Some Critical Issues for the Evolution of Wireless

Markets, Regulation, Technology: What is Pulling the Wagon?

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Abstract

This paper addresses several "issues" which relate to the evolution of wireless, in the Unites States and in Europe and Asia. The issues fall into four categories; markets, regulatory, technology, and industry structure. The wireless evolution may be about to change in a more rapid fashion given what may be occurring on all four of these landscapes. The intent of this paper is to structure those landscapes, articulate the most visible issues and prognosticate possible implications.

Contents

1 The Telmarc Group, LLC. Presented at Columbia University, May 28, 2003 for Ericsson Conference.

1. INTRODUCTION

This paper is a working paper focusing on key elements of the evolving wireless landscape and it addresses issue which may arise in each of four key sectors; technology, markets, regulatory and industry structure. The intent of this paper is to address what the issues are and then to attempt to provide a logical analysis of the implications and possible outcomes.

Wireless has made great strides over the past twenty years. That time frame is important since in the last twenty years we have seen the introduction of cellular, or mobile if you are non-American, wireless data, and now the current hype of WiFi, or 802.11. Before commencing on the analysis of issues it is worth a brief reminder of what has happened or is happening in each of these areas:

Voice; Cellular or Mobile: In 1984 there was analogy cellular. Then in the late 80s the battle between TDMA and CDMA began in the US. In a similar fashion Europe focused on a single standard, now GSM, a TDMA variant which was feature rich. Today, one cal make a call from almost anywhere in Europe, from the Urals to the Portuguese coast, in ski resorts, small Czech towns on the Austrian border, or in mid town Paris. In contrast in New York on 57th street, after almost twenty years you can place a call about half the time! It was easier before cellular. The question may possibly be why, but at this point it is irrelevant, other forces are overcoming this issue.

Wireless Data: In 1984 Motorola delivered a system, latter called ARDIS, to IBM to assist IBM field services to more effectively deal with their customers. The almost 10 pound block called the KDT terminal allowed a packetized data stream to but at multi Megabit rates on a shared data backbone. This evolved to RAM Mobile, then CDPD in the early 90s, and today there are variants of wireless data provided by the cellular or mobile carriers but not rally that much. The question is why? Technology, demand, regulation, or what?

WiFi and its Descendents: The current technology rage is WiFi, or 802.11. This is a technological approach to data which has short range, and works in shared spectrum, which is subject to many debilitating threats to long term viability, that it may be questionable. Is WiFi extensible, scaleable, cost effective? There are many questions, but what seems clear is that there is a data demand, but at what price and what cost?

One can look at wireless as another way to deliver voice, data and possibly video. One may recall the Negroponte structure wherein about ten years ago he suggested that all broadcast would be over fiber and all data and voice over wireless. Is that truly the way to the evolution. Is there any threat from fiber, moreover a fiber to the home, FTTH, or is wireless able to co-habit with that technology?

Is wireless primarily technology driven. Simply stated, given enough spectrum at the right place, we can do anything; who is the "we" and what are the things being demanded.

The regulatory environment is also quite a mess. Spectrum has gone through the auction process, which has in many ways been a disaster. In the US Nextwave still has the spectrum it "won" at one tenth of what it bid, and has not put it to use. The dominant cellular carriers are now agreeing to swap spectrum for use amongst each others and similarly well sanctified parties of their choosing. In effect the FCCs desire to open spectrum has actually ended in closing the spectrum gates, so what else is new.

2. MARKET ISSUES

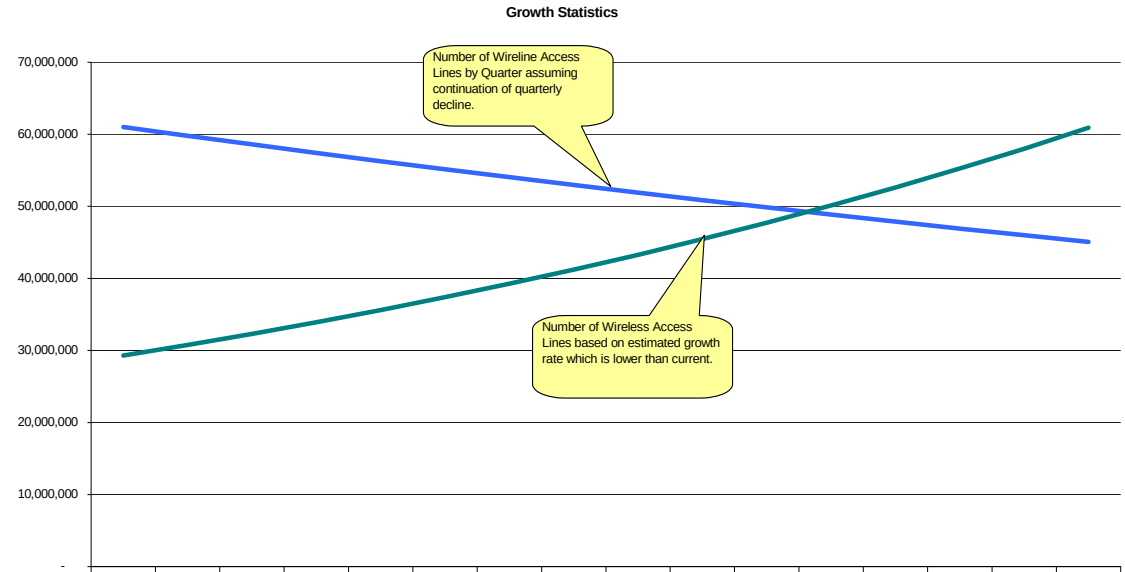
The first set of issues are the market issues; what does the end user want. The market issues are frequently the most important. However, in this paper we recognize the delaying and potentially confusing elements of the regulatory issues and the exogenous factors which are compelling on the side of industry reorganization and consolidation. Thus, in the case of wireless evolution, the market issues are necessary but clearly not sufficient.

2.1 Market Penetration of Wireless

We have just completed several market studies in New England, covering over 200,000 HH and have over 50,000 responses.[2] What cam as a major surprise if the percent of HH who have no wired telephone line, namely they have wireless only. That number is between 8% and 13%. The towns range from those just outside the Boston area, the direct suburbs to those in more remote areas in the southern tier of New Hampshire. People are leaving their wire phones for wireless only. However, they have CATV and use the CATV line for Internet access. The triple play of voice, data, and video is bifurcated in a Negropontean schema; video on cable, voice on wireless, BUT data is also on cable, not Negropontean.

The compelling conclusion is simply that wireless will be overtaking wireline.

If one were to look at Verizon growth rates for wireline and wireless and project them out two years then the wireless lines exceeds the wireline lines in mid 2004. This phenomenon has been seen in Italy where the current mobile phone penetration is twice that of wireline. Although the wireline in Italy was low in terms of penetration, the growth has been in wireless. The quarterly growth rate for cellular have been above 8% but we assume that they drop to only 5% and that the wireline losses which have been in excess of 3% are only 2%. In this world, the following chart depicts the growth and decline.[3]



	Q1 2002	Q2	Q3	Q4	Q1 2003	Q2	Q3	Q4	Q1 2004	Q2	Q3	Q4	Q1 2005	Q2	Q3	Q4
Wireline	61,000,00	59,780,00	58,584,40	57,412,71	56,264,45	55,139,16	54,036,38	52,955,65	51,896,54	50,858,61	49,841,44	48,844,61	47,867,72	46,910,36	45,972,15	45,052,71
Wireless	29,295,00	30,759,75	32,297,73	33,912,62	35,608,25	37,388,66	39,258,10	41,221,00	43,282,05	45,446,16	47,718,46	50,104,39	52,609,61	55,240,09	58,002,09	60,902,20

This begs the question of what do customers want. It appears that they want telephone service like a cellular phone, and they want CATV but more, and they want Internet access but not clear how much broadband, since quite frankly there is little if any. The challenge for a Verizon is to understand what the end-user wants. The risk to Verizon is that they are defending old turf and this is forcing other non-traditional competitors to consider alternatives. The clearest example is the explosive growth of municipal broadband, the unbundling of the local loop in the extreme, with full and complete open access.

[2] Merton Group, LLC market research performed in over 20 towns in Massachusetts and New Hampshire.

[3] It should be noted that Prof. Negroponte several years ago predicted that wireless would be used for narrow band and fiber for broadband. This projection shows how prescient this was. McGarty, in 1992 also stated that wireless when commodicized would be an efficient replacement for the wireline option.

2.2 Expanded Services of Wireless: Data

Wireless has been primarily a voice based service. There have been small in roads with data. The separate data networks still exist. There are companies such as Airvana and others using Qualcomm type technology developing schemes to get 1-2 Mbps type data access. The main driver for new services is Internet access, which in turn can be for personal or business use. The main driver for expanding Internet access is enhanced features such as music, games and video. This means a more broadband environment. The current data provision capabilities for the end users are:

DSL: Maximum of 1.5 – 2 Mbps but throttled to 192 Kbps shared on residential services due to costs of transiting to backbone.

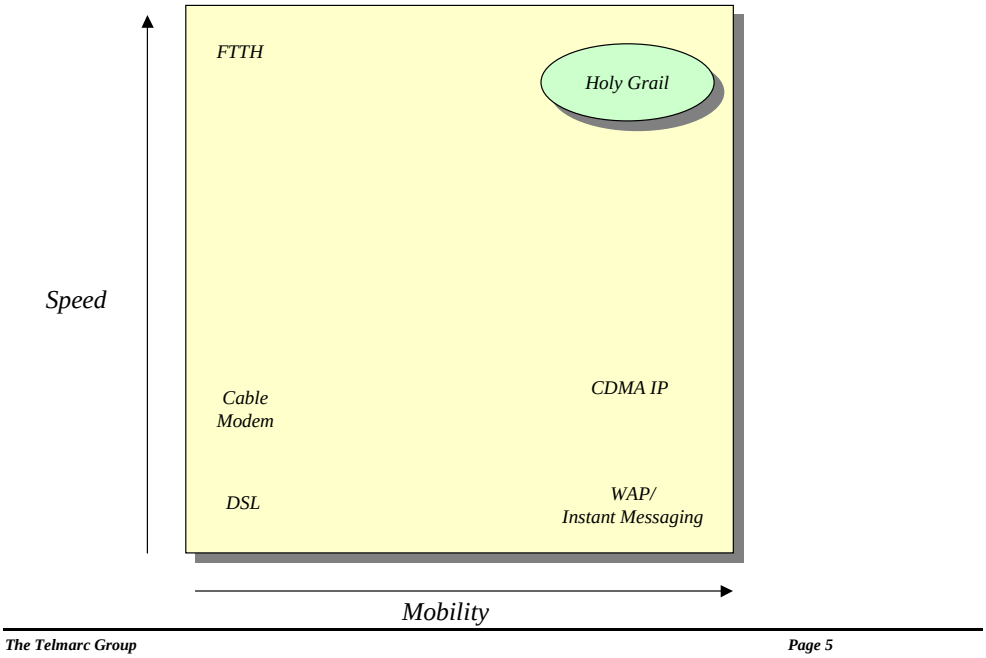
Cable Modems: 1.5 Mbps burst speed but shared amongst N users, typically 10 and resulting in effective throughput of 150-250 Kbps.

FTTH: Fiber to the home, single fiber providing peak of 100 Mbps typically on Giga Bit Ethernet backbones.

CDMA IP Wireless: Using the CDMA flexibility there are several companies with Qualcomm chips sets deploying data backbones which are all IP. The original Qualcomm IS 95 design was IP based and it supported a 1.25 MHz band for access. This is still a narrow band solution. It is implementable and mobile.

WiFi: A catch all for a variety of 802.11 type technologies. The common thread is shared spectrum. This will always be a road block.

The question is what does the end user want and need. FTTH provides speed and access. It lack mobility. WiFi gives speed and limited mobility, 50-100 feet. CDMA type system give modest speed, albeit again shared like cable modems but have significant mobility. The summary is shown below. The high speed, in excess of 10 Mbps, and high mobility, anywhere, is the holy grail of this approach. It currently does not exist. It is technically possible but the spectrum is not available and the fights over the possible standard are severe.



2.3 Pricing Changes

Pricing on wireless has been a slow evolutionary process. It has not seen the rapid declines of long distance. One can argue that long distance saw rapid change because of two main issues: (i) rapid reduction of interconnect, down to less than $0.005 per minute, and (ii) the players in the industry became dominated by non-"Telco" types such as Worldcom and Ebbers. The IECs were compelled to meet growing revenue demands and expectations on growth. This led to price wars, almost always leading to prices being less than costs of service.

In wireless, the first proposal for fixed pricing for unlimited usage was made in 1990, which was $29.95 for unlimited local usage. This was followed by free on weekends and after 7 PM. The current pricing of anywhere roaming by say AT&T gives blocks of minutes for a fixed price. So far the factors which drove suicidal pricing in the LD business have not really emerged in cellular. However, the conditions are ripe for such an evolution. With consolidation, and with the demands to meet debt repayments, revenue growth will be essential and that can only be obtained by more customers. However, the new customers will come at lower revenues which will cause a problem with older customers, it will drive down the entire revenue stream. The answer, hopefully, is trying to bundle added services, still problematic.

2.4 Coverage vs. Capacity

Coverage is the concept of having a cell site "cover" a certain area. It is a power and antenna gain issue. Typically a 600 mw portable can with an FCC approved eirp cell site provide 3-5 mi radius of coverage, depending on topography. The rule of thumb is 3 mi so hat a cell covers approximately 10 sq. mi.

However, there is the capacity issue, namely each cell site has so much spectrum, and this spectrum can handle so many instantaneous calls, depending on the multiple access scheme, and this has now become the dominant factor. For example, on 57th and 5th in New York, I can have four bars one minute and have none

in a second latter, did I loose signal for some strange electromagnetic reason or did all capacity get captured. It was the latter.

The market is demanding more capacity, it is annoyed by bad coverage, more than half of the major highways in the US still remain barren to coverage, but the capacity issue is a major problem. If pricing is driven to fixed for some form of unlimited usage, then as more capex is deployed no more revenue per user is attained! The only way to gain new revenue is to add more users which drives up the need for more CAPEX! This then becomes the deadly cycle of supply and demand.

3. REGULATORY ISSUES

The regulatory issues have been at the forefront of driving wireless. The major fiascos of the bidding process in the mid 90s left a bad taste in everyone's mouth and it was further soured by the 3G bubble in Europe. In the US the major problem now is outright warfare at the FCC amongst the Commissioners, especially the Chairman and the most recent Republican representative. The following are just a few of the current issues which will have long term impacts on wireless.

3.1 Interconnection Fees and Market Growth

Access or interconnection fees are a one way process; the wireless carriers pay the wireline ILECs. This has been based on the less than credible concept of externality theories of economics. That is, the wireless companies needed the wireline since they were the ones who connected to the world. In view of the fact that by January 2004 that will have switched, at last in terms of wireless and wireline access lines, then should one expect the fee to switch to the other direction, Hardly!

What can one expect. What seems like an evolving process is "bill and keep", namely no costs for interconnection between "peers". This is akin to the peeing which has been done amongst the Tier 1 Internet companies, whereby they agree to interconnect at no fee to each other.

What will be the impact of this factor? First will be a dramatic cost of services reduction to the wireless carriers. This may be an incentive for a price war, but given the past experience it is unlikely.

3.2 New Bandwidth Expansion

On May 15, 2003, the FCC took the step to issue new spectrum in the 5.470-5.725 GHz band. This is 255 MHz of spectrum using a shared Part 15 set of rules for management. Namely low eirp or erp emission standards and shared use.[4] The need to deliver broadband with mobility is a driving force. The demand, the coverage, the data rates all dictate the spectrum and architecture. The calculation to determine the goal is simple:

Question: How much bandwidth, what frequency, and how should the bandwidth be allocated amongst whom?

To address this compound question one must address the following issues:

Modulation efficiency is the number of bits per second per Hz which a specific modulation scheme can support. Thus we all want high modulation efficiencies.

Multiple Access: This is a means for many users to access the same spectrum. This is the TDMA, CDMA, XDMA type question. If is a free for all, then all try to gain access subject to the constraint of not having to encumber others. This leads to great inefficiencies. If one player controls the rules then greater efficiency can result.

[4] See FCC Press Release May 15, 2003: "FCC PROPOSES ADDITIONAL SPECTRUM FOR UNLICENSED USE"

Power: The greater the power the greater the range, the higher the modulation efficiency all other things being common, since noise may be just the ambient levels.

The process of getting to closure on these issues is very long and not expected to yield results in the next few years.

3.3 Factoring Bandwidth

In 1996 the Telecommunications Act mandated unbundling by the ILECs. We petitioned the FCC under the Act to unbundle spectrum from the ILEC wireless entities. Four years latter the FCC denied the petition. Last month they reversed themselves for the purpose of doing this for the ILEC dominated wireless carriers. They can now swap spectrum.

In May of 1996, we filed a petition on the behalf of COMAV, a CLEC, which stated:

"The Petitioner (COMAV) requested that Bell Atlantic NYNEX Mobile ("BANM") be required to unbundle its "air time" access and provide the unbundled air time to the Petitioner under the rules that apply to Incumbent LECs as per the Act (Communications Act, as amended, in particular Section 251 of the 1996 Act). The specifics of this request were solely for application in the Commonwealth of Massachusetts, wherein the Petitioner seeks to provide telecommunications services, specifically, exchange access and telephone exchange services, thus being a local exchange carrier.

In this Petition, the Petitioner addresses three issues; (i) clarification of its position regarding the claim for Incumbent unbundling, (ii) interconnection with other CMRS companies, and (iii) the treatment of all licenses CMRS providers as Common Carriers and thus requiring that such entities if they offer themselves as carriers of service under a license from the Commission do so as a Common Carrier and hold themselves and their services out to all who so desire to buy such service in a form as offered to any other party. The Petitioner also specifically states its requests of actions from the Commission.

The Petitioner specifically request that the Commission adjudge the following, applicable in the Commonwealth of Massachusetts, and specifically for the Petitioner only, the following:

1. That an Incumbent LEC's CMRS be considered for the purpose of LEC interconnection as an I-LEC as determined under Section 251 of the Act. Therefore, the CMRS so defined must unbundle the airtime elements available.

2. That any CMRS be required to connect directly with any competitive LEC, not being the I-LEC, and not providing services only as a connection via the I-LEC. Specifically, the Petitioner requests that any CMRS provide trunk connections directly with the C-LEC.

3. That any CMRS be treated as a common carrier and that if the CMRS sells its services as wholesale or otherwise that it do so equally and equitably to any purchaser of services and not "ware house" spectrum or services."

In four and a half years the FCC decided to deny the petition. On May 15, 2003 it reversed itself by stating:[5]

"The spectrum leasing policies adopted in the Report and Order are a landmark step in the Commission's evolution toward greater reliance on the marketplace to expand the scope of available wireless services and devices. These policies will lead to more efficient and dynamic use of the important spectrum resource to the ultimate benefit of consumers throughout the country. Facilitating the development of these secondary markets enhances and complements several of the Commission's major policy initiatives and

5 See FCC Press Release, May 15, 2003 regarding spectrum leasing; "FCC ADOPTS SPECTRUM LEASING RULES AND STREAMLINED PROCESSING FOR LICENSE TRANSFER AND ASSIGNMENT APPLICATIONS, AND PROPOSES FURTHER STEPS TO INCREASE ACCESS TO SPECTRUM THROUGH SECONDARY MARKETS"

public interest objectives, including efforts to encourage the development of broadband services for all Americans, promote increased facilities-based competition among service providers, enhance economic opportunities and access for the provision of communications services by small businesses, and enable development of additional and innovative services in rural areas. Today's order also implements key recommendations of the Spectrum Policy Task Force, which advocated the development of secondary markets mechanisms, including spectrum leasing, in its report."

The focus here is on broadband.

In addition the FCC goes on to state two ways in which this may be implemented:

The *Report and Order* creates two different mechanisms for spectrum leasing depending on the scope of the rights and responsibilities to be assumed by the lessee.

Spectrum Manager Leasing – enables parties to enter into spectrum leasing arrangements without obtaining prior Commission approval so long as the licensee retains both *de jure* control (*i.e.*, legal control) of the license and *de facto* control (*i.e.*, working control) over the leased spectrum pursuant to the updated *de facto* control standard for leasing.

***de facto* Transfer Leasing** – permits parties to enter into long-term or short-term leasing arrangements whereby the licensee retains *de jure* control of the license while *de facto* control is transferred to the lessee for the term of the lease. *De facto* transfer leases under this option will require prior Commission approval under a streamlined approval process. Under the *de facto* transfer leasing option, the *Report and Order* establishes different rules and procedures for long-term and short-term leases ("short-term" leases are defined as leases of 360 days or less in duration).

Features of the "spectrum manager" leasing option:

1. *The licensee must file a notification at least 21 days in advance of operation and provide certain relevant information with regard to each lease.*
2. *All technical and operational rules applicable to the licensee are applicable to the spectrum lessee.*
3. *Lessees will be required to meet foreign ownership criteria and the Commission's character qualifications.*
4. *The licensee must maintain an oversight role to ensure lessee compliance with the Communications Act and applicable Commission rules, and is responsible to the Commission for such compliance.*
5. *The licensee is ultimately responsible to the Commission for all spectrum-related applications and notifications.*
6. *In enforcing spectrum-related rules, the Commission will look primarily to the licensee on compliance issues, but lessees are potentially accountable as well.*
7. *Lessees are primarily responsible for compliance with non-spectrum-related requirements relating directly to their provision of whichever service they pursue (e.g., Title II requirements in the case of lessees providing common carriage).*
8. *Following notification of the lease, the Commission retains the right to investigate and nullify a leasing arrangement to the extent it raises significant public interest concerns.*

Features of long-term *de facto* transfer leasing:

1. *Prior FCC approval of the lease is required, but achieved through streamlined procedures.*
2. *Lease applications are placed promptly on public notice, and approved within 21 days of the public notice unless "offlined" for more detailed review.*
3. *All service rules and policies applicable to licensee, including all eligibility rules, are applicable to lessee.*
4. *Spectrum lessees are directly and primarily responsible for ensuring compliance with all applicable Commission policies and rules, and for submitting filings relating to leased spectrum.*

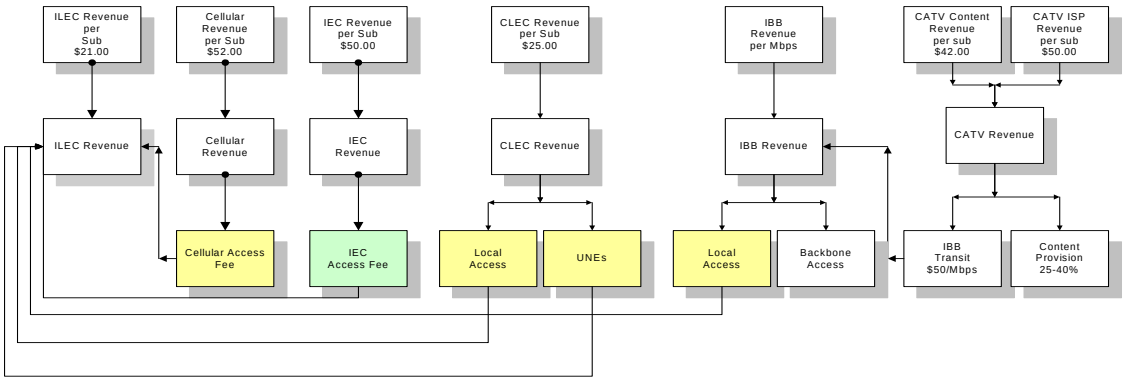
5. *For enforcement purposes, the Commission will look primarily to the spectrum lessee for compliance, and lessees will be subject to enforcement action as appropriate.*
6. *Licensees' responsibility for lessee compliance is limited to instances of actual or constructive knowledge of the lessee's failure to comply or violation of the terms of the lease.*

3.4 Economics of Costs

The following Figure depicts some of the key linkages between the six elements of the market. These elements are; (i) the RBOCs or ILECs, (ii) cellular providers (CMRS), (iii) IEC or long distance companies, (iv) CLECs, (v) IBB or Internet Backbone Providers such as UUNet or Genuity, and (vi) CATV companies.

The key observation is that so many contribute to the ILEC and so few anywhere else. This will become evident when analyzing the Verizon viability long term. In addition, this model, simple as it may be, shows that there are significant feedback loops in the business, loops that are well know, loops with delays, and as we know, such systems have significant tendencies to instability. This is a topic which itself need further analysis.

The model below reflects some of the interdependencies of the telecom market, especially the flows back to the ILECs, all generated by regulatory mandates. In this paper we will present a simple but generally broad model showing telecom competition between players and show how if the players compete on price and have a constraint of cash then there is a stability point. If, however, the players compete on price but one player controls cost elements, the system is inherently unstable. The approach we use is the dynamics and dynamic models of businesses, and we avoid the complexities of microeconomic models which focus on details which do not come to play. We deal with dynamic systems and look at their inherent stabilities and instabilities.[6]



The key observations in the above flow are as follows:

1. The ILEC/RBOC collects substantial revenue, in our analysis enough to create substantial operating losses if they are removed, from four of its immediate peers in the overall telecommunications industry. Most of those peers are now in financial difficulty.

2. The revenue that the RBOC collects comes from regulatory machinations that pre dates any telecommunications reform, namely the access fees.

3. The CMRS pay a disproportionate share of the total costs of the RBOC.

[6] See McGarty, Stochastic Systems and State Estimation, Wiley 1974.

4. The telecommunications infrastructure and financial relationships are readily analyzed and it is the interdependencies created by regulation that led to the instabilities in the system. These can be remedied but time and true attempts a de-regulation are critical.

5. Failure to remedy these regulatory instabilities will ultimately lead to a collapse of this infrastructure.

We can further extend this understanding of the integrated nature of the telecommunications business by looking one level down at the CMRS. Take three elements; revenue, cost of service, and cost of sales. In these three elements we can see the influence of the ILEC.

Consider the following simple example:

(i) Revenue for a CMRS is determined in many ways by the price set by the ILEC. The CMRS must meet or beat the price since the product is fundamentally a commodity. This fact makes an analysis of this industry fairly straightforward. Thus the sustaining competitive advantage of a new entrant must be price. This is also the main reason that one sees price wars, since there is very little else to fight over.

(ii) Now let us look at the cost of getting a new customer. First the ILEC has no such cost, since at the resident monopoly it already has the customer. Thus the CMRS must seek out and convince a customer to switch. This costs may be say $300 which is a one time costs. In addition there is churn. The churn may be due to the CMRS's own ability to serve but it is also due to the ILEC's delays; delays in UNE installation such as a loop, delays in number portability, delays in a variety of factors. Thus to keep a customer the CMRS pays a substantial fee for churn, namely for getting new customers lost due directly to actions of ILECs in their required provisioning of the CMRS at the interconnection point. This is a measurable and quantifiable cost.

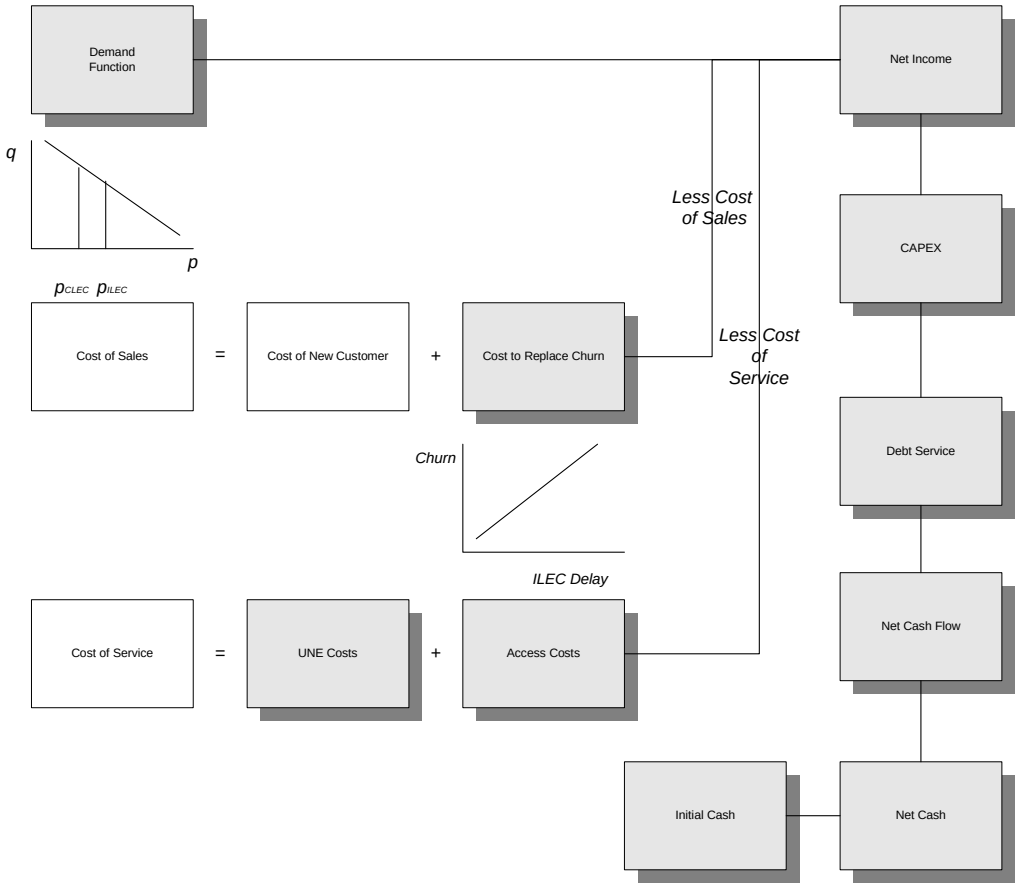
(iii) Cost of Service is the costs incurred by the CMRS in implementing the service. Here we show two elements; UNE or loop costs and access fees. These are fees in addition to what the ILEC may pay and as we argue herein these are in many cases disproportionately too high or unnecessary.

(iv) Cash is the ultimate metric of this system. Cash at the end is the only way to measure success. If a CMRS starts with $x in cash, then in two years does it have more or less. If less, then it may never survive, if more then is may. The cash metric is the measure of sustainable stability in the industry.

If we further look at this type of model for each segment, and then go down one or two more layers, it is readily easy to create a dynamic model for the overall industry and then ask the following questions:

(i) Is the industry stable, and if not can it be made so?

(ii) What impact does government regulation have on the industry and if such an impact can be ascertained, which many can, what should the policy be and is the regulation consistent with policy?



It is possible and further the models have been developed to determine the dynamics of the telecommunications industry.[7] For example, using the above paradigm, we can create the following model:

The detailed analysis of this industry model is introduced in the Appendix. The model has been generalized for an N player industry and considers pricing as the sole strategy which can be played and the limiting facto is cash at the end of the game. Each move adds or reduces cash positions of all players. All players must play at each round. It can be shown that the ILEC and CMRS two player game is always biased in the favor of the ILEC under the current regulatory regime. However, it is also shown that there are instabilities which can result in industry instabilities as we suggest herein.

4. TECHNOLOGY ISSUES

Technology was the driver for the past twenty five years. It is not clear if it will be the driver going forward. However, the following are several issues.

4.1 Data, Data Rates, and Data Quality

People want faster data transfer rates. Technology can do almost anything. In the 70s, we could design any military system to run at any rate. The advantage is that there was a single point of control, almost unlimited resources, and the "market" was captured and the competition was always assumed to have a better advantage so it was catch up. Technology in thirty years has just gotten better, but now we must deal with standards, backward compatibility, FCC regulations, established dominant carriers such as Verizon, and interconnection and access costs which control pricing.

[7] See McGarty, Business Plans, Wiley, 1989, also see papers by McGarty in TPRC wherein this issue is developed for PCS market valuation.

The end user desires 100 Base T connections, at a minimum, to put a RJ 45 connector, figuratively, in the back of their PC and to have it work anywhere. They may want the rate to go to 1 Gbps in ten years. How can this happen in a wireless environment, especially one that is portable. The issue then is band, bandwidth, power, allocation, and costs. The frequency band must allow for adequate coverage ate economic rates, thus less than 6 GHz. The bandwidth must be enough to support the burst rates, thus in excess of 250 MHz, and using good modulation efficiencies and multiple access schemes, and possibly adaptive beam forming antenna schemes. The costs of the bandwidth must be "reasonable", free would be a good starting point. The allocation process must be such that the "best" providers at the most competitive prices bubbles to the top. That is the ultimate challenge.

The end point is clear; 100 Mbps or greater, good capacity and coverage, prices comparable to a terrestrial circuit, and low costs capital per subscriber.

4.2 Grid Computing and Wireless Extension

This is speculation, but GRID computing is becoming an interesting and attractive technology.[8] Grid computing is simply the next step in distributed processing. Using a wireless connection, it takes the 802.11 standards another step, it places more intelligence in the pc at each node and makes each a participant in the overall computing process.

There are currently may projects looking at Grid and Wireless Grid computing and the implications of such interplay.

As McKnight et al have proposed, wireless grid application requirements may have significant effects on advanced network architectures, including wireless grid needs for inter-system mobility management. Research on wireless power-constrained devices and grid application requirements may also help clarify some of the remaining critical research challenges to be overcome to manage wireless Peer-to-Peer and grid services across networks and organizations.

A key area is the design of a resource discovery protocol that fits in with the fast changing environment of a wireless grid. One focus is to develop a framework for a dynamic ad-hoc resource discovery protocol. We are in the process of developing the high-level design of a resource sharing protocol suitable for use in a wireless grid. A prototype resource sharing protocol for communication across devices is being developed. This new dynamic protocol could be a "Web Service" that can be published into a UDDI framework for dynamic discovery and invocation. It could allow a client to interrogate what services are available on the local portion of the wireless grid that a client is currently connected to using well-defined WSDL documents. It also will allow a server to advertise a service to interested clients.

In future wireless p2p computing, the heterogeneous resources available for sale or barter could include the basic building blocks of communications, such as bandwidth, data storage, and computational power. But there will also be more abstract resources such as databases, directories, catalogs, resource maps, security keys, identities, membership lists, price lists and many other information resources across wireless grids. For information resource transaction services in wireless networks and distributed computing environments, our resource sharing protocol is intended not only to provide resource discovery mechanisms, but also to support heterogeneous standardized solutions to transaction security, directory services, quality of service and accounting.

An important aspect of wireless networks is the fact that wireless devices are frequently power constrained in an environment characterized by other interesting aspects such as location independence, shared spectrum with weak security mechanisms and ad hoc protocols. We can envision a scenario that a wireless network of resource-constrained devices may form a virtual organization (VO), working together with multiple Actual Organizations (AOs), to conduct business transactions or to share information. In such a

[8] The Physiology of the Grid, Foster et al, IBM, June 2002.

resource constrained scenario, one needs to examine a number of critical questions such as, how are these devices managed, what kind of protocols involve less power, how are the nodes discovered, how are policies implemented and how does the dynamic nature of the ad hoc wireless network impact the aspects of node discovery, authentication as well as authorization across organization boundaries.

Providing a power efficient routing mechanism is an essential issue to wireless grid networks when most devices are power constrained. Many wireless ad hoc routing protocols have been proposed for wireless network connectivity and a variety of bandwidth related performance studies have been done. However, the power efficiency issue still needs much more exploration for integrating power efficient capability into wireless grids. In the early stage of the wireless grid project, the team is studying the nature of power consumption characteristics of current routing protocols. It has been shown that the power efficiency of ad hoc routing protocols is highly dependent on the mobility and traffic pattern in the wireless grid it is running on.

4.3 Integration of Wireless and Fiber

Fiber to the Home, FTTH, is another potentially compelling technology. Unlike wireless, however, it is not dominated by regulation, only by capital. There is a move afoot in the US to have municipalities build and fund open network fiber loops in their municipalities, despite the attempts by the monopolists of the ILECs to prevent them. This means that there may be a significant growth in the next five years of FTTH backbone networks. They would be funded by 20 year muni bonds at 3.75%. This means that for every $1,000 per HH in CAPEX the monthly bond payment is less than $4.25! There are over 400 towns who have done this already, out of 55,000. The trend is growing.

What does this imply about technology? Two immediate things; expanded WiFi backbone and expanded Cellular coverage and capacity via distributed antennas on the FTTH backbone. Specifically:

Wireless: The services considered here are the application of an integrated WiFi type network using a strand or more of the trunk and feeder fibers. This would be a fully integrated service platform providing 802.11 type services.

Cellular Support: This is a service which allows cellular carriers to have capacity and coverage expansion using the fiber trunks and feeder networks. It would deploy a distributed cell site technology and again would be fully integrated from an operational perspective.

4.4 WiFi (802.11 et al) and the Competition

The WiFi developments have been perceived as a threat to the cellular carriers. As stated recently:[9]

"The Big Six -- Verizon Wireless, Cingular, AT&T Wireless, Sprint PCS, Nextel , and T-Mobile – have billions in debt. Their revenue growth has slowed to 20% annually from the triple-digit pace of the mid-1990s, delaying sustained profitability for some to 2004 or 2005 -- a decade or so after they started in the business…. Now, the carriers find themselves under attack in every cellular market, from data transmission to voice calls. The rivals range from Wi-Fi providers and radio broadcasters to Internet service providers (ISPs). If that weren't enough, proposed legislation that would let customers keep their phone numbers no matter which carrier they move to threatens to further intensify wireless competition -- and worsen the industry's losses."

The same Business Week source states that Nextwave, the phoenix from bankruptcy has taken to use their spectrum for data. Specifically it states:

"Another threat to carriers could come from NextWave Telecom, which is planning a data only, nationwide network with speeds of 2 megabytes per second -- twice the speed offered by Wi -Fi and a more advanced

[9] See Business Week, March 18, 2003.

network than those of U.S. carriers today. The outfit, currently in bankruptcy, holds the necessary spectrum to run this technology, which could be used to send both voice calls and data. NextWave is searching for investors to finance the buildout and hopes its creditors will ratify the idea by this summer, says Michael Wack, a NextWave senior vice -president. "There's a tremendous opportunity to respond to demand for broadband access," he declares."

5. INDUSTRY ISSUES

There are several industry issues which are also of concern. The two major ones are the potential collapse of wireline and the pending consolidation of wireless.

5.1 Collapse of Wireline

The wireline segment of the telecommunications market in the US is potentially suffering a great defeat. Consider Verizon simply. The following facts are based upon recent quarterly financials:[10]

1. *Verizon books over $12 billion per quarter on wireline revenues.*
2. *It makes $2 billion on that revenue in pre tax income.*
3. *However, $4+ billion of the revenue comes from access and interconnection, 90% of which is from cellular carriers.*
4. *Verizon owns only 20-25% of the cellular business in its territories.*
5. *If "bill and keep" is implemented, then Verizon will loose almost $2 billion per quarter on wireline.*
6. *Verizon has $8 billion in cash and almost $60 billion in debt.*

This story has played out before. The end point is on par with Worldcom. The irony is that Verizon is now trying to get the Courts to make Worldcom go into Chapter 7 and liquidate. This appears to be a strategy to attack just before collapse. This also is not unique, in fact Verizon may be the healthiest. SBC, Qwest and Bell South suffer from the same disease. The threats to the ILECS are:

1. *Decaying base of wireline*
2. *Increase of wireless over which they have no control.*
3. *Pending losses of interconnection revenue on wireline.*
4. *Pending price pressure on wireless which may loose effective wireline interconnection advantage.*
5. *Increased cost of capital.*
6. *Pending labor problems, such a Verizon strike, and loss of productivity.*

The concern is one of uncertainty. Government policy staff see to have been ignoring this issue totally, or inadvertently taking the position of "nationalizing" the telcos by their protective efforts.[11] The potential

[10] See, McGarty, The Imminent Collapse of Telecom, August, 2002.

[11] The nationalization argument is based upon the following three observations: (i) **Elimination of all competitors:** This is currently under way. Commissioner Martin's approach would have the FCC create conditions with UNE-P which would immediately eliminate all competition. (ii) **Providing Government protection and support:** This means simply that the monopolist which has been nationalized has been given protection from any competition as well as being given financial support. Gore Tax rebates and Universal

collapse of the wireline business is driven by the observations presented above about Verizon. There are many policy issues which the US Government should address but it seems defocused in this area. The FCC is in an internal war between the Chairman and Commissioner Martin, and the potential is that the remainder of the wireline business may suffer dramatically, especially since the Administrations efforts have led to the near total elimination of any viable competition set.

5.2 Consolidation of Wireless

As discussed above, the six major players are in various forms of health. Sprint, Nextel and T Mobile are debt ridden and cash flow poor. AT&T must rebuild its system from the ground up, it is still relying on IS 54 TDMA technology which has no working capability, a fact known in 1989 when it was McCaw's property. It is the poor man's TDMA as compared to GSM. The only result is consolidation. Verizon may very well consolidate with one or two of the others, and that leaves AT&T or Cingular as the catalyst for the other consolidation players. Nextel, Sprint, and T Mobile will most likely disappear with Verizon, Cingular and AT&T being survivors.

This possible scenario would result in an attempt to consolidate systems, seek common technologies, and most likely delay and aggressive roll out of enhanced services. This would mean another delay in any aggressive data play.

6. CONCLUSIONS

Wireless has many challenges and many opportunities. This paper presented a summary of several of them. The conclusion drawn are:

Regulation is a delay process, as it always has been

Industry consolidation is another which will reduce potential infrastructure spending.

Alternative networks such as muni FTTH represent interesting alternatives since they can provide low costs capital and become "market makers"

Data is problematic, users want high speed, not what can be offered with cellular, and throughput and reliability, found wanting in WiFi

7. REFERENCES

The following are several of the papers by the author over the past few years which reflect on the issues contained herein. It should be noted that the earlier papers reflecting trends can now be validated by the facts.

1. Alternative Networking Architectures; Pricing, Policy, and Competition, Information Infrastructures for the 1990s, John F. Kennedy School of Government, Harvard University, November, 1990.

2. Information Architectures and Infrastructures; Value Creation and Transfer, Nineteenth Annual Telecommunications Research Conference, Plenary Address and Paper, Solomon's Island, September, 1991.

services, as finally structured by the FCC, allow the ILECs to obtain direct subsidies. The total subsidy pool thus accumulated and redistributed to the monopolists is in excess of $10 billion annually! (iii) **Erect barriers to Entry:** The antitrust laws were set up to ensure competition, not protect competitors. Their elimination, in light of the Trinko case, would take away the last vestige of consumer protection and establish the final leg of nationalization. In addition the FTC and the Solicitor General, representing the Administration directly, have intervened in Trinko and take any power away from the consumer and provide de facto as well as de jure coverage for the monopolists.

3. Communications Networks; A Morphological and Taxonomical Approach, Private Networks and Public Policy Conference, Columbia University, New York, October, 1991.

4. Alternative Networking Architectures, B. Kahin Editor, McGraw-Hill (New York), October, 1991.

5. Communications Network Morphological and Taxonomical Policy Implications, Telecommunications Policy Research Conference, Solomon's Island, MD, September, 1992.

6. Architectures et Structures de L'Information, Reseaux, No 56, pp. 119-156, December, 1992, Paris.

7. Economic Structural Analysis of Wireless Communications Systems, Advanced Telecommunications Institute Policy Paper, Carnegie Mellon University, February, 1993.

8. Access to the Local Loop; Options, Evolution and Policy Implications, Kennedy School of Government, Harvard University, Infrastructures in Massachusetts, March, 1993.

9. Wireless Access to the Local Loop, MIT Universal Personal Communications Symposium, March, 1993.

10. Spectrum Allocation Alternatives; Industrial; Policy versus Fiscal Policy, MIT Universal Personal Communications Symposium, March, 1993.

11. Access Policy and the Changing Telecommunications Infrastructures, Telecommunications Policy Research Conference, Solomon's Island, MD, September, 1993.

12. Internet Architectural and Policy Implications, Kennedy School of Government, Harvard University, Public Access to the Internet, May 26, 1993.

13. A Précis on PCS Economics and Access Fees, presented at the NPC SC Seminar on "Wireless Technology and Policy Implications" at MIT Lincoln Laboratory, in Lexington, MA, May 18, 1994

14. Wireless: The Challenge of Using Bandwidth Intelligently, presented at the Symposium on Communications , Optics and Related Topics, held in honor of the 60th birthday of Professor Robert S. Kennedy, at Endicott House of the Massachusetts Institute of Technology, June 4, 1994

15. Wireless Architectural Alternatives: Current Economic Valuations versus Broadband Options, The Gilder Conjectures; Solomon's Island, MD, September, 1994.

16. From High End User to New User: A New Internet Paradigm, McGraw Hill (New York), 1995.

17. Disaggregation of Telecommunications, Presented at Columbia University CITI Conference on The Impact of Cybercommunications on Telecommunications, March 8, 1996.

18. The Economic Viability of Wireless Local Loop, and its Impact on Universal Service, Columbia University CITI seminar on "The Role of Wireless Communications in Delivering Universal Service", October 30, 1996.

19. Internet Voice: Regulatory and Legal Implications, Presented at the VocalTec Seminar on September 9, 1996, New York, NY.

20. Communications Networks; A Morphological and Taxonomical Approach, Private Networks and Public Objectives (Noam, Editor),Elsevier (London), 1996.

21. Competition in the Local Exchange Market: An Economic and Antitrust Perspective, *Federal Communications Law Journal*, submitted and to be published.

22. The Economic Viability of Wireless Local Loop, and its Impact on Universal Service, Telecommunications Policy, Elsevier (London), 1997.

23. Economic Factors on International Internet/Intranet Telecommunications, MIT Research Program on Communications Policy Conference Internet Telephony Interoperability Forum, Bristol, England, June 11, 1997

24. Comparative Deregulation of Far Eastern Telecommunications Markets, Telecommunications Policy Research Conference, Washington, DC, September 28-30, 1997.

25. Telecommunications Infrastructure, Technology, and Policy in Russia, A Plan for the Development of an Information Based Economy, Russian Freedom Channel Report, September, 1997.

26. International IP Telephony, to be Published, MIT Press, 1999.

27. The Internet Protocol (IP) and Global Telecommunications Transformation, Tufts University, Fletcher School, March, 1999.

28. The Application of IP Telephony to Local Exchange Carriers, MIT, Internet Telephony Consortium, March, 1999.

29. IP Telecommunications QoS (Quality of Service), Is Service Quality a Sustainable Metric?, MIT Internet Consortium, Aquila, Italy, June 2000.

30. The Evolution of International Internet Telephony, TPRC, Arlington VA, September 2000.

31. Virtual Global Telcos: International Internet Telephony Architectures, in Internet Telephony, MIT Press (Cambridge), 2001.

32. Internet Telephony Markets and Services, in Internet Telephony, MIT Press (Cambridge), 2001.

33. The Internet Protocol and the Creative Destruction of Revenue, in Creative Destruction, MIT Press (Cambridge), 2001.

34. Peering, Transit, Interconnection: Internet Access In Central Europe, MIT Internet Consortium, January 2002.

35. Privacy in the Internet Environment, MIT ITC Conference, December, 2002.

36. Municipal Broadband Networks: A Revised Paradigm of Ownership, MIT ITC Conference, December, 2002.

37. The Imminent Collapse of the Telecommunications Industry, MIT ITC Working Paper, August, 2002.

38. Privacy in the Internet Environment, MIT ITC Working Paper, November 2002.

39. Current Telecommunications Legal Issues, Litigation v. Legislation: Is the 1996 Act a Beginning or an End?, MIT ITC Working Paper, December 2002.