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Wireless Communications:
Is the Future Playing Out as Predicted?

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ABSTRACT

Much of the rationale for the launch of 3G networks from 2000 onwards was to promote the expected rise in wireless data usage. Consumers were predicted to make widespread use of mobile internet and mobile TV but it was felt that the data rates offered by 2G networks were insufficiently fast to give them the experience that they expected. But more recently success has been achieved with different types of phone such as the iPhone and with new applications rather than higher data rates. This article takes a look at predictions of the future, considers whether they need to be modified in the light of events and makes its own suggestions as to where things might go from here.

Keywords: Cognitive Radio; Mesh Networking; Smart Antennas; Software Defined Radio

INTRODUCTION

In late 2007, arguably, the mobile internet arrived. A new phone was launched with which users generated 50 times more data traffic than the average. But this dramatic increase in data traffic was not based on higher speed access – indeed, the phone was not even capable of accessing 3G networks. The phone, of course, was Apple's iPhone, and the increased data usage came about because of the superior user interface. The success of the iPhone demonstrated clearly that it was not insufficient data rates that were discouraging the use of wireless data; it was the ease of use and practicality of small devices.

And yet, despite this clear evidence, the industry continues to focus on ever higher data rates – spending much time and effort debating 4G, LTE, WiMax and others and showing charts predicting data rates in the region of 100Mbits/s. We predicted in our book that this was completely unnecessary. In this article we will take a look at why this is, how the industry has developed over the last two years and where we predict it is going.

Understanding Technological Progress

One of the key drivers of the future is technological change. Understanding how technology might evolve over the next two decades is therefore one of the key components of making any prediction. Equally, though, it is easy to get carried away. Just because something

is technically possible does not necessarily mean that it will happen – video calling has been technically possible for decades and yet is still very rarely used. In essence, a new service cannot happen until it is technically viable but it must also be economic and become socially accepted. For example, controlling the home heating system remotely from a cell phone is technically simple but the cost of installing wireless heating control systems is currently much higher than the utility many would perceive to get from moving from the current systems to one that can be remotely controlled. Video calling is both technically possible and, for users with broadband connections and PCs, inexpensive, but has not yet become socially acceptable and hence is not in widespread use.

There are two key ways to predict technological progress. One is through broad trends, making use of physical and empirical laws such as Moore's law. The other is to look at specific technologies that are currently in the research stage and ask how long it will take for them to become commercial propositions and what impact they might have. Both approaches are discussed below.

The Laws

Shannon's Law (Shannon, 1948, 1949). This is more of a physical limit than an empirical law. It sets out the capacity of a single channel in the presence of noise. While directly applicable to wired connections, it cannot be easily applied to wireless systems where frequencies can be reused in neighbouring areas. Much work is underway to estimate the maximum capacity of a wireless network with a given spectrum allocation and number of cells and results vary depending on the approach taken. However, it seems likely that we are within a factor of 10 of the maximum we can achieve, and may well be much closer than that in practice – perhaps as close as a factor of 3. Hence, there is little room for technological breakthroughs that dramatically increase the capacity per cell. However, as will be explained shortly, this can be circumvented simply by increasing the number of cells.

Moore's Law (www.intel.com). Easily the most well-known of the empirical laws, this predicts that the number of transistors that can be placed on a chip will double every 12-18 months (in practice it has been doubling every 24 months). The implications for wireless of this are mixed. It does imply that handsets will continue to increase in memory and processing power. However, as we approach the limits of what is possible over wireless channels, massive increases in processing are needed for even small gains in capacity.

Cooper's Law (www.arraycomm.com). This is a most intriguing prediction that notes that the number of wireless voice channels in the world doubles around every 30 months, and has done so since 1901. What is most interesting is that of the million-times improvement that has occurred since 1950 roughly 15 times was the result of being able to use more spectrum (3 GHz vs. 150 MHz) and five times was from using frequency division, that is, the ability to divide the radio spectrum into narrower slices (25-kHz channels vs. 120-kHz channels). Modulation techniques (such as FM, single sideband, time-division multiplexing, and various approaches to spread spectrum) can take credit for another five times or so. But the lion's share of the improvement - a factor of about 2,700 – Cooper suggested was the result of effectively confining individual conversations to smaller and smaller areas by spatial division or spectrum re-use. Again, this gives us a pointer that smaller cells may well be more important in the future than any "wonder" technology.

Edholm's Law (Cherry, 2004). Edholm pointed out that data rates over wired and wireless networks increase over time. Wired networks typically support data rates about two orders of magnitude (ie a hundred times) greater than wireless. While wireless improves steadily over time so does wired making convergence between them unlikely. This suggests that wireless will not replace wired networks where high speed is needed, although it may