The TCO of Enterprise Wireless & Mobile Data Services and Applications

White Paper

October 2007

Executive Summary

The daily use of mobile devices and their underlying wireless voice and data networks are now a necessary part of business for the majority of the estimated 54 million mobile workers in the United States today. Indeed, many of these mobile workers carry at least two types of mobile devices – primarily cell phones and notebook computers.

Notwithstanding the increasing use, functionality and versatility of smartphones, many mobile users still prefer their notebooks for accessing, reading and responding to email, as well as viewing and/or editing attachments. And when "out-of-the-office," mobile workers have a wide variety of connectivity options, including dialup, Ethernet, Wi-Fi and mobile broadband – i.e., the third-generation (3G) wireless broadband networks being rolled out by mobile operators in the U.S. and around the world.

Until recently, the primary way of connecting a notebook computer to a mobile broadband network was via external devices which, in this white paper, refers to PC Cards, Express Cards and USB modems. In the past two years, however, several external device OEMs, notebook computer manufacturers and wireless carriers have partnered to produce 3G modules which were embedded into notebook computers, much as Wi-Fi radios are built into almost every notebook computer produced.

Moreover, end users and/or enterprises can purchase the embedded module as a configuration option directly from the OEM. This development has greatly increased the ease of use associated with mobile broadband – making it seem as simple and easy as Wi-Fi.

This white paper will discuss the benefits associated with using notebook computers with embedded mobile broadband modules versus external device-based deployments and Wi-Fi-only implementations. As compared to external device-based solutions, notebooks with embedded mobile broadband modules provide several tangible benefits:

- Increased durability,
- Faster connection speeds,
- Greater reliability, and
- Lower total cost of ownership (TCO).

As compared to notebooks with only Wi-Fi connectivity, notebook computers with mobile broadband modules not only provide a lower total cost of ownership but also truly mobile access to data.

This whitepaper will provide an overview of the broadband connectivity options available to mobile workers and enterprises, their cost, and the pros and cons associated with each type of connectivity. This paper also describes various primary and secondary, as well as a detailed TCO model, which substantiate the benefits delivered by notebook computers with embedded mobile broadband modules.

Disclaimer

The opinions expressed in this white paper are those of iGR and do not reflect the opinions of the companies or organizations referenced in this paper. All research was conducted exclusively and independently by iGR. Although this white paper was sponsored by Dell, Dell personnel were not involved in any of the research, ongoing or otherwise.

In 2006, there were approximately 107.3 million total workers in the United States, excluding jobs in the Public/Government and Education industry sectors. About 54.6 million of those employees qualify as mobile workers.

*i*GR defines a mobile worker as any employee whose job function is not tied to a single physical location (e.g., a desk) and/or requires them to move about or work in a location that does not have (or has limited) wired voice/data communications (e.g., a warehouse) more than 20 percent of the work week. Note that a mobile worker could be a telecommuter, but a telecommuter is not necessarily a mobile worker. A better term for a telecommuter is "remote worker."

None of these attributes necessarily require the worker to use a mobile device or wireless data network (WAN or LAN) provided by the organization for which they work – i.e., an employee can be "mobile" without needing to use a wireless device. Nurses, maids and janitors are good examples. That said, different types of mobile workers use different devices and even wireless data networks. A mobile professional (e.g., a sales executive) might use a smartphone and a notebook computer, whereas a nurse might use a ruggedized handheld device.

This white paper focuses on total cost of ownership (TCO) associated with the use of notebook computers, wireless data networks and applications used by mobile professionals such as managers, sales executives and other types of knowledge workers.

Devices Used

To a large degree, mobile professionals have come to rely on their wireless devices (cell phones, smartphones, notebook computers and/or PDAs) and the underlying wireless voice and data networks (Wi-Fi, CDMA+, GSM+, etc.) to get their work done. And, of course, many mobile workers still use Ethernet and/or dialup when traveling or when they are in the office. At home, some mobile workers will use their cable modem or DSL connection, which they might access through a home Wi-Fi network.

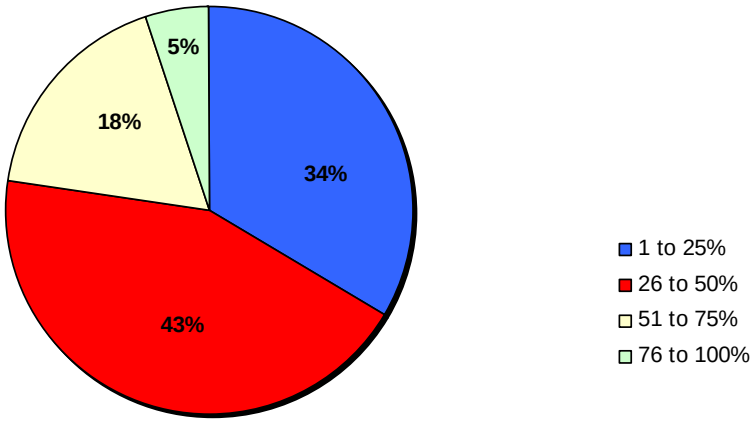
*i*GR's research has found that the vast majority of white collar mobile workers carry at least two types of mobile devices – primarily cell phones and notebooks – but smartphones are increasingly prevalent. (Note that a RIM BlackBerry is a smartphone.) Despite the increasing functionality and versatility of smartphones, those devices are often used for email "triage": that which can be handled on the smartphone is dealt with; that which requires a more involved response is handled on the notebook when the user has the time or is in a place where working on a notebook is practicable.

In its 2007 survey of 428 mobile workers, *i*GR asked the respondents to consider the total amount of time they spend managing (reading, writing and responding) their email per day while they are mobile. The respondents were then asked to indicate what percentage of that time is spent using a smartphone versus a notebook computer to manage email.

As Figure 1 shows, 33 percent of the respondents said that they use a smartphone less than 25 percent of the total time they spend managing their email; 44 percent said that they use a smartphone between 26 and 50 percent of the time; and only 17

percent said that they use a smartphone between 51 and 75 percent of the time. On average, the survey respondents sent/received approximately 35 email per day from their handheld devices.

Figure 1: Approximate Time Spent Using a Smartphone to Manage Email



Source: *i*GR, 2007

Clearly, mobile workers use both their smartphones and notebook computers to manage their email. The device is only part of the picture, however. Of equal importance is the data network used to access email or other types of data.

Networks Used

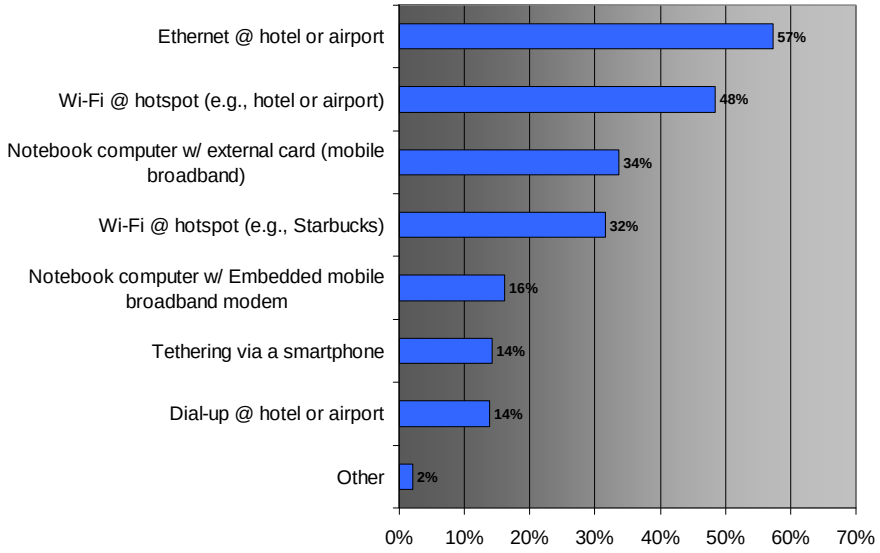
As Figure 2 shows, the mobile workers surveyed by *i*GR use a variety of wired and wireless data networks to access their information – Ethernet, Wi-Fi and mobile broadband – while at a variety of locations, such as hotels or airports or in coffee shops.

Note the multitude of available hardware options for making that wireless broadband connection:

- Wired Ethernet / Dial-up: The conventional connection methods.
- Wi-Fi: Typically referred to as "portable" wireless access because the user must be within range of a Wi-Fi hotspot in order to use the network.
- External Card: In this survey, this term referred to PC Cards and/or Express Cards. These are external modems inserted into the notebook computer's PC/Express card slot. The Express Card standard is an updated and improved version of the PC Card (CardBus) technology. Recently, PC/Express Card manufacturers such as Sierra Wireless and Novatel Wireless have begun producing mobile broadband USB modems. These are external modems which plug into one of the notebook computer's USB slots; they provide essentially the same functionality as the external cards.

- Embedded Modules: To oversimplify, these are external mobile broadband modems which have been miniaturized and embedded in the notebook's form factor. This integrated technology will be discussed in greater detail in the subsequent section.

Figure 2: Types of Networks Used by Mobile Workers



Source: *i*GR, 2007

This data suggests that, to date, no single data network – wired or wireless – has such extensive coverage and/or availability that mobile workers are able to use it 100 percent of the time. So, although mobile workers will use whatever network is available, they will prefer the highest-speed alternative.

High-speed data is first and foremost a productivity issue for mobile workers. They are busy, on-the-move and want their tasks completed as soon as possible. Cost can certainly be an issue when it comes to choosing which data connection to use, but in most cases that expenditure is either already paid for by the company or is simply expensed back to the company as another fully justified "line item" on their expense report.

The Different Types of Wireless Data Networks

Today's mobile workers have several different options for accessing their data, as summarized below.

Wired Connections

Most hotels provide wired Ethernet connections in their guest rooms, with rates typically ranging from $9 to $15 for a 24-hour period. Mobile workers can also use an analog phone port for dialup connections. And while these connections are available "a la carte," many global companies have begun using aggregator products from companies such as Fiberlink or iPass.

Home broadband networks (DSL or cable modems) are also often used by mobile workers and remote workers. Many homes also have Wi-Fi routers, but a sizeable percentage of those either have poor security or are left entirely unsecured. Note that enterprises typically enforce stringent security protocols for their remote workers.

Wireless LANs (WLANs or Wi-Fi)

The two predominant versions of WLANs are 802.11b and 802.11g; Draft 802.11n is the up-and-coming version of Wi-Fi. 802.11b operates in the 2.4 GHz unlicensed spectrum on three radio channels with a peak data rate of 11 Mbps. Actual throughput ranges from 1 Mbps to 6 Mbps, depending on a variety of factors such as distance to the access point (AP), attenuation and interference.

802.11g is the upgrade to 11b and, like its predecessor, 11g also operates in the 2.4GHz spectrum and uses non-overlapping radio channels. One of 11g's key features is its backward-compatibility with 11b access points. The main advantage to 11g is higher speed – its real-world throughput is up to 22 Mbps, which is about four times faster than actual 11b throughput.

Draft 802.11n can operate on the 2.4 GHz band, the 5 GHz band, or both, and is based on multiple-input multiple-output (MIMO) air interface technology. The use of MIMO, as well as additional improvements and changes in the 802.11 standard – has allowed 11n to take a huge step forward in terms of bandwidth delivered and signal range as compared to 11b/g. According to the Wi-Fi Alliance, 802.11n will support a maximum of 600 Mbps in the 5 GHz band at up to double the range of 11b/g networks. Current products (of which there are about 70 certified by the Wi-Fi Alliance at the time of this writing) can transmit at up to 300 Mbps. Note that 11n is compatible with legacy WLAN networks.

The maximum range for legacy Wi-Fi is approximately 300 feet, but it can often be much less depending on the access point's power settings and/or the radio frequency (RF) characteristics of the space in which the Wi-Fi network is deployed. 11n networks will potentially have almost twice the range of 11b/g.The limited range of Wi-Fi has caused WLANs to be deployed in the form of hotspots, which provide either free or paid access.

For example, T-Mobile USA sells Wi-Fi connectivity through its T-Mobile Hotspot service; Wayport also sells Wi-Fi connections through hotels and other venues in the U.S. Other Wi-Fi hotspot providers include Boingo Wireless and weRoam.

Additionally, many municipalities are rolling out public Wi-Fi networks to which users can connect to for no monthly or per-use fee. However, some municipalities in the U.S. are finding that the business models for "free municipal Wi-Fi" are unproven and are therefore discontinuing their rollout plans.

Two of the key issues with nationwide and/or global Wi-Fi connectivity are:

- **Fragmentation:** There are numerous Wi-Fi service providers, mostly due to the limited range of the technology itself.

- **Lack of Seamless Roaming:** Provider fragmentation contributes to this issue, but so does the technology itself. There is currently no standards-based way to seamlessly roam between different Wi-Fi networks – and even if there were, there would be a host of billing and settlement issues to address. Products from Wi-Fi network aggregators such as Fiberlink and iPass help alleviate these issues as their connection software (and reseller agreements with companies such as Wayport and Boingo) permit users to access whatever network happens to be available, regardless of which company actually owns the physical network through which the user connects.

Mobile Broadband

The term "mobile broadband" refers to 3G wide area wireless data networks (WWANs) such as CDMA EV-DO (Rev. 0 and Rev. A) and UMTS/HSPA that are owned and operated by mobile operators (e.g., Verizon Wireless, AT&T, Sprint). WWANs such as GPRS, EDGE and CDMA 1x are properly classified as 2.5G networks, since they are a stepping-stone between the wireless data rates provided by 2G and 3G networks.

EV-DO Rev. 0, for example, provides 400-700 Kbps download rate with higher "peak" speeds (up to 2 Mbps). CDMA EV-DO Rev. A is the newly available, faster version, which provides between 600 Kbps and 1.4 Mbps download rates and 500 to 800 Kbps upload rates, according to Verizon Wireless's published statements.

AT&T is implementing a high speed downlink packet access (HSDPA) network, which is part of the high speed packet access (HSPA) radio interface standard. AT&T's HSDPA network currently provides an average 400-700 Kbps download rate, with potentially higher peak download speeds (up to 7 Mbps). The upload rates on AT&T's HSDPA network are faster than EDGE or GPRS – roughly 300 to 400 Kbps.

Mobile broadband access is available in most major metropolitan areas, the surrounding suburban areas and along major highways. 3G coverage is improving, but gaps do exist. In those uncovered areas, however, 2.5G networks are typically available. This backup provides somewhat slower wireless data connectivity to end users whose devices operate on the requisite frequencies. Note, too, that actual mobile broadband throughput varies based on such factors as network load, distance to the cell towers and signal strength.

Tethering

This option typically involves a USB cable or Bluetooth connection from a mobile broadband-enabled smartphone to a notebook computer. (This is also an option on 2.5G CDMA 1XRTT, GPRS and EDGE smartphones.) Once tethered, the smartphone functions as a wireless data modem, thereby providing the end user with a mobile broadband connection.

The advantage to tethering is that the user can obtain data access without using an Express Card, PC Card or USB modem. However, the downsides are numerous:

- Tethering can be difficult for an inexperienced user, who might have to download and install drivers and then setup a "dial-up networking" connection from the notebook computer to the smartphone, as well as configure the smartphone to accept such connections.
- Not all mobile operators permit smartphones to be used in this manner and, when they do, they sometimes charge an additional monthly fee.
- The smartphone may not support tethering.
- On CDMA-based smartphones, users currently cannot employ their phone for cellular voice while the device is tethered to the notebook.
- Lastly, tethering drains two batteries at the same time, which could prove problematic if he/she is not near a power outlet.

Table 1 compares the cost of these various broadband network options. The monthly costs are all in the same price range, but the throughput varies greatly – obviously the non-mobile, wired connections provide the highest throughput. The portable option (Wi-Fi) provides higher speeds than those provided by the mobile broadband networks.

Table 1: Comparison of Predominant Broadband Options

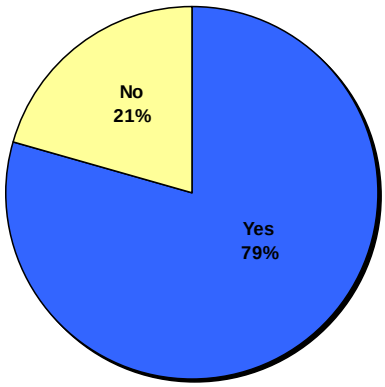
Operator	Type of Plan	MB Permitted	Mobility	Average Throughput	Average Cost
Mobile operator	Mobile Broadband (USB modem PC card or embedded)	Unlimited	Mobile	Average: 400-700 Kbps	$60 to $80 per month (assuming yearly contract)
Mobile operator	Tethering	Unlimited	Mobile	Average: 400-700 Kbps	Additional $10/month (assuming yearly contract)
Hotspot service provider	Wi-Fi hotspot service	Unlimited	Portable	Typically greater than 1 Mbps	$30 per month (assuming yearly contract)

Operator	Type of Plan	MB Permitted	Mobility	Average Throughput	Average Cost
Hotel	Ethernet	Unlimited (per 24 hours)	Not mobile	Typically greater than 1 Mbps	$10-15 (daily fee, but sometimes free)
Hotel	Wi-Fi within the hotel	Unlimited (per 24 hours)	Portable within hotel	Typically greater than 1 Mbps	$10-15 (daily fee, but sometimes free)
Telecom Internet service provider	DSL	Unlimited	Not mobile	Up to 768 Kbps	$15 per month (assuming yearly contract)
Cable Internet service provider	Cable modem service	Unlimited	Not mobile	Typically greater than 1 Mbps	$50 per month (assuming yearly contract)

Source: *i*GR, 2007

When it comes down to a purchase decision, then, enterprises really need to evaluate how valuable mobile access to data is for their mobile employees. The mobile workers themselves rate it highly valuable. As Figure 3 shows, 79 percent of the surveyed mobile workers say that they value mobility versus fixed broadband access (e.g., Ethernet) or portable access (e.g., Wi-Fi or tethering via a smartphone).

Figure 3: Do You Value Mobility?



Source: *i*GR, 2007

Key Differences: 3G vs. Wi-Fi

There are three primary distinguishing factors between WWANs and WLANs:

- **Coverage Area:** Mobile broadband networks measure geographic coverage in miles, whereas WLANs measure it in feet (an approximately 300 foot radius for 11b/11g).

- **Throughput:** WLANs typically offer faster speeds as compared to mobile broadband networks, but the trade-off is the lack of true mobility.

- **Mobility:** Mobile broadband networks provide true mobility – users can go wherever they please and still connect at broadband speeds. Given the pace at which the mobile operators are rolling out their 3G networks, coverage is becoming less and less of an issue with each passing month. Conversely, Wi-Fi users are limited to a significantly smaller coverage area. This is why Wi-Fi access is typically referred to as a "portable" wireless solution – i.e., the user can connect at one hotspot but must disconnect and then travel to another hotspot before regaining data access.

  With mobile broadband networks, users can move anywhere within the coverage area and even between cell sites as handoffs are managed by the mobile operator's network. Seamless handoffs between Wi-Fi when each hotspot is owned and operated by different providers is not possible without a unified management layer of software and hardware.

Despite its limitations, Wi-Fi is an enormous success. Intel played a large part in that success with its Centrino products that are found in almost every notebook produced by the major notebook original equipment manufacturers (OEMs).

Essentially, Centrino-equipped notebooks ship with an embedded WLAN radio card. The antenna for that radio is also built into the notebook – usually in the screen/cover of the notebook. Once turned on, the radios and preloaded connection software automatically discover any open Wi-Fi networks within range. The end user then selects and connects to one of the available networks.

Embedded Mobile Broadband Modules

Until recently, the primary method of connecting to mobile broadband networks was via external cards which function as wireless data modems. In the past 12 to 18 months, however, several external card OEMs, notebook manufacturers and wireless carriers have partnered to produce mobile broadband modules that are embedded into notebook computers.

In other words, the modem functions and antennas which were previously in the external cards were further miniaturized and built into the form factor of the notebook itself – in much the same way, conceptually, as the Centrino solution gave notebook manufacturers a way to embed WLAN modems and antennas in their products. Note that, despite being embedded, the mobile broadband modules can be made fully removable and upgradeable, which is the case with the modules produced by Dell.

Embedding the mobile broadband modules minimizes the radio frequency interference from the components and circuitry in the notebook by placing the antenna(s) behind the notebook's screen, or along the edge or top of the screen – in other words, as far away from the base of the notebook as possible. The base of a notebook computer contains the "noisy" components – e.g., the central processing unit (CPU), memory chips, video circuits and other components.

Benefits of Embedded Modules in Notebook Computers

Recent primary research conducted by *i*GR found that there are four key benefits to using notebooks with embedded modules: increased durability, faster connection

speeds, improved reliability and lower cost. The majority of this research comes from survey data and focus group interviews with IT managers.

Increased Durability

Because embedded modules and antennas are contained within the form factor of the notebook itself, they are far less likely to break than external devices, which protrude from slots in the device's side. End users are notorious for breaking the antenna on the PC card or for otherwise damaging the card (if it snags on something, for example) so as to render it useless. USB modems, which are proving to be a popular product among mobile professionals, are equally likely to be lost or broken.

*i*GR's research has found, moreover, that the error rate (breakage, loss, malfunction) of external devices was higher than the failure rate of embedded modules. For example, at a large golf equipment manufacturer whose field sales force is using both external devices and embedded modules on an EV-DO network, there was not a single failure with any of the embedded-module notebooks in more than 7 months of continual use.

There is also a cost aspect to this issue, at least as compared to notebooks with external devices. If end users are not breaking or losing those devices – because they are using an embedded solution – then the cost of repairing and/or replacing those external cards/modems is avoided.

Faster Speeds

As compared to an external card-based solution, notebooks with embedded modules provide faster wireless connection speeds for two main reasons: the hardware (modem and antenna) is more tightly integrated with the connection software and because the embedded solution minimizes RF interference.

Note that a mobile broadband network's upload and download speeds can be affected by numerous factors such as interference, distance, coverage and load on the network. There will also be speed differences between networks deployed by each mobile operator. It would be misleading to categorically state that notebooks with embedded modules will always outperform notebooks with external cards/modems, as there are simply too many factors that might conspire against such statements.

In 2006, *i*GR conduct 18 focus groups with more than 100 enterprise IT managers and mobile professionals in three U.S. states. During those focus groups, *i*GR performed side-by-side bandwidth speed tests of 6 different notebooks with both embedded modules and PC cards.

In those real-world tests, *i*GR found that embedded modules outperformed their external card/modem cousins by about 15 percent in those bandwidth speed tests (for CDMA EV-DO Rev. 0 and UMTS/HSDPA). To date there is nothing to suggest that Rev. A embedded products will not enjoy a similar performance advantage over notebooks connecting via external Rev. A devices. Note that *i*GR currently has no test data to validate this opinion.

Convenience

Notebooks with embedded mobile broadband data modules provide improved convenience to both end users and IT managers.

From an IT manager's perspective, the notebooks ship with the module and drivers already installed and are ready-to-go with the particular mobile operator – e.g., Verizon Wireless, AT&T or Sprint. When the notebook is first turned on, the IT managers or end users only need to log in to the mobile broadband network in order to activate the card. This process is very similar to how the embedded Wi-Fi card discovers any open WLAN in the vicinity.

With external cards, the IT staffers have to install drivers, configure the card, make sure it works on the notebook and then log in to the mobile broadband network – several extra steps compared to the embedded mobile broadband module paradigm.

The IT support process for notebooks with embedded modules is also more streamlined. In many cases, a broken or lost external card or modem means that the notebook user is out of commission until he or she receives a new one. Typically, the user has to ship the broken card/modem back to his or her IT department and then wait at least a day for a replacement to be shipped to them. Some IT departments require the user to return the notebook along with the card. In either event, there are significant costs associated both with user downtime and with IT's role in repairing and/or replacing the notebook or external card.

Reliability

Preliminary indications suggest that the embedded modules are more reliable than external devices. From its interviews with IT managers in the previously mentioned focus groups (as well as from other primary and secondary research), *i*GR determined that there is an approximate 25 percent replacement rate for notebooks with embedded modules versus an approximate 30 percent replacement rate for notebooks with external cards. In the case of external cards, the replacement is due more to loss, breakage or theft than to malfunction of the device. In the case of notebooks with embedded modules, there is comparatively less to go wrong.

From the end user perspective, a mobile worker's productivity may be negatively impacted if his or her notebook or wireless data connection stops functioning. Since the preliminary indications are that the embedded modules fail less frequently than their external card analogues, it is reasonable to conclude that mobile workers using notebooks with embedded modules will have more hours of uptime and less of downtime. This translates to a lower total cost of ownership for the enterprise.

Also, with truly broadband speeds available anytime the notebook is opened, mobile workers will have less need – if any need at all – to pay for either Ethernet service in a hotel or a Wi-Fi hotspot service. This is another cost which can be avoided by choosing a notebook with an embedded module. Certainly this is possible with external card- or modem-based solutions, but with embedded modules the entire process of connecting becomes much more streamlined and faster from a bandwidth perspective.

Lower Cost

To help quantify these savings, *i*GR adapted its wireless total cost of ownership model to focus on the TCO of deploying different types of Dell notebooks to different total numbers and types of mobile workers. The cost savings are addressed more fully in the next section.

TCO Models

The TCOs in the following models were calculated by summing all direct and indirect one-time costs, as well as all direct and indirect ongoing costs. The models assumed a three year deployment. This sum was then divided by the number of mobile devices to calculate the total cost of the mobile solution per device (Table 2).

The following are all the types of costs incorporated in the model. All currency figures are in U.S. dollars.

- **Notebook Computer Costs:** Can be variable, especially if the enterprise purchases a large number of notebooks. *i*GR assumed a baseline cost of $1,337, which was the cost (at the time of this writing) for a Dell™ Latitude D630 with an Ethernet card and Wi-Fi. This also includes the cost of purchasing spares/replacements. To calculate the cost of equipment, *i*GR multiplied the cost of the notebook by the number of end users (100, 500 and 1,000). To calculate the replacement cost, *i*GR multiplied the replacement rate by the number of deployed notebooks and then by the cost of the notebook.

- **Cost of a Mobile Broadband Embedded Module or Express Card:** The cost of the notebook with an embedded mobile broadband module was added to the base cost of the notebook, whereas the Express Card was separate. In many cases, mobile operators provide PC cards for free (via discounts and/or rebates) with a two-year data services contract. Express Cards, however, are not given away for free – and as a newer technology they typically cost more than PC cards. On the embedded module side, there are often similar promotions to offset the cost of the module. What this essentially amounts to is that all of the communications hardware costs about the same. To calculate the replacement cost of the embedded and Express Cards, *i*GR applied the percentage replacement rate to the number of deployed notebooks and then multiplied that number by the cost of replacing that component – e.g., approximately $150 for embedded modules and $300 for Express Cards.

- **Cost of Monthly Mobile Data Connectivity:** *i*GR assumed $60 per month for mobile broadband and $30 per month for Wi-Fi hotspot service. These costs can vary greatly based on the size of the enterprise and its purchasing power, the number of end users and the number of cellular voice users on the mobile data service provider's network. *i*GR calculated the cost of connectivity by multiplying the monthly cost by 12 (to achieve the yearly cost) and then by the number of end users.

- **Cost of Security Software:** No data should be sent or received over wireless data networks (or wired, for that matter) without adequate security. *i*GR's model assumed the bare minimum: anti-virus (AV), firewall and virtual private network (VPN) software. Pricing for enterprises will vary; *i*GR's model assumed an average cost of $40 per user for the AV and firewall software and a range of $40 to $70 for the VPN software, based on the total number of end users. The cost was calculated by multiplying the number of users by the unit cost of the software.

- **Cost of IT:** A company's IT staff will often comprise the "main line" of device, network and software-related support. *i*GR's model accounted for a range of support and deployment activities, as well as some limited training of end users. The cost of IT support was calculated by dividing an average IT staffer's loaded salary ($129,000) by the number of man hours (or fraction thereof) required to support the varying number

of end users (i.e., 100, 500, 1000). The amount of time IT spends supporting users was based on best estimates from *i*GR's primary and secondary research.

- **Cost of Lost End User Productivity:** When an end user is unable to perform his job function due to equipment, software or network failures, the company incurs cost in the form of lost productivity. This model makes some conservative assumptions regarding the amount of downtime a mobile professional might have if he has to drive 15 minutes to find a Wi-Fi hotspot or he cannot connect to the mobile broadband network. In the latter case, the end user will typically try to troubleshoot the problem first and then, if he cannot fix it, will contact his IT department for assistance – which incurs an additional cost. The cost of lost productivity was calculated by dividing an average sales person's loaded salary ($195,000) by the number of man hours (or fraction thereof) that they spend unable to perform their job function because of the device, network and/or software failure. The amount of time IT spends supporting users was based on best estimates from *i*GR's from its primary and secondary research.

- **Miscellaneous Costs:** This category includes the cost of administrative labor support, which was calculated by dividing an average administrative employee's loaded salary ($77,000) by the number of man hours (or fraction thereof) that they spend supporting the given notebook solution. The amount of time attributable to administrative labor was based on best estimates from *i*GR's secondary research. It also includes the cost of shipping failed equipment back and forth to the enterprise's IT department.

*i*GR developed TCO models for five different types of mobile workers. Note that, in each model, the hypothetical mobile worker uses a notebook computer with one of the following types of wired and/or wireless connectivity:

1) **Wired Broadband (Office and Home) User:** This model assumed no cost for the existing wired LAN, but did assume a $15 per month charge for the home DSL service.

2) **Wi-Fi User:** As discussed, the Wi-Fi access market is characterized by fragmentation and a lack of roaming between the various providers. *i*GR therefore assumed that each mobile professional would need hotspot service with two independent Wi-Fi access providers in order to have sufficient coverage while traveling. At $30/month per provider, this is a significant cost – but it is far less than permitting users to pay repeatedly for the "24 hour-only" service.

3) **Notebook Computer with Express Card User (Mobile Broadband):** *i*GR assumed an average cost of $60 per user per month for mobile broadband service in the U.S. It is possible that an enterprise could obtain this service for less depending on a variety of factors: total number of end users using the data service, number of cellular voice users with the operator providing the data service and the length of the contract.

4) **Notebook Computer with an Embedded Mobile Broadband Module:** The cost of mobile broadband service is the same regardless of the type of equipment used to obtain access, except in the case of tethering via a smartphone.

5) **Dual Access:** Wired (office) and Wi-Fi (traveling): This model is essentially the same as the pure Wi-Fi user.

The following summarizes the assumptions used when creating the TCO models with regard to the types of equipment used to access the wireless data services. These assumptions are best estimates based on *i*GR primary research which is, to a large extent, summarized in much of the explanatory material in this white paper:

- Reduced IT staffer time required to deploy the notebook with an embedded module or a Wi-Fi radio as compared to PC card deployments.

- Embedded modules, as well as Wi-Fi radios and Ethernet cards, are typically more reliable than PC cards. These models assume a 25 percent replacement rate for notebooks with embedded modules, Wi-Fi radios or no radio versus a 30 percent replacement rate for notebooks with external devices. In the case of Express Cards, the replacement is due more to loss, breakage or theft than to malfunction of the card itself. This means that IT staffers spend less time overall supporting embedded modules versus external devices.

- Reduced end user downtime with embedded modules, Wi-Fi notebook computers or non-wireless notebook computers, because those devices tend to fail less as compared to external devices (as noted above). In the case of Wi-Fi, an end user might actually have to take 15 to 20 minutes to seek out a hotspot, whereas a mobile broadband user could just open his or her notebook computer and get instant, high-speed access. End user downtime – a.k.a., lost productivity – can be very expensive to the company, especially in the case of highly paid mobile workers such as sales professionals.

- Lower failure rate of embedded modules, Wi-Fi-only notebook computers and non-wireless notebooks as compared to external devices. Because these types of devices tend to fail less often than external devices, the overall cost of replacing the embedded modules is less than the overall cost of replacing the external devices. When an embedded module (or Wi-Fi notebook) fails, however, the end user will likely be required to ship the entire notebook to their IT department. This is done for two main reasons: end users typically lack the necessary technical expertise to replace the embedded module, and because IT departments typically prefer to handle those types of repairs themselves. In both cases, the impact on the end user is significant – and arguably greater if they have to return their entire notebook. However, many IT departments do keep backup notebooks on-hand for these types of contingencies. Shipping and handling is also a component of this cost.

- Cost of service: Mobile broadband service coverage is nationwide and fairly solid, at least where mobile workers tend to go (metropolitan areas). It is also available wherever the user can get a cell phone signal, although the data rate might not be as good as it might be in other locations. The same cannot be said of Wi-Fi, due to the limited range of access points and the fragmentation of Wi-Fi service providers. In order to achieve decent nationwide coverage, mobile workers who rely on Wi-Fi must often obtain service from at least two independent hotspot carriers.

Table 2 compares the TCO of the five connectivity models. The TCO declines in each category as the number of users increases – this is due to the enterprise leveraging economies of scale to reduce its costs. A large percentage of the implementation and maintenance costs actually involve labor (IT staff) and losses in end user productivity due to equipment or network failures.

Table 2: Connectivity TCO Model Comparison (USD)

Type of Connectivity Used	100 end users Cost per Device per Year	500 end users Cost per Device per Year	1000 end users Cost per Device per Year
Wired broadband (Office and Home)	$1,994.5	$1,794.0	$1,727.0
Wi-Fi	$3,956.7	$3,723.9	$3,646.1
Express Card (Mobile Broadband)	$3,787.0	$3,538.7	$3,458.9
Embedded Mobile Broadband	$3,234.9	$2,993.0	$2,914.1
Dual User (Wi-Fi + Office User)	$3,956.7	$3,723.9	$3,646.1

Source: *i*GR, 2007. Please contact *i*GR with any questions regarding its TCO model.

Note, too, that those models which incorporate Wi-Fi usage exhibit higher TCOs than either the Express Card (Mobile Broadband) or Embedded Mobile Broadband models. The common perception is that Wi-Fi is "free" – in actuality, it is quite expensive and does not provide nearly as much usage flexibility as mobile broadband solutions.

Table 3 shows the percent difference between the various models – which serves to further illustrate the cost savings associated with deploying a mobile broadband solution (Express Card or embedded) versus a Wi-Fi connectivity solution:

1) A mobile broadband Express Card solution to 100 mobile workers is 4.3 percent less expensive than a Wi-Fi deployment; to 500 users, it is 5 percent less expensive; to 1,000 users, it is 5.1 percent less expensive.

2) An embedded mobile broadband solution to 100 mobile workers is 14 percent less expensive than a similar Express Card deployment; to 500 users, it is 15.4 percent less expensive; and to 1,000 users, it is 15.8 percent less expensive.

3) An embedded mobile broadband solution to 100 mobile workers is 18 percent less expensive than a similar Wi-Fi deployment; to 500 users, it is 19 percent less expensive; and to 1,000 users it is 20 percent less expensive.

Table 3: Percent Difference between TCO Models

#	Model Comparison: % Difference	100 Users	500 Users	1000 Users
1	A mobile broadband Express Card is X% cheaper than Wi-Fi.	-4.3%	-5.0%	-5.1%
2	Embedded is Y% cheaper than an Express Card (both are mobile broadband).	-14.6%	-15.4%	-15.8%
3	Embedded mobile broadband is Z% cheaper than Wi-Fi.	-18.2%	-19.6%	-20.1%

Source: *i*GR, 2007

Note that the cost savings tend to level out in larger deployments because the savings achieved with economies of scale only go so far, especially where human resource costs are involved.

*i*GR then created additional TCO models to illustrate the usage of various applications. The cost of these applications were layered on top of the baseline notebook and connectivity options, along with some conservative assumptions regarding the cost of support and maintaining those various applications as well as lost productivity associated with application failures. The applications so modeled include:

- **Email:** *i*GR's model assumed no additional cost for the email client on the notebook computer, nor did the model assume any additional cost for server-side software. In the case of mobile email, only email "pushed" to handhelds such as Palm Treo or RIM BlackBerry which require a back-end client. In the case of RIM devices, for example, the enterprise would install a BlackBerry Enterprise Server (BES) which would monitor the actual email server and then push new email for BlackBerry users out to the handheld device over the data WWAN. Note that this email model did include some additional slight cost for email support and lost productivity.

- **Sales Force Automation (SFA) Applications:** SFA solutions, provided by companies such as Oracle and Salesforce.com, typically include contact management, sales lead tracking, sales forecasting, order management and product knowledge/database systems. Costs for this type of software can vary greatly; *i*GR assumed a per user cost of $65.

- **Field Force Automation (FFA) Applications:** FFA solutions attempt to optimize processes and information needed by companies who send mobile workers out to install, service or repair a variety of systems or equipment. Again, costs for these products vary greatly based on the degree of functionality and/or amount of customization that needs to occur. *i*GR assumed an average cost of $80/user.

- **Public Safety Applications:** There are a wide variety of applications that can be deployed by public safety organizations such as police, fire, emergency medical, etc. Generally speaking, these applications enable "first responders" to complete calls for service/help, submit offense reports for review/action or directly access State or Federal databases (e.g., driver's license or license plate look-ups). These applications are typically expensive, given the high-level of security and customization required. *i*GR assumed an average cost of $95/user.

Essentially, the introduction of an application raises the TCO per implementation as compared to the equivalent connectivity model by at least 5 percent across the board (Table 4). In some cases, the percent increase is much greater – e.g., adding an SFA application to the Wired Broadband (Office and Home) model increases the TCO by 16 percent.

Again note that *i*GR used average numbers for the software licenses and per seat prices; individual enterprises may have higher or lower costs depending on a range of factors. Those differences will have an impact on the TCO, as well.

Table 4: Summary of TCO for Mobile Applications

	Cost of Solution per Device per Year (USD)		
Email TCO Model	**100 Users**	**500 Users**	**1000 Users**
Wired broadband (Office and Home)	$2,197.6	$1,997.5	$1,932.2
Wi-Fi	$4,158.7	$3,926.9	$3,850.1
Express Card (Mobile Broadband)	$3,986.8	$3,739.4	$3,660.7
Embedded Mobile Broadband	$3,436.9	$3,196.0	$3,118.1
Dual User (Wi-Fi + Office User)	$4,158.7	$3,926.9	$3,850.1
Sales Force Automation TCO Model	**100 Users**	**500 Users**	**1000 Users**
Wired broadband (Office and Home)	$2,313.4	$2,113.3	$2,047.9
Wi-Fi	$4,274.5	$4,042.7	$3,965.9
Express Card (Mobile Broadband)	$4,102.5	$3,855.2	$3,776.5
Embedded Mobile Broadband	$3,553.8	$3,311.8	$3,233.9
Dual User (Wi-Fi + Office User)	$4,275.6	$4,042.7	$3,965.9
Field Force Automation TCO Model	**100 Users**	**500 Users**	**1000 Users**
Wired broadband (Office and Home)	$2,328.4	$2,128.3	$2,062.9
Wi-Fi	$4,289.5	$4,057.7	$3,980.9
Express Card (Mobile Broadband)	$4,117.5	$3,870.2	$3,791.5
Embedded Mobile Broadband	$3,567.7	$3,326.8	$3,248.9
Dual User (Wi-Fi + Office User)	$4,289.5	$4,057.7	$3,980.9
Public Safety TCO Model	**100 Users**	**500 Users**	**1000 Users**
Wired broadband (Office and Home)	$2,343.4	$2,143.3	$2,077.9
Wi-Fi	$4,304.5	$4,072.7	$3,995.9
Express Card (Mobile Broadband)	$4,132.5	$3,885.2	$3,806.5
Embedded Mobile Broadband	$3,582.7	$3,341.8	$3,263.9
Dual User (Wi-Fi + Office User)	$4,304.5	$4,072.7	$3,995.9

Source: *i*GR, 2007

Conclusion

For mobile workers, high-speed Internet access is about productivity – getting their jobs done while they are out of the office. Smartphones are increasingly used to deal with daily email, but mobile workers still rely on their notebook computers.

Those notebook computers need high-speed access to be useful, and users have shown that they will use whatever network is at hand, be it wired Ethernet, Wi-Fi or mobile broadband. From a pure throughput perspective, wired networks provide the fastest connections, followed by portable access (Wi-Fi) and then mobile broadband (HSPA or EV-DO Rev. A). On an even playing field, then, mobile workers would probably choose the wired connectivity.

The playing field is not level, however. Mobile broadband provides something that the other options do not: true mobility. A user can simply open his/her notebook computer (with an embedded module or even Express Card installed) and be on the Internet seconds later regardless of where they are – in a hotel room, taxi, airport or in the comfort of their own home. And not only does mobile broadband provide mobility and a high-speed wireless data connection, it does so at a lower TCO than the other available wireless alternatives.

About *i*GR

*i*GR, formerly *iGillott*Research, is a market strategy consultancy *focused* on the wireless and mobile communications industry. Founded by Iain Gillott, one of the wireless industry's leading analysts, we research and analyze the impact new wireless and mobile technologies will have on the industry, on vendors' competitive positioning, and on our clients' strategic business plans.

Our clients typically include service providers, equipment vendors, mobile Internet software providers, wireless ASPs, mobile commerce vendors, and billing, provisioning, and back office solution providers. We offer a range of services to help companies improve their position in the marketplace, clearly define their future direction, and, ultimately, improve their bottom line.

A more complete profile of the company can be found at www.iGR-inc.com.

Methodology

The data for this white paper was obtained from several reports and surveys conducted by *i*GR, as well as from ongoing research in the wireless industry. Dell was not involved in any of the reports, surveys and/or other information used to create the *i*GR TCO model or this report.