5 where 4.5 is the best value.</td><td> 
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