ANACOM
AUTORIDADE NACIONAL DE COMUNICAÇÕES

GSM/UMTS
Mobile Communications Systems

Quality of Service Evaluation

Evaluation of the QoS of Short
Message (SMS) and Multimedia Messaging (MMS) services

July 2008

ACRONYMS

CoDec	Codifier/De-codifier.
CPICH RSCP	Common Pilot Channel, Received Signal Code Power – Level of the signal received at a mobile terminal (WCDMA).
ETSI	European Telecommunications Standards Institute
GSM	Global System for Mobile communications – Second generation (2G) Mobile Communications System.
ITU	International Telecommunications Union.
MMS	Multimedia Messaging Service.
MMSC	Multimedia Messaging Service Centre.
MOS	Mean Opinion Score – Quality rate quantifying the effort that it takes to understand an end-to-end type conversation. Its value is 0 (zero) when there is no communication and 5 (five) when the communication is perfect. Value "zero" never shows on the results since only situations where the connection was established and maintained during a given period are considered. "Five" also never shows on the results because CoDec used by mobile networks renders impossible such high voice or video quality values (the voice or video quality reached with the usually used CoDec has MOS values below 4.5).
PESQ	Perceptual Evaluation of Speech Quality – Algorithm used in the analysis of the audio quality of a voice communication (Recommended by ITU: *ITU-T Recommendation P.862 (02/2001)*; *ITU-T RecommendationP.862.1 (11/2003)*).
ISDN	Integrated Services Digital Network – Technology used in the fixed access network.
RF	Radio Frequency.
RxLev	Received signal level – Received signal level, at a mobile (GSM) terminal.
Scanner	Measurement equipment that collects radio signal levels for each channel of a frequency band.
SMS	Short Message Service.
SMSC	Short Message Service Centre – Message Centre.
SQuad-LQ	SwissQual's speech quality algorithm for Listening Quality – Algorithm developed by SwissQual to analyse the audio quality of a communication.
UMTS	Universal Mobile Telecommunications System – Third generation (3G) Mobile Communications System.
VQuad	Objective Model for Video Quality Assessment – Algorithm used in the analysis of the video quality of a communication (developed by *SwissQual*).
WCDMA	Wideband Code Division Multiple Access – Technology used in the radio component of the UMTS communications systems.

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I EXECUTIVE SUMMARY

I.I GENERAL FRAMEWORK

Autoridade Nacional de Comunicações (ANACOM) carried out an assessment of the quality of the SMS (Short Message Service) and MMS (Multimedia Messaging Service) services provided by operators OPTIMUS, TMN and VODAFONE, by analysing technical parameters that translate the quality perception from the consumer's standpoint.

The main quality indicators were analysed, considering the user's perspective and the services under study, with highlight to:

1. Service Accessibility – probability of having access to the services, i.e., probability of success when sending messages;
2. Message Delivery Rate – probability of a message being successfully delivered to its destination, i.e., rate between the number of messages successfully received at the destination terminal equipment and the number of messages sent by the origination terminal equipment;
3. Message Delivery Time – time elapsing from the beginning of the sending of a message to the Message Centre and the end of its reception at the destination terminal;
4. Variation along the day.

The methodology followed in this study is based on tests carried out in the field from the user's standpoint, using an automatic measurement system. It reproduced the several aspects affecting the services' quality (end-to-end measurements). Measurements were carried out under equal terms for the three operators, namely at the same time, at the same locations and with the same parameters, thus enabling a comparative analysis of the registered performances.

On-the-field measurements took place at ANACOM's premises, at Porto and Barcarena, from 9 to 15 July 2008. 15,117 test messages were sent, corresponding to about 72 hours of measurements.

The used sample provided global results, by operator, with a maximum precision error below 1%, for the *Service Accessibility* and *Message Delivery Rate* indicators, and below 1.26 seconds, for the *Message Delivery Time* indicator, for a 95% confidence level.

In view of these services' penetration rate, of the diversity of the used terminal equipment, and given

each user's subjective view itself, it is impossible to rigorously reproduce each consumer's conditions of interaction with the networks. In this context, the results of this study must thus be understood as an indicator of the networks' overall behaviour, while it does not intend to evaluate the fulfilment of licenses by the mobile operators. The transposition/extrapolation of these results to specific situations requires some prudence, at the risk that biased conclusions might be taken.

The technical and methodological options of this study directly influenced its results and must be taken into account when analyzing the results, namely the following ones:

- Tests were exclusively based on a technical solution (hardware + software) and performed in a totally automatic way, thereby setting homogenous conditions for the monitoring of the three operators and eliminating the subjectivity inherent to the human user;
- It used *NOKIA 6680* terminal equipment, configured with automatic selection of 2G or 3G (GSM/UMTS) infrastructure. The terminal equipment was kept motionless at locations with an adequate (good) coverage and the minimum interference, each one with a unique role, i.e., acting as a message sender or a receiver;
- Test messages were 120-charatercers long for SMS and 25kB for MMS. The latter was made up of text and a still image;
- The minimum interval between a terminal's consecutive SMS sendings was 70 seconds for SMS, and 120 seconds for MMS;
- Messages with a delivery time above 175 or 650 seconds, for SMS and MMS respectively, or with errors, were considered failed messages;
- The results of the study reflect the behaviour of the networks at the time that the measurements were carried out in the field. Possible technical interventions by the operators on the networks can modify the provided service's quality levels.

I.II MAIN RESULTS AND CONCLUSIONS

The results of the quality of service indicators that were analyzed in this study show a very good performance of the SMS and MMS messaging services.

The studied mobile communications systems have message delivery rates above 98%. The average message delivery time is below 9 seconds, for the SMS service, and below 54 seconds for the MMS service.

No considerable differences were registered along the day or between working days and the weekend.

SMS – Short Message Service

The studied mobile communications systems have very good performance levels regarding the SMS service, with no major differences among operators (Figure 1). The best performances were registered by operators TMN and VODAFONE, since 99.7% and 99.3% of sent messages, respectively, were delivered to their destination with no failure.

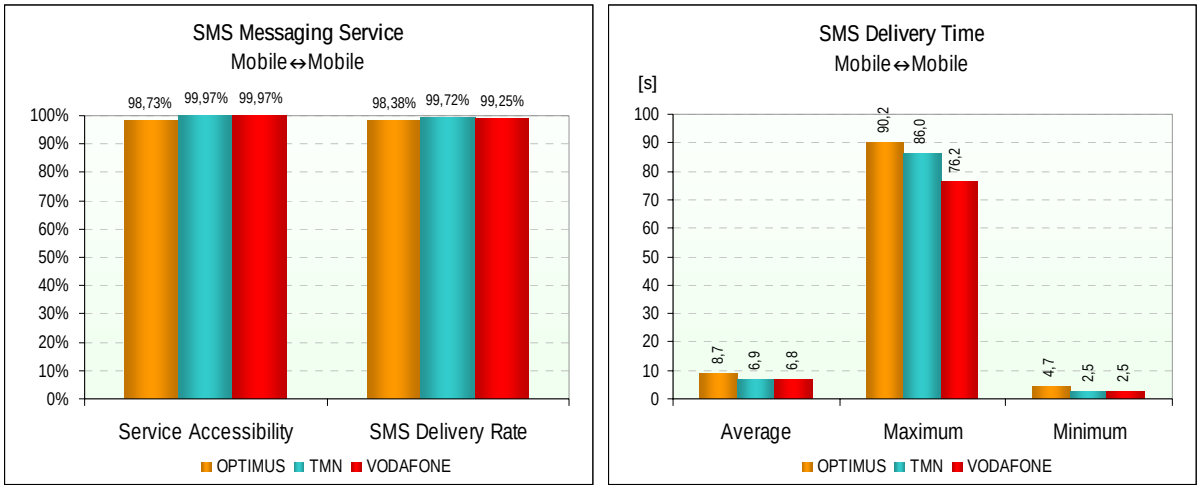


Figure 1 – *Accessibility*, *Delivery Rate* and *Message Delivery Time* indicators, on the SMS service.

Registered average message delivery times are also good. VODAFONE and TMN had the best performances, with average message delivery times of about 7 seconds (Figure 1).

Regarding the behaviour of the SMS service along the day, with the exception of operator OPTIMUS in

the period between 9h00 pm and midnight, there is no considerable variation in the analyzed indicators (Figure 2, Figure 3 and Figure 4).

The *Service Accessibility* levels of operators TMN and VODAFONE are always above 99%. Operator OPTIMUS has levels above 98%, except in the period between 9h00 pm and midnight, were this indicator shows degradation (Figure 2).

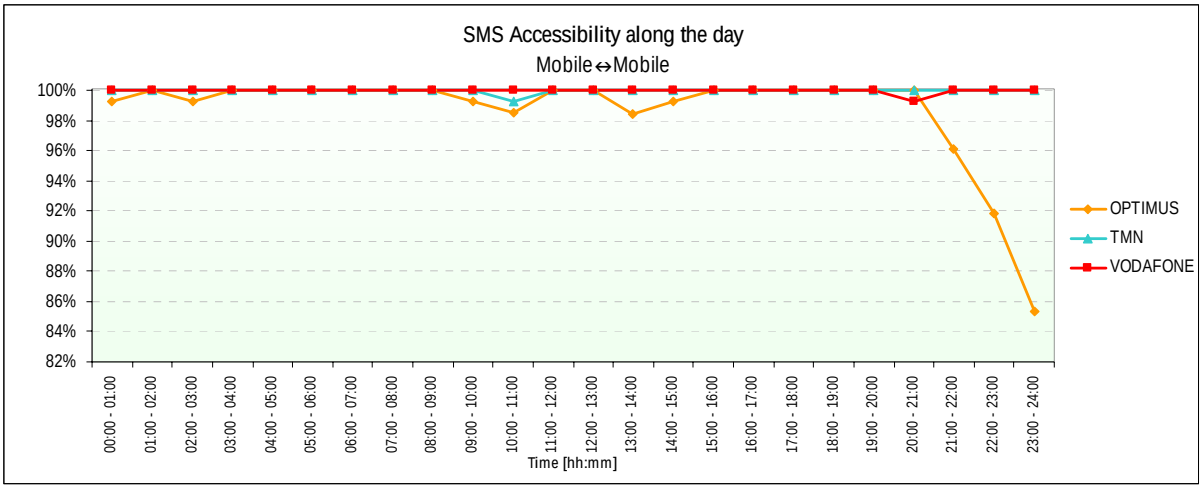


Figure 2 – Time variation of the *Accessibility*, indicator, on the SMS service.

Figures for the *Message Delivery Rate* are between 98% and 100%, with little exceptions. The lowest rates were recorded by operator OPTIMUS, between 9h00 pm and midnight, due to the low *Service Accessibility* recorded during that period (Figure 3).

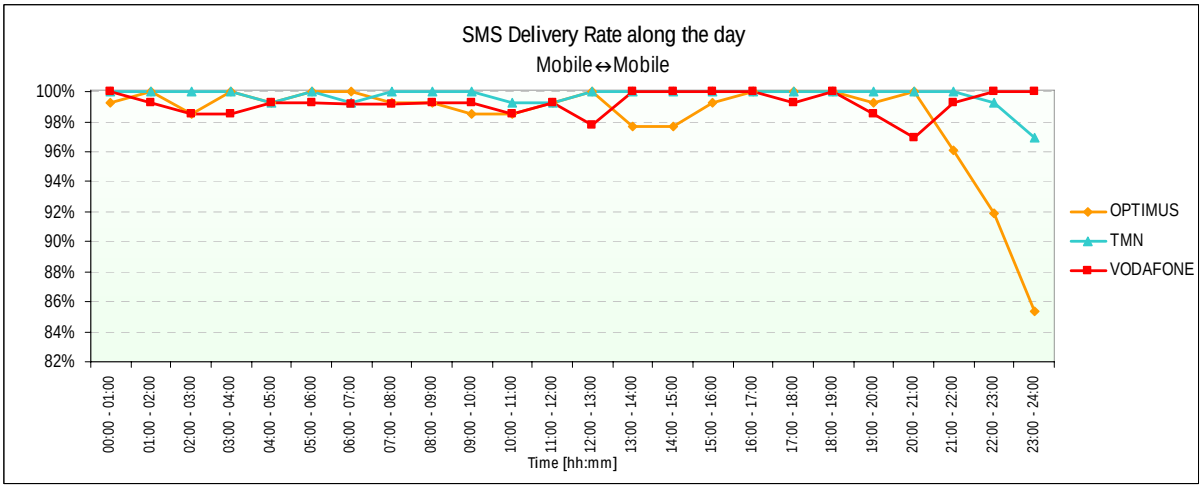


Figure 3 – Time variation of the Message Delivery Rate indicator, on the SMS service.

Variations in the *Average Message Delivery Time* along the day are very low (close to 1 second, between the best and the worse recorded average time for each operator (Figure 4).

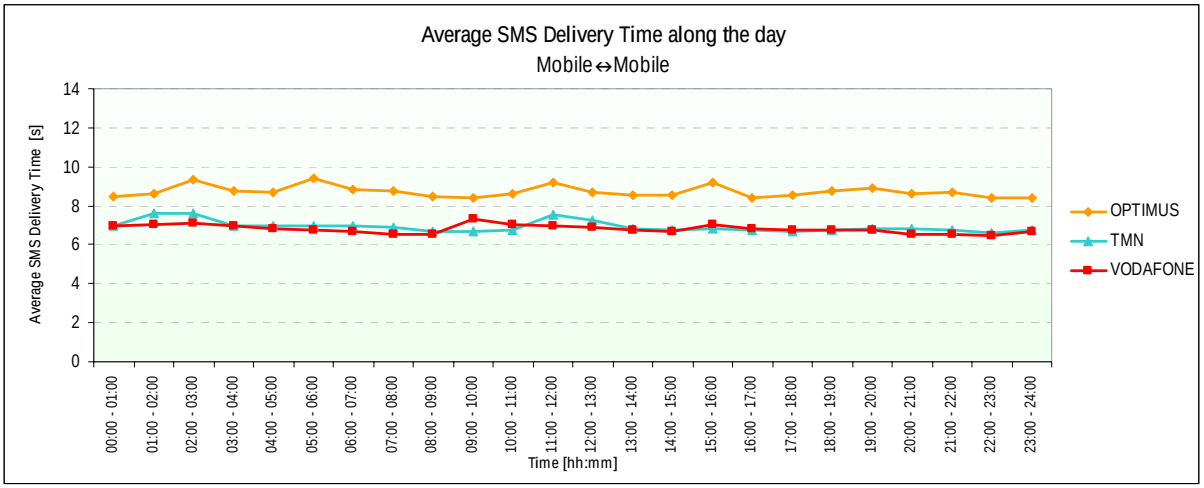


Figure 4 – Time variation of the Average Message Delivery Time, on the SMS service.

MMS – Multimedia Messaging Service

Mobile communications systems have a very good performance as far as the MMS service is concerned. The *Message Delivery Rate* indicator records levels above 98.5%, with no considerable differences among operators (Figure 5).

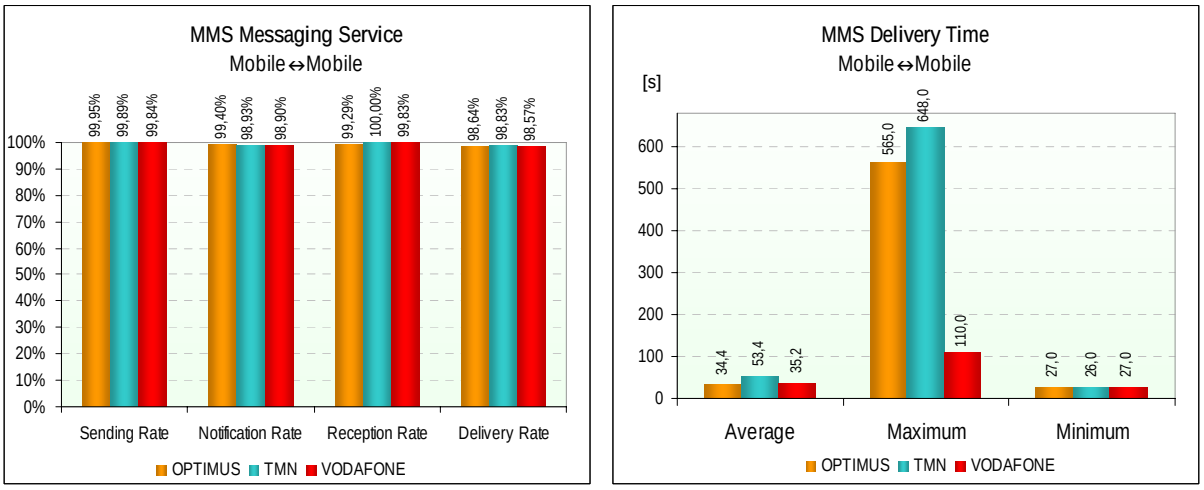


Figure 5 – *Sending Rate, Notification Rate, Reception Rate, Delivery Rate* and *Message Delivery Rate* indicators, on the MMS service.

There were considerable differences among operators regarding the *Average Message Delivery Times*. The best performances were recorded by operators OPTIMUS and VODAFONE, with average message delivery times around 35 seconds, while TMN registers a 53.4 seconds average time (Figure 5).

Concerning the behaviour of the MMS service along the day, the analyzed indicators show no major variations (Figure 6, Figure 7 and Figure 8).

The message *Sending Rate* varies between 98.5% and 100%, with a single exception for the period from 9h00 pm to 10h00 pm, when operator TMN registers a 97.3% rate (Figure 6).

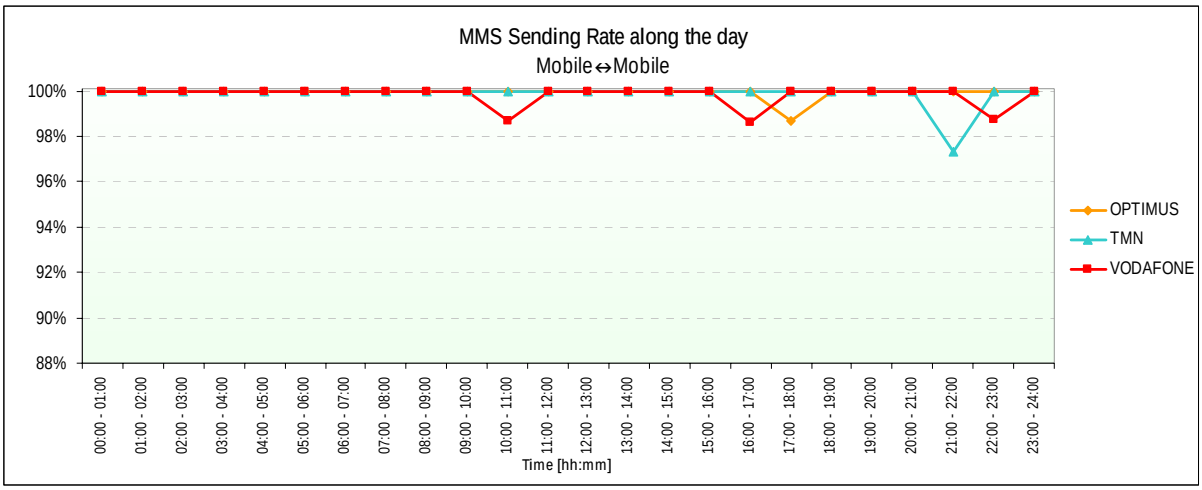


Figure 6 – Time variation of the *Message Sending Rate* indicator, on the MMS service.

The studied operators show a similar behaviour regarding message delivery, with delivery rates between 96% and 100% (Figure 7).

During most of the day, the *Average Message Delivery Time* shows a regular behaviour. Operators OPTIMUS and VODAFONE have average times between 30 and 40 seconds, and TMN between 48 and 58 seconds. The highest variation was recorded by TMN, for whom this indicator had an average figure of 91 seconds in the period between 3h00 pm and 4h00 pm (Figure 8).

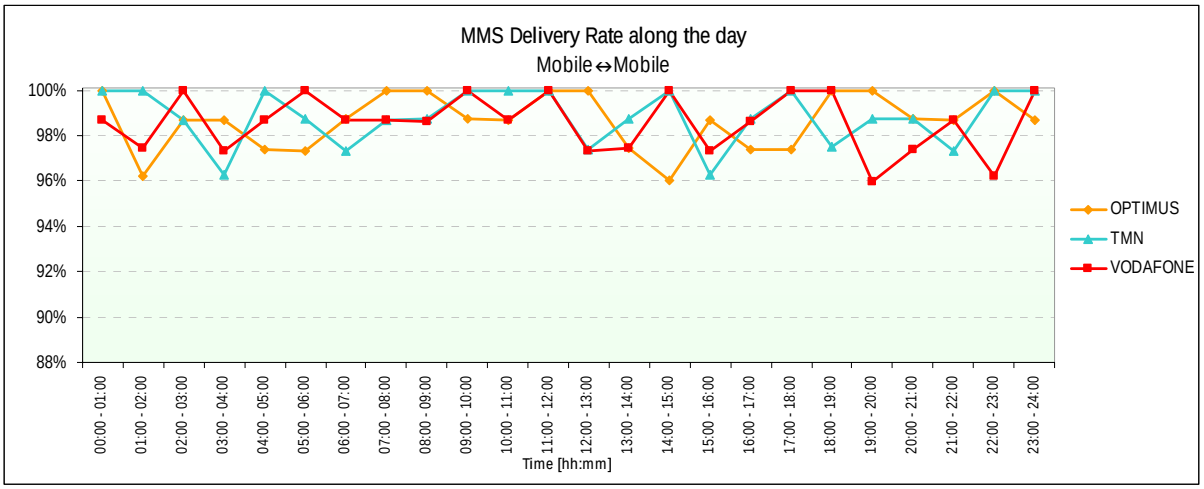


Figure 7 – Time variation of the Message Delivery Rate indicator, on the MMS service.

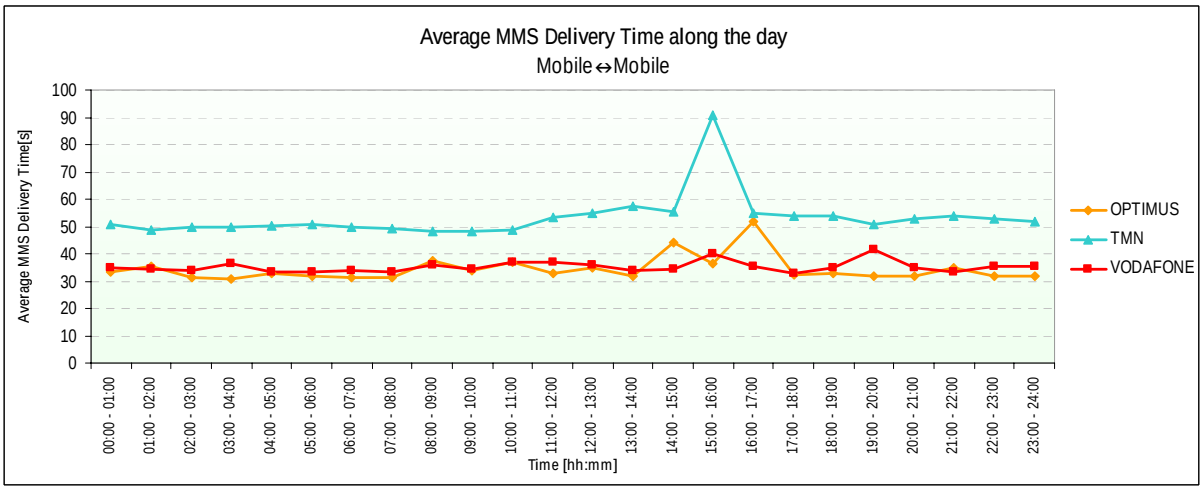


Figure 8 – Time variation of the *Average Message Delivery Time* indicator, on the MMS service.

1 GOAL

This study intends to analyze the performance of the Short Message Service (SMS) and the Multimedia Messaging Service (MMS) based on the Portuguese mobile networks, on an Intra-Net Mobile-to-Mobile configuration and from the user's standpoint. It was based on end-to-end measurements.

2 METHODOLOGY

The methodology followed in this study is based on tests carried out in the field from the user's standpoint, using an automatic measurement system. It reproduced the several aspects affecting the services' quality (end-to-end measurements). Measurements were carried out under equal terms for the three operators, namely at the same time, at the same locations and with the same parameters, thus enabling a comparative analysis of the registered performances.

2.1 FUNDAMENTALS

This study's methodology is based on 3 fundamentals:

a) End-to-end measurements – measured values reflect all aspects that influence a services quality.

b) Impartiality – measurements are made under equal terms for the three operators (OPTIMUS, TMN and VODAFONE).

c) Objectivity – tests are carried out in a totally automatic way, thus eliminating the subjectivity inherent to human intervention or decision.

2.2 MAIN QOS INDICATORS

2.2.1 SMS – SHORT MESSAGE SERVICE

2.2.1.1 SMS SERVICE ACCESSIBILITY

This parameter represents the probability of having access to the SMS service, i.e., probability of

success when sending SMS.

$$\text{SMS Service Accessibility}\,[\%] = \frac{\text{No. of Successfully Sent SMS}}{\text{Total No. of SMS Sending Attempts}} \times 100\%$$

2.2.1.2 SMS SENDING TIME

The SMS sending time is the time elapsing between the beginning of the sending of an SMS to the Message Centre (SMSC) and the reception of its delivery notification at that Message Centre.

$$\text{SMS Sending Time}\,[\text{s}] = t_{\text{notification}} - t_{\text{sending}}$$

$t_{sending}$ – moment when the user starts sending the SMS.

$t_{notification}$ – moment when the mobile equipment originating the SMS receives the confirmation that the SMS was delivered to the SMSC.

2.2.1.3 SMS DELIVERY TIME

This stands for the time elapsing between the beginning of the sending of an SMS to the Message Centre (SMSC) and its reception at the destination terminal.

$$\text{SMS Delivery Time}\,[\text{s}] = t_{\text{reception}} - t_{\text{sending}}$$

$t_{sending}$ – moment when the user starts sending the SMS.

$t_{recepção}$ – moment when the destination terminal equipment receives the SMS sent by the origination terminal equipment.

Messages not delivered within a specified delivery time frame are considered failed messages and discarded from the reckoning of this indicator.

2.2.1.4 SMS DELIVERY RATE

This rate is the probability of an SMS to be successfully delivered at its destination, i.e., the rate between the number of messages successfully received at the destination terminal equipment and the number of messages sent by the origination terminal equipment.

$$\text{SMS Delivery Rate}\,[\%] = \frac{\text{No. of Successfully Received SMS}}{\text{Total No. of SMS Sending Attempts}} \times 100\%$$

Error messages and messages not delivered within a previously-defined time frame are considered failed messages. Doubled messages are not taken into account for the SMS delivery rate.

An SMS is considered to be received with an error when it has at least one incorrect bit upon reception.

2.2.2 MMS – MULTIMEDIA MESSAGING SERVICE

2.2.2.1 MMS SENDING RATE

MMS sending rate is the probability of having access to the MMS service, i.e., probability of success when sending MMS.

$$\text{MMS Sending Rate}\left[\%\right] = \frac{\text{No. of Successfully Sent MMS}}{\text{Total No. of MMS Sending Attempts}} \times 100\%$$

2.2.2.2 MMS SENDING SPEED

This is the average data transfer speed when sending a MMS.

$$\text{MMS Sending Speed}\left[\text{kbps}\right] = \frac{\text{Sent MMS Size}\left[\text{kbit}\right]}{\text{MMS Sending Time}\left[\text{s}\right]}$$

MMS Sending Time – only the "pure" MMS transfer time is considered, i.e., the time needed to start and end the corresponding data sessions is not taken into account.

2.2.2.3 MMS NOTIFICATION RATE

This represents the probability of the destination terminal equipment to receive the notification of a successfully delivered MMS (the message was properly received by the MMSC)

$$\text{MMS Notification Rate}\left[\%\right] = \frac{\text{No. of Received MMS Notifications}}{\text{No. of Successfully Sent MMS}} \times 100\%$$

2.2.2.4 MMS RECEPTION RATE

This rate is the probability of an MMS to be successfully received (downloaded) at its destination terminal, which has previously received an MMS notification.

$$\text{MMS Reception Rate}\left[\%\right] = \frac{\text{No. of Successfully Received MMS}}{\text{Total No. of Received MMS Notifications}} \times 100\%$$

2.2.2.5 MMS RECEPTION SPEED

The MMS reception speed is the average data transfer speed during the reception of an MMS.

$$\text{MMS Reception Speed}\left[\text{kbps}\right] = \frac{\text{Received MMS Size}\left[\text{kbit}\right]}{\text{MMS Reception Time}\left[\text{s}\right]}$$

MMS Reception Time – only the "pure" MMS transfer time is considered, i.e., the time needed to start and end the corresponding data session is not taken into account.

2.2.2.6 MMS DELIVERY RATE

The MMS delivery rate is the probability of an MMS to be successfully delivered at its destination, i.e., the rate between the number of MMS successfully received at the destination terminal equipment and the number of messages sent by the origination terminal equipment.

$$\text{MMS Delivery Rate}\left[\%\right] = \frac{\text{No. of Successfully Received MMS}}{\text{Total No. of MMS Sending Attempts}} \times 100\%$$

Messages not delivered within a specified delivery time frame are considered failed messages.

2.2.2.7 MMS DELIVERY TIME

MMS delivery rate stands for the time elapsing between the beginning of the sending of an MMS to the Message Centre (MMSC) and its reception at the destination terminal equipment.

$$\text{MMS Delivey Time}\left[\text{s}\right] = t_{\text{end\_reception}} - t_{\text{beginding\_sending}}$$

$t_{início\_envio}$ – moment when the user starts sending the MMS.

$t_{fim\_recepção}$ – moment when the destination terminal equipment receives the MMS sent by the origination terminal.

This parameter is determined by the message's size. Thus it must be individually reckoned for each MMS size used on the tests.

Messages not delivered within a specified delivery time frame are considered failed messages and discarded from the reckoning of this indicator. The duration of the time frame is determined by the size of the MMS.

2.3 MEASUREMENT PROFILES[1]

Measurement profiles define a set of conditions that must the verified in order to correctly assess the services' quality and to guarantee the reliability of the tests. They also include process standardization and the definition of testing and measurement parameters, thus making it possible to perform analyses and compare results.

2.3.1 GENERAL FEATURES

Tests are performed automatically and using the Seven Five system (there is no human intervention or decision during the caring out of a test).

These services are evaluated end-to-end, using the transmission of an SMS or MMS message as the base testing unit.

Messages are originated and ended at mobile terminal equipment. However, each terminal equipment has a unique task, i.e., acting as a message sender or a receiver;

The terminal equipment is kept motionless at locations with an adequate (good) coverage and the minimum interference.

Another important aspect to guarantee test reliability is to avoid upsetting the mobile terminal with the following message while it is still receiving the previous one. Thus, a suitable interval was established between consecutive message sendings.

For practical reasons, a time frame was established for message delivery. Messages not delivered within this delivery time frame are considered failed messages. Likewise, messages with errors (at least one bit) are considered failed messages. Doubled messages are not taken into account for the delivery rate.

Each test message is connected to a unique identifier in order make it easy to identify upon reception and to prevent any ambiguity in the correlation between sent messages and received messages. Invalid received messages (which haven't been sent by the origination terminal or don't belong to test session)

[1] The measurement profiles presented here are supported on the technical specifications ETSI TS 102 250, namely part 5 (ETSI TS 102 250-5 V1.3.1(2005-11)), and ETSI EG 202 057, namely parts 3 and 4 (ETSI EG 202 057-3 V1.1.1 (2005-04) and ETSI EG 202 057-4 V1.1.1 (2005-10)).

were discarded.

The used mobile terminals have no physical storage limitations that could affect message sending or reception.

2.3.2 SMS – SHORT MESSAGE SERVICE

The test message used on the analysis of the SMS service is 120 characters long and uses different symbols in order to validate the content's integrity.

In order to fulfil the conditions established in the previous section, the test parameters for the SMS messaging service must have the following values (based on ETSI TS 102 250-5 technical specification):

- Test message size: 120 characters
- Test message character sequence: "`The quick brown fox jumps over the lazy dog. 1234567890 aeiou QUICK BROWN FOX`"
- Time frame for SMS delivery: 175 s
- Interval between consecutive SMS sendings: 70 s
- Service Accessibility SMS MO Timeout: 65 s
- Access Delay SMS MO Timeout: 65 s
- End-to-end Delivery Time SMS Timeout: 175 s

2.3.3 MMS – MULTIMEDIA MESSAGING SYSTEM

The MMS messaging service enables users to send different contents, such as text, audio and image, which can have considerably different sizes. The user can chose to send only one type of content on a message or a blend of contents, which leads to highly heterogeneous MMS sizes. This study used a medium-size message (for this type of service) made up of text and a still image.

Test parameters are determined by the size if the MMS. Considering this aspect and also the condition established in section 2.3.1, the test parameters for the MMS messaging service have the following values (based on ETSI TS 102 250-5 technical specification):

- Sent message sixe: 25 kB
- Time frame for MMS delivery 650 s
- Interval between consecutive MMS sendings 120 s
- MMS Send Failure Ratio (MO) Timeout & MMS Send Time (MO) Timeout: 235 s
- MMS Retrieval Failure Ratio (MT) Timeout & MMS Retrieval Time (MT) Timeout: 215 s
- MMS end-to-end Delivery Failure Ratio Timeout & MMS End-to-end Delivery Time Timeout: 650 s
- MMS Notification Failure Ratio Timeout & MMS Notification Time Timeout: 120 s

2.4 TEST/MEASUREMENT AND POST-PROCESSING SYSTEM

The Seven.Five/NetQual system, conceived and developed by SwissQual, A.G. (Switzerland), was used for measurements on the field and for their post-processing. This is a set of tools specifically designed for the analysis and benchmarking of mobile communications systems.

The system is made up of the following modules:

a. 7.5 Multi – Mobile Unit, with an RF scanner and commercial mobile terminal equipment (NOKIA 6680 terminals were used in the study);

b. Land Unit – Fixed Unit, with ISDN interface cards, used for voice tests;

c. Video Call Server – Fixed Unit, with commercial mobile terminal equipment (also NOKIA 6680), used for video-telephony tests;

d. Media Server – Fixed Unit, server used for data and video streaming tests;

e. NQDI – Post-processing System, for analysis and reporting of the completed measurements.

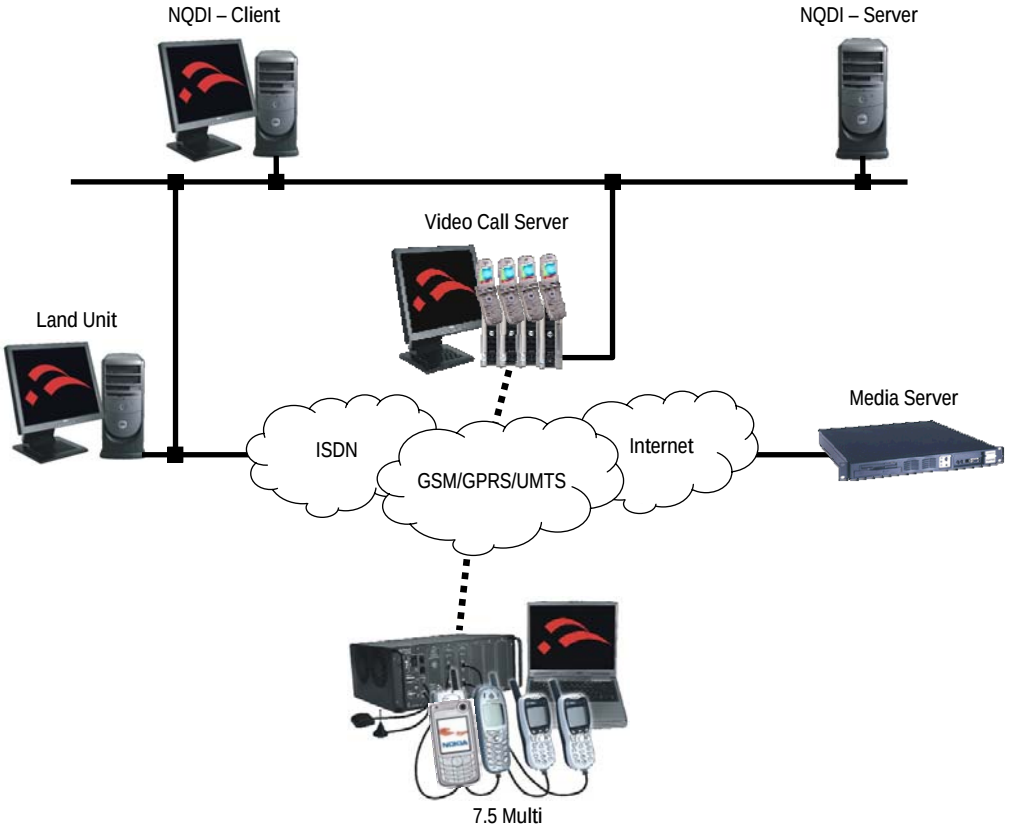


Figure 9 – *Seven.Five/NetQual* system architecture

3 STUDY SAMPLE

A sample representing the use of the messaging services (SMS and MMS) was chosen for a proper assessment of these services.

3.1 TEST LOCATIONS

Test messages were originated at Porto and received at Barcarena (testing and measurement equipment located at ANACOM's premises).

3.2 SAMPLE SIZE

Table 1 – Sample, for the three analyzed operators.

	Hours of Measurements	SMS	MMS
Working Days	48 h 02	6.391	3.703
Weekends	23 h 58	3.187	1.836
Total	72 h 00	9.578	5.539

3.3 DATA COLLECTION CONDITIONS

Tests were carried out during three 24 hour periods, two of those on working days and the other during the weekend, in order to make a time analysis of the messaging services' performance.

4 RESULTS

4.1 SMS – SHORT MESSAGE SERVICE

Measurement Sessions carried out on:

- 9 July 2008, between 7h30 am and 11h30 pm;
- 10 July 2008, between 1h20 am and 12h00 pm;
- 11 July 2008, between 12h00 pm and 3h20 pm;
- 12 July 2008, between 12h00 pm and 6h30 pm;
- 13 July 2008, between 9h00 am and 12h00 pm;
- 14 July 2008, between 10h10 am and 12h00 pm;
- 15 July 2008, between 12h00 pm and 1h40 am.

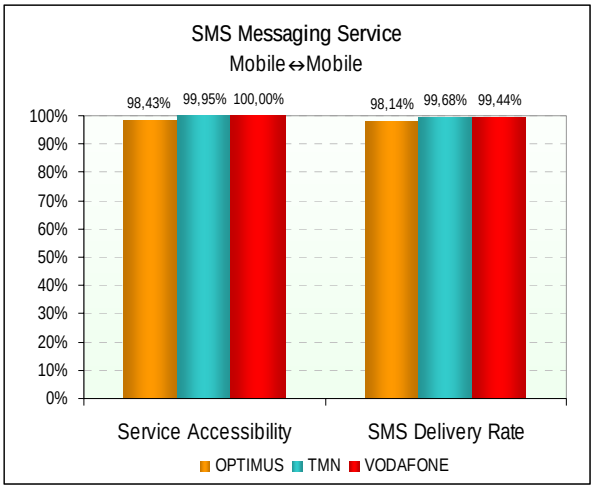
4.1.1 WORKING DAYS

		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
SMS Messages	Sending Attempts	2,098	2,155	2,138
	Successfully Sent	2,065	2,154	2,138
	Successfully Received	2,059	2,148	2,126
	Service Accessibility	98.43%	99.95%	100.00%
	SMS Delivery Rate	98.14%	99.68%	99.44%
	Average Sending Time [s]	6.5	4.7	5.4
	Maximum Sending Time [s]	10.3	13.1	11.,2
	Minimum Sending Time [s]	3.3	1.6	2.3
	Standard Deviation [s]	0.4	0.4	0.4
	Average Delivery Time [s]	8.8	6.9	6.9
	Maximum Delivery Time [s]	90.2	86.0	76.2
	Minimum Delivery Time [s]	4.7	2.5	2.5
	Standard Deviation [s]	3.3	2.3	1.7

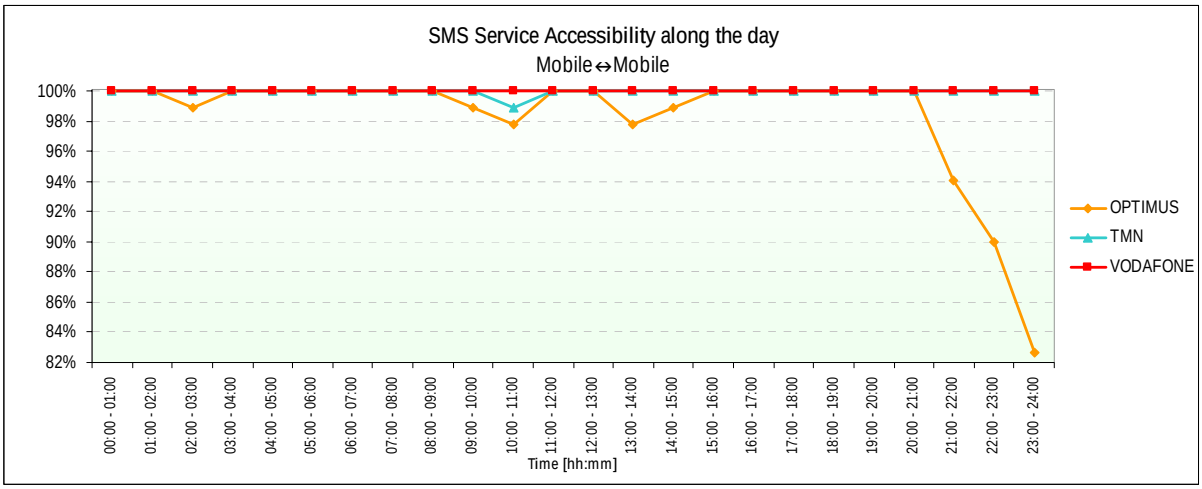
		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
Precision Error	Service Accessibility	0,6%	0,2%	0,0%
	SMS Delivery Rate	0,7%	0,3%	0,4%
	SMS Sending Time [s]	0,019	0,018	0,017
	SMS Delivery Time [s]	0,144	0,099	0,073

Confidence Level = 95 %

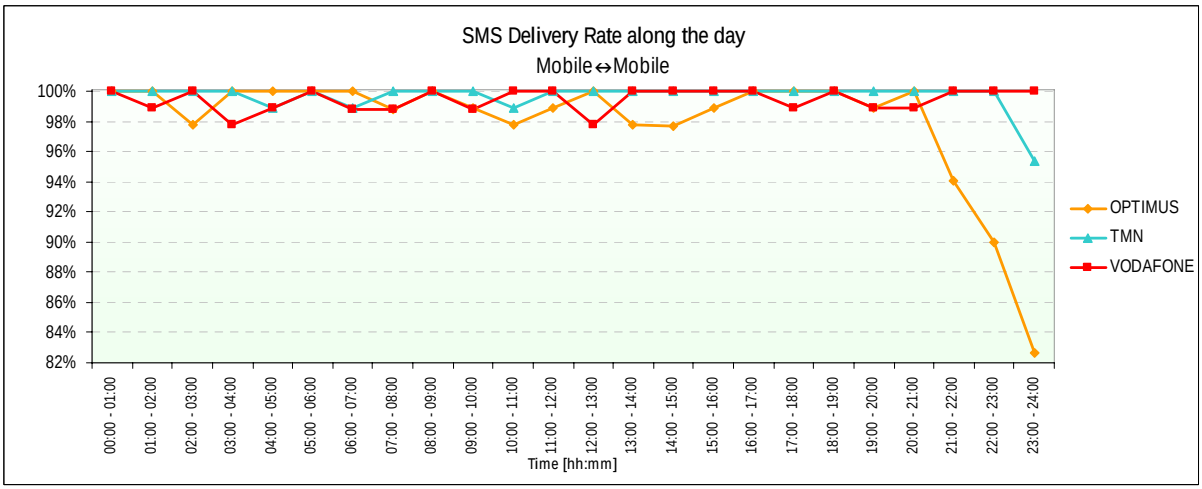
4.1.1.1 *SERVICE ACCESSIBILITY* AND *SMS DELIVERY RATE* INDICATORS



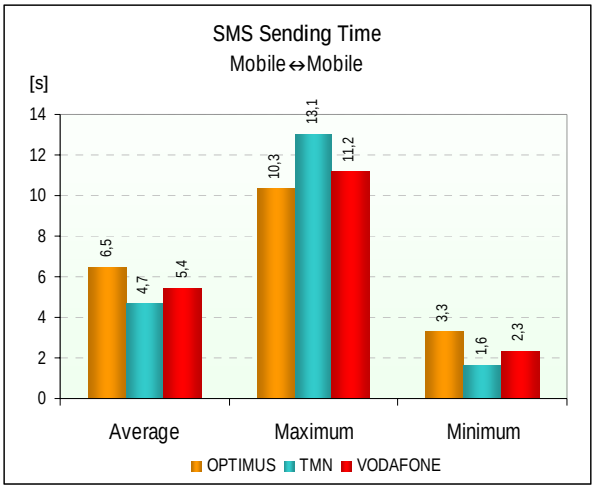
4.1.1.2 VARIATION IN THE *SMS ACCESSIBILITY* INDICATOR ALONG THE DAY



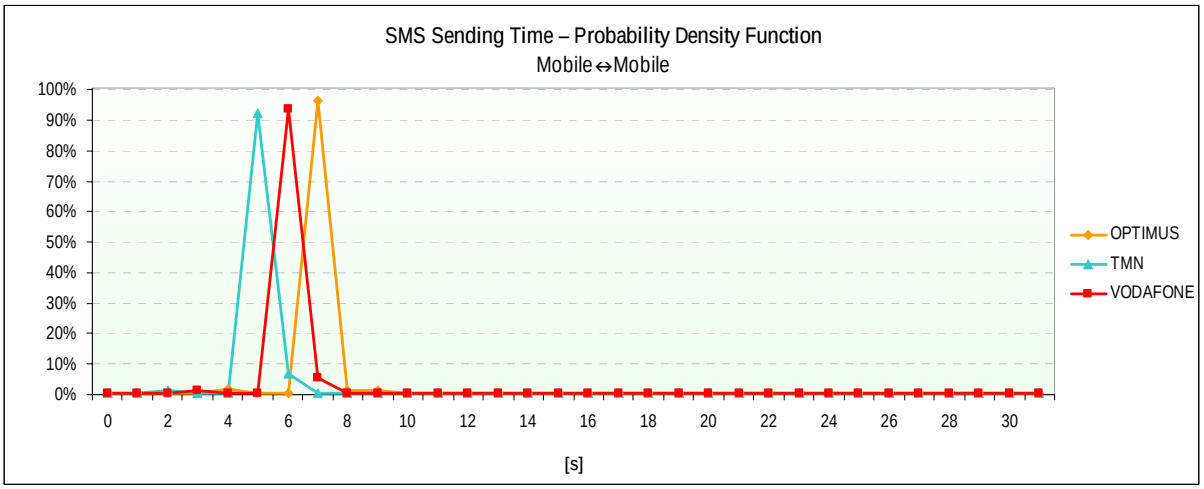
4.1.1.3 VARIATION IN THE *SMS DELIVERY RATE* INDICATOR ALONG THE DAY



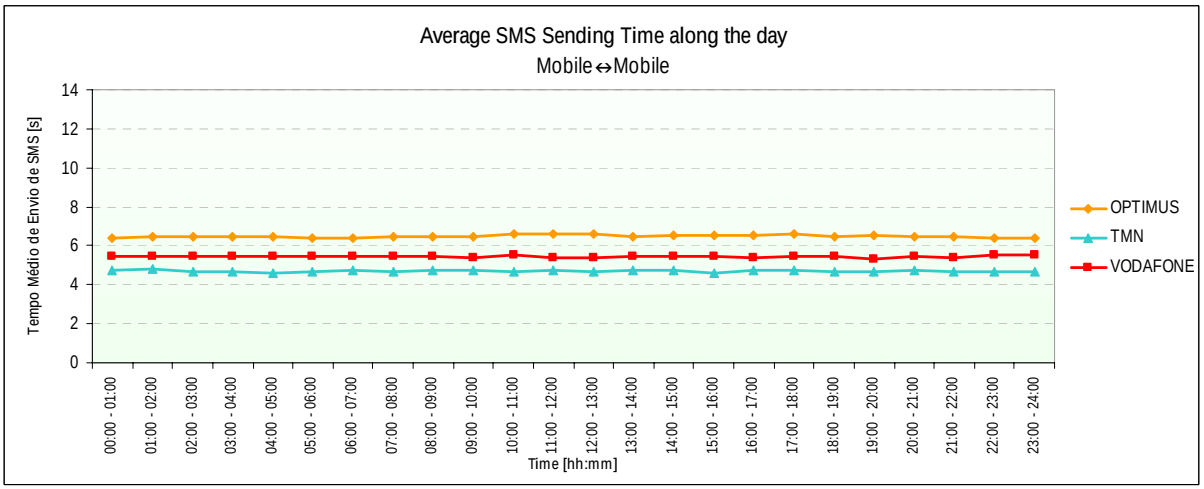
4.1.1.4 *SMS SENDING TIME INDICATOR*



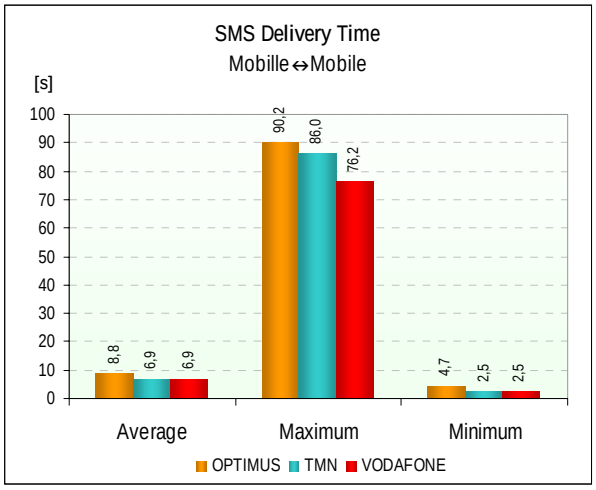
4.1.1.5 PROBABILITY DENSITY FUNCTION OF THE *SMS SENDING TIME*



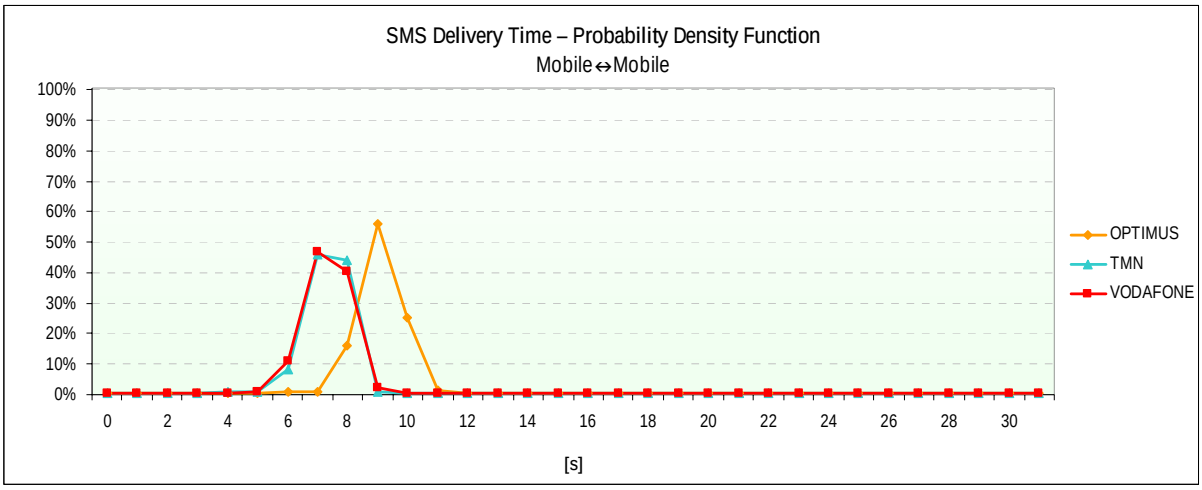
4.1.1.6 VARIATION IN THE *AVERAGE SMS SENDING TIME* ALONG THE DAY



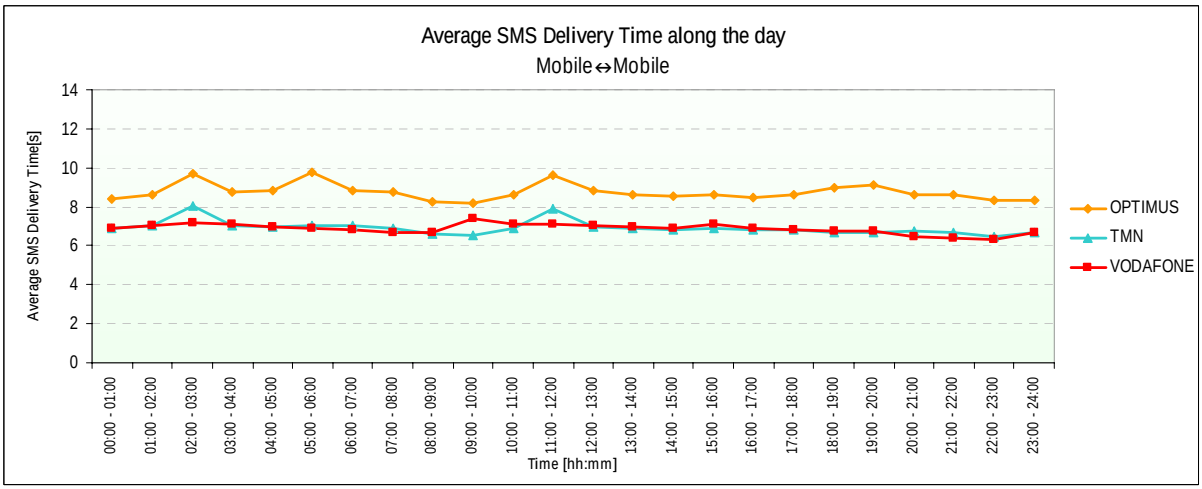
4.1.1.7 *SMS DELIVERY TIME* INDICATOR



4.1.1.8 PROBABILITY DENSITY FUNCTION OF THE *SMS DELIVERY TIME* INDICATOR



4.1.1.9 VARIATION IN THE *AVERAGE SMS DELIVERY TIME* INDICATOR ALONG THE DAY

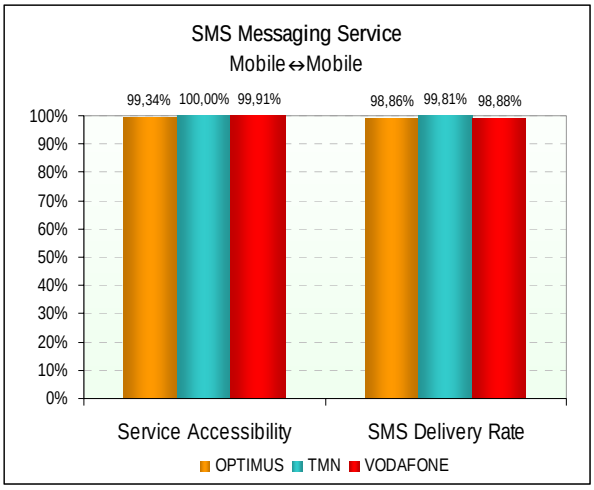


4.1.2 WEEKEND

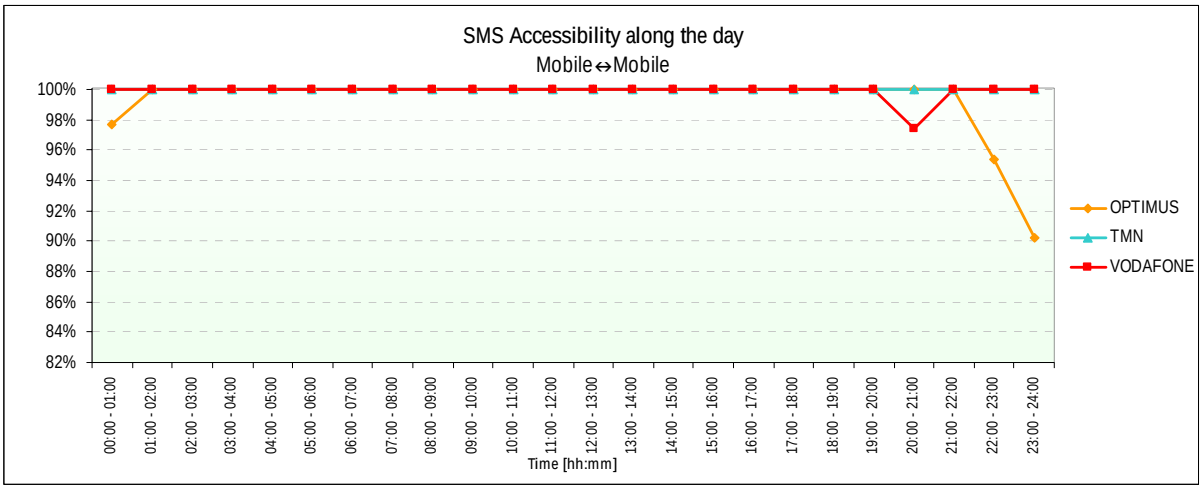
		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
SMS Messages	Sending Attempts	1.054	1.066	1.067
	Successfully Sent	1.047	1.066	1.066
	Successfully Received	1.042	1.064	1.055
	Service Accessibility	99,34%	100,00%	99,91%
	SMS Delivery Rate	98,86%	99,81%	98,88%
	Average Sending Time [s]	6,5	4,7	5,4
	Maximum Sending Time [s]	10,5	7,1	6,9
	Minimum Sending Time [s]	3,4	1,6	2,3
	Standard Deviation [s]	0,4	0,3	0,4
	Average Delivery Time [s]	8,6	6,9	6,7
	Maximum Delivery Time [s]	89,9	85,8	12,3
	Minimum Delivery Time [s]	5,4	3,1	3,2
	Standard Deviation [s]	2,6	3,0	0,5

		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
Precision Error	Service Accessibility	0,7%	0,0%	0,4%
	SMS Delivery Rate	0,8%	0,5%	0,8%
	SMS Sending Time [s]	0,026	0,019	0,025
	SMS Delivery Time [s]	0,156	0,177	0,032

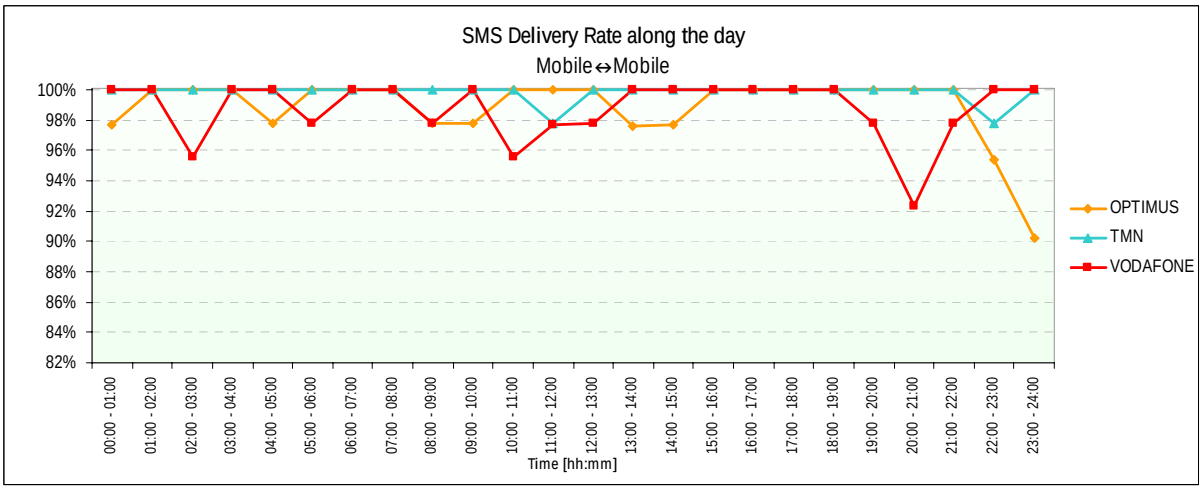
4.1.2.1 *SERVICE ACCESSIBILITY* AND *SMS DELIVERY RATE* INDICATORS



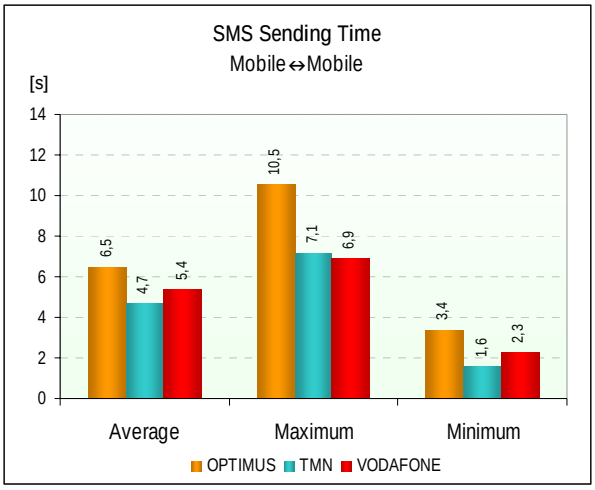
4.1.2.2 ARIATIONS OF THE *SMS ACCESSIBILITY* INDICATOR ALONG THE DAY



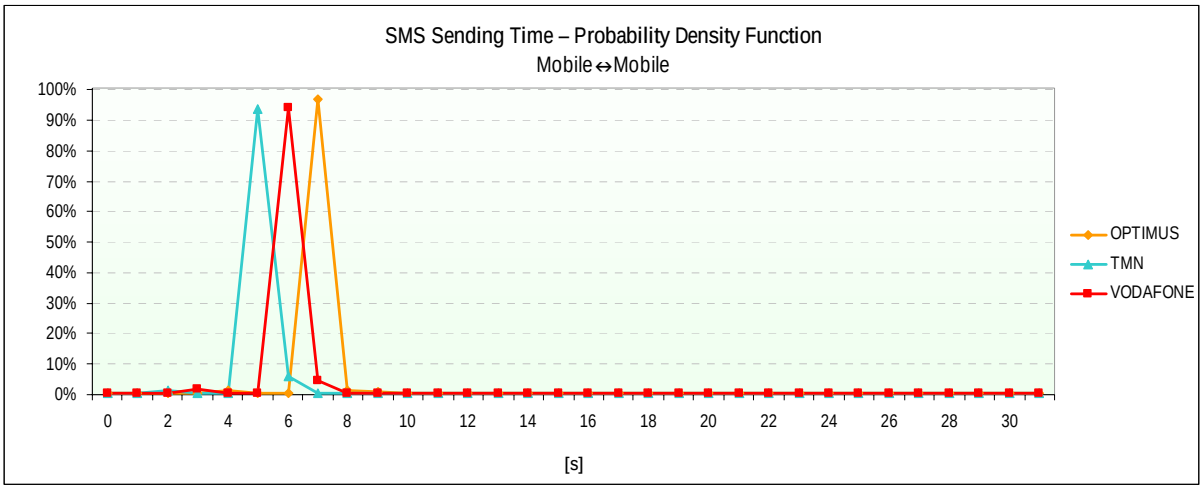
4.1.2.3 VARIATION IN THE *SMS DELIVERY RATE* INDICATOR ALONG THE DAY



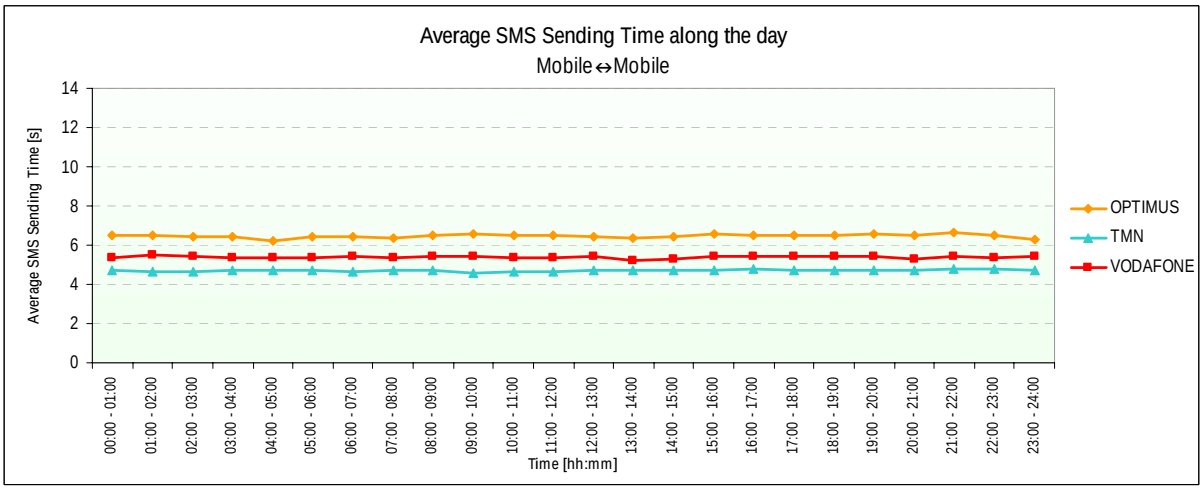
4.1.2.4 *SMS SENDING TIME* INDICATOR



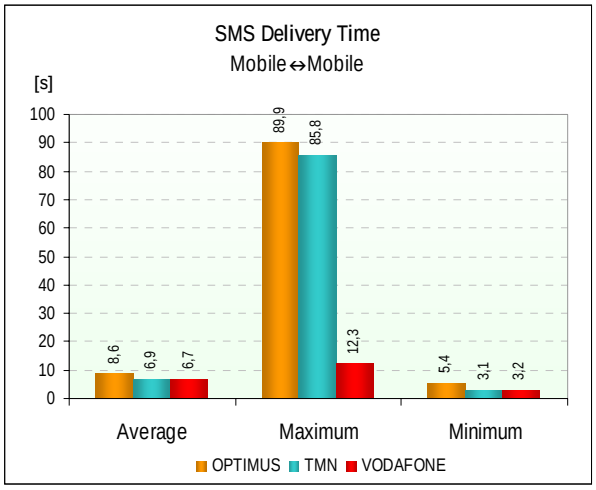
4.1.2.5 PROBABILITY DENSITY FUNCTION OF THE *SMS SENDING TIME* INDICATOR



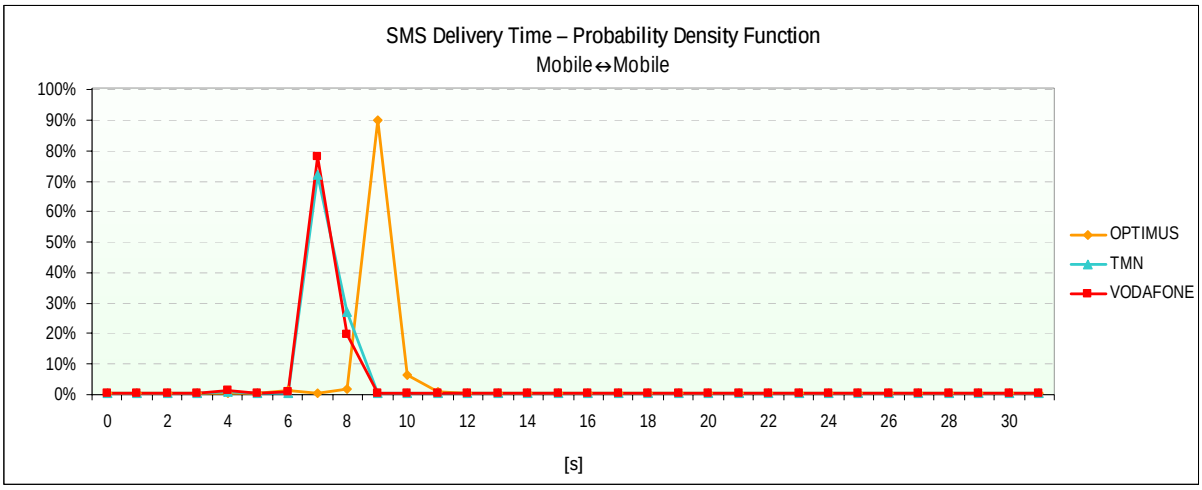
4.1.2.6 VARIATION IN THE *AVERAGE SMS SENDING TIME* INDICATOR ALONG THE DAY



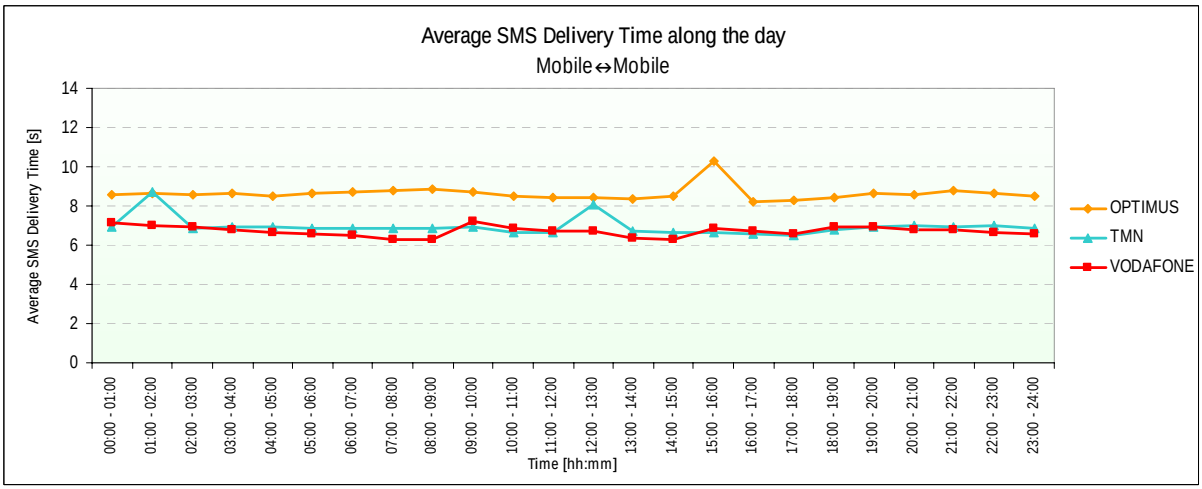
4.1.2.7 *SMS DELIVERY TIME* INDICATOR



4.1.2.8 PROBABILITY DENSITY FUNCTION OF THE *SMS DELIVERY TIME* INDICATOR



4.1.2.9 VARIATION IN THE AVERAGE SMS DELIVERY TIME ALONG THE DAY



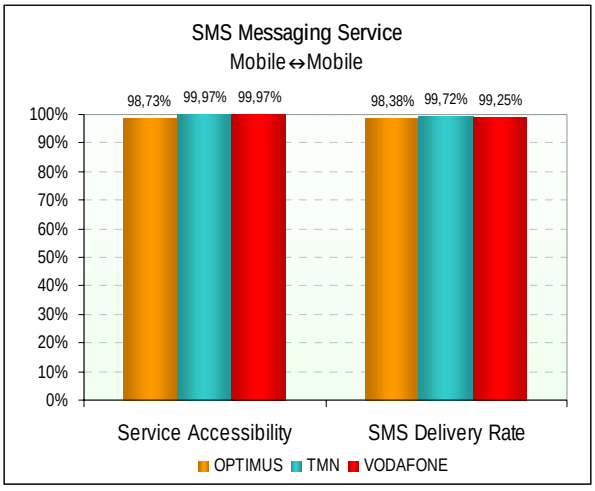
4.1.3 GLOBAL

		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
SMS Messages	Sending Attempts	3.152	3.221	3.205
	Successfully Sent	3.112	3.220	3.204
	Successfully Received	3.101	3.212	3.181
	Service Accessibility	98,73%	99,97%	99,97%
	SMS Delivery Rate	98,38%	99,72%	99,25%
	Average Sending Time [s]	6,5	4,7	5,4
	Maximum Sending Time [s]	10,5	13,1	11,2
	Minimum Sending Time [s]	3,3	1,6	2,3
	Standard Deviation [s]	0,4	0,4	0,4
	Average Delivery Time [s]	8,7	6,9	6,8
	Maximum Delivery Time [s]	90,2	86,0	76,2
	Minimum Delivery Time [s]	4,7	2,5	2,5
	Standard Deviation [s]	3,1	2,6	1,4

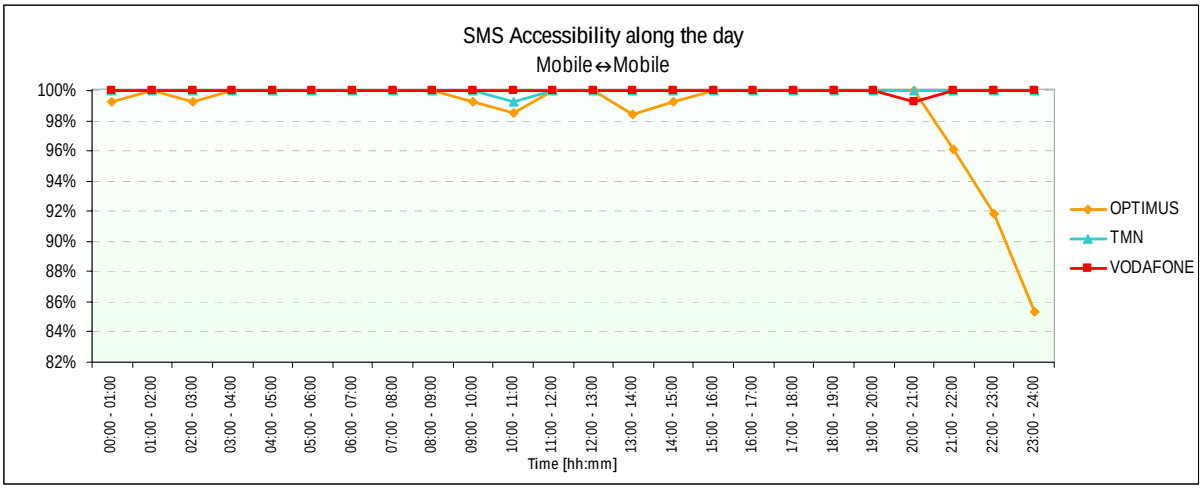
		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
Precision Error	Service Accessibility	0,5%	0,1%	0,1%
	SMS Delivery Rate	0,5%	0,3%	0,4%
	SMS Sending Time [s]	0,015	0,014	0,014
	SMS Delivery Time [s]	0,109	0,089	0,050

Confidence Level = 95 %

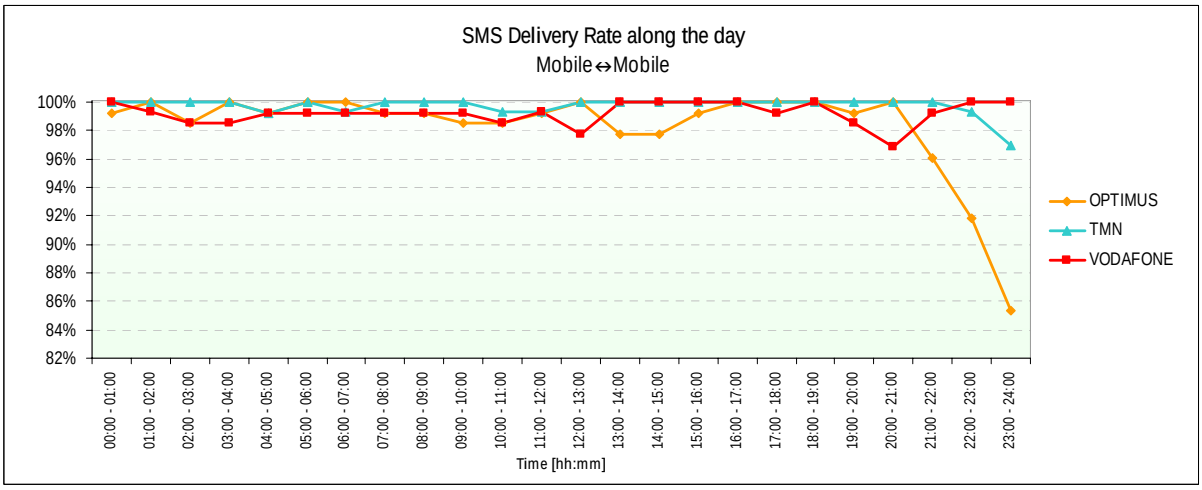
4.1.3.1 *SERVICE ACCESSIBILITY* AND *SMS DELIVERY RATE* INDICATORS



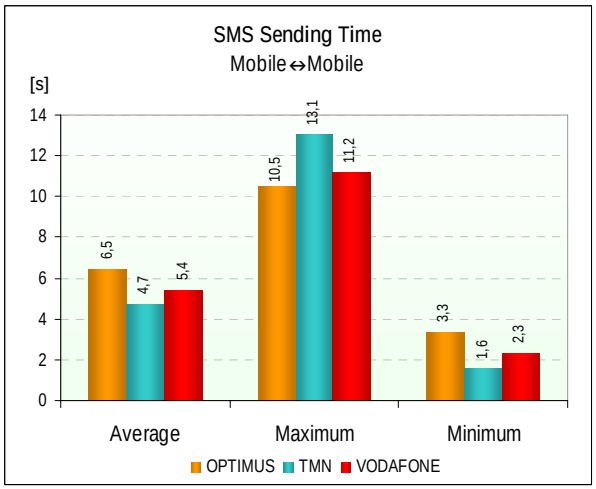
4.1.3.2 VARIATION IN THE *SMS ACCESSIBILITY* INDICATOR ALONG THE DAY



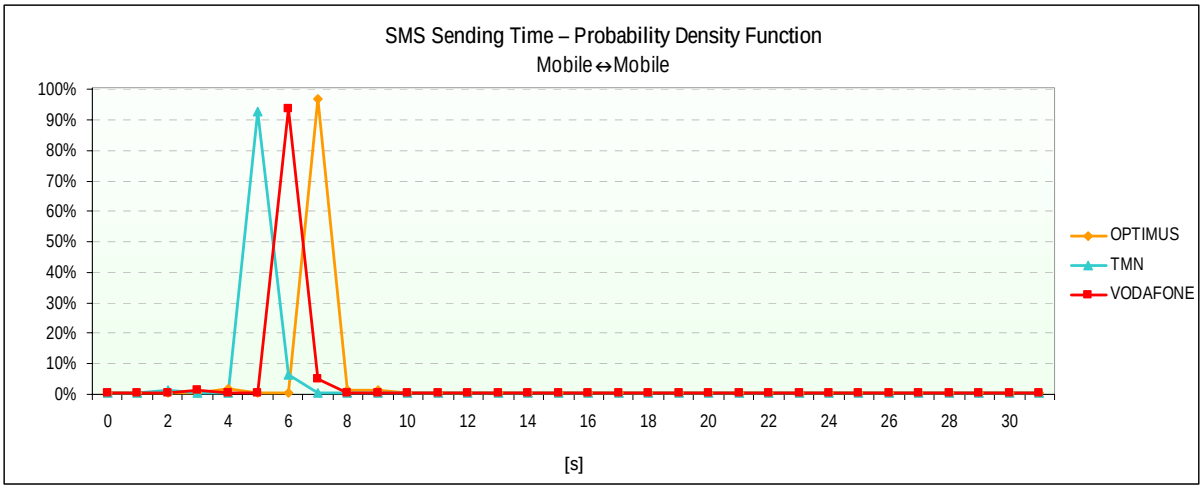
4.1.3.3 VARIATION IN THE *SMS DELIVERY RATE* ALONG THE DAY



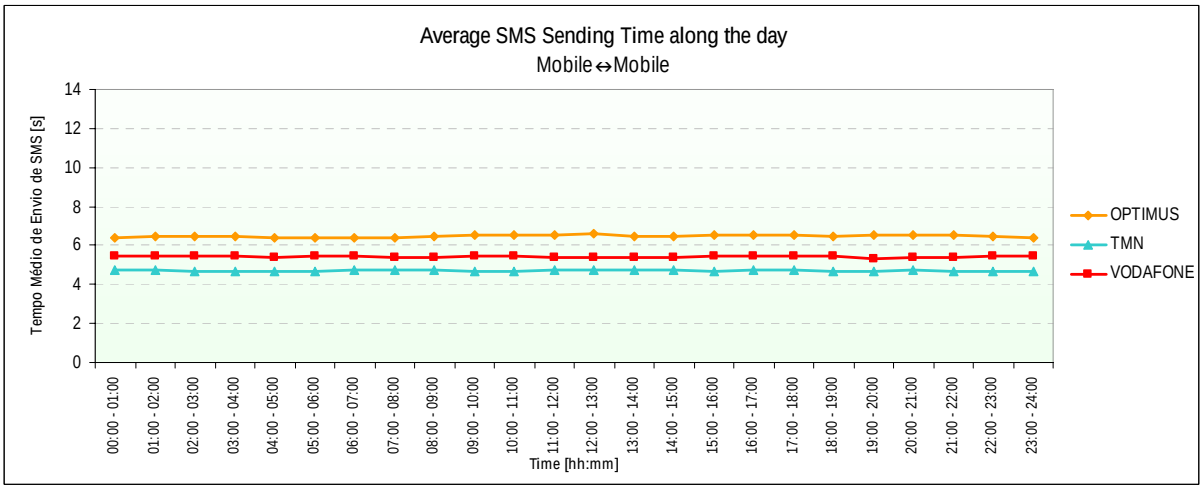
4.1.3.4 *SMS SENDING TIME* INDICATOR



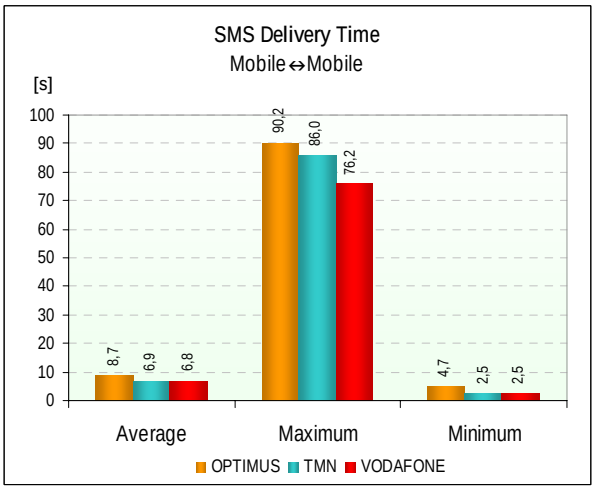
4.1.3.5 PROBABILITY DENSITY FUNCTION OF THE *SMS SENDING TIME* INDICATOR



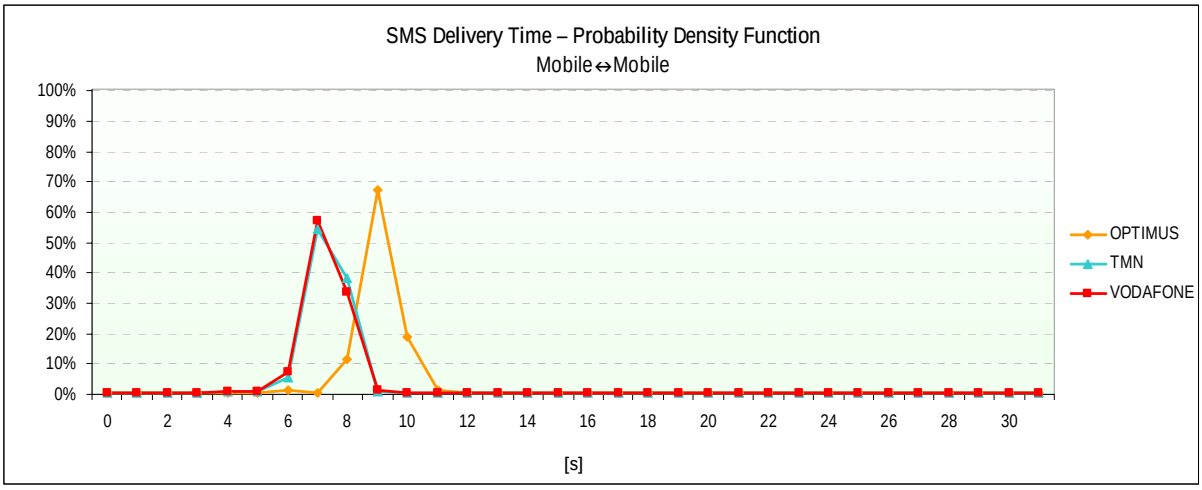
4.1.3.6 VARIATION IN THE AVERAGE *SMS SENDING TIME* INDICATOR ALONG THE DAY



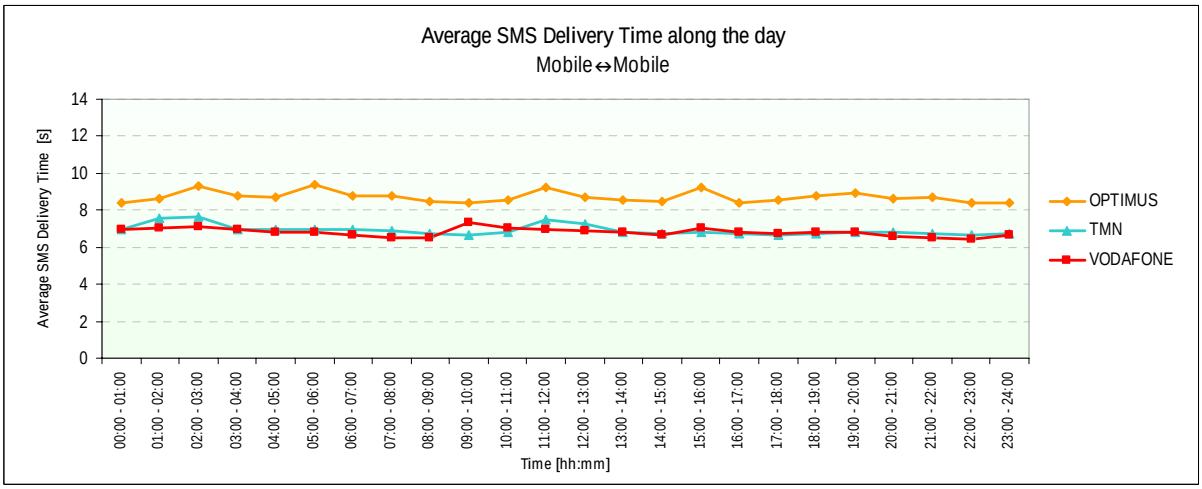
4.1.3.7 *SMS DELIVERY TIME* INDICATOR



4.1.3.8 PROBABILITY DENSITY FUNCTION OF THE *SMS DELIVERY TIME* INDICATOR



4.1.3.9 VARIATION IN THE *AVERAGE SMS DELIVERY TIME* ALONG THE DAY



4.2 MMS – MULTIMEDIA MESSAGING SERVICE

Measurement sessions carried out on:

- 9 July 2008, between 7h30 am and 11h30 pm;
- 10 July 2008, between 1h20 am and 12h00 pm;
- 11 July 2008, between 12h00 pm and 3h20 pm;
- 12 July 2008, between 12h00 pm and 6h30 pm;
- 13 July 2008, between 9h00 am and 12h00 pm;
- 14 July 2008, between 10h10 am and 12h00 pm;
- 15 July 2008, between 12h00 pm and 1h40 am.

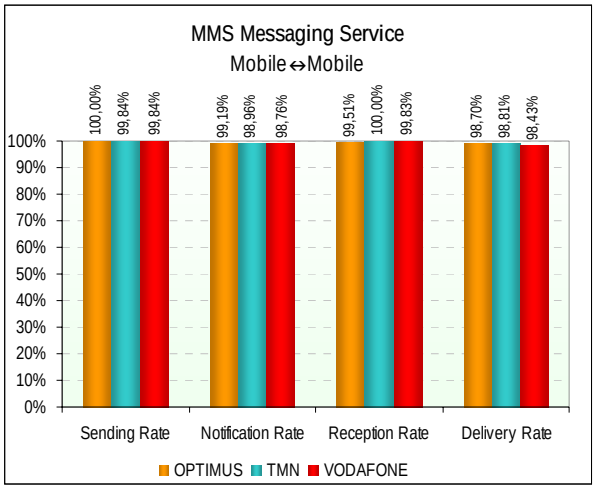
4.2.1 WORKING DAYS

		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
MMS Messages	Sending Attempts	1.233	1.256	1.214
	Successfully Sent	1.233	1.254	1.212
	Notification Received by the Receiver	1.223	1.241	1.197
	Successfully Received	1.217	1.241	1.195
	Sending Rate	100,00%	99,84%	99,84%
	Notification Rate	99,19%	98,96%	98,76%
	Reception Rate	99,51%	100,00%	99,83%
	Delivery Rate	98,70%	98,81%	98,43%
	Average Sending Speed [kbps]	43,9	44,9	31,6
	Maximum Sending Speed [kbps]	47,3	46,4	33,1
	Minimum Sending Speed [kbps]	9,3	19,3	5,0
	Standard Deviation [kbps]	3,2	3,3	1,9
	Average Reception Speed [kbps]	43,4	10,9	39,1
	Maximum Reception Speed [kbps]	46,0	48,3	44,2
	Minimum Reception Speed [kbps]	22,3	3,9	2,4
	Standard Deviation [kbps]	1,9	2,1	7,7
	Average Delivery Time [s]	34,7	52,4	35,3
	Maximum Delivery Time [s]	565,0	196,0	110,0
	Minimum Delivery Time [s]	27,0	31,0	27,0
	Standard Deviation [s]	26,5	13,5	6,9

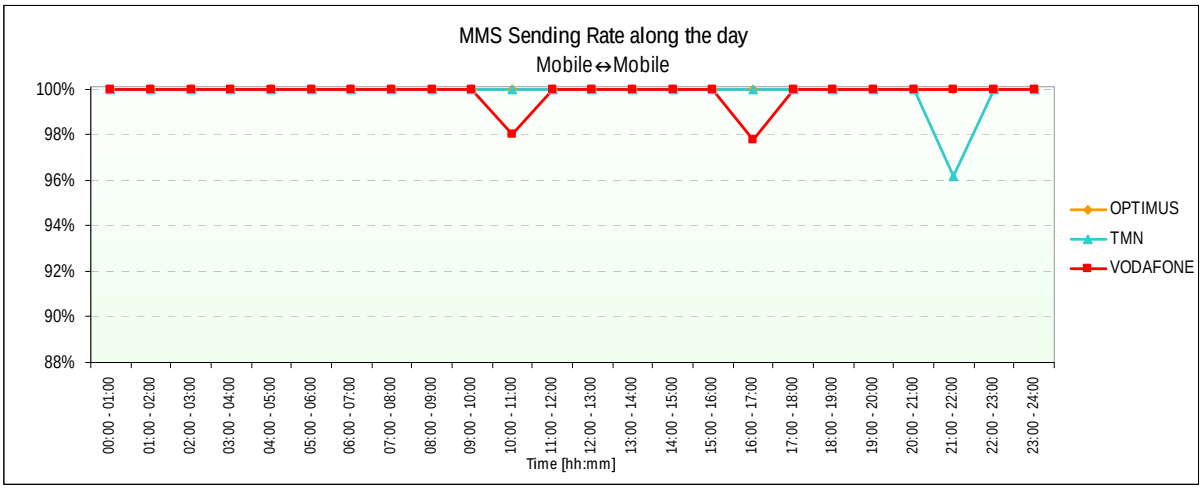
		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
Precision Error	MMS Sending Rate	0,0%	0,4%	0,4%
	MMS Notification Rate	0,7%	0,7%	0,8%
	MMS Reception Rate	0,6%	0,0%	0,4%
	MMS Delivery Rate	0,8%	0,8%	0,9%
	MMS Sending Speed [kbps]	0,2	0,2	0,1
	MMS Reception Speed [kbps]	0,1	0,1	0,4
	MMS Delivery Time [s]	1,488	0,754	0,392

Confidence Level = 95 %

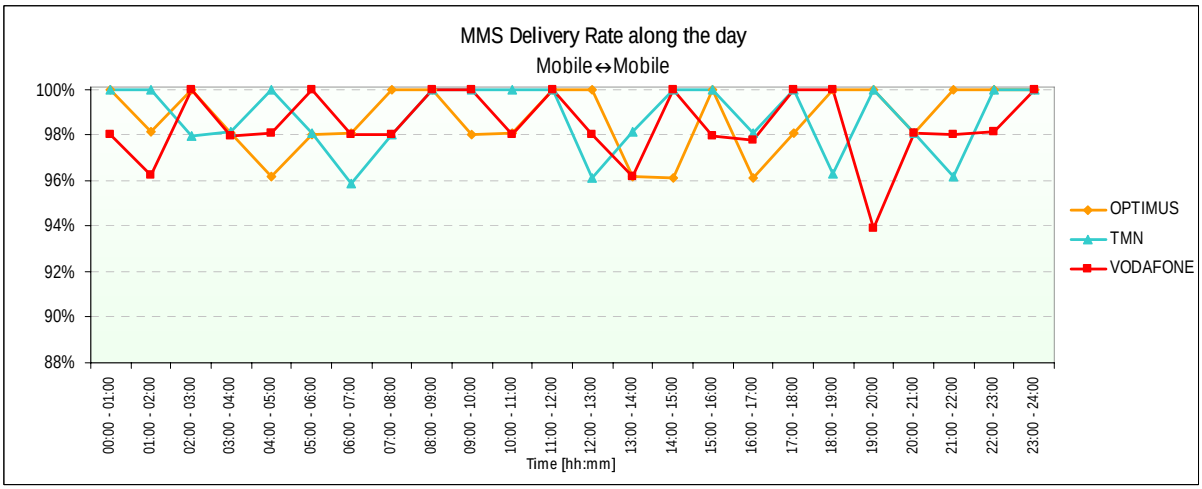
4.2.1.1 *MMS SENDING RATE, NOTIFICATION, RECEPTION AND DELIVERY* INDICATORS



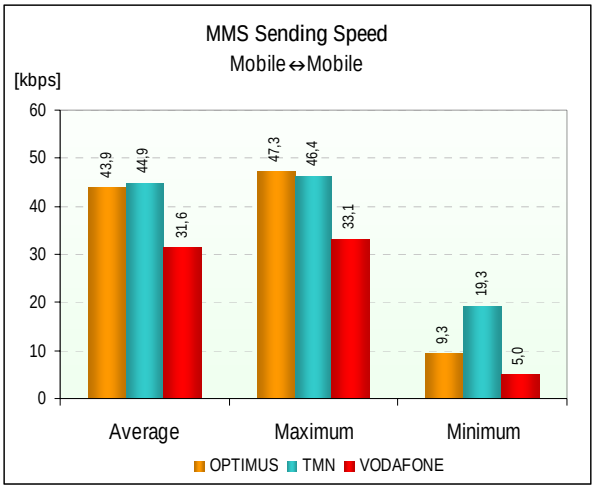
4.2.1.2 VARIATION IN THE *MMS SENDING RATE* ALONG THE DAY



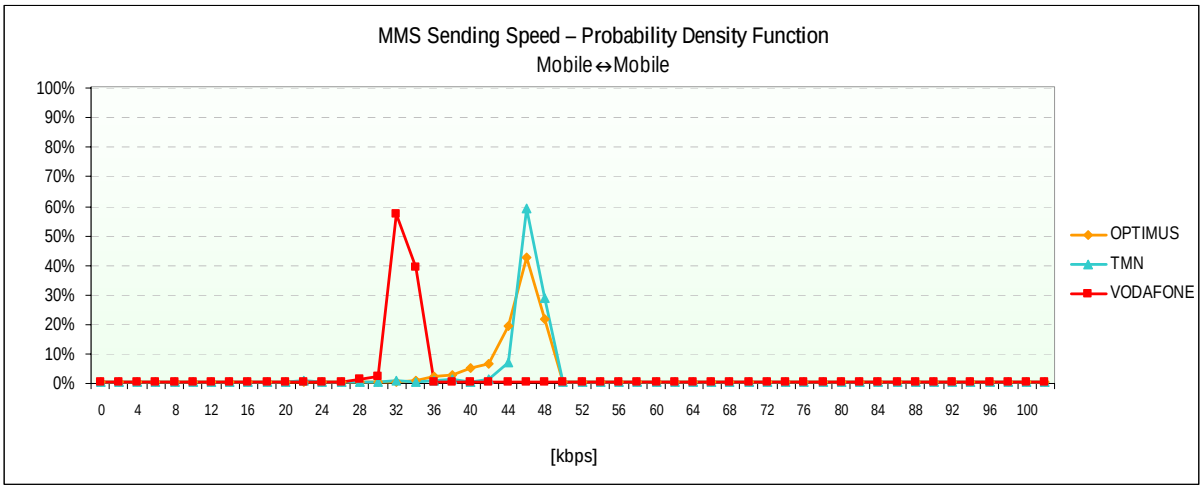
4.2.1.3 VARIATION IN THE *MMS DELIVERY RATE* ALONG THE DAY



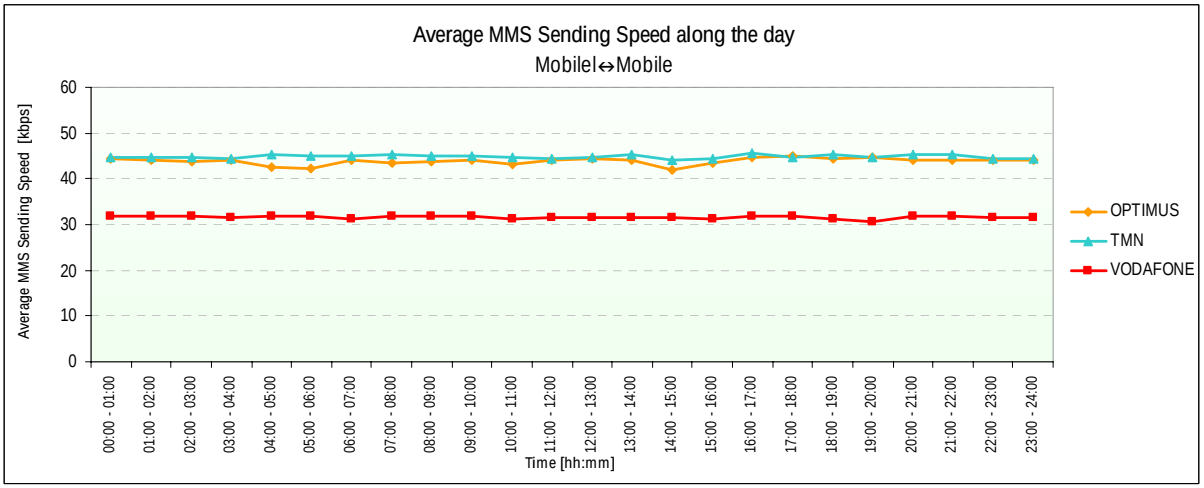
4.2.1.4 *MMS SENDING SPEED* INDICATOR



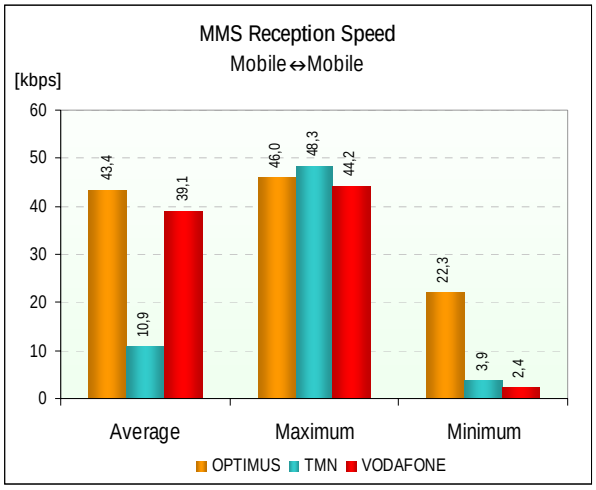
4.2.1.5 PROBABILITY DENSITY FUNCTION OF THE *MMS SENDING SPEED* INDICATOR



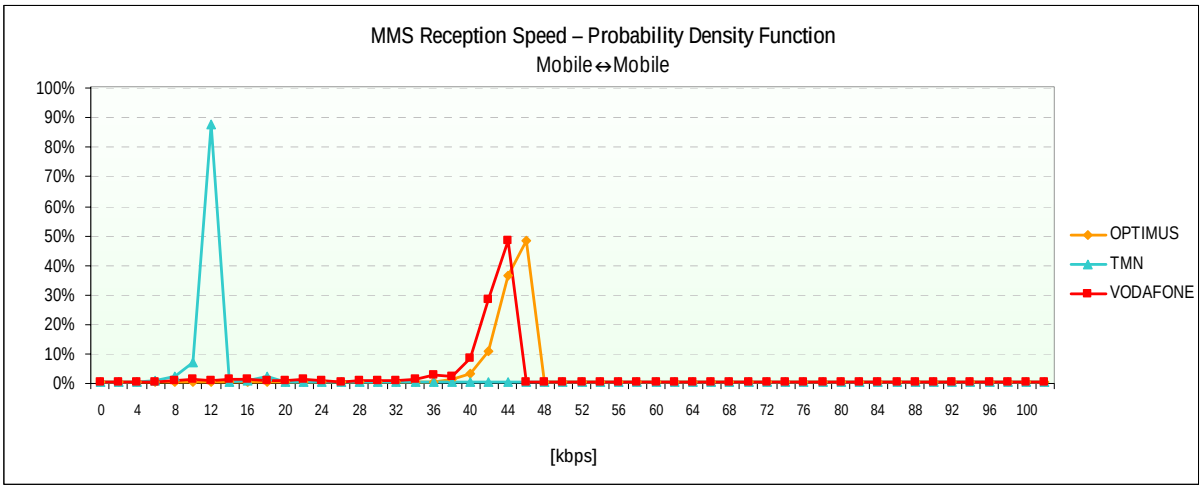
4.2.1.6 VARIATION IN THE *AVERAGE MMS SENDING SPEED* INDICATOR ALONG THE DAY



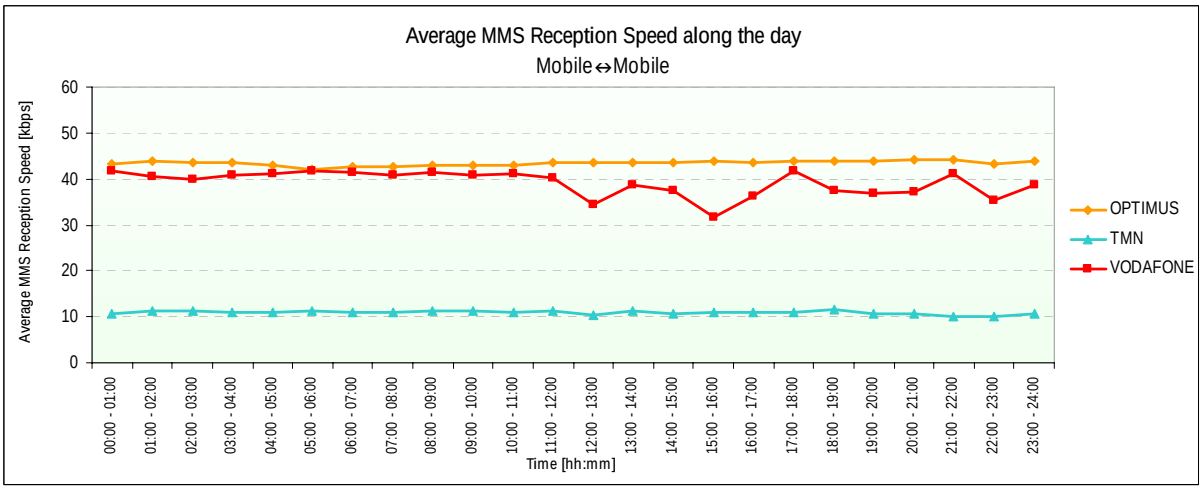
4.2.1.7 *MMS RECEPTION SPEED* INDICATOR



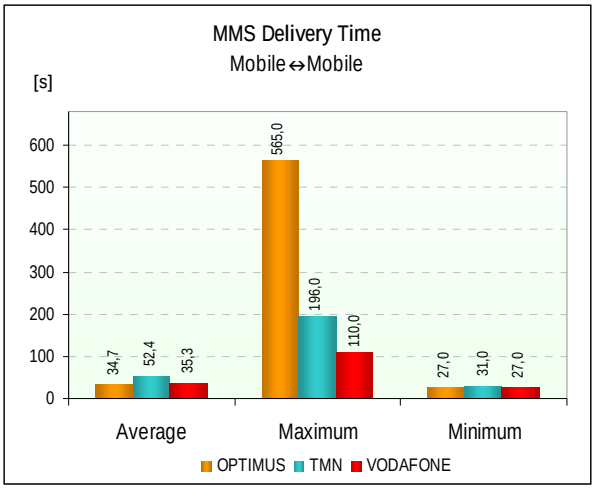
4.2.1.8 PROBABILITY DENSITY FUNCTION OF THE *MMS RECEPTION SPEED* INDICATOR



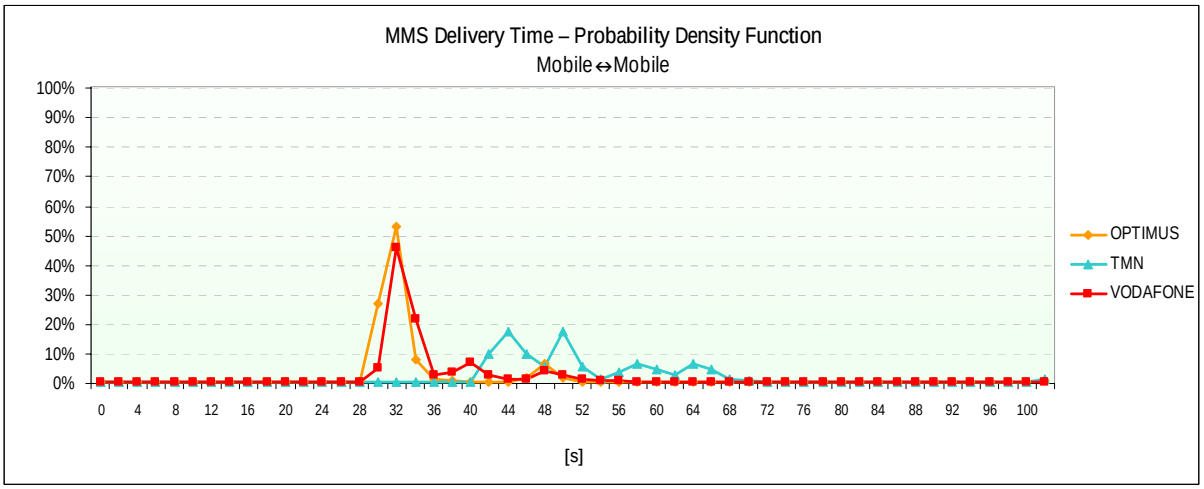
4.2.1.9 VARIATION IN THE *AVERAGE MMS SENDING SPEED* INDICATOR ALONG THE DAY



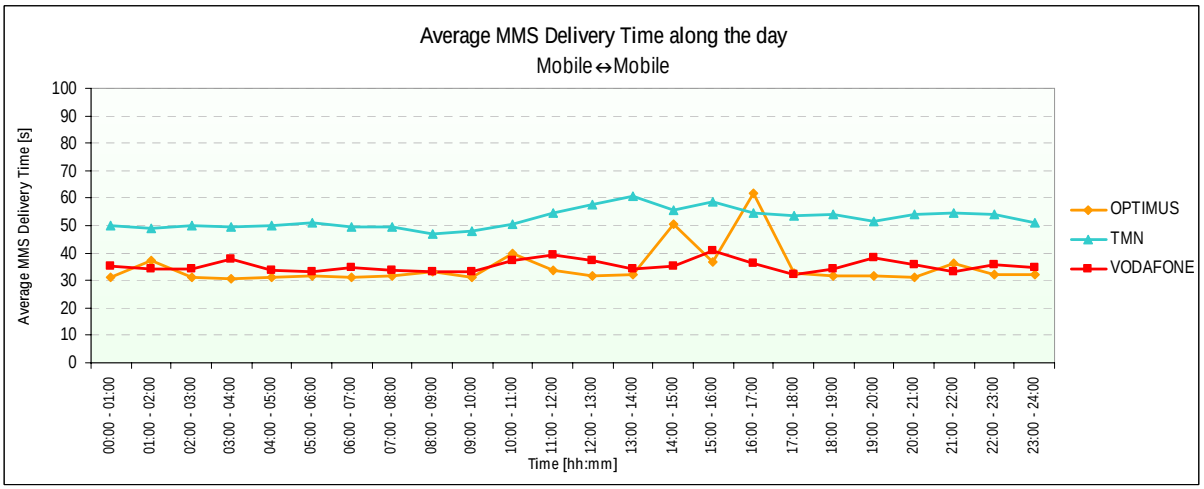
4.2.1.10 *MMS DELIVERY TIME* INDICATOR



4.2.1.11 PROBABILITY DENSITY FUNCTION OF THE *MMS DELIVERY TIME* INDICATOR



4.2.1.12 VARIATION IN THE *AVERAGE MMS DELIVERY TIME* INDICATOR ALONG THE DAY



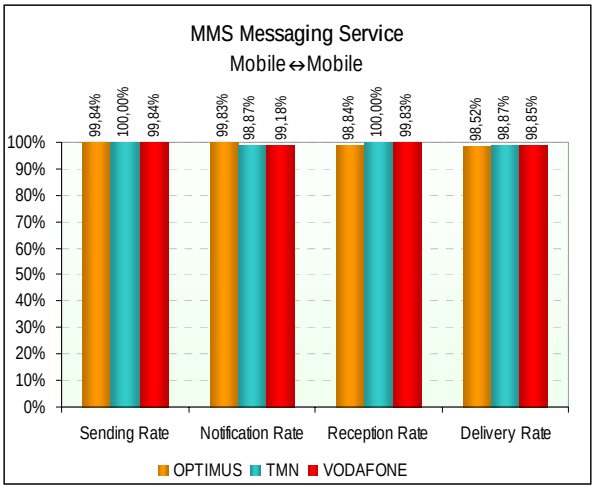
4.2.2 WEEKEND

		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
MMS Messages	Sending Attempts	607	621	608
	Successfully Sent	606	621	607
	Notification Received by the Receiver	605	614	602
	Successfully Received	598	614	601
	Sending Rate	99,84%	100,00%	99,84%
	Notification Rate	99,83%	98,87%	99,18%
	Reception Rate	98,84%	100,00%	99,83%
	Delivery Rate	98,52%	98,87%	98,85%
	Average Sending Speed [kbps]	42,3	44,9	31,8
	Maximum Sending Speed [kbps]	46,9	46,5	32,9
	Minimum Sending Speed [kbps]	20,9	20,7	18,6
	Standard Deviation [kbps]	3,4	3,1	0,9
	Average Reception Speed [kbps]	42,5	10,9	38,6
	Maximum Reception Speed [kbps]	45,8	46,5	44,1
	Minimum Reception Speed [kbps]	20,0	4,8	4,1
	Standard Deviation [kbps]	2,3	2,0	8,4
	Average Delivery Time [s]	33,7	55,2	35,1
	Maximum Delivery Time [s]	415,0	648,0	85,0
	Minimum Delivery Time [s]	29,0	26,0	29,0
	Standard Deviation [s]	16,5	44,0	6,6

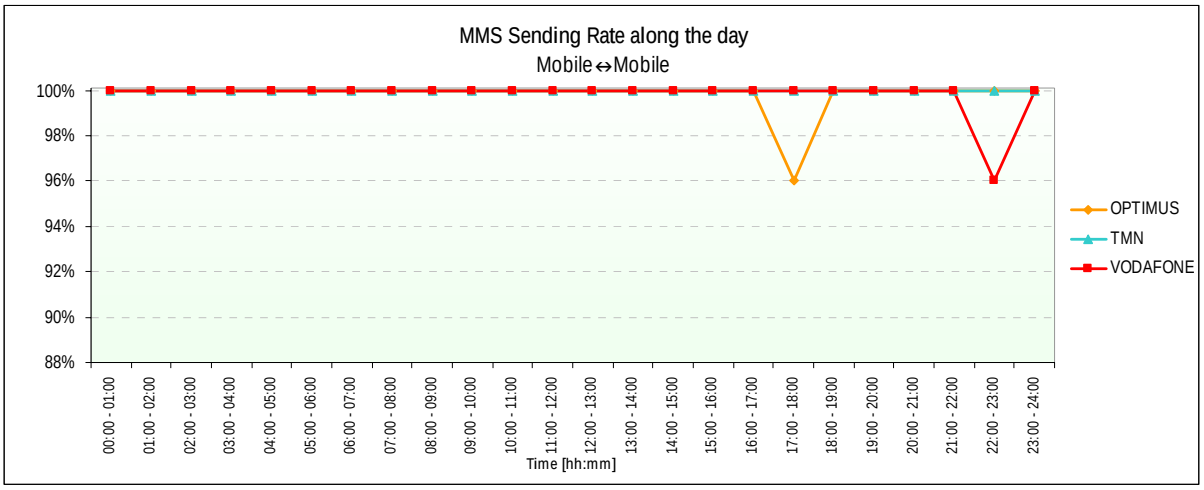
		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
Precision Error	MMS Sending Rate	0,7%	0,0%	0,7%
	MMS Notification Rate	0,8%	1,2%	1,1%
	MMS Reception Rate	1,2%	0,0%	0,8%
	MMS Delivery Rate	1,3%	1,2%	1,2%
	MMS Sending Speed [kbps]	0,3	0,2	0,1
	MMS Reception Speed [kbps]	0,2	0,2	0,7
	MMS Delivery Time [s]	1,320	3,479	0,530

Confidence Level = 95 %

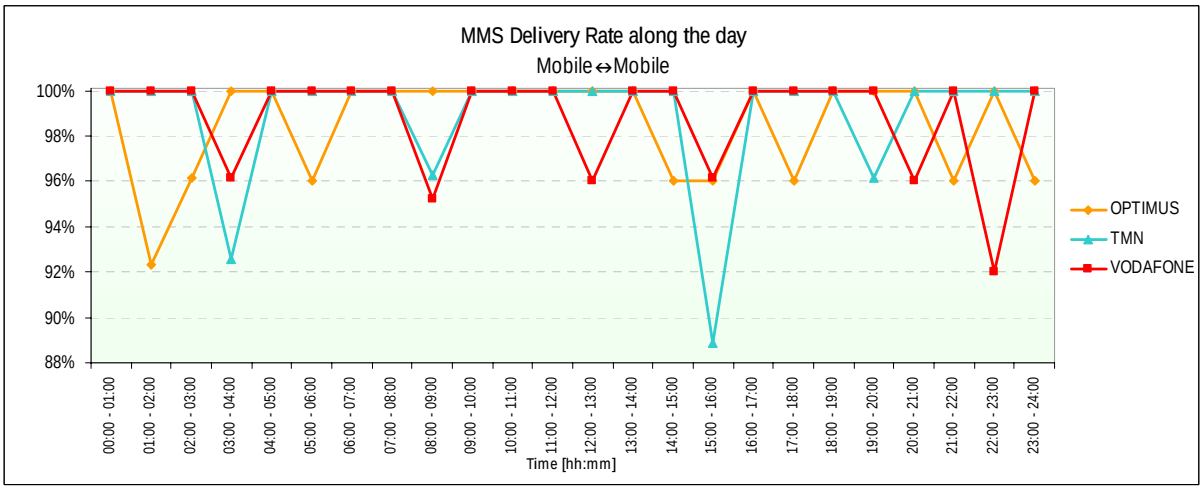
4.2.2.1 *MMS SENDING RATE, NOTIFICATION, RECEPTION AND DELIVERY INDICTORS*



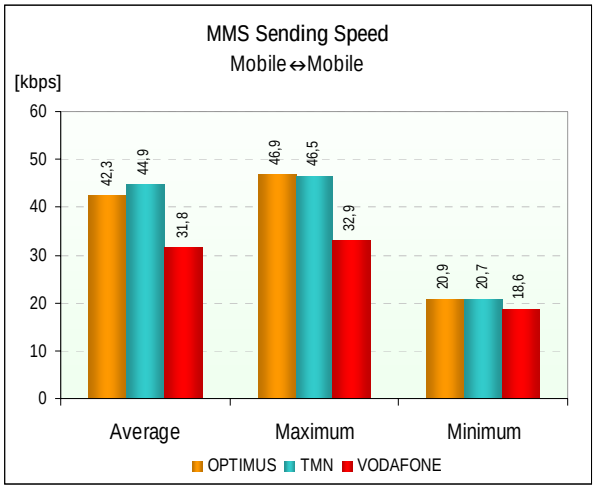
4.2.2.2 VARIATION IN THE *MMS SENDING RATE* ALONG THE DAY



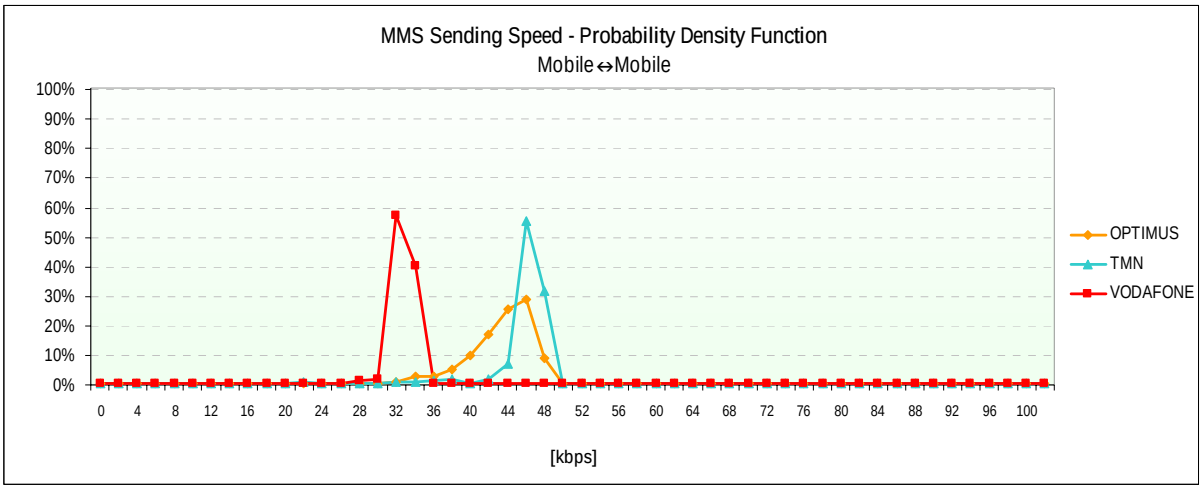
4.2.2.3 VARIATION IN THE *MMS DELIVERY RATE* ALONG THE DAY



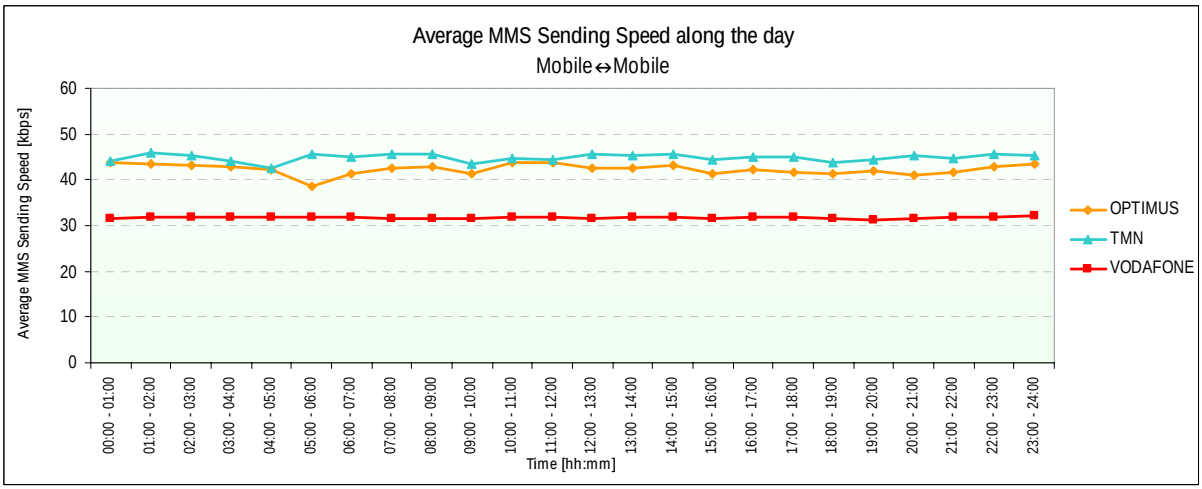
4.2.2.4 *MMS SENDING SPEED* INDICATOR



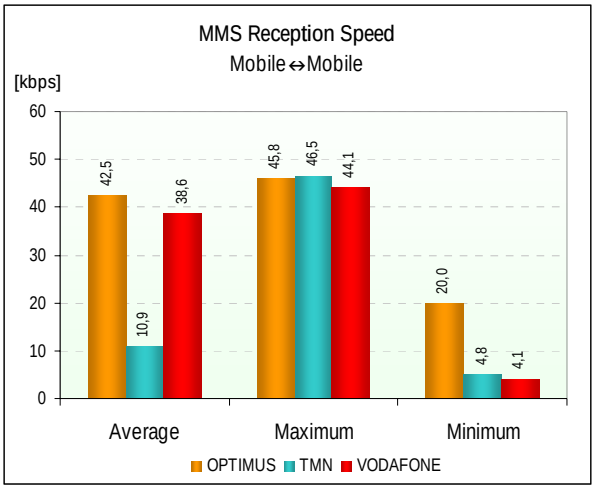
4.2.2.5 PROBABILITY DENSITY FUNCTION OF THE *MMS SENDING SPEED* INDICATOR



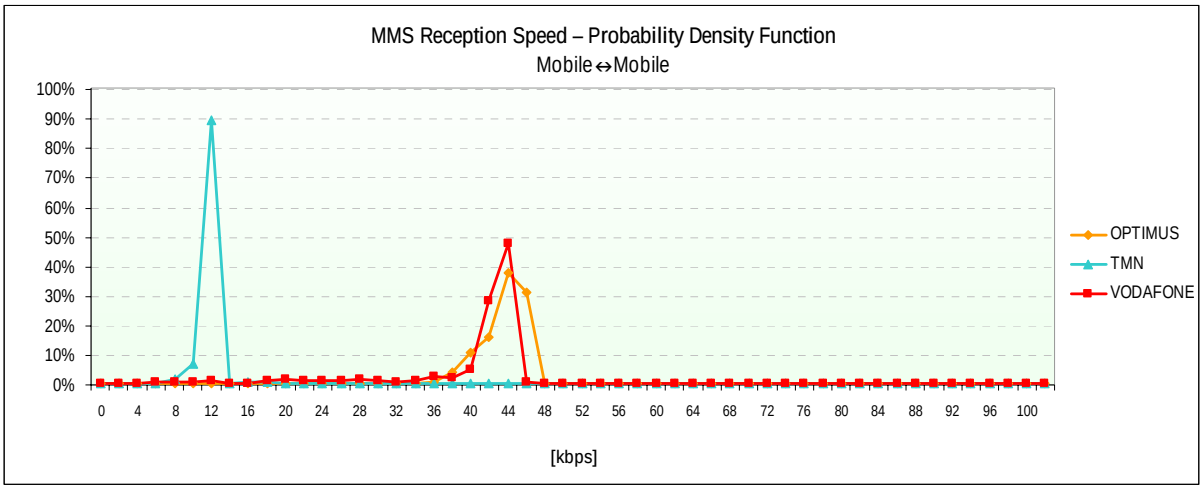
4.2.2.6 VARIATION IN THE *AVERAGE MMS SENDING SPEED INDICATOR* ALONG THE DAY



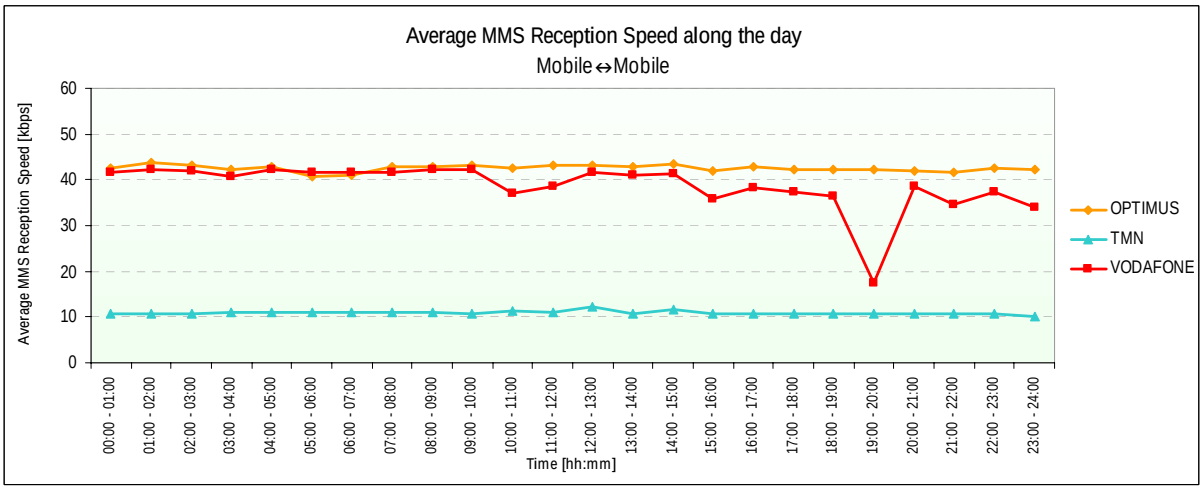
4.2.2.7 *MMS RECEPTION SPEED* INDICATOR



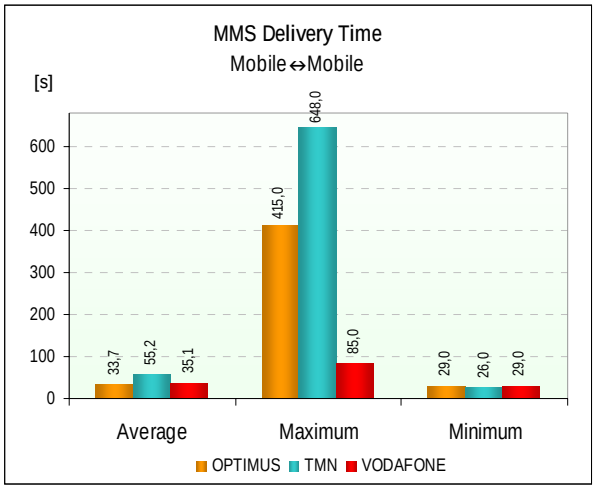
4.2.2.8 PROBABILITY DENSITY FUNCTION OF THE *MMS RECEPTION SPEED* INDICATOR



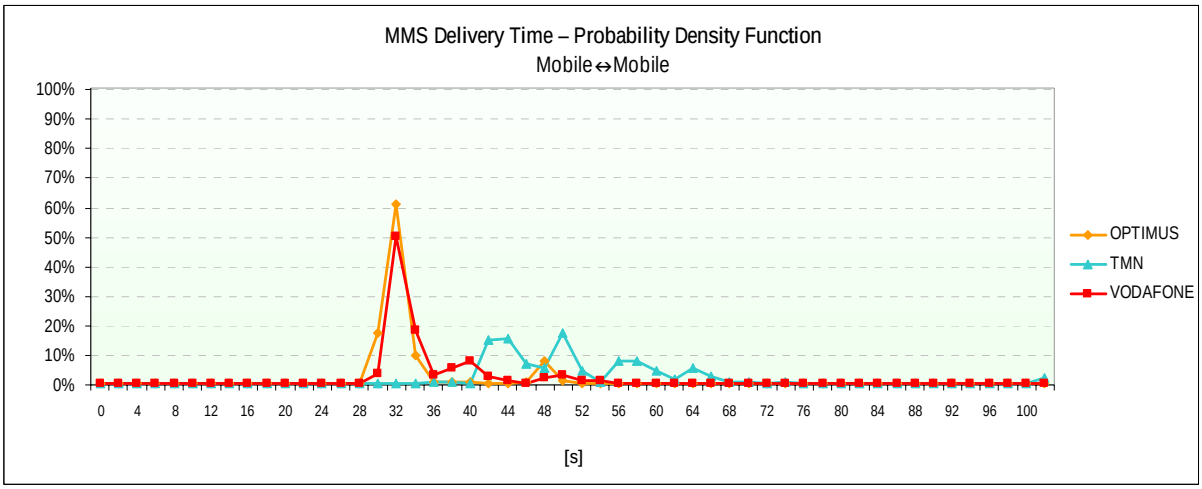
4.2.2.9 VARIATION IN THE *AVERAGE MMS RECEPTION SPEED* INDICATOR ALONG THE DAY



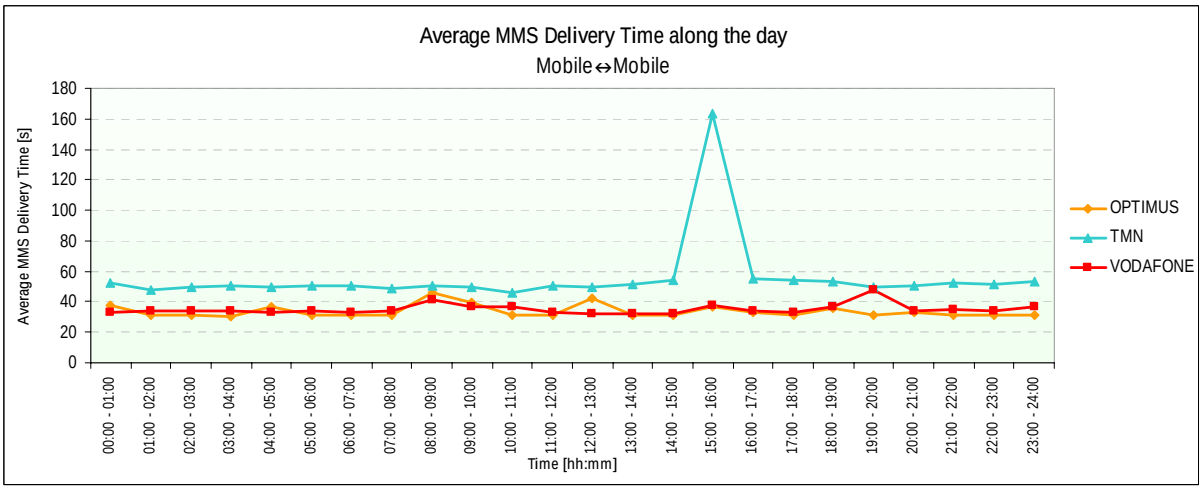
4.2.2.10 *MMS DELIVERY TIME* INDICATOR



4.2.2.11 PROBABILITY DENSITY FUNCTION OF THE *MMS DELIVERY TIME* INDICATOR



4.2.2.12 VARIATION IN THE *AVERAGE MMS DELIVERY TIME* INDICATOR ALONG THE DAY



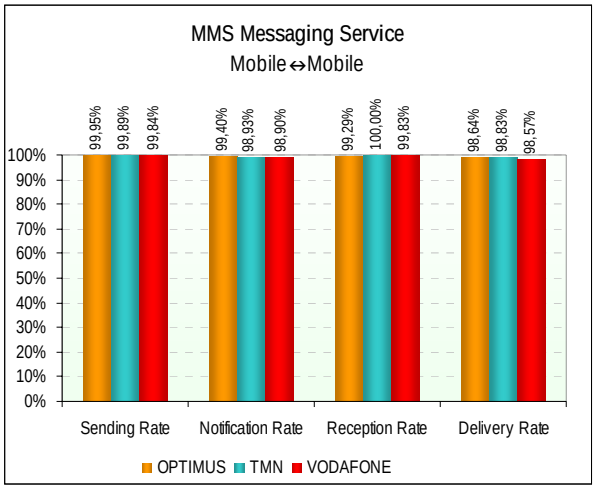
4.2.3 GLOBAL

		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
MMS Messages	Sending Attempts	1.840	1.877	1.822
	Successfully Sent	1.839	1.875	1.819
	Notification Received by the Receiver	1.828	1.855	1.799
	Successfully Received	1.815	1.855	1.796
	Sending Rate	99,95%	99,89%	99,84%
	Notification Rate	99,40%	98,93%	98,90%
	Reception Rate	99,29%	100,00%	99,83%
	Delivery Rate	98,64%	98,83%	98,57%
	Average Sending Speed [kbps]	43,4	44,9	31,6
	Maximum Sending Speed [kbps]	47,3	46,5	33,1
	Minimum Sending Speed [kbps]	9,3	19,3	5,0
	Standard Deviation [kbps]	3,3	3,2	1,7
	Average Reception Speed [kbps]	43,1	10,9	39,0
	Maximum Reception Speed [kbps]	46,0	48,3	44,2
	Minimum Reception Speed [kbps]	20,0	3,9	2,4
	Standard Deviation [kbps]	2,1	2,1	7,9
	Average Delivery Time [s]	34,4	53,4	35,2
	Maximum Delivery Time [s]	565,0	648,0	110,0
	Minimum Delivery Time [s]	27,0	26,0	27,0
	Standard Deviation [s]	23,7	27,6	6,8

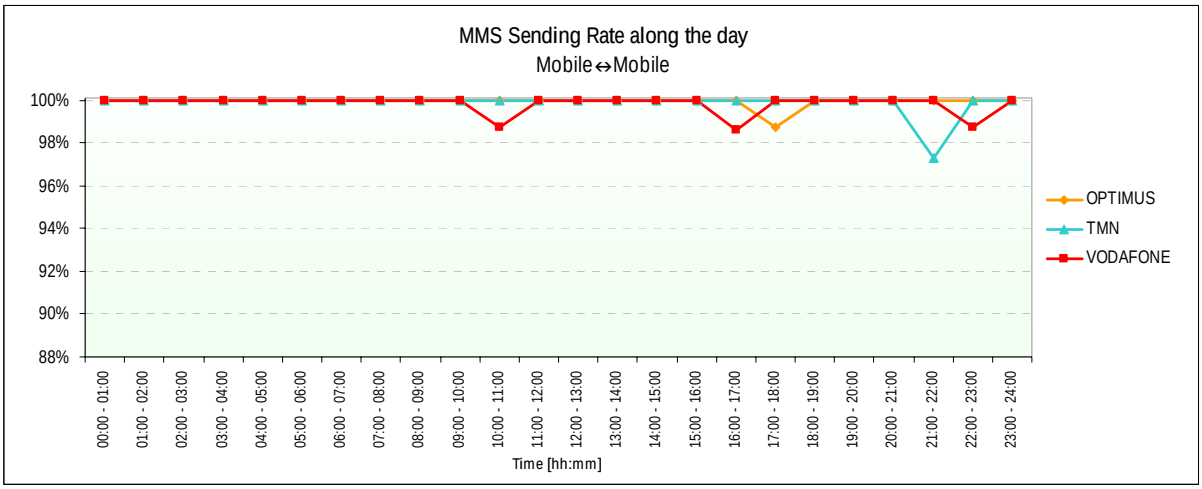
		OPTIMUS	TMN	VODAFONE
		Mobile↔Mobile	Mobile↔Mobile	Mobile↔Mobile
Precision Error	MMS Sending Rate	0,2%	0,3%	0,3%
	MMS Notification Rate	0,5%	0,6%	0,6%
	MMS Reception Rate	0,5%	0,0%	0,3%
	MMS Delivery Rate	0,6%	0,6%	0,7%
	MMS Sending Speed [kbps]	0,2	0,1	0,1
	MMS Reception Speed [kbps]	0,1	0,1	0,4
	MMS Delivery Time [s]	1,088	1,258	0,315

Confidence Level = 95 %

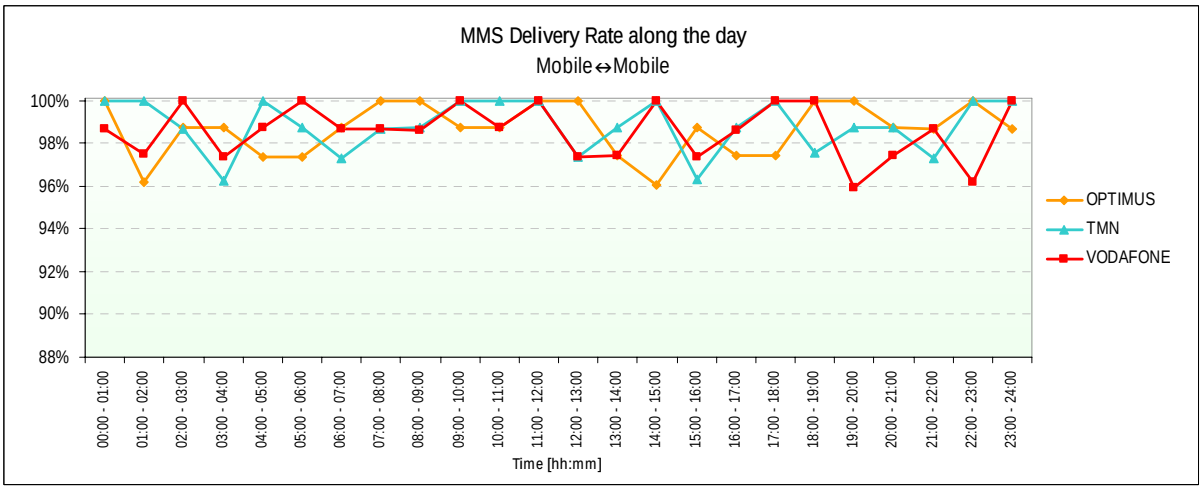
4.2.3.1 *MMS SENDING RATE, NOTIFICATION, RECEPTION AND DELIVERY* INDICATORS



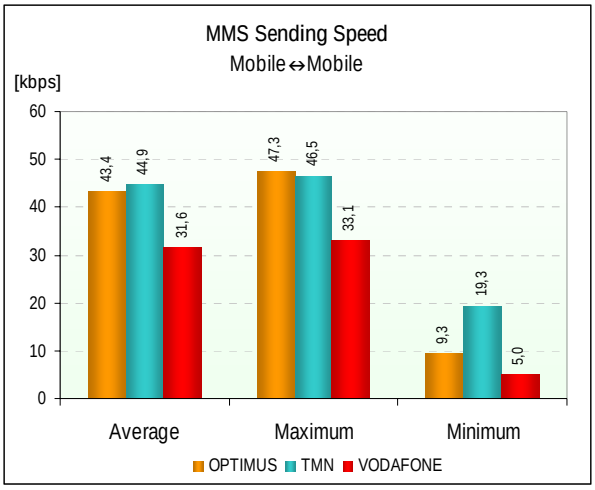
4.2.3.2 VARIATION IN THE *MMS SENDING RATE* INDICATOR ALONG THE DAY



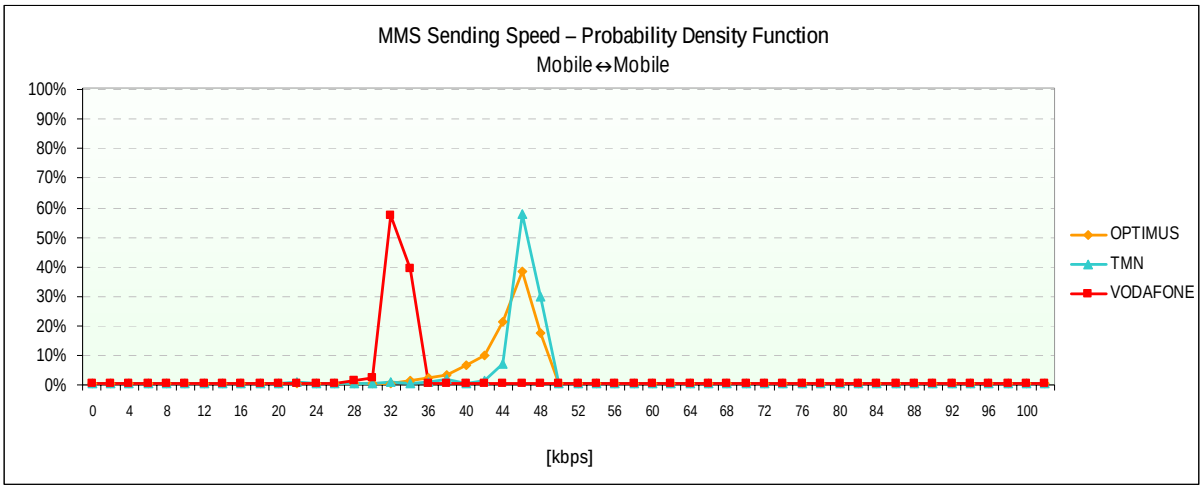
4.2.3.3 VARIATION IN THE *MMS DELIVERY RATE* ALONG THE DAY



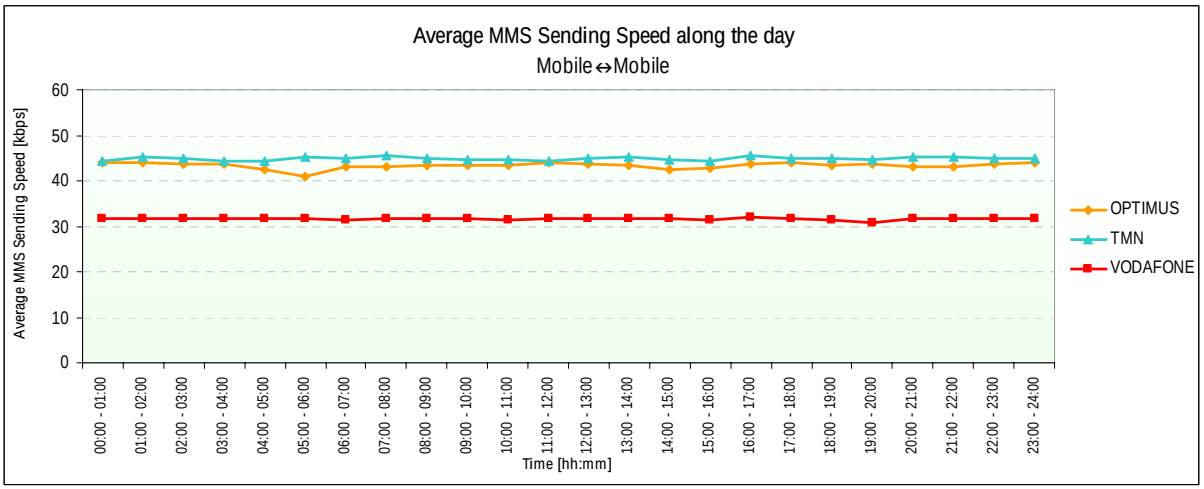
4.2.3.4 *MMS SENDING SPEED* INDICATOR



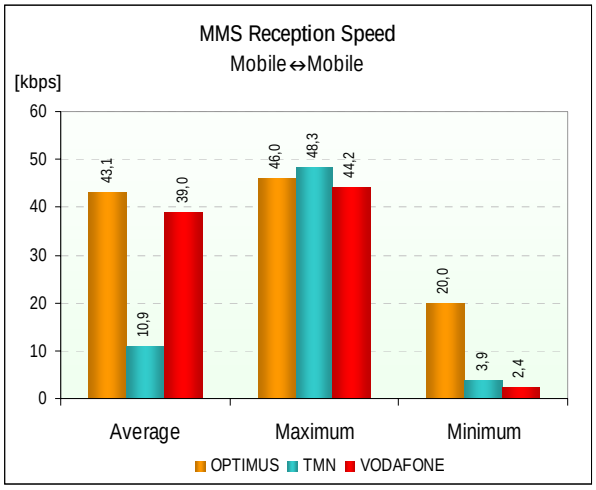
4.2.3.5 PROBABILITY DENSITY FUNCTION OF THE *MMS SENDING SPEED* INDICATOR



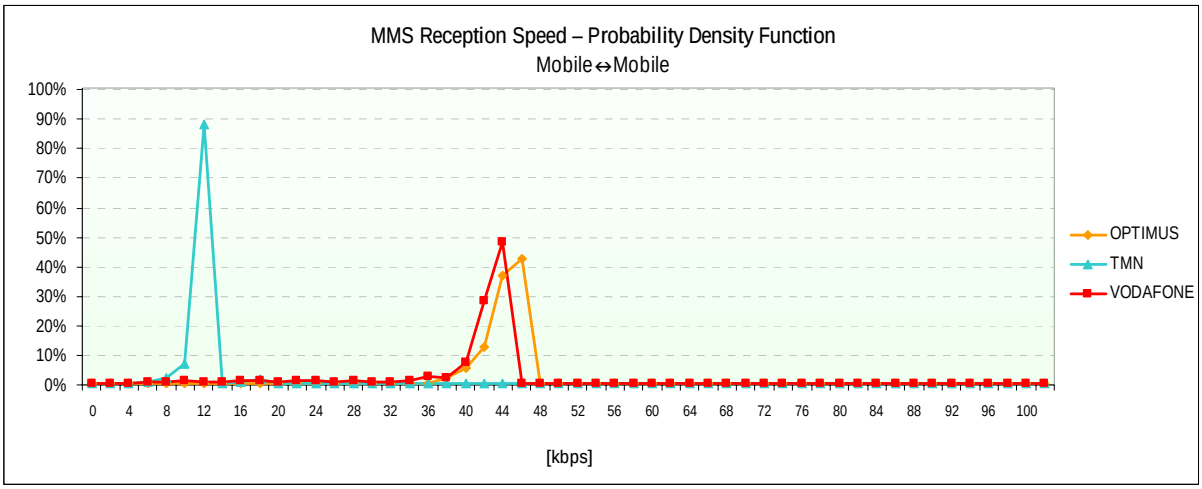
4.2.3.6 VARIATION IN THE *AVERAGE MMS SENDING SPEED* INDICATOR ALONG THE DAY



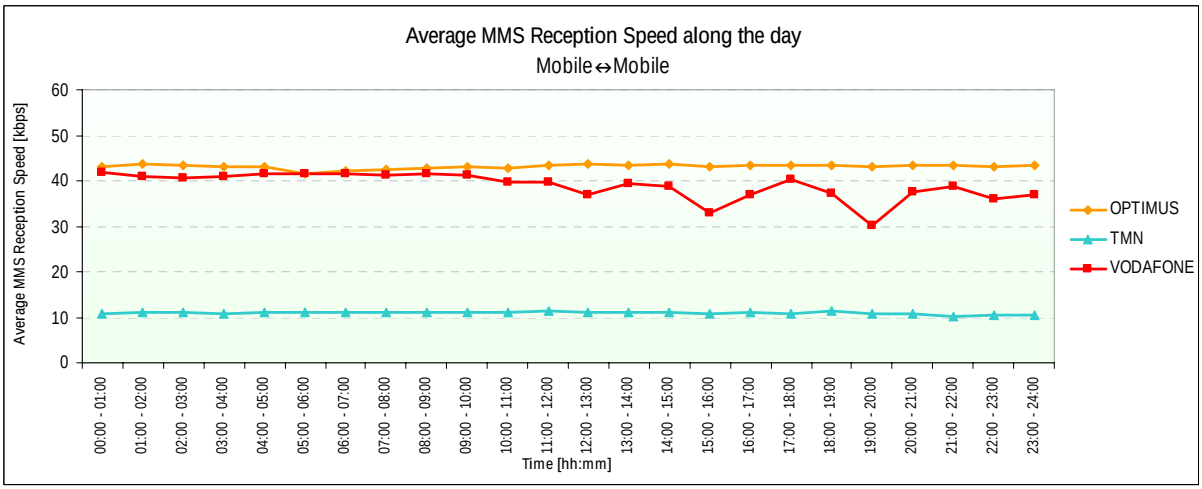
4.2.3.7 *MMS RECEPTION SPEED* INDICATOR



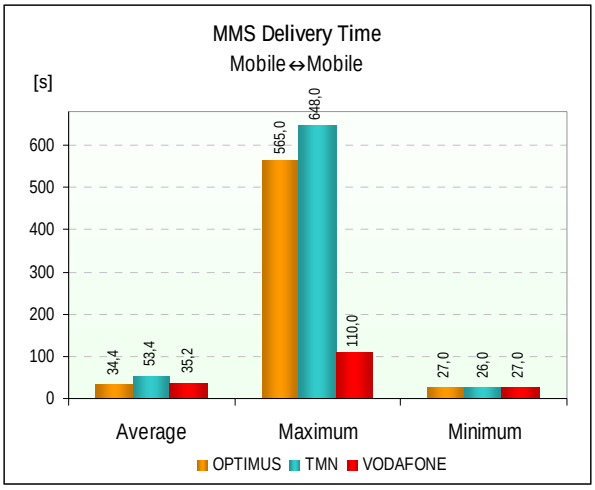
4.2.3.8 PROBABILITY DENSITY FUNCTION OF THE *MMS RECEPTION SPEED* INDICATOR



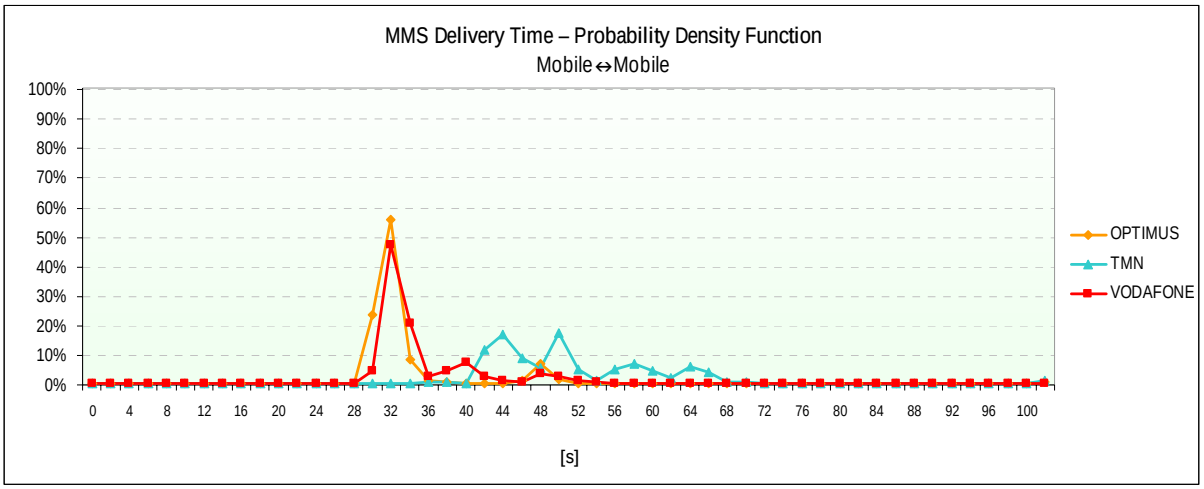
4.2.3.9 VARIATION IN THE *AVERAGE MMS RECEPTION* SPEED ALONG THE DAY



4.2.3.10 *MMS DELIVERY TIME* INDICATOR



4.2.3.11 PROBABILITY DENSITY FUNCTION OF THE *MMS DELIVERY TIME* INDICATOR



4.2.3.12 VARIATION IN THE *AVERAGE MMS DELIVERY TIME* INDICATOR ALONG THE DAY