Innovation in the Telecommunications Industry

Separating Hype from Reality

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EXECUTIVE SUMMARY

Considered one of the most important and vital sectors of the United States economy, the telecommunications industry has received an inordinate amount of attention over the last five years. From contributing to the "Internet bubble" to sharing credit for creating incredible economic productivity gains, telecommunications is a dynamic industry that has undergone dramatic change.

Based on Harvard Business School Professor Clayton M. Christensen's research, this paper presents a set of frameworks and observations intended to help industry participants understand the forces of innovation and change within the U.S. telecommunications industry.

There are two goals we hope to achieve with this paper:

- Present a clear analysis of the forces of innovation that have influenced and will continue to influence the industry.
- Define a set of tools and frameworks that give industry participants and pundits a new and common language to identify, better understand and discuss the signposts that will reveal the industry's future direction.

The target audience for this work is industry participants (e.g., incumbent firms, analysts, venture capitalists, etc.), with an emphasis on service providers, defined as the traditional firms engaged in providing telecommunications services in the United States, namely Interexchange Carriers (IXCs) and the Regional Bell Operating Companies (RBOCs).

There are six central messages to our work:

1) Industry participants need an updated "innovator's toolkit," as the forces of innovation have been misunderstood and misapplied resulting in massive misallocation of resources. At a minimum, participants need to add the following to their toolkit:
   a) A new classification scheme of industry change we have termed the "4-D" model to better understand how different types of innovations are likely to unfold.
   b) An updated version of the disruptive technology model with detailed litmus tests to predict technologies that have a high potential of being disruptive.
   c) The modularity / interdependence framework that predicts which types of firms are likely to capture value in an industry and where competitive markets are likely to erupt.
2) While there have been many examples of impactful change in the telecommunications industry, natural monopoly and regulatory forces have insulated traditional service providers from the forces of disruption. The highly related but orthogonal enterprise data market has been seething with disruptive forces, laying the groundwork for fundamental changes within traditional telecommunications markets.
3) Today, disruptive forces swirl around the telecommunications industry. While many pundits predict that wireless will be the lead disruptive force, it must overcome barriers (e.g., spectrum limitations and changes in consumer demand) that deflect its disruptive trajectory. However, Voice over IP (VoIP) in its many incarnations has the potential to be a powerful disruptive catalyst with seismic effects. Although there are many barriers to VoIP's improvement trajectory, the modularization of the industry and the decoupling of services from the transport media could radically change the industry's competitive dynamics.

4) The enterprise – with its low regulatory hurdles, high user density and value per node – has been the primary incubator and funding source of disruptive telecommunications innovations. Born in the enterprise communications and data market, IP-based internetworking may, in fact, be the most formidable innovation likely to result in disruption.

5) The regulated natural monopoly that dominates the local loop deflects the expected trajectory of disruptive innovations. The RBOC's stranglehold over access to the "last mile," particularly in the residential market, restricts the ability of innovations to reach potential customers.

6) Government policy has an overwhelming influence in shaping the opportunities that innovators target. Legislation created to respect the forces of innovation can create an environment ripe for yielding disruptive change.

While there are an infinite number of paths the industry could follow, a number of key factors – like regulatory changes and unanticipated technological breakthroughs – ultimately will influence how innovation shapes the industry. Firms that identify and understand the impact of each of these factors are more likely to emerge triumphant after the dust of change has settled. Regardless of the industry's actual development, important forces are at work that will cause leading players to undergo massive change, with those that can harness those changes likely to emerge as leaders.

RBOCs appear to be well positioned to capitalize on many of the innovations and potential forces of change in the industry today. In fact the high degree of interdependence in the telecommunications networks may entirely prevent the disruption of the RBOCs. However, traditional IXCs seem to be in much greater danger of disruption by new providers focused on pushing the IP-internetworking paradigm.

By understanding the different forces that influence how innovation and change occur and who is best positioned to their capture value:

- industry participants can take appropriate action to improve their competitive position
- potential new entrants can better understand the points in an industry that truly represent attractive opportunities
- industry investors and analysts can understand where scarce resources really stand the greatest chance of succeeding.

Ultimately, this paper aspires to give industry participants a robust set of tools to separate hype from reality.

INTRODUCTION

Considered one of the most important and vital sectors of the United States economy, the telecommunications industry has received an inordinate amount of attention over the last five years. From contributing to the “Internet bubble” to sharing credit for creating incredible economic productivity gains, telecommunications is a dynamic industry that has undergone dramatic change.

The last five years demonstrate that there are tremendous opportunities for innovation and creativity but the industry remains fraught with risk. With more than $500 billion invested, there have been both remarkable changes and spectacular failures. Capital markets have dried up and new entrants have gone bankrupt while incumbents have flourished and marched on. In a few short years the popular wisdom has swung from a certainty that incumbents would topple in the face of new classes of competitors to a sense that incumbent local exchange carriers (ILECs) will inevitably triumph. Once again, popular wisdom is overly simplistic and shortsighted. To be prepared for the future, most industry participants want to know the answer to two critical questions: what happened, and why?

Although the market has shifted from hysteria to despair, innovation inexorably marches on and tremendous industry change is afoot, promising new challenges and new challengers. Service providers – the traditional market leaders like Verizon and AT&T – face a set of tough decisions brought on by a burgeoning number of promising new technologies converging to shape the next stage of industry evolution. However, traditional ways of evaluating dynamic change are insufficient; to understand the forces at work and craft appropriate strategies, industry participants need to update their tool-kit. This paper presents a series of tools and models to analyze the history of the telecommunications industry and aspires to help players develop effective strategy in the “post-bubble” world, allowing them to separate hype from real opportunities.

Framing of the Telecommunications Industry Context

Innovation has been an increasing source of dramatic change within the U.S. telecommunications industry over the last 100 years. In fact, since deregulation first allowed competitors into certain market segments, a series of important systemic changes has dramatically affected the industry. With its history of innovations spawned from Bell’s famous New Jersey laboratory, the industry is teeming with opportunities to revisit and extend our theories. Dissecting any industry that attracts both top engineers to solve its problems and leading government officials to craft its complex regulations can only help further the academic study of the process of innovation. Before diving too deeply, it is useful to highlight some important distinctions that define the context within which this innovation and change has occurred.

The telecommunications market is quite complex consisting of many segments and technologies. The rise of private corporate data networking in the 1960s and 1970s and mobile telephony in the 1980s have joined voice and its related services as the three pillars of service provider revenue. More specifically, there are a number of important and interrelated segments, displayed in **Exhibit 1**. While innovations have blurred some of these distinctions, **Exhibit 1** notes the important differences between voice and data, residential and business markets, and, specifically related to voice services, local and long distance calling. It is particularly important to note the difference between the residential and the business markets. We will demonstrate later in this paper that, while natural monopoly and regulatory forces have inhibited innovation in the residential market, the enterprise is a fertile ground where innovation can be incubated.

Exhibit 1

Key industry framing issues

Voice	V.	101010111 001101001 101010000 Data	• Historically, voice has been the most important service • With the recent rise of computing power and networking, data is now the predominant driver of value
Residential	V.	Business	• The residential business remains a local monopoly controlled by incumbents • Business has always been where the "real money" is made. The high value per user, high concentration of users and lower number of regulatory barriers creates a fruitful environment for innovation
Transport	V.	Services	• The transport business (or basic connectivity) consists of the transmission media and is rapidly commoditizing • Services are layered on top of transport and are higher margin offerings; with the rise of any-to-any networking, services have been decoupled from the medium over which they are transported
Local	V.	Long distance	• Local transmissions are switched within a single RBOC • Long distance transmissions are generally switched with the aid of an additional intermediary such as an interexchange carrier (IXC)
Wired	V.	Wireless	• Wired transmissions go entirely over wires • Wireless transmissions can originate or terminate from un-tethered devices connected to and relying upon a wired infrastructure for completion

Once inextricably linked, today new distinctions must be drawn between transport (basic connectivity) and services since the emergence of Internet Protocol (IP) networking has allowed the decoupling of network services from their dependence on transmission media that provide the physical connectivity. Another important, yet relatively new, distinction is that of wireless versus wired connections. Although still dependent on the "wired" network infrastructure for origination and completion, wireless technologies have un-tethered devices from the Public Switched Telephone Network (PSTN) and enterprise data networks, creating exciting new opportunities in and around mobility.

Additional factors that must be acknowledged to draw meaningful lessons and understand industry dynamics are the:

- industry's historical legacy as state-run or state-sponsored monopolies with trillions of dollars of fully depreciated assets.
- continued specter of government regulation after the split of AT&T and deregulation.
- economic forces in the industry, including the highly interdependent nature of networks and huge scale economics, which result in strong natural monopoly forces.

Until recently, innovation and change had primarily occurred in the voice telephony market, which until deregulation was a regulated monopoly controlled and operated by AT&T. The 1980s served as a transitional period where partial deregulation focused on long-distance operators at a modular point of intersection between local and long-haul voice networks. During this period, many industry changes were dictated from the bench not the battlefield in the form of fiats from Judge Harold Greene.

Deregulation intensified in the 1990s, best exemplified by the 1996 U.S. Telecommunications Reform Act. While analysts focused their attention on the emergence of new players created by the latest wave of deregulation, such as Competitive Local Exchange Carriers (CLECs), a fundamental misunderstanding of the forces of innovation led to a massive waste of investor capital. However, while excitement quickly turned to disappointment, a set of core technologies incubated in the data enterprise market is creating the pre-conditions needed to unleash powerful forces of change within the telecommunications industry.

The Local Area Network (LAN), a simpler, more flexible technology enabled by IP and Ethernet standards spawned innovations, such as the multi-protocol router, that disrupted a series of highly reliable but rigid incumbent technologies and accelerated the rise of a new paradigm – any-to-any networking. Dramatic improvements in Voice over IP (VoIP) technology are finally enabling convergence – the multiplexing of voice, video and data onto a single data network. As convergence spreads throughout the enterprise data market and services are decoupled from the transport media, the “any-to-any” computing paradigm threatens to become a tsunami that crashes out of the enterprise data market to overwhelm today’s service providers. While visibility into a precise industry future is limited, it is clear that industry participants face substantial changes if they are to successfully navigate – rather than drown in – the waters ahead.

What we plan to do

Using our disruptive technology model as the foundation, this paper will develop a set of observations to classify and extract key lessons from important innovations and changes that have affected the telecommunications industry. As the sheer size and reach of the telecommunications industry makes fruitful analysis a daunting task, drawing clear boundaries facilitates the analytical process. The target audience for this work is service providers, defined as the traditional firms engaged in providing telecommunications services in the United States, namely Interexchange Carriers (IXCs) and the Regional Bell Operating Companies (RBOCs) with specific case studies in areas such as wireless and metro-area network (MAN) providers.

The paper is divided into four sections:

- The first section of the paper uses the history of the voice telephony industry to build a set of frameworks and analytical tools to better understand the impact of innovation and change. It will demonstrate that while there have been a number of important innovations, regulatory barriers and natural monopoly forces have deflected any of the most wrenching forms of innovation – disruption.

- The second section will turn to the enterprise data market, using the frameworks developed in section one to show how a series of disruptions have led to massive change within this market. While these developments have not affected service providers to date, they have laid the groundwork for disruptive technologies to strike at traditional service providers. This section also will demonstrate how the enterprise has been the industry’s “breeding ground” for innovation.

- Turning to present developments, the third section of the paper will use our tools and frameworks to look at key innovations that many pundits have classified as disruptive, notably wireless telephony, 802.11, VoIP and metro-area network (MAN) providers. This section will show how rigorous application of our frameworks can help industry watchers understand what technologies truly have disruptive potential.

- Finally, the fourth section will summarize the key findings from the paper, describe our prediction for the future evolution of the industry and highlight how the tools developed in the paper can help separate hype from reality.

SECTION 1: ANALYZING THE HISTORICAL VOICE MARKET

In the 1960s, Western Electric controlled virtually 100 percent of the residential customer-premise equipment (CPE) market. It produced a phone that was basically indestructible, and was available in any color you wanted – as long as it was black or beige. Under the auspices of "foreign attachment" tariffs, efforts to sell non-Western Electric CPEs were restricted as they purportedly threatened the reliability of the telephone network. Entrepreneur Tom Carter challenged the foreign attachment clause with the introduction of the "Carterphone," a simple device targeted at consumers who wanted to speak on the phone from a distance, like farmers. Using a walkie-talkie-like device, users could transmit a signal to a speaker placed next to the phone. When the government ruled in 1968 that the Carterphone attachment posed no threat to the integrity of the phone system, the floodgates opened. The CPE instantly became a "modular" piece of the telephone system. Almost overnight, new companies offering a wide variety of devices entered the CPE market rapidly *displacing* Western Electric.

In the early 1980s, the entire telecommunications system was undergoing an incredibly pain-staking upgrade from analog to digital services. This *discontinuous* change was a massively complex and critical evolutionary step in the telecommunications industry and demanded an enormous amount of resources and energy. The incumbent-led effort to upgrade the network infrastructure required huge up-front capital outlays and complex integration and deployment efforts. Engineers spent countless hours devising novel solutions to improve the performance of what was already touted as the best performing system in the world.

In 1991, after more than a decade of chipping away at AT&T's long-distance monopoly, MCI had a breakthrough. Why not utilize an advanced billing system to allow customers to pay different rates to call different people? And why not enlist its delighted customers to be its sales associates, telling their "Friends and Family" about the great new plan that they enjoyed so much? This innovative customer acquisition and retention campaign was a marketing coup and created a major market *distraction*, helping MCI's share of the U.S. long-distance marketplace grow from 16 percent in 1991 to 21 percent in 1994.

* * *

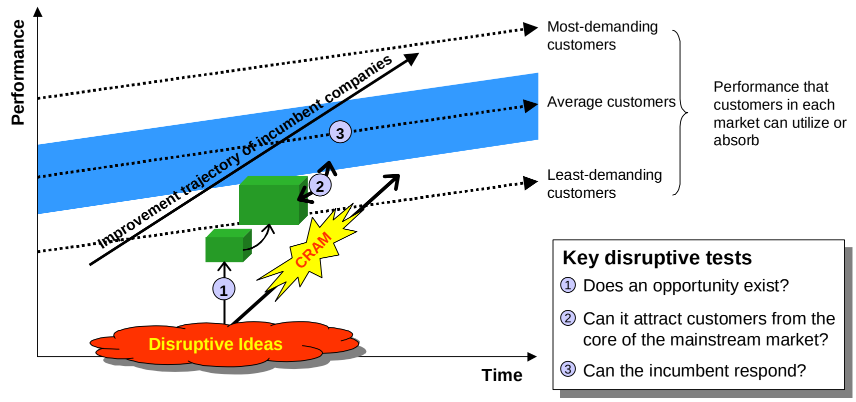
These three case studies illustrate how innovation – defined as the creation of a new product, service or business model – has been a constant factor in the voice telephony market. Before studying the telecommunications industry in greater depth, it is first important to provide participants with the essential tools of innovation. With this "innovator's toolkit," participants can better understand how current developments are likely to unfold. While each of the above examples led to important industry change, none are an example of the most dynamic and dramatic form of change: "disruption."

Disruptive innovations

As described by research summarized in *The Innovator's Dilemma*, disruptive innovations often end with industry leaders mortally wounded and unable to respond. Disruption occurs when an incumbent is unable to mount an effective competitive response against a technology or business model resulting in a loss of significant market share and dramatic changes in the competitive landscape of a market or an industry. Disruptive technologies are so pernicious because, although incumbents can often see them coming and often in fact initially develop them, even the best-managed firms find these innovations impossible to defend against. The fundamental driver of disruption is the phenomena of incumbent firms "overshooting" the needs of their mainstream customers, displayed in **Exhibit 2**. Well-run firms that listen to their customers produce

Exhibit 2

Overview of the disruptive technology model

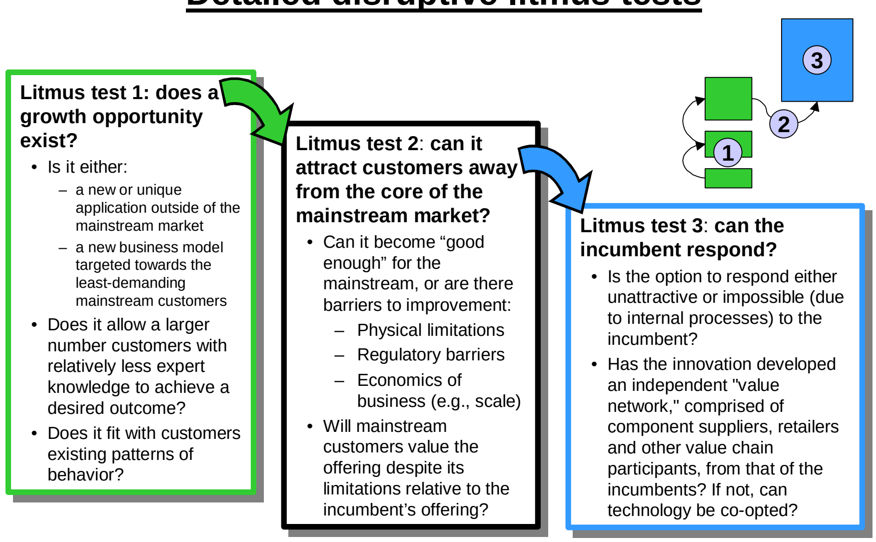


sustaining innovations that improve the performance of their product or service along the dimensions that its customers have historically valued;[1] each of the three changes listed above are sustaining innovations. However, firms almost always innovate faster than their customers' behaviors can change to utilize the new innovations. A firm "overshoots" when customers receive diminishing marginal utility from product improvements to the point where they are overserved and question the value of these additional improvements. For example, users of Microsoft's suite of office products cannot change their behavior or business processes quickly enough to utilize all of the enhancements Microsoft offers, with the typical user utilizing roughly 5 percent of Microsoft's features. As firms overshoot the needs of their core mainstream customers, they create the opportunity for a simpler, cheaper, more flexible technology to "come in from below" and pull those customers away from them.[2]

There are three key litmus tests to determine whether a technology will be disruptive or not (**Exhibit 3)**. The first test determines whether there is a large new growth opportunity that gives the technology a "home" to incubate and improve. These niche markets can either be in a "green-space" market – depicted in **Exhibits 2** & **3** as green rectangles outside of the mainstream market[3]

Exhibit 3

Detailed disruptive litmus tests



– or within niche pockets of overserved least-demanding customers in the mainstream market. This second group of customers is typically attracted to new, low-cost business models. Disruption begins with a product or service that initially under-performs the incumbent's offering along the dimension competition is based on for mainstream customers in the industry. For example, the personal computer (PC) initially had dramatically less functionality than the minicomputer, and was a "toy" to mainstream users. However, **Exhibit 3** points to factors that could allow the disruptive technology to find a new growth opportunity where users value some aspect of the technology despite its limitations. In certain niche markets, customers were delighted by the PC because it allowed a larger group of customers, who did not need the high-end functionality of the mainstream offering, to flexibly or conveniently achieve an outcome that would previously have required expert skill to accomplish.

While the "green space" growth opportunities can be quite exciting and rewarding, eventually managers of potentially disruptive technologies hungrily eye the big prize of the "sweet spot" of the mainstream market, depicted in **Exhibits 2** & **3** as a large blue rectangle. Once adopted in its initial niche market, the technology improves at a rapid pace, fulfilling the needs of an ever-growing population of customers. The next key test a disruptive technology will face is getting "good enough" to attract customers away from the sweet spot of the mainstream market. A technology is defined as being "good enough" when it meets some minimum required performance to encourage customers to give up an incumbent's offering. **Exhibit 3** points to the two key issues facing a disruptive technology. Core customers must value the disruptive technology's benefits despite the fact that it typically under-performs the incumbent's offering along some key dimensions. Customers are often willing to make this tradeoff because they feel overserved by the incumbent's offering.

Of course, attracting customers away from the core market is predicated on the potential disruptive technology's ability to continue on its improvement trajectory and get "good enough" to be acceptable to the majority of core customers. For example, the rapid growth in processing power allowed the personal computer to meet the needs of the mainstream customers in the "blue space" who had previously relied on minicomputers. Factors such as fundamental physical limitations or regulatory barriers can often deflect the trajectory of potential disruptive technologies. However, it is important to note the power of the dynamic forces of innovation – oftentimes factors deemed "impossible" to overcome have been tackled or circumvented by determined entrepreneurs. In fact, entrepreneurs are often best suited to find ways around seemingly insurmountable barriers in pursuit of sizable rewards.

The final, and most important, litmus test an innovation must pass is whether the incumbent, who "owns" the core mainstream market, can fend off the attack from below or whether it must "retreat" up-market. **Exhibit 3** points to the two key questions that determine an incumbent's ability to respond. First, a disruptive technology that reshapes the industry to earn profits in a new way usually features lower gross margin dollars per unit sold and higher asset turnover or utilization. This makes it either difficult or unattractive for incumbent managers to allocate resources towards the technology. Second, a disruptive technology grows up in an independent "value network," made up of component suppliers, retailers and other value chain participants (see **Box 1** for a more detailed discussion of value networks). This independent value network makes it difficult and costly for incumbents to "co-opt" the technology. Co-option is a typical defense mechanism where an incumbent tries to "cram" a potentially disruptive technology, into its business model and mainstream market before it is good enough – much like forcing a square peg into a round hole.

Supported by its independent value network, the disruptive technology can unseat the incumbent firm. The incumbent, who has already overshot the needs of much of the mainstream market, inexorably moves further and further up market in search of customers to serve and profits to make. Low cost personal computers had their own network of suppliers and retailers, separate from the minicomputer value network, facilitating the PC's ultimate disruption of the minicomputer.

There is an important principle of relativity that must be considered when evaluating potential disruptive technologies in order to define what an innovation is likely to disrupt. While an innovation may be disruptive to one incumbent, it could prove sustaining to another. For example, while Internet retailing could be deemed as highly disruptive *relative* to a personal service-oriented bricks and mortar retailer, it was **not** disruptive to catalog retailers. Catalog retailers' established processes facilitated using the Internet as a complementary new channel and their values allowed them to prioritize and allocate resources to its development. Thus, if a technology is disruptive relative to a company's business model, we would expect the firm to be paralyzed; if the technology is sustaining relative to a company's business model, we would expect the firm to continue on.

> **BOX 1: VALUE NETWORKS**
>
> A value network incorporates both the physical attributes of a product or system as well as the associated cost structure (as typically measured by gross margin). This cost structure includes all business-related costs (e.g., research, engineering, development, sales, marketing) necessary to sustain a business. A value network also includes all the critical upstream and downstream value chain participants. Tightly intertwined value networks prevent disruption by giving incumbents an easy avenue to "co-opt" potentially disruptive technologies by cramming them into their existing business model. On the other hand, disruptions are almost always associated with independent value chains, as illustrated by the rapid Japanese penetration of the U.S. automobile market. Toyota's value network that supported the manufacture of the Corona was completely separate from that of the incumbent US auto manufacturers. Based on the quality-oriented Toyota Production System and comprising an entirely separate set of upstream (supply chain) and downstream (distribution and retail outlets) partners, Toyota products were built using a business model completely different from, and not easily reproduced by, U.S. automakers.

Classification of industry changes: the 4-D model

The three telecommunications case studies that began this section indicate that disruption is not the only form of important change that affects an industry. To help managers and analysts understand other forces that are at work in an industry, we have developed an additional taxonomy of industry change called the "4-D" model (see **Exhibit 4**). **Exhibit 5** lists out the predictive factors for each type of change explored in the "4-D" model.

To classify the type of change a firm faces, the first question managers must ask is whether the change meets the criteria defined in the disruptive "litmus tests" described above. If the change

Exhibit 4

The 4D industry change classification model

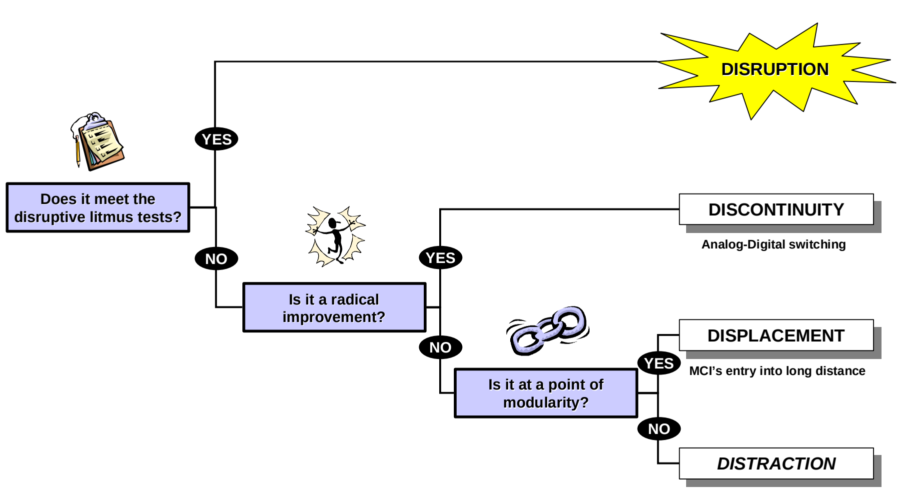
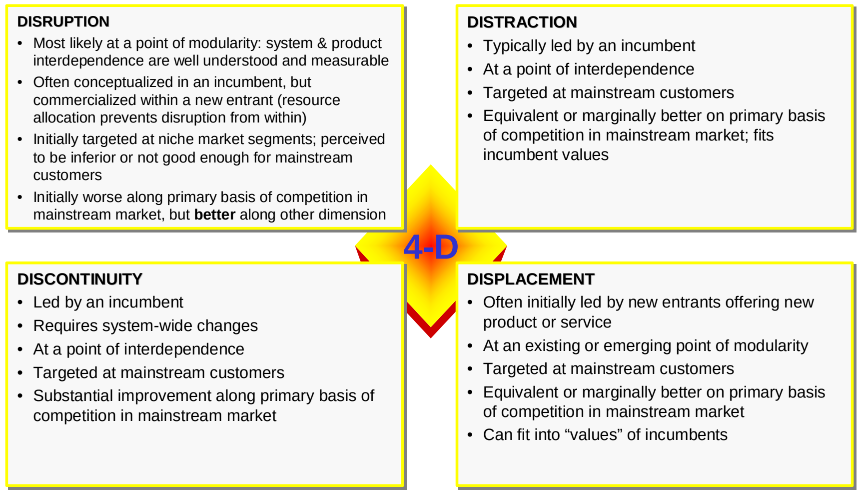


Exhibit 5

Predictive factors for 4-D classification scheme



does not meet the litmus tests, it is one of three separate types of *sustaining* innovation. It is important to distinguish between sustaining and disruptive innovations because sustaining innovations can be mastered and controlled by incumbent firms, while incumbents are powerless to defend against disruptions. Also start-ups with sustaining technologies should adopt a very different "go-to-market" approach than those with potentially disruptive innovations.

If a change is not disruptive, the next question asked on **Exhibit 4** is whether it is radical or incremental, with a radical change termed a **discontinuity. Exhibit 5** notes that an industry incumbent almost always spearheads a discontinuity, which often manifests itself in an entire network upgrade or a new technology platform. Discontinuities, which also can be termed radical sustaining innovations, are more expensive, more complicated but better performing technologies that either meet or exceed the current needs of the mainstream market. The move from black and white to color television is a classic example of a market discontinuity; a complete and difficult overhaul of the entire broadcasting system championed by incumbents that ultimately led to a massive improvement in customer experience.

If a change is incremental, the next key question is whether it occurs at a point of "modularity" or a point of "interdependence." Before explaining the final two types of change, it is worth stepping back to explain how predictable moves from interdependence to modularity can help explain innovation's influence on industry evolution.

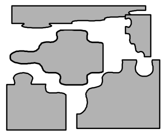
Modularity & Interdependence

In the early stages of a product's life cycle, its functionality is often not good enough to meet the needs of mainstream customers. Firms that strive to improve the functionality of a product almost always find it necessary to manage the entire product design and development processes, producing key components internally. **Exhibit 6** shows a puzzle where all the pieces cannot fit together. In this early stage of a product or service's development, centralized management is typically required to coordinate design and development. Thus, a single firm that is either vertically integrated, horizontally integrated or both, is needed to coordinate the design of the puzzle and build *interdependent* products. For example, in the early days of the computer industry, it was necessary for a single firm to produce all of the computer's components because of the complex interdependencies inherent in making the computer function well enough to meet

Exhibit 6

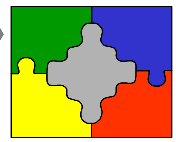
Modularity

Interdependence



- Management is the only tool that can coordinate the complex interdependencies with the system
- Integrated firms are better suited to develop products / services

Modularity



- Pieces of product/service be outsourced
- Specialist firms can understand and easily handle interdependencies
- Value goes to component providers

Determining questions:

1) **Specifiability**: Can managers specify what attributes are critical to the interface between components?
2) **Verifiability**: Can these attributes be accurately measured?
3) **Predictability**: Are there no poorly understood or unpredictable interdependencies between all the components of a system across the customer-supplier interface?

mainstream customers' needs. The eventual creation of AT&T as a monolithic monopoly (see **Box 2**) also illustrates how complex interdependencies are best handled by an integrated firm.

Once the functionality of the product gets good enough, and firms find that they need to compete on metrics such as speed and flexibility, the industry tends to disintegrate around "modular" interfaces. In **Exhibit 6**, the puzzle pieces all fit together around defined interfaces, and individual firms can produce key pieces of the product. **Exhibit 6** also points to the three key tests an interface must meet before it is defined as modular: its attributes must be "specifiable," its attributes must be measurable, and the interactions between components must be robustly predictable. As the computer industry matured and companies needed to quickly bring new computers to the market, standards emerged and the industry disintegrated. Whereas the most profitable firms in the first stage of the computer industry were the integrated producers, the most valuable firms in the next stage were companies that provided key sub-systems, like Microsoft and Intel.

BOX 2: THE FORMATION OF AT&T

The Bell Telephone Company was founded in 1877 to license Alexander Graham Bell's patents. This licensing model led to the creation of thousands of independent local operators and numerous equipment suppliers, creating significant management challenges related to network monitoring and coordination. To increase control and promote network interoperability and reliability, the Bell Company consolidated equipment manufacturing with its purchase of Western Electric in 1882. Under the stewardship of Theodore Vail and the rubric of "universal access," AT&T, after its buyout of the Bell System in 1899, followed a methodical process of horizontal and vertical integration to manage the complex interdependencies within the system to ensure a reliable phone connection for every American.

If an incremental change happens at a point of interdependence, it is termed a **distraction,** otherwise known as an incremental sustaining innovation. As illustrated in **Exhibit 5**, a **distraction** is a new technology, typically offered by an incumbent, which leads to a temporal change in the competitive structure of a marketplace without fundamentally changing the industry structure. A distraction can be thought of as a small discontinuity.[4] Competitors are often able to respond to a distraction to stop a permanent shift in market share with the introduction of new products or pricing models. Because of the interdependence, it is unlikely that a new entrant will spearhead a distraction but it is imperative for other incumbents respond in order to level the competitive playing field. For example, AT&T's Digital One Rate plan led wireless telephony players to experiment with new pricing schemes that allowed customers to purchase a block of minutes for a single price.

Unlike the other two types of sustaining innovations that are typically led and mastered by incumbents, **displacements** are often, but not always, introduced by new firms. Unlike disruptions, however, displacements are targeted squarely at the mainstream market and, while introduced by new firms, can be successfully co-opted by incumbents. Displacements can lead to substantial shifts in market share as incumbents grapple with the new competitive landscape. The entrance of MCI in the long-distance marketplace in the late 1970s is an example of a displacement. Leveraging microwave technology, MCI's strategy was to force entry into the long-distance market, offering basic services to a targeted sub-set of AT&T's best business customers. MCI's basic goal was to recreate AT&T's long-distance system and use aggressive and novel marketing techniques to gain market share. Exploiting regulatory constraints imposed on AT&T, MCI was able to undercut AT&T's published tariffs and bundle minutes in a new and novel way its competitor was prevented from matching. MCI gained market entry at the intersection between local and long-haul voice networks – a natural point of modularity "freed up" by the government. With the implicit aid of the government (who aided MCI in reaching minimum efficient scale), MCI grew to capture more than 25 percent of the marketplace. An interesting example of a potential displacement in progress is occurring in the mobile telephone handset market. By deciding to release its production specifications for mobile telephony chipsets, Motorola has ostensibly modularized its product, enabling new firms to follow a displacing strategy and manufacture competing devices. Presumably, Motorola will benefit from this displacement as it transforms itself from a manufacturer to a supplier.

Drivers of change in the voice telephony market

The telecommunications industry has gone through a tremendous amount of change, especially over the past 20 years (key changes are summarized in **Exhibit 7**). The introduction of a competitive market for long-distance services and the upgrade of the PSTN backbone from analog to digital to fiber are examples of events that have forced major changes on incumbent service providers. While each of these changes was substantial and important, none led to the radical reshaping of an industry that comes from disruption.

Given its omnipresence in the industry, it is not surprising that regulation plays a major role in distorting the disruptive process. From the Consent Decree in 1956 to the Modified Final Judgment in 1984 to the Telecommunications Act of 1996, regulation has played a pivotal role in industry development. There are two specific areas where we believe regulation influences the

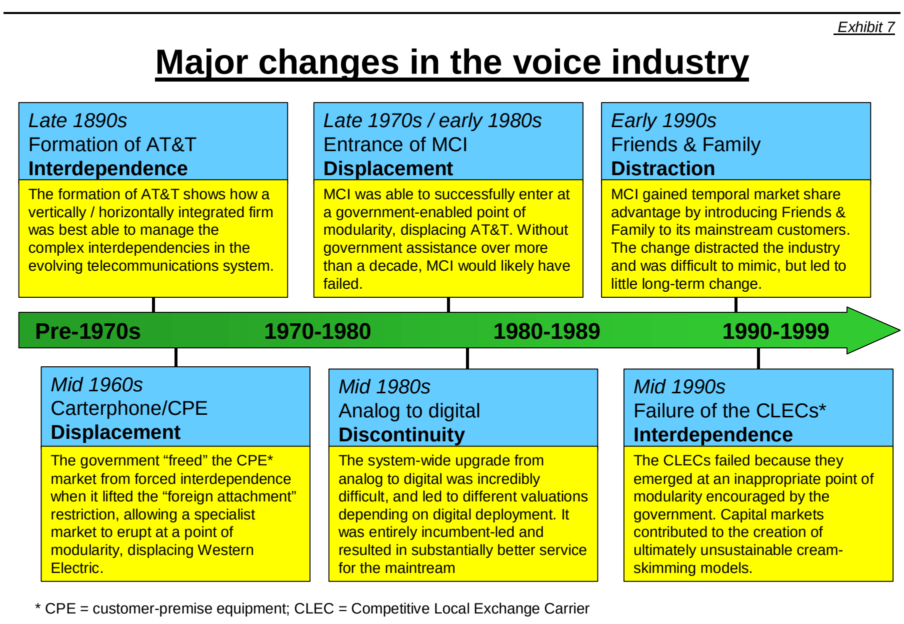
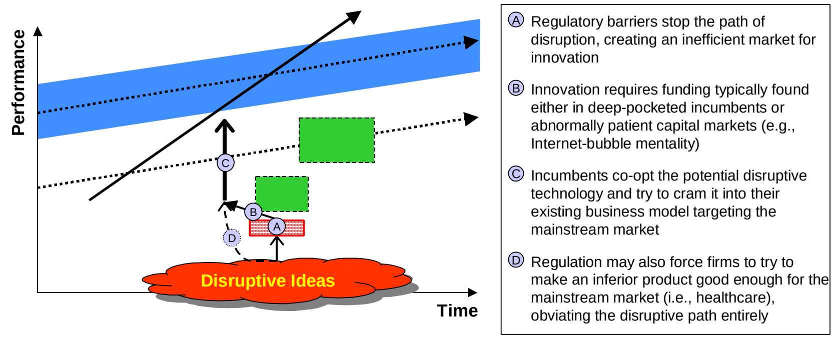


Exhibit 8

Overview of effect of regulation



forces of innovation:

1. Stops disruptive innovations by exacerbating incumbent cramming (Exhibit 8)

For a disruptive technology to be successful, it must be introduced to the "right" group of customers. However, regulation makes the "market for innovation" inefficient by creating artificial barriers (shown as a brick wall on **Exhibit 8**) that prevent innovations from finding these customers. For example, the government's tightly controlled allocation process over a limited amount of wireless spectrum makes it difficult for a new entrant to target a niche segment. RBOCs and incumbent operators already control a majority of spectrum and the auction process reinforces incumbent's power as firms need "deep pockets" to purchase spectrum. This effect is only reinforced in a "natural monopoly" environment such as the local loop. Potential new entrants, blocked from reaching a group of customers, are forced to turn to deep-pocketed incumbents to incubate their new technology. However, the resource-allocation process within the incumbent naturally pushes offering the potential disruptive innovation to mainstream customers, "cramming" the technology into its existing business model.

Regulation can also exacerbate incumbent cramming by forcing a potential disruptive technology to stretch to meet the needs of the most-demanding customers. For example, regulation in health care only allows the introduction of products that are able to serve all types of patients. This policy deflects the potential disruptive path of a new technology, as, by definition, a disruptive technology is not initially good enough for the most-demanding customers.

2. Forces artificial interdependence/encourages inappropriate modularity into a marketplace

Regulation affects industry change by "artificially" influencing the makeup of the industry, either forcing artificial interdependence or encouraging inappropriate modularity. For example, the CPE market was "bottled up" by foreign attachment provisions although all the conditions were in place for the CPE to be a modular piece in the telephone system architecture. Once the government removed these restrictions (in our lenses an appropriate act recognizing the modularity of the industry), competition erupted at the point of modularity. On the other hand, the 1996 Telecommunication Reform Act tried to unbundle the local loop, which remains a tightly coupled interdependent architecture. Some observers thought the CLECs would unseat the incumbents, who would be relegated to providing basic phone service to unprofitable and relatively uninteresting customers in rural areas. The titanic failure of these new players uncovers our government officials' fundamental misunderstanding of the telecommunications' industry DNA. The local loop is essentially a natural monopoly[5] with an incumbent regulated monopoly controlling a highly interdependent system. Any effort to force modularity on the system was doomed to fail, as a market of specialists would not be capable of managing the complex interdependencies in the system. Unbundling elements of the local loop did not create accessible interfaces; it transformed central offices into competitive war-zones full of questionable tactics and finger pointing. Even if the incumbents had allowed new entrants completely unfettered access, the interdependence of the system would have made it very difficult for specialists to be successful. Without control over hard transport assets, the new entrants had little choice but to follow a basic cream-skimming (tariff arbitrage) business model to earn profits quickly to please anxious investors. Incumbents held all the cards as capital markets forced new entrants to overextend themselves and eventually be dragged down by high leverage. Since new entrants fell short of minimum efficient scale when the capital markets rediscovered discipline in 2000, they were doomed to failure. Any effort to try to legislate competition without acknowledging the underlying structure of the interfaces is destined to come up short of the intended results.

* * *

Despite numerous predictions – especially over the past few years – the ILECs march on, as powerful – if not more so – than ever. However, forces are at work in the data enterprise market – a natural place for innovation to incubate, as it is relatively free from regulatory and natural monopoly barriers – that will lead to major changes for the ILECs and present the possibility of their ultimate disruption.

SECTION 2: DISRUPTION IN DATA

After studying the history of the telecommunications market, our research failed to uncover any strong classic examples of disruptive technologies that dramatically altered the competitive landscape. However, an examination of the seemingly unrelated enterprise data networking market uncovered a number of disruptive innovations that had predictable seismic effects on the industry. Analyzing these disruptions more closely will provide fruitful insight into how disruptive forces work and present a description of the technological underpinnings capable of spawning a new series of disruptive models. The business market has always been a catalyst for change and innovation in telecommunications. Today we see this same pattern emerging in the enterprise data market. Data has always been as important to businesses as voice has been to consumers. As voice becomes a data application industry dynamics will change and data will become an increasingly important driver of industry change. In particular, the spread of IP internetworking has sparked a wave of market disruptions (see **Exhibit 9**) that appears poised to topple the circuit-switched networking paradigm that has dominated the last century.

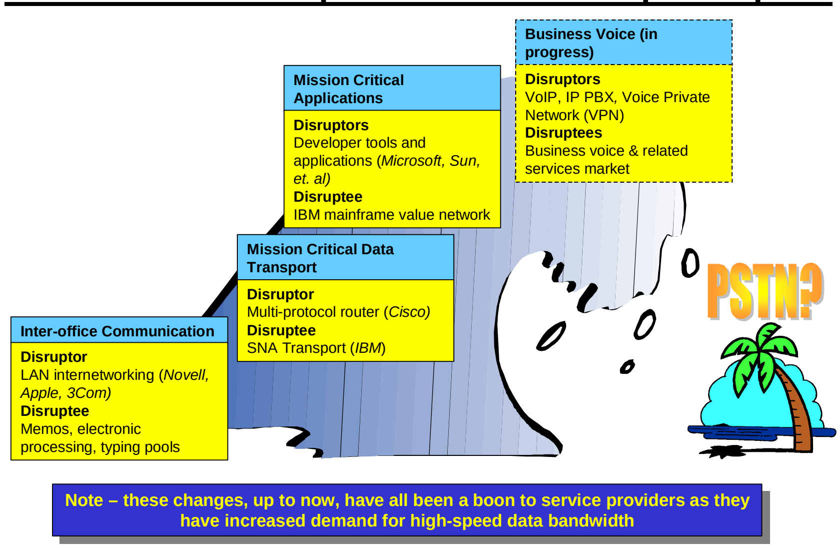
The data enterprise market, with its low regulatory hurdles and high density and value per user, has proved fertile ground for the incubation of disruptive business models. Technologies have been able to improve mostly unencumbered by the regulatory and technological barriers that exist in the residential market. To date, traditional service providers have remained largely insulated from these disruptions, instead benefiting as the rise in networking has led to increased demand for bandwidth and connectivity. That said, the disruptive models that have encouraged the IP-based "any-to-any" computing revolution (see **Box 3**) have now led to convergence – the ability to send voice, video and data on one IP network – which stands to serve as a catalyst for change. The emergence and rapid improvement of VoIP technologies provide companies with a reliable way to translate voice traffic into data packets and route them over existing IP private data networks, enabling new functionality and eliminating the need to pay access tolls. For incumbent service providers, IP-based networking creates both threats and opportunities that cannot be ignored.

The First Disruption: Interoffice Communication

In the early 1980s, the Institute of Electronics and Electrical Engineers defined standards for networking computers in the local area. While few realized it at the time, LAN standards would

Exhibit 9

The 'wave' of disruptions in data enterprise space



become the building block of one of the most powerful disruptive forces in process today within telecommunications – the emergence of the "any-to-any" networking paradigm.

The rise of the minicomputer and the PC in the early 1980s created demand for scalable, flexible and efficient high bandwidth corporate data networks as computing power became more distributed. Prior to the PC's introduction, enterprise computing was dominated by centralized mainframes with costly and difficult to implement customized applications and functionality was limited to what could be developed by corps of professional programmers. While most major corporations did employ a tremendous amount of information technology, these large, expensive mainframes typically were reserved for the most demanding and complex jobs: mission-critical business applications (e.g., accounting functions, transaction processing, payroll, etc.).

The vast private data networks found throughout a major enterprise were used to support the centralized systems architecture of these corporate mainframes. Mainframes transmitted data to "dumb" terminals via owned or leased dedicated connections interconnected to create elaborate corporate private data networks. These high-quality, circuit-switched connections were typically purchased from telecommunications service providers and were expensive to install, provision and maintain.

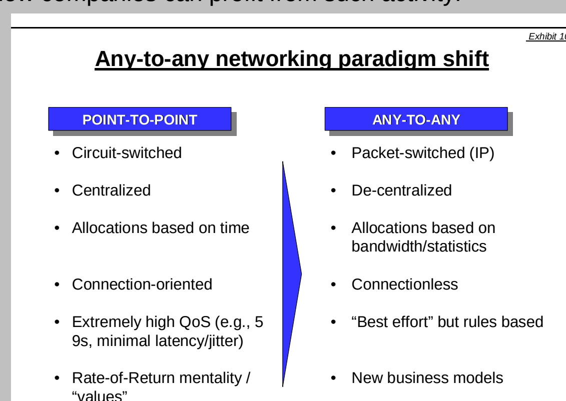
IBM dominated the enterprise data networking with an overwhelming share of the mainframe, data application development and data transport markets. IBM sold mainframes for the collection, processing and storage of mission critical corporate data as well as the equipment and services to support the processing and transport of that data. At the core of every IBM system was the company's Systems Network Architecture (SNA) – an archaic, proprietary computing language and networking scheme designed by IBM specifically for its enterprise data business systems. SNA-based networks carried a solid reputation for reliability and security that let corporate information technology professionals sleep at night without the worry of lost data. Any changes to an IBM-based data network required the expertise of highly trained SNA programmers and technicians.

BOX 3: THE INTERNETWORKING PARADIGM

A paradigm shift – away from point-to-point architectures to "any-to-any" computing (see **Exhibit 10**) – is underway in the telecommunications industry. Born in the local area, it quickly spread throughout the enterprise data market.

PCs connected with LANs represented the first example of a connection-less network world. Data no longer had to travel down dedicated, expensive to create and maintain pathways. Instead, data was partitioned into packets (datagrams created by networking protocols such as Ethernet and IP) and blasted through a common transmission medium in a "best effort" fashion – traveling along any and every potential path. Once at their destination, packets were re-assembled and presented to the user in a recognizable form.

This distinction between "point-to-point" and "any-to-any" cannot be trivialized. "Any-to-any" computing represents a very disruptive force within the telecommunications industry and has enabled a series of product-level disruptions within the data enterprise space. It has brought about structural changes to pricing as the purchase of circuits based on time has shifted to the purchase of capacity measure in packets and bandwidth by sophisticated mathematical and statistical methods. "Any-to-any" computing represents a fundamental shift in the way data is shared and sent across a network and how companies can profit from such activity.



The Local Area Network (LAN) was the first major identifiable disruptive technology in the data enterprise market. Taking root in a true "green space" market, LAN technology got good enough to completely disrupt the labor intensive "sneakernet" that exemplified office communications. Prior to the introduction of LANs, inter-office communications had experienced relatively little change since the introduction of the telephone. While the fax machine had introduced the ability to send data over existing telephone lines, inter-office communication remained relatively unsophisticated, relying on slow, manual processes. Typing pools (legions of typists responsible for the creation of office documents), memo distribution boxes and the U.S. mail system were essential components of the modern day enterprise. They were highly accurate and had the "personal touch" that provided a high sense of reliability to their consumers.

PCs introduced users to the countless ways to simplify work tasks and improve efficiency within a typical corporate functional department. Users quickly discovered communication and information sharing could be dramatically improved by connecting PCs together – with LAN technology as the key connector – to create rudimentary networks.

Early LAN internetworking standards represented an orthogonal departure from the "hub" and "spoke" model of computing enforced and necessitated by the mainframe. LAN protocols introduced simple, easy to implement, universally understood open standards, such as Ethernet, that created the possibility of inexpensively connecting co-located computers. At the departmental level, virtually anyone could and did build LANs by plugging together PCs with networking cables available at any local computer store. LANs allowed workers to share information in ways not possible under the old regime. LAN technology easily met all the necessary criteria to pass the first litmus test of a disruptive technology.

LAN technology quickly pulled customers out of the mainstream inter-office communications market. Word processing and email quickly obviated the need for memo typing pools and their manual distribution processes. Additionally, once connected, users could transfer files, share expensive laser printers, and almost effortlessly circulate pertinent information. Users quickly stumbled on to Metcalfe's law and demand for LAN technology exploded. Networks created for the purpose of inter-office communications were deployed alongside but separate from the legacy private data networks supporting mainframes and their mission critical applications.

In the opinion of most IT managers, initial LAN technology was not yet good enough to handle the mission critical data networking needs of the modern enterprise. Corporate IT managers were responsible for ensuring that that a firm's mission critical data applications were highly reliable, fault tolerant, and secure. Most IT managers relied on IBM mainframes with SNA-based networking architectures and considered the LAN to still be a "toy" technology.

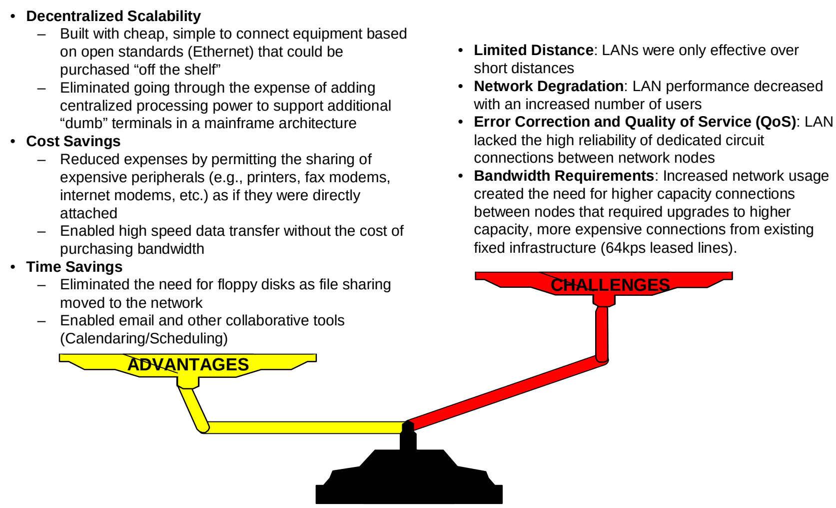
While LANs were considered simplistic and generally unreliable relative to SNA networks, the technology had a number of disruptive qualities (see **Exhibit 11** for a detailed explanation of the pros and cons of LANs). Companies such as Novell, Apple and 3Com capitalized on the growth of LANs by developing and producing additional equipment and protocols that redefined the interoffice communications market and disrupted "sneakernet".

IP Networking Takes Over the Corporate Data Transport Market (summarized in ***Exhibit 12****)*

While the LAN was terrific to connect small offices or adjacent buildings in a local area, networking users in geographically disparate locations required more robust networking solutions. LAN technology was not good enough to support the huge number of users and devices found on a typical enterprise data network. The introduction of the multi-protocol router was the pivotal development that turned the data-networking world upside-down and enabled the

Exhibit 11

Advantages & challenges of the LAN



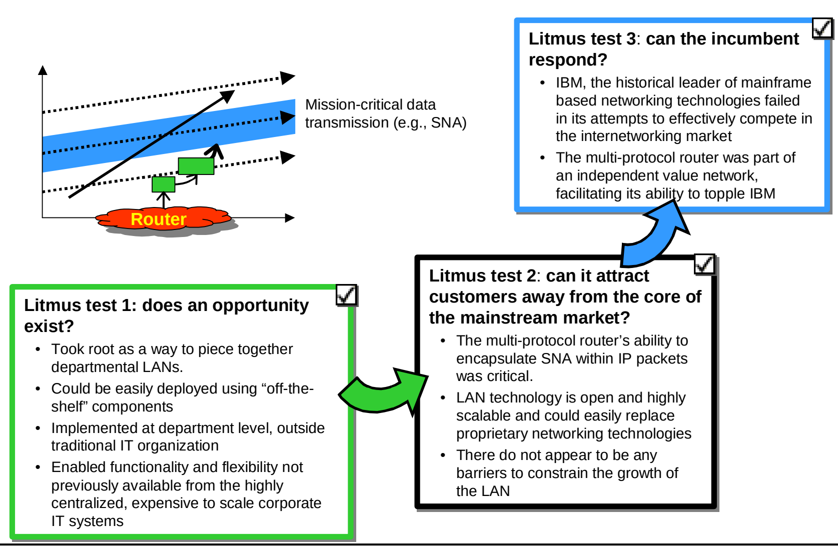
disruption of both incumbent networking companies – created by the disruption of sneakernet – and IBM's data transport businesses.

Developed out of the need to manage exponentially increasing LAN data traffic, the multi-protocol router "spoke" the varied "dialects" (Appletalk, Ethernet, Xerox, Novell, etc.) of the LAN, translated them into IP – the open, connectionless, "best effort" protocol – and layered on intelligence that forwarded packets towards their ultimate destination. Easily added to any network, these routers enabled LANs to be interconnected within the "green space" of departmental networks in a manner that minimized network degradation and increased network efficiency while allowing any device on the network to communicate with any other device. Early networking companies such as Novell and 3Com that used proprietary networking standards found themselves unable to compete with the open, any-to-any computing architecture created by the multi-protocol router created. The router's IP-based technology was cheaper, more flexible and scalable.

As email and file sharing became essential components of business, demand for enterprise communication networks increased resulting in a huge build out of IP networks. This build out

Exhibit 12

Mission-critical data transport disruption



funded the router's rapid improvement in reliability and security – two attributes that were very important to the managers of mission-critical data networks. However, the multi-protocol router's biggest test was whether it was good enough to support mission critical systems, specifically the data transport portion of the enterprise networking where IBM mainframes and SNA still dominated (and where all the real money was made).

As LANs, bolstered by the multi-protocol router, spread throughout the enterprise and the reliability of the technology improved, corporate IT managers better understood the intrinsic benefits of router-enabled IP-networking. For the first time, data networking could be accomplished in a flexible, simpler and inexpensive way without the need for expensive connection costs and customized development. Additionally, as departmental spending on LAN technology increased, many firms centralized responsibility for all networking related purchases to the traditional IT function under the supervision of professional buyers. However, relative to SNA, IP-based internetworking was still considered inferior and not robust enough to manage the mission-critical data transmission networks.

IT managers' attitudes changed dramatically with Cisco Systems'[6] introduction of SNA over IP transport technology. This improved version of the multi-protocol router layered in the ability to encapsulate and transmit data coded into SNA over the existing connection-less IP infrastructure in place from the build out of LANs. Router technology had finally gotten good enough to begin its attack on the mainstream market. Instead of traveling over expensive to maintain dedicated open circuits, SNA data traffic could now be split into IP packets, efficiently routed over a private data network, and reassembled at its destination. While lacking the 99.999 percent reliability and security of a point-to-point connection provided by SNA over dedicated leased lines, SNA over IP was a critical step in the disruptive march up market and attack on IBM's data transport business by the multi-protocol router. Corporate customers could now satisfy their networking needs with the slightly less reliable but dramatically cheaper and more flexible IP-based router technologies.

Sales of routers with SNA over IP technology skyrocketed with the deployment of IP-based networking products. The way the world worked was changing and the complete disruption of the mainstream data transport market was underway. Wounded but not down, IBM challenged by introducing its own line of internetworking products that ultimately could not compete with Cisco. The multi-protocol router passed litmus test three: IBM's capabilities were based on values developed in the circuit-switched world and its products were inferior to those developed by firms that lived by the new paradigm. Cisco had developed a unique capability to discover, understand and incorporate emerging internetworking concepts into their products while IBM ceded increasing market share. Additionally, IP-based networking technologies were incubated in their own value network, separate from the IBM's mainframe value system making any type of co-option unlikely.

In September of 1999, the knockout blow was thrown when IBM arranged to sell its entire internetworking business to Cisco for $2 billion including an agreement to collaborate in serving IBM's legacy customer base. IBM also agreed to sell Cisco networking products as it shifted its focus to what it described as "higher margin sales support and service opportunities." The 60-percent plus margins in its internetworking products that delighted Cisco were incongruent with IBM's values. This asymmetry is typical of the disruptive process – margins earned by a disruptive technology appear relatively unattractive to incumbents.

IP-Based Improvement Trajectory

In response to the disruption in process within the enterprise data transport market caused by IP-based networking technologies, many companies entered the market to create the software development tools and build the applications needed to run mission-critical functions (e.g., billing and payroll). Companies such as Sun, Microsoft, Intel and Oracle actively engaged in defining the tools required to drive the creation of IP-based applications. One by one, the proprietary development tools that governed the rules of application development in the "point-to-point" world were replaced with tools based on open standards, flexible architectures and networked computing platforms. Thus, these new application providers led the disruption of the "value network" – companies involved in the creation specific tools, products and services – that developed around the IBM mainframe-computing platform.

The importance of and spending on data networking technologies increased dramatically. Technology issues appeared on the CEO's agenda and technology became an integral part of the overall corporate strategy. New applications brought new features and capabilities that triggered a massive build-out of Internet and intranet networking technologies. The net result of all this activity was that most large enterprises deployed IP networking technologies throughout their entire enterprise, setting the stage for VoIP and the potential for disruption of the business voice telephony market.

While the disruption of IBM's mainframe value network profoundly changed the enterprise data market, the service provider market remained mostly insulated from change. Service providers continued to benefit as demand for bandwidth increased, but because of their independent (with respect to mission-critical applications) value network, they were spared from any of the major types of change classified by the 4D model. Instead, networking companies, such as Cisco, were the primary beneficiaries of the massive build out of networking equipment and made impressive enhancements to their core networking technologies (e.g., routers and switches). The disruption of mission critical applications was to networking companies what the SNA over IP innovation had been to service providers – it increased demand for their products without fundamentally reshaping their business models.

The Next Disruptive Force: Voice Over Internet Protocol

The pervasiveness of IP networking in the corporate market provided a technology platform from which the ultimate disruption to telecommunications can finally erupt. Standards for data transmitted in packets based on open, universal protocols have opened the doors for convergence. A common IP networking standard now exists across most large enterprises. Convergence, enabled by VoIP technologies – the ability to translate voice signals into IP data packets – will allow voice, video, and data to travel on a single IP data network. As the technology inevitably improves and delays, created by latency and jitter, which break down voice and video communication are resolved, VoIP – powered by several key system-level enablers (described in **Box 4**) – is poised to disrupt the mainstream corporate voice market historically controlled by the RBOCs and IXCs.

BOX 4: SYSTEM-LEVEL ENABLERS

The LAN case exposes several underlying technologies critical to fueling the engines of the disruptive process. These system level enablers – core technologies that define the foundation from which product level disruptions can be built – are many in the telecommunications world. In more general terms, a system-level enabler is necessary, but not sufficient to create a product-level disruption. It still takes ingenuity and effective operational practices and market-based tactics to create a disruptive technology according to the definitions presented in our model.

Ethernet and IP are two system level enablers that have fueled a wave of disruptions that has crashed through the enterprise data market and is rapidly approaching the rigid shores of the Service Providers. While, to date disruption has remained within the enterprise voice market, emerging technologies such as VoIP and Dense Wave Division Multiplexing (DWDM) are increasing the likelihood that IP-based data transfer will make the leap and threaten fundamental change to historic voice market leaders.

SECTION THREE: IN-PROCESS 'DISRUPTIONS'

As the Internet and telecommunications bubbles expanded over the past few years, industry watchers and entrepreneurs tossed around the term "disruptive" as a simple and acceptable justification for easy money and lofty valuations. The implosion of both bubbles in 2000 demonstrates that overly simplistic analysis of innovation can lead to a massive misallocation of resources towards opportunities that actually have very little hope of achieving the level of success detailed in their business plans.

There are numerous technologies in the telecommunications industry – both widely known and largely unknown – that continue to be widely touted as "disruptive." A rigorous application of the disruptive technology model can help managers and financiers begin to separate the truly disruptive from the potentially disastrous. Specifically, we will use the disruptive "litmus tests" developed in Section 1 to evaluate the disruptive potential of: wireless, VoIP and MAN providers. **Exhibit 13** summarizes our assessment of how key specific technologies stack up against the disruptive litmus tests. For each technology, we will also assess its likely future developments, explain key gating factors and summarize important implications for incumbents.

Wireless

Since wireless is an umbrella term that has come to describe almost any form of communication involving no wires, it is worth stepping back to properly frame the industry. **Exhibit 14** details the important segments and the comparisons we will focus our analysis on. **Exhibit 14** delineates the key segments of wireless as cellular services, fixed wireless (e.g., Multichannel Multipoint Distribution System), local unlicensed band services like 802.11 and satellite services. While analysts at times have ascribed disruptive potential to each of these technologies, we will focus on two of the most frequently touted examples: cellular telephone services and unlicensed wireless data services, specifically 802.11x.

Wireless vs. wired

Wireless communication, typified by the now ubiquitous mobile telephone, offers an appealing disruptive case. Wireless clearly meets the *first disruptive litmus test* – almost half a billion global subscribers indicate a massive "green space" or new growth opportunity. Mobile phones began

Exhibit 13

Litmus tests applied to in-process disruptions

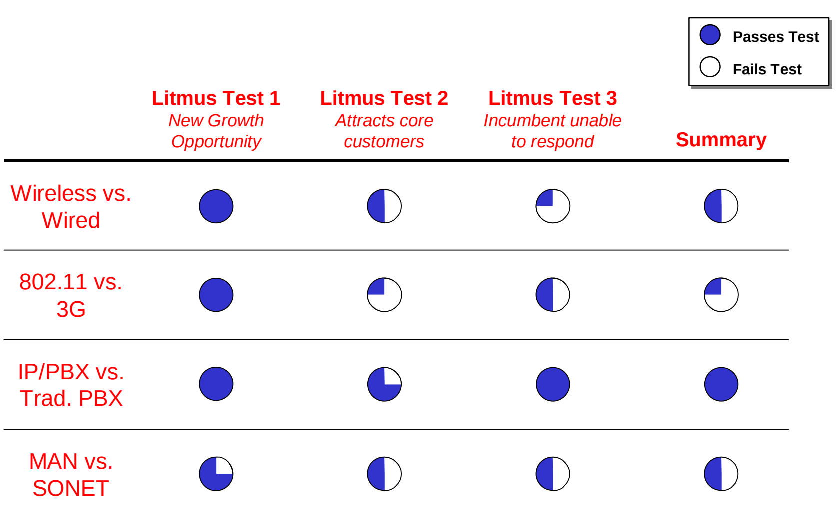
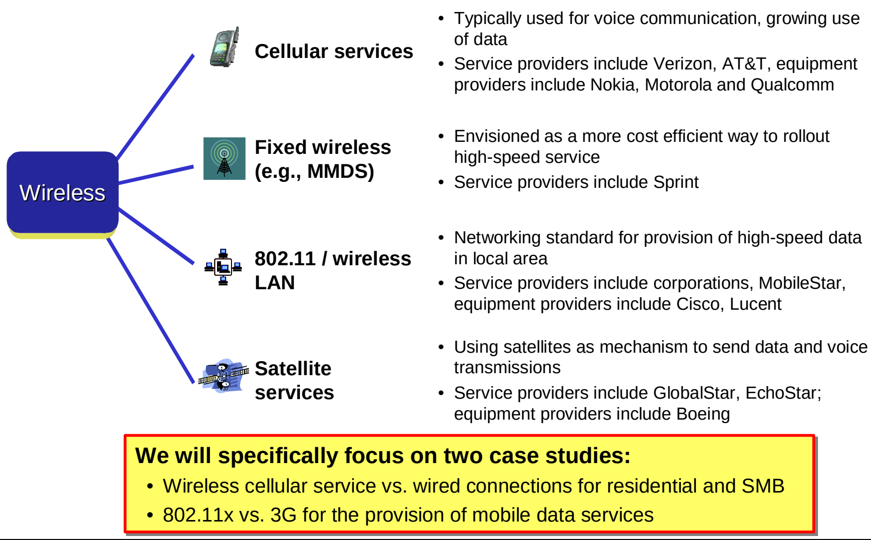


Exhibit 14

Key segments in wireless market



their growth in the mid-1980s in an application outside of the mainstream market, providing mobile communications to businesspeople in their cars. Mobile telephones were vastly inferior to wired connections on dimensions of basic functionality and reliability, but offered the convenience of mobility. And wireless phones clearly fit customers' behavior patterns – while the devices were "brick-like" in nature, they still looked, felt and almost sounded like "regular" phones. Wireless phones then followed a predictable pattern of improving quality and decreasing cost fueling expansion into additional customer segments. Similar to when Toyota first entered the U.S. market with the Corona, a low-priced, highly fuel efficient, inferior vehicle that General Motors could not and did not want to compete with, the least-demanding phone customers (mainly students, people who live in group homes, and second lines in homes) have un-tethered themselves from the PSTN and rely entirely on less reliable, often cheaper mobile phone service to meet their voice call needs. Wireless has been quickly pulling customers out of the mainstream wired market. For example, recent studies have noted that in the United States 3 percent of wireless users report "cutting the cord," and almost 20 percent of wireless minutes now take place in wired locations like the home.

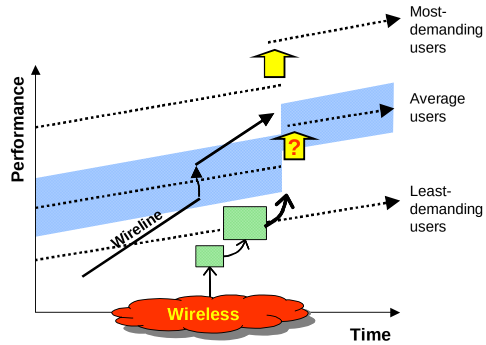
Wireless vs. wired through the litmus tests

- **LT1:** Huge new growth in new, novel application
- **LT2:** Changing consumer demands makes it hard for wireless to cross over
- **LT3:** High degree of interdependence limits disruptive potential

With its new growth market clearly established, *litmus test two* asks whether wireless can now invade the mainstream market of wired connections in the residence and in small/medium businesses. While there are signs that this process has begun, changes in the nature of customer demand appear to deflect wireless' disruptive trajectory. While wireless penetration has continued at a rapid pace, the minutes of residential landline use showed no signs of waning in the late 1990s. This indicates that, while customers may be substituting wireless *voice* for wired *voice*, the rapid growth of second and third lines for fax and then Internet access led to consumers placing increasing data-related demands on their wired connection, only exacerbated by the increased rollout of digital subscriber lines (DSL). These new technologies stimulate a new base of demand for customers from their wired connection, in essence creating a discontinuous shift up in the demands of given market tiers displayed in **Exhibit 15**.

Exhibit 15

Traditional voice through the disruptive lens



- Wireless voice has gotten good enough to meet the needs of the least-demanding wireline customers (e.g., students, payphones users, group homes)
- However, more demanding tiers are shifting their demand upwards as they substitute data uses for voice uses.
- The PSTN/wireline has gone through a series of improvements to meet those discontinuous needs (e.g., analog to digital, DSL), indicating it may take a long time/be impossible for wireless to completely "disrupt" the PSTN
- It remains unclear if the "average" consumer will actually shift its demand upwards

The central question is whether wireless service, with its many data-oriented enhancements in upcoming 2.5G and 3G standards will get "good enough" for the high-speed data needs of the average consumer. Based on the untold billions spent in spectrum auctions across the globe, it would seem that many operators assume the answer is yes. However, 3G operators appear to have fallen prey to a pernicious "double cram" that further deflects the disruptive trajectory of wireless. The first cram occurred when 3G was conceived more than 10 years ago. Industry players viewed 3G as a way to tap into the burgeoning high-speed data communications market. Hence, they worked to develop a standard that would allow the seamless provision of up to two megabits per second of data. Planners hoped to stretch the technology to meet the needs of the most-demanding user of the time – the mobile salesperson – instead of targeting a market that would be delighted by data mobility even at relatively slow rates.

While 3G was primarily designed to enhance voice service by better managing capacity, the rise of the Internet and the belief that next generation data applications would drive significant profit opportunities has placed a greater emphasis on 3G's data transmission capabilities. As average revenue per user has stabilized, wireless operators are searching for new ways to drive revenue growth, primarily through data services. With the initial 3G standard never implemented, potential operators are "cramming" all over again by trying to market 3G on its high-speed data attributes to the most-demanding customers.

Current and future generations of wireless technology are thus unlikely to meet customer's data requirements, meaning wireless will not obviate the need for a wired connection. While wireless can "break through" the lower tier of the marketplace, sudden shifts upward in the needs of the most-demanding – and eventually mainstream customers – displayed in **Exhibit 15** appear to constrain the disruptive path of wireless versus the wired connection. This analysis does indicate a disruption in progress in the residential voice market, where incumbent players who traditionally earn large revenue from metered calls (e.g., IXCs) are feeling pressure from the onslaught of wireless players.

The power of the entrepreneurial spirit often allows managers to come up with unanticipated ways around perceived barriers. If wireless can get "good enough" to attract customers from the mainstream market, it then must face *litmus test three* and the inevitable response by incumbents. Here, the disruptive luster falls even further off wireless. Wireless does reshape the industry to earn profits in new ways, as providers offer unique bundled plans that cannot be easily matched by wireline providers. However, the extremely high degree of interdependence between the wireless and the wired value network seriously deflects the potential disruptive trajectory of wireless. Driven by the limited availability of spectrum, many wireless providers are also wired providers, and hence have no incentive to channel the disruptive energy in wireless and disrupt themselves. Additionally, wireless fundamentally depends on the wired infrastructure to complete calls. The overlap between wireless providers and wired providers and the interlinking of the transport networks pushes wireless even further towards being a complementary product to wired access.

A common theme that leads to the deflection of the disruptive trajectory of wireless is the limits on available spectrum. Limited spectrum "caps" the number of players who might embrace wireless' disruptive potential. Also, by allocating spectrum largely to incumbents or by making them the likely winners in an auction (given their deep pockets), governments encourage sustaining behavior.

Wireless LAN versus 3G[7]

802.11x vs. 3G through the litmus tests

LT1: Big new growth through departments, hotspots, home networking

LT2: Serious limits to the improvement trajectory of 802.11

LT3: New business models, potential independence although network access through incumbents

While wireless operators continue to trudge towards rolling out 3G services across the world, wireless LAN (WLAN) pundits argue that services running on the 802.11x standard (also know as WiFi) and rely on unlicensed spectrum in the 2.4 or 5 gigahertz band threaten to disrupt 3G before it ever comes to fruition. WLANs already appear to have passed *litmus test one* and are in the process of creating attractive new growth opportunities. This relatively cheap and simple to deploy high speed wireless data technology uses unlicensed spectrum to achieve reliable data transfer rates (up to 11mps) that in many cases exceed the capabilities of 3G. However, as with most disruptive technologies, early iterations of WiFi leave great room for improvement, with issues related to limited distance, presence management and security all representing big concerns. Even with these limitations, WLANs are following the "golden rule" of networking technology adoption – gaining a significant foothold within the enterprise at the departmental level and then expanding to enterprise applications in "hot spots" such as airport lounges, coffee shops, airports and conference centers.

Despite its exciting growth and a growing chorus of industry watchers who excitedly hail its disruptive potential, WLANs look significantly less disruptive through the lens of *litmus test two*. Without widespread deployment, mainstream customers are unlikely to eschew 3G and embrace 802.11x WLANs. The showstopper is the severe constraints that regulation and physics impose on the improvement trajectory of WLAN services, creating formidable barriers to WLANs invading the "blue space." Current operators are attempting to band together to create roaming and billing relationships to allow the fragmented market to offer a semblance of national coverage and services. However, government limitations on the use of unlicensed spectrum and constraints based on the physics of the technology (e.g., power, range, interference with other devices such as cordless phones and microwaves) are very likely to keep 802.11x WLANs out of the mainstream market of the mobile consumer.

While disruptive technologies and innovative businesspeople often find unanticipated ways around constraints, government-imposed barriers limit potentially novel solutions. If 802.11x can find a way to enter the mainstream market, its prospects to pass *litmus test three* and unseat incumbents are somewhat more promising. WLAN providers could choose data-based business models that would prove difficult for incumbents to respond to. Also, WLAN providers are growing in a moderately independent value network from incumbent service providers. The largest point of interdependence is at the point of network access. If WLANs access the networks through incumbent service providers, they present an easy avenue for co-option. However, if they choose to access the network through independent Internet Service Providers or MAN providers, they could develop a completely freestanding value network that could facilitate the ultimate disruption of incumbents. The quintessential question to realize disruption will be can the new wireless CAPs create public networks of minimum equivalent functionality and scale to be appealing enough to pull enough customers from the mainstream market.

Summary and implications for incumbents

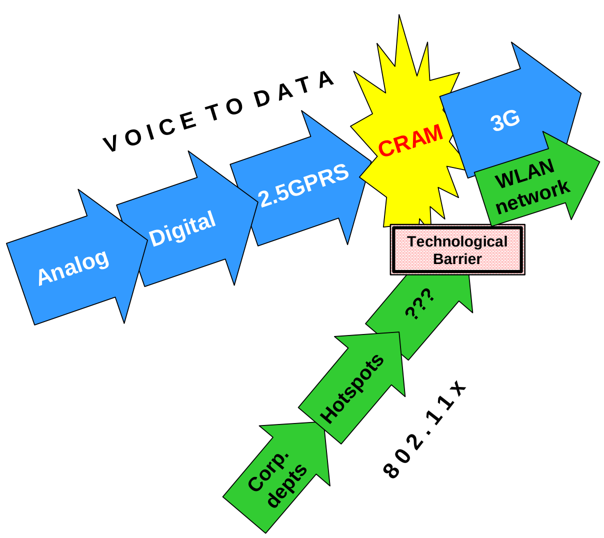
We do not believe the fate of wireless changes, even with the introduction of 3G and high-speed wireless data capabilities. 3G technologies represent a *discontinuity* to incumbent wireless service operators as they attempt to cram a data model on top of a historically voice-centric business model. 2.5G, an interim step to 3G that features slower speeds but "always-on" connectivity will likely represent a *distraction* to incumbent operators, with the greatest expected short-term benefits attributable to the first mover.

Given the statutory and physics-related constraints on 802.11x's improvement trajectory, 3G and 802.11x are quite likely to emerge as complementary products that will combine to provide a blanket of wireless voice and data access (see **Exhibit 16**). In fact, 802.11x's greatest disruptive impact is likely to be felt within the enterprise vis-à-vis wired LANs. A new class of competitive access providers (CAPs) will emerge in the public network providing wireless connectivity using 802.11x technologies in "hot spots" such as airports, coffee shops and other crowded user locations. These CAPs may prove attractive acquisition targets to 3G operators who are looking to augment their coverage. This outlook is predicated on continued regulatory barriers leading to entrepreneurs failing to find ways around the limitations of 802.11x. Unusually patient capital markets or the entrepreneurial spirit could help circumvent these barriers and fund more widespread 802.11x technology deployment.

With the limits on available spectrum continuing to perpetuate interdependent systems and with changing consumer needs, these new combined providers will still be unable to fully disrupt the wired connection to residences and small businesses. Wireless companies that do not have hard assets, like Voicestream and Nextel, will lead the charge to attract more and more customers

Exhibit 16

Wireless through the disruptive lens



- 3G appears to be an example of a "cram" of an inferior technology to the most demanding customers
- Although 802.11 fits the disruptive criteria, there may be a "cap" on its trajectory because of spectrum limitations and physics (e.g., power and bandwidth)
- Hence, a new class of competitive access providers will likely arise, whose future is indeterminate at this time
- 802.11 will likely end up being complementary to 3G, and the combination could still prove disruptive

away from their wired connections, which could continue to harm the ILECs and IXCs.

In the next few years, we expect that consumers in the middle and upper tiers of the market will rely on a wired connection for most of their data needs. As voice becomes a data application, it can be bundled as a free add-on to high-speed service. Wireless will provide some voice and data for the least-demanding tiers of the market but will not be good enough to "catch" rising consumer demand. As 3G is crammed, it will prove disappointing to operators, burdened by the large amount of debt issued to fund its build out. 802.11x will act as the cordless phone of the PC age, enabling wireless connectivity within homes and businesses but still relying on a wired connection to the network.

Wireless presents the following implications to incumbent operators:

- Follow closely the development of 802.11x, as a new class of CAPs could emerge focused on the development and deployment of 802.11x-based wireless LAN technologies. Broad deployment could result in the creation of a *de facto* wireless network infrastructure. While network management issues would need to be solved, this *de facto* network could be a potentially disruptive alternative to 3G. Specifically, incumbents should examine the developments related to unique 802.11x deployments in niche segments. These developments could be enhanced by the deployment of 10-gigabit Ethernet in the metro area network.

- Don't bet the farm on 3G wireless services. A slow and steady adoption is likely the right course, as the interim technology, 2.5 GPRS, provides a lower cost learning opportunity and offers many of the benefits of 3G.

- Do not be afraid to cannibalize your wired business with your wireless offerings. As stated above, wireless voice is potentially very disruptive relative to lower-end wired voice applications. For consumers that are over-served by the PSTN, mobile telephony is an attractive and potentially disruptive alternative. If the incumbents do not ride the disruptive wave, they could find themselves spending a tremendous amount of money to defend their once sacred and inaccessible local telephony ground. Additionally, companies that have fewer "traditional" depreciated assets in the ground to protect are most likely to embrace the disruptive potential in wireless and fight against incumbents.

VoIP

The existence of a pervasive, common networking in the enterprise standard enables the possibility of one final, crucial IP conversion: voice sent over IP. Like "wireless," "VoIP" has become a "catch-all" term for numerous technologies and business models that all relate to sending voice using IP data packets in a connectionless environment. While sending voice in packets is not a new concept (Asynchronous Transfer Mode [ATM] has existed for many years), technology has only recently gotten good enough to allow for voice to serve as a data application. As the VoIP story is complex, there are several important factors to keep in mind during the following analysis:

- It is vital to remember the distinction between transport and services. Transport (sometimes called "naked connectivity" or simple 1-plus dialing) is provided over the physical connection media between communication nodes. Services refer to value-added features that telecommunications companies sell to consumers and business that enhance the functionality of the communications network. Services range from basic services handled at the local level (e.g., voice mail and 3-way calling) to relatively advanced services that are handled at the network level (e.g., call-center management, 800 services).

- Providing advanced, network-based voice services such as 800 services or call center management requires more than a single solution; the tightly coupled, real-time interactions necessitate complex interdependent solutions.
- The disruptive potential of VoIP-based advanced services will depend on the development of independent value networks capable of incubating the technologies completely outside of the traditional service provider networks; a high degree of interdependence implies that incumbents are likely to successfully co-opt VoIP technologies.

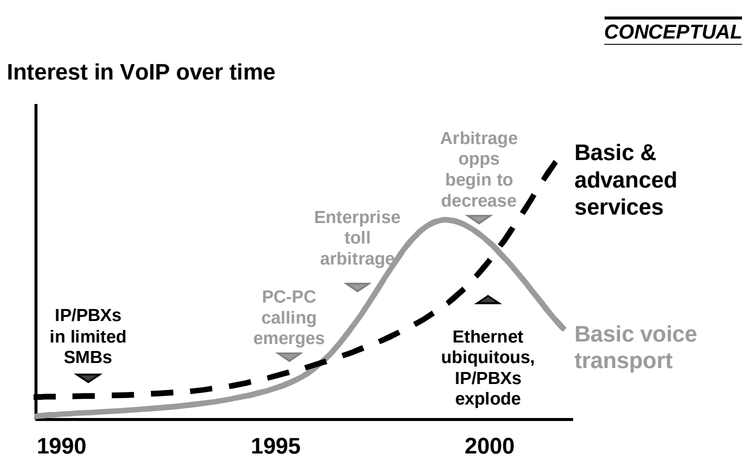
We focus our discussion of current developments in VoIP in two areas. First, we examine VoIP's initial commercialization as a tool to provide pure voice connectivity. Then we turn to VoIP's deployment as a means to provide basic and advanced voice services within enterprises through IP/PBXs and related solutions. The two stories are somewhat related and have followed parallel paths (displayed conceptually in **Exhibit 17**), with interest in pure connectivity rising in the mid-1990 before peaking and declining in the late 1990s just as previously slowly growing interest in the basic and advanced services began to take off.

The initial commercialization of VoIP

While the initial commercialization of VoIP to provide connectivity seems disruptive, it essentially is an arbitrage story that, while interesting, is not central to current VoIP developments. As the Internet began its explosive growth in the mid-1990s, hackers were entranced by the concept of using their PCs to get around oligopolistic access charges on long distance and international phone calls. Although the high latency and jitter led to inferior call quality intolerable to most users, students and immigrants were delighted by the almost-free calls. Companies like Net2Phone and DialPad sprung up to latch on to the new growth opportunity, eventually adding pre-paid calling cards to let people make VoIP calls from regular telephones. The arbitrage opportunity spread to the enterprise, with companies using gateways to allow VoIP to provide basic voice connectivity. While companies continue to take advantage of "green space" developments in the "naked voice connectivity" market, this story is more about arbitrage-enabled displacement than disruption. As long distance rates continue to decline, this arbitrage

Exhibit 17

Link between residential and enterprise VoIP



opportunity is largely dissipating except for international calls.

VoIP in the enterprise: IP/PBXs

While consumers were enjoying the novelty of almost-free international calls on their PCs, the "wave" of disruption in the enterprise resulted in the foundation for the true emergence of VoIP. The wave of disruption and the subsequent buildout of IP-related technologies resulted in very low prices for Ethernet, leading to the deployment of switched 10/100 megabit per second Ethernet to every desk within most corporations. The open standards embodied by IP allow services to be decoupled from the transport media. While IP/PBXs, which essentially allow companies to have all traffic within the "walled garden" of their enterprise data network be IP-based, have been around for more than 10 years (with limited deployment in small and medium businesses, depicted on **Exhibit 17** as the slowly rising dark line), these technological developments allowed them to move from concept to real deployment within a corporation.

IP/PBXs vs. traditional PBXs

- **LT1:** Big growth at departmental level; some debate over big vs. small companies
- **LT2:** IP/PBXs seem to be able to "break through" to mainstream and offer convenience to trump their weaknesses compared to PBXs
- **LT3:** New business models, quite independent value networks

The deployment of VoIP within corporations in the edge of the network with IP/PBX solutions definitely "smells" disruptive. While still plagued by relatively poor functionality, IP/PBXs presents some distinct advantages, providing the potential for significantly more convenience and flexibility than traditional telephone services. Specifically, it:

- facilitates "unified messaging," with voice-mail, e-mail and faxes all in a single location.
- makes the "move/add/drop" process extremely easy – users can "plug in" anywhere within the corporation and have their regular telephone number.
- allows new and novel convergence-enabled features, combining voice, video and data.
- lets corporations use a single architecture for all of their traffic needs instead of maintaining separate networks.

IP/PBXs and related services are passing *litmus test one* and creating new "green space" opportunities, with some companies targeting departments or offices within large corporations and others targeting small and medium businesses (see **Box 5**: The Right Disruptive Path?).

IP/PBXs now look poised to surge past *litmus test two* and aggressively enter the mainstream market controlled by incumbent PBX providers such as Lucent, Nortel and Alcatel. With their

BOX 5: THE RIGHT DISRUPTIVE PATH?

As excitement continues to grow around IP/PBXs, companies are following very different paths to grow successful "green space" businesses. Companies like Cisco are targeting large enterprises, while startup companies like Mitel are focusing their efforts at small or medium businesses. It appears that both are logical "green space" opportunities:

- Cisco's approach to target large enterprises, a subset of the mainstream market, follows the lessons learned from the deployment of other disruptive technologies in the enterprise. Large enterprises have the most to gain (e.g., cost savings) from moving towards a converged data/voice network, and also have the scaled data networks that have enough reliability to conceivably support voice as a data application. Additionally, large organizations have the budgets to support new technological developments. Although some may argue that this is really not a new growth opportunity, Cisco's point of entry is often through departments or greenfield sites as opposed to full-spread corporate deployment. Cisco's general business approach has been to acquire companies that have created new growth opportunities and take its products to its large customer base.
- Startups who are offering Application Service Provider (ASP) offerings to small and medium businesses are following a different but still valid "green space" approach. Small and medium businesses are clearly overserved by traditional PBX manufacturers, and, in fact, many SMBs cannot afford most PBX offerings. They also might be much more willing to "tolerate" problems with IP/PBXs – for SMBs two- or one-nine reliability might be acceptable.

super-high reliability, high complexity and long development cycles, traditional PBXs seem to overserve the marketplace – especially for small and medium businesses who can not even dream of affording a PBX. While the reliability of IP/PBXs depends on the reliability of a corporation's underlying data network, there do not seem to be any fundamental barriers on IP/PBXs' improvement trajectory that would prevent them getting good enough for the mainstream market. Cisco's current strong market position points to an interesting example of the need for interdependent product design before a product is "good enough" for widespread use. With its expert knowledge of how networks function, Cisco can design its IP/PBX to interdependently operate with an enterprise's existing data network to achieve reliability that is far higher than an individual system.

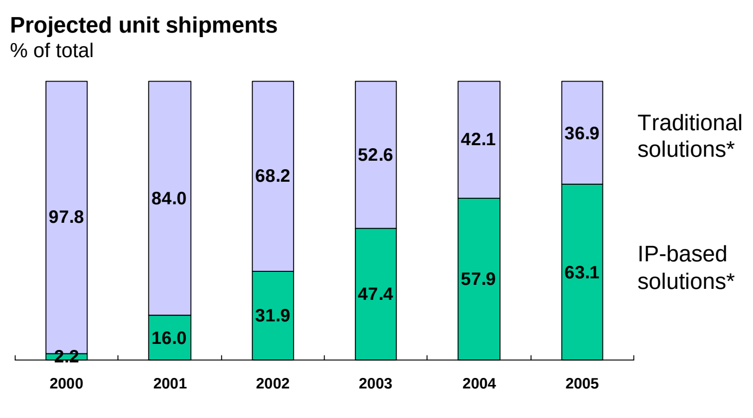
As IP/PBXs continue to improve, they could pass *litmus test three* and present a very real disruptive threat to incumbent PBX manufacturers, who build many basic telecommunications services into their systems. IP/PBXs are growing up in a completely independent value chain, making it difficult for incumbents to co-opt the technology. Additionally, IP/PBXs entail completely different business models, with different upgrade cycles, pricing structures and feature deployments that are antithetical to the processes of incumbent providers. With their interdependent design (which is substantially less flexible than IP-based designs) and long-lead time to add features, traditional PBX manufacturers like will find it very difficult to adapt to the modular design inherent in IP-based systems. In fact, there is some evidence that the disruptive process is already underway, and could gather enough momentum to become a self-fulfilling prophecy. Industry projections displayed in **Exhibit 18** show how IP-based solutions are poised to take much of the market in the next few years. As standards such as the Session Initiated Protocol (SIP) continue to propagate, PBX systems will be ripe for disintegration, with new players competing at different points of the value chain. Ironically, SIP will likely lead to a second wave of disruption, as IP/PBX-like functionality migrates from hardware to software. While these developments still remain within an enterprise, the internal transmission of voice as a data application lays the final piece of groundwork for disruption to finally leap out of the enterprise and strike the incumbent service providers.

Summary and implications for incumbents

VoIP appears capable of pushing the waves of disruption over the historical barriers that protect many incumbent service providers, although this prognosis depends on several key factors, notably the improvement of VoIP to solve so-called "network services issues," widespread

Exhibit 18

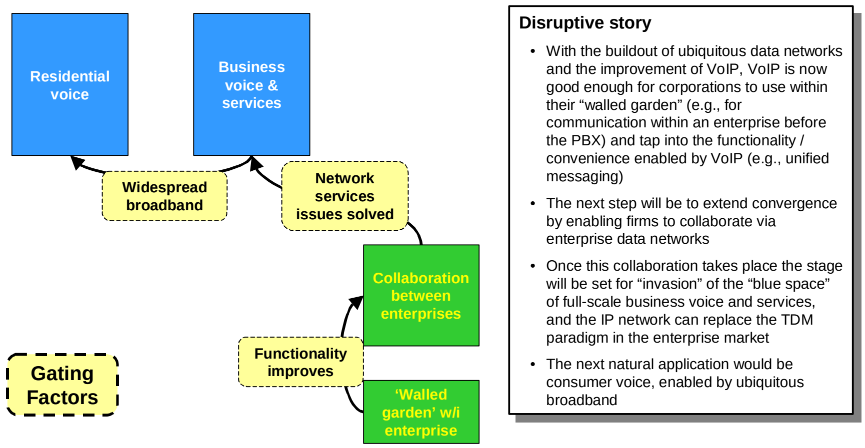
Projected growth of IP solutions*



* Solutions refer to PBX/Centrex/Key Systems
Sources: The Yankee Group; Frost & Sullivan; Forrester Research; Team Analysis

Exhibit 19

VoIP through the disruptive lens



broadband deployment and the true degree of interdependence in the telecommunications system (see **Exhibit 19** for VoIP's possible development path).

As the functionality and reliability of VoIP get good enough and the technology's convenience-related basic services are implemented, VoIP could be extended beyond the "walled garden" of the corporation to facilitate collaboration among companies. This collaboration would allow service providers to build the scaled networks needed to solve the "black art" issues required to develop network services (like network restoration) in an IP network, allowing the provision of advanced services like call center management. These challenges (see **Box 6**) will only be identified and solved with experience gained from managing a scaled network as interdependencies only appear once a tightly coupled system is fully deployed. If providers replicate the minimum functionality of the PSTN in providing network services, the stage will be set for the "invasion" of the mainstream business voice services market. The failure of new players to build an IP network that is minimally functionally equivalent to the PSTN would mean incumbents could squash the invasion with their superior network functionality. Customers would not be willing to bolt from the reliability of the incumbent offerings.

If these network services issues could be solved and if VoIP solutions incubate in a truly independent value network from time-division multiplexing (TDM)-based solutions (see following), services could be completely decoupled from the transport media. This would be allow a full-scale modularization of the telecommunications industry, with the development of new standards allowing new players to disrupt the incumbent service providers, who would be powerless to respond.

However, given the apparent interdependency between the enterprise data "value network" and that of the voice telephony market, it is unclear whether or not incumbents will be able to successfully "co-opt" VoIP by mimicking new entrants and transitioning to an IP-network. The dependence of large enterprises on traditional telecommunications service providers for enabling and supporting the build out of data networks indicates the two value networks are at least somewhat interdependent. This interdependence can be observed at a number of points between the two value networks. First, the physical layer of the network (the "pipes") has not truly been separated from the data link and networking layers. Second, incumbents already both deploy and support IP-data networks (e.g., AT&T and UUNet, a business unit of Worldcom) demonstrating that the two can coexist. It is important to note that these players thus far have focused on IP-based connectivity, not services. This peaceful coexistence also indicates that existing incumbent resource allocation processes have assigned, and thus are likely to continue to assign, resources to support IP networking architectures. Network-based, business-class services enabled by point-to-point networking have not been replicated by IP-based technologies, creating a meshed world. Lastly, converged IP voice, data and video traffic can easily be switched and routed over existing networks enabled by technologies such as multi protocol label switching (MPLS), ATM and frame relay. Additionally, efforts by service providers to extend the life of billions of dollars of investment in fully depreciated assets will reinforce their interest in maintaining interdependence.

With the implicit symbiotic relationship between the two markets, new VoIP players would be unable to disrupt the incumbent players. The interdependence of voice and data value networks implies that incumbent business models would continue to change and adapt to the distracting and discontinuous forces at work, but there could not be any serious disruption.

Regardless of its exact development, VoIP is a complex technology with different implications for different classes of incumbents:

- VoIP presents both a disruptive threat and a potential opportunity for **traditional IXCs** who provide advanced telecommunications services to businesses. If an IP network can replicate the network services, new Internet Telephony Service Providers (ITSPs) could provide IP-based services such as call center management and voice Virtual Private Networks (voice VPNs) that would threaten traditional IXC's high-margin service offerings. These offerings would leverage the inherent flexibility of an IP-based solution and would allow true one-stop shopping for businesses. While WorldCom, with its UUNet-based data network, might seem to be poised to take advantage of these opportunities, mastery of VoIP potentially requires different process and values that may prove surprisingly difficult for WorldCom to master.

- **Hybrid IXCs/LECs**, like Qwest with no legacy processes or business models, appear to be well positioned to move into advanced, network-based services and ride the disruptive forces.

BOX 6: HIDDEN BARRIERS TO NETWORK SERVICES DISRUPTION

As with any tightly coupled system architecture, there are interdependencies between various components in a network that cannot be understood prior to the assembly of the entire system. For example, consider the development of a large software program. While many software companies attempt to develop their programs in "modular" fashions, with different sets of programmers working on different pieces of the program, the program can not be debugged until all of the modules are combined. The combination of the modules into an integrated product often leads to unforeseen interactions and complications that only become apparent when the modules interact with each other. Hence, a single enterprise is more likely to move down the learning curve quickly and develop the "black art" required to bring this new technology to market.

Network services (e.g., Virtual Private Networks) and network architectures (e.g., PSTN) are created through the complex, tightly coupled (near) real-time interaction of multiple distributed systems interconnected across wide area interfaces. Both rely on distributed algorithms and protocols that require a combination of network operation status (reports on occurrence and location of failures) and real-time (requests for new services) inputs to function.

Creating an IP-based alternative to circuit-switched voice VPNs capable of disrupting the PSTN thus requires more than the development of a single product (e.g., softswitch) or set of products (softswitch, feature servers, voice gateways, etc.). Complete disruption of the PSTN would require the mastery and replication at scale of the distributed systems level interactions of the network. The ability to understand this complex set of interdependent interactions within the network is a unique capability onto itself.

Given the complex interdependency needed to create network services, it should not be surprising that there has been no disruption. First it is not clear that existing network services (e.g., VPNs) overserve their customers. Second, offering these services requires a considerable amount of "black art" development capabilities to comprehend and resolve all the issues that emerge when a fully integrated system is deployed in a live network and scaled.

From this perspective, it is unlikely that carriers who do not have the necessary resident capabilities would first deploy these services. In fact, complex network-level services are more likely to be first incubated in smaller scale, less-demanding installations (e.g, within an enterprise).

Suppliers of potential disruptive systems have only just begun to climb the "black art" engineering learning curve associated with delivering real-world implementations of any scale. Thus, despite a large pot of gold at the end of the rainbow, there are significant hidden barriers that must be scaled before the network services market or even the PSTN can be disrupted.

Indeed, Qwest, with its ownership of a cash-cow local monopoly (US West) and its existing data network may be in the best position to capitalize on the disruptive process. However, the collapse of bandwidth prices has forced Level3 to move towards higher-margin services as well.

- Because **RBOCs** currently focus on local residential and small and medium business voice services, VoIP appears to represent a relatively minor threat to their current business unless the last-mile problem can be solved. However, if the last-mile problem were solved, the door would be opened for customers to circumvent service providers with independent VoIP solutions. Although this seems unlikely on a national scale, high-density areas might see novel solutions to the last-mile problem, allowing new providers to take consumer business away from the RBOCs. Thus, the RBOCs must embrace VoIP, because they will not be able to get high-margin business services without it and risk "missing the boat" while their core business is steadily chipped away.

The future of VoIP remains very unclear. It still must overcome key functionality barriers before it is good enough to be widely deployed. Even if those functionality barriers are overcome, VoIP's impact might be limited to the PBX market and basic connectivity within an enterprise unless the "black art" of network services can be solved, allowing companies to offer advanced VoIP-based services. Finally, the evolution of VoIP depends critically on actions by incumbents, who could embrace the technology and successfully implement it or face the possibility of disruption.

Metro-area Ethernet providers

Companies such as Yipes and Telseon have recently captured the attention of investors and telecommunications aficionados as the "next big thing." Sighted for their disruptive potential, these two MAN companies claim to be redefining telecommunications by offering high-speed voice, video and data connections over 10 gigabit Ethernet (10 gigE) to business customers. As 10 gigE is the IP-based any-to-any computing paradigm disruption extended to a metro-area network, MANs pose the greatest near-term threat to the vendors of Synchronous Optical Network (SONET) gear.

MANs vs. SONET

LT1: Growth opportunity to serve corporate customers in top-tier markets with new services

LT2: MANs face barriers in cost of deploying fiber, incumbent co-option

LT3: Relatively new business models, can be independence

MAN companies have two essential layers: physical and services. To create the high-speed connections, MAN providers are deploying fiber (the physical layer). Once installed, these companies intend to sell converged voice, data, and video services based on a 10gigE-based connection. Voice, data and video are multiplexed from the enterprise network over the MAN provider network and routed to their intended destinations.

While MANs are still in the early stages of their development, they appear to have the potential to pass *litmus test one*. There is a new growth opportunity of companies in high-density areas that are attracted by the 10gigE connections that cost approximately one-sixth the amount of the highly reliable circuit switched alternative, SONET. SONET was created as a modular alternative to the traditional dedicated connections of the Bell system. IXCs, such as MCI, created the demand for SONET as it offered vast improvements in interoperability with other systems over the proprietary Bell System and was not manufactured by the Bells. Compared to SONET, 10gigE, while more flexible and cheaper, is still not reliable or secure enough to convince large enterprises to trust MANs with their network traffic. Additionally, most enterprise voice traffic today travels over TDM circuits, early MAN customers are limited to purchasing lower cost data connections. Where MANs begin to run into trouble is passing *litmus test two*. Not only do MAN providers have to improve dramatically before they can offer advanced services to customers, it is extremely expensive to deploy fiber. Competitive actions by incumbents could make it very difficult for MANs to reach minimum efficient scale. If MANs can overcome the barriers to improvement, they could have an easier time passing *litmus test three*. MANs are developing an independent value network that slots into a modular piece of the telecommunications network, making it difficult for them to be co-opted by incumbents if they can reach minimum scale.

Summary and implications for incumbents

Over the longer term, MANs have the theoretical potential to be highly disruptive to both the PSTN and RBOCs, but this scenario is predicated on a number of technological developments and changes in customer behavior.

Given that the MANs are entering at a modular point in the telecommunication network, specialist firms should be able to successfully compete under a truly competitive industry structure. As MAN technology improves, it offers a potentially disruptive alternative to SONET connections. In fact, combined with Dense Wave Division Multiplexing technologies, 10gigE signals can be reliably carried over longer distances making them even more threatening to SONET. However, to truly unlock the disruptive potential of 10 gigE, a number of technological events will have to take place. First, VoIP service will have to get good enough to be deployed pervasively throughout the enterprise. Once this occurs, enterprises can multiplex their voice and data traffic together making it compatible with the IP-based Ethernet networks of the MAN providers. Simultaneously, MAN provider network reliability will have to improve to the point that it meets the needs of the mainstream enterprise customer. Thus, enterprises would send all of their traffic through the MANs, potentially disrupting traditional operators who provide connectivity and services to these customers.

However, this scenario is predicated on widespread deployment of MANs, who are currently following a cream-skimming model targeting small groups of large companies in densely populated areas. The natural monopoly of RBOCs in metropolitan areas once again skews the competitive dynamics of this market. The PSTN represents a formidable barrier to entry to new competitors, making it difficult for new entrants to expand beyond niche markets. Although patient capital markets have been willing to fund the build out of the MANs, MAN providers could struggle to gain scale, be relegated to niche players, and ultimately become attractive acquisition targets to the RBOCs. The RBOCs could slot their local fiber deployment alongside their existing networks, extending their ability to go into the advanced, network-based services market.

SECTION 4: THE FUTURE AND ITS IMPLICATIONS

Aggressiveness has given way to acceptance. Hungry competitors have been transformed into vanquished rivals. Incumbents have not only survived the five years since the passage of the Telecommunications Reform Act, they have grown stronger and now display an air of indestructibility. History often shows, however, that companies at their pinnacle are often most vulnerable to disruption as they ignore threats attacking them from below. Disruptive innovations historically find ways around seemingly insurmountable barriers. Unfortunately, regulatory uncertainty, rapid technological development and continued natural monopoly forces limit the visibility of the telecommunications industry making predictions cloudy at best.

Firms are not, however, left without the means to formulate realistic hypotheses about the future direction of the industry. Our analysis in Section 3 uncovered seven key gating factors that will disproportionately influence the future course of the telecommunications industry (listed on **Exhibit 20**). These gating factors will impact the potential disruptive technologies discussed in the previous section, and push the industry in one of two general directions: an evolutionary path with incremental change driven primarily by incumbents and a revolutionary path with new and nascent competitors rising to reshape the industry (a high-level summary of each path is presented in **Exhibit 21**). For instance, if incumbents turn their attention to a "pie fight" over market share, they may unwittingly open themselves up for disruption; if forward thinking incumbents co-opt new technologies, it would lead to more gradual industry evolution. While the actual impact of these gating factors is unknown, companies that understand them will gain superior insight and be able to formulate stronger strategies. In the near-term, numerous prognosticators have predicted the massive consolidation of the service provider market leading to the creation of a handful of "mega-carriers." We have no reason to believe this will not be the case, and this is another factor that is likely to push the industry down an evolutionary path over the next several years.

In thinking about the future, industry participants must also keep in mind some of the major lessons from our analysis:

- The enterprise – with its low regulatory hurdles, high user density and value per node and deep pockets – has been the location within which disruptive innovations have been nurtured. Born in the enterprise communications and data market, IP-based internetworking may, in fact, be the most formidable innovation likely to result in

Exhibit 20

Signposts for gating factors

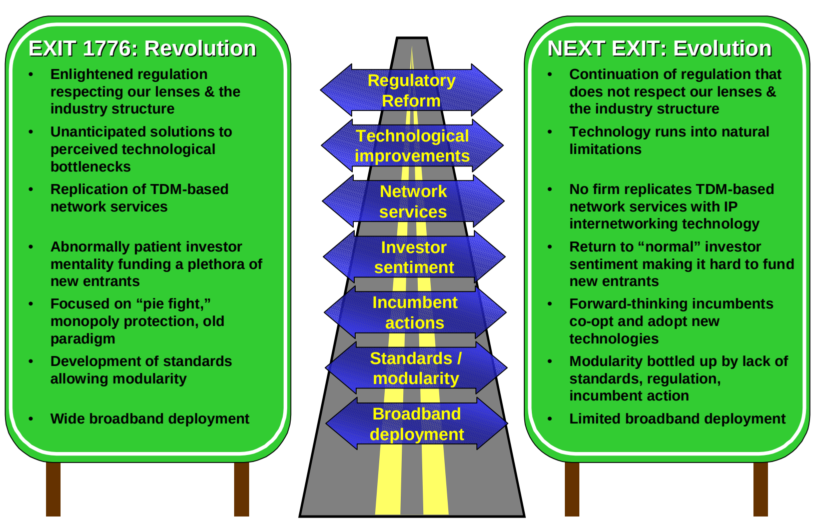
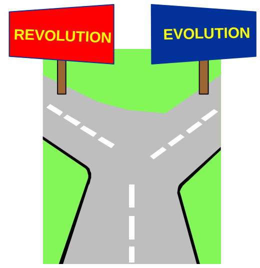


Exhibit 21

Possible paths for industry evolution

- Independence allows the emergence of a separate value network around enterprise data capable of incubating IP internetworking good enough to replace TDM paradigm
- Data transmission of voice follows a disruptive path:
  - PBX manufacturers disrupted by IP/PBX
  - Traditional business voice service providers disrupted by new IP-based service providers (e.g., Qwest, ITSPs)
- Traditional IXCs get slaughtered
- Wireless, driven by companies with fewer landline assets, picks off more wired customers; 802.11 improves and is a massive threat to 3G providers
- MANs develop profitable niches and pick off more and more of the high-margin business clients
- The RBOCs and other incumbents struggle to adapt to the new world order and end up as regulated transmission local companies



Key gating factors

- Regulatory reform
- Technological development
- Solution of network services "black art"
- Capital market sentiment
- Actions by incumbents
- Standards / modularity
- Deployment of broadband

- Interdependence prevents any full scale disruption, with IP internetworking being a massive discontinuity for incumbents to manage as they slowly and painfully absorb it into their existing value networks
- VoIP remains only within enterprise; functionality never gets good enough for business-class services
- Traditional IXCs struggle as RBOCs enter long-distance and long-distance moves to becoming a commodity; IXCs may be acquired by RBOCs
- Wireless reaches its limits and can not match any of the features of wireline; 802.11 ends up as a complement to 3G
- MANs are acquired by RBOCs
- Disruptions occur only at points of modularity
- RBOCs resiliency continues and incumbents march on

disruption.

- The regulated natural monopoly that dominates the local loop deflects the expected trajectory of disruptive innovations. The RBOC's stranglehold over access to the "last mile," particularly in the residential market, restricts the ability of innovations to reach potential customers.
- Government policy has an overwhelming influence in shaping the opportunities that innovators target. Legislation either facilitates or impedes disruptive innovation but has the ability to create an environment ripe for yielding disruptive change.
- The potential decoupling of services from the transport media (in our lenses a form of modularization) would create the opportunity for specialist firms, who will be motivated by the increasingly lucrative pot of services-related revenues, to attack incumbents.

What's next

Regardless of the industry's actual development, important forces are at work that will cause leading players to undergo massive change, with those that can harness those changes likely to emerge as leaders. That said, incumbents appear well positioned to absorb many of the disruptive forces in the market today. Within the wireless market, incumbents, such as Verizon and Cingular, dominate the market. In the residential market, cellular telephone usage from the home will increase, especially in the lower tiers of the market, taking an increasingly larger bite out of the voice telephony market. As wireless data capabilities are introduced to the market, tiers of the market that value mobility and will put up with the relatively slow speed, are likely to completely un-tether themselves from the PSTN. This will be a small segment of the market, however, if wireless operators continue to cram 2.5G and 3G technologies by targeting the most demanding tiers of the market instead of finding new applications that take advantage of the technology's inherent attributes, such as the early path of NTT's hugely successful I-mode technology in Japan.

The slow improvement and deployment of high-speed wired broadband connections to the home will likely outpace wireless' ability to obviate the need for a wired connection, as wired connections are currently better suited to transmit large volumes of bits cheaply. The increasing deployment of high-speed wired connectivity, the transformation of voice to an "add-on" of home data services and the ability of cordless phones to provide mobility within the home, will reinforce the incumbents' control of local access and deflect the complete disruption of the wire by wireless technologies. Incumbent operators face tough decisions as new entrants – such as wireless companies without "in the ground" depreciated assets and cable and satellite companies – increase competitive pressure. RBOCs that currently own both wired and wireless assets will be forced to make decisions based on cost to serve and channel efficiency. Cannibalization of the existing wired customer based may also prove to be a viable and increasingly necessary option.

As described in Section 3, VoIP in its various incarnations contains an incredible amount of disruptive energy. The proprietary, highly reliable, dedicated connections that defined the past are quickly being replaced by open, less reliable, shared IP connections. These changes have led customers to become more sophisticated in defining data networking requirements and to recognize differences in various networking options. For example, to combat latency and jitter in a voice call, VoIP traffic must be prioritized over other, less time sensitive types of data. These class and quality of service (QoS) distinctions have resulted in an unanticipated, but growing relationship between IP-based networking and traditional connection-oriented technologies that is capable of deflecting IP's disruptive trajectory. To meet customers' increasing requirements for reliability and still allow them to take advantage of IP-based solution, operators appear to be meshing highly reliable dedicated point-to-point connections with IP networking solutions.

The interdependence of voice and data value networks implies that incumbent business models would continue to evolve and adapt to the distracting and discontinuous forces at work, but there cannot be any serious disruption. Deep-pocketed service providers would be able to co-opt IP-based technologies and incorporate them into their existing business models, maintaining and perhaps even improving the gross margins they expect from their existing business. Data services would continue to increase in importance and mastery over fiber and optical networking would become a clear differentiating factor, especially as the RBOCs expand beyond their local areas. Leveraging their low marginal marketing costs and their strong brand names, the RBOCs would continue to successfully enter the residential long-distance connectivity market. The picture is significantly less rosy for traditional IXCs who have to contend with the triple threat of the infiltration of RBOCs on their long-distance assets, the continued pressure from wireless carriers and the rise of specialists firms as services begin to decouple from the transport media. An important asymmetry reinforces the pressures on the IXCs: whereas the modularity of the long-haul network makes it relatively easy and attractive for RBOCs to add long distance services, the interdependence of the local loop makes it quite difficult for IXCs to backwards integrate. Already struggling under intense competition within their own market, the IXCs could end up looking like attractive acquisition targets to the RBOCs.

A major assumption underlying this evolutionary development path is the interdependence of the enterprise data market "value network" with that of the voice telephony market. Given the implicit symbiotic relationship between the two markets – enhanced by the fact that service providers are big customers of IP companies – the IP revolution will never fully disrupt the incumbent players of the traditional TDM-based voice telephony market. Incumbent service providers appear to have high motivation to deploy IP-based technologies alongside their existing offerings. Key questions market analysts must ask when evaluating future scenarios include:

- Is the "any-to-any" computing paradigm brought about by IP truly disruptive to the business models of incumbent telecommunications service providers? Or do the low marginal costs associated with either IP-based or traditional services make incumbents platform agnostic, implying a non-disruptive business model?

- Will the incumbents' resource allocation processes stop the allocation of the resources necessary to deploy and support IP-based networking technologies? Or do the relatively similar business models and the fact that incumbents **already** have deployed data-based solutions refute this notion?

- Are IP-based internetworking technologies truly incompatible with service provider value networks? Or can technological solutions bridge the incompatibility, allowing both networks to sit side by side?

For those still betting on disruption, the game is not yet over, for the disruptive potential of IP-based networking cannot be completely discounted. IP solutions, while good enough for customers with less demanding data networking requirements, will continue to march up market. Assuming VoIP continues to improve, the network services development issues are solved and value networks are more independent than we believe, new firms that embrace pure IP-based networking can lead a major disruption of incumbents in markets ranging from PBX services to advanced network-based services such as content networking and call-center management. Increased standards and modularization embodied in and enabled by technologies such as softswitches would further this disruption, which would allow services to be decoupled from the transport media and be offered by specialists. Entrepreneurial motivation to pull customers away from the mainstream market will only swell when services inevitably become the driver of industry profitability. Then, if the "last-mile" problem could be solved by a combination of cable companies, fiber to the home or novel wireless solutions, these new players could extend their reach to the residence and disrupt the RBOCs. Interestingly, while many RBOCs have argued for a subsidized build out of broadband technology (see **Box 7**, Ubiquitous Broadband: A Boon or The Return of Theodore Vail?), this solution could in fact be their ultimate undoing. Billing applications for data and bandwidth could prove unable to provide the RBOCs with a means to properly charge for decoupled services, allowing specialists to selectively target RBOCs' customers. This would make it very difficult for RBOCs to become anything other than regulated data transmission companies not too dissimilar from their cousins in the electricity industry.

The IP-internetworking paradigm, accelerated by VoIP, is likely to continue to follow the disruptive path it started on with the emergence of the LAN more than two decades ago. But, interrelated supply and demand issues related to IP networking technologies and the gating factors described above will heavily influence the disruptive trajectory. As increasingly sophisticated customers rely more and more on data networks, they are demanding products that can discriminate between different types of data (e.g., real time voice versus best effort email). Companies are racing to supply technologies to meet customer's needs with IP-based technology, which is still not good enough for the most demanding applications (see **Exhibit 22**).

In the foreseeable future, point-to-point, dedicated connections will continue to dominate, particularly for long-haul connectivity as technologies such as ATM, frame relay and MPLS enhance the reliability of IP-networks. Advancements in fiber optics and optical networking will continue to drive costs down, making these point-to-point technologies effective solutions. However, longer term, as IP-based networking technologies improve, providers of these expensive, dedicated connections could be forced to retreat up-market in search of customers to serve with the most demanding data networking needs.

However, even if IP continues its disruptive trajectory, incumbents have already begun to deploy and offer customers IP-based networking solutions. While a closer study of how incumbents are using these technologies is required (e.g., are they attempting to cram them into their existing business model or completely embracing the decentralized and-to-any networking paradigm), evidence that incumbents have been able to absorb IP-based technology would lead to the

BOX 7: UBIQUITOUS BROADBAND: A BOON OR THE RETURN OF THEODORE VAIL?

Across America, there is a growing weariness of the last-mile problem. Internet startups that depended on rapidly increasing broadband deployment have exploded, their basic business model unable to serve a world where almost 90 percent of home connectivity is made by dial-up modem. While broadband deployment continues to grow substantially, there are a group of powerful voices calling for the government to step in and subsidize ubiquitous broadband. These voices sing the praises of broadband and present numbers like a percent increase in gross domestic product a year. Although the debate seems to have moved on, it is worth stepping pack to evaluate the pros and cons of government involvement in broadband deployment.

The Pro Case

The case for government action to speed up broadband deployment rests on the assumption that broadband is a "public good" that generates substantial positive externalities for the country. As a public good, companies that deploy the infrastructure without any form of subsidization would not capture the true upside from the technology and hence do not have incentives to follow a speedy rollout. There is evidence that demand for broadband in certain geographical areas greatly outstrips supply (particularly in rural areas). Even worse, companies have incentives to create "walled gardens," where they vigorously control access to their pipes in an effort to capture as much value as possible, thus limiting the development of new services to those developed by notably slow-moving incumbents. Subsidization has historically proven necessary for public goods (e.g., the PSTN, the highway infrastructure) because financial models cannot value the future positive network externalities. Without government involvement, broadband will continue to be rolled out at a glacial pace, stunting first-order network effects (the value of the good to the end user) and inhibiting second-order network effects (by making it less interesting for third-parties to provide services to the network).

The Con Case

While a logically consistent argument can be constructed supporting heavy government involvement in the deployment of consumer-based broadband technologies, there are numerous concerns that must be considered:

- While there clearly is a "last-mile problem," it is unclear that there is a vast pent-up demand for people willing to pay for broadband services. Although rollout has not proceeded as quickly as analysts anticipated, many consumers who truly want broadband can obtain it from either the telephone company or the cable company. Increased competition as opposed to guaranteed monopolies would lead to more innovation and better solutions for customers.
- It is unclear whether demand truly exists for new broadband services. While people point to chicken-and-egg problems inhibiting the development of valuable services, there already more than 10 million consumers who have broadband at home. If this market is too small to allow for innovative offerings, it raises fundamental questions as to how much demand there really is for broadband-based applications and what constitutes a minimum critical mass. In fact, this could be evidence that broadband "overserves" the market and consumers do not have jobs to be done beyond always-on connectivity and high-speed access to services they already know and use in their homes.
- Having the government encourage the widespread deployment of broadband assumes that today's version of the technology is the "correct" one, worthy of being a "universal service." However, history often proves that technology develops in unpredictable ways, and forcing a universal service might inhibit the growth of the next generation of technology. For example, France surely thought Minitel would provide an economic boon to the country. However, the deployment of what proved to be a radically inferior system seriously limited the deployment of the Internet in France. The U.S. could similarly end up inadvertently prematurely locking in a proprietary interdependent network.

While today's incumbents would obviously welcome government assistance in augmenting their natural monopoly, and while government assistance would speed up the deployment of today's technologies, a dose of caution is necessary. When Theodore Vail convinced a nation of the need for universal service, there were no viable alternative technologies to the telephone network. Today, innovators are developing numerous alternative last-mile solutions. What is the hurry?

conclusion that IP technology is not disruptive, but an large discontinuity – greater in magnitude then any observed before.

Implications for incumbents

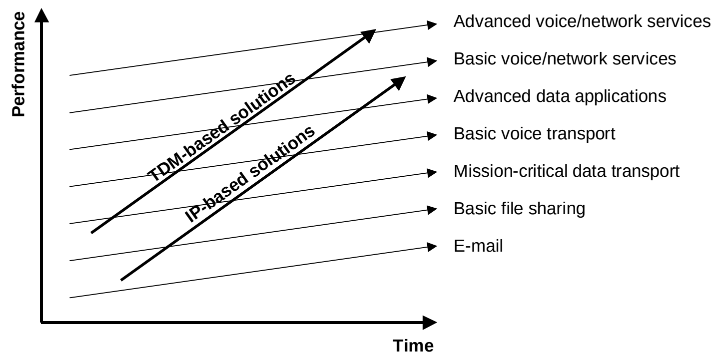
Our models and tools can help industry participants understand the impact of different types of innovations, helping them to determine what types of innovations are threats and what types are opportunities. **Exhibit 23** explores the four major classifications of industry change, describing the expected outcome from each type of change.

The disruptive technology model provides a series of litmus tests (described in Section 1) to determine if a business model has the potential to be disruptive. In general, disruptive business models can fundamentally re-shape profits within an industry. Once a disruptive business model reaches the mainstream, incumbents find it very difficult to mimic or respond to, as it entails

Exhibit 22

IP improvement trajectory

CONCEPTUAL



While IP-based solutions have improved dramatically in recent years, they still are not good enough for heavy-duty voice applications

entirely different processes and values. Although incumbents can clearly see a disruptive technology – in fact, it is often first developed within an incumbent – they find it extremely difficult to successfully commercialize, as their mainstream customers do not initially value the relatively inferior performance of the product or service. New entrants are often better able to introduce the disruptive technology successfully to niche markets that value its relative convenience, flexibility or low price. As a disruptive technology develops an independent value network, new entrants can pull customers away from the mainstream market. Facing a potential disruptive technology presents incumbent service providers with three options:

- **Ride the wave**: Incumbent companies can invest in small startup companies that are following a disruptive trajectory or set up external units with separate resources, processes and values to commercialize the technology. While this will still end with the incumbent eventually being disrupted, the incumbent can profit from this process.

- **Co-opt**: Another option for incumbents is to take hold of the disruptive technology and attempt to "co-opt" it by introducing it to its mainstream market, thus attempting to control

Exhibit 23

Implications of industry change model

DISRUPTION
- Incumbents struggle to commercialize
- New entrants take control of industry with mastery over requisite new business models
- Eventually improves enough to meet the needs of the mainstream market

DISTRACTION
- Some first-mover advantage
- Moderate, although often temporary, shifts in competitive structure
- New entrants struggle to manage change successfully; lack all required capabilities

4-D

DISCONTINUITY
- Leaders will be those who can "block and tackle" the best
- New entrants find change almost impossible to manage
- Little long-term competitive change

DISPLACEMENT
- Can be successfully "co-opted" by forward thinking incumbents
- New entrants can be very successful if aggressive and tenacious
- Significant first-mover advantage
- Potential long-term shifts in competitive structure in industry
- Emergence of a more refined customer segmentation

the improvement trajectory and the rise from below. With its regulatory and scale-driven barriers of entry, this tactic can be quite successful in the telecommunications industry. However, this can be quite expensive, as the disruptive technology must be “crammed” within the incumbent’s business model.

- **Block**: Deep-pocketed incumbents in a regulated environment can attempt to block disruptive technologies from ever getting to the market.

Two other types of innovation discussed in the 4-D model can also prove to be quite profitable for incumbents. Incumbents almost invariably control discontinuous and distracting innovations as they improve the performance of their products or business models. As both types of change are aimed at interdependent pieces of the value chain and are valued by the mainstream market, new firms should struggle tremendously to develop and commercialize the innovation. Incumbents that are best able to move quickly to master the implementation of these innovations have the ability to capture temporary and potentially long-term gains in market share and profitability. New entrants that develop potentially discontinuous or distracting innovations should consider licensing them to incumbents who are best positioned to commercialize them. However, incumbents need to beware of displacing innovations that threaten to “shake up” the industry and lead to share gain by new entrants. While incumbents can often be powerless in the face of a classic disruptive technology, they can more easily co-opt potential displacing innovations. Because the mainstream market values those innovations, they should fit more closely into an incumbent firm’s processes and values. Displacing innovations frequently involve product proliferation along a more refined customer segmentation, skills that can be learned by incumbent companies. Forward-thinking incumbents who see emerging pieces of modularity in an industry can either attempt to acquire displacing innovations or can “bottle up” points of modularity within the firm, limiting the ability of a new firm to follow a true displacement strategy.

Finally, the modularity framework can be very helpful in understanding what type of firm will capture value in a network. Once an interface becomes modular, it creates the opportunity for a series of displacing or disruptive firms to enter the market and rapidly take share from the incumbent while value moves predictably away from final assembly to sub-systems of components. Specifically, companies should look for points within a value network where products or services overserve existing customers. At these points, smart specialist companies should seek out modular components and then capture value by providing interdependent solutions, becoming the “Intel Inside” to enable the new flexibility required by assemblers.

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[1] In reality, the improvement in performance of all innovations is driven by customer demand to solve problems they face in operating their businesses. This demand is a key factor in defining the slope of the improvement trajectory.

[2] For simplicity, the basic disruptive technology model only has two dimensions. In reality, there are multiple dimensions of performance. The key is that disruptive technologies are initially worse along the primary basis of competition (e.g., functionality) but better along another dimension (e.g., convenience). As disruptive technologies improve, their advantage on the secondary dimension trumps the limitations on the primary dimension.

[3] We define mainstream market as the incumbent’s primary market, which is made up of many different tiers of customers.

[4] In reality, there is an implementation complexity continuum between distractions and discontinuities as both entail sustaining changes introduced by incumbents.

[5] Because of the massive investment required to reach local customers, a new company would only enter if it were guaranteed the possibility of monopoly rents or a government-guaranteed rate of return. Our

observation is that natural monopolies are driven by two key factors: extremely high scale economics and highly interdependent systems.

[6] It is important to note that while the corporate rubric of Cisco Systems marketed these technologies, many of the firm's capabilities were acquired during an aggressive acquisition spree in the 1990s. The acquisition of many companies with innovative technologies fueled Cisco's rapid growth.

[7] We recognize that 802.11 represents only one of many competing wireless local access technologies (e.g., Bluetooth, home RF). That said, we believe 802.11 is the most disruptive and are focusing on its potential vis-à-vis 3G technologies.

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