Introduction

The purpose of this guide is to educate consumers on ways to improve their mobile internet speeds and offer an insight into how the mobile networks operate when it comes to data.

Mobile internet is growing rapidly due to low setup costs, decrease in price and the fact nearly everyone has access to it. We also live in a wireless world, where the demand for internet everywhere we go on our laptops, tablets and smart phones is a necessity.

However not everyone has access to the data speed they require. The main reason for slow internet speeds is low signal strength and within this guide we will show you how to maximize your signal, so you get the best possible internet speeds.
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Mobile Internet Technology

As the mobile evolution has evolved from 2G through to 4G, the technology to send data over the network has dramatically changed. This has resulted in higher data speeds, reduced response times and better coverage. These data protocols are what you can experience today:

GPRS & EDGE Data (2G)

GPRS is one the very first data protocols since the birth of the mobile networks. Several years later the GRPS towers were updated to EDGE, resulting in triple the data speeds. Both protocols did not support simultaneous voice and data, so when a voice call is received the data transmission is put on hold, then resumes once the call is hung up.

Peak Data Rates
GPRS – 115 kbps
EDGE – 384 kbps

Bandwidth
124 channels at 200KHz wide

Symbols on Phone

3G Data

With the next evolution, 3G Data opened up the world of wireless communication with increased data rates. Simultaneous voice and data was introduced, so you could be on a call and also access the internet. Also video streaming, video calling, fast internet browsing and sending files all became possible.

Peak Data Rates
3G – 384kbps

Bandwidth
5MHz wide

Symbols on Phone

HSPA Data

Often called 3.5 G, HSPA opens up increased browsing speeds, business applications, VOIP calls and more reliable video streaming. HSPA is currently the base for mobile data offering the best network coverage and is often the only mobile protocol for those in rural areas.

HSPA+ introduced antenna diversity, optimally combining two signals from separate receiving antennas.
Peak Data Rates
HSPA – 7.2 mbps
HSPA+ – 21 mbps
DC-HSPA+ – 42 mbps

Symbols on Phone

LTE Data

The latest and fastest data protocol available, with the initial release offering speeds of up to 100 mbps. LTE in Australia does not support voice yet, with your phone dropping back to 3G when you place or receive a call. LTE offers faster data speeds, less latency and reduced congestion on the network.

LTE utilises MIMO technology, with the modem having two antennas and two separate data streams back to the tower. This theoretically doubles the internet speed. To help in differentiating between the two streams, MIMO introduces slant polarisation, whereby one antenna is positioned on a 45 degree angle and the other at 135 degrees.

Recently LTE Advanced was introduced in some areas of Australia. In order to achieve such high speeds you must also increase the bandwidth over that provided by a single channel. Therefore carrier aggregation was introduced which allows the use of two channels on different frequency bands. Telstra for example plan to offer LTE Advanced using both 700 and 1800 MHz.

Peak Data Rates
LTE – 100 mbps
LTE-A – 200 mbps

Bandwidth
10-20 MHz wide

Symbols on Phone

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Mobile Internet Modems

There are many devices available that enable you to connect to the internet over the mobile networks. The most common ones can be found below.

Phones

Most smart phones offer the ability to share the internet connection and turn the phone into a WiFi hotspot. This enables you to share the internet connection with laptops, tablets and other phones using a WiFi connection.

Antenna Connection:

A limited number of phones have external antenna ports. Most of the Telstra branded phones have antenna ports on the back. Some Samsung phones are under the back cover. Patch leads are available for a direct connection to these ports. To get around this cradle style patch leads are available that transfer the signal using induction.

USB Sticks
One of the cheapest option for mobile internet access is via a USB style modem. Often they cost under $50 and can be used to provide internet access to a single computer. They can also be connected to a compatible WiFi router to share the connection.

**Antenna Connection:**

![USB Modem](image)

Nearly all USB modems have external antenna ports covered by a rubber plug. Some have dual antenna ports for MIMO or diversity.

**MiFi Hotspots**

![MiFi Hotspot](image)

Designed as a way to share mobile internet amongst multiple devices. The MiFi is basically a compact mobile hotspot for up to 10 devices and provides a WiFi signal in a small area.

**Antenna Connection:**

![MiFi Hotspot Antenna](image)

Nearly all MiFi Hotspots have external antenna ports. Most have dual antenna ports for MIMO or diversity.
Mobile Broadband Routers

Ideal for business or residential use, these are a wireless router that also connects to the mobile network. Multiple devices can be connected to the router using WiFi or an Ethernet cable. The 4G routers will support internet only, whilst some of the 3G routers have telephone ports for connecting a landline phone handset.

Antenna Connection:

Nearly every Mobile Broadband Router has an external antenna port. Most of the newer routers have dual antenna ports for MIMO or diversity. If the router has external stubby antennas these can usually be unscrewed to reveal the external antenna ports.

M2M Modems

M2M Modems are designed for industrial applications, providing a mobile internet connection for machines and other devices. These can include vending machines, water monitors, wireless cameras and electricity meters just to name a few.
They connect to the devices using WiFi, Serial or Ethernet cable.

**Antenna Connection:**

M2M modems all have external antenna ports, which are usually SMA on the back of the modem. This allows for direct connection to an external antenna without the need for patch leads.

**What Influences Internet Speeds**

There are a number of factors that can influence the internet speed that a user will experience, these are the main ones:

**Bandwidth**

Bandwidth is one of the set factors on the mobile network that caps your data speed. Bandwidth is the width or capacity of the channel, the wider the bandwidth the more data that can be transferred though and the more users the network can handle. As mobile networks have evolved we have seen bandwidth increase from 2 x 5MHz up to 2 x 20MHz channels. Bandwidth can vary between carrier and region of Australia you are in.

![Bandwidth Chart](chart)

**Latency**

Latency put simply is the time between when you click on a link and when the data is received back by the user. The lower the latency (measured in milliseconds) the better the network performance. 4G will typically have around half the latency of 3G. Recent tests on Australian networks had an average latency of around 150ms (HSPA+) and 80ms (LTE).

**Signal Strength & Quality**

The main cause of slow data speeds is low signal levels and poor signal quality. Low signal is usually caused by being too far away from the base station, or having obstructions blocking the signal. The speed drops due to limitations in power to push the data through. As a result the quality of the signal will drop and degradation of the data coming through will occur. MIMO can also be affected when the signal is low and the modem may switch off the auxiliary antenna.

**Backhaul**

The connection from the base station to the core network is also referred to as backhaul. If a base station experiences a large amount of traffic or data throughput and does not have a large enough pipe to send that back to the network, users will experience slower data speeds.
Network Congestion

The more users connected to a tower, the slower the data speeds will become. This is due to the bandwidth available on that tower and the backhaul capacity. Towers will also allocate their resources to serve those with the best signal and response times first. If a large number of users are close to the tower, those of the outer edge may not receive a data stream back from the tower.

MIMO & Diversity

You will notice many modems have two antenna ports, a main port (1) and an auxiliary port (2). You can connect two antennas to the modem to help improve data speeds.

HSPA+ utilises a diversity system, whereby using two antennas can be used on your modem to receive the signal. This system basically gives you two ears to listen instead of one. The incoming transmission is combined to provide a more reliable and better quality signal. Diversity antenna systems are recommended in areas where there is not clear line of site to the tower and the signal is bouncing to you from multiple angles.

LTE benefits greatly by having two antennas. LTE supports 2x2 MIMO (multiple input multiple output) which enables two separate streams of data to be sent and received at a time. Having two streams of data virtually doubles the data speeds. Two separate antennas must be used and to assist in separating the two streams, the first antenna is positioned on a 45 degree angle and the other on a 135 degree angle.

Preparing to Improve your Data Speeds

There are a number of things you need to do in order to prepare for the task of improving your data speeds.

Locate Your Nearest Tower & Frequency

Knowing the location of the nearest mobile base station or tower can be extremely useful in helping improving your signal. Knowing which way to point a directional antenna, which side of the building to mount an antenna, or which tree to trim can go a long way to getting the best possible signal.

Radio Frequency National Site Archive
The Australian Mobile Telecommunications Association (AMTA) is the peak industry body representing Australia’s mobile telecommunications industry. They also keep an up to date list of mobile base stations with information on the frequencies used by these sites.

**Step 1**

**Step 2**
Enter your address

**Step 3**
Tick the ‘Nearby Site’ checkbox

**Step 4**
Hover over the sites on the map to see the carriers using that site.

**Step 5**
To identify the frequency being used, click on the site and under reports, open the Environmental EME Report. This report will list the existing frequencies being used and may mention future plans.

### Measuring Signal Strength

The signal bars on your mobile device will offer a very basic interpretation of the mobile signal and also the signal quality. Each manufacturer calculates how many bars to display differently, resulting in different readings between phones in the same location. It is important to stress that signal bars do not always mean you can get data throughput. Users will sometimes have signal bars, but cannot access the internet due to network congestion.

The bars on your modem are a representation of both signal strength and the quality of the signal. As we have progressed from GSM, 3G and now 4G, the quality of the signal has become just as important as the signal strength level in determining your quality of service. Users with five bars may have a low signal strength reading, but have excellent signal quality.
Exact Signal Readings

The other way to measure signal is using exact readings from your modem. To access these readings you need either to put your phone into service mode or use the modem's web interface. There are several measurements that determine the quality of your mobile signal:

**Signal Strength – GSM & 3G/HSPA (RSSI)**
Applicable to GSM and 3G networks. The exact signal strength, often called Received Signal Strength Indication (RSSI), is measured in dBm. The dBm scale is roughly between -50 and -120dBm, with -50 being perfect signal and -120 being when you fall off the network. RSSI measures both the usable signal and the noise in a single figure.

-50 to -75 dBm – High Signal

-76 to -90 dBm – Medium Signal

-91 to -100 dBm – Low Signal

-101db to -120 dBm – Poor Signal

**Signal Strength – 4G/LTE (RSRP)**
LTE signal strength is measured on a different scale than 3G/HSPA, it is measured in Reference Signal Received Power (RSRP). This often ends up being around -20dBm lower than RSSI, so -100dBm (RSSI) would equate to around -120dbm (RSRP).

RSCP = RSSI + Ec/Io

RSRP does a much more accurate job of measuring signal strength than RSSI, as it excludes noise and interference on the network, measuring just the usable portion of the signal. Just because RSRP signals appear lower, it will not mean your signal is worse.

-75dBm and -88dBm is a strong signal

-89dBm and -96dBm is a very good signal

-97dBm and -105dBm is good

-106dBm and -112dBm is fair

-113dBm and -125dBm is poor

**Signal Quality**

**SNR**
The “Signal to Noise Ratio” is a measurement that compares the signal strength to the level of
background noise. The higher the SNR the better your signal quality will be. The SNR reading will be automatically calculated by the base station in dB. On the SNR scale 4 is poor and 25 is great.

**ASU**
"Arbitrary Strength Unit" is a value that is proportional to your RSRP. The higher the number the better your signal quality. ASU = RSRP + 140, so if you have a RSRP of -100dBm, then the ASU will be 40.

**Ec/Io**
Very similar to SNR above, this measurement is the ratio of signal to interference. With the best being around -10 and the worst quality being around -40.

**RSRQ**
Reference Signal Received Quality is the ratio of usable signal to noise and interference measured in dBm. RSRQ=RSRP-RSSI

**Phone Field Test, Service & Engineering Modes**

To access the exact readings you need to go into your phones field test mode or into the phones settings to get the current network status.

Field test mode is entered by typing a code into the phones keypad, with each phone model having it’s own unique code.

**iPhone**
dial *3001#12345#* into the keypad and press call.

**Android**
You can view the db reading by going into Settings > About Phone. For service mode enter *#0011# into the keypad.

**ZTE/Telstra Phones**
For service mode enter *983*3641# into the keypad. To exit service mode enter *983*3640#
Solutions for Improving Data Speeds

Antennas

The most common and cheapest way to improve your mobile signal is by using an external antenna connected to your mobile device. A majority of modems have an external antenna port, others may require a 'mobile patch lead' to connect an external antenna. For those smart phones without an external antenna port a cradle style patch lead is usually available to transfer the signal using induction.

Antennas come in all shapes and sizes, from vehicle whip style antennas, marine grade, vandal proof, desktop, wallmount, ceiling mount and even antennas shaped like lamp posts.

Antenna's can be divided into two categories:

i) Omni-Directional Antennas - These antennas will receive a signal from all directions and are often called a whip antenna. They are useful in situations where the mobile device is constantly moving such as on a vehicle, where the location of the nearest mobile tower is not known or when there is not a clear line of site to the tower and the signal is bouncing off nearby objects.

ii) Directional Antennas - As the name suggest these antennas are designed to receive a signal from a particular direction. Sometimes called a panel or yagi antenna, they are often much higher gain. They are ideal in low to medium signal areas where there is near line of site to the tower.

The gain of an antenna is its effectiveness in focusing radio frequency energy in a particular direction. The higher the gain the more focused the antenna is and the narrower the field of reception. Antenna gain is measured in dBi or dBd and the greater the gain the better your signal should usually be.
3G & GSM Modems – Single Antenna Setup

This type of modem will have a single external antenna port and usually support under 14.4mbps.

Setup is very simple and requires mounting one antenna pointed towards the tower or where signal is coming from.

HSPA+ Modems - Diversity Antenna Setup

To get the most speed out of your modem two antennas can be used, as long as your modem has two antenna ports. HSPA+ modems supporting 21mbps will have two antenna ports for antenna diversity.

Using two antennas gives a modem two ears to listen instead of one. The incoming transmission is combined to provide a more reliable and better quality signal.

Diversity really assists in areas where the signal is reflecting off trees, buildings or mountains and coming from multiple angles.

HSPA signals are vertically polarised, represented by an up and down wave pattern.

For effective diversity one antenna is positioned at 0° and the other at 90°.

LTE Modems - Diversity Antenna Setup

LTE benefits greatly by having two antennas. Two separate streams of data can be sent and received at a time. Having two streams of data virtually doubles the data speeds.

LTE signals are slant polarised, represented by a diagonal wave pattern.

In order to help separate the two data streams, antenna one needs to be mounted at 45 degrees and antenna two at 135 degrees.

MIMO is turned on and off by your modem. If the signal drops below a certain signal level MIMO is switched off.

If using multiple antennas is not an option, then you can still just connect one external antenna to main antenna port of your modem.
IMPORTANT
Some modems require diversity to be turned on or the external antenna port enabled in the web interface. Check with your modem user guide for further information.

Smart Repeaters

Smart Repeaters have built in smarts to help protect the mobile network. They amplify and then disburse a mobile signal in a defined area, but will also monitor the gain to ensure it is not overpowering or interfering with the external mobile network. A typical setup includes a window unit placed near a window inside the building, and an indoor unit to disburse the signal within the building.

Smart repeaters will generally have a 50-100dB gain signal amplifier, providing a 10-50m coverage area from the indoor unit. Multiple mobile devices and modems can then share the signal.

An external antenna can be connected to the Smart Repeater in areas where the signal is extremely low or there is no signal indoor at the window. Smart Repeaters on the market today do not support MIMO and external antennas directly connected to the modem can often offer the fastest data throughput.

The Cel-Fi Smart Repeater can be purchased from www.cel-fi.com.au
Further Information

If you require further information on increasing your mobile signal please visit our website at www.mobilenetworkguide.com.au or contact us at the address below.

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