Selected Paper

IAC-05-B3.1.02

無線革命における衛星通信

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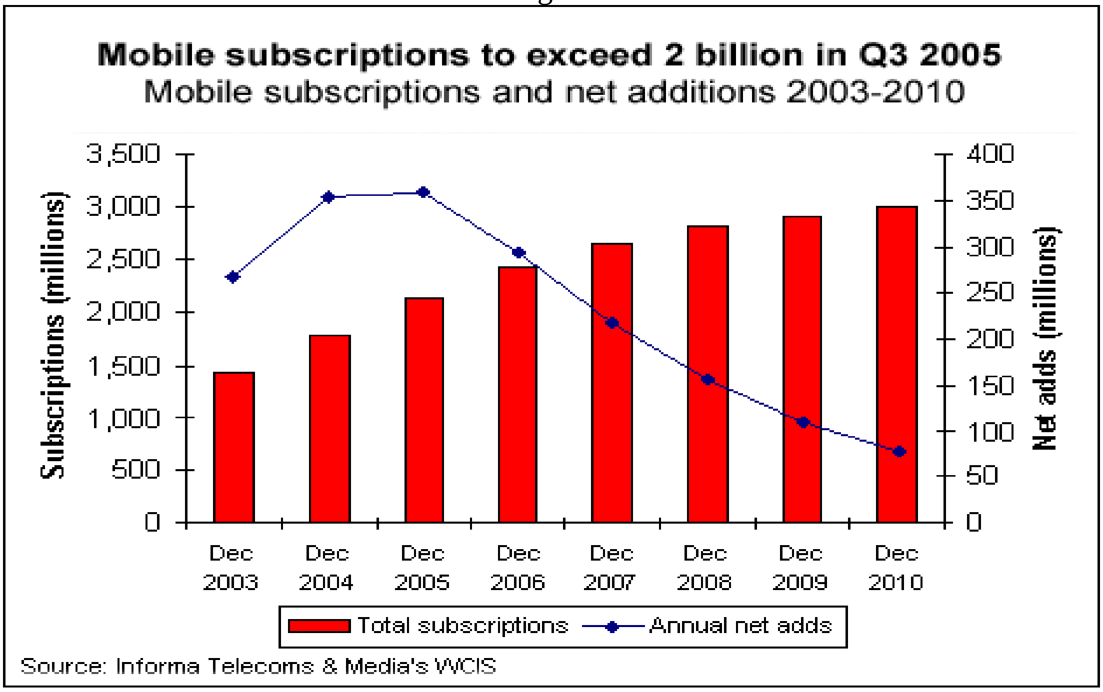
要約

無線革命はグローバルコミュニケーションに無線技術の新しい相乗効果を静かにもたらしています。 この相乗効果の初期のドライバーは主として低パワー、低価格、干渉の少ない無線通信ネットワーク(Wi-Fi)であり、また他の無線技術、WiMAX、wVoIP、Ultra Wideband、ブルートゥース、および RFID があり本論文で扱われています。 Wi-Fi 装置(ホットスポット)は今日、10 ドル程度でシングルチップに製造可能であります、そして増産するだけで、すぐ、1 ドル未満まで下げることができます。 これらの低価格デバイスは一一多くの高度な無線技術、賢いアンテナ、アジャイルラジオや網目状ネットワークをデジタル信号処理におけるブレークスルー技術として共有しつつ一一コンピュータ制御無線通信ネットワークの中に統合されるでしょう。 これらのインテリジェントネットワークはまもなく、数百万、何十億個の新しい無線非接触データキャリア装置(RFID)センサに関連づけられるでしょう。 Wi-Fi のような、これらのセンサは低価格でかつ砂粒ほどの大きさのシングルチップに組立てられるでしょう。 センサデータは無線によってコンピュータ処理と高度な記憶装置にネットワークでつながれるでしょう。 この相乗効果は賢いネットワークを通したセンサチップから記憶装置まで「ワンチップ上に搭載された無線インターネット」というアプリケーションを提供するでしょう。 これらのアプリケーションには、私たちがものを作成して、商業を動かして、最小量の人間の交流でマルチ寸法でそれをモニターして、測定する上で、これらを理解する方法を変える能力があるでしょう。 多くの RFID センサが材料の物量と品質を追跡できます—それらの熱、動き、および外観も、さらに品質の確率的な変化までも追跡できるでしょう。 これらセンサ駆動ネットワークは、開発途上地域で稼動させ実績を積みながら、大きな精巧なコンピュータ制御ネトワークから小さいデータ収集ネットワークに進化することができます。 特に開発途上地域では、これらのセンサは小型衛星通信地上装置に接続され、無線ローカル・エリア・ネットワーク(WLANs)で稼動するでしょう。 これらのセンサネットワークは、まず潜在的要求条件を持たないで、衛星通信には応用され易くなるでしょう。 チップ駆動の、無線の低価格センサ、ネットワーク、およびアプリケーションは衛星通信に大きな新しい市場を供給する事になるでしょう。

1.0 A WIRELESS REVOLUTION

While wireless communications goes back to Marconi, and even before, the large telecommunications systems and networks that connected large numbers dedicated to short waves for the military and delivery industries. A synergy among integrated circuits, digital technologies and signal processing techniques brought about a cellular wireless revolution, that in 2005 will see the ~ 2 billion of wireless subscriptions/ phones in operation exceed the number of the people in the world, beginning some 100 years ago, were based on fixed wires and cables. Wireless communications through all but the last 25 years of the 20th century were largely of wired phones and minutes of operation.[1] Figure 1 shows the global growth of wireless subscriptions from 2003 with forecasts through 2010. The net annual growth is shown peaking in 2005 and falling as many developed nations approach wireless saturation.

Figure 1



The decline in subscriptions, and to a lesser extent, handsets, should not be considered as a decline in the wireless industry as new technologies, applications, message systems, radio and many types of video streaming and television receptions are a part of the wireless revolution. Currently three generations of cellular wireless technologies are being used, with the latest "3G" such as the EV-DO cellular data service being able to carry data, audio and even video traffic, with speeds of 300-500 kbps, along with easy connection to the Internet. The demand for mobility on behalf of large numbers of the population who want their communications to be with them wherever they are, even in moving cars, boats and airplanes, is a prime mover of this growth. Houses and offices may have fiber optic cables, but the occupants want mobility within the structures. The cost and complexity of laying cable thru walls and across campuses greatly increased the demand for wireless solutions, including wireless local area networks, WLANs. Reliable, and basically inexpensive interface equipment between the wired and wireless networks were also drivers of the new wireless growth.

2.0 NEW WIRELESS TECHNOLOGIES

A number of the new technologies are based on the breakthrough in unlicensed, low power, low interference technologies and systems. These systems can operate efficiently under the interference level of other communications systems. Initially the government set aside unlicensed spectrum in the 800 MHz band for microwaves, garage door openers and some scientific and research work. In a world where national and international regulators treat spectrum as a very scarce resource, developers applied advanced signal processing techniques to these unlicensed frequencies with great success. IEEE Working Groups were established to set standards for the use of the unlicensed bands. Out of their work, new technologies and systems have been developed, that will openly compete with segments of the licensed bands. The success of these low frequency, low power, unlicensed systems have caused the regulators to assign additional frequency bands for their use. This has allowed the unlicensed systems to become even more efficient. This paper will provide a summary of the more successful of these technologies and systems. Finally, the expanded use of unlicensed frequencies gives rise to an improved regulation of all spectrum. In 2003, independent engineers set up a large antenna on top of a building in the center of Washington, DC and monitoring the use of the common bands. Their findings showed that only 19% to 40% of the spectrum was occupied at any moment during an eight-hour period.

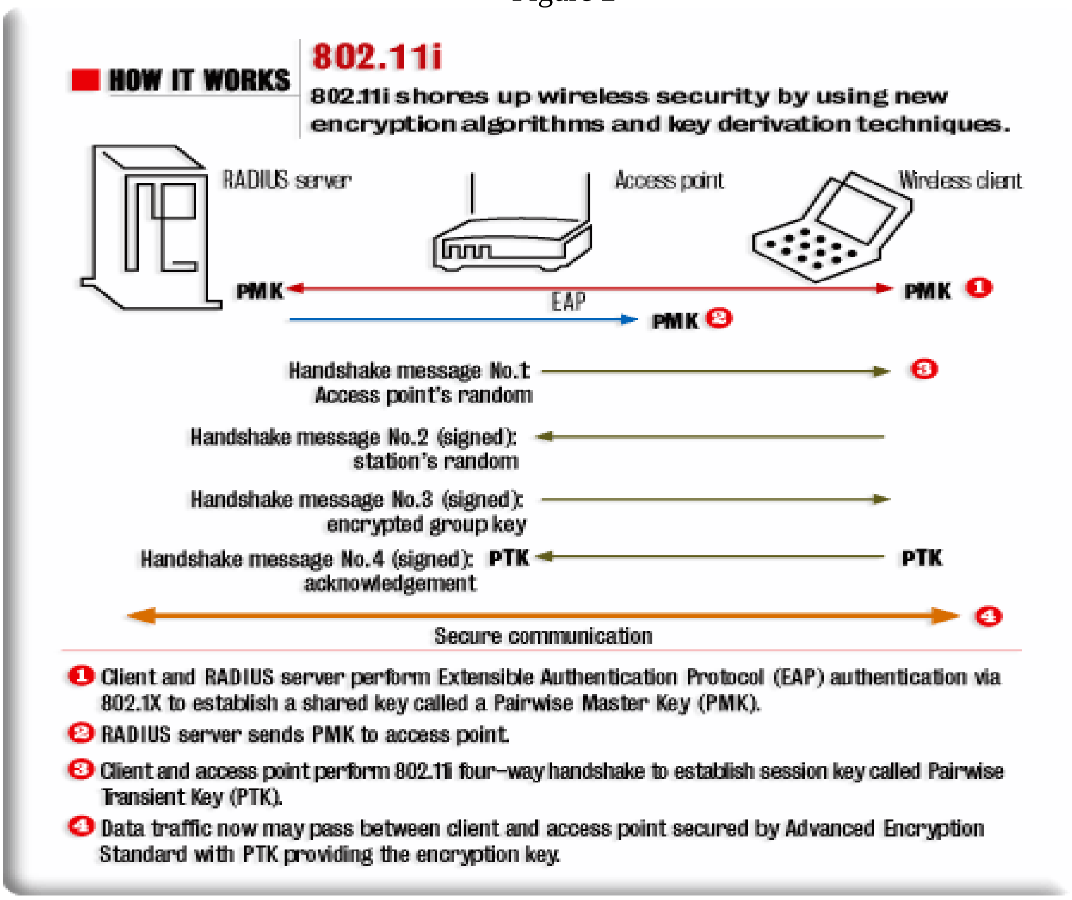
While the military and large communications carriers will argue with these findings, improved technologies and the use, for example, of unlicensed spectrum will increase the overall efficiency of the global spectrum.

2.1 Wi-Fi

Short for **wi**reless **fi**delity, Wi-FI refers to IEEE802.11 standard networks, including 802.11b, a, g & the next generation “n”. Its strong growth is fostered by a Wi-Fi alliance of companies that include nearly all of the large communications vendors, who must certify every Wi-Fi product. Starting with frequencies in the 2.4 GHz range, Wi-Fi was expanded by the ITU in 2003 by 455 MHz of spectrum in the 5 GHz region. These additional frequencies were allocated to wireless local area networks, both in the U.S. and Europe. Also 1.2 GHz was made available in the 60 GHz band. The start-up challenges of any technology are seen in Wi-Fi systems, as improvements are being proposed on a weekly basis and some large enterprises are waiting until a more stable set of standards and equipment become available. The good news is that the improvements have been substantial. Initial Wi-Fi service was limited to kilobits of data being transmitted 10 meters in distance. In just a couple of years the throughput has increased to tens of megabits and 300 meters in operational equipment. New equipment is being developed in the 1 & 2 Gb/s data rates with a range of 1- 4 kilometers, with the use of towers.[2]

Approximately 100 cities in the US, including Philadelphia, have announced that they will install citywide Wi-Fi networks for its inhabitants. The increases in technological improvement, makes these citywide networks more achievable. In addition, there are three major elements that will drive future Wi-Fi growth: (1) demand, 70-80% of all new laptop computers are equipped with Fi-Wi chips. This means more than 50 million computers will have potential access to network “hotspot” nodes throughout the world; (2) interoperability within the a, b, & g standards, provide added assurance that equipment purchased today will not be obsolete tomorrow; and (3) enterprise Wi-Fi alliance providers are providing a supply of affordable, reliable equipment that is giving confidence to the marketplace. Wi-Fi infrastructure revenue are expected to reach $5.2 billion in 2005, according to Telecommunications Industry Association’s annual 2005 publication. However, there is a remaining growth challenge and that is security. The first security standard was not adequate and while it has been modified with some success, the user market needs to feel secure in making wireless transactions. The following chart shows a specific 802.11i security solution that may have merit in the marketplace.

Figure 2



Source: Radius, http://www.nwfusion.com/news/tech/2005/032805techupdate.html

2.2 WiMAX

Short for Worldwide Interoperability for Microwave Access, WiMAX is a promising wireless broadband technology. Able to use licensed and unlicensed frequencies, WiMAX can operate on a point-to-point basis with ~30Mb/s over distances of 30 kilometers. It can use omni- or multi-directional antennas to provide broadband coverage to small towns and rural areas. It also holds great promise as the "last mile" broadband technology. WiMAX can be compatible with Wi-Fi and other wireless and wired networks. In the US, the FCC has recently allocated 35Mb/s in the 3.65-3.70 GHz band for WiMAX, which seems to be a generally agreed segment of spectrum by many other countries. Although Singapore has allocated 30MHz of spectrum in the 2.5GHz band to support a broadband wireless and fixed wireless services in that nation. The WiMAX IEEE 802.16-2004 standard has been approved and the mobile WiMAX standard IEEE 802.16e, due for approval in October, 2005, provides wireless broadband connectivity without base station line-of-sight. The mobile standard will provide Internet connection from fast moving cars and trains—faster than today's cellular-based technologies. US mobile WiMAX vendors want an allocation in the 2.5GHz band similar to Singapore, as well as unlicensed spectrum in the 5GHz band. While the standards are being understood, equipment suppliers are making handset chips and base station equipment that is less expensive than cellular. WiMAX will compete with cellular providers, especially the 3G carriers. Spectrum and equipment costs are being shown to be much less than 3G. For example, the Singapore developer paid S$2 million for the WiMAX spectrum rights, a fraction of the S$100 million paid by mobile operators for the 3G rights in Singapore. Mauritius**,** an Indian Ocean island of 1.2 million people, announced it would be the first unwired WiMAX nation. WiMAX test beds are operating in many nations including England and Austria. A Japanese developer has recently announced a WiMAX network for Tokyo. The wireless revolution synergy is showing WiMAX-based VoIP (voice over IP) networks to be superior to many other broadband wireless technologies, as built-in Quality of Service and IP compatibility will attract vendors and users. A research firm, Strategy Analytics, estimated that there will be 20 million fixed WiMAX installations by 2009. This proposed growth makes the technology a success. Mobile WiMAX may be more difficult to adapt in the early years of the technology, but analysts say that it will see outstanding growth as well, but after 2010. Eventually, WiMAX advocates hope to see the standard evolve into a mobile wireless Internet service similar to cellular data technologies such as EvDO (Evolution Data Only).

2.3 Ultra Wide-Band

Ultra Wide-Band, (UWB), a promising short-range, high-rate wireless technology, has unfortunately been engulfed in a standards battle within the IEEE 802.15.3a task group. Two rival groups the WiMedia Alliance and a Freescale-led group have been deadlocked for over a year, and ultimately failed to achieve a common UWB standard. Both sides are now making equipment based on their uncommon designs. These differences may have killed weaker technologies, however, both are predicting success and a third vendor has already developed a chip that is interoperable between the two designs. UWB utilizes a wide (1 GHz or more) frequency spectrum of the 7.5GHz allocated by the FCC in the 3.1 to 10.6 GHz band. Sometimes called personal area networking (PAN), UWB can tradeoff data rate and distance, for example, proposed specifications include 110 Mb/s at 10 meters, or 480 Mb/s at 1 meter. In addition, research groups are claiming 1.2Gb/s over 25 meters through interior walls. Also known as "impulse radio," ultra wideband radio transmissions spread a wide spectrum with short, 100-picosecond pulses that flow below the noise floor of conventional radio receivers. The technology is especially liked by the military that have developed the technology so it is nearly impossible to detect, intercept or jam. The US FCC recently approved a second UWB chip set for wireless radio systems. Spectral keying UWB allows the combining of impulse radio architectures with multiple, independent frequency bands. The chip set vendor claims to be able to provide error-free streaming video up to 15 meters through normal interior walls, even in high multi-path environments. A second use of UWB technologies is for “through-the-wall radar” as the pico second pulses penetrate most walls except solid metal. Fire and disaster responders are using first generation equipment to scan homes for victims. The military is also using the radar technology for security purposes. This low power, low interference technology is finding foes, however, that claim the interference will be an eventual problem. The aviation airport guidance community seems to be the loudest foe of the standard. These foes may restrict the growth of this technology, but will not be able to stifle it completely.

2.4 Bluetooth, Zigbee, Etc.

There are a number of high data rate, low distance technologies, that have good application around the home and factory floor, connecting appliances and sensors. The Bluetooth standard has gotten complicated and some critics have written off the specific technology, while looking closely at similar replacements. Supporters, however, show that 63 million Bluetooth chip sets were sold in 2003 and 250 million chips are expected to be sold in 2005. These devices can be especially useful in industrial structures like power plants where running wires are difficult. But applications are showing up in credit card machines, autos and wireless earphones, with the conclusion that some type of this technology will find itself into the future wireless revolution. There is a group within the IEEE 802 standards group that is conducting R&D somewhere between active RFID and ZigBee specifications that provide communications and high-precision, sub-1-meter ranging and location capability, high aggregate throughput and ultra-low power.[3] Whatever technology is developed must also be scalable in data rate, range, power consumption and cost. The group is looking hard into impulse or direct-sequence UWB, but alternative technologies such as near-field ranging and "chirp" spread-spectrum radio are also being researched. Again, these technologies will fit well into the synergy with RFID sensors. The educated conclusion is that some type of this technology will find a good market position in the future wireless revolution.

2.5 Wireless Voice over IP (wVoIP)

Voice over IP is causing a real disruption in the way the wired communications carriers provide services. Businesses and large enterprises are equipping their employees with VoIP phones with significant savings to their bundled communications costs. In the same way, wireless VoIP will change the cost and service structure of the large cellular carriers. The combination of Wi-Fi and WiMAX with VoIP will allow any number of companies to launch inexpensive mobile voice services. This author, for many years, has predicted that future smart phones will have the capability to search for the least expensive and most efficient network. Your phone, having technologies such as Unlicensed Mobile Access (UMA) will search for Wi-Fi, possibly WiMAX, IEEE 802.20 Mobile Broadband Wireless Access (MBWA), UWB cellular networks, high-altitude platforms and satellites until its finds the most cost effective path for its transmission. Wireless—wired interface technologies will provide the user with connections into wireless or wired networks, again, driven by cost considerations.

2.6 High-frequency Wireless

Spurred by the available bandwidth, with the associated potential to allow data rates of up to 2 Gbp/s, the FCC in 2001 allocated 7 GHz in the 57- to 64-GHz band for unlicensed use. That action, combined with advances in process technologies and wireless communications techniques, bought about a new interest in a region of the spectrum once reserved for expensive point-to-point links. Now that region is being seen as prime property for next-generation wireless personal-area networks and backbone nets.[4]

2.7 Radio Frequency Identification

Of all the technologies in the new wireless revolution, Radio Frequency Identification (RFID) will probably produce the greatest change in our world. There have been industrial sensors working for many years, but most are different in design and cost and most communicate the output of the sensor in complex wired networks. Now we are seeing low-cost RFID devices, working as a single sensor and/or aligned wirelessly with other sensors, all synchronized in a computer controlled wireless smart network. The sensors can track quantities and qualities of things—their heat, movement and even look for probabilistic changes in things. Or to keep the sensors low cost, computers along the network can monitor very small changes in the sensor data and make the probabilistic calculation at that point in the network. These sensor driven networks will have major changes in our commercial supply lines, as they will be able to track the movement of commerce in details that we are now only imagining. RFID started as a sophisticated upgrade to barcodes, with large retailers calling for improved methods of tracking the movements of their goods. Then, the wireless synergy took place and the sensors, now made on a single chip, many the size of a grain of sand, found new, complimentary networks with computing and storage devices all interoperating in a low cost design that will find strong acceptance in the marketplace. New applications are finding quick approval. One manufacturer sews sensors into the sleeping clothes of children and an alarm will sound if the children wander or are taken out of their room. The US government has mandated a new drivers license that will be able to be readable. Some countries have already incorporated RFID sensors into its passports. This author believes that in the name of global security all individuals will, in the future, be required to carry, wear or be embedded with some type of a RFID device.

2.8 Wireless Networks

The wireless synergy will need smart network technologies that collect and carry the increasing amount of digital data that will come from sensors, phones, computers and many other sources. Most networks currently work with ten or perhaps hundreds of nodes, however, the future proliferation of low cost sensors and low power communications devices will require networks to handle thousands of nodes. A new mesh enabled architecture is allowing the explosion of wireless mesh networks that don't require towers and have the potential of bringing communications much closer to the user. One type of mesh network , normally in a WLAN, will scan for the nearest computer or phone to carry the network along. Using Wi-Fi devices, these nodes will be aligned in a mesh architecture to carry the network. Dual channel devices allow one channel to be used to communicate while the second channel works as the backbone for the network. A number of technologies like smart antennas and agile radios, working in a synergy with mesh networks, not only eliminate the expense of towers but provide the most efficient and cost effective communications for the consumer. The military is currently working on a agile radio system that uses six frequency bands and allows the system to seek the most efficient route for the traffic request it has queuing in the system. This radio system can hop in and out of empty spaces in the spectrum, operating in a variety of different bands, in spaces nobody else is using.[5] This is especially important as critics of the tight, expensive spectrum, as mentioned above, are monitoring the spectrum and will be able to provide data to the FCC and the NTIA on the amount of spectrum available at any given time, not only in cities like Washington, DC, but in the smaller cities and less populated areas as well. The use of the unlicensed frequencies in the wireless mainstream will bring about a global review of the current costs being charged for spectrum, especially for the 3g frequencies. These 2g and 3g vendors are not going to be competitive in the marketplace, when other vendors are offering similar services with spectrum that is free or only a small percentage of the 3g frequencies.

2.9 High Altitude Platforms (HAPS)

While this technology has not currently demonstrated its capabilities and rumors of its "killer application" qualities have not yet been displayed. Nevertheless, a number of companies are designing and building platforms that are planned to be able to hover over one area of the globe at altitudes from 18 – 25, 000 meters. At these altitudes, the platforms, manned or unmanned—balloons or glider type aircraft, can provide large service areas with different types of two-way wireless communications and broadcast type information. The following chart, Figure 3, shows one candidate that has been built and is entering its test and demonstration phase. Certainly the value of a platform would be very high, that could be positioned over a disaster area, like hurricane Katrina, and support disrupted wireless networks.

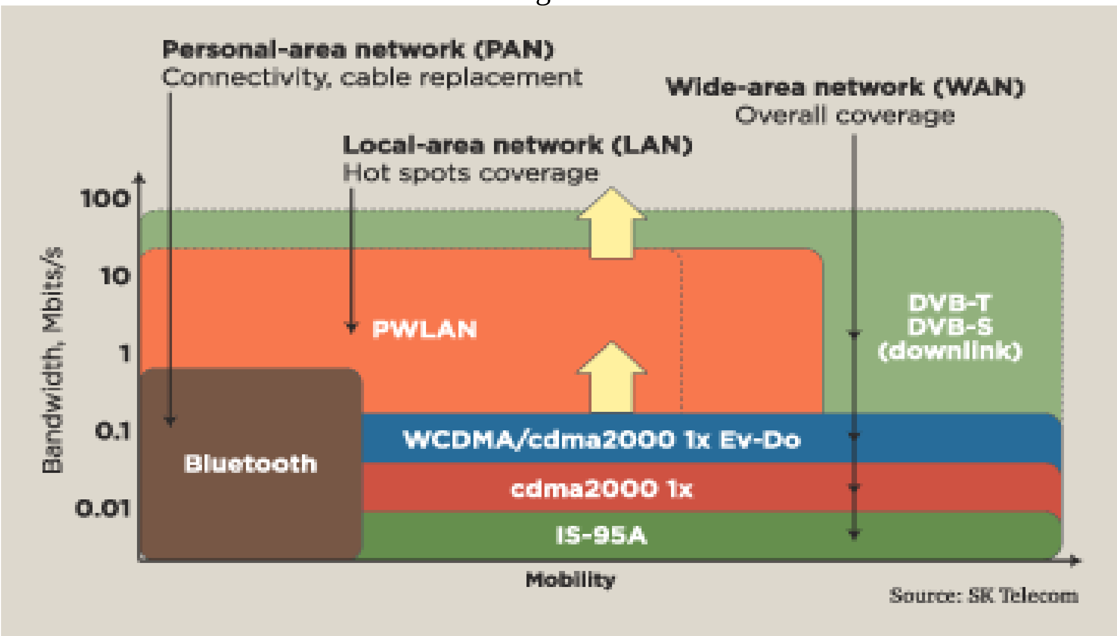
Figure 3

3.0 SATELLITES

Communications satellites were in the 1970s and 1980s the most used wireless technology. Traditional two-way satellite communications experienced a slow down along with the general communications slow down in the early years of this decade. The US military is now using expanded satellite capacity for its activities in the Middle-east. A single unmanned reconnaissance plane transmits data at hundreds of megabits. Also, traditional point-to-multipoint transmissions are seeing good growth, especially in the broadcast mode. The radio direct broadcast systems have experienced outstanding growth with numerous agreements tied to auto manufacturers and specialty broadcasters. With the current wireless revolution, the multipoint-to-point technologies are poised to see new growth. The proliferation of sensors will see low cost terminals, especially in rural areas, being used to transfer the data to a central facility. Broadband satellite vendors have developed the Internet Protocol over Satellite (IPoS) standard for markets through the world. One vendor has an operational platform that is able to support more than 35 simultaneous accelerated TCP sessions, more than 45 Mb/s of multicast traffic, over 10 Mb/s of UDP throughput and more than two

Mb/s of accelerated HTTP throughput. The keys to this wireless growth will be the efficiency of the network and the cost of the terminals. The point-of-sale industry, like gas stations, has moved the technology forward, but another factor in two-way, low cost terminals are needed to move satellites into the current wireless synergy. The final chart, Figure 4, shows the wireless revolution from low-bandwidth and data rate systems to personal WLANs using the 802.11 technologies, to the current 3G cellular and satellite (DVB-S) systems that compete for the greatest mobility.

Figure 4



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