WiMAX™ data throughput measurements with the R&S®CMW 270

The R&S®CMW 270 not only allows the theoretical data rates on a WiMAX™ air interface to be measured, but it also makes it possible to perform any kind of data throughput measurement. This includes, for example, testing of an application – using the R&S®CMW 270 as a WiMAX™ base station emulator – and inspection of individual wireless modules in development and production.

Data throughput – a term with several definitions

Ask several experts what the highest possible data throughput is for a wireless broadband interface, such as a WiMAX™ air interface, and you will probably receive different answers that are, nevertheless, correct. This is because there are different ways to define data throughput. For example, users who pay for a commercial broadband network are only interested in the application-specific payload data rate, i.e. the data throughput available for "their" application. Developers of wireless modules are more interested in the data rate that can be achieved across the module as a function of the modulation or channel coding scheme, for instance. Consequently, it is always necessary to differentiate between an application-specific end-to-end (e2e) payload data rate (e.g. the throughput between FTP server and client) and the data rate that can be achieved across a specific (air) interface. The R&S®CMW 270 WiMAX™ communication tester enables all interested parties to perform the throughput measurements that are important for their requirements.

Data throughput via WiMAX™

Prior to testing the quality of a WiMAX™ wireless module implementation or evaluating an application's throughput on a WiMAX™ interface, it is necessary to determine the theoretical maximum data throughput that can be achieved with WiMAX™ and to establish the reference values in this way. This requires some insight into WiMAX™ transmission. The WiMAX™ wireless broadband interface transmits data with 2M QAM using CP-OFDM transmission [1] [2] in both directions. This means that the available transmission bandwidth is used by a defined number (N_{data}) of orthogonal data subcarriers. Each of these subcarriers transmits a modulation symbol of the order M, i.e. M bits. Therefore, the maximum instantaneous data rate R across the duration of a symbol (T_{symbol}) is as follows:

$$R = \frac{M \cdot N_{data}}{T_{symbol}}$$

FIG 1 shows the data rates calculated for a WiMAX™ air interface standardized in line with IEEE 802.16™ as a function of the nominal bandwidth (BW). However, these values do not

The R&S®CMW 270 WiMAX™ communication tester is the first real all-in-one solution for the cost-optimized mass production of WiMAX™ mobile stations. An article in NEWS 199/09 (pp. 21–23) described how to use this tester to perform extensive end-to-end performance tests.

BW (MHz)	N_{used}	T_{symbol} (µs)	QPSK (M = 2) (Mbit/s)	16QAM (M = 4) (Mbit/s)	64QAM (M = 6) (Mbit/s)
10	720	102.9	14	28	42
8.75	720	115.2	12.5	25	37.5
7	720	144	10	20	30
5	360	102.9	7	14	21
3.5	360	144	5	10	15

FIG 1 Maximum SISO instantaneous data rate in the PUSC mode with a CP ratio of 1/8 as a function of the nominal bandwidth (BW).

Radio frame structure

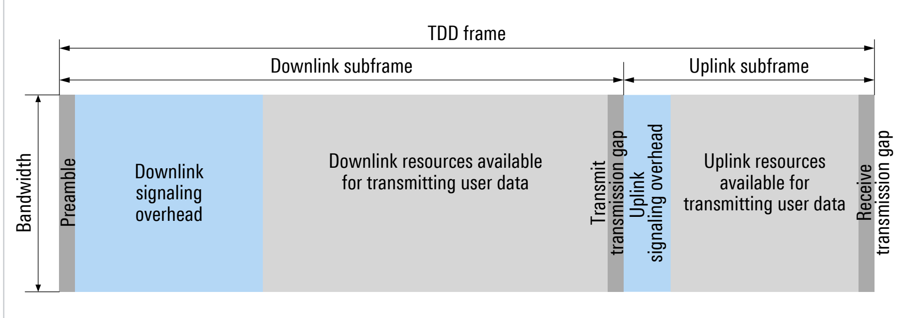

FIG 2 WiMAX™ radio frame structure in time division duplex.

SISO data throughput

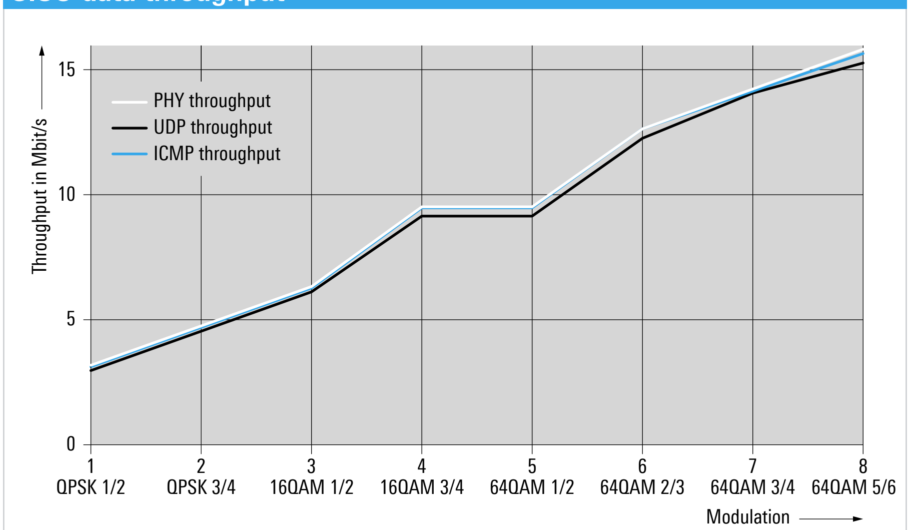

FIG 3 Results of a SISO data throughput measurement with the R&S®CMW270.

correspond to the maximum possible payload data rate. The payload data rate depends on numerous other parameters such as the channel coding rate and the duplex scheme. For instance, when a convolutional code with the coding rate 2/3 is used, the two bits at the input turn into three bits at the output. This means that channel coding alone increases the data rate by 50 %.

In addition, the duplex scheme employed has a significant influence on the data throughput. FIG 2 shows the basic structure of a WiMAX™ radio frame in time division duplex (TDD). The available resources are first divided between downlink and uplink. When the resources required for the reference signals (e.g. the preamble) and for general signaling (for instance, for transmitting system information) are subtracted, only a portion of the resources remains available per radio frame for transmitting payload data in both directions. The WiMAX Forum® defines the exact distribution of resources for the different bandwidths in the profile document [3].

FIG 3 shows an example of the maximum throughput on the physical layer (PHY throughput) determined with the aid of the R&S®CMW270 as a function of the modulation mode and the coding rate. The results are based on a channel with a nominal bandwidth of 10 MHz and a downlink signaling overhead (see FIG 2) of 12 OFDMA symbols. They show that the maximum PHY throughput of 15.84 Mbit/s is achieved with 64QAM and a coding rate of 5/6. This data rate could be increased further by reducing the downlink signaling overhead, but this is not possible in real-world networks. In the lab, however, this reduction is definitely of interest, and it can be accomplished with the R&S®CMW270. It is also possible to achieve a noticeable increase by employing space division multiplexing. In this way, a 2×2 antenna configuration (Matrix B MIMO [4]), for instance, can be used to double the data rates. An R&S®CMW270 with two channels is even able to implement this configuration without requiring additional T&M instruments.

Data throughput measurement

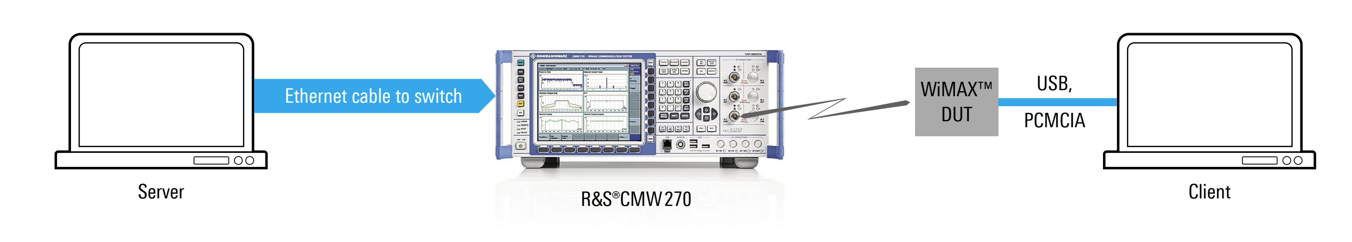

FIG 4 Test setup for data throughput measurements with the R&S®CMW270 WiMAX™ communication tester.

Data throughput measurements with the R&S®CMW270

FIG 4 shows the basic test setup for performing data throughput measurements with the R&S®CMW270. Here, the tester acts as a WiMAX™ base station emulator. An application – such as a UDP data stream or an FTP file transfer – is implemented using a server PC at the network end and a client PC at the WiMAX™ DUT end. The R&S®CMW270 routes the server data to the WiMAX™ air interface's downlink; the WiMAX™ DUT receives this data and forwards it to the application layer. In the case of UDP, a protocol for unidirectional connectionless data transmission without acknowledgement, the maximum data rates are obtained after deduction of the protocol overhead, as can be seen from the measurement results in FIG 3. The same holds true for throughput measurements at the ICMP level. Using a connection-oriented protocol with acknowledgements (such as TCP or FTP) reduces the payload data rate with decreasing packet size and increasing latency (round trip time).

Summary

The R&S®CMW270 WiMAX™ communication tester enables users not only to achieve the theoretical data rates on a WiMAX™ air interface, but also allows them to perform any type of data throughput measurement. This includes, for example, testing of an application – using the R&S®CMW270 as a WiMAX™ base station emulator – or inspection of individual wireless modules in development and production. All technical background information on this topic and additional details about WiMAX™ throughput measurements using the R&S®CMW270 are covered in detail in an application note [5] from Rohde&Schwarz. This application note is available for free download on the Rohde&Schwarz website.

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Abbreviations

BW	Bandwidth (nominal)
CP	Cyclic prefix
DUT	Device under test
FTP	File transfer protocol
ICMP	Internet control message protocol
MIMO	Multiple input multiple output (multiple transmit and receive antennas)
OFDM	Orthogonal frequency division multiplex
QAM	Quadrature amplitude modulation
QPSK	Quadrature phase shift keying
SISO	Single input single output (one transmit and one receive antenna)
TCP	Transfer control protocol
TDD	Time division duplex
UDP	User datagram protocol
WiMAX™	Worldwide interoperability for microwave access

References
[1] IEEE 802.16™ Revision 2, Draft 8.
[2] IEEE Communications Magazine, October 2008.
[3] WiMAX Forum® Mobile System Profile, Rel. 1.0 (Revision 1.7.0: 2008-09-18).
[4] Complete test solution for WiMAX™ applications. News from Rohde&Schwarz (2005) No. 187, pp. 33–37.
[5] Mobile WiMAX™ throughput measurements using the R&S®CMW270. Application Note 1SP10 (2009) from Rohde&Schwarz.

Additional literature about WiMAX™
– IP-based application testing on WiMAX™ mobile stations. News from Rohde&Schwarz (2009) No. 199, pp. 21–23.
– RC test systems ready for MIMO (in this issue).
– R&S®SMx signal generators / R&S®FSQ / FSL analyzers: WiMAX™ goes mobile – new T&M solutions are required. News from Rohde&Schwarz (2006) No. 190, pp. 24–27.
– R&S®TS8970 WiMAX™ radio conformance test system: Benchmark for the certification of WiMAX™ end products. News from Rohde&Schwarz (2006) No. 191, pp. 26–28.
– R&S®TS8970 WiMAX™ radio conformance test system: State-of-the-art – all WiMAX™ RF certification tests. News from Rohde&Schwarz (2007) No. 194, pp. 15–17.