Workshop on "Monitoring Quality of Service and Quality of Experience of Multimedia Services in Broadband/Internet Networks"

(Maputo, Mozambique, 14-16 April 2014)

Session 11: LTE QoS, QoE and performance

Seppo Lohikko

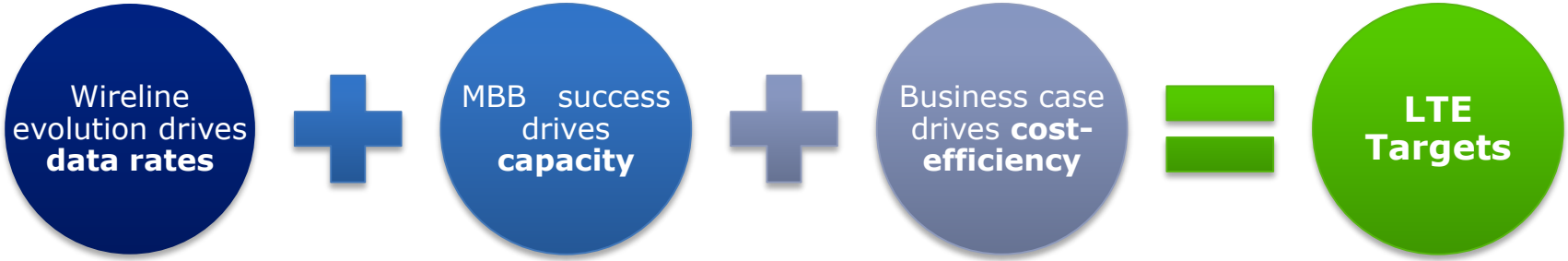
Principal Consultant, Omnitele Ltd

seppo.lohikko@omnitele.com

topics discussed

- **Introduction to LTE**
- LTE and mobile services
- LTE and WWW browsing QoE
- Considerations on LTE QoE
- Use cases

Key drivers of LTE: Capacity, QoS, Cost, Competition from other techs (e.g. WiMAX). 3GPP work started 2004 with target definitions.



LTE Targets [1]:

- 2-4 fold spectral efficiency compared to R6 HSPA (the "14.4 Mbit/s")
- Peak rate 100Mbit/s DL and 50Mbit/s UL
- RTT < 10ms possible
- Optimised for PS transmission
- High level of mobility and security
- Optimised terminal power efficiency
- Frequency flexibility with allocations below 1.5MHz up to 20MHz
- Lower CapEx & OpEx

Selected solutions to meet the targets

ARCHITECTURE

- Flat architecture: No RNC-element
- Optimised for PS, no CS domain in place

Spectral efficiency & latency gain

RADIO

- DL Radio: OFDMA, 64QAM and 2x2 MIMO
- UL Radio: SC-FDMA, 16QAM modulation

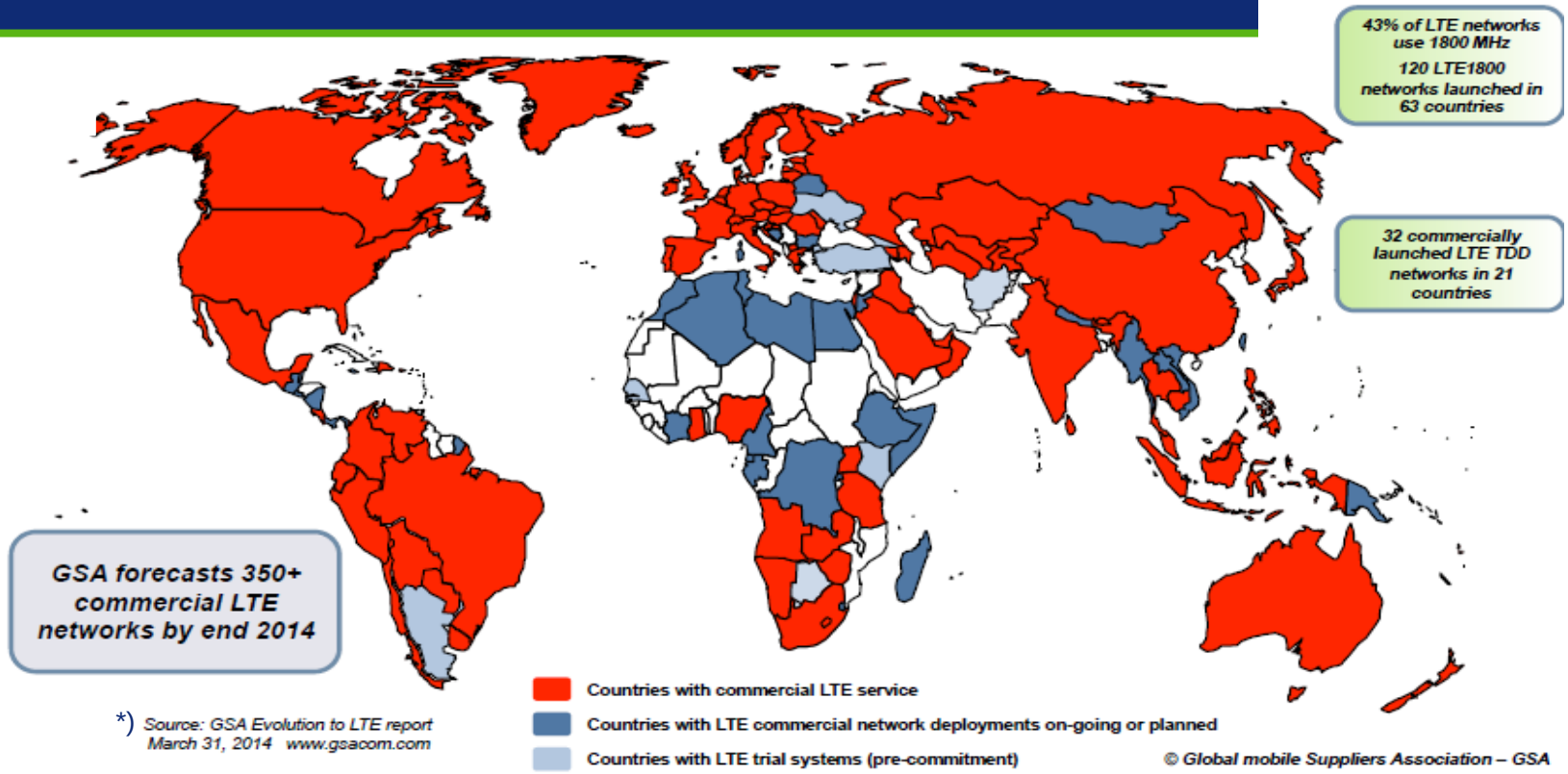
Spectral efficiency and peak rate gain

DEPLOYMENT FLEXIBILITY:

- BW options: 1.4; 3; 5; 10; 15; 20 MHz
- ~45 FDD and TDD frequency bands

Easy refarming, wide adoption expected.

279 live LTE networks in 101 countries*



*) Source: GSA Evolution to LTE report March 31, 2014 www.gsacom.com

omnitele

topics discussed

- Introduction to LTE
- **LTE and mobile services**
- LTE and WWW browsing QoE
- Considerations on LTE QoE
- Use cases

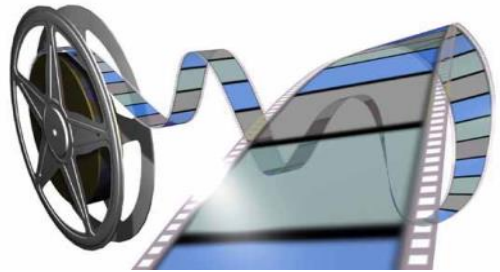
LTE AND QoS:

End of tech talk…let’s explore what LTE really means for subscribers!

Application Performance is the *Make It or Break It*

END-USERS MIND SERVICE QUALITY, NOT NW PERFORMANCE

- They consume VoIP, video, news, social networking, etc
- They don't consume average throughput

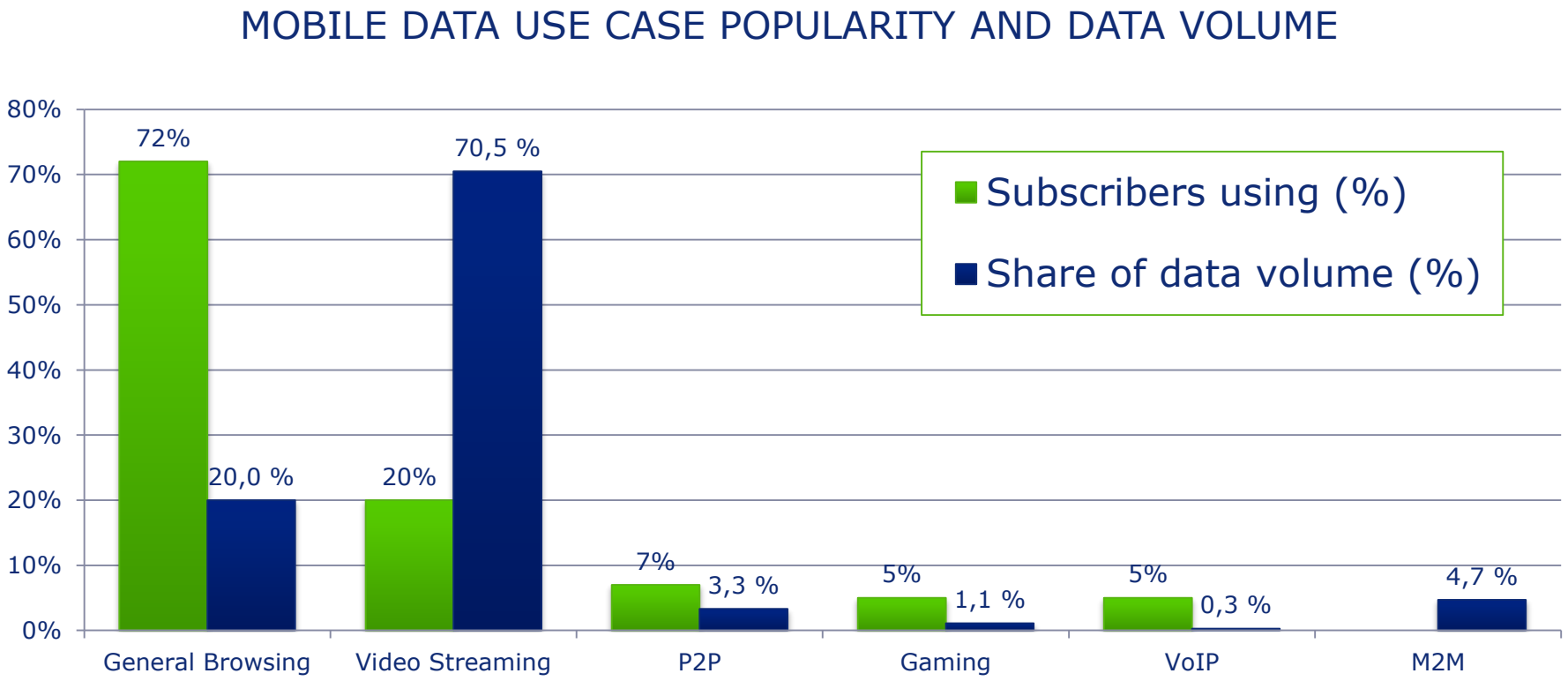


WIKIPEDIA YouTube facebook Google amazon.com YAHOO! skype bing Gmail

⇨ focus on the services – not the networks

OMNITELE

WWW & Video dominate usage



Source: Allot MobileTrends Report Q2/2013, CISCO VNI 2012

omnitele

No revolution expected from LTE…

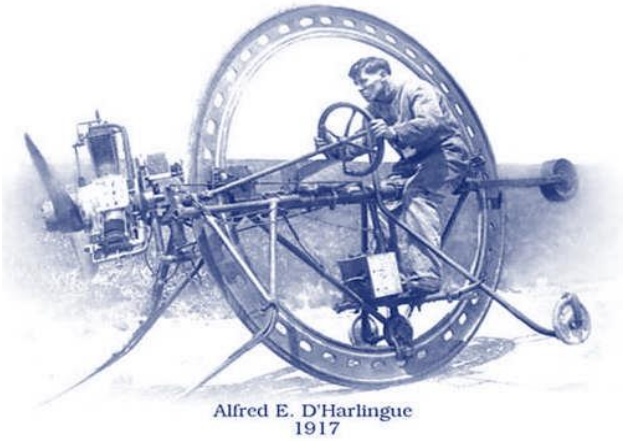
SHORT RECAP OF MOBILE SERVICES HISTORY

- GSM: reliable digital voice & SMS, simple data services
- UMTS: CS64 Video Telephony – a true *killer-app*?
- HSDPA: Real access to mobile data and rich web content

WHAT LTE BRINGS?

- No new services – Even worse, voice is still a challenge
- Higher throughput – some impact on service experience
- Latency gains – More robust VoIP
- Mobile HD video conferencing would require LTE…Demand?

Re-inventing the wheel?



Alfred E. D'Harlingue
1917

topics discussed

- Introduction to LTE
- LTE and mobile services
- **LTE and QoE**
- Considerations on LTE QoE
- Use cases

LTE AND WWW BROWSING QoE

If LTE doesn’t come with new services, is there at least a QoE improvement?

omnitele

recap | QoE – QoS – NW performance

In Session 10 we linked together NW performance, end-user QoS and QoE …

service specific QoE

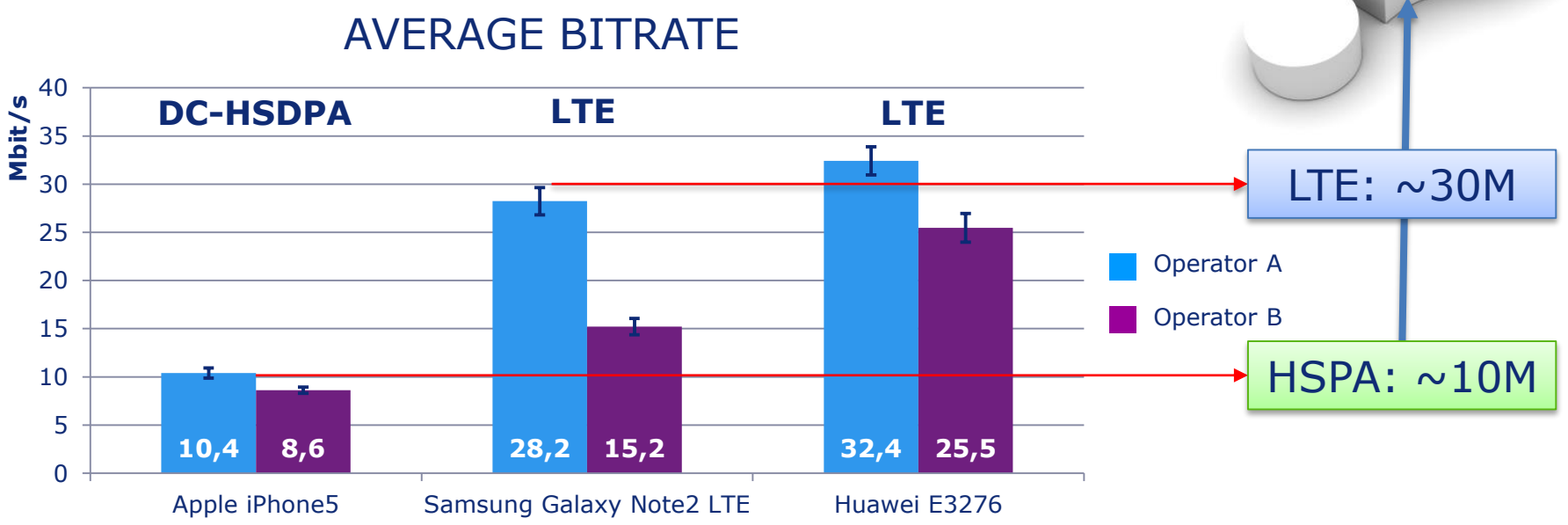
end-user QoS

NW performance KPIs

…to see LTE impact on QoE, we just need to explore the same path in opposite direction!

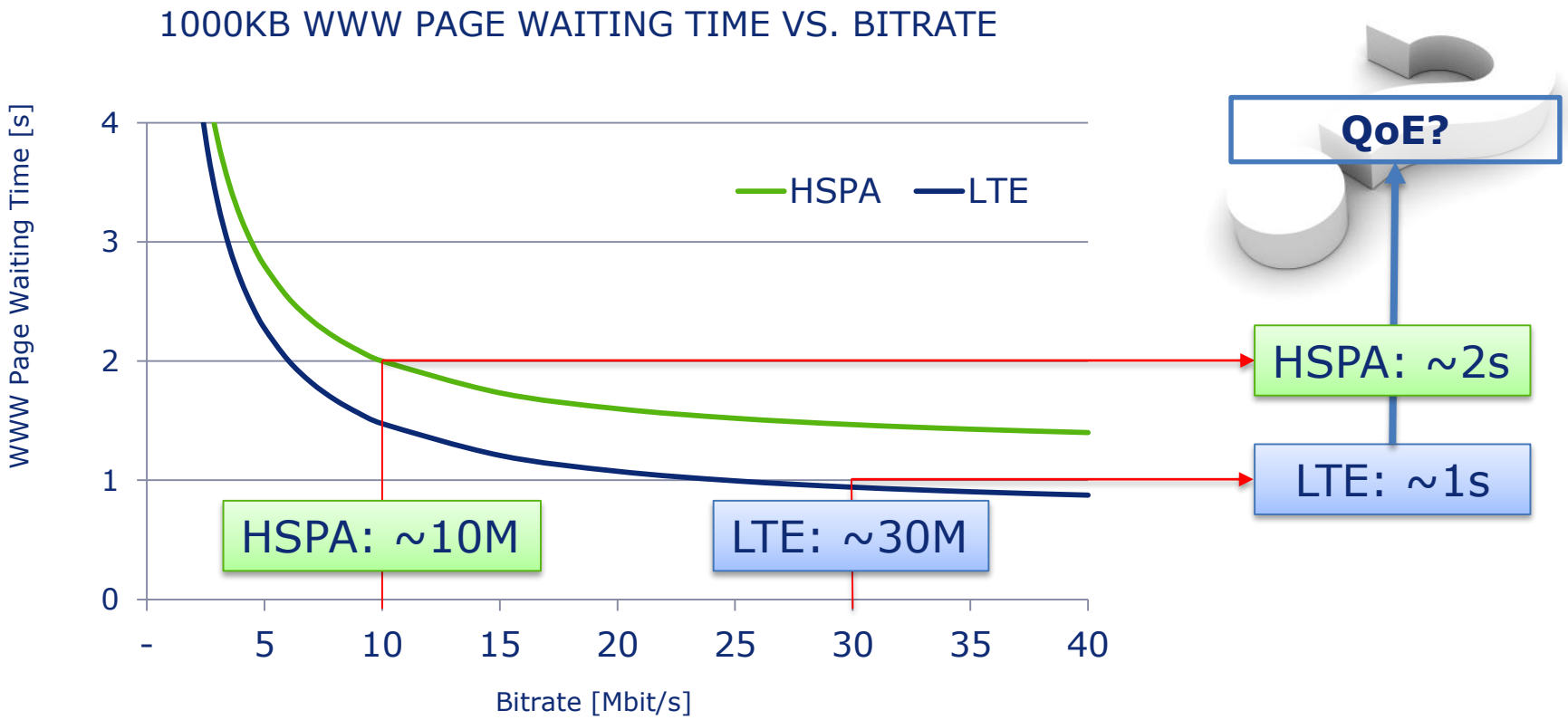
1. NW Performance | LTE real life bitrates

Q1/2013 Omnitele Benchmark in Sweden:
LTE outperforms DC-HSPA with factor of ~3



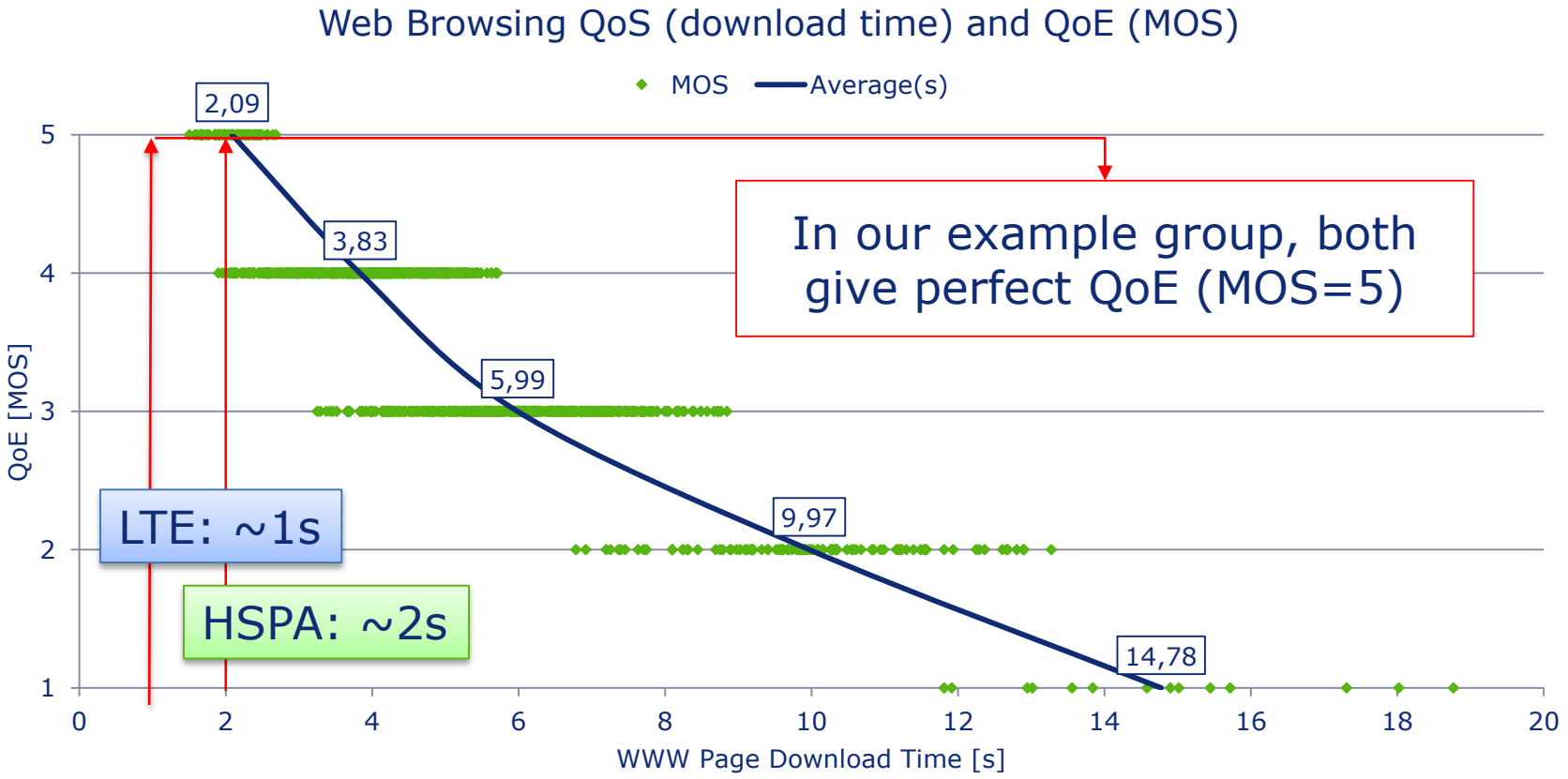
http://www.omnitele.com/2013/omnitele-benchmarks-mobile-service-quality-in-sweden/

2. End-user QoS | WWW page waiting time



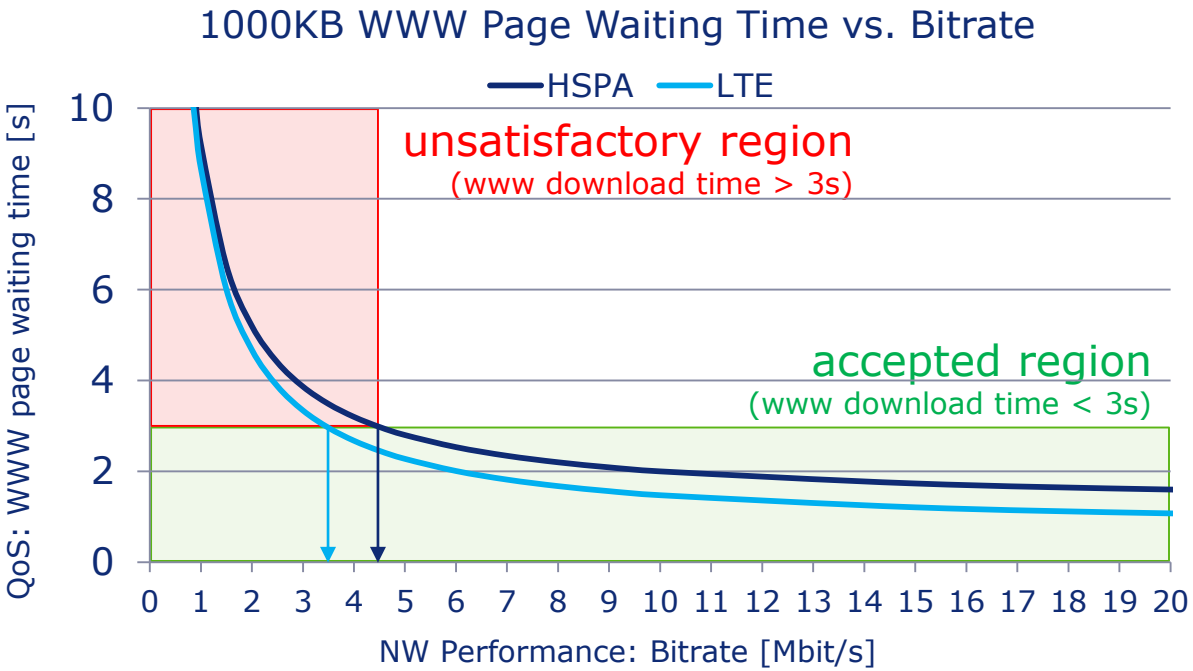
omnitele

3. QoE | LTE: Virtually zero gain in WWW QoE



omnitele

4. CTO targets | find required NW performance



CTO TARGET

90% of subs get

>3.5 Mbit/s in 4G

>4.5 Mbit/s in 3G

omnitele

WWW Browsing QoE: LTE vs. HSPA summary

NW performance

+200%

with LTE

end-user QoS

+100%

with LTE

QoE

+0%

with LTE

LTE does not revolutionise WWW browsing experience

topics discussed

- Introduction to LTE
- LTE and mobile services
- LTE and QoE
- **Considerations on LTE QoE**
- Use cases

LTE QoE CONSIDERATIONS

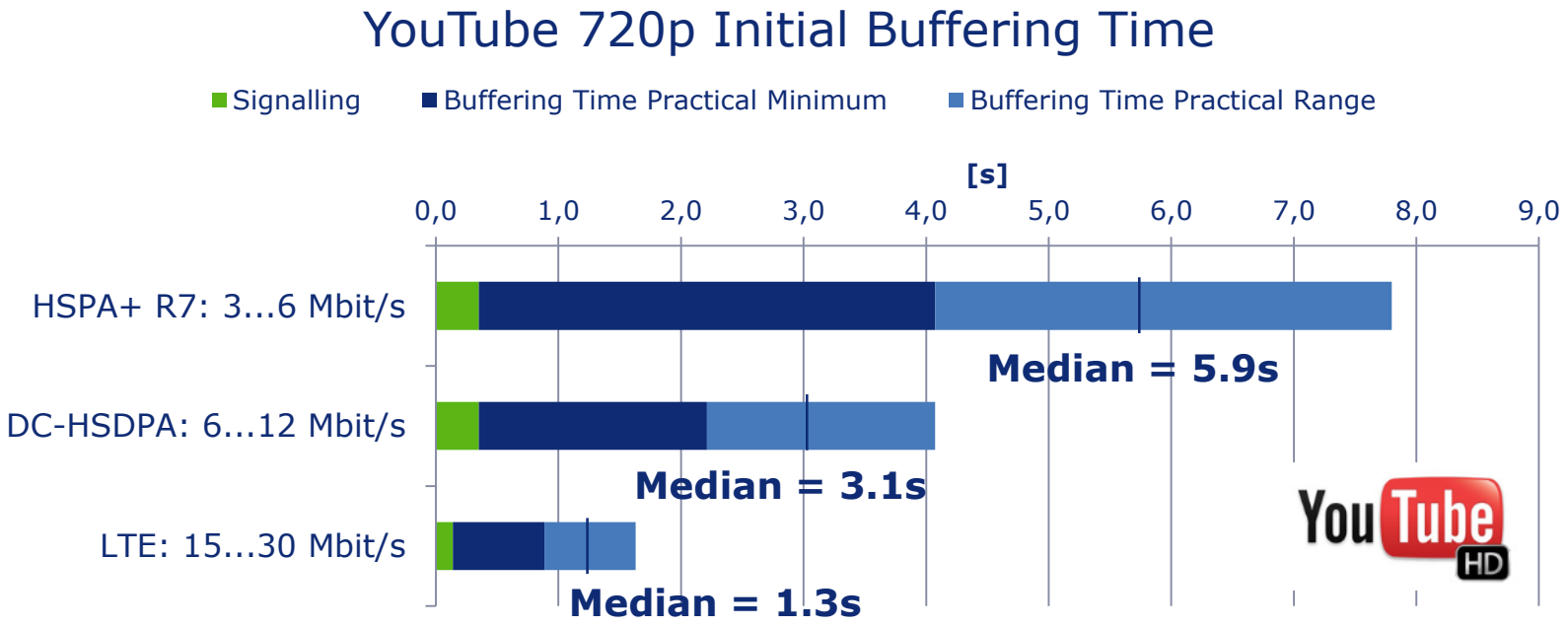
Maybe the example of WWW QoE with LTE didn’t still tell the whole truth…

Legacy 3G and user expectations

In our study, LTE gave 1s gain over HSPA in www page waiting time…but the measured HSPA network was in extremely good shape

Q | Can we actually generalise LTE's QoE improvement at all?

LTE QoE improvement with YouTube?



Though LTE has no impact on the content quality, the buffering time is notably lower

key messages | LTE is not a game changer

- LTE won’t redefine mobile broadband experience like HSDPA did on its time
- LTE is not likely to solve all QoE problems, but helps a lot…at least in short term
- All missteps taken with 3G are easy to reproduce with LTE…

topics discussed

- Introduction to LTE
- LTE and mobile services
- LTE and WWW browsing QoE
- Considerations on LTE QoE
- **Use cases**

OPERATOR CASE: CUSTOMER EXPERIENCE BENCHMARK

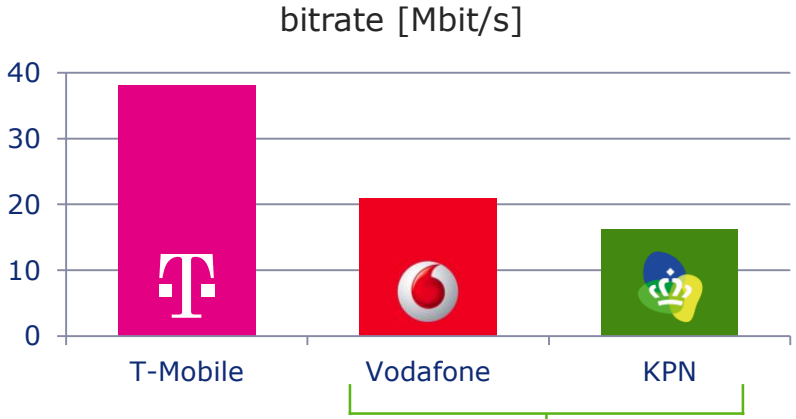
competitive positioning of YouTube experience

omnitele

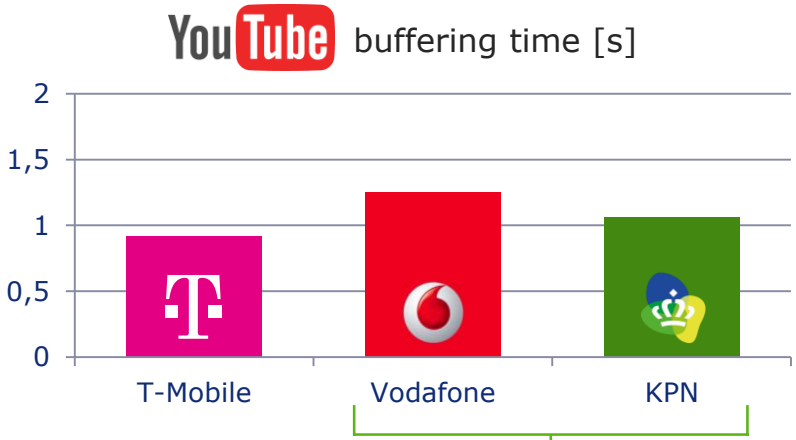
4G smartphone benchmark in Netherlands

Anite CEM NEMO solution

big difference in NW performance…



…thin margins in customer experience



Vodafone higher bitrate,
but KPN faster YouTube

omnitele

CUSTOMER EXPERIENCE BENCHMARK IN SWEDEN

Country-wide comparison of subscriber perceived data service quality in two mobile networks

Omnitele Report | 5 March 2014

omnitele

STRAIGHTFORWARD | TRUSTED | INTELLIGENT

TABLE OF CONTENTS

omnitele

Operator A assigned Omnitele to conduct an independent customer experience benchmark of mobile services in Sweden

1. **Measure** mobile data service quality with iPhone 5s smartphones in **A** and **B** mobile networks across Sweden
2. **Analyse** and compare the customer experience of WWW browsing and YouTube video streaming services for both operators
3. **Report** and publish the survey results for the general public in clear and understandable fashion

Operator A

VS

Operator B

Three test cases were measured for both WWW browsing and YouTube video streaming. Test sources were selected by Omnitele to represent typical use cases of Swedish mobile subscribers.

iPhone 5s WWW browsing

TESTED WEB PAGES:

Aftonbladet	http://aftonbladet.se
Google search	https://www.google.se/search?q=zlatan
Wikipedia	https://sv.wikipedia.org

iPhone 5s YouTube video streaming

TESTED YOUTUBE VIDEOS:

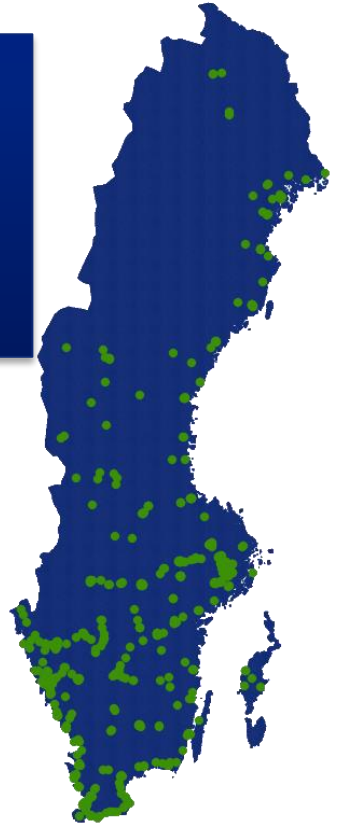
Test video 1 (1:16)	Volvo Trucks – The Epic Split feat. Van Damme
Test video 2 (0:33)	Harlem Shake (original army edition)
Test video 3 (0:51)	What Your Body Does in 30 Seconds

TEST CAMPAIGN

- tests conducted Jan 20 – Feb 14, 2014
- total 101 test days by 5 measurement teams
- 680 test locations across Sweden (550 city, 100 rural, 30 holiday)
- 8 160 individual mobile data use case tests

Test Execution	Totals
Benchmarked Operators	2
Number of cities	79
Number of test locations	680
Test days	101

Sample Counts / operator	Totals
WWW page download attempts	2040
YouTube video stream attempts	2040



End-user centric analysis methodology and competitive quality positioning

- For each of the 2 test cases 3 individual measurement samples are collected in every test location
- For each test case, the better operator in a given location is defined primarily based on success rate (1)
- If both operators have equal success rate in a specific test location, the winning operator is defined by test case usability (2)

1. test case success rate

Probability that the user can successfully initiate and complete the use case

2. test case usability

WWW: web page waiting time [s]
YouTube: buffering time [s]

TABLE OF CONTENTS

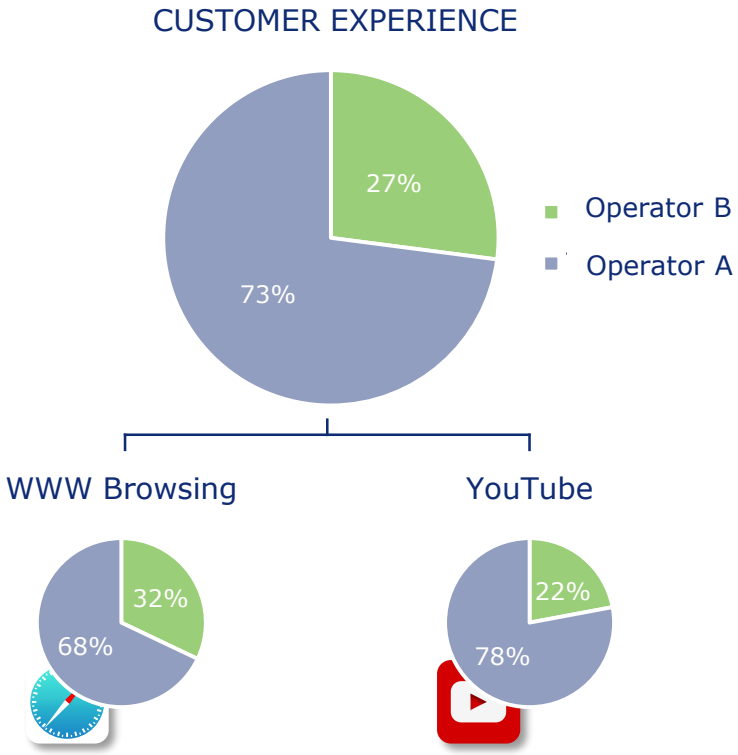
omnitele

benchmark results | table of contents

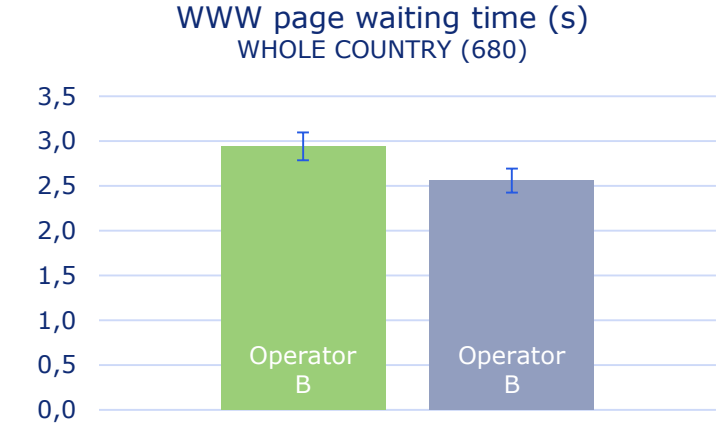
omnitele

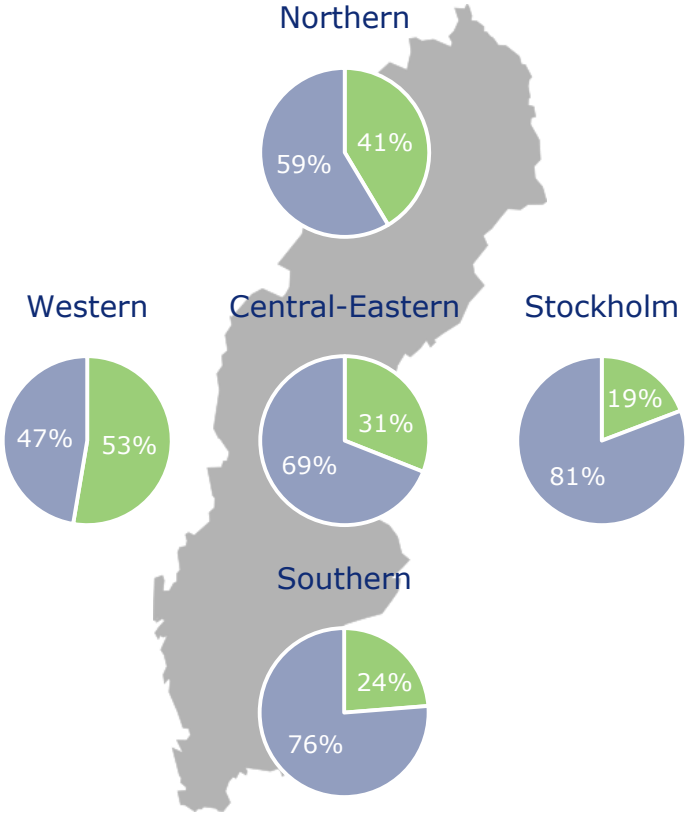
Considering all performed tests, **Operator A** scores higher than **Operator B** in 73% of the test locations. Numeric results however show that from typical mobile subscriber perspective the differences are rather marginal.

Omnitele concludes that both Operators provide outstanding customer experience compared to any international references and industry standards.



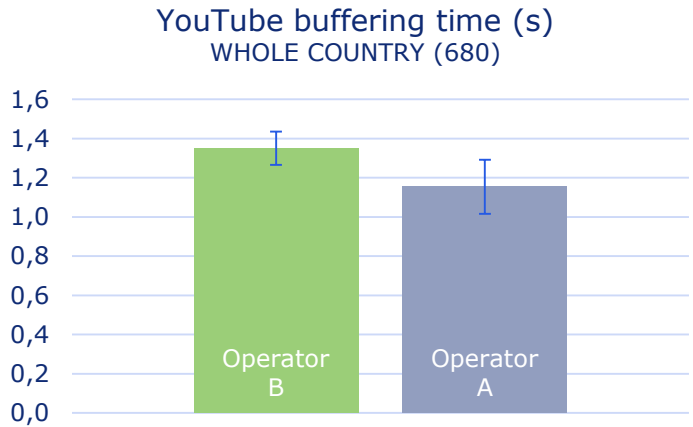
In WWW browsing test Operator A scores slightly better in most parts of Sweden. In Western Sweden Operator B results are better. The absolute difference in WWW page waiting time is marginal.

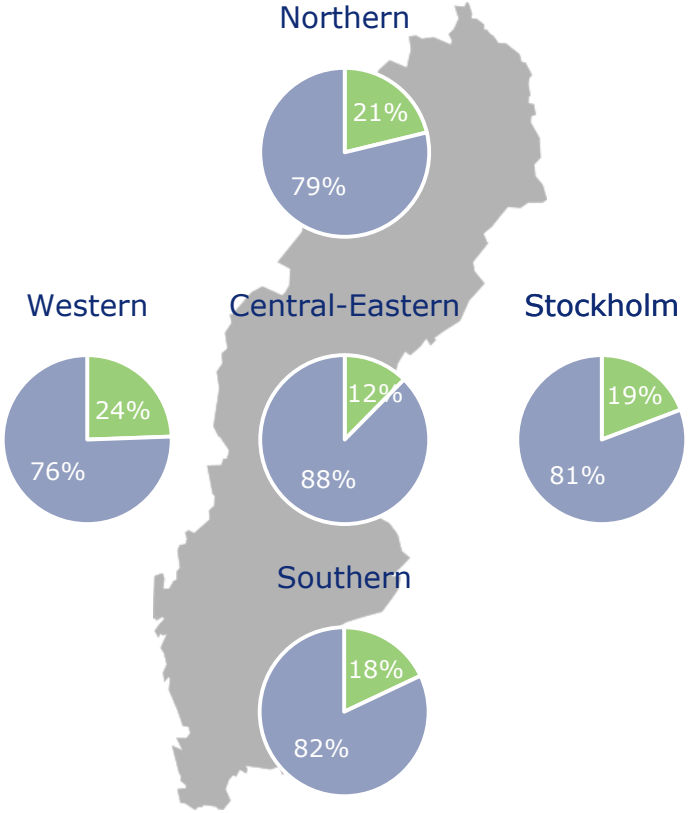




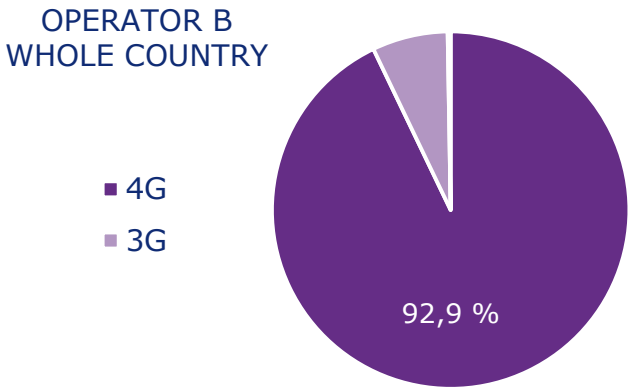
omnitele

In YouTube video streaming test Operator A scores slightly better than Operator B consistently across Sweden. The difference in video buffering time is however hardly noticeable.





4G is no longer a rarity in Sweden but instead widely available across the country with both operators. Considering the tested locations, 4G availability with iPhone 5s terminal is slightly wider for Operator A.



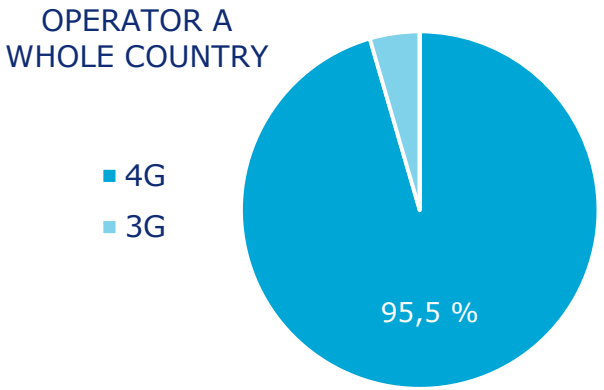


TABLE OF CONTENTS

omnitele

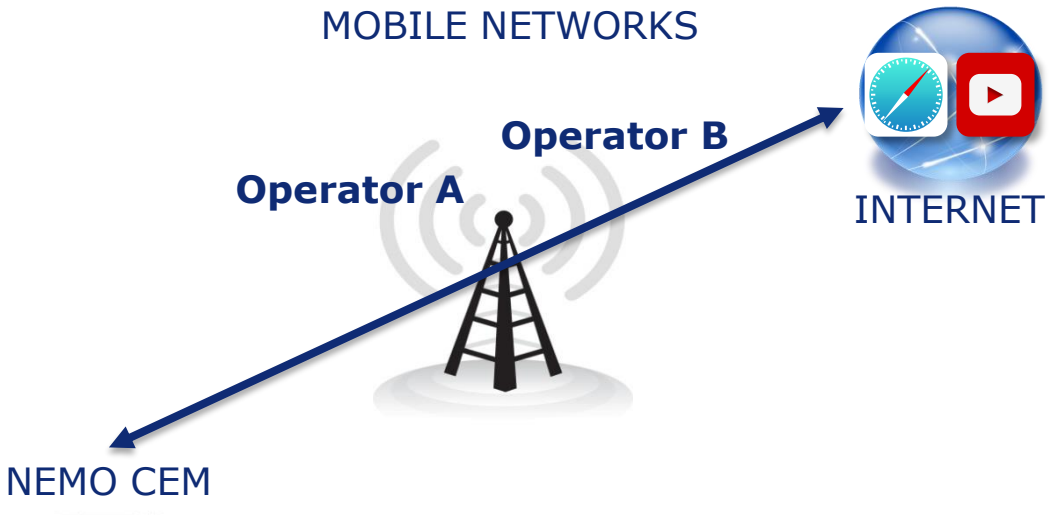
Measurement methodology designed to capture true end-user experience

TESTING TIMES

- Test days: Monday - Saturday
- Test hours: 06.00 – 00:00, focus on morning and night busy hours
- Saturdays: Measurements between 10:00 – 00:00. No measurements in business or university areas.
- Sundays: No testing.

METHODOLOGY

- Commercial state of the art smartphones used for capturing best available end-user quality
- Devices sourced from retail stores and SIM cards from operator stores
- Test locations chosen independently by Omnitele in blind test fashion
- Frequency band and technology (2G/3G/4G) selection as per network parameterisation
- All tests conducted in stationary state inside car



Mobile data testing was conducted with commercial iPhone 5s terminals and Nemo CEM measurement system. Test cases included WWW browsing and YouTube video streaming.

MEASUREMENT EQUIPMENT

Nemo CEM is a flexible and scalable set of tools for monitoring smartphone data services from the end user perspective.

More information:
http://www.anite.com/businesses/network-testing/products

methodology | test cases and test parameters

Three test cases were measured for both WWW browsing and YouTube video streaming. Test sources were selected by Omnitele to represent typical use cases of Swedish mobile subscribers.

TC1	WWW Browsing
Sequence	3 x WWW page download
Interval	10s interval between WWW requests
Time-out	30s time-out limit for WWW download
Reference point	Public internet
Methodology	Stationary test in a car

TC2	YouTube video streaming
Sequence	3 x YouTube video stream (60s each)
Interval	10s interval between WWW requests
Time-out	30s time-out for setup and re-buffering
Reference point	Public YouTube
Methodology	Stationary test in a car

Test parameters are defined based on ETSI standardisation (TS 102 250-2), success rate includes service accessibility and retainability.

test case	success rate	usability
WWW browsing	$\frac{(\#attempts - \#setup\ failures - \#connection\ drops)}{\#attempts}$	WWW page waiting time [s] = T2 – T1 T2: time WWW page content downloaded [s] T1: time user request WWW page [s]
YouTube video streaming		YouTube Buffering time [s] = T3 + T4 T3: initial buffering time [s] T4: total rebuffering time [s]

ANNEXES

1. **result tables**
2. measurement location details
3. statistical significance analysis
4. test devices and SIM cards

ANNEX 1 | www browsing, details

WHOLE COUNTRY (680)

WWW browsing, whole country	Operator B	Operator A
WWW page waiting time (s)	3,0	2,7
Number of locations	149	149
Standard deviation (s)	1,92426963	1,174307
Confidence interval (s)	0,31	0,19
Statistically significant difference?	**NO**	

WWW success, whole country	Operator B	Operator A
Number of locations	149	149
Locations with failures	2	0
Locations without failures	147	149
WWW page success rate	**98,7%**	**100,0%**
Confidence interval	1,8%	0,0%
Statistically significant difference?	**NO**	

URBAN (550)

WWW browsing (Mbit/s), urban areas	Operator B	Operator A
WWW page waiting time (s)	3,1	2,7
Number of locations	123	123
Standard deviation (s)	2,09395854	1,249532
Confidence interval (s)	0,37	0,22
Statistically significant difference?	**NO**	

WWW success, urban areas	Operator B	Operator A
Number of locations	123	123
Locations with failures	2	0
Locations without failures	121	123
WWW page success rate	**98,4%**	**100,0%**
Confidence interval	2,2%	0,0%
Statistically significant difference?	**NO**	

RURAL (100)

WWW browsing (Mbit/s), rural areas	Operator B	Operator A
WWW page waiting time (s)	2,8	2,4
Number of locations	24	24
Standard deviation (s)	0,65776225	0,705966
Confidence interval (s)	0,26	0,28
Statistically significant difference?	**NO**	

WWW success, rural areas	Operator B	Operator A
Number of locations	24	24
Locations with failures	0	0
Locations without failures	24	24
WWW page success rate	**100,0%**	**100,0%**
Confidence interval	0,0%	0,0%
Statistically significant difference?	**NO**	

HOLIDAY (30)

WWW browsing (Mbit/s), holiday locations	Operator B	Operator A
WWW page waiting time (s)	2,2	2,4
Number of locations	2	2
Standard deviation (s)	0,24772308	0,018856
Confidence interval (s)	0,34	0,03
Statistically significant difference?	**NO**	

WWW success, rural areas	Operator B	Operator A
Number of locations	2	2
Locations with failures	0	0
Locations without failures	2	2
WWW page success rate	**100,0%**	**100,0%**
Confidence interval	0,0%	0,0%
Statistically significant difference?	**NO**	

ANNEX 1 | YouTube video streaming, details

WHOLE COUNTRY (680)

YouTube video streaming, whole country	Operator B	Operator A
YouTube buffering time (s)	1,3	1,1
Number of locations	149	149
Standard deviation (s)	0,64409219	0,287732
Confidence interval (s)	0,10	0,05
Statistically significant difference?	**YES**	

YouTube success, whole country	Operator B	Operator A
Number of locations	149	149
Locations with access failures	3	1
Locations with connection drops	2	2
Locations without failures	144	146
YouTube success rate	**96,6%**	**98,0%**
Confidence interval	2,9%	2,3%
Statistically significant difference?	**NO**	

URBAN (550)

YouTube video streaming (Mbit/s), urban	Operator B	Operator A
YouTube buffering time (s)	1,3	1,1
Number of locations	123	123
Standard deviation (s)	0,69905192	0,302874
Confidence interval (s)	0,12	0,05
Statistically significant difference?	**YES**	

YouTube success, urban areas	Operator B	Operator A
Number of locations	123	123
Locations with access failures	3	0
Locations with connection drops	2	2
Locations without failures	118	121
YouTube success rate	**95,9%**	**98,4%**
Confidence interval	3,5%	2,2%
Statistically significant difference?	**NO**	

RURAL (100)

YouTube video streaming (Mbit/s), rural	Operator B	Operator A
YouTube buffering time (s)	1,4	1,1
Number of locations	24	24
Standard deviation (s)	0,26581636	0,212602
Confidence interval (s)	0,11	0,09
Statistically significant difference?	**YES**	

YouTube success, rural areas	Operator B	Operator A
Number of locations	24	24
Locations with access failures	0	1
Locations with connection drops	0	0
Locations without failures	24	23
YouTube success rate	**100,0%**	**95,8%**
Confidence interval	0,0%	8,0%
Statistically significant difference?	**NO**	

HOLIDAY (30)

YouTube video streaming (Mbit/s), holiday	Operator B	Operator A
YouTube buffering time (s)	1,2	1,0
Number of locations	2	2
Standard deviation (s)	0,04831896	0,105359
Confidence interval (s)	0,07	0,15
Statistically significant difference?	**YES**	

YouTube success, rural areas	Operator B	Operator A
Number of locations	2	2
Locations with access failures	0	0
Locations with connection drops	0	0
Locations without failures	2	2
YouTube success rate	**100,0%**	**100,0%**
Confidence interval	0,0%	0,0%
Statistically significant difference?	**NO**	

omnitele

ANNEXES

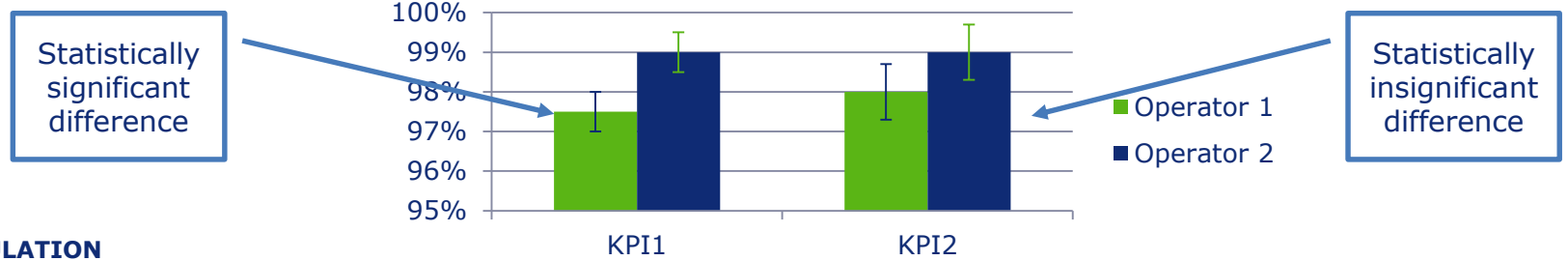
1. result tables
2. measurement location details
3. **statistical significance analysis**
4. test devices and SIM cards

ANNEX 3 | statistical significance analysis

In order to analyse the **statistical reliability** of the results, Omnitele applies confidence interval analysis on the calculated KPIs. Confidence Interval can be considered as the error margin of the reported results.

The error margins are visible in the error bars of report graphs, see example figure below. In case two operators have differing mean values, but overlapping error bars, the observed difference is not statistically significant. If the error bars don't overlap, the difference is statistically significant.

Omnitele targets to conduct the measurement campaigns so that the confidence intervals allow sufficient accuracy for the conclusions. That is, the error margins are smaller than truly significant QoS differences from end-user point of view. This is achieved by dimensioning the projects with sufficient test sample counts.



CALCULATION

The calculated confidence interval ***CI*** is based on (two-tailed) confidence level of 95%. That is, with 95% probability the true **population mean** is within the **sample mean** +/- ***CI***.

The ***CI*** is calculated as 1.96 x ***SE***, where

- ***SE*** is equal to the standard error for the sample mean, and
- 1.96 is the .975 quantile of the normal distribution (*CL* = 0.95 ⇨ α = 0.05 ⇨ 1- α/2 = 0.975, Norm.Inv[0.975] = 1.96)

Standard Error ***SE*** of the sample mean, is defined as $s/\sqrt{n}$, where

- ***s*** *is the sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population), and*
- ***n*** *is the size (number of observations) of the sample.*

omnitele

ANNEXES

1. result tables
2. measurement location details
3. statistical significance analysis
4. **test devices and SIM cards**

ANNEX 4 | test devices and SIM cards

Terminal	Model	Modem Firmware	OS Version	Sourced from
iPhone 5s 32GB Silver/Space Grey	ME435KS/A ME436KS/A	1.03.01	7.0.4 (11B554a)	Apple Store Online

Operator A SIM profile	Xxxxxxxxx 16GB
Operator B SIM profile	Yyyyyyyyy 10GB

End of Session 11…

OMNITELE

Any further enquiries:

Mr. Seppo Lohikko
Principal Consultant

Omnitele Ltd.

Mobile: +358 44 2793811
seppo.lohikko@omnitele.com
www.omnitele.com

Follow us at www.linkedin.com/company/omnitele

http://www.youtube.com/channel/UCyMeM3j2L9MQoB0qeDCev3g

OMNITELE | 25 YEARS
STRAIGHTFORWARD | TRUSTED | INTELLIGENT

OMNITELE