

# Wi-Fi networks and the rerun of the cycle

**Harmeet Sawhney**

*Harmeet Sawhney is Associate Professor in the Department of Telecommunications at Indiana University, Bloomington, Indiana, USA.*

**Keywords** Communications, Development

**Abstract** *While it is quite natural for us to be drawn to the new potentialities wireless fidelity (Wi-Fi) represents, we should give pause and place it within its proper context and take a long-term view of the phenomenon. One of the repeated shortcomings of the research on new technologies has been that the researchers have time and again studied them in isolation. A new technology does not strike roots and grow on a virgin ground. Instead, it encounters a terrain marked by old technologies. The new technology's growth then is shaped not only by its own potentialities but also the opportunities and restraints created by the systems based on old technologies. In order to expand the perspective beyond Wi-Fi to those that preceded it, this paper draws on the framework provided by Infrastructure Development Model (IDM), which delineates eight stages through which infrastructure networks (railroads, telegraph, telephone, and others) typically go in their development, to study its emergence.*

The "new" of a new technology invariably captures our imagination. The emerging Wi-Fi, short for wireless fidelity, technology has much to offer that is new and spectacular. It allows ordinary people to extend the Internet into the wireless arena through relatively inexpensive and easy to install wireless links. Interestingly, by creating these links they make the Internet more accessible not only for themselves but also strangers who wander into the hot spots their transmitters generate. The growing awareness of Wi-Fi coupled with falling equipment prices have energized technology enthusiasts to create their own hot spots and in the process contribute to the development of an entirely new kind of a bottom-up network. In many ways, the activities of these technology enthusiasts are fueled by the same libertarian impulse that drove the creators of the original Internet. At a time when many fear the rationalization of the Internet by commercial forces, we are seeing an insurrection by libertarian bands of sorts who take pleasure in subverting corporate frameworks. Only time will tell whether or not this insurrection will rearrange the communications landscape or

get subdued by corporate interests and fizzle out after a brief but pregnant moment in history.

While it is quite natural for us to be drawn to the new potentialities Wi-Fi represents, we should give pause and place it within its proper context and take a long-term view of the phenomenon. One of the repeated shortcomings of the research on new technologies has been that the researchers have time and again studied them in isolation. A new technology does not strike roots and grow on a virgin ground. Instead, it encounters a terrain marked by old technologies. The new technology's growth then is shaped not only by its own potentialities but also the opportunities and restraints created by the systems based on old technologies. In order to expand the perspective beyond the new technology to those that preceded it, this paper draws on the framework provided by Infrastructure Development Model (IDM) (Sawhney, 1992). IDM, which delineates eight stages through which infrastructure networks (railroads, telegraph, telephone, and others) typically go in their development, captures the motif that recurs whenever America creates its infrastructure networks. While research on other countries is limited, studies on infrastructure networks in France and Canada indicate that patterned growth of infrastructure networks also occurs in other socio-cultural contexts. However, each country has its own infrastructure development pattern (Sawhney, 1993, 1999). Since this paper uses the analytical framework provided by IDM which is derived from the American experience, the analysis of Wi-Fi networks in this paper will be limited to the USA.



The Emerald Research Register for this journal is available at <http://www.emeraldinsight.com/researchregister>

The current issue and full text archive of this journal is available at <http://www.emeraldinsight.com/1463-6697.htm>

The first section provides an overview of IDM and thereby sets the framework for the rest of the paper. The next section examines the evolution of wireless technologies before the advent of Wi-Fi. It discusses why for a while it seemed likely that wireless technologies would break out of the mold and not follow the development pattern indicated by IDM. The third section examines the development of Wi-Fi and finds that it seems poised to follow the IDM pattern. The concluding section ponders on the future development trajectory of Wi-Fi technology.

### **Infrastructure development model**

The infrastructure networks in the USA tend to develop in a decentralized, uncoordinated, and bottom-up manner. Their development is not guided by a blueprint, a grand plan, or a vision of any sort. They sort of emerge. This peculiarly American process is a reification of the country's political ethos. As Anderson (1985, p. 280) points out, "the American political and problem-solving style is incremental, not synoptic – this country is wary of large-scale blueprints." While the polycentricity of the American socio-political environment energizes the infrastructure development process by encouraging entrepreneurial activity, it creates major problems when the time comes to forge the disparate networks into a unified national system. Yet, like in other arenas of American life, operating underneath the chaos created by the push and pull of multiple centers of initiative there are unifying forces which eventually create an integrated network. This underlying pattern which gives a distinctive character to the development of infrastructure networks in the USA is captured by IDM (Figure 1).

The reader will find a detailed explanation of IDM in Sawhney (1992). In this section, only the pattern underlying the development of railroads will be discussed in its entirety. In the case of other networks, only the high points of their development will be mentioned to highlight its defining characteristics.

The first major infrastructure network in the USA was the inland waterways. The man-made canals were used to link rivers, lakes, and oceans to create an extensive network of inland waterways. Considering the fact that the waterways, with relatively minor intervention in the form of canals, were essentially nature's creation, they do not fall within the ambit of IDM. At the same time, the waterways provided the spine around which the railroads first sprouted. Therefore they form an important part of the analysis.

Today's gigantic railroad systems started as small experimental networks far removed from each other (Stage 1). The first major commercial application of railroads was as feeders for the canal system. Typically, they were used to transport coal from the mines to a nearby canal. In essence, they filled in gaps in areas where the terrain did not allow an extension of the canal system (Stage 2). The canal companies invested heavily in the development of railroads

because they saw them as complementary networks which extended their reach and thereby fed traffic from the outlying areas into the canal systems (Stage 3). At this point in time, long-distance railroads were beyond imagination as it seemed fanciful to suppose that the railroads would ever displace rivers and canals as the chief means of transporting bulky cargo over long-distances. Eventually, the development of long-distance capabilities tied the once isolated railroad islands into an integrated system (Stage 4). With the emergence of an integrated system, the railroads became competitors to the canals, and the earlier complementary relationship was decoupled (Stage 5). The railroads became the dominant system, and the canals saw a rapid decline (Stage 6). Now, only those elements of the erstwhile canal system survive which can play a useful role in the new order (Stage 7). After the collapse of the canals, the railroads almost totally dominated other modes of transportation for many decades. But the cycle did not stop here as a new technology appeared on the horizon automobiles (Stage 8).

The railroads developed an expansive national network but they could not get around the feeder problem similar to that of the canals. Quite simply, the railroad network could not be extended to each farm or factory. The farmers and factory owners had to haul their goods to the nearest railroad track. Within this context, the automobile generated much enthusiasm because of its potential to extend the railroad's catchment area by moving goods and passengers from the surrounding area to the railroad tracks. The railroads made a concerted effort to encourage the development of roads to expand the use of automobiles. So much so, they started "good roads" trains that took road building equipment into the countryside and helped communities build roads. In an eerie parallel to their own history, the railroads encouraged the development of roads without ever imagining that the automobile would one day develop long-distance capability and thereby become competitors. As they say, the rest is history.

In the case of telecommunications networks, we see similar patterns. The telegraph network could not be extended to every office and home because of the nature of the technology, especially the need for trained operators to send and receive messages. Consequently, the problem of getting the message from the central office to the designated person was the weakest link in the telegraph system. The telephone was seen as the feeder technology which would fill in this gap. At that time, the conventional wisdom was that the telephone would never develop long-distance capabilities because of the technical challenges involved. Furthermore, even if long-distance telephony did become possible, there would be very little demand for it as the main users of long-distance communications were businessmen who need written records of their communications. The possibility of conducting business transactions verbally over

**Figure 1 — Infrastructure development model**



**Stage 1: Sprouting of infrastructure islands**

The infrastructure technologies first appear as technological islands. There is no interconnection among them and the islands are isolated from one another. These islands are hotbeds of entrepreneurial energy. They are basically demonstration projects which test out revolutionary ideas. Their actual commercial potential is still uncertain.



**Stage 2: Development as a feeder**

The new technology is found to be viable and its basic potential is seen in its role as a complement to the old system. The new technology reaches into areas which were inaccessible to the old technology due to its different technological base. At this stage it is still a short-haul technology.



**Stage 3: Encouragement by the old system**

The new technology in its role as a feeder generates additional traffic for the old system. In effect, the new technology increases the old system's catchment area by extending its reach. The old system encourages and aids the development of the new technology.



**Stage 4: Long-distance capabilities and system formation**

The long-distance capabilities are developed. The isolated bits of new technology become directly interconnected and start bypassing the old system. The interconnection process creates problems of coordination and standardization. Eventually the long-distance capability results in an integrated system.



**Stage 5: Competition with the old system**

The old system finds itself threatened. At first it goes on an offensive but soon adopts a defensive posture. Charges are made about “unfair” subsidy. The need to protect the franchises of the old system is stressed. Emerging competition is depicted as something wasteful. Finally an attempt is made to accommodate the new technology within the existing order.

*Continued*

Figure 1 —



### Stage 6: Subordination of the old system

The old system's rearguard action is unable to withstand the onslaught of new technological developments. Eventually the old system caves in or is pushed into a subservient role.



### Stage 7: Reversed feeder relationship

The old system disintegrates into fragments, and only those fragments which can serve a unique niche survive. They either fill in a gap where for economic or technological reasons it is not attractive to extend the new system, or supplement it along routes where there is a specialized kind of traffic. In effect these fragments now serve as feeders for the new system.



### Stage 8: Rerun of the above cycle

The new system dominates until another technology appears. The newer technology then grows along the same cycle. Eventually it replaces the new system. The cycle goes on. Just when it seems the ultimate technological plateau has been reached, another technology appears.

**Notes:** The different “S” shapes are mnemonics for the concept “system”

Reprinted from *Telecommunications Policy*, Vol. 16, Harmeet Sawhney, “Public telephone network: stages in infrastructure development,” pp. 538-52, copyright (1992), with permission from Elsevier Science

the telephone was beyond imagination. Eventually, the development of long-distance telephony displaced telegraph as the dominant communications technology.

In all the examples discussed above, we see a consistent pattern. A new technology strikes roots as a feeder to the established system and thereby is seen as extending its reach. The relationship between the new and old technology seems symbiotic and thereby stable and enduring. In effect, the new technology appears to have strengthened the entrenched paradigm. It, however, is eventually shattered with the unanticipated development of an independent system based on the new technology. IDM, which captures this pattern as an abstraction, provides a conceptual foil for

analyzing the relationship between wireline and wireless networks in the next section.

### **Wireline-mobile relationship**

Mobile communication first became possible in the form of walkie-talkies. They were in effect little islands of communication (Stage 1). With the advent of cellular, mobile communication became a networked phenomenon. Cellular plugged the gap between the wireline network and automobiles. In effect, it extended the reach of the wireline network into the mobile environment and thereby became a feeder technology (Stage 2). The wireline companies saw cellular as a complementary technology and invested in its

development (Stage 3). At the time of the publication of IDM in 1992, it was apparent that mobile communication had followed the pattern outlined in IDM in the initial stages of its development. The big question then was whether or not the development process would move onto the next stage (Stage 4) where the new system starts decoupling from the old one. At that point in time, it seemed unlikely for the following reasons.

One, the wireline companies had been major players in the cellular business right since its inception. They had every reason to keep cellular technology as a “complement to, rather than as a substitute for, their existing services” (Noll and Owen, 1987, pp. 10-11). It was very unlikely that they would do anything that disrupted the entrenched paradigm. The transfer of AT&T’s cellular licenses to Baby Bells as part of the MFJ settlement had further strengthened their position. On the other hand, if new entrants in the telecommunications arena had acquired control over cellular, the entire dynamic would have been very different. They would have sought to dislodge the entrenched system and not merely fit within it. While the existing industry organization seemed immutable at that point in time, it was not sufficient reason to believe that the unexpected will not happen. After all, in their heydays, the railroads and the Western Union’s telegraph monopoly also seemed to be invincible. This circumstantial factor was perhaps of a short-term nature that would dissipate over time.

Two, the inter-modal compatibility of modern communications technologies was likely to change the dynamics of network development. In the case of transportation systems, inter-modal compatibility was poor, as goods had to be physically transferred from one system to another when they were complementary to one another. For example, coal that was shipped by the railroads from the mines to the canals had to be unloaded from railroad wagons and carried to the barges. Within this context, the benefits of disrupting the complementary relationship between the old and new technology and creating a new integrated system around the new one were great. On this score, the situation is very different in the case of modern communication technologies. The information can relatively easily be transferred from one mode to another, mobile to wireline to mobile. This was not always the case with earlier communication technologies. For example, telegraph messages could not be seamlessly carried over to telephone and vice versa. Today, digitization and the accompanying development of translation technologies have greatly mitigated inter-modal transfer problems and thereby removed one important impetus for the creation of an integrated system.

Three, the new technology in this particular case, mobile, required a scarce resource-spectrum. On the other hand, the old technology, wireline network, conserved this very same resource. In such a case, a complementary relationship is

advantageous because it optimizes the use of spectrum. Cordless phone, a relatively simple commonplace technology, illustrates the point. The low powered transmitter on the base station allows for mobile communication within a 75-yard range. On the other hand, the base station itself is connected to the wireline network. In this configuration, the wireline network provides connectivity with the rest of the world without consuming the spectrum, while the low powered transmitter provides mobility where it is needed and yet limits the use of the spectrum to a small area. If the system were to go entirely wireless, it would use far more spectrum than a hybrid arrangement. The same archetypal pattern can be found in the architectures of PCS networks, wireless LANs, and other wireless networks. Thus it would seem that wireless technologies, because of the mobility they offer and lower implementation costs, would become the primary interface between the subscribers and the telephone network. The public telephone network itself would remain by and large a wireline network that provides high-bandwidth transports and universal connectivity. While the wireline network will be pushed to the background as mobile interfaces grow, it will remain the vital backbone of the entire network.

Of these three factors, while the first one looked like a formidable barrier for the movement of mobile beyond a complementary relationship with the wireline network, it could be discounted as a circumstantial factor. The other two factors seemed far more insurmountable because they suggested major changes in the relationship between the old and the new technology at a conceptual level. Considering all these factors, it seemed unlikely that mobile would develop along the path suggested by the IDM. But then, IDM also suggests that one should expect a surprise somewhere down the line. As we shall see in the following section, this surprise shows up in the form of Wi-Fi technology.

### **Wi-Fi networks**

The Internet, for most of its history, piggybacked on wireline networks. As it grew into a popular medium used by a large number of people on an everyday basis, telecommunications companies started sensing potential in wireless technologies that would allow mobile access to the Internet. They invested large amounts of monies in 2.5G and 3G networks that sought to provide mobile Internet access over the cell phones. These initiatives by and large were not successful as these systems did not provide functionalities that the consumers were willing to pay for. One notable exception is DoCoMo’s I-Mode in Japan. It is built on a very innovative business model wherein the I-Mode web sites charge micro-payments of a few cents per transaction or monthly subscriptions of less than \$5 that are paid through the cellular phone bills. DoCoMo has control over both the service providers, who have to win DoCoMo’s approval to provide the service, and subscribers, who can be denied

service if they do not pay up, and thus can create a very safe and secure environment for I-Mode transactions. But then, the planned nature of I-Mode raises the question whether it is the same as the Internet or a highly sanitized version, one that is masquerading as the real thing.

While the corporate world has either stumbled with its mobile Internet projects or created pseudo-Internets like I-Mode, a grassroots phenomenon in the form of Wi-Fi network seems poised to overturn the corporate apple cart. Interestingly, the cordless phone once again provides a good model for understanding this new technology. Initially, the Wi-Fi technology was directed at creating mobility within a building. Just as a cordless user can walk around the house or office while talking over the telephone, the early Wi-Fi networks sought to create similar mobility for Internet access via laptop computers. Instead of directly connecting a high-speed line (telephone or cable) to a computer, it was connected to a low powered transmitter that communicated with laptops within its range. The Wi-Fi users were thus able to move around their houses and offices with their laptops while maintaining Internet access. The technology took a new turn when users started leaving these Wi-Fi transmitters unsecured. This allowed their neighbors and others within the unsecured transmitter's range to use the Internet connection for free. The people who left their transmitters unsecured did not care because they were paying a flat monthly fee for Internet access. Unauthorized use by others did not cost them anything[1]. In fact many take pleasure at the subversive nature of their actions[2]. So much so, several hundred Wi-Fi boosters from all over the USA have listed the location of their networks on [freenetworks.org](http://freenetworks.org) web site (Harmon, 2002). As Negroponete (2002) explains:

Depending on the intervening materials, a vanilla Wi-Fi can radiate more than 1,000 feet. Since I live in a high-density area, my system reaches perhaps 100 neighbors. I do not know how many use it (totally free) – frankly, I do not care. I pay a fixed fee and am happy to share.

Because further down the street, beyond the reach of my system, another neighbor has put in Wi-Fi. And another, and another. Think of a pond with one water lily, then two, then four, then many overlapping, with their stems reaching into the Internet (online)[3].

The water lily imagery nicely captures the complementary relationship between Wi-Fi and wireline Internet. The flower symbolizes the hot spot, the circular area generated by a Wi-Fi transmitter within which the Internet can be accessed, and the stem represents the telephone or cable line that connects the transmitter to the Internet. The overlapping water lilies allude to a high concentration of hot spots in parts of Silicon Valley, Boston, and other urban areas that overlap to create fairly large Wi-Fi patches.

So far, Wi-Fi's development pattern has stayed within the mold of earlier mobile technologies, i.e. it has not gone past Stage 3 of IDM. However, it seems poised to go onto Stage 4 in a totally unexpected way:

In the future, each Wi-Fi system will also act like a small router, relaying to its nearest neighbors. Messages can hop peer-to-peer, leaping from lily to lily like frogs – the stems are not required (Negroponete, 2002, online).

What Negroponete is suggesting is not mere fantasy but theoretically possible (Markoff 2002a). If this were indeed to happen, we would start seeing a bypass of the old technology which is characteristic of the Stage 4 of IDM. Interestingly, the industry's reaction to the emergence of Wi-Fi networks is already one that one usually sees in Stage 5 of IDM. Quite clearly, the industry perceives a threat in Wi-Fi technology:

Until now Wifi (sic) has been viewed by many technology analysts as an upstart from-the-bottom technology that has the potential of upsetting other capital-intensive technology deployments, like the expensive next-generation data-oriented cellular networks known as 2.5G and 3G that are being established by companies like AT&T Wireless, Cingular, Nextel, T-Mobile, Sprint and Verizon (Markoff, 2002b, pp. C1 and C4).

The industry's response to this threat is even more telling. Like the canals, railroads, and telegraph, it seeks to accommodate the new technology within the existing order by strengthening the complementary relationship between the old and the new technology:

It (VoiceStream Wireless) announced in mid-March that it will integrate Wi-Fi technology . . . with its existing network to provide "seamless service" – an Internet connection that switches automatically from Wi-Fi to 3G and back – starting early next year. Sprint PCS is working on something similar, although it hasn't unveiled an offering. "There is no question that Wi-Fi will be complementary to 3G wireless," says Sprint spokesman Dan Wiliinsky. Already, Nokia and Ericsson are working on handsets that allow seamless roaming (Stone, 2002).

When viewed from within the existing framework, a complementary relationship between cellular and Wi-Fi makes a great deal of sense because the strengths and weaknesses of the two technologies complement each other. Wi-Fi offers much greater bandwidth and therefore higher transmission speeds mainly because it employs low powered transmitters for communication over short distances. It, however, is limited to high population density areas. Cellular, on the other hand, has an extensive network already in place. Its downside is significantly lower transmission rates. Therefore a seamless service that automatically switches back and forth between the two networks would be a win-win solution for everybody. While in the downtown area a subscriber could use higher bandwidth Wi-Fi networks and then switchover to cellular service when driving into the outlying areas. The logic of a complementary relationship is indeed compelling. IDM, however, prompts us to remember that what seems very rational within the existing framework may not remain so in a new network paradigm.

## The question of the future

As mentioned earlier, at the time of the publication of IDM in 1992, it seemed unlikely that wireless would move beyond Stage 3 of the model because of the following three reasons:

- (1) industry structure;
- (2) inter-modal compatibility; and
- (3) spectrum scarcity.

Subsequently, with the emergence of Wi-Fi, wireless is today on the verge of entering Stage 4. The big question now is whether it will complete Stage 4 and go to Stage 5.

When the Wi-Fi transmitters start directly routing messages to their neighbors or as Negroponte poetically says “lily to lily,” wireless will enter Stage 4. But that does not mean that it will necessarily complete Stage 4. Direct communication between neighboring Wi-Fi transmitters would indeed result in the bypass of the entrenched wireline system, the defining feature of a system in Stage 4 of the development cycle. However, at this level of development, the bypass will occur only at a local level. In a city center covered by overlapping hot spots, a message from one Wi-Fi transmitter could be sent to another located many blocks away without ever touching the wireline network, neighboring transmitters relaying the message forward all the way. However, if the message has to be sent from a transmitter in one city to another, say from New York to Los Angeles, the entire dynamic changes. While theoretically one could imagine a chain of overlapping hot spots connecting New York to Los Angeles, the obvious advantages of using the existing wireline network would make the construction of a transcontinental Wi-Fi link impractical to say the least. In other words, even with the emergence of Wi-Fi, inter-modal compatibility remains a factor that could potentially deflect the evolution of the wireline-wireless relationship away from the IDM pattern. Similarly, spectrum scarcity continues to be a constraining factor that reinforces the continuation of the existing complementary relationship. Yet, even if the present framework endures, there are likely to be significant changes in the wireline-wireless equation as wireless grows deeper into the network and the wireline recedes into the background as a long haul transport vehicle. We are already seeing the deployment of Wi-Fi as a backhaul link, as opposed to the end-user link that has been the focus of the discussion so far, which connects unwired collection point towers to the wireline network. The advantage of Wi-Fi over microwave as a backhaul link is that it is not as severely constrained with regard to line of sight issues (Wilson, 2003).

With regard to industry structure, there has been a radical new development. Ordinary citizens operating in a bottom-up mode deployed the earliest Wi-Fi networks and are now a major force behind the development of the technology[4]. For example, Silicon Valley has hobbyist groups like Bay Area Wireless Users Group and Bay Area Wireless Regional Network that are working to cover the Bay Area with Wi-Fi networks (Markoff, 2002a, 2003)[5]. In the past, when a new

technology supplanted the old one, it was a result of corporate battles fought in the market place. The corporate interests invested in the old technology sought to protect their franchise while new firms sought to use a new technology to dislodge them. We see the beginnings of such a battle in the current scenario with different types of corporations entering the Wi-Fi arena[6]. But we also see a very different phenomenon as corporate interests as a whole are arrayed against a loose collection of ingenious technology enthusiasts driven by a libertarian impulse. It is not clear how this dynamic will shape the competition between Wi-Fi networks and the earlier more established technologies.

Arthur C. Clarke classifies forecasting failures into two categories: “failures of nerve” and “failures of imagination.” In the case of the former, the forecaster fails to see the obvious even when all the relevant facts are in front of him or her. The latter occur when the forecaster is unable to make the leaps of imagination necessary to grasp a new phenomenon (Clarke, 1962). The above analysis of the potential development of Wi-Fi technology in Stage 4 is quite reasonable and that is probably its greatest weakness. As we have seen time and again, future is rarely a logical extension of the present. We need to guard against failures of nerve and failures of imagination.

### Failures of nerve

In order to guard against failures of nerve, we need to interrogate our assumptions and biases and foster out of the box thinking. The above analysis is based on the assumption that future choices will be made on the basis of economic rationality. We need to dwell on this assumption at two levels: IDM itself and the players currently in the Wi-Fi arena.

At first glance, the IDM pattern appears to be generated by the play out of the economic rationality logic. The incremental development of a new technology in the IDM pattern encourages this notion. In the initial stages, the new technology is unproven and it makes sense to deploy it in phases. Furthermore, for a new technology, it is a very rational strategy to develop a complementary relationship with the dominant system. Later, with the development of long-distance capabilities, it is quite natural to form an integrated system. Thus the entire network development process can be explained on the basis of the economic rationality logic. If this explanation were indeed correct, we would expect to see similar patterns of network development in other countries. But then, as we will see in the case of France and Canada, the network development patterns greatly vary across countries. In keeping with the earlier US discussion, we will use railroad examples to highlight the network development pattern in France and Canada.

The French were late starters in experimenting with the railroads. The British were the innovators. The success of London & Manchester and Stockton & Darlington Railways in England attracted the attention of the French legislature

which promptly appropriated 500,000 francs for a study of the new technology (Caron, 1988). In the next decade “the government considered the whole subject of railroad construction with a very lively sense of its importance, and in 1842 it announced a policy both with respect to the railroads which should be built and with regard to the methods by which these railroads should be financed which, at least so far as construction was concerned, was substantially adhered to” (Daggett, 1928, pp. 45-46). Soon the French had one of the finest railroad systems. Thus in France, unlike the USA, the railroads were conceptualized as a full-blown network at the very outset. We see a similar pattern in the development of French highway, electrical, and telecommunications systems. The French are rarely innovators. The initial innovation usually takes place in the UK, the USA, or other countries which have a less centralized environment. Once the new technology starts showing promise, the French government recognizes its national importance. It swiftly steps in and finances a world-class system designed as an integrated system from the very beginning (Sawhney, 1993).

The railroads in Canada developed as an embankment to stem American expansionism. Canada perceived the development of the Northern Pacific Railroad as a real threat to its territorial claims in the West. It therefore scrambled to put together its own transcontinental railroad – Canadian Pacific Railroad (CPR). The dogged nature of these moves and countermoves becomes most apparent in CPR’s response to Northern Pacific’s extension of its lines from Fargo to Spokane and Portland. CPR felt threatened by the possibility that the American railroad might drive branch lines into Manitoba. Consequently, it moved to block the development of these branch lines by shifting its original route 200 miles south (Waite, 1971). This thumbnail sketch of Canadian railroad history highlights a pattern of infrastructure marked by a desire to: first, block the expansionary tendencies of the USA and second, re-channel internal commerce and communication along the east-west axis and away from the US border. We see a similar pattern in the development of telegraph, airline, radio, TV, and other networks in Canada (Sawhney, 1999).

Obviously, the patterns of network development in France and Canada are very different from the one in the USA. One could conceivably argue that considering the fact that France operates in a catch-up mode, after the new technology has proven itself in another country, its network development pattern too follows the economic rationality logic. Why follow an incremental approach when it is already clear through the experience of another country what should be the overall organization of the network? But then, consider the case of Minitel where France was the leader rather than a follower. It was also implemented in a centralized mode. Conversely, consider a technology, say cellular phones, where the US is behind other countries. Is it conceivable that

the US will adopt a centralized strategy even when it is economically more efficient? Quite clearly, the network development pattern is not solely driven by the economic rationality logic. There are many other socio-economic factors that come into play[7]. The Canadian example highlights a situation where the political trumps the economic. In sum, IDM is not entirely a product of economic rationality. It has a strong cultural dimension.

With regard to the players currently in the Wi-Fi arena, the technology enthusiasts are driven by the thrill of working with a new technology and an ideology that celebrates the subversive potential of their actions. Their activities are not constrained by the economic rationality logic. In fact Wi-Fi enthusiasts, fueled by the libertarian impulse, take delight in overturning the corporate apple cart. So, it is quite likely that they might push technologies that disrupt the entrenched paradigm even if their deployment does not make economic sense, at least in the short run.

### **Failures of imagination**

Failures of imagination become evident only with hindsight. There is little we can do to eliminate them. Yet, we need to think ahead knowing well that time and again the future has outfoxed the most prescient of human beings. In the case of telecommunications, the future is a particularly pesky issue. On one level, we know that it is foolhardy to predict the future. On another level, we cannot ignore it in an arena marked by rapid technological change. We are constantly faced with decisions about the future even though we do not know what it will entail. What technology should a company deploy to meet future demand? What regulatory frameworks should the regulators create that can cope with the pace of technological change? We have to act today and in order to do so we have to have some notion of the future, however tentative and ill formed. We would like to devise computer models that print out a detailed roadmap. But the processes driving technological change are too complex to model. We can fall back on raw hunch and intuition but that can lead to impressionistic and historically uninformed decisions. Or, as this paper suggests, we can use heuristic models to expand the range within which our imagination roams.

IDM, the heuristic model employed in this paper, is in many ways an extended metaphor that prompts us to rise above our taken for granted assumptions and think about the future in a new way. It alerts us to the possibility of unexpected developments such as the development of long-distance capabilities by the new technology and the subsequent bypass of the old system. Wayne Gretzky, when asked to provide an insight into his prowess in the hockey rink, said, “I skate where I think the puck will be” (quoted in Gilster, 1993). This is exactly what the IDM does. It gives us some idea of what to expect. It, however, does not “guarantee” that the proverbial puck will be there for sure. ■

## Notes

- 1 The only time people who leave their transmitters unsecured have to bear a cost of sorts is when a large number of freeloaders simultaneously download many large files and thereby degrade the quality of their Internet connection (Harmon, 2002).
- 2 The cable and telephone companies contend that subscribers who leave their transmitters unsecured are violating their service agreements and possibly breaking the law. They equate allowing neighbors and strangers to tap into one's Internet connection to cable theft. Wi-Fi enthusiasts argue that satellite broadcasts provide a more appropriate analogy. It is not a crime to pick up unscrambled satellite signals. However, it is against the law to decode the encryption of scrambled signals. In other words, securing connections is the responsibility of the network owner and not the users. These arguments have not yet been tested in the courts and it is difficult to predict how the justices will rule (Harmon, 2002).
- 3 Negroonte credits Alessandro Ovi, technology adviser to European Commission president Romano Prodi, for the lily analogy.
- 4 Many city governments have also started creating Wi-Fi networks as economic development and quality of life initiatives. For example, the city of Long Beach, California, has plans to provide Wi-Fi connectivity in a four-block area around the convention center and later extend it to the marina, airport, and other areas. There are similar efforts afoot in San Francisco, Seattle, Jacksonville (Florida), and other cities (Markoff, 2003).
- 5 What differentiates these networks from commercial networks is that they self assemble by "expanding from one neighborhood to the next as individuals and businesses join by buying their own cheap antennas that either attach to the wired Internet or pass a signal on to another wireless node" (Markoff, 2002a, p. C4).
- 6 On the commercial front, many different types of players have sought to leverage Wi-Fi technology for business purposes. AT&T, IBM, and Intel have partnered to create a new company, Cometa Networks, to develop Wi-Fi networks. Its goal is to deploy by the end of 2004 over 20,000 wireless access points across the country so as to bring Wi-Fi connectivity within five-minute walking distance in urban areas and five-minute driving distance in suburban areas. Interestingly, in light of the discussion in the previous section, even Cometa executives expect cellular and Wi-Fi to be complementary technologies (Markoff, 2002b). Wayport already provides connections in 450 hotels and a number of airports. It charges corporate users \$19.95 a month per employee who uses their network (Harmon, 2002). On the retail end, Starbucks shops in New York provide 30 minutes of free access to their Wi-Fi network and then charge \$2.95 for every 15 minutes of additional use (Harmon, 2002).
- 7 The near total abandonment of the old technology in Stage 7 of IDM is also not based on economic rationality. For example, the

abandonment of railroads in the USA with the advent of the automobiles had more to do with cultural factors than anything else. In fact the economic rationality logic would have prompted a coordinated co-existence of old and new technologies as seen in many European countries.

## References

- Anderson, O.W. (1985), *Health Services in the United States: A Growth Enterprise since 1875*, Health Administration Press, Ann Arbor, MI.
- Caron, F. (1988), "The evolution of the technical system of railways in France from 1832 to 1937", in Mayntz, R. and Hughes, T.P. (Eds), *The Development of Large Technical Systems*, Westview Press, Boulder, CO, pp. 69-103.
- Clarke, A.C. (1962), *Profiles of the Future*, Victor Gollancz, London.
- Daggett, S. (1928), *Principles of Inland Transportation*, Harper & Brothers, New York, NY.
- Gilster, P. (1993), "Information intrastates", *State Government News* (Nebraska), October, pp. 18-21.
- Harmon, A. (2002), "Good (or unwitting) neighbors make for good Internet access", *The New York Times*, 4 March, pp. C1 and C4.
- Markoff, J. (2002a), "The corner Internet network vs. the cellular giants", *The New York Times*, 4 March, pp. C1 and C4.
- Markoff, J. (2002b), "High-speed wireless Internet network is planned", *The New York Times*, 6 December, pp. C1 and C4.
- Markoff, J. (2003), "More cities set up wireless networks", *The New York Times*, 6 January, p. C7.
- Negroonte, N. (2002), "Being wireless", *Wired*, October, available at: [www.wired.com/wired/archive/10.10/wireless.html](http://www.wired.com/wired/archive/10.10/wireless.html)
- Noll, R.G. and Owen, B.M. (1987), *United States vs. AT&T: An Interim Assessment*, Publication No. 109, Center for Economic Policy Research, Stanford University, Stanford, CA.
- Sawhney, H. (1992), "Public telephone network: stages in infrastructure development", *Telecommunications Policy*, Vol. 16 No. 7, pp. 538-52.
- Sawhney, H. (1993), "Circumventing the center: the realities of creating a telecommunications infrastructure in the USA", *Telecommunications Policy*, Vol. 17 No. 7, pp. 504-16.
- Sawhney, H. (1999), "Patterns of infrastructure development in the US and Canada", in Sawhney, H. and Barnett, G. (Eds), *Progress in Communication Science*, Vol. XV: *Advances in Telecommunications*, Ablex, Stamford, CT, pp. 71-91.
- Stone, A. (2002), "Wi-Fi: it's fast, it's here – and it works", *Business Week Online*, 1 April, available at: [www.businessweek.com/technology/content/apr2002/tc2002041\\_1823.htm](http://www.businessweek.com/technology/content/apr2002/tc2002041_1823.htm)
- Waite, P.B. (1971), *Canada 1874-1896: Arduous Destiny*, McClelland & Stewart, Toronto.
- Wilson, S. (2003), "No strings attached: introduction to unlicensed wireless data technologies", presentation at the 7th Annual Florida Communications Policy Symposium, April 3, Tallahassee, FL.