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International Journal Of Engineering And Computer Science ISSN:2319-7242
Volume 2 Issue 4 April, 2013 Page No. 1023 -1027

Mobile Wireless Networks :Challenges

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Abstract

We are seeing demand for broadband services is continuously exploding. So, mobile wireless networks must expand greatly their capacities. Here we are reviewing the economic and technical challenges associated with wireless networks to meet this exploding demand. The paper first reviews a brief technical background on mobile wireless networks and these basic methods to deepen their capacity. We can divide the Methods of capacity expansion into three general categories: the deployment of more radio spectrum; more intensive geographic reuse of spectrum; by increasing the capacity of each MHz of spectrum within a given geographic area. We find that without significantly increased allocations of spectrum, wireless capacity expansion will be wholly inadequate to accommodate expected demand growth.

1. Overview

The purpose of this paper is to describe and quantify the challenges particularly associated with wireless network “deepening”. This includes an analysis of the technical issues concerning what techniques for capacity deepening are feasible, and also consideration of the costs of these techniques to determine the economic capability of these techniques to keep up with growing demand. In February 2013, Cisco released the Cisco VNI Global Mobile Data Traffic Forecast, 2012 - 2017. Highlights from the updated research include the following projections:

By 2017, global mobile data traffic will reach 11.2 exabyte per month (134 exabytes annually); growing 13-fold from 2012 to 2017. [The *exabyte* (derived from the SI prefix exa-) is a unit of information or computer storage equal to one quintillion bytes (short scale).]

By 2017, mobile video will represent 66% of all mobile data traffic.

By 2017, 45% of global mobile data traffic will be offloaded to fixed networks.

By 2017, tablets will account for more than 12% of global mobile data traffic.

By 2017, 4G connections will account for 45% of global mobile data traffic.

While in many parts of the world, significant portions of expansion in mobile wireless network capacity will continue to be due to expansions in the geographic coverage of wireless data networks, in developed countries such as the U.S., advanced mobile broadband networks already cover 98.5% of potential subscribers. So, the Demand for mobile wireless services continues to explode.One of the hottest topics in the mobile industry is the need for more capacity to serve the growing quantities of data emerging from 3G-connected devices like iPhones, iPads, Android devices and 3G modems. Some commentators are keen to paint this as a crisis, leading to the imminent collapse of mobile networks. We have taken a more sober look at the available capacity options and concluded there is scope to meet the demand now and in the future. Thus, the expansion of mobile wireless networks is necessary to accommodate demand growth in developed countries. And it will be focused most greatly on "deepening" network capacities.This paper will be providing a brief technical background on how mobile wireless capacity can be measured, and the basic challenges that may be faced while expand mobile wireless capacity. In which it includes increasing raw amounts of available radio spectrum, increasing the absolute carrying capacity of each MHz of spectrum, reducing the bandwidth required to carry popular applications and increasing the utilization of each MHz of spectrum or unit of infrastructure through cell-splitting, sharing or multiple use.

2. Mobile wireless network basics

Modern mobile wireless networks are hybrids of wireless and wireline links. Within a "last-mile" local area (often called a "cell"), the network uses radio waves to convey signals between a cell site or tower and the mobile customer's wireless device. High capacity wireline facilities are also used to link these regional mobile network facilities with fixed telecommunications networks or with mobile network facilities in other regions. The carrying capacity of a mobile wireless system is the total amount of data or voice traffic that the system is able to transfer to and from customers. For data traffic, this is commonly measured in bytes. These bytes divide into two categories: user data and radio network overheads.

The former are data that actually are transferred from the originating user to the receiving user. The latter are data that are "consumed" by the radio network for the purpose of enabling and managing the user data flows. Wireless data are carried by radio waves. Such waves undulate with a periodicity (i.e., frequency) measured in Hertz (Hz) or cycles per second. These radio waves are made to carry data by modulating or distorting them from otherwise uniform patterns.Thus, one pattern of distortion may be employed as code for a digital "zero," while another distortion pattern may be code for a digital "one." The more waves a system can modulate in a second, the more coded zeros or ones it can send, or we can say more the data.

The quantity of waves (or amount of spectrum) a wireless system is allowed to modulate each second is called its bandwidth, and is measured in Hz. Everything else equal, a signal with a higher bandwidth (i.e., more Hz) can carry more data per second than a signal of lower bandwidth (i.e., less Hz). The total amount of data that a network may transfer over a given period of time relates closely to the rate at which it transfers data bytes. All things equal, a "faster" network will transfer more bytes than a "slower" network. Rates of data transfer are measured in terms of bits per second (bps).Note,the transmission medium used for wireless (i.e., the air) is much less protected against outside interferers or other signal impairments than the copper or fiber cables that constitute wireline transmission media. The second challenge comes from mobility. When a signal source or receiver is moving, this not only creates additional sources of signal degradation, but degradations that are constantly changing. Each of these challenges makes it less assured that a bit sent across the airwaves will be received as accurately as a bit sent through a cable. As a result, to achieve a given level of accurate throughput, more overhead bytes are required by wireless networks than by wireline networks.

Perhaps the most well-known way for cellular networks to increase the amount of data they carry is by dividing or splitting cells to reduce cell size, and thus increase the number of cells serving a given area. This is done by deploying more radio towers/antennas and shrinking the reach of each tower by reducing the radiated power of its radio transmissions. By doing so, radio spectrum may be "reused" for multiple simultaneous transmissions within a larger geographic area, rather than just one. Thus by subdividing cells, the amount of traffic that a Hz of spectrum can carry within an overall geographic area (measured by bps/km square) is increased. But while very effective at deepening wireless network capacity, this method is also expensive – requiring the construction of extra towers/antennas, deploying more radios and base station equipment; as well as extending additional backhaul links to link new towers back into the mobile operator's core network.

3. Challenges

Network failure. It is of greater concern in mobile computing than in traditional computing because wireless communication is so susceptible to disconnection. Designers must decide whether to spend available resources on the network, trying to prevent disconnections, or to spend them trying to enable systems to cope with disconnections more gracefully and work around them where possible.The more autonomous a mobile computer, the better it can tolerate network disconnection. For example, certain applications can reduce communication by running entirely locally on the mobile unit rather than by splitting the application and the user interface across the network. In environments with frequent disconnections, it is better for a mobile device to operate as a stand-alone computer than as a portable terminal

*Low bandwidth.*Mobile computing designs need to reflect a greater concern for bandwidth consumption and constraints than do designs for stationary computing. Wireless networks deliver lower bandwidth than wired networks: cutting edge products for portable wireless communication achieve only 1 megabit per second for infrared communication, 2 Mbps for radio communication, while Ethernet provides 10 Mbps, fast Ethernet and FDDI 100 Mbps, and ATM (asynchronous transfer mode) 155 Mbps. Network bandwidth is divided among the users sharing a cell. The deliverable bandwidth per user, therefore, is an important measure of network capacity in addition to the raw transmission bandwidth. But because this measure depends on the size and distribution of a user population. Weiser and others recommend measuring a wireless network's capacity by its bandwidth per cubic meter.Improving network capacity means installing more wireless cells to service a user population. There are two ways to do this: overlap cells on different wavelengths, or reduce transmission ranges so that more cells fit in a given area. The scalability of first technique is limited because the electromagnetic spectrum available for public consumption is scarce. The second technique is generally preferred, it is arguably simpler, reduces power requirements, and may decrease signal corruption because there are fewer objects in the environment to interact with. Also, it involves a hardware trade-off between bandwidth and coverage area: transceivers covering less area can achieve higher bandwidths.

Mobility. The ability to change locations while connected to the network increases the volatility of some information. Certain data considered static for stationary computing becomes dynamic for mobile computing. For example, a stationary computer can be configured statically to prefer the nearest server, but a mobile computer needs a mechanism for determining which server to use. As volatility increases, cost-benefit trade-off points shift, calling for approximate modifications in the design. For example, a high volatility data object has fewer uses per modifications. For such objects it makes little sense to cache the data. However, even where such methods exist, they may be ill-suited for the dynamism of mobile computing. Mobility introduces several problems: A mobile computer's network address changes dynamically, its current location affects configuration parameters as well as answers to user queries, and the communication path grows, as it wanders away from a nearby server

4. The solutions….?

4.1 Spectrum is an essential input and more is needed.

Access to appropriate radios pectrumisa clearly an essential asset for any wireless service .If the quantity of spectrum available to an operator is increased, inprinciple the available capacity increases directly without any need to add additional cell sites. In practice, however, spectrum is not an eutral resource. The particular choice of frequency band relates directly to the globale conomies of scale which determine whether user devices are available in and price points to be attractive. Although regulator sincrea singly make spectrum available on a 'liberalized' or technology neutral basis, in practice market forces mean that there is a close mapping between frequency band sand technologies :in Europe, for example, use of the 800MHz and 2.6GHzb and sessentially dictates the use of LTE(both bands) and/or WiMAX (2.6GHz) with no support from existing 3Gequipment, despite the inclusion of these band sin the 3Gst and ards. Further, the specific frequency band impacts directly on the economics of network roll-out. From a capacity view point, provided interference is carefully managed, 1Hzof spectrum delivers essentially the same capacity in any frequency band. However, interference management may be more challenging at lower frequencies, requiring larger antennas and more careful site optimisation.

Over whelmingly, the number of sites required to deliver cover age at lower frequencies (lessthan1GHz) is much lower than at higher frequencies (Figure1). When combined with a sufficient total quantity of spectrum–which typically requires use of some higher frequency bands–operators can roll out initially at lowcost and build up capacity progressively as demand evolves. However, this will only help with capacity if users can be equipped with devices which support the relevant frequency band sand technologies in time to meet the demand .So operators need the *right* spectrum at the *right* time. Finally, the big down side ofusing spectrum to ease capacity bottle necks is that changes in spectrum are slow to implement, and are subject to regulatory and commercial forces beyond the operator's control, while also introducing competitive threats for the operators (and potentially the burden of expenditure on multiple similar networks for consumers). In many cases this introduces delays which mean the major spectrum changes may only serve significant proportion soft he overall demand beyond 2015

Some governments have recognized the need to take action to introduce more spectrums. In June 2010 President Barack Obama committed the US federal government to auctioning of f500MHz of federal and commercial spectrum–over ten years. In a strikingly similar announcement, in October 2010 the UK Chancellor of the Exchequer announce dplanstore lease at least 500MHz of public sector spectrum for mobile Communication uses. While such evolution is welcome asalong-term opportunity for additional capacity, it should be noted that the federal/public sector spectrum which is the main source of new spectrum is not harmonized in any of the relevant standards at this stage.

4.2 Installing more cells allows capacity to grow almost without limit and improves user experience substantially, but requires a cheaper small cell network topology and a new delivery model The evolution of mobile standards between generations, from 2G and on to 3G and 3.5Ghas seen very substantial growth in the available spectrum efficiencies and has done much to allow huge capacity increases without the use of substantial new spectrum. It would be natural to expect another generation of technology to achieve a similar step forward. Both LTE and Wi MAX technologies, via the use of MIMO antennas OFDMA access schemes and flexible modulation and coding schemes do indeed achieve spectrum efficiencygainsover3GandLTE-Advanced and WiMAX2 are slated to achieve a further increment. However , the gains are slowing with time with each successive generation of technology (Figure2). Although further gains can in principle be achieved with additional antennas for MIMO and advanced technologies such as coordinated multipoint transmission (Co MP), these gains have to be weighed carefully against the associated costs and the practicality of cost and space in user devices.

FIGURES:

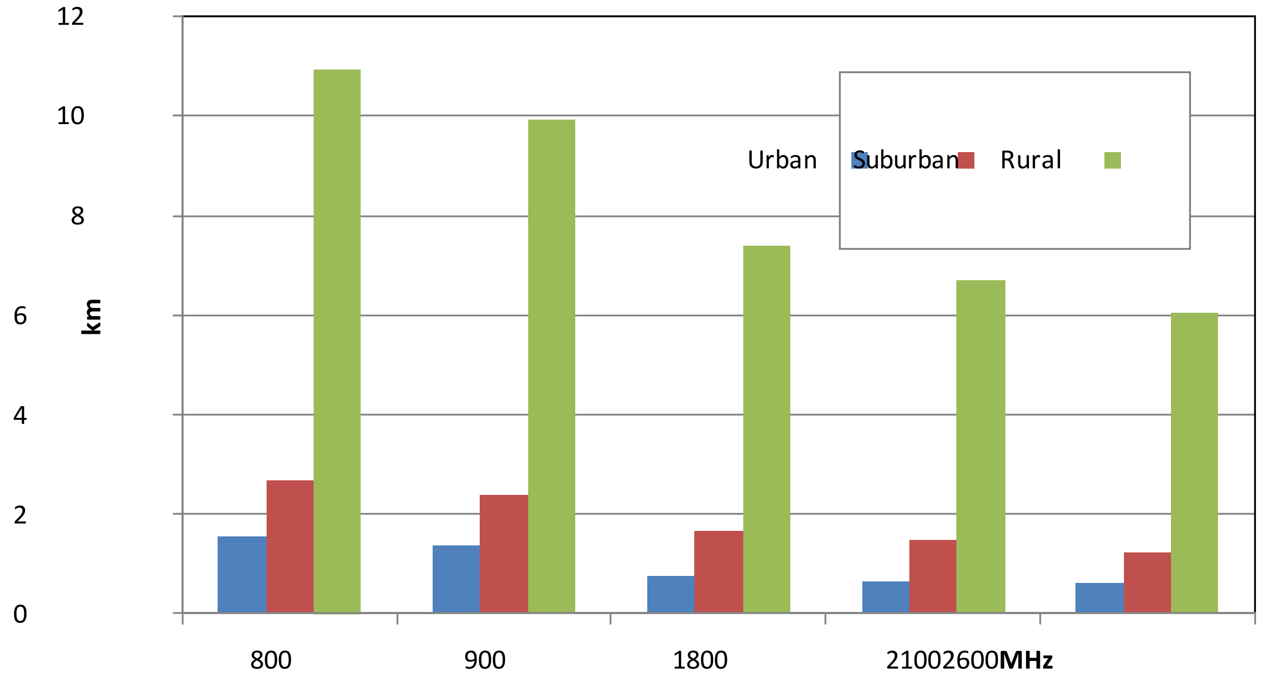

Figure1:Comparative LTEmacrocell coverageradiusforequivalentservice qualitydepending onfrequency bandand environment

Source:Qualcomm

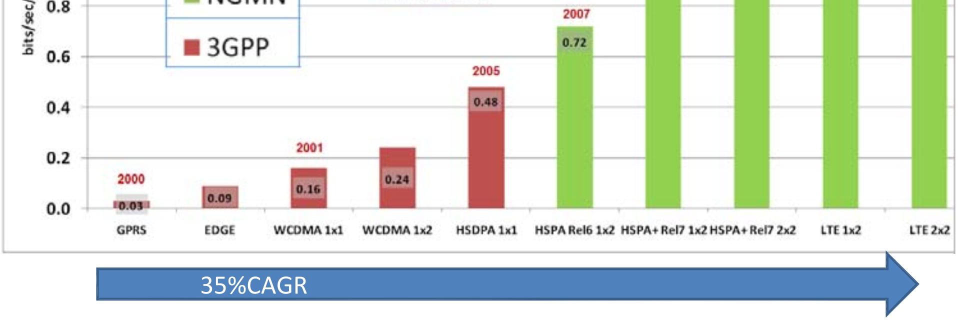

Figure 2: **Growthof spectrum efficiency amongst3GPPtechnologies**(Source:Qualcomm)

Conclusions:

The mobile-wireless industry is experiencing tremendous success, yet its very success is undermining its ability to deliver a consistent, reliable trouble-free experience. As the number of users increases with ever more demanding applications, it is inevitable that there will be more cases in which the volume of traffic in different coverage areas exceeds capacity, resulting in congested operation. More efficient applications not only reduce the likelihood of congestion occurring in the first place, but they also are inherently more resilient, since they require less time and data to operate. They also reduce battery consumption, and most importantly for users, reduce costs, especially with usage-based pricing plans.

Beyond user benefits, greater application efficiency results in significant savings for operators including lower costs in the radio network, lower costs in backhaul, lower infrastructure costs and the need for less new spectrum.

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