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experience

Mobile Voice and Data Experience in Denmark

Summary Report

18 May 2015

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Maximised Customer Experience, Minimised Network Cost

We provide consulting and expert services for telecom operators and regulators in network strategy, design and quality assurance. Our mission is to maximise mobile subscriber quality of experience and minimise operator network expenditures.

Delivering Omnitele Experience

The company was founded in 1988 to set up world's first GSM network. Since then we have completed over 1000 projects in over 80 countries around the globe. Always delivering *Omnitele Experience* - a fact proven by our long lasting client relationships.

International and Independent

Our headquarters is located in Helsinki, Finland and we have local presence in the Netherlands. Our company is owned by Finnish telecom investors and we are independent of operator groups and network vendors.

The Omnitele Way

Our unique way of working sets us apart from the competition and gives us a strong identity in the world of telecommunications. We call this the *Omnitele Way*, which means being Straightforward, Trusted and Intelligent.

1 Introduction

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Omnitele Ltd is a pioneer within the wireless industry with over two decades of consulting experience worldwide. We conduct independent mobile network quality surveys frequently around the globe. Our aim with this activity is to secure continuous visibility into mobile network quality trends and to promote competition and mobile subscriber customer experience.

In this report we show key results of the customer experience benchmark conducted in Denmark, April 2015. The tested mobile operators were TDC, Telenor, Telia and Tre.



The benchmark consisted of a country-wide drive test campaign and stationary hot-spot tests. The drive tests focused on assessing voice call service quality and data speeds. The stationary tests involved testing of popular smartphone applications: WWW browsing, Facebook, Twitter, Instagram, YouTube and Dropbox.



The measurements were conducted with Omnitele's *be-the-customer* methodology. The tested services, testing times and test locations were selected independently by Omnitele, based on expected end-user behaviour.

In this report we publish only the key results and selected customer centric Key Performance Indicators (KPI) on whole country level. Detailed technical network analysis and location level results are omitted.

The presented results illustrate a snap-shot view of the perceived customer experience and network performance within the given time and location contexts. Omnitele has conducted the measurements and analysis with an objective and reliable methodology following industry standards and best practices.

2 Results

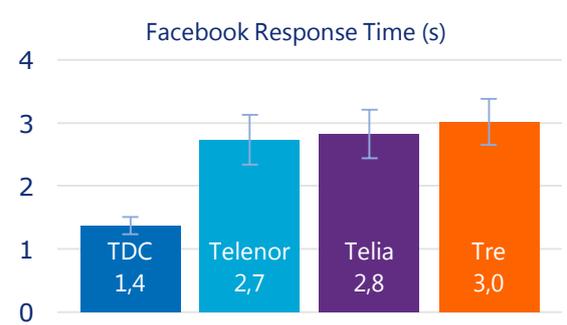
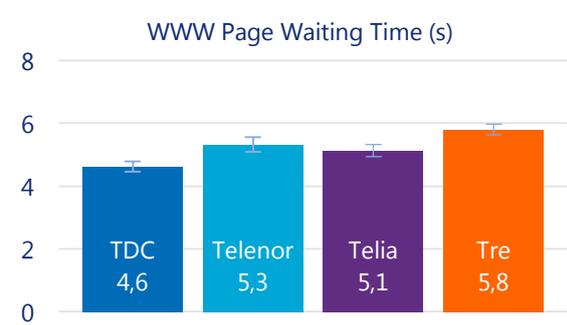
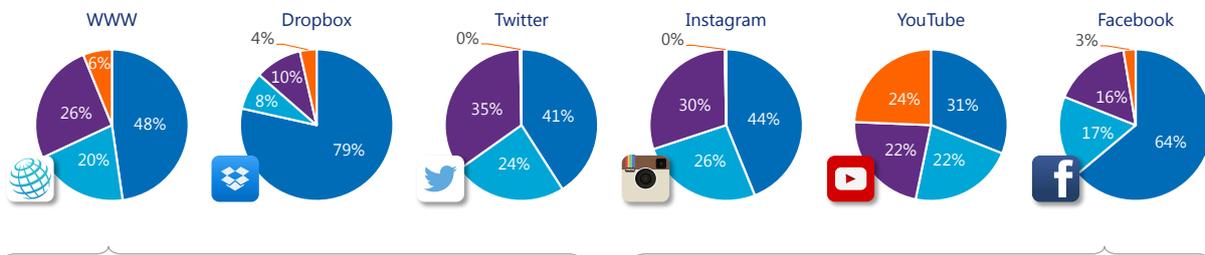
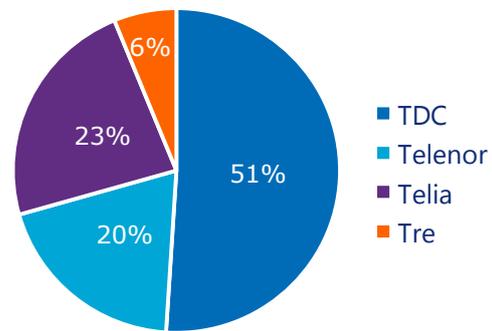
2.1 Application Tests

A high bitrate – although desirable – is not sufficient alone to guarantee smooth experience for today's smartphone applications. In order to capture the true smartphone application experience, from end-user perspective, the tests are performed in application level rather than only network level; hence the WWW browsing, Facebook, Twitter, Instagram, YouTube and Dropbox test cases.

Taking into account all tests in every measured location (1872 averaged samples in 312 locations), the results show that TDC performs the best in 51% of smartphone application tests. Telia and Telenor follow with 23% and 20% respectively. Tre performs the best in 6% of the tests.

The absolute differences vary among applications. For example in average web page waiting time the operators are rather close to each other. In Facebook response time (posting a picture, status update and wall refresh) TDC is about 50% faster than Telenor, Telia and Tre. The latter three are neck and neck despite the fact that Tre wins in only 3% of locations.

All Application Tests
BEST OPERATOR PER LOCATION

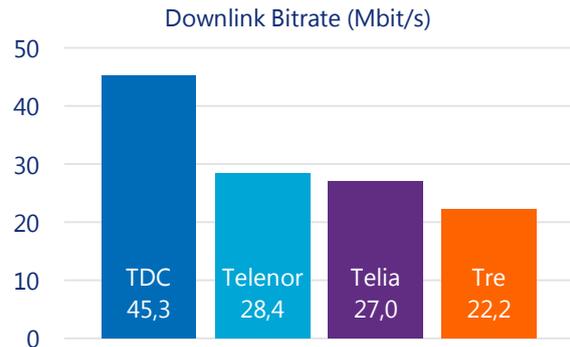


The results indicate that from smartphone application performance perspective all Danish mobile service providers offer good end-user experience. In the light of this study TDC seems to have an advantage over Telenor, Telia and Tre in the examined smartphone applications' performance.

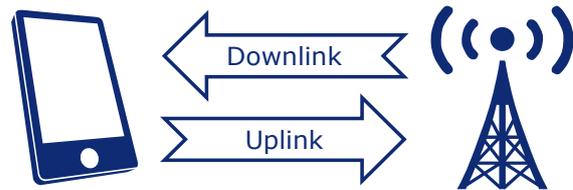
2.2 Data Speed

Data speed tests give an overview of the mobile network’s capabilities for file transfers, e.g. downloading applications or email attachments or uploading videos to a social network. The mobile networks’ bitrate capabilities were tested in drive testing fashion with FTP (File Transfer Protocol) transfers.

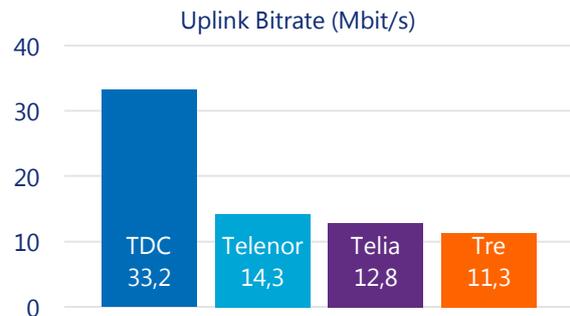
The downlink bitrate tests (network ⇒ user) suggest that all four operators offer good data speeds. TDC outperforms the other three operators with average bitrate of 45 Mbit/s. Telenor and Telia follow TDC with 28 and 27 Mbit/s respectively. Tre closes the ranking with 22 Mbit/s. The achieved peak bitrates (not visible in the graphs) were also rather high for all operators: TDC 137 Mbit/s; Telia 110 Mbit/s; Telenor 104 Mbit/s and Tre 95 Mbit/s.



Most of the mobile network traffic is originated from network towards the user. The growing popularity of social media, picture and video sharing portals still emphasises the importance of sufficient uplink capacity (user ⇒ network).



The uplink bitrate tests indicate good uplink data speeds for all operators. The competitive positioning follows the downlink results: TDC is the first with an average bitrate of 33 Mbit/s. Compared to downlink tests, the TDC advantage against competition is even greater. Telenor has the second highest value 14 Mbit/s, followed closely by Telia 13 Mbit/s, and Tre 11.3 Mbit/s.



Omnitele sees that the observed average downlink and uplink bitrates of all service providers are sufficient for good customer experience with most popular applications and services. The high data rates of TDC are especially beneficial with data-intensive applications such as FullHD video streaming and cloud file storage services.

In the light of this study, TDC seems to have a clear advantage over Telenor, Telia and Tre in average download and upload speeds. All operators are well aligned with international reference markets and industry standards.

2.3 Voice Calls

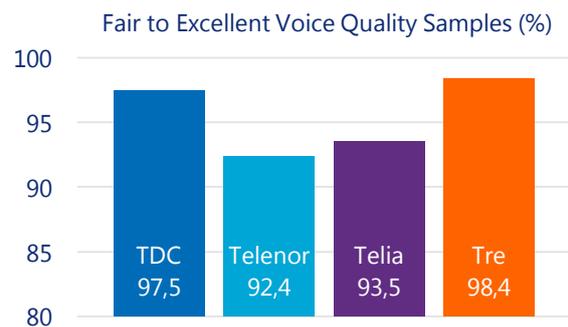
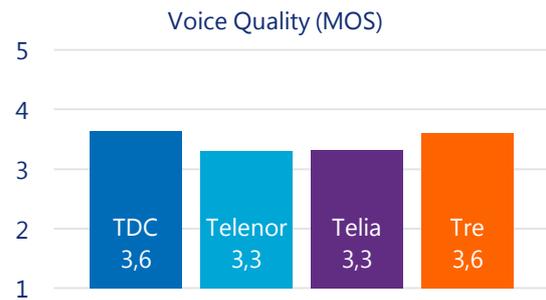
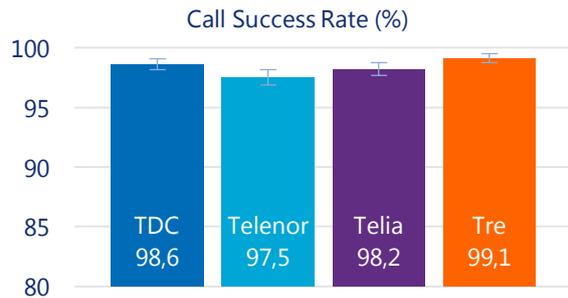
Despite the surge of mobile data, the mobile voice service functionality and quality still represents significant part of end-users' smartphone experience. Omnitele tested the Danish mobile operators' voice service quality in drive testing fashion. Altogether over 9000 test call attempts were initiated.

The results indicate that mobile voice call service in Denmark complies with industry standards. Call Success Rate (% of calls that are successfully initiated and terminated without a drop) is rather high for all operators: Tre 99.1%; TDC 98.6%; Telia 98.2% and Telenor 97.5%. The difference between Tre and Telenor is statistically significant, other differences are within error margin.

Omnitele also measured the voice call audio quality. Voice Quality is reported in MOS (Mean Opinion Score) scale [1...5]. With the applied POLQA super wideband algorithm, MOS values below 2.5 can be considered to indicate at least slightly annoying quality distractions.

The results imply good voice quality for TDC (3.6) and Tre (3.6). Telenor and Telia follow very close with an average MOS of 3.3.

Assessing the amount of fair to excellent quality samples (MOS \geq 2.5) reveals more differences between operators' voice quality. Tre scores the highest with 98.4% and performs slightly better than TDC that comes the second with 97.5%. Telia is third with 93.5% leaving Telenor to fourth position with 92.4%.



In light of this study, voice call service is on good level for all Danish operators. Taking into consideration all parameters, Tre and TDC seem to have an advantage over Telia and Tre in mobile voice service.

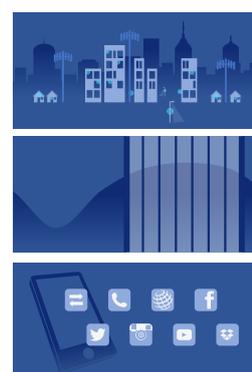
3 Methodology

3.1 Measurements

The measurement phase comprised of two different measurement methodologies: 1. Stationary hotspot measurements for assessing Smartphone data customer QoS and; 2. Drive test measurements for assessing voice call quality and data capacity.

For measurements Omnitele applied internally standardised *Be-the-Customer* approach, which emulates real subscribers' smartphone usage patterns, times and locations.

WHERE	Dense population areas selected independently by Omnitele
WHEN	Test focus on peak hours, avoid empty network testing
HOW	Test terminals and use cases as per real subscriber behaviour



Further details of the test methodology are summarised in below table.

Item	Description
Test Devices	Samsung Galaxy S5 (voice & hotspot) and Galaxy Note 4 (for data) with measurement software. The selected test devices represent typical modern consumer handsets with advanced technical functionalities.
SIM cards	Publicly available SIM cards sourced from operator stores. Preferred unlimited voice and data plans with best available data speeds.
Test locations	Chosen independently by Omnitele to preserve the objectiveness and integrity of the results. Focus on high subscriber density locations. Amount of km driven per city proportional to population. Includes connecting roads between cities. Number of hotspots per city proportional to population.
Approximate Testing Times	Test days: Testing only between Monday and Saturday, no Sunday measurements. Test hours, Mon – Fri: Focus on busy hours 08:00 – 20:00. No testing during night time: 00:00 – 06:00. Test hours, Saturday: Measurements only between 10:00 – 00:00. Focus on busy hours 12:00 – 20:00. No measurements in business or university areas

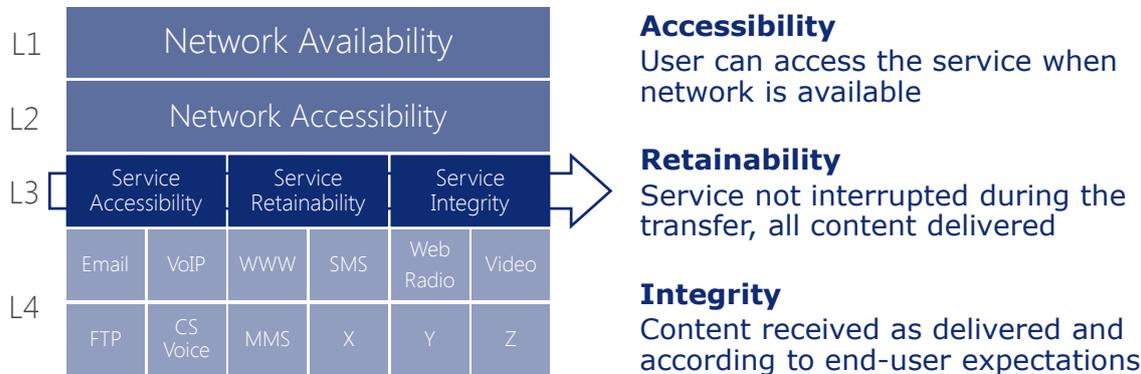
Measurements were conducted in Danish cities with at least 30 000 inhabitants: Copenhagen, Aarhus, Odense, Aalborg, Esbjerg, Randers, Kolding, Horsens, Vejle, Roskilde, Herning, Helsingør, Hørsholm, Silkeborg, Næstved, Fredericia, Viborg, Køge, Holstebro, Taastrup, Slagelse and Hillerød. In addition, measurements were also conducted in touristy towns such as Blokhus and Billung. In total, the measurement campaign included 3923 kilometres of drive testing and stationary tests in 312 locations.

All test cases were executed with test terminals in “floating mode”, freely selecting frequency band and network technology as per network parameterisation. This ensures that measurements illustrate true customer behaviour. The table below contains a high level description of the test cases.

	Test Case	Description
	Mobile-to-Mobile Voice Call	- 120s call, MOS quality measured using POLQA ¹ algorithm
Drive test	Downlink File Transfer	- 90s FTP file transfer, high capacity FTP server (zone.ee), multiple TCP threads
	Uplink File Transfer	- 90s FTP file transfer, high capacity FTP server (zone.ee), multiple TCP threads
	Dropbox	- 3 Dropbox file downloads per test location, fixed file size 20MB
	Facebook	- 3 Facebook wall refresh, comment post and post picture
Hotspots	WWW Browsing	- 4 different WWW page downloads per test location - Popular pages chosen from public internet according to country trends: ekstrabladet.dk; wikipedia.org; news.yahoo.com; mobil.dr.dk
	YouTube Video Streaming	- 1 YouTube video stream per test location. Test video length 40s. https://youtu.be/bQRLVxZHkPs
	Twitter	- 2 Twitter refresh and comment post
	Instagram	- 2 Instagram home feed load and tag search

3.2 Analysis Principles

Omnitele’s analysis methodology follows ETSI standardisation (TS 102 250). For each test case we define key performance indicators (KPI) for service accessibility, service retainability and service integrity.



The verification, evaluation and analysis of the measurements data was executed in parallel with the measurements.

¹ POLQA i.e. *Perceptual Objective Listening Quality Assessment*, also known as ITU-T Rec. P.863 is an ITU-T Standard that covers a model to predict speech quality by means of digital speech signal analysis.

3.3 Location Winners

In order to quantify the mobile operators' competitive quality positioning for stationary tests, Omnitele applies the concept of *location winners*. That is, in every test location and for every test case one of the operators is better than the others. (1) For each test case, the winning operator in a given location is defined primarily based on test case success rate. (2) If all operators have equal success rate in a given location, the winning operator is defined by test case usability.



3.4 Statistical Reliability

The purpose of the statistical analysis is to ensure that the conclusions are supported by statistically significant differences in measurement data. That is, *Operator X* should be considered better than *Operator Y* only if the measured difference in sample average is greater than the error margin (*X*'s and *Y*'s error margins are not overlapping).

To assess the error margins, Omnitele applies standard error methodology with 95% confidence level. The Standard Error SE is expressed as:

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

where s is the sample standard deviation and n is the number of samples. The following expressions apply for upper and lower 95% confidence limits:

$$\text{Upper 95\% Limit} = \bar{x} + (SE \cdot 1.96);$$

$$\text{Lower 95\% Limit} = \bar{x} - (SE \cdot 1.96)$$

where \bar{x} is equal to the sample mean and 1.96 is the .975 quantile of the normal distribution.

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