

JANUARY 2007

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## Foreword

### Happy New Year!

IT's the beginning of a new year and I hope you have enjoyed X'mas and New Year !

Let us recap the major wireless events that took place over the past couple of months in Singapore and what we can expect in 2007.

As we know, Wireless@SG project was awarded to 3 wireless Internet Service Providers (SingTel, QMax and iCell) and the basic-tier connection is offered to us free for the first 3 years starting December last year.

What did not appear on the news headline is that StarHub is also offering their wireless hotspots free\*\* starting from January 2007 with the option to connect to Wireless@SG via QMax. In fact, StarHub is also offering free broadband (Maxonline FlexiSurf Plan) access to selected websites\*\*\*.


Other exciting events include the launch of Singapore first 3.5G network (HSDPA) by M1 in Dec 2006. On this network, M1 has provided another alternative to broadband service at a competitive speed and subscription rate to the existing broadband providers. Meanwhile, SingTel and StarHub are preparing to launch their 3.5G services later this year.

In line with the preparation for 3.5G and mobile broadband services, iDA (Singapore) has called for a Request for Proposal for vendor neutral ad-

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ministrator who will roll out true number portability for fixed-line and mobile phone in the fourth quarter this year. As competition among the providers intensifies and the playing field leveled, hopefully it will also bring about better customer services, especially after-sales.

Today, we are certainly closer to “Getting connected, Anytime, Anywhere”. Depending on your needs, if you are an Internet-lite user, you could choose to connect to Wireless@SG which provides free Internet connection and subscribe to broadband internet access at home for high speed access. If mobility and constant connectivity is of top priority, mobile broadband offers you island wide coverage with decent speed.

Once you have successfully connected to Internet, the next thing to do will be securing your home network. Unlike campus network, IT security for home network lies entirely on oneself and thus should not be an after-thought.

Last but not least, we would like to hear from you what topics you will like to see in future issues of the newsletter and look forward to hearing from you ([wireless@nie.edu.sg](mailto:wireless@nie.edu.sg)).

Pua Tee Wee  
Computer Services Centre

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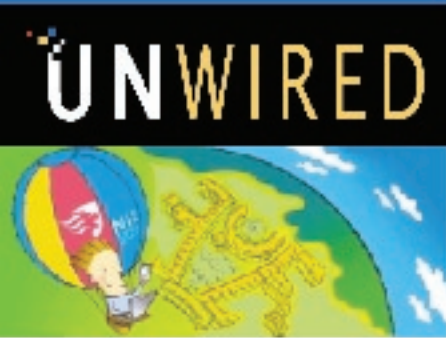
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\* Mobile broadband will be covered in the next issue of Unwired newsletter.

\*\* StarHub News Room @ Press Release 11 December 2006

\*\*\* StarHub News Room @ Press Release 01 February 2007





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### Featured Article

## Wireless is Here to Stay!

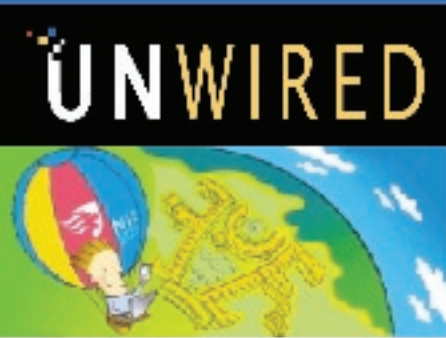
By Benny Lam & Low Chin Hong, Converscient Pte Ltd

Wireless technology has accelerated the way mobile computing has worked for us. A wireless internet connection is now a de-facto standard in all modern setups be it a classroom, office or fast-food restaurant to satisfy our wireless data hunger.

The internet is everywhere today. After years of being caged in homes, offices and learning institutions, the internet has broken loose of its chains and taken off into free air space. On the wings of wireless technology, the internet has soared to many places that we have not thought of.

Wireless internet is widely accessible in Singapore today, with more than 900 internet hotspots available for us to get connected. With a Wi-Fi enabled device such as a laptop, mobile phone or PDA, we are now able to surf the web in fast-food restaurants, cafes and even major shopping malls and places of interest. A simple log in, and we have our own cyber world on the go!

Left your computer at home? You still can access the internet via your mobile phone. On the GSM band, there is the GPRS, 3G, EDGE, UMTS and the upcoming HSDPA standards which grants you access to the internet practically anywhere within Singapore, and perhaps at anywhere in the world.



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With these technologies at hand, productivity and connectivity has gone beyond the desk for a lot of people. Emails, instant messaging and internet surfing are now available on the go. PDAs have evolved from the offline productivity tool to the powerful 3G telecommunication gadgets that are available nowadays.

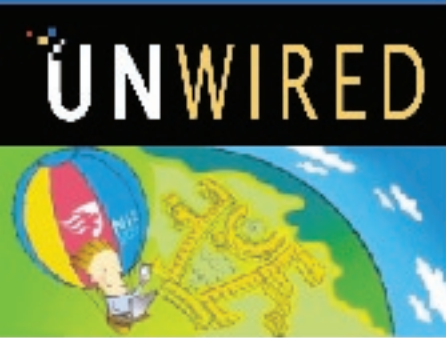
In this article, we will be exploring the new frontiers in technology for both wireless computing and mobile communications. We will also take a look at the Wireless@SG initiative by the Infocomm Development Authority (IDA) of Singapore to make the internet available out in the public.

## The Next Generation of Wi-Fi

The growing pervasiveness of Wi-Fi is helping to extend the technology beyond the PC and into consumer electronics applications like Internet telephony, music streaming, gaming, and even photo viewing and in-home video transmission. These new uses, as well as the growing number of conventional wireless users, increasingly combine to strain existing Wi-Fi networks.

In order to address this issue, the next generation Wi-Fi technology, 802.11n, promises trail-blazing bandwidth capacities, and blazing-fast speeds with the kind of stability and range that will let audio and video (even HDTV signals) cut through the air like butter.

802.11n is a new modulation technique that promises bandwidth up



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to 50 times faster than 802.11b, and up to 10 times faster than the 802.11g standards currently in use today. It makes use of MIMO technology, wireless communications systems which uses multiple transmitter and receiver antennas, to allow for increased data throughput through spatial multiplexing and allows sending of data in parallel with multiple antennas. 802.11n also promises a much longer range over the current standards. This allows us to roam a much longer distance providing more versatility for the mobile user.

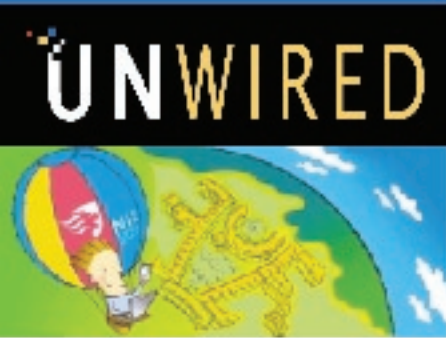
This standard is currently in development, and probably will not surface until mid 2007, so stay tuned, and prepare to surf wirelessly like never before!

## **The Next Generation in Telecommunications**

Mobile telephony allowed us to talk on the move. The internet turned raw data into helpful services that people found easy to use. Now, these two technologies are converging to create third generation mobile services.

In simple terms, third generation (3G) services combine high speed mobile access with Internet Protocol (IP)-based services. But this doesn't just mean fast mobile connection to the internet, it gives rise to whole new ways to communicate, access information, conduct business, learn and be entertained - liberated from slow, cumbersome equipment and immovable points of access.





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3G enables us to transmit voice, data, and even moving images at transmission speeds of up to 144Kbps in a high-speed moving environment, 384Kbps in a low-speed moving environment, and 2Mbps in a stationary environment. 3G has enabled and provides for services like Internet access, software downloading, transmission of emails, large-scale data and multimedia contents photographed by digital cameras and videos.

At present, maximum mobile data transmission speed in Singapore is 384Kbps, but this would all change with the introduction of High Speed Downlink Packet Access (HSDPA) technology in mid 2007.

High-Speed Downlink Packet Access (HSDPA) is a 3G mobile telephony protocol, an enhancement from the UMTS-based networks currently in use in 3G networks today. Current HSDPA deployments now support 1.8 Mbps or 3.6 Mbps in downlink. Further steps to 14.4 Mbps and beyond are planned for the near future. This means we can have broadband Internet access anywhere a cell phone signal is available!

Get your phones ready, it's time to surf!

### **What is Wireless@SG?**

Wireless@SG is the Government's wireless broadband programme that aims to extend broadband access beyond the homes, schools and offices, to public places. This programme is developed by IDA as part



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of its Next Generation National Infocomm Infrastructure initiative. It is currently run and developed by three local wireless operators - iCELL Network Pte Ltd, QMax Communications and Singapore Telecommunications.

Wireless@SG is available at public areas with high human traffic such as the Central Business District, downtown shopping belts like Orchard Road, and many other places across the nation. Users can access Wireless@SG services in major cafes, clubs, commercial buildings, community clubs, country clubs, fastfood outlets, food courts, hospitals, hotels, libraries, others, restaurants, retail outlets, schools, shopping centres, sports facilities, tourist attractions. Network coverage will be made available progressively from 1 December 2006 and by September 2007, the number of Wi-Fi hotspots in Singapore will increase by more than five-fold from 900 today to about 5,000. The ever-growing list of hotspots is available on the IDA's website.

The targeted users of this wireless broadband network are broadly classified as "people on the move" - people who require wireless broadband access while away from their homes, schools and offices. These include students, tourists, business travellers and enterprise users such as insurance agents and real estate agents who use widely-available and wireless-enabled devices such as notebook PCs and PDAs. Users can enjoy free, both in-door and outdoor seamless wireless broadband access with speeds of up to 512kbps at these hotspots. Once connected, users will be able to access all Internet-based services e.g. online gaming, web surfing, instant messaging, VoIP and email.

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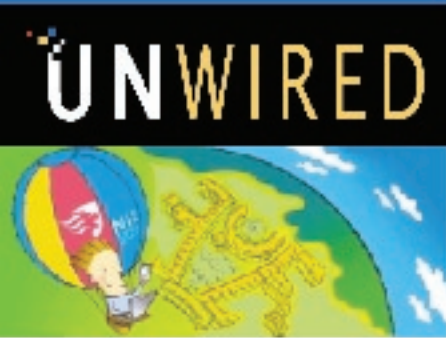
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To connect to the Wireless@SG wireless broadband network, a user just needs a WiFi-enabled device, a web browser, and a registered Wireless@SG account. With this registered account, the user is able to roam within any of Wireless@SG's coverage areas, regardless of the operators' network. New users can also register for new accounts at these hotspots.

In addition to the free "basic tier", there will be a paid "premium tier" for those hungry for bandwidth beyond 512 Kbps, or for connectivity options with higher-quality of service. The three operators have different packages to suit different needs and there is no limit on the number of premium accounts users can sign up for.

With this Wireless@SG in place, you'll never worry about being disconnected again!





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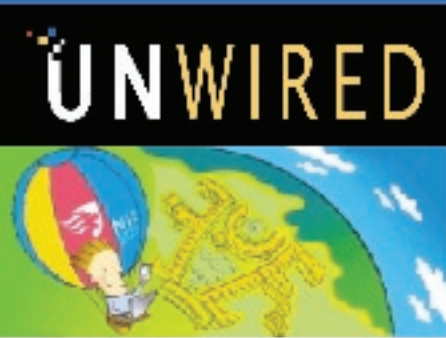
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## Technology

### Wifi Technology Updates, 802.11n: A practical guide

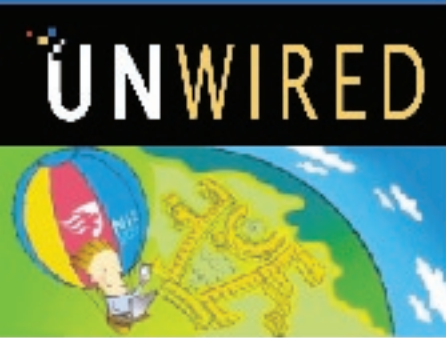
By Benny Lam, Converscient Pte Ltd

The next generation Wi-Fi Technology with trail-blazing bandwidth capacities, everyone wants it. Blazing-fast Wi-Fi speeds with the kind of stability and range that will let audio and video (even HDTV signals) cut through the air like butter. Is it real? Do we jump on the bandwagon?

Demand for wireless LAN hardware has experienced phenomenal growth during the past several years, evolving quickly from novelty into necessity. Thus far, demand has been driven primarily by users connecting notebook computers to networks at work and to the Internet at home as well as at coffee shops, airports, hotels, and other mobile gathering places. As a result, Wi-Fi technology is most commonly found in notebook computers and Internet access devices such as routers and DSL or cable modems. In fact, more than 90 percent of all notebook computers now ship with built-in WLAN.

### Do we need a faster network?

The growing pervasiveness of Wi-Fi is helping to extend the technology beyond the PC and into consumer electronics applications like Internet telephony, music streaming, gaming, and even photo viewing and in-home video transmission. Personal video recorders and other



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A/V storage appliances that collect content in one spot for enjoyment around the home are accelerating this trend.

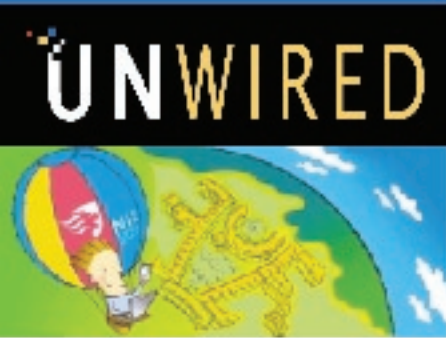
These new uses, as well as the growing number of conventional WLAN users, increasingly combine to strain existing Wi-Fi networks. Fortunately, a solution is close at hand. The industry has come to an agreement on the components that will make up 802.11n, a new WLAN standard that promises both higher data rates and increased reliability, and the Institute of Electrical and Electronics Engineers (IEEE) standards-setting body is ironing out the final details. Though the specification is not expected to be finalized before 2007, the draft is proving to be reasonably stable as it progresses through the formal IEEE review process.

### **Consumers and Enterprises Demand 802.11n**

Because it promises far greater bandwidth, better range, and reliability, 802.11n is advantageous in a variety of network configurations. And as emerging networked applications take hold in the home, a growing number of consumers will come to view 802.11n not just as an enhancement to their existing network, but as a necessity.

With most Internet connection speeds below 5 Mbit/s, it is unlikely that consumers who use WLAN technology simply to pair a single computer with an Internet connection are taxing their existing network, at least when used at close range. Some of the current and emerging applications that are driving the need for 802.11n are streaming video



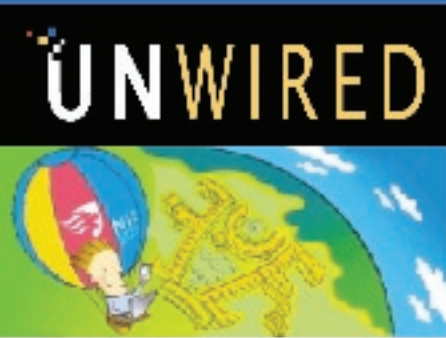


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and music, gaming, and network attached storage (NAS).

A growing application that demands all that 802.11n has to offer, i.e. high data rates as well as range and reliability, is NAS. NAS has become popular in the enterprise as an inexpensive, easy-to-install alternative for data backup. More recently, NAS is taking hold in small offices and even some homes, as users want to safeguard their growing digital photo albums from hard disk failure. New, more exciting applications for NAS are emerging, such as video storage centers that demand reliable, high-bandwidth connections to stream prerecorded TV shows, music videos and full-length feature films to televisions and computers throughout the house.

The enterprise may have the most to gain from the higher raw data rates that the 802.11n standard promises. Knowledge workers have grown accustomed to the benefits of WLANs in the office. They can carry their notebooks to conference rooms, coworkers' desks, even break areas, and still have access to e-mail, instant messaging, and the Internet, as well as corporate data. But some everyday applications such as transferring large files from a group server, accessing corporate databases, and system backups, can be painstakingly slow on a 54 Mbit/s WLAN. For such high-traffic applications, many otherwise un-tethered workers anchor their computers to an Ethernet cable, which connects to the network at 100 Mbit/s or even 1 Gbit/s. With 802.11n hardware, users can have the best of both worlds: the speed of wired Ethernet and the mobility of WLAN.



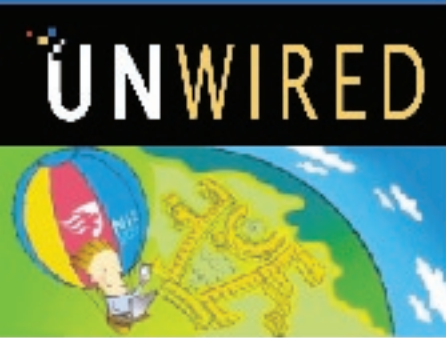
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## What is IEEE 802.11?

IEEE 802.11, the Wi-Fi standard, denotes a set of Wireless LAN/WLAN standards developed by working group 11 of the IEEE LAN/MAN Standards Committee. The current 802.11 family includes six over-the-air modulation techniques that all use the same protocol. The most popular (and prolific) techniques are those defined by the b, a, and g amendments to the original standard. Security was originally included and was later enhanced via the 802.11i amendment. 802.11n is another modulation technique that has recently been developed. 802.11b was the first widely accepted wireless networking standard, followed (somewhat counter-intuitively) by 802.11a and 802.11g.

802.11b and 802.11g standards use the 2.4 gigahertz (GHz) band. Because of this choice of frequency band, 802.11b and 802.11g equipment can incur interference from microwave ovens, cordless telephones, Bluetooth devices, and other appliances using this same band. The 802.11a standard uses the 5 GHz band, and is therefore not affected by products operating on the 2.4 GHz band.

Protocol	Release Date	Operating Frequency	Typical Data Rate	Maximum Data Rate	Range (Indoor)
Legacy	1997	2.4 GHz	1 Mbit/s	2 Mbit/s	
802.11b	1999	2.4 GHz	6.5 Mbit/s	11 Mbit/s	100 metres
802.11a	1999	5 GHz	25 Mbit/s	54 Mbit/s	50 metres
802.11g	2003	2.4 GHz	25 Mbit/s	54 Mbit/s	100 metres
802.11n	Mid-2007	2.4 GHz or 5 GHz	200 Mbit/s	540 Mbit/s	250 metres



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## What is 802.11n?

802.11n is a new modulation technique that promises bandwidth up to 50 times faster than 802.11b, and up to 10 times faster than 802.11a or 802.11g. It can also make use of MIMO technology (MIMO refers to wireless communication systems using multiple antennas at both the transmitter and receiver).

## So what does 802.11n do for me?

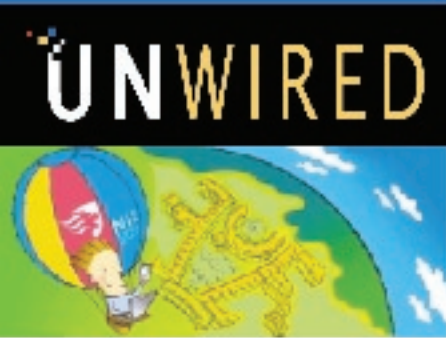
802.11n would mean that wireless would be faster and have longer range for the consumer user. Well that's cool but for a pragmatic consumer user the following criteria would be of concern before one would jump on the bandwagon

- ☐ Bandwidth
- ☐ Range
- ☐ Security
- ☐ Hardware
- ☐ Software
- ☐ Health concern

Let us look through the following in turn.

- ☐ **Bandwidth** - 802.11n promises much faster bandwidth for higher value real-time applications such as video streaming or

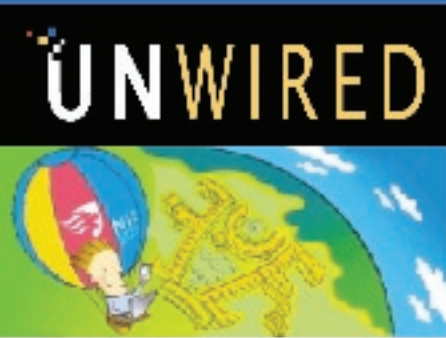




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video conferencing

- ☐ **Range** - 802.11n promises much longer range so that a single client computer can roam a much longer distance providing more versatility for the mobile user
- ☐ **Security** - 802.11n standard does not dictate the security standards but however since March 2006, WPA2 support is mandatory for all products wishing to be Wi-Fi CERTIFIED. It is important to check for Wi-Fi certification in any product that you buy.
- ☐ **Hardware** - 802.11n should be readily available in forms of 802.11bgn equipment as all of these utilize the 2.4 Ghz band. New hardware needs to be purchased for 802.11n. 802.11n add-on hardware is expected to be pricey in the initial launch but as more players come into the fray, it would bring the price to an affordable level. Intel has plans to in build 802.11n into its Centrino technology, which is good news for many laptop users (however this can only be firmed when the 802.11n standard is firmed)
- ☐ **Software** - New drivers needs to be utilized for 802.11n as with each new version of wireless standard
- ☐ **Health** - There are conducted measurements in schools, typical exposures from wi-fi are around 20 millionths of the international guideline levels of exposure to radiation. As a comparison, a child on a mobile phone receives up to 50 per



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cent of guideline levels. So a year sitting in a classroom near a wireless network is roughly equivalent to 20 minutes on a mobile. If wi-fi should be taken out of schools, then the mobile phone network should be shut down, too—and FM radio and TV, as the strength of their signals is similar to that from wi-fi in classrooms. So wifi should be still rather safe for our health concerns.

### Is 802.11 final?

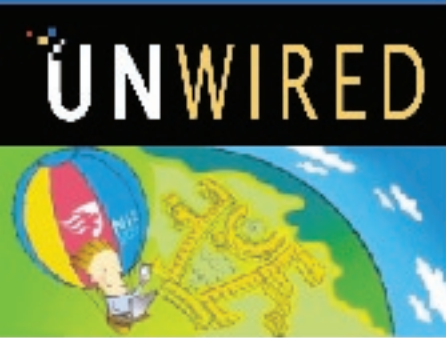
According to the IEEE 802.11 Working Group Project Timelines, the 802.11n standard is not due for final approval until April 2008.

So are the 802.11n products in the market usable?

What you see in the market now are implemented with draft version of 802.11n, they are probably usable but would not guarantee inter-operability with 802.11b and 802.11g equipment. The final standard would only be approved in 2008, the equipment would take a while longer.

Conclusion

When 802.11n becomes a reality, today's pre-N MIMO solutions most probably will not be fully compatible with the gear based on the ratified specifications. For this reason, it is advisable to wait for the ratified standard than to start building your network with non-standard gear. Scalability and interoperability problems can come back to haunt you down the road when you start adding newer standard-compliant equipment.



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With fast speeds, long range, and strong resistance to interference, 802.11n gear may finally deliver on the promise of home entertainment networking.

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## TECHNOLOGY

### WiMax, The Emerging Technology?

By Ang Choon Gei, Computer Services Centre

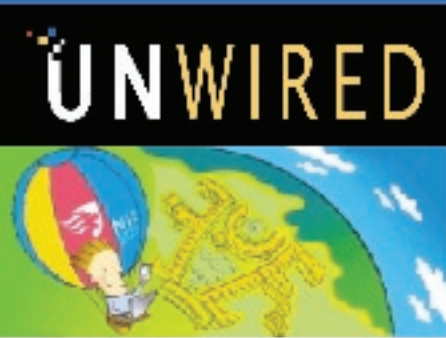
Singapore is going to enjoy the wireless broadband technology in most areas. This is free for 2 years. But this is a Wi-Fi technology.

Korean is always the frontrunner in the broadband technology. In the year 2002, Korean government allowed 100MHz spectrum of 2.3 Ghz. After that, WiBro was developed by Korean telecommunication companies. In 2005, the WiBro was adopted to be the standard for the IEEE 802.16d. Currently, the WiBro is capable of downloading speed of 2-3Mbps with traveling speed of 120km/h. By 2007, the WiBro service is going to be WiMax Forum certified with IEEE 802.16e. In addition, the WiBro is expected to have download speed of 100Mbps.

On 11 October 2006, the Intel press release had brought excitement to the broadband user. The Intel is going to ship the new Next Generation WiMax Chip with Mobile Networks Support.

*"Intel is bringing its first mobile WiMAX compliant product to market, marking an incredibly important step in the launch of mobile WiMAX," said Maloney. "The first with dual mode support, the new chip bridges the worlds of fixed and mobile WiMAX, helping equipment manufacturers build customer premise equipment at increasingly attractive price points, and service providers to break ground on upgradeable networks."*

Source: <http://www.intel.com/pressroom/archive/releases/20061011comp.htm>



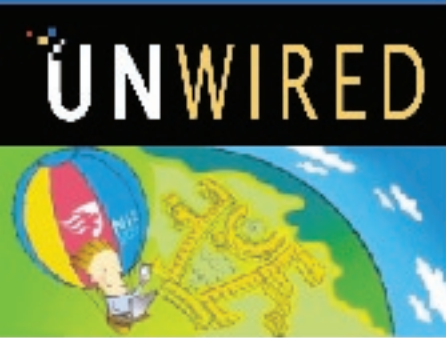
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The Intel WiMax Connection 2250 is able to support all the global WiMax frequency and it is expected to deliver the chip in year 2007. The Intel WiMax Connection 2250 is going to support both IEEE 802.16-2004(d) for fixed WiMax standard and IEEE 802.16-2005(e) for fixed, nomadic and mobile WiMax standard.

On the other hand, Singaporean may have access to the Wireless Metropolitan Area Network as early as year 2007.

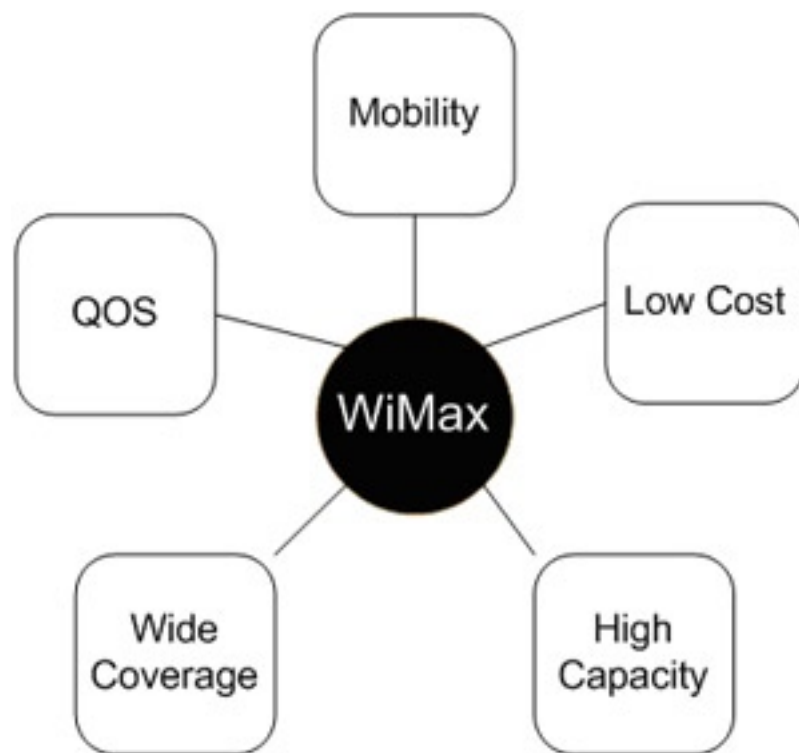
### **What is WiMax?**

WiMax is defined as the Worldwide Interoperability for Microwave Access. It is based on the IEEE 802.16 standard (Reference URL: <http://www.ieee802.org/16/>). It is a wireless broadband technology, an alternative to the wired broadband technology such as cable and DSL.



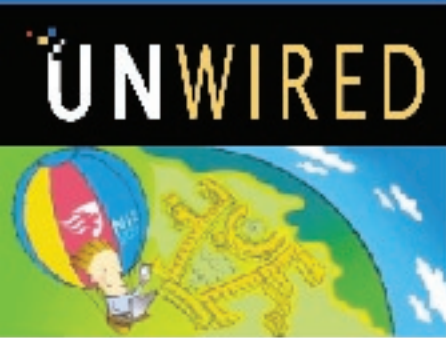
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There are many objectives for the WiMax as shown below:



With the objectives in place, the application for the WiMax can be as follows:

1. **Real Time Application**
  - ☐ Online Gaming
  - ☐ Video conference
  - ☐ Voice over IP
  - ☐ Video streaming



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## 2. Non-Real Time Application

- ☐ Email
- ☐ Web Browsing
- ☐ Instant Messaging
- ☐ Peer to Peer Data Sharing; Upload and download

In year 2007, PDA and notebook are expected to have WiMax certified chipset. Only “WiMax Forum Certified” (and not “WiMax Ready”, “802.16e compliant” or etc) equipment is compliant and it is interoperable with the other “WiMax Forum Certified” equipment.

It is a complex process to certify a vendor product. There is an requirement for the vendor product to be interoperable with their competitor product. The Wi-Fi Alliance has been successful in their certification program as the certified product is capable of interoperability. The WiMax Forum is no exception and it is taking similar route. The certification program is done in phases by adding new profile and functionality. The WiMax product is tested for compliance and interoperability before it is certified.

## WiFi or WiMax?

WiFi and WiMax are not competing technology. In fact, they complement each other. WiFi and WiMax are classified as Wireless LAN (Local Area Network) and Wireless MAN (Metropolitan Area Network). They can co-exist in your PDA or your notebook. The Bluetooth is con-





sidered as the Personal Area Network (PAN).

Type of Network	Standards	Distance	Speed	Remarks
MAN	IEEE 802.16-2004(d) or IEEE 802.16-2005(e)	50 km	40 Mbps-50 Mbps	
LAN	IEEE 802.11(a/b/g)*	150 m	11 Mbps or 54 Mbps	Local Wireless
PAN	IEEE 802.15.1	1 m, 10 m or 100 m**	736 kbps, 1 Mbps or 3 Mbps	Bluetooth

\*- IEEE 802.11n is the new standard with 108Mbps wef

\*\* - Class 1=100m, Class 2=10m and Class 3=1m

With WiMax technology, it is going to be wireless broadband on the move as the coverage area is sufficient for the whole island.

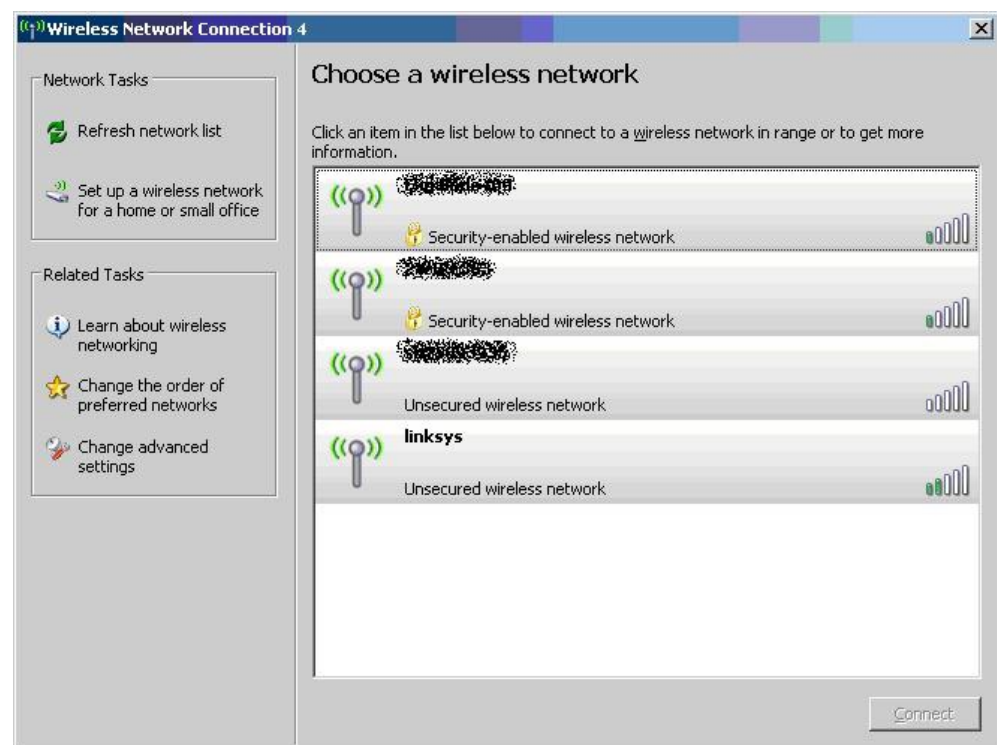


## Security

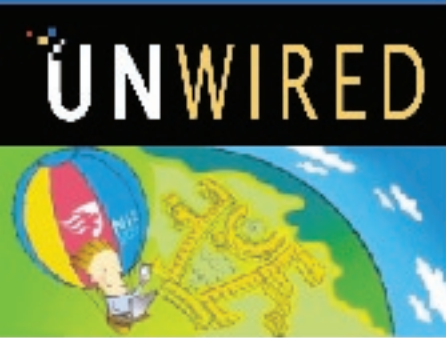
### How to secure your Home Wireless LAN?

By Ang Choon Gei, Computer Services Centre

When you turn on your wireless devices such as a PDA or Notebook at home, you may notice several unsecured wireless network access around at your neighbourhood. You may be tempted to connect to one of these free wireless networks as shown below.



Please do **NOT** make any attempts to connect to your neighbour's wireless network without proper authorization. If found guilty, you may face up to 3 years jail or fines of up to \$10,000 or both under the



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Section 6(1)(a) of the Computer Misuse Act. Last year, a polytechnic student was charged in court under Computer Misuse Act. He pleaded guilty and admitted the offence.

Another reason for not connecting to an unknown wireless network is that it may offer 'information' to an untrusted network owner. Unencrypted information that you send over the unsecured network may be sniffed by the untrusted network owner. Your surfing pattern then becomes known to the untrusted network owner.

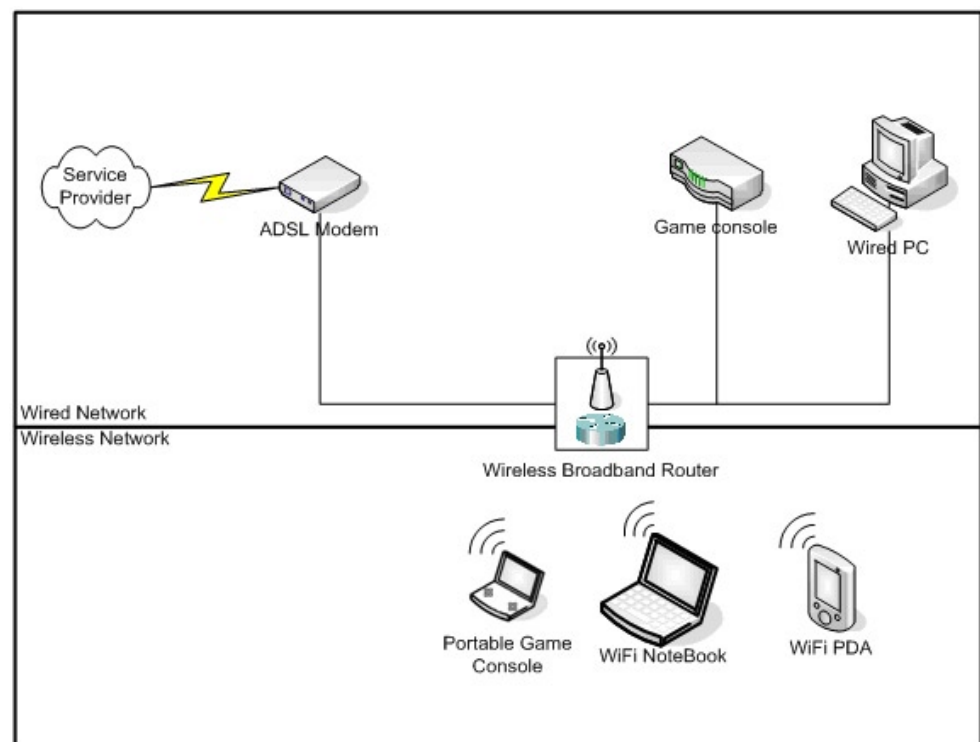
On some occasions, your PC may be compromised if it does not have adequate security measures in place. Most of the time, a wired network is considered more secure than a wireless network. The former has the cable runs within your home which is not accessible by the public whereas a wireless network is accessible by the public if it is not configured securely.

If you need mobile computing in your home, setting up a wireless setup network is not difficult. Wireless security needs to be addressed to protect your data.

IT security believes in the defense-in-depth concept. What does this mean to us? In layman terms, the strategy of defense-in-depth deploys many different layers of security measure within the entire IT infrastructure. In this context, the home wireless network comprises the Wireless Router or Access Point, the Wireless Transport, the wired node (eg. Client PC) and wireless node (eg. WiFi Notebook). These are the recommended guidelines for the home wireless infrastructure.

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A typical home wireless infrastructure is shown below.

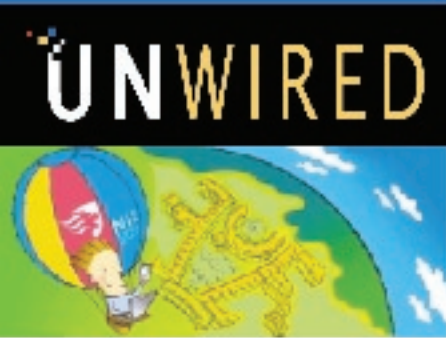


## Wireless Router/Access Point

In Wireless Router/Access Point, the default setting must be changed.  
The following :

1. **Administrator Password**  
Change the administrator default password





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[www.microsoft.com/athome/security/privacy/password.msp](http://www.microsoft.com/athome/security/privacy/password.msp)

2. **Login Page Access**

Change the Login Page Access to https

3. **Unused Wireless network**

Turn off the wireless network in the Wireless Router/Access Point if it is not in used

## Wireless Transport

In a typical wireless network setup, there are 6 parameters configured to enhance the wireless security. The guidelines are as follows:

1. **SSID**

Configure the SSID in the Router/Access Point to be non-broadcast

2. **Network MAC Address**

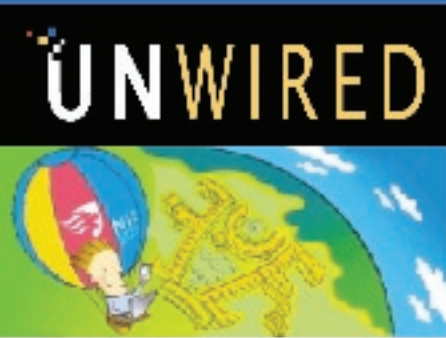
Configure the permitted client MAC Address in the Router/Access Point

3. **Network Authentication**

Configure the Router/Access Point and Client PC to WPA

4. **Data Encryption**

Configure the Router/Access Point and Client PC to AES  
<http://www.microsoft.com/technet/community/columns/>



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[cableguy/cg0604.msp](http://cableguy/cg0604.msp)

5. **Network Key**

Configure the Network Key in the both Router/Access Point and Client PC

Use strong network key in alpha-symbolic-numeric key to the maximum key size

6. **Power Transmission**

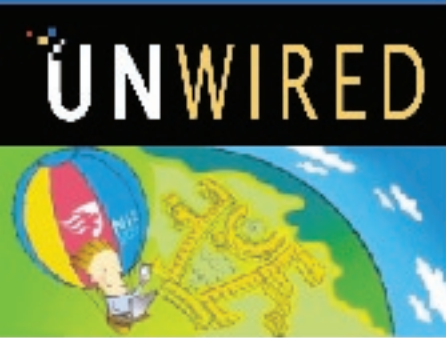
Configure the power of the Wireless Router/Access Point to be sufficient without extending out to the public area

## Wired Node and Wireless Node

To have a secured Wired Node or Wireless Node, the following security products are recommended but not limited to:

1. Anti-Virus Software with latest update of engine and signature
2. Anti-Spyware Software with latest update of engine and signature
3. Personal Firewall Software with latest update of engine and signature
4. Regular update of OS patch and software patch

As of today, the game console security is applicable to item 4 and the



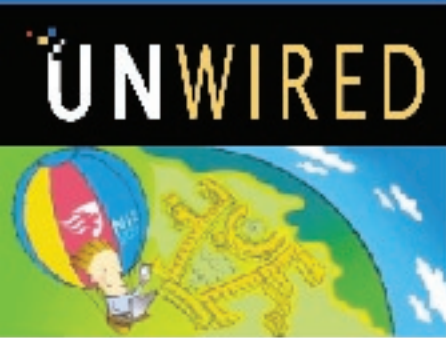
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PDA is applicable to item 1, 3 and 4.

Please note the above-mentioned must be properly configured to be effective.

For most freeware or shareware, the Anti-virus software and Anti-spyware software scanning are on demand. It does not scan the files in real time. It is recommended the Anti-virus software and Anti-spyware software is capable of real time scanning.

Last but not least, we have to keep vigilance of the latest vulnerabilities and the new security measure in the IT industry.



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## How To Report Low Wireless Coverage

Computer Services Centre encourages all users of Wireless @ NIE to report any poor wireless coverage in NIE Yunnan Garden Campus and Townsville Campus. You can visit Wireless Support Website (<http://wireless.nie.edu.sg>) and fill in the Feedback Form. Though we can't guarantee immediate fix for every area, your valuable feedback will help us to plan and extend the wireless coverage accurately.

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